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Introduction

Artificial Intelligence (AI)

Artificial intelligence (AI) is both the intelligence of machines and the branch of computer science which aims to create it. Artificial Intelligence is a combination of cognitive science, linguistics, ontology, physiology, psychology, philosophy, operations research, economics, control theory, neuroscience, computer science, probability, optimization and logic. AI is a very large subject-matter. It consists of many different fields, from machine vision to expert systems.

The aim of all the fields is the creation of machines that can "think". Researchers hope that AI machines will be capable of reasoning, knowledge, learning, communication, planning, perception and the ability to move and manipulate objects.

What's it all about?

Artificial Intelligence (AI) is the science and engineering of creating intelligent machines and computer programs. It is related to similar tasks of using computers to understand human intelligence but AI does not only have to confine itself to methods that are biologically observable. The interest in AI has commonly increased since years and some classical sub-disciplines like robotics, language processing, or natural computing have produced reliable solutions

Intelligence is prediction

Intelligence is the ability to predict what comes next, even when faced with incomplete knowledge. Artificial Intelligence, therefore, should be software that predicts. Software that can do the right thing - sufficiently right to be valuable for a business or an individual. Artificial Intelligence has reached the stage of sufficiency. A machine can understand natural language, respond and act such as to be genuinely useful. It doesn't have to possess human-level intelligence. It doesn't have to fool you that it's human, even though, surprisingly often, **i**t can. It just has to do a good job - a better job, that is, than countless imperfect websites, telephone systems and even complete, staffed call centres. Any modern computer can cope with support or telesales 'scripts' with millions of times the complexity of your average human, and can have any amount of information or knowledge 'at

its   fingertips'.   The   missing   element,   until   now,   has   been   understanding.

There are, frankly, too many examples of conversational agents that do not say the right thing often enough. They don't understand, spotting just a few key words in what is said. That's not enough.

Our software predicts what comes next, at every stage in a process. It 'thinks of' the trillions of possible sentences that you might say, and knows exactly which one came closest. So it 'understands' you. It knows every part of what you said, and can act on that understanding. It uses context to resolve ambiguity. Our AI can show sufficient intelligence. Our AI concentrates currently on natural language processing and on emotional states, yet its universal principles can be applied to any sensory or data inputs.

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Intelligent Agent

In artificial intelligence, an intelligent agent (IA) is an autonomous entity which observes and acts upon an environment (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is rational).[1] Intelligent agents may also learn or use knowledge to achieve their goals. They may be very simple or very complex: a reflex machine such as a thermostat is an intelligent agent, as is a human being, as is a community of human beings working together towards a goal.

Intelligent agents are often described schematically as an abstract functional system similar to a computer program. For this reason, intelligent agents are sometimes called abstract intelligent agents (AIA) to distinguish them from their real world implementations as computer systems, biological systems, or organizations. Some definitions of intelligent agents emphasize their autonomy, and so prefer the term autonomous intelligent agents. Still others (notably Russell & Norvig (2003)) considered goal-directed behavior as the essence of intelligent and so prefer a term borrowed from economics, "rational agent".

Intelligent agents in artificial intelligence are closely related to agents in economics, and versions of the intelligent agent paradigm are studied in cognitive science, ethics, the philosophy of practical reason, as well as in many interdisciplinary socio-cognitive modeling and computer social simulations.

Intelligent agents are also closely related to software agents (an autonomous software program that carries out tasks on behalf of users). In computer science, the term intelligent agent may be used to refer to a software agent that has some intelligence, regardless if it is not a rational agent by Russell and Norvig's definition. For example, autonomous programs used for operator assistance or data mining (sometimes referred to as bots) are also called "intelligent agents
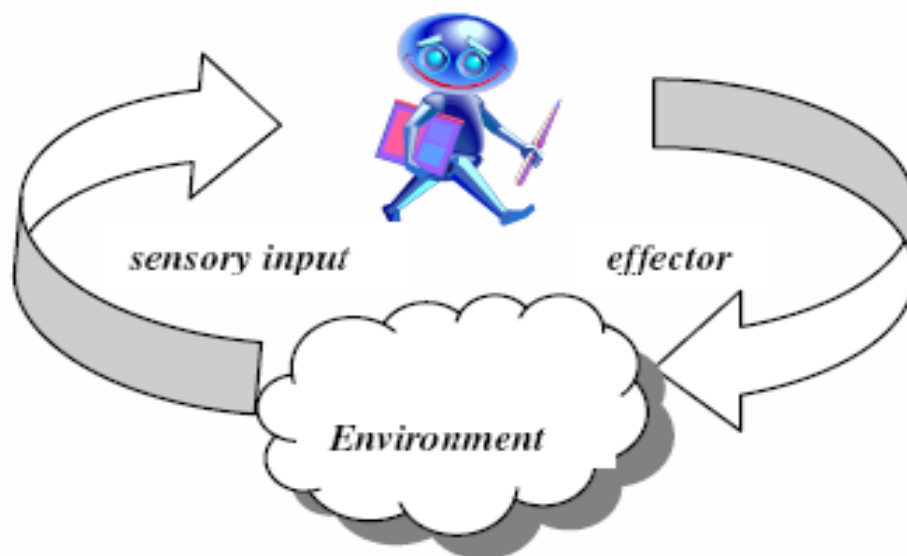
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Agent

A program that performs some information gathering or processing task in the background. Typically, an agent is given a very small and well-defined task.

Although the theory behind agents has been around for some time, agents have become more prominent with the growth of the Internet. Many companies now sell software that enables you to configure an agent to search the Internet for certain types of information.

In computer science, there is a school of thought that believes that the human mind essentially consists of thousands or millions of agents all working in parallel. To produce real artificial intelligence, this school holds, we should build computer systems that also contain many agents and systems for arbitrating among the agents' competing results

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Rational Agent

In economics, game theory, decision theory, and artificial intelligence, a rational agent is an agent which has clear preferences, models uncertainty via expected values, and always chooses to perform the action that results in the optimal outcome for itself from among all feasible actions. Rational agents are also studied in the fields of cognitive science, ethics, and philosophy, including the philosophy of practical reason.

A rational agent can be anything that makes decisions, typically a person, firm, machine, or software.

The action a rational agent takes depends on:

- the preferences of the agent
- the agent's information of its environment, which may come from past experiences
- the actions, duties and obligations available to the agent
- the estimated or actual benefits and the chances of success of the actions.

In game theory and classical economics, it is often assumed that the actors, people, and firms are rational. However, the extent that people and firms behave rationally is subject to debate. Economists often assume the models of rational choice theory and bounded rationality to formalize and predict the behavior of individuals and firms. Rational agents sometimes behave in manners that are counter-intuitive to many people, as in the Traveler's dilemma.

Artificial intelligence has borrowed the term "rational agents" from economics to describe autonomous programs that are capable of goal directed behavior. Today there is a considerable overlap between AI research, game theory and decision theory. Rational agents in AI are closely related to "intelligent agents", autonomous software programs that display intelligence.

Common Attributes of Intelligent Agents

While no definitive definition of what makes a computer program an intelligent agent currently exists, researchers have reached some consensus on the common attributes of intelligent agents:

Autonomy: an intelligent agent must be capable of working without human supervision.

Self-learning: an intelligent agent should be capable of changing their behaviour according to their accumulated knowledge.

Proactive: an intelligent agent should be capable of making decisions based on its own initiative.

Communication: an intelligent agent needs to be able to communicate with other systems and agents, while also communicating with the end user in natural language.

Co-operation: some of the more advanced intelligent agents should be able to act in unison with other agents to carry out complex tasks.

Mobility: an intelligent agent will need to be mobile, to enable it to travel throughout computer systems in order to accumulate knowledge and carry out tasks.

Goal Driven: all intelligent agents must have a goal, a user-defined purpose, and then act in accordance with that purpose.

Not all agents must possess every one of these attributes to be considered valid. For example, each agent is likely to have different knowledge, capabilities, reliability, resources and responsibilities that will all have a bearing on the design of the agent

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Intelligent Agent Competition Model
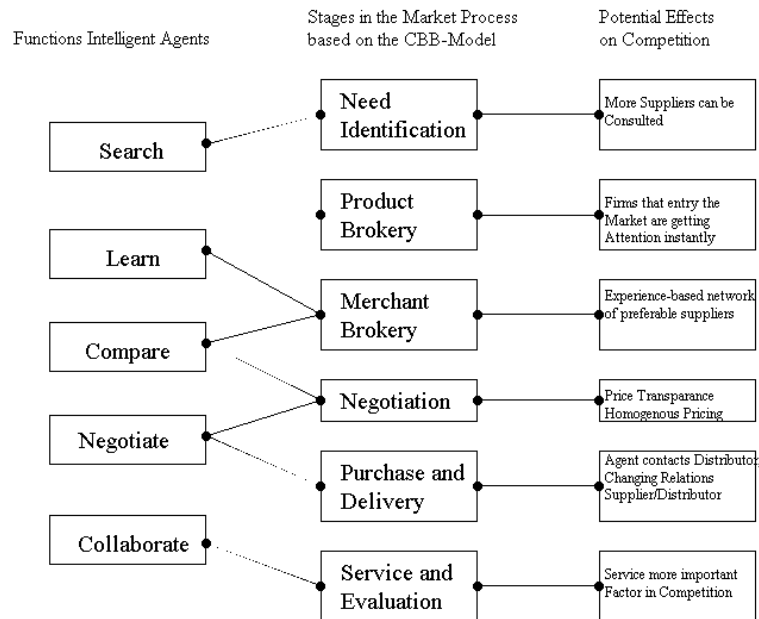
Bounded Rationality

Some models of human behavior in the social sciences assume that humans can be reasonably approximated or described as "rational" entities (see for example rational choice theory). Many economics models assume that people are on average rational, and can in large enough quantities be approximated to act according to their preferences. The concept of bounded rationality revises this assumption to account for the fact that perfectly rational decisions are often not feasible in practice due to the finite computational resources available for making them.

The term is thought to have been coined by Herbert Simon. In Models of Man, Herbert Simon points out that most people are only partly rational, and are in fact emotional/irrational in the remaining part of their actions. In another work, he states "boundedly rational agents experience limits in formulating and solving complex problems and in processing (receiving, storing, retrieving, transmitting) information" (Williamson, p. 553, citing Simon). Simon describes a number of dimensions along which "classical" models of rationality can be made somewhat more realistic, while sticking within the vein of fairly rigorous formalization.

These include:

- limiting what sorts of utility functions there might be.

- recognizing the costs of gathering and processing information.

- the possibility of having a "vector" or "multi-valued" utility function.

Simon suggests that economic agents employ the use of heuristics to make decisions rather than a strict rigid rule of optimization. They do this because of the complexity of the situation, and their inability to process and compute the expected utility of every alternative action. Deliberation costs might be high and there are often other economic activities where similar decision making is required.

Daniel Kahneman proposes bounded rationality as a model to overcome some of the limitations of the rational-agent models in economic literature. As decision makers have to make decisions about how and when to decide, Ariel Rubinstein proposed to model bounded rationality by explicitly specifying decision making procedures on the research agenda.

Gerd Gigerenzer argues that most decision theorists who have discussed bounded rationality have not really followed Simon's ideas about it. Rather, they have either considered how people's decisions might be made sub-optimal by the limitations of human rationality, or have constructed elaborate optimizing models of how people might cope with their inability to optimize. Gigerenzer instead proposes to examine simple alternatives to a full rationality analysis as a mechanism for decision making, and he and his colleagues have shown that such simple heuristics frequently lead to better decisions than the theoretically optimal procedure.

From a computational point of view, decision procedures can be encoded in algorithms and heuristics. Edward Tsang argues that the effective rationality of an agent is determined by its computational intelligence. Everything else being equal, an agent that has better algorithms and heuristics could make "more rational" (more optimal) decisions than one that has poorer heuristics and algorithms.

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Agent Environment

Environments in which agents operate can be defined in different ways. It is helpful to view the following definitions as referring to the way the environment appears from the point of view of the agent itself.[6]

Observable vs. partially observable

In order for an agent to be considered an agent, some part of the environment - relevant to the action being considered - must be observable. In some cases (particularly in software) all of the environment will be observable by the agent. This, while useful to the agent, will generally only be true for relatively simple environments.

Deterministic vs. stochastic

An environment that is fully deterministic is one in which the subsequent state of the environment is wholly dependent on the preceding state and the actions of the agent. If an element of interference or uncertainty occurs then the environment is stochastic. Note that a deterministic yet partially observable environment will appear to be stochastic to the agent.

An environment state wholly determined by the preceding state and the actions of multiple agents is called strategic.

Episodic vs. sequential

This refers to the task environment of the agent. If each task that the agent must perform does not rely upon past performance, and will not effect future performance then it is episodic. Otherwise it is sequential.

Static vs. dynamic

A static environment, as the name suggests, is one that does not change from one state to the next while the agent is considering its course of action. In other words, the only changes to the environment are those caused by the agent itself. A dynamic environment can change, and if an agent does not respond in a timely manner, this counts as a choice to do nothing.

Discrete vs. continuous

This distinction refers to whether or not the environment is composed of a finite or infinite number of possible states. A discrete environment will have a finite number of possible states, however, if this number is extremely high, then it becomes virtually continuous from the agents perspective.

Single-agent vs. multiple agent

An environment is only considered multiple agent if the agent under consideration must act cooperatively or competitively with another agent to realize some tasks or achieve goal. Otherwise, another agent is simply viewed as a stochastically behaving part of the environment.

Overview of environments rising order of complexity →
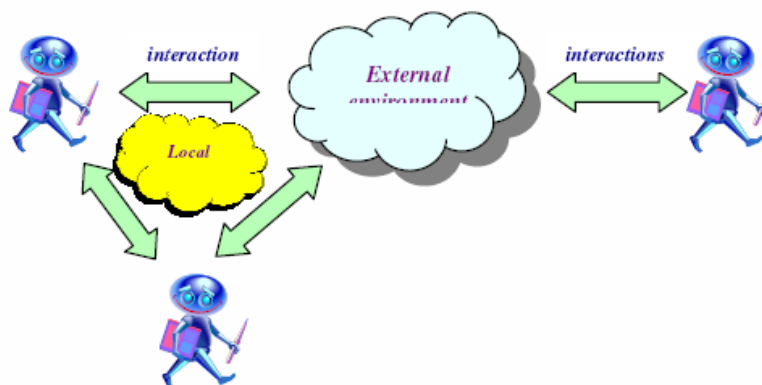
Observable   Partially observable

Deterministic Stochastic

Episodic   Sequential

Static   Dynamic

Discrete   Continuous

Single-agent   Multiple agent

Multi-agent model

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Applications

1. Systems and Network Management:

Systems and network management is one of the earliest application areas to be enhanced using intelligent agent technology. The movement to client/server computing has intensified the complexity of systems being managed, especially in the area of LANs, and as network centric computing becomes more prevalent, this complexity further escalates. Users in this area (primarily operators and system administrators) need greatly simplified management, in the face of rising complexity.

Agent architectures have existed in the systems and network management area for some time, but these agents are generally "fixed function" rather than intelligent agents. However, intelligent agents can be used to enhance systems management software. For example, they can help filter and take automatic actions at a higher level of abstraction, and can even be used to detect and react to patterns in system behaviour. Further, they can be used to manage large configurations dynamically;

2. Mobile Access / Management:

As computing becomes more pervasive and network centric computing shifts the focus from the desktop to the network, users want to be more mobile. Not only do they want to access network resources from any location, they want to access those resources despite bandwidth limitations [1] of mobile technology such as wireless communication, and despite network volatility.

Intelligent agents which (in this case) reside in the network rather than on the users' personal computers, can address these needs by persistently carrying out user requests despite network disturbances. In addition, agents can process data at its source and ship only compressed answers to the user, rather than overwhelming the network with large amounts of unprocessed data;

3. Mail and Messaging:

Messaging software (such a software for e-mail) has existed for some time, and is also an area where intelligent agent function is currently being used. Users today want the ability to automatically priorities and organize their e-mail, and in the future, they would like to do even more automatically, such as addressing mail by organizational function rather than by person.

Intelligent agents can facilitate all these functions by allowing mail handling rules to be specified ahead of time, and letting intelligent agents operate on behalf of the user according to those rules. Usually it is also possible (or at least it will be) to have agents deduce these rules by observing a user's behavior and trying to find patterns in it;

4. Information Access and Management:

Information access and management is an area of great activity, given the rise in popularity of the Internet and the explosion of data available to users. It is the application area that this thesis will mainly focus on.

Here, intelligent agents are helping users not only with search and filtering, but also with categorization, prioritization, selective dissemination, annotation, and (collaborative) sharing of information and documents;

5. Collaboration:

Collaboration is a fast-growing area in which users work together on shared documents, using personal video-conferencing, or sharing additional resources through the network. One common denominator is shared resources; another is teamwork. Both of these are driven and supported by the move to network centric computing.

Not only do users in this area need an infrastructure that will allow robust, scalable sharing of data and computing resources, they also need other functions to help them actually build and manage collaborative teams of people, and manage their work products. One of the most popular and most heard-of examples of such an application is the groupware packet called Lotus Notes;

6. Workflow and Administrative Management:

Administrative management includes both workflow management and areas such as computer/telephony integration, where processes are defined and then automated. In these areas,

users need not only to make processes more efficient, but also to reduce the cost of human agents. Much as in the messaging area, intelligent agents can be used to ascertain, then automate user wishes or business processes;

7. Electronic Commerce:

Electronic commerce is a growing area fueled by the popularity of the Internet. Buyers need to find sellers of products and services, they need to find product information (including technical specifications, viable configurations, etc.) that solve their problem, and they need to obtain expert advice both prior to the purchase and for service and support afterward. Sellers need to find buyers and they need to provide expert advice about their product or service as well as customer service and support. Both buyers and sellers need to automate handling of their "electronic financial affairs".

Intelligent agents can assist in electronic commerce in a number of ways. Agents can "go shopping" for a user, taking specifications and returning with recommendations of purchases which meet those specifications. They can act as "salespeople" for sellers by providing product or service sales advice, and they can help troubleshoot customer problems;

8. Adaptive User Interfaces:

Although the user interface was transformed by the advent of graphical user interfaces (GUIs), for many, computers remain difficult to learn and use. As capabilities and applications of computers improve, the user interface needs to accommodate the increase in complexity. As user populations grow and diversify, computer interfaces need to learn user habits and preferences and adapt to individuals.

Intelligent agents (called interface agents [3]) can help with both these problems. Intelligent agent technology allows systems to monitor the user's actions, develop models of user abilities, and automatically help out when problems arise. When combined with speech technology, intelligent agents enable computer interfaces to become more human or more "social" when interacting with human users

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Limitations of Intelligent Agents

As with any technology-based solution, a number of limitations and concerns exist regarding the usage of intelligent agents.

No overall system controller:

intelligent agents may not be appropriate where there are global constraints that need to be enforced, due to the fact that each agent is effectively acting independently of any central controller. Applications requiring real-time responses are also inappropriate.

No global perspective:

an agent can only make decisions based on locally accumulated knowledge, therefore an agent might be missing the "big picture" of a problem domain.

Trusting delegation:

a user of an intelligent agent is effectively giving responsibility of data acquisition and decision making to a piece of computer code, therefore they must be sure that they can trust the agent to carry out the delegated task with integrity.

While some of these issues are technology related, others are side effects of the concept of intelligent agents itself. We cannot design an agent to be autonomous and capable of reaching its own decisions, only to decide that we now want to exert a central control over these agents, which is defeating the purpose of the concept.

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Additional information.

Intelligent agents are computer programs that possess aspects of intelligence, and can act independently of their users. These programs can be thought of as autonomous applications acting on the initial instructions of the user, in effect acting as an agent of the user.

The amount of intelligence in such agents may vary, but this term generally refers to the programs ability to act autonomously or to make decisions while attempting to carry out the user-assigned task.

The term intelligent agent is used widely within the Information Technology (IT) industry to describe a wide-range of computer programs, many of which may have different design goals. For example, some agents are designed to undertake the entire task themselves; others work together while communicating with one another. Some agents are actually quite capable of learning and adapting to their environment, in order to carry out their tasks effectively.

Intelligent agents are designed to assist users by acting on their behalf, normally carrying out time-consuming repetitive tasks such as accumulating information. For busy managers and professionals, such time-consuming work can be delegated to intelligent agents, which will act on their instructions and report back findings at regular intervals.

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Common Attributes of Intelligent Agents

While no definitive definition of what makes a computer program an intelligent agent currently exists, researchers have reached some consensus on the common attributes of intelligent agents:

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Goal Driven: all intelligent agents must have a goal, a user-defined purpose, and then act in accordance with that purpose.

Not all agents must possess every one of these attributes to be considered valid. For example, each agent is likely to have different knowledge, capabilities, reliability, resources and responsibilities that will all have a bearing on the design of the agent.

What this means is that different agents may perceive the same data or event in different ways, dependent on the attributes and user agenda of the agent. As a consequence, careful consideration must be given to the business rules under which an agent will operate before it is deployed in a live environment.

Possible Usage of Agents in the Business Domain

If managers and professionals are to delegate tasks to intelligent agents, then what are the likely tasks to delegate Well, the usage of intelligent agents is only limited by two factors:

- The imagination of the designers of intelligence agents.

- The capabilities of the underlining technology supporting the development of intelligent agents.

As with many new technologies, the initial deployments often tend to be for demonstration purposes, with non-trivial deployments evolving over time when end users start to look for solutions to real problems, and cannot find these solutions in existing technologies, therefore turn to intelligent agent-based solutions. It is these deployments that will yield the most important and interesting work in the area.

The main technology-enabler for the wide spread use of intelligent agents is already in place: the Internet. In fact, due to the increasing complexity of the World Wide Web, where everything is available but services change by the second, intelligent agents are becoming necessary for user to make a cohesive view out of the information overload.

Amazon.com is a prime example of a business that has made extensive usage of intelligent agent technology. Thousands of activities and sales reports are automatically distributed to its associates each week, while digital sales clerks gently suggest to customers that people who bought a particular book also bought this other similar book by the same author. The use of agents is not limited to the retail sector, however.

- Applications that are highly suited for intelligent agent usage are:
- Data filtering and analysis.
- Information brokering.
- Condition monitoring and alarm generation.
- Workflow management.
- Personal assistance.
- Simulation and gaming.

Working with only these general area headings, it is clear to see that the adaptation of intelligent agent technology could become widespread throughout organizations. For example, Human Resource (HR) professionals could use agents to data mine online recruitment websites for potential employees with certain pertinent skill sets, or stock brokers could use agents to monitor stock markets and news feeds to aid in risk management of funds. In short, the deployment of the technology is likely to be widespread and varied.

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Limitations of Intelligent Agents

As with any technology-based solution, a number of limitations and concerns exist regarding the usage of intelligent agents.

No overall system controller: intelligent agents may not be appropriate where there are global constraints that need to be enforced, due to the fact that each agent is effectively acting independently of any central controller. Applications requiring real-time responses are also inappropriate.

No global perspective: an agent can only make decisions based on locally accumulated knowledge, therefore an agent might be missing the "big picture" of a problem domain.

Trusting delegation: a user of an intelligent agent is effectively giving responsibility of data acquisition and decision making to a piece of computer code, therefore they must be sure that they can trust the agent to carry out the delegated task with integrity.

While some of these issues are technology related, others are side effects of the concept of intelligent agents itself. We cannot design an agent to be autonomous and capable of reaching its own decisions, only to decide that we now want to exert a central control over these agents, which is defeating the purpose of the concept.

Conclusion

The issue of control raises a fundamental philosophical concern with the widespread use of intelligent agents in business organizations: how much decision-making controls are we willing to give up to an intelligent agent

In order to make business decisions based on the information provided in reports from intelligent agents, or to allow intelligent agents to carry out such business decisions, the intelligent agent developers must convince the users of such agents of the reliability of the software. While one hundred percent reliability is unrealistic in real world applications, a measure of dependability must be established.

The parallel has been made with intelligent agents and computer viruses, for example computer viruses act independently within computer networks just as agents do. The concern here is what would happen if an intelligent computer agent went rogue, returning false data in reports, or even worse actively causing damage on the Internet.

It is certainly possible, although agents from reputable developers are likely to include measures to prevent such things from happening. Less reputable developers have already shown a talent for modifying technology to meet ill aims, for example using automated web site crawling software, or spider bots, to harvest e-mail addresses from unsuspecting websites to be automatically added to spam mail lists.

Just as with any other technology that gives a business a competitive advantage, however short lived, intelligent agents are likely to follow a similar pattern of widespread adoption. If you know that your competitor uses them, then you are likely to want to follow suit, then before you know it everyone is using them. In-house development of highly specialized intelligent agents is likely to yield the most benefit where possible, as these agents can be highly suited to your needs, while the intellectual property of the agent code can be protected from competitors.

Agents have been discussed since about 30 years but are still at an early stage of development. With the rise of the Internet the interest in agents also grew, resulting in a number of environments focusing on different aspects. The very high expectations for artificial intelligence could not quite be met, so agents are today only semi-intelligent. This does not exclude some specialist agents, which can do their (limited) task with an appearance of high intelligence. Especially teleworkers are concerned by the difficulties that have arisen by the mass-usage of electronic communication