A Research on BPM System based on Process Knowledge

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***Abstract*—Accompanied with the development of IT and market globalization, business process shows more and more dynamic, flexible and variable, which leads to more strict requirements on Business Process Management Systems (BPMS). Using relevant theory and method of Knowledge Management (KM), this paper analyzes the knowledge related in BPM process and brings forth the concept of Process Knowledge (PK), the classification and description of PK from the perspective of BPM are also presented. Furthermore, the paper points out the meaning of extracting PK from BPM, using PK to help BPM system monitoring, adjusting, analyzing and optimizing. This method can improve the BPM system's capability of monitoring and analyzing and makes the system more flexible to a certain extent through experimental verification system. This paper also provides a new perspective for research on improving BPM system's effectiveness and flexibility of implementation.**

***Key words*— business process knowledge, BPM, system flexibility, process knowledge base, Process monitoring, exception warning**

I、 INTRODUCTION (CURRENT STATUS OF BPM SYSTEM INDUSTRY)

Based on computer network, workflow management and enterprise application integration, the business process management system performs all-dimension management of business process from the process perspective. By unified modeling and environment monitoring, the business process management system provides support for a variety of transboundary enterprise business process and its continual improvement.

Currently BPM related research is an industry hotspot. Its research usually centers on system framework, process model and management of process execution. For example, reference 1 and reference 2 studied BPM framework combined with TQM. Reference 3 and reference 4 studied the execution of BPM process modeling from the perspective of ARIS framework. Reference 5 and reference 6 studied the heterogeneous process collaboration mechanism in distributed environment based on proxy technology. Reference 7 proposed the executing method of BPM system and laid more emphasis on the evaluation and improvement of business process. There are also a few researchers studying the

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composition, classification, extraction and presentation of process knowledge and its application of artificial intelligence and expert system in improving the system's controll abilities based on process knowledge.

This paper analyses the process knowledge involved in BPM system, proposes the concept of business process knowledge and its classification, explains the nature of business process knowledge and its assisting role in BMP monitoring management and optimization of all BPM links and finally provides a new perspective for BPM execution research.

II、 PROCESS KNOWLEDGE

A. Definition and characteristics of knowledge

In knowledge economy times, knowledge serves as the only production tool that does not observe the Law of Diminishing Returns and it has become an indispensable resource for enterprises. Knowledge decides the improvement of enterprise productivity and accumulation of wealth. There could be several definitions for knowledge from different purpose or research perspective. The author believes Guus Schereiberti's definition of knowledge is comprehensive and profound, which is to say, knowledge is produced based on data and signaling, it is a combination of data and information which carries clear purpose and regeneration capacity[10]. The definition specifies two basic characteristics---sense of goal and regeneration capacity, the former represents that knowledge is used to accomplish certain purpose and the latter represents that new knowledge can be produced automatically by some means.

The nature of knowledge management in enterprise can be summarized as the delivery of the most appropriate knowledge to the most needed person at the right time. The realization of this goal is under the condition that there is sufficient related knowledge for the enterprise or high quality knowledge is delivered. The process, as a whole, is from the acquisition and organization of knowledge to the sharing and utilization of knowledge. New knowledge is created and produced in the process and again the process is returned to the link that acquires knowledge, which formulates a cycling and spiral uprising process. By this recycle, the related knowledge gathered for enterprise is accumulated and the knowledge gains a great impact on enterprise.

B. Knowledge in process---process knowledge

1) The origin of process knowledge an its characteristics

The daily work in an enterprise comprises a variety of processes. Some of them are daily routine and some of them are exclusive to enterprise. The so-called enterprise knowledge, actually, is large quantities of highly redundant data information involved in various processes. They all have direct or indirect relations with process running.

A good mastery of knowledge and the applying of its rules are certain to bring benefits for process and even for the enterprise. As a result, the rules and experience related to process can be extracted from large quantities of process data. After processing and organizing, the knowledge extracted is possible to direct the running of process and help the analyzing of optimized knowledge. The knowledge extracted is so-called business process knowledge with the abbreviation PK (process knowledge).

Process knowledge features two characteristics---sense of goal and regeneration capacity. The former represents the guidance on the process and the latter represents the capabilities of directing process management and the capabilities of generating new knowledge in enterprise process. According to the classification of knowledge by OCED, Process knowledge is based on knowledge such as "Know-How" while also comprises knowledge like "Know-What" 、 "Know-Why" 、 "Know-Who"[11]. Consequently, process knowledge is a kind of compositional knowledge.

2) Classification of process knowledge

a) Basic process knowledge

Process knowledge is a sort of combinable knowledge. It centers on the actions in process and their relations. Process knowledge is a combination of a series of related knowledge organized by certain rules under the participation of different action bodies to accomplish specific business process. Process knowledge includes four aspects of contents as resources, rules, personnel and goal.

First of all, process is accomplished by various

departments and personnel from various posts. Process knowledge definitely comprises the properties of action bodies and objects involved in them. Secondly, all process actions have to obey the rules, consequently rules are important content of process knowledge, including time, conditions and constraints, for example, the earliest/latest starting time, the earliest/latest completing time of process and actions, the conditions that actions have to satisfy and constraints of execution. Thirdly, the execution of any action has to consume certain recourses, so the recourses needed in process is an indispensable part of process knowledge. The goal and evaluation system of process has to be incorporated into process knowledge for example, whether the evaluating goal has been reached or the index of an evaluation system has been achieved.

b) Creative process knowledge

One of the two basic attributes of knowledge is regeneration, which is to say, by means of deduction and reasoning, new knowledge can be produced from the knowledge at hand. Similarly, process knowledge helps and guides the running of process and in the meantime it contributes to create new process knowledge.

There are three fundamental approaches to create new process knowledge from the perspective of business process management:

- While process is running, because of changes from environment and conditions, the definition of process is adjusted or modified to ensure process output. With this continuous adapting, adjusting and modifying steps, related process changes and new process knowledge are created when changes reaches a threshold.
- While process is running and when it is impossible to handle practical situation (such as unpredictable exception) based on available process knowledge, the system usually notifies administrators and comes up with current exception handling strategy based on actual practice and current status of process. This is the new process knowledge created by deduction and reasoning based on actual situation from available knowledge.
- By means of process running history record, related process statistic spreadsheet is produced by BPM system based on various purposes. For example, statistic spreadsheet of process output or resource utilization from performance perspective, which is used for process optimization and long-term decision-making. The statistic spreadsheet is based on new knowledge produced by running history record.

Based on the analysis above, process can be classified into basic process knowledge and creative process knowledge. They can be classified into more detailed categories according to resources, rules, personnel and goal. The classifications are listed in figure 1.

III、 PRESENTATION/ACQUISITION AND UTILIZATION OF PROCESS KNOWLEDGE.

A. Formal description of process knowledge

Based on the analysis and classification of process knowledge discussed above, it is possible to give a formal description of process knowledge in detail. If a piece of process knowledge is identified as PK, it can be presented as a two-element group showed in formula 1. *Activities* represents the combination of all actions that consists the process and *Relations* represents the relationship between those actions. The descriptions of them are showed in formula 2 and formula 3.

$$PK=<Activities, Relations> \quad (1)$$

$$Activities = \{Act_1(B\_Attr, E\_Attr), \ldots, Act_i(B\_Attr, E\_Attr), \ldots, Act_n(B\_Attr, E\_Attr)\} \quad (2)$$

$$Relation = (Rela\text{-}Bas\text{-}Attribute, Rela\text{-}Ext\text{-}Attribute) \quad (3)$$

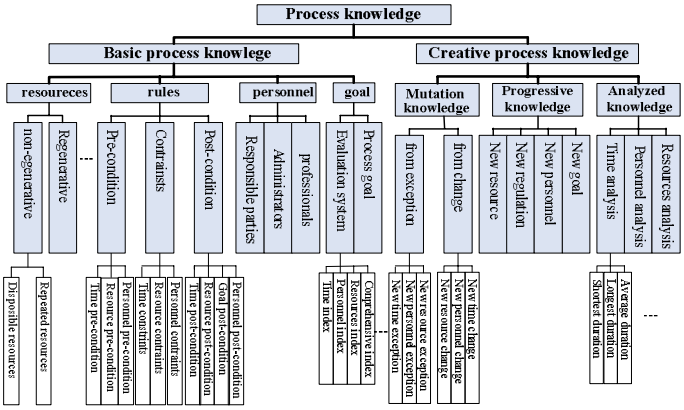

Figure 1. Classification of process knowledge

In formula 2, *B_Attr* represents the fundamental attributes of related action and contains main body and time of the action. *Ext_Attr* represents extended attributes and its content items can be added or deleted if needed. Thus it is an open collection that usually comprises pre-conditions (*Pre_Cond*), limited conditions (*Lim_Cond*), consumption conditions (*Con-Reco*), used conditions (*Use_Reco*), output, method, technology, tools, related estimation and authorization etc. They are described in formula 4 and formula 5.

$$B\_Attr = (MainBody, Action, Time) \quad (4)$$

$$E\_Attr = (Pre\_Cond, Lim\_Cond, Con\_Reco, Use\_Reco, Output, Method, Technology, Tool, Estimation, Authority) \quad (5)$$

The relations between process actions can be classified into basic relations attributes and extended relation attributes. The basic relation attributes comprises relation sort and time-relation （*Time_Rela*）between actions. Relation sort mainly contains *Sequence*, *FrontAnd*, *FrontOr*, *BackAnd*, *BackOr* and *BackXor* etc. Time-relation contains *Overlap*, *Contain*, *Continue* and *Interval*. They are described in formula 6, formula 7 and formula 8. Similar to actions collections, extended relation attributes are an open collection that comprises the *Probability* attributes of various relations and can be configured as needed as in formula 9.

$$Rela\text{-}Bas\text{-}Attribute = (Kind, Time\_Rela) \quad (6)$$

$$Kind = Sequence \mid FrontAnd \mid FrontOr \mid FrontXor \mid BackAnd \mid BackOr \mid BackXor \quad (7)$$

$$Time\text{-}Rela = Overlap \mid Contain \mid Continue \mid Interval \quad (8)$$

$$Rela - Ext - Attribute = (Probability, \ldots\ldots) \quad (9)$$

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B. Utilization of process knowledge

1) Design of enterprise business process based on enterprise knowledge library

Practical and flexible process design is key to ensure flexible operation of process. Consequently, process design has to start from strategic perspective, the scope of primary/secondary business process and the hierarchy and relations of business process at all levels has to be clarified. Based on it, according to resource allocation, process rules, involved personnel and objective, based on related knowledge or similar process in the process knowledge, the resource allocation scheme, process regulation, involved personnel and objective is specified properly. It is necessary to formulate detailed definition of process model. Meanwhile, the related content and process output is returned to process knowledge library for later utilization of monitoring, optimization and process modification. Details are showed in figure 2.

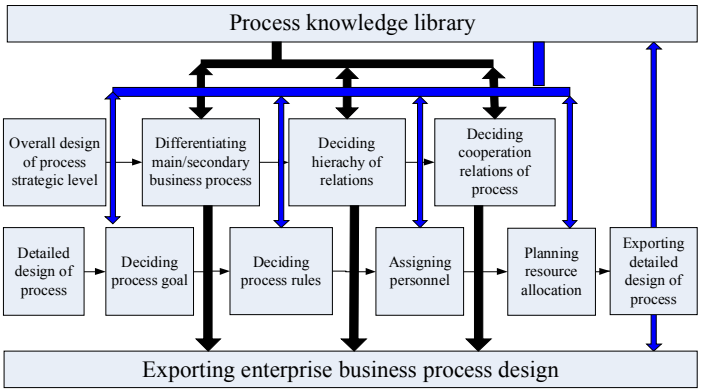

Figure 2. Designing of business process utilizing process knowledge

2) Implementation of BPM monitoring based on process knowledge

Currently most BPM monitors are based on Web proxy application and they all provide monitor administrators with related process information by virtue of graphic interface. The process data and information gathered by the monitor are fundamental reference for administrators to perform online analysis management, ensure process operation and come up with further optimization scheme. Deploying process knowledge in BPM monitoring, the real-time data and information can be introduced into BPM monitors and the

BPM monitor system is provided with capabilities of database query. The related history data and statistic information are available to all levels of users in graphic and tabular form, helping mastering the whole status of process.

3) Exception handling utilizing process knowledge

BPM exceptions are classified into environmental exceptions and system exceptions. The former represents power cutout and low-level system malfunction of network terminals. The latter is usually the focal point of research, mainly including exceptions on BPM process resources, personnel or rules. Deploying the system monitor module, it is possible to speed up the response to exception, find out exceptions at an early stage and take remedy measures when the exception occurs at an early stage. Consequently, the impact of exception can be decreased and process output ensured.

IV、 IMPLEMENTATION OF BPM SYSTEM BASED ON PROCESS KNOWLEDGE

A. BPM system framework based on process knowledge.

The workflow management system decomposes a detailed job into multiple assignments and roles. By certain rules or process, the BPM system monitors and manages the implementation of process so that the standard of enterprise business process management is improved. The Business Process Management System based on Process Knowledge (PK-BPMS) developed by CIMS research center of Tongji University centers on business process oriented workflow management system. The PK-BPMS introduces knowledge searching and knowledge arrangement module into the system by means of flexible modeling and automatic management functioning. The time, personnel and process knowledge needed can be extracted from the process and used to assist process monitoring management. The PK-BPMS provides all levels of process management administrators with knowledge information needed, so the monitor response to the process is improved and the scope of monitor extended. Remedy measures are taken when exception occurs so that the smooth running of process is ensured and the flexibility of BPM system improved. The architecture of its implementation framework is showed in figure 3.

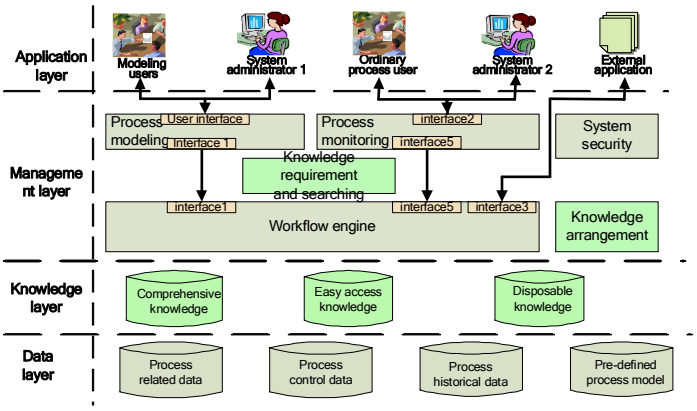

Figure 3. Architecture of PK-BPM system based on process knowledge

Compared with ordinary BPM system, the PK-BPMS adds a knowledge layer between management layer and data layer to assist the extraction, storage and utilization of process knowledge. In the running of process, monitoring module is provided with related knowledge from the knowledge library. Timely and accurate judgment is made by mean of real-time data and appropriate exception handling plan are chosen based on related experience. So it is possible to adjust/modify process timely to ensure the running of process. The action sequence is showed in figure 4.

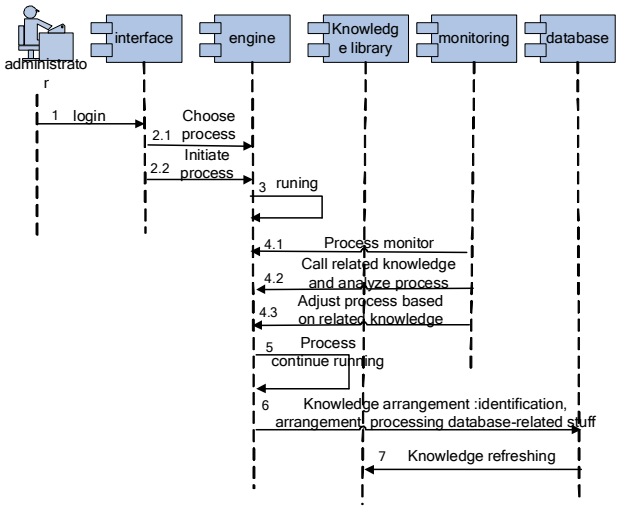

Figure 4. Process modification/ sequence adjustment based on process knowledge

The left side of the system monitor interface represents real-time status of the process and it is marked with three different colors to differentiate the status of different actions (showed in figure 5).

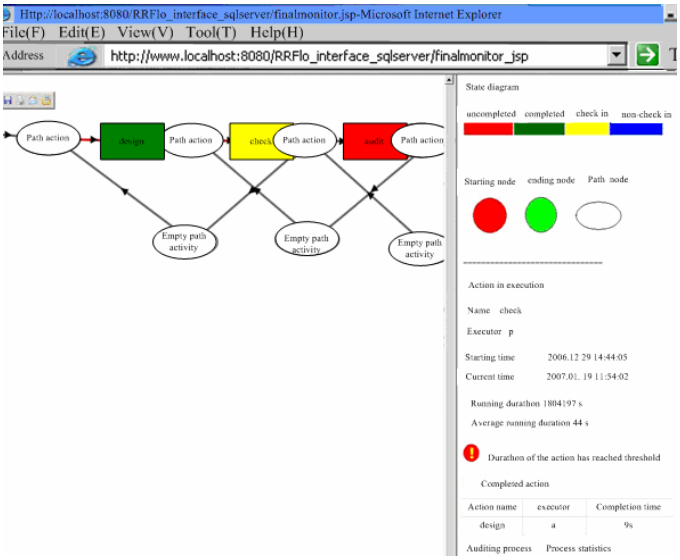

Figure 5. Monitoring interface No.1

1) Real-time information of current action such as starting time/ completing time/ administrators. Time threshold is set according to certain rules. Time exception alarm is issued when action exceeds the threshold ("!"is showed in the right side). So administrators or online operators are notified of the possible exception in the process and so the cause of the exception (such as administrators on a business trip or shortage of needed resources) is ascertained and exception resolved. To ascertain system failure or the cause of alarm, process statistic information query button is set at the right-bottom side of the system interface to provide process related knowledge record (showed in figured 6).

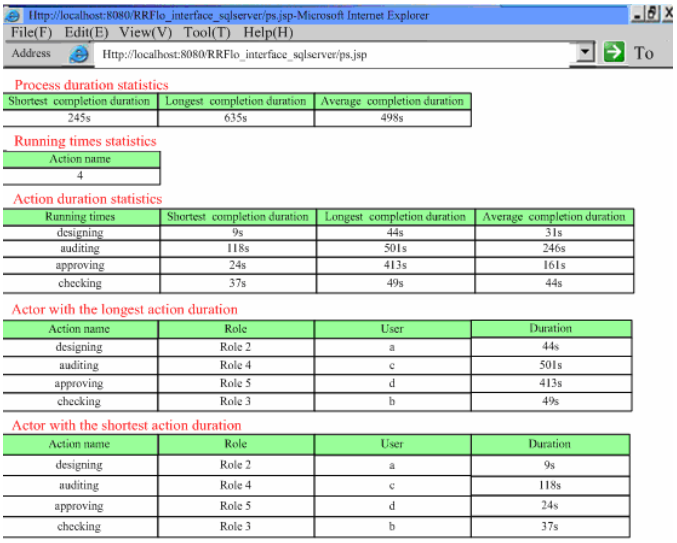

Figure 6. Monitoring interface No.2

2) Process related information record such as implementing times of current process/ action, longest/ shortest completion duration, average completion duration, longest/ shortest administrators of the process and all the administrators that ever took part in the action. This information helps to make accurate judgment for users to ensure the smooth running of the process. In practice, the statistic data provides process administrators or decision-making analyzer with reference basis for long-term planning and decision-making.

V、 CONCLUSION

Large volumes of process knowledge is involved in enterprise business process. Since it is closely related to the business process and proves to be the most direct knowledge for process and enterprise. The process knowledge plays an indispensable role in guiding and assisting enterprise business process management. This paper proposes a method of process-oriented classification of process knowledge and the formal description method is also proposed in this paper. This paper analyses the means to extract and utilize process knowledge and points out the assisting role of process knowledge in process modeling, operation monitoring and analysis of optimizing management. They are all tested in the experimenting system that provides a new method to study the performance of process management and improve system flexibility.

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