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Software Reuse: What really works

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ABSTRACT

With the advent of E-Commerce and the increased need to deliver reliable systems in a short timeframe, software reuse is progressively receiving increased interest from both the academic and practitioner communities. Like other technologies, software reuse, has been surrounded by a lot of hype. A major problem often cited in the reuse literature is that management in many organizations is not willing to undertake a long-term reuse initiative. In an attempt to identify reasonable requirements that are acceptable by both reuse experts and management in software developing organizations, we studied the practices of five reuse programs in four organizations. Our research question focuses on qualitatively describing key attributes of a reuse program from the perspective of both reuse experts and top management. Our findings suggest that the key requirements for the success of a reuse program are creating a shared vision for the reuse program, and gaining customer support.

INTRODUCTION:

With the advent of E-Commerce and the increased need to deliver reliable systems in a short timeframe, software reuse is progressively receiving increased interest from both the academic and practitioner communities. Like other technologies, software reuse, has been surrounded by a lot of hype. A large number of studies have touted the capabilities of this technology in reducing software development costs and in improving quality (SPC 1993, Joos 1994, Frakes and Fox 1995, Mili et al. 1995, STARS 1996, Basset 1997). However despite the hype, reuse is not a short term quick-fix solution to software development, au contraire reuse is a long-term investment that requires the establishment of a sound infrastructure before it starts paying off (Poulin 1997). A major problem often cited in the reuse literature is that management in many organizations is not willing to undertake a long-term reuse initiative especially when it is difficult to assess in quantitative (dollar) terms the value of such initiatives to the organization as a whole (Cardow 1989, Jones 1994). In an attempt to identify reasonable requirements that are acceptable by both reuse experts and management in software developing organizations, we studied the practices of five reuse programs in four organizations. In all five sites reuse experts, asset creators, asset utilizers and top managers were

interviewed. Our research question focuses on qualitatively describing key attributes of a reuse program from the perspective of both reuse experts and top management. Our findings suggest that while the wish lists of reuse experts are substantively different from that of program managers enough similarities exist to allow three of the reuse experts who participated in the study to reach conciliation without compromising the quality of the reuse program. Among the key requirements identified are creating a shared vision for the reuse program, and gaining customer support.

RESEARCH DESIGN

A multiple case study approach was adopted to gain an in-depth understanding of the key attributes of a successful reuse program as agreed upon by all reuse stakeholders. The four stakeholders included in this study were: reuse experts, asset creators, asset utilizers and IT management. The beliefs of these stakeholders with respect to the key success factors for a reuse program were examined. Interview questions focused on the organizational readiness for adopting reuse. In particular we questioned the individual and organizational support to the reuse infrastructure in terms of setting goals, formulating strategies, providing resources and achieving goals.

Site Selection

The organizations studied were selected based on their relevance to the central phenomena of this study, the adoption of reuse. Each company contacted expressed an interest in software reuse. The final selection of sites was based on theoretical sampling as opposed to the random sampling used in theory testing research studies. A total of five cases were selected. The five cases are described in further detail below:

Case 1: The Energy Solution Group (ESG) at SCC -- a leading software consulting firm. ESG develops accounting systems for customers in the energy industry. They realized the importance of designing reusable components to develop applications at a fast rate.

Case 2: Reuse II at OGC an Oil and Gas Company (OGC) that operates worldwide. The group develops assets for computer applications that deal with sub-surface data in the exploration and production field. All of their customers are internal customers.

Case 3: The Production and Operation Management (POM) group at OGC The department studied developed software solutions for refineries and chemical plants operation.

Case 4: The client server computing group at ITS -- a leading software consulting firm with offices in thirteen states. The client server-computing group provides solutions to telecommunication companies.

Case 5: The Customer Billing Systems at TCC -- a worldwide telecommunication firm that provides local and long distance services to customers worldwide. Several attempts have been launched within the organization to capture corporate knowledge and disseminate it among the different information seekers within the organization.

Data Collection

The data collection activity primarily used structured interviews. A set of open-ended questions were posed to each of the participants at the beginning of the interview. The aim was to allow the interviewees to freely express beliefs related to personal experiences. After the initial round of interviews, a new set of

questions was added to the list in light of concepts that emerged from the data. Follow-up interviews were conducted to collect data on emerging concepts that were not considered in the original interviews. This approach is deemed legitimate in grounded theory methodology.

Beside interviews, archival data in the form of articles, promotional material and Internet World Wide Pages were collected. A number of stakeholders at different organizational levels were interviewed providing us with a rich data set at various grades of abstraction. Our goal was to slice vertically through the organization to obtain data from multiple levels and perspectives. A Total of 33 interviews were conducted for the five organizations. 29 interviews were taped and transcribed. In the course of the remaining four interviews the interviewees refused being taped. With the permission of the participants, in these interviews, extensive notes were taken. The distribution of interviews among the five cases is provided in Table 1. During the course of the study, the researcher alternated between the data collection, coding and the data analysis to opportunistically decide on new sources of data required for grounding the theory.

Table 1. Type and Amount of Interviews Conducted at Each Site

Position	SCC	ITS	POM at OGC	Reuse II at OGC	TCC	Total
Reuse Expert	1	1	3	1	2	7
Asset Creators	2	2	2	1	1	10
Asset Utilizers	2	1	4	1	2	11
Project Managers		1	one of the reuse experts	1	2	2
Managers		reuse expert	1	reuse expert	1	2
Total	5	5	10	4	8	33

Data Analysis

The data analysis commenced with the transcription of every single interview and the inclusion of the comments taken during the course of the interview. Every transcribed interview was carefully read for the extraction of codes. The QSR NUD*IST software was used to dissect every interview to a set of quotes categorized under a code. QSR NUD*IST allows the transcribed interviews to be imported as text files and subsequently each interview was browsed and every sentence categorized. We followed an *open coding* approach as recommended in grounded theory methodology (Strauss and Corbin 1990). The main focus was to compare and contrast the key attributes of a reuse program. Concepts and categories were compared for interviews within and across cases.

RESEARCH FINDINGS

The analysis focused on answering the research question: what are the key attributes of a successful reuse program from the perspective of both reuse experts and top management. While the requirements identified by reuse experts seemed unrealistic by top management, three of the reuse experts at SCC, ITS and Reuse II at OGC were able to work out compromises without affecting the quality of the reuse programs. In the following sections we will examine the views of the two reuse stakeholders in an attempt to identify a reasonable list of key attributes of a reuse program.

Reuse Experts

According to the Reuse experts in all five organizations creating a shared vision for reuse was an important attribute of a successful reuse program. Reuse

experts believed that all reuse stakeholders should understand what reuse is and believe in its strategic value to the organization. The commitment of all reuse stakeholders is considered important for the continual support of reuse. It is not just the commitment of top management but

The cooperation of project managers, developers, testers, and everybody in the whole development life cycle. It has to be driven by management, but everybody else has to share that common vision and help in the process.

A second factor that was identified was the formation of a reuse organization that is solely responsible for the development and management of reusable assets. The ideal group would have formal roles for a reuse expert, asset creators and asset utilizers. As the reuse expert at SCC explains :

As each of the projects goes on, one person from the reuse group would actually be involved with the functional project when they are using those architecture components for making additions and modifications. So in a sense they would be part of the reuse group, but they would kind of be assigned to each of the projects that are going. To me, that would be the easiest way for them to get a feel of what's going on as far as the development within the component. It would also be the other way round for each of the projects to have a good feel of what's going on with the architecture, what they can and can't do.

In all five organizations the reuse expert was seen as a senior developer with expertise in the domain of focus for reuse. The reuse expert would be the one responsible for the design of the reuse framework. Asset creators are also experienced developers who participated in the development of several systems within the domain of focus. Their exposure to different systems within the domain enables them to design for reuse. In general it takes 3 to 4 years for developers to understand the business functionality and the architecture to be able to switch their roles to asset creators. Not every developer, however, gets to be a creator but everyone should go through the role of being a re-user. This is because it requires a special skill to be able to do the analysis and design for reuse as well as building the architecture. Though Schools do not teach this skill and focus more on system development, the reuse experts assume the responsibility of teaching the staff the necessary skills. Among the skills needed for asset utilizers, however, is the technical background to understand the concepts of

reuse. Reuse experts believed that some developers may take longer to understand the concepts and need "comrades who help them see the light" to use the architecture and the reusable assets.

A third attribute that is believed to be crucial for the success of a reuse program is the availability of a source of funding. Reuse is believed to require a considerable amount of investment up front before it starts to pay off. As one reuse expert asserts:

If a company is not willing to make the investment or isn't in a financial position to be able to make that investment, then a reuse strategy that's set out upon will fail.

Resources are needed to determine the feasibility of adopting reuse, determine the domain of focus, assess the costs and benefits, set the strategy, develop the right organizational structure to build the reusable assets, test the assets, maintain assets and deploy them to projects. Tools are also needed to store, locate and retrieve assets. With the focus on projects, reuse infrastructure costs are perceived as overhead costs. There is no willingness from management or the customers to absorb them.

All reuse experts at the five sites asserted that funds for a reuse program should not be tied to specific projects especially at the early stages of the program. This is particularly because projects could influence reusable assets design to make them customized for their specific needs. As one developer puts it,

One given project can't afford to take the hit up front to develop reusable components for other applications that are coming down the road. There has to be some way of sharing that cost.

A fourth and last requirement that the five reuse experts believed is an important requirement for the reuse program is the formulation of a reuse strategy. The reuse experts believe that the strategy needs to address multiple facets. First, it must define the goal of the reuse initiative. Second, it must evaluate the opportunities that exist within an organization by selecting a number of developers and encouraging them to evaluate the different application domains and come up with recommendation for reuse. Accordingly, they would need to define the reuse stakeholders and get them involved. The action plan for reuse would include incorporating reuse into the organizational goals, getting management support for funding, educating and training the reuse stakeholders, and promoting the benefits of reuse. From a technical perspective, the reuse policies need to address a set of procedures for asset creators to follow when developing reusable components. The success of these standards and

procedures will depend on periodic evolution resulting from the incorporation of feedback from the different asset utilizers who use the assets for building applications. Two policies are particularly missing from all sites; one to measure the cost and benefit of reuse, and another to reward increased productivity resulting from both asset creation and utilization.

Top Management

When asked about the critical success factor for a reuse program top management views the most important requirement is success itself. In all five organizations they considered reuse as a risky investment with the threat of no return. Thus they believed that the reuse initiative should start with a limited scope project that would demonstrate the value of a full-blown reuse program to all reuse stakeholders. As one manager puts it:

The only way to actually break that skepticism is to actually have a success to tell, and I think that would be a critical success factor. But of course to get that first success there are other critical success factors including discipline, having the tools that support reuse, and having a process that ensures that everything we do is geared for reuse. We can probably throw in many other success factors, like the ability to slow down the pace when necessary, but again I think that most critical one is to actually have a single success story that will actually break that skepticism and get people more committed to doing more of it.

Top management support was unquestionably limited in all five sites. Developers believe that

The main thing that causes reuse not to be successful, was senior management not totally buying into it and being willing to spend the money and take the risk to buy the tools, and put the people in place to manage those tools and create the change in culture so that everybody is supporting it. It is a very significant change that a company has to make in order to take advantage of reuse. And most companies look at it and get sold to some level or to some degree on doing reuse. It sounds good, and they want it to happen, but when push comes to shove, management isn't really totally behind it.

Managers themselves admit that they have not committed to reuse. One manager at the Production and Operation Management group thinks that the main

barriers are the cost and time of developing reusable assets. He explains that

[Reuse] requires an initial investment, both in terms of dollars and time that a company would have to be willing to invest and only expect their return after a while, and so far we have not, we have not made that commitment.

With regard to developing a reuse entity, managers felt that the number of reusable products developed does not economically justify the formation of a reuse entity. In addition, the lack of enough staff to perform current assignments does not allow groups to formally cast developers into one role only. Managers believed it would be beneficial to set a reuse entity if a large number of products are involved. The challenge for managers is how to cost justify such a structure. There has to be some demonstrable value that this reuse organization will enable the different application groups to develop business functionality either in a substantially quicker time frame, or at a substantially lower cost. Managers were concerned if such a structure exist it would create communication problems between asset creators and asset utilizers with the reuse group "setting themselves up as an ivory tower organization."

Separate Funding for reuse was also not justified. Managers believed there are two options that can still help the organization implement reuse. The first option is to get R&D to fund the development of reusable assets and be responsible for charging the projects for the use of these assets. This requires developing an accounting system that would be able to assess the costs of reuse and bill the projects for use. The reuse experts believed that this is a preferred solution because "computer people like to pay for what they use and move away from it." Projects do not want to be charged for the reuse infrastructure, but are willing to pay a usage fee for using the assets.

The second option is to let projects and management share the funding so that Any part of creating a reusable asset that addresses the exact functionality required by the project should be covered by the project, however any work above and beyond that would have to be covered by management.

Management believed that the formulation of reuse strategies is important and can be enforced top down, though they did not agree that a reward system is necessary for a reuse initiative. They believed that setting an effective reward system in place would be difficult. The main problem would be defining the criteria for rewarding asset creators and asset utilizers. Should reward be based on quantity or quality?

Table 2: A summary of the requirements of a reuse program as viewed by reuse experts and top management

Reuse Stakeholder	Views regarding the requirements of a reuse program	What really worked
Reuse Expert	<ol style="list-style-type: none"> 1. Shared vision for reuse 2. Formation of a reuse organization 3. Availability of a source of funding 4. Formation of a reuse strategy 	<ol style="list-style-type: none"> 1. Shared vision for reuse 2. Gaining the support of customers to fund reuse. 3. The formation of an informal and flexible reuse organization.
Top Management	<ol style="list-style-type: none"> 1. Success of a pilot study 2. An accounting system to assess the cost and benefits of reuse. 3. Evolutionary development of assets through projects. 	

What Really Worked

It becomes apparent from the earlier sections that there is a large gap between the views of top management and reuse experts regarding the requirements of a reuse program. Three of the reuse experts interviewed were able to reconcile these views without compromising the quality of the reuse program. In these three organizations the reuse experts were able to create a shared vision among the reuse stakeholders. Evidence from the data suggests that the efforts of the reuse experts in converging stakeholders' interest to focus on reuse and building a sound technological infrastructure to service reuse intensive projects play a critical role in bolstering support for the technology and preventing its lapse. At SCC, Reuse II, and ITS the reuse champions were devoted to reuse and highly respected by their customers who were mainly application groups. In all three cases, the reuse experts took the responsibility of mentoring the developers on the development and integration of reusable assets. They implemented different strategies to build up the technical skills required for reuse.

With regard to funding, the reuse experts at Reuse II, SCC, and IT'S signed contracts with their customers to finance the reusable assets. At SCC, the reuse group would promote systems to Energy Solution Group customers before even building it to support the creation of reusable assets. The clients pay a certain amount for the base version plus an extra amount of money *per annum* to get base version enhancements. The support fee finances assets' evolution that takes place every time the group reuses the assets for new clients. The biggest advantage to the Energy Solution Group is that they own the solutions they develop to the clients. The group "is a little bit of an oddity within the whole SCC Consulting structure" because it is against SCC 's general agreement with customers to resell a client solution. In the case of the Energy Solution Group, the clients realize the benefits of sharing a version that is constantly going through a quality improvement process. As the project manger explains it: "It's kind of like a pool of companies that are all pitching to better enhance one product." The

key success factor here is the agreement by the clients for the Energy Solution Group to own the assets. This is against SCC 's policy that clients own the systems and the organization does not market the same solution to different clients.

ITS worked out deals with the customers to partially fund the reuse initiative in return for free updates of the assets. ITS's incentive to customers was that with an existing base of reusable assets, ITS can start the project with 30% or more of the functionality already done. Customers also get highly flexible modified assets free even after their projects have been delivered.

The creation of a reuse entity was not feasible except at Reuse II. The establishment of a separate team to build reusable assets has a positive effect on reuse because the assets are not originally targeted to any specific project. However the lack of formal organization structure at ITS and SCC was not considered a barrier.

CONCLUSION

In this paper we demonstrated the difference between the views of reuse experts and top management regarding the requirements of a reuse program. While reuse experts viewed the formation of a formal reuse entity with a separate budget and formal reuse strategies as an important requirement for the success of a reuse program, top managers believed that these requirements are not likely to be honored without a success story to break management's skepticism regarding the risk of no return. Three of the sites studied were able to reconcile the views without affecting the quality of the reuse program.

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