Ontology Agents in FIPA-compliant Platforms: a Survey and a New Proposal

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Outline

Motivation: the Importance of Being Semantically Interoperable...

- Semantic interoperability, namely "*the ability of two or more computer systems to exchange information and have the meaning of that information automatically interpreted by the receiving system accurately enough to produce useful results*" (Wikipedia, `http://en.wikipedia.org/wiki/Semantic_interoperability`), is one of the most relevant and lively research fields of the last fifteen years.
- The advent of ontologies in computer science in the early nineties, the settlement of Web Services in the beginning of the new millennium, the combination of both into Semantic Web Services, all witness the fervid activity of academia and industry for finding algorithms, languages, tools, and infrastructures aimed at making the "semantic interoperability dream" come true.

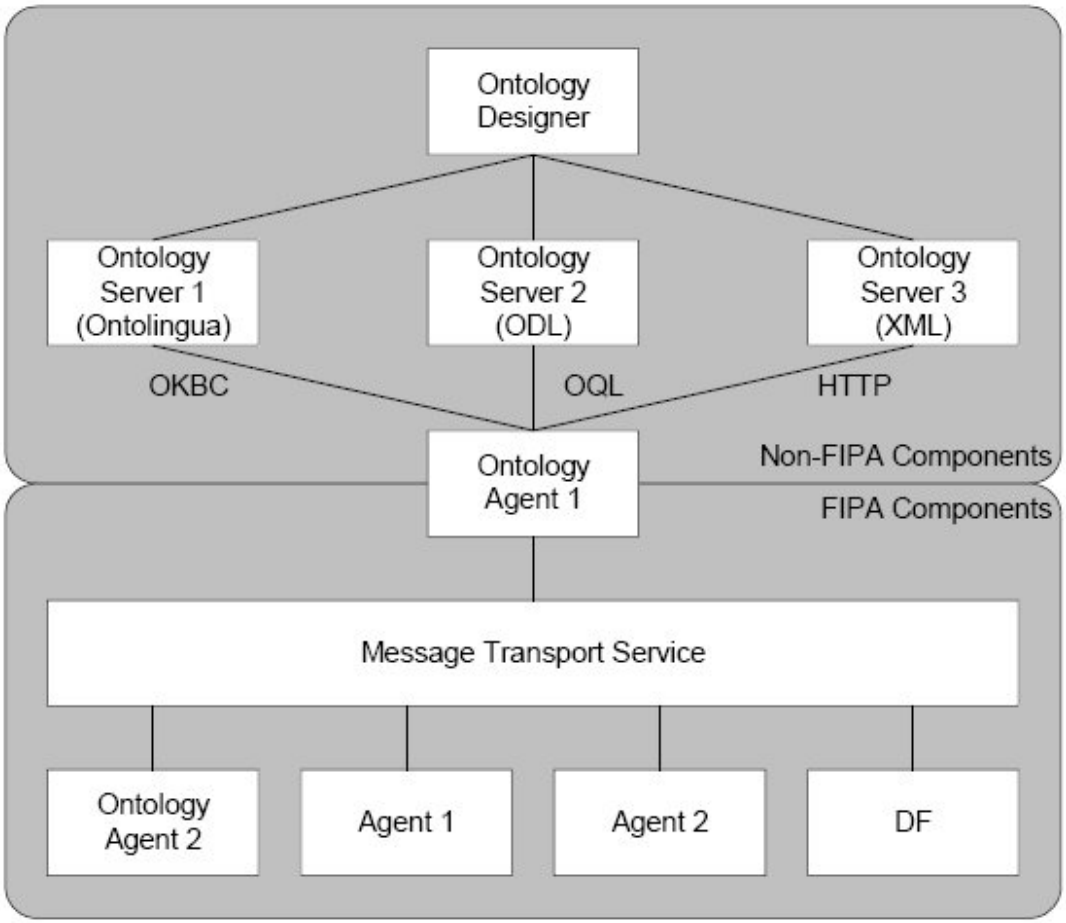
Motivation: the Importance of Being Semantically Interoperable...

- The reason for the interest in this topic is easy to explain. In a recent paper, Jan Walker et al. assess the value of information exchange and interoperability in the domain of health care, and state that a fully standardised system supporting information exchange and interoperability could yield a net value of 77.8 billion dollars per year once implemented.
- Other studies cited below confirm these impressive economic advantages in implementing solutions for semantic interoperability.

Motivation: the Importance of Being Semantically Interoperable...

[J. Walker, E. Pan, D. Johnston, J. Adler-Milstein, D. W. Bates and B. Middleton, *The Value of Healthcare Information Exchange and Interoperability*, Health Affairs, Web Exclusive, 19 January 2005]
[M. P. Gallaher, A. C. O'Connor, J. L. Dettbarn Jr. and L. T. Gilday, *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*, U.S. Department of Commerce, National Institute of Standards and Technology, 2004, NIST GCR 04-867]
[S. B. Brunnermeier and S. A. Martin, *Interoperability Cost Analysis of the U.S. Automotive Supply Chain*, U.S. Department of Commerce, National Institute of Standards and Technology, 1999, NIST 99-1]

FIPA Ontology Service Specification, 2001



http://www.fipa.org/specs/fipa00086/XC00086D.pdf

Services offered by the FIPA OA

A FIPA-compliant OA should offer the following services to the agents in the MAS:

1. discover public ontologies in order to access them,
2. maintain (for example, register with the Directory Facilitator, upload, download, and modify) a set of public ontologies,
3. translate expressions between different ontologies and/or different content languages,
4. answer queries about relationships between terms or between ontologies,
5. facilitate the identification of a shared ontology for communication between two agents.

Implementation over the COMTEC platform

Divided into two parts:

1. an interface to the OKBC front-end. From the OKBC point of view, the OA is one of the front-end user applications.
2. the FIPA interface, namely an agent wrapper that takes care of the management of ontology names and the relationship between the ontologies.

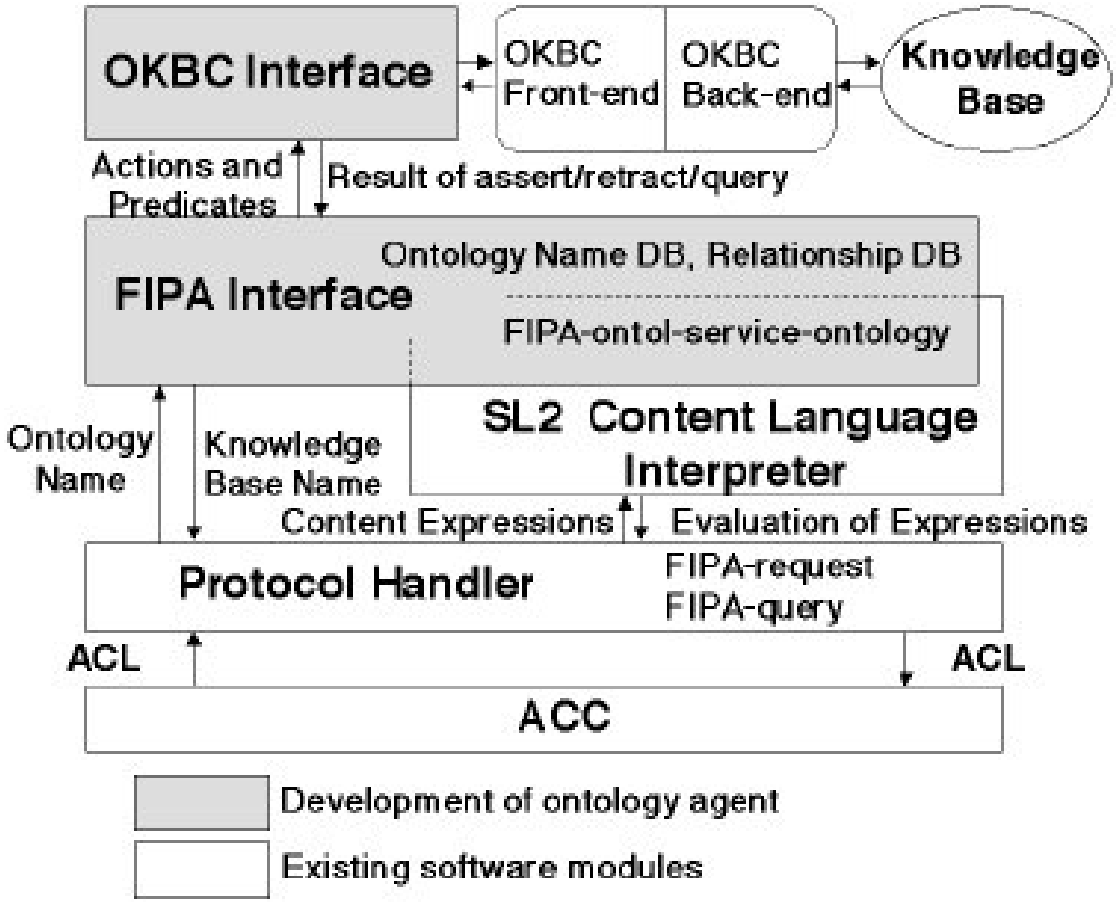
The COMTEC OA

1. registers an ontology in the framework;
2. operates over an ontology;
3. answers queries about ontologies's structure, and their level of similarity.

No ontology matching service is provided.

[H. Suguri, E. Kodama, M. Miyazaki, H. Nunokawa and S. Noguchi, *Implementation of FIPA Ontology Service*, Workshop on Ontologies in Agent Systems, Proceedings, 2001]

Implementation over the COMTEC platform

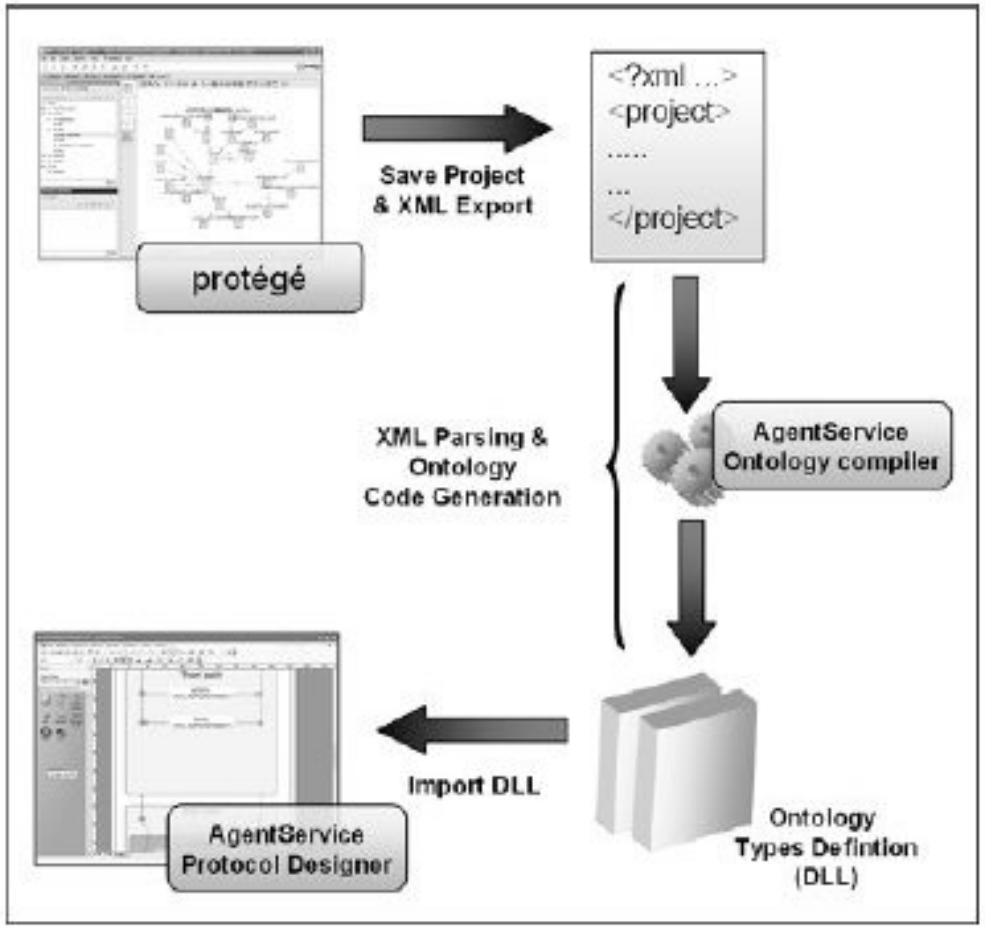


Implementation over the AgentService platform

- AgentService is based on the .NET platform.
- Ontologies in AgentService are represented in OKBC.
- The services that the OA offers are
  1. discovery and publication of the ontology and its maintenance,
  2. support to check whether two agents use the same ontologies and if not, help them to download the “missing” ones.
- Neither ontology matching nor translation are supported.
- AgentService uses Protégé to support the designer from the creation of the ontology to the development of an agent that can communicate using that ontology, and MS Visio to design agent interaction protocols.

[A. Passadore and C. Vecchiola and A. Grosso and A. Boccalatte, *Designing agent interactions with Pericles*, ONTOSE 2007, 2nd International Workshop]

Implementation over the AgentService platform

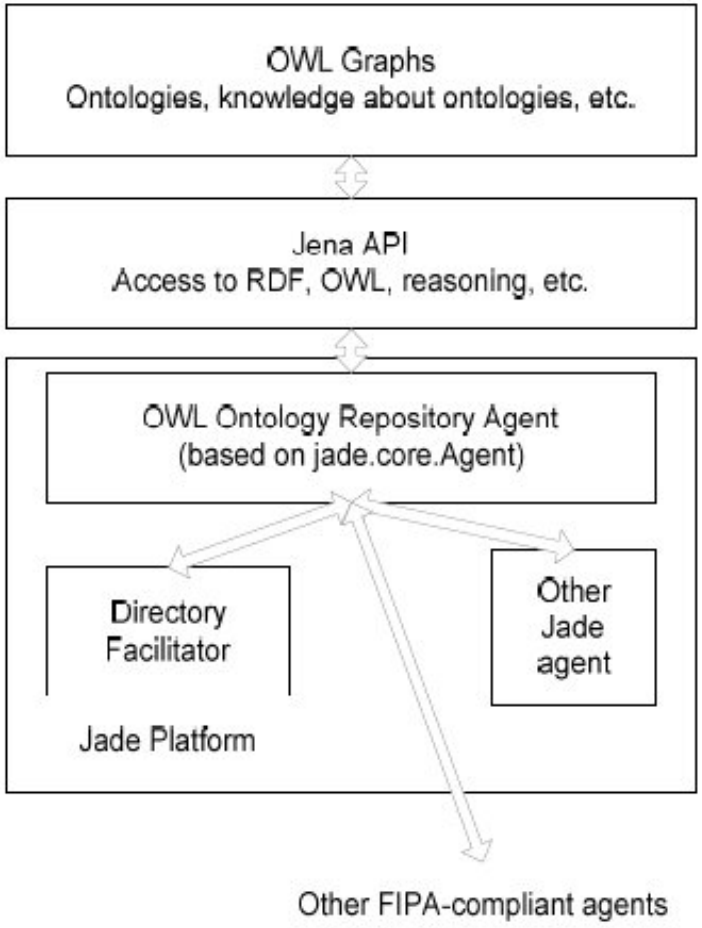


Implementation over the Jade platform

- The only other attempt of integrating a FIPA-compliant OA into Jade we are aware of, is that by Obitko and Snáěl.
- Their implementation follows the FIPA specification but adapts it to ontologies represented in OWL, as we do.
- Their OA agent exploits Jena and implements the basic functionalities of the ontology services as specified in the FIPA proposal, i.e. the possibility
  1. of modifying ontologies (assert and retract) and
  2. of querying ontologies using RDQL.
- No ontology matching service is provided.

[M. Obitko and V. Snáěl, *Ontology Repository in Multi-Agent System*, Artificial Intelligence and Applications, AIA 2004]

Implementation over the Jade platform



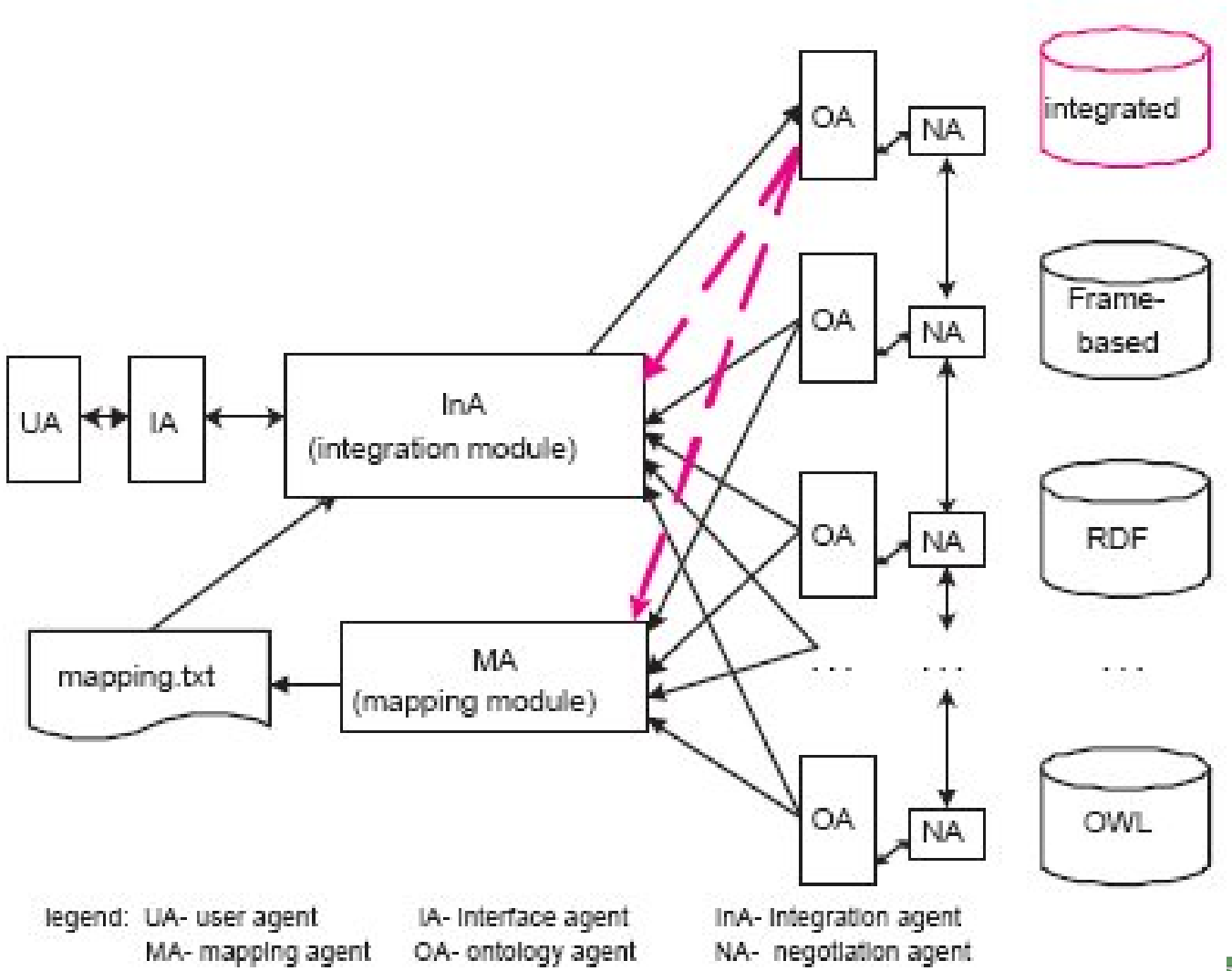
Ontology Services as the result of Distributed Cooperation

Li, Wu and Yang concentrate on the process of mapping and integrating ontologies: these functionalities are integrated in the MAS thanks to a set of agents which collaborate to offer them to the other agents:

1. User Agent (UA)
2. Interface Agent (IA)
3. Ontology Agent (OA)
4. Mapping Agent (MA)
5. Similarity Agent (SA)
6. Query Agent (QA)
7. Integration Agent (InA)
8. Checking Agent (CA)

[L. Li and B. Wu and Y. Yang, *Agent-Based Ontology Integration for Ontology-Based Application*, AOW 2005, associated with the 18th CRPIT Conference series by Australian Computer Society, Vol 58]

Ontology Services as the result of Distributed Cooperation

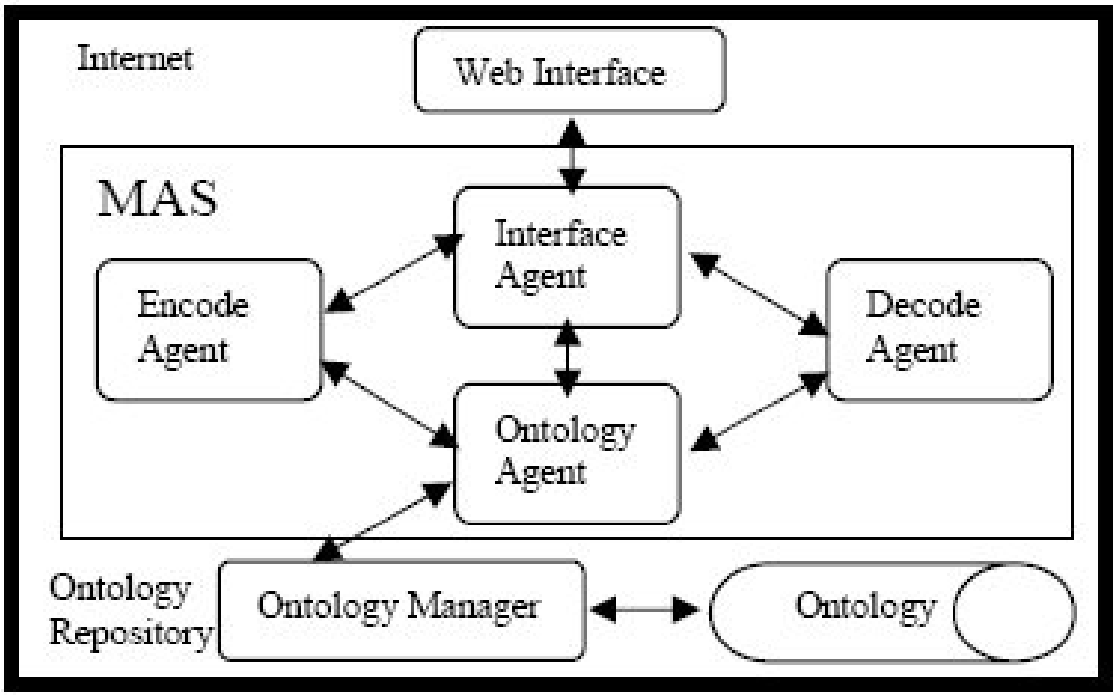


An OA implemented as a Web Service

- Sossa and Gutierrez implement the OA as a Web Service, in order to offer its services also over the Internet.
- The OA carries out the management of the ontologies through an interface between the application agents and the ontologies. It is responsible for catching the requests arriving from the agents, interpreting them, forwarding them to the Ontology Manager in charge of the Ontology referenced in the request, and forward back the response from the Ontology manager.
- Ontologies are in OWL format, and each Ontology Manager answers only to requests about the structure of the ontology or for changing its structure.
- No support is offered to the mapping, translating or more complex queries about two ontologies.

[A. Peña and H. Sossa and F. Gutierrez, *Web-Services based Ontology Agent*, Distributed Frameworks for Multimedia Applications, 2006]

An OA implemented as a Web Service

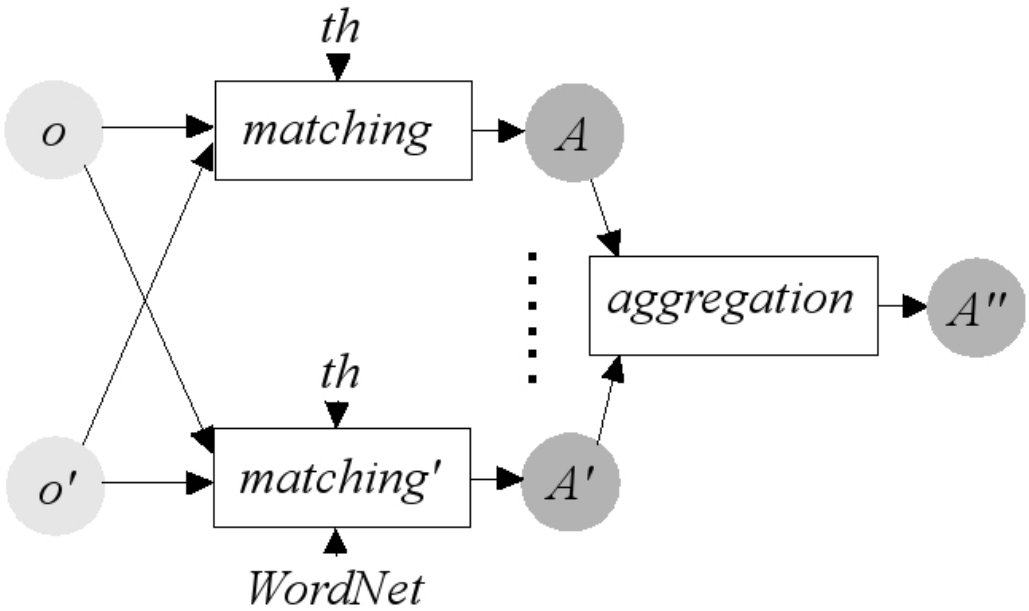


Our OA for Ontology Matching in Jade

The OA we have implemented in Jade provides the following services:

1. matching two OWL ontologies through a direct matching;
2. matching two OWL ontologies via an upper ontology (represented in OWL too);
3. evaluating an alignment against a reference alignment.

Direct Matching

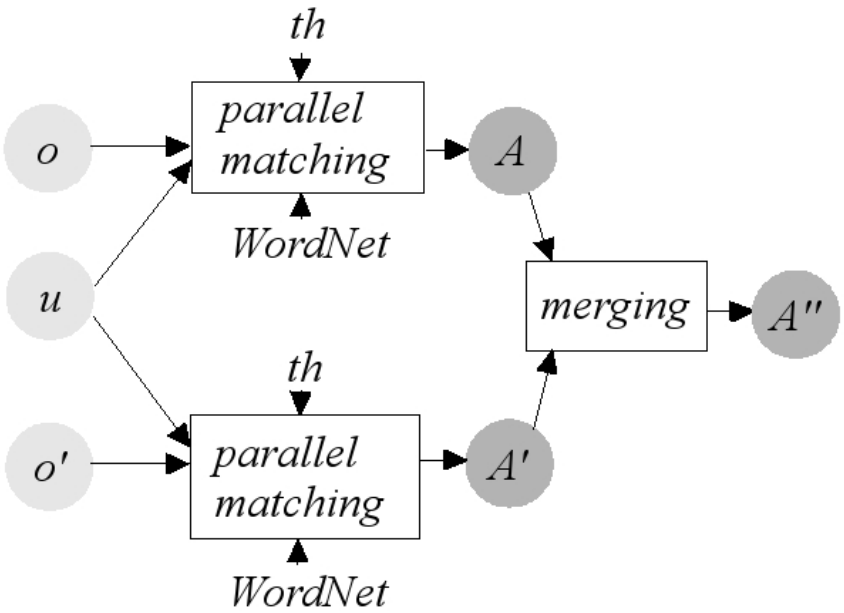


The *parallel_match*(o, o', {*WordNet*}, *th*) function

Matching via Upper Ontologies

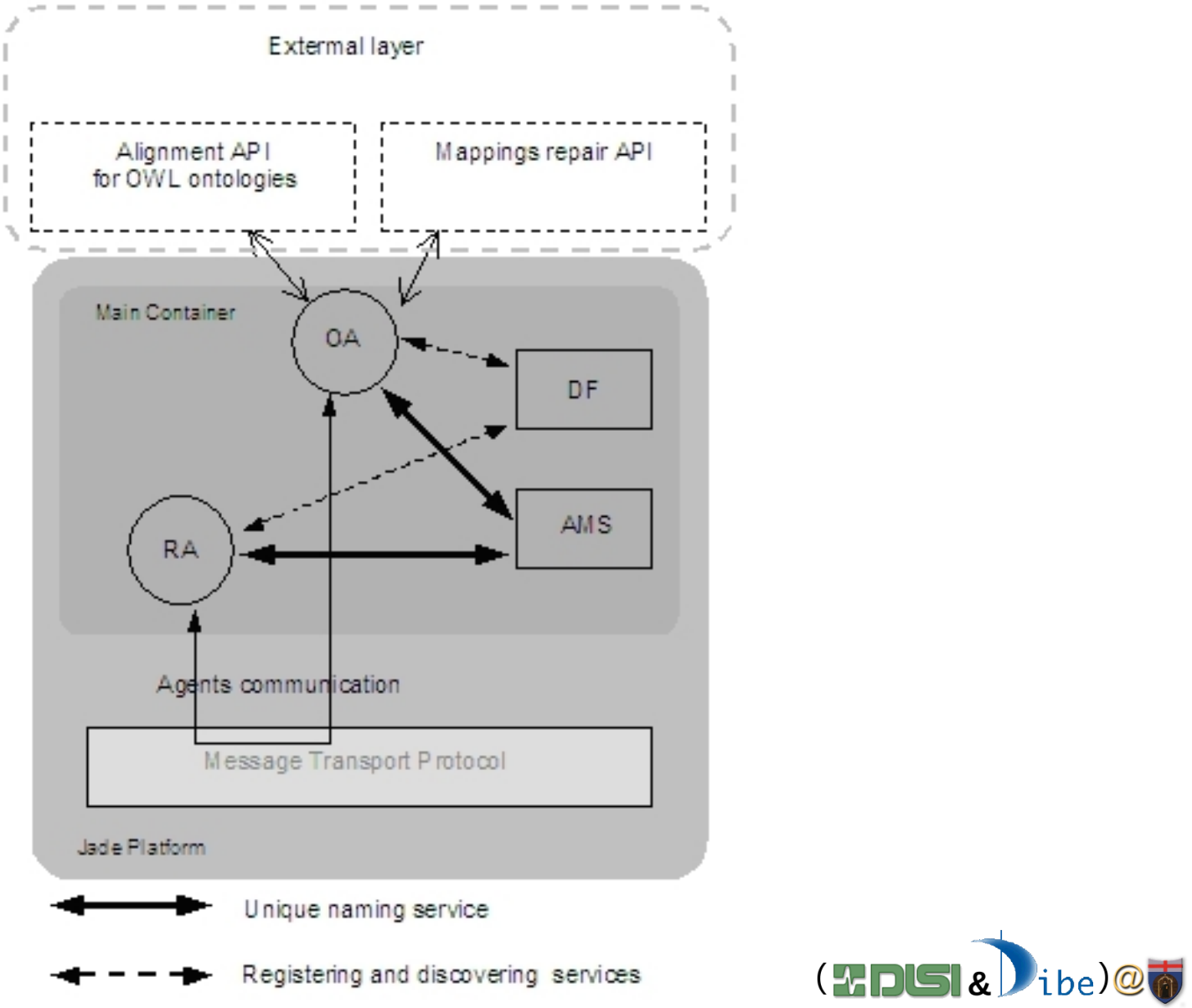
- For matching two ontologies o and o' via an upper ontology uo we compute the $parallel\_match(o, uo, \{WordNet\}, th)$ and $parallel\_match(o', uo, \{WordNet\}, th)$, obtaining two alignments between o and uo, and o' and uo respectively.
- These two alignments are given in input to a $merge(a, a')$ function.
- *Merge* produces the final alignment between o and o' by combining the correspondences of o-uo and o'-uo in such a way that: if $\exists$ a correspondence $< c, c_u, r, conf1 >$ in o-uo and $\exists$ a correspondence $< c', c_u, r, conf2 >$ in o'-uo, then the *merge* function creates a new correspondence $< c, c', r, conf1 * conf2 >$ and adds it to the final alignment.

Matching via Upper Ontologies

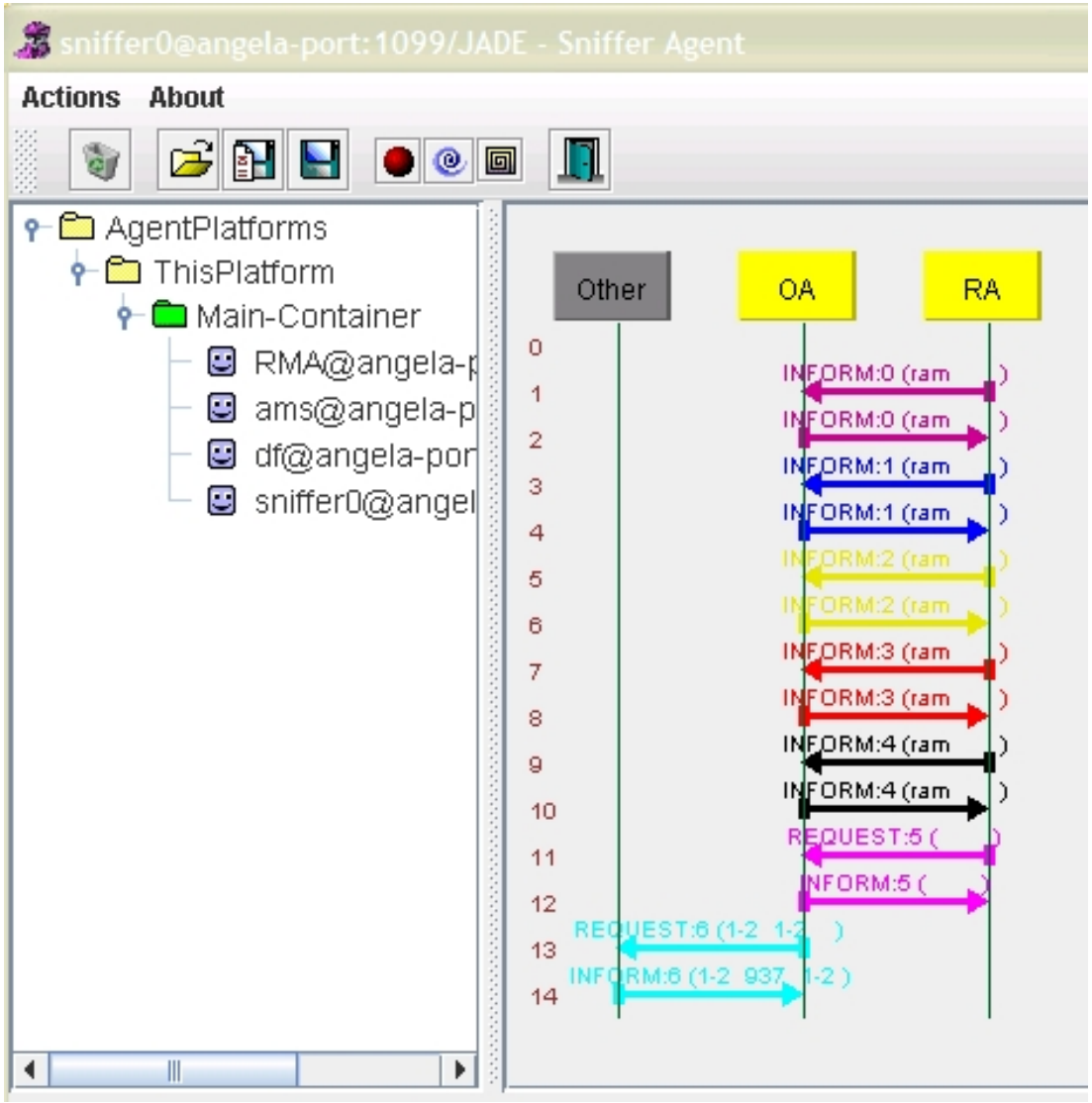


The $uo\_match(o, o', u, \{WordNet\}, \{th\})$ function

System Architecture



Execution Run



Some Results

Method	Found	Correct	Prec.	Recall	F-meas.
Direct	27	7	0.26	**0.08**	**0.13**
SUMO-OWL	9	6	**0.67**	0.07	**0.13**

Matching Ka and Bibtex: results summary.

Conclusions

- This paper describes a FIPA-compliant Ontology Agent integrated in Jade, able to deal with OWL ontologies.
- Our OA is able to produce alignments between two OWL ontologies via direct matching or via an OWL version of an upper ontology.
- It can also evaluate the obtained alignment with respect to a given reference one.
- The exploitation of an upper ontology for performing an alignment between two ontologies represents an original contribution to the ontology matching process.

Future Work

- We will extend our OA with more “standard” services such as registration, discovery, and maintenance of ontologies.
- We will analyse if it is feasible to join the description of the services provided by our OA with concepts of the Jade `BasicOntology`, thus allowing the matching process, the evaluation and the correspondences repair services to be a part of the Jade Agents semantic.