

Multi-agent systems

The agents may be subject to mechanisms for adjusting their behavior at some level in order to orchestrate a global behavior. [1] Multi-agent systems are useful in open systems, because heterogeneous agents are able to join and leave the system at runtime. To regulate the behavior of agents, electronic contracts are used in several domains, such as for service procurement in the insurance industry, service level agreement management in software engineering, and aircraft engine aftercare. These contracts thus represent agreements of the parties, making explicit what each party can expect from the others, but providing flexibility in how they accomplish their own obligations. [1]

- goal-oriented architectures: cognitive models for weighting competing alternatives (some of them non-compliant with the norms) on the basis of preference orders
- utility-based models: normative reasoning with focusing on the maximization of rewards to measure the profits and losses brought about by the adoption of a given set of norms

For norms to be used in agent-based systems, norms must be specified in a way that enables them to be processed by artificial agents [2]:

- deontic logic, other variations of modal logic, and first-order logic
- rules: collections of condition/action pairs
- sequences of ones and zeros
- strategies

The presence of norms can manifest itself in at least three ways, each representing a different level of abstraction. [3] (TODO: check relevance? add more, robot example)

Tasks

Uses to simulate human behavior.

Simulate individual behaviors and social interactions in **case of emergency**. To calculate the number, width and distribution of exits it is assumed that occupants would evenly utilize all available exits to escape in case of an emergency. But people tend to exit a building following the exits that they are familiar with. As a result, egress designs often fail to meet their functional expectations when a real emergency occurs. [4]

Trust negotiation. access control is based on digital credentials that encode properties (such as subscription ownership, membership to certain organizations, date of birth, etc.). users can formulate policies to control the disclosure of any piece of sensitive information that may be encoded in their credentials. [5]

price negotiations [6] aim to use autonomous agents to completely substitute for humans to automate basic e-commerce activities such as: product brokering, merchant brokering, negotiations, payment etc.

Albatross is a multi-agent rule-based system that predicts which activities are conducted where, when, for how long, with whom and the transport mode involved to support **scheduling decisions**. [7]

Techniques

Why not just logic

The primal property that is subject of verification is what is known as coherence: whenever the set of rules is “contradictory” in any sense, sometimes referred to as “absence of conflicts”. suppose you have a norm stating that it is forbidden to cross red lights, and another that says that it is forbidden but paying a fine is way of “fixing” it. Is there a conflict or not? [8]

Norm Negotiation. Violation Recognition. Sanction Application

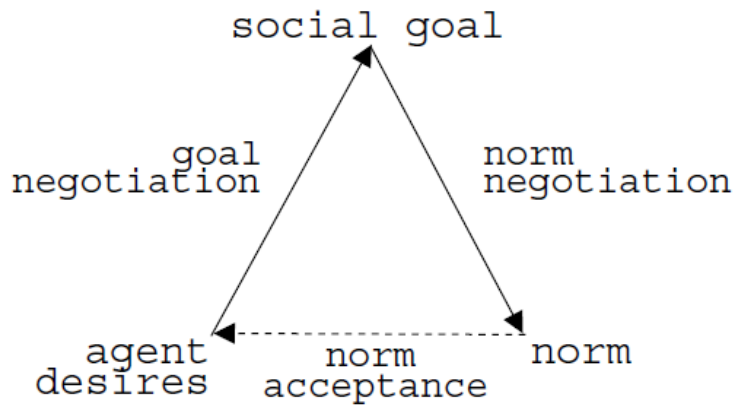
normative systems include not only regulative norms like obligations, prohibitions and permissions

A normative multiagent system is a multiagent system together with normative systems in which agents can decide whether to follow the explicitly represented norms, and the normative systems specify how and in which extent the agents can modify the norms.

Mechanisms used by agents to coordinate themselves, and in general to organize the multiagent system. Norms are communicated, for example, since agents in open systems can join a multiagent system whose norms are not known. Norms are distributed among agents, for

example, since when new norms emerge the agent could find a new coalition to achieve its goals. Norm violations and norm compliance are detected, for example, since spontaneous emergence norms of among agents implies that norm enforcement cannot be delegated to the multiagent infrastructure. [9]

norms guiding the emergent behavior of the system can also emerge themselves to accept a norm, an agent has to recognize it as a norm, the norm must contribute to the goals or desires of the agent, and it must be obeyed by the other agents.



The norm is accepted when the norm is stable in the sense that agents will act according to the norm, and effective in the sense that fulfilment of the norm leads to achievement of the agents' desires – i.e., when the benefits outweigh the costs. [10]

Rule Based System

[10]

Rule Responder is an open source framework for creating virtual organizations as multi-agent systems that support collaborative rule-based agent networks on the Semantic Web, where independent agents engage in conversations by exchanging event messages and cooperate to achieve (collaborative) goals. [11]

PROTUNE [5].

[6]

Answer Set Programming

The *INSTAL* framework [12] is a normative framework architecture with a formal mathematical model to specify, verify and reason about the norms that govern an open distributed system.

[13] not multiagent

Conclusion

Traditionally normative systems have been studied in philosophy, sociology, law, and ethics, and during the past thirty years they have been studied in deontic logic in computer science. The research focus changes from logical relations among norms, to, for example, agent decision making, and to systems in which norms are created and in which agents can play the role of legislators.

There are several conferences and workshops in this area. For example, the eighth conference on Deontic Logic in Computer Science in 2006 in Utrecht, the Netherlands had as special focus “artificial normative systems”, and the seventh conference in 2004 in Madeira, Portugal had as special theme “deontic logic and multiagent systems.” Third workshop on normative multiagent systems was co-located in Luxembourg in July 2008 and had as special topic “security and trust,” [9] The Multi-Agent Logics, Languages, and Organizations Federated Workshops 2010. [14]

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