Artificial Societies and Agent Technology

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Introduction

Software is the essential enabler for the new society. It creates new markets and new directions for a more reliable, flexible, and robust society. This paper presents a new trend and theory in the direction in which we believe software science and engineering may develop to transform the role of software and science in tomorrow's information society. This is an attempt to capture the essence of a new state of art in software science and its supporting technology.

What is "Society"?

Society defined by Sociologists and Anthropologists as the totality of social relationships among humans. It is a group of humans broadly distinguished from other groups by mutual interests, participation in characteristic relationships, shared institutions, and a common culture.It is also an organization or association of persons engaged in a common profession, activity, or interest: a folklore society; a society of bird watchers. Many at times it is also defined as the rich, privileged, and fashionable social class or the socially dominant members of a community. In Biology it is defined as a colony or community of organisms, usually of the same species, for instance an insect society.

Development of Computers and IT has given opportunity to develop entities which are as intelligent as human beings. In engineering the use of robots for perform hazardous processes is there for few decades. The recent development in Artificial Intelligence helped to develop new systems for such purposes. These were possible due to the enormous research going in various labs on Artificial Intelligence and Software Agents.

What are Software Agents?

The term "agent" is used (and misused) increasingly to describe a broad range of computational entities. An entity with goals, actions, and domain knowledge, situated in an environment or broad

range of computational entities. The way it acts is called its ``behavior.' Some agents perform tasks individually and others need to work together.

Some are mobile and some are static. Agents communicate via messages and some don't communicate at all. Some learn and adapt and others don't. Despite this diversity, we can identify some common properties.

Working definition of "agent"

An agent is a reusable software component that provides controlled access to (shared) services and resources. Example: a printer agent that provides printing services schedules requests to a shared printer. Agents are the basic building blocks for applications, and applications are organized as networks of collaborating agents. Example: a desktop agent "recruits" the services of a screen and a connection agent to physically connect a call.

The behavior of each agent is constrained by policies, which are set by higher-level agents (security, load balancing, user preferences etc.). Similar to human society, agents also form their own societies. These are called artificial societies.

Development of Agent technology

Agents research is happening over the years. We can split agent research into three strands:

1. Distributed Artificial Intelligence (DAI) - Multi-Agent Systems (MAS)

2. Much broader notion of "agent" (from the 90's till now)

3. Agent-based modeling and yet another type of agents (the future)

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[                    ]                          1980
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DAI and MAS
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[                            ]                                      1990
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Much broader notion (interface, reactive, mobile, information)
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[                         ]                           1995
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Agent-based modeling (ALife, cas) and new agents species (economic agents)

Why agents?

Most uses of agents can be subsumed under two headings:

1. Simplifying distributed computing

2. Agents as intelligent resource managers

Agents are used to overcome user interface problems. Many at times Agents are used as personal assistants, which adapt to the user. These are particularly relevant to telecommunications. Telecommunications companies also account for the largest portion of agent research. The ROI is tangible for them!

Types of Agents

1. Information agents

These are the agents, which are used for managing the explosive growth of information. They manipulate or collate information from many distributed sources. These

Information agents can be mobile or static. Examples: BargainFinder comparison shops among Internet stores for CDs, Jasper works on behalf of a user or community of users and stores, retrieves and informs other agents of useful information on the WWW.

Internet Softbot infers which internet facilities (finger, ftp, gopher) to use and when from high-level search requests.

2. Interface agents

These are strand 2 agents. These agents support and provide assistance. They cooperate with the user in accomplishing some task in an application. These Interface agents learn by observing and imitating the user (from user) through receiving feedback from the user

By receiving explicit instructions by asking other agents for advice (from peers) Filters (eg, your email) eager assistant (eg Open Sesame) social filtering (referrals). They are basically representing the users.

3. Heterogeneous agents

These are the agents, which are made of at least two agents from different agent types. For example, CAD systems are heterogeneous agents.

4.Mobile agents

These are the programs that can migrate from one machine to another. They are generally, executed in a platform-independent execution environment. These require agent execution environment (places). However, mobility is not necessary or sufficient condition for agenthood. One such agent is the ones

used in PDAs.

5.Reactive agents

These are the agents, which do not have internal symbolic models. They generally act by stimulus-response to the current state of the environment. This is based on subsumption architecture (Brooks). Each reactive agent is simple and interacts with others in a basic way. Complex patterns of behavior emerge from their interaction.

Common properties that make agents different from conventional programs:

Agents are autonomous, that is they act on behalf of the user. Agents contain some level of intelligence, from fixed rules to learning engines that allow them to adapt to changes in the environment. Agents don't only act reactively, but sometimes also proactively. Agents have social ability that is they communicate with the user, the system, and other agents as required. Agents may also cooperate with other agents to carry out more complex tasks than they themselves can handle. Agents may move from one system to another to access remote resources or even to meet other agents.

Agent Technology is the latest paradigm of software engineering methodology. The development of autonomous, mobile, and intelligent agents brings new challenges to the field. Multi-agent-system researchers have started to develop agents with "social" abilities and complex "social" systems. However, most of these systems lack the foundation of the social sciences. The construction of artificial (agent) societies leads to questions that already have been asked for human societies. Computer Scientists have adopted terms like emerging behavior, self-organization, and evolutionary theory in an intuitive manner. It is the intention to bring together researchers from computer science as well as the social sciences that see their common interest in social theories for the construction of multi-agent-systems.

A: Social Theory for Agent Technology (Socionics)

B: Norms and Institutions in MAS(multi-agent-systems)

C: Agent-based social networks

Need of the Hour

Today's agent systems are mostly closed and centrally designed, with predefined rules and constraints, which the agents have to follow. Existing development and design of multiagent systems has largely focused on global optimization issues and on providing an infrastructure enabling agents to technically interact with and collaborate.

Open agent systems, like electronic marketplaces and artificial societies gain significance and pose new problems in the realm of collaborative behavior and resolving conflicts between self-interested agents. As software agents are increasingly assisting human users in both closed and open environments, their goals, strategies and preferences will reflect the self-interest of their human or institutional owners. This is of increasing concern for future applications like electronic commerce,

peer-to-peer computing, or mobile computing, where software agents have a huge potential to act as intelligent assistants. In these open environments, software agents do not necessarily work towards a common goal, but are individually designed to pursue the self-interest of the respective owner. Conflicts about e.g. the access to goods, services, schedules and other resource assignments will occur inevitably and often. Fraudulent agents may even submit unjustified resource claims. For establishing open agent systems, new mechanisms and approaches to conflict resolution have to be found which not yet exist. However, a centralized, acknowledged coordinator institution cannot be assumed to exist. Thus, self-interested software agents will have to detect and resolve conflicts either individually, in a cooperative group, or by delegation to specialized instances. They need assessment and management tools to detect and resolve conflicts.

Similar to human conflict resolution, they may use negotiation, mediation, arbitration or legislative approaches. While constructing robust, fault-tolerant, and flexible multiagent systems one has to focus on :

- Coping with conflicts caused by self-interested agents
- Theoretical and methodological foundations of conflicts and self-interested agents
- Distributed Artificial Intelligence(DAI) specific approaches to conflict detection and resolution
- Economical and legislative approaches to conflict detection and resolution
- Equipping agents to work in conflict-prone, insecure and unsafe environments
- Mechanisms to assess and measure conflict probability in MAS
- Conflict detection, resolution and management concepts
- Transferable examples of conflict resolution from closed agent systems
- Conflict prevention or avoidance concepts for open, decentralized MAS, e.g.construction of third party instances

Artificial Life

The different techniques covered by the term 'Artificial Life' can be used, among other things, for improving our understanding to what extent observed social behaviour may be due to self-organisation and what implications this has for evolutionary theories.

Although in this field major discoveries have been made, the methods developed by Artificial Life have not been adopted sufficiently in mainstream biology, anthropology and sociology. The paper aims to promote integration in the vast area of the study of social behaviour.

Research areas

- Group formation/coordination

- Collective decisions

- Dominance interactions

- Societies

- Task distribution

- Mate choice

- Communication

- Cultural Transmission

- Evolution of Social Systems

- Social and economic evolution

Social Action Theory and multi-agent Systems

This is an area where sociological concepts about roles, positions, situations and negotiations in a structure that allows to implement a supporting and simulating multi-agent systems for special applications. That is to equip artificial agents with social abilities so that they can work much more realistic as deputies of human actors in complex environments (Lettkemann et al).

Socionics

Socionics is the interdisciplinary field of Sociology and Computer Sciences. Sociology that deals with the investigation of properties of human societies, shares some similarities with the area of multi-agent systems. The special aim of the research is the modeling and implementation of cooperative agents in complex organizations.

Social Network

The social network theory suggests that the social relationships among individuals are based on exchange. Each individual's feelings,ideology, emotions etc. are exchanged with others in order to develop strong bond among them(Srinivasan)

Similar interactive exchanges are possible in Multi-agent systems.

Future Scope

In developing agents and multi-agent systems, computer scientists typically bring their work to bear on theories and methods from social sciences. Examples include computational and agent-based approaches to the study of negotiation, social interaction, contracts, agreement, organisation, cohesion, social order, and collaboration.eX

Negotition and Interaction by Social Agents in a complex environment

Article

This has played an influential role in the development of an interdisciplinary area called "Socionics". In the last few years researchers in such areas as Artificial Intelligence, Sociology, Organisation

Theory, Social Networks, Evolution Theory and Self-Organizing Principles have increasingly shown interest in some of the following research problems:

- What are the similarities between human and artificial societies?

- How can we represent and reason about artificial communities composed of individual computational agents?

- What are the main difficulties in designing hybrid societies composed of both human and artificial agents?

- What are the effects of the increasing involvement of artificial societies in social life?

The presentation aims at exchanging and integrating ideas from different aspects of agent-oriented approaches in connection with such topics as organisational knowledge, structure and behaviour. Of particular interest is recent work in any of the following areas:

- modeling of artificial and hybrid organisations

- agent and organisational behaviour

- commitment, responsibility and obligations in artificial and hybrid organisations

- semantics of the dynamics of organisational models

- agent specifications in artificial and hybrid societies

- organisational roles and structures

- adaptive learning and models of organisational cognition

- simulation of artificial and hybrid organisations

- self-organizing systems and emergent organisations

There have been a number of attempts at designing distributed systems by drawing on agent-oriented concepts. However, the impact on human behaviour exerted by interactions with artificial agents within hybrid societies still remains to be addressed.

Artificial Society

As mentioned earlier, the society consisting of agents as members are called Artificial Society. As per the definition of Society, there are relationships among the members. Artificial society creates an environment to facilitate relationship among agents. Further, the interactions happen for mutual interest. Many at time there are participation in characteristic relationships, sharing resources and a common behaviour. They also organize or associate with other agent engaged in a common activity, or interest: E-commerce customers, and online bidders.

Number of studies was conducted on artificial societies of intelligent agents, in order to understand and simulate adaptive behaviour and social processes. García's (2001) study obtained this processes in three parallel ways: First, present a behaviours production system capable of reproducing a high number of properties of adaptive behaviour and of exhibiting emergent lower cognition. Second, introduce a simple model for social action, obtaining emergent complex social processes from simple interactions of imitation and induction of behaviours in agents. And third, present approximation to a behaviours virtual laboratory, integrating our behaviours production system and social action model in animats. In behaviours virtual laboratory, the user can perform a wide variety of experiments, allowing him or her to test the properties of behaviours production system and social action model, and also to understand adaptive and social behaviour. They can also be accessed and downloaded through the Internet.

In general agents operate at three levels(Fasil, 2004). 1.At individual level, 2. Bilateral level, and 3. Collective level. At the individual level, agents have intentions, beliefs, desires and preferences over states of affairs. At the bilateral level, agents hold attitudes in relation to one other agent: obligations, rights, social commitments and roles. Social commitments involve obligations, rights, individual intentions as well as mutual beliefs and in that sense they can be synthesized by other attitudes. As a result one could drop the operator for social commitments. Roles are associated with social commitments. At the collective level, a group (or a *social agent*) is held together by attitudes such as collective commitments and mutual intentions. An organization would be held together by a number perhaps of collective commitments undertaken by its constituent agents. These would include some mutual intentions and beliefs. The constituent members would have certain roles within the organization, which require social commitments, which in turn are based on intentions, obligations and rights.

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