Cognitive Information Systems in Pervasive Computing and Management Application

Marek R. Ogiela and Lidia Ogiela

***Abstract*—Recently they have been introduced several types of intelligent information systems. The most important class is cognitive systems, which may support different management tasks and have many applications in pervasive or ubiquitous computing. Besides supporting company management activities, such systems allow to semantically analyze visual information or even be used in security areas. In this paper we will present the most important application of such systems, and evaluate theirs role in future development of cutting edge IT technologies. In particular the application in decision supporting tasks and company management activities will be described, as well as application in cognitive and personal cryptography will be shown.**

***Index Terms*—Cognitive systems, cryptographic protocols, decision support systems, information management.**

I. Introduction

Cognitive information systems create a new class of intelligent information systems, which allow to evaluate semantic meaning of analyzed data or perform cognitive resonance processes, which imitate human thinking processes [1], [2]. The first cognitive information systems were developed a few years ago, and were oriented on supporting image semantic evaluation or scene analysis [3], [4]. Recently there were also proposed a new classes of cognitive information systems dedicated to decision supporting task in financial or economical application [5], as well as intelligent data or information management for security purposes [6], [7]. Actually is seems that intelligent and cognitive information systems will play increasing role in many different areas of application like social media, security, healthcare, economy etc.

In this paper we try to show the great importance and wide application spectrum of cognitive information systems, which became really important classes in modern IT solutions. In particular we try to show application of such systems in different management tasks as well as in security areas.

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II. Cognitive Information Systems

Describing cognitive information systems it is worth noting that such systems are based on knowledge based perception phenomenon, which is most typical for human being. In knowledge based perception analysis, the cognitive processes are performed in brain, and some hypothesis about the meaning of observed things are generated. During any observation, brain can generates some possible semantic interpretation. After such generation, a verification stage is performed by permanent comparing of the selected features with some expectations, previous experiences or acquired knowledge.

Based on knowledge-based perception model we tried to develop a few classes of intelligent information systems called Cognitive Information Systems. All such systems, despite the application area perform computer cognitive resonance processes [4].

The main features of computer cognitive resonance procedure are following:

1) It corresponds to the model of human visual perception, based on the concept of using important knowledge about the recognized object or situation.
2) Cognitive resonance is based on a generation of expectations about semantic meaning.
3) It allows verifying only some the most important features without a need to analyze all features or information.
4) Interpretation or classification stage is identified with interference processes between expectations and evaluated features.

The main features of cognitive information systems are:

1) The learning abilities.
2) Possibilities to extract or evaluate semantic meaning for analyzed information, including context situation.

Having mentioned features cognitive information systems seems to be very universal, and easy for application for many different applications. Below will be presented two selected areas of such systems application i.e. security and information management.

III. Cognitive Systems in Cryptography

One of the most important features of cognitive information systems is ability to extract some important semantic information from analyzed data. This means that it is possible to use extracted from patterns information for security purposes.

Depending on the protocol and encrypted data, cognitive

information systems may perform the semantic analysis, and evaluate the meaning of analyzed encrypted data. Obtained semantic record may be further used for creation different cryptographic solutions and security protocols. Such information encoding and transmission techniques create a new branch of modern cryptography called cognitive cryptography [7], [8].

Cognitive cryptography techniques (Fig. 1) may be associated with participants of security protocol, and depends on the information semantic content, or even encrypted messages. Usefulness of such solution swill obviously depend on the use of cognitive information systems, which will allow defining the meaning of encrypted information, or extraction of personal features which may be involved into encryption process.

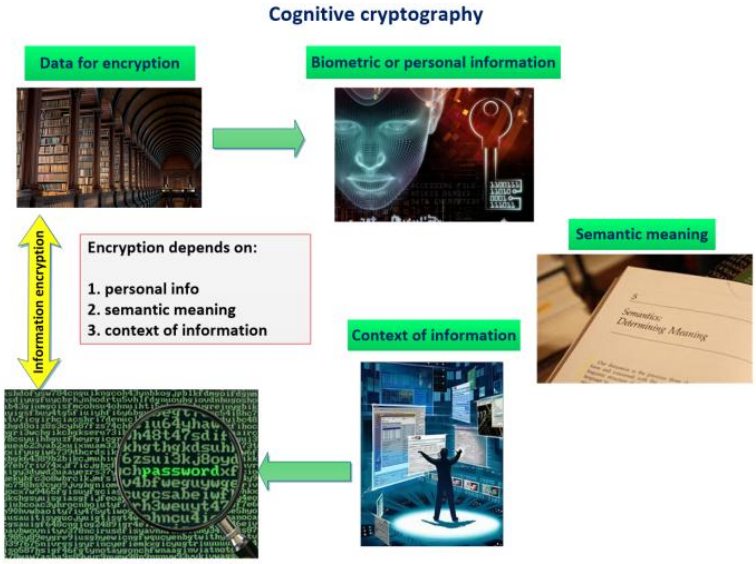

Fig. 1. General idea of cognitive cryptography.

In general two main areas of application of cognitive information systems in cryptography exist:

1) Personal cryptography.
2) Content based information sharing or encoding.

Inthe first application we can use selected biometrics or personal information to create strong encryption keys. Such keys contain both personal sequence of bits describing particular person, and also random sequences, which will guarantee cryptographic security.

In the second case it is possible to use semantic information extracted from encrypted or transmitted data to determine how it may be encrypted, shared, or distributed between a trusted groups of persons.

Below will be described general methodology how to use semantic information to successfully perform secret sharing protocol [8]. Secret sharing using cognitive information systems may be realized in following way:

1) For secret data semantic meaning must be evaluated using appropriate cognitive information system.
2) Having a-priori defined information about the number of protocol participants, we can encode information using semantic meaning, and distribute it among trusted persons.
3) For particular group of persons information may be divided and distributed, using theirs personal characteristics [9], [10].
4) As a result, each participant of the protocol can obtain his own personalized secret part [11].

Described protocol allow to divide selected strategic information in different manners depending on the number of trusted persons, as well as personal accessing grants to restore such distributed information. Application of personal information in generation secret shares allows determining, who the owner of such secret parts is.

Looking on this protocol it is easy to determine following features:

1) Obtained secret parts are independent, and secure.
2) Information reconstruction may be performed within particular group of persons.
3) Using biometric information allow to create personalized shadows (parts of secret information).
4) In case of secret part leakage it is possible to determine who the owner of such secret part is.

Presented above protocol may have many different possible application, but the most important area is intelligent, information sharing and management in distributed environment or in computational Cloud.

IV. Cognitive Systems in Management and Economy

The second important area of application of cognitive information systems is management areas supporting decision making processes [12].

Themain classes of cognitive information systems supporting data or company management processes were described in [1], [13]. Such systems may be divided into several subclasses. The essence of such split is the creation of different systems module dedicated for supporting different company activities evaluating current company states or forecasting future developments.

For example the main classes of cognitive financial system dedicated for evaluation financial aspect of company activities have been distinguished in the group of systems supporting financial management processes [12]:

1) UBMLRSS (Understanding Based Management Liquidity Ratios Support Systems) – systems, which allow analyzing enterprise liquidity ratios. Such systems can reason about the amount and the solvency of the working capital of the company as well as about the company's current operations.
2) UBMARSS (Understanding Based Management Activity Ratios Support Systems) – systems, which allow analyzing turnover ratios. Such systems can reason the speed of assets rotation and productivity.
3) UBMPRSS (Understanding Based Management Profitability Ratios Support Systems) – systems, which allow analyzing profitability ratios. Such systems can reason about the financial efficiency of the business activities.
4) UBMFLRSS (Understanding Based Management Financial Leverage Ratios Support Systems) – systems, which allow analyzing financial leverage ratios. Such systems can reason about the sources financing the company's assets and the proportion of external.

Each of the above described systems has several sub-classes of cognitive systems focused on detailed operations or financial activities.

Describing applications of cognitive information systems in economy and financial areas, it is worth noting about the universality and efficiency of such applications.

Because the main idea of creation of cognitive economy information systems was to improve the management processes, such systems seem to be very flexible and efficient in such tasks. In particular it allows:

1) Analyzing the internal situation of the enterprise.
2) Analyzing of the external situation of the enterprise.
3) Forecasting the future states.
4) Supporting decision-making processes.
5) Supporting strategic decision-making.
6) Supporting enterprise management processes in the global or local environment.

The high efficiency of the cognitive information systems isa result of using at the inference stage linguistic formalisms, which allow mining some expectations or knowledge, which is also important for proper evaluation of financial or economical states. Depending on the class of grammar used, the decision supporting stage may have at most polynomial complexity.

V. Conclusion

In this paper we described cognitive information systems, and the role of such systems in pervasive computing, and management application. The most important aspects of developing such systems are performing semantic reasoning or content evaluation. This allows extracting semantic description for processed data or even acquires personal or biometric features which may be used in security application. Cognitive information systems will be very important in future scientific research and developments. In security applications such systems allow to involve the semantic meaning of encrypted or shared information, into the encryption process or communication protocols [14]. Such methodology may be used for example in information sharing and management. Presented in this paper protocol allow performing selective and dedicated management of secure data in various manners depending on the context and infrastructure in which information should be distributed.

Cognitive information systems may be also applied for semantic analysis tasks, which consist in extracting semantic information from analyzed datasets and interpreting this information in financial areas.

Financial information management systems are an example of cognitive data analysis systems. In this class of systems, linguistic formalisms have been proposed for the formal description of the analyzed data, and evaluation of current and future company states [15].

Analysis of different company activities using cognitive systems allow to improve or support processes of strategic or financial information management. Such analysis not only allows analyzing financial values, but also evaluating the situation of the enterprise and indicates the possible directions of its change, or implements remedial action if necessary.

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