Planning for Public Sector Software Projects Using Value-Based Requirements Engineering Techniques; A Research Agenda

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ABSTRACT

The introduction of e-Government enabled services has resulted in the public- sector wide integration of different software applications, often scaled up to a national level. Out of observation, the way these initiatives are handled differs in the way software-development projects are managed in the private sector. The anticipated value of these projects tends to differ significantly in the long run. We have particularly picked interest in the health sector in which e-Health initiatives have been defined. We aim at understanding how value proliferation can be understood and quantified from the onset on such large-scale projects using requirement engineering techniques. In this work we infer that effective planning of large scale ICT initiatives, such as e-Health, should be long term driven so as to ensure effective sector management. Novel approaches in this realm should strive at linking strategy, measurement and operational decisions from the onset. In here we examine what has been done, key opportunities, challenges and gaps that can be addressed by the research community. In bridging these gaps, we propose an agenda by formulating key research questions which both the industry and academia can address as future direction to align this view.

CCS CONCEPTS

•**Requirements Engineering → Value-based Requirements Engineering**; *Project-scoping*; project success criteria; prioritization

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KEYWORDS

Value-based requirements engineering, project planning and success, e-Health based projects

1 INTRODUCTION

Software project planning for large-scale systems, such as e-Health based application development projects, still remains a daunting task. Some of these projects are donor-driven under the auspices of health system strengthening programmes [1] or public sector management for other e-Government projects. As such many stakeholders are involved with varying views of what perceived value such projects can create; for we have donor interests on one side and government interests on the other. This disparity tends to prolong activities on the project and often raise the ground for conflict. Hence, aligning both interests requires novel approaches that can help both parties realize the actual areas where value should be leveraged and where project focus should be. We believe that value-based requirement engineering techniques are a critical enabler in unlocking this potential.

The field of Software Engineering provides different approaches for problem-domain analysis including elicitation techniques that would fit a particular context [2]. Using such techniques, we observe that as our understanding of the problem deepens, so does our contextualization of the problem from a system perspective. Ideally looking at how best a given problem can be addressed or solved. However, at this point we tend to dwell mostly on the functionality and most of the time, the value-related aspect, upon which implementation success will be measured, is overtly excluded; [3] yet this should be the driving factor as observed. As engineers we tend to dwell on whether the requirement has been developed and tested and that it is working.

Sadly, after the product goes into the operation environment, we have no way of assessing if the system actually provided the intended value that was envisaged at project inception. Some clients may measure this value over time yet others may not. Proponents of this value mapping have proposed various ways of computing or quantifying this value especially within the information-systems domain [4]. While these are novel approaches, we are inclined to believe that value creation in software development is not a one-off event and it is not only monetary. Rather, it is an iterative approach which is supported by aligning product, project and business-level decisions throughout the development process and even after product implementation.

We thus need mechanisms that can help us reflect on how best we can predict this value from the onset as we undertake domain analysis and as we shape fundamental project goals. Luckily, projects in the public sector tend to allow for substantial time on planning where various assessments can be made. Our overall goal is to find the intersection of the perceived value at project inception and overall anticipated value over time; as the application or system matures in its environment. We are confident that exploring the value-based requirements engineering approaches, in combination with predictive mathematical modelling techniques, we can be able to achieve this.

The rest of the paper is structured as follows. Section I constitutes this introduction, Section II describes the rationale upon which this motivation is based, Section III highlights what has been done across the research community to address this challenge. In Section IV we set the research agenda and challenges ahead of this study and the next steps as a way of steering future direction. We conclude our paper with Section V by making key highlights from our observations.

2 RATIONALE

It is fundamentally critical to establish synergy between the overall objectives of the project and the defined scope of the product. Successful planning would focus on both these issues so as to align the product scope with the project scope. From available literature, models or techniques that make it possible to non-monetarily pre-assess projects against the project objectives during the project inception and through the development process, while using requirements engineering approaches, are scanty. Most studies are technologically driven and rarely attend to valued stakeholders' requirements. Besides, modelling for improving e-Health for environments which involve a number of dispersed stakeholders is tested to be challenging [5]. In this case value and e-Health goals stand to conflict each other in the absence of proper strategic alignment.

The key issue we are addressing is that we can leverage effective planning of such large-scale initiatives by using value-based requirements engineering methods. In particular, if we apply requirements-modelling techniques in conjunction with predictor models that support the understanding of process change against impact given the requirements, we are bound to uncover various project dimensions. Ultimately, we will be moving a step closer to providing strategic insights prior to project implementation as well as post-implementation analysis.

3 RELATED WORK

3.1 Software Value Perception on e-Health Projects

Value on a product or project is perceived by those receiving the service. As such it tends to be specific to the project or service outputs [6]. Hence, it is something that is highly predictable on the assumption that there is a relationship between how the software is created and the value perceived. There are some well-established value indicators associated with value for money, customer satisfaction, among others [7]. However, as some researchers have observed, it is important to try to capture some of the strategic and cultural values that are unique to every organization [8]. Usually these form the basis for evaluating project success.

Establishing project success can vary significantly given the varying dimensions of what success is. Some studies show that success can be measured based on how best a product meets the intended requirements [9]. However, we would like to believe that this success goes beyond this step. We contend that the actual value of the project can only be assessed if the actual product can perform as expected in the operation environment and hence result in fulfilling the general project establishment objectives. Unfortunately, this kind of measurement is often done during the support and maintenance phase of the application lifecycle, as a post-project assessment.

We have particularly picked interest in the health sector in which e-Health initiatives have been defined. For instance, within the medical world, there are Electronic Medical Records (EMR) systems, atop other information systems, built around the standard operating procedures and processes of hospitals as defined by the World Health Organization (WHO) stands. However, despite this similarity, their perceived value against the actual value realized over time, differs significantly.

Some countries have been taken by the storm usually due to donor funding requirements via health system strengthening programmes. As such many of them have taken on the e-Health initiative without effectively planning for it; resulting in ad-hock implementations that creates different problems on their own. In such circumstances it becomes extremely difficult to measure the relative value accrued from such initiatives.

Hence, if e-Health is initiated as a project to drive this strategy, we have to ponder on the standard software project definition procedures. In this case, it is important to establish if the project being embarked on is the right project, or understanding how the results will be achieved in addition to understanding how success will be measured over time. The output of this is the business case which augments the planning phase. But this business case must be as comprehensive as possible.

3.2 Existing Novel Approaches to Support this Understanding

Requirements prioritization, dependency analysis and negotiation techniques are at the forefront as plausible mechanisms in

addressing this bottleneck. As such, various approaches have been proposed around this area. For instance, Voola & Vinaya, [10] propose a technique to assess number of decisions, time consumption, ease of use, attractiveness, scalability and reprioritization of requirements. Their technique is based on Numerical Assignment (NA), Analytic Hierarchy Process (AHP) and Extensive Numerical Assignment (ENA), each based on ordinal, ratio and interval scales respectively. Renzel *et al.* [11] propose requirements Bazaar which supports requirements prioritization with a modular extensible requirements ranking framework. Their framework uses a linear weighted combination of multiple scoring providers which serves as foundation for computing one singular normalized requirement relevance ranking score.

Additionally, we observe that the complex network theory has offered a new theoretical understanding and a new perspective to solve this kind of complexity problem. Other authors have proposed clustering and complexity measurement models as Complements to requirement prioritization techniques. For example, Dali, [12] proposes a new technique for the structural complexity measurements of large-scale software system using numerical simulations. Heip *et al*. [13] proposes a pairwise constrained clustering method in lieu of partitioning a set of data points into clusters. Carrizo & Nilchiani [14] uses a mathematical model to demonstrate the concept of joint entropy as a way of dealing with the minimum level of complexity a system can achieve for a given set of requirements**.**

Smith [15] proposes a proactive approach that uses quantitative techniques to predict the performance of software early in design to identify viable options and eliminate unsatisfactory ones before implementation begins. Salado & Nilchiani, [16] propose a new complexity metric at requirement stage that measures the complexity limit of the system at conceptual stage (even before a specific design is determined). Christopher & Chandra, [17] propose a multi-criteria Fuzzy Based approach that is able to estimate the software complexity early which in turn predicts the Software Requirement Stability during the software development life cycle.

The goal of this is to map system complexity and increase organization understanding as well as minimize conflict between stakeholders; thereby ably negotiating on system-implementation requirements. Negotiation is regarded as crucial in many disciplines. Win-Win Negotiation model is one of the most common models to resolve requirement conflicts. Khan *et al.* [18] propose an agile framework to resolve conflicts between stakeholders and provide observational results based on a formal negotiation process.

While all this is commendable work, some gaps still exist. As observed by Achimugu *et al.* [19], these existing prioritization techniques suffer from a number of limitations which includes: lack of scalability, methods of dealing with rank updates during requirements evolution, coordination among stakeholders and requirements dependency issues. Gunner & Faegri [20] maintain that system scalability requirements is hard because they lack a conceptually sound language for expressing scalability requirements.

4 RESEARCH AGENDA

Planning is a crucial phase in the development process, as it determines the level of success and reliability of an application. Invariably, if we are to do it successfully, we ought to set realistic objectives that are not only driven by architecture and design or development time but also by the net benefit this application will create. This benefit is summarily described as non-functional requirements which are seldom tested aside performance and security. Hence, as a conflict mitigating strategy, our research agenda is aimed at highlighting this benefit when planning is underway. In fig.1 below, we summarize our agenda and how it can be used to align stakeholder perspectives on the project using a two-step model.

Step 1- Relationship definition: Basing on the public-sector scenario, we see the government (ministry) as the main customer. Where donors are involved, they also become co-customers given their funding. In cases where projects are outsourced to external companies (and this could be a consortium given the nature of the project), these companies also become stakeholders. Otherwise it is a software development unit within the ministry.

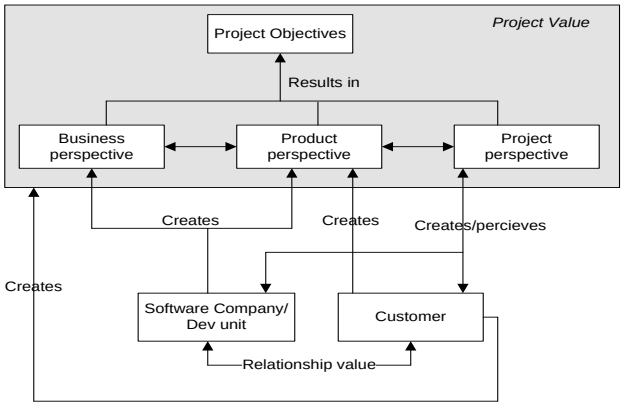

Figure 1: Value analysis conceptual framework.

In this case customers have to leverage a relationship that is valuable to both. For the software development company, it must realize a return on investment while ensuring that it delivers what the customer wants. On the other hand, the customer must monitor the deliverables to ensure that they fulfil his/her needs or interests. As such, during this planning phase, the customer will create the business perspective, the product perspective and also creates or perceive the project perspective. The software-development company is premised on creating a product that conforms to business perspective. It is important to note that the business perspective will drive the product perspective and consequently the

project perspective. Once these relationships are well understood, then we can start defining the project objectives that can align the three perspectives. We view this as the first leg of defining this value mapping.

***Step 2*- Align product requirements to a project objective**: Fundamentally, business applications are developed to address key challenges experienced in certain areas of business (where business means what we do on a daily basis). These challenges could be as a result of inefficiency in terms of operations or a way of standardizing what we do to suit a specific international standard expected. To capture this perspective, we explore the existing business processes upon which key product requirements are premised. In this exploration we can determine where it hurts most and the plausible solution thereof.

We need to go an extra level to assess how the perceived requirements are distributed across the business processes that are meant to be improved by the envisaged product. This is where the requirements engineering techniques such as dependency analysis, prioritization and negotiation etc., come into play. We have to be able to observe where most requirements are clustered by performing a requirements density analysis. This analysis should be able to map back to the project objectives. For instance, the initial project perspective could have revolved around enhancing a certain business process. However, after the analysis, it is possible to observe that the requirements density of the product is skewed towards another business process which could have been excluded or ranked lower when defining the business perspectives. Such an invariant presupposes concentrating resources on that area more than anticipated. These resources could be both at the development level and post implementation such as training; given the value attachment.

Additionally, the analysis should also provide an opportunity to answer 'what if' questions as a future likelihood of project outcomes so as to quantify anticipated value. In the end, this should allow for holistic requirements negotiation and reprioritization. In driving stakeholder satisfaction, the key output to this analysis would be the basis to decide which project objectives can be achieved or not or those that need to be refined. Secondly, to understand the value proliferation on the project and which areas that will be impacted accordingly. Hence, this approach assumes some considerable time spent on analyzing the project domain and shaping the project objectives accordingly. Once this is established, we can then set project success measurement criteria with maximum certainty.

4.1 Challenges

Our research direction is pointed towards understanding challenges aimed at value mapping in large-scale software projects in lieu of establishing unified project success criteria based on project objectives. In particular we intend to understand mechanisms that can support: achieving multiple stakeholder goals, managing scalability and refinement of requirements, refinement of project goals and their linkage to proposed requirements including their constraints as well as non monetary measurement of project value prior to (and post) project implementation. This shall take into perspective available techniques in requirements elicitation, clustering, prioritization, dependency analysis, negotiation, and re-prioritization, so as to ably observe value proliferation on the project.

As future direction for this agenda, future research can help in addressing the following questions:

- By integrating predictor models in software project planning for large scale systems, how best can these be aligned with value-based requirements engineering methods to provide reliable results for effective decision making?
- Given that there is a wide usage of agile methods in software development today, how best can such approaches fit into the agile environment?
- Given that predictor models could have their own flaws, can the utilization of one or more predictor models provide significant comparative analysis for better decision making?
- Given that budgeting is a fundamental aspect of planning, how best can the output of this analysis drive the project budget and business case at inception and during the development phase of the product?

5. CONCLUSION

Software development, as an economic activity in the private sector, requires making monitory assessments on the project. However, in the public sector this is the contrary given the nature of the projects. With this slack, we are inclined to think that executing such large projects on an ad-hock basis is not an effective way. Rather, if we apply formal and structured approaches that are informative enough, different results will be realized. This will require simplification of metrics that shall allow stakeholders judge the value being delivered by such initiatives over time. We thus need to plan for both the technological impact and the people responses towards technology integration. Our measure of success will primarily hinge on our understanding of effectively planning and overall implementation.

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