

Technologies de l'information — Accès à la base de données à distance pour SQL avec sécurité accrue

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 9579 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

This second edition cancels and replaces the first edition (ISO 9579:1999), which has been technically revised.

Annexes A to E and G form a normative part of this International Standard. Annexes F, H and I are for information only.

Introduction

Remote Database Access for SQL (RDA/SQL) International Standard is a member of a set of International Standards produced to facilitate the interworking of computer systems. This International Standard conforms to the model defined in ISO/IEC 10032, *Information technology – Reference Model of Data Management*.

Remote Database Access for SQL can be used to provide remote data access to a database management system conforming to ISO/IEC 9075 (Database Language SQL).

The goal of Remote Database Access for SQL is to allow, with a minimum of technical agreement outside this International Standard, the interconnection of applications and database systems:

- from different manufacturers,
- under different managements,
- of different levels of complexity,
- exploiting different technologies.

An application may itself be a database system and therefore this International Standard can be used to support multi-database system interworking.

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Information technology — Remote database access for SQL with security enhancement

1 Scope

This International Standard, Remote Database Access for SQL (RDA), defines a model for the remote interaction of an SQL-client and one or more SQL-servers through communication media, and defines the encoding of messages, the semantics of messages and associated facilities for mediating the interaction between one SQL-client and one SQL-server.

This International Standard also defines a mapping of the RDA Protocol to the specific communication infrastructures TCP/IP and Transport Layer Security (TLS).

This International Standard relies upon the facilities provided by ISO/IEC 9075 (SQL) and ISO/IEC 9075-3 (SQL/CLI).

This International Standard also:

- identifies potential security vulnerabilities in remote database access using RDA,
- defines RDA facilities which protect against the potential vulnerabilities.

Normative annexes provide:

- a Conformance Proforma,
- an optional language independent Application Programming Interface defined in the notational conventions of ISO/IEC 9075-3 (SQL/CLI) for invoking RDA Operations,
- an optional mapping of ISO/IEC 9075-3 (SQL/CLI) functions to RDA Operations,
- definitions of optional SQL-servers, the RDA Location Server and the RDA Support Server, to facilitate interoperation and data distribution in a heterogeneous environment,
- a set of security profiles that identify which RDA facilities and other security facilities are required for different levels of protection against potential vulnerabilities.

Informative annexes provide:

- an analysis of security service requirements,
- an ASN.1 specification for the RDA Protocol,
- an ASN.1 specification for the encoding of multiple rows.

This International Standard does not constrain:

- conforming RDA-client environments to be implemented using any particular processor decomposition,
- conforming RDA-server environments to be implemented using any particular processor decomposition.

This International Standard refers to but does not define:

- protocols and security mechanisms for communication confidentiality, integrity and authentication of communicating peers,
- digital signature and authentication mechanisms supported by protocol elements of RDA.

This International Standard does not define:

- algorithms for query decomposition or for the combining of results in a distributed database environment,
- mechanisms for recovery in the event that transaction co-ordination fails,
- mechanisms for storage integrity and confidentiality using cryptography,
- mechanisms to counter Denial of Service attacks.

2 Remote Database Access for SQL (RDA/SQL)

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1 International Standards

- ISO/IEC 8824-1:1995 *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*
- ISO/IEC 8825-1:1995 *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*
- ISO/IEC 8825-2:1996 *Information technology – ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)*
- ISO/IEC 7498-2:1989 *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 2: Security Architecture*
- ISO/IEC 9075:1992 *Information technology – Database Languages SQL*
- ISO/IEC 9075-3:1995 *Information technology – Database Languages SQL – Part 3: Call Level Interface*
- ISO/IEC 9075-4:1996 *Information technology – Database Languages SQL – Part 4: Persistent Stored Modules*
- ISO/IEC 9594-8:1995 | ITU-T Recommendation X.509
Information technology – Open Systems Interconnection – The Directory: Authentication Framework.
- ISO/IEC 10032:1995 *Information technology – Reference Model of Data Management*
- ISO/IEC 10646-1:1993 *Information technology – Universal Multiple-Octet Coded Character Set (UCS) – Part 1: Architecture and Basic Multilingual Plane*

2.2 Internet Engineering Task Force

- RFC 791 *Internet Protocol*
- RFC 793 *Transmission Control Protocol*
- RFC 819 *The Domain Naming Convention for Internet User Applications*
- RFC 1122 *Requirements for Internet Hosts – Communication Layers*
- RFC 1123 *Requirements for Internet Hosts – Application and Support*
- RFC 2246 *The TLS Protocol*

Internet Engineering Task Force standards may be obtained in electronic form from the InterNIC Directory and Database Services at <http://www.internic.net> and <ftp://ftp.internic.net>.

2.3 Institute of Electrical and Electronics Engineers

IEEE 754-1985 *Standard for Binary Floating-Point Arithmetic*

Institute of Electrical and Electronic Engineers (IEEE) standards may be obtained from *IEEE Customer Service*, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA or ordered electronically from <http://www.ieee.org>.

4 Remote Database Access for SQL (RDA/SQL)

3 Interoperability

This clause defines the compatibility of RDA-client or RDA-server implementations of the Operations and Protocol defined by this edition of this International Standard with RDA-server or RDA-client implementations respectively of the Operations and Protocol defined by this and other editions of this International Standard.

3.1 Interoperability between implementations

An RDA-client or RDA-server implementation that conforms to this International Standard will interoperate with any other RDA-server or RDA-client that conforms to this International Standard provided that the implementations use the same Transport Mapping.

Any cryptographic algorithms and authentication mechanisms must be common to both the RDA-client and RDA-server if they are to interoperate.

NOTE 1 – Cryptographic algorithms are not defined by this International Standard.

NOTE 2 – There are circumstances under which the RDA Protocol and RDA Operations defined by this International Standard require that RDA Messages between interoperating implementations are rejected. These circumstances include the failure to satisfy authentication requirements and the use by one implementation of an encoding that is not supported by the other (the Default Encoding is always supported).

3.2 Interoperability with conforming OSI implementations

An earlier (three part) version of this International Standard published in 1997, now superceded, maps the Service and Protocol to an OSI transport provider. This edition of this International Standard maps the RDA Protocol to a TCP/IP transport provider. Implementations conforming to the obsolete International Standard can therefore co-exist with implementations conforming to this International Standard but cannot directly interoperate.

3.3 Interoperability with future editions

Features have been included in this version of the Protocol to permit server implementations to detect which version of the protocol a client has implemented and to behave appropriately.

Future editions of this International Standard will be compatible with this edition to the extent that:

- RDA Operations and Protocol defined by this edition will be retained in future editions using the same encodings.
- Changes to the Operations, Protocols and encodings in future editions will be extensions that are recognised by implementations of this edition and discarded after raising an exception.

4.1 Definitions

4 Definitions, Conventions and Notations

4.1 Definitions

For the purposes of this International Standard, the definitions given in ISO/IEC 9075 (SQL) and ISO/IEC 9075-3 (SQL/CLI) and the following definitions apply.

The following terms are defined in RFC 791, RFC 793, RFC 819, RFC 1122, RFC 1123:

- IP Address,
- Local Socket,
- Foreign Socket,
- Port Number,
- Push.

The following terms are defined in ISO/IEC 7498-2:

- Access Control,
- Authentication,
- Confidentiality,
- Integrity,
- Non-repudiation.

The following terms are defined in ISO/IEC 9594-8:1997 | ITU-T X.509 (1997):

- Attribute Certificate,
- Public Key Certificate.

The following term is defined in ISO/IEC 10032:

- Distribution Controller.

In addition, the following definitions apply:

RDA Message: a protocol element as defined by this International Standard exchanged between an RDA-client and an RDA-server.

RDA Operation: a facility that is accessible remotely provided by an RDA-server, together with the means of invoking the facility through a protocol, the encoding of parameters that influence or result from an invocation of the facility, and rules governing the invocation of the facility.

RDA Programming Interface: a language independent Application Programming Interface defined in the notational conventions of ISO/IEC 9075-3 (SQL/CLI) for invoking RDA Operations.

RDA Protocol: the set of permissible exchanges of requests and responses between an RDA-client and an RDA-server, together with the encoding of the exchange, and rules governing the exchange.

RDA Relay: a system that receives RDA protocol elements as defined in this International Standard for the purpose of forwarding them to the intended recipient.

6 Remote Database Access for SQL (RDA/SQL)

4.2 Conventions

4.2.1 Convention for Figures

The convention used for figures is that defined in the Reference Model of Data Management, ISO/IEC 10032.

4.2.2 Naming of Concepts

Where a concept has been defined in ISO/IEC 9075 (SQL) and used in this International Standard, the name used in ISO/IEC 9075 (SQL) is used for that concept.

Concepts whose name begins with 'RDA-' are defined in this International Standard.

4.2.3 Naming of Parameters

The same identifier is used to designate both an RDA/API routine parameter and an RDA Protocol or Operation parameter where the items are semantically equivalent.

NOTE 3 — For data values of type other than RDAOctetString the encoding of this value may differ between the parameter in the RDA-client environment, the parameter in the protocol and the parameter in the RDA-server environment. This may be due to, for example, architecture, precision or language differences between the client and the server system.

Where there is a parameter in an SQL/CLI function which corresponds to an RDA Operation parameter or an RDA/API parameter, and the SQL/CLI parameter is semantically equivalent to the RDA parameter, the SQL/CLI parameter name is used.

Whether an identifier designates an SQL/CLI parameter, RDA/API client parameter, protocol parameter or RDA/API parameter is determined by the context.

4.2.4 Specification of RDA Protocol, RDA Operations and RDA encoding elements

The definition of each RDA protocol element, RDA Operation element or Encoding component has up to four parts

- *function*, a short statement of the purpose of the element,
- *encoding*, the syntax for the encoding of the element in terms of RDA Protocol or RDA Operation parameters,
- *parameters*, a definition of the RDA Protocol parameters or RDA Operation parameters for the element,
- *rules*, a sequence of Protocol Rules or Operation Rules for the element to be evaluated within the RDA-client environment or the RDA-server environment as indicated.

4.2.5 Evaluation of Rules

Rules are used:

- to specify RDA Protocol Rules,
- to specify RDA Operation Rules.

4.2 Conventions

When Rules are evaluated, the required effect is that which would be obtained by beginning with the first Rule and evaluating the rules in numerical sequence until a rule is evaluated that specifies or implies either a change in sequence or termination of the evaluation of the Rules. Unless otherwise specified or implied by a specific Rule that is evaluated, evaluation of Rules terminates when the last in a sequence has been evaluated.

Evaluation of a sequence of Rules *R1* may involve the evaluation of another sequence of Rules *R2* referred to in *R1*. Termination of *R2* does not of itself terminate the evaluation of *R1*.

If the evaluation of a sequence of Rules causes an exception to be raised, evaluation of the sequence of Rules causing the exception is terminated after raising the exception.

If the evaluation of a Rule *R* results in the evaluation of a sequence of General Rules of ISO/IEC 9075-3 (SQL/CLI) then that sequence of General Rules is evaluated in the manner defined by ISO/IEC 9075-3 (SQL/CLI). If such evaluation causes an exception to be raised, then the exception is deemed to have been raised by *R*.

8 Remote Database Access for SQL (RDA/SQL)

4.3 Notations

4.3.1 SQL/CLI functions

An SQL/CLI function *X* defined in ISO/IEC 9075-3 (SQL/CLI) is referred to in this International Standard as SQL*X*. This notation makes no assumption as to whether the function is a “by value” function or a “by reference” function.

4.3.2 Implicit encoding definitions

For each definition of an encoding with identifier *X*, an additional definition is implied for an encoding *XL*ist defined as SEQUENCE OF *X*.

4.3.3 Encoding Attributes

For the purposes of this document, each encoded item, whether basic or compound, is deemed to have the following attributes which can be derived from the encoding or from the RDA encoding syntax:

Encoded Length: the length in octets of an encoding, including any octets that specify length.

Encoded Type: the type of an encoding.

Encoded Value: the value encoded.

Furthermore, certain encoded items have the following additional attributes that can be derived from the encoding:

Encoded Character Length: the length in characters of an encoding of a value of type RDAStrCharString.

Encoded Count: the number of items in a SEQUENCE OF encoding.

4.3.4 Notation for encoding syntax

The notation for defining encoding syntax is ASN.1 Basic Notation as defined in ISO/IEC 8824-1.

5 Model and Facilities

5.1 Model

ISO/IEC 9075 (SQL) defines an SQL-environment, SQL-client and SQL-server. This International Standard (RDA) defines how an SQL-client and SQL-servers interact when supported by an underlying communication system. Concrete definitions for some aspects of the SQL model and some SQL concepts are given to the extent that is required for remote, heterogeneous, interoperation of an SQL-client and an SQL-server using the facilities defined by this International Standard, RDA.

The model adds the following key concepts: *RDA-client*, *RDA-server*, *Transport Provider*, and *Transport Connection*. Subsequent subclauses of this clause define each of these concepts.

Figure 1 provides a representation of the interrelationship of these components and related SQL terms.

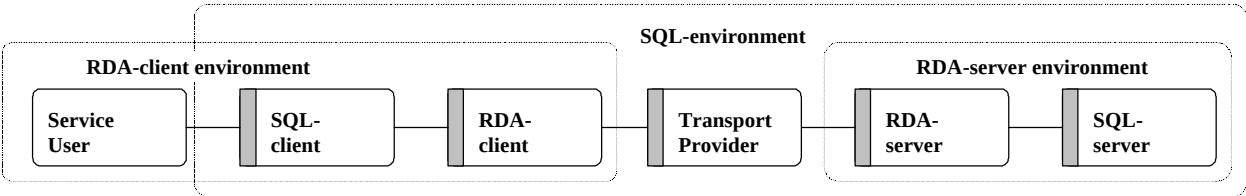


Figure 1 – RDA model of SQL-environment

The model adopted by this International Standard is that an RDA-client environment, which includes a Service User and an SQL-client, uses one or more Transport Providers to connect to RDA-server environments, each of which has one or more SQL-servers associated with it thereby establishing SQL-sessions between the SQL-client and the SQL-servers. Each SQL-session is associated with an SQL-connection. These are in turn supported by Transport Connections within Transport Providers that are established and terminated as required for communicating through the SQL-connection. More than one Transport Provider may be used concurrently to support concurrent SQL-sessions. A particular SQL-server may be in more than one RDA-server environment so the particular Transport Provider used to support a session between an SQL-client and a particular SQL-server may differ between SQL-sessions.

5.2 The RDA-client environment

The RDA-client environment is described with reference to five functional components: a *Service User*, *SQL-client Services* which establish connections with SQL-servers and co-ordinate operations involving more than one SQL-server, *RDA-client Services* which provide the client end of the RDA Protocol and the RDA Operations, a *Transport Mapping* that interfaces to a communications infrastructure and an optional *RDA Location Server* that facilitates control of distributed data. How these five functional components interrelate is depicted in Figure 2.

NOTE 4 – An implementation containing a conforming RDA-client need not materialise the five different components corresponding to these five functional components nor their intermediate interfaces.

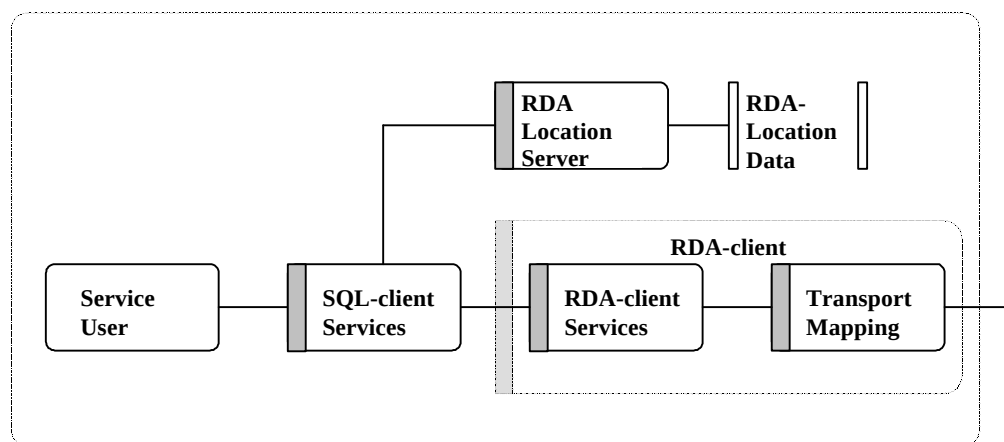


Figure 2 – Model of the RDA-client environment

5.2.1 Service User

The Service User is the component of the RDA-client environment that invokes SQL/CLI routines.

NOTE 5 – The Service User is not further defined by this International Standard.

5.2.2 SQL-client Services

SQL-client Services:

- map the SQL/CLI routines used within the RDA-client environment by the Service User to the RDA Operations defined by this International Standard,
- hold SQL Diagnostic and SQL Descriptor information,
- buffer the results of SQL operations,
- perform locally those SQL operations that can be carried out without communication with an RDA-server environment,
- co-ordinate SQL operations involving more than one SQL-server.

SQL-client Services also co-ordinate SQL operations involving more than one SQL-server by:

5.2 The RDA-client environment

- processing the SQL-connection statements, that is <connect statement>, <set connection statement> and <disconnect statement>,
- processing the SQL-transaction statements, that is <set transaction statement>, <set constraints mode statement>, <commit statement> and <rollback statement>,
- co-ordinating the protocol flows for multiphase commitment,
- mapping instances of entities that have only local validity into instances of entities with more extended validity
- translating an SQL statement into a number of other SQL statements, causing these statements to be executed, and combining the results of their execution.

NOTE 6 – Components outside the RDA-client environment may include further facilities for co-ordinating SQL operations involving more than one SQL-server.

Those constraints on SQL-client Services that must be enforced to ensure conforming behaviour of the SQL-environment when RDA components are present in that environment are defined in Annex C.

NOTE 7 – SQL-client Services are not further defined by this International Standard.

5.2.3 RDA-client Services

The RDA-client Services are the client component of the RDA Protocol and RDA Operations. RDA-client Services use the RDA Protocol defined in clause 6 to communicate RDA-server Services through a Transport Provider.

RDA-client Services:

- allocate Connection Idents, Request Idents and Statement Idents,
- establish and terminate Transport Connections,
- use Transport Facilities to send request messages to an RDA-server and receive response messages from that RDA-server,
- link response messages to the corresponding request messages and detect protocol errors.

RDA-client Services are defined as part of the definition of the RDA Protocol in clause 6 and RDA Operations in clause 7.

5.2.4 Transport Mapping

A Transport Mapping provides a mapping from the RDA Protocol to a Transport Provider, mapping the RDA Operations to a specific transport protocol and providing the facilities for communicating between the transport addresses of RDA-clients and RDA-servers.

Transport Mappings are defined in clause 10.

5.2.5 RDA-client

An RDA-client is RDA-client Services together with a Transport Mapping.

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5.2.6 RDA Location Server

The RDA Location Server is an optional facility to assist in the distribution of data in a heterogeneous environment by providing a standard mechanism for identifying the location of SQL-servers. The RDA Location Server is defined in Annex D.

5.3 The RDA-server environment

The RDA-server environment is described with reference to three functional components: a *Transport Mapping* which interfaces to the communications infrastructure, *RDA-server Services* which provide the server end of the RDA Operations and Protocol and *SQL-server*. How these three functional components interrelate is depicted in Figure 3.

NOTE 8 – An implementation containing a conforming RDA-server need not materialise three different components corresponding to these three functional components nor their intermediate interfaces.

Associated with each RDA-server environment there is an optional *RDA Support Server*.

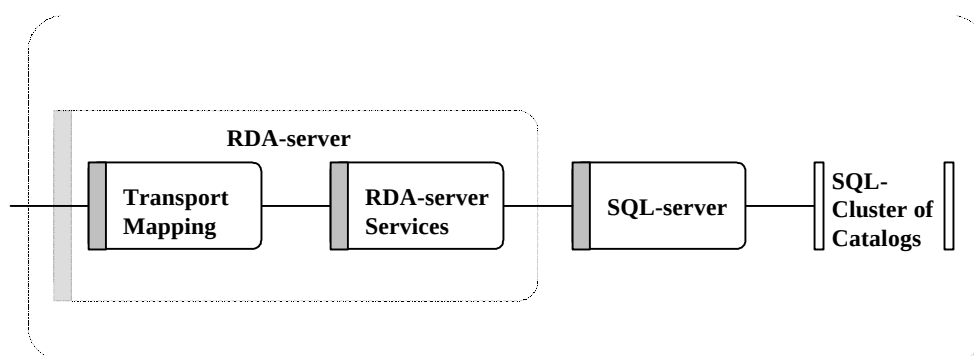


Figure 3 – Model of the RDA server environment

5.3.1 Transport Mapping

A Transport Mapping provides a mapping from a specific Transport Provider to the RDA Protocol. Transport Mappings are defined in clause 10.

5.3.2 RDA-server Services

The RDA-server Services are the server component of the RDA Protocol and RDA Operations. RDA-server Services are invoked by RDA-client Services by means of the RDA Protocol defined in clause 5.6 from precisely one instance of RDA-client Services through a Transport Provider.

RDA-server Services:

- check those aspects of an RDA Request that are not checked by an SQL-server or its interface,
- translate communication concepts to and from local concepts, and
- invoke SQL-server facilities.

RDA-server Services are defined as part of the definition of the RDA Protocol in clause 6 and RDA Operations in clause 7.

5.3.3 RDA-server

An RDA-server is RDA-server Services together with a Transport Mapping, and maps the Operations and Services defined by this International Standard to the SQL-binding offered by the SQL-server.

5.3.4 SQL-server

An SQL-server functional component is defined in ISO/IEC 9075 (SQL).

An SQL-server has associated with it a portion of SQL-data that is described by a set of Catalogs termed a “Cluster of Catalogs” by ISO/IEC 9075 (SQL).

5.3.5 RDA Support Server

The RDA Support Server is an optional facility to assist interoperation in a heterogeneous environment by providing a standard mechanism for identifying characteristics of SQL-servers retrieving historic operation information. The RDA Support Server is defined in Annex E.

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5.4 RDA concepts and the mapping of SQL/CLI concepts

5.4.1 Application Communication Areas

The communication between a Service User and an SQL-environment is facilitated by means of *Application Communication Areas*. These are Attributes, diagnostic areas and descriptor areas and are described in the following subclauses.

Although many functional components contribute to Application Communication Areas, this International Standard locates these areas in the RDA-client environment and designates the SQL-client Services as responsible for the direct maintenance of these areas in the RDA-client environment.

The RDA Protocol and RDA Operations provide facilities to ensure that the contents of the RDA-client environment communication areas and copies of these areas within RDA-server environments are synchronised to the extent required for conforming behaviour of the SQL-environment.

5.4.1.1 Attributes

ISO/IEC 9075-3 (SQL/CLI) uses the concept of *environment attribute* to identify certain characteristics of an SQL-environment, *connection attribute* to identify certain characteristics of an SQL-connection and *statement attribute* to identify certain characteristics of an SQL-statement. RDA regards these characteristics collectively as *Attributes*.

The RDA-client environment and the RDA-server environment must have a consistent view of Attributes. An operation RDAClientAttribute is provided which can be used to synchronise the RDA-server environment copy of Attribute values with the corresponding values within an RDA-client environment. In addition, each response message includes a parameter that permits an RDA-client environment to synchronise its copy of the Attribute values with the corresponding values within an RDA-server environment.

5.4.1.2 Diagnostics areas

ISO/IEC 9075 (SQL) defines SQL diagnostics areas and ISO/IEC 9075-3 (SQL/CLI) specialises the definition to CLI diagnostics areas.

Information for inclusion in diagnostics areas can be generated by the SQL-client Services, the RDA-client Services, the Transport Provider, the RDA-server Services or the SQL-server.

Each response message includes a parameter that communicates to the RDA-client environment diagnostics generated within the RDA-server environment.

5.4.1.3 Descriptor areas

ISO/IEC 9075 (SQL) defines SQL descriptor areas and ISO/IEC 9075-3 (SQL/CLI) specialises the definition to CLI descriptor areas. Associated with each allocated SQL-statement there are four specific descriptor areas: Implementation Parameter Descriptor *IPD*, Implementation Row Descriptor *IRD*, Application Parameter Descriptor *APD* and Application Row Descriptor *ARD*.

Descriptor information is communicated with the results of a request to prepare an SQL-statement, with the request to execute an SQL-statement and with the results of a request for rows of results.

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5.4 RDA concepts and the mapping of SQL/CLI concepts

5.4.2 SQL_TEXT

ISO/IEC 9075 (SQL) defines a character set SQL-TEXT whose character repertoire contains every character used in the SQL language and every character that is in any other character set supported by the SQL-implementation. To ensure heterogeneous interoperability, this International Standard requires the character repertoire of SQL_TEXT to be the Basic Multilingual Plane of ISO/IEC 10646.

5.4.3 SQL-session and SQL-connection

ISO/IEC 9075 (SQL) defines an SQL-connection associated with each SQL-session. An SQL-connection is supported by an RDA-client and an RDA-server pair. An RDA-client and an RDA-server can each support at most one SQL-connection at any time.

A Transport connection (as defined in 5.5.4) is established between the RDA-client and the RDA-server of an SQL-connection as required for communication. Each Transport Connection is therefore associated with at most one SQL-connection at any time.

The underlying Transport Connection of an SQL-connection may be terminated and re-established without disruption of the SQL-connection.

5.4.4 SQL User Name and Password

ISO/IEC 9075 (SQL) restricts access to SQL-data on the basis of Privileges assigned to Users.

ISO/IEC 9075-3 (SQL/CLI) provides for Users to identify themselves by means of a User Name which may be authenticated by a Password. The SQL User Name and Password are used by this International Standard as a basis for authenticating the identity of the User.

Additionally, the User Name may be authenticated by other types of RDA Service User Authentication as described in 5.8.3.

NOTE 9 — The User Name does not necessarily identify the user uniquely but is sufficient for an SQL-server to allocate the user with appropriate access privileges.

5.4.5 Multi-site Transactions

ISO/IEC 9075 (SQL) permits SQL-transactions to involve more than one SQL-server. Each SQL-connection is mapped to a separate RDA-client, RDA-server pair. A COMMIT or ROLLBACK request from a Service User is mapped onto a series of transaction co-ordination exchanges with each participating RDA-server unless the SQL-transaction is part of an Encompassing Transaction, in which case the request is handled outside the protocol defined by this International Standard.

5.4.6 SQL/CLI Handles

ISO/IEC 9075-3 (SQL/CLI) uses the concept of a *handle* to uniquely identify an allocated resource. In an RDA environment the allocated resource has two sub-components, one in the RDA-client environment and one in the RDA-server environment. A handle is not required to have validity outside the compilation unit that allocated it. In an RDA environment, therefore, an allocated resource may have two handles associated with it: one with validity within the RDA-client environment to identify the RDA-client sub-components of the resource, another within the RDA-server environment to identify the RDA-server sub-components of the allocated resource.

5.4 RDA concepts and the mapping of SQL/CLI concepts**5.4.7 Connection Ident**

Each SQL-connection is assigned a Connection Ident by the RDA-client Services. This Connection Ident is a code that differs from the Connection Ident of any other allocated SQL-connection within the RDA-client environment. A Connection Ident thus serves to establish a correspondence between a Connection Handle within an RDA-client environment and a Connection handle within an RDA-server environment.

5.4.8 Statement Ident

Each allocated SQL-statement is assigned a Statement Ident by the RDA-client Services. This Statement Ident is a code that differs from the Statement Ident of any other allocated SQL-statement within the SQL-session. A Statement Ident thus serves to establish a correspondence between a Statement Handle within an RDA-client environment and a Statement handle within an RDA-server environment.

5.4.9 Request Ident

Each request for an RDA Operation is assigned a Request Ident by the RDA-client Services. This Request Ident is a code that differs from the Request Ident of any other RDA Operation request originating from that RDA-client environment.

RDA-client Services use the Request Ident to identify the request messages for an RDA Operation to which a response message relates.

5.4.10 Encodings

RDA protocol elements and their constituent parts are encoded for transmission. Encodings are defined in clause 9. For each Transport Mapping there is one encoding, the *Default Encoding* which every conforming implementation supporting that Transport Mapping must provide.

5.5 RDA Model of Transport

5.5.1 Transport Provider

A *Transport Provider* is a communications infrastructure that permits the RDA-client and RDA-server components in an SQL-environment to communicate using the operations and the protocol defined by this International Standard.

A Transport Provider is required to be reliable and always available to RDA. The format of RDA protocol elements includes a length field to assist mapping to streaming transport providers.

Mappings of the RDA Operations and the RDA Protocol to Transport Providers are defined in clause 10.

NOTE 10 – An SQL-client may invoke RDA Operations through more than one RDA-client and those RDA-clients need not all use the same Transport Provider.

NOTE 11 – Transport Providers are not defined by this International Standard.

5.5.2 Transport Address

Communication takes place between an RDA-client and an RDA-server each of which is identified within a Transport Provider by one or more *Transport Addresses*.

5.5.3 Destination SQL-server Name

An SQL-server associated with an RDA-server has a *Destination SQL-server Name* which is different from the Destination SQL-server Name of every other SQL-server associated with that RDA-server.

NOTE 12 – The Destination SQL-server Name of an SQL-server may be the <SQL-server name> by which it is identified to SQL-clients “local” to the server in a <connect statement> and may be the same as the Destination SQL-server Name of an SQL-server associated with some other RDA-server.

More than one SQL-server may be associated with an RDA-server and hence with a Transport Address within a Transport Provider. Also, one SQL-server may be associated with more than one RDA-server.

In an RDA-client environment an SQL-server name presented to an SQL-client is mapped by the SQL-client Services to a Transport Provider, a Transport Address and a Destination SQL-server Name.

NOTE 13 – The three values Transport Provider, Transport Address and Destination SQL-server Name when considered together by an SQL-client uniquely identify an SQL-server from among the SQL-servers that it is possible for that SQL-client to connect to using the available Transport Providers.

5.5.4 Transport Connection

A Transport Connection is a service provided by a Transport Provider for communicating encodings between an RDA-client and an RDA-server with the minimum of protocol overhead.

5.5.5 Transport Facilities

Each Transport Provider must have five Transport Facilities available at each associated RDA-client or RDA-server:

Transport Connect: a facility that requests the establishing of a Transport Connection.

Transport Disconnect: a facility that requests the termination of the Transport Connection. This facility shall not disrupt encodings that have already been sent through the Transport Connection.

Transport Fail: a facility that terminates the Transport Connection, possibly with loss of RDA Messages.

Transport Send: a facility that sends an encoding through a Transport Connection.

Transport Receive: a facility that receives an encoding through a Transport Connection.

NOTE 14 – Transport Facilities are not further defined by this International Standard.

5.6 RDA Facilities for Transport Connections

The RDA Transport Connection facilities are:

RDA Suspend and Resume: a mechanism for terminating and re-establishing a Transport Connection without disrupting the associated SQL-connection.

RDA Encoding: a mechanism for encoding RDA protocol elements and their constituent parts for sending through a Transport Connection.

The following subclauses describe how features defined by this International Standard are used to provide the RDA Transport Connection facilities.

5.6.1 RDA Suspend and Resume Facility

The underlying Transport Connection of an SQL-connection may be terminated and re-established without disruption of the SQL-connection, as defined in 5.4.3. Attributes are provided to control this behaviour:

CLIENT RESUME PERMITTED: Indicates whether an RDA-server permits an RDA-client to terminate and re-establish Transport Connections within an SQL-connection.

SERVER RESUME SUPPORTED: Indicates whether an RDA-server may re-establish Transport Connections that have been terminated by an RDA-client within an SQL-connection.

RESUME MODE: Indicates the RDA Suspend and Resume facility requested by the client, this can be one of:

- *none*, the Transport Connection will not be terminated and re-established,
- *client*, the RDA-client may terminate and re-establish the Transport Connection,
- *server*, the RDA-client may terminate the Transport Connection and the RDA-server will re-establish it.

CLIENT DISCONNECT INTERVAL: When Client RDA Suspend and Resume is selected, the maximum length of time (in seconds) that an RDA-client may delay between terminating a Transport Connection and re-establishing it.

CLIENT CONNECT INTERVAL: When Client RDA Suspend and Resume is selected, the minimum length of time (in seconds) that an RDA-client must delay between sending an encoding through a Transport Connection and terminating it with the intention of re-establishing it later.

NOTE 15 – An implementation need not support the RDA suspend and resume facility

5.6.2 RDA Encoding Facility

An Attribute is provided to permit an RDA-client to identify what encodings other than the Default Encoding are recognised by an RDA-server:

ENCODINGS SUPPORTED: The sum of the codes identifying encodings that are supported by the RDA-server on this SQL-connection as defined in clause 9.

NOTE 16 – Encodings have codes which are (small) powers of 2.

5.7 RDA Facilities for Transaction Co-ordination

The RDA Transaction Co-ordination facility is:

RDA Transaction Co-ordination: a mechanism for ensuring that Service User operations leave the SQL-environment in a consistent state.

The following subclause describes how features defined by this International Standard are used to provide the RDA Transaction Co-ordination facility.

5.7.1 RDA Transaction Co-ordination Facility

An RDA Operation RDAEndTran is provided which may be used to communicate transaction co-ordination requests.

Three types of RDA Transaction Co-ordination are supported:

- *encompassing*, transaction co-ordination is the responsibility of some external transaction management component. A field, MessageContext, is provided in the RDAMessage protocol element for the use of the external transaction management component to communicate transaction context information. RDAEndTran is not used except as required by the external transaction management component.
- *one-phase*, when a Service User requests that a transaction be committed, the request is communicated to each SQL-server participating in the transaction independently. This level of support may not preserve the transaction semantics of ISO/IEC 9075 (SQL) if the SQL-servers do not all commit the transaction. RDAEndTran is used to communicate COMMIT or ROLLBACK requests.
- *two-phase*, when a Service User requests that a transaction be committed, a multiphase commitment exchange is entered into with the SQL-servers participating in the transaction. This level of support preserves the transaction semantics of ISO/IEC 9075 (SQL) in multi-site transactions except possibly in the event of a breakdown during the final phase of the two-phase exchange in a server or in the communications. RDAEndTran is used to communicate PREPARE TO COMMIT, COMMIT or ROLLBACK requests.

Mechanisms to recover automatically from breakdowns in the final phase of a two-phase exchange are outside the scope of this International Standard.

Attributes are provided to permit an RDA-server to indicate what types of RDA Transaction Co-ordination it provides and a Service User to request an RDA Transaction Co-ordination Type:

ONE-PHASE CO-ORDINATION SUPPORTED: Indicates whether the server supports One-phase RDA Transaction Co-ordination.

TWO-PHASE CO-ORDINATION SUPPORTED: Indicates whether the server supports Two-phase RDA Transaction Co-ordination.

CO-ORDINATION REQUESTED: Indicates the type of RDA Transaction Co-ordination requested by the Service User.

5.8 RDA Facilities for Security

5.8.1 RDA Security Services

The requirements for security services are discussed in Annex F. These services are:

RDA Service User Authentication: corroboration of the identity of the Service User defined in 5.2.1.

RDA-client Authentication: corroboration of the identity of the RDA-client.

RDA-server Authentication: corroboration of the identity of the RDA-server.

RDA Outgoing Access Control: access control enforced by the RDA-client environment.

RDA Firewall Access Control: access control enforced by the RDA relay system

RDA Incoming Access Control: access control enforced by the RDA-server environment.

SQL Access Control: access control enforced by the SQL-server.

RDA Transfer Integrity: protection of communication against unauthorised modification.

RDA Transfer Confidentiality: protection of communication against unauthorised disclosure.

RDA Request Non-repudiation: protection against the RDA-client denying having requested a specific RDA Operation.

RDA Response Non-repudiation: protection against the RDA-server denying having responded to a specific request for an RDA Operation.

The following subclauses describe how facilities defined or identified by this International Standard may be used to provide the security services. Profiles of combinations of services to achieve defined levels of security are defined in Annex G.

NOTE 17 – In this International Standard RDA Outgoing Access Control, RDA Firewall Access Control and RDA Incoming Access Control are to a resource such as an SQL-server rather than to data. SQL Access Control is to data.

5.8.2 Use of Transport Provider security facilities

The Transport Provider may have facilities for providing RDA Transfer Integrity, RDA Transfer Confidentiality, RDA-client Authentication and RDA-server Authentication.

A Transport Mapping is defined in 10.2 that can be used to provide RDA Transfer Integrity, RDA Transfer Confidentiality, RDA-client Authentication and RDA-server Authentication.

In cases where the RDA Client represents a single Service User then RDA Client Authentication may be used to support RDA Service User Authentication as described in 5.8.3.

5.8.3 Use of Authentication in RDAConnect

The RDAConnect operation fields *AuthenticationType* and *Authentication* can be used to authenticate the name of the RDA Service User (defined in 5.2.1) as identified by the *UserName* field.

Four types of RDA Service User Authentication, identified by the *AuthenticationType*, are supported:

- *password*, the *UserName* is authenticated using a password carried in the *Authentication* field.
- *transfer*, the *UserName* is matched against the RDA-client identity authenticated by RDA-client Authentication (for example using a local equivalence table or mapping algorithm). This mechanism requires that the RDA-client represent a single Service User.

NOTE 18 – The Service User may, however, use several User Names to represent different privileges and may be represented by several RDA-clients.

- *attributeCertificate*, the User Name is related to the identity of an RDA-client by an Attribute Certificate (as defined in ISO/IEC 9598-8 | X.509 1997) carried in the *Authentication* field. This mechanism requires that the RDA-client represent a single Service User.

NOTE 19 – The Service User may, however, use several User Names to represent different privileges and may be represented by several RDA-clients. Also, if Service Users share common privileges, and do not need to be separately identified for other reasons (for example, accountability), then they can be treated as the same Service User for the purposes of authentication, sharing a common *UserName* authenticated through the same RDA-client. An amendment to this International Standard is in preparation that gives further details of how Attribute Certificates are used for the management of privileges.

- *other*, the *Authentication* field is used to carry authentication information to support an externally defined mechanism.

The *AuthenticationType* may also be set to *none* to indicate that no support is provided for RDA User Authentication.

An Attribute is provided to permit an RDA-client to request a particular type of RDA Service User Authentication:

AUTHENTICATION TYPE: a value defining the type of RDA Service User Authentication requested by the RDA-client environment.

5.8.4 Use of MessageAuthentication in RDAMessage

Each *RDAMessage* protocol element has a field *MessageAuthentication* that provides a means of communicating information required for RDA Request Non-repudiation and RDA Response Non-repudiation.

Three levels of RDA Request Non-repudiation and RDA Response Non-repudiation are supported:

- *none*, no support is provided
- *originatorSigned*, RDA Non-repudiation is supported by a timestamp and signature produced by the originator of the message
- *ttpSigned*, RDA Non-repudiation is supported by a timestamp and signature produced by the originator of the message, together with a timestamp and signature produced by a trusted third party (TTP).

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Attributes (as defined in 5.4.1.1) are provided to permit an RDA-client and an RDA-server to negotiate the RDA Request Non-repudiation level and the RDA Response Non-repudiation level, and for a Service User to request a particular level of RDA Request Non-repudiation and RDA Response Non-repudiation.

REQUEST NON-REPUDIATION PROVIDED: a value defining the level of RDA Request Non-repudiation provided by the RDA-client environment.

REQUEST NON-REPUDIATION REQUIRED: a value defining the level of RDA Request Non-repudiation required by the RDA-server environment.

RESPONSE NON-REPUDIATION SUPPORTED: a value defining the level of RDA Response Non-repudiation supported by the RDA-client environment.

RESPONSE NON-REPUDIATION REQUIRED: a value defining the level of RDA Response Non-repudiation required by the RDA-client environment.

6 RDA Protocol

The RDA Protocol is defined in terms of:

- an exchange of protocol elements between an RDA-client environment and an RDA-server environment, as defined in 6.1,
- the encoding of the RDA protocol element, RDAMessage, as defined in 6.2,
- a set of operations that are invoked through the protocol, as identified in Table 3,
- the behaviour of the RDA-client and RDA-server when an RDA Operation is invoked, as defined in 6.3,
- the encoding of operation requests, operation results and component elements of these, as defined in clause 7,
- the encoding of the basic data types, as defined in clause 10 for each Transport Mapping.

6.1 The RDA Protocol Exchange

The RDA Protocol consists of:

- A protocol element sent by RDA-client Services from an RDA-client environment to an RDA-server environment carrying the encoding of a request for the execution of an RDA Operation by the RDA-server environment.
- A protocol element sent by RDA-server Services from an RDA-server environment to an RDA-client environment carrying a response resulting from the execution of an RDA Operation.

The RDA Protocol is a confirmed protocol. That is, the RDA-client expects to receive an appropriate protocol element in response to each protocol element it sends.

Protocol elements may be sent asynchronously. That is, RDA-client Services do not require that an RDA-client wait for a response to a protocol element before sending the next protocol element.

NOTE 20 – The logic of an application may require that an RDA Operation completes before the next RDA Operation is invoked.

NOTE 21 – An RDA-server environment may limit the number of RDA Operation invocations it can support concurrently.

Protocol elements may be concatenated. That is, a sender may collect several protocol elements and send them together.

NOTE 22 – The logic of an application may require that a response is received before the next operation request can be sent.

6.2 RDAMessage

6.2.1 RDAMessage protocol element

Function

Carry an RDA message.

Encoding

```
RDAMessage ::= SEQUENCE
{
  MessageProtocol      RDAInteger,
  MessageVersion       RDAInteger,
  MessageEncoding      RDAInteger,
  MessageLength        RDAInteger,
  messageConnectionId  RDAInteger,
  MessageRequestIdent  RDAInteger,
  MessageType         RDAInteger,
  MessageContext       RDAOctetString,
  MessageData          RDAOctetString,
  MessageAuthentication RDAOctetString
}
```

The RDAMessage protocol element is encoded according to the Base encoding defined in 9.1.

Protocol Parameters

MessageProtocol: a code identifying the RDA Protocol. Valid codes are defined in Table 1.

Table 1 – Codes used to identify the protocol

Protocol	Code
ISO/IEC 9579, Remote Database Access for SQL	959788857

NOTE 23 – The code 959788857 is the ASCII encoding for the four characters “9579”

MessageVersion: a code identifying the version of the RDA Protocol. Valid codes are defined in Table 2.

Table 2 – Codes used to identify the protocol version

Protocol	Version	Code
ISO/IEC 9579 Remote Database Access for SQL	ISO/IEC 9579:1998 Remote Database Access for SQL	3