The Database and Architecture of Virtual and Remote Laboratories: Implementations in the Virtual Electro Lab Project

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Abstract. This paper treats the database structure and the architecture of "Virtual ElectroLab". The "Virtual ElectroLab" makes use of a relational database (MS SQL). It is also covered the communication procedure between the client and server. The paper describes the database structure exemplified through the database diagram. The web-based experiments are executed in an asynchronous mode.

1 Introduction

A relational database is a collection of data items organized tables from which data can be accessed or reassembled in many different ways without having to reorganize the database tables.

The standard user and application program interface to a relational database is the *structured query language* (SQL). SQL statements are used both for interactive queries for information from a relational database and for gathering data for reports.

In addition to being relatively easy to create and access, a relational database has the important advantage of being easy to extend. After the original database creation, a new data category can be added without requiring that all existing applications be modified.

A relational database is a set of tables containing data fitted into predefined categories.

Each table (which is sometimes called a *relation*) contains one or more data categories in columns.

Each row contains a unique instance of data for the categories defined by the columns. For example, a typical business order entry database would include a table that described a customer with columns for name, address, phone number, and so forth. Another table would describe an order: product, customer, date, sales price, and so forth. A user of the database could obtain a *view* of the database that fitted the user's needs. For example, a branch office manager might like a view or report on all customers that had bought products after a certain date. A financial services manager in the same company could, from the same tables, obtain a report on accounts that needed to be paid.

The definition of a relational database results in a table of metadata or formal descriptions of the tables, columns, domains, and constraints. [2]
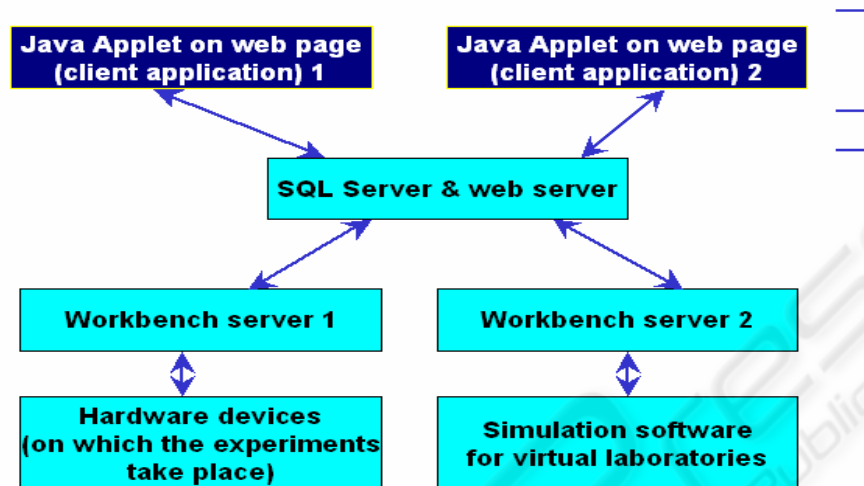

Fig. 1. Virtual Lab architecture.

2 Architecture

The current architecture for the Virtual Lab is presented in figure 1. The Java applet is the client side (front-end) for the virtual laboratory and it contains the user interface. Its role is to allow the user to send requests to execute requests and to show the results of these experiments to the user.

The SQL and web server, the workbench servers and the hardware devices will be treated from now on as Virtual Laboratory Server (VLS).

The visible part of the VLS is the SQL server, together with the web server. To this part will be sent the requests and from here will be read the responses. It is responsible for managing the experiment requests and the experiment results.

So, a request will be sent to the VLS and the response will be read from the VLS, independent of the nature of laboratory underneath the SQL and web server layer.

Considering these, we may see the architecture as a two-tier one. The client side is the Java applet and the server side is the VLS.

This architecture is integrated with the Learning Management System (LMS)

3   Communication procedure

The Communication procedure is presented in figure 2. The login page is provided by the LMS. The user is prompted for authentication before accessing the LMS.

If the login is successful, on the client's computer a cookie, containing the user name, session ID and other information is created.

After the user has acknowledged the material in the course, the LMS will show a link button to the remote laboratory page. The user clicks this link

The LMS "knows" where to find the laboratory page and opens it. The laboratory page is found on the VLS and it contains the Java Applet that the user will see.

The user needs to have the Java Runtime Environment installed. If so, the Java virtual machine will start and run the applet. The first thing the applet does is reading the information stored in the cookie (step 2). After all the initialization is done, the user will be able to use the applet for creating requests.

The user sends a request to the VLS (the location that provided the physical page and the applet classes) for measuring. This request also contains the information stored in the cookie. So, the VLS can check for validity.

The VLS sends the cookie information to the LMS. The LMS checks if the session is still valid and sends the verification result back to the VLS.

If the check at step 7 was successful (the LMS returned OK), the VLS will make the measurements and generate the results.
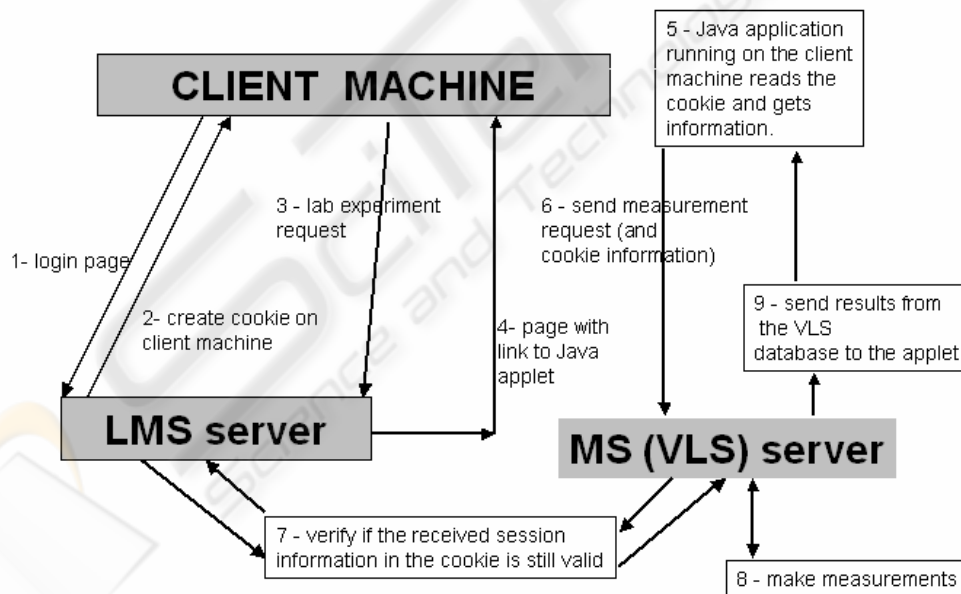

Fig. 2. Virtual Lab architecture.

The measurement results are stored in the VLS database and are sent immediately to the Java Applet running at the user, if the mode is 2, or sent when requested if the mode is 1.

4 Database structure

The figure 3 illustrates the structure of the three tables associated with the three already finished remote laboratories.

The tables on the left hold the measurement requests, and their structure differs from one laboratory to another.

The tables on the right hold measurement responses and for each table in the left, there is a corresponding table on the right.
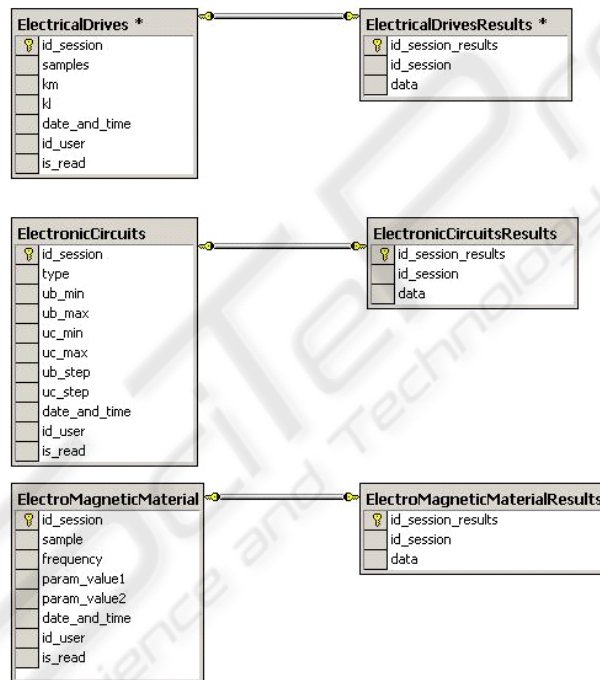

Fig. 3. Database structure.

For each record in the left table there is one corresponding record (with the same id and id_session) in the right table for a solved request and for unsolved requests, there is no corresponding record. This record (response) is created by an application, which does the actual data measuring.

5 Asynchronous web based experiments

Figure 4 presents a snapshot with example records from the requests table for the "Electromagnetic materials" laboratory.

Figure 5 presents a snapshot with example records from the responses table for the "Electromagnetic materials" laboratory.

id_session	sample	frequency	param_value1	param_value2	date_and_time	id_user	is_read
1	SST 280x30	50	induction	1000	2004 April 15 01:56:27	1082026143767	1
2	SST 280x30	50	induction	1000	2004 April 15 01:56:40	1082026143767	1
3	SST 280x30	50	induction	1000	2004 April 15 01:59:53	1082026785750	1
4	SST 280x30	50	induction	1000	2004 April 15 02:38:24	1082026143767	1
76	SST 280x30	50	field_strength	555	2004 April 17 12:02:54	1082192566639	1
77	Epstein 50	50	induction	565	2004 April 17 12:05:08	1082192566639	1
78	SST 280x30	50	induction	1000	2004 April 17 01:20:37	1082195934973	1
79	SST 280x30	50	induction	1000	2004 April 17 01:20:52	1082195934973	1
82	SST 280x30	50	induction	500	2004 April 17 02:24:52	1082201064869	1
83	SST 280x30	50	induction	1000	2004 April 17 04:56:09	1082210136815	1
84	SST 280x30	50	induction	1000	2004 April 17 04:56:24	1082210136815	1
85	SST 280x30	50	induction	1000	2004 April 17 04:59:07	1082210306048	1
86	SST 280x30	50	field_strength	10000	2004 April 17 05:01:11	1082210424829	0
87	SST 280x30	50	field_strength	10000	2004 April 17 05:11:19	1082211070758	1
88	SST 280x30	50	induction	555	2004 April 17 05:12:31	1082211070758	0
89	SST 280x30	50	induction	1000	2004 April 17 05:12:59	1082211175518	0
90	SST 280x30	50	field_strength	8888	2004 April 17 05:36:22	1082212571946	1
91	SST 280x30	50	field_strength	8888	2004 April 17 05:36:45	1082212571946	0
92	Epstein 50	50	induction	1000	2004 April 17 05:36:54	1082212571946	1
93	SST 280x30	50	field_strength	8888	2004 April 17 05:37:12	1082212571946	1
94	SST 280x30	50	field_strength	8888	2004 April 17 05:38:53	1082212571946	1
95	SST 280x30	50	field_strength	789	2004 April 18 11:41:51	1082277682421	1
96	Epstein 50	50	induction	1000	2004 April 18 11:50:57	1082278233974	0
97	SST 280x30	50	induction	888	2004 April 18 12:06:30	1082279182448	0
98	SST 280x30	50	induction	898	2004 April 18 12:08:47	1082279309941	0
99	SST 280x30	50	induction	1000	2004 April 20 03:14:32	1082463113750	0

Fig. 4. Requests table for the "Electromagnetic materials" laboratory.

id	id_sample	data
2	1	response=<res req="78" deviceid="12"><attribute id="1" name="response" type="varchar" value="1000#30000#706.7006#648.5051#1.1109483048496#8
3	2	response=<res req="78" deviceid="12"><attribute id="1" name="response" type="varchar" value="1000#30000#706.7006#648.5051#1.109483048496#86
4	3	response=<res req="78" deviceid="12"><attribute id="1" name="response" type="varchar" value="1000#30000#706.7006#648.5051#1.1109483048496#8
8	76	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
9	77	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
10	78	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
11	79	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
14	82	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
15	83	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
16	84	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
17	85	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
18	86	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
19	87	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
20	88	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
21	89	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
22	90	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
23	91	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
24	92	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
25	93	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
26	94	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
27	95	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
28	96	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
29	97	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
30	98	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51
31	99	response=<res req='78' deviceid='12'><attribute id='1' name='response'type='varchar' value='1000#30000#706.7006#648.5051#1.1109483048496#86.51

Fig. 5. Responses table for the "Electromagnetic materials" laboratory.

In order to split the synchronous functionality into three asynchronous steps, our Web Page Team has developed a more complex system, which includes the SQL Server as database.

Now, the web experiment goes through the following steps:

When the user posts a request, this is stored into the database table, which corresponds to that laboratory. From there, the application that executes the physical meas-

urement takes the request, gets the experimental data from the hardware equipment and places the measuring results into another table in the database as a new record, corresponding to the request solved.

The user can look anytime at the posted requests for a certain laboratory, because they are stored into the database. Also, the user will see which request has been solved and which not.

When a user wants to see the graphic results for a certain solved request, these will be retrieved from the corresponding database table (from where the results were posted by the application that made the measurements).

6 CONCLUSIONS

The asynchronous experiments approach brings the great advantage. This is the possibility to post measurement requests and see the results at a later time, without the need to wait online for the results.

Another advantage of this system is that it stores all the measurement values for different parameter configurations. Like this, when a student posts a request for an experiment that was already done by another student, the experiment's results will be taken from the database instead of executing the redundant laboratory test again.

The system's architecture is based on three functional levels (client – server – laboratory software (workbench server)).

REFERENCES

1. Louis, R., 1999. Software agents' activities. In ICEIS'99, 1st International Conference on Enterprise Information Systems. ICEIS Press.
2. Taylor, A., 1997. *JDBC Developer's Resource*, Informix Press.
3. Smith, J., 1998. *The book*, The publishing company. London, 2nd edition.