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Internet of Thing Architecture and Research Agenda

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Abstract- Internet of Things (IoT) will covers a diverse range of technologies which provide a wide range of smart applications and services that enable smart solutions. While the potential impact of the IoT is considerable, a concerted effort is required to in order to show the architecture and the direction of the research fields in IoT. Many institutions all over the world give main focus on the IoT. This paper presents the architecture and the research agenda of the IoT.

Keywords— IoT, IoT architecture, IoT research agenda

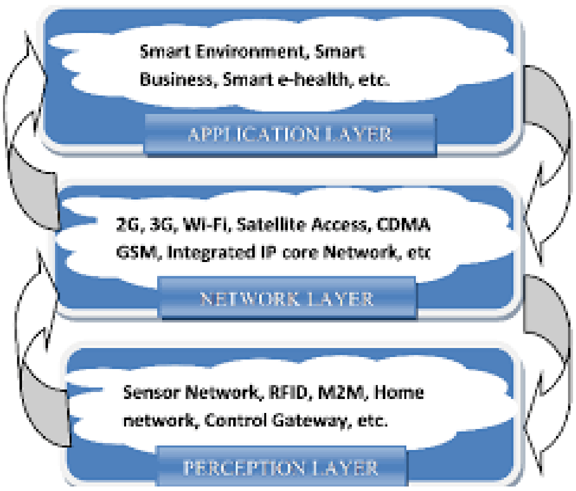
1-Introduction

The Internet of Things (IoT) is a vision of connectivity for anything, at anytime and anywhere, It is recognized as an extension of today's Internet to the real world of physical objects. The paradigm is coined firstly by Kevin Ashton in the year 1998 [1,6]. Atzori et al. [7] identified the IoT can be realized in three paradigms—internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge). Researcher in the industry fields predict the connected devices number will surpass 15 billion nodes by 2015 and reach over 50 billion by 2020 [2]. Most of these connected devices will be smaller, cheaper, simpler embedded devices which includes smart phones, tablets, TVs, gaming consoles, home appliances, security systems, smart thermostats, smart meters, personal fitness trackers, portable medical devices, smart watches, vending machines and numerous other products. The IoT combines a heterogeneous disciplines, this multidisciplinary domain covers a large number of topics from technical issues (routing protocols, semantic queries), to a mix of technical, social and business issues (security, privacy, usability) [4]. According to McKinsey, the Internet of Things has the potential to add $6.2 trillion to the global economy by 2025. Other estimates range from $1.9 to $14.4 trillion of global economic value added by 2020 [12]. The IoT has the chance to deliver solutions that improve energy efficiency, security, health, education and many other aspects of daily life for consumers. Also, it can support the solutions that improve decision-making and productivity in manufacturing, retail, agriculture and other sectors for enterprises [5,6]. building the IoT needs wide

range of technologies. The enhancement of the communications networks infrastructure, through heterogeneous technologies, as well as adoption of IPv6 in order to provide a unique address to each thing connected to the network [8,4]. Radio Frequency IDentification (RFID) and sensor network technologies will be the backbone of IoT, where information and communication systems are embedded in the environment around us [6]. There are three components required for Internet of Things [9,10,11] these are a) Hardware - made up of sensors, actuators and embedded communication hardware b) Middleware - computing tools for data analytics and c) Presentation - visualization and interpretation tools which can be accessed on different platforms and different applications. According to [12] The Internet of Things will affect different sectors of the economy approximately 25% of global manufacturers are already using Internet of Things technologies. This is anticipated to grow to over 80% by 2025 [13,14].
This paper will focus on providing an overview of the Internet of Things architecture and its future research agenda.
Rest of the paper is organized as follows: Section 2 gives an overview of IoT architecture. Research agenda for IoT are discussed in Section 3. Section 4 concludes the paper with references at the end.

2- IoT Architecture

IoT Architecture can be divided into three layers Perception, Network and Application. As shown in Fig.1, perception layer (also called as recognition layer) gathers data or information and identifies the physical world. Network layer is the middle one (also called as wireless sensor networks), which accountable for the initial processing of data, broadcasting of data, assortment and polymerization. The topmost application layer offers these overhauls for all industries. Among these layers, the middle one network layer is also a "Central Nervous System" that takes care of global services in the IoT, since it acts the part of aggregating with upward application layer and makes the link downward of perceptual layer. Fig. 3.a. Architecture of Internet of things [34]. Various basic networks including, mobile/ private network, wireless and wired network offers and affirms the underlying connection. IoT are set up in this new network which is composed Business applications of networks [33]. Regarding the IOT Protocol Stack, as shown in the Fig 3.b, from a PHY perspective, the current IEEE 802.15.4-2006 PHY layer(s) suffice in terms of energy efficiency. Given that a large amount of IoT applications however will require only a few bits to be send. It may be advisable to commence looking into



IoT architecture model

3- Internet of Things Research Agenda

The future of IoT architecture faces a series of important technical challenges need an effort from the researchers in many scientific fields here are some research agenda that facilitate IoT technologies:

I-Identity Management (IDM)
The architecture of IoT in many fields faces tedious technical challenges, This includes the management of unique identities for physical objects and devices, and handling of multiple identifiers for people and locations and possible cross-referencing among different identifiers for the same entity

and with associated authentication credentials [16]. The IoT will include a very large number of nodes, each of which will produce content that should be retrievable by any authorized user. further research for IoT Identification technology is needed in the development, convergence and interoperability of technologies for identification and authentication that can operate at a global scale. Also, new effective addressing policies mobility management are required and frameworks are needed for reliable and consistent encoding and decoding of identifiers.

II- Internet of Things Architecture Technology

An open architecture is required for The IoT to increase interoperability among heterogeneous systems and distributed resources like providers and consumers of information and services, whether they be human beings, software, smart objects or devices. Wireless Sensor Network (WSN) is a dominant technology of IoT [17]. The WSN is named the Ubiquitous Sensor Networks (USN), when it is integrated in an application system of IoT [18]. IoT architecture should consist of well-defined abstract data models, interfaces and protocols, together with concrete bindings to neutral technologies (such as XML, web services etc.). Further research for IoT architecture technology is needed in the development of sensors network technology, data models, interfaces and protocols to adopt the requirement of the USN architecture.

III- Communication Technology

The Internet Architecture Board (IAB) introduced a guiding architectural document for networking of smart objects [20] which outlines a framework of four common communication models used by IoT devices these models are device-to-device communication which is used in applications like home automation systems,, Device-to-Cloud Communications, Device-to-Cloud Communications and back-End Data-Sharing Model [19]. The potential quantity of interconnected links between the devices in IoT may need new researcher consideration for existing tools, methods, and strategies associated with IoT security [21].

IV- Network Technology

The architecture of the Internet of Things needs to build on a network structure that integrates wired and wireless technologies in a transparent and seamless way. IoT Network users will be humans, machines, things and groups of them. The research will focus on understand the complexity of these future networks and the expected growth of complexity due to the growth of Internet of Things to give guidelines and timelines for defining the requirements for the functions, management, growth and variability of the network [22]. Based on the research of the growing network complexity, caused by the Internet of Things, predictions of traffic and load models will have to guide further research on unfolding the predicted complexity to real networks, their standards and on-going implementations. Research is needed on Networks exploiting, Scalable communication infrastructure, Power aware networks, Adaptability and resolvability to heterogeneous environments, Solutions to effectively support mobility of billions of smart things, Solutions to effectively support connectivity and Cross-cutting challenge covering Network foundation [23].

V- Software, Services and Algorithms

The challenging design of large-scale IoT systems need software, services and algorithms to be developed. Such systems need to cope with the large number of heterogeneous components involved and with the complex iterations among devices introduced by cooperative and distributed approaches. One of challenges in building IoT applications lies in the lack of a common software fabric underlying how the software in the different environments can be combined to function into a composite system and how to build a coherent application out of a large collection of unrelated software modules [24]. One of challenges in building IoT applications lies in the lack of a common software fabric underlying how the software in the different environments can be combined to function into a composite system and how to build a coherent application out of a large collection of unrelated software modules.
software, services and algorithms to be addressed in IoT as stated in [22]:

1. Open middleware platforms
2. Energy efficient micro operating systems
3. Distributed self-adaptive software for self-optimization, self-configuration, self-healing (e.g. autonomic)
4. Lightweight and open middleware based on interacting components/modules abstracting resource and network functions;
5. Bio-inspired algorithms (e.g. self-organization) and game theory (to overcome the risks of tragedy of commons and reaction to malicious nodes)

6. Self-management techniques to overcome increasing complexities
7. Password distribution mechanisms for increased security and privacy
8. Energy-aware operating systems and implementation.

VI- Cloud Computing

The current and future Internet is expected to be affected by a novel IT paradigm in which Cloud and IoT are merged together [26, 25]. The Internet of Things will be the biggest consumer of cloud computing because it the future Internet. IoT involves by definition a large amount of information sources (i.e., the things), which produce a huge amount of non-structured or semi-structured data [28] having the three characteristics typical of Big Data [27]: volume (i.e., data size), variety (i.e., data types), and velocity (i.e., data generation frequency). Cloud computing facing research challenges that affect enterprise users, such as cost evaluations, legal issues, trust, privacy, security, and the effects of cloud computing on the work of IT departments [29].

VII- Hardware

To service the communication demands of potentially tens of billions of hardware devices for IoT, researches will be focus on three main trends [30]:

1. Ultra low cost tags with very limited features.
2. Low cost tags with enhanced features such as extra memory and sensing capabilities.
3. Smart fixed/mobile tags and embedded systems.

Smart devices enhanced with inter-device communication will result in smart systems with much higher degrees of intelligence and autonomy. This will enable the more rapid deployment of smart systems for IoT applications and creation of new services.

IIX-Discovery and Search Engine Technologies

There are two type of discovery in IoT Service discovery (SD) is a procedure used by a client to learn about the endpoints exposed by a server. A service is discovered by a client by learning the uniform resource identifier (URI) [31] that references a resource in the server namespace. A Resource Directory (RD) [32] is a network element hosting the description of resources held on other servers, allowing lookups to be performed for those resources. There are significant challenges in ensuring metadata and semantic tagging of information. It will also be important that terrestrial mapping data is available and cross-referenced with logical locations such as postcodes and place names and that the search and discovery mechanisms are able to handle criteria involving location geometry concepts, such as spatial overlap and separation.

IX- **Security and Privacy Technologies**

security and privacy are probably the most challenging issues in the Internet of Things. The connected smart thing in the IoT which is able to communicate with other smart objects, facing new security and privacy problems. like confidentiality, authenticity, and integrity of data sensed and exchanged by things. Though providing improvements in social efficiency it creates an array of new problems concerning breach of privacy and that information security [35]. The various threats in the security of IoT is as below [36]:

a- Front-end sensors and Equipment
  - Unauthorized access to data
  - Threats to Internet
  - Denial of service attack
  - Attack and privacy analysis of M2M or contract information
  - Attack to availability of M2M or contract information

b- Network
  - Unauthorized access to data
  - Unauthorized access to service
  - Steal or change the communication information
  - Viruses or malware attack
  - Network security

c- Back-end of IS systems
  - Safety management of code resources
  - Replacement of operators

X- **Standardisation**

IoT standards is a requirement, because IoT support interactions among many heterogeneous sources of data and many heterogeneous devices through the use of interfaces and data models to ensure a high degree of interoperability among diverse systems. The standardization bodies are addressing the issue of interoperable protocol stacks and open standards for the IoT. This includes as well expending the HTTP, TCP, IP stack to the IoT-specific protocol stack. This is quite challenging considering the different wireless protocols like ZigBee, RFID, Bluetooth, BACnet 802.15.4e, 6LoWPAN, RPL, CoAP, AMQP and MQTT. Some of these protocols use different transport layers. HTTP relies on the Transmission Control Protocol (TCP) [37].

4- **Conclusion**

In this paper, we presented Internet of Things architecture and research agenda. we identified several open issues related to the research agenda that need to be addressed by research community. In future, research on the IoTs will remain a hot issue, many problems are waiting for researchers to deal with.

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