

# A Model for Achieving the Goals of Requirement Development Process Area in CMMI Level3 on Workflow Applications

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## **Abstract.**

*Fast change of information techniques introduces the considerable needs of better software integration and generation over various hardware, operating systems, and applications. To extract the requirements of projects is getting more difficult; however, there is no perfect solution currently.*

*Capability Maturity Model Integration (CMMI) is the most popular one used to guide process improvement across a project, a division, or an entire organization. One CMMI benefit expected is increasing the focus and consistency in the requirement development and management. There are lots of researches which address related problems in requirement development process.*

*Usually, a software company emphasizes on several specific application areas only. Each area has its own characters, thus its CMMI guidance might be different from others. In this paper, we aim the problem from another viewpoint: software development in an area might be summarized as a set of templates. The development processes associated with these templates might cause them to satisfy CMMI 3. With years of experiences on WfMS researches and advices, we developed a model for requirement development process area in CMMI level 3 that might be a good way for the software development of this area. The validation will be down in the future.*

## **1. INTRODUCTION**

During requirement development, we encounter many problems that occur again and again. The question we must ask ourselves is how we are going to solve it this time. Documenting useful models is one way that you can reuse. The information associated with the documents that represent how to solve the requirement development problem [1] in a better way.

On the other hand, CMMI is a process improvement approach that provides organizations with the essential elements of effective processes. It can be used to guide process improvements across a project, a division, or an entire organization. CMMI is claimed to help integrate

traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes [2-5], but there is no a systematic approach to get the realistic benefit from this process improvement approach.

In addition, requirement development is the hardest work of software life cycle, but it is the most important factor to decide the success of project. Most software companies center on several particular application areas only. Improving the requirement development process of a software company with CMMI guidance might cover the characteristics of its area implicitly. Therefore, it might be useful to construct a model (or a set of process templates) to help the company's software development following CMMI such as level 3.

With experiences of years on WfMS researches and advices for software companies, we present a model which is expected to help developers achieve the goals of Requirement Development process area in CMMI Level 3 on workflow applications. Our model elaborates requirements of the workflow application [6] from identifying the organization structure, business process, interactive relationship of activities, and related data according to the practices of RD process area in CMMI Level3. Developing requirements obeys the recommendable requirement development processes provided in CMMI. Our model follows the order of these processes to provide corresponding operators (e.g., questionnaire and template) as well as to get the expected products, which fulfill the goals then.

The paper is structured as follows: In Section2, we present a short survey on the requirement development of workflow application and related researches of CMMI. In Section 3, 4, 5 and 6, we present our model which is defined as a set of questionnaires and templates executed on the recommended process provided from CMMI Level3. In these sections, we also use a purchase workflow application to illustrate the method provided. Then, summarizing what goals of RD process area in CMMI Level3 are realized with our model in Section 7. Conclusion and future direction of our work are given in Section 8.

## 2. RELATED WORKS

### 2.1 CMMI and Related Researches

The first version of Capability Maturity Model (CMM) [2] was released in 1991. The CMM has evolved to CMMI [3], which enables the continual growth and expansion of the CMM concept to multiple disciplines, such as system engineering, software engineering, integrated product and process development, and supplier sourcing.

Requirement Development (RD) Process Area (PA) is concerned necessarily in Level 3 of Capability Maturity Model Integration (CMMI) [4][5]. In RD-PA3 (RD-PA in Level 3), there are several goals to be achieved. RD-PA3 has three types of requirements: customer, product, and product-component requirements. These requirements address the needs of relevant stakeholders, project attributes and constraints for design decision. Above goals are implemented by practices that not only cover the products, but also consider their generation processes and limitations from stakeholders. There is a method [7] creating a meta-model which represents the relationships among elements such as organization policy, restricted resources, and functional requirements. The design of the meta-model is emphasized on requirement management and elicitation traceability, but disregarded other influence factors. This model does not cover the whole improvement essentials of RD-PA3, so we provided a model which could further the organization maturity to RD-PA3.

### 2.2 The workflow application analysis

Traditional software requirement analysis methods, such as object-oriented, data-centered, and functional analysis are mainly concerned with developing generic software requirements and specifications that express a system's objects, data, and functions. These methods are weak to elicit the requirements of business process-centered software [8].

During the workflow application analysis, the developers collect requirements according the composition of workflow application. A workflow application consists of a network of activities associated corresponding participants to generate related data. The set of linked activities realises a business objective. The participants of a workflow application could be an application or a person. There are some necessary tasks for developing a workflow application which are the identification of roles and related capabilities, recognition of business process, configuration of activities of business process, and data interaction mechanism.

## 3. THE MODEL

Our model elaborates requirements of workflow application from identifying organization structure,

business process, the interactive relationship of activities of processes, and related data according to the practices of RD process area in CMMI Level3. The model realizes the requirements specification by questionnaires and templates. The replies of questionnaires and the instances of templates can be used to construct the work products of RD-PA3. The recommended process shown in Figure 1 has three stages which are development customer requirements, development product and product-component requirements, and analysis and validation requirements.

In development customer requirement stage, developers elicit customer needs with the questionnaire designed with high level concepts (e.g., goal, need, expectation, operation, and constrain). The replies got from the questionnaire are used to roughly identify the components in the application (e.g., the number of business processes, applications, and relevant data). Our model depends on the information to select the major stakeholders.

In development product requirement stage, our model designed for translating the high-level goals specified in domain specific language into detailed software functions with the operational concepts, characters of targeted software (workflow application) and domain knowledge. There are some iterative tasks to develop functional requirements of workflow application: (1) identifying the organizational structure; (2) analyzing the legacy system integrated; (3) identifying the business process; (4) identifying the elements of workflow relevant data set; (5) identifying the atomic activities of business process; and (6) establishing the network of activities and their relationships. The products generated from these tasks are maintained with Customer Requirement Derivation Model (CRDvM). When there is an acceptable change request, the corresponding tasks should be executed to fix the problem then generate the appropriate output. Maintaining the traceable records to denote the scope affected.

The model provided is demonstrated on the requirement development of workflow application which works on a commercial workflow platform Agentflow [9]. The last stage of the recommended process is not concerned here; because of space limitation of paper.

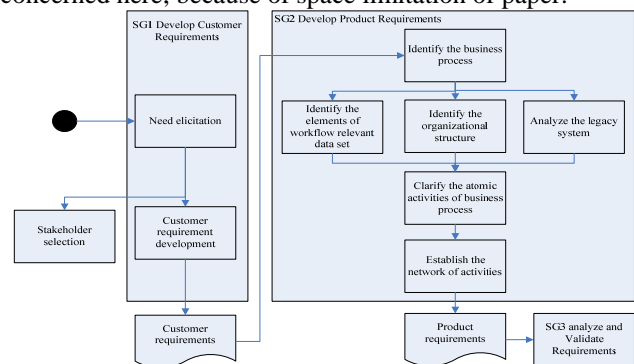


Figure 1. RD-PA3 based workflow requirement development process

## 4. DEVELOPMENT CUSTOMER REQUIREMENTS

### 4.1 Needs Elicitation

Customers' needs should be clearly identified and an iterative process is used throughout the life of the project to accomplish this objective.

In project inception stage, our model not only collects project needs (e.g., goals, expectations, operational concepts) provided by customers, but also identifies additional requirements implied in needs. To facilitate the required interaction, our model provides a set of questions to gather original materials from customers, then progress customer requirements step by step.

Table 1: a set of questions support collecting original needs from customers

Category/ Questions	Example (Flowring Corp.)
<b>Goal/</b> What are the major goals of the project?	Flowring Corp. has an ERP purchase system but its document approval procedure is executed manually. The company wants to exploit the approval application of electronic document to increase the performance and reduce error rate.
<b>Functional Needs/</b> What are the major functionalities of the targeted application?	<ol style="list-style-type: none"> <li>1. The workflow application can support automatic approval procedure.</li> <li>2. The workflow application can support adjusting flexibly the authorized amount of money of each position.</li> <li>3. Each approved document should be backup with .pdf file.</li> </ol>
<b>Non-functional Needs/</b> What are the non-functional expectations of the targeted application?	<ol style="list-style-type: none"> <li>4. Fifty persons can use concurrently the workflow application.</li> </ol>
<b>Operation concepts/</b> What are the operation procedures (include the operation among legacy system and workflow application)?	<ol style="list-style-type: none"> <li>5. The staffs of Flowring Corp. interact with the purchase system to record the orders of which each will be instantiated an approved workflow on the application system. After the approval, the new application needs updating the related data in the original database.</li> </ol>
<b>Constraints/</b> What are the constraints of the targeted application?	<ol style="list-style-type: none"> <li>6. The first constraint is that modify purchase system as least as possible in developed period.</li> <li>7. The applicant and approver of order can not be the same person. The order must be approved by a higher level manager, if such a case occurs.</li> </ol>
Environment	
hardware	Server Intel 2.6G/1G RAM
software	Database SQL Server 2000 Client Win2000/Win98
network	Intranet Internet 512K
Legacy system(ERP)	Database Informix 7.3

The design of questions is configured from various perspectives which include the major purposes of this project, the functional needs, non-functional needs, operational concepts, the specific constraints and expectations, and particular hardware (software) conditions.

A business process means that a set of one or more linked procedures or activities which collectively realise a business objective or policy goal [6]. The automation of a

business process is exhibited during which documents, information or tasks are passed from one participant to another for action according to a set of procedural rules. The process definition consists of a network of activities and their relationships, criteria to indicate the start and termination of the process, and information about the individual activities, such as participants, associated IT applications and data, etc. The details are shown as Figure 2 and Figure 3.

The results generated in this stage are used to roughly identify the components in the application (be shown as Figure 3) including what business processes should be automated (workflow application), what documents are executed on the processes (relevant data), what workflow platform (Agentflow) will manage these processes, and what legacy system (ERP purchase system) will be integrated with. Table 2 shows the results elicited from the original needs shown in Table 1.

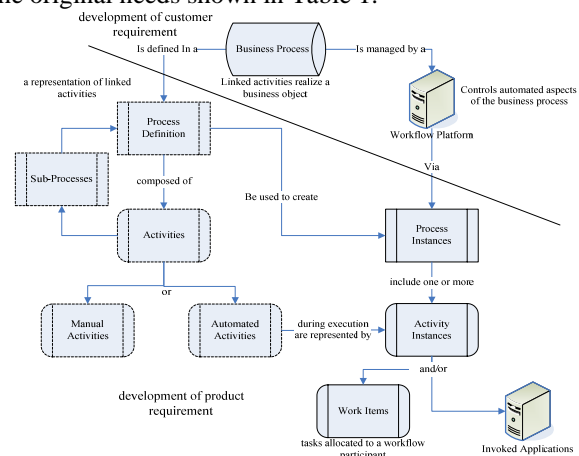


Figure 2 the relationship between elements of a workflow [6]

Table 2: customer requirements elicited from original needs

Module Name	Purchase Module	Date	8.3.06
Module ID	M00001	Designer	Chris
Workflow platform	Agentflow 2.1	Version	1.1
<b>Module Description</b>			
Fetch the data of orders from ERP purchase system, and then instantiate an approval workflow. After the approval, the new application updates the related data of original database.			
<b>The number of workflows</b>		2	
<b>Description</b>			
1. A workflow of periodical checking of purchase order 2. Approval workflow			
<b>The number of e-forms</b>		2	
<b>Description</b>			
1. Purchase order 2. the hard copy of purchase order with pdf format			
<b>The number of applications</b>		1	
<b>Description</b>			
1. Inquiry order application			
<b>Others: System Architecture</b>			



relationships of departments) of these participants?

4. What positions does each organizational unit such as have?
5. What are the relationships among these positions in each unit?
6. Which staffs can be assigned for these positions?
7. In this business process, is there any participant assigned a temporary position? If yes, what are the temporary positions?
8. In this business process, what are the responsibilities and authorities of these temporary positions?
9. What conditions are applied to initialize/terminate the temporary positions?
10. What are the relationships among these temporary positions?

The first and second questions help developers to sequentially gain a better understanding of the positions of participants and the responsibilities and authorities of these positions. The third question is designed in order to retrieve the organizational hierarchy. The fourth question guides customers to reply by referring to the results of question (1) & (3) and thus recognizes the connection between the positions and the organizational units. The fifth question attempts to gain the information about the relationships among positions in each unit. Next, the sixth question clarifies the current roles assignment. The identification procedure of temporary positions and assignments are similar to those for regular cases as above, so it is omitted here.

The organizational structure of our case study is shown as Figure 4, which displays the configuration among different departments, the relationships between various positions, and the roles assignments. The information supports the rule definitions of allocating participants to the activities of a workflow process.

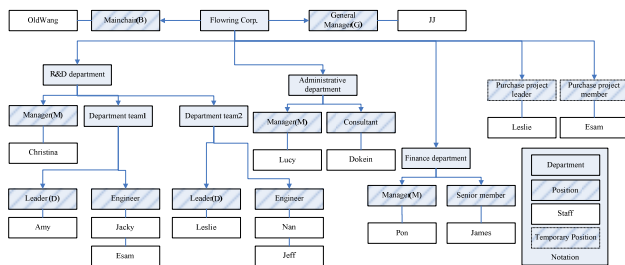


Figure 4 the organizational structure of participants of approval workflow.

### 5.3 Analyzing the Legacy System

Before automating a business process, the set of linked activities could be partially supported by some legacy systems to realise the business objective. In case there is such a system, analyzing the legacy system(s) is a necessary task to help understand requirements of a new system more precisely.

In our case study, the staffs of Flowring Corp. were used to handle purchase orders with ERP purchase system. Analyzing the data model of the purchase system is a task

which aids developers to identify the communication mechanism among ERP purchase system and approval workflow. The details of legacy system analysis are out off the scope of this paper, so it is omitted here.

### 5.4 Identifying the elements of workflow Relevant data set

The elements of workflow relevant data set are obtained from the hard copy or legacy system executed in manual or semi-automated procedure. The elements of workflow relevant data set support the identification of the atomic activities in next stage. Figure 5 shows the relevant data set of approval workflow which is transformed from the traditional paper document of manual approval procedure into electronic form.

No	Order serial number	Software ID	Software Name	Standards	Price	Quantity	Tax-free price	Delivered date	Previous order quantity	Previous order price	Previous order date

Figure 5 the form of approval workflow.

### 5.5 Identifying the Atomic Activities of Business Process

An activity is a piece of work that forms one logical step within a process. An activity may be a manual activity or a workflow automated activity. A workflow activity requires human and/or machines resource(s) to support execution.

The execution of an activity passes whole or part of the elements of relevant data set from one participant to another according a set of rules.

The pre- and post-conditions are used by workflow management system to determine the state transitions of a workflow instance. The design of our model concerns above factors of a workflow activity, including the supportive resource, relevant data set, pre- and post-conditions, pre- and post-actions of workflow management system, to identify an atomic activity. The identification of each atomic activity should include the factors shown in Table 6.

Elaborating the identification of an activity is driven by the factors shown in Table 6 and refinement of user scenarios that describes how the end-user interacts with the system. All atomic activities of purchase workflow are

shown in Figure 6 that includes checking the purchase order, determining the approval level, approving by direct boss, manager, general manager, or chairman, and notifying the purchasing agent.

Table 6: detailed identification of an atomic activity

Activity Name	Checking the purchase order		
Activity ID	At000001		
Date	8.3.06	Version	1.0
Designer	Christina	Platform	Agentflow2.1
The workflow activity participant	All members of financial department (purchasing agent)		
Other agents	No		
Computer automated execution	No		
Multiple approval	No		
Description	The purchasing agent checks the data of the purchase order.		
Enable elements of the form (is shown in Figure 5)	Attached file, confirmation of purchasing agent, the comment of purchasing agent		
Disable elements of the form (be shown in Figure 5)	Purchase information, the comment of directed boss, approval of manager, general manager, and chairman, purchase agreement.		
Visible elements of the form	All		
Invisible elements of the form	No		
Pre-conditions of the activity	There is a purchase order in ERP system not approved yet.		
Post-conditions of the activity	The approval result should be stored into the ERP system.		
Pre-actions of the workflow management system	Taking out all global variables from ERP purchase system and setting these variables to approval form of the approval workflow application.		
Post-actions of the workflow management system	Updating the related data of ERP legacy system when the order is approved.		

In checking order activity, shown in Table 6, the workflow management system sets the information to the approval form obtained from legacy system. All elements of the approval form are visible to purchasing agents, but approval segments are disabled in this activity. When there is a purchase order in ERP system not approved yet, the activity can be initialized. After checking the order, the approval results will be written back to ERP system.

### 5.6 Establishing the network of activities

A workflow process represents as a co-ordinated (parallel and/or serial) set of activities that are connected by routing pattern to achieve a common goal. There are four basic routing patterns in workflow system: sequential, parallel, selective and iterative routings.

The network is composed of realistic activity nodes and supported with control nodes such as AND-split, AND-join, OR-split and OR join. Figure 6 shows the network of approval workflow.

In the example case, the first activity of approval workflow is that the purchasing agent checks the purchase order. If the order is correct, the approval form is submitted to direct boss, else the approval procedure is cancelled immediately. The next activity is selected according to the outcome of the checking result, so using OR-split control node links the checking activity to next activities. The boss approval triggers the activity that sets the approval degree according to the procedural rules (be

shown in Table 7). The rules decide the number of levels of a sequential approval sub-process. The OR-split control node links the approval degree activity with these possible sub-processes. The sub-processes merged are shown in Figure 6, because the activities composed these sub-processes represent repeatedly. If all assigned managers agree the order, the system notifies the purchasing agent.

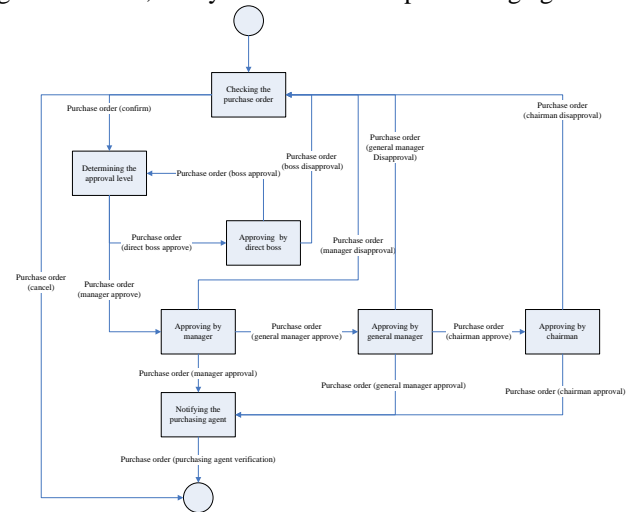


Figure 6 the network of purchase workflow

Table 7: the approval procedural rules

Classification	Leader(D)	Manager(M)	General Manager(G)	Mainchair(B)
01 material	0	Under 10,000NT	Over 200,001NT	N/A
02 development device	0	0	Under 1,000,000NT	Over 1,000,001NT
03 general device	0	Under 10,000NT	Under 100,000NT	Over 100,001NT
04 new factory building	0	0	0	Over 1NT
05 maintenance of development device	0	Under 10,000NT	Under 200,000NT	Over 200,001NT
06 maintenance of general device	0	Under 10,000NT	Under 100,000NT	Over 100,001NT
07 others	0	Under 5,000NT	Under 100,000NT	Over 100,001NT
08 consumer goods	0	Under 5,000NT	Under 100,000NT	Over 100,001NT

## 6. REQUIREMENT MANAGEMENT

A Customer Requirement Derivation Model (CRDvM) is created here for supporting developers to 1) establish traceable links to model requirement dependencies, 2) develop requirements taking account of risks, and 3) generate requirement change proposals based on customer requirements.

CRDvM represents the interaction relationships among software requirements, organizational needs, and risks, etc. The structure of CRDvM is shown as Figure 8.

The details of CRDvM are described based on the six components below:

### 6.1 Organizational Needs

A software system is built to preliminary satisfy customer needs. The needs could influence the objectives of the system. Our model uses questionnaire (Table 1) to elicit original needs from customer and organizes the replies as customer requirements (Table 2), since there is a link to be created between these two instances implicitly.

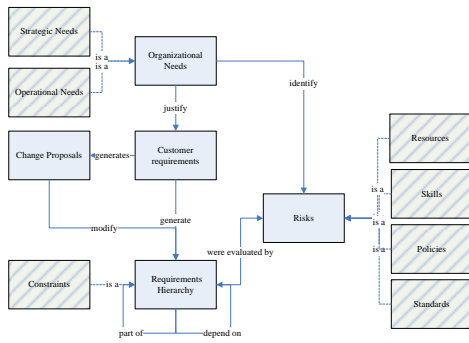


Figure 8. The structure of Customer Requirement Derivation Model

## 6.2 Customer requirements

The customer requirements are composed from the needs of various stakeholders such as customer, project manager, programmer, etc according to the process operational concepts, workflow characteristics, and organizational needs.

## 6.3 Risks

After having a draft understanding of the project (identify the stakeholders and got customer requirements), our model evaluates the risk(s) of the project from three perspectives which are project environment, hardware, and application. The evaluation result(s) indicates the risk degree of the project. The detailed design of the evaluation mechanism is shown in Table 8. Our model divides the degree of risk into three ranks (low=5, middle=10, and high=15), and gives the weight for each perspective. So, if the result of risk estimation is lower than 21.5, it means that most of essential items of the project are ready. If the result value is higher than 21.5 but lower than 64.3, it means that partial items demanded are not ready. The worst situation is the value higher than 64.3, and means nothing under expectation.

## 6.4 Requirement Hierarchy

The requirements are specified in a hierarchy where the specification of the top level is abstract. The requirements of the top level are customer requirements which are referred to estimate the project risk degree and support to make the stakeholder selection. These business processes described in customer requirement specification are transformed into workflow modeling representation. The representation is composed of three major elements: activity, relevant data, and role. So, the business process is transformed into the components of a workflow now. After identifying the necessary components, we create the relationships among them to form the activity network. The details are shown on Figure 9.

## 6.5 Change Proposals

Change proposals are extracted from customer requirements. The proposals are used to guide the modifications of software requirements. A change request initiated could raise conflicts among elements such as customer requirements and product requirements. Our model estimates change impact from influence scope, the

degree of software architecture modification, potential cost, and latent unclear rules (be shown as Table 9).

The influence scope evaluates based on the number of forms and activities of the workflow application could be modified. The modification of software architecture is evaluated according to the potential changes of linkage among the activities of the workflow application. Estimating the man days are needed to modify each item in the list of the forms, activities and architecture influenced by the requirement change. Depend on the list, assessing the latent unclear rules implies in accomplishing the modification. The change impact estimation mechanism also supports designing the criteria of change acceptability.

Table 8: risks evaluation questionnaire

Risk evaluation				
1. Project environment				
Item	Risk	Weight		
1-1 How many teams will attend the project development? (1)1 (2) 1-2 (3)3 or over 3	3	15		
1-2 Is there any international team attends the project? (1)no (2)yes, one (3)yes, two	2	10		
1-3 Did the roles and responsibilities of project members be clarified? (1)yes (2)partial (3)not yet	2	10		
1-4 Did the subprojects of the project be clarified? (1)yes (2)partial (3)not yet	1	5		
1-5 Do all members of development team stand by? (1)yes (2)partial (3)not yet	2	10		
2. Hardware				
Item	Risk	Weight		
2.1 Did the hardware specification of the project be identified? (1)yes (2)partial (3)not yet	1	5		
2.2 Does the cost of hardware under the budget? (1) yes, under the budget (2)no, need extra cost	1	5		
2.3 Does the hardware adopted of the project satisfy the customer needs? (1)yes (2)not evaluate yet (3)no	1	5		
2.4 Do we have successful experience of developing a project on the hardware architecture? (1)yes (2)partial (3)no	1	5		
3 Application				
Item	Risk	Weight		
3-1 Did the requirements of project be identified? (1)yes (2)partial (3)not yet	2	10		
3-2 Do we have the relevant development experience on this kind of project? (1)yes, successful experience (2)similar project (3)no	1	5		
3-3 How long does the project develop in? (1) less than half year (2)between half to one year (3)more than one year	2	10		
3-4 Are there suitable developers who have the skills needed by the project in the development team? (1)yes (2)partial (3)no	3	15		
	Weight	Risk	Result	Total
1. Project environment	0.3	50	15	41
2. Hardware	0.1	20	2	
3 Application	0.6	40	24	

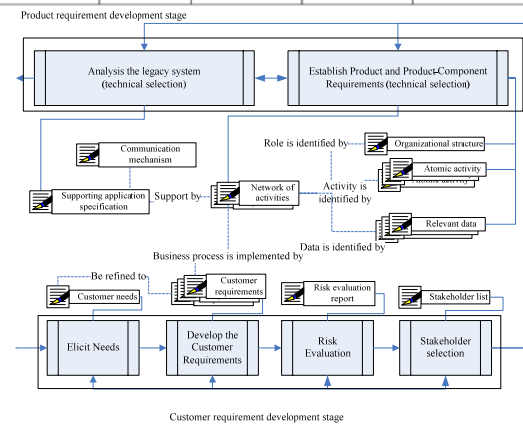


Figure 9 the relationship between requirements of workflow application

Table 9: the change request evaluation

Change Request From		
Change requests		
Impact analysis	Scope	Comment:
	Architecture	Comment:
	Cost	Comment:
	Rule conflict/ unclear rule	Comment:
Effort and cost estimation		Comment:
Manager:	<input type="checkbox"/> agree <input type="checkbox"/> disagree	Reason:
Impact degree: 0 – no impact, 1 – low impact, 2 – middle impact, 3 – high impact		

## 7. CONCLUSION AND FUTURE WORK

Although there are many researches and commercial tools tried to solve the problems of developing software requirements, they can not give a total solution still. In this paper, based on the past experience of workflow application development, we tried to propose a model established upon the recommended process provided in RD-PA3 and the development processes associated with this model might cause them to satisfy CMMI 3. Our model elaborates the requirements of workflow application from the rough customer requirements to explicit product requirements. The model utilizes the questionnaires and templates provided to develop software requirement step by step. There are some successful projects [9] developed with the model.

Here, we summarize the corresponding mechanism(s) in our model which attempts to achieve the goals of RD-PA3 on developing the requirements of a workflow application.

Table 10: summary the achievement of the model provided

Specific Goal	Specific Practice	The Requirement Development Process of Workflow Application	Tools
SG 1 Develop Customer Requirements	SP 1.1 Elicit Needs	Needs Elicitation	Questionnaire (Table 1)
	SP 1.2 Develop the Customer Requirements	Customer requirements Elicitation	Template (Table 2)
SG 2 Develop Product Requirements	SP 2.1 Establish Product and Product-Component Requirements	Identifying the Business Process, Identify the Organizational Structure, and Identify the Relevant Data Sets	Template (Table 3)
	SP 2.2 Allocate Product-Component Requirements	Identifying the Atomic Activity, Establishing the Network of Activities	Template (Table 6)
	SP 2.3 Identify Interface Requirements	Analyzing the Legacy System	
Generic Goal	Generic Practice		
GG 3 Institutionalize a Defined Process	GP 2.1 (CO 1) Establish an Organizational Policy	The organization policy did not be considered in this paper.	
	GP 3.1 (AB 1) Establish a Defined Process	The requirement development process of workflow application provided which is according to the recommended process of RD-PA3 in CMMI Level3	
	GP 2.2 (AB 2) Plan the Process	The requirement development process of workflow application provided which not only is created according to the recommended process of RD-PA3 in CMMI Level3, but also concern the characteristics of workflow application.	
	GP 2.3 (AB 3) Provide Resources	Human resource manage by Stakeholder Selection mechanism (the templates are shown in Table 3 & 4). Requirements manage based on the CRD/M mechanism (the templates are shown in Table 8 and Figure 9)	

The future work of this research is to extend this model to achieve the goals “Analyze and Validate Requirement” in RD-PA3, and implement a CASE tool to support the validation procedure. Besides, experiments with more real cases measure the capability of the model and make the refinement if necessary while applied to.

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