Development of Distributed Mobile Learning Systems

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Abstract: Mobile learning systems are presented as distributed systems containing next generation educational tools for remote education. The paper describes mobile applications and their role in the learning process. The quality characteristics of distributed mobile learning systems are presented. The security, that is very important for this type of applications, is analyzed. A knowledge management performance indicator is built in order to measure the degree of knowledge management that a distributed mobile learning system has. The costs related to development process are analyzed and metrics are built to measure these costs.

Key-Words: mobile application, security, metrics, project management, m-learning, education system, methodology

1 Introduction

The evolution of knowledge-based society involves the development of educational process through a distributed mobile learning environment.

Mobile applications provide the advantage that can be accessed from anywhere and anytime.

The development of mobile applications is different by the development of a normal application, because mobile applications are designed starting from the mobile devices on which are used.

The difference between a mobile application and desktop applications is that the mobile application provides the opportunity to answer users’ requests wherever they may be [4].

Over the years, all the traditional learning techniques were revised and new ones were introduced. Internet-oriented and m-learning applications were the revolutionary new ways through which the students got the necessary needed skills and knowledge [5].

The use of m-learning applications can develop higher level thinking skills, social interaction skills, responsibility for each other and even promote higher achievement [6].

2 Characteristics of Distributed Mobile Learning Systems

Distributed m-applications need a network connection in order to operate. This type of applications may rely upon a permanent or a temporary connection. WAP (Wireless Access Protocol) or Wi-Fi based applications for mobile phones that connect to a server via Internet are an example of distributed applications.

The development of mobile learning distributed applications has specific characteristics. Distributed platforms have a similar architecture as Web-based platforms, but the client application is a rich application and not a simple mobile Web browser. The advantages of this platform are:

- Rich user interface;
- Support for multimedia content;
- E-learning content can be easily updated on the server;

There are also some disadvantages:

- The user need to install and setup the client application;
- The user have to learn how to use the application;
- Possible additional costs for traffic usage.

Errors and applications failures influence the learning process. Distributed applications and Web-based requires more test because of network access. The test plans need to include use cases on various hardware platforms, operating systems, networks bandwidths in order to cover a large number of scenarios.

Figure 1 depicts the architecture of a distributed mobile learning system. The mobile clients connect to the server using an existing or newly developed communication protocol. Due to the distributed nature of the system, the security has an important role in the application development.

The client and server can use Web services for communication. The supported requests types for Web services by most mobile API are for for are HTTP GET, HTTP POST and SOAP. The Web services consumers are the client applications that access the Web services interface methods initiated through TCP/IP or UDP protocols. Developing and using XML Web services can
be done using many programming languages. Android devices and Java ME support the open source kSOAP 2 implementation. Most of Java ME mobile devices support the Web Services API (WSA), defined by JSR 172.

Most important characteristics of distributed mobile learning systems are: concurrency, which means providing simultaneous access to shared resources, and transparency, meaning that the various operations taking place between components are typically hidden from the end user, which actually perceives the system as a whole.

The anywhere-anytime characteristic and its potential to support interactive group learning have convinced many teachers to believe that distributed mobile learning systems are the promising next generation of educational tools for remote education.

The increasing of the educational process’ quality in a distributed mobile learning system is achieved through diversification. This means that the assessment methods should not be the same for all the exams. Will be supported not only tests with multiple choices, but certain problems are also solved. If a linear system of differential equations is given, the student solves it and submits the solutions and, if these are correct, he gets necessary points. Another example of assessment methods diversification is that in which the student receives a problem, he solves it, submits the results on the platform, the system displays an option to solve it and if its results are invalid, then it learns how was the correct way to do. Diversification is achieved also through the use of smart books, in which the student is tested before and, depending on the points that he gets, it provides more complex or simple material.

The distributed m-applications concur decisively to the creation of new knowledge, the on-line conversations helping to refine this knowledge and thus generating relevant pieces of knowledge [7].

The knowledge in a distributed mobile learning system can be explicit or tacit. Explicit knowledge can be expressed in words or numbers and shared in the form of data, audio, video, etc. Explicit knowledge is easy to share and formalize. On the other hand, tacit knowledge is that which is in people’s brains and is more personal and difficult to formalize, being harder to communicate and share with others [8].

In order to measure the degree of knowledge management that a distributed mobile learning system has, a knowledge management performance indicator was defined, \( KMPI \), as follows:

\[
KMPI = \frac{KCI + KAI + KSI + KUI + KII}{5}
\]

where:
- \( KCI \) is the knowledge creation indicator in the distributed mobile learning system;
- \( KAI \) is the knowledge accumulation indicator in the distributed mobile learning system;
- \( KSI \) is the knowledge sharing indicator in the distributed mobile learning system;
- \( KUI \) is the knowledge utilization indicator in the distributed mobile learning system;
- \( KII \) is the knowledge internalization indicator in the distributed mobile learning system.

The aforementioned characteristics are the ones that attracted normal users and spread the concept throughout the world. They give a plus of flexibility to the concept of mobile device and ease in use, finally making users to stay tuned to whatever will appear in the next generation of mobile devices.

3 Security based development process

Development of distributed mobile learning systems is a process part of a life cycle which is full of unexpected events that should be seriously treated if compromise is not a viable option. To preserve, maintain the set of quality characteristics for mobile learning systems, the security should not be left aside in none of the life cycle stages, especially in the process of development.

3.1 Aimed security features

The security of distributed mobile learning applications is very important and challenging compared with standalone applications.

The challenges come, mainly, from the limitations brought by the impossibility of high processing due to energy costs. For this reason, security is somehow partially implemented, or at all. But in most cases the rules, procedures and other protective measures are not as efficient as outside and inside risks are effective.

Security should target specific problems based on the main field of activity for each particular mobile application. Following are presented some of these types
of characteristics that should be aimed depending on the application objective:

- applications for mobile payment, mobile banking; should implement a reliable and safe security protocol through which mobile bank transactions should be managed like [11];
- descriptive or presentation mobile applications; they must secure the data that is viewed by numerous users, preserving the reliability and accurateness of presented information;
- mobile applications for tracking purposes; the most vulnerable aspects are given by unwanted access or interception of data on the communication channel which can lead to confusions between the packages that are tracked;
- medical mobile applications; should be accurate with Nano microns precision and without no errors in their algorithm;
- global positioning mobile applications; must always be updated and have the latest maps and bugs free as users tend to rely on their functionality and availability.

The security characteristics should be maintained also for distributed mobile learning systems as they are for distributed systems. Besides the usual ones, like availability, confidentiality and integrity, mobile distributed learning systems must keep an eye on the aspects debated between users and the mobile system like: users’ actions authenticity, safe keep of events logs for later debugging or maintainability and allow save points or backups in case of battery low energy.

### 3.2 Security measures in the development process

Some security requirements which should increase significantly the output of such mobile systems, both quantitatively and qualitatively are described in [2] with the remark that for having them all implemented in one single distributed mobile learning system a wide range of architectures should be used in developing such systems:

- authentication – characteristic available if some of the application’s resources are available in a restrictive manner, based on roles and privileges;
- network security – is the characteristic that usually is missing or is very limited due to the technological restrictions that are still present;
- application security – for standalone application, running in a secure and protected environment is the key of minimizing the risks, as for online applications, certificate management implementation should be the solution of achieving higher security level;
- secrecy – is given by the power in which a mobile device is able to implement encryption to protect its sensitive data;
- availability – the feature which provides permanent access to application’s resources.

For the development process of a distributed mobile learning system a component should evaluate all implemented measures in terms of costs and benefits.

A point is defined; let it be \( P_0 \) above which any security measure added to the distributed mobile learning system will only do it harm and it will increase the costs of using that system.

Let \( C_i \) be the cost for a security component with \( i = 1, n \), where \( n \) is the number of total security components that are wanted to be integrated into the system.

Let \( CT \) be the total costs that could results from losing vital information in case of a security breach which wasn’t treated.

Let \( P_i \) with \( i = 1, n \) be the benefit brought by the application per security implemented feature.

\[
P_i = \frac{TP}{p_i}
\]

where:

- \( TP \) – is the total profit gained as a result of using the application;
- \( p_i \) – is the contribution of each security component to the entire system.

In order that the distributed mobile learning system to be efficient than the following restriction should be meet between the aforementioned components:

\[
\sum_{i=1}^{n} P_i > CT + \sum_{i=1}^{n} C_i
\]

The above restriction tells us if the distributed mobile learning system is producing any added value or is consuming more than it gives away.

### 4 Development Related Costs

A distributed mobile learning system has a life cycle containing its evolution and the stages in which the system go through. The development of a distributed mobile learning system is similar with the life cycle of an open source project. The cost and quality of distributed mobile learning systems should be considered as an important factor in the new system development phase. In Figure 2 is presented the life cycle of a distributed mobile learning system.
The distributed mobile learning system is developed based on a set of specifications that were defined in the analysis stage in order to define objectives for the development process.

The life cycle presents the same phases as almost any software type of development. The specific characteristics of distributed mobile learning applications can be on each phase detailed.

![Fig. 2. Life cycle of a distributed mobile learning system](image)

There are many models that can be used to compute the mobile learning applications costs. The models can be linear and nonlinear and they can take into account many factors that contribute to the final cost of the applications.

The cost model presented here is based on the effort used to develop an application during the development cycle. In order to calculate the cost of the distributed mobile learning applications, for each application are recorded data into a matrix, as given in table 2.

In table 2 are identified the following costs:
- CML – the cost of the mobile learning application
- PC – planning costs
- MC – manpower costs
- SC – software costs
- HMC – hardware costs (mobile devices)
- HSC – hardware costs (servers)
- OC – other costs
- AC – analysis costs
- DC – design costs
- CC – coding costs
- TDC – testing and debugging costs
- OAC – other activities costs (e.g. content management)

<table>
<thead>
<tr>
<th>Development phase</th>
<th>Planning</th>
<th>Analysis</th>
<th>Design</th>
<th>Coding</th>
<th>Testing and debugging</th>
<th>Other activities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manpower</td>
<td>MC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td>SC</td>
<td></td>
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<tr>
<td>Hardware (server)</td>
<td>HSC</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware (mobile devices)</td>
<td>HMC</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>OC</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>PC</td>
<td>AC</td>
<td>DC</td>
<td>CC</td>
<td>TDC</td>
<td>OAC</td>
<td>CEB</td>
</tr>
</tbody>
</table>

The manpower cost is the most important [4], having the main contribution to the final cost, and it includes salaries and other expenses related to salaries. The entities involved in the development are: Mobile application developer, mobile learning content provider and mobile learning services consumer.

Software and hardware costs usually are fixed costs, and include the costs of renting or buying software and hardware systems used to develop and to test the applications.

Other costs are composed by variables and fixed costs that are not related to manpower, software and hardware costs, and they are included in the final price of the application.

The cost of analysis, requirements, design and coding is mostly compounded by the manpower costs and is the effort recorded during the correspondent development phases of the application.

Software testing is a very expensive process. The cost of testing applications is higher than the cost of testing classical software. It requires a supplementary effort due to:
- testing the application server;
- testing the Web server;
- testing the transactions (database, login etc.);
- security testing;
- testing the mobile learning application (client).

Integration testing costs are also higher than the integration costs for the classical applications. For the mobile distributed applications there are many...
combinations of components that have to be integrated and tested.

The total cost of testing the mobile learning applications is given by the sum of all testing activities. There are also some overhead costs. The main cost category is the personnel’s salaries. Other costs include the costs of the tools and hardware used in testing. The main costs of software testing are described in [12].

Based on the existent technologies on the market, the cost of testing mobile learning application can be reduced by automation of this process. Another way to reduce the costs of software testing is to use verification activities like inspections and technical reviews earlier in software development cycle, before the testing process. This will decrease the testing effort.

Other activities costs include various costs, like:
- the manpower required to configure and administrate specific components
- the effort required to write the technical reports and product documentation and guides, either in electronic or paper format.

The cost of an m-learning application can be calculated using the data recorded in table 2 with the formula:

\[
CML = PC + AC + DC + CC + TDC + OAC
\]

or

\[
CML = MC + SC + HSC + HMC + OC
\]

If CA\textsubscript{i} is considered the cost of activity \(i\), where the activities are analysis, design, coding, testing, debugging and other activities, and \(h\) is the total number of hours required for the activity \(i\), the total cost of manpower for an m-learning application is, based on [3]:

\[
MC = \sum_{i=1}^{n} CA_{i} \times h_i
\]

This decomposition can be used for every cost component.

Distributed m-learning applications project management is a necessary to complete the goals having the cost minimized. The management of a project involves several sub-processes: planning, coordination (project implementation), project end, and on a regular basis project control.

Project initiation (project start) is usually organized as a workshop, after the project manager was assigned. The project’s plans are developed in this process. Project coordination/implementation is a continuous process, and it is based on the plans developed in the project start process [1]. Periodically is done the control process, in order to assure that the project is according to the plans.

The close-down process is the last project management process, where all the project information is transferred to the organization.

The entire project management process has to be evaluated continuously for quality. In [10] is analyzed the project management process for Web-based mobile learning applications.

5 Conclusions

All the mobile applications introduced into the market have some environmental impacts during their life cycle. Therefore, it is important that applications designers have access to relative environmental information so that they can make appropriate decisions and de-offs with other design requirements [9].

The distributed mobile learning system must behave and must give the results the users want and that they have stated at the start. The knowledge-based society evolves only through the high quality of distributed mobile learning systems.

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References:


