Multi-Agent Systems

Albert-Ludwigs-Universität Freiburg

Bernhard Nebel, Felix Lindner, and Thorsten Engesser

Summer Term 2017

Lecturers

Prof. Dr. Bernhard Nebel Room 52-00-028

Phone: 0761/203-8221

email: nebel@informatik.uni-freiburg.de

Dr. Felix Lindner Room 52-00-043

Phone: 0761/203-8251

email: lindner@informatik.uni-freiburg.de

Thorsten Engesser Room 52-02-019

Phone: 0761/203-8278

email: engesser@informatik.uni-freiburg.de

Lectures

Where

Building 101, Room 01-018

When

Monday 10:15–11:00, 5 Minutes break, 11:05–11:50, Thursday 14:15-15:00

Web page

http://gki.informatik.uni-freiburg.de/teaching/ss17/multiagent-systems/

Exercises: Dates

Where

Building 101, Room 01-018

When

Thursday 15:05-15:50

Exercises: Procedure

- Exercises will be handed out and posted on the web page the day of the monday lecture.
- You work in groups of size 2–4.
- Each group hands in one solution (in English or in German).
- Solutions to previous week's exercises have to be handed in until monday 10 a.m.
  - to Thorsten Engesser, engesser@informatik.uni-freiburg.de

Examination

- Admission to the exam: necessary to have reached at least 50% of the points on exercises.
- An oral or written examination takes place in the semester break.
- The examination is obligatory for all Bachelor students (oral) and Master students (oral or written).

Course goals

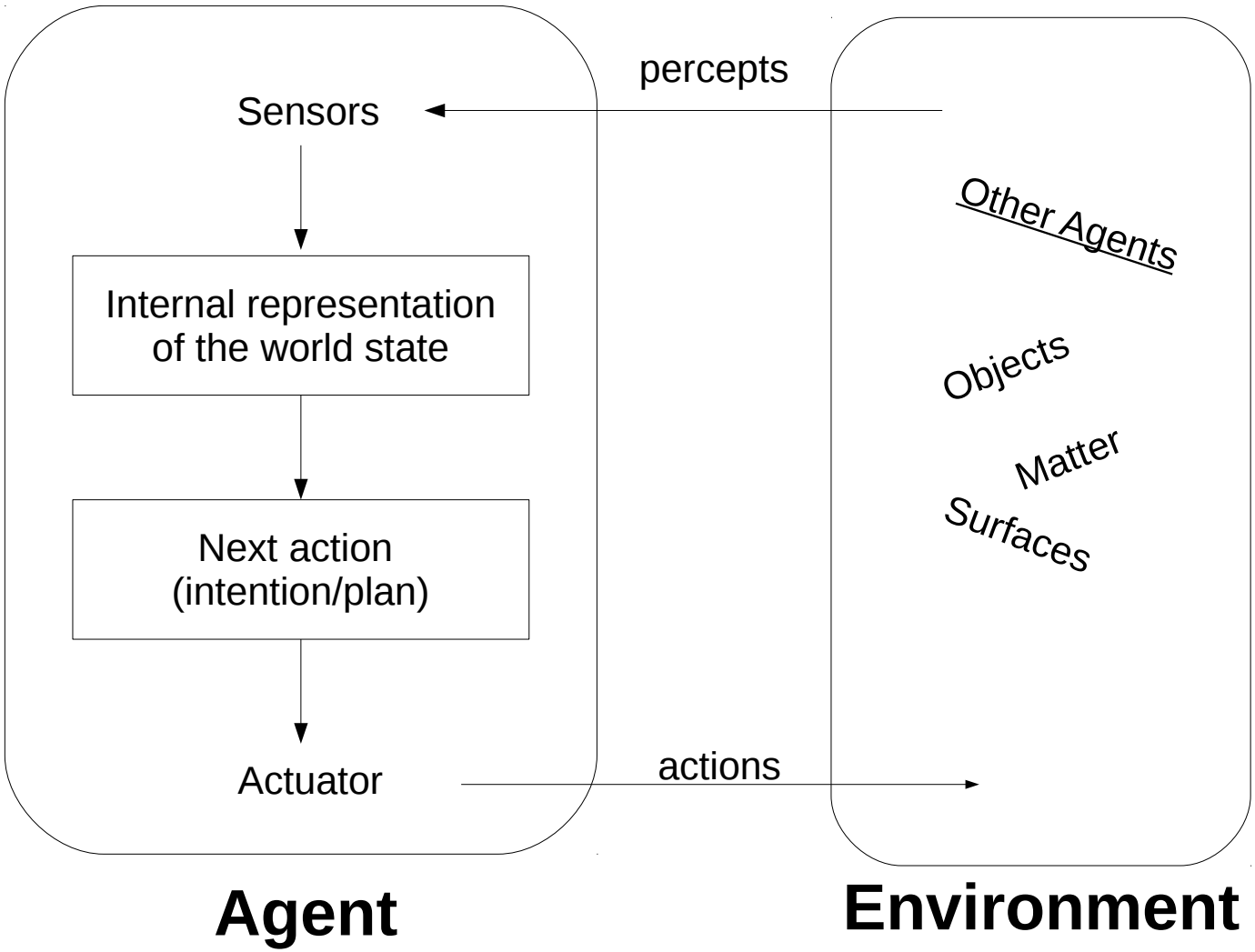
Goals

- You know about MAS algorithms and some of their formal properties
- You can render problems as multi-agent problems
- You can read and understand MAS research literature
- You can complete a project/thesis in this research area

Helpful

- Basic knowledge in the area of AI
- Basic knowledge in formal logics
- Programming skills

Agents: Standard View



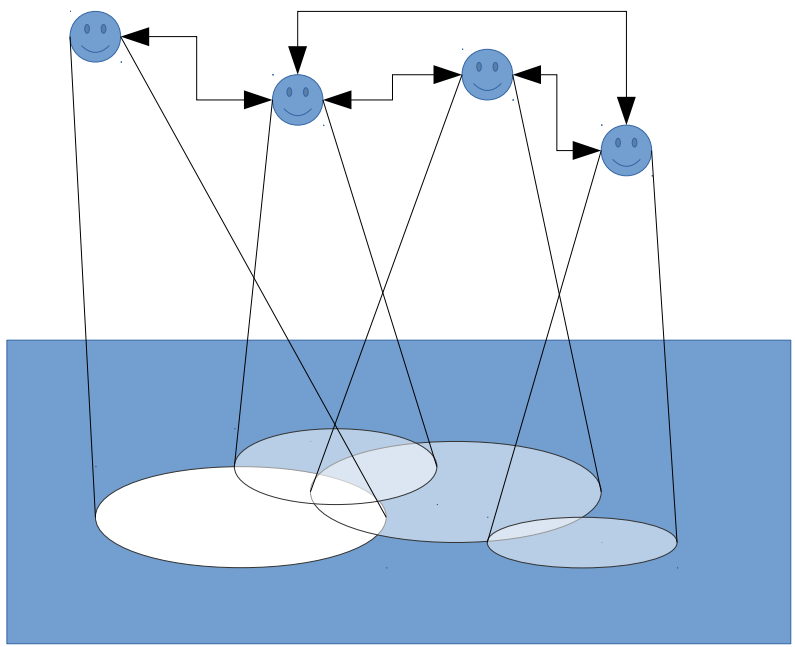
Agents: Examples

Which of these entities qualify as agents:

- Human beings
- Animals
- Plants
- (Non-)Self-driving cars
- Light switches
- Tables

Shoham, Layton-Brown, 2009

Multiagent systems are those systems that include multiple autonomous entities with either diverging information or diverging interests, or both.



Multi-Agent Systems: Example

- Video: Cooperation
- Common goal, different local views, different capabilities
- Cooperation, Communication protocol, Assembly

Agent-oriented paradigm versus Object-oriented paradigm

- “Objects do it for free; agents do it for money.” (Jennings, Sycara, Wooldridge, 1998)
- “Objects do it because they have to; agents because they want to.” (Joseph, Kawamura, 2001)

- Objects are passive service providers but agents are:
  - autonomous: Decide themselves whether or not to perform an action
  - smart: reactive, pro-active, social behavior
  - active: MAS is inherently multi-threaded (at least one thread per agent)
- (However, this does not imply that agents must not be implemented in an OOP framework!)

Connection to other areas

- Distributed/Concurrent Systems
  - Similarity: Agents too are autonomous systems capable of making independent decisions $\rightarrow$ need for mechanisms to synchronize and coordinate at run time
- Artificial Intelligence
  - MAS often seen as a sub-field of AI
  - Historically, MAS stresses the social aspect of agency more than classical AI does
- Economics/Game Theory
  - Game theory is heavily used in MAS, but
  - MAS is more concerned with computational aspects in context of resource-bounded agents
  - Some assumptions (such as rational agency) may not entirely match with requirements of some kinds of artificial agents

Course outline

Agent-Based Simulation

Agent-Based (Individual-Based) modeling and simulation of emergent phenomena in

- Ecology: Animal populations, Butterfly behavior
- Economy: Prices and consumer behavior
- Sociology: Neighborhoods, Traffic jams
- Epidemiology: Spread of diseases

Agent Architectures

Software architecture for different types of agents:

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents
- Learning agents
- Cognitive architectures
- The BDI architecture

Beliefs, Desires, Intentions

- The GOAL Agent Programming Framework (Koen Hindriks, TU Delft `https://goalapl.atlassian.net/wiki/`)
- Modal logics for Beliefs, Desires, Intentions

Norms and Duties

Socialization is the process of internalizing the norms and ideologies of society, e.g., Kohlberg (1996):

- Pre-conventional phase
- Conventional phase
- Post-conventional phase

- Modal logics for obligations, permissions, prohibitions
- Defining agents types based on conflict resolution strategies (e.g., Desires vs. Obligations)

Communications and Argumentation

- Communication at the knowledge level (Speech Act Theory)
- Argumentation Frameworks: Modeling disputes and persuation

Coordination and Decision Making

- Distributed Constraint Satisfaction
- Auctions and Markets: Allocating tasks and ressources to agents
- Cooperative Games: Distributing value among group members

- Objectives: Optimality and Fairness

Course outline

Literature I

- M. Wooldridge, An Introduction to MultiAgent Systems, 2nd Edition, John Wiley & Sons, 2009.
- D. Easley, J. Kleinberg, Networks, Crowds, and Markets: Reasoning about a Highly Connected World, Cambridge University Press, 2010.
- Y. Shoham, K. Layton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press, 2009.

Further literature to be announced.