Agent-based systems

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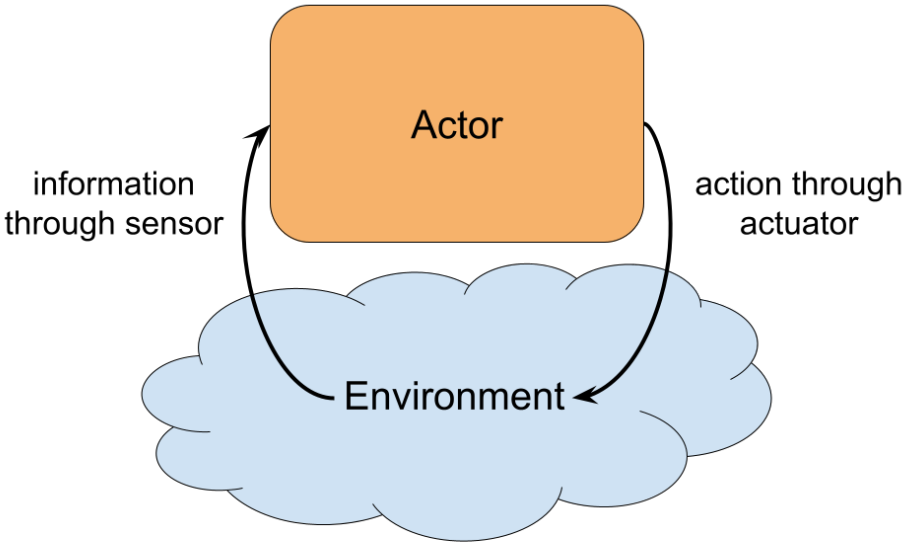
What is an agent?

The word “agent” has its origin in the Latin word “agens” meaning “to drive, lead, manage, perform, do”. A more liberal translation is “the one who acts” or “entity that performs an action”. This already gives a hint to what the primary definition of an agent is: An agent performs actions based on decisions made by the agent. Again, the decisions are based on information the agent collects from its environment. When talking about agents the main focus is their ability to make decisions with the goal to solve problems [1].

The concept ”agent” is widely used in different academic fields like game theory, economics, information technology and artificial intelligence which all have an overlapping understanding about what an agent is.

Agents are always designed with the intent to solve a problem which occurs in its environment. To make this possible they gather information about their surroundings through sensors, the interaction with the environment is facilitated by actuators. The following image visualizes this concept.



Besides the aforementioned properties agents are defined by the following additional characteristics [2]:

- *Autonomy:* They perform actions without any direct external influence, they control their own actions and own internal states.
- *Proactiveness:* They take initiative if necessary to reach their goals.
- *Responsiveness:* They watch their environment and respond to its changes.
- *Social ability:* If necessary they interact with other agents with the goal to finish their own problem solving. To make this possible they have the ability to communicate with each other via an agent-communication language.

What is an agent-based system?

A system is defined as “agent-based” if for its description or design the key abstraction concept of an “agent” is being used [2]. Such systems can contain a single agent, for example a continuously running program that labels e-mails according to their subjects or senders. Designing a system to use multiple agents opens up new possibilities for effective problem solving.

Agents working together

Problems can be deconstructed into smaller problems which are easier to handle. “Easier” in this case might mean “smaller” in the sense of “divide and conquer” or identifying clearly defined sub-problems which require specialized problem solving capabilities.

One advantage of an agent-based system is that its agents can be heterogenous meaning each one can be designed to solve a different problem which leads to reaching the whole system’s goal more effectively.

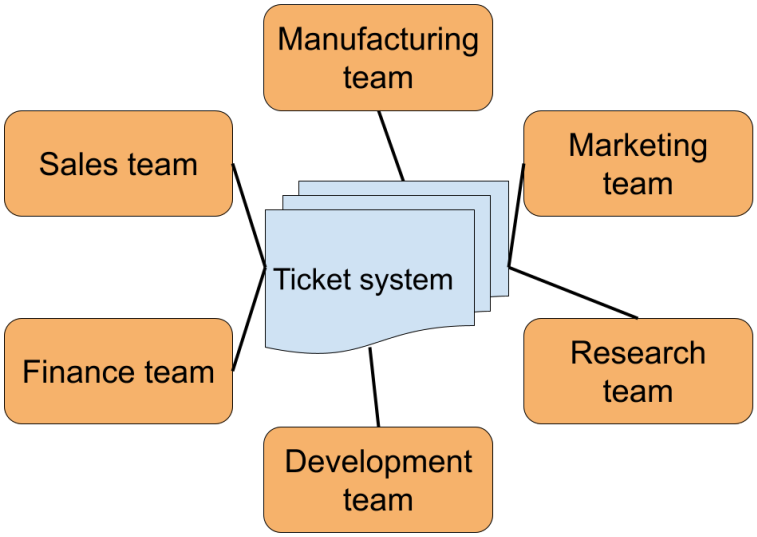
A technical example is a production line which produces knives. In three steps knives are stamped out from raw metal, grinded as well as sharpened and packaged. Each step is implemented by a highly specialized machine, each machine acts as an agent in the system with the goal “produce knives”. A conveyor belt linearly moves the knife parts between the machines, both the belt and the parts are the environment the agents are embedded in. With the help of sensors they notice when a part arrives so their respective actions can be performed. Additionally the machines are connected by some communication network to signal their neighbors “increase/decrease the production rate” to prevent over- and underproduction.

This example shows the properties of agents: Each machine works independently to solve its own goal. They are social and show initiative by sending signals to each other to optimize their production rates leading to optimized problem solving. They watch their environment and act upon its changes.

Agents in a business environment

Classical management theories focus on hierarchical organizational structures in which managers with authority make decisions. The manager acts as a leader and communicates decisions downward to employees which follow them [3]. The manager, as a single individual, bases his decision making on a plethora of information from marketing, sales, research, development, manufacturing, finance and other departments. This is a complex task and might be overwhelming for larger and complex goals and thus not feasible [1].

A different approach to reach a goal in a business environment is the use of agents. The agents are realized by single persons or groups of persons, it is appropriate to call those agents “teams”. Each team provides a specialized service so there might be a marketing team, a sales team, a manufacturing team and so on. Each team acts autonomously and tries to reach its own goal. To fulfill goals interaction between teams is necessary, for example the sales team must reach out to the manufacturing team for the supply of products to sell. The interaction between teams is enabled by a common interaction protocol. There is an agreement between the teams on how interaction is implemented, for example communication happens through a ticket system. The following images visualizes this system:



The agent-based business system is self-organizing, each team tries to reach their own goals which in turn allows the whole business to reach its goal. The need for a centralized top-down management is eliminated.

Depending on the business goals and the system’s structure a management-like agent might be useful which improves the coordination between the agents [4]. In the aforementioned example of a linear production line in which machine agents are only allowed to talk to direct neighbours a coordination agent can improve the production flow by informing the first agent to slow down its work if a jam at the last agent is to be expected. Additionally the coordination agent can take care of maintenance taks which affects all prodution agents.

Literature

[1]: Agent-bases Business Process Management; N. R. Jennings et al.; 1996
[2]: Agent-Oriented Software Engineering: State of the Art; Michael Wooldridge and Paolo Ciancarini; 2001
[3]: Villanova University; What is Classical Management Theory?; https://www.villanovau.com/resources/leadership/classical-management-theory
[4]: Developing Multiagent Systems: The Gaia Methodology; Franco Zambonelli et el.; 2003