

Combining reactive & deliberative agents for complete ecosystems in infospheres

*“The diversity of resources and information in real infospheres calls for artificial ecosystems with a diversity of interacting agents ranging from reactive to deliberative paradigms and maintaining the information ecology.” **proceedings IAT p. 297***

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- **General position**

Argue for complete ecosystems in infospheres

- **Technological stance**

Summarize interests of XML for infospheres

- **Initial and current work**

Examples of implementations and experiments

- Information resources and services:
 - Situated and **scattered** on the net;
 - Ever **changing** in form and content;
 - Ever **growing** in size and **heterogeneity**.
- Overwhelming **complexity** for humans.
- Overwhelming **complexity for machines**:
unorganized and too heterogeneous in form,
content, quality, *etc.* for direct automation.
- Alike our own world:
 - Vast, distributed, heterogeneous landscape;
 - Rich fertile soil of information resources;
 - Actors and resources are situated;
 - Actors can perceive, act and interact.

The infosphere metaphor

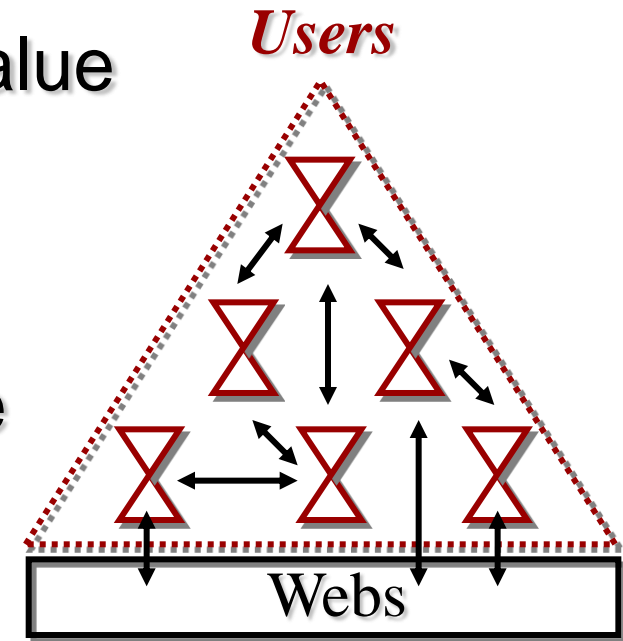
- Infosphere: the equivalent in information worlds of our biosphere and its ecosystem.
- Ecosystem:
 - System encompassing **beings** and **environment**;
 - **Self-regulating** through complex cycles involving multiple types of interaction;
 - **Interactions** between a huge variety **of beings**;
 - **Interactions beings** and huge variety **environments**.
- Good news... convergence between:
 - Distributed AI / Multi-agent systems (beings)
 - Structured and semantic Web & Services (enviro.)
- Bad news...

Compartmentalized current trends

- Autecology and compartmentalized schools
 - Focus on **one type of agent**
e.g. information extraction.
 - Follow one **school of thoughts**
e.g. reactive agents vs. deliberative agents
 - Integration of **at agent level** e.g. layered architecture
 - Interactions at **one level only** e.g. knowledge level
- A lot of scenarios can benefit from **hybrid solutions**
- To address complete scenarios real infospheres have to **overcome** this **compartmentalization**.

Toward complex information ecosystems

- A complex information ecosystem includes **chains and webs** leveraging the variety of agents
 - Allows for a **pyramid of species** where each level brings some added value to the whole information chain;
 - Allows for a **large spectrum** of agent types addressing the large spectrum of information tasks required by scenarios of use;
 - Allows **direct interactions and indirect chains and webs of interactions** across the different levels.



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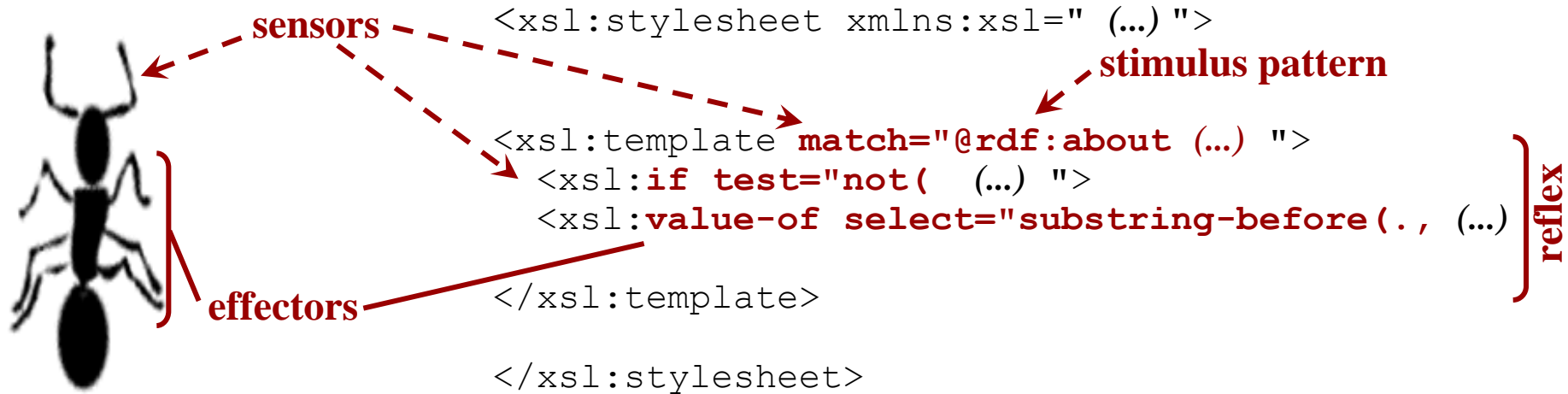
Technological stance: XML standards

- XML: **shaping** distributed information landscapes.
 - Structure documents and data using a text format.
 - Platform-independent, internationalization, localization, validation, license-free, *etc.*
 - **Distributed information that can be processed.**
- RDF/S and OWL: encoding distributed **semantics**.
 - Annotate **Web resources** with **properties/relations**.
 - Encode **ontologies** for annotation and interactions.
- XSLT+XPath: describe **modification** of information.
 - Rule-based language for XML **tree transformation**.
 - Selecting, sorting, counting, variables, parameters, **importing** other stylesheets, extensions, *etc.*

XSLT and agents

- XML → exchange format for structured data.
XSLT → exchange format for data manipulation.
- XML: declarative language in agent com.
XSLT: procedural language in agent com.
- Two perspectives on XSLT in agent interactions
 - Dynamically customize generic information agent roles at run-time // **holonic approach**.
 - Describe and propagate simple reactive XML agents // **ecosystem approach**.
 - In both cases XSLT is used to propagate simple XML manipulation behaviors.
 - Use **standard protocols** for propagation e.g. FIPA-Request

XSLT Agents



- Constructors provided by XSLT:

- Sensors = patterns of a template or the test instructions both using the XPath expressions;
- Effectors = the value-manipulating instructions;
- Reactions = recursive rules & branching instructions

- Rule #1: respect the environment

```
<xsl:template match="@*|node()">  
  <xsl:copy>  
    <xsl:apply-templates select="@*|node()" />  
  </xsl:copy>  
</xsl:template>
```

Progression of the talk

- ✓ General position

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Context of experimentation

- CoMMA (IST INRIA, ATOS-Origin, CSTB, LIRMM, Deutsche Telekom, Univ. Parma)
 - Corporate memory as a **corporate semantic** web
= ontology + annotations of docs, org. & people
 - Improve precision/recall, push, organize archives
 - User Interface Controller; Profile Manager; Profile Archivist; Ontology Archivist; Corporate Model Archivist; Annotation Archivist; Annotation Mediator
- *my*Campus (DAML CMU, DARPA, Boeing, HP, IBM, Symbol, Fujitsu, Amazon, IST)
 - Mobile accesses to **context-aware services**
 - Open architecture: e-Wallets, User Interaction Manager, Task-Specific Agents.
- Both cases: Semantic Web + Deliberative agents

Customize behaviors: Web wrapper

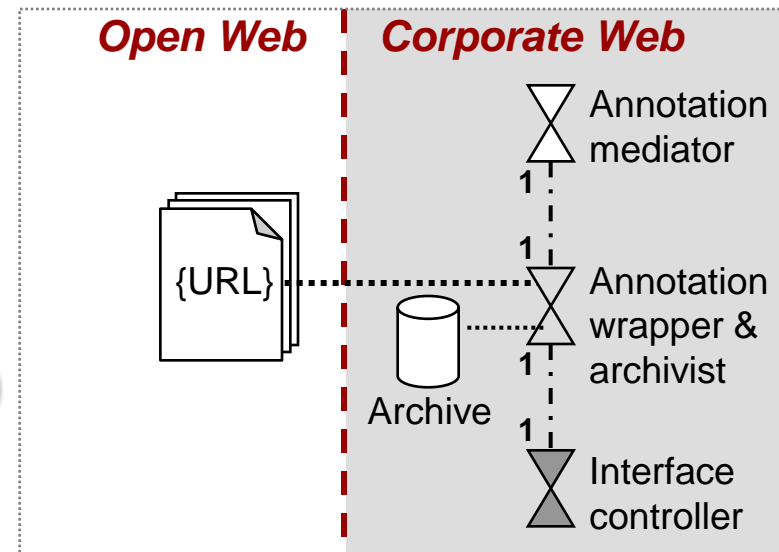
- Automate **extraction** of relevant pieces from Web
Integrate them to the organizational memory:

- Sample page → HTML → XHTML
- XHTML → Example annotation → XSLT
- Create Annotation Wrapper (XSLT + Web sources)
- Annotation Mediator (query solving & monitoring)

- XSLT for extraction task

- Built-in templates = high level extraction functions
- Composition, extension, propagation

- Behavior of wrappers initially with generic task of extraction then customized at run-time // **holonic**

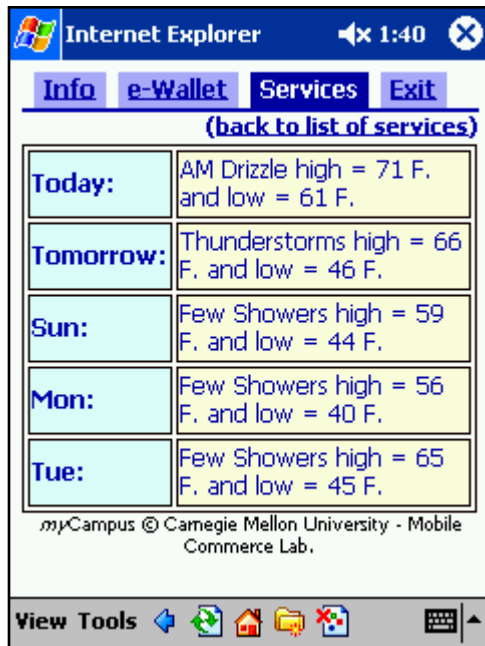




CoMMA HOME

[Home](#)**Look for information**[New query](#)[Previous query...](#)**Add information**[New indexation](#)[Previous indexation...](#)[Comments](#)**Add Annotation**[Create wrapper](#)**Any problem ?**[Contact us](#)[About CoMMA](#)[Quit](#)**Profile**[Edit user profile](#)[Edit query profile](#)**Registration**[Register to a COI](#)[Register as new comer](#)[Register to a news gro...](#)

myCampus wrapped services



Internet Explorer 1:40

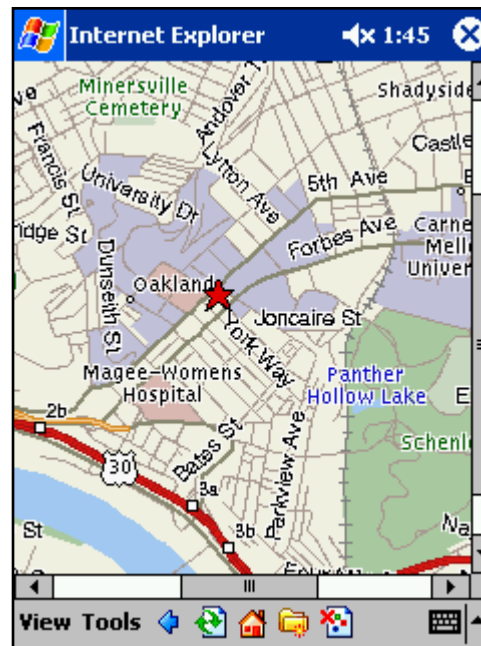
Info e-Wallet **Services** Exit

(back to list of services)

| | |
|------------------|---|
| Today: | AM Drizzle high = 71 F. and low = 61 F. |
| Tomorrow: | Thunderstorms high = 66 F. and low = 46 F. |
| Sun: | Few Showers high = 59 F. and low = 44 F. |
| Mon: | Few Showers high = 56 F. and low = 40 F. |
| Tue: | Few Showers high = 65 F. and low = 45 F. |

myCampus © Carnegie Mellon University - Mobile Commerce Lab.

View Tools



Internet Explorer 1:45

A map of Pittsburgh, PA, showing streets, landmarks, and a red star marker. The map includes labels for Minersville Cemetery, University Dr, Oakland, Magee-Womens Hospital, Panther Hollow Lake, and Schenley Park. A red star is located near the intersection of University Dr and Oakland.

View Tools



Internet Explorer 1:41

Bad Boys II (Carmike Maxi Saver 12:30 PM, 3:45, 6:45, 9:40)

Bruce Almighty (Carmike Maxi Saver 12:00 PM, 3:20, 5:35, 7:45, 10:05)

Cabin Fever (Loews Waterfront Theatre 2:20 PM, 5:20, 7:50, 10:25)

Cold Creek Manor (Loews Waterfront Theatre 12:20 PM, 1:30, 3:20, 4:30, 6:35, 7:30, 9:20, 10:30, 12:10)

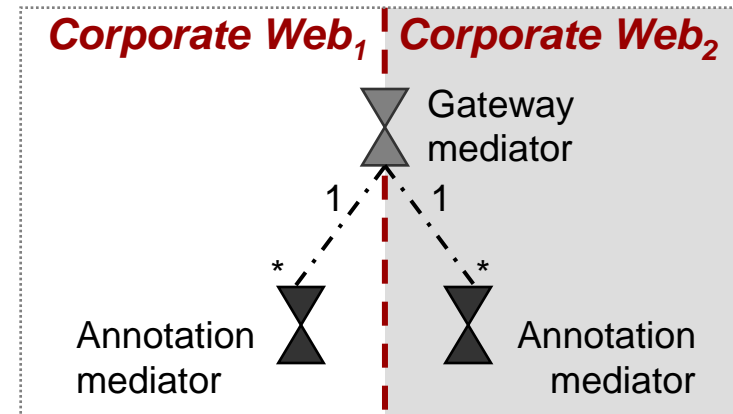
Cold Creek Manor (Showcase Cinemas Pittsburgh East 1:30 PM, 4:30, 7:10, 9:45)

Daddy Day Care (Carmike Maxi

View Tools

Customize behaviors: semantic gateway

- Temporary **extranets** supporting a virtual organization: **connection of semantic intrawebs**
 - Generic gateway agent **translating between ontologies** of the different organizations
 - Semi-automatic mapping construction (simple tf*icf)
 - Set of XSLT templates to translate query/annotation
 - Upload / customization of translation behavior
- Generic gateways for translation and security task of translation customized at run-time // **holonic**



Customize behaviors: dynamic interfaces

- Customizing and extending interfaces

CoMMA:

*my*Yahoo-like
ontology-based
querying

Looking for something Fabien ?

computer science :

[artificial intelligence, AI, A.I.](#) / [computer graphics](#) / [HCI, H.C.I., human-computer interaction](#) / [network](#) / [programming](#) / [simulation](#) / [software engineering](#)

service :

[administration, administer](#) / [advertise, advertising, advertisement](#) / [commerce](#) / [consulting](#) / [development](#) / [education](#) / [finance](#) / [human resources](#) / [insurance](#) / [legal](#) / [marketing](#) / [research](#) / [restoration, food](#) / [transport](#) / [travel](#)

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person, human, human being :

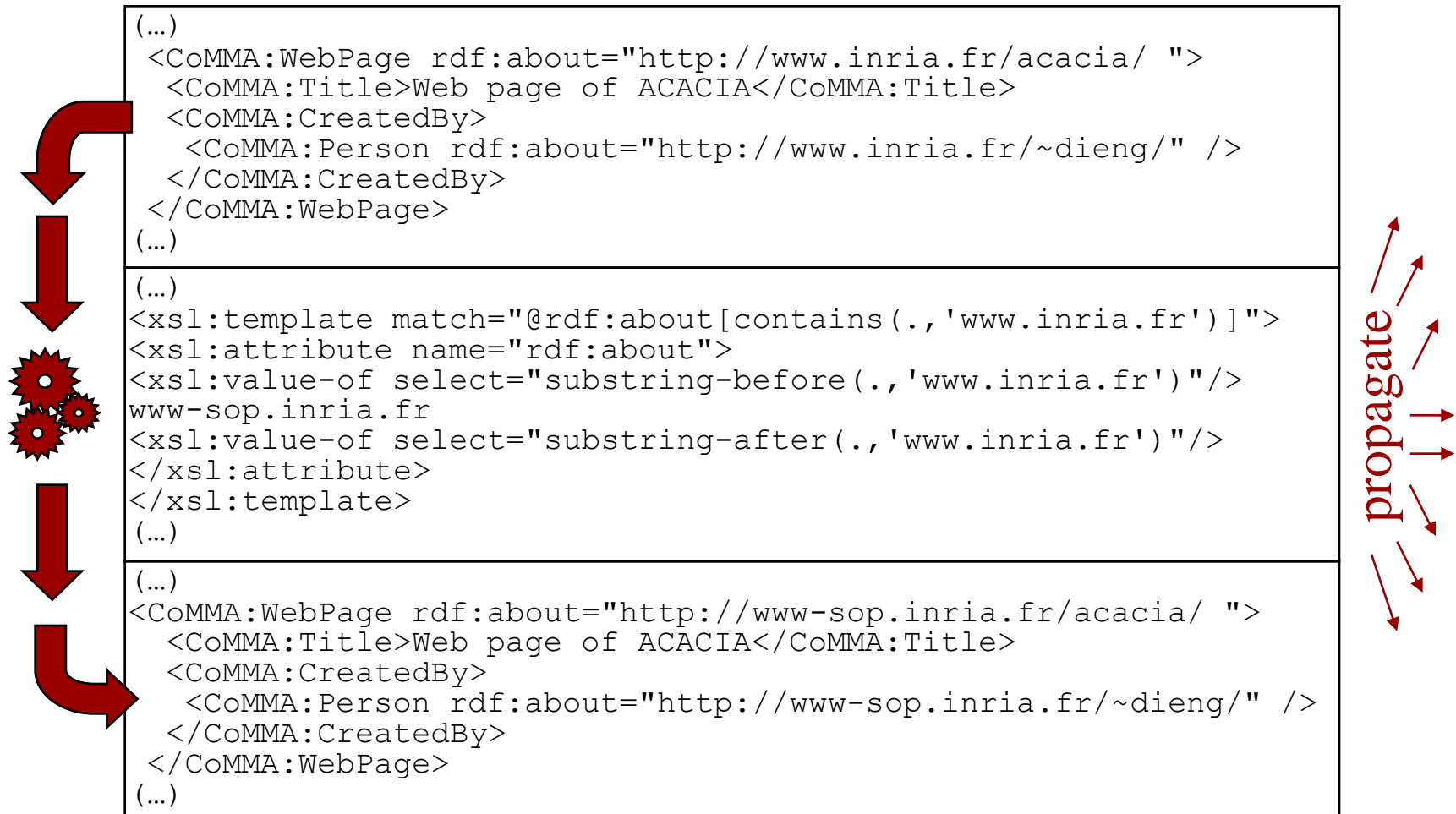
[integration process actor](#) / [professional](#) / [student](#) / [technology monitoring actor](#)

organization group, organisation group :

[group of individuals](#) / [international organization, multinational](#) / [local organization, regional organization, local organisation, regional organisation](#) / [national organization, national organisation group](#) / [organization, organisation](#) / [organization part](#) / [single site organization](#)

Swarm propagation: maintenance

- Life-cycle of (distributed) knowledge: update annotations, maintain coherence, erase old ones...
- Generate swarm agent e.g. update URI of resource



Swarm propagation: info. fermentation (I)

- Reactive agents and shallow processing, e.g.:
 - Annotations added & archived in distributed bases
 - Reactive agents propagated to enrich annotations
 - Query & push agents retrieve relevant annotations
 - Interface agents display enriched results
- Testing: PubMed from National Library of Medicine
 - 9981 annotations extracted by Annotation Wrapper
 - Behavior = cross-pollenizing/pollination; bee2bee ☺
 1. XSLT script starts from an annotation & extracts its list of authors
 2. Propagate
 3. For each other annotation visited leave pheromone if the visited annotation shares authors with the initial annotation

Swarm propagation: info. fermentation (II)

- Pheromone track left by pollination agent:

```
<c:ResearchReport rdf:about="URL in visited annotation">  
  (...)
```

```
<c:sameAuthorAs>
```

```
  <c:SameAuthorDoc c:nbSharedAuthors="nb shared authors"  
    rdf:about="url initial document" />
```

```
  </c:sameAuthorAs>
```

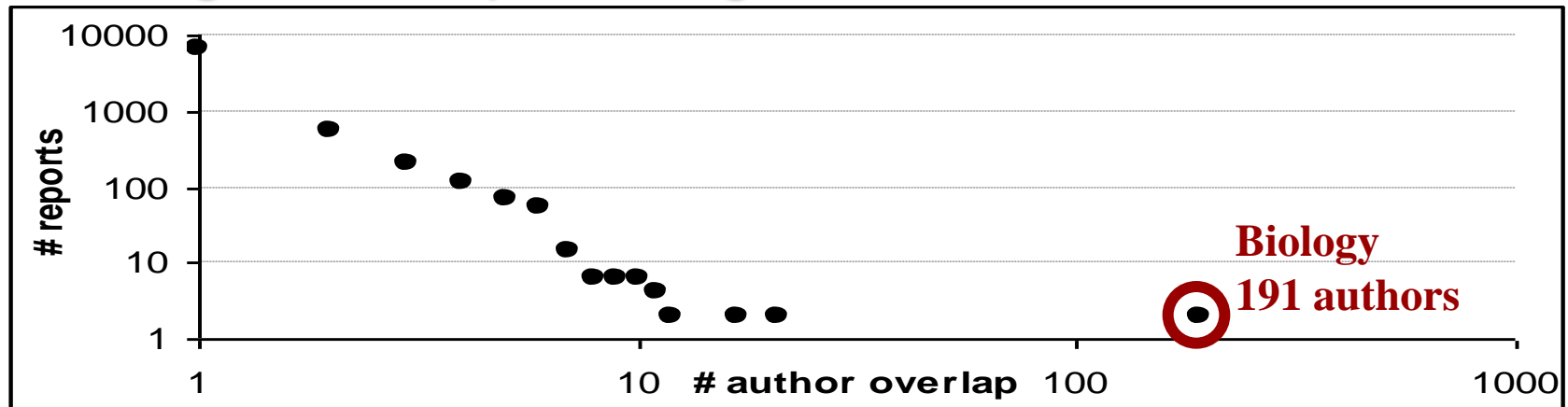
```
</c:ResearchReport>
```

used to ranks

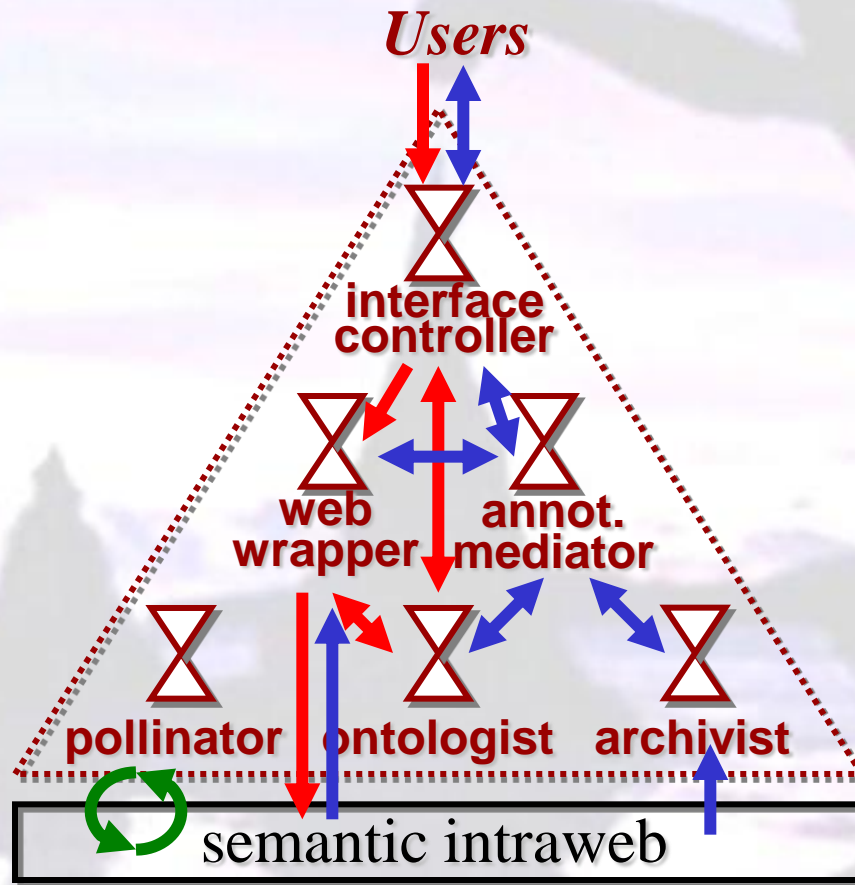
one step in a track

- Over the 9981 annotations:

- 7724 'sameAuthorAs' links generated
- Linking 2728 reports together *i.e.* 27% of the base



Swarm propagation: info. fermentation (III)



Conclusion

- This is **not about** expressiveness of **XSLT**, XPath...
- **Beyond** organizational approaches purely **deliberative or reactive**.
- **Infosphere** = ecosystem with large diversity of interactions between lots of different agent types to maintain & exploit information landscape.
- Two perspectives:
 - Intelligent agents tasks customized at runtime.
Relying on standard protocols to exchange proc. k.
// holonic approach
 - Intelligent agents farming swarm intelligence
Reactive agents encapsulate ad-hoc protocols.
// ecosystem approach

Acknowledgements

- CoMMA - ACACIA Laboratory

INRIA Sophia Antipolis

IST Program, ATOS-Origin, CSELT/Telecom Italia,
CSTB, INRIA, LIRMM, T-Nova/Deutsche Telekom,
University of Parma

- *my*Campus - Mobile Commerce Laboratory

Carnegie Mellon University

DAML / DARPA, Carnegie Mellon University,
Boeing, HP, IBM, Symbol, Fujitsu, Amazon,
IST (SWAP)