Architectures for Semantic Integration[1]

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Introduction

One of the goals of this workshop was to begin to lay the foundations for a comprehensive framework for understanding and classifying different problems, approaches and techniques in the field of semantic integration and interoperability. Another way to look at this, is to create a map of the field. In this short paper, we give an example of what a region on such a map might look like. We consider the area of architectures for semantic integration. We followed the following steps:

1. Identify various approaches, e.g. by conducting a literature search
2. Identify the similarities and differences between the different approaches
3. Identify specific issues, or dimensions of variation that are the basis for characterizing the above differences. These will be used to classify the different approaches
4. Identify key questions for each dimension.

Dimensions of Variation

A literature search identified a variety of architectures that may be used to achieve semantic integration. The differences depend on the following dimensions of variation: origins of the semantic mappings, whether there is a mediating ontology, and the nature and degree of the agreements that exist among the anticipated community of interacting agents. Different architectures can be distinguished and compared to one another by considering the following questions:

1. Who is generating the agent to agent semantic mapping?
    a. The *agent designer*.
    b. The *ontology designer*.
    c. The *agents.*
2. When is the mapping between two agents' ontologies created?
    a. Mappings are *pre-defined* before the agents interact.

[1] The major content of this paper is drawn from a much larger report [Gruninger & Uschold 2004?] on ontologies and semantic integration.

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   b. Mappings are dynamically generated at *agent-interaction time*.
3. What is the topology of the architecture?
   a. Mapping is done *point-to-point* between the agents.
   b. Mapping is *mediated* (e.g. by a neutral ontology).
4. What is the nature of the agreements among the agents?
   a. Agreement is on a single *global ontology* for all interacting agents.
   b. Agreement is on an *interlingua ontology*.
   c. Agreement is on *alignments/mappings* between ontologies.
   d. There is *no* a priori agreement.

Five Different Architectures

We outline five architectures that can be used to integrate agents. Each answers the above questions in different ways. The properties of these various architectures are briefly described below and summarized in Table 1.

Questions / Architecture	Who generates the mappings?	When define Agent to Agent mapping?	Topology	Degree of Agreement
Global ontology	*no mappings*	*no mappings*	Point-to-point	Agree on Everything
Manual mapping	Agent designers	Before agents interact.	Point-to-point	No *a priori* agreement
Interlingua ontologies	Agent designers	Auto-generated at agent interaction time.	Mediated	Agree on Interlingua ontologies
Community Ontology Mappings	Ontology designers	Auto-generated at agent interaction time.	Mediated	Agree on alignment mappings
Ontology Negotiation	Agents themselves	Auto-generated at agent interaction time.	Point-to-point	No *a priori* agreement

Ontology Negotiation [Truszkowski & Bailin 2001] – In the Ontology Negotiation architecture, the agents themselves generate and test the mappings automatically, at agent-interaction time. There is no mediated ontology, the mappings are point to point between the agents. There are no a priori agreements. To do this reliably an consistently is the Holy Grail of semantic integration.

Global Ontology—In this case, we assume that all agents use the same ontology. This approach alleviates the need for mappings entirely. This architecture is severely

limited. It is only practical for small communities, or where there is an able and powerful dictator.

Manual Mapping ([Obrst 2001], [Fillion *et al.* 1995]) **–** In the case of Manual Mapping, the human agent designers specify the agent to agent mapping between the agent's ontologies prior to their interaction. These mappings are point-to-point between the agents. There is no *a priori* agreement about semantics between the agents. This architecture can be thought of as a fully manual version of ontology negotiation.

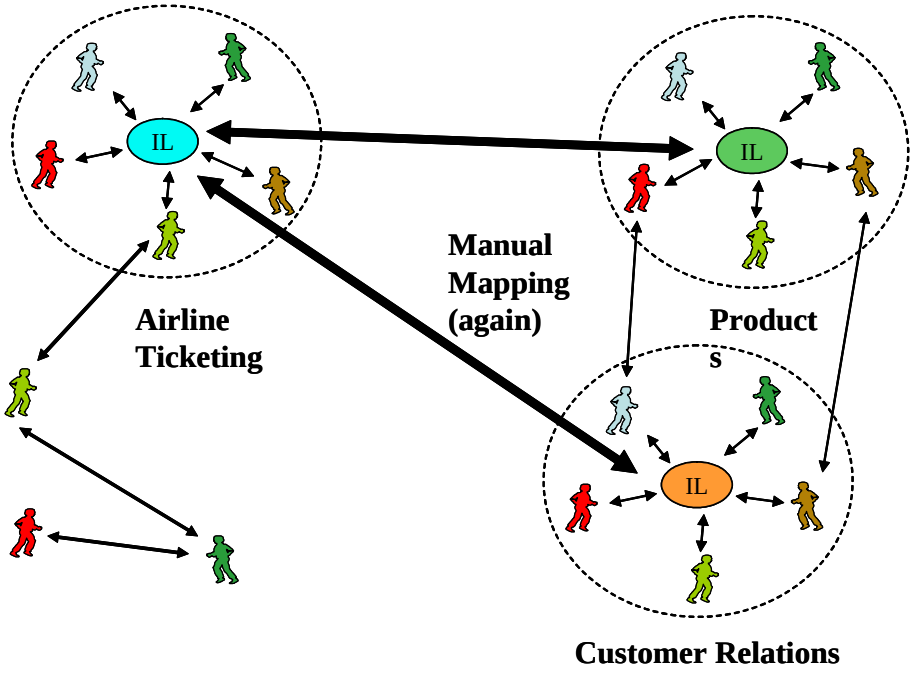
Interlingua [Ciociou *et al* 2001]**–** In the Interlingua architecture, each agent designer generates a mapping from their agent's ontology to a standard interchange ontology, or interlingua. This is done before the agents interact. The agent to agent semantic mappings are generated dynamically at agent-interaction by executing the pre-specified mappings to and from the interlingua. In this case, the interlingua ontology mediates the mapping between the agent ontologies. The agents that wish to participate in this architecture must agree *a priori* to use the interlingua ontology. This is a partially automated version of ontology negotiation.

Community Ontology Mappings – In the Community architecture, we assume the existence of a library of ontologies that has been built by aligning and mapping ontology modules developed by some user community. The ontology designers create the alignments and mappings before agent-interaction time. Different agent designers use ontologies from this library. When the agents interact, they invoke these pre-specified inter-ontology mappings in order to automatically generate the agent to agent mappings. This architecture uses the various community ontologies as mediating ontologies, rather than a single interlingua ontology. This approach is also a partially automated version of ontology negotiation. This is an elaboration of the idea of agents specifying their semantics by pointing to existing ontologies on the Web [Hendler 2001].

A Hybrid Approach

These architectures are not mutually exclusive alternatives – rather, they are the building blocks for a semantically connected network of agents, data sources and applications the future. All of these, and perhaps other approaches will evolve and be combined in creative ways. Consider the figure below. Initially, there were a handful of applications who needed to share information. So they created manual mappings between them (not depicted in the figure). Eventually, there was a motivation to create an interlingua. This happened for a number of different application groups, Airline Ticketing, Products, and Customer Relations. However there are important overlaps in these subjects as well. There was sufficient motivation to share between the ticketing group and both the product group and the customer relationship group. Interlingua to interlingua mappings were created, thus forming community mappings between community ontologies. In this case, there was insufficient need for sharing

between the product group and the customer relationships group, to warrant the effort of creating a mapping between them.



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