

Standardizing Agent Interoperability: the FIPA Approach



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Outline

- What is FIPA?
- Why have MAS Standard Specifications?
- Standard Development Issues
- Modelling and Representation
- Scientific & Engineering Issues
- Specification Overview
- How to Use Them
- Current and Future Concerns
- Summary & Conclusions

The leading Agent Standard: FIPA



Foundation for
Intelligent
Physical
Agents

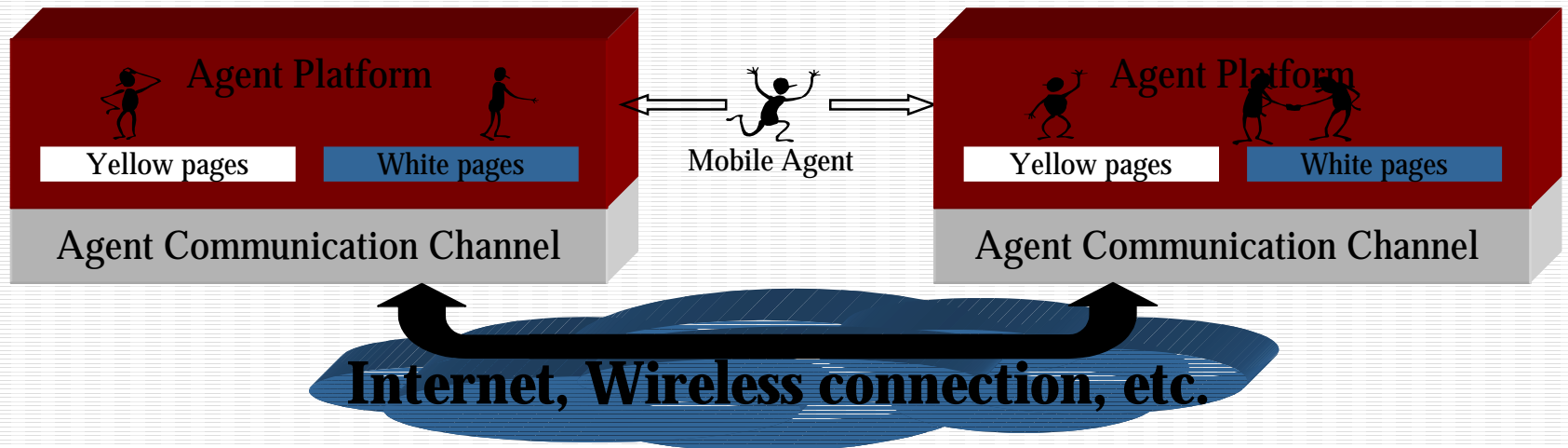
16 implementations

5 open source implementations

JCP

70 + members

Several related European projects



FIPA's Goal

- FIPA's official mission statement: **the promotion of technologies and interoperability specifications that facilitate the end-to-end inter-working of intelligent agent systems in modern commercial and industrial settings.**
- FIPA was established in 1996 to **identify and select usable specifications of agent technology in a timely fashion**

FIPA: What's in a Name?

- Foundation for **I**ntelligent **P**hysical **A**gents
- Key focuses:
 - **software** agents but initial vision was physical agents (robotics)
 - specifying communication and **interoperability** between agents
 - specifies **external behaviour** not internal behaviour - don't specify how agents process and reason about the information they receive.
 - Use in **heterogeneous** environments
- Foundation for **I**ntero**P**erable **A**gents

FIPA - Who is in

- 70 over member organisations with a very wide coverage of interests
 - from Europe, USA, Canada, Japan, Korea
 - consultant companies (Arthur D. Little, Lockheed Martin)
 - telecoms (TLABs, BT, Nortel, NTT, KPN, FT, ...)
 - manufacturers (Alcatel, Motorola, Siemens, Boeing, Matsushita, Mitsubishi, ...)
 - broadcasters (NHK)
 - Academics (Queen Mary, Imperial College, DARPA, Sandia, ...)
 - service companies (Sun, Toshiba, Fujitsu, IBM ...)

FIPA: the organization

- Not-for-profit organisation, established 1996
- Low-cost membership
- Open process for specification development
 - Published on Web, free,
 - Input & review invited from membership and agent community at large
 - Contributors & non members can attend meetings

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Why standards (for MAS interoperability) are needed (1)

- Many incompatible, proprietary agent systems exist
- This leads to closed systems and cluster of agents that are unable to communicate with each other
- Unlikely to scale (e.g., across the Internet), kills the market

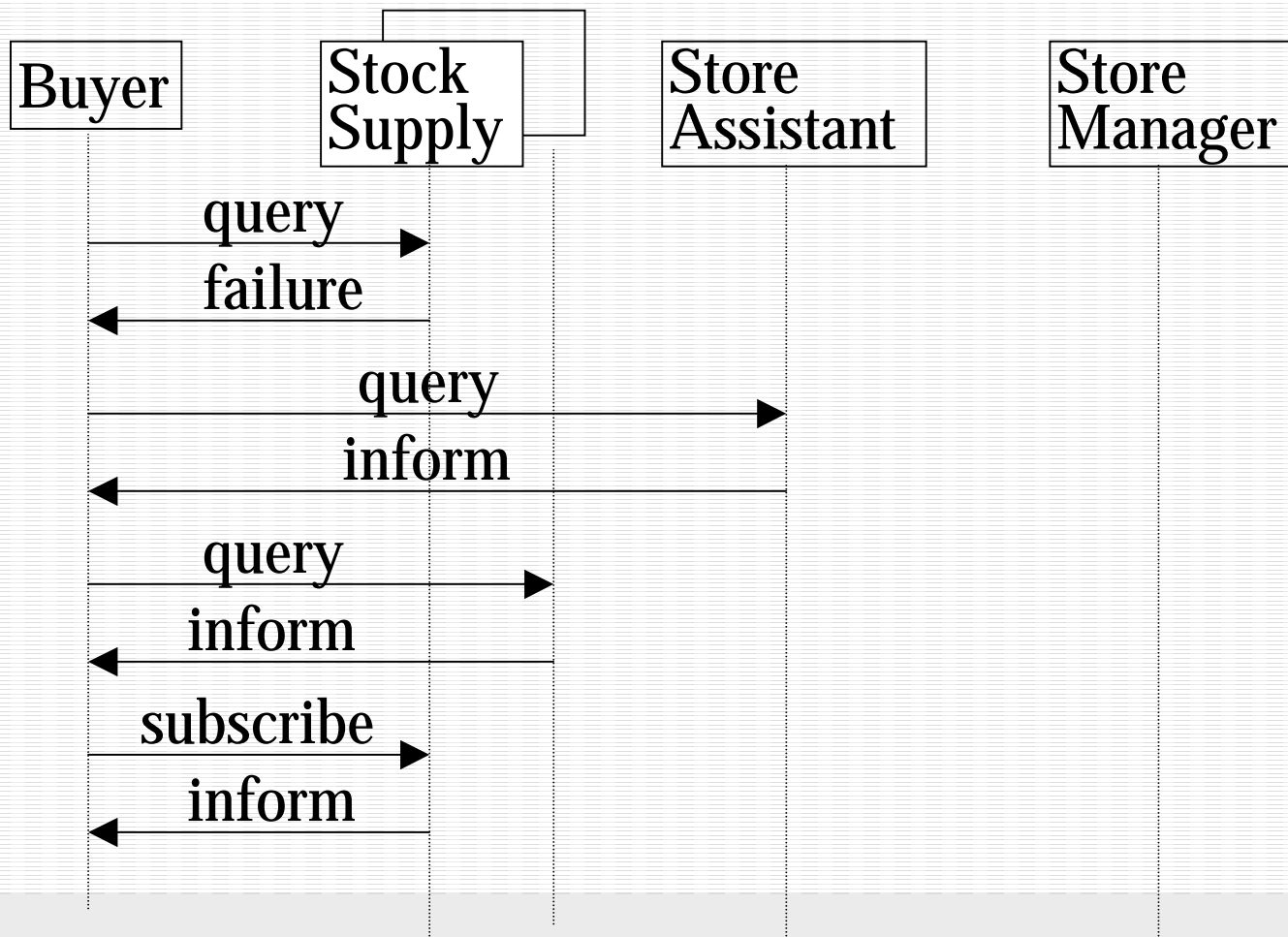
Why standards are needed (2)

- Interoperability and Openness are drivers
 - customers strive for simplicity and universality when accessing multiple services
 - service providers can act in unison to attain a critical mass for a sustainable customer-base
 - public standards lessen barrier for uptake by third-parties
 - Industry may only get serious about technologies if standards / specifications are in place
- There is a need for agent standards that standardize agent interoperability, that are public

Why focus on communication & on speech acts, protocols & ontologies?

- Our plan is to retrieve an article in a known place -but it is not there. What do we do?
 - Initiate our own general search
 - Reason internally (where else might it be?)
- Don't wish the action to delegate to assistant to retrieve article
 - Not competent, don't trust them, privacy issues
- Ask assistant for help
 - Advice on search for article in new location
 - Article not in stock: wait for new delivery
 - Modify search for equivalent article in old location

Why focus on on speech acts, protocols & ontologies (2)?



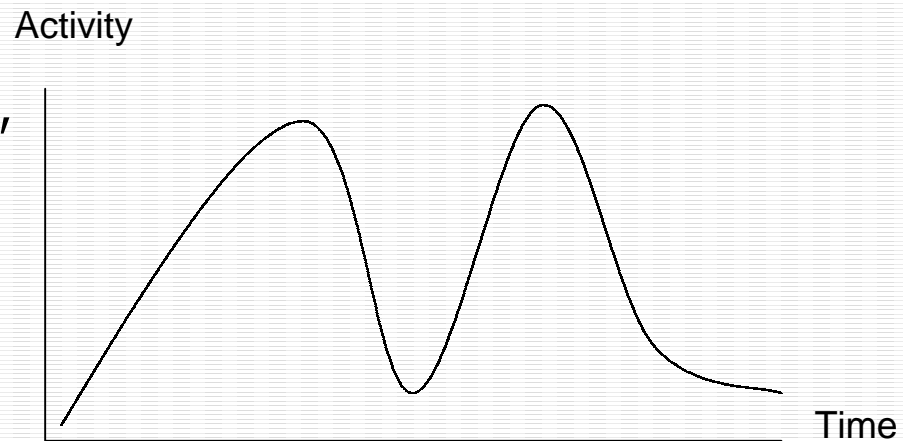
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Agent standards (1): issues

- Timing

- "Camel Model"



- Extensibility

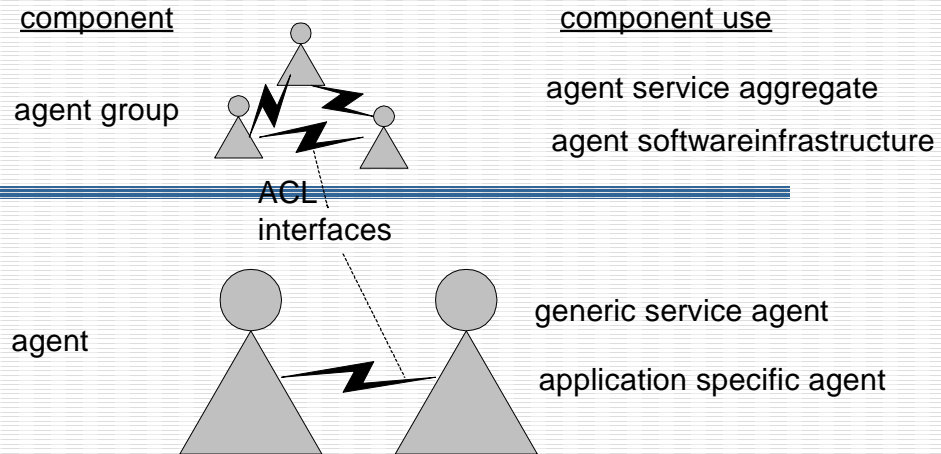
- Core set of communication primitives
 - Extensibility via composition rather than by sub-typing

Agent standards (2) : issues

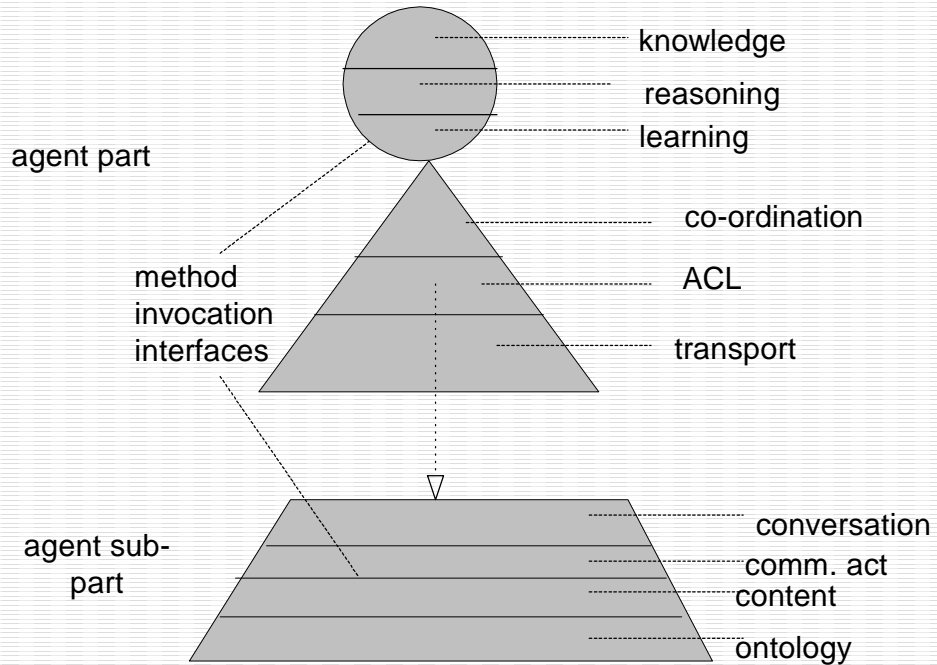
- Scope
 - ACL, facilitator agents? HCI / PA agents?
- Interfaces to the non-FIPA world:
 - General agent - software interfaces, persistence, transport etc
- Relation with other standards
 - FIPA aims to reuse other standards
 - Messaging: W3C (*XML*), DAML / OIL
 - Transports: HTTP, IIOP, WAP
 - Arch / infrastructure: Java, CORBA, JavaBeans, JINI ...

MAS standards (1): scope

FIPA specifications



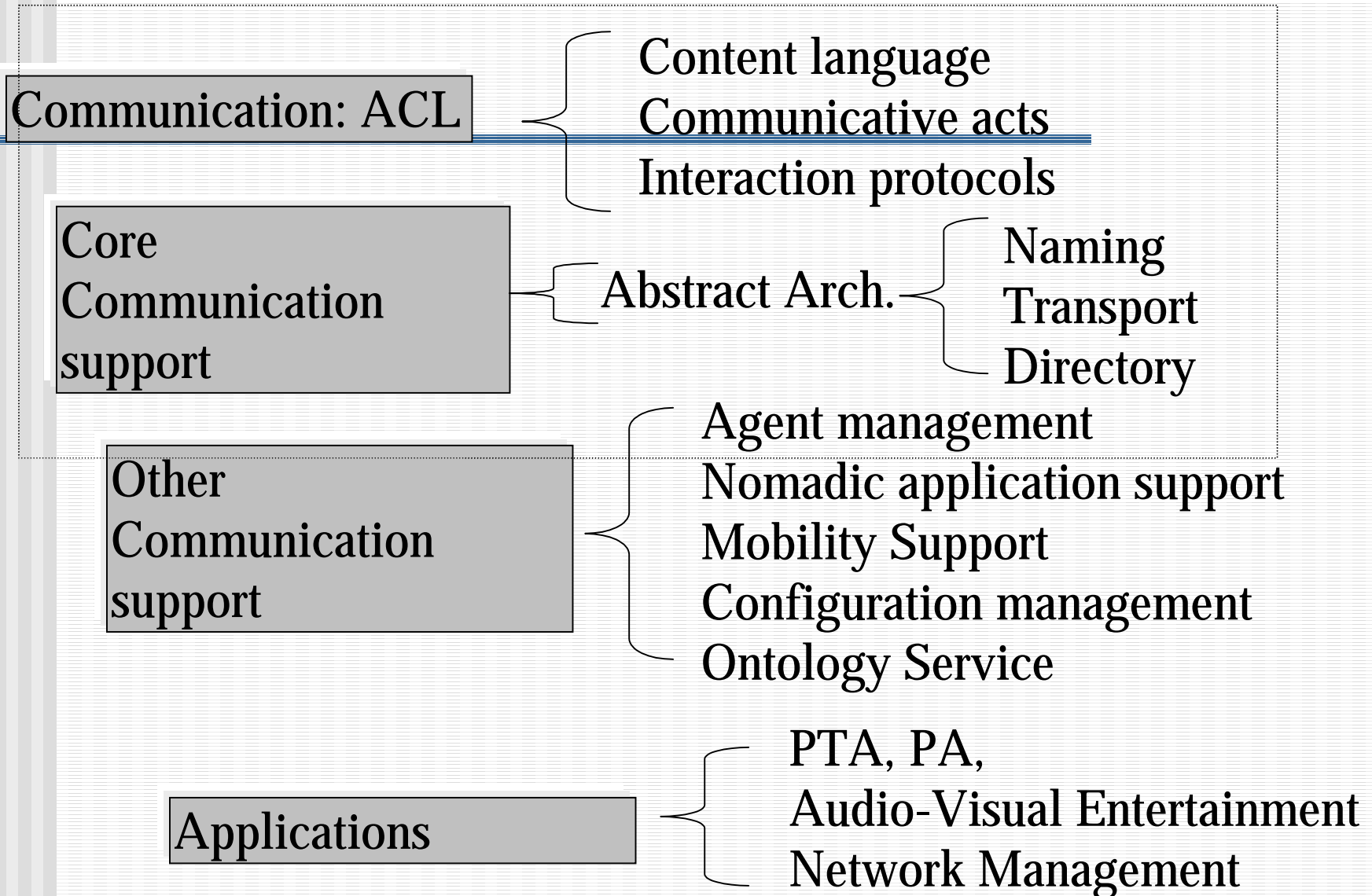
FIPA toolkits
implementations of specifications



MAS standards (2) : scope

- Communication
 - Dialogues, communication, primitives, content(actions), ontologies, encodings
- Organisation (indirect)
 - Roles: P2p, client-server, manager-contractor
 - MMAS: Domains vs. Platforms
- Communication Support Services
 - Core: Transport, Directory, Naming
 - Other: ontology,

Agent communication (3): scope



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Models and Representation

- For interoperability, it is not enough to have a de facto standard
 - Standard needs to be verifiable
 - Conformance to the standard needs to be verifiable
- Examine FIPA Agent Specifications as:
 - Descriptive Models
 - Prescriptive Models
 - Formal Models
- Descriptive Vs. Formal Models

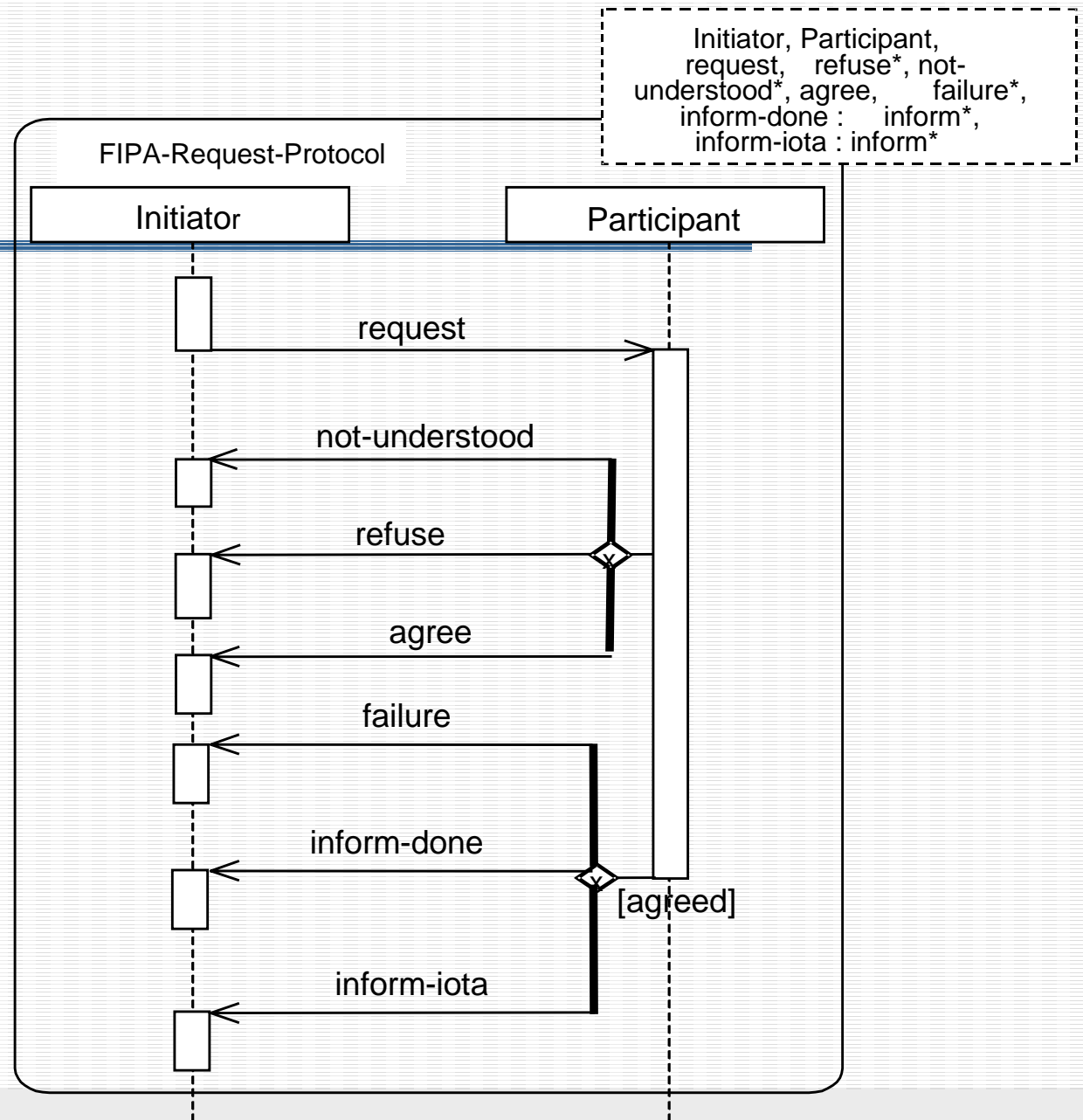
Descriptive models

- Various types of models
 - Functional or behavioural model, data or information model, organisational model and an interaction, operational model
 - These different types of models are complimentary
- Notation
 - Frame-based ontologies for different communication elements
 - standard models such as UML

Descriptive models of communication elements (1)

Frame Ontology	envelope FIPA-Agent-Management		
Parameter	Description	Presence	Type
to	This contains the names of the primary recipients of the message.	Mandatory	Sequence of agent-identifier
from	This is the name of the agent who actually sent the message.	Mandatory	agent-identifier
comments	This is a comment in the message envelope.	Optional	String
acl-representation	This is the name of the syntax representation of the message body.	Mandatory	String

Descriptive models of interaction in AUML



Descriptive models can have Prescriptive parts (1)

- Specifications have policy rules
 - “The basic role of the directory-service function is to provide a location where agents register ... Other agents can search the directory-entries to find agents with The directory-entry is a key-value-tuple”

Prescriptive policy rules (2)

- Examples from the FIPA agent management specification
 - “An agent must have at least one owner ..”
 - “A Directory Facilitator (DF) is a mandatory component of the Agent Platform ..”

Prescriptive policy rules (3)

- The following rules are adopted to select the appropriate communicative act that will be returned when a management action causes an exception:
 - “If the communicative act is not understood by the receiving agent, then the replied communicative act is not-understood.”
 - “If the requested action is not supported by the receiving agent, then the communicative act is refuse.”

Formal model in FIPA

- It is an alternative approach to a descriptive framework
- E.g., the semantics of FIPA agent communication is (partially) underpinned by a formal logic.
- The FIPA ACL has formal semantics that are defined using a multi-modal (BDI-type) logic called Semantic Language or SL.

FIPA semantic language

- The semantic model maps each agent message type (speech act) to an SL-formula that defines constraints that the sender must satisfy called the **feasibility conditions**.
- FIPA also maps each message to an SL formula that defines the **rational effect of the action**.

Formal model: conceptual, use issues

- Formalisms within the FIPA are used intermittently
- FIPA semantic logic issues for agent interoperability
 - Intentional semantics problematic at receiver end, hard to prove
 - Formalism not easy to deploy in domains requiring agreements etc
- Limited expressiveness, computation tractability, fault-tolerance of logics for use in actual, open distributed systems

Descriptive model: verification issues

- Test for conformance at specific points
 - Compare the actual o/p to the expected o/p for a specific input
 - Verify or conform only at specific points
- Use trigger constraints
 - Functions as contracts – specify conditions, inputs, outputs
 - Higher order effects are difficult to capture as a contract

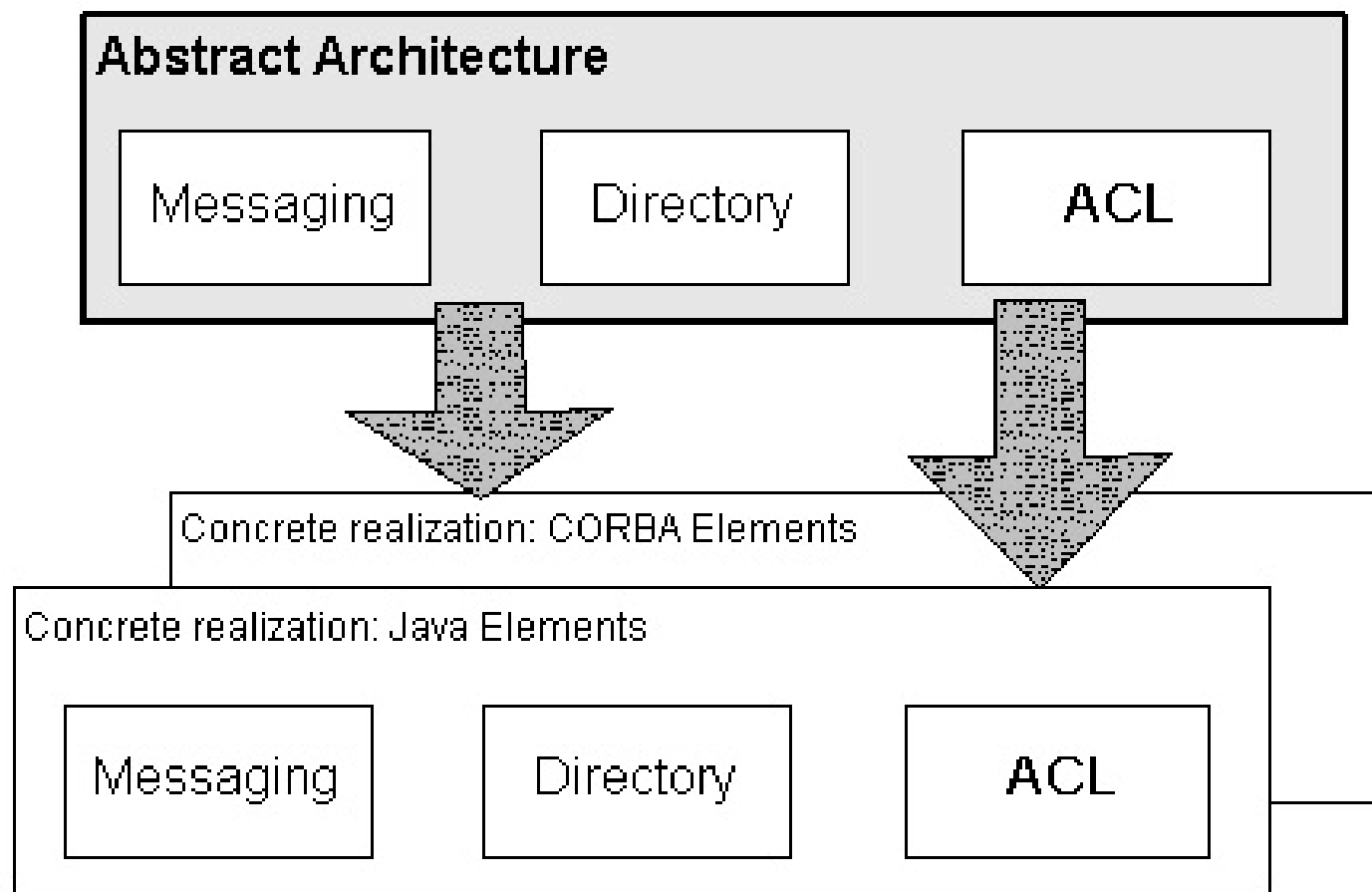
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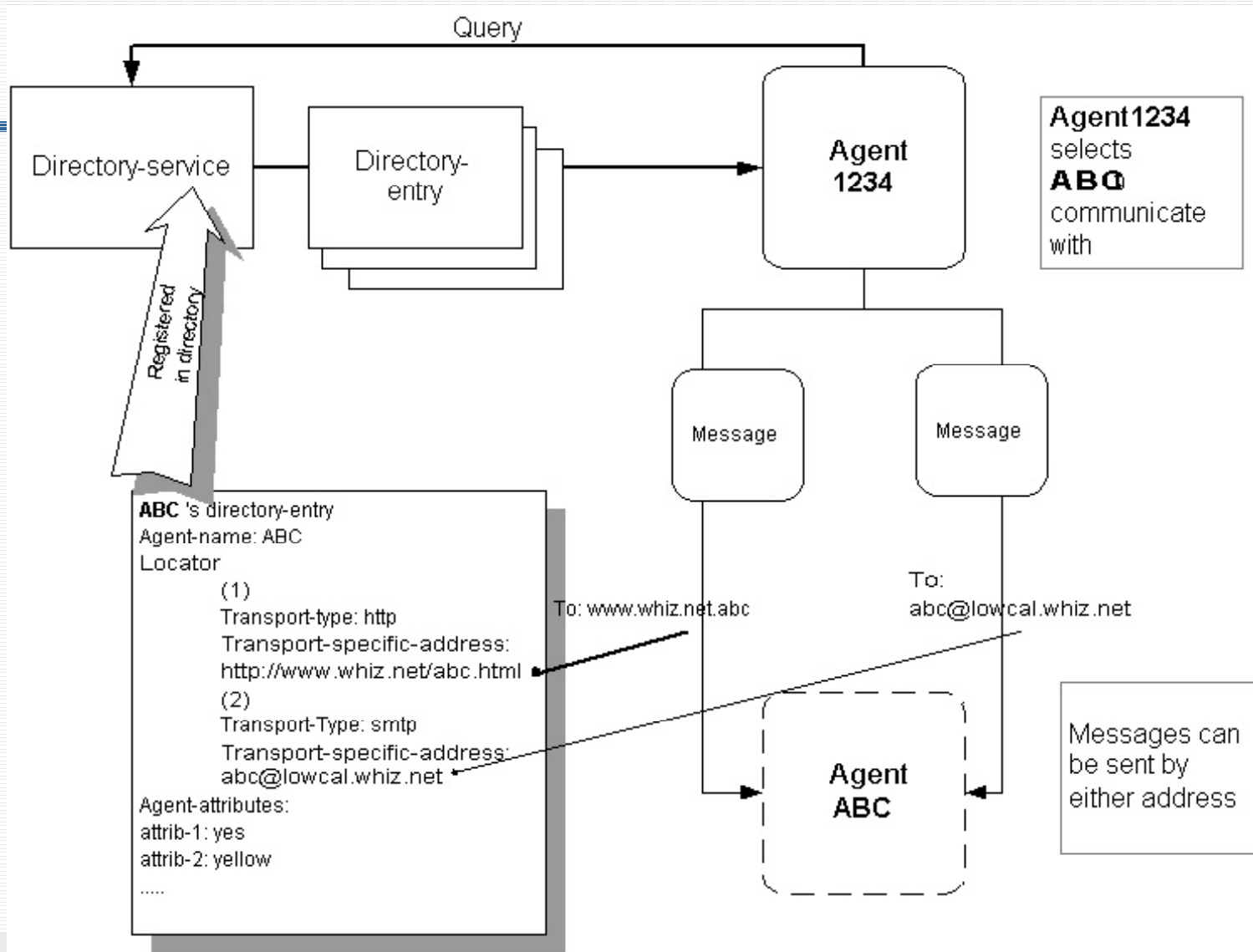
Scientific & Engineering issues

- Abstractions
 - architecture, naming, agnostic about specific agent parts
- Scope
 - Specify **external** communication **or** **internal** msg. handling and reasoning
- What to model as an agent?
- Reuse of other standards
 - XML, DAML / OIL

Abstractions (1): architecture



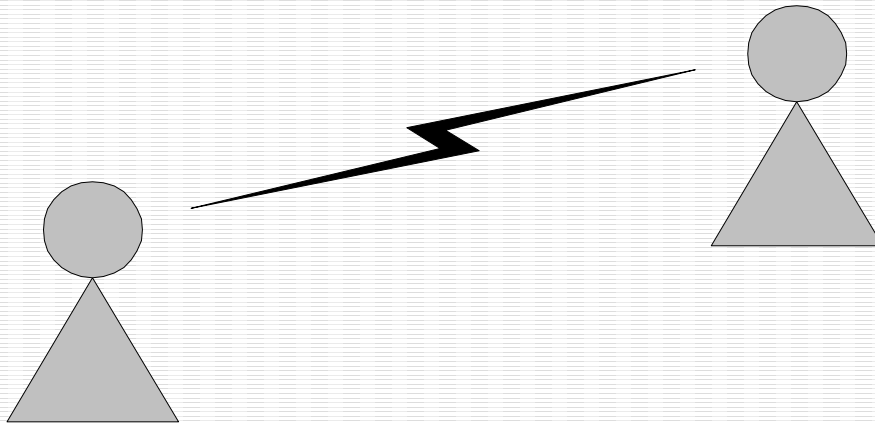
Abstractions (2): what's in a name?



Abstractions (3): agnosism about specific non-agent services

- In 1997-1998, FIPA specified the use of a single so called base-line message transport
 - IIOP transport is OK for low volume transaction, wire-line, private networks (without firewalls).
 - IIOP transport is not OK for use via firewalls, for high-transaction processing and for wireless environments.
- Agent component interfaces needed to neutral and abstract, e.g., the new Agent transport specification supports multiple message transport protocols.

Scope: external communication or internal message processing

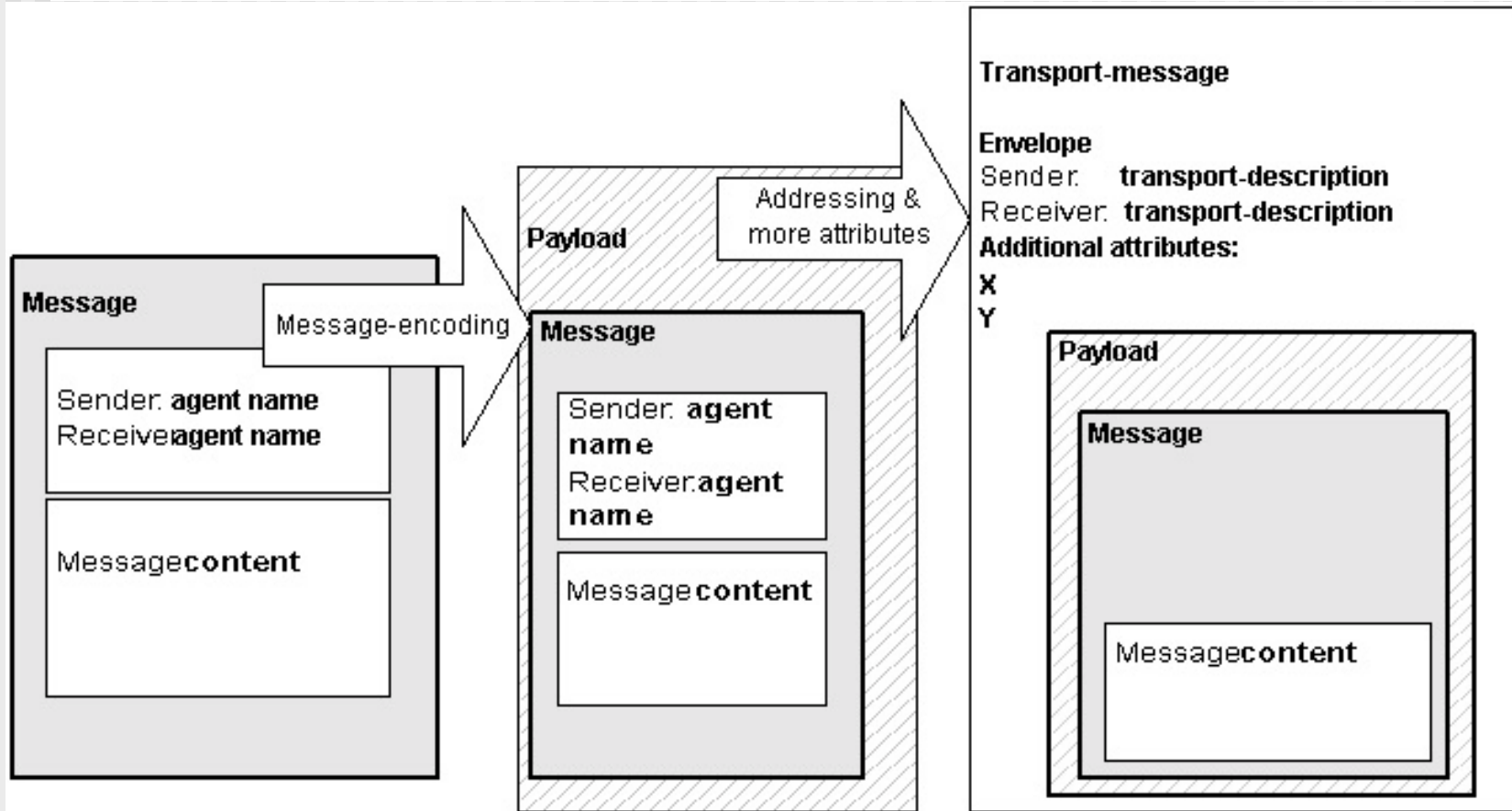


what features should be modelled as agents vs. non-agent parts?

e.g., should a message transport service be an agent?



Reuse of other standards: encoding information using XML



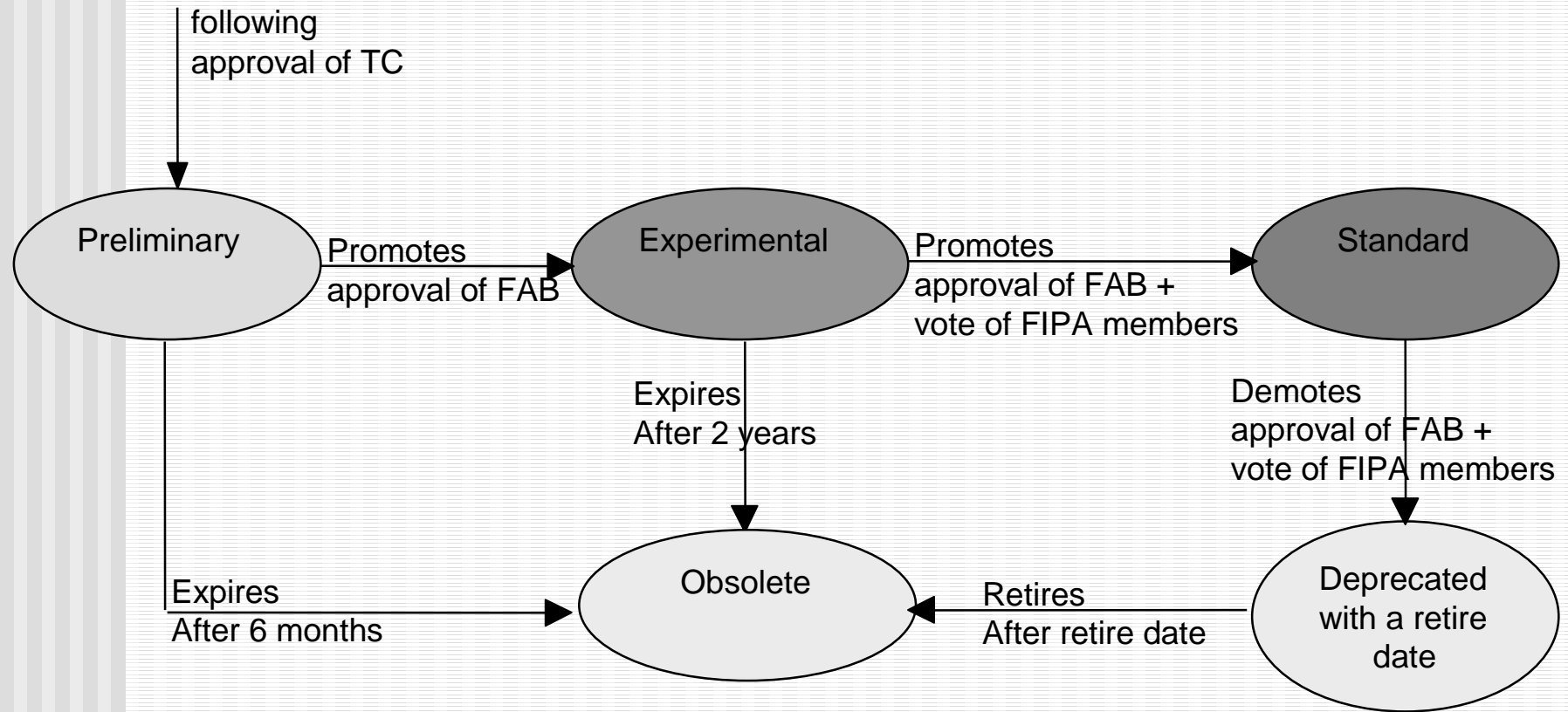
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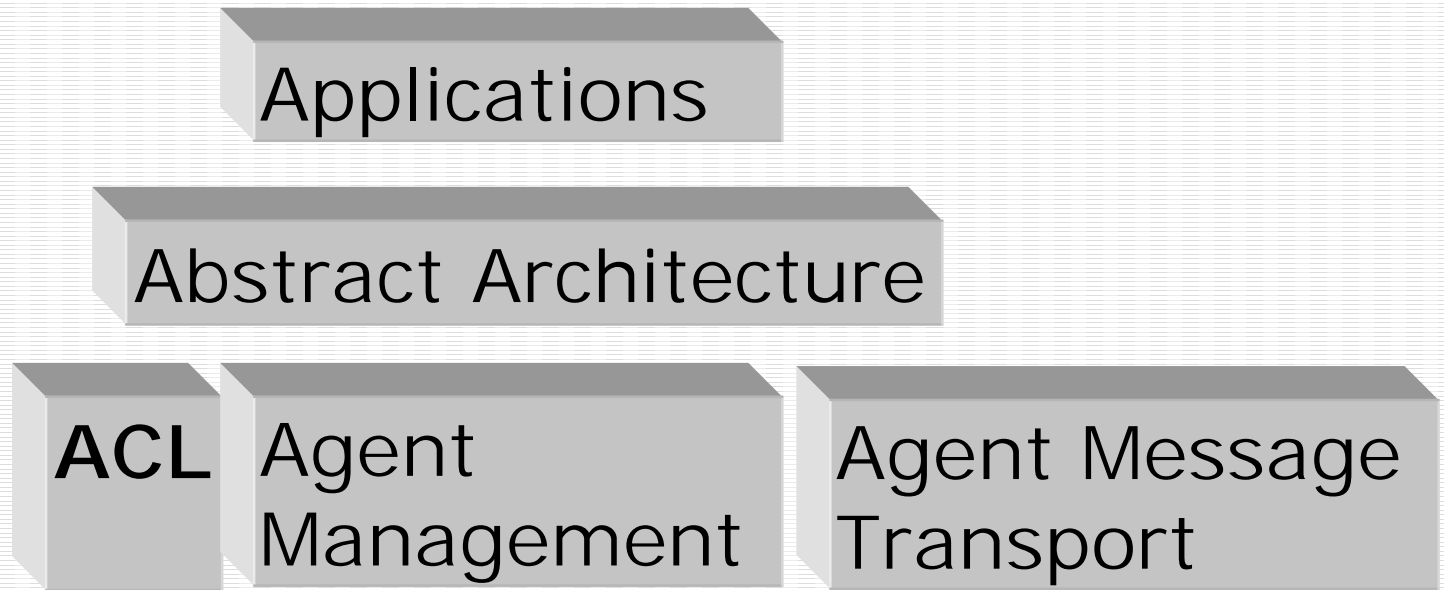
Overview of the specifications

- There are several ways to organise the specifications – it depends on the perspective ...
 - Packaging at FIPA site for retrieval
 - Communication centric view
 - Developer's view (next section)
 - View From the application domain
- The relationship between the abstract architecture and agent platforms
- Content languages and ontologies

Specify than experiment



FIPA site view of specifications



Another view of the specifications

Communication: ACL

Content language
Communicative acts
Interaction protocols

Core
Communication
support

Naming
Transport
Directory

Abstract Arch.

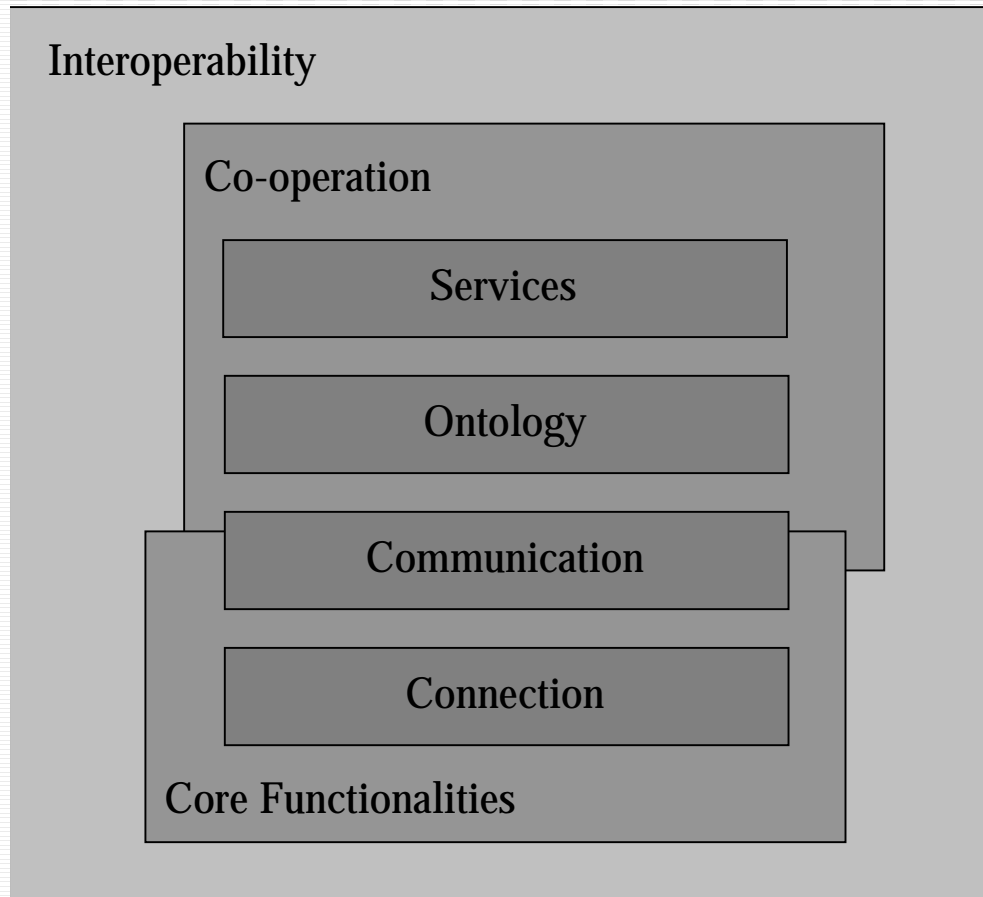
Other
Communication
support

Agent management
Nomadic application support
Mobility Support
Configuration management
Ontology Service

Applications

PTA, PA,
Audio-Visual Entertainment
Network Management

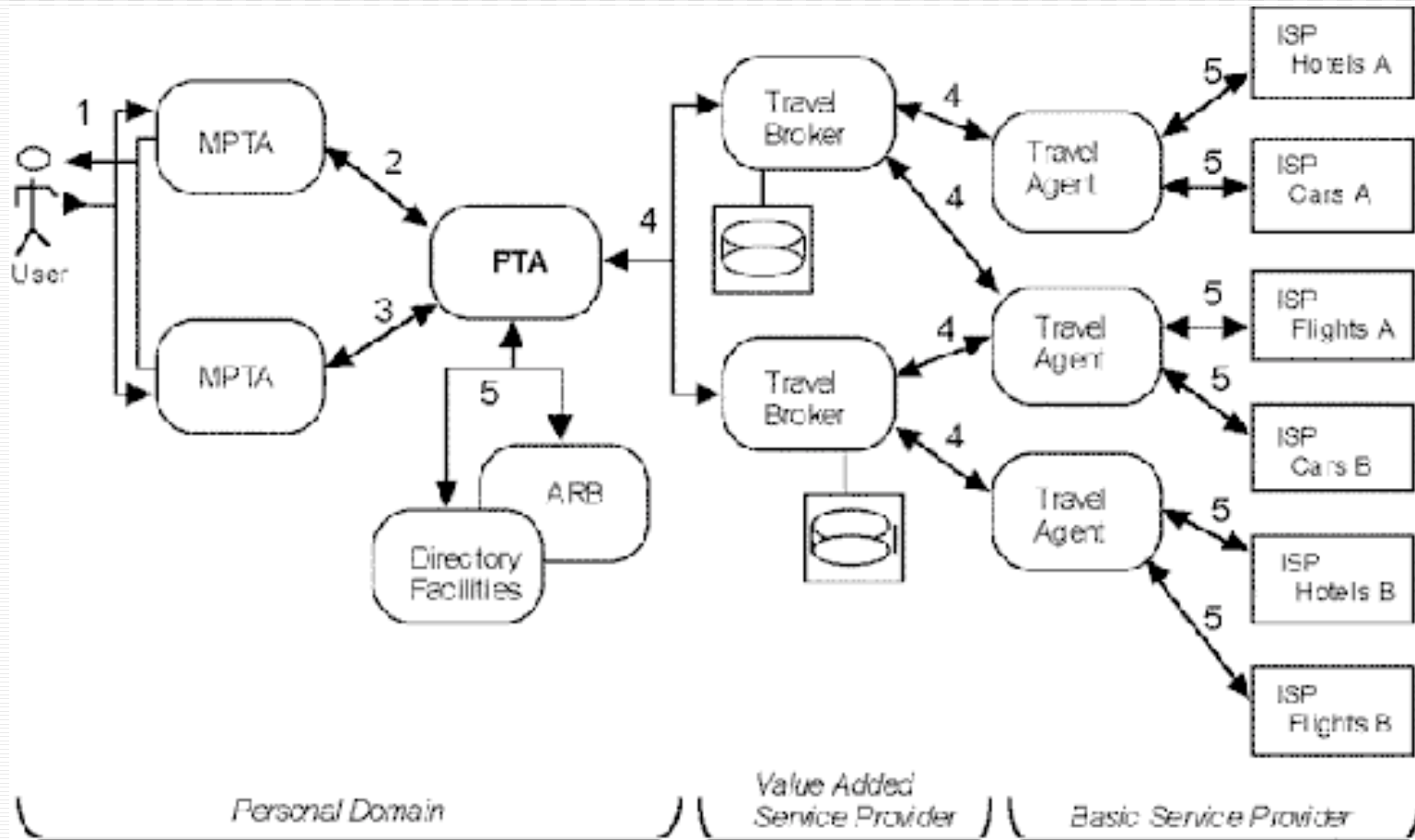
Another view of the specifications (2)



Application specifications give a good overview

- FIPA Personal Travel Assistance Specification
- FIPA Audio-Visual Entertainment and Broadcasting Specification
- FIPA Network Management and Provisioning Specification
- FIPA Personal Assistant Specification

FIPA Personal Travel Assistance Specification



About the abstract architecture ..

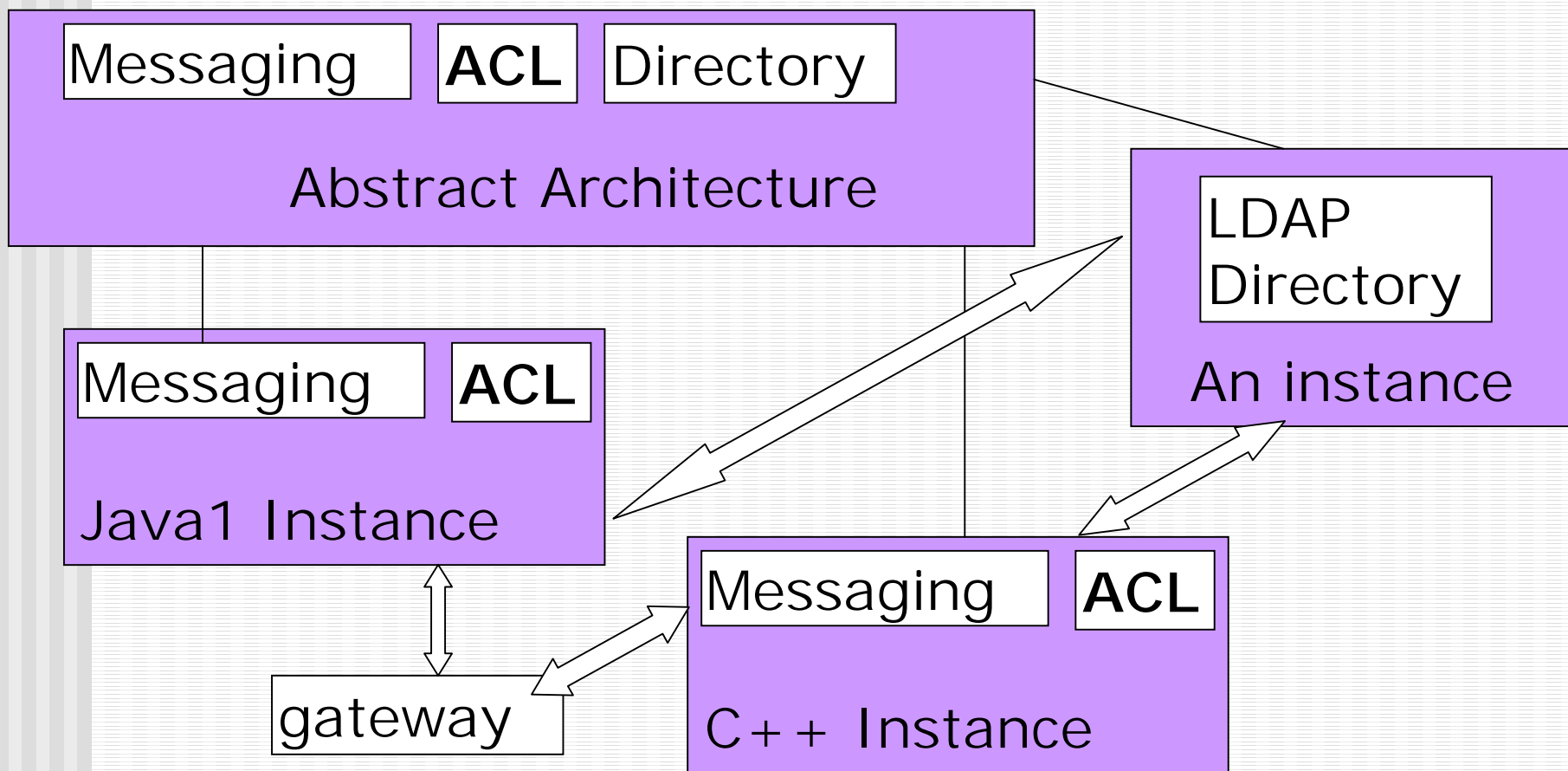
- And its relationship to agent platforms

....

Abstract Architecture

- Focuses on core interoperability services:
 - ACL, message transport directory
- The Abstract Architecture explicitly avoids
 - agent-platform, gateways, bootstrapping, agent configuration and coordination.
 - These elements are not included in the abstract architecture because they are implementation specific. Some elements will exist only in specific instantiations.

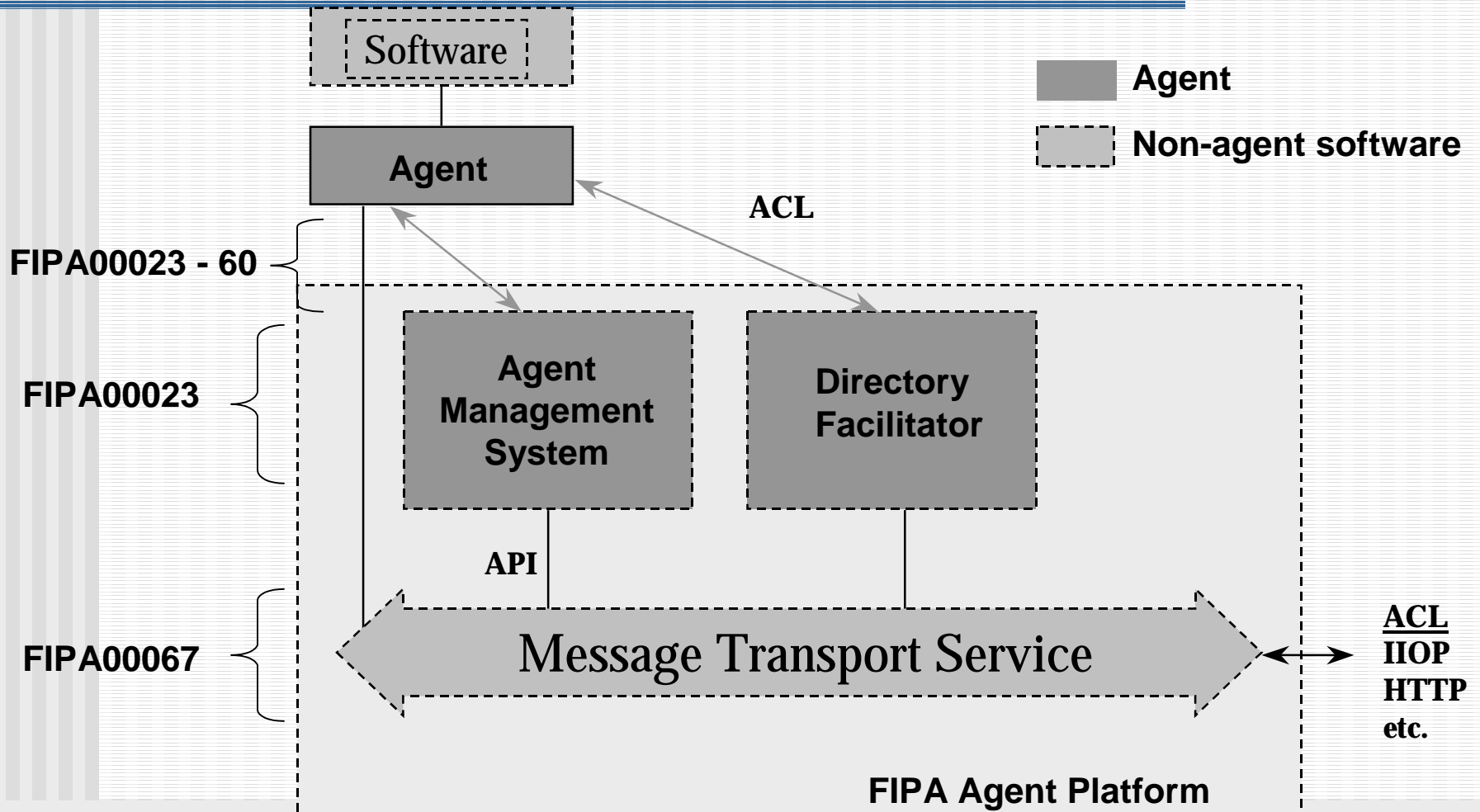
Abstract architecture and Interoperability



Abstract architecture vs. Agent Platform

- FIPA Agent Platform is specified in
 - FIPA00023 agent management specification
 - FIPA00067 message transport specification
- Agent platform can be regarded as a concrete realisation of the abstract architecture

FIPA Agent Platform



Content languages vs. ontologies

Content language

Ontology language?

- Representation for handling input, generating new output & processing information
- Domain independent
- E.g., SL(0-2), CCL, OIL?
- Defined in the content language specifications

Ontology

domain instance ontology

- Representation for Defining Storing, retrieving & indexing domain information
- Domain dependent
- E.g., fipa-mgt-ontology
- These are defined in the management specs

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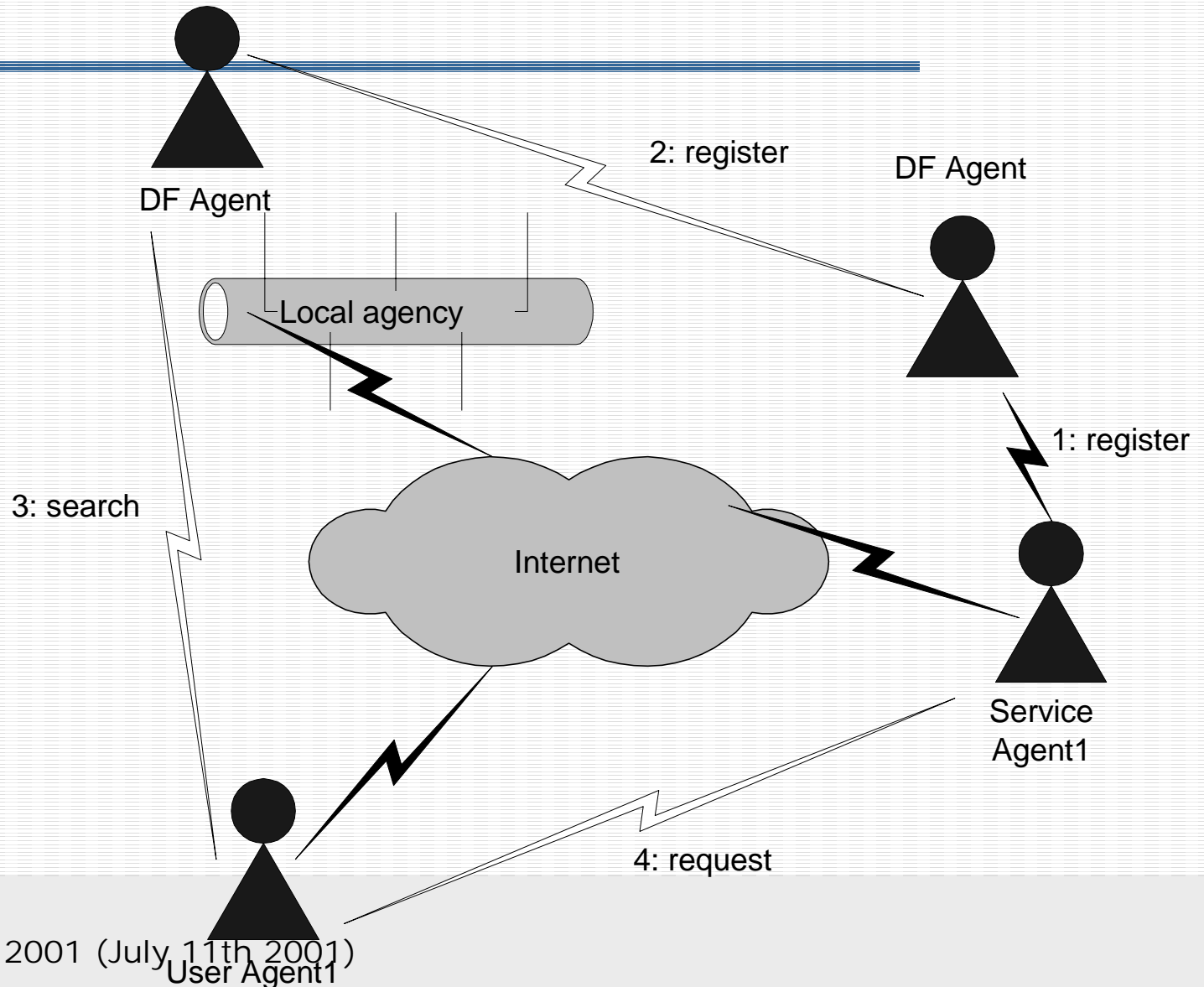
Basic issues in using the specs. to develop agents & services

- Parse ACL messages
- Offer mandatory services
 - Naming, directory, transport
- Set transport encoding, content languages
- Use an existing open source platform to help do these
- Interlink agent platforms
- Test platforms
- Offer new services
- Some example projects and applications

FIPA open source implementation

<i>Company</i>	<i>Agent Platform</i>
■ <i>Comtec (Jp)</i>	
■ <i>CSELT (It)</i>	<i>JADE</i>
■ <i>Fujitsu Labs (USA)</i>	<i>AAP</i>
■ <i>Nortel Networks (UK)</i> <i>/ Emorphia Ltd</i>	<i>FIPA-OS</i>
■ <i>British Telecom (UK)</i>	<i>ZEUS</i>

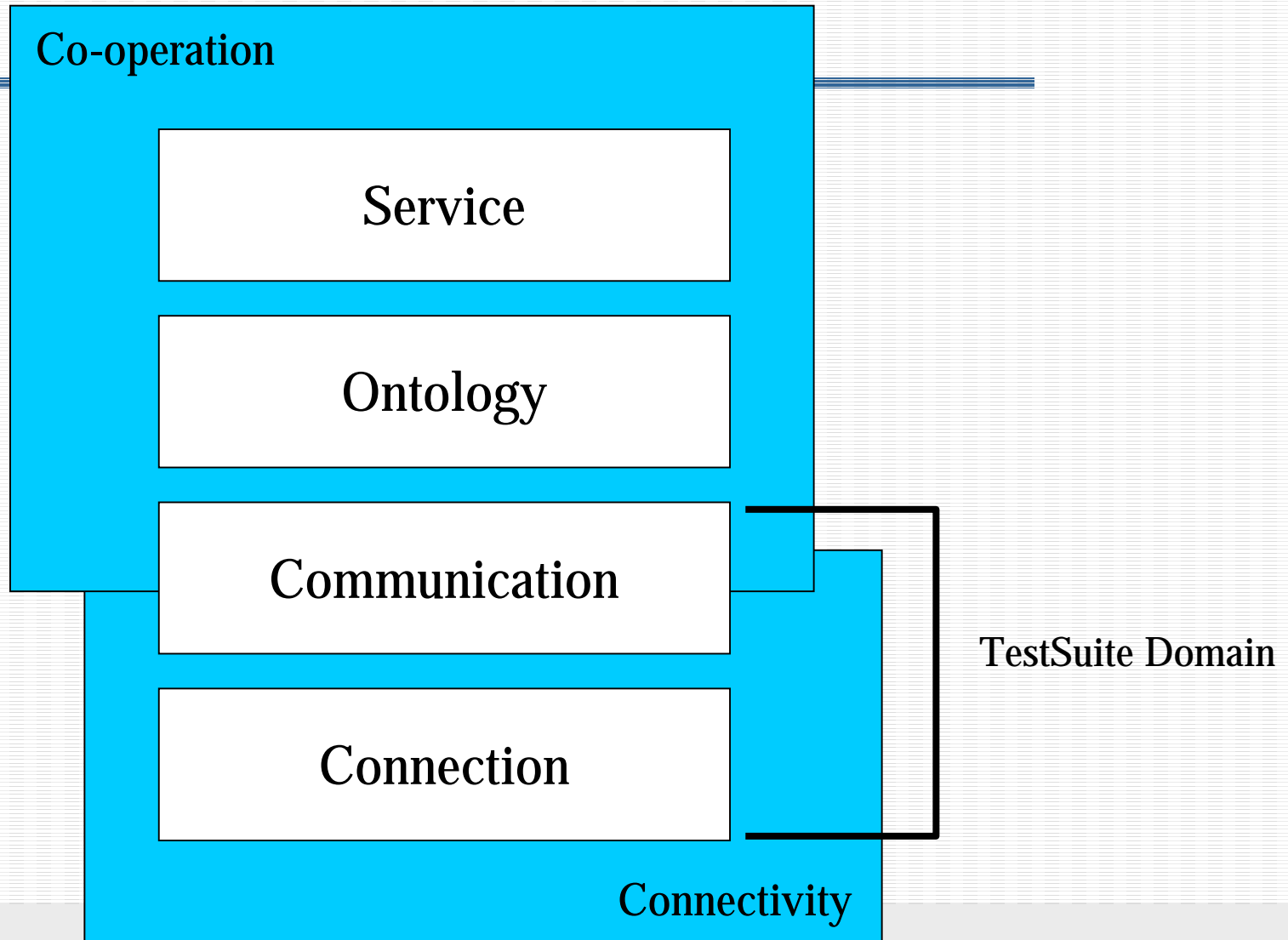
Interlinking multiple platforms



Overview of the Test Suite

- Specified by Motorola and EPFL, Implemented by the LEAP project (specifications available at <http://www.agentcities.org/Testsuite>)
- To be used as a conformance test suite by the Agentcities project
- Tests the Connection and Communication layers for FIPA platforms

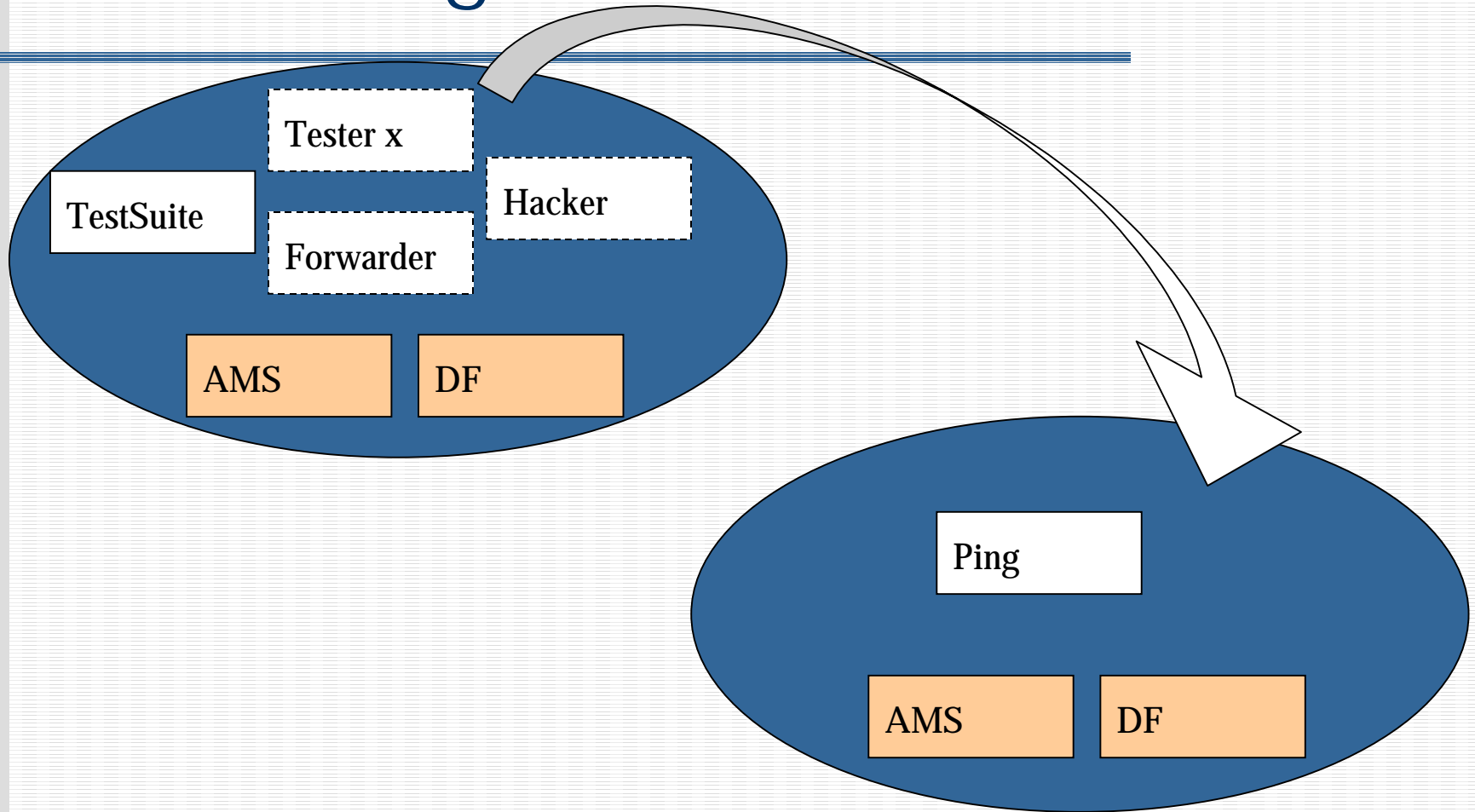
Test suite (1)



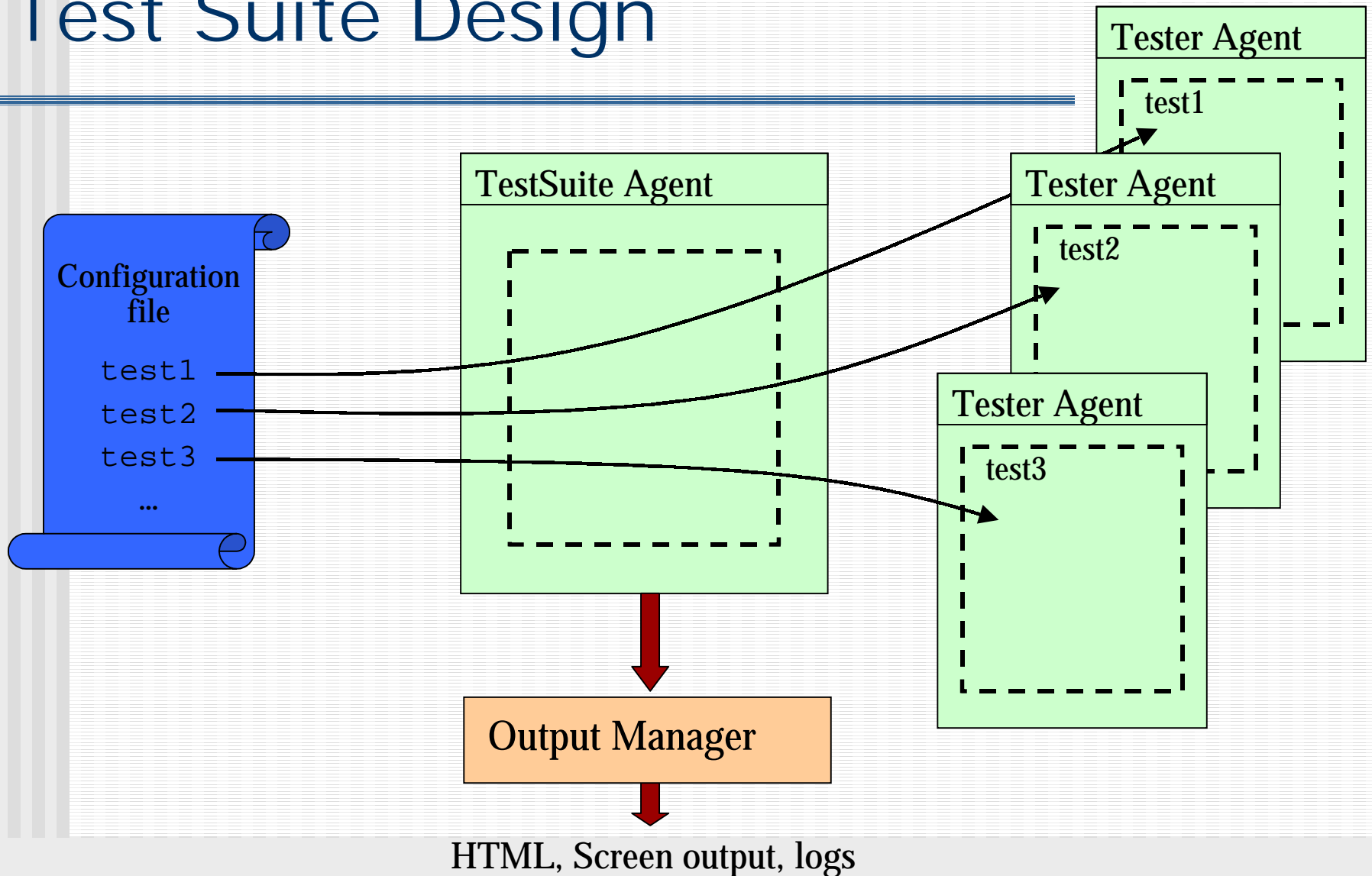
Test suite (2): testing FIPA AP Connection and Communication

- Agent Message Transport Service
 - Send message to one/multiple/non-existing agents...
- Conversation management
 - conversation-id, reply-with/in-reply-to
- Agent Management Service
 - ap-description
 - dynamic registration (register, change registration, search, deregister)
 - security
- Directory Facilitator
 - register, change registration, search, deregister
 - security
 - federation

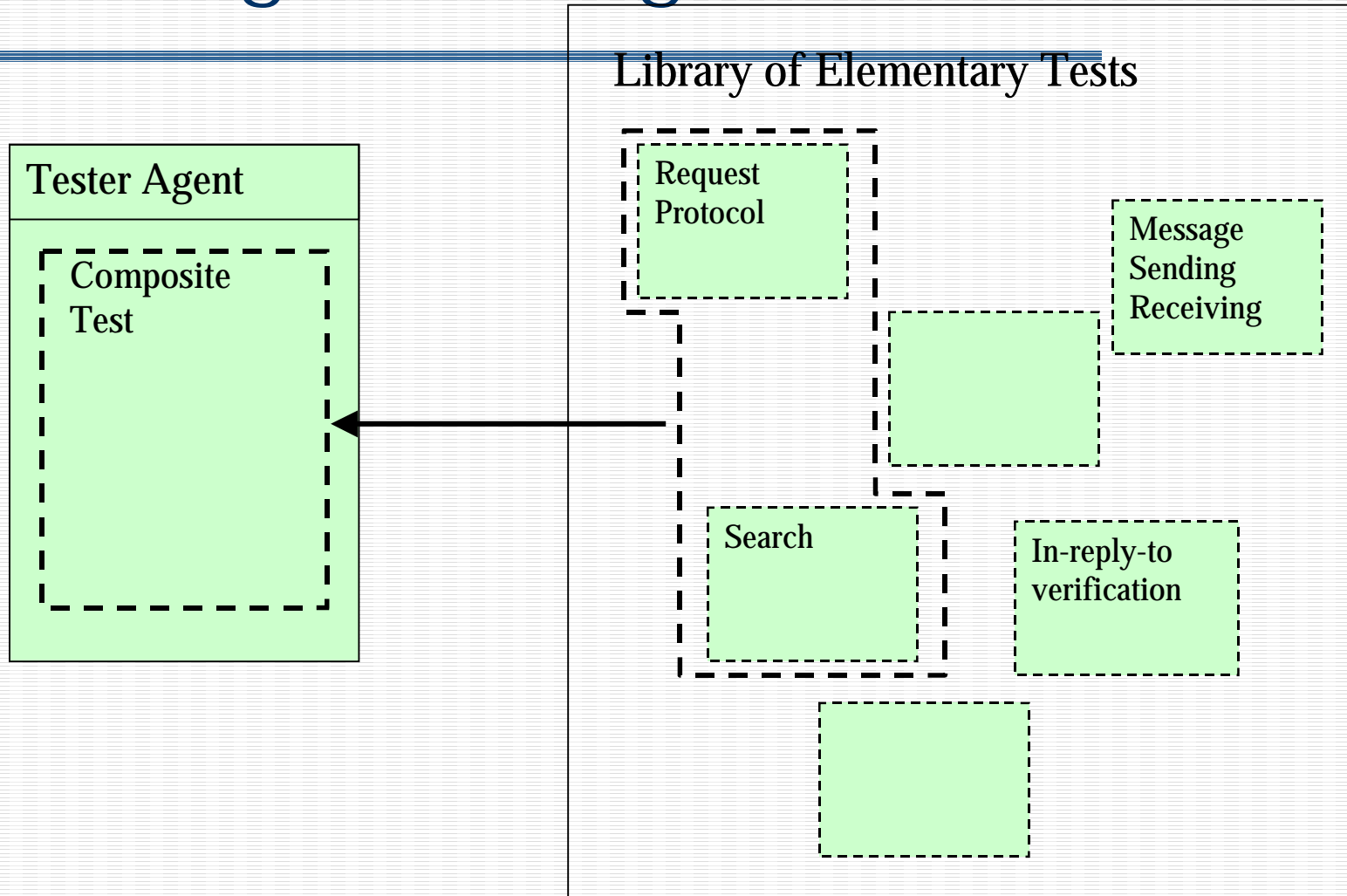
Test Suite Agents



Test Suite Design



Tester Agent Design



Example

```
platformAddress = http://liasun17.epfl.ch:8080/acc
```

```
# list of test identifiers
tests =
(test11;test12;test13;test14;test21;test22;test30;tes
t31;test32;test33;test34;test35;test36;test41;test42;
test43;test44;test45;test46;testS11;testS12;testS13;t
estS14;testS21;testS22;testS23;testS24)
```

```
# tests details
# Test 1 (MTS)
# parameters
(T:target1;T:target2...;F:forwarder1;F:forwarder2;...
;
X:unknowntarget1;X:unknowntarget2...)
# T: target (existing target)
# X: non-existing target
# F: forwarder
# P: protocol used (include in the message a wrong
address)
```

```
test11 =
leap.testsuite.tests.agentcities.TestMTS1(T:acl_ping)
test12 =
leap.testsuite.tests.agentcities.TestMTS2(T:acl_ping;
F:forwarder)
test13 =
leap.testsuite.tests.agentcities.TestMTS3(X:nemo)
```

Test Suite Report

Fri May 18 13:11:22 CEST 2001

Message Transport System - test 1	
send/receive a message to/from a single agent	OK
Message Transport System - test 2	
send a message to one agent with multiple agents in reply-to (multicast-reply)	FAILED
Message Transport System - test 3	
send a message to a non-existing agent	OK
Message Transport System - test 4	
send a message with incorrect address	FAILED
Test Protocol Management 1	
Conversation id protocol verification	OK
Test Protocol Management 2	
Reply-with/in-reply-to protocol verification	OK

Offering new services

- Event-driven programming
 - Develop message [protocol] handlers
 - Develop message dispatcher / rule inference engine
- Specify information
 - Ontology instance
 - Content language
- Advertise service
 - Register it with name & directory service

Some current [EU] FIPA projects

- CRUMPET: personalised nomadic services for tourism
- EDEN-IW: environment data network
- Agentcities: global test bed of 14 -> 100+ agent platforms and services
 - with other national networks as spurs
- TORRENT: home network
- LEAP: services for a mobile work-force
- Etc.

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FIPA Activities

- TC Architecture
- TC Agreement management
- TC Gateways
- WG Agentcities
- WG Image
- WG Security
- WG Product design and manufacturing
- SIG Ontologies

MAS Security Issues

- Agent systems can be made secure
- Agents can enhance security

MAS security issues (2)

Security & agent security is multi-faceted:

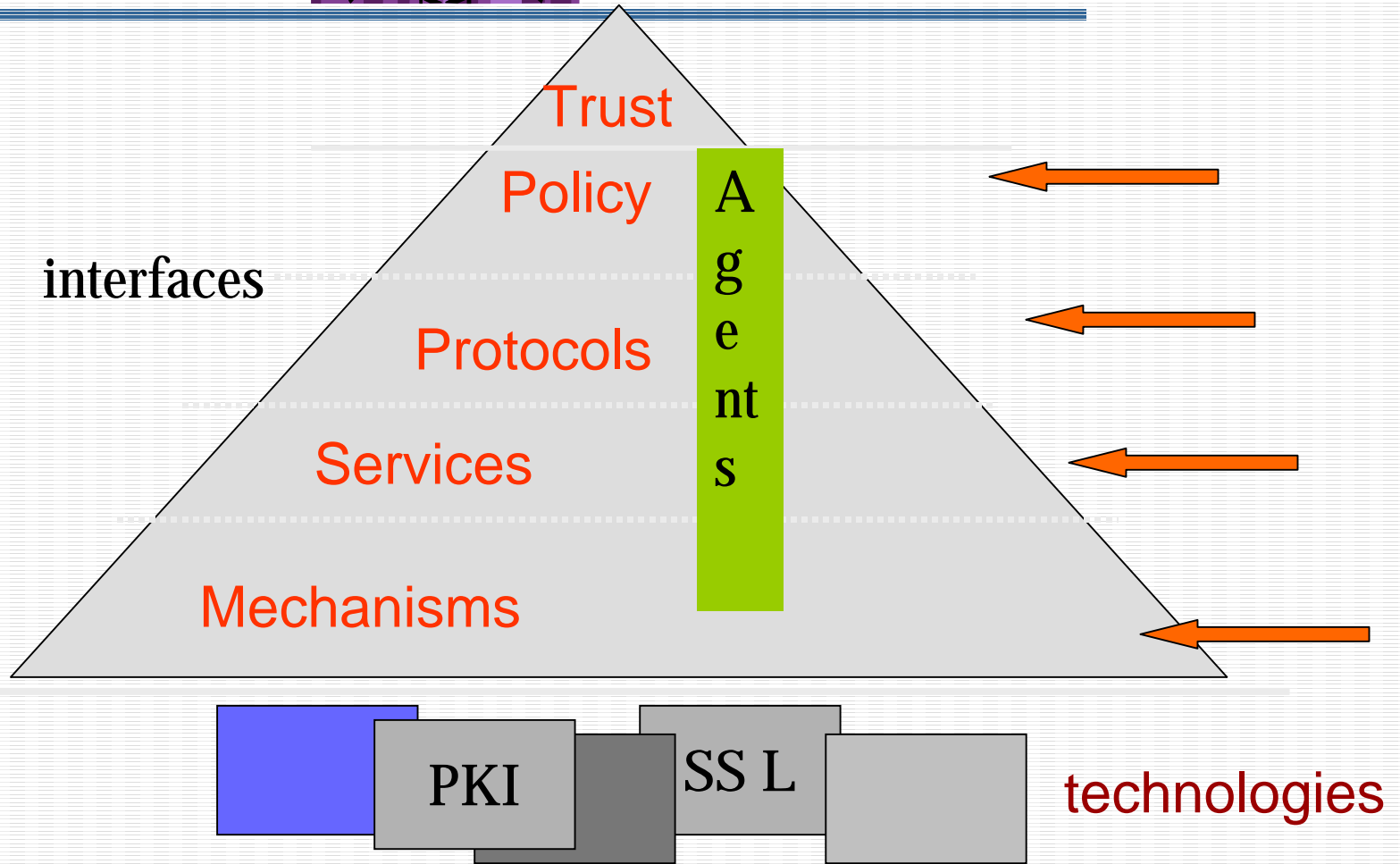
- understand requirements & properties of (agent) systems that operate in such distributed, dynamic, open environments
- define how to use agents and their peculiar properties in conjunction with any underlying infrastructure security.
- address a new generation of security issues that arises as automated, dynamic, delegated peer-to-peer interaction becomes more pervasive

Early Barriers to Agent Security

- Security is v. complex, requires I/P from experts
- Security is part of the software infrastructure and is outside the scope of an Agent architecture
- Agents do not need to carry-out a discourse on security configuration at the ACL level
- Security is domain and platform (implementation) specific - there are no useful general agent security architecture abstractions
- Complete spec., policy etc are required at start
- Early focus on collaborative, rational agent services within Intranets – security not an issue.



The Trust Iceberg

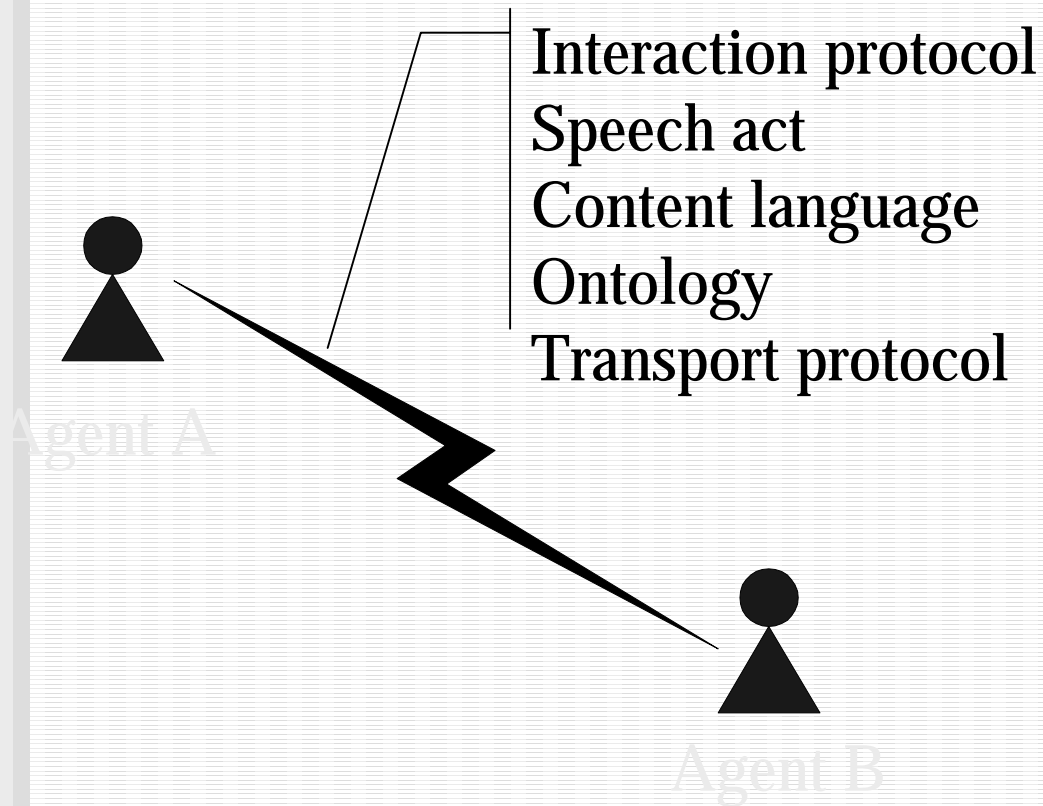


Agent specific attacks

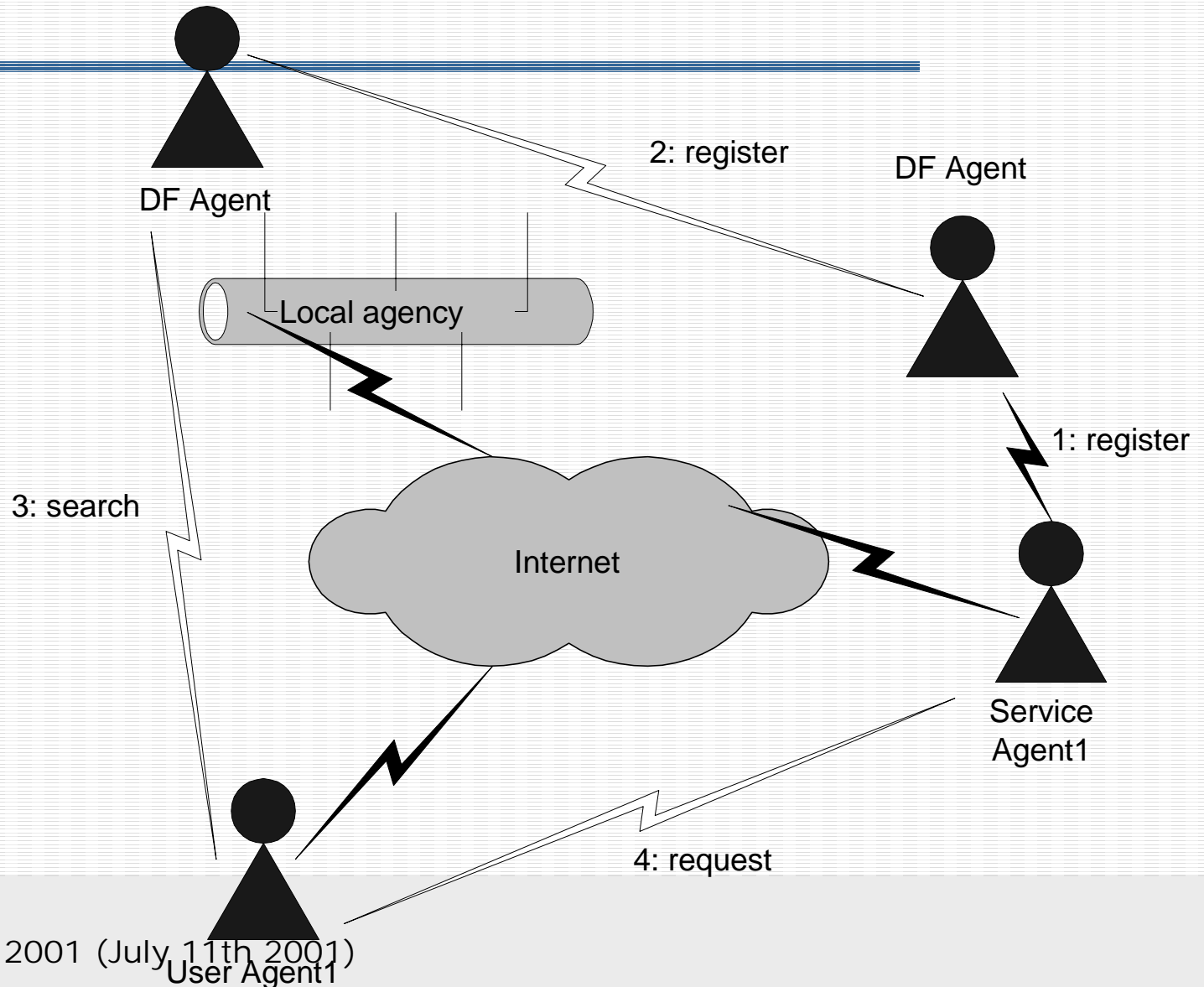
We highlight three main risks:

1. Agents communicate with other agents using syntactically complex and semantically rich, complex, messages.
2. Agents make heavy use of facilitators, match-makers and brokers to discover and hence interoperate and co-operate with unknown agents.
3. Agents within one domain or agency interact with agents in other autonomous domains or agencies.

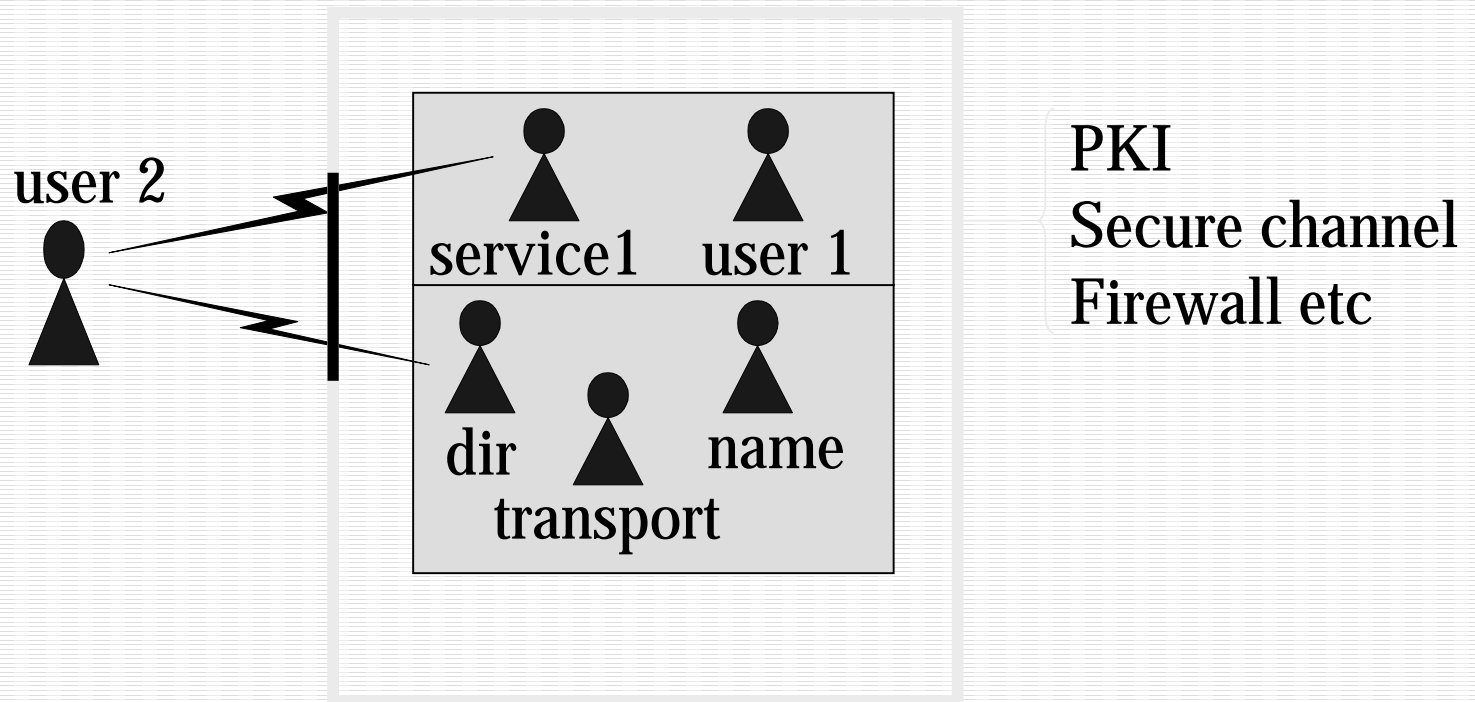
Breaking the message handling



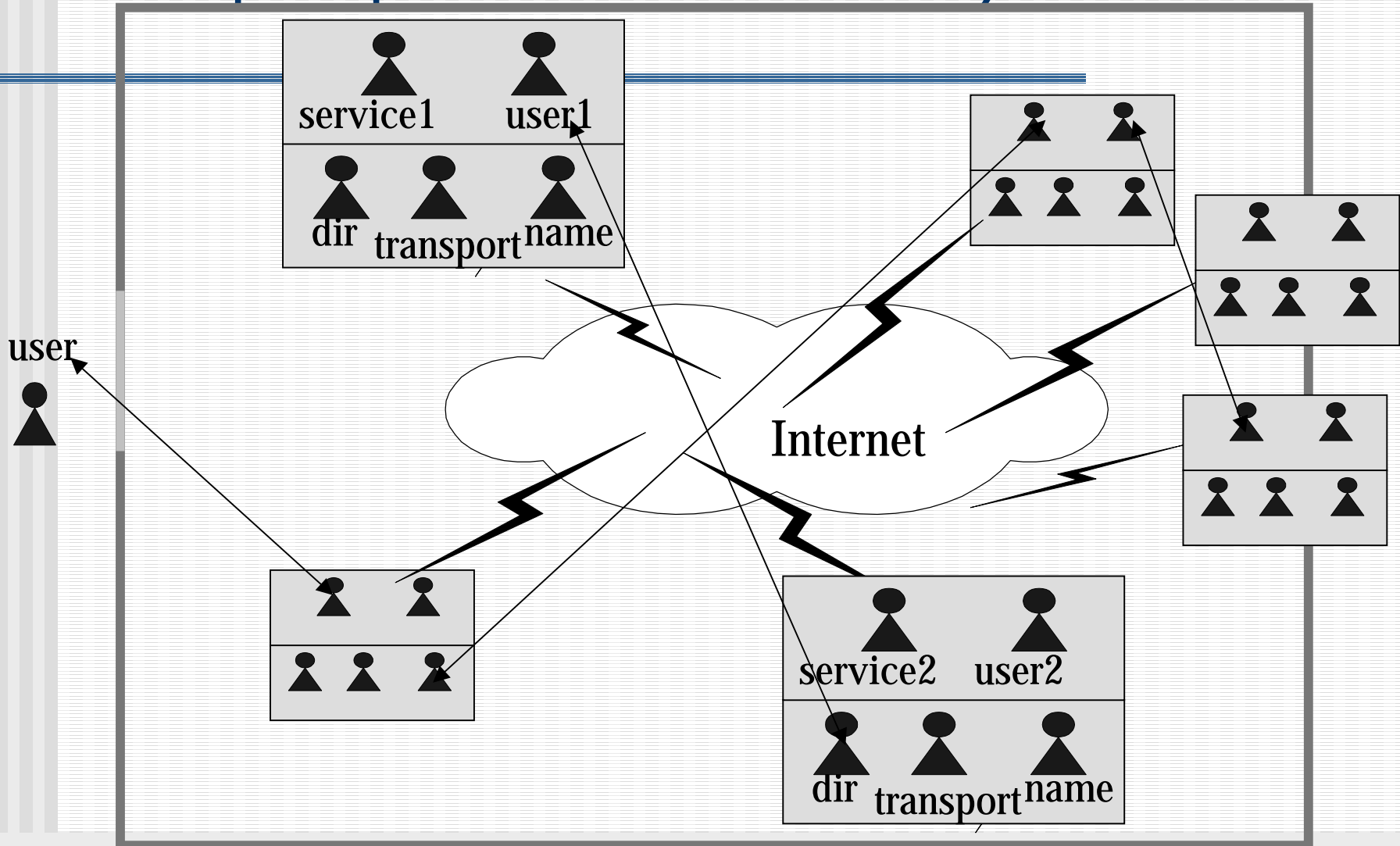
Attacking the mediators




Interlinking multiple domains: Single platform security (1)



Interlinking multiple domains: Multiple platform security



Scope (1):

- 
- Delegate security to the platform
 - Agents trust it 100% to maintain security
 - Agents as security monitors
 - Agents can observe what is available and ..
 - Agents control security: coarse
 - switch on and off their own security
 - switch between various levels of security
 - Agent control security: fine
 - control and reason about security in a more detailed level

Scope (2): current work-plan

- Where in the ACL to add hooks for agent security?
 - Envelope? Speech acts? Interaction protocols?
 - Ontology: generic vs. service specific
- At the platform / infrastructure / service level (API vs. ACL)
 - Transport service
 - Directory service
 - Naming service
 - Platform description / profile

Scope (3): next work-plan?

- Policies
- Ownership issues and authenticating the owner
- Authorisation access to middleware agents
- Delegated authority from owner to PA to service agent hierarchy
- Auditing via gateways
- Security for nomadicity

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Conclusions (1)

- Challenges for the agent community
 - Interlinking multiple instances of heterogeneous platforms is harder than interlinking homogenous platforms
 - Need to learn from the experiences of the Internet community
- Challenges for the Internet community
 - Evolve to use MAS as a solution to handle dynamism, ubiquity, complexity
- Challenges for both
 - Semantic web is a hard problem
 - Work together & learn from each other

Conclusions (2)

- Standards are needed to support agent interoperability and mass-use
- Standards for agent interoperability are not enough
 - Require verifications and conformance
- FIPA currently offers the best potential for agent interoperability

Thank you!

Some useful URLs:

<http://www.fipa.org>

<http://www.ist-crumpet.org>

<http://www.agentcities.org>

<http://www.ist-torrent.org>

<http://leap.crm-paris.com>

EDEN-IW web-site is under development

stefan.poslad@elec.qmul.ac.uk