International Journal of Engineering Research in Computer Science and Engineering (IJERCSE) Vol 2, Issue 1, January 2015

The Next evolution of the Internet... ―Internet of Things‖

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Abstract: In recent years, the term "Internet of Things" has spread rapidly we're entering a new era of computing **technology that many are calling the Internet of Things (IoT). Machine to machine, machine to infrastructure, machine to environment, the Internet of Everything, the Internet of Intelligent Things, intelligent systems call it what you want, but it's happening, and its potential is huge. We see the IoT as billions of smart, connected "things" (a sort of "universal global neural network" in the cloud) that will encompass every aspect of our lives, and its foundation is the intelligence that embedded processing provides. The IoT is comprised of smart machines interacting and communicating with other machines, objects, environments and infrastructures. As a result, huge volumes of data are being generated, and that data is being processed into useful actions that can "command and control" things to make our lives much easier and saferand to reduce our impact on the environment. The creativity of this new era is boundless, with amazing potential to improve our lives. Now consider that IoT represents the next evolution of the Internet, taking a huge leap in its ability to gather, analyze, and distribute data that we can turn into information, knowledge, and, ultimately, wisdom. In this context, IoT becomes immensely important.**

Index Terms **Internet of Things, RFID, smart objects, wireless sensor networks.**

I. INTRODUCTION

The Internet of Things (IoT), sometimes referred to as the Internet of Objects, will change everything including ourselves. This may seem like a bold statement, but consider the impact the Internet already has had on education, communication, business, science, government, and humanity. Clearly, the Internet is one of the most important and powerful creations in all of human history. Internet extends into the real world embracing everyday objects. Physical items are no longer disconnected from the virtual world, but can be controlled remotely and can act as physical access points to Internet services. An Internet of Things makes computing truly ubiquitous this development is opening up huge opportunities for both the economy and individuals. However, it also involves risks and undoubtedly represents an immense technical and social challenge.

The Internet of Things vision is grounded in the belief that the steady advances in microelectronics, communications and information technology we have witnessed in recent years will continue into the estimated future. In fact due to their diminishing size, constantly falling price and declining energy consumption processors, Communications modules and other electronic components are being increasingly integrated into everyday objects today.―Smart‖ objects play a key role in the Internet of Things vision, since embedded communication and information technology would have the potential to revolutionize the utility of these objects. Using sensors, they are able to distinguish their context, and via built-in networking capabilities they would be able to communicate with each other, access Internet services and interact with people.[1] ―Digitally upgrading‖ conventional object in this way enhances their physical function by adding the capabilities of digital objects, thus generating substantial added value. Harbinger of this development are already apparent today more and more devices such as sewing machines, exercise bikes, electric toothbrushes, washing machines, electricity meters and photo- copiers are being ―computerized‖ and equipped with network interfaces.[2]

In other application domains, Internet connectivity of everyday objects can be used to remotely determine their state so that information systems can collect up-to-date information on physical objects and processes. This enables many aspects of the real world to be ―observed‖ at a previously unattained level of detail and at negligible cost. This would not only allow for a better understanding of the underlying processes, but also for more efficient control and management. The ability to react to events in the physical world in an automatic, rapid and informed manner not only opens up new opportunities for dealing with complex or critical situations, but also enables a wide variety of business processes to be optimized.

Basics of IoT

The Internet of Things is new technology that provides technical developments provide capabilities that taken together help to bridge the gap between the virtual and physical world. These capabilities include:

Communication and cooperation: Objects have the ability to network with Internet resources or even with each other, to make use of data and services and update their state. Wireless technologies such as GSM and UMTS, Wi-Fi, Bluetooth, ZigBee and various other wireless networking standards currently under development, particularly those relating to Wireless Personal Area Networks (WPANs), are of primary relevance here.

Identification: Objects are uniquely identifiable. RFID, NFC (Near Field Communication) and optically readable bar codes are examples of technologies with which even passive objects which do not have built-in energy resources can be identified (with the aid of a ―mediator‖ such as an RFID reader or mobile phone).

Addressability: Within an Internet of Things, objects can be located and addressed via discovery, look-up or name services, and hence remotely interrogated or configured.

Actuation: Objects contain actuators to manipulate their environment (for example by converting electrical signals into mechanical movement). Such actuators can be used to remotely control real-world processes via the Internet.

Sensing: Objects collect information about their surroundings with sensors, record it, forward it or react directly to it.

Localization: Smart things are aware of their physical location, or can be lo- cated. GPS or the mobile phone network are suitable technologies to achieve this, as well as ultrasound time measurements, UWB (Ultra-Wide Band), radio beacons (e.g. neighboring WLAN base stations or RFID readers with known coordinates) and optical technologies.

Embedded information processing: Smart objects feature a processor or micro- controller, plus storage capacity. These resources can be used, for example, to process and interpret sensor information, or to give products a ―memory‖ of how they have been used.

User interfaces: Smart objects can communicate with people in an appropriate manner (either directly or indirectly, for example via a Smartphone). Innovative interaction paradigms are relevant here, such as tangible user interfaces, flexible polymer-based displays and voice, image or gesture recognition methods.

Most specific applications only need a subset of these capabilities, particularly since implementing all of them is often expensive and requires significant technical effort. Logistics applications, for example, are currently concentrating on the approximate localization (i.e. the position of the last read point) and relatively low cost identification of objects using RFID or bar codes.[3] Sensor data or embedded processors are limited to those logistics applications where such information is essential such as the temperature controlled transport of vaccines.

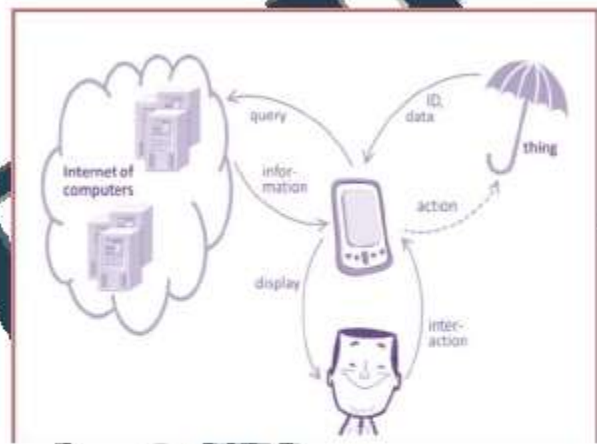

Figure1. The smart-phone as a mediator between people, things and the Internet.

But these days wireless communications modules are becoming smaller and cheaper, IPv6 is progressively more being used, the capacity of flash memory chips is growing, the per-instruction energy requirements of processors continues to fall and mobile phones have built-in bar code recognition, NFC and touch screens and can take on the role of intermediaries between people, everyday items and the Internet (see Figure 1). All this contributes to the evolution of the Internet of Things paradigm: From the remote identification of objects and an Internet ―with‖ things, we are moving towards a system where (more or less) smart objects actually communicate with users, Internet services and even among each other. These new capabilities that things offer open up delightful prospects and interesting application possibilities; but they are also accompanied by adequate requirements relating to the underlying technology and infrastructure. In fact, the infrastructure for an Internet of Things must not only be efficient, scalable, reliable, secure and trustworthy, but it must also conform to general social and political expectations, be widely applicable and must take economic considerations into account.

IoT as a Network of Networks

The Internet of Things (IoT) is defined in different ways, and it encompasses many aspects of life—from connected homes and cities to connected cars and roads to devices that track an individual‘s behavior and use the data collected for ―push‖ services. Some mention one trillion Internet-connected devices by 2025 and define mobile phones as the ―eyes and ears‖ of the applications connecting all of those connected ―things.‖ Depending on the situation Currently, IoT is made up of a loose collection of disparate, purpose-built networks. Today's cars, for example, have multiple networks to control engine function, safety features, communications systems, and so on. Commercial and residential buildings also have various control systems for heating, venting, and air conditioning (HVAC); telephone service; security; and lighting. As IoT evolves, these networks, and many others, will be connected with added security, analytics, and management capabilities (see Figure). This will allow IoT to become even more powerful in what it can help people achieve.

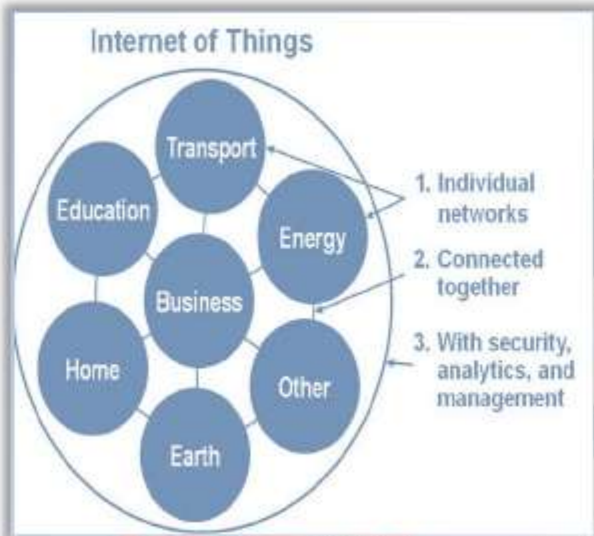

Figure 2. IoT Can Be Viewed as a Network of Networks

Cloud based Internet of Things

The vision of IoT can be seen from two perspectives _Internet' centric and _Thing' centric. The Internet centric architecture will involve internet services being the main focus while data is contributed by the objects. In the object centric architecture the smart objects take the center stage. An Internet centric approach a conceptual framework integrating the ubiquitous sensing devices and the applications is shown in Fig 3. In order to realize the full potential of cloud computing as well as ubiquitous sensing, a combined framework with a cloud at the center seems to be most viable. This not only gives the flexibility of dividing associated costs in the most logical manner but is also highly scalable. Sensing service providers can join the network and offer their data using a storage cloud; analytic tool developers can provide their software tools; artificial intelligence experts can provide their data mining and machine learning tools useful in converting information to knowledge and finally computer graphics designers can offer a variety of visualization tools. Cloud computing can offer these services as Infrastructures, Platforms or Software where the full potential of human creativity can be tapped using them as services.

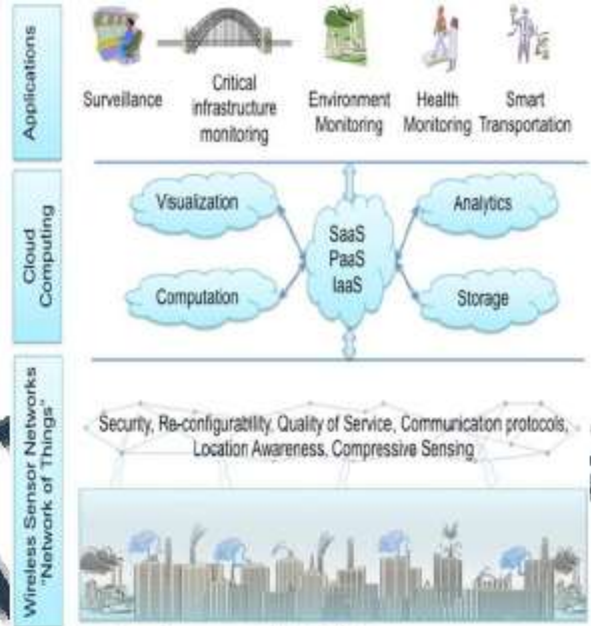

Figure 3. Cloud based Internet of Things

The data generated, tools used and the visualization created disappears into the background, tapping the full potential of the Internet of Things in various application domains. As can be seen from Fig. 3, the Cloud integrates all ends of ubiquitous computing (ubicomp) by providing scalable storage, computation time and other tools to build new businesses. In this section, the cloud platform to demonstrate how cloud integrates storage, computation and visualization paradigms and introduce an important realm of interaction between clouds.

APPLICATIONS

There are several application domains which will be impacted by the emerging Internet of Things. The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact. We categorize the applications into four application domains: (1) Per- sonal and Home; (2) Enterprise; (3) Utilities; and (4) Mobile. There is a huge crossover in applications and the use of data between domains. For instance, the Personal and Home IoT produces electricity usage data in the house and makes it available to the electricity (utility) company which can in turn optimize the supply and demand in the Utility IoT. The internet enables sharing of data between different service providers in a seamless manner creating multiple business opportunities. A few typical applications in each domain are given.

Personal and home: The sensor information collected is used only by the individuals who directly own the network. Usually WiFi is used as the back- bone enabling higher bandwidth data (video) transfer as well as higher sampling rates (Sound).Ubiquitous healthcare has been envisioned for the past two decades.[4] IoT gives a perfect platform to realize this vision using body area sensors and IoT back end to upload the data to servers. For instance, a Smartphone can be used for communication along with several interfaces like Bluetooth for interfacing sensors measuring physiological parameters. So far, there are several applications available for Apple iOS, Google Android and Windows Phone operating systems that measure various parameters. However, it is yet to be centralized in the cloud for general physicians to access the same.

Control of home equipment such as air conditioners, refrigerators, washing machines etc., will allow better home and energy management. This will see consumers become involved in the IoT revolution in the same manner as the Internet revolution itself. Social networking is set to undergo another transformation with billions of interconnected objects. An interesting development will be using a Twitter like concept where individual _Things‘ in the house can periodically tweet the readings which can be easily followed from anywhere creating a Tweet. Although this provides a common framework using cloud for information access

Enterprise: We refer to the _Network of Things‘ within a work environment as an enterprise based application. Information collected from such networks is used only by the owners and the data may be released selectively. Environmental monitoring is the first common application which is implemented to keep track of the number of occupants and manage the utilities within the building. Sensors have always been an integral part of the factory setup for security, automation, climate control, etc. This will eventually be replaced by a wireless system giving the flexibility to make changes to the setup whenever required. This is nothing but an IoT subnet dedicated to factory maintenance. One of the major IoT application areas that is already drawing attention is Smart Environment IoT [5]. There are several test beds being implemented and many more planned in the coming years.

Utilities: The information from the networks in this application domain is usually for service optimization rather than consumer consumption. It is already being used by utility companies (smart meter by electricity supply companies) for resource management in order to optimize cost vs. profit. These are made up of very extensive networks (usually laid out by large organization on a regional and national scale) for monitoring critical utilities and efficient resource management. The backbone network used can vary between cellular, Wi-Fi and satellite communication.[6]

Smart grid and smart metering is another potential IoT application which is being implemented around the world [38]. Efficient energy consumption can be achieved by continuously monitoring every electricity point within a house and using this information to modify the way electricity is consumed. This information at the city scale is used for maintaining the load balance within the grid ensuring high quality of service.

Water network monitoring and quality assurance of drinking water is another critical application that is being addressed using IoT. Sensors measuring critical water parameters are installed at important locations in order to ensure high supply quality. This avoids accidental contamination among storm water drains, drinking water and sewage disposal. The same network can be extended to monitor irrigation in agricultural land. The network is also extended for monitoring soil parameters which allows informed decision making concerning agriculture [12].

Mobile: Smart transportation and smart logistics are placed in a separate domain due to the nature of data sharing and backbone implementation required. Urban traffic is the main contributor to traffic noise pollution and a major contributor to urban air quality degradation and greenhouse gas emissions. Traffic congestion directly imposes significant costs on economic and social activities in most cities. Supply chain efficiencies and productivity. The transport IoT will enable the use of large scale WSNs for online monitoring of travel times, origin destination route choice behavior, queue lengths and air pollutant and noise emissions. The IoT is likely to replace the traffic information provided by the existing sensor networks of inductive loop vehicle detectors employed at the intersections of existing traffic control systems.[7]

The prevalence of Bluetooth technology (BT) devices reflects the current IoT penetration in a number of digital products such as mobile phones, car hands-free sets, navigation systems, etc. BT devices emit signals with a unique Media Access Identification (MAC-ID) number that can be read by BT sensors within the coverage area. Readers placed at different locations can be used to identify the movement of the devices. Complemented by other data sources such as traffic signals, or bus GPS, research problems that can be addressed include vehicle travel time on motorways and arterial streets, There are many privacy concerns by such usages and digital forgetting is an emerging domain of research in IoT where privacy is a concern [8,9].Another important application in mobile IoT domain is efficient logistics management. This includes monitoring the items being transported as well as efficient transportation planning. The monitoring of items is carried out more locally, say, within a truck replicating enterprise domain but transport planning is carried out using a large scale IoT network [10].

Open Challenges of IoT

The challenges include IoT specific challenges such as privacy, participatory sensing, data analytics, GIS based visualization and Cloud computing apart from the standard WSN challenges including architecture, energy efficiency, security, protocols, and Quality of Service. The end goal is to have Plug n‘ Play smart objects which can be deployed in any environment with an interoperable backbone allowing them to blend with other smart objects around them. Standardization of frequency bands and protocols plays a pivotal role in accomplishing this goal. A roadmap of key developments in IoT research in the context of pervasive applications in which includes the technology drivers and key application outcomes expected in the next decade [11]. The section ends with a few international initiatives in the domain which could play a vital role in the success of this rapidly emerging technology.

CONCLUSION

Internet of Things activities are gathering momentum around the world, with numerous initiatives underway across industry, academia and various levels of government, as key stakeholders seek to map a way forward for the coordinated realization of this technological evolution. The large number of devices with communicating actuating capabilities is bringing closer the vision of an Internet of Things, where the sensing and actuation functions seamlessly blend into the background and new capabilities are made possible through access of rich new information sources. The evolution of the next generation mobile system will depend on the creativity of the users in designing new applications. IoT is an ideal emerging technology to influence this domain by providing new evolving data and the required computational resources for creating revolutionary apps. The consolidation of international initiatives is quite clearly accelerating progress towards an IoT, providing an overarching view for the integration and functional elements that can deliver an operational IoT.

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