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Human and Computer interaction with "Internet on Things"

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Abstract **— The Internet of Things (IoT) represents to the use of smartly connected devices, instruments and systems to leverage data collected by embedded sensors and actuators in machines and other physical objects. IoT is expected to spread rapidly over the coming years and this convergence will unleash a new dimension of services that improve the quality of life of consumers and productivity of enterprises, unlocking an opportunity that the GSMA refers to as the 'Connected Life'.**

Keywords-component: IOT(Internet on Things), Connection, Things, Health, Security, Mobile

I. INTRODUCTION

Mobile networks already serves connectivity to a wide range of devices, enabling the progress of innovative new services and applications. This new innovation of connectivity is going beyond tablets and laptops; to connected cars and buildings; TVs and game consoles; smart meters and traffic control; with the prospect of virtually and intelligently connecting almost anything and anyone. This is what the GSMA refers to as the "Connected Life". As the Connected Life evolves, the number of mobile connections worldwide is set to rise suddenly to reach 10.5 billion by 2018, while the total number of connected devices across all access technologies could reach 24.6 billion. These devices will bridge the physical and digital worlds, enabling a new category of services that improve the quality of life and productivity of individuals, society and enterprises. This Internet of Things - a widely spreaded, locally intelligent network of smart devices - will enable extensions and enhancements to fundamental services in education, health and other sectors, as well as providing a new ecosystem for application development. By enabling devices to communicate with each other independently of human interaction, the Internet of Things will open up new innovative streams, facilitate new business models, drive efficiencies and improve the way existing services across many different sectors are delivered. It will represent a very important demand-side functions that helps finance the deployment of mobile broadband networks around the world. In total, the positive impact on the global economy could be as much as US$3.5 trillion per annum, according to a study by Machine Research.

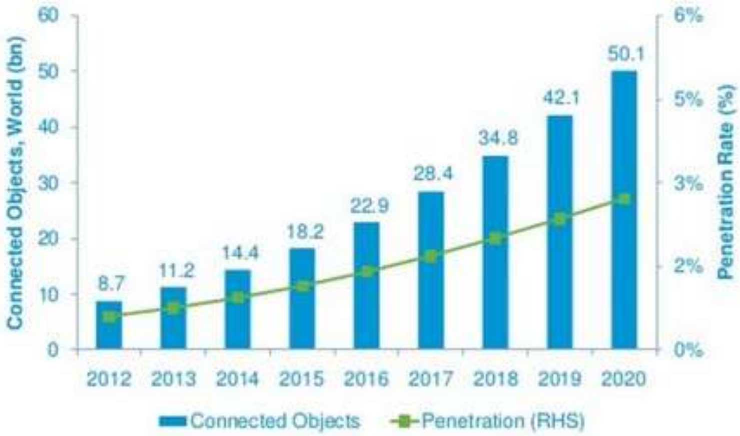

Figure 1. Expected penetration of connected objects by the year 2020, according to CISCO

1. BASIC CONCEPT

Many people, including myself, hold the view that cities and the world itself will be overlaid with sensing and actuation, many embedded in "Things" creating what is referred to as a smart world. But it is important to note that one key issue is the degree of the density of sensing and actuation coverage. I believe that there will be a transition point when the degree of coverage triples or quadruples from what we have today. At that time there will be a qualitative change. For example, today many buildings already have sensors for attempting to save energy; home automation is occurring; cars, taxis, and traffic lights have devices to try and improve safety and transportation; people have smartphones with sensors for running many useful apps [2]; industrial plants are connecting to the Internet [1]; and healthcare services are relying on increased home sensing to support remote medicine and wellness. However, all of these are just the tip of the iceberg. They are all still at early stages of development. The steady increasing density of sensing and the sophistication of the associated processing will make for a significant qualitative change in how we work and live. We will truly have systems-of-systems that synergistically interact to form totally new and unpredictable services. or a similar sans-serif font. Callouts should be 9-point non-boldface Helvetica. Initially capitalize only the first word of each figure caption and table title. Figures and tables must be numbered separately. For example: "***Figure 1. Dimensions for the IOT", "Table 1. Input data***". Figure captions are to be centered *below* the figures. Table titles are to be centered *above* the tables.

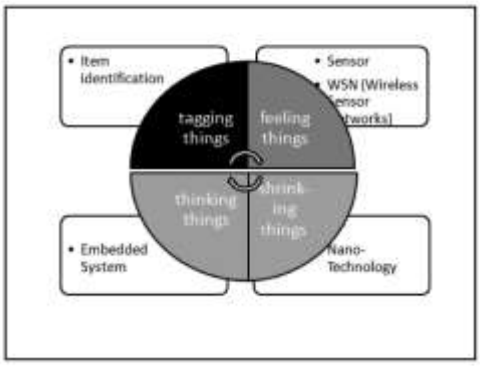

Figure 2. Dimensions for the IOT

2. RESEARCH

The spectrum of research required to achieve IoT at the scale envisioned above requires significant research along many directions. In this section problems and required research are highlighted in 8 topic areas: massive scaling, architecture and dependencies, creating knowledge and big data, robustness, openness, security, privacy, and human-in-the-loop. Each of the topic discussions primarily focuses on new problems that arise for future IoT systems of the type described in Section II. The research topics presented in each case are representative and not complete. Many important topics such as the development of standards, the impact of privacy laws, and the cultural impact on use of these technologies are outside the scope of the paper

3. SMART HOME, SMART BUILDING AND INFRASTRUCTURE

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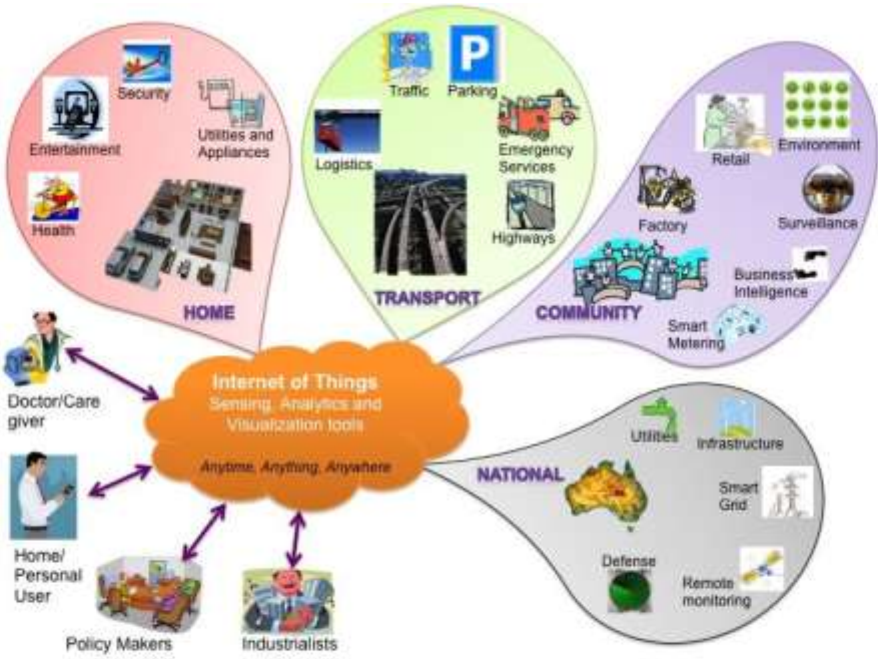

Figure 3. Internet on Things schematic showing the end users and application areas based on data

3.1. Evolution in IOT Web versus the Internet

The web has gone through several distinct evolutionary stages: Stage 1. First was the research phase, when the web was called the Advanced Research Projects Agency Network (ARPANET). During this time, the web was primarily used by academia for research purposes. Stage 2. The second phase of the web can be coined “brochureware.” Characterized by the domain name “gold rush,” this stage focused on the need for almost every company to share information on the Internet so that people could learn about products and services. Stage 3. The third evolution moved the web from static data to transactional information, where products and services could be bought and sold, and services could be delivered. During this phase, companies like eBay and Amazon.com exploded on the scene. This phase also will be infamously remembered as the “dot-com” boom and bust. Stage 4. The fourth stage, where we are now, is the “social” or “experience” web, where companies like Facebook, Twitter, and Groupon have become immensely popular and profitable (a notable distinction from the third stage of the web) by allowing people to communicate, connect, and share information (text, photos, and video) about themselves with friends, family, and colleagues.

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3.2. Current scenario vs research

The current trajectory of the numbers of smart devices being deployed implies that eventually trillions of things will be on the Internet. How to name, authenticate access, maintain, protect, use, and support such a large scale of things are major problems. Will entirely new standards and protocols emerge? Since many of the things on the Internet will require their own energy source, will energy scavenging and enormously low power circuits eliminate the need for batteries? How will the massive amounts of data be collected, used, and stored? What longitudinal studies will be performed? How will the real-time and reliability aspects be supported? How will devices including mobile devices be discovered? Will the emergence of a utility model, if it occurs, mean entirely new standards? How will such a utility be achieved? It is unlikely that any solution immediately becomes the norm. Many protocols and variations will coexist. What will be the architectural model that can support the expected heterogeneity of devices and applications? Architecture and Dependencies As trillions of things (objects) are connected to the Internet it is necessary to have an adequate architecture that permits easy connectivity, control, communications, and useful applications. How will these objects interact in and across applications? Many times, things or sets of things must be disjoint and protected from other devices. At other times it makes sense to share devices and information. One possible architectural approach for IoT is to borrow from the Smartphone world. Smartphone employ an approach where applications are implemented and made available from an app store. This has many advantages including an unbounded development of novel applications that can execute on the smartphones. Various standards and automatic checks are made to ensure that an app can execute on a given platform. For example, the correct version of the underlying OS and the required sensors and actuators can be checked when the app is installed. A similar architectural approach for IoT would also have similar advantages. However, the underlying platform for IoT is much more complicated than for smart phones. Nevertheless, if IoT is based on an underlying sensor and actuator network that acts as a utility similar to electricity and water, then, different IoT applications can be installed on this utility. While each application must solve its own problems, the sharing of a sensing and actuation utility across multiple simultaneously running applications can result in many systems-of-systems interference problems, especially with the actuators. Interferences arise from many issues, but primarily when the cyber depends on assumptions about the environment, the hardware platform, requirements, naming, control and various device semantics. Previous work, in general, has considered relatively simple dependencies related to numbers and types of parameters, versions of underlying operating systems, and availability of correct underlying hardware. Research is needed to develop a comprehensive approach to specifying, detecting, and resolving dependencies across applications. This is especially important for safety critical applications or when actuators can cause harm. Let's consider a few examples of dependencies. Assume that we integrate several systems responsible for energy management (controlling thermostats, windows, doors, and shades) and home health care (controlling lights, TVs, body nodes measuring heart rate and temperature, and sleep apnea machines). If information can be shared, this would allow the energy management system to adjust room temperature depending on the physiological status of this is the author's version of an article that has been published in this journal.

4. CONCLUSION

In summary, one vision of the future is that IoT becomes a utility with increased sophistication in sensing, actuation, communications, control, and in creating knowledge from vast amounts of data. This will result in qualitatively different lifestyles from today. What the lifestyles would be is anyone's guess. It would be fair to say that we cannot predict how lives will change. We did not predict the Internet, the Web, social networking, Facebook, Twitter, millions of apps for smart phones, etc., and these have all qualitatively changed societies' lifestyle. New research problems arise due to the large scale of devices, the connection of the physical and cyber worlds, the openness of the systems of systems, and continuing problems of privacy and security. It is hoped that there is more cooperation between the research communities in order to solve the myriad of problems sooner as well as to avoid re-inventing the wheel when a particular community solves a problem.

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