# TOWARDS THE DEVELOPMENT OF INTERNET OF THINGS ORIENTED INTELLIGENT SYSTEMS

Mihnea Alexandru MOISESCU[1], Ioan Ştefan SACALĂ[2],
Aurelian Mihai STĂNESCU[3]

*Activităţile de cercetare şi dezvoltare în domeniul ICT, susţinute de Comisia Europeană şi de Programul de Cerectare de Cadru 7, se focalizează pe dezvoltarea de noi tehnologii în domeniul "Internetului Viitorului". Una dintre paradigmele propuse în cadrul acestui domeniu este legată de "Internetul obiectelor". Principalul promotor în cadrul acestui domeniu este constituit de tehnologia RFID şi în acest sens dezvoltarea de astfel de dispozitive este importantă pentru constituirea unei infrastructuri. Obiectivele acestei lucrări sunt legate de prezentarea stadiului cerecetărilor în acest domeniu şi de dezvoltarea unei arhitecturi de sistem ce permite virtualizarea obiectelor din lumea reală şi interactiuni între acestea.*

*Current R&D activities, sustained by the European Commission and by FP7 financial support are focusing on the development and standardization of new technologies to sustain the "Future Internet". One of the paradigms proposed in this area is the "Internet of Things". In this context, there is a necessity for the development of RFID compliant devices, the main enabler for the development of the Internet of Things infrastructure. The use of standard compliant intelligent objects for both economical and private purposes increases the demand for interaction-based devices. The main objectives of this paper are to provide an overview of the current progress of Internet of Things oriented technologies and to propose an architecture which will enable the transformation of real world objects into intelligent virtual objects.*

**Keywords**: Internet of Things, intelligent objects

## 1. Introduction

As Dr. J Schwartz da Silva, the Director of the Converged Networks and Services in the EU DG-INFSO, expressed in his intervention at the NSF/OECD Workshop on "The Future of Internet:

[1] Assist., Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania
[2] Assist., Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania
[3] Prof., Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania

*"It is indeed clear that Internet architecture is today facing several challenges, many of them being related to scalability issues in view supporting an ever growing number of users, devices, service attributes, …"* [1]

The concept of enabling interaction between intelligent objects is closely related and supported by the imminent change from the "Internet of Data" to the "Internet of the Future" paradigm including the "Internet of Data" and the "Internet of Things".

We can define the "Internet of things" as: "*the Internet of the future will be suffused with software, information, data archives, and populated with devices, appliances, and people who are interacting with and through this rich fabric*". The 2D communication provided by the "internet of data": any time, any place is completed to a 3D model by a new dimension: anything. In this context "changing business strategies becomes the name of the game" [2].

Another way to define the concept of the Internet of Things is provided by the FP7 project CASAGRAS [3]:

" *A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor, actuator and connection capability as the basis for the development of independent federated services and applications. These will be characterized by a high degree of autonomous data capture, event transfer, network connectivity and interoperability*".

The new proposed "intelligent objects" are capable of unrestricted communication between themselves and any other entity through the infrastructure provided by the Internet of Things.

## 2. Internet of Things oriented technologies

Three main benefits have been emphasized within the Internet of Things research area: "things on the move", "ubiquitous intelligent devices", "ambient and assisted living".

The "things on the move" concept will allow: better identification and transport efficiency of food products along the Supply Chain from the producer to the distributer, the shop floor, cashier and check-out leading to the intelligent logistic management. This will also prevent counterfeiting and assure consumers of controlled origin of the food product. [4]

The "ubiquitous intelligent devices" concept will allow the possibility of information exchange between any intelligent object. Another capability is the implementation of reactive behaviors according to a predetermined set of actions.

One of the main advantages for the user is the "ambient and assisted living" concept. The development of "digital assistants" connected to the internet of things makes “choice” easier in regard to diet and health issues. But the implementation of such devices has to take care of the right choice and opinion [5].

These features of the “Internet of Things” (IoT) will enhance considerably human-robot collaboration if the robot becomes part of the network and has access to important information that otherwise he cannot acquire. Thus, the robot will have more information for the decision process and more action power, being able to send direct commands to other smart objects/devices in the environment.

Integrating devices and everyday objects to a smart environment is the first step towards the Internet of Things.

The "ubiquitous intelligent devices" concept will allow for the possibility of information exchange between any intelligent object. Another capability is the implementation of reactive behaviors according to a predetermined set of actions.

One of the main advantages for the user is the "ambient and assisted living" concept. The development of “digital assistants” connected to the internet of things along with specialized doctors can makes “choice” easy in regard to health issues. But the implementation of such devices has to account for the right of choice and opinion.[6]

The integration of objects within the “Internet of Things” produces great benefit, but it is not easy to implement at this point, taking into consideration the following aspects [7]:

- different intercommunication and interoperation standards
- different service descriptions and capability declaration
- different radio interfaces and media access
- different resources management
- different encryption
- different publication and subscription of devices

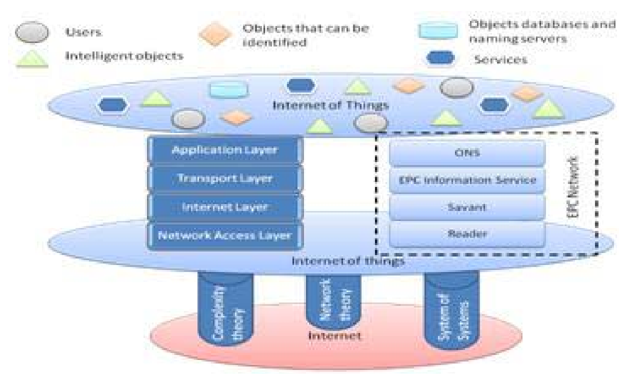


Fig. 1. Internet of Things architecture

Technical, extensible standards and protocols suitable for "Internet of Things" are required in order to integrate all types of devices. A set of standards has been proposed for identifying and tracking objects based on RFID tags widely accepted (***, 2006):

- EPC (Electronic Product Code) – analogous to IP address
- ONS(Object Name Service) – analogous with DNS
- PML(Physical Markup Language) – analogous with XML

A consistent set of middleware for interfaces, communication and other services are also necessary to ease the creation of applications for smart devices within the network.

Three available communication channels have to be considered in order to sustain the development of the IoT: the audio, the environmental and the video channel. This principles and tools can be regarded also as basis for the whole robotic systems – human interaction.

Regarding the audio communication there are numerous systems, readily available for automated speech recognition (ASR) and text to speech (TTS) synthesis. The requirements for a robust dialogue management system are shortly expressed as follows: the capacity of taking the appropriate human input from the ASR system and convert this input into appropriate robot commands, the capacity to take input from the robot control system, convert this information into suitable text strings for the TTS system to synthesize into understandable audible output for the human collaborators.

Regarding the video canal several concepts are to be implemented. Augmented Reality as a technique to overlay computer generated images (to integrate virtual objects) on the real world. The use of this technique in combination with Image Processing gesture recognition has lead to the specification of Mobile Augmented Reality Interface Sign Interpretation Language (MARISIL) [8]. One of the possible implementations is the introduction of a Mixed Reality Agent (MiRA), represented as an agent consisting of real and virtual components that can be regarded as a single entity.

Telepresence as a compelling illusion that gives an operator a feeling of actual presence at the worksite, thereby, improving operator performance and task completion The interaction is done by controlling a physical proxy, which in this case is represented by a robot and provides a multi-user environment with navigation support and a rich interactive framework .

HandSmart (Device-less Interface) is an interface between user and an information appliance that has no mechanical interference with the user enabling several functionalities like filtering, interface customization, personalization. The personalized interface consisting of the recognition system (a video camera with high color resolution) and see-through glasses will not need to change when changing the device [8].

Regarding the Environmental Channel a robot will need to be able to identify the use of objects by its human counterpart, such as using an object to point or making a gesture. Two concepts are to be discusses as the foundation for communication through the environment channel: Social Awareness and Situation awareness (SA). Social Awareness deals with the "following" behavior that respects socially acceptable conditions, and gives readable social cues indicating how the robot tries to maintain engagement during the work scenario. Situation awareness (SA) is defined as "knowing [the important aspects of] what is going on around you", where importance is "defined in terms of the goals and decision tasks for [the current] job". There have been explored three levels of SA: perception, comprehension, and projection.

Researches in AR and gesture recognition have enabled human –robot interaction by enabling the human to point to a 3D object that both the robot and human refer to, common ground. The robot (robots acting together or the robot system) is also able to express its intentions by interacting with the human user through the AR glasses the internal state, and the commands to be executed. This concept, referred to as the shared AR environment, becomes an effective spatial communication tool. An example of environmental channel implementation is the ALBERT robot project. The user is able to interact with a robot using natural and direct communication techniques in order to ensure a robust performance of simple task completion.

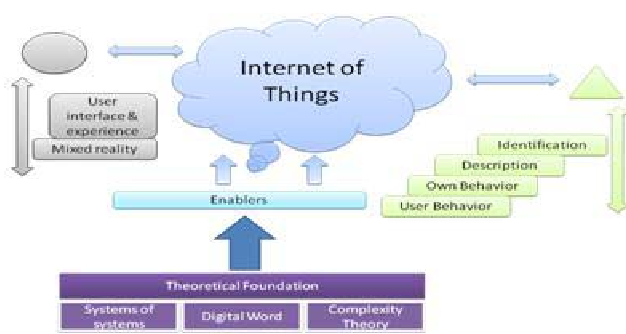


Fig. 2. Object identification within the Internet of Things

### 3. Internet of Things proposed architectures

Two system architectures can be implemented using the set of standards described.

First architecture requires an Object Name Service in order to produce the information or data associated with the "intelligent object" EPC acquired code as shown in Fig. 1. In this case the device must be connected to the IoT in order to be able to identify the object and to download its proprieties. [9], [10]

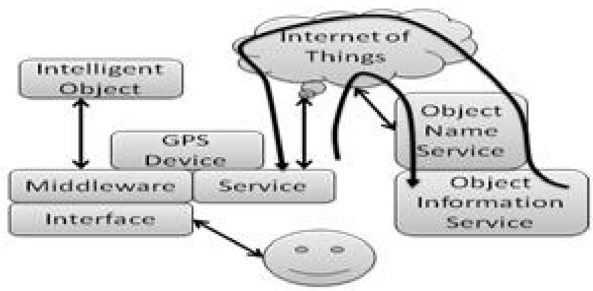


Fig. 3. Object identification using an Object Information Service

The other approach will require, along with the middleware software, an interpreter or parser capable of converging the coded information within the object's memory as shown in Fig. 2. This approach will require a standard property coding language. One choice for such a standard language may be represented by PML. The connection with the IoT will not be necessary, in this case, in order to describe the object, but it can still be used in order to facilitate the communication with other IoT compliant objects.

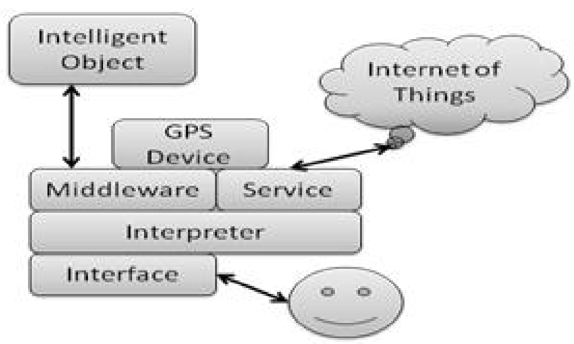


Fig. 4. Object identification using an Interpreter

We have identified the following prerequisites to integrate a GPS device within IoT:

- The device must be equipped with a RFID reader
- The device must have a IoT compliant communication module
- The robot must be compliant with a RFID / IoT Standard Architecture

As for the other standards and protocols it depends entirely on the application.

## 4. A framework for modeling and design of intelligent objects

A framework for modeling the tag data, assigned to a real object has been provided in fig 5. The framework ads to the data describing the object, as discussed in the former chapter, data that allows for the virtualization of the object and information regarding the object's own behavior, or it's functionality and information regarding other object's behaviors towards this object. All of these data and information can be stored in the tag's memory. A problem would be to find a wide used tool to describe this data and information. [12]

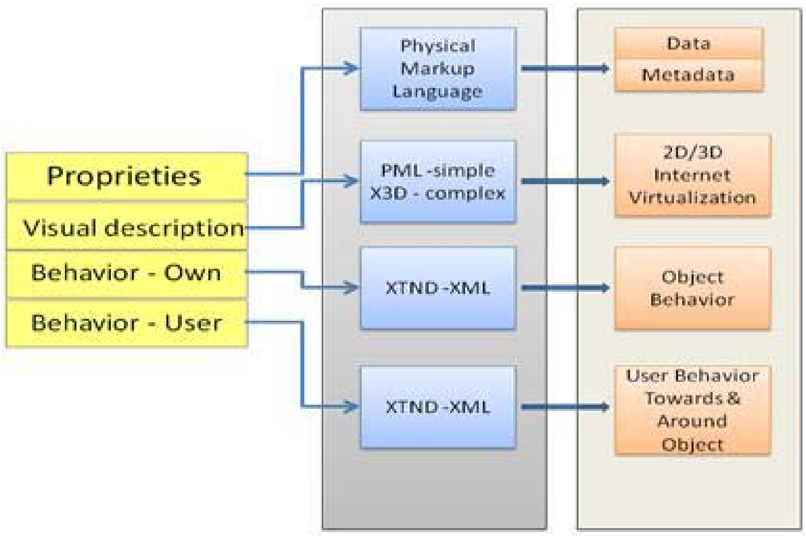


Fig. 5. Framework for local object identification and interaction

As discussed, a suitable and largely available way for data transfer is the Extended Markup Language. As PML (based on XML) has been widely adopted by the users of the EPC standard, we chose PML for the object proprieties description within the framework. PML also allows for the description of object shape and color but we consider that a more appropriate way to describe the object's visual properties would be to use standard 3D web oriented language: X3D. X3D language is considered to be the next step after VRML (Virtual Reality Markup Language) aiming at communicating 3D on the web, between applications and across distributed networks and web services. In order to describe the behavior of the object and the behavior towards the object XTND - XML Transition Network Definition Language has been chosen. We can model behaviors using transition networks. This kind of networks are used to describe a set of states and the transitions, that are possible between them. [13], [14] These aspects will allow:

- The possibility to access, at local level, the information that describe an object, represented in an universal format (XML), without the need of a regional or global database.
- The possibility to retrieve from the object's memory its behavior (the functionality)
- The possibility to retrieve from the object's memory the behavior of other objects towards this object (allowing for the possibility to create chained behaviors)
- The possibility to create a virtual object using the information stored in an universal language (XML-based)

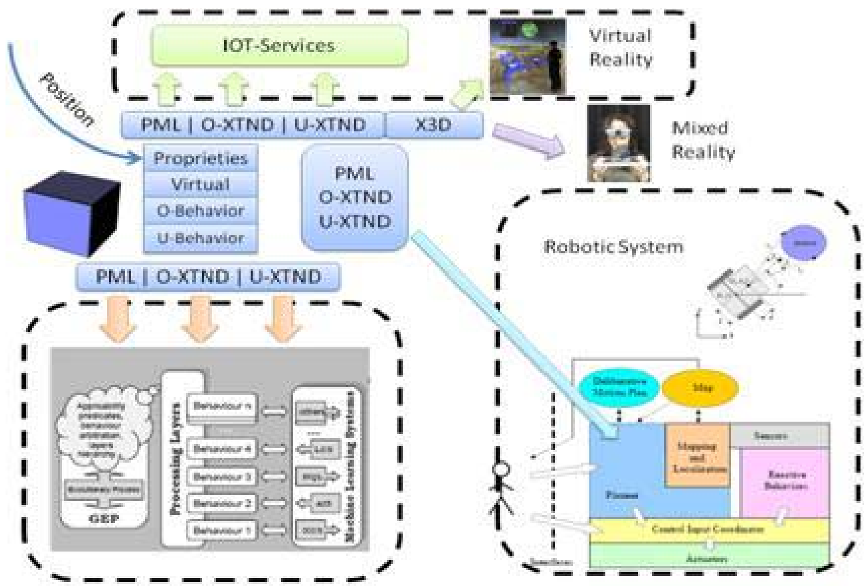


Fig. 6. The interaction of an intelligent object with a robotic system, an agent and IoT services

Fig. 6 describes the interaction of the intelligent object with other components of an intelligent system, such as multi-agent systems, robotic systems and human – machine interfaces represented by the mixed reality and IoT services.

The communication with the mobile robot implies:

- Transmitting the information regarding the position (both regarding a reference system and contextual), acquired by the exemplified means, as a PML file.

- Transmitting the information regarding the size of the object as a recorded in the PML file, information that will be used to grip the object.
- Transmitting the information regarding the behavior of the object, as a Xtnd XML file, information that will be integrated in the behavior chain, generating complex behaviors
- Transmitting the information regarding the user behavior (including the robot) in comparison to the object, as a Xtnd XML file, information that will be integrated in a behavior network that will help in the object manipulation process.

The communication with the intelligent agent implies the creation of an intelligent agent describing the object as an integrated part of a multi agent system. This agent will be created with the help of the information regarding the object's behavior.

The communication with an augmented reality device will allow real time display of the information about the object by using an output device. In this way, a fast description of the object is generated, including information regarding the functionality and use, without the need to access an external database.

## 6. Conclusions

The concepts, proposed within the Internet of Things, paradigm are starting to become a reality due to the research leading towards the development of new devices and services.

The current research area is focused on the development of DNS-like systems capable of linking a tag code to the object information stored on the network. A new approach has been proposed in this paper sustained by the development of more comprehensive storage devices. An architecture for data and information interchange has been proposed. This will allow for the development of new devices which will need only local access and will provide seamless interoperability with robotic systems.

## R E F E R E N C E S

[1] NSF/OECD Workshop "Social and Economic Factors Shaping the Future of the Internet", , http://www.oecd.org/document/59/0,3343,en_2649_34223_37921851_1_1_1_1,00.html, 31 January 2007

[2] *G. Santucci,* From Internet of Data to Internet of Things, Available from: http://ec.europa.eu/information_society/ policy/rfid/ Accessed: 2009-08-12

[3] CASAGRAS WP2, Final Report, Regulatory Issues in Respect of RFID Standards, Coordination and Support Action for Global RFID-related Activities and Standardisation, CASAGRAS, EU Project Number 216803, June 2009

[4] *A.M. Stanescu, I. Dumitrache, M. Pouly, S.I. Caramihai, M.A. Moisescu,* Towards a General Systems Theory Approach for Developing Concurrent Engineering Science, In: Complex Systems Concurrent Engineering Collaboration, Technology Innovation and Sustainability, Loureiro, G.; Curran, R. (Ed.), pp 3-11, Springer, ISBN: 978-1-84628-975-0, London UK, 2007

[5]. Internet of Things 2020, A Roadmap to the Future, European Technology Platform on Smart Systems Integration, Available from: http://ec.europa.eu/information _society /policy/rfid/documents/iotprague2009.pdf Internet of Things: an early reality of the Future Internet Accessed: 10-08-2009

[6] EPC Global, Radio-Frequency Identification Implementation Cookbook 2nd Release - Sept. 2006, Available from: http://www.epcglobalinc.org/what/ cookbook Accessed: 10-07-2009

[7]. *K.B.* S*orensen, P. Christiansson, K. Svidt, K. Jacobsen, T. Simoni,* Towards Linking Virtual Models with Physical Objects in Construction using RFID - Review of Ontologies, Proceedings of the CIB-W78 25th International Conference on Information Technology in Construction Rischmoller, L. (Ed), pp. 418-428 ISBN: 978-956-319-361-9 Santiago de Chile, July 2008

[8]. *P. Antoniac, S. Hickey*, Mobile Augmented Reality for the m-Worker, in *1st AMI@Work Communities Forum Day 2005* (M. Pallot and K. S. Pawar, eds.), Towards Ambient Intelligence at Work, Vision 2010, (Munich, Germany), pp. 29-37, Centre for Concurrent Enterprising, 2005

[9]. *P. Plaggenbor.*, Social RFID internet for things, Rotterdam, http://www. socialrfid.org/, August 2006

[10]. *M. Risler, O. von Stryk*, Formal Behavior Specification of Multi-Robot Systems Using Hierarchical State Machines in XABSL. In AAMAS08-Workshop on Formal Models and Methods for Multi-Robot Systems, Estoril, Portugal, 2008

[11]. *C. Cîrstoiu., N. Ţăpuş,* Framework for data-intensive applications optimization in large-scale distributed systems, in U.P.B. Sci. Bull., ISSN 1454-2358, Series D, **Vol. 71**, Iss. 2, 2009

[12]. *Jalal Frihat, Florica Moldoveanu, Alin Moldoveanu*, General guidelines for the security of a large scale data center design, in U. P. B. Sci. Bull., ISSN 1454-234x, Series C, **Vol. 71**, Iss. 3, 2009

[13]. *A.M. Stanescu, M.A Moisescu, I.S. Sacala, C. Vintila, A. Cornescu*, Towards a New Science Foundation of Collaborative & Concurrent Enterprising, Klaus-Dieter Thoben, Kulwant S Pawar, Bernhard Katzy & Robert Bierwolf (eds), in Proceedings of the 15th International Conference on Concurrent Eneterprising ICE2009 'Collaborative Innovation Emerging Technologies, Environments and Communities' Leiden, Nederlands, 22-24Iunie 2009 ISBN 978 085358 259 5

[14]. *A.M. Stanescu, M.A. Moisescu, I.S. Sacala, A Nita*, FROM INDUSTRIAL ROBOTICS TOWARDS INTELLIGENT ROBOTIC SYSTEMS, 4th International IEEE Conference Intelligent Systems, Date: SEP 06-08, 2008 Varna BULGARIA Source: 2008 4TH INTERNATIONAL IEEE CONFERENCE INTELLIGENT SYSTEMS, VOLS 1 AND 2 Pages: 306-310 Published: 2008, Publisher: IEEE, 345 E 47TH ST, NEW YORK, NY 10017 USA, ISBN: 978-1-4244-1739-1.