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ABSTRACT

It is usually difficult for companies to keep up with the development of new information technologies and adapt in face of the opportunities and threats those advances may represent. This is especially true for small and medium enterprises (SME) in emerging economies, where resources tend to be scarce and markets more volatile. This paper describes an action-research conducted in a small Brazilian software house that adopted an open-source Web Services development platform in order to improve its software development process. Data analysis revealed critical success factors (CSF) in the adoption process, as well as specific benefits and barriers prone to be faced by small software houses in their adoption efforts. In the process of overcoming such barriers, SME may acquire intellectual capital that represents an essential resource to ensure their competitiveness and survival in emerging economies.

Keywords

Web Services, SME, Emerging Economies.

INTRODUCTION

In order to meet an increasing need for information storage, recovery and exchange in companies, IS researchers have been looking into new information systems development (ISD) tools, methods and techniques. The traditional client/server architecture that is still widely adopted by organizations around the world tends to hinder the implementation of faster business strategies due to the difficulties it presents to the adjustment and innovation of business processes and products (Hagel, 2004). Frequently, IT management has to resort to integrated software packages with high costs and deep impact in several areas of the organization (e.g.; structure, processes, skills, relationships). To address such problems, the architectures based on components and, more recently, on services (SOA – Service Oriented Architecture) have been developed by the software industry, aiming at the improvement of ISD processes and a better alignment with ever changing business needs.

Web Services (WS) technology has evolved as a standard platform to implement service-oriented architectures. In a recent survey (Krill, 2008), 53% of 200 companies worldwide stated that they already were using SOA. In a previous survey with 273 of the largest companies in the world, 37% of the participants confirmed they were using WS and 44% were at the research and development stage (Westbridge, 2004). As large organizations start to ask for solutions that are able to interact with the already implemented WS systems, the pressure on smaller companies to adopt that technology tends to increase. Software development and consulting companies that respond promptly to this challenge will possibly establish a competitive advantage in their markets.

In emerging economies, which are usually characterized by constant changes, inadequate infrastructures, and scarce resources, SME usually account for a large proportion of the workforce. Nevertheless, their survival rates tend to be dismal, as few companies make it through their first three years. For instance, in Brazil, micro and small enterprises accounted for 98% of the 5.1 million companies that operated in the country in 2006, over 60% of the private sector's workforce, and 20% of the GNP (SEBRAE-SP, 2009). Among those companies, 51,240 provided IT services, of which only 1,653 employed 20 or more people (IBGE, 2006). Regrettably, around 50% of the Brazilian companies close their doors before their third year of operation (SEBRAE-SP, 2009).

In general, it is argued that, to maintain competitiveness, SME must reduce costs while fulfilling customers' expectations (c.f. SEBRAE-SP, 2009). In the case of software houses, open-source WS ISD architectures may facilitate the accomplishment of this objective, not only by decreasing licensing expenses, but also by allowing a better alignment with the customer's business requirements (e.g., functionality, time to complete the project, costs, etc.) (W3C, 2004).

This paper reports the major findings of an exploratory action-research (Thiollent, 1997; Baskerville & Wood-Harper, 1996) that investigated the WS adoption process in a small software house in Brazil. One of the authors was responsible for facilitating the introduction of WS standards, tools and techniques in the company, and collecting data for the research. The other author was mostly involved in data analysis, always keeping in check the possibility of the first one introducing any

bias due to his personal involvement in the project. Critical success factors of open-source WS adoption, as well as its potential benefits and pitfalls were identified. Their relevance to the particular context of SME in emerging economies is highlighted in the conclusion of the paper.

WEB SERVICES AND SOA

In SOA, software components are offered as services in a computer network, and can be integrated and used for different applications and purposes. Roughly, in such architecture, the development of new applications would consist of selecting appropriate services and orchestrating them according to relevant business rules. In this way, SOA could allow a faster, simpler and less expensive implementation of new business requirements in the organization's information systems.

Since the 2000's, the World Wide Web Consortium (W3C) has strived to develop and promote a computer-based architecture that improves support conditions and integration among companies (W3C, 2004). This architecture, named Web Services, defines open standards and open protocols that are able to advance the integration of loosely coupled applications (Sleeper, 2001; Iyer et al., 2003). According to Clabby (2002, p. 2), "WS intends to change the way information systems are modulated, distributed and purchased".

The appeal of WS to IT and business managers derives from its prospective strategic and operational benefits. WS may add significant opportunities to the traditional software development economic model. Its flexibility allows organizations to use their current infrastructure to implement new business models and develop new products and services, which can be offered through the Internet to a vast number of potential customers. Companies not only can make information available to external partners, but also sell their own internal services to other organizations that have similar needs (Booch, 2003; Lim, 2003). Additionally, WS enhances interconnectivity and supports integration with legacy systems. This, together with the fact that it is based on open standards and technologies, suggests that WS can help organizations reduce time and costs associated with managing, maintaining, adjusting and developing their information systems.

Nevertheless, as emerging technologies, WS and SOA still require further development. Although new frameworks were proposed to overcome some of their limitations, issues related to security, coordination, transactions and Business Process Management (BPM) aspects are still reported in the literature (e.g.; BNET, 2009; Kreger, 2003; Papazoglou & Heuvel, 2007). Moreover, the interoperability premise, one of the pillars of the architecture, has been questioned by some authors (Stal, 2003). Such issues may pose a considerable threat to the adoption of WS, especially for companies that struggle with the lack of resources in volatile business environments.

RESEARCH METHODOLOGY

In order to assess the difficulties, costs, benefits and critical success factors of Web Service adoption by SME in emerging economies, the authors conducted an action-research (e.g., Thiollent, 1997; Baskerville & Wood-Harper, 1996) in a small Brazilian software house, from here on denominated JGSoft. Some of the company's main customers were small accounting firms. In general, those firms' core business process consisted of gathering their clients' invoices and bills, registering the correspondent transactions in the appropriate accounting books, and calculating due taxes. At the end of each month, a detailed balance sheet report of all accounting activities was generated and sent to the clients by mail. In 2006, JGSoft partnered with one of its main customers to develop a system that would enable the accounting firm's clients to obtain such reports over the Internet.

Although JGSoft had a strong record on software development using traditional three-layer architecture, its owner believed it was important to develop in-house expertise on SOA and WS. One of the authors was contacted and agreed to act as the overall project manager. In such capacity, he was directly involved in negotiations with customers, systems analysis and design, and hiring process. His position also allowed him to collect qualitative data through conversations, email messages, project documentation, direct observation, and formal interviews with all stakeholders. Seizing the opportunity, the authors obtained permission of JGSoft's owner to carry out the development initiative as an action-research project.

As described in the action-research methodology (e.g., McKay & Marshall, 2001; Thiollent, 1997), the first step was to review the relevant literature, including references on WS architecture, SME's competitiveness, WS adoption, and ISD success factors. Information obtained in the literature was complemented with data collected in interviews with five experienced developers, and used to identify potential critical success factors (CSF) of the adoption of an open-source WS architecture (e.g., Wasmund, 1993; Rothenberger et al., 1998; Reel, 1999). To assess the results of the project, the authors defined performance criteria that captured essential aspects of the ISD process and its results (e.g., Colombo & Guerra, 2002).

The research proceeded as follows, over a period of approximately one and half years:

1. The researcher that acted as project leader obtained and installed the necessary open-source WS development tools and class libraries.

2. JGSoft's new WS-based ISD environment was created and checked using some of the examples that were included in the software libraries. Tests conducted in the development environment and in the Internet verified the WS examples' conformity and quality.

3. The functionalities of the new accounting system were defined based on their complexity and usefulness from the customer's standpoint.

4. Systems analysis and programming tasks were initiated and conducted as follows:

   a. The researchers published a website in the Internet to promote the project and invite other developers to join it. Guidance materials on WS were developed and made available to help newcomers get up to speed with the technology and the project.

   b. The researcher acting as project leader recruited, selected and hired developers to participate in the ISD process.

   c. Example WS were made available in the Internet, so that developers could carry out tests.

   d. The first WS modules were developed. Their model was made available to selected partners (other ISD companies), so that they could make comments and suggestions. Their input was documented and used to make adjustments in the development process and its results.

   e. The WS modules were completed, installed and evaluated. The assessment of each released module and the analysis of its development process were used not only to promote adjustments in the ISD methodology and the software framework, but also to identify potential barriers and success factors for WS adoption. In this way, the iterative nature of the action-research method, which progresses through planning-acting-evaluating and reflection cycles, was an essential characteristic of our study.

5. Quality and productivity performance criteria were used to check if there was any improvement in relation to previous architectures used by JGSoft.

6. CSF were compared to those originally identified in the literature.

Data analysis was overseen by the author who had no direct involvement in the ISD project. It consisted mainly of coding textual data and developing, relating and integrating themes and categories that emerged from the iterative analysis process. The latter author critically assessed his peer's interpretation of events, offering alternative meanings and suggesting new venues to be explored in the ISD project. Both researchers were constantly aware of the possibility of the introduction of bias in their analysis, given the role one of them played in the project. From time to time, participants in JGSoft and its customer were asked to check the authors' interpretations, so that they correctly represented the participants' point of view.

ISD PERFORMANCE CRITERIA

Three main aspects were contemplated in the definition of ISD performance criteria: the quality of the product; the costs of the development process; and the productivity level achieved in the development activities. Product quality refers to the degree to which the developed system meets customer's expectations, while cost and productivity are directly connected to profitability. Therefore, the adopted criteria attempted to measure elements that are critical to SME's competitiveness and survival.

Current research on software quality has usually drawn on perspectives put forth in ISO/IEC 9126 (e.g., Colombo, 2002; Bhatti, 2005). The same approach has also been adopted by the Brazilian Software Quality Study Commission to evaluate new IS architectures and software. The following ISO/IEC categories were assessed in the study:

- Functionality: the degree to which the system meets clients' needs.

- Reliability: how flawless the system is and how resilient it is when problems occur. It takes into consideration recovery capabilities (e.g., the time needed to recover information that has been lost) and how long the system works uninterruptedly (i.e., time between failures).

- Usability: how easy it is for users to work with the system.

- Efficiency: how effective the system is, i.e., the relation between consumption of computer resources and the functionalities implemented in the system.

- Maintainability: the level of complexity and flexibility involved in introducing new features in a system or adjusting it to correct defects or cope with changes in its environment.

- Portability: how adaptable and independent of specific technology the system is, i.e., how easy it is to migrate the system to different platforms of hardware and software.

The second group of criteria focused on profitability. Given the scarcity of resources and turbulence that characterize their business environment, it is important for ISD SME in emerging economies to be able to correctly estimate and control the development costs associated with their architectures (e.g., basic hardware and software, development tools, people). Furthermore, to reduce costs, they must strive to increase productivity, which can be achieved by making software code as reusable as possible. Reusability refers to how much of a code can be used to build different systems (Coad & Yourdon, 1991). By reusing code, developers can not only increase productivity, but also improve the quality of their software (Coad & Yourdon, 1991; Rothenberger, 1998). Therefore, total cost and degree of reusability were also chosen as criteria to evaluate the project.

CRITICAL SUCCESS FACTORS IN ISD

A review of the literature on WS and ISD (e.g., Reel, 1999; Wasmund, 1993; Boehm, 1994; Booch, 2001; W3C, 2001; Stal, 2003) revealed a number of potential critical success factors (CSF) for WS-based ISD processes. They were revised and complemented with data collected in in-depth interviews with five directors of small and medium Brazilian software houses who had vast experience in ISD projects. The resulting CSF were then aggregated according to their scope. The final list of the potential CSF evaluated in this research is presented below.

- Adoption of appropriate development tools: usability, efficiency and functionality, as well as associated costs, must be aligned with the project's goals, requirements, team expertise, and budget.

- Adequate team of developers: developers must be motivated and have a level of expertise and experience in ISD that is compatible with the complexity of the project.

- Formalization of unitary tests: tests must be adequately performed to ensure software quality. They may have a direct impact on reliability, as far as they help eliminate errors that hinder system's operation.

- WS publication: publication of the WS modules and related information using appropriate standards and channels is essential to ensure their quality and consistent usage.

- Interoperability: WS must meet the established standards and interact with any compliant application and platform. Interoperability improves software portability and maintainability.

- Incremental maintenance: WS implementation must ensure that adjustments in specific modules can be easily accomplished without compromising the rest of the system. Incremental maintenance improves maintainability and reliability, insofar as it minimizes system maintenance downtime.

JGSOFT'S DEVELOPMENT PROCESS

To reduce development costs, the project leader assembled a software framework consisting of Borland Kylix 3 Open Edition, the Mandrake Linux operating system, the Apache web server, FreeCLX and ZeosDB libraries for database access, and IndySOAP for the SOAP/XML interface. The following issues guided the selection process: (1) project developers' lack of knowledge on Java and .NET development tools; (2) their large previous experience with Object Pascal and Borland development environment; (3) and JGSoft's lack of financial resources to invest in proprietary solutions and training. The selection of Kylix allowed the developers to use the programming language that they were most familiar with, thereby helping them ease the transition to WS technology. As a result, project completion time would be shortened and no investments in training and hiring new developers would be necessary. These benefits are certainly significant to small software houses such as JGSoft, which normally have to conduct their projects under strict budget limitations and tight schedules. In fact, in JGSoft's case, the ISD project would not be viable without the use of free software. The expenses with licenses of proprietary development tools by themselves would exceed the total price charged for the project.

Initially, the project team consisted of the project leader (one of the authors), a programmer and a web designer. At that time, all developers were very confident and excited about participating in the project. Besides being motivated by the fact that they could try new ways to develop a system, they also realized it was possible to synchronize WS class modeling and physical implementation, which would make the development tasks much easier and "a lot more elegant".

Nonetheless, the team had some difficulty in adapting to the Linux operating system. All of them were more used to working in the MS Windows environment. Simple issues such as the lack of shortcut keys and visual resources created considerable discomfort. These adaptation problems had a negative impact on the team's productivity, but were overcome by most developers in the first month of the project.

Later, still during the system analysis phase, after a long search, two other developers that were capable of working with the chosen platform were hired. The difficulty to find Kylix developers was seen as a natural consequence of the increasing adoption of Java and .NET by Brazilian programmers (e.g., Cesar, 2003; Yuri, 2008). Although the project leader developed and published tutorials and ancillary materials in a web site to encourage developers to join the project, recruiting team members proved to be quite hard. In spite of this, JGSoft decided to continue to use Kylix to avoid further delays to the project.

Team members soon perceived they could work more independently when modeling the system architecture. The inherent modularity of WS technology made possible to separate the graphic interface from the business rules. As a result, the project itself, as well as the related specifications, was clearer and easier to understand. Although developers believed that this could have a positive impact on software quality, their newly acquired relative independence gave way to some heated discussions. Some of them argued that if a single service interface (parameter definition and new methods definitions) had to be altered, all others would have to be compiled and tested again, and that would generate delays and increase costs. Since no consensus was achieved on this issue, it was then agreed that the developers would simulate changes in the business rules to see what kind of adjustments and tests would have to be made in the system and also how they compared to similar situations in the old ISD architecture.

Technical problems were often faced by the project team. For instance, there were incompatibilities among Kylix, Mandrake Linux and the Apache web server. Also, it was necessary to convert the libraries and correct bugs so that they could be used with the chosen development platform. Although developers recognized they gained important knowledge during this process, the project was delayed by four months. The team also faced problems related to access security and the way WS management was supposed to be implemented. The standards for WS security were not yet published at that time and there were no tools available to implement the corresponding security layers. Consequently, the developers had to come up with their own proprietary solution, which they knew would probably not conform to prospect W3C standards. JGSoft saw no alternative but to accept the risk of having to rewrite their software modules in the future to ensure compatibility and interoperability.

One and half years after the beginning of the project, JGSoft's WS-based system was fully tested and installed in the accounting firm's premises. The customer attested that it met all requirements and successfully supported its new business process. Overall, the project involved eight people, including programmers, web designers, consultants and suppliers, and cost about US$ 15,000. More than 40,000 lines of code were generated, and eight Web Services were published. Furthermore, due to compatibility issues and bugs, the project team had to maintain over 200,000 lines of code of auxiliary libraries, such as Indy, IndySOAP, Zeos and Web Provider. Although it was still necessary to develop the final front-end programs to access the services, the project was considered a success by all parts involved.

DISCUSSION OF FINDINGS

The analysis of the data collected in the study suggests that the adoption of the new open-source WS-based development platform allowed JGSoft to significantly improve its ISD processes. Due to space limitations, the CSF identified in this research were summarized in Table 1. The table contains information on how the CSF relate to the events and characteristics of the project and their overall perceived impact on the performance criteria described above, from the standpoint of the JGSoft's owner and the project team. A positive/negative sign (+/-) indicates a significant improvement/deterioration of the criterion in comparison with the previous situation in JGSoft. Most criteria showed positive gains; those that apparently deteriorated tend to reflect the characteristics of the development tools employed in the project, rather than problems of WS technology itself.

Improved interoperability is one of the main goals of SOA. However, there was a gap between the literature and the tools, techniques and practices that were available to developers in JGSoft. For example, several of the standards published at the time seemed not yet sedimented in the IS community, as they were interpreted differently by WS developers. This of lack of rigor on standards implementation is prone to result in problems observed in previous architectures that succumbed to their own incompatibilities (cf. Stal, 2003). Paradoxically, it is usually argued in the literature that web services are effectively used only when they are reused and shared among people and organizations (e.g., W3C, 2004). In fact, the authors wanted to find other organizations that could be interested in using the WS developed by JGSoft, so that they could evaluate whether the reuse and sharing of the published services could generate further benefits. Nevertheless, the accounting firm did not

grant them permission to do this. This attitude is consistent with reports that indicate that most organizations do not take real financial advantage from their own Web Services and use them merely to reduce costs via automation and code reuse (e.g., CIOL, 2007; BNET, 2009). However, especially for SME in emerging economies, financial benefits obtained with WS could represent significant revenue increases and competitiveness gains, thereby increasing their chances of survival.

CSF / project characteristics and events	Performance Criteria							
	Functionality	*Reliability*	*Usability*	*Efficiency*	*Maintainability*	*Portability*	*Cost*	*Reusability*
Development tools: the inherent characteristics of the WS platform allowed the achievement of several of the expected benefits; the necessity of adjusting the source code of tools and libraries made it harder to implement the required functionalities and to maintain the code.	−	+		+	−	+	+	+
Adequate team: in spite of the difficulty in finding developers with the necessary expertise, those who effectively participated in the project perceived substantial gains in terms of knowledge and professional experience, which translated into a more reliable and efficient system; the ability to work independently caused problems in the services test phase.		+		+	−			
Tests formalization: the well-designed interface and inherent modularity of WS made it easy to create testing programs that covered most of the functionalities of each service; by ensuring software quality, the tests also enhanced their reusability.					+			+
WS publication: constant communication with developers' communities helped the team to solve technical problem and advertise the developed WS; most developers did not speak Portuguese, which made the contacts harder for the JGSoft team.	+		+				+	
Interoperability: despite the industry's problems in interpreting and implementing the WS standards, the new architecture improved interoperability beyond the levels achieved with the previous architecture; the possibility of easily interacting with other systems and platforms increased the system's portability and made it easier to add new functionalities.	+					+		
Incremental maintenance: the WS architecture and platform used in the project were very flexible and ease to use as far as implementing changes in the services; the lack of rigor in implementing the WS standards and the constant updates of different technologies generated conflicts when the new WS versions were installed.			+		+			

Table 1. CSF and Performance Criteria in JGSoft's Project

JGSoft's decision to use a free, open-source development platform contributed in many ways to the ISD project, suggesting that such alternative can provide considerable benefits to small and medium ISD companies. Nevertheless, its daily usage in the project proved to be more complex than initially expected. Usually, open-source software is in constant, unrestricted evolution, as its community of developers continuously adds new features and corrects bugs. One of the most important findings of this research is that ISD companies that intend to employ open-source technology should plan ahead and allocate

appropriate resources to enable its project teams to engage in the development process of the tools they will eventually use. Thus, one should keep in mind that, typically, the adoption and utilization of "free" development software is not actually free of costs. To use it effectively, companies may have to incur in expenses related to testing, improving and supporting software code and documentation, and further training their own employees.

On the other hand, the need to correct conflicts and bugs in the free, open-source software provided developers with an opportunity to acquire in-depth knowledge of their development tools. This is regularly not possible when proprietary software is used. By having access to the tools and libraries' source code and directly contacting its authors to ask questions and make suggestions, developers were able to better understand XML, WS and SOA architecture. In this way, they acquired experience and skills whose usefulness went beyond the scope of the project at hand. The intellectual capital thus obtained by JGSoft may prove to be an important strategic resource to create business value for the company (cf. Melville et al., 2004).

CONCLUSION

JGSoft's experiences suggest that WS architecture offers interesting opportunities for small and medium software development companies. More than supporting improvements in systems development processes and outcomes, in terms of quality, costs and productivity, WS can be used strategically to develop new products and services and attract new customers. The complexities involved in using a free and open-source development platform can also be seen as an opportunity to develop in-house capabilities that boost the company's capacity to adapt, innovate and compete. In emerging economies, were markets tend to be volatile and resources, scarce, such intangible assets may prove essential to SME's survival. Nevertheless, even a free, open-source WS platform tends to require some level of investment. To be successful, SME must be prepared to allocate human, technological and financial resources before they can obtain the expected benefits of the adoption of open-source WS-based ISD architectures.

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