Agent Oriented Software Engineering (AOSE)

PROMETHEUS METHODOLOGY

ASSIGNMENT (due October 21 at class)

1. Give an example (from your project) of concept and its description (as per slides 28, 31, 32)
2. Define an agent from your project (as per slide 30)
3. Write the description (or draw a diagram or show an image) of a use case for your project.

For 1, 2, 3 above as well as for any part of the other assignments due October 21) prepare as well a .ppt slide for each to present at class for clarifying the way forward to accomplish your project.

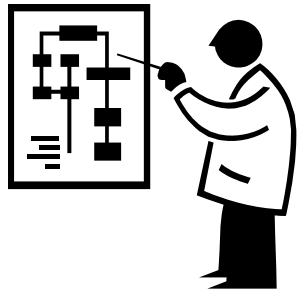
We will negotiate together on October 21 at class the expectations that I have from your projects.

Software Engineering

- “The establishment and use of sound engineering principles (methods) in order to obtain economically software that is reliable and works on real machines” (Bauer, F. L. *Software Engineering.* Information Processing 71., 1972)

Software Engineering

- "The computer science discipline concerned with developing large applications."; process, notation, ...
- Typical activities in developing a system:
  - Requirements
  - Analysis
  - Design
  - Implementation
  - …



Agent Oriented Software Engineering (AOSE)

- Software Engineering …
  - "We know how to do SE, how apply to agents?"
- … of Agent Oriented systems
  - "We know about agents and AI, how engineer large (agent) systems?"
- Relatively recent development (first AOSE workshop was in 2000)

Why not traditional SE?

- High level design differs for different programming paradigms, different abstractions:
  - Procedural: What does it do?
  - OO: What objects are there? (data+operations)
  - Agent: What **goals** are there? What are the **relationships** between agents?

Why not traditional SE?

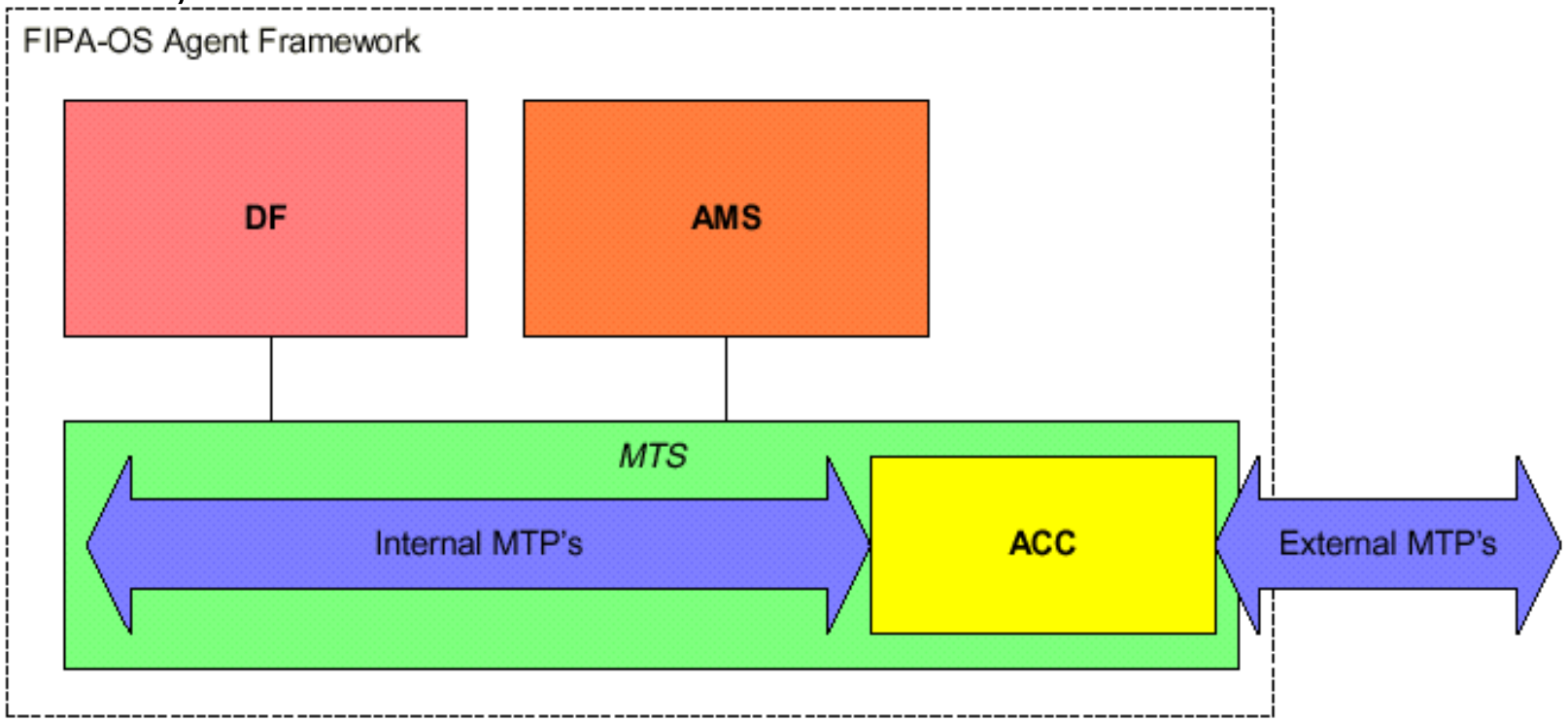
- Low level design differs since agent systems face uncertainty and failing actions:
  - Need to have alternative plans - can't assume things will work
  - Not monolithic single plans!

Software Engineering

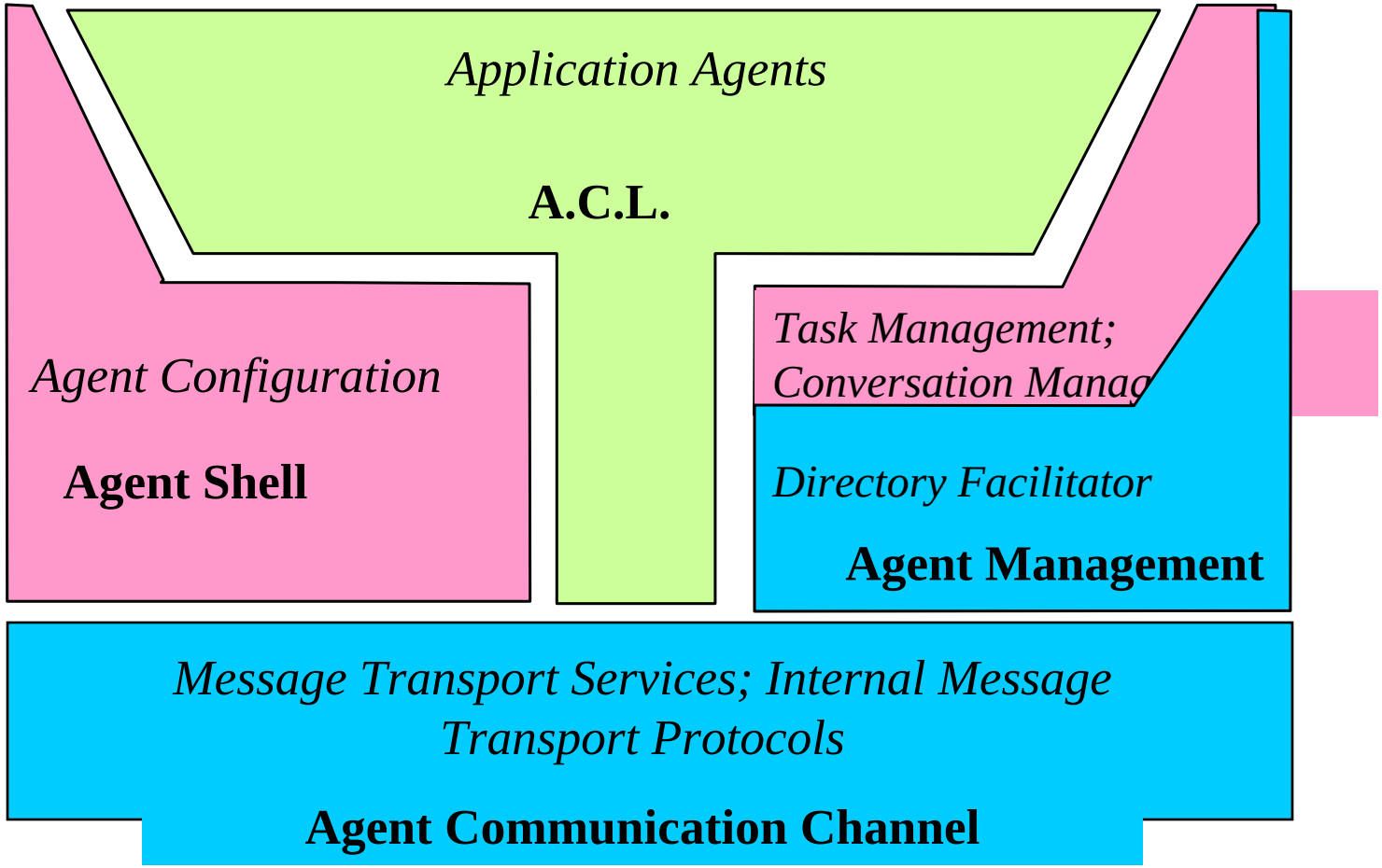
- Some principles
  - Modularity
  - Abstraction
- Process of developing software
  - Requirement analysis, design, testing,…
- Software Architecture

Core Platform Functionality (FIPA - mK)

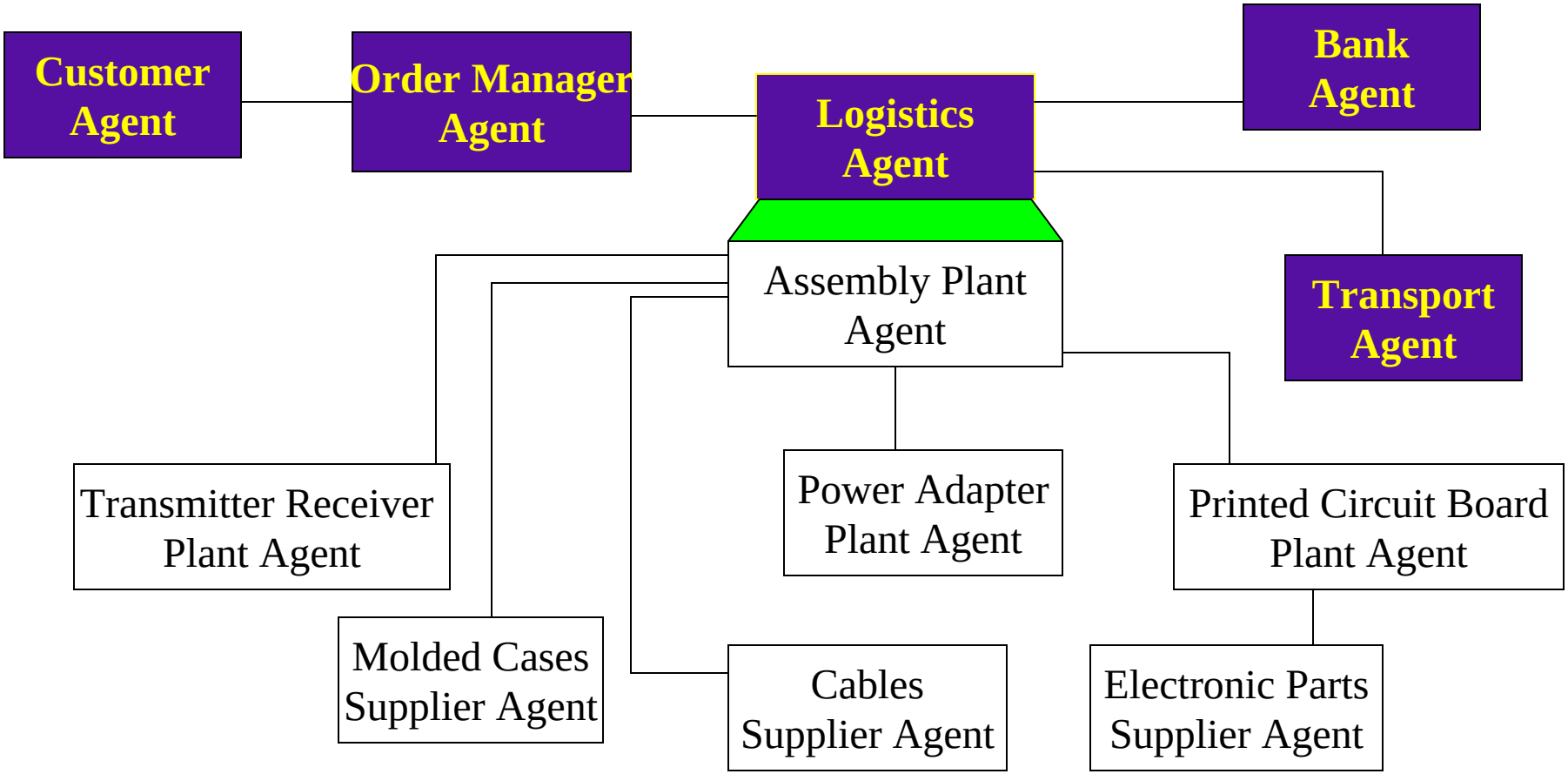
- a collection of services that are closely coupled
- provides an infrastructure where agents are deployed
- a FIPA-compliant AP consists of three agents:AMS, ACC,DF



FIPA-OS as Microkernel

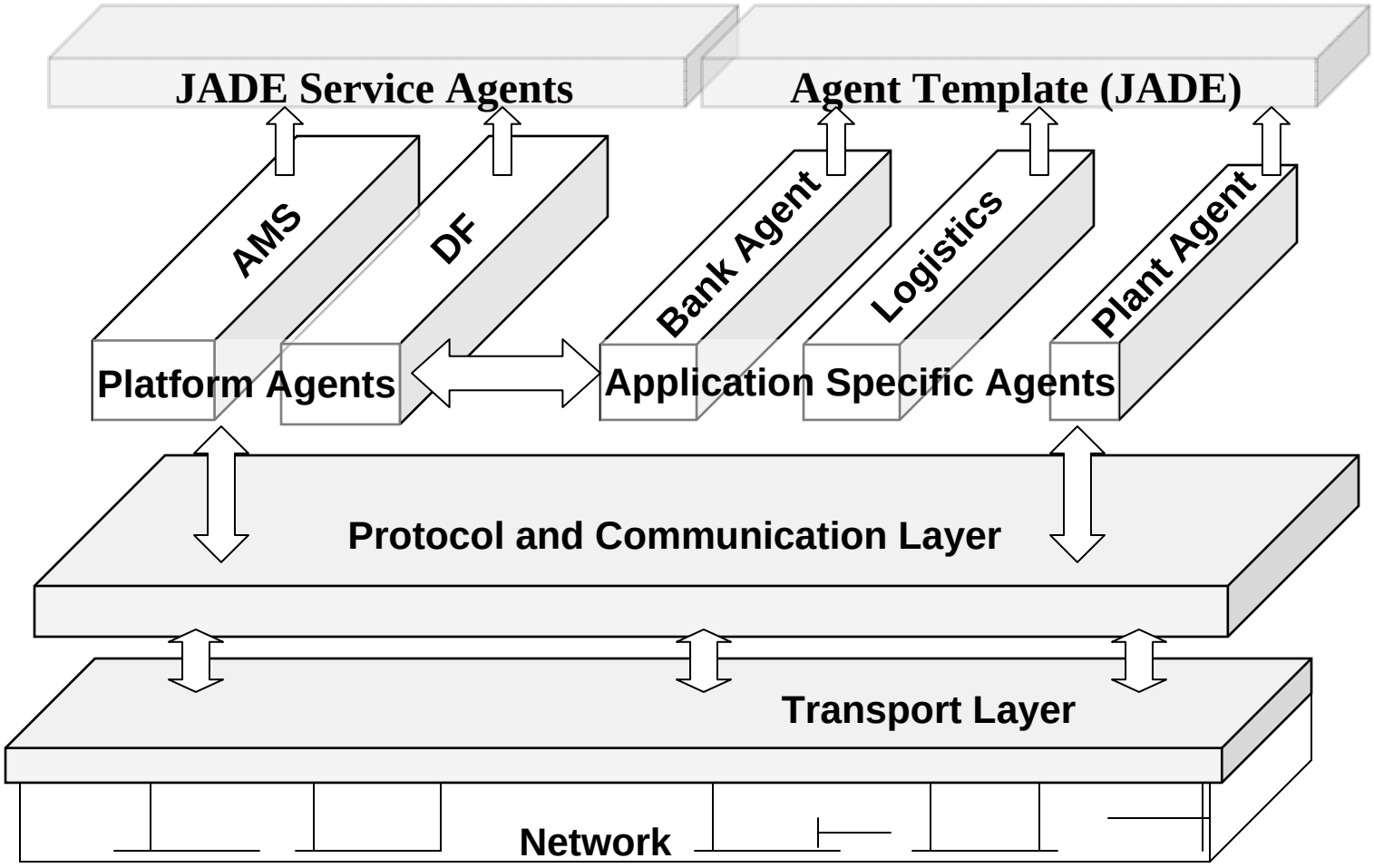


Supply Chain Scenario



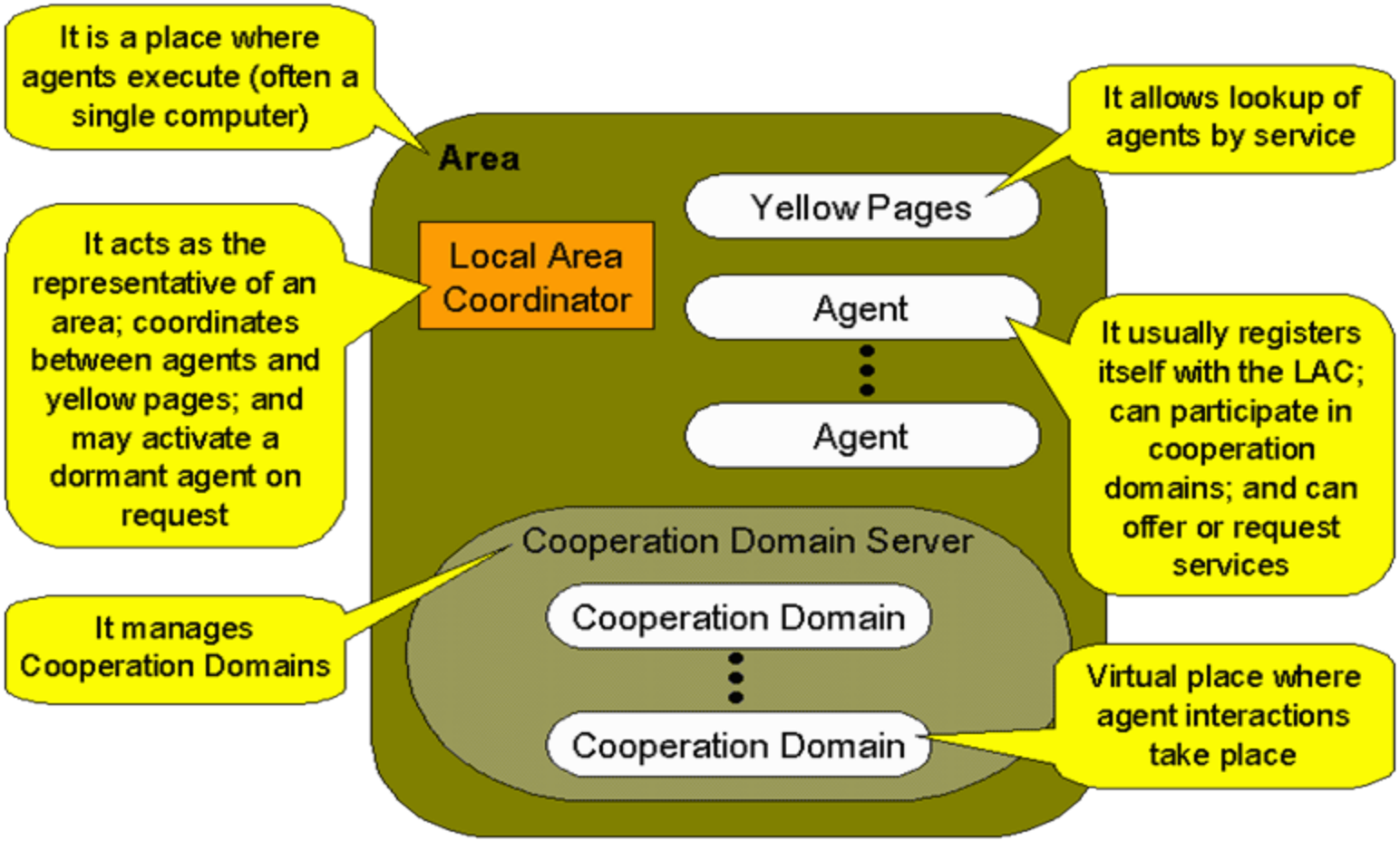
Agency Design

- **System Architecture**
- Agent Definitions
- Knowledge Modeling
- Agent Class Structure



THE COOPERATION-COMMUNICATION LAYER

- URL: [protocol://] [id@] host : port [/path]



Agents

- Definition

  "An agent is a system situated within and part of environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future."

- Agent properties
  - Autonomy—has control over its behavior
  - Re-activity—continuously observes and react to changes in its environment in timely fashion
  - Pro-activity—goal oriented
  - Sociality—communicate in a high-level way

Agents

- Contributors to agent research
  - Artificial intelligence
  - Object systems
  - Human-computer interface design
- Multi-agent systems
  - Agent communication languages
  - KQML & FIPA

The Problem

- Agents are a powerful technology with demonstrated potential
- But …
- Agent systems still scarce - why?

➔ Agents hard to develop

AOSE: Milestones

- **Agent-based computing** is a synthesis of both Artificial Intelligence (AI) and Computer Science
- An **agent** is an *encapsulated* ***computer system*** that is situated in some *environment* and that is capable of *flexible, autonomous action* in that environment in order to meet its *design objectives*
- Agents are being advocated as a next generation model for engineering *open, complex, distributed* systems
  - *Open:* components can join or leave the dynamic operating environment and the operating conditions change in unpredictable ways
  - *Complex:* the software has a large number of **components** that interact following complex **interaction protocols**; every agent has a **partial view** of the environment and there is **no centralized control**

AOSE: Challenges

- In real-world applications the environment is open, complex and dynamic. As a consequence,
  - **Interaction** among components cannot be completely foreseen at compile-time
  - The system's inherent **organizational structure** must be explicitly represented
- We need the right abstractions, methodologies and instruments to correctly engineer applications of this kind

Agent-Oriented Software Engineering [Jen00]

- The case for agent orientation to software engineering
  - **Agent-oriented decomposition** is an effective way of partitioning a problem space
  - **Agent 'mindset'** (agent, interactions, and organizational relationships) are a natural means for modeling complex systems

Agent-Oriented Software Engineering

- Problems of agent-based approaches to software engineering
  - Unpredictable patterns and outcomes of the interactions
  - Difficult (or impossible) to predict the behavior of the overall system based on its constituent components

Agent Modeling Tools

- UML – unsuitable for agent modeling
- Two major extensions to UML
  - AUML – extends UML specifically it extends UML interaction diagrams to support agent protocols
  - AML – extends UML and uses concepts from AUML, OWL, MESSAGE, FIPA-S…

Methodologies

- Methodologies based on agent theory
- Extensions of object-oriented methodologies
- Methodologies based on knowledge engineering
- Hybrid methodologies

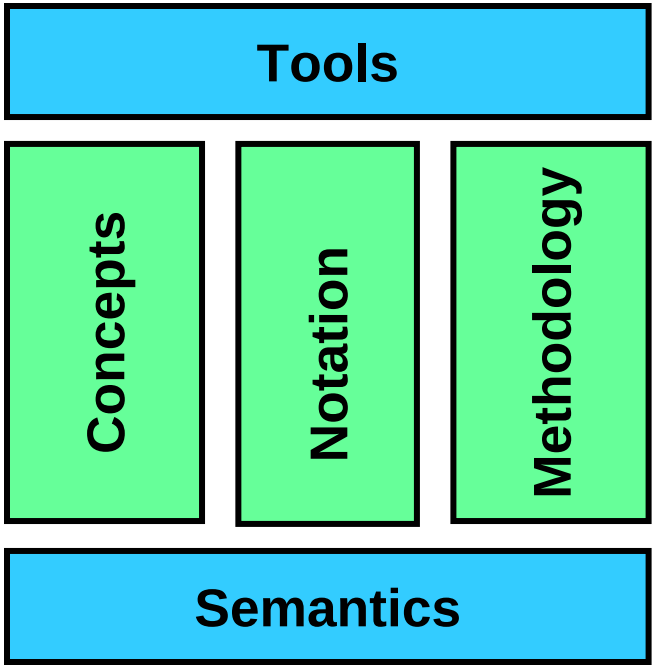
AOSE

To make developing intelligent agents easier (without losing the power of the BDI model).

"Easy things should be easy, hard things should be possible"

Target audience: professional developers or senior undergrads

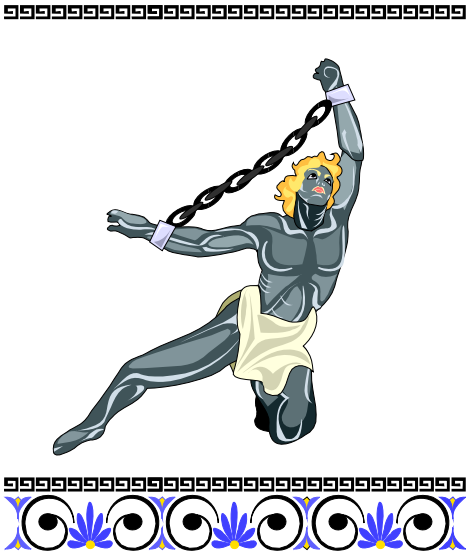
BDI = belief, desire, intention



The Prometheus Methodology

(Padgham & Winikoff)

- Supports the development of *intelligent* agents
- "start-to-end" support
- Detailed process and products
- Evolved out of practical industrial and pedagogic experience
- Has been used
- Hierarchical structuring: scales to large designs
- Cross checking



Prometheus was the wisest Titan. His name means "forethought" and he was able to foretell the future. Prometheus is known as the protector and benefactor of man. He gave mankind a number of gifts including fire. (*http://www.greekmythology.com/*)

Methodology

- Concepts (what are we talking about? E.g. object, class, inheritance for OO)
- Models (and a notation to express them)
  - Static - system structure
  - Dynamic - system behaviour
- Process (for generating/deriving models)

- Other: tools, software engineering (coupling, cohesion, abstraction …)

Agent Concept Soup

team

task

obligation

behaviour

desire

goal

commitment

protocol

belief

role

time

percept

action

situation

intention

resource

event

Knowledge base

capability

aim

plan

choice

decision

world

state

objective

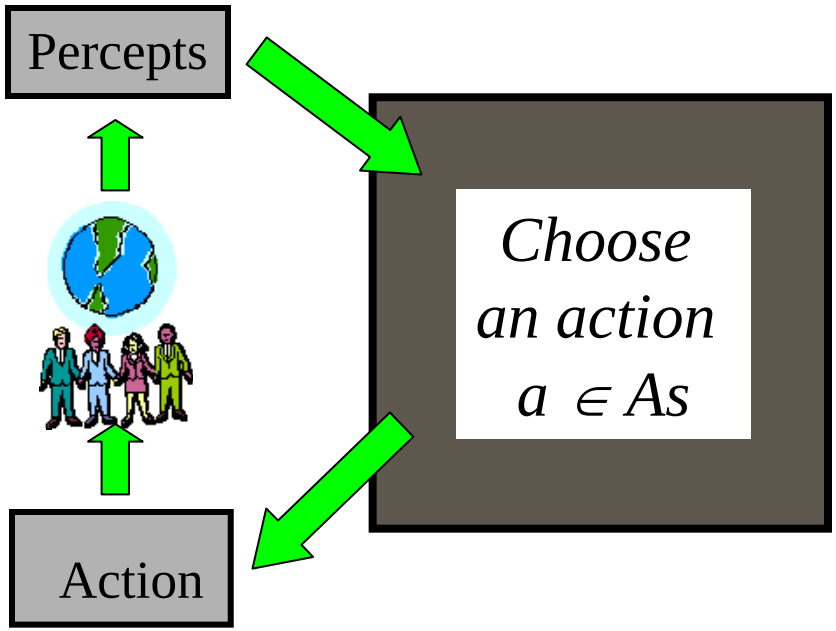
AOSE regarded as a software methodology for the real-world

- Agent: **autonomous**, **situated** in an environment
- Real world: dynamic, uncertain, non-deterministic …things *will* go wrong
- An intelligent agent blends **pro-active** & **reactive** behaviour:

- Also flexible, robust, rational, social, …

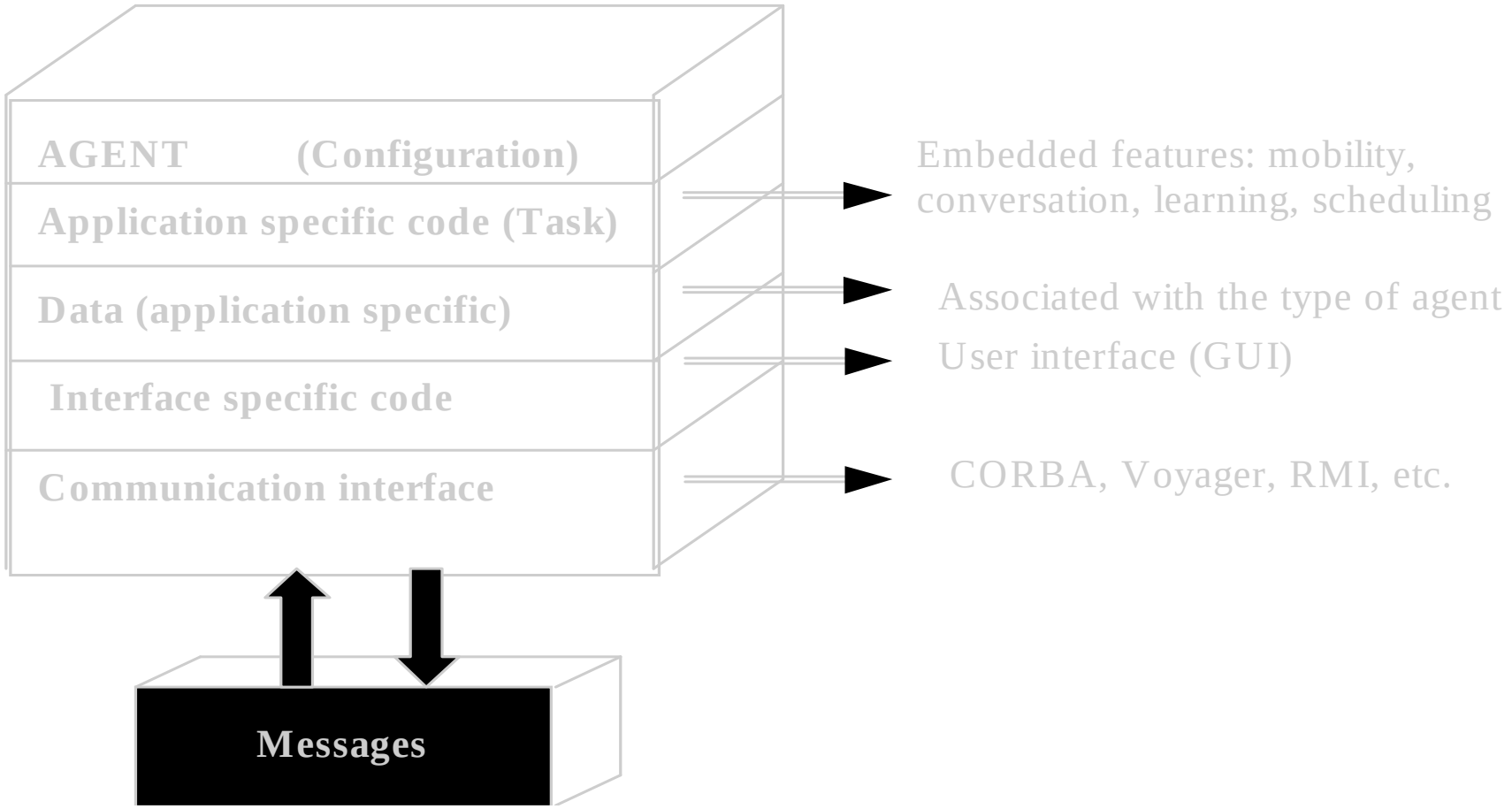
Agent Concepts

- *Situated* so **actions**, **percepts**, time
- Fire engine:
  - *See nearby fires & road conditions, hear messages from other agents, hear civilian calls for help.*
  - *Move, squirt, tell (broadcast), say, plan route (internal)*



- Software Agents
- Agent Structure
- Multi Agent Systems

Agent Oriented Concepts



Agency Design

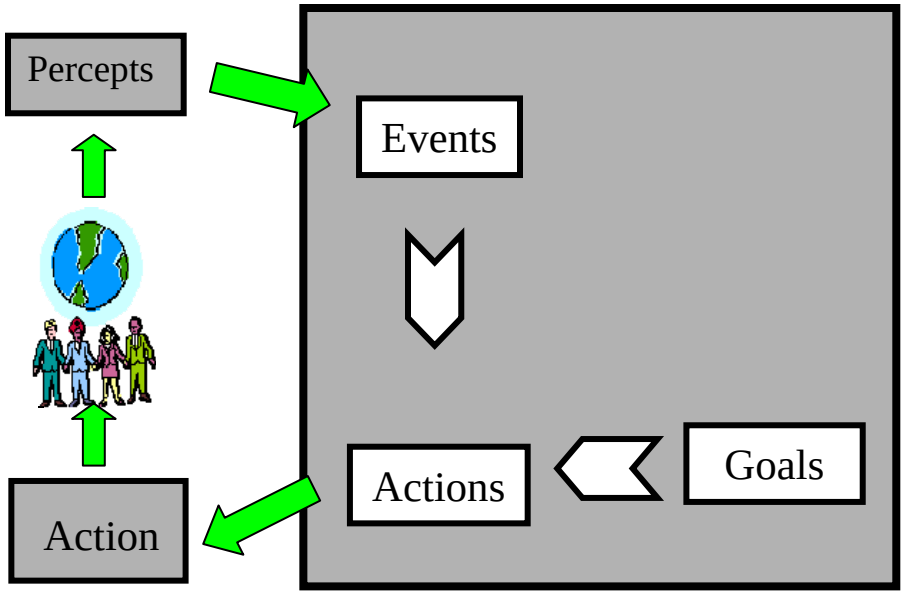
- System Architecture
- **Agent Definitions**
- Knowledge Modeling
- Agent Class Structure

- The agents are defined and their responsibilities are presented.
- Example:

Role Schema:	**Manufacturer Agents**
Description: Manufacturers represent providers of components to the Assembly plant consumer of resources (parts) provided by suppliers	
Protocols: FIPA REQUEST and FIPA ITERATED CONTRACT NET	
Responsibilities: To respond to requests to supply the required components, to initiate request for needed parts, to transfer the required components, to receive and consume resources, to be aware of suppliers of parts and their capabilities, to participate in negotiations about the terms of acquiring and/or supplying a specified resource	

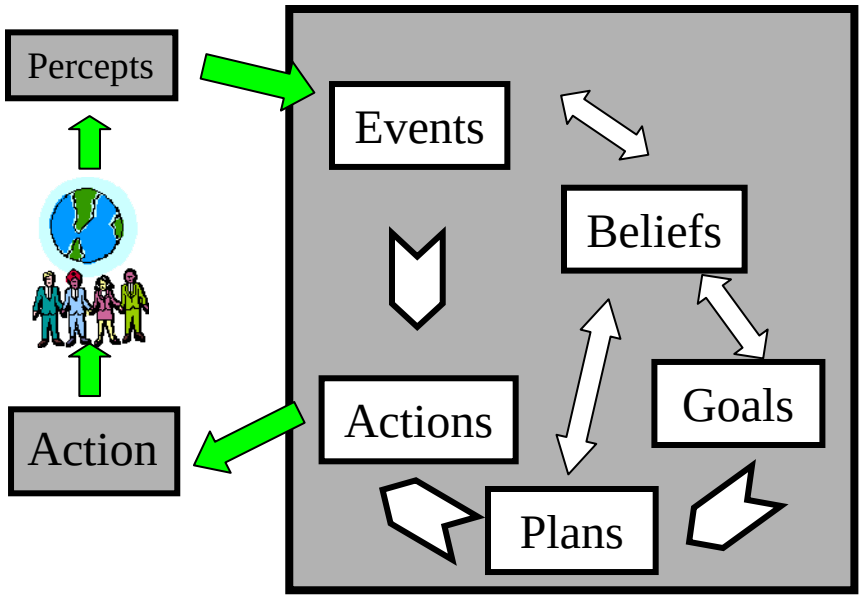
Agent Concepts

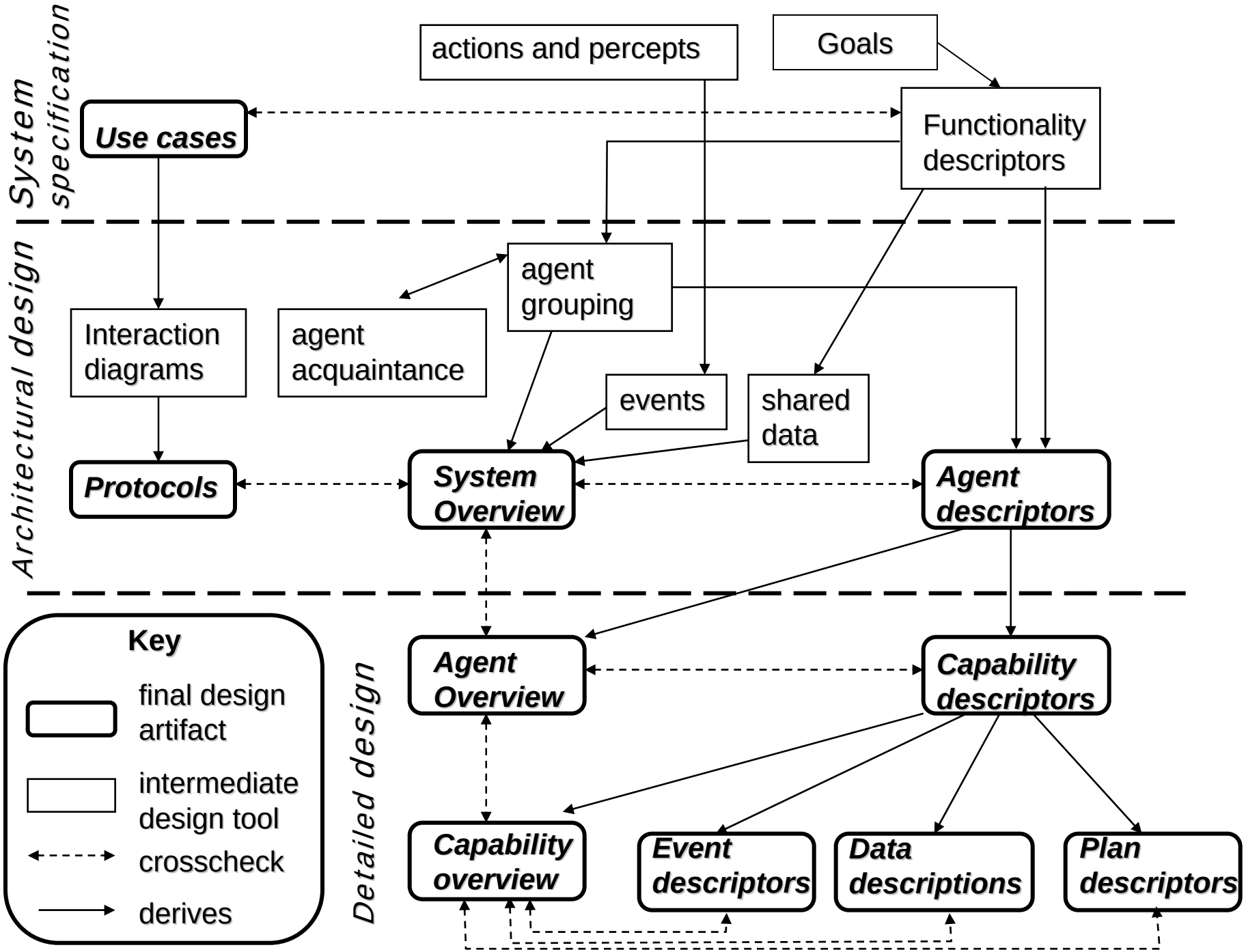
- *Reactive* so **events** (significant occurrence)
  - *New fire, fire extinguished, fire urgent, help requested*
- *Proactive* so **goals**
  - *Put out fire, discover fire, assist, coordinate*



Agent Concepts

- Implementation uses **plans** and **beliefs**
  - Cache for means, and world information respectively
  - *Beliefs: Map (incl. fires, buildings), fire assignment and priority*
  - *Plans: Put out fire, roam, …*



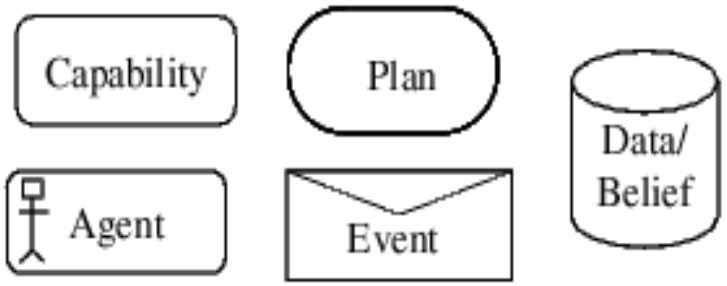

System specification
Architectural design
Detailed design
actions and percepts
Goals
Use cases
Functionality descriptors
agent grouping
Interaction diagrams
agent acquaintance
events
shared data
Protocols
System Overview
Agent descriptors
Agent Overview
Capability descriptors
Capability overview
Event descriptors
Data descriptions
Plan descriptors
Key
final design artifact
intermediate design tool
crosscheck
derives

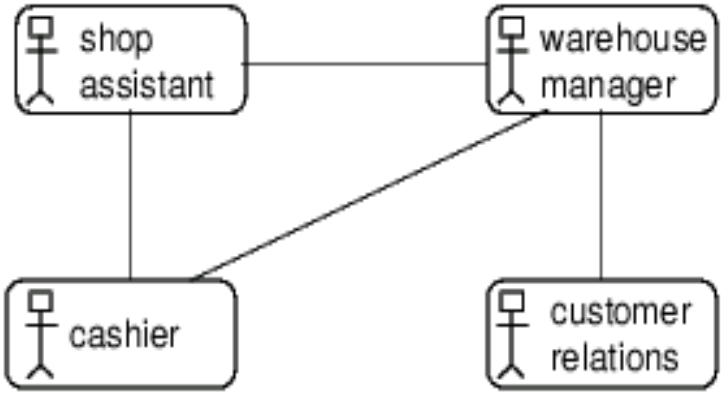
AOSE: Prometheus (2)

- **SYSTEM SPECIFICATION:**
  - In this stage "percepts" and "actions" that characterize the agent's interaction with the environment are defined
  - **Functional descriptors** that contain a name, description, actions, percepts, data used, and produced and a description of interactions are defined
  - **Use cases:** contain an identification number, a natural language overview, an optional field context, the scenario , a summary of all the *information used, and a list of small variants*

AOSE: Prometheus (3)

- **ARCHITECTURAL DESIGN:**
  - During this stage the following activities are performed**:**
    - Identification of which agents should belong to the MAS
    - identification of groups of agents which share the same functionalities
    - identification of the **agent acquaintance diagram** which defines the links among interacting agents

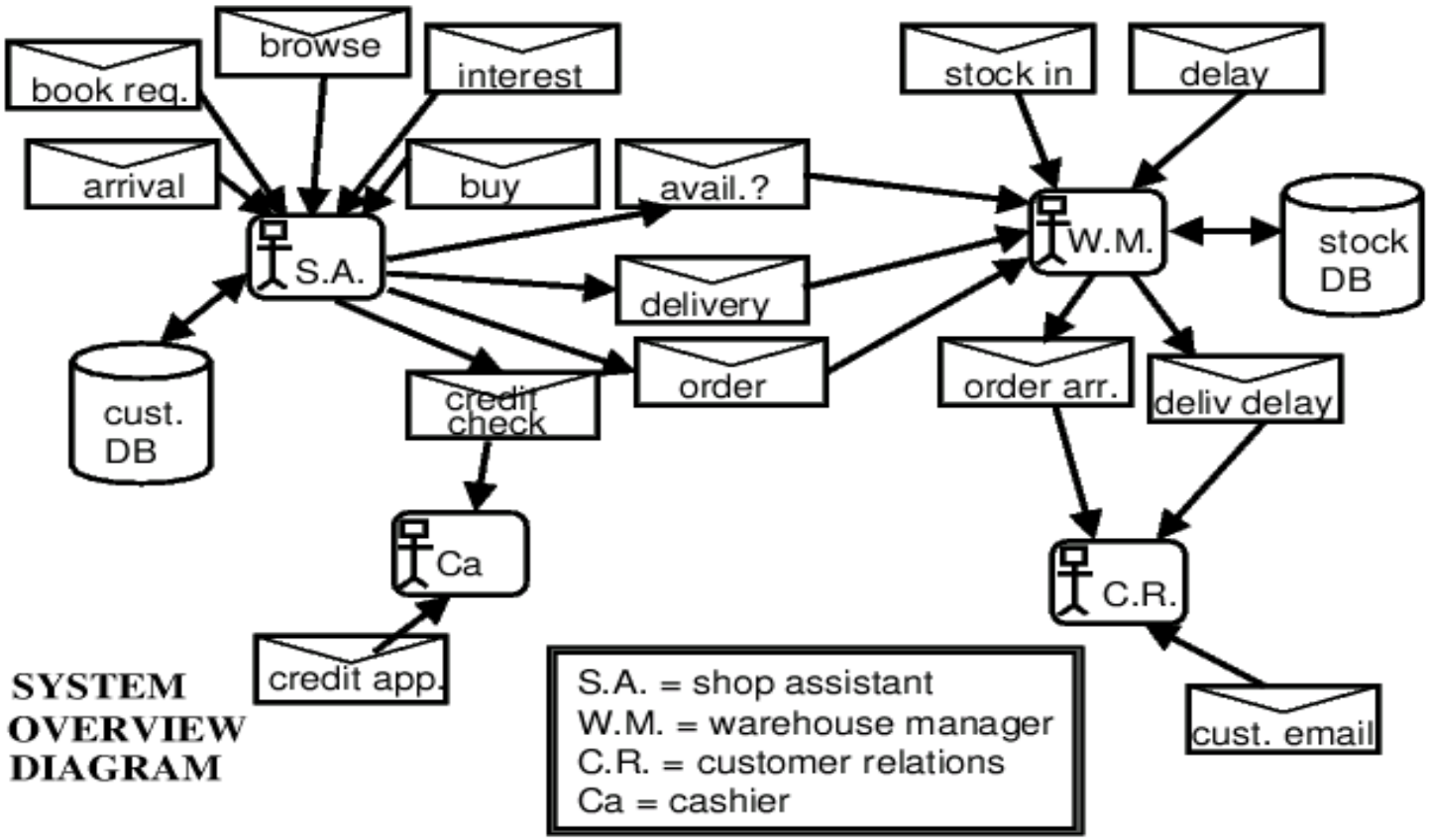




AOSE: Prometheus (4)

- ⌘ definition of the **agent descriptors**, characterized by name, description, cardinality, functionalities, reads data, writes data, interacts with
- ⌘ definition of the **events**, messages and shared data objects

- identification of the **system overview diagram** which ties together agents, events and shared data objects
- definition of the **interaction diagrams** and **interaction protocols** using AUML



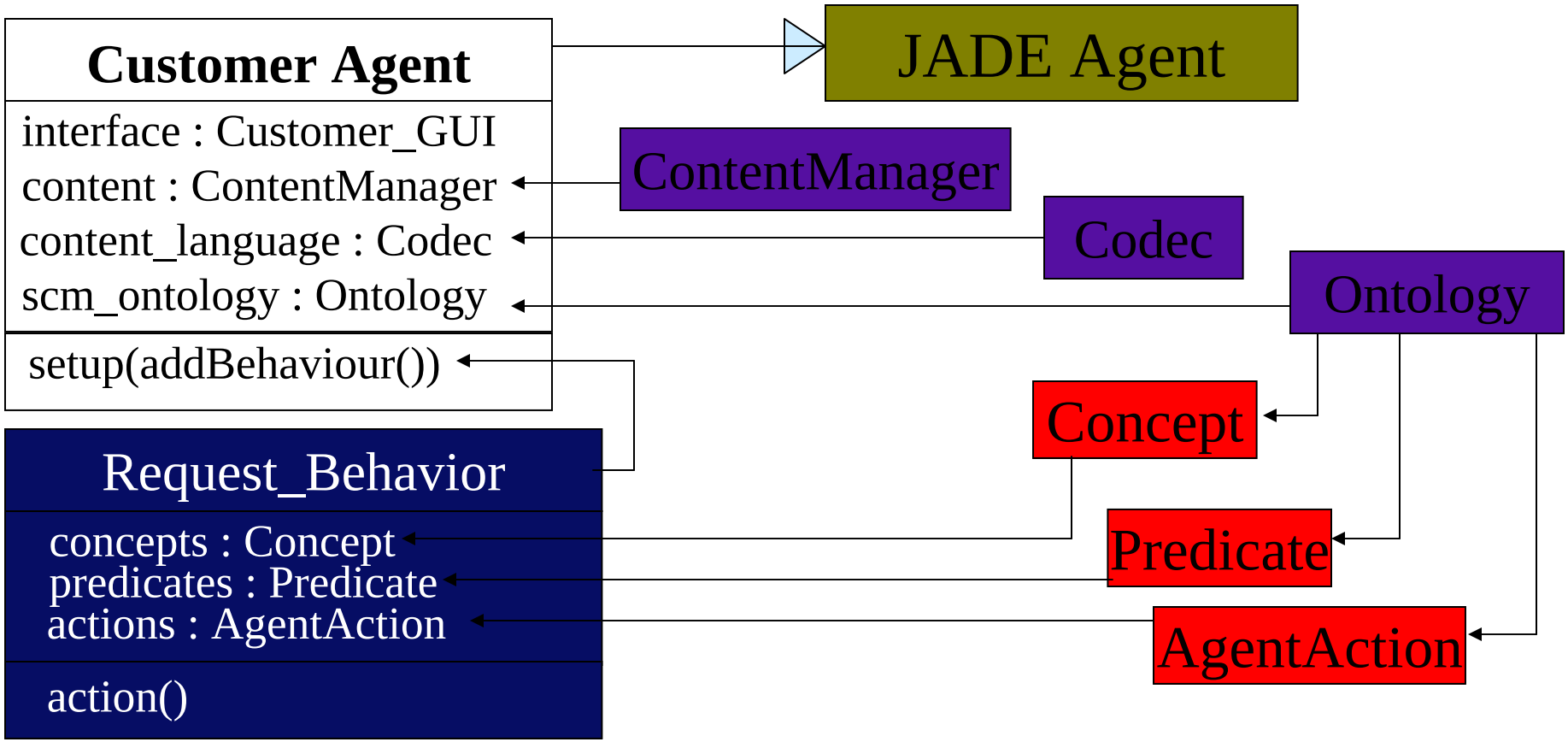
AOSE: Prometheus (5)

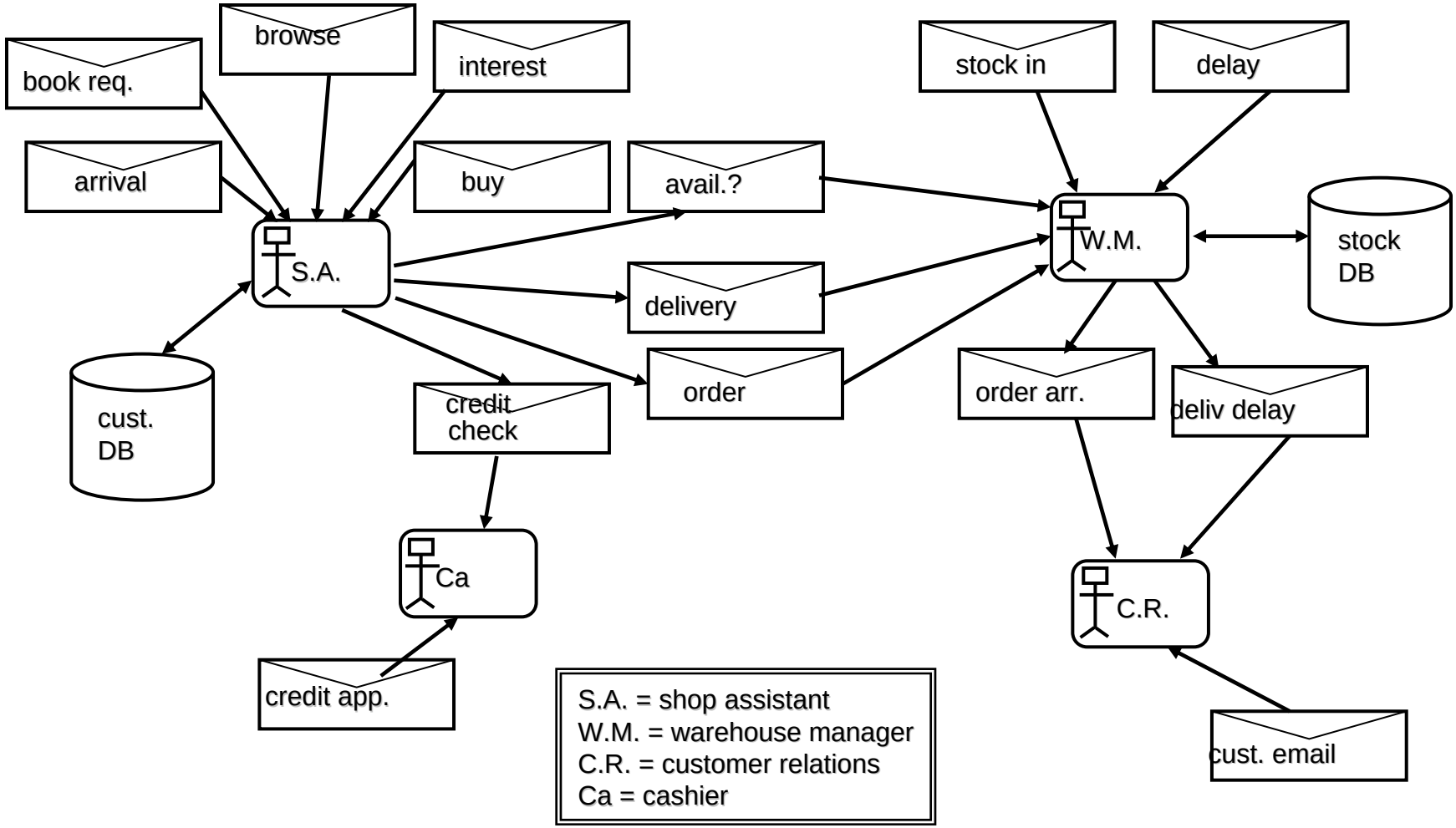
❑ DETAILED DESIGN:

- ⌘ Focuses on developing the internal structure of each agent and how it will achieve its task within the system
- ⌘ The developer must define capabilities, internal events, plans and detailed data structures
- ⌘ **Capability descriptor:** contains inputs and produced events, a description of functionality, a name, interactions with other capabilities, inclusions and a reference to read and write data
- ⌘ **Agent overview diagram:** shows capabilities within an agent
- ⌘ ***Capability overview diagram:*** takes a single capability and describes its features
- ⌘ The final design artifacts are the **individual plan, even and data descriptors**
- ⌘ ***The Plan descriptor*** provides an identifier, the triggering event type, the plan steps, a context and a list of data read and written

Agency Design

- System Architecture
- Agent Definitions
- Knowledge Modeling
- **Agent Class Structure**





Static Structure

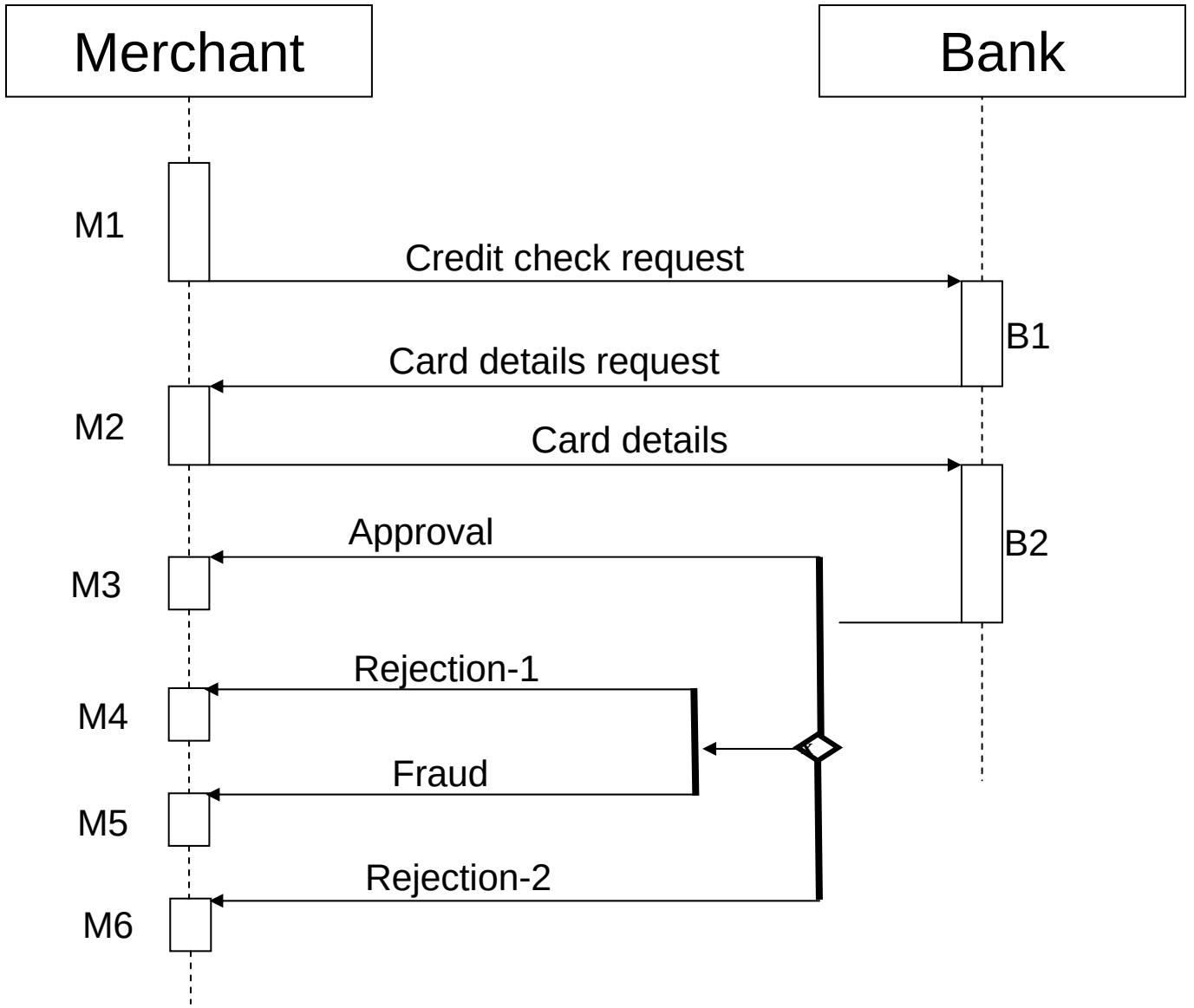
Capability

Plan

Agent

Event

Data/ Belief



Dynamic behavior (Agent-UML)

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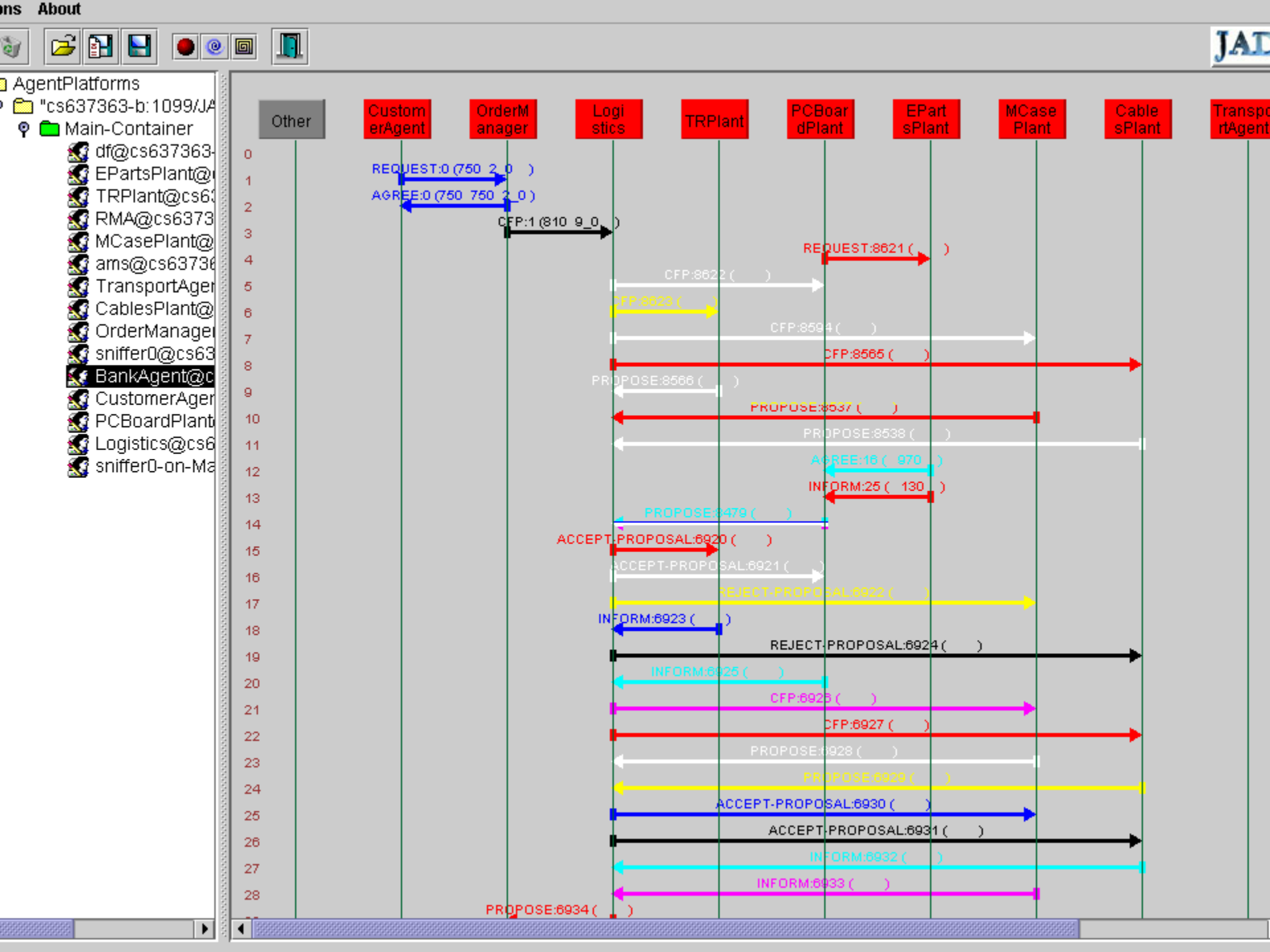
AgentPlatforms
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Main-Container
df@cs637363-
EPartsPlant@
TRPlant@cs6
RMA@cs6373
MCasePlant@
ams@cs6373
TransportAger
CablesPlant@
OrderManage
sniffer0@cs63
BankAgent@c
CustomerAger
PCBoardPlant
Logistics@cs6
sniffer0-on-Ma
Other
CustomerAgent
OrderManager
Logistics
TRPlant
PCBoardPlant
EPartsPlant
MCasePlant
CablesPlant
TransportAgent
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AGREE:0 (750 750 2 0)
CFP:1 (810 9 0)
REQUEST:8621 ( )
CFP:8622 ( )
CFP:8623 ( )
CFP:8624 ( )
CFP:8565 ( )
PROPOSE:8566 ( )
PROPOSE:8537 ( )
PROPOSE:8538 ( )
AGREE:16 (970)
INFORM:25 (130)
PROPOSE:6479 ( )
ACCEPT-PROPOSAL:6920 ( )
ACCEPT-PROPOSAL:6921 ( )
REJECT-PROPOSAL:6922 ( )
INFORM:6923 ( )
REJECT-PROPOSAL:6924 ( )
INFORM:6925 ( )
CFP:6926 ( )
CFP:6927 ( )
PROPOSE:6928 ( )
PROPOSE:6929 ( )
ACCEPT-PROPOSAL:6930 ( )
ACCEPT-PROPOSAL:6931 ( )
INFORM:6932 ( )
INFORM:6933 ( )
PROPOSE:6934 ( )

Tool support for Methodology