MODELING ONTOLOGY-BASED TASK KNOWLEDGE IN TTIPP

KWOTING FANG
Department of Information Management
National Yunlin University Of science and Technology
123 university road, section 3, Douliou, Yunlin, TAIWAN
R.O.C

Abstract: -The main purpose of this study was twofold. First, it adopted the theory of task ontology to build up a three-level mediating representation for a task analysis and the task of "Manage goods and materials" served as an example. Five phases, task analysis, task ontology, IDEF0 model, Petri net model, and PNML, are displayed for domain experts and can further transfer for computer to generate code. Second, from modeling standpoint, a methodology, called TTIPP, was provided to systemically analyze the process of the task and subtask, in terms of the inputs, outputs, mechanisms, controls, using IDEF0 and Petri net.

It is hope that the results of task knowledge on emergency response for Debris-flow, represented by ontology, can give valuable and reusable problem solving process knowledge for person with the similar goals.

Keywords: -Task Ontology, IDEF0/Petri net, TTIPP

1 Introduction

Way back in the past decade, there were many massive-scale earthquakes that shocked the world, such as the earthquake that shook Northridge, United States in 1994 and the great earthquake of Hanshin-Awaji, Japan in 1995. And unfortunately in 1999, the 9-21 Earthquake hit Chi-chi, Taiwan and another one hit Izmit and Istanbul , Turkey. In 2001, a quake shook BHUJ, India. Then in 2003, a series of earthquakes shook the world, hitting first Altay, Russia; Boumerdes, Algeria; Hokkaido, Japan; Bam, Iran; and at the end of December 2004, Southern Asia.

The velocity and dynamic nature of the global environment, in terms of the progress of the industry, has driven a serious damage and brought exhaustive resources in our Earth environment. A lot of efforts have been spent on global sustainable development around the world, however, the systematic and practical standpoints for the Incident or Hazard Command System (IHCS), especially on emergency response for Debris-flow, is spare in Taiwan. Taiwan lies on the typhoon and earthquake belts, which makes the country vulnerable to natural calamities.

Thus, the call for the government to reduce the enormous losses brought about natural calamities and share, copy, and reuse prior or existing knowledge in a complex IHCS, as a means of sustainable development over time in a community, becomes loud.

The work presented in this paper is part of a large project, supported by National Science Council in Taiwan, aimed at developing a comprehensive and dynamic IHCS framework capable of enhancing the probability of project success, and to lead the country to establish practices that are self-sustaining with the expanding impacts of community, grounded in systematic and effective knowledge capture, reuse, sharing and learning.

2 Related Work

2.1 Knowledge Management

In the past decade, perhaps, the most dramatic evolution, a new agenda, in business is the dawn of the new economy [9]. A hallmark of the new economy is the ability of organization to increasingly recognize that in the post-industrial era, an organization success is determined mainly by economic value from their collection of intellectual assets as well as their assets of information, production distribution, and affiliation.

In order to achieve competitive sustainability, many organizations are launching extensive knowledge management efforts and relying heavily on knowledge creation. Unfortunately, due to lack of absorptive capacity, many knowledge management projects are, in reality, information projects [23]. Gold et al. further indicated that when these projects yield some consolidation of data but little innovation in the ability to use prior knowledge, and create new knowledge, the concept of knowledge management is cast in doubt. In essence, from viewpoint of combination and exchange, the quest to move beyond information management and into the realm of knowledge management is a complex undertaking involving the development of knowledge structure that allow the organizations to recognize, create, transform, and distribute knowledge effectively.

Musen [19] pointed out that one of the major shortcomings of the current technology for knowledge based building is lack of reusability and sharability of knowledge. This makes it difficult to build knowledge bases, since one always has to build them from scratch, "what he/she believe" and ignore the actual and potential resources embedded within, available through, and derived from the "justified true believe". Clearly, facilitating knowledge usable and useful thus should contribute to making it easier to build knowledge bases and to fit to the use-context. In order to achieve this, Mizoguchi et al. [18] indicated that expertise could be decomposed into a task-dependent but domain-independent portion and a task-independent but domain-dependent portion. The former is called task knowledge, formalized the knowledge for problem solving domain-independently.

2.2 Task Ontology

At the end of the 20th century and the beginning of the 21th, ontologies have emerged as an important and increasing interest research area in a variety of academic setting. This phenomena stem from both their conceptual use of organizing information and their practical use in communicating about system characteristics [8].

In general, an ontology can be viewed as an information model that explicitly describes the various entities and abstractions that exist in a universe of discourse, along with their properties [11]. Moreover, an ontology is a partial specification of a conceptual vocabulary to be used for formulating knowledge-level theories about a domain of discourse. From system standpoint, ontologies provide an overarching framework and vocabulary to describe system components and relationships for communicating among architecture and domain areas [7]. Therefore, the more the essence of things is captured, the more possible it is for the ontology to be shared [10].

Ontologies and problem solving methods (PSMs) have been created to share and reuse knowledge and reasoning behavior across domains and tasks [10]. In general, ontologies are concerned with static domain knowledge, a given specific domain, while PSMs deal with modeling reasoning processes, described the vocabulary related to a generic task or activity. Benjamins and Gomez-Perez [1] defined PSMs as a way of achieving the goal of a task. It has inputs and outputs and many decompose a task into subtask, and tasks into methods. In addition, a PSM specifies the data flow between its subtask.

Given the definition from Guarino [12], task ontology is an ontology formally specifying the terminology associated with a problem type, a high-level generic task which characteristics generic classes of knowledge-based application. Chandrasekaren [5] also defined task ontology as " a base of generic vocabulary that organizes the task knowledge for a generic task". From the problem solving viewpoint, Newell [21] illustrated that task ontology can be used to model the problem solving behavior of a task either at the knowledge level or symbol level.

3 Research Methodology

In this section we present the TTIPP (Task analysis, Task ontology, IDEF0, Petri net, PNML) framework, shown as Fig.1, to organize and model the task knowledge acquire during the knowledge acquisition activity, using external resources and implement XML-based languages in which the task ontology will be formalized and implemented. TTIPP framework aimed at not only reducing the brittle nature of traditional knowledge-based system, but also enhancing the knowledge reusability and sharability over different applications. Furthermore, based on Rajathak et al. [22] suggestions, three important issues, including appropriate level of generality, domain independent knowledge representation, domain expert perspicuity, were considered while developing the task ontology. Also, according to the analogy of natural language, TTIPP was composed three layers and five phases. The top layer is called "lexical level model" mainly deals with the syntactic aspect of the problem solving description in terms of the task analysis phase and task ontology phase were presented. The middle layer is called "conceptual level model" captures conceptual level meaning of the description, IDEF0 model phase and Petri net model were shown in this layer. The bottom layer is called "symbol level model", with PNML phase, corresponds to runnable program and specifies the computational semantics of the problem solving.

Phase-I: The Task Analysis

During the first phase of development the nature task needs to be analyzed thoroughly at a fine-grained level with diverse information needs. The structure, semi-structure, or even unstructured knowledge could be acquired and elicited from the various sources such as, the available literature on the task, the test cases specific to the problem area, the actual interview of the domain experts, the previous experience in the field etc. Ikeda et al. [13] pointed out that task analysis is made according to two major steps: (1) rough identification, and (2) detailed analysis. Based on the various sources of knowledge, rough identification of task structure is a classification problem and detailed task analysis however is to interact with domain experts and articulate how they perform their task.

Phase-II: Conceptualization of the Task Ontology

Detailed level of the concept is indispensable for task knowledge description. Thus, this stage is generic in the sense that it gives the fundamental understanding about the relations among different concepts. Also, in according with the elicited concepts given in the previous phase, this stage provides the knowledge or ontological engineer an idea about the important axioms that needs to be developed in order to decide over the competence of the task ontology. From the standpoint of granularity and generality, Ikeda et al.[13] suggested that lexical level task ontology should consist of four concepts: (1) Generic nouns representing objects reflecting their roles appearing in the problem solving process, (2) Generic verb representing unit activities appearing in the problem solving process, (3) Generic adjective modifying the objects, and (4) Other words specific to the task. Fig.2 presents a hierarchy of lexical level task ontology.

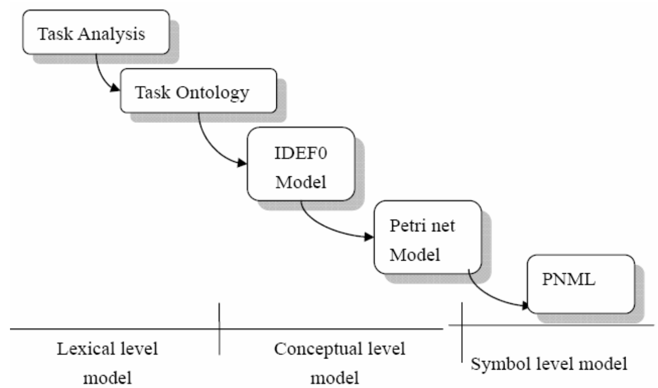

Fig.1 Research Framework

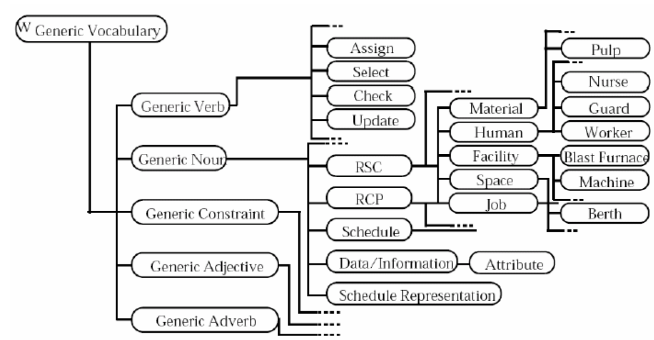

Fig.2 Lexical level of Task Ontology

Phase-III: IDEF0 Model

During this phase, task ontology in the research framework can be operationalized by using the formal modeling language tool. It transforms the concepts described at the natural language level into the formal knowledge modeling level in terms of structured graphical forms. Multi-level model with different classes and relations can be created in order to formalize the complex problem into being simple and more detailed to understand at each individual level based on its input parameters. Thus, the input parameters, altered by the activity or function, identified at each level can be modeled in such a way that the expected output to the problem can be achieved. IDEF0 is an activity-oriented and has been widely used modeling approach [9]. Its diagram based on a simple syntax, as showed in Fig.3, contains of an ordered set of boxes representing activities performed by the task.

Phase-IV: Petri net Model

Broadly speaking, the IDEF0 has a number of disadvantages in terms of its time-based function, including cumbersomeness, ambiguity in activity specification, and perhaps most significantly, its static nature [6]. Petri nets (PN) has emerged over the last ten years as a powerful tool especially suitable for systems that exhibit concurrent, conflict, and synchronization [15]. A Petri net necessarily consists of three entries: 1) the place, drawn as a circle, 2) the transition, drawn as a bar, and 3) the arcs, connecting places and transitions, as shown in Fig.4(a) [7]. Generally, the PN is defined as follows [4]:

PN = ($P, T, A, W, M0$)

where,

$P = \{P1, P2, ..., Pm\}$ is the finite set of places;

$T = \{T1, T2, ..., Tn\}$ is the finite set of transitions with $P \cup T \neq \emptyset$ and $P \cap T = \emptyset$;

$A \subseteq \{P \times T\} \cup \{T \times P\}$ is the set of arcs between The places and transitions;

$W: A \rightarrow \{1, 2, 3, ...\}$ is the weight function on the arcs;

$M0 : P \rightarrow \{0, 1, 2, 3, ...\}$ is the initial marking.

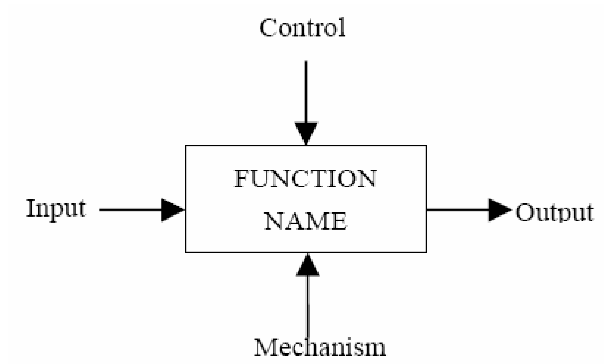

Fig.3 Component of the IDEF0

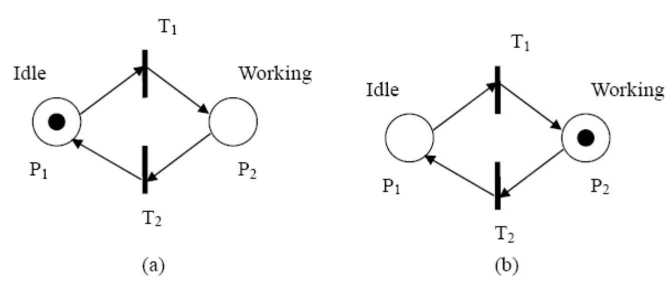

Fig.4 Component of Petri net Model

Phase-V: Petri Net Markup Language

The Petri Net Markup Language (PNML) is an XML-based interchange format for Petri nets. It is designed to be a Petri net interchange format that is independent of specific tools and platforms. Moreover, the interchange format needs to support different dialects of Petri nets and must be extensible.

4 The Application Domain

Sustainable development is a complex problem especially Incident or Hazard Command System which requires collaboration and participation from national level to local communities. The area of Homchu at Natou county, located at central Taiwan, where has ever caused significant disasters from earthquake on 21st September in 1999 and from debris flow in past two decades was chosen as a research site of local communities. Focusing on safety and the sustainability of lives and livelihoods, residents of Homchu involved of the community in a participatory way in owning both the problem and solution for the natural calamities. Six stakeholders (different team leaders) involved in the Incident or Hazard Command System (IHCS) operations were invited to share their experience and also reconfirmed the content of their interview.

Based on the suggestion of Ikeda et al, [1998] task knowledge of Incident or Hazard Command System (IHCS) operations from a variety of sources such as, the available literature, and the interview of the domain experts was analyzed for the lexical level task ontology. Normally, there are four IHCS stages: Mitigation (A1), Preparedness (A2), Response (A3), and Post-disaster Reconstruction (A4). Due to the complex and dynamic nature of problem solving methods for IHCS, emergency response (A3) of debris flow was chosen to serve as an example for presenting the TTIPP framework.

At the modeling stage, the IDEF0 model is built for describing the function of the emergency response. From a functional point of view, the present emergency response has six activities as shown in Fig.5. The six activities are “Establish an advance command post” (A31)、”Monitoring of any possible disaster locations” (A32)、”Evacuation of residents” (A33) 、 ”Urgent repair on construction” (A34)、”Emergency rescue for casualties”(A35) and “Manage goods and materials” (A36).

For being simple to understand purpose, the hierarchical decomposition of each activity into sub-activities was performed to reveal more detail at each level. "Manage goods and materials" (A36), served as an example, was deco posited into four sub-activities: "Collect goods and materials " (A361)、" Keep goods and materials " (A362)、" Tally the goods and materials " (A363)、 and "Provide goods and materials " (A364) as shown in Fig.6. The different mechanisms support the different sub-activities as shown in Fig.6. After obtaining the functional IDEF0 model, we can then develop the Petri net model for behavior analysis at next stage.

According to the six activities in the IDEF0 model built at previous stage, the PN model is constructed, as shown in Fig.7. The PN model consists of 15 places and 8 transitions, of which the corresponding notations for " Manage goods and materials"(A36) are described in Table 1.

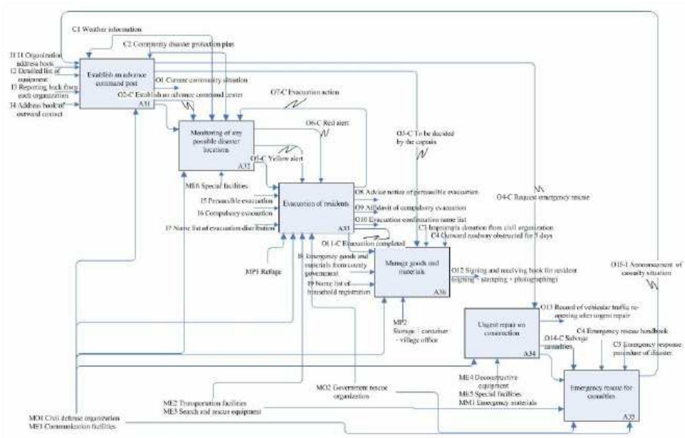

Fig.5. The IDFE0 model of the "Emergency response " (A3)

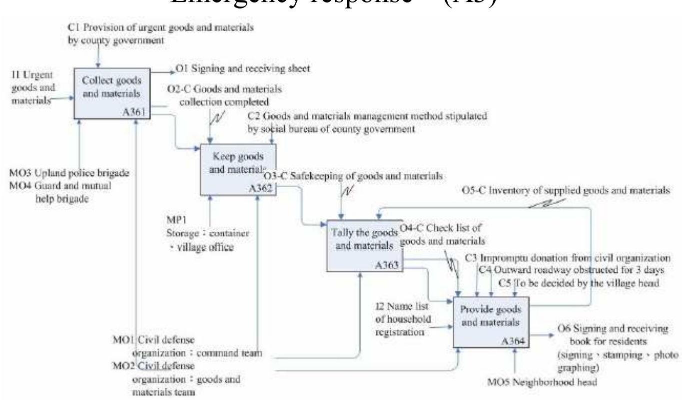

Fig.6. The IDFE0 model of the "manage goods and materials " (A36)

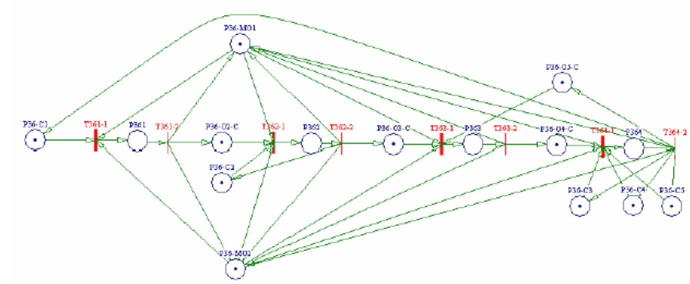

Fig.7. The PN model of the "manage goods and materials " (A36)

Table 1. The Notation of place and transition for "manage goods and materials" (A36)

Place	Name	IDEF0	Transition	Name	IDEF0
P1	P361	A361 Collect goods and materials	T1	T361-1	A361 Start collect goods and materials
P2	P362	A362 Keep goods and materials	T2	T361-2	A361 End Collect goods and materials
P3	P363	A363 Tally the goods and materials	T3	T362-1	A362 Start keep goods and materials
P4	P364	A364 Provide goods and materials	T4	T362-2	A362 End keep goods and materials
P5	P36-C1	C1 Provision of urgent goods and materials by county government	T5	T363-1	A363 Start tally the goods and materials
P6	P36-O2-C	O2-C Goods and materials collection completed	T6	T363-2	A363 End tally the goods and materials
P7	P36-C2	C2 Goods and materials arrangement method stipulated by social bureau of county government	T7	T364-1	A364 Start provide goods and materials
P8	P36-O3-C	O3-C Safekeeping of goods and materials	T8	T364-2	A364 End provide goods and materials
P9	P36-O4-C	O4-C Check list of goods and materials			
P10	P36-C3	C3 Impromptu donation from civil organization			
P11	P36-C4	C4 Outward roadway obstructed for 3 days			
P12	P36-C5	C5 To be decided by the village head			
P13	P36-O5-C	O5-C Inventory of supplied goods and materials			
P14	P36-MO1	MO1 Civil defense organization：command team			
P15	P36-MO2	MO2 Civil defense organization：goods and materials team			

5 Conclusions and Future Works

To bridge the understanding gap between the computer and human, we presented the TTIPP framework and its related methodologies. TTIPP consisted of three layers, including lexical, conceptual, and symbol, level model and five phases: task analysis, task ontology, IDEF0 model, Petri net model, and PNML, for task analysis problem and mediating representation based on task ontology. The IDEF0 model is used to capture the requirements corresponding to the system specification at the stage of functional analysis. Subsequently, at the stage behavior analysis, the Petri net model is constructed according to the IDEF0 model. Finally, at the implementation stage, the obtained model can be realized by using Petri net marked coding languages.

References:

[1] Benjamins, V. R. & Gomez-Perez, A. (n.d.). *Knowledge-System technology: ontologies and Problem-Solving Methods*, Retrieved December 13, 2004, from http://hcs.science.uva.nl/usr/richard/pdf/kais.pdf

[2] Berner-Lee, T., *Weaving the web: The original design and ultimate destiny of the world wide web by its inventor*, HarperCollins Publishers, NY, 1999.

[3] Billington, J. Christensen, S. van Hee, K. Kinder, E. Kummer, O. & Petrucci, L., *The petrinet markup language: Concepts, technology, and tools*, URL htto://www.informtik.hu-berlin.de/top/PNX/, 2004.

[4] Cassandras, C. G. & Lafortune, S., *Introduction to discrete event systems*, Boston, MA: Kluwer, 1999.

[5] Chandrasekaran, B, Generic tasks for knowledge-based reasoning the right level of abstraction for knowledge acquisition. *IEEE Expert*, 1(3), 1986, pp.23-30.

[6] Colguhoun, G. J. Baines, R. W. & Crossley, R., A composite behavior modeling approach for manufacturing enterprise, *International Journal of Computer Integrated Manufacturing*, Vol.9, No.6, 1996 pp.463-475.

[7] David, R, & Alla, H., Petri nets for modeling of dynamics systems—A survey, *Automatica*, Vol.30, No.2, 1994, pp.175-202.

[8] Dold, A. H. Malhotra, A. & Segars, A. H., Knowledge management: An organizational capabilities perspective. *Journal of Management Information System*, Vol.8, No.1, 2001, pp.185-214.

[9] Feldmann C. G., *The practical guide to business process reengineering using IDEF0*. New York: Dorset House Publishing, 1998.

[10] Gomez-Perez, A., Fernandez-Lopez, M. & Corcho, O, *Ontology engineering*. London: Springer, 2004.

[11] Gruber, T. R. A., A translation approach to portable ontology specification, *Knowledge Acquisition*, Vol.5, No.2, 1993, pp.199-221.

[12] Guarino, N., *Formal ontology and information system*, 1998, Retried December 6, 2004, from http://www.loa-cnr.it/Papers/FOIS98.pdf

[13] Ikeda, M., Seta, K., Kakusho, O. & Mizoguchi R., Task ontology: ontology for building conceptual problem solving models. *Proceedings of ECAI98 Workshop on Applications of ontologies and problem-solving model*, 1998, pp.126-133.

[14] Lassila, O. & McGuinness, D , The role of frame-based representation on the semantic web (KSL-01-02), *Knowledge System Laboratory*, Stanford University, Stanford, CA, 2001.

[15] Lee, J. S. & Hsu, P. L., An IDEF0/Petri net approach to the system integration in semiconductor manufacturing systems. *IEEE International Conference Systems, Man and Cybernetics*, Vol.5, 2003, pp.4910-4915

[16] Mizoguchi, R., Tijerino, Y. & Ikeda, M., Task ontology and its use in a task analysis interview system – Tow-level mediating representation in MULTIS, *Proceedings of the 2nd Japanese JKAW92*, 1992, pp.185-198.

[17] Mizoguchi, R., Tijerino, Y. & Ikeda, M., Task analysis interview based on task ontology. *Expert Systems With Applications*, Vol.9, No.1, 1995, pp.15-25.

[18] Mizoguchi, R., Vanwelkenhuysen, J. & Ikeda, M., Task ontology of reuse of problem solving knowledge. *Towards Very Large Knowledge Bases: Knowledge Building & Knowledge Sharing,* 1995*,* pp.46-59.

[19] Musen, M., Dimension of knowledge sharing and reuse, *Knowledge Systems Laboratory (report KSL-91-65)*. Stanford, CA: Stanford University, 1991.

[20] National Institute of Standards and Technology , Integration definition for function modeling (IDEF0), *FIPS 183*, 1993, Retrieved November 30, 2004, from http://www.itl.nist.gov/fipspubs/idef02.doc