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Internet of Things: Current Research, Trends and Applications

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ABSTRACT: Internet of Things (IoT) provides a promising opportunity to establish powerful industrial systems and applications by emerging the growing ubiquity of RFID, wireless, mobile and sensor devices. To understand the development of IoT in industries, it reviews the current research of IoT, key enabling technologies, major IoT applications in industries and identifies different research trends and challenges. It summarizes the current state-of-the-art of IoT in industries systematically. Wireless Sensor Networks (WSNs) are playing main key role in several application scenarios such as healthcare, environment monitoring, agriculture, and smart metering. In addition, WSNs are also characterized by high heterogeneity as there are many different proprietary and non-proprietary solutions. This wide range of technologies is delaying new deployments and also integration with existing sensor networks. The current trend, is to move away from proprietary and closed standards is to embrace IP-based sensor networks using the emerging standard WPAN/IPv6. It allows connectivity between WSN and Internet, which enables smart objects to participate to the Internet of Things (IoT). Building an IP infrastructure would be very difficult because nowadays many different sensors and actuators technologies which includes both wired and wireless have already been deployed over the years. It delivers a framework able to produce legacy and new installations, allowing migrating to an IP environment at a later stage. The term ‘‘Internet-of-Things’’ is used as an important keyword for covering various aspects related to the extension of the Internet and the Web into the physical domain, by means of the impressive deployment of spatially distributed devices with embedded identification, actuation capabilities and/or sensing. Internet-of-Things predicts a future in which digital and physical entities can be linked by various means of appropriate information and different communication technologies, to enable a whole new class of various applications and services. In this article, a survey of technologies, applications and research challenges for Internet-of-Things is presented.

KEYWORDS: Internet of Things (IoT), RFID, Wireless Sensor Networks, ICT, Enterprise Systems, Industrial Informatics

I. INTRODUCTION

As an emerging technology, the Internet of Things (IoT) is looking forward to offer promising solutions to change the operation and role of many existing industrial systems such as manufacturing systems and transportation systems. For example, when IoT is used for developing intelligent transportation systems, the transportation authority can be able to track each vehicle’ existing location, monitor its movement and also predict its future location and expected road traffic. The term IoT was initially proposed to refer to uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology [1]. After that researchers relate IoT with more technologies such as actuators, sensors, GPS devices, and mobile devices. Today IoT can defined as “a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network" [2].

Specifically, the integration of sensors or actuators, RFID tags and communication technologies serves as the foundation of IoT and demostrate how a variety of physical objects and devices around us and in day to day life can be associated to the Internet and allow these objects and devices to cooperate and communicate with one another to reach common goals [3]. There is a growing and emerging interest in using IoT technologies in various industries [4]. A number of industrial IoT projects have been conducted in areas such as food processing industry, environmental monitoring, agriculture, security surveillance, and others. Meanwhile, the number of IoT publications is quickly growing.

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As a rising technology, the internet of Things (IoT) is wanting forward to provide promising solutions to change the operation and role of the numerous existing industrial systems like manufacturing systems and transportation systems. as an example, once IoT is utilized for developing intelligent transportation systems, the transportation authority is also ready to track each vehicle' existing location, monitor its movement and in addition predict its future location and expected road traffic. The term IoT was initially planned to raise unambiguously identifiable sensible connected objects with radio-frequency identification (RFID) technology [1]. at the instant researchers relate IoT with extra technologies like actuators, sensors, GPS devices, and mobile devices. of late IoT can outlined as "a dynamic world network infrastructure with self-configuring capabilities supported standard and practical communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network" [2].
Specifically, the integration of sensors or actuators, RFID tags and communication technologies is that the inspiration of IoT and demostrate but a variety of physical objects and devices around America and in day to day life is also associated to the net and allow these objects and devices to collaborate and communicate with one another to attain common goals [3]. there is a growing and rising interest in exploitation IoT technologies in varied industries [4]. form of business IoT comes are conducted in areas like food processing industry, environmental monitoring, agriculture, security surveillance, and others. Meanwhile, the amount of IoT publications is quickly growing.

II. BACKGROUND & CURRENT RESEARCH OF IOT

IoT has become a global network infrastructure composed of numerous connected devices that depend on sensors, communication, networking, and most of information processing technologies [5]. A foundational technology for IoT is the RFID technology, which allows microchips to transmit the identification information to a reader through wireless communication. By using RFID readers, people can identify, track and monitor any objects attached with RFID tags automatically [6]. RFID has been widely used in logistics, pharmaceutical production, retailing, and supply chain management since 1980s [7,8]. Another foundational technology for IoT is the wireless sensor

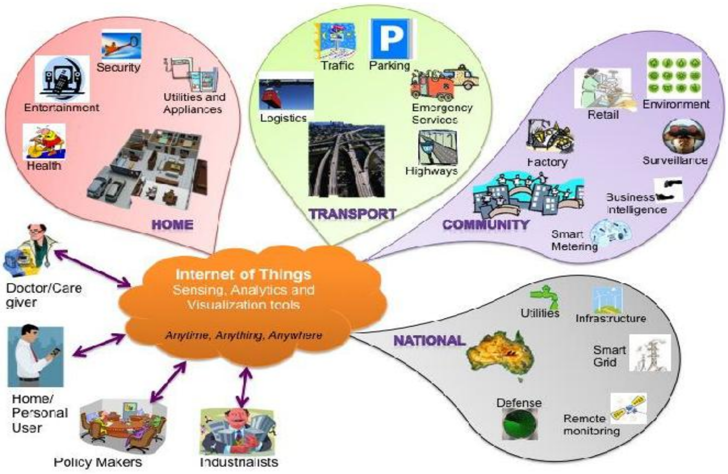

Figure 1 Internet of Things Schematic showing the end users and application areas based on data

networks (WSN), which mainly use interconnected intelligent sensors to sense and monitoring. Its' applications include environmental monitoring, healthcare monitoring, industrial monitoring, traffic monitoring and so on [9,10]. The advances in both RFID and WSN significantly contribute to the development of IoT. In addition, many other technologies and devices such as barcodes, smart phones, social networks, and cloud computing are being used to form an extensive network for supporting IoT [11-16].
So far IoT has been gaining attraction in industry such as logistics, manufacturing, retailing and pharmaceutics. With the advances in wireless communication, smartphone, and sensor network technologies, more and more networked

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things or smart objects are being involved in IoT. As a result, these IoT related technologies have also made a large impact on new ICT and enterprise systems technologies as shown in Figure 3.

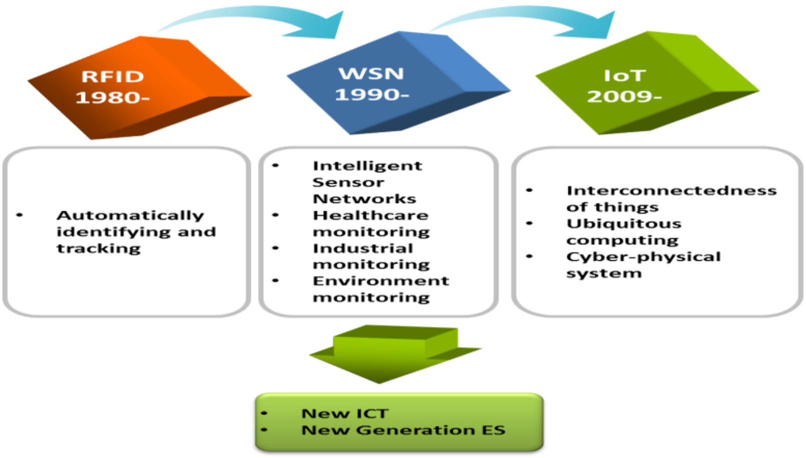

Figure 3. IoT related technology and their impact on new ICT and enterprise systems

In order to provide high quality services to end users, IoT technical standards need to be designed to define the specification for information exchange, processing, and communications between things. The success of IoT depends on standardization, which provides interoperability, compatibility, reliability, and effective operations on a global scale [17]. Many countries and organizations are interested in the development of IoT standards because it can bring tremendous economic benefits in the future. Currently, numerous organizations such as International Telecommunication Union, International Electro-technical Commission, International Organization for Standardization, IEEE, European Committee for Electro-technical Standardization, China Electronics Standardization Institute, and American National Standards Institute are working on the development of various IoT standards [18,19]. As so many organizations are involved in the development of IoT standards, a strong coordination between different standardization organizations is necessary to coordinate and govern the relationships between international standards organizations and national/regional standards organizations [20].

III. SERVICE-ORIENTED ARCHITECTURE FOR IOT

IoT aims to connect different things over the networks. As a key technology in integrating heterogeneous systems or devices, service-oriented architecture (SOA) can be applied to support IoT. SOA has been successfully used in research areas such as cloud computing, wireless sensor networks and vehicular network [25-32]. Quite a few ideas have been proposed to create multi-layer SOA architectures for IoT based on the selected technology, business needs, and technical requirements. For example, the International Telecommunication Union recommends that IoT architecture consists of five different layers: sensing, accessing, networking, middleware, and application layers. From the perspective of functionalities, a four-layered service-oriented architecture of IoT is shown in Table 1. Figure 4 shows a service-oriented architecture where the four layers interact to each other.

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Layers	Description
Sensing layer	This layer is integrated with existing hardware (RFID, sensors, actuators, etc.) to sense/control the physical world and acquire data.
Networking layer	This layer provides basic networking support and data transfer over wireless or wired network.
Service layer	This layer creates and manages services. It provides services to satisfy user needs.
Interface layer	This layer provides interaction methods to users and other applications.

Table 1. A Four Layered Architecture for IoT

The architectural design of IoT is concerned with architecture styles, networking and communication, smart objects, web services and applications, business models and corresponding process, cooperative data processing, security, etc. From the technology perspective, the design of an IoT architecture needs to consider extensibility, scalability, modularity, and interoperability among heterogeneous devices. As things might move or need real-time interaction with their environment, an adaptive architecture is needed to help devices dynamically interact with other things. The decentralized and heterogeneous nature of IoT requires that the architecture provides IoT efficient event-driven capability. Thus, SOA is considered a good approach to achieve inter-operability between heterogeneous devices in a multitude of way [19,20].

A. Sensing layer

In the sensing layer, the wireless smart systems with tags or sensors are now able to automatically sense and exchange information among different devices. These technology advances significantly improve the capability of IoT to sense and identify things or environment. In some industry sectors, intelligent service deployment schemes and a universal unique identifier (UUID) is assigned to each service or device that may be needed. A device with UUID can be easily identified and retrieved. Thus, UUIDs are critical for successful services deployment in a huge network like IoT [35].

B. Networking layer

The role of networking layer is to connect all things together and allow things to share the information with other connected things. In addition, the networking layer is capable of aggregating information from existing IT infrastructures (e.g. business systems, transportation systems, power grids, healthcare systems, ICT systems, etc.). In SOA-IoT, services provided by things are typically deployed in a heterogeneous network and all related things are brought into the service Internet [19]. This process might involve QoS management and control according to the requirements of users/applications.

C. Service layer

Service layer relies on the middleware technology, which provides functionalities to seamlessly integrate services and applications in IoT. The middleware technology provides the IoT with a cost-efficient platform, where the hardware and software platforms can be reused. A main activity in the service layer involves the service specifications for middleware, which are being developed by various organizations. This layer includes the following components:

i. Service discovery: finding objects that can offer the needed services and information in an efficient way [19].
ii. Service composition: enabling the interaction and communication among connected things. The discovery phase leverage the relationships among different things to discover the desired service, and the service composition component is to schedule or re-create more suitable services in order to acquire the most reliable services to meet the request [19,20].
iii. Trustworthiness management: aiming at determining trust and reputation mechanisms that can evaluate and use the information provided by other services to create a trustworthy system [19].
iv. Service APIs: supporting the interactions between services required in IoT [24].

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D. Interface layer

In IoT, a large number of devices involved are made by different manufacturers/vendors and they do not always follow the same standards/protocols. As a result of the heterogeneity, there are many interaction problems with information exchange, communication between things, and cooperative event processing among different things. Furthermore, the constant increase of things participating in an IoT makes it harder to dynamically connect, communicate, disconnect, and operate. There is also a necessity for an interface layer to simplify the management and interconnection of things.

IV. RESEARCH CHALLENGES & FUTURE TRENDS

It is broadly accepted that the IoT technologies and applications are still in their infancy [32]. There are still many research challenges for industrial use such as technology, standardization, security and privacy [19,20]. Future efforts are needed to address these challenges and examine the characteristics of different industries to ensure a good fit of IoT devices in the industrial environments. A sufficient understanding of industrial characteristics and requirements on factors such as cost, security, privacy, and risk is required before IoT will be widely accepted and deployed in industries.

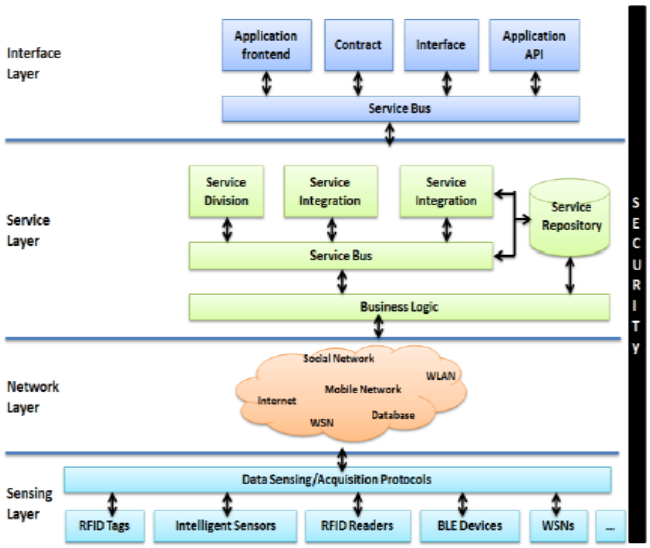

Figure 4 .Service-oriented architecture for IoT

A. Technical challenges

Although a lot of research efforts have been made on IoT technologies, there are still technical challenges:
(1) Design a service-oriented architecture for IoT is a big challenge, in which service-based things might suffer from performance and cost limitations. In addition, scalability issues often arise as more and more physical objects are connected to the network. When the number of things is large, scalability is problematic at different levels including data transfer and networking, data processing and management, and service provisioning [20].
(2) From the viewpoint of network, the IoT is a very complicated heterogeneous network, which includes the connection between various types of networks through various communication technologies. Currently, there is lack of a widely accepted common platform that hides the heterogeneity of underlining networks/communication technologies and provide a transparent naming service to various applications [20].
(3) From the viewpoint of service, a lack of a commonly accepted service description language makes the service development and integration of resources of physical objects into value-added services difficult. The developed services could be incompatible with different communication and implementation environments [19,22].

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(4) As IoT is often developed based on a traditional ICT environment and it is affected by everything connected to the network, it requires a lot of work to integrate IoT with existing IT systems or legacy systems into a unified information infrastructure.

B. Research Trends

The development of IoT infrastructures will likely follow an incremental approach and expand from existing identification techniques such as RFID. International cooperation efforts and a system-level perspective are needed to address the above IoT-related challenges [20]. In addition to conducting research to address the above challenges, identify a few other research trends:

(1) Integrating social networking with IoT solutions. There is a strong interest to use social networking to enhance the communications among different IoT things. A new paradigm named Social Internet of Things (SIoT) was recently proposed by Atzori et al. [21]. There is a trend for the move from IoT to a new vision named Web of Things that allows IoT objects to become active actors and peers on the Web.

(2) Developing green IoT technologies. As IoT involves billions of connected sensors communicating through the wireless network, the power consumption of sensors is a big concern and limitation for the widespread of IoT. Saving energy should become a critical design goal for IoT devices such as wireless sensors. There is a need to develop energy-efficient techniques or approaches that can reduce the consumed power by sensors.

(3) Developing context-aware IoT middleware solutions. When billions of sensors are connected to the Internet, it is not feasible for people to process all the data collected by those sensors. Context-awareness computing techniques such as IoT middleware are proposed to better understand sensor data and help decide what data needs to be processed. [22].

(4) Employing artificial intelligence techniques to create intelligent things or smart objects. Arsénio et al. propose to create Internet of Intelligent Things by bringing artificial intelligence into things and communication networks. Future IoT systems should have characteristics including "self-configuration, self-optimization, self-protection, and self-healing".

(5) Combining IoT and cloud computing. Clouds provide a good way for things to get connected and allow us to access different things on the Internet. Further research will focus on implementing new models or platforms that provide "sensing as a service" on the cloud.

V. APPLICATIONS

There are several application domains which will be impacted by the emerging Internet of Things. The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact [22]. We categorize the applications into four application domains: (1) Personal and Home; (2) Enterprise; (3) Utilities; and (4) Mobile. This is depicted in Figure 1 which represents Personal and Home IoT at the scale of an individual or home, Enterprise IoT at the scale of a community, Utility IoT at a national or regional scale and Mobile IoT which is usually spread across other domains mainly due to the nature of connectivity and scale. A few typical applications in each domain are given.

6.1. Personal and Home

The sensor information collected is used only by the individuals who directly own the network. Usually WiFi is used as the backbone enabling higher bandwidth data (video) transfer as well as higher sampling rates (Sound). Ubiquitous healthcare [7] has been envisioned for the past two decades. IoT gives a perfect platform to realize this vision using body area sensors and IoT backend to upload the data to servers. For instance, a Smartphone can be used for communication along with several interfaces like Bluetooth for interfacing sensors measuring physiological parameters. An extension of the personal body area network is creating a home monitoring system for aged-care, which allows the doctor to monitor patients and elderly in their homes thereby reducing hospitalization costs through early intervention and treatment [23,24]. Control of home equipment such as air conditioners, refrigerators, washing machines etc., will allow better home and energy management.

6.2. Enterprise

Network of Things within a work environment as an enterprise based application. Information collected from such networks are used only by the owners and the data may be released selectively. Environmental monitoring is the first

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common application which is implemented to keep a track of the number of occupants and manage the utilities within the building (e.g., HVAC, lighting). Sensors have always been an integral part of factory setup for security, automation, climate control, etc. This will eventually be replaced by wireless system giving the flexibility to make changes to the setup whenever required. This is nothing but an IoT subnet dedicated to factory maintenance.

6.3. Utilities

The information from the networks in this application domain is usually for service optimization rather than consumer consumption. It is already being used by utility companies (smart meter by electricity supply companies) for resource management in order to optimize cost *vs.* profit. These are made up of very extensive networks (usually laid out by large organization on regional and national scale) for monitoring critical utilities and efficient resource management. The backbone network used can vary between cellular, Wi-Fi and satellite communication.

6.4. Mobile

Smart transportation and smart logistics are placed in a separate domain due to the nature of data sharing and backbone implementation required. Supply chain efficiencies and productivity, including just-in-time operations, are severely impacted by this congestion causing freight delays and delivery schedule failures. Dynamic traffic information will affect freight movement, allow better planning and improved scheduling. The transport IoT will enable the use of large scale WSNs

	Smart Home/Office	Smart Retail	Smart City	Smart Agriculture/Forest	Smart Water	Smart transportation
Network Size	Small	Small	Medium	Medium/Large	Large	Large
Users	Very few, family members	Few, community level	Many, policy makers, general public	Few, landowners, policy makers	Few, government	Large, general public
Energy	Rechargeable battery	Rechargeable battery	Rechargeable battery, Energy harvesting	Energy harvesting	Energy harvesting	Rechargeable battery, Energy harvesting
Internet connectivity	Wifi, 3G, 4G LTE backbone	Wifi, 3G, 4G LTE backbone	Wifi, 3G, 4G LTE backbone	Wifi, Satellite communication	Satellite Communication, Microwave links	Wifi, Satellite Communication
Data management	Local server	Local server	Shared server	Local server, Shared server	Shared server	Shared server
IoT Devices	RFID, WSN	Smart Retail	RFID, WSN	WSN	Single sensors	RFID, WSN, Single sensors
Bandwidth requirement	Small	Small	Large	Medium	Medium	Medium/Large

V. CONCLUSION

IoT integrates many devices equipped with sensing, identification, processing, communication, and networking capabilities as cyber physical system. Sensors and actuators are becoming increasingly powerful, less expensive and smaller, which makes their use ubiquitous. Industries have extreme interest in deploying IoT devices to develop industrial applications such as automated monitoring, controlling, managing, and maintaining. Due to the rapid development in technology and industrial infrastructure, it can be widely applied to industries. For example, the food industry is integrating WSN and RFID to build automated systems to track, monitor, and trace food quality along the food chain in order to food quality. It discovered the recent researches in IoT area from the industrial view. It introduces the background, service oriented architecture models of IoT and elaborating the fundamental technologies that might be used in IoT. Next, introduce key industrial applications of IoT. Afterwards, the research challenges and future trends associated with IoT are analyzed. It concentrated on industrial latest IoT applications and highlights the challenges and possible research opportunities for future industrial researchers. The proliferation of devices with communicating and actuating capabilities are responsible for clear vision of an Internet of Things, where the sensing and/or actuation functions integrated into the background as well as new capabilities are made possible through access of new and vast information sources. IoT is an emerging technology to influence mobile domain by providing new evolving data and the required computational resources for creating revolutionary apps.

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REFERENCES

[1] K. Ashton, "Internet of Things," *RFID Journal*, June 22 2009.
[2] R. van Kranenburg, *The Internet of Things: A Critique of Ambient Technology and the All-Seeing Network of RFID.* Institute of Network Cultures, 2008.
[3] R. van Kranenburg, E. Anzelmo, A. Bassi, D. Caprio, S. Dodson, and M. Ratto, "The Internet of things," in *Proceedings of 1st Berlin Symposium on Internet and Society*, pp. 25-27, 2011.
[4] Y. Li, M. Hou, H. Liu, Y. Liu,"Towards a theoretical framework of strategic decision, supporting capability and information sharing under the context of IoT," *Information Technology and Management*, vol.13, no.4, pp.205-216, 2012.
[5] L. Tan, and N. Wang, "Future internet: The Internet of Things," in *Proceedings of the 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE)*, August 20-22, 2010, pp.V5-376-380.
[6] X. Jia, O. Feng, T. Fan, and Q. Lei, "RFID technology and its applications in Internet of Things (IoT)," in *Proceedings of the 2nd IEEE International Conference on Consumer Electronics, Communications and Networks (CECNet)*, April 21-23, 2012, pp.1282-1285.
[7] C. Sun, "Application of RFID technology for logistics on Internet of Things," *AASRI Procedia*, vol.1, pp.106-111, 2012.
[8] E. W. T. Ngai, K. K. Moon, F. J. Riggins, and C. Y. Yi, "RFID research: an academic literature review (1995–2005) and future research directions," *International Journal of Production Economics*, vol.112, no.2, pp.510-520, 2008.
[9]S. Li, L. Xu, and X. Wang, "Compressed sensing signal and data acquisition in wireless sensor networks and Internet of Things," *IEEE Transactions on Industrial Informatics*, vol.9, no.4, pp. 2177-2186, 2013.
[10] W. He, and L. Xu, "Integration of distributed enterprise applications: a survey," *IEEE Transactions on Industrial Informatics*, vol.10, no. 1, pp.35-42, 2014.
[11] D. Uckelmann, M. Harrison, and F. Michahelles, "An architectural approach towards the future internet of things", in *Architecting the Internet of Things*, pp. 1-24, Springer, 2011.
[12] S. Li, L. Xu, X. Wang, J. Wang, "Integration of hybrid wireless networks in cloud services oriented enterprise information systems," *Enterprise Information Systems*, vol.6, no.2, pp.165-187, 2012.
[13] Li. Wang, L. Xu, Z. Bi, Y. Xu,"Data Filtering for RFID and WSN Integration," *IEEE Transactions on Industrial Informatics*, vol.10, no.1, pp. 408-418, 2014.
[14] L. Ren, L. Zhang, F. Tao, X. Zhang, Y. Luo, Y. Zhang, "A methodology towards virtualization-based high performance simulation platform supporting multidisciplinary design of complex products," *Enterprise Information Systems*, vol.6, no.3, pp.267-290, 2012.
[15] F. Tao, Y. Laili, L. Xu, L. Zhang, "FC-PACO-RM: a parallel method for service composition optimal-selection in cloud manufacturing system," *IEEE Transactions on Industrial Informatics*, vol.9, no.4, pp.2023-2033, 2013.
[16] Q. Li, Z. Wang, W. Li, J. Li, C. Wang, R. Du, "Applications integration in a hybrid cloud computing environment: modelling and platform," *Enterprise Information Systems*, vol.7, no.3, pp.237-271, 2013.
[17] D. Bandyopadhyay, and J. Sen, "Internet of things: applications and challenges in technology and standardization," *Wireless Personal Communications*, vol.58, no.1, pp.49-69, 2011.
[18] ITU NGN-GSI Rapporteur Group, "Requirements for support of USN applications and services in NGN environment," Geneva: International Telecommunication Union (ITU), 2010.
[19] L. Atzori, A. Iera, and G. Morabito, "The Internet of things: a survey," *Computer Networks*, vol.54, no.15, pp.2787-2805, 2010.
[20] D. Miorandi, S. Sicari, F. De Pellegrini, and I. Chlamtac, "Internet of things: vision, applications and research challenges," *Ad Hoc Networks*, vol.10, no.7, pp.1497-1516, 2012.
[21] L. Atzori, A. Iera, G. Morabito, and M. Nitti, "The social Internet of Things (SIoT)-when social networks meet the Internet of Things: concept, architecture
[22] O. Vermesan, P. Friess, P. Guillemin, "Internet of things strategic research roadmap," The Cluster of European Research Projects, 2009, available from http://www.internet-of-things-research.eu/pdf/IoT Cluster Strategic Research Agenda 2009.pdf
[23] A. Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, T. Razafindralambo, A Survey on Facilities for Experimental Internet of Things Research, IEEE Commun Mag. 49 (2011) 58–67.
[24] L. Haiyan, C. Song, W. Dalei, N. Stergiou, S. Ka-Chun, A remote markerless human gait tracking for e-healthcare based on content-aware wireless multimedia communications, IEEE Wirel Commun. 17 (2010) 44–50.
[25] G. Nussbaum, People with disabilities: assistive homes and environments, Computers Helping People with Special Needs. (2006).
[26] A. Alkar, U. Buhur, An Internet based wireless home automation system for multifunctional devices, IEEE T Consum Electr. 51 (2005) 1169–1174.
[27] M. Darianian, M.P. Michael, Smart Home Mobile RFID-based Internet-Of-Things Systems and Services, 2008 International Conference on Advanced Computer Theory and Engineering. (2008) 116–120.
[28] H.S. Ning, Z.O. Wang, Future Internet of Things Architecture: Like Mankind Neural System or Social Organization Framework? IEEE Commun Lett. 15 (2011) 461–463.
[29] L. Atzori, A. Iera, G. Morabito, SIoT: Giving a Social Structure to the Internet of Things, IEEE Commun Lett. 15 (2011) 1193–1195.
[30] G.M. Gaukler, R.W. Seifert, W.H. Hausman, Item-level RFID in the retail supply chain, Prod Oper Manag. 16 (2007) 65–76.
[31] C. Kidd, R. Orr, G. Abowd, C. Atkeson, I. Essa, B. MacIntyre, et al., The Aware Home: A living laboratory for ubiquitous computing research, in: Lect Notes Comput Sc, 1999: pp. 191–198.
[32] S.R.L. Labs, Future Retail Centeer, SAP Research Living Labs. http://www.sap.com/corporate-en/our-company/innovation/research/livinglabs/futureretail/index.epx (n.d.).
[33] J. Hernández-Muñoz, J. Vercher, L. Muñoz, Smart cities at the forefront of the future internet, The Future Internet. (2011).
[34] R.N. Murty, G. Mainland, I. Rose, A.R. Chowdhury, A. Gosain, J. Bers, et al., CitySense: An Urban-Scale Wireless Sensor Network and Testbed, in: 2008: pp. 583–588.
[35] System of Monitoring and Environmental Surveillance, http://www.dimap.es/enviromental-agriculture-services.html (2011)., *Oxford University Press*, ISBN 0-8218-0531-2, 2000.