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Product development (PD) in a network of collaborative companies is different from the traditional way of doing PD within single organization. Parallel way of doing PD increases the need for synchronization of PD activities, but the flow of design information in the company network is difficult to manage. There are indications that the automation of document management should improve the performance of networked PD projects. However, the dynamic nature of networked PD is an obstacle for this, as it requires such flexibility and speed from the setup and further maintenance of integrated document management that is currently unavailable. This article is a work-in-progress publication about research that seeks ways to reduce the setup time of integrated document management for a network of companies that collaborate on PD. This article reviews literature to create the basis for developing solutions to solve this problem, presents our suggestions, and define the following research steps in the road towards integrated document management in networked PD.

***Keywords:*** Product development, Product data management, PDM, integration, e-business, RosettaNet

## 1. INTRODUCTION

From business process perspective, e-business means automation of business processes by using electronic networks [25]. Vital for the automation of business processes is to ensure that the different information systems participating in the business processes can communicate with each other. E-business frameworks such as Electronic Data Interchange (EDI) and RosettaNet are collections of standards that can be used to achieve interoperability between the different information systems participating in a business process, thus enabling their communication [16][19][22].

The most important business processes of an enterprise are typically order fulfilment and product development (PD) [10]. Enterprises have been automating their order fulfilment processes for a considerable time, and e-business framework support for order fulfilment process automation exist. The benefits, such as reduced order fulfilment process costs, have also been reported [17]. PD process automation has progressed slower, and the e-business framework support for PD process automation is partly inadequate [12][13].

Previous research indicates that many PD projects have significant shortcomings, such as poorly functioning engineering change (EC) management that could be substantially improved by automated document management [2][10]. Besides the reported e-business framework support shortcomings for PD process automation, one important reason that prevents the automation of PD processes is that PD projects cannot afford as much time for setting up and maintaining the process automation, as order fulfilment processes. In networked PD the formation of the network may change on every new PD project, and often also during the PD project. This temporary nature of PD projects is a fundamental difference in comparison to order fulfilment processes, which are typically continuous [10].

In this paper, we proceed to define the methodology for our work-in-progress research to support EC process automation in PD projects by enabling fast setup and configuration of Product Data Management (PDM) systems integration. The integration of PDM systems facilitates the automation of design document management, which has been found important in EC management and networked PD [2]. We also provide background information for the relevance of the research objective, and the results of a literature review that we conducted at the early part of the research.

Rest of this article is organized as follows. In section 2, we discuss certain networked PD project characteristics, and what role e-business frameworks play in automating PD processes. Section 3 presents our literature review. In section 4, we define our research protocol and a suggestion for a solution to enable faster setup of automated document management in networked PD. Section 5 presents our concluding remarks.

## 2. BACKGROUND

### 2.1. Product development in company networks

Recently companies have started to do PD in company networks instead of within a single organization. This is partly due to the increasing outsourcing of PD activities, but also because the shortening life cycles of products in many industry sectors, such as consumer electronics has increased the demand to reduce PD project lead-times [2]. The shift to do PD collaboratively in company networks instead of within a single organization has created problems. Organizational boundaries reduce the

informal communication between people involved in the PD project, and doing PD activities in parallel creates a need to synchronize the PD activities between all companies in the PD project. In addition, with multiple companies involved, the PD project is now being done in a more heterogeneous environment than before [2]. For example, when doing PD within a single company the design data can be managed with the company's PDM system. In networked PD, the functionalities offered by PDM systems, such as version control management, are typically not available as the design data is distributed across several different PDM systems that cannot interoperate [13].

Eloranta et al. [10] argue that project oriented business processes, such as PD, could benefit from partially automated document management conventions, and that the economic potential of the approach could be considerable. They argue that information sharing is the common denominator of all project oriented business processes and that the use of electronic documents would facilitate the information sharing.

The need to improve information sharing in networked PD has been reported in a case study of product geometry changes in injection moulding company network [2]. In this company network, there was a client company that developed consumer electronics products that required demanding plastic components developed by several supplier companies. The impact of product geometry changes to the initially estimated lead-time of the projects varied from 140% to 257%. According to the case study, PD processes are driven by the exchange of design documents such as CAD-models and improvement in the design document exchange process could have substantially reduced the impact of the product geometry changes. Two sources of extra work were found: working with an out-dated version of a design document or the absence of a design document. The case study suggested that the automation of design information flow between the enterprises could ensure better controllability and performance of the PD projects.

### 2.2. Support for automated document management in PD networks

Despite the advantages of automated document management in PD projects, it is not a common practice in the industry although a proof-of-concept demonstration exists [13]. PD in company networks involves collaborating with multiple companies that may change each time a new PD project is started. Thus, heterogeneity of the involved information systems, such as PDM systems, is inevitable and a solution supporting automated document management in PD networks should be based on standards.

Kotinurmi et al. [12] argue that e-business frameworks are the standards that could support automated document management in PD networks. Approaches such as point-to-point integration and portal were considered infeasible, as portals require more human involvement and the management of point-to-point integration is not feasible in a large company network. Kotinurmi et al. evaluated 15 different e-business frameworks based on their support for process integration, secure messaging, PDM related messages and industry usage. Based on the evaluation, RosettaNet was considered best suited to support automated document management in PD projects.

The most important part of the RosettaNet standard are the inter-company business process definitions called Partner Interface Processes (PIP). RosettaNet marks each PIP with maturity level information, and the highest maturity level has been assigned to several order fulfilment PIPs. PIPs for PD processes typically have a lower maturity level, and although the PIP category "Collaborative Design & Engineering" existed already in the beginning of year 2002, it still contains not even drafts [20]. This PIP category would likely contain the PIPs for enabling automated document management that are currently missing from RosettaNet [12]. Thus, even if RosettaNet is the best-suited e-business framework to support networked PD, it lacks process definitions to support it [13].

Case studies of RosettaNet implementations, such as the Arrows case study conducted by the Stanford University, suggest implementation times measured in months [20]. Indeed, even with mature vertical industry standards, it is necessary to agree with trading partners (TP) on how to use the standard, which can take considerable time [6]. An implementation time measured in months is clearly infeasible for a PD project that may last only a few months. It appears that networked PD requires different approach to the process automation implementation than has been used before.

## 3. LITERATURE REVIEW

This section presents our literature review process and the methodological background. We classify the key articles found in the literature review, and present a short summary of each.

Literature review was performed to find existing scientific knowledge on e-business architectures, PD information systems integration and the requirements for IT support in networked PD projects. Research was carried out according to the structured approach recommended by Webster and Watson [28].

The first step of literature review was performed by looking through the relevant top journals of Computer Science and Management Information Systems. Our choices were MIS Quarterly, Communications of the ACM, Computers in Industry, Production Planning & Control, Journal of Manufacturing Technology

Management (formerly Integrated Manufacturing Systems), Information Systems Research, Journal of Systems and Software, and Computer Standards & Interfaces. Due to recent upraise in e-business and business process automation, we examined the journals starting from year 2001. The full text of each article was reviewed in order to eliminate those articles that were not related to our research problem.

From the key articles found from the journals, we reviewed the citations for the articles. The key articles were also forward examined to find more articles for the review. Using these methods, we found a few more articles. In addition, we defined a set of keywords such as 'e-business architecture' and 'PDM integration'. Then we searched a number of electronic collections such as Science Direct, the ACM digital library, IEE Explore, Citeseer, Web of Science and Lecture Notes in Computer Science using the keywords for full text searches. This led to a discovery of few new articles relevant to our research. Validation was accomplished by comparing the articles we found against those we had found previously by unsystematically observing research publications on the field. The literature review had found all important articles and many new ones, 48 articles in total.

### 3.1 Fast collaborative network setup, research on virtual enterprises

The research on virtual enterprises (VE) and virtual organisations has covered issues related to integrating participating enterprise information systems within virtual enterprise partners. Virtual enterprise, defined as a network of autonomous firms that co-operate to achieve common business goals, has received considerable attention in the academic community [4][14]. Although multiple software architectures to support virtual enterprises have been defined, e.g. ones listed in [4][14][30], there are still many challenging issues requiring further research [4]. These include collaborative network support for setting up networks, operating them, and the evolution and dissolution of the network. In addition, definition of ICT infrastructures and identifying relevant standards that enable co-operation are needed. E-business frameworks are expected to have an impact on the development of support software for virtual organisations and other collaborative networks [5]. The use of Standard for the Exchange of Product model data (STEP) and Internet communication have also been proposed to support the data exchange between the different systems used at the different companies participating in the VE [30].

### 3.2 E-business architectures

Several publications present software architectures supporting e-business [1][3][4][7][14][16][23][24] utilizing XML. However, most of them are only suggestions without reporting experiences on implementation and use. Only a few experience papers using modern XML-based e-business frameworks exist [18][19][21].

### 3.3 PD collaboration and PDM integration

Liu and Xu [15] state requirements for web-based PDM systems supporting collaboration. They propose web browser PDM interface as a solution. The modern PDM systems have web interfaces, but they differ in usage logic. This is why integration is needed also between participating systems. For PDM integration, agent-based systems have also been developed [27]

There are many collaboration infrastructures for PD collaboration based on the use of Common Object Request Broker Architecture (CORBA) and STEP [8] [9][29][30]. The modelling capabilities distributed over the Internet using CORBA facilitate collaboration between product designers, and STEP provides the common terminology. These papers lack industrial validation, and most concentrate just on laboratory testing. The use of STEP in industry is limited, concentrating in geometry based applications.

## 4. RESEARCH PROTOCOL

In a research project conducted at Helsinki University of Technology, we are trying to improve the performance of engineering change (EC) processes in networked PD. A key element in this is to use standard, automated inter-company processes between the members of the PD network. We have identified two obstacles for this: 1) standard process definitions for inter-company engineering change management do not exist 2) current approaches to achieve systems integration are too slow. The two obstacles are inter-connected, as the process definitions and their use set requirements for the systems integration needed to enable them. We are working on the process definitions and currently they are based on a case study of two separate PD networks.

In this paper, we define the methodology for our work-in-progress research to address the second obstacle, i.e. how to setup integrated document management for new, networked PD projects, in a short time.

The rest of this section is organized as follows. First we give a brief overview of the design research methodology on which our research protocol is based. Then, we proceed to identify how the different design research phases relate to our research.

### 4.1. Design research

Our research approach is based on the design research methodology [11]. Design research views the creation of new knowledge as a loop, as illustrated in figure 1. The loop starts from awareness of a problem, followed by a suggestion how to solve it. The suggestion is then

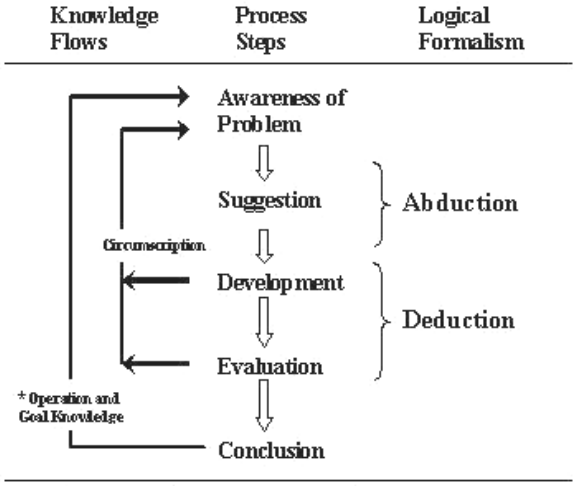
developed, and the result is a new artifact. The artifact is then applied to the problem, and the results are evaluated. If the artifact solved the problem, the conclusions present new knowledge that can be used on subsequent research. If it did not solve the problem, a new suggestion, development and evaluation follow.

In design research, the suggestion is usually done intuitively, but it must always be novel and innovative, either solving a new problem or solving an old problem in a more effective way than previously. Moreover, the created artifact must always be clearly defined, evaluated and reported [11] [26].

The position of our research in the design research loop is currently in the initial stage of development. We are now aware of the problem and have a high-level suggestion on how it might be solved. We expect that the development work will proceed iteratively together with a more detailed solution suggestion.

### 4.2. Awareness of the problem

In our case, the design research loop started with the awareness of the research problem through talks with several industry experts in previous PD related research projects. Next, we reviewed existing knowledge by conducting a literature review to confirm that we are facing a new and valid research objective. The results of the literature review, and the commitment from the companies represented by the industry experts to




participate in the research, convinced us that we are facing a real research problem.

### 4.3. Suggestion

The project-oriented nature of networked PD would require repeatable systems integration work, if done in the traditional way. Because of the inevitable ambiguity of standard specifications and how different individuals understand them, and the diverse needs of companies using the standards, PDM systems integration using e-business frameworks will likely continue to consume considerable time in the near future [6][13][20].

In our opinion a solution to support fast setup of systems integration might be based on the concept of reusing past systems integration work between different PD projects. This seems feasible, as networked PD is usually done within fairly small and stable network of companies, with only the roles and project teams changing frequently. Thus, only the first systems integration work between two TPs collaborating in networked PD would require considerable time. Systems integration work for subsequent networked PD projects between the two TPs would be small.

The limited size of the network and relative stability of the partnerships in networked PD, is different from the requirements for VEs. However, there are still many commonalities between the requirements for networked PD and VE, so the research for VE might be used in our research.

### 4.4 Development

We are now in the early phase of the development of an artifact to enable fast integration of PDM systems in networked PD. The artifact will consists of a concept, a software tool, supporting software architecture and a management process.

The reuse of past systems integration work between two TPs in future networked PD projects would in our opinion require dividing the parameters of PDM systems integration in two groups: PD-project related parameters and TP related parameters. For example, parameters such as ‘Document Type’ that derive from the PDM systems that the TPs use, or IP-addresses required for data exchange are likely to remain same in all networked PD projects between the two TPs. However, parameters, such as project identifiers and contact persons for exceptional situations, typically change on every project.

These two groups of parameters must be defined, as not only is their speed of change different but typically they are controlled by different parties. For example, the TP related parameters may be controlled by people with technical background who are responsible for the IT infrastructure of the company. The project related parameters, however, may be controlled by a project manager in a PD group. People with different backgrounds may require different software tools, or at least user-interfaces, for managing the parameters. Moreover, if the people reside in different divisions of the company, it may be obstacle for the information flow between them.

Previously these two groups of parameters have been treated as one. B2B integration architectures such as the one presented by [3] recognize the need for TP management, but not for project data management. In our experience, the software tools for configuring systems integration parameters are suited for

configuring TP parameters, but not for project related parameters.

### 4.5 Evaluation and conclusions

The artifact will be iteratively designed and evaluated by an industrial focus group. Once this preliminary validation has been achieved, the adoption of the artifact by industry would bring stronger market validation. The artifact and results of the evaluation will be reported publicly, and evaluated against the other related research we found during the literature review.

## 5. CONCLUDING REMARKS

Previous research indicates that engineering change (EC) management in a network of companies collaborating on product development (PD) is often functioning poorly. Automation of design document exchange process between the companies could offer considerable potential for savings, but it has been found difficult. The use of e-business frameworks, particularly RosettaNet, in the automation of the design document exchange process has been suggested.

In this paper, we argue that there are two obstacles for using RosettaNet in the integration of the design document exchange process: unsuitable or missing process definitions for EC management, and typical implementation times that are too long for networked PD.

We define the methodology for work-in-progress research to seek ways to reduce the setup time of automated document management for a network of companies collaborating on PD. Our approach is to introduce basis for reuse in systems integration work, so that subsequent PD projects between two trading partners could benefit from past integration work.

The contributions of this article are the definition of the research objectives, the methodology for solving it, a potential solution suggestion and the literature review.

The literature review indicated that project oriented business processes, such as PD, would benefit from increased integration, but that e-business frameworks have not been previously specifically discussed within PD needs as older standards such as STEP and CORBA have dominated the research applications. We have found previous research that can be compared to our approach, and can aid to position our research in relation to other research on the subject.

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