TYPES OF COGNITIVE DECISION-MAKING IN COMPLEX SYSTEMS: MODELLING USING THE TOGA META-THEORY

MARTA W. WRONIKOWSKA
Adam Mickiewicz University,
Cognitive Science (graduate),
Szamarzewskiego 89,
60-658 Poznan
marta.wronikowska@yahoo.com

ABSTRACT

One of the more complex systems of the real-world is the intelligent agent reasoning. The key elements of this mental activity is cognitive decision-making (CDM). The aim of this work is the recognition of the initial situations depended types of CDM which are realized by an intelligent agents, such as a human beings, their organizations and intelligent human-machine systems. The assumed framework of this classification is based on the TOGA meta-theory (Top-down Object-based Goal-oriented Approach) of Gadomski. The model of information, preferences and knowledge (IPK) enables classification and recognition of the human cognitive errors in CDM. In parallel, the dependence of IPK on the assumed agent ontology is underline.

Keywords:

Abstract Intelligent Agent, Cognitive decision-making, Complex systems, meta-theory TOGA, model IPK,

1. INTRODUCTION AND THEORY

In recent decades the cognitive decision-making (CDM) is a domain of always more research activities in different application fields, see for example [3], [5], [10]. In parallel, from the above reason the authors used different definitions of this concept. Here we can mention only a few of them:

- *Cognitive decision-making process itself is based on a complex human psychological process made up of cognitive and motivational elements* [6].

- *Cognitive (perspective) decision-making is a dynamic process in which temporally varying noisy information is integrated across multiple time scales with a decision resulting when the information stream relevant of one of the alternative actions crosses a threshold."* [1].

- *Cognitive decision making is a complex abstract decision making (where decision-making is a mental activity implied by the necessity of a choice** [8]) *patterned on the functioning of the human mind, which takes into account the biological constraints of organism, as well as current information, knowledge and preferences of the decision maker."* [11].

In this paper we assume the third definition which is congruent with a general frame of the TOGA meta-theory. Such assumption enables to apply the TOGA's IPK (Information Preferences Knowledge) model as a basic conceptual framework for the modeling of CDM. Hence, CDM is described through two conceptualization layers model. One is based on IPK model and the second on criteria or alternatives searching in the simple decision-making model.

- **INFORMATION PROCESSING LAYER –** in meta-theory TOGA, the **IPK model** [2] forms an elementary repetitive unit of the construction of the IPK intelligent agent.

The IPK cell is funded of 3 key concepts:

☑ **Information (I)** – *are data which have meaning and represent a specific property of a preselected domain of human or artificial agent's activity* [9].

☑ **Preferences (P)** – *are ordered relations among two states of the domain of activity of the agent* [9].

☑ **Knowledge (K)** – *is every abstract system able to transform information into other information or knowledge* [2].

The basic scheme of interaction between I, P and K is realized in two steps [8b]:

Information1 **->** **Preferences** **->** *Goal* **->** **Knowledge A**
Information1 **->** **Knowledge A** **->** *Information2* **->** **Action.**

- **DECISION-MAKING LAYER:**

Here, a decision-making is based on the application of criteria to alternatives which produce a decision.

☑ **Criteria** - a set of rules which are used to make a choice from a specified set of alternatives, for ex.: maximal acceptable travel's time or number of operation steps. Those criteria depends on policymakers preferences.

☑ **Alternatives** - are available activity/action resulting from user's knowledge, which realization can or should lead to the expected state.

☑ **Information** - data, which represent the properties of agent's decision domain, hence they are attributes of criteria and alternatives necessary in cognitive decision making.

CDM of intelligent agent is also based on an ontology (personal ontology), where an ontology constitute a set of concepts and relations between these concepts, which are necessary to describe a selected domain for a given goal.

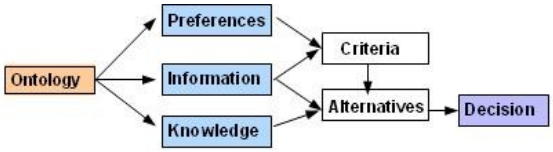

Figure 1. Influence of ontology on the components of the two mentioned layers of CDM.

2. MODELLING OF CDM

According to the TOGA meta-theory a decision-making starts from the agent situation which is not congruent with its maximal preferences and may rely either on the development of criteria when alternatives are known or on the development of alternatives when criteria are before established. Taking into account the state of choice criteria and alternatives of an intelligent agent before decision-making, we have distinguished eight cognitive situations (Si) presented in the Table 1, from which some of them lead to the initialization of CDM.

CDM SITUATIONS	S1	S2	S3	S4	S5	S6	S7	S8
CRITERIA	−	+	+	−	+	−	+	−
ALTERNATIVES	−	+	−	+	−	+	+	−
INFORMATION	−	+	−	+	+	−	−	+

Table 1. Types of decision processes depending on criteria, alternatives and information in initial states.

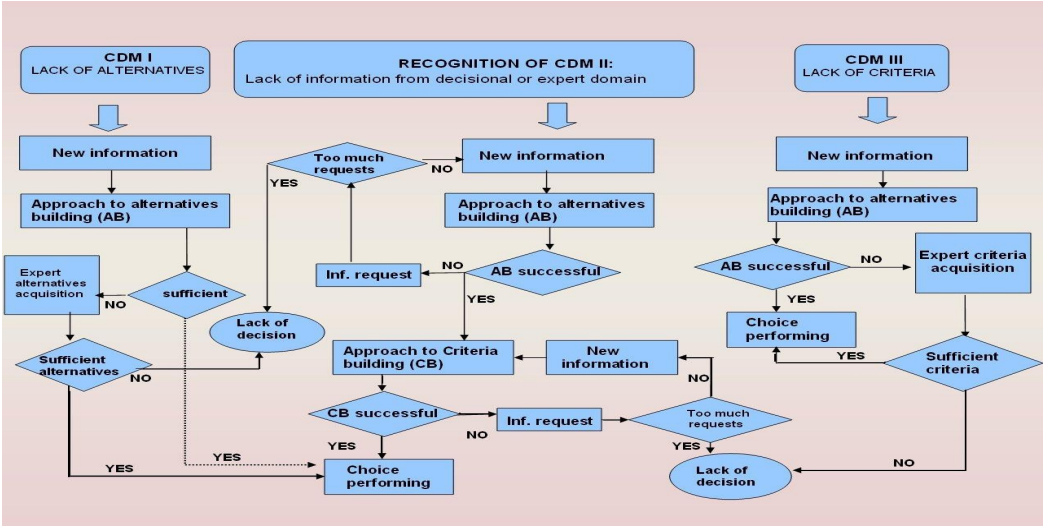

Figure 2. An general scheme of the realization of second type of cognitive decision making which is driven by information acquired during the decision-making process.

The situation S1 make impossible the performing of decision-making, while S2 activates realization of a procedure because the possessed criteria, alternatives and information enable only the realization of unique mental process and not CDM. The first type of is when the initial state of decision-making lacks only alternatives. The second type is when in the initial states of the decision-making lacks information which may enable to build criteria and alternatives. The third type is when in the initial state of CDM lacks only criteria Figure 2, illustrated such situation when can be impossible to make the choose of type I or II or III, might lead to abandonment decision-making or can lead to the decision, which is randomly selected.

3. APPLICATION AND RESULTS

The presented model of CDM is congruent with the Universal Management Paradigm of TOGA [7], what should enable to use the developed CDM for the programming of decision support systems applied for the large scale emergency, as well as autonomous robots. The CDM model can provide the information to a client which intend to buy a car by top-down and goal oriented restricting his domain of information search, was presented in the master thesis of Wronikowska [11]. The developed model frames of CDM are planed to be applied in the prototype of intelligent decision support system for the operators of nuclear power plant.

4. CONCLUDING REMARKS

The recognized CDM models can be specialized in any area and for every type of intelligent agent, i.e. for a human, computer or robot. Its basic invariant properties form the so-called cognitive architecture of cognitive decision-making system [4] and TOGA[7],[8],[9].

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