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A Workflow Model based on Homogeneous Activities*

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Abstract

In process-oriented software systems, many processes have large number of parallel redundant activities which are often used in split and merge workflow structures and make workflow model too complex to manage. Aiming at the homogeneity of redundant activities the structure characteristics of these homogeneous activities are analyzed and they are being classified into eight modes. Also the constraints is identified which defined the coexistence of these modes. At last a workflow model based on homogeneous activities is presented. Comparison shows that the method has obvious advantage in reducing description time and maintaining cost of workflow model.

Keywords: *Workflow, Homogeneous Activity, Redundant Activities, Structure Mode, Constraints*

1. Introduction

In the cross-regional distributed large enterprise business processes, there usually exists complex business logic composed of split and merge. A large number of duplicate activity information exist in those modes, including task to performed, data used and precursor/subsequent structure, *etc*. [1,2]. These activities have the same position, goal and data which are called redundant activities in workflow model. When the number of redundant activities is large, using traditional workflow modeling method not only takes much time to describe activities, but also generates a huge processes difficult to maintain [3]. Redundant activities is the difficulty of workflow research area and it is included into workflow patterns involving multi-instance mode [4-5]. But multi-instance mode includes a large range and can't solve redundant activities in different scenarios, let alone the distributed workflow management system [6].

2. Related Work

In recent works on distributed workflow management systems, Muthusamy [7-8] developed a flexible and distributed platform to develop, execute and monitor business process supporting service discovery and composition which can describe redundant activities but the description method is too complex for workflow modeler.

Khalaf [9] presented a BPEL fragmentation covering data and explicit control dependencies to handle fragmenting loops. Hamann [10] proposed a migration data meta-model to realize the runtime migration of business processes, which improved the flexibility of the distribution of the ad-hoc workflow. The above workflow models are extended from the BPEL which can't describe redundant activities in simple forms.

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Besides, most workflow management systems such as Staffware, WebSphere, FLOWer and COSA, are able to support part multiple-instances patterns through some special mechanisms, such as “bundle model” or “dynamic parallel process management table”[11-12]. However, their description methods are too complex to support complicated workflow model containing multi-level split-merge structures, also most of them can be used only in centralized environment.

Our work distinguishes itself from other methods by concentrating on a small part of multiple-instances modes -- homogeneous activities. Also we propose workflow model based on homogeneous activities to reduce the complexity of modeling.

3. Homogeneous Activity Mode

Homogenous activity mode is a kind of workflow pattern in which a set of redundant activities can be represented by a special activity called homogenous activity. Homogenous activity mode is divided into Static Structure mode and Dynamic Structure mode, the former focuses on describing the topology relationships between redundant activities and the latter describes how to dynamically select running nodes.

3.1. Static Structure Mode

Homogeneous activity mode can be divided into starting mode, serial mode, parallel mode and sub-flow model.

1. Starting Mode

When homogeneous activity acts as a workflow starting node, the pattern is called starting mode. Here, redundant activities represented by homogeneous activity have a parallel XOR relationship shown in Figure 1. They also have permission to start workflow instance, but only one redundant activity is actually executed in one workflow instance. Multiple possible starting branches existing in homogeneous activity can significantly reduce the size of process , though not allowed in many workflow management system it is very useful.

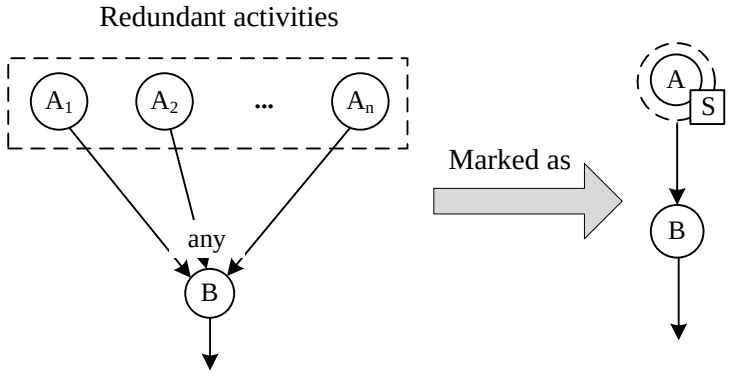

Figure 1. Starting Mode

2. Serial Mode

When homogeneous activity has a relationship of sequential, the pattern is called serial mode. Redundant activities are organized in the follow three ways shown in Figure 2 in serial mode.

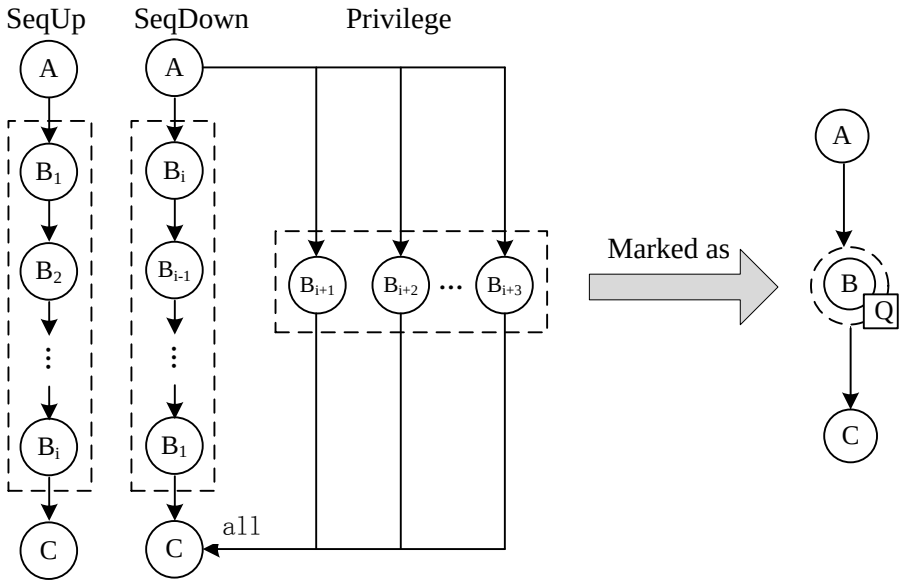

Figure 2. Serial Mode

Sequence Up(SeqUp). Redundant activities are executed sequentially from low to high according to performer position. It is common in approval processes to realize approval step by step.

Sequence Down(SeqDown). Redundant activities are executed sequentially from high to low according to performer position. It is often used in dissemination processes to achieve progressively sign.

Privilege. Homogeneous activity exists with serial activities simultaneously, but in dependent of serial activities. privilege mode can be used if some performers are unable to handle workflow instance because of special reasons in SeqUp or SeqDown mode. For example, some high position leaders often can't issue documents due to time constraints, in order to prevent delay in process execution, privilege mode is used to allow them to retroactive sign while others issue documents with normal procedure. Privilege mode has often been used without it many workflow will not be processed timely.

3. Parallel Mode

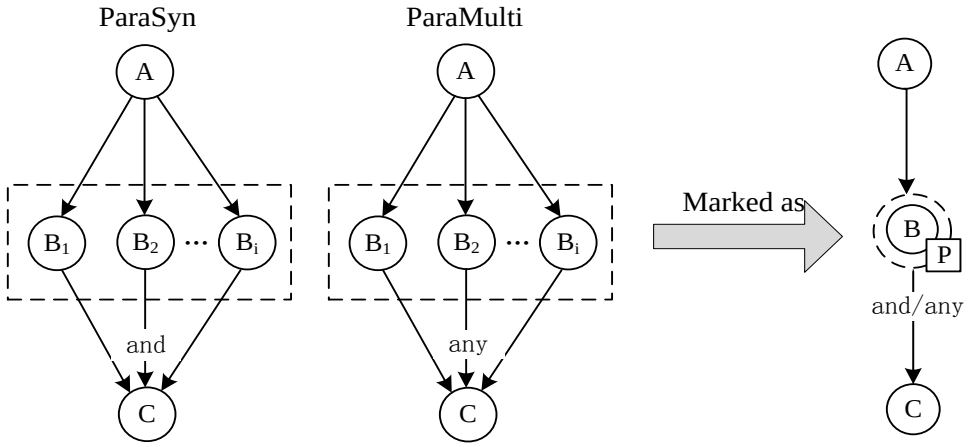

Figure 3. Parallel Mode

When homogeneous activity has a relationship of concurrent, the pattern is called parallel mode. Parallel mode includes two types shown in Figure 3.

Parallel Synchronous merge (ParaSyn). Activity can be performed only after all precursors have been completed. ParaSyn is essentially a multi-node cooperative mode.

Parallel Multiple merge (ParaMulti). Activity can be performed once there has a precursor completed. It can be used to increase workflow instance number.

4. Sub-flow Mode

When homogeneous activity is composed by sub workflow, the pattern is called sub-flow mode shown in Figure 4. Sub-flow mode can be realized nesting without depth limit thus to support more complex workflow model.

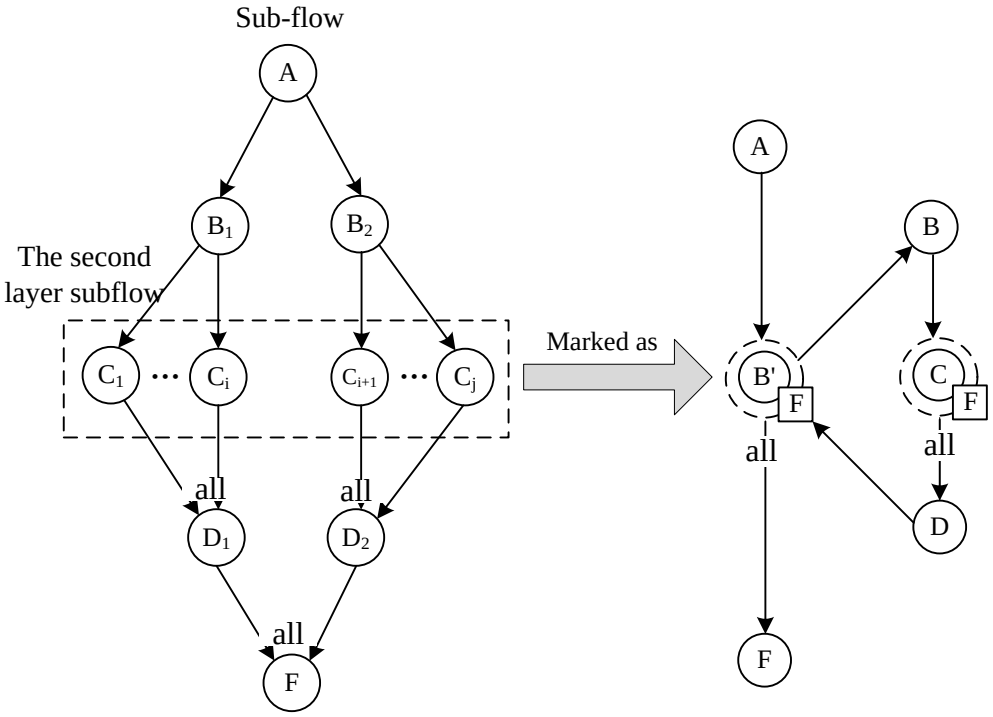

Figure 4. Sub-flow Mode

3.2. Dynamic Structure Mode

Dynamic Structure mode of homogeneous activity usually relies on its precursor because it determines which redundant activities can be executed. Dynamic Structure mode includes auto selection mode, manual selection mode, association selection mode and association avoidance mode.

1. Auto Selection Mode

The precursor of homogeneous activity automatically determines whether redundant activities are executed, the pattern is called auto selection mode. It is generally used for one choice, namely only one activity can be automatically selected to be executed. Selection algorithm such as RoundRobin, Random and Weight shown in Figure 5 can be used. Auto selection mode is used to automatically distribute tasks. For example, when several performers undertake tasks from the same queue, their property value can be set to ensure the workload balance.

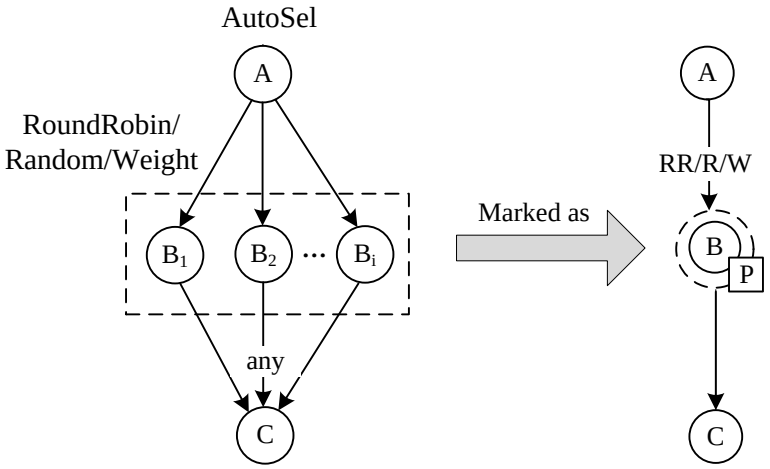

Figure 5. Auto Selection Mode

2. Manual Selection Mode

Manual selection mode can be divided into two kinds of single selection and multiple selection shown in Figure 6. The former is relatively simple and equivalent to the combination of XOR-split and XOR-merge, while the latter is more complex and can be used with several other modes simultaneously. Manual selection mode provides sufficient flexibility for instances and improves the representation ability of workflow model.

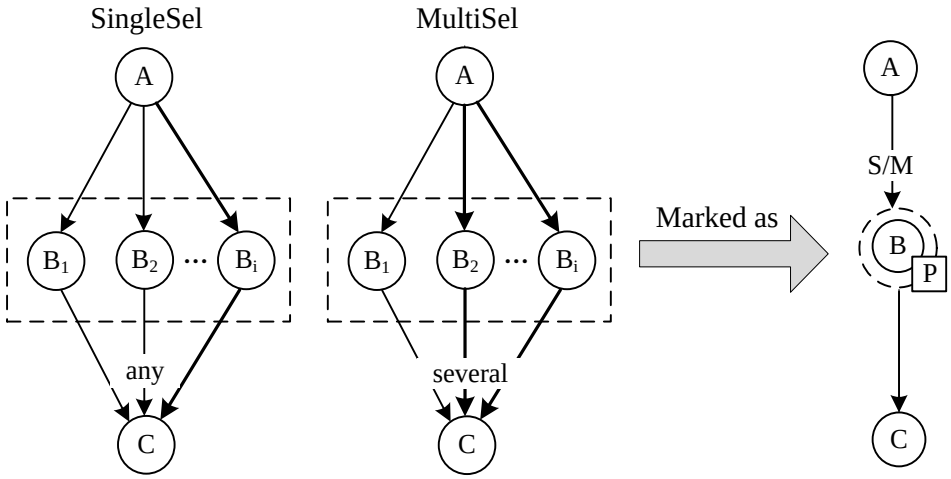

Figure 6. Manual Selection Mode

3. Association Selection Mode

When the performer of homogeneous activity has some special relationship with its precursor performer, the pattern is called association selection mode. It is a common and useful selection mode to describe "relative role" of performer and complex structure combined with sub-flow mode shown in Figure 7. Association selection mode is a homogeneous activity mode which can be used with auto selection mode and manual selection mode, also can be used with serial mode and parallel mode.

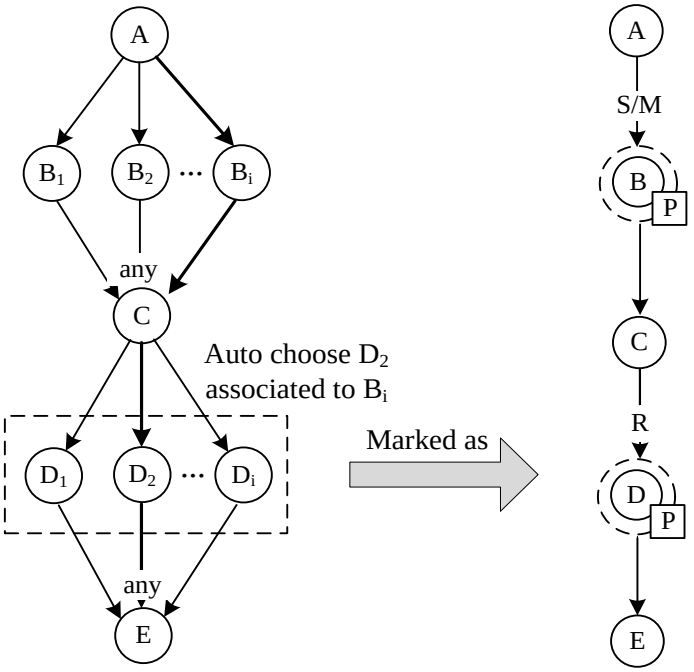

Figure 7. Association Selection Mode

4. Association Avoidance Mode

When the performer of homogeneous activity can't have some relationships with its precursor performer, the pattern is called association avoidance mode. In converse to association selection mode, it is used to avoid some options, commonly activity performer. For example, if the performer or its organization process the precursor activity, then he/she is not allowed to process the current activity. Association avoidance mode has a very wide range of uses and can be combined with most other homogeneous activity mode.

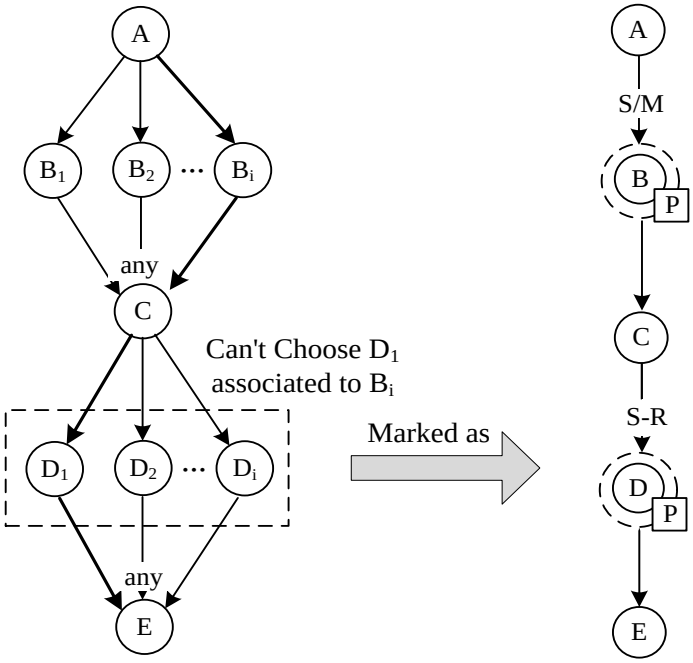

Figure 8. Association Avoidance Mode

3.3. Homogeneous Activity Mode Constraints

When configuring homogeneous activity, the mode relationships of redundant activities must be known except the set of redundant activities. The following constraint rules can be concluded from the relationships of the above eight types.

(1) Serial mode and parallel mode can't coexist.

(2) Manual selection mode and auto selection mode can't coexist.

(3) Serial mode can coexist with auto selection mode and sub-flow mode.

(4) Starting mode must be parallel mode and can't be serial mode. Also it can only coexist with sub-flow mode and can't coexist with selection mode because of no precursor.

(5) Association selection mode and association avoidance cant' coexist with starting mode and serial mode.

(6) Sub-flow mode can coexist with any other mode.

The constraint of homogeneous activity modes are shown in Figure 9. Where the solid line represents both ends of the connection can coexist and rectangle represents the set of modes.

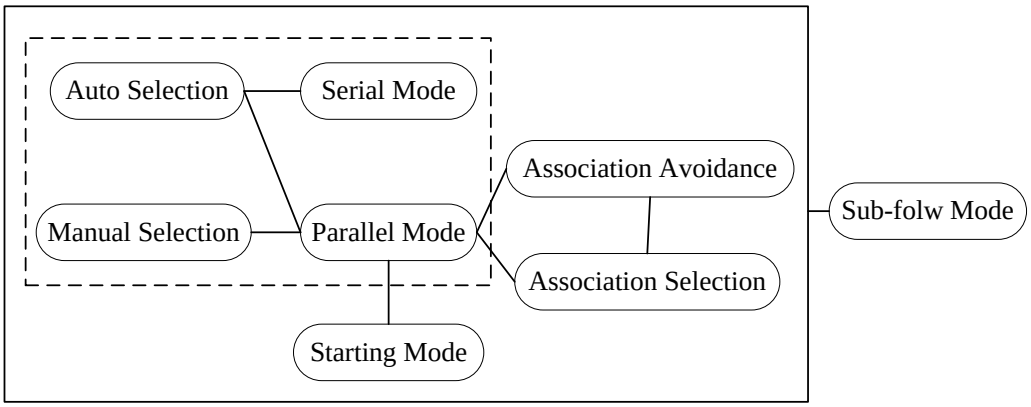

Figure 9. Homogeneous Activity Mode Constraints

4. Workflow Mode based on Homogeneous Activity

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4.1. Homogeneous Activity Workflow Mode

Homogeneous activity workflow model $hwf = (hwid, ACT, HACT, FC, WFD)$.

(1) $hwid$ is the identification of homogeneous activity workflow model.

(2) $ACT = \{act_1, act_2, \cdots, act_n\}$ is the collection of basic activities[13,14].

(3) $HACT = \{hact_1, hact_2, \cdots, hact_n\}$ is the collection of homogeneous activities.

(4) $FC = (link, forwardCond)$ is inter-active transition conditions in which $forwardCond$ is transfer condition expression, $link \in (ACT \cup HACT) \times (ACT \cup HACT)$.

(5) WFD is the collection of workflow data.

4.2. Homogeneous Activity

$hact = (hactid, Role, SRole, smode, dmode, CD, subhwf)$ is Homogeneous activity.

(1) $hactid$ is the identification of homogeneous activity.

(2) $Role = (role_1, role_2, \cdots, role_n)$ is the collection of performers consistent with association mode constraints. Association mode includes association selection mode and association avoidance mode. For each performer role $\forall role \in Role$, $role \in ((UN \cup thisUnit) \times R) \cup thisUnit$, which UN is the collection of organization units, R is the collection of roles in organization unit, $thisUnit$ is an special organization unit to indicates the node of head department, usually used in sub workflow to describe the relative role.

(3) $SRole = (srole_1, srole_2, \cdots, srole_n) \in Role$ is the collection of roles which have privileged. When serial mode is used, namely $smode \in \{SeqDown, SeqUp\}$, privilege role can work.

(4) $smode \in \{SeqDown, SeqUp, ParaSyn, ParaMulti\}$ is the collection of static structure mode of homogeneous activity.

(5) $dmode \in \{RoundRobin, Random, Weight, SingleSel, MultipleSel\}$ is the collection of dynamic structure mode of homogeneous activity.

(6) $CD \subset WFD$ is data set concerned with the activity.

(7) $subhwf$ is sub workflow model with the same property of hwf.

5. Case Study

A purchasing process of a large enterprise is shown in Figure 10 which is related to six department including financial department(FD), purchase department(PD), ERP department(ED), BI department(BD), E-business department(EBD) and Administration department(AD). ED, BD, EBD consist of three separate project teams and PD consists of two procurement centers.

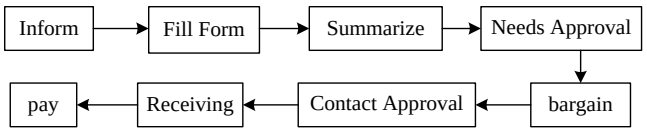
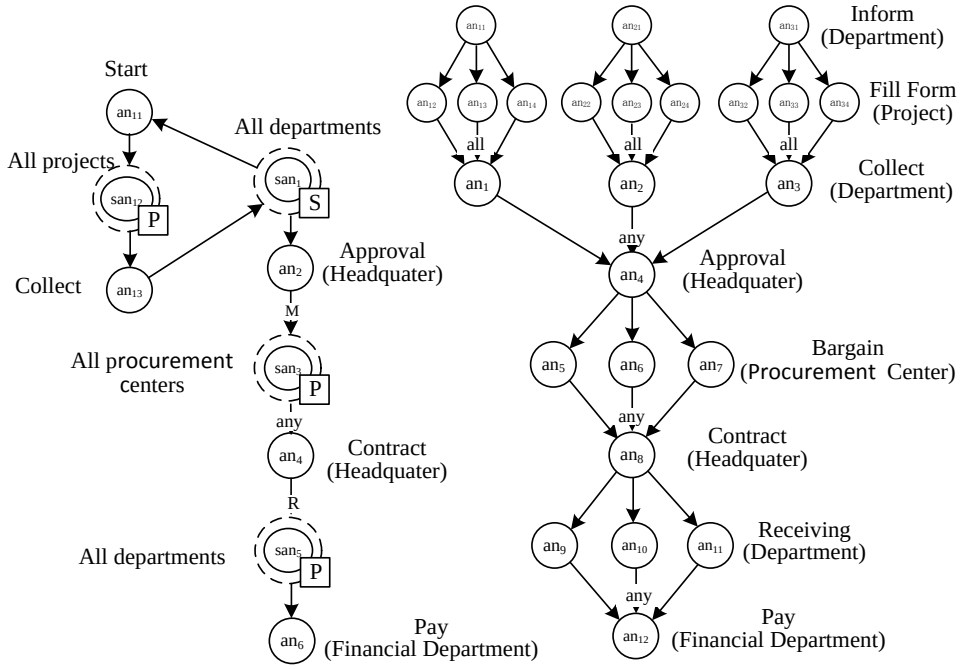


Figure 10. Purchasing Process

The purchasing process is started by the managers of ED, BD and EBD, and the purchasing instructions are forwarded to each project team in his organization. After all material requirement forms are received by the manager they can be collected to generate purchase requisitions and submit headquarter. Once reviewed the requisitions will be distributed to the corresponding procurement center according to material type. After bargaining the result will be handed over the headquarter for contact. Only material has been received, FD can pay in accordance with contract. Then the purchasing process is completed.

The homogeneous activity workflow model of purchasing process is shown in **Error! Reference source not found.**(a). Homogeneous activity san_1 is responsible for the department purchase requisition consisted with starting mode which corresponds to the sub workflow of the collection of procurement requirements. Activities an_{11} and an_{13} executed by project managers realize to dispatch and collect work of material requisition

forms. The activity san_{12} is the homogeneous activity of sub workflow consisted with ParaSyn mode to be executed by each project to realize form filling work.



(a)Homogeneous activity workflow model (b)Basic workflow model

Figure 11. Workflow Model Diagram

The purchasing request proposed by san_1 is forwarded to activity an_2 which represents the approval of headquarters. Any workflow instance coming from san_1 can activate an_2. The corresponding procurement center will be selected based on material type in activity an_2 .Activity san_3 consisted with auto selection and ParaMulti mode realizes the work of bargaining. After suppliers are determined the contract will be send to headquarters. Activity an_4 realizes the approval of contract of headquarters. Multiple workflow instances are generated after activity an_4 because every procurement center will submit his own contract and each contract needs an instance to be executed. Also an_4 will notify activity san_5 to receive which consisted with association selection mode. Once all materials are received by ED or BD or EBD, the department will execute activity an_6 to inform FD to pay, then the instance is being completed.

The basic workflow model is shown in Figure 11(b). From the comparison of Figure 11(a) and (b), we can see the introduction of homogeneous activity greatly simplifies the complexity of workflow model.

6. Comparison

The distributed workflow management system EasyWork[15] developed based on homogeneous activity is compared with other mainstream workflow management system including Staffware, COSA, FLOWer, WebSphere MQ Workflow and SAP/R3. The result can be seen in Table 1. Also fully support is represented by "√", not support is represented by "×", part support is represented by "-" . Some parts of information comes in the table is derived from [12,16].

Table 1. Comparison of Homogeneous Activity Describing

Mode / WFS	Start-ing	Serial	Para-llel	Auto-Sel	Single-Sel	Multi-Sel	Asso-Sel	Asso-Avoid
Staffware 9		×	×	×	√	×	×	×
COSA 4.2		×	×	√	√	×	√	×
FLOWer 3		×	×	×	√	×	√	×
Meteor		×	×	×	×	×	×	×
WebSphere MQ Workflow 3.3.4		√	-	×	√	-	√	-
SAP R3		√	×	×	√	×	√	×
EasyWork	√	√	√	√	√	√	√	√

It can be seen from the table that WebSphere MQ Workflow can support homogeneous activity to a certain extent and SAP R3 provides only limited support. In contrast EasyWork has the unique advantage.

7. Conclusions

In this research, the concept of homogeneous activity is presented according to the homogeneity of redundant activities. Then eight workflow modes are summarized based on the characteristic of homogeneous activities including starting mode, serial mode, parallel mode, sub-flow mode, auto selection mode, manual selection mode, association mode and association avoidance mode. After analyzing the constraints of the above modes the workflow model based on homogeneous activities is proposed which can not only significantly improve the description ability but also can reduce the maintenance cost.

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