Understanding Functional Reuse of ERP Requirements in the Telecommunication Sector: an Empirical Study

Maya Daneva University of Twente The Netherlands <u>m.daneva@utwente.nl</u>

Abstract—This paper is an empirical study on the application of Function Points (FP) and a FP-based reuse measurement model in Enterprise Resource Planning (ERP) projects in three organizations in the telecommunication sector. The findings of the study are used to compare the requirements reuse for one particular package, namely SAP. We found (1) that reuse is possible up to 80% at best, and (2) that, while for some modules, the organizations achieved the same levels of reuse, for other modules, the organizations' levels of reuse varied widely. We conclude with some implications of our findings for both practitioners and researchers.

Keywords—Enterprise Resource Planning; Reuse Level; Functional Size; Requirements Engineering;

I. INTRODUCTION

Understanding how much of a standard ERP software package an organization can reuse is an important question for every company that adopts ERP. While the management and deployment of reuse-driven requirements engineering processes have become common in many organizations adopting ERP solutions [7], relatively little empirical research has been published about the variety of reusability aspects in ERP projects at the level of requirements. Neither, there is published empirical data on the levels of reuse possibly achievable for ERP client organizations. Nether, we know enough about how exactly ERP adopters compare among themselves regarding the levels of reuse they achieve when implementing the same package, and the same components of this package.

This paper sheds some light into these questions and reports on empirical results from comparing reuse levels that have been achieved in three organizations of the telecommunication sector. The companies are all adopters of the SAP package, a leading product in the ERP marketplace. They all are active members of the North-American SAP User Group (ASUG) in Telecommunications. In what follows we first describe the research approach, and then - the Function-Point-based reuse measurement process that has been used to a selected set of ERP projects in the three organizations as well as the results and their implications for both practitioners and researchers.

II. RESEARCH APPROACH

Our overall research process implements the case study research guidelines by Robert Yin [10]. We chose the case study approach because it fosters an intensive collaboration between companies and university's researchers and ensures the research remains industry-relevant. Our case study plan includes the following: First, we chose three organizations that share a number of common characteristics:

(1) they all implement five SAP components, namely Material Management, Project System, Financial Accounting, Sales and Distribution, Service Management;

(2) they all deployed the Accelerated SAP (ASAP) methodology for rapid SAP implementation [7];

(3) they all used the Accelerated SAP requirements engineering tools and documented the organization's requirements by using SAP's standard modeling language (namely the Event-driven Process Chains [7] approach);

(4) they all shared similar attitude towards package customization in that they considered it a risky undertaking (this means, they had interest in reusing as much as possible from the standard functionality embedded in the package).

The telecommunications services operators also share some business-related characteristics: they all are very large organizations, employing between 19 000 and 23 000 people, with offices and service development locations distributed across the provinces in the country of their operation. They all provides a wide range of telecommunications products and services including internet access, voice, entertainment, healthcare, video, and satellite television. In terms of market the companies operate it, they are competitors.

For confidentiality reasons, in the rest of the paper we refer to the three companies as Telco 1, Telco 2 and Telco 3.

Furthermore, the researcher proposed to use the reuse measurement model described in [2] to get information on the reuse levels that each company achieved with respect to the five SAP components previously mentioned. This model is based on Function Points Analysis (FPA) as the technique to



estimate size in cases when business user requirements are used as input into the sizing exercise. As all the companies are mature in software processes and process-oriented thinking, each one had a Project Management Office team responsible for collecting and analyzing data on project execution (including ERP and non-ERP projects). The staff members of these teams were familiar with FPA, and to various extents had a history of using FPA in planning projects that are parts of their company's project portfolio. Each company provided requirements specifications to the researcher and let one of their SAP requirements engineers get to know the approach [2] to Function Point counting and reuse measuring. The researcher has then run the counting process on the requirements models that have been provided by the companies. Below we provide a summary on the types of ERP reuse implied in ERP projects and the concept of requirements reuse that is the subject of this paper. After this, we summarize the SAP FP counting approach and the FP-based reuse measurement process [2] being used in this study.

A. Types of Reuse

The term 'software reuse' has been defined by the international software reuse community as 'the repeated use of any part of a software system: documentation, code, design, requirements, test cases, and more' [11]. More generally, V. Basili [1] also emphasizes that experience, project team members' knowledge, lessons learned, processes are also good candidates for reuse, as are any other tangible or intangible artefacts of software development activities. Specifically, in this paper, we narrow down the concept of reuse to the requirements to the ERP system that will be adopted in a client organization's ERP projects. Reusing the business requirements in such a project implies the reuse of architecture designs, code, test cases and other related artefacts in the ERP implementation stages that follow. An important feature of the vendor- and consultant-provided tools that are to assist ERP implementation project teams, is the ability to verify that a reused requirement is technically implementable and is translatable in the business transactions that are preprogrammed in the ERP package. From the perspective of ERP-adopters, one can distinguish between two important types of requirement reuse:

(1) the use of a whole piece of requirements (for example, a process specification model, or a data specification) without modifications, or

(2) the modification of it to fit a particular adopter's need.

While the software engineering literature agrees on that the first type of reuse is of great value, the topic of the potential benefits and costs involved in implementing the second type of reuse is controversial. This is because it is very difficult for the second type of reuse to evaluate whether or not the benefits of it would overweight the costs. Generally, for reuse to pay off, the effort to understand and modify the design, the code and the test cases that are associated with the reused requirement should be less that the effort to develop a piece of functionality from scratch.

B. The SAP FP counting process

This study used a standard functional size measurement methodology, namely the IFPUG Function Point Analysis (FPA) [5]. As we will see in Section II.C, we will apply this methodology to size the total and the reused requirements in the project. We chose this approach because of its appropriateness to the software artifact being measured (namely, requirements models specified in SAP's standard modeling notation) [2] and its previous usage in software reuse studies [3]. The approach is an adaptation of FPA to the SAP requirements and is published elsewhere [2]. It includes defining rules for mapping SAP requirements, specified as business process models and data object models, to the FPA counting components: we mapped SAP data entities to FPA data types, and SAP process components to FPA transaction types. As a result, the size of a scenario process model is assumed to be a function of the process components included in the model and the data objects defining the data that support the process. The step-by-step procedure for counting Function Points (FP) from scenario process models and business object models is described in [2] in terms of inputs, outputs and deliverables. Generally, it involves three stages:

(1) analysis of the process and data components,

(2) assignment of complexity values to the components and

(3) calculation of the final FP value.

For clarity, we make the note that according to the ASAP process, SAP adopter's requirements are not defined from scratch, but by using pre-defined requirements process and data templates represented by means of the SAP's standard modeling notations (which are the EPC and the extended entity-relationship model [7]). These templates are provided to adopters for free by the SAP company and represent integrated and function-spanning collections of business processes that occur often in practice and can be handled to the greatest extend possible automatically if a corporation implements the complete SAP System [7]. The templates are called 'reference models' and are available in a special repository that is part of the SAP package itself. For more information on the reference models, we refer interested readers to [7].

C. The Requirements-based Reuse Indicator

This study directly deploys the results of our previous research on the derivation of reuse indicators from SAP scenario process models and business object models [2]. Our reuse measurement model is based on the notion of "reuse percents" [2] and suggests a reuse indicator that includes reused requirements as a percentage of total requirements delivered [2]:

SAP Reuse = (RR / TR) * 100%

where *RR* represents reused requirements, and *TR* represents total requirements delivered. In this paper, a requirement borrowed from the SAP's reference model repository is classified as *reusable* if it does not require

modification. If a borrowed requirement does require minor or major enhancement before use, we term it '*customized requirement*'.

To build well-defined and valid metrics [4], we selected a consistent and reliable means for structuring and collecting data to make up the metrics. Based on the analysis of the changes [7] that could be applied to the SAP requirements models throughout the reuse-based process modelling exercise, the measurement data collected throughout the FP sizing procedure [2], and the modes of component reuse investigated by Karllson [6], we have defined three levels of requirements reuse:

Level 3: It refers to process and data components that were reused without any changes. This category of reuse would bring the greatest benefits to the SAP customer's organization. ERP-supported business processes with higher reuse rate at this level have greater potential of practicing reuse.

Level 2: It refers to minor enhancements applied to reference processes and data components. A minor enhancement is defined as a change of certain parameter of a business process or a data component that does not result in a change of the process logic. This category of reuse refers to those processes and data components of the SAP's reference model repository that logically match the business requirements but their parameters need to be changed at code level to achieve their business purpose. Level 2 reuse is as desirable as level 3 reuse. For example, in a situation where a very slight customization leads to a much greater degree of acceptance or use.

Level 1: It refers to major enhancements applied to reference processes and data components. A major enhancement is any considerable modification in the definition of a process or a data component that affects the process logic from business user's point of view. This category of reuse refers to those processes and data components that do not match the business requirements and require changes at conceptual level, as well as at design and code level to achieve their business purpose. Level 1 reuse is the least desirable.

In these definitions, the term *process component* refers to the functional units of any SAP-supported business process models and the term *data component* means a data entity, a relationship or an attribute from the data model describing the SAP business data requirements. Furthermore, we introduce a level of new requirements, *No_Reuse*, to acknowledge the fact that reuse is not practiced at all. It refers to newly introduced processes and data components. This does not mean a reuse category; it just helps us to partition the overall requirements and to get understanding of how much requirements are not covered by the standard reference processes and business models. Given our definition of what to count as reuse and how to count it, we have derived three reuse indicators [2]:

Level_i SAP_Reuse = (RR_i / TR) *100%

where $i = \{1, 2, 3\}$, RR_i represents reused requirements at Level_i, and TR represents total requirements delivered. The

indicator No_Reuse = (NR / TR) $^{100\%}$, where NR represents the new requirements, and TR has the above meaning, reports the percentage of requirements that can not be met by the SAP application package unless some customerspecific extensions are not developed.

III. THE CASE STUDY EXECUTION

To assure the quality of both the FP counting and the reuse data, we use two tools:

(i) a form for recording all the counting details;

(ii) a reuse metrics database.

We extended the FP counting form suggested in [3] by including information needed for calculating the reuse indicators. Based on our FP counting model [2], we devised a counting form usage procedure that indicates at exactly what point each piece of data should be collected. The counting information has been stored and processed in Excel spreadsheet software. Summarized and detailed reports have been extracted from Excel tables. For example, Table I reports on size numbers for four SAP business processes at Telco I and Table II presents the summarized results from measuring reuse regarding the same business processes. Typically, two types of reuse profiles could be derived from a requirements reuse measurement table (Table II): *process-specific* profiles which present the levels of reuse pertinent to a given scenario, and *level-specific* profiles which show how the requirements are reused at a specific level within a project.

A. Detailed results for the Material Management module

Tables similar to Tables I and II were generated for each company and each of the five SAP modules. In this section we present examples only that pertain to the Material Management (MM) module in which we compared the reuse levels achieved by the three companies. Tables III and IV show the reuse levels at Telco 2 and Telco 3. Below, we use these examples to illustrate the kind of analysis one can do by using the data in the tables.

TABLE I.FP COUNTING FOR THE MM MODULE AT TELCO 1.

MM business process	Level 3 FP	Level 2 FP	Level 1 FP	New FP
Material Master Processing (100 FP in total)	65	9	9	17
Purchase Order Processing (258 FP in total)	145	65	26	22
Credit Master Data Processing (112 FP in total)	85	0	16	11
Invoice Processing with Reference (151 FP in total)	95	12	30	14

MM business process	Level 3	Level 2	Level 1	No Reuse
Material Master Processing	65%	9%	9%	17%
Purchase Order Processing	56%	25%	10%	9%
Credit Master Data Processing	76%	0%	14%	10%
Invoice Processing with Reference	63%	8%	20%	9%

TABLE II. REUSE LEVELS FOR FOUR SCENARIOS IN THE MM MODULE AT TELCO 1.

Comparing business-process-specific profiles: Our results indicate that regarding the four processes in this example (see Tables III. and IV.), three of them achieve comparable reuse levels in the three companies. These processes are Material Master Processing, Purchase Order Processing and Credit Mater Data Processing. We however notice that the process of Invoice Processing with Reference (to a Purchase Order) varies widely regarding Level 3 reuse: while Telco 1 achieved 63%, Telco 2 and Telco 3 achieved 43% and 39%, correspondingly. An implication of this difference is that practitioners should expect in their organization that important company-specific requirements might have higher priority over their overall commitment to reuse as much of the standard functionality. For SAP implementation consultants, this variability also signals a SAP reference process that requires special care, as it looks like a candidate for significant customization (which is deemed risky overall). To researchers, the implication of our findings is that deeper case study research is needed to understand why this variability exists and what requirements engineers and SAP implementation consultants do about it. Exploring the variation across reuse levels in companies in the same sector is, thus, a viable and interesting line for future research.

TABLE III. REUSE LEVELS FOR FOUR SCENARIOS IN THE MM MODULE AT TELCO 2.

MM business process	Level 3	Level 2	Level 1	No Reuse
Material Master Processing	68%	12%	0%	20%
Purchase Order Processing	50%	30%	6%	9%
Credit Master Data Processing	70%	10%	12%	8%
Invoice Processing with Reference	46%	12%	20%	22%

TABLE IV. Reuse levels for four scenarios in the MM module at Telco 3.

MM business process	Level	Level	Level	No
Ĩ	3	2	1	Reuse
Material Master Processing	60%	12%	11%	17%
Purchase Order Processing	60%	25%	15%	9%
Credit Master Data Processing	76%	8%	6%	10%
Invoice Processing with Reference	39%	20%	20%	21%

B. Summaries of results for the four other modules

This section presents the results for the four remaining components that the three companies have in common. Table V is about the reuse levels regarding the Financial Accounting processes, Table VI present the data for the Sales and Distribution module, Table VII – for the Service Management module, and Tables VIII – for the Project System module. In these tables, the four upmost right columns indicate the reuse levels in the three companies.

TABLE V. Summary results for the reuse levels referring to the Financial Accounting (FI) module at Telco 1, Telco 2 and Telco $\frac{3}{2}$

FI business process	Level 3	Level 2	Level 1	No Reuse
Vendor Master Record Processing	45/65/70	45/10/20	0/10/0	10/25/10
Customer Processing	70/70/70	10/20/10	0/0/0	20/10/20
Clearing	45/70/70	0/20/10	15/0/10	40/10/10
Dunning	80/80/80	0/0/0	10/0/0	10/20/20

For example, in Table V, the data '60/62/70' in the cell corresponding to the Vendor Master Process and Level 3 means that, for this process, Telco 1 achieved 60% reuse at Level 3, Telco 2 achieved 62% reuse and Telco 3 achieved 70% reuse.

SD business process	Level 3	Level 2	Level 1	No Reuse
Standard Sales Order Handling	35/65/50	45/10/30	0/10/0	20/15/20
Contract Handling	25/40/30	60/10/35	0/20/10	15/30/25
Picking	75/70/70	10/20/10	0/0/0	15/10/20
Packing	75/70/70	0/20/10	10/0/0	15/10/20
Shipping	80/65/80	0/0/0	10/20/10	10/15/10

TABLE VI. SUMMARY RESULTS FOR THE REUSE LEVELS REFERRING TO THE SALES AND DISTRIBUTION (SD) MODULE AT TELCO 1, TELCO 2 AND TELCO 3.

TABLE VII. SUMMARY RESULTS FOR THE REUSE LEVELS REFERRING TO THE EXTERNAL SERVICE MANAGEMENT (SM) MODULE AT TELCO 1, TELCO 2 AND TELCO 3.

SM business process	Level 3	Level 2	Level 1	No Reuse
Service Master Processing	45/65/70	45/10/20	0/10/0	10/25/10
Service Contract Handling	70/70/70	10/20/10	0/0/0	20/10/20
Purchase Order for Services	45/70/70	0/20/10	15/0/10	40/10/10
Invoice Verification	60/60/80	20/10/10	0/0/0	20/30/10
Payment Processing for Services	75/85/60	0/0/30	25/0/0	0/15/10

TABLE VIII. SUMMARY RESULTS FOR THE REUSE LEVELS REFERRING TO THE PROJECT SYSTEM (PS) MODULE AT TELCO 1, TELCO 2 AND TELCO 3.

PS business process	Level 3	Level 2	Level 1	No Reuse
Bill-of- Material (BOM) Processing	45/65/70	45/10/20	0/10/0	10/25/10
Engineer-to- Order Handling	65/60/45	10/20/10	0/10/0	25/30/45

IV. LIMITATIONS

This study has some limitations. First we focused on five SAP modules and our results are indicative for those modules only. Clearly, the results could not be generalizable in any way concerning the other application modules that make up the SAP's business suite. Studies as this need to be carried out if one wants to know the levels of reuse achievable in projects that implement the other SAP modules.

Second, we looked at requirements in three organizations that are in the same geographic zone, operate in the same market, offer a similar variety of telecommunication products and services, are similar in terms of software process maturity, and have similar attitudes concerning their SAP implementation projects. But would our findings be observable in other telecommunication companies that exhibit similar characteristics? We think, this might well be the case. As Yin [10] suggests, if there are some contextual similarities among other organizations that implement similar projects to those in our three case study organizations, then one could expect to observe similar phenomena as those observable in the case study organizations. We would be cautious however to generalize our results to telecommunication companies that are les similar to our three case study companies, e.g. operating in other markets, or being less structured and less documentdriven. We consider our requirements documents very systematically written. Also, the requirements process that was used to produce these documents was based on ASAP and the EPC models [2]. Other companies that do not use such models in the conceptualization of their projects' requirements might therefore achieve a different granularity of their requirement definitions, which would have an implication for sizing.

Third, comparing the levels of reuse in the three companies (Tables II, III, IV, V, VI, VII and VIII), we observe that regarding a specific process, the values vary across the companies. For example, Tables II, III and IV show that while the values of reuse level 3 at Telco 2 and Telco 3 for the process of Invoice Processing with Reference are similar (46% and 39% respectively), for Telco 1 this value is 63%. One may ask why this variation occurs. Based on the data we collected, this question can not be answered as it was not in our research scope. We however consider it important and worthwhile investigating. Further research is therefore needed in order to get a deep understanding of the reasons of each organization for such a variation. To start such an exploratory follow-up study, we think that good starting points could be those projects that dealt with the following processes (that vary in terms of reuse level percentages): Clearing (see Table V), Standard Sales Order Handling and Contract Handling (Table VI), Service Master Processing, Purchase Order Processing and Invoice Verification (see Table VII). Informal discussion of the author with practitioners from the three companies suggests that reasons could vary widely: some are trivial (e.g. not being aware of reuse options), while others are traceable to compliance to standards or specific business conditions, e.g. the request of a critical business partner to connect their SAP system to the one of the telecommunications company. We therefore think that exploring the context of each ERP-adopter in more depth would possibly reveal important information about the variety of situations that achieving reuse is contingent on.

V. CONCLUSION

This study is the first attempt to investigate the levels of reuse of ERP across companies in the same business sector. We applied an SAP-adapted FP counting and reuse measuring process to five SAP modules at three companies in the telecommunication services sector.

Given all the data pieces pertaining to the five modules, we found:

(1) that reuse is possible up to 80% at best, and

(2) that, while for some modules, the organizations achieved the same levels of reuse, for other modules, the organizations' levels of reuse varied widely.

While these conclusions are unsurprising, they have also implications for practice: ERP vendors should not oversell the reusability of their packages, and ERP adopters should be prepared to live with the fact that as a minimum at least 20% of their package will not match their needs (in some cases it represents 40%) and customization has to be undertaken so that the ERP solution meets their organization's requirements.

Furthermore, the present study also raises a few new questions. Which is the most appropriate level of reuse for a particular business sector? A particular organization within a business sector? A particular ERP component? How an ERP adopter minimizes the customization costs and maximizes the 'good' type of reuse? Understanding this all can help ERP adopters to become more aware of the reuse levels that are realistic to achieve in their specific settings and provide a better basis for planning the introduction of ERP systems.

Our case study has the following implications for researchers: we motivated that more qualitative research is needed to understand the reasons for variability regarding customization and their relationships to particular reuse levels/customization percentages. If we know the reason for customization decisions and what reuse levels can be expected in case a reason is present, then more realistic estimates could be done about the potential benefits and cost of reuse. Recent studies [8] have already started elucidating the customization as a phenomenon and the motivation for it. For example, these authors found that high customization might occur "because of unnecessary redevelopment of functionality that is available in the ERP system standard, resistance to change based on low project acceptance and cultural issues, insufficient weight of the implementation team's recommendations, consultants' acceptance of the organization's wish to customize the system, and because of the classification of too many business processes as unchangeable". Other authors (Sherif and Vinze) [9] have investigated the individual and organizational barriers associated with the adoption of reuse. Their study found that the barriers at the individual level are actually a consequence of the interaction of barriers caused at the organizational level. The findings of these published studies can serve as hypotheses could possibly be checked for confirmation/ that disconfirmation at our three companies' sites. This presents a line of future research that draws upon this study and the already published work by other authors.

V. FUTURE RESEARCH PLANS

This study serves as a starting point for a larger research initiative on ERP reuse economics, which includes two lines of research:

1. Investigating the relationship between reuse levels and the effort required to implement the package. For example, it's interesting to understand whether the amount of code not reuse correlates with the effort required to implement the package.

2. Designing an project estimation model that accounts for the relative cost of reuse. For example, could the knowledge of reuse levels be fed into an estimation model for ERP deployments

ACKNOWLEDGEMENT

The author is indebted to the three IWSM/Mensura 2014 reviewers for their suggestions and feedback on how to improve this paper. This research has been carried our as part of the COSMOS Project and as part of the QuadREAD project at the University of Twente. The author thanks the NWO – the Nederlands Research Foundation for supporting the QuadREAD project. The author also thanks her colleagues and companies' representatives for helping her in various ways to carry out this study.

REFERENCES

- Basili, R.V., Viewing Maintenance as Reuse-Oriented Software Development, IEEE Software, 7(1), Jan/Feb 1990, pp. 19-25
- [2] Daneva M.: Mesuring Reuse of SAP Requirements: a Model-based Approach, Proc. Of 5th Symposium on Software Reuse, ACM Press, New York, 1999
- [3] Daneva, M, Integrating Reuse Measurement Practices into the ERP Requirements Engineering Process. Proceedings of the International Conference on Product-Focused Software Process Improvement (PROFES), LNCS Springer, 2006, p. 112-126
- [4] Fenton, N., Pfleeger, S.L.: Software Metrics: Rigorous and Practical Approach, PWS Publishing, Boston Massachusetts, 1997
- [5] Garmus D., D. Herron, Function Point Analysis: Measurement Practices for Successful Software Projects, Addison-Wesley, 2001
- [6] Karlsson, E.-A. (ed.): Software Reuse, John Wiley & Sons, Chichester, 1998
- [7] Keller, G., Teufel, T.: SAP R/3 Process Oriented Implementation, Addison-Wesley Longman, Harlow (1998)
- [8] Rothenberger, M., M. Srite, "<u>Customization in Enterprise Resource Planning System Implementations</u>", IEEE Transactions on Engineering Management, 56(4), 2009, pp. 663-676.
- [9] Sherif, K., Vinze, A., <u>Barriers to adoption of software reuse: A qualitative study</u> Original Research, Information & Management, 41(2) 2, 2003, pp. 159-175
- [10] Yin, R. K. Case Study Research, Design and Methods, 3rd ed. Newbury Park, Sage Publications, 2002
- [11] Pfleeger, S.L. Software Engineering: Theory and Practice, Prentice Hall, 1998