An Ontology-Based Approach to the Automated Triggering of CogInfoCom Messages

István Marcell Fülöp¹, Ádám Csapó¹, Péter Baranyi¹, Péter Várlaki²

¹Institute for Computer Science and Control, Hungarian Academy of Sciences, Budapest, Hungary
²Széchenyi István University, Department of Logistics and Forwarding, Győr, Hungary

E-mail: ifulop@sztaki.mta.hu, csapo@sztaki.mta.hu, baranyi@sztaki.mta.hu, varlaki@sze.hu

Abstract—The semantic synthesis of intelligent space, emotional-behavioral modeling and cognitive info-communications is a promising approach in the multidisciplinary field applied for ambient assisted living. The ambient assisted living application can be regarded as a complex cooperation and communication of different kinds of intelligent entities in a well-limited, semi-structured environment. The intelligent space aspect deals with the possible cooperation of intelligent entities as matching between needs and capabilities. The emotional-behavioral modeling handles the internal states and attitudes of the entities. The cognitive info-communications aspect deals with communication situations and processes between the entities. The semantic information framework is intended to provide a synthesis of the different fields in order to unite the represented knowledge in the form of information transfer between the field scopes.

Index Terms—Assisted living, Cognitive info-communications, CogInfoCom triggers, CogInfoCom messages, Semantic information

I. INTRODUCTION

In the field of ambient assisted living the demand for knowledge integration has been important from the outset. Cooperation in the heterogenous set of possible available devices implied a challenge. The first overall framework for device integration was the ASK-IT project [1]. The use of semantic information proved to be an efficient method for functional service integration. During the project, ontologies were developed for several application fields. This research of knowledge integration framework continued in the OASIS project [2] [3] [4]. The framework developed during the project intended to serve as a hyper-ontological framework which can integrate the knowledge of different semantically modeled domains. Based on the experiences of the ASK-IT project, further semantic frameworks were developed during the ACCESSIBLE and the AEGIS projects [5] [6] [7].

These projects proved the viability of semantic information application for knowledge integration in the field of ambient assisted living. Related to research on intelligent space at MTA SZTAKI, an ambient assisted living framework with semantic service matching was developed based on the VirCA platform [8]. Related to research on cognitive info-communications, the results were applied efficiently in the field of emotional-behavioral modeling of interactions in the VirCA platform [9]. The question naturally arose as to, whether the results of cognitive info-communications and emotional-behavioral modeling could be usefully applied in the field of ambient assisted living in order to extend the capabilities of the existing framework.

During this research, the framework for ambient assisted living was extended with the semantic representation of the field of cognitive info-communications [10] [11]. The semantic representation is tightly based on the definitions and descriptions of CogInfoCom [12] [13]. The developed CogInfoCom-ontology is unique on the one hand, in the sense that the field of cognitive info-communications was not semantically modeled before and on the other hand, in that an existing framework was extended with a semantic representation of a further field whose results were applied in the framework.

For the demonstration of the research results, a proof-of-concept version of the semantic framework was developed. The framework consists of the core component of the VirCA system, cyber device components for the VirCA system, a manager cyber device component, an ontology manager component and ontologies of the different paradigms [Fig.1].

The capabilities, the emotional state and the behaviour of the user and the instructions of the family doctor are modeled in the human ontology. The CogInfoCom interfaces of the intelligent entities, the CogInfoCom communication
possibilities are modeled in the CogInfoCom-ontology. The capabilities of the different robots and devices, the possible demands of the user and their decomposition are modeled in the intelligent space ontology.

In the first part of the paper, the applied technologies for the framework are introduced and the construction of CogInfoCom semantic representation is described. In the second part of the paper, a brief application example is presented in order to provide a view of the operation and conceptual build-up of the framework and the paper is finally concluded.

II. APPLIED TECHNOLOGIES

For the spatial representation of the application room and for the management of spatial objects, the virtual reality management function of VirCA was chosen [14]. The VirCA system proved to be an appropriate platform for collaboration of single devices distributed over the Internet [15].

For the interaction with the human user and between the intelligent components of the system, different cyber devices were developed for the VirCA platform. Cyber devices were developed for the different devices in the room, e.g. for the fridge, microwave-oven, elevator, etc., which can be used by intelligent entities, i.e. by humans or by mobile robots. Cyber devices were developed for the different mobile robots. For the main manager component a cyber device was developed as well. Cyber devices can communicate with each other through the communication subsystem of VirCA.

For the representation of the ontologies the OWL-DL 1.0 format was chosen. For the manipulation of the ontology files by hand or by program, the Protégé framework was chosen. The Protégé framework has its own editor program for the manipulation by hand and its Java libraries for the manipulation by program. Therefore, an RTM component in Java was developed in order to mediate between the cyber device and the ontologies. The Java component uses the Protégé libraries to manipulate the ontologies. The cyber device is an RTM component as well to be able to be connected to the Java component [Fig.2].

For the inference on the semantic information represented in the ontologies, the Jess rule engine was chosen. The Jess engine has the appropriate interface of the Protégé framework to be able to be integrated as a rule engine. The appropriate semantic concepts can be represented as fuzzy facts as well. In this case, fuzzy inference rules can be applied [16] [17].

III. BUILD-UP OF THE ONTOLOGY

The CogInfoCom channel and CogInfoCom interface entities are related to CogInfoCom communication processes. The CogInfoCom interface entities are related to CogInfoCom system entities together with the CogInfoCom engine entities. The relations between these entities are based on the one hand on the definitions and descriptions and on the other hand, on the semantic interpretation of their domain [12] [Fig.3].

For the representation of CogInfoCom communication, the CogInfoCom Communication class is introduced which models a communication process between two CogInfoCom systems. According to the definition, it has the Intra-cognitive Communication and Inter-cognitive Communication subclasses depending on that whether the two CogInfoCom systems have the same cognitive capabilities or not. It has the Representation-sharing Communication and Representation-bridging Communication subclasses depending on whether the same information representation was used during information forwarding or not. It has the Sensor-sharing Communication and Sensor-bridging Communication subclasses depending on that whether the same modality was used during information forwarding or not. It has the hasSender and hasReceiver properties to connect to CogInfoCom System instances as the sender and the receiver of the process. It has the hasChannel property to connect to CogInfoCom Channel instances as channels of the communication. It has the hasConcept property to connect to CogInfoCom Concept instances as concepts which are communicated during the process.

For the representation of CogInfoCom channel, the CogInfoCom Channel class is introduced which models a medium of a CogInfoCom communication between two CogInfoCom systems.
interfaces. It has the Audio Channel, Scent Channel, Touch Channel, Video Channel subclasses which model the corresponding types of CogInfoCom channel. It has the hasStartPoint and hasEndPoint properties to connect to CogInfoCom Interface instances as the start- and endpoints of the medium. It has the isChannelOf property to connect to CogInfoCom Communication instances to which it serves as a medium.

For the representation of CogInfoCom interface, the CogInfoCom Interface class is introduced which models a start or an end point of a CogInfoCom channel. It has the Audio Interface, Scent Interface, Touch Interface, Video Interface subclasses which model the corresponding types of CogInfoCom interface. It has the isCapableOf property to connect to CogInfoCom Message instances whose communication it is capable of. It has the isInterfaceOf property to connect to an instance of CogInfoCom System as the system whose part the interface is.

For the representation of CogInfoCom system, the CogInfoCom System class is introduced which models an intelligent entity which takes part in a CogInfoCom communication. It has the hasEngine and the hasInterface properties to connect to a CogInfoCom Engine instance and to CogInfoCom Interface instances as the CogInfoCom interface parts of the CogInfoCom system. It has the hasEngineOf property to connect to an instance of CogInfoCom System as the system whose part the interface is.

For the representation of CogInfoCom trigger, the CogInfoCom Trigger class is introduced which models a trigger condition for an action which is triggered. According to the definition, it has the Direct Trigger and Indirect Trigger subclasses depending on whether the properties of the action were directly set by the user or were indirectly inferred by the system. It has the hasAction property to connect to a CogInfoCom Communication instance as the communication process in which the intelligent entity takes part.
an Action instance as the action which should be executed when the trigger is activated. It has the hasCondition property to connect to an Event instance as the event which is the condition of the trigger activation.

IV. APPLICATION EXAMPLE

There are two complex demo scenarios. The scenarios demonstrate the results of three fields: the ontology-based task matching itself, the modeling of the abilities and emotional states of the human user and the modeling of the CogInfoCom process between the intelligent entities of the system. [Fig.5]

The scenarios are located in a flat where there are two floors. On the first floor, there is the kitchen, the dining room and the living room. On the second floor, there is the bedroom and the bathroom. There is an elevator between the two floors which can transport objects of limited size. In the kitchen, there is a fridge, a microwave-oven and an oven. In the bedroom, there is a bed, a cupboard and a table where a computer is situated as the main control unit of the framework. The computer can transmit speech or text messages to the user. In the bathroom, there is a basin, a lamp and a bell. The lamp can indicate a light warning, while the bell can indicate a ring warning to the user.

There are three mobile robots situated in the flat. The first robot is a PR-2 mobile robot with manipulator located on the first floor. The robot can use the fridge, the microwave-oven and the oven, but cannot use the elevator. The robot can transport objects with its manipulator. The second robot is a NAO humanoid robot located on the second floor. The robot can use the sink, but cannot use the elevator. The robot can transport objects with its hands. The third robot is a mobile platform without manipulators. The robot can transport objects on its platform. The objects need to be put on and taken from the platform. The robot can use the elevator, so it can transport objects between the two floors.

In the first scenario, there is an indirect pull trigger which the human user can activate to serve the lunch of the human user. The destination of the lunch depends on the position of the user, the mood of the user, the instructions of the doctor and the capabilities of the user. If the user is in a good mood, the instructions of the doctor are followed whether the user should walk or not, otherwise the user will not walk. If the user is lying in bed in the bedroom, the meal should be transported either to the bed or to the table. If the user can walk only with a walker, it should be transported to the user as well. After the lunch is served, depending on the CogInfoCom capabilities of the user, either a speech or a text message indicates that the meal is ready to be consumed. If the user is in the bathroom, the meal should be transported to the table. After the lunch is served, depending on the CogInfoCom capabilities of the user, either a lamp or a bell signals that the meal is ready to be consumed.

In the second scenario, there is an indirect push trigger which is activated in the appropriate time to serve the medicine of the human user. The destination of the medicine depends on the position of the user, the mood of the user, the instructions of the doctor and the capabilities of the user. If the user is in a good mood, the instructions of the doctor are followed whether the user should walk or not, otherwise the user will not walk. If the user is lying in bed in the bedroom, the medicine should be transported either to the bed or to the table. If the user can walk only with a walker, it should be transported to the user as well. After the medicine is served, depending on the CogInfoCom capabilities of the user, either a speech or a text message indicates that the medicine is ready to be taken. If the user is in the bathroom, the medicine should be transported to the table. After the medicine is served, depending on the CogInfoCom capabilities of the user, either a lamp or a bell signals that the medicine is ready to be taken.

V. CONCLUSION

The brief proof-of-concept version of the framework demonstrated the use and the sense of semantic information-based knowledge synthesis of different paradigms. The latest research results of cognitive info-communications could be applied in the current field of ambient assisted living. Based on the first order logic rules of operation, with the help of machine inference, the framework could produce appropriate responses...
to user requests. In the course of development, the original framework for intelligent space could be easily and flexibly extended with ontologies of further paradigms. The framework was proved to be a good basis for knowledge integration of other paradigms as well in the future.

ACKNOWLEDGMENT

The research was supported by the Hungarian Scientific Research Fund (OTKA K105529).

REFERENCES


