컨텐츠 및 모델의 효과적 관리를 위한 메타-지식 생성 메커니즘 연구

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요 약

글로벌 네트워크 시대에는 전세계적으로 흩어져있는 수많은 컨텐츠가 실시간으로 우리 생활의 스며들 것이며 그로 인해 많은 변화를 줄 것이다. 아울러 컨텐츠 및 다양한 모델 제공 업체들의 환경은 급속하게 변화할 것이다. 인터넷이나 무선인터넷으로 컨텐츠나 모델들을 적시에 활용할 수 있는 점은 기업측면에서 의사결정 프로세스를 변화시키며, 공급체인 상에서 많은 기업들이 자신들의 의사결정에 필요로 하는 정보나 모델을 짧은 시간에 탄력적으로 제공 받을 수 있어서 기업이 환경변화에 대한 높은 대응력을 갖출 수 있게 한다. 이 논문은 컨텐츠와 모델을 필요로 하는 기업들에게 효과적이면서 효율적으로 제공하기 위한 메타지식의 생성 메커니즘을 제안하는 것이다. 그리고 본 논문에서 제안한 메커니즘을 통해서 실험결과를 얻었으며, 그 결과를 가지고 이 논문에서 제시한 탄력적인 컨텐츠나 모델 제공 이론이 인터넷이나 모바일 네트워크에서 요약된 모델 제공과 트래픽 감소 측면에서 매우 우수함을 보이고 있다.

A Study on Production Mechanism of Meta-knowledge for Effectively Managing Contents and Models

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ABSTRACT

On global interconnectivity, the activation of real-time and worldwide contents will permeate and impact all aspects of day-to-day life well throughout this century. In managing contents and models, we too will see the impact of this rapidly changing environment. The real time availability of contents pertaining to a company's supply chain through means of the Internet and mobile networks (e.g., the IMT-2000) will necessitate a change in decision-making processes for effective management of contents and models. To increase the availability of many contents and models, a management system should have adaptive function in providing adequate content and model for companies. In the respect of management of contents and models, this paper discusses a production mechanism of meta-knowledge for effectively managing contents and models. Through two experimental analyses with the production mechanism, it is proven that the system enabling adaptive contents and models provision goes beyond existing ones in view of efficiency of management of contents and models in the wire and wireless networks.

키워드 : 생산 메커니즘(Production Mechanism), 탄력적 컨텐츠 및 모델 제공자(Adaptive Contents and Models Provider), 메타 지식(Meta-knowledge)

1. Knowledge and Meta-knowledge in Managing Contents and Models

On global interconnectivity, the activation of real- time and worldwide contents will permeate and impact all aspects of day-to-day life well throughout this century. In managing contents and models, we too will see the impact of this rapidly changing environment. The real time availability of contents pertaining to a company's supply chain through means of the Internet and mobile networks (e.g., the IMT-2000) will necessitate a change in decision-making processes for effective management of contents and models. To increase the availability of many contents and models, a management system should have adaptive function in providing adequate content and model for companies. So it needs function of managing contents with knowledge.

A Knowledge-based system(KBS) is a computer system

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that provides a way of formalizing and automating knowledge. A KBS mimics the behavior of human experts by encapsulating their heuristics and expertise to solve problems in a particular domain. From a business viewpoint, a KBS usually has "friendly characters" in their systems and a variety of benefits as follows : retaining knowledge even after an expert leaves ; used for on-the-job-training programs ; able to improve the consistency of decisions ; increasing the availability of expertise and the promotion of 'knowledge sharing'.

KBSs have been extensively used in various areas of business. Each application is a functional business area of which prototyped or developed KBSs have been well designed. The distribution of the research by application area has been well summarized by Neches et. al. (1991), Roanes-Lozano et. al. (2000), Quah, et. al., (1999) and Wong et. al.(1995). According to their surveyes, the areas of production and operations, finance, and information systems represent a majority of the total number of the articles published (85.8%). The most heavily researched area is production and operations (59.5%) while the least is human resources (2.1%). KBSs, from the perspective of optimization model integration, have inspired much research.

Let us explain knowledge-based systems and optimization models that have inspired numerous studies. Model management researchers have pursued the integration of the two models. For integration, three important types of knowledge role of model management area are considered : knowledge to assist a user to model, knowledge as involvement in the solution step, and knowledge to assist the system to adjust to a new procedure that is appropriate to a user's level on modeling. In the first type, a knowledge base system contributes to the formulation of an optimization model (Geoffrion, 1989 ; Krishnan, 1992). In the second type, the knowledge of the system helps it find the solution method appropriate to a model or helps adequately change a primary model to the relaxed model of it used for the solution method (Lee et al., 1995). And finally, the third type means that, to consider the variety of user levels, a procedure for constructing new model should be produced to reflect multi-tier levels of users. To do that, we should use meta knowledge representing relationships between models.

The remainder of this paper is organized as follows : In the next section, it proposes an ontology for contents and models, and semantically the representation for the ontology needs two kinds of knowledge : individual model knowledge and meta-knowledge. In the following section, the paper proposes two providing methods (sequential procedure and adaptive procedure) using the prototype ontology, and mostly focus on adaptive procedure. In section 4, the overall architecture of the production mechanism for meta-knowledge is suggested. In section 5, through two experimental analyses with the production mechanism, it is proven that the system enabling adaptive contents and models provision goes beyond existing ones in view of efficiency of management of contents and models in the wire and wireless networks.

2. An Ontology for Contents and Models

To represent semantically an ontology for contents and models, this section explains two kinds of knowledge, individual knowledge and meta-knowledge.

Individual model knowledge is about specific model (e.g. supply chain model) and is shown as the set of frames that represents each object containing information about a problem.

To be able to adaptive provision for models, this study proposes embedded relationships between models as meta knowledge. And the knowledge can be used in several purposes : construction of a model, identification of its structure for a model, and selection of the solution method appropriate to it. To generate the relationships from some models, an investigator that is a user in the web-based model system first investigates the relationships between models, and converts it into frames as a rule sequentially. This subsection shows the format for representations of the relationships with an illustrative example of network problems. The investigating process tends to be complex even though simple structure of a problem. So, it is assumed that the relationships are already prepared for adaptive modeling. Let's regard the study as other issue.

For the format for representation of the relationships, if two models belong to same set of problems and are subordinative each other, then one of both can easily be generated from the other by using a structural chunk in level of a constraint object. The chunk is abstraction for constraints all having same structure. In other words, two models above are the same in the structure of a chunk, but not same in the VALUE.

To be more specific for the subordinate, this paper explains the structure of a structural chunk. The chunk can be easier to understand than mathematical constraints, because it is shown as combination of nodes and arcs, not one of mathematical equations for the set of network problems. Following is the format of the chunk.

```
{{chunk_1
    (IS-A : constraint_chunk
    (INDEX : source/transfer/destination/commodity/path/hup)
    (CONDITION : more/less/equal/gain)
    (VALUE : integer number)
    (DISTINCTIVENESS : conservation/tour/hub)}}
```

3. Effective Management of Models

Model provision in the system (e.g. supply chains) is a procedure that builds a model as semantic representation for a problem and provides it for distribution center's agent or plant's gent. The representation consists of five objects mentioned before and it is constructed by formulation reasoning process. And whether subordinative relationships in model provision are used or not, it selects one of two procedures : sequential model provision and adaptive model provision.

And following six steps for sequential model provision is explained.

(step 1) Decide a type of *decision_variable* of a problem to be done

(step 2) Select an adequate component from the set of *node* object

(step 3) Select an adequate component from the set of *link* object

(step 4) Decide a type of *objective* of a problem.

(step 5) Select one or more adequate components from the set of *structural_constraint* object

(step 6) Make a data set to be inputted to new model

And, this paper proposes the following seven steps as adaptive model provision with the relationships, and enables readers to be understandable about the procedure with an example of network models in section 4.

(step 1) Display five objects (*objective, node, link, structural_constraint,* and *decision_variable*) to get information related to an agent's problem.

(step 2) Interpret the information to extract a structural chunk most suitable to it.

(step 3) Get sequentially information of object related to each of components of the chunk, and build new model after that.

(step 4) If the chunk involved in new model is different from chunks in the database, Update the relationship knowledge with new one.

(step 5) Get the data of the problem from the agent or a database to get optimal solution for the problem.

(step 6) Identify "DISTINCTIVENESS" of new model by using the identification rules.

(step 7) After identifying it, select a solution method adequate to new model.

4. Production Procedure of Meta-knowledge for Contents and Models

Following procedure describes the repeat communications between a System (in AMP/SCM) and an Agent (in distribution center), for instances, trying to find a way to delivery products into retailers as fast as it could.

(step 1) Display five objects (*objective, node, link, structural_constraint,* and *decision_variable*)
[Agent] Input "COST_MINIMIZATION_FLOW" as the objects, *objective.*

(step 2) Interpret the information, "COST_MINIMIZATION_FLOW", and extract a structural chunk, "*conservativation_constraint*", most suitable to it.

{{conservation_constraint
(IS-A : structural_chunk
(INDEX :)
(CONDITION :)
(VALUE :)
(DISTINCTIVENESS : *conservation*)}}

(step 3) Display the slots of the "*conservativation_constraint*" sequentially.

[Agent] Input the VALUEs in the slots. For examples, it's assumed that following frame is completed.

{{conservation_constraint
(IS-A : structural_chunk
(INDEX : source/destination)
(CONDITION : equal)
(VALUE : one)
(DISTINCTIVENESS : *conservation*)}}

[System] Display the slots of the "*limitation_constraint*".

[Agent] Input the VALUEs in the slots. The agent inputs the VALUE of following slots in the limitation_constraint.

{{*limitation_constraint*
(IS-A : LIMIT_CONSTRAINT
(LOWER_BOUND : 0)
(UPPER_BOUND : infinite)}}

(step 4) Because the chunk involved in new model is not different from chunks in the database, it doesn't have to update the relationships.

(step 5) Display the items to get the data.

[Agent] Input the data into the items.

(step 6) Identify the characteristics of new model by using the identification rules. The following shows illustrative rules for identifying the characteristics.

(RULE shortest_path_structure_rule
[RULE_GROUP MODEL]
IF (IS CONSTRAINT.DISTINCTIVENESS
'amount_of_source_constraint)
(IS CONSTRAINT.DISTINCTIVENESS
'amount_of_destination_constraint)
(IS CONSTRAINT.DISTINCTIVENESS
'amount_of_transfer_constraint)
(IS CONSTRAINT.DISTINCTIVENESS
'lower_bounded_flow_constraint)
(IS CONSTRAINT.DISTINCTIVENESS
'upper_bounded_flow_constraint)
THEN (IS DISTINCTIVENESS
'pure_minimum_cost_flow_structure))
....

(step 7) [System] After identifying it, select a solution method appropriate to new model by using following rules.

(RULE Connection_into_Hungarian_Method
[RULE_GROUP NETWORK_FLOW_PROBLEM]
IF (IS DISTINCTIVENESS OF
NETWORK_MODEL
('DISTINCTIVENESS
'Assignment_Problem_Structure))
(AND (EXIST 'Hungarian_Method))
THEN (IS SOLVER 'Hungarian_Method))
....

Through above seven procedures, the system have found that the structure of new model is shortest_path_structure and the suitable solution method for it is Dijkstar method, and provides them for a agent in distribution center.

5. Experimental analysis

This experiment proceeded in a supply chain system, which has two distribution centers (two agents), one plant(a agent), and four retailers. Several numbers in first row indicate the number of models that three agents would require in a day. Following figure is a result of comparison between two procedures : adaptive model provision and sequential model provision.

Through (Figure 1), we can summary meanings as follows.

(1) In all aspects (traffic, process time, and waiting time), the procedure of AMP is absolutely more predominant than one of SMP. (2) The waiting time in SMP is more increasing as the number of models becomes large. That means that SMP has no benefit in timely providing models for agents. And the rate (wating time / number of models) is decreasing even though models agents require are too many. (3) This idea plays an important role in the aspect of real-time supply chain systems. In other word, model provision services of AMP through global interconnectivity supply a wealth of real time and up-to-date model related information.

Classification		50 models	100 models	200 models	400 models	800 models
SMP	Traffic	929	1635	3325	7200	15500
	ProcessTime	97	183	377	721	1560
	WaitingTime	20	46	106	238	608.4
AMP	Traffic	167	305	521	988	1620
	ProcessTime	41	72	90	165	289
	WaitingTime	9	18	25	51	86

* SMP : Sequential Model Provision,
AMP : Adaptive Model Provision
Traffic : number of frames transferred between AMP/SCM and agents (in distribution center and plant)
Process Time (Minute) : the time that AMP/SCM spends to provide models
Waiting Time (Minute) : total of the time that agents wait for receiving required models

(Figure 1) Comparison between SMP and AMP

6. Concluding Remarks

This study has shown the following contributions :

(1) Suggestion of ontology for contents and models, and semantically the representation for the ontology needs two kinds of knowledge : individual model knowledge and meta-knowledge.
(2) Proposition of the concept of adaptive provision for models and the procedure of it.
(3) Construction of prototype of a production mechanism.
(4) Through experimental analysis, it is proven that the system capability goes beyond existing ones in real-time and adaptiveness over global interconnectivity environment.

References

[1] Byrd, T. A. "Implementation and use of expert systems in organizations : perceptions of knowledge engineers," *Journal of Management Information Systems* 8(8), pp.97-116, 1992.

[2] Dutta, S. "Strategies for implementing knowledge-based systems," *IEEE Transactions on Engineering Management* 44(1), pp.79-90, 1997.

[3] Engelmore, R. S., "Knowledge-based systems in Japan," Baltimore, *Japanese Technology Evaluation Center*, 1993.

[4] Gavish, B. P. "Topological design of telecommunication networks-local access sesign methods," *Annals of Operations Research*, 33, pp.17-71, 1991.

[5] Geoffrion. A. M., "The formal aspects of structured modeling," *Operations Research*, 37(1) 1989.

[6] Gruber, T. R., "The role of standard knowledge representation for sharing knowledge-based technology," *Stanford University, Knowledge Systems Laboratory, Technical Report* KSL-90-53, 1990.

[7] Gruber, T. R, J. M. Tenenbaum, J. C. Weber, "Toward a knowledge medium for collaborative product development," *Proceedings of the Second International Conference on Artificial Intelligence in Design (Pittsburgh)*, Kluwer Academic, pp.413-432, 1992.

[8] Heijst, G., M. Hofman, E. Kruizinga, R. van der Spek, "AI-Techniques and the knowledge pump," *Proceedings of the AAAI Spring Symposium on Artificial Intelligence in Knowledge Management*, Stanford University, Palo Alto, pp.168-171, 1997.

[9] Kalakota, Ravi, Jan Stallaert, Andrew B. Whinston, "Implementing realtime supply chain optimization systems, global supply chain and technology management," *Production and Operations Management Society*, 1998.

[10] Kim, Chulsoo, and Jae K. Lee, "UNIK-RELAX : A Generator of the Lagrangian problem and its application to the distributed database systems," *Expert Systems with Applications*, 12(3), 1997.

[11] Krishnan, R., X. Li, and D. Steier, "A Knowledge-based mathematical model formulation system," Communications of the ACM 35(9), 1992.

[12] Lee, J. K., Y. U. Song, "Unification of linear programming with a rule-based system by the post-model analysis approach," *Management Science*, 41(5), pp.835-847, 1995.

[13] Neches, R., R. Fikes, T. Finin, T. Gruber, R. Patil, T. Senator, W.R. Swartout, "Enabling technology for knowledge sharing," *AI Magazine* 12(3), pp.16-36, 1991.

[14] Roanes-Lozano, E., et. al., A Grobner bases-based Shell for Rule-based xpert Systems Development, *Expert Systems with Applications*, 18, pp.221-230, 2000.

[15] Tsai, Yao-Chuan, "Model integration using SML," *Decision Support Systems*, 22, 1998.

[16] Wong, B. K., J. A. Monaco, "Expert system applications in business : A review and analysis of the literature," *Information and Management* 29, pp.141-152. 1995.

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