Magnitude Simba SDK

Developer Guide Using SQLEngine

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About This Guide

Purpose

This guide explains how to use the Magnitude Simba SDK to document what SQL grammar the JSQLC++ engine supports.

Audience

The guide is intended for developers who have created a connector with the Simba SDK. This guide is also intended for end users of the Simba SDK.

Knowledge Prerequisites

To use the Simba SDK, the following knowledge is helpful:

- Familiarity with the platform on which you are using the Simba SDK.
- Ability to use the data store to which the Simba SDK is connecting.
- An understanding of the role of ODBC or JDBC technologies and driver managers in connecting to a data store.
- Experience creating and configuring ODBC or JDBC connections.

Variables Used in this Document

The following variables are used in this document:

Variable	Description
[DRIVER_NAME]	The name of your connector, as used in Windows registry keys and names of configuration files.
[INSTALL_DIR]	Installation directory for the Simba SDK.

Contents

Introducing the Simba SDK

The Simba Software Development Kit (SDK) is a collection of database access tools packaged in a flexible, reusable set of components. These components are used to create custom database connectors for any data store, even if the data store is not SQL-capable. Connectors can be built to access both local and remote data stores.

This guide introduces the components of the Magnitude Simba SDK and explains how you can use them to create custom connectors for ODBC, JDBC, OLE DB and ADO.net applications.

Note:

This guide explains how to build a connector for data stores that do not support SQL. If you want to build a connector for data stores that support SQL, see Developing Connectors for SQL-capable Data Stores.

You may find the HTML version of this guide easier to use. See Developing Connectors for Data Stores Without SQL.

Note:

This guide explains how to build a connector for data stores that support SQL. If you want to build a connector for data stores that do not support SQL, see Developing Connectors for Data Stores Without SQL.

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Creating a Custom Connector with the Simba SDK

The components of the Simba SDK implement all the required functionality of ODBC, JDBC, OLE DB, and ADO.net, as well as handling session management, state management, data conversion, and error checking. These components provide an abstraction layer to insulate your underlying connector functionality from any changes to data access standards. By basing a custom connector on the Simba SDK, you can leverage the experience of leaders in data connectivity.

For data stores that do not support SQL, the Simba SDK provides an SQL parser and an execution engine to translate between SQL commands and your custom datastore API.

For data stores requiring remote deployment, the Simba SDK allows you to re-build your existing connector into a server for a client/ server deployment. This allows you to build your connector as a server that reside near data source, then deploy an ODBC or a JDBC client that handles communication with the end user's application. For more information about client-server deployment, see the *SimbaClientServer User Guide* at http://www.simba.com/resources/sdk/documentation/.

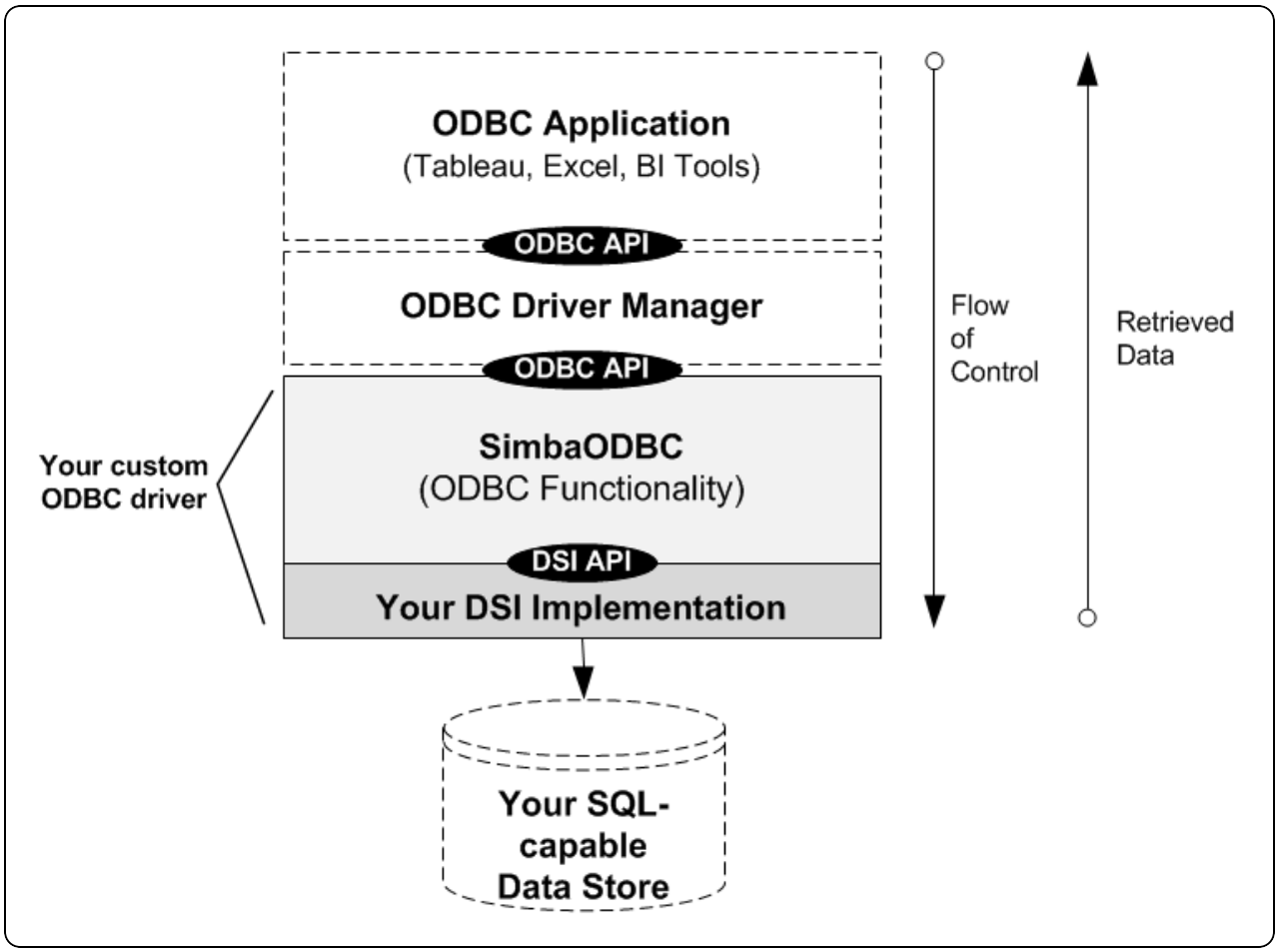
Data Store Interface Implementation (DSII)

To write a custom connector using the Simba SDK, you write a component called the "DSI implementation" to access your data store. You then link this component with the Simba SDK components, which takes care of meeting the data access standards, and optionally converting SQL commands to commands that your data store can understand. The result is a shared object: a `.dylib`, `.jar`, or `.dll`, `.so` file, depending on your development platform. Applications, such as Tableau or Microsoft Excel, use this shared object to access your data store, even if your data store is not SQL-enabled.

Example - Build an ODBC Connector for a SQL-Capable Data Store

The easiest custom ODBC connector you can build with the Simba SDK is a standalone connector connecting to an SQL-capable data store. In this configuration, the application (such as Tableau or Excel) creates SQL queries and sends them to the ODBC connector. The ODBC connector can choose to modify these queries, then sends them to the data store. The data store executes the SQL queries and creates a result set. Finally, the ODBC connector moves the result set from the data store back to the application.

This flow of control is illustrated below:



Note:

The Simba SDK provides a similar solution for JDBC, OLE DB, and ADO.net applications.

The following sections describe the components shown in the above diagram.

SimbaODBC Component

For data stores that are SQL-capable, your custom ODBC connector is composed of the SimbaODBC component and your DSI implementation. The SimbaODBC component implements most of the connector functionality, including:

- session and statement management
- abstracting and implementing the low-level requirements of the ODBC API
- error checking

Note:

When changes are made to the ODBC API, or when applications change how they use the ODBC API, the Simba SDK incorporates these changes transparently. As a result, connectors based on the Simba SDK can handle these changes without code rewrites.

The Data Store Interface (DSI)

The data store interface, or DSI, defines a generic view of an SQL database that is independent of the data access standards (ODBC, JDBC, ADO.NET and OLE DB). The Simba SDK translates the ODBC, JDBC, ADO.NET and OLE DB interfaces to the DSI in C++, Java, or C#. By writing code to map from the DSI to your data store, you are creating a connector that can use one of these standard interfaces.

Note:

- The DSI API is object-oriented and simpler to use than the industry-standard interfaces, making it easier to translate standard APIs to your custom data store.
- The DSI API provides a consistent API for all the standards it supports: ODBC, JDBC, ADO.NET or OLE DB. This makes creating connectors for different standards much easier, because you can re-use your knowledge.

Your DSI Implementation (DSII)

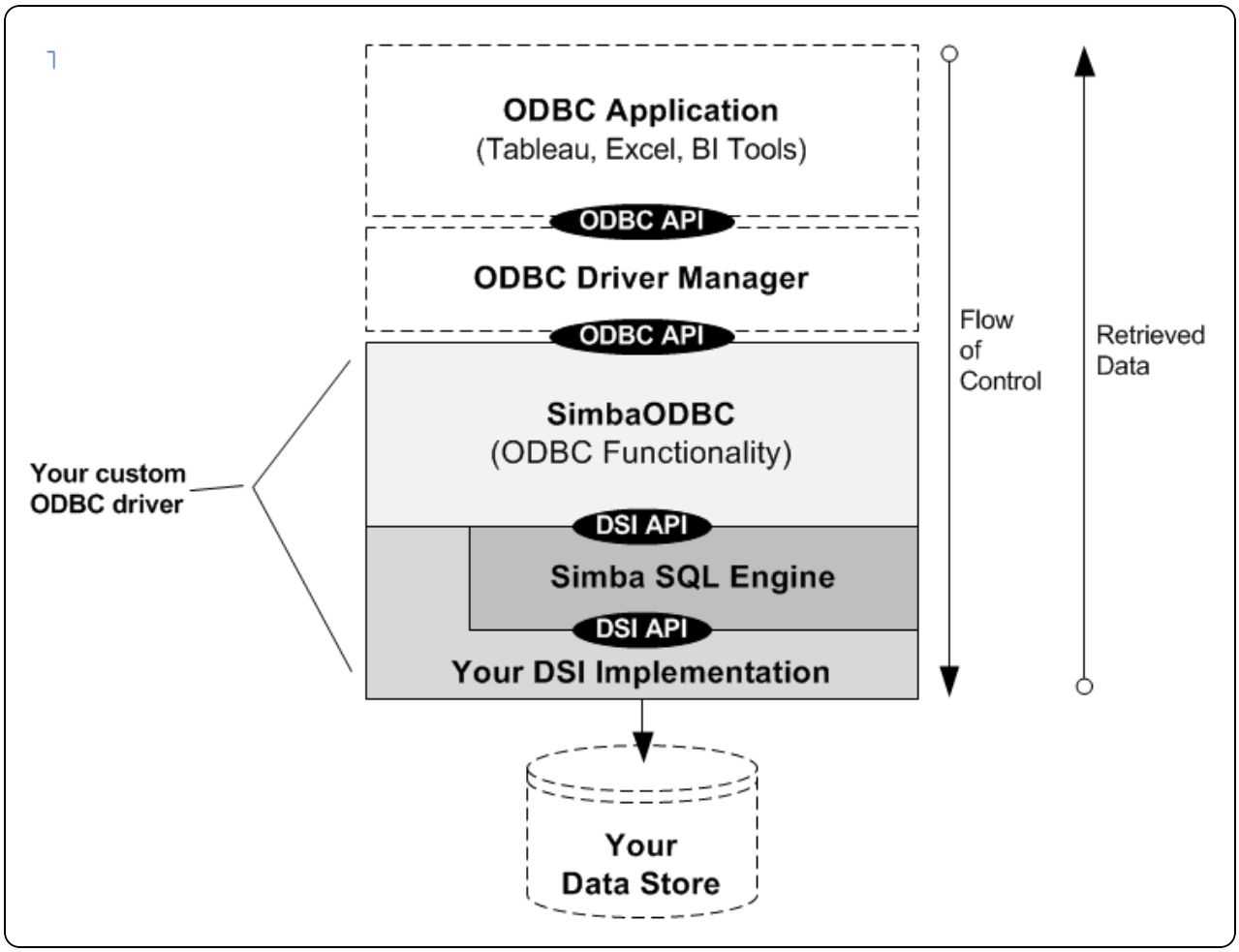
The SimbaODBC component uses the data store interface, or DSI, to communicate with the your DSI implementation. The DSI interface is common to all Simba SDK components that communicate with customer code. You write your DSI implementation (DSII) to connect directly to your data store and translate its interface to the DSI API.

Note:

Every DSII is custom designed for a specific data store and that data store's interface.

Example - Build an ODBC Connector for a non-SQL-Capable Data Store

Many data stores, like Big Data, object oriented, and XML data stores, do not understand SQL. To create a custom connector for these data stores, use the same components shown above, with the addition of the Simba SQLEngine:



Note:

The Simba SDK provides a similar solution for JDBC applications.

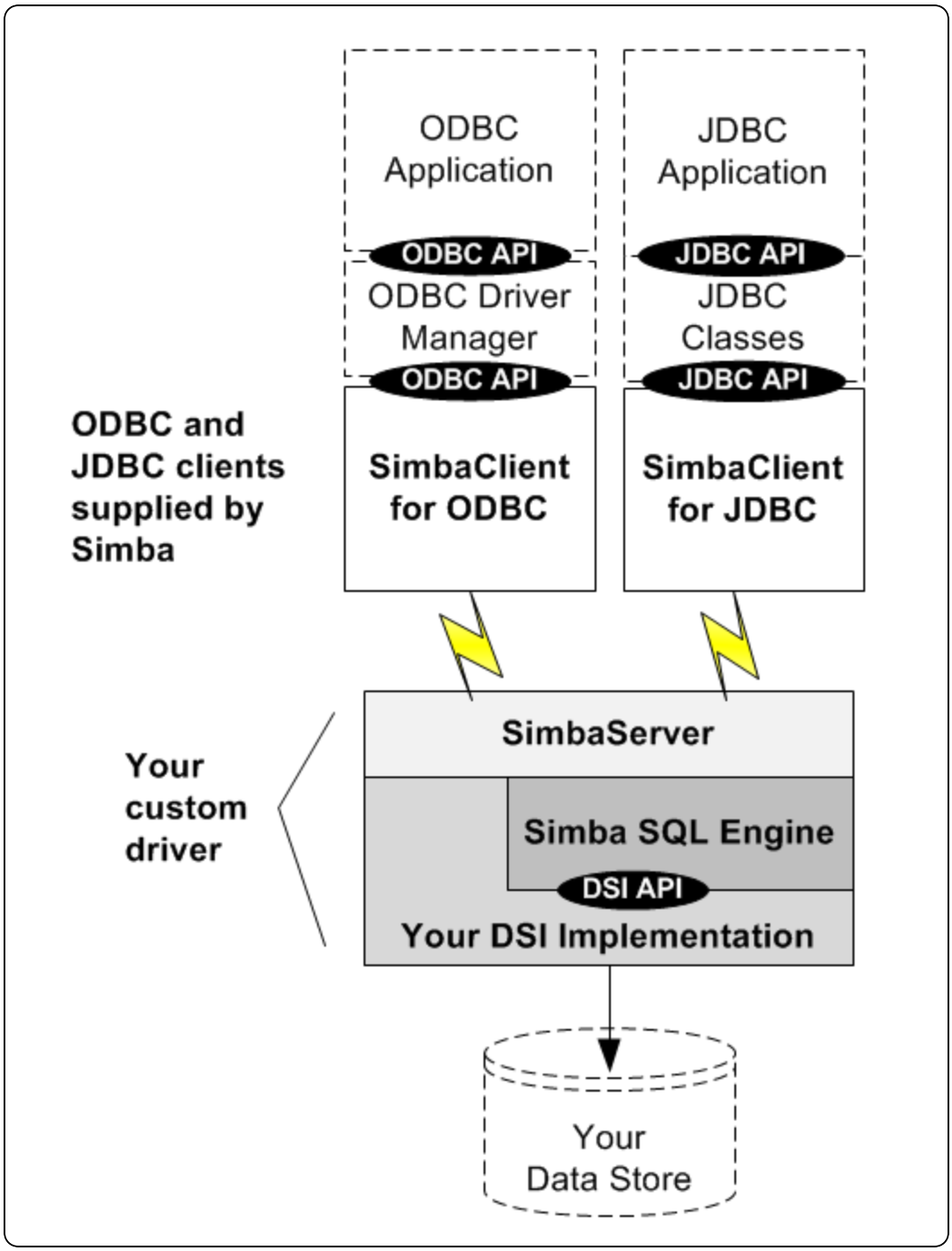
For data stores that are not SQL-capable, your custom ODBC connector is composed of the SimbaODBC component, the SQL Engine, and your DSI implementation. The Simba SQL Engine provides the SQL processing required to support ODBC interfaces.

Simba SQLEngine

The Simba SQLEngine is a self-contained SQL parser and execution engine. It consumes SQL-92 queries, parses them, creates an optimized execution plan, allows your DSI implementation to take over part or all of the execution, and then executes the plan against the DSI implementation.

Example - Build a Client/Server Solution

Once you have created a DSI implementation and built a custom connector, either for a SQL-enabled or non-SQL-enabled data store, you can rebuild your DSI implementation into a client/server solution. You can do this without making any changes to the code - simply link your DSI implementation to the Simba Server to provide remote data access:



The following sections describe the components shown in the above diagram.

Simba Client/Server protocol

The Simba Client/Server protocol is a network protocol that works on any network to provide remote access to a DSI implementation. Simba Server translates the Simba Client/Server protocol to the DSI API.

Note:

- A client/server deployment lets you locate your custom connector close to the data store, while the client applications are located with your users.
- Both the ODBC and the JDBC client can talk to the same SimbaServer. That means you can write one custom connector, built it as a server, then use it to service SQL requests from both ODBC and JDBC applications.

SimbaClient for ODBC and Simba Client for JDBC

The ODBC and JDBC clients are shared objects provided by Simba. These clients use the Simba Client/Server protocol to handle communication between the application and Simba Server.

Related Topics

Simba SDK Usage Scenarios

Build a Connector in 5 Days

Simba SDK FAQ

Implementation Options

You can use the Simba SDK to build custom connectors for ODBC, JDBC, OLE DB, and ADO.Net applications. Depending on the interface standard that your connector supports, you can develop the connector in C++, Java, or C#.

The Simba SDK provides many different implementation options for developing your custom connector. For example, you can develop an ODBC connector in C++ using the DSI API. You can also develop an ODBC connector in Java using the Java DSI API and the JNI bridge. Or, you can develop a custom JDBC connector for data stores that do not support SQL, and implement the connector for either a local or a client-server deployment.

Note:

This guide explains how to build a connector for data stores that do not support SQL. If you want to build a connector for data stores that support SQL, see Developing Connectors for SQL-capable Data Stores.

You may find the HTML version of this guide easier to use. See Developing Connectors for Data Stores Without SQL.

Note:

This guide explains how to build a connector for data stores that support SQL. If you want to build a connector for data stores that do not support SQL, see Developing Connectors for Data Stores Without SQL.

You may find the HTML version of this guide easier to use. See Developing Connectors for SQL-capable Data Stores.

The following table shows the possible types of custom connectors you can build with the Simba SDK, and the components and APIs required for each. The table includes options for local and remote (client/server) deployments, and for SQL-enabled and non-SQL-enabled data stores. The *Sample Connector(s)* column lists the sample connector(s) that provide a working example of your chosen implementation option.

Note:

- Every connector, except for those written in C#, is supported on Windows, Unix/Linux, and macOS. C# is supported on Windows.
- The sample connectors are included with the Simba SDK in the folder`C:\Simba Technologies\SimbaEngineSDK\10.0\Examples\Source`.

Connector Type	Language	Data Store Type	Sample Connector (s)	Simba SDK Component (s)
Custom ODBC connector	C++	SQL, Local	Ultralight	DSI API
Custom ODBC connector	C++	SQL, Remote	Ultralight + SimbaServer	DSI API
Custom ODBC connector	C++	Not SQL capable, Local	Quickstart	DSI API + SQL Engine

Connector Type	Language	Data Store Type	Sample Connector (s)	Simba SDK Component (s)
Custom ODBC connector	C++	Not SQL capable, Remote	Quickstart + SimbaServer	DSI API + SQL Engine
Custom ODBC connector	Java	SQL, Local	JavaUltraLight	Java DSI API + JNI DSI
Custom ODBC connector	Java	SQL, Remote	JavaUltraLight + SimbaServer	Java DSI API + JNI DSI
Custom ODBC connector	Java	Not SQL capable, Local	JavaQuickstart or JavaQuickJSON	Java DSI API + JNI DSI + SQL Engine
Custom ODBC connector	Java	Not SQL capable, Remote	JavaQuickstart + SimbaServer	Java DSI API + JNI DSI + SQL Engine
Custom ODBC connector	C#	SQL, Local	DotNetUltraLight	.NET DSI API + CLI DSI
Custom ODBC drive	C#	SQL, Remote	DotNetUltraLight + SimbaServer	.NET DSI API + CLI DSI
Custom ODBC connector	C#	Not SQL capable, Local	DotNetQuickstart	.NET DSI API + CLI DSI + SQL Engine
Custom ODBC connector	C#	Not SQL capable, Remote	DotnetQuickstart + SimbaServer	.NET DSI API + CLI DSI + SQL Engine

Connector Type	Language	Data Store Type	Sample Connector (s)	Simba SDK Component (s)
Custom JDBC connector	Java	SQL, Local	JavaUltraLight	Java DSI API
Custom JDBC connector	Java	SQL, Remote	JavaUltraLight + SimbaServer	Java DSI API + JNI DSI
Custom JDBC connector	Java	Not SQL capable, Local	JavaQuickJson	Java DSI API
Custom JDBC connector	Java	Not SQL capable, Remote	JavaQuickstart + SimbaServer	Java DSI API + JNI DSI + SQL Engine
Custom ADO.NET connector	C#	SQL, Local	DotNetUltraLight	.NET DSI API
Custom OLE DB connector	C++	Not SQL capable, Local	Quickstart	DSI API + SQL Engine

The following section provides more details about the information in the table above.

Options for Programming Languages

The programming language you use to write the DSII depends partly on the interface standard you need to support. The supported combinations of programming language and interface standard are shown in the table above.

Example:

- To write a JDBC connector that is deployed locally, you must write the DSII in Java.
- To write an ODBC connector that is deployed locally, you can write the DSII in C++, Java, or C#. If you write the DSI in Java, you need to link with a JNI bridge. If you write the DSI in C#, you need to link with a CLI bridge.

Programming Languages for ODBC applications

To build a local connector for ODBC applications, you can write your DSII in the following languages:

- C++ (the most common choice)
- C# with a CLI bridge
- Java with a JNI bridge

Programming Language for JDBC Applications

To build a local connector for JDBC applications, you must write your DSII in Java. Or, you can deploy the JDBC client to support the JDBC applications and implement the SimbaServer in Java, C++, or C#.

Programming Language for ADO.NET Applications

To build a local connector for ADO.NET applications, you must write your DSII in C#.

Supported Combination of Components

This section explains the different ways you can leverage the Simba SDK components in each of the supported programming languages.

C++ Development

For C++ connector development, you have the following options:

- Use the DSI API, build as an ODBC connector (connected locally to your data store) and link your DSII to SimbaODBC.
- Build as a SimbaServer connector, supporting remote connections from SimbaClients for JDBC and ODBC. Link your C++ DSII upwards to SimbaServer via the DSI API.

In the above cases, you can link against the C++ SQLEngine to access non-relational data stores.

Java Development

For Java connector development, you have the following options:

- Use the Java DSI API, build as a JDBC connector (connected locally to your data store) and link your DSII with SimbaJDBC.
- Build as an ODBC connector (connected locally to your data store) using the Java DSI API and link via the C++ to Java Bridge to SimbaODBC.

- Build as a SimbaServer connector, supporting remote connections from the JDBC and ODBC clients. Link your Java DSII upward via the Java DSI API and C++ to Java Bridge to SimbaServer.

In the above cases, you can link to the Java SQLEngine to access non-relational data stores.

C# Development

For C# development, you have the following options:

- Use the DotNet DSI API, build as an ADO.NET connector (connected locally to your data store) and link your DSII with Simba.NET.
- Use the DotNet DSI API, build as an ODBC connector (connected locally to your data store) and link via the C++ to C# Bridge to SimbaODBC.
- Build as a SimbaServer connector, supporting remote connections from the JDBC and ODBC clients. Link your DotNet DSII upward via the DotNet DSI API and C++ to C# Bridge to SimbaServer.

Options for Deployment

The Simba SDK provides you a number of different optional components for building and deploying a custom connector for a wide variety of solutions.

SQL Engine

If your data store is SQL-capable, you do not need to use the SQLEngine. If your data store is not SQL-capable, link your connector to the Simba SQLEngine libraries to provide the SQL processing needed by ODBC or JDBC. The SQL Engine is available in the C++ and Java SDKs.

Local Deployments

Local deployments are typically used in the following scenarios:

- Client applications access a database that runs on each user's machine. For example, an ODBC connector might support a client management database where each user performs analysis of their own, local data.
- You have already configured your database for network access and some component of your software is already installed on user machines. Your new connector will allow other, general-purpose client applications to access the same connection to your database that your own client application uses.
- You are in the early stages of testing your connector and as a developer, you are accessing a local instance of your database. You will eventually change the compilation options to link to the SimbaServer libraries, but there will be no changes needed to your DSI implementation to do this.

Remote (Client/Server) Deployments

Client-Server deployments are best when software runs on a server and users access it from their own machines. Your custom connector, using SimbaServer, runs on the network server. SimbaClient is installed on user machines to allow applications such as Excel and Tableau to access your remote data store.

Related Topics

Introducing the Simba SDK

Simba SDK FAQ

Library Components

This section introduces the components comprising the Simba SDK.

Note:

This guide explains how to build a connector for data stores that do not support SQL. If you want to build a connector for data stores that support SQL, see Developing Connectors for SQL-capable Data Stores.

You may find the HTML version of this guide easier to use. See Developing Connectors for Data Stores Without SQL.

Note:

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You may find the HTML version of this guide easier to use. See Developing Connectors for SQL-capable Data Stores.

SimbaODBC (the "C++ SDK")

SimbaODBC provides a complete ODBC 3.80 interface and all of the processing required to meet the ODBC 3.80 specification. It is the connection between your custom DSI implementation and ODBC applications such as Tableau and Microsoft Excel.

Your custom ODBC connector is composed of the SimbaODBC component and your DSI implementation. The SimbaODBC component implements most of the connector functionality, including:

- session and statement management
- abstracting and implementing the low-level requirements of the ODBC API
- error checking

Tip:

When changes are made to the ODBC API or the way the standard is used by applications, Simba incorporates these changes in a manner that is transparent to your DSI implementation.

For information about the Simba SDK C++ API method calls, see the Simba SDK C++ API Reference at https://www.simba.com/docs/SDK/SimbaEngine_C++_API_Reference.

Simba OLE DB

This component is part of the C++ SDK. SimbaOLEDB provides interfaces and all the processing required to meet the OLE DB specification. It is the connection between your custom DSI implementation and common OLE DB reporting applications such as Microsoft SQL Server Analysis Services.

SimbaJDBC (the "Java SDK")

SimbaJDBC provides complete interfaces for JDBC 4.0, JDBC 4.1, and JDBC 4.2, as well as all of the processing required to meet these specifications. It is the connection between your custom DSI implementation and common JDBC reporting applications.

For information about the Simba SDK Java API method calls, see the SimbaSDK Java API Reference at https://www.simba.com/docs/SDK/SimbaEngine_Java_API_Reference.

Simba.NET

Simba.NET provides a complete ADO.NET interface and all the processing required to meet the ADO.NET specification. It is the connection between your custom DSI implementation and common ADO.NET reporting applications such as Microsoft SQL Server Analysis Services.

The Data Store Interface (DSI)

The data store interface, or DSI, defines a generic view of an SQL database that is independent of the industry standards for data access, such as ODBC, JDBC, ADO.NET and OLE DB. The Simba SDK translates the ODBC, JDBC, ADO.NET and OLE DB interfaces to the DSI in C++, Java, or C#. By writing code to map from the DSI to your data store, you are creating a connector that can use one of these standard interfaces.

The DSI API is object-oriented and simpler to use than the industry standard interfaces. This makes it easier to write a DSI implementation that will translate to your custom data store. Also, because the DSI API provides a consistent API whether you are implementing ODBC, JDBC, ADO.NET or OLE DB, it is easier to re-use your knowledge when creating a connector for a different industry standard.

The Data Store Interface (DSI)

The data store interface, or DSI, defines a generic view of an SQL database that is independent of the industry standards for data access, such as ODBC, JDBC, ADO.NET and OLE DB. The Simba SDK translates the ODBC, JDBC, ADO.NET and OLE DB interfaces to the DSI in C++, Java, or C#. By writing code to map from the DSI to your data store, you are creating a connector that can use one of these standard interfaces.

Simba SQLEngine

You can use the SQL Engine to create a custom ODBC or JDBC connector that allows SQL-enabled applications to access non-SQL-capable data stores. The Simba SQLEngine is a self-contained SQL parser and execution engine. It consumes SQL-92 queries, parses them, creates an optimized execution plan, allows your DSI implementation to take over part or all of the execution, and then executes the plan against the DSI implementation.

It is available in the Java and the C++ SDKs.

Simba Client/Server

Simba Client/Server allows remote access to your data store. You link the SimbaServer component with your DSII to create a custom connector than can accept requests from SimbaClient. You deploy SimbaClient with the application to send requests to the remote connector.

SimbaServer is most frequently used as a stand-alone executable, although it can be set up as a DLL or shared object under another server.

The DSI implementation used with SimbaServer can choose to include the Simba SQLEngine. It can be written to perform a wide range of functionality including SQL query processing with Simba SQLEngine, concentrating client requests through one executable, aggregating data stores, or controlling data access through role-based permissions. There are many possibilities for using SimbaServer as an intermediate processing step in a larger system.

The SimbaServer can be written in C++, or written in Java including the JNI Server. For more information see the *SimbaClient/Server Developer Guide*.

SimbaClient for ODBC

SimbaClient for ODBC is an ODBC connector DLL or shared object that can connect to SimbaServer. It includes SimbaODBC and a DSI implementation that communicates via the Simba Client/Server protocol to SimbaServer. Since any SQLEngine in the stack will be on the server side, there is no need for Simba SQLEngine in this connector. This is a completely generic ODBC connector that, when queried, reports the capabilities of the database that is connected to SimbaServer.

Note:

SimbaClient for ODBC is provided by Simba, and is ready to deploy with no additional development effort required.

SimbaClient for JDBC

SimbaClient for JDBC is a JDBC connector packaged as a .jar file so you can install it in an end user's client-side Java Run Time Environment. SimbaClient for JDBC includes the equivalent of SimbaODBC and custom Java code that communicates via the Simba Client/Server protocol with SimbaServer.

Note:

SimbaClient for JDBC is provided by Simba, and is ready to deploy with no additional development effort required.

C++ to Java Bridge (JNI DSI)

This component of the Simba SDK allows you to write the DSII in Java, then link to SimbaODBC or SimbaServer (including Simba SQLEngine) to create an ODBC connector.

C++ to C# Bridge (CLI DSI)

This component of the Simba SDK allows you to write the DSII in C#, then link to SimbaODBC or SimbaServer (including Simba SQLEngine) to create an ODBC connector.

Sample Connectors

The Simba SDK includes a number of sample connectors and sample connector projects to help you get started quickly with your custom ODBC or JDBC connector. For more information on sample connectors, see Sample Connectors and Projects.

Related Topics

Simba SDK C++ API Reference

Simba SDK Java API Reference

Simba SDK FAQ

Sample Connectors and Projects

The Simba SDK includes a number of sample connectors and sample connector projects to help you get started quickly with your custom ODBC or JDBC connector. The compiled C++ sample connectors are in the `Examples\Builds\Bin` folder of your Simba SDK installation directory, the compiled Java sample connectors are in `Examples\Builds\Lib`, and the sample connector projects are in `Examples\Source`.

Note:

This guide explains how to build a connector for data stores that do not support SQL. If you want to build a connector for data stores that support SQL, see Developing Connectors for SQL-capable Data Stores.

You may find the HTML version of this guide easier to use. See Developing Connectors for Data Stores Without SQL.

Note:

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You may find the HTML version of this guide easier to use. See Developing Connectors for SQL-capable Data Stores.

Getting Started with the Sample Connector Projects

The sample connector projects are a great way to get started developing your custom connector. Each sample connector is accompanied by a 5-Day Guide, which walks you through the steps of building, configuring, and customizing the project.

For information on how to use the sample connector projects, see 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

The following sections describe each of the sample connector projects and sample connectors.

> **Note:**
>
> Although this guide explains how to build a connector that does not use the SQL Engine, information on using the SQL Engine is included in this section for reference.

Quickstart Sample Connector

C++	Not SQL-Capable	ODBC

Quickstart is a C++ sample DSI implementation of an ODBC connector that reads text files in tabbed Unicode text format. This is not a SQL aware data source, so the Simba SQLEngine component is employed to perform the necessary SQL processing. This sample's purpose is to provide a simple, working connector that you can copy and transform into a connector that accesses your non-SQL data store. An ODBC configuration DLL is included.

The 5-Day Guide for the Quickstart sample connector project is located at 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ under the section "Build a C++ ODBC Connector in 5 Days". Select one of the guides for a non-SQL-based data source.

DotNetQuickstart Sample Connector

C#	Not SQL-Capable	ODBC

DotNetQuickstart is a C# sample DSI implementation that is the same as the Quickstart sample above, except that it is written in C# using Simba's C++ to C# bridge API (also referred to as the CLIDSI API). See the document, "Build a C# ODBC Connector in 5 Days" for a step-by-step walk-through of the process of creating a custom ODBC connector using C#.

JavaQuickstart Sample Connector

Java	Not SQL-Capable	ODBC

JavaQuickstart is a Java sample DSI implementation that is the same as the Quickstart sample, except that it is written in Java using Simba's C++ to Java bridge API (also referred to as the JNIDSI API). See the document "Build a Java ODBC Connector in 5 Days" for a step-by-step walk-through of the process of creating a custom ODBC connector using Java.

Ultralight Sample Connector

C++	SQL-Capable	ODBC

Ultralight is a sample connector that illustrates how to build a DSII for a database that already supports SQL and therefore does not require the SQLEngine component.

The Ultralight example does not truly support SQL; rather, it simply looks for keywords in the query and returns a hardcoded result set. Nevertheless, this is sufficient to show all the necessary building blocks and provide a placeholder where your real SQL processing and result set generation could take place.

The 5-Day Guide for the Ultralight sample connector project is located at 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ under the section "Build a C++ ODBC Connector in 5 Days". Select one of the guides for a SQL-based data source.

DotNetUltralight Sample Connector

C#	SQL-Capable	ODBC

DotNetUltralight is a C# sample DSI implementation that is the same as the Ultralight sample above, except that it is written in C#. DotNetUltralight can be built using either Simba.ADO.NET or using Simba's C++ to C# bridge API (also referred to as the CLIDSI API). When using Simba.ADO.NET, the resulting connector will be written entirely in C#, providing an ADO.NET interface. When using Simba's C++ to C# bridge API, the resulting connector will be a mixture of C# and C++, providing an ODBC interface or SimbaServer executable for use with any of the SimbaClient connectors.

JavaUltralight Sample Connector

Java	SQL-Capable	JDBC	ODBC

JavaUltralight is a Java sample DSI implementation that is the same as the Ultralight sample above, except that it is written in Java. JavaUltralight can be built using either SimbaJDBC or using Simba's C++ to Java bridge API (also referred to as the JNIDSI API). When using SimbaJDBC, the resulting connector will be written entirely in Java, providing a JDBC 4.0, 4.1, or 4.2 interface. When using Simba's C++ to Java bridge API, the resulting connector will be a mixture of Java and C++, providing an ODBC interface or SimbaServer executable for use with any of the SimbaClient connectors.

The 5-Day Guide for the JavaUltralight sample connector project is located at 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ under the section "Build a JDBC Connector in 5 Days". Select the guide for a SQL-based data source.

JavaQuickJson Sample Connector

Java	Not SQL-Capable	JDBC	ODBC

JavaQuickJson is a sample Java DSI imlplementation written purely in Java to demonstrate usage of the Java Simba SQLEngine. The connector accesses a data store comprised of JSON files and uses a third party JSON API to read and write data to those files. By including the Java Simba SQLEngine, the connector demonstrates how to implement some of the classes specific to the Java Simba SQLEngine and how the Java Simba SQLEngine can be used to access a data store that is not organized using traditional tables and columns.

The 5-Day Guide for the JavaQuickJson sample connector project is located at 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ under the section "Build a JDBC Connector in 5 Days". Select the guide for a non-SQL-based data source.

Using the Sample Connectors for Debugging

You can use the sample connectors to analyze and debug suspected problems in your custom connector. For example, if you think your DSI implementation is working correctly but there is a problem in your Simba SDK system, there is a simple way to determine where the problem lies. If the problem shows up when you run the system you have assembled with the sample connector project implementation, then the problem is likely to be in Simba SDK components.

If the problem goes away when you replace your DSI implementation with the sample connector project, then you need to do some more investigation of your implementation. In either case, analysis and debugging is focused and reduced, lowering your cost to deliver a solution to your customers

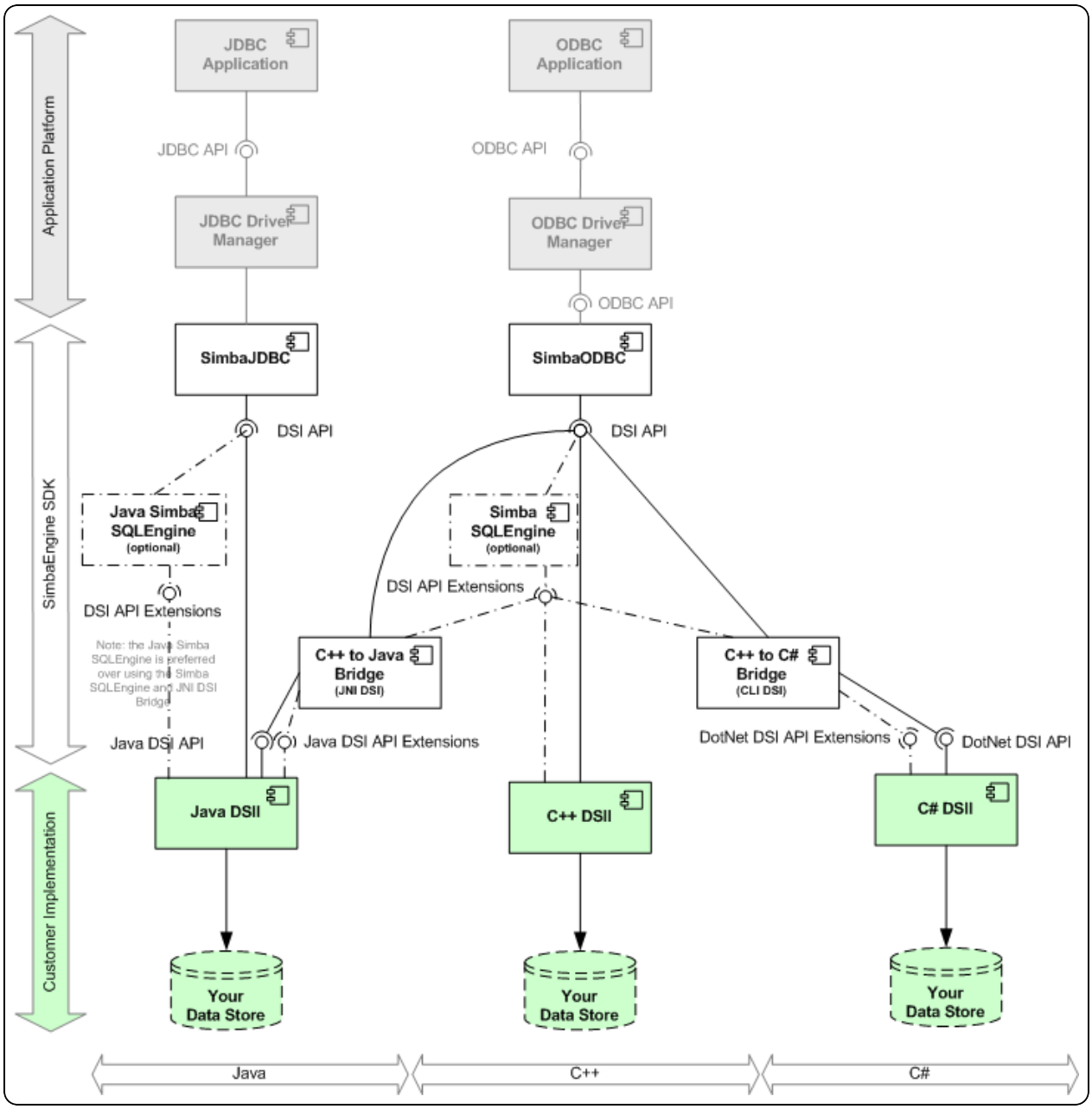
Related Topics

Building Blocks for a DSI Implementation

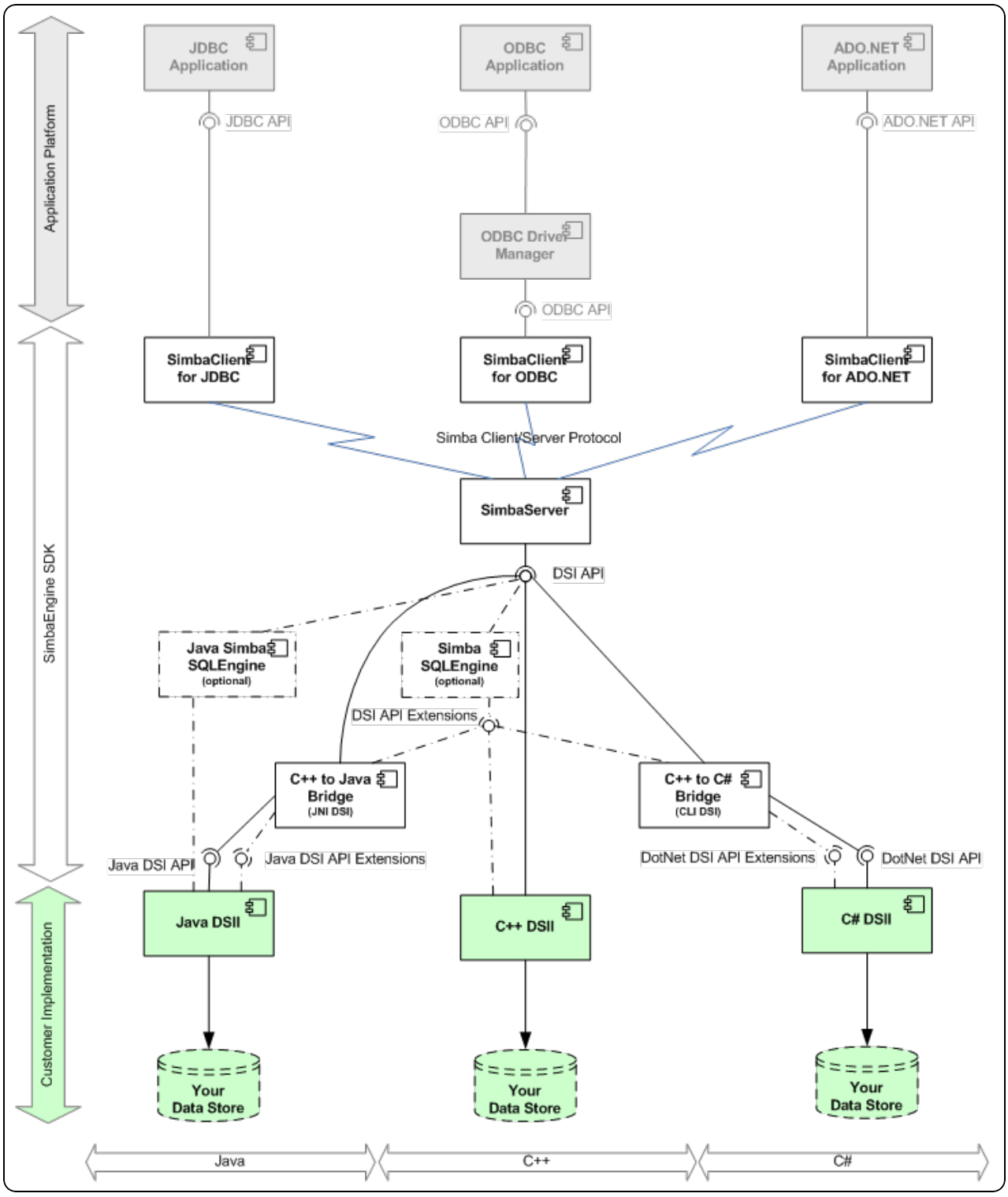
The diagrams in this section illustrate the how the Simba SDK components work together in both the standalone and the client/server deployment.

Note:

Although this guide explains how to build a connector that does not use the SQL Engine, information on using the SQL Engine is included in this section for reference.



Standalone Deployment



Client/Server Deployment

Each of these diagrams has three zones horizontally and vertically. The horizontal zones are:

Zone	Description
Application Platform	These elements, shown in gray boxes, represent the client-side applications that will connect to the completed ODBC, JDBC connector, or ADO.NET provider that you build with the SDK.
Simba SDK	These elements, shown in white boxes, are the components that make up the SDK itself.
Customer Implementation	These elements, shown in green boxes, represent the unique code you write to access your data store.

The vertical zones align with the different development environments available to you:

Zone	Description
C++	A C++ DSII may be written to support ODBC applications by linking upward from your implementation to the SimbaODBC component. Alternately, you can also support JDBC or ADO.NET applications by linking upward to the SimbaServer component.
Java	A Java DSII may be written to support JDBC applications by linking to the SimbaJDBC component. Alternately, you can support ODBC applications by linking upward through the C++ to Java Bridge to the SimbaODBC component, or support ODBC or ADO.NET applications by linking your Java DSII upward via the same bridge to the SimbaServer component.
C#	A C# DSII may be written to support ADO.NET applications by linking to the Simba.NET component. Alternately, you can support ODBC applications by linking upward via the C++ to C# Bridge to the SimbaODBC component, or support ODBC or JDBC applications by linking your C# DSII upward via the same bridge to the SimbaServer component.

Related Topics

Simba SDK FAQ

Getting Started

To get started building a custom ODBC, JDBC, OLE DB, or ADO.net connector using the Simba SDK, follow these general steps:

1. Plan how to map your data store schema to the DSI model.
2. Use one of the 5-Day Guides to set up your development environment. For more information on the 5-Day Guides, see http://www.simba.com/drivers/simba-engine-sdk/#documentation.
3. Implement your plan for translating your data store to the DSI.

Mapping Your Data Store Schema to the DSI Model

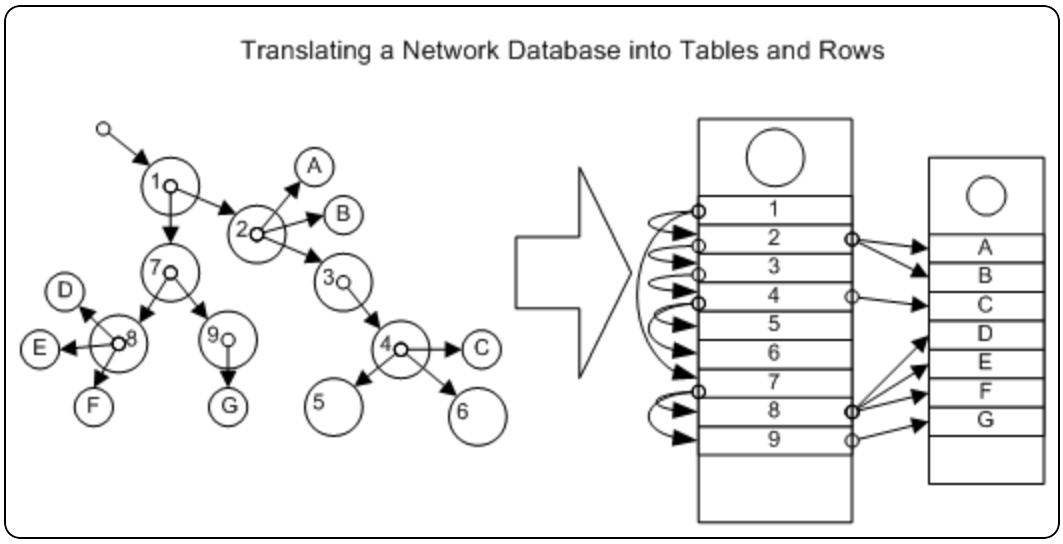
The first step is to map your data store to the DSI model. The DSI represents the data store as a series of tables and columns, and the purpose of your DSI implementation is to translate your real data store schema into the DSI representation.

Note:

The DSI represents the data store as a series of tables and columns. The purpose of your DSI implementation is to translate your data store schema into tables and columns that the DSI can understand.

The diagram below shows an example of one type of mapping. The database on the left uses an object-oriented or networked schema to store the data. However, a relational SQL execution engine cannot directly use this schema.

If you represent the same database as tables and columns, even though you do not actually transform the database into this new form, it fits the relational paradigm. Now you can write a DSI implementation to create this view of the data and Simba SDK can use the SQL Engine to execute SQL queries against it. In this way, any database you can represent as tables and columns can be accessed by Simba SDK and made accessible to applications and reporting tools.



Relational applications, or applications that can access relational databases, cannot access the networked data store on the left, because it is not a relational database. Once you translate the data store to use tables and columns, as shown in the data store on the right, relational applications can use the SQL Engine to send SQL queries to it. Simba SQLEngine works with tabular database schema (but not non-tabular database schema).

Using Virtual Tables

It might be tempting to create a tabular view of your data store by reading the entire database into temporary tables, and accessing these tables through the DSI. However, this is inefficient and only works for very small databases. A more efficient method is to create virtual tables and then access the original database when the Simba SDK requests data through the DSI.

Related Topics

Build a Connector in 5 Days

Simba SDK FAQ

Frequently Asked Questions

This section answers the questions that are commonly asked by people who are new to the Simba SDK product and technology. For a more detailed FAQ, see the *Testing and Troubleshooting* section of this guide.

What Platforms does the Simba SDK Support?

For information about the supported versions of Windows, Unix, Linux, and macOS, plus a list of supported compilers, see Supported Platforms.

What is ODBC?

ODBC stands for Open Database Connectivity (ODBC). It is a C-language open standard Application Programming Interface (API) for accessing relational databases.

In 1992, Microsoft contracted Simba to build the world's first ODBC connector; SIMBA.DLL, and standards-based data access was born. Using ODBC, you can access data stored in many common databases. A separate ODBC connector is needed for each database to be accessed. An ODBC Driver Manager is also needed. This is supplied with the Windows operating system, and is available commercially and as open source on Unix and Linux.

What is MDAC?

MDAC, or Microsoft Data Access Components, are runtime components that are shipped with the Windows operating system. These components contain interfaces for ODBC, OLEDB and ADO, as well as the ODBC connectors for Microsoft's database-related products.

The MDAC SDK is available from the Microsoft Developer Network (MSDN) and can be downloaded from: http://www.microsoft.com/downloads/en/details.aspx?familyid=5067FAF8-0DB4-429A-B502-DE4329C8C850&displaylang=en.

In newer versions of Windows (Vista & 7), MDAC is now called Windows DAC. For more information, see http://msdn.microsoft.com/en-us/library/ms692877%28v=vs.85%29.aspx.

What Third-Party Components Does the Simba SDK Use?

For information on the third-party components used by the Simba SDK, see Third Party Licenses.

I am new to ODBC. How does my application work with an ODBC Connector?

ODBC-enabled applications always access ODBC connectors through the Driver Manager that is installed on the operating system. An instance of the Driver Manager is created for each ODBC application. The application will specify to the Driver Manager which ODBC connector to use when establishing a connection. The Driver Manager will then load the appropriate ODBC connector. Once the ODBC connector is loaded, the Driver Manager will map all incoming requests to the appropriate functions exported by the ODBC connector.

To interact with a Driver Manager, ODBC-enabled applications will request the following three ODBC handles:

SQL_HANDLE_ENV

Represents an environment handle. Every instance of an ODBC connector will be associated with a single environment handle.

SQL_HANDLE_DBC

Represents a connection handle. Connections are created using one of the following three ODBC methods: SQLConnect(), SQLBrowseConnect(), SQLDriverConnect(). Every connection handle is associated with its parent environment handle.

SQL_HANDLE_STMT

Represents a statement handle. Every statement that is to be executed via ODBC will be associated with its own statement handle. Every statement handle is associated with its parent connection handle.

The Driver Manager interacts with an ODBC connector in much the same way. The Driver Manager will request the handles for the environment, connection and statement. All calls made from the ODBC-enabled application to the Driver Manager require the Driver Manager allocated handle and will be implemented as follows:

1. Map incoming Driver Manager allocated handle to an instance representing the handle.
2. Call the ODBC connector associated with the instance using the ODBC connector associated handle.

What is ICU?

ICU stands for the International Components for Unicode (ICU) libraries. These libraries provide Unicode handling mechanisms on which the SimbaODBC components are dependent. These libraries are distributed under an open source license at:

http://source.icu-project.org/repos/icu/icu/trunk/license.html

ICU is freely available from:

http://www.icu-project.org/download

What is SimbaODBC?

SimbaODBC is a component part of Simba SDK for developing full-featured, optimized ODBC 3.80 connectors on top of any SQL-enabled data source. SimbaODBC provides extensibility for JDBC, OLE DB as well as ADO.NET connectivity. SimbaODBC simplifies exposing the query parsing, query execution and data retrieval facilities of your SQL-enabled data source.

What do the Different Components of SimbaODBC do?

SimbaODBC ships with a number of static libraries. You will link these libraries into the code you write to communicate with an underlying SQL-92 enabled data store.

What SQL Conformance Level Does Simba SDK support?

ODBC specifies three levels of SQL grammar conformance: Minimum, Core and Extended. Each higher level provides more fully-implemented data definition and data manipulation language support. Simba SDK fully supports Core DML SQL grammar, as well as many Extended grammars.

Related Topics

5 Day Guides at http://www.simba.com/resources/sdk/documentation/

Core Features

This section explains the features that most custom connectors will implement.

Fetching Metadata for Catalog Functions

ODBC applications need to understand the structure of a data store in order to execute SQL queries against it. This information is provided using catalog functions. For example, an application might request a result set containing information about all the tables in the data store, or all the columns in a particular table. Each catalog function returns data as a result set.

Your custom ODBC connector uses metadata sources, provided by the Simba SDK, to handle SQL catalog functions. Of the 13 `DSIMetadataSource` sub-classes, there is only one that you need to modify to make a basic connector work. This section describes the other metadata classes and under what circumstances you need to update them.

Implementation

Your `CustomerDSIIDataEngine` class has to derive from `IDataEngine` or `DSIDataEngine`. If it is derived from `IDataEngine`, then the following function has to be implemented:

```
Simba::DSI::IResult* MakeNewMetadataResult(
Simba::DSI::DSIMetadataTableID in_metadataTableID,
const std::vector<Variant>& in_filterValues,
const simba_wstring& in_escapeChar,
const simba_wstring& in_identifierQuoteChar,
bool in_filterAsIdentifier);
```

This function creates a new `IResult*` which contains a metadata data source and filters out rows in the metadata table that are not needed. If the connector does not support a metadata table, then the metadata source in the `IResult*` should be an empty metadata data source with no rows.

The function takes the following parameters:

- in_metadataTableID: Identifier to create the appropriate metadata table. For a list of the possible identifiers, refer to the table below. For complete details on each identifier, refer to DSIMetadataTableID.h in the API guide.

- in_filterValues: Filters to be applied to the metadata table. These filters are passed in by the application that calls the catalog function and cannot be modified. For example, the catalog function `SQLTables` contains the arguments `CatalogName`, `SchemaName`, `TableName`, and `TableType`. These arguments are extracted to the `in_filterValues` vector.
  While these values cannot be modified, if the CatalogName is NULL, the current catalog name is used.
- in_escapeChar: Escape character used in filtering.
- in_identifierQuoteChar: Quote identifier, which is the quotation mark that this filter recognizes.
- in_filterAsIdentifier: Indicates if string filters are treated as identifiers. This can be set through the connection attribute SQL_ATTR_METADATA_ID.

If it is derived from`DSIDataEngine`, then the following function has to be implemented:

```
Simba::DSI::DSIMetadataSource* MakeNewMetadataTable(
Simba::DSI::DSIMetadataTableID in_metadataTableID,
Simba::DSI::DSIMetadataRestrictions& in_restrictions,
const std::vector<Simba::Support::Variant>& in_filterValues,
const simba_wstring& in_escapeChar,
const simba_wstring& in_identifierQuoteChar,
bool in_filterAsIdentifier);
```

This function creates a new `Metadatasource*` which contains raw metadata. If the connector does not support a metadata table, then it should return an empty metadata source with no rows by returning a `DSIEmptyMetadataSource` object.

The function takes the following parameters:

- `in_metadataTableID`: Identifier to create the appropriate metadata table. For a list of the possible identifiers refer to the table below. For complete details on each identifier refer to DSIMetadataTableID.h in the API guide.
- `in_restrictions`: Restrictions that may be applied to the metadata table. Map of DSIOutputMetadataColumnTag that identify columns in the result set, to the restriction that apply to those columns. For example, if the DSIOutputMetadataColumnTag identifies a catalog name, then the restriction specifies that the result set should only contain rows with the same catalog name

as the restriction. For a complete list and details of DSIOutputMetadataColumnTag values, refer to DSIMetadataColumnIdentifierDefns.h in the API guide.

- `in_filterValues`: Filters to be applied to the metadata table. These filters are passed in by the application that calls the catalog function and cannot be modified. For example, the catalog function `SQLTables` contains the arguments `CatalogName`, `SchemaName`, `TableName`, and `TableType`. These arguments are extracted to the `in_filterValues` vector.
  While these values cannot be modified, if the CatalogName is NULL, the current catalog name is used.
- `in_escapeChar`: Escape character used in filtering.
- `in_identifierQuoteChar`: Quote identifier, which is the quotation mark that this filter recognizes.
- `in_filterAsIdentifier`: Indicates if string filters are treated as identifiers. This can be set through the connection attribute SQL_ATTR_METADATA_ID.

If the metadata table is supported by the connector, then a new class should be implemented by deriving from`Simba::DSI::DSIMetadataSource` and implementing all the functions.

Note:

The Ultralight connector is a sample connector derives `ULDataEngine` from `DSIDataEngine`. It implements classes for metadata tables for DSI_TABLES_METADATA, DSI_CATALOGONLY_METADATA, DSI_SCHEMAONLY_METADATA, DSI_TABLETYPEONLY_METADATA, DSI_COLUMNS_METADATA, and DSI_TYPE_INFO_METADATA metadata table identifiers.

Implementation

If the connector is using the SQL Engine, then the `CustomerDSIIDataEngine` class has to derive from `DSIExtSqlDataEngine`, and implement the following function: `Simba::DSI::DSIMetadataSource* MakeNewMetadataTable(`

Simba::DSI::DSIMetadataTableID in_metadataTableID,

Simba::DSI::DSIMetadataRestrictions& in_restrictions,

const simba_wstring& in_escapeChar,

const simba_wstring& in_identifierQuoteChar,

bool in_filterAsIdentifier) = 0;

This function creates a new `DSIMetadataSource*` which contains raw metadata. If the connector does not support a metadata table, then it should return an empty metadata source with no rows by returning a `DSIEmptyMetadataSource` object.

The function takes the following parameters:

- `in_metadataTableID`: Identifier to create the appropriate metadata table. For a list of the possible identifiers, refer to the table below. For complete details on each identifier, refer to DSIMetadataTableID.h in the API guide.
- `in_restrictions`: Restrictions that may be applied to the metadata table. Map of DSIOutputMetadataColumnTag that identify columns in the result set, to the restriction that apply to those columns. For example, if the DSIOutputMetadataColumnTag identifies a catalog name, then the restriction specifies that the result set should only contain rows with the same catalog name as the restriction. For a complete list and details of DSIOutputMetadataColumnTag values, refer to DSIMetadataColumnIdentifierDefns.h in the API guide.
- `in_escapeChar`: Escape character used in filtering.
- `in_identifierQuoteChar`: Quote identifier, which is the quotation mark that this filter recognizes.
- `in_filterAsIdentifier`: Indicates if string filters are treated as identifiers. This can be set through the connection attribute SQL_ATTR_METADATA_ID.

If the metadata table is supported by the connector, then a new class should be implemented by deriving from `Simba::DSI::DSIMetadataSource` and implementing all the functions.

The connector is required to implement a class for DSI_TYPE_INFO_METADATA metadata table identifier, which is for catalog function SQLGetTypeInfo. This class should derive from pure abstract class called DSIExtTypeInfoMetaDataSource that has the following pure virtual function:

```
virtual Simba::SQLEngine::TypePrepared PrepareType
(Simba::SQLEngine::SqlTypeInfo& io_typeInfo) = 0;
```

This function takes the specified SQL type information, modifies any fields that need to be changed to fit the data source, and indicates if that type is supported or not. For a sample implementation, refer to the Quickstart sample connector.

The SQLEngine also provides default implementation for the following metadata table identifiers:

- DSI_TABLES_METADATA
- DSI_CATALOGONLY_METADATA

- DSI_SCHEMAONLY_METADATA
- DSI_TABLETYPEONLY_METADATA
- DSI_COLUMNS_METADATA
- DSI_PROCEDURES_METADATA
- DSI_PROCEDURES_COLUMNS_METADATA
- DSI_STATISTICS_METADATA

If the connector chooses to use these default implementations, then the connector has to implement a class that derives from `Simba::SQLEngine::DSIExtMetadataHelper` and implement all the functions. The two pure virtual functions `GetNextProcedure()` and `GetNextTable()` are called by the default implementations to retrieve the next procedure and the next table, respectively. For a sample implementation of `MetadataHelper` class, refer to the Quickstart sample connector.

Note:

Note: If the connector does not use the default implementations for the metadata table identifiers mentioned above, then the connector should implement its own class for the metadata table identifiers by deriving from Simba::DSI::DSIMetadataSource. The connector should create an empty metadata source with no rows by returning a DSIEmptyMetadataSource object for the metadata table identifiers that it does not support. For a sample implementation of DSIMetadataSource classes, refer to the sample connector.

Adding Custom Metadata Columns

Each catalog function returns data as a result set. In addition to the ODBC-standard columns that are returned when a catalog function is executed, the data store can return additional columns. Your custom connector can add custom metadata columns to the Metadata result tables in order to support data source-specific data. The `DSIMetadataSource`-derived classes support custom columns, which are enabled by proper implementations of several functions. These functions are:

- `GetCustomColumns`
- `GetCustomMetadata`

Note:

- All custom metadata columns must be of type `DSICustomMetadataColumn`. The header file for `DSICustomerMetadataColumn` can be found at `[INSTALL_DIRECTORY]\DataAccessComponents\Include\DSI\Client\DSICustomMetadataColumn.h`
- This feature is only supported in the C++ SDK.

A sample implementation of a custom metadata column for `CustomerDSIITablesMetadataSource` is shown below. Adding custom metadata columns to any other metadata source follows a similar formula.

To Add Custom Metadata Columns:

1. Define a custom column tag for the custom column:

   ```
   const simba_uint16 CUSTOM_TABLES_COLUMN_TAG = 50;
   ```

2. Define a member variable for the custom column:

   ```
   std::vector<Simba::DataSToreInterface::DataEngine::Client::
    DSICustomMetadataColumn*> m_customMetadataColumns;
   ```

3. Initialize the metadata for the custom columns in the `CustomerDSIITablesMetadataSource` constructor. Use the static `MakeNewSqlTypeMetadata` function of the `Simba::Support::TypedDataWrapper::SqlTypeMetadataFactory` class.

   ```
   using namespace Simba::DSI;
   using namespace Simba::Support;
   DSICustomMetadataColumn* column = NULL;
   DSIColumnMetadata* colMetadata = NULL;
   SqlTypeMetadata* metadata = NULL;
   // Custom column
   colMetadata = new DSIColumnMetadata();
   colMetadata->m_autoUnique = false;
   colMetadata->m_caseSensitive = false;
   colMetadata->m_label = L"CUSTOM_COL";
   colMetadata->m_name = L"CUSTOM_COL";
   colMetadata->m_unnamed = false;
   colMetadata->m_charOrBinarySize = 128;
   ```

```
colMetadata->m_nullable = DSI_NULLABLE;
colMetadata->m_searchable = DSI_PRED_NONE;
colMetadata->m_updatable = DSI_READ_ONLY;
// Create SqlTypeMetadata*
metadata = SqlTypeMetadataFactorySingleton::GetInstance
()>CreateNewSqlTypeMetadata(SQL_VARCHAR);
column = new DSICustomMetadataColumn(
metadata,
colMetadata,
CUSTOM_TABLES_COLUMN_TAG);
m_customColumnMetadata.push_back(column);
```

4. For information on `DSIColumnMetadata`, refer to Simba SDK Java API Reference or Simba SDK C++ API Reference.
5. Implement `CustomerDSIITablesMetadataSource::GetCustomColumns`:

```
void CustomerDSIMetadataSource::GetCustomColumns
(std::vector<Simba::DSI::DSICustomMetadataColumn*>& out_
customColumns)
```

6. Iterate over `m_customColumns` and push them into `out_customColumns`.
7. Implement `CustomerDSIITablesMetadataSource::GetCustomMetadata`:

```
bool CustomerDSIITablesMetadataSource:::GetCustomMetadata
(
simba_uint16 in_columnTag,
SqlData* in_data,
simba_signed_native in_offset,
simba_signed_native in_maxSize)
```

The implementation is the same as `CustomerDSIITablesMetadataSource::GetMetadata` except the column tags you check are your custom column tags.For example:

```
switch (in_columnTag){

    case CUSTOM_TABLES_COLUMN_TAG:{
    //retrieve the appropriate data from your m_
    result
    }
```

```
    default:{
    //throw exception - metadata column not found.
    }

}
```

Overriding the Value of Default Properties

ODBC and JDBC connectors use connection, connector, environment, and statement properties to specify and define their behavior and capabilities. The Simba SDK provides default values for these properties. If the capabilities of your custom connector are different from the specified defaults, or if you need to support the requirements of a specific application, you can override these default values.

The Simba SDK implements these properties in the following classes in the Core library:

Property Type	Class	Name of Property Map
Connection properties	`DSIConnection`	`m_connectionProperties`
Connector properties	`DSIDriver`	`m_driverProperties`
Environment properties	`DSIEnvironment`	`m_environmentProperties`
Statement properties	`DSIStatement`	`m_statementProperties`

Note:

For information about SQL Engine properties, see Using SQL Engine Properties.

Properties are represented as key-value string pairs, which are stored in a property map as shown in the table above. Properties are initialized with their default value in the constructor of the corresponding class.

You can override these properties in your DSII subclass of the corresponding Core class, but you must only override the default value for any property during the

construction of each class instance. After that, property changes should only come from the ODBC application calling the appropriate API function. The one exception to this rule is that connection properties may be updated at the time a connection is successfully established. This should be done before returning from the `CustomerDSIIConnection::connect` function.

Each of these four Core classes has a function called `SetProperty`, which is used to set the value for a property or attribute.

For a description of properties and default values in the C++ SDK, see the Simba SDK C++ API Reference. Select **Namespaces** -> **Simba::DSI** then see the following enumerations:

- `DSIConnPropertyKey`
- `DSIDriverPropertyKey`
- `DSIEnvPropertyKey`
- `DSIStmtPropertyKey`

For a description of properties and default values in the Java SDK, see the following classes in the Simba SDK Java API Reference:

- `ConnPropertyKey`
- `DriverPropertyKey`
- `EnvPropertyKey`
- `StmtPropertyKey`

Note:

The term "property" and "attribute" are used interchangeably in the Simba SDK. For example, a method might be called `GetProperty` but work with `AttributeData` objects.

Example: Overriding the Value of Connection Properties

The example in this section shows how to override default property and attribute values for the `DSIConnection` class. You can use the same method to override default values in the `DSIStatement`, `DSIDriver` and `DSIEnvironment` classes.

Note:

This example is in C++ but it also applies to the Java SDK.

The example subclass of `DSIConnection` is called `CustomerDSIIConnection`. In the `CustomerDSIIConnection` constructor, use the `DSIConnection::SetProperty()` method to set the property or attribute value. The signature of the `DSIConnection::SetProperty` function is:

```
virtual void SetProperty(


    DSIProperties::DSIConnPropertyKeys::DSIConnPropertyKe
    y in_key,
    Simba::Support::Utility::AttributeData* in_value)
```

Example: Set the server name

The default value for DSI_SERVER_NAME is “”. It should be set to the name of the DSI server. Pass in the key for the server name and the name of the server to the `SetProperty` function.

```
SetProperty(

    DSIProperties::DSIConnPropertyKeys::DSI_SERVER_NAME,
    Utility::AttributeData::MakeNewWStringAttributeData
    (<name_of_server>)

);
```

Example: Specify the Supported SQL_CHAR Conversions

The default value for DSI_SUPPORTED_SQL_CHAR_CONVERSIONS is DSI_CVT_CHAR. If the application supports more conversions, you need to change this value. Here, the value for the DSI_SUPPORTED_CHAR_CONVERSIONS property is made up of a concatenation of all the values provided.

```
SetProperty(

    DSIProperties::DSIConnPropertyKeys::DSI_SUPPORTED_SQL_
    CHAR_CONVERSIONS,
    Utility::AttributeData::MakeNewUInt32AttributeData(
    DSIProperties::DSIConnPropertyValues::DSI_CVT_CHAR |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_NUMERIC
    |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_DECIMAL
    |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_INTEGER
    |
```

```
    DSIProperties::DSIConnPropertyValues::DSI_CVT_SMALLINT
    |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_FLOAT |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_REAL |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_VARCHAR
    |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    LONGVARCHAR |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_BINARY |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    VARBINARY |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_BIT |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_TINYINT
    |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_BIGINT |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    TIMESTAMP |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    LONGVARBINARY |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_WCHAR |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    WLONGVARCHAR |
    DSIProperties::DSIConnPropertyValues::DSI_CVT_
    WVARCHAR)
);
```

Related Topics

Using SQL Engine Properties

Implementing Logging

The Simba SDK includes comprehensive logging functionality that you can use when developing and troubleshooting your connector.

For information on how to turn on logging in the sample connectors, see *Enable Logging* in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

For information on logging to Event Tracing for Windows (ETW), see Logging to Event Tracing for Windows (ETW).

The Simba SDK enables multiple logger objects logging to separate files: one for the single `IDriver` instance, and one for each `IConnection` instance. This allows for

easier debugging of threading issues, while still allowing for logging of issues that happen before a connection is established. If only one central log is needed, then child `IConnection` objects can return the parent `IDriver` log instance to have all logging calls focus on one `ILogger`.

The `ILogger` has a default implementation in `DSILog`, each of which logs to a file. There are several functions to log messages at varying levels of importance as needed. The `DSILog` allows for filtering of logging messages based on both log level and namespace, enabling you to narrow logging to suspect areas of your DSII. If the default `DSILog` does not provide enough functionality, then you may choose to create a full implementation of `ILogger` directly from the interface that provides the functionality that you need.

Log Settings

There are three settings that affect logging by default:

- **LogLevel** – Used to set the level of logging that is performed. Valid values are:
  - 0 or “Off”
  - 1 or “Fatal”
  - 2 or “Error”
  - 3 or “Warning”
  - 4 or “Info”
  - 5 or “Debug”
  - 6 or “Trace”
- **LogPath** – Set the path that the default logging implementation will create the log files in. Defaults to the current working directory.
- **LogNamespace** – Filters the logging based on the namespace/package that the messages are coming from. For instance, the value “Simba” will filter all logging messages to namespaces starting with “Simba” such as “Simba::Support”.

The settings are read from the registry at **HKLM\SOFTWARE\<OEM NAME>\Driver** for both SimbaODBC and Simba.NET, while they are read from the connection string for SimbaJDBC.

For Simba.NET on platforms using .NET Core, there may be no registry to read configuration from if not using Windows. Instead, the configuration can be read from one of several configuration files:

1. User-level configuration for the current application: `%APPDATA%/[COMPANY]/[APPLICATION]/[APPLICATION VERSION]/user.config`. (`%APPDATA%` is typically `C:\Users\username\AppData\Roaming` on

Windows and `/home/username/.config/` on other operating systems.)

2. User-level configuration for the provider: `%APPDATA%/`*`[BRANDING]`*`/`*`[BRANDING]`*`.config`.
3. Application-level configuration: *`[APPLICATION DIRECTORY]`*`/`*`[APPLICATION NAME]`*`.config`.
4. Provider-level configuration: *`[PROVIDER DIRECTORY]`*`/`*`[BRANDING]`*`.config`.

The format of the configuration file is the same as a typical .NET `App.Config` file:

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
<configSections>
<section name="Simba.UltraLight"
type="Simba.DotNetDSI.ConfigReader, Simba.DotNetDSI" />
</configSections>
<Simba.UltraLight
LogLevel="0"
LogPath="/tmp/ultralight.log" />
</configuration>
```

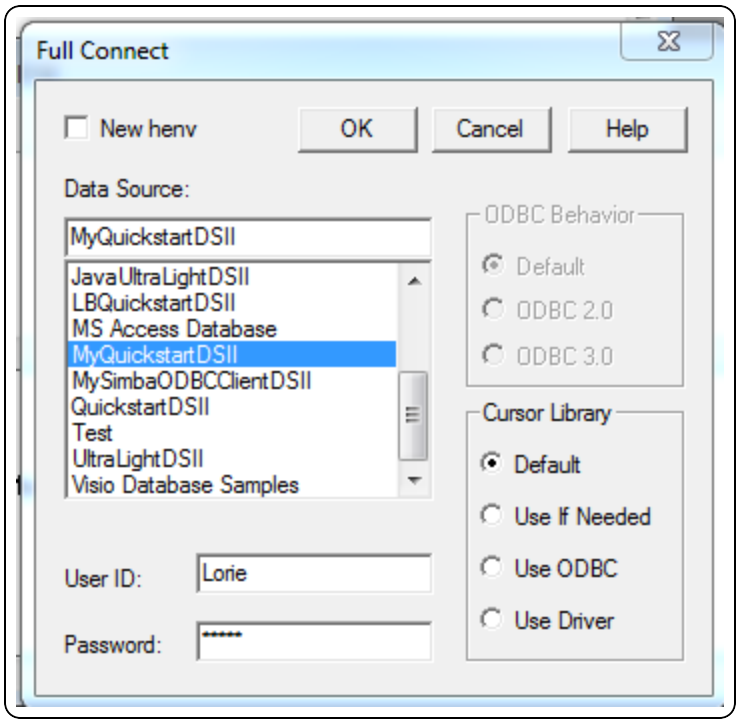
The section name and name of the tag added are based on the branding set in the provider, with " \ " replaced by " . ". If adding to an existing configuration file, the `<section>` tag should be added to an existing `<configSections>` tag.

Hiding Sensitive Information in the Log Files

The Simba SDK does not log the value of the connection parameters username (`UID`) and password (`PWD`). Instead, the values are logged as asterisks (****). The `DSIConnection::IsSensitiveAttribute()` method determines whether or not the value of a connection parameter should be logged. The `IsSensitiveAttribute()` method is called by the `ConnectionSettings` class when a connection is established.

Example

If you enter a username and password when connecting to the `MyQuickstartDSII` connector, the resulting log file will contain the strings `"PWD" = "***"` and `"UID" = "***"`, rather than the actual username and password.



Your custom ODBC connector can specify additional connection parameters that should not have their values logged in plain text. To do this, override `DSIConnection::IsSensitiveAttribute()` in your `Connection.cpp` class.

For example, in the following code, the values of the connection parameters `Secret1` and `Secret2` will be logged as asterisks (`*****`):

```
bool QSConnection::IsSensitiveAttribute(const simba_wstring&
in_attribute)
{

    if ((in_attribute.IsEqual("Secret1")) ||(in_
    attribute.IsEqual("Secret2")))

        {

            return true;

        }

    return DSIConnection::IsSensitiveAttribute(in_
    attribute);

}
```

Logging in the Java DSI

The Java Simba SDK includes a helper class called `LogUtilities` to help you implement logging functionality. This class provides a copy of many of the functions that exist in `ILogger`, but the functions take an `ILogger` instance and do not take the namespace or class names from which the logging call originates. Instead, it uses reflection to determine that information, easing use of the logger.

Logging in the DotNet DSI

The dotNet Simba SDKincludes a helper class called `LogUtilities` to help you implement logging functionality. This class provides a copy of many of the functions that exist in `ILogger`, but the functions take an `ILogger` instance and do not take the namespace or class names from which the logging call originates. Instead, it uses reflection to determine that information, easing use of the logger.

Simba.NET Specific Features

Note that there is an extra setting for Simba.NET to provide logging if an error occurs before a DSI DLL is loaded:

- PreloadLogging – Set to 0 (off) or 1 (on) to log to the file InitialDotNet.log. Once a DSII DLL is loaded, the DSI ILogger will be used.

Related Topics

Enable Logging in the Data Engine

Logging to Event Tracing for Windows (ETW)

Enable Logging in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

http://www.simba.com/resources/sdk/knowledge-base/enable-logging-in-odbc/

http://www.simba.com/resources/sdk/knowledge-base/simbaengine-logging/

Using SQL Engine Properties

This section describes the properties you can use to modify the default behaviour of the Simba SQLEngine. In the C++ SDK, you set these properties on the `DSIExtSqlDataEngine` class, while in the Java SDK you set them on the `SqlDataEngine` class.

For general information on overriding default properties, see Overriding the Value of Default Properties.

Properties in the C++ and Java SQL Engine

These properties are available in both the C++ and the Java SQL Engine.

DSIEXT_DATAENGINE_NULL_EQUALS_EMPTY_STRING

This property determines if the IS NULL predicate is treated the same way that = '' (empty string) is. Available values are:

- `Y` - Specifies that IS NULL and = '' are treated the same way.
- `N`- Specifies that IS NULL and = '' are not treated the same way.

Defaults to `N`.

DSIEXT_MAX_OPEN_FILE_PER_NODE

This property specifies the aximum number of open files that one execution node or unit, for example a sort or join node, are allowed to use. The property is to make sure that SQLEngine do not consume too much file descriptors as many Linux like systems limit the number of open file descriptors per process.

This must be a positive, signed int-32 value. The minimum value for this property is 4, and the default value is 50.

DSIEXT_DATAENGINE_TABLE_CACHING

This property determines if the SQLEngine caches tables that it reads if a row would be visited more than once, so that the DSII can safely discard data once a row has been visited. Available values are:

- `Y` - SQLEngine caches tables if needed.
- `N` - SQLEngine dpes not cache tables, and the DSII will cache the tables to allow rows to be visited multiple times.

Defaults to `N`.

DSIEXT_DATAENGINE_AETREEOPTIMIZATION

This property determines if the SQLEngine performs optimizations on an AE Tree. Available values are:

- `Y` - SQLEngine performs AE Tree optimizations.
- `N` - SQLEngine does not perform AE Tree optimizations.

Default is `Y`.

DSIEXT_DATAENGINE_LOG_AETREES

This property specifies which types of logging to perform on an AE Tree before and after Collaborative Query Execution (CGQ). If a specific value is set, then the file `AETree.log` is created in the global logging path, otherwise no logging is performed. The available bitwise values are:

- DSIEXT_LOG_PRE_OPTIMIZE – logs the tree prior to optimization.
- DSIEXT_LOG_POST_REORDER - logs the tree prior to reordering.
- DSIEXT_LOG_POST_OPTIMIZE - logs the tree after optimization.
- DSIEXT_LOG_POST_PASSDOWN - logs the tree after passdowns are complete.
- DSIEXT_LOG_DOT_GRAPH – logs the tree in DOT format for viewing in a suitable graphing program.

Default is 0.

DSIEXT_DATAENGINE _COALESCE_DUPLICATE_GROUP_BY_ EXPRESSIONS

This property determines if the SQLEngine removes duplicate expressions in the GROUP BY list in the AETree. Available values are:

- `Y` - SQLEngine removes duplicate expressions.
- `N` - SQLEngine does not remove duplicate expressions.

Default is `Y`.

DSIEXT_DATAENGINE_IGNORE_PARSER_LIMITS

This property determines if the SQLEngine ignores limits defined by SQLGetInfo when building the parse tree. Available values are:

- `Y` - parser limits are ignored.
- `N` - parser limits are respected.

Default is `N`.

DSIEXT_DATAENGINE_LOG_PARSETREE

This property determines if the SQLEngine logs the parse tree. Available values are:

- `Y` - SQLEngine logs the parse tree.
- `N` - SQLEngine does not log the parse tree.

Default is `N`.

DSIEXT_DATAENGINE_LOG_ETREE

This property determines if the SQLEngine logs the AETree.

- `Y` - SQLEngine logs the ETree.
- `N` - SQLEngine does not log the ETree.

Default is `N`.

DSIEXT_DATAENGINE_USE_DSII_INDEXES

This property determines if the SQLEngine uses DSII indexes during execution.

- `Y` - SQLEngine uses DSII indexes.
- `N` - SQLEngine does not use DSII indexes.

Default is `N`.

DSIEXT_DATAENGINE_PREFER_INDEX_ONLY_SCANS

This property determines if the SQLEngine uses DSII indexes for 'Index-Only scans' even if no filters are satisfied by the indexed columns.

- `Y` - SQLEngine prefers the use of index-only scans to table scans.
- `N` - SQLEngine does not prefer the use of index-only scans to table scans.

Default is `Y`.

DSIEXT_DATAENGINE_USE_LITERAL_LEN_FOR_PARAM_META

This property determines if the SQLEngine uses the DSI_CONN_MAX_CHAR_LITERAL_LEN and DSI_CONN_MAX_BINARY_LITERAL_LEN when exposing parameter metadata.

- `Y` - DSI_CONN_MAX_CHAR_LITERAL_LEN and DSI_CONN_MAX_BINARY_LITERAL_LEN is used.
- `N` - length returned by the column being inserted into or being compared against is exposed.

Default is `Y`.

Properties in the Java SQL Engine

These properties are available in the Java SQL Engine only.

DSIEXT_RECOMMENDED_TEMPORARY_TABLE_BLOCK_SIZE

This property specifies the recommended block size (in bytes) that is used for memory intensive operations such as SORT or JOIN that use a temporary table to save

intermediate results to disk.

Default is `1000000`.

DSIEXT_MAX_COLUMN_SIZE_TO_INCLUDE_IN_BLOCK

This property specifies the maximum column size in bytes for SQL-CHAR and SQL-BINARY types that is stored in a memory block during memory intensive operations such as SORT or JOIN that use a temporary table to save intermediate results to disk.

Default is `1000000`.

DSIEXT_PROVIDE_DEFAULT_CATALOG_NAME

This property determines if the SQLEngine provides the default catalog name to `SqlDataEngine::openTable()` when the user has not specified it in the input SQL statement.

- `Y` - SQLEngine provides the default catalog name to `SqlDataEngine::openTable()`.
- `N` - length returned by the column being inserted into or being compared against is exposed.

Default is `Y`.

SQLEngine Specific Switches

The SQLEngine also provides some switches to customize its behavior. These switches are read from either **HKLM\SOFTWARE\<OEM NAME>\Driver** in the Windows registry or from the vendor `.ini` file on non-Windows platforms.

SwapFilePath

This property sets the path that SQLEngine will use for creation of temporary swap files that are needed for certain operations.

Related Topics

Overriding the Value of Default Properties

Adding Custom Connection and Statement Properties

Custom properties can be added to `Connection` and `Statement` objects. These properties allow you to customize how your connection and statement objects behave.

Important:

Before you can implement custom properties for your connection and statement attributes, you should request and reserve a value for each attribute from the Open Group. This ensures that no two connectors will assign the same integer value to different custom attributes. If you do not reserve a unique attribute or use one that is already in use, your connector may experience compatibility issues with any application that uses the conflicting custom attributes for other connectors.

For more information on requesting a value from the Open Group, refer to the *Connector-Specific Data Types, Descriptor Types, Information Types, Diagnostic Types, and Attributes* section of the MSDN ODBC Programmer's Reference.

Custom Properties in the C++ SDK

You must define keys for each of the custom `Connection` or `Statement` properties or attributes for which you would like to add support. For each custom key, create a `Simba::Support::AttributeData*` to store data for the property or attribute. Use a map to map keys to their corresponding `AttributeData*`. For more information on creating a custom key refer to the `DSIConnProperties.h` or `DSIStmtProperties.h` header files in the folder `[INSTALL_DIRECTORY]\DataAccessComponents\Include\DSI`.

To add custom connection and statement properties, implement the following methods in your `CustomerDSIIConnection` and/or `CustomerDSIIStatement` class:

- **IsCustomProperty()**

  In this function, check if the provided key corresponds with one of the standard ODBC properties. Return `false` if it does not; `true` otherwise.

  To see the list of keys for ODBC properties, see the `Simba::DSI::DSIStmtPropertyKey` enum or the `Simba::DSI::DSIConnPropertyKey DSIConnPropertyKey` enum in the C++ API reference. Go to Simba SDK C++ API Reference, select the **Namespaces** tab, select **Simba::DSI**, then search for **DSIConnPropertyKey**.
- **SetCustomProperty()**

  In this function, set an `AttributeData*` for the custom property key. In your implementation, check to ensure the provided key corresponds to a custom property or attribute. If it does not, an appropriate error or exception should be thrown and logged.

- **GetCustomProperty()**

  This function retrieves the `AttributeData*` associated with a custom key. In your implementation, check to ensure the provided key corresponds to a custom property or attribute.
- **GetCustomPropertyType()**

  This function retrieves the data type associated with the custom property or attribute. Data types are defined in the `Simba::Support::AttributeType` enum, located in the header folder `[INSTALL_DIRECTORY]\DataAccessComponents\Include\Support\AttributeData.h`.

Custom Properties in the Java SDK

Custom properties can be added to the connectors using the Java DSI with either the JNI DSI API, or the SimbaJDBC component. When using the JNI DSI API, custom properties are accessed in the same way that custom properties are accessed for ODBC connectors. When using the SimbaJDBC component, the custom properties are exposed through the following custom extensions to the `Connection` and `Statement` objects:

- **getAttribute(int)**

  Retrieve a custom property identified by the integer key.
- **setAttribute(int, Object)**

  Set a custom property identified by the integer key.

> **Note:**
>
> Because these are custom extensions, applications will have to be coded to explicitly use these functions.

Custom Properties in the DotNet SDK

Custom properties can be added to connectors using the DotNet DSI, but can only be directly accessed when using the CLI DSI to build an ODBC connector.

Handling Connections

The ODBC application, the Simba ODBC layer, and your custom DSII layer interact to establish a connection to your data store. An important part of this process is obtaining all the required connection settings. The Simba SDK provides functions to help you manage the set of required and optional connection settings, and to repeat the request for settings until all required settings are obtained.

For a description of the connection process, see Understanding the Connection Process below.

Obtaining Settings and Connecting to the Data Store

In your `CustomerDSIIConnection::UpdateConnectionSetting` method, the `in_connectionSettings` parameter includes the connection settings that the user specified in the connection string, DSN, and/or prompt dialog. Your implementation of this method should return any modified or additional required (or optional) connection settings in the `out_connectionSettings` parameter.

You can use the utility functions `VerifyOptionalSetting` and `VerifyRequiredSetting` to help you check if a setting exists. If a setting does not exist, these functions put the appropriate value in the `out_connectionSettings` map.

To specify a list of acceptable values for one of your connection settings in the `out_connectionSettings` map, you must enter it yourself. For example:

```
DSIConnSettingRequestMap::const_iterator itr = in_
connectionSettings.find(L"SomeSetting");
if (itr == in_connectionSettings.end())
{

    // Missing the required key, so add it to the
    requested settings.
    AutoPtr<ConnectionSetting> reqSetting(new
    ConnectionSetting(SETTING_REQUIRED));
    reqSetting->SetLabel(L"SomeSetting");
    reqSetting->RegisterWarningListener
    (GetWarningListener());
    std::vector<Simba::Support::Variant> values;
    values.push_back(Variant(L"YES"));
    values.push_back(Variant(L"NO"));
    values.push_back(Variant(L"UNKNOWN"));
    reqSetting->SetValues(values);
    out_connectionSettings[L"SomeSetting"] =
    reqSetting.Detach();

}
```

If `out_connectionSettings` contains additional required connection settings, then the Simba ODBC Layer will call `PromptDialog` to request these settings. Connection settings can be required or optional. This retrieve-request cycle repeats until all required connection settings have been provided. Once all required settings have

been provided (even if some optional settings have not been provided), then the Simba ODBC Layer will call your `CustomerDSIIConnection::Connect` function.

Your implementation of the `CustomerDSIIConnection::Connect` function should establish a connection to your data store. You should inspect the `in_connectionSettings` parameter to retrieve any connection settings that are needed to establish and set up a connection to your data store. You can use the utility functions `GetOptionalSetting` and `GetRequiredSetting` to help you extract the settings from the `in_connectionSettings` parameter.

When your implementation of the `CustomerDSIIConnection::PromptDialog` function is called, you have the option of displaying a graphical dialog box to the user for requesting parameters or other connection settings. See Creating and Using Dialogs for more information about creating dialog boxes.

For example, if you require the user to enter a user id and a password, you can request those parameters from the user using this dialog box. If you do not wish to implement a dialog box, you can simply leave the `PromptDialog` function empty.

Example: Handling a Missing Password

Assume your DSII requires a user ID and password to establish a connection to your data store. Then, an application attempts a connection using `SQLDriverConnect` supplying the user ID setting but missing the password setting.

First, `UpdateConnectionSettings` is called so that all the settings that are needed for a connection can be verified. Your `UpdateConnectionSettings`f unction would use `VerifyRequiredSetting` for both the user ID and password keys to verify that they are present.

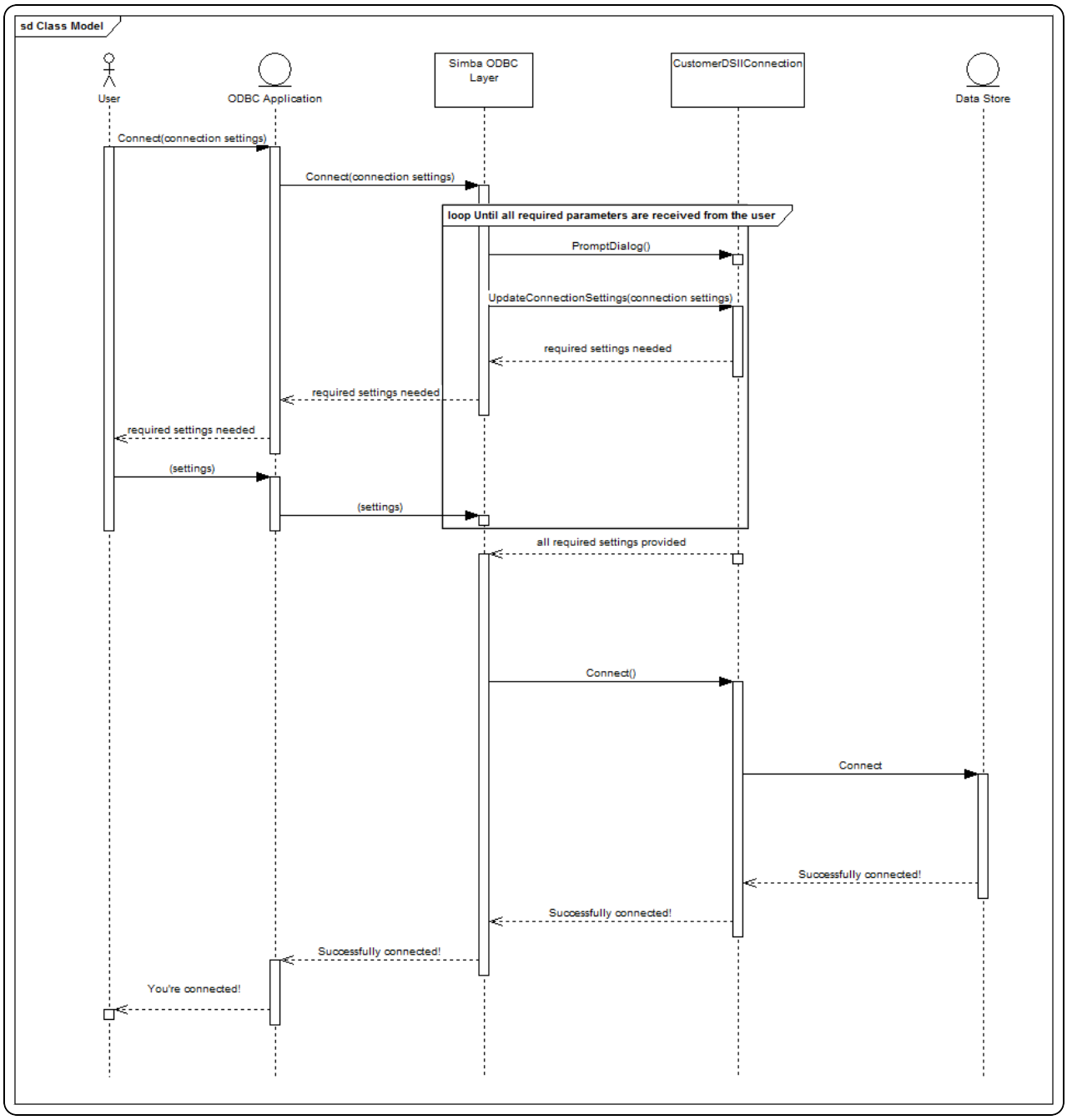
If any key is not present, it will be added to the `out_connectionSettings` parameter by `VerifyRequiredSetting`. Since the password key is missing, `out_connectionSettings` now contains that setting, and `UpdateConnectionSettings` will return.

When the Simba ODBC layer detects that a required setting is missing, it calls `PromptDialog`. This allows your DSII to prompt a dialog to the user to request any additional or missing information. Once the user has filled out the dialog and returned, the Simba ODBC layer will call `UpdateConnectionSettings` again to verify that all the required settings are now present. If all the required settings are present, it will then call `Connect` to proceed with the connection. If all the required settings are not present, it continue the `PromptDialog` and `UpdateConnectionSettings` cycle until the user cancels the dialog.

Understanding the Connection Process

This section provides a detailed explanation of how the end user, your ODBC-enabled application, the Simba ODBC Layer and your DSII layer interact to establish a connection to your data store. It then explains how you must handle the connection process in your own custom connector.

When the end-user initiates a connection to your data store, the Simba ODBC Layer will call your `CustomerDSIIConnection::UpdateConnectionSettings` function. Note that in some cases the Simba ODBC Layer may call your `CustomerDSIIConnection::PromptDialog` function, discussed later in this section, first if the connection parameters indicate it should do so. This process is shown in the diagram below:



Related Topics

Creating and Using Dialogs

Creating and Using Dialogs

The Simba SDK includes functionality to help you implement dialogs. You can use these dialogs to retrieve user input such as connection settings or configuration

information.

Dialogs in Windows

The Quickstart sample connector for Windows platforms includes a sample implementation of a user dialog. For information on the Quickstart sample connector, see *Build a C++ ODBC Connector in 5 Days* at http://www.simba.com/resources/sdk/documentation/.

This section shows you how to use the `PromptDialog` method of your `CustomerDSIIConnection` class to display a dialog box that prompts the user for settings for this connection. For more information on the connection process, see Handling Connections.

The `CustomerDSIIConnection::PromptDialog` method has the following signature:

```
virtual bool PromptDialog(
Simba::DSI::DSIConnSettingResponseMap& in_connResponseMap,
Simba::DSI::DSIConnSettingRequestMap& io_connectionSettings,
HWND in_parentWindow,
Simba::DSI::PromptType in_promptType
);
```

This method has the following parameters:

- **in_connResponseMap**

  The connection response map updated to reflect the user's input.
- **io_connectionSettings**

  The connection settings map updated with settings that are still needed and were not supplied. The connection settings from io_connectionSettings are presented as key-value string pairs. The input connection settings map is the initial state of the dialog box. The input connection settings map will be modified to reflect the user's input to the dialog box.
- **in_parentWindow**

  Handle to the parent window to which this dialog belongs.
- **in_promptType**

  Indicates what type of connection settings to request either both required and optional settings or just required settings.The return value for this method indicates if the user completed the process by clicking OK on the dialog box

(return true), or if the user aborts the process by clicking CANCEL on the dialog box (return false).

Linux/Unix/macOS

Dialogs are also possible on Linux/Unix/macOS platforms, although the Quickstart sample connector for those platforms does not include a sample implementation.

The `PromptDialog` function is the same as for Windows. However, the meaning of the `in_parentWindow` argument is undefined. Different applications may potentially pass in different types of window handles. Therefore, `in_parentWindow` can only be used if your connector can make assumptions about running within a specific window system or API toolkit. Otherwise, the window you create will need to be parentless.

Related Topics

Handling Connections

Canceling Operations

Prior to ODBC 3.8, only statement operations could be cancel using `SQLCancel`. In ODBC 3.8 a new function called `SQLCancelHandle` was added that can cancel both statement and connection operations. Note that canceling a statement in 3.8 using `SQLCancelHandle` is identical to canceling it using `SQLCancel`.

Simba SDK supports both `SQLCancelHandle` and `SQLCancel`. The implementations of `DSIConnection` and `DSIStatement` can handle and clear the cancel requests through the `OnCancel` and `ClearCancel` callbacks. The following table summarizes this functionality:

Class	OnCancel	ClearCancel
DSIConnection	Invoked when SQLCancelHandle is called on the `DSIConnection`'s handle.	Invoked at the beginning of a connection related function that has the ability to be canceled.

Class	OnCancel	ClearCancel
DSIStatement	Invoked when `SQLCancelHandle` or `SQLCancel` is called on the `DSIStatement`'s handle.	Invoked at the beginning of a statement function that has the ability to be canceled.

In `OnCancel`, the object can perform any cancellation logic such as setting flags to indicate that an operation should be canceled.

In `ClearCancel`, the object can clear any pending cancel notification (e.g. clear flags).

Handling Transactions

A transaction is a set of operations that are executed on a data store. If a transaction is successful, all of the data modifications made during the transaction are committed. If a transaction encounters errors and must be canceled or rolled back, then all of the data modifications are erased.

If your data store supports transactions, you can enable them in your custom ODBC or JDBC connector. To enable transactions in your connector, your DSII must enable both read and write functionality.

To enable read/write capability on your connector:

- For the C++ SDK, call `DSIPropertyUtilities::SetReadOnly`, passing in `false` for the second parameter.
- For the Java SDK, call `PropertyUtilities::SetReadOnly`, passing in `false` for the second parameter.

Enabling Transaction Support

After adding read/write capability to your custom connector, you can enable transaction support by creating your own implementation of the `DSIIConection` class and implementing the `BeginTransaction()`, `Commit()`, and `Rollback()` methods.

Implement the DSIConnection Class

Support for transactions is implemented in the `DSIConnection` class. Override this class so you can provide your own implementation.

Specify that Transactions are Supported

The Simba SDK uses a property to specify the level of transaction support for a custom connector. This is done differently in C++ and in Java.

To set the DSI_CONN_TXN_CAPABLE Property in C++:

Set the DSI_CONN_TXN_CAPABLE property in your `DSIConnection` object to specify the level of transaction support that your connector can handle. You can use the `DSIPropertyUtilities::SetTransactionSupport()` helper method.

Example: Setting the DSI_CONN_TXN_CAPABLE property in C++

In this example, a helper method called `SetConnectionPropertyValues()` is used to set the DSI_CONN_TXN_CAPABLE property. This method is invoked from the `MyConnection` class's constructor. It calls the `SetReadOnly` method, passing in `false`:

```
void MyConnection::SetConnectionPropertyValues(){
  DSIPropertyUtilities::SetReadOnly(this, false);
  DSIPropertyUtilities::SetTransactionSupport(this, DSI_TC_
DML);

    ...
```

In the above example, transaction support is set to DSI_TC_DML, which only supports DML statements within a transaction.

To set the DSI_TXN_CAPABLE Property in Java:

Set the ConnPropertyKey.DSI_TXN_CAPABLEin your `DSIConnection` object to specify the level of transaction support that your connector can handle. You can do this using the `DSIConnection::SetProperty()` method, passing DSI_TXN_CAPABLE as the attribute data.

Implement the Required Methods in the DSIConnection Class

To support transactions, your connector must implement the methods as described in this section.

1. **BeginTransaction()**

   This method is invoked by the Simba SDK at the start of a new transaction on the connection. This method is responsible for performing any logic that is required before the transaction starts, such as ensuring that transactions are supported, or checking that a transaction is not already in progress.

   Example: Check whether a transaction is already in progress

In this example, the custom connector checks a member variable that tracks whether a transaction is already in progress. If so, an exception is thrown. Otherwise, the member is set to `true` at this point. Subsequent transaction methods will check this variable to coordinate their workflows with the current transaction.

```
void MyConnection::BeginTransaction() {
    if (isInTransaction) {
        XMTHROWGEN(" Illegal transaction state change
(BeginTransaction). ");
    }
    else {
        isInTransaction = true;
    }
}
```

2. **Commit()**

   This method is invoked by the Simba SDK to commit the statements of a transaction. This method is responsible for performing commit-related logic for the outstanding transaction on the connection, such as storing any inserted or updated data.

   Example: Sample Commit() Implementation

   This example shows one way that you could implement your `Commit()` method. It also shows a helper method, `MyConnection::CommitImp()`.

```
void MyConnection::Commit(){

    if (!isInTransaction) {

        XMTHROWGEN(" Illegal transaction state
        change(Commit). ");

    }
    else {

        isInTransaction = false;
        CommitImpl();

    }

}
////////////////////////////////////////////////////////////
////////////////////////////////////////
```

```
void MyConnection::CommitImpl() {

    // Get the Connector's Tables
    AutoValueMap<XMTableIdentifier, const
    XMTableData>& driverTableDataMap = GetTableDataMap
    ();
    CriticalSectionLock lock(m_criticalSection);
    for (AutoValueMap<XMTableIdentifier, const
    XMTableData>::iterator it = m_changedTables.begin
    (); it != m_changedTables.end(); it++){

        MapUtilities::InsertOrUpdate
        (driverTableDataMap, it->first, it-
        >second);
        it->second = NULL;

    }

}
```

`MyConnection::Commit()` first ensures that a transaction is in progress, and then delegates the commit logic to `MyConnection::CommitImpl`. `MyConnection::CommitImpl` first takes a lock. Then, it iterates through its `m_changedTables` member, which is used to track tables that have had inserts or updates to made to their values. Finally, it uses the `MapUtilities::InsertOrUpdate` helper method to perform the actual data value insertion/updates on these tables.

3. **Rollback()**

   This method is invoked by the Simba SDK when a ROLLBACK statement is encountered in a transaction query. This method is responsible for rolling back data for an outstanding transaction on the connection, to the state it was in before the start of the transaction.

   Example: Sample Rollback() Implementation

   This example shows one way that you could implement your `Rollback()` method.

```
void XMConnection::Rollback(){

    if (!isInTransaction){

        XMTHROWGEN(" Illegal transaction state
        change(Rollback). ");

    }
    else {

        isInTransaction = false;
        m_changedTables.DeleteClear();

    }

}
```

This method first ensures that a transaction is in progress. If the transaction is in progress, it resets `isInTransaction` to indicate that a transaction is no longer in progress, followed by a call to `m_changedTables.DeleteClear()`, which clears the listing of tables that have been modified.

Adding Support for Savepoints (SimbaJDBC only)

A *savepoint* is a way of implementing subtransactions, which are also called *nested transactions*. A savepoint is used to mark a point in a transaction that you can roll back to without affecting any work done in the transaction before the savepoint was created. Savepoints are supported for DSIIs that are written in Java and use the SimbaJDBC component.

Set the DSI_SUPPORTS_SAVEPOINTS property

Set the DSI_SUPPORTS_SAVEPOINTS property in your custom `DSIConnection` object to DSI_SUPPORTS_SAVEPOINTS_TRUE.

Implement the Required Methods in the DSIConnection Class

Modify your custom `DSIConnection` object to override and implement the following virtual methods:

1. **createSavepoint(String)**

   This method is invoked by the Simba SDK when a SAVEPOINT statement is encountered in a query. This method is responsible for creating a new Savepoint with the specified name in the current transaction, and performing any save point logic such as caching information about the current state of data, that could be used to restore the state if a subsequent rollback operation occurs.

2. releaseSavepoint(String)

   This method is invoked by the Simba SDK when a RELEASE statement is countered in a query. This method is responsible for releasing the Savepoint with the specified name so that the Savepoint is no longer available to rollback to. This could also include performing any related logic such as freeing up resources and clearing any state information that was related to the specified save point.
3. rollback(String)

   This method is invoked by the Simba SDK when a ROLLBACK statement is encountered in a transaction query. This method is responsible for rolling back data for an outstanding transaction on the connection, to the state it was in before the start of the transaction.

Supporting Transactions through SQL

In some data sources, transactions can also be triggered by executing certain SQL queries (e.g. BEGIN, COMMIT, AND ROLLBACK statements). Support for this is provided through the `ITransactionStateListener` interface, which allows your DSII to inform the Simba components of any changes in transaction state.

In your `CustomerDSIConnection` object, invoke the following methods on the `m_transactionStateListener` member exposed by the `DSIConnection` class. This informs the Simba components of any changes to transaction state.

In the C++ SDK:

1. When a transaction has started, call `ITransactionStateListener::NotifyBegin`.
2. When a transaction is committed, call `ITransactionStateListener::NotifyCommit`.
3. When a transaction is rolled back, call `ITransactionStateListener::NotifyRollback`.

In the Java SDK:

1. When a transaction has started, call `ITransactionStateListener.NotifyBeginTransaction`.
2. When a transaction is committed, call `ITransactionStateListener::NotifyCommit`.
3. When a transaction is rolled back, call `ITransactionStateListener::NotifyRollback`.

If your DSII is written in Java and is using the SimbaJDBC component, then you may need to notify the `ITransactionStateListener` about Savepoint operations as well:

1. When a Savepoint is created, call `ITransactionStateListener::notifyCreateSavepoint`.
2. When a Savepoint is released, call `ITransactionStateListener::notifyReleaseSavepoint`.
3. When a transaction is rolled back to a Savepoint, call `ITransactionStateListener::notifyRollbackSavepoint`.

Important:

ODBC does not support Savepoints, and attempting to use the `notify*Savepoint`functions on the `ITransactionStateListener` while using the JNI DSI API will cause an exception.

Bulk Fetch in the C++ SDK

Prior to Simba SDK 10.0, data had to be retrieved from an `IResult` row by row and column by column using the `Move` method to position the cursor, and `RetrieveData` to return a cell of data. Retrieving data in this manner is acceptable for small-to-medium sized datasets, or those with results spanning non-contiguous rows, but has the following drawbacks:

- Data is accessed per cell, which means the ODBC layer of the SDK needs to loop through each row and each column, invoking methods to retrieve and convert each individual cell of data. This results in a large number of small data transfers, with each of them requiring a small amount of overhead, but collectively resulting in a noticeable impact on performance.
- The retrieval of each data cell involves invoking multiple virtual methods, which can stall a CPU's instruction pipeline and decrease a connector's execution performance.

As of 10.0, `IResult` now exposes the Bulk Fetch API which provides a more optimized data retrieval mechanism allowing a connector to fetch contiguous rows of data via a single method call and store the data directly into the buffer allocated by the calling application. This "bulk fetch" mechanism eliminates the need to iterate over rows and columns to return data and allows all the data for many rows to be returned in one pass.

Note:

- Bulk fetch is currently supported for ODBC connectors that do not use the SQL Engine and are not implemented by the Simba SDK's ODBC Client. Bulk Fetch can be implemented in SimbaServer, as described below.
- Bulk fetch is supported in the C++ SDK only.

Overview

This section describes the high-level overview for Bulk Fetch.

1. The ODBC layer of the SDK instantiates one Bulk Processor for each column bound by the application. A Bulk Processor is an object that oversees the process of copying and converting contiguous rows of data for a bound column. Each Bulk Processor contains all the necessary information about the data buffer and length/indicator field that the application has bound to the column as well as a Bulk Converter which is an object that is able to convert values from the SQL data type (the data type that the DSII uses to talk to the SDK) to a C data type (the data type returned to the application).
2. The ODBC layer calls the BulkFetch method implementation of the DSII.
3. The DSII retrieves multiple rows for all the bound columns. Note that it can also retrieve the data of other columns, but they won't be used. The DSII can organize the data as it wants in memory, but needs to leave it unchanged until the bulk conversion is complete.
4. The DSII needs to instantiate one Column Segment per bound column. A Column Segment describes where in memory the contiguous set of data rows for a column can be found as well as the offsets required to find the next row. The Bulk Processor uses a Column Segment so it knows where the values of the retrieved rows have been stored in memory.
5. The DSII instructs the Bulk Processors to convert the columns (i.e. perform the bulk fetch), providing them with the Column Segments it has just instantiated for each bound column. The Bulk Processors convert all the SQL values retrieved by the DSII to the C values directly into the buffer bound by the application.
6. Once the bulk fetch completes, the ODBC layer of the SDK does not need to perform any further data processing because the Bulk Fetch has both converted and copied the data for all rows to be returned directly to the application's buffer.

Since the Bulk Fetch API writes directly to the buffer provided by the application, bulk fetch functionality can only be used for columns which are bound by the calling application (i.e. columns for which memory has been allocated and associated with each column to store the data returned by the connector) and of those, only for columns which have been selected for retrieval (i.e. those columns specified in a

SELECT query). For efficiency reasons, the SDK also uses the Bulk Fetch API only when the application requests multiple rows during each fetch (when the size of the row set being requested contains at least two rows).

In its first release, the Bulk Fetch API is only supported for DSII's that do not rely on the SEN SDK SQLEngine for query execution. Performance is gained with "bulk fetch" when multiple rows of bound columns are accessed and converted sequentially. The SQLEngine on the other hand, gets the value of cells (the value of a specific column of a specific row) on demand and might apply a different data conversion for each cell value. This does not fit the Bulk Fetch API design.

In addition to the performance benefits listed above, bulk fetch also provides the following advantages:

- Bulk Processors implemented in the SDK are independent of each other. A DSII can therefore create one thread per bound column and do the bulk conversion of all the columns in parallel. This could also include the retrieval of data if the rows of the various columns are independent of each other (e.g. if the data store has a columnar organization).
- Bulk Converter factories are created by the connection. The factory objects which create the Bulk Converters are instantiated by the DSII's connection object (via `IConnection::GetSqlToCBulkConverterFactory()`) which means the connection can determine the type of factories to create (for example, a connection could return a factory type based on the type of server it is connecting to). This provides more flexibility than the singleton converter factory used under normal (non bulk fetch) data retrieval which forces all connections to use the same type of converter.

Bulk Fetch API

This section describes the objects and methods that are related to the bulk fetch API.

Methods in IResult

These methods, defined in IResult, make up the bulk fetch API. These methods must be implemented in your connector's `IResult` class.

IsBulkFetchSupported()

This method is invoked by the Simba ODBC layer before attempting a bulk fetch, in order to determine if bulk fetch is supported. This method takes in the indices of the bound columns for which data is being selected, and allows the connector to tell the Simba ODBC layer whether or not it can support bulk fetching for those columns.

If bulk fetch is not supported by your connector, then return false for `IsBulkFetchSupported`. In the `DSISimpleResultSet` class provided by the SDK, this method returns false and must be overridden to return true if your connector supports bulk fetch. This class also defines a simple implementation for the `BulkFetch` method which positions the cursor and then invokes a `DoBulkFetch()` method which must be overridden to perform the bulk fetch.

BulkFetch()

This method is invoked by the Simba ODBC layer to perform a bulk fetch, when an application requests rows for bound columns. This method takes in the number of rows to return and a collection of `IBulkProcessors`. An `IBulkProcessor` converts the data for multiple rows of a bound column and stores it directly into the buffers bound to those columns by the application. Additional detail is provided below.

Additional Classes and Methods

This section summarizes the additional interfaces and classes that your connector will use to support bulk fetch functionality. Note that default implementations are provided for each. Additional detail for each of these components is provided later in this section.

IBulkProcessor

This interface defines the interface for a Bulk Processor. The ODBC layer of the SDK provides an implementation called `SqlToCBulkConverterWrapper`. `SqlToCBulkConverterWrapper` delegates the copy-and-conversion process to an `ISqlToCBulkConverter` (described below).

AbstractColumnSegment

A concrete implementation of this class is constructed by the `IResult` object when the `BulkFetch` method is invoked by the Simba ODBC layer. The `IResult` object will then pass this object to the `IBulkProcessors` for use in converting column data from the data source. The SDK provides the following two default concrete implementations, although applications can also implement their own:

- `FixedRowSizeColumnSegment`: suitable for use when the underlying data to be retrieved is stored in a buffer in which a fixed number of bytes are allocated per cell and the address of the cell for each successive row can be computed by adding a constant offset to the memory pointer.
- `DataLengthColumnSegment`: suitable for use when the data to be retrieved is stored in a buffer in which a variable number of bytes are allocated per cell, and therefore the address of the next cell cannot be computed using a constant

offset. This class stores a collection of DataLengthColumn objects each of which describes the memory location and length of data for a particular cell.

- `ServerColumnSegment`: must be used when implementing bulk fetch on the server. It is designed to optimize performance over the SimbaClient/Server wire protocol. This class takes the following arguments:
  - `in_data` - An array of pointers to the data
  - `in_lengths` - an array specifying the length of each item of data in in_data. The array value must be -1 if the corresponding data has no length (is NULL). If the corresponding data is fixed-length type, the array value is not used (but must be a non-negative integer). If the corresponding data is a variable-length type, the array value must specify the length of the data, in bytes.
  - `in_count` - a counter specifying the length of in_data and in_lengths.

Note:

Using Bulk Fetch in SimbaClient/Server may cause issues in exposing warnings and errors associated with fetching ResultSet data. When data is fetched row by row, the error can be associated with a specific cell in the data, and is returned to the client when the cursor moves to the next row. With Bulk Fetch however, the error is returned to the client along with the bulk chunk of data, and the error is not associated with a specific cell.

ISqlToCBulkConverter

Defines an interface for a Bulk Converter. The SDK provides a default implementation called `SqlToCBulkConverter` which is (derives from) a templated functor and performs a conversion from a SQL data type to a C data type. The SDK also #defines hundreds of templated functor operator() methods for conversions of specific data types. Although the use of templates per converter increases the size of the compiled binary connector (i.e. a `SqlToCBulkConverter` class will be defined by the compiler for each #defined template), it eliminates the need to subclass a converter for each possible data type conversion and therefore eliminates virtual calls.

ISqlToCBulkConverterFactory:

Creates the `ISqlToCBulkConverter` object that will be used by the `IBulkProcesser` object to copy and convert data for a specific column. The SDK provides a default implementation called `DSIBulkConverterFactory` which, through templates, determines the correct `ISqlToCBulkConverter` to return to handle the data type of the column.

IConnection::GetSqlToCBulkConverterFactory

Invoked by the Simba ODBC layer on a connection to obtain the `ISqlToCBulkConverterFactory` object that will be used to construct `theISqlToCBulkConverter` objects for each `SqlToCBulkConverterWrapper`. The Simba ODBC layer will create a `SqlToCBulkConverterWrapper` for each column, passing the `ISqlToCBulkConverterFactory` to the constructor.

Settings

When supporting bulk fetch, you can allow your customers to configure additional settings at runtime. This step is optional. For example, the following settings can be configured in the registry or through a connection string:

- `UseBulkFetch`: set to 1 to enable bulk fetches, or 0 to disable.
- `UseSqlEngine`: must be set to 0 when enabling bulk fetches. Currently the SQL Engine cannot be used with bulk fetches.
- `ColumnSegmentId`: specifies the Column Segment class that should be used to provide information about the buffer bound by the application. Set to 1 to use `FixedRowSizeColumnSegment`, 2 for the `DataLengthColumnSegment`, or the ID of your custom Column Segment class (see Creating a Custom Column Segment and Converter for more information).

One way to implement these runtime setting is to pass them in to the connector's `Connection::Connect()` method. The method then passes the `UseBulkFetch` and `ColumnSegmentId` values to the table during construction. The table then uses these values to determine if bulk fetch is supported, and which Column Segment type to use.

Adding Bulk Fetch to a Connector

To add bulk fetch to your connector, we recommend subclassing `DSISimpleResultSet`. This is the quickest way to implement your IResult, and provides easy access to the default implementations provided by the Simba SDK.

This section provides code samples that you can use when subclassing `DSISimpleResultSet` and adding bulk fetch to your connector.

When subclassing `DSISimpleResultSet`, the first method to override is `IsBulkFetchSupported()`.This method is invoked by the Simba ODBC Layer for each bound column in the bulk fetch, and provided with the column index. Your connector will use this method to signal to the Simba ODBC layer whether bulk fetch is supported for each column in the table from which data is being requested by a bulk

fetch. If your connector does not support bulk fetch or if bulk fetch is disabled (e.g. through a setting), then this method should always return false. The following code snippet shows the implementation from an example `DSISimpleResultSet`-derived class, `XMTableLight`.

```
bool XMTableLight::IsBulkFetchSupported(std::set<simba_
uint32>& in_boundColumnIndex)
{
    UNUSED(in_boundColumnIndex);
    return m_useBulkFetch;
}
```

This example shows the latter case where bulk fetch can be enabled or disabled. The class stores a flag (`m_useBulkFetch`) which is set in the class's constructor based on the settings provided to it from the Simba ODBC layer (i.e. a flag indicating whether or not the user enabled bulk fetch). `IsBulkFetchSupported` then returns this flag to the ODBC layer regardless of the column index. In your connector, you will most likely want to examine the column metadata corresponding to the column indexes provided in `in_boundColumnIndex` and then decide whether or not bulk fetch is supported for all corresponding columns for the query currently under execution.

Note:

When deriving a result set from `DSISimpleResultSet`, the default implementation returns `false`, so `DSISimpleResultSet`-derived classes don't have to do anything if a connector doesn't support bulk fetch. However, a connector which directly implements IResult must implement this method and return false if it doesn't support bulk fetch.

The next method to implement is `BulkFetch`. `DSISimpleResultSet` provides a `BulkFetch` implementation which keeps track of the current row, and delegates the bulk fetch logic to a protected method called `DoBulkFetch` that your connector must implement. The following snippet shows the `BulkFetch` implementation provided by `DSISimpleResultSet`:

```
simba_unsigned_native DSISimpleResultSet::BulkFetch(
    simba_unsigned_native in_rowsetSize,
    const std::vector<Simba::DSI::IBulkProcessor*>& in_
bulkProcessors)
{
    if (!m_hasStartedFetch)
    {
```

```
        // Go to the first row.
        m_hasStartedFetch = true;
        m_currentRow = 0;
    }
    else
    {
        // Move on to the next row.
        m_currentRow++;
    }
    const simba_unsigned_native rowsFetched(DoBulkFetch(in_
rowsetSize, in_bulkProcessors));
    if (rowsFetched > 0)
    {
        m_currentRow += (rowsFetched - 1);
    }
    return rowsFetched;
}
```

`BulkFetch` takes in the number of rows to obtain along with the collection of bulk processors to use for each column. Note that in default implementation, the Simba ODBC layer will pass a collection of `SqlToCBulkConveterWrapper` objects.

In `DSISimpleResultSet`'s implementation, the class manages an `m_currentRow` member, which is the index of the current row to obtain data from. Since multiple bulk fetches can be invoked where each obtains a limited number of rows, this method begins by checking `m_hasStartedFetch` to determine if a previous bulk fetch has been made. If not (i.e. this is the first bulk fetch or the cursor has been closed), `m_currentRow` is set to the first row, otherwise, it is advanced to the next row in preparation of the bulk fetch. The method then delegates the bulk fetch logic to the `DoBulkFetch` method, and forwards the parameters to that method. `DoBulkFetch` performs the bulk fetch returning the number of rows fetched. `BulkFetch` then advances `m_currentRow` by the number of rows fetched and adjusts it (subtracts 1) since it is zero based.

For example, the `XMTableLight` class derives from `DSISimpleResultSet` and provides the implementation of `DoBulkFetch`. The following code snippets break down the main parts of this method:

```
simba_unsigned_native XMTableLight::DoBulkFetch(
    simba_unsigned_native in_maxRows,
    const std::vector<IBulkProcessor*>& in_bulkProcessors)
{
```

```
    const simba_unsigned_native firstRow(GetCurrentRow());
    if (firstRow >= m_totalRows)
    {
        return 0;
    }
    const simba_unsigned_native rowsToReturn(simba_min(in_
maxRows, m_totalRows - firstRow));
    const AutoVector<XMTableColumnDataBase>& columns(m_
tableData->GetDataCol());
    AutoVector<IBulkProcessor>::const_iterator it(in_
bulkProcessors.begin());
    const AutoVector<IBulkProcessor>::const_iterator end(in_
bulkProcessors.end());
```

This method begins by ensuring that `m_currentRow` has not been advanced passed the end of the rows in the table. If it has (i.e. all rows have been fetched), then the method returns 0 to indicate that no more rows are available to be fetched. The method then determines the number of rows that will be returned by determining the lower value of the number of rows remaining or the number of rows requested for bulk fetch.

After this, the method prepares a collection of `XMTableColumnDataBase` objects which provide access to the underlying data for each column. It then constructs an iterator that will be used to iterate over each of the bulk processors passed to the method by the Simba ODBC SDK, and perform the bulk fetches.

The next snippet shows the core loop where the method performs this iteration. The purpose of this loop is to invoke the bulk fetch process on each column bound by the application. This is accomplished by iterating through each Bulk Processor passed in from the Simba ODBC layer, constructing the appropriate Column Segment object based on the configuration settings, and invoking the Process method on the current Bulk Processor, passing in the newly-constructed Column Segment describing where the table data can be found.

```
for (; it != end; ++it)
{

    IBulkProcessor& processor(**it);
    const SelectListItem& item(GetSelectListItem
    (processor.GetColumnIndex()));
    const XMTableColumnDataBase& column(*columns
    [item.first]);
```

```
    RightTrimmer* const rightTrimmer(item.second ? m_
    rightTrimmers[item.first] : NULL);
    switch (m_columnSegmentId)
    {

        case AbstractColumnSegment::FIXEDROWSIZE_ID:
        ... do fixed row size processing (see below)
        break;
        case AbstractColumnSegment::DATALENGTH_ID:
        ... do data length row processing (see below)
        break;
        case XMStringColumnSegment::XM_COLUMNSEGMENT_
        ID:
        ... do row processing using a custom Column
        Segment (see below)
        break;

    }

}
```

The loop starts by using the column index reported by the current Bulk Processor to determine if the column data should be right trimmed (a typedef called `SelectListItem` stores the index and a flag) and then obtains a reference to the `XMTableColumnDataBase` object corresponding to the column index of the current Bulk Processor, which contains the underlying data for the column.

A switch/case statement is then used to determine which type of Column Segment to construct, based on the application settings:

```
switch (m_columnSegmentId)
{

    case AbstractColumnSegment::FIXEDROWSIZE_ID:
    {

        std::vector<std::pair<const void*, simba_
        uint32> > sourceBuffers(rowsToReturn);
        simba_uint32 maximumDataSize = 0;
        for (simba_signed_native index = 0; index <
        rowsToReturn; index++)
        {
```

```
            const RowIdentifier& rowId = m_rows
            [firstRow + index];
            sourceBuffers[index] =
            column.GetBuffer(rowId);
            if (maximumDataSize < sourceBuffers
            [index].second)

            {
                 maximumDataSize = sourceBuffers
            [index].second;
            }

        }
        std::vector<simba_byte> cachedDataBuffer
        (maximumDataSize * rowsToReturn);
        std::vector<simba_signed_native>
        cachedLengthBuffer(rowsToReturn);
        simba_byte* cellPtr = &cachedDataBuffer[0];
        for (simba_signed_native index = 0; index <
        rowsToReturn; index++, cellPtr +=
        maximumDataSize)
        {

            const std::pair<const void*, simba_
            uint32>& sourceBuffer =
            sourceBuffers[index];
            if (NULL != sourceBuffer.first)
            {

                memcpy(cellPtr,
                sourceBuffer.first,
                sourceBuffer.second);
                cachedLengthBuffer[index] =
                sourceBuffer.second;

            }
            else
            {
```

```
                cachedLengthBuffer[index] =
                CvtLength::MakeNull();

            }

        }
        FixedRowSizeColumnSegment columnSegment(
        &cachedDataBuffer[0],
        maximumDataSize,
        &cachedLengthBuffer[0],
        sizeof(simba_signed_native),
        rowsToReturn);
        processor.Process(columnSegment);
        break;

    }
    case AbstractColumnSegment::DATALENGTH_ID:
    {

        std::vector<DataLengthColumn>
        dataLengthColumns(rowsToReturn);
        for (simba_signed_native index = 0; index <
        rowsToReturn; index++)
        {

            const RowIdentifier& rowId = m_rows
            [firstRow + index];
            const std::pair<const void*, simba_
            uint32> columnData(column.GetBuffer
            (rowId));
            if (NULL == columnData.first)
            {

                dataLengthColumns
                [index].SetAttributes(NULL,
                CvtLength::MakeNull());

            }
            else
            {
```

```
                dataLengthColumns
                [index].SetAttributes
                (columnData.first,
                columnData.second);

            }

        }
        DataLengthColumnSegment columnSegment
        (&dataLengthColumns[0], rowsToReturn);
        processor.Process(columnSegment);
        break;

    }
    case XMStringColumnSegment::XM_COLUMNSEGMENT_ID:
    {

        // For the SQLite custom column segment, the
        conversion is specialized depending on the
        // column type. So delegate the conversion to
        the colum object.
        column.Process(processor, m_rows, firstRow,
        rowsToReturn, rightTrimmer);
        break;

    }
    ...
}
```

Fixed Row Size Processing

In the case of a `FixedRowSizeColumnSegment`, the Column Segment constructor takes in pointers to two buffers: one containing the underlying table data stored in a contiguous array of values, and the other containing the data length for each cell stored for the column.

Since this sample connector does not store its underlying table data contiguously, the code first iterates through each row starting at the first row identified above, fetching the cell value for the column along with the size of the data, and storing it in a temporary collection of data/length pairs. During this process it also identifies the maximum data size, and stores it in `maximumDataSize`. This is used further down to specify the offset for finding the cell for the next row, within the buffer.

The code then separates and caches these data/length pairs into the two separate buffers required by `FixedRowSizeColumnSegment`. When `FixedRowSizeColumnSegment` is being constructed, the buffers are passed into the constructor along with `maximumDataSize`, the size of the length values (which specifies the offset to find the next cell size value), and the number of rows to fetch. The segment uses `maximumDataSize` and the size of the length values so that it knows where to find the next element in to two buffers respectively, as it iterates through each row.

Finally, the Column Segment is passed to the Process method of the current Bulk Processor to bulk fetch the data for the column. Process will then use its internal converter to convert and copy each cell to the application buffer bound to the column. Since the Simba ODBC layer has already configured the Bulk Processor with the location of the application buffer, the Bulk Processor already knows where the data is to be copied to.

Note that this example is for demonstration purposes only. Since the sample connector doesn't store its data in the format required by the `FixedRowSizeColumnSegment` class, additional overhead in terms of processing and memory was necessary to cache the variable length data and sizes into the buffers expected by `FixedRowSizeColumnSegment`. Therefore, a better solution for this type of table data would be to use the `DataLengthColumnSegment` as described next.

Data Length Row Processing

In the case of `DataLengthColumnSegment`, a collection of `DataLengthColumn` objects are created for each cell from each row to return. `DataLengthColumn` is a helper class which describes the location and length for a single cell of data, and the `DataLengthColumnSegment` class requires a collection of these objects for each row to return, along with the total number of rows to return.

In the example snippet, the code iterates through each row, obtaining the row's ID and invoking `column.GetBuffer` to obtain the address where the cell's data is stored for that row. This address is stored a temporary pair object which takes in and stores the location of the cell data, and automatically computes the sizeof the data based on the second template parameter. Note that for simplicity, this example assumes that the column contains integer data. In your connector, it may be necessary to compute or obtain the length of cell data based on the type of data stored in the column (e.g. variable length character data), rather relying on sizeof.

This information is then passed to the `DataLengthColumn` object via the `SetAttributes` method. After the collection of `DataLengthColumn` objects has been created, it's passed along with the row count to return to a new

`DataLengthColumnSegment` which in turn, is passed to the Bulk Processor to perform the bulk fetch.

As this example shows, the use of `DataLengthColumnSegment` is a better solution for the sample `XMTableLight` class than `FixedRowSizeColumnSegment`, because `XMTableLight` stores its data in non-contiguous arrays and can easily and more quickly describe the location and size of each cell by simply populating a collection of `DataLengthColumn` objects.

Also note the use of the `CvtLength` class. This utility class provides methods which allow the DSII to encode and decode the length of the data before and after data conversion. This is necessary because the encoded length must be used when creating Column Segments. Bulk Converters use this length to detect cases when data is null or was not successfully retrieved from the data source. Custom Bulk Converters also need to use this class when setting the target length resulting from the conversion. The following list outlines the various cases that the `CvtLength` class handles:

- Normal length: the length of data that is not null and was successfully converted (no truncation required).
- Truncated length: the length of data was either truncated during data retrieval or data conversion.
- Null value: a null value was retrieved from the data source. Note that null values are not passed to the conversion functors in the `SqlToCBulkConverter` template that handles the SDK Column Segment implementations (see `SqlToCBulkConverter.h`). For optimization reasons, the Conversion Functors do not handle null values and most of them will assert in debug mode or generate an invalid value in release mode. Therefore the same must be done in the implementation of a custom Column Segment.
- Retrieval error: used if the value of a cell cannot be retrieved successfully from the data source. The default behaviour of the Column Segment implementations provided by the SDK is to generate a retrieval error diagnostic. A DSII could however decide to discard the row (not referencing it in the column segment) or terminate the Bulk Fetch operation. The recommended approach is to handle it in the same way as when encountering a retrieval error during a single cell fetch.

For more information about the various methods available, see `CvtLength.h`.

Row Processing using Custom Column Segment

The final case statement in the example, checks for a custom Column Segment ID and the delegates the Bulk Fetch to the `XMTableColumnDataBase` object's Process method which has been set up to use a custom Column Segment. Information on creating and using a custom Column Segment is provided next.

Creating a Custom Column Segment and Converter

The `FixedRowSizeColumnSegment` and `DataLengthColumnSegment` classes provided by the SDK can be used by most connectors for bulk fetch because they describe data in both fixed-length, and variable-length storage respectively. However, developers are free to implement their custom Column Segment classes to improve efficiency or provide additional convenience in specifying where data is located.

For example you could implement your column segment and StringColumnSegment to provide direct access to your data address/length mappings, rather than requiring the DSII to copy pointers/lengths into an intermediate buffer.

The following steps describe how to create and use a custom Column Segment:

1. Derive a new class from `AbstractColumnSegment` for your custom Column Segment ensuring that at a minimum, the constructor takes in a number of type `simba_unsigned_native`, which will be used to specify the number of rows that are to be retrieved for a given bulk fetch. Additional parameters can also be added as required by your connector. For example, `XMColumnSegment` also takes in a reference to the underlying column data, a reference to the row ID's from which to obtain data, and the row number of the starting row:

```
XMColumnSegment(
const std::map<RowIdentifier, T>& in_columnData,
const std::vector<RowIdentifier>& in_rows,
simba_unsigned_native in_startRow,
simba_unsigned_native in_numRows) :
AbstractColumnSegment(XM_COLUMNSEGMENT_ID, in_numRows),
m_columnData(in_columnData),
m_rows(in_rows),
m_startRow(in_startRow)
{

    // Do nothing.

}
```

2. Generate a unique "strategy" ID for the new class and pass this to `AbstractColumnSegment`'s constructor (note that ID's less than `AbstractColumnSegment::STARTCUSTOM_ID` are reserved by the SDK). For example, `XMColumnSegment` defines this ID as a static member called `XM_COLUMNSEGMENT_ID` and then passes it to `AbstractColumnSegment` constructor in the member initialization list. This is used by the Bulk Converter to determine which type of concrete `Column` Segment has been passed to it.

3. Modify your implementation of your IResult's `BulkFetch` method (or `DoBulkFetch` if subclassing from `DSISimpleResultSet`) to perform or delegate the bulk fetch process. Since the SQLite sample connector demonstrates the use of different Column Segment types based on that specified in its connector settings, it uses a switch/case statement in `XMTableLight::DoBulkFetch` to check which Column Segment type was specified and delegates accordingly. For example, if `XMStringColumnSegment::XM_COLUMNSEGMENT_ID` was specified in the connector's settings (stored in the class's `m_columnSegmentId` member), it delegates the bulk fetch to an XMTableColumnDataBase object:

```
switch (m_columnSegmentId)
{

    ....
    case XMStringColumnSegment::XM_COLUMNSEGMENT_ID:
    {

        column.Process(processor, m_rows,
        firstRow, rowsToReturn, rightTrimmer);
        break;

    }
    ...

}
```

> **Note:**
>
> Connectors requiring their own custom Column Segment implementation will always use their implementation rather than perform the check, as was illustrated above, to determine the type. However a connector could implement different column segment types depending on the metadata of the column or mix the use of SDK Column Segments for some columns with custom Column Segments for other columns.

4. Instantiate your custom Column Segment, and pass it to the Bulk Processor's Process method to perform the bulk fetch. For example, the `XMTableColumnDataBase` object's `Process` method instantiates an `XMColumnSegment` and passes it directly to the Bulk Processor's `Process` method:

```
template<typename T> void XMTableColumnData<T>::Process(
    Simba::DSI::IBulkProcessor& in_bulkProcessor,
    const std::vector<RowIdentifier>& in_rows,
    simba_unsigned_native in_startRow,
    simba_unsigned_native in_numRows,
    RightTrimmer* in_rightTrimmer) const
{
UNUSED(in_rightTrimmer);
    in_bulkProcessor.Process(XMColumnSegment<T>(m_
dataColumn, in_rows, in_startRow, in_numRows));
}
```

5. Implement a custom `ISqlToCBulkConverter` class which can perform a conversion using your custom Column Segment class. For example, a connector might implement a `XMSqlToCBulkConverter` class to handle conversions for XM's underlying database. Its `Convert` method iterates through each row to fetch, invoking `XMColumnSegment::GetData` to return the address and data size for a cell from the underlying data source as a pair. It then uses that information to perform the fetch and conversion of data for the cell by invoking the conversion functor operator():

```
for (
simba_unsigned_native row = columnSegment.m_startRow,
endRow = row + columnSegment.GetNumberRows();
row < endRow;
++row, ++currentRow1Based, targetPtr += in_toDataOffset,
targetLenPtr = reinterpret_cast<simba_signed_native*>
(reinterpret_cast<simba_byte*>(targetLenPtr)+in_
toLengthOffset))
{

const std::pair<const void*, simba_uint32> data(columnSegment.GetData
(rowIDs[row % numRowIDs]));

if (!data.first)

{

*targetLenPtr = CvtLength::MakeNull();

}

else
```

```
{
*targetLenPtr = in_toDataLength;
(*this)(
data.first,
data.second,
targetPtr,
*targetLenPtr,
in_listener);
}
}
```

6. Create a mapping between your custom converter and all SQL types that it should convert. In the SQLitesample connector, the `XMSqlToCBulkConverterWrapperMap` defines the mapping between the SQL types the connector supports and the template class (implementing `ISqlToCBulkConverterWrapper`) with which to wrap the functors for that destination SQL type.
7. Create a custom class template with the same interface as `DefaultSqlToCBulkBuilderFuncGenerator` (provided by the SDK). For convenience, you can reuse some definitions from `DSISqlToCBulkBuilderFuncGenerator.h`. The struct must have a static `GetBuilder` method which takes in a reference to an `IConnection` and returns a new `SqlToCBulkBuilderFunction`. `SqlToCBulkBuilderFunction` is a pointer to a factory function used by a Bulk Converter factory to create the converter. The following sample shows one way of implementing this functionality:

```
template <TDWType SqlType, TDWType SqlCType> struct
XMSqlToCBulkBuilderFuncGenerator{static
SqlToCBulkBuilderFunction GetBuilder
(Simba::DSI::IConnection& in_connection){

return Simba::DSI::Impl::SqlToCBulkBuilderFuncGenerator<

Simba::DSI::Impl::SENSqlToCConversionSupport<SqlType,
SqlCType>::IsSupported,

SqlType,
```

SqlCType,

Simba::DSI::Impl::DSISqlToCBulkConverterFunctorMap,

XMSqlToCBulkConverterWrapperMap,

CharToCharIdentEncCvtFunctor,

CharToFromWCharCvtFunctor>::GetBuilder(in_connection);

}
};

This method delegates the creation to the SDK's SqlToCBulkBuilderFuncGenerator::GetBuilder method, but passes the XMSqlToCBulkConverterWrapperMap type as a template parameter.

8. Override or modify the `GetSqlToCBulkConverterFactory` method in your `DSIConnection`-derived class so that it instantiates a new `DSISqlToCBulkConverterFactory` using your custom `SqlToCBulkBuilderFunction` function. The following code snippet shows the implementation of `XMConnection::GetSqlToCBulkConverterFactory` which first checks if a factory has been created, and if not, checks to see if the SQLite Column Segment ID was specified. If it was specified, then a new `DSISqlToCBulkConverterFactory` is created using XM's custom `XMSqlToCBulkBuilderFuncGenerator` as the template type:

```
const ISqlToCBulkConverterFactory&
XMConnection::GetSqlToCBulkConverterFactory(

{
    if (m_sqlToCBulkConverterFactory.IsNull())
    {
        if (XMStringColumnSegment::XM_COLUMNSEGMENT_ID ==
m_XMSettings.m_columnSegmentId)
        {
            m_sqlToCBulkConverterFactory.Attach(
                new
DSISqlToCBulkConverterFactory<XMSqlToCBulkBuilderFuncGene
rator>(*this));
        }
        else
        {
```

```
            DSIConnection::GetSqlToCBulkConverterFactory();
          }
      }
    return *m_sqlToCBulkConverterFactory;
}
```

Creating a Custom Conversion Functor

A conversion functor is an object that defines the `operator()` method for an `ISqlToCBulkConverter` implementation, to convert a specific SQL type to a specific C type. More specifically, it performs the conversion and copying of a single data cell of a specific data type, from the source to the target locations passed to it by the `SqlToCBulkConverterWrapper` that contains the converter and invokes its `operator()`.

The SDK defines a generic conversion functor template class called `SqlToCFunctor` along with templated operator() methods for all SQL-to-C data type conversions supported by the SDK, however developers are free to extend or create customized functors (e.g. to convert a special data type in your connector).

Note:

Extending or customizing functors can be done independently of creating a custom Column Segment. A custom Column segment doesn't require a custom conversion functor, and a custom conversion functor does't require a custom Column segment.

The following outlines the steps required to add an `operator()` method:

1. Define a new functor class, similar to `SqlToCFunctor`. This class can optionally be a template class which takes in template parameters specifying the SQL and C types to convert from and to. This class must also define `operator()` with the same parameters that `SqlToCFunctor`'s `operator()` takes in:

```
void operator()(
const void* in_source,
simba_signed_native in_sourceLength,
void* in_target,
simba_signed_native& io_targetLength,
```

```
IConversionListener& in_listener);
```

2. Create a new mapping between the converter and functor by defining a templated structure which maps the SQL and C types for which the functor is to convert. The SDK defines the following default mapping for the basic SQL-to-C conversions:

```
template <TDWType SqlType, TDWType SqlCType>
struct DSISqlToCBulkConverterFunctorMap
{
    typedef SqlToCFunctor<SqlType, SqlCType> Type;
};
```

A connector can then extend this map as required. For example, a connector could define functor classes called `CustomCharConversionFunctor` and `CustomIntToStringConversionFunctor` to perform custom conversions of characters and integers to strings respectively, after which, the following maps could be defined:

```
template <TDWType SqlType, TDWType SqlCType>
struct CustomSqlToCBulkConverterFunctorMap
{
    typedef DSISqlToCBulkConverterFunctorMap<SqlType, Sql
CType> Type;
};
template <TDWType SqlCType>
struct CustomSqlToCBulkConverterFunctorMap<TDW_SQL_
CHAR, SqlCType>
{
    typedef CustomCharConversionFunctor<SqlCType> Type;
};
template <>
struct CustomSqlToCBulkConverterFunctorMap<TDW_SQL_
SINTEGER, TDW_C_CHAR>
{
    typedef CustomIntToStringConversionFunctor Type;
};
```

3. Specify the mapping in your `SqlToCBulkBuilderFuncGenerator`'s `GetBuilder()` method. The following code snippet shows the SQLitesample's custom `GetBuilder()` method:

```
struct XMSqlToCBulkBuilderFuncGenerator
{
   static SqlToCBulkBuilderFunction GetBuilder
(Simba::DSI::IConnection& in_connection)
   {
     return
Simba::DSI::Impl::SqlToCBulkBuilderFuncGenerator<
     Simba::DSI::Impl::SENSqlToCConversionSupport<SqlTyp
e, SqlCType>::IsSupported,
     SqlType,
     SqlCType,
     Simba::DSI::Impl::DSISqlToCBulkConverterFunctorMap,
     XMSqlToCBulkConverterWrapperMap,
     CharToCharIdentEncCvtFunctor,
     CharToFromWCharCvtFunctor>::GetBuilder(in_
connection);
    }
 };
```

The parameter: `Simba::DSI::Impl::DSISqlToCBulkConverterFunctorMap` can replaced with the mapping created in the previous step, for example, `CustomSqlToCBulkConverterFunctorMap`.

For more information on optimizing data retrieval, see http://www.simba.com/blog/optimization-of-odbc-data-retrieval-with-the-simbaengine-sdk/

Parsing ODBC and JDBC Escape Sequences

Many SQL-enabled data stores represent data and implement SQL in slightly different ways. To allow applications to handle these differences transparently, the ODBC and JDBC standards specifies a set of escape sequences to represent functionality such as date, time, scalar functions, and procedure calls. ODBC and JDBC connectors must translate these escape sequences into a format that their data store supports.

The Simba SDK includes the MiniParser feature to help developers parse SQL commands for escape sequences, then replace them with the command format understood by their data store. SQL commands can contain multiple escape sequences with multiple parameters, and escape sequences themselves can be nested. The MiniParser implements all of the recursive processing and the creation of complex regular expressions required to support escape sequences. Using the Simba

SDK, it is easy for your connector to translate SQL commands containing complex, nested escape sequences into a format that your data store understands.

ODBC and JDBC Escape Sequences

Escape sequences are grouped into types, making them easier to parse and process. Notice they are all enclosed in curly braces ({ }). For example, some common escape sequences are shown below:

Escape sequence type	Format	Example
date	{d 'value'}	{d '2001-01-01'}
scalar function	{fn scalar-function}	{ fn DAYOFWEEK(DATE '2000-01-01') }
procedure call	{[?=]call procedure-name[([parameter][,[parameter]]...)]}	{?=call LENGTH ('hello world')}

For information about the complete set of ODBC escape sequences, see "*ODBC Escape Sequences*" in the ODBC Programmer's Reference: https://msdn.microsoft.com/en-us/library/ms711838(v=vs.85).aspx. For information about JDBC escape sequences, see http://docs.oracle.com/cd/E13222_01/wls/docs91/jdbc_drivers/sqlescape.html.

Note:

The Simba SDK handles all escape sequences in the ODBC and JDBC specification.

Converting Simple Escape Sequences

Connectors must locate escape sequences and convert them to commands that are understood by their data source.

Simple Example: Dates

Consider a SQL command that contains an escape sequence of type date:

```
SELECT OrderNum, OrderDate FROM Orders WHERE OrderDate = {d '2015-08-12'}
```

A PostgreSQL connector converts the command as:

```
SELECT OrderNum, OrderDate FROM Orders WHERE OrderDate = DATE
'2015-08-12'.
```

A Microsoft SQL connector converts the command as:

```
SELECT OrderNum, OrderDate FROM Orders WHERE OrderDate ='08-
12-2015'.
```

Converting Complex Escape Sequences

Escape sequences can be nested, requiring recursive programming to replace them correctly.

Complex Example: Nested Escape Sequences

Given an escape sequence with the following format:

```
{fn EXTRACT( YEAR FROM {ts '2001-02-03 16:17:18.987654'} ) }
```

A PostgreSQL connector converts the command as:

```
EXTRACT(YEAR FROM TIMESTAMP '2001-02-03 16:17:18.987654')
```

Non-Escaped Scalar Functions

Some applications use ODBC scalar functions in a SQL command without enclosing the function in an escape clause. For example, an application might use `CONVERT (sqltype,value)` instead of `{fn CONVERT(value, odbctype)}`. The miniParser handles the CONVERT scalar function in non-escaped form. Currently, other non-escaped scalar functions are not handled.

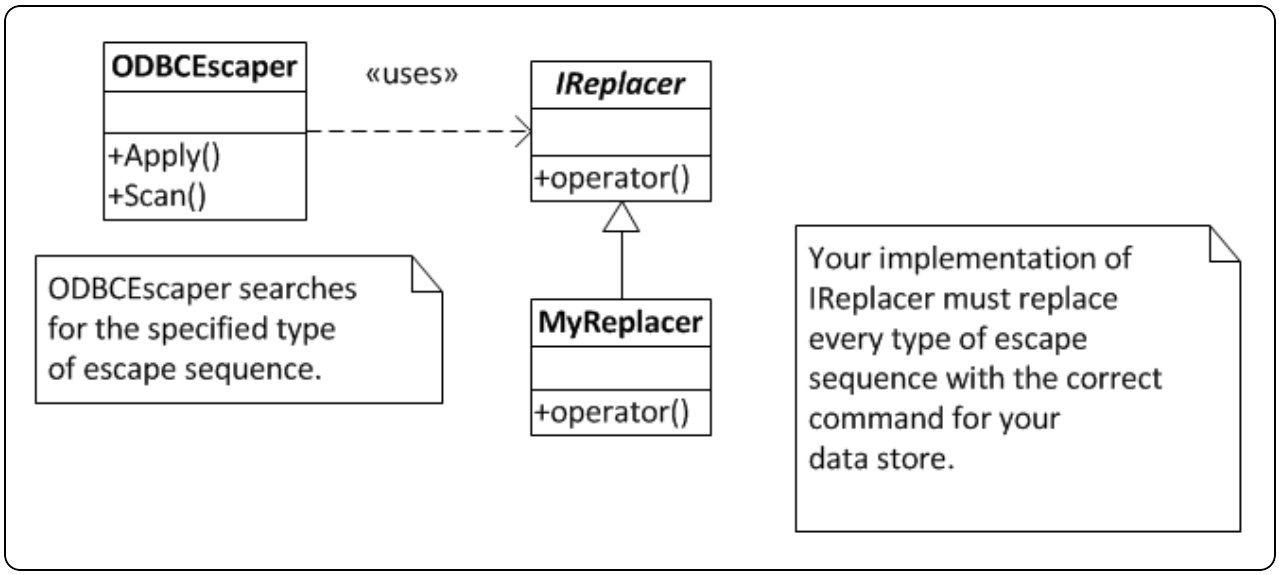
MiniParser Architecture

The miniParser is included in the `Support` package of the Simba SDK. It is composed of two main classes:

ODBC Architecture:

- **`ODBCEscaper`**: searches the SQL command for ODBC escape sequences and parameters. To use this class, pass an `IReplacer` implementation and the SQL command to `ODBCEscaper.Apply()`.
- **`IReplacer`**: converts each type of escape sequence to the format required for a particular data store. Override this class to provide your own implementation.

This architecture is shown in the figure below:



JDBC Architecture:

- **`JDBCEscaper`**: searches the SQL command for JDBC escape sequences and parameters. To use this class, pass an `IReplacer` implementation and the SQL command to `JDBCEscaper.Apply()`.
- **`IReplacer`**: converts each type of escape sequence to the format required for a particular data store. Override this class to provide your own implementation.

Error Handling

This section explains how `ODBCEscaper` handles errors and malformed SQL statements.

Text in unsupported locations is discarded

If a SQL statement is incorrectly formed and contains text in unsupported locations, `ODBCEscaper` will discard the text. For example, the escape sequence `{fn ABS (myNum) bad string}` is incorrectly formed, as no text is allowed after the function name. In this case, `ODBCEscaper` will discard the text `bad string`.

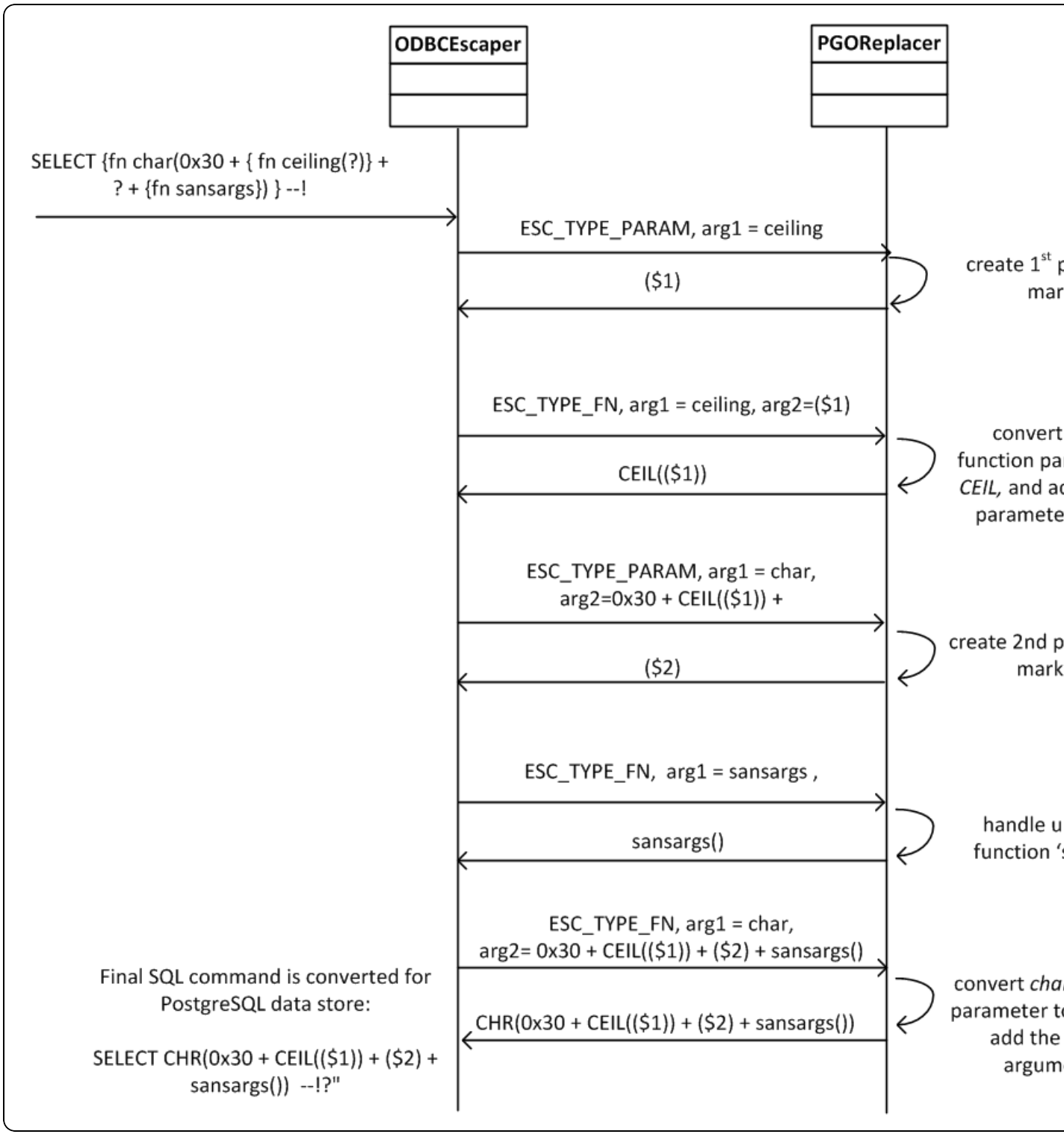
Incorrectly formatted escape sequences are not sent to IReplacer

If an escape sequence is incorrectly formatted, `ODBCEscaper` will not pass it through to `IReplacer`, and will leave it unchanged. For example, `{D 2001-1-1}` is incorrectly formatted because it does not contain quotation marks (`''`). The incorrect escape sequence is simply included in the final SQL command. This allows the data store to handle the incorrect command sequence with the appropriate error.

Example Workflow

The following diagram shows how the `ODBCEscaper` and a sample `IReplacer` implementation, `PGOReplacer`, work together to convert a SQL statement containing parameters and escape sequences into a SQL statement for a PostgreSQL data store.

> **Note:**
>
> The work flow is the same for JDBCEscaper.



1. The connector calls `ODBCEscaper.Apply()`, passing in the SQL command `SELECT {fn char(0x30 + { fn ceiling(?)} + ? + {fn`

`sansargs}) } --!?`. This command contains nested functions, a custom (non-ODBC) function, and a comment string.

2. `ODBCEscaper` starts with the inner most escape sequence, `{fn ceiling (?)}`. First, it tells `PGOReplacer` to create the parameter marker.
3. `PGOReplacer` creates and returns the first parameter marker in the format that the PostgreSQL data store understands.
4. `ODBCEscaper` then tells `PGOReplacer` to handle `{fn ceiling(?)}`, passing in the first converted parameter, `($1)`.
5. `PGOReplacer` converts the ceiling function to CEIL as required by the PostgreSQL data store, and uses the parameter marker `($1)` in the function.
6. This process repeats until `IReplacer` converts all the escape sequences and parameter markers. Then `ODBCEscaper` reassembles the SQL command, including the comment and the string.

The original SQL command is now converted into a SQL command that PostgreSQL data store can understand.

Example Implementation

This section shows an example implementation of `IReplacer` for a custom ODBC or JDBC connector. The following steps are required:

- Step 1: Implement Your Custom IReplacer
- Step 2: Create an Instance of ODBCEscaper
- Step 3: Ensure Additional Requirements are Met

Step 1: Implement Your Custom IReplacer

Implement your `IReplacer` to convert ODBC standard escape sequences to the commands that your data store understands.

Note:

- For Java, use `JDBCEscaper` instead of `ODBCEscaper`. All other methods and techniques shown in this section are the same.
- In this example, `IReplacer` handles a subset of the possible ODBC escape sequences. Typically, your custom ODBC connector implements the complete set of ODBC escape sequences described in https://docs.microsoft.com/en-us/sql/odbc/reference/appendixes/odbc-escape-sequences.

Example

```
#include <Simba.h>
#include <ODBCEscaper.h>
static char const* keyword[] = {
     "DATE ", "ESCAPE ", "TIME "
};
class MyReplacer : public IReplacer
{

    MyReplacer()
    {
         m_numParams = 0;
    }
    simba_wstring operator()(ODBCEscaper::ESC_TYPE in_
    etype, std::vector<simba_wstring>& args)
    {

        switch (in_etype)
        {
        // Date, Time, and Timestamp Escape Sequences
        case ODBCEscaper::ESC_TYPE_DATE:
        case ODBCEscaper::ESC_TYPE_ESCAPE:
        case ODBCEscaper::ESC_TYPE_TIME:
        {
             return simba_wstring(keyword[in_etype -
        ODBCEscaper::ESC_TYPE_DATE]) + args[0];
        }
        break;
        // Here replace ? with ($1)....
        case ODBCEscaper::ESC_TYPE_PARAM:
        {

            char buf[99];
            sprintf(buf, "($%d)", ++m_
            numParams);
            // implicit conversion to simba_
            wstring
            return buf;

        }
        break;
```

```
        //Scalar Functions Escape sequences.
        case ODBCEscaper::ESC_TYPE_FN:
        {

            if (args[0].IsEqual("CEILING",
            false))
            {
            args[0] = "CEIL";
            }
            else if (args[0].IsEqual("CHAR",
            false))
            {
            args[0] = "CHR";
            }
            else if (args[0].IsEqual("POWER",
            false))
            {
            args[0] = "POW";
            }
            if ((args[0].IsEqual("CONVERT",
            false)) && (3 == args.size()))
            {
            args[0] = "CAST";
            }
            return args[0] + "(" + simba_
            wstring::Join(args.begin() + 1,
            args.end(), ", ") + ")";

        }
        break;
        // Handling the non-escaped scalar functions:
        Note different argument order.
        case ODBCEscaper::ESC_TYPE_FUNC:
        {

            if ((args[0].IsEqual("CONVERT",
            false)) && (3 == args.size()))
            {
```

```
                return "CAST_RAW(" + args[2] +
            " AS " + args[1] + ")";
                }
            }
            break;
            // unimplemented Escape Types.
            default:
            {
                return simba_wstring("TODO: ")
            + ODBCEscaper::type_name[in_etype];

        }
        break;
        }

    }

}
private:
     int m_numParams;
};
```

Step 2: Create an Instance of ODBCEscaper

`ODBCEscaper` or `JDBCEscaper` handles the parsing of the SQL command, identifying parameter markers and escape sequences while passing over the contents of strings, identifiers and comments. It passes each parameter marker and escape sequence to `IReplacer`, along with the type and argument information. `IReplacer` returns the converted command.

Parsing is done from left to right, and in the case of nested escape sequences, from the inner to the outer brackets. When the parsing and replacements are finished, `ODBCEscaper` or and `JDBCEscaper` reassemble the SQL command, adding back any strings or comments.

Create an instance of `ODBCEscaper`, then call `ODBCEscaper.Apply()`, passing a instance of your custom `IReplacer` and the SQL command to parse and convert. Because `IReplacer` maintains state for the duration of a SQL command, you must create a new `IReplacer` for each SQL command that you want to parse.

Example:

```
ODBCEscaper esc;
MyReplacer replacer;
simba_wstring newSQLstr;
```

```
// newSQLstr will contain the converted SQL command
simba_wstring newSQLstr = esc.Apply(replacer, "SELECT {fn LOG
( {fn LOG10({fn POWER(10,2)})})}");
```

Step 3: Ensure Additional Requirements are Met

This section contains additional information and requirements for implementing your `IReplacer`.

Return commands that are not ODBC or JDBC compliant

If `IReplacer` encounters a command escape sequence that is not part of the ODBC or JDBC specification, it should return the command back to `ODBCReplacer` without modification. This is illustrated in the "Workflow" section in Parsing ODBC and JDBC Escape Sequences, as the parameter `sansargs` is not ODBC compliant.

Maintain a parameter count

Your `IReplacer` implementation must keep track of the number of parameter markers it returns so that it can increment them correctly. For example, “@1”, “@2”, “@3”, or ($1), ($2), ($3).

Reject unknown input

If your `IReplacer` implementation receives input that it does not know how to handle, it must throw an exception or return the string in curly brackets (`{ }`).

Important:

For security reasons, an `IReplacer` must never return a string that forces a syntax error.

Return an expression in parenthesis or surrounded by spaces

Where possible, the commands or expressions that your `IReplacer` returns should be surrounded by parentheses (`()`) or spaces ( ). This allows the ODBCEscaper to correctly reassemble the SQL command. The `IReplacer` sample surrounds the commands and parameters with parentheses. For example, when returning the value `['4:05'::TIME]`, format the value in one of the following ways:

- `[ '4:05'::TIME ]` // notice the spaces
- Or, `[('4:05'::TIME)]` // notice the parenthesis

Ensure correct syntax

In order for `ODBCReplacer` to correctly parse and reassemble the SQL statement, the `IReplacer` implementation must always return parameters and converted escape sequences that contain correct syntax.

Important:

`IReplacer` must not return an odd number of quotes, an unterminated comment, or mismatched parentheses.

Related Topics

Non-Escaped Scalar Functions

Error Handling

Native Syntax Queries

When using the Simba SQLEngine with a datasource that is SQL enabled or supports another query language, the NATIVE ODBC escape sequence can be used to embed a query the datasource in its native syntax language.

For example:

```
{NATIVE 'SELECT Column1 FROM NativeTable' COLUMNS(Col1
VARCHAR(25))}
```

To add this functionality to your ODBC driver, make the following changes:

Note:

Corresponding class and function names from the SQLite sample driver are noted in square brackets.

1. Modify your `CustomerDSIIDataEngine [SLDataEngine]` object to override and implement the virtual method `CreateNativeResultSet()` to return a `CustomerDSIINativeResultSet [SLNativeResultSet]`. This method is responsible for preparation of the native result, but not execution.
2. Implement the virtual methods of your `CustomerDSIINativeResultSet`:

a. `Execute`: This is responsible for actual execution of the native query and producing a `DSIExtResultSet`. Input parameters, if any, are passed to this function.

b. `UpdateColumnMetadata`: This is responsible for reporting changes to any column metadata when the actual result columns of the native result are different than the COLUMNS clause of the query. In the simple example above, if `NativeTable.Column1` is actually a SQL_INTEGER, that can be described here so that the Simba SQLEngine can perform the necessary conversion.

c. `UpdateParameterMetadata`: This is responsible for making changes to any parameter metadata when the actual parameters of the native result are different than the PASSING clause of the query.

d. `GetBookmarkSize`: Return the bookmark size that will be used by the `DSIExtResultSet` returned by execution.

e. `GetColumns` (Optional): This is responsible for reporting all the column metadata if the COLUMNS clause of the query is empty.

Native Value Expressions

When using the Simba SQLEngine with a datasource that is SQL enabled or supports another query language, the NATIVE ODBC escape sequence can also be used to embed a query to the datasource in its native syntax language as a scalar value in a SQL query. Native queries used for this must produce only a single row with a single column.

For example:

```
SELECT {NATIVE 'SELECT Column1 FROM NativeTable LIMIT 1'
RETURNING VARCHAR(25) } AS NativeCol1, Col2 FROM
NonNativeTable
```

To add this functionality to your ODBC driver, make the following changes:

Note:

Corresponding class and function names from the SQLite sample driver are noted in square brackets.

1. Modify your `CustomerDSIIDataEngine [SLDataEngine]` object to override and implement the virtual method `CreateNativeValueExpression ()` to return a `CustomerDSIINativeValueExpression [SLNativeValueExpression]`. This method is responsible for preparation of the native value, but not execution.
2. Implement the virtual methods of your `CustomerDSIINativeValueExpression`:
   a. `Execute`:This is responsible for actual execution of the native query and producing a `INativeValuePtr`. This will be a new class implemented in step 3 below. Input parameters, if any, are passed to this function.
   b. `UpdateReturningMetadata`: This is responsible for reporting changes to any metadata of the returned value when the actual result of the native result is different than the RETURNING clause of the query. In the simple example above, if `NativeTable.Column1` is actually a SQL_INTEGER, that can be described here so that the Simba SQLEngine can perform the necessary conversion.
   c. `UpdateParameterMetadata`: This is responsible for making changes to any parameter metadata when the actual parameters of the native result are different than the PASSING clause of the query.
3. Implement an `INativeValuePtr` as `CustomerDSIINativeValue [SLNativeValue]`. Only one method needs to be implemented on this class: `RetrieveData`. This will retrieve a value for the native expression into the `ETDataRequest` object.

Errors, Exceptions, and Warnings

This section explains how to implement the classes that handle errors, exceptions, and warnings. It also explain how to use and localize the files that contain error messages. Error message files are available in several different languages.

Handling Errors and Exceptions

ODBC, JDBC, and ADO.NET require that connector provide standard error codes so that applications have a standard way of dealing with error conditions. Data stores can also provide their own custom error codes. This section explains what your custom connector should do when it encounters an error or an exception.

Using the ErrorException Class

When your DSII detects an error condition, it should throw an exception of type `ErrorException`. This class has the following signature:
`ErrorException(`

DiagState in_stateKey,

simba_int32 in_componentId,

const simba_wstring& in_msgKey,

simba_signed_native in_rowNum = NO_ROW_NUMBER,

simba_int32 in_colNum = NO_COLUMN_NUMBER);

The parameters for this method are described below:

- **in_componentId**

  The component id is used to determine which component threw the exception and where the message should be loaded from. The list of reserved component Ids (1-10) and their names can be found in `SimbaErrorCodes.h`. It is suggested that any custom component Id you define for your DSII start counting from 100.
- **in_msgKey**

  The `in_msgKey` argument is a string shortcut to indicate which message to load from the standard error message file or your own custom message source. For information about error message files, see Localizing Messages.

- **in_stateKey**

  The in_stateKey argument is used to control which SQLSTATE code should be associated with the error returned by ODBC. SQLSTATE is a 5-character sequence defined by SQL standards that is used to return a standard error code. The most common state to throw is DIAG_GENERAL_ERROR. A full list of available DiagState keys can be found in `DiagState.h`.

Exception Macros in the Sample Connectors

The Quickstart sample connector provides sample macros that you can adapt to throw your own exceptions. These macros are defined in `Quickstart.h`. For information on using Quickstart, see the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

Example: Using Quickstart's Exception Macro

In the sample Quickstart connector, the following macro is used to throw an exception if the required DBF setting is missing:

```
QSTHROW(DIAG_INVALID_AUTH_SPEC, L"QSDbfNotFound");
```

This throws an `ErrorException` with a `DiagState` of DIAG_INVALID_AUTH_SPEC and the `QSDbfNotFound` message key. The macro automatically includes the Quickstart component Id.

Some messages are also parameterized, and there are sample macros to assist in constructing the vector of parameters before throwing the exception.

Example: Throwing an Exception With Parameters

This example throws an `ErrorException` with a DiagState of DIAG_GENERAL_ERROR and the `QSInvalidCatalog` message key.

```
QSTHROWGEN1(L"QSInvalidCatalog", in_schemaName);
```

`in_schemaName` is a `simba_wstring` parameter that is added to a vector and passed to a constructor for `ErrorException`, which accepts a parameter vector. The message source will use the parameter vector to do string substitution on special markers in the message string.

Using or Building a Message Source

All exceptions and warnings in your custom connector are looked up by their message key using an `IMessageSource` constructed by your custom connector. An implementation of this class, called `DSIMessageSource`, is provided to handle looking up any message key generated by SDK components. This class looks up the messages in the error messages files. The error message files are located in the

directory `[INSTALL_DIRECTORY]\DataAccessComponents\ErrorMessages`. The connector determines the location of this file by looking up the `ErrorMessagesPath` value in the registry at **HKLM\Software\<OEM NAME>\Driver**, or inside the configuration file on Linux, Unix, or macOS platforms.

In order to provide messages of your own, you must register an error messages file with `DSIMessageSource` or construct your own `MyDSIIMessageSource` class deriving from `IMessageSource`. If you use `DSIMessageSource`, you will only be responsible for providing an XML message file for all of the messages your DSII uses. If you derive from `IMessageSource`, you will be responsible for looking up any message key generated by either the SDK or your DSII.

All of the sample connectors register an additional message file with the default `DSIMessageSource`, and it is recommended that your DSII do the same unless there is good reason to do otherwise. The error messages XML files are placed in directories named after the locale that the message files are associated with, for example, `[INSTALL_DIRECTORY]\DataAccessComponents\ErrorMessages\en-US`.

For information about error message files, see Including Error Message Files.

Custom SQL States

SQLSTATE is a 5-character sequence defined by SQL standards. It provides detailed information about the cause of a warning or error. The Simba SDK attempts to return SQL states, or equivalent, that accurately follow the specifications of ODBC, JDBC, and ADO.NET. However, in some cases your custom connector may need to return a different SQL state than what is used by the SDK. In those cases, your DSII will return a custom SQL state as described in the this section:

ODBC

Exceptions are implemented in the `ErrorException` base class. The predefined SQL states are mapped to `DiagStates`, and there are constructors that take a `DiagState` along with other information for this purpose. When using custom SQL states, use the constructors that take a `simba_string` for the SQL state to provide any 5 character SQL state.

Likewise, warnings with custom SQL states will post warnings to the `IWarningListener` using the `simba_string` constructor instead of the `DiagState` constructor.

JDBC

Exceptions are implemented in the `DSIException` base class. The predefined SQL states are mapped to `ExceptionID`, and there are constructors that take an `ExceptionID` along with other information for this purpose. When using custom SQL

states, use the constructors that take a `String` for the SQL state to provide any 5 character SQL state.

Likewise, warnings with custom SQL states will post warnings to the `IWarningListener` using a `Warning` constructed with the `String` constructor instead of the `WarningCode` constructor.

ADO.NET

Exceptions are implemented in the `DSIException` base class. Note that SQL states are not directly supported by the ADO.NET API. Instead, the custom SQL state is prepended to the exception error message. The predefined SQL states are mapped to `ErrorCode`, and there are constructors that take an `ErrorCode` along with other information for this purpose. When using custom SQL states, use the constructors that take a string for the SQL state to provide any 5 character SQL state.

Likewise, warnings with custom SQL states will post warnings to the `IWarningListener` using the string constructor instead of the `WarningCode` constructor.

OLE DB

SQL states, custom or not, are exposed using the custom error object through the `ISqlErrorInfo` interface. For details on the `ISqlErrorInfo` interface, see http://msdn.microsoft.com/en-us/library/windows/desktop/ms711569%28v=vs.85%29.aspx. Also, refer to the topic *How a Provider Returns an OLE DB Error Object in MSDN* at http://msdn.microsoft.com/en-us/library/windows/desktop/ms723101%28v=vs.85%29.aspx.

Related Topics

Posting Warning Messages

Including Error Message Files

Localizing Messages

Posting Warning Messages

The Simba SDK supports warning messages in a similar way as it supports error messages.

Using the IWarningListener interface

You can post warnings to an `IWarningListener` interface. The `DataStoreInterface` core classes, `DSIEnvironment`, `DSIConnection` and

`DSIStatement`, each have an associated `IWarningListener`. Your custom implementation of these classes can access an `IWarningListener` through the parent `GetWarningListener()` method.

For the complete list of warnings that can be posted to an `IWarningListener`, see the file `DataAccessComponents\Include\Support\DiagState.h` in your Simba SDK installation directory.

Similar to `ErrorException`, `IWarningListener` uses the error messages files associated with the `DSIMessageSource` to retrieve the warning messages corresponding to the error or warning code. For more information on this functionality, see Including Error Message Files.

Subscribing to an IWarningListener

The SDK controls most of the classes that warning listeners can be registered with. This means you don't have to explicitly register them in your custom connector code. The one exception is the `ConnectionSetting` object - you must register the warning listener with this class after construction. See the example in Handling Connections.

Posting Warnings to an IWarningListener

Use `GetWarningListener()->PostWarning()` to post a warning to the warning listener.

Example: ConnectionSetting object Posting Warnings to an IWarningListener

```
// In CustomerDSIIEnvironment, CustomerDSIIConnection and
// CustomerDSIIStatement, use the parent GetWarningListener()
// function to retrieve the IWarningListener
this->GetWarningListener()->PostWarning(
```

Diagnostics::OPT_VAL_CHANGED,

ComponentKey,

L”WarningMessageKey”);

Related Topics

Posting Warning Messages

Including Error Message Files

Localizing Messages

Including Error Message Files

This section describes the error message files used by the SDK for ODBC and JDBC connectors.

Error Messages in ODBC

The ODBC error messages are defined in `.xml` files. The table below describes each file, and explains which error message files must be included when you distribute your connector.

Error Message File Name	Description	Do I Need to Ship this File?
`ODBCMessages.xml`	Contains the error messages for the ODBC, DSI, and Support components.	Yes, always with your connector. If you distribute SimbaClient for ODBC, you will also need to include this file.
`SQLEngineMessages.xml`	Contains the error messages for the Simba SDK components.	Only if your connector uses Simba SDK.
`ClientMessages.xml`	Contains the error messages for SimbaClient for ODBC.	Only if you are distributing SimbaClient for ODBC.
`CSCommonMessages.xml`	Contains the error messages for the Client/Server protocol components.	Only if you have built your connector as a server. If you distribute SimbaClient for ODBC, you will also need to include this file.

Error Message File Name	Description	Do I Need to Ship this File?
`ServerMessages.xml`	Contains the error messages for SimbaServer.	Only if you have built your connector as a server.
`CLIDSIMessages.xml`	Contains the error messages for the CLIDSI component.	Only if your connector uses the CLIDSI component.
`JNIDSIMessages.xml`	Contains the error messages for the JNIDSI component.	Only if your connector uses the JNIDSI component.

Organizing your ODBC Error Message Files

By default the SDK uses the English - United States (en-US) locale. You can add support for additional locales by organizing your additional language files in one of the following ways:

Subdirectory organization

You can store each locale's message files in a subdirectory, where the subdirectory is named using the locale code.

Example: Subdirectory organization of message files

```
...\ErrorMessages\en-US\ODBCMessages.xml
...\ErrorMessages\fr-CA\ODBCMessages.xml
...\ErrorMessages\ja-JA\ODBCMessages.xml
```

Single directory organization

You can store all message files for every locale in a single folder. The name of each locale is added as a suffix in the file names.

Example: Single directory organization of message files

```
...\ErrorMessages\ODBCMessages_en-US.xml
...\ErrorMessages\fr-CA\ODBCMessages_fr-CA.xml
...\ErrorMessages\ja-JA\ODBCMessages_ja.xml
```

Error Messages in JDBC

The JDBC error messages are divided into several files. The table below describes each file, and explains which error message files must be included when you distribute

your connector.

Error Message File Name	Description	Do I Need to Ship this File?
`JDBCMessages.properties`	Contains the error messages for the JDBC component.	Yes, always with your connector. If you distribute SimbaClient for JDBC, you will also need to include this file.
`DSIMessages.properties`	Contains the error messages for the DSI and Support components.	Yes, always with your connector. If you distribute SimbaClient for JDBC, you will also need to include this file.

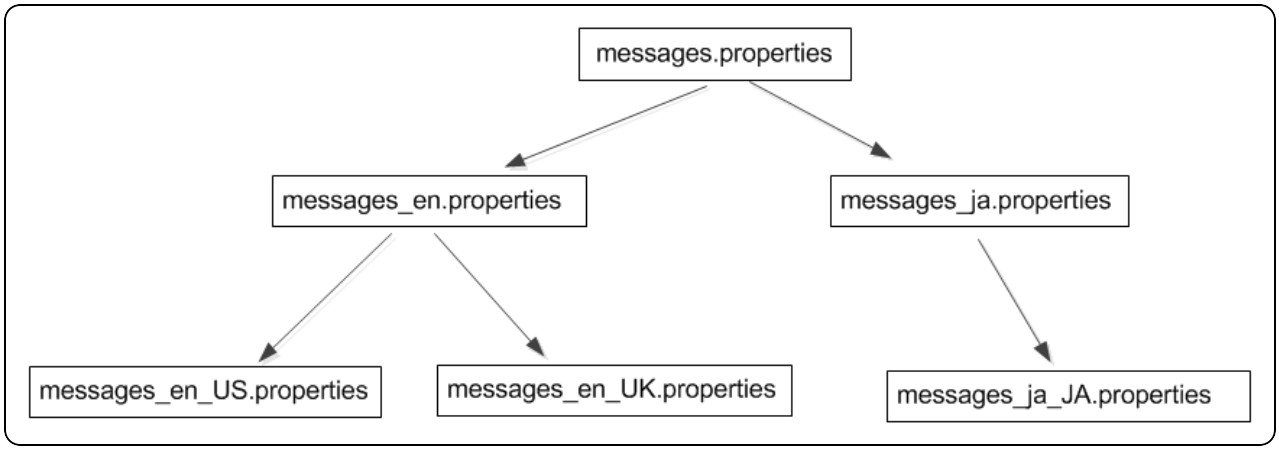
`CSMessages.properties`
`CommunicationsMessages.properties`
`Messages.properties`
	Contains the error messages for SimbaClient for JDBC and the Client/Server protocol components.	Only if you are distributing SimbaClient for JDBC.

Organizing your JDBC Error Message Files

By default, the SDK uses the English - United States (en-US) locale. You can add support for additional locales using Java Resource Bundles.

The common convention for localization with resource bundles is to organize the error message files in a hierarchy. This ensures that messages from a parent message file will be used, even if a locale is not supported.

For example, the structure for message files could be organized in the following hierarchy. In this example, is the base file name is *messages*:



Note:

Each message file must be registered separately with `DSIMessageSource`.

Related Topics

Handling Errors and Exceptions

Posting Warning Messages

Localizing Messages

Localizing Messages

Simba SDK includes sample string resources for the warning and error messages that it may generate. These strings are provide in English, as well as other languages including German, French, Spanish, and Japanese. These files are intended as a starting point to aid you in the localization process. You can modify the localized strings that are provided, provide your own connector-specific messages, and add support for additional languages.

Note:

The files provided for languages other than English are not complete. Some of these strings are still in English and require further translation.

Customers can configure the locale, or language, of the messages that the connector uses. Configuration can be done connector-wide so that all connections use the same locale for their messages, or per-connection so each connection uses a different locale.

Configuring the Connector Locale

Customers can configure the locale of connector for all connections (connector-wide locale) or for individual connections. If the locale is not configured, the default locale of US English (en-US) is used for all messages.

Configuring the Connector-Wide Locale

A single locale is specified for the connector, and all connections use the same language for any messages.

To configure the connector-wide locale on Windows:

1. In the Windows registry, navigate to the following registry key:
   - For 32-bit connectors on 32-bit machines or 64-bit connectors on 64-bit machines, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE*<Company>**<ConnectorName>*\Driver**, where *<Company>* is your company name and *<ConnectorName>* is the name of your connector.
     For example, for the Simba Quickstart connector, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\Simba\Quickstart\Driver**.
   - Or, for 32-bit connectors on 64-bit machines, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node*<Company>**<ConnectorName>*\Driver**, where *<Company>* is your company name and *<ConnectorName>* is the name of your connector.
     For example, for the Simba Quickstart connector, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE/Wow6432Node\Simba\Quickstart\Driver**.
2. In the **<Customer>/<ConnectorName>/Driver** section of the registry, add or modify the **DriverLocale** key to contain the desired locale code. For a list of locale codes, see Locale Codes.

To configure the connector-wide locale on Unix, Linux, and macOS:

1. Locate the `.ini` configuration file for the desired connector.
2. Modify the `DriverLocale` string to contain the desired locale code. For a list of locale codes, see Locale Codes.

Configuring Per-Connection Locale

A locale is configured for each connection, so each connection can use a different language for error messages. If the locale is not configured for a connection, then the connector-wide locale is used.

To configure the connection-wide locale on Windows:

1. In the Windows registry, navigate to the to the registry key for the DSN that is used for the connection:
   - For 32-bit connectors on 32-bit machines or 64-bit connectors on 64-bit machines, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\ODBC\ODBC.INI*<Company>*DSII**, where *<Company>* is your company name.
     For example, for the Simba Quickstart connector, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\ODBC\ODBC.INI\QuickstartDSII**.
   - Or, for 32-bit connectors on 64-bit machines, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432\ODBC\ODBC.INI*<Company>*DSII**, where *<Company>* is your company name.
     For example, for the Simba Quickstart connector, navigate to **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432\ODBC\ODBC.INI\QuickstartDSII**.
2. Modify the **Locale** key to contain the desired locale code. For a list of locale codes, see Locale Codes.

To configure the connector-wide locale on Unix, Linux, and macOS:

1. Locate the `.ini` configuration file for the desired connector.
2. Modify the `Locale` string to contain the desired locale code. For a list of locale codes, see Locale Codes.

Locale Codes

Locales are specified using a two-letter language code in lower case and an optional two letter country code in upper case. If a country code is specified, it must be separated from the language code by a hyphen (-).

Examples:

- en-US (English – United States)
- fr-CA (French – Canada)
- it-IT (Italian – Italy)
- de-DE (German – Germany)
- es-ES (Spanish – Spain (Traditional))
- ja (Japanese)

The language code can be any language in the ISO 639-1 standard: http://www.loc.gov/standards/iso639-2/php/code_list.php. The country code can be any country in the ISO 3166-1 Alpha-2 standard: http://www.iso.org/iso/country_codes/iso-3166-1_decoding_table.htm.

Localizing Your Connector

The Simba SDK provides English strings for the error and warning messages that its components generate. These messages are contained XML files for ODBC and in a Java Resource Bundle for JDBC. When developing your own connector, you can create additional messages in English for any errors and warnings that are specific to your connector. To provide your connector-specific messages, create connector-specific XML files or Java a Resource Bundle containing your messages in the same format as the exiting Simba SDK message files. For information about error messages files, see Including Error Message Files.

`DSIMessageSource` automatically handles the loading and exposure of these messages to your connector. Your connector has to call `DSIMessageSource::RegisterMessages`, passing in the root name of the connector specific message file. The root name is the file name without an extension or locale code. For example, the root name for the QuickStart connector is `QSMessages`. A good place to call this method is in the constructor of the connector class that inherits from `DSIDriver`.

The connector can also implement its own message source by inheriting from `DSIMessageSource` and handling connector-specific messages, which may be in different format and location than those from the Simba SDK. For example, the messages may be stored in a database. The handling of SDK messages in this case can still be delegated to `DSIMessageSource`. Alternatively, `IMessageSource` can be implemented directly, but the implementation must handle both the connector specific messages and the Simba SDK messages. For more information on implementing error messages, see Using or Building a Message Source in Handling Errors and Exceptions.

To support a locale for which the Simba SDK provides a translation when using the default `DSIMessageSource` class, translate the messages in your connector-specific message file and follow the naming convention described in the following subsections. To support a locale for which the SDK does not provide a translation, translate both the connector-specific and Simba SDK message files.

Additional Language Support

In addition to the languages that are shipped with the Simba SDK, translated messages strings for other languages are also available. For more information on obtaining these strings, contact Simba Technologies Inc.

Related Topics

Localizing Messages

Posting Warning Messages

Including Error Message Files

Localizing Messages

Multithreading

The Simba SDK typically handles all processing in a single thread, using the same thread as the application uses to make the ODBC or JDBC request. However, multiple threads may be started in the following cases:

- If the application creates a new thread for each ODBC or JDBC connection, each request is processed on its own thread. Processing is handled concurrently.
- In a client/server deployment, multiple clients can send a request to the same Simba Server. SimbaServer handles each request on its own thread.

In addition, the Simba SDK provides support for multithreading that you can use in your custom ODBC or JDBC connector.

Using the Thread Class (C++ only)

The `Thread` class provides the implementation for a thread. There are different options for using this class in your custom connector:

- You can subclass the `Thread` class and implement the `DoExecute()` interface.
- Or, you can call `StartDetachedThread()`, passing in a pointer to a function that will be executed when the thread is started.

Note:

There is no overall difference in functionality between these methods.

Using the ThreadPool Class

The `ThreadPool` class starts and manages the running threads. It implements the pool of threads, and is responsible for creating new threads and assigning tasks to them.

To implement a multi-threaded environment using the ThreadPool class:

1. To make a runnable task, subclass `ITask` and implement the `Run()` method.
2. Call the `PostTask()` method to add runnable tasks to a queue of unprocessed tasks on the `ThreadPool` class.

Note:

The maximum number of threads is specified by `m_maxThreads`.

Asynchronous ODBC Support

The Simba SDK enables your custom ODBC connector to support asynchronous ODBC. ODBC 3.8 supports asynchronous execution of ODBC connection functions, while ODBC 3.52 only supports asynchronous execution of statement functions. For more information about asynchronous ODBC support, see http://msdn.microsoft.com/en-us/library/ms713563%28v=vs.85%29.aspx

Simba SDK 9.3 and later releases supports the polling method for this asynchronous functionality. However, this support varies by platform as listed below.

> **Note:**
>
> Executing functions asynchronously using the polling method involves calling the same function is repeatedly until the function no longer returns SQL_STILL_EXECUTING. When repeatedly calling the function in such a loop, it's recommended that the same parameters be passed each time and that their values remain unchanged. This will prevent any unexpected errors from occurring.

Windows 7 +

- SQLBROWSECONNECT
- SQLCOLATTRIBUTE
- SQLCOLUMNPRIVILEGES
- SQLCOLUMNS
- SQLCONNECT
- SQLDESCRIBECOL
- SQLDESCRIBEPARAM
- SQLDISCONNECT
- SQLDRIVERCONNECT
- SQLENDTRAN
- SQLEXECDIRECT
- SQLEXECUTE
- SQLFETCHSCROLL
- SQLFETCH
- SQLFOREIGNKEYS
- SQLGETDATA
- SQLGETTYPEINFO

- SQLMORERESULTS
- SQLNUMPARAMS
- SQLNUMRESULTCOLS
- SQLPARAMDATA
- SQLPREPARE
- SQLPRIMARYKEYS
- SQLPROCEDURECOLUMNS
- SQLPROCEDURES
- SQLPUTDATA
- SQLSETPOS
- SQLSPECIALCOLUMNS
- SQLSTATISTICS
- SQLTABLEPRIVILEGES
- SQLTABLES

Non-Windows including iODBC, UnixODBC, SimbaDM

- SQLCOLUMNPRIVILEGES
- SQLCOLUMNS
- SQLEXECDIRECT
- SQLEXECUTE
- SQLFETCHSCROLL
- SQLFETCH
- SQLFOREIGNKEYS
- SQLGETTYPEINFO
- SQLPRIMARYKEYS
- SQLPROCEDURECOLUMNS
- SQLPROCEDURES
- SQLSPECIALCOLUMNS
- SQLSTATISTICS
- SQLTABLEPRIVILEGES
- SQLTABLES

Note:

- Asynchronous functionality at the connection level is not supported on non-Windows platforms.

Critical Section Locks

A critical section is a section of code that accesses a shared resource, where this resource must not be accessed at the same time as another thread. For example, only one thread at a time should write to a log file. If multiple threads write to a log file at the same time, the resulting text in the file could be an unpredictable mix up of text from each thread.

It is important to implement critical section locks when using either the Java or the C++ SDKs. If you are using the Java SDK, you can use standard Java classes to handle locking. If you are using the C++ SDK, you can use the classes provided by the Simba SDK.

Critical Section Locks in the C++ SDK

A critical sections of code should be specific using a `CriticalSection` object. A `CriticalSectionLock` object can then be used to lock this critical section to prevent concurrent access by another thread.

Tip:

Your implementation of `GetDriverLog`, for example `CustomerDSIIDriver::GetDriverLog`, should use a `CriticalSectionLock`.

To use critical sections and critical section locks:

1. Include the following files:
   ```
   #include "CriticalSection.h"
   #include "CriticalSectionLock.h"
   ```
2. Define a `CriticalSection` member variable. For example:

   ```
   Simba::Support::CriticalSection m_criticalSection;
   ```
3. For functions that use shared resources, use a `CriticalSectionLock` to lock the critical section. Add the following line of code to the start of the function:

   ```
   CriticalSectionLock lock(&m_criticalSection);
   ```

The lock will be released once the function returns.

For more information on the `CriticalSection` and `CriticalSectionLock` classes, see the Simba SDK C++ API Reference.

Concurrency Support

Some ODBC functions can be run concurrently on statements that share the same connection, while other functions block.

For example, the ODBC catalog function `SQLTables` cannot be run concurrently. Suppose a thread is executing `SQLTables` on a statement, while another thread attempts to execute a function on another statement that shares the same connection. The second thread blocks until `SQLTables` on the first thread is finished.

This section explains the concurrency behaviour for the different ODBC functions, and explains how to change the behaviour from concurrent to blocking.

ODBC Functions that Support Concurrency

By default, the following ODBC functions support concurrency:

- `SQLPrepare`
- `SQLCloseCursor`
- `SQLFreeStmt`
- `SQLMoreResults`
- `SQLAllocHandle`
- `SQLFreeHandle`

These functions can be executed concurrently, even if the statements that are executing them share the same connection. For example, suppose a statement is executing a function on a connection. If you pass that connection handle to `SQLAllocHandle()`, the `SQLAllocHandle()` function is executed concurrently and does not block.

Similarly, suppose two statements, `Statement1` and `Statement2`, are using the same connection. `Statement1` is already executing. You can call `SQLFreeHandle()` on `Statement2` and it will not block.

Overriding the Default Behaviour

If you want these functions to block by default, you can change the default behaviour by setting a connector property.

To set ODBC functions to block:

- In your `IDriver` implementation, set the DSI_DRIVER_ALLOW_INCREASED_ODBC_STATEMENT_CONCURRENCY property to `false`:

```
SetProperty(DSI_DRIVER_ALLOW_INCREASED_ODBC_STATEMENT_
CONCURRENCY, AttributeData::MakeNewUInt32AttributeData
(DSI_AIOSC_FALSE));
```

ODBC Functions that Do Not Support Concurrency

The following ODBC functions do not support concurrency:

- `SQLExecute`
- `SQLExecDirect`
- All catalog functions.

API Overview

This section introduces the functionality and workflows of the C++ DSI API and the DSI API Extensions, which are the main APIs that you use to build a custom connector. The Java APIs are similar.

DSI API

The DSI API exposes the classes needed to build your own Data Store Interface Implementation using C++. The C# and Java versions of these classes, the DotNet DSI API and the Java DSI API, provide similar functionality as the C++ classes.

The DSI API functionality is grouped into Core classes and Data Engine classes.

Core classes

The Core classes provide all of the essential functionality to establish and manage the connection to your data source:

Class	Description
`IDriver`	`IDriver` is a singleton instance constructed when the connector is first loaded. Its primary responsibility is to construct `IEnvironment` objects and manage any connector-wide properties. An abstract base class `DSIDriver` is provided to assist in some of these responsibilities, including initializing defaults and managing properties.
`IEnvironment`	`IEnvironment` objects correspond to the ODBC environment (ENV) handles allocated by `SQLAllocHandle`. Their primary responsibility is to construct `IConnection` objects and manage any environment properties. An abstract base class `DSIEnvironment` is provided.

Class	Description
`IConnection`	`IConnection` objects correspond to the ODBC connection (DBC) handles allocated by `SQLAllocHandle`. Their primary responsibility is to handle user authentication, construct `IStatement`objects, and manage any connection properties. An abstract base class `DSIConnection` is provided.
`IStatement`	`IStatement` objects correspond to the ODBC statement (STMT) handles allocated by `SQLAllocHandle`. Their primary responsibility is to construct `IDataEngine` objects and manage any statement properties. An abstract base class `DSIStatement` is provided.
`IMessageSource`	`IMessageSource` is responsible for loading error messages and warnings from your connector. An abstract implementation `DSIMessageSource` is provided to load messages generated by the SDK. For more information, see "*Using or building a message source*" in Handling Errors and Exceptions.
`ILogger`	`ILogger` is responsible for storing or printing log messages from your connector. Each of the `IDriver`, `IEnvironment`, `IConnection`, and `IStatement` classes has a `GetLog()` method which must return the most appropriate logger for that object. You may share loggers between all the objects or construct a different logger for each. The `DSIFileLogger` class is fully implemented to store the log messages to a text file, but you may change the behaviour in any way by extending the `ILogger` interface directly or by subclassing the partially implemented `DSILogger`class.

Data Engine classes

The Data Engine classes are the subset used to perform the data access functions against your data store:

Class	Description
`IDataEngine`	`IDataEngine` is responsible for constructing an `IQueryExecutor` when preparing queries or constructing an `IResult` for catalog function metadata. An abstract base class `DSIDataEngine` is provided to assist in implementing filters for the catalog function metadata.
`IQueryExecutor`	`IQueryExecutor` is responsible for executing a query and generating `IResults` objects.
`IResults`	An `IResults` object represents a collection of one or more `IResult` objects. `DSIResults` provides a basic implementation for accessing and managing a collection of `IResult` objects.
`IResult`	`IResult` is responsible for retrieving column data and maintaining a cursor across result rows. At a minimum, the cursor should support movement in a forward-only direction. Abstract base classes `DSISimpleResultSet`and `DSISimpleRowCountResult` are provided to deal with some basic functionality.

DSI API Extensions

These API Extensions provide access to the SQL Engine through abstract or concrete implementation of the above data engine classes. The C# and Java versions of these classes, the DotNet DSI API Extensions and the Java DSI API Extensions, provide all the same functionality as the C++ classes.

Class	Description
`DSIExtSqlDataEngine`	`DSIExtSqlDataEngine` is an abstract class, which derives from `DSIDataEngine`. It is responsible for parsing and optimizing prepared SQL as well as opening tables from your data store.

Class	Description
`SqlDataEngine`	`SqlDataEngine` represents the Java Simba SQLEngine for use with JDBC connectors in the Java environment. It derives from `DSIDataEngine` and performs the same tasks as `DSIExtSqlDataEngine`.
`DSIExtQueryExecutor`	`DSIExtQueryExecutor` is constructed by the`DSIExtSqlDataEngine`and is responsible for executing the query.
`SqlQueryExecutor`	`SqlQueryExecutor` is the Java equivalent of `DSIExtQueryExecutor` for use with the Java Simba SQLEngine.
`DSIExtResultSet`	`DSIExtResultSet` and the `DSIExtSimpleResultSet` are abstract classes derived from `IResult`. They require several new virtual functions, not required by `IResult`, to be implemented so that the result may be used in the SQL Engine. Tables opened by `DSIExtSqlDataEngine` must be instances of `DSIExtResultSet`.
`DSIExtJResultSet`	`DSIExtJResultSet` is the Java equivalent of The `DSIExtResultSet` for use with the Java Simba SQLEngine.

Class	Description
`DSIExtMetadataHelper`	`DSIExtMetadataHelper` is an optional abstract class that may be constructed by the `DSIExtSqlDataEngine`. It is responsible for iterating through tables and stored procedures so the engine can generate catalog function metadata.
`IMetaDataHelper`	`IMetadataHelper` interface is the base definition for metadataelpers. Since there is no default implementation in Java (e.g. no `DSIExtMetadataHelper`), a Java-based DSII must implement `IMetadataHelper`.
`DSIExtOperationHandlerFactory`	`DSIExtOperationHandlerFactory` is an optional abstract class that may be constructed by the `DSIExtSqlDataEngine`. It is responsible for constructing pass-down operation handlers that can optimize queries by allowing certain operations to be performed by your data store.

Related Topics

Simba SDK C++ API Reference

Simba SDK Java API Reference

Building Blocks for a DSI Implementation

Lifecycle of DSI Objects

API Overview

This section introduces the functionality and workflows of the C++ DSI API and the DSI API Extensions, which are the main APIs that you use to build a custom connector. The Java APIs are similar.

DSI API

The DSI API exposes the classes needed to build your own Data Store Interface Implementation using C++. The C# and Java versions of these classes, the DotNet DSI API and the Java DSI API, provide similar functionality as the C++ classes.

The DSI API functionality is grouped into Core classes and Data Engine classes.

Core classes

The Core classes provide all of the essential functionality to establish and manage the connection to your data source:

Class	Description
`IDriver`	`IDriver` is a singleton instance constructed when the connector is first loaded. Its primary responsibility is to construct `IEnvironment` objects and manage any connector-wide properties. An abstract base class `DSIDriver` is provided to assist in some of these responsibilities, including initializing defaults and managing properties.
`IEnvironment`	`IEnvironment` objects correspond to the ODBC environment (ENV) handles allocated by `SQLAllocHandle`. Their primary responsibility is to construct `IConnection` objects and manage any environment properties. An abstract base class `DSIEnvironment` is provided.
`IConnection`	`IConnection` objects correspond to the ODBC connection (DBC) handles allocated by `SQLAllocHandle`. Their primary responsibility is to handle user authentication, construct `IStatement`objects, and manage any connection properties. An abstract base class `DSIConnection` is provided.

Class	Description
`IStatement`	`IStatement` objects correspond to the ODBC statement (STMT) handles allocated by `SQLAllocHandle`. Their primary responsibility is to construct `IDataEngine` objects and manage any statement properties. An abstract base class `DSIStatement` is provided.
`IMessageSource`	`IMessageSource` is responsible for loading error messages and warnings from your connector. An abstract implementation `DSIMessageSource` is provided to load messages generated by the SDK. For more information, see "*Using or building a message source*" in Handling Errors and Exceptions.
`ILogger`	`ILogger` is responsible for storing or printing log messages from your connector. Each of the `IDriver`, `IEnvironment`, `IConnection`, and `IStatement` classes has a `GetLog()` method which must return the most appropriate logger for that object. You may share loggers between all the objects or construct a different logger for each. The `DSIFileLogger` class is fully implemented to store the log messages to a text file, but you may change the behaviour in any way by extending the `ILogger` interface directly or by subclassing the partially implemented `DSILogger`class.

Data Engine classes

The Data Engine classes are the subset used to perform the data access functions against your data store:

Class	Description
`IDataEngine`	`IDataEngine` is responsible for constructing an `IQueryExecutor` when preparing queries or constructing an `IResult` for catalog function metadata. An abstract base class `DSIDataEngine` is provided to assist in implementing filters for the catalog function metadata.

Class	Description
`IQueryExecutor`	`IQueryExecutor` is responsible for executing a query and generating `IResults` objects.
`IResults`	An `IResults` object represents a collection of one or more `IResult` objects. `DSIResults` provides a basic implementation for accessing and managing a collection of `IResult` objects.
`IResult`	`IResult` is responsible for retrieving column data and maintaining a cursor across result rows. At a minimum, the cursor should support movement in a forward-only direction. Abstract base classes `DSISimpleResultSet`and `DSISimpleRowCountResult` are provided to deal with some basic functionality.

DSI API Extensions

These API Extensions provide access to the SQL Engine through abstract or concrete implementation of the above data engine classes. The C# and Java versions of these classes, the DotNet DSI API Extensions and the Java DSI API Extensions, provide all the same functionality as the C++ classes.

Class	Description
`DSIExtSqlDataEngine`	`DSIExtSqlDataEngine` is an abstract class, which derives from `DSIDataEngine`. It is responsible for parsing and optimizing prepared SQL as well as opening tables from your data store.
`SqlDataEngine`	`SqlDataEngine` represents the Java Simba SQLEngine for use with JDBC connectors in the Java environment. It derives from `DSIDataEngine` and performs the same tasks as `DSIExtSqlDataEngine`.

Class	Description
`DSIExtQueryExecutor`	`DSIExtQueryExecutor` is constructed by the`DSIExtSqlDataEngine`and is responsible for executing the query.
`SqlQueryExecutor`	`SqlQueryExecutor` is the Java equivalent of `DSIExtQueryExecutor` for use with the Java Simba SQLEngine.
`DSIExtResultSet`	`DSIExtResultSet` and the `DSIExtSimpleResultSet` are abstract classes derived from `IResult`. They require several new virtual functions, not required by `IResult`, to be implemented so that the result may be used in the SQL Engine. Tables opened by `DSIExtSqlDataEngine` must be instances of `DSIExtResultSet`.
`DSIExtJResultSet`	`DSIExtJResultSet` is the Java equivalent of The `DSIExtResultSet` for use with the Java Simba SQLEngine.
`DSIExtMetadataHelper`	`DSIExtMetadataHelper` is an optional abstract class that may be constructed by the `DSIExtSqlDataEngine`. It is responsible for iterating through tables and stored procedures so the engine can generate catalog function metadata.

Class	Description
`IMetaDataHelper`	`IMetadataHelper` interface is the base definition for metadataelpers. Since there is no default implementation in Java (e.g. no `DSIExtMetadataHelper`), a Java-based DSII must implement `IMetadataHelper`.
`DSIExtOperationHandlerFactory`	`DSIExtOperationHandlerFactory` is an optional abstract class that may be constructed by the `DSIExtSqlDataEngine`. It is responsible for constructing pass-down operation handlers that can optimize queries by allowing certain operations to be performed by your data store.

Related Topics

Simba SDK C++ API Reference

Simba SDK Java API Reference

Building Blocks for a DSI Implementation

Lifecycle of DSI Objects

Lifecycle of DSI Objects

The objects of the DSI API have a lifecycle that is modeled on, though not exactly the same as, the lifecycle of ODBC handles. This section explains the lifecycle in the C++ SDK for ODBC connectors.

The `IDriver` object is instantiated when the connector is loaded, and a single instance is alive until the connector is unloaded.

The `IDriver` object creates an `IEnvironment` when an application allocates environment handles. `IDriver` can create multiple `IEnvironment` objects. These are guaranteed to have been destroyed by the time the `IDriver` is destroyed.

`IEnvironment` create `IConnections`, which are guaranteed to have been destroyed by the time the parent `IEnvironment` has been destroyed.

`IConnections` can be created and freed when an application chooses, but are typically long-lived objects, with multiple actions occurring before being destroyed.

`IConnections` create `IStatements`, which are guaranteed to have been destroyed by the time the parent `IConnection` has been destroyed. `IStatements` can be short- or long-lived objects depending on the application. If the application re-uses statements, then they tend to be long-lived, while if the application does not re-use statements they tend to be short-lived.

`IStatements` create `IDataEngines`, which are guaranteed to have been destroyed by the time the parent `IStatement` has been destroyed.

`IDataEngines` create `IQueryExecutors`, which are guaranteed to have been destroyed by the time the parent `IDataEngine` has been destroyed. `IQueryExecutors` have a lifespan that matches the lifespan of a prepared and executed, or directly executed, query. A single `IQueryExecutor` is used for multiple executions of a prepared query.

Note:

If you are using the Simba SQLEngine, the IQueryExecutor is already implemented by the SQLEngine.

Any objects created by an `IQueryExecutor` are guaranteed to have been destroyed by the time the parent `IQueryExecutor` has been destroyed.

`IQueryExecutors` create `IResults`, which are destroyed by the `IQueryExecutors` that created them. As stated above, `IResults` are guaranteed to have been destroyed before the `IQueryExecutor`.

`IResult` objects are accessed through `IResults` objects. However, the timing of their creation and destruction is determined by a connector's implementation. The `DSIResults` implementation creates `IResult` objects during construction and destroys them during destruction. Note that an `IResult` object is not accessible after it has been destroyed by the parent `IResults`object.

Related Topics

API Overview

Working With the Java API

This section describes the features in the Simba SDK that are specific to the Java API.
JDBC Time and Timestamp with Timezone

JDBC exposes the time and timestamp types with timezone information, represented as a `Calendar` object. If your data store supports timezone information for these types, it can be accessed by the `TimeTz` and `TimestampTz` types, both for insertion and retrieval.

To supply timezone information when retrieving data, instead of using the normal `java.sql.Time` or `java.sql.Timestamp` types, use the supplied `com.simba.dataengine.utilities.TimeTz` or `com.simba.dataengine.utilities.TimestampTz` types. These types are essentially a pair of the datetime class, along with a `Calendar` that supplies the timezone information. The SDK will automatically perform the correct operations to interpret that data when it passes it to applications.

To use timezone information when inserting data, use the `getTimeTz()` and `getTimestampTz()` methods of the `DataWrapper` class to get the classes which hold both the datetime types and the `Calendar` holding the timezone information. If your data store does not support timezones for the datetime types, calling the normal `getTime()` and `getTimestamp()` methods will automatically convert the datetime types to the local timezone.

JDBC Updatable ResultSets

JDBC provides the functionality to modify result sets that are generated from statements. SimbaJDBC allows you to add this functionality to your JDBC connector, if your data source supports it, by making the following changes to your CustomerDSII:

1. Set the DSI_SUPPORTS_UPDATABLE_RESULT_SETS property in your `CustomerDSIIConnection` object to a combination of DSI_SUPPORTS_URS_INSERT, DSI_SUPPORTS_URS_DELETE, and DSI_SUPPORTS_URS_UPDATE, depending on the extent of the modifications you will support on your result set.
2. Override and implement the following virtual methods:
    a. `appendRow()` – Add a new empty row to the end of the result set.
    b. `deleteRow()` – Delete the row at the current cursor position.
    c. `writeData()` – Write data to the specified cell in the current row.
3. The following virtual methods from `IResultSet` should also be overridden and implemented. However, you may choose to return `false` if this information is not available:
    a. `rowDeleted()` – Determine if the current row has been deleted.
    b. `rowInserted()` – Determine if the current row has been inserted.
    c. `rowUpdated()` – Determine if the current row has been updated.

4. The following virtual methods from `IResultSet` may also optionally be overridden and implemented:
   a. `onStartRowUpdate()` - Called before writing data to update a row. This is not called after `appendRow` because it is implied that data will be written.
   b. `onFinishRowUpdate()` - Called after writing all updated or inserted data in a row.

Developing for different Versions of JDBC

Simba SDK includes implementations for building connectors that work with JDBC 4.0, 4.1, and 4.2. You can develop connectors for any of these versions of JDBC, or you can develop a 'hybrid' connector that works with multiple versions, instantiating the appropriate classes at runtime.

Interface Versions

This section lists the classes that have different versions in order to support the different versions of JDBC:

AbstractDataSource

- Use `JDBC4AbstractDataSource` for JDBC 4.0
- Use `JDBC41AbstractDataSource` for JDBC 4.1
- Use `JDBC42AbstractDataSource` for JDBC 4.2
- Use `HybridAbstractDataSource` for hybrid versions

AbstractDriver

- Use `JDBC4AbstractDriver` for JDBC 4.0
- Use `JDBC41AbstractDriver` for JDBC 4.1
- Use `JDBC42AbstractDriver` for JDBC 4.2
- Use `HybridAbstractDriver` for hybrid versions

ObjectFactory

- Use `JDBC4ObjectFactory` for JDBC 4.0
- Use `JDBC41ObjectFactory` for JDBC 4.1
- Use `JDBC42ObjectFactory` for JDBC 4.2
- Use `HybridJDBCObjectFactory` for hybrid versions

If you are upgrading the code for an existing connector developed using Simba SDK 9.1 or earlier, then you must rename and modify your implementations of `JDBCAbstractDataSource`, `JDBCAbstractDriver`, and `JDBCObjectFactory`

to implement the appropriate classes listed in the table above. If you are upgrading from Simba SDK 9.4, you may need to remove support for JDBC 3.0 if your implementation has support for it. If you are creating a new connector, then determine the appropriate classes to implement from the table above.

Internally, the Simba SDK includes JDBC version-specific implementations for the various JDBC classes such as `SConnection`, `SDatabaseMetadata`, etc. Examples of these include `S3Connection`, `S4Connection`, etc. Each version of the `AbstractFactory` will therefore return the appropriate subclasses for its target JDBC version (e.g. `JDBC4ObjectFactory`'s `creationConnection()` method will return an `S4Connection` object. In the case of a hybrid connector, its factory will determine which classes to create at runtime as described in the next section.

Determing and Recording the JDBC Version at Runtime

When developing a hybrid connector, the connector must determine which version of JDBC is running, and pass this information to the Simba SDK via the `HybridAbstractDataSource` and `HybridAbstractDriver` classes.

While there are a number of techniques for determining the JDBC version at runtime, JavaUltralight checks the value of the 'MODE' parameter in the connection string. For information on the Java Ultralight sample connector, see JavaUltralight Sample Connector. The following example shows a connection string that includes this MODE parameter:

```
jdbc:simba://User=odbc_user;Password=odbc_user_
password;MODE=JDBC4
```

If the MODE parameter does not exist, JavaUltraLight detects its absence and then assumes that JDBC 4.0 should be used.

JavaUltralight provides an example of determining the version using the connection string. Its `HybridUtilities` class contains a static method that looks for this parameter and, if found, returns the appropriate JDBC version enum:

```
public final class HybridUtilities
{
    public static JDBCVersion runningJDBCVersion(String
modeProperty)
    {
        if ((null != modeProperty) && (modeProperty.equals
("JDBC42")))
        {
           return JDBCVersion.JDBC42;
        }
```

```
        else if ((null != modeProperty) &&
(modeProperty.equals("JDBC41")))
        {
           return JDBCVersion.JDBC41;
        }
        else
        {
        return JDBCVersion.JDBC4;
        }
    }
}
```

Once the JDBCVersion enum version is determined, it must then be passed to the Simba SDK by implementing the `runningJDBCVersion()` methods when subclassesing `HybridAbstractDriver` and `HybridDataSource`.

The following example shows how JavaUltralight's `ULJDBCHybridDriver` and `ULJDBCHybridDataSource` classes use the static `HybridUtilities::runningJDBCVersion()` method, described above, to pass this information to the Simba SDK:

```
public class ULJDBCHybridDriver extends HybridAbstractDriver
{

    private String m_mode = null;
    protected Pair<IConnection, ConnSettingRequestMap>
    getConnection( Properties info) throws SQLException
    {

        Pair<IConnection, ConnSettingRequestMap>
        result = super.getConnection(info);
        ConnSettingRequestMap connectionProperties =
        result.value();
        if ((null != connectionProperties) && (null
        != connectionProperties.getProperty
        (ULPropertyKey.MODE)))
        {
             m_mode =
        connectionProperties.getProperty(
        ULPropertyKey.MODE).getString();
        }
```

```
        return result;

    }
    protected JDBCVersion runningJDBCVersion()

        {

            return
            HybridUtilities.runningJDBCVersion
            (m_mode);

        }

    }
    public class ULJDBCHybridDataSource extends
    HybridAbstractDataSource
    {

        protected JDBCVersion runningJDBCVersion()

    {

        return HybridUtilities.runningJDBCVersion
        (getCustomProperty( ULPropertyKey.MODE));

    }

}
```

Connector Auto-Loading

To allow for the auto-loading of a JDBC 4.0, JDBC 4.1, JDBC 4.2, or hybrid connector, you must have the file `META-INF/services/java.sql.Driver` containing the connector class to load in this .jar.

To create the file using Ant, add the following `Service` tag to the .jar tag in the connector's `.xml` build file:

```
<service type="java.sql.Driver"
provider="your.driver.class.name"/>
```

For example, JavaUltralight's `JavaUltraLightBuilder.xml` build file specifies the following for JDBC 4.0 and hybrid builds respectively:

```
<service
type="java.sql.Driver" provider="com.simba.ultralight.core.jd
bc4.ULJDBC4Driver"/>
<target name="JavaUltraLightBuildDebug4"
   .
   .
   <jar jarfile="${jardest}/${JavaUltraLight4Jar}"
basedir="${dest}" includes="com/simba/**">
       <service type="java.sql.Driver"

provider="com.simba.ultralight.core.jdbc4.ULJDBC4Driver"/>
   </jar>
</target>
<target name="JavaUltraLightBuildDebugHybrid"
        depends="JavaUltraLightCompileDebugHybrid,
UnjarHybrid"
        description="generate the Java UltraLight Jar file in
debug mode">
        <mkdir dir="${jardest}"/>
   .
   .
   <jar jarfile="${jardest}/${JavaUltraLightHybridJar}"
    basedir="${dest}"
    includes="com/simba/**">
       <service
type="java.sql.Driver" provider="com.simba.ultralight.core.hy
brid.ULJDBC4Driver"/>
   </jar>
</target>
```

To auto-load the connector in your application, simply pass in `jdbc:simba://localhost` along with the user name and password as the URL, as shown in the following code example:

```
String url = "jdbc:simba://localhost;UID=username;PWD=test;";
m_connection = DriverManager.getConnection(url);
```

JDBC 4.0, 4.1, and 4.2 Exceptions

Exceptions created by the connector generate a `SQLException` by default. To generate an exception specific to JDBC 4.0, 4.1, or 4.2, specify the exception type when calling `createGeneralException()` as shown in the following example:

```
ULDriver.s_ULMessages.createGeneralException
(DSIMessageKey.NOT_IMPLEMENTED.name(),
ExceptionType.INTEGRITY_CONSTRAINT_VIOLATION);
```

Pooled Connections

A pooled connection can be created by calling `JDBCObjectFactory::createPooledConnection()`. If any specific behaviour is required, a connector can optionally override `createPooledConnection()` to return a subclass of `PooledConnection`. The three classes provided by Simba SDK for the respective JDBC versions each return the appropriate version of 'SPooledConnection' by default. For example, `JDBC4ObjectFactory::createPooledConnection()` returns an `S4PooledConnection` as shown in the following example:

```
/**
     * Attempts to establish a physical database connection
that can be used as a pooled connection.
     * @param connection The connection to use to create the
     * <code>PooledConnection</code>.
     * @return A <code>PooledConnection</code> object that is
a physical connection to the database that this
<code>ConnectionPoolDataSource</code> object represents.
     * @throws SQLException    If a database access error
occurs.
*/
protected PooledConnection createPooledConnection(SConnection
connection) throws SQLException
{
    return new S4PooledConnection(connection);
}
```

Setting and Initializing Client Information

If a connector uses non-standard client info properties, both the initialization (e.g. loading) and the setting of these properties must be handled by the connector's connection class. These tasks are handled in the `loadClientInfoProperties()` and`setClientInfoProperty()` methods of the connection as shown in the following example from JavaUltraLight:

```
private void loadClientInfoProperties() throws ErrorException
{
```

```
    // TODO #XX: Define your custom client info
    properties.
    // Standard client info properties are Application_
    name, Client_user and
    // client_hostname.
    // Other client info properties have to be defined
    here
    ClientInfoData fakeCustomCLientInfo = new
    ClientInfoData(
    ULClientInfoPropertyKey.UL_CUSTOM_CLIENT_INFO,
    25,
    "FakeCustomClientInfoForUltralight",
    "Just a fake client info property to show how to
    define them.");
    setClientInfoProperty(fakeCustomCLientInfo);

}
public void setClientInfoProperty(String propName, String
propValue)throws ClientInfoException
{

    // Check that the property name is valid and store
    the new property
    // values.
    super.setClientInfoProperty(propName, propValue);
    // TODO: Implements the wanted behaviour
    // Usually the connector stores the value specified
    in a suitable location
    // in the database.
    // For example in a special register, session
    parameter, or system table
    // column.
    LogUtilities.logInfo(
    String.format("Property {0} has now the value {1}",
    propName,
    propValue), m_log);

}
```

Handling Deregistration

JDBC 4.2 introduced the new `DriverAction` interface allowing JDBC connectors to be notified when they are being deregistered by the JDBC DriverManager. Implementing this interface allows connectors to handle the notification and perform

clean up tasks such releasing resources. Note that the implementation should not perform the deregistration, but rather, perform any clean up required while the connector is being deregistered by the DriverManager.

Simba SDK 10.3 exposes this notification via the `IDriver` interface and a default implementation is provided in the `DSIDriver` class which does nothing. If you need to handle the deregisration event to perform clean up tasks, implement the `deregister()` method in your `DSIDriver`-derived class.

Related Topics

API Overview

Lifecycle of DSI Objects

Sample Connectors and Projects

JavaUltralight Sample Connector

Data Types

The Simba SDK provides a data type to handle each of the types in the SQL specification. This section lists the types for each SDK, and includes instructions on how to convert the types from your data store into the Simba SDK data types.

In the C++ SDK, you can also create your own custom C and SQL data types.

SQL Data Types in the C++ SDK

`SqlData` objects represent the SQL types and encapsulate the data in a buffer. When you have a `SqlData` object and would like to know what data type it is representing, you can use `GetMetadata()->GetSqlType()` to retrieve the associated `SQL_[TYPE]` type. For more information, see the file `SqlData.h`.

Fixed Length Types

The structures used to store the fixed-length data types represented by `SqlData` objects are listed below:

SQL Type	Simba SDK Data Type
SQL_BIT	simba_uint8
SQL_BIGINT (signed)	simba_int64
SQL_BIGINT (unsigned)	simba_uint64
SQL_DATE	TDWDate
SQL_DECIMAL	TDWExactNumericType
SQL_DOUBLE	simba_double64
SQL_FLOAT	simba_double64
SQL_GUID	TDWGuid
SQL_INTEGER (signed)	simba_int32

SQL Type	Simba SDK Data Type
SQL_INTEGER (unsigned)	simba_uint32
SQL_ INTERVAL_ DAY	TDWSingleFieldInterval
SQL_ INTERVAL_ DAY_TO_ HOUR	TDWDayHourInterval
SQL_ INTERVAL_ DAY_TO_ MINUTE	TDWDayMinuteInterval
SQL_ INTERVAL_ DAY_TO_ SECOND	TDWDaySecondInterval
SQL_ INTERVAL_ HOUR	TDWSingleFieldInterval
SQL_ INTERVAL_ HOUR_TO_ MINUTE	TDWHourMinuteInterval
SQL_ INTERVAL_ HOUR_TO_ SECOND	TDWHourSecondInterval

SQL Type	Simba SDK Data Type
SQL_ INTERVAL_ MINUTE	TDWSingleFieldInterval
SQL_ INTERVAL_ MINUTE_ SECOND	TDWMinuteSecondInterval
SQL_ INTERVAL_ MONTH	TDWSingleFieldInterval
SQL_ INTERVAL_ SECOND	TDWSecondInterval
SQL_ INTERVAL_ YEAR	TDWSingleFieldInterval
SQL_ INTERVAL_ YEAR_TO_ MONTH	TDWYearMonthInterval
SQL_ NUMERIC	TDWExactNumericType
SQL_REAL	simba_double32
SQL_ SMALLINT (signed)	simba_int16
SQL_ SMALLINT (unsigned)	simba_uint16

SQL Type	Simba SDK Data Type
SQL_TIME	TDWTime
SQL_ TIMESTAMP	TDWTimestamp
SQL_TINYINT (signed)	simba_int8
SQL_TINYINT (unsigned)	simba_uint8
SQL_TYPE_ DATE	TDWDate
SQL_TYPE_ TIME	TDWTime
SQL_TYPE_ TIMESTAMP	TDWTimestamp
SQL_TYPE_ DATE	TDWDate
SQL_TYPE_ TIME	TDWTime
SQL_TYPE_ TIMESTAMP	TDWTimestamp

Date, Time and DateTime Types

The associated SQL types for date, time, and datetime are listed below:

Type	SQL Type for ODBC 3.x
date	SQL_TYPE_DATE
time	SQL_TYPE_TIME
datetime	SQL_TYPE_TIMESTAMP

Important:

SQL_DATE, SQL_TIME and SQL_TIMESTAMP are ODBC 2.x types, while SQL_TYPE_DATE, SQL_TYPE_TIME, and SQL_TYPE_TIMESTAMP are ODBC 3.x types. Since you are developing an ODBC 3.x connector, use the ODBC 3.x types.

Example: Simple Fixed-Length Data

The `SQLData` for a SQL_INTEGER contains a `simba_int32` type. This example shows you how to copy your integer value into the `simba_int32` type.

```
switch (in_data->GetMetadata()->GetSqlType())
{
    case SQL_INTEGER:
    {
        simba_int32 value = 1234;
        *reinterpret_cast<simba_int32*>(in_data->GetBuffer())
= value;
    }
}
```

Variable Length Types

The following variable-length data types are stored in buffers and represented by `SqlData` objects:

SQL Type	Data Type
SQL_BINARY	simba_byte*
SQL_CHAR	simba_char*
SQL_LONGVARBINARY	simba_byte*
SQL_LONGVARCHAR	simba_char*
SQL_VARBINARY	simba_byte*
SQL_VARCHAR	simba_char*

SQL Type	Data Type
SQL_WCHAR	simba_byte*
SQL_WLONGVARCHAR	simba_byte*
SQL_WVARCHAR	simba_byte*

Note:

You can use `DSITypeUtilities::OutputWVarCharStringData` and `OutputVarCharStringData` for setting character data.

Example: Variable-Length Data

In the example below, the SQL_CHAR case shows how to use the type utilities, while the SQL_VARCHAR case shows how to use `memcpy`.

Note:

- In your custom connector code, SQL_CHAR, SQL_VARCHAR and SQL_LONGVARCHAR do not require separate cases.
- You custom connector code has other considerations, such as handling offsets in the data.

```
switch (in_data->GetMetadata()->GetSqlType())
{
    case SQL_CHAR:
    {
        simba_string stdString("Hello");
        return DSITypeUtilities::OutputVarCharStringData(
            &stdString,
            in_data,
            in_offset,
            in_maxSize);
    }
    case SQL_VARCHAR:
    {
       simba_string stdString("Hello");
       simba_uint32 size = stdString.size();
```

```
  in_data->SetLength(size);
  memcpy(in_data->GetBuffer(), stdString, size);
return false;
    }
}
```

SQL DataTypes in the Java SDK

This section explains the mapping between SQL types and the Simba SDK data types for JDBC.

Note:

Because Java does not support unsigned types, SQL types that have both unsigned and signed variations are mapped to the next largest data type.

SQL Type	Data Type
SQL_BIGINT (signed)	java.math.BigInteger
SQL_BIGINT (unsigned)	java.math.BigInteger
SQL_BINARY	byte[]
SQL_BIT	java.lang.Boolean
SQL_CHAR	java.lang.String
SQL_DECIMAL	java.math.BigDecimal
SQL_DOUBLE	java.lang.Double
SQL_FLOAT	java.lang.Double
SQL_INTEGER (signed)	java.lang.Long
SQL_INTEGER (unsigned)	java.lang.Long

SQL Type	Data Type
SQL_INTERVAL_DAY	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_DAY_TO_HOUR	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_DAY_TO_MINUTE	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_DAY_TO_SECOND	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_HOUR	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_HOUR_TO_MINUTE	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_HOUR_TO_SECOND	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_MINUTE	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_MINUTE_SECOND	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_MONTH	com.simba.dsi.dataengine.utilities.DSIMonthSpan
SQL_INTERVAL_SECOND	com.simba.dsi.dataengine.utilities.DSITimeSpan
SQL_INTERVAL_YEAR	com.simba.dsi.dataengine.utilities.DSIMonthSpan
SQL_INTERVAL_YEAR_TO_MONTH	com.simba.dsi.dataengine.utilities.DSIMonthSpan
SQL_LONGVARBINARY	byte[]
SQL_LONGVARCHAR	java.lang.String
SQL_NUMERIC	java.math.BigDecimal

SQL Type	Data Type
SQL_REAL	java.lang.Float
SQL_SMALLINT (signed)	java.lang.Integer
SQL_SMALLINT (unsigned)	java.lang.Integer
SQL_TINYINT (signed)	java.lang.Short
SQL_TINYINT (unsigned)	java.lang.Short
SQL_TYPE_DATE	java.sql.Date
SQL_TYPE_TIME	java.sql.Time or com.simba.dsi.dataengine.utilities.TimeTz
SQL_TYPE_TIMESTAMP	java.sql.Timestamp or com.simba.dsi.dataengine.utilities.TimestampTz
SQL_VARBINARY	byte[]
SQL_VARCHAR	java.lang.String
SQL_WCHAR	java.lang.String
SQL_WLONGVARCHAR	java.lang.String
SQL_WVARCHAR	java.lang.String

Interval Conversions

Type Name	SQL Type	Parameters
INTERVAL DAY	SQL_INTERVAL_DAY	Whole Day Precision For example: INTERVAL DAY (3)

Type Name	SQL Type	Parameters
INTERVAL DAY TO HOUR	SQL_INTERVAL_DAY_TO_HOUR	Day Precision For example: INTERVAL DAY (2)
INTERVAL DAY TO MINUTE	SQL_INTERVAL_DAY_TO_MINUTE	Day Precision For example: INTERVAL DAY (2) TO MINUTE
INTERVAL DAY TO SECOND	SQL_INTERVAL_DAY_TO_SECOND	Day Precision, Fractional Seconds Precision For example: INTERVAL DAY (2) TO SECOND (3)
INTERVAL HOUR	SQL_INTERVAL_HOUR	Hour Precision For example: INTERVAL HOUR (3)
INTERVAL HOUR TO MINUTE	SQL_INTERVAL_HOUR_TO_MINUTE	Hour Precision For example: INTERVAL HOUR (2)
INTERVAL DAY TO SECOND	SQL_INTERVAL_HOUR_TO_SECOND	Hour Precision, Fractional Seconds Precision For example: INTERVAL HOUR (3) TO SECOND (4)
INTERVAL MINUTE	SQL_INTERVAL_MINUTE	Minute Precision For example: INTERVAL MINUTE(2)

Type Name	SQL Type	Parameters
INTERVAL MINUTE SECOND	SQL_INTERVAL_ MINUTE_TO_SECOND	Minute Precision, Fractional Seconds Precision For example: INTERVAL MINUTE (3) SECOND (4)
INTERVAL MONTH	SQL_INTERVAL_ MONTH	Month Precision For example: INTERVAL MINUTE(2)
INTERVAL SECOND	SQL_INTERVAL_ SECOND	Whole Seconds Precision, Fractional Seconds Precision For example: INTERVAL SECOND (4,5)
INTERVAL YEAR	SQL_INTERVAL_YEAR	Year Precision For example: INTERVAL YEAR(3)
INTERVAL YEAR TO MONTH	SQL_INTERVAL_YEAR_ TO_MONTH	Year Precision For example: INTERVAL YEAR(2) TO MONTH)

Adding Custom SQLDataType

Using the C++ Simba SDK, you can add custom SQLDataTypes to your DSII. Each custom data type that you add must be based on an existing data type. This allows applications to handle your custom types transparently without requiring additional logic.

The SQLite Sample driver demonstrates this to implement a Tweet custom data type as a fixed length character field combined with a length field.

This functionality is available to connectors that use the SQL Engine, and to those that do not.

Example:

You can add a type called `Money` that is based on `Numeric`, but is restricted to two decimal places. It may also contain a custom conversion to character types that adds the currency character.

Simba SDK uses the following classes to handle custom SQLDataTypes:

- `UtilityFactory` class create a `SqlTypeMetadataFactory` object, which creates the metadata about the custom types.
- `SqlDataFactory` creates the object which represents the custom type.
- `SqlConverterFactory` converts the custom type to other data types.

This functionality is explained more in the instructions below.

To Add a Custom SQLDataType:

> **Note:**
>
> Corresponding class and function names from the SQLite sample driver are noted in square brackets.

1. Modify your custom `DSIIDriver [SLDriver]` object to override and implement the virtual method `CreateUtilityFactory`. In this method, return a `CustomerDSIIUtilityFactoryClass[SLUtilityFactory]`. This class provides the other factories that implement custom data type behavior.
2. Create a `CustomerDSIIUtilityFactory [SLUtilityFactory]` class, which subclasses `Simba::Support::UtilityFactory`. This factory class provides classes that handle the custom type metadata, data, and conversion of the custom data types.
    a. `CreateSqlConverterFactory()` creates a factory to create converters that convert custom data types to other types.
    b. `CreateSqlDataFactory()` creates a factory to create the actual SqlData objects that represent the custom data types.
    c. `CreateSqlTypeMetadataFactory()` creates a factory to create the metadata about the custom data types.
3. Create a `CustomerDSIISqlConverterFactory [SLSqlConverterFactory]` class which subclasses `Simba::Support::SqlConverterFactory`, and override and implement the following virtual methods:
    a. `CreateNewCustomSqlToCConverter()` - Takes a `SqlData` and `SqlCData` object representing the source and target types, and an `IWarningListener` for posting any conversion warnings to. The returned converter `[SLCustomTypeTweetConverter]` is responsible

for converting from the source SQL data type to the target C data type.

b. `CreateNewCustomCToSqlConverter()` - Takes a `SqlCData` and `SqlData` object representing the source and target types, and an `IWarningListener` for posting any conversion warnings to. The returned converter `[SLCustomTypeTweetConverter]` is responsible for converting from the source C data type to the target SQL data type.

4. Create a `CustomerDSIISqlDataFactory [SLSqlDataFactory]` class which subclasses `Simba::Support::SqlDataFactory`, and override and implement the following virtual methods:

   a. `CreateNewCustomSqlData()` - Takes a `SqlTypeMetadata` object representing a SQL data type, which is used to determine what SqlData object to create. Return a subclass of SqlData that represents the custom type `[SLTweetSqlData]` if supported, otherwise return NULL.

5. Create a `CustomerDSIISqlTypeMetadataFactory [SLSqlTypeMetadataFactory]` class which subclasses `Simba::Support::SqlTypeMetadataFactory`, and override and implement the following virtual methods:

   a. `CreateNewCustomSqlTypeMetadata()` - Create a new `SqlTypeMetadata` object that represents the custom data type specified. The helper function `SetupStandardMetadata` is provided to set up the standard type metadata for the standard SQLDataTypes. Return NULL if the specified type is not supported.

   b. `SetCustomTypeDefaults()` - Set the default metadata for the specified data type on the specified `SqlTypeMetadata` object. This allows for reuse of existing `SqlTypeMetadata` objects, rather than creating new objects.

6. Ensure that the custom data types are reported in the metadata source for type information. In particular, the DSI_USER_DATA_TYPE_COLUMN_TAG should return the custom type identifier.

   If your connector is using the Simba SQLEngine, then you can customize the behavior of the data types within the SQLEngine as well by making the following changes:

   Note:

   The SQLite sample driver does not currently demonstrate this, despite using the SQLEngine.

7. In the `CustomerDSIISqlConverterFactory` class, override and implement the following virtual methods:

a. `CreateNewSqlToSqlConverter()` - Takes a `SqlData` and `SqlData` object representing the source and target types, and an `IWarningListener` for posting any conversion warnings to. The returned converter is responsible for converting from the source SQL data type to the target SQL data type.

8. Modify your `CustomerDSIIDataEngine` object to override and implement the virtual method `CreateBehaviorProvider()` to return a `CustomerDSIIBehaviorProvider`. This class will provide the other factories that provide the custom data type SQLEngine behavior.
9. Create a `CustomerDSIIBehaviorProvider` class which subclasses `Simba::SQLEngine::DSIExtCustomBehaviorProvider`. This factory class will initialize classes that handle the type coercion and custom type behavior within the SQLEngine. In this context, type coercion is the conversion of one type to a new type with similar content, where the conversion happens automatically.
   a. `InitializeCellComparatorFactory()` - Initializes the `m_cellComparatorFactory` member with a `CustomerDSIICellComparatorFactory` that implements `ICellComparator` for comparing two data type values.
   b. `InitializeCoercionHandler()` - Initializes the m_coercionHandler member with a CustomerDSIICoercionHandler that implements ICoercionHandler for coercing different data types into one data type.
   c. `InitializeCollatorFactory()` - Initializes the m_collatorFactory member with a CustomerDSIICollatorFactory that implements ICollatorFactory for comparing/collating text.
   d. `InitializeFunctorFactory()` - Initializes the `m_functorFactory` member with a `CustomerDSIIFunctorFactory` that implements `IFunctorFactory` for returning functors that perform operations on specific data types.

   Note:

   The behavior provider does not need to override all of the functions. You only need to override the functions that need to be customized.

10. If custom comparisons are needed, create a `CustomerDSIICellComparatorFactory` class which implements `ICellComparatorFactory`. The factory should override and implement the following virtual functions:
    a. `MakeNewCellComparator` - Create a cell comparator that can compare two values of the type specified by the passed in `SqlTypeMetadata`. The

cell comparator should be able to do comparisons such that it can determine when two values are equal, or one is greater than the other. Return NULL if the comparison is not supported.

11. If custom coercions between two types are needed, create a `CustomerDSIICoercionHandler` class which extends `DSIExtCoercionHandler`. The handler should override and implement the virtual functions with signature that are similar to the following:
    a. `Coerce*Type()` - For example, `CoerceLikeType`. Takes `SqlTypeMetadata` objects and coerces them to create one result `SqlTypeMetadata` that would result from the operation that the metadata is being coerced for. Return NULL if the coercion is not supported.
    b. `Coerce*ColumnMetadata()` - Takes `ColumnMetadata` objects and coerces them to create one result ColumnMetadata that would result from the operation that the metadata is being coerced for. Return NULL if the coercion is not supported.

12. If custom collations are needed, create your own collation interface by extending `ICollation`. Override and implement the required virtual functions as shown in `ICollation.h`.

    You can choose to implement the `CreateHasher` method in the `ICollation` interface. This method returns an `IHasher` interface that the Simba SDK uses to perform join operations. By default, `ICollation::CreateHasher` returns `null`.

    If you implement your own `ICollation` and your own `IHasher`, queries that contain equality joins on your custom type columns will complete more quickly, because Simba SDK can use a hash-based join algorithm.

    Follow these guidelines when implementing `IHasher::Hash`:

    - Return a uint64 value for each string buffer that is passed in.
    - Always return the same value for the same string buffer and/or seed value input.
    - For optimal performance, return unique values for each different string buffer and seed input. That is, try to prevent collisions in your hash implementation.
    - For optimal performance, create return values that evenly span a `uint_64` range. That is, the return values should have a uniform and independent distribution of bits.

    For an example `IHasher` implementation, see `DSIUnicodeHasher` or `DSIBinaryHasher`. These classes use the Murmur hash function, which

satisfies the requirements listed above. An alternative to using Murmur is to use the `DSIBinaryHasher` on a collation normalized buffer, also called a "collation key".

13. If custom operation behavior is needed, create a `CustomerDSIIFunctorFactory` class which extends `DSIExtFunctorFactory`. The factory should override and implement the following virtual functions:
    a. `CreateBinaryArithmeticFunctor()` - Create a new `DSIExtBinaryValueFunctor` subclass which handles the specified arithmetic operation of two values of the type specified by the `SqlTypeMetadata`. The `DSIExtBinaryValueFunctor` should operate on the m_`leftData` and m_`rightData` member values during `Execute()`.
    b. `CreateComparisonFunctor` - Create a new `DSIExtBinaryBooleanFunctor` subclass which handles the specified comparison between two values of the type specified by the `SqlTypeMetadata`. The `DSIExtBinaryBooleanFunctor` should operate on the `m_leftData` and `m_rightData` member values during `Execute`, and use the `ICollator` supplied by the `ICollatorFactory` if needed.
    c. `CreateNegationFunctor` - Create a new `DSIExtUnaryValueFunctor` subclass which handles negation of the type specified by the `SqlTypeMetadata`. The `DSIExtUnaryValueFunctor` should operate on the `m_data` member during `Execute`.
    d. `CreateExistsFunctor` - Create a new `DSIExtBinaryValueFunctor` subclass which handles the EXISTS clause for the type specified by the `SqlTypeMetadata`. The `DSIExtBinaryValueFunctor` should operate on the `m_leftData` and m_`rightData` member values during `Execute`.
    e. `CreateInFunctor` - Create a new `DSIExtBinaryValueFunctor` subclass which handles the IN clause for the type specified by the `SqlTypeMetadata`. The `DSIExtBinaryValueFunctor` should operate on the `m_leftData` and `m_rightData` member values during `Execute()`.
    f. `CreateLikeFunctor()` - Create a new `DSIExtBinaryValueFunctor` subclass which handles the LIKE clause for the type specified by the `SqlTypeMetadata`. The `DSIExtBinaryValueFunctor` should operate on the `m_leftData` and `m_rightData` member values during `Execute()`.

ODBC Custom C Data Types

Using the C++ Simba SDK, you can add custom C data types to your DSII. Each custom data type that you add must be based on an existing data type. This allows applications to handle your custom types transparently without requiring additional logic.

This functionality is available to connectors that use the SQL Engine, and to those that do not.

Simba SDK uses a UtilityFactory class to create a `SqlCTypeMetadataFactory` object to create the metadata about the custom types, then use and a `SqlConverterFactory` to convert the custom type to other data types.

The SQLite Sample driver demonstrates this by implementing a Tweet custom data type as a fixed length character field combined with a length field.

To Add Custom C Data Types:

> **Note:**
>
> Corresponding class and function names from the SQLite sample driver are noted in square brackets.

1. Create a header file to package with your ODBC connector. In this header file, define the type ID for your custom C type, field ID's for any custom metadata fields, and the struct of your custom C data type. Note that field ID's must start at 0x4100.
2. Modify your `CustomerDSIIDriver [SLDriver]` object to override and implement the virtual method `CreateUtilityFactory()` to return a `CustomerDSIIUtilityFactoryClass [SLUtilityFactory]`. This class will provide the other factories that implement custom data type behavior.
3. Create a `CustomerDSIIUtilityFactory [SLUtilityFactory]` class that subclasses `Simba::Support::UtilityFactory`. This factory class will provide classes that handle the custom type metadata, data, and conversion of the custom data types.
    a. `CreateSqlConverterFactory()` creates a factory to create converters that convert custom data types to other types.
    b. `CreateSqlCDataTypeUtilities()` creates a utility class which describes the custom C data types.
    c. `CreateSqlCTypeMetadataFactory()` creates a factory to create the metadata about the custom data types.

4. Create a `CustomerDSIISqlConverterFactory [SLSqlConverterFactory]` class which subclasses `Simba::Support::SqlConverterFactory`, and override and implement the following virtual methods:
   a. `CanConvertCustomCTypeToSql()` takes the ID of a custom C data type and the TDWType enum of the target SQL type to convert to, and determines if the type conversion can be performed.
   b. `CanConvertSqlToCustomCType()` takes the TDWType enum of a SQL data type and the ID of a custom C data type to convert to, and determines if the type conversion can be performed.
   c. `CreateNewCustomSqlToCConverter()` takes a SqlData and SqlCData object representing the source and target types, and an IWarningListener for posting any conversion warnings to. The returned converter `[SLCustomTypeTweetConverter]` is responsible for converting from the source SQL data type to the target C data type.
   d. `CreateNewCustomCToSqlConverter()` takes a SqlCData and SqlData object representing the source and target types, and an IWarningListener for posting any conversion warnings to. The returned converter `[SLCustomTypeTweetConverter]` is responsible for converting from the source C data type to the target SQL data type.
5. Create a `CustomerDSIISqlCDataTypeUtilities [SLCDataTypeUtilities]` class which subclasses `SqlCDataTypeUtilities`, and override and implement the following two methods:
   a. `IsSupportedCustomType()` takes in the ID of a type and determines if it is a valid custom C data type.
   b. `GetStringForCType()` takes is in the ID of a C data type and returns the string representation of it.

   Optionally override the following two methods if the custom C data type will support custom metadata fields:
   a. `IsSupportedCustomMetadataField()` takes in the ID of a field identifier, along with the field's indent and determines if the field identifier and indent are valid.
   b. `GetCustomMetadataFieldType()` takes in the field indent and returns the data type that it represents.

> **Note:**
>
> When you override a function, your custom function should defer to the implementation of the parent class when the ID of a non-custom type is passed in. That is, your custom function should only handle your custom types.

6. Create a `CustomerDSIISqlCTypeMetadataFactory [SLCTypeMetadataFactory]` class which subclasses `Simba::Support::SqlCTypeMetadataFactory`, and override and implement the following virtual methods:
   a. `CreateNewCustomSqlCTypeMetadata()` creates a new `SqlCTypeMetadata` object that represents the custom C data type specified.
   b. `ResetCustomTypeDefaults()` sets the default values for the custom C data type.

   Optionally create `CustomerSqlCTypeMetadata` which subclasses `SqlCTypeMetadata` if custom metadata fields are required for the custom C data type. This object will then be constructed and returned by the `CreateNewCustomSqlCTypeMetadata()` method.

   In `CustomerSqlCTypeMetadata`, the `SetField()/GetField()` methods must be overridden if there are custom metadata fields to set/get.

Simba SQLEngine

The Simba SQLEngine is a self-contained SQL parser and execution engine that you can use in your custom connector to convert SQL queries and commands into a format that your data store understands. This component allows you to add SQL processing capability to a non-SQL-capable data store, making your data available to common reporting tools through standard interfaces. The Simba SQLEngine can also expose support for Data Definition Language (DDL), Data Manipulation Language (DML), and Data Control Language (DCL) SQL statement, if your data store supports this functionality.

The Simba SQLEngine consumes SQL-92 queries, parses them, and creates an optimized execution plan, then allows your DSI implementation to take over part or all of the execution, and finally executes the plan against the DSI implementation. To use the Simba SQLEngine, your DSI implementation must translate your data store schema into a view with tables and columns.

Simba SQLEngine Architecture

The Simba SQLEngine is available in the C++ and Java version of the Simba SDK. You can create ODBC connectors and pure-Java JDBC connectors for data sources that do not support SQL. You can also use a C# development environment to write the data access portion of your connector, and then use CLI to link with the C++ Simba SDK.

Note:

To write a custom connector for client-server deployment, you must use the C++ Simba SQLEngine.

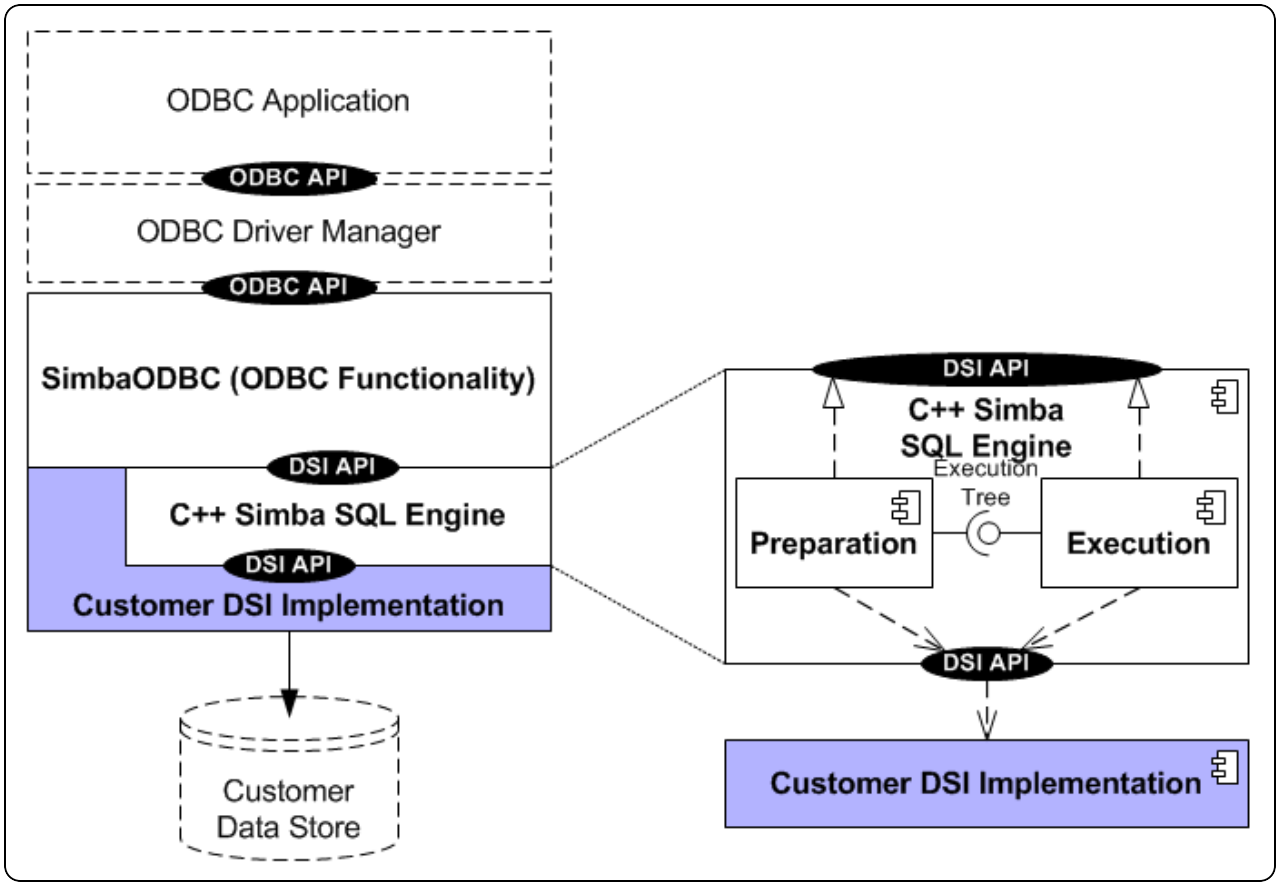
The Simba SQLEngine does not expose another API. It is designed to be enclosed between two instances of the DSI. The top end of the Simba SQLEngine is compatible with the SimbaODBC, SimbaJDBC, or SimbaServer DSI specification. Your connector code can link directly to the C++ Simba SQLEngine to create a stand-alone ODBC connector or a server, or it can link directly to the Java Simba SQLEngine to create a stand-alone JDBC connector.

The bottom end of Simba SQLEngine is compatible with another part of the DSI specification, which calls into a DSI implementation that connects to a non-SQL data store.

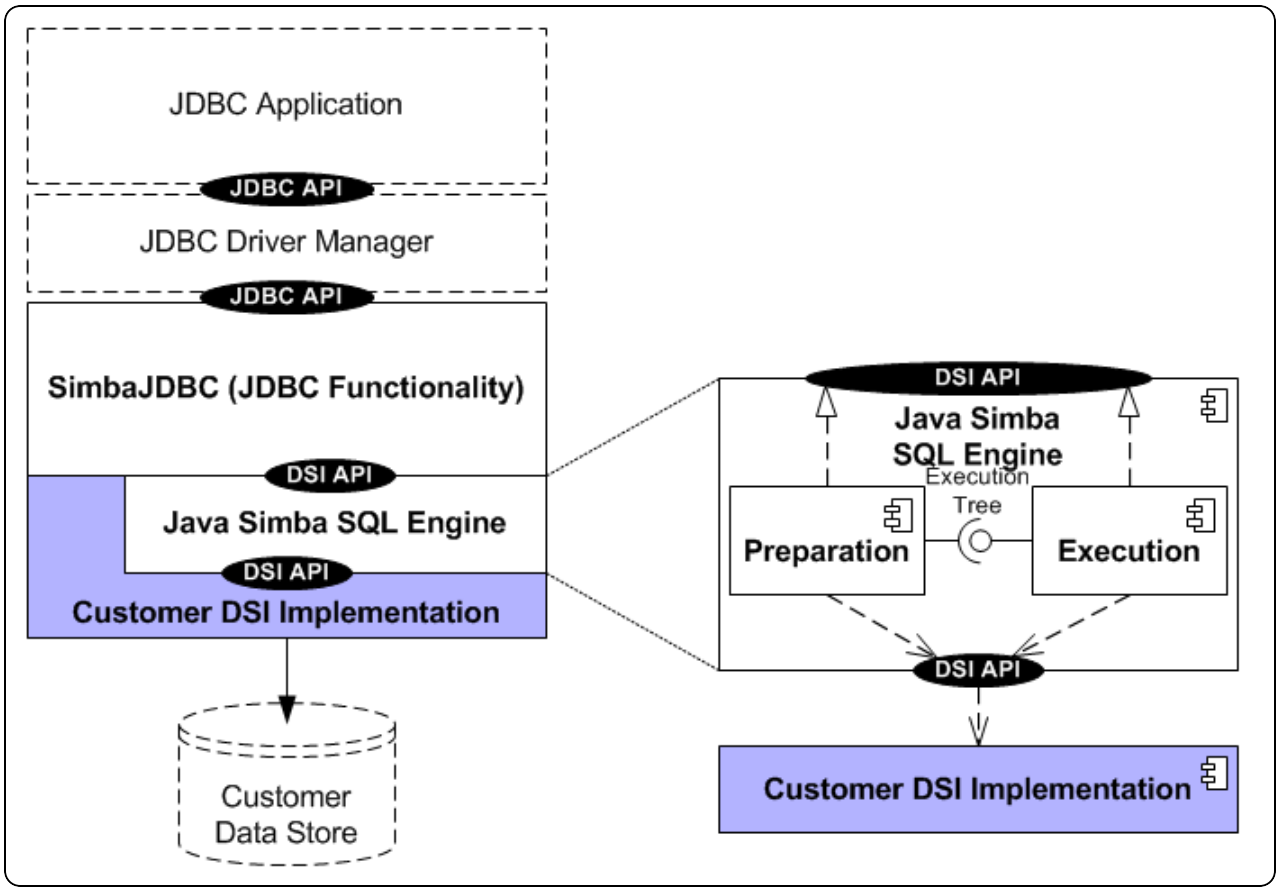
At a high level, the Simba SQLEngine is composed of the Preparation component, the Execution component, and the Execution tree. The Preparation component contains

the SQL parser. It also validates the SQL by ensuring that data store objects such as tables and columns exist. Once the SQL statement is prepared, it is handed to the Execution component. The Execution component provides the environment for executing the execution tree and retrieving the result set.

This architecture is illustrated in the following diagrams:



Architecture of the C++ Simba SQLEngine



Architecture of the Java Simba SQLEngine

Optimizing Queries with the Simba SQLEngine

The Simba SQLEngine contains several features that allow you to optimize queries and improve performance in your custom connector.

If your data store implements indexes or a similar functionality, or if it is able to find specific data rows very quickly, then Simba SQLEngine can use this functionality to optimize operations such as filtering and sorting. Your data store does not have to implement indexes according to the Indexed Sequential Access Method (ISAM) model. As long as the data store can seek to specific data rows as if it was using an index (that is, faster than the Simba SQLEngine could step through the data itself), then Simba SQLEngine can use that functionality as if it was a real index. For more information on using Indexes, see Support for Indexes.

If your data store has high performance features that enable fast processing of some queries or commands, you can tell the Simba SQLEngine to pass these sections of the command directly to the data store. This feature is called Collaborative Query

Execution. For more information on Collaborative Query Execution, see Collaborative Query Execution.

Simba SQLEngine also uses table cardinality and other metadata to optimize the query before execution. If indexes and table cardinality are not available, Simba SQLEngine will still work, but it will be slower because it will not be able to perform the more advanced optimizations.

Related Topics

Collaborative Query Execution

SQL Engine Memory Management

Data Manipulation Language (DML)

Data Definition Language (DDL)

Support for Indexes

Sample Index Implementation

Custom Scalar and Aggregate Functions

Stored Procedures

Collaborative Query Execution

SQL Engine has features that allow a DSII to alter and optimize the execution of a query according to the strengths of the data store. This takes place by providing access to the Algebraic Expression Tree (AE-Tree), which is an object-oriented representation of the operations necessary to perform the query. The ability to optimize the tree comes in two different forms:

- You have full access to the AE-Tree. You can analyze it and add, remove, or alter the nodes.
- Or, the SQL Engine can analyze the tree for you. It will use pass-down handlers for the operations that can often be executed in the data store, thus eliminating the need for them to be processed in the SQL engine.

Note:

- For a JDBC connector, the functionality described in this section can be accomplished using the Java SQL Engine.
- The SQLite sample implements some of the Collaborative Query Execution (CQE) optimizations. You can use it as a reference for implementing your own optimizations.

The advantage of using Collaborative Query Execution is that it allows your DSII to take over execution of the parts of the SQL query that your data store excels at, while leaving the rest to the Simba SQLEngine. For instance, if your data store can join tables extremely quickly, then this operation can be executed by your DSII while Simba SQLEngine takes care of the rest of the operations. When Simba SQLEngine and your DSII use Collaborative Query Execution, your connector supports all of the SQL that Simba SQLEngine supports, while still exposing the strengths of your data store.

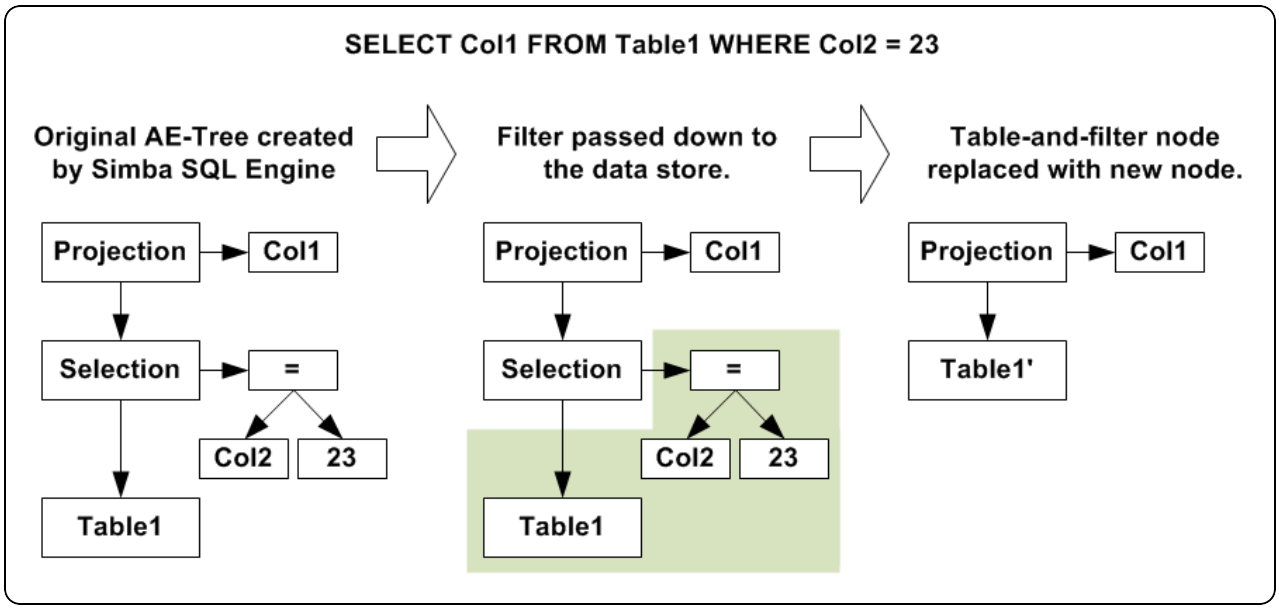
If your data store cannot perform any additional operations, then Collaborative Query Execution does not need to be used. Simba SQLEngine will still support the full range of SQL in a fast and efficient manner.

Passing Down Processing to a Data Store

Before it executes a SQL statement, Simba SQLEngine can pass an optimized representation of the SQL statement to the DSI implementation. This optimized representation is called an Algebraic Expression Tree, or AE-Tree. The SQL statement takes this form just before Simba SQLEngine transforms it into an execution plan and executes it. When Simba SQLEngine passes the AE-Tree to the DSI implementation, the DSI implementation can choose to execute any part of the AE-Tree itself. It signals its intentions by modifying the AE-Tree before returning it to Simba SQLEngine.

For example, if your data store can filter data, or join data, or execute aggregate functions quickly, it can modify those nodes of the AE-Tree to point to the DSI implementation for execution. The DSI implementation can modify any part of the AE-Tree if it can perform the execution quickly, or it can replace the entire tree and execute the whole query itself.

The following diagram illustrates an example of creating an AE-Tree passing down a filter to the data store, then replacing the original table node with a new filtered table node:



The diagram above shows three views of a notional AE-Tree corresponding to the SQL query SELECT Col1 FROM Table1 WHERE Col2 = 23.

1. The first view shows the AE-Tree originally created by Simba SQLEngine. All the columns in the projection are retrieved and filtered by the Simba SQL execution engine.
2. The second tree is the same as the first. “Table1” and sub-tree rooted from “=” , shown in the highlighted section, are passed down to the data store. That is, the SQL Engine provides access to those nodes so that the DSII can determine whether it can handle the filter. The original tree is not changed until the DSII tells the SQL Engine that the filter can be passed down.
3. If pass-down succeeds, it is converted into the tree shown in the third view, where “Selection” and “=” are replaced by “Table1’”.

After the DSI implementation passes back the AE-Tree, Simba SQLEngine transforms the modified AE-Tree into an execution plan and executes it. Simba SQLEngine execution engine, and the DSI implementation and data store collaborate on the execution of the SQL statement, with the data store executing the parts it can do quickly, and Simba SQLEngine executing the rest. Of course, the DSI implementation does not have to modify the AE-Tree at all. Simba SQLEngine can execute the entire SQL statement relatively quickly and efficiently by itself.

Related Topics

Statements

Pass-Down Operation Handlers

Algebraic Expression Tree and Optimization

Before it executes an SQL statement, the Simba SQLEngine can pass a representation of the SQL statement, called an Algebraic Expression Tree, or AE-Tree, to your DSI implementation. The SQL statement takes this form before the Simba SQLEngine transforms it into an execution plan and executes it.

The AE-Tree is optimized in a three-step process, the first two of which are handled internally by the Simba SQLEngine. First, tables are re-ordered within the query, then operations are pushed-down in the AE-Tree, and finally operations are passed down to the DSII via Collaborative Query Execution (CQE). This section briefly reviews the three steps to give developers using the Simba SQLEngine some insight into the whole optimization process. Although CQE is only involved in the third step, it is useful to first understand the first two steps that the Simba SQLEngine performs during optimization.

Note:

The AE-Tree diagrams shown in this section were generated by the SQLEngine logs that are controlled by the DSIEXT_DATAENGINE_LOG_AETREES data engine property. This property includes values for logging in four different locations, each of which corresponds to a step in the optimization process as that have been outlined above. These AE-Tree logs can be used to help understand what is going on in each case.

Step 1 – Table Reordering

Cross joins, which can result when a query is made against multiple tables, are a very common occurrence. Thus an important optimization is to attempt to change them into INNER JOINs since passing down cross joins later on could negate other optimizations. To accomplish this, the tables are first re-ordered within the AE-Tree, to allow for SELECT nodes with a child CROSS-JOIN to be converted into an INNER JOIN which can eventually be passed-down via CQE. The conversion to an INNER JOIN in itself reduces the number of rows that will be returned. Note that additional optimizations based on table statistics may be added in the future.

Consider the following example query:

```
SELECT EMPLOYEE.FIRST_NAME FROM EMPLOYEE, ADDRESS, DEPT WHERE
EMPLOYEE.DEPT=DEPT.DEPT_ID
```

Before optimization, the AE-Tree looks as follows:

```
AEQuery
AEProject
AESelect
AECrossJoin
AECrossJoin

    AETable: DBF.Shop.EMPLOYEE
    AETable: DBF.Shop.ADDRESS

AETable: DBF.schema.DEPT
AEComparison: EQ
AEValueList

    AEColumn: DBF.Shop.EMPLOYEE.DEPT

AEValueList

    AEColumn: DBF.schema.DEPT.DEPT_ID

AEValueList
AEColumn: DBF.Shop.EMPLOYEE.FIRST_NAME
```

In its current form, the AESelect node can't be pushed down in a later optimization as the condition involves a table in another cross-join, and thus we can't turn the AESelect->AECrossJoin relation into an inner join as the two tables involved in the filter are at different levels. After re-ordering the tables, we have the following AETree:

```
AEQuery

    AEProject

        AESelect

            AECrossJoin

                AECrossJoin

                    AETable:
                    DBF.Shop.EMPLOYEE
                    AETable:
                    DBF.schema.DEPT

                AETable: DBF.Shop.ADDRESS

            AEComparison: EQ
```

```
                AEValueList

                    AEColumn:
                    DBF.Shop.EMPLOYEE.DE
                    PT

                AEValueList

                    AEColumn:
                    DBF.schema.DEPT.DEP
                    T_ID

        AEValueList

            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

You can see the ADDRESS and DEPT tables have swapped positions, and now the AESelect can be pushed down to involve only the two required tables, which allows the AESelect operation to be turned into an inner join which can be passed-down. Conceptually, this would be the same as the following query:

select EMPLOYEE.FIRST_NAME from DEPT, EMPLOYEE, ADDRESS WHERE EMPLOYEE.DEPT= DEPT.DEPT_ID

Step 2 – Push Down Optimization

The second step involves push-down optimizations where by filters are pushed down the AE Tree by the SQLEngine to their lowest possible location. This is not to be confused with pass-down optimization (CQE) which is the third and final step.

Push down optimization allows for data to be filtered out at the earliest possible time, reducing work for the SQLEngine. In addition, AESelect->AECrossJoin relationships are transformed into AEJoin nodes if possible. Other optimizations may also be performed during this phase, but the push down is the most significant.

To demonstrate pushing down of a simple filter, consider the following query:

```
select EMPLOYEE.FIRST_NAME from EMPLOYEE, ADDRESS where
EMPLOYEE.FIRST_NAME = 'Susan'
```

which has an AETree that looks like this before push-down:

```
AEQuery
AEProject
AESelect
```

```
AECrossJoin
AETable: DBF.Shop.EMPLOYEE
AETable: DBF.Shop.ADDRESS
AEComparison: EQ
AEValueList

    AEColumn: DBF.Shop.EMPLOYEE.FIRST_NAME

AEValueList

    AELiteral: Susan; Character String Literal

AEValueList
AEColumn: DBF.Shop.EMPLOYEE.FIRST_NAME
```

You can see that the AESelect is above the AECrossJoin, which means the condition would be applied to the result of the cross-join, and thus be applied to many more rows than was needed. After push-down the AETree looks as follows:

```
AEQuery

    AEProject

        AECrossJoin

            AESelect

                AETable: DBF.Shop.EMPLOYEE
                AEComparison: EQ

                    AEValueList

                        AEColumn:
                        DBF.Shop.EM
                        PLOYEE.FIRS
                        T_NAME

                    AEValueList

                         AELiteral:
                    Susan; Character
                    String Literal

            AETable: DBF.Shop.ADDRESS

        AEValueList
```

```
            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

Here you can see that the AESelect has been pushed down so the condition is only applied to the EMPLOYEE table, and the cross-join is then applied to the filtered EMPLOYEE result and the ADDRESS table, resulting in many fewer rows being processed.

To demonstrate pushing down of filters which cause an AESelect->AECrossJoin relationship to become an AEJoin, we can continue the example from the table re-order phase from above which had an AETree that looked like this:

```
AEQuery

    AEProject

        AESelect

            AECrossJoin

                AECrossJoin

                    AETable:
                    DBF.Shop.EMPLOYEE
                    AETable:
                    DBF.schema.DEPT

                AETable: DBF.Shop.ADDRESS

            AEComparison: EQ

                AEValueList

                    AEColumn:
                    DBF.Shop.EMPLOYEE.DE
                    PT

                AEValueList

                    AEColumn:
                    DBF.schema.DEPT.DEP
                    T_ID

        AEValueList
```

```
            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

After the push-down phase, the tree looks like this:

```
AEQuery

    AEProject

        AECrossJoin

            AEJoin: AE_INNER_JOIN

                AETable: DBF.Shop.EMPLOYEE
                AETable: DBF.schema.DEPT

                AEComparison: EQ

                    AEValueList

                        AEColumn:
                        DBF.Shop.EM
                        PLOYEE.DEPT

                AEValueList

                    AEColumn:
                    DBF.schema.DEPT.DEP
                    T_ID

            AETable: DBF.Shop.ADDRESS

        AEValueList

            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

What has happened here is that the AESelect was pushed down one level as the filter condition only applied to the EMPLOYEE and the DEPT table, so the ADDRESS table could be left out of the filtering. Once this happened, there was an AESelect->AECrossJoin relationship where the condition for the AESelect only involved the two child tables, and could be turned into an AEJoin.

Note that the transformation of an AESelect->AECrossJoin into an AEJoin only occurs after the initial push-down of filters occurs. This is to allow filters that might apply only to one operand of the AECrossJoin to be pushed down directly to that operand and not be applied at the join level.

Step 3 - Pass Down Optimization (CQE)

The third and final step is pass down optimization in which the Simba SQLEngine passes portions of the AE Tree to the pass down handlers implemented in your DSI. When the Simba SQLEngine passes a subtree to your DSI handlers, these handlers can choose to execute all or part of the operation reflected in that subtree.

For instance, if the data store can filter data, join data, or execute aggregate functions particularly fast, pass down handlers can be used to signal to the Simba SQLEngine that the DSII will handle all or part of the operation. In this case the handler will return an optimized result set which the Simba SQLEngine will update the AE Tree subtree with.

Note:

- The terms Pass-down and CQE are used interchangeably.
- Although the Simba SQLEngine passes the AE Tree to the handlers, handlers should not directly manipulate the tree. Direct manipulation should be done by implementing an `IQueryExecutor` as described in Pre Optimization Analysis of the AE Tree.

Before discussing these pass down handlers, it's important to review the four main types of AENodes in an AE Tree as these will be used as input to the various handlers: Statements; Boolean; Query Operations and Relational Expressions; and Values. Each of these is explained below.

Statements

The root node of the tree representing the type of operation being performed: Query, Procedure Call, or DML. The first two are represented by nodes of type`AEQuery` and`AEProcedureCall` respectively, while DML statements are represented by statement nodes which subclass`AERowCountStatement`.

Boolean

A logical expression representing a true or false outcome. The most common use of this is for the WHERE clause of a SELECT statement.The base class of this type of node is`AEBooleanExpr`.

Query Operations and Relational Expressions

A representation of retrieval or manipulation of relational data such as selecting from a table. The base class of this type of node is`AEQueryOperation`. These nodes represent operations on the entire query result, such as sorting.

`AERelationalExpr`, which derives from`AEQueryOperation`, is the base class of most other nodes of this type. They represent retrieval, filtering, or modification of some relational data. Typically, they take one or two other relational expressions as an operand.

Three such examples are:

- `AETable` - This represents the retrieval of data from a table in your data store.
- `AESelect` - This represents the WHERE clause of a query by taking another relational expression and combining it with a boolean expression to use as a filter. The operand may be as simple as an AETable or a complicated combination of many other relational expressions.
- `AEJoin` - This represents any join of two tables or relational expressions and an optional boolean expression to use as a join condition.

Values

A representation of a scalar value that is either a literal, a parameter, a column reference, or an expression composed of one or more other values. The base class of this type of node is`AEValueExpr`. The basic value expression nodes from which other values are built from are`AELiteral`, `AEParameter`, and`AEColumn`. Most arithmetic value expressions derive from`AEUnaryValueExpr` or`AEBinaryValueExpr` to represent an operation on one or two value expression operands.

Related Topics

Collaborative Query Execution

Pass-Down Operation Handlers

Pass-Down Operation Handlers

After parsing a SQL query and generating the AE-Tree, the Simba SQLEngine does analysis to identify the following types of operations that a data store may be able to handle in an optimized way:

- Filter
- Join
- Aggregation
- Projection
- Union
- Distinct
- Top
- Sort

- Except
- Intersect
- Pivot
- Unpivot

Note:

Pivot and Unpivot require the implementation of passdown in the DSII because SQLEngine does not handle them at this time.

After identifying these operations, the Simba SQLEngine checks if the operation handlers for each operation exist and if passdown is enabled. If so, the SQLEngine attempts to pass down details of the operation to the DSII so that it may fully or partially perform that operation. If it can't perform the operation, it will fall back to being performed by the Simba SQLEngine.

The operation handlers are constructed by a factory class, `DSIExtOperationHandlerFactory`, which you must subclass to construct your own handler classes. The factory class itself is to be constructed by overriding the `DSIExtSqlDataEngine::CreateOperationHandlerFactory` method. Under the Java Simba SQLEngine, the equivalent method is `SqlDataEngine.createOperationHandlerFactory()`. Note that a subclass of `DSIExtSqlDataEngine` (`SqlDataEngine`for Java) is required since CQE may utilize the Simba SQLEngine. See Implementation.

More generally, any connector which uses the Simba SQLEngine for execution must subclass `DSIExtSqlDataEngine`, or `SqlDataEngine` if building a JDBC connector.

Note:

If you don't want to support pass downs, for example if you don't plan to have pass down handler implementations, then return `null`in the `CreateOperationHandlerFactory` override in your `DSIExtSqlDataEngine`or `SqlDataEngine` derived class. The sample takes this a step further by providing the ability to enable or disable pass down support at runtime by setting PASSDOWN=1 or PASSDOWN=0 respectively in the connector's registry settings or in the DSN connection string.

In the SQLite example, the `SLDataEngine` class constructs a `CBOperationHandlerFactory`:

```
AutoPtr<DSIExtOperationHandlerFactory>
SLDataEngine::CreateOperationHandlerFactory(){

    AutoPtr<DSIExtOperationHandlerFactory> if (!m_
    settings.m_disablePassdown) result.Attach(new
    SLOperationHandlerFactory(*GetLog(), *this));
         {
         result.Attach(new
         SLOperationHandlerFactory(*GetLog
         (), *this));
         }

     return result;
}
```

The `SLOperationHandlerFactory` then returns the appropriate subclassed handlers via the respective methods (e.g. `CreateFilterHandler()`, `CreateJoinHandler()`, etc.) which are invoked by Simba SQLEngine.

Each handler class defines and implements some or all of the following methods which will be invoked by the Simba SQLEngine during CQE:

- **Passdown()**

  This method is defined and implemented for all handlers because it performs the pass down logic. Depending on the type of handler, this method may return a scalar (e.g. the number of rows found in a count operation), boolean (e.g. indicating if an expression can be handled), or a result set (e.g. an aggregated result set).
- **TakeResult()**

  Returns a result set generated by the DSII. This method is defined and implemented only for Join, Filter, and Sort handlers and thus used in cases where Passdown() indicates a status result of whether the expression could be handled either fully, partially, or not at all. In these cases, the operation handling and result generation are performed via two methods (Passdown() and TakeResult() respectively), as opposed to just using the Passdown() method. This allows the Join, Filter, and Sort operations to indicate to the Simba SQLEngine whether the DSII will be able to handle the operation (i.e. supports it), and if so, whether it can handle it fully or partially.
- **CanHandleMoreClauses()**

  This method is defined and implemented in the handler used for Joins and Filters and is invoked by the Simba SQLEngine so that the handler can signal whether

or not any further passdowns of expressions should be made to the handler. For example, a Join handler may determine that predicates cannot be handled by the DSII and thus no further pass downs should be sent to the handler.

More information about each handler and their usage of these methods is provided next.

Filter and Join Handlers

Both filters and join pass-downs are handled by classes of type `IBooleanExprHandler`. Note that a join is conceptually a filter applied to the result of a cross join, which is why it is also handled by the same interface as for filters (`IBooleanExprHandler`). Both are constructed from one or two base tables and then the filter or join conditions are passed down. For each passed-down condition, the handler must return true or false indicating if it will process the filter. If it returns true, the Simba SQLEngine will remove that filter clause from the AE-Tree and use the result set returned by `IBooleanExprHandler::TakeResult` instead of the base table(s). In the case of a filter handler, the returned result set must have the same columns as the base table. For a join handler, the returned result set must have all the columns of the left base table followed by all the columns of the right base table.

If the handler returns false there are several possibilities. If the filter or join condition is a conjunction, the engine will attempt to pass down each conjunct individually, allowing your handler to selectively handle each. Like before, for each clause that returns true when passed down, it will be removed from the AE-Tree. Clauses that return false will still be processed by the Simba SQLEngine.

If all conjuncts return false when passed down the engine, it will still call `IBooleanExprHandler::TakeResult`. If a non-null result set is returned, the engine will replace the base table(s) in the AE-Tree with the returned result but still process all the filter conditions on top of the new result. This allows a handler to partially process a filter in the data store, reducing the size of the result that the engine must fully process the filter on. If TakeResult returns null, then no change will be made to the AE-Tree.

To implement your handler there are several base classes to choose from:

- **IBooleanExprHandler**

  This class has one passdown function to which all `AEBooleanExpr` nodes will be passed.
- **DSIExtAbstractBooleanExprHandler**

  This class implements the passdown method to delegate the passdown of each type of node to separate passdown methods.

- **DSIExtSimpleBooleanExprHandler**

  This class subclasses `DSIExtAbstractBooleanExprHandler` further to implement several of these previous methods to identify and pass down some simple cases that are easier to handle, such as simple comparisons between two columns or a column and a literal.

Typically you will subclass the `DSIExtSimpleBooleanExprHandler`, which provides support for some common boolean conditions. Note that classes that inherit from `SimpleBooleanExprHandler` only handle AND conditions. To handle OR conditions you must override `PassdownOr()`. If you need more functionality then you should override other functions in the parent classes as needed, or subclass `DSIExtAbstractBooleanExprHandler`.

`DSIExtAbstractBooleanExprHandler` has `Passdown*()` functions, such as `PassdownOr()` and `PassdownNot()`. These functions take AETree nodes, which should be inspected to see if your DSII can handle the condition. If so, then `Passdown()` should return true and `TakeResult()` should return a result set representing the filtered result.

For more information on filters, see http://www.simba.com/resources/sdk/knowledge-base/cqe-filters/.

Filter Example

Consider a typical filter query such as the following:

select EMPLOYEE.first_name from EMPLOYEE, ADDRESS where EMPLOYEE.FIRST_NAME = 'Susan'

Before the pass-down optimization step, the AE Tree looks like this:

```
AEQuery
    AEProject
        AECrossJoin
            AESelect
                AETable: DBF.Shop.EMPLOYEE
                AEComparison: EQ
                    AEValueList
                        AEColumn:
                        DBF.Shop.EM
                        PLOYEE.FIRS
                        T_NAME
                    AEValueList
                        AELiteral:
                        Susan;
                        Character
                        String
                        Literal
            AETable: DBF.Shop.ADDRESS
        AEValueList
            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

In the SQLite example connector, `SLFilterHandler` class handles the pass down. After passing this tree down to `SLFilterHandler`, the AE Tree now looks as follows:

```
AEQuery

    AEProject

        AECrossJoin

            AETable: DBF.Shop.EMPLOYEE
            AETable: DBF.Shop.ADDRESS

        AEValueList

            AEColumn: DBF.Shop.EMPLOYEE.FIRST_
            NAME
```

SQLite's `SLFilterHandler` class has handled the filter (EMPLOYEE.FIRST_NAME = 'Susan') and returned a `SLPassdownResultTable` object (a subclass of SLTableBase) representing that result to the SQLEngine. The SQLEngine uses this result returned from the DSII to do the filtering for it, and discards the AESelect node that was previously used.

Through CQE with `SLFilterHandler`, the Simba SQLEngine has performed the following steps to accomplish this:

1. Attempt to pass-down the entire condition for the AESelect node.
2. Is passing down the condition successful (`Passdown()` returned true)?
    A. Yes, Passdown() returned true. Call `TakeResult()` and substitute the returned result in for the AESelect node.
    B. No, Passdown() returned false. Is there only one CNF clause (see below for more information CNF clause handling)?
        a. Yes, only one clause. Call `TakeResult()` and substitute the returned result, if any, for the `AETable`operand of the `AESelect`.
        b. No, more than one clause. Attempt to pass-down each CNF clause one-by-one. For each CNF clause passed down, is passing down the clause successful?
            i. Yes, `Passdown()` returned `true`. Record the clause and continue to the next clause. If no more clauses, go to Step iii.
            ii. No, `Passdown()` returned `false`. Attempt to break clause down according to step ii and pass-down, then continue to the next clause. If no more clauses, go to Step iii.
            iii. Call `TakeResult()` and substitute the returned result, if any, for the `AETable` operand of the `AESelect`. Remove any clauses that were recorded in Step 1 from the `AESelect` condition.

A CNF clause is any clause that is separated by an &&. For example, with the condition (A || B) && (C && D), the statement could be broken down by one step to the following two clauses:

- (A || B)
- (C && D)

The first clause could not be broken down any further, but the second could be broken down into:

- C
- D

The SQLEngine will recursively try and pass-down CNF clauses to the DSII for it to handle, until the DSII either handles the full clause or there are no more clauses to pass down. Note that (A || B) could not be broken down and passed down to the DSII because if the DSII filtered out rows according to clause A, then it may have filtered out rows that would pass for clause B, thus causing an incorrect result to be returned.

Note:

If a filter is to be applied on the result of a sub-section of the AETree, and that section had an operation which could not be handled via CQE by the DSII, then the filter will not be passed to the DSII. This is because if the DSII could not handle the operation that would result in the result set to be filtered, then it would not be possible for it to then apply a further filter on that result set. For example, consider the following query:

```
select * from (select * from EMPLOYEE where NUM_SALARY >
10000) t1 WHERE t1.FIRST_NAME = 'Susan'
```

If the DSII can't apply the filter "NUM_SALARY > 10000" then it would also not be able to apply the filter "FIRST_NAME = 'Susan'", as that filter would need to be applied to the result of "select * from EMPLOYEE where NUM_SALARY > 10000".

Implementation

The `SLFilterHandler` constructor is the first significant method to review. During construction, the handler factory passes in the table on which the filter is to be applied to, if the handler is able to do so, along with the connector setting information:

```
SLFilterHandler::SLFilterHandler(

    SharedPtr<SLTableBase> in_table,simba_unsigned_native
    in_paramSetCount,ILogger& in_log)
    :
    m_table(in_table),
    m_paramSetCount(in_paramSetCount),
    m_log(in_log)
    {

        assert(!in_table.IsNull());
        m_table->GetTableName(m_tableName);

}
```

A reference to the table is stored for use during the pass down operation as well as for the connector's settings. In addition, the count of parameter set and driver's log information are also stored for use during `PassdownComparison()` and `TakeResult()`.

The next method to review is `Passdown()`.`SLFilterHandler` does not directly implement `Passdown()` as this has been implemented in its parent class. Instead it implements various`Passdown()` "sub" methods which the parent class delegates (invokes). For example, the partial snippet below from `SLFilterHandler::PassdownComparison()` shows some of the checks that the class performs near the start of the pass down. This includes checks for whether the pass down is enabled, the filter is on a table, and if exactly one operand is being compared on each side of the filter. Additional checks not shown in this partial snippet are also performed after which the class constructs a filter string to be used in obtaining the final result set in `TakeResult()`:

```
bool SLFilterHandler::PassdownComparison(AEComparison* in_
node)
{
```

```
// After project, they are back to their original
name, so no need to rename.
// This case is for handling passdown of parameters.
AEValueList* lOperand = in_node->GetLeftOperand();
AEValueList* rOperand = in_node->GetRightOperand();
if ((1 != lOperand->GetChildCount()) || (1 !=
rOperand->GetChildCount()))
{
return false;
}
AEValueExpr* lExpr = lOperand->GetChild(0);
AEValueExpr* rExpr = rOperand->GetChild(0);
SEComparisonType compOp = in_node->GetComparisonOp();
if ((AE_NT_VX_COLUMN != lExpr->GetNodeType()) ||
(AE_NT_VX_PARAMETER != rExpr->GetNodeType()))
{
    if ((AE_NT_VX_COLUMN == rExpr->GetNodeType())
    &&
    (AE_NT_VX_PARAMETER == lExpr->GetNodeType()))
    {
        // Swap the pointers, so the
        expressions are always in the form
        of
        // <column_reference> <compOp>
        <parameter>.
        std::swap(lExpr, rExpr);
        compOp = SLFilterHelper::FlipCompOp
        (compOp);
        }
        else
        {
        // Not a parameter. Try the regular
        simple passdown operations.
        return
        DSIExtSimpleBooleanExprHandler::Pass
        downComparison(in_node);
        }
```

```
        }
        // Get the column reference information.
        DSIExtColumnRef colRef;
        if (!GetTableColRef(lExpr, colRef) || 1 < m_
        paramSetCount)
        {
        // Column not found or too many parameter
        sets.
        // The value of parameter nodes cannot be
        inspected if the parameter set count is
        greater than 1.
        // (See DSIExtOperationHandlerFactory for
        more information)
        return false;
        }
        simba_wstring paramValue = GetParameterValue
        (rExpr->GetAsParameter());
        if (paramValue.IsNull())
        {
        // Can't handle NULL parameters.
        return false;
        }
        simba_wstring columnName = m_table-
        >GetQueryColumnName(colRef.m_colIndex);
        SLFilterHelper::PrepareCompFilter(
        m_tableName,
        columnName,
        *rExpr->GetMetadata(),
        paramValue,
        compOp,
        m_filters);

    return true;

}
```

If the filter was successfully applied, this method signals to the Simba SQLEngine that a result can be obtained. `TakeResult()` is invoked. Internally the class's `TakeResult()` method looks at the `m_filters` field which was set by calling `SLFilterHelper::PrepareCompFilter()` near the bottom of the `PassdownComparison()` method and uses that to determine whether to return null or a result set:

```
SharedPtr<DSIExtResultSet> SLFilterHandler::TakeResult()
{

    if (!m_filters.empty())
    {

        // Return filter result.
        simba_wstring filterString =
        SLFilterHelper::CreateFilterString(m_
        filters);
        // Creating the new query.
        simba_wstring newQuery = "SELECT * FROM " +
        m_table->GetQueryDefinition() + " WHERE " +
        filterString;
        return SharedPtr<DSIExtResultSet>(new
        SLPassdownResultTable(

            m_table,
            newQuery.GetAsUTF8(),
            AutoPtr<SLResultSetColumns>(m_table-
            >GetSelectColumnsClone()), m_log));

    }
    // Return NULL and let the engine do the filtering.
    return SharedPtr<DSIExtResultSet>();

}
```

If a result set can be returned, the filter constructed in the `PassdownComparison()` method is passed to the constructor of the `SLPassdownResultTable` class which uses it to build the result set to be returned. The `SLFilterHandler` class is a specialized result set class for filtered results.

The `CBFilterHandler` class also implements `CanHandleMoreClauses()` which always returns true to indicate to the Simba SQLEngine that all filter clauses will always be handled.

```
bool SLFilterHandler::CanHandleMoreClauses()
{

    // Always returns true since any incrementally adding
    more filter clauses is supported.
    return true;

}
```

This method is useful for signaling to the Simba SQLEngine whether additional filters should be passed down to the handler. For example, if your data source can only filter on one column, then the Simba SQLEngine needs to know that no further filters should be passed down because none of them would succeed. By returning false from this method after handling the first column, the DSII can signal this to the Simba SQLEngine.

Join Example

Joins are handled in a similar manner to that of Filters. Consider a typical join query such as the following:

SELECT EMPLOYEE.first_name from EMPLOYEE INNER JOIN DEPT ON EMPLOYEE.DEPT = DEPT.DEPT_ID

Before the pass-down optimization step, the AETree looks like this:

```
AEQuery
    AEProject
        AEJoin: AE_INNER_JOIN
            AETable: DBF.DBF.EMPLOYEE
            AETable: DBF.DBF.DEPT
            AEComparison: EQ
                AEValueList
                    AEColumn:
                    DBF.DBF.EMPLOYEE.DEP
                    T
                AEValueList
                    AEColumn:
                    DBF.DBF.DEPT.DEPT_ID
        AEValueList
            AEColumn: DBF.DBF.EMPLOYEE.FIRST_
            NAME
```

In SQLite, the `SLJoinHandler` class handles the passdown. After passing this tree down to `SLJoinHandler`, the AE Tree now looks as follows:

```
AEQuery
    AEProject
        AESelect
            AETable: CBJoinResult(EMPLOYEE,
            DEPT)
```

```
            AEComparison: EQ

                AEValueList

                    AEColumn:
                    SLPassdownJoinResult
                    Table(EMPLOYEE,
                    DEPT).DEPT

                AEValueList

                    AEColumn:
                    SLPassdownJoinResult
                    Table(EMPLOYEE,
                    DEPT).DEPT_ID

        AEValueList

            AEColumn: SLPassdownJoinResultTable
            (EMPLOYEE, DEPT).FIRST_NAME
```

SQLite's `SLPassdownJoinResultTable` class has handled the join condition (EMPLOYEE.DEPT = DEPT.DEPT_ID) and returned a `SLPassdownJoinResultTable` to the SQLEngine representing that joined result set. The `SLPassdownJoinResultTable` AETable node represents this as can be seen in the above AE Tree. When the DSII fully handles the join condition, the SQLEngine uses the returned result to do the join and discards the AEJoin node. As noted above, can't fully handle the join condition so the SQLEngine works in collaboration with it to properly join the results. This can be seen in the first AE Tree where there is now an AESelect instead of an AEJoin node.

Through CQE with `SLFilterHandler`, the SQL Engine has performed the following steps to accomplish this:

1. Attempt to pass-down the entire join condition for the AEJoin node.
2. Is passing down the condition successful (`Passdown()` returned true)?
    A. Yes, `Passdown()` returned true. Call `TakeResult()` and substitute the returned result in for the AEJoin node.
    B. No, `Passdown()` returned false. Is there only one CNF clause? (see below for more information on this step).
        a. Yes, only one clause. Is there a result returned from `TakeResult()`?

i. Yes, a result is returned. Create an AESelect node with the same filter condition as the AEJoin join condition, and use the returned result as the operand for the AESelect node. Replace the AEJoin with the AESelect node.

ii. No, no result is returned. Leave the AETree as is.

b. No, more than one clause. Attempt to pass-down each CNF clause one-by-one. For each CNF clause passed down, is passing down the clause successful?

i. Yes, `Passdown()` returned true. Record the clause and continue to the next clause. If no more clauses, go to step iii.

ii. No, `Passdown()` returned false. Attempt to break clause down according to step ii and pass-down, then continue to the next clause. If no more clauses, go to Step iii.

iii. Create an AESelect node with the same filter condition as the AEJoin join condition, and use the returned result as the operand for the AESelect node. Replace the AEJoin with the AESelect node. Remove any clauses that were recorded in Step 1 from the AESelect condition.

Note:

If a join is to be applied where one of the join operands had an operation which could not be handled via CQE by the DSII, then the filter will not be passed to the DSII. This is because if the DSII could not handle the operation that would result in the result set to be filtered, then it would not be possible for it to then apply a further filter on that result set. For example, take the following example query:

SELECT * FROM (SELECT * FROM EMPLOYEE WHERE NUM_SALARY > 10000) t1 INNER JOIN DEPT ON t1.DEPT = DEPT.DEPT_ID

If the DSII can't apply the filter "NUM_SALARY > 10000" then it would also not be able to apply the join condition "t1.DEPT = DEPT.DEPT_ID", as that condition would need to be applied to the result of "SELECT* from EMPLOYEE WHERE NUM_SALARY > 10000" and the DEPT table.

Implementation

The `SLJoinHandler`'s constructor is provided with the left and right tables for which the join pass down operation will attempt to run the filter on. References are stored for each, as well as for the connector settings:

```
SLJoinHandler::SLJoinHandler(SharedPtr<SLTableBase> in_
tableLeft,SharedPtr<SLTableBase> in_tableRight,AEJoinType in_
joinType,ILogger& in_log)

    :
    m_tableLeft(in_tableLeft),
    m_tableRight(in_tableRight),
    m_joinType(in_joinType),
    m_log(in_log)
    {

        assert(!in_tableLeft.IsNull());
        assert(!in_tableRight.IsNull());
        assert(m_joinType != AE_RIGHT_OUTER_JOIN);
        m_leftTable->GetTableName(m_leftTableName);
        m_rightTable->GetTableName(m_rightTableName);

    }
```

Like `SLFilterHandler`'s, `SLJoinHandler` class does not directly implement `Passdown()` but implements other `Passdown()` methods which are delegated (invoked) by the base class to handle various join comparisons. Of particular interest is the `PassdownSimpleComparision()` method which hosts similar logic to that of `SLFilterHandler::PassdownComparision()`. The following is code snippet shows the various checks the method makes, such as whether pass down is enabled and whether the order of tables matches those in the join handler:

```
bool SLJoinHandler::PassdownSimpleComparison(DSIExtColumnRef&
in_leftExpr,LiteralValue in_rightExpr,SEComparisonType in_
compOp)
{

    // Column reference may come from left or right
    table.
    if (SLFilterHelper::PrepareCompPassdown(m_leftTable,
    in_leftExpr, in_rightExpr, in_compOp, m_filters) ||
```

```
    SLFilterHelper::PrepareCompPassdown(m_rightTable, in_
    leftExpr, in_rightExpr, in_compOp, m_filters))
    {

        {
        return true;
        }
        return false;
        }

bool SLJoinHandler::PassdownSimpleComparison(DSIExtColumnRef&
in_leftExpr,DSIExtColumnRef& in_rightExpr,SEComparisonType
in_compOp)
{

    if (SLFilterHelper::PrepareCompPassdown(in_leftExpr,
    in_rightExpr, in_compOp, m_filters))
    {
    return true;
    }
    return false;

}

bool SLFilterHelper::PrepareCompPassdown(
const SharedPtr<SLTableBase>& in_table,
const DSIExtColumnRef& in_column,
const Simba::SQLEngine::LiteralValue& in_rightExpr,
const SEComparisonType& in_compOp,std::vector<simba_wstring>&
io_filters)
{

    assert(in_rightExpr.first);
    assert(!in_column.m_table.IsNull());
    if (in_table->IsReadOnlyTable())
    {

        const simba_wstring& tableName = in_table-
        >GetQueryReference();
        const simba_wstring& columnName = in_table
        ->GetQueryColumnName(in_column.m_colIndex);
```

```
        const simba_wstring& literalVal =
        GetLiteralValue(in_rightExpr);
        // Construct the filter string for input to
        SQLite.
        PrepareCompFilter(

            tableName,
            columnName,
            *in_rightExpr.first->GetMetadata(),
            literalVal,
            in_compOp,
            io_filters);

        return true;

    }
    return false;

}

bool SLFilterHelper::PrepareCompPassdown(
DSIExtColumnRef& in_leftColumn,
DSIExtColumnRef& in_rightColumn,
const SEComparisonType& in_compOp,
std::vector<simba_wstring>& io_filters)
{

    assert(!in_leftColumn.m_table.IsNull());
    assert(!in_rightColumn.m_table.IsNull());
    SEComparisonType compOp = in_compOp;
    const simba_wstring& leftTableName = static_
    cast<SLTable*>(in_leftColumn.m_table.Get())
    ->GetQueryReference();
    const simba_wstring& rightTableName = static_
    cast<SLTable*>(in_rightColumn.m_table.Get())
    ->GetQueryReference();
    const simba_wstring& leftColumnName = static_
    cast<SLTable*>(in_leftColumn.m_table.Get
    ())>GetQueryColumnName(in_leftColumn.m_colIndex);
    const simba_wstring& rightColumnName = static_
    cast<SLTable*>(in_rightColumn.m_table.Get())
    ->GetQueryColumnName(in_rightColumn.m_colIndex);
```

```
    }
    PrepareCompFilter(
        leftTableName,
        leftColumnName,
        rightTableName,
        rightColumnName,
        compOp,
        io_filters);
    return true;
}
```

If the filter was successfully applied, this method signals to the Simba SQLEngine that a result can be obtained in which `TakeResult()` will be invoked. Internally the class's `TakeResult()` method checks whether the join type is supported by SQLite (SQLite does not support the RIGHT JOIN clause and also the FULL OUTER JOIN clause) and uses that to determine whether to return null or a result set:

```
SharedPtr<DSIExtResultSet> SLJoinHandler::TakeResult()
{
    // SQLite only directly supports cross, inner, left
    outer joins. Right outer join is emulated using a
    left outer join.
    // The "JOIN" operator produces the same result as
    "CROSS JOIN" and "INNER JOIN" in SQLite.

    if (AE_INNER_JOIN == m_joinType || AE_LEFT_OUTER_JOIN
    == m_joinType)
    {
        AutoPtr<SLResultSetColumns> resultSetColumns
        (new SLResultSetColumns);
        PreparePassdownResultSetColumns
        (*resultSetColumns, m_actualJoinType);
        simba_wstring joinString = AE_INNER_JOIN ==
        m_joinType ? "JOIN" : "LEFT OUTER JOIN";
        simba_wstring filterString =
        SLFilterHelper::CreateFilterString(m_
        filters);
```

```
        // Creating the new query.
        simba_wstring leftTableQuery = m_leftTable-
        >GetQueryDefinition();
        simba_wstring rightTableQuery = m_rightTable-
        >GetQueryDefinition();
        simba_wstring newQuery = L"SELECT " + m_cols
        + " FROM " + leftTableQuery + " " +
        joinString + " " + rightTableQuery;
        simba_string tets = m_cols.GetAsUTF8();
        simba_string test = newQuery.GetAsUTF8(); //
        used for testing
        if (!filterString.IsNull())
        {

            newQuery += L" ON " + filterString;

        }
        SLTableIdentifier joinResultIdentifier(
        m_leftTable->GetTableIdentifier().GetCatalog
        (),
        m_leftTable->GetTableIdentifier().GetSchema
        (),
        m_leftTableName + "_JOINED_WITH_" + m_
        rightTableName);
        return SharedPtr<DSIExtResultSet>(

            new SLPassdownJoinResultTable(

                m_leftTable,
                m_rightTable,
                newQuery.GetAsUTF8(),
                joinResultIdentifier,
                resultSetColumns,
                m_log));

    }
    // Return null and let the engine do the join.
    return SharedPtr<DSIExtResultSet>();

}
```

If a result set can be returned, the filter constructed in the`PassdownSimpleComparison()` method is passed to the constructor of the `SLPassdownJoinResultTable` class which uses it to build the result set to be

returned. The `SLPassdownJoinResultTable` class is a specialized result set class for filtered results.

The `SLJoinHandler` class also implements `CanHandleMoreClauses()` which always returns true to indicate to the Simba SQLEngine that all filter clauses will always be handled.

```
bool SLJoinHandler::CanHandleMoreClauses()
{
    // Always returns true since any incrementally adding
    more filter clauses is supported.
    return true;
}
```

Aggregation Handlers

Passed down aggregations are handled by classes which implement `IAggregationHandler`. This interface defines one passdown function that accepts an `AEAggregate` node. If the aggregation can be handled, the passdown function must return a new result set that will represent the aggregation of the base result. If the aggregation cannot be handled, the passdown function must return null and the Simba SQLEngine will handle the aggregation.

To simplify analysis of the `AEAggregate` node, two abstract subclasses are defined. `DSIExtAbstractAggregationHandler` divides the `AEAggregate` into passdowns for the individual aggregations needed and the individual groupings to use for the aggregations. If each aggregation and grouping passed down is accepted by returning true, a method called CreateResult will be invoked to create the aggregation result that will replace the `AEAggregate` node in the AE-Tree. If any aggregation function or grouping passed down is rejected by returning false, the entire aggregate passdown will be abandoned and `CreateResult` will not be invoked.

Note:

Despite having a different name, the invocation of `CreateResult` and the operation performed by this method is similar to that of the `TakeResult` method of the other handlers.

The `DSIExtSimpleAggregationHandler` class derives further from `DSIExtAbstractAggregationHandler` to identify and pass down several simple cases that are easier to handle. It only passes down aggregations of literals or column references and only passes down groupings of column references. If the aggregation

or grouping contains any more complex value expressions then the passdown will be rejected.

Unlike filter and join handlers, the columns in the generated result set do not match columns in the base tables directly. Instead, one column must be created for each aggregate function or grouping expression passed down. The order of the columns must match the order that the pass down functions are called in. That is, if SetGroupingExpr is called twice followed by SetAggregateFn once, the generated result set must contain exactly three columns; the first two being columns for the grouping values, the third being the aggregated result values.

Aggregation Example

Consider a typical query involving an aggregation:

```
SELECT COUNT(*) from EMPLOYEE
```

Before the pass-down optimization step the AETree looks like this:

```
AEQuery

    AEProject

        AEAggregate

            AETable: DBF.DBF.EMPLOYEE
            AEValueList

                AECountStarAggrFunction

        AEValueList

            AERename: EXPR_1

                AEProxyColumn: AEAggregate -
                column #0
```

In SQLite, the `SLAggregationHandler` class handles the pass down. After passing this tree down to `SLAggregationHandler`, the AETree looks as follows:

```
AEQuery

    AEProject

        AETable: DBF.DBF.EMPLOYEE
        AEValueList

            AERename: EXPR_1

                AEProxyColumn:
                DBF.DBF.EMPLOYEE1.
```

has handled the aggregation (COUNT(*)) in the DSII and returned a SLTableBase representing the aggregation to the Simba SQLEngine. The AETable node for the EMPLOYEE node represents this. To verify this, you can place a breakpoint in `SLTableBase::GetTableName()`, which is a method to alter the returned table name, and view the value of `out_tableName`. The Simba SQLEngine uses this result returned from the DSII, and discards the AEAggregate node that was previously used.

The Simba SQLEngine attempts to pass-down the entire aggregation, which can contain one or more aggregate functions. If at least one of the aggregate functions can't be handled, then the pass-down is aborted and the Simba SQLEngine will handle the aggregation. The Simba SQLEngine does not allow partial aggregations.

Note:

A CQE aggregation can't be applied to the result of a sub-section of the AETree if that section had an operation which could not be handled via CQE, instead the Simba SQLEngine will handle it. This is because if the DSII could not handle the operation to cause the result set to be filtered, then it would not be possible for it to apply a further aggregation on a result it could not compute.

If there are no columns in the GROUP BY clause, then the result should only have a single row. Otherwise, there should be one row for each group specified by the set of columns in the GROUP BY clause. For example, the following query:

```
SELECT C1, COUNT(*) FROM T1 GROUP BY C1
```

would result in two columns, one for C1 and one for COUNT(*), and should return a row for every different value of C1. In otherwords, if table T1 contained the following columns and rows:

C1	C2
A	B
A	D
B	E

then the result returned from the query should look like the following:

C1	count (*)
A	2
B	1

If a query containing an aggregation is in a complicated form, the SQL Engine will transform it into a "standard" form. For example, consider the following query:

SELECT C1 + AVG(C2) * COUNT(C3) FROM T1 GROUP BY C1

Simba SQLEngine will ensure that an IAggregationHandler object only needs to deal with a query that resembles this:

SELECT C1, AVG(C2), COUNT(C3) FROM T2 GROUP BY C1

Implementation

The `SLAggregationHandler's` constructor is provided with the table on which to perform the aggregation on, along with connector configuration settings. The constructor stores references to each and also initializes a Boolean member called `passdownSupported` which will be used later on to determine if a result should be returned:

```
SLAggregationHandler::SLAggregationHandler(

    SharedPtr<SLTableBase> in_table,
    ILogger& in_log,
    IStatement& in_statement) :
    m_table(in_table),
    m_passdownSupported(true),
    m_log(in_log),
    m_statement(in_statement)

{

    assert(!in_table.IsNull());
    m_table->GetTableName(m_tableName);

}
```

`SLAggregationHandler`'s does not implement Passdown because this has been done in a base class. Instead, a number of `Set()*` methods have been defined in the base class which are called by Passdown to provide the handler with information about the specific aggregation that has been encountered in the query. Each method can then return true or false to specify if that aggregation can be handled. For example, `SLAggregationHandler::SetAggregateFn`, shown below, first it checks if the given aggregate function is a `COUNT(*)` (since `COUNT(*)` is the only aggregate function supported by our SQLite sample), and if it's not a `COUNT(*)`, then set `m_passdownSupported` to `false` and let SQLEngine handle it:

```
bool SLAggregationHandler::SetAggregateFn(SEAggrFunctionID
in_aggrFnID)
{

    // COUNT(*) is supported.
    if (SE_FUNCT_COUNT_STAR == in_aggrFnID)
    {
```

```
        /SLAggrInfo aggrInfo = {

            COUNT_STAR, -1, false };
            m_aggrFunctionList.push_back
            (aggrInfo);
            return true;

        }

    }
    m_passdownSupported = false;
    return false;

}
```

Projection Handlers

Projection handling provides a DSII with the opportunity to handle the selection of individual columns. Passed down projections are handled by classes which implement `IProjectionHandler`. This interface defines one passdown method that accepts an AEProject node. If the projection can be handled, the handler must return a new result set that represents the projection of the base result.

Typically you will subclass the `DSIExtAbstractProjectionHandler`, which provides support for the projections of columns, but does not handle projections of complex elements such as scalar functions. If you need more functionality then you should override other functions in the parent classes as needed, or subclass.

Note:

The handling of columns is considered the minimal support necessary to implement projection handling.

Projection Example

Consider the following example query being handled by and example connector:

SELECT FIRST_NAME, LAST_NAME, EMP_ID, DATE_HIRE, NU_SALARY, DEPT, INTERESTS FROM EMP

Prior to passdown, the AE Tree for this query is as follows:

```
AEQuery

    AEProject

        AETable: DBF.DBF.EMP
        AEValueList

            AEColumn: DBF.DBF.EMP.FIRST_NAME
            AEColumn: DBF.DBF.EMP.LAST_NAME
            AEColumn: DBF.DBF.EMP.EMP_ID
            AEColumn: DBF.DBF.EMP.DATE_HIRE
            AEColumn: DBF.DBF.EMP.NUM_SALARY
            AEColumn: DBF.DBF.EMP.DEPT
            AEColumn: DBF.DBF.EMP.INTERESTS
```

Simba SQLEngine reduces the tree to:

```
AEQuery

    AETable: DBF.DBF.PASSDOWN_EMP
```

In the SQLite sample, projection handling is performed by `SLProjectionHandler` which subclasses `DSIExtAbstractProjectionHandler`. In the example above, `SLProjectionHandler` handled the projection in the DSII and returned a result set which consists of a new table (PASSDOWN_EMP) containing only the columns being projected. The projection node was then replaced by the result table node since the query was passed down entirely (i.e fully handled by the DSII).

The sample connector only handles simple projection items (i.e. columns), but not complex ones such as scalar functions. The Simba SQLEngine however, assumes that a DSII can handle both simple columns and complex projection columns.

Consider a query like the one shown in the following example which is handled by a connector that supports projection handling of simple columns and the substring scalar function, but not other scalar functions:

```
SELECT FIRST_NAME, SUBSTRING(LAST_NAME, 0, 3), DEPT, ABS(NUM_
SALARY) FROM EMP
```

Prior to pass down, the AE Tree would look as follows:

```
AEQuery

    AEProject

        AETable: DBF.DBF.EMP
        AEValueList

            AEColumn: DBF.DBF.EMP.FIRST_NAME
            AERename: EXPR_1

                AEScalarFn: substring

                    AEValueList

                        AEColumn:
                        DBF.DBF.EMP
                        .LAST_NAME
                        AELiteral:
                        0; Unsigned
                        Integer
                        Literal
                        AELiteral:
                        3; Unsigned
                        Integer
                        Literal

            AEColumn: DBF.DBF.EMP.DEPT
            AERename: EXPR_2

                AEScalarFn: abs

                    AEValueList

                        AEColumn:
                        DBF.DBF.EMP
                        .NUM_SALARY
```

After pass down, the partially handled AE tree would look as follows:

```
AEQuery
```

```
AEProject

    AETable: DBF.DBF.PASSDOWN_EMP
    AEValueList

        AEColumn: DBF.DBF.PASSDOWN_
        EMP.FIRST_NAME
        AEColumn: DBF.DBF.PASSDOWN_EMP.EXPR_
        1
        AEColumn: DBF.DBF.PASSDOWN_EMP.DEPT
        AERename: EXPR_2
             AEScalarFn: abs
                  AEValueList

                    AEColumn: DBF.DBF.PASSDOWN_
EMP.NUM_SALARY
```

In this case, the connector was able to handle the columns (first_name, last_name, dept and num_salary), and the `substring` scalar function. Since it was not able to handle the `abs` function, the “abs(num_salary)” column was partially passed down: the “num-salary” column was passed down but “abs(num_salary)” was not. Therefore, in this case the columns in PASSDOWN_EMP table are:“first_name”, “dept”, “substring (last_name, 0, 3)”, “num_salary”.

The DSII returns the result table (PASSDOWN_EMP) and the Simba SQLEngine updates the AEColumn nodes in the tree to reflect this. The engine would also handle the projection expressions not being passed down.

Through CQE with the SLProjectionHandler, the Simba SQLEngine has performed the following steps during the passdown of a projection:

1. Attempt to pass down all columns/expressions in projection list one by one. Can the current projection item be passed down?
   A. Yes. Go to step 1.c.
   B. No. Walk through the sub-tree rooting from the current item and look for columns. If there are any column references, pass them. Go to step 1.C.
   C. Is the current item the last one in the projection list?
      i. Yes. Go to step 2.
      ii. No. Go to the next item. Go to step 1.

2. Take the passdown result from the DSII. Is the result null?
    A. Yes (the DSII is not able to handle the projection, so no passing down occurred). Leave the projection node as intact and the engine will handle it. Go to End.
    B. No (the DSII is able to handle the projection, either entirely or partially, so passing down occurred). Were all items in projection list passed down successfully?
        i. Yes (entirely passed down). Replace the projection node with the result table node. The engine will just use the table node and discard the projection node. Go to End.
        ii. No (partially passed down). Update the projection node to have all projection items reference the new table as the old table will be discard. The engine will handle the updated projection node (take care of all the projection expressions that couldn't be passed down).

Note:

It is important to be aware of how projection handling works when implementing other types of operation handlers, because projections are a common pattern and are often passed down before other pass down operation handlers are invoked. Generally, supported handlers for Distinct, Sort, Top, and Union would happen ‘after’ projection, while handlers for Join, Filter, and Aggregation would happen before, though this can change when subqueries are present.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateProjectionHandler` method creates the `XMProjectionHandler` object passing in the table associated with the projection query. The constructor also initializes a `SharedColumns` object which the handler will populate with column metadata during the passdown operation:

```
SLProjectionHandler::SLProjectionHandler
(SharedPtr<SLTableBase> in_table,ILogger& in_log) :

    ;m_table(in_table),
    m_log(in_log),
    m_metadata(new SLResultSetColumns()),
    m_passdown(false)

{
}
```

SLProjectionHandler does not directly implement `Passdown` as this has been implemented in its parent class. Instead it implements various Passdown "sub" methods which the parent class delegates (invokes). Most notably is the `SLProjectionHandler::PassdownColumn()` method (shown below) which handles the pass down of a column and will be invoked by the Simba SQLEngine for each column in the projection:

```
void SLProjectionHandler::PassdownColumn(AEColumn* in_node,
const simba_wstring* in_name)
{

    assert(!m_table.IsNull());
    assert(in_node);
    m_table->GetTableName(m_tableName);
    AddColumn(in_node, in_name);
    m_passdown = true;

}

//////////////////////////////////////////////////////

void SLProjectionHandler::AddColumn(const AEColumn* in_node,
const simba_wstring* in_name)
{
```

```
    DSIExtColumnRef colRef;
    GetTableColRef(in_node, colRef);
    simba_wstring tableName;
    simba_wstring colOriginal;
    simba_wstring colAlias;
    simba_uint16 colIndex = colRef.m_colIndex;
    GetColumn(colRef)->GetName(colOriginal);
    tableName = m_table->GetQueryReference();
    colAlias = m_table->GetQueryColumnName(colIndex);
    simba_string testTableName = tableName.GetAsUTF8();
    simba_string testColOriginal = colOriginal.GetAsUTF8
    ();
    simba_string testColAlias = colAlias.GetAsUTF8();
    simba_wstring colName;
    if (!colOriginal.IsEmpty())
    {

        colName = tableName + "." +
        SLPassdownUtilities::QuoteAndEscapeQuotes
        (colAlias, SL_DOUBLEQUOTE);AddColumnName
        (colName);

    }
    // Record the column metadata.
    AutoPtr<SqlTypeMetadata> metadata(in_node-
    >GetMetadata()->Clone());
    AutoPtr<DSIColumnMetadata> dsiColumnMetadata(new
    DSIColumnMetadata(in_node->GetColumnMetadata()));
    if (in_name)
    {

        dsiColumnMetadata->m_name = *in_name;
        dsiColumnMetadata->m_label = *in_name;
        dsiColumnMetadata->m_unnamed = false;

    }
    m_metadata->AddColumn(new SLResultSetColumn(metadata,
    dsiColumnMetadata, colAlias));

}
////////////////////////////////////////////////////////////
////////////////////////////////void
```

```
SLProjectionHandler::AddColumnName(const simba_wstring& in_
colName)
{

    if (m_cols.IsEmpty())
    {

        im_cols = in_colName;

    }
    else
    {

        m_cols = m_cols + L", " + in_colName;

    }

}
```

This method uses the `AEColumn` object passed in to obtain and store metadata about the projection column of interest. The method also takes in the column alias, and uses that to reference the column in the metadata, if the alias exists. Each time this method is invoked, the column metadata is added to the m_metadata member. This collection of metadata is used later in the `TakeResult` method (described next) to build the result set that is to be returned to the Simba SQLEngine.

Note that since columns are the minimally supported projection entity which must be supported by a projection handler, PassdownColumn must be implemented. Also note that this method does not return a value, because it is assumed that the pass down is not only supported by the DSII but will also succeed when provided with a projection column.

After `PassdownColumn` has been invoked for each column, the Simba SQLEngine then invokes `SLProjectionHandler::TakeResult` once, to obtain a result set consisting of all projected columns:

```
SharedPtr<Simba::SQLEngine::DSIExtResultSet>
SLProjectionHandler::TakeResult()
{

    if (m_passdown)
    {
```

```
        simba_wstring newQuery = "SELECT " + m_cols +
        " FROM " + m_table->GetQueryDefinition();
        // Getting projected column metadata.
        AutoPtr<SLResultSetColumns> colMetadata(m_
        metadata.Detach());
        return SharedPtr<DSIExtResultSet>(new
        SLPassdownResultTable(

            m_table,
            newQuery.GetAsUTF8(),
            colMetadata,
            m_log));

    }
    return SharedPtr<DSIExtResultSet>();

}
```

This method takes the collection of column metadata (m_metadata) and the name of all projection columns (m_cols), and uses them to construct a result set.

Union Handlers

Union handling provides a DSII with the opportunity to handle the union of columns from two or more tables. The Simba SQLEngine passes down the AE Tree node for the union expression. This node is handled by classes which implement `IUnionHandler`. This interface defines one Passdown method that accepts an AEUnion node and must return a new result set containing the result of the whole union.

Note:

Unlike most other pass down handlers, there are no abstract union handlers to subclass so a union handler must directly implement `IUnionHandler` as has been done in the sample connector.

Union Example

Consider the following example query being handled by the sample connector:

select a.log_c, a.char_c from alltype1 a UNION ALL select b.log_c, b.char_c from alltype2 b

Prior to pass down, the AE Tree looks as follows:

```
AEQuery
AEUnion
AEProject
AETable: a
AEValueList
AEColumn: a.LOG_C
AEColumn: a.CHAR_C
AEProject
AETable: b
AEValueList
AEColumn: b.LOG_C
AEColumn: b.CHAR_C
```

After pass down, the Simba SQLEngine has optimized the AE Tree as follows:

```
AEQuery

AETable: PASSDOWN_a
```

In the sample connector, union handling is performed by `SLUnionHandler` which implements `SLUnionHandler`. For the example above, the operations on both sides of the union were first passed down to the sample connector and handled using the connector's projection handler. The Simba SQLEngine then passed down the node representing the union operation which contains the projection tables in subnodes to `SLUnionHandler`. `SLUnionHandler` then generated and returned a result set containing the row data for the columns of the union. Note that implementing a union handler requires that a projection handler also be implemented. This is because there are always AEProject nodes under an AEUnion node, so if the connector doesn't handle the projections, then the Union will not be passed down.

Through CQE with the SLUnionHandler, the Simba SQLEngine has performed the following steps to accomplish this:

1. Check both operations preceeding the union operation. Were both of them passed down successfully (already table objects)?

   A. Yes. Attempt to pass down the union operation to the DSII. Go to Step 2.
   B. No. Unable to pass down union operation. Go to End.
2. Is passing down union successful?
   A. Yes. Take the result table from the DSII and replace the union node with the new table node. The engine will use the table node and discard the union node. Go to End.
   B. No. Leave the union node as intact and the engine will handle it. Go to End.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateUnionHandler` method creates the `SLUnionHandler` object. The tables to perform the union on will be provided during pass down, so the object's constructor does not take in a table like other pass down handlers do:

```
SLUnionHandler::SLUnionHandler(

    ILogger& in_log):
    m_log(in_log)

{

    // Do nothing.

}
```

SLUnionHandler's Passdown method handles the pass down of a union operation:

```
SharedPtr<DSIExtResultSet> SLUnionHandler::Passdown(AEUnion*
in_node)
{

    SharedPtr<DSIExtResultSet> leftTable = in_node-
    >GetLeftOperand()->GetAsTable()->GetTable();
    SharedPtr<DSIExtResultSet> rightTable = in_node-
    >GetRightOperand()->GetAsTable()->GetTable();

        assert(!leftTable.IsNull());
        assert(!rightTable.IsNull());
        SLTableBase* firstTable = static_
        cast<SLTableBase*>(leftTable.Get());
        SLTableBase* secondTable = static_
        cast<SLTableBase*>(rightTable.Get());
        simba_wstring firstQuery = L"SELECT * FROM "
        + firstTable->GetQueryDefinition();
        simba_wstring secondQuery = L"SELECT * FROM "
        + secondTable->GetQueryDefinition();
        simba_wstring passDownQuery = firstQuery + L"
        UNION ";
        if (in_node->IsAllOptPresent())
```

```
        {
            passDownQuery += L"ALL ";
        }
        passDownQuery += secondQuery;
        SLTableIdentifier unionResultIdentifier(
            firstTable->GetTableIdentifier
            ().GetCatalog(),
            secondTable->GetTableIdentifier
            ().GetSchema(),
            firstTable->GetTableName() + L"_
            UNION_WITH_" + secondTable-
            >GetTableName());
        return SharedPtr<DSIExtResultSet>(new
        SLTableBase(
            firstTable->GetDatabase(),
            passDownQuery.GetAsUTF8(),
            unionResultIdentifier,
            m_log,
            false,
            false,
            firstTable->GetDataEngine(),
            firstTable->GetConnection(),
            NULL));
}
```

The method begins by creating a “select * from table” query for each of the two tables for union operation (e.g. “tableA UNION tableB” => “select * from tableA UNION select * from tableB”). When constructing the new query, it also checks if the keyword ALL is present. Then the new query is used to create the result set to be returned. And the new table (the result of the union operation) is returned to Simba SQLEngine with the new name “tableA _UNION_WITH_tableB”.

Note:

`IUnionHandler` will support both UNION and UNION ALL, so implementing this interface in your own connector will allow you to support both statements.

If the option was specified, then the pass down handler obtains the left and right tables from the union and proceeds to perform the union operation by iterating through all the row data for the columns specified in the union. This data is combined into a new result set and then returned to the Simba SQLEngine. Note that this example is mainly for demonstration purposes to show how a union can be handled, and does not provide any significant increase in performance.

Distinct Handlers

Distinct handling provides a DSII with the opportunity to handle the selection of distinct row data for columns of a single table. The Simba SQLEngine passes down the AE Tree node for the distinct expression which contains subnodes for the tables involved in the union. This node is handled by classes which implement `IDistinctHandler`. This interface defines one Passdown method that accepts an AEDistinct node and must return a new result set containing the result of the distinct operation. Note that implementing a distinct handler requires that a projection handler also be implemented. This is because there is always an AEProject node under an AEDistinct node, so if the connector doesn't handle the projection, then the distinct will not be passed down.

Note:

Unlike most other pass down handlers, there are no abstract distinct handlers to subclass so a distinct handler must directly implement IDistinctHandler as has been done in the sample connector.

Distinct Example

Consider the following example query being handled by a connector:
`SELECT DISTINCT FIRST_NAME FROM EMP`

Prior to pass down, the AE Tree looks as follows:

```
AEQuery

    AEDistinct

        AEProject

            AETable: DBF.DBF.EMP

            AEValueList

                AEColumn: DBF.DBF.EMP.FIRST_
                NAME
```

After pass down, the Simba SQLEngine has optimized the AE Tree as follows:

```
AEQuery
     AETable: DBF.DBF.PASSDOWN_EMP
```

In the connector above, distinct handling is performed by `SLDistinctHandler` which implements `IDistinctHandler`. For the example above, the select statement is first passed down to the sample connector and handled using the connector's projection handler. The Simba SQLEngine then passed down the node representing the distinct operation which contains the projection table in a subnode to `SLDistinctHandler`. `SLDistinctHandler`then generated and returned a result set containing the columns and rows for the distinct statement.

Through CQE with the `SLDistinctHandler`, the Simba SQLEngine has performed the following steps to accomplish this:

1. Attempt to pass down the top operation. Is passing down top successful?
    a. Yes. Take the result table from the DSII and replace the top node with the new table node. The engine will use the table node and discard the top node. Go to End.
    b. No. Leave the distinct operation and distinct node as intact and the engine will handle it. Go to End.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateDistinctHandler` method creates the `SLDistinctHandler` object. The table to perform the distinct selection on will be provided during pass down, so the object's constructor does not take in a table like other passdown handlers do:

```
SLDistinctHandler::SLDistinctHandler(ILogger& in_log) :
m_log(in_log)
{

    // Do nothing.

}
```

`SLDistinctHandler`'s`Passdown()` method handles the pass down of the distinct operation:

```
SharedPtr<DSIExtResultSet> SLDistinctHandler::Passdown
(AEDistinct* in_node)
{

    assert(in_node);
    SLTableBase* originalTable = static_
    cast<SLTableBase*>(
    in_node->GetOperand()->GetAsTable()->GetTable().Get
    ());
    m_table.Reset(originalTable);
    simba_wstring newQuery = "SELECT DISTINCT * FROM (" +
    m_table->GetQueryDefinition() + ")";
    return SharedPtr<DSIExtResultSet>(new
    SLPassdownResultTable(

        m_table,
        newQuery.GetAsUTF8(),
        AutoPtr<SLResultSetColumns>(m_table-
        >GetSelectColumnsClone()),
        m_log));

}
```

The method creates a new "select distinct * from inputTable" query and uses it to construct a result set returned to Simba SQLEngine.

Sort Handlers

Sort handling provides a DSII with the opportunity to handle the sorting of data based on the columns specified in an ORDER BY clause. Passed down sorts are handled by classes which implement ISortHandler. This interface defines a Passdown method that accepts an AESort node in which nodes for a projection are contained. If the sort can be handled, the method must return the number of columns that it is able to sort. The Simba SQLEngine will then invoke the class's TakeResult method to obtain the sorted result set. Note that implementing a sort handler requires that a projection handler also be implemented. This is because there is always an AEProject node under an AESort node, so if the connector doesn't handle the projection, then the sort will not be passed down.

Consider the following example query being handled by the SQLite sample connector:

SELECT FIRST_NAME, NUM_SALARY FROM EMP ORDER BY NUM_SALARY

Prior to pass down, the AE Tree for this query is as follows:

```
AEQuery
    AESort
        AEProject
            AETable: DBF.DBF.EMP
            AEValueList
                AEColumn: DBF.DBF.EMP.FIRST_
                NAME
                AEColumn: DBF.DBF.EMP.NUM_
                SALARY
```

After pass down to the sort handler, the Simba SQLEngine reduces the tree to:

```
AEQuery
    AETable: DBF.DBF.PASSDOWN_EMP
```

In the SQLite sample connector, sort handling is performed by `SLSortHandler` which implements `ISortHandler`. In the example above, the sort handler handled the projection in the DSII and returned a result set which consists of a new sorted table (PASSDOWN_EMP). The AESort node was then replaced by the result table node since the query was successfully passed down.

Note that the SQL Engine does not support partial pass downs for sort (i.e. the pass down handler must handle (sort) on all columns). If the handler cannot fully handle the sort, then the AE Tree in the example above, would not be altered.

Note:

Currently the SDK only supports using the result of a full sort; partial sorts may be supported in the future. Currently, if a handler signals to the Simba SQLEngine that it will handle a partial sort, then the Simba SQLEngine will not take the result, and handle the full sort itself instead.

Through CQE with the `SLSortHandler`, the Simba SQLEngine has performed the following steps to accomplish this:

1. Attempt to pass down the sort operation. Is passing down sort successful (`Passdown()` returns an integer greater than 0)? (`Passdown()` would return the number of sort specifications being passed down)
    A. Yes. Is the returned number equal to the total number of sort specifications (entirely passed down) and is the sort order the same as the one in the engine?
        i. Yes. Go to End.
        ii. No, sort was partially passed down (currently not supported by the Simba SQLEngine). So though the DSII is able to help do part of the work, the engine will still do all the work itself. Go to End.
2. No. Leave the sort node as intact and the engine will handle it. Go to End.

Implementation

This section shows a sample implementation. In this example, the `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers and its `CreateSortHandler` method creates the `SLSortHandler` object. Since the table to sort on will be provided to the Passdown method, the constructor doesn't take the table as a parameter:

```
SLSortHandler::SLSortHandler(ILogger& in_log) :
m_log(in_log)
{

    // Do nothing.

}
```

The Passdown method takes in an AESort node containing the projection to sort on, as well as an enum specifying the order of sorting, if specified:

```
simba_uint16 SLSortHandler::Passdown(AESort* in_node,
SESortOrder& io_sortOrder)
{

    assert(in_node);
    SLTableBase* originalTable = static_
    cast<SLTableBase*>(
    in_node->GetOperand()->GetAsTable()->GetTable().Get
    ());
    m_table.Reset(originalTable);
    m_restrictedColCount = in_node->GetColumnCount();
    const SESortSpecs* sortSpecs = in_node->GetSortSpecs
    ();
    PrepareSort(sortSpecs);
    io_sortOrder = NOT_ODBC_ORDER;
    return sortSpecs->size();

}
```

The methods initializes `m_table` member and call the helper method `SLSortHandler::PrepareSort()` to prepare the order by clause.

```
void SLSortHandler::PrepareSort(const SESortSpecs* in_
sortSpecs)
{
```

```
    m_orderBy = L"ORDER BY ";
    simba_wstring colAlias, currColName, currOrder;
    simba_wstring tableName = m_table->GetQueryReference
    ();
    for (simba_size_t i = 0; i < in_sortSpecs->size();
    ++i)
    {

        const SESortSpec& curSortSpec = in_sortSpecs-
        >at(i);
        colAlias = m_table->GetQueryColumnName
        (curSortSpec.m_colNumber);
        currColName =
        tableName + "." +
        SLPassdownUtilities::QuoteAndEscapeQuotes
        (colAlias, SL_DOUBLEQUOTE);
        currOrder = curSortSpec.m_isAscending ?
        ORDER_ASC : ORDER_DESC;
        // Forming order by clause.
        m_orderBy += currColName + " " + currOrder;
        if (i != in_sortSpecs->size() - 1)
        {

            m_orderBy += ", ";

        }

    }

}
```

The PrepareSort() method constructs an order-by clause (e.g. “order by tableA.COL1 asc, tableB.COL2 desc”) and stores the clause in m_orderBy member. This order-by clause is used in SLSortHanlder's TakeResult() method to construct the new query. The following code snippet shows the implementation of TakeResult:

```
SharedPtr<DSIExtResultSet> SLSortHandler::TakeResult()
{

    simba_wstring restrictedColNames =
    PrepareRestrictedColNames();
    simba_wstring newQuery =

        "SELECT " + restrictedColNames +
```

```
        " FROM " + m_table->GetQueryDefinition() +
        " " + m_orderBy;
        return SharedPtr<DSIExtResultSet>(new
        SLPassdownResultTable(
        m_table,
        newQuery.GetAsUTF8(),
        AutoPtr<SLResultSetColumns>(m_table-
        >GetSelectColumnsClone(0, m_
        restrictedColCount-1)),
        m_log));

}
```

This method creates a new query using m_orderBy member (initialized in SLSortHandler::PrepareSort()) and restrictedColNames (returned from SLSortHandler::PrepareRestrictedColNames()), and uses the new query to construct the result set. The following code snippet shows the implementation of PrepareRestrictedColNames():

```
simba_wstring SLSortHandler::PrepareRestrictedColNames()
{

    simba_wstring colAlias, currColName;
    simba_wstring tableName = m_table->GetQueryReference
    ();
    simba_wstring restrictedColNames;
    for (simba_size_t i = 0; i < m_restrictedColCount;
    ++i)
    {

        if (!restrictedColNames.IsEmpty())
        {

            restrictedColNames += ",

        }
        colAlias = m_table->GetQueryColumnName(i);
        currColName =
        tableName + "." +
        SLPassdownUtilities::QuoteAndEscapeQuotes
        (colAlias, SL_DOUBLEQUOTE);
```

```
        // Forming the restricted column names in
        select clause
        restrictedColNames += currColName;

    }
    return restrictedColNames;

}
```

This helper method prepares the restricted column names in select clause (in the form of “tableA.COL1, tableB.COL2, tableC.COL3”).

Top Handlers

Top handling provides a DSII with the opportunity to handle the selection of a limited number of rows. Passed down top operations are handled by classes which implement `ITopHandler`. This interface defines one `Passdown`method that accepts an `AETop`node. If the top selection can be handled, the handler must return a new result set that represents the selection of the base result.

Typically you will subclass the `DSIExtAbstractTopHandler`, which provides support for queries with Top specified. Although this class supports both TOP N and TOP P PERCENT, currently the Simba SQLEngine does not support the latter. Note that implementing a top handler requires that a projection handler also be implemented. This is because there is always an AEProject node under an AETop node, so if the connector doesn't handle the projection, then the top will not be passed down.

Consider the following example query being handled by an example connector:

SELECT TOP 3 NUM_SALARY FROM EMP

Prior to pass down, the AE Tree for this query is as follows:

```
AEQuery

    AETop

        AEProject

            AETable: DBF.DBF.EMP
            AEValueList

                AEColumn: DBF.DBF.EMP.NUM_
                SALARY
```

After pass down to the top handler, the Simba SQLEngine reduces the tree to:

```
AEQuery
AETable: DBF.DBF.PASSDOWN_EMP
```

In this sample connector, top handling is performed by `SLTopHandler` which implements `DSIExtAbstractTopHandler`. In the example above, `SLTopHandler` handled the top selection in the DSII and returned a result set which consists of a new table (PASSDOWN_EMP) containing only the first three rows. The AETop node was then replaced by the result table node since the query was passed down entirely (i.e. fully handled by the DSII).

Through CQE with the `SLTopHandler`, the Simba SQLEngine has performed the following steps to accomplish this:

1. Attempt to pass down the top operation. Is passing down top successful?
    A. Yes. Take the result table from the DSII and replace the top node with the new table node. The engine will use the table node and discard the top node. Go to End.
    B. No. Leave the top node as intact and the engine will handle it. Go to End.

Implementation

The SQLite sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateTopHandler` method creates the XMTopHandler object passing in the table associated with the selection query:

```
AutoPtr<ITopHandler>
SLOperationHandlerFactory::CreateTopHandler
(SharedPtr<Simba::SQLEngine::DSIExtResultSet> in_table)
{
SharedPtr<SLTableBase> table(static_cast<SLTableBase*> (in_
table.Get()));
return AutoPtr<ITopHandler>(new SLTopHandler(table, m_log));
}
```

`SLProjectionHandler` does not directly implement Passdown as this has been implemented in its parent class which extracts the value for the total number of rows to be returned. The parent class then invokes the (virtual) PassdownSkipMTopN method implemented in XMTopHandler, passing along this number and the table provided to Passdown. The following code snippet shows the implementation of `SLTopHandler::PassdownSkipMTopN` which performs the Top logic:

```
SharedPtr<DSIExtResultSet> SLTopHandler::PassdownSkipMTopN(
    SharedPtr<DSIExtResultSet> in_table,
    simba_uint64 in_skip,
    simba_uint64 in_limit)
    {
        simba_wstring limitClause = L"LIMIT " +
        NumberConverter::ConvertUInt64ToString(in_
        limit);
        if (in_skip != 0)
        {
            limitClause += L" OFFSET " +
            NumberConverter::ConvertUInt64ToStri
            ng(in_skip);
        }
```

```
        simba_wstring newQuery = "SELECT * FROM (" +
        m_table->GetQueryDefinition() + ") " +
        limitClause;
        return SharedPtr<DSIExtResultSet>(
        new SLPassdownResultTable(
        m_table,
        newQuery.GetAsUTF8(),
        AutoPtr<SLResultSetColumns>(m_table-
        >GetSelectColumnsClone()),
        m_log));

    }
```

The most important aspect of this method is that it is capable of performing a sort. As illustrated in the section Pass-Down Operation Handlers, when a Sort accompanies a Top statement, the Sort passdown will be invoked before the Top passdown. For this situation the Simba SQLEngine provides the DSII with two options for when to best handle the sort:

1. When the Sort is being passed down, the DSII can sort all rows in the table and return the result table with all rows sorted. Then when Top is being passed down with the result table from the Sort passdown, it picks the first n rows in the sorted table and returns a new result table with first n rows.
2. When the Sort is being passed down, the DSII can first check if there is a TOP with the SORT. If so, the DSII can delay sorting, which means the DSII doesn't do sorting right away. Instead it creates the result table with same row order as the original table and marks it as "needs sort". Then when the Top is being passed down with the result table from Sort passdown (the table with the mark "needs sort"), it first checks whether the table needs sorting. If so, it performs the sorting but only needs to do so on the most top n rows.

`SLTopHandler::PassdownSkipMTopN` first obtains a reference to the table from which to retrieve the rows. And since the sample connector implements the second option for handling the Sort statement, a check is made using the `if (table->GetSortInfo().m_needsSort)` statement to determine if the handler should perform the sorting. Note that the `m_needsSort` member was set by the Sort handler. If set to true, the method gets the rows, but then sorts and returns only the top N rows. If sorting is not required, then a copy of the table is made and all rows beyond the maximum number are deleted one by one. From the table created, the method then creates a result set to be returned to the Simba SQLEngine.

Except Handlers

An Except operator is used to handle situations where only one of two combined select statements returns rows. The Simba SQLEngine passes down the AE Tree node for the except expression. This node is handled by classes which implement `IExceptHandler`. This interface defines one Passdown method that accepts an AEExcept node and must return a new result set containing the result of the whole except.

Note:

Unlike most other pass down handlers, there are no abstract except handlers to subclass so an except handler must directly implement `IExceptHandler` as has been done in the sample connector.

Except Example

Consider the following example query being handled by the sample connector:

Select a.log_c, a.char_c from alltype1 a EXCEPT ALL Select b.log_c, b.char_c From alltype2 b

Prior to pass down, the AE Tree looks as follows:

```
AEQuery
AEExcept
AEProject
AETable: a
AEValueList
AEColumn: a.LOG_C
AEColumn: a.CHAR_C
AEProject
AETable: b
AEValueList
AEColumn: b.LOG_C
AEColumn: b.CHAR_C
```

After pass down, the Simba SQLEngine has optimized the AE Tree as follows:

```
AEQuery

AETable: PASSDOWN_a
```

In the sample connector, except handling is performed by `SLExceptHandler` which implements `IExceptHandler`. For the example above, the operations on both sides of the except were first passed down to the sample connector and handled using the connector's projection handler. The Simba SQLEngine then passed down the node representing the except operation, which contains the projection tables in subnodes, to `SLExceptHandler`. `SLExceptHandler` then generated and returned a result set containing the row data for the columns of the except.

Implementing a except handler requires that a projection handler also be implemented. This is because there are always AEProject nodes under an AEExcept node, so if the connector does not handle the projections, then the Except is not passed down.

Through CQE with the SLExceptHandler, the Simba SQLEngine has performed the following steps to accomplish this:

1. Check both operations preceeding the except operation. Are the results already table objects?
   A. Yes. Attempt to pass down the except operation to the DSII. Go to Step 2.
   B. No. Unable to pass down except operation. Go to End.
2. Was the except successfully passed down?
   A. Yes. Take the result table from the DSII and replace the except node with the new table node. The engine uses the table node and discards the except node. Go to End.
   B. No. Go to End.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateExceptHandler` method creates the `SLExceptHandler` object. The tables to perform the except on will be provided during pass down, so the object's constructor does not take in a table like other pass down handlers do:

```
SLExceptHandler::SLExceptHandler(ILogger& in_log) :
m_log(in_log)
{

    // Do nothing.

}
```

SLExceptHandler's Passdown method handles the pass down of a except operation:

```
SharedPtr<DSIExtResultSet> SLExceptHandler::Passdown
(AEExcept* in_node)
{

    return SLSQLiteHelper::GetSetOperationQueryResultSet
    (*in_node, m_log);

}
```

The method is aimed to produces the result set query for intersect or except handler. It begins by checking if the ALL keyword is present. If the ALL keyword is present, then a SQL query in the following form is constructed:

```
SELECT [leftColNames]
FROM [leftTable]
WHERE [EXISTS / NOT EXISTS]
SELECT [rightColNames]
FROM [rightTable]
WHERE [conditions on leftTableColumns and rightTableColumns]
```

If the ALL keyword is not present, then a SQL query in the following form is constructed:

```
SELECT *FROM [leftTable]
[EXCEPT / INTERSECT]
SELECT *FROM [rightTable]
```

Then either case the query is used to construct the result set to be returned to the Simba SQLEngine.

Note:

`IExceptHandler` will support both EXCEPT and EXCEPT ALL, so implementing this interface in your own connector will allow you to support both statements.

If the option was specified, then the pass down handler obtains the left and right tables from the except and proceeds to perform the except operation by iterating through all the row data for the columns specified in the except. This data is combined into a new result set and then returned to the Simba SQLEngine. Note that this example is mainly for demonstration purposes to show how a except can be handled, and does not provide any significant increase in performance.

Intersect Handlers

The Intersect operator is used when you are only interested in the common or overlapping results of two or more select statements. The Simba SQLEngine passes down the AE Tree node for the intersect expression. This node is handled by classes which implement `IIntersectHandler`. This interface defines one Passdown method that accepts an AEIntersect node and must return a new result set containing the result of the whole intersect.

Note:

Unlike most other pass down handlers, there are no abstract intersect handlers to subclass so an intersect handler must directly implement `IIntersectHandler` as has been done in the sample connector.

Intersect Example

Consider the following example query being handled by the sample connector:

Select a.log_c, a.char_c from alltype1 a INTERSECT ALL Select b.log_c, b.char_c From alltype2 b

Prior to pass down, the AE Tree looks as follows:

```
AEQuery
AEIntersect
AEProject
AETable: a
AEValueList
AEColumn: a.LOG_C
AEColumn: a.CHAR_C
AEProject
AETable: b
AEValueList
AEColumn: b.LOG_C
AEColumn: b.CHAR_C
```

After pass down, the Simba SQLEngine has optimized the AE Tree as follows:

```
AEQuery
AETable: PASSDOWN_a
```

In the sample connector, intersect handling is performed by `SLIntersectHandler` which implements `IIntersectHandler`. For the example above, the operations on both sides of the intersect were first passed down to the sample connector and handled using the connector's projection handler. The Simba SQLEngine then passed down the node representing the intersect operation, which contains the projection tables in subnodes, to `SLIntersectHandler`. `SLIntersectHandler` then generated and returned a result set containing the row data for the columns of the intersect.

Implementing a intersect handler requires that a projection handler also be implemented. This is because there are always AEProject nodes under an AEIntersect node, so if the connector doesn't handle the projections, then the Intersect will not be passed down.

Through CQE with the SLIntersectHandler, the Simba SQLEngine has performed the following steps to accomplish this:

1. Check both operations preceeding the intersect operation. Are the results already table objects?
    A. Yes. Attempt to pass down the intersect operation to the DSII. Go to Step 2.
    B. No. Unable to pass down intersect operation. Go to End.
2. Is passing down intersect successful?
    A. Yes. Take the result table from the DSII and replace the intersect node with the new table node. The engine uses the table node and discards the intersect node. Go to End.
    B. No. Go to End.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateIntersectHandler` method creates the `SLIntersectHandler` object. The tables to perform the intersect on will be provided during pass down, so the object's constructor does not take in a table like other pass down handlers do:

```
SLIntersectHandler::SLIntersectHandler(ILogger& in_log) :
m_log(in_log)
{

    // Do nothing.

}
```

SLIntersectHandler's Passdown method handles the pass down of a intersect operation:

```
SharedPtr<DSIExtResultSet> SLIntersectHandler::Passdown
(AEIntersect* in_node)
{

    return SLSQLiteHelper::GetSetOperationQueryResultSet
    (*in_node, m_log);

}

SharedPtr<DSIExtResultSet>
SLSQLiteHelper::GetSetOperationQueryResultSet(

    AESetOperation& in_node,
    ILogger& in_log)
    {

        assert(AE_NT_RX_TABLE == in_
        node.GetLeftOperand()->GetNodeType());
        assert(AE_NT_RX_TABLE == in_
        node.GetRightOperand()->GetNodeType());
        SharedPtr<SLTableBase> leftTable(static_
        cast<SLTableBase*>(in_node.GetLeftOperand()-
        >GetAsTable()->GetTable().Get()));
```

```
        SharedPtr<SLTableBase> rightTable(static_
        cast<SLTableBase*>(in_node.GetRightOperand()-
        >GetAsTable()->GetTable().Get()));
        simba_wstring resultQuery;
        if (in_node.IsAllOptPresent())
        {
            simba_wstring leftColNames,
            rightColNames;
            simba_wstring existsCondition,
            orCondition, combinedCondition;
            simba_wstring currLeftColName,
            currRightColName;
            simba_uint16 columnCount = in_
            node.GetColumnCount();
            for (simba_uint16 i = 0; i <
            columnCount; i++)
            {
                currLeftColName = leftTable-
                >GetQueryReference() + "." +
                leftTable-
                >GetQueryColumnName(i);
                currRightColName =
                rightTable-
                >GetQueryReference() + "." +
                rightTable-
                >GetQueryColumnName(i);
                leftColNames +=
                currLeftColName;
                rightColNames +=
                currRightColName;
                existsCondition =
                currLeftColName + L" = " +
                currRightColName;
                orCondition = L"(" +
                currLeftColName + L" IS NULL
```

```
                AND " + currRightColName +
                L" IS NULL) ";
                combinedCondition += L"(" +
                existsCondition + L" OR " +
                orCondition + L")";
                if (i < columnCount - 1)
                {

                    leftColNames += L",
                    ";
                    rightColNames += L",
                    ";
                    combinedCondition +=
                    L" AND ";

                }
                // NULL values in the
                subquery are viewed as
                unknown(not true), so
                without the orCondition,
                // NULL value comparisons
                are all excluded from result
                set.
                simba_wstring existsClause =
                (AE_NT_RX_INTERSECT == in_
                node.GetNodeType()) ? L"
                EXISTS " : L" NOT EXISTS ";
                resultQuery = L"SELECT " +
                leftColNames + L" FROM " +
                leftTable-
                >GetQueryDefinition() + L"
                WHERE" + existsClause + L"
                (SELECT " + rightColNames +
                L" FROM " + rightTable-
                >GetQueryDefinition() +
```

```
                " WHERE " + L"(" +
                combinedCondition + L"))";

            }
            else
            {

                resultQuery = L"SELECT *
                FROM " + leftTable-
                >GetQueryDefinition();
                resultQuery += (AE_NT_RX_
                INTERSECT == in_
                node.GetNodeType()) ? L"
                INTERSECT " : L" EXCEPT ";
                resultQuery += "SELECT *
                FROM (" + rightTable-
                >GetQueryDefinition() + ")";

            }
            return SharedPtr<DSIExtResultSet>(
            new SLPassdownResultTable(
            leftTable,
            resultQuery.GetAsUTF8(),
            AutoPtr<SLResultSetColumns>
            (leftTable->GetSelectColumnsClone
            ()),
            in_log));

        }

    }
```

The method is aimed to produces the result set query for intersect or except handler. And the logic here for “intersect” operation is similar to “except” operation (refer to the EXCEPT example).

Note:

`IIntersectHandler` will support both INTERSECT and INTERSECT ALL, so implementing this interface in your own connector will allow you to support both statements.

If the option was specified, then the pass down handler obtains the left and right tables from the intersect and proceeds to perform the intersect operation by iterating through

all the row data for the columns specified in the intersect. This data is combined into a new result set and then returned to the Simba SQLEngine. Note that this example is mainly for demonstration purposes to show how a intersect can be handled, and does not provide any significant increase in performance.

Pivot Handlers

SQL Pivot pass-down is handled by `IPivotHandler` classes. The `IPivotHandler` interface defines one pass down function that accepts an `AEPivot` node. If the pivot operation can be handled, the passdown function returns a new result set that represents the pivot result. If the pivot cannot be handled (the passdown function returns a null result) the query fails because SQLEngine currently doesn't have logic to evaluate the PIVOT clause.

To simplify analysis of the `AEPivot` node, two abstract subclasses are defined (similar to the `AEAggregate` passdown). The `DSIExtAbstractPivotHandler` class divides the `AEPivot` into passdown composed of a list of elements including:

- The individual aggregation functions specified in the aggregation list (see the example below for details).
- The column reference list.
- The pivot column list.
- The pivot alias name.
- The grouping columns and the result measure columns (the last two are derived elements from the pivot clause provided by SQLEngine, which helps make the pass-down implementation easier).

If all the elements passed down are accepted (return TRUE), a method called `CreateResult` will be invoked to create the pivot result that will replace the `AEPivot` node in the AE-Tree. If any element passed down is rejected (returns FALSE), the entire pivot passdown is abandoned and `CreateResult` will not be invoked.

The `DSIExtSimplePivotHandler` class derives further from `DSIExtAbstractPivotHandler` to identify and pass down several simple cases for each aggregation in the aggregation list. It only passes down aggregations of literals or column references. If the aggregation contains any more complex value expressions, the passdown is rejected.

The evaluation result of a PIVOT clause will contain all the columns from the pivot source table except those appearing in the aggregation list and column reference list. It also includes the generated (measure result) columns by combining each pivot column with each aggregation (see example below).

Pivot Example

For this example we will use the following query:

```
SELECT * FROM T1 PIVOT (AVG(C1) as A1, COUNT(C2) FOR C3 IN
('a', 'b'))
```

In the query above, `T1` is the source table relation, `AVG(c1) as A1, COUNT(C2)` is the aggregation list, `C3` is the column reference list, and `('a', 'b')` is the pivot column list. Each aggregation is represented either by an `AERename` (in case the aggregation has an alias) or `AEAggrFunction` node. Each column reference is represented by an `AEColumn` node. Each pivot column is represented by an `AEPivotColumn` node.

If table (`T1`) has 4 columns (`C1`, `C2`, `C3`, `C4`), then `C4` represents the grouping column list and `a_A1`, `a`, `b_A1`, `b` is the list of result measure columns as described earlier during the passdown processing in `DSIExtAbstractPivotHandler` (see the `AEPivot.h` and `DSIExtAbstractPivotHandler.h` header files in the Simba SDK installation for details).

For the sample query above, the result columns would include `C4`, `a_A1`, `a`, `b_A1`, `b` (the actual measure column names can be customized). The passdown handler should create a table representing the pivot result with these columns.

For the sample query, the AETree looks like this before pass-down:

```
AEQuery
AEProject
AEPivot: PivotTable
AETable: T1
AEValueList
AERename: A1
AEAggrFunction: AVG ALL
AEColumn: C1
AEAggrFunction: COUNT ALL
AEColumn: C2
AEValueList
AEColumn: C3
AEPivotColumnList
AEPivotColumn
AEValueList
AELiteral: a
AEPivotColumn
AEValueList
AELiteral: b
AEValueList
```

```
AEColumn: "PivotTable"."C4"
AEColumn: "PivotTable"."a_A1"
AEColumn: "PivotTable"."b_A1"
AEColumn: "PivotTable"."a"
AEColumn: "PivotTable"."b"
The AETree looks like this after pass down to the pivot
handler:
AEQuery
AETable: PASSDOWN_PivotTable
```

Implementation

The pivot handler implementation in DSII can choose to inherit from `IPivotHandler` directly. In this case, the required information to implement pivot operation can be retrieved from the input `AEPivot` node directly in the function: `Passdown (AEPivot& in_node)`

Alternatively, DSII can choose to inherit from `DSIExtAbstractPivotHandler` or `DSIExtSimplePivotHandler`. The constructor for the sample `SLPivotHandler` is provided with the source table for the pivot operation. It also initializes the data structure pointers for storing the elements that are set during the passdown processing.

```
SLPivotHandler::SLPivotHandler(
SharedPtr<SLTableBase> in_table,
SLDataEngine& in_dataEngine,
ILogger& in_log) :
m_table(in_table),
m_pivotColumnList(NULL),
m_groupByColumns(NULL),
m_pivotMeasureColumns(NULL),
m_dataEngine(in_dataEngine),
m_log(in_log)
{
     ; // Do nothing.
}
```

`SLPivotHandler` relies on the `Passdown()` implementation of the `DSIExtAbstractPivotHandler` base class. As a number of `Set()*` methods are defined in the`DSIExtAbstractPivotHandler` class which are called by `Passdown` to provide the handler with information specified in the pivot clause. Each method then returns TRUE or FALSE to specify if that element can be handled, and store the element for implementing the pivot operation later on.

For example, `SLPivotHandler::SetPivotColumnList` shown below stores the input pivot column list and determines whether pass down is supported based on whether the pivot columns only contain identifiers.

```
bool SLPivotHandler::SetPivotColumnList(AEPivotColumnList &
in_pivotColumnList)
{

     assert(!m_columnReferences.empty());
     assert(NULL == m_pivotColumnList);
```

```
    m_pivotColumnList = &in_pivotColumnList;
    // Only support identifiers in the IN value list
    for (simba_size_t k = 0; k < m_pivotColumnList-
    >GetChildCount(); k++)
    {
        const Simba::SQLEngine::AEValueList* values =
        m_pivotColumnList->GetChild(k)->GetOperand();
        for (simba_size_t j = 0; j < values-
        >GetChildCount(); j++)
        {
            const Simba::SQLEngine::AEValueExpr*
            aValue = values->GetChild(j);
            if (AE_NT_VX_LITERAL != aValue-
            >GetNodeType()
            {
                return false;
            }
        }
    }
    return true;
}
```

Unpivot Handlers

Unpivot handling provides a DSII with the opportunity to rotate columns of a table-valued expression into column values. The Simba SQLEngine passes down the `AE Tree` node for the unpivot expression. This node is handled by classes which implement `IUnpivotHandler`. This interface defines one passdown method that accepts an `AEUnpivot` node and must return a new result set containing the result of the unpivot operation.

Note:

There are no abstract unpivot handlers to be subclassed, so an unpivot handler must directly implement `IUnpivotHandler`. See the sample connector for an example.

Unpivot Example

For this example, we will use the following query:

```
SELECT Customer, Provider, AvgExpanse FROM Orders UNPIVOT
(AvgExpanse FOR Provider IN (Apple_AvgExpanse as 'Apple',
SamSung_AvgExpanse as 'SamSung')) Orders_Unpivot
```

This is how the AE Tree would appear before pass down:

```
AEQuery
AEProject
AEUnpivot: Alias="Orders_Unpivot" MeasureCols={"AvgExpanse"}
UnpivotCols={"Provider"}
AETable: ORDERS
AEUnpivotGroupDefinitionList
AEUnpivotGroupDefinition
AEValueList
AEColumn: "ORDERS"."Apple_AvgExpanse"
AEValueList
AELiteral: Apple; Character String Literal
AEUnpivotGroupDefinition
AEValueList
AEColumn: "ORDERS"."SamSung_AvgExpanse"
AEValueList
AELiteral: SamSung; Character String Literal
AEValueList
AEColumn: "Orders_Unpivot"."Customer"
AEColumn: "Orders_Unpivot"."Provider"
AEColumn: "Orders_Unpivot"."AvgExpanse"
```

After passdown, this is how the SQL Engine optimized AE Tree looks:

```
AEQuery
AETable: PASSDOWN_Orders_Unpivot
```

In the sample connector, unpivot handling is performed by `SLPivotHandler`, which implements `IUnpivotHandler`. In the example above, the Simba SQLEngine passes down the `AEunpivot` node representing the unpivot operation which contains the table and the group definition list, in subnodes, to `SLPivotHandler`. This handler then generates and returns a result set containing the row data for the columns of the unpivot.

Implementation

The sample's `SLOperationHandlerFactory` class is responsible for the construction of all pass down handlers. Its `CreateUnpivotHandler` method creates the `SLPivotHandler` object. The tables for the unpivot are provided during pass down, so the object's constructor does not need to be implemented.

The `Passdown` method for `SLPivotHandler` handles the pass down of a unpivot operation:

```
SharedPtr<DSIExtResultSet> SLUnpivotHandler::Passdown
(AEUnpivot& in_node)
{

    m_table.Reset(static_cast<SLTableBase*>(in_
    node.GetOperand()->GetAsTable()->GetTable().Get()));
    // Column containing values.
    const std::vector<simba_wstring>& measureColumnList =
    in_node.GetMeasureColumnList();
    // Column containing types.
    const std::vector<simba_wstring>& unpivotColumnList =
    in_node.GetUnpivotColumnList();
    // List to get column index and alias name values.
    AEUnpivotGroupDefinitionList* unpivotGroupDefList =
    in_node.GetUnpivotGroupDefinitionList();
    if (!GetUnpivotGroupDefinitionInfo
    (*unpivotGroupDefList))
    {

        return SharedPtr<DSIExtResultSet>();

    }
    // Generate column metadata.
    std::vector<simba_uint16> unreferencedColumnNumbers =
    in_node.GetUnreferencedColumnNumbers();
    AutoPtr<SLResultSetColumns> newColumnMetadata
    (GenerateColumnMetadata(unreferencedColumnNumbers,
    measureColumnList, unpivotColumnList));
    bool isIncludeNULL = false;
    if (in_node.IncludeNulls())
    {

        isIncludeNULL = true;

    }
```

```
    simba_wstring newQuery;
    newQuery = GetQuery(
    unreferencedColumnNumbers,
    measureColumnList,
    unpivotColumnList,
    isIncludeNULL);
    return SharedPtr<DSIExtResultSet>(
    new SLPassdownResultTable(
    m_table,
    newQuery.GetAsUTF8(),
    AutoPtr<SLResultSetColumns>(newColumnMetadata),
    m_log));
}
```

For each row in the source table, the `Unpivot` method iterates through the group definition list and does the following:

1. Ignores the rows where the data of measure columns are null, unless unpivot is set to include nulls.
2. Creates an empty row for the result table.
3. Copies the data of unreferenced columns.
4. Sets the data in measure columns.
5. Sets the data in unpivot columns.

Combining Pass-Downs

For complex queries involving multiple tables, filters, joins, or aggregations, there may be many operations that can be passed down. However, to pass down an operation higher in the AE Tree, all operations below that node must have been fully passed down. This limitation is required so that when constructing the new operation handler, the base tables passed to the factory are always tables either opened by the data engine or constructed by earlier operation handlers. Therefore, if a table filter could not be passed down, the engine cannot pass down a join higher up in the AE-Tree involving the result of the table filter because the engine must first process the filter itself before the join can be performed.

Pre Optimization Analysis of the AE Tree

If optimizations cannot be performed within pass down handlers, the DSII has the option to analyze an AE Tree after it has been generated from the query, and to optimize or alter it prior to the three stop optimization process. Doing this can completely change the query and is only recommended as a last resort if the optimizations cannot be performed elsewhere.

This can be accomplished by overriding the`DSIExtSqlDataEngine::CreateQueryExecutor`to intercept the AEStatements before calling the base class function to finish constructing the query executor:

```
DSIExtQueryExecutor*
CustomerDSIISqlDataEngine::CreateQueryExecutor(

    AutoPtr<AEStatements> in_aeStatements)
    {

        // Analyze and alter the AE-Trees found in
        in_aeStatements
        return
        DSIExtSqlDataEngine::CreateQueryExecutor(in_
        aeStatements);

    }
```

The SQLite sample implementation of the overridden CreateQueryExecutor method is shown below:

```
IQueryExecutor* SLDataEngine::CreateQueryExecutor
(AutoPtr<Simba::SQLEngine::AEStatements> in_aeStatements)
{

    assert(!in_aeStatements.IsNull());
    // Allow the logged pre-optimized AETree to be
    retrieved via a custom statement property.
    if (in_aeStatements->GetCount() > 0)
    {

        m_statement->SetCustomProperty(
        SL_CUSTOM_PROP_PRE_OPTIMIZE_AETREE,
        AttributeData::MakeNewWStringAttributeData(
        AETreeLog::DumpToString(in_aeStatements-
        >GetStatement(0))));

    }
    AutoPtr<DSIExtQueryExecutor> executor(new
    SLQueryExecutor(
    in_aeStatements,
    m_context,
    static_cast<SLStatement*>(m_statement)));
```

```
    // Prepare the results (ETree) before returning the
    query executor
    executor->PrepareResults();
    return executor.Detach();

}
```

How to analyze the tree, and what changes to make, is up to the DSII implementer according to whatever circumstances require it so no example can be given here. Instead, refer to the API reference guide for full details on the structure of the AE-Tree.

Related Topics

Collaborative Query Execution

Statements

SQL Engine Memory Management

The SQL Engine component of the Magnitude Simba SDK allows applications to execute SQL commands on data stores that are not SQL-capable. Performing these operations often requires the SQL Engine to cache the data in memory; for example, to execute an ORDER BY command, the SQL engine must retrieve all the requested data, allocate memory to perform the sort, then return the result. Many SQL commands utilize a significant amount of memory when executed against large data sets.

You can design your custom connector for optimum behavior and performance during memory-intensive operations by configuring how the SQL Engine uses memory and disk resources. For example, you may decide that connectors deployed in the cloud should not use on-disk memory. You can also design your custom connector for maximum speed given a single memory-intensive operation, or you can choose to share memory resources between multiple operations.

Tip:

If you see a Memory Management error or the performance is affected, you can try increasing the memory manager limit. Add or edit the **MemoryManagerMemoryLimit** key in your `simba.ini` file or registry setting, and increase the limit.

Configuring Memory Properties

You can use DSI properties to configure the SQL Engine memory strategy. The `DSIDriver` class defines default values for the memory properties in `DSIDriver.h`.

It also reads in values for these properties from the registry on Windows or from `.ini` files on Linux and Unix. Properties set in the registry or `.ini` files will override the properties set programmatically. If your connector extends the `DSIDriver` class, you can use this functionality to set the memory properties.

Note:

The `MemoryManager` object is a singleton class and sets the memory strategy for all connections and statements of one connector instance. You cannot set a memory strategy per connection. `MemoryManager` is instantiated the first time the SQL Engine is required. If you decide to specify memory configuration properties on the connection string, be aware that the first connection may not preceded the instantiation of the `MemoryManager` object.

The memory properties are set in the Simba Setting Reader location. For example, this location for the QuickStart connector is:

- In the Windows registry, **HKEY_LOCAL_MACHINE\SOFTWARE\Simba\Quickstart\Driver** (for a 64-bit connector on a 64-bit machine, or a 32-bit connector on a 32-bit machine)
- On Linux or Unix, `simba.quickstart.ini`

Memory Properties

Use the properties in this section to configure your connector's memory strategy. Each DSI property has a corresponding key in the registry or `.ini` file.

For example, you can set the default value of DSI_MEM_MANAGER_STRATEGY property in your `MyDSIDriver.h` file. If the corresponding registry key **HKEY_LOCAL_MACHINE\SOFTWARE\Simba\Quickstart\Driver\MemoryManagerStrategy** is set, that value will override the default value.

DSI_MEM_MANAGER_STRATEGY

Type	Description	Key Name
UInt16	Specifies the memory strategy. Defines whether the SQL Engine can swap memory to disk, and whether to maximize the performance of fewer operations or to support more concurrent operations. **Allowed Values**: 1, 2, or 3. See SQL Engine Memory Management.	**MemoryManagerStrategy**

DSI_MEM_MANAGER_MEMORY_LIMIT

Type	Description	Key Name
UIntNative	Specifies the total amount of memory, in megabytes, that the SQL Engine can use when executing commands. The default value depends on the operating system's bitness. The value is 1GB on 32-bit machines and 2GB on 64-bit machines. **Note:** Memory management is only performed for operations that consume memory. The SQL Engine will not allocate more memory (RAM) for these operations than is specified by this limit. However, the internal variables and data members of these memory-controlled algorithms are not included in this limit.	**MemoryManagerMemoryLimit**

DSI_MEM_MANAGER_THRESHOLD_PERCENT

Type	Description	Key Name
UInt16	Specifies the maximum percentage of the memory limit, specified by DSI_MEM_MANAGER_MEMORY_LIMIT, that can be used by existing operations. **Allowed Values**: An integer between 1 and 100. The default value is 80.	**MemoryManagerThresholdPercent**

DSI_MEM_MANAGER_SWAP_DISK_LIMIT

Type	Description	Key Name
UIntNative	Specifies the maximum size of all the swap files on disk, in megabytes. The default value is no limit.	**MemoryManagerSwapDiskLimit**

SwapFilePath

Type	Description	Key Name
String	Specifies the full path to the directory where the swap files are located. By default, this is set to the default temporary directory of the operating system. You can get and set this property using `SimbaSettingReader::GetSwapFilePath()` and `SimbaSettingReader::SetSwapFilePath()`. There is no corresponding DSI property. Allowed Value: Any valid directory path. **Note:** • This property does not map to a DSI property. • To improve performance, map this to a folder in an SSD drive.	**SwapFilePath**

For information on how to configure these properties in a connector, see SQL Engine Memory Management.

SQL Engine Memory Strategy

In general, when the SQL Engine receives a command, it will make a request to allocate memory (RAM) to complete the operation. As the operation requires more memory, the SQL Engine will continue to request that more memory be allocated. At some point in the operation, the SQL Engine may decide to stop allocating more RAM and start swapping to disk, so that it can reserve more memory for new operations. The memory strategy, specified by DSI_MEM_MANAGER_STRATEGY, specifies the tradeoff between allocating more RAM for the current operation and reserving more RAM for new operations. It also specifies whether or not to swap memory to disk.

Note:

- Because the SQL Engine allocates memory before executing a query, it can return a memory error immediately if the requested memory is larger than the memory limit. However, if the requested memory is within the memory limits but currently not available, due to other consumers consuming memory (e.g. in a multi-threaded scenario) the memory manager makes the requester wait until enough memory becomes available.
- Memory swapping increases the amount of available memory and enables commands on very large data sets; however, writing to disk also negatively affects performance.

The SQL Engine supports three memory configuration strategies.

Memory Manager Strategy 1

When this memory strategy is used, the SQL Engine does not swap memory. When executing commands, memory is allocated up to the limit specified by DSI_MEM_MANAGER_MEMORY_LIMIT. If this amount of memory is insufficient, the command will be terminated with an out of memory error.

This strategy is useful if the connector should not write to disk, for example in cloud deployments.

Memory Manager Strategy 2

When this memory strategy is used, the SQL Engine prevents any single operation from using all the available memory. If a single operation uses a significant percentage of the memory limit and then requests more memory, the SQL Engine may swap to disk rather than allocate more memory. This ensures that enough memory is available for new commands to be processed with good performance. The SQL Engine's internal logic, which takes into account the value of DSI_MEM_MANAGER_THRESHOLD_PERCENT, determines the percentage of the memory limit that a single operation can use.

Use this strategy to ensure that a connector can always handle multiple commands with good performance.

Memory Manager Strategy 3

When this memory strategy is used, the SQL Engine allows a single command to access all the available memory, up to the limit specified by DSI_MEM_MANAGER_THRESHOLD_PERCENT. This strategy ensure maximum performance of a single

command, while allowing subsequent commands to be processed with slower performance.

The SQL Engine reserves a percentage of the memory limit, specified by DSI_MEM_MANAGER_THRESHOLD_PERCENT, for new operations. Each new operation received after the DSI_MEM_MANAGER_THRESHOLD_PERCENT is reached is allocated only the minimum amount of RAM, and uses disk swapping.

Use this strategy to ensure that a connector can execute a single command with maximum performance.

Example:

Assume the following:

```
DSI_MEM_MANAGER_STRATEGY = 3
DSI_MEM_MANAGER_THRESHOLD_PERCENT = 80 /* percent */
DSI_MEM_MANAGER_MEMORY_LIMIT = 8 /* megabytes */
```

Suppose the SQL Engine is executing a single query against a very large data store. Once the memory allocated for this query reaches 6.4 megabytes, the SQL Engine uses memory swapping to complete the query. While executing the first query, the SQL Engine receives more queries. For each of the subsequent queries, SQL Engine allocates only the minimum amount of memory required and then uses memory swapping. All queries complete. The performance of the first query is maximized while the performance of the subsequent queries is affected.

Data Manipulation Language (DML)

The SQL Engine can support SQL Data Manipulation Language (DML) queries for INSERT, UPDATE and DELETE statements. You can choose to support some or all of these queries in your custom connector's result set implementation.

Note:

The SQL Engine does not support ALTER, TRUNCATE, COMMENT, or RENAME statements.

You can also use an index to optimize these queries. Since UDPATE and DELETE queries might involve a WHERE clause, using an index can improve performance.

The following sections explains how to enable support for DML queries in your custom connector.

Preparing to Support DML in the C++ SDK

This section explains how to change your connector from read-only to read-write, in order to support DML.

Step 1 - Specify the Connection is Read/Write

Set the `DSI_CONN_DATA_SOURCE_READ_ONLY` property in the constructor of your `CustomerDSIIConnection` object, to "N" which enables read/write access to the datasource. The preferred method for setting this is to call the `DSIPropertyUtilities::SetReadOnly` helper method and pass in `false` for the `in_isReadOnly` parameter.

Example: SQLite's Connection class

In this example, the SQLite sample connector's `SLConnection` class contains a helper method called `SetConnectionPropertyValues()`, which is invoked from the class's constructor. One of the first actions this method performs is to call the `SetReadOnly` method passing in `false`:

```
void SLConnection::SetConnectionPropertyValues()
{

    DSIPropertyUtilities::SetStoredProcedureSupport(this,
    true);
    DSIPropertyUtilities::SetReadOnly(this, false);
    ...
```

Step 2 - Open the Underlying Table in Read/Write Mode

In your connector's `DSIExtSqlDataEngine`-derived class, ensure that the `OpenTable` method can open your data source's underlying table in read/write mode.

Example: SQLite's OpenTable Method

In the SQLite sample connector, the `in_openType` parameter is forwarded to the underlying `CBTable` class that the `OpenTable` method creates:

```
SharedPtr<DSIExtResultSet> SLDataEngine::OpenTable(const
simba_wstring& in_catalogName,const simba_wstring& in_
schemaName,const simba_wstring& in_
tableName,DSIExtTableOpenType in_openType)
{

    CBUtilities utilities(m_codeBaseSettings);
    SharedPtr<DSIExtResultSet> table;
    simba_wstring schemaName(L"");
    if (utilities.DoesTableExist(m_codeBaseSettings->m_
    dbfPath,in_catalogName,in_schemaName,in_
    tableName,schemaName))
    {
```

```
            table = new CBTable(
            m_codeBaseSettings,
            m_statement,
            in_catalogName,
            schemaName,
            in_tableName,
            (TABLE_OPEN_READ_ONLY == in_openType));

        }
        return table;

}
```

Step 3 - Specify how UPDATE and DELETE Queries are Handled

Determine if UPDATE and DELETE queries will be handled by a result set or by an index. Set DSIEXT_DATAENGINE_USE_DSII_INDEXES property to “N” or “Y” respectively to enable indexing. By default, the DSII indexes are disabled in DSI layer in the method `DSIExtSqlDataEngine::SetDefaultPropertyValues()`.

Step 4 - Implement the Required Methods

Implement the following required methods:

- `AppendRow()`
- `DeleteRow()`
- `WriteData()`

Optionally, you can implement the additional methods:

- `OnStartRowUpdate()`
- `OnFinishRowUpdate()`
- `OnStartDMLBatch()`
- `OnFinishDMLBatch()`

These methods are described further in the following sections, as well as in the C++ API Reference.

Preparing to Support DML in the Java SDK

Supporting DML in the Java SDK is similar to supporting it in the C++ SDK, as described in this section.

Step 1 - Specify Read/Write on your Connection

Set the DSI_DATA_SOURCE_READ_ONLY property in the constructor of your `CustomerDSIIConnection` object, to "N" which enables read/write access to the datasource. The preferred method for setting this is to call the `PropertyUtilities::SetReadOnly` helper method pass in false for the `isReadOnly` parameter.

Step 2 - Open the Underlying Table in Read/Write Mode

In your connector's `DSIExtSqlDataEngine`-derived class, ensure that the `OpenTable`method can open your data source's underlying table in read/write mode.

> **Note:**
>
> There is no Step 3, because the Java SDK does not support indexing.

Step 4 - Implement the Required Methods

Implement the following required methods:

- `AppendRow()`
- `DeleteRow()`
- `WriteData()`

Optionally, you can implement the additional methods:

- `OnStartRowUpdate()`
- `OnFinishRowUpdate()`
- `OnStartDMLBatch()`
- `OnFinishDMLBatch()`

These methods are described further in the following sections, as well as in the Java API Reference Guide.

Handling INSERT Statements

If a connector will handle INSERT statements, these must be handled in a result set regardless of whether indexes are enabled or not.

To handle row insertions, any table (that is, any `DSIExtResultSet`-derived class) returned by `OpenTable` in TABLE_OPEN_READ_WRITE mode must override and implement the `AppendRow` and `WriteData` methods, and optionally `OnFinishRowUpdate`. Note that `OnStartRowUpdate` will not be called for INSERT

statements because the invocation of the `AppendRow` method implies that a row update will occur.

Note:

Under the Java Simba SQLEngine, result sets are typically defined by deriving from the `DSIExtJResultSet` class. `DSIExtJResultSet` provides default implementations which throw an exception, and therefore each must be implemented.

`AppendRow` is invoked by the Simba SQLEngine when an INSERT statement is encountered, to signal to the connector that a new row needs to be created. This method must append an empty row to the end of the underlying data source and position the cursor at the new row. After the method exits, the Simba SQLEngine will then invoke the class's `WriteData` method (described below) to write the column data to the cells in this row. Connectors can also perform other row insertion logic as required. For example a connector could cache flags to indicate that a row insertion has occurred, where the flags are used in other phases of data insertion.

Example: SQLite's CBTable::AppendRow method

The `CBTable::AppendRow` method from the SQLite sample connector positions the cursor at the bottom of the underlying table. It then adds an empty row and caches flags indicating that a row is in the process of being appended and that the table has been modified:

```
void CBTable::AppendRow()
{
    ENTRANCE_LOG(m_log, "Simba::", "CBTable", "AppendRow");
    SE_CHK_INVALID_OPR("AppendRow", m_isReadOnly);
    // Move to the last record.
    m_tableHandle.bottom();
    // Append a blank row.
    m_tableHandle.appendStart();
    m_tableHandle.blank();
    m_isAppendingRow = true;
    m_hasInsertedRecords = true;
}
```

The `m_isAppendingRow` flag will be checked at a later point after the row has been updated, in order to perform the final data commit. See `OnFinishRowUpdate` below. The `m_hasInsertedRecords` flag is later checked when closing the cursor, to determine if table operations should be flushed:

```
void CBTable::DoCloseCursor()
{
    ...
    if (m_hasInsertedRecords)
    {
        m_tableHandle.flush();
    }
    ...
}
```

Implementing OnFinishRowUpdate

Optionally, the result set can also implement `OnFinishRowUpdate` if needed. `OnFinishRowUpdate` is invoked by the Simba SQLEngine after a row has been updated or inserted. A connector can use this method to perform any final steps required to complete the data update or row insertion, such as committing the data to disk.

Example: SQLite's OnFinishRowUpdate method

In this example, SQLite checks if the method is being invoked due to a row insertion operation. It then performs the final logic necessary to append a row to the underlying table. Afterwards, it increments the known row count, sets the cursor to the new row, and resets the flag it uses to determine if the row is being inserted.

```
void CBTable::OnFinishRowUpdate()
{
    if (m_isAppendingRow)
    {
        // Commit the new row.
        m_tableHandle.append();
        // Update the row count and current row.
        ++m_rowCount;
        assert(m_rowCount == m_tableHandle.recCount());
        SetCurrentRow(m_rowCount - 1);
        m_isAppendingRow = false;
    }
}
```

Optionally, the `OnStartDMLBatch` and `OnFinishDMLBatch` methods can also be implemented to handle the start and end of an INSERT operation in the result set class. `OnStartDMLBatch` takes in the `DMLType` enum which specifies the type of operation (DML_INSERT in this case), as well as the number of rows that will be affected by the operation. This method will be invoked before `AppendRow` and `OnFinishDMLBatch` will be invoked after the INSERT operation is complete. These

methods can be used by a connector to prepare for the insertion of new rows and to perform any post-INSERT logic in the result set class.

Note:

The corresponding methods also exist under the Java Simba SQLEngine.

Handling UPDATE and DELETE Statements in a Result Set

A connector can handle UPDATE and DELETE statements on a table, for example `DSIExtResultSet` for C++ or `DSIExtJResultSet` for Java. A connector can also handle UPDATE and DELETE statements on one of its indexes, for example `DSIExtIndex`. This section describes the methods you use to implement the handling of these statements in a result set.

Note:

- If indexes are enabled, these methods will not be invoked. The analogous methods in `DSIExtIndex` will be called instead.
- Indexes are not supported when using the Java Simba SQLEngine.

Handling Updates

This section explains how to handle an update statement in a result set when using the C++ SDK.

Note:

Handling row updates/insertions and DML batches under the Java Simba SQLEngine is similar. except that tables derive from `DSIExtJResultSet` and the `TableOpenType.READ_WRITE` enum must be passed to `OpenTable()`.

To handle an UPDATE statement in a result set, any table (i.e. `DSIExtResultSet`-derived class) returned by `OpenTable` in TABLE_OPEN_READ_WRITE mode must override and implement `WriteData`. Optionally, it can also override and implement `OnStartRowUpdate`, `OnFinishRowUpdate`, `OnStartDMLBatch`, and `OnFinishDMLBatch`.

`WriteData` is invoked by the Simba SQLEngine when inserting a row or updating row values. This method is responsible for writing a single column of data for a particular

row to the underlying table, and will be invoked for each column which is to be inserted or updated.

Example: Codesbase's CBTable::WriteData() method

This method starts by ensuring that the operation is not being performed on a read-only table and that the column and row specified are within range. A handle to the underlying column is then obtained which will be used to specify the cell to write to. The method then checks if the column's default value (e.g. null) should be stored, and then delegates the writing of the data to a helper class called `CBTypeUtilities` which handles the details of storing the data in the underlying table.

```
bool CBTable::WriteData(
    simba_uint16 in_column,
    SqlData* in_data,
    simba_signed_native in_offset,
    bool in_isDefault)
{
    ENTRANCE_LOG(m_log, "Simba::", "CBTable", "WriteData");
    SE_CHK_INVALID_OPR("WriteData", m_isReadOnly);
    SE_CHK_INVALID_ARG(
        (in_isDefault ? (NULL != in_data) : (NULL == in_data))
||
        (m_tableHandle.numFields() < in_column));
    if (m_tableHandle.data->readOnly)
    {
        CBTHROW(DIAG_GENERAL_ERROR,
L"CBReadOnlyWriteFileError");
    }
    if (GetCurrentRow() >= m_rowCount)
    {
        CBTHROW2(
            DIAG_ROW_VAL_OUT_OF_RANGE,
            L"CBInvalidRowNum",
            NumberConverter::ConvertToWString(GetCurrentRow()
+ 1),
            m_tableName);
    }
    // Get the column handle.
    Field4 columnHandle(m_tableHandle, in_column + 1);
    if (columnHandle.isNull())
    {
        CBTHROW1(
            DIAG_COLUMN_MISSING,
```

```
            L"CBInvalidColumnIndex",
            NumberConverter::ConvertToWString(in_column + 1));
    }
    if (in_isDefault)
    {
        // NULL is the default value for our connector.
        return CBTypeUtilities::WriteDefault(
            columnHandle,
            GetSelectColumns()->GetColumn(in_column)-
>GetMetadata()->GetSqlType());
    }
    return CBTypeUtilities::WriteConvertData(
        columnHandle,
        m_binaryFile.Get(),
        in_data,
        in_offset,
        GetSelectColumns()->GetColumn(in_column)-
>GetColumnSize(),
        m_parentStatement->GetWarningListener());
}
```

The `OnStartRowUpdate` and `OnFinishRowUpdate` methods from `DSIExtResultSet` can also be overridden and implemented if needed.

`OnStartRowUpdate` is invoked by the Simba SQLEngine when an UPDATE operation is about to be performed, before writing data to update a row with (i.e. before `WriteData` is invoked). This method does not take in any parameters but can be optionally used by a connector to cache information that a row update is about to take place (e.g. to store a flag that `WriteData` can use to determine if the write is part of an insert or update operation). Note that this method is not called after `AppendRow` (i.e. during an INSERT operation) because it is implied that data will be written.

`OnFinishRowUpdate` is invoked by the Simba SQLEngine after data has been updated or a row inserted. This method can be used by a connector to perform any final steps required to complete the data update or row insertion, such as committing the data to disk. Note that the sample connector only uses this method to complete the insertion of a new row and not for row updates.

Optionally, the `OnStartDMLBatch` and `OnFinishDMLBatch` methods can also be implemented to handle the start and end of the UPDATE operation in the result set class. `OnStartDMLBatch` takes in the DMLType enum which specifies the type of operation (DML_UPDATE in this case), as well as the number of rows that will be affected by the operation. This method will be invoked before `OnStartRowUpdate`

and `OnFinishRowUpdate`. The `OnFinishDMLBatch` method will be invoked after the UPDATE operation is complete. These methods can be used by a connector to prepare for the updates of rows and to perform any post-UPDATE logic in the result set class.

Handling Deletes

To handle DELETE statements in a result set, the `DeleteRow` method must be overridden and implemented.

`DeleteRow` is invoked by the SQL Engine or Java Simba SQLEngine when a DELETE statement is encountered. This method is responsible for performing the deletion logic for the current row on the underlying table.

Example: SQLite's CBTable::DeleteRow method

This example shows the type of operations that are typically performed by a connector to delete a row.

This method starts by ensuring that the DELETE operation is not being performed on a read-only table and that the cursor is on a valid row. Note that the Simba SQLEngine first invokes the class's methods to properly position the cursor before DeleteRow is called, so this check should always be successful.

Finally, the method delegates the deletion to its underlying table class, reduces the cached row count, repositions the cursor to the row preceding the deleted row, and sets a flag indicating that a deletion has occurred. The class will check this flag later on when closing the cursor to perform proper cleanup.

```
void CBTable::DeleteRow()
{
    ENTRANCE_LOG(m_log, "Simba::", "CBTable", "DeleteRow");
    SE_CHK_INVALID_OPR("DeleteRow", m_isReadOnly);
    // Ensure the cursor is positioned on a valid row.
    if ((GetCurrentRow() >= m_rowCount) ||
        (GetCurrentRow() < 0))
    {
        CBTHROW2(
            DIAG_ROW_VAL_OUT_OF_RANGE,
            L"CBInvalidRowNum",
            NumberConverter::ConvertToWString(GetCurrentRow()
+ 1),
            m_tableName);
    }
    // Mark the current record for deletion.
    assert(m_rowCount > 0);
```

```
    m_tableHandle.deleteRec();
    // Update the row count.
    --m_rowCount;
    SetCurrentRow(GetCurrentRow() - 1);
    m_hasDeletedRecords = true;
}
```

Optionally, the `OnStartDMLBatch` and `OnFinishDMLBatch` methods can also be implemented to handle the start and end of the DELETE operation in the result set class. `OnStartDMLBatch` takes in the DMLType enum which specifies the type of operation (DML_DELETE in this case), as well as the number of rows that will be affected by the operation. This method will be invoked before `DeleteRow`. The `OnFinishDMLBatch` method will be invoked after the DELETE operation is complete. These methods can be used by a connector to prepare for the deletion of new rows and to perform any post-DELETE logic in the result set class.

Handling UPDATE and DELETE Statements in an Index

A connector can handle UPDATE and DELETE statements in an index to provide better performance in locating a row to update or delete, than when handling the statement via a result set. This section describes the methods to implement the handling of these statements in an index. Note that DSII indexes must be enabled in order for the Simba SQLEngine to invoke these methods.

Note:

Indexes are not supported by the Java Simba SQLEngine.

Handling Updates

To handle an UPDATE statement in an index, a DSIExtIndex-derived class must override and implement `WriteData`, and optionally `OnStartRowUpdate` and `OnFinishRowUpdate`.

`WriteData` is invoked by the Simba SQLEngine when inserting a row or updating row values. This method is responsible for writing a single column of data for a particular row to the underlying table, and will be invoked for each column which is to be inserted or updated.

Example:

This method delegates the writing of cell data to its underlying index table and then instructs that object to set a flag indicating that the table has been modified.

```
bool XMIndex::WriteData(simba_uint16 in_column,SqlData* in_
data,simba_signed_native in_offset,bool in_isDefault)
{

    assert(!m_beforeFirstRow);
    assert(m_rowPos != m_rows.end());
    const bool truncated(
    m_tableData.WriteData(in_column, in_data, in_offset,
    in_isDefault, *m_rowPos));
    m_table.SetTableModified();
    return truncated;

}
```

The `OnStartRowUpdate`, `OnFinishRowUpdate`, `OnStartDMLBatch`, and `OnFinishDMLBatch` methods from `DSIExtIndex` can optionally be overridden and implemented.

`OnStartRowUpdate` is invoked by the Simba SQLEngine when an UPDATE operation is about to be performed, before writing data to update a row with (i.e. before `WriteData` is invoked). This method does not take in any parameters but can be optionally used by a connector to cache information that a row update is about to take place.

`OnFinishRowUpdate` is invoked by the Simba SQLEngine after data has been updated or a row inserted. This method can be used by a connector to perform any final steps required to complete the data update or row insertion, such as committing the data to disk.

The `OnStartDMLBatch` and `OnFinishDMLBatch` methods can be implemented to handle the start and end of the UPDATE operation in the index class. `OnStartDMLBatch` takes in the DMLType enum which specifies the type of operation (DML_UPDATE in this case), as well as the number of rows that will be affected by the operation. This method will be invoked before `OnStartRowUpdate`. The `OnFinishDMLBatch` method will be invoked after the UPDATE operation is complete. These methods can be used by a connector to prepare for the updates to rows and to perform any post-UPDATE logic in the index class.

Handling Deletes

To handle DELETE statements in an index, the `DeleteRow` method must be overridden and implemented.

`DeleteRow` is invoked by the SQL Engine when a DELETE statement is encountered. This method is responsible for performing the deletion logic for the current row on the underlying table.

Example:

This example shows the type of operations that are typically performed by a connector to delete a row.

```
void XMIndex::DeleteRow()
{
    assert(!m_beforeFirstRow);
    assert(m_rowPos != m_rows.end());
    std::vector<RowIdentifier>::iterator currRow = m_rowPos;
    // Delete the row from the table.
    m_tableData.DeleteDataRow(*currRow);
    if (currRow == m_rows.begin())
    {
        // Remove the row from the list of rows in the index
        m_rows.erase(currRow);
        // Set the row position to before the first row.
        m_beforeFirstRow = true;
    }
    else
    {
        // Set the position to the previous row.
        --m_rowPos;
        // Remove the row from the list of rows in the index.
        m_rows.erase(currRow);
    }
    m_table.SetTableModified();
}
```

This method obtains a pointer to the current row and then determines whether that row is the first row in the index's table. If it is the first row, the code removes the row and then sets a flag (`m_beforeFirstRow`) indicating that the cursor no longer points to a row. If the row is not the first in the table, the cursor is decremented to the row preceding the row to be deleted, and the current row is removed. Finally, a flag is set on the underlying table to indicate that the table has been modified.

Optionally, the `OnStartDMLBatch` and `OnFinishDMLBatch` methods can also be implemented to handle the start and end of the DELETE operation in the index class. OnStartDMLBatch takes in the DMLType enum which specifies the type of operation (DML_DELETE in this case), as well as the number of rows that will be affected by the operation. This method will be invoked before DeleteRow. The OnFinishDMLBatch method will be invoked after the DELETE operation is complete. These methods can be used by a connector to prepare for the deletion of new rows and to perform any post-DELETE logic in the index class.

Data Definition Language (DDL)

SQL Engine can support SQL Data Definition Language (DDL) CREATE and DROP queries for tables and indexes. If your data source supports this functionality, you can implement it in your custom connector.

Note:

SQL Engine does not support ALTER, TRUNCATE, COMMENT, or RENAME.

The following sections explains how to enable support for DDL queries in your custom connector.

Enable Write Operations

All DDL features require the following change to enable write operations:

Call `DSIPropertyUtilities::SetReadOnly()` during the construction of your `CustomerConnection` object, passing in `false` for the second parameter. This enables write operations on tables.

Create a Table (C++ Only)

This section explains how to allow for table creation in your custom connector.

Set the DSI_CONN_CREATE_TABLE property

In the C++ SQL Engine, set the DSI_CONN_CREATE_TABLE property in your `CustomerDSIIConnection` object. This can be done using the `DSIConnection::SetProperty` method, passing DSI_CT_CREATE_TABLE as the attribute data.

Note:

This attribute takes a bitmask that describes functionality, so if you want to support constraints you also need to set the DSI_CT_TABLE_CONSTRAINT bit by or'ing it with DSI_CT_CREATE_TABLE.

In the SQLite sample connector, this call is made from the `SLConnection` class's constructor, which invokes a helper method called `SetConnectionPropertyValues` to set all of the properties required by the connector.

Implement the CreateTable method

Implement the `CreateTable` method in your `CustomerDataEngine` class. This method is invoked by the Simba SQLEngine when a CREATE TABLE statement is encountered. This method is responsible for performing the logic necessary to create the underlying table.

Example: SQLite's CreateTable method

This method takes in a `TableSpecification` which contains the table information specified in the CREATE TABLE statement (i.e. column names and constraints). Using this information, the method creates the column metadata and places it into a vector of FIELD4INFO objects describing each column. This is then stored on disk if certain column types are encountered (e.g. a binary field). Otherwise, the table is created in memory only for demonstration purposes.

```
void SLDataEngine::CreateTable(const
SharedPtr<TableSpecification> in_specification)
{
    ...
    // Should have been rejected in AETree validation.
    assert(in_specification->GetConstraints().empty());
    // A catalog must be provided.
    if (in_specification->GetCatalog().IsNull())
    {
        CBTHROW(DIAG_INVALID_CATALOG_NAME, L"CBEmptyCatalog");
    }
    // If no schema is provided, default to 'DBF'.
    const simba_wstring& schema =
        in_specification->GetSchema().IsNull() ? L"DBF" : in_
specification->GetSchema();
    // Whether any of the column data will be stored in a
separate binary file.
    bool needBinaryFile = false;
    // Hold the column names (since they are NOT OWNED by the
FIELD4INFO structs).
    // This will be reserve()'d to the proper size to prevent
allocations, which would
    // cause to be pointing to deleted memory.
    vector<simba_string> columnNames;
    // Convert the IColumns into equivalent column
definitions.
    assert(in_specification->GetColumns());
    vector<FIELD4INFO> columnDefinitions =
```

```
        CreateColumnMetadata(*in_specification->GetColumns(),
columnNames,needBinaryFile);
    CBUtilities utilities(m_Settings);
    // Create the directory structure (needed for 'new'
catalog/schema)
    utilities.CreateDirectoryStructureIfNeeded(in_
specification->GetCatalog(), schema);
    // Create the binary file for the table if one is needed.
    if (needBinaryFile)
    {
        simba_wstring binaryFilePath
(utilities.GetBinaryFilePath(in_specification->GetCatalog
(),schema, in_specification->GetName()));
        // Check that a file with the same name does not
already exist.
        try
        {
            BinaryFile shouldNotExist(binaryFilePath,
OPENMODE_READONLY);
            // If we get here, the file existed.
            const simba_wstring fullName = in_specification-
>GetCatalog() +
                L"." +
                schema +
                L"." +
                in_specification->GetName();
            CBTHROWGEN2(L"CBBinaryFileAlreadyExists",
fullName, binaryFilePath);
        }
        catch (ProductException&)
        {
            // The file did not exist. Continue.
        }
        // This should create the binary file.
        try
        {
            BinaryFile binaryFile(binaryFilePath, OPENMODE_
READWRITE_NEW);
        }
        catch (ProductException&)
        {
            // Could not create the file.
```

```
            const simba_wstring fullName = in_specification-
>GetCatalog() +
                L"." +
                schema +
                L"." +
                in_specification->GetName();
            CBTHROWGEN2(L"CBCannotCreateBinaryFile", fullName,
binaryFilePath);
        }
    }
    // Finally, create the table using the API.
    simba_string tablePath = utilities.GetTablePath(
        in_specification->GetCatalog(),
        schema,
        in_specification->GetName()).GetAsPlatformString();
    Data4 tableHandle;
    int error = tableHandle.create(
        m_Settings->m_settings,
        tablePath.c_str(),
        &columnDefinitions[0]);
    if (!tableHandle.isValid())
    {
        // An error occurred creating the table.
        const simba_wstring fullName = in_specification-
>GetCatalog() +
            L"." +
            schema +
            L"." +
            in_specification->GetName();
        const simba_wstring errorText(e4text(error));
        CBTHROWGEN2(L"CBErrorCreatingTable", fullName,
errorText);
    }
    // Close the table after it was successfully created.
    error = tableHandle.close();
    if (error < 0)
    {
        // An error occurred closing the table.
        const simba_wstring fullName = in_specification-
>GetCatalog() +
            L"." +
            schema +
```

```
            L"." +
            in_specification->GetName();
        const simba_wstring errorText(e4text(error));
        CBTHROWGEN2(L"CBErrorClosingTable", fullName,
errorText);
    }
}
```

By default, column types specified in the CREATE TABLE statement are resolved by `DSIExtColumnFactory` using the type names and SQL types returned by the Type Info metadata source's TYPE_NAME and DATA_TYPE columns respectively. An exception is made for interval types, which are determined according to the rules outlined in Interval Conversions.

Add Additional Types (Optional)

If you want to add additional types you can subclass `DSIExtColumnFactory`. If you require different behavior, you can implement `IColumnFactory` directly. Doing so will enable you to override the `CreateColumn` method (which is invoked during table creation) to perform custom logic during the creation of columns.

To create a column factory:

1. Derive a class from `DSIExtColumnFactory` and override `CreateCustomColumn` or implement the `IColumnFactory` interface directly, and override the `CreateColumn` method. This method will be invoked by the Simba SQLEngine for each column to be created in the table. This method is responsible for returning a pointer to an `IColumn` object which provides all the information about the column to the SQLEngine. Connectors can also use this method to check and verify that the requested column type and parameters match what the connector is able to support.

   Example: SQLite's CBColumnFactory::CreateCustomColumn method

   The method is provided with numerous parameters such as the table and column names. The method starts by performing a few basic checks on the column and related information passed in. It then creates an `SqlTypeMetadata` object to store the information about the SQL type for which a column is to be created, as well as a `DSIColumnMetadata` object to store information about the column.

   Then, this example shows how checks are made for a numeric column type to ensure that the type parameters provided match what the connector can handle. Note that your own implementation likely requires additional checks. Once these

checks pass, a new `DSIResultSetColumn` object is constructed using the `SqlTypeMetadata` and `DSIColumnMetadata` objects.

```
Simba::DSI::IColumn* CBColumnFactory::CreateCustomColumn(
const simba_wstring& in_catalogName,
const simba_wstring& in_schemaName,
const simba_wstring& in_tableName,
const simba_wstring& in_columnName,
const simba_wstring& in_typeName,
const std::vector<simba_wstring>& in_typeParameters,
Simba::DSI::DSINullable in_nullable)
{

    // SQLite allows column names which are at most 10
    characters.
    if (in_columnName.GetAsPlatformString().length() >
    10)
    {

        CBTHROW1(DIAG_SYNTAX_ERR_OR_ACCESS_
        VIOLATION, L"CBColumnNameTooLong", in_
        columnName);

    }
    else if (0 == in_columnName.GetLength())
    {

        CBTHROW(DIAG_SYNTAX_ERR_OR_ACCESS_
        VIOLATION, L"CBEmptyColumnName");

    }
    // Check that the column name has the right prefix
    for its type.
    CBTypeUtilities::CheckColumnPrefix(in_
    columnName.GetAsPlatformString(), sqlType);
    AutoPtr<SqlTypeMetadata> typeMeta
    (SqlTypeMetadataFactorySingleton::GetInstance()-
    >CreateNewSqlTypeMetadata(sqlType));
    AutoPtr<DSIColumnMetadata> columnMeta(new
    DSIColumnMetadata());
    columnMeta->m_catalogName = in_catalogName;
    columnMeta->m_schemaName = in_schemaName;
```

```
columnMeta->m_tableName = in_tableName;
columnMeta->m_name = in_columnName;
columnMeta->m_unnamed = false;
columnMeta->m_label = in_columnName;
columnMeta->m_nullable = in_nullable;
// Set default, will be overwritten for variable-
length types.
columnMeta->m_charOrBinarySize =
SqlDataTypeUtilitiesSingleton::GetInstance()-
>GetColumnSizeForSqlType(sqlType);
// Deal with type parameters.
switch (sqlType)
{

    ....
    case SQL_NUMERIC:
    {

        if (in_typeParameters.size() > 2)
        {

            CBTHROW1(DIAG_SYNTAX_ERR_
            OR_ACCESS_VIOLATION,
            L"CBTooManyTypeParams",
            in_columnName);

        }
        if (in_typeParameters.size() >=
        1)
        {

            try
            {

                simba_uint64
                precision =
                NumberConverter:
```

```
:ConvertWStringT
oUInt64(in_
typeParameters
[0]);
if (precision >
SIMBA_INT16_MAX)
{
    CBTHROW3
    (
    DIAG_
    SYNTAX_
    ERR_OR_
    ACCESS_
    VIOLATIO
    N,
    L"CBPrec
    isionToo
    Large",
    in_
    typePara
    meters
    [0],
    NumberCo
    nverter:
    :Convert
    UInt32To
    WString
    (SIMBA_
    INT16_
    MAX),
    in_
```

```
                    columnNa
                    me);

                }
                typeMeta-
                >SetPrecision
                (static_
                cast<simba_int16>
                (precision));

            }
            catch (...)
            {

                CBTHROW2(
                DIAG_SYNTAX_ERR_
                OR_ACCESS_
                VIOLATION,
                L"CBCannotConver
                tPrecision",
                in_typeParameters
                [0],
                in_columnName);

            }

        }
        if (in_typeParameters.size() ==
        2)
        {

            try
            {
            simba_int64 scale =
            NumberConverter::ConvertW
            StringToInt64(in_
            typeParameters[1]);
```

```
if (scale > typeMeta-
>GetPrecision())
{
    CBTHROW3(
    DIAG_SYNTAX_ERR_
    OR_ACCESS_
    VIOLATION,
    L"CBScaleTooLarg
    e",
    in_typeParameters
    [1],
    NumberConverter:
    :ConvertUInt32To
    WString(typeMeta-
    >GetPrecision()),
    in_columnName);
    }
    typeMeta-
    >SetScale(static_
    cast<simba_int16>
    (scale));
}
catch (...)
{
    CBTHROW2(
    DIAG_SYNTAX_ERR_
    OR_ACCESS_
    VIOLATION,
    L"CBCannotConver
    tScale",
    in_typeParameters
    [1],
```

```
                        in_columnName);

                    }

                }
                break;
                }
                ...

            }

        return new DSIResultSetColumn(typeMeta.Detach(),
        columnMeta.Detach());

    }
```

2. Derive a class from `DSIExtCustomBehaviorProvider` and override `InitializeColumnFactory` to create your column factory. The following code snippet shows how uses this method to create a `CBColumnFactory` object:

   Example:

   ```
   void CBCustomBehaviorProvider::InitializeColumnFactory
   (DSIExtSqlDataEngine* in_dataEngine)
   {
       m_columnFactory = new CBColumnFactory(in_dataEngine,
   m_isODBC3);
   }
   ```

   When using the Simba SQLEngine, override is `SqlCustomBehaviourProvider.initColumnFactory(SqlDataEngine dataEngine)`.

3. In your derived `DataEngine` class, override the `CreateCustomBehaviorProvider` method to return the `CustomBehaviourProvider` class from Step 2.

4. **Example:SQLite's SLDataEngine class**

   ```
   AutoPtr<Simba::SQLEngine::DSIExtCustomBehaviorProvider>
   SLDataEngine::CreateCustomBehaviorProvider()
   {
       return
   AutoPtr<Simba::SQLEngine::DSIExtCustomBehaviorProvider>(
           new CBCustomBehaviorProvider(IsODBCVersion3()));
   }
   ```

Once these steps have been completed, the `CreateColumn` method in your `ColumnFactory` class will be invoked for each table column.

Drop A Table (C++ Only)

This section explains how to handle table dropping.

Set the DSI_CONN_DROP_TABLE

In the C++ SQL Engine, set the DSI_CONN_DROP_TABLE property in your `CustomerDSIIConnection` object. This can be done using the `DSIConnection::SetProperty` method passing in DSI_DT_DROP_TABLE as the attribute data. In SQLite, this call is made from the `SLConnection` class's constructor which invokes a helper method called `SetConnectionPropertyValues` to set all of the properties required by the connector.

Implement the DropTable method

Add and implement the `DropTable` method in your `CustomerDataEngine` class. This method will be invoked by the Simba SQLEngine when a DROP TABLE query is encountered. This method is responsible for performing all logic necessary to drop the specified table from the data source.

Example: SQLite's SLDataEngine::DropTable implementation

This example method starts by performing the calls necessary to temporarily open files in exclusive mode and then checks to ensure that the specified table exists using a helper class called `CBUtilities`. If so, the method attempts to open the binary file containing the table data in exclusive mode so that no other processes can interfere with the deletion of the file. If the open succeeds, the method then deletes the binary file. Note that the method uses the low level Data4 class which handles file operations for data files.

```
void SLDataEngine::DropTable(
    const simba_wstring& in_catalogName,
    const simba_wstring& in_schemaName,
    const simba_wstring& in_tableName,
    Simba::SQLEngine::DSIExtTableDropOption in_dropOption)
{
    assert(TABLE_DROP_UNSPECIFIED == in_dropOption);
    // Temporarily change the settings to open files in
exclusive mode.
    TemporarySettingsOverride override(m_Settings->m_
settings);
    override.OverrideAccessMode(OPEN4DENY_RW);
```

```
    override.OverrideReadOnly(0);
    CBUtilities utilities(m_Settings);
    simba_wstring schemaName(L"");
    if (utilities.DoesTableExist(
        m_Settings->m_dbfPath,
        in_catalogName,
        in_schemaName,
        in_tableName,
        schemaName))
    {
        simba_wstring tablePath =
            utilities.GetTablePath(in_catalogName, schemaName,
in_tableName);
        // Open the table exclusively
        Data4 tableHandle;
        AutoHandleCloser<Data4> tableCloser(tableHandle);
        int error = tableHandle.open(
            m_Settings->m_settings,
            tablePath.GetAsPlatformString().c_str());
        if (!tableHandle.isValid())
        {
            tableCloser.CancelClose();
            const simba_wstring table =
                in_catalogName + L"." + in_schemaName + L"." +
in_tableName;
            const simba_wstring errorText(e4text(error));
            CBTHROWGEN2(L"CBCannotOpenDropTable", table,
errorText);
        }

        // Drop the table
        error = tableHandle.remove();
        if (error < 0)
        {
            const simba_wstring table =
                in_catalogName + L"." + in_schemaName + L"." +
in_tableName;
            const simba_wstring errorText(e4text(error));
            CBTHROWGEN2(L"CBCannotDropTable", table,
errorText);
        }
        // Dropping the table succeeded.
```

```
        tableCloser.CancelClose();
        // Delete the binary file if there is one.
        utilities.DeleteBinaryFile(in_catalogName, schemaName,
in_tableName);
    }
    else
    {
        const simba_wstring table =
            in_catalogName + L"." + in_schemaName + L"." + in_
tableName;
        CBTHROW1(DIAG_BASE_TABLE_OR_VIEW_MISSING,
L"CBDropNonExistentTable", table);
    }
}
```

Create an Index (C++ Only)

Use the following steps to handle index creation:

1. Set the DSI_CONN_DDL_INDEX property in your `CustomerDSIIConnection` object. This can be done using the `DSIConnection::SetProperty` method passing in DSI_DI_CREATE_INDEX as the attribute data. In the SQLite sample, this call is made from the `SLConnection` class's constructor which invokes a helper method called `SetConnectionPropertyValues` to set all of the properties required by the connector.

   Note:

   If index dropping is to also be supported as described in the next subsection, DSI_DI_CREATE_INDEX can be evaluated with DSI_DI_DROP_INDEX using a bitwise OR operator '|' ".

2. Implement the `CreateIndex` method in your `CustomerTable` class. This class is derived from `DSIExtResultSet`, which handles all table operations. The `CreateIndex` method is invoked by the Simba SQLEngine when a CREATE INDEX query is encountered. This method is responsible for creating an index for the specified columns.

   Example: SQLite's CBTable::CreateIndex method

   Note that this method doesn't create a real index. Rather, it just maintains a list of indexes the tables have to show the consumption of the parameters passed to `CreateIndex`.

The method starts by checking if an index type was specified as part of the query. If so, it ensures that the specified index type is supported by the connector and that the index doesn't already exist. It then builds up an index specification (a string containing index information) and iterates through the columns passed in, adding column information to that string. Finally, it adds this string to an index file.

```
void CBTable::CreateIndex(
    const simba_wstring& in_name,
    std::vector<DSIExtIndexColumn>& in_columns,
    const simba_wstring& in_type,
    bool in_isUnique)
{
    assert(!in_columns.empty());
    simba_wstring indexType = L"OTHER";
    if (!in_type.IsNull())
    {
        if (!in_type.IsEqual(L"BTREE", false) &&
            !in_type.IsEqual(L"CLUSTERED", false) &&
            !in_type.IsEqual(L"CONTENT", false) &&
            !in_type.IsEqual(L"HASHED", false) &&
            !in_type.IsEqual(L"OTHER", false))
        {
            CBTHROW1(DIAG_SYNTAX_ERR_OR_ACCESS_VIOLATION,
L"CBInvalidIndexType", in_type);
        }
        indexType = in_type;
        indexType.ToUpper();
    }
    if (SIMBA_NPOS != in_name.Find(L"\t"))
    {
        CBTHROW1(DIAG_SYNTAX_ERR_OR_ACCESS_VIOLATION,
L"CBInvalidIndexName", in_name);
    }
    // Check that an index with that name doesn't exist
already.
    if (NULL != m_indexMetaList.GetIndexMetadata(in_name))
    {
        // This should never happen, as the SDK checks for
this, and
```

```
        // the index list does not get updated
asynchronously.
        assert(false);
    }
    // Initialize the index spec with the column-
independent information.
    simba_string indexSpec =
        in_name.GetAsPlatformString() +
        '\t' +
        indexType.GetAsPlatformString() +
        '\t' +
        (in_isUnique ? 'Y' : 'N');
    // Add each column to the index spec.
    std::vector<DSIExtIndexColumn>::iterator it = in_
columns.begin();
    std::vector<DSIExtIndexColumn>::iterator end = in_
columns.end();
    for (;it != end; ++it)
    {
        // Find the ordinal of the column in this table.
        DSIExtIndexColumn& indexColumn = *it;
        simba_wstring indexColName;
        indexColumn.GetName(indexColName);
        simba_uint16 columnOrdinal = GetColumnOrdinal
(indexColName);
        if (SE_INVALID_COLUMN_NUMBER == columnOrdinal)
        {
            // This should never happen, as this is
checked by the SDK.
            assert(false);
        }
        indexSpec +=
            ('\t' +
            NumberConverter::ConvertUInt16ToString
(columnOrdinal) +
            '\t' +
            ((indexColumn.GetSortOrder() == DSIEXT_SORT_
DESCENDING) ? 'N' : 'Y'));
    }
    if (m_indexFile.IsNull())
```

```
    {
        // This means that there was no index file upon
opening the table, so create one.
        CBUtilities utilities(m_Settings);
        simba_wstring indexFileName(
            utilities.GetIndexFilePath(m_catalogName, m_
schemaName, m_tableName));
        m_indexFile.Attach(new TextFile(indexFileName,
OPENMODE_WRITE_NEW));
    }

    m_indexFile->WriteLine(indexSpec);
}
```

Drop an Index (C++ Only)

1. Set the DSI_CONN_DDL_INDEX property in your `CustomerDSIIConnection` object. This can be done using the `DSIConnection::SetProperty` method passing in DSI_DI_DROP_INDEX as the attribute data. In SQLite, this call is made from the `SLConnection` class's constructor which invokes a helper method called `SetConnectionPropertyValues` to set all of the properties required by the connector.

   Note:

   If index creation is to also be supported as described in the previous subsection, DSI_DI_DROP_INDEX can be evaluated with DSI_DI_CREATE_INDEX using a bitwise OR operator '|' ".

2. Implement the `DropIndex` method in your `CustomerTable` class. This method is invoked by the Simba SQLEngine when a DROP INDEX query is encountered and is responsible for removing the specified index from the table.

   Example: SQLite's CBTable::DropIndex method

   The method starts by ensuring that a valid index has been provided by the SDK and if so, closes the underlying index file. If the table only has one index (i.e. this is the only index that has been created), then the index file is deleted. Otherwise, the remaining indexes (strings containing index information) are cached, the file is deleted, then a new file is created and the remaining indexes added back in to the new file. Finally, the dropped index is removed from the list of cached indexes.

   ```
   void CBTable::DropIndex(const IIndexMetadata* in_index)
   {
   ```

```
    assert(in_index);
    // Check that this is a valid index.
    const simba_size_t numIndexes = m_
indexMetaList.GetIndexCount();
    bool found = false;
    simba_size_t indexIndex = -1;
    for (simba_size_t i = 0; i < numIndexes; ++i)
    {
        if (m_indexMetaList.GetIndexMetadata(i) == in_
index)
        {
            found = true;
            indexIndex = i;
            break;
        }
    }
    if (!found)
    {
        // This should never happen, as this is checked
for by the SDK, and the index list
        // does not change asynchronously.
        assert(false);
    }
    // If the index was found, we must have opened the
index file to populate m_indexes.
    // Close it so that we can delete the file.
    m_indexFile.Attach(NULL);
    if (1 == numIndexes)
    {
        // This was the only index, so we can simply
delete the index file.
        CBUtilities utilities(m_Settings);
        utilities.Delete(utilities.GetIndexFilePath(m_
catalogName, m_schemaName, m_tableName));
    }
    else
    {
        // We have to remake the file, but remove the line
with the index in question.
        assert(1 < numIndexes);
```

```
        vector<IIndexMetadata*> remainingIndexes;
        remainingIndexes.reserve(numIndexes - 1);
        // Copy over every index other than the one to be
deleted.
        for (simba_size_t i = 0; i < numIndexes; ++i)
        {
            IIndexMetadata* indexMeta = m_
indexMetaList.GetIndexMetadata(i);
            if (indexMeta != in_index)
            {
                remainingIndexes.push_back(indexMeta);
            }
        }
        // Delete the index file.
        CBUtilities utilities(m_Settings);
        utilities.Delete(utilities.GetIndexFilePath(m_
catalogName, m_schemaName, m_tableName));
        // Recreate it so we can add the remaining
indexes.
        OpenIndexFile(false, true);
        assert(!m_indexFile.IsNull());
        for (vector<IIndexMetadata*>::iterator it =
remainingIndexes.begin();
             it != remainingIndexes.end();
             ++it)
        {
            m_indexFile->WriteLine(IndexMetaToIndexSpec
(*it));
        }
    }
    // Remove the dropped index from our list of existing
indexes.
    m_indexMetaList.RemoveIndexMetadata(indexIndex);
}
```

Support for Indexes

If your data store supports indexes, the C++ SimbaSQL Engine enables you to use these indexes in your custom connector code. Using indexes improves the speed of data retrieval.

Note:

The Java version of the SQL Engine does not support indexes. You can build a custom JDBC connector that supports your data store's indexes by using the JNIDSI bridge to the C++ Simba SDK.

SQL Engine uses indexes following ways:

- **Index-only scan**

  If a single `DSIExtIndex` object contains the data for all needed columns, then the SQL Engine can scan only the index in order to retrieve data. Retrieving data from rows in the result set is not necessary. The SDK may use the index without using the indexing capability of the index. Simba SDK can also use the index for filtering or joining while performing an index-only scan.

- **Bookmark usage scan**

  If a data source can use bookmarks, then a `DSIExtIndex` can be used to retrieve a set of bookmarks for rows in the parent table that satisfy a filter.

To control the use of index-only scans, set the property DSIEXT_DATAENGINE_PREFER_INDEX_ONLY_SCANS to `Y`. This tells the SQL Engine to attempt an index-only scan whenever possible. An index generally contains less data than the parent table, and therefore can be traversed more efficiently.

If scanning an index is slower than scanning a table, or for other design reasons, then set the DSIEXT_DATAENGINE_PREFER_INDEX_ONLY_SCANS property to the value `N`. When set to `N`, index-only scans are still performed if the scan satisfies one or more filters. If the DSIEXT_DATAENGINE_USE_DSII_INDEXES property is set to `N`, then the DSIEXT_DATAENGINE_PREFER_INDEX_ONLY_SCANS property is not used.

If you inherit from `DSIExtSimpleResultSet`, to enable the use of indexes you need only to implement `GetBookmarkSize`, `GetBookmark` and `GotoBookmark` in addition to your DSIExtIndex implementation.

Information on implementing indexes can be found in the section Support for Indexes. See also to the Simba SDK C++ API Reference for details on how to implement Simba SDK usage of data store indexes.

Implementation Overview

The use of indexes is implemented as follows:

- Use of indexes is enabled and disabled using the DSIEXT_DATAENGINE_USE_DSII_INDEXES property. If the property is set to `N`, then use of indexes is disabled. If the property is set to `Y`, then use of indexes is enabled. By default, the use of indexes is disabled.
- Information about indexes that exist in relation to a `DSIExtResultSet` result set object are retrieved using the `DSIExtResultSet::GetIndexes` method.

Note:

The `IIndexMetadata` objects returned from `GetIndexes` must be subclasses of `IUseableIndexMetadata` or the SQLEngine cannot use the indexes, except for the purposes of SQLStatistics.

- Based on the information retrieved about available indexes using `DSIExtResultSet::GetIndexes`, indexes are retrieved as DSIExtIndex objects using `DSIExtResultSet::OpenIndex`.

Note:

When the DSIEXT_DATAENGINE_USE_DSII_INDEXES property is set to `N`, then `DSIExtResultSet::OpenIndex` is not called.

- The columns found in a `DSIExtIndex` object can be ascertained using `IUseableIndexMetadata::GetIndexColumns`, `IUseableIndexMetadata::GetIncludedColumns`, or `IUseableIndexMetadata::GetTableColumnToIndexColumnMap`.
  - `GetIndexColumns` returns the column objects on which an index is searchable. For example, if a given index can be used to efficiently satisfy a filter involving a column, then that column should appear in the collection returned by this method. Note that the order of columns returned is significant if the index is a sorted index.
  - `GetIncludedColumns` returns the column indices for which the SDK can call `DSIExtIndex::RetrieveData` (i.e. the column indicies for which data can be retrieved from the index as opposed to the associated `DSIExtResultSet`). Note that this is usually a subset of the columns that would be returned from `GetIndexColumns` and this subset can sometimes be empty. When all columns required for the current query appear in this set, it can allow the SDK to retrieve data from the index instead of from the table, which can be more efficient in some cases. It can also help efficiency when there is a condition on one of the included columns which cannot be directly satisfied by the index (e.g. 'C1 LIKE

%ness'), as it allows the SDK to evaluate the filter before looking up the row in the associated `DSIExtResultSet`.

- `GetTableColumnToIndexColumnMap` returns a mapping from columns in the parent `DSIExtResultSet` to columns included (see `GetIncludedColumns` above) in this index. For example, given a column index i (with respect to the parent result), if the map contains an entry for i, then `dsiextresult.RetrieveData(i, …)` retrieves data from the same column as `dsiextindex.RetrieveData (indexMeta.GetTableColumnToIndexColumnMap()[i], …)`.

- SQL Engine can take advantage of an index's structure to reduce the number of rows retrieved from the index.

This functionality will be explained further in the following sections.

Index-Only Scan Example

In this example, the SQL Engine is executing the following query:

SELECT C1 FROM T1 WHERE C1 = 5

The column T1.C1 has type SQL_INTEGER (signed). Also, a DSII index that has the capability of retrieving data from T1.C1 exists and is named `IDX1`.

From the perspective of the DSII, the following steps occur:

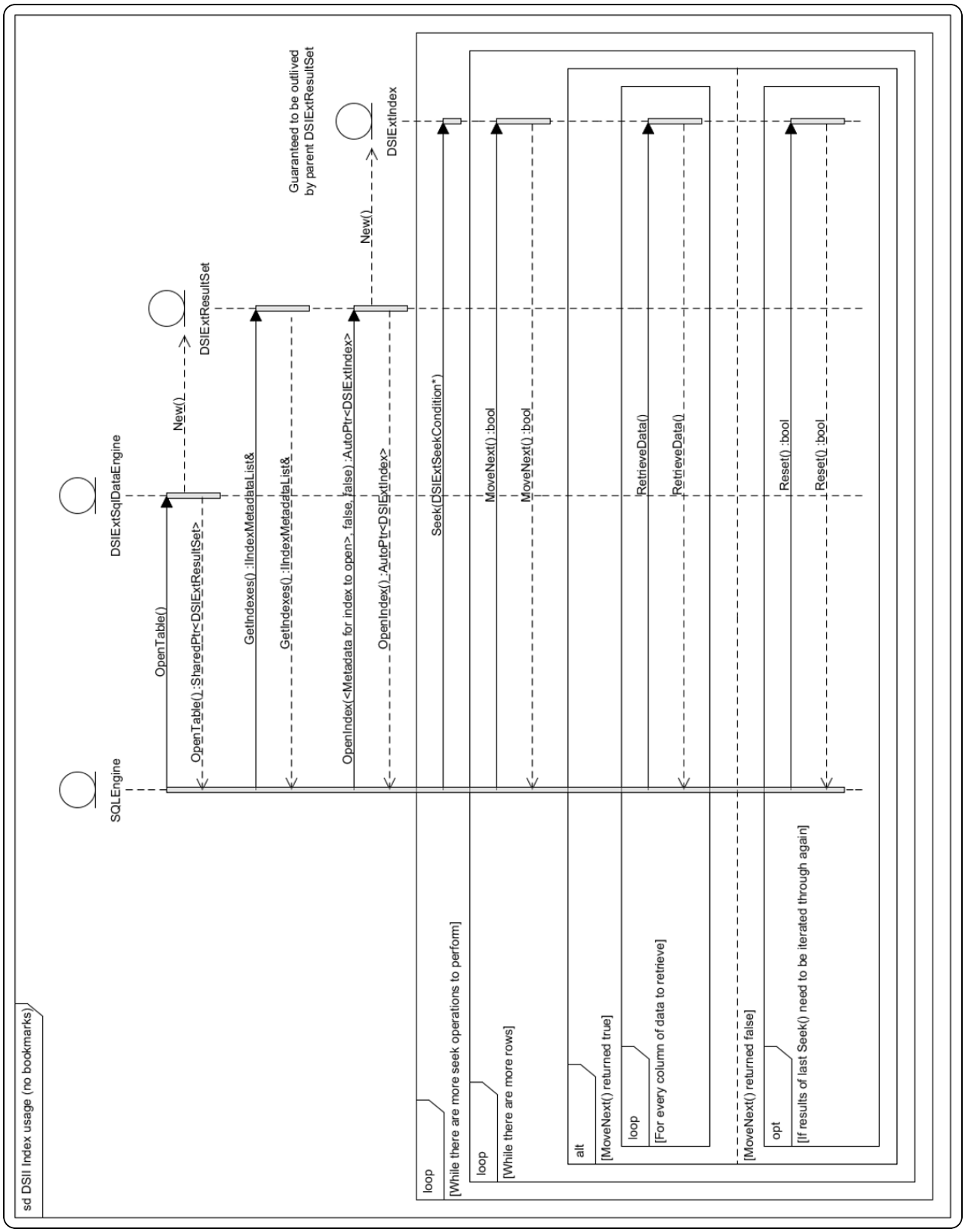
1. The SDK opens the table T1 via a call to `DSIExtSqlDataEngine::OpenTable`, creating the object `<A>`.
2. The SDK requests information related to T1's indexes by calling `DSIExtResultSet::GetIndexes` on `<A>`.
3. The SDK opens the index `IDX1` by passing in the appropriate `IUseableIndexMetadata*` into `DSIExtResultSet::OpenIndex` on `<A>`, as well as values of false for the `in_mustKeepOrder` and `in_mustSupplyBookmarks parameters`. The SDK shall not attempt to retrieve bookmarks from the index and the order of rows retrieved is irrelevant for the example query. Calling `DSIExtResultSet::OpenIndex` creates and returns a `DSIExtIndex` object `<B>` representing the index `IDX1`.
4. The SDK searches `IDX1` by calling `DSIExtIndex::Seek` on `<B>`, passing in a `DSIExtSeekCondition` object `<C>`, with `<C>.GetEqualitySegments` returning a vector of size 1 containing the `simba_int32` value 5 wrapped in a `DSIExtKeySegment`, and `<C>.HasLastColumnCondition` returning `false`.

> **Note:**
>
> For more details on seek conditions, see Support for Indexes.

5. After the call to `DSIExtIndex::Seek`, calling `DSIExtIndex::MoveNext` followed by `DSIExtIndex::RetrieveData` in a loop steps through `<B>`, returning the values in the column C1 for rows satisfying the condition T1.C1 = 5. In an index-only scan, `<B>` acts similarly to an `IResult` object.
6. The SDK may also call `DSIExtIndex::Reset` or `DSIExtIndex::Seek`.

For a flow chart illustrating methods in the DSIExtIndex class, see the DSIExtIndex class in the C++ API Reference Guide.

The following sequence diagram illustrates the general steps of the index-only scan example.



Bookmark Usage Example

If an index does not contain the data for all needed columns, then the SQL Engine accesses table data using bookmarks. If an index is unable to provide bookmarks, then the index is ineligible for use.

Consider the following example, where the SQL Engine is executing the following query:

SELECT D1 FROM T1 WHERE C1 = 5

The column T1.C1 has type SQL_INTEGER (signed). Also, a DSII index on T1.C1 named `IDX1` is capable of retrieving bookmarks.

From the perspective of the DSII, the following steps occur:

1. The SDK opens the table T1 via a call to `DSIExtSqlDataEngine::OpenTable`, creating the object `<A>`.
2. The SDK requests information related to T1's indexes by calling `DSIExtResultSet::GetIndexes` on `<A>`.
3. The SDK opens the index IDX1 by passing in the appropriate `IUseableIndexMetadata*` into `DSIExtResultSet::OpenIndex` on `<A>`, as well as a value of `false` for the `in_mustKeepOrder` parameter and a value of `true` for the `in_mustSupplyBookmarks` parameter. The SDK needs to retrieve bookmarks from the index and the order of rows retrieved is irrelevant for the example query. Calling `DSIExtResultSet::OpenIndex` creates and returns a `DSIExtIndex` object <B> representing the index `IDX1`.
4. The SDK searches `IDX1` by calling `DSIExtIndex::Seek` on <B>, passing in a `DSIExtSeekCondition` object `<C>`, with `<C>.GetEqualitySegments` returning a vector of size 1 containing the simba_`int32` value 5 wrapped in a `DSIExtKeySegment`, and `<C>.HasLastColumnCondition` returning `false`.

> **Note:**
>
> For more details on seek conditions, see Support for Indexes.

5. The SDK calls `DSIExtResultSet::SetBookmarkSource` on `<A>`, passing in a `DSIExtBookmarkSource` object `<D>`. `<D>` is an opaque iterator for bookmarks that internally retrieves bookmarks from `<B>`.
6. Calling `DSIExtResultSet::Move` positions the cursor to the table row indicated by the next bookmark retrieved from `<D>`. The `DSIExtResultSet` calls `DSIExtBookmarkSource::MoveNext` on `<D>` followed by `DSIExtBookmarkSource::GetBookmark` to produce a pointer `<E>` to the bookmark for the next row satisfying the condition T1.C1 = 5. Repeating this step

in a loop facilitates retrieving the value in column `T1.D1` for all records satisfying the condition `T1.C1 = 5`.

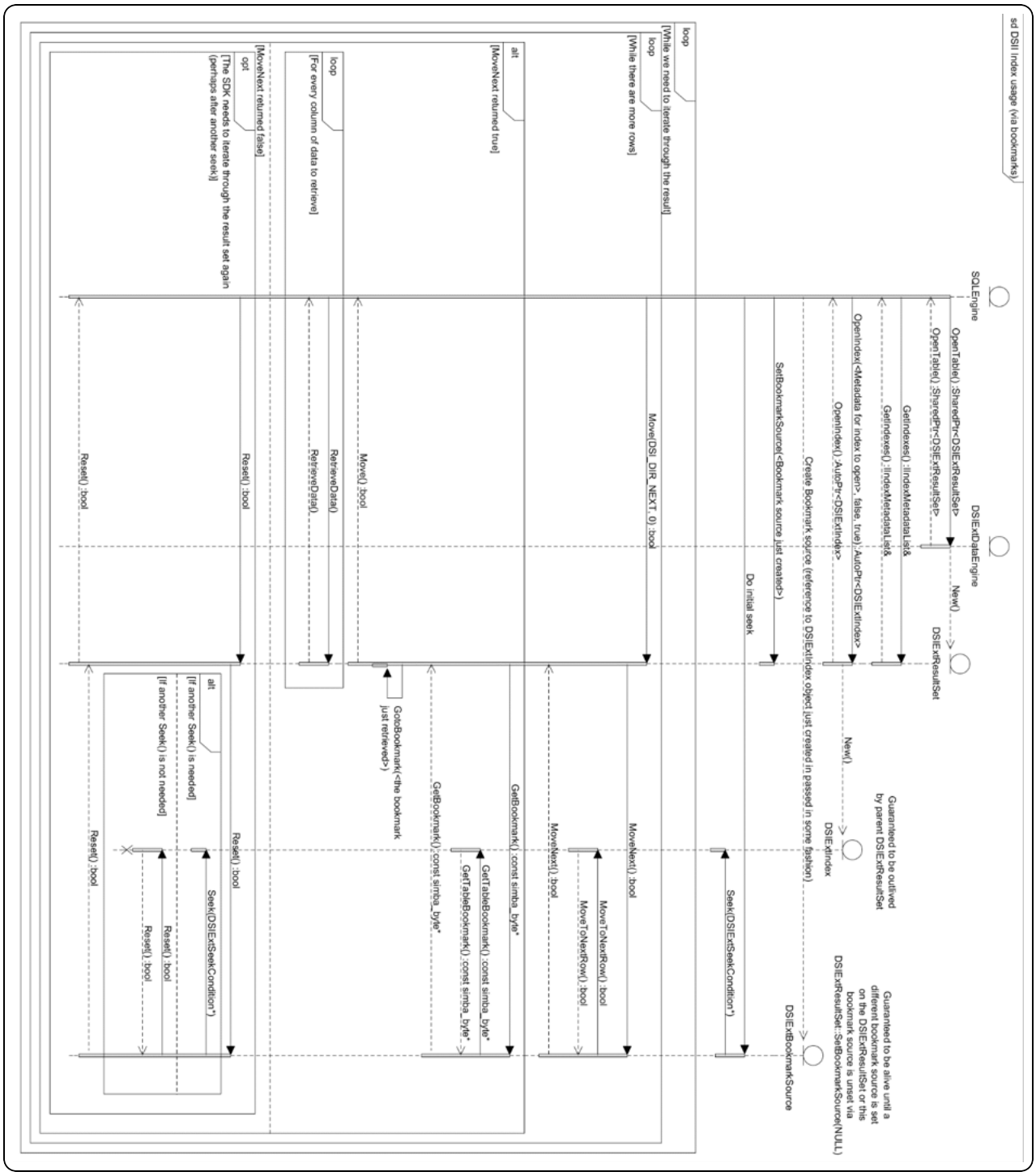
Note:

When a bookmark source is set, the SDK will only call `Move` with a direction of DSI_DIR_NEXT. If `DSIExtBookmarkSource::MoveNext` returns `true`, then there is a bookmark to retrieve. Also, when calling `DSIExtResultSet::Reset` on a result set having a bookmark source, `DSIExtBookmarkSource::Reset` must also be called. As an optimization, `DSIExtBookmarkSource::Reset` returning false indicates that the same bookmarks that were returned for the last traversal through the bookmark source will be returned for the next traversal so that if rows are cached, then the cache may be used instead of using the bookmark source directly.

For joins, `Seek` is called multiple times–once for each row of an outer relation during a join operation. Sorting combined lists of bookmarks based on a well-defined `IBookmarkComparator` object ensures that rows are retrieved as efficiently as possible.

For more information on sorting lists of bookmarks, see Support for Indexes.

The following sequence diagram shows how bookmarks are used:



Understanding Bookmarks

A bookmark is an opaque iterator that identifies a row. Lists of bookmarks that satisfy query conditions, retrieved from an index, can be sorted based on the

`IBookmarkComparator` object that the index exposes.

If `IBookmarkComparator::ShouldAlwaysSortBookmarks()` is true, then bookmarks are sorted. You must define an order for bookmarks via `IBookmarkComparator`. The order for bookmarks must be a strict total ordering. Ordering is defined per `DSIExtResultSet` and must be consistent in the context of a single query. While not essential, the ordering should facilitate retrieving bookmarks from a table as efficiently as possible.

If `IBookmarkComparator::ShouldAlwaysSortBookmarks()` is false, then bookmarks are not sorted based on the IBookmarkComparator object. Bookmarks may be sorted by coincidence, for example if an intersection of bookmark sets is performed.

To avoid unnecessary sorts, indicate whether a specific index naturally produces bookmarks in `IBookmarkComparator` order (as long as the `in_mustKeepOrder` flag was set on construction of the index) via `IUseableIndexMetadata::IsInBookmarkComparatorOrder()`

`IBookmarkComparator::GetBookmarkSize()` gets the size, in bytes, of bookmarks that the `IBookmarkComparator` object compares.

`DSIExtBookmarkSource::GetBookmark()` retrieves a pointer to data for the current bookmark.

The DSII also must implement `DSIExtResultSet::GetBookmarkSize()` and `DSIExtResultSet::GetBookmark()`

`DSIExtResultSet::GotoBookmark()` moves the cursor to the row identified by the given bookmark.

Last Column Conditions for Sorted Indexes

A last column condition is a condition applied to the next column of an index, after the columns taken care of by the equality conditions. When searching indexes by calling `DSIExtIndex::Seek()`, the SDK will only use last column conditions if an index is sorted.

If `DSIExtSeekCondition::HasLastColumnCondition()` returns true, then you may retrieve the last column condition using `DSIExtSeekCondition::GetLastColumnCondition()`.

Important: If a DSIExtSeekCondition seek condition object passed to `DSIExtIndex::Seek()` contains a last column condition, then the last column condition must be satisfied or an exception must be thrown. Otherwise, an incorrect result set may return.

The following last column conditions are defined in the `DSIExtColumnConditionType.h` file:

- COLUMN_CONDITION_IS_NOT_NULL–Corresponds to “C1 IS NOT NULL” in SQL or, in some cases, is used for range queries when conversions overflow or underflow. When present, the index should filter out rows with null values for the associated column.
- COLUMN_CONDITION_IS_IN_RANGE–A range condition can contain either a minimum endpoint, a maximum endpoint, or both. If a range condition contains a minimum endpoint, then the index should filter out rows in which the associated column has a value less than the endpoint. If the minimum endpoint is exclusive, then the index should also filter out rows where the associated column has a value equal to the endpoint. If a range condition contains a maximum endpoint, then the index should filter out rows in which the associated column has a value greater than the endpoint. If the maximum endpoint is exclusive, then the index should filter out rows where the associated column has a value equal to the endpoint.
- COLUMN_CONDITION_MINIMUM–Selects only the row having the lowest value for the given column, within the subset of rows matching any other equality conditions. COLUMN_CONDITION_MINIMUM is currently unused.
- COLUMN_CONDITION_MAXIMUM–Selects only the row having the highest value for the given column, within the subset of rows matching any other equality conditions. COLUMN_CONDITION_MAXIMUM is currently unused.
- COLUMN_CONDITION_INVALID–Indicates that no last column condition is set.

`IUseableIndexMetadata::IsConditionTypeSupported()` returns `true` if a `DSIExtColumnConditionType` is applicable to a specific index column.

`IUseableIndexMetadata::CanIndexOnNull()` returns true if a specific index column supports indexing IS NULL. IS NULL conditions are specified as an equality condition, but the `DSIExtKeySegment` is NULL.

For more details on conditions that may apply to the last column of a sorted index, see the Simba SDK C++ API Reference.

Note:

For non-sorted indexes, the seek condition on every column in the index is an equality condition.

Current Limitations

In the current version of Simba SDK, the use of indexes is limited as follows:

- SQL OR, IN and LIKE operators are not supported.
- Indexes are not used for SQL UPDATE or DELETE statements.
- User-defined and interval SQL data types are not supported.
- If the index does not support IS_NOT_NULL, then some range filters are not supported.
- In some cases, table reordering may cause indexes not to be used.
- Indexes can be used to apply filters and joins in a query that contains sorts or aggregations, but indexes cannot be used to perform sorts or aggregations.

Further enhancements and new features will be introduced in upcoming releases of Simba SDK.

Implementing Indexes

This section describes how to implement the most complex parts of a data store index using the SDK. Note that implementation can vary depending on the DSII developer's design decisions.

Before the SQLEngine is able to use a data store index, it needs to receive information about all of the data store indexes available for a table and its columns. The SQLEngine achieves this by calling the `GetIndexes()` method, defined in the abstract `DSIExtResultSet` class that the data source table class implements.

This method is expected to return a reference to an `IIndexMetadataList` object. This list must be composed of objects derived from the `IUseableIndexMetadata` abstract class, one for each data store index linked to the table. Each of these `IUseableIndexMetadata` objects contains general information about the index (e.g. the name of the index, flags to indicate if the index is sorted and unique, etc.) and metadata information for all the columns that are part of this index.

Step 1: Create the List of Table Columns and Their Related Metadata

Note:

The functionality in this step may have been implemented elsewhere in your DSII table class since it is necessary in order to use the table itself (e.g. to perform a SELECT). In this case, if you save the column list as a member variable then you should be able to reuse this list in Step 2 and onward.

A. Add the following member variable to your table class:

```
DSIResultSetColumns m_tableColumns;
```

B. In your table object's constructor, build the list of table column metadata. For each column of your table, do the following:

   i. Determine the characteristics of the column and populate the following variables:

```
simba_wstring catalogName = <catalog name of the
table>;
simba_wstring schemaName = <schema name of the
table>;
simba_wstring tableName = <name of the table>;
simba_wstring columnName = <name of the column>;
simba_int16 sqlType = <SQL type corresponding to the
internal type of your column>;
bool isSigned = <true if the column is signed or
false otherwise>;
simba_int16 precision = <precision for the column>;
simba_int16 scale = <scale for the column>;
DSINullable nullable = <see enumerated values for
DSINullable and set accordingly>;
```

   ii. Create a new `DSIColumnMetadata` object and initialize all of its attributes. The following example shows most of the attributes (see "`Include/DSI/Client/DSIColumnMetadata.h`" for the full list of attributes and determine which value to put into each depending on your DSII):

```
AutoPtr<DSIColumnMetadata> columnMetadata;
columnMetadata->m_catalogName = catalogName;
columnMetadata->m_schemaName = schemaName;
columnMetadata->m_tableName = tableName;
columnMetadata->m_name = columnName;
columnMetadata->m_label = columnName;
columnMetadata->m_autoUnique = false;
columnMetadata->m_caseSensitive = true;
columnMetadata->m_nullable = nullable;
columnMetadata->m_unnamed = false;
columnMetadata->m_updatable = DSI_WRITE;
```

   iii. Create a `SqlTypeMetadata` object and initialize all of its attributes (see "`Include/Support/TypedDataWrapper/SqlTypeMetadata.h`" for details about these attributes):

```
AutoPtr<SqlTypeMetadata> sqlTypeMetadata(
SqlTypeMetadataFactorySingleton::GetInstance()->
CreateNewSqlTypeMetadata(sqlType, !isSigned));
if (sqlTypeMetadata->IsDateTimeType() ||
sqlTypeMetadata->IsExactNumericType()) {
sqlTypeMetadata->SetPrecision(precision);
}
if (sqlTypeMetadata->IsExactNumericType()){
sqlTypeMetadata->SetScale(precision);
}
if (sqlTypeMetadata->IsCharacterOrBinaryType()){
sqlTypeMetadata->SetLengthOrIntervalPrecision(len);
/// VERY IMPORTANT STEP: it is necessary to set the
length
/// of the DSIColumnMetadata object for variable size
/// types otherwise the column is considered having a
size
/// of 0 bytes.
columnMetadata->m_charOrBinarySize = len;
}
```

iv. Create a `DSIResultSetColumn` object from the `columnMetadata` and `sqlTypeMetadata` objects (it is necessary to detach the auto pointers of both objects to transfer ownership to the column object, since they are destroyed once the method exits, resulting in the column object referencing an invalid object):

```
AutoPtr<IColumn> column(new DSIResultSetColumn
(sqlTypeMetadata.Get(),columnMetadata.Get()));
sqlTypeMetadata.Detach();
columnMetadata.Detach();
```

v. Add the column object to the list of columns and detach it:

```
m_tableColumns.AddColumn(column.Get());
column.Detach();
```

At this point, the list of table columns is available during the life of the table object. Since it is under control of an AutoVector, this list and all of its elements are automatically destroyed during the destruction of the table object.

Step 2: Implement the IUseableIndexMetadata class

Write a class that implements the `IUseableIndexMetadata` class. An instance of this class represents the metadata of one index. Therefore it has to reference the `DSIResultSetColumn` objects representing the column of this index, though implementation of this interface will depend on your data source.

For a possible implementation of this class, see Sample Index Implementation. While a DSII developer might implement it differently, the following are some of the important points:

A. This class `contains CreatePrimaryKeyInstance()` for creating a primary index, `and CreateIndexInstance()` for other indexes. If primary keys are handled the same as other indexes, or there are no primary keys, only one factory method may be needed or the construction of the instance can be performed in the constructor.

B. The objective of the constructor factories is to create the link between the index columns and the table columns. The two most significant parameters received by the factories are:

   I. `in_indexColumns` (type `IColumns`): the list of table columns. When creating an index for a specific table, we provide the `m_tableColumns` variable (see Step 1) that was built for the table object to which this index relates.

   II. `in_indexColumns` (`type vector<simba_unit16>`): a vector of columns index. This is the index of the column in the `in_indexColumns` set. For example, if you have Table A with columns C1, C2, C3 and C4 and the index is composed of columns C3 and C1 in this order, then in_ indexColumns should contain the (zero-based) index values: 2, 0.

C. These factories create a `DSIExtIndexColumn` object for each column included in the index in the order they are referenced in the `in_indexColumns` vector and push them into an `IndexColumns` object (an `AutoVector` of `DSIExtIndexColumn` objects). The implementation provided creates another mapping between the index columns and the table columns, but this may not be needed for other data sources. Once these mappings are done, these objects call the constructor of the `DBIndexMetadata` class.

D. The constructor stores the previously created IndexColumns vector and some other fields into a member variable.

E. The other methods of the `DBIndexMetadata` class implement the pure virtual methods of `IUseableIndexMetadata`. These methods should be implemented in order to return values meaningful for the DSII, in particular, `GetIndexColumns()` which returns the list of `DSIExtIndexColumn` objects this index is based on.

At this point, a `DBIndexMetadata` object has been created for each index of the table. These objects derive from `IUseableIndexMetadata` and are to be placed in the list returned by `GetIndexes()`.

Step 3: Create the List That Needs to be Returned by GetIndexes()

Create the list that needs to be returned by GetIndexes():

A. If the DSII table object class derives from `DSIExtSimpleResultSet`, then the `m_indexMetaList` protected member variable (type `DSIExtIndexMetadataList`) is available for population. If not, then create the member in the DSII table class.
B. In the constructor of the DSII table class, go through all the indexes for the related table of your data store and create one DBIndexMetadata object per index as follows:
    I. Create the vector of column indexes as explained in Step 2.b.
    II. Create the DBIndexMetadata object by calling the factory corresponding to your index and adding this object to the m_indexMetaList member variable using the AddIndexMetadata() method. The following is an example for a non-primary key index:

```
AutoPtr<DBIndexMetadata> indexMeta(
DBIndexMetadata::CreateIndexInstance(
m_indexName, m_indexID, m_columns, m_indexColumns,
m_primaryKeyColumns, m_indexIsUnique));
m_indexes.AddIndexMetadata(AutoPtr<IIndexMetadata>(
indexMeta.Detach()));
```

When the DSII table object is created, it creates the list of objects needed for the definition of the data store's indexes. Since these objects are AutoVectors, they will have the same lifespan as the table object.

Step 4: Implement the GetIndexes() method

Implement the `GetIndexes()` method and return a reference to the `m_indexMetaList` member variable. If the DSII table class derives from `DSIExtSimpleResultSet`, then its implementation of `GetIndexes()` already performs the correct logic and there is nothing more to do. If not, implement `GetIndexes()` to return `m_indexMetalist`:

```
const IIndexMetadataList& DSIITable::GetIndexes() const
{
     return m_indexMetaList;
}
```

Related Topics

Sample Index Implementation

Sample Index Implementation

This section provides an example of how you can implement your indexes.

```
//=============================================================
=========
/// @file DBIndexMetadata.h
///
/// Definition of the Class DBIndexMetadata
///
/// Copyright (C) 2013-2014 Simba Technologies Incorporated.
//=============================================================
=========
#ifndef _SIMBA_SQLENGINE_DBINDEXMETADATA_H_
#define _SIMBA_SQLENGINE_DBINDEXMETADATA_H_
#include "IUseableIndexMetadata.h"
#include "DB.h"
#include "AutoPtr.h"
#include <vector>
namespace Simba
{
namespace DBDSII
{
/// @brief Represents the metadata for a single index.
class DBIndexMetadata : public
Simba::SQLEngine::IUseableIndexMetadata
{
//Public=======================================================
====
public:
/// @brief Factory method.
///
/// @param in_name The name of the index.
/// @param in_indexID The ID of the index.
/// @param in_tableColumns The columns in the table this is
an index for.
/// @param in_indexColumns The columns this is an index on.
These indices index
```

```
/// in_tableColumns.
static AutoPtr<DBIndexMetadata> CreatePrimaryKeyInstance(
const simba_wstring& in_name,
db_id_t in_indexID,
Simba::DSI::IColumns& in_tableColumns,
const std::vector<simba_uint16>& in_indexColumns);
/// @brief Factory method.
///
/// @param in_name The name of the index.
/// @param in_indexID The ID of the index.
/// @param in_tableColumns The columns in the table this is
an index for.
/// @param in_indexColumns The columns this is an index on.
These indices index
/// in_tableColumns.
/// @param in_primaryKeyColumns The columns this primary key
is on. These indices index
/// in_tableColumns.
/// @param in_usUnique Whether this is a unique index.
static AutoPtr<DBIndexMetadata> CreateIndexInstance(
const simba_wstring& in_name,
db_id_t in_indexID,
Simba::DSI::IColumns& in_tableColumns,
const std::vector<simba_uint16>& in_indexColumns,
const std::vector<simba_uint16>& in_primaryKeyColumns,
bool in_isUnique);
/// @brief Return whether the associated index supports
indexing on IS NULL for
/// the given column.
///
/// @param in_column The column of interest.
///
/// @return True if the associated index supports indexing IS
NULL on the given column,
/// False otherwise.
virtual bool CanIndexOnNull(simba_uint16 in_column) const;
/// @brief Return whether the associated DSIExtIndex object
can produce table bookmarks.
///
/// Whether GetTableBookmark() can be called on the
associated DSIExtIndex to
```

```
/// produce a bookmark
/// for the row in the table referred to by the current row
in the DSIExtIndex.
///
/// If false, this index can only be used for 'index only
scans'.
///
/// @return Whether the associated DSIExtIndex object can
produce table bookmarks.
virtual bool CanProduceTableBookmarks() const;
/// @brief Get the name of the index.
///
/// @return The name of the index.
virtual const simba_wstring& GetName() const;
/// @brief Get the indexed columns.
///
/// @return The columns involved in the index.
virtual const Simba::SQLEngine::IndexColumns& GetIndexColumns
() const;
/// @brief Get the indices (into the parent table) of columns
/// whose data is retrievable via the associated index.
///
/// These are the columns whose data may be retrieved using
/// RetrieveData() on the associated DSIExtIndex object.
///
/// @return The indices of columns whose data is retrievable
via the associated index.
virtual const std::set<simba_uint16>& GetIncludedColumns()
const;
/// @brief Get a map from column indices in the parent
relation
/// to column indices in this index.
///
/// Specifically, this is a map from column indices from
columns retrievable
/// from the parent relation (for example, in the case of a
table, the
/// columns returned from DSIExtResultSet::GetSelectColumns()
) to
/// columns retrievable in the associated DSIExtIndex object
(in other words,
```

```
/// from this->GetIncludedColumns() ).
///
/// @return A map from column indices in the parent relation
/// to column indices in this index.
virtual const Simba::SQLEngine::ColumnIndexMap&
GetTableColumnToIndexColumnMap() const;
/// @brief Get the type of the index.
///
/// @return The type of the index.
virtual Simba::SQLEngine::DSIExtIndexType GetType() const;
/// @brief Get if the indicated condition type is supported
/// for the given column of the index.
///
/// @param in_type The condition type of interest.
/// @param in_column The column of interest.
///
/// @return True if the condition type is supported for the
given column;
/// false otherwise.
virtual bool IsConditionTypeSupported(
Simba::SQLEngine::DSIExtColumnConditionType in_type,
simba_uint16 in_column) const;
/// @brief Get if the index is the primary key.
///
/// Note that only one index should be the primary key for
any table.
///
/// @return True if the index is the primary key; false
otherwise.
virtual bool IsPrimaryKey() const;
/// @brief Get if the index traverses its rows in the order
defined by the bookmark
/// comparator.
///
/// For example, this will be true if the bookmark comparator
for the parent table is
/// based on the row's location on disk, and this index is
clustered.
///
/// If this returns true, the SQLEngine will not attempt to
sort the stream of
```

```
/// bookmarks produced by this index with the table's
bookmark comparator. This
/// will cause incorrect results if the index does not
actually follow that order.
///
/// @return True the index traverses its rows in the order
defined by the bookmark
/// comparator, False otherwise.
virtual bool IsInBookmarkComparatorOrder() const;
/// @brief Get if the index is a sorted index.
///
/// @return True if the index is a sorted index; false
otherwise.
virtual bool IsSorted() const;
/// @brief Get if the index is a unique index.
///
/// @return True if the index is a unique index; false
otherwise.
virtual bool IsUnique() const;
/// @brief Get the ID for this index.
///
/// @return The ID for this index.
db_id_t GetIndexID() const;

// Private
============================================================
====================
private:
/// @brief Private constructor so that consumers must use
factory method.
///
/// @param in_name The name of the index.
/// @param in_columns The columns involved in the index, in
the order
/// they appear
/// in the index. Takes ownership of the objects held.
/// (in_columns will be empty after the constructor returns)
/// @param in_includedColumns Metadata for all columns
included in this index,
/// including ones which cannot be SEEKed on.
```

```
/// @param in_columnIndexMap A map from table column indices
to column indices
/// in this index.
/// @param in_isInBookmarkComparatorOrder Indicate if the
index order respect the one
/// of the bokmark comparator.
/// @param in_isUnique Indicate if the index is unique.
/// @param in_indexID The DB internal index identifier.
DBIndexMetadata(
const simba_wstring& in_name,
Simba::SQLEngine::IndexColumns& in_columns,
const std::set<simba_uint16>& in_includedColumns,
const Simba::SQLEngine::ColumnIndexMap& in_columnIndexMap,
bool in_isInBookmarkComparatorOrder,
bool in_isUnique,
db_id_t in_indexID);
simba_wstring m_name;
Simba::SQLEngine::IndexColumns m_indexColumns;
std::set<simba_uint16> m_includedColumns;
Simba::SQLEngine::ColumnIndexMap m_columnIndexMap;
bool m_isUnique;
bool m_isInBookmarkComparatorOrder;
// The ID for this index.
db_id_t m_indexID;
};
}
}
#endif

//
============================================================
==================================
/// @file DBIndexMetadata.cpp
///
/// Implementation of the Class DBIndexMetadata
///
/// Copyright (C) 2013 Simba Technologies Incorporated.
//
============================================================
==================================
#include "DBIndexMetadata.h"
```

```
#include "DSIColumnMetadata.h"
#include "DSIExtIndexColumn.h"
#include "DSIResultSetColumn.h"
#include "DSIResultSetColumns.h"
#include "SqlTypeMetadata.h"
#include <algorithm>
using namespace Simba::DBDBDSII;
using namespace Simba::DSI;
using namespace Simba::SQLEngine;
using namespace std;
//
Public=============================================================
==============================
AutoPtr<DBIndexMetadata>
DBIndexMetadata::CreatePrimaryKeyInstance(
const simba_wstring& in_name,
db_id_t in_indexID,
Simba::DSI::IColumns& in_tableColumns,
const std::vector<simba_uint16>& in_indexColumns)
{
IndexColumns indexColumns;
indexColumns.reserve(in_indexColumns.size());
// Create the list of the columns that are part of the
primary index.
vector<simba_uint16>::const_iterator it = in_
indexColumns.begin();
const vector<simba_uint16>::const_iterator end = in_
indexColumns.end();
for (; it != end; ++it)
{
indexColumns.push_back(
new DSIExtIndexColumn(in_tableColumns.GetColumn(*it), DSIEXT_
SORT_ASCENDING));
}
// Create a map between the columns of the table and the
corresponding
// column in the index. We do this for all columns in the
index (key of
// the map=column index in table, value=column index in
tuple).
ColumnIndexMap columnIndexMap;
```

```
set<simba_uint16> includedColumns;
for (simba_uint16 i = 0; i < in_indexColumns.size(); ++i)
{
columnIndexMap[in_indexColumns[i]] = i;
includedColumns.insert(in_indexColumns[i]);
}
// A primary index is clustered and unique.
AutoPtr<DBIndexMetadata> result(new DBIndexMetadata(
in_name,
indexColumns,
includedColumns,
columnIndexMap,
true,
true,
in_indexID));
return result;
}
////////////////////////////////////////////////////////////////
////////////////////////////////////
AutoPtr<DBIndexMetadata> DBIndexMetadata::CreateIndexInstance
(
const simba_wstring& in_name,
db_id_t in_indexID,
IColumns& in_tableColumns,
const vector<simba_uint16>& in_indexColumns,
const std::vector<simba_uint16>& in_primaryKeyColumns,
bool in_isUnique)
{
IndexColumns indexColumns;
indexColumns.reserve(in_indexColumns.size());
// Create the list of the columns that are directly part of
the index.
// NOTE: A DBDB tuple on a secondary index includes the
columns of the
// primary index, but these columns are not included here
except for
// the ones that are in both indexes.
vector<simba_uint16>::const_iterator it = in_
indexColumns.begin();
const vector<simba_uint16>::const_iterator end = in_
indexColumns.end();
```

```
for (; it != end; ++it)
{
indexColumns.push_back(
new DSIExtIndexColumn(in_tableColumns.GetColumn(*it), DSIEXT_
SORT_ASCENDING));
}
// Create a map between the columns of the table and the
corresponding
// column in the index. We do this for all columns in the
index (key of
// the map=column index in table, value=column index in
tuple).
ColumnIndexMap columnIndexMap;
set<simba_uint16> includedColumns;
for (simba_uint16 i = 0; i < in_indexColumns.size(); ++i)
{
columnIndexMap[in_indexColumns[i]] = i;
includedColumns.insert(in_indexColumns[i]);
}
// As an DBDB tuple on a secondary index contains also the
columns of the
// primary index, we add the mapping between the column of
the table and the
// corresponding column in the primary index. In case the
primary and secondary
// index have one or more columns in common, the DBDB tuple
won't duplicate
// them.
// The tuple columns are then built as follows: put the
columns of the
// secondary index in the order they were created in the
secondary index
// followed by the columns of the primary index that have not
yet been included
// in the order they were created in the primary index.
simba_uint16 numberPKIncluded = 0;
for (simba_uint16 i = 0; i < in_primaryKeyColumns.size();
++i)
{
if (columnIndexMap.end() == columnIndexMap.find(in_
primaryKeyColumns[i]))
```

```
{
columnIndexMap[in_primaryKeyColumns[i]] = in_
indexColumns.size() +
(numberPKIncluded++);
includedColumns.insert(in_primaryKeyColumns[i]);
}
}
// A secondary index is not clustered.
AutoPtr<DBIndexMetadata> result(new DBIndexMetadata(
in_name,
indexColumns,
includedColumns,
columnIndexMap,
false,
in_isUnique,
in_indexID));
return result;
}
////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::CanIndexOnNull(simba_uint16 in_column)
const
{
UNUSED(in_column);
return false;
}
////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::CanProduceTableBookmarks() const
{
return true;
}
////////////////////////////////////////////////////////////////
//////////////////////////////////////
const simba_wstring& DBIndexMetadata::GetName() const
{
return m_name;
}
////////////////////////////////////////////////////////////////
//////////////////////////////////////
const IndexColumns& DBIndexMetadata::GetIndexColumns() const
```

```
{
return m_indexColumns;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
const std::set<simba_uint16>&
DBIndexMetadata::GetIncludedColumns() const
{
return m_includedColumns;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
const ColumnIndexMap&
DBIndexMetadata::GetTableColumnToIndexColumnMap() const
{
return m_columnIndexMap;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
DSIExtIndexType DBIndexMetadata::GetType() const
{
return m_isInBookmarkComparatorOrder ? INDEX_CLUSTERED :
INDEX_BTREE;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::IsConditionTypeSupported(
DSIExtColumnConditionType in_type,
simba_uint16 in_column) const
{
UNUSED(in_column);
return (COLUMN_CONDITION_IS_NOT_NULL == in_type) || (COLUMN_
CONDITION_IS_IN_RANGE == in_type);
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::IsPrimaryKey() const
{
return m_isInBookmarkComparatorOrder;
}
```

```
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::IsInBookmarkComparatorOrder() const
{
return m_isInBookmarkComparatorOrder;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::IsSorted() const
{
return true;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
bool DBIndexMetadata::IsUnique() const
{
return m_isUnique;
}
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
ib_id_t DBIndexMetadata::GetIndexID() const
{
return m_indexID;
}
// Private
================================================================
============================
//////////////////////////////////////////////////////////////////
//////////////////////////////////////
DBIndexMetadata::DBIndexMetadata(
const simba_wstring& in_name,
Simba::SQLEngine::IndexColumns& in_columns,
const std::set<simba_uint16>& in_includedColumns,
const Simba::SQLEngine::ColumnIndexMap& in_columnIndexMap,
bool in_isInBookmarkComparatorOrder,
bool in_isUnique,
ib_id_t in_indexID) :
m_name(in_name),
m_includedColumns(in_includedColumns),
m_columnIndexMap(in_columnIndexMap),
```

```
m_isInBookmarkComparatorOrder(in_
isInBookmarkComparatorOrder),
m_isUnique(in_isUnique),
m_indexID(in_indexID)
{
m_indexColumns.swap(in_columns);
}
```

Related Topics

Support for Indexes

Custom Scalar and Aggregate Functions

Simba SDK version 9.3 introduced support for the creation of custom scalar and aggregate functions. To enable this functionality, the following changes were made to the SDK:

- In the PSDataType enum, PS_DT_SCALARFN has been renamed to `PS_DT_SCALARORAGGRFN`.
- In the `PSNonTerminalType` enum, `PS_NT_SCALAR_FN` has been renamed to `PS_NT_SCALAR_OR_AGGR_FN`, and `PS_NT_CUSTOM_AGGR` has been added. `PS_NT_CUSTOM_AGGR` is used when the parser knows unambiguously that a function is an aggregate function (i.e. a set quantifier ALL or DISTINCT has been specified).
- Custom scalar functions are represented in the AETree as `AECustomScalarFn` nodes.
- Custom aggregate functions are represented in the AETree with `AECustomAggregateFn` nodes.

Note:

Custom aggregate functions are not supported in Java.

To implement a custom scalar function in the C++ or Java SDK:

1. In the C++ SDK, create a `CustomerDSIExtScalarFunction` class which subclasses `DSIExtScalarFunction` and represents your custom scalar function.

   Or, for the Java SDK, subclass `CustomScalarFunction`.

2. Implement the methods defined by `DSIExtScalarFunction` or `CustomScalarFunction`, in particular the following:
   - **Execute()**

     Takes in a collection of input values and performs the execution of the scalar function.
   - **RetrieveData()**

     Used to retrieve the output from Execute().

     > **Note:**
     >
     > If you use Simba's execution engine, `Execute()` will be called with the input arguments, and then `RetrieveData()` will be called to get the result. This happens at least once per row. If you do not plan to use Simba's execution engine, then the implementation of both methods should throw an exception to avoid the cases where `Function` is never passed down and the engine tries to call the unimplemented `ScalarFunction` methods.

   - **UpdateMetadata()**

     Called once during prepare and should compute preliminary metadata for the input arguments and return value of the scalar function. Note that this metadata could be inaccurate (e.g. due to parameters in the query), so the method should not throw any exceptions related to invalid argument types. The method will be called again at execution time, so you can update the metadata to the final input and output metadata, and throw an exception if the given input metadata is not valid for your scalar function.

     > **Note:**
     >
     > The SQLEngine will attempt to convert any inputs into the specified argument types, so an exact match of types is not required.

3. Override `OpenScalarFunction()` in your `DSIExtSqlDataEngine` derived class for C++, or `SqlDataEngine`derived class for Java. This method takes in the name of the scalar function to execute along with the arguments, and returns your `CustomerDSIExtScalarFunction` class. An exception can be thrown if the number of parameters doesn't match that required by the scalar function.

To implement a custom aggregate function:

1. Create a `CustomerDSIExtAggregateFunction` class which subclasses `DSIExtAggregateFunction` and represents your custom aggregate function.

   There are no `Execute()/RetrieveData()` functions since we currently do not support using custom aggregate functions in our execution engine. This means that if you use our execution engine, your DSII MUST handle the custom aggregate function during CQE. This limitation may be lifted in a future version of the SDK.
2. Override `OpenScalarFunction()` in your `DSIExtSqlDataEngine` class (e.g. `CustomerDSIIDataEngine`) to return an instance of `CustomerDSIExtAggregateFunction` when provided with the aggregate function's name and correct number of arguments (currently only one parameter is supported).

   > **Note:**
   >
   > Custom aggregate functions currently only support one parameter and are also not supported in the execution engine; they must be handled via CQE.

   The SQLite sample connector contains examples of custom scalar and aggregate functions. See `SLDataEngine`, `SLAggrFnName`, `SLAggrFnum`, `SLScalarFnAdd`, and `SLScalarFnConcat`. Note that the custom aggregate functions in this connector are only for illustration and cannot be executed as CQE handling has not been implemented for aggregate functions.

Related Topics

How to Implement Custom SQL Scalar Functions in an ODBC Connector

Stored Procedures

This feature is available in the C++ and the Java SDK. Instead of calling a SQL statement on the data store, an application can call a stored procedure. A stored procedure is an operation that allows the DSI to take advantage of internal functions or extended non-SQL functionality that the data store may support. Custom functions that can be implemented inside these stored procedures may allow access to data that is not stored in standard relational tables.

Stored Procedures in the C++ Simba SDK

The C++ Simba SDK provides the following DSI API classes to support stored procedures:

- **DSIExtProcedure**

  The base class for DSII stored procedures. Implement the pure virtual functions to provide functionality. This class provides the framework for custom stored procedures, which are returned to SQLEngine via `DSIExtSqlDataEngine::OpenProcedure()`.
- **DSIExtMetadataHelper**

  We recommend that you implement the virtual function `GetNextProcedure()` to allow the SDK to get a list of defined procedures. Although this is optional, it is recommended.
- **DSIExtSqlDataEngine**

  Use this to implement `OpenProcedure()`, same as `OpenTable()`.

Note:

The SQLite sample shows many examples of the different ways that stored procedures can be used, and is an excellent reference.

Stored Procedures in the Java Simba SDK

The Java Simba SQLEngine provides the following DSI API classes to support stored procedures:

• **StoredProcedure**
The base class for DSII stored procedures. Implement the pure virtual functions to provide functionality. This class provides the framework for custom stored procedures, which are returned to SQLEngine via `DSIExtSqlDataEngine::OpenProcedure()`.

• **IMetadataHelper**
Use this to support `GetNextProcedure()` to allow the SDK to get a list of defined procedures.

• **SqlDataEngine**
Use this to implement `OpenProcedure()`, same as `OpenTable()`.

Create Table As Select (CTAS)

In SQL, you can use the CREATE TABLE AS SELECT statement to copy the contents of an existing table or tables into a new table. The CTAS statement creates a new table based on the output of a SELECT statement. The Simba SQLEngine allows you to support CTAS commands in your custom ODBC connector.

Example CTAS statement:

The following statement copies the table Employee to the table NewTable:

```
CREATE TABLE NewTable AS SELECT * FROM Employee
```

> **Note:**
>
> The command CREATE TABLE AS SELECT is also called CREATE TABLE AS.

Level of support for CTAS

The Simba SDK supports the SQL 2003 specification for CREATE TABLE AS, with the following exceptions:

- table distribution options are not supported
- union, except and intersect select options are not supported

Implementing CTAS in your custom ODBC Connector

To implement CTAS in your connector, your connector must have read-write capability. As well, your connector must implement the `MyDataEngine::CreateTable()` method, where `MyDataEngine` is your `DSIExtSqlDataEngine`-derived class.

When a CTAS SQL command is received, the Simba SDK calls your connector's `MyDataEngine::BeginCreateTable()`. Then, the Simba SDK passes in a table specification. The `BeginCreateTable()` method must return an object of a class that implements `ITableTemplate`. The Simba SDK fills in the table template, then calls `Instantiate()` on the template. Your connector must provide the implementation of `Instantiate()`.

Example - Implementing CTAS in Your Connector

1. Change your `MyTable` class to extend `ITableTemplate` in addition to any other classes that it extends.
2. Implement the `MyTable::Instantiate()` method. This method should ensure that the table is ready to be used.
3. Update the `MyDataEngine` class to implement the `BeginCreateTable()` method.

Specifications

This section lists the platform and compiler requirements for the Simba SDK. It also lists the level of SQL conformance that is supported.

Supported Platforms

This section lists the platforms and compilers that are supported by the Simba SDK version 10.3.0.

Hardware Requirements

On all supported platforms, the minimum hardware requirements are as follows:

- 8 GB of free disk space
- 1 GB RAM

Software Requirements

The following table lists the supported platforms and compilers:

Platform	Versions	Compilers	Bits
Windows	10 & 11 Server 2016, 2019 & 2022	Visual Studio 2019 & 2022 .NET Standard 2.0 .NET Core .NET Framework 3.5 & 4.6.2	32, 64
Linux	CentOS/Oracle Linux/RHEL 7 & 8 Debian 10 SLES 12 & 15 Ubuntu 18.04 LTS, & 20.04 LTS	GNU GCC 4.8.5 & 5.5	32, 64
Linux ARM	Debian 10	GNU GCC 8.3	32, 64

Platform	Versions	Compilers	Bits
			64
macOS	11 (Apple M1)	Xcode 12.4	64
			64
Solaris SPARC	10, 11	Oracle Solaris Studio 12.6 (Solaris 11)	32, 64
Solaris x86	11	Oracle Solaris Studio 12.6 (Solaris 11)	32, 64
	7.2	XLClang C/C++ V16.1	32, 64

JDBC and JDK Support

The following list shows the JDK requirements for each version of JDBC:

- JDBC 4.2 used with JDK 1.8

Supported ODBC/SQL Functions

This section lists the ODBC-defined scalar functions that are supported by the SQL Engine.

Explicit Covert functions

- CONVERT
- CAST

String Functions

- ASCII
- CHAR
- CONCAT
- INSERT
- LCASE
- LEFT
- LENGTH
- LOCATE
- LTRIM

- REPEAT
- REPLACE
- RIGHT
- RTRIM
- SOUNDEX
- SPACE
- SUBSTRING
- UCASE

System Functions

- DATABASE
- IFNULL
- USER

Numeric Functions

- ABS
- ACOS
- ASIN
- ATAN
- ATAN2
- CEILING
- COS
- COT
- DEGREES
- EXP
- FLOOR
- LOG
- LOG10
- MOD
- PI
- POWER
- RADIANS
- RAND
- ROUND
- SIGN

- SIN
- SQRT
- TAN
- TRUNCATE

Aggregate Functions

- AVG
- COUNT
- MAX
- MIN
- STDDEV
- STDDEV_POP
- SUM
- VAR
- VAR_POP

Time, Date, and Interval Functions

- CURDATE
- CURTIME
- CURRENT_DATE
- CURRENT_TIME
- CURRENT_TIME (time precision)
- CURRENT_TIMESTAMP
- CURRENT_TIMESTAMP (time precision)
- DAYNAME
- DAYOFMONTH
- DAYOFWEEK
- DAYOFYEAR
- HOUR
- MINUTE
- MONTH
- MONTHNAME
- NOW
- QUARTER
- SECOND

- TIMESTAMPADD
- TIMESTAMPDIFF
- WEEK
- YEAR

Supported SQL Conformance Level

The Simba SDK supports the full core-level ODBC 3.80. It supports most of the Level 1 and Level 2 API.

The ODBC specification provides three levels of SQL grammar conformance: Minimum, Core and Extended. Each higher level provides more fully implemented data definition and data manipulation language support. The level of supported SQL grammar is dependent on your SQL-enabled data source. At the very least, your SQL-enabled data source must conform to the minimum SQL grammar defined by the ODBC version 3.52 specification.

Conformance Level	Interfaces	Conformance Level	Interfaces
Core	SQLAllocHandle	Core	SQLGetInfo
Core	SQLBindCol	Core	SQLGetStmtAttr
Core	SQLBindParameter	Core	SQLGetTypeInfo
Core	SQLCancel	Core	SQLNativeSql
Core	SQLCloseCursor	Core	SQLNumParams
Core	SQLColAttribute	Core	SQLNumResultCols
Core	SQLColumns	Core	SQLParamData
Core	SQLConnect	Core	SQLPrepare
Core	SQLCopyDesc	Core	SQLPutData
Core	SQLDescribeCol	Core	SQLRowCount
Core	SQLDisconnect	Core	SQLSetConnectAttr

Conformance Level	Interfaces	Conformance Level	Interfaces
Core	SQLDriverconnect	Core	SQLSetCursorName
Core	SQLEndTran	Core	SQLSetDescField
Core	SQLExecDirect	Core	SQLSetDescRec
Core	SQLExecute	Core	SQLSetEnvAttr
Core	SQLFetch	Core	SQLSetStmtAttr
Core	SQLFetchScroll	Core	SQLSpecialColumns
Core	SQLFreeHandle	Core	SQLStatistics
Core	SQLFreeStmt	Core	SQLTables
Core	SQLGetConnectAttr	Level 1	SQLBrowseConnect
Core	SQLGetCursorName	Level 1	SQLMoreResults
Core	SQLGetData	Level 1	SQLPrimaryKeys
Core	SQLGetDescField	Level 1	SQLProcedureColumns
Core	SQLGetDescRec	Level 1	SQLProcedures
Core	SQLGetDiagField	Level 2	SQLColumnPrivileges
Core	SQLGetDiagRec	Level 2	SQLDescribeParam
Core	SQLGetEnvAttr	Level 2	SQLForeignKeys
Core	SQLGetFunctions	Level 2	SQLTablePrivileges

Methods

The following section contains guidelines and considerations for implementing specific methods in your connectors.

IStatement::ExecuteBatch()

This method is used to execute a set of statements in a batch.

> **Note:**
>
> This method can only be used to execute a statement batch coming from a JDBC client. See the documentation for Java's `java.sql.Statement#executeBatch()` for more information.

The statements in in_statements are not already converted to the underlying datas source's native syntax. If the IDriver property `DSI_DRIVER_NATIVE_SQL_BEFORE_PREPARE` is set to `DSI_PROP_TRUE`, the default implementation of this method transforms the statements with `IConnection::ToNativeSql()`.

All statements in in_statements should return a single rowcount result (no result sets).

The `DSI_CONN_STOP_ON_ERROR` connection property should be respected.

By default, the implementation runs according to the following logic:

> **Note:**
>
> This is not functioning code.

```
BatchResult res = new BatchResult();
for (stmt : in_statement)

    {
    try
    {

        res.AddRowCount(Execute(stmt));

    }
    catch (...)
    {

        res.AddError(GetCurrentException());
```

```
            if (StopOnError)
            break;

        }

}
return res;
```

Where `Execute(stmt)` calls `IStatement::CreateDataEngine()`, uses it to execute the statement via the query executor returned by `IDataEngine::Prepare()`, and then destroys the query executor and data engine. If the executed statement returns multiple results, or a resultset, this is represented as an error in the returned IBatchResult object.

Statements

`@param in_statements`

The list of SQL statements to execute as part of the batch.
`@return`

An IBatchResult object describing the results of the execution (OWN)

```
virtual Simba::DSI::IBatchResult* ExecuteBatch(const
std::vector<simba_wstring>& in_statements);
```

Exposes an iterator to the results of `IStatement::ExecuteBatch()`.

Initially, this object is positioned before the first result, and may only be iterated over once.

This object's results are sequential. The first result is for the first statement in the batch, the next result is for the second statement, and so forth. There is at most 1 result per statement.

The function produces results for a contiguous prefix of the statements, and those results are either a single rowcount or a set of errors. Depending on the structure of the statements, this prefix may be the entirety of the set. No gaps occur in the results and, if there are no errors, there are as many results in the object as there were statements in the batch. If the DSII stops on errors within a batch (`DSI_CONN_STOP_ON_ERROR` is set), then fewer objects than statements can occur. The JDBC specification states a given data source must be consistent in this behavior, either always stopping on error or never stopping. The SDK does not enforce this.

Result

Returns IBatchResult object. This object includes the following interface.

```
IBatchResult() {}
```

Constructor

```
virtual ~IBatchResult() {}
```

Destructor

```
enum ResultType
```

Describes the state of this object.

```
ROWCOUNT_RESULT
```

Indicates this object is currently positioned on a rowcount result.

```
ERROR_RESULT
```

Indicates this object is currently positioned on an error result.

```
NO_MORE_RESULTS
```

Indicates this object has no more results.

```
virtual ResultType MoveNext() = 0;
```

Moves to the next result exposed by this object (if there are any). Returns `NO_MORE_RESULTS` if there are no more results, otherwise returns `ROWCOUNT_RESULT or ERROR_RESULT` to indicate the type of the current result.

```
virtual bool GetCurrentRowCount(simba_uint64& out_rowCount)
const = 0;
```

Gets the current rowcount result. If the rowcount was known, it is returned via the out parameter out_rowCount.

> **Note:**
>
> This may only be called if the last call to `MoveNext()` returned `ROWCOUNT_RESULT`.

```
virtual const std::vector<ErrorException>& GetCurrentErrors()
const = 0;
```

Gets any errors that occurred for the current result.

> **Note:**
>
> Will return an empty vector unless MoveNext() returned ERROR_RESULT.

Compiling Your Connector

The 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ provide step-by-step instructions on how to compile and build the debug version of each sample connector. This section provides more details on the compile and build process, and explains the available options.

For information on packaging your connector as a product for end customers, see Packaging Your Connector.

Upgrading Your Makefile to 10.1

In the 10.1 release, the Simba SDK introduces a new, simplified makefile system which is very different from the ones used in previous versions. This section explains how to customize and upgrade the sample makefiles in SDK 10.1 for your own custom ODBC connectors.

Updated Name and Location of Makefiles

This section explains the name and location of the new makefiles, including how to invoke them when building your custom ODBC connector.

How to invoke the makefile

We recommend that you invoke the makefile using `[DriverFolder]/Source/mk.sh`. This script invokes and passes along all the arguments to the makefile, `[DriverFolder]/Source/GNUmakefile`.

Note:

We do not recommend using `[DriverFolder]/Source/GNUmakefile` directly, because all object files will be generated directly under the source directory.

The following table summarizes the differences in the makefiles between the 10.1 and 10.0 release.

10.1	10.0
How to invoke the makefile	

10.1	10.0
From the `[DriverFolder]/Source` folder, type: `./mk.sh`	From the `[DriverFolder]/Makefile` folder, type: `make -f [DriverName].mak`
Main entry makefile	
`[DriverFolder]/Source/GNUmakefile`	`[DriverFolder]/Makefile/[DriverName].mak`
Supporting makefiles for each connector	

The content of the supporting makefiles for each connector is merged into the entry makefile.	These makefiles are invoked by the entry makefile:
	`[DriverFolder]/Source/Makefile`
	`[DriverFolder]/Source/Makefile_FLAGS.mak`
	`[DriverFolder]/Source/Makefile_SRCS.mak`

Common makefiles shared by all connectors	

10.1	10.0

These makefiles are invoked by the entry makefile:
`[SIMBAENGINE_DIR]/Makefiles/kit.mk`
`[SIMBAENGINE_DIR]/Makefiles/kit.sh`
• `Platform.mak`, which was used to obtain platform-dependent information, has been replaced by the new `kit.sh` script file.
• `Settings_XXX.mak`, `Rule_XXX.mak` and `Master_Targets.mak` have been merged into the new `kit.mk` file.
	These makefiles are invoked by the entry makefile:
	`[SIMBAENGINE_DIR]/Makefiles/Platform.mak`
	`[SIMBAENGINE_DIR]/Makefiles/Settings_[PlatformName].mak`
	`[SIMBAENGINE_DIR]/Makefiles/Master_Targets.mak`
	`[SIMBAENGINE_DIR]/Makefiles/Rules_[PlatformOrCompilerName].mak`

Customizing the Sample Makefiles

The main entry makefile is `[DriverFolder]/Source/GNUmakefile`. In most cases, this is the only file that you need to modify for your custom ODBC connector. This section includes the following steps:

Step 1: Modify the name and location of the generated binary files

Step 2: Add source files and specify where to find them

Step 3: Add Search Paths for .h files and other compiler/linker flags

Step 1: Modify the name and location of the generated binary files

1. Modify `target.driver = libQuickstart${BITS}.${SO}` and `target.server = QuickstartServer${BITS}` to change the default file name for the connector and server. Note the following:
   - `${BITS}` represents the bitness of the current product, typically 32 or 64 (for OSX, it could also be 3264).
   - `${SO}` is the default platform-dependendent extension name for shared library. Typically this is `dylib` for OSX and `so` for other UNIX systems.
2. Optionally, update the location. By default, the final product is built under `[DriverFolder]/Bin/[PlatformName]/[ConfigurationMode][BitNess]`, for example `[DriverFolder]/Bin/Linux_x86_gcc/debug64`. If this location needs to be changed, modify the `DESTDIR.bin` variable.

Example:

```
# SDK 10.1 [DriverFolder]/Source/GNUmakefile
### Define the product names
target.driver = libMyCustomDSII${BITS}.${SO}
target.server = MyCustomDSII${BITS}
#...
### Change default install location
DESTDIR.bin = $./../MyDirectory/${PLATFORM}/${MODE}${BITS}
```

Comparing 10.0 and 10.1 variables for this step:

This table shows how the 10.1 variables in this step map to the 10.0 variables. In 10.0, the variables are in `[DriverFolder]/Source/Makefile`.

Description	Name in 10.1	Name in 10.0
name of connector	`target.driver`	`TARGET_SO`
name of server	`target.server`	`TARGET_BIN`
location of generated binary	`DESTDIR.bin`	`TARGET_BIN(SO)_PATH`
config mode (release/debug)	`MODE`	No equivalence
bitness (32/64/3264)	`BITS`	`BITNESS`
suffix of shared libs (so / dylib)	`SO`	`SO_SUFFIX`

In 10.0, `[DriverFolder]/Source/Makefile` uses `TARGET_BIN` and `TARGET_SO` to define binary file names. As well, destination directories are specified by `TARGET_BIN_PATH` and `TARGET_SO_PATH`, as shown in the following example:

Example:

```
# SDK 10.0 [DriverFolder]/Source/Makefile
PROJECT = MyCustomDSII
MAKEFILE_PATH = ../Makefiles
ifeq ($(BUILDSERVER),exe)
TARGET_BIN_PATH = ../Bin/$(PLATFORM)
TARGET_BIN = $(TARGET_BIN_PATH)/$(PROJECT)_server_<TARGET>
else
```

```
TARGET_SO_PATH = ../Bin/$(PLATFORM)
TARGET_SO = $(TARGET_SO_PATH)/lib$(PROJECT)_<TARGET>.$(SO_
SUFFIX)
endif
#...
```

Note:

In 10.0, the `_<TARGET>` suffix in `TARGET_BIN(SO)` is not a variable. Instead, this is a special string that was replaced by either a `_Debug` suffix or an empty string (depending on the config mode) in the master makefiles provided under SIMBAENGINE_DIR. By default, both debug and release connectors were generated into the same folder, and relied on suffixes in filenames to differentiate release and debug builds.

In 10.1, binary files do not have a `release` or `debug` suffix in their name. Instead, release and debug builds are put under different folders.

Step 2: Add source files and specify where to find them

1. Modify the file names. To do this, modify the following line to list your own source files:
   `${target}: Main_Unix.o QSConnection.o QSDataEngine.o...`

   Note:

   This list actually contains object files, so they should all have `.o` extension, rather than their original `.cpp` extension names. As well, you do not need to include the paths to the source files.

2. Modify the target-specific files. If some source files should only be included when the DSII is built as a server, then you must add these files to a `${target.server}: ...` dependency list, instead of the common object file list `${target}: ...;` As well, when the DSII is build as a connector (a shared library), these files should be added to `${target.driver}: ...`
3. Modify the file paths. To do this modify the following line to include all directories that contain source files for the connector:

   ```
   drvsrcdirs = $./Common $./Core $./DataEngine
   $./DataEngine/Metadata
   ```

Note:

The symbol `$.` is a variable defined in `kit.mk` that represents the full path of the directory where GNUmakefile is located, for example `[DriverFolder]/Source/`. We recommend using this variable instead of using `[DriverFolder]/Source/`.

Example:

Suppose the source files of the `MyCustomDSII` connector are laid out in the following folder hierarchy:

```
Source
--/MySourceDir1
----MyCommonSource1.cpp # Common source files for both
connector and server
----MyCommonSource2.cpp
----MyDriverSpecificSource1.cpp # Connector specific
source file.
----MyCommonSource1.h # Common header files
----MyCommonSource2.h
----MyDriverSpecificSource1.h # Connector specific header
file.
--/MyFolder2
----MyCommonSource3.cpp
----MyServerSpecificSource1.cpp # Server specific source
file
----MyCommonSource3.h
----MyServerSpecificSource1.h # Server specific header
file
--/MyIncludeDir1
----MyOtherInclude1.h
--/MyIncludeDir2
----MyOtherInclude2.h
```

In this case, the filename and path lists should be configured as follows:

```
makefile # SDK 10.1 [DriverFolder]/Source/GNUmakefile
#... ### Specify directories to all folders that contain
source files for this connector drvsrcdirs =
$./MySourceDir1 $./MySourceDir2
```

4. Add the source file specific to "connector". For example:
   ```
   ${target.driver} : MyDriverSpecificSource1.o
   ${target.driver} : LDLIBS += $(call Mutual, ${CORESDK.a}
   ${SQLENGINE.a} ${ODBCSDK.a}) #...
   ```
5. Add source file specific to "server". For example:
   ```
   ${target.server} : MyServerSpecificSource1.o
   ${target.server} : CPPFLAGS += ${SERVERSDK_CPPFLAGS} #...
   ```
6. Modify source file list shared by both "connector" and "server". For example:
   ```
   ${target} : MyCommonSource1.o MyCommonSource2.o
   MyCommonSource3.o #...
   ```

Comparing 10.0 and 10.1 variables:

The 10.1 variables involved in this step corresponds to variables in `[DriverFolder]/Source/Makefile_SRCS.mak` in 10.0:

Description	Name in 10.1	Name in 10.0
list of files	listed directly in target rules as .o	COMMON_SRCS
list of directories	drvsrcdirs	COMMON_SRCS

In 10.0, the list of source files, along with their paths, are specified by the `COMMON_SRCS` variable in `[DriverFolder]/Source/Makefile_SRCS.mak`.

Example:

```
# SDK 10.0 [DriverFolder]/Source/Makefile_FLAGS.mak
## Common Sources used to build this project.
COMMON_SRCS = \
Common/QSTableMetadataFile.cpp \
Common/TabbedUnicodeFileReader.cpp \
Core/QSConnection.cpp \
Core/QSDriver.cpp \
Core/QSEnvironment.cpp \
Core/QSStatement.cpp \
DataEngine/QSDataEngine.cpp \
DataEngine/QSMetadataHelper.cpp \
DataEngine/QSTable.cpp \
DataEngine/QSTypeInfoMetadataSource.cpp
```

Step 3: Add Search Paths for .h files and other compiler/linker flags

1. Add search paths for headers. To do this, modify the following line to include your own search directories for header files:
   `${target} : CPPFLAGS += $(addprefix -I, $. ${drvsrcdirs} $(patsubst %,%/Include, ${drvsrcdirs}) $./Setup)`

   In this sample makefile, all directories listed in `drvsrcdirs`, and an `Include` directory under each of those directories are automatically added as search directories. You may append additional directories if they are not already in this default list.
2. Add or modify other compiler and preprocessor flags other than the header file search paths. To do this, add or modify existing target dependency lists that contains `${target}: CXXFLAGS+=` and `${target}: CPPFLAGS+=...` respectively.
3. Modify the linker flags. To add or modify linker flags and thirdparty libraries to be linked, add or modify existing target dependency lists that contains `${target}: LDFLAGS+=` and `${target}: LDLIBS+=...`, respectively.
4. Modify the target specific flags. If a flag should be added when building connector but not server (or the other way around), then it should be listed under `${target.driver}` or `${target.server}`, instead of the common `${target}`. For example, `${target.server}: LDFLAGS+=...` means this LDFLAGS list only applies when building a server.
5. Modify the config mode specific flags. If a flag should be added only for either "release" or "debug", but not both, then users can append a `.release` or `.debug` suffix to the corresponding `XXXFLAGS` variable to allow such config mode specific flags. For example, `CXXFLAGS.release += -myflag1` indicates `-myflag1` will only be added to `CXXFLAGS` in release mode. Similarly, `CPPFLAGS.debug += -DMY_MACRO` and `LDFLAGS.debug += -LMySearchPath` indicates `-DMY_MACRO` and `-LMySearchPath` will only be added to `CPPFLAGS` and `LDFLAGS` in debug mode.

For more information on implicit variables CXXFLAGS, CPPFLAGS, LDFLAGS, LDLIBS used in GNU make, see the GNU make documentation at https://www.gnu.org/software/make/manual/html_node/Implicit-Variables.html.

Example:

```
# SDK 10.1 [DriverFolder]/Source/GNUmakefile`
### Add a flag only for connector
#...
${target.driver} : CPPFLAGS += -DMY_DRIVER_MACRO
### Add preprocessor flags only for connector in debug mode
```

```
${target.driver} : LDFLAGS.debug += -LMyLibSearchPath_Driver_
Debug/
### Add linker flag only for connector in release mode
${target.driver} : LDFLAGS.release += -LMyLibSearchPath_
Driver_Release/
### Add preprocessor flags only for server in release mode
${target.server} : LDFLAGS.release += -LMyLibSearchPath_
Server_Release/
### Add a CXXFLAG for both connector and server in all config
modes
${target} : CXXFLAGS += -Weffc++
### Add a CXXFLAG for both connector and server only in debug
mode
${target} : CPPFLAGS += -DMY_COMMON_MACRO
### Add common search path
${target} : CPPFLAGS += $(addprefix -I, $. ${drvsrcdirs}
$./MyIncludeDir1 $./MyIncludeDir2)
#...
```

Comparing 10.0 and 10.1 variables:

The 10.1 variables involved in this step corresponds to variables in `[DriverFolder]/Source/Makefile_FLAGS.mak` in 10.0:

Description	Name in 10.1	Name in 10.0
list of header search paths	CPPFLAGS	COMMON_CFLAGS
preprocessor flags	CPPFLAGS	COMMON_CFLAGS
compiler flags	CFLAGS, CXXFLAGS	CFLAGS CXXFLAGSCFLAGS
linker flags	LDFLAGS	BIN_LDFLAGS(_DEBUG) SO_LDFLAGS(_DEBUG)

In 10.0, compiler and preprocessor flags that are common to all config mode (release/debug) and target type (connector/server) are added to `COMMON_CFLAGS` in `[DriverFolder]/Source/Makefile_FLAGS.mak`. As well, `COMMON_CFLAGS` are

always added into the implicit `CLFAGS` variable. Target-type or config-mode specific flags are conditionally appended to CFLAGS using `if-else` blocks.

Also in 10.0, linker flags that are common to all config mode and target type are added to `COMMON_LDFLAGS`. There are four other variables that represent the different combinations of target-type and config-mode specific flags: `BIN_LDFLAGS`, `BIN_LDFLAGS_DEBUG`, `SO_LDFLAGS` and `SO_LDFLAGS_DEBUG` . In 10.1, the target-type specificity is represented as target-specific rules such as `${target.driver}: LDFLAGS +=...`, and the config-mode specificity is represented with a release or debug suffix, such as `${target.server}: LDFLAGS.release +=....`

Example

This example shows a 10.0 `[DriverFolder]/Source/Makefile_FLAGS.mak` file that is roughly equivalent to the 10.1 GNU makefile example above.

```
# SDK 10.0 [DriverFolder]/Source/Makefile_FLAGS.mak
### Common compiler and preprocessor flags
COMMON_CFLAGS = $(DMFLAGS) \
-I./MySourceDir1 \
-I./MySourceDir2 \
-I./MyIncludeDir1 \
-I./MyIncludeDir2 \
-DMY_COMMON_MACRO \
-Weffc++
ifeq ($(BUILDSERVER),exe)
### Add conditional preprocessor flags for server
CFLAGS = $(COMMON_CFLAGS)
else
CFLAGS = $(COMMON_CFLAGS) -DMY_DRIVER_MACRO
endif
### Define the common linker flags
COMMON_LDFLAGS = ...
#...
ifeq ($(BUILDSERVER),exe)
### Config-mode specific linker flags for server
BIN_LDFLAGS = $(COMMON_LDFLAGS) -LMyLibSearchPath_Server_
Release/
BIN_LDFLAGS_DEBUG = $(COMMON_LDFLAGS)
else
### Config-mode specific linker flags for connector
SO_LDFLAGS = $(COMMON_LDFLAGS) -LMyLibSearchPath_Driver_
Release/
```

```
SO_LDFLAGS_DEBUG = $(COMMON_LDFLAGS) -LMyLibSearchPath_
Driver_Debug/
```

Example Customized Makefile

This example shows a customized GNUmakefile that incorporates the modifications described in this section. All modifications are preceded with a ### comment line.

```
# Makefile for MyCustomDSII
#--------------- Target Definition
buildtype = $(if ${BUILDSERVER},server,connector)
target = ${target.${buildtype}}
### Change the product names
target.driver = libMyCustomDSII${BITS}.${SO}
target.server = MyCustomDSIIServer${BITS}
### Specify directories to all folders that contain source
files for this connector
drvsrcdirs = $./MySourceDir1 $./MySourceDir2
#----------------
.DEFAULT_GOAL := install
clean += ${target.driver} ${target.server}
bin.install : ${target}
### Change default install location
DESTDIR.bin = $./../MyDirectory/${MODE}${BITS}
#---------------- Target dependencies.
### Add source file specific to "connector"
${target.driver} : MyDriverSpecificSource1.o
### Add a flag only for connector
${target.driver} : CPPFLAGS += -DMY_DRIVER_MACRO
### Add a flag only for connector in debug
${target.driver} : CPPFLAGS.debug -DMY_DRIVER_DEBUG_MACRO
### Add preprocessor flags only for connector in debug mode
${target.driver} : LDFLAGS.debug += -LMyLibSearchPath_Driver_
Debug/
### Add linker flag only for connector in release mode
${target.driver} : LDFLAGS.release += -LMyLibSearchPath_
Driver_Release/
${target.driver} : LDLIBS += $(call Mutual, ${CORESDK.a}
${SQLENGINE.a} ${ODBCSDK.a})
${target.driver} : LDFLAGS += $(call LD.soname,$@)
${target.driver} : LDFLAGS += ${LD.exports}
### Add source file specific to "server"
```

```
${target.server} : MyServerSpecificSource1.o
### Add preprocessor flags only for server in release mode
${target.server} : LDFLAGS.release += -LMyLibSearchPath_
Server_Release/
### Add preprocessor flags only for server in debug mode
${target.server} : LDFLAGS.release += -LMyLibSearchPath_
Server_Debug/
### Add a third party library only for server
${target.server} : LDLIBS += -mythirdpartylib
### Add release-specific flags linker flag
${target.driver} : LDFLAGS.release += -lmy_release_lib
${target.server} : CPPFLAGS += ${SERVERSDK_CPPFLAGS}
${target.server} : LDLIBS += $(call Mutual, ${CORESDK.a}
${SQLENGINE.a} ${SERVERSDK.a})
${target.server} : LDLIBS += ${OPENSSL_LDLIBS}
${target.server} :; ${LINK.o} -o $@ $^ ${LDLIBS}
### Modify source file list shared by both "connector" and
"server"
${target} : MyCommonSource1.o MyCommonSource2.o
MyCommonSource3.o
### Add a CXXFLAG for both connector and server in all config
modes
${target} : CXXFLAGS += -Weffc++
### Add a CXXFLAG for both connector and server only in debug
mode
${target} : CPPFLAGS.debug += -DMY_COMMON_DEBUG_MACRO
### Remove some default search paths and add user search
paths
${target} : CPPFLAGS += $(addprefix -I, $. ${drvsrcdirs}
$./MyIncludeDir1 $./MyIncludeDir2)
${target} : CPPFLAGS += ${CORESDK_CPPFLAGS} ${SQLENGINE_
CPPFLAGS} ${EXPAT_FLAGS}
${target} : LDLIBS += ${ICU_LDLIBS}
#--- Define search paths
vpath %.cpp ${drvsrcdirs}
vpath %.mm ${drvsrcdirs}
```

C++ on Windows

This section explains the different settings that are available on the Project Properties page in Microsoft Visual Studio. For a full listing of all compiler options, see the Microsoft MSDN documentation.

You can use the sample projects from the 5 Day Guides as an example of how to build your own custom connector. For a step-by-step example on how to build the sample projects, see the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

Build as an ODBC Connector (a DLL) for Local Connections

The sample connectors discussed in the *Build a C++ Connector in 5 Days* documents are set up to build as Windows DLLs. To build your own connector as a Windows DLL, use the following settings:

1. Set configuration type to Dynamic Library (.dll):

   Select **Configuration Properties** -> **General** -> **Configuration Type**.
2. Link against `SimbaODBC.lib`. Choose the correct version of the library for release/debug, and whether MTDLL is used or not.

   Select **Configuration Properties** -> **Linker** -> **Input** -> **Additional Dependencies**.
3. Set the module definition file to `Exports.def` included in all sample connectors:

   Select **Configuration Properties** -> **Linker** -> **Input Module Definition File**.
4. Set the output file to a DLL name:

   Select **Configuration Properties** -> **Linker** -> **General** -> **Output File**.
5. Include the DSI and Support include paths:

   Select **Configuration Properties** -> **C/C++** -> **General** -> **Additional Include Directories**:
   - `$(SIMBAENGINE_DIR)\Include\DSI`
   - `$(SIMBAENGINE_DIR)\Include\DSI\Client`
   - `$(SIMBAENGINE_DIR)\Include\Support`
   - `$(SIMBAENGINE_DIR)\Include\Support\Exceptions`
   - `$(SIMBAENGINE_DIR)\Include\Support\TypedDataWrapper`

Note:

If your custom connector uses the SQL Engine, see Build with the SQL Engine for additional settings.

Build as a SimbaServer (an EXE) for Remote Connections

To build a connector as a stand-alone SimbaServer executable, use the following settings:

1. Set configuration type to Application (.exe):

   Select **Configuration Properties** -> **General** -> **Configuration Type**
2. Link against `SimbaServer.lib`. Choose the correct version of the library for release/debug, and whether MTDLL is used or not.

   Select **Configuration Properties** -> **Linker** -> **Input** -> **Additional Dependencies**.

   For more information on these settings, see Run-time library options.
3. Unset the module definition file:

   Select **Configuration Properties** -> **Linker** -> **Input**-> **Module Definition File**.
4. Set output file to an EXE name.

   Select **Configuration Properties**-> **Linker** -> **General Output File**.
5. Include the DSI and Support include paths:

   Select **Configuration Properties** -> **C/C++** -> **General** -> **Additional Include Directories**:
   - `$(SIMBAENGINE_DIR)\Include\DSI`
   - `$(SIMBAENGINE_DIR)\Include\DSI\Client`
   - `$(SIMBAENGINE_DIR)\Include\Support`
   - `$(SIMBAENGINE_DIR)\Include\Support\Exceptions`
   - `$(SIMBAENGINE_DIR)\Include\Support\TypedDataWrapper`

Note:

If your custom connector uses the SQL Engine, see Build with the SQL Engine for additional settings.

Build with the SQL Engine

If your custom connector uses the SQL engine, use the following setting in addition to those described in Build as an ODBC Connector (a DLL) for Local Connections or Build as a SimbaServer (an EXE) for Remote Connections.

1. Link against SimbaEngine.lib:

   Select **Configuration Properties** -> **Linker** -> **Input** -> **Additional Dependencies**.
2. Include the SQLEngine include paths:

   Select **Configuration Properties** -> **C/C++** -> **General** -> **Additional Include Directories**:
   - `$(SIMBAENGINE_DIR)\Include\SQLEngine`
   - `$(SIMBAENGINE_DIR)\Include\SQLEngine\AETree`
   - `$(SIMBAENGINE_DIR)\Include\SQLEngine\DSIExt`

Run-time library options

Each Simba library file has a Debug, Debug_MTDLL, Release and Release_MTDLL version. You an choose to link against any of these versions. In order to successfully link against your chosen version of the library, your project settings must match some of the settings used to build the library:

Debug

The `Debug` version of the Simba libraries are the debug version that uses a statically linked C++ runtime. To use this version of the library:

1. In **Configuration Properties** -> **C/C++**-> **Preprocessor** -> **Preprocessor Definitions**, include `_DEBUG`.
2. In **Configuration Properties** -> **C/C++** -> **Code Generation** -> **Runtime Library**, select `Multi-threaded Debug (/MTd)`.

Debug_MTDLL

The `Debug_MTDLL` version of the Simba libraries are the debug version that uses a dynamically linked C++ runtime. To use this version of the library:

1. In **Configuration Properties** -> **C/C++**-> **Preprocessor** -> **Preprocessor Definitions**, include `_DEBUG`.
2. In **Configuration Properties** -> **C/C++** -> **Code Generation** -> **Runtime Library**, select `Multi-threaded Debug DLL (/MDd)`.

Release

The `Release` version of the Simba libraries are the release version that uses a statically linked C++ runtime. To use this version of the library:

1. In **Configuration Properties** -> **C/C++**-> **Preprocessor** -> **Preprocessor Definitions**, include `_NDEBUG`.

2. In **Configuration Properties** -> **C/C++** -> **Code Generation** -> **Runtime Library**, select `Multi-threaded(/MT)`.

Release_MTDLL

The `Release_MTDLL` version of the Simba libraries are the release version that uses a dynamically linked C++ runtime. To use this version of the library:

1. In **Configuration Properties** -> **C/C++**-> **Preprocessor** -> **Preprocessor Definitions**, include `_NDEBUG`.
2. In **Configuration Properties** -> **C/C++** -> **Code Generation** -> **Runtime Library**, select `Multi-threaded DLL (/MD)`.

Character Set

In the Visual Studio “Configuration Properties” for your DSII project, on the “General” property page, ensure that the “Character Set” property is set to “Use Unicode Character Set”. This is the default setting used in the sample connector projects.

C# on Windows

This section explains the different settings that are available on the Project Properties page in Microsoft Visual Studio. For a full listing of all compiler options, see the Microsoft MSDN documentation.

As of Simba SDK 10.2.1, the Simba .NET components are packaged as NuGet (`.nupkg`) files. You should configure your NuGet environment to add the Simba SDK as a package source using this directory: *`[INSTALL_DIRECTORY]`*`\Bin\Release`.

In this section, anything referring to referencing the Simba.DotNetDSI, Simba.DotNetDSIExt, and Simba.ADO.NET assemblies can be interpreted as referencing the corresponding NuGet packages. When building for .NET Core or .NET Standard, it is strongly encouraged to only use the NuGet packages instead of directly referencing the assemblies.

Most people use the C# SDK to build an ADO.NET provider, but you can also use the C# SDK to write your DSII and build the project as an ODBC connector. The connector can be built to support either local or remote connections, with or without the SQL Engine.

You can use the sample projects from the 5 Day Guides as an example of how to build your own custom connector. For a step-by-step example on how to build the sample projects, see the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

Most of the settings described in the section C++ on Windows also apply to C#, but building C# uses a different project for the .Net DSII code.

DotNetDSI and DSII

When writing a C# DSII, you must create a new Visual Studio project for a managed C# class library that does not include any of the settings described for a C++ DSII. Add the following to the project:

- If the DSII uses the Simba SQLEngine, add the Simba.DotNetDSI and Simba.DotNetDSIExt assemblies.
- If the DSII does not use the Simba SQLEngine, add the Simba.DotNetDSI assembly.

The base classes from which you derive to code your DSII are all defined in these assemblies. These assemblies can be used for both 32-bit and 64-bit connector development.

Note:

If you are using the CLIDSI, you must match the bitness of your compiled C# DLL to the bitness of the CLIDSI library that is being used.

When using your provider, server, or ODBC connector, you must register this assembly in the Global Assembly Cache (GAC) of Windows.

Simba.NET

In order to build a pure C# ADO.NET provider, you only need your DotNet DSII project and the Simba.DotNetDSI and Simba.ADO.NET assemblies.

Note:

When building a pure C# ADO.NET provider, you cannot use the Simba SQLEngine. To support this deployment scenario, use SimbaServer and the ODBC client.

When using Simba.NET to create an ADO.NET provider, you must extend the following additional abstract classes.

- `SCommand`
- `SCommandBuilder`
- `SConnection`
- `SConnectionStringBuilder`
- `SDataAdapter`

- `SFactory`
- `SParameter`

These are part of the Simba.ADO.NET assembly, not the normal DotNet DSI.

You must extend the `SConnectionStringBuilder` subclass and add any additional properties that are needed to establish a connection to your provider. For example, see the Simba DotNetUltralight sample described in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

The rest of the classes that you extend do not typically need to be modified.

When using your provider, the Simba.DotNetDSI and Simba.ADO.NET assemblies should be registered in the Global Assembly Cache (GAC) of Windows.

Build as an ODBC Connector (a DLL) for local connections

This section explains how to build an ODBC connector for local connections, with or without the Simba SQLEngine. In addition to the DotNet DSII project, you must create a CLIDSI project that provides the bridge between the native C++ Simba ODBC libraries and your CustomerDotNetDSII.dll assembly:

1. Follow the instructions in Build with the SQL Engine , including all the specified libraries.
2. Include the library `CLIDSI_$(ConfigurationName).lib`.

   This library forms the bridge between the unmanaged and managed DSI classes.
3. Enable Common Language Runtime Support (/clr) by selecting the following option:

   Configuration Properties -> General -> Common Language Runtime Support
4. Implement the factory function that constructs your `IDriver` object:

```
Simba::DotNetDSI::IDriver^ Simba::CLIDSI::LoadDriver()
{
return gcnew CustomerDotNetDSII::CustomerDSIIDriver();
}
```

The output of this project is your custom connector DLL, for example `CustomerCLIDSIDriver.dll`. This is the actual ODBC connector which will load your `CustomerDotNetDSII.dll` assembly.

Build as a SimbaServer (an EXE) for Remote Connections

This section explains how to build an ODBC connector for remote connections, with or without the Simba SQLEngine.

In addition to the DotNet DSII project, you must create a CLIDSI project that provides the bridge between the native C++ Simba ODBC libraries and your CustomerDotNetDSII.dll assembly:

1. Follow the instructions in Build with the SQL Engine, including all the specified libraries.
2. Include the library `CLIDSI_$(ConfigurationName).lib`.

   This library forms the bridge between the unmanaged and managed DSI classes.
3. Enable Common Language Runtime Support (/clr) by selecting the following option:

   Configuration Properties -> General -> Common Language Runtime Support
4. Implement the factory function that constructs your `IDriver` object:

```
Simba::DotNetDSI::IDriver^ Simba::CLIDSI::LoadDriver()
{

return gcnew CustomerDotNetDSII::CustomerDSIIDriver();
}
```

The output of this project is your custom connector DLL, for example `CustomerCLIDSIDriver.dll`. This is the actual ODBC connector which will load your `CustomerDotNetDSII.dll` assembly.

C# on Linux, Unix, and macOS

Simba.NET may be used to build pure C# ADO.NET providers for anywhere that .NET Core is available. All of the above in the Simba.NET section still applies.

CLIDSI cannot be used to build ODBC connectors for non-Windows platforms.

Java on Windows

This section explains how to build a connector written in Java on Windows platforms.

You can use the sample projects from the 5 Day Guides as an example of how to build your own custom connector. For a step-by-step example on how to build the sample projects, see the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

Options for Writing a Connector in Java

As explained in Implementation Options , you can write a custom ODBC or JDBC connector in Java using the following methods:

- Use Java to write a DSII for an ODBC connector, and connect it to the C++ SDK using a JNI component.

  This option can be implemented with or without the C++ Simba SQLEngine.
- Use Java to write a DSII for an JDBC connector.

  This option can be implemented with or without the Java Simba SQLEngine.

The compilation instructions for these two methods are described below.

Build a Pure-Java JDBC Connector

This type of connector can optionally use the Java SQL Engine. You can use it with or without the Java Simba SQLEngine.

Building a JDBC Connector for SQL-Capable Data Stores

The following steps describe how to build a pure-Java JDBC connector that does not use the SQL Engine:

1. Ensure that the SimbaJDBC JAR file, located at [INSTALL_DIRECTORY]\DataAccessComponents\Lib, is in the classpath.
2. Create your connector DSII JAR file.
3. No additional libraries need to be linked.

The JavaUltraLight sample connector shows how to implement and build this type of connector.

Building with the Java Simba SQLEngine

To build a pure-Java JDBC connector that uses the Java SQL engine, follow the steps in Building a JDBC Connector for SQL-Capable Data Stores above, and also include the `SimbaSQLEngine.jar` in your build process.

The JavaQuickJson sample connector shows how to implement and build this type of connector. In this sample connector, the ANT build script packages the pre-compiled files with those of the DSII.

Build Java DSII for an ODBC Connector

This type of connector uses a JNI bridge to connect to the C++ API components. You can use it with or without the C++ Simba SQLEngine.

Building as an ODBC Connector (a DLL) for Local Connections

The following steps describe how to build an ODBC connector that doesn't use the SQL Engine and is not built for client-server deployments:

1. Include the settings for C++ connectors described in C++ on Windows.
2. Include the additional directory for the JVM library that is under `$(JAVA_HOME)\lib`:

   Configuration Properties -> Linker -> General -> Additional Library Directories

   > **Note:**
   >
   > JAVA_HOME is an environment variable that should refer to the 32-bit Java installation directory when building the 32-bit ODBC connector or the 64-bit Java installation directory when building the 64-bit ODBC connector.

3. Link against `SimbaJNIDSI_$(ConfigurationName).lib` and `jvm.lib`:

   Configuration Properties -> Linker -> Input -> Additional Dependencies

   Set **ConfigurationName** to one of the following values: `Debug`, `Debug_MTDLL`, `Release` or `Release_MTDLL`. For information on these options, see Run-time library options.

4. Include the general and Java include paths:

   Configuration Properties -> C/C++ -> General -> Additional Include Directories:

   - `$(SIMBAENGINE_DIR)\Include\JNIDSI`
   - `$(JAVA_HOME)\include`
   - `$(JAVA_HOME)\include\win32`

The sample connectors discussed in the document *Build a Java ODBC Connector in 5 Days* are configured to build as Windows DLL's.

Building as a SimbaServer (an EXE) for Remote Connection

To build a connector as a stand-alone SimbaServer executable, follow the steps in Building as an ODBC Connector (a DLL) for Local Connections with the additional C++ settings described in Build as a SimbaServer (an EXE) for Remote Connections.

Building with the C++ Simba SQLEngine

To build a Java ODBC connector that uses the C++ SQL engine, follow the steps in Build as an ODBC Connector (a DLL) for Local Connections above with the additional

SQL Engine settings described in Build with the SQL Engine.

The JavaQuickstart sample connector shows how to implement and build this type of connector.

C++ on Linux, Unix, and macOS

The Simba SDK include a sample makefile with each of the sample connector projects. You can use this makefile to build the sample connector, then use it as a template for creating a makefile for your custom connector.

Note:

We recommend that you use the script `mk.sh` in the `Source` directory of your sample connector project. It is not recommended to use the makefile directly.

Build Configurations

The sample makefiles include targets for both debug and release versions of the connectors and the SimbaServer. The output location, or file path, indicates the bitness, compiler, and platform version. For example, when the debug version of the Quickstart connector is build on a 64-bit Linux machine with the gcc compiler, the resulting shared object is located in:
`.../Bin/Linux_x86_gcc/debug64/libQuickstart64.so`

Default Settings in the Sample Makefile

To help you compile and build the sample connectors on a variety of machines, the sample shell script and sample makefiles automatically detect your machine's operating system, bitness, and default compiler, then use the appropriate settings to run the build. By default, the makefiles build a release version that is dynamically linked to dependencies.

You can override these default settings by specifying them in the `mk.sh` command line, or by setting them as environment variables.

Changing the version of XCode on macOS

By default, on macOS the sample makefile detects the highest available version of the XCode compiler, and uses that to build the sample connectors. If you download a different version of the Simba SDK, you must set the active developer directory to match.

Example:

Assume you have both XCode 6 and XCode 7 on your machine, and you download the XCode 6 version of the Simba SDK. The sample makefile tries to use the XCode7 compiler, but this fails. Set the environment variable DEVELOPER_DIR to configure the active developer directory:
`export DEVELOPER_DIR=/Application/Xcode6.1.app`

Overriding Default Settings

The following table describes the options that you can use to override the default behaviour of the sample makefiles. Multiple options are allowed, for example:
`./mk.sh MODE=debug BITS=32`

Option	Description
`BUILDSERVER`	Set to `1` to build a server (`.exe`) instead of a connector (`.so` or `.dylib`). By default, a connector is built. **Example:** `./mk.sh BUILDSERVER=1`
`CXX`	On Solaris, specify the compiler to use. Allowed values are the name of the compiler, for example `g++`, `g++44`, or `g++59`. **Example:** `./mk.sh CXX=g++59`
`SDK_PLATFORM`	Specifies the subpath to the dependencies. This value is autodetected by default, but you can override it. The path where the dependencies are installed contains architecture information and the compiler version. For example, the ICU libraries might be installed at `ThirdParty/icu/53.1/centos5/gcc4_4`. The Simba SDK autodetects this information to allow your connector to use the correct dependencies. You can override this information to specify dependencies in a different location. **Example:** `./mk.sh SDK_PLATFORM=Darwin/xcode7_2`

Option	Description
MODE	Set to `debug` to build the debug version of the connector. By default, the release version of the connector is built. **Example:** `./mk.sh MODE=debug`
BITS	Specifies the bitness of the connector you wish to build. By default, the makefiles build a connector that matches the bitness of your operating system, but you can override this option. For example, when building on a 64-bit platform, you can use this option to specify a 32-bit connector. Allowed values are `32`, `64`, and `3264`. Use `3264` to indicate an OSX universal binary that combines 32 and 64 bit code. **Example:** `./mk.sh BITS=32`
ICU_STATIC	Set to `1` to statically link to the ICU library. By default, the makefiles build a connector that dynamically links to the ICU library. **Example:** `./mk.sh ICU_STATIC=1`
OPENSSL_ STATIC	Set to `1` to statically link to the OpenSSL library. By default, the makefiles build a connector that dynamically links to the OpenSS library. **Example:** `./mk.sh ICU_STATIC=1`

Build an ODBC Connector (a Shared Object) for Local Connections

This section describes the settings you can use to build your custom ODBC connector for local connections (that is, not as a SimbaServer). You can build with or without the Simba SQLEngine. This section references the core makefile for the sample connectors, `${SIMBAENGINE_DIR}/Makefiles/kit.mk`.

Note:

For each of the steps below, be sure to include the correct libraries for the compiler, bitness, and release/debug configuration.

1. Set the compiler and linker to build a shared object. The exact option depends on the compiler.
2. Include the Simba Core SDK libraries, as specified by the variable `CORESDK.a` in the file `${SIMBAENGINE_DIR}/Makefiles/kit.mk`. Be sure to include the correct libraries for the compiler, bitness, and release/debug configuration. For example:
   - `libCore.a`
   - `libSimbaDSI.a`
   - `libSimbaSupport.a`
3. Include the Simba ODBC libraries, as specified by the variable `ODBCSDK.a`. For example:
   - `libSimbaODBC.a`
4. If your connector uses the SQL Engine, include the SQL Engine libraries, as specified by the variable `SQLENGINE.a`. For example:
   - `libAEProcessor.a`
   - `libDSIExt.a`
   - `libExecutor.a`
   - `libParser.a`
5. Include the Core SDK include paths, as specified by the variable `CORESDK_CPPFLAGS`. For example:
   - `${SIMBAENGINE_DIR}/Include/DSI`
   - `${SIMBAENGINE_DIR}/Include/DSIClient`
   - `${SIMBAENGINE_DIR}/Include/Support`
   - `${SIMBAENGINE_DIR}/Include/Support/Exceptions`
   - `${SIMBAENGINE_DIR}/Include/Support/TypedDataWrapper`
   - `${SIMBAENGINE_DIR}/ThirdParty/odbcheaders`
6. Include the ICU include paths, as specified by the variable `ICU_LDLIBS`. The path and file name contain version, bitness, and release/debug information. For example:
   - `${SIMBAENGINE_DIR}hirdParty/icu/53.1.x/Linux_x86_gcc/release64/lib`

7. If your connector uses the SQL Engine, include the SQL Engine and expat include paths, as specified by the variables `SQLENGINE_CPPFLAGS` and `EXPAT_FLAGS` in the `kit.mk` file. Note that the `Expat` directory contains a version number. For example:
   - `${SIMBAENGINE_DIR}/Include/SQLEngine`
   - `${SIMBAENGINE_DIR}/Include/SQLEngine/AETree`
   - `${SIMBAENGINE_DIR}/Include/SQLEngine/DSIExt`
   - `${SIMBAENGINE_DIR}/Include/ThirdParty/Expat/2.2.0`

Build as a SimbaServer (an EXE) for Remote Connections

This section describes the settings you can use to build your custom ODBC connector as a SimbaServer. You can build with or without the Simba SQLEngine. This section references the core makefile for the sample connectors, `${SIMBAENGINE_DIR}/Makefiles/kit.mk`.

Note:

For each of the steps below, be sure to include the correct libraries for the compiler, bitness, and release/debug configuration.

1. Set the compiler and linker to build an application (.exe). The exact option depends on the compiler.
2. Include the Simba Core SDK libraries, as specified by the variable `CORESDK.a` in the file `${SIMBAENGINE_DIR}/Makefiles/kit.mk`. Be sure to include the correct libraries for the compiler, bitness, and release/debug configuration. For example:
   - `libCore.a`
   - `libSimbaDSI.a`
   - `libSimbaSupport.a`
3. Include the Simba Server libraries, as specified by the variable `SERVERSDK.a`. For example:
   - `libSimbaCSCommon.a`
   - `libSimbaServer.a`
   - `libSimbaServerMain.a`
4. If your connector uses the SQL Engine, include the SQL Engine libraries, as specified by the variable `SQLENGINE.a`. For example:
   - `libAEProcessor.a`
   - `libDSIExt.a`

- libExecutor.a
- libParser.a

5. Include the Core SDK include paths, as specified by the variable CORESDK_CPPFLAGS. For example:
   - ${SIMBAENGINE_DIR}/Include/DSI
   - ${SIMBAENGINE_DIR}/Include/DSIClient
   - ${SIMBAENGINE_DIR}/Include/Support
   - ${SIMBAENGINE_DIR}/Include/Support/Exceptions
   - ${SIMBAENGINE_DIR}/Include/Support/TypedDataWrapper
   - ${SIMBAENGINE_DIR}/ThirdParty/odbcheaders
6. Include the Server SDK include paths, as specified by the variable SERVERSDK_CPPFLAGS. For example:
   - ${SIMBAENGINE_DIR}/Include/Server
7. Include the ICU include paths, as specified by the variable ICU_LDLIBS. The path and file name contain version, bitness, and release/debug information. For example:
   - ${SIMBAENGINE_DIR}/ThirdParty/icu/53.1.x/Linux_x86_gcc/release64/lib
8. Include the Open SLL include paths, as specified by the variable OPENSSL_LDLIBS. The path and file name contain version, bitness, and release/debug information. For example:
   - ${SIMBAENGINE_DIR}/ThirdParty/openssl/1.1.0/Linux_x86_gcc/release64/lib
9. If your connector uses the SQL Engine, include the SQL Engine and expat include paths, as specified by the variables SQLENGINE_CPPFLAGS and EXPAT_FLAGS in the kit.mk file. Note that the Expat directory contains a version number. For example:
   - ${SIMBAENGINE_DIR}/Include/SQLEngine
   - ${SIMBAENGINE_DIR}/Include/SQLEngine/AETree
   - ${SIMBAENGINE_DIR}/Include/SQLEngine/DSIExt
   - ${SIMBAENGINE_DIR}/Include/ThirdParty/Expat/2.2.0

Related Topics

5 Day Guides at http://www.simba.com/resources/sdk/documentation/

SimbaClientServer User Guide at http://www.simba.com/resources/sdk/documentation/

Productizing Your Connector

In order to package your custom connector as a product for end customers, you may want to finish rebranding the configuration information and error messages. You also need to include the required dependencies in the install package, and handle configuration on the customer's machine during installation.

Packaging Your Connector

This section explains which files need to be included with your custom connector package, and what configuration steps must be performed on the customer machine in order for customers to install and use your custom connector.

The requirements for local connectors are included in this section. For client-server connectors, see the *SimbaClientServer User Guide* at http://www.simba.com/resources/sdk/documentation/.

C++ On Windows

This section explains how to package connectors written in C++ and built on Windows platforms.

1. Include the connector DLL and any additional DLLs that you added.
2. Include the ICU DLLs from `[INSTALL_DIRECTORY]\DataAccessComponents\ThirdParty\icu\53.1.x\<PLATFORM>\<CONFIGURATION>\lib\`.
   - For 32-bit connectors, include `sbicudt53_32.dll`, `sbicuin53_32.dll`, and `sbicuuc53_32.dll`.
   - Or, for 64-bit connectors, include `sbicudt53_64.dll`, `sbicuin53_64.dll`, and `sbicuuc53_64.dll`.
3. Include the error message files from `[INSTALL_DIRECTORY]\DataAccessComponents\ErrorMessages`. Include the subdirectories for the languages that you want your connector to support.
4. Create the following key in the Windows registry:
   - For 32-bit connectors on 32-bit machines, or 64-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE*Simba**Quickstart*\Driver**, replacing *Simba* with your company name and *Quickstart* with your connector name.
   - For 32-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node*Simba**Quickstart*\connector**, replacing *Simba* with your company name and *Quickstart* with your connector name.

Add the following entries:

- DriverManagerEncoding = UTF-16
- ErrorMessagesPath = <Path to the parent directory where error message files are located>
- (OPTIONAL) LogLevel = 0
- (OPTIONAL) LogPath = <Path to directory to store the log files>

5. Create the following key in the Windows registry:
   - For 32-bit connectors on 32-bit machines, or 64-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\ODBC\ODBCINST.INI\ODBC Drivers**.
   - For 32-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\ODBC\ODBCINST.INI\ODBC Drivers**.

   Add the following entry:
   - <DRIVER_NAME>=Installed
6. Create the following key in the Windows registry:
   - For 32-bit connectors on 32-bit machines, or 64-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\ODBC\ODBCINST.INI*QuickstartDSIIDriver***, replacing *QuickstartDSIIDriver* with the name of your connector.
   - For 32-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\ODBC\ODBCINST.INI\QuickstartDSIIDrivers**, replacing *QuickstartDSIIDriver* with the name of your connector.

   Add the following entries, ensuring you include the correct path for either the 32-bit or the 64-bit connector:
   - Driver=<Full path to the connector DLL>
   - Description=<Brief description of your connector>
   - Setup=<Full path to the 32-bit connector configuration dialog DLL>

For an explanation of the registry keys that are created for the sample connectors, see *Examine the Windows Registry* and *Update the Windows Registry* in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

C++ On Linux, Unix, and macOS

This section explains how to package drivers written in C++ and built on Linux, Unix and macOS platforms.

1. Include the connector shared object and any additional shared objects that you added.
2. Include all ICU shared objects from `[INSTALL_DIRECTORY]/DataAccessComponents/ThirdParty/icu/53.1.x/<PLATFORM>/<CONFIGURATION>/lib`.
3. Include the error message files from `[INSTALL_DIRECTORY]/DataAccessComponents/ErrorMessages`. Include the subdirectories for the languages that you want your connector to support.
4. Add the following entries to your connector's `.ini` configuration file.
   - `DriverManagerEncoding=UTF-16` (or UTF-32, depending on the driver manager being used)
   - `ErrorMessagesPath=<Path to the directory where error message file is located>`
   - `ODBCInstLib=<Full path to the Driver Manager's ODBCInst library>`
   - `(OPTIONAL) LogLevel=0`
   - `(OPTIONAL) LogPath=<Path to directory to store the log files>`
5. Add the following entries to `.odbcinst.ini`:
   - `<DRIVER_NAME>=Installed`
   - `[<DRIVER_NAME>]`
   - `Driver=<Full path to the connector shared library>`
   - `Description=<Brief description of your connector>`

For an explanation of the configuration files that are created for the sample connectors, see *Configure the Connector and Data Source* and *Configure Your Custom Connector and Data Source* in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

C# On Windows

This section explains how to package connectors written in C#.

Packaging Connectors Built With Simba.NET

This section explains how to package connectors written in C# with the Simba.NET component.

1. Include the C# connector DLL.
2. Include `Simba.DotNetDSI.dll` and `Simba.ADO.Net.dll` from `[INSTALL_DIRECTORY]\Bin\Win`.

3. Using `gacutil.exe`, install the following DLLs to the Global Assembly Cache (GAC) on the target machine:
   - `Simba.DotNetDSI.dll`
   - `Simba.ADO.Net.dll`
   - `Driver's C# DLL`

   The DLLs can be installed using the following commands:
   - `gacutil.exe /i Simba.DotNetDSI.dll`
   - `gacutil.exe /i Simba.ADO.Net.dll`
   - `gacutil.exe /i YourDriver.dll`

   If you need to reinstall a DLL to the GAC, you have to uninstall it first using the following command:
   - `gacutil.exe /u Simba.DotNetDSI`

   > **Note:**
   >
   > The .dll extension is removed from the name when uninstalling a DLL from GAC.

Packaging Connectors Built With Simba.NET using .NET Core

- Include the entire contents of the output directory, except `.pdb` files.
- This will include your C# connector `.dll`, `Simba.DotNetDSI.dll`, `Simba.ADO.NET.dll`, and all other dependency `.dll` files.
- Unlike .NET Framework providers, this does not need to be installed in the GAC.

Packaging Connectors Built With Simba.NET using .NET Standard

- Providers built targeting .NET Standard should be packaged the same as .NET Core providers. However, they may also be installed in the GAC to be used by .NET Framework applications.
- Install `Simba.DotNetDSI.dll`, `Simba.ADO.NET.dll`, and `YourDriver.dll` into the GAC as described earlier.

Packaging Connectors Built with CLI DSI and Simba SQLEngine

This section explains how to package connectors written in C# with the CLI DSI component. The Simba SQLEngine component can optionally be included.

1. Include the requirements listed in the section C++ On Windows
2. Include connector's CLIDSI DLL in addition to the C# connector DLL.

3. Include `Simba.DotNetDSI.dll` and `Simba.DotNetDSIExt.dll` from `[INSTALL_DIRECTORY]\Bin\Win`.
4. In the registry, ensure the **Driver** entry is the full path to the C++ CLIDSI DLL, not to the C# DLL.
5. Using `gacutil.exe`, install the following DLLs to the Global Assembly Cache (GAC) on the target machine:
   - `Simba.DotNetDSI.dll`
   - `Simba.DotNetDSIExt.dll`
   - `Driver's C# DLL`

   The DLLs can be installed using the following commands:
   - `gacutil.exe /i Simba.DotNetDSI.dll`
   - `gacutil.exe /i Simba.DotNetDSIExt.dll`
   - `gacutil.exe /i YourDriver.dll`

   If you need to reinstall a DLL to the GAC, you have to uninstall it first using the following command:
   - gacutil.exe /u Simba.DotNetDSI (NOTE: the .dll extension is removed from the name when uninstalling a DLL from GAC)

C# On Linux, Unix, and macOS

Packaging is the same as .NET Core in the above section.

Java Packaging on Windows

This section explains how to package connectors written in Java and built on the Windows platform.

Packaging JDBC Connectors Built With SimbaJDBC

This section explains how to package Java connectors built with the SimbaJDBC component.

1. Include the SimbaJDBC JAR file located at *`[INSTALL_DIRECTORY]`*`\DataAccessComponents\Lib`
2. Include the Java connector's JAR file.
3. If your connector uses the Java Simba SQLEngine, include the SimbaSQLEngine JAR file located at *`[INSTALL_DIRECTORY]`*`\DataAccessComponents\Lib`.

Packaging Java ODBC Connectors Built With JNI DSI and/or SQLEngine

This section explains how to package JDBC connectors built with the SimbaJDBC component.

1. Include the requirements listed in the section C++ On Windows
2. Include the connector's JNIDSI DLL and the Java connector JAR file.
3. In the registry, ensure the **Driver** entry is the full path to the C++ CLIDSI DLL, not the connector's Java JAR file.
4. Create the following key in the Windows registry:
   - For 32-bit connectors on 32-bit machines, or 64-bit drivers on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE*Simba**Quickstart*\Driver**, replacing *Simba* with your company name and *Quickstart* with your connector name.
   - For 32-bit connectors on 64-bit machines, create the key **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node*Simba**Quickstart*\Driver**, replacing *Simba* with your company name and *Quickstart* with your connector name.

   Add the following entry. If multiple options exist, separate them by a "`|`" character. For example:
   `-Djava.class.path=<full path>\JavaQuickstart.jar>|-Xdebug:`
   - `JNIConfig=<Java Virtual Machine (JVM) Configuration options>`
5. If `-Djava.class.path` is not specified in the JNIConfig, add or modify the CLASSPATH environment variable:
   - CLASSPATH=*<Full path of the connector's JAR file>*

   For example: `<full path>\JavaQuickstart.jar`
6. Add or modify the PATH environment variable to include the location of the Java executable, as well as the 64-bit or 32-bit Java Virtual machine (Depending on the bitness of JNIDSI connector).

> **Note:**
>
> For a Java Runtime Environment (JRE), the location of the JVM on 32-bit Windows is usually in <JRE Path>\bin\client while on 64-bit it is usually in <JRE Path>\bin\server.

Java Packaging On Linux, Unix, and macOS

This section explains how to package connectors written in Java and built on Linux, Unix, or macOS platforms.

Packaging JDBC Connectors Built With SimbaJDBC

This section explains how to package Java connectors built with the SimbaJDBC component.

1. Include the SimbaJDBC JAR file located at `[INSTALL_DIRECTORY]\DataAccessComponents\Lib`.
2. Include the Java connector's JAR file.
3. If your connector uses the Java Simba SQLEngine, include the SimbaSQLEngine JAR file located at `[INSTALL_DIRECTORY]/DataAccessComponents/Lib`.

Packaging Java ODBC Connectors Built With JNI DSI and/or SQLEngine

This section explains how to package Java connectors written in Java and built with the SimbaJDBC component.

1. Include the requirements listed in the section C++ On Linux, Unix, and macOS.
2. Include the connector's JNIDSI library and the Java connector JAR file.
3. In the .ini file, ensure the **Driver** entry is the full path to the C++ CLIDSI DLL, not the connector's Java JAR file.
4. Add the following entry to your connector's .ini configuration file. If multiple options, separate them with a "`|`" character.
   - `JNIConfig=<Java Virtual Machine (JVM) Configuration options>`

     For example, `-Djava.class.path=<full path>/JavaQuickstart.jar>|-Xdebug`
5. If `-Djava.class.path` is not specified in the JNIConfig, add or modify the CLASSPATH environment variable:
   - CLASSPATH=*<Full path of the connector's JAR file>*

   For example: `<full path>\JavaQuickstart.jar`
6. Add or modify the LD_LIBRARY_PATH (or equivalent) environment variable to include the location of the Java executable, as well as the 64-bit or 32-bit Java Virtual machine, depending on the bitness of JNIDSI connector.

   For a Java Runtime Environment (JRE), the location of the JVM on 32-bit Unix is usually in `<JRE Path>/lib/<architecture>/client`, where *architecture* is `amd64` on 64-bit linux, or `i386` on 32-bit linux, or other values on other platforms.

Note:

The library path environment variable has the following values on the different platforms:

- `LD_LIBRARY_PATH` on most Linux platforms
- `SHLIB_PATH` on HP/UX
- `LIBPATH` on AIX
- `DYLD_LIBRARY_PATH` on macOS

Related Topics

Including Error Message Files

Adding a DSN Configuration Dialog

You can add a custom dialog in the ODBC Data Source Administrator. This dialog is displayed when users click Add, Remove, or Configure. By using your custom dialog, customers can perform custom configuration of the ODBC connection without having to modify the Windows registry or by editing the `.ini` files on Unix or Linux platforms.

To create a custom DSN configuration dialog, implement the connector setup DLL API by implementing and exporting the `ConfigDSN` function:

```
BOOL INSTAPI ConfigDSN(

    HWND in_parentWindow,
    WORD in_requestType,
    LPCSTR in_driverDescription,
    LPCSTR in_attributes)
```

You can implement this in the connector shared library, or as a separate shared library.

Note:

- If you build the configuration dialog as a separate DLL, we recommend changing the extension from.dll to .cnf, as this is conventional practice.
- The QuickStart sample project provides an example of implementing `ConfigDSN` and exporting it from within the connector DLL.

To get your setup function recognized by the ODBC Data Source Administrator, you must add the **Setup** key to your connector's entry in **ODBCINST.INI** in the registry.

For an example of adding the Setup key, see *C++ Packaging for Windows* in the *Simba SDK Deployment Guide*.

For more information on creating a DLL, refer to the Setup DLL API Reference and the Installer DLL API Reference Function in the Microsoft ODBC Programmer's Reference.

Rebranding Your Connector

The sample connectors are branded with a default connector name, for example *Quickstart*, and the default company name *Simba*. These names are visible to customers in the following locations:

- The Windows registry
- The `.ini` configuration files on Linux, Unix, and macOS
- The vendor name in error messages

The Simba SDK allows you to rebrand your custom connector with the connector name and company name of your choice. The 5 Day Guides at http://www.simba.com/resources/sdk/documentation/ provide detailed instructions on how to use the rebranding functionality in Windows, Linux, Unix, and macOS.

Using INI Files for Connector Configuration on Windows

On Windows platforms, ODBC connectors normally retrieve configuration information from the Windows registry. As an alternative, your connector can retrieve its connector-specific configuration information from an `.ini` file. This enables customers to deploy multiple versions of the DLL, each with a different version of the connector-specific configuration information. You can also specify that your connector to look for the `.ini` file initially, then fall back to the registry if the file cannot be found.

You can use a configuration file, for example `simba.quickstart.ini`, to specify the information that is normally retrieved from the **SOFTWARE\Simba\Quickstart\Driver** registry key.

Note:

- The registry key and the file name can be rebranded with your own company and connector name, but this example uses *simba* and *Quickstart* for simplicity.
- This feature does not include using `.ini` files for information that is stored in the **\ODBC\ODBC.INI** and **\ODBC\ODBCINST** registry keys. You still need to configure these registry keys for your custom connector.

Step 1 - Create the simba.quickstart.ini file

Create a text file that contains all the information in the connector's **HKEY_LOCAL_MACHINE\SOFTWARE\Simba\Quickstart\Driver** registry key. The file has the same format as the `simba.quickstart.ini` file on Linux and Unix platforms.

Example - simba.quickstart.ini file

```
[Driver]
ErrorMessagesPath=C:\Drivers\Quickstart\Maintenance\10.1\Prod
uct\ErrorMessages
UnicodeDataPath=C:\Drivers\Quickstart\Maintenance\10.1\Produc
t\Setup
DriverLocale=en-US
DriverManagerEncoding=UTF-16
LogLevel=3
LogNamespace=
LogPath=C:\SimbaLogs
```

Step 2 - Update Simba::DSI::DSIDriverFactory()

In the `Simba::DSI::DSIDriverFactory()` method in the `Main_Windows.cpp` file, replace the call to `SetConfigurationBranding()` with `SetConfigurationRegistryKey()`, `SetConfigurationIniFile()`, and `SetModuleId()`. These methods must be called before any parameter from the `SimbaSettingReader` is accessed, because the configuration is loaded only once, and cannot be reloaded.

You also need to provide the module ID, using the value provided to the `DLLMain()` function that is called when the connector is loaded.

Example - DSIDriverFactory

```
//==============================
/// @brief Creates an instance of IDriver for a connector.
/// The resulting object is made available through
DSIDriverSingleton::GetDSIDriver().
/// @param out_instanceID Unique identifier for the IDriver
instance.
/// @return IDriver instance. (OWN)
//==============================
IDriver* Simba::DSI::DSIDriverFactory(simba_handle& out_
instanceID)
{
```

```
    out_instanceID = s_quickstartModuleId;

    //Set the name of the INI file from which to load the
    connector-specific configuration.
    // If a file name is specified here, the SEN SDK will
    first try to load the connector specific
    // configuration from that INI file. If it can't find
    the file, it will fall
    // back to the registry, as described below.
    // You can specify a relative path for the file name.
    If the module ID (see below) is
    // 0, then the path is relative to the current
    working directory. If the module
    // ID is non-zero, the path is relative to the
    // directory where the DLL is located.

    #if defined(SERVERTARGET)
    SimbaSettingReader::SetConfigurationIniFile
    (“simbaserver.quickstart.ini”);
    #else
    SimbaSettingReader::SetConfigurationIniFile
    (“simba.quickstart.ini”);
    #endif

    // Set the module identifier provided in DLLMain().
    //This allows the SDK to determine in which
    // directory the connector DLL is located, which is
    used to load INI file defined
    // as relative path as described above.

    SimbaSettingReader::SetModuleId(s_
    quickstartModuleId);

    // Use this setting to specify the registry key that
    is used if the
    // connector cannot find the .ini file.
    // For example, if you use the value
    "Simba\Quickstart", then
```

```
    // the connector looks for the configuration
    information at
    // HKLM\SOFTWARE\Simba\Quickstart, or
    //
    HKLM\SOFTWARE\SOFTWARE\Wow6432Node\Simba\Quickstart
    if
    // running a 32-bit connector on 64-bit Windows).
    // If the DSII is compiled as a connector, then it
    will use \Driver as the final
    // value in the registry path.
    // If the DSII is compiled as a server, then it will
    use \Server as the final
    // value in the registry path.
    // For example, a 64-bit connector would use
    // HKLM\SOFTWARE\Simba\Quickstart\Driver to look up
    the registry keys such as ErrorMessagesPath.

    SimbaSettingReader::SetConfigurationRegistryKey
    (“Simba\\Quickstart”);

    // Set the server branding for this data source. This
    will only be used if the DSII is compiled
    // as a server and then installed as a service.
    #if defined(SERVERTARGET) && defined(WIN32)
    SimbaSettingReader::SetServiceName
    ("SimbaQuickstartService");
    #endif

    return new QSDriver();

}
```

Logging to Event Tracing for Windows (ETW)

By default, the Simba SDK logging functionality writes events and messages to text files. You can develop your custom ODBC or JDBC connector log events and messages to Event Tracing for Windows (ETW) instead. You can also enable it to switch between file and ETW logging at runtime.

The basic steps are as follows:

1. Define the provider GUID in your connector code
2. Use the `ETWLogger` Class in your connector code

For an example of how to implement ETW logging in the QuickStart sample OBBC connector, see Example: Implementing ETW Logging.

Step 1 - Define the Provider GUID in your Connector Code

When creating a manifest file to define your provider, you created a provider GUID. Add this GUID to the connector's main header file. If you have both 32 and 64-bit connectors, you need to include both GUIDs. If your connector code is used on multiple platforms, ensure the GUID is defined just for Windows platforms. For example:

```
#if defined(_WIN64)
/// The 64-bit connector specific ETW provider GUID.
const GUID PROVIDER_GUID = {0x69bacf08, 0x09d0, 0x400a,
{0xab, 0xd8, 0x52, 0x06, 0xd4, 0xbd, 0x79, 0x39}};
#elif defined(WIN32)
/// The 32-bit connector specific ETW provider GUID.
const GUID PROVIDER_GUID = {0x9bbc191d, 0x1d80, 0x40d1,
{0xad, 0xab, 0xe1, 0x1b, 0x97, 0x3a, 0x1e, 0x90}};
#endif
```

Step 2 - Use the ETWLogger Class in your Connector Code

Change your custom connector code to use the `ETWLogger` class instead of the `DSIFileLogger` class.

For example, in the Quickstart sample connector you would have the following `QSDriver` constructor

```
QSDriver::QSDriver() : DSIDriver(), m_driverLog(new ETWLogger
(PROVIDER_GUID))
{

    ENTRANCE_LOG(m_driverLog, "Simba::Quickstart",
    "QSDriver", "QSDriver");
    SetDriverPropertyValues();
    ...

}
```

Further Considerations

You may want to refine the example shown in Example: Implementing ETW Logging with the additional functionality described in this section.

Understanding Log Levels in Windows ETW Logging

The Simba SDK supports six different log levels for file-based logging, and four different log levels for ETW-based logging. The following table shows the mapping between ETW log level and the LogLevel setting in the Windows registry or `.ini` file.

LogLevel setting	ETW Log Level
1	1 (Fatal)
2	2 (Error)
3	3 (Warning)
4,5,6	4 (Debug, Information, Trace)

For example, if you configure **LogLevel** to `6`, then Debug, Information, and Trace logs are all logged as level 4 in the ETW logger.

Increasing the File Size

By default, the maximum size of the log files for ETW logging is 1028 KB. Subsequent events are overwritten in the file. In order to see more events in the log file, you may want to increase the maximum file size by selecting **properties** in the Event Viewer.

Set an Activity ID

By default, the activity ID for the events is set to `0`. To change this activity ID to the string of your choice, use `ETWLogger::SetActivityId()`.

Enable logging for both 32-bit and 64-bit connectors

If you plan to ship a 32-bit and a 64-bit version of your connector, you need to create a manifest file for each version. For example, create a `QuickStart32.man` and a `QuickStart64.man`.

> **Important:**
>
> Be sure you create a different GUID for the 32-bit and the 64-bit manifest files. Each manifest file must have its own, unique GUID.

In the source code, define each provider GUID for the correct platform.

Example:

```
#if defined(_WIN64)
/// The 64-bit connector specific ETW provider GUID.
const GUID PROVIDER_GUID = {0x69bccf01, 0x08d0, 0x400a, {0xbb,
0xc8, 0x52, 0x06, 0xb4, 0xbd, 0x72, 0x39}};
#elif defined(WIN32)
/// The 32-bit connector specific ETW provider GUID.
const GUID PROVIDER_GUID = {0x9bbc737c, 0x1d70, 0x40d9, {0xad,
0xab, 0xe1, 0x8b, 0x17, 0x3a, 0x4e, 0x20}};
#endif
```

Allowing the user to switch between ETW and File logging

If you want allow your customers to switch between ETW logging and file logging, you can create a registry key that defines the type of logging. Then in your code, instantiate the correct logging class depending on the registry setting.

Related Topics

Example: Implementing ETW Logging

Example: Implementing ETW Logging

This example shows one way that you could configure ETW logging for the QuickStart connector. The steps are:

- Step 1 - Create a Manifest File for the QuickStart Connector
- Step 2 - Create the Master Resources File
- Step 3 - Update the QuickStart Connector Code
- Step 4 - Configure ETW to Log QuickStart Events
- Step 5 - Generate Loggable Activity in the QuickStart Connector

Note:

This examples helps you get started. For more details, see Further Considerations.

Step 1 - Create a Manifest File for the QuickStart Connector

Create a manifest file to define the QuickStart connector as an event provider, then compile the file to generate resources.

To create the manifest file:

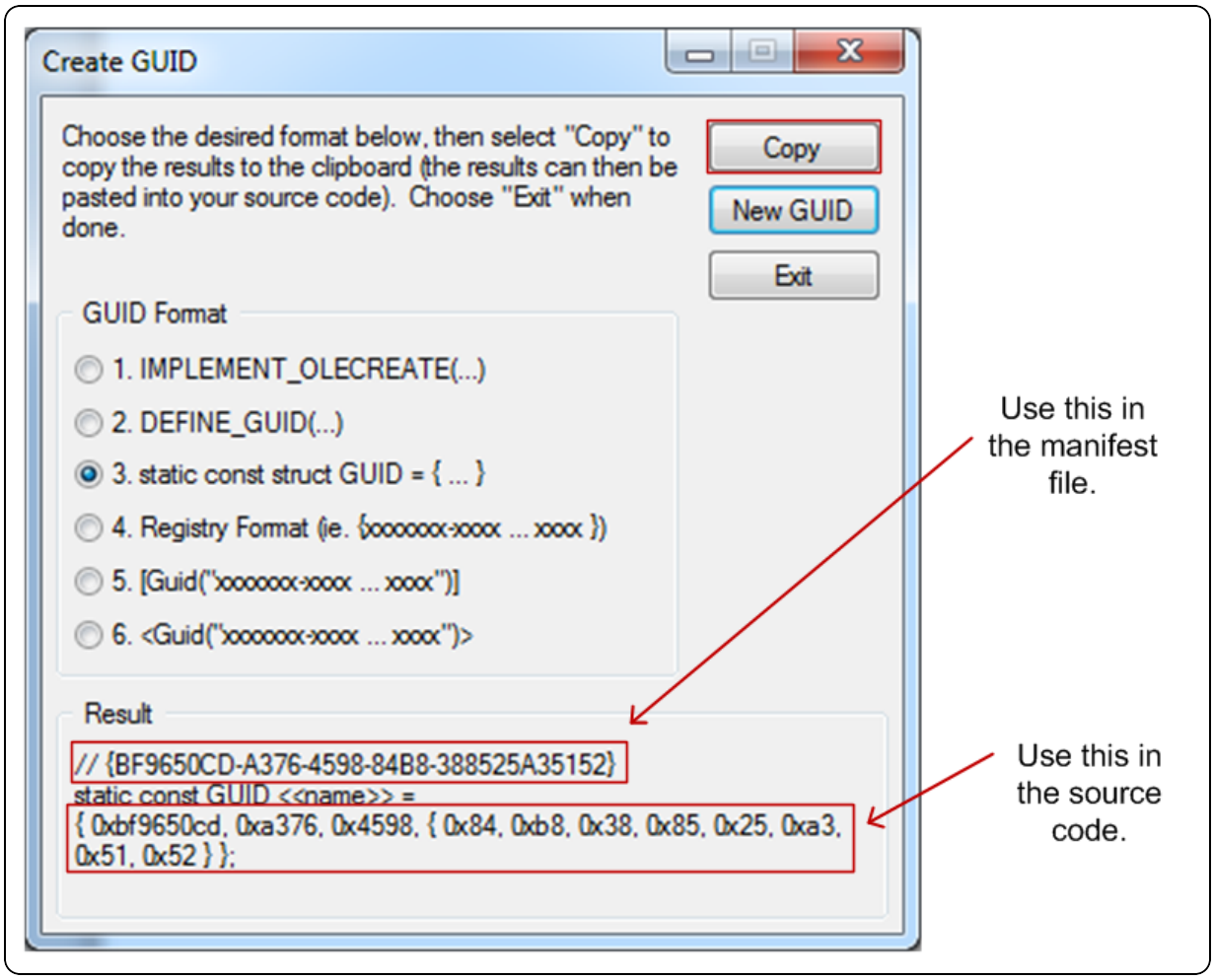
1. Copy the following XML into a text editor:

```
<?xml version="1.0" encoding="UTF-16"?>
<instrumentationManifest xsi:s-
chem-
aLoca-
tion="http://schemas.microsoft.com/win/2004/08/events
eventman.xsd" xmlns-
s="http://schemas.microsoft.com/win/2004/08/events"
xmlns:win-
="h-
ttp://manifests.microsoft.com/win/2004/08/windows/events"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:trace-
="h-
ttp://schemas.microsoft.com/win/2004/08/events/trace">
  <instrumentation>
    <events>
      <provider name="DriverName" guid="{MYGUID}" sym-
bol="DriverName" resourceFileName="Path to connector dll"
messageFileName="Path to connector dll">
        <events>
          <event symbol="DebugInfoTraceEvent" value="0"
version="0" channel="Admin" level="win:Informational" tem-
plate="AllEventsTemplate" mes-
sage="$(string.DriverName.event.0.message)">
          </event>
          <event symbol="ErrorEvent" value="1" ver-
sion="0" channel="Admin" level="win:Error" tem-
plate="AllEventsTemplate"
message="$(string.DriverName.event.1.message)">
          </event>
          <event symbol="FatalEvent" value="2" ver-
sion="0" channel="Admin" level="win:Critical" tem-
plate="AllEventsTemplate"
message="$(string.DriverName.event.2.message)">
          </event>
```

```
          <event symbol="WarnEvent" value="3" version="0"
channel="Admin" level="win:Warning" tem-
plate="AllEventsTemplate" mes-
sage="$(string.DriverName.event.3.message)">
          </event>
        </events>
        <levels>
        </levels>
        <channels>
          <channel name="Admin" chid="Admin" sym-
bol="Admin" type="Admin" enabled="true">
          </channel>
        </channels>
        <templates>
          <template tid="AllEventsTemplate">
            <data name="message" inType-
e="win:UnicodeString" outType="xs:string">
            </data>
          </template>
        </templates>
      </provider>
    </events>
  </instrumentation>
  <localization>
    <resources culture="en-US">
      <stringTable>
        <string id="level.Warning" value="Warning">
        </string>
        <string id="level.Informational" value-
e="Information">
        </string>
        <string id="level.Error" value="Error">
        </string>
        <string id="level.Critical" value="Critical">
        </string>
        <string id="DriverName.event.3.message" value-
e="%1">
        </string>
        <string id="DriverName.event.2.message" value-
e="%1">
        </string>
```

```
        <string id="DriverName.event.1.message" value-
e="%1">
        </string>
        <string id="DriverName.event.0.message" value-
e="%1">
        </string>
      </stringTable>
    </resources>
  </localization>
</instrumentationManifest>
```

2. Save the file as `Quickstart.man`.
3. Replace every instance of `DriverName` with `QuickStart`.
4. Find and replace `Path to connector dll` with the complete path to your connector. Be sure to use the correct DLL for debug, platform, and bitness.
5. Generate a new GUID and use it to replace *`MYGUID`*:
    a. In Visual Studio, select **Tools** > **Create Guid**.
    b. Select option **3** then select **Copy.**



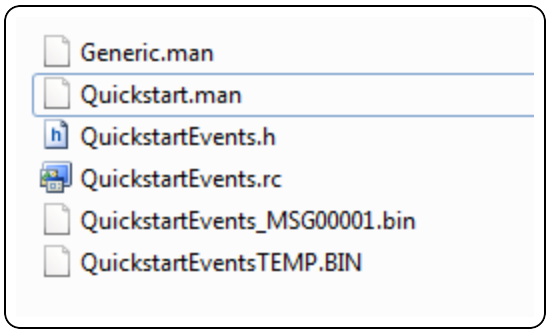
c. Paste the first line into the manifest file, and save the second line to paste into your source code.

6. Save and close the `Quickstart.man` file.

To compile the manifest file:

1. Open a command prompt and navigate to the directory where your `Quickstart.man` file is stored.
2. Run the following command:
```
"C:\Program Files (x86)\Windows Kits\8.1\bin\x64\MC"
Quickstart.man -um -z QuickstartEvents
```

The manifest file is compiled and the resource files are generated:



Step 2 - Create the Master Resources File

Create a master resources file to consume the resources you generated in the previous step.

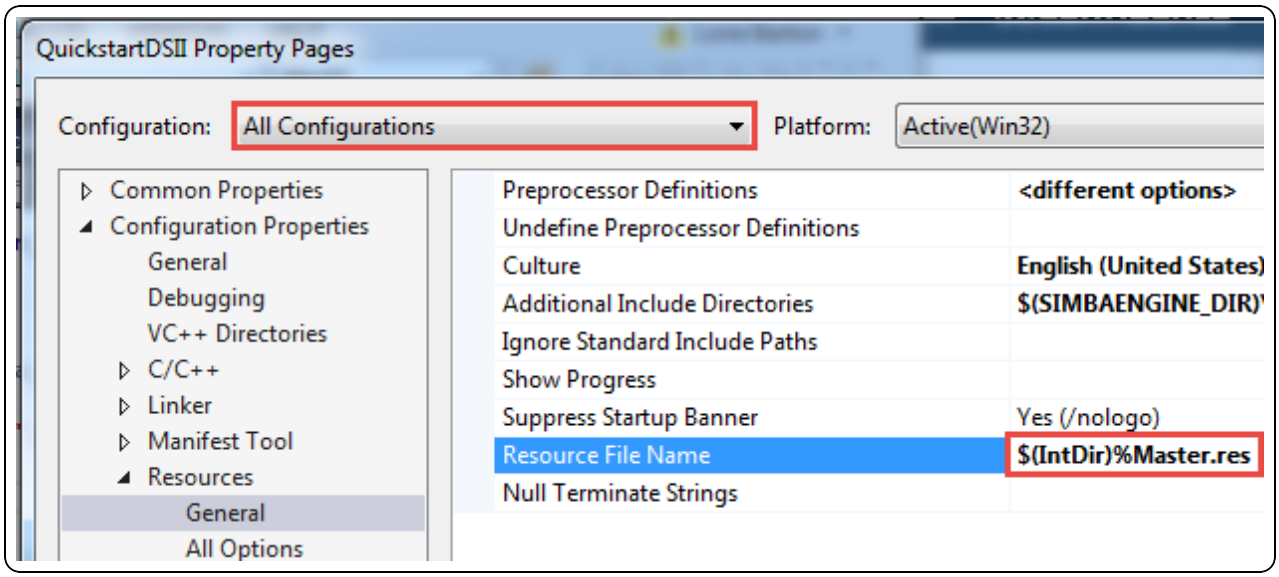
To create the master resources file:

1. In the `Source/Resources` folder of your Visual Studio project, create a text file called `Master.rc`.
2. Add this file to the connector's Visual Studio project:
   a. Right click the **Resources** folder in the connector project in Visual Studio and select **Add** > **Existing Items**
   b. Browse to **Resources** folder, select the **Master.rc** file that you created, and click **Add**.
3. In a text editor, open the **Master.rc** file and `#include` all of the `.rc` files in the QuickStart project. Also include the files you generated in the previous step. Save and close the file.

   Example: Master.rc file
   ```
   #include "Dialogs.rc"
   #include "QuickstartVersion.rc"
   #include "QuickstartEvents.rc"
   ```
4. In a text editor, open the Visual Studio project and remove references to any resource files other than the `Master.rc` file.

   Example: Remove the lines shown below
   ```
   <ItemGroup>
   <ResourceCompile Include="Resources\Dialogs.rc" />
   <ResourceCompile Include="Resources\Master.rc" />
   <ResourceCompile Include="Resources\QuickstartVersion.rc" />
   </ItemGroup>
   ```

5. Update the QuickStart connector project:
   a. In Visual Studio, right-click the QuickStart project and select **Properties**.
   b. Select **Configuration Properties** > **Resources** and select **General**.
   c. Change the **Resource File Name** field to **$(IntDir)\Master.res** .
   d. Click **Apply**.



Step 3 - Update the QuickStart Connector Code

Modify the QuickStart connector code to use the `ETWLogger` class instead of the default file logger class.

To use the ETW logger class:

1. In Visual Studio, open the QuickStart solution, then open the file **Core** > **Include** > **QSDriver.h**.
2. Define the GUID you created earlier. This will be the connector's provider GUID.

   Example: In QSDriver.h

   ```
   namespace Simba
   {
   ```

   namespace Quickstart

   {

   const GUID PROVIDER_GUID = { 0xf77f8f1e, 0xb189, 0x49ed, { 0xa3, 0xd9, 0xab, 0x72, 0x39, 0x19, 0xd2, 0x17 } };

3. Open the `QSDriver.cpp` file and add the following line:
   `#include "ETWLogger.h"`
4. In the QuickStart connector's constructor, change the existing logger to `ETWLogger`. Pass in the `PROVIDER_GUID`.

   Example:
   ```
   QSDriver::QSDriver() : DSIDriver(), m_driverLog(new
   ETWLogger(PROVIDER_GUID))
   ```

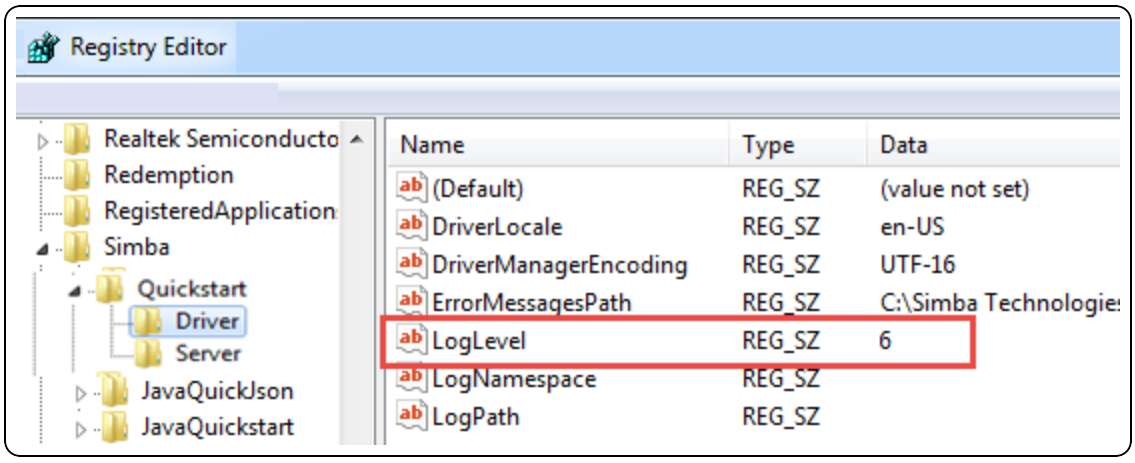
Step 4 - Configure ETW to Log QuickStart Events

Register the connector with ETW and enable logging.

To configure ETW to log QuickStartEvents:

1. Register the QuickStart connector as an ETW provider:
   a. Open a command prompt with administrator privileges.
   b. In the directory containing the `Quickstart.man` file, type the following command:
   ```
   wevtutil im Quickstart.man /resourceFilePath:"C:\Simba
   Technologies\SimbaEngineSDK\10.1\Examples\Source\Quick
   start\Bin\Windows_
   vs2013\debug32md\QuickstartDSIIODBC32.dll"
   /messageFilePath:"C:\Simba
   Technologies\SimbaEngineSDK\10.1\Examples\Source\Quick
   start\Bin\Windows_
   vs2013\debug32md\QuickstartDSIIODBC32.dll"
   ```
2. Ensure the connector is configured for logging by setting the following registry key to `6`:>
   - Use **HKEY_LOCAL_MACHINE\SOFTWARE\Simba\Quickstart\Driver** for a 32-bit connector on a 32-bit machine or a 64-bit connector on a 64-bit machine
   - Or, use **HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Simba\Quickstart\Driver\LogL**

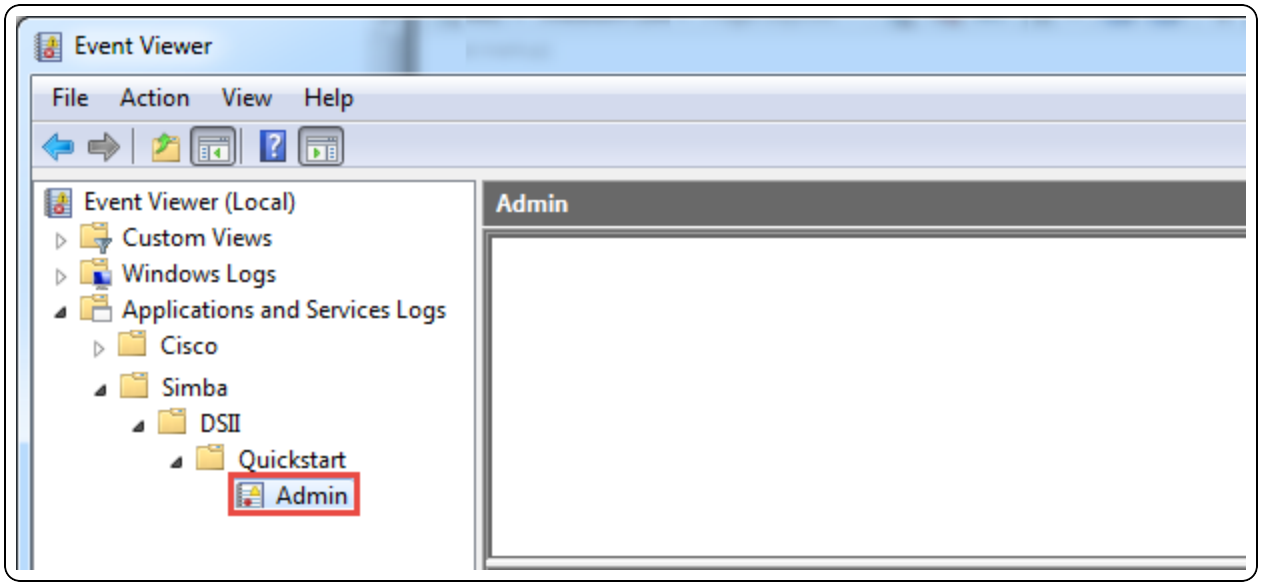
evel for a 32-bit connector on a 64-bit machine



3. Open Event Viewer by typing **Event Viewer** in the Start Menu.
4. In Event Viewer, expand **Applications and Services Logs** > **Simba** > **DSII** > **Quickstart** and select **Admin**.

> **Note:**
>
> If nothing appears under Applications and Services Logs, wait a few minutes for Event Viewer to populate.

5. Right-click on **Admin** and select **Enable Log**.



Step 5 - Generate Loggable Activity in the QuickStart Connector

To see events logged in ETW, you need to configure the connector to start logging, then use it for something such as establishing a connection.

To create activity that will be logged:

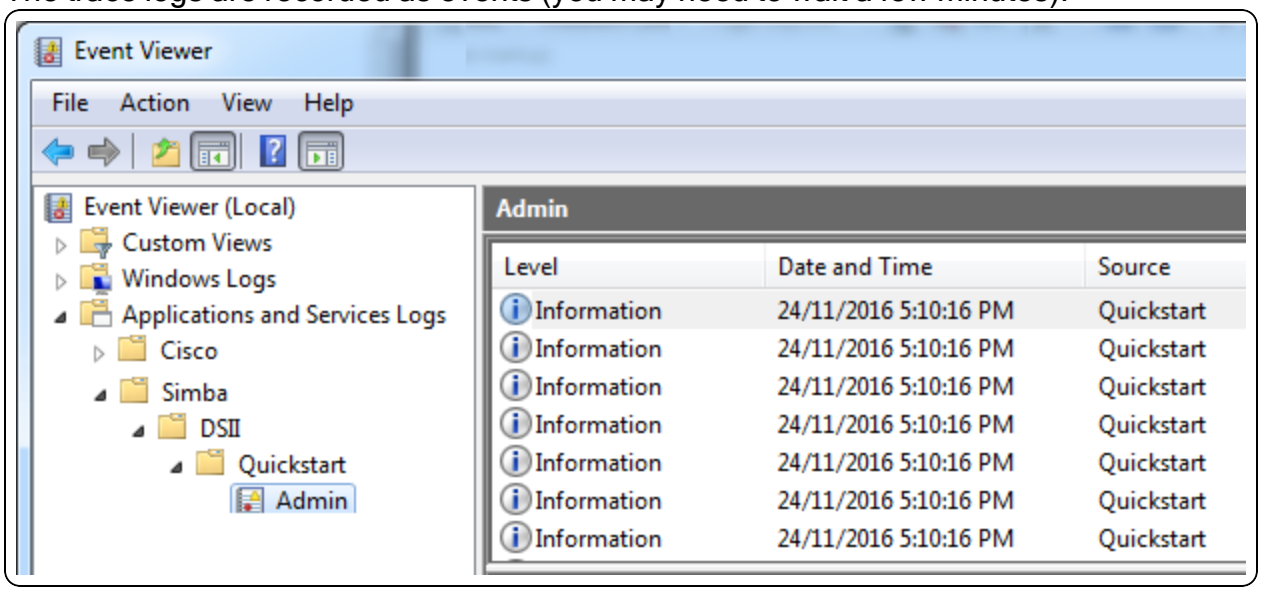
1. Navigate to the folder containing the ODBC Test application, by default:
   `C:\Program Files (x86)\Microsoft Data Access SDK 2.8\Tools`
2. Navigate to the folder that corresponds to your connector's architecture: **amd64**, **ia64** or **x86**.

   Example:

   If you built the 32-bit version of your connector on a 64-bit machine, select the **x86** version.
3. Click one:
   - **odbcte32.exe** to launch the ANSI version
   - Or, **odbct32w.exe** to launch the Unicode version.

   Important:

   Make sure that you run the correct version of the ODBC Test tool for ANSI or Unicode and 32-bit or 64-bit.
4. In the ODBC Test tool, click **Conn** > **Full Connect**.
5. In Event Viewer, navigate to **Applicationsand Services Logs** > **Simba** > **DSII** > **Quickstart** and select **Admin**.
6. The trace logs are recorded as events (you may need to wait a few minutes):



Related Topics

Logging to Event Tracing for Windows (ETW)

For information on rebranding the Simba registry key to your own company name, see Rebranding Your Connector.

Testing your DSII

During the development of your connector, you may want to test its functionality using applications such as Microsoft Excel on Windows or iODBCTest on Linux. This section explains how to use different applications to test your connector. It also explains how to resolve common problems and errors messages that you may encounter at different stages of development.

Testing On Windows

This section explains how to use Microsoft Access, Microsoft Excel, and the ODBCTest tool to test your custom ODBC connector.

Testing With Microsoft Access

Running your connector against Microsoft Access is a good test to prove basic functionality. Microsoft Access uses much of the ODBC API, including many of it's edge cases.

> **Note:**
>
> To get the widest test coverage of the ODBC API, test your connector under Microsoft Access by loading your data as linked tables.

To Test Your Custom ODBC Connector with Microsoft Access:

1. Open Access and create a new Blank Database.
2. Select **External Tab** -> **More** -> **ODBC Database**.
3. In the Get External Data - ODBC Database dialog, select **Link to the data source by creating a linked table**.
4. In the Select Data Source dialog, select the **Machine Data Source** table and choose your DSN. Click **OK**.
5. In the Link Tables dialog, select the tables you want to link to. Click **OK**.
6. In the Select Unique Record Identifier dialog, click **OK** without choosing any specific field.
7. In the All Table panel, right click on a table name and click **Open**.

The data from the table appears in Microsoft Access.

Testing with Microsoft Excel

You can test your data source with Microsoft Excel by importing data using the Data Connection Wizard.

To Test Your Custom ODBC Connector with Microsoft Excel:

1. Open Excel and create a new blank workbook.
2. Select **Data** -> **From Other Sources** -> **From Data Connection Wizard**.
3. In the Data Connection Wizard dialog, select **ODBC DSN** and click **Next**.
4. In the ODBC data sources box, Select your DSN and click **Next**.
5. In the Table box, select a table and click **Next** and then click **Finish.**
6. In the Import Data dialog, select **Table** for how you want to view the data in the workbook and click **OK**.

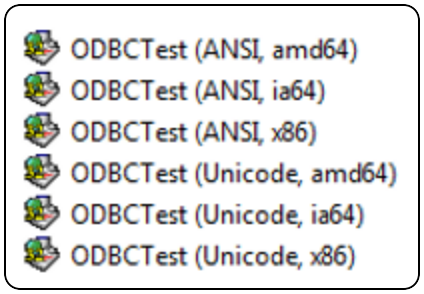
The data from the table appears in your Excel workbook.

Testing with ODBCTest

ODBCTest is a test application provided by Microsoft as part of the Microsoft Data Access Components (MDAC) SDK and the Platform SDK. For more information about MDAC, see What is MDAC?.

This application allows you to manually execute any SQL query. You can also use it to directly call any method in the ODBC API. The full ODBC API is exposed through the ODBCTest menus, allowing you to walk through each step of an ODBC API call and viewing the results in real time.

The MDAC installation includes both ANSI and Unicode-enabled versions of ODBC Test, for both 32-bit and 64-bit systems. The versions are clearly marked in the Programs menu:



Note:

- Select the correct version of MDAC for the bitness of your connector and ANSI or Unicode requirements.
- On 64-bit Windows, ensure that your DSNs are configured correctly.

Running your connector under the debugger with ODBCTest configured as the launch application is an excellent way to test. You can set breakpoints in your DSII, and break

into them as various ODBC calls trigger corresponding DSII calls. You can break at every DSII API call, and step through the execution of each of your DSII methods to track down problems with precision.

For more information on using Visual Studio to debug into your custom ODBC connector with ODBCTest, see the section *Debug the Custom ODBC Connector* in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

To Test Your Custom ODBC Connector with ODBCTest:

Before running this test, ensure you have already configured a DSN for your connector. For more information on creating a DSN in the Windows registry for your custom ODBC connector, see *Update the Windows Registry* in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

1. Start the ODBCTest application, ensuring you run the correct version for ANSI or Unicode and 32-bit or 64-bit.
2. To configure the application to use ODBC 3.52 menus, select **Tools** -> **Options** menu.
3. Select the **ODBC Menu Version** -> **ODBC 3.x**.
4. Create a connection to your connector using the appropriate DSN you already configured.
5. Select **Connect** -> **Full Connect**.

   This option allocates the environment and connection handles, then opens the connection.
6. Locate your DSN in the data source list.
7. Select **OK**. A new window appears with the message “Successfully connected to DSN ‘<your connector name>”. The top half of the window allows you to enter SQL queries to be executed. The bottom half displays the results.

Note:

If you see the error “SQLDriverConnect returned: SQL_ERROR=-1”, use the following tips for troubleshooting. This error usually occurs because the Windows Driver Manager cannot find or load the requested connector’s DLL. Check the following:

- Does your DSN exist in the registry both as a registry key in **ODBC.INI** and as a value in **ODBC.INI\ODBC Data Sources**?
- Does your connector exist in the registry both as a registry key under **ODBCINST.INI** and as a value in **ODBCINST.INI\ODBC Drivers**?
- Does your DSN have a **Driver** entry?
- At the path specified in the DSN’s **Driver** entry, does the specified DLL exist?

8. Enter a simple SQL query by selecting **Statement** -> **SQLExecDirect**. Select **OK** on the resulting dialog.
9. From the Results menu, select **GetDataAll**.
10. Review the results.
11. Select **Catalog** -> **SQLTables**. Select **OK** on the resulting dialog.

    SQL Catalog functions work only if you have implemented the appropriate MetadataSources.
12. Select **Results** -> **GetDataAll**.
13. Review the results

Related Topics

Debug the Custom ODBC Connector in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/

Update the Windows Registry in the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/

Testing On Linux, Unix, and MacOS

This section explains how you can test your custom ODBC connector in Linux, Unix, and macOS platforms.

iODBCTest and iODBCTestW

The utilities iodbctest and iodbctestw are included with the iODBC driver manager installation. You can use one these utilities to establish a test connection with your connector and your DSN. Use iodbctest to test how your connector works with an ANSI application, and use iodbctestw to test how your connector works with a Unicode application.

For more information on how to use this utility, see www.iodbc.org. For an example of how to use iODBCTest, see the section *Connect to the Data Source* in the Linux or macOS version of the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/.

To Test Your Custom ODBC Connector with iODBCTest or iODBCTestW:

1. Use the following command to run `iodbctest` or `iodbctestw`:
   `./iodbctest`

   Or, `./iodbctestw`

   > **Note:**
   >
   > There are 32-bit and 64-bit installations of the iODBC driver manager available. If you have only one version of the driver manager installed, you will have the appropriate version of iodbctest (or iodbctestw). However, if you have both 32-bit and 64-bit versions installed, you will need to ensure that you are running the version from the correct installation directory.

2. The program will ask you to enter an ODBC connect string. Type `?` if you do not remember the name of your DSN. Your ODBC connect string has the following format:
   `DSN=<your_DSN_name>;UID=<user_id> (if applicable);PWD=<your password> (if applicable)`
3. If you have successfully connected, the prompt `SQL>` appears.
4. Test out some simple SELECT queries to see if your data is being retrieved properly from your data source.

UnixODBC

iSql is a utility that is included with the UnixODBC driver manager installation. You can use this utility to test a connection with your connector and your DSN.

For more information on how to use this utility, see www.iodbc.org.

1. Run iSql:
   `./isql <DSN> <UID (if applicable)> <PWD (if applicable)> <options (if applicable)>`
2. If you have successfully connected, the prompt `SQL>` appears.
3. Test out some simple SELECT queries to see if your data is being retrieved properly from your data source.

Related Topics

Connect to the Data Source in the Linux or macOS version of the 5 Day Guides at http://www.simba.com/resources/sdk/documentation/

Driver Manager Encodings on Linux, Unix, and MacOS

On Linux, Unix, and macOS platforms, it is possible to specify that an application use a particular driver manager. You may need to configure a connector to work with an application, depending on which driver manager has been linked to the application. The connector configuration file can set the `DriverManagerEncoding` setting to indicate what type of Unicode is being passed to the connector from the driver manager.

The following table outlines the Unicode setting to use:

Platform	Bitness	iODBC	UnixODBC
Linux	32	UTF-32	UTF-16
Linux	64	UTF-32	UTF-16
Linux Itanium	64	UTF-32	UTF-16
AIX (PowerPC)	32	UTF-16	UTF-16
AIX (PowerPC)	64	UTF-32	UTF-16
macOS	32	UTF-32	
macOS	64	UTF-32	
HP-UX (Itanium)	32	UTF-32	UTF-16
HP-UX (Itanium)	64	UTF-32	UTF-16

Platform	Bitness	iODBC	UnixODBC
Solaris (SPARC)	32	UTF-32	UTF-16
Solaris (SPARC)	64	UTF-32	UTF-16
Solaris (x86)	32	UTF-32	UTF-16
Solaris (x86)	64	UTF-32	UTF-16

Solving Common Problems

This section contains information on debugging and troubleshooting your connector.

Process Can't Locate the DLL

A common cause of failure to connect to the data store is an ODBC connector or a server process that cannot find the ICU DLL or shared object and refuses to start. This can be frustrating to diagnose, so watch out for it. It is the general case of the connector not being able to find all of its dependencies.

On Windows, this manifests itself as a “-1 Error”. One way to approach this problem is with the Dependency Walker program. This free program identifies the items on which an executable depends. For more information on dependency walker, see the MSDN article at http://msdn.microsoft.com/en-us/magazine/bb985842.aspx. The application can be installed from this location: http://dependencywalker.com/.

Connector Cannot Find the Data Store

Another cause of failure is the server or ODBC connector being unable to find your data store. This is usually a case of configuring the connector or server incorrectly. Make sure to include the right checks in your DSI implementation code to detect this condition, and to return clear error messages to the user. This is a frustrating problem to diagnose because the cause is often buried at the very bottom of the data access stack.

AETree Log File Too Large

AETree logging is not considered part of the regular logging functionality in the Simba SDK. Therefore, the `LogFileSize` parameter doesn't affect the size of the `AETree.log` file.

You can enable and disable AETree logging by using the DSIEXT_DATAENGINE_LOG_AETREES property as explained in Enable Logging in the Data Engine.

Incomplete Types Compiler Warning

In order to prevent the possibility of memory leaks when using class templates such as `AutoPtr`, `AutoArrayPtr` or `AutoValueMap`, a compiler warning will be generated when they are instantiated on an incomplete type. If you encounter a compiler warning about an incomplete type (the actual warning varies between compilers), simply include the header file of the pre-declared class, and remove the pre-declaration. This allows the compiler to have full access to the underlying class destructor of in the class template AutoXXX destructor.

Example: Code That Causes an Incomplete Type Warning

```
namespace MyDriver
{

    class MyClass1; // Pre-declaration of MyClass1
    class MyClass2
    {

        public:
        MyClass2 {}
        ~MyClass2 {}
        private:
        // when this is cleaned up, the destructor of
        MyClass1 will not be called :-(
        Simba::Support::AutoPtr<MyClass1> m_obj;

    }

}
```

Example: Resolving an Incomplete Type Warning

```
//To resolve the issue, include the header file for
// MyClass1 and remove the forward declaration:
#include MyClass1.h
namespace MyDriver
{

    class MyClass2
    {

        public:
        MyClass2 {}
        ~MyClass2 {}
        private:
```

```
        // when this is cleaned up, the destructor of
        MyClass1 will be called :-)
        Simba::Support::AutoPtr<MyClass1> m_obj;

    }

}
```

Background on the Use of Incomplete Types

In C++, it is possible to pre-declare a class, then define pointer or reference to it. This results in a pointer to an incomplete type. This is fine as long as the code does not need to access any methods or attributes of the pre-defined class, including the destructor. The C++ specification also allows you to delete the pointer to an incomplete type. This may cause a problem, because the compiler does not know the type of the referenced object, or how to call its destructor (it might not even have a destructor). The compiler frees the memory of the object but cannot call its destructor first. This could lead to memory leaks or other issues, such as a file remaining open.

The Simba SDK provides class templates such as `AutoPtr`, `AutoArrayPtr` or `AutoValueMap` to help manage your dynamically created objects. These classes will clean up an object when their instances are destroyed. However, if these class templates are instantiated on an incomplete type, the compiler does not have access to the underlying class's destructor. Therefore, it cannot add a call to the destructor of the underlying object when compiling the destructor of these class templates.s

Incorrect version of libc Library

When deploying a connector on AIX platforms, a supported version of the system library `libc` must be available on the machine. We recommend having the following version of this library for each supported version of AIX:

AIX version	
AIX 7.1	bos.rte.libc.7.2.0.2
AIX 6.1	bos.rte.libc.6.1.9.30

To download this library, see http://www-01.ibm.com/support/docview.wss?uid=isg1fileset-870201775.

If this library does not exist on the deployment machine, the following errors may be encountered:

- [unixODBC][Driver Manager]Can't initiate unicode conversion
- [unixODBC][Driver Manager]Can't open lib *<path to connector library>*: file not found
- [ISQL]ERROR: Could not SQLConnect

Error Messages Encountered During Development

The following table lists some of the error messages you may encounter during the development and testing phases of your DSII. For a complete list of error codes and messages, see the files in `[INSTALL_DIRECTORY]\DataAccessComponents\ErrorMessages\`.

Error Message	Meaning	Solution
Out of Memory	The SQL Engine did not have enough memory to complete the SQL command.	If your SQL statement results in an "Out of Memory" error, and you are using the SQL Engine, you may need to adjust how the SQL Engine uses memory. To resolve this error, try tuning the memory strategy as described in SQL Engine Memory Management. In particular, see the tip about DSI_MEM_MANAGER_THRESHOLD_PERCENT.
The license file <*file*> could not be found.	The `Simba.lic` license file is not in the correct directory, or you do not have a valid license.	Install the license file, or re-install it in the correct location. For information on installing the license file, see .
SQLDriverConnect returned: SQL_ERROR=-1	The Driver Manager cannot find or load the requested connector's DLL.	Make sure that your connector is installed correctly and that the DSN is correctly configured.

Error Message	Meaning	Solution
Specified driver could not be loaded.	The connector is missing some dependencies. Another possibility is that all libraries have not been compiled with the same bitness. Check that your ICU, iODBC, and your DSII libraries are all the same bitness.	Try listing the dynamic dependencies of your connector and ensuring all the dependencies are available. e.g.: ldd -d driver.so on Unix or use Dependency Walker on Windows.
Your evaluation period has expired. Please contact Simba Technologies Inc. at support@simba.com	Your license has expired.	Contact Simba for support.
Error file not found: <file>	The error message file is missing or the configuration value used to locate the file was not set.	Ensure the ErrorMessagesPath configuration value exists and is pointing at the correct directory containing the error message files. On Windows, this configuration is in the registry at HKLM/Software/Simba/Driver and on other platforms it is found in the simba.ini config file.
The error message <message> could not be found in the en-US locale.	Same as above.	

Error Message	Meaning	Solution
Incomplete Type	A template class, such as `AutoPtr`, `AutoArrayPtr` or `AutoValueMap`, is used as a reference to an incomplete type.	See .

Enable Logging in the Data Engine

The Simba SDK provides logging capability that is specific to AETree and ETree functionality. This logging is controlled separately from the other log functionality in the Simba SDK, and isn't affected by settings such as `LogFileSize` parameter.

You can enable AETree and ETree logging using the DSIEXT_DATAENGINE_LOG_AETREES and the DSIEXT_DATAENGINE_LOG_ETREE data engine properties.

Example:

To enable AETree logging, add this line to your connector, for example in your `DSIExtSqlDataEngine` subclass.

```
SetProperty( DSIEXT_DATAENGINE_LOG_AETREES,
AttributeData::MakeNewUInt32AttributeData(0xF));
```

This setting will create a log file, `AETree.log`, in the path specified by the `LogPath` parameter.

Related Topics

Statements

Using SQL Engine Properties

Contact Us

For more information or help using this product, please contact our Technical Support staff. We welcome your questions, comments, and feature requests.

Note:

To help us assist you, prior to contacting Technical Support please prepare a detailed summary of the Simba SDK version and development platform that you are using.

You can contact Technical Support via the Magnitude Support Community at www.magnitude.com.

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