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AN APPROACH TO A WEB-BASED FLEXIBLE WORKFLOW MODELING

**Abstract**

The effective implementation of workflow system in manufacture enterprises enables the enterprises to achieve the benefits associated with the integration, automation and management of their business process. The conventional workflow model based approaches hinder the change of workflow logic flexibly. These approaches face difficulties in satisfying the changing market demands, meeting the demands from intensifying market competition, and adopting new information technology development. After the analysis of the demand for a flexible workflow modelling approach and the characteristics of workflow flexibility, a dynamic workflow modelling framework based on a directed graph theory is proposed in this paper to model the flexible workflow. The key elements of the framework are explained and the modelling approach is described. Using the approach, the changeable business process can be modelled flexibly and concisely without the need of redefinition of workflow model. Finally the paper describes the implementation of the flexible workflow model using a Web-based flexible customer service system.

**1 INTRODUCTION**

With the rapid development of network and distributed database technologies, the workflow technology which was developed since the 1980s has presented an advanced method to increase the organizational efficiency, reduce the cost and enhance the competitiveness of enterprises. Workflow and its management encompass a computerized approach to allow one to define the activities of a process, establish the relationship among each activities, modify these activities and their relationships and perform simulation to study the what if scenarios, and provide flexibility to allow changes made during the execution of activities in a process. The design or business process is translated from the real world into a formal, computer processable definition; the resulting definition is called a workflow model. Because the workflow must describe the business process clearly, many workflows pay more attention to the process model at first, such as the flowchart, states chart and so on. Most of these workflow model based on the directed graph are easy to understand [1]. The node in directed graph is used to represent the activity; the directed arc or connection is used to represent the sequence of the activities; the roles are a placeholder for a human skill or an information system service required to perform a particular task; the resources are the related data and computer applications used by the workflow in the execution.

The conventional centralized workflow systems work as follows: a workflow model should be defined by the workflow modelling tools at first, then the workflow model is submitted to a workflow engine; the workflow engine interpret the model, form the user interface, and control the execution of workflow [1, 2]. The execution of conventional workflow is suitable for the situation that the logic of design or business process can be decided beforehand. But with the intensification of market

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competition, the increase of the customer demand, the business processes often change regularly [1, 7, 9]. Due to the rigid centralized workflow model structure, this type of workflow management system doesn't allow the change of the workflow logic agilely, not to mention to change the design or business process in order to satisfy the demand of market agility.

The flexible workflow means that by using a workflow model executed in a workflow engine, the workflow can be adapted to the change of without the need to redefine workflow model. There has been previous research work on flexible workflow modelling. The EPC (Event-driven Process Chain) was introduced in reference [1], the EPC model can adapt to the change by its different Event, but the logic of Event is still fixed; In reference [3], the knowledge-based modelling was proposed, but its node can't execute different tasks; Robert Muller explained a agent-based flexible modelling in reference [5], it is an efficient way to derive a flexible model, but it is complicated and need concise expression; In reference [9], Inheritance of workflows was used to tackle the change in the business process, but the model needs to be constructed dynamically by the inheritance of workflow. In this paper, an approach of flexible workflow modelling was proposed, the approach is based on the directed graph [1,10], it can dynamically and concisely adapt to the change without modification to the workflow model. In the following part of this paper, section 2 will provide a detailed analysis of workflow and its requirements for flexibility, followed by section 3 describing a proposed modelling approach to support such a flexible workflow system. Section 4 will describe the implementation of the approach with an example. Finally, we offer some concluding remarks in Section 5.

## 2 THE ANALYSIS OF FLEXIBLE WORKFLOW

The current conventional workflow models have certain limitations which are typically defined as constrains for flexible workflow modelling. These can be summarized as follows:

- The workflow model can not support the flexibility of workflow very well;
- The execution sequence of workflow model is fixed and can't be changed dynamically in response to the real-time circumstance changes;
- The tasks of the workflow activity are defined before the execution of the workflow model, therefore one can not change or update the tasks dynamically;
- In the conventional workflow model, the tasks of workflow can not be divided dynamically and the granularity of task is therefore reduced;
- The resources of workflow are already committed in the definition of workflow model. The model can not adapt to the dynamic resources allocation due to the change of workflow tasks and workflow environment.

Some enterprise's business process has the dynamic change of business workflow quite often. If the system has the flexibility itself in defining workflow model, under the control of the workflow engine, the workflow can be changed in terms of its execution route and tasks according to the workflow execution state and environment without the modification of workflow model. The flexible workflow can satisfy better the need of business process in the enterprise.

## 3 MODELING APPROACH TO SUPPORT THE FLEXIBLE WORKFLOW

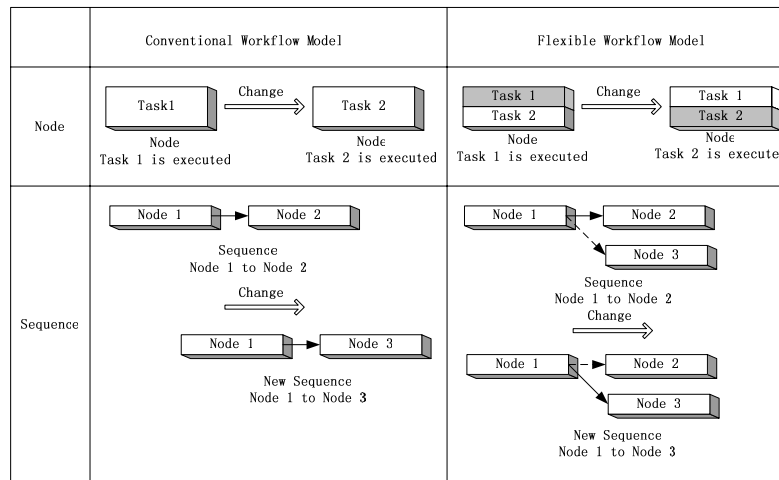
### 3.1 The analysis of flexible workflow modelling

In the workflow model a node is a graphical representation of an activity, which is defined by its behaviour termed as function; the function of the activity is determined in the model definition. For example a node is designed to triggers the application of UG to model the geometry of a mechanical part, so the node can only trigger this fixed activity in the execution. When the node wants to trigger the CATIA to model the geometry of a mechanical part according to the changed demand of customers, the workflow must be redefined, time will be wasted and the valuable opportunity will be lost in the market. In this paper, we propose the *Parametric Workflow Modelling* approach, in which a change of the system functions or other system parameters can be mapped onto the change of the parameters in the workflow model. Based on the above approach, the specific

function of the node in the workflow model don't need to be defined, instead only the related parameters in the node need to be defined, and the parameters in the node can be added or deleted. In the execution of the workflow, the workflow engine can choose different parameters to execute different functions without redefinition of the workflow model.

In present workflow models, such as the directed graph, there exists a fixed connection arc between one workflow node and its subsequent node. This means if the condition allows the workflow to be executed the subsequent nodes will be executed definitely after its previous node. But the flow of the workflow is uncertain in the real time situation; in most of the circumstances it can only be decided dynamically in the execution. In order to adapt to the flexibility of workflow, the task and the control of the workflow must be separated, the workflow node should have the property similar to the pointer in the programming language. It can point to the suitable subsequent node dynamically in the execution, hence providing the flexible workflow modelling.

The principle of the proposed flexible workflow model is shown in figure 1. The flexibility has been enabled through two key elements: the node and the sequence. In figure 1, the node in conventional model must be redefined from the former Task 1 to Task2, but the node can choose Task 2 instead of Task 1 in flexible workflow model; the sequence from Node1 to Node 2 must be redefined into a new sequence from Node 1 to Node 3 when there is the change for the workflow, but the sequence can be chosen either to the Node 2 or Node 3 in the flexible workflow model.



**Fig. 1** The principle of flexible workflow model

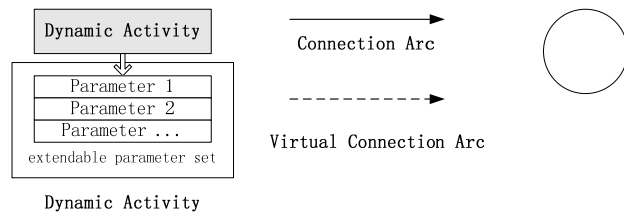
### 3.2 The dynamic structure and modelling approach of the flexible workflow

According to the analysis of flexible workflow, a set of key elements named dynamic structure used to model the flexible workflow is proposed in this paper. The dynamic structure is based on the directed graph, the difference lies in the agile structure the dynamic structure has, and these agile structures can constitute the workflow system which can satisfy different tasks and business process. In this paper, these consist of the dynamic node, sequence, virtual sequence and condition.

- **Dynamic node:** dynamic node is the basic element of the flexible workflow; the dynamic node binds a set of dynamic program which can be added, modified and deleted dynamically. When the node begins, the program is executed according to its parameters. After the execution, the result becomes the condition of the next node and affects the sequence of the workflow. Different from the conventional models, the program or function of dynamic node is created in run-time to execute flexibly using the related parameters of a dynamic node when considering the run-time environment and state of workflow; the parameters can be extended, and in this paper the related parameters are defined as extendable parameters set.
- **Connection:** the sequence is used to define the execution order between two nodes; the connection is represented by connection arc in the directed graph.

- Virtual connection: the virtual connection is used to define the execution sequence too. Different from the connection, the virtual connection point to a virtual node in the workflow model instead of pointing to a fixed node. It means only when in the execution of the workflow, the direction of the connection can be determined.
- Condition: condition is the Boolean function on the workflow data set. It is used to decide the different processing method of the activity on the different situations.

The elements of the dynamic structure are illustrated in figure 2. The dynamic nodes comprise of extendable parameter set; connections are represented by the directed solid lines; virtual connections are represented by void directed lines; the circles represent the conditions. In this model, activity can execute different function with different parameters. Due to space limit, some common elements in the workflow model, such as the XOR and parallel activity are not described in this paper. Similarly, the organization and resource model can also be realized by the extendable parameters.



**Fig. 2** The process elements of flexible workflow model

#### 4 THE REALIZATION OF THE WEB-BASED FLEXIBLE WORKFLOW MANAGEMENT SYSTEM

The workflow engine controls the execution of flexible workflow through the information of the flexible workflow model. In this paper, the workflow engine is realized by the ActiveX component and programmed by using of the Microsoft's ASP (Active Server Page); the ASP is used to develop the reading and storing of flexible workflow model, the control logic of the flexible workflow and the tasks allocation of the workflow. The Web server used by the flexible workflow management system is Internet Information Server 5.0 which processes all the requests from the ASP pages. In the flexible workflow management system, the basic function of the nodes in the workflow model are encapsulated into the ActiveX component, the workflow engine only need to invoke these components, the component select related information and parameters in the flexible workflow mode, the flexible execution of workflow is finally realized.

The flexible modelling method described in this paper has been applied in a System Integration company with good initial results. This Company has many outlets; the distribution and expansion of their operation demand an intelligent customer service system to respond to the customer requirements promptly, allocating the resources reasonably to improve the work efficiency and quality of their customer service. The customer service system must react to the different customer demands (termed as CASE in this paper); choose different actions and engineers to realize the flexible and intelligent customer service based on the different CASE status.

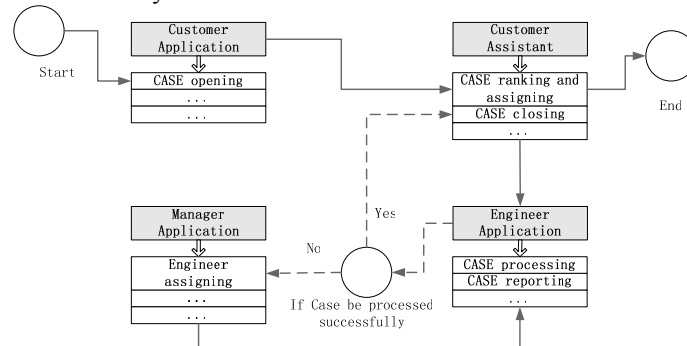
The flexibility of the customer service system mainly is as follows:

- Different department in the company handles different CASE processing. For example, a customer service assistant is responsible for assigning the CASE to an engineer; the engineer is then responsible for the processing of a particular CASE; the engineer can report the CASE to the manager or the customer service assistant to reallocate the CASE or to ask for help, if it is beyond the engineer's responsibility.
- The selection of an engineer can be supported by the system flexibly. It is determined by considering the domain knowledge, ability and workload of the engineer.

The flexible workflow model can express the intelligent customer service process clearly. The dynamic nodes of the intelligent customer service process include:

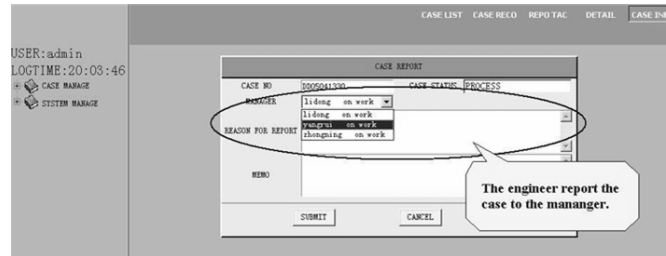
- Customer application: The extendable parameters set only have one parameter, which is applying to open a new CASE. This is a fixed node for it only has one parameter.
- Customer services assistant application: the extendable parameter set includes ranking and assigning CASE, and closing CASE.
- Engineer application: The extendable parameter set includes two parameters: processing CASE and reporting CASE to the manager.
- Manager application: the extendable parameter set includes the allocating engineer.

The flexible model of the prototype system of the customer service system is illustrated in figure 3. In order to have a concise and brief description, the organization and resource model of the flexible workflow model are not shown in the figure. In figure 3 each of the dynamic nodes can select different parameters in the extendable parameter set to execute the corresponding dynamic function. The dynamic sequence is exemplified in the subsequent activity of the engineer application, the sequence of the workflow process point to the customer service assistant application or the manager application if the engineer can process the CASE or not. The flexible workflow model describes the customer service system concisely and clearly by using of the extendable parameter set of the dynamic nodes and the virtual connection. The interfaces of the customer service system are illustrated in figure 4 and figure 5. The figure 4 is the interface of engineer's CASE processing, and the figure 5 is the interface of engineer's CASE reporting. The customer service system helps the company to become successfully The Silver Certification Partner of CISCO.



**Fig. 3** The customer service system's flexible workflow model

**Fig. 4** The interface of engineer's CASE processing



**Fig. 5** The interface of engineer's CASE reporting

## 5 CONCLUSIONS

The emergence and development of workflow management technology satisfy the objective demands of enterprise's business reengineering and strategy of advanced manufacture. But the conventional workflow modelling often cannot fulfil the flexibility, which comes from the semi-structural or the non-structural business process as well as in inevitable changes in the business process. Based on the thoroughly analysis of the characters of the workflow flexibility, the modelling approach of flexible workflow based on the dynamic structure is proposed in this paper. The flexible modelling method can adapt to the change of business process very quickly through dynamically changing the tasks and the logic of the workflow in execution. How to ensure the accuracy of the dynamic route in the flexible workflow model is the further research effort of the future work.

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