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Bearing Manufacturing process quality knowledge study system based on GQM

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Abstract: In order to guarantee the functional influence of artificial action during the course of 5M1E bearing manufacturing process and increase the bearing machining quality and the rate of finished products, a new kind of quality and knowledge study system in bearing manufacturing process based on goal question metric (GQM) is proposed. According to the bearing manufacturing technical procedures, the functional targets in bearing manufacturing process are decomposed by using GQM method to obtain the requirements of bearing quality and knowledge study. In allusion to the requirements above, combining the workflow engine method, bearing manufacturing knowledge study functional frame model and knowledge performance model are established, and the executive function modules division and interactive data dependency relations are provided. By process-role-knowledge session configuration method, improve the tightness and vertical depth of bearing quality knowledge, and the specific quality management service for users is realized by role-based access control (RABC) method. Experiments prove that this method can realize the functions of on-line management, dynamic correlation and rule production for bearing quality knowledge, and provide effective technical support for improving bearing manufacturing process management efficiency and product quality.

Keywords: GQM, bearing manufacturing, quality, knowledge study,workflow.

1 Introduction

With the disciplinary technical flourish, the fusion and the penetration between the disciplinary approach, technology and tools also becomes more and more closely. Knowledge management must be closely linked with the process of quality management, combining knowledge creation and evolution of diffusion with the process flow, to save a lot of expenses, improve production performance, and produce a more significant economic benefits, while the quality knowledge management is one of the important objects of study. Quality knowledge management is to organize a conscious strategy, which guarantees the most needed quality knowledge transfer to those most in need at best time, helping people to share quality information, then put them into practice through different ways and ultimately achieve the purpose of improving product quality and Enterprise competitiveness.

As a common mechanical component, bearing is widely used in such fields as industry, agriculture, transportation and health care. It has an irreplaceable role and its quality directly affects the quality of the product machine [1-2]. The quality of bearing product depends on the bearing assembly process, which is the quality of the four major pieces of the bearing: the quality of steel ball, the quality of cage, the quality of inner and outer rings. Of course, the quality of the four major pieces of the bearing also depends on the respective manufacture and process. In the manufacturing process of these bearing components, the 5M1E bearing manufacturing process system is composed by Material, Man, Machine, Measure Method and Environment, which have the influence of different weights on the bearing processing quality [3]. In the 5M1E system, the factors of artificial action are particularly important. Therefore, to improve the comprehensive quality of the technical related person in bearing manufacturing enterprise, which guarantees the function influence of artificial action during the course of 5M1E bearing manufacturing process, will effectively improve and secure the bearing manufacturing process quality.

Goal Question Metric is a systematic quantitative measure of the target object and its development process[4]. It summarizes the functional objectives of the organization, decomposes as measurable technical indicators, then integrates these indicators into measurable specific data, so the process performance can better predicted and controlled and quantitative

management of management system can be developed. With the continuous development of the relevant supporting technologies, GQM method has been applied better in the field of software development, process management and organization optimization.

The quality management in the production site of bearing manufacturing can also be around the three elements of expansion- Goal, Question, Metric, but in the process it is essential to make clear the needed specific measures and methods. Therefore, in this paper the GQM method was imported into the field of bearing quality management and a kind of bearing manufacturing process quality knowledge study system realization method was bring forward. Bearing manufacturing knowledge study functional frame model and knowledge performance model were established, and the related application software system was also developed. The experiment shows the feasibility and effectiveness of this method. This research work can provide effective technical support to improve bearing quality, and provide help for the improvement of bearing manufacturing process management performance.

2 Target Decomposition Based On GQM

Since the various kinds and the different structure and function of the bearing, this article takes Radial Ball Bearing as an example to analyze. Radial Ball Bearing, which can withstand high-speed movement of the load of different sizes, is a common design bearing that composed by a complete set of precision ball, cage and inside and outside ring, its manufacturing process is shown in Fig. 1.

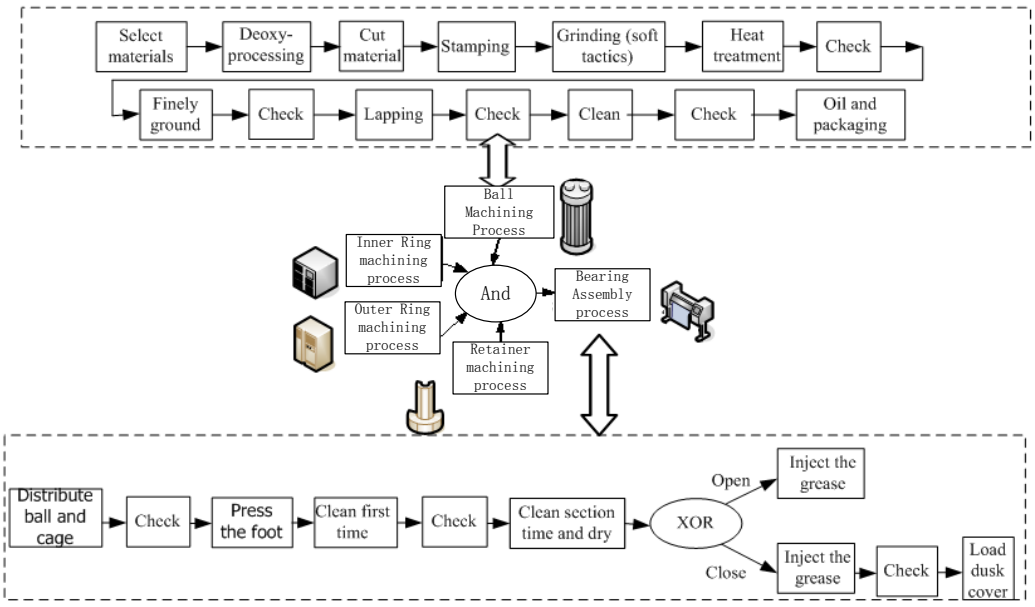


Figure 1: Manufacturing Process of Radial Ball Bearing

In allusion to the bearing manufacturing process Shown in Fig. 1, the bearing manufacturing process and the knowledge related to the target were decomposed by using the GQM method. GQM method is assembled by process goal, quality issue, technology indicator and implementation method, in which process goal, quality issue, technology indicator are the same level, belong to the static elements, while the implementation method is represented by a function of these three. The implementation method represents the decomposition process from goal to quality issue then to indicator and the assembly of solving quality problems and improving the indicators. Therefore, the specific function analysis of the goal layer, the issue layer, the indicator layer and the method layer in bearing the manufacturing process can be achieved by the use of the GQM method. Considering the hierarchical analysis process above, the goal layer analyzes the bearing manufacturing process from the perspective of the quality goal; the issue layer analyzes the bearing manufacturing process from the perspective of the quality issue; the indicator layer analyzes the bearing manufacturing process from the perspective of the quality indicator; the method layer analyzes the

implementation process of bearing manufacturing from the perspective of the quality plan.

Due to the limited length, this paper takes the quality goal module as an example to establish the relevant research. The technical implementation ideas of the quality objectives module in the bearing manufacturing process can be described as follows: ①Put forward the quality goal of bearing from the perspective of the market; ②Introduce the assembly quality goal of bearing from the quality goal of bearing; ③ Introduce the quality function goal, assembly quality goal and personnel operate goal of the four pieces from the assembly quality goal of bearing; ④Introduce the respective manufacturing process quality goal and personnel operate quality goal of the four pieces from the quality goal of the four pieces. Quality goal of bearing manufacturing process and its knowledge decomposition are shown in Fig. 2.

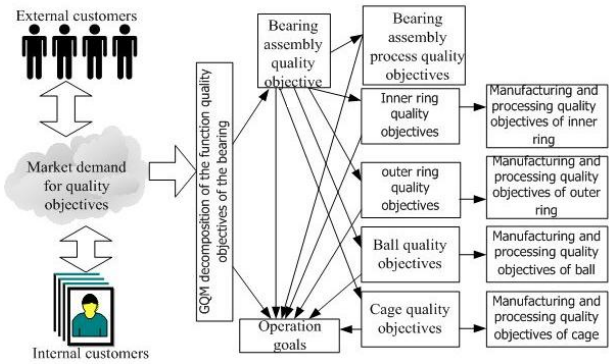


Figure 2: Quality Goal Decomposition of Manufacturing Process.

The main purpose of this study is to construct a management platform that can support the related quality knowledge of the role study in the bearing manufacturing process. In allusion to the production process role in the bearing manufacturing process, quality knowledge is composed of courseware knowledge, case knowledge, customer knowledge and expert knowledge. Case knowledge, customer knowledge and expert knowledge are tacit knowledge while courseware knowledge is explicit knowledge. Case knowledge is used as reference knowledge to assist in the process role and diagnose process problem; courseware knowledge is used as subject knowledge to train the professional quality of the process role; customer knowledge is the knowledge supplied by external person of the enterprise to the organization; expert knowledge is the knowledge supplied by relevant professionals to the organization.

After the process role studies the courseware and case knowledge, tacit knowledge in bearing manufacturing process will become explicit; Transfer the tacit knowledge of customers and expert to explicit quality knowledge in the bearing manufacturing process by external knowledge fusion and technically by methods such as virtual communities. Study the relevant process courseware and case to improve professional quality of the process role and ultimately achieve the purpose of improving and to guarantying the quality of bearing manufacturing.

3 Frame Design Of System Function

In allusion to the result of system requirements analysis shown in last section, combining the workflow engine method[5], bearing manufacturing knowledge study functional frame model was established and is shown in Fig. 3.

As shown in Fig. 3, flat hierarchy is used in bearing manufacturing knowledge study functional frame model, mainly composed by the data layer, the operation monitoring layer and the application layer. The data layer supplies quality knowledge to bearing manufacturing process to provide specific data support to the operation monitoring layer and the application layer; the operation monitoring layer provides the interface support to the application layer; the application layer provides a mutual dialogue platform for the system and the internal and external person, also provides interfaces for external systems to connect and achieve. Specific technical information contain in the above-mentioned functional hierarchy can be described as follows:

① The data layer contains process quality knowledge base and ontology base. Process quality knowledge base contains role base, case base, question base, courseware base and process base.

②The operation monitoring layer contains the workflow engine, the coding engine and the process quality knowledge configuration engine. The workflow engine lays the foundation for workflow-based process modeling. The coding engine lays the foundation for the process, the role, the case and the courseware coding of bearing manufacturing, the role of case, courseware coding foundation. The process quality knowledge configuration engine lays the foundation for the process quality knowledge base configuration and the process quality knowledge profile configuration.

③ The application layer includes the process modeling, the process, role, case, courseware coding, process quality knowledge base configuration and quality knowledge profile configuration of the bearing manufacturing process and the system search and reasoning.

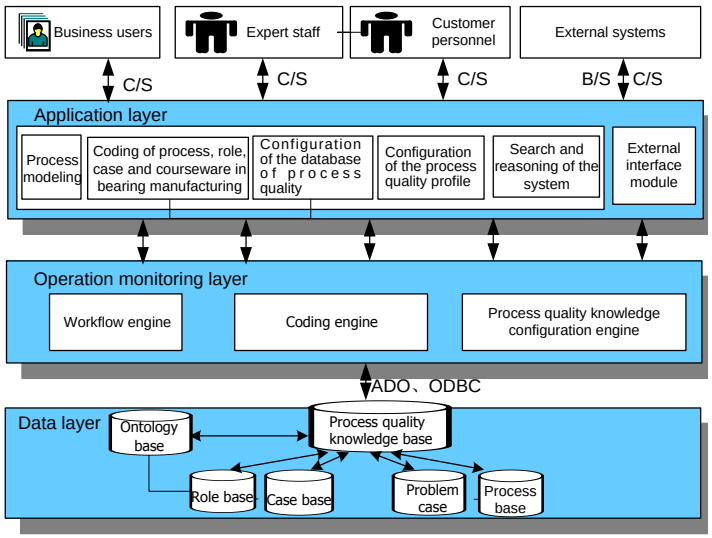


Figure 3: Framework Model of Knowledge study Function in Bearing Manufacturing Process

The process operation based on knowledge relays on the coordinated operation of the workflow execution machine and knowledge management tools, which is specifically reflected as the configuration operation of the workflow and knowledge. In this paper, The Model of Operational Process Based on Knowledge was established, as shown in Fig. 4.

As shown in Fig. 4, each active node of the bearing manufacturing workflow corresponds to one knowledge node, which is the activity-related quality knowledge selected from the process quality knowledge base. When performing an activity, the activity gets useful specific quality knowledge from the process quality knowledge base through the knowledge configuration module in the system, and stores them on the active node in the workflow; Constantly update quality knowledge in the process of performing the activity, meanwhile feedback the updated quality knowledge to the process quality knowledge base through knowledge update tool. After the performance of the activity, workflow is navigated to the next active node, and accordingly, gets useful specific quality knowledge from the quality knowledge base through the knowledge configuration module and stores them on the relevant active node in the workflow.

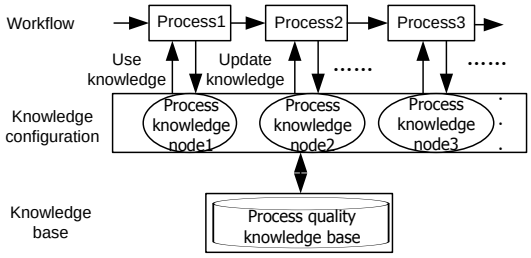


Figure 4: The Model of Operational Process Based on Knowledge

Based on the research conclusion above, system behavior model of bearing manufacturing quality knowledge study was put forward and data dependencies between modules were confirmed, as shown in Fig. 5.

As shown in Fig. 5, the overall system operating framework includes the process quality knowledge configuration layer and the process role quality knowledge study layer. And the process quality knowledge configuration layer includes process quality knowledge configuration and process knowledge profile configuration.

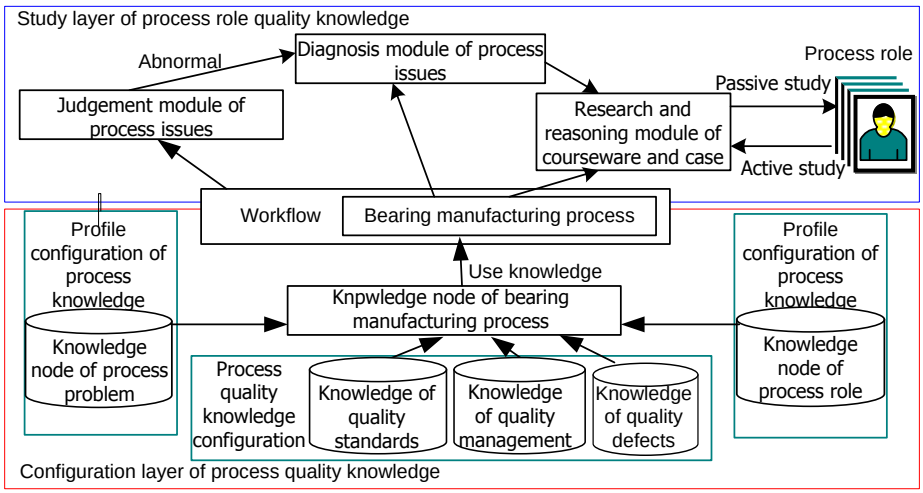


Figure 5: System Behavior Model and Data Dependencies

Process quality knowledge configuration is mainly to configure knowledge of quality judgment, quality management, quality defects that related to the knowledge node of the bearing manufacturing process, which also means to configure the courseware, the case and the role of the bearing manufacturing process. Bearing manufacturing process knowledge scene configuration is mainly to configure the relevant key point of process question knowledge and process role knowledge. Accordingly, the quality role quality knowledge study layer provides a platform for the process role to actively and passively study the knowledge of quality management (courseware and case knowledge). In the process role knowledge study layer, the process role of can achieve the automatic learning of the knowledge of quality management (courseware and case knowledge) by the modules of courseware inquiry, case inquiry and reasoning; when the bearing manufacturing process node becomes abnormal, the process role can achieve the passive learning of the knowledge of quality management (courseware and case knowledge) by the modules of process problem diagnosis and courseware inquiry, case inquiry and reasoning.

If want to search and reason the relevant process courseware knowledge by key point of process role knowledge or to search and reason the relevant process case knowledge by key point of process problem, the bearing manufacturing process has to have knowledge profile configuration firstly.

The scene is universal and objective existed and closely related to things, activities and others. For this system, the purpose is to provide a platform for the process role to learn the relevant courseware and case knowledge. Therefore, for this system, there must be profile configuration of process-role-knowledge's node and profile configuration of process-problem-problem's node. Due to space limitation, this paper only describes profile configuration of process-role-knowledge's node.

Profile configuration of process-role-knowledge's node is used to research and reason the relevant courseware for the process role to study when the process role face problems, so profile configuration of process-role-knowledge's node is a link between process role and courseware. Profile Configuration of Process-Role-Knowledge's Node is shown in Fig. 6.

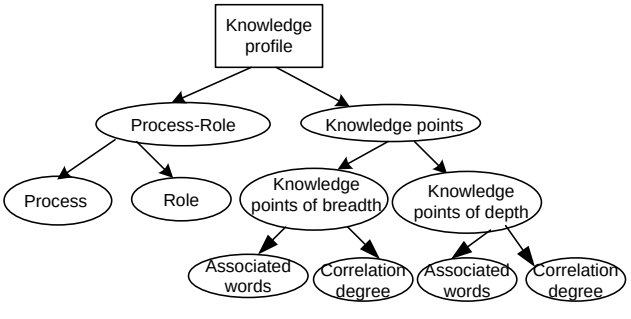


Figure 6: Profile Configuration Mode of Process-Role-Knowledge's Node

Fig. 6 shows profile configuration of process-role-knowledge's node consists of two parts,

namely process-role and knowledge node. Process-role consists of process and role and is used to describe the bearing manufacturing process and the characteristic of the process role. Knowledge node consists of knowledge keyword and associate degree. Knowledge keyword is mainly used to describe the quality knowledge node should possessed by process-role, while the associate degree is used to show the breadth and depth of quality knowledge node and provides the condition of level query for courseware knowledge to research and reason.

4 Development Of System Application Examples

The purpose of the development of the system is to help the process role to learn the knowledge of quality management (courseware and case knowledge), thereby enhancing the basic quality and the professional quality of the process role, and ultimately improving and protecting the processing quality of the bearing manufacturing process. Therefore courseware and case knowledge is very important resource for the system, and is not allowed to easily modify, copy and delete courseware and case knowledge without authorization. In allusion to the above functional requirements for the system, this paper proposes a system network distribution structure was put forward in this paper, as shown in Fig. 7.

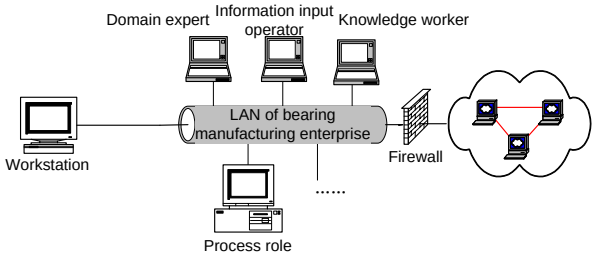


Figure 7: System Network Distribution Structure

As shown in Fig. 7, LAN of bearing manufacturing enterprise mainly consists workstation, and personal (domain expert, information input operator, knowledge worker, process role) computer platform, and even other LAN connected through a firewall. In this system the knowledge of quality management (courseware and case knowledge) is stored in the workstation, and the database is also installed in the workstation. Other personal computer platforms are only used as the application back-end of the system and can only connect the resources in the workstation through this system software.Then the user is awarded the role by using finite state machine, BLP modeling thought and RABC (Role-based Access Control), then the role is awarded the rights, and the rights is associated with the operation [6]; The user get the relevant rights of the role by this awarded role, thus the rights management of the operations can be accomplished. RABC model of knowledge management in bearing manufacturing process is shown in Fig. 8.

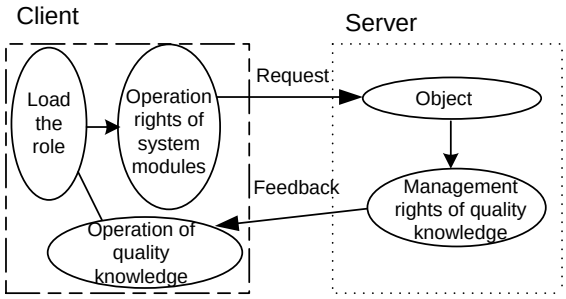
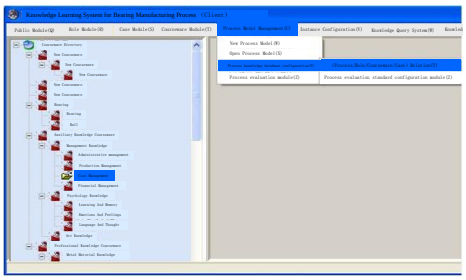


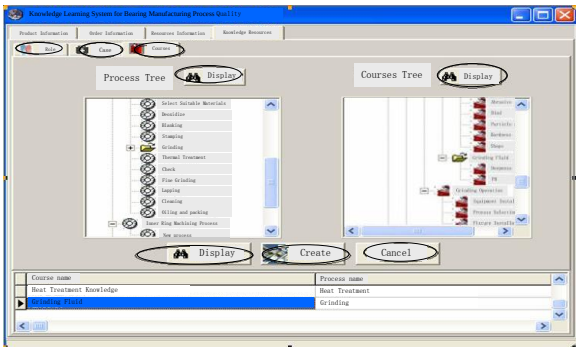
Figure 8: RABC Model of Knowledge Management in Bearing Manufacturing Process

According to the user's specific task requirement, the client sends to the task request to the server, which contains operation rights and status parameters of system modules of the role, then the server gives the role the relevant management rights of quality knowledge according to the client's request to operate and manage the quality knowledge.

Based on the research result above, in the environment of Windows Advanced Server operating system, knowledge management system software of bearing manufacturing process is developed by SQLServer2008, Delphi2009 and other integrated development environment and software tools and object-oriented approach to realize the function of online management, dynamic association and rule production of bearing quality knowledge. and rules and other functions, as shown in Fig. 9. The software system has been tried out in Ruian Valve Plant and many other enterprises and obtained a good application effect.



(a) Client Management Interface



(b) Knowledge Management Interface of Process

Figure 9: Knowledge Management System Software of Bearing Manufacturing Process

5 Conclusion

1) In allusion to the basic quality problems in the manufacturing process of radial ball bearings, in order to guarantee the function influence of artificial action during the course of 5M1E bearing manufacturing process, increase the bearing machining quality and the rate of finished products, a kind of bearing manufacturing process quality knowledge study system realization method based on GQM was bring forward.

2) According to the bearing manufacturing technical procedures, the bearing manufacturing process functional targets were decomposed by using GQM method, to obtain the requirements of bearing quality knowledge study. In allusion to the requirements above, combining the workflow engine method, bearing manufacturing knowledge study functional frame model and knowledge performance model were established, and the executive function modules division and interactive data dependency relations were provided.

3) By process-role-knowledge session configuration method, improve the tightness and vertical depth of bearing quality knowledge, and the specific quality management service for users was realized by RABC method and the relevant application software system was developed.

4) Experiments prove that this method can realize the functions of on-line management, dynamic correlation and rule production for bearing quality knowledge, and provide effective technical support for improving bearing manufacturing process management efficiency and product quality. Follow-up study will focus on the aspects of optimization of the knowledge process management, structure of the ontology system model and real time of the software.

References

[1] Zhang Jun, Lu Senlin, He Weixing, et al. Vibrating Diagnosis of Rolling Bearings Based on Wavelet Packet Energy Feature[J]. Transactions of the Chinese Society for Agricultural Machinery, 38 (10): 178-181 (2007).

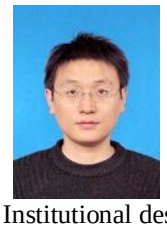
[2] Wei Xiaoming, Liu Xiaobing, Yang Chunli. Study on the Knowledge Management Methodologies for Mass Customization Design [J]. Transactions of the Chinese Society for Agricultural Machinery, 37(7): 133-137 (2006).

[3] Song R, Wu B Z, Wang Y C, et al. Research on quality knowledge learning oriented to bearing manufacturing process[J]. Advanced Materials Research, 215: 159-162 (2011).

[4] Yang Jiping, Yu Zhonghua. Research on the GQM method and its application[J]. Manufacturing Automation, 25 (6): 20-23 (2003).

[5] Fan Yushun, Wu Cheng. Current state and development trends of workflow management research and products[J]. Computer Integrated Manufacturing Systems, 2000, 6 (1): 1-7 (2000).

[6] Aziz B, Foley S N, Herbert J, et al. Reconfiguring role based access control policies using risk semantics[J]. Journal of High Speed Networks, 15 (3): 261-273 (2006).



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