Equating human and machines in the management perspective

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ABSTRACT

The increased application of Information Technology in organizations, has led to the development of intelligent software that can handle various conventional management functions. Distributed Artificial Intelligence (DAI) views such autonomous software applications as intelligent agents and complex systems as a collection of such interacting agents. Extending this to management, an organization is viewed as a multi-agent system having many agents (human and software) and a manager is viewed as an agent in the hierarchy. This paper gives a new perspective to such systems, accommodating a blend of human skills and machine skills. The skills required for various management processes are equated to intelligent agent properties, and a new model, which has the ability to compare the efficiency of man and machine in handling similar managerial functions, is proposed.

Keywords: Management processes, Managerial skills, Intelligent agents, Multi-agent systems, Agent properties

Introduction

Information Technology (IT) has started replacing humans in many processes and functions once thought to require human intelligence. Such entities are called *Intelligent Agents* by Artificial Intelligence (AI) literature. The future systems will no longer distinguish between interactions of humans and non-humans (Parunak, 1996). AI scientists and sociologists consider an organization as a specific solution created by a

collection of many agents (human or non-human) each assigned one or more tasks or roles and having interrelations with others to achieve common goals (Jeans Henoch and Heinz Ulrich, 2000). This agent based approach to organizations as a Multi-Agent System (MAS) has been applied to many fields including Internet, Services, Manufacturing, and Supply chain management. The concept of managers acting as Intelligent Agents with focussed skills in an organisational context is gaining currency of late.

Management systems and methodologies are predominantly human oriented. This is obviously natural as management science and the science of DAI did not evolve simultaneously. However, today, there is a need to assess the efficacy of the current systems and methodologies in terms of their accommodating human skills and machine skills in a blended form. The use of AI vis-à-vis human intelligence needs sincere consideration in the formulation and evaluation of management systems.

Are computer systems intelligent?

There are two schools of thought for this problem. The Social/Behavior school argues that intelligence is a quality of human behavior and insists that emotions is an essential part of human intelligent behavior. The second school is based on the Turing test which focus on the desired output by the entity whether human or machine. Since Management Science is all about achieving goals the second school of thought is considered to be more appropriate in the area of management. For example, a biometric ATM (Automated Teller Machine in a Bank) can be considered functionally equivalent to a human teller in Bank who verifies credentials of a customer and makes cash payment.

What is an Intelligent Agent?

Researchers in the field of Distributed Artificial Intelligence (DAI) have offered a variety of definitions for an agent. We have also many synonyms including knowbots

(knowledge-based robots), softbots, taskbots, userbots, robots and artificial agents. But the term Intelligent Agent or simply Agent has become the generic term to describe such entities in Artificial Intelligence (AI) paradigm. Agents can be defined to be autonomous, problem-solving computational entities capable of effective operation in dynamic and open environments. An agent perceives its environment through sensors and acts upon that environment through effectors (Russel, & Norving, 1995).

Nwana S H (1996) identified a minimal list of three properties: *autonomy, adaptivity* and *cooperation or sociability* for an intelligent agent. *Autonomy* makes an agent act without direct intervention by humans or other agents and has control over its own resources and internal state and they act in such a manner as to meet its goals on behalf of its user. *Sociability or Cooperation* means that an agent is capable of *interacting* with other agents or humans via some communication language. *Adaptivity* implies that an agent is capable of taking proactive and goal directed initiative, learning from own experience. These properties result in a variety of capabilities for agents. UMICH (2004) identified seven fundamental capabilities for an agent viz. Perception, Action, Planning, Learning, Natural Language Processing (NLP), Co-operation and Meta-reasoning.

Perception is the interface to dynamic external world to input data to the agent system by sensing the environment, while action system is the output channel to influence outer world with the results of deliberation of the agent. Taking appropriate action in a given moment is one of the fundamental capabilities for intelligent agents. Planning refers to the process of computing several steps of a problem solving procedure before executing any of them. Learning covers a wide range of phenomena, from skill refinement to knowledge acquisition at the other end of the spectrum. Natural language understanding and generation capabilities are required to communicate and cooperate with other agents. Meta-reasoning, as the name implies, consists of various meta-rules conjoining other capabilities such as learning and planning. These capabilities are summarised in Table 1.

Agent Capability	Related Agent properties
Perception	Sociability
Action and Meta-reasoning	Autonomy
Planning, Learning	Adaptivity
NLP and Cooperation	Sociability

Table 1: Agent capabilities and related properties

Manager as Intelligent Agent

The characteristics and properties of multi-agent systems are well researched in Artificial Intelligence (AI) and social sciences (Wooldridge M, Jennings N.R, & Sycara K, 1998). However, no serious attempt has been made to apply these principles to management science. This paper is an attempt in this direction.

Agents continuously perform three functions: perception of dynamic conditions in the environment; action to affect conditions in the environment; and reasoning to interpret perceptions, solve problems, draw inferences, and determine actions to achieve a designed goal (Hayes-Roth, 1995). *This is what a manager also is required to do*. Managers act in response to their environment (reactivity) and also take initiative (proactiveness); they co-operate with other functionaries via some communication language; they also learn as they react or interact with environment, which result in increased performance over a time. In this backdrop, an organization is viewed as a multi agent system (MAS) and manager as an intelligent agent in the MAS hierarchy.

Management Processes & Agent properties

A commonly used management model is the POLC model with Planning, Organizing, Leading and Controlling (abbreviated as POLC) as the processes to achieve the objectives of an organization. Planning skills are mainly strategic thinking and decision

making which corresponds to adaptivity and autonomy of the agent properties. Thus planning requires more of adaptivity and autonomy than sociability. We notice that controlling too requires similar agent properties. The process of organizing demands self-managing skills and teamwork, corresponding to autonomy and sociability of the agent properties. Leading process focus on people interaction and problem solving which correspond to sociability and adaptivity of the agent properties.

Process (1)	Required skills (2)	Agent capabilities (3)	Agent properties (4)
Planning	Strategic thinking, Vision, Decision making	Planning, Learning, Action	Adaptivity, Autonomy
Organizing	Self managing, Teamwork	Perception, Cooperation, Action	Sociability, Autonomy
Leading	People skills, Problem solving, Consistency, Friendliness, Responsiveness	NLP, Cooperation, Perception, Planning	Sociability, Adaptivity
Controlling	Performance assessment, Flexibility, Adaptive to change	Meta-reasoning, Learning	Autonomy, Adaptivity

Table 2: Correspondence between managerial skills and agent properties

The associated skills required for the four management processes are listed in first two columns of Table 2 (NSW HSC online, 2004). The identified agent properties (in the order of importance) for each of the processes are added to the table (columns 3 & 4), by grouping the skills required for each management process and matching them with agent capabilities and agent properties (listed earlier in Table 1). The objective here is to map management processes in terms of agent properties.

Mapping to managerial skills - The ASD model

We observe that each of the POLC processes has two *dominant* agent properties (refer Table 2) for a manager. And this does not imply that the third property is not required. The relative importance or weight of each of these properties for a process depends on the organization. For example, a marketing organization may require pro-active action

from its managers (higher autonomy score) whereas a sales organization need only to be reactive requiring a lower autonomy score. Some organization may need equal (1:1) adaptivitiy and autonomy for planning process and another organization may need them in ratio 3:2. We may assign a 3 digit number scheme (*process weight*) for indicating the weight of each property required for a process. When relative weights of the three agent properties Autonomy, Sociability and aDaptivity required for a process are represented as variables A, S and D respectively, the process weight is ASD. For example, if we assume that the leading process in an organization requires autonomy, sociability and adaptivity in the ratio 1:5:4 (each value in a 10-point basis), the process weight for this process is 154 where each digit is the relative weight for that agent property in ASD sequence. Mathematically we represent a process as Mp=A.S.D where the suffix 'p' represents the process and A, S and D represent the weights of the agent properties for the process 'p'. This model makes it possible to represent the managerial skills for the management processes specific to an organization or business.

Graphically, combination of the three primary properties of agents for a management process is mapped in fig.1 as different sectors of a pie chart, each area representing the extent of the agent property for that process.

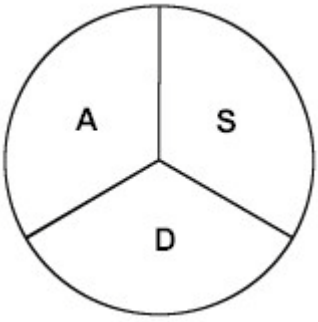

Fig 1: Mapping Agent properties for a management process
(A-autonomy S-sociability D- adaptivity)

The proportion of the areas of A, S and D varies depending on the type of business and the management process.

Evaluation of skills

Application of the model in practice requires necessary test methodologies for assessing Autonomy, Sociability and Adaptivity characteristics of managers in the organizational context. Such measures exist for intelligent agents in MAS environment, in AI literature, which can be a basis for developing effective test methodologies. Each agent property has a continuum of values – Autonomy ranges from Passive-Reactive-Proactive, Sociability from Communication-Interaction-Cooperation, and Adaptivity from Reflex-Preference-Reasoning-Learning. These properties are usually measured across a continuum of levels as a relative concept, on a 10-point scale.

Assuming that the properties are measured in a 10-point scale using suitable test methodologies, we shall now illustrate how the scores can be used to find the most suitable person for the leading process in an organization with process weight 154 for the leading process (as discussed earlier).

Person/Machine	*Personal scores*			
	Autonomy	Sociability	Adaptivity	Overall score *
Candidate 1	4	5	7	57
Candidate 2	5	4	7	53
Candidate 3	7	6	6	**61**

Table 3: Scoring sheet for ASD model (leading process)

Table 3 lists the scores by 3 candidates for the various agent properties. The overall score (*) is calculated by multiplying each score by the corresponding proportion of the process weight and summing up. For candidate 1, the overall score is 4x1 + 5x5 + 7x4 = 57 and so on. The candidate with the highest score is the most suited (candidate 3 in this example).

Applications

Since the ability measure of managers is transformed into agent properties, the proposed ASD model contributes to study of *hybrid* multi-agent systems where humans and machines co-exist as agents, using mathematical models available in DAI literature, which is otherwise not possible in the current management methodologies.

Conclusion

The paper equates a manager in an organization to an agent in a Multi Agent System (MAS). The skills required for a manager (in management science) is compared with the capabilities and properties of an agent in the DAI domain and a new model for representing managerial process skills is proposed, bringing human managers and I.T agents on a comparable platform.

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