Integrating Process Mining and Success Factors in Information Systems Projects: A Decision Support System Approach

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Abstract: The management of Information Systems (IS) projects involves addressing complex challenges such as communication issues, resource allocation, time constraints, customer interaction and evolving requirements. A project manager faces, therefore, a significant number of decisions on the progress of these projects, based on the most important Success Factors (SF) that each project encloses. As far as we are aware, there is currently no automated solution capable of effectively tackling these challenges, forcing managers to depend on conventional approaches that often prove insufficient to provide the necessary support. This paper proposes an architecture for a Decision Support System (DSS) designed to enhance project success by providing project managers with recommendations. The DSS integrates Process Mining techniques with SF to suggest valuable insights for decision-making. The system proposed aims to optimize project decisional outcomes and can combine algorithms from Process Mining, Data Mining, and Predictive Mining to enhance its recommendations.

1 INTRODUCTION

The development of Information Systems (IS) has become more complex, requiring advanced planning, scheduling and control processes, as they justify high costs. Project management is fundamental to ensuring that these systems are delivered on time, within budget and to expectations (Avison & Torkzadeh, 2009).

In these projects, organizations also face difficulties in terms of communication, resources or even processes, such as changing requirements during the project, ineffective communication between the team, or problems allocating resources, which makes managing IS projects particularly challenging. The failure of these projects can have a significant impact, given the strategic relevance they represent and the often high costs involved (Pereira et al., 2021). Evaluating project success is therefore essential, for success management to become a systematic process (Varajão, 2018). Freeman and Beale (1992) define project success based on stakeholder perspectives (customers, programmers, team, end users). Shenhar et al. (1997) identify four success dimensions: efficiency, customer impact, business success, and preparation for the future.

Thus, the question emerges: how can IS project managers maximize project success, considering the multiplicity of critical decisions they must make throughout project development? To our knowledge, there is no automatic mechanism capable of meeting this challenge, leaving managers dependent on conventional practices that often lack adequate support. We have already proposed in Pedrosa et al. (2021) a general technological framework for this matter, including the overall approach to tackle the problem stated.

In this scenario, the implementation of Decision Support Systems (DSS) appears to be a promising solution. DSS are tools designed to help managers

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make complex decisions, by integrating historical data, advanced algorithms and analytical techniques to provide informed recommendations.

Process Mining techniques can, therefore, become essential components for analysing and optimizing IS project management processes. This approach uses data generated by event logs, often dispersed in project management tools such as Jira, Trello or version control systems, offering a detailed view of organizational processes (Gupta, 2014). By applying Process Mining, it is possible to map actual workflows, identify bottlenecks and promote continuous improvements, providing valuable information for more informed decision-making.

In this paper, we expand our previous work in Pedrosa et al. (2021), taking it a step forward in defining decision types that a project manager can benefit from by using a DSS, as well as details on such a system. Particularly, the objective is to present the architectural components of the DSS to analyse event logs from project histories, correlate the results obtained through Process Mining with predefined SF, and finally provide feedback to the project manager on the recommended decisions to make.

This paper is organized as follows: the next section outlines the main motivation for this work, highlighting challenges in IS project management and most related work. Section 3 introduces the research methodology applied. Section 4 focuses on the architecture of the DSS, and finally, Section 5 presents conclusions and future work.

2 MOTIVATION AND RELATED WORK

Information system project management presents significant challenges, especially given the multifactorial and multidimensional nature of the decisions that need to be made. Decision-making is a central element in any organization and is intrinsic to its management and success. As Ada & Ghaffarzadeh (2015) note, the success, growth, and even failure of an organization are directly linked to the quality of decisions made over time. However, decision-making presents significant challenges, including uncertainty about the outcomes that a particular choice may produce.

Decision-making in IS project management is crucial, involving choices on technology, resources, strategy, and stakeholders. Given its complexity, managers cannot rely solely on experience or intuition. Decisions must consider multiple factors, such as the SF that directly influence the outcome of projects, as well as historical data and performance standards for teams and processes.

Decisions also involve multiple dimensions - such as human, financial and technological resources - and depend on distributed sources of information, which increases the level of complexity. As Eierman et al. (1995) point out, the complexity and importance of this task highlight the need for additional support for decision-makers, particularly through the aid of science and technology. A DSS is therefore considered to play a decisive role for organisations and project managers.

IS project management includes, by its nature, a significant amount of decision-making, considering not only the amount of project management processes involved but also the variety of SF that each project encloses. It is widely recognised that IS project management is challenging, and many studies have identified its problems, as illustrated in Table 1. For Salmani et al. (2022) poor communication and lack of domain knowledge are major challenges and often cause other problems to emerge, such as a high amount of rework and delays in project development.

The existence of bottlenecks is one of the most frequently mentioned problems in the literature (Gupta, 2014; Marques et al., 2018; Rubin et al., 2014).

Urrea-Contreras et al. (2024) highlight several software development project management issues, affecting product quality, notably event flow inconsistency and the lack of a formal document on the software development process. In the Process category, some authors point to problems related to the process, such as the constant change in requirements, their volatility (Salmani et al., 2022a, 2022b; Santos et al., 2015), difficulty in defining priorities or even prioritising user stories (Mendes et al., 2018; Vavpotič et al., 2022). Promising approaches dealing with this changeability include the work of Ferreira et al. (2014) and Mejri et al. (2015), which comprise the notion of process invariants and process flexibility, as ways to model (software) processes with expected exceptions and requiring more agile or flexible execution. Nevertheless, Marques et al. (2018) mention the failure to implement agile software processes, in this case, the Scrum framework, as a possible problem. Sometimes during the development of a software project, the team does not follow the guidelines established in Scrum and skips tasks or phases or bypasses the basic meetings defined in the framework.

Table 1: List of problems, their SF and decisions.

Category	SF	Problems	Decision
Communication	Communication / Cooperation	Poor communication	Improving communication between all stakeholders
	Multidisciplinary Work Teams	Ineffective communication between the multidisciplinary team	
	Relationship Management		
	Balanced Team/Healthy Environment		
Team	Define Clear Responsibilities	Lack of mutual understanding between the team members	Define clear roles and responsibilities/ Meet regularly for alignment
	Efficient Project Management / Project Planning	High rework rates	Reduce rework
	Human Resources Management	Team rotation	Evaluate team rotation
Resource	Sufficient and Appropriate Resources	Influence of resource allocation on the control-flow of the process	Adjusting resources
	Define Clear Responsibilities	Unsatisfactory performance by specific actors	Clearly define the role of each actor
	Human Resources Management	Inefficiencies in resource allocation	Allocate resources according to each of your roles
	Define Clear Responsibilities		
	Balanced Team/Healthy Environment		
	Sufficient and Appropriate Resources		
	Knowledge Management	Lack of domain knowledge	Share information about the domain
	Knowledge Sharing		
Process	Use Appropriate Business Methodologies	Deficiencies in the software development process	Adopt agile methodologies
	Complete Requirements / Avoid Customisation	Occasionally changing requirements	Avoid changing requirements during the project
	Formal Documentation	Inconsistency in the flow of events / Inconsistencies in the system's documentation	Improve the sequence of events/activities / Map and document the workflow
		Lack of documentation related to processes/Lack of explicit process modelling	Document the process/system correctly
	Complete Requirements	Gaps in process activity	Assign people responsible for key activities/ Redefine the process flow
	Project Planning		
	Define Clear Responsibilities / Human Resources Management	A lot of issues were closed by the same assignee	Automate the assignment of tasks
	Monitoring/Control / Project Planning	Presence of loops	Remove loops
	Use Appropriate Business Methodologies	Failures in the implementation of the Scrum methodology	Correctly implement/follow the methodology
	Use of Methodologies / Processes (Gantt Chart, CPM, WBS, among others)		
	Avoid Customisation	Deviations in process execution	Clearly prioritise each task. Eliminate deviations
	Project Planning	Redundant activities	Define clear responsibilities

Table 1: List of problems, their SF and decisions (cont.).

Category	SF	Problems	Decision
	Use of Methodologies/Processes (Gantt Chart, CPM, WBS, among others)	Skipping the analysis task	Don't skip the task of analysing the project
		Deviations in the flow of activities	Avoid deviations. Follow the defined flow of activities
	Monitoring/Control / Risk Management	Identification of the main bottlenecks in the workflow	Monitor workflows in real time
	Complete Requirements	Volatility in software requirements	Define clear responsibilities
	Project Planning		
	Clarifying Business Objectives		
	Clarifying Business Objectives	Loops showing undesired repetition of activities	Analysing historical data / Review and optimise processes
	Use of Methodologies/Processes (Gantt Chart, CPM, WBS, among others)	Difficulty in defining and changing priorities	Adopt agile methodologies
	Complete Requirements	Omission of crucial phases in the process	Describe all the phases of the process clearly
	Project Planning		
	Clarifying Business Objectives		
	Well-defined and Quality Information/Services		
	Formal Documentation	Developers often deviate from the defined process	Document the process/system correctly
	Realistic Estimates	Often exceeded estimated sprint tasks' time limits	Review initial estimates / Divide tasks into smaller parts
		Priority of user stories	Prioritise user stories correctly
	Establishing Output Requirements	Inefficiencies in project outcomes	Perform regular retrospectives. Adopt monitoring tools
Performance	Efficient Project Management / Project Planning	Incorrect sequencing of performance between activities	Select the best sequencing performance between activities
	Performance Management / Systems Testing	Performance bottlenecks	Carry out performance analyses. Test in real scenarios
	Paying Attention to User Needs / User Participation/ Systems Testing	Ignore real user and system runtime behaviour	Conduct tests based on real scenarios
Time	Time Management	Delays in follow-up activities	Define the time for each task/activity
		High waiting time between activities	Eliminate unnecessary dependencies
		Response time	Reduce response time

The annual Chaos Report by the Standish Group[1] evaluates software project outcomes, classifying them as successful, challenged, or failed. Since 1994, it has highlighted a high failure rate in IT/IS projects.

For each problem, there are one or more decisions that the project manager must make, which the DSS must suggest to help solve the problem. Table 1 shows a sample of the possible decisions for some of the problems mentioned in the 'Problems' column. Analysing the table, it can be seen, for example, that for the problem "High rework rates", the decision involves reducing rework. Similarly, for "Inconsistency in the flow of events", the corresponding decision could be improving the sequence of events/activities.

The application of Process Mining techniques to this theme can be highly advantageous, as it allows the project manager to obtain a clear vision based on the historical analysis of the organization's projects, or even by types of projects, customers, teams or other specific perspective. Process Mining stands out as a non-intrusive area of research focused on extracting knowledge from the records generated by IS about the control-flow, data and resources

[1] https://standishgroup.myshopify.com/

involved in carrying out business processes (Van Der Aalst et al., 2012). Using its three main techniques - discovery, conformance checking and improvement – Process Mining helps identify bottlenecks, reduce rework, improve communication, and address other IS project management problems (such as those listed in Table 1).

Given this, and to the best of our knowledge and research, no system covers all these criteria to support the project manager's decision-making.

3 METHODOLOGY

To achieve the aim of this research, the application of Design Science Research as a research method was considered (Hevner & Chatterjee, 2010; Peffers et al., 2007).

The first stage of the DSR process is identifying the problem and the motivation to solve it. This study addresses the need for a system to support IS project managers in decision-making, given the complexity of the challenges involved.

Once the problem is identified, the next step is to define the solution's objective: to enhance managers' decisions by providing information on project SF, reducing risks and failures. The goal is to maximize project success and support managers. Given the range of issues, a technological and innovative artifact is proposed to diagnose and predict the success of IS projects, enabling more agile and organization-specific decisions. Both these DSR stages have already been addressed in our previous work in Pedrosa et al. (2021).

DSR stage 3 - Design & Development as suggested by Peffers et al. (2007) consists of developing an artefact. Thus, in the context of this work, the artefact is a DSS based on Process Mining techniques to study the organisation's context in terms of IS projects and corresponding SF.

Some of the activities for the development and evaluation of this artefact are as follows: 1) identification of IS project management data of event logs, to feed Process Mining algorithms; 2) applying multiple-perspective Process Mining algorithms to discover and check the conformance of IS project management processes, towards identifying project success deviations; 3) identify heuristics for the mapping of Process Mining results and SF, and generate corresponding alarmistic and recommendations.

Concerning DSR's steps 4 (Demonstration) and 5 (Evaluation), we will be, in further research, collecting data from real projects in real organisations to validate the developed DSS.

4 DSS SOFTWARE ARCHITECTURE

Given the many challenges in IS project management, organizations and project managers must proactively address and mitigate these issues to maximize project success. In this way, the approach proposed by Pedrosa et al. (2021) aims to help the organisation's project manager make decisions considering the history of previous projects and the SF. The approach proposed and shown in Figure 1 includes two phases: the diagnostic phase and the prognostic phase.

The approach comprises the use of business logic to correlate historical data between project management processes (discovered and measured through Process Mining) and SF registered or retrieved automatically from a knowledge base. It also includes two main components:

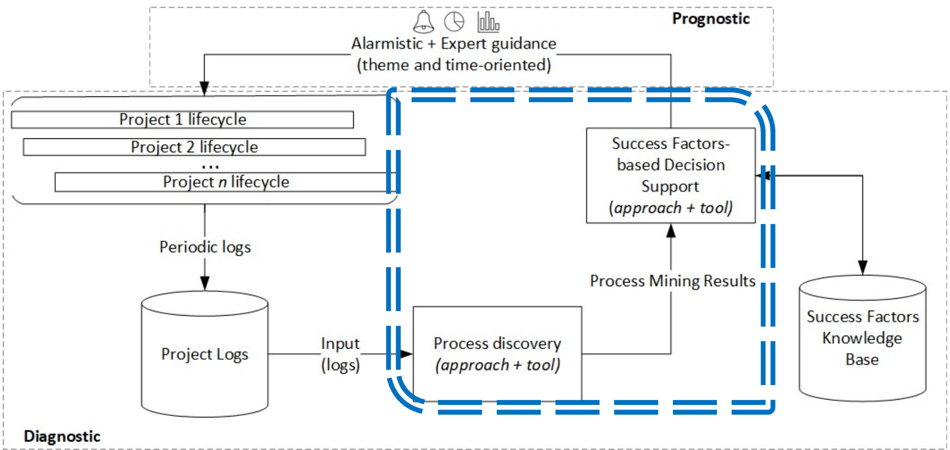

Figure 1: A Process Mining approach for IS project success factors management (Pedrosa et al., 2021).

the ‘Process Discovery’ and the ‘Success Factors-based Decision Support’, represented by the blue dotted line. The DSS will take the event logs from the project management IS as input data. The system concludes in the prognosis phase, presenting the user, in this case, the project manager, with a set of possible decisions.

A DSS consists of three main modules: Interface (user interaction), Data Management (integration and processing), and Model Management (analytical and simulation models for decision support)(Bâra & Lungu, 2012). Thus, the approach illustrated in Figure 2 is composed of these main modules, each one being subdivided into more specific components.

The interface module serves as the user interaction point and is divided into two sections. The Pre-Selection Interface allows users to select the parameters needed to run the DSS, such as the project to optimize and the SF to evaluate. The SF will be in a predefined list according to those available in the knowledge base.

The Feedback Interface, presented at the end, provides the project manager with alerts and recommended decisions. Based on these selections, the system automatically derives the relevant Process Mining perspectives (time, case, organizational, control-flow) for further analysis.

The Model Management module contains all the business logic models needed for the DSS to function correctly. This module can integrate data mining techniques (Apriori, Decision Tree, Association Rules), Process Mining methods (discovery, conformance checking, improvement), and prediction models (Linear Regression, Predictive Process Mining).

Ideally, the three types of models should interact with each other to maximize the chosen SF for a particular project. In addition to the models mentioned above, this module also includes a specific component called Choreographer, whose main function is to choreograph the possible interactions between the previously mentioned models. That is, it

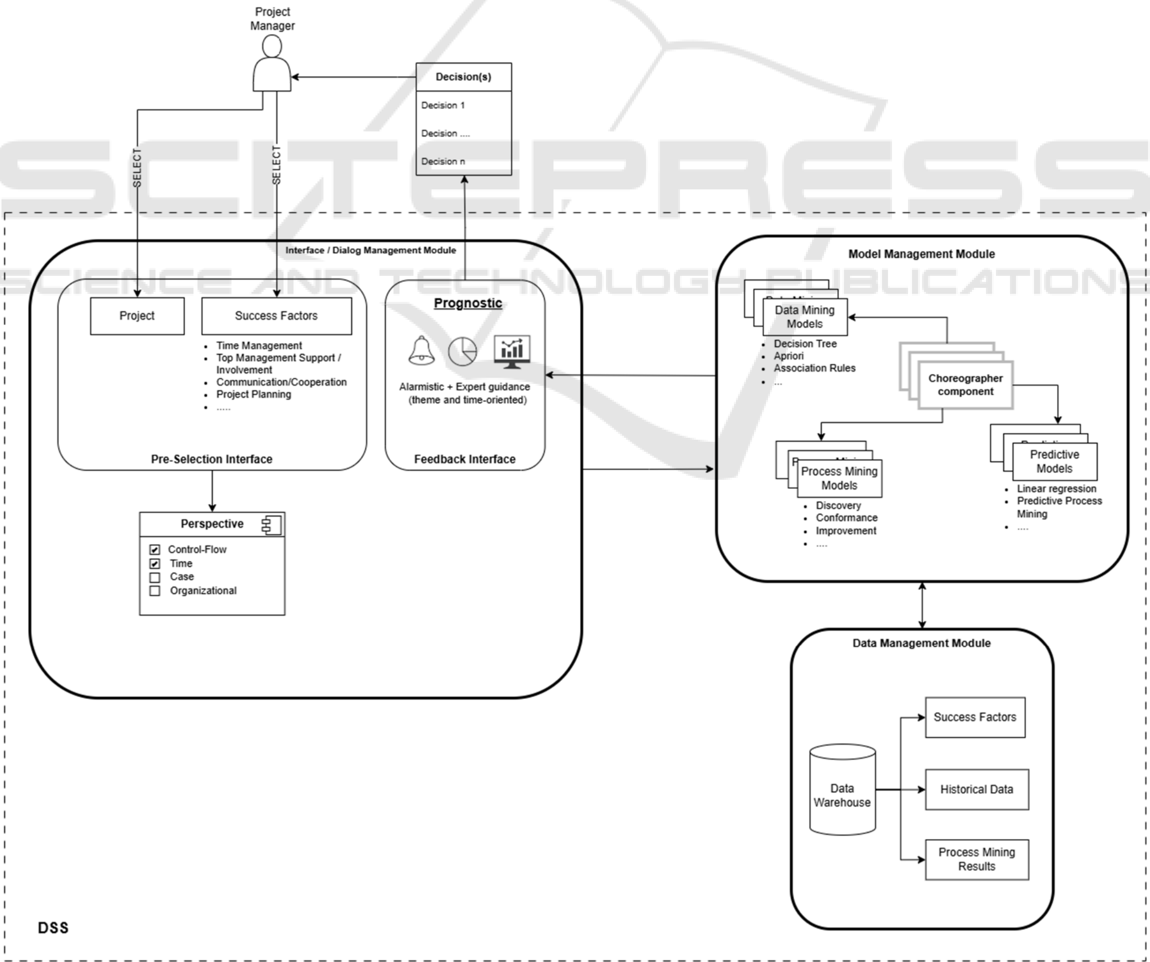

Figure 2: DSS software architecture.

will coordinate the interaction between the different models and the sequence in which each executes its algorithms. For example, for a particular SF, the component could choose to run a certain sequence of business logic models, starting, for instance, with a Process Mining algorithm, then injecting the results into a specific data mining algorithm and finally applying a predictive algorithm for recommendations.

For better understanding, we will be specifying a concrete example of our architectural approach in Figure 2. Therefore, the starting point for using the DSS is for the project manager to select the project for which s/he wants to have decision-making support (for instance, Project A), as well as the set of SF to maximize. Within this set, the manager can choose, for instance, "Time Management" as a specific SF. Next, the DSS derives which IS project management process perspectives it needs to analyse, considering the pre-selected project and SF. For example, the system would, in this case, consider the time and control-flow perspectives

That said, based on the selection, the DSS can run appropriate Process Mining techniques on the events logs of the organization's projects stored in the Data Warehouse (e.g., heuristics miner) to discover the most common performance metrics for the project to be analysed, including, for example, average execution, service, wait and synchronisation times, as well as accuracy, generalisation and simplicity - see, for example, Van der Aalst (2016). Next, the choreographer component would use the results of Process Mining to correlate them with the chosen SF. For instance, it could choose the Apriori algorithm to discover which activity sequences from similar projects had the most performant execution time. Finally, the choreographer component would ask a predictive model to calculate decision-support recommendations, such as following a certain sequence or imposing stricter deadlines for the remaining project management activities.

In the end, the DSS would return a decision grid to its interface module. In this way, the manager would be able to identify where to act and how. In this example, the manager should reduce execution time and take task D after task C.

5 CONCLUSIONS

The paper begins with identifying and correlating the most common SF, problems and improvement decisions associated with IS project management. Considering the number of variables involved in these contexts, we recognize the need for a project manager to be supported when defining such SF and performing decisions along the management of an IS project.

Nevertheless, and since each organization might have its own SF and particular ways to optimize them, we earlier proposed an approach which takes into consideration the organizations historical data on IS project management for better decision-making.

It includes a diagnosis phase, where Process Mining algorithms are executed to identify the best-performing projects based on a specific SF, and a prognosis phase, where these results are correlated and compared with the performance of the current project to support decision-making.

This paper presents the software architecture of a DSS to implement such an approach, composed of three main modules: Model Management, Data Management, and Interface Management. In the latter, the project manager can select the project to optimize, as well as the targeting SF (for instance, for project A, optimize the time management SF). In the Data Management module, the DSS stores previously executed project management data and computed SF, which can be retrieved by the Model Management module as input to Process Mining, data mining and/or predictive algorithms. These can, in turn, discover the best performant projects regarding the chosen SF, and predict/advise the project management where to conduct the current project.

The approach points out that integrating Process Mining techniques with SF can provide valuable recommendations for informed decision-making. The DSS architecture provides an additional Choreographer component to allow a flexible and customisable business logic sequencing and interaction between Process Mining, data mining and predictive models.

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