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December 2001

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### Recommended Citation

Zhang, Hong; Kim, Dan; and Ramesh, Ram, "Multiagent Systems: An Ontological Meta-model" (2001). *AMCIS 2001 Proceedings*. 81.  
<http://aisel.aisnet.org/amcis2001/81>

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# MULTIAGENT SYSTEMS: AN ONTOLOGICAL META-MODEL

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## Abstract

*There exist many multiagent systems. However, a lack of standards for agent architecture results in serious compatibility and interoperability problems among heterogeneous agents. In this research, we develop an ontological meta-model for the design of multiagent architecture. The meta-model is termed RITA, which identifies four basic constructs in designing multiagent systems: role, infrastructure, taskflow, and agent. We intend to develop the RITA meta-model into a framework. Our final objective is to develop a design tool that designers can use to “stamp out” agents and integrate their schemas to suit their application needs.*

**Keywords:** Multiagent systems, ontologies, systems design, multiagent architectures, meta models

## Introduction

Although agent-based technology has expanded tremendously in the last decade, there is, as yet, little evidence of an ontological approach developed for designing multiagent systems. Many different multiagent systems exist nowadays. However, a lack of standards for agent architecture design results in serious compatibility and interoperability problems among heterogeneous agents. We have developed an ontology for designing multiagent systems based on pragmatic and theoretical approaches. Termed RITA (Role-Infrastructure-Taskflow Agents), the ontology abstracts itself from the existing different agent architectures and is refined by theories such as role theory, organization theory, and learning theory.

The objective of this research is to develop a design tool that designers can use to “stamp out” agents and integrate their schemas to suit their application needs. Section 2 describes definitions of the RITA ontology in detail. Section 3 provides overall conclusions and discusses our ongoing work.

## RITA: Ontological Foundations of Multiagent Systems

The objective of the RITA ontology is the conceptualization of the common constructs of multiagent systems, which are unaffected by application-specific demands. Several key dimensions are identified in agent and multiagent systems (Jennings, et al., 1998; Wooldridge and Jennings, 1995): *situatedness*, *autonomy*, *responsive*, *pro-active*, and *social*. The RITA ontology is designed to capture these dimensions. We differentiate four constructs in the RITA ontology: role, infrastructure, taskflow and agent. The infrastructure construct consists of two different types: knowledge-based infrastructure and other resources-based infrastructure. Figure 1 shows all the constructs and their relationships.

### *Role Construct*

The role construct captures the social aspect of agents. It is a natural way to introduce the role concept into multiagent systems if we adopt an organizational view of multiagent systems. In a human organization, there are many roles such as “manager”, “accountant”, “clerk”, and so on, and each role is performed by an actual individual. In the RITA ontology, we consider

multiagent systems similar to human organizations: a multiagent system is composed of different roles, and the roles are played by different agents.

Role and role models have been identified to be suitable as the basic unit for interaction modeling (Andersen, 1997; Reenskaug, et al., 1996). In RITA, a role interacts with other roles. We basically adopt the concept of role in role theory (Biddle and Thomas, 1966), and define a role as a collection of responsibilities and permissions. Responsibilities are functions or services an agent must provide. The RITA ontology defines two responsibilities: resource control and behavior control. The resource control provides the basic functions to manage and utilize the resources which are under an agent's control. The behavior control defines what kind of services can be provided to other agents. Permissions have two types: resource permissions and behavioral permissions. While resource permissions specify which resources are accessible to an agent, behavior permissions specify what kinds of behaviors are permitted when interacting with other agents.

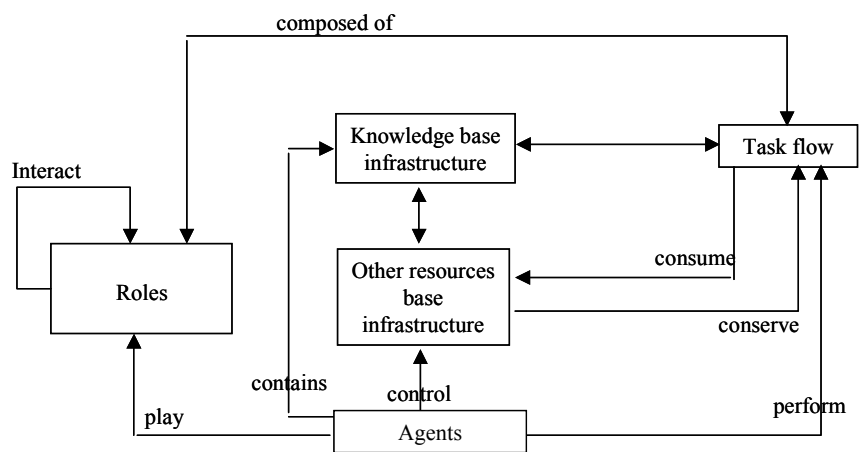


Figure 1. RITA Ontological Meta-Model

### Infrastructure Construct

The infrastructure provides bases for agents to be autonomous, responsive, and pro-active. There are two types of infrastructures in the RITA ontology: knowledge base infrastructure and other resources base infrastructure. The knowledge base infrastructure describes the mental states of agents. The resource base infrastructure specifies all resources under an agent's control. The resources can be physical resources such as materials, and other agents such as its subordinates.

Knowledge base is a large collection of facts, rules, and heuristics that capture knowledge about a specific domain of application (Schmidt and Thanos, 1989). RITA defines three knowledge levels: conceptual, specification, and operational knowledge level. The conceptual knowledge level is about general belief knowledge including facts and rules. The specification knowledge is a detailed and exact goal description of an agent. This level of knowledge includes goals that an agent may possibly adopt, fundamental functional modules of the agent, components architectures, communication frameworks, and resource data constructs. The operational knowledge level includes plans that an agent may possibly employ to achieve its goals, and methods that constrain and define how goals are to be achieved. Knowledge base and resource base are interdependent. For example, an agent's goals and plans may depend on what types of resources it has.

### Taskflow Construct

The taskflow construct focus on activities in multiagent systems. A task refers to a set of coherent activities that are performed to achieve a goal in a given domain (Duursma, 1994). Taskflow is defined as a coordinated set of tasks, which are performed by agents in order to achieve a set of common goals. The taskflow construct has three aspects: the functional perspective, the behavioral perspective, and the organizational perspective. The functional perspective defines the task structures. It solves the issues such as whether a task should be decomposed into subtasks and how it should be decomposed. The behavioral perspective studies the interdependencies of tasks, and describes how these activities can be organized in order to achieve goals most efficiently. How an agent decomposes and performs tasks depends on the knowledge base infrastructure the agent contains. When a task is performed, it always requires certain resources to be consumed. The organizational perspective shows that a taskflow is composed of roles. It defines capacities and skills an agent needs to perform the task.

## Agent Construct

The agent construct describes physical agent types in multiagent systems. Agents are entities that actually perform tasks in multiagent systems. Each agent type contains a different knowledge base infrastructure and has some resources under its control. Therefore, each agent type has its own perception of the environment and has different plans to perform a task. In performing a task, agents play roles. One agent type may play only one role, but it is possible that it play several roles at the same time.

## Conclusions and Ongoing Work

In this paper, we have proposed a meta-model for a systematic design and development of multiagent systems. In order to capture both the static aspects and the dynamic aspects of multiagent systems, the RITA model consists of four basic constructs: role, infrastructure, taskflow, and agent. The role construct defines the services and responsibilities of the roles involved in the system. The infrastructure construct identifies the internal state and knowledge/resource base of an agent. The taskflow construct determines the internal/external environments and coordination in a multi-agent system. The agent construct specifies the different agent types.

The proposed meta-model provides a start point for our research in developing a comprehensive framework for designing multiagent systems. Our current works includes the following:

- *Development of the foundational archetype*: we are currently developing representation structures and flow structures of the RITA framework. This includes (a) detailed specifications of agent and role class hierarchies, (b) task structure and activity models, and (c) primitive libraries which define the basic units in both the structural and behavioral components in the framework.
- *Validation of the RITA framework*: an ontological framework applies to designing and developing different multiagent systems. Our validation work includes (a) to map existing multiagent systems in different application domains to the RITA framework, and (b) to have designers and developers of existing multiagent systems review the framework and provide feedback.
- *Development of multiagent systems design principles*: design principles are necessary to integrate the RITA framework with the application domain specific ontologies. Some examples of the principles are how agents are mapped to roles, how roles map to goals and plans, and how resources and tasks are allocated etc.
- *Development of a Java based CASE tool*: the RITA framework is being implemented in Java as a design tool which can be used to “stamp out” agents. The architecture includes basic class library, data dictionary for primitives, guidance and support for schema integration, and experimentation tools for system realization and validation in a given application.

## References

- Andersen, E.P. “Conceptual Modelling of Objects: A Role Modelling Approach,” PhD Thesis, University of Oslo, 1997.
- Biddle, B.J. and Thomas, E.J. *Role Theory: Concepts and Research*, John Wiley & Son, Inc, 1966.
- Duursma, C. “Task Model Definition and Task Analysis Process,” KADSII /M5/VUB/RR/004/2.0, Vrije university, 1994.
- Jennings, N.R., Sycara, K. and Wooldridge, M. “A Roadmap of Agent Research and Development,” *Autonomous Agents and Multi-Agent Systems* (1:1), 1998, pp. 7-38.
- Reenskaug, T., Wold, P. and Lehne, O.A. *Working with objects, The OOram Software Engineering Method*, Manning Publications Co, Greenwich, 1996.
- Schmidt, J.W. and Thanos, C. “Preface,” In *Foundations of Knowledge Base Management: Contributions from Logic, Databases, and Artificial Intelligence*, J. W. Schmidt and C. Thanos (Ed.), Springer, Berlin, Heidelberg, 1989.
- Wooldridge, M. and Jennings, N.R. “Intelligent Agents: Theory and Practice,” *The Knowledge Engineering Review* (10:2), 1995, pp. 115-152.