Integration of University Information Resources into the Unified Information Environment

Carina Shakhgeldyan, Vladimir Kryukov

Vladivostok State University of Economics,
carinash@vvsu.ru
kryukov@vvsu.ru

Abstract

Integration problems are the main subject of the paper. We determine several tasks of integration while developing of unified information environment of University: integration of technologies, applications, features, and data. We consider ways to solve all of the integration problems through web-services.

Keywords: Integration, web-service, unified information environment

1 Introduction

Any University is a complex organization to manage. It has several important features in view of business-process automation that differ it (a University) from other organization:

1. University is a big organization with updating staff and contingent of students.

2. University is organization with wide range of actions including education, research study, advertising, construction and so on.

3. There are many different information technologies in University; sometimes it is impossible to use the only technology in the unified information environment.

The first layer of business process automation is automation of every separate process with own data space. Application operates a local database. At present this approach takes place in some Russian Universities. But we can talk about the second layer of business processes automation of Russian Universities.

The second layer of business process automation implies using client-server software and database management system (DBMS). Data are integrated into the unified DBMS and the applications get client-servers. The main feature of the second layer is the data integration.

The further evolution of automation results in the third layer. The main feature of the third layer is application integration into unified software (ERP-system). The layer is not attractive for a University. There are several causes.

1. ERP system is very expensive for a University.

2. There are many problems that are not able to resolve through the only ERP-system.

3. There are several good showing applications at any University and ERP–system is difficult to integrate with the applications.

4. The University is democratic organization and it is impossible to force all developers to use some ERP–solution.

These reasons explain why ERP-systems are not popular for Russian Universities.

Sometimes the first item can be resolved for some University but the others can not be satisfied through the only ERP-system. The following layer of automation arises from attempt to solve the above problems.

The fourth layer of automation is integration of technologies, applications, features, and data. We seem the fourth layer of automation is the most attractive for University. It allows using all operating software (including ERP-systems) and databases. It allows developing new applications using different technologies and databases into heterogeneous environment. It allows implementing the unified information environment of University. The unified environment of University supports management of data and information resources efficiently.

We may reduce to table the features of the layers (Table 1).

Automation level	Applications	Data Base	Technologies
The first	Local applications	Local data base	Different without limits
The second	Two tiers client-server	Single	Different with limits
The third	Application server	Single	Single
The fourth	Multi tiers components, web-services	Different without limits	Different without limits

Table 1. Compare of automation levels

The fourth layer of automation can be provided with web-service conception. Web-services support integration applications [1, 2]. They are successful alternative to ERP-systems [3, 4]. The most of big software company announced to support web-services: Microsoft, IBM, Oracle, Sun, Bea, and so on. Moreover new class of integration tool emerges. It is Enterprise Service Bus (ESB) [5].

2 Integration of technologies

The fourth layer of business process automation assumes an integration of technologies in heterogeneous environment. There are different technologies using at the University. For example, ERP-systems (SAP\R3, OAS, or Navision) allow managing University as a corporation. They cover financial area, planning, and personal administration. Geo Information Systems (AcrVew/ArcInfo, MapObject/MapExtreme) allow managing accommodations of the University and controlling construction and repair. Lotus/Notes/Domino provides for document circulation. Oracle Application Server, Sun One, .Net or client-server applications support enterprise portal, management of education, and education directly. Directory service (Active Directory, e-Directory, Sun ONE Directory Server) manages user accounts and access to network resources.

Every of the technologies can be is used at the University to solve some problem in the best way. The technologies are not interchangeable. The using all of them are attractive at the University. The technologies can be used within the unified information environment of the University. There is way to use the technologies simultaneously. It is web-services.

Support of web-services, SOAP, WSDL by Microsoft, Oracle, Sun, IBM, Bea and many others means that we are able to organize joint operations of all technologies.

For example if Lotus application needs user rights from SQL Server database the Lotus application should send request to authentication web-service operating with SQL Server database. If web-server does not support Active Directory (AD), then web-application can request web-service to authenticate in AD. The usage of web-services allows integrating .Net and Sun One also. It is useful for integration of environments of several Universities.

Web-services allow using any technologies inside the unified information environment and not limiting one framework.

There are several different technologies at the Vladivostok State University of Economics (VSUE): .Net (C#, ASP), Oracle Application Server (J2EE), Lotus/Notes/Domino, client-server C++ and Delphi, MapObject (MapExtreme). Conception of web-services allows joining their into the unified information systems.

3. Integration of applications

There are many legacy applications at a University. The most of them are useful and necessary. They should be operated within the unified information environment. The usage of web-services in the applications allows exchanging data between applications using SOAP. The applications were developed on the base of different technologies. Architecture of the applications has to meet the fixed demands to operate within the unified information environment. The demands are

1. All applications have two parts at least. The first part is user interface and the second part is web-services. The web-services can support work with databases or implement business-logic. The web-services can talk with each other necessarily.

2. All applications interact with databases not directly but through web-services.

3. There is the only router web-service (Main web-service). It knows additional information about other web-services (where they are located) and has method for search of other web-services using key words.

4. When web-service was run it had registered in Main web-service. Main web-service knows locations (URL) of other web-services and sends addresses to all clients. The necessary web-service may be found using key words. Thus it may be connected to the web-services not having knowledge about the services. A client may know the main service and key words from knowledge domain of the web-service only.

5. Every application should be authenticated and authorized with every web-service. But some web-services or some methods of the web-services do not need to authenticate. They are accessible for anything. Free web-services allow integrating anything.

6. Authentication and authorization of user accounts are implemented with the intended web-service of authentication and authorization (AUTH web-service).

7. There is web-service supporting catalog of web-services (CATALOG). The catalog contains description web-services, URLs of web-services, WSDL files, and key words concerning with web-services. To support actuality of description CATALOG web-service compares WSDL with the web-service description into database. If it was being found discrepancy then records into database was updated and e-mail was sent to the web-service's administration and users of the web-service.

The unified information environment architecture is shown at the pic.1. There are different databases into the unified information system (Active Directory, MS SQL Server, Oracle, and Lotus/Notes). Other databases can be used (MySql, DB2, Informix) but the work with them looks like to work with MS SQL server and Oracle.

There are many web-services for the work with a database. Its quantity and functionality depend on applications and tasks of information environment. The web-services are intended to work with databases or to implement some business logic.

The web-services can refer to another web-service to get necessary information. For example, AUTH web-service can implement authentication using both Active Directory account and record about user in the MS SQL server.
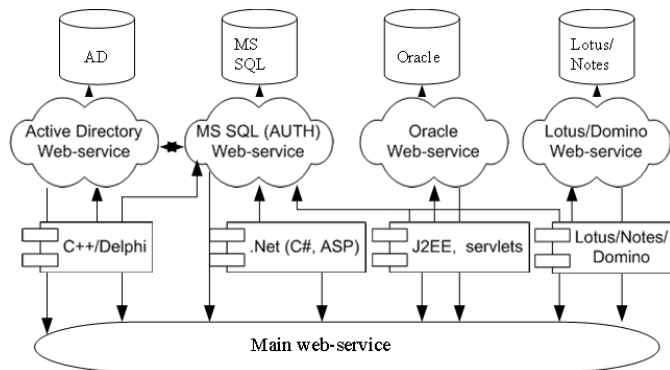
Pic.1. Architecture of the unified information environment

The applications of the information environment do not know URL of all web-services except Main web-service URL. The applications connect to it and get URLs of the necessary web-services. Then the applications may refer to the web-service directly. If application needs authentication and authorization of an account it should refer to AUTH web-service.

If an application knows nothing about web-services except knowledge domain it can refer to Main web-service using key words. Main web-service looks for the web-service concerned with the key words and returns information about the requested web-service and the invocations of the necessary methods. The application may invocate the necessary methods using the obtained information.

The applications from different data domains have been joined through the usage of web-services at the VSUE. The applications are study management, enterprise portal, finance management, information technology management, team-work support, and general management. The unified information environment of VSUE contains about 50 applications.

4 Integration of features

The integration of features implies extraction of general functions from all applications into unified system. The unified system is available from others; general functions should be moved from these systems. The approach allows aggregating identical functions into one application, to simplify maintenance and updating of applications.

We try to abstract our mind from specific business processes and we will consider software of information environment in the view of the design and the development. We may distinguish several general features irrespective of system functionality:

1. user's registration;

2. administration of users (assign roles determining user's rights including functionality and data domain);

3. creation of reference books;

4. implementation of specific functions for the systems (for example, salary accounting, operating with special-purpose equipment and so on);

5. reporting.

We have gotten five blocks that should be present in the most information systems. We may implement four blocks (1-3-th, 5-th blocks) the only time in the specific system. All applications should be direct to use the system. Thus software development may reduce to develop of the only fourth block using different databases, technologies, and applications.

4.1. The unified registration

The unified information environment proposes the management of different systems, network, and communication recourses and the support of regulated, controlled access to the recourses. The combination of login and password are used for access to the recourses. As databases storing login and password can be considered DBMS (MS SQL Server, Oracle, MySql, DB2 and so on) or directory service (Active Directory, e-Directory, and other LDAP-servers).

If at the University there are several systems having own set of users then we can not manage user's rights efficiently and we can not support actuality of user accounts. Moreover the users will forget different logins and passwords permanently.

Recently several software companies support a dictionary services. But there are many constrains. For example not all software may operate with the certain dictionary service and sometimes the dictionary service can not be used because of the safety requirements. AD, for example, stores user accounts into domain controller located inside corporative network. Web-server located in external network can not use accounts from the domain controller because there is a firewall between internal and external network obstructing requests from outside to inside. In the other side accounts of AD are proper to access internal recourses including network.

Attractive solution is unified registration system for internal local and external nets. The user will obtain the only login for access to all recourses independently from its location. The system should support the actuality of user accounts. As a result of the registration two accounts for one user will be created. One account is account of the directory service and another account is record in database. The second account provides access to external recourses where AD controllers are not available.

Active Directory is used at the VSUE for local network. The account of AD provides access to

- local net;

- file servers;

- corporative databases;

- Internet and e-mail;

- internal corporative portal.

The accounts storing into DBMS are used for access to external recourses of the University: external web-servers and external portal of the University.

We use Active Directory with four domains: root, adm, stud, and empl at the VSUE. Adm domain contains corporative servers, Empl domain includes employee's accounts and its computers. Stud domain contains student's accounts, computers from educational rooms, and computers of library.

Pic.2 shows the usage of accounts in the unified information environment.
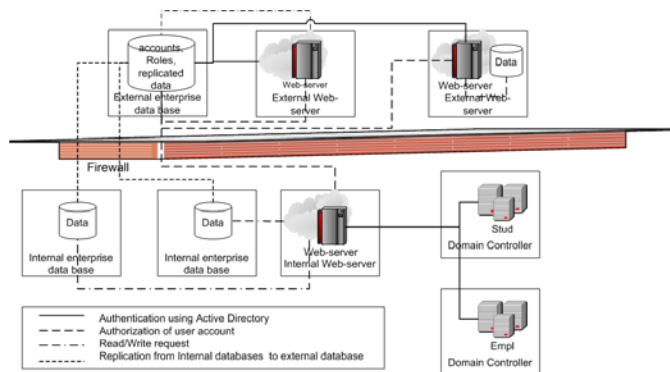
Pic.2 The usage of two user accounts

At the University there is necessary to use file servers for teachers, employees, and students to interchange files, to support team work and to store information into private folders. File servers can store system and corporative software, data for backup and others.

Because of often change of staff and contingent of students it is difficult to manage file servers: to assign the rights, to create, move, and delete the folders. The management of file servers should be automated. The creation of private folders and assignment of user's rights are accomplished through user registration.

We suppose there are two file servers: student's file server and employee's file server.

The unified registration system has the following parts

1. End-user web interface;

2. Web-service (bridge between Web-interface and manager-service);

3. Manager-service IRAS (the main part of the registration system);

4. Service for creation of AD account (IRA LDAP);

5. Service for employee's file server (IRA FSE);

6. Service for student's file server (IRA FSS);

7. Service for data actualization (IRA DB).

The students and employees (including teachers) may register through web-interface at the University portal. Module located on the web-server (web-service) verifies information using corporative data replicating on the external database server and passes management to manager-service IRAS. IRAS passes management to service for creation of AD accounts, the service creates account and enters the account in all authorized groups of AD. Then the management is passed to services for employee and student file servers. The services create predefined folders for the account and assign the rights on the different folders. In case of success registration AD accounts has been created and management is passed to module located at the Web-server. One more account (having the same login and password as AD account) is created and located in DBMS.

As a result of registration two accounts for one person have been created. One account is located in Empl or Stud domain of AD. It has defined rights for access to file servers. It has been included into specific user groups. Its rights depend on user's role at the University. If user is head of a department he has one rights group, if he is subordinate he has another one. If user was teacher the specific folder on the student file server had been created. The folder is intended for exchange files between the teacher and students. The other account has been created as record in database.

The registration web-site is located on the internal web-server for the users of internal network and on the external web-server for the users of outside. Two DNS-servers support the same URLs for two web-servers. Internal registration creates two accounts at the same time. External registration creates one account as record in database. Account of AD is created by actualization service operating one time a day. Actualization service is located on the internal web-server. It connects with external database and creates AD account. The procedure was introduced in connection with security demands (requests from outside to inside are prohibited but requests from inside to outside are permitted).

External registration is used for registration of outside users also. The account provides access to external University portal.

Structure of folders on the file servers corresponds to organization structure. The folders are created automatically through user's registration. The private folders had been deleted after dismissal of the users automatically. If user went to work at the other department of the University his folder had been moved to suitable place of folders structure. These procedures are carried out with actualization service.

Pic.3 shows architecture of the unified registration system. It has been implemented at the VSUE. All employees, students, and external users registered using the system. Employees and students have two accounts with the same logins and passwords. The passwords can be changed in future and they

get different. External user has the only account.
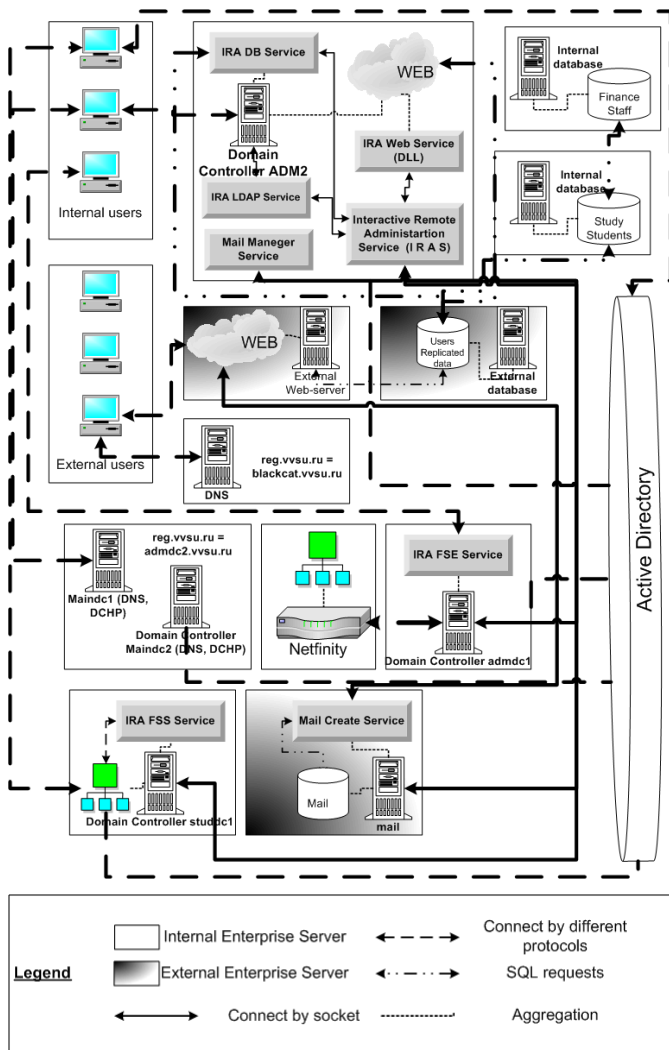
Pic.3. Architecture of unified registration system

Structure of folders on the employee file server is organized in the following way:

- The first folder is Employee
- Folders corresponding to structure of organization are arranged into Employee folder
- Folder of department contains the following folders
  - Incoming
  - Outgoing
  - Inside Info
  - Backup
  - private folders of department's employee

Access to Incoming and Outgoing folders is given for heads of departments. The folders are intended for exchange of files between different departments. Access to Inside Info is permitted for all employees of the department (including embedded departments). The folder is intended for exchange

of files between employees of the department and embedded departments. Backup folder is intended for storage of information intended for copy to tapes or CD-ROM.

Every employee has private folder. Nobody has access to it. The folder contains embedded folders:

- Personal
- Shared
- Incoming

Personal folder is inaccessible for anybody except the employee. Shared folder is accessible for anybody to read. Incoming folder is accessible for anybody to read and write. The employee can be created new folders into Shared or Incoming where access is limited for somebody.

There are several folders at the same level as Employee. The folders are intended for system software, enterprise software, and others. Access to the folders is given for all employees to read and some employee to write.

Structure of the folders on the student file server is organized in the following way:

- Teachers is folder intended to exchange files between students and teachers
- Students is folder for students
- Free software is folder where anybody can find required software.

Teachers folder has folders corresponding to structure of University. Every teacher has his folder to put files for students. All students have access the folder to read. Students folder has embedded folders corresponding structure of University and student groups. Every student has his folder. The teachers have access to some folders to read. Access is determined where the teacher works.

4.2 Access management system

The users should have rights at the University information environment to access the recourses. The rights are assigned basing on the user's positions at the University, his status, and feature of his functions.

The system of access management is intended for assignment of access rights. We are discussing conception of the system.

The unified information environment of University contains project groups. There are groups of education, financial management, education management, personal information, information technology management, and others. The every project has a number of features such as name, belonging to a group, URL, creation date.

The role in a project is a collection of some capabilities for user in the framework of the project. The role has name, belonging to a project, creation date, URL of role (if it differs

from project's URL), constraints of life time, scopes of data domain.

The roles may be assigned to user accounts storing into database. But Active Directory account has login the same as account from database so the roles are assigned for user independently of used account. The most part of roles are assigned automatically. For example the roles "Student" in any project are assigned to all users who has category "student". But some roles should be assigned manually by a system administrator. The scope of role confines available data space. For example, the role "head of a department" provides access to information of the only department where the user is head.

Role may be assigned basing on some features. The features is named filter. There are several filters:

- User category (student/employee/external user/application user/ex employee/ex student);

- User's position at the University (president, vice-president, teacher, developer, book-keeper, and so on);

- Department where user works;

- Type of position (for example, department head)

- Type of department (for example educational department, library, dean's office, sub-faculty)

- Specific registered user.

The filter can be unified through assignment. Dean role may be assigned using two filters: type of position (head) and type of department (dean's office). The filters were joined with logical "AND". Filter groups may be joined with logical "OR" or "NOT".

UML class diagram is shown at the Pic. 4.
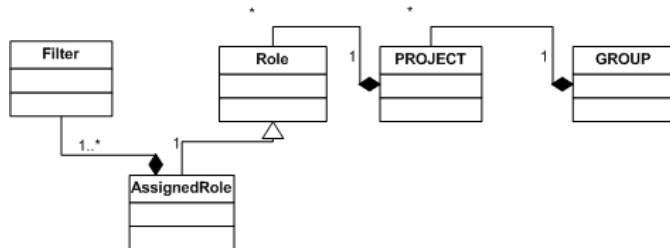
Pic. 4. Class diagram of access management system

The roles can be assigned before certain date. After the date user loses his rights at the project. The role can be inherited from others roles. If role B is derived from role A then role B has at least the same access as role A. The role of project administration can aggregates others role. If role A aggregates role B then role A has access to role B as A but role A has not the same access to the project as B.

The flexibility of access management system allows assigning any rights to various groups of users. All applications in the environment of VSUE support the system.

5 Integration of data

The unified information environment supposes the usage of several database servers on the different computers. Data should be integrated with each other. How can be implemented the integration.

1. For every data space there is the only server for primary data input.

2. The only application is responsible for data generation in some data space. The other applications can use the data but they can not change it. For example ERP-system allows entering staff's information and other systems can use it but they can not change it. It is necessary to be guided by rule "data should be created in the only place but data may be used in the different places". The rule allows avoiding information inconsistency and to use different technologies at the same time. For example, we guarantee that the user account may appear only after employee's information has been inserted into employee's database.

3. There are many database servers with different technologies in the unified information environment. Data can be replicated from one server to other servers. Some servers contain data replications from several different servers. Replications are implemented as often as necessary.

4. Databases can be integrated at the application level. One database contains references to another database (MS SQL Server on Oracle, for example). These relationships are understandable for applications but not for databases.

5. The important feature of data integration is support of data actualization. Data actualization is implemented though triggers, database procedures, services, and applications.

6. There is general data repository of all databases. The base part of the repository was generated using the intended tool. But the real repository of the unified information environment contains much additional information: binding data to software projects, definition of primary data, and integration of data at application level.

Data actualization has to provide actuality of data in real time mode. For example if employee was fired then changes had to be done as soon as possible. His account got disable, his rights were deleted, and records including his account were killed in all databases (or update to null) if it was necessary.

One of the complex procedures of actualization is change of unique identifier. It is desirable to avoid change of unique identifier but if it is impossible it is necessary to have procedure when all references to the changed identifier were updated. General repository is needed there. Triggers or procedures have to trace the change of identifiers and to store information in the intended tables (old and new identifiers).

Then the intended service scans the table and update identifiers where it is necessary.

Integration of departments in the system of personal management results in automatic transfer educational programs to one new department regardless of the fact that the business-processes are implemented by the different systems operating different data

Actualization process except replications may be removed to separate application or service. The process includes also shutting e-mail on the mail server of University for discharged person, blockage of access to rooms, and other prohibitions.

It is necessary to use database description to support the unified information environment. There is automatic-manual database description (general database repository). General database repository aggregates separate database repositories and includes descriptions of peculiar features. These descriptions include links between data and projects (the systems of University environment), definitions of primary data, and relations between different databases. The information should be input manually as it can not be gotten automatically.

6 Conclusion

The unified information environment has been developing at the Vladivostok State University since 2002. The registration and access management system was developed. University portal has been developed using the system. There are fifty services and applications using the system.

The usage of web-services simplifies updating, maintenance and development of new applications for the unified information environment.

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