Human Error Control in the Collaborative Workflow Modeling Tool Based on GEMS Model

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ABSTRACT

Business process should support the execution of collaboration process with agility and flexibility through the integration of enterprise inner or outer application and human resources from the collaborative workflow view. Although the dependency of enterprise activities to the automated system has been increasing, human role is as important as ever. In the workflow modelling this human role is emphasized and the structure to control human error by analysing decision-making itself is needed. Also, through the collaboration of activities agile and effective communication should be constructed, eventually by the combination and coordination of activities to the aimed process the product quality should be improved. This paper classifies human errors can be occurred in collaborative workflow by applying GEMS(Generic Error Modelling System) to control them, and suggests human error control method through hybrid based modelling as well. On this base collaborative workflow modeling tool is designed and implemented. Using this modelling methodology it is possible to workflow modeling could be supported considering human characteristics has a tendency of human error to be controlled.

Keywords

Workflow Modeling, Business Process, Human Error

1.0 INTRODUCTION

Business process is the developmental conformation of the process for the aggregated form of workflow to achieve goals of the enterprises or organizations. It is the series of process including work performance to accomplish the objectives, restricted conditions and resources [1, 2]. It is significant since it can increase efficiency by enforcing consistency and structure to the series of activities in organization [3]. Workflow based on business process signifies the flow of the series of the tasks occurred to execute process for attaining goals. Also, Workflow Management System (WfMS) is to direct, control and monitor the prepared work for forming workflow and it interprets the definition of process while assisting the corresponding application to be implemented effectively by the interaction of the participants in workflow [4, 5]

In view of collaboration workflow among the enterprises, business process supports collaboration process to be executed promptly and flexibly through the organic association between applications in and out of the corporate and manpower [6]. At present, in spite of the fact that the corporate business is more automatized and depends on the systems, human being still plays the key role in business process. From this standpoint, workflow system is recognized to execute the functions of assigning and transmitting appropriate work suitable for the role of human factor and namely, to do so, the controlling structure for the human errors by analyzing the process of decision making is required [7]. To integrate this corporate collaboration into workflow, adequate standards and base structures are essential. As for the related standards, there are XPDL (XML Process Definition Language) and Wf-XML (Workflow-XML), which are the standards of definition suggested by the workflow related organizations such as WfMC (Workflow Management Coalition) leading standardization. Among these, XPDL is the language of definition for the workflow process on the basis of XML suggested by WFMC for the exchange of the definition of common process formation [8]

In this paper, GEMS model is applied to hybrid modeling method for controlling human errors in the workflow system, based on this, the former for modeling business process is designed and implemented on the basis of XPDL. The rest of dissertation is composed of the followings. In section 2, the existing studies related to this subject are investigated and the existing GEMS model is applied to the workflow system to control human errors in section 3. In section 4, the controlling method of human errors in collaboration workflow system via hybrid modeling method is provided and in section 5, the former for collaboration workflow modeling is designed and implemented. Finally, conclusion and the direction for future works are presented in section 6.

2.0 RELATED WORKS

In the field of business process, useful modeling methods and tools have been investigated in the past decades. [6, 9]. And even up to now, the numerous works on the methodologies and significant components for integration in the related fields are in progress [10].

2.1 Business Process and Workflow Modeling

The modeling methods for business process were suggested in many domains and the notation and tools appropriate for business process have been contemplated. From these works, various modeling methods for business process have been provided [9, 11]. Generally, the approaches towards business process modeling can be classified into four viewpoints such as information, organization, procedures and actions [12]. Among these, as the major outlook in the business process modeling to the present, the views from procedures and action have been discussed and studies. In the light of procedures and action, the most critical problem to approach business process modeling is to reflect the dynamic aspect focusing on time. To describe this dynamic aspect, there are various viewpoints [13] and most of all, there is the viewpoint of workflow focused on the chronological order of action. Usually, from the standpoint of workflow, the flow is delineated as a diagram and activity diagram and petri-net are widely used for workflow modeling.

There are three modeling methods to describe business process in workflow in general [7]. First, the communication based method stemming from the concept of the communication with many action models can be referred and this put the purpose of business process on increasing customer satisfaction. However, this method projects the difficulties in describing the relations between the complicated work and the participants. Secondly, there is the activity-based method focusing on modeling work itself rather than action among human beings. This method is executed centering on the related works with process and it is difficult to accomplish the goal such as customer satisfaction. Finally, there is the hybrid-based method, which is the combination of the communication-based method, and activity based method. The study on this method is in progress at present and there is neither presented tools nor methods yet. This method makes much of the man's role in the workflow system focusing on work and it is considered to be the most appropriate method to accomplish actual process and to reduce exception handling or errors.

2.2 Human Errors

The most widely recognized study on cognitive psychology to reduce human errors in decision-making is Rasmussen's classification method so called SRK model [14]. He categorized human errors into three types [15]. First, skill-based errors are controlled by unconscious behavioral relations and stored behavior types, and it can not perceive risks for the skilled worker as the adequate one as it is mostly execution errors by perception and movement in the relational situation. Secondly, rule-based errors are the ones by wrong work methods or erroneous environmental recognition although it acknowledges environment sufficiently equipped with knowledge. Finally, knowledge-based errors occur in the unique and unfamiliar circumstances when execution has to be planned in relation to the goals. It is the error in decision making by inappropriate analysis or wrong knowledge [16]. And there is GEMS model objectified and revised for the convenience in actual application through the applied study on Rasmussen's SRK model [17]. GEMS model is suitable for being applied to the goal oriented activities and in this paper, it is revised and applied to collaboration workflow.

In the mean time, efficient control of human resources in workflow modeling is recognized as the critical element in the success of WFMC and there have been consistent studies on this matter [18]. However, the existing studies on controlling errors in workflow system like these are the ones on the countermeasures in failure mostly via systematic approach [19, 20].

3.0 APPLICATION OF GEMS MODEL FOR HUMAN ERRORS CONTROL

The direction of workflow in software stems from two different sources; that is, people-based business process based on human beings and rules-based automation process [6]. The former aims to facilitate collaboration among people in teams or groups and workflow to be smooth and efficient. In the tools for collaboration like this, most parts are decided and made a progress by human beings and human errors play a significant role. Accordingly, as the most representative and appropriate recognition model to control human errors, Rasmussen's SRK model is applied in this paper. In particular, GEMS model suggested to facilitate the generalization and application of SRK model is revised and presented as the one to be easily applied to the goal-based activities like workflow system. In GEMS model, the basic error types are classified into three categories according to the stages for cognition as show in table 1.

Table 1 : Basic error types(GEMS model)

Cognitive Stage	Basic Error Types	Error Category	
Plan	Mistakes	Complex	Knowledge-Based
		Simple	Rule-Based
Store & Executes	Lapse & Slips	Skill-Based	

Depending on the cognitive stage to plan, store and execute, these are mistakes, lapses and slips. Among these three types such as knowledge, rule and skill based levels, dynamic changes as in figure 1 occur.

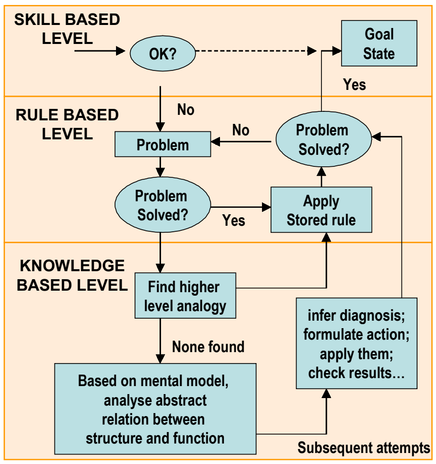


Figure 1 : Outlining the dynamic of the GEMS

To apply this GEMS model to workflow system, the process is as follows. First, skill-based errors correspond to simple lapses or mistakes omitting one of the series of behavioral procedures occurred in repetitive execution in general. Automation in workflow system itself is considered to control this case but eventually, it is more or less related to the aspect in interface and improving this is the most efficient method in controlling. And rule-based errors are the mistakes in the midst of considerate behavior in familiar environment and the errors on this level can be controlled by appropriate execution with right rules. Namely, it can be controlled by approaching workflow system on the level of business process fundamentally via regulated patterns and adequate rules. Finally, knowledge-based errors are the ones occurred where a know-how and rules are not useful, that is, unfamiliar circumstances. Especially, in the consideration of the characteristics of workflow, they are stipulated as the errors occurred in dynamically changing environment or complicated working area and classified into two groups as suggested in GEMS model. That is, the cause of occurrence is classified into the limit of resources & imperfectness, and inaccuracy of intelligent model. To reduce these errors in workflow system, the type of knowledge-based errors is stipulated fundamentally and seeks measures via mutual communication.

4.0 HYBRID MODELING METHOD FOR HUMAN ERROR CONTROL IN THE COLLABORATION WORKFLOW

4.1 Hybrid Modeling Method in the Collaboration Workflow

In business process modeling, there are two concepts of work that is automated and manual ones. Automated Work in concept is executed automatically by the computerized system and manual one contains human interference. In other words, if the participants in workflow system are classified into two, there are manual and automated process. Figure 2 describes the conceptual diagram related to this business process [8].

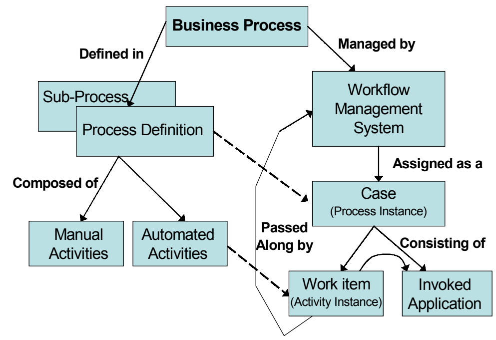


Figure 2 : Conceptual diagram (related business process)

In figure 2, there are manual activities by human interference and automated activities without it. Hybrid modeling method in the collaboration workflow in this paper is based on these concepts basically with the structure in figure 3.

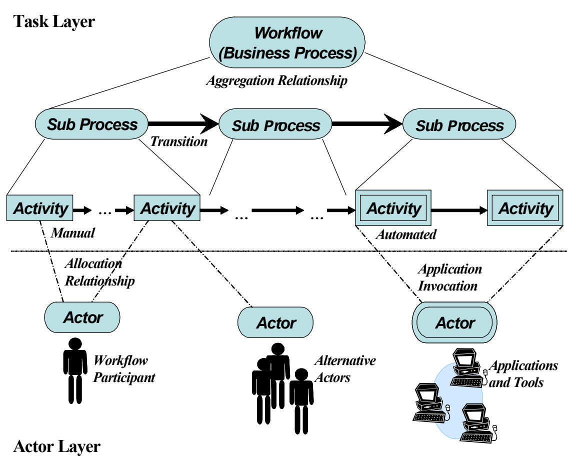


Figure 3 : Hybrid based workflow modeling structure

In figure 3, the layers are categorized into task layer and actor layer. Task layer is in the area of business process of workflow and herein business process is composed of several processes. And actor layer is in the area of actors and herein actors in the process are contained. In addition, actors are categorized into two forms; human actor is the subject executing manual and semiautomatic activities while automated actors are in charge of automatic activities by the computerized system. In this structure, actual progress is made by mutual communication. Particularly, in case of the activity work by human actors, communication among the participating actors is required in workflow. Basically, hybrid-modeling method in workflow emphasizes collaboration by mutual communication focusing on human actors rather than one-sided workflow. Figure 4 as shown below designates hybrid-modeling method in workflow.

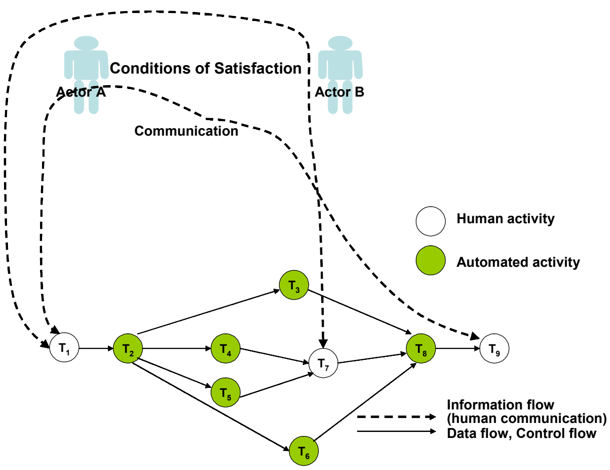


Figure 4 : Hybrid modeling method in workflow

It is the combination of activities based modeling method and communication based modeling method.

When human beings are involved in work, communication occurs via exchanging information in other activities whenever collaboration is necessary. Under the close collaboration system in workflow by hybrid modeling method, more actual and dynamic modeling is executed. The strategies for hybrid modeling method suitable for the application in dynamic situation when collaboration is requested are suggested as the followings.

Strategy 1: It executes dynamic business responding instantly to changing environment focusing on the goals.
Strategy 2: It makes actual collaboration feasible by separating workflow and information flow by task layers and actor layers.
Strategy 3: It uses communication pattern for efficiency by controlling errors through communication in case of human interfered activities (manual or semiautomatic activities)
Strategy 4: It sets the best route to achieve the goal according to workflow by using preliminary regulated work pattern in case of automated activities.

4.2 Hybrid Modeling Method for Human Error Control

Hybrid modeling method requires outcome-oriented activities focusing on the goals absolutely. Accordingly, the roles of human resources are emphasized and controlling human error is highlighted as the relatively significant part. The table 2 below shows the basic controlling strategies for human errors through hybrid modeling method.

Table 2 : Basic controlling strategies for human errors through hybrid modeling method

Level of behavior/ work performance	Error type		Control strategies in the workflow
Technology based (Slips & lapses)	Slips	Errors occurred by carelessness in daily routine (attention failures)	Convert manual work into automated work as much as possible and consider the aspect of user interface.
	Lapses	Errors occurred by lack of concentration (memory failures)	
Rule based (Mistakes)	Errors occurred in breaking procedure and forms considered as regulation as well as usual practice by most people		Control by applying stipulated notation of business process and task pattern
Knowledge based (Mistakes)	Factors - Limit of resources - Imperfectness and inaccuracy of intelligent model in the space of problem		Execute task by communication pattern with the application of hybrid method.
	Problem solving type (Communication pattern) - Static configurations - Reactive-dynamic configurations - Multi-dynamic configurations		

4.2.1 Control of skill-based errors

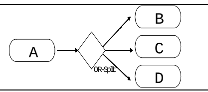
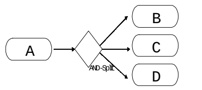
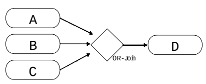
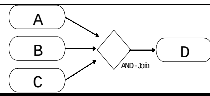
In this case providing convenience for the users in view of interface can minimize errors. Also, feasible manual work can be converted into automated work in collaboration workflow.

4.2.2 Control of rule-based errors

To control rule-based errors standardized and current methods are stipulated and applied, and for instance, the developers and planners can minimize the rule-based errors by using standardized modeling language such as UML. That is, through stipulated notation of business process and work pattern, it can be controlled by providing the methods where the user can work in the accustomed environment. The following table 3 describes basic work (branch) pattern applied in this paper in collaboration workflow.

Table 3 : Basic work(branch) pattern applied in collaboration workflow.

Branch pattern	Notation	Description

Split(OR-Split)		A pattern of branch and it can be branched as only one alternative.
Fork(AND-Split)		A pattern of branch and it can be branched many parallel routes. The difference with OR-Split is for every routes to be executed in parallel (simultaneously) manner.
Merge(OR-Join)		Grouping several alternative routes into one and the difference with AND-Join (join) is to allow only one route among many alternative routes.
Join(AND-Join)		Grouping many routes into one.

Rule-based errors uses only pattern with fixed meaning and that is, they refuse to use illogical pattern.

4.2.3 Control of knowledge-based errors

It is the most difficult to control skill-based errors cognitively and therefore, there has to be comprehensive consideration for the status and surrounding environment such as intelligent capacity as the characteristics of human being and the level of accumulation of knowledge. In this case, taking preventative measures against the occurrence of errors is difficult but the effort to analyze the potential errors and managing them successfully are essential. Especially, to avoid the execution of work by independent interpretation, the communication between the related actors and activities should be pursued via mutual sharing of information. In this paper, the types of problem solving for knowledge-based errors against the suggested factors are categorized into three groups and they are used as the patterns of communication. Figure 5 shows these patterns;

a) Static composition pattern: There is no feedback for providing information among the activities required and communication is feasible by supplying information necessary for problem solving. In most cases, it can control the errors against the limit of resources.

b) Responding dynamic composition pattern: It is the type for negotiation to respond and exchange information required for problem solving and there should be a feedback. Mainly, it can control the imperfectness of the intelligent models in the space of problems.

c) Multi-dynamic composition pattern: It is the concept combining responding dynamic composition with external environmental response even taking into account external components of system. Mainly it can control the imperfectness of intelligent models in the space of problems.

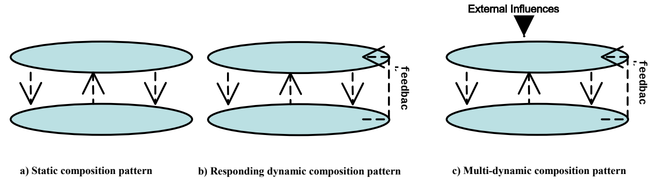


Figure 5 : Communication patterns

Using these three patterns of communication we can prevent the limit of resources and imperfectness and inaccuracy of intelligent models. Particularly, in case of manual activities with human interference, knowledge-based errors can be controlled by using the communication pattern with information flow, and in case of semiautomatic and automatic activities, if necessary, modeling should be done with the communication pattern in the area related to modeling (actors and activities).

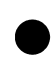
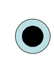
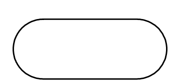
5.0 DESIGNING AND IMPLEMENTING THE TOOL FOR COLLABORATION WORKFLOW MODELING

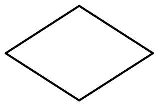
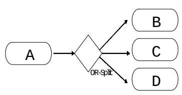
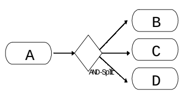
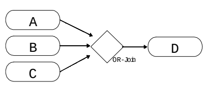
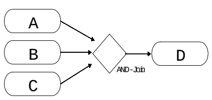
In this paper, business process is diagramed by using general notation of UML and in view of workflow it is extended. Especially, in describing the dynamic aspect of system in flow, well-known diagram of activities are applied to collaboration workflow. Also, as for the definition of language of workflow for process exchange, XPDL is utilized and implemented.

5.1 Designing the tools for collaboration workflow modeling

XPDL is a language of definition for the process of workflow suggested by WfMC in order to exchange the definition of process. The table 4 below describes mapping between the schemas of XPDL and notation of the base of diagram for the activities used in this paper.

Table 4 : Mapping between the schemas of XPDL and notation of the base of diagram for the activities

Element	Notation	XPDL Mapping
Initial Node		<Activity> <Route/> </Activity)
Final Node		<Activity> <Route/> </Activity)
Activity Node		<activity Id="..." Name="..."> <Implementation> ... </Implementation> <TransitionRestrictions> ... </TransitionRestrictions> <ExtendAttributes> ... </ExtendAttributes>

		</Activity>
Decision Node		<Activity> <route/> <TransitionRestriction> <SplitType="AND"/> </TransitionRestriction> <Activity> Combined with: <Transition> <Condition> <Transition>
Transition		<Transition Id="..." From="..." To="...">
Swimlane		<Participant Id="..."> <ParticipantTypeType="..."> <Description>...</Description> </Participant>
Split(OR-Split)		<TransitionRestriction> <SplitType="XOR"> <TransitionRefId="..."/> <TransitionRefId="..."/> </Split> </TransitionRestriction>
Fork(AND-Split)		<TransitionRestriction> <SplitType="AND"> <TransitionRefId="..."/> <TransitionRefId="..."/> </Split> </TransitionRestriction>
Join(AND-Join)		<TransitionRestriction> <JoinType="AND"> <TransitionRefId="..."/> <TransitionRefId="..."/> </Join> </TransitionRestriction>
Merge(OR-Join)		<TransitionRestriction> <JoinType="XOR"> <TransitionRefId="..."/> <TransitionRefId="..."/> </Join> </TransitionRestriction>
Information (communication)		<ExternalReference xref="..." location="..." namespace="..."/>

As shown in table 4, UML is used for visual expression and XPDL is utilized for implementation. Viewing the schemas of XPDL on the elements of information, the definition and information on specific entity are referred for outside reference, and figure 6 expresses the example for use. As for outside references, there are data related to workflow, the participants and application.

```
<xsd:element name="ExternalReference">
    <xsd:complexType>
        <xsd:attribute name="xref"
type="xsd:NMTOKEN" use=optional"/>
        <xsd:attribute name="location"
type="xsd:anyURI" use=required"/>
        <xsd:attribute name="namespace"
type="xsd:anuURI" use=optional"/>
    </xsd:complexType>
</xsd:element>
```

Figure 6 : Schema of XPDL on the elements of information

5.2 Implementation

In this paper, as the tool for collaboration workflow modeling, JHotDraw's architecture[26] is used. JhotDraw is the architecture on the basic components of the tools for modeling and has the structure centering on javax.swing.Jframe and javax.swing.Jpanel. Based on this structure, the tool for collaboration workflow modeling is implemented(Refer to figure 7).

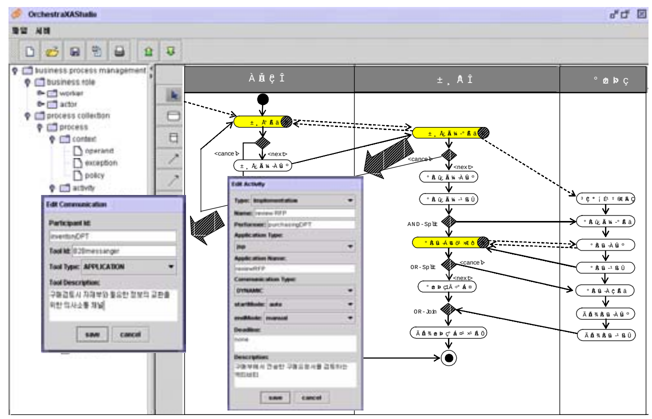


Figure 7 : Collaboration workflow modeling Tool

5.3 Evaluation

As for the representative studies on controlling errors in workflow system, ADOME-WFMS [19], WIDE [20] and Jablonski's method[18] can be referred. ADOME-WFMS defines and categorizes the errors and it suggests the characteristics of workflow and feasible errors systematically. However, it is the systematic approach and tends to overlook the cognitive models with the limitation in handling exceptions. So does WIDS and it suggests the method to control errors in view of handling errors. Finally, Jablonski's method is the architectural approach using the suggested patterns and standards of errors occurred from the standpoint of changes and still lacks supporting data on the area of cognition. The existing methods provided the method for handling exceptions in the aspect of systematic handling, and yet systematic approaches using cognitive models based on decision-making are not sufficient. Also, language support for modeling and the implemented outcomes are not suggested sufficiently enough. On the other hand, the tool for workflow modeling is approached on the basis of representing cognitive models and it has the strength such as language support for standardized workflow modeling.

6.0 CONCLUTIONS

In this paper, modeling methods applicable to various environments are provided using hybrid modeling method. That is, hybrid-modeling method reflects the dynamic property of the enterprises and supports the goal-oriented activities.

And the collaborative behavior itself in the goal oriented workflow system corresponds to the goal and GEMS models are classified while their characteristics are provided for the application in workflow system to control human errors eventually by directing the considerate behavior in problem solving and decision making. In addition, the tool for modeling business process on the basis where GEMS model is applied to hybrid modeling method suggested to control human errors in workflow system is designed and implemented. The enterprises can implement business process modeling for optimal workflow system suitable for work environment by applying GEMS strategies suggested in this paper for reducing human errors in collaboration workflow system to hybrid modeling method. For further studies, by developing the control for human errors applicable to workflow modeling, the measures on controlling human errors applied in workflow engine from the entire workflow system should be investigated.

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