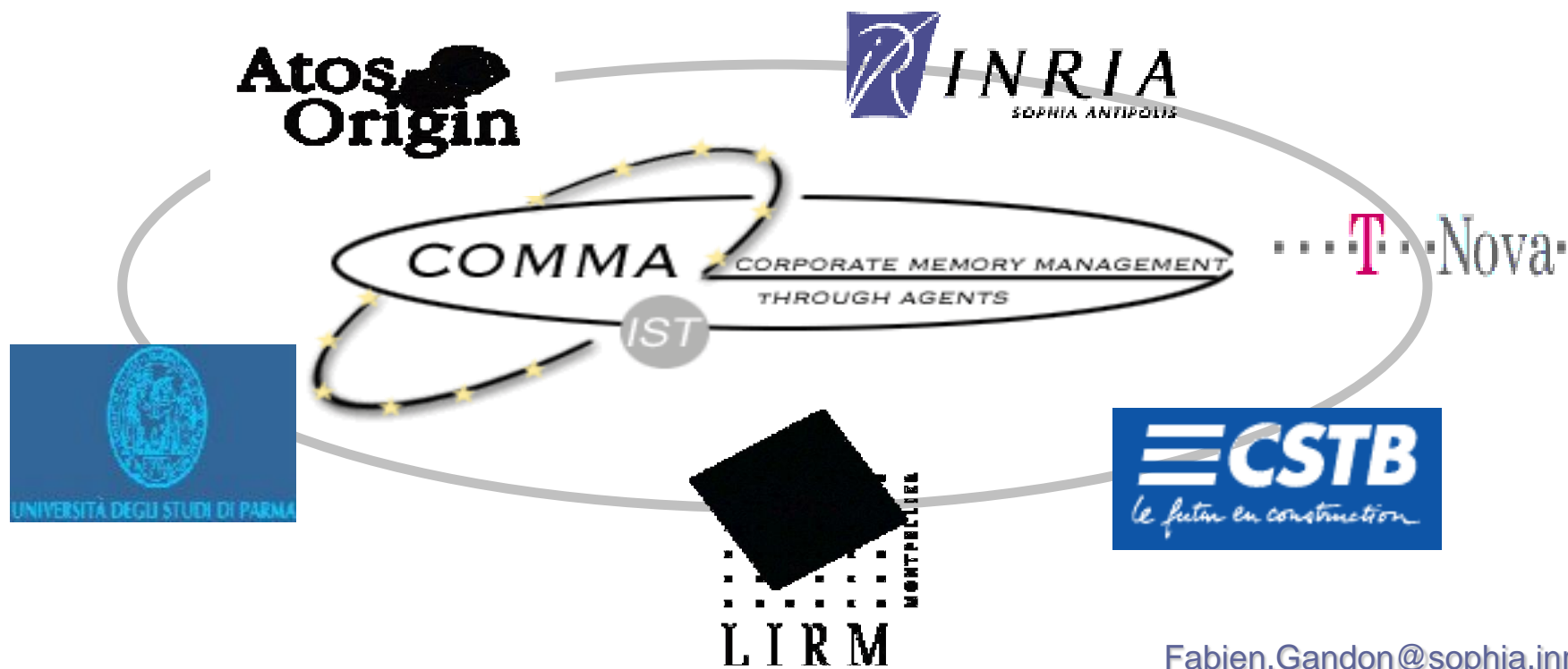


# Distributed Artificial Intelligence for Distributed Corporate Knowledge Management



- ◆ **Dynamically integrating heterogeneous sources of information:** OBSERVER [Mena *et al.*, 1996] ; InfoSleuth [Nodine *et al.*, 1999] ; Carnot [Collet *et al.*, 1991] ; InfoMaster [Genesereth *et al.*, 1997] ; SIMS [Arens *et al.*, 1996] ; RETSINA [Decker and Sycara, 1997] ; Manifold [Kirk *et al.*, 1995]
- ◆ **Digital libraries:** SAIRE [Odubiyi *et al.*, 1997] ; UMDL [Weinstein *et al.*, 1999]
- ◆ **Knowledge management:**
  - Collaborative gathering, filtering and profiling: CASMIR [Berney and Ferneley, 1999]; Ricochet [Bothorel and Thomas, 1999]
  - Mobile access to memory and domain model for classification: KnowWeb [Dzbor *et al.*, 2000]
  - Taxonomy, profiling and push: RICA [Aguirre *et al.*, 2000]
  - Ontology and corporate memory: FRODO [Van Elst and Abecker, 2001]

## ◆ Knowledge and information management:

- **Needs:** improve reaction time & address turnover
  - Persistent memory: store and/or index knowledge
  - Nervous system: capture and diffuse knowledge
- **O.M.:** an explicit and persistent representation and/or indexing of knowledge in an organization, in order to facilitate its access and reuse by members of the organization, for their individual and collective tasks.
- **Current trend:** reuse internet and web technologies to build intranets and intrawebs
  - Same advantages: standardised technology, browser unique access means, distributed architecture, etc.
  - Same drawbacks: human-understandable but only machine readable; problem of retrieval, automation, *etc.*

## ◆ Corporate Memory Management through Agents:

- Assist new employee integration
- Support technology monitoring activities

## ◆ In CoMMA:

- Corporate memories are *heterogeneous and distributed information landscapes*
- Stakeholders are an *heterogeneous and distributed population*
- Exploitation of CM involves *heterogeneous and distributed tasks*

## ◆ Choices:

<u>Materialization CM</u>	<u>Exploitation CM</u>
<b>XML:</b> Standard, Structure, Extensible, Validate, Transform	<b>Multi-Agent System:</b> Modularity, Distributed, Collaboration
<b>RDF:</b> Annotation, Schemas	<b>Machine Learning:</b> Adaptation, Emergence
<b>C</b> orporate <b>M</b> emory	<b>M</b> anagement through <b>A</b> gents

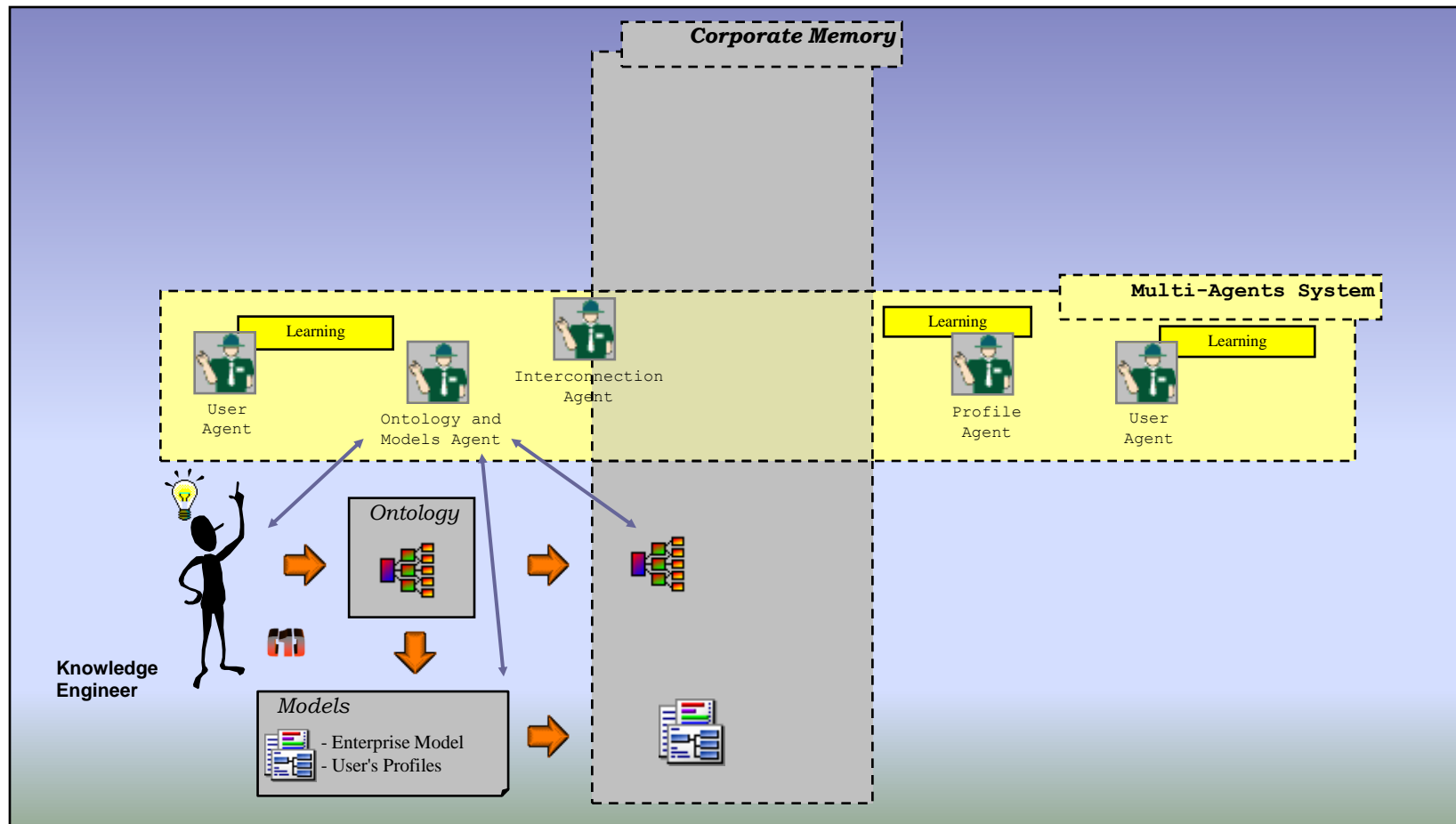


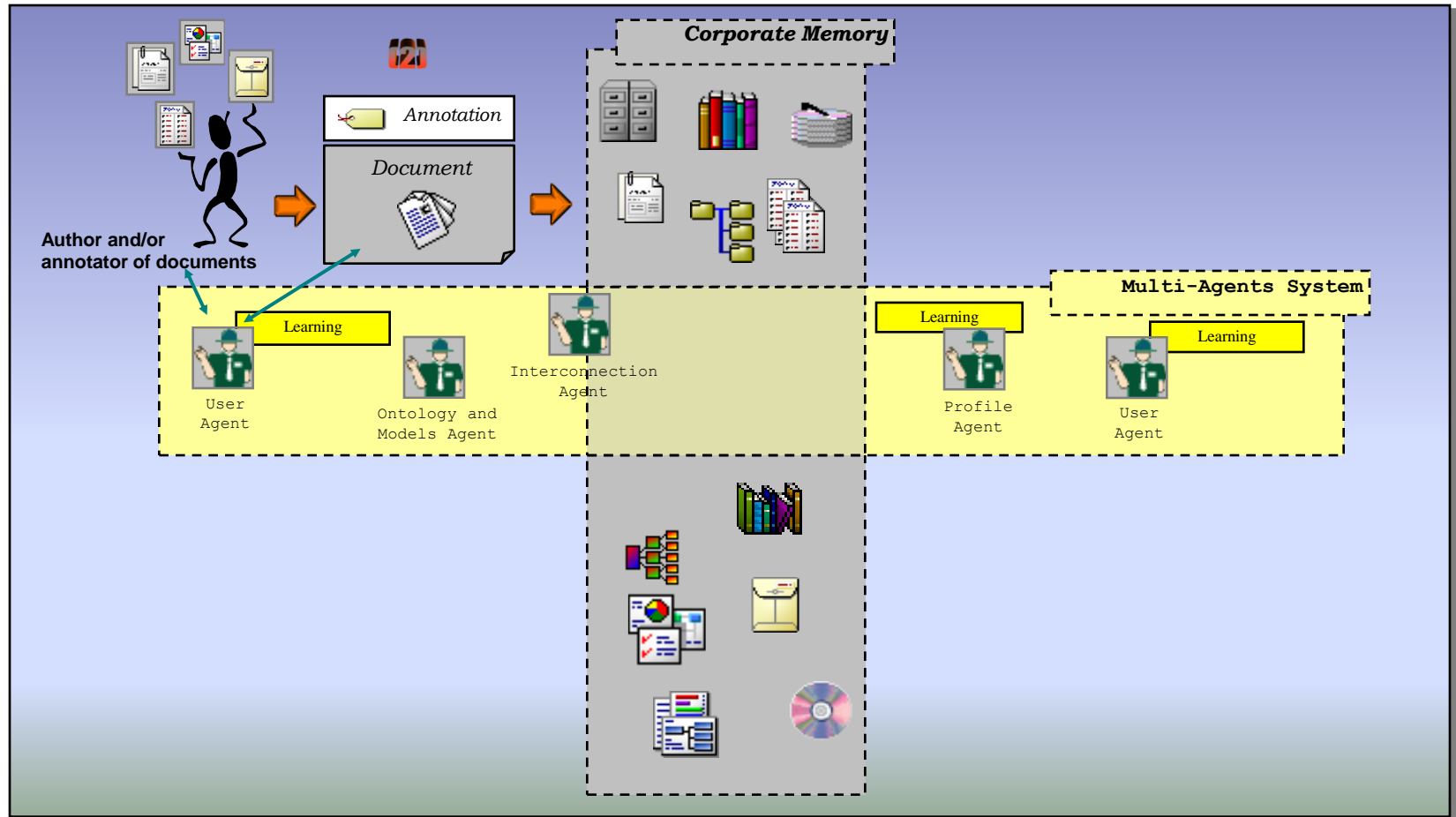
## ◆ **This is not a presentation of...**

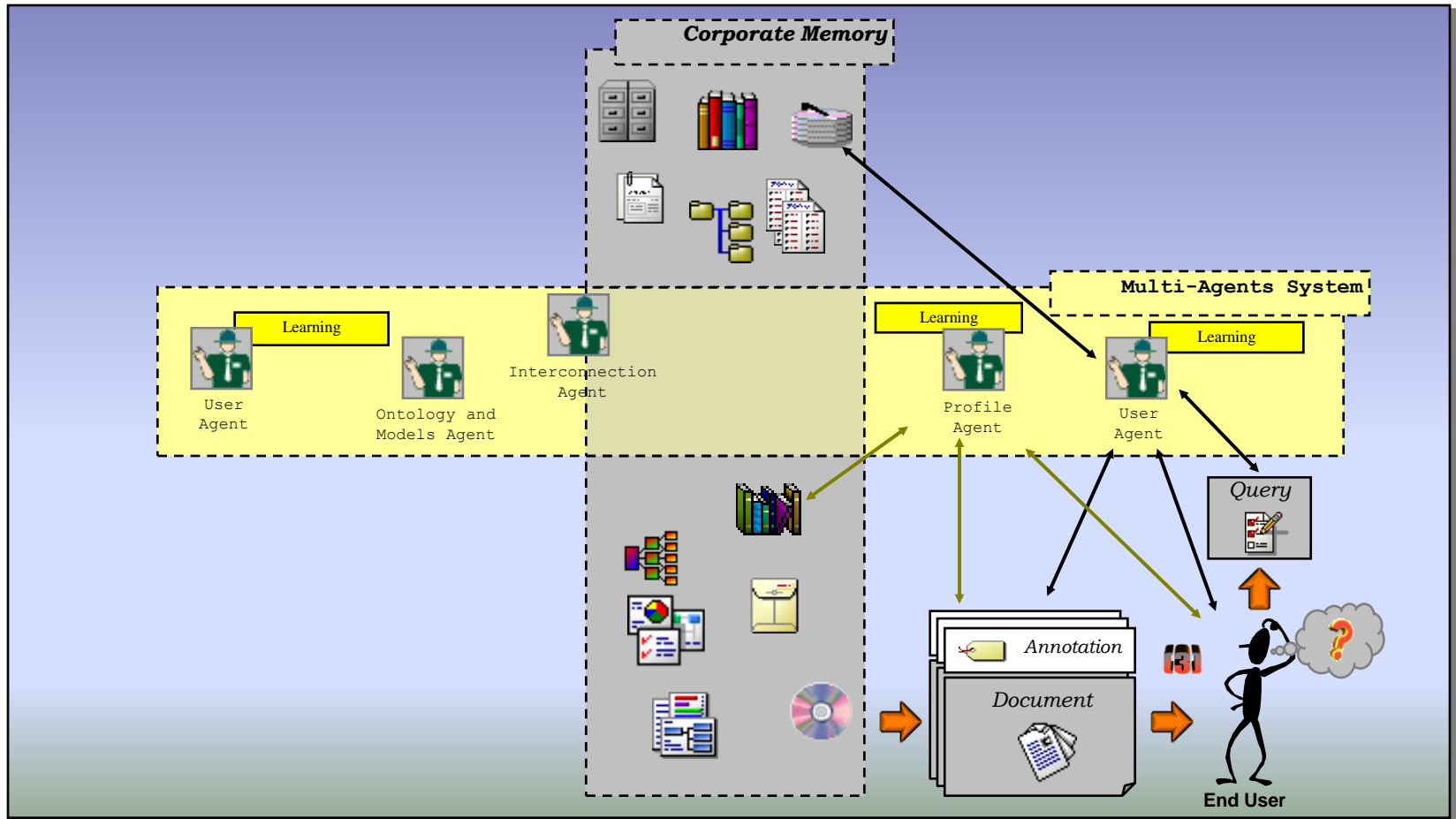
- The overall design rationale of CoMMA (see IFIP 2002)
- The top-down organisational function analysis and implementation of the MAS (see AT2AI 2002)
- The ontology design (see ISMICK 2001)
- The machine learning (see PKDD 2001)
- The semantic search engine based on conceptual graphs (see WWW 2002 - RDF workshop)
- Pseudo-semantic distance and distributed query-solving protocols (see AAMAS 2002)

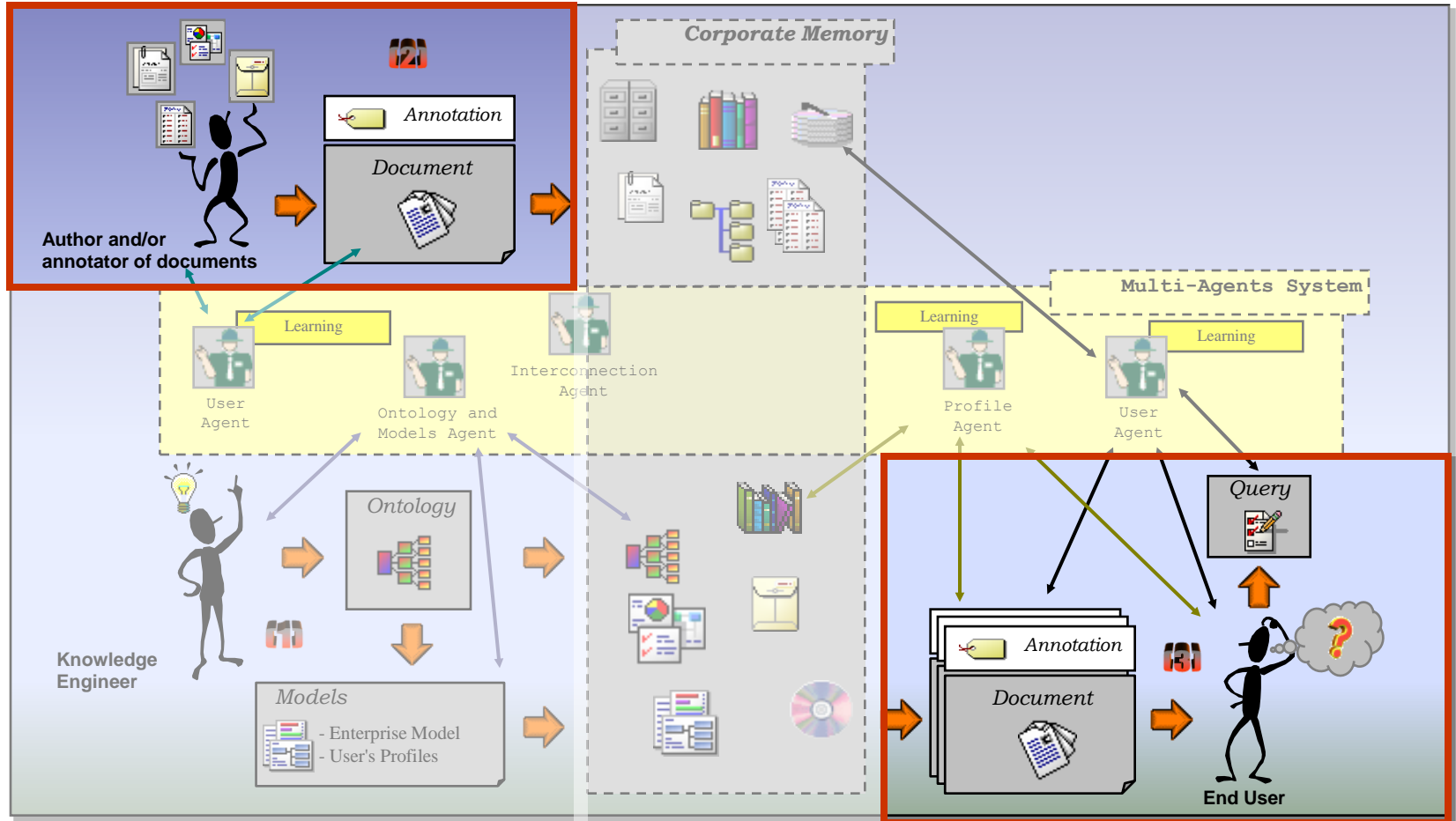
## ◆ **This is an overview a the CoMMA solution as it was in the last trial:**

- The corporate semantic web (distributed knowledge)
- The multi-agent architecture (distributed AI)

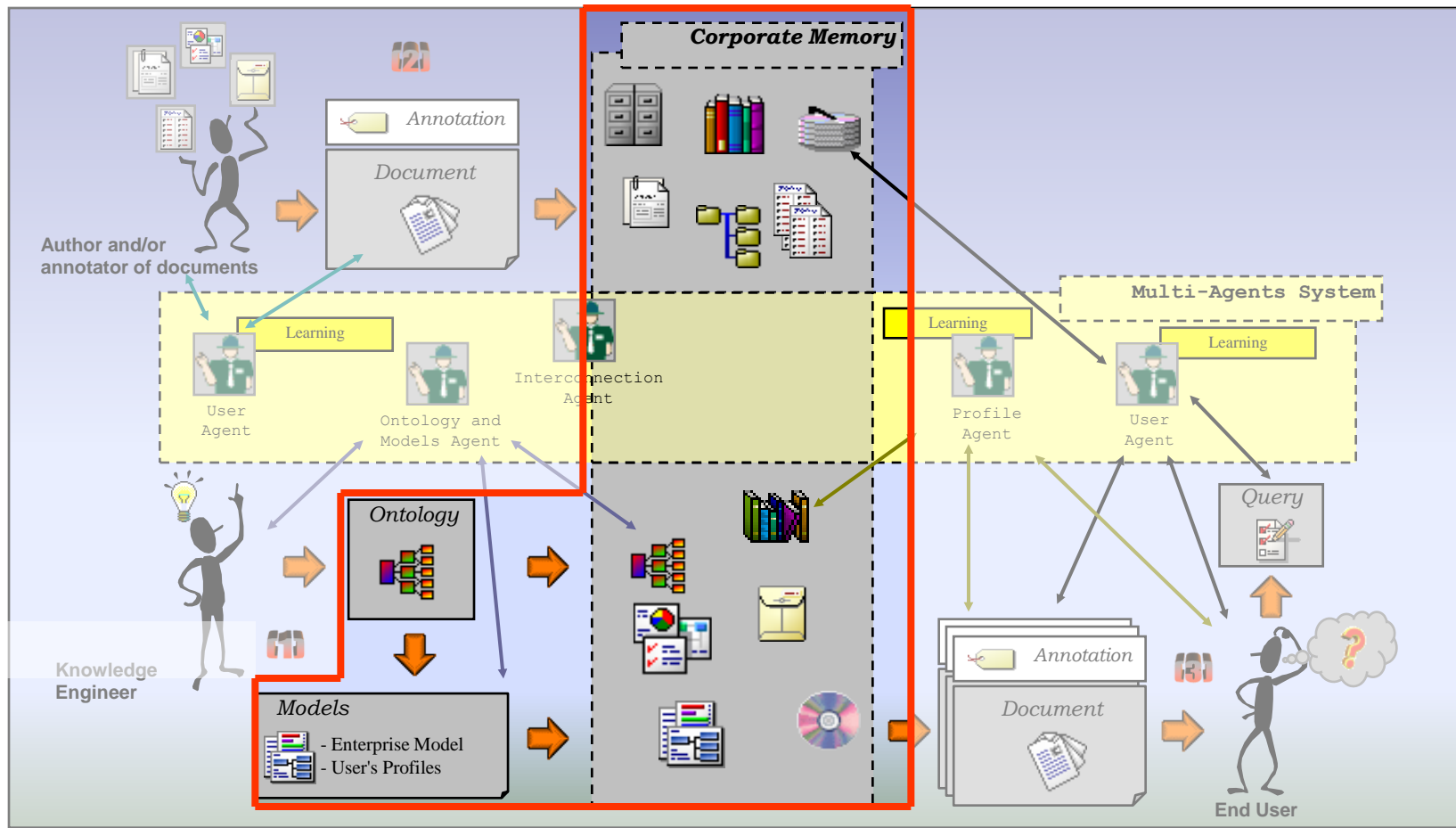




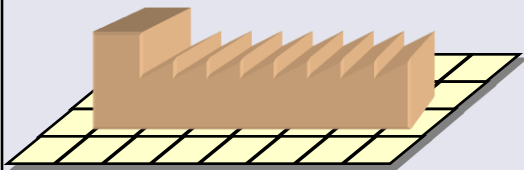
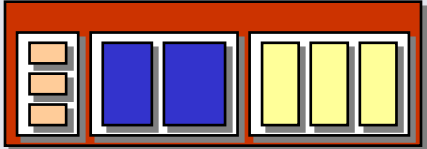
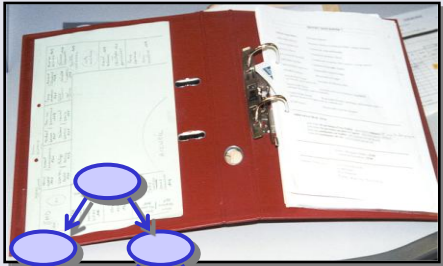









◆ **Ontology**: explicit partial account of concepts used in the corporate memory management scenarios and their relations

   	<p><b>Organizational Entity (X)</b> : The entity X is or is a sub-part of an organization.</p> <p><b>Person (X)</b>: The entity X is living being pertaining to the human race.</p> <p><b>Include (Organizational Entity: X, Organizational Entity / Person Y)</b> : the organizational entity X includes Y as one of its members.</p> <p><b>Manage (Person: X, Organizational Entity: Y)</b> : The person X watches and directs the organizational entity Y</p>	<p><b>Person</b>(Rose) <b>Person</b>(Fabien) <b>Person</b>(Olivier) <b>Person</b>(Alain)</p> <p><b>Organizational Entity</b>(INRIA) <b>Organizational Entity</b>(Acacia)</p> <p><b>Include</b>(INRIA, Acacia) <b>Manage</b>(Rose, Acacia)</p> <p><b>Include</b>(Acacia, Rose) <b>Include</b>(Acacia, Fabien) <b>Include</b>(Acacia, Olivier) <b>Include</b>(Acacia, Alain)</p>
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**a - Reality**

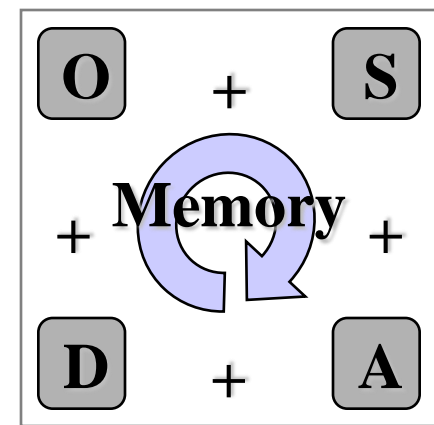


**b - Ontology**



**c - Situation & Annotations**

- ◆ **XML leitmotiv**: Bring structure to the memory to improve search and manipulation of documents using an emerging standard in industry.
- ◆ **RDF leitmotiv**: If the corporate memory becomes an annotated world, software can use the semantics of these annotations and through inferences help the users exploit the corporate memory.
- ◆ **Corporate semantic web: (annotated info world)**
  - Ontology in RDFS (O'CoMMA)
  - Description the Situation in RDF:
    - User Profiles (annotate person)
    - Organization model (annotate groups)
  - Annotations in RDF describing Documents (manipulation at semantic level)
- ◆ **Annotated persons & organizational entities**  
→ **context awareness**

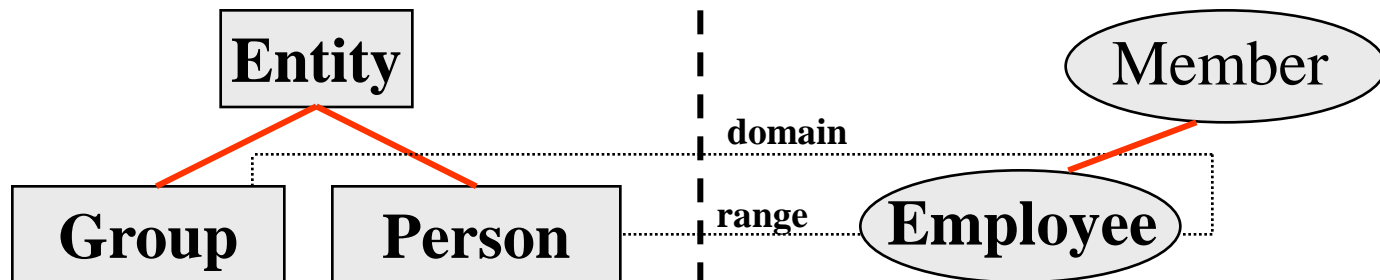


*Ontology  
in RDFS*

```

<rdfs:Class rdf:ID='Entity' />
<rdfs:Class rdf:ID='Group' >
  <rdfs:subClassOf rdf:resource='#Entity' />
</rdfs:Class>    ...
<rdf:Property rdf:ID='Employee' >
  <rdfs:subPropertyOf rdf:resource='#Member' />
  <rdfs:domain rdf:resource='#Group' />
  <rdfs:range rdf:resource='#Person' />
</rdf:Property>    ...

```

*Ontology  
hierarchy**RDF  
annotation*

```

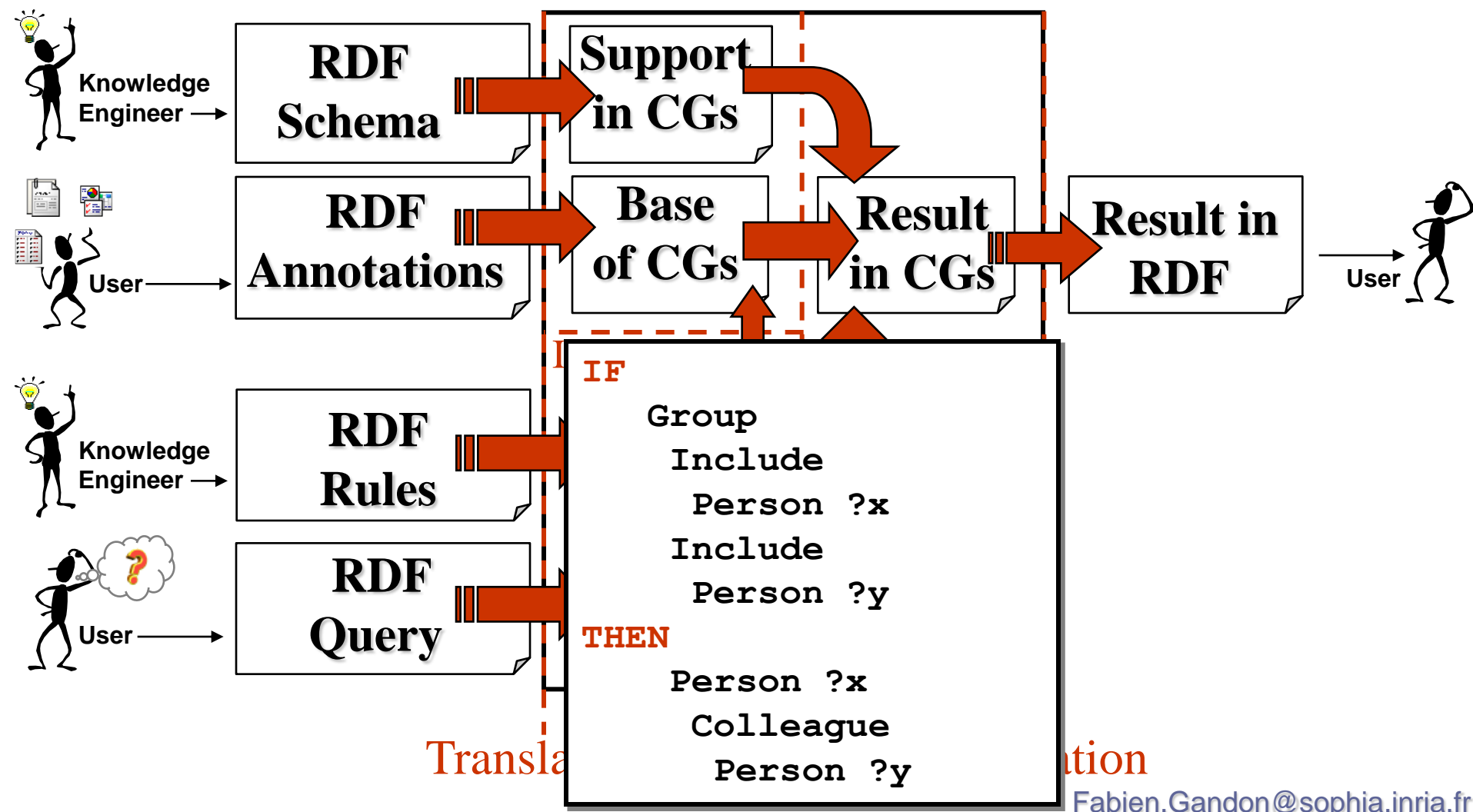
<CoMMA:Group rdf:about="http://www-sop.inria.fr/acacia/">
  <CoMMA:Employee>
    <CoMMA:Person rdf:about="http://www.inria.fr/~fab/" />
  </CoMMA:Employee>
</CoMMA:Group >

```

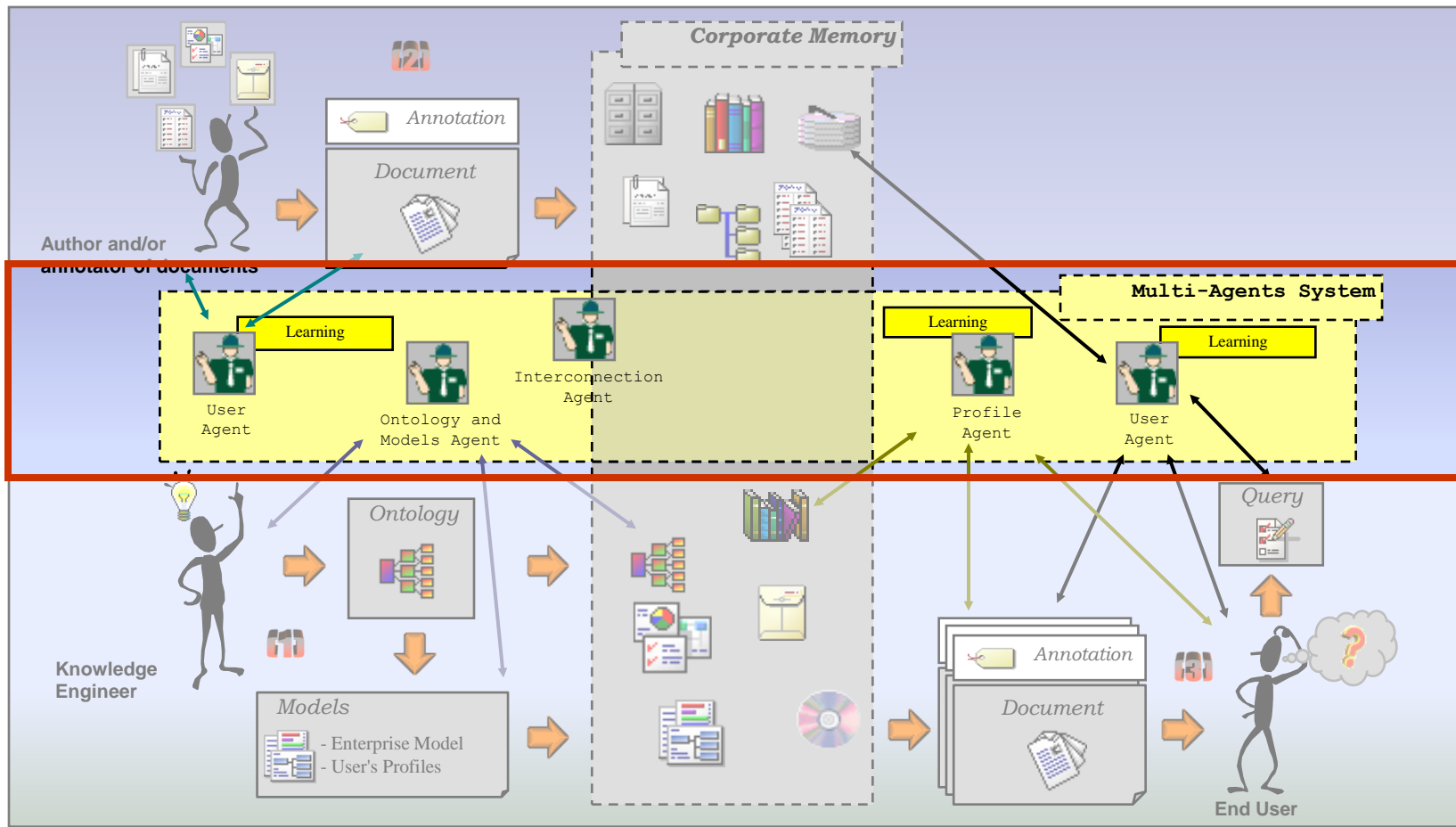
*Annotation  
triplet and graph***(Acacia, Employee, Fabien)**

# ◆ CORESE: COncceptual REsources Search Engine


- RDF(S) for schema, annotations, rules(+), queries(+)
- Light weight component & API



















- ◆ **Leitmotiv:** One functional architecture leading to several possible configurations in order to adapt to the broad range of environments that can be found in a company
  - **Architecture:** Agent kinds and their relationships  
*Fixed at design time*
  - **Configuration:** Exact topography of a given MAS  
*Fixed at deployment time*
  - **One** architecture → **Several** configurations  
*Adapt to context*
- ◆ **Agent paradigm adequacy:**
  - Agent collaboration → Global capitalization
  - Agent autonomy & individuality → Local adaptation
- ◆ **CoMMA** is an heterogeneous multi-agents information system

 **Ontology and Model Society**



    

Ontologist Agents

 **Annotations Society**

Archivists      


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Mediators  

 **Interconnection Society**

Federated Matchmakers

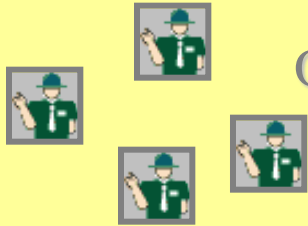
 **Users' society**

Interface Controllers      Profile Managers      Profiles Archivists



### Ontology and Model Society



Ontologist Agents



### Annotations Society

Archivists

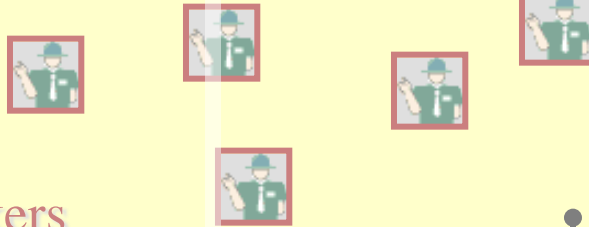


Mediators



### Interconnection Society

Federated Matchmakers



### Users' society

Interface  
Controllers



Profile  
Managers



Profiles  
Archivists

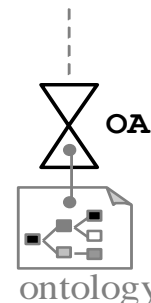


## ◆ Societies of replication and serving

### ■ Ontologist: to store and provide ontology

<b>role model</b>	Ontology Archivist role in the Ontology and Model society
<b>responsibilities</b>	store and retrieve O'CoMMA
<b>collaborators</b>	Directory facilitator, Interface Controller, User Profile Manager, User Profile Archivist, Annotation Mediator, Annotation Archivist, Corporate Model Archivist
<b>external interfaces</b>	RDFS schemas manipulation interface
<b>relationships</b>	-
<b>expertise</b>	ontology management an querying
<b>interactions</b>	Query-Ref, Request and Subscribe; FIPA ACL
<b>others</b>	-

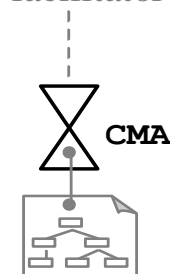
directory  
facilitator



### ■ Corporate model archivist: to store and provide structural model of the (human) organisation

<b>role model</b>	Corporate Model Archivist role in the Ontology and Model society
<b>responsibilities</b>	store, query, retrieve the organisational model
<b>collaborators</b>	Directory facilitator, Interface Controller, Annotation Mediator, Ontology Archivist
<b>external interfaces</b>	RDF annotation manipulation interface
<b>relationships</b>	composition: management and annotation archivist
<b>expertise</b>	annotation management an querying
<b>interactions</b>	Query-Ref, Request, Subscribe; FIPA ACL
<b>others</b>	-


directory  
facilitator



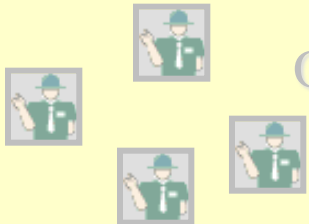
corporate model


### ■ One agent + CORESE





 **Ontology and Model Society**

Ontologist Agents



 **Annotations Society**


Archivists 




Mediators 

 **Interconnection Society**

Federated Matchmakers

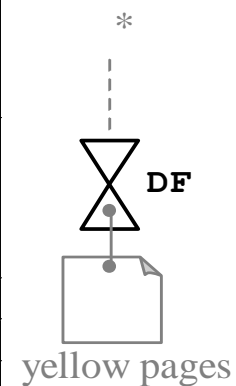


 **Users' society**


Interface Controllers  Profile Managers  Profiles Archivists 

- ◆ The Connection-dedicated sub-society:
  - Yellow pages service management
  - Federable to allow us to configure the MAS
  - Cooperating matchmakers (DF)

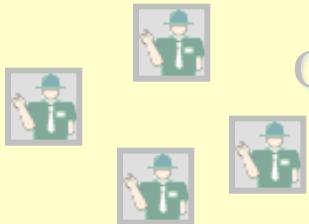
<b>role model</b>	Directory Facilitator role in the Yellow and White pages society
<b>responsibilities</b>	handles matchmaking among agents providing registering and de-registering services as well as service querying
<b>collaborators</b>	Ontology Archivist, Interface Controller, User Profile Manager, User Profile Archivist, Annotation Mediator, Annotation Archivist, Corporate Model Archivist
<b>external interfaces</b>	-
<b>relationships</b>	-
<b>expertise</b>	FIPA Service description management
<b>interactions</b>	Request; FIPA ACL, FIPA-Agent-Management ontology
<b>others</b>	(Provided by JADE)




(Plus the AMS for white pages)


 **Ontology and Model Society**


Ontologist Agents




Dashed lines connect this box to the Interconnection Society box.

 **Annotations Society**

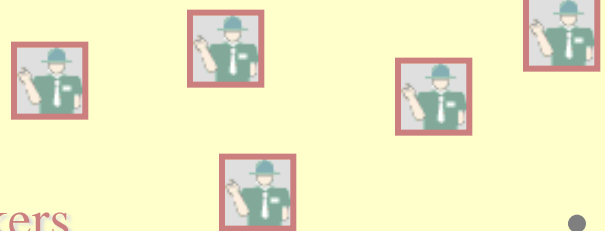
Archivists 

Mediators 


Dashed lines connect this box to the Interconnection Society box.


 **Interconnection Society**


Federated Matchmakers




Dashed lines connect this box to the Users' society box.

 **Users' society**

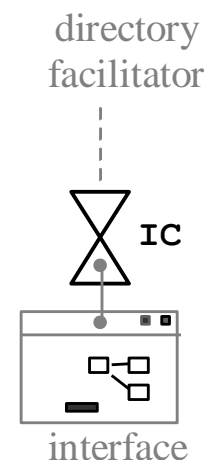
Interface Controllers 

Profile Managers 

Profiles Archivists 

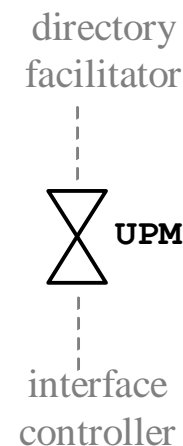
- ◆ Three main roles in user-dedicated sub-society:
  - GUI management: direct interactions with user (IC)
  - User Profile management:
    - Symbolic learning techniques (UPM)
    - Archiving and ensuring secured login (UPA)

<b>role model</b>	Interface Controller role in the user-dedicated society
<b>responsibilities</b>	handles interface between the user and the rest of the multi-agent system
<b>collaborators</b>	Ontology Archivist, User Profile Manager, Corporate Model Archivist, Directory Facilitator
<b>external interfaces</b>	graphic interfaces, HTML browser and XLM/XSLT engines
<b>relationships</b>	-
<b>expertise</b>	User interactions management
<b>interactions</b>	Request; FIPA ACL
<b>others</b>	not persistently running



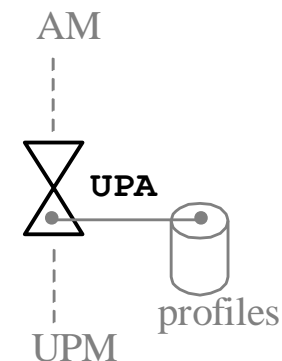
## ■ User profile manager: machine learning

<b>role model</b>	User Profile Manager role in the user-dedicated society
<b>responsibilities</b>	handles customisation and adaptation in the user profile
<b>collaborators</b>	Ontology Archivist, Interface Controller, Annotation Mediator, User Profile Archivist, Directory Facilitator
<b>external interfaces</b>	machine learning techniques libraries
<b>relationships</b>	(partly absorbed the User profile processor)
<b>expertise</b>	learning from usage patterns
<b>interactions</b>	Request; FIPA ACL
<b>others</b>	-




## ■ User profile archivist: profile storage and login

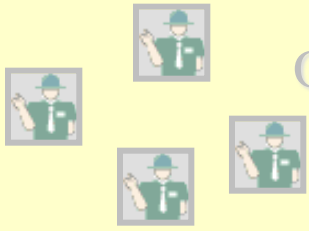
<b>role model</b>	User Profile Archivist role in the user-dedicated society
<b>responsibilities</b>	handles storage and access in the user profile
<b>collaborators</b>	Ontology Archivist, Annotation Mediator, User Profile Manager, Directory Facilitator
<b>external interfaces</b>	RDF annotation manipulation interface
<b>relationships</b>	composition: management and annotation archivist
<b>expertise</b>	storage, access right and retrieval of profiles
<b>interactions</b>	Request; FIPA ACL
<b>others</b>	-








 **Ontology and Model Society**


Ontologist Agents




 **Annotations Society**


Archivists 




Mediators 

 **Interconnection Society**

Federated Matchmakers

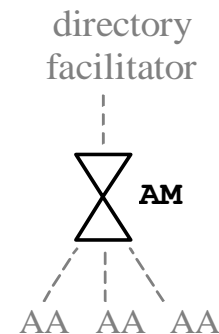


 **Users' society**

Interface Controllers  Profile Managers  Profiles Archivists 

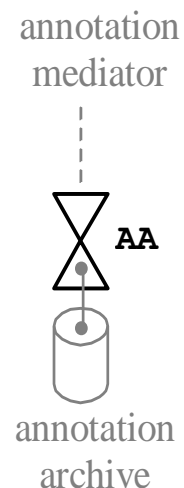
- ◆ The annotation-dedicated sub-society:
  - Distributed local sources
  - Archive annotations on documents of the O.M.
  - Search & retrieve references matching queries
- ◆ **Hierarchy:** to federate two aspects of the society
  - Mediator role (manage social aspect):
    - supervising distributed query solving process
    - managing allocation of new annotations
    - notification of new annotations to trigger push functions

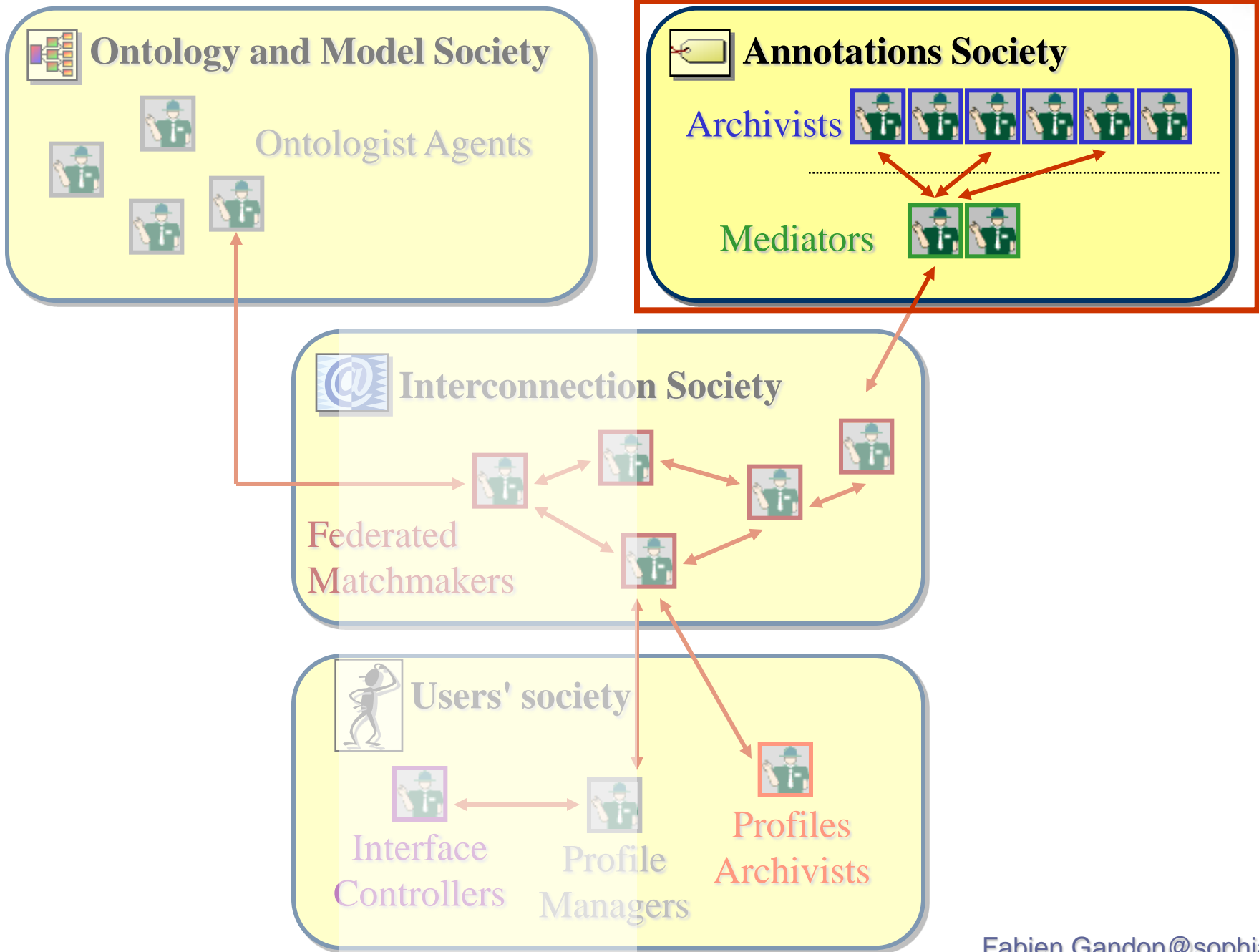
<b>role model</b>	Annotation Mediator role in the Annotation-dedicated society
<b>responsibilities</b>	handle distribution of annotations over the archivists both for new annotation submissions and query solving processes
<b>collaborators</b>	Directory facilitator, User Profile Manager, Ontology Archivist, Annotation Archivist, Corporate Model Archivist
<b>external interfaces</b>	RDF annotation manipulation interface
<b>relationships</b>	-
<b>expertise</b>	query and submission management
<b>interactions</b>	Query-Ref, Contract-Net, Subscribe, Request; FIPA ACL
<b>others</b>	-



- ◆ The annotation-dedicated sub-society:
  - Distributed local sources
  - Archive annotations on documents of the O.M.
  - Search & retrieve references matching queries
- ◆ **Hierarchy:** to federate two aspects of the society
  - **Archivist role (manage local aspect):**
    - attached to & exploits local base
    - answers to query & proposes archiving services

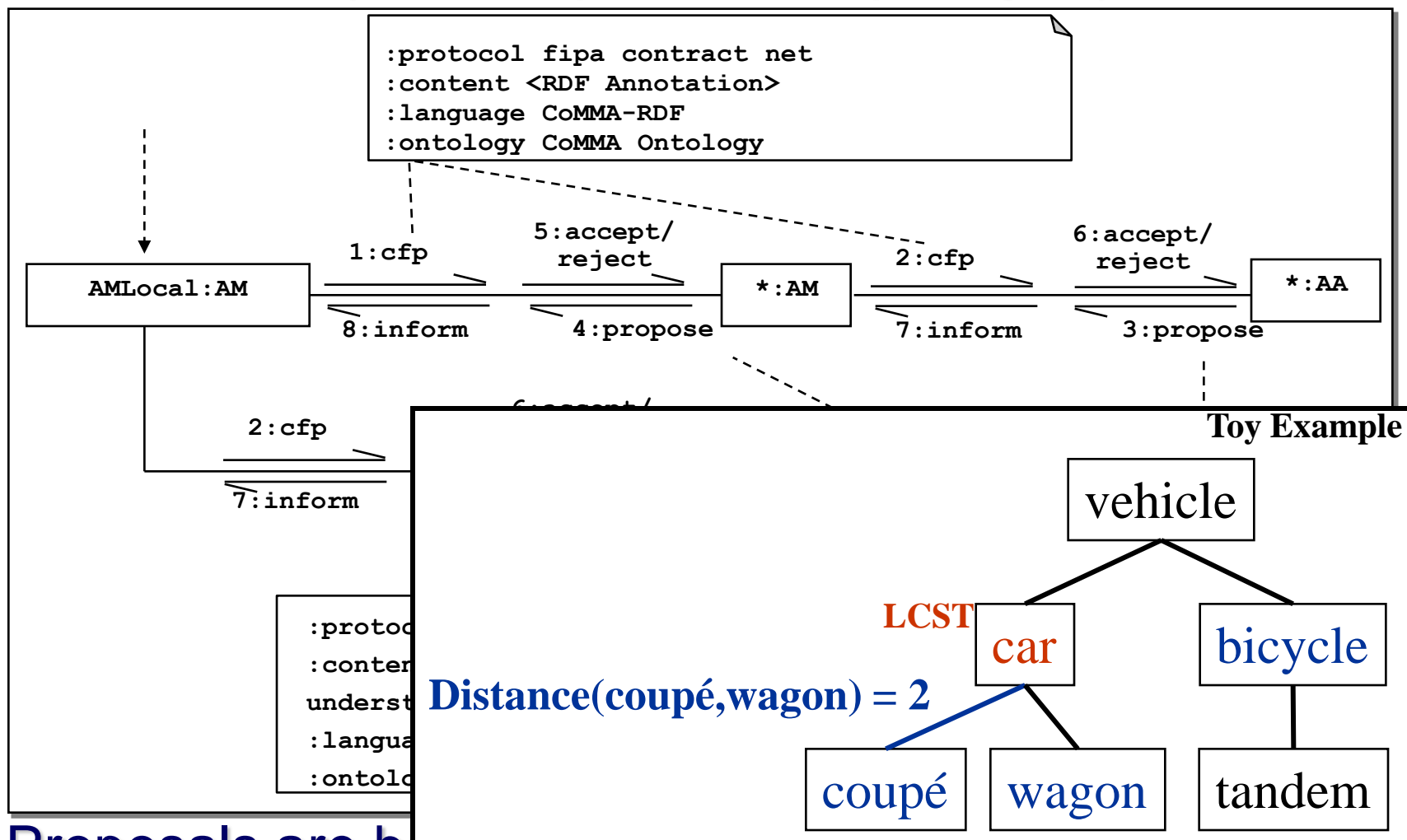
<b>role model</b>	Annotation Archivist role in the Annotation-dedicated society
<b>responsibilities</b>	store and query the annotations of the memory
<b>collaborators</b>	Directory facilitator, Annotation Mediator, Ontology Archivist
<b>external interfaces</b>	RDF annotation manipulation interface
<b>relationships</b>	also part of the roles in Corporate Model Archivist and User Profile Archivist
<b>expertise</b>	annotation archiving an querying
<b>interactions</b>	Query-Ref, Contract-Net; FIPA ACL
<b>others</b>	-





## ◆ C-Net : Annotation allocation

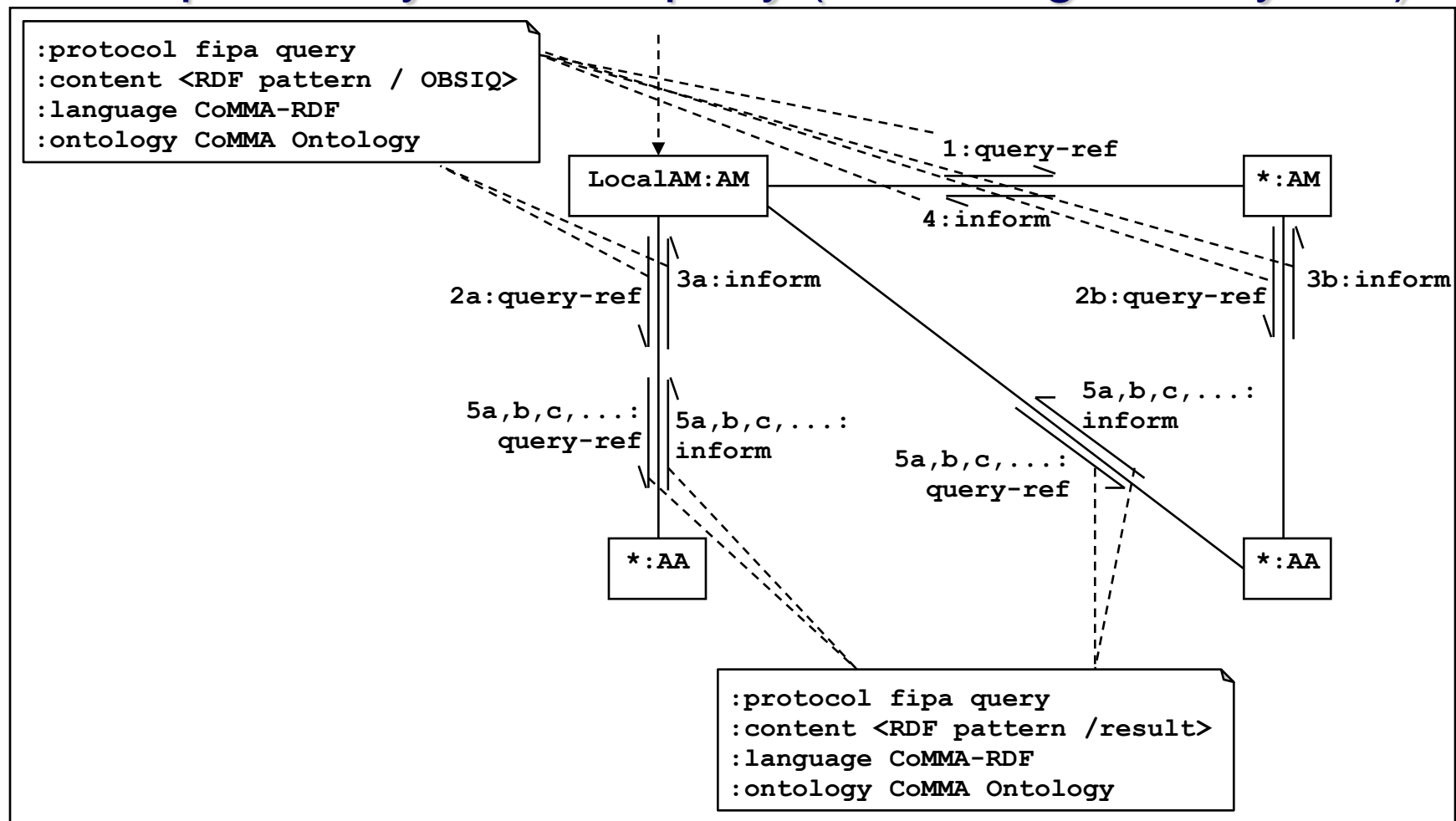
- Mediator & Archivists discuss best place to archive
- Contract-net (CfP, Proposal, Accept/Reject):



- Proposals are based on pseudo semantic distance over ontology space

## ◆ Fragmentation et distributed queries

- Co-operatively solve a query (multi-stage Query-Ref):



- Query decomposition using URIs as cut/join points
- Allocation of sub-query based on overlap description
- Ontology primitives usage statistics

**(QUERY-REF****:sender ( agent-identifier****:name localUPM@fapollo:1099/JADE)****:receiver (set ( agent-identifier****:name AM@fapollo:1099/JADE) )****:content****((all ?x (is-answer-for****(query****:pattern "<?xml version =\"1.0\"?> <rdf:RDF xml:lang=\"en\" xmlns:rdf=  
\"http://www.w3.org/1999/02/22-rdf-syntax-ns#\"  
xmlns:comma=\"http://www.inria.fr/acacia/comma#\">****<comma:Memo><comma:Designation>?</comma:Designation>****</comma:Memo>****</rdf:RDF>\" ) ?x ) ) )****:reply-with QuerylocalUPM987683105872****:language CoMMA-RDF****:ontology CoMMA-annotation-ontology****:protocol FIPA-Query****:conversation-id QuerylocalUPM987683105872****)**



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xmlns:comma=\"http://www.inria.fr/acacia/comma#\">****<comma:Memo><comma:Designation>?</comma:Designation>****</comma:Memo>****</rdf:RDF>\" ) ?x ) ) )****:reply-with QuerylocalUPM987683105872****:language CoMMA-RDF****:ontology CoMMA-annotation-ontology****:protocol FIPA-Query****:conversation-id QuerylocalUPM987683105872****)**

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\"http://www.w3.org/1999/02/22-rdf-syntax-ns#\"  
xmlns:comma=\"http://www.inria.fr/acacia/comma#\">****<comma:Memo><comma:Designation>?</comma:Designation>****</comma:Memo>****</rdf:RDF>\" ) ?x ) ) )****:reply-with QuerylocalUPM987683105872****:language CoMMA-RDF****:ontology CoMMA-annotation-ontology****:protocol FIPA-Query****:conversation-id QuerylocalUPM987683105872****)**

**(QUERY-REF****:sender ( agent-identifier****:name localUPM@fapollo:1099/JADE)****:receiver (set ( agent-identifier****:name AM@fapollo:1099/JADE) )****:content****((all ?x (is-answer-for****(query****:pattern "<?xml version =\"1.0\"?> <rdf:RDF xml:lang=\"en\" xmlns:rdf=  
\"http://www.w3.org/1999/02/22-rdf-syntax-ns#\"  
xmlns:comma=\"http://www.inria.fr/acacia/comma#\">****<comma:Memo><comma:Designation>?</comma:Designation>****</comma:Memo>****</rdf:RDF>\" ) ?x ) ) )****:reply-with QuerylocalUPM987683105872****:language CoMMA-RDF****:ontology CoMMA-annotation-ontology****:protocol FIPA-Query****:conversation-id QuerylocalUPM987683105872****)**

## ◆ **Ontology as a cornerstone of DAI for KM**

- Modelling and representation consensus
  - Communication between humans (ontology as a component of the memory, annotations and models)
  - Communication between agents (c.f. message)
  - Formal structures (annotations, schemata, etc.) for inferences
- Ontological consensus to build consensus above:
  - computational consensus, e.g.: measure
  - co-operation consensus, e.g.: protocols

## ◆ **Vice-versa: DAI as a cornerstone for ontologies**

## ◆ **Complementary domains**

- D.A.I.  $\leftrightarrow$  Ontology
- D.A.I.  $\leftrightarrow$  Semantic Web
- Ontology  $\leftrightarrow$  Semantic Web

## ◆ Two trials and one open-day

## ◆ Results & feedback:



☹ Ergonomics problems

☹ Specialization problems

☹ Monolithic solution evaluation problem

☹ No large-scale evaluation (groups of 4/6 users)

😊 Proof of concept: usability and usefulness recognized

😊 Integration of results from different domains

😊 Developers appreciation of ontology-agent approach

😊 Industrial interest in the development of the prototype

## ◆ On going improvements in the team:

- pseudo distance & decomposition algorithms

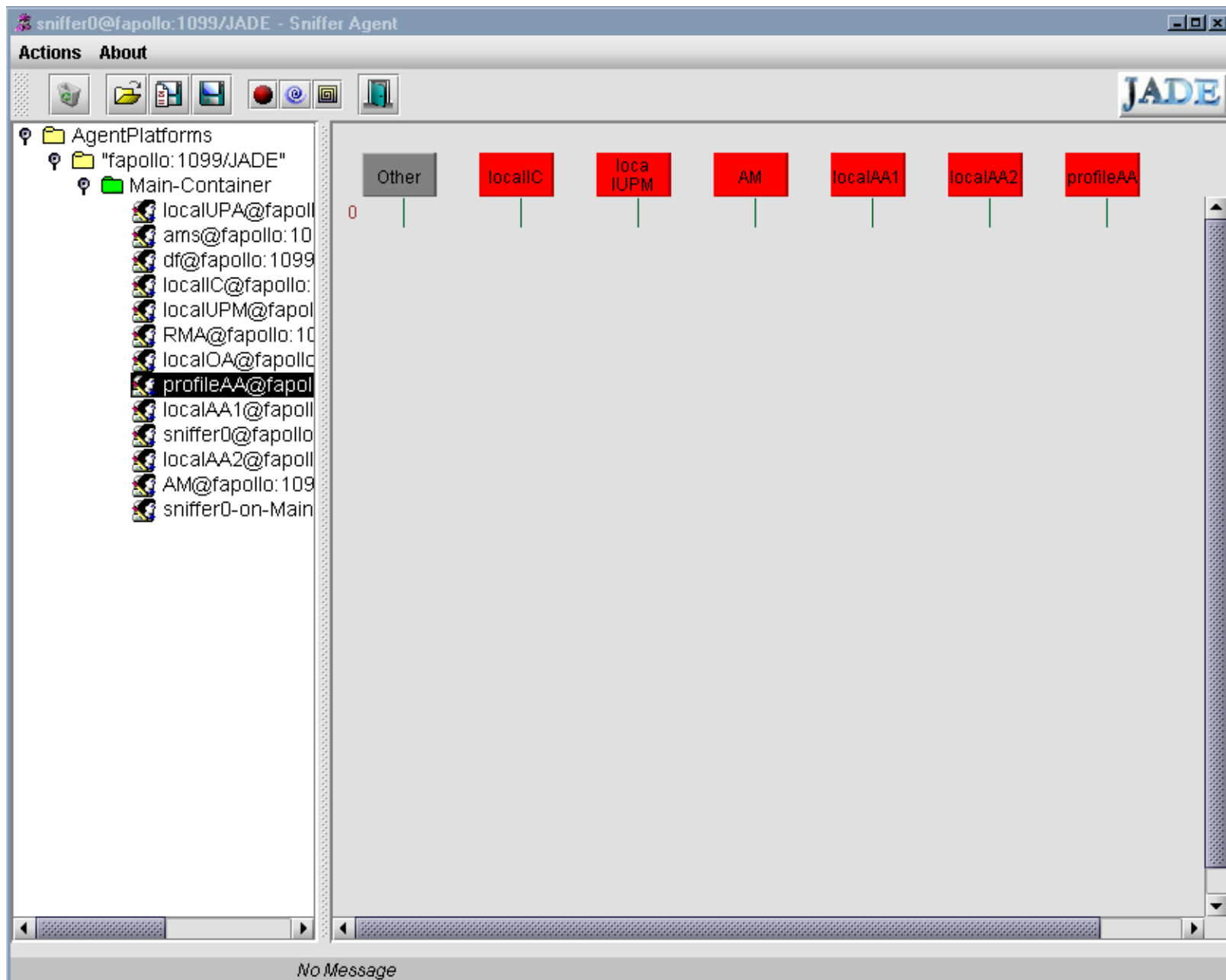
- Web mining wrappers: semi-automatic annotation

- Ontology mapping: connect 2 corporate semantic webs

- Ontology reuse and integration and NLP tools

The screenshot shows a web browser window titled "CoMMA Home Page". The main content area features the text "CoMMA HOME" in a large, serif font. On the left side, there is a vertical navigation menu with several buttons: "Home", "Ontology", "Look for information" (with a sub-button "New query" and a link "Previous query..."), "Add information" (with a sub-button "New indexation" and a link "Previous indexation..."), "Comments", "Any problem ?" (with sub-buttons "Contact us" and "About CoMMA"), and "Quit". At the bottom of the page, there are two sections: "Profile" containing an "Edit user profile" button, and "Registration" containing buttons for "Register to a COI", "Register as new comer", and "Register to a news gro...". The CoMMA logo is located in the top left corner of the page content.









CoMMA Home Page

**CoMMA HOME**

Home

Ontology

Look for information

New query

Previous query...

Add information

New indexation

Previous indexation...

Comments

Any problem ?

Contact us

About CoMMA

Quit

Profile

Registration

Edit user profile

Register to a COI

Register as new comer

Register to a news gro...

sniffer0@fapollo:1099/JADE - Sniffer Agent

Actions About

AgentPlatforms

- "fapollo:1099/JADE"
  - Main-Container
    - localUPA@fapoll
    - ams@fapollo:10
    - df@fapollo:1099
    - localIC@fapollo:
    - localUPM@fapol
    - RMA@fapollo:10
    - localOA@fapollc
    - profileAA@fapol
    - localAA1@fapoll
    - sniffer0@fapollo
    - localAA2@fapoll
    - AM@fapollo:109
    - sniffer0-on-Main

JADE

Other	localIC	loca IUPM	AM	localAA1	localAA2	profileAA
0						

No Message

The screenshot shows a web browser window displaying three ontology instances. Each instance is represented by a colored box (light blue, light green, and light blue) containing structured information. The first instance is a 'transparency show' with a target 'organizational entity' interested in 'knowledge management'. The second is another 'transparency show' with a target 'organizational entity' interested in 'knowledge management'. The third is a 'presentation' with a target 'organizational entity' interested in 'knowledge management'. Each instance includes a 'title' field and a 'target' field.

© **transparency show** <http://www-sop.inria.fr/acacia/personnel/Fabien.Gandon/cstb.ppt> (?)

target:

© **organizational entity**

is interested by:

© **knowledge management** (U)

title: Presentation of CoMMA to the CSTB

© **transparency show**  
<http://www-sop.inria.fr/acacia/personnel/Fabien.Gandon/research/ekaw2000/ekaw.ppt> (?)

target:

© **organizational entity**

is interested by:

© **knowledge management** (U)

title: Presentation of CoMMA Methodology at EKAW2000

© **presentation** <http://fapoll0:8080/comma/doc/CoMMATerms.avi> (?)

target:

© **organizational entity**

is interested by:

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***Thank you !***