

# Knowledge Management in Multimedia Communication using Software Agents

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**Abstract:** This paper presents the problem of knowledge management related to software agents and agent systems (i.e. systems composed of communicating and cooperating software agents). The author presents basic theoretical issues, but the main focus is on the areas of application of software agents in multimedia communication - both existing and prospective applications. Particular attention has been paid to the applications of software agents for: supporting customer service processes through the Contact Centre system; supporting the distance learning system; creating virtual assistants in the form of conversation bots; searching for information in the Semantic Web, and assisting in setting up a video conference call. Software agents are often referred to as 'intelligent' - due to their intelligent behaviour. At their core, they involve: perception, reasoning, learning, communication and operation in complex environments, using all multimedia techniques and procedures. Software agents and agent systems, as presented in this article, represent a new approach to the analysis, design and implementation of complex (usually decentralised and distributed) computer systems, offering a whole range of concepts, techniques and tools to significantly improve the software development process. The ability of software agents to make autonomous decisions have been a subject of considerations. Among other things, they are based on the example of cognitive sciences, which deal with modelling real processes of information processing in humans and building programmes that imitate these processes. Research on the common understanding of shared knowledge and knowledge management in agent-based systems focuses on ontologies, understood as a description of the relationship between the way knowledge is represented and the concept represented by that knowledge. In contrast, research on knowledge sharing has focused on communication languages and their associated - interaction protocol and message transport protocol.

**Keywords:** Software agents, Agent systems, Distance learning, Conversation bots

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## 1. Introduction

In the era of the Knowledge Based Economy (KBE), information and knowledge constitute key resources of enterprises. The activities of economic entities depend very much on the information technologies they use, which encompass much more than just computers and their software; they also include know-how and, consequently, intellectual capital.

Knowledge management, as a young management field, encompasses the latest methods and techniques to ensure the most effective use of knowledge resources, especially those accumulated in organisations. The literature on the subject is abundant in the definitions that characterise knowledge management (Kiełtyka, 2013). One of them that could be quoted here is the definition proposed by Polanyi (Polanyi and Sen, 2009), in the following wording "Knowledge management is a set of processes allowing to transform the tacit knowledge possessed by the employees of an organisation and its environment into explicit knowledge resources valuable to the organisation, allowing it to gain a competitive advantage".

The importance of managing information, and subsequently knowledge that is based on it, is increasing with the process of globalisation and the tightening of cooperative ties between companies. Without the ability to quickly acquire and transfer information, as well as to skilfully use the knowledge accumulated within a company, it is impossible to manage effectively, make decisions or create effective strategies.

The paper presents principles and methods of creating and using multimedia messages in the field of knowledge management. The basic idea and at the same time the main idea of the study is the thesis that it is possible to distinguish a group of software agents supporting various forms of knowledge management carried out on the basis of multimedia messages. The decision-maker's cognitive system, supported by an isolated group of software agents, is the essential regulator of knowledge and information selection, guaranteeing the effectiveness of decision-making. The measure of quality is adjustment to individual needs and human characteristics. The decision-maker is a specific system that assimilates and generates information. Learning about the peculiarities of this group of software agents and associating them with multimedia is crucial in creating effective decision-making tools.

## 2. Multimedia Communicators

Multimedia communicators are a heterogeneous group. The most basic solutions are used for direct communication on the Internet. They offer modern audio and video chat technology, spell-checking, the ability

to change 'skins', support avatars, drag & drop image transfer, multiple conversations in a single window and built-in radio. These solutions are mainly intended for private (individual) users. Therefore, despite their many versions and improvements, they are characterised by their ease of use and installation, while the creation of contact lists is still intuitive and simple, and new services are available at the click of a button.

The popularity of instant messaging is also influenced by the fact that versions are available for many platforms, including Linux, PocketPC or PalmOS, from which users can freely exchange information. The more advanced multimedia communicators contain usability features such as video conferencing and HD video chat.

In accordance with the thesis that it is possible to identify a group of software agents supporting various forms of knowledge management based on multimedia messages, we should try to use commercial solutions available on the market for this purpose, such as: Windows Live Messenger or Camfrog Video Chat. Instant messaging producers also create solutions intended for specific groups of users. The group of so-called social communicators includes, for example, Xfire (a global communicator for gamers, which enables text and voice chat during gaming) or Evermotion Communicator (instant messaging created by one of the largest portals in the computer graphics industry). Although solutions for individual users comprise the largest part of the instant messaging market, business solutions constitute a technologically developed group. Examples of popular business solutions on the market include GGPro or LIVECHAT Communicator. These are used not only for chatting, but also manage the company's communication and enable the sharing of business and private contact lists, and thus manage the use of other communicators in the company, perhaps also through software agents.

It is generally accepted that a software agent is software that assists managers and functions on their behalf. "A software agent, as opposed to the reactive software of the past - reacting to user instructions - is supposed to be proactive, i.e. once the user's needs have been specified, it will perform tasks for them. The agent must be equipped with a specific set of skills and knowledge (heuristics) and other activities (cooperation, communication, command and control) (Kiełtyka, 2020).

In turn, a multi-agent system is a system made up of communicating and cooperating agents pursuing common goals. When creating enterprises for the new era, the features, advantages, areas or skills of using multimedia programmes should be taken into account, especially by software agents.

Multimedia communication is realised by displaying information in a number of multimedia formats. These include static and dynamic images, video, graphics, audio, text and animation. A single instance of multimedia communication does not necessarily have all the components listed. Multimedia communication presents information in interesting, creative way that helps many different types of information to internalise data. Multimedia communication proved particularly useful during the COVID-19 pandemic. The outbreak of the COVID-19 pandemic was a shock to education systems around the world and forced the closure of schools. Remote continuity of learning became a particular challenge for vocational education, a key component of which is practical classes that are difficult to deliver remotely. Multimedia communication has proved particularly useful in preserving the continuity of both education and business entities. Students felt comfortable with multimedia because the Internet itself is filled with all types of media and they could find the type of multimedia that would particularly benefit their communication and learning style (Grewening et al., 2021).

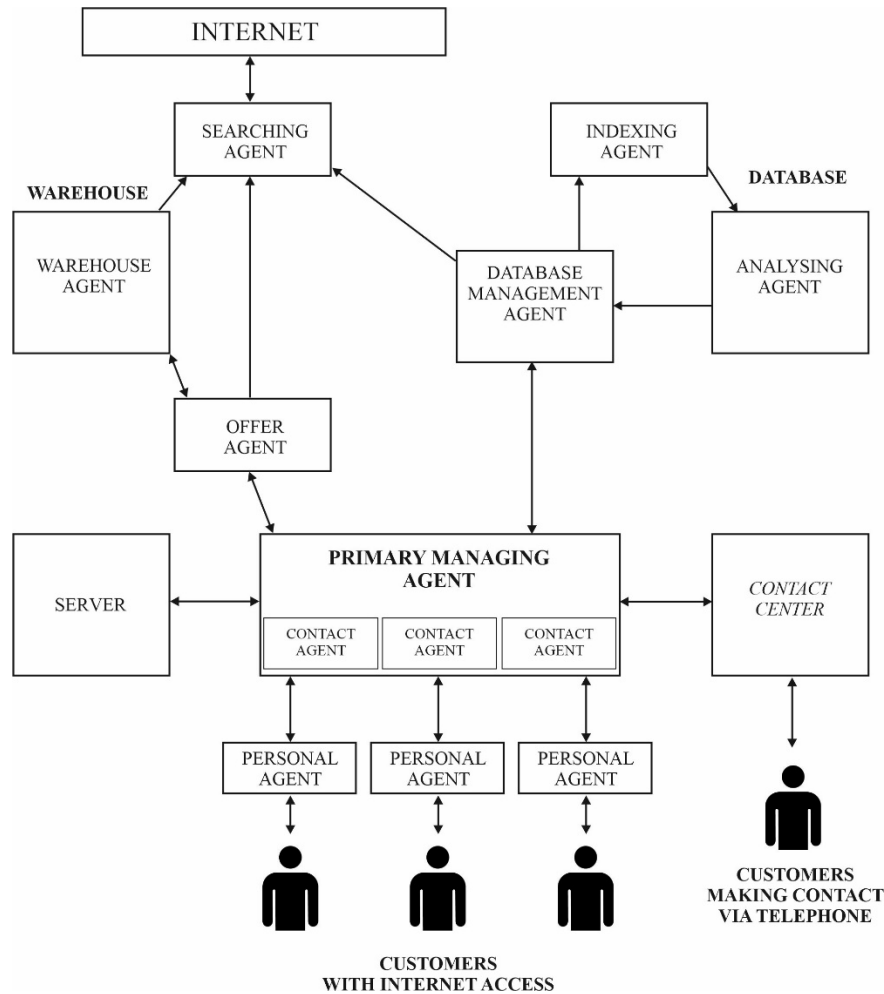
Software agents and agent systems built on them are inspired by real systems and organisations. Particularly close links can be observed with the fields of Artificial Intelligence (AI) and Cognitive Science (CS). Therefore, software agents are often referred to as 'intelligent' (Kiełtyka, 2013), and the degree of their intelligence is also analysed in the literature on the subject. The set of characteristics attributed to software agents and agent systems is as follows: reactivity, autonomy, interactivity, intelligence, reasoning based on collected knowledge, mobility, reliability, capacity for reasoning, ability to communicate, goal orientation, adaptivity, predictivity, capacity for cooperation, learning ability (Paprzycki, 2021). An important issue in open systems is the cooperation of software agents developed by different manufacturers. This is only possible if the used technological solutions are compatible (Kiełtyka and Niedbal, 2015).

The article focuses on several application areas of software agents using multimedia communication.

### **3. Agent System Supporting Operations of Contact Centre**

Not so long ago, the standard customer contact centre (call centre) consisted of a few telephone lines for communicating with agents - people. Today, this is no longer enough to meet customer expectations. Nowadays,

a large proportion of customers prefer to use Internet services and e-mail, only as a last resort opting for a telephone call. For this reason, the call centre is now transforming into a contact centre. This is an organisational and technological solution which allows for the integrated and equal treatment of all channels of communication with the customer, such as telephone, e-mail, SMS (Short Message Service), Live chat (live conversation), contact via a form placed on a website, and visual contact. The Contact Centre unifies the standard of customer service regardless of the communication channel and makes it possible to build an information base of all contacts occurring at the meeting point of the enterprise and its customers. The functions of searching, displaying information about the caller, their previous problems currently can be performed by a software agent. The Contact Centre system is a virtual environment, which makes it a natural environment for software agents. A group of software agents operating within an agent system could, for example, be used to run a contact centre in a web shop (Al-Jaljoui et al., 2018). The software agents would then take on the role of collecting customer data, analysing the collected data, contacting customers to provide an offer (Fig.1).



Source: Own elaboration

**Figure 1: Agent System Supporting Operations of Contact Centre**

The server running the agent system supporting Contact Centre operations receives the data from the database and then converts the data for the customer into the appropriate format, thus creating knowledge packages. For example: if the communication is to take place via e-mail, it converts the data into a text or HTML (HyperText Markup Language) document; if, on the other hand, the customer has requested an SMS, the data is converted into the appropriate format and sent via the GSM (Global System for Mobile Communications) mobile phone network. Communication between agents within the system is in ACL (Agent Communication Language), with the exception of database agents, which communicate in RDQL (RDF Data Query Language).

#### 4. Supporting Distance Learning System

In distance learning, software agents can be used to assist the 'virtual' learner. The software agent can suggest to them specific content on the web, where there are materials facilitating learning (Aldhelai et al., 2015). It can

also keep track of a given student's learning progress, suggest what he or she still needs to work on and select appropriate tests for him or her. The use of software agents relieves the workload of humans controlling students. In addition, instructor's fatigue or a wrong adjustment of the materials to the students' level of knowledge can be associated with a loss of interest and desire to acquire knowledge. It is possible to automate repetitive, routine tasks performed by a teacher (human). Tasks such as, for example: answering simple questions, reminding learners of the necessity and deadlines for sending in solved assignments or checking computer code can be performed by a software agent - called in this case a knowledge robot or knowbot. Knowledge robots are placed between the teacher and the learner, enabling interaction.

Currently, there are numerous IT solutions that support distance learning. Some of them are based on software agents and agent systems built from them. For example, there is a proposal by researchers at the University of Tokyo called Web On-line Force-Directed Animated Visualisation (WebOFDAV for short) (Kulej-Dudek, 2012). Other examples include the system developed at Tottori University (Japan), based on P2P architecture and mobile software agents (Kulej-Dudek, 2012) or the DILE (Distributed Intelligent Learning Environment) system developed at Pelotas University (Brazil), based on the FIPA-OS platform (Hyla, 2005; Aldhelai et al., 2015).

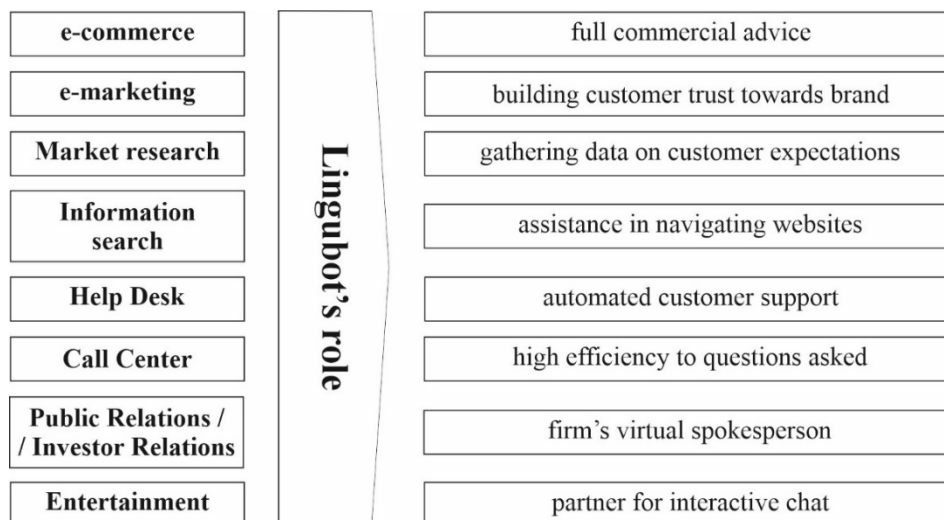
### 5. Virtual Assistants in the Form Of Conversation bots

Software agents equipped with artificial intelligence elements are so-called conversation bots, also called lingubots, chatbots or chatterbots. These are computer programmes, placed on social networks and considered in the field of online marketing communication as innovative solutions (Van den Broeck et al., 2019), with which a human can converse - primarily using a keyboard. During the conversation, they can express their own emotions. The high level of interactivity in communication compensates for the impersonal nature of the chatbot (Go and Sundar, 2019).

Conversational bots that use human speech and respond in the form of a question are also called virtual advisors, personal assistants, digital assistants or virtual assistants (Gentch, 2019; Corti and Gillespie, 2016; Mehrotra et al., 2017).

The person seeking information is not forced to mundane browsing through individual pages, tables or links, as the lingubot presents the relevant data, opens the right page, and assists in filling in forms. This approach increases user satisfaction, which leads to more frequent visits to a particular organisation's website, use of the service for a longer period of time and an improved brand image.

As an example, one can point to the implementations of the technology developed by Artificial Solutions (<http://www.artificial-solutions.com/>). Virtual assistants created with this technology are 'hired' by companies to help those who visit their website. The role of virtual assistants is primarily to provide information, although they are also capable of conversing on other topics. User interaction with conversational bots is mainly carried out using instant messaging embedded in websites. The design of bots often also includes elements of artificial intelligence to assist them in recognising the context of a conversation with a human.



Source: Own analysis

Figure 2: Possible Applications of Lingubots

All conversations are anonymously recorded and can serve as valuable material for various marketing analyses of customer preferences, tastes and expectations. Websites supported by virtual consultants carry out efficient provision of information about commercial offers to customers [Kiełtyka, 2020]. The virtual salesperson, thanks to their extensive commercial knowledge, 'patience' and friendly interface, encourages and assists in concluding transactions. By leaving a positive impression on the user, it creates an opportunity for repeated contact. However, the role of the virtual advisor does not end with providing information on the details of the commercial offer and support during the electronic transaction. The technology is used in many related fields (Fig. 2).

An interesting solution is offered by the company Oddcast226. This is a tool called SitePal™, which is used to build animated, talking assistants - so-called avatars. The SitePal™ animated avatar is constructed using an online interface. The avatar is included in the HTML page code and implemented in Flash technology.

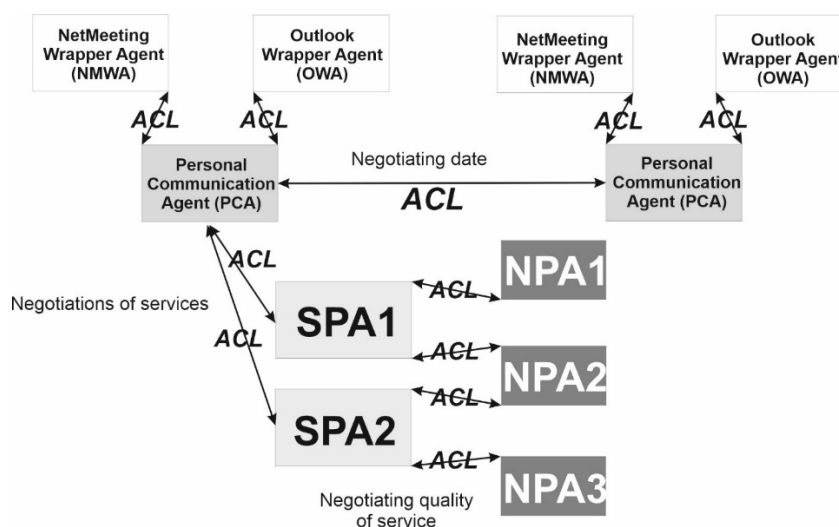
## 6. Knowledge Accumulated in Semantic Web

The concept of the semantic web is sometimes associated with 'machine-readable data', 'intelligent agents', 'distributed database' or 'automated infrastructure'. The Semantic Web makes it possible to systematically assign meaning to elements of web pages so that the programs that read them, called software agents, can perform complex tasks assigned to them by users. The Semantic Web is not created from scratch, but is created as an extension of the existing World Wide Web - by precisely defining the meaning of the data available in it, allowing for closer human-computer collaboration.

In order to realise the idea of the Semantic Web, a common terminology is needed for the exchange and management of information and knowledge between the various applications, describing the domain that these applications deal with. Information about the links between them is needed. Such a collection of terms and linkages is an ontology (Haliżak, 2015). Ontologies provide the terminology for the need of such a description. It can be drawn from classified domains, not necessarily dependent domains. In addition, ontologies need to define logical relationships between terms, in order to provide a deep level of analysis, as well as to improve search methods and intelligent inference by computer programmes (Gładysz, 2017).

This draws a comparison between the Semantic Web and an ontology-based knowledge management system, where ontologies provide tools for the formal description of knowledge. On the basis of such a description, computer programs can perform data retrieval and processing. It is thanks to ontologies that it is possible to integrate the huge number of heterogeneous documents currently existing on the Internet. The concept of ontologies can also be viewed in the context of a model of a fragment of reality representing the objects of interest and the relations occurring between them, as well as containing the required properties (attributes) of these objects (Śnieżko, 2015).

Setting up a videoconferencing connection over the Internet is a challenging task to build a complex distributed information system. A solution may be to implement such a system in the form of an agent system. Such a concept has been proposed by P. Faratin, N.R. Jennings, P. Buckle and C. Sierra (Faratin et al., 2001) (Fig. 3).



Source: (Faratin et al., 2001)

**Figure 3: Using an Agent System to set up a Videoconference Call, Where: PCA - Personal Communication Agent, SPA - Service Provider Agents, NPA - Network Provider Agent, ACL - Agent Communication**

## **Language**

Various individuals and organisations are involved in setting up a videoconference call. End users can be represented by Personal Communication Agents (PCAs). Each of the units providing services on the network - consisting in, among other things, organising videoconferences - can be represented by Service Provider Agents (SPA). In contrast, the telecommunication infrastructure through which these services will actually be transmitted can be represented by so-called Network Provider Agents (NPAs). Since applications such as NetMeeting or Outlook are not agent-based applications, it is necessary to use what is referred to in the literature as "Wrapper Software" - which converts a form of communication into an ACL (Agent Communication Language). In Figure 3, the NetMeeting Wrapper Agent (NMWA) and the Outlook Wrapper Agent (OWA) perform these functions.

The concept behind the operation of the proposed agent system is based on mutual negotiation between different types of programme agents. The PCA agents negotiate with each other in order to find a suitable date for a videoconference call. If they reach an agreement, then one of the PCA agents negotiates with the various SPA agents providing videoconferencing services. These negotiations mainly concern the cost of the call and the required quality of service. The SPA agent that wins the contract then negotiates with the various NPA agents to determine which one is able to deliver the required quality of service - at the best price. Software agents should be responsive to changes occurring in their environment. For example, an NPA agent providing network access may need to obtain additional lines from another NPA agent - to maintain the agreed quality of service in the event that part of its own network fails. Also, if there is a need to adapt to new targets when they arise - for example, two SPA programme agents may discover that they have the capacity to provide complementary services. They may therefore decide to work together to gain the capacity to provide new services. In order to set up a videoconference date or select a suitable service provider or network access entity, the software agents go out with proposals, commercial offers, make concessions - and eventually come to an agreement. The programme agents shown in Figure 3 communicate by exchanging messages in ACL (Agent Communication Language).

## **7. Summary/Conclusions**

Based on the few areas selected in the paper, where the applicability/use of software agents has been signalled, the thought often arises that intelligent software agents will be the next revolution in computing and communication. In my opinion, this will particularly apply to the use of agents as a software development methodology. Increasingly powerful supercomputers may lead to a breakthrough of human contact with a personal computer agent. The future of software agent applications and agent systems seems promising. The way in which computers or other electronic devices are perceived increasingly resembles communication and interaction with other people. We are also increasingly dealing with applications that operate in a global environment of networked devices. The above insights open up a wide area of applications for software agents and agent systems. Therefore, when analysing the role of agent technologies in the construction of the information society, can it be assessed in terms of synergy or contradiction? In addressing the issue of agent technologies, it is important to bear in mind the general view that it is increasingly popular to replace personal human contact with contact in the form of electronic communication. New types of 'connector' are needed that more closely correspond to the natural behaviour of people contacting each other. Agent technologies are such a form of 'connector' between humans and information systems. Currently, work is still underway to build the standards needed to implement the idea of the Semantic Web. This should result in making the information available on the web processable not only at the level of individual characters in the text, but also taking into account the structure of the document and the concepts contained in the text. The aim is to create and disseminate standards for describing content on the Internet in such a way that it can be processed by machines and programs taking into account the meaning and context of the information (Folta and Stolinska, 2012). The Semantic Web is based on ontologies (Abramowicz et al., 2011) and software agents.

An ontology, as a specialised conceptual apparatus, 'is intended to support and be responsible for the efficient and unambiguous exchange of information/knowledge between its users'. The recipients of the ontology are agents operating in information systems and within the concept of the Semantic Web. The manager (human) will still make the key decisions, but agent technologies and the information systems built using them will represent them to some extent (playing an autocratic role) and will assist them in decision-making (playing an advisory role). The role of agent technologies in building an information society defined in terms of people's

work should be assessed in terms of contradiction (mutual contradiction, divergence) rather than synergy (cooperation). The situation is different when identifying the role of agent technologies in building a digital society. A key issue for the development of agent technologies is the continuation of work related to the creation of Semantic Web standards, and in particular the popularisation of ontologies as a method of knowledge representation in an information system (Niedbał, 2015).

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