Chapter 16
A brief review of IoT platforms and applications in industry

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Abstract The Internet of Things (IoT) is a paradigm where everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the Internet to accomplish some objective. Besides, the IoT implies that any single object is a real time data source. This is beginning to transform the way of doing business, the organization of the public sector, the daily living style of millions of people and particularly in the various activities of the industry. The main objective of this book chapter is to present the application of the IoT in the industry, describing its application domains, platforms and various study cases. In addition, we present a comparative analysis of the study cases, as well as the trends and challenges of the IoT according to each domain of application.

16.1 Introduction

The IoT is a new paradigm that is rapidly gaining ground on the new modern wireless technology stage. The basis of this concept is to have interconnected common objects or things, such as radio frequency identification devices (RFID), sensors, actuators, smart phones, among other things or objects, which through addressing schemes unique, are able to interact with each other, cooperating and collaborating with other objects to achieve common objectives (Atzori et al. 2010).

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On the other hand, wireless sensorial technologies significantly increased the sensorial capabilities of the devices (things or objects), and in consequence, the original IoT concept. Nowadays, there are some technologies used for IoT, such as RFID, wireless sensor networks (WSN), near field communication (NFC), low energy wireless communication, cloud software, among others (S. Li et al. 2015), (Kortuem et al. 2010), (Welbourne et al. 2009).

Certainly, the IoT is captivating the academic and industrial attention, due to the mobile short range receivers' integration in a wide range of additional devices and daily use objects, these allow new communication ways such as: peer to peer (P2P), peer to machine (P2M) and machine to machine (M2M) communication; a new dimension between the information and communication (Bandyopadhyay and Sen 2011). In this way, the IoT has characteristic with the real world things, widely distributed with limited storage and processing a capability that implies concerns and improvement opportunities according to reliability, performance, security and privacy (Botta et al. 2016).

The IoT also represents an important Internet evolution, where the heterogeneous devices and machines are being connected to Internet, interconnected among them and also with people. More than ten million micro controllers are built every year and each one connects to Internet to a variety of intelligent and networked devices that are becoming more frequently available from digitally enhanced objects, movement sensors, health monitor devices, electrical measurement devices, and also the street lights. These smart devices are characterized by their detection capacity, processing and network creation; besides, they are used in several domains described in the section below (Bonomi et al. 2012).

This chapter presents a proposal for application domains for the IoT, a comparative analysis of study cases of IoT, and the trends and challenges of the IoT according to each domain of application. This chapter is structured as follows: section 16.2 presents a proposal of IoT application domains and sub domains; section 16.3 presents the IoT application platforms; section 16.4 presents various study cases related to the proposed IoT domains of application; section 16.5 presents a comparative analysis: trends and challenges of IoT, based on the study cases that are related with IoT domains of application. Finally, section 16.6 presents the conclusions and future studies.

16.2 Application Domains

The main IoT idea is the great impact over several life aspects and their conductible habits. As a user, the more evident effects of IoT are on the labor, domestic and industrial fields.

In this context, there are different scenarios in the IoT, for this reason, as shown in Fig. 16.1, we present seven domains of application: Industrial; Transportation and Logistics; Smart Business / Inventory and Product Management; Environment, Agriculture and Breeding; Personal and Social; Security and Surveillance; Healthcare.

Fig. 16.1 IoT application domains.

In the following we describe the seven domains of application and their corresponding subdomains.

16.2.1 Industrial

Smart environments also help in improving the automation in industrial plants with the deployment of RFID tags associated to the production parts. In a scenario, as production parts reach the processing point, the tag is read by the RFID reader. Then, an event is generated by the reader with the necessary data, such as the RFID number, and stored on the network. The machine/robot gets notified by this event (as it has subscribed to the service) and picks up the production part. By matching data from the enterprise system and the RFID tag, it knows how to further process the part. In parallel, a wireless sensor mounted on the machine monitors the vibration and if it exceeds a specific threshold an event is raised to immediately stop the process (quality control). Once such an emergency event is propagated, devices that consume it react accordingly. The robot receives the emergency shutdown event and immediately stops its operation. The plant manager also immediately sees the status of the so called Enterprise Resource Planning (ERP) orders, the production progress, the device status, as well as a global view on all the elements and the possible side effects of a production line delay due to shop-floor device malfunctions. The integration of sensors and RFID empowers IoT in the implementations of industrial services and the further deployment of services in extended applications. IoT integrating with RFID and WSNs makes it possible to develop IoT applications in healthcare, decision-making of complex systems, and smart systems such as smart transportation, smart city, or smart rehabilitation systems (Atzori et al. 2010), (Sundmaeker et al. 2010), (Bandyopadhyay and Sen 2011), (Perera et al. 2014), (S. Li et al. 2015), (Botta et al. 2016). The domain Industrial is integrated by the following sub domains:

a) Automotive industry. Advanced cars, trains, buses and bicycles are equipped with advanced sensors and actuators with greater processing power, so applications in the automotive industry include the use of smart things or objects to control and report a wide several pressure tires or the proximity distance among cars. That is the reason why RFID is being used to rationalize vehicle production, improve logistics, increase quality control and improve customer services overall. Additionally, devices connected to the parts of a car contains information related to the manufacturer, manufacturing data, serial number, type, product code and in some applications the precise location. To supplement, RFID provides real time data on manufacturing processes, maintenance processes and offers new, more efficient forms of management. Then again vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication advances significantly in intelligent transportation systems (ITS) as well as vehicle safety and traffic control services, which are integrated into the IoT infrastructure.

b) Telecommunications industry. The IoT allows the possibility of merging various telecommunication technologies and creates new services. One example is the use of the global system for mobile (GSM) communications, NFC, low power Bluetooth, wireless local area network (WLAN), multi-hop networks, global positioning system (GPS) and sensor networks together with the technology of subscriber identification module (SIM) cards, where in these types of applications the reader tag is a part of the mobile phone and various applications that share the SIM card. In this sense NFC allows communication between objects in a simple and safe way just by being close to each other. Consequently the mobile phone is used as an NFC reader and further transmits the read data to a central server. When using a mobile phone, the SIM card plays an important role as NFC data storage and as an authentication credential. For this reason, things join networks and facilitate P2P communication for a specialized purpose or to increase the robustness of channels and communication networks. In this context, things are able to form ad-hoc P2P networks in catastrophic cases to maintain the vital information flow if there are infrastructure failures in telecommunications.

c) Manufacturing industry. By linking elements with information technologies, either through embedded smart devices or through the use of unique identifiers and data carriers that interact with an intelligent system with network infrastructure, in addition to the support information, production processes are optimized and if the whole life cycle of objects, in this sense, from production to disposal is monitored. On the other hand, through the labeling of articles and containers, there is greater transparency for the production plant, the location, layout of the lots and the state of the production machines. For this reason, self-organization and intelligent manufacturing solutions are designed around identifiable elements.

d) Insurance industry. Often, the introduction of IoT technology is perceived as a serious invasion of the privacy of individuals, however, sometimes people are willing to commercial privacy to obtain a better service or a monetary benefit. An example is auto insurance, where if insurance customers are willing to accept electronic records in their car that are able to record acceleration and speed among other parameters, allowing this information to be communicated to your insurance company, it is likely to get some kind of discount or a bonus. Meanwhile the insurer saves money by being involved in a pre-accident stage and discharging responsibilities or calculating the cost of damages. Then again, savings for customers are made through discounts on insurance premiums; the same applies to other assets such as buildings, machinery, among others, that are equipped with IoT technology. In such cases, the technology helps primarily in the prevention of large scale maintenance operations or allows predictive maintenance cheaper, before an incident occurs.

16.2.2 Logistic and Transportation

The IoT offers solutions for fees and toll collection systems, passenger and goods handling that are moved by the international cargo system supporting government's security policies and the transportation industry, in order to satisfy the demanding safety in the world. Monitoring traffic jams through users' cell phones and the deployment in ITS. On the other hand, helps to make transportation of goods and people more efficient. The use of IoT technologies for passenger baggage handling at airports and airline operations allows automated tracking, sorting, checking for excess baggage charges and increased security.

Additionally, IoT provides solutions to transform the transportation system and the car service. To this end, the integration of the cloud with IoT technologies represents a promising opportunity, so, a new generation of cloud data mining services is under development to achieve many business benefits, such as increased road safety, traffic congestion reduction, traffic management and parking, performance of warranty analysis and recommendation of car maintenance date. In addition, numerous vehicles are equipped with powerful sensors, for networking, communication and with capacity to process data, exchanging information with other vehicles (V2V) or exchanging information with the road infrastructure, such cameras and street lights (V2I) over several protocols including HTTP, SMTP, TCP / IP, WAP and the next generation of telematics protocols (NGTP).

Then again, the adoption of IoT in the cloud, promises in logistics a new way of service that is really changing the paradigm of business. It allows new interesting scenarios facilitating the automated handling of goods flows between the point of origin and the point of consumption, in order to meet the specific requirements expressed in terms of time, cost or means of transportation. In addition, thanks to geolocation technologies, automatic tracking of goods in transit is carried out (Atzori et al. 2010), (Sundmaeker et al. 2010), (Bandyopadhyay and Sen 2011), (Gubbi et al. 2013), (Da Xu et al. 2014).

16.2.3 Smart Bussiness / Inventory and Product Management

Actually, RFID technology is used in many sectors of inventory management, through the supply chain. On the other hand, in relation to retail sales, the IoT technologies are used to monitor the availability of the product in real time and maintain the appropriate inventory. It also plays a very important role in the post sale, because users automatically retrieve all the data about the products they purchased. Basically, identification technologies help limit theft and counterfeiting, offering products with a unique identifier that includes a complete and trusted description of the product (Atzori et al. 2010), (Sundmaeker et al. 2010), (Bandyopadhyay and Sen 2011), (Miorandi et al. 2012), (Aggarwal et al. 2013), (Said and Masud 2013), (Gluhak et al. 2011), (Whitmore et al. 2015), (Botta et al. 2016). The domain Smart Business / Inventory and Product Management is made up of the following subdomain:

a) Retail, logistics and supply chain management. In this subdomain application, the IoT provides several advantages, for example with objects equipped with RFID and smart tags it tracks the articles in real time and many applications are monitored such as automatic check of goods receipt, real time tracking of the existence of products, tracking of the product out of the store and even detection of any theft. The IoT provides considerable savings in retail stores, because the loss of sales has been detected when customers do not find the required product in the store. Particularly, the IoT contributes to the optimization of supply chain logistics, since if manufacturers know the information on the quantity of products required by each store, they will be able to produce and send the appropriate quantities of the products, thus avoiding the situation of excessive production or insufficient production. Then again the processes of the supply chain are optimized based on the availability of dynamic data collected in the real world directly by diverse objects in the IoT. Consequently, in the stores they offer applications such as guides according to a pre-selected shopping list, quick payment solutions such as check out automatically using biometrics, detection of a possible allergy of a certain product, personalized marketing, among others.

16.2.4 Environment, Agriculture and Breeding

The IoT is applied properly in the applications of environmental monitoring. In this case a role is played by the sensorial capacity, to perceive autonomously and distributed, phenomena and natural processes such as temperature, wind, rain, level of water, among other aspects; as well as to integrate heterogeneous data into global applications, processing real time information along with the ability of a large number of devices to communicate with each other, and provides a robust platform for detecting and monitoring human and animal life threatening anomalies. The deployment of small devices allows access to certain critical areas, because in some cases the human being is not a viable option (Aggarwal et al. 2013; Atzori et al. 2010; Bandyopadhyay and Sen 2011; Miorandi et al. 2012; Perera et al. 2014; Sundmaeker et al. 2010), (Botta et al. 2016). The domain Environment, Agriculture and Breeding is made up of the following subdomains:

a) Environmental monitoring. The use of identifiable wireless devices and other IoT technologies in green applications, and environmental conservation are one of the most promising market subdomains, because there is an increase in the use of identifiable wireless devices in environmental programs around the world.

b) Agriculture and breeding. The regulations for the traceability of agricultural animals and their movements require the use of technologies such as IoT, which makes possible the real time detection of animals, for example during outbreaks of contagious disease. On the other hand, in many cases, countries give subsidies according to the number of animals in a herd and other requirements, to the exploitation of breeding, sheep and goats, where there is always the possibility of fraud, however, good systems can minimize this type of fraud. Therefore, with the application of identification systems, animal diseases are controlled, treated and in some cases managed to prevent such disease. In particular, it is possible to identify animals vaccinated or those that still present a certain, disease; even blood and tissue samples are accurately identified, obtaining the health status of the animals in real time. Then again, individual farmers are able to deliver crops directly to consumers or shops, not only in a small region, but in larger areas. This undoubtedly reduces the supply chain, because producers are in direct contact with their consumers without the need for intermediaries.

c) Recycling. The IoT and wireless technologies are used to advance the efficiency and effectiveness of numerous major cities and national environmental programs, including tracking vehicle pollutants to help monitor air quality, collection of recyclable materials, reuse of packaging resources and electronic parts, as well as electronic waste disposal (RFID is used to identify the electronic subcomponents of computers, mobile phones and other consumer electronic products to increase the reuse of these components and reduce e-waste). Additionally, RFID provides greater visibility into the supply chain, helping companies to track and manage their inventories, reducing unnecessary transportation requirements and more efficient fuel consumption.

16.2.5 Personal and Social

The applications that are in this domain are those that allow the user to interact with other people to maintain and build social relationships. In fact, things automatically trigger social media (Facebook, Twitter, Micro-blog and Linkedin) to send messages to friends so they are aware of what they are doing or what they have done in the past, such as since leaving the home, the office, going on a trip, even locating common companions to play their favorite sport, among other things (Aggarwal et al. 2013; Atzori et al. 2010; Bandyopadhyay and Sen 2011; Botta et al. 2016; Gluhak et al. 2011; Gubbi et al. 2013; S. Li et al. 2015; Miorandi et al. 2012; Perera et al. 2014; Said and Masud 2013; Whitmore et al. 2015). The domain Personal and Social is made up of the following subdomains:

a) Media, entertainment industry. The deployment of IoT technologies allows a compilation of news announcements based on the location of users. The collection of news is carried out by consulting the IoT to visualize which multimedia devices with capabilities and characteristics necessary for the reception of announcements or news, are present in the range of a certain place and thus send an offer to collect material multimedia about an event. In addition field communication tags are attached to the ads to provide more data by connecting the reader to a URI address that contains the detailed information of the advertisement.

b) Intelligent buildings (automatic energy metering / home automation / wireless monitoring). Several researches have been carried out on the benefits and possibilities of smart houses, because as technologies mature and because wireless communication is increasingly cheaper, the range of applications is increased. For example smart metering is popular for measuring power consumption and sending information to the supplier. Another example is modern home entertainment systems, which are based on general purpose computing platforms that easily communicate with other sensors and actors in the home, thus forming a smart environment. In this context, the additional value of IoT in this subdomain of application is provided by the control and reaction to human activity, so that exceptional situations are detected and people are assisted in daily activities, thus supporting adult's in particular older people.

c) Social IoT. Recently IoT integrated with social networks, resulting in a new paradigm called the social Internet of Things (SIoT), which proposes to describe a world where the things of every human being are detected intelligently and networked. SIoT performs service activities and discoveries effectively and improves the scalability of IoT, similar to human social networks. Besides, the privacy and protection technologies used in social networks are implemented in IoT to improve security.

16.2.6 Security and Surveillance

In a virtual model of the IoT, each physical object finds a response, which provides services to the users. Therefore, each object is well directed and labeled by the IoT; however, interactions between things need to have security aspects to prevent attacks and malfunctions. In traditional networks, such as the Internet, security protocols and privacy guarantees are widely used to protect privacy and communication; however, security techniques applied in conventional networks are insufficient in IoT. Therefore, it is required that exist security protocols and that mechanisms are improved before they are applied in the context of IoT (Bandyopadhyay and Sen 2011), (Botta et al. 2016; S. Li et al. 2015; Miorandi et al. 2012; Said and Masud 2013). The domain Security and Surveillance is made up of the following subdomains:

a) Aerospace and aviation industry. The IoT contributes to improving the safety of products and services by identifying counterfeit products and elements. In this sense, for example, the aviation industry is vulnerable to the problem of suspect approved parts that do not meet the stringent quality restrictions of the aviation industry. It is therefore possible to solve this problem by introducing electronic sensors for certain categories of aircraft parts, documenting their origin and safety certifications during their life cycle, storing this information in a decentralized database (BD), as well as in RFID tags for the authentication of the parts before installing them in an airplane, in this way the safety and reliability of the operation of an aircraft is significantly improved.

b) Process industry. In many plants in the oil and gas industry, scalable architectures are being used which consider the "plug and play" possibilities of new identification methods combined with integrated/detection IoT, the wireless monitoring of the operations of the terrestrial or maritime personnel in the petroleum industry, the monitoring of pipelines of drilling components, the monitoring and the management of fixed equipment, among other aspects. The IoT contributes to reduce the number of accidents in the oil and gas industry by equipping dangerous chemical containers with smart wireless sensors.

c) Food traceability. Efficient traceability of food saves lives, because foodborne pathogens cause various diseases and deaths each year, generating a significant social cost. The IoT helps the implementation of food traceability, if an RFID tag is attached to the elements or, products; the tracking information is stored and updated in the articles themselves. However, manufacturers are concerned about privacy when using RFID, because competitors may have access to this important information, so there is a need for appropriate security methods.

16.2.7 Healthcare

Health is an important application in the IoT area, because it is adapted to improve service quality and reduce costs. In this sense, a series of medical sensors or devices are used to monitor medical parameters, such as body temperature, blood glucose level and blood pressure. Recent advances in sensors, wireless communications and processing technologies are the driving force behind the application of IoT in health systems. Recently the adoptions of portable body sensors, better known as Wearables, are being developed to monitor patient activities or parameters continuously and in real time. In this context, the IoT provides in the health systems an interconnection of the diverse heterogeneous devices to obtain fast, complete and accurate information of the parameters of health of a patient. The domain Healthcare is made up of the following subdomains:

a) Pharmaceutical industry. For pharmaceutical products, safety is of utmost importance, so in the IoT paradigm the placement of smart labels to medicines provides many benefits such as tracking through supply chain support and monitoring their status by means of sensors. For example, in medicines that require specific storage conditions such as refrigeration, monitoring of the condition of the drug is carried out continuously and verified if the conditions were not met during transportation. It also identifies counterfeit products that particularly affect developing countries. Additionally, drug smart cards also directly benefit patients, for example, by reporting the dose, expiration date, storage conditions, and ensuring the authenticity of the drug. Together, a smart medicine kit reads the information transmitted by medication labels to remind the patient of the appropriate time and dose, which is monitored by the physician.

b) Independent living (Wellness, mobility monitoring of an aging population). The applications and services in the IoT have a significant impact on independent living by supporting the elderly through the detection of their activities of daily living, monitoring social interactions using portable and environmental sensors, chronic disease control using portable vital signs sensors and sensors in the body. On the other hand, with the emergence of detecting patterns and machines with learning algorithms, things in a patient's environment are able to care for external factors, because things learn regular routines and generate alerts or they send notifications in situations of anomaly or emergency, where the services of common use are combined with the services of the medical technology.

c) Medical technology, healthcare, (personal network area, monitoring of parameters, positioning, real time localization systems). IoT has many applications in the area of health, with the possibility of using the cell phone with sensory capabilities with RFID as a platform for monitoring medical parameters and drug administration in patients. One of the advantages of IoT in the area of health is prevention and easy control of diseases, diagnoses and provides immediate medical care in the event of an accident. In this sense, implanted and directed devices are used to store health records, which save the life of a patient in an emergency situation, especially for people with diabetes, cancer, coronary heart disease, heart attack, lung disease chronic, cognitive disorders, seizure disorders, blood pressure and Alzheimer's disease. Then again, edible biodegradable chips are introduced into the human body for certain guided actions; for example, paraplegic people have muscle stimuli through the implementation of an intelligent controller linked to an electrical simulation system with the aim of restoring movement functions.

In this context, the IoT in this domain is able to simplify healthcare processes and improve the quality of medical services by allowing cooperation between the different entities involved (patients, nurses, physicians, others) through constant monitoring and control. On the other hand, thanks to IoT's global connectivity, all information related to healthcare (logistics, diagnosis, treatment, recovery, medication, management, finances and even the various daily activities) is collected, managed and shared efficiently. For example, a patient's heart rate is provided by a sensor on a constant basis and is then sent to the doctor's office, this is possible through the use of personal computing devices (laptop, mobile phone, tablet) and access mobile Internet (Wi-Fi, 3G, LTE, among others), allow health services based on the IoT to be mobile and personalized. Besides, assisted living environments, in particular, are focused on facilitating the daily lives of people with disabilities and chronic medical conditions. In particular, thanks to the efficient management of data provided by the sensors, it is possible to provide assisted living services in real time. By applying IoT in healthcare it is possible to provide many innovative services, such as: collection of vital patient data through a network of sensors connected to medical devices, delivery of data in the cloud of a medical center for its storage and processing, adequate management of the information provided by the various sensors and ensure ubiquitous access or sharing of medical data such as electronic health records.

Then again, there are challenges in this area of application to be addressed, such as: security, privacy and reliability of patient data (exposure to hacking attacks, violation of confidential medical data, data blocking and loss of data, governance, abuse of privileges), improved medical data security, service availability, redundancy, unpredictable performance (resource depletion, data transfer bottlenecks, impact on real time services, QoS transmission) and legal aspects (contracts, intellectual property rights, data jurisdiction). Therefore, they are areas of opportunity to develop and implement the IoT in this domain and thus contribute to improving healthcare (Aggarwal et al. 2013; Atzori et al. 2010; Bandyopadhyay and Sen 2011; Botta et al. 2016; Da Xu et al. 2014; Gubbi et al. 2013; S. Li et al. 2015; Miorandi et al. 2012; Sundmaeker et al. 2010; Whitmore et al. 2015). The following section presents architecture and the main platforms for the application of the IoT.

16.3 IoT Application Platforms

A fundamental requirement in IoT is that things on the network are interconnected with each other, so IoT architecture guarantees the proper functioning of things, and serves as a bridge between the physical world and the virtual world. Designing architecture for IoT involves many factors such as networking, communication, security, business models and processes. Additionally, extensibility, scalability and interoperability between heterogeneous devices and their business models are considered. Because things in the IoT move geographically and the need to interact with other things in real time, an IoT architecture is adaptable to make the devices interact with other things dynamically and helps to achieve an unequivocal communication of the events, in addition the IoT has the characteristic of being decentralized and heterogenous.

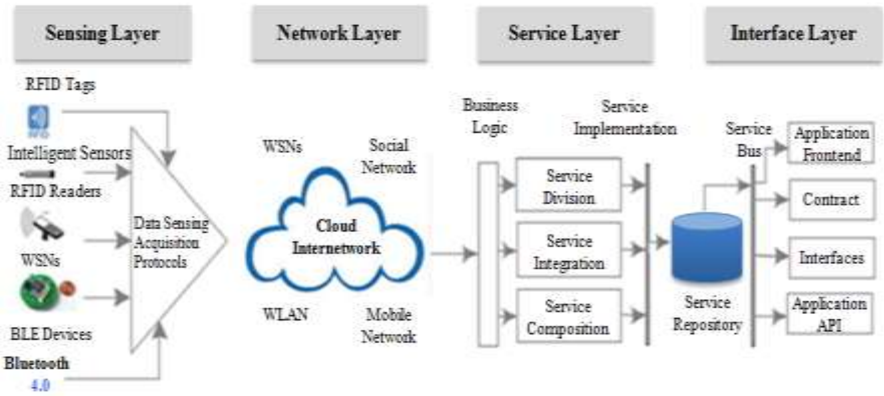

Fig. 16.2 Service-Oriented Architecture (SOA) for the IoT (S. Li et al. 2015).

Service oriented architecture (SOA) is imperative for service providers and users, and guarantees interoperability between heterogeneous devices in multiple ways. In Fig. 16.2, we present an SOA architecture consisting of four stages:

1. Sensing Layer. Integrates with hardware objects available to receive the states of things.
2. Network Layer. Is the infrastructure supporting via wireless cable connections between things.
3. Service Layer. This layer creates and manages the services required by users or applications.
4. Interfaces Layer. Consists of methods of interaction with users or applications.

SOA is a complex system, a set of well defined simple objects or sub-systems, where these are reused and maintained individually; therefore the software and hardware components in the IoT are reused and updated efficiently. Thanks to these advantages SOA has been widely applied as the main architecture of wireless sensor networks, because it is designed to provide scalability, scalability, modularity and mainly interoperability between heterogeneous things. Besides, the functionalities and capacities are summarized in a common set of services (S. Li et al. 2015).

Table 16.1 IoT appplication platform (Han et al. 2016).

Platform	Target objects	Service modeling	Service composition	Aplications
Axeda	IP networked	Cloud	N/A	Cloud-based platform
BUGswarm	IP networked	RESTful APIs, Cloud	N/A	Cloud-based platform
Carriots	Web-enable	RESTful APIs	N/A	IoT platform
Etherios	Embedded	Android M2M device	N/A	Platform-as-a-service (PaaS)
EVRYTHNG	Web-enable	RESTful APIs	Web 2.0 mashup	Personalize/Track/Socialize
GroveStreams	Web-enable	RESTful APIs	N/A	In-cloud real-time big data analytics for IoT.
Nimbits	WSN	RESTful APIs	N/A	In-cloud data processing
Open.Sen.se	(Not specified)	RESTful APIs	Web 2.0 mashup (perspective)	Data storage Visualization
Paraimpu	Web-enable	RESTful APIs	Web 2.0 mashup	Social Web of things
NanoService	Mobile phone embedded	Nano service platforms RESTful APIs	N/A	Embedde Web applications
SensorCloud	MicroStrain WSN Andorid, iOS NI CompactRIO Web-enabled	SensorCloud OpenData APIs	N/A	Cloud sensor data storage
ThingSpeak	WSN	RESTful APIs	N/A	Sensor logging Location tracking Social network of things
ThingWorx	(Not specified)	RESTful APIs Sockets, MQTT, AlwaysOn	Web 2.0 mashup	Cloud services Social services
Xively (Pachube)	(Not specified)	RESTful APIs Sockets, MQTT	N/A	IoT public cloud Platform as a service (PaaS)
Yaler	Embedded (Arduino, BeagleBone Netduino, Raspberry Pi)	RESTful APIs SSH Service	N/A	Relay infrastructure for Web acces of divices

In the IoT many platforms are developed with the aim of supporting their development, in this sense Table 16.1, shows some platforms developed, these platforms mainly address the integration of intelligent objects of different types within the Web through RESTful APIs or cloud services. These platforms provide a middle service point for encapsulating objects, fundamentally heterogeneous intelligent objects within Web interfaces that are integrated into modern Web structures, such as the cloud and the platform as a service (PaaS).

On the other hand, these approaches present some difficulties in scaling the systems in the IoT, because each platform handles the routing of the discrepancy and the translation of the protocol. Therefore, from these platforms, RESTful APIs make possible the composition of service although there are only few of them, in addition provide the connectivity of intelligent objects to the Web, however it is unknown how several intelligent objects interact even if they do not use these platforms, therefore there is a need for service composition models or mechanisms that solve this problem (Han et al. 2016). In the next section we present several study cases related to the advances and use of IoT in various application domains.

16.4 Study Cases

This section presents various study cases related to application, platform development, service composition (SC) and other aspects related to IoT, which are addressed according to the application domains for IoT presented in section 16.2; additionally it is relevant to mention that there are validated study cases in more than one application domain.

16.4.1 Industrial

In this study case (Pisching et al. 2015) presented a study on cloud-based manufacturing SC 4.0, because in this context all objects, features and resources that represented their states, information and mode of operation considered as services; where services are described, published, localized and invoked in a network, which responded to requests between consumers and service providers. Besides, it was indicated that an increase in the number of members in the production chain is expected in a collaborative environment, where the location is indifferent and access to all resources through ubiquitous systems from anywhere in the world. Likewise, it was pointed out that all objects involved in the production processes are expected to be available as services and to communicate and exchange information between them. Expectations and complexity in the industry 4.0 are the large number of interconnected machines, products, processes and people that undoubtedly increase the challenges and expand research opportunities such as data security, standardization and service interoperability.

Then again (Gama et al. 2012) developed a middleware for the IoT called RFID suite designed in a multilayered architecture with the presence in each stage of service oriented computing (SOC). The novelties and contributions that were identified are: SOA and multilayer in the context of RFID, the dynamism and flexibility of the approach of the SOC in the layer of data collection, the flexibility protocol introduced in the middle layer and the service of object names oriented to the Web service (WS). The middleware was initially tested in an industry application for tracking and monitoring objects in the supply chain and then extended to other larger application domains.

In addition, (Rodríguez-Valenzuela et al. n.d.) presented a data fusion mechanism based on the SC model for IoT, because the relevance of IoT in the field of ubiquitous computing is growing and the world of devices in life daily is increasing exponentially both at home, at work and even in the relationship of people. A new method for performing distributed data fusion was proposed using the SC model of the DOHA middleware which is based on SOA and has an extended markup language (XML) based SC map. The distributed nature of this proposal makes the service model very dynamic and scalable, really important aspects in the development of applications that are seen in embedded devices. To illustrate the SC model on the DOHA platform, several scenarios were tested in some areas of IoT application, such as home automation, assisted living and industry.

16.4.2 Logistics and Transportation

In this study case (Stelmach 2013) presented a discussion of SC scenarios in the IoT paradigm, particularly in the transport field, where SC is defined with a holistic approach. Besides, the steps for the proposed composition process were described: requirements definition, decomposition or aggregation requirements making use of the domain ontology, composite construction of the service structure, service discovery, structure and optimization of the service plan. In this proposal, the PlaTel platform for the composition and management of telecommunications services was used as part of the dynamic behavior component in the composite services execution engine. Finally the application of SC was discussed with different scenarios.

16.4.3 Smart Business / Inventory and Product Management

In this study case (Dar et al. 2015) developed the ROA architecture, a design and implementation of a generic architecture model that provided the basic components for an integration of end to end systems in IoT, with special attention to the flow of business processes (BP) of the IoT. The architecture was standard and compatible to integrate devices with limited resources within processes based on business process modeling notations (BPMN). Additionally, the architecture was characterized by its application programming interfaces needed to invoke the services in the IoT that facilitated the life of the programmers in the IoT BPs, an integration model based on events built on a publication subscription mechanism of services dynamic in the event of a failure of the IoT devices and the decentralized execution of the BPs. This proposal is an alternative to develop small services in the IoT that are easily accessible within the BP development environment.

Besides, (Świ ą tek 2015) presented the development of the ComSS platform that was designed to be a middleware for the operation and management of the flow of composite services in the IoT paradigm, where its performance depends on several factors, including the number of available services, their instances and data, and the flow formats used. In this proposal the consultation of the compound services was simple or referred to the applications of complex services that include many services. In this context, the execution time of the composition is the key performance indicator of a platform of this type and determines how quickly the application of the service required by a user is answered and deployed. In the results analyzed, it was identified that in the request of structures of simple services, the platform ComSS did not show a significant result since the response time was little, however when increasing the number of nodes or connections the response time increases from one second to two minutes.

On the other hand, (L. Liu et al. 2012) proposed a cloud-based SC architecture for the IoT, additionally several key technologies such as light service semantics, context sensitive service discovery mechanisms and a model of SC adapted. In this proposed architecture of SC based on the cloud, both cloud computing and IoT were combined. Finally, the main objective was to efficiently support services using cloud technology of different types of objects, particularly in the IoT approach.

In this study case (Ara et al. 2014) proposed a semantic functional module for the user and an algorithm centered on SC for the Web of objects (WoO) platform, which aims to simplify object and application development, maintenance and operation of the IoT infrastructure, in addition it offers a service of the IoT centered on the user allowing the virtualization of the object and the SC based on semantic ontologies. In particular, an ontology model for virtual objects (ViO) was designed, which is the physical representation of real world objects. In this proposal the ontologies described the relation between the objects, services and rules to compose new services dynamically. Finally, this proposal was evaluated when comparing it with the existing SC approaches and those that were developing the user application in order to guarantee the complete functionality.

Then again, (L. Li et al. 2014) proposed a three layer QoS planning model for service oriented IoT: 1) application layer, 2) network layer and 3) detection layer. In the first layer, the planning scheme of the QoS explored the optimal SC that considers the QoS using the knowledge of each of the components. In the second layer, the model was aimed at addressing the heterogeneous network environment programming. In the third layer, the planning of acquisition of information and the allocation of resources to the different services was approached. In addition, QoS was considered for service oriented IoT architecture because it was feasible to optimize IoT programming network performance and reduce resource costs. Besides, the optimization algorithms for QoS depended on the specific requirements of the service.

In this study case (Qu et al. 2016) presented a model for the specification of dynamic services for entities in the IoT, in this model the state information of the entity was emitted in real time by the extended structure and freed the applicants as dynamic services. In this way, transactions in the IoT are intelligently constructed and executed as needed. The semantic Web is an effective technology for IoT intelligence, where WS are commonly used to describe the entity's functions in the transaction process, however, in a specification for information processing, WS do not fully meet the requirements for execution and control of transactions in the IoT. Finally, in this model the OWL-S ontology was expanded with the service state to describe the information of the queue as well as the current state of the entities that are involved in the services, additionally the experimental results demonstrated the efficiency of the model.

Besides, (Yang and Li 2014) presented an efficient strategy from the point of view of the selection of sensory data and the aggregation in the SC of IoT information, where the selection of candidate services was discussed by the modeling and evaluation of QoS in the IoT. In this work, an improved binary genetic algorithm (GA) was used as the global optimization method; this algorithm was in charge of finding the optimal solutions in SC. Finally the experimental results demonstrated the feasibility of the optimization based on the improvement of the GA, the efficiency of the criterion of optimization based on the QoS and the functional value of the service.

16.4.4 Environment, Agriculture and Breeding

In this study case (Di Salle et al. 2015) presented a biological approach preliminarily inspired to take advantage of the peculiarities of the immune system in such a way as to allow the composition of software and services in a dynamic and reliable way, in order to provide a tool capable of managing the combination and selection of software and services in the context of the IoT. The composition was generated to meet the need for reliability and due to the need to write data based applications (Big Data) of which the IoT is a large producer. Imitate the behavior of nature is not new in the field of computing, classic examples are neural networks, genetic algorithm, the same immune system and more calculation of biological inspiration, which have certain characteristics such as distributive property, dynamism, reliability and resilience; All the new challenges that mobile devices present every day.

Therefore, it was recommended to adopt the paradigm based on functional programming because it offers an effective technique for the challenges in the context of IoT.

On the other hand, (Shehu et al. 2015) developed two evolutionary algorithms that perform the SC in the IoT considering the network. The objective of the algorithms was the search for composite services with an optimal cost, response time, reputation and latency of the network in QoS. The first VPSO algorithm used evolutionary techniques such as non-dominated type and multiple populations in its operation. The second is an N-Genetic or NGA algorithm that used a clustered k-average algorithm to classify IoT services into clusters, depending on their round-trip time to other services and subsequently attempts to mutate individuals with others individuals in the same cluster. From the results of the experimentation it was identified that the NGA was better in terms of fitness quality, while the VPSO algorithm was better in terms of calculation speed. In addition the VPSO algorithm is more efficient compared to the NGA.

In this study case (Rodríguez-Valenzuela et al. 2014) presented a new method to implement a fused acquisition of distributed data using a lightweight SC model, which guaranteed the accuracy of collaborations without a cyclic behavior, allowing working with the data in a distributed and decentralized manner. The method also summarizes the typical complexity in the IoT scenarios due to its heterogeneity of the devices, however due to the high level of abstraction of the method; the developers used the concept of service and the interaction between the services to design the IoT scenarios. Finally, this study case was validated, determining the local time prediction from the measurement of the atmospheric conditions of a specific location, where to achieve this, several devices were implemented providing the information to know the atmospheric conditions of temperature, pressure and humidity.

Additionally, (J. Liu et al. 2013) developed an algorithm based on cooperative evolution based on particle cloud optimization to solve the QoS problem. This work also presented a series of effective strategies to solve this problem in the simulation of the biological genetic evolution process, which included a better local and global strategy that introduced the perturbations. This proposal also considered at the same time population diversity and selection pressure. Particularly, twelve steps were proposed for the implementation of this algorithm and it was indicated that to begin to differentiate the traditional SC in the virtual domain of the information, the SC in the IoT is necessary to process data in real time, obtained from the electronic devices that work together in the real world.

16.4.5 Personal and Social

In this study case (F. and I.-R. 2012)presented a scalable trust management protocol for the IoT, which takes social relations into account and considers the use of three trust properties: honesty, cooperation and interest in assessing trust. In this study, it was shown that using more direct observations on past information increase the accuracy of evaluation and the speed of convergence of confidence. In addition, it was demonstrated that by using more indirect recommendations on past information, the speed of convergence of confidence increases, but decreases the accuracy of false recommendation attacks of malicious nodes. The tests demonstrated that the evaluation protocol provides confidence to the current state of the node and demonstrated its effectiveness in an application of SC in IoT environments. Finally the result showed that the confidence based SC exceeds the SC at random and approaches the maximum real world performance.

Then again, (Atzori et al. 2012) presented an integration of social networks with the objects of IoT, which is what is known as the SIoT paradigm, which has the potential to support innovative applications and network services for IoT in an efficient and efficient way. It also proposed a possible architecture that includes the functionalities required to integrate things within the social network. Another contribution of this work was the identification of suitable policies for the establishment and management of social relations between objects in such a way that the resulting social network is navigable. On the other hand, the characteristics of the structure of the SIoT network were analyzed by means of the outputs of the SWIM mobility simulator, where the results showed that the probability distributions of the distance between the nodes that are linked by a social relation depend on the kind of relationship.

Besides, (Zhou et al. 2013) presented the "CloudThings" architecture, which is a common approach to integrating IoT and cloud computing, which examined a scenario of a smart home enabled to analyze application requirements IoT. Additionally to the architecture, a cloud based IoT platform was proposed with the ability to integrate the IaaS, PaaS and SaaS of things in the cloud to accelerate the application, development and management of IoT. Particularly, the LM35 temperature sensor was used to detect the ambient temperature in the house. In addition, the LDR analog sensor was used to detect light in the house. Then again, the Ethernet cable was used to connect Arduino to the Internet. Through the HTTP protocol, data was sent between the Arduino compatible IoT and the cloud application, as well as a Google App service to host the application in the cloud that stored the sensor readings and finally visualized them Paraimpu used a cloud-based IoT service to connect Arduino compatible sensors and share sensor readings with friends.

In this study case (Yu et al. 2016) presented a platform adapted for the convergence of IoT and WoT, which was essential in the implementation of intelligent networks through the fusion of dynamic elements without the intervention of the user. This proposal is a new type of platform that provided inter-compatibility to help users to easily communicate with each other through the connection through networks and also helped in communication between users and things, by merging connected things to the Web. This proposal guaranteed an efficient management platform for IoT and WoT, adaptive synchronization between things, a scalable platform environment and the creation of new services. Besides, the proposal was validated through experiments that verified that the simulations were satisfactory.

On the other hand, (Stavropoulos et al. 2013) performed a comparative review of the systems performed by SC in environmental intelligence environments that comply with ubiquitous computing guidelines, using intelligent environments (InE) systems for the orientation of services, which use WS technology to facilitate interoperability. Because SC in the environmental systems is done manually, which creates some discomfort for the user; there is a need to develop methods or mechanisms that automate this process. It was identified that the spread of multimedia devices has led to widespread use of InE residential multimedia systems such as smart offices, meeting rooms, teleconferencing and health. Additionally, approaches adopted in recent years vary widely in aspects such as application domain, service modeling, compositional method, knowledge representation and interfaces.

In this study case (Chen et al. 2014) presented the design and analysis of the adaptation and survival of a trust management protocol for user centered IoT systems, where the user performed the confidence assessment based on their past and past satisfaction experiences in the confidence assessments of other users who shared similar social interests. Three types of social relations were considered: friendship, social contact and the community of interest, for the measurement of similarity assessments and the confidence of social filtering based on social similarity. In addition, an adaptive filtering technique was developed through which it was determined that the best way to combine direct trust and indirect feedback is dynamically, allowing each node to adaptively select its best confidence parameter to minimize convergence time and confidence bias. The applicability of the protocol was demonstrated applying it to an application of SC in IoT systems based on SOA, where the result was that the protocol is able to approach the optimum performance and significantly exceeds the protocol of random selection not based on trust.

Besides, (Sulistyo 2013) introduced the AMG (abstract, model and generate) method for the development of composite systems, because in IoT trillions of software driven devices and networks are connected on the Internet, these devices communicate and cooperate between themselves to function as a composite system. With the AMG method the development of software applications was done in an automatic way, reducing the cost and time of development. For the SC, the AMG method considered only specific services (real time services). Then again SC was performed in a scenario of an intelligent house, using models at different levels of abstraction, while the execution of compound services was generated automatically.

16.4.6 Security and Surveillance

In this study case (Cassar et al. 2013) developed a divide and conquer algorithm on semantic SC in ubiquitous environments such as IoT. The proposed algorithm was used in the execution of the service to repeatedly split an SC request into some simple sub-requests. The algorithm is repeated until each sub-request meets with at least one atomic service that meets the requirements of the sub-request, and then the identified atomic services are used to create an SC. Basically, the proposal was evaluated based on a set of requests for services composed in different domains including: business, city, commerce, geography, military, office, technology, travel and climate, where it was observed that the proposed algorithm efficiently performed the decomposition of a service request composed of a number of sub-requests and found service components that met the request of the SC.

16.4.7 Healthcare

In this study case (Pang et al. 2015) presented a business technology co-design methodology applied to the design of an in-home healthcare station (IHHS). The core of the methodology was the alignment of three elements: 1) the business models (BM); 2) the device and service integration architecture (DSIA); 3) the information services integration architecture (ISIA). In relation to BM, a cooperative health ecosystem was formulated in the IoT through the deconstruction and reconstruction of traditional medicine and mobile Internet value chains, where everything is integrated into a cooperative health cloud and extended to the house of Patients through an IHHS. Additionally to complying with ISIA and BM requirements, the design principles of an IHHS solution including the reuse of the 3C platform, an effective SC, among other aspects were used. To verify the proposal, a prototype IHHS solution called iMedBox was developed, which is an intelligent medicine box based on the methodology proposed and with a high performance.

In addition, (Cubo et al. 2014) presented the DEEP platform for managing the integration and conscious orchestration of the behavior of heterogeneous devices such as services, storage and access through the cloud. Additionally, a slight model was described to specify the behavior of the devices to determine the order of the message exchange sequence during device composition. Additionally, a common architecture was defined using a standard service oriented environment to integrate heterogeneous devices through their interfaces through a gateway to orchestrate them according to their behaviors; On the other hand, a platform based on cloud computing technology was designed, connecting the gateway responsible for data acquisition of the devices with the platform in the cloud, to remotely access and monitor the data in real time in emergency situations. Finally, the proposal was validated in a set of approaches in real scenarios for its application in a specific environment of assisted living.

Then again, (Tektonidis et al. 2014) presented an intuitive user interface to help increase the adoption of IoT and Internet content services by providing better support to users with disabilities and disabilities from the comfort of their providing a set of scalable services that were offered for free or at some cost through some centralized service repository. In this proposal, three scenarios were presented: an intelligent house, an intelligent hospital and an intelligent city, where support or requirements were proposed for users with a disability or deficiency, suggesting the need to provide them with counseling services, alert services, services, an accessible and intelligent interface, orchestration of services and services to third parties. In this context, it was identified that it is necessary to improve the service model so as to consider the additional specifications related to accessibility issues, semantics to enrich services and a market for personalized services and applications where developers publish them and where users locate the services or applications according to their profile.

In this study case (Dar et al. 2011) developed a SC model for the IoT paradigm that consists of two complementary levels: 1) local orchestration process; 2) process of global choreography. The Business Process Modeling Notation (BPMN) 2.0 was used to define the orchestration scheme, which is supported by BPEL. However in the experimental part due to the scarcity of resources of intelligent devices, they used REST for the exchange of messages. For the process of choreography, they used the BPMN 2.0 notations, which also translate into a BPEL code, particularly to the process of orchestration and choreography used the Eclipse platform. Finally, through a study case of an assisted housing system focused on healthcare, they evaluated the proposal in a real world environment. The following section presents a comparative analysis of the IoT related study cases described in this section.

16.5 Comparative Analyses of Study Cases of IoT

After presenting and describing the various study cases on IoT according to their domain of application, Tables 16.2, 16.3, 16.4, 16.5 and 16.6 present a comparative analysis, which describes the following analyzed aspects:

- Authors - year. The first author and the year of publication are placed.
- Study case. A description of the study case is made.
- Target objects. The objects used are indicated.
- Resource constraint indicates if the objects had restrictions of speed of processing and storage of information.
- Power efficiency indicates whether the objects used an efficient battery.
- Data/Event-driven, whether data or events were used in the study case.
- Asynchrony. Indicates the use of asynchronous communication between objects.
- QoS. Indicates whether QoS was considered in the study case.
- Wearable indicates whether Wearables were used in the study case.

Table 16.2 Comparative analysis for IoT study cases (A).

Author – year	Study Case	Target objects	Resource constraint	Power efficiency	Data/Event-driven	Asynchrony	QoS	Wearable
(Dar et al. 2011)	SC model for the IoT paradigm that	WS	Yes	Yes	Yes	No	No	No

	considers the orchestration and choreography							
(Rodríguez-Valenzuela et al. n.d.)	Data fusion mechanism based on the SC model for IoT, using DOHA and the SC in XML.	RFID	Yes	Yes	Yes	Yes	No	No
(L. Liu et al. 2012)	Cloud-based SC architecture for the IoT, considers light service semantics, context-sensitive service discovery mechanisms and a model Of SC adapted.	RFID	Yes	No	Yes	Yes	Yes	No
(Gama et al. 2012)	Middleware for the IoT called RFID suite designed in a multilayered architecture with the presence in each stage of COS.	RFID NFC	Yes	Yes	Yes	Yes	No	No
(F. and I.-R. 2012)	Scalable trust management protocol for the IoT, which takes social relations into account and considers the use of three trust properties: honesty, cooperation and interest in assessing trust.	NFC	Yes	No	Yes	Yes	Yes	No
(Atzori et al. 2012)	Integration of social networks with the objects of IoT, which is what, is known as the SIoT.	RFID NFC WSN	Yes	Yes	Yes	Yes	No	No

Table 16.3 Comparative analysis for IoT study cases (B).

Author – year	Study Case	Target objects	Resource constraint	Power efficiency	Data/Event-driven	Asynchrony	QoS	Wearable
(Stavropoulos et al. 2013)	Comparative review of the systems performed by SC in environmental intelligence environments that	RFID	Yes	No	Yes	Yes	Yes	No

	comply with ubiquitous computing guidelines, using InE and WS.							
(Cassar et al. 2013)	Divide and conquer algorithm on semantic SC in ubiquitous environments such as IoT.	RFID	Yes	Yes	Yes	Yes	No	No
(J. Liu et al. 2013)	Algorithm based on cooperative evolution based on particle cloud optimization to solve the QoS problem.	WS	Yes	No	Yes	Yes	Yes	No
(Stelmach 2013)	Discussion of SC scenarios in the IoT paradigm, particularly in the transport field, where SC is defined with a holistic approach, using the PlaTel platform.	WS	Yes	No	Yes	No	Yes	No
(Zhou et al. 2013)	"CloudThings" architecture, which is a common approach to integrating IoT and cloud computing.	RFID WSN	Yes	Yes	Yes	Yes	No	No

Table 16.4 Comparative analysis for IoT study cases (C).

Author – year	Study Case	Target objects	Resource constraint	Power efficiency	Data/Event-driven	Asynchrony	QoS	Wearable
(Sulistyo 2013)	AMG method for the development of composite systems, because in IoT, for communication and collaboration between devices.	WS	No	No	Yes	Yes	No	No
(Cubo et al. 2014)	DEEP platform for managing the integration and conscious orchestration of the behavior of	WSN	Yes	Yes	Yes	Yes	Yes	No

	heterogeneous devices such as services, storage and access through the cloud.							
(Ara et al. 2014)	Semantic functional module for the user and an algorithm centered on SC for the WoO platform.	WSN	Yes	Yes	Yes	Yes	No	No
(Rodríguez-Valenzuela et al. 2014)	Method to implement a fused acquisition of distributed data using a lightweight SC model in the IoT.	WSN	Yes	Yes	Yes	Yes	No	No
(Tektonidis et al. 2014)	Intuitive user interface to help increase the adoption of IoT and Internet content services by providing better support to users with disabilities and disabilities.	RFID NFC WSN	Yes	Yes	Yes	Yes	No	No
(Yang and Li 2014)	Efficient strategy from the point of view of the selection of sensory data and the aggregation in the SC of IoT information.	WSN	Yes	Yes	Yes	Yes	Yes	No

Table 16.5 Comparative analysis for IoT study cases (D).

Author – year	Study Case	Target objects	Resource constraint	Power efficiency	Data/Event-driven	Asynchrony	QoS	Wearable
(L. Li et al. 2014)	Three layer QoS planning model for service oriented IoT: 1) application layer, 2) network layer and 3) detection layer.	RFID WSN	Yes	Yes	Yes	Yes	Yes	No
(Dar et al. 2015)	ROA architecture, a design and implementation of a generic architecture model that provided the basic components for an integration of	WSN	Yes	Yes	Yes	Yes	No	No

	end to end systems in IoT.							
(Pang et al. 2015)	Business technology co-design methodology applied to the design of an IHHS. The core of the methodology was the alignment of three elements: BM; DSIA and ISIA.	RFID WSN NFC	Yes	Yes	Yes	Yes	No	Yes
(Świ ą tek 2015)	Development of the ComSS platform that was designed to be a middleware for the operation and management of the flow of composite services in the IoT paradigm.	WSN	Yes	Yes	Yes	Yes	No	No
(Shehu et al. 2015)	Evolutionary algorithms that perform the SC in the IoT considering the network: VPSO and N-Genetic or NGA.	WSN NFC	Yes	Yes	Yes	Yes	Yes	No
(Chen et al. 2014)	Design and analysis of the adaptation and survival of a trust management protocol for user centered IoT systems.	NFC WSN	Yes	Yes	Yes	Yes	No	No

Table 16.6 Comparative analysis for IoT study cases (E).

Author – year	Study Case	Target objects	Resource constraint	Power efficiency	Data/Event-driven	Asynchrony	QoS	Wearable
(Pisching et al. 2015)	Study on cloud-based manufacturing SC 4.0, because in this context all objects, features and resources that represented their states, information and mode of operation were considered as services.	RFID WSN	Yes	Yes	Yes	Yes	No	No
(Di Salle et al. 2015)	Biological approach preliminarily inspired to take advantage of the peculiarities of the	WS	No	No	Yes	Yes	No	No

	immune system in order to provide a tool capable of managing the combination and selection of software and services in the context of the IoT.							
(Yu et al. 2016)	Platform adapted for the convergence of IoT and WoT, which was essential in the implementation of intelligent networks through the fusion of dynamic elements without the intervention of the user.	RFID WSN USN	Yes	Yes	Yes	Yes	No	No
(Qu et al. 2016)	Model for the specification of dynamic services for entities in the IoT, using the OWL-S ontology.	WSN	Yes	Yes	Yes	Yes	Yes	No

The result of the comparative analysis indicates that the most frequently used target objects are RFID, WSN and NFC. Besides, in most of the study cases, there were restrictions on the speed of processing and storage of information. On the other hand not in all cases of study the objects had an efficient battery, additionally in all cases were used data or events, likewise only in some proposals considered asynchronous communication and QoS. Then again, only one study case used a Wearable, however because it was manufactured in a testing laboratory adapting some sensors for monitoring and sending information locally, it lacked the technology currently available new generation of Wearable devices.

Finally, in Fig. 16.3 the tendencies and challenges of the IoT application domains proposed are presented according to the study cases presented in this book chapter. Where it can be observed that the Personal and Social domain is the one that has the highest number of study cases related to this domain, while the domain of Security and Surveillance has the lower number of study cases.

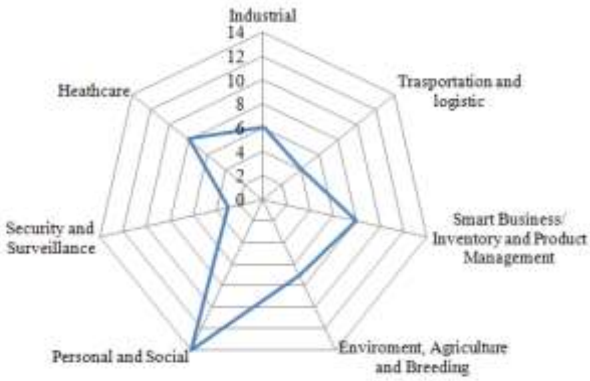

Figure 16.3 Trends and challenges of the IoT application domains.

In addition, the domain Industrial is related to six study cases, the domain Transportation and Logistics has a relationship with four study cases, the domain Smart Business/Inventory and Product Management is related to eight study cases, the domain Environment, Agriculture and Breeding is related to seven study cases and the domain Healthcare has a relationship with eight study cases. The next section presents conclusions, future work and acknowledgments.

16.6 Conclusions and Future Work

The IoT is a paradigm that has been able to penetrate quickly in scenarios of the modern wireless technology. The basic idea is the presence in the real world environment of diverse interconnected objects, such as RFID, sensors, actuators, smart phones, among others; which through unique addressing schemes interact with each other, cooperating and collaborating with other neighboring objects to achieve a common goal. On the other hand, the main strength of IoT is the high impact it has on various aspects of everyday life, user behavior and industry. Also a fundamental requirement in IoT is that things in the network are interconnected with each other, so architecture for the IoT guarantees the proper functioning of things, additionally serves as a bridge between the physical world and the virtual world. Additionally, from the point of view of a user, the most obvious effects of the introduction or insertion in the world of IoT are visible particularly in the labor, domestic and industrial fields, therefore their applicability in scenarios of the different domains of application of the IoT. Besides, IoT is the evolution of the Internet where diverse heterogeneous devices and machines are being connected, interconnecting themselves and also with people. But the question is not only how to make intelligent objects capable of communicating over the Internet, but how their services are composed to create new and creative applications.

Finally, the future work consists of analyzing and evaluating the use of the new generation of Wearable devices (glasses, watches, bracelets, rings, among others) in the various IoT application domains, as well as analyzing and evaluating their platforms and technologies, but particularly to work in the service composition under the IoT approach as a continuation of this work.

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