MAI4CAREU | Master programmes in Artificial Intelligence 4 Careers in Europe

University of Ruse “Angel Kanchev”

MULTIAGENT SYSTEM WITH ARTIFICIAL INTELLIGENCE

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LECTURE 5

Society of Agents

1. Society of Agents
2. Attributes of MAS
3. Coordination through Interaction
4. Task Decomposition and Assignment

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Society of Agents

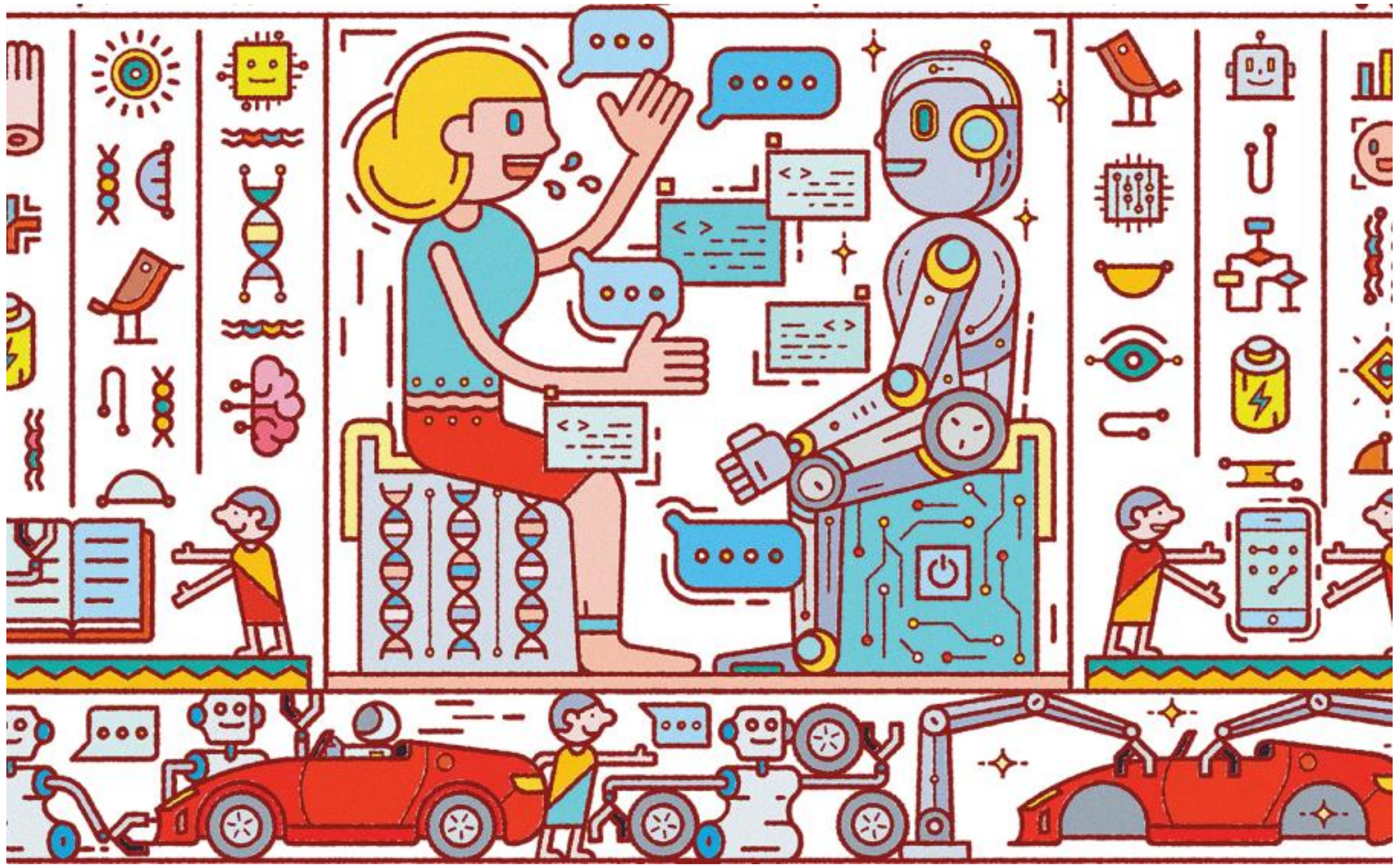
Normally AI focuses on one agent.

But, what happens when we have more than one agent:

– could they work together?

– will there be any problems?

All those questions are concerning the Society of agents.



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Society of Agents

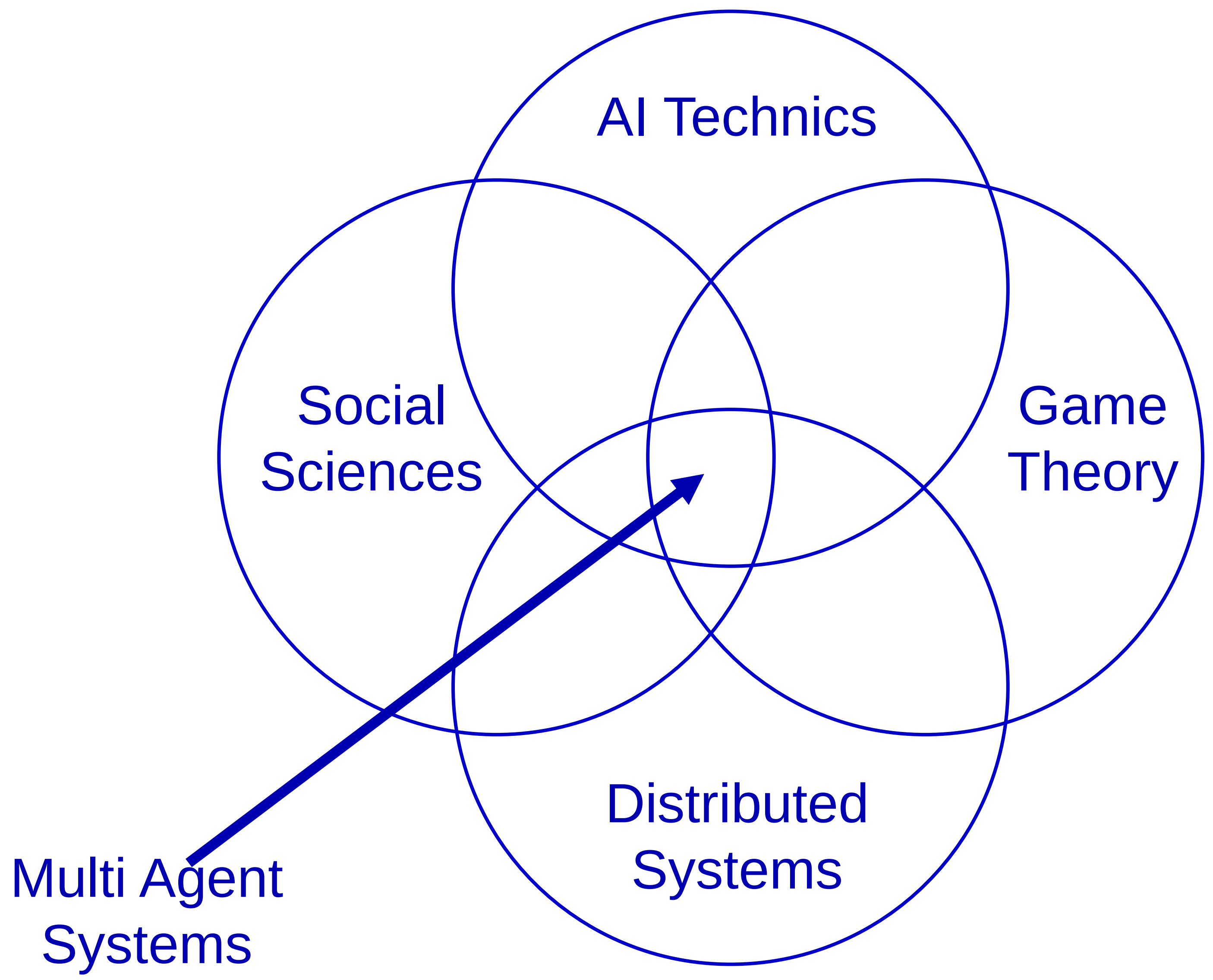
- What is an agent as part of society?
- It is an intelligent agent that has more characteristics such as:
  - Reactivity - the ability to respond to the environment changes in real time
  - Pro activeness - ability to take initiative for action to achieve goals, i.e. not to be guided by events, but to be able to choose the course of action himself
  - Social ability - opportunities for agents to interact (communicate, cooperate, cooperate) with each other as well as with humans using some kind of agent communication language

Society of Agents

- Do we have to solve all the problems of the AI itself (eg planning, communication, training...) before creating an agent??

➢ …In brief, although we use artificial intelligence techniques for agent design, it is not necessary to solve all problems before we have created an AI agent

- Classical AI does not consider the social aspects of agents. But in fact, these are very important aspects of intelligent activity in the real world



Attributes of MAS

	Attribute	Range
Agents	Number	From two upward
	Uniformity	Homogeneous / heterogeneous
	Goals	Contradictory / complementary
	Architecture	Reactive / deliberative
	Abilities (sensors etc.)	Simple / Advanced

From Huhns & Singh 1998, “Agents and multi-agent systems: Themes, approaches and challenges”

Attributes of MAS

	Attribute	Range
Interaction	Frequency	High / low
	Persistence	Short-term / Long-term
	Level	Signal level / Knowledge level
	Pattern	Decentralized / hierarchical
	Variability	Fixed / changeable
	Purpose	Competitive / cooperative

From Huhns & Singh 1998, “Agents and multi-agent systems: Themes, approaches and challenges”

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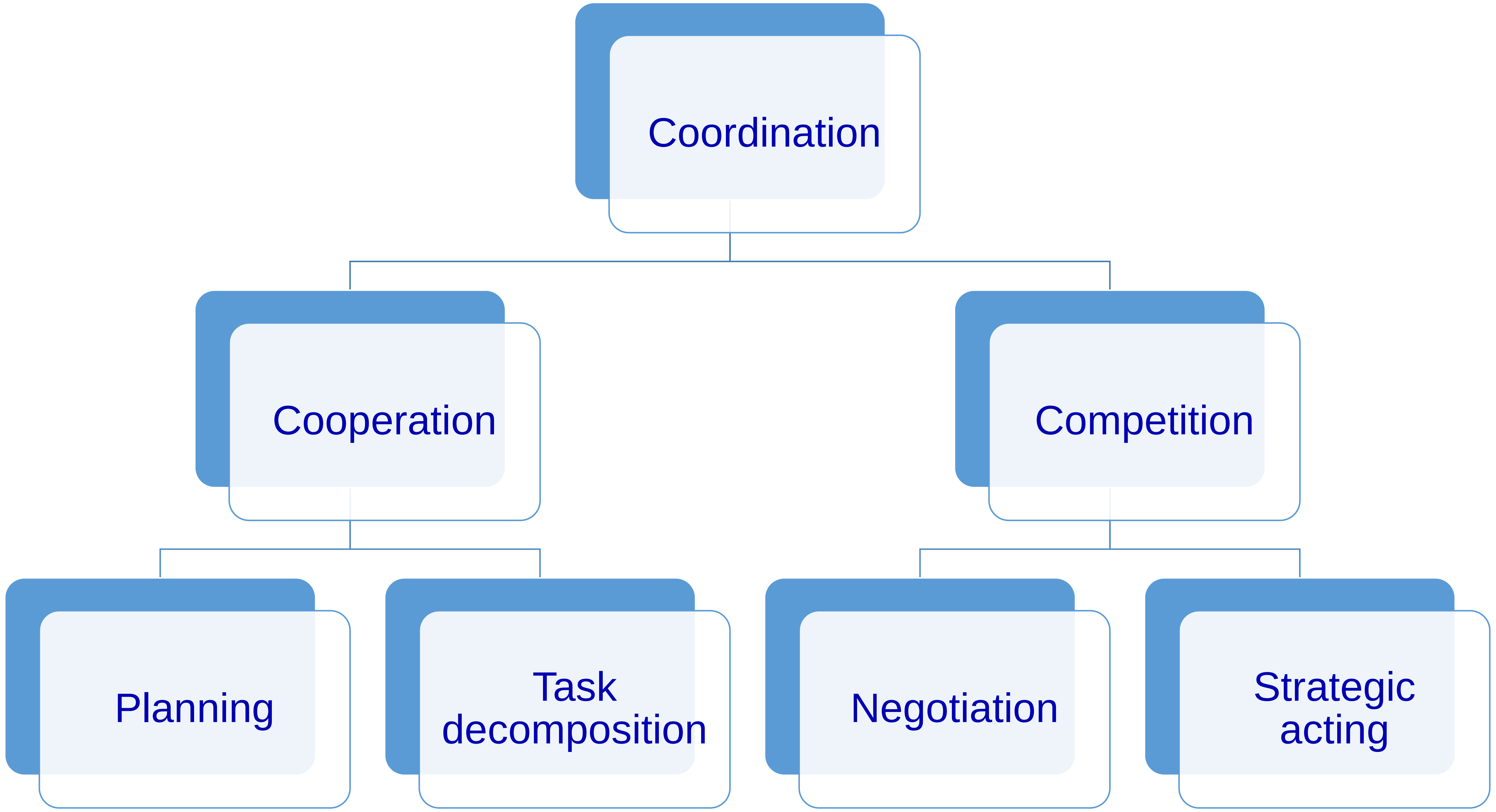
Attributes of MAS

	Attribute	Range
Environment	Predictability	Foreseeable / unforeseeable
	Accessibility	Limited / unlimited
	Dynamics	Low / high
	Diversity	Poor / rich
	Availability of resources	Restricted / ample

From Huhns & Singh 1998, “Agents and multi-agent systems: Themes, approaches and challenges”

Coordination through Interaction



Coordination through Interaction

Benevolent agents (like team of fire brigades, robots exploring unknown terrain):

- The agent voluntarily helps other agents without being commanded to do so.
- The agent's benevolent actions are intended to benefit the society to which the agent belongs.
- The agent should not expect an immediate reward or benefit for its benevolent actions. If it did, then the agent is instrumental, not benevolent.
- The agent's benevolent action is taken while the agent is pursuing one of its own goals in such a way that it should neither prevent nor help the agent accomplish its goal.

- Agents are assumed to act truthfully
- Cooperative distributed problem solving: agents can be designed to help when ever asked
- Cooperation mechanisms are for example contract nets, and blackboard system

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Coordination through Interaction

Self-interested agents (from different organizations, Internet markets, computer games):

- Agent has its own description of the environment it uses and its actions are based on that description
- Agents assumed to work for their own benefit, possibly at expense of others
- Coordination by adequate mechanism design, e.g. Game theory, Auctions

- It does not mean that they want to harm other agents
- It does not mean that they only care about things that benefit them

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Contract Nets

There are different roles in a net of agents.

The roles are not specified in advance, they are rather dynamic and can change during the execution of the task. For example, a contractor can further break the task into subtasks and assign them to other contractors!

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Task Decomposition and Assignment

Contract Nets

Manager - An agent that wants a task to be solved is the manager

- announces a task (the task specification)
- receives and evaluates bids from potential contractors
- awards a contract to a suitable contractor
- receives and synthesizes the results

- Contractors - Agents able to solve the task are potential
  - receives task announcements
  - evaluates the capability to respond
  - responds with a bid or declines
  - perform task if the bid is accepted
  - report the results back

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Task Decomposition and Assignment

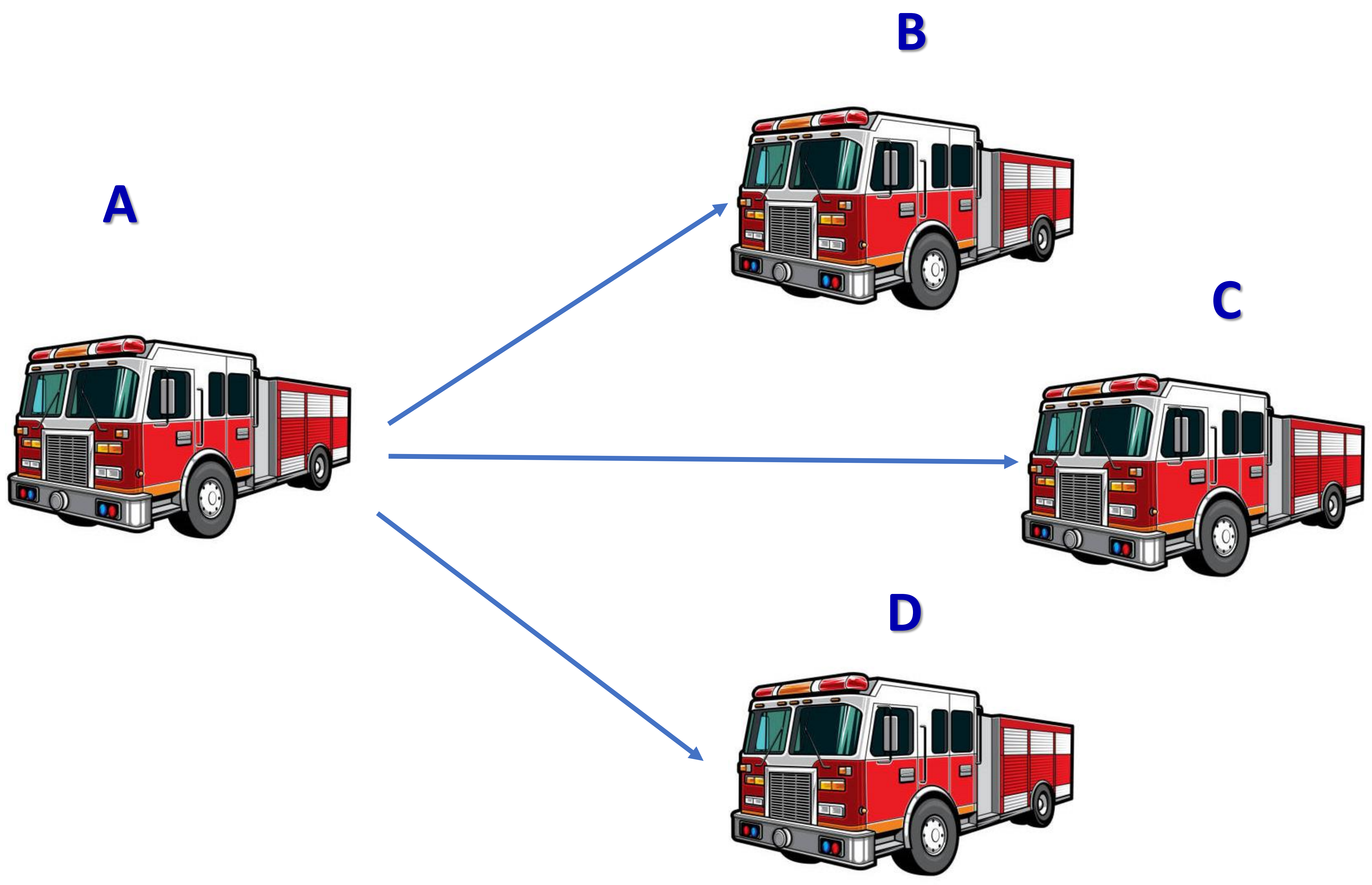
Contract Nets

Fire Brigade Example

Fire brigade A needs help
to extinguish a building

Task specification:

- needed amount of water,
- the location of the fire,
- and a deadline



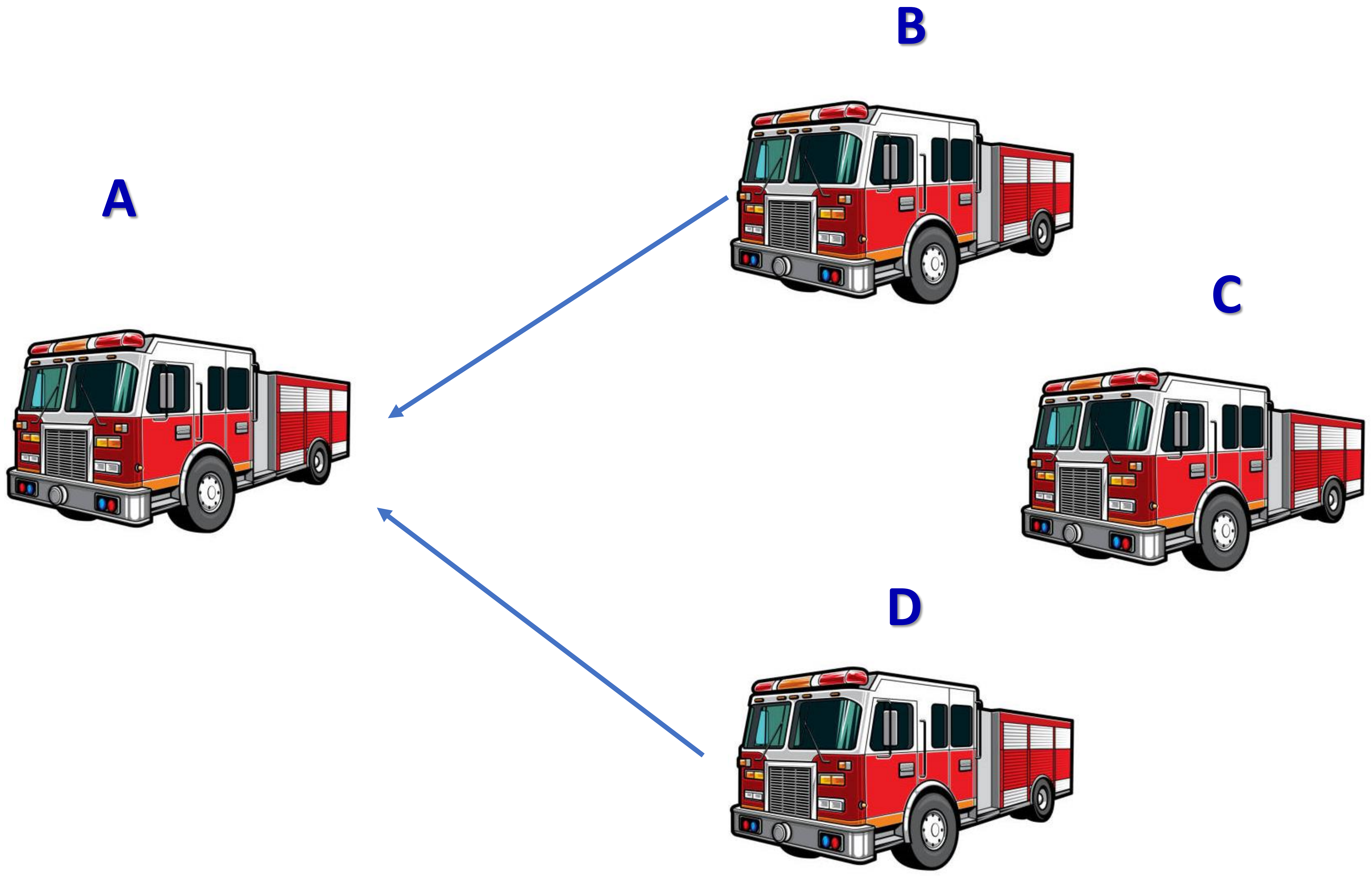
Task Decomposition and Assignment

Contract Nets

Fire Brigade Example

Agent B and D submit their bits

The bit contains estimated costs for traveling to the location and for refilling the tank



Task Decomposition and Assignment

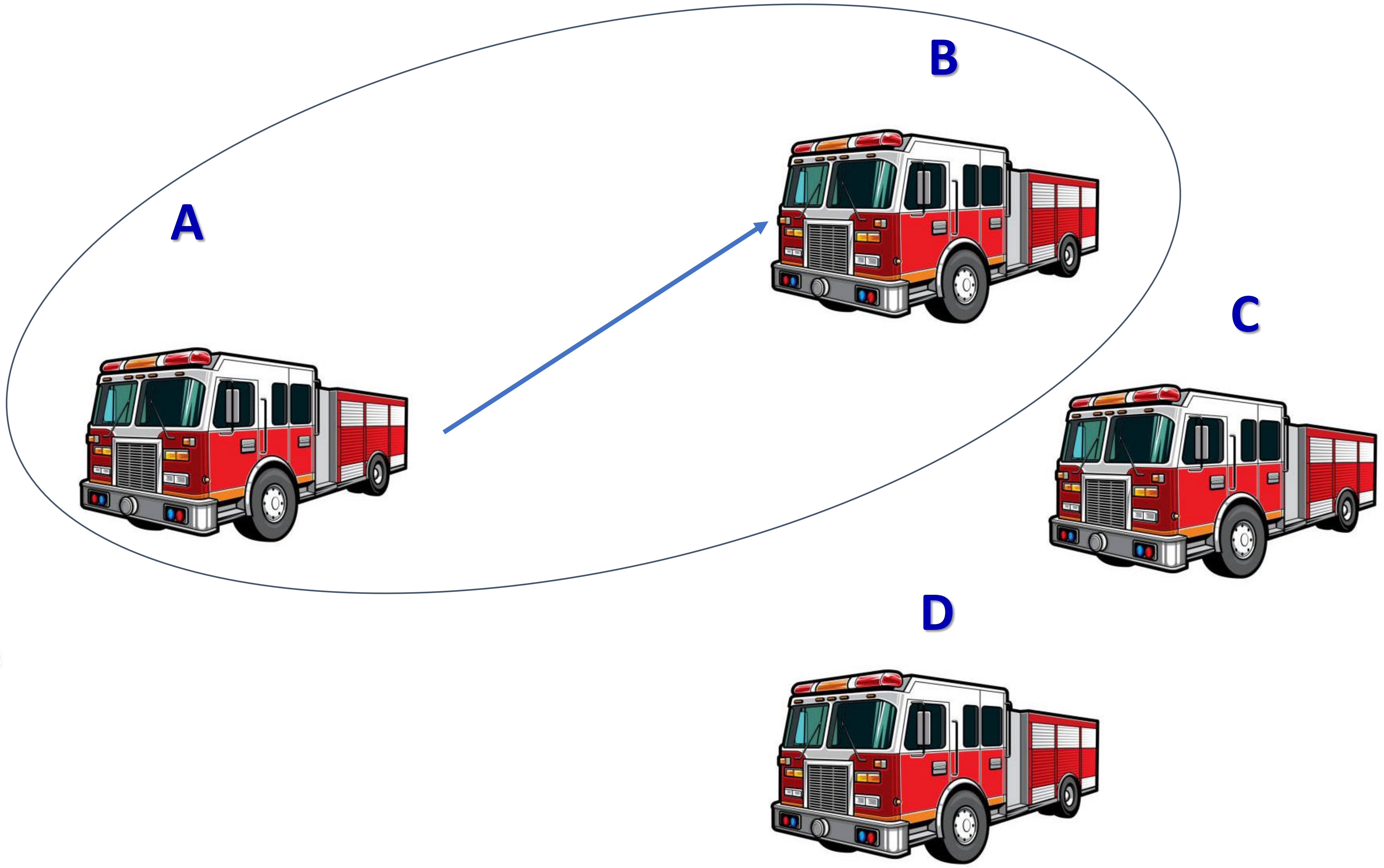
Contract Nets

Fire Brigade Example

The manager awards a contract

to the most appropriate agent

- For example, agent B, which is closer to the fire



The contractor sends back a report after finishing the task or further subdivides the task …

Contract Nets

Limitations:

- Task allocation and problem detection and resolution can be non-trivial
- Communication overhead
- The selected contractor may not be the best choice, but a better candidate may be temporarily employed in the task allocation process

- Efficiency modifications
  - Focused addressing / direct contracts (e.g. team structure)
  - Agent send status message
    - ✓ eligible but busy
    - ✓ ineligible
    - ✓ uninterested
    - ✓ …

Blackboard Systems

- Data-driven approach to task assignment
  - A number of “experts” are sitting next to a blackboard
  - When one of the experts sees that she can contribute something, she writes this on the blackboard
  - This continues until the “solution” comes up on the blackboard
- Mainly used for distributed problem solving, e.g. speech recognition
- Requires a common interaction language
- Event-based activation
- Can have different levels of abstraction

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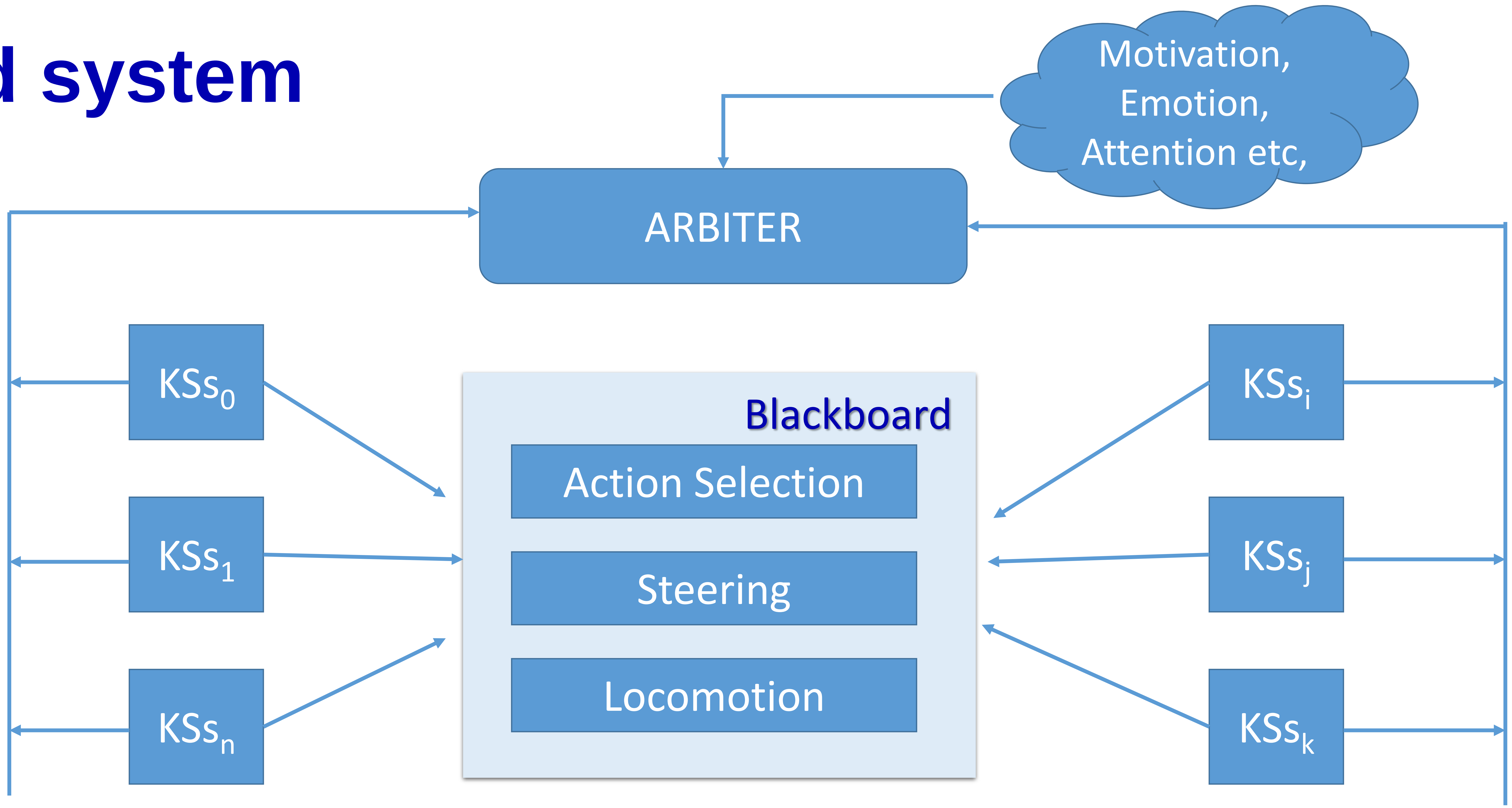
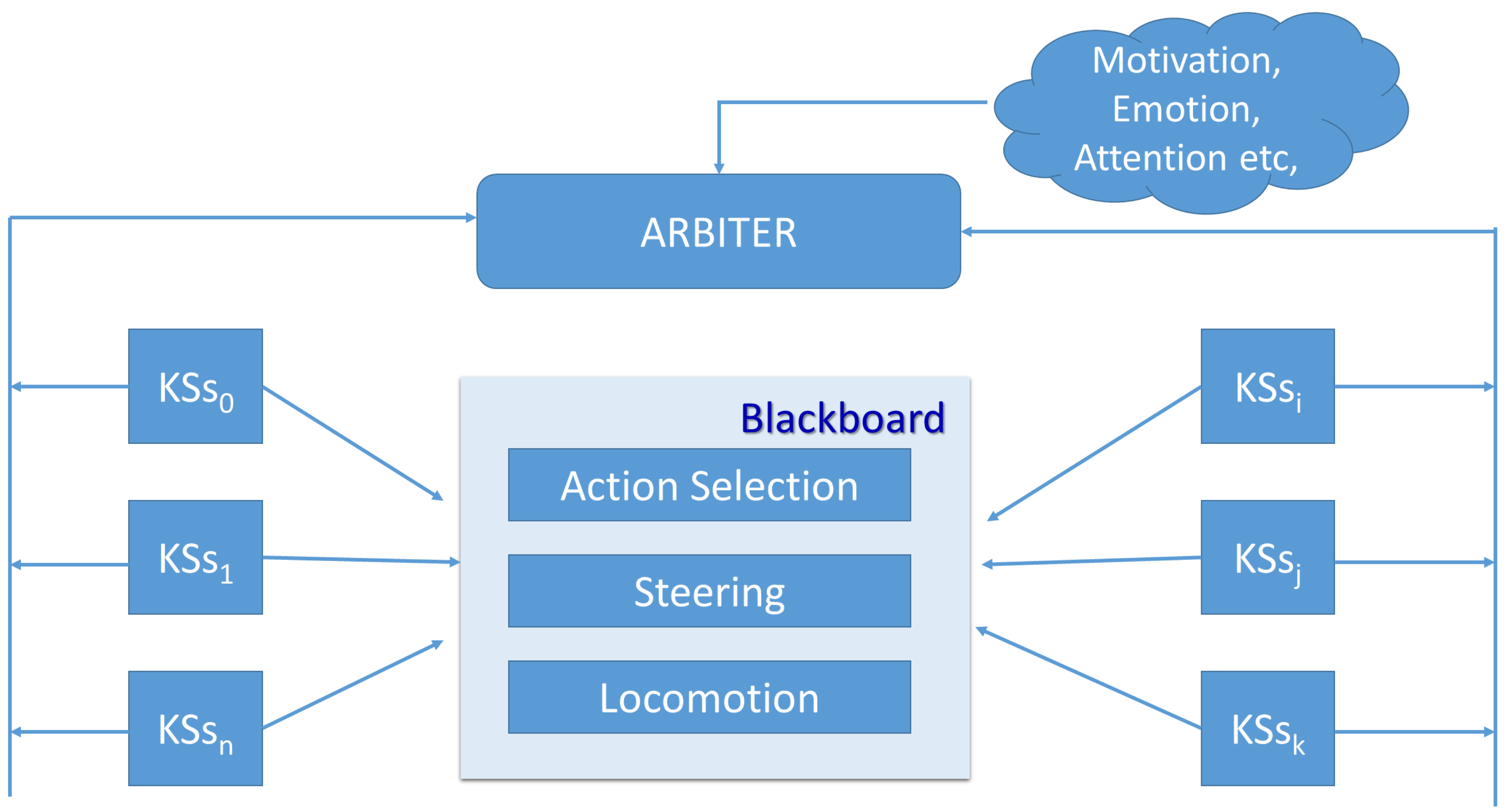
Blackboard system



"Blackboard Architectures," Steve Rabin, AI Game Programming Wisdom, pp. 333 - 344

Blackboard system



Arbiter
Selects "winning" KS for accessing blackboard. Mechanism can be reactive (data-driven) but also goal-driven, e.g. select KS with highest expected future outcome

Knowledge sources (KSs)
A series of components that are able to operate on the blackboard

Blackboard
publicly read / writeable data structure (e.g. shared memory)

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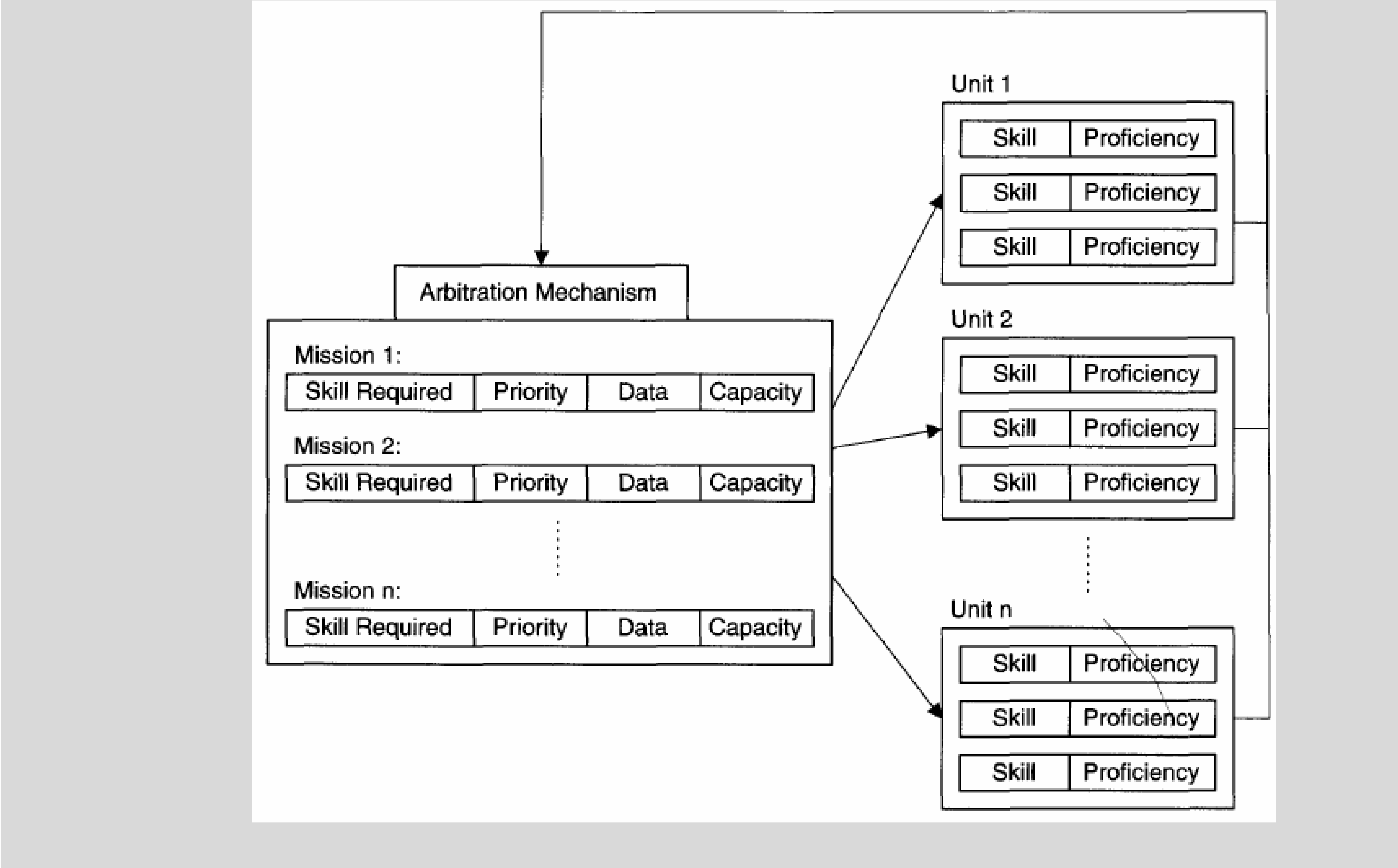
Blackboard System

Example: RTS game BBWar using the C4 blackboard architecture (MIT 2001)

- The KSs are individual units that have special skills that can be executed on demand
- The blackboard contents take the form of open missions
- Units from different levels of the hierarchy pay attention to different types of postings
  - ➢ Commanders look for ATTACK-CITY missions and create ATTACK- LOCATION missions
  - ➢ Soldiers look for ATTACK-LOCATION missions
  - ➢ …
- Implemented as a hash table mapping skill names to open missions



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Blackboard System

Advantages:

- Simple mechanism for cooperation and coordination
- KSs do not need to know about other KSs they are cooperating with
- Postings can be overwritten by different systems, e.g. units can be replaced
- Can also be used for inter-agent communication

Disadvantages:

- Mainly suitable for agents executed on the same architecture

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Self-interested Agents

- What happens when agents are not benevolent?
  - Why should they report their capabilities truthfully?
  - Why should they actually complete contracted tasks?
- Cooperation works fine if we can design the entire system by ourselves
  - We can then try to maximize some performance measure and guarantee that all member of a team of agents work towards the common goal

- If agents work for different parties the common goal might not be the goal of the single agents
  - e.g., assume an arrival management system for airports with a number of different airlines or the Internet
- If an MAS becomes large and complex the overall goal is not evident (e.g. in an intelligent house)
  - It might be more robust to design agents as self-interested agents

Self-interested Agents

- What is the self-interest of a competitive agent?
- She tries to maximize her expected utility!
- AI techniques are good for that, but …
- …here we have other agents that also act
- All agents know (to a certain extend) what their options are and what the payoff will be

➢ Strategic deliberation and decision making
    ➢ Choose the option that maximizes own payoff under the assumption that everybody also acts rationally
    ➢ Does not maximize social welfare but is robust

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Game Theory

- Game Theory is the field that analyzes strategic decision situations
  - ➢ economic settings
  - ➢ military contexts
  - ➢ social choices

- Usual assumption: All agents act rationally
  - ➢ Unfortunately, humans do not follow this pattern all the time
  - ➢ Often change their utility function on the way or simply do not maximize or do not assume that all others act rationally

- Nevertheless: For designing MAS it might just be the right theoretical framework because we can designour agents to act rationally.

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