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Analysis on Internet of Things and Its Application

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ABSTRACT

This paper studies the state-of-art of Internet of Things (IoT). By enabling new forms of communication between people and things, and between things themselves, IoT would add a new dimension to the world of information and communication just as Internet once did. In this paper, IoT definitions from different perspective in academic communities are described and compared. The main enabling technologies in IoT are summarized such like RFID systems, sensor networks, and intelligence in smart objects, etc. The effects of their potential applications are reviewed. Finally the major research issues remaining open for academic communities are analysed.

Keywords: Internet of Things, RFID

I. INTRODUCTION

This IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired Internet connections. These sensors can use various types of local area connections such as RFID, NFC, Wi-Fi, Bluetooth, and Zigbee. Sensors can also have wide area connectivity such as GSM, GPRS, 3G, and LTE. The Internet of Things will:

A. Connect Both Inanimate and Living Things

Early trials and deployments of Internet of Things networks began with connecting industrial equipment. Today, the vision of IoT has expanded to connect everything from industrial equipment to everyday objects. The types of items range from gas turbines to automobiles to utility meters. It can also include living organisms such as plants, farm animals and people. For example, the Cow Tracking Project in Essex uses data collected from radio positioning tags to monitor cows for illness and track behavior in the herd.

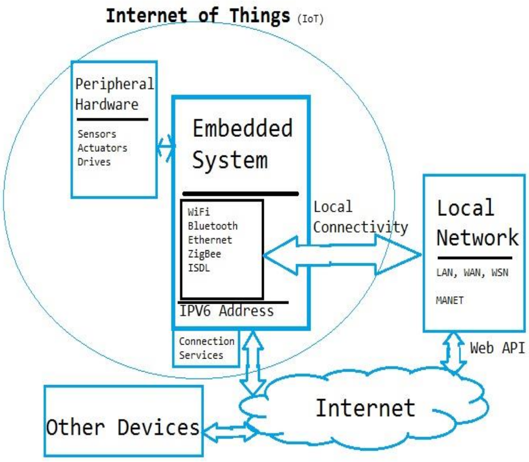

Figure1. Architecture of IOT

Wearable computing and digital health devices, such as Nike+ Fuel band and Fitbit, are examples of how people are connecting in the Internet of Things landscape.

Cisco has expanded the definition of IoT to the Internet of Everything (IoE), which includes people, places, objects and things. Basically anything you can attach a sensor and connectivity to can participate in the new connected ecosystems.

B. Use Sensors for Data Collection

The physical objects that are being connected will possess one or more sensors. Each sensor will monitor a specific condition such as location, vibration, motion and temperature. In IoT, these sensors will connect to each other and to systems that can understand or present information from the sensor's data feeds. These sensors will provide new information to a company's systems and to people.

C. Change what types of item communicate over an IP Network

In the past, people communicated with people and with machines. Imagine if all of your equipment had the ability to communicate. What would it tell you? IoT-enabled objects will share information about their condition and the surrounding environment with people, software systems and other machines. This information can be shared in realtime or collected and shared at defined intervals. Going forward, everything will have a digital identity and connectivity, which means you can identify, track and communicate with objects. IoT data differs from traditional computing. The data can be small in size and frequent in transmission. The numbers of devices, or nodes, which are connecting to the network are also greater in IoT than in traditional PC computing. Machine-to-Machine communications and intelligence drawn from the devices and the network will allow businesses to automate certain basic tasks without depending on central or cloud based applications and services. These attributes present opportunities to collect a wide range of data but also provide challenges in terms of designing the appropriate data networking and security.

D. IoT Elements

Radio Frequency Identification (RFID): This technology is used in embedded communication, for designing of microchips for wireless data communication.

Wireless Sensor Networks (WSN): These are efficient, low cost, low power devices useful in remote sensing applications.

Addressing Schemes: Addressing schemes are useful to uniquely identify the "Things" i.e. smart objects.

Data Storage and analytics: IoT deals with sharing and storing of large amount of data. The data have to be stored and used intelligently for smart monitoring and actuation.

Visualization: This allows interaction of the user with the environment. Extraction of meaningful information from raw data is non-trivial.

Benefits

Three major benefits of IOT that will impact every business, which include: communication, control and cost savings.

E. The Three Cs of IoT

Communication

IoT communicates information to people and systems, such as state and health of equipment (e.g.it's on or off, charged, full or empty) and data from sensors that can monitor a person's vital signs. In most cases, we didn't have access to this information before or it was collected manually and infrequently. For example, an IOT-enabled HVAC system can report if its air filter is clean and functioning properly. Almost every company has a class of assets it could track. GPS-enabled assets can communicate their current location and movement. Location is important for items that move, such as trucks, but it's also applicable for locating items and people within an organization. In the healthcare industry, IoT can help a hospital track the location of everything from wheelchairs to cardiac defibrillators to surgeons. In the transportation industry, a business can deliver real-time tracking and condition of parcels and pallets. For example, Maersk can use sensors to track the location of a refrigerated shipping container and its current temperature.

Control and Automation

In a connected world, a business will have visibility into a device's condition. In many cases, a business or consumer will also be able to remotely control a device. For example, a business can remotely turn on or shut down a specific piece of equipment or adjust the temperature in a climate-controlled environment. Meanwhile, a consumer can use IoT to unlock their car or start the washing machine. Once a performance baseline has been established, a process can send alerts for anomalies and possibly deliver an automated response. For example, if the brake pads on a truck are about to fail, it can prompt the company to take the vehicle out of service and automatically schedule maintenance.

Cost Savings

Many companies will adopt IoT to save money. Measurement provides actual performance data and equipment health, instead of just estimates. Businesses, particularly industrial companies, lose money when equipment fails. With new sensor information, IoT can help a company save money by minimizing equipment failure and allowing the business to perform planned maintenance. Sensors can also measuring items, such as driving behavior and speed, to reduce fuel expense and wear and tear on consumables. New smart meters in homes and businesses can also provide data that helps people understand energy consumption and opportunities for cost savings.

II. APPLCATIONS

An overview of some of the most prominent application areas is provided here. Based on the application domain, IoT products can be classified broadly into five different categories: smart wearable, smart home, smart city, smart environment, and smart enterprise. The IoT products and solutions in each of these markets have different characteristics.

A. Media

In order to hone the manner in which the Internet of Things (IoT), the Media and Big Data are interconnected, it is first necessary to provide some context into the mechanism used for media process. It has been suggested by Nick Couldry and Joseph Turow that Practitioners in Media approach Big Data as many actionable points of information about millions of individuals. The industry appears to be moving away from the traditional approach of using specific media environments such as newspapers, magazines, or television shows and instead tap into consumers with technologies that reach targeted people at optimal times in optimal locations. The ultimate aim is of course to serve, or convey, a message or content that is (statistically speaking) in line with the consumer's mindset. For example, publishing environments are increasingly tailoring messages (advertisements) and content (articles) to appeal to consumers that have been exclusively gleaned through various data-mining activities.

The media industries process big data in a dual, interconnected manner:

- Targeting of consumers (for advertising by marketers)
- Data-capture

Thus, the internet of things creates an opportunity to measure, collect and analyse an ever-increasing variety of behavioural statistics. Cross-correlation of this data could revolutionise the targeted marketing of products and services. For example, as noted by Danny Meadows-Klue, the combination of analytics for conversion racking with behavioural has unlocked a new level of precision that enables display advertising to be focused on the devices of people with relevant interests. Big Data and the IoT work in conjunction. From a media perspective, Data is the key derivative of device inters connectivity, whilst being pivotal in allowing clearer accuracy in targeting. The Internet of Things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness.[61] The wealth of data generated by this industry (i.e. big data) will allow Practitioners in Advertising and Media to gain an elaborate layer on the present targeting mechanisms used by the industry.

B. Environmental monitoring

Environmental monitoring applications of the IoT typically use sensors to assist in environmental protection by monitoring air or water quality, atmospheric or soil conditions, and can even include areas like monitoring the movements of wildlife and their habitats. Development of resource constrained devices connected to the Internet also means that other applications like earthquake or tsunami early-warning systems can also be used by emergency services to provide more effective aid. IoT devices in this application typically span a large geographic area and can also be mobile. It has been argued that the standardization IoT brings to wireless sensing will revolutionize this area.

C. Infrastructure Management

Monitoring and controlling operations of urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IoT. The IoT infrastructure can be used for monitoring any events or changes in structural conditions that can compromise safety and increase risk. It can also be used for scheduling repair and maintenance activities in an efficient manner, by coordinating tasks between different service providers and users of these facilities. IoT devices can also be used to control critical infrastructure like bridges to provide access to ships. Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas. Even areas such as waste management can benefit from automation and optimization that could be brought in by the IoT.

D. Manufacturing

Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IoT within the realm on industrial applications and smart manufacturing as well. The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together.

Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IoT. But it also extends itself to asset management via predictive maintenance, statistical evaluation, and measurements to maximize reliability. Smart industrial management systems can also be integrated with the Smart Grid, thereby enabling real-time energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by a large number of networked sensors.

National Science Foundation established an Industry/University Cooperative Research Center on Intelligent Maintenance Systems (IMS) in 2001 with a research focus to use IoT-based predictive analytics technologies to monitor connected machines and to predict machine degradation, and further to prevent potential failures. The vision to achieve near-zero breakdown using IoT-based predictive analytics led the future development of e-manufacturing and e-maintenance activities.

The term IIOT (Industrial Internet of Things) is often encountered in the manufacturing industries, referring to the industrial subset of the IoT. IIoT in manufacturing would probably generate so much business value that it will eventually lead to the fourth industrial revolution, so the so-called Industry 4.0. It is estimated that in the future, successful companies will be able to increase their revenue through Internet of Things by creating new business models and improve productivity, exploit analytics for innovation, and transform workforce. The potential of growth by implementing IIoT will generate $12 trillion of global GDP by 2030.

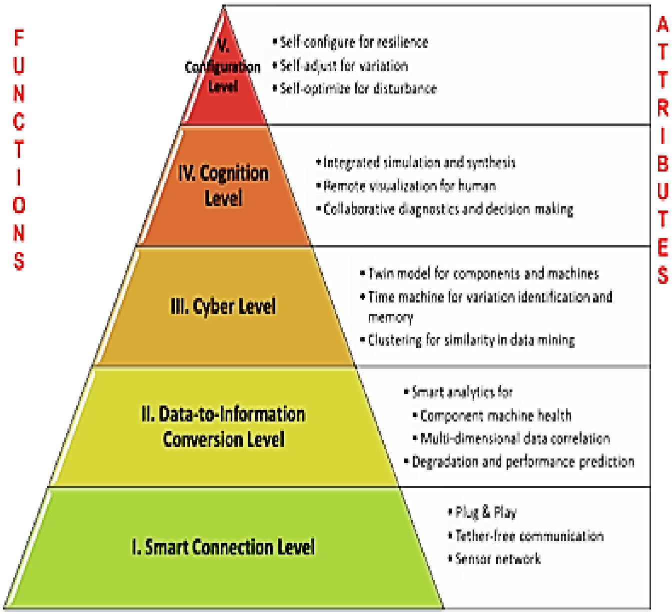

Figure 2. Pyramid of IOT functions

E. Design architecture of cyber-physical systems-enabled manufacturing system

While connectivity and data acquisition are imperative for IIoT, they should be the foundation and path to something bigger but not the purpose. Among all the technologies, predictive maintenance is probably a relatively "easier win" since it is applicable to existing assets and management systems. The objective of intelligent maintenance systems is to reduce unexpected downtime and increase productivity. And to realize that alone would generate around up to 30% over total maintenance costs. Industrial Big Data analytics will play a vital role in manufacturing asset predictive maintenance, although that is not the only capability ofIndustrial Big Data. Cyber-physical systems (CPS) are the core technology of Industrial Big Data and it is will be an interface between human and the cyber world. Cyber-physical systems can be designed by following the "5C" (Connection, Conversion, Cyber, Cognition, and Configuration) architecture and it will transform the collected data into actionable information, and eventually interfere with the physical assets to optimize processes.

An IIoT-enabled intelligent system of such cases has been demonstrated by the NSF Industry/University Collaborative Research Center for Intelligent Maintenance Systems (IMS) at University of Cincinnati on a band saw machine in IMTS 2014 in Chicago. Band saw machines are not necessarily expensive, but the band saw belt expenses are enormous since they degrade much faster. However, without sensing and intelligent analytics, it can be only determined by experience when the band saw belt will actually break. The developed prognostics system will be able to recognize and monitor the degradation of band saw belts even if the condition is changing, so that users will know in near real time when is the best time to replace band saw. This will significantly improve user experience and operator safety, and save costs on replacing band saw belts before they actually break. The developed analytical algorithm was realized on a cloud server, and was made accessible via the Internet and on mobile devices.

F. Energy management

Integration of sensing and actuation systems, connected to the Internet, is likely to optimize energy consumption as a whole. It is expected that IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage. Such devices would also offer the opportunity for users to remotely control their devices, or centrally manage them via a cloud based interface, and enable advanced functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.). In fact, a few systems that allow remote control of electric outlets are already available in the market, e.g., Belkin's WeMo, Ambery Remote Power Switch, Budderfly, Telkonet's EcoGuard, WhizNets Inc., etc.

Besides home based energy management, the IoT is especially relevant to the Smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. Using Advanced Metering Infrastructure (AMI) devices connected to the Internet backbone, electric utilities can not only collect data from end-user connections, but also manage other distribution automation devices like transformers and reclosers.

G. Medical and Healthcare Systems

IoT devices can be used to enable remote health monitoring and emergency notification systems. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers or advanced hearing aids. Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well. Other consumer devices to encourage healthy living, such as, connected scales or wearable heart monitors, are also a possibility with the IoT. More and more end-to-end health monitoring IoT platforms are coming up for antenatal and chronic patients, helping one manage health vitals and recurring medication requirements.

H. Building and home automation

IoT devices can be used to monitor and control the mechanical, electrical and electronic systems used in various types of buildings (e.g., public and private, industrial, institutions, or residential) in home automation and building automation systems.

I. Transportation

Figure 3. Digital Variable Speed-Limit Sign

The IoT can assist in integration of communications, control, and information processing across various transportation systems. Application of the IoT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user). Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistic and fleet management, vehicle control, and safety and road assistance.

J. Large scale deployments

There are several planned or ongoing large-scale deployments of the IoT, to enable better management of cities and systems. For example, Songdo, South Korea, the first of its kind fully equipped and wired smart city, is near completion. Nearly everything in this city is planned to be wired, connected and turned into a constant stream of data that would be monitored and analyzed by an array of computers with little, or no human intervention.

Another application is a currently undergoing project in Santander, Spain. For this deployment, two approaches have been adopted. This city of 180,000 inhabitants, has already seen 18,000 city application downloads for their smart phones. This application is connected to 10,000 sensors that enable services like parking search, environmental monitoring, digital city agenda among others. City context information is used in this deployment so as to benefit merchants through a spark deals mechanism based on city behavior that aims at maximizing the impact of each notification.

Other examples of large-scale deployments underway include the Sino-Singapore Guangzhou Knowledge City; work on improving air and water quality, reducing noise pollution, and increasing transportation efficiency in San Jose, California; and smart traffic management in western Singapore. French company, Sigfox, commenced building an ultra-narrowband wireless data network in the San Francisco Bay Area in 2014, the first business to achieve such a deployment in the U.S. It subsequently announced it would set up a total of 4000 base stations to cover a total of 30 cities in the U.S. by the end of the 2016, making it the largest IoT network coverage provider in the country thus far.

Another example of a large deployment is the one completed by New York Waterways in New York City to connect all their vessels and being able to monitor them live 24/7. The network was designed and engineered by Fluidmesh Networks, a Chicago-based company developing wireless networks for critical applications. The NYWW network is currently providing coverage on the Hudson River, East River, and Upper New York Bay. With the wireless network in place, NY Waterway is able to take control of its fleet and passengers in a way that was not previously possible. New applications can include security, energy and fleet management, digital signage, public Wi-Fi, paperless ticketing and others.

K. Disaster Alerting & Recovery

Recently, natural disasters (flood, landslide, forest fire, etc.) and accidental disasters (coal mine accident, etc.) are taking place more and more frequently. Technologies in IoT, such like RFID and WSN could play a crucial role in disaster alerting before it happens, and disaster recovery after it ends. In order to lessen the effects of natural disasters such like flood, landslide or forest fire, it is necessary to anticipate its occurrence and to alert in time. The timely access to relevant information on hazardous environmental conditions gives residents in the nearing area time to apply preparedness procedures, alleviating the damage and reducing the number of casualties derived from the event. WSN enables the acquisition, processing and transmission of environmental data from the location where disasters originate to potentially threatened cities. Then this information could be used for authorities to rapidly assess critical situations and to organize resources [23]. As to accident disaster recovery, for example, after a coal mine accident occurs, instant tracking and positioning of trapped workers using RFID technologies could provide timely rescue and lessen casualties and economic loss to the largest extent. Knowing trapped workers' geographic distribution and comparatively accurate position, the rescue action would be more targeting thus is time-efficient. Apart from the above applications, many others could be described as futuristic since they rely on some (communications, sensing, material and industrial processes) technologies that are still to come or whose implementation is still too complex [5]. The most appealing futuristic applications included robot taxi, city information model and enhanced game room.

III. CHALLENGES

For IoT to achieve its vision, a number of challenges need to be overcome. Recently, many researchers have proposed IoT technology. However, there are still a lot of challenges. In this section, we introduce the challenges of IoT and discuss them in detail. To do this, we classify the challenges of IoT into three major categories of security, data capacity, and application. The first challenge to IoT is security. A number of things in IoT send data to each other using the Internet. That is a security weakness. In particular, many studies about the IoT have proposed the REST protocol. REST has a weakness of security because it does not maintain sessions when data is sent. Therefore, it should resolve the weakness of security to provide IoT services. The second is data capacity. In IoT, many things send data to a web server or another thing. The backbone network for the IoT must support a huge amount of data. To do this, existing web servers must be expanded. In addition, the backbone network for the IoT must be accommodated. Therefore, the Content Centric Network (CCN) technology and big data technology should be used for the IoT. The last is the application of IoT. Recently a number of applications developed for smartphones and tablets. However, they are not related to the Internet of Things. Therefore, we need a variety of applications to realize the IoT. To do this, we should invigorate an ecosystem for the IoT and support a number of application developers.

IV. SECURITY ISSUES IN IOT

A. Access Control

Access control deals with access rights given to the things/devices in IoT environment. In traditional database systems, processing of discrete data are done, however in IoT, processing of flowing data is done. Two terminologies are described for Access Control [8]: 1) data holders (Users), who send/receive data to things. They must send data to authenticated things 2) data collectors (things), which must authenticate users. [9] Presents an identity based system for personal location in emergency situation. Authentication problem for outsourced data stream is found in [10]. Access control of streaming data is specified in [11].

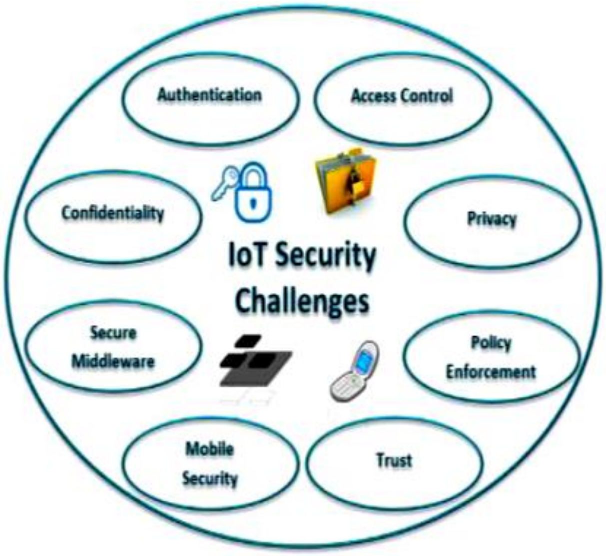

Figure 5. Security in IOT

Some of the challenges related to Access Control in IoT context involve: How to handle the huge amount of transmitted data (i.e., in the form of stream data) in a common recognized representation? How to support the identification of entities?

B. Privacy

A data tagging for managing privacy in IoT is proposed in [12]. A user-controlled privacy-preserved access control protocol, based on k-anonymity privacy model is proposed in [13]. [14] defines k-anonymity model by changing quasi-identifiers to preserve sensitive data. The privacy risk that occurs when astatic domain name is assigned to a specified IoT node is analysed in [15]. Only some of the privacy issues related to IoT are covered in recent work, there is still a large scope to create privacy preserving mechanisms in IoT context.

V. CONCLUSION

In this paper, we survey the state-of-art on the IoT, including the manifold definitions, enabling technologies, already or soon available applications and open research issues with efforts been. However, it is not this paper's main purpose to provide a comprehensive review of the details of the relevant technologies. It is believed that in the near future the achievement of the vision of "from anytime, anyplace connectivity for anyone, we will now have connectivity for anything" should depend on cross-discipline and cooperative efforts in related fields.

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