The background of the slide features a repeating pattern of stylized human figures in white outlines against a light green background. The figures are arranged in a grid-like fashion, with some appearing to be in motion or interacting. The figures have circular heads and rectangular bodies with simple limbs.

# Environment as a First-Class Abstraction in Multiagent Systems

Danny Weyns, Andrea Omicini, James Odell  
EUMAS 2006. Lisbon

# Aim of this Talk?

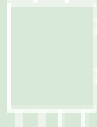
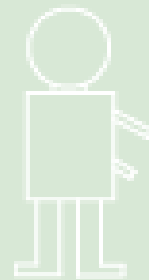
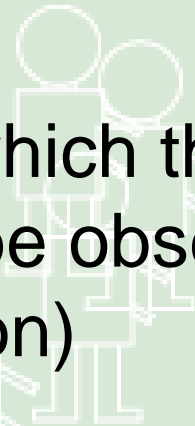
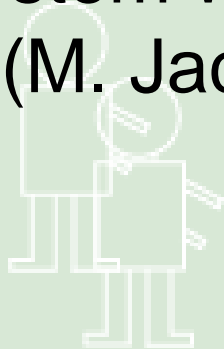
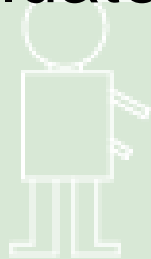
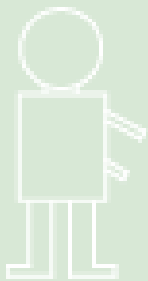
- What is the environment in MAS about?
- Putting forward the environment as an explicit part in MAS engineering
- Showing that the environment as an explicit part in MAS engineering
  - improves engineering practice
  - provides a powerful means to engineer MAS

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# What is the Environment in MAS about?

- What is the environment for a software system in general?
  - “Part of the world in which the effects of the software system will be observed and evaluated” (M. Jackson)

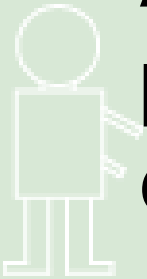


# What is the Environment in MAS about?

- What is specific for MAS?
  - MAS = decentralized system
  - Agents are just individual loci of control
  - To build useful system agents should be able to coordinate their behavior
    - not only indirectly through the manipulation of external resources in the environment
  - Environment should provide (at least) the means for agents to interact

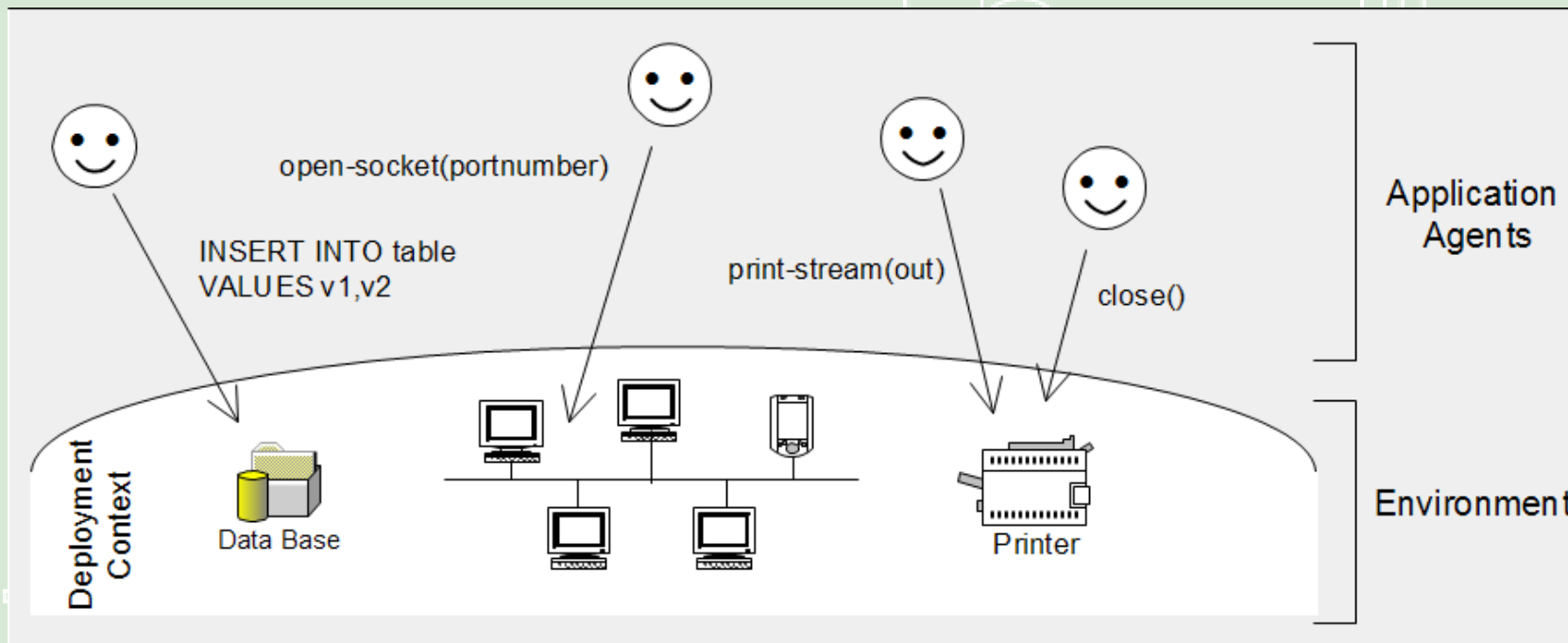
# What is the Environment in MAS about?

- Interaction is typically considered as message exchange
- Additional system responsibilities can be assigned to the environment
- An overview of levels of support provided to the agents by the environment...



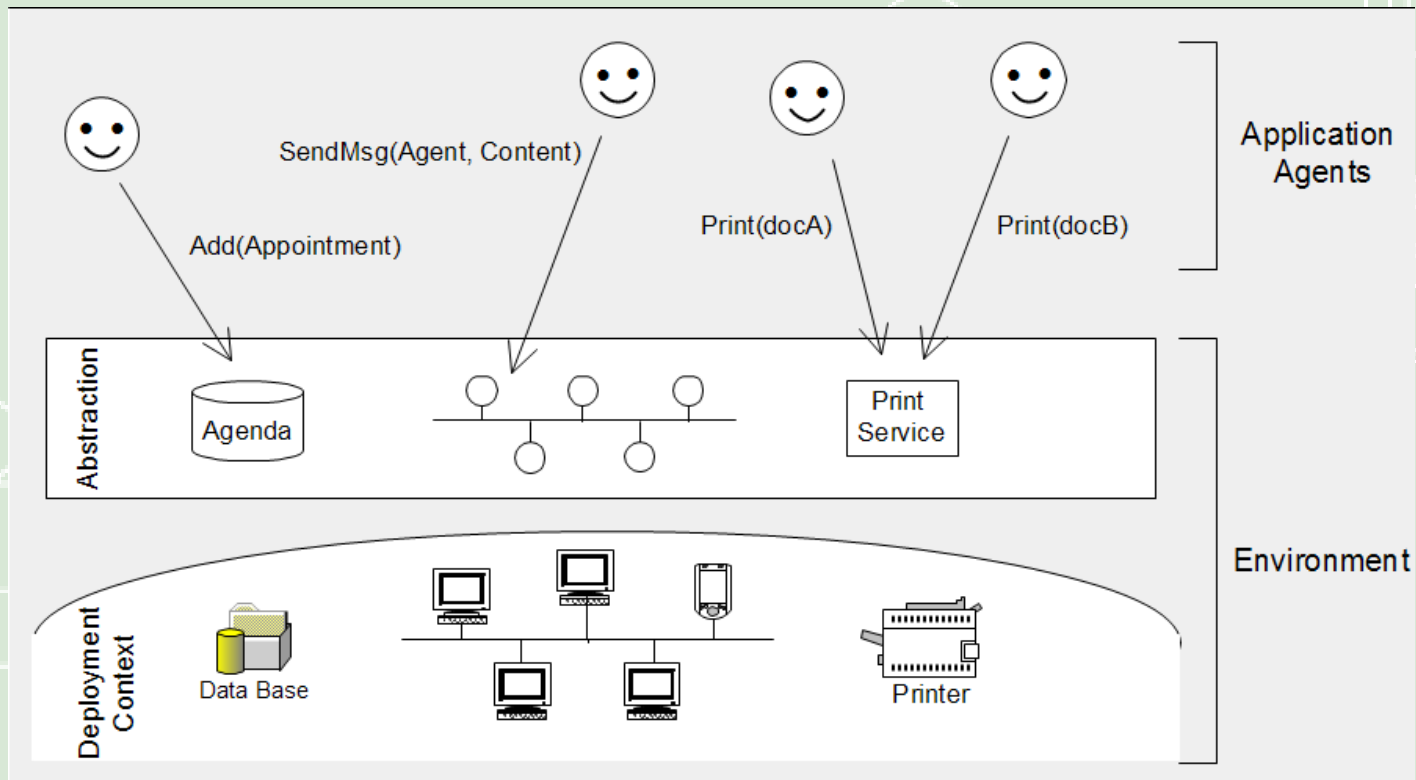
# Levels of support provided by the environment in MAS

- “Basic level”



# Levels of support provided by the environment in MAS

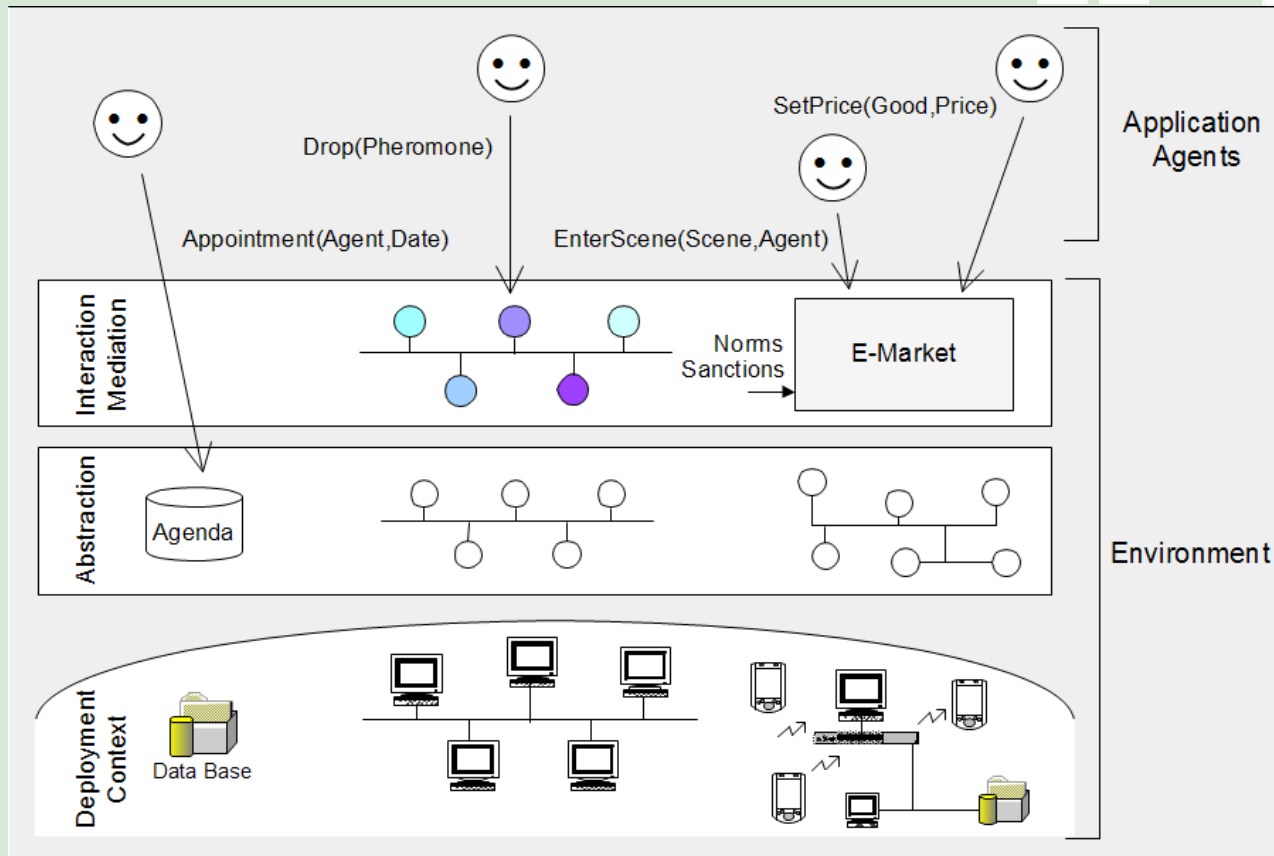
- “Abstraction level”





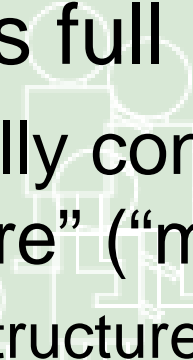
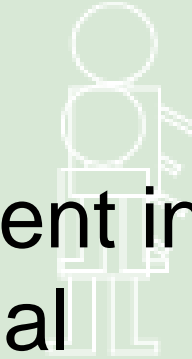
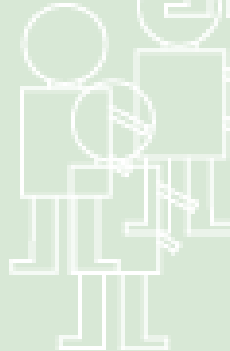
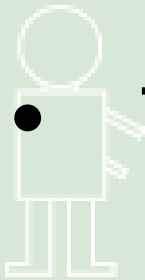
# Levels of support provided by the environment in MAS

- “Interaction-mediation level”



# Levels of support provided by the environment in MAS

- These perspectives on environment in MAS do not exploit its full potential
  - Environment is typically considered as “reusable infrastructure” (“middleware”)
    - Communication infrastructure, pheromone infrastructure, etc.
- This leads to a number of problems...



# Environment as Reusable Infrastructure

1. Hampers flexible assignment of responsibilities among agents and the environment

⇒ This often results in very complex agents

2. Infrastructure typically accounts for particular set of responsibilities

– Communication infrastructure, pheromone infrastructure, electronic institutions,...

⇒ The rest of the responsibilities are often handled in ad-hoc manner, or even worse, are handled by “agents”

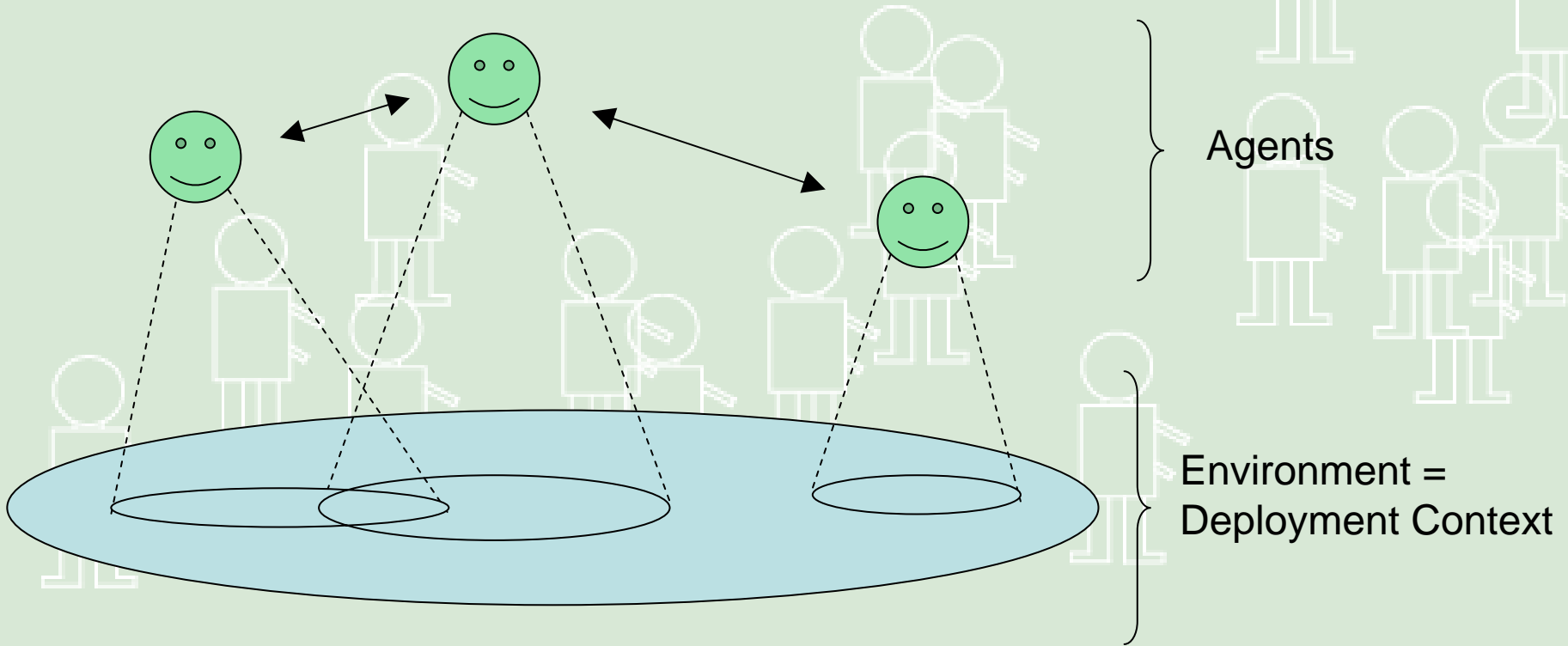
3. Solution may benefit from integration of different kinds of approaches

# Aim of this Talk?

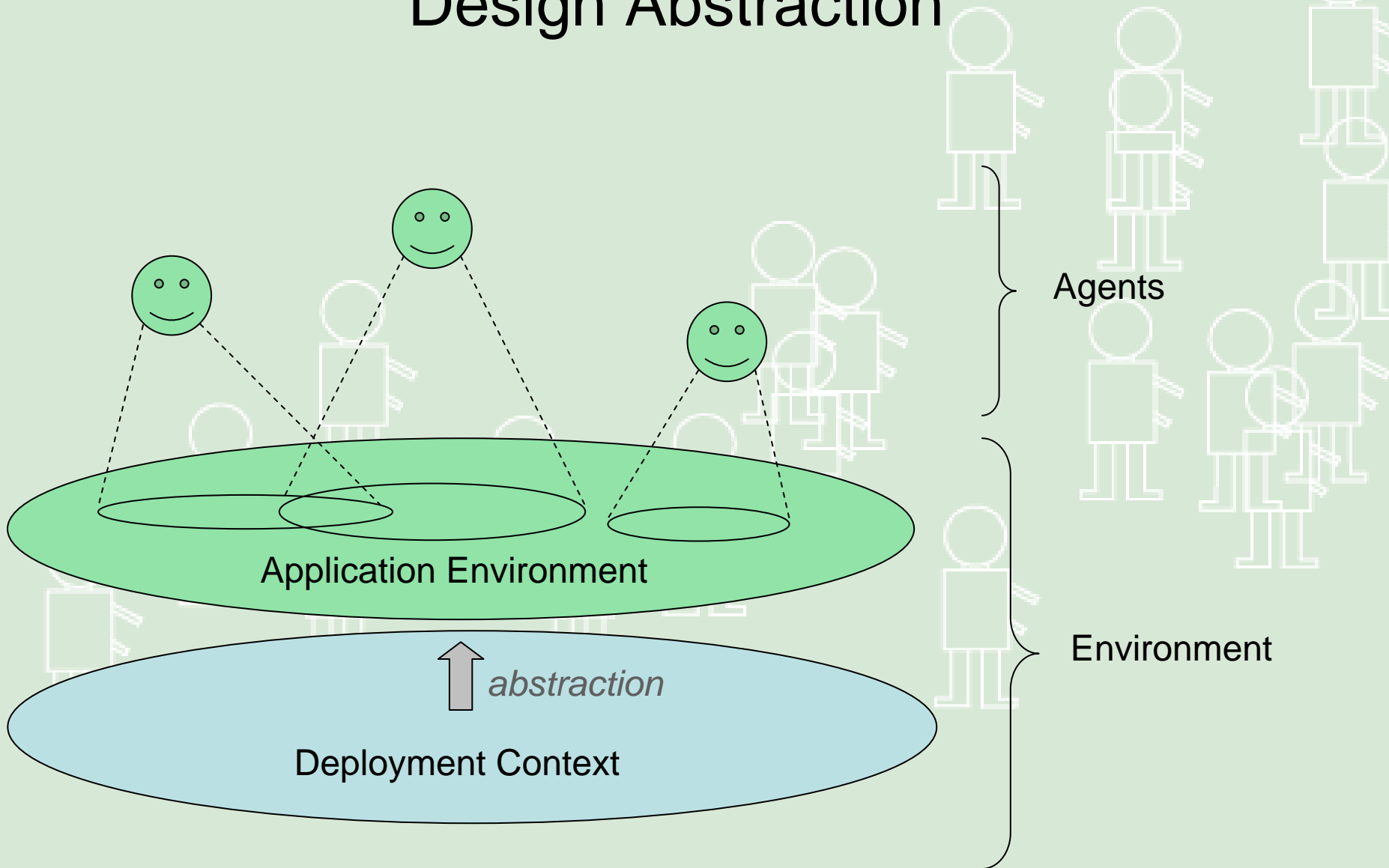
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# Environment as a First-Class Abstraction in MAS

## Common Perspective on MAS



# Application Environment as a Design Abstraction



# Application Environment as a Design Abstraction

## To be designed

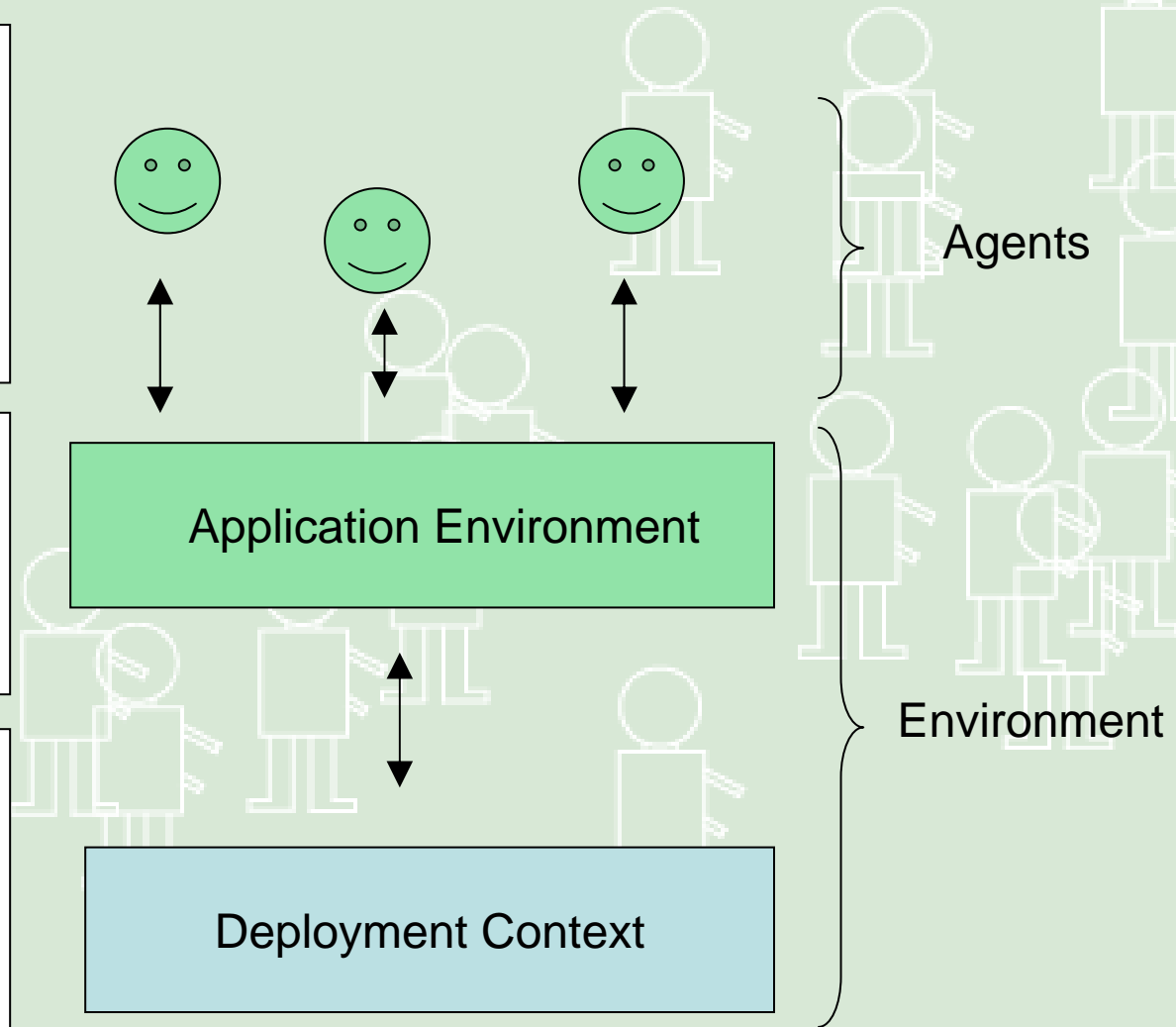
- Decision making entities
- Act in the environment
- Interact through the environment

## To be designed

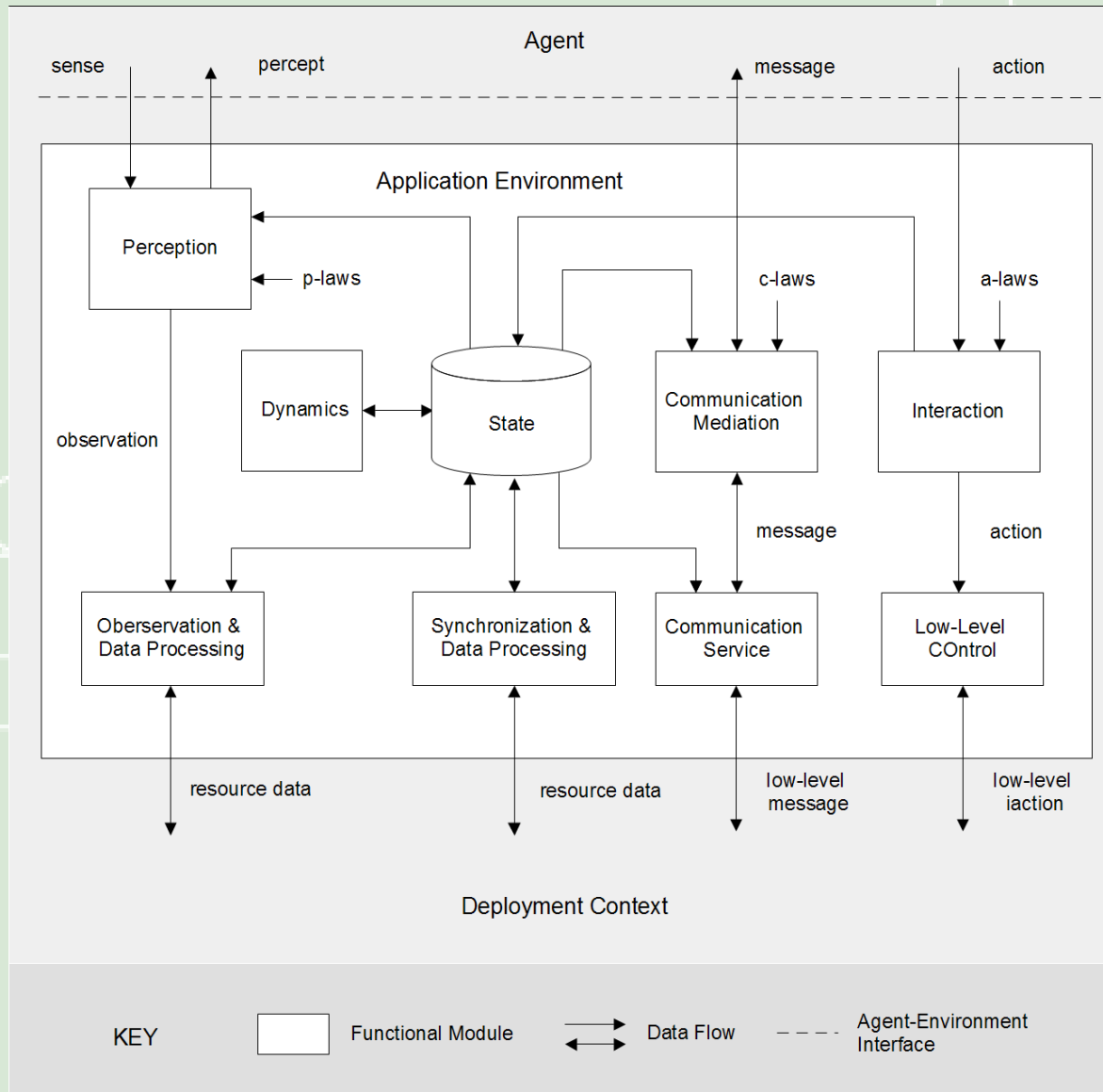
- Abstraction of deployment context
- Interaction mediation

## Given

- Part of the world where problem has to be solved
- Resources external to the system



# Reference Model of Application Environment





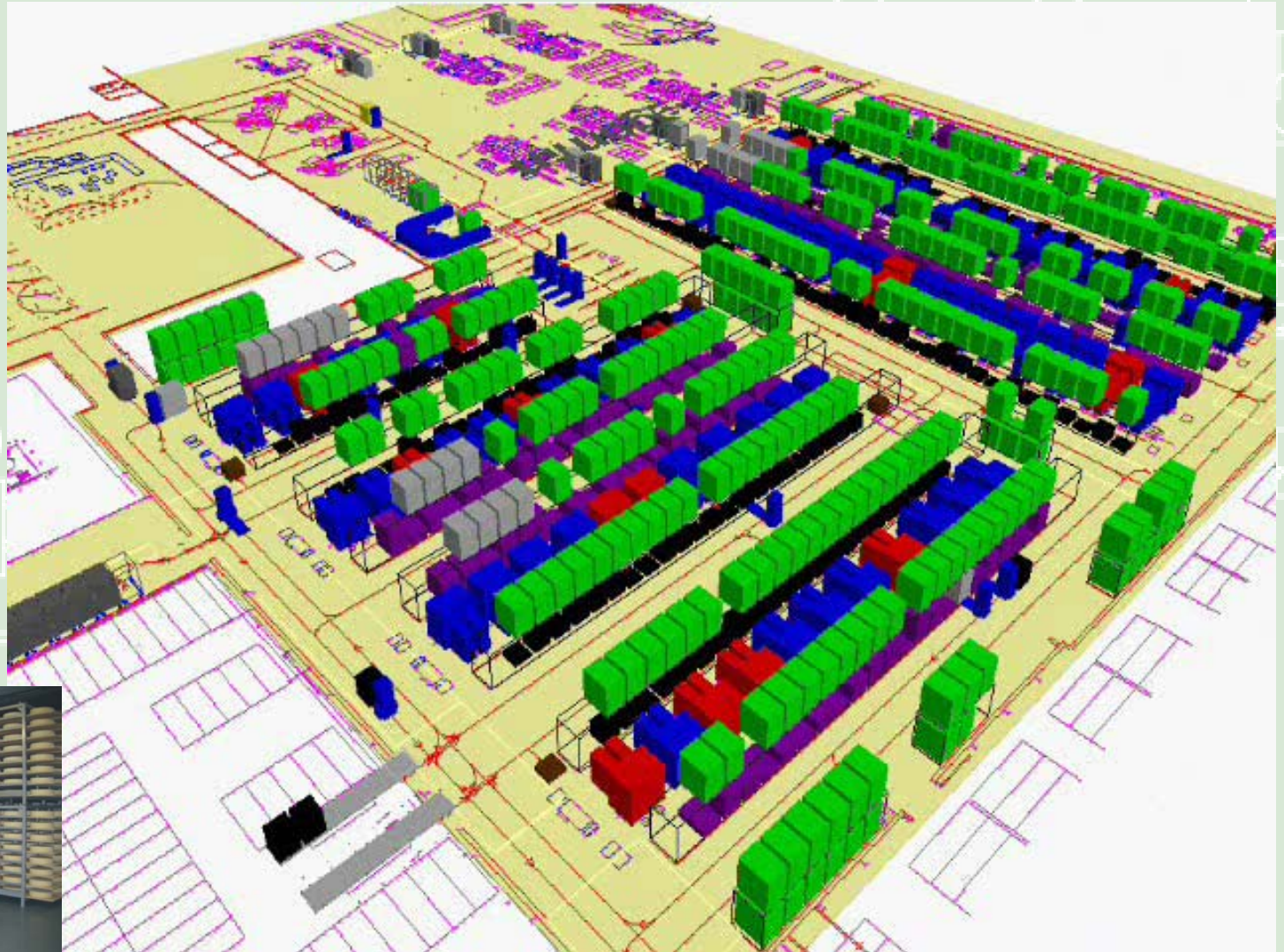
# Reference Model of Application Environment

- Describes basic functionalities and relationships
- Concrete application environment = define appropriate software architecture
- Software architecture maps functionalities to software elements
  - architectures differ in the way this mappings is applied
  - achieving different system requirements

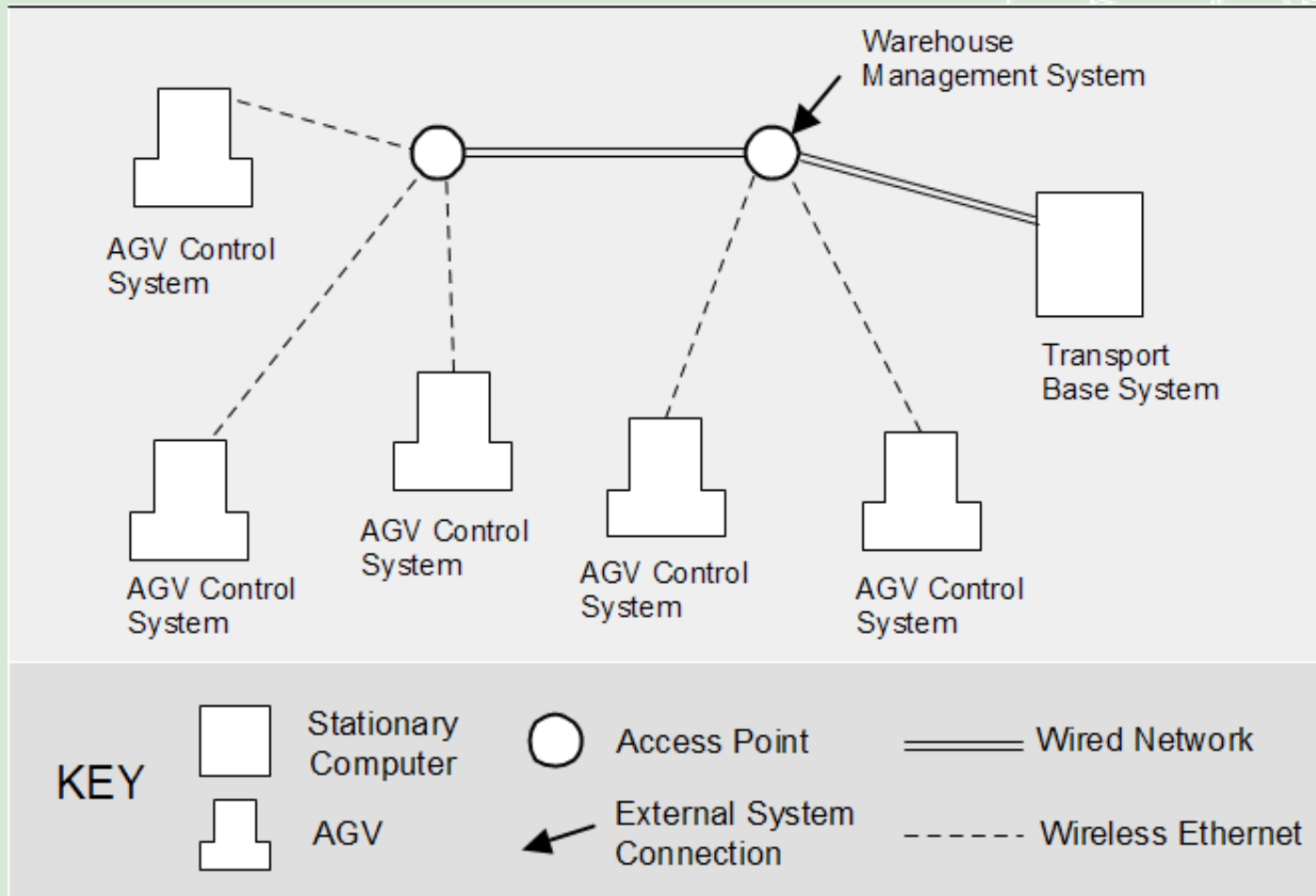
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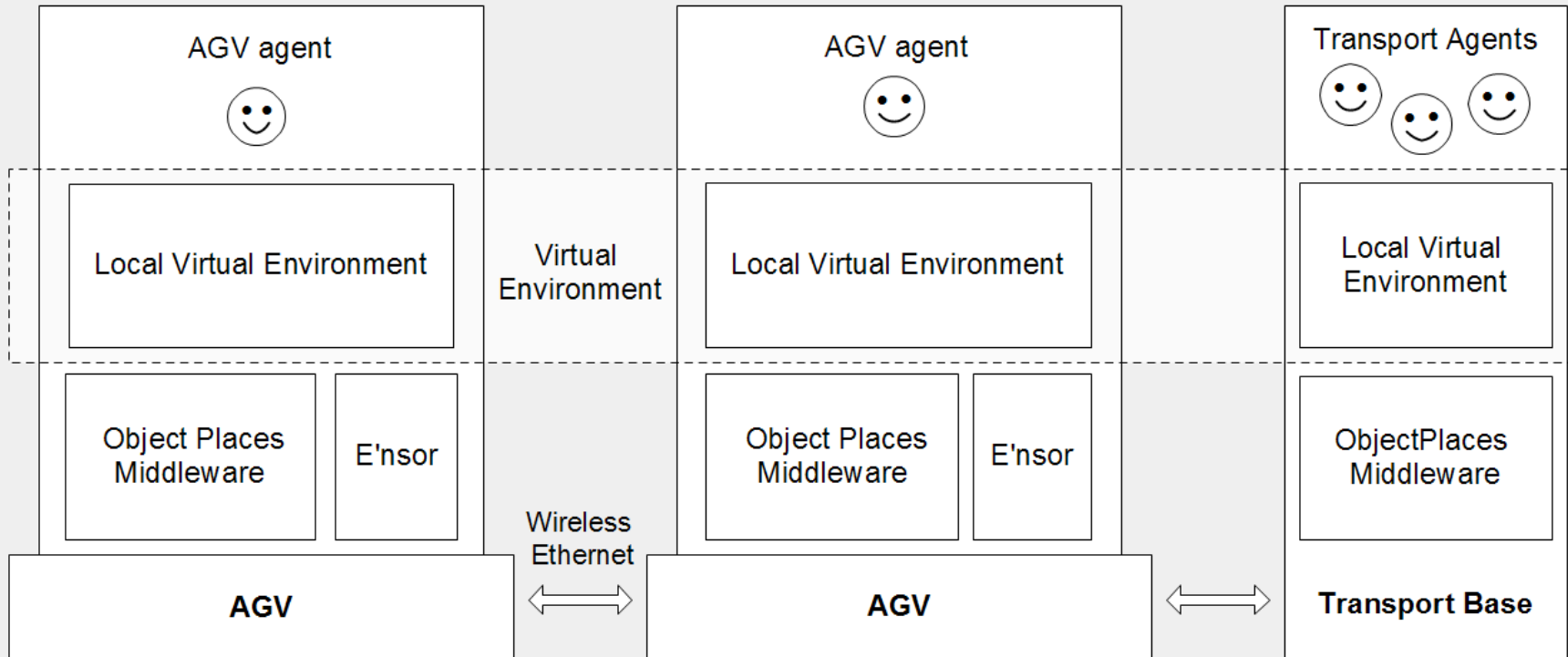
# AGV Transportation System



# MAS Architecture AGV Transportation System (Deployment View)



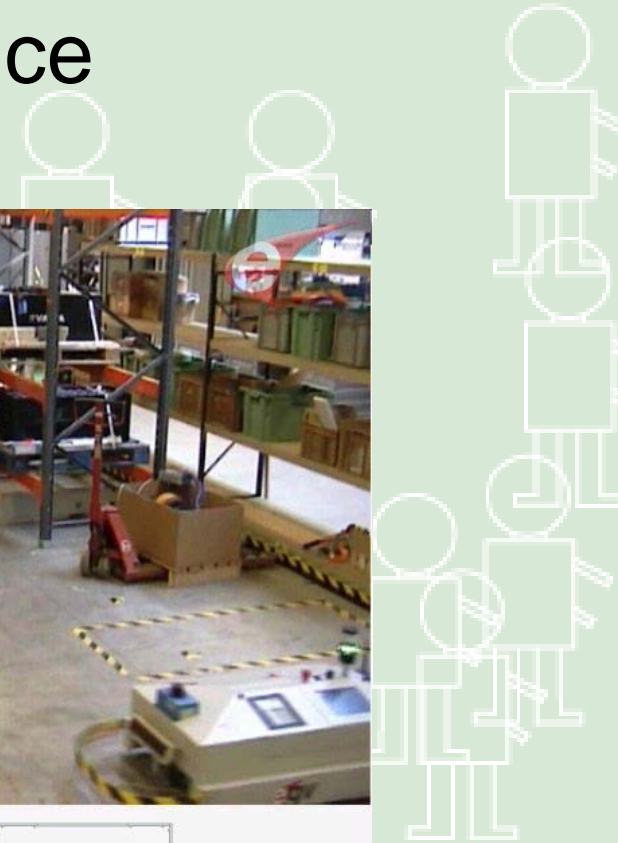
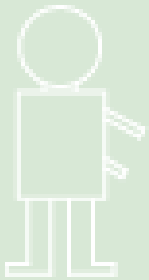
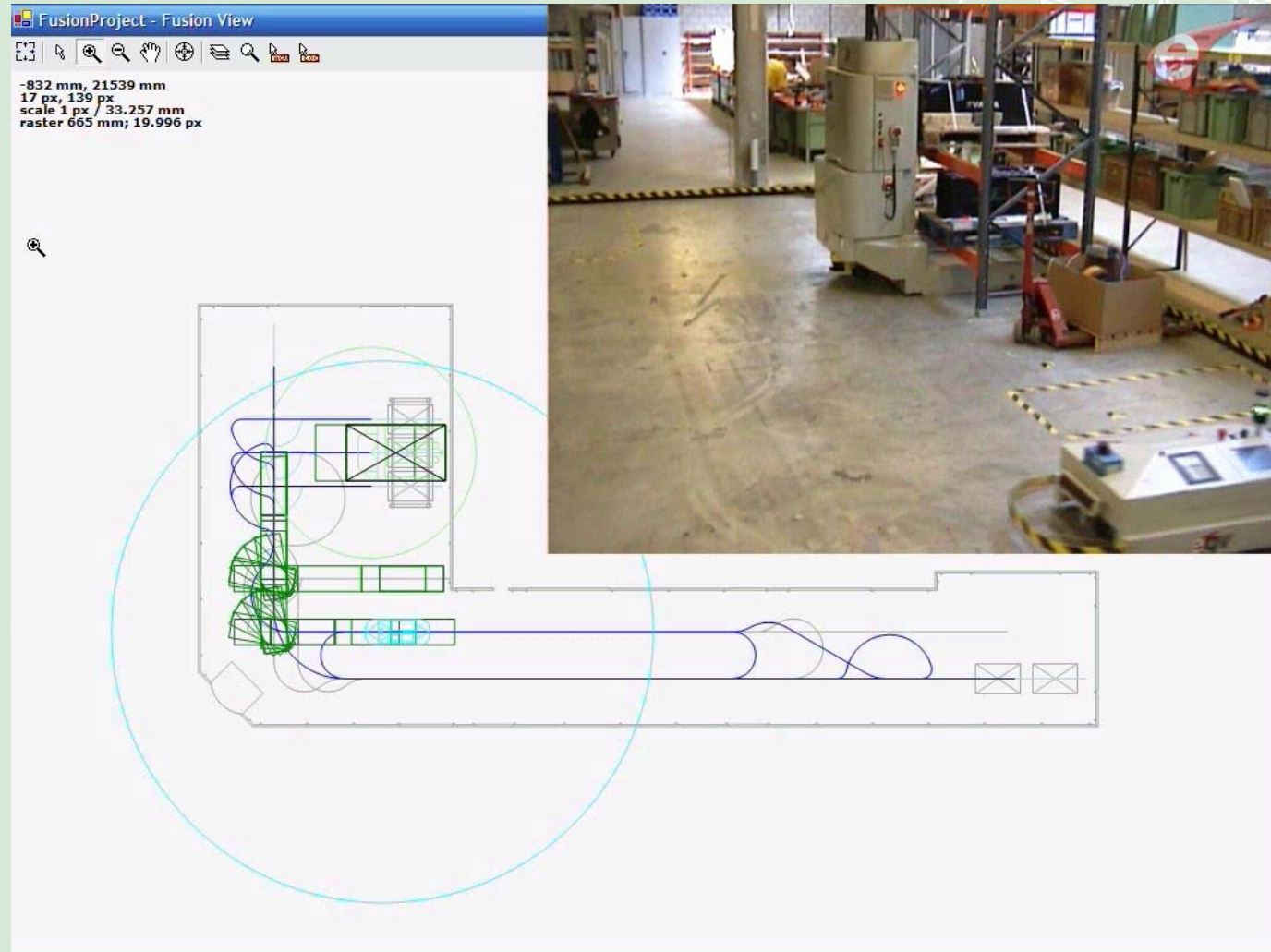
# MAS model of AGV Transportation System



# Exploiting the Virtual Environment in AGV Transportation System

- Transport assignment: Field-based approach
  - Tasks emit fields in virtual environment that attract idle AGVs, AGVs emit repulsive fields
- Routing
  - Traffic map in virtual environment provides signs with costs to particular destinations
- Traffic information for busy paths
  - AGVs mark busy paths on traffic map with pheromones (increases the cost along that paths)
- Collision avoidance...

# Exploiting the Environment for Collision Avoidance



# Conclusions

- Dealing with responsibilities of environment in ad-hoc manner = poor engineering practice
- We put forward environment as explicit part in MAS engineering
- Application environment enables to manage complexity and supports separation of concerns
- Major challenge: development of software architectures for application environments



