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The need for task ontologies in interoperable GIS

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The need for task ontologies in interoperable GIS

Abstract

In this paper I argue that GIScience needs task ontologies in addition to domain ontologies to enable knowledge sharing and reuse for interoperable GIS. One of the main challenges for interoperable GIS is the sharing of semantic information and the intelligent reuse of services. Ontologies enable knowledge sharing. Task Ontologies enable reuse of services. In combination they enable the sharing of semantic information. Additionally, geographic Services using generic tasks or methods will be used more often than highly specialized services. I propose to model generic tasks within each application domain.

The need for task ontologies in interoperable GIS

1. Tasks provide context for knowledge

A task guides cognition and perhaps even perception of objects in a given situation. The reason for a task and the way we perform this task guide which parts of reality we look at and perceive. For example, we give different route directions to a pedestrian than to a truck driver: our cognitive model of the route changes with the specific task. The task influences the types of objects and the parts of objects that we consider important, i.e., object ontology and its level of abstraction: The directions for a pedestrian yield different objects (sidewalks, foot-paths, stairs, etc.) than the directions for the truck driver (highways, stop lights, one-way streets etc.).

Tasks produce partitions of reality (Smith 2000), where reality is composed of those things that are interesting (the smaller part but very detailed) and of those things that are not interesting for the task at hand (the larger part). *Domain Ontologies* (in the sense of Guarino 1998, Gruber 1993) describe those parts of partitions, i.e. concepts, that are interesting for a certain domain. These concepts are used for all tasks that occur within that domain. *Task Ontologies* describe the reasoning concepts and their relationships occurring within a certain domain and for a specific task. Task ontologies are models of partitions of reality preserving the context that determines the semantics of the concepts within the partition.

Task ontologies link the reasoning process to domain factual knowledge (Chandrasekaran 1998). For example in personal navigation by car, the wayfinding process has three stages: planning, instruction giving and driving (Timpf et al. 1992). Each stage, or level, corresponds to a single task that produces a partition of reality. Each partition includes different objects, but they are related by the level of detail of corresponding objects.

2. Task ontologies enable knowledge sharing and reuse

In this paper I argue that GIScience needs task ontologies in addition to domain ontologies to enable knowledge sharing and reuse for interoperable GIS (OGC 1999). One of the main challenges for interoperable GIS is the sharing of semantic information and the intelligent reuse of services. Ontologies enable knowledge sharing. Task Ontologies enable reuse of services. If we have knowledge about processes and tasks within a specific domain, there is a higher potential for reuse of the knowledge and of the processes.

One way to make semantics of domain factual knowledge explicit is to store information about the task(s) this knowledge was gathered and used for. Together with information on tasks

and relations between tasks, the question of reuse of this knowledge becomes a question of which tasks is more generic or specific than another. If the task is more specific, then we will need more knowledge to solve the task. If the task is more generic, then we need abstraction mechanisms to make the knowledge more abstract. If the task is at the same level of abstraction, then the question is if the two tasks share a common generic task. If they do, the likelihood increases that the knowledge used for the first task can be re-used for the second.

After a successful re-use of knowledge an association between task and knowledge should be established. The more associations exist between a 'piece' of domain factual knowledge and tasks, the more 'generic' is this 'piece' of knowledge. This is true for tasks as well: the more associations exist between a task and many 'pieces' of knowledge, the more 'generic' is the task. The aim of this research is to find out about generic tasks and relations between tasks and other tasks and between tasks and knowledge. In the direction giving example above both types of task belong to the same activity: giving directions. The strategy of providing the directions is the same and the reasoning process of the human is similar for both tasks. This indicates that although the specifics are different, some portion of the tasks can be considered to be generic.

Geographic Services using generic tasks or methods will be used more often in an interoperable environment than highly specialized services. Specialized services work only under few circumstances. Generic services will be used and reused, because of their being generic. They will serve as building blocks for more complex geographic tasks and thus as components of a toolbox for interoperable GISystems.

Which are the generic tasks within GIScience? They can be identified and modeled for each application domain. I propose to model first task ontologies within domains (also called task hierarchies by Freksa 1991, Timpf et al. 1992). In a second step, generic tasks are extracted from the formal representation of task ontologies. Those tasks are modeled in the last step as geographic services.

3. Modeling task ontologies within the framework of Activity Theory

Activity theory (Nardi 1986, Kaptelinin et al.1999) states that meaning can only be attributed to objective reality by a human being. Human beings interact with the world and meaning arises only while the human agent is performing a task. In order to convey meaning data needs to be combined not only with operations but also with corresponding tasks and activities. Our approach to modeling task ontologies has three steps.

The first step identifies tasks that belong to the same reasoning process. This can be done either through classical task analysis or through verb and noun extraction from a written description of the reasoning process. Verbs correspond to actions and nouns correspond to objects (Ikeda et al. 1997, Kuhn 2000, Kitamura and Mizoguchi 1999, p.9, Mizoguchi and Ikeda 1996).

The second step identifies which actions act upon which objects and notes the relations between actions and between objects. Properties also may play a role in this step. From this follows a definition of operations (low-level actions), actions (what we called tasks so far), and activity (giving the motive for a sequence of actions). Operations are parts of actions and actions are parts of activities.

The third and last step is to model the object ontology for each action and the relations between actions. This yields the task ontology.

4. Future Work

There is a body of research within the knowledge engineering community that deals with problem-solving knowledge (Chandrasekaran 1986, Chandrasekaran 1998, Fensel et al. 1997, Schreiber et al. 1999) as opposed to knowledge about objective realities in the domain of interest (Guarino 1998). One of the first steps of future work will be to determine the suitability of those approaches for spatial tasks.

Within the GIScience community there has been work done on functionalities of GIS (Maguire and Dangermond 1992, Albrecht 1996). Where do the functions analyzed in those research papers fit into the framework of activity theory and task ontology?

Hierarchical decomposition as presented in (Brazier et al. 1995) provides a means to formally specify re-use: to specialise and instantiate generic task models, to include existing specifications of subtasks, to specialise and instantiate existing specifications of subtasks, etc. How does this decomposition relate to the decomposition made by activity theory? This line of research could also shed light on the formal relationship between task and object ontologies.

Tasks have relationships that have been described as sub-task to task or to supertask relation. However a theory of part-whole relations for tasks does not exist. Starting from a theory of part-whole relations for objects (see e.g., Tversky 1990), what are the part-whole relations between tasks? How do abstraction mechanisms for tasks look like? Within the linguistic literature, the method of entailment for verbs (Fellbaum 1998) has been proposed. Are entailment, presupposition, inclusion, causation, and troponymy abstraction mechanisms for tasks?

More general questions that are part of future work pertain to the notion of ‘genericness’ of tasks. How do we determine that a task is generic? Are all generic tasks at the same level of granularity? How can generic tasks act as building blocks for interoperable GIS?

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