Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 100 (2016) 171 – 178

Procedia Computer Science

Conference on ENTERprise Information Systems / International Conference on Project MANagement / Conference on Health and Social Care Information Systems and Technologies, CENTERIS / ProjMAN / HCist 2016, October 5-7, 2016

Analysis and Design of a Project Management Information System: practical case in a consulting company

Leonor Teixeira[a,b,*], Ana Raquel Xambre[a,c], João Figueiredo[a], Helena Alvelos[a,c]

[a]*Department of Economics, Management, Industrial Engineering and Tourism, University of Aveiro, 3810-193 Aveiro, Portugal*
[b]*IEETA - Institute of Telematics and Electronic Engineering of Aveiro, University of Aveiro, 3810-193 Aveiro, Portugal*
[c]*CIDMA - Center for Research and Development in Mathematics and Applications, University of Aveiro, 3810-193 Aveiro, Portugal*

Abstract

Nowadays, due to globalization, business diversification and a growing number of different business projects, the need to support people involved in tasks related to project management is becoming increasingly important. Timely and accurate data about projects' plans, their progress and related costs, are extremely important for project managers and consequently for assuring the success of the project. In this context, Project Management Information Systems (PMIS) are commonly viewed as an important tool for project management. However, this kind of Information Systems (IS) is relatively expensive and therefore out of reach for many small and medium enterprises (SME) that often choose not to use them. As a way to overcome this situation many consulting companies decide to invest in the development of their own PMIS. This paper presents the design process of an Information System for Project Management, whose main purpose is to manage investment projects throughout their life cycle. The system supports all the application process for incentive programs, as well as the documentation and procedures required, and helps to manage the project itself, when it is approved. This solution will thus contribute to the improvement of the performance of the Projects & Incentives' division of the consulting company, but can also be replicated by other companies that have similar needs.

Peer-review under responsibility of the organizing committee of CENTERIS 2016

Keywords: Information Systems; Project Management; Analisis and Design; UML; Consulting Company

*Corresponding author. Tel.: +351-234-370361; fax: +351-234-370215.
E-mail address: lteixeira@ua.pt

Peer-review under responsibility of the organizing committee of CENTERIS 2016
doi:10.1016/j.procs.2016.09.137

1. Introduction

In certain areas, globalization allied with the markets' competiveness has been a challenge for most companies, leading them to expand their business portfolio. Additionally, the current growing number of incentive programs initiatives, like, for example, the H2020 program, has contributed to an increasing interest of consulting companies for this new business area. This type of companies work with their clients helping them to build their application for European funds, as well as following the project's evolution, when they are approved.

A project is defined in PMBOK Guide[1] as "a temporary endeavour with definitive beginning and end, undertaken to create a unique product, service, or result". Nonetheless, although projects may lead to specific outcomes (products and/or services), a large amount of the tasks required for their development are the same regardless of the project. Those tasks and the inherent processes can then be structured into procedures and managed accordingly (project management).

Project management is thus characterized as an effort that results from the use of knowledge, skills, tools, and techniques applied to a set of project activities in order to meet the project objectives, taking into account the established and predefined resources[1]. Managing a project implies planning and monitoring its execution (tasks), helping to achieve the predefined objectives[2].

In this context, Information Systems (IS) are very important tools that can contribute to the project's success, in the sense that they can help plan the work, facilitate the control and tracking of the tasks, promote the supervision of every activity and, above all, potentiate the execution of the work within the established deadlines, involving the right people, and reducing deviations from the budget.

According to Vre *et al*.[3] Information Systems to support the needs and work of project management, usually so-called Project Management Information Systems (PMIS), are relatively expensive and organizations often choose not to use them.

In order to overcome this difficulty many consulting companies choose to invest in the development of their own PMIS. This work describes the experience of developing an IS for Project Management, to help manage project's life cycle, as well as all the documentation and associated resources. The final goal was to improve the performance of the Projects & Investments division of a consulting company.

This paper is structured as follows: section two presents the theoretical foundation of this article, based on review of existing approaches regarding project, project management and PMIS. A brief description of the practical case, more specifically the analysis and design of an IS in a consulting company are provided in section three. Section four outlines the main conclusions.

2. Foundation and related work

2.1. Project and project management concepts

Project can be characterized as a set of activities that aims to achieve specific results, using a set of available resources. Typically, a project is related to the production of a product or the supply of a service, with a predefined implementation period and a stipulated budget[1]. There are different approaches to characterize the concept of project, but considering the perspective of Vre *et al.*[3] all definitions have a common ground: "a project is a goal oriented, time limited and unique process, always introducing something new, having particular complexity, limited budget, certain legal and organizational status, content which is determined by the product or the result of the project, its own structure and temporarily available resources."

The cost, time and quality are the key pillars of a project, being referred by Atkinson[4] as the *Iron Triangle* of project management. The cost determined by the available and necessary resources must be incorporated in a pre-established financial plan. Time defines the schedule of tasks to be performed and consequently the timetable of the project. The quality pillar is the required success factor for the satisfaction of the stakeholders, assuming that the two previous aspects (cost and time) are fulfilled. However, some authors[4] report that these criteria are not enough to ensure the success of a project, presenting a list of critical factors that can lead to the failure of projects.

A project requires "a complex effort involving interconnected activities, with the purpose of achieving an objective, and a temporary, non-repetitive process"[2]. The application of knowledge, skills, tools and techniques to carry out the different project activities, is defined by the Project Management Institute[1] as a project management.

Project management is a complex task that can easily fail due to poor planning, inaccurate estimation and lack of control. Particularly, in organizations that are engaged in several projects at the same time, as is the case of consulting firms, the project management activity becomes a challenging task[5]. Faced with the amount of information available for decision making, and considering the several necessary resources that have to be allocated and managed, managers may become overwhelmed, which can lead to poor decision making[6].

Reasons that contribute to an inefficient implementation of projects are numerous, among which it is possible to identify the insufficiency of appropriate Information Technologies (IT) tools for management and control of information and resources of the projects[3]. In fact, IS to support project management are referred by several authors as one of the key tools to achieve project's success[7].

2.2. Information system for project management

In the last decade, due to the increase in the diversity of projects' types and complexity, IS to support Project Management, usually called PMIS, have changed considerably. They no longer focus only on scheduling and resource management, but they have become comprehensive systems that support the entire life-cycle of projects, project programs, and project portfolios[8,9]. PMIS have been developed to assist managers in making decisions during the project processes. Jaafari and Manivong[10] define PMIS as systems that support all the resulting information of a project's life-cycle, facilitating its conclusion, particularly if it is complex, subject to uncertainty and under market, time or money constraints. Ahlemann and Riempp[9] present the PMIS concept as socio-technical systems that integrate people, processes and software in order to ensure the delivery of information to the right people at the right time. According to Raymond and Bergeron[11,12] PMIS are systems that provide managers with the decision-making support needed in planning, organizing, and controlling projects. One of the most consensual definitions is given by the Project Management Institute[1], characterizing PMIS as "IS consisting of tools and techniques used to gather and integrate data, and disseminate the outputs of project management processes, used to support all aspects of the project from the beginning to its closing".

Although the study of this kind of IS is widely disseminated in the literature, in practice there are a significant number of companies (more specifically SME) that have not yet adopted them to management their projects. The high cost of this kind of IS (usually acquired by organizations as software packages), and the fact that they are generic solutions that therefore, do not support certain specific needs of projects, are two strong reasons for the non-adoption by small and medium-sized businesses. Thus, many project-oriented organizations are facing a new challenge in designing and implementing their own and dedicated IS to support their specific needs in the context of Project Management.

3. Practical Case: analysis and design of a IS in a consulting company

3.1. Problem contextualization and objectives

The main purpose of this work is to specify an IS to support Project Management at a Projects & Incentives division of a consulting company that, for confidentiality reasons, will be referred to as Consulting@COM.

The Consulting@COM is a company that assists their clients in developing several types of projects, including investment projects and applications for European incentives programs. To help managing those projects the company has a set of IT tools but, because those tools are not specific for project management, their use is limited and thus less comprehensive than needed.

With an increase in the needs for supporting and accompanying external investment projects and applications for European incentive programs, the project management process at Consulting@COM, as well as the existing ITs, started to become insufficient.

Because the IS used at Consulting@COM were not dedicated, they lack some essential features such as automatic alert systems, validation mechanisms to signal the conclusion of tasks or if tasks were missing or overdue,

capability to assign resources to different tasks, among others. This led, on one hand, to the decentralization and redundancy of information and, on the other hand, to the inexistence of essential data.

There was an increasing difficulty for the company in reacting adequately when there were peaks in the demand and when they had several projects being developed at the same time. Also, they were unable to accurately determine which resources were used in each project and that made it difficult to calculate work and financial productiveness (productivity indicators).

The idea of developing a dedicated IS arose from the need to overcome those limitations. Specifically, the goal was to have an IS capable of supporting the Project & Incentives division in the **application stage**: (i) preparing the application, (ii) monitoring the application; and in the **project management stage**, if the application is approved: (iii) monitoring the project, and (iv) closing the project.

Figure 1 represents the UML activity diagram of the process that the IS should address and one can see the 4 main sub-processes present in the analysis of investment projects and applications for European incentive programs.

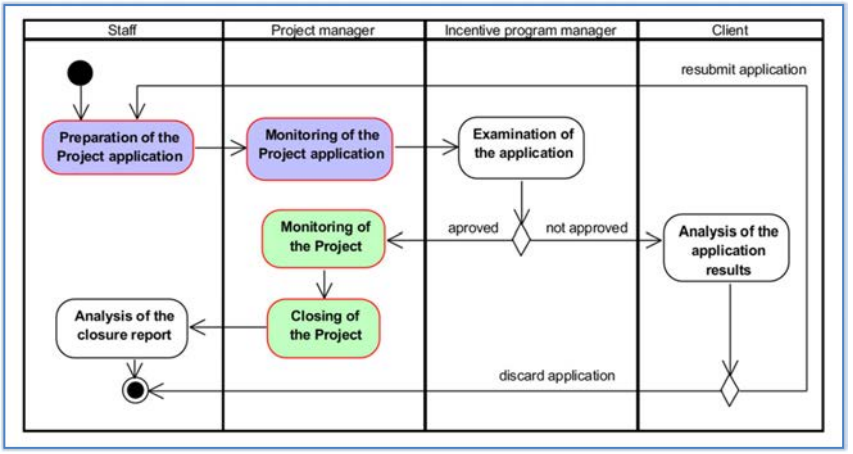

Fig. 1. UML Activity diagram representing the project management process.

3.2. Methodology of development

Regardless of the application area, an IS is a complex system that comprises software, hardware, and involves social, cultural and economic aspects surrounding the organizational system. In this context the use of models plays an important role, helping in the design and implementation of IS. In this process three main stages can be identified:

- **Requirements elicitation**, which helps with analyzing and understanding the requirements that IS need to meet.
- **Conceptual models**, that help with documenting and communicating with the different stakeholders involved in the development process. The resulting models of this stage do not take into consideration any technical aspects but focus on the problem that needs to be solved or the processes that need to be supported.
- **Implementation models**, which depend on specific technologies, are closely related to software programming. During this stage, the model is converted into technical building blocks called components, resulting in the final system.

This work only comprises the first two stages of the IS' development, specifically the requirements engineering (that resulted in a list of system's requirements as well as a mapping of the sub-processes), and the system's modeling (that resulted in an interaction model developed in accordance with the actors involved and respective use-cases, as well as a data model).

First, as a way of understanding the scope of the problem, as well as the requirements of the system, an exploratory study was conducted at Consulting@COM's Projects & Incentives division. During this stage a set of requirements engineering techniques were used, namely:

- Documental analysis – a set of documents were studied like, for example, work procedures, meeting minutes, applications, incentive programs regulations, and also the functionalities of the existing IS that were used to support parts of the process;
- Informal interviews – it was the way used to listen to the collaborators that, directly or indirectly, are involved in the project's management and monitoring process;
- Direct observation – used to observe work processes associated with project management, as well as the inherent procedures;
- Group meetings – in those weekly meetings collaborators in management and decision-making positions were involved, with the purpose of validating the requirements previously identified and also to identify new needs.

In a second stage an iterative and incremental approach was used in order to build the required models to describe the process and the IS' characteristics. Models represent the static or dynamic aspects of information systems and can present information processes (process models); system boundaries and interactions with external actors (interaction model); and data structures (data models). While data models lead to the design of databases, the interaction model determines the interfaces and the access levels for the different actors, and the process models are generally used as a basis for the programming of functionalities[8]. For modelling IS, the most widely used graphical language is the Unified Modeling Language (UML)[13], that employs activity diagrams for process modelling, use-case diagrams for interaction modelling and class diagrams for data modelling.

3.3. Results and discussion

According to Chang[14] through UML diagrams, clients, users, business analysts, system analysts, and programmers can better communicate their needs and build a system in order to solve the organizational problems. The solution found to address the needs of Consulting@COM, was described using a set of UML graphic representations, including the mapping of the business main processes in an activity diagram (previously shown in figure 1), as well as the conceptual model for the solution, designed with use-case diagrams and a class diagram.

As a way of understanding the 4 previously identified sub-processes and also show a global view of the existing interactions within the process, the connections between them and their impact in the outputs' quality, were analyzed using the SIPOC (Suppliers, Inputs, Process, Outputs, Customers) tool[15].

Table 1. SIPOC matrix.

Suppliers	Inputs	Process	Outputs	Customers
– Client – Incentive program management	– Customer needs – Application procedures	**Preparation of the Project application**	– Electronic submission of the application (report with financial plan and plan for project execution)	– Client – Incentive program management
– Incentive program management – Client	– Electronic submission of the application (report with financial plan and plan for project execution)	**Monitoring of the Project application**	– Signed contract	– Client – Incentive program management – Administrative / financial division
– Client – Incentive program management – Project area	– Decision of Incentive program management – Signed contract – Evolution of plan for project execution – Evolution of financial plan	**Monitoring of the Project**	– Internal report – Invoice order	– Administrative / financial division – Client – Incentive program management
– Client – Project area – Incentive program management	– Project procedures – Internal report – Invoice order	**Closing of the Project**	– Internal closing report (I.C.R) – E.C.R. (external closing report); – Final financial report	– Client – Incentive program management – Administrative / financial division

The SIPOC matrix, originally used as a tool for quality control, when applied in this context, details the information provider (Supplier), information needed for the process (Input), the stages of the process (Process), the information generated (Output), and the information receiver (Customer) for the purpose of systems development (see table 1).

Afterwards each sub-process was mapped using UMLs' activity diagrams. Due to space limitations those diagrams are not included in this paper but it should be noticed that they were essential for identifying the associated procedures and the respective interactions, thus serving as an input for the next stage.

In that stage, and taking into account the requirements previously established, the main actors that will interact with the system were identified and the functionalities each one would access were defined.

Four main users' profiles were identified: the coordinator, the collaborator, the project manager and the financial technician, and each one should be able to use, after its authentication and validation, a wide range of functionalities. Figure 2 shows the use cases diagram with the system's main high level functionalities.

Fig. 2. High-level use case diagram of proposed system.

The Project Coordinator is responsible for starting the project, more specifically for creating the application and (i) plan the tasks, (ii) choose the project team, and (iii) allocate the necessary resources to each task. All collaborators in a project (Collaborator) will be notified, by the system, of their inclusion in the project and of the tasks that need to be done, with the associated timetable. The Collaborator represents the profile of all the users, allocated to projects, that are responsible for developing the tasks, and will have a specific area in the system that will allow them to manage the work each one does for each project they are in (e.g. introduce the state of tasks, closing tasks when they are concluded, introducing the already used resources). Collaborators should be notified by the system of upcoming deadlines, overcome deadlines, scheduled meetings, or other sporadic warnings. The Project Manager is responsible for the project, after the approval of the application, and is appointed by the Project Coordinator. Finally, the Financial Technician is responsible for all the financial aspects and all the payments of a project.

Both the Coordinator and Project Manager can, at any moment, obtain from the system some statistical data regarding indicators that help to monitor the progress of the application and /or the project (for example, the number of warnings sent to the collaborators, number of unsolved situations, overdue tasks) and see the used resources and expenses of a project (for example, number of internal meetings, number of external meetings, time per task, number of car trips). The system will also provide this actors with other performance indicators like, for example, the number of projects per collaborator, the number of collaborators involved in a specific project, the number of attached documents, the total project time, the number of billing requests, among others.

In order to address the identified requirements a data model was developed using an UML's class diagram, as shown in figure 3.

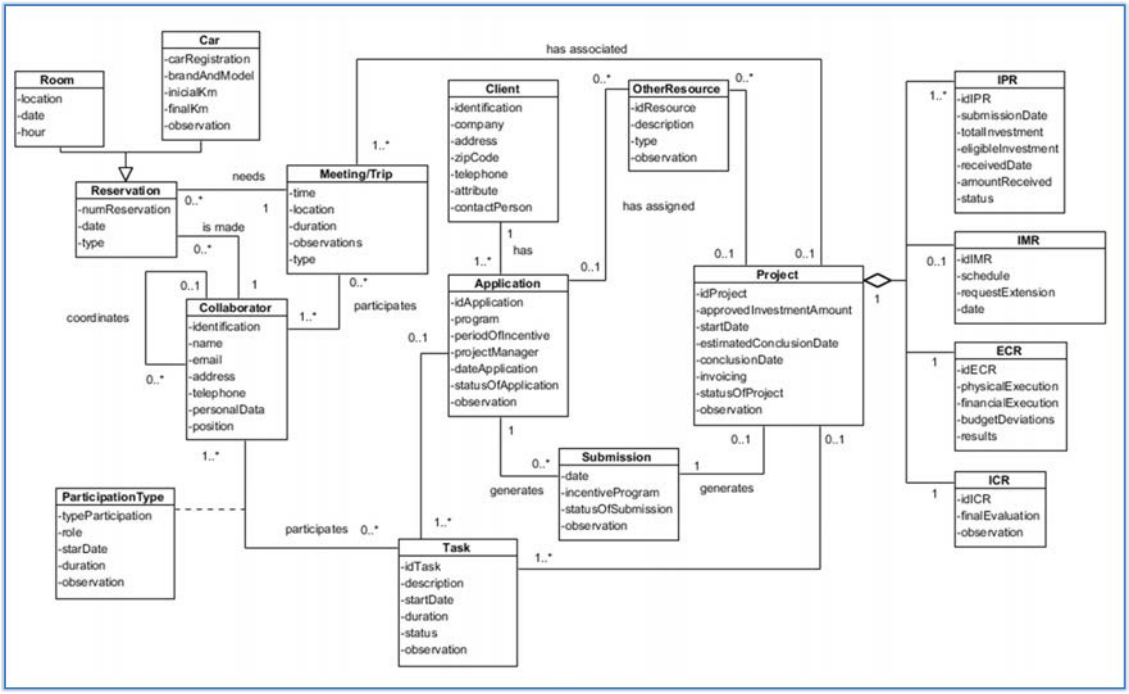

Fig. 3. UML class diagram representing the data model.

The class diagram, shown in figure 3, presents, in a general way, the abstract information model related to the life cycle of the development and monitoring of investment projects, as well as the preparation of applications for European incentives programs.

With regard to the application class, it is identified by an internal number, unique throughout the life cycle of the project, and belongs to a single client, but it can be subject to more than one submission if it is not approved the first time it is submitted. The application, if approved, becomes a project and so, a work plan, similar to what was done for the application, will be created and that entails defining and scheduling the necessary tasks and allocating resources.

The project class, characterized by an internal number, amount of approved investment, project period, among other attributes, aggregates four distinct subclasses: I.P.R. (incentive payment request), I.M.R. (investment modification request), E.C.R. (external closing report), and I.C.R. (internal closing report), whose objects are created accordingly to the stage the project.

With regard to meetings or trips, each one requires its own record (in 'Meeting/Trip' class) because they must be justified under a certain project. Meetings or trips may involve room or car reservations, which must be done by a collaborator of the project and the used resources (namely for trips) must be justified under a specific project.

4. Conclusions

The purpose of this paper was to present the design process of an Information System for Project Management, in the context of a consulting company that helps its clients manage investment projects and application processes for incentive programs.

A review of the concept of project, project management and of the role of PMIS was also presented and discussed. Regarding the PMIS, some studies emphasize several advantages that can be obtained with its use. Nevertheless, the practical reality observed points to a scenario of low usage of such systems, by small and medium enterprises (SME). The two main reasons for this scenario are the high cost of this kind of IS, that are usually acquired by organizations as software packages, and the fact that they are generic solutions and consequently do not support certain specific needs of projects. To overcome those difficulties many SME choose to invest in the development of their own IS for Project Management, as such was the case of Consulting@COM, whose experience was described in this article.

The development process of PMIS at Consulting@COM included the problem identification, the mapping of the processes and the definition of the information architecture (models). The main results were presented through the use of UML diagrams. As future work, the implementation and test of the Information System will be proposed in order to validate the solution.

This paper can be valuable both for researchers on information systems for project management, and companies' decision makers or staff that want to implement these types of systems in their organizations.

5. Acknowledgement

This work was supported by Portuguese funds through the CIDMA - Center for Research and Development in Mathematics and Applications, and the Portuguese Foundation for Science and Technology, within project UID/MAT/04106/2013 and by National Funds through FCT - Foundation for Science and Technology, in the context of the project PEst-OE/EEI/UI0127/2014.

References

1. P.M.I. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) , Fifth Edition*. (Project Management Institute, 2013).
2. Salazar-Aramayo, J. L., Rodrigues-da-Silveira, R., Rodrigues-de-Almeida, M. & De Castro-Dantas, T. N. A conceptual model for project management of exploration and production in the oil and gas industry: The case of a Brazilian company. *Int. J. Proj. Manag.* **31,** 589–601 (2013).
3. Vre, I., Barilovi, Z., Kr, B. A., Management, P. & Kr, B. A. Web 2 .0 technologies supporting project. 219–226
4. Atkinson, R. Project management: cost time and quality two best guesses and a phenomenon, it's time to accept other success criteria. *Int. J. Proj. Manag.* **17,** 337–342 (1999).
5. Engwall, M. & Jerbrant, A. The resource allocation syndrome: The prime challenge of multi-project management? *Int. J. Proj. Manag.* **21,** 403–409 (2003).
6. Caniëls, M. C. J. & Bakens, R. J. J. M. The effects of Project Management Information Systems on decision making in a multi project environment. *Int. J. Proj. Manag.* **30,** 162–175 (2012).
7. Caniëls, M. C. J. & Bakens, R. J. J. M. in *Handbook on Project Management and Scheduling Vol. 2* (eds. Schwindt, C. & Zimmermann, J.) 1355–1383 (Springer International Publishing, 2015). doi:10.1007/978-3-319-05915-0_31
8. Ahlemann, F. Towards a conceptual reference model for project management information systems. *Int. J. Proj. Manag.* **27,** 19–30 (2009).
9. Ahlemann, F. & Riempp, G. RefModPM: A Conceptual Reference Model for Project Management Information Systems. *WIRTSCHAFTSINFORMATIK* **50,** 88–97 (2008).
10. Jaafari, A. & Manivong, K. Towards a smart project management information system. *Int. J. Proj. Manag.* **16,** 249–265 (1998).
11. Raymond, L. & Bergeron, F. Project management information systems: An empirical study of their impact on project managers and project success. *Int. J. Proj. Manag.* **26,** 213–220 (2008).
12. Raymond, L. & Bergeron, F. in *Impact of Project Management Information Systems on Project Performance, Vol 2* (eds. Schwindt, C. & Zimmermann, J.) 1339–1354 (Springer International Publishing, 2015). doi:10.1007/978-3-319-05915-0_30
13. Booch, G., Rumbaugh, J. & Jacobson, I. *Unified Modeling Language User Guide, The (2Nd Edition) (Addison-Wesley Object Technology Series)*. (Addison-Wesley Professional, 2005).
14. Chang, L.-C. Rethinking the Project Management Process by Using Unified Modeling Language. *Int. J. Inf. Technol. Proj. Manag.* **6,** 58–73 (2015).
15. Rasmusson, D. *The SIPOC Picture Book: A Visual Guide to SIPOC/DMAIC Relationship*. (Oriel Incorporated, 2006).