Enhancement of Problem-solving Capability by Reduction of Project Complexity
- A Case Study on Empirical Validation of Information Centric Project Management-

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Abstract

A product design is a search process to derive one design solution. This process is iteration process. Through this processe, projects bring out the issues. For solving the issues, projects repeat those processes again. In short development process is a repeat of clarification of the issue and solution of the issue. Efficiency of development might be depending on the capability of communication in iteration processes. Thus this paper shows the relation between efficiency of development and capability of communication in a project.
The complexity of a project by the information centric project model is useful in evaluating of the capability of communication. Through the research, the number of issues is counted and the complexity is measured every week in real enterprise information system development project. As a result, there is a negative correlation between the complexity and the number of issues. The issues can become the risks. Thus, it is very important for project management to solve the issues smoothly. The smoothness of communication reduces the number of issues and risks. The reduction of issues and risks enhances quality, cost, and delivery. This report indicates the key for success to control the obstacle factor in project.

Keywords & Phrases: Information Centric, Complexity, Problem Solving, Correlation, Capability of Communication

1. Introduction

The iterations arise during the process of design necessarily. Simon [1] said that problem solution systems and processes of design not only assemble problem solutions from composition elements but also have to find a right combination of these problem solutions. In addition, Simon [1] said that processes to find a right combination of issues and solutions are processes to seek problem solution, processes to gather information about structure of problem. Suh [2] said that design is process of trial and error in the following manner. 1. Knew customer's needs 2.Define the problem, 3.Conceptualize the solution through synthesis, 4.Analysis, 5.Check the result design solution.
In this manner, design process is iteration. Objective of iteration process is to find out a solution of issue about design. In short, an iteration design process is a solution process of issue. To solve an issue, a project gathers information. Using information, a project finds a right combination of issues and solutions to solve the issue through a trial and error process. Thus period of trial and error might be accelerated by the quality of information and the speed of gathering information.
On the other hand, the issue is clearly distinguished from risk in project management. Preston G. Smith, Guy M. Merritt [3] describe risks as uncertainty, issues as certainty. According to PMBOK [4], a risk is an uncertain event or status that has an influence on at least one of project objects.
Issues turn into risks as a result of uncertainty about increase of issue and protracted issue. Fukushima [5], [6] empirically points to some correlations between issues and quality, cost, delivery (QCD), and between risks and QCD. Increase and prolongation of issue, risk reduces QCD. These studies show that smooth solution of issues is very important. But the earlier study did not mention the mechanism how issues were smoothly solved.
The purpose of this study is to examine relation between the capability of communication and efficiency of solving issues in real enterprise information system development project. Design process depends on the information indicated as above. Capability of communication is depend on mechanism of exchange information in a project

2. Hypothesis of This Study

Risks and issues need to be reduced for project success. To reduce issues and risks, an iteration process must be done in an efficient way. To realize the efficient iteration process, smooth exchange of information is needed.

The reason is that smooth exchange of information facilitates to find and gather necessary information. Thus, this paper proposes a following hypothesis, "The capability of communication in a project correlates with the ability of issue-solving skill".

3. Concept of Project Mode for Validation

Concept of Information Exchange Model

Sakaednai et al. [7], [8] develop the information centric project model. This model focuses on the information flows in a project. Elements of this project model configure team, activity, artifact, component, function, requirement, feature and needs. Each element has relationships based on axiomatic design (Suh [2]). Information is exchanged among these elements.

Characteristics of information are information stickiness (von Hippel [9]) and equivocality（Draft, R. l., & Lengel, R. H. [10]). These characteristics are obstructive factor of communication. Information stickiness means the difficulty of transmitting information. The difficulty results from the information transfer cost, which lowers the productivity of a project. Equivocality means ambiguity that is subject to multiple interpretations. For a given piece of information, the number of interpretations increases with the number of information recipients. To decrease the number of interpretations, additional information is required, which incurs additional information transfer costs. Moreover, multiple senders will provide many pieces of information. The receiver must ensure the consistency of the information. For that purpose, it is necessary to evaluate the quality and consistency of much information. Therefore, equivocality increases information stickiness by the connections between elements. With consideration for these characteristics, this model provides a measure of capability of communication. In figure 1, idealized project model is low information stickiness and low equivocality. As a result, the capability of communication is good. By contrast, large, complex project model is high information stickiness and high equivocality. As a result, the capability of communication is bad.

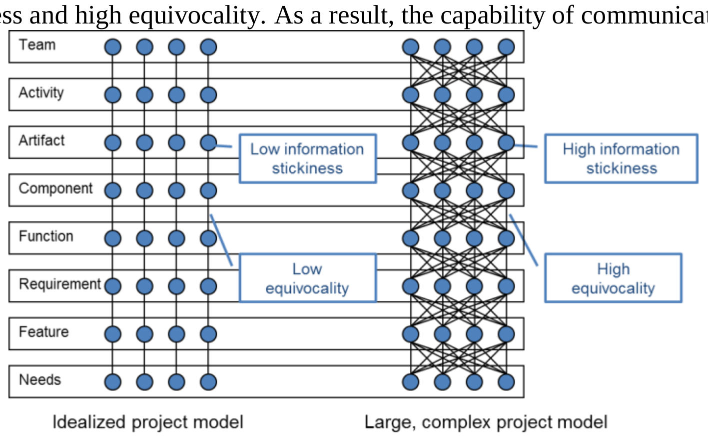

Figure 1. Project model (from Sakaedani et al. [7], [8])

The project model is converted into the system matrix as a traceability matrix. Sakaednai et al. (2012) [7], [8] define the system matrix as Multiple-Domain Matrix (MDM) [11] stretching the concept of DSM (figure 2)

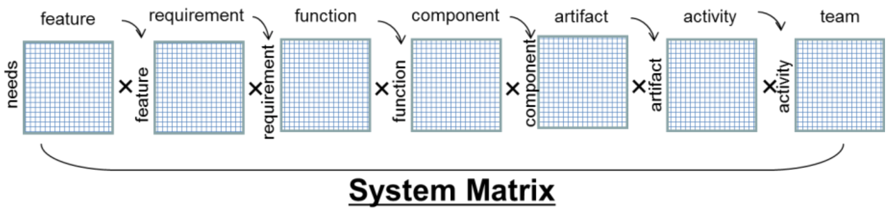

Figure 2. System matrix (from Sakaedani et al.[7][8])

Interdependency

Sakaedani et al. [8] define equivocality as interdependency. Interdependency is the norm of system matrix s minus the unit matrix. The value of elements in this matrix is 0 or 1. A value of 0 means that there is no relationship between the two elements. A value of 1 indicates that a relationship between the two elements exists. This equation measures the length of difference from the idealized project.

Difficulty

Information stickiness cannot be measured (Szulanski [12]). Sakaedani et al. [8] define information stickiness as difficulty. Thus, the level of difficulty can be quantified as information stickiness. The elements of the matrix are configured as the product of each difficulty. The difficulty is the norm of system matrix n.

Complexity

Information-carrying capacity affects the cost of information transfer. Sakaedani et al. [8] define information transfer cost as the product of equivocality and information stickiness. This cost is equal to the product of interdependency and difficulty. The complexity of the system matrix can be defined by the following equation:

$$1/\text{productivity} \propto \text{information transfer cost} \propto \text{complexity}$$

Partition of System

In software development project, a system integrates several sub-systems. System matrix also integrates several sub-matrices. The system matrix consists of several sub-matrices, where the system matrices of the projects are located in the diagonal positions. Other sub-matrices indicate the relationship between the reused elements (figure 3).

Large complex system need not to lump sub-matrices. Each sub-matrices visualize each subsystems. And a few interconnect subsystem can be visualized by small sub-matrix.

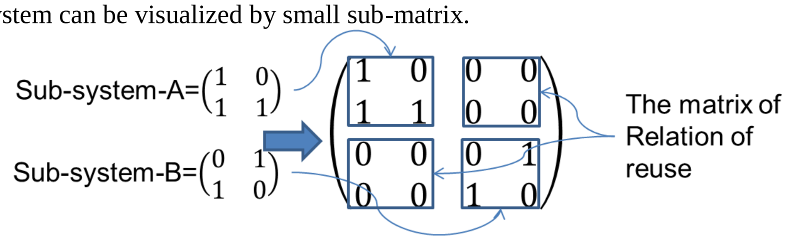

Figure 3 partition of system (from sakaedani et al. [13])

Limitation of Project Model

The project model may have applicability to general software development project. However, the model has two restrictions. First, the model does not track changes over time and instead records a snapshot of the project. Second, the model does not explicitly show the sequence of tasks.

This study addresses first restriction by following the time course of the project model. The project models are made on many occasions. The study addresses have no effect. Measuring object for this study is not metrics associated with the sequence of tasks

4. Validation

Validation Data-gathering Process

The following is the procedure for validation (figure 4). Objective of validation is real enterprise information system develop project. This system consists of four sub-systems. In this study, two sub-systems in the system are the objective of validation. One system is developed by a business application functional group, the other system is by a common functional group. The common functional group provides common functions to business application functional group. The authors examine the capability of communication and ability of issue-solving skill in the two sub-systems. Business application functional group has no interconnections except the common functional group.

Over a period of time, the number of issues is counted, and measured the capability of communication every week in real enterprise information system development project

First, The project model for two sub-systems is generated from information of project situation as weekly (appendix 1). The project model is converted to system matrix-s. Interdependency is derived from the system matrix-s by using spreadsheet. System matrix-n is derived from interviewing the project manager and other key man. Difficulty is calculated based on system matrix-n by using spreadsheet. At last, Complexity multiplies interdependency by difficulty.

Secondly, the number of issues is counted every week. Listing date and delisting date for issues are written in the list. The listed issue (raised issues) and delisting issue (solved issue) are determined by these date. The purpose for making the list is to share design issues. The issues affecting the system included four sub-systems are listed.

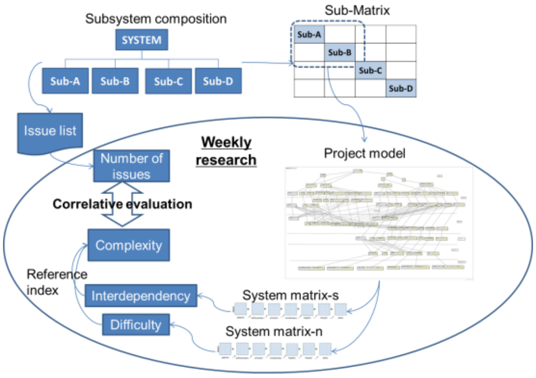

Figure 4. Whole picture of validation

Overview the Project, the Number of Issues and Complexity

Overview of the Project

This paragraph describes the basic policy of the project management. At first, the basic policy of the project management placed more emphasis on source code and less on design document. The project substituted oral communication among members for communication through design documents. Therefore the project manager assumed that designers built on close relationship with programmers. But the basic policy failed and the project came back to the traditional document-driven after fourth weeks. Around the same time, requirements increased. Project commences studies toward reduction of development functions.

This paragraph describes approach to development of each function. The project did not develop all functions at the same time. Developments of each function start in order of priority. Common functions are completed by 5th weeks. Business application functional group begins in earnest on development from 6th weeks. In the meantime, one of business application functions halts a development (figure 5).

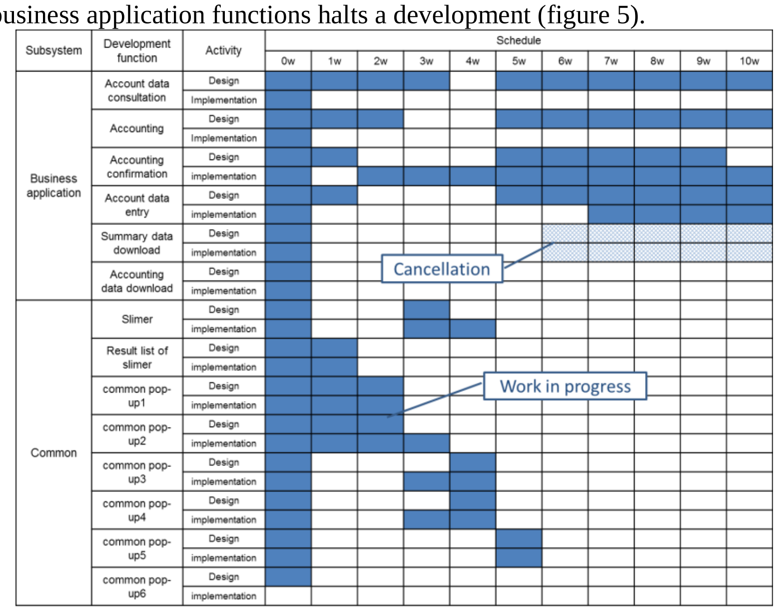

Figure 5. Record of each function development

This paragraph describes action for listing and delisting of issue. The project conducts an interim review of design document for other sub-systems in 2th weeks. A lot of issues are listed. At the same time, a lot of issues are delisted. The number of listing and delisting issue achieve a peak. In 6th weeks, The project makes a short list of the development function. Because specifications change increase development scales. Therefore, the number of delisting issues is increase.

Project Management and Mechanism of Communication

This paragraph describes management of difficulty and mechanism of time-variable difficulty. Development of business application functions depends on design documents (document-driven). Especially, The project requires accurate representation in design documents from 4th weeks. Accurate representation causes an increase in information stickiness. Information stickiness causes an increase in difficulty. The project formalizes know-how by using design documents. Formalization causes an increase in difficulty. But formalization causes a decline in repetition by non-skilled engineer. The project supply complete and accurate details design information. This information causes a decline in repeat count by trial and error. As trade off, the project raise the difficulty of one repetition. In the beginning, the project maintained close communication. The project developed the information system by verbal communication without design documents. Though the project increased the opportunity to repeat design process, the project shortened the cycle by lightening project member's workload of documentation. The project thought that it was not difficult to communicate with skilled engineers. The project made a choice of repetitions for sharing large amount of design information. In the process of development, the project changed the basic policy.

This paragraph describes management of interdependency and mechanism of time-variable interdependency. Project avoids the difficulty resulting from multitasking. The project did not develop all functions at the same time. Developments of each function start in order of priority. And one of business application functions halts a development. The project reduces the elements of project. As a result, interdependency is low.

After common functional group finish work, concurrent development of business application cause a modest increase in interdependency. Figure 6 shows a graph of interdependency and difficulty. Y-axis translates interdependency and difficulty into percentage.

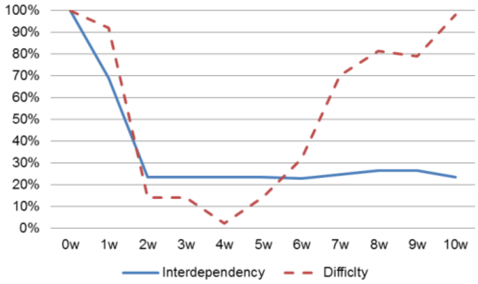

Figure 6. Time change for interdependency and difficulty

This paragraph describes management of complexity and mechanism of time-variable complexity. Complexity multiplies interdependency by difficulty. Thus complexity varies according to variation in interdependency and difficulty (figure 7). Interdependency and difficulty fall abruptly. Complexity also falls abruptly. Since then, interdependency is just about constant. Difficulty falls again in 4th weeks. And since then, difficulty increases. As a result, complexity varies according to variation in difficulty. These factors considered, it may be said that The project makes a choice of management as follows: interdependency keeps constant value, difficulty increase. Difficulty is not necessarily affect complexity materially. The complexity has increased up to nearly 20%.

The project could make a choice between speeds of repetition and repeat count. In this case, the project makes choice of repeat count by trial and error. In according with this decision, the project increases difficulty. But the project manages to keep constant value of interdependency. As a result, the project keeps complexity at a minimum.

Figure 7 shows a graph of complexity, listing issues and delisting issues. Y-axis translates complexity, listing issues and delisting issues into percentage.

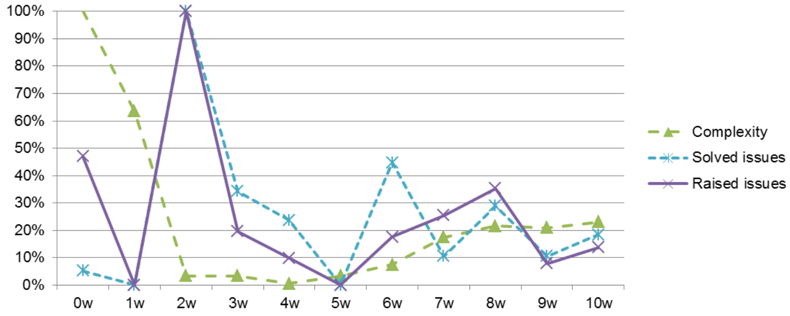

Figure 7. Time change for complexity, listing issues and delisting issues

5. Discussion

Hypothesis Validation for Correlation between the Capability of Communication and Ability of Issue-solving Skill

Table 1 shows results of this validation. Subset of hypothesis is validated. There is a negative correlation between complexity and delisting issues (coefficient of correlation=-0.44, p<0.01). There is no correlation between complexity and listing issues.
Complexity means capability of communication. Thus there is a correlation between capability of communication and ability of issue-solving skill.

Table 1. Correlation

		Correlation coefficient
Number of delisting issues (Solved issues)	Complexity	-0.44
	Difficulty	-0.48
	Interdependency	-0.37
Number of listing issues (Raised issues)	Complexity	0.03
	Difficulty	-0.13
	Interdependency	0.07

Significance probability: p = 0.0046

Evaluation of the Result

Complexity and Delisting Issues

Issues in this paper focus on all of system included other two sub-systems. Settled issues affect all sub-systems. Settled issues relating to all sub-systems solve issue of each sub-system. Issues produce information stickiness. Solving issue reduce information stickiness. Reduction of information stickiness enhances capability of communication.

Complexity and Listing Issues

Raised issues in this paper also focus on all of system included other two sub-systems. But this paper measures only two sub-systems by complexity. Raised issue includes a list of other two sub-systems. For that reason, raised issues do not necessarily correlate with complexity.

6. Conclusion

This paper shows reduction of complexity leads a project to a successful conclusion. There is a correlation between complexity and the number of solved issues. Through understanding of mechanism for complexity, a project deters increase and protraction of issue. Increase and protraction of issue reduces QCD.
Design process depends on the information. Capability of communication is depend on mechanism of exchange information in a project. To realize the efficient iteration process, smooth exchange of information is needed. The reason is that smooth exchange of information facilitates to find and gather necessary information. Thus, the capability of communication in a project correlates with the ability of issue-solving skill.

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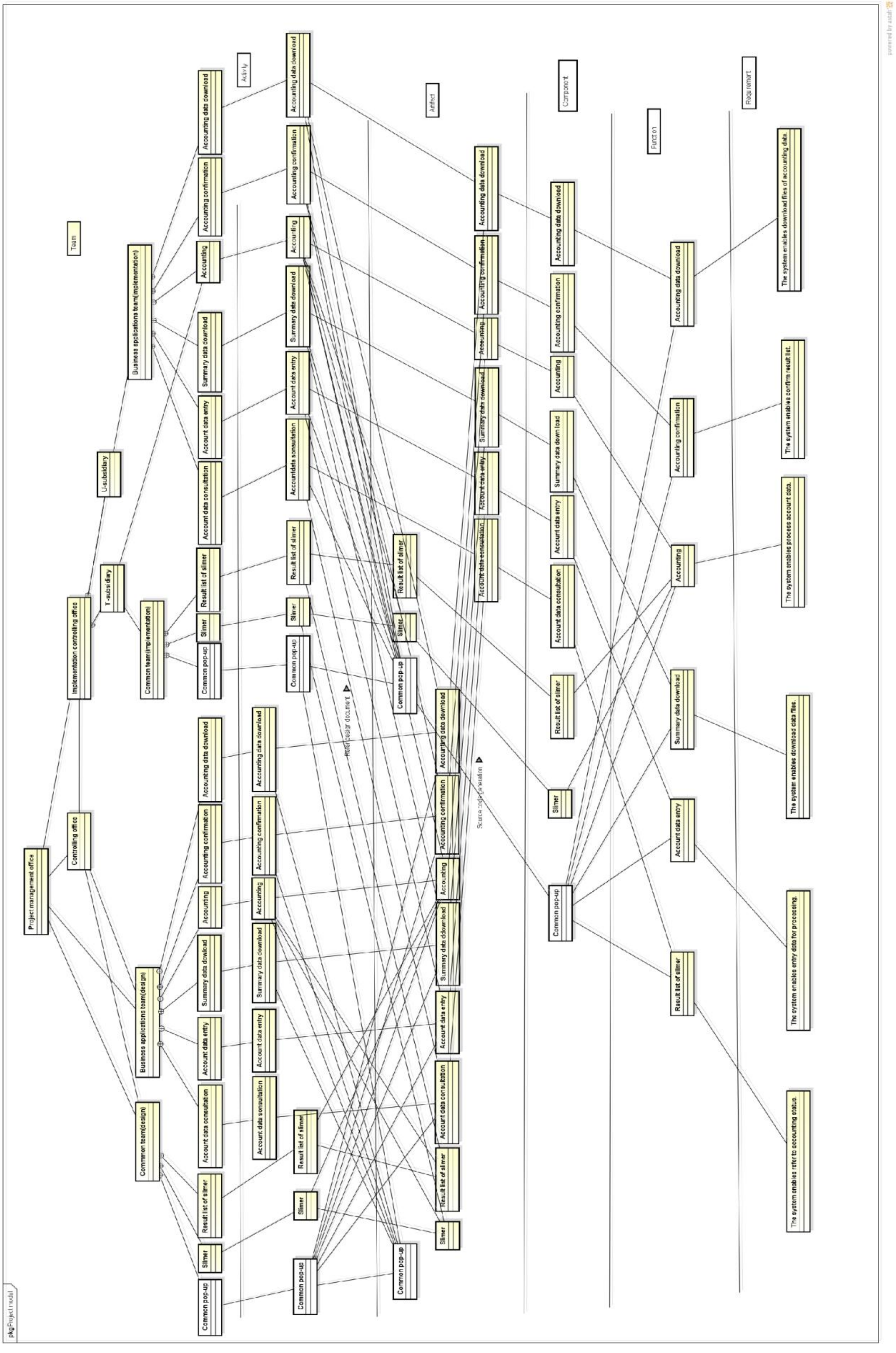
Appendix 1



pkg Project model
Team
Activity
Artifact
Component
Function
Requirement
Project management office
Controlling office
Implementation controlling office
U-subsidiary
T-subsidiary
Business applications team(implementation)
Common team(implementation)
Business applications team(design)
Common team(design)
Accounting data download
Accounting confirmation
Accounting
Summary data download
Account data entry
Account data consultation
Result list of slimer
Slimer
Common pop-up
Basic design document
Source code generation
The system enables download files of accounting data.
The system enables confirm result list.
The system enables process account data.
The system enables download data files.
The system enables entry data for processing.
The system enables refer to accounting status.