Proceedings of Engineering & Technology (PET)
pp. 168-172

2nd International Conference on Automation,Control, Engineering and Computer Science (ACECS-2015)
Proceedings of Engineering & Technology (PET)

Machine-to-Machine Communications: Technologies Standardization Activities, and Challenges

Sulaiman Khalifa Yakhlef(1) , Nasaraldian Ambark Shashoa(1), Omar Abusaeeda(2), Ismail sherina(2)
(1)Azzaytuna University, Faculty of Engineering, Electrical and Electronics Engineering Department, Tarhuna, Libya
(2) Azzaytuna University, Faculty of Engineering, Computer Engineering Department, Tarhuna, Libya
s.yakhlef@it.uot.edu.ly

***Abstract*—Machine-to-Machine (M2M) communication refers to technology that enables machines to be networked so data can be freely exchanged among these assets. It is a form of data communication that involves one or more entities that do not necessarily require human interaction or intervention in the process of communication. M2M communications emerge to autonomously operate to link interactions between Internet cyber world and physical systems. We present the technological scenario of M2M communications consisting of wireless infrastructure to cloud, and machine swarm of tremendous devices. Related technologies toward practical realization are explored to complete fundamental understanding and engineering knowledge of this new communication and networking technology front.**

***Keywords— Machine-to-machine; Internet of Things; Cyber Physical System; Manufacturing Systems; Historic Preservation; Home Networks*.**

I. INTRODUCTION

M2M works by embedding a communication module, sensor, or tag in a physical asset (service, finished product etc.) for sending the information about its status and performance to a computer information system. The information flow is automated and allows to remotely monitor, maintain, and track these machines. Important data about a machine can be uploaded to a computer system from the machine itself rather than being manually collected and uploaded by a human being. Following tremendous deployment of Internet and mobile communications, Internet of Things (IoTs) and cyber–physical systems (CPS) emerge a technologies to combine information communication technology (ICT) with our daily life [1–2]. By deploying great amount of machines that are typically wireless devices, such as sensors, we expect to advance human being's life in a significant way. In particular, autonomous communications among machines of wireless communication capability creates a new frontier of wireless communications and networks [3,4]. In this paper, we will survey some techno- logical milestones and research opportunities toward achieving machine-to-machine (M2M) wireless communication ultimately serving human beings.

II. RELATED WORK

The basic concepts of M2M and CPS, and their typical applications have been the subject of many research studies recently. Both of M2M and CPS are applied to the similar domain. M2M is from the point of view of communications without or with limited human intervention. By contrast, CPS emphasizes not only communications but also distributed/real-time control and across-domain optimization. Here, we mainly focus on their research advances. At present, the various applications of M2M have already emerged in several fields, such as intelligent transportation, healthcare, smart robots, home networks, and smart grids. In [5, 6], the network design issue of M2M communications for a home energy management system in the smart grid was analyzed, and a hierarchical smart grid architecture was designed.

In Ref. [7], the architecture of home M2M networks decomposed into three sub-areas depending on the radio service ranges and potential applications were proposed. In [8, 9], a dialogue agent among the sensory agent, the dialogue agent, and the decision support agent, was designed. Besides these, other applications include pollution control facilities, experiments for learning, hygienic meteorology service, integrated video services, etc [10, 11]. In order to substantially reduce development costs and improve time to market, the collaboration among standards organizations across different industries is quite essential. Fortunately, the technical standardizations for M2M are proceeding in standards developing organizations such as 3GPP, ETSI, IEEE, and TIA [12, 13]. In recent years, the organizations have defined the network architectures and functions to support the unique features of M2M communications in their standard bodies.

III. ARCHITECTURES FOR M2M COMMUNICATIONS

The applications of M2M communications extraordinarily depend on many technologies across multiple industries. Consequently, the required scope of standardization is significantly greater than that of any traditional standards development. The technical standardizations for M2M are proceeding in standards developing organizations, such as 3GPP, IEEE, TIA, and ETSI. The ETSI drafting standards for

ISSN: 2356-5608

information and communications technologies considers an M2M network as a five-part structure [14]. (1) Devices, usually are embedded in a smart device and reply to requests or sends data. (2) Gateway, acts as an entrance to another network. It provides device inter-working and inter-connection. (3) M2M area network, furnishes connection between all kinds of intelligent devices and gateways. (4) Communication networks, achieve connections between gateways and applications. (5) Applications and services, pass datum through various application services and is used by the specific business-processing engines.

It is a software agent analyzes data, takes action and reports data. According to ETSI, this standardization plays an indispensable role in long term development of the M2M technology. The five elements structure proposed by ETSI forms the three interlinked domains, including M2M area domain formed by an M2M area network and M2M gateway, communication network domain consisting of all kinds of wired/wireless networks such as xDSL and 3G, and application domain [15, 16]. Fig. 1 shows M2M architecture domains.

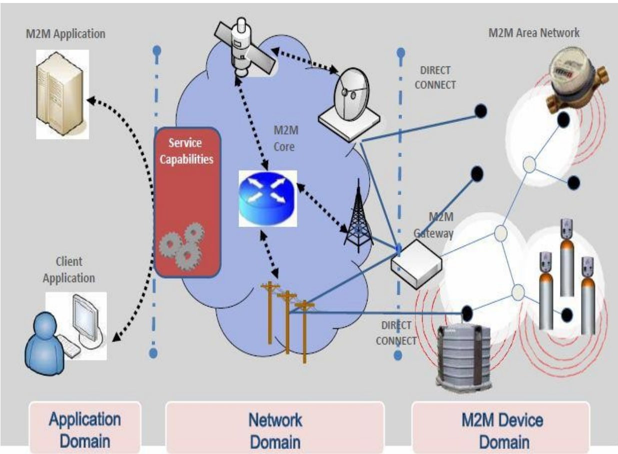

Fig. 1: M2M architecture domains.

IV. M2M APPLICATIONS

In this subsection, we analyze some applications by comparison, and then give three examples (i. e., historic preservation, manufacturing systems and home M2M networks) to illuminate the good application prospects.

A. M2M for Historic Preservation

We propose an innovative M2M architecture for historic preservation, as shown in Fig. 2. Concretely, the architecture is divided into a number of hierarchical networks, namely, neighborhood area network (NAN), building area network (BAN), and house area network (HAN). Based on the existing standards of gateways, IP-based communications networking is preferred, which permits virtually effortless interconnections with HAN, BAN, and NAN. The location of antique with wireless sensor is determined by some location algorithms such as RSSI. Once the antique is moved over a certain range without permission, the information on the appointed identification number is passed to the heritage management center and administrator. For this M2M system, the outstanding design challenges are to hide the sensors and ensure positioning accuracy. Therefore, we adopt UWB technology to achieve accurate positioning [17].

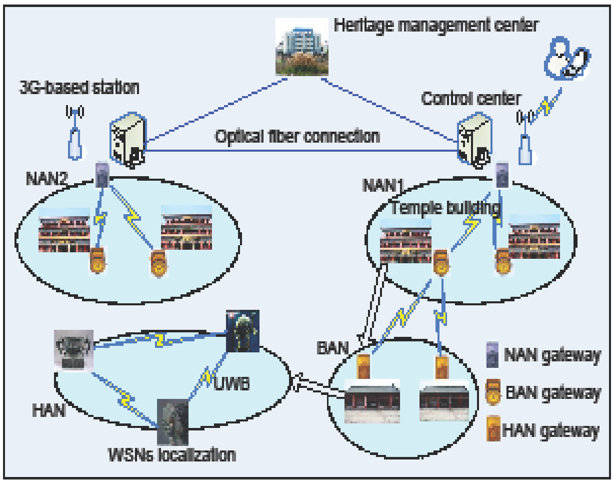

Fig 2: Proposed M2M architecture for historic preservation

B. M2M for Manufacturing Systems

In the near future, the predictable improvement in machine tools will be in the form of a knowledge evolution- based intelligent device. Machine tools have always been regarded as objects of integration, but if intelligence technologies for knowledge evolution are further developed, it is expected that they may be the subject of cooperation. Fig. 3 shows the outline of a M2M environment that could be expected to minimize the roles of human experts and even to substitute for mechanical experts [9]. Machine-dependent knowledge and machine-independent knowledge are examples of types of information exchange in an M2M environment. The information may make evolution of knowledge possible with the exchange of information in real time with computer-aided manufacturers, tool makers and marketers, material producers and marketers, remote service distributors, and even e-machines. This innovation increases efficiency and saves cost.

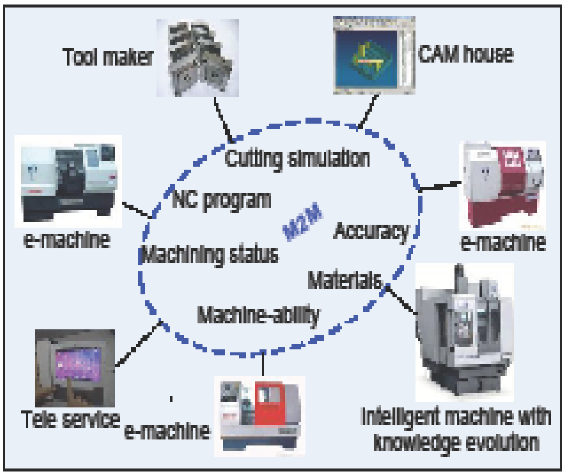

Fig. 3: M2M architecture for manufacturing systems

C. M2M for Home Networks

A feasible architecture for home M2M network is proposed [7]. This network architecture is decomposed into three complementary M2M structures, including home networking, health care and smart grid. The main features and promising applications in each subnetwork are identified as shown in Fig. 4. The home M2M network is essentially a heterogeneous network that has a backbone network and multiple sub-networks. In the backbone network, there is a central machine home gateway that manages the whole network and connects the home network to the outside world (e. g., Internet). The network- related functionalities are implemented in the home gateway, including access control, security management, QoS management, multimedia conversion, etc. Each sub-network operates in a self organized manner and may be designed for a specific application. Each sub-network has a sub- gateway as an endpoint to connect the sub-network to the home gateway and the backbone network. Both home gateway and sub-gateway are logical entities, and their functionalities can be physically implemented in a single device (i.e., cognitive gateway).

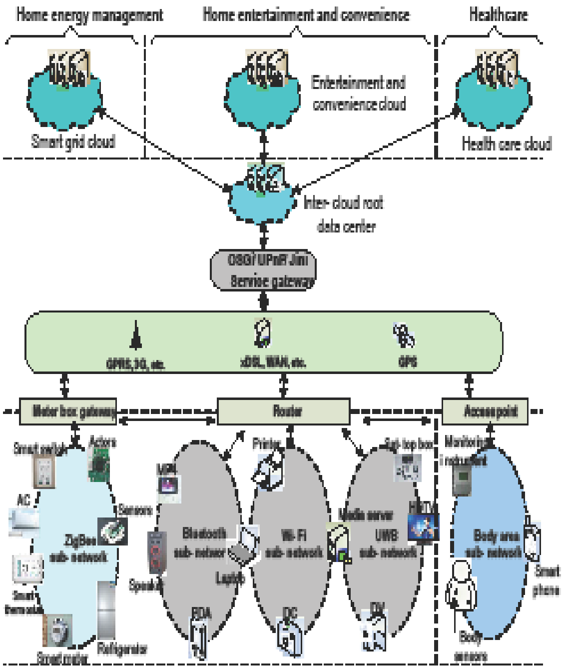

Fig.4: M2M for smart grid, home networking, and health care

V. M2M ISSUES FOR TELECOMMUNICATIONS OPERATORS

Taking into account the growing interests in various industry sectors for using M2M and new deployments of M2M equipment invoked by national legislation, the number of M2M devices is expected to increase sharply in the future. For instance, Cisco Systems, Inc. forecasts that by 2020, the number of devices connected to the Internet will reach 50 billion[18], of which the majority will be M2M-related devices. In comparison with the current number of global mobile subscriptions, which is around 5.4 billion [19], M2M devices of the next higher order of magnitude will be connected to the Internet by 2020. In addition to this, the range of network traffic needed by M2M devices varies widely from one M2M application to another: for instance, the volume of traffic generated by sensor equipment will be low, while that generated by security surveillance cameras will be relatively high. Supporting the enormous number of M2M devices to be connected and efficiently covering the wide range of traffic volume are challenging issues for telecommunication operators.

VI. M2M STANDARDIZATION ACTIVITIES

Standardization activities covering M2M-related technical issues are currently under development by various SDOs and forums. A study of this area under the title “Internet of Things” (IoT) has been started by ITU-T (International Telecommunication Union, Telecommunication Standardization Sector). The term IoT is also used in the EU Frame work Programme 7 project.

A. 3rd Generation Partnership Project(3GPP)

3GPP started standardization activities on mobile network-based M2M in September 2008 under the title “Machine Type Communications” (MTC). This study is regarded as one of the most advanced studies of M2M. 3GPP Release 10 specifications approved in March 2011 cover use cases, service requirements, and a functional architecture for MTC intended for application to mobile networks [20]. In this release, 3GPP standardized overload and congestion controls for networks and secure telecommunication functions for MTC devices in roaming environments in order to cope with new traffic characteristics caused by collecting small amounts of information at the same time from a huge number of MTC devices, which has not previously been done in existing human-oriented telecommunication. Technical documents covering the service requirements and architectural model have also been issued as TS 22.368 and TR 23.888, respectively.

At present, issues such as group-based MTC device management capabilities and communications between MTC devices are being studied under a new work item entitled System Improvements to Machine Type Communications (SIMTC).

B. Internet Engineering Task Force (IETF)

In IETF, an informal Bar BOF (birds of a feather) on IoT research issues was held at IETF 77 March 2010. Research is merely at the preliminary stage of calling for the need to study IoT, on the basis of individual drafts, and trying to identify issues that may arise in the case of connecting various things, such as radio-frequency identification tags to the Interne.

C. International Telecommunication Union, Telecommunication Standardization Sector (ITU-T's)

ITU-T's Telecommunication Standardization Advisory Group (TSAG) agreed to establish a Global Standards Initiative on the Internet of Things (IoT GSI) at the February 2011 meeting. IoT-GSI com- prises relevant Questions from Study Groups, and at its first meeting held in May 2011, IoT-GSI began a study mainly targeting IoT definitions, IoT over-views, and an IoT work plan for deploying IoT. The third IoT-GSI meeting held in November 2011 Almost completed the draft ITU-T Recommendation "IoT Overview", which covers the definition of terms including IoT definition, general overview, requirements, and the architecture. Activities of the EU Framework Programme 7 project are also recognized, and coordination has started. Three draft ITU-T Recommendations Overview of Internet of Things, Requirements for support of machine oriented communication applications in the NGN environment, and Framework of object-to-object communication for ubiquitous networking in NGN began the approval procedure as Y.2060, Y.2061, and Y.2062, respectively, at the SG13 meeting held in February 2012 (NGN: Next Generation Network).

VII. CONCLUSION

In recent years, the representative applications of M2M have been attracting significant interest, and will continue to do so for the years to come. M2M architectures, typical applications, and design challenges of M2M were reviewed. This paper presents state-of-the-art technologies for the entire M2M communications and remaining intellectual and engineering challenges. As a young technology, we do foresee tremendous potential for M2M systems and M2M communication plays a central role to benefit modern and future human life. M2M standardization has just started towards services from various industry sectors integrated horizontally. From a practical viewpoint, however, the creation of a common place for discussion involving various industry sectors that have traditionally had different backgrounds will be a key factor not only for the success of this effort.

REFERENCES

[1] E.A. Lee, Cyber physical systems: design challenges, in: 11th IEEE Symposium on Object Oriented Real-Time Distributed Computing, 2008.

[2] L. Atzori, A. Iera, G. Morabito, The internet of things: a survey, Computer Networks 54 (2010) 2787–2805.

[3] G. Wu et al., M2M: from mobile to embedded internet, IEEE Communications Magazine 49 (4) (2011) 36–43.

[4] S.Y. Lien, K.C. Chen, Y.H. Lin, Toward ubiquitous massive accesses in 3GPP machine-to-machine communications, IEEE Communications Magazine 49 (4) (2011) 66–74.

[5] N. D., Lu, X., Wang, P.: Machine-to-Machine Communications for Home Energy Management System in Smart Grid. IEEE Communications Magazine, Vol. 49, No. 4, 53-59. (2011).

[6] S. H., Wan, J., Li, D., Zou, C.: Energy Management Framework Designed for Autonomous Electric Vehicle with Sensor Networks Navigation. In Proc. of the 12th IEEE International Conf. on Computer and Information Technology, Chengdu, China, 914-920. (2012).

[7] Z. Y., Yu, R., Xie, S., Yao, W., Xiao, Y., Guizani, M.: Home M2M Networks: Architectures, Standards, and QoS Improvement. IEEE Communications Magazine, Vol. 49, No. 4, 44-52. (2011).

[8] K. B. H., Ahn, H., Kim, J. O., Yoo, M.: Application of M2M Technology to Manufacturing Systems. In Proc. of 2010 International Conf. on Information and Communication Technology Convergence, 519-520. (2010).

[9] K. D. H., Song, J. Y., Lee, J. H., Cha, S. K.: Development and Evaluation of Intelligent Machine Tools Based on Knowledge Evolution in M2M Environment. Journal of Mechanical Science and Technology, Vol. 23, 2807~2813. (2009).

[10] J. S., Park, K. W., Ryu, H. W., Kim, Y. H.: A Design of M2M-based Intelligent Operating System for Effective Pollution Control Facilities. In Proc. of 2010 International Conf .on Information and Communication Technology Convergence, 521-522. (2010).

[11] Z. D., Wan, J., Liang, X., Guan, X., Liu, Q., Ji, G.: A Taxonomy of Agent Technologies for Ubiquitous Computing Environments. KSII Transactions on Internet and Information Systems, Vol. 6, No. 2, 547-565. (2012).

[12] D. M., Watteyne, T., Alonso-Z rate, J.: Machine-to-Machine: An Emerging Communication Paradigm. Presentation Report. (2010).

[13] Wu, G., Talwar, S., Johnsson, K., Himayat, N., Johnson, K. D.: M2M: From Mobile to Embedded Internet. IEEE Communications Magazine, Vol. 49, No. 4, 36-43. (2011).

[14] Available at: http://www.etsi.org/website/homepage.aspx

[15] Lu, R., Li, X., Liang, X., Shen, X., Lin, X.: GRS: The Green, Reliability, and Security of Emerging Machine to Machine Communications. IEEE Communications Magazine, Vol. 49, No. 4, 28-35. (2011).

[16] T. N., Uysal-Biyikoglu, E.: Energy Efficient Wireless Unicast Routing Alternatives for Machine-to-Machine Networks. Journal of Network and Computer Applications, Vol. 34, No. 3, 1587-1614. (2011).

[17] T. P.: Ultra Wide Band (UWB) and Short-Range Devices (SRD) Technologies. Technical Report. (2009).

[18] http://blogs.cisco.com/news/the-internet-of-things - infographic /.

[19] Ed. by InfoCom Research, Inc., "Information & Communications in Japan 20?2," p. ?84, NTT Publishing Co., Ltd., (2011).

[20] Wu, G.; Talwar, S.; Johnsson, K.; Himayat, N.; Johnson, K. M2M: From mobile to embedded internet. IEEE Commun. Mag. 2011, 49, 36–43.