Towards developing multi-agent systems in Ada

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Summary

- Agents and multi-agent systems
- SPADE
- ADA application interface for SPADE
- Conclusions
- Future Work

Where do agents come from?

- Software Objects
- Artificial Intelligence
- Distributed Systems
- Psychology, society
- Intentional systems

Where do agents come from?

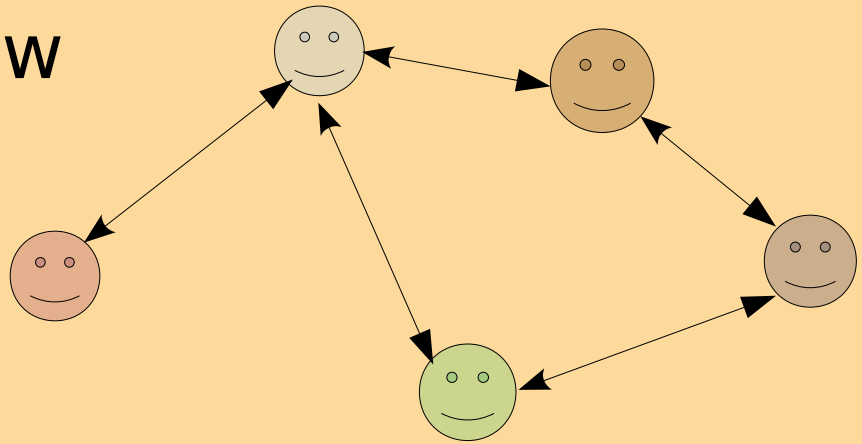
- Software Objects
  - Inter-Object Messages
  - Inheritance
  - Classes
  - Independence
- Artificial Intelligence
  - Knowledge
  - Reasoning
  - Learning
  - Focus: sensors+deliberation+actuation
- Distributed Systems
  - Distributed data
  - Distributed processes
  - Networks
  - Interoperability
- Psychology, society
  - Cognitivism
  - Behaviorism
- Intentional systems
  - Autonomous

What is an Agent?

- Permanent process
- Independent
- Autonomous
- Intelligent
- Flexible
- **Reactive**, **Proactive** and **Social**

Multi-Agent Systems

- Interaction between some similar or heterogeneous agents
- No global control
- Decentralized data
- Individual points-of-view



Agent Applications

- E-Commerce
- Traffic control
- Intelligent manufacture
- Information Agents
- Co-operation networks
- Software Engineering

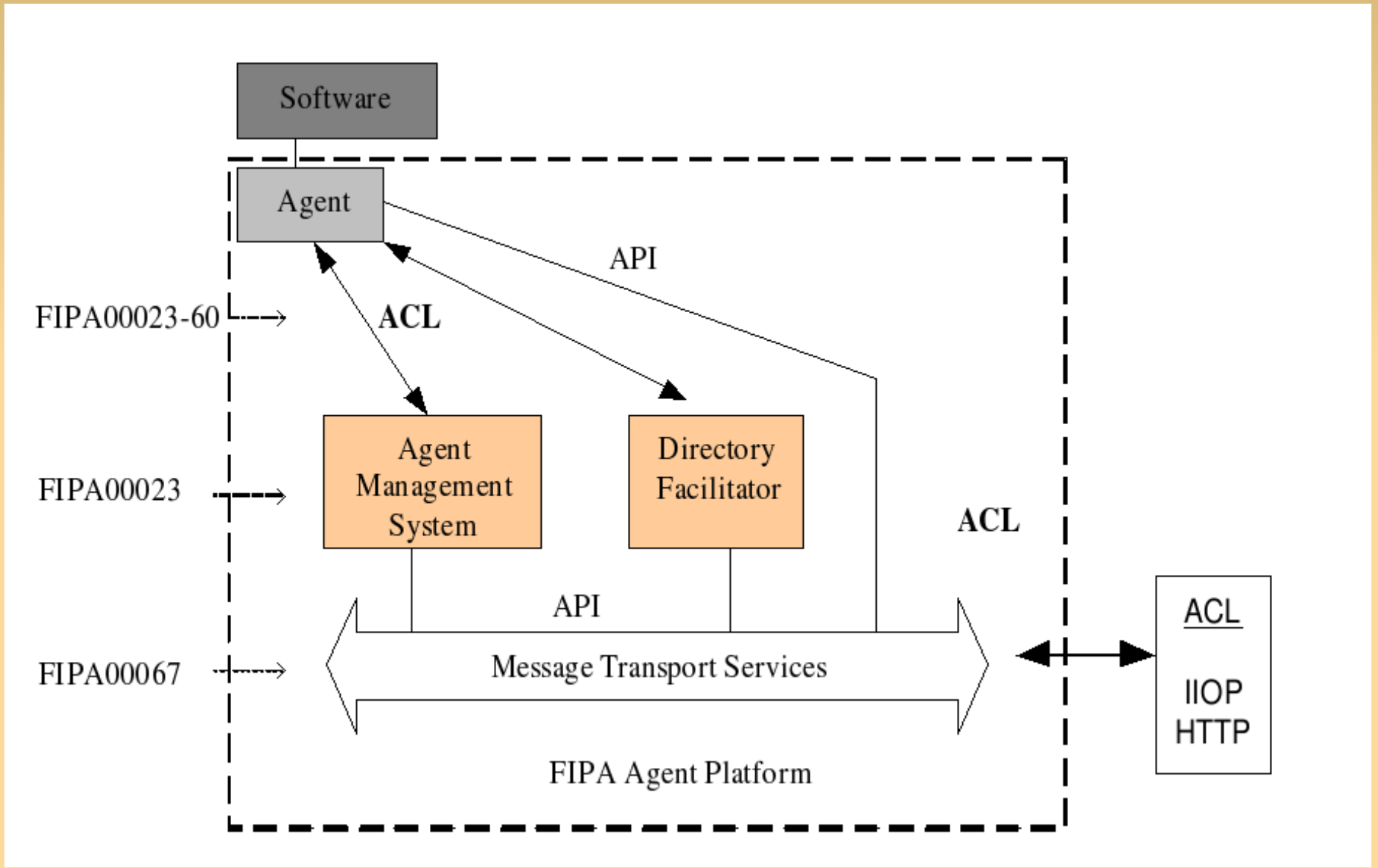
- Huge and distributed problems
- Open and dynamic environments
- Flexible, inter-operable, efficient, robust, trust...

FIPA

- **F**oundation for **I**ntelligent **P**hysical **A**gents
- IEEE Computer Society standards organization
- Promotes agent-based technology and the interoperability of its standards with other technologies

www.fipa.org

Agent Platforms



SPADE

Smart **P**ython multi-**A**gent **D**evelopment **E**nvironment

- Developed using Python
- Covers the FIPA standard
- Allows different OS and platforms
- Based on the JABBER protocol

- Allows different programming languages using the Jabber protocol

SPADE and Jabber

- SPADE is based on the **JABBER** protocol

- Jabber is an Instant Messaging protocol to communicate people

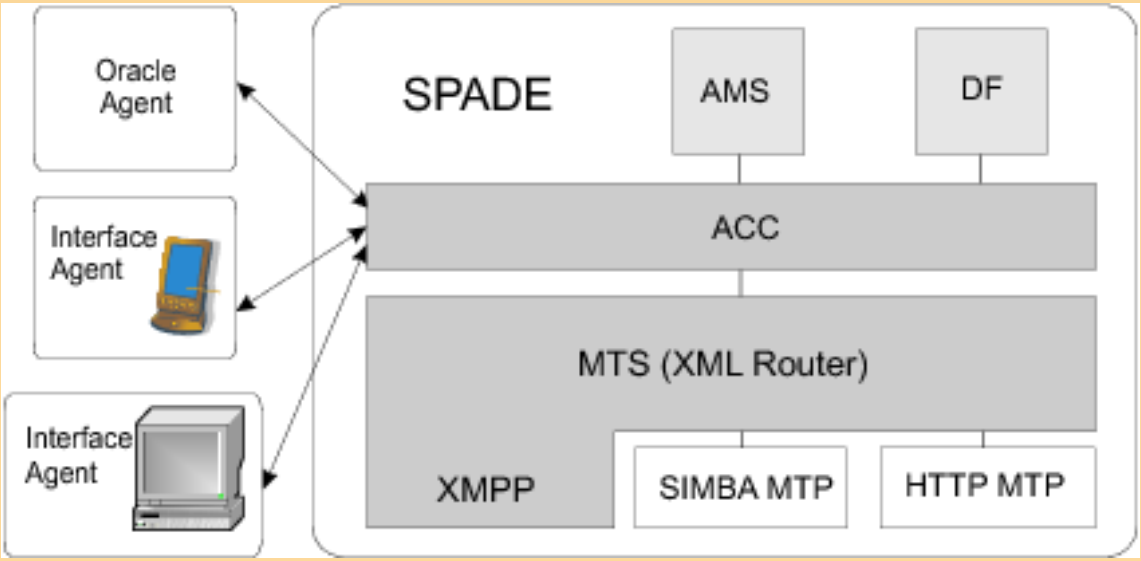
- Jabber enables to exchange messages, presence and other structured information in close to real-time

- Jabber is a set of XML protocols and technologies

- SPADE uses Jabber to **communicate agents**!

SPADE: Platform Model

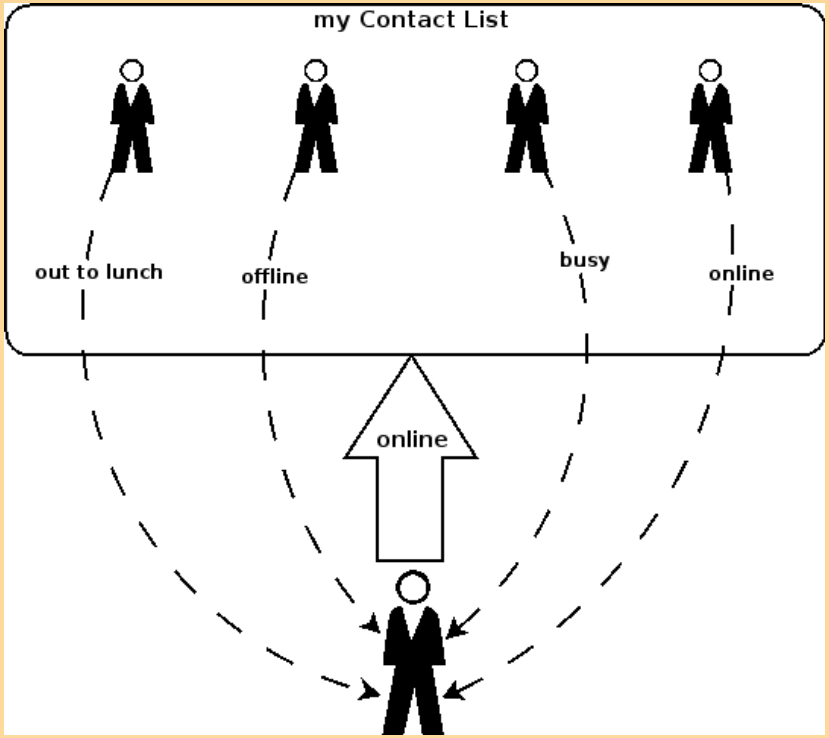
- Based on the Jabber server (XML Router)
- Links all the platform components (ACC, agents, AMS...) one with each other.



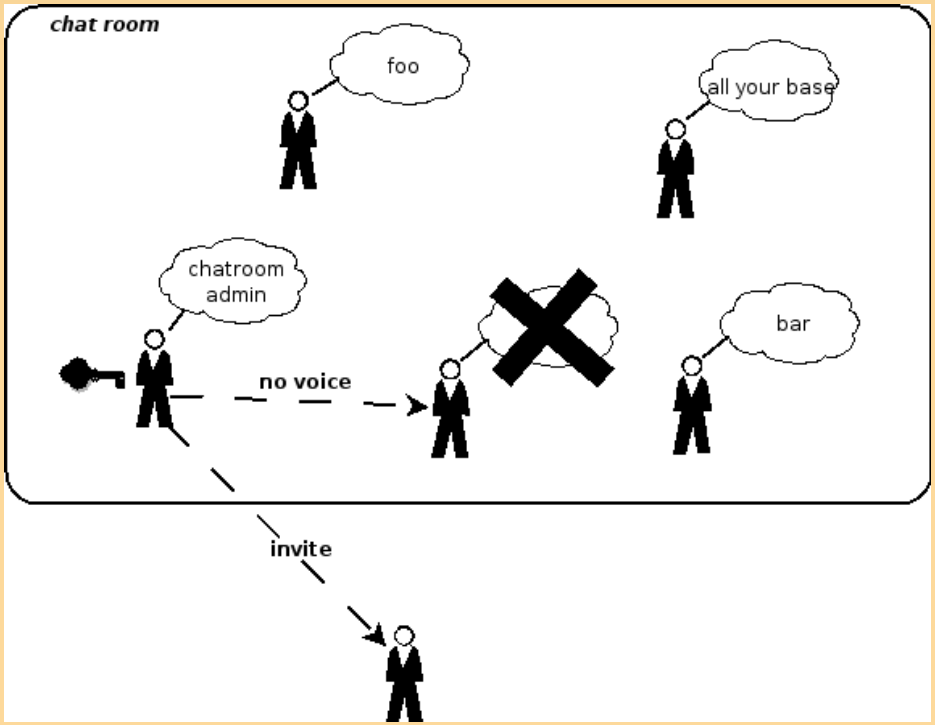
- Every SPADE component is an agent
- Agents use the ACC (Agent Communication Channel) to route messages inside the platform

SPADE: Communication Model

- Jabber gives SPADE some extra features:
  - Presence Notification
  - Multi-user Conference



Presence Notification

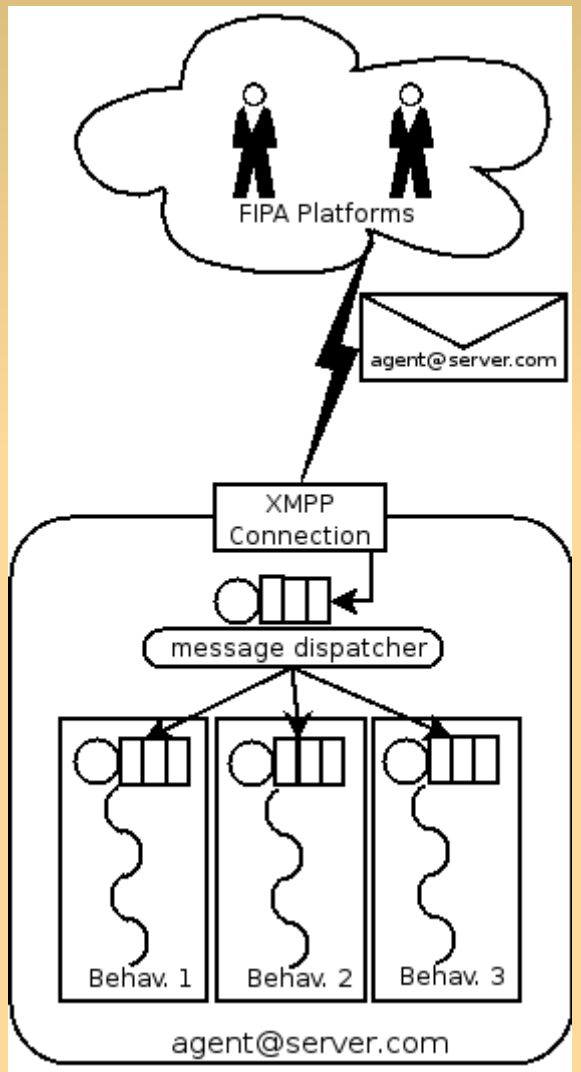


Multi-user Conference

SPADE: Agent Model

- The Agent model is composed by:
  - A connection mechanism to the platform (a TCP/IP connection to the Jabber server)
  - A message dispatcher
  - A set of different behaviors.

- SPADE agents do reach their goals by running deliberative and reactive behaviors.



ADA API

- The interface that connects agents with SPADE is **XML**

- This allows to develop agents in any programming language (that could work with sockets and XML)

- SPADE provides *ONLY* a python API to develop agents. (and its ok)

- And there is no other supported programming language...

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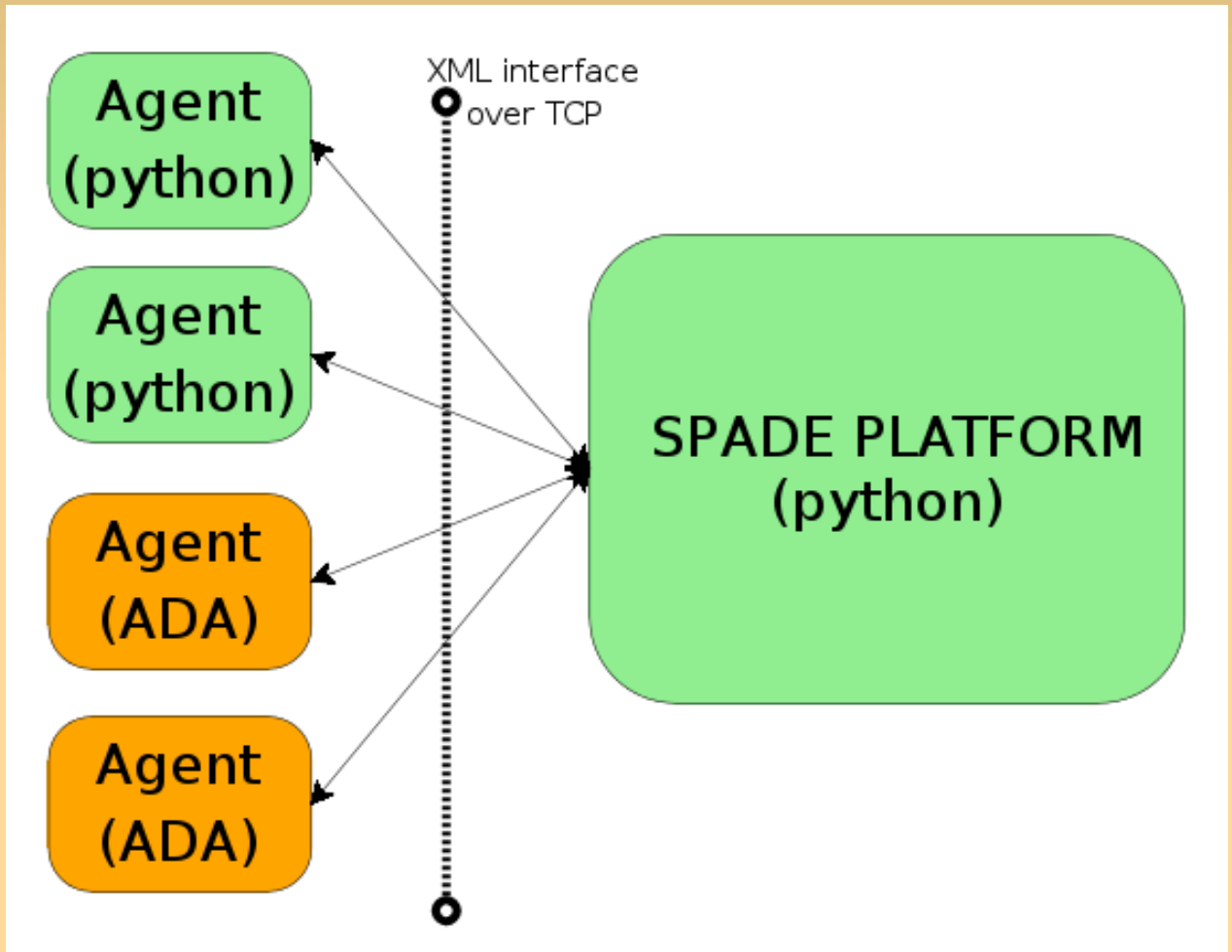
except for

ADA

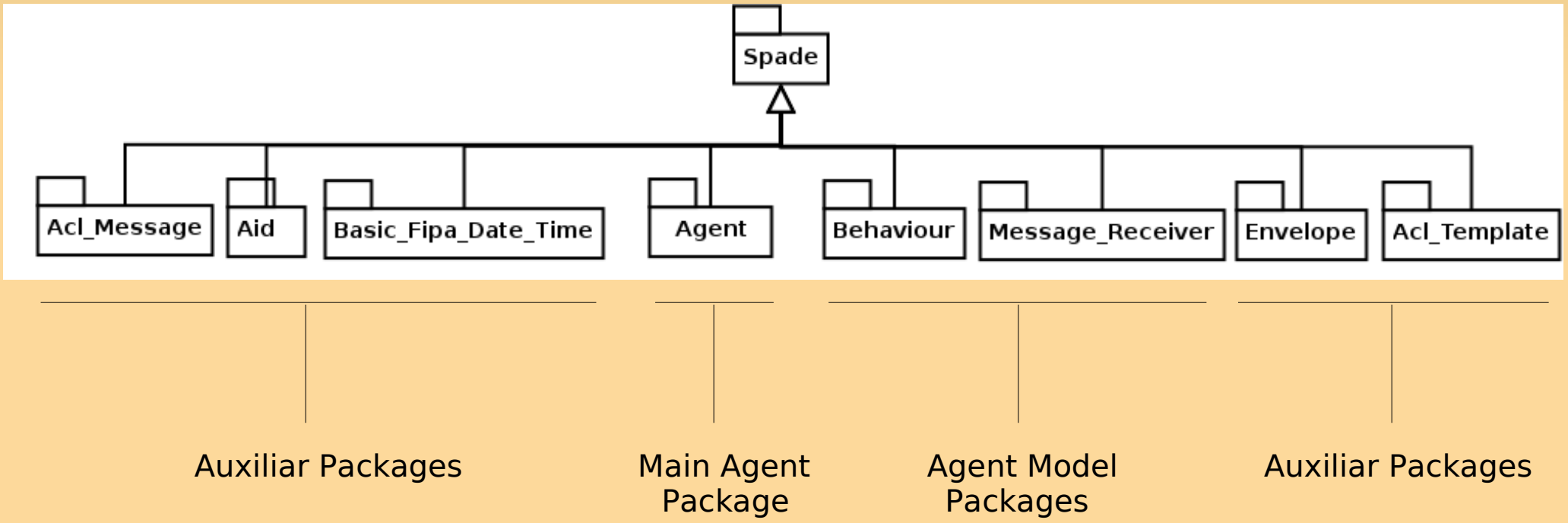
ADA API

- Our aim is to develop agents using ADA which will be able to connect to a python agent platform (SPADE)



ADA API

- Package structure

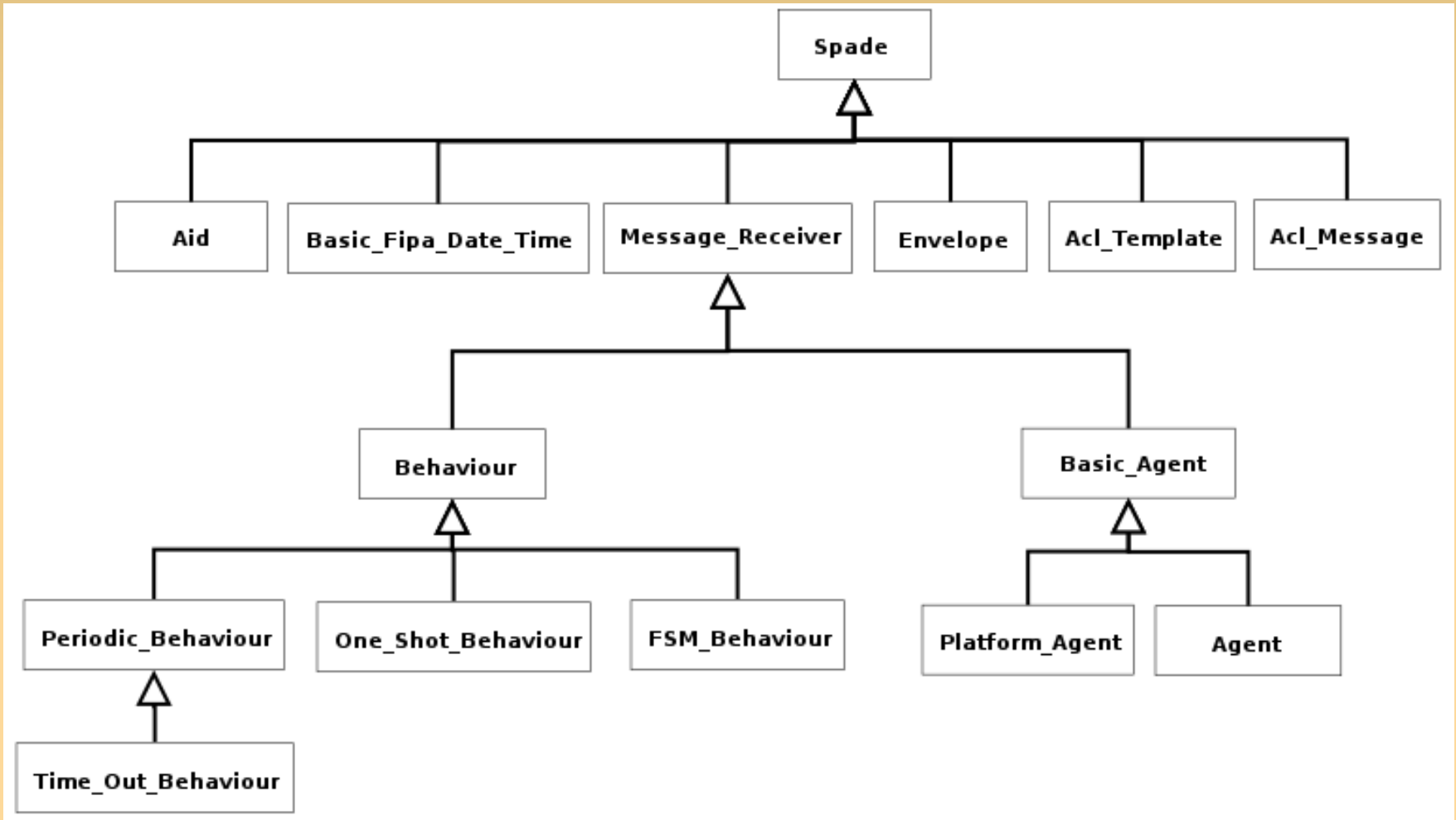


ADA API

```
package Spade.Aids is

type Aid is private;

function Get_Name      ( From: Aid ) return Aid_Name;
function Get_Addresses ( From: Aid ) return List_Addresses;
function Get_Resolvers ( From: Aid ) return List_Resolvers;


procedure Set_Name     ( To: in out Aid; Name:     in Aid_Name );
procedure Add_Address  ( To: in out Aid; Address:  in Address  );
procedure Add Resolver ( To: in out Aid; Resolver: in Resolver );

...

end Spade.Aids;
```

ADA API

- Types Hierarchy



ADA API

```
package Spade.Agents is
        type Basic_Agent is new Message Receiver with private;

        function  Get_Aid   (From: Basic_Agent Class) return Aid;
        procedure Start     (What: in out Basic_Agent'Class);
        procedure Take_Down (What: in out Basic_Agent'Class);
        procedure Setup     (What: in out Basic_Agent'Class);
        procedure Kill      (What: in out Basic_Agent'Class);
        procedure Add_Behavior (   To: in out Basic_Agent'Class;
                                   Behav: in Behavior'Class;
                                   Template: in Acl_Template);
        function Search_Agent  (   From: Basic_Agent'Class;
                                   Template: Ams_Agent_Description)
                                   return List_Ams_Agent_Description;
        procedure Register_Service(From: in Basic_Agent'Class;
                                   Service: in Df_Agent_Description);
        procedure Send_Message (   From: in out Basic_Agent'Class;
                                   Env: in Envelope;
                                   Message: in Acl_Message);
        type Agent is new Basic_Agent with private;
        type Platform_Agent is new Basic_Agent with private;
        ...
end Spade.Agents;
```

Example

```
An_Agent: Agent;
Behavior_One: Periodic_Behavior;
Behavior_Two: One_Shot_Behavior;
A_Template: Acl_Template;


Set_Default_Behavior (To => An_Agent, Behav => Behavior_One);

Add_Template (To => Behavior_Two, Template => A_Template);
Add_Behavior (To => An_Agent, Behav => Behavior_Two);

Start (What => An_Agent);
```

Conclusions and Future Work

- A middleware that allows the development of intelligent agents using Ada has been developed.

- This middleware focuses on creating Ada agents that are compatible with the SPADE agent platform.

- It allows bringing the advantages of Ada to the agent realm and vice-versa.

- As Future Work we will test both implementations for performance and scalability.

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