Dynamic Service Generation:
Agent interactions for service exchange on the Grid

LIRMM
Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier

I2S ECOLE DOCTORALE

UM2 UNIVERSITÉ MONTPELLIER 2
SCIENCES ET TECHNIQUES

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PhD defence

Thursday November 16, 2006

Speech overview

1. Introduction to Dynamic Service Generation (DSG)
2. GRID and Service Oriented Computing (SOC) key concepts
3. Multi-Agent Systems (MAS) and the STROBE model
4. Service based integration of GRID and MAS (AGIL)
5. Conclusion

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Example: ‘looking for a job’ scenario

HELEN

- Job seeker
- Precise project manager position

• Complex wish to explain

• Long & dynamic interactive conversation

• Stateful & asynchronous

• Collaborative (other services)

• Generation of service

JOBWINER

- Job agency
- <search_offer> service

• Precise request with parameters

• Remote procedure call

• Short, one-shot interaction

• Stateless & synchronous

• Delivery of product

MAPPY

- Road and map guide
- <distance> service

Context

- WHAT
  - **Modelling** dynamic service exchange interaction in computer mediated contexts for both human and artificial entities
- WHY
  - Enhancing the way these distributed entities work in collaboration to **solve** the problem of one of them
- HOW
  - Proposing **models** and tools inspired from 3 different domains of Informatics: SOC, GRID and MAS

➔ *What kind of services do we want for the Informatics of tomorrow?*

Thesis statement and objective

- A service exchange is not a simple delivery of product
  - It is based on conversation
- Tools that enable to provide and use services by means of conversations
  - Importance of the concept of state
- Going towards a new vision of the concept of service
  - Dynamic service generation

Dynamic Service Generation (DSG)

- A solution, identified and chosen among many possible ones, offered to the problem of someone
- Services
  - Imply creation of something 'new'
  - Are associated with processes
  - Are constructed by means of conversations
  - Have a learning dimension (knowledge creation)
  - Create relationships between members of communities

➔ *Computerization of the concept of service is not easy*

DSG vs. Product delivery

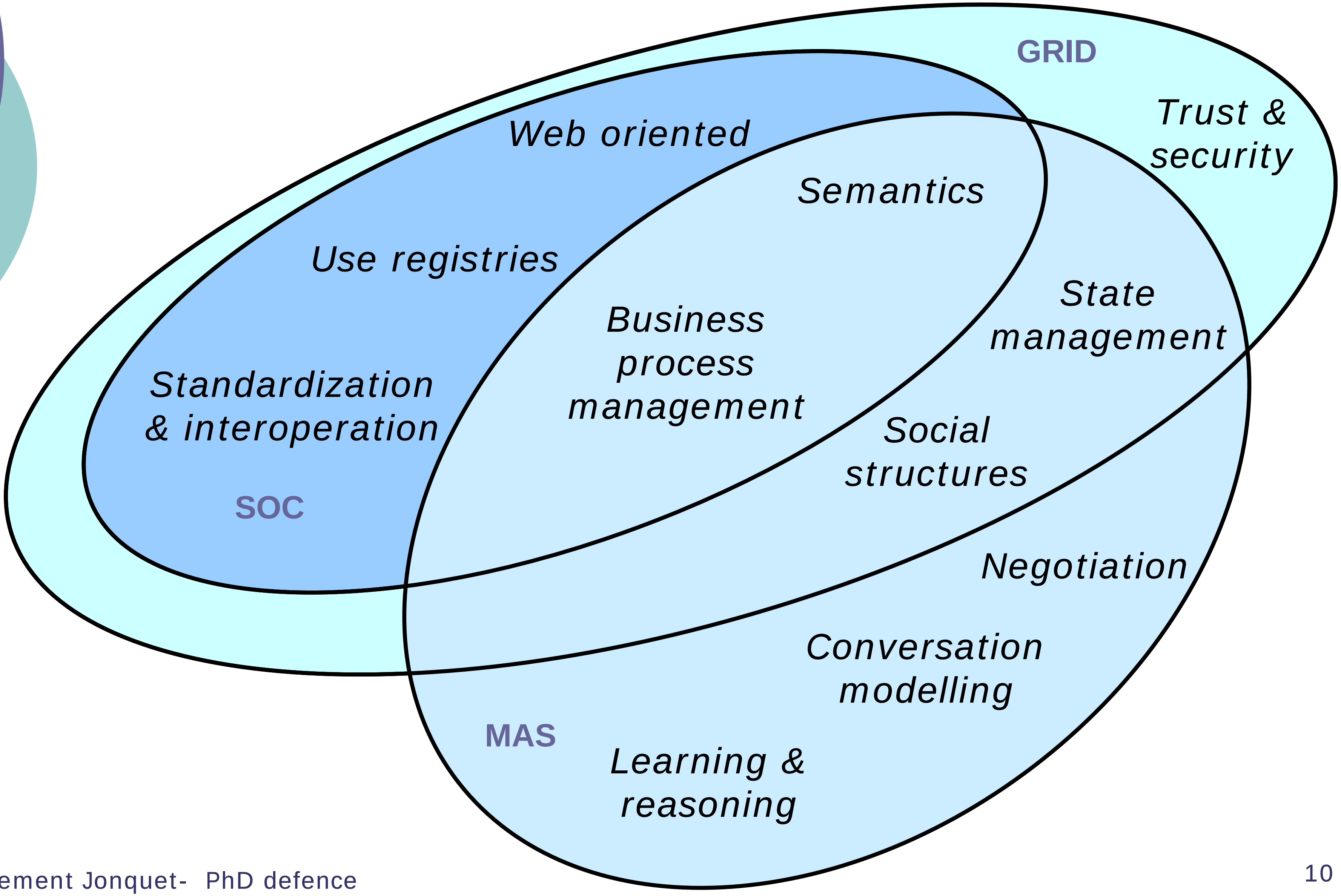
- Product delivery approach
  - One-shot interaction process between a pair
    - User
    - Provider
  - ex: buying ready-to-wear clothes
  - ex: asking to MAPPY a distance

- DSG approach
  - Result of the activation and management of a process defined by the triplet
    - User
    - Conversational process
    - Provider
  - ex: having clothes made by a tailor
  - ex: finding a job thanks to JOBWINER

Method adopted

- Characterization process
  - List of DSG characteristics
- Try to address some of these characteristics
  - Concrete tools and models
  - Experimentations on simple scenarios
  - Re-usability of concrete principles
- Motivation
  - To formalize the convergence of 3 important domains for DSG: SOC, GRID and MAS
- Integration approach

Why SOC, GRID and MAS?



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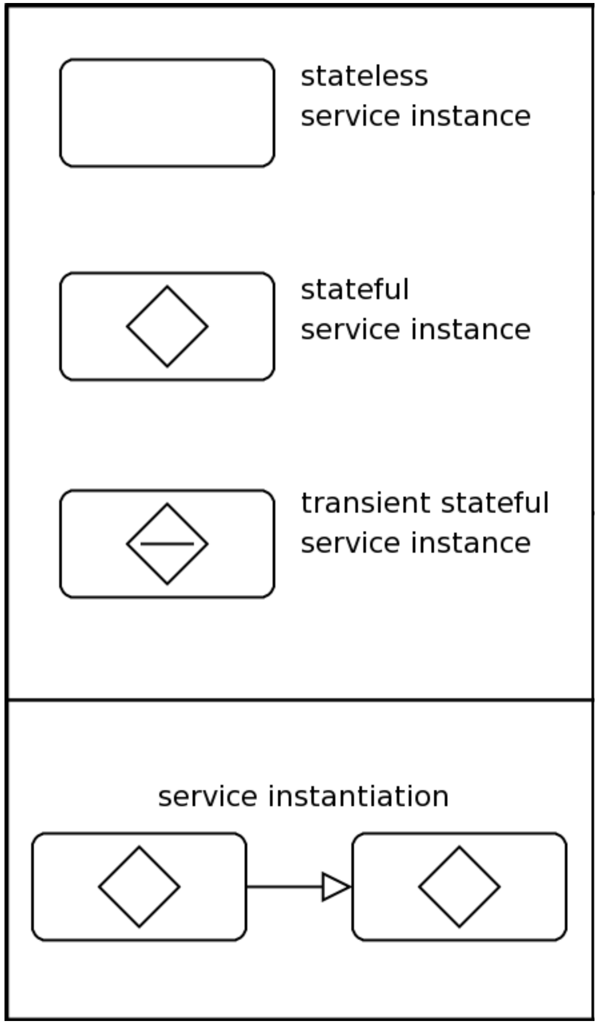
What is GRID?

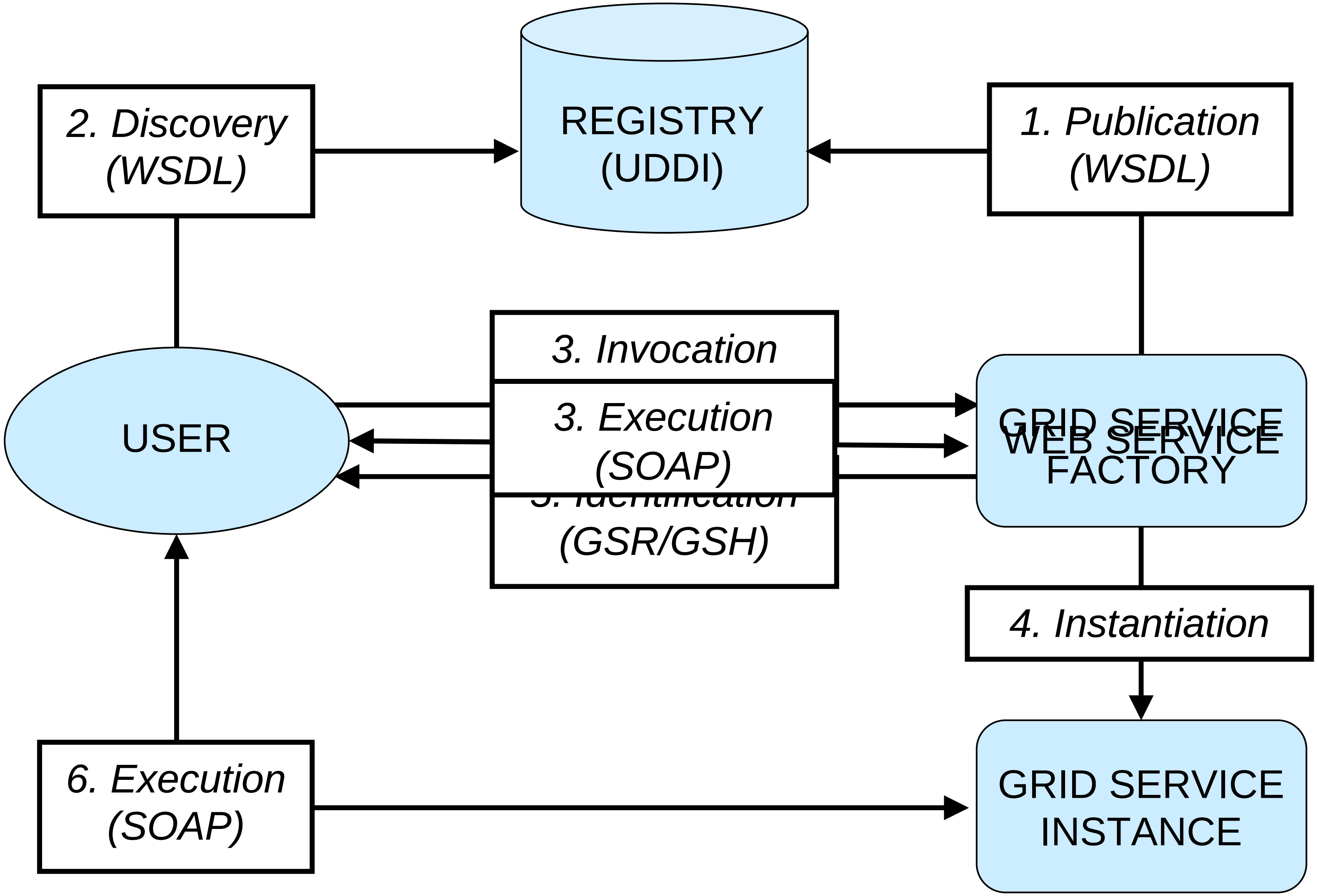
- Foundation
  - Flexible, secure, coordinated resource sharing among Virtual Organizations (VO) [Foster et al., 1999, Blueprint] & [Foster et al., 2001, Anatomy]
- Originally
  - Environment with a large number of networked computer systems where computing and storage resources could be shared as needed and on demand
- Extended
  - Virtualization of resources and assignment to stateful and dynamic services [Globus alliance, 2002, Physiology (OGSA)]
- Last standard
  - Web Service Resource Framework [Globus alliance, 2004, WSRF]
  - GRID-SOC convergence
  - Grid service = stateless service + stateful resource

Grid service



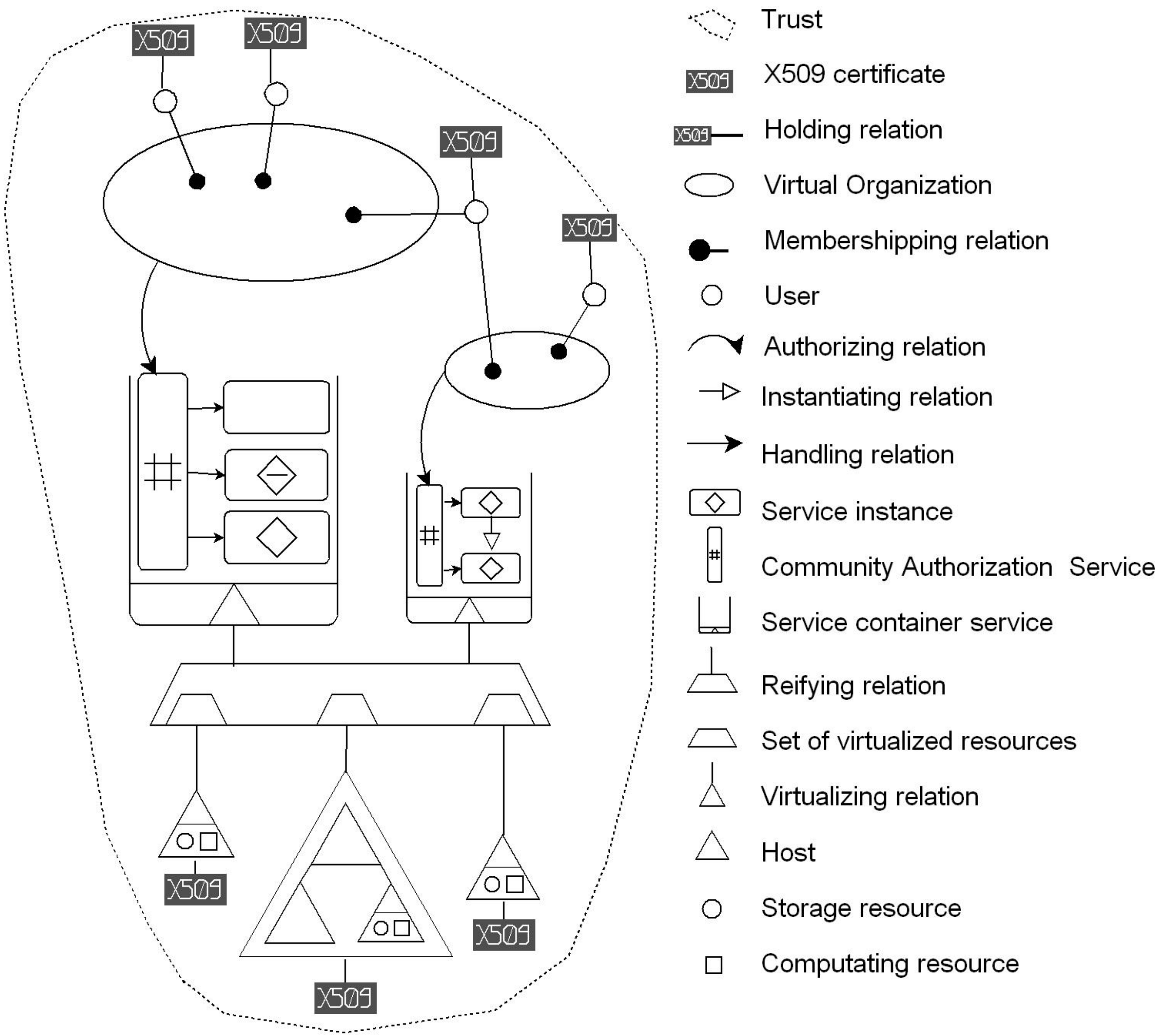
- Compliant with Web service and SOA standards [W3C]
  - Describable, discoverable component
  - Message based communication
  - Perform some function
- 2 major new aspects
  - State management (stateful/stateless)
  - Lifetime management (transient/persistent)
- Dynamic assignment of resources to a service
  - Instantiation mechanism

Grid service life cycle



2. GRID & SOC key concepts

GRID key concepts



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What are agents and MAS?

- Definition [Ferber, 1995] & [Jennings, 2001]:
  Physical or virtual autonomous entities:
  - Situated in a particular environment
  - Capable of perceiving and acting in that environment
  - Designed to fulfil a specific role
  - Communicate directly with other agents
  - Possess their own state (and controls it) and skills
  - Offer services
  - Have a behaviour that tends to satisfy their objectives

- Service oriented characteristics
  - Reactive, proactive, and adaptive
  - Know about themselves, and have a memory and a persistent state
  - Interact and work in collaboration
  - Able to learn and reason in order to evolve
  - Deal with semantics associated to concepts by processing ontologies

Why a new architecture?

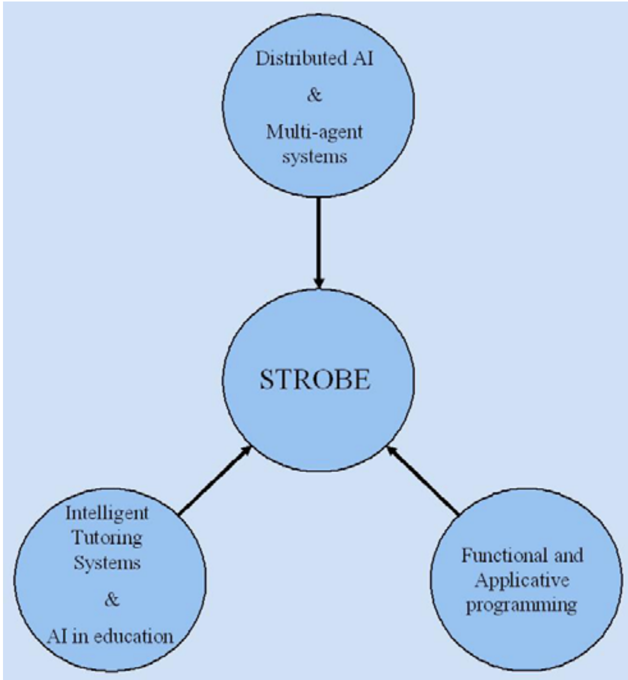
- Agent communication requirements
  - To allow dynamic language evolution
  - Strong interlocutor model
- No dedicated conversation context
  - To develop a dedicated language
  - To adapt interlocutor's specific aspects
- Composed of set of modules
  - Separate the interaction module and the service execution module

STROBE proposition [Cerri, 1996 & 1999]

- **OB**ject
  - To represent agents
  - Encapsulation of state
  - Message passing
- **STR**eam
  - Flow of messages exchanged
  - Lazy evaluation
- **E**nvironment
  - To interpret messages
  - Multiples
- 3 first-class primitives
- Agents as interpreters
  - Read-Eval-Print-Listen loop

"Shifting the focus from control to communication"

[Hewitt, 1977]

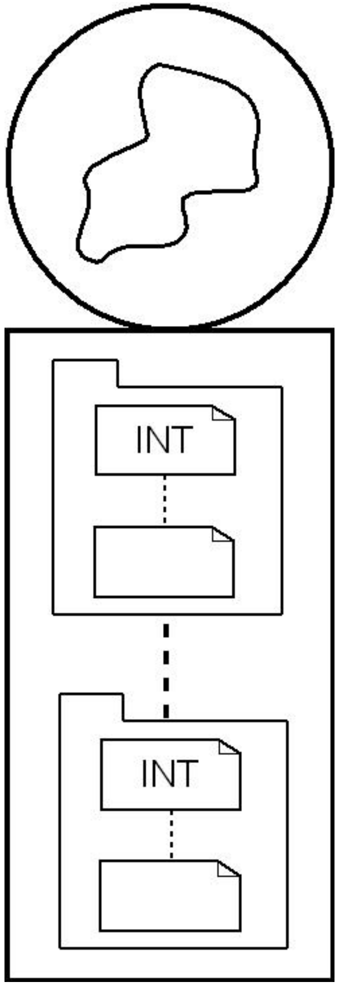


3. MAS & the STROBE model

The STROBE model [Jonquet & Cerri, AAI journal, 2005]

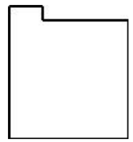
- Agent representation and communication model
- Include an interpreter in each environment
  - Dedicated to interlocutors
- STROBE agents build their own dedicated languages while communicating
  - Language = environment + interpreter
- Language evolution done dynamically at:
  - The *data* and *control* level
  - The *interpreter* level (using reflection and meta-programming techniques)
- Formalized, implemented and experimented
  - Scheme & Java/Kawa in MadKit

STROBE agent representation



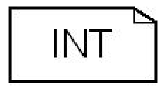
- Brain
  - Set of modules
  - e.g., learning & reasoning

- Cognitive Environment
  - Set of bindings (data level)
  - e.g., [a 3]



- Capabilities
  - Functions/procedures (control level)
  - e.g., [square (lambda (x) (* x x))]

- Cognitive Interpreter
  - Specific capability (interpreter level)
  - [INT (lambda (exp) (eval exp env))]



Cognitive Environment

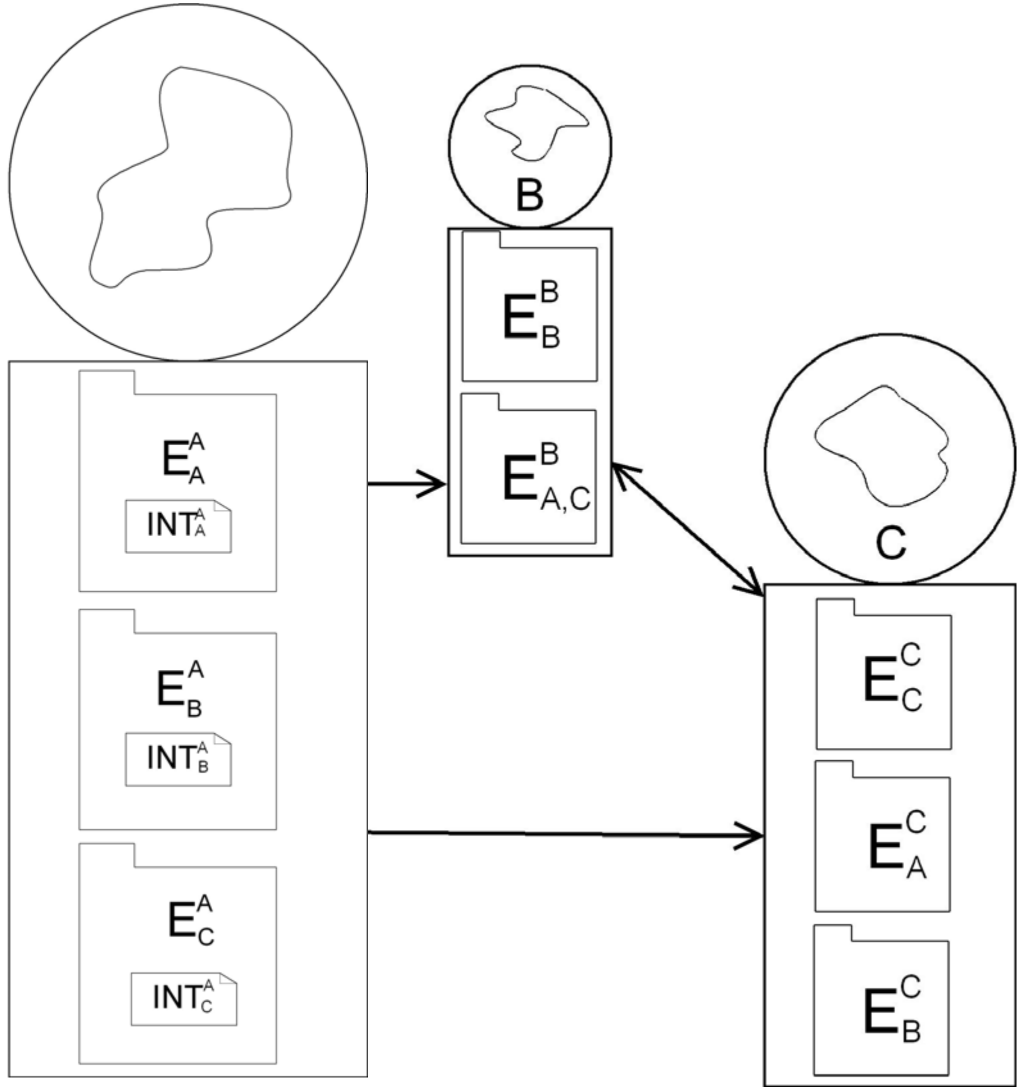
- Conversation context
  - Keeps the state of a conversation
  - Context of evaluation of messages
  - Interlocutor model
  - Evolves dynamically at the data, control and interpreter levels
- Dedicated to an interlocutor or a group of interlocutors
  - Agents develop a communication language for each interlocutor (environment + interpreter)
  - Agents have dedicated capabilities
- A STROBE agent has only one CE dedicated to a given interlocutor
- When an agent meets a new interlocutor, it:
  - Instantiates a new CE by copying an existing one
  - Shares an already existing CE

Message interpretation

- Done:
  - in a given environment
  - with a given interpreter

- Both dedicated to the interlocutor (or group of interlocutors)

- Both able to change.



Speech overview

Motivation

- Early suggested for the Computational Grid [Rana & Moreau, 2000]
- Agents as a key element of the Semantic Grid [DeRoure, Jennings et al., 2001]
- MAS and GRID need each others: brain meets brawn [Foster, Jennings & Kesselman, 2004]
- Significant complementarities
  - GRID is secure but interaction poor
  - GRID manage raw data without semantics
  - MAS need interoperation and standardisation
- Service-oriented MAS [Huhns et al. 2005]

GRID-MAS analogies

Direct message passing based communication	Idem
Service interoperation	Agent interaction
Orchestration and choreography of services • Business process management	Interaction protocol and agent conversation • Collaboration scenario
Service state and lifetime	Agent intelligence and autonomy

GRID-MAS analogies

[Foster et al. OGSA, 2002]

- Grid user
  - Member of VOs
  - Uses services
  - *Offers services*
    [Cerri et al., OGSHA, 2004]
- VO
  - Context of service exchanges
  - Exchanges inside
  - Services publication
- Service
  - Functional position
  - CAS
  - Services are local to VO

[Ferber et al. 2003]

- Agent
  - Member of groups
  - Holds roles
  - Delegates tasks
- Group
  - Context of activities
  - Communications inside
  - Capabilities become roles
- Role
  - Functional position
  - Role management
  - Roles are local to groups

4. Service based integration

State of the art of current 'integration' activities

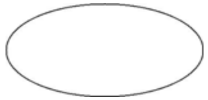
- Agents and Web services (WS)
  - Distinct/uniform view of agents and WS
    - e.g., transform SOAP call into FIPA ACL message [Greenwood et al, 2004]
  - MAS based Service Oriented Architecture
    - e.g., agents for WS selection [Singh, 2003]
  - MAS based Business Process Management
    - e.g., workflow approaches [Bulher & Vidal, 2003]
- MAS to improve core GRID functionalities
  - Resource management [ARMS, 2001][AgentScape, 2002]
  - VO management [Conoise G, 2005]

➔ *Interesting approaches, but not really interested in integrating the 3 domains*

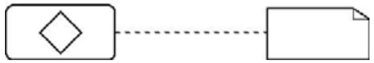
Mapping of GRID and MAS concepts

- Agent
  - Unifies AA, HA, Grid user
  - Active entities involved in service exchange
  - Autonomous, intelligent and interactive
  - Grid users as potential artificial entity

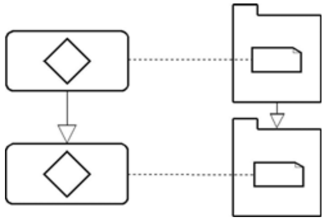
- VO (= Group = Community)
  - Dynamic social group (virtual or not)
  - Context of service exchanges



- Service-Capability relationship
  - Virtualization of an agent capability
  - A service is an *interface* of a capability available for a VO



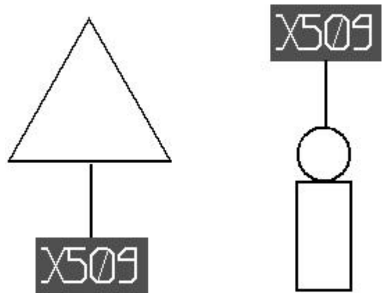
- Instantiation
  - Process of creating a new service-capability couple
  - Instantiating a new service means to instantiate a new CE containing the new capability



Agent-Grid Integration Language

[Jonquet, Dugenie & Cerri, MAGS journal, 2007]

- 3 elements:
  - Set concepts
  - Set of relations between concepts
  - Set of integration rules
- Graphical description language
  - Kind of UML for GRID-MAS integrated systems
- Set-theory formalization
  - Example: *holding* relation



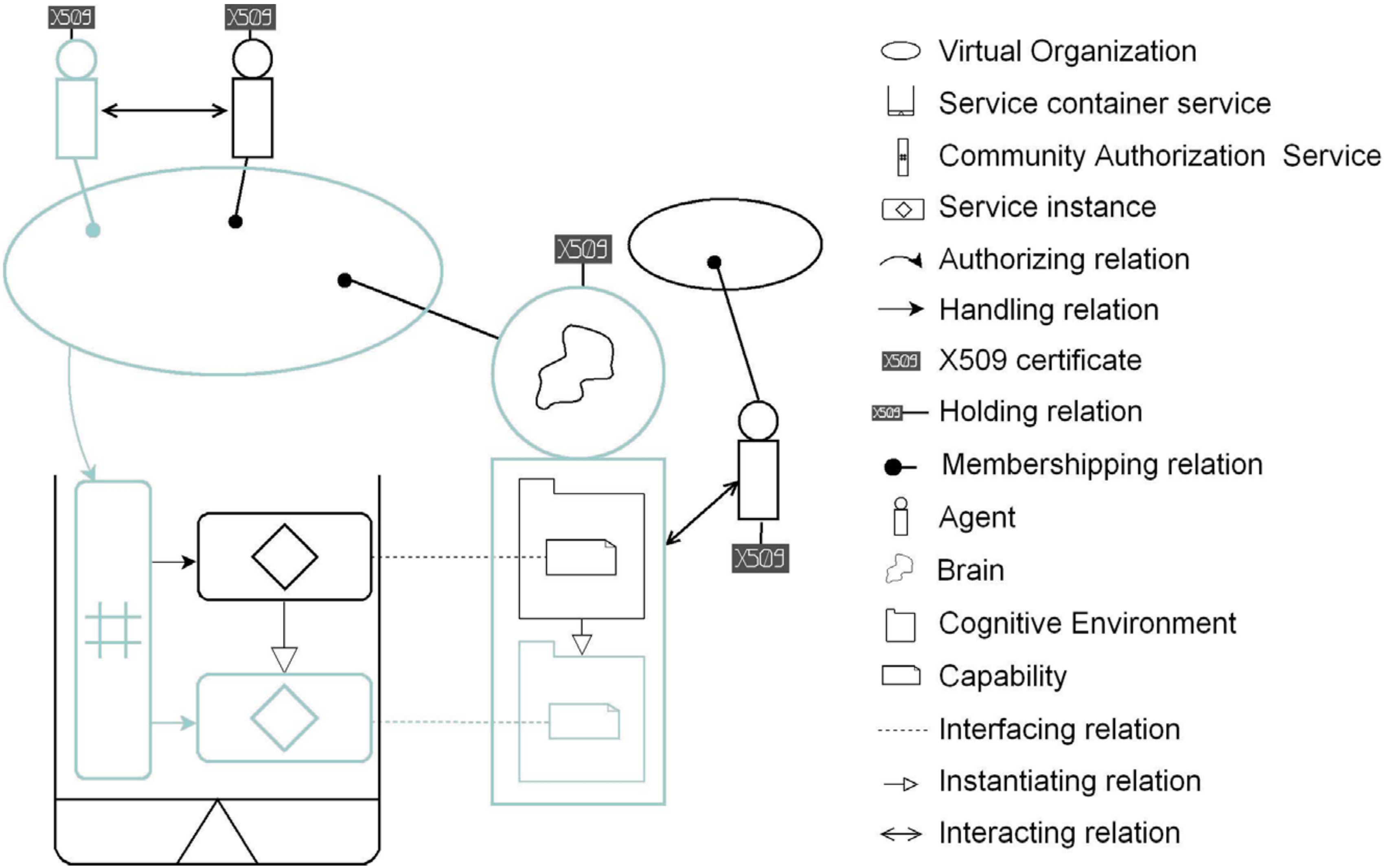
$$holding : X \rightarrow A \cup H \text{ (application)}$$

Rule 23 *All agents members of a VO hold a X509 certificate.*

$$\forall a \in A, \forall o \in O, a \in o \Rightarrow \exists x \in X, holding(x) = a$$

4. Service based integration

AGIL’s integration model



AGIL discussion (1/2)

- Integrates both GRID and MAS properties
  - Bottom-up vision of service in GRID
  - Top-down vision of service in MAS
- Not restrictive neither for MAS nor GRID
  - Today, but tomorrow?
- Includes some of the MAS based GRID approaches
  - Meta GRID core mechanism are themselves Grid services

AGIL discussion (2/2)

- Both a description language and a integration model
  - Allows to represent both the meta-model and its instances (i.e., future integrated systems)
  - Rigorously fix the concepts, relations and rules

- STROBE is adequate for AGIL
  - WSRF: stateful resource + stateless service
    ➔ evolution only at the resource level
  - AGIL: CE + capability
    ➔ evolution of the CE and capability levels

- A service is an interface of a capability executed with Grid resources but managed by an intelligent, autonomous and interactive agent

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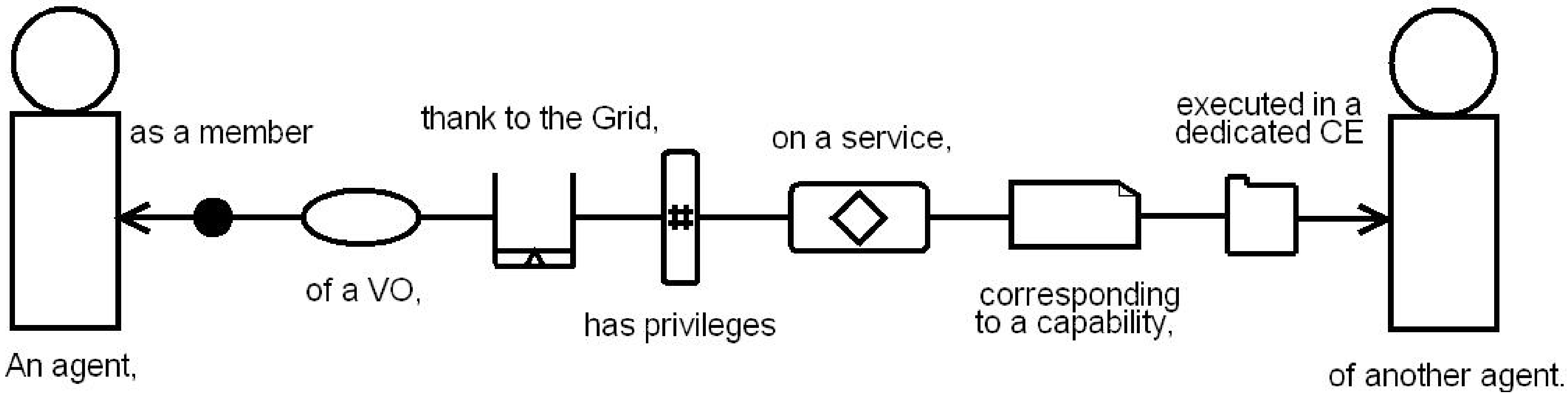
Conclusion (1/2)

- We tried to address the question of service exchange modelling in computing context
- Dynamic Service Generation
  - A reflection about the concept of service that defends an integration of SOC, MAS and GRID
  - Conversation based view of services
- 3 concretes contributions
  - STROBE
  - i-dialogue (not presented today)
  - AGIL

Conclusion (2/2)

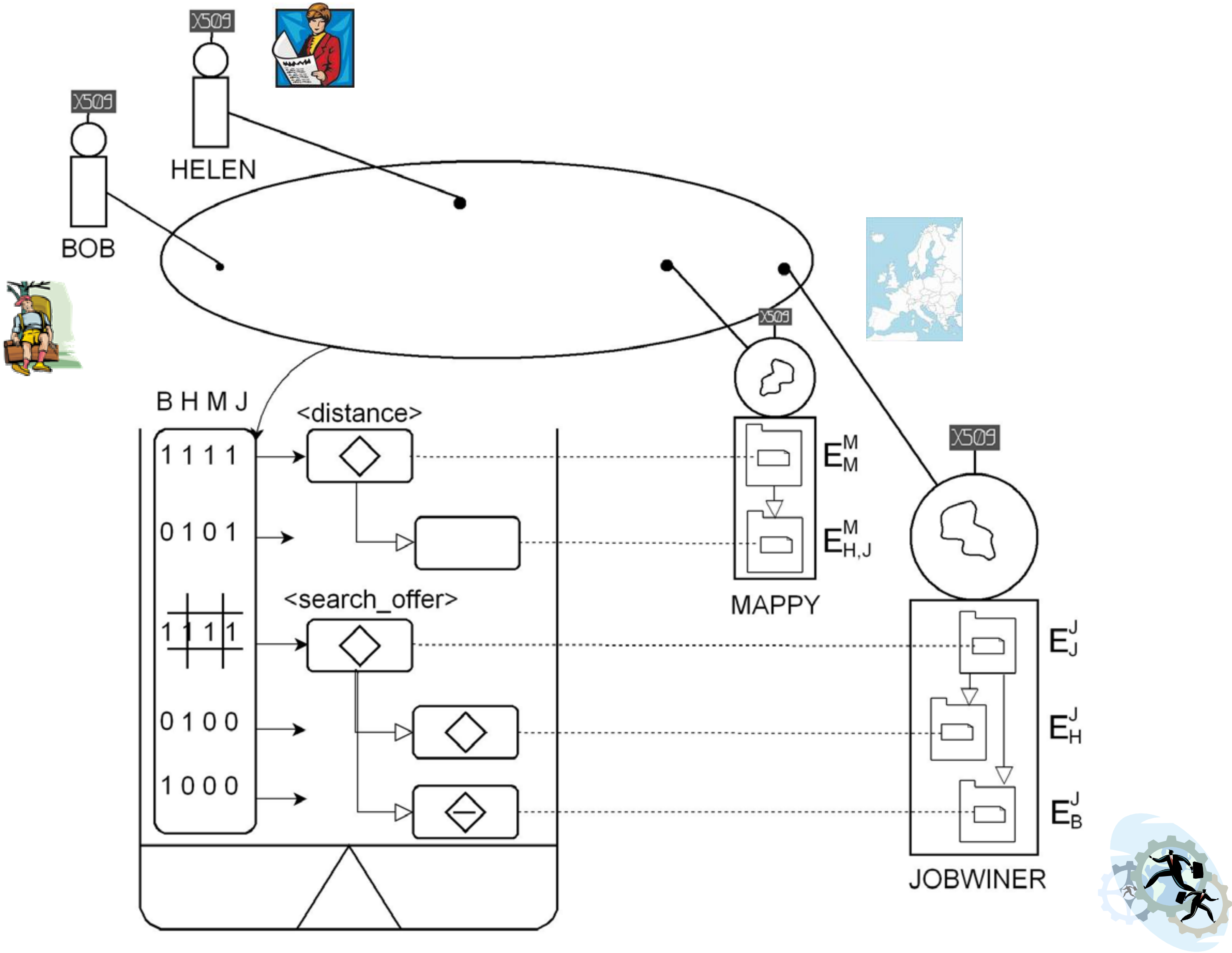
- We adopted an integration approach
- AGIL is a formalization of agent interactions for service exchange on the Grid



- An answer to the problem of service exchange modelling
  - Contributes to go towards future DSG systems

5. Conclusion

The ‘looking for a job’ scenario in AGIL



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Thank you!

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Perspectives

- Short term ones
  - Learning rules on CEs in the STROBE model
  - Integrate first-class continuations in CE

  - Add to AGIL other concepts, relations and rules
  - Implement AGIL as an ontology [Duvert & Jonquet et al., AweSOMe workshop, 2006]

- Long term ones
  - Integrate new aspects and characteristics of DSG (specially coming from SOC [Singh & Huhns, 2005])
  - Continue the DSG characterization process

  - Validate the AGIL integration model on a large scale project
  - Integration with Semantic Web Services approaches (service container as a semantic platform) [Domingue & Motta, IRS and WSMO, 2005]
  - Provenance of dynamically generated services [Moreau et al., 2005]

Publications

www.lirmm.fr/~jonquet/Publications

- **Journal**
  - Clement Jonquet, Pascal Dugenie, Stefano A. Cerri, **Agent-Grid Integration Language,** *Multiagent and Grid Systems,* Accepted for publication - Expected middle of 2007.
  - Pascal Dugénie, Philippe Lemoisson, Clement Jonquet, Monica Crubézy, **The Grid Shared Desktop: A Bootstrapping Environment for Collaboration**, *Advanced Technology for Learning, Special issue on Collaborative Learning,* Accepted for publication - Expected end of 2006.
  - Clement Jonquet, Stefano A. Cerri, **The STROBE model: Dynamic Service Generation on the Grid**, *Applied Artificial Intelligence, Special issue on Learning Grid Services,* Vol. 19 (9-10), p.967-1013, Nov. 2005.
- **International conference**
  - Clement Jonquet, Stefano A. Cerri, **I-Dialogue: Modelling Agent Conversation by Streams and Lazy Evaluation**, *International Lisp Conference, ILC'05,* Stanford University, CA, USA, Jun. 2005.
- **Workshop**
  - Frédéric Duvert, Clement Jonquet, Pascal Dugénie, Stefano A. Cerri, **Agent-Grid Integration Ontology**, *R. Meersman, Z. Tari, P. Herrero(eds.) International Workshop on Agents, Web Services and Ontologies Merging, AWeSOMe'06*, Vol. 4277, LNCS, pp. 136-146, Montpellier, France, Nov. 2006.
  - Clement Jonquet and Marc Eisenstadt and Stefano A. Cerri, **Learning Agents and Enhanced Presence for Generation of Services on the Grid**, *Towards the Learning GRID: advances in Human Learning Services,* Vol. 127, Frontiers in Artificial Intelligence and Applications, p.203-213, IOS Press, Nov. 2005.
  - Clement Jonquet, Stefano A. Cerri, **Cognitive Agents Learning by Communicating**, *P. Aniorté (ed.), 7ème Colloque Agents Logiciels, Coopération, Apprentissage & Activité humaine, ALCAA'03*, Bayonne, France, Sep. 2003.
- **National conference**
  - Clement Jonquet, Pascal Dugenie, Stefano A. Cerri, **Intégration orientée service des modèles Grid et multi-agents**, *14èmes Journées Francophones sur les Systèmes Multi-Agents,* p. 271-274, Annecy, France, Oct. 2006.
  - Clement Jonquet, Stefano A. Cerri, **Les Agents comme des interpréteurs Scheme : Spécification dynamique par la communication**, *14ème Congrès Francophone de Reconnaissance des Formes et Intelligence Artificielle,* Vol. 2, p. 779-788, Toulouse, France, Jan. 2004.
  - Clement Jonquet, Stefano A. Cerri, **Apprentissage issu de la communication pour des agents cognitifs**, *11ème Journées Francophones sur les Systèmes Multi-Agents*, p. 83-87, Hammamet, Tunisie, Nov. 2003.

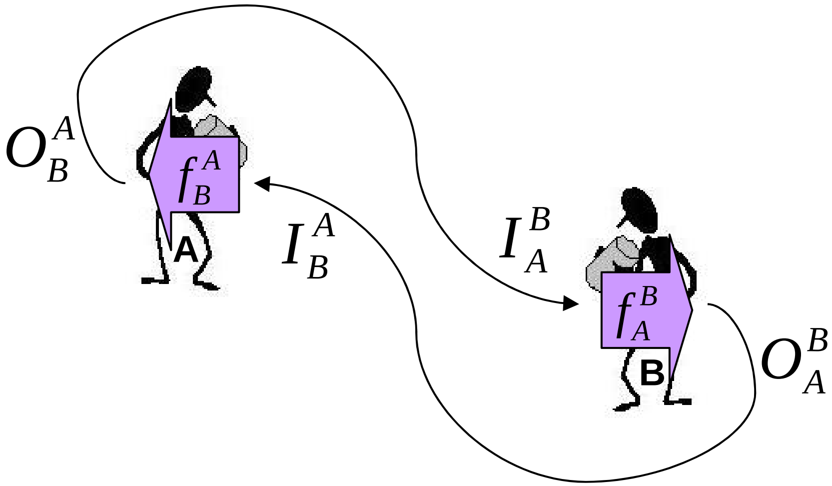
I-dialogue

[Jonquet & Cerri, International Lisp Conference, 2005]

- An computational abstraction to model agent multi-party conversations
  - Inspired by the *dialogue* abstraction proposed by [O'Donnel, 1985] to model process interactions
  - Uses first-class procedures, streams and lazy evaluation
- Enables to manage the entire conversation dynamically (not pre-determined)
- Adequate for intertwined dialogues
  - Executed simultaneously
  - Inputs and outputs depend on each other
  - Service composition

The *dialogue* abstraction

- Interactive session between 2 agents, which take turns sending messages to each other:

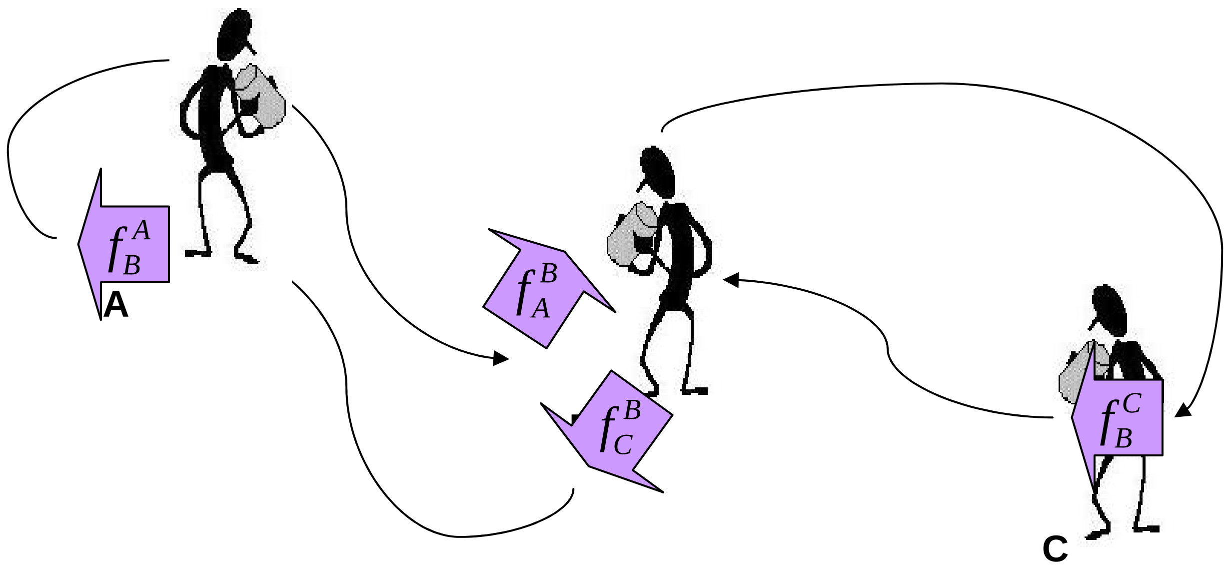


- Each agent computes a new state and a new output from its previous state and the last input it received from the other agent, using its transition function:

$$f_B^A : \left[\alpha_{j+k} \; I_B^A\right] \longrightarrow \left[\alpha_{j+k+1} \; O_B^A\right]$$

$$f_A^B : \left[\beta_k \; I_A^B\right] \longrightarrow \left[\beta_{k+1} \; O_A^B\right]$$

The *i-dialogue* abstraction



- Agent B should consumes 2 input streams and produces 2 output streams

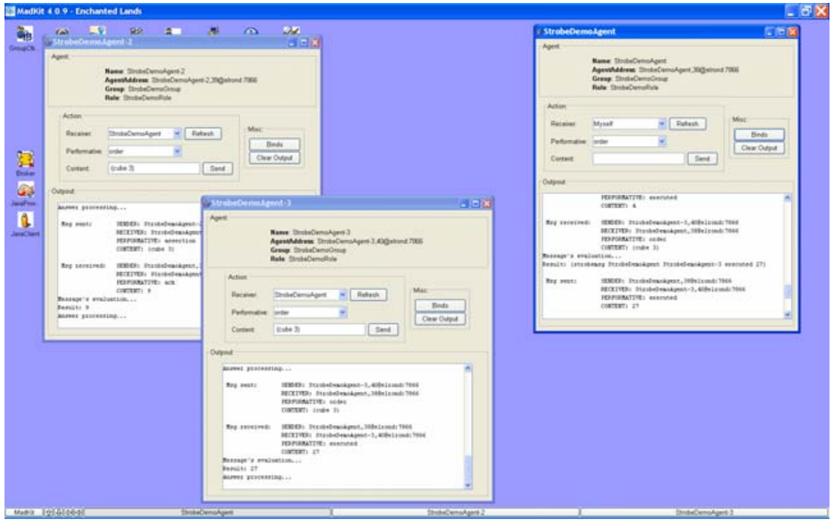
- Transition functions of B, do not produce respectively an output stream for A and B but the opposite

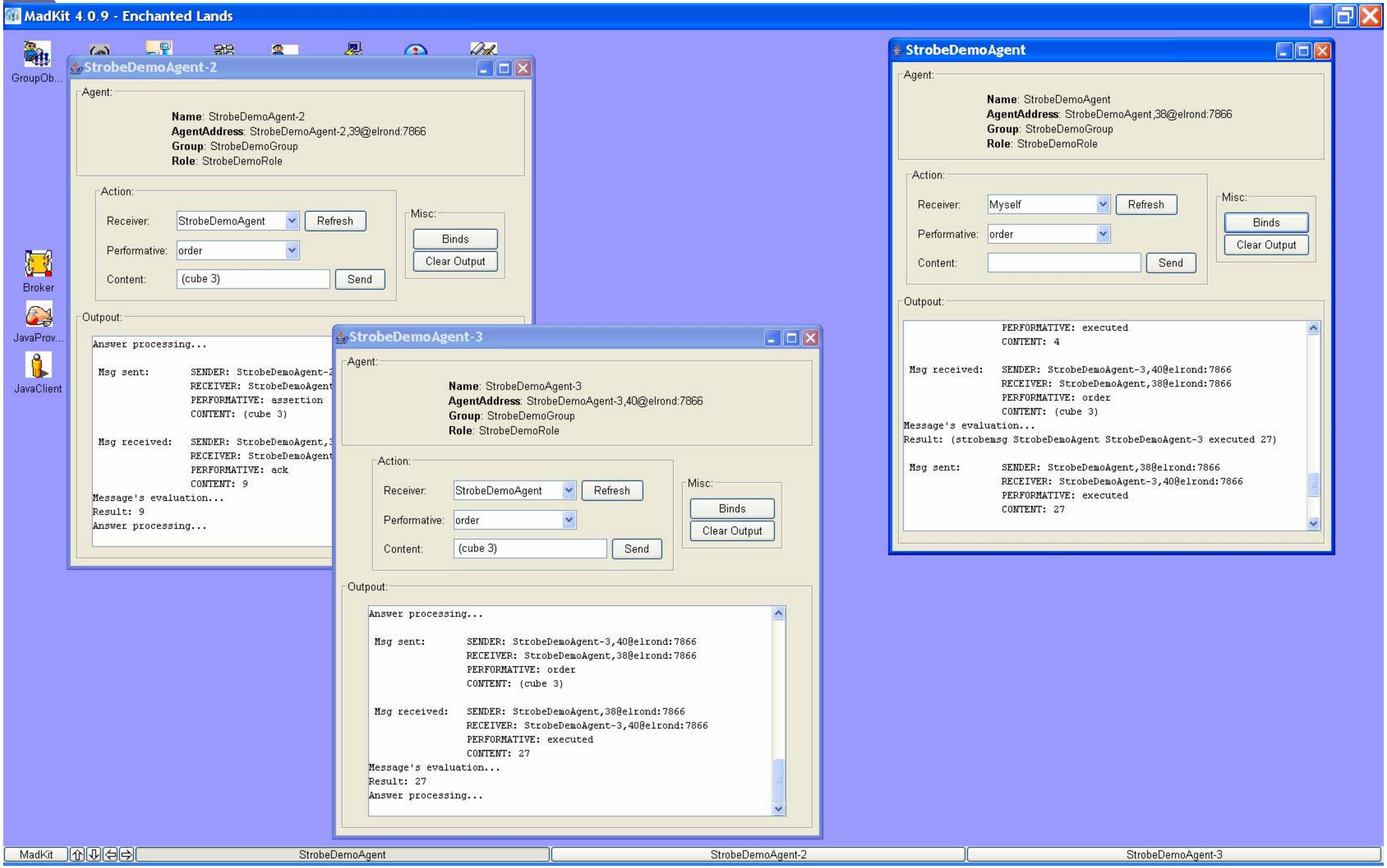
Evaluation & experimentations

- STROBE
  - 2 implementations (Scheme & Java/Kawa in MadKit)
  - 2 main experimentations
    - *Meta-level learning by communicating* (teacher – student dialogue for the learning of a new performative)
    - *Dynamic specification of a problem* (client – service provider dialogue to construct an train ticket reservation. Use of non-deterministic interpreters (constraints specification))
- I-dialogue
  - Implemented in Scheme
  - Integration with the STROBE implementation in progress
- AGIL
  - Implementation under the form of an ontology started

STROBE agent in MadKit

- MadKit: Multi-Agent platform developed at LIRMM [Ferber, Gutknecht & Michel, 2000]
  - www.madkit.org
- Based on the Agent/Group/Role model
- Java agents but also Scheme, Python etc.
- Scheme – Java link with Kawa




MadKit 4.0.9 - Enchanted Lands
StrobeDemoAgent-2
Agent:
Name: StrobeDemoAgent-2
AgentAddress: StrobeDemoAgent-2,39@elrond:7866
Group: StrobeDemoGroup
Role: StrobeDemoRole
Action:
Receiver: StrobeDemoAgent
Refresh
Performative: order
Content: (cube 3)
Send
Misc:
Binds
Clear Output
Output:
StrobeDemoAgent-3
Agent:
Name: StrobeDemoAgent-3
AgentAddress: StrobeDemoAgent-3,40@elrond:7866
Group: StrobeDemoGroup
Role: StrobeDemoRole
Action:
Receiver: StrobeDemoAgent
Performative: order
Content: (cube 3)
Output:
Answer processing...
Msg sent: SENDER: StrobeDemoAgent-3,40@elrond:7866
RECEIVER: StrobeDemoAgent,38@elrond:7866
PERFORMATIVE: order
CONTENT: (cube 3)
Msg received: SENDER: StrobeDemoAgent,38@elrond:7866
RECEIVER: StrobeDemoAgent-3,40@elrond:7866
PERFORMATIVE: executed
CONTENT: 27
Message's evaluation...
Result: 27
Answer processing...
StrobeDemoAgent
Agent:
Name: StrobeDemoAgent
AgentAddress: StrobeDemoAgent,38@elrond:7866
Group: StrobeDemoGroup
Role: StrobeDemoRole
Receiver: Myself
Performative: order
Content:
Output:
PERFORMATIVE: executed
CONTENT: 4
Msg received: SENDER: StrobeDemoAgent-3,40@elrond:7866
RECEIVER: StrobeDemoAgent,38@elrond:7866
PERFORMATIVE: order
CONTENT: (cube 3)
Message's evaluation...
Result: (strobemsg StrobeDemoAgent StrobeDemoAgent-3 executed 27)
Msg sent: SENDER: StrobeDemoAgent,38@elrond:7866
RECEIVER: StrobeDemoAgent-3,40@elrond:7866
PERFORMATIVE: executed
CONTENT: 27
GroupOb...
Broker
JavaProv...
JavaClient
MadKit
StrobeDemoAgent-2

STROBE communication language

- Message structure:

$$MSG = \{AGENT_S, AGENT_R, PERFORM, CONTENT\}$$

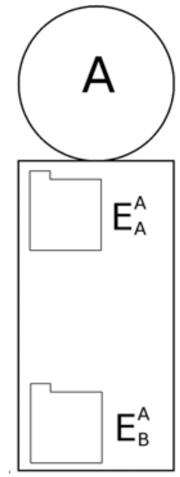
with $PERFORM = \{assertion, ack, request, answer, order, executed, broadcast\}$

- Example of exchanges:

Teacher (A_T)	Student (A_S)
$\{A_T, A_S, request,$ `square` $\}$	$\{A_S, A_T, answer,$ `undefined` $\}$
$\{A_T, A_S, assertion,$ `(define (square x) (* x x))` $\}$	$\{A_S, A_T, ack,$ `(*.*)` $\}$
$\{A_T, A_S, order,$ `(square 3)` $\}$	$\{A_S, A_T, executed,$ `9` $\}$

Creation of a new CE

- 2 types of CE
  - A global one (private)
  - Several local ones (dedicated)
- An agent has only one CE dedicated to a given interlocutor
- When an agent meets an new one, local CE are instantiated by:
  1. Copying the global CE
  2. Copying a local CE
  3. Sharing a local CE



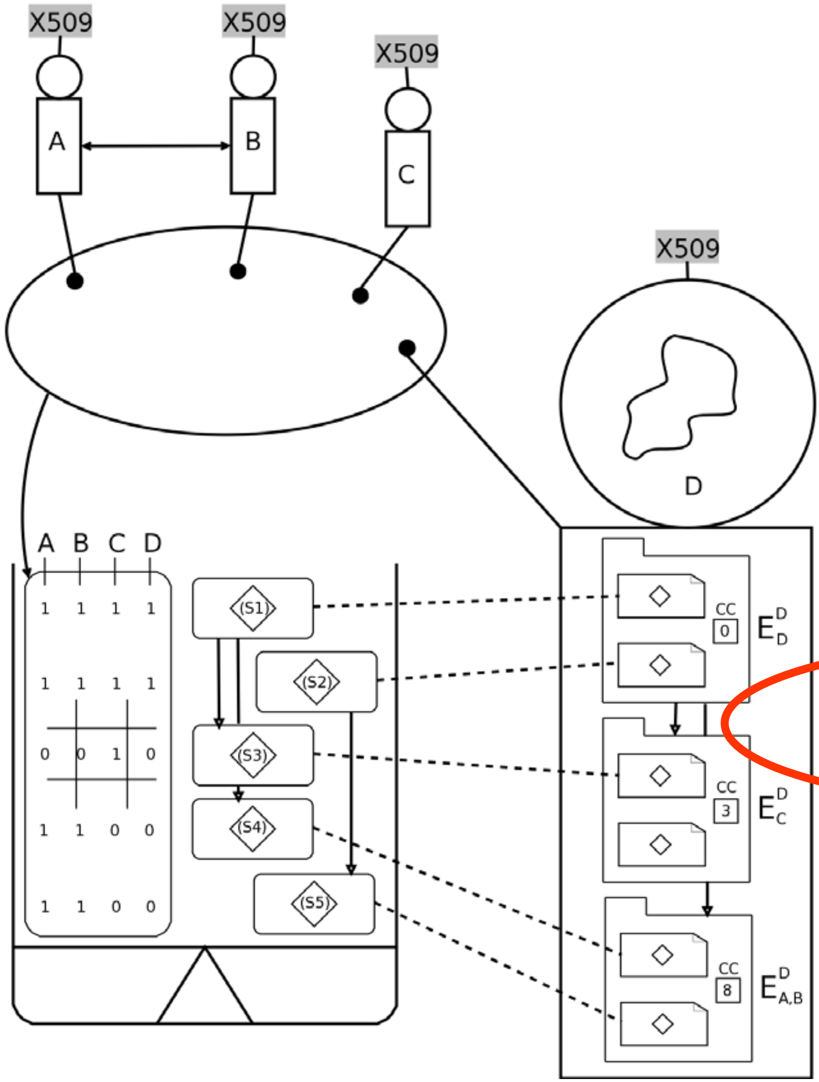
Learning by communicating

- Every languages propose 3 levels of abstraction

Data	Control	Interpreter
⇩	⇩	⇩
(set! a 3)	(define (square x) (* x x))	add a special form

- STROBE enables ‘learning-by-being told’ at the 3 levels
  - Reflective interpreters and reifying procedures [Jefferson et al., 1992]
  - First class interpreters [Simmons et al., 1992]
  - 2 levels of evaluation using the `eval` function in the language

A ‘counter’ example in AGIL



(S1) <incr_count_factory> : cc:=cc+1;

(S2) <decr_count_factory> : cc:=cc-1;

(S3) <incr_count_inst1> : cc:=cc+1;

(S4) <incr_count_inst2> : cc:=cc+1; print(cc);

(S5) <decr_count_inst1> : cc:=cc-1; print(cc);

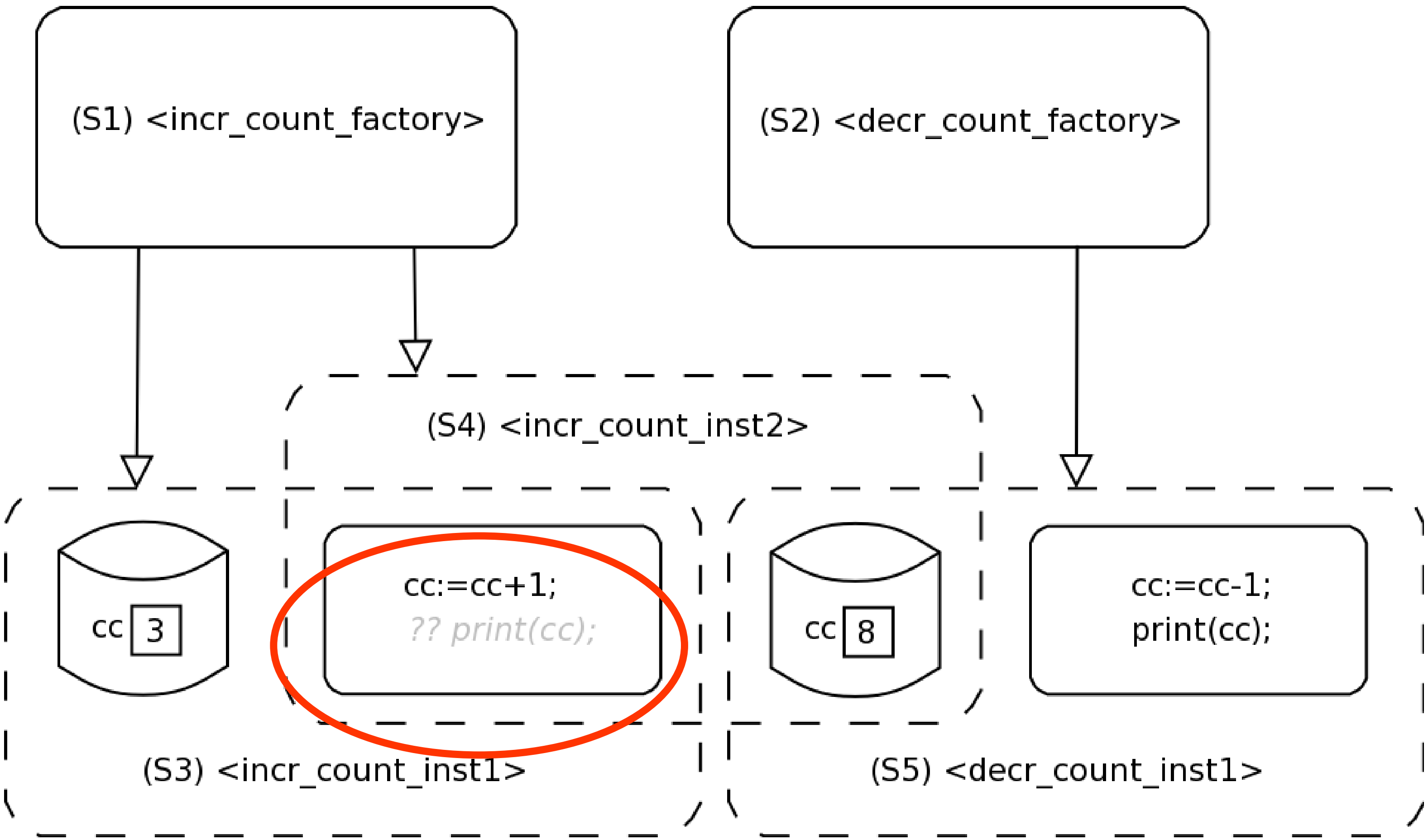
E^D_D D's global cognitive environment

E^D_C D's local cognitive environment dedicated to C

$E^D_{A,B}$ D's local cognitive environment dedicated to A and B

$\overset{CC}{\boxed{0}}$ CC local variable binding

Comparison with WSRF



PD vs. DSG (1/2)

- User exactly knows:
  - what he wants (clearly defined problem)
  - what the system can offer him (clearly defined product)
  - how to express his request (adaptation to provider's language)
- Same type of deliveries
- No history
- Cannot realise DSG
- Pre-developed by the provider (clearly defined goal)

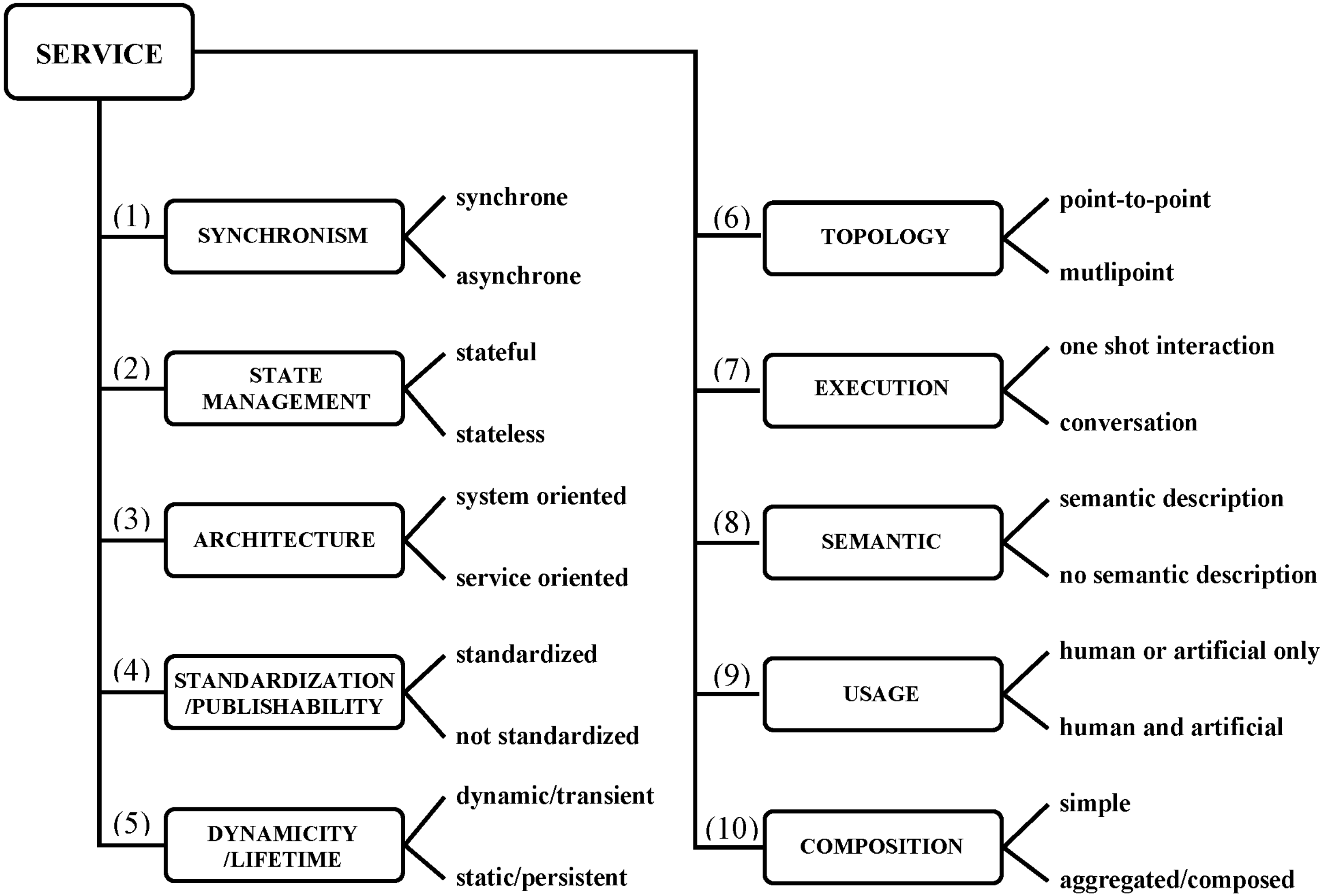
- User :
  - has unclear wish (bootstrapping situation)
  - elicits and understands progressively the provider's capabilities
  - the provider adapts to the user's language
- Unique generated services (conversation is unique)
- Depend from previous DSG and history
- Can realise PD
- Offered within a service domain and constructed dynamically (user's specific objectives)

PD vs. DSG (2/2)

- Long lifetime
- Slow evolution
- No reasoning
- No knowledge creation
- Same satisfaction for each delivery
- No possible retraction
- No emotion or psychological impacts
- Easily valuable an billable
- Able to announce the result
- Inactive when not engaged in a delivery phase
- Passive

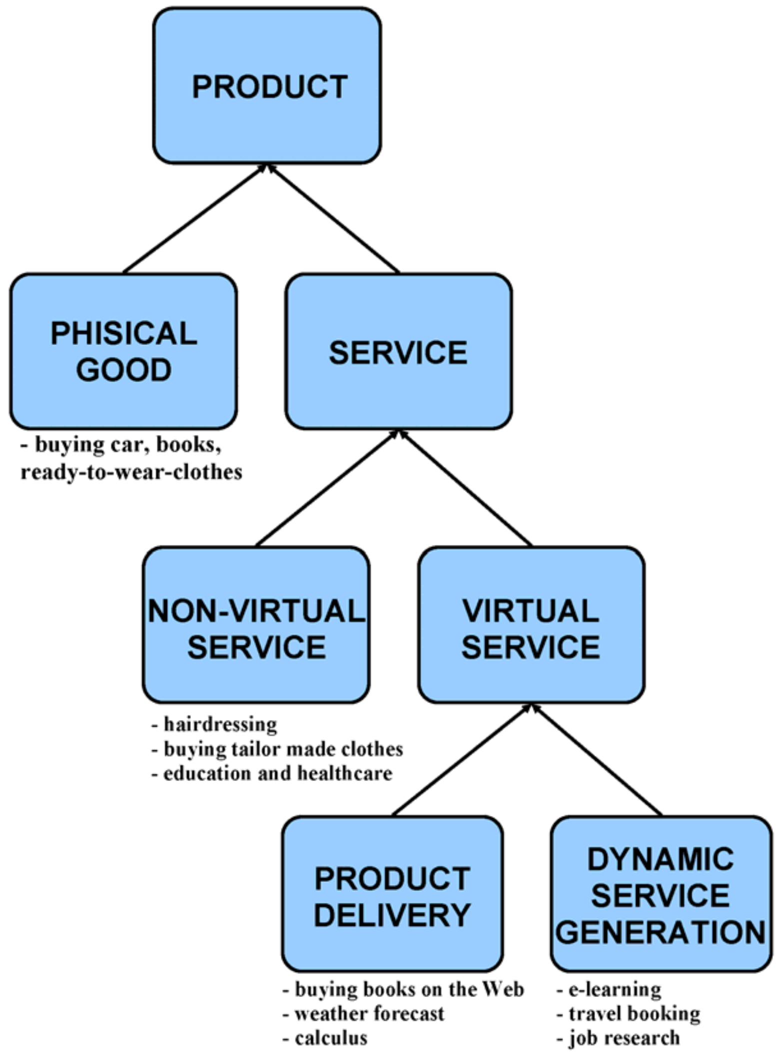
- Ephemeral life-cycle
- Dynamic and natural evolution
- Static and dynamic reasoning
- Pedagogical perspective
- Satisfaction increases with each generation
- Anytime mind changing
- Implies (+ or -) emotions
- Hardly valuable and billable
- Gain the user's trust (not announce or guarantee a final result)
- Perpetually evolving, learning on their previous generation to improve the next ones
- Pro-active

Service taxonomy

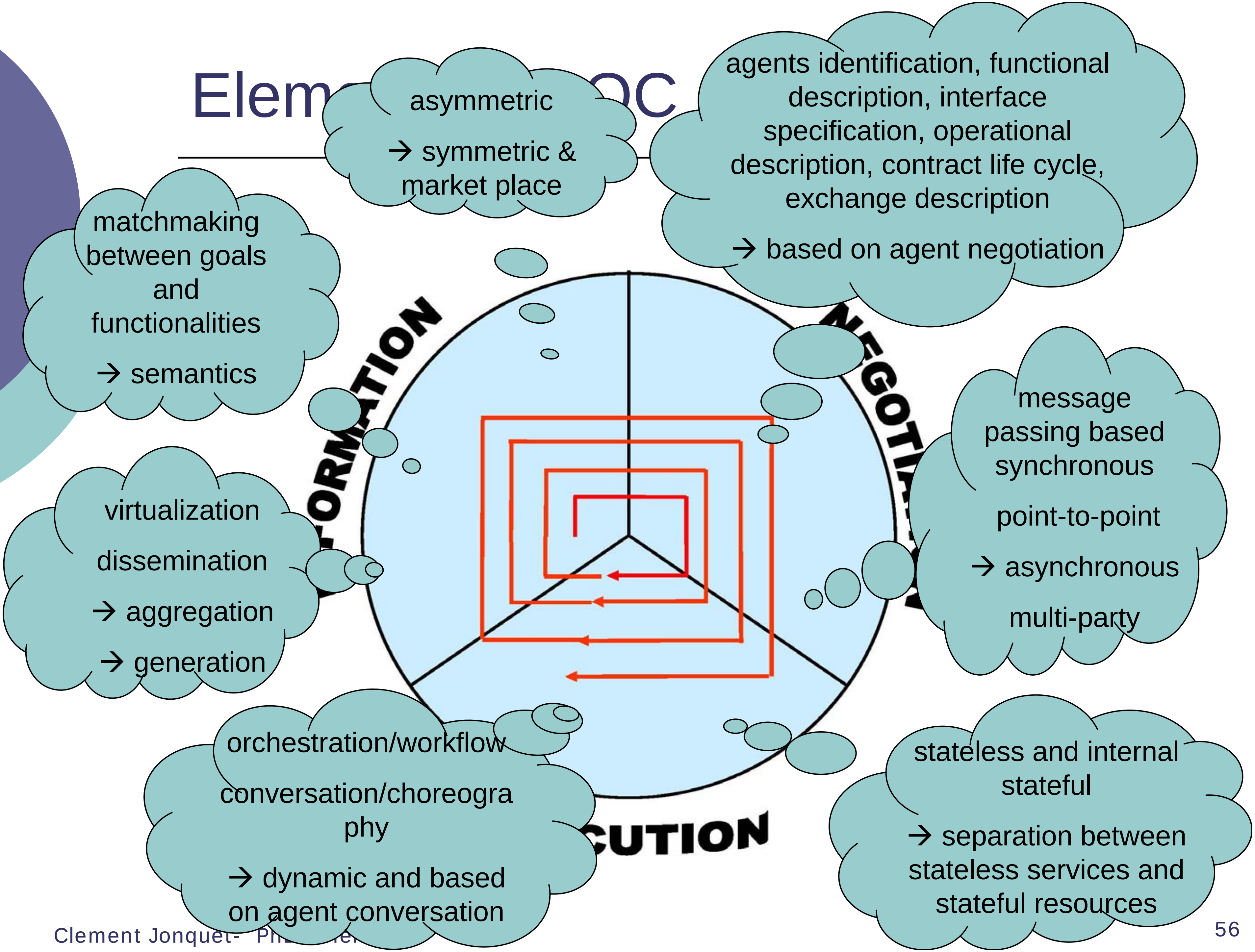


Economic taxonomy extension

- **Good:** physical, tangible object (natural or man-made) used to satisfy people's identified wants and that upon consumption, increases utility.
- **Service:** non-material equivalent of a good. (e.g., information, entertainment, healthcare and education).
- **Product:** Output of any production process (tangible good or intangible service).

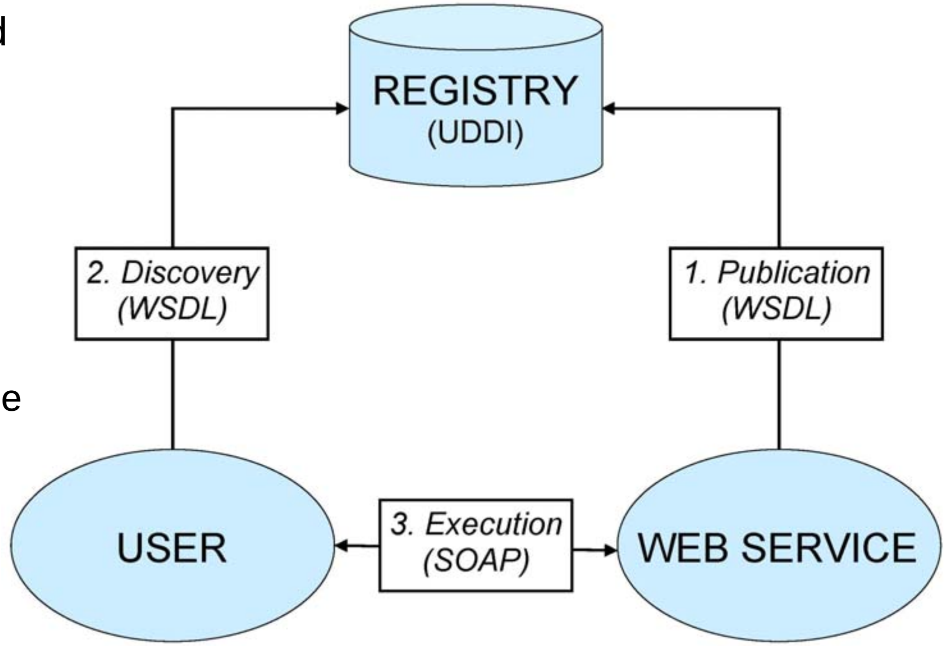


Elem OC


asymmetric
→ symmetric & market place
agents identification, functional description, interface specification, operational description, contract life cycle, exchange description
→ based on agent negotiation
matchmaking between goals and functionalities
→ semantics
message passing based synchronous
point-to-point
→ asynchronous
multi-party
virtualization
dissemination
→ aggregation
→ generation
orchestration/workflow
conversation/choreography
→ dynamic and based on agent conversation
stateless and internal stateful
→ separation between stateless services and stateful resources
CUTION

Elements of Service Oriented Architecture

- Historically:
  - software component based approaches (DCE, CORBA, COM, RMI)
  - to standardize invocation mechanisms



- Framework:
  - Web services [W3C]
    - describable, discoverable
    - message based
    - perform some function
  - interoperability and standardization
  - identifies 3 components

- Evolution:
  - simple service invocations, to business processes (orchestration, choreography, composition)

- Technologies:
  - WSDL, SOAP, UDDI, WSCL, WSFL, BPEL4WS, PSL...

Web services limits

- RPC like computing
- Object-oriented behaviour
- No user adaptation
- No memory (stateless)
- No conversation
- Synchronous communication
- No lifetime management
- Passive
- No semantics

➔ Web services are typical PDS

A service is seen as a standardized and interoperable interface of a specific function (accessed remotely)