Integration of a Workflow System in Class Management and Teacher Service Distribution in ESTSetúbal

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Workflow, XML, Application Integration.

1. EXECUTIVE SUMMARY

The Superior School of Technology of Setúbal (ESTSetúbal) is one of the schools from the Polytechnic Institute of Setúbal, in Portugal. ESTSetúbal owns an Information System (SI-IPS) that integrates information about students, teachers and academicals records, but it doesn't contemplate the creation of a class and its attribution to teachers, nor counts the lectured hours. In these conditions the School felt the need to develop an application for that effect.

This paper describes the methodology used in the development of a new integrated application and the respective benefits for the users. This new application will allow a correct distribution of the teachers lecturing load, considering the type of lecturing hours and organization roles, according to the teacher's categories. On the other hand, it will be possible to have historical data of the several semesters and management reports in a fast and precise way. The existent process is rudimentary. A standard model doesn't exist when it is necessary to communicate with other entities. Version control and historical data does not exist and it is always very difficult to maintain the Teacher's Service Distribution updated along the semester.

Another problem is the approval and decision flow, it implicates that the file flows among the intervening entities, causing the loss or alteration of the contained information. In addition, this process takes several days, between rulings and "mail" sending.

With these facts in consideration, it was created a Workflow management tool allowing the delivering and control of information, in agreement with the phase the process is in. When a phase of the workflow is achieved, XML files are generated with an image of the existent information in the Database. This version, in XML, is available for the users/entities that don't belong to the next phase of the workflow, and just the users of this phase get to manage information in the Database. This technique allows that conflicts or differences between the validated information by the workflow and the work version are not visible to users, reducing the "interpellation" to the people responsible and increasing the flexibility in the simulation of alternative scenarios.

As some data in the new application exists in the Information System database, integration between the two databases was taken place using XML. This way the information is updated without committing the safety and integrity of both databases. The application has advantages to the improvement and optimization of existent processes, namely in what concerns with the information flowing between the departments and Management Councils, delivering a larger transparency and simplification of processes and requests answering capacity. This paper also analyses some results and the used methodology to validate them, and proposes future work.

## 2.	INTRODUCTION

The main objective of class timetable is to distribute classes and resources uniformly, considering teachers and classrooms. It is impracticable to have classes, of the same discipline, lectured in the same day or at the same time, because it would require an enormous effort of teacher's coordination and a larger number of teachers to fill all the lecturing classes, and pedagogically, for the student would be disastrous.

For a good school image near the student and to the society, it is necessary that the timetables are ready and functional at the beginning of the semester. If the school doesn't comply with this rule, it may evidence disorganization, student complaints and semester beginning delay.

The Superior School of Technology of Setúbal has an Information System (SI) that integrates information about students, teachers, records and academic acts. This SI was not prepared to create classes and its attribution to teachers, neither to account lectured hours of a teacher, which varies according to his career category, position and job contract regime. From these factors emerged the need for the School to have an application that fills this gap and deliveries and effective management tool.

The objective of the new application is to improve and optimize the processes in use, namely the information flow between the Departments and Management Council, to achieve higher transparency and simplification of the processes and faster response capacity to solicitations.

The new application will allow a correct distribution of the teacher lecturing load, having in mind the career categories, job contract regimen and teacher's positions. It will be possible to have historical class creation iterations and TSD – Teacher Service Distribution, of the semesters, and have precise and fast management reports.

A problem to resolve is the approval and decision flow of class creation and TSD, which currently implies that an Excel file circulates between the intervening entities. This can lead on loss of the information contained, and this process can be delayed for several days, between approval forwarding and email sending.

With this in mind, a Workflow tool was created that will allow the delivery and information control in accordance with the phase of the process the workflow is.

To provide consistent information between the Portal of ESTSetúbal from SI-IPS and SI-EST DSD (our developed application) an integration module was created, using XML manipulation techniques, which allow the easy and fast delivery of data between the two applications.

## 3.	THE SI-IPS PROJECT AND ITS ENVIRONMENT

3.1. Setúbal Polytechnic Institute

Setúbal Polytechnic Institute, a public institution of higher education, was created in 1979, and includes the Presidency Service, a Welfare Social Service and five Colleges that offer a range of graduate courses in different areas such as Technology, Education, Business Administration and Health Care. The institution has 6500 students, 505 teachers and 169 technical and administrative collaborators.

3.2. ESTSetúbal

The Superior School of Technology of Setúbal – ESTSetúbal, is one of five schools from Setúbal Polytechnic Institute. Allying quality, technological and scientific knowledge it has degrees in Engineering Courses, develops Investigation and Post-Graduate Courses.

Formally created in the 26 of December of 1979, the ESTSetúbal initiated its learning activity in 1988/89, having the objective to form qualified intermediate superior level technicians, in important technological domains for its region.

This school has technical engineering like Computer Science, Mechanical, Electronic, Environment, Automation Control and Instrumentation and Biomedics Engineering. ESTSetúbal also has Master

Degrees in some areas, Pos-Graduated Courses and Scientific Research, Technologic Specialization Courses, Experimental Development and Cooperation in national and foreign projects.

ESTSetúbal has more then two thousand students, 188 professors and 79 administrative and technical collaborators.

3.3. Information System on IPS – SI-IPS

Five years ago, IPS felt that some existing information systems were islands of information, spread by departments and School's. At the same time the IPS and the schools needed to get management indicators and felt that information was spread on small non integrated information systems. All the stakeholders of the education process needed to have access to their information online and therefore needed a new integrated system.

Five years ago, a team started to analyze all the academic information systems all over the country and defined that there was only a really stable, solid and tested system that could be installed in IPS – SIGARRA.

SIGARRA - Information System for the Aggregate Management of Resources and Academic Registers is an academic system of conceived information as central tool of information management for Superior educational establishments. The system initiated its implementation outside Porto University in Setúbal Polytechnic Institute (Ribeiro et al. 1998), (Ribeiro et al. 1999), (Ribeiro et al. 1999a), (Ribeiro et al. 1997).

The functionalities currently available are related with information about courses, academic registers of students, management of human resources and installations and registers of the scientific activity (Ribeiro et al. 1999), (Ribeiro et al. 1999). SIGARRA's system architecture is an integrated Web based information system, a student's management application (GA) and human resources management application (GRH).

The implementation of SIGARRA system started more than two years ago and takes place in all the organic units of the Polytechnic. The system is in production in the Superior School of Technology of Setúbal (ESTSetúbal) from the beginning of the winter semester of 2006.

4. INFORMATION SYSTEM PROJECT SI-EST-DSD

ESTSetúbal has an Information System (SI) that integrates information about students, teachers, academic registers and acts, but does not contemplate creation of classes and its attribution to teachers, nor accounts for lectured hours. It also does not have the ability to assign the discipline responsibility or co-responsibility to a teacher and to manage teacher's job regime contract or career category lecturing hours. (Gonçalves et al. 2007).

Has a final course Project, it was developed an information system with the main objective to improve and automate the Teachers Service Distribution Management (SI-EST-DSD) with the existent SI, because the process was manually made and with few defined rules. The objective is to improve and optimize the existent processes of the information flow between Departments and Management Council, in view of a greater transparency and simplification of the process and ability to fast reply to requests.

The main objectives are: create an data infrastructure support; obtain the today's practices; propose better alternatives; create the flow of actions and necessary rules to the functioning of the application and optimization of TSD process; deliver forms of information viewing in a simple and fast way and to deliver predefined base reports.

Attending the requirements, the Project is divided in three main modules (see Figure 1):

1st Module - Automate all the TSD process, that is, to collect all information for timetables creation and accounting of all teachers lecturing hours.

2nd Module - TSD creation and update, Version Management and TSD Historic Management. From the update of the TSD throughout the semester, some versions are created, that later will be the historic of the application.

3rd Module - Creation and integration of Class Map with TSD. Creation of functionalities to automatically generate and group classes with statistical data supplied by the Human Resources

Management application (GRH), or the possibility to do this manually. At this moment the Class Map is made in MS Excel and is imported for the SI-IPS application.
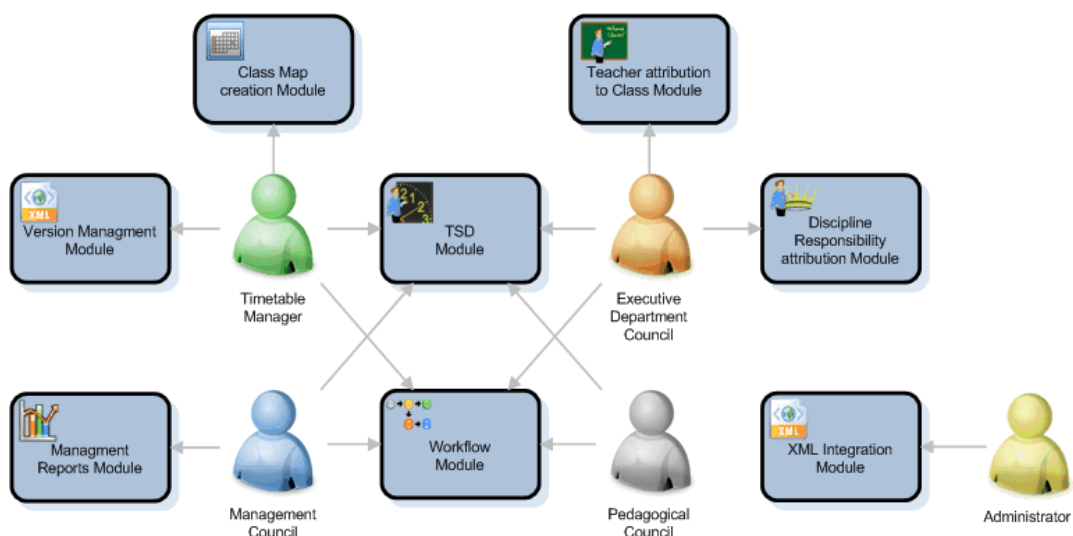

Figure 1 – Application Modules and actors

The project design is based on the existing Information System, having to be total integrated with it.

The application has three access levels: General, Department and Teacher access. Depending on the user level, the privileges will be different for access to the application. Each user only has access the areas where he is involved, preventing uninformed users to modify certain department plans which they do not belong. Pages information access is limited by user level, having guaranteed the segregation of functions. The information is automatically filtered by department if the user is a Department user, meaning that the Timetable Manager, Management and Pedagogical Councils can see all the department's information but the Executive Department Council user can not.

4.1. SI-EST-DSD Portal Implementation

The existent TSD Information System is rudimentary, at this moment the process is manual. It consists of an MS Excel file that contains all the information that is worked throughout the semester and is passed along all the intervening persons. MS Excel is a powerful application, but anyone can change the contained information and it is very difficult to create a workflow in the file.

When it is necessary to communicate with other entities there's no standard model, for this fact, becomes difficult to work the information. There's no historical version control and is always very difficult to keep the TSD updated throughout the semester. Other problems are the flow of approval and decision, which imply that the MS Excel file circulates between the intervening entities. This can take to contained information loss or alteration and the process can be delayed for some days, between approval forwarding and email sending. As this process have various iterations in information, its makes nearly impossible to have instant delivery of information to every personnel and to maintain one master version.

The objective of this application his the improvement and optimization of existing processes, flowing of information between the Executive Department Councils and the Management Council, in view of a bigger transparency, processes simplification and fast reply capacity to requests.

4.2. Methodological Approach

Our approach is organized in different phases - analysis and specification of the requirements, design process, implementation, test and documentation and users training as showed in Figure 2.

Analysis, specification of the requirements and design that had as objective to structuralize the specific problem in study, defining the objective of the project, chronogram of the work, pointers of

performance and a symbolic representation of the system through UML diagrams and drawing of the database entity-relation model.

Implementation: application development in agreement with the requirements previously elaborated. All the error tests also had been carried through in this phase, being the solution in constant show in a server so that the customer could follow the work and make suggestions. Diverse customer presentations and meetings had been made.

Test and documentation: User and Administration Manual of the application will be developed. The manuals are to be delivered in the final phase during the training activity. The referred tests are not to discover programming errors or faults, but tests to application compatibility with School needs and to get final suggestions about displayed information.

Training: Training for the Administrator and Timetable Manager.
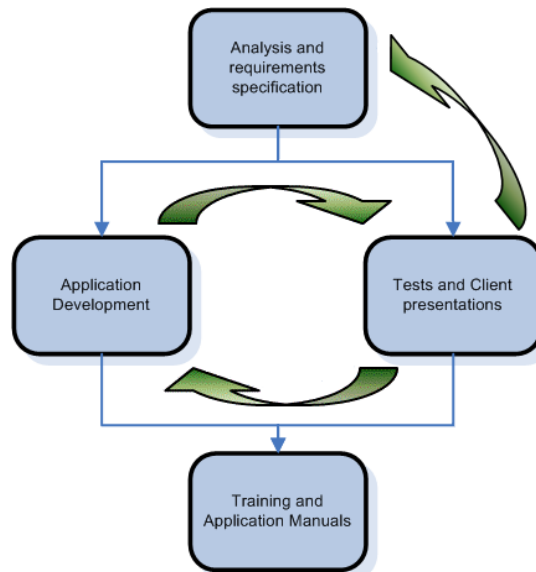
Figure 2 - Application Development Model

4.3. Technological Approach/Methodology

The application is web-based, where the final user only needs a PC with an internet or intranet connection, a browser and Office Applications to view predefined and downloadable information.

The application uses the .NET 2.0 Framework with C# programming language.

The interface is implemented through Web ASP.NET pages, so it is used the Web Server IIS - Microsoft Internet Information Services. The data base server is the Oracle 10G Release 2. To improve the usability and performance of the application the AJAX technology was used to allow the update of only parts of the page, decreasing the requests to database and becoming faster in deploying the functionalities.

The information supported in these technologies, of recognized efficiency and stability, are of easy use and installation, as well as they facilitate the contained data management and are of fast access to online help and documentation.

5. SI-EST-DSD PORTAL MAIN FUNCTIONALITIES

The application is divided in five areas: Automation of all the TSD process, TSD creation and update, Version Management, Historic Management, Workflow and XML integration. The main functionalities are:

- Teacher information and TSD;
- TSD History;
- Workflow phase state viewing;
- Send to next Workflow phase;
- XML Integration.

After automatic classes/instances creation it is necessary to associate a class to a teacher. This association is made by the Executive Department Councils users. The functionality described allows viewing resumed information about classes and the teacher's choose to lecture them (see Figure 3). If needed, by following the instance, discipline or teacher link, it can be seen the specific and detailed information about teacher and disciplines associated to an instance, or all classes for a discipline or all classes lectured by a teacher, respectively.

Figure 3 – Class Map with TSD integrated

5.1. TSD - Teachers

The teachers have to lecture a determined number of lessons per week, which can vary according to his career category and with the contract percentage (ex: the contract defines only 20% of the number of weekly lessons for the category). Of the hours above can be attributed periods of non lecturing hours to perform specific functions or positions (ex: Course Director). As the hourly load of lessons, for Department, varies according to the semester, it is necessary that the teachers lecture more or less hours of what foreseen for its category. These hours will be compensated in the following semesters.

This functionality allows displaying the summary of the TSD and navigation to detailed information of a specific teacher (see Figure 4). All the hour attribution, reduction and others are accounted and displayed resulting in total hour availability in the semester.

Figure 4 – All Teachers TSD

5.2. TSD of one Teacher

So, for a transparent process it is necessary that exists TSD History throughout the various semesters. This functionality allows displaying information of a certain teacher and, in detail, the summary of his TSD (see Figure 5). Displayed in page bottom is the historic information accounted for TSD.

Figure 5 – Teacher TSD

5.3. Workflow Phases Viewing

The workflow phases have priorities between themselves, phase type (initial, intermediary or final), and also know which phase is the previous phase and the following phase in the flow. To each phase, intervening user types are attributed to the phase, in accordance with its role in EST. This page allows viewing the relation between phases (see Figure 6).
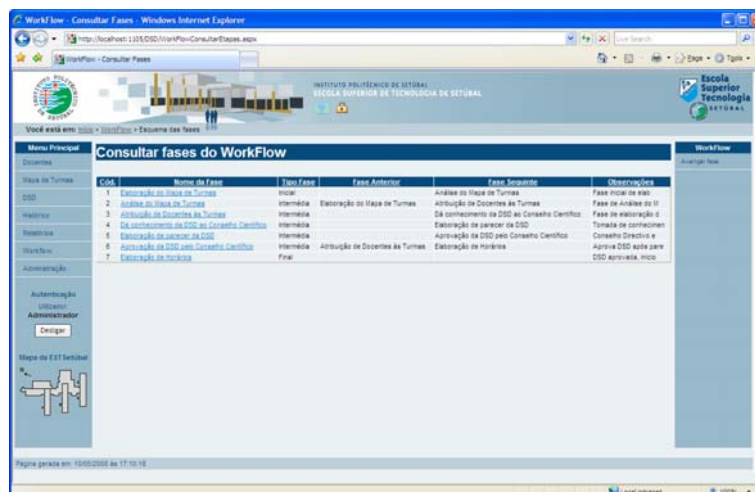
Figure 6 – Workflow Phases Viewing

5.4. Workflow Phase Viewing

With the page in Figure 7 it can be viewed, in detail, the structure of a phase, knowing also its intervenient and which departments they belong, as well as viewing the previous and following phase. On the page bottom there is a table with links to follow the different phases. This functionality helps in perceiving the flow and potentials errors of configuration.
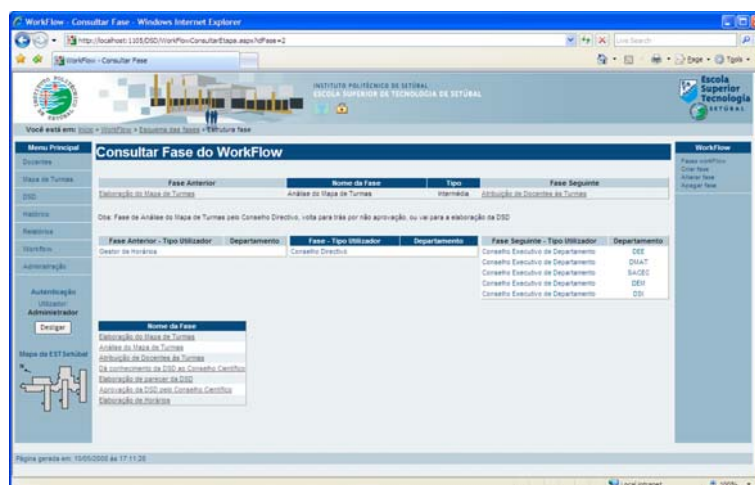

Figure 7 – Workflow Phase Viewing

5.5. Workflow Phases State Viewing

The state of the workflow phases can be viewed (see Figure 8) to control the flow of work of TSD or the class's creation process. It can be retrieved information of the user type whom the phase withholds and which it's his department, the phase state, beginning and end date (in case already finished). This functionality is of extreme importance for the Timetable Manager and to Executive Department Councils, since it allows following, and consequentially to speed up the management processes.
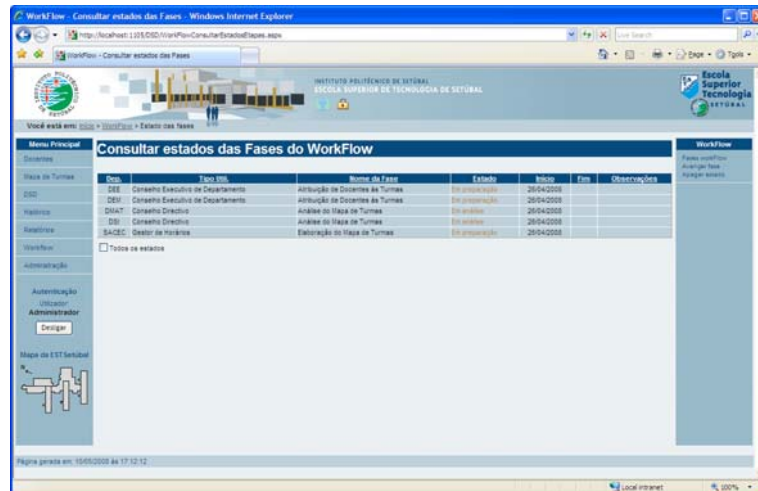
Figure 8 – Workflow Phases State Viewing

In this "Workflow Phases State Viewing" page fragment (Figure 9), witch is the result of expanding the table in Figure 8, it can viewed detailed information about the state and phase the process passed trough and the states beginning and end dates. This fragment it's obtained with a user type that intervenes in all department's workflows, but one department user type can only see information about his department. The highlighted lines are the current workflow phase states and there is a colour code for the state type.

Figure 9 – Detailed Workflow Phases State Viewing

5.6. Current Workflow Phase Reporting

This page (see Figure 10) is the one that allows a user to report the phase passed to him. It allows inserting notes to register his decision. The Timetable Manager, the Management Council and the Pedagogical Council belong to workflows of all the departments, therefore exists the possibility to report the phases of one specific department. There is the possibility for viewing a summary of all the phases and there states to this point. This functionality does not finish the Workflow phase; this capacity is presented in the option "5.9.Send To Next Workflow Phase".
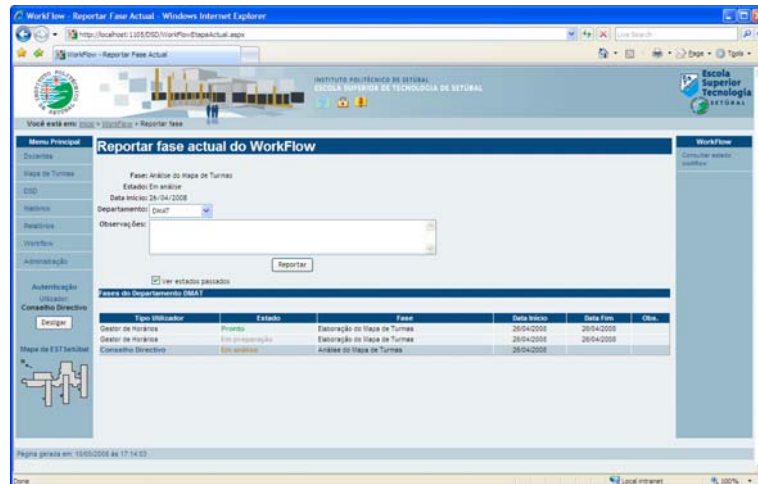
Figure 10 – Current Workflow Phase Reporting

5.7. Choose Next Workflow Phase

In this page (see Figure 11) are presented workflows that the user belongs to and in which its intervention is asked for. Phases have states defined that make possible to advance to the next phase or to fallback, as the state is of approval or denial or simply for information. It is possible, through one configured link, to get the information that is necessary to be able to take the decision to advance the current phase. There is a flashing icon on the top of the page that signals to get attention to the workflow and remains flashing until there's no need for intervention in workflow.

Figure 11 – Choose Next Workflow Phase

5.8. Send To Next Workflow Phase

In the page presented in Figure 12 there is information about current phase, its state and former notes. At the page bottom it is showed information about the next phase according to the phase final state the user choose. This page allows to write notes on the taken decision. When creating the next phase, the token is transferred for the next intervening in the workflow, giving continuity to the process. In this moment the XML file is created with the database information of the department in question.

Figure 12 – Send to Next Workflow Phase

6. XML INTEGRATION WITH SI-ESTSETÚBAL

The integration between systems allows getting more detailed and rigorous information that facilitates business analysis by allowing different systems to function together as one by combining information. It makes all the processes more efficient, leading to a more reliable relation between all systems, saving time, effort and errors reduction.
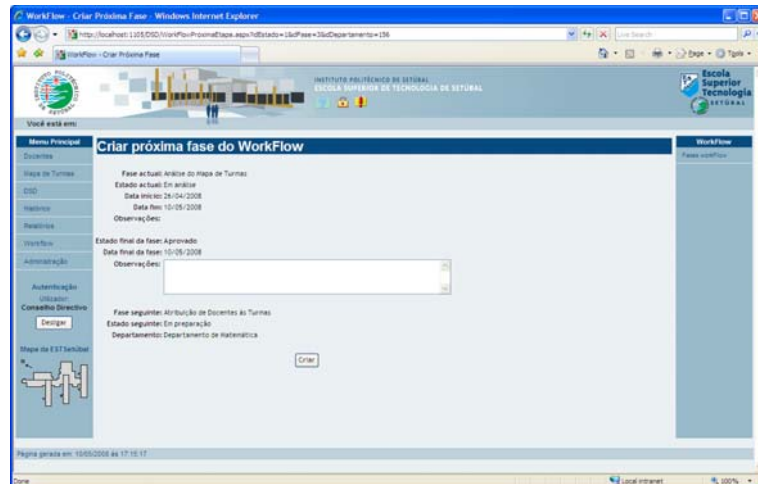
The XML appeared has facilitator, promoting a standard of integration in the exchange of digital data, simple, structuralized, extensible, flexible and semantically rich (Champion 2007). Its primary purpose is to facilitate the sharing of structured data across different information systems.

Any type of data can be represented in XML. It uses an opening and closing system of tags similar to HTML but not fixed. It is platform-independent, and adapts to changes in technology. XML file may have a description of the type of XML document called XML Schema, typically expressed in terms of constraints on the structure.

A database table can be represented by XML, the table name may be the root element, table column names can be XML elements and data is inside each XML element. Therefore the XML Schema is of great use, because it can define the structure of each table represented and the data type of each table attributes.

If XML can represent a database table, it means that the table data now is portable and can be use in other systems.

Differences between importing XML data and other importations exist. XML Data Import normally is made to an existing table and not to a new table, witch requires the existence of a table for which to import. The XML Data Import is a transitional operation. It can be composed of a set of operations and if an operation fails, the entire transaction will be reverted and none of the data will be imported. This set of operations is very dangerous to database consistence, meaning that a minor error can ruin the integrity of information. The XML Data Import executes the following tasks as represented in Figure 13: XML file uploading, consistency verification between stored data in XML file and on the database, introduction of the XML file data in the selected table.
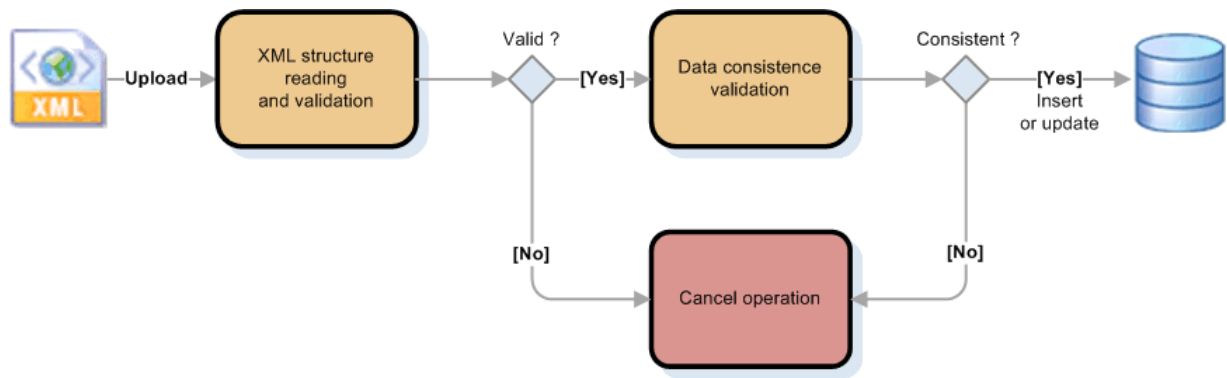
Figure 13 – XML file validation

For example, the discipline update process can be done through the loading of a XML file, or the classes can be exported to a XML file in order to be processed by an external application.

The XML is also used to manage the workflow versions. The action of passing the token of the workflow to other intervening user, triggers operations of XML file creation with the information of the department that workflow withheld.

7. WORKFLOW

The organizations must automate its internal processes, to not only reduce costs, but also to increase the satisfaction of the collaborators. The capacity of an information system to automate certain tasks in an organization is crucial for the adaptation to the business necessities. The Workflow technology allows the combination of rules associated with the business processes, necessary to its execution. It makes modelling possible, management and monitoring of the information flows and associated work to the business processes (Fischer 2003), (Georgakopoulos et al. 2005), (Aalst et al. 2002). A Workflow implementation helps the organization to think about its information flow and may even potentiate the discovery of ambiguous user roles or unnecessary steps in information approval or flow.

7.1. Workflow Specification

The Workflow integration in SI-EST DSD allows faster and more comfort ways to delivery information and permits the elimination of existing work copies in MS Excel files with TSD drafts. The Workflow allows configuring process intervenient and the associated departments; it is possible to the administrator to define which actors, which phases and which the states are part of the process; it is possible to configure the chaining between phases of workflow and to define which phase is the trigger to the process and which finishes it. The Workflow technology is a way to guarantee fast deployment of trustworthy contents and with quality.

Main advantages:

- Definition of the actions sequence to be executed for the process of workflow;
- Definition of the specific information of each process;
- Visualization of the action that each person has to execute;

It is possible to view all the history of actions for each process, who made what and when, and the phase duration.
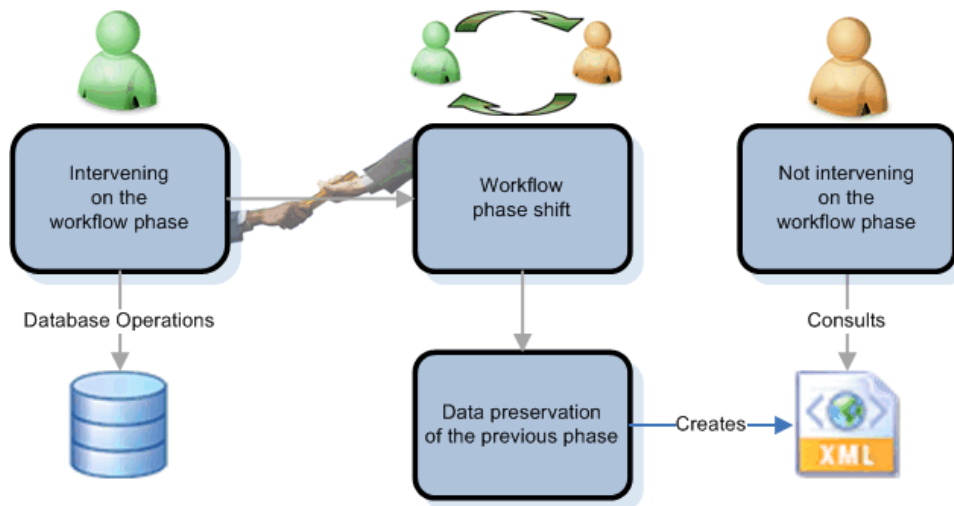
Figure 14 – Information managed by Workflow

The conclusion of a workflow phase operation normally means that another actor will have intervention in the process. The next intervenient has a distinct role in the organization, and will be able to modify information of SI in accordance with its role in EST. In order to allow scenarios simulation, without others modify, view or question the created hypotheses, it was introduced a XML manipulation technique. This technique allows to keep constant the information created until the moment of the workflow transition and to make possible the modification of the information in the database for the detainers of the workflow phase. The data in the database, at the moment of workflow transition, is preserved using XML technology in order to keep an information copy of one specific department (see Figure 14). Only one XML version will exist, for each department, which is immediately collected before the finishing of the workflow phase.

This implies that, in this transition, all the referring information to a department will be gathered and preserved through a query in the database, keeping a set of XML elements for each line returned by the "query" in a XML file. This XML file contains a XML Schema with information about table and data structure. To minimize file reading, in the search of which XML file contains information about a specific department, a table exists in the database that withholds the information about the created files. The name of the file contains the name of the method that created the file and the department. It must be created an entry in the table, where it's registered the date/hour of the operation, the name of the file, the intervenient name and the method that gave to origin to the XML file creation.

7.2. Workflow Technological Implementation

In order to make possible this implementation all the queries to the database were gathered into one static Class and the method invocation returns a DataTable (.NET Framework 2). This returned object in such a way can be the result of a direct query to the database, as of the reading of a XML file. That is possible because the DataTable is a data representation in XML of a database table. The DataTable has methods that allow all the data structure to be saved directly to a file, including the XML schema.

All the listings in Web Pages have the possibility to apply simple filters to the presented information. This possibility is obtained sending by parameter, to the methods of the DMLBD static class, the necessary filter (ex: ID_STUDENT=1). These functionalities demand XML manipulation to apply XML filtering (in evaluation LINQ Project) (Hejlsberg 2008).

Therefore the application must know witch data to get, must it query the database or read a XML file? The Workflow is the master controller in this operation, if the intervenient has the workflow token then he gets database data and may set it, else he only views XML preserved data and can not set it. This restriction guarantees that information can be altered and various hypotheses can be tested without displaying it to other non workflow intervenient.

8. CONCLUSION AND FUTURE WORK

The developed TSD Information System reveals reliable and meeting to the most important requirements. The system is not yet in full production, since some details need to be improved, such as Class instances automatic creation and semantic validation of some functionalities.

ESTSetúbal is in a changing process concerning to the rules of the TSD. This is a great challenge for the SI-DSD that will have to implement the current TSD, but to be flexible in order to integrate the future restrictions and rules.

The functionalities of TSD history with XML are concluded, but it is in progress the implementation of the information integration with the SI-EST as well as the restart of the process after timetables inconsistence.

It is possible to implement all the new functionalities with the SI-DSD Information System in production and not compromising the information displayed for users.

As future work we intend to develop a Web Service. With this technology the new application will interact with all the existent and be compatible with systems developed in distinct platforms. It will allow the applications to send and to receive data in XML format (and other data type) and the clients can request query, set, and transform data operations in master applications. Each application can have its own "language", that it is translated into a universal language, XML format. All and any communication between systems will be dynamical and most important; it will be error safe, because it does not have human intervention.

The LINQ Project is a codename for a set of extensions to the .NET Framework that encompass language-integrated query, set, and transform operations using C#.

LINQ to XML was developed with Language-Integrated Query over XML in mind and takes advantage of standard query operators and adds query extensions specific to XML.

The use of this technology can be interesting when it is necessary to treat the information in XML as a query result to a database, like in the case of the participants on a workflow phase that have no intervention in it.

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