Universita' degli Studi di Lecce

GRelC Project

Grid Relational Catalog

An easy way to manage Relational Databases in the Globus Community

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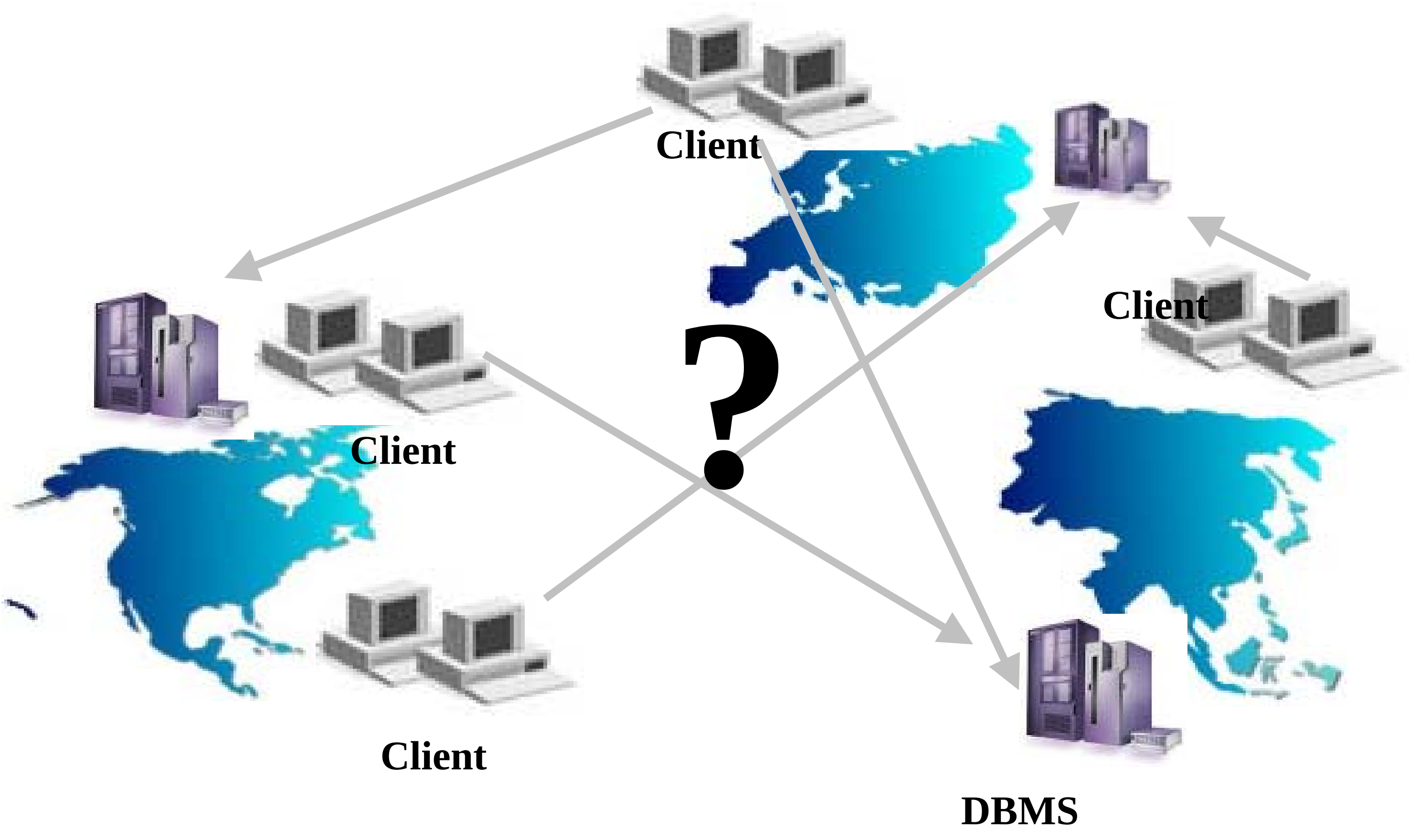
A simple Scenario

“How can Grid-aware Applications interact with their relational Data Resources in a distributed environment in order to make the most of a computational Grid?”

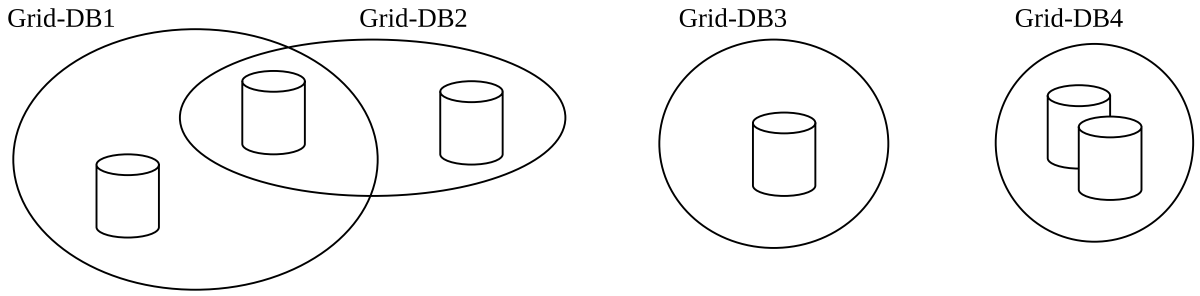


Definition of Grid-DBMS

A ***Grid-DBMS*** *is a system which dynamically and transparently* ***reconfigures*** *components such as Data Resources at runtime, according to the Grid state, in order to maintain a desired performance level. It must offer an efficient, robust, intelligent, transparent, uniform access to* ***Grid-Databases***

Definition of Grid-DataBase

*A **Grid-DataBase** is a collection of one or more Databases which can also be heterogeneous and contain replica, accessible through a Grid-DBMS front end . It represents an extension and a virtualization of the Database concept in a grid environment."*

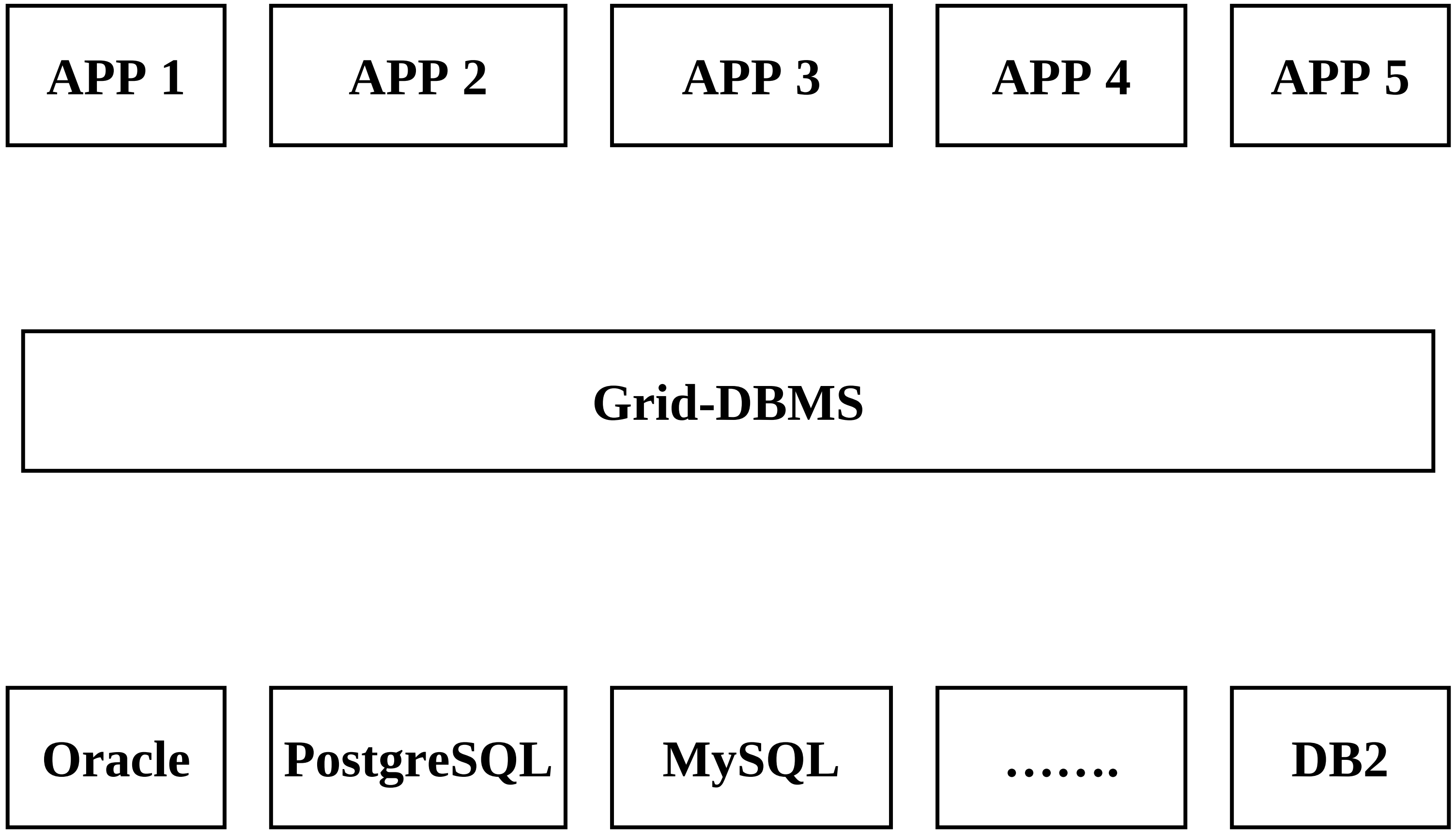


Dynamic Reconfiguration

What do we mean by Dynamic Reconfiguration?

- *Dynamic Database Relocation*
- *Dynamic Database Replication*
- *Dynamic Database Partition*

The **Grid-DBMS layer**



Grid-DBMS requirements

A Grid-DBMS must be:

- Secure
- Transparent
- Easy to manage
- Robust
- Efficient
- Intelligent

...and it must support:

- Different DBMS
- High level functionalities
- High level Grid technologies(e.g. GridFTP)
- Dynamic reconfiguration mechanisms
- Performance Monitoring of the DBMS

Introducing the GRelC Project

Grid Relational Catalog is a project that aims at designing and deploying the first **Grid-DBMS** for the **globus community**

First Steps

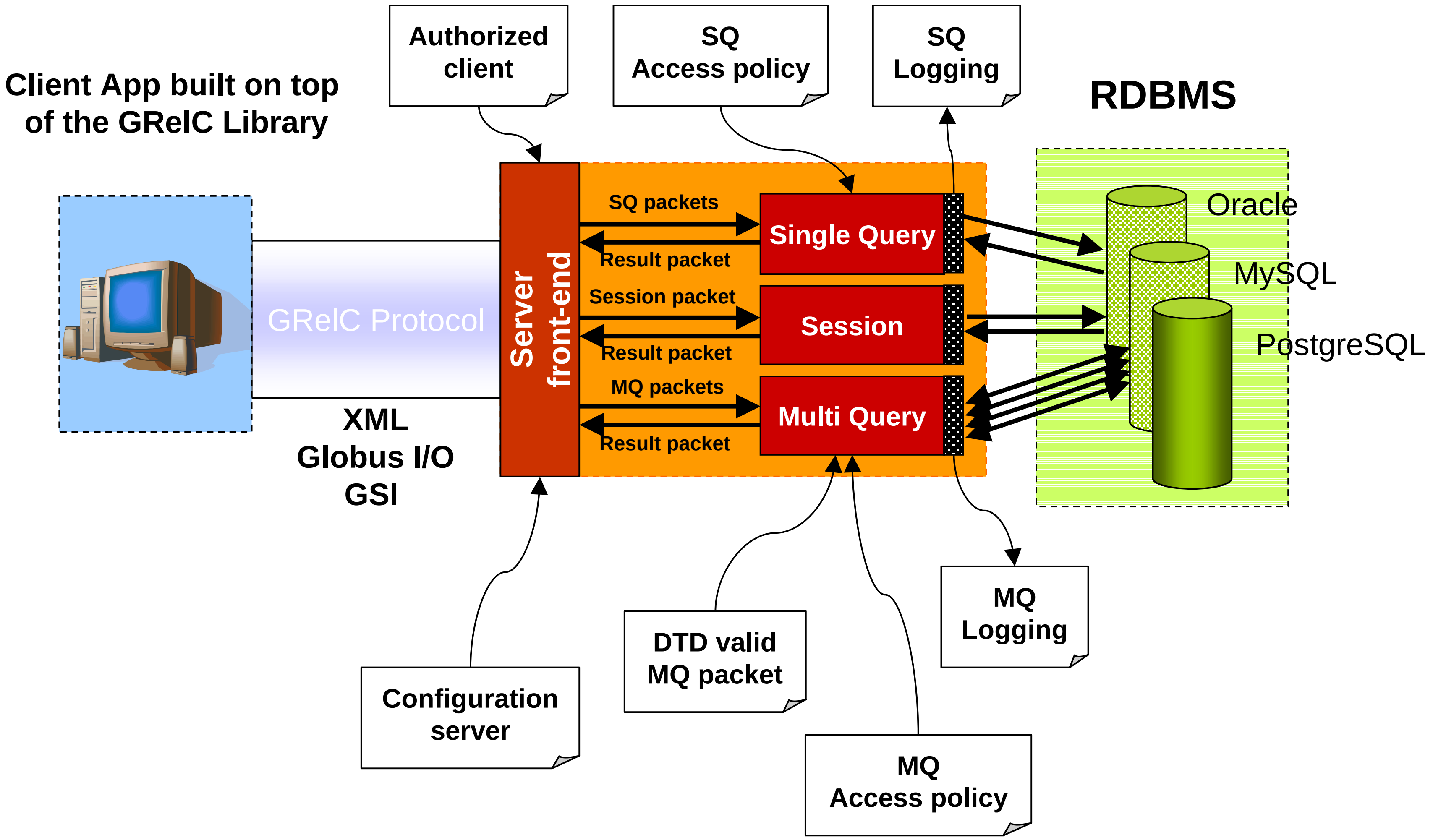
Connection

- Drivers (basic building blocks)

Interaction

- Queries (core and advanced)

GRelC Basic Architecture



Main Features

- Authentication
- Authorization
- Access control policy
- Data Encryption
- Single Query Support
- Multi Query Support
- MultiDBMS Support
- XML Data Validation
- Logging

GRelC-Server Configuration

```
          <CONFIGURATION_SERVER>
GRelC-Server    <SERVER_PORT>13002</SERVER_PORT>
General Info    <VALIDATION_DATA_STREAM>y</VALIDATION_DATA_STREAM>
                <REPOSITORY_DATA_PACKET>../grelc_repository_data_packet/</REPOSITORY_DATA_PACKET>
                <DATABASES>
                     <DATABASE GRELC_DBNAME="Student">
                               <DB_HOST_NAME>gandalf.unile.it</DB_HOST_NAME>
                Database       <DB_NAME>grelcdb</DB_NAME>
                Configuration  <DB_LOGIN>db-login</DB_LOGIN>
                               <DB_PASSWORD>db-pwd</DB_PASSWORD>
                               <DB_PORT>5432</DB_PORT>
Database Student               <DTD_FILENAME>../grelc_dtd/grelc_schema2.dtd</DTD_FILENAME>
Configuration                  <AUTHORIZATION_CLIENT>y</AUTHORIZATION_CLIENT>
                               <AUTHORIZED_CLIENT>
                                         <DN INSERT="TRUE" DELETE="FALSE">DN-user1</DN>
                Database                 <DN CREATE_DB="TRUE" DROP_DB="TRUE">DN-user2</DN>
                Authorization            <DN UPDATE="TRUE" GRIDFTPSQ="TRUE">DN-user3</DN>
                Policy                   <DN MQ="TRUE" INSERT="TRUE">DN-user3</DN>
                               </AUTHORIZED_CLIENT>               Access Control
                     </DATABASE>                                  Policy
Database Library     <DATABASE GRELC_DBNAME="Library">
Configuration                  ...
                     </DATABASE>
                     ...
                </DATABASES>
          </CONFIGURATION_SERVER>
```

Access Policy

Access Policy	If true...
CREATE_DB	Allow user to create new databases
DROP_DB	Allow user to drop databases
MQ	Allow user to do MultiQuery
GRIDFTPMQ	Allow user to do MultiQuery Grid FTP
GRIDFTPSQ	Allow user to do SingleQuery Grid FTP
TRANSACTION	Allow user to do transactions
INSERT	Allow user to do Insert Query
UPDATE	Allow user to do Update Query
DELETE	Allow user to do Delete Query

Logging

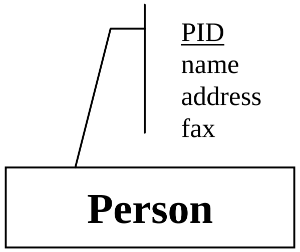
GRelC_Connection.log

```
Connection from /O=Grid/O=Globus/OU=unile.it/CN=Sandro Fiore to grelcdb at 15/07/2003 13:25     [  OK  ]
Connection from /O=Grid/O=Globus/OU=unile.it/CN=Daniele Lezzi to grelcdb at 15/07/2003 13:40     [  OK  ]
Connection from /O=Grid/O=Globus/OU=unile.it/CN=Marco Polo to grelcdb at 15/07/2003 13:44     [  FAILED  ]
```

GRelC_server.log_grelcdb

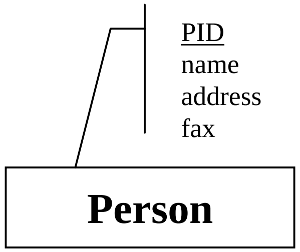
```
/O=Grid/O=Globus/OU=unile.it/CN=Sandro Fiore   SINGLE  select * from student   15/07/2003 13:25
/O=Grid/O=Globus/OU=unile.it/CN=Sandro Fiore   SINGLE  select * from seminar   15/07/2003 13:25
/O=Grid/O=Globus/OU=unile.it/CN=Daniele Lezzi   SINGLE  select title from seminar   15/07/2003 13:40
```

MultiQuery XML file example



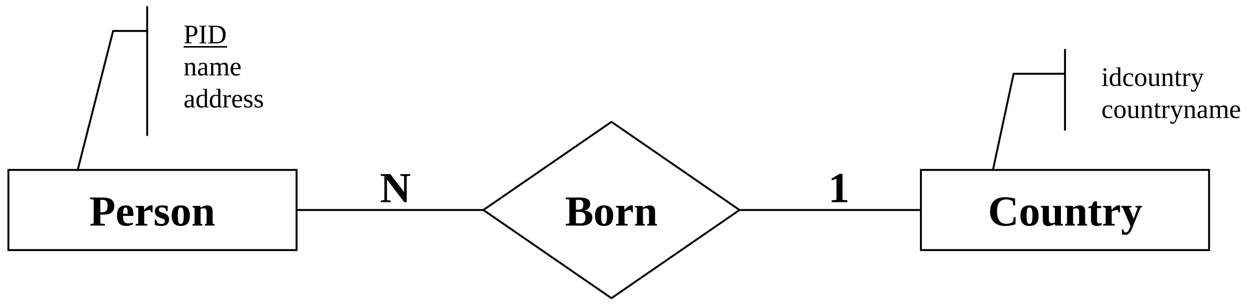
```
<TABLES GRELC_DBNAME="grelcdb">
      <TABLE NAME="person">
         <RECORDS>
            <RECORD>
                  <ATTRIBUTES>
                      <ATTRIBUTE NAME="PID" TYPE="STRING">DTJdfjksdk£23423</ATTRIBUTE>
                      <ATTRIBUTE NAME="name" TYPE="STRING">Sandro Fiore</ATTRIBUTE>
                      <ATTRIBUTE NAME="address" TYPE="STRING">Via Carlo V</ATTRIBUTE>
                      <ATTRIBUTE NAME="fax" TYPE="STRING">+39 0832 297279</ATTRIBUTE>
                </ATTRIBUTES>
           </RECORD>
            <RECORD>
                  <ATTRIBUTES>
                      <ATTRIBUTE NAME="PID" TYPE="STRING">kjgjkgdd£32424</ATTRIBUTE>
                      <ATTRIBUTE NAME="name" TYPE="STRING">Marco Polo</ATTRIBUTE>
                      <ATTRIBUTE NAME="address" TYPE="STRING">Via America</ATTRIBUTE>
                      <ATTRIBUTE NAME="fax" TYPE="STRING">+39 0832 555777</ATTRIBUTE>
                  </ATTRIBUTES>
           </RECORD>
        </RECORDS>
    </TABLE>
</TABLES>
```

MultiQuery DTD file example



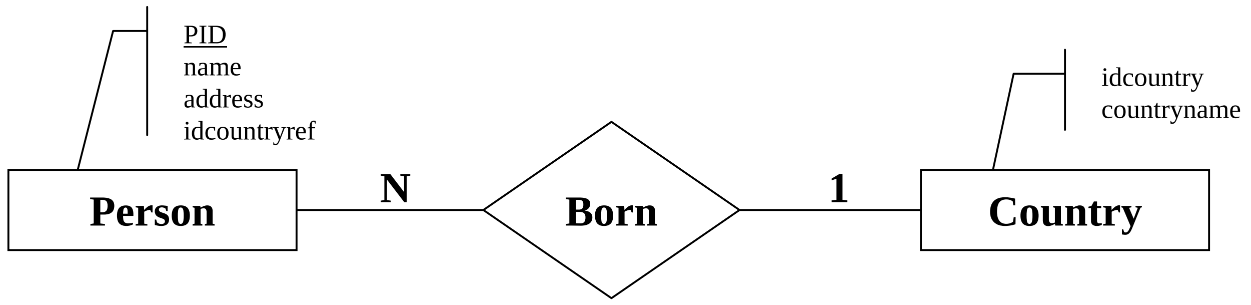
```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT TABLES (RELATIONS?,TABLE+)>
<!ELEMENT RELATIONS (RELATION+)>
<!ELEMENT RELATION (REFERENCEFIELDS)>
<!ELEMENT REFERENCEFIELDS (ATTRIBUTE+)>
<!ELEMENT TABLE (RELATIONS?,RECORDS)>
<!ELEMENT RECORDS (RECORD+)>
<!ELEMENT RECORD (ATTRIBUTES?, RELATIONS?)>
<!ELEMENT ATTRIBUTES (ATTRIBUTE+)>
<!ELEMENT ATTRIBUTE (#PCDATA)>
<!ATTLIST TABLES GRELC_DBNAME (grelcdb) #REQUIRED>
<!ATTLIST TABLE NAME (person) #IMPLIED>
<!ATTLIST ATTRIBUTE NAME ( name| PID |address | fax ) #IMPLIED
TYPE (INTEGER | FLOAT | DOUBLE | STRING | LONG) #IMPLIED>
```

MultiQuery XML file example



```
<TABLES GRELC_DBNAME="grelcdb">
    <TABLE NAME="person">
        <RECORDS>
           <RECORD>
              <RELATIONS>
                    <RELATION FOREIGNKEY=”idcountryref” REFERENCETABLE=”country” REFERENCEKEY=”idcountry”>
                       <REFERENCEFIELDS>
                              <ATTRIBUTE NAME="countryname" TYPE="STRING">Italy</ATTRIBUTE>
                       </REFERENCEFIELDS>
                    </RELATION>
              </RELATIONS>
              <ATTRIBUTES>
                    <ATTRIBUTE NAME="name" TYPE="STRING">Sandro Fiore</ATTRIBUTE>
                    <ATTRIBUTE NAME="address" TYPE="STRING">Via Carlo V</ATTRIBUTE>
                    <ATTRIBUTE NAME=“PID" TYPE="STRING">jhdhsfdhj9833</ATTRIBUTE>
              </ATTRIBUTES>
           </RECORD>
        </RECORDS>
    </TABLE>
</TABLES>
```

MultiQuery DTD file example



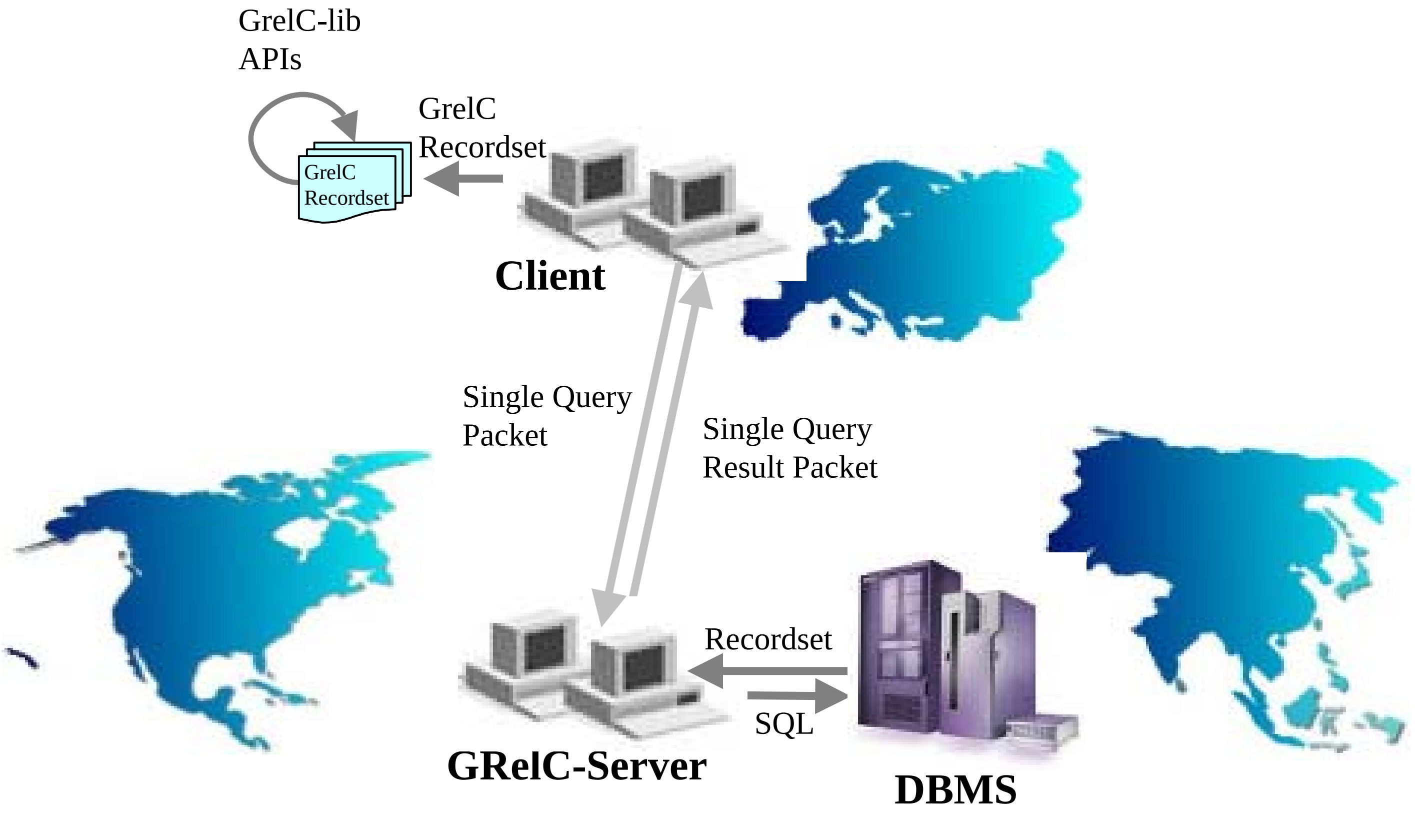
```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT TABLES (RELATIONS?,TABLE+)>
<!ELEMENT RELATIONS (RELATION+)>
<!ELEMENT RELATION (REFERENCEFIELDS)>
<!ELEMENT REFERENCEFIELDS (ATTRIBUTE+)>
<!ELEMENT TABLE (RELATIONS?,RECORDS)>
<!ELEMENT RECORDS (RECORD+)>
<!ELEMENT RECORD (ATTRIBUTES?, RELATIONS?)>
<!ELEMENT ATTRIBUTES (ATTRIBUTE+)>
<!ELEMENT ATTRIBUTE (#PCDATA)>
<!ATTLIST TABLES GRELC_DBNAME (grelcdb) #REQUIRED>
<!ATTLIST TABLE NAME (person | country) #IMPLIED>
<!ATTLIST RELATION
FOREIGNKEY (idcountryref) #IMPLIED
REFERENCETABLE (country) #IMPLIED
REFERENCEKEY (idcountry) #IMPLIED>
<!ATTLIST ATTRIBUTE
NAME ( name | address | PID | countryname | idcountry ) #IMPLIED
TYPE (INTEGER | FLOAT | DOUBLE | STRING | LONG) #IMPLIED>
```

GRelC QUERIES

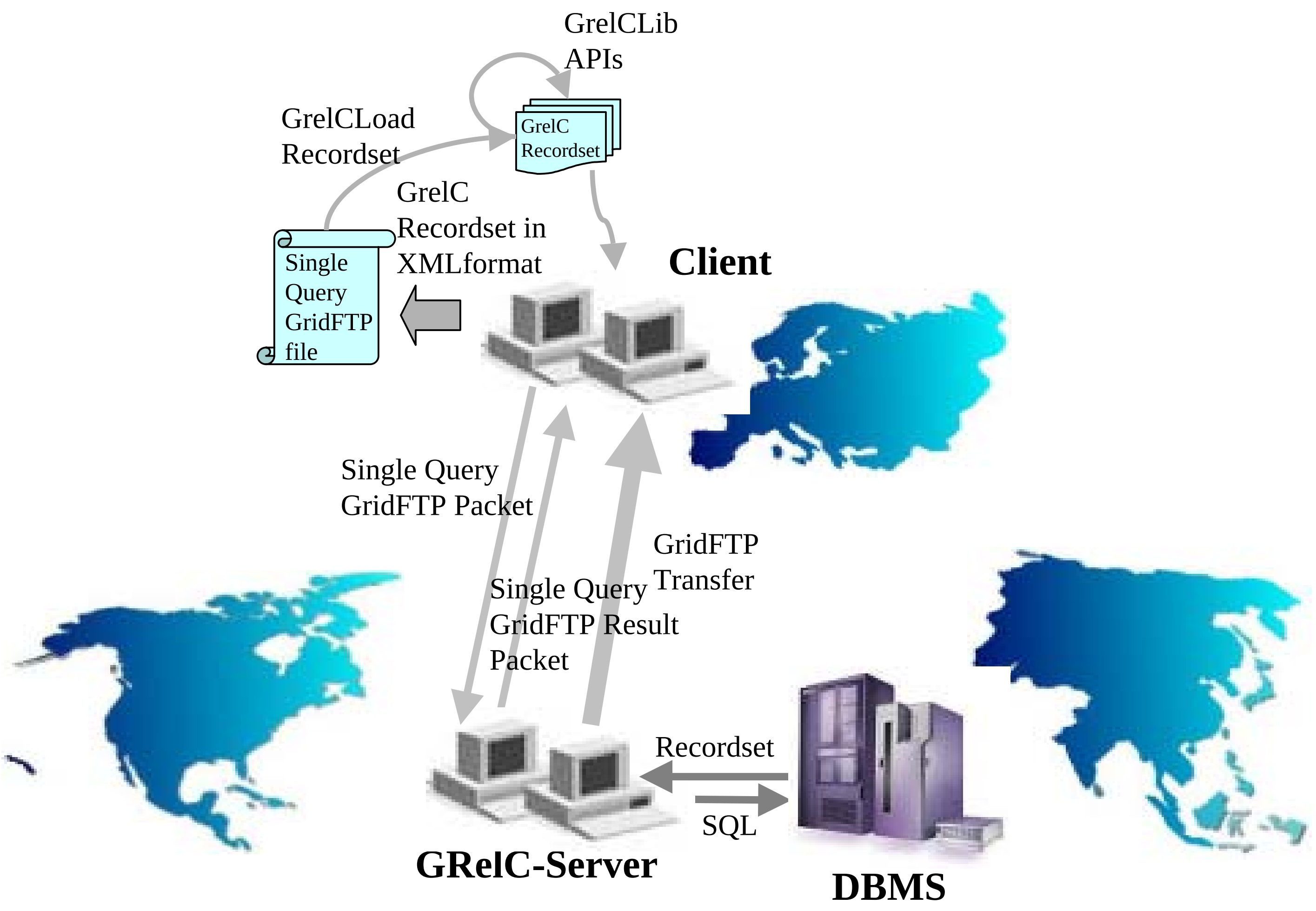
You can submit several GRelC-Queries to the GRelC-Server:

1) Single Query *(SQ)*
2) Single Query GridFTP *(SQ-GridFTP)*
3) Single Query Remote GridFTP *(SQR-GridFTP)*
4) Multi Query *(MQ)*
5) Multi Query GridFTP *(MQ-GridFTP)*
6) Multi Query GridFTP-ThirdParty *(MQ-GridFTP-TP)*

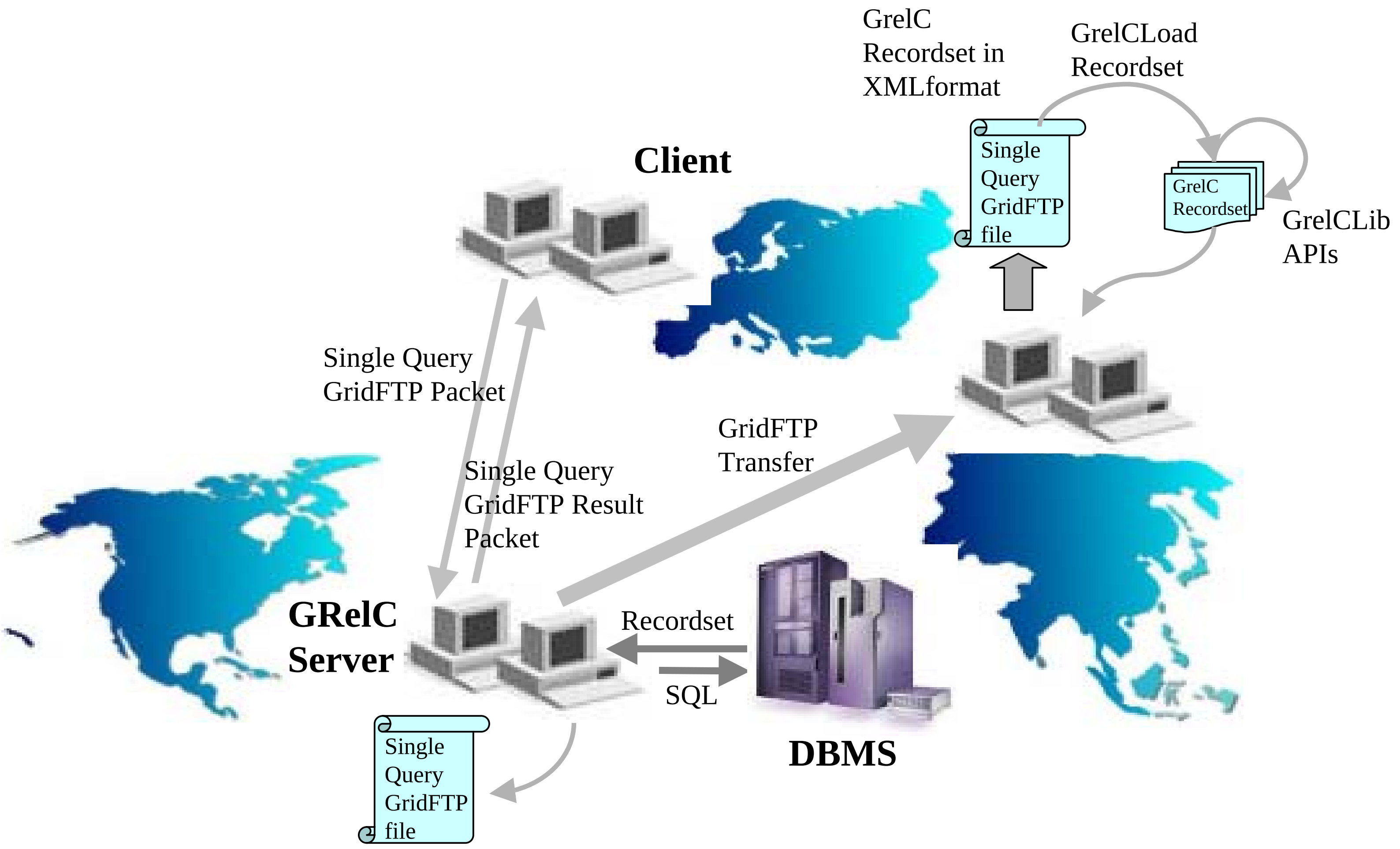
SINGLE QUERY



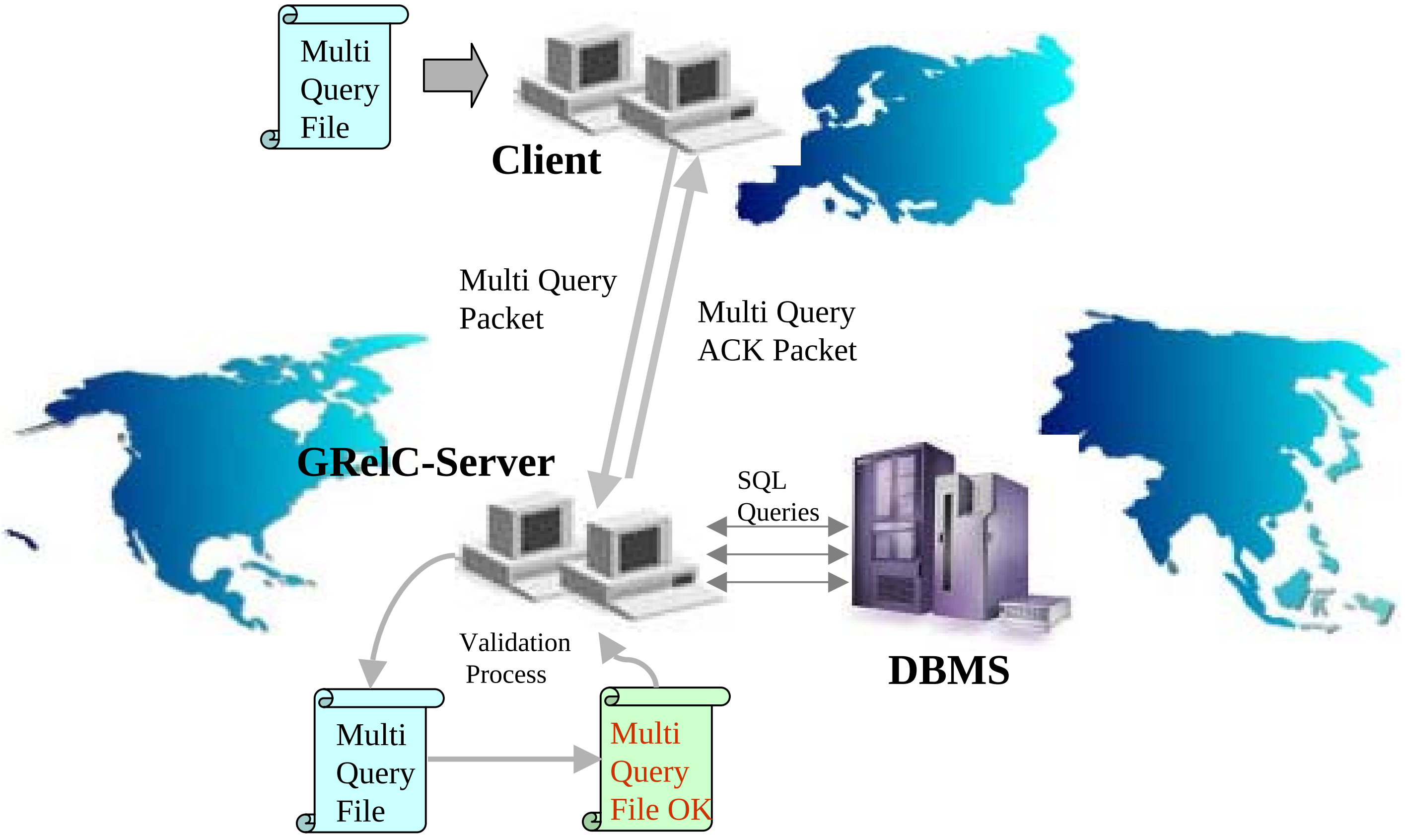
SINGLE QUERY GRIDFTP


GrelCLib APIs
GrelC Recordset
GrelCLoad Recordset
GrelC Recordset in XMLformat
Single Query GridFTP file
Client
Single Query GridFTP Packet
GridFTP Transfer
Single Query GridFTP Result Packet
Recordset
SQL
GRelC-Server
DBMS

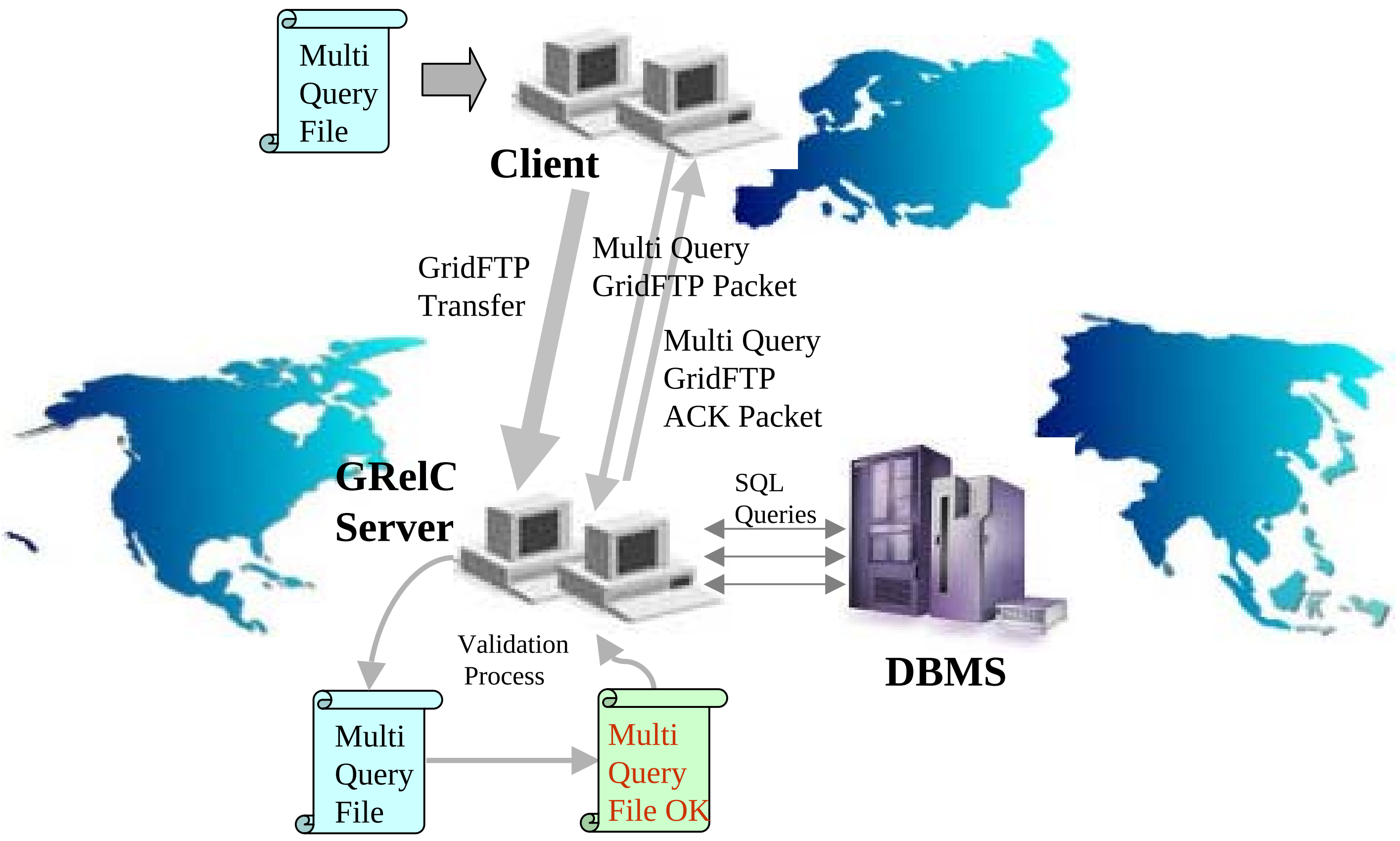
SINGLE QUERY REMOTE GRIDFTP


GrelC Recordset in XMLformat
GrelCLoad Recordset
Client
Single Query GridFTP file
GrelC Recordset
GrelCLib APIs
Single Query GridFTP Packet
GridFTP Transfer
Single Query GridFTP Result Packet
GRelC Server
Recordset
SQL
DBMS
Single Query GridFTP file

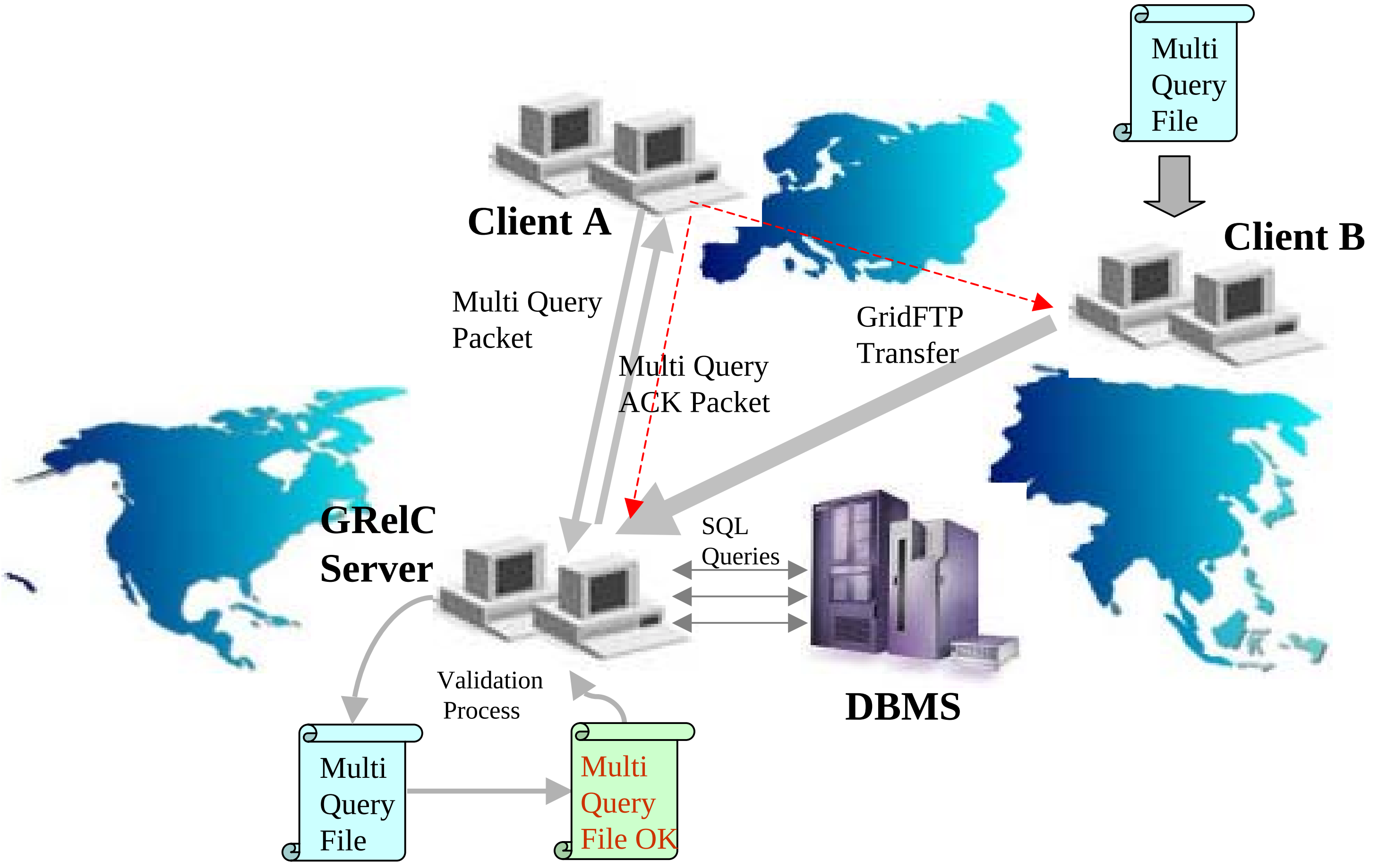
MULTI QUERY


Multi Query File
Client
Multi Query Packet
Multi Query ACK Packet
GRelC-Server
SQL Queries
DBMS
Validation Process
Multi Query File
Multi Query File OK

MULTI QUERY GRIDFTP



MULTI QUERY GRIDFTP THIRD-PARTY

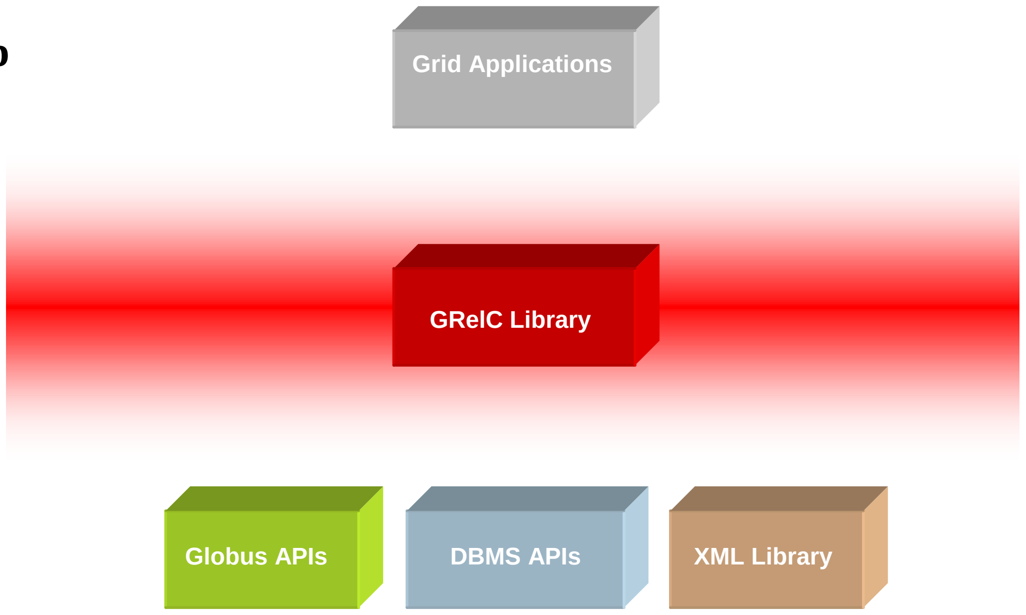


The GRelC Library: a new layer

Appl. built on top of the GRelC-lib

New Layer

Core Libraries



The GRelC Library: APIs Classification

We can classify the 42 APIs into 5 categories:

1) Connection APIs

2) Data Manipulation APIs

3) Core APIs

4) Administration APIs

5) High level APIs

GRelC Library v2.0 (1/2)

```
int    grelc_select(globus_io_handle_t*, char*, Grelc_Answer* );
int grelc_search_MQ(globus_io_handle_t*, char*, char* );
int grelc_grid_ftp_SQ(globus_io_handle_t*, char*, char*, char*, char* );
int grelc_grid_ftp_MQ(globus_io_handle_t*, char* );
int     grelc_unbind(globus_io_attr_t* attr, globus_io_handle_t* handle);
int     grelc_bind(globus_result_t result, char* hostname, unsigned short port, globus_io_attr_t* , globus_io_handle_t* );
int     grelc_schema(Grelc_Answer* );
int     grelc_schema_table(Grelc_Answer* );
int grelc_free_data(Grelc_Answer* );
void    grelc_channel_initialization(globus_io_attr_t* attr,
        globus_io_secure_authorization_callback_t globus_io_secure_authorization_callback, void *args);
void grelc_channel_initialization_without_callback(globus_io_attr_t* attr);
int grelc_create_database(globus_io_handle_t* handle,char* database);
int grelc_drop_database(globus_io_handle_t* handle,char* database);
int grelc_create_table(globus_io_handle_t* handle,char* query);
int grelc_drop_table(globus_io_handle_t* handle,char* table);
int grelc_open_transaction(globus_io_handle_t* handle);
int grelc_abort_transaction(globus_io_handle_t* handle);
int grelc_rollback_transaction(globus_io_handle_t* handle);
int grelc_commit_transaction(globus_io_handle_t* handle);
```

GRelC Library v2.0 (2/2)

```
int grelc_insert(globus_io_handle_t* handle,char* query);
int grelc_update(globus_io_handle_t* handle,char* query);
int grelc_delete(globus_io_handle_t* handle,char* query);
int grelc_get_number_records(Grelc_Answer* );
int grelc_get_number_fields(Grelc_Answer* );
int grelc_get_position_record(Grelc_Answer* );
int grelc_find_first(Grelc_Answer* data, char* attribute, char* comp, char* value);
int grelc_find_next(Grelc_Answer* data, char* attribute, char* comp, char* value);
int nomatch(Grelc_Answer* data);
int grelc_move_first(Grelc_Answer* );
int grelc_move_last(Grelc_Answer* );
int grelc_move_next(Grelc_Answer* );
int grelc_move_previous(Grelc_Answer* );
int grelc_move(Grelc_Answer* ,int );
int grelc_eof(Grelc_Answer* );
int grelc_bof(Grelc_Answer* );
int grelc_is_null(char* );
char* grelc_get_field_by_attribute(Grelc_Answer* ,char* );
char* grelc_get_field_by_position(Grelc_Answer* ,int );
char* grelc_get_name_field_by_position(Grelc_Answer* ,int );
```

How to use the GRelC Library

Connection

```
grelc_channel_initialization_without_callback(&attr);
grelc_bind(result,hostname,database_name,port,&attr,&handle);
```

Query

```
grelc_select(&handle,query,&data);
```

Close Connection

```
grelc_unbind(&attr,&handle);
```

Data Manipulation

```
                // Library Usage //
        printf("Number of Records %d\n",grelc_get_number_records(&data));
        printf("Number of fields %d\n",grelc_get_number_fields(&data));
        grelc_move_first(&data);
        while(!grelc_eof(&data)){
                        for (i=1; i<=grelc_get_number_fields(&data) ; i++)
                                    printf("Field: %s ->
%s\n",grelc_get_name_field_by_position(&data,i),grelc_get_field_by_position(&data,i));
                        grelc_move_next(&data);
                }
        grelc_free_data(&data);
        exit(EXIT_SUCCESS);
}
```

Releases

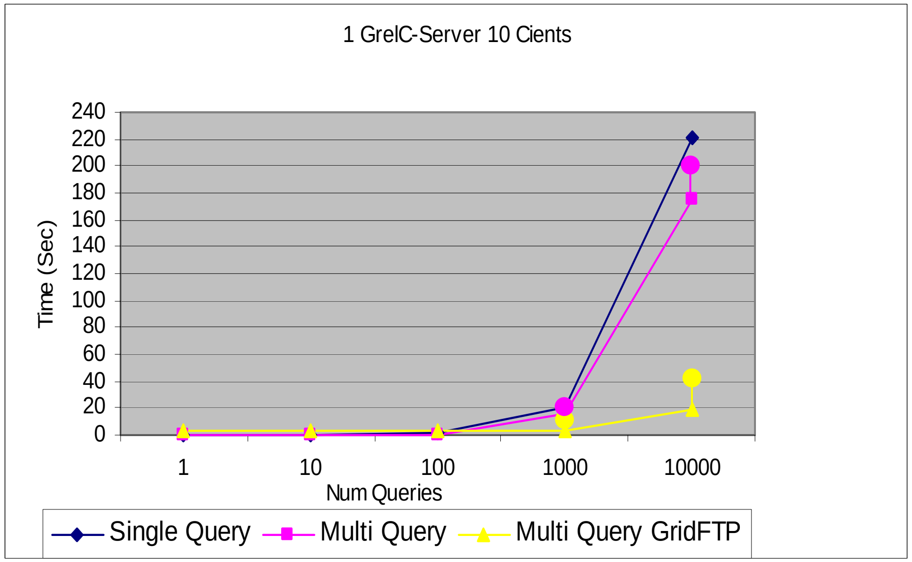
Two current releases:

1. *GRelCv1.0*
2. *GRelCv2.0*

Differences:

- Only 23 APIs in the first version vs 42 in the second one.
- Different Grelc-Server management
- New operations for data manipulation
- Extended recordset structure
- Access control policy
- Logging
- High-level functionalities supported.

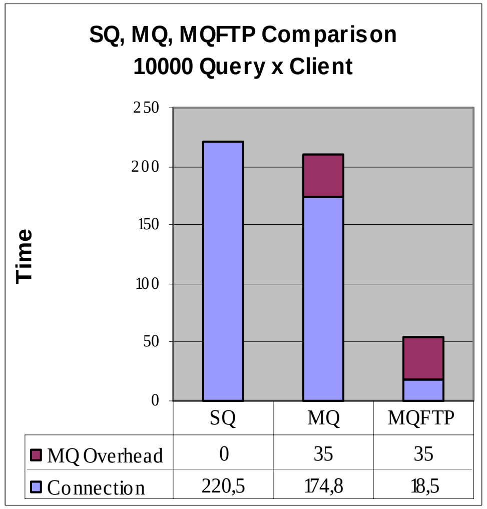
First Tests in our Campus



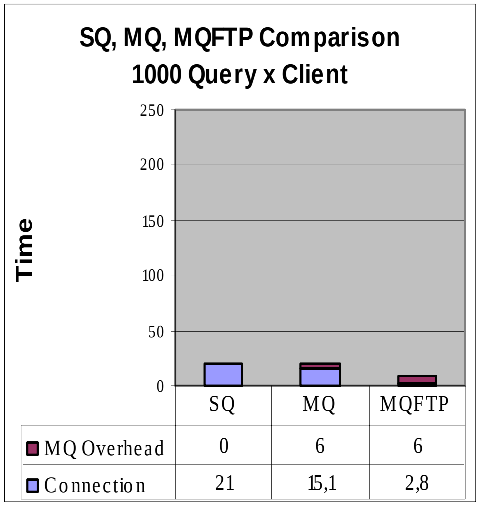
10 Clients each one submitting n (1:10000) insert queries to a unique GRelC-Server

(10:100.000 total insert queries)

Three different ways to do that.
1) 1:10.000 Single Query
2) 1 MultiQuery
3) 1 MultiQuery GridFTP



	SQ	MQ	MQFTP
🟥 MQ Overhead	0	35	35
🟦 Connection	220,5	174,8	18,5



	SQ	MQ	MQFTP
🟥 MQ Overhead	0	6	6
🟦 Connection	21	15,1	2,8

Two parallel directions

- **GRelC Library** (more performant)

  Industries

  Real Applications

- **Web / Grid Services** (less performant but OGSA compliant)

  Academic environment

  Research

Future Works

- **Web/Grid Services** Version (a basic version is already deployed and used for internal projects)
- Support for **Oracle, MySQL** DBMS
- Support for **Distributed Query** (very hard and interesting challenge)
- **Library Extensions** (new APIs)
- New Queries that support **compression** mechanisms
- **Scheduling** strategies related to replicated and partitioned databases
- **XML temporary datasets** management

GRelC Project

Grid Relational Catalog

For any information

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Project P. I. : Sandro Fiore (sandro.fiore@unile.it)

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WebSite : **http://gandalf.unile.it/grelc.html**