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Evolving Applications for Internet of Things

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Abstract: The Internet of Things (IoT) is a unique model that uses wireless/wired technologies to connect variety of electronic devices around us to the Internet. From the time concept of IoT was introduced in 2005 till today, numerous IoT applications with new generation of networked smart objects with sensing, communication and actuation capabilities are conceptualized. These applications will revolutionize the techniques we use to interact with homes, offices, factories, farms, retailing, transportation, logistics etc. This paper classifies different application domains of IoT. It then discusses some emerging projects and applications in each of the IoT realm with detailed description of the tools used for the application development. Finally the factors which limit the full exploitation of the IoT are conferred.

Keywords: Internet of Things, Application Realms, Wireless Sensor Networks.

1. INTRODUCTION

The next trend in the age of computing will be outside the realm
of the desktop or laptops or tablets. In the Internet of Things (IoT) model, most of the electronic devices surrounding us will be connected to the Internet. Radio Frequency IDentification (RFID) and wireless sensor network technologies will help us to meet this new challenge. The information and communication systems will be imperceptibly embedded in our environment. This will lead to generation of huge amounts of data which has to be stored, processed and presented in a unified, effectual, and easily understandable form. The model will entail services that are commodities and delivered like traditional commodities. The model is gaining momentum very expeditiously and a lot of projects have been going on to make the aforementioned statement a reality.

The rest of the paper is organized as follows: Section 2 discusses the application realms and present ongoing IoT projects. Section 3 discusses the hurdles in the adoption of IoT. Finally, the paper is concluded in Section 4.

2. APPLICATION REALMS

There are several application realms which will be impacted by the emerging Internet of Things technology. Based on coverage requirement, scalability, heterogeneity, user involvement, node movement we have classified IoT applications into categories like home and

building, transport, logistics, industrial control, retail, environment, agriculture, and health realms. Home applications include automation of daily tasks, security, locating day to day items. Industrial automation application includes monitoring of material flow, downtime analysis, production efficiency. Precision agriculture system can be used to automate the irrigation process and manage agricultural operations remotely.

2.1 Smart Homes

The profiilaration in the use of electronic gadgets like smartphones, tablets, laptops have led to building of personal area networks of these devices at home. This idea is taken further to connect all the electronic devices inside a home. 'OOMI' is one such initiative that provides devices for Home Security, Entertainment, Comfort, and Ambiance [3]. It is built with the next generation Z-Wave [4] and allows easy integration with other 3rd party electronics devices. The heart of the system is the decision-making base station that is located within the house-'Oomi Cube'. It doesnot rely on cloud-based services and hence the system works even when the Internet is not working. The system consist of smart devices like: Oomi-Touch (controller), Cube (hub), Cam (intrusion alarm system), Multiple Sensors (sensors for detecting motion, temperature, ligt, water detection, door and window tracking, air contamination etc.), bulbs, lighting strips, plug, Streamer (multimedia device for T.V.). Nest [5]-[6], a subsidiary of Alphabet Inc. provides similar kind of products. It provides Smart Thermostat for giving input to heat ventilation and air control system. The system sends climate change alerts on the phone and features smart learning to automatically adapt to the climate change depending on the user's lifestyle. Nest Cam is a device that streams every detail from the camera to the phone, intimates when something is wrong, makes monitoring in dark better with night vision led sensors, allows the user to talk and listen through mic and speaker.

Another device is smoke and carbon monoxide detector which detects both fast and slow burning fires with split-spectrum sensors. All these devices are interconnected by a smart home hub called 'works with nest'.

2.2 Smart Civil Infrastructure

With age, the structural health of civil infrastructures like highways, bridges, fly-overs, underground tunnels, subways depreciates leading to breakdown. Further, poorly lit roads and their potholes result in grave accidents. In 1967, the U.S. Highway 35 bridge connecting Point Pleasant, West Virginia and Kanauga, Ohio state in United States of America suddenly collapsed into the Ohio River. At the time of failure, 37 vehicles were crossing the bridge span, and 31 of those fell with the bridge costing lives of 46 people. Among the several reasons of the collapse debated at that time included the presence of hair line cracks that were not monitored, which ultimately led to the disaster. If the bridge structure had been monitored with deployment of sensors, actuators and networking capabilities it would have been more organized, stable and hence safe. In this discourse, Internet of Vehicles (IoV) [7] can raise a host of new features and functionalities. IoV technology refers to dynamic mobile communication systems that provide means for communication between vehicles and public networks (cellular, cable TV and Internet) using V2V (vehicle-to-vehicle), V2R (vehicle-to-road), V2H (vehicle-to-human) and V2S (vehicle-to-sensor) interactions. It enables gathering and sharing of information related to traffic and civil infrastructure monitoring like density of vehicles, conditions of roads, and their environment. More specifically, it gives platform for processing, computing, sharing and secure release of information onto communication entities. The collected data is used by the system to guide and supervise vehicles.

Solar Roadways, an indiegogo project [8] plans to replace roads, pavements, and other outdoor flooring with smart hexagonal solar panels encompassing microprocessors, LEDs and data lines [9]. The proposal suggests replacement of asphalt/concrete surfaces with tempered glass. These smart roadways will keep the surface temperature few degrees above the freezing point, making it ice-free during snowfall. Further, each panel has a series of LEDs which are programmable and can be used to re-define parking lines, road lanes, desired playground layout, and give warning signs. It can warn about weakened driving patterns, pedestrians and animals crossing the road, and improving night visibility. The system supports detours around traffic congestion and arrows can appear on the road for guidance by entering the terminus in the GPS device attached with the vehicle. A similar project in this line is Smart Highway Infrastructure, featuring - Electric Priority Lane, Glowing Lines, and Interactive Lights [10].

2.3 Smart Parking

Internet-connected smart parking at the city of Santander in Spain is a best example of smart parking using IoT [11]. The system consist of ferromagnetic sensor nodes deployed under each bay across the city. These nodes collect parking occupancy data, which is instantly forwarded to drivers and traffic control system through the Internet. Traffic lights and display devices at cross roads display information about empty parking lots. A parking history feature can be added to analyze and determine parking provisions in the city. Further, to tackle traffic congestion; vehicles and pedestrian levels are monitored, thereby suggesting optimal routes for driving and walking.

2.4 Smart Logistics

Present day's demand for real-time status information about all business processes can be addressed with IoT. With the inception of IoT in the field of logistics, numerous promising payoffs would be brought to logistics operators, their business collaborators, and the end users. These would be spread across cargo transportation, value chains, warehouse maneuvers, and last mile transport. Moreover, assets along the supply chain could be analyzed to a better detail to capture new insights. This would lead to improved functioning efficiency, flexibility and will eventually aid in automating the facilities. Accurate details about the real-time location of the goods, its condition and estimated delivery time can be known. The system being connected to smart roads, information about road blockages and traffic statistics would be available beforehand, along with suggestions for the shortest route to the destination. For last mile delivery, IoT can help enhance the collection of parcels or letters from the mailboxes. Postybell is an example of such a mailbox, which has a sensor installed, and sends real-time data to the delivery person [12]. This helps the delivery person to visit only the mailboxes that have parcels/letters. This results in optimization of collection time. SemProM-Semantic Product Memory project [13] has created Smart Labels for products, which can store related information about the product like its environmental requirements and transport information. This can be used by Logistics Company to take appropriate care of the product while handling it.

2.5 Smart Industry

Unique developmental prognoses and modernization are all set to be released by the Industrial Internet of Things (IIoT). According to Accenture, IIoT has the capacity to add $14.2 trillion to the global economy by 2030 [14]. IoT is now shifting the earlier trademark communication standards to open IP standards at production floors. IIoT is facilitating managers with real-time monitoring of essential factory data such like energy consumption, route for material flow, inventory status etc.

To improve equipment lifespan and enhance process visibility monitoring of chemical in tanks, indoor air

quality, temperature, ozone presence (in food factories), equipment wear and tear etc., can be done. This leads to prevention of equipment failures and ultimately the downtime of machines can be reduced. Further for easy location identification active (ZigBee [15], Ultra Wideband [16]) and passive (RFID, Near Field Communications [17]) tagging can be used. Another field of IoT application in the production industry is Preventive Maintenance. For this sensors are deployed at essential locations in the Industry to alert whenever the equipment performance exceeds the safety limits. Continental Tires reduces their waste component costs and increases their production efficiency, by connecting production floors through IoT [18].

2.6 Smart Retail

Retail sector is directly in contact with consumers which are abreast with the latest technology. So retail sector needs to stay up-to-date with the latest technologies to earn the loyalty of the novel generation of consumers. IoT has brought a revolution in the following fields of retail services: (1) Supply chain management, (2) Inventory and warehouse management, (3) Marketing, (4) Customer's in-store experience. This is provided through products enabled with RFID-based sensors [19], automated shelves giving alerts of the quantity and product offerings in the malls [20], smart fulfillment centers, delicate goods tracking, navy operations sustainability monitoring, automated heat, ventilation and air control of store, personalized marketing by proximity-based consumer interaction in the passageway of malls, parking assistance, security, fraud and counterfeiting controls, automated checkouts via smartphone, automated vending machines, connected homes, wearable devices, etc. A wholesome retail experience is the main aim of IoT in retail sector. This widely includes, location based services which remind the customer of the latest trends and offers in the mall when customer passes by it, updating the inventory according to the developments in the area, assisting customers, marketing and increasing sales [21].

2.5 Smart Environment

An intelligent environment monitoring system using IoT can be used to predict natural calamities, collect information on temperature, humidity, light, wind, rainfall, air pollution, glacier displacements etc. Oceanography can tell about coastal deposition and erosion and consequently about flooding and sea defenses. IoT offers a new paradigm for oceanography, to collect spatially distributed data points, by providing a spatially dispersed measurement array. IoT can also be implemented for tracking and monitoring of waste sources, transport vehicles, waste disposal sites, etc. [22].

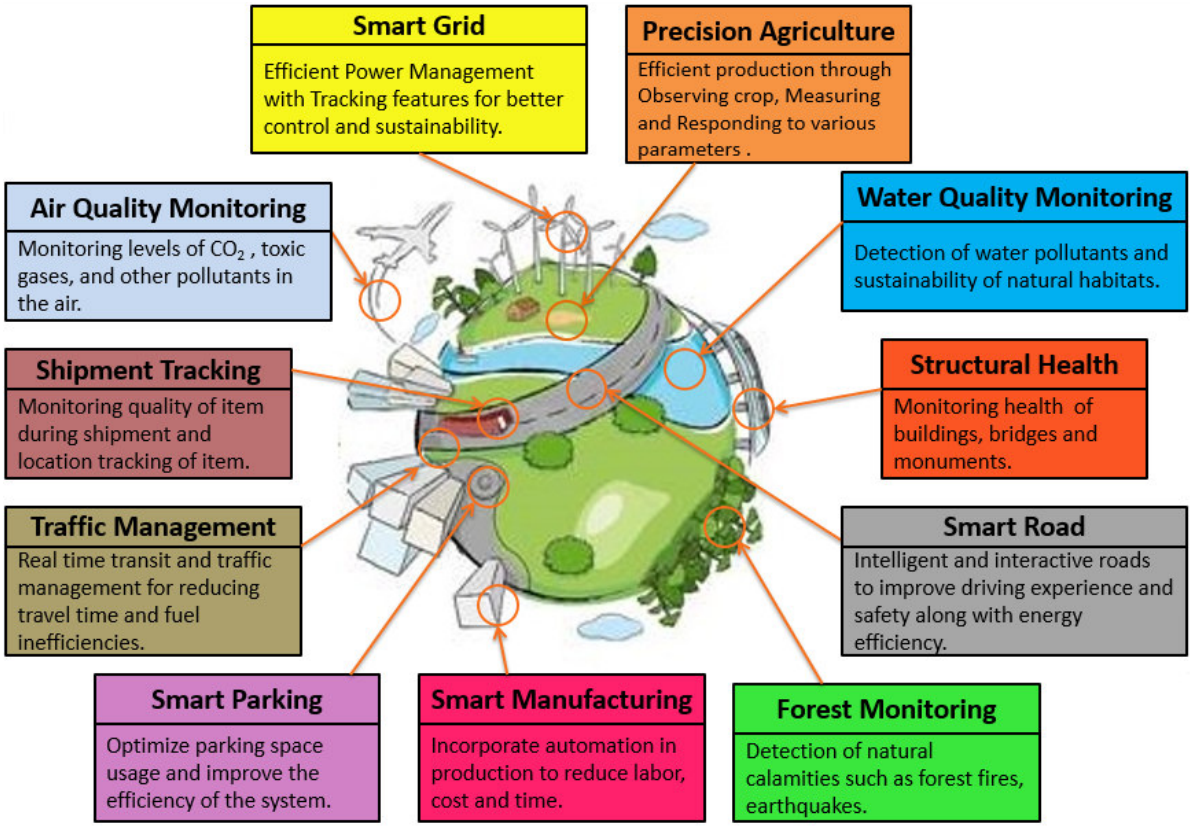

Figure 1. Smart world with IoT

IoT is efficacious in fire detection and prevention applications. One of the applications is this direction is presented in [23]. It proposes array of sensors (temperature, smoke or dust sensors) for detection of a fire. The actuators then sent the alerts to the fire station along with parameters like location/description of area affected by fire, possibility of presence of people and of inflammable materials etc. [23]. The increase in developments in nuclear sector, necessitates affordable radiation meters. One such initiative is the Radiation Sensor Board for Arduino by Libelium, which can measure levels of radiation in everyday life and can be used directly by the citizens. It has open hardware design and publicly available source code [24]. As a part of smart city initiative, Opticits [25], a Barcelona startup created and deployed a City Resilience Management platform that integrates Libelium's Waspmote Plug and Sense [26] sensor nodes and Meshlium gateways [27]. It helps resist and recover from the natural disasters [28].

2.6 Smart Agriculture

Smart agriculture through IoT can assist spatial environment and soil data collection as per the crop requirements for farmers and based on the data collected support irrigation control. The system will be used for Plant/Crop monitoring, Soil Monitoring, Climate Monitoring and Insect-Disease-Weed Monitoring. By using technology such as Geographic Information System (GIS) [29], Remote Sensing (RS), Global Positioning System (GPS), numerous parameters can be measured and monitored, helping farmers to make the right decision. This will increase production, economic benefit and mitigate environmental impact caused by traditional practices. Some more applications include: tracking farm vehicles, livestock monitoring, indoor farming, fish farming, monitoring of water tanks, fuel tanks, and storage house. An IoT and WebGIS [30] based Precision Agriculture Management System (PAMS) was implemented at Hunan, China in an ecology farm [31]. The system consist of a mobile client though which farmers can post real-time data such as images and environmental conditions. The data is analyzed and recommendations on fertilizers, watering cycle etc. is given to the farmer. Other features include video monitoring of the farm, crop production management, remote operation and information publishing with feedback. PAMS is reported to have reduced monitoring time of the farmer and better growth of crops. Work in [32] presents hardware and network architectures, software tools for IoT-based precision irrigation systems for practical implemention. Dolphin Engineering [33], a firm in Switzerland has developed a 'PreDiVine' system which is a Decision Support System monitoring microclimate conditions such as leaf wetness, rainfall, humidity, temperature. Moreover, it predicts the spread of grapevine pests and diseases. The firm implements these functionalities using a wireless sensor network based on Libelium's Waspmote sensor platform [34]. I addition the system offers timely corrective treatment suggestions, needed to keep vineyards in good health and generate more profit. Also, an adaptive web-based management framework makes the system dynamic.

2.7 Smart Health

Human health is very importance as it is a matter of survival for them. IoT technologies help in improving assisted living conditions by monitoring body temperature, breathing rate, blood pressure, pulse rate, blood sugar etc. [35]. Old age people who depend on others for living their normal life can be helped by the implementation of IoT. A comprehensive approach on how to aid people with disabilities and old age is presented in [36]. The vital parameters of body can be collected through wearable or ambient sensors. The data is transmitted to remote medical centers which can monitor the conditions and provide a response when needed. This has been attempted through telemedicine, mHealth [37], Home Health Hub Internet of Things (H3IoT) [38] etc. Wearable sensors can also be used to monitor daily activities to provide personalized health care solutions for better lifestyle and prevention of health problems [39].

To promote developers, Broadcom brings in another smart invention-WICED (Wireless Internet Connectivity for Embedded Devices) [40]. It is a smart development kit with low power Bluetooth Smart, and five MEMS sensors for easy and quick prototyping. It is a cost effective and sets up in about five minutes, enabling devices to team with portable technology like mobile phones. They, in turn, connect to the Internet to transmit and receive data from cloud-based applications. It has a great potential in wearable technology, especially in health and personal care. It facilitates users to constantly monitor and control heart rate, blood glucose and other health parameters from their phones. This information can be uploaded to the cloud in real time so that the data from a single sensor can be accessed by any device at any time.

3. CONCLUSION

Sensors, actuators, and wireless networks have been in existence for long now, but inception of IoT, provides a platform to integrate for smart Internet based applications. End user is at the forefront of all these applications. For development and penetration of these applications in our daily life it is required to design simpler mechanisms for using smart devices, making the hardware and software knowledge available to all, setting up multidisciplinary projects, spreading awareness about the perks of the technology and by stimulating standardization. Applications of IoT extend over a variety of sectors affecting different groups of individuals. Individual challenges in applications do exist which revolve around bottlenecks such as ubiquitous Internet access, requisite apps/OS in devices, Bluetooth and location services

always enabled, loyal customer base, and allocation of funds by the government for upgrading infrastructure. Apart from eliminating these bottlenecks, the main challenge lies in developing a common platform which integrates all sectors of applications and provides the necessary solitariness.

4. REFERENCES

[1] European Research Cluster on the Internet of Things, [Online]. Available: http://www.internet-of-things-research.eu/about_iot.htm

[2] The Internet of Things-Concept and Problem Statement draft-lee-iot-problem-statement-00.txt, [Online]. Available: https://tools.ietf.org/html/draft-lee-iot-problem-statement-00

[3] Oomi Home, [Online]. Available: http://oomihome.com/specs/

[4] Z-wave alliance, [Online]. Available: http://z-wavealliance.org/

[5] Nest Labs, [Online]. Available: https://nest.com/

[6] Nest Labs works with nest, [Online]. Available: https://nest.com/works-with-nest/

[7] "Internet of Vehicles-Your next connection"- Huawei-winwin magazine-by Dr. Liu Nanjie. [Online]. Available: http://www.huawei.com/en/publications/winwin-magazine/11/HW_110848

[8] Solar Roadways Campaign, Indiegogo, [Online]. Available: https://www.indiegogo.com/projects/solar-roadways

[9] Solar Roadways, [Online]. Available: http://www.solarroadways.com/intro.shtml

[10] Studio Roosegaarde, [Online]. Available: https://www.studioroosegaarde.net/project/smart-highway/info/

[11] 'Smart Santander', [Online]. Available: http://www.smartsantander.eu/

[12] Postybell, Postbox sensor, [Online]. Available: http://www.postybell.com/

[13] Semantic Product Memory, [Online]. Available: http://www.semprom.de/semprom_engl/html/overview.html

[14] Industrial Internet of Things Report, Accenture, [Online]. Available: https://www.accenture.com/in-en/insight-industrial-internet-of-things

[15] ZigBee Alliance, [Online]. Available: http://www.zigbee.org/

[16] Ultra Wideband Technology Tutorial, [Online]. Available: http://www.radio-electronics.com/info/wireless/uwb/ultra-wideband-technology.php

[17] Near Field Communication, [Online]. Available: http://www.nearfieldcommunication.org/

[18] IoT in Logistics, DHL trend report, [Online]. Available: http://www.dhl.com/en/about_us/logistics_insights/dhl_trend_research/internet_of_things.html#.Vgoa92vP-AU

[19] Jia, X., Feng, Q., Fan, T., Lei, Q. 2012. RFID technology and its applications in Internet of Things (IoT). In Consumer Electronics, Communications and Networks (CECNet), 2012 2nd International Conference, (April 21-23, 2012), 1282-1285. DOI: 10.1109/CECNet.2012.6201508

[20] Vargheese, R., Dahir, H. 2014. An IoT/IoE enabled architecture framework for precision on shelf availability: Enhancing proactive shopper experience. In Big Data (Big Data), 2014 IEEE International Conference, (October 27-30, 2014), 21-26. DOI: 10.1109/BigData.2014.7004418

[21] Internet of Everything at Work: Retail, Cisco [Online]. Available: http://ioeassessment.cisco.com/see/ioe-work-retail-0

[22] Jing-yang, W., Yu, C., Guang-ping, Y., Ming-zhe, Y. 2014. Research on application of IOT in domestic waste treatment and disposal. In Intelligent Control and Automation (WCICA), 2014 11th World Congress, (June 29, 2014-July 4, 2014), 4742-4745. DOI: 10.1109/WCICA.2014.7053515

[23] Jun, W., Di, Z., Meng, L., Fang, X., Hu-Lin, S., Shu-Feng, Y. 2014. Discussion of Society Fire-Fighting Safety Management Internet of Things Technology System. In Intelligent Systems Design and Engineering Applications (ISDEA), 2014 Fifth International Conference, (June 15-16, 2014), 422-425. DOI: 10.1109/ISDEA.2014.101

[24] Libelium World: Detecting Radiation Levels in Fukushima: an example of crowdsourcing, Case study, [Online]. Available: http://www.libelium.com/fukushima_crowdsourcing_radiation_social_project/

[25] Opticits, [Online]. Available: http://opticits.com/

[26] Libelium Plug sense, [Online]. Available: www.libelium.com/products/plug-sense/

[27] Libelium Meshlium Xtreme, [Online]. Available: http://www.libelium.com/products/meshlium/

[28] Libelium World: Urban Resilience in the Smart City: River Flood and Forest Fire Early Detection, Case study, [Online]. Available: http://www.libelium.com/smart-city-urban-resilience-smart-environment/

[29] Geographical Information System, [Online]. Available: http://gis.nic.in/

[30] WebGIS Geographical Information Systems Resource, [Online]. Available: http://www.webgis.com/

[31] Ye, J., Chen, B., Liu, Q., Fang, Y. 2013. A precision agriculture management system based on Internet of Things and WebGIS. In Geoinformatics

(GEOINFORMATICS), 2013 21st International Conference, (2013), 1-5.

[32] Li, S. 2012. Application of the Internet of Things Technology in Precision Agriculture Irrigation Systems. In Computer Science & Service System (CSSS), 2012 International Conference, (August 11-13, 2012), 1009-1013.

[33] Dolphin Engineering Sagl, [Online]. Available: www.dolphin-engineering.ch

[34] Libelium Agriculture Board Technical Guide, [Online]. Available: http://www.libelium.com/development/waspmote/documentation/agriculture-board-technical-guide/

[35] Istepanian, R.S.H., Hu, S., Philip, N.Y., Sungoor, A. 2011. The potential of Internet of m-health Things "m-IoT" for non-invasive glucose level sensing. In Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE, (August 30, 2011-September 3, 2011), 5264-5266.
DOI: 10.1109/IEMBS.2011.6091302

[36] Domingo, M. C. 2012. An overview of the Internet of Things for people with disabilities. In Journal of Network and Computer Applications, (March 2012), 584-596.
DOI: 10.1016/j.jnca.2011.10.015

[37] Istepanaian, R. S. H., Zhang, Y.-T. 2012. Guest Editorial Introduction to the Special Section: 4G Health- The Long-Term Evolution of m-Health. In IEEE Transactions on Information Technology in Biomedicine, (January 2012), 1-5.
DOI: 10.1109/TITB.2012.2183269

[38] Ray, P.P. 2014. Home Health Hub Internet of Things (H3IoT): An architectural framework for monitoring health of elderly people. In Science Engineering and Management Research (ICSEMR), 2014 International Conference, (November 27-29, 2014), 1-3.
DOI: 10.1109/ICSEMR.2014.7043542

[39] Hiremath, S., Geng, Y., Mankodiya, K. 2014. Wearable Internet of Things: Concept, architectural components and promises for person-centered healthcare. In Wireless Mobile Communication and Healthcare (Mobihealth), 2014 EAI 4th International Conference, (November 03-05, 2014), 304-307.
DOI: 10.1109/MOBIHEALTH.2014.7015971

[40] WICED Sense Bluetooth Smart Sensor tag kit, [Online]. Available: http://www.broadcom.com/products/wireless-connectivity/bluetooth/wiced-sense

[41] The Internet of Things Is Poised to Change Everything, IDC, October 2013, [Online]. Available: http://www.idc.com/getdoc.jsp?containerId=prUS24366813.

[42] "More than 50 Billion Connected Devices," Ericsson, February 2011. [Online]. Available: http://www.ericsson.com/res/docs/whitepapers/wp-50-billions.pdf

[43] "The Internet of Things Has Arrived—And So Have Massive Security Issues" Wired, January 2013, [Online]. Available: http://www.wired.com/2013/01/securing-the-internet-of-things/

[44] How Machine-to-Machine Communication Works, [Online]. Availble: http://computer.howstuffworks.com/m2m-communication.htm

[45] Online portal to Government Technology, [Online]. Available: http://www.govtech.com/policy-management/Why-the-Internet-of-Things-Needs-IPv6.html

[46] Oomi-Smart Home Indiegogo Campagin, [Online]. Available: https://www.indiegogo.com/projects/oomi-smart-home-simplified-redefined#/

[47] Ganache, J.A., Ghulam, A., Gutierrez, V., Kroc, S., Muñoz, L., Fosterer, D, Ramadhan, R., Sanchez, L., Santana, J.R., Stores, P., Theodoratos, E. 2014. SmartSantander: IoT experimentation over a smart city testbed. In Computer Networks, 14 March 2014, 217-238.
http://dx.doi.org/10.1016/j.bjp.2013.12.020

[48] Libelium World: Precision Agriculture case study, [Online]. Available: http://www.libelium.com/precision-agriculture-predicting-vineyard-conditions-preventing-disease

[49] Cognizant Report-Reaping the Benefits of the Internet of Things, [Online]. Available: http://www.cognizant.com/InsightsWhitepapers/Reaping-the-Benefits-of-the-Internet-of-Things.pdf

[50] Computer Now, [Online]. Available: http://www.computer.org/web/sensing-iot/content?g=53926943&type=article&urlTitle=defining-the-internet-of-thing