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Web Services Data Access and Integration – The Relational Realisation (WS-DAIR)

Status of This Memo

This memo provides information regarding the specification of service-based interfaces to relational data resources. The specification is presently a draft for discussion. It does not define any standards or technical recommendations. Distribution is unlimited.

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Abstract

Data resources play a significant role in many applications across multiple domains. Web services provide implementation neutral facilities for describing, invoking and orchestrating collections of networked resources. The GGF (Global Grid Forum) Open Grid Services Architecture (OGSA), and its associated specifications, defines consistent interfaces through web services to components of the grid infrastructure. Both the web and grid communities stand to benefit from the provision of consistent and agreed web service interfaces for data resources and the systems that manage them.

This document, *Web Services Data Access and Integration: The Relational Realisation (WS-DAIR)*, presents a specification for a collection of data access interfaces for relational data resources, which extends interfaces defined in the *Web Services Data Access and Integration* document [WS-DAI].

Related DAIS specifications define how other data resources and systems can be described and manipulated through web services. The DAIS specifications form part of a broader activity within the GGF to develop OGSA. The DAIS specifications can be applied in regular web services environments or as part of a grid fabric.

Contents

Abstract.....	1
1. Introduction	3
1.1 Specification Scope.....	3
1.2 Specification Organisation	3
1.3 Interface Composition	3
2. Notational Conventions.....	4
3. Terminology	4
4. Concepts.....	4
4.1 Port Types	4
4.2 Relationships with other specifications	5
5. SQL.....	6
5.1 SQLAccessDescription	6
5.2 SQLAccess.....	8
5.3 SQLAccessFactory	9
6. SQLResponse.....	11
6.1 SQLResponseDescription	11
6.2 SQLResponseAccess	12
6.3 SQLResponseFactory.....	14
7. SQLRowSet	15
7.1 SQLRowSet Description	15
7.2 SQLRowSetAccess.....	16
8. Mapping to WSRF	17
9. Security Considerations.....	17
10. Conclusion	17
Editor Information	17
Contributor Information	18
Acknowledgements.....	18
Intellectual Property Statement	19
Full Copyright Notice	19
References	20
Appendix A.1 – SQLAccess WSDL Interfaces	21
Appendix A.2 – SQLAccess XML Schema.....	21
Appendix A.3 – SQLAccess WSDL	25
Appendix B.1 – SQLResponseAccess WSDL Interfaces.....	29
Appendix B.2 – SQLResponseAccess XML Schema	31
Appendix B.3 – SQLResponseAccess WSDL.....	32
Appendix C.1 – SQLRowSetAccess WSDL Interfaces	39
Appendix C.2 – SQLRowSetAccess XML Schema.....	40
Appendix C.3 – SQLRowSetAccess WSDL	42

1. Introduction

Data access plays a central role for many types of Grid applications. Data access generally involves the retrieval, manipulation and insertion of data, which may be stored using a range of different formats and infrastructures.

This document presents a specification for a collection of data access interfaces for relational data resources. A relational data resource is a data source/sink, together with any associated management infrastructure, that is characteristic of relational database systems, e.g., can be queried or updated using SQL or any other suitable relational query/update language. The Port Types are thus categorized according to the support they provide for:

- Data Description
- Data Access
- Data Factories

As such, this document should be read in conjunction with the generic *Web Services Data Access and Integration* document [WS-DAI], which defines the base interfaces that are extended in this document. These specifications are being developed for representing data resources as web services, and form part of a broader activity within the Global Grid Forum to develop the Open Grid Services Architecture (OGSA) [OGSA].

1.1 Specification Scope

The `DataAccess`, `DataFactory` and `DataManagement` interfaces and the role of `Data Description` in the provision of service-based interfaces to data resources are discussed in the *Web Services Data Access and Integration* document [WS-DAI]. This specification extends those interfaces to allow access to and description of relational data resources. The relational data resources are assumed to be composed of tabular data structures such as relations and result sets typically accessed either using SQL queries or by row iteration.

1.2 Specification Organisation

This specification separates the function of a Data Service from its operational representation as expressed in WSDL. This approach allows functions to be mapped to WSDL in more than one way and a single such mapping is provided in Section 9.

The relational model is described using the terminology defined in Section 3 and employs the concepts described in Section 4. Sections 5, 6 and 7 describe the interfaces for posing SQL queries, accessing the results of SQL queries and for iterating through result sets respectively.

An illustrative mapping of the relational model to the Web Services Resource Framework (WSRF) [WS-Resource] is described in Section 8, Section 9 discusses security and Section 10 draws conclusions from this specification exercise.

1.3 Interface Composition

This specification does not mandate how interfaces are composed into services; the proposed interfaces may be used in isolation or in conjunction with others. Viable compositions of interfaces will, initially, follow established patterns for data access.

Here a Data Service provides `SQLAccess`, `SQLResponseAccess` and `SQLRowSetAccess` interfaces for a relational Data Service that is associated with a relational database.

2. Notational Conventions

The key words “MUST,” “MUST NOT,” “REQUIRED,” “SHALL,” “SHALL NOT,” “SHOULD,” “SHOULD NOT,” “RECOMMENDED,” “MAY,” and “OPTIONAL” are to be interpreted as described in RFC-2119 [RFC2199].

When describing concrete XML schemas, this specification uses the notational convention of [WS-Security]. Specifically, each member of an element's children or attributes property is described using an XPath-like notation (e.g., `/x:MyHeader/x:SomeProperty/@value1` indicates that namespace *x* is being used, the root element *MyHeader* and a child element *SomeProperty* with an attribute *value1*). The use of `{any}` indicates the presence of an element wildcard (`<xsd:any/>`). The use of `@{any}` indicates the presence of an attribute wildcard (`<xsd:anyAttribute/>`).

When patterns of messages are described the layout of the XML of each message is presented, as opposed to the XML schema. The following notation is used to indicate cardinality of XML elements in these cases:

- * zero or more
- + one or more
- ? zero or one

Where no notation is added to an element only one instance of the element is expected.

This specification uses namespace prefixes throughout; these are listed in the table below. Note that the choice of any namespace prefix is arbitrary and is not semantically significant.

Prefix	Namespace
http	http://www.w3.org/2002/06/wSDL/http
wSDL	http://schemas.xmlsoap.org/wSDL/
xsd	http://www.w3.org/2001/XMLSchema
wsdai	http://www.ggf.org/namespaces/2004/09/WS-DAI
wsdair	http://www.ggf.org/namespaces/2004/09/WS-DAIR
wsdaisr	http://www.ggf.org/namespaces/2004/09/WS-DAISR
wsdairs	http://www.ggf.org/namespaces/2004/09/WS-DAIRS
wrs	http://java.sun.com/xml/ns/jdbc/webrowset.xsd
wsa	http://schemas.xmlsoap.org/ws/2004/03/addressing

3. Terminology

The model independent terminology, i.e., data resource, Data Service, Consumer and Data Set, is given in the *Web Services Data Access and Integration* document [WS-DAI].

4. Concepts

4.1 Port Types

DAIS classes its Port Types into four broad categories, which are defined in the WS-DAI specification. They are extended in this document to target relational data resources.

4.1.1 Data Description

The *DataDescription* interfaces allow a description of data represented by Data Services to be provided. The model-independent specification for these is given in the *Web Services Data Access and Integration* document [WS-DAI]. Here they are extended to provide a description of relational data resources. These are the main points of extension for relational data resources:

- *SQLAccessDescription*: provides information about *LanguageCapabilities* and relational logical schemas that describe Databases, Domains, Tables, Constraints, Columns, ColumnTypes, Keys, Views, StoredProcedures, UserDefinedTypes, UserDefinedFunctions and Triggers that a Data Service may represent. It also describes physical schemas that describe indexes, sizes of tables and statistics on column values.
- *SQLResponseDescription*: provides information about the values represented by a *SQLExecuteResponseType* including *SQLResponseItemSequenceNumber* and *SQLResponseItemFormatType* (one of each of the two preceeding for each Item in a *SQLResponse*). In addition the *NumberOfSQLRowSets*, *NumberOfSQLUpdateCounts*, *NumberOfSQLReturnValues*, *NumberOfSQLOutputParameters* and *NumberOfSQLCommunicationsAreas* are also provided.
- *SQLRowSetDescription*: provides information about a particular instance of a query result that a Data Service may represent. This interface will make available information about the schema for representing the query result and the number of rows within the *SQLRowSet*.

These capabilities are described in Sections 5 to 7.

4.1.2 Data Access

DataAccess operations allow relational data resources to be modified through insertion, updates or deletes, or queried through an appropriate language. Some relational data resource products also support XML access – these are addressed in the WS-DAIX specification. The following Data Access interfaces are defined in this specification:

- *SQLAccess*: provides access to a relational data resource.
- *SQLResponseAccess*: provides access to each type of Response that can result from the execution of a *SQLExpression*.
- *SQLRowSetAccess*: provides access to a set of rows, which are usually the result of a *SQLExpression* containing a SELECT statement.

These are covered in more detail in Sections 5 to 7. .

4.1.3 Data Factory

The *DataFactory* interfaces allow data represented in relational data resources, usually as the result of a query or update, to be instantiated as Data Services. The specializations in this instance thus deal with the type of *SQLExpression* that can be passed to a *DataFactory* to expose the results in a meaningful fashion. The properties and interfaces that will be supported by these Data Services are specified in the schema for the creation parameters. *DataFactory* specializations are:

- *SQLAccessFactory*: provides access to a relational data resource.
- *SQLResponseFactory*: provides access to a SQL response.

These are covered in more detail in Sections 5 to 7.

4.2 Relationships with other specifications

WS-DAIR does not provide its own query/update languages for relational data resources. Instead, it acts as a conduit for existing relational query and update languages to be conveyed to the appropriate data resources, in this instance relational data resources or a data resource that supports relational type queries. As such WS-DAIR relies on existing relational query and update languages. In this document, interface support is provided for languages based on the following standards:

- SQL: an ISO standard defining a language for querying and updating relational data resources [SQL2003].

- WebRowSet: a Java Community Process standard for relational results is one of the valid *ResponseFormats* for responses from SQLAccess operations [JSR114].
- CIM: is the Common Information Model, a DMTF standard, to which the DAIS-WG and the CGS-WG plan to submit a proposal for extension to include relational database properties and data management operations [CIM].

5. SQL

5.1 SQLAccessDescription

Note the details and values of the complex types below will be defined in a proposal arising from a joint activity of the DAIS-WG and the CGS-WG to extend the DMTF Common Information Model [CIM].

5.1.1 SQLExecuteResponseTypeList

```
<!-- the list of response types validly returned by the sql execute
      operation -->
<xsd:element name="SQLExecuteResponseTypeList"
      type="wsdai:ResponseTypeListType" />
```

/wsdair:SQLExecuteResponseTypeList

The list of response types validly returned by the sql execute operation.

5.1.2 SQLExecuteFactoryParameterDocumentTypeList

5.1.3 LanguageCapabilities

```
<xsd:simpleType name="LanguageCapabilitiesType">
  <xsd:union>
    <xsd:simpleType>
      <xsd:restriction base="xsd:token">
        <xsd:enumeration value="SQL92Expression"/>
        <xsd:enumeration value="SQL99Expression"/>
        <xsd:enumeration value="SQL03Expression"/>
      </xsd:restriction>
    </xsd:simpleType>
    <xsd:simpleType>
      <xsd:restriction base="xsd:token"/>
    </xsd:simpleType>
  </xsd:union>
</xsd:simpleType>

<xsd:element name="LanguageCapabilities"
  type="wsdair:LanguageCapabilitiesType" />
```

/wsdair:LanguageCapabilities

Describes the dialect of the SQL language that the underlying relational database management system should support.

5.1.4 RelationalSchema

```
<xsd:complexType name="RelationalSchemaType">
  <xsd:sequence>
    <xsd:element name="Content" type="xsd:string"/>
```

```

        <!--Content will be determined from a collaboration with CIM -->
    </xsd:sequence>
</xsd:complexType>

<xsd:element name="RelationalSchema"
    type="wsdair:RelationalSchemaType" />

```

/wsdair:RelationalSchema

Describes the schema of the relational data, for example Databases, Domains, Tables, Constraints, Columns, ColumnTypes, Keys, Views and Indexes.

5.1.5 StoredProcedures

```

<xsd:complexType name="StoredProceduresListType">
    <xsd:sequence>
        <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:element name="StoredProcedures"
    type="wsdair:StoredProceduresListType" />

```

/wsdair:StoredProcedures

Describes the names, input and output types of the stored procedures available.

5.1.6 UserDefinedTypes

```

<xsd:complexType name="UserDefinedTypesListType">
    <xsd:sequence>
        <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:element name="UserDefinedTypes"
    type="wsdair:UserDefinedTypesListType" />

```

/wsdair:UserDefinedTypes

Describes the names and definitions of the user-defined types available.

5.1.7 UserDefinedFunctions

```

<xsd:complexType name="UserDefinedFunctionsListType">
    <xsd:sequence>
        <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:element name="UserDefinedFunctions"
    type="wsdair:UserDefinedFunctionsListType" />

```

/wsdair:UserDefinedFunctions

Describes the names and definitions of the user-defined functions available.

5.1.8 Triggers

```

<xsd:complexType name="Triggers">
    <xsd:sequence>
        <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

```

```

    </xsd:sequence>
</xsd:complexType>

<xsd:element name="Triggers" type="wsdair:TriggersType" />

```

/wsdair:Triggers

Describes the names and definitions of the triggers available.

5.2 SQLAccess

This *SQLAccess* interface provides access to the underlying relational data resource by means of SQL statements.

5.2.1 Overview

Data Access collects together messages that directly access and modify the data represented by a Data Service along with the behavioral properties that describe the behavior of these access messages, as, for example, illustrated in Figure 1.

A relational Data Service implements the *SQLAccess* operations and exposes the *SQLAccessDescription* informational properties. In this example a consumer uses the *SQLExecute* message to submit a *SQLExpression*. The associated *SQLExecuteResponse* message will contain some combination of *SQLExecuteResponseTypeList*. The actual combination will depend upon the actual *SQLExpression*, for example:

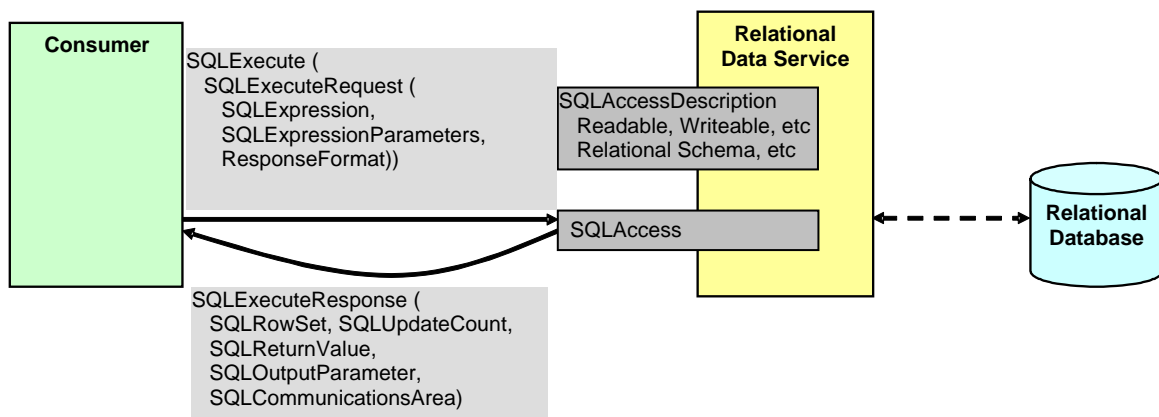


Figure 1 – Overview – SQLAccess

- Usage of SELECT produces:
 - *SQLRowSet* – (1)
 - *SQLCommunicationsArea* – (*)
- Usage of INSERT, UPDATE, DELETE produces:
 - *SQLUpdateCount* – (1)
 - *SQLCommunicationsArea* – (*)
- Usage of a StoredProcedure produces:
 - *SQLRowSet* – (*)
 - *SQLReturnValue* – (*)
 - *SQLOutputParameter* – (*)
 - *SQLCommunicationsArea* – (*)
- Usage of a UserDefinedFunction produces:
 - *SQLReturnValue* – (+)
 - *SQLCommunicationsArea* – (*)

The Consumer will need to process the *SQLExecuteResponse* appropriately.

5.2.2 Operations

5.2.2.1 SQLAccess::SQLExecute

Directs a *SQLExpression* and optional *SQLExecuteRequestParameters* to the relational data resource.

The *SQLExecuteRequestParameters* are primarily for use with Stored Procedures and User Defined Functions. However, it is also intended that a *SQLExecuteRequestParameter* be used to provide a dataset reference to a *SQLExpression* containing a bulk load or similar update statement.

Input

- *SQLExecuteRequest* – the *SQLExecute* operation that is to be run on the relational data resource.
 - *SQLExpression* – (1) – any SQL statement
 - *SQLExpressionParameters* – (*)
 - *ResponseFormat* – the format(s), selected from the *SQLExecuteResponseTypeList* property, which the *SQLExecuteResponse* will conform to.

Output

- *SQLExecuteResponse* – the *SQLExecuteResponse* returned in the *ResponseFormats* from the *SQLExecute* operation.
 - *SQLRowSet* – (*) – e.g. *WebRowSet* see [JSR114]
 - *SQLUpdateCount* – (*)
 - *SQLReturnValue* – (*)
 - *SQLOutputParameter* – (*)
 - *SQLCommunicationsArea* – (*)
 - *SQLState* – (+) – an XOPEN or SQL99 code identifying the Exception, Warning or Message.
 - *VendorCode* – (+) – a database vendor-specific code for the Exception, Warning or Message.
 - *MessageText* – (+) – a text description of the Exception, Warning or Message.

Faults

- *InvalidSQLExecuteRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLExpressionParameters* – Parameters do not match *SQLExpression*.
- *InvalidResponseFormat* – *ResponseFormat* not valid.
- *OtherFault* – any other fault.

5.3 SQLAccessFactory

The *SQLExecuteFactory* operation is used to create a service representing a relational data resource, which fulfills the desired behavior, exposes the desired interfaces and represents the results of the SQL Query.

5.3.1 Overview

This factory pattern allows a Data Service to relational data resource relationship to be established as a result of messages going to another Data Service. This ability to derive one Data Service from another to provide different views of the same relational data resources leads to a collection of notionally related Data Service instances, for example, see Figure 2.

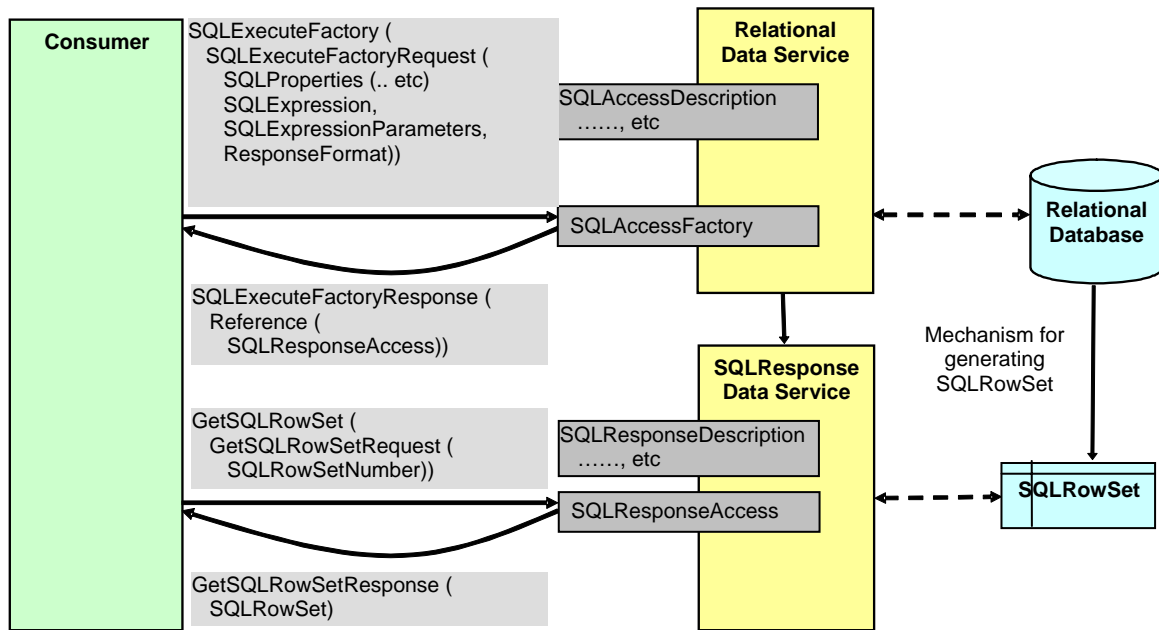


Figure 2 – Overview – SQLAccessFactory

The example in Figure 2 presents a SQLAccessFactory interface. The SQLExecuteFactory operation is used to construct the derived SQLResponse Data Service. This service provides access to the *SQLRowSet* resulting from a *SQLExpression* against the Relational Database, assuming that the expression contains a SELECT statement. The *SQLRowSet* is a subset or restriction of the data in the database and is presented in tabular form. The *SQLRowSet* could be stored as a table in a relational database or decoupled from the database, but the important distinction here is that the data is represented as a collection of rows that does not implement the SQLAccess portType. Instead, the SQLResponse Data Service presents the *SQLResponseAccess* collection of operations that allows the *SQLRowSet* to be retrieved but does not provide facilities for submitting SQL expressions.

5.3.2 Operations

5.3.2.1 SQLAccessFactory::SQLExecuteFactory

Create a new Data Service that corresponds to the results of a SQL Query.

Input

- *SQLExecuteFactoryRequest*
 - *PropertiesDocument* – (1) *DataAccessPropertyType* for target data service
 - *SQLExpression* – (1) – any SQL statement.
 - *SQLExpressionParameters* – (*)

Output

- *SQLExecuteFactoryResponse*
 - *Reference* – (1) – to *SQLResponseAccess* operation.

Faults

- *InvalidSQLExecuteFactoryRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLBehavioralProperties* – Properties not valid.
- *InvalidSQLExpressionParameters* – *SQLExpressionParameters* do not match *SQLExpression*.
- *InvalidResponseFormat* – *ResponseFormat* not valid.
- *OtherFault* – any other fault.

6. SQLResponse

6.1 SQLResponseDescription

TBD.

6.1.1 GetSQLRowsetResponseTypeList

TBD.

6.1.2 SQLRowsetSelectionFactoryParameterDocumentTypeList

TBD.

6.1.3 SQLResponseItem

```
<xsd:complexType name="SQLResponseType">
  <xsd:sequence>
    <xsd:element name="SQLResponseItemSequenceNumber" type="xsd:int" />
    <xsd:element name="SQLResponseItemFormatType" type="xsd:string" />
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="SQLResponseItem"
  type="wsdair:SQLResponseType" />
```

/wsdair:SQLResponseItem

This comprises two properties, namely *SQLResponseItemSequenceNumber*, the Sequence Number of a *SQLResponseItem* in the *SQLExecuteResponse* which is paired with *SQLResponseItemFormatType*, the Format Type for that same *SQLResponseItem*.

6.1.4 NumberOfSQLRowSets

```
<xsd:element name="NumberOfSQLRowSets" type="xsd:int" />
```

/wsdair:NumberOfSQLRowSets

The total number of *SQLRowSets* in the *SQLExecuteResponse*.

6.1.5 NumberOfSQLUpdateCounts

```
<xsd:element name="NumberOfSQLUpdateCounts" type="xsd:int" />
```

/wsdair:NumberOfSQLUpdateCounts

The total number of *SQLUpdateCounts* in the *SQLExecuteResponse*.

6.1.6 NumberOfSQLReturnValues

```
<xsd:element name="NumberOfSQLReturnValues" type="xsd:int" />
```

/wsdair:NumberOfSQLReturnValues

The total number of *SQLReturnValues* in the *SQLExecuteResponse*.

6.1.7 NumberOfSQLOutputParameters

```
<xsd:element name="NumberOfSQLOutputParameters" type="xsd:int" />
```

/wsdair:NumberOfSQLOutputParameters

The total number of *SQLOutputParameters* in the *SQLExecuteResponse*.

6.1.8 NumberOfSQLCommunicationsAreas

```
<xsd:element name="NumberOfSQLCommunicationsAreas" type="xsd:int" />
```

/wsdaisr:NumberOfSQLCommunicationsAreas

The total number of *SQLCommunicationsAreas* in the *SQLExecuteResponse*.

6.2 SQLResponseAccess

This allows access to each *SQLExecuteResponseType* in the *SQLExecuteResponse* data by executing the appropriate *SQLResponseAccess* operation.

6.2.1 Operations

6.2.1.1 SQLResponseAccess::GetSQLResponseItem

Return a specified number of Items from a service that represents a SQL Response. This provides an alternative way to access SQL Response Items to the operations (*GetSQLRowSet*, *GetSQLUpdateCount*, etc) for *SQLResponseAccess*. The Response Format for each Item is obtained from the associated *SQLResponseItem* property.

Input

- *GetSQLResponseItemRequest*
 - *StartPosition* – the position of the first SQL Response Item to be returned (First Item is position 1).
 - *Count* – the number of SQL Response Items.

Output

- *GetSQLResponseItemResponse*
 - *SQLResponseItem* – (+) – e.g. *SQLRowSet*, *SQLUpdateCount*, etc.

Faults

- *InvalidGetSQLResponseItemRequest* – XML syntax error or XML schema non-compliance.
- *InvalidStartPosition* – not a valid *StartPosition*; cannot start with SQL Response Item specified (out of bounds value).
- *InvalidCount* – not a valid *Count*; cannot return that number of Response Items.
- *OtherFault* – any other fault.

6.2.1.2 SQLResponseAccess::GetSQLRowSet

Get a *SQLRowSet* from the *GetSQLRowSetResponse*.

Input

- *GetSQLRowSetRequest*
 - *SQLRowSetNumber* – (1) – the number of the required *SQLRowSet*.

Output

- *GetSQLRowSetResponse*
 - *SQLRowSet* – (1) – the requested *SQLRowSet* e.g. *WebRowSet* see [JSR114].

Faults

- *InvalidGetSQLRowSetRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLRowSetNumber* – not a valid *SQLRowSetNumber*.
- *OtherFault* – any other fault.

6.2.1.3 SQLResponseAccess::GetSQLUpdateCount

Get a *SQLUpdateCount* from the *GetSQLUpdateCountResponse*.

Input

- *GetSQLUpdateCountRequest*
 - *SQLUpdateCountNumber* – (1) – the number of the required *SQLUpdateCount*.

Output

- *GetSQLUpdateCountResponse*
 - *SQLUpdateCount* – (1) – the requested *SQLUpdateCount*.

Faults

- *InvalidSQLUpdateCountRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLUpdateCountNumber* – not a valid *SQLUpdateCountNumber*.
- *OtherFault* – any other fault.

6.2.1.4 SQLResponseAccess::GetSQLReturnValue

Get a *SQLReturnValue* from the *GetSQLReturnValueResponse*.

Input

- *GetSQLReturnValueRequest*
 - *SQLReturnValueNumber* – (1) – the number of the required *SQLReturnValue*.

Output

- *GetSQLReturnValueResponse*
 - *SQLReturnValue* – (1) – the requested *SQLReturnValue*.

Faults

- *InvalidGetSQLReturnValueRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLReturnValueNumber* – not a valid *SQLReturnValueNumber*.
- *OtherFault* – any other fault.

6.2.1.5 SQLResponseAccess::GetSQLOutputParameter

Get a *SQLOutputParameter* from the *GetSQLOutputParameterResponse*.

Input

- *GetSQLOutputParameterRequest*
 - *SQLOutputParameterNumber* – (1) – the number of the required *SQLOutputParameter*.

Output

- *GetSQLOutputParameterResponse*
 - *SQLOutputParameter* – (1) – the requested *SQLOutputParameter*.

Faults

- *InvalidSQLOutputParameterRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLOutputParameterNumber* – not a valid *SQLOutputParameterNumber*.
- *OtherFault* – any other fault.

6.2.1.6 SQLResponseAccess::GetSQLCommunicationsArea

Get a *SQLCommunicationsArea* from the *GetSQLCommunicationsAreaResponse*.

Input

- *GetSQLCommunicationsAreaRequest*
 - *SQLCommunicationsAreaNumber* – (1) – the number of the required *SQLCommunicationsArea*.

Output

- *GetSQLCommunicationsAreaResponse*
 - *SQLCommunicationsArea* – (1) – the requested *SQLCommunicationsArea*.
 - *SQLState* – (+) – an XOPEN or SQL99 code identifying the Exception, Warning or Message.
 - *VendorCode* – (+) – a database vendor-specific code for the Exception, Warning or Message.
 - *MessageText* – (+) – a text description of the Exception, Warning or Message.

Faults

- *InvalidSQLCommunicationsAreaRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLCommunicationsAreaNumber* – not a valid *SQLCommunicationsAreaNumber*.
- *OtherFault* – any other fault.

6.3 SQLResponseFactory

The *SQLResponseFactory* is used to create a service representing a row set.

6.3.1 Overview

The example in Figure 3 presents a *SQLResponseFactory* interface. The *SQLExecuteFactory* operation is used to construct the derived *SQLResponse* Data Service; the *SQLResponseFactory* operation of which is in turn used to construct the derived *SQLRowSet* Data Service. This service provides access to tuples in the *SQLRowSet* resulting from a *SQLExpression* against the Relational Database.

6.3.2 Operations**6.3.2.1 SQLResponseFactory::SQLRowSetSelectionFactory**

Get a Reference to a *SQLRowSetAccess* from the *SQLRowSetSelectionFactoryResponse*.

Input

- *SQLRowSetSelectionFactoryRequest*
 - *PropertiesDocument* – (1) *DataAccessPropertyType* for target data service.
 - *SQLRowSetSelectionNumber* – (1) – the number of the required *SQLRowSet*.

Output

- *SQLRowSetSelectionFactoryResponse*
 - *Reference* – (1) – to *SQLRowSetAccess* operation which provides access to the requested *SQLRowSet*.

Faults

- *InvalidSQLRowSetSelectionFactoryRequest* – XML syntax error or XML schema non-compliance.
- *InvalidSQLRowSetSelectionNumber* – not a valid *SQLRowSetSelectionNumber*.
- *OtherFault* – any other fault.

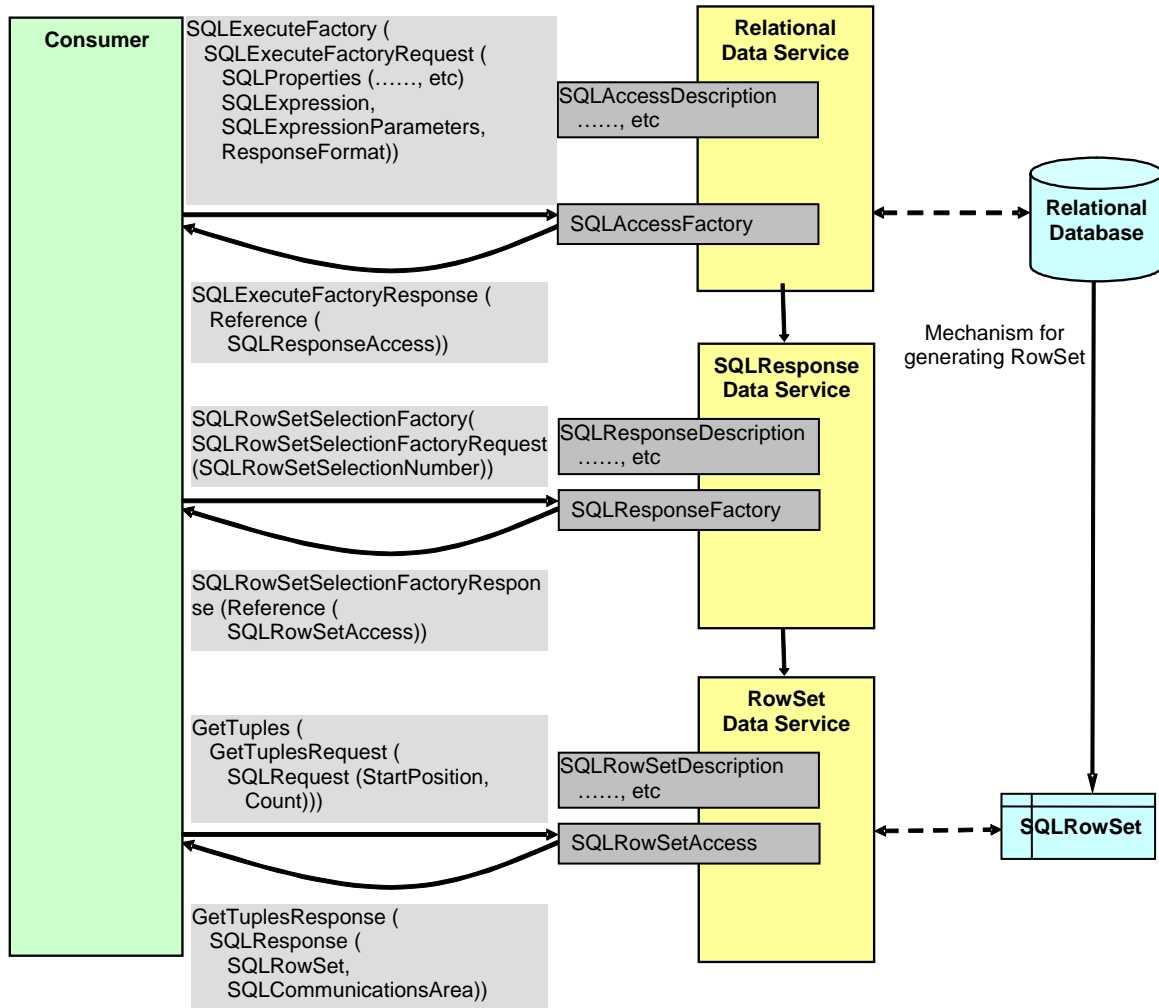


Figure 3 – Overview – SQLResponseFactory

7. SQLRowSet

7.1 SQLRowSet Description

7.1.1 AccessMode

```
<xsd:complexType name="AccessModeType">
  <xsd:sequence>
    <xsd:element name="Content" type="xsd:string" minOccurs="0"
      maxOccurs="unbounded" />
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="AccessMode" type="wsdair:AccessModeType" />
```

/wsdairs:AccessMode

Describes how the SQLRowSet can be navigated, for example sequentially in a forward direction; whether random access is allowed, etc. Possible values would be one or more from a set of values which will be implementation specific, for example ForwardSequential, RandomAccess. The "Content" element at the moment is purely acting as a temporary placeholder.

7.1.2 DataAccessibleOverTxnBoundary

```
<xsd:element name="DataAccessibleOverTxnBoundary" type="xsd:boolean" />
```

/wsdairs:DataAccessibleOverTxnBoundary

Describes whether the SQLRowSet can still be navigated after a transaction has been committed.

7.1.3 GetTuplesResponseTypeList

7.1.4 SQLRowSetSchema

```
<xsd:complexType name="SQLRowSetSchemaType">
  <xsd:sequence>
    <xsd:element ref="wrs:metadata" />
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="SQLRowSetSchema"
  type="wsdairs:SQLRowSetSchemaType" />
```

/wsdairs:SQLRowSetSchema

For example, WebRowSet, see [JSR114].

7.1.5 NumberOfRows

```
<xsd:element name="NumberOfRows" type="xsd:int" />
```

/wsdairs:NumberOfRows

The total number of rows in the result set.

7.2 SQLRowSetAccess

This allows access to the underlying data by means of rows.

7.2.1 Operations

7.2.1.1 SQLRowSetAccess::GetTuples

Return a specified number of tuples from a service that represents a result set.

Input

- *GetTuplesRequest*
 - *StartPosition* – the position of the first tuple to be returned (First tuple is position 1).
 - *Count* – the number of tuples.

Output

- *GetTuplesResponse*
 - *SQLRowSet* – (1) – e.g. WebRowSet see [JSR114].
 - *SQLCommunicationsArea* – (*)
 - *SQLState* – (+) – an XOPEN or SQL99 code identifying the Exception, Warning or Message.
 - *VendorCode* – (+) – a database vendor-specific code for the Exception, Warning or Message.
 - *MessageText* – (+) – a text description of the Exception, Warning or Message.

Faults

- *InvalidGetTuplesRequest* – XML syntax error or XML schema non-compliance.

- *InvalidStartPosition* – not a valid StartPosition; cannot start with tuple specified (out of bounds value).
- *InvalidCount* – not a valid Count; cannot return that number of tuples.
- *OtherFault* – any other fault.

8. Mapping to WSRF

For a mapping to the Web Services Resource Framework (WSRF) [WS-Resource] proposal see the following Sections:

- SQLAccess
 - WSDL Interfaces – Appendix A.1
 - XML Schema – Appendix A.2
 - WSDL – Appendix A.3
- SQLResponseAccess
 - WSDL Interfaces – Appendix B.1
 - XML Schema – Appendix B.2
 - WSDL – Appendix B.3
- SQLRowSetAccess
 - WSDL Interfaces – Appendix C.1
 - XML Schema – Appendix C.2
 - WSDL – Appendix C.3

9. Security Considerations

The relational realization of a Grid Data Service will use standard Grid Security mechanisms as specified by OGSA Security working group combined with standard ways of relating Grid credentials and authorities to resource access rights. The assumption is that these standards will also indicate how to make information related to authentication, authorization security etc available.

10. Conclusion

This document has discussed a specialization of the interfaces defined in the *Web Services Data Access and Integration* document [WS-DAI] and the additional capabilities required to properly address relational data resources. This is work in progress and feedback is welcomed on this document.

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Appendix A.1 – SQLAccess WSDL Interfaces

```
<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdair"
    targetNamespace="http://www.ggf.org/namespaces/2004/05/WS-DAIR"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:wsa="http://schemas.xmlsoap.org/ws/2004/03/addressing"
    xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR">

  <!-- WSDL IMPORTS ##### -->
    <wsdl:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
        location="./wsdair-types-0.3.wsdl" />

  <!-- WSDL INTERFACES ##### -->
    <wsdl:portType name="SQLDataService">

      <wsdl:operation name="SQLExecute">
        <wsdl:input message="wsdair:SQLExecuteRequest" />
        <wsdl:output message="wsdair:SQLExecuteResponse" />
      </wsdl:operation>

      <wsdl:operation name="SQLExecuteFactory">
        <wsdl:input message="wsdair:SQLExecuteFactoryRequest" />
        <wsdl:output message="wsdair:SQLExecuteFactoryResponse" />
      </wsdl:operation>

    </wsdl:portType>
</wsdl:definitions>
```

Appendix A.2 – SQLAccess XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR">

  <xsd:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
      schemaLocation="./wsdai-types-0.3.xsd" />
```

```
<!-- sql description -->
<!-- the following properties are examples only and are subject to change -->
<!-- the CGS working group is build models that describe the properties -->
<!-- that go here -->
  <xsd:complexType name="RelationalSchemaType">
    <xsd:sequence>
      <xsd:element name="Content" type="xsd:string"/>
      <!--Content will be determined from a collaboration with CIM -->
    </xsd:sequence>
  </xsd:complexType>

<xsd:element name="RelationalSchema" type="wsdair:RelationalSchemaType" />

  <xsd:complexType name="StoredProceduresListType">
    <xsd:sequence>
      <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>

<xsd:element name="StoredProcedures" type="wsdair:StoredProceduresListType" />

  <xsd:complexType name="UserDefinedTypesListType">
    <xsd:sequence>
      <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>

<xsd:element name="UserDefinedTypes" type="wsdair:UserDefinedTypesListType" />

  <xsd:complexType name="UserDefinedFunctionsListType">
    <xsd:sequence>
      <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>

<xsd:element name="UserDefinedFunctions" type="wsdair:UserDefinedFunctionsListType" />

  <xsd:complexType name="TriggersListType">
    <xsd:sequence>
      <xsd:element name="Content" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>
```

```

    <xsd:element name="Triggers" type="wsdair:TriggersListType" />

<xsd:simpleType name="LanguageCapabilitiesType">
  <xsd:union>
    <xsd:simpleType>
      <xsd:restriction base="xsd:token">
        <xsd:enumeration value="SQL92Expression"/>
        <xsd:enumeration value="SQL99Expression"/>
        <xsd:enumeration value="SQL03Expression"/>
        <xsd:enumeration value="SQL07Expression"/>
        <xsd:enumeration value="AstronomyDataQueryLanguage"/>
      </xsd:restriction>
    </xsd:simpleType>
    <xsd:simpleType>
      <xsd:restriction base="xsd:token"/>
    </xsd:simpleType>
  </xsd:union>
</xsd:simpleType>

<xsd:element name="LanguageCapabilities"
  type="wsdair:LanguageCapabilitiesType" />

<!-- sql access -->
<!-- the Behavioral Properties that control the behaviour of the sql access operations -->
<xsd:complexType name="SQLAccessBehavioralPropertiesType">
  <xsd:complexContent>
    <xsd:extension base="wsdai:DataAccessBehavioralPropertiesType">
      <xsd:sequence>
        <xsd:element name="LanguageCapabilities" ref="wsdair:LanguageCapabilities" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

  <xsd:element name="SQLAccessBehavioralProperties" type="wsdair:SQLAccessBehavioralPropertiesType"/>

  <!-- the Behavioral Properties document to be used when creating a -->
<xsd:complexType name="SQLAccessBehavioralPropertiesDocumentType">
  <xsd:complexContent>
    <xsd:restriction base="wsdai:BehavioralPropertiesDocumentType">
      <xsd:sequence>

```

```
<xsd:element name="PortType" >
  <xsd:simpleType>
    <xsd:restriction base="xsd:QName">
      <xsd:enumeration value="wsdair:SQLDataService"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
  <xsd:element name="BehavioralProperties"
type="wsdair:SQLAccessBehavioralPropertiesType"/>
</xsd:sequence>
</xsd:restriction>
</xsd:complexContent>

<xsd:element name="SQLAccessBehavioralPropertyDocument"
  type="wsdair:SQLAccessBehavioralPropertyDocumentType"
  substitutionGroup="wsdai:BehavioralPropertyDocument"/>

<!-- the list of response types validly returned by the sql execute operation -->
<xsd:element name="SQLExecuteResponseTypeList" type="wsdai:ResponseTypeListType"/>

<xsd:complexType name="SQLCommunicationsAreaType">
  <xsd:sequence>
    <xsd:element name="SQLState" type="xsd:string" />
    <xsd:element name="VendorCode" type="xsd:string" />
    <xsd:element name="MessageText" type="xsd:string" />
  </xsd:sequence>
</xsd:complexType>

  <xsd:element name="SQLCommunicationsArea" type="wsdair:SQLCommunicationsAreaType"/>

<!-- sql factory -->
  <!-- the list of Behavioral Properties constructs that are valid - this implies the service type -->
  <xsd:element name="SQLExecuteFactoryBehavioralPropertiesDocumentTypeList"
type="wsdai:BehavioralPropertiesDocumentTypeListType"/>

<!-- sql management -->
  <!-- TBD -->

</xsd:schema>
```


Appendix A.3 – SQLAccess WSDL

```
<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdair"
    targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:wrs="http://java.sun.com/xml/ns/jdbc"
    xmlns:wsa="http://schemas.xmlsoap.org/ws/2004/03/addressing"
    xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR">

  <!-- WSDL IMPORTS ##### -->

  <!-- WSDL TYPES ##### -->
    <xsd:schema targetNamespace="http://java.sun.com/xml/ns/jdbc"
        elementFormDefault="qualified">
      <xsd:include schemaLocation="./webrowset-jdbc150.xsd" />
    </xsd:schema>

    <xsd:schema targetNamespace="http://schemas.xmlsoap.org/ws/2004/03/addressing"
        elementFormDefault="qualified">
      <xsd:include schemaLocation="./wsa-0304.xsd" />
    </xsd:schema>

    <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
        elementFormDefault="qualified">
      <xsd:include schemaLocation="./wsdai-types-0.3.xsd" />
    </xsd:schema>

    <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
        elementFormDefault="qualified">
      <xsd:include schemaLocation="./wsdair-types-0.3.xsd" />

  <!-- ##### -->
  <!-- ### Common Message Types ### -->
  <!-- ##### -->

    <!-- general request types -->
    <xsd:complexType name="SQLExpressionParametersType">
      <xsd:sequence>
```

```

        <xsd:element name="Name" type="xsd:string" />
        <xsd:element name="Value" type="xsd:string"/>
        <xsd:element name="Type" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="SQLExpressionType">
<xsd:complexContent>
    <xsd:extension base="wsdai:ExpressionType">
        <xsd:sequence>
            <xsd:element name="Expression" type="xsd:string" minOccurs="1" maxOccurs="1"/>
            <xsd:element name="SQLExpressionParameters"
type="wsdair:SQLExpressionParametersType" minOccurs="0" maxOccurs="unbounded"/>
        </xsd:sequence>
    </xsd:extension>
</xsd:complexContent>

</xsd:complexType>

<xsd:element name="SQLExpression" type="wsdair:SQLExpressionType" abstract="true" />

<!-- general response types -->
<xsd:element name="SQLUpdateCount" type="xsd:int" />
<xsd:element name="SQLOutputParameter" type="xsd:string" />
<xsd:element name="SQLReturnValue" type="xsd:string" />

<xsd:complexType name="SQLDatasetType">
<xsd:complexContent>
    <xsd:extension base="wsdai:DatasetType">
        <xsd:sequence>
            <xsd:element ref="wrs:WebRowSet" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element ref="wsdair:SQLUpdateCount" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element ref="wsdair:SQLOutputParameter" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element ref="wsdair:SQLReturnValue" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element ref="wsdair:SQLCommunicationsArea" minOccurs="0" maxOccurs="unbounded"/>
        </xsd:sequence>
    </xsd:extension>
</xsd:complexContent>
</xsd:complexType>

<xsd:element name="SQLDataset" type="wsdair:SQLDatasetType" substitutionGroup="wsdai:Dataset"/>

```

```

<!-- ##### -->
<!-- ### sqlExecute Message Types ### -->
<!-- ##### -->

    <xsd:element name="SQLExecuteRequest">
        <xsd:complexType >
            <xsd:sequence>
                <xsd:element ref="wsdair:SQLExpression" minOccurs="1" maxOccurs="1"/>
                <xsd:element ref="wsdai:ResponseFormat" minOccurs="0" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <xsd:element name="SQLExecuteResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="wsdai:Dataset" minOccurs="1" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

<!-- ##### -->
<!-- ### sqlExecuteFactory Message Types ### -->
<!-- ##### -->
    <xsd:element name="SQLExecuteFactoryRequest">
        <xsd:complexType >
            <xsd:sequence>
                <xsd:element ref="wsdair:SQLExpression" minOccurs="1" maxOccurs="1"/>
                <xsd:element ref="wsdai:BehavioralPropertiesDocument" minOccurs="0"
maxOccurs="1" />
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <!-- assumes that these messages result in a service/resource that contains all of -->
    <!-- the possible responses from a SQL execute (rowset, count, value, parameter etc) -->
    <xsd:element name="SQLExecuteFactoryResponse">
        <xsd:complexType>

```

```

        <xsd:sequence>
            <xsd:element ref="wsa:EndPointReference" minOccurs="0" maxOccurs="1"/>
        </xsd:sequence>
    </xsd:complexType>
</xsd:element>

<!-- ##### -->
<!-- ### Resource Properties ### -->
<!-- ##### -->
    <xsd:element name="SQLAccessDescription">
        <xsd:complexType>
            <xsd:sequence>
                <!-- from wsdaï - data description - properties of the data resource -->
                <xsd:element ref="wsdaï:Name" minOccurs="0" maxOccurs="1" />
                <xsd:element ref="wsdaï:Description" minOccurs="0" maxOccurs="1"/>

                <!-- from wsdaïr - sql description - properties of the data resource -->

                <xsd:element ref="wsdaïr:RelationalSchema" minOccurs="1" maxOccurs="1" />
                <xsd:element ref="wsdaïr:StoredProcedures" minOccurs="1" maxOccurs="1" />
                <xsd:element ref="wsdaïr:UserDefinedTypes" minOccurs="1" maxOccurs="1" />
                <xsd:element ref="wsdaïr:UserDefinedFunctions" minOccurs="1" maxOccurs="1" />
                <xsd:element ref="wsdaïr:Triggers" minOccurs="1" maxOccurs="1" />

                <!-- from wsdaïr - sql access - properties controlling access behaviour -->
                <xsd:element ref="wsdaïr:SQLAccessBehavioralProperties" minOccurs="1" maxOccurs="1" />
            />

            <!-- from wsdaïr - sql access - properties controlling valid response formats -->
            <xsd:element ref="wsdaïr:SQLExecuteResponseTypeList" minOccurs="1" maxOccurs="1" />

            <!-- from wsdaïr - sql factory - properties controlling valid Behavioral
Properties document types-->
            <xsd:element ref="wsdaïr:SQLExecuteFactoryBehavioralPropertiesDocumentTypeList"
minOccurs="1" maxOccurs="1" />
        </xsd:sequence>
    </xsd:complexType>
</xsd:element>

</xsd:schema>

<!-- WSDL MESSAGES ##### -->

```

```

<!-- ##### -->
<!-- ### sqlExecute Messages ### -->
<!-- ##### -->
<message name="SQLExecuteRequest">
    <part name="SQLExecuteRequest" element="wsdair:SQLExecuteRequest" />
</message>

<message name="SQLExecuteResponse">
    <part name="SQLExecuteResponse" element="wsdair:SQLExecuteResponse" />
</message>

<!-- ##### -->
<!-- ### sqlExecuteFactory Messages ### -->
<!-- ##### -->
<message name="SQLExecuteFactoryRequest">
    <part name="SQLExecuteFactoryRequest" element="wsdair:SQLExecuteFactoryRequest" />
</message>

<message name="SQLExecuteFactoryResponse">
    <part name="SQLExecuteFactoryResponse" element="wsdair:SQLExecuteFactoryResponse" />
</message>

</wsdl:definitions>

```

Appendix B.1 – SQLResponseAccess WSDL Interfaces

```

<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdair"
    targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAISR"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
    xmlns:wsdairr="http://www.ggf.org/namespaces/2004/09/WS-DAISR">

<!-- WSDL IMPORTS ##### -->
    <wsdl:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAISR"
        location="./wsdairr-types-0.3.wsdl" />

```

```
<!-- WSDL INTERFACES ##### -->
  <wsdl:portType name="SQLResponseDataService">

    <wsdl:operation name="GetSQLResponseItem">
      <wsdl:input message="wsdairs:GetSQLResponseItemRequest" />
      <wsdl:output message="wsdairs:GetSQLResponseItemResponse" />
    </wsdl:operation>

    <wsdl:operation name="GetSQLRowSet">
      <wsdl:input message="wsdairs:GetSQLRowSetRequest" />
      <wsdl:output message="wsdairs:GetSQLRowSetResponse" />
    </wsdl:operation>

    <wsdl:operation name="SQLRowSetSelectionFactory">
      <wsdl:input message="wsdairs:SQLRowSetSelectionFactoryRequest" />
      <wsdl:output message="wsdairs:SQLRowSetSelectionFactoryResponse" />
    </wsdl:operation>

    <wsdl:operation name="GetSQLUpdateCount">
      <wsdl:input message="wsdairs:GetSQLUpdateCountRequest" />
      <wsdl:output message="wsdairs:GetSQLUpdateCountResponse" />
    </wsdl:operation>

    <wsdl:operation name="GetSQLReturnValue">
      <wsdl:input message="wsdairs:GetSQLReturnValueRequest" />
      <wsdl:output message="wsdairs:GetSQLReturnValueResponse" />
    </wsdl:operation>

    <wsdl:operation name="GetSQLOutputParameter">
      <wsdl:input message="wsdairs:GetSQLOutputParameterRequest" />
      <wsdl:output message="wsdairs:GetSQLOutputParameterResponse" />
    </wsdl:operation>

    <wsdl:operation name="GetSQLCommunicationsArea">
      <wsdl:input message="wsdairs:GetSQLCommunicationsAreaRequest" />
      <wsdl:output message="wsdairs:GetSQLCommunicationsAreaResponse" />
    </wsdl:operation>

  </wsdl:portType>
</wsdl:definitions>
```

Appendix B.2 – SQLResponseAccess XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAISR"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:wrs="http://java.sun.com/xml/ns/jdbc"
  xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
  xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAISR"

  <xsd:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    schemaLocation="./wsdai-types-0.3.xsd" />

  <!-- sql response description -->
  <xsd:complexType name="SQLResponseItemType">
    <xsd:sequence>
      <xsd:element name="SQLResponseItemSequenceNumber" type="xsd:int" />
      <xsd:element name="SQLResponseItemFormatType" type="xsd:string" />
    </xsd:sequence>
  </xsd:complexType>

  <xsd:element name="SQLResponseItem"
    type="wsdair:SQLResponseItemType"/>
  <xsd:element name="NumberOfSQLRowSets" type="xsd:int" />
  <xsd:element name="NumberOfSQLUpdateCounts" type="xsd:int" />
  <xsd:element name="NumberOfSQLReturnValues" type="xsd:int" />
  <xsd:element name="NumberOfSQLOutputParameters" type="xsd:int" />
  <xsd:element name="NumberOfSQLCommunicationsAreas" type="xsd:int" />

  <!-- sql response access -->

  <xsd:complexType name="SQLResponseAccessBehavioralPropertiesType">
    <xsd:complexContent>
      <xsd:extension base="wsdai:DataAccessBehavioralPropertiesType">
        <xsd:sequence>
          <xsd:element ref="TBD" minOccurs="1" maxOccurs="1"/>
        </xsd:sequence>
      </xsd:extension>
    </xsd:complexContent>
  </xsd:complexType>

  <xsd:element name="SQLResponseAccessBehavioralProperties"
type="SQLResponseAccessBehavioralPropertiesType"/>
```

```

<xsd:complexType name="SQLResponseAccessBehavioralPropertiesDocumentType">
  <xsd:complexContent>
    <xsd:restriction base="wsdai:BehavioralPropertiesDocumentType">
      <xsd:sequence>
        <xsd:element name="PortType" >
          <xsd:simpleType>
            <xsd:restriction base="xsd:QName">
              <xsd:enumeration value="wsdair:SQLResponseDataService"/>
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="BehavioralProperties"
type="wsdair:SQLResponseAccessBehavioralPropertiesType"/>
      </xsd:sequence>
    </xsd:restriction>
  </xsd:complexContent>
</xsd:complexType>

  <xsd:element name="SQLResponseAccessBehavioralPropertiesDocument"
<!-- sql response management -->

</xsd:schema>

```

Appendix B.3 – SQLResponseAccess WSDL

```

<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdair"
  targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAISR"
  xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
  xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
  xmlns:wsdairs="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
  xmlns:wsdaisr="http://www.ggf.org/namespaces/2004/09/WS-DAISR">

<!-- WSDL IMPORTS ##### -->

<!-- WSDL TYPES ##### -->
  <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
    elementFormDefault="qualified">

```



```

        <xsd:include schemaLocation="./wsdai-types-0.3.xsd" />
    </xsd:schema>

    <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
        elementFormDefault="qualified">
        <xsd:include schemaLocation="./wsdair-types-0.3.xsd" />
    </xsd:schema>

    <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
        elementFormDefault="qualified">
        <xsd:include schemaLocation="./wsdairs-types-0.3.xsd" />

    <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAISR"
        elementFormDefault="qualified">
        <xsd:include schemaLocation="./wsdaisr-types-0.3.xsd" />

    <!-- ##### -->
    <!-- ### Common Message Types ### -->
    <!-- ##### -->
    <xsd:complexType name="SQLRowSetDatasetType">
        <xsd:complexContent>
            <xsd:extension base="wsdai:DatasetType">
                <xsd:sequence>
                    <xsd:element ref="wrs:WebRowSet" minOccurs="0" maxOccurs="unbounded"/>
                </xsd:sequence>
            </xsd:extension>
        </xsd:complexContent>
    </xsd:complexType>

    <!-- ##### -->
    <!-- ### GetSQLResponseItem Message Types ### -->
    <!-- ##### -->
        <xsd:element name="GetSQLResponseItemRequest">
            <xsd:complexType >
                <xsd:sequence>
                    <xsd:element name="StartPosition" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
                    <xsd:element name="Count" type="xsd:int" minOccurs="1" maxOccurs="1"/>
                    <xsd:element ref="wsdai:ResponseFormat" minOccurs="0" maxOccurs="1"/>

                </xsd:sequence>
            </xsd:complexType>

```

```

    </xsd:element>

    <xsd:element name="GetSQLResponseItemResponse">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element ref="wsdai:Dataset" minOccurs="1" maxOccurs="1"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>

<!-- ##### -->
<!-- ### GetSQLRowSet Message Types ### -->
<!-- ##### -->
    <xsd:element name="GetSQLRowSetRequest">
      <xsd:complexType >
        <xsd:sequence>
          <xsd:element name="SQLRowSetNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
          <xsd:element ref="wsdai:ResponseFormat" minOccurs="0" maxOccurs="1"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetSQLRowSetResponse">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element ref="wsdai:Dataset" minOccurs="1" maxOccurs="1"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>

<!-- ##### -->
<!-- ### SQLRowSetSelectionFactory Message Types ### -->
<!-- ##### -->
    <xsd:element name="SQLRowSetSelectionFactoryRequest">
      <xsd:complexType >
        <xsd:sequence>
          <xsd:element name="SQLRowSetNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
          <xsd:element ref="wsdai:BehavioralPropertiesDocument" minOccurs="0"
maxOccurs="1" />

```

```

        </xsd:sequence>
    </xsd:complexType>
</xsd:element>

<xsd:element name="SQLRowSetSelectionFactoryResponse">
    <xsd:complexType>
        <xsd:sequence>
            <xsd:element ref="wsa:EndPointReference" minOccurs="0" maxOccurs="1"/>
        </xsd:sequence>
    </xsd:complexType>
</xsd:element>

<!-- ##### -->
<!-- ### GetSQLUpdateCount Message Types ### -->
<!-- ##### -->
    <xsd:element name="GetSQLUpdateCountRequest">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element name="SQLUpdateCountNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetSQLUpdateCountResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element name="SQLUpdateCount" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <!-- ##### -->
    <!-- ### GetSQLReturnValue Message Types ### -->
    <!-- ##### -->
        <xsd:element name="GetSQLReturnValueRequest">
            <xsd:complexType>
                <xsd:sequence>
                    <xsd:element name="SQLReturnValueNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
                </xsd:sequence>
            </xsd:complexType>
        </xsd:element>

```

```

        </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetSQLReturnValueResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element name="SQLReturnValue" type="string" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <!-- ##### -->
    <!-- ### GetSQLOutputParameter Message Types ### -->
    <!-- ##### -->
    <xsd:element name="GetSQLOutputParameterRequest">
        <xsd:complexType >
            <xsd:sequence>
                <xsd:element name="SQLOutputParameterNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetSQLOutputParameterResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element name="SQLOutputParameter" type="string" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <!-- ##### -->
    <!-- ### GetSQLCommunicationsArea Message Types ### -->
    <!-- ##### -->
    <xsd:element name="GetSQLCommunicationsAreaRequest">
        <xsd:complexType >
            <xsd:sequence>
                <xsd:element name="SQLCommunicationsAreaNumber" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
            </xsd:sequence>

```

```

        </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetSQLCommunicationsAreaResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="wsdair:SQLCommunicationsArea" minOccurs="1" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <!-- ##### -->
    <!-- ### Resource Properties          ### -->
    <!-- ##### -->
        <xsd:element name="SQLResponseDescription">
            <xsd:complexType>
                <xsd:sequence>
                    <!-- from ws dai - data description - properties of the data resource -->
                    <xsd:element ref="wsdai:Name" minOccurs="0" maxOccurs="1" />
                    <xsd:element ref="wsdai:Description" minOccurs="0" maxOccurs="1"/>

                    <!-- from ws dairs - sql response description - properties of the data resource -->
                    <xsd:element ref="wsdairs:NumberOfSQLRowSets" minOccurs="1" maxOccurs="1"/>
                    <xsd:element ref="wsdairs:NumberOfSQLUpdateCounts" minOccurs="1" maxOccurs="1"/>

                    <xsd:element ref="wsdairs:NumberOfSQLReturnValues" minOccurs="1" maxOccurs="1"/>
                    <xsd:element ref="wsdairs:NumberOfSQLOutputParameters" minOccurs="1" maxOccurs="1"/>
                    <xsd:element ref="wsdairs:NumberOfSQLCommunicationsAreas" minOccurs="1"
maxOccurs="1"/>

                    <!-- from ws dairs - sql response access - properties controlling access behaviour -->
                    <xsd:element ref="wsdairs:SQLResponseAccessBehavioralProperties" minOccurs="1"
maxOccurs="1"/>

                    <!-- from ws dairs - sql response access - properties controlling valid response
formats -->
                    <xsd:element ref="wsdairs:SQLRowSetSelectionFactoryResponseTypeList" minOccurs="1"
maxOccurs="1" />
                </xsd:sequence>
            </xsd:complexType>
        </xsd:element>
    </xsd:sequence>
</xsd:complexType>
</xsd:element>

```

```

        </xsd:element>

    </xsd:schema>

<!-- WSDL MESSAGES ##### -->

    <!-- ##### -->
    <!-- ### GetSQLRowSet Messages ### -->
    <!-- ##### -->
    <message name="GetSQLRowSetRequest">
        <part name="GetSQLRowSetRequest" element="wsdair:GetSQLRowSetRequest" />
    </message>

    <message name="GetSQLRowSetResponse">
        <part name="GetSQLRowSetResponse" element="wsdair:GetSQLRowSetResponse" />
    </message>

    <!-- ##### -->
    <!-- ### SQLRowSetSelectionFactory Messages ### -->
    <!-- ##### -->
    <message name="SQLRowSetSelectionFactoryRequest">
        <part name="SQLRowSetSelectionFactoryRequest"
element="wsdair:SQLRowSetSelectionFactoryRequest" />
    </message>

    <message name="SQLRowSetSelectionFactoryResponse">
        <part name="SQLRowSetSelectionFactoryResponse"
element="wsdair:SQLRowSetSelectionFactoryResponse" />
    </message>

    <!-- ##### -->
    <!-- ### GetSQLUpdateCount Messages ### -->
    <!-- ##### -->
    <message name="GetSQLUpdateCountRequest">
        <part name="GetSQLUpdateCountRequest" element="wsdair:GetSQLUpdateCountRequest" />
    </message>

    <message name="GetSQLUpdateCountResponse">
        <part name="GetSQLUpdateCountResponse" element="wsdair:GetSQLUpdateCountResponse" />
    </message>

<!-- ##### -->

```

```

<!-- ### GetSQLReturnValue Messages   ### -->
<!-- ##### -->
<message name="GetSQLReturnValueRequest">
    <part name="GetSQLReturnValueRequest" element="wsdairs:GetSQLReturnValueRequest" />
</message>

<message name="GetSQLReturnValueResponse">
    <part name="GetSQLReturnValueResponse" element="wsdairs:GetSQLReturnValueResponse" />
</message>

<!-- ##### -->
<!-- ### GetSQLOutputParameter Messages   ### -->
<!-- ##### -->
<message name="GetSQLOutputParameterRequest">
    <part name="GetSQLOutputParameterRequest" element="wsdairs:GetSQLOutputParameterRequest" />
</message>

<message name="GetSQLOutputParameterResponse">
    <part name="GetSQLOutputParameterResponse" element="wsdairs:GetSQLOutputParameterResponse" />
</message>

<!-- ##### -->
<!-- ### GetSQLCommunicationsArea Messages   ### -->
<!-- ##### -->
<message name="GetSQLCommunicationsAreaRequest">
    <part name="GetSQLCommunicationsAreaRequest" element="wsdairs:GetSQLCommunicationsAreaRequest"
/>
</message>

<message name="GetSQLCommunicationsAreaResponse">
    <part name="GetSQLCommunicationsAreaResponse"
element="wsdairs:GetSQLCommunicationsAreaResponse" />
</message>

</wsdl:definitions>

```

Appendix C.1 – SQLRowSetAccess WSDL Interfaces

```

<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdairs"
    targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"

```

```

        xmlns:xsd="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
        xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
        xmlns:wsdairs="http://www.ggf.org/namespaces/2004/09/WS-DAIRS">

<!-- WSDL IMPORTS ##### -->
    <wsdl:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
        location="./wsdairs-types-0.3.wsdl" />

<!-- WSDL INTERFACES ##### -->
    <wsdl:portType name="SQLRowSetDataService">

        <wsdl:operation name="GetTuples">
            <wsdl:input message="wsdairs:GetTuplesRequest" />
            <wsdl:output message="wsdairs:GetTuplesResponse" />
        </wsdl:operation>

    </wsdl:portType>

</wsdl:definitions>

```

Appendix C.2 – SQLRowSetAccess XML Schema

```

<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:wrs="http://java.sun.com/xml/ns/jdbc"
    xmlns:wsdai="http://www.ggf.org/namespaces/2004/05/WS-DAI"
    xmlns:wsdairs="http://www.ggf.org/namespaces/2004/09/WS-DAIRS">

    <xsd:import namespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
        schemaLocation="./wsdai-types-0.3.xsd" />

<!-- SQLRowSet description -->
    <xsd:complexType name="SQLRowSetSchemaType">
        <xsd:sequence>
            <xsd:element ref="wrs:metadata"/>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:element name="SQLRowSetSchema" type="wsdairs:SQLRowSetSchemaType" />

    <xsd:element name="NumberOfRows" type="xsd:int" />

```



```

<!-- SQLRowSet access -->
<xsd:complexType name="AccessModeType">
  <xsd:sequence>
    <xsd:element name="Content" type="xsd:string" minOccurs="0"
      maxOccurs="unbounded" />
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="AccessMode" type="wsdair:AccessModeType" />

<xsd:element name="DataAccessibleOverTxnBoundary" type="xsd:boolean" />

<xsd:complexType name="SQLRowSetAccessBehavioralPropertiesType">
  <xsd:complexContent>
    <xsd:extension base="wsdai:DataAccessBehavioralPropertiesType">
      <xsd:sequence>
        <xsd:element ref="wsdairs:AccessMode" minOccurs="1" maxOccurs="1"/>
        <xsd:element ref="wsdairs:DataAccessibleOverTxnBoundary" minOccurs="1" maxOccurs="1"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:element name="SQLRowSetAccessBehavioralProperties" type="SQLRowSetAccessBehavioralPropertiesType"/>

<xsd:complexType name="SQLRowSetAccessBehavioralPropertiesDocumentType">
  <xsd:complexContent>
    <xsd:restriction base="wsdai:BehavioralPropertiesDocumentType">
      <xsd:sequence>
        <xsd:element name="PortType" >
          <xsd:simpleType>
            <xsd:restriction base="xsd:QName">
              <xsd:enumeration value="wsdairs:SQLRowSetDataService"/>
            </xsd:restriction>
          </xsd:simpleType>
        </xsd:element>
        <xsd:element name="BehavioralProperties"
type="wsdairs:SQLRowSetAccessBehavioralPropertiesType"/>
      </xsd:sequence>
    </xsd:restriction>
  </xsd:complexContent>

```

```

</xsd:complexType>

<xsd:element name="SQLRowSetAccessBehavioralPropertiesDocument"
             type="wsdairs:SQLRowSetAccessBehavioralPropertiesDocumentType"
             substitutionGroup="wsdai:BehavioralPropertiesDocument"/>

<!-- the list of response types validly returned by the get tuples operation -->
<xsd:element name="GetTuplesResponseTypeList" type="wsdai:ResponseTypeListType"/>

<!-- SQLRowSet factory -->

<!-- SQLRowSet management -->

</xsd:schema>

```

Appendix C.3 – SQLRowSetAccess WSDL

```

<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="wsdairs"
                  targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAIRS"
                  xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
                  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                  xmlns:wsdai="http://www.ggf.org/namespaces/2004/09/WS-DAI"
                  xmlns:wsdair="http://www.ggf.org/namespaces/2004/09/WS-DAIR"
                  xmlns:wsdairs="http://www.ggf.org/namespaces/2004/09/WS-DAIRS">

<!-- WSDL IMPORTS ##### -->

<!-- WSDL TYPES ##### -->
  <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/09/WS-DAI"
              elementFormDefault="qualified">
    <xsd:include schemaLocation="./wsdai-types-0.3.xsd" />
  </xsd:schema>

  <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/05/WS-DAIR"
              elementFormDefault="qualified">
    <xsd:include schemaLocation="./wsdair-types-0.3.xsd" />
  </xsd:schema>

  <xsd:schema targetNamespace="http://www.ggf.org/namespaces/2004/05/WS-DAIRS"
              elementFormDefault="qualified">

```

```

    <xsd:include schemaLocation="./wsdairs-types-0.3.xsd" />

<!-- ##### -->
<!-- ### Common Message Types ### -->
<!-- ##### -->

<!-- ##### -->
<!-- ### GetTuples Message Types ### -->
<!-- ##### -->
    <xsd:element name="GetTuplesRequest">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element name="StartPosition" type="xsd:int" minOccurs="1"
maxOccurs="1"/>
                <xsd:element name="Count" type="xsd:int" minOccurs="1" maxOccurs="1"/>
                <xsd:element ref="wsdai:ResponseFormat" minOccurs="0" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

    <xsd:element name="GetTuplesResponse">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="wsdai:Dataset" minOccurs="1" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

<!-- ##### -->
<!-- ### Resource Properties ### -->
<!-- ##### -->
    <xsd:element name="SQLRowSetDescription">
        <xsd:complexType>
            <xsd:sequence>
                <!-- from wsda - data description - properties of the data resource -->
                <xsd:element ref="wsdai:Name" minOccurs="0" maxOccurs="1" />
                <xsd:element ref="wsdai:Description" minOccurs="0" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>

```

```

        <!-- from wsdairst - SQLRowSet description - properties of the data resource -->

        <xsd:element ref="wsdairst:RowsSchema" minOccurs="1" maxOccurs="1"/>
        <xsd:element ref="wsdairst:NumberOfRows" minOccurs="1" maxOccurs="1" />

        <!-- from wsdairst - SQLRowSet access - properties controlling access behaviour -->
        <xsd:element ref="wsdairst:SQLRowSetAccessBehavioralProperties" minOccurs="1"
maxOccurs="1"/>

        <!-- from wsdairst - SQLRowSet access - properties controlling valid response formats
-->
        <xsd:element ref="wsdairst:GetTuplesResponseTypeList" minOccurs="1" maxOccurs="1" />
        </xsd:sequence>
        </xsd:complexType>
        </xsd:element>

    </xsd:schema>

<!-- WSDL MESSAGES ##### -->

    <!-- ##### -->
    <!-- ### GetTuples Messages ### -->
    <!-- ##### -->
    <message name="GetTuplesRequest">
        <part name="GetTuplesRequest" element="wsdairst:GetTuplesRequest" />
    </message>

    <message name="GetTuplesResponse">
        <part name="GetTuplesResponse" element="wsdairst:GetTuplesResponse" />
    </message>

</wsdl:definitions>

```