

MANAGING COMPOUND INFORMATION USING INTELLIGENT AGENTS

Hiroshi Sugimura¹, Yoshiaki Takano², Yasushi Tanaka² and Kazunori Matsumoto^{1,2}

¹ *Course of Information and Computer Sciences, Graduate School of Kanagawa Institute of Technology*

² *Department of Information and Computer Sciences, Kanagawa Institute of Technology*

^{1,2} *1030 Shimo-ogino, Atsugi-shi, Kanagawa 243-0292, JAPAN*

ABSTRACT

This paper presents a framework for managing compound information by using agents. Various components of information are circulated in the Internet. They are created independently by different authors and distributed under different management policies. It however becomes hard to properly maintain the policy of a component once it is published in the Internet. Moreover components of compound information possibly have different policies so that it should be managed independently. In this paper, we deal with a component of information as a mobile, autonomous and intelligent agent which includes knowledge to control itself. In this setting, a circulation of a document is formalized as a chain of migrations of the corresponding agent. An agent monitors itself and maintains its policy inviolate during its lifecycle, thus its inherent properties can be preserved. In this framework, a compound information becomes a new agent that is built up with a combination or migration of agents. Similar to the simple agent case, a compound agent has its policy to maintain its right. The entire policy is maintained by combinations of agent's cooperation. In this paper, we also explain a policy description language having the similar syntax to ACL, which is also based on the speech act theory.

KEYWORDS

Mobile agent, compound information, policy.

1. INTRODUCTION

Information management over the Internet is a complex, and becomes a broadly scoped crucial problem. We focus the discussion in this paper on the information that is handleable with a usual computer, thus say the terminology of document, with the broadest sense, instead of information. An existing document management system [6,7], DMS for short, assumes that the environment is closed in a server computer, and the access is closed inside an intranet. Similar assumptions are also included in the case of the groupware technologies [2,12]. Thus these tools and concepts cannot be applicable directly to the case of documents over the Internet. This situation is illustrated in Figure 2 of the next chapter.

The notion of compound document has relatively long history, and is widely spread in current computing environments. Various types of components including texts, images and videos, which are independently created, can be combined together, and they build up one compound document. Several software frameworks provide basic abilities to handle compound documents. In a standard definition, a compound document is consists of two different parts, which are content and applications to handle them. Contents are maintained in the component, however, the application are often not. We thus need to externally prepare the application to handle the contents. In several studies [1,7,8], propose mechanisms to escape from this problem by using agents. The idea of agents [4,11] is derived from the one of objects, which [4] includes internal data and methods that acts over the data.

A mobile agent [9,14] has ability to migrate to other computers over the Internet. Furthermore, mobile agents can accomplish a cooperative work, and can combine with other agents. In the mobile agent based approach, a compound document corresponds to a combination of agents, each of which is associated with a component in the document. In this approach, a use of a component can be modeled as a migration of the agent.

In the existing studies on compound documents using agents, the main purpose is to provide a certain environment that guarantees the applicability of a document. This means the necessary applications for document are always built in the corresponding agent.

We in this study emphasize a different perspective, and show an architecture based on the agent approach that protect the properties and rights of a document. This view point becomes important in a consideration of circulating documents over the Internet. Each creator of information has its own rights. He/she usually has a policy under which the rights is exercised. The policy must not be violated throughout the life cycle of the document. This protection inevitably is necessary an ability to continuously monitor the document and judge the validity of operations over it. We show an intelligent agent is effective for this purpose. The agents are realized on the technologies of artificial intelligence [10]. We explain an outline of agent based document management system that solves the issues mentioned in this chapter.

2. AGENT ARCHITECTURE

The left side part of (a) in Figure 1 shows a rough illustration of a document management using mobile agents, and the right side part is a typical conceptual sketch of traditional one. The DMS runs in a server computer and manages and protects a document D inside it with a list L of predefined policies and rules, which are also managed inside DMS. Once D is downloaded or copied into another computer, it goes beyond the control of DMS. On the other hand, agent G keeps inside not only a document D but also L , and G continuously controls D depending on L . After a completion of download or copy, which corresponds to a migration of G in this case, the combination of D and L remains so that the control is still effective.

We briefly explain, by using (b) in Figure 1, an architecture that realizes agent based management of compound documents. The base of this architecture is an agent platform P . Many studies develop [13] middle-wares or frameworks which are applicable to P . A mobile agent can move to any computer on which the platform P runs, thus P becomes the field of agent activities. In principle, an agent can migrate to any field where P is implemented. The inference engine E interprets the knowledge stored in the knowledge-base KB , and intelligent behaviors of agents are induced on the resulting inference derived from KB . The knowledge is separated into several categories, for example that of general-purpose, of migration, of cooperation with others, of domain specific, and so on. Then, in practice, it is convenient to manage it according to the structure corresponding to these categories. Tools that perform validation and optimization are also attached to KB . PL stores a set of policies that is necessary to protect the content during the life cycle of the agent. As we describe in the successive section, a description language is developed for this purpose. The policy wall PW with the engine E , KB , and PL .

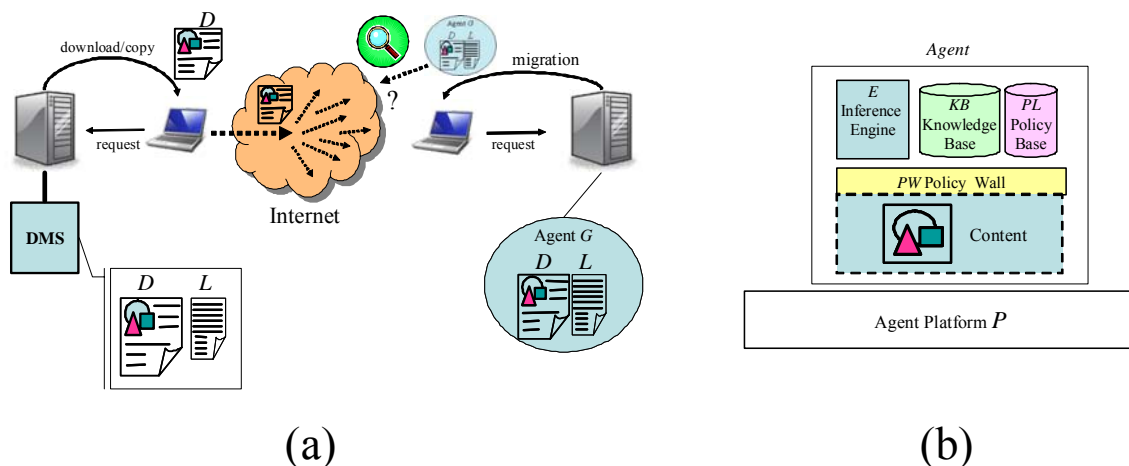


Figure 1. DMS and Agents

2.1 Circulation of Information under Policies

As we explain in the above, a document circulation, if it means a mere copy of the information without any restriction, is realized as a simple migration of an agent. In practical situations, a circulation includes more complex concepts, and its realization requires a combination of primitive tasks. Even in the case of document copy, there exist some types of restrictions including an allowable maximum number of copies, a possible scope, possible persons, and so on. These restrictions are decided mainly by the initial creator of a document, and the agent corresponding it must maintain the restrictions regardless its location. The set of restriction of a document becomes the management policy, hereafter we simply say policy. A compound document consists of separate parts that are independently created and thus have different policies. This requires painstaking mechanism to properly maintain them.

We devise a policy description language that is an extension of ACL [11,13], which is the standard language for agents communications. Although several studies [3,4] also provides languages for policy description, our proposal uniquely covers wide ranges of concepts of document managements. Similar to ACL and other famous agent languages, our language is based on the speech act theory [11]. The essential point of the theory is to treat a communication as an action. In ACL, a performative specifies the intension of an action, and the parameters of it add further information that is necessary to complete the action. Our language also deals with a primitive operation, such as copy, download, replace, erase, etc., on a document as an action. For example, the performative *copy* means a agent's intension that wants to take an action of copy, and the parameter adds detail restrictions such as a source or destination of this action. Other operations can be defined in a similar way. In this approach, a policy becomes a set of rules that responds to a given performative with the parameters. In some situations, a conversation is invoked, which is similar to the usual ACL case, to obtain further information about the given performative. A protocol is useful to define such the conversation.

2.2 Template Agent

The idea of variable document [5] is relatively new. A variable is object which can be replaced with other component including another compound document. By using this, we can modify a compound document according to a given situation. In Figure 3, D, which is a part of A in the original compound document, is converted the variable x . A template agent is associated with a document having a variable. We show an example of its structure in the figure, where the dotted rectangular corresponds to the variable that also becomes an agent. Reusability of documents is increased with this invention.

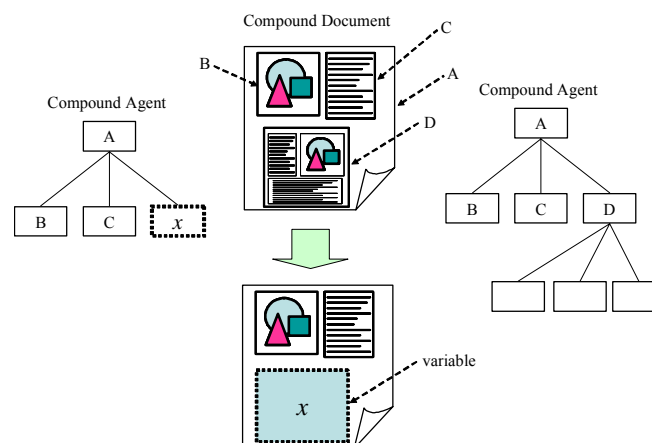


Figure 2. Compound Document with Variable

3. CONCLUSION

This paper presents a framework for managing compound information by using mobile intelligent agents. In this framework, a document corresponds to an agent, and basic circulation operations on documents are interpreted as operations on agents. Typically, a copy or download is expressed as a migration of agents. A document is called a compound one when it is built up by combining other components or documents. We show a method to deal with a compound document as a combined agent that is hierarchically combined agents.

One of the main purpose of the framework is to provide a mechanism that guarantee the inherent rights and properties of a document which corresponds to the agent. We point out the importance of policy, and define a language for policy description. Similar to ACL, the language is based on the speech act theory, and then a request to a document/agent becomes a message to the agent. The agent obtains further information, if necessary, by make a conversation with other agents.

As we point out in the introduction, the ability of intelligent and autonomous behaviors is important. This means an agent is necessary to make a decision autonomously depending on its knowledge and making cooperation with other agents if needed. Agents should work even in uncertain and incomplete situations, thus mechanism of agent decision making need to express degree of uncertainty and accomplish logical inferences under the uncertainty. It further needs to have an ability to update the uncertainty degree in accordance with a change of situation. For this purpose we need to devise a logical inference system which can deal with uncertainty. This becomes a future work of the study.

REFERENCES

- Bellavista, P., Corradi, A., Montanari, R., and Stefanelli, C., Paolo Bellavista, Antonio Corradi, Rebecca Montanari, and Cesare Stefanelli, 2003, Policy-Driven Binding to Information Resources in Mobility-Enabled Scenarios, *The 4th International Conference on Mobile Data Management*, Vol.2574, pp. 212-229.
- David Pinelle, Carl Gutwin, and Saul Greenberg, 2003, Task analysis for groupware usability evaluation: Modeling shared-workspace tasks with the mechanics of collaboration, *ACM Trans. Comput.-Hum. Interact.*, vol. 10, No.4, pp. 281-311.
- Fuyuki Ishikawa, Nobukazu Yoshioka, Yasuyuki Tahara, and Shinichi Honiden, 2007, A Hierarchical Mobile Agent Framework and Its Application to Multimedia Contents, *Systems and Computers in Japan*, Vol. 38, No. 1, pp. 1-17.
- Fuyuki Ishikawa, Nobukazu Yoshioka, Yasuyuki Tahara, and Shinichi Honiden, 2005, Mobile and Cooperative Compounds of Multimedia Services, *The 2005 IEEE International Conference on Services Computing (SCC2005)*, Orlando, U.S.A., pp.129-136.
- John Lumley, Roger Gimson, and Owen Rees, 2008, Configurable editing of XML-based variable-data documents, *DocEng '08: Proceeding of the eighth ACM symposium on Document engineering*, New York, U.S.A., pp.76-85.
- Mark Ginsburg, 1999, An Agent Framework for Intranet Document Management, *Autonomous Agents and Multi-Agent Systems*, Vol.2 No.3, p.271-286.
- Mark Ginsburg, 2000, Intranet Document Management Systems as Knowledge Ecologies, *33rd Hawaii International Conference on System Sciences*, Vol.3, pp. 3017-3026
- Martin S. Lacher, and Michael Koch, 2000, An agent-based knowledge management framework, in *Proc. AAAI Spring Symposium 2000*, California, U.S.A., pp. 145-147.
- Masahito Kurihara, and Masanobu Numazawa, 2003, Logic for multi-path message forwarding networks for mobile agents, *Proceedings of 14th International Symposium on Methodologies for Intelligent Systems*, Maebashi, Japan, pp.374-383,
- Nils j. Nilsson, 1998, *ARTIFICIAL INTELLIGENCE: A New Synthesis*, Morgan Kaufmann, CA, U.S.A.
- Peter Braun, and Wilhelm R. Rossak, 2005, *Mobile Agents. Concepts, Mobility Models, and the Tracy Toolkit*, Dpunkt.Verlag GmbH, Heidelberg, Germany.
- Renata Mendes de Araujo, Flavia Maria Santoro, and Marcos R. S. Borges, 2004, A conceptual framework for designing and conducting groupware evaluations, *Int. J. Comput. Appl. Technol.*, Vol.19 No.3/4, pp.139-150.
- Steven L. Waslander, 2009, *Multi-agent System Design*, VDM Verlag, Saarbrücken, Germany.
- Tomas Liska, and Pavel Tvrdik, 2002, INTELLIGENT MOBILE AGENT BASED E-AUCTIONS, *IADIS International Conference WWW/Internet 2002*, Lisbon, Portugal, pp.209-216.