FIPA and FIPA-OS

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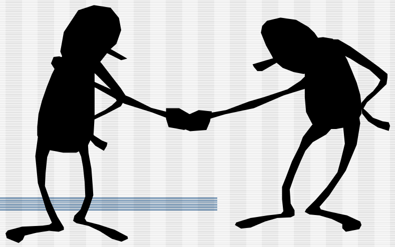
Tutorial Objectives

- Develop a mind-set for how (FIPA) MAS type agents operate
- Understand how to develop a simple (FIPA) agent service
- Understand how FIPA-OS can be used to develop such agent services

Outline

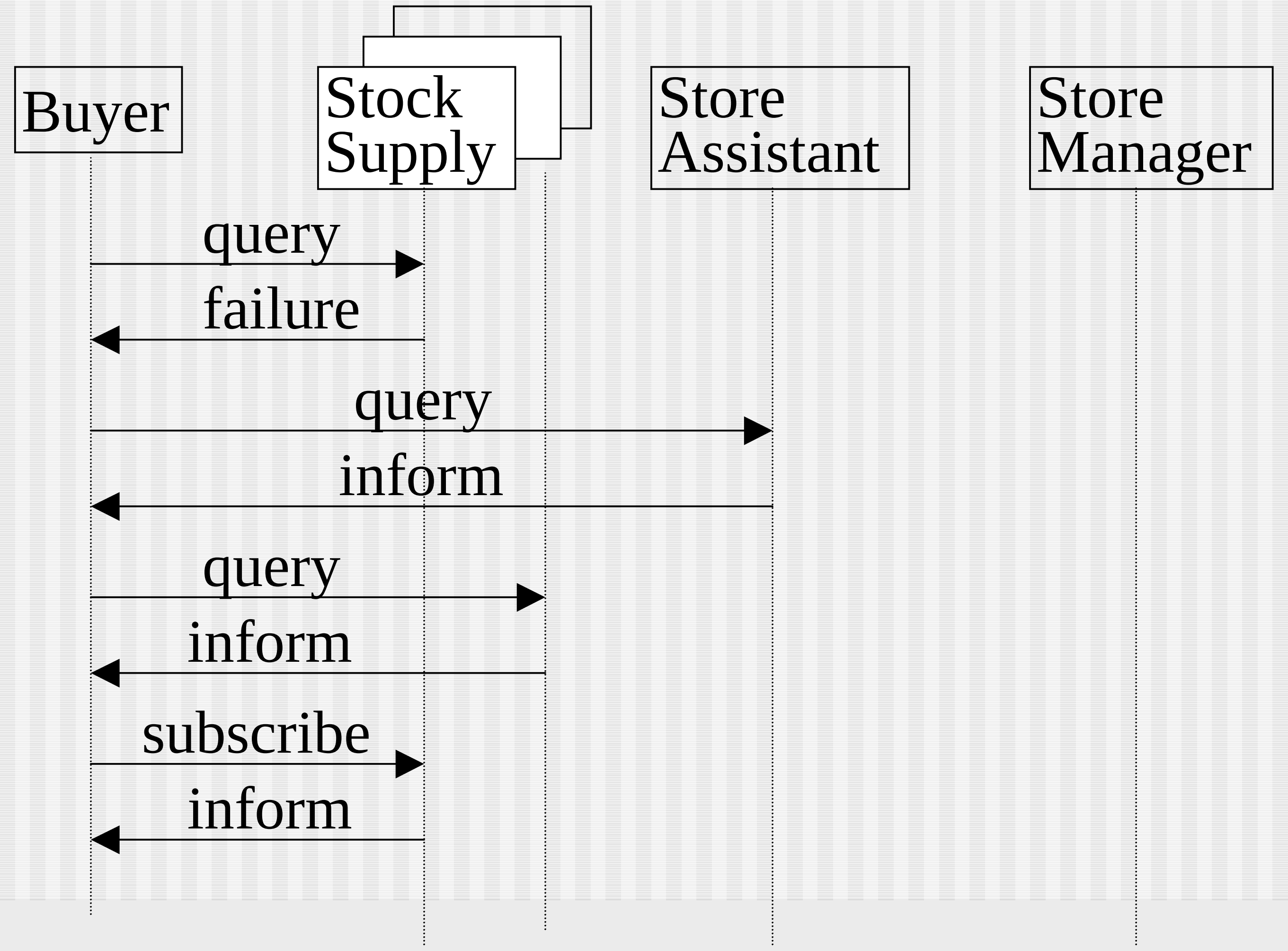
- The essence of FIPA
- The FIPA Specifications
- Using FIPA ~ using the FIPA-OS Implementation

The FIPA type of agent



- Wooldridge & Jennings (1995) weak notion of agents:
  - **Social ability:** agents can communicate & collaborate
  - **Autonomy**: agents can say no (can also be commanded)
  - Reactive: agents perceive the environment & respond in a timely fashion
  - Pro-active: agents are goal-directed, they can take the initiative.
- W & J Stronger (mentalistic) notion of agents
  - supported by mentalistic models of communication
- In practice require mobility and nomadicity etc

FIPA focuses on speech act protocols, dialogues & ontologies



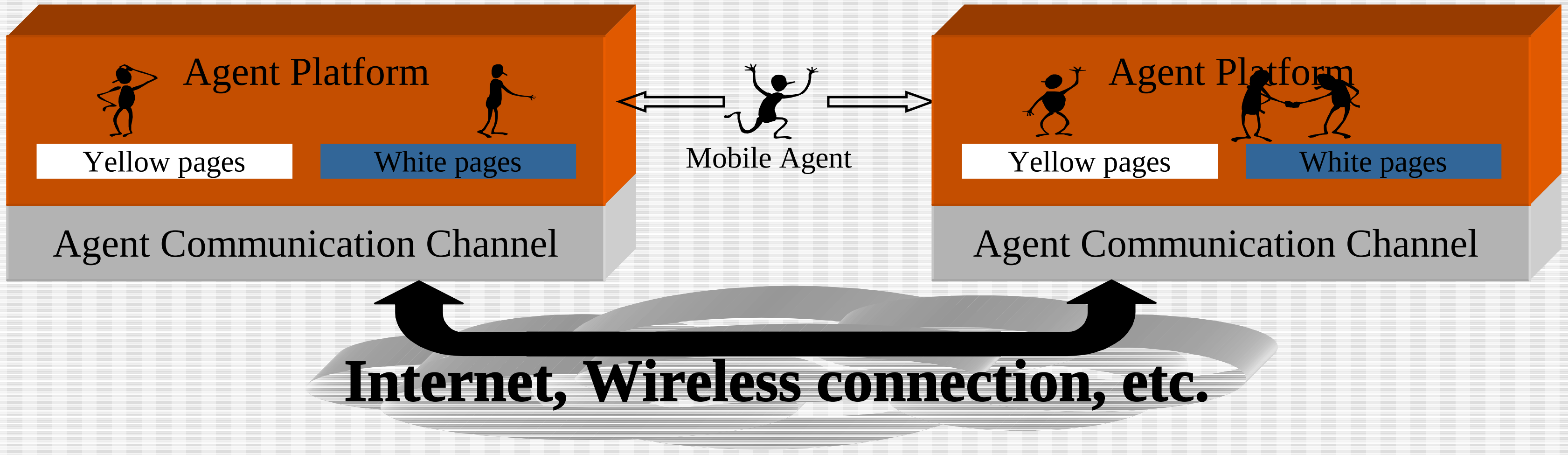
Agent standards: a driver for scaleable agencies

- Many incompatible, proprietary agent systems exist
  - 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
- Interoperability and Openness as driving forces
  - 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

The leading Agent Standard: FIPA

Foundation for Intelligent Physical Agents

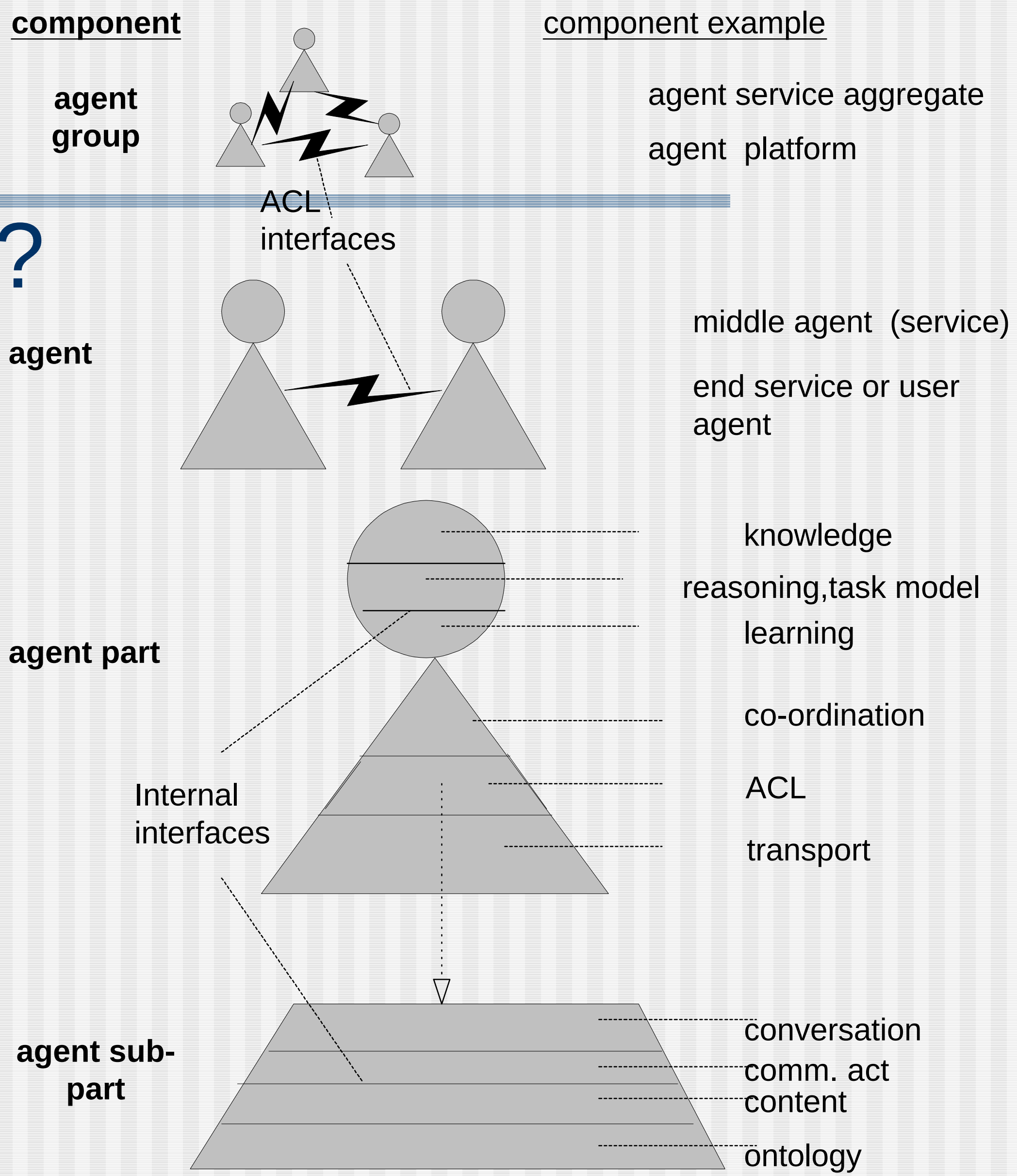
16 implementations
5 open source implementations
JCP called JAS
70 + members
Several related European projects


Agent Platform
Yellow pages
White pages
Agent Communication Channel
Mobile Agent
Agent Platform
Yellow pages
White pages
Agent Communication Channel
Internet, Wireless connection, etc.

FIPA: What’s in a Name?

- **F**oundation 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
- **F**oundation for **I**nteroP**e**rable **A**gents

What is standardized?



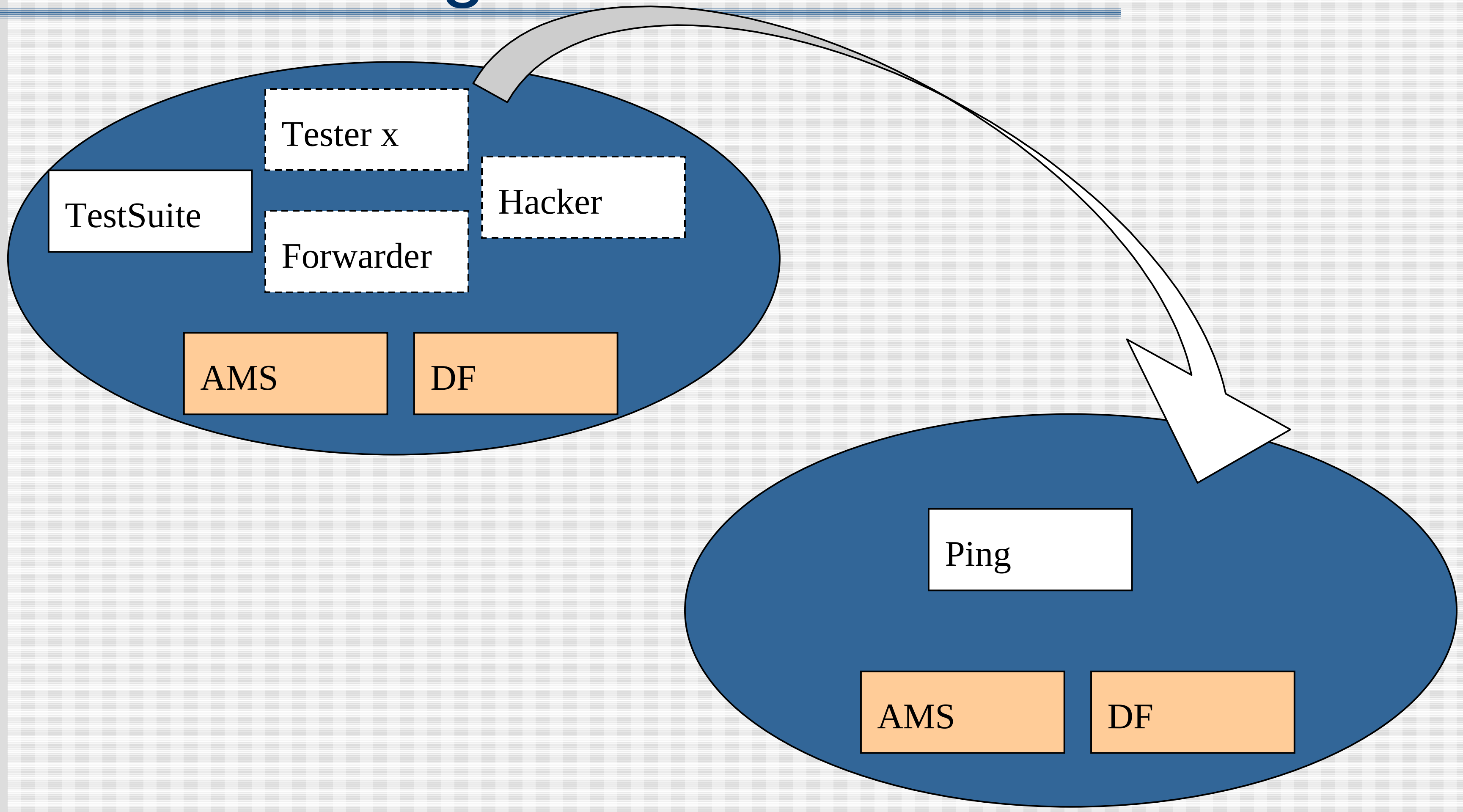
What is standardized? (2)

- Communication
  - Dialogues, communication primitives or speech acts, content (actions), ontologies
- Communication roles
  - (Set by the choice of speech act & dialogue)
  - P2p, client-server, manager-contractor
- Communication Support Services
  - Core: Transport (encodings), Directory, Naming
  - Other: ontology, mobility, nomadicity, etc
- Organisation & architecture
  - MAS &MMAS: Platforms, Domains, Abs. Arch.

Models, Representation & Verification

- 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
- FIPA Agent Specifications consist of:
  - Formal Models (design)
    - can be verified using logic proofs
    - but can't easily verify complexity of implementation
  - Descriptive Models
    - Well-established mapping of design to implementation
    - Verify implementation at specified points

Test Suite Agents



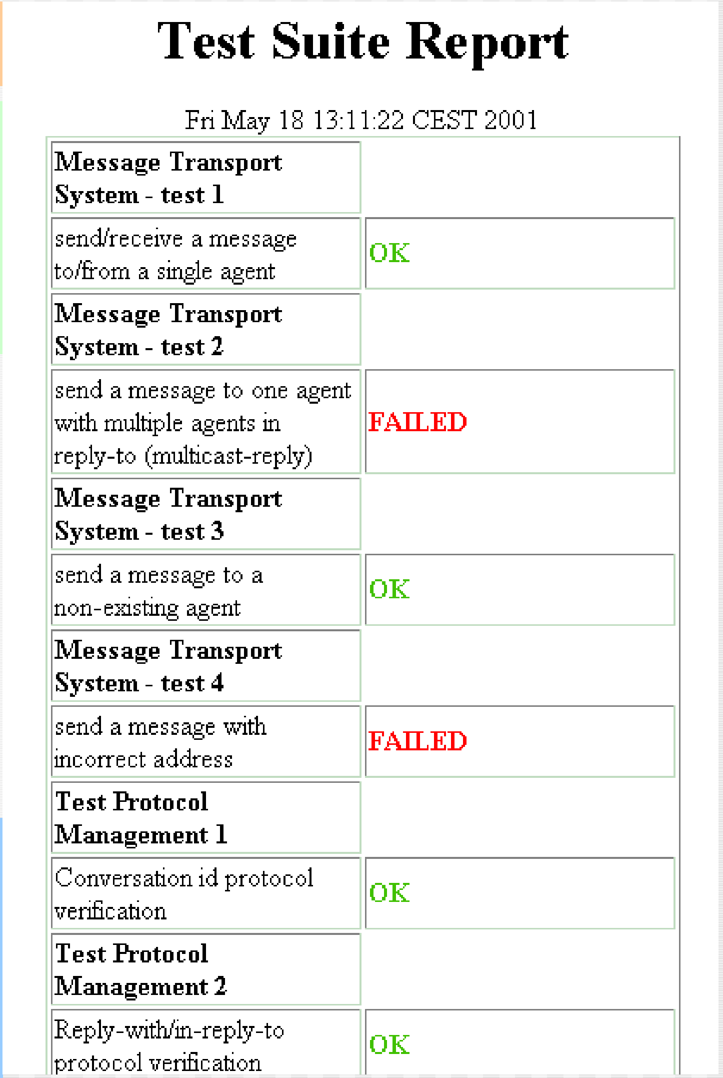
Example

```
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 (exiting 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

Outline

- The essence of FIPA
- Specifications
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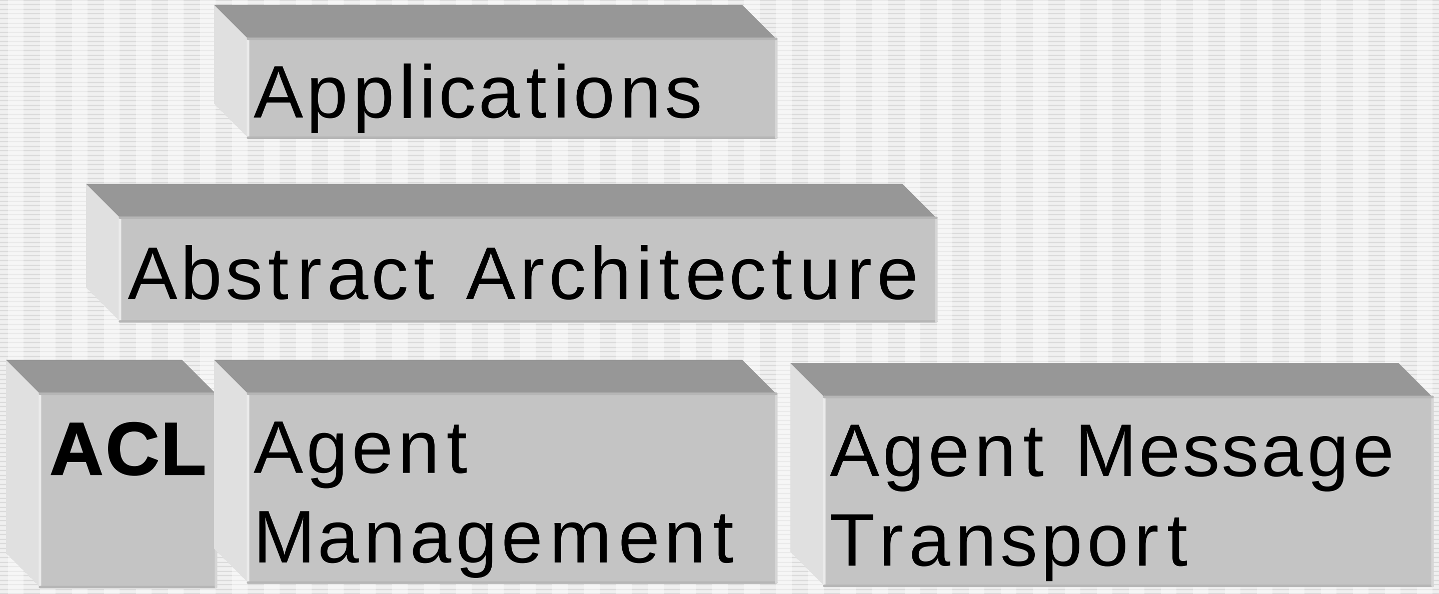
FIPA site view of specifications

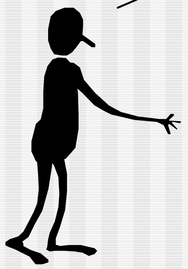


Another view of the specifications

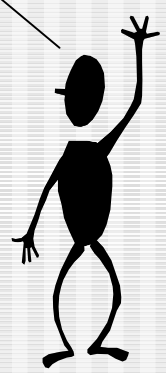
- Communication: ACL
  - Content language
  - **Communicative acts**
  - Interaction protocols
- Core Communication support
  - Naming
  - Transport
  - Directory

  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

Speech or Communicative Act based Agent Communication

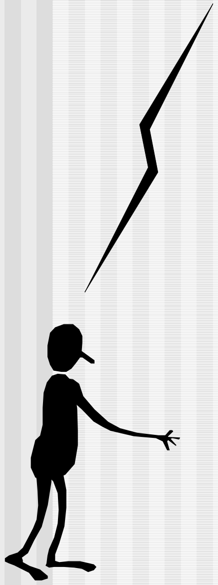


1. (Request … it is raining, in Montreal, today (?)…)
2. (Agree (to the request))
3. (Inform (it is raining))

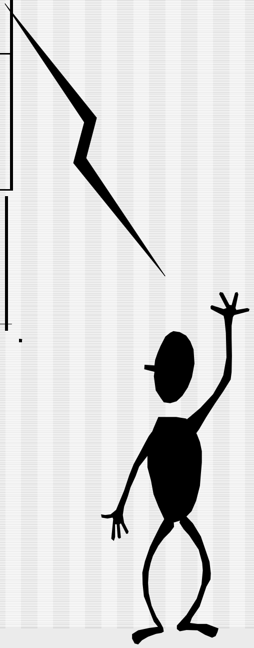


(interaction) **protocol** or conversation dialogue = Request
communicative act = Request, agree (or refuse or failure), inform
content = It is raining
(content or ontology) **language** = English
ontology = weather | general conversation

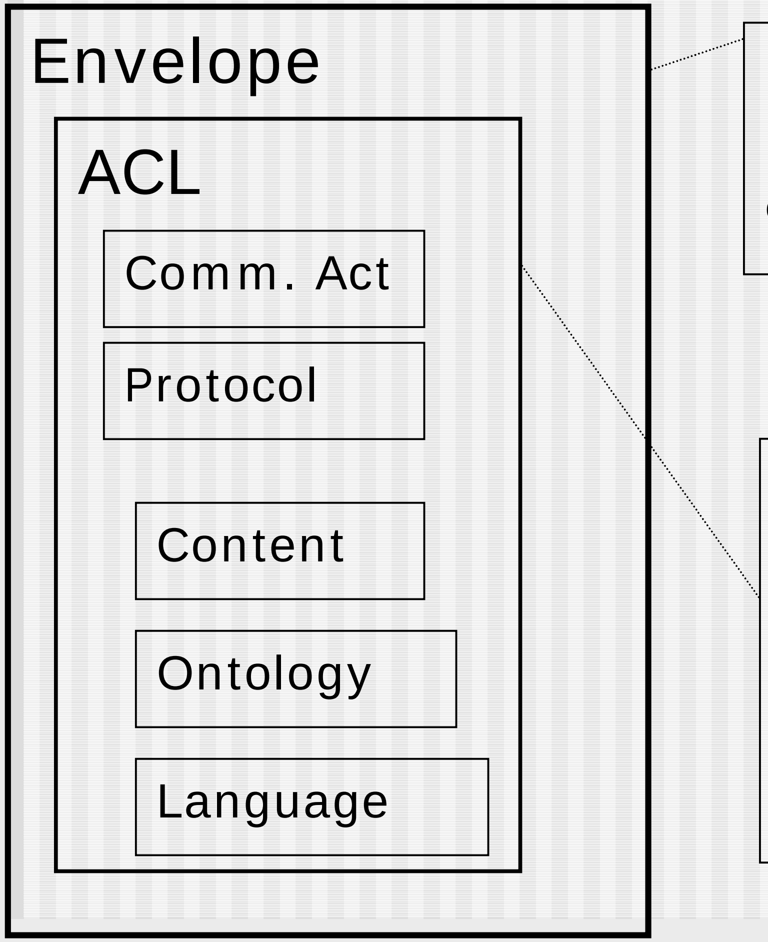
Speech Act based Agent Communication (2)



Accept-proposal	Agree	Cancel	Cfp
Confirm	Disconfirm	Failure	Inform
Inform-if	Inform-ref	Not-understood	Propose
Query-if	Query-ref	Refuse	Reject-proposal
Request	Request-when	Request-whenever	Subscribe



Agent Communication using the FIPA ACL



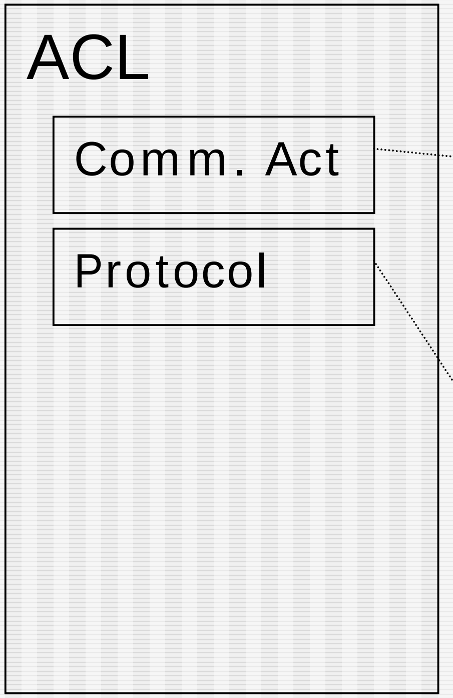
Transport encoding

```
<!-- Document Type: XML DTD -->
<!ELEMENT envelope ( params+ )>
<!ELEMENT params ( to?,from?,comments?, acl-
representation?,payload-length?,payload-encoding?,
date?,encrypted?,intended-receiver?,
received? )> ......
```

Message

```
<!-- Document Type: XML DTD -->
.......
<!ENTITY % communicative-acts
"agree|confirm|failure|inform|not-
understood|refuse||request|…"
<!ELEMENT content (#PCDATA)> ..
<!ELEMENT language (#PCDATA)> ..
<!ELEMENT ontology (#PCDATA)>
<!ELEMENT protocol (#PCDATA)>
```

Communicative acts & dialogues use 2 layers of protocols

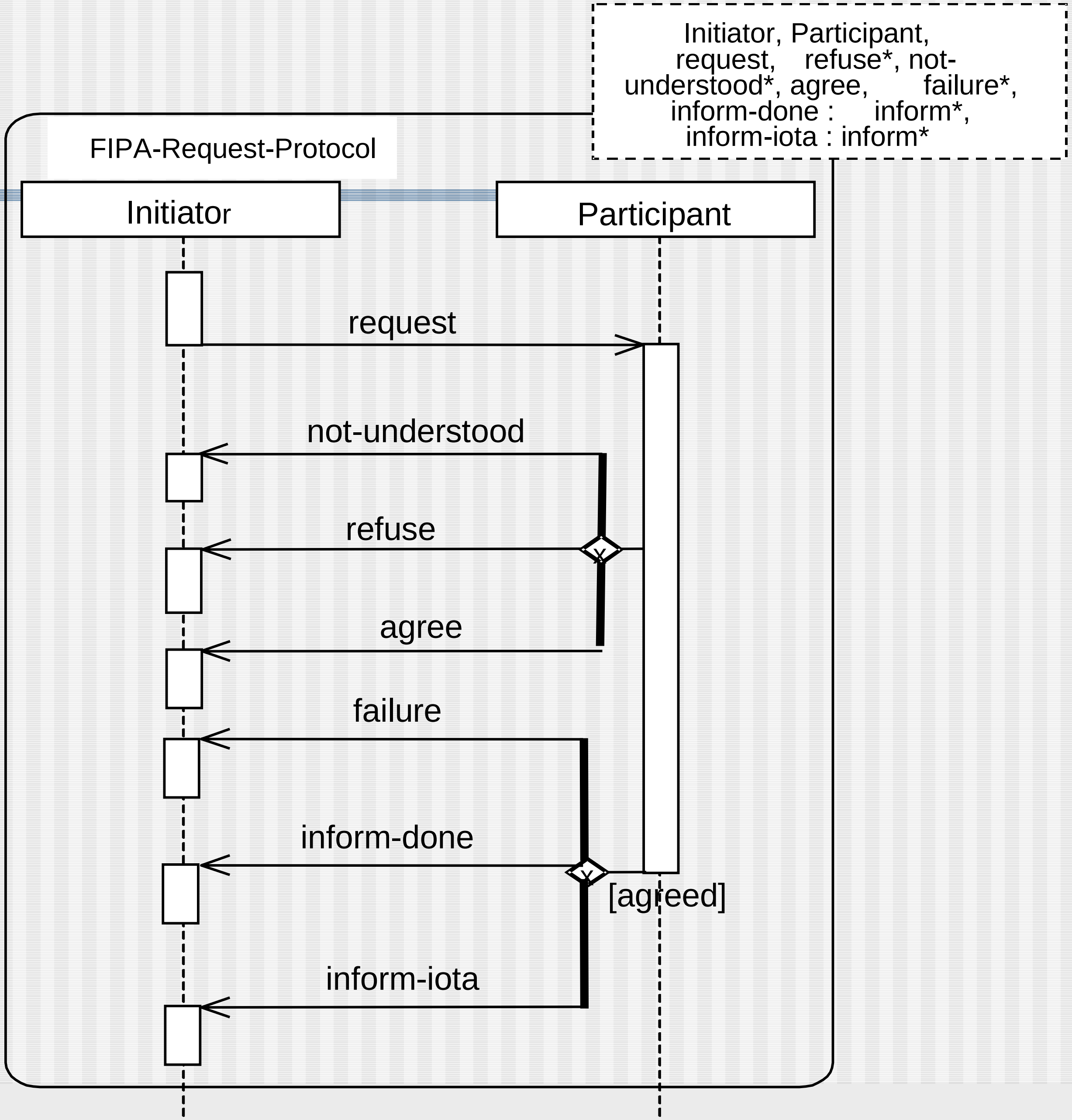


FIPA communicative acts are basic types:
Assertives: inform, refuse, failure, etc.
Directives: request, query-reg, etc.

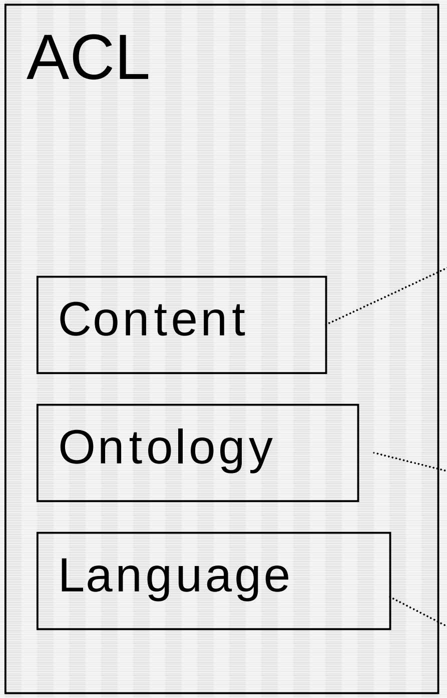
Commissives (promises): agree
Expressives (wishes?): subscribe

Messages occur in patterns called conversations or dialogues
e.g., fipa-request, fipa-cfp

Descriptive models of interaction in AUML


Initiator, Participant, request, refuse*, not-understood*, agree, failure*, inform-done : inform*, inform-iota : inform*
FIPA-Request-Protocol
Initiator
Participant
request
not-understood
refuse
x
agree
failure
inform-done
x
[agreed]
inform-iota

Content is defined using a (ontology) language & a (domain) ontology



```
:content
    (action
      (agent-identifier
        :name ams@foo.com
        :addresses (sequence iiop://foo.com/acc))
      (register
        (ams-agent-description
......
```

Domain Ontology defines terms, relationships between terms, operations for the content, for a particular domain

Ontology or content language defines the generic constraints, rules and operations for inferencing from the content

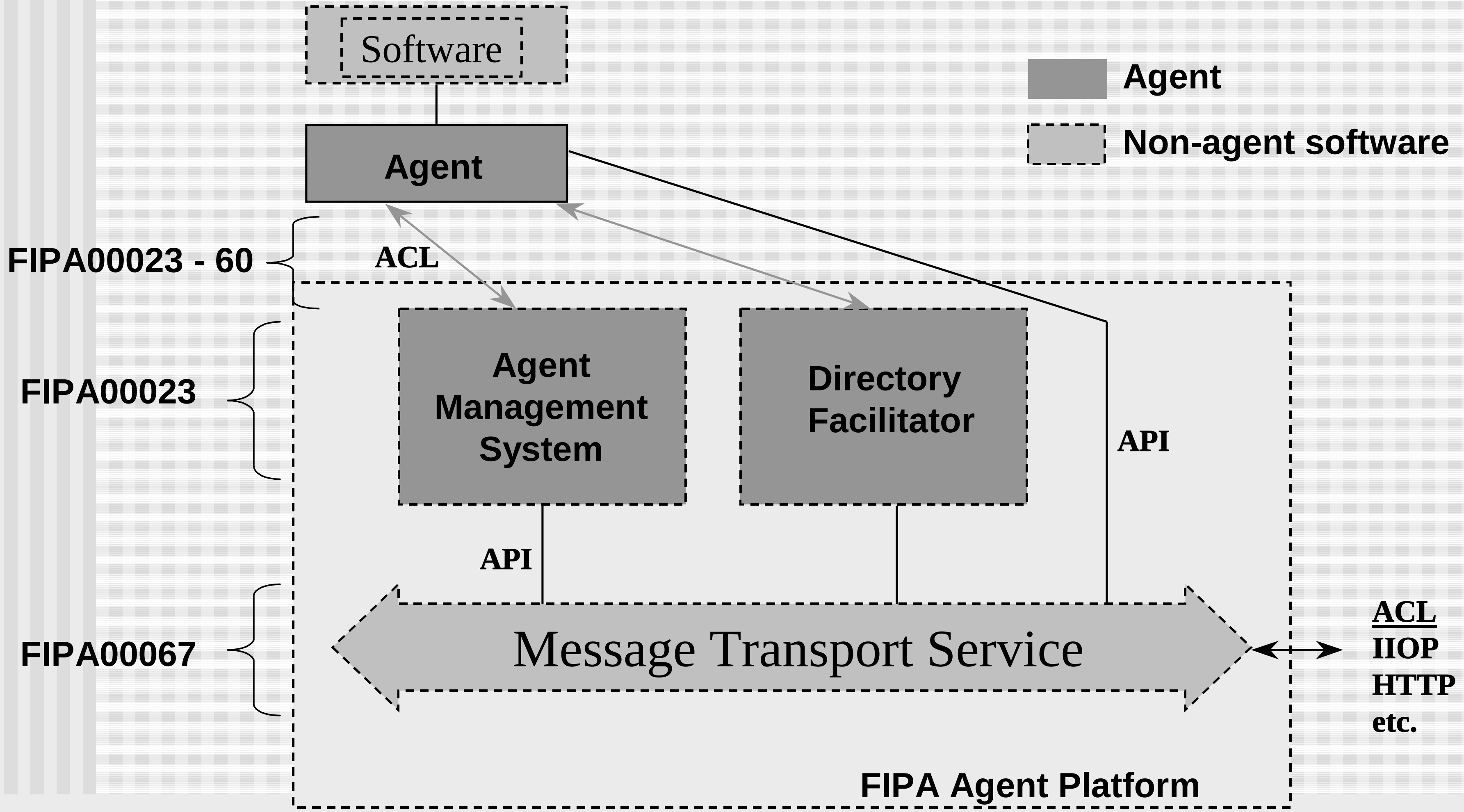
A frame-based ontology example: a FIPA management ontology (part)

Frame	`df-agent-description`			
Ontology	`FIPA-Agent-Management`			
Parameter	**Description**	**Presence**	**Type**	**Reserved Values**
`name`	The identifier of the agent.	Mandatory	`agent-identifier`	
`services`	A list of services supported by this agent.	Optional	Set of `service-description`	
`protocol`	A list of interaction protocols supported by the agent.	Optional	Set of `String`	See [FIPA00025]
`ontology`	A list of ontologies known by the agent.	Optional	Set of `String`	`FIPA-Agent-Management`
`language`	A list of content languages known by the agent.	Optional	Set of `String`	`FIPA-SL` `FIPA-SL0` `FIPA-SL1` `FIPA-SL2`

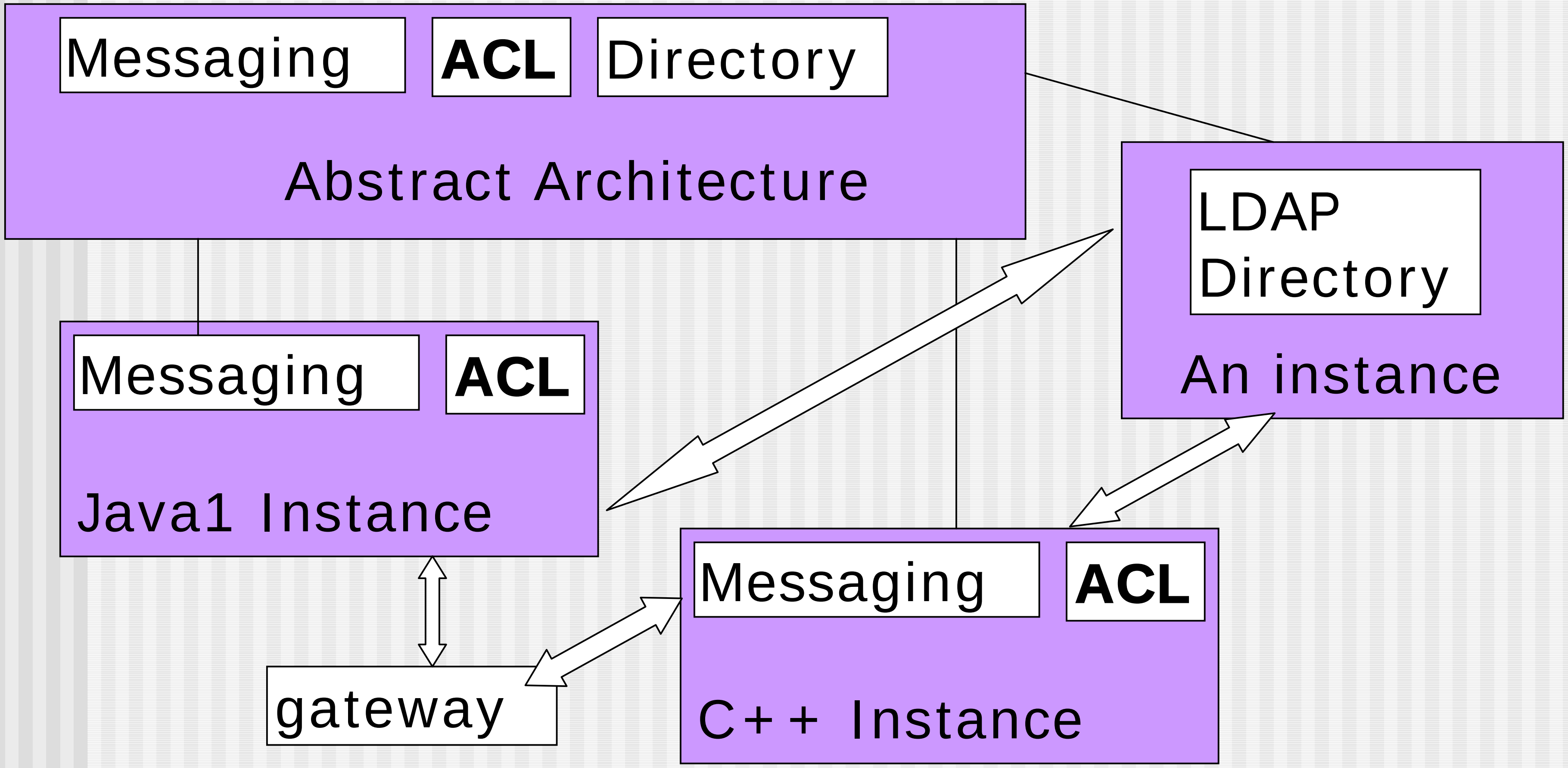
Abstract Architecture & the service model

- Focuses on core interoperability services:
  - ACL, message transport directory
  - Services don’t have to be agents but they can be
- 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.
  - Hence in practice, FIPA is realized using FIPA implementations such as **FIPA-OS** to provide these features

FIPA Agent Platform



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 [FIPA0001]

Outline

- What is FIPA?
- Specifications
- Using FIPA ~ using the FIPA-OS Implementation
  - Installing an agent platform and running agents
  - A look inside FIPA-OS
  - Developing agent services

FIPA-OS

- A ‘reference implementation’ of the core FIPA specifications for agent interoperability
  - ACL, Agent platform, etc.
- OS means Open Source, freely available and modifiable source code (c.f. Linux)
- Enables adoption of FIPA without the need to implement the *core* specifications
- Assist in validating and evolving FIPA standards
- Started in August 1999, 12+ formal releases to date (25,000+ downloads)

FIPA-OS is the first Open Source implementation of FIPA

The core types of agent behaviour supported by FIPA-OS

The basic agents supported are:

- **Reactive**: can react to ACL messages from other agents in the environment
- **Proactive**: they can decide when to initiate interaction with other agents
  - N.B. simple goals. E.g., register with the name service, without plans
- **Social**: (see reactive and proactive)
- **Autonomous**: each agent has multiple threads of control
- *Mentalistic features: via use of ACL*

Using FIPA-OS to install and run FIPA agents

1. Download FIPA-OS source & tutorials from source-forge (fipa-os.sf.net)
2. Install FIPA-OS in 1 of 2 ways:
   1. Executable: self extracting zip that automatically runs the configurer tool
   2. Manually unzip and run the configurer tool
   - Installation assumes enough environment space, write access and a suitable version of the JVM)
3. Start the agent platform and load agents
4. Test the platform using the IOTest agent and the (Tutorial) Ping agent

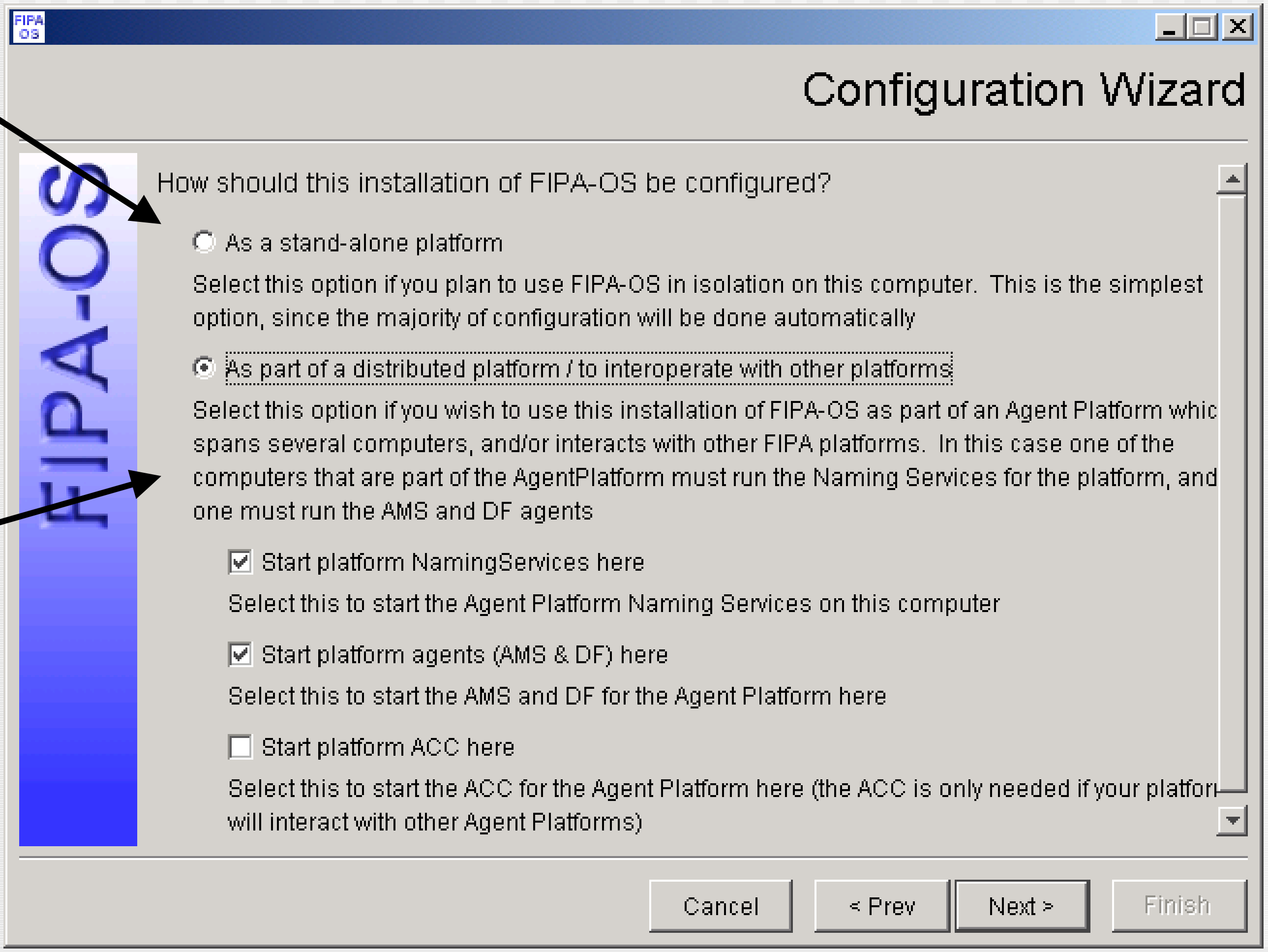
Configuring FIPA-OS: using the Wizard (Simple)

- FIPA-OS Wizard aims to simplify initial configuration and start-up
- Can be used when installing FIPA-OS, or anytime the platform needs to be configured
- Wizard modifies following files
  - acc, platform and default profiles
  - SetupFIPAOS batch files
- Wizard GUI consists of multiple panels, depending upon complexity of installation
- Information about configuration options are provided within the GUI

Configuration Wizard

Stand-alone for simple development

Distributed platform for serious development



Configuration Wizard

How should this installation of FIPA-OS be configured?

- As a stand-alone platform

Select this option if you plan to use FIPA-OS in isolation on this computer. This is the simplest option, since the majority of configuration will be done automatically

- [✓ As part of a distributed platform / to interoperate with other platforms]

Select this option if you wish to use this installation of FIPA-OS as part of an Agent Platform whic spans several computers, and/or interacts with other FIPA platforms. In this case one of the computers that are part of the AgentPlatform must run the Naming Services for the platform, and one must run the AMS and DF agents

- [✓] Start platform NamingServices here

Select this to start the Agent Platform Naming Services on this computer

- [✓] Start platform agents (AMS & DF) here

Select this to start the AMS and DF for the Agent Platform here

- [ ] Start platform ACC here

Select this to start the ACC for the Agent Platform here (the ACC is only needed if your platfor will interact with other Agent Platforms)

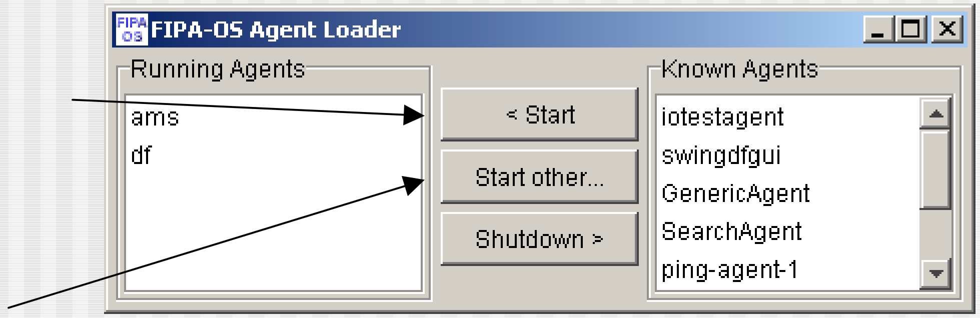
Initialising a FIPA Agent Platform (AP)

1. Start any transport specific Naming services
   - E.g., Sun CORBA and RMI
   - Start by using batch files provided
2. Start the Message Transport Service (ACC)
   - Via Agent Loader or manually via batch file
3. Start the core AP agents
   - (Use of FIPA-OS Agent Loader enables agents to be managed easily)
   - E.g., Name Service (AMS), Directory Service (DF)
4. Start any End Service and End user agents
   - (Use of FIPA-OS Agent Loader enables agents to be managed easily by users)
   - E.g., Ping service Agent
   - E.g., IOTest Agent (service user agent)

Starting Up: using the Agent Loader

- By starting the Agent Loader, the platform agents (DF, AMS) will start up
- New agents can be started by selecting them in the right list, and clicking “Start”
- Unlisted agents can be started by selecting “Start other…”

- Exercise
  - Install and Configure FIPA-OS using the Wizard for a ‘stand alone platform’
  - Install the Tutorial agents
  - Start-up the platform using the AgentLoader (StartFIPA-OS)



Testing the Platform

- Start up the IOTestAgent from the GUI and try sending the example ACL messages provided in the ‘examples’ directory
- Platform can also be tested by using the tutorial agents (separate installation) like Ping Agents
- Exercise
  - Start the IOTestAgent using the AgentLoader
  - Start the PingAgent using the AgentLoader
  - Use the IOTestAgent to send the example ‘ping’ message (acping.txt) to the PingAgent
  - Use the IOTestAgent to register with the AMS and DF

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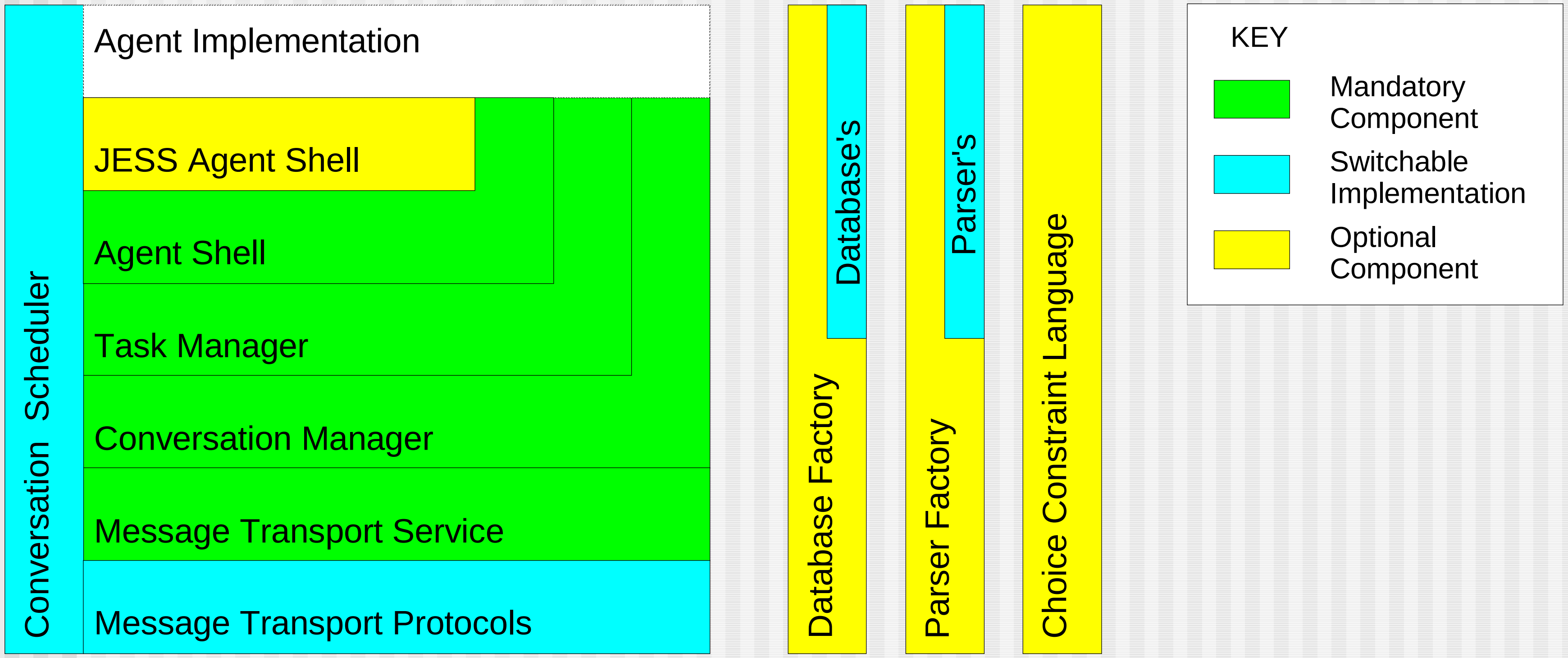
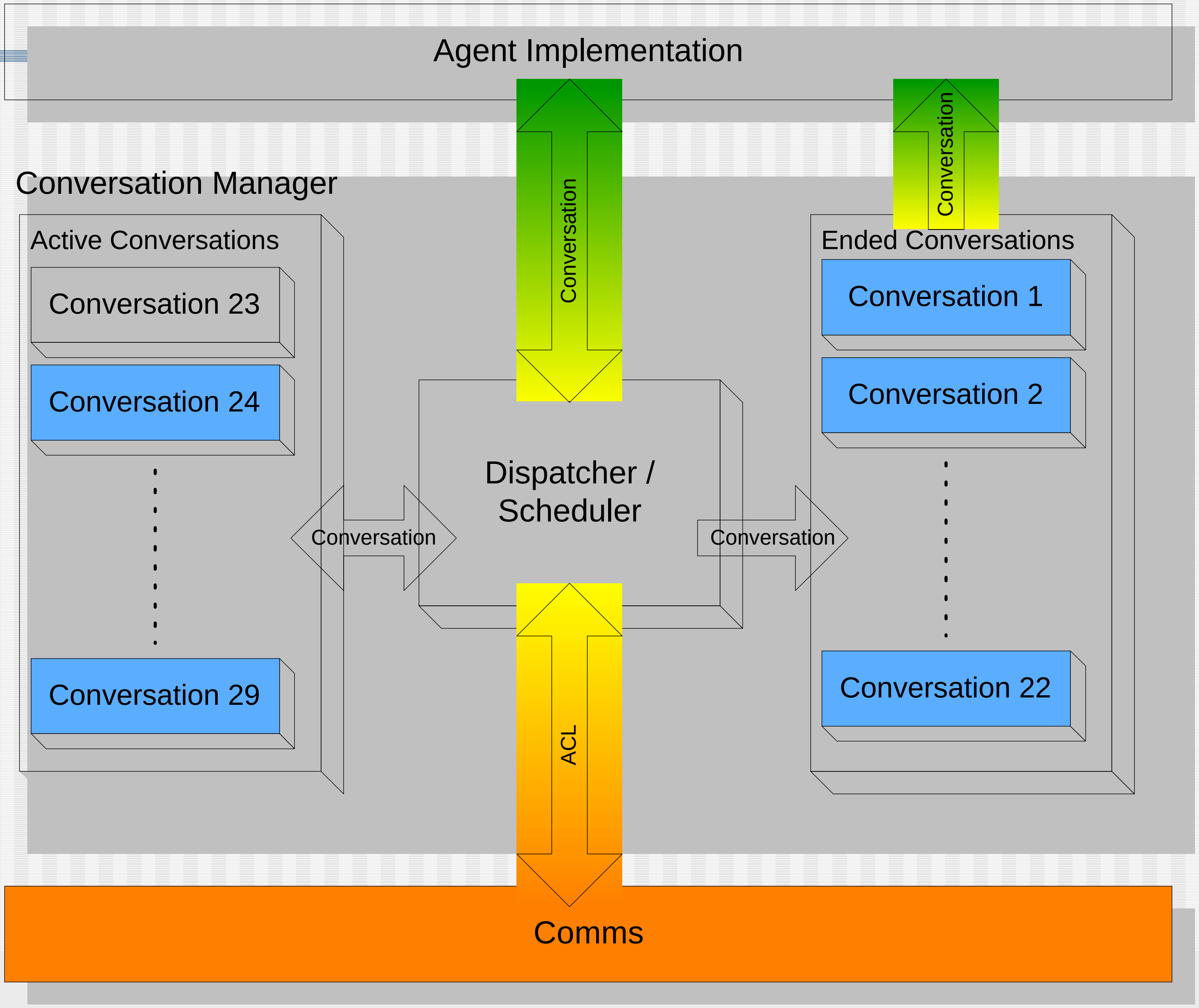
High Level Architecture of FIPA-OS Agent Shell

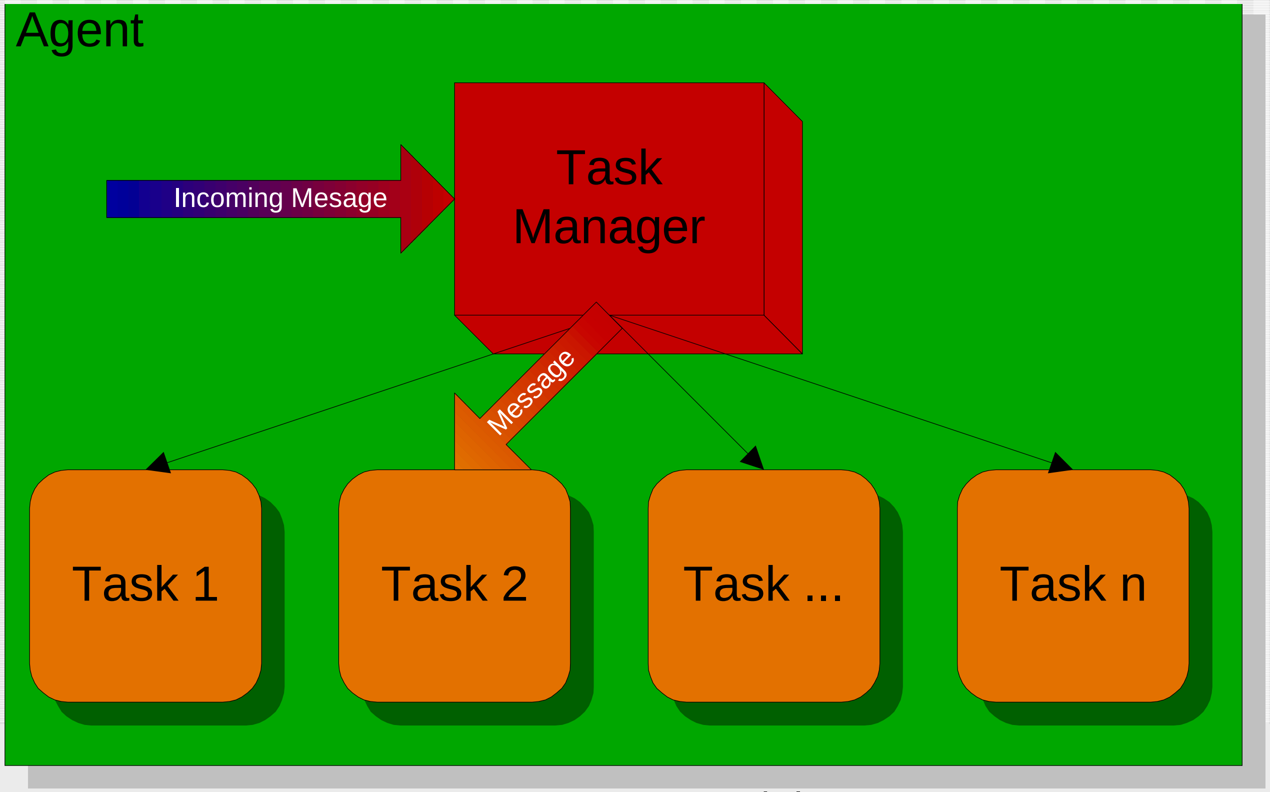


FIPA-OS: Conversation Manager



FIPA-OS: Task Manager

- Separates agent ‘tasks’ into distinct objects
- Messages are automatically routed to the correct state
- Inter-task events are possible



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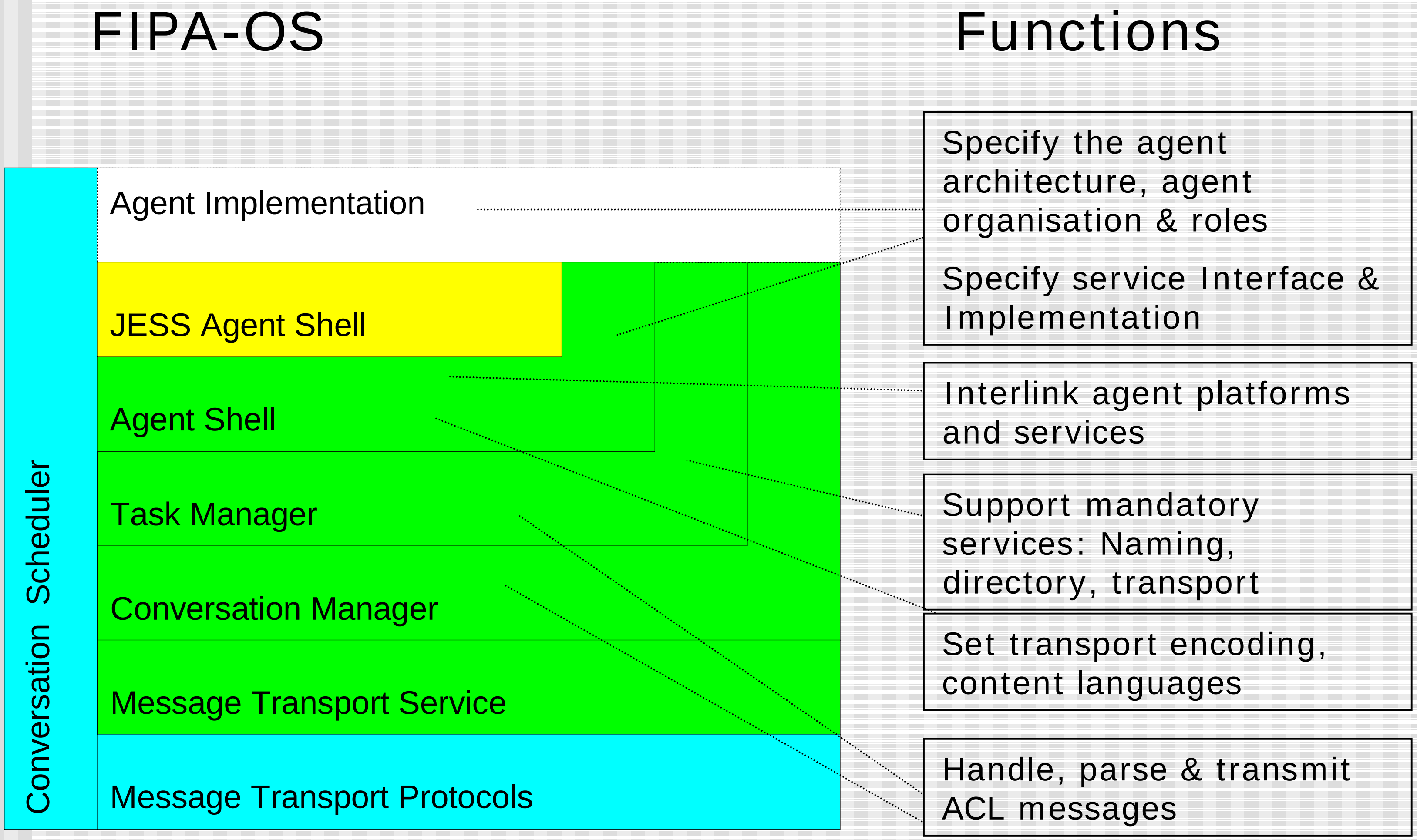
Developing agents & services


FIPA-OS
Functions
Agent Implementation
JESS Agent Shell
Agent Shell
Task Manager
Conversation Manager
Message Transport Service
Message Transport Protocols
Conversation Scheduler
Specify the agent architecture, agent organisation & roles
Specify service Interface & Implementation
Interlink agent platforms and services
Support mandatory services: Naming, directory, transport
Set transport encoding, content languages
Handle, parse & transmit ACL messages

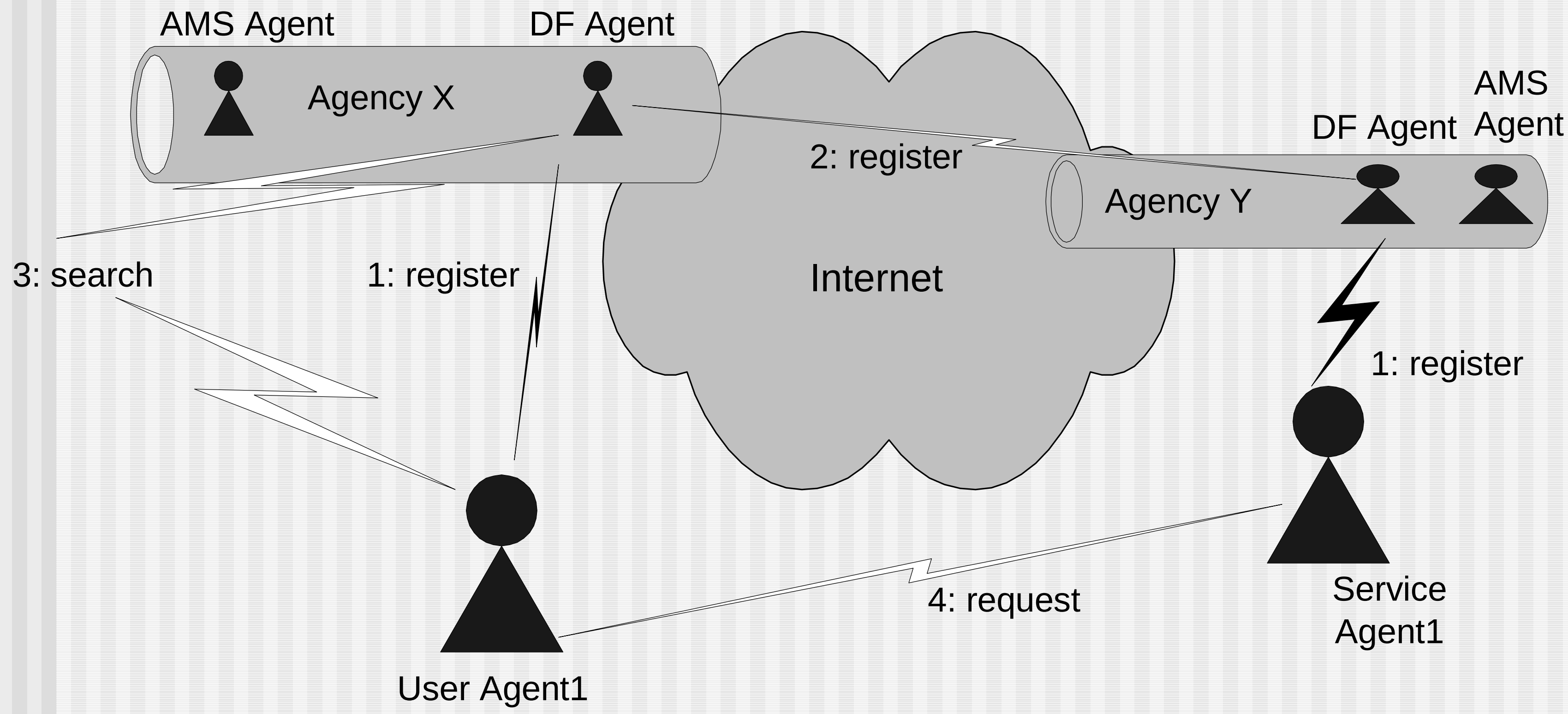
Specifying the agent architecture, organisation & roles

Determined by

- Conversation patterns used
- The middle agent hierarchy depth
- Platform & Service interlinking

- E.g., SearchAgent
  - service discovery: uses a 3 tier client server arch. & the fipa-request conversation pattern
  - service usage: uses a 2 tier client server arch. & fipa-request conversation pattern

Interlinking or Federating Agent Platforms



Developing agents & services

- Define service description to advertise service (in DF)
  - Use the standard FIPA agent management ontology
- Define run-time service interface
  - Define a domain-specific ontology

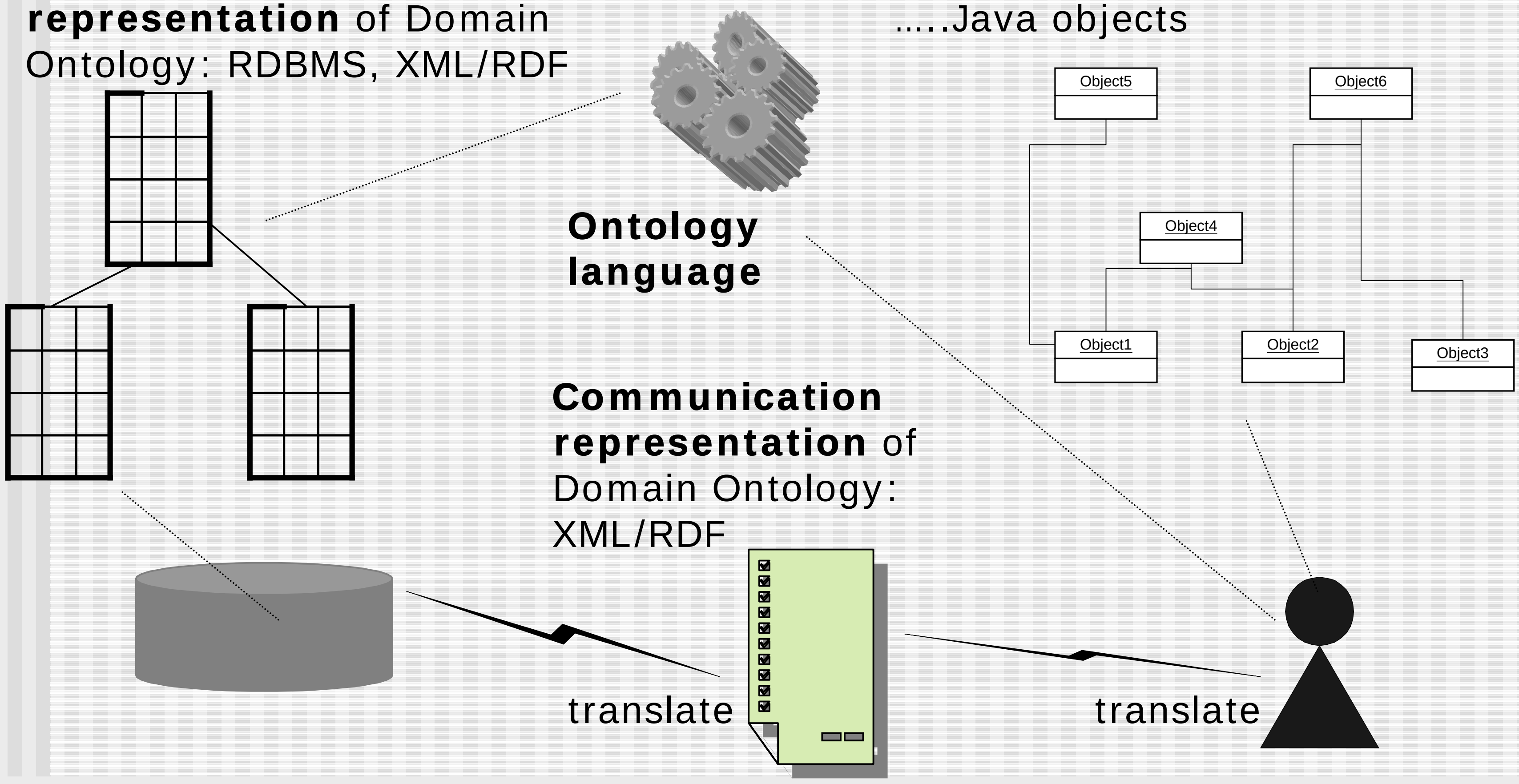
Using Ontologies

Repository, Document, Environment representation of Domain Ontology: RDBMS, XML/RDF

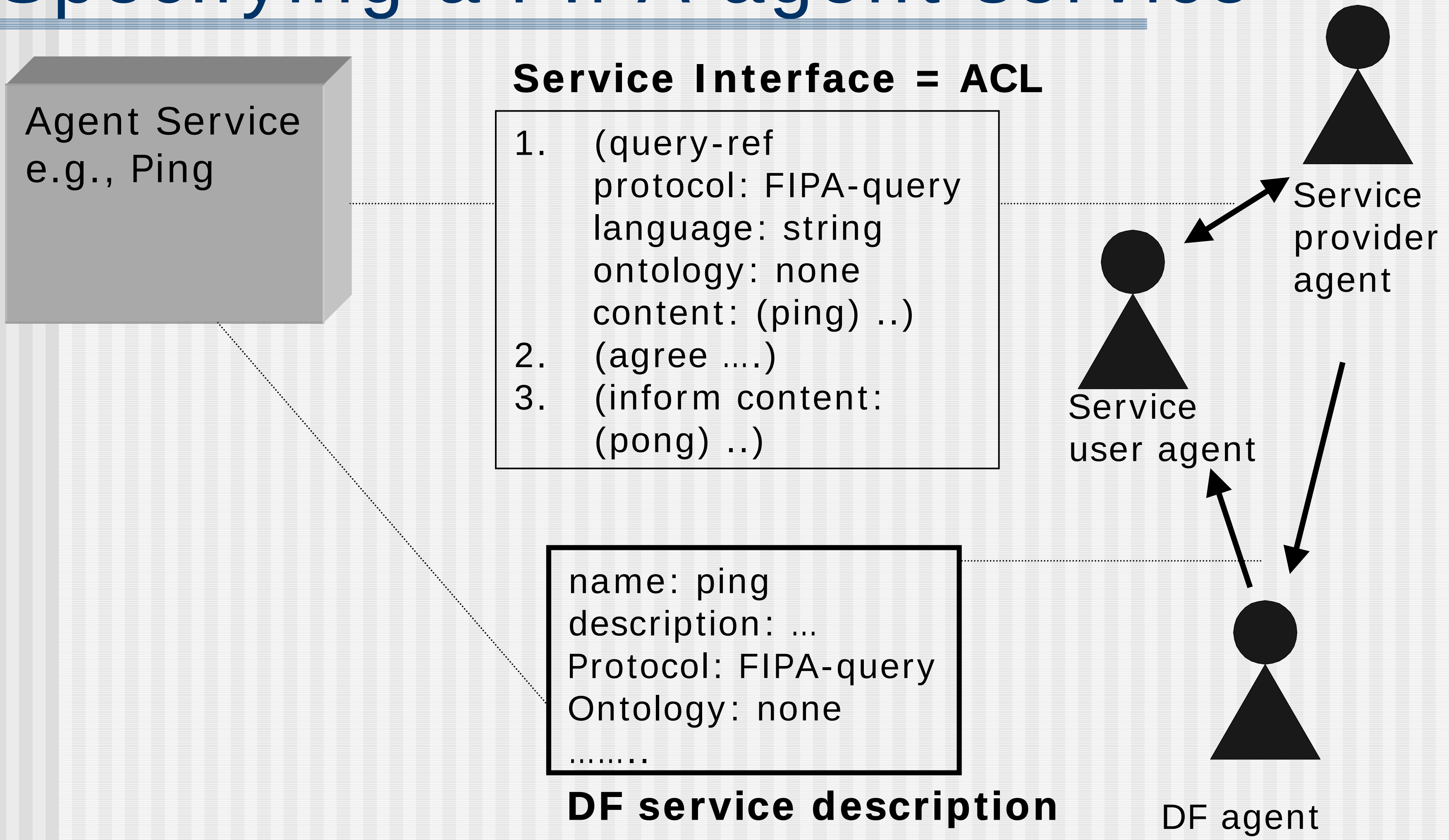
Agent internal representation of Domain Ontology, e.g., …..Java objects

Ontology language

Communication representation of Domain Ontology: XML/RDF



Specifying a FIPA agent service



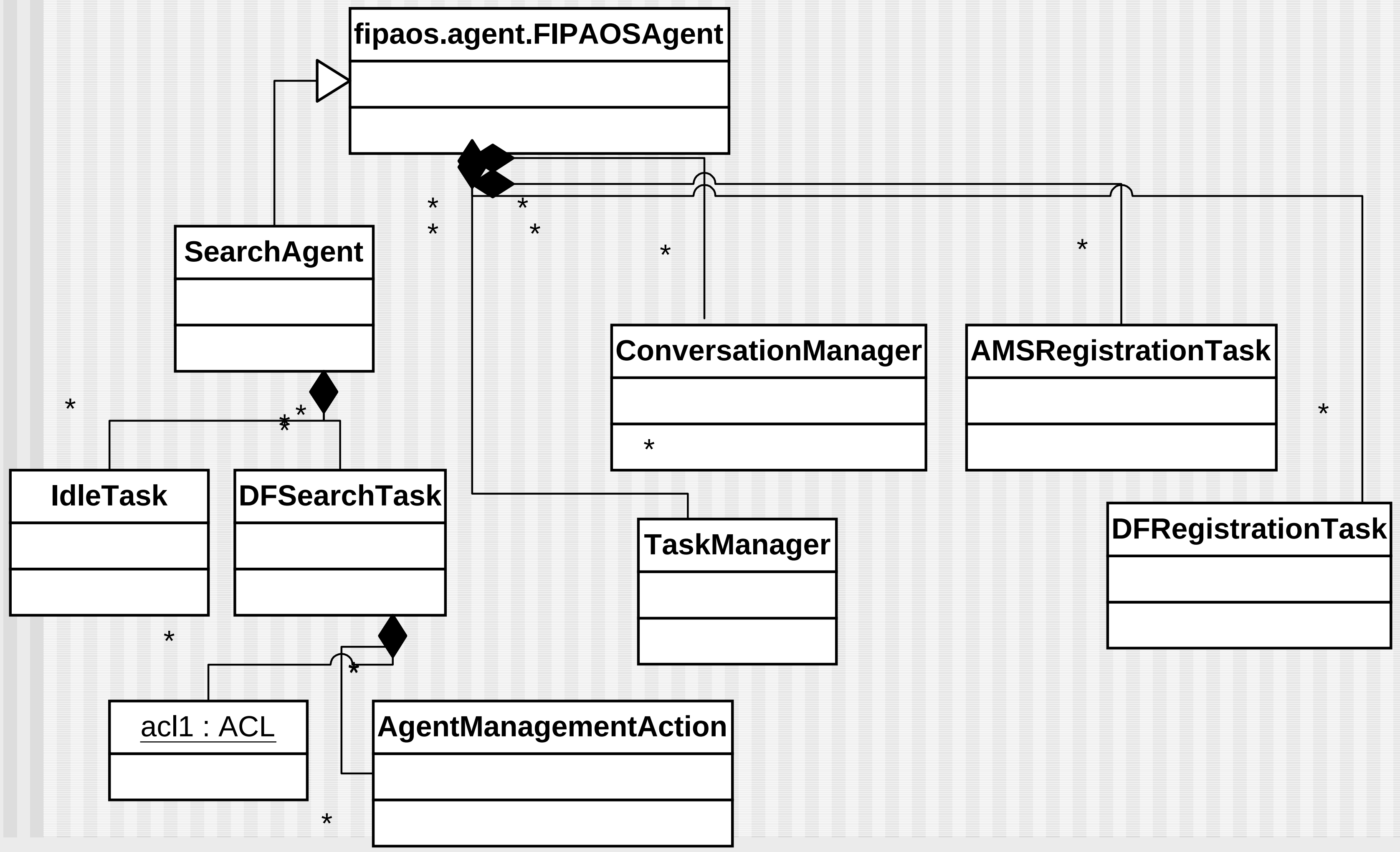
Service Interface = ACL

1. (query-ref
   protocol: FIPA-query
   language: string
   ontology: none
   content: (ping) ..)
2. (agree ….)
3. (inform content: (pong) ..)

name: ping
description: …
Protocol: FIPA-query
Ontology: none
……..

DF service description

Message handling (SearchAgent): task & conversation design



Tutorial Summary

- Develop a mind-set for how (FIPA) MAS type agents operate
- Understand how to develop a simple (FIPA) agent service
- Understand how FIPA-OS can be used to develop agent services

Thank you!

Some useful URLS:

- http://www.fipa.org
- http://fipa-os.sf.net

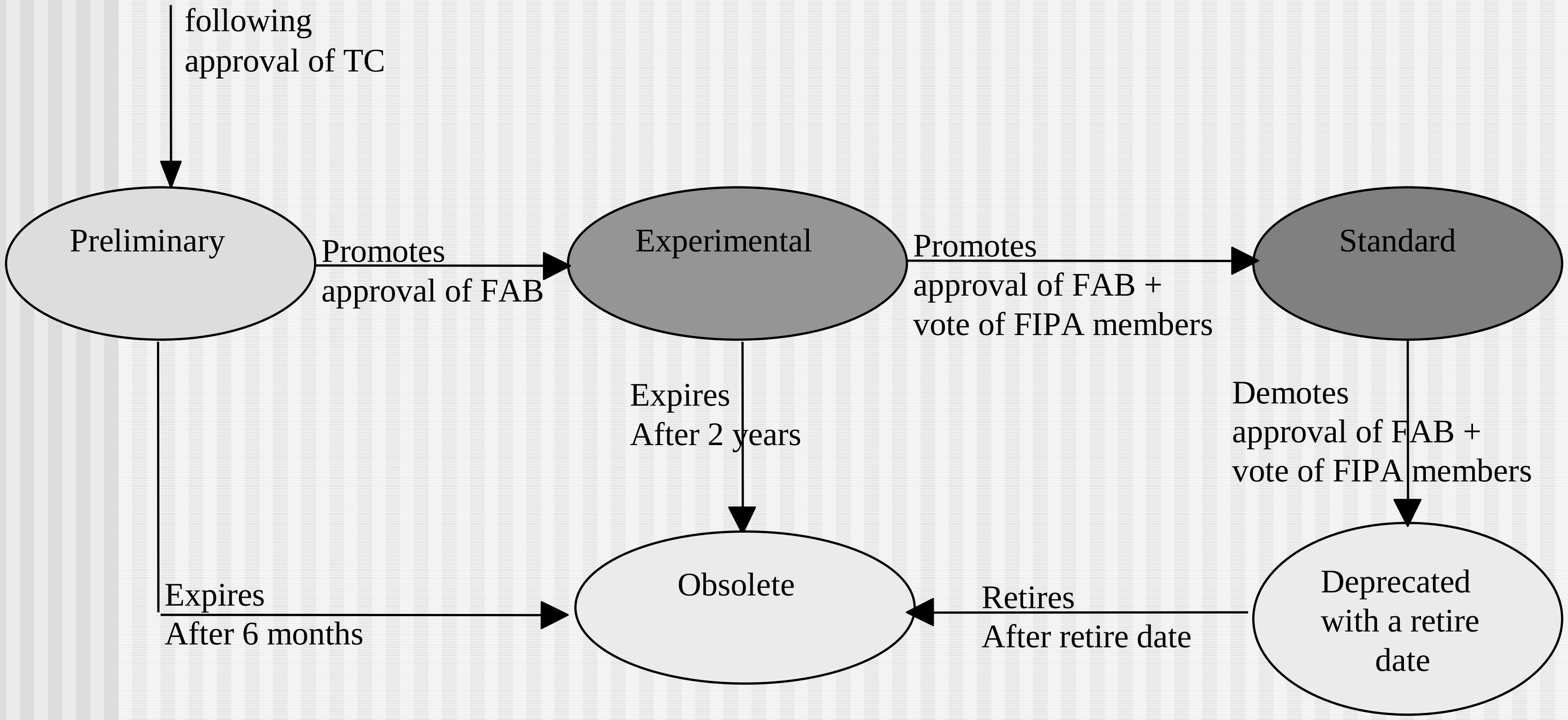
Some FIPA agent projects

- http://www2.elec.qmul.ac.uk/~stefan
- At FIPA web-site

Acknowledgement: thanks to Emorphia Ltd for the use of some slides for this presentation

Reserve slides

The FIPA specification life-cycle: specify -> experiment -> standard



An agent consists of objects but it is more than a set of objects

- An agent has a strong notion of autonomy
- Agents are active, they have their own threads of control
- Async. comms. (MP)
- FIPA agents support a universal lingua franca
- FIPA agents support a richer semantic, varied communication for co-operation

- An object can be controlled externally
- Objects are passive
- Synch. comms. (MI)
- Objects use proprietary interfaces
- Objects support syntactic, synchronous communication

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

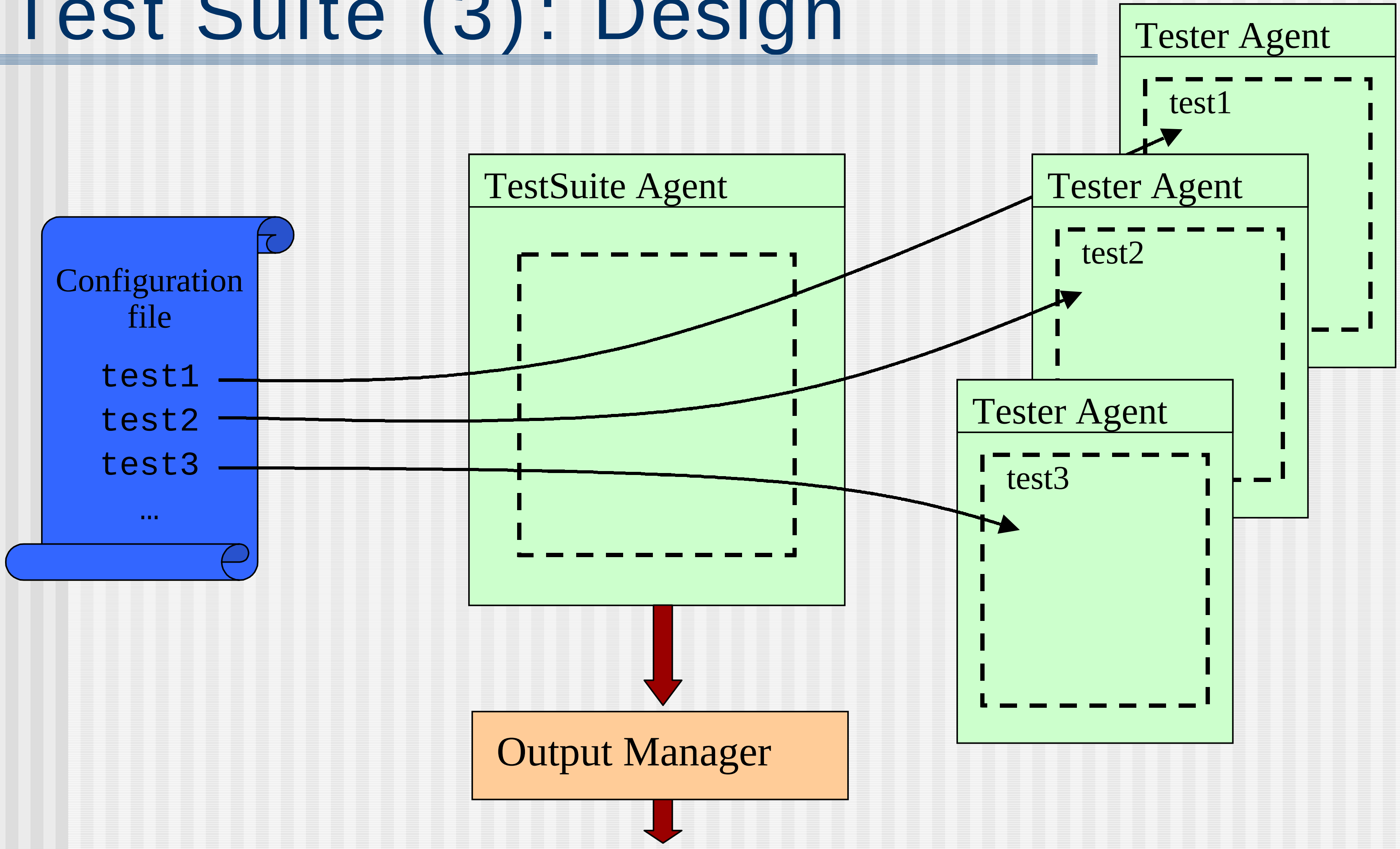
FIPA Test Suites

- 1st one 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 (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 (3): Design



HTML, Screen output, logs

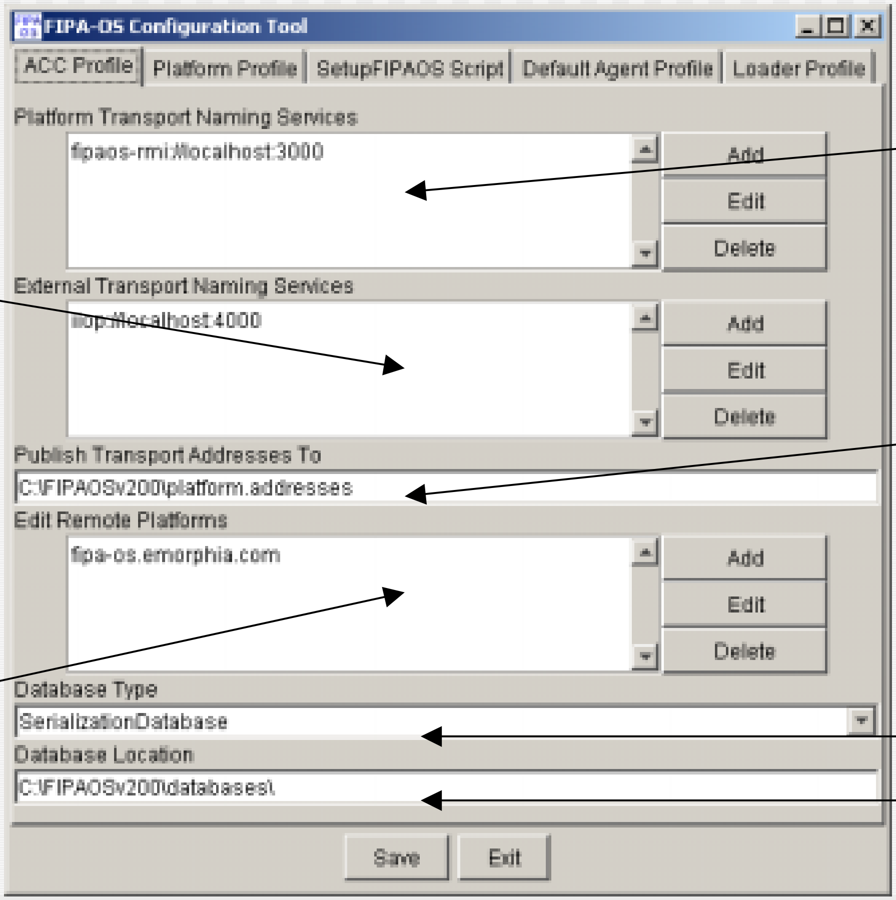
Configuring FIPA-OS Using the Configurator (Advanced)

- Can be used when installing FIPA-OS, or anytime the platform needs to be configured
- Configurator modifies following files
  - acc, platform and default profiles
  - SetupFIPAOS batch files
- Configurator GUI consists of five panels

ACC Profile Configuration

Details of the **external** MTP's that the ACC should bind into upon start up

Details about a **remote agent platforms**



Platform Transport Naming Services: fipaos-rmi://localhost:3000

External Transport Naming Services: iiop://localhost:4000

Publish Transport Addresses To: C:\FIPAOSv200\platform.addresses

Edit Remote Platforms: fipa-os.emorphia.com

Database Type: SerializationDatabase

Database Location: C:\FIPAOSv200\databases\

Details of the **platform** MTP's that the ACC should bind into upon start up

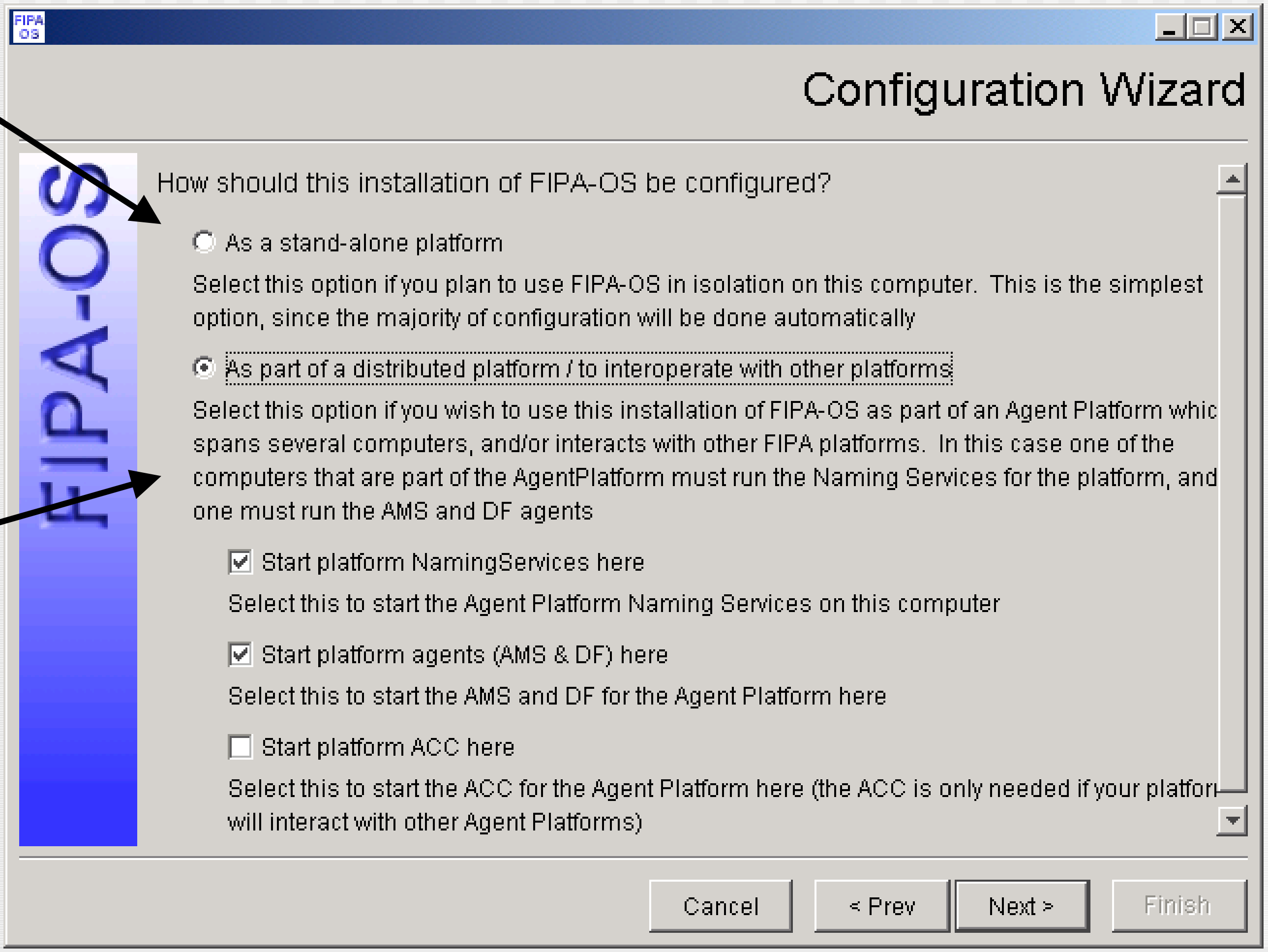
Filename to which the ACC publishes its **MTP's addresses**

Type of **database** used by the ACC and the location

Configuration Wizard

Stand-alone for simple development

Distributed platform for serious development



Configuration Wizard

How should this installation of FIPA-OS be configured?

( ) As a stand-alone platform

Select this option if you plan to use FIPA-OS in isolation on this computer. This is the simplest option, since the majority of configuration will be done automatically

(●) As part of a distributed platform / to interoperate with other platforms

Select this option if you wish to use this installation of FIPA-OS as part of an Agent Platform whic spans several computers, and/or interacts with other FIPA platforms. In this case one of the computers that are part of the AgentPlatform must run the Naming Services for the platform, and one must run the AMS and DF agents

[✓] Start platform NamingServices here

Select this to start the Agent Platform Naming Services on this computer

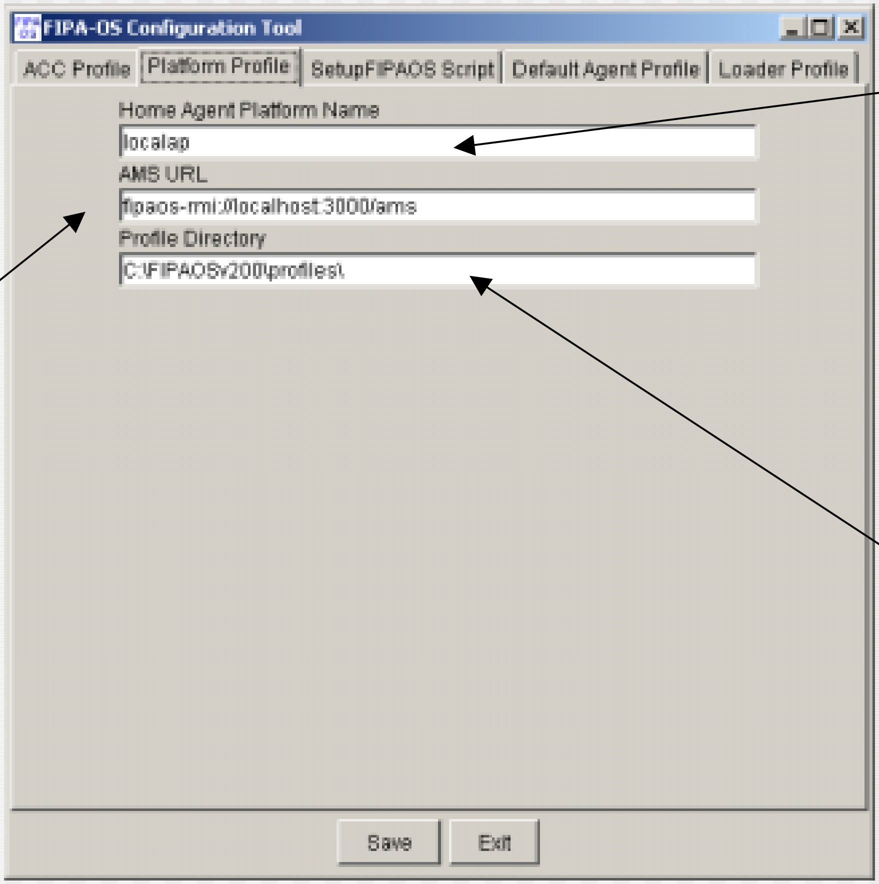
[✓] Start platform agents (AMS & DF) here

Select this to start the AMS and DF for the Agent Platform here

[ ] Start platform ACC here

Select this to start the ACC for the Agent Platform here (the ACC is only needed if your platfor will interact with other Agent Platforms)

Platform Profile Configuration



Home Agent Platform Name
localap
AMS URL
fipaos-rmi://localhost:3000/ams
Profile Directory
C:\FIPAOSv200\profiles\

The **HAP name** used by agents on the platform - this should be globally unique, like IP address or domain name

This is the internal MTP address via which the **AMS** can be contacted

This specifies where the **profiles** for entities belonging to this platform can be located

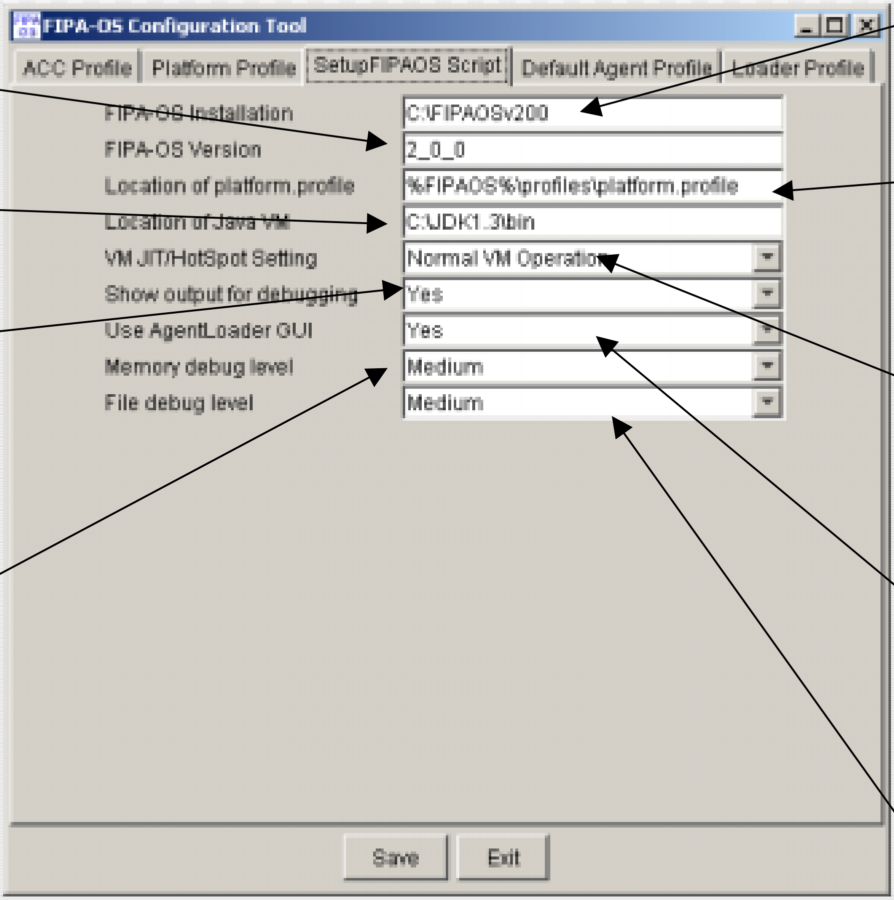
FIPA-OS Script Configuration

Indicating the **version** of FIPA-OS

Location of **JVM**

Choice of whether to show **debugging** information or not

If debugging is used, what level messages are **shown** (5 = MAX)



FIPA-OS Installation	C:\FIPAOSv200
FIPA-OS Version	2_0_0
Location of platform.profile	%FIPAOS%\profiles\platform.profile
Location of Java VM	C:\JDK1.3\bin
VM JIT/HotSpot Setting	Normal VM Operation
Show output for debugging	Yes
Use AgentLoader GUI	Yes
Memory debug level	Medium
File debug level	Medium

The **directory** where FIPA-OS is installed

Location of the **platform.profile**

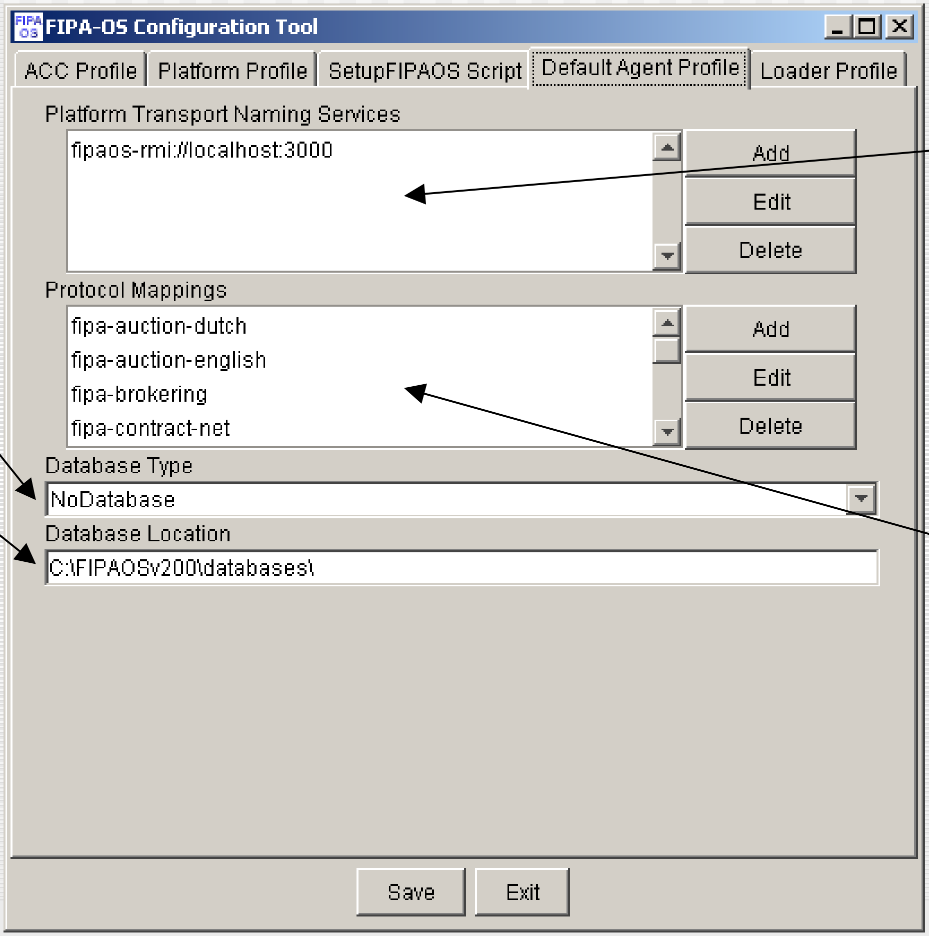
Allow the disabling of any JIT or HotSpot performance **compiler**

Choice of whether to use **Agent Loader** GUI or not

If debugging is used, what level messages are written to **file**

Default Profile Configuration

The type of **database** used by agents using the default profile and it's location



Platform Transport Naming Services

fipaos-rmi://localhost:3000

Protocol Mappings

fipa-auction-dutch
fipa-auction-english
fipa-brokering
fipa-contract-net

Database Type: NoDatabase

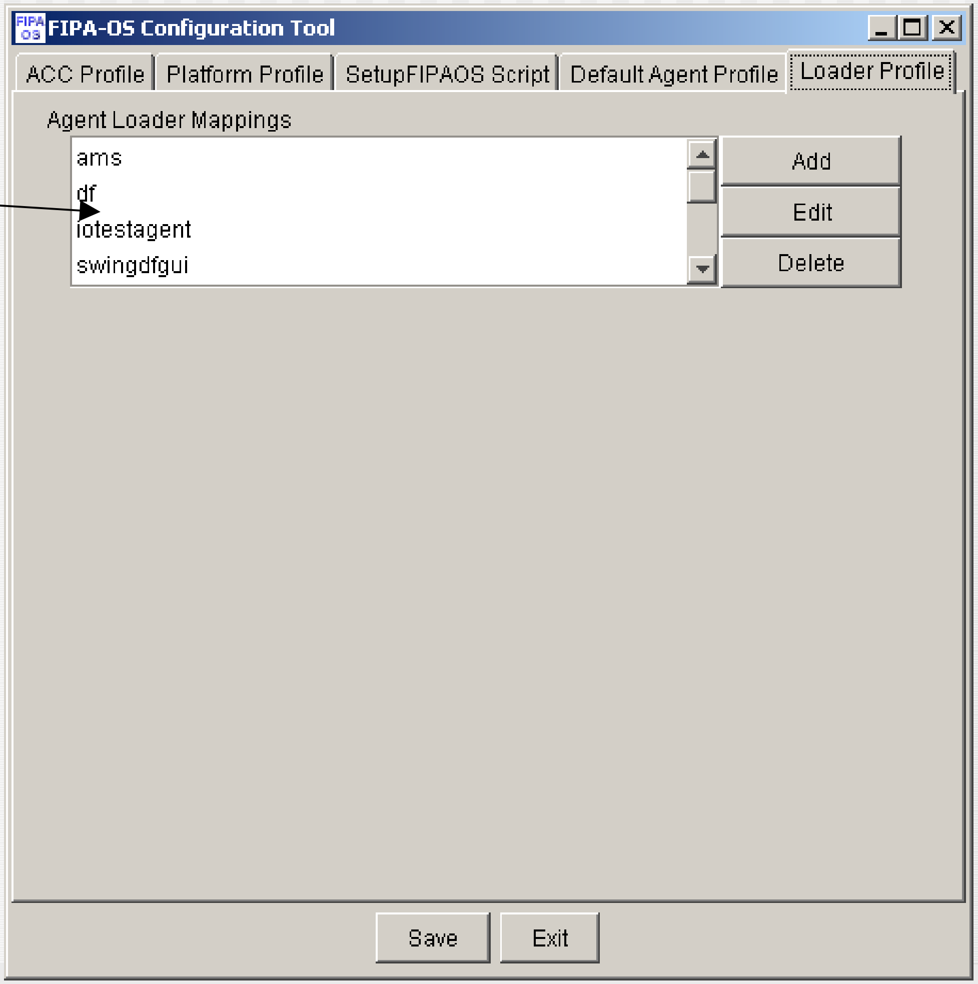
Database Location: C:\FIPAOSv200\databases\

Details of the **platform MTP's** that Agents should bind into upon start up

Details of the protocols known by Agents

Agent Loader Configuration

Details of Agents known by Agent-Loader



Agent Loader Mappings

ams
df
iotestagent
swingdfgui