# Industrial Internet of Things with Data Distribution Service for Real Time Systems

**Ioan Ungurean[1]**

[1] *Faculty of Electrical Engineering and Computer Science, Stefan cel Mare Univesity of Suceava, Romania*

---------------------------------------------------------------------***---------------------------------------------------------------------

**Abstract -** ***At this moment, the IoT (the Internet of things) concept is in the process of developing, maturation, and standardization. This concept aims to interconnect all things from daily life to the Internet as part of the Internet of the Future. IoT concept caught the attention of the industrial environments in order to develop the develop factories of the future. For this reason there were defined the Industrial Internet of Things (IIoT) and Industry 4.0 concepts. These concepts defined the factories of the future by introducing the IoT in industrial fields. In this paper it is presented an IIoT architecture that response to challenges provided by industrial environments: reliability, safety, hardware real time, predictability, robustness, , and security.***

***Key Words:*** *Key word1, Key word2, Key word3,ggdg etc…*

## 1. INTRODUCTION

The "Internet of Things" (IoT) term was proposed by Kevin Ashton from MIT Auto-ID Center referring to the connection between the information provided by RFID and Internet [1]. This concept quickly caught the interest of researchers and currently IoT is not limited to RFID and wireless sensor networks, the concept including all things that have Internet connectivity and can transmit/receive information, activating the people-things and things-things communication [2].

The basic idea of IoT is to connect all things from everyday life to the Internet [3], concept that is part of the Internet of the Future [3][4], which can connect millions of heterogeneous devices that can communicate transparently in terms of communication infrastructure used without human intervention [4][5]. International Telecommunications Union (ITU) identified four dimensions to IoT [6]: identifying things ("labeling things"), sensor networks and wireless sensor networks ("things that feel"), embedded systems ("things that think") and nano-technology ("things that shrink").

Most research projects and scientific literature deal with the use of RFID and wireless sensor networks to add connectivity and intelligence to things from everyday life, in order to enable their connection to the Internet. Such IoT architectures are presented in [7][8][9]. Other projects focus on how smart devices are integrated into new IT applications and processes, such as those presented in [10][11]. A new concept, presented in [12], is based on a type of relations between things like relationships. Other papers address particular aspects such as security of IoT systems [13].

Being an emergent technology, IoT is beginning to be used in industrial environments in order to monitor production chains and transmit information to the ERP systems [14]. Anticipating the impact that will have IoT concept in the industry, the German government initiated the "Industrie 4.0" project, which outlines strategies for including the IoT in the industry in order to develop "smart factories" [15]. "Industrie 4.0" is a sophisticated change of the entire value chain: communication, planning, logistics and production, preparing the path for a new social and technological revolution that will drastically change the industrial landscape. German industry and academia prepared a report on the way in which this transformation can be achieved [15]. The German government expects that this technology will be the fourth industrial revolution and will take place in the next 10-20 years [15]. In the USA, there is a similar initiative under the name Smart Manufacturing Leadership Coalition [16] Furthermore, the International Society of Automation (ISA) defined the Industrial IoT (IIoT) concept as future development strategy [17].

Due to the success of communications and information technologies and embedded systems that are connected together, or to the Internet, by wire or over, it tends towards a convergence between the physical and virtual (cyberspace) worlds. This convergence takes the form of Cyber-Physical Systems (CPS). For example, the proposed “Industrie 4.0” architecture has four levels (from bottom to top): Internet of Things, Internet-based system &

service platforms, Internet of Services, and Applications. More details can be found in [15].

This paper is organized as follows. The proposed IIoT architecture is presented in Section 2, and the integration of different fieldbuses is presented in Section 3. Finally, the conclusions are drawn in Section 4.

## 2. The proposed IIoT architecture

In this paper, it is proposed IIoT architecture of Fig. 1. This is developed by integrating the OpenDDS (an open source implementation for the Data Distribution Service for Real Time Systems standard) middleware in order to transport information in the Internet. The proposed IIoT architecture is organized into four levels: things, data provider, middleware, and application.

The things level includes psychical things that are virtualized. These things are represented by sensors and actuator that are attached to the physical things in order to be transformed in smart things. The sensors acquire information from the physical environment, and the actuators can execute different operations in the physical word. These sensors and actuators are connected to a wireless network (wireless) or a wired network used in the industrial fields (Profinet, EtherCAT, etc.) or building automation (KNX, Lonwork, 6LowPAN, etc.). For each of these fieldbuses it is used an adapter that can connect the fieldbus to a PC. It can be used simple interfaces (e.g. USB-S485, USB-CAN) or intelligent devices developed around a microcontroller to provide real-time data acquisition from field networks.

Next, according to Fig. 1, is the driver level. This level is a wrapper between the fieldbuses connected to the PC and the middleware level. This level provides the same interface to the superior level regardless of the fieldbuses used to interconnect the sensors and the actuators. Also, the driver level transmits data received from the middleware level to the fieldbuses, data that will reach the actuator to which is addressed. At this level, software adapters are implemented for the communication with devices connected to the fieldbuses connected to the PC.

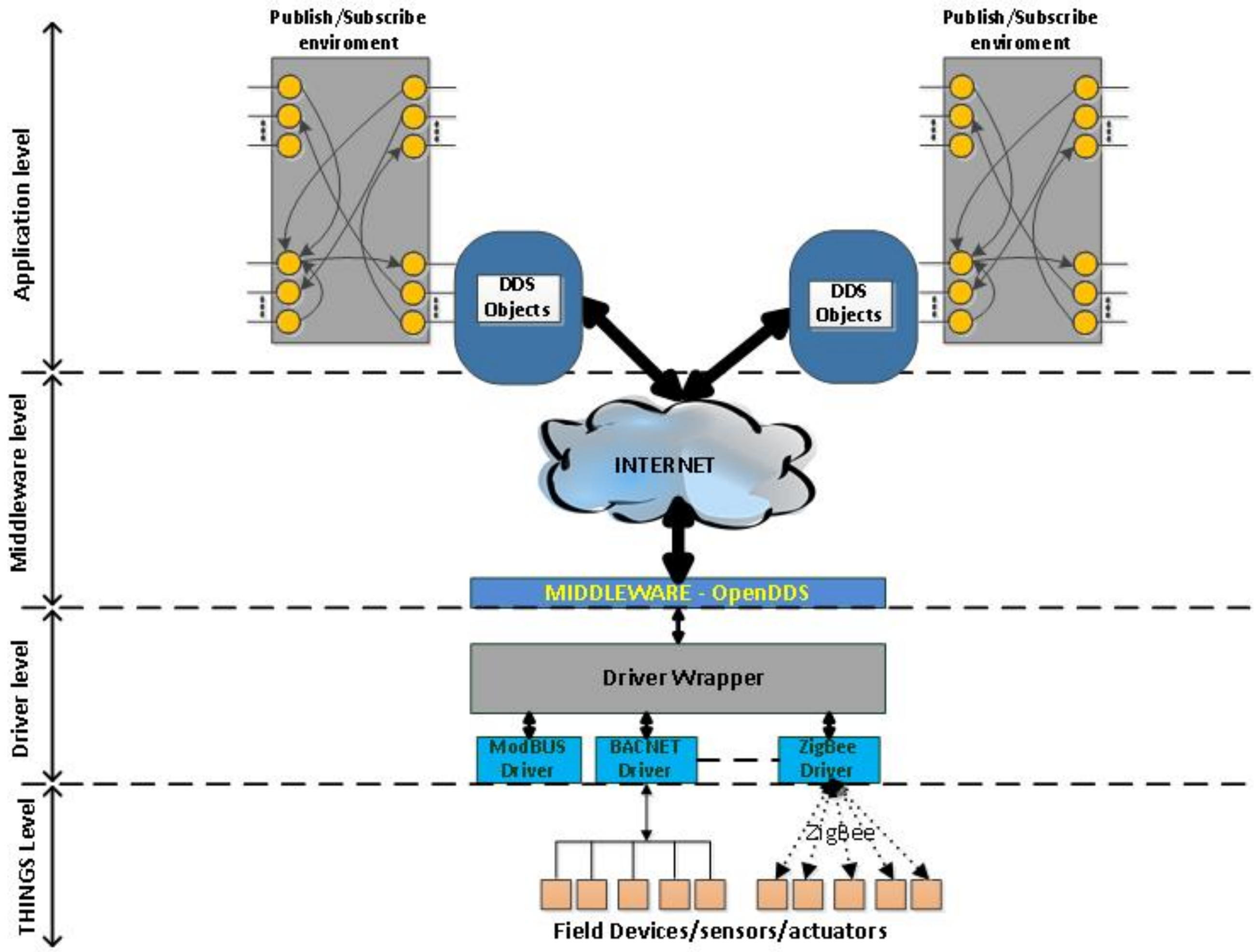


**Fig -1**: The proposed IIoT architecture

The propose of the middleware level is to distribute the information throughout the Internet network, At this level, we chose the DDS standard with OpenDDS open source implementation in order to transport information. The DDS is based on the consumer producer paradigm and there can be done various peer to peer network architectures.

At the application level, we have an application that can instantiate middleware objects for connecting to the industrial environment and graphic objects that allow graphic expose of the information from things (is an HMI application). The HMI application is described in [18]. The architecture was developed at the middleware level (based on OpenDDS implementations of the DDS standard) with focus on activation of QoS parameters and at the application level.

## 3. The integration of the fieldbuses in the IIoT architecture

The most important challenge in the design and the development of the IIoT architecture is the huge number of networks used in the industrial field. The integration of these fieldbuses in software systems is difficult due to their different characteristics, requiring an automatic method to describe devices from these fieldbuses. For this propose we chose the EDS (Electronic Data Sheet) technology defined for CanOpen fieldbus. Also we propose an embedded device that will interface fieldbuses with the driver level from the IIoT architecture. The proposed solution is a new approach for integrating fieldbuses in IIoT architectures or other type of software application because it allows the decoupling from the industrial environment where hard real time and predictability are essential parameters and a unified integration of fieldbuses (for application level the communication with industrial devices is transparent in terms of fieldbus used).

## 4. CONCLUSIONS

In this paper, it was proposed an IIoT architecture based on DDS middleware standard. We chose the DDS protocol because it is based on producer consumer paradigm and was designed for critical application and real time systems. These features are activated through QoS parameter that can be used to setup the application.

## ACKNOWLEDGEMENT

This paper was supported by the project ―Sustainable performance in doctoral and post-doctoral research PERFORM-Contract no. POSDRU/159/1.5/S/138963, project co-funded from European Social Fund through Sectorial Operational Program Human Resources 2007-2013.

## REFERENCES

[1] Ashton, Kevin. "That 'internet of things' thing." RFiD Journal 22 (2009): 97-114.
[2] Tan, J.; Koo, S.G.M., "A Survey of Technologies in Internet of Things," Distributed Computing in Sensor Systems (DCOSS), 2014 IEEE International Conference on , vol., no., pp.269,274, 26-28 May 2014, doi: 10.1109/DCOSS.2014.45
[3] Chun-Wei Tsai; Chin-Feng Lai; Ming-Chao Chiang; Yang, L.T., "Data Mining for Internet of Things: A Survey," Communications Surveys & Tutorials, IEEE , vol.16, no.1, pp.77,97, First Quarter 2014, doi: 10.1109/SURV.2013.103013.00206
[4] Whitmore, Andrew, Anurag Agarwal, and Li Da Xu. "The Internet of Things—A survey of topics and trends." Information Systems Frontiers (2014): 1-14.
[5] Li, Shancang, Li Da Xu, and Shanshan Zhao. "The internet of things: a survey." Information Systems Frontiers (2014): 1-17.
[6] International Telecommunications Union, ITU Internet Reports 2005: The Internet of Things. Executive Summary, Geneva: ITU, 2005.
[7] Tracey, D.; Sreenan, C., "A Holistic Architecture for the Internet of Things, Sensing Services and Big Data," Cluster, Cloud and Grid Computing (CCGrid), 2013 13th IEEE/ACM International Symposium on, vol., no., pp.546, 553, 13-16 May 2013. doi: 10.1109/CCGrid.2013.100.
[8] Zorzi, M.; Gluhak, A.; Lange, S.; Bassi, A., "From today's INTRAnet of things to a future INTERnet of things: a wireless- and mobility-related view," Wireless Communications, IEEE, vol.17, no.6, pp.44,51, December 2010, doi: 10.1109/MWC.2010.5675777.
[9] Palattella, M.R.; Accettura, N.; Vilajosana, X.; Watteyne, T.; Grieco, L.A.; Boggia, G.; Dohler, M., "Standardized Protocol Stack for the Internet of (Important) Things," Communications Surveys & Tutorials, IEEE , vol.15, no.3, pp.1389,1406, Third Quarter 2013, doi: 10.1109/SURV.2012.111412.00158.
[10] Kelly, S.D.T.; Suryadevara, N.K.; Mukhopadhyay, S.C., "Towards the Implementation of IoT for Environmental Condition Monitoring in Homes," Sensors Journal, IEEE, vol.13, no.10, pp.3846, 3853, Oct. 2013, doi: 10.1109/JSEN.2013.2263379
[11] Sungmin Hong; Daeyoung Kim; Minkeun Ha; Sungho Bae; Sang Jun Park; Wooyoung Jung; Jae-Eon Kim, "SNAIL: an IP-based wireless sensor network approach to the internet of things," Wireless Communications, IEEE , vol.17, no.6, pp.34,42, December 2010 doi: 10.1109/MWC.2010.5675776
[12] Atzori, L.; Iera, A.; Morabito, G., "SIoT: Giving a Social Structure to the Internet of Things," Communications Letters, IEEE, vol.15, no.11, pp.1193-1195, November 2011 doi: 10.1109/LCOMM.2011.090911.111340.
[13] Huansheng Ning; Hong Liu; Yang, L.T., "Cyberentity Security in the Internet of Things," Computer, vol.46, no.4, pp.46-53, April 2013, doi: 10.1109/MC.2013.74
[14] Li Da Xu; Wu He; Shancang Li, "Internet of Things in Industries: A Survey," Industrial Informatics, IEEE Transactions on , vol.10, no.4, pp.2233,2243, Nov. 2014, doi: 10.1109/TII.2014.2300753
[15] ACATECH – Recommandations for implementing the strategic initiative INDUSTRIE 4.0. April 2013, http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf
[16] Smart Manufacturing Leadership Coalition, https://smartmanufacturingcoalition.org/
[17] Herman Storey (co - chair ISA 100), Rick Bullota and Daniel Drolet. The Industrial Internet of Things, 2013, [Online]. Available: http://www.controleng.com/single-article/the-industrial-internet-of-things.
[18] Ungurean, I.; Gaitan, N.C.; Gaitan, V.G., "Transparent interaction of SCADA systems developed over different technologies," in System Theory, Control and Computing (ICSTCC), 2014 18th International Conference , vol., no., pp.476-481, 17-19 Oct. 2014.