Universidade do Minho
Escola de Engenharia
Departamento de Informática

Mestrado Integrado em Engenharia Informática
Mestrado em Engenharia Informática
Agentes Inteligentes
2020/2021

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ISLab
Synthetic Intelligence Lab

Agentes Inteligentes @ 2020/2021

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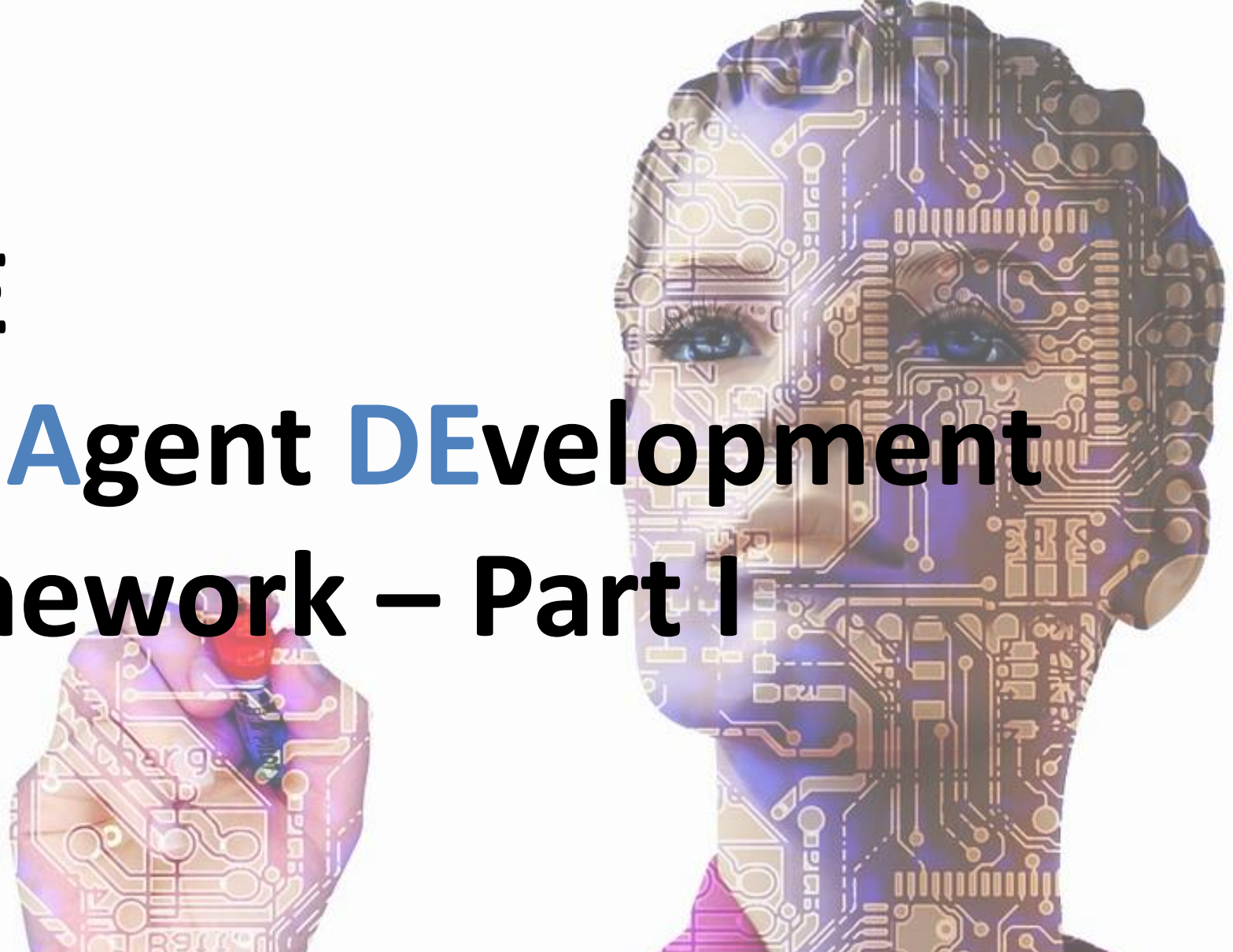
  Universidade do Minho
- ISLab – (Synthetic Intelligence Lab)
- Centro ALGORITMI
  Universidade do Minho

JADE

Java Agent DEvelopment Framework – Part I



JADE Features

- Agent platform with the purpose of simplifying the development of agents
- API/Interface
  - Execution environment
  - Provides a class library for multi-agent development
  - Graphical administration and management tools for agents
- Agent Structure/Standard
  - Agent lifetime management
  - Message transport management
  - Message structure
  - Protocol Interaction
  - Ontologies
  - Safety

Containers

- Each instance of the execution environment is a Container
- Each Container can have zero or more agents running simultaneously
- Main-Container is required to support the platform
- All other Containers have to register on it when they are created
- Containers can be remote

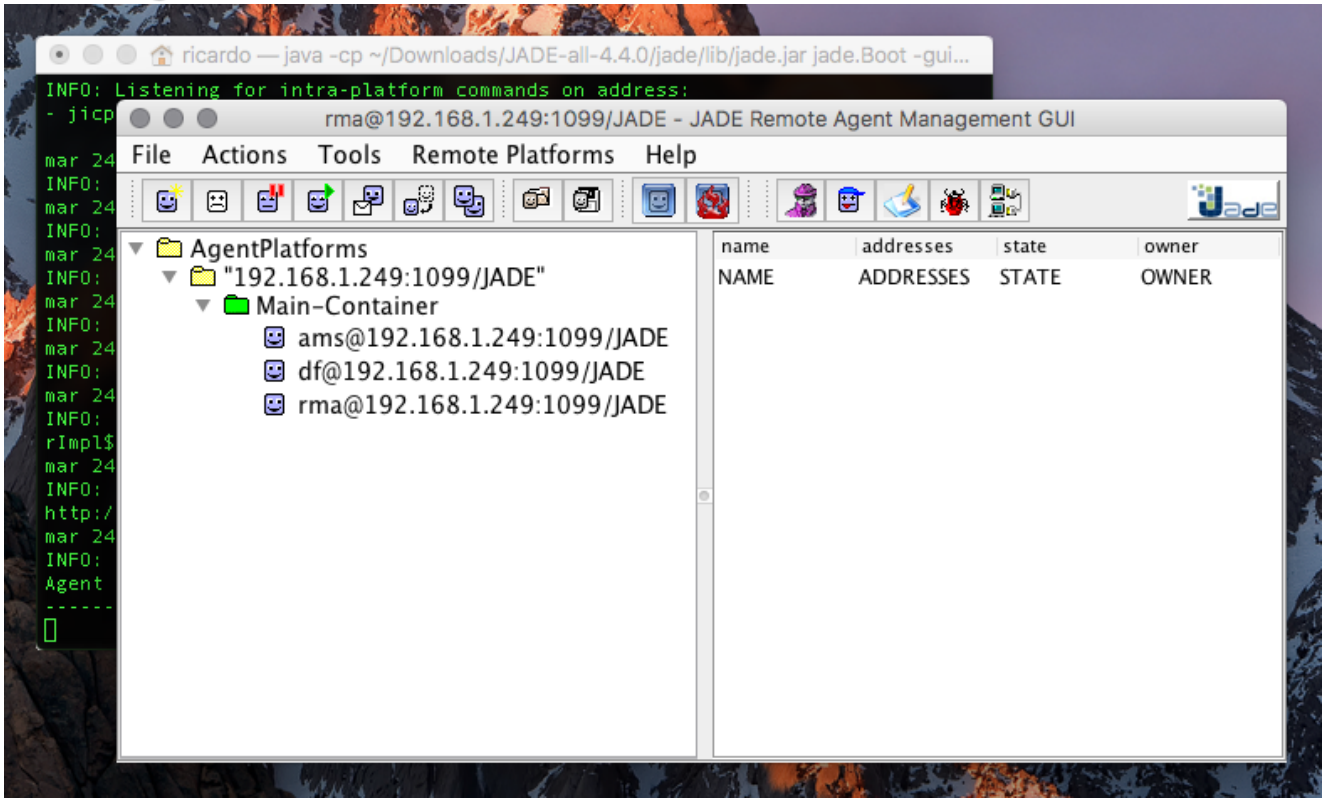
Containers

- Main-Container:
  - Agent Management System (AMS): make sure there are no name collisions and lets you start and end agents.
  - Directory Facilitator (DF): provides a yellow pages services through which an agent can search for other agents.

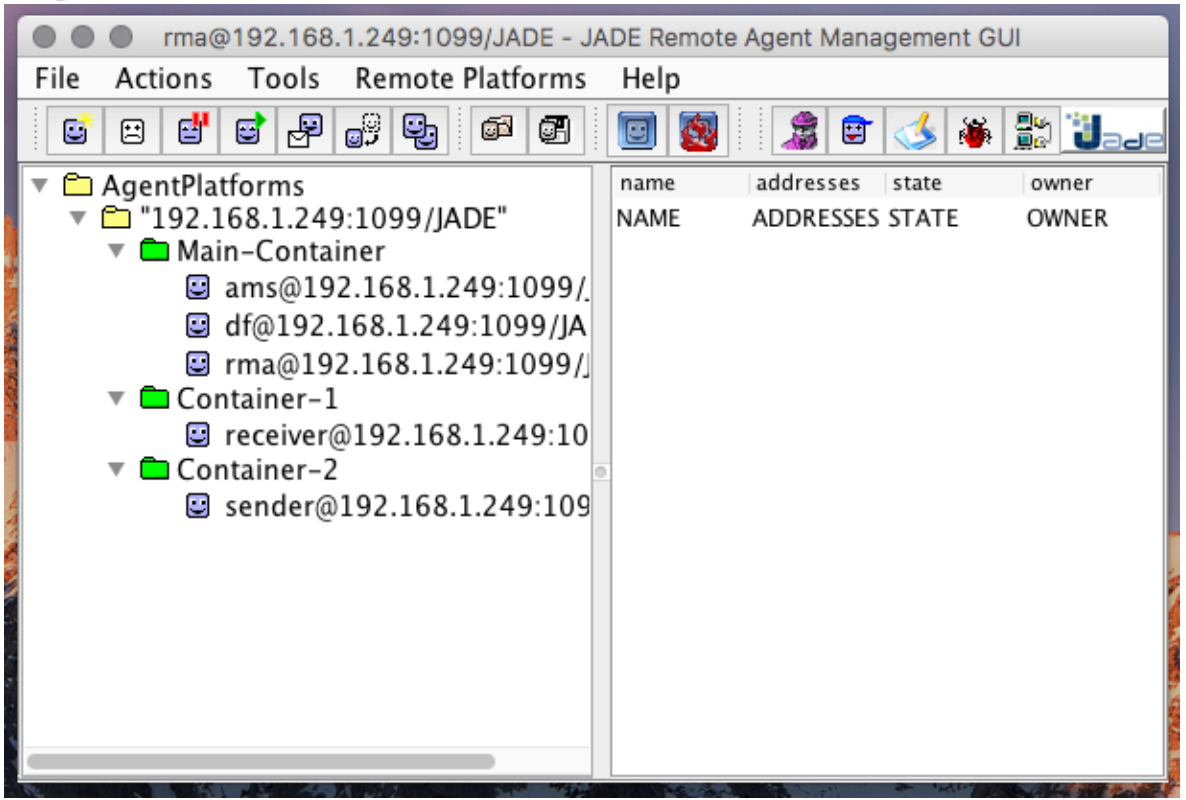
  Optionally:

  - Remote Monitoring Agent (RMA): allows to manage the platform through a GUI.

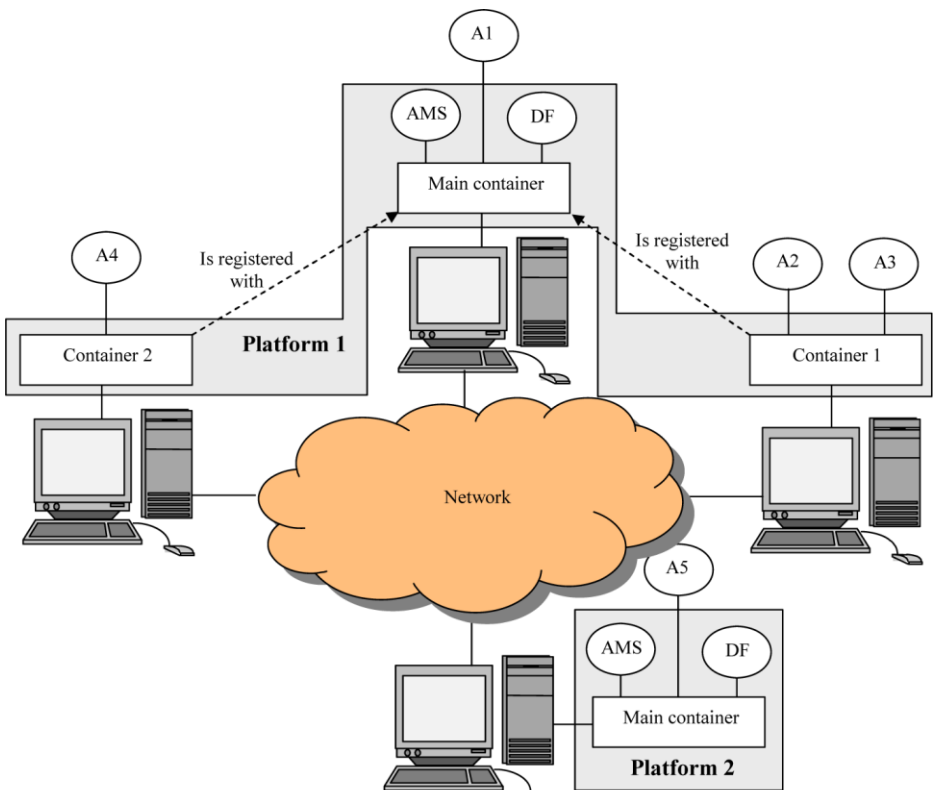
GUI without agents



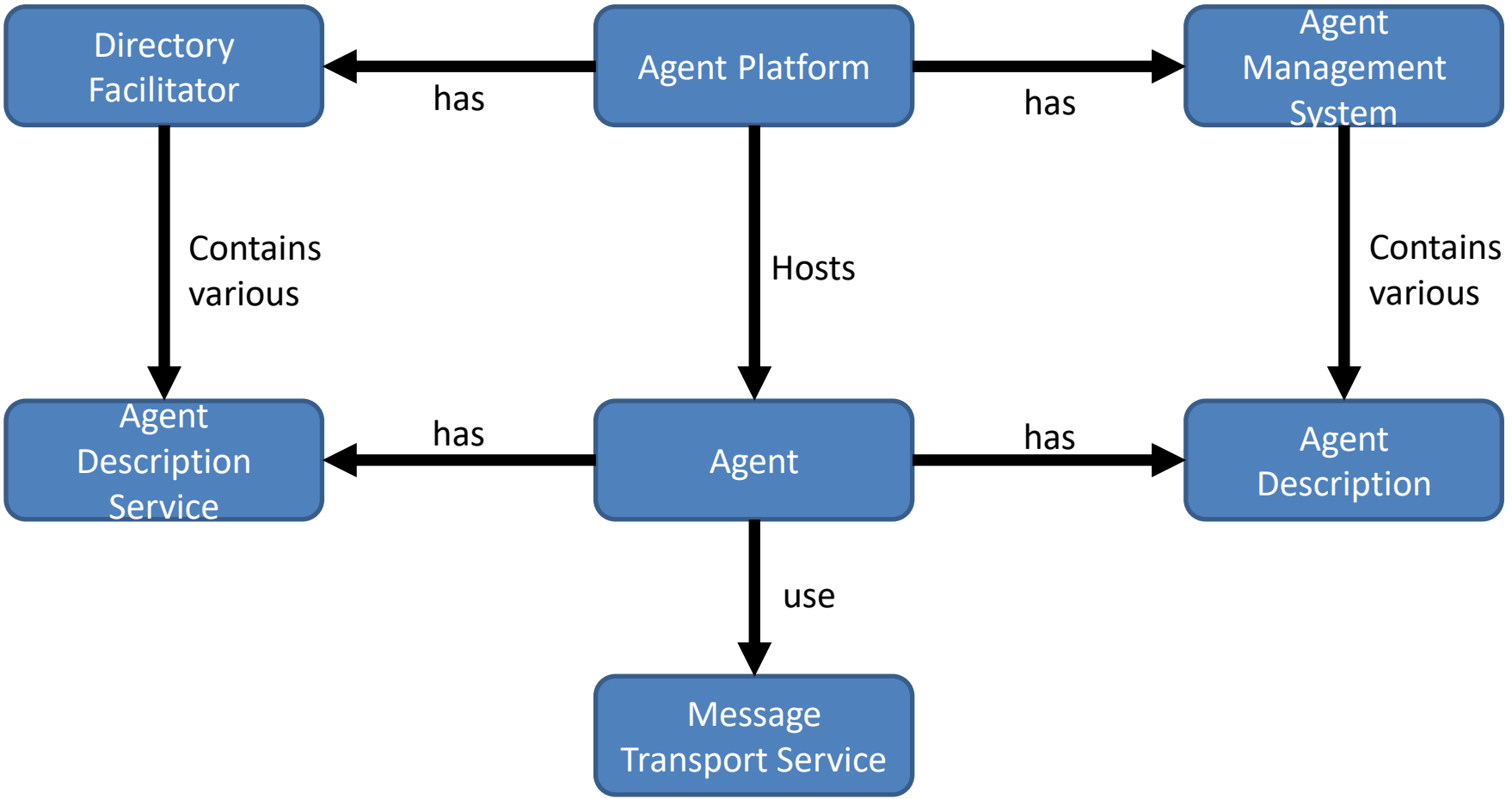
GUI with 2 agents



Platform - Set of distributed containers



Agent UML Diagram



Performative-FIPA compliant

- FIPA - Foundation for Intelligent Physical Agents.
- Promotes standards for agent development.
- Delivers Messages Representation, Agents Structure, Messages Structure, etc.
- FIPA Message Types: ASK, INFORM, REQUEST, PROPOSE, REFUSE, etc.

Agent Behaviours

- Primitive:
  - SimpleBehaviour
  - CyclicBehaviour
  - TickerBehaviour
  - OneShotBehaviour
  - WakerBehaviour
  - SimpleAchieveREInitiator
  - SimpleAchieveREResponder
  - FSMBehaviour
- Complex:
  - ParallelBehaviour
  - SequentialBehaviour

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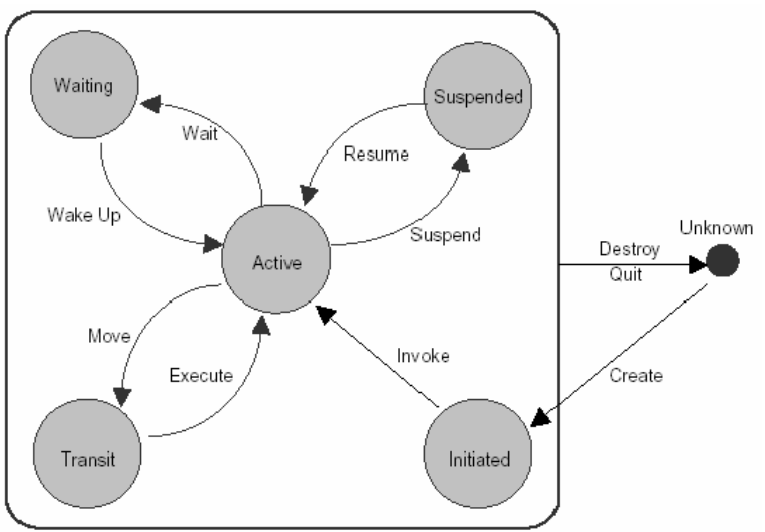
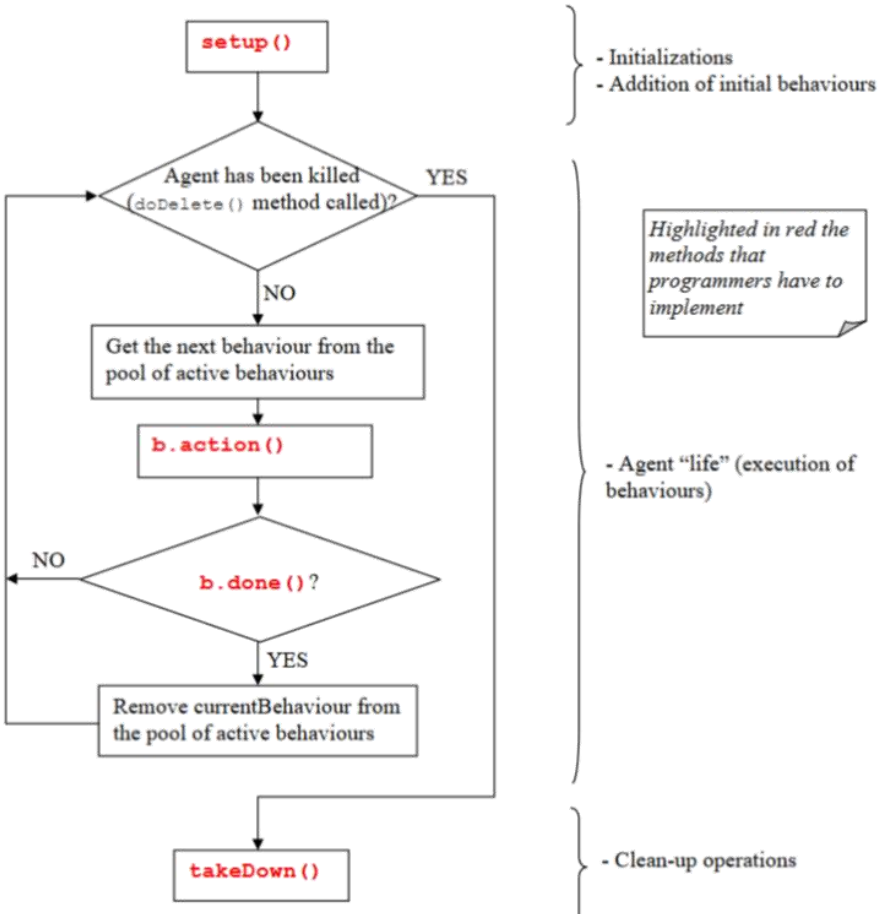
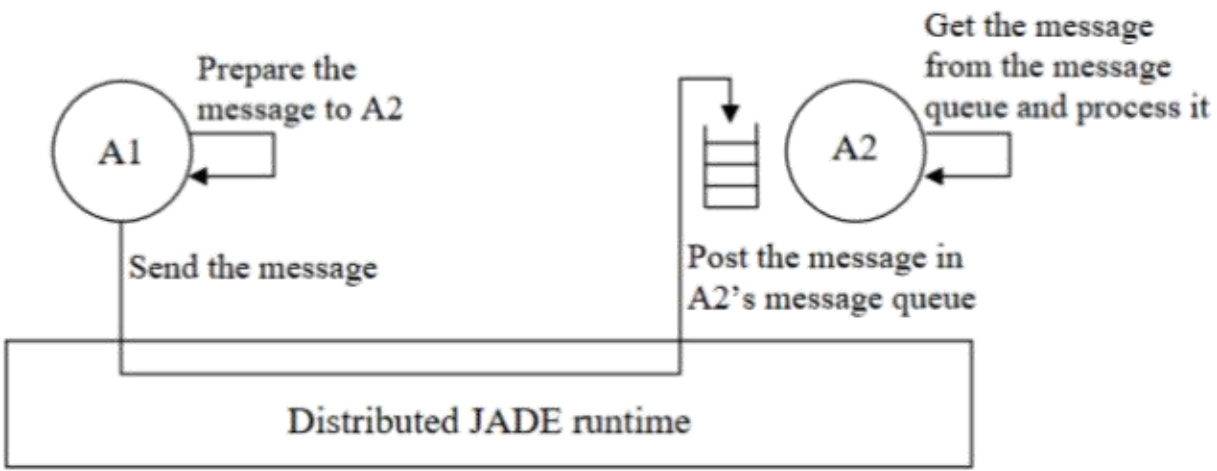
Agent Life Cycle





Message Transfer Procedure

- Asynchronous message transfer
- May have more than one receptor



Message Example

```
(inform
          :sender     Admin@AdmM
          :receiver   AM0001@AmM
          :reply-with 1203302
          :language   XML
          :ontology   new_event
          :content    <new-event>
                           <id>   0001                    </id>
                           <prio> 3                       </prio>
                           <sum>  “Visit dentist”         </sum>
                           <dateb>20090514                </dateb>
                           <timeb>110000                  </timeb>
                           <datee>20090514                </datee>
                           <timee>123000                  </timee>
                      </new-event>
)
```

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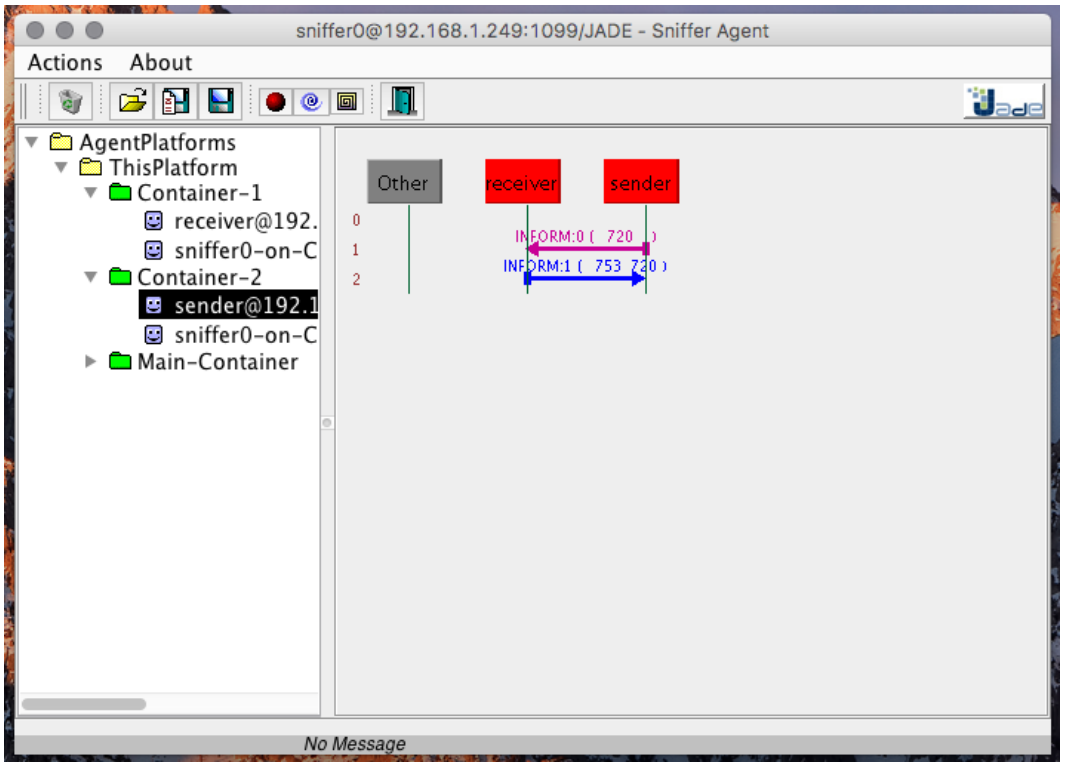
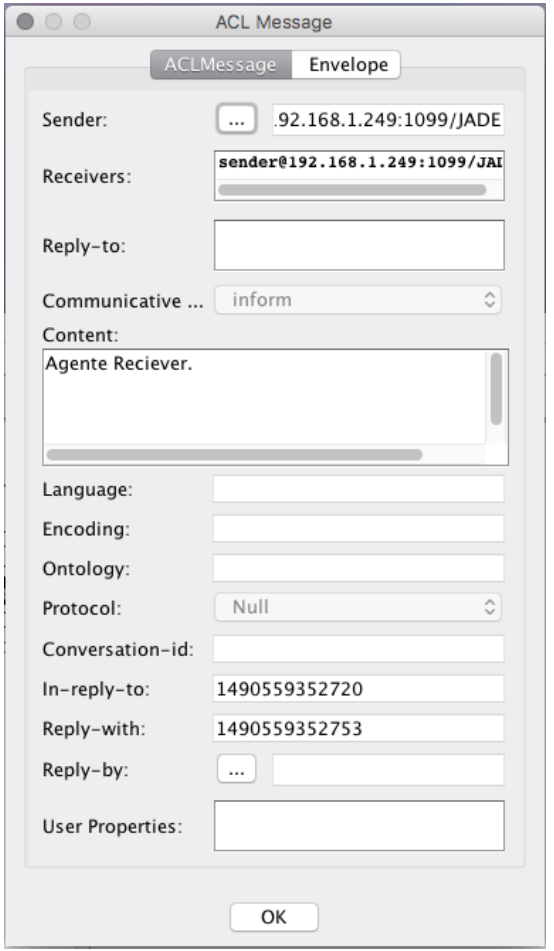
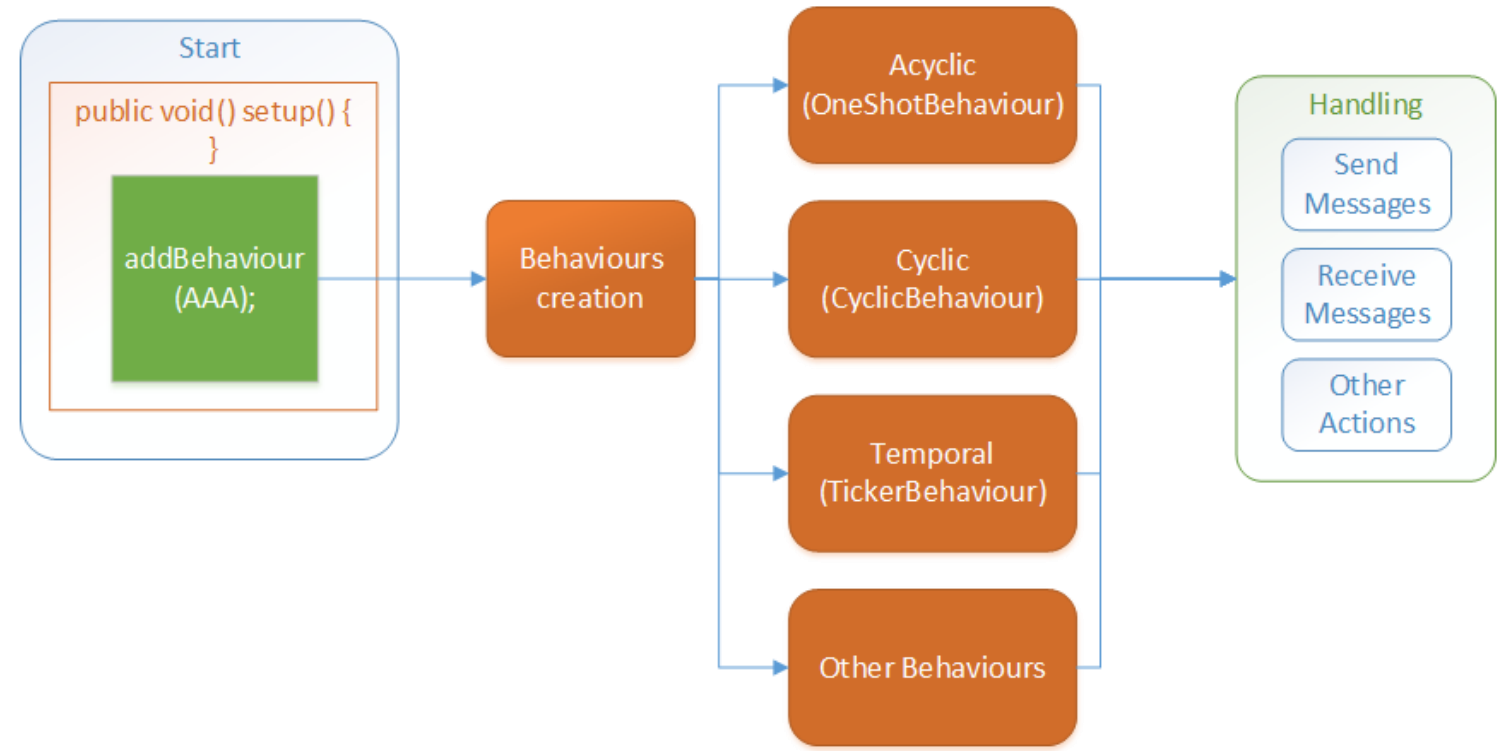
Sniffer



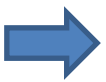


Development Process



Agent Skeleton

```
public class HelloAgent extends
Agent {
    public void setup() {
        ...
    }
}
```



```
public class Hello extends Agent
{
    public void setup()
    {
        this.addBehaviour(do_something);
    }
}

private class do_something extends
CyclicBehaviour {
    public void action()
    {
    // Actions that the behaviour will do
    // Such as actions to send/receive messages
    }
}
```

Create & Send Messages

```
AID receiver = new AID();
receiver.setLocalName("receiver");
ACLMessage msg = new ACLMessage(ACLMessage.INFORM);
msg.setContent("HelloWorld");
msg.setConversationId(""+System.currentTimeMillis());
msg.addReceiver(receiver);
myAgent.send(msg);
```

Receive Messages

```
private ACLMessage msg = null;
if ((msg = myAgent.receive()) != null)
{
    System.out.println("New message received");
    System.out.println("Sender: " + msg.getSender().getLocalName());
    System.out.println("Name:" + msg.getSender().getName());
    System.out.println("Content: " + msg.getContent());
}
```

Start Platform

- Run the following command to start the Main-Container (console):
  - java jade.Boot [Options] [Agents]
- [Options]:
  - -container
  - -host “HostName” (default: localhost)
  - -port “PortNumber” (default: 1099)
  - -gui (RMA GUI)
- [Agents]:
  - Identifiers separated by spaces
  - Identifier is of type: AgentName:JavaPackage.ClassName

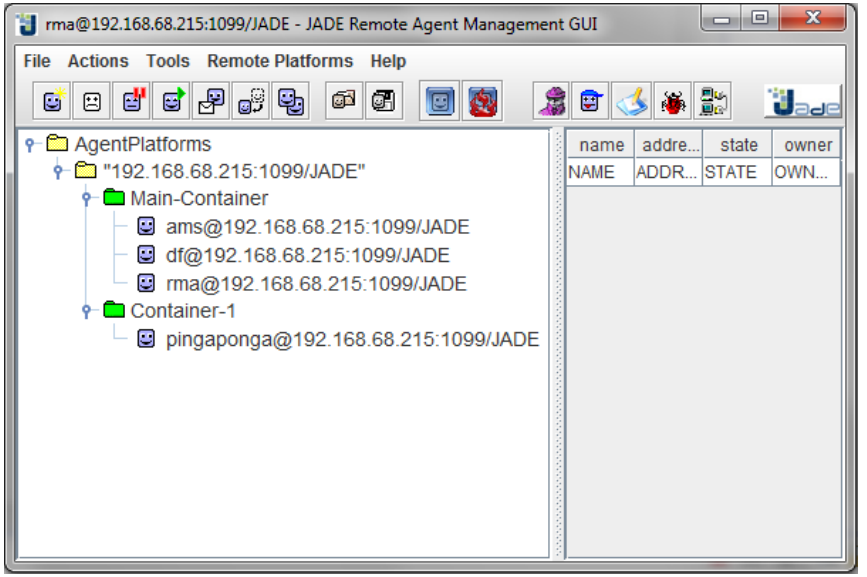
Start Platform

- Tools that simplify platform administration and Application development:
  - Remote Monitoring Agent;
  - Dummy Agent;
  - Sniffer Agent;
  - Introspector Agent;
  - Directory Facilitator GUI;

Basic Agent

```
public class PingPong extends Agent
{
    @Override
    protected void setup()
    {
        super.setup();

        System.out.println(this.getLocalName()+" a começar!");
    }

    @Override
    protected void takeDown()
    {
        super.takeDown();

        System.out.println(this.getLocalName()+" a morrer...");
    }
}
```

```
set 15, 2015 10:17:58 AM jade.core.BaseService init
INFO: Service jade.core.management.AgentManagement initialized
set 15, 2015 10:17:58 AM jade.core.BaseService init
INFO: Service jade.core.messaging.Messaging initialized
set 15, 2015 10:17:58 AM jade.core.BaseService init
INFO: Service jade.core.resource.ResourceManagement initialized
set 15, 2015 10:17:58 AM jade.core.BaseService init
INFO: Service jade.core.mobility.AgentMobility initialized
set 15, 2015 10:17:58 AM jade.core.BaseService init
INFO: Service jade.core.event.Notification initialized
set 15, 2015 10:17:58 AM jade.core.AgentContainerImpl joinPlatform
INFO: ----------------------------------------
Agent container Container-1@192.168.68.215 is ready.
----------------------------------------------
pingaponga a começar!
```

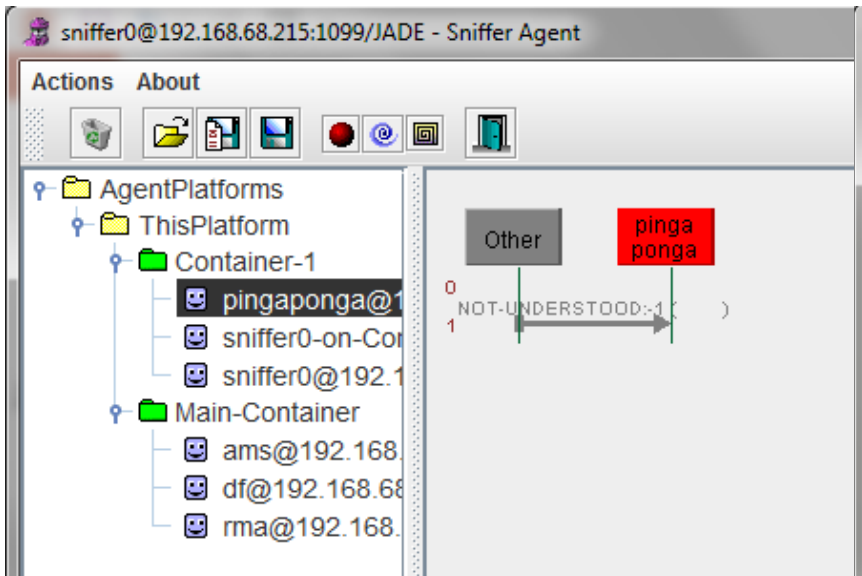


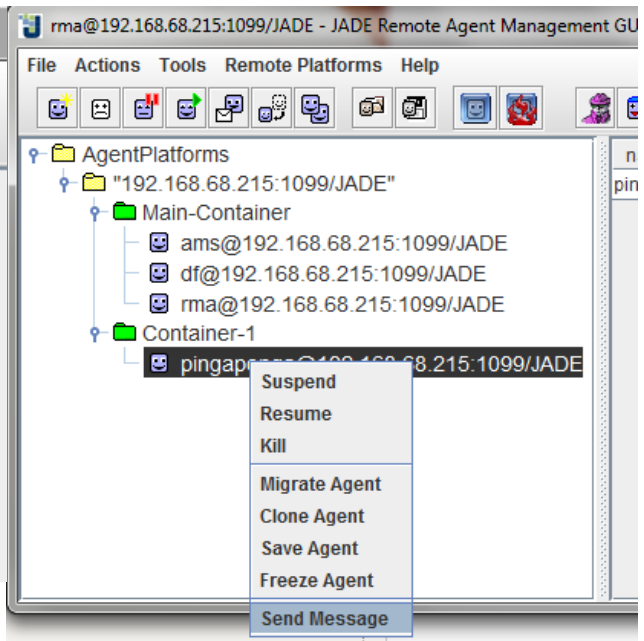
In order to execute takeDown() method, the agent must invoke the doDelete() method inside the setup() method.

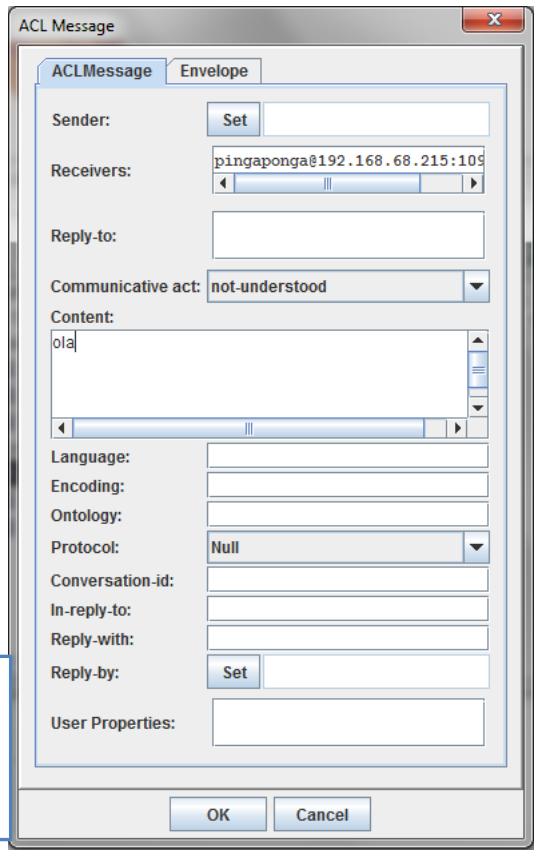
Message Receive

```
public class PingPong extends Agent
{
    @Override
    protected void setup()
    {
        super.setup();
        System.out.println(this.getLocalName()+" a começar!");

        this.addBehaviour(new ReceiveBehavior());
    }

    @Override
    protected void takeDown()
    {
        super.takeDown();

        System.out.println(this.getLocalName()+" a morrer...");
    }

    private class ReceiveBehavior extends CyclicBehaviour
    {
        @Override
        public void action()
        {
            ACLMessage msg = receive();
            if (msg != null)
            {
                System.out.println("Recebi uma mensagem de "+msg.getSender()+". Conteúdo: "+msg.getContent());
            }
            block();
        }
    };
}
```

Message Receive







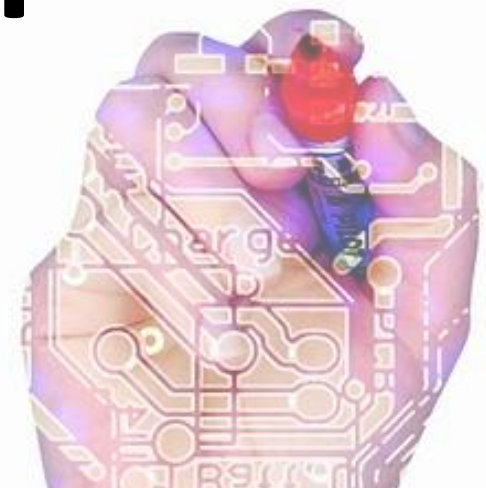

```
set 15, 2015 10:23:28 AM jade.core.BaseService init
INFO: Service jade.core.event.Notification initialized
pingaponga a começar!
set 15, 2015 10:23:28 AM jade.core.AgentContainerImpl joinPlatform
INFO: ----------------------------------------
Agent container Container-2@192.168.68.215 is ready.
---------------------------------------------
Recebi uma mensagem de ( agent-identifier :name rma@192.168.68.215:1099/JADE  :addresses (sequence http://192.168.68.215:7778/acc )). Conteúdo: ola
```

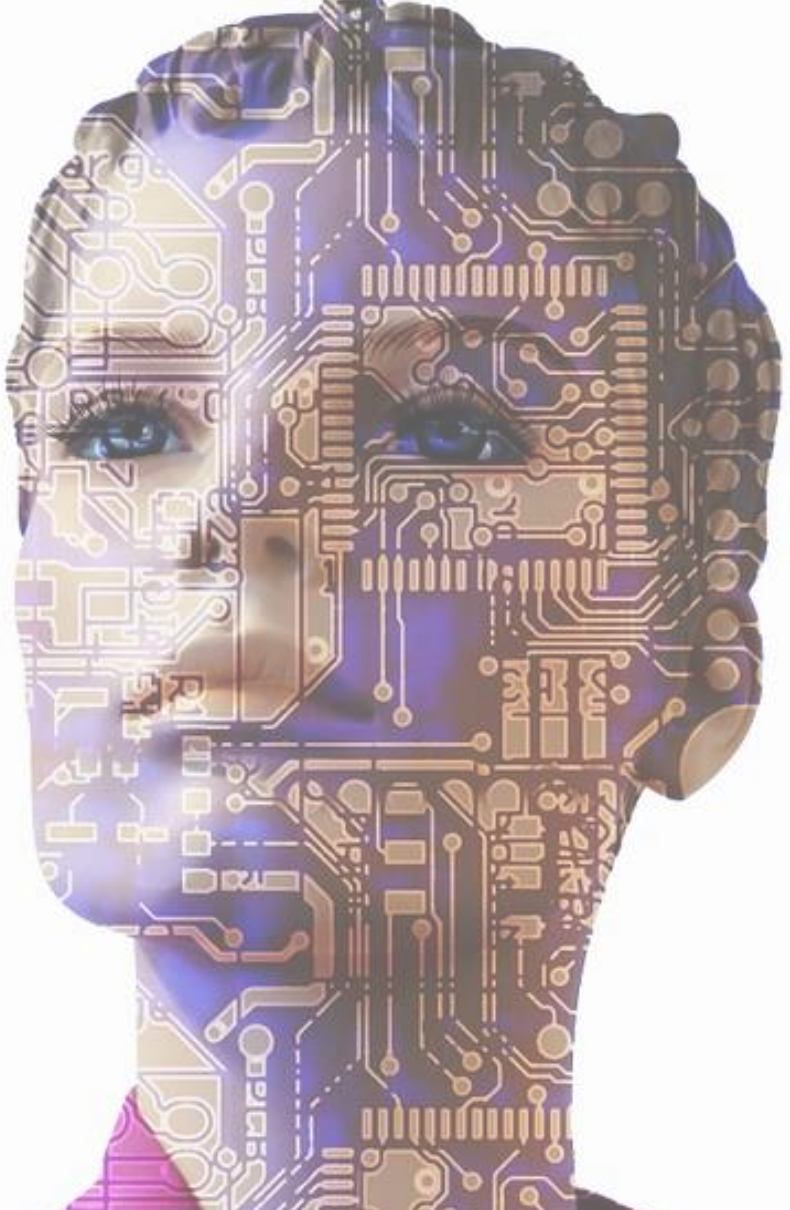
Message Reply

```
private class AnswerBehavior extends CyclicBehaviour
{
    @Override
    public void action()
    {
        ACLMessage msg = receive();
        if (msg != null)
        {
            System.out.println("Recebi uma mensagem de "+msg.getSender()+". Conteúdo: "+msg.getContent());
            ACLMessage resp = msg.createReply();

            if (msg.getContent().equals("ping"))
            {
                resp.setContent("pong");
                resp.setPerformative(ACLMessage.INFORM);
            }
            else
            {
                resp.setContent("Não percebi...");
                resp.setPerformative(ACLMessage.NOT_UNDERSTOOD);
            }

            send(resp);
        }
        block();
    }
}
```

```
@Override
protected void setup()
{
    super.setup();
    System.out.println(this.getLocalName()+" a começar!");

    //this.addBehaviour(new ReceiveBehavior());
    this.addBehaviour(new AnswerBehavior());
}
```

Environment Setup



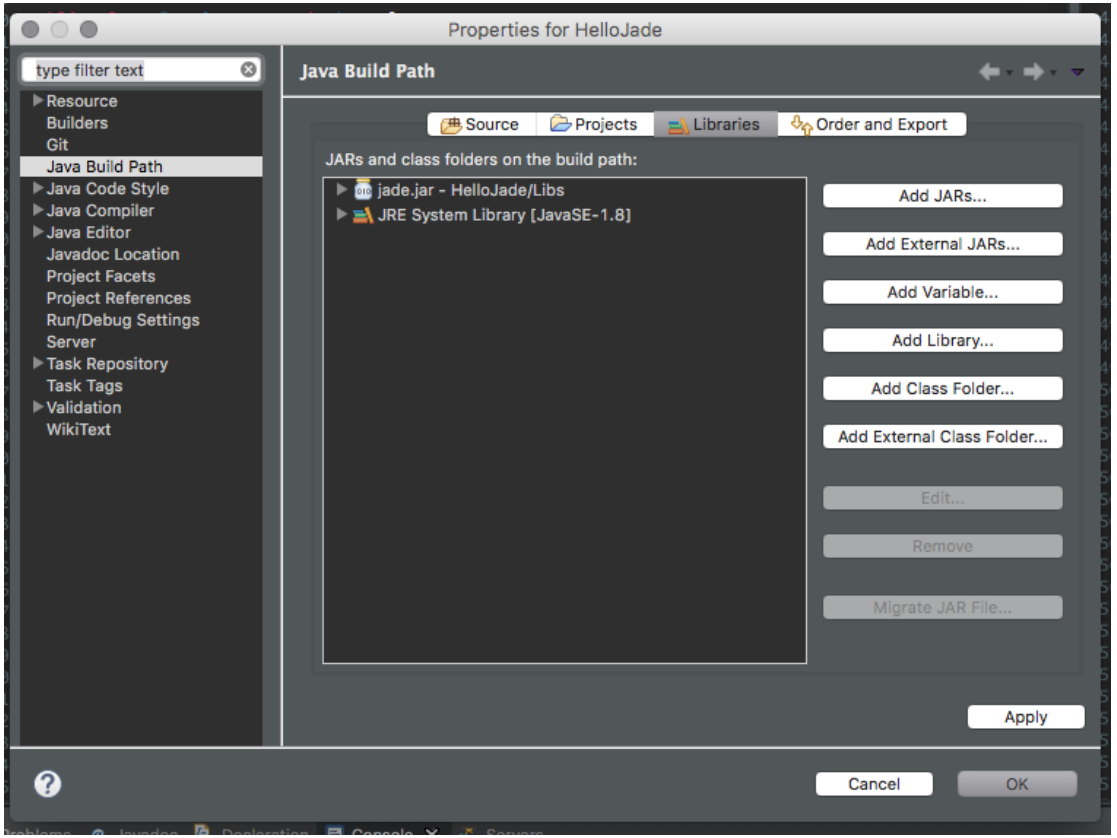


Software Required:

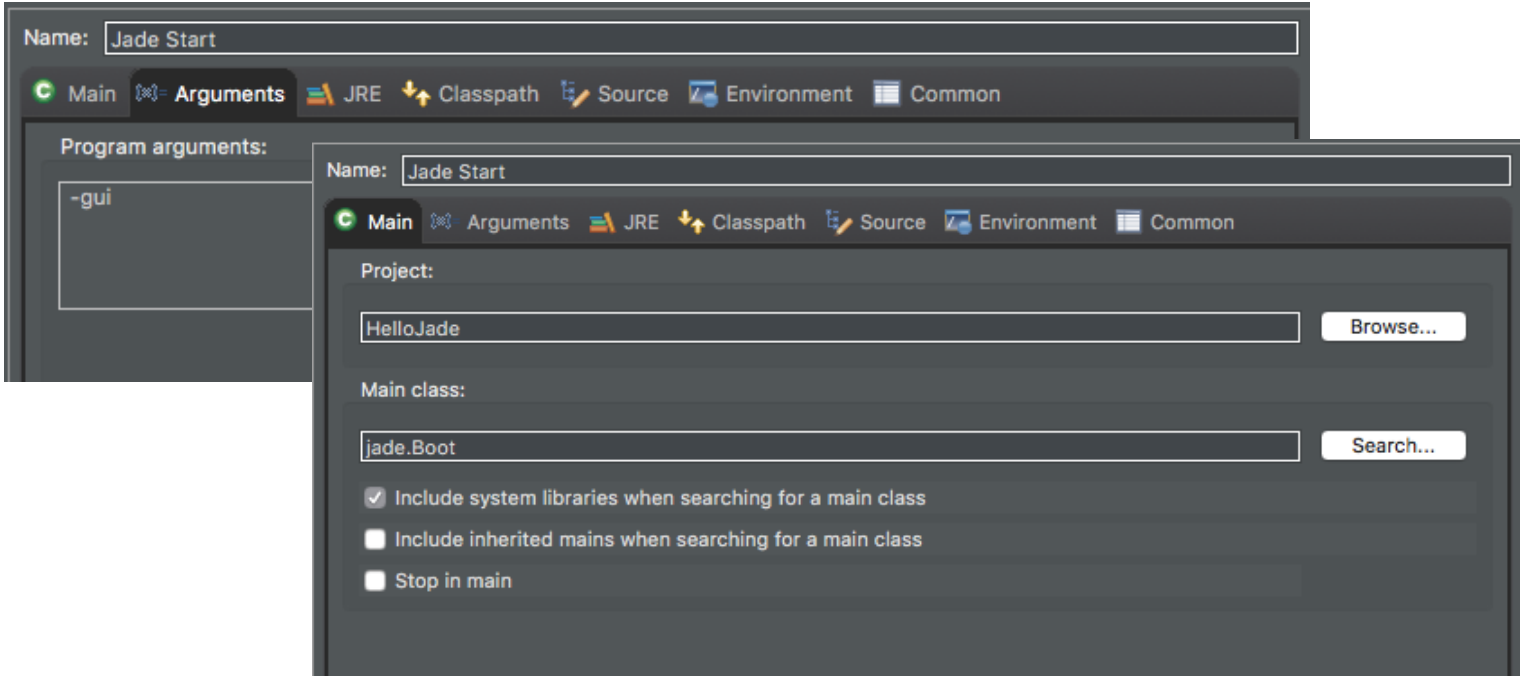
- Downloads:
  - Eclipse IDE for Java Developers (requirements: Java Development Kit)
    - https://www.eclipse.org/downloads/
  - JADE API (jadeBin is enough!)
    - https://jade.tilab.com/download/jade/

- After Installing Eclipse, configure it to use JADE API:
  - Open Eclipse -> Create new Java Project
  - Right Click Project -> Java Build Path -> Add External JAR (select JAR file found in JADE zip)
  - Time to develop and run your own Agent (https://jade.tilab.com/doc/tutorials/JADEProgramming-Tutorial-for-beginners.pdf)
    - Chapter 3. CREATING JADE AGENTS – THE AGENT CLASS

Eclipse Setup

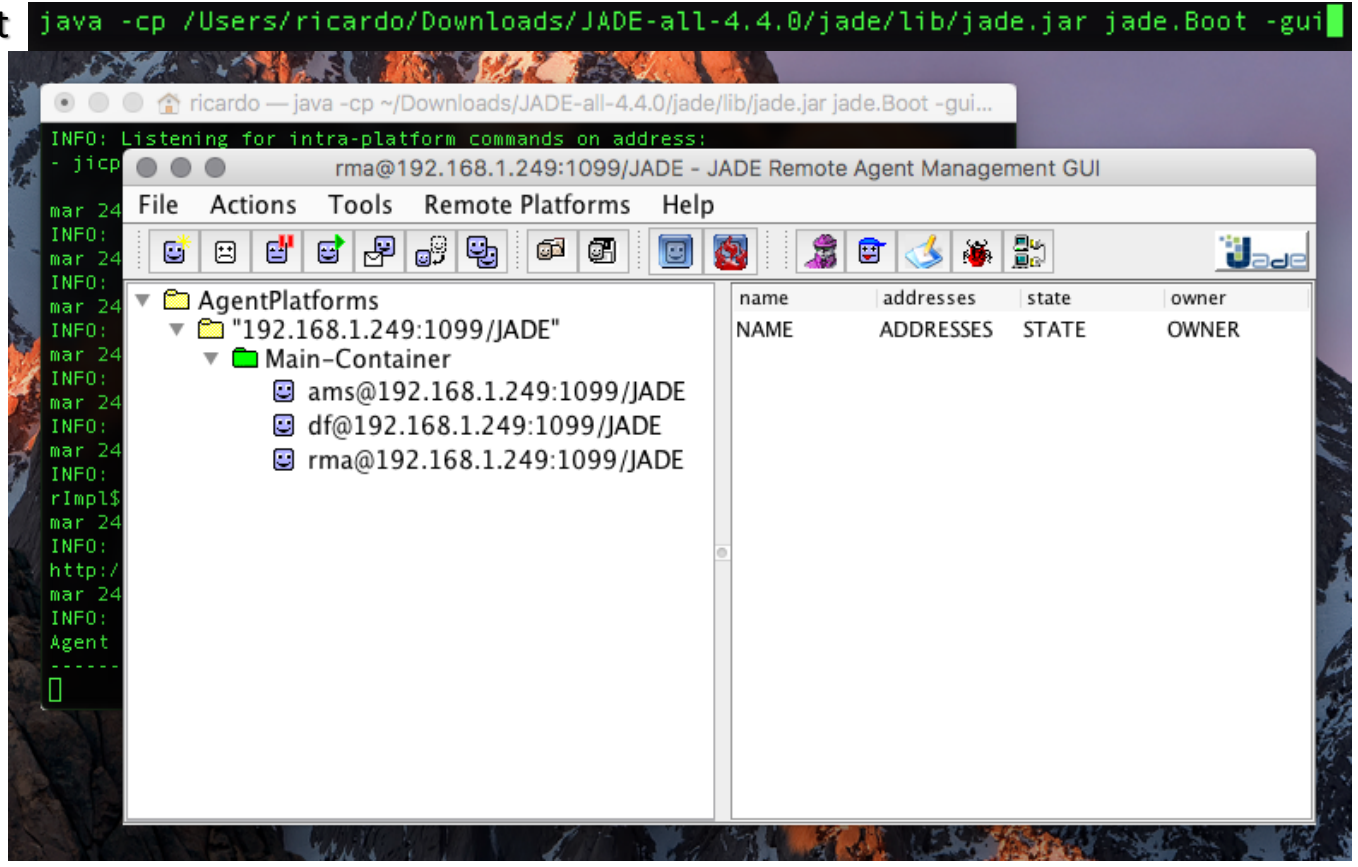


Run Configuration – Launch Main Container

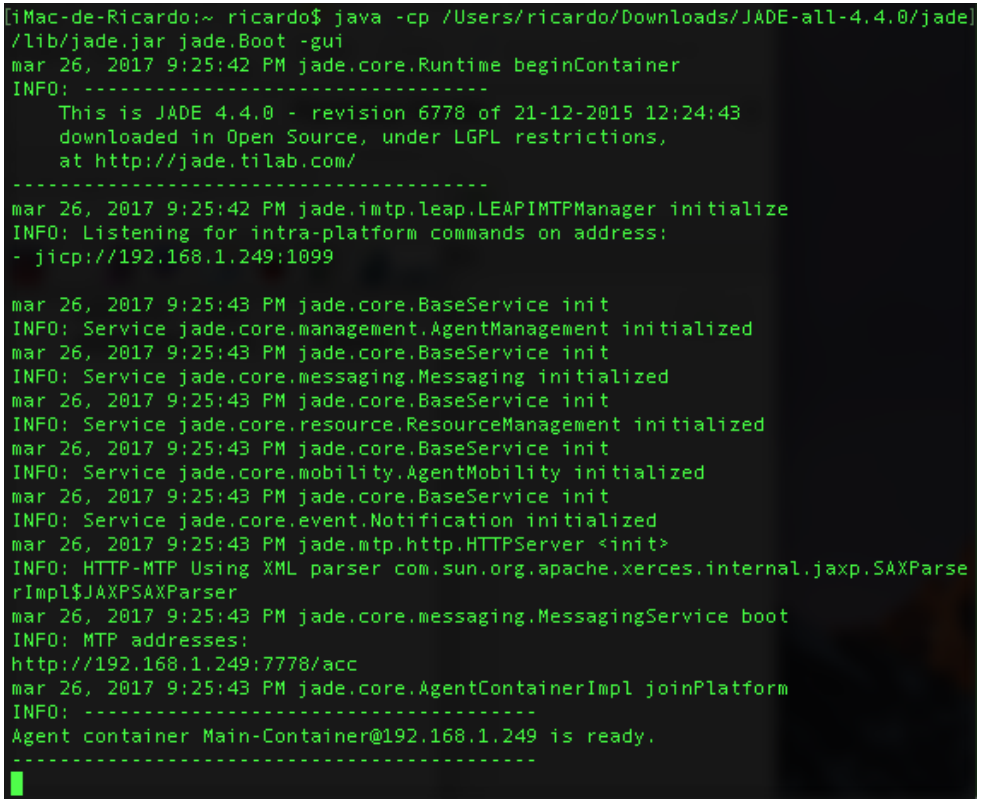


Run Configuration – Execute Agent in Container

Jade Start


java -cp /Users/ricardo/Downloads/JADE-all-4.4.0/jade/lib/jade.jar jade.Boot -gui
ricardo — java -cp ~/Downloads/JADE-all-4.4.0/jade/lib/jade.jar jade.Boot -gui...
INFO: Listening for intra-platform commands on address:
rma@192.168.1.249:1099/JADE - JADE Remote Agent Management GUI
File
Actions
Tools
Remote Platforms
Help
AgentPlatforms
"192.168.1.249:1099/JADE"
Main-Container
ams@192.168.1.249:1099/JADE
df@192.168.1.249:1099/JADE
rma@192.168.1.249:1099/JADE
name
addresses
state
owner
NAME
ADDRESSES
STATE
OWNER

Jade Start


iMac-de-Ricardo:~ ricardo$ java -cp /Users/ricardo/Downloads/JADE-all-4.4.0/jade/lib/jade.jar jade.Boot -gui
mar 26, 2017 9:25:42 PM jade.core.Runtime beginContainer
INFO: ----------------------------------
This is JADE 4.4.0 - revision 6778 of 21-12-2015 12:24:43
downloaded in Open Source, under LGPL restrictions,
at http://jade.tilab.com/
----
mar 26, 2017 9:25:42 PM jade.imtp.leap.LEAPIMTPManager initialize
INFO: Listening for intra-platform commands on address:
- jicp://192.168.1.249:1099
mar 26, 2017 9:25:43 PM jade.core.BaseService init
INFO: Service jade.core.management.AgentManagement initialized
mar 26, 2017 9:25:43 PM jade.core.BaseService init
INFO: Service jade.core.messaging.Messaging initialized
mar 26, 2017 9:25:43 PM jade.core.BaseService init
INFO: Service jade.core.resource.ResourceManagement initialized
mar 26, 2017 9:25:43 PM jade.core.BaseService init
INFO: Service jade.core.mobility.AgentMobility initialized
mar 26, 2017 9:25:43 PM jade.core.BaseService init
INFO: Service jade.core.event.Notification initialized
mar 26, 2017 9:25:43 PM jade.mtp.http.HTTPServer <init>
INFO: HTTP-MTP Using XML parser com.sun.org.apache.xerces.internal.jaxp.SAXParserImpl$JAXPSAXParser
mar 26, 2017 9:25:43 PM jade.core.messaging.MessagingService boot
INFO: MTP addresses:
http://192.168.1.249:7778/acc
mar 26, 2017 9:25:43 PM jade.core.AgentContainerImpl joinPlatform
INFO: --
Agent container Main-Container@192.168.1.249 is ready.

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