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# Towards the development of functional technological units in the academic area of computing and electronics

# Hacia el desarrollo de unidades tecnológicas funcionales en el área académica de computación y electrónica

POZAS-CÁRDENAS, Mariano Javier†*, HERNÁNDEZ-SÁNCHEZ, David, CURIEL-ANAYA, Arturo and TORRES-SAMPERIO, Gonzalo Alberto

*Universidad Autónoma del Estado de Hidalgo-Área Académica de Computación y Electrónica*

ID 1st Author: *Mariano Javier, Pozas-Cárdenas* / **ORC ID:** 0000-0003-3502-7740, **Researcher ID Thomson:** P-6719-2018, X_mpozas89018

ID 1st Co-author: *David, Hernández-Sánchez* / **ORC ID:** 0000-0002-0328-303X, **Researcher ID Thomson:** P-6717-2018

ID 2nd Co-author: *Arturo, Curiel-Anaya* / **ORC ID:** 0000-0002-9383-3452, **Researcher ID Thomson:** P-6718-2018, **CVU CONACYT ID:** 255222

ID 3rd Co-author: *Gonzalo Alberto, Torres-Samperio* / **ORC ID:** 0000-0002-9328-6970

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**Abstract**

The objective of this project is to show the feasibility of systematizing some of the administrative activities of the electronics laboratory and computer classrooms in the Academic Area of Computing and Electronics (AACyE), where its main activity is teaching and research, to move towards more functional work units with the use of technology, which we will call Functional Technological Units. In the present work the conditions in which the technological work units are stagnant due to not having adequate information management are described in an introductory manner. The methodologies used for the development of this research were based on the Organizational Development model and the use of agile methodologies such as XP, ERP or WSDM. As a result, two developments of web-oriented systems validated by the ISO 9126 standard and making a qualitative weighting based on the Likert scale are shown. As for the discussion, it focuses on collaborative work and the creation of a synergy between students, teachers and administrative staff. The results that were obtained have allowed administrative processes to be carried out with greater efficiency, impacting on the teaching, administrative work and the training of students in the AACyE.

**Organizational development, Agile development methodologies, Strategic planning, Functional technology unit**

**Resumen**

El objetivo de este proyecto es mostrar la factibilidad de sistematizar algunas de las actividades administrativas del laboratorio de electrónica y aulas de cómputo en el Área Académica de Computación y Electrónica (AACyE), en donde su principal actividad es la docencia y la investigación, para transitar hacia unidades de trabajo más funcionales con el empleo de la tecnología a las cuales les denominaremos Unidades Tecnológicas Funcionales. En el presente trabajo se describe en forma introductoria las condiciones en que las unidades tecnológicas de trabajo se encuentran estancadas por no tener un adecuado manejo de información. Las metodologías utilizadas para el desarrollo de esta investigación se basaron en el modelo de Desarrollo Organizacional y la utilización de metodologías ágiles como XP, ERP o WSDM. Como resultado se muestran dos desarrollos de sistemas orientados a la web validados mediante la norma ISO 9126 y haciendo una ponderación cualitativa basada en la escala de Likert. En cuanto a la discusión esta se centra en el trabajo colaborativo y la creación de una sinergia entre estudiantes, profesores y personal administrativo. Los resultados que se obtuvieron han permitido realizar los procesos administrativos con mayor eficiencia impactando en el quehacer docente, administrativo y la formación de estudiantes en el AACyE.

**Desarrollo organizacional, Metodologías de desarrollo ágil, Planeación estratégica, Unidad tecnológica funcional**

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† Researcher contributing as first author.

 

## Introduction

Productive institutions or service providers face multiple challenges every day. They try to achieve goals that reflect constant or sustained growth, which allows stability and harmonious coexistence in healthy work environments. Most people want to be integrated into environments where there is respect, collaboration and professional development. Notwithstanding, they are frequently part of organizations where there is regularly inadequate planning, deficient management, lack of control, and diminished execution in projects, and all this just leads to cyclical failures. They almost never excels and because of this, the Organizations have greater restrictions. The same behavior is followed by some higher education institutions. Regularly the information systems that operate are insufficient or work in isolation, some departments such as school control work well, provide agile services to students supported by computerized systems, but it is not the only department that requires control of information. There is also a demand for information and on several occasions it is duplicated. There is no innovation. There is work saturation in teachers and sometimes certifications are compromised by restrictions on subsidies or support for the investigation.

The question that arises is: how can work areas be supported and strengthened, in a chaotic situation, using basic computer knowledge as a discipline? Is it possible to create a Functional Technological Unit (UTF) in an Academic Area of Computing? Are there strategies that help us move towards a more productive work area?

Fortunately, yes, there are strategies and models that can help to survive and excel. One of these strategies is the use of the Organizational Development (OD) model, which contemplates the management and incorporation of knowledge (Sánchez, 2009), (Morillo and Suárez, 2011), combined with agile methodologies for system development, enhancing productivity without sacrificing quality (Delgado, 2021), (Bautista, 2022).

Organizational Development makes it possible to achieve a culture of development in which formal or informal knowledge, the talent of people, the use and exploitation of technological resources that are available to organizations, the application of new models or ways of working, as well as innovative proposals that allow faster transition to sustainable work areas, are privileged and promoted, (Finol de Franco, 2011).

The proposal in this project is the automation of the electronics laboratory and computer rooms after having carried out an analysis to identify their needs. Later, develop a system that allows achieving better efficiency in the services offered such as loan of materials, equipment and allocation of spaces for common use of the computer rooms, considering the limitations that usually exist in public education institutions, such as: budgetary restrictions for the administration, saturated modernization departments or scarce hiring of personnel to modernize the academic areas. The Hiring of personnel is mainly focused on teaching, little motivation on the part of teachers to get involved in development or automation tasks, since, in the first instance, there will only be more work and little recognition.

An important factor that must be considered is collaboration and teamwork. The participation and appreciation of the most important resource of a university, which are people. That is students and teachers mainly. The great potential they often have is not taken advantage of. students and are also denied the opportunity to participate in real and productive projects such as the development of information systems focused on solving the needs of an academic area or department. The activities must be under the supervision and direction of professors focused on the development of information systems, whether in final projects, theses, social service students or professional practices.

Although many of the final projects of the students are oriented to the development of educational materials or hypothetical cases. It is also feasible to orient projects to the development of applications in the administrative work areas of the department that facilitate the automation of information.

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Thus, promoting the availability of information at all times and in any place where there is internet and a computer fin such a way that the processes of access to information would be optimized. In this way, it would be moving towards a functional technological unit. We can mention large public and private corporate companies that take strategic planning seriously within their organizations, strengthening their technological units. For example, banking and government service institutions such as Google, Facebook, Santander, SAT, INFONAVIT, among others.

**Methods used**

One of the models that inspired the project to move towards the creation of a functional technological unit is the Organizational Development Model. Especially the creation of intelligent companies or institutions and knowledge management. The first is characterized by having information and knowledge available in an organized way providing multiple advantages when generating new knowledge, both for its workers and for its users and the second helps to create creative processes and environments, transfer and apply knowledge to be more productive This OD model can be synthesized in four phases which they were applied as follows (Sánchez, et all., 2017):

- Socialization, which allows the identification of the problem, through the participation of those in charge of the electronic laboratory and computer rooms who externalized the manual procedures of their services by written requests, as well as the control formats.

- Exteriorization, in this phase the ideas are organized in a group to know what is happening?, why?, how to solve it? and Who could be the actors that help solve the problem?

- Combination allows systems to be developed in various ways with diverse groups of students, teachers, and administrators.

- Internalization, after implementing the systems, the results are valued to improve the processes.

The use of the DO model allows the creation of synergy between the actors involved. It conduces to express problems that affect the functionality of the work areas and at the same time proposing creative ideas.

Several agile methodologies were also used, the ERP (Enterprise Resource Planning) methodology and the Xtreme-XP methodology. The ERP and XP methodology are based on continuous feedback between the client and the development team, fluid communication between all participants, as well as the simplicity of the implemented solutions.

The benefits for both developers and the company are:

- Speed and focus on development.

- Greater efficiency in the fragmentation and integration of development tasks.

- Easy access to the company's own information.

- Portability and Accessibility for all components of the organization.

- Elimination of unnecessary operations for the company or for the end user.

These methodologies are flexible and when applied they present quick results. Even though the complete idea of the project is imprecise, which allows alternative ideas to be proposed to a problem. For this reason, it is oriented towards the development of software for internal use of the organization. Some applications can be, warehouses and inventories, internal reports, finances, sales, human resources, development and analysis departments, manageable work areas, among others (Beck, & Andres, 2005).

Based on the principles of the Xtreme-XP rapid development methodology, we sought to enhance the interpersonal relationships of the development team and achieve continuous feedback between those in charge of the laboratory and the work team, achieving agility and flexibility in project management. Considering the scope of the project and the first delivery dates of the system, as well as the estimated time priorities in development (Arias, 2017).

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It was sought to obtain a first version in a short time that would serve as a basis to extend it. The work periods were four-monthly, since it was difficult to integrate or continue the project after the end of the school year of the students who made up the system development team.

Another of the methodologies used was the WSDM (Web Site Design Method), which refers to the method of designing a website, which consists of four phases.

- User model Phase.
- Concept design Phase.
- Implementation Design Phase.
- Implementation Design Phase.

Part of this methodology served as a reference for the design of the interfaces and the database, in such a way that it was easier for the user to manage the information (Molina, et all, 2017).

The use of the WSDM methodology stands out because it allows the development of the system in an orderly manner from the analysis, to the implementation and validation process, in such a way that the results of the developed application are shown. Also, to know if it meets the objective specific as well as the degree of approval by the user, knowing the possible errors and complications that could arise when interacting with the application, since a system must be validated and tested before its official presentation.

Next, a first project is described using the ERP (Enterprise Resource Planning) and Xtreme-XP methodologies, following collaborative and learning strategies through the solution of real problems of interest to companies or institutions.

## Developing

The process carried out to generate the systems is described by applying the methodologies previously proposed, which have a very similar general structure, which is the identification of the problem, proposal, design, construction and implementation. Afterwards, both systems are described showing their characteristics in detail.

*Problem*

At the Autonomous University of the State of Hidalgo (UAEH) in the Institute of Basic Sciences and Engineering, there is a central electronics laboratory that provides service to various educational programs such as the Bachelor of Electronics Engineering (LIE), Bachelor of Telecommunications Engineering (LIT), Degree in Civil Engineering and Architecture (LICA), Degree in Computer Science (LCC) and occasional users of the UAEH from other degrees or high schools that request it.

The loan process has been carried out manually through the filling of loan vouchers, without this procedure representing a problem. However, it is believed that an automated system will speed up the loan process, improve control of the use of the equipment, propose a better planning and use of spaces for the realization of practices, as well as the reduction of operating expenses.

*Proposal*

It is proposed to develop an Administration System for the Loan of Materials and Equipment in the Electronic Laboratory (SAPMELE), which helps to digitize the operational processes of the Electronic Laboratory that guarantees a better operation for the users who are students, teachers and administrators. The system consists of two modules in its initial stage that will be in charge of satisfying the specific needs of:

- Loans.
- Inventories.

*Design*

During the design stage, the laboratory administrators and the project leader were in charge of communicating the needs of the laboratory to the team of programmers made up of a group of students. In this stage, two agile methodologies were used, the ERP (Enterprise Resource Planning) methodology and the Xtreme-XP methodology. The ERP and XP methodology, so that the entire work team collaborated in the design and development of the system. Table 1 list the main classes of the system and Figure 1, the use case diagram.

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| Administration System Electronics Lab |
|---|
| - Users administration.<br>- Practice management.<br>- Materials' loans management.<br>- Accesss control and users' permission.<br>- Working areas and materials reservation. |
| - System administration use control ()<br>- Users' register ()<br>- Users' access accreditation ()<br>- Users' permission ()<br>- Practices' schedule and creation ()<br>- Areas assignation for booked practices ()<br>- Creation of materials reservation application ()<br>- Validation of materials existing on storage ()<br>- Autentication and validation of user's access ()<br>- Non booked areas and materials reservation ().<br>- Storehouse creation ().<br>- Materials and objects assignation ().<br>- Permissions of storehouse access (). |

**Table 1** Main classes involved in the system

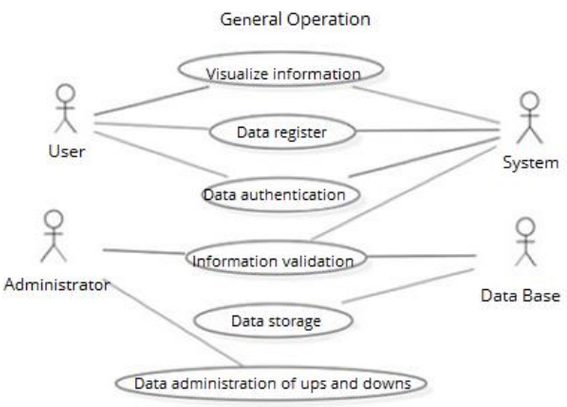


**Figure** 1 Use case diagram

*Construction*

The tools that were chosen for the development of the web-oriented system are:

- Laravel: PHP-based web development framework.
- JavaScript: allowed to develop the functionality of the system, as well as its configuration.
- HTML: View in any web browser.
- CSS: For designing system interfaces.
- PostgreSQL: Database manager.

**Laravel**

It was used since it is a cross-platform open source framework that allows the inclusion of functional tools such as libraries, plugins, designs, utilities to create views with Blade that can be integrated with PHP and Java code. Some of the general characteristics of these bookstores are (Arias, 2017):

- Blade-based templates.
- Fluent Requests.
- Composer-based.
- Cache support.
- MVC support.

Laravel facilitated the handling of events and authentication in addition to the robust support for the handling of the databases, the PostgreSQL database manager was used, where the different schemes, tables and data that make up the Laravel Laboratory project were implemented. Electronics.

*Implementation*

Once the development of the SAPMELE loan system was completed, it was implemented in the Electronics Laboratory. This serves as support for the entire university community, facilitating and streamlining the loan and inventory control processes, as well as reducing the costs of consumables and stationery. Below are some views of the SAPMELE loan system (Aguirre & Armenta, 2020).

Figure 2 shows the main view for the different types of users such as: students, administrators, teachers, social service providers; all of them access the system through a carousel.

Figure 3 shows the different options that a student has once they have entered, they can know and select the material available in the store, they can also know what is the material required for the practice they choose and finally in the option of the cart request the loan.

A partial list of materials or equipment available for your loan is shown in Figure 4.

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**Figure 2** System main view

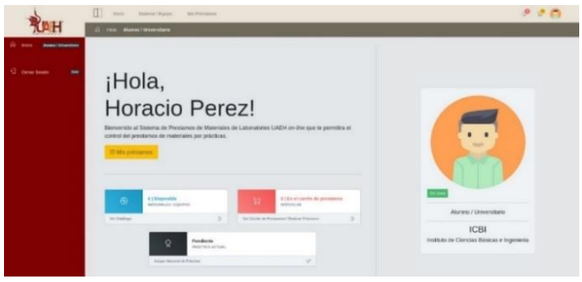


**Figure 3** Consultation and loan options

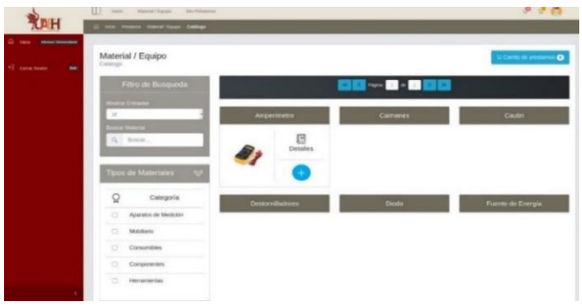


**Figure 4** Materials catalog.

Next, a second project is described using the WSDM methodology, following collaborative and learning strategies through the solution of real problems.

*Problem*

There is a recurring problem in the Academic Area of Computing and Electronics (AACyE), which occurs during the registration and control of the use of the different classrooms, computer labs and spaces for common use. The registration of this information is always of manually and due to the number of teachers who enter and leave the class. This this process leads to limit the effective using time of the equipment and facilities on many occasions, as well as the lack of an agile space allocation process when there are unoccupied or unscheduled workspaces.

Another of the problems associated with the process of registering use and attendance manually, is the limited availability of information to follow up on equipment that stops working, is lost, or even student belongings that are left behind in the work areas.

The availability of information is reduced by the physical accumulation of record sheets or by the lack of record sheets, coupled with this, on many occasions the administrators are assigned different activities cataloged with higher priority, such as payroll among other.

*Proposal*

The creation of a Common Use Spaces Registration and Reservation System (SRREUC) is proposed, which optimizes the attendance processes, as well as the control of classrooms and computer labs and common use spaces, within the Computer Academic Area called SRREUC (Cruz, 2020).

The objective is that the application helps professors mainly to make the attendance registration process timely, avoiding crowds at the beginning of the different class hours. Moreover, it benefits the administrative staff, in the task of organizing and optimizing the use of computer labs and common use areas.

*Design*

This phase is one of the most important and for this the WSDM model was used as a basis, since it refers to the method of designing a website, since all the interfaces, methods and programming of activities are designed here. Also the roles of the users, the navigational design, as well as the use cases and the entity relationship diagram of the system are described. By respecting the framework of the methodology, it becomes a valuable guide to represent all the navigational and functional structures that developers will follow, which will benefit end users. Figure 5 shows the use case diagram that reflects the functions that the system administrator can perform, and figure 6 shows the class diagram, as well as their interrelationship between them.

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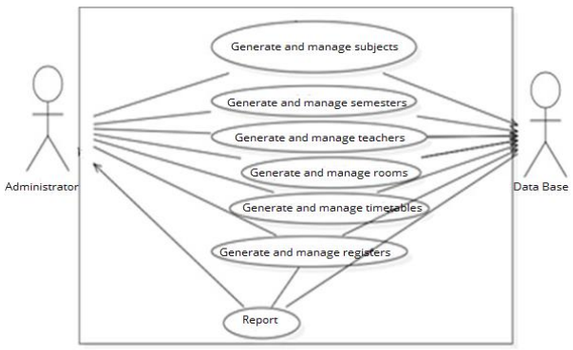


**Figure 5** Use case diagram.

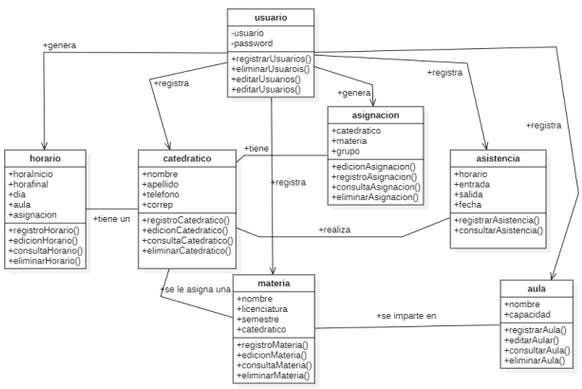


**Figure 6** Class diagram

*Construction*

In this phase, the development environment Visual Studio Code and a set of tools called WAMP were used. By using the Apache module, a local server was enabled for the deployment of the web application. MySQL was also used as a database manager. A great Part of the system is developed in PHP for its flexibility and handling with the structure. It is also a language that works on the server side, this makes the processes even faster and the execution time of the programs is much less (Putier, 2015).

HTML was also used in conjunction with the CSS style sheet generator to create interfaces with the user, the entire layout of the web system, that is, the front-end, so that the system has a user-friendly design and that at its At the same time, take the style similar to any page or web application promoted by the University as a standard, since its main use would be for it.

*Implementation*

The system for the administration of the computer laboratories and spaces for common use, was implemented in a common access area in such a way that teachers can register and obtain information from the auditorium laboratories and work rooms to reserve them, if necessary, in a more agile and orderly way.

Below are some boxes that partially illustrate how the system works. For example, Figure 7, contains the menu with the login, check-in and check-out options, each button has a specific function. To illustrate, with the input button the teacher or user can register their attendance corresponding to a subject previously assigned at the beginning of the semester. In the same way with another button the end of use of the classroom or computer equipment can be registered and on the other hand we have the login that describes the different areas depending on the user that has been authenticated. Figure 8 shows the options that the administrator has to organize the work areas, and finally, Figure 9 shows an interface with the different options to obtain reports.


**Figure 7** System main menu


**Figure 8** Menu for the administrator Title

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**Figure 9** *Reports section*

## Results

As a result of the application of the DO model. This allowed the creation of a proactive environment among the various members of the academic area that involves teachers, administrators and students. Apathy was broken, socialization led to the expression of various problems that affect the functionality of the areas of work and at the same time come up with creative ideas that led to the development of two web-oriented information systems.

A. Administration System for the Loan of Materials and Equipment in the Electronic Laboratory of the Institute of Basic Sciences and Engineering (ICBI)

B. System of Registration and Reservation of Common Use Spaces such as rooms, classrooms and computer laboratories within the academic area.

In each of the developments, the problem is raised, a solution proposal, its design, development and implementation.

## Discussion

The proposals for innovation or alternative work model were encouraged to promote alternative changes, which promote work environments or more functional technological units supported with the most valuable resource, the human resources of a company or institution, as they are also in public universities.

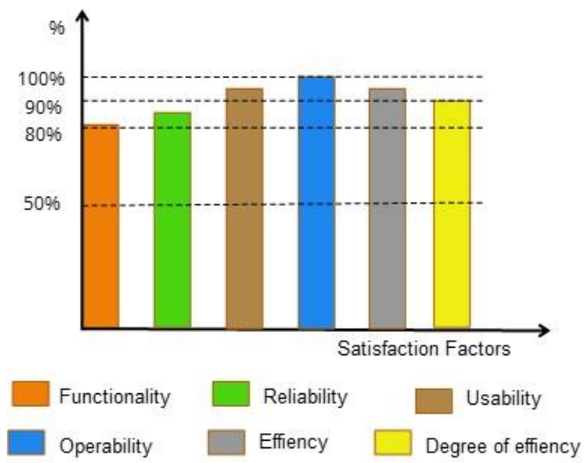
And, if the proposals are also socialized, shared, discussed and executed collaboratively, this action will allow us to plan with a global perspective, including monitoring all the actors involved. We will not only be solving a technical problem, but also moving towards a labor culture typical of advanced knowledge societies. This way we can reduce the generational gaps in the use of technologies.

## Conclusions

Both systems were implemented and are working in their respective work areas, their validation is based on the metrics of the ISO/IEC 9126:2001 standard, and the McCall model (McCall & Cavano, 1978), which establishes various elements that must be evaluated, such as functionality, reliability, usability, efficiency, operability, maintainability, portability and satisfaction.

It should be noted that the information was collected through online Google forms applied to 120 users of the electronics laboratory and 45 teachers who use the commonly used computer rooms who answered after using the applications.

The results of the evaluations of the systems are shown in Graphs 1 and 2. A simple random statistical method was used, applying the Likert scale for the type of categorical variables used within the investigation (Méndez, 2007), the results of the evaluations will allow to improve the processes, thus facilitating a better management of the information that it handles the academic area.




**Graphic 1** Evaluation result of the SAMPELE loan system

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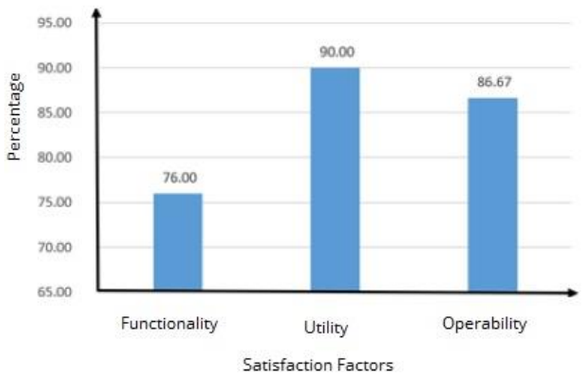


**Graphic 2** Evaluation result of the SRREUC system

To achieve a functional technological unit. It is not enough to develop a couple of computer systems, which by themselves already provide operational advantages in information management. It is necessary to maintain the synergy of work, collaboration and socialization, a mature organizational culture that allows moving towards functional technological units within companies or institutions.

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