Internet of Things Paradigms as Enablers of Ambient Assisted Living Systems

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Abstract

The Internet of Things (IoT) has emerged in the last decade as Technological advancements that offers smart objects being capable of identifying, locating, sensing and connecting. The estimated population of connected IoT devices in 2018 is 23.14 billion and its forecasts to be 75 billion by 2025. In the other hand, another field has emerged; Ambient Assisted Living. These AAL applications and solutions are designed to face an urgent crisis facing the world: the increasing number of elder and senior citizens. AAL systems tend to offer a better life quality for these stakeholders, and at the same time, reducing the economic cost of this process for the society. The IoT and its paradigms become the enablers for many applications and domains such as Ambient Assisted Living systems. The objective of this study is to explore the two fields: Internet of Things and Ambient Assisted Living. In this paper, we present an overview of the Internet of Things. We also investigate the paradigms that make the Internet of Things area a successful and promising field. The seven layers and the technologies associated to IoT, the AAL generations are also discussed. Finally, we present the application domains and scenarios related to Internet of Things that serves the development of Ambient Assisted Living field.

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1. Introduction

The increasing population of elder and senior citizens in the modern society becomes an urgent issue. In Morocco for example, the age group 65 and above had doubled its size in less than 30 years. In 1990 there were only one million Moroccan person aging over 65, where in 2016 this number reaches 2.4 million (The World Bank, IBRD DATA). This phenomenon led to the increasing costs of healthcare and well-being of this group within their homes. Thus, it is vital to develop technologies that aid older adults to age in place, offer them independency and enhance their autonomy in a human-free assistance and fully automatized environments. Consequently, Ambient Assisted Living arises as a solution of providing all these services, with a reduced cost and high quality benefits.

Many people confuses the Ambient Assisted Living systems as the Internet of Things. This confusion is led by the similarities between the two concepts. In order to investigate this subject we will follow the next outline: first, we start by defining the Internet of Things and its elements. Secondly, we will explore the paradigms of IoT which are:

a Applications.

b Analysis and transformation of data.

c Communication & connectivity

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d   Physical devices, machines and equipments

To emphasize these paradigms, we will project the technologies involved into seven layers and 4 fields. The firth section is dedicated to AAL. We will review the three generations of AAL. In this part, the relationship between IoT and AAL will be detailed. Also, we give the major applications domain and relevant scenarios of AAL based on IoT.

2. Internet of Things

Kevin Ashton coined the term Internet of Things (IoT) in 1999 in a presentation that he made at Procter and Gamble [1]. Its first purpose was to link and apply RFID (radio frequency identification) technology to supply chain management. The concept has shifted the world of IT to cover much wider technologies and applications [2–6].
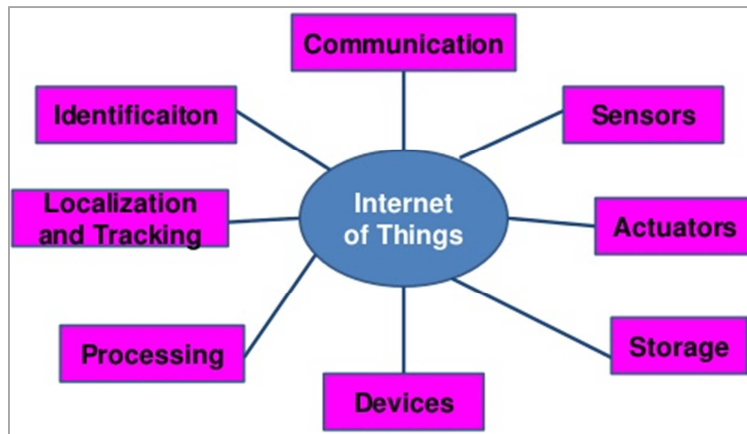

Figure 1. IoT elements

The Internet of Things (IoT) is considered as the new big thing for the IT world not only for researchers and experts, but also for industry and markets. In 2011, Cisco systems predicted that the number of IoT connected devices would reach 50 billion by 2020. Whereas an estimation made by Gartner claimed that where too far from this number, and said that 6.4 Billion Connected "Things" are in use in 2016. The conclusion that can be taken from these forecasts is that IoT device population is exponentially increasing.

The simplest way to define the Internet of Things is to determine its essential elements. The IoT can be seen as the combination of Internet, Things (devices) and data. Also, it's called the Internet of Everything [7–9]. Things are devices connected to Internet via various types of connectivity (wired and wireless). They can be sensors or/and actuators. Sensors collect physical information (temperature, pressure, movement …). The combination of all the above made smart environments possible, but meanwhile the complexity and the processing power needed increases (figure 2).
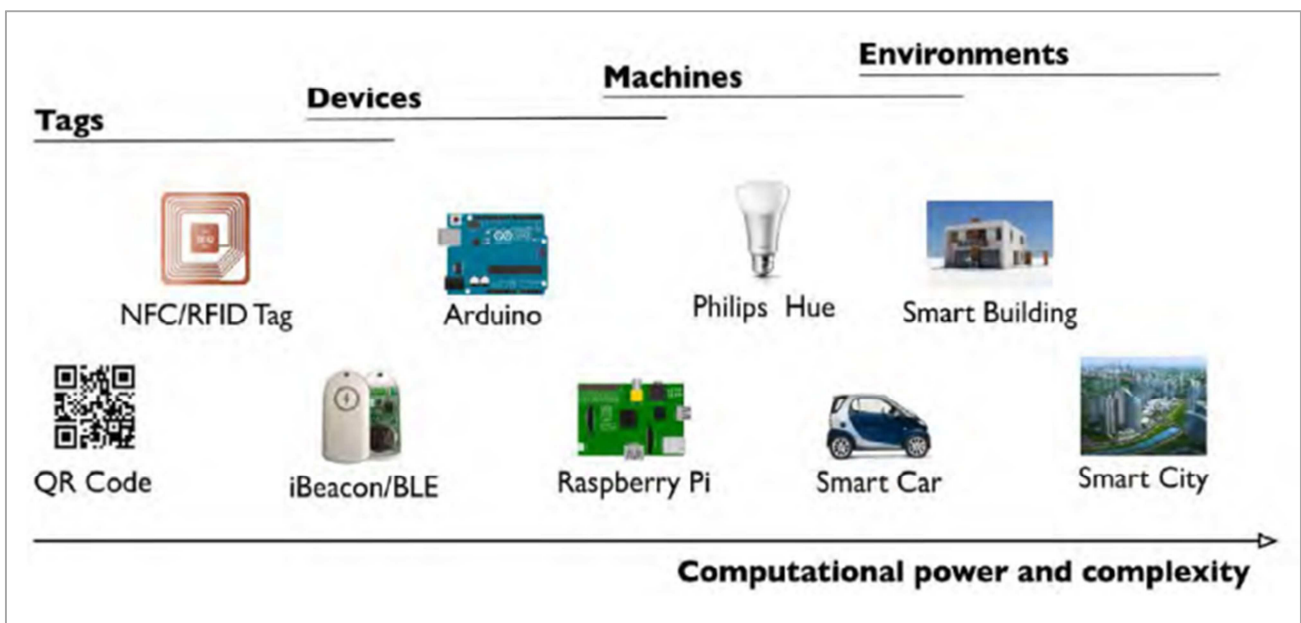

Figure 2. Smart environments and computational power and complexity

3. IoT paradigms

The fact that the IoT has not been developed for specific applications made it so hard to be defined. For the time being, there is no common understanding for the term IoT. It has been widely known as interconnecting objects, devices, machines and people thought the internet. It is defined as service oriented network where virtual or physical objects can communicate in order to provide services to defined stakeholders without requiring human-to-human or human-to-computer interaction [10]. Communication M2M between sensors and actuators in smart spaces via the Internet is the core objective of IoT. As a result of the technologies used in IoT such as monitoring, WSN …etc. many fields will be impacted. The medical supervision and the healthcare domain are among them [11].

IoT is covering multiple aspects related to the Internet and the web into the physical spaces. Using distributed devices with sensing and actuating abilities. Generally, these ''things'' are not designed to work together due to the differences in functionalities, complexities, interfaces and communication protocols, designed for different purposes

and dealing with small data, which makes the orchestration a hard mission to be achieved [12].

Devices used on the IoT are called smart dust or smart motes, which are supposed to sense and act in autonomous behavior. The interconnection between these devices embraces the concept of smart environments. IoT embraces many other concepts such as context-awareness, Ambient Intelligence…etc. as well as it opens new possibilities for noninvasive monitoring, surveillance and pervasive healthcare systems.

The IoT is based on four paradigms. Sensing, communication, data management and application as illustrated in Figure 3. Each one of them concerns specific elements. The sensing paradigm is responsible for collecting data using different devices such as sensors, smart-phones, cameras…etc. and transmit it to the data management using communication networks. The communication protocols use different technologies from standard ones to the wireless ones. Data is analyzed and visualized by the data management elements and the application layer triggers the functionalities according to the defined needs.
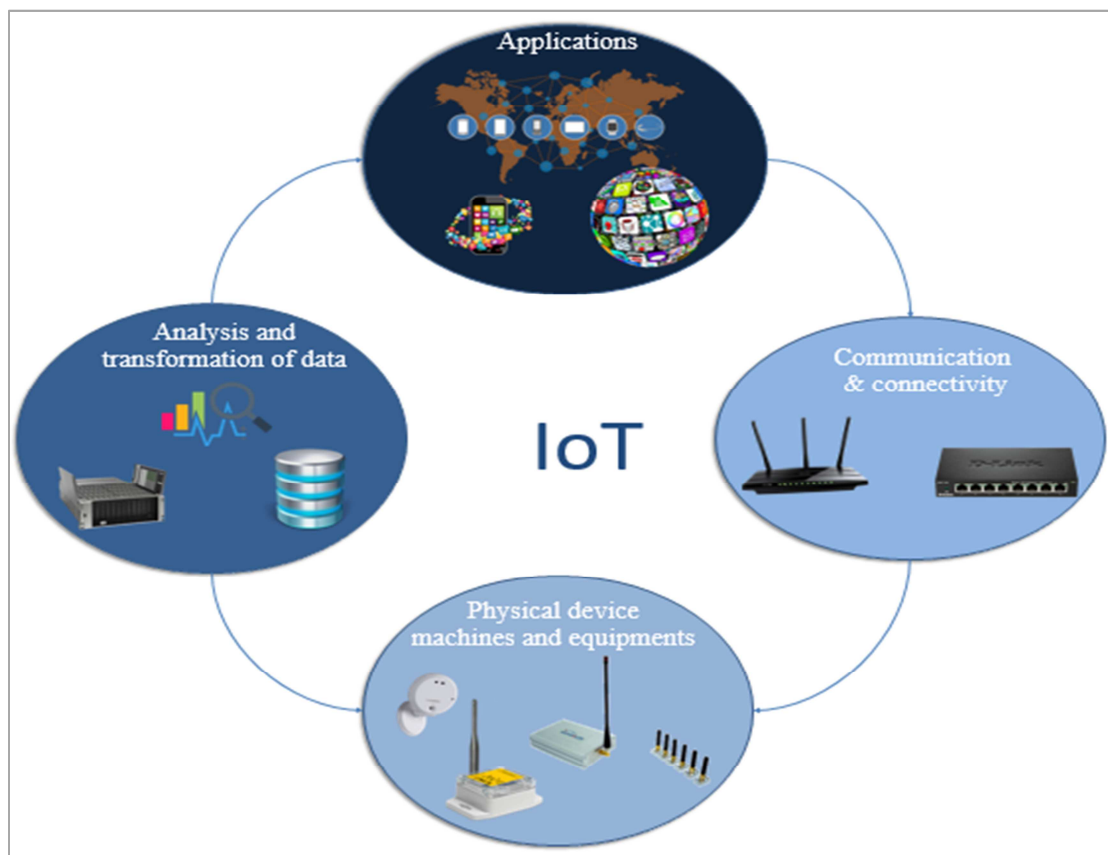

Figure 3. The IoT paradigms.

Many architectural designs have been proposed to answer to the IoT needs. Some of these architectures based their vision

into using all the possible elements that might be useful in a smart environment connected to the Internet. Visions diverge

from a field of application to another, depending on the usefulness of the elements and the layers required to determine predefined functionalities. As of our knowledge, there is no common design of IoT environment nor a reference model to adapt while using the concepts. In Figure 4 we present a proposed 7 layer architecture for IoT. The ''Thing'' is the layer responsible of the multiple devices that could be implemented in an IoT space. Connectivity is assembling the communication protocols where in the cloud the global infrastructure is determined. The big data is divided into two layers including the data ingestion and the data analysis. Finally, the business values are presented by the applications and the transformational decisions based on Thing, Apps and Data.

Figure 4. The seven layers of the Internet Of Things [13].

IoT embraces the Embeddedness the context awareness and the personalization characteristics in addition to the adaptation and anticipation. The objects of an IoT environment are embedded in the space to support the software, which gives the possibility to extract the context. The applications developed under the umbrella of the IoT has to be personalized and adaptive to the needs of multiple situations. Finally, these applications have to analyze heterogeneous data to anticipate and react to specified situations.

4. The IoT for AAL

IoT is extending many areas of application such as Transportation & logistics, personal & social, Ambient Intelligence…etc. As shown in Figure 5,

Figure 5. Internet of Things for Active and Assisted Ambient Living.

The technologies are large and diverse. Moreover, it includes the Healthcare, smart environment and many other aspects of the AAL filed. The common understanding between the IoT and the AAL is that many objects are interconnected in a smart space. Which approved the appearance of integrating these concepts.
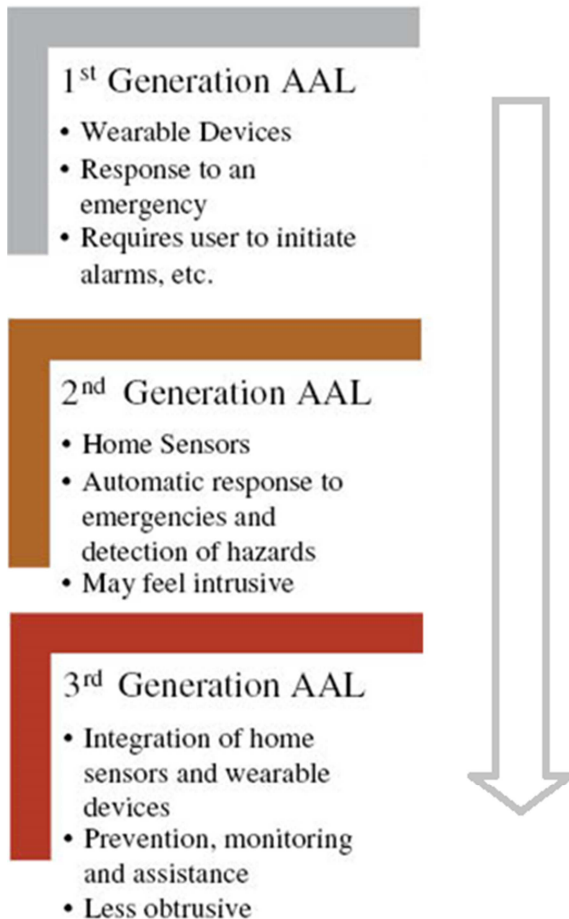

Figure 6. Assisted Ambient Living generations.

The AAL since its appearance, has evolved through three stages. The first generation of these systems was based on wearable devices. Their main objective was to response to emergency cases and generally, the users must trigger the alarm. The second generation was based on home sensors. The response of the system become automatic by detecting emergencies and hazards. Many qualifies these systems as intrusive. The third generation combines both wearable devices and home sensors. This collaboration has the intention to prevent, monitor and assist.

An AAL is a connected, context-sensitive, adaptive and anticipative space [14]. To increase the safety and enhance the quality of life of the stakeholders the home, the hospitals and the public places had to become more intelligent using embedded smart items, which is the vision of the IoT. It is able of providing all the necessities for an ambient assisted environment. Furthermore, it is possible to accomplish many other fields by the use of the IoT. The health monitoring, the alarming systems, the social contact …etc. are just mentionable applications of AAL through the IoT. The scope of the IoT applications is devoted to addressing the social challenges [15].

The Internet of Things is an advancement in the communication between the users, the objects and the users, and between the objects themselves. Providing smart elements for identifying, locating, sensing and connecting. AAL as well uses these objects and technologies with the aim of providing wellbeing for the elderly. In an AAL scenario, there is a combination of applying the IoT infrastructure, using the smart objects and technologies with the processing of the data. Through this combination, a central AAL paradigm can be realized through the IoT.

There has been many shifts in research towards integrating both concepts IoT and AAL [17] in a matter of management and integration of heterogeneous things (objects or devices) in one efficient space.

5. Conclusion

In this paper, we investigated two trends in technology, which are the Internet of Things and the Ambient Assisted Living. As a conclusion, we can say that the power of AAL applications are driven essentially by the four paradigms of IoT. In addition, many applications of IoT are integrated in AAL field to more reliable solutions. Thus, the development of AAL field is tighten to the advance made in IoT.
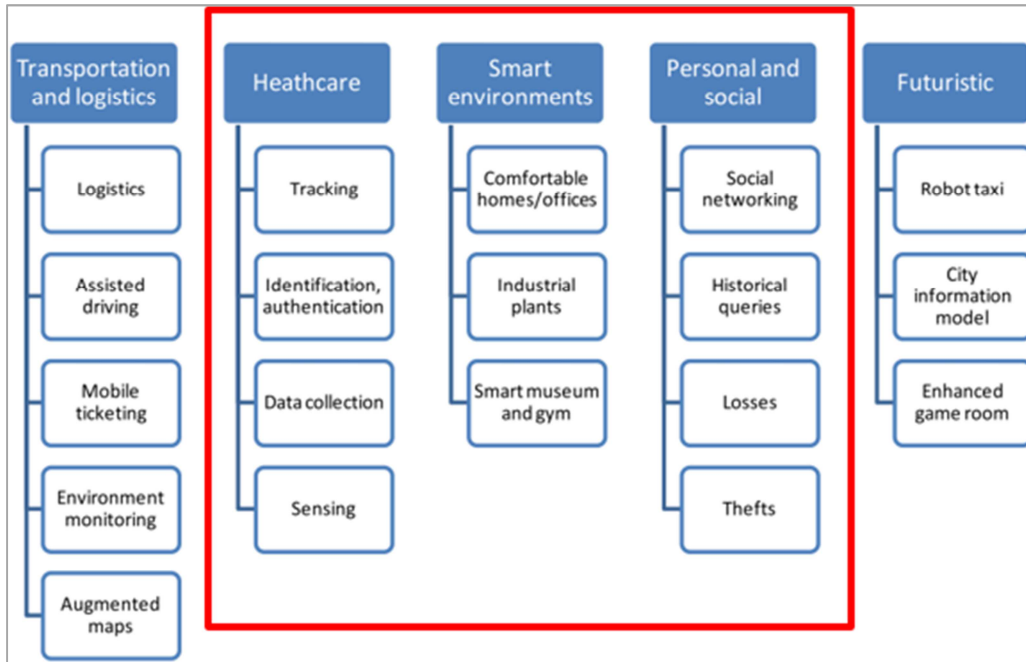
Figure 7. Applications domain and relevant major scenarios [16].

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