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A Survey on Substantial Evolution of Internet in Rural India: An Analogy towards Adaptability of IoT and Its Future Economic Viability

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ABSTRACT

Internet of things (IoT), sometimes referred to as Internet of objects can be stated as an environment in which any physical thing or object with an unique address and an internet connection can communicate to an external object or person without requiring any human intervention. In the year 2014, around three billion people across the world, are reported to use internet for social networking applications, ecommerce applications, surfing the web etc. which is tenfold times as compared to 1993. India is not only leading the IT industry globally but it is also the second largest country after China in terms of Internet consumption. It is also an astonishing fact that the Internet usage is going beyond the literacy, which is clear from the analysis done in 2015 that out of 50 million users, 50% i.e. 26 million users are from rural India. Many initiatives have been launched by major companies like Google India, Tata communication and Intel to bring internet at their doorstep to educate rural women. As more and more masses avail to such plethora of Information and communication platform, the day is not far when Internet will be used as an infrastructure for allowing every objects to talk, communicate, coordinate, compute and share information with no human intervention. Hence it's important to study and predict the technology associated with Internet communication such as IoT. This paper studies the evolution of Internet usage over time and proposes IoT framework comprising major building blocks needed to develop any real time application. The paper also consists of classification of smart objects depending on various characteristics. The climax of the paper investigates all possible future impacts of IoT in various sectors at both consumer and commercial space.

Keywords: IoT, Smart Objects, IoT Framework, Future Impact

1. INTRODUCTION

Computers have been connected to the Internet for some time now, phones got connected a few years ago, and now it's time for all the rest. IoT is about connecting all the rest. In year 2014 around three billion people around the world are reported to use internet either using social networking applications, ecommerce applications, surfing the web etc which is tenfold times as compared to 1993 which has made India second largest country after China in terms of internet consumption. As more masses avail to such plethora of information and communication platform, the day is not far when Internet will be used as an infrastructure for objects to talk, communicate, coordinate, compute and share information with no human intervention.

The paper comprises of five sections: Section I briefly explains introduction to Internet of things. Section II describes tremendous adoption of Internet technology in India and mushrooming increase of internet users in urban and rural areas. The evolution in terms of number of connected devices and their miniaturization with cost reduction over the years have been graphically explained. Also it provides glimpse of IoT framework comprising major components needed to build any real time application. Section III presents classification of smart objects on basis of functional capability, Bandwidth capability and Human interaction capability

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in detail. Section IV enlightens future impact of IoT in various application domains keeping in mind both positive and negative aspects. Lastly, section V carries conclusion remarks.

2. IoT Paradigm

A "thing" in the IoT could be a table, chair, bicycle, an animal or even the people around us. Everyone and everything will be connected to the internet, giving access to information about the objects and ability to communicate with each other. Some smart objects are already part of our lives. Notable examples are connection of smart TV's, smart watches, smart security system and other home appliances.

Adding more intelligence to the objects with wireless connectivity and unique addressing schemes helps it to communicate to other objects and create new applications and services [1].

2.1. Evolution of Internet Technology and Web over the years

Much like the Industrial revolution, Internet revolution has changed the life of people about how they live, work, shop and socializes. Fig 1 shows exponential increase of Internet connected devices over world population. It is expected that by 2020 internet devices will reach to 50 billion crossing 7.6 billion of world population.

In a span of 20 years, India has shown a tremendous growth in Internet communication and technology field. By the year 2006, Internet had its roots into every sector like education, corporate, entertainment, e-

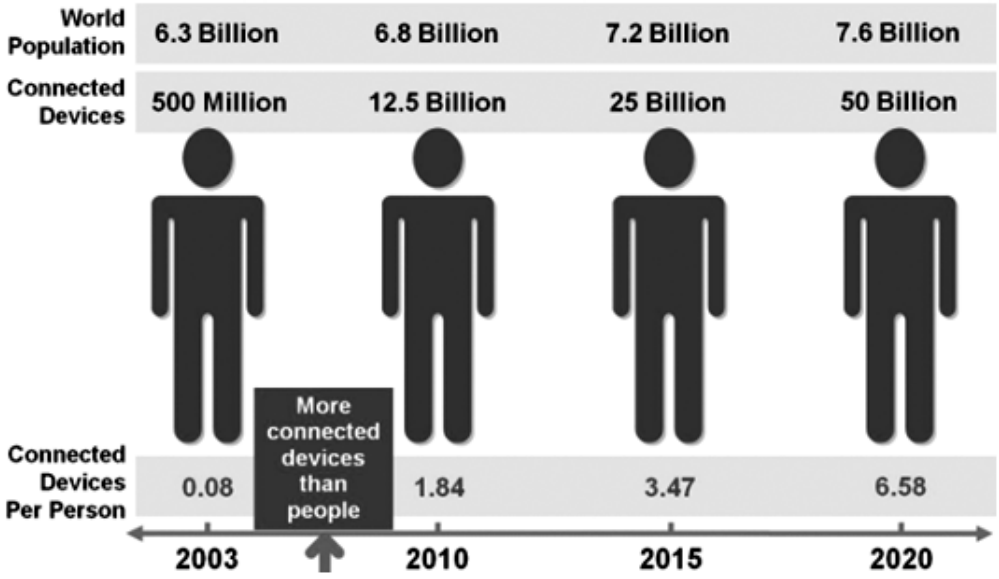

Figure 1: Relation between World population and Internet connected devices [2]

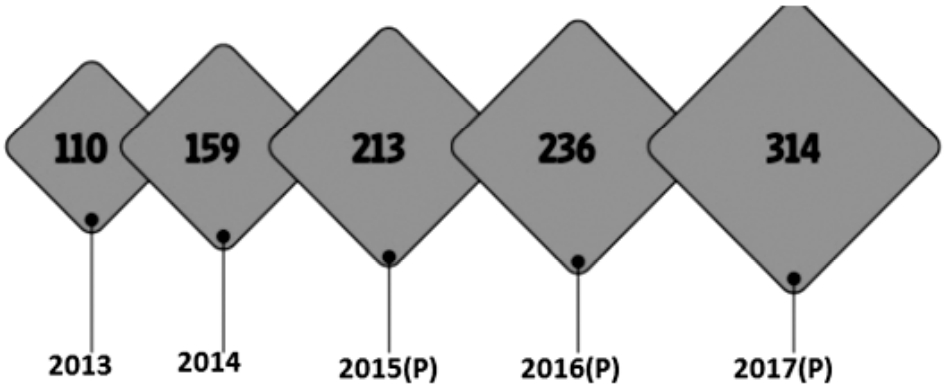

Figure 2: Mobile internet users in India [3]

commerce etc but it was still far from common man's reach. People used to rely on cyber- cafes for Internet access until the avalanche of personal computers and Broadband connection at an affordable price. In recent span of 5 years with more advent of technology, internet connection is easily available at any Indian home running on numerous devices say on their laptops, ultra book or smart phone with the use of Wi-Fi.

Going with the fact, India is second largest country after china in terms of Internet consumption amongst public. As per IAMAI-KPMG report [3], mass of public i.e around 60% access internet via Mobile phones and the count is estimated to reach 314 million in 2017 as shown in Fig 2. This mobile and internet driven technologies are transcending and bypassing differential limits to technology access, knowledge acquisition and literacy in not only urban areas but also in rural areas. In the first six months of 2015, India is estimated to have added 52 million internet users of which 50 per cent (26 million) are from rural India. Mobile has created a hub where the users can access the content and they are consuming the content in an incremental manner, while being connected to the world through these devices. There is still an untapped area in the requirements of rural mobile internet users in terms of the content being available and being accessible in their local languages. Although content providers have started providing the flavours of localized content but still there seems to be a lot of opportunity for the mobile apps industry to increase user experiences. A company called N-Logue had been introduced to spread awareness regarding Internet and voice services in small villages and towns, where it was successful to start internet services [4] .

Figure 3: People of Parvatapur adapting to Internet [5]

2.2. Evolution of Things/devices over the years

Fig 4 shows graph projecting evolution of devices v/s miniaturization and cost reduction over time. Initially affording mainframe supercomputer was exceptional due to its huge cost and size. The miniaturization of electronic components, desktop computers and laptops and replacement of mobile phones with smart phones has led to an industrial revolution in computing world. Now it's time to make everyday objects/things smart by embedding intelligence, so that objects can perform on their own with minimal human intervention.

The acquisition of Nest Labs by Google with their very popular *Nest Thermostat* in market, Samsung's *Smart Things kit , Home Kit* by Apple, all are real examples of transforming IoT a substantial business opportunity.

2.3. Vision of Internet of things

Just as RFID still awaits persistence into its application, similarly there are obstacles for IoT before it reaches maturity [7]. IoT is combination of many technologies and Wireless sensor networks (WSN) is one of the key enabling technologies for IoT Paradigm. Sensor nodes being the major component in

WSN applications contribute towards gathering, sensing and processing data while communicating [9]. The integration between WSN and IoT objects forms a system heterogeneous in nature with an ability to cooperate and provide common services [10]. This integration is a fact supported by many companies worldwide. Few examples are 'CeNSE' Project by HP Labs [10] and 'A Smarter Planet' [11] by IBM

A robust technology like IoT needs an understanding of its architecture. IoT's framework comprises major components viz sensors, smart objects, IoT Gateway, strong internet connectivity and cloud solution

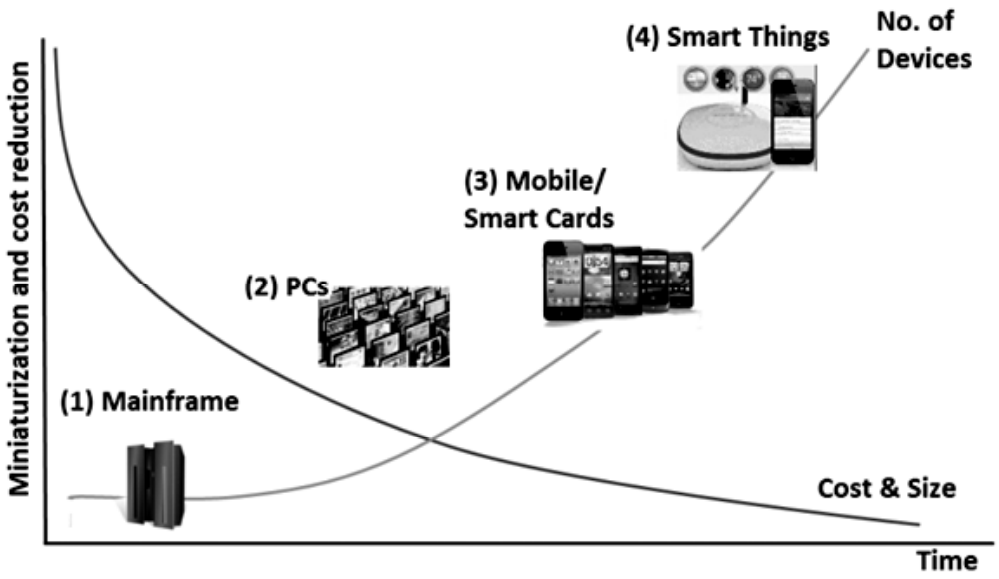

Figure 4: Graph showing Evolution of devices v/s miniaturization and cost reduction over time

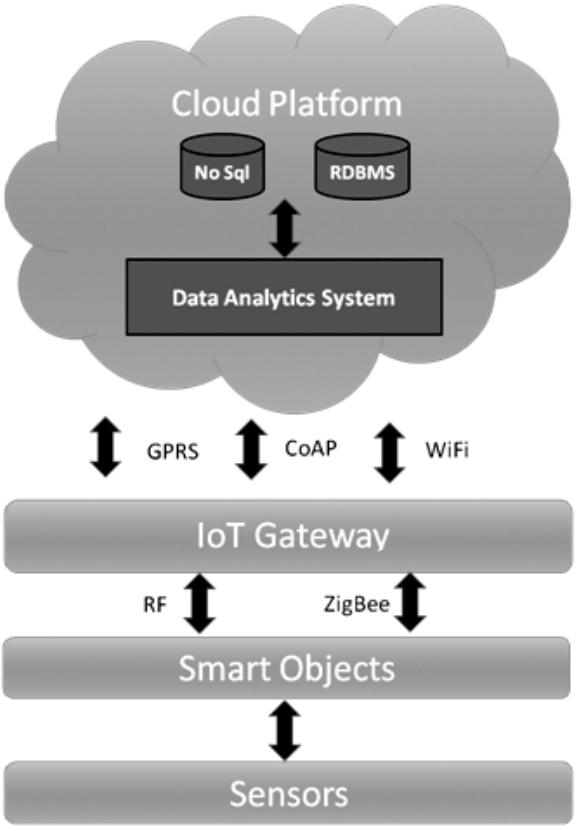

Figure 5: Proposed IoT Framework comprising major components

for efficient and secure data storage as shown in Fig 5. The uniqueness of IoT lies in the identification and deployment of these varied smart objects to its respective application in the real world.

3. CLASSIFICATION OF SMART OBJECTS

The uniqueness of IoT lies in pervasive deployment of smart objects [8]. Anything can be termed as a smart object which possesses a wireless connectivity to internet and a component to process sensor data [12]. Here we categorize smart objects on the basis of functional capability, Bandwidth capability and Human interaction capability.

In functional capability, objects can be classified as

- Input objects
- Output objects
- Mobile objects
- Update objects

Input objects can be any physical object or thing having minimal set of communication functionalities, possess a unique identifier, and possess basic computational capabilities and a sensor to sense physical phenomena. They can also be termed as *Passive objects* where sensor data is stored but no decision making is involved. E.g. An object connected to main door which senses when the door opens or shut down.

Output Objects in addition to above characteristics of input objects also have actuators to trigger some action to external phenomena. E.g. A single smart object connected to main door automatic turn on the lights of the room when it opens. It can also communicate to other smart objects to turn on lights of other rooms, turn on the heater and so forth.

Mobile Objects are mobile in nature. Example of mobile objects can be an autonomous mobile service robot outfitted with RFID reader which directly interacts with sensor tags to perform any remote monitoring task. Such objects can be used in multiple applications of agriculture monitoring, crop monitoring, infrastructure monitoring etc.

Update Objects have capability to update to outer world. E.g. A smart refrigerator can keep track of availability of food items in stock and automatically places order online when stock falls below prescribed limit.

In Bandwidth capability, objects can be classified as

- Low Bandwidth objects
- Very Low Bandwidth objects
- Bursty High Bandwidth objects
- Continuous Mid Bandwidth objects

3.1. Low Bandwidth objects

Bandwidth of a object can be defined as the average rate of successful data transfer through wireless communication channel. Low bandwidth object examples are, a smoke detector at home which can detect where the smoke is coming from and sends an activity alert on smart phone, an intelligent street lighting system which offers on demand adaptive lighting based on the presence of pedestrians, cars and switch off lights on its own to conserve energy.

3.2. Very Low Bandwidth objects

Very low bandwidth objects can interact within limited area say restricted within home. E.g. a smart learning thermostat which learns every member's schedule and changes the home temperature accordingly. It learns member's routine and then emulates it.

3.3. Bursty High Bandwidth objects

A bursty high bandwidth object needs high data speed internet connection for continuous data transfer. E.g. A smart IP camera installed at home can take video of your child or pet of their activities and stream it live on phone.

3.4. Continuous Mid Bandwidth objects

An example of Mid Bandwidth object is wearable objects (shoes, belts, watch) connected to body of elderly people who lives alone and will be used to monitor their health condition and transfer data to their smart phone via Bluetooth. The phone can then transfer report to a base station (Medical centre) via internet where the doctor can take any emergency action/support if needed.

In Human Interaction capability, objects can be classified as

- No interaction objects
- Touch Interaction objects
- Speech Interaction objects
- Visual Interaction objects
- Body Implant Interactive objects

3.4.1. No interaction objects

No interaction objects does not support network capability to interact with human or other objects around them but can themselves act intelligently. For e.g. An object which measures water level of the tank and switch on/off the pump when the level exceeds the limit.

3.4.2. Touch interaction objects

An example of the touch interaction object is smart lock known as "Ola smart Lock"[13]. It's the very first Bluetooth-enabled door lock that offers a keyless and a phoneless way to enter one's home. It works through a CMOS fingerprint sensor as shown in Fig 6. The scanner is placed on the part of the door handle where you naturally place your thumb to hold the lock. Aside from fingerprints, it is also manageable through Bluetooth connectivity. After installing its app and scanning the QR code, user can register himself by pressing thumb over fingerprint sensor and can also grant access to a friend or relative to unlock the door.

3.4.3. Speech interaction objects

Wireless Voice Node architecture [14] comprising of sensors and voice synthesis actuator can be integrated with other sensor node components and thus can form a smart object by providing intelligence and network capability to it. During some emergency e.g. during fire or land sliding, a network of speech interactive objects can be deployed in remote areas through air which can measure different environmental parameters along with providing speech instructions to people for their evacuation and safety [14].

Figure 6: Ola Fingerprint Smart Lock [13]

3.4.4. Visual interaction objects

Cameras have always been the eyes of the security industry and now when the technology is going beyond excellence, there are smart surveillance systems with *Intelligent IP surveillance camera*, a good example of visual interaction object which can automatically detect the human behaviour, illegal acts of persons or emergency situation. It is very much advantageous for smart home applications e.g. with the use of IP camera set up in one's room you can constantly observe your child while at office. Additionally with built in intelligence, it can alert you and can communicate with other smart objects of home in case of any emergency.

3.4.5. Body Implant interaction objects

Body Implant interactive objects ranges from E-textiles, wearable computers to "intelligent" artificial replacements. Wearable objects such as smart shoes, belts, watch etc. connected to body of aged person or handicapped person can be used to monitor the health condition and transfer report to central diagnosis station. Based on collected data from central diagnosis station, doctor is able to monitor and analyse the patient's behaviour.

4. FUTURE IMPACT OF IOT IN VARIOUS SECTORS

Internet of Things is already high on the rise and it has completely revitalized the areas ranging from Daily life style, Smart home, Health sector, and environment to Smart cities, Industry etc. All these areas are completely under its effect, but in conjunction to it, it has also posed a threat to people's personal and social life. Some of the points are highlighted here considering both positive and negative impacts of it.

4.1. Impact on Daily life style

Some of the largest Tech companies like Google, Apple, and Samsung have recently come up with smart products to make IoT a closer reality in all of our homes. The acquisition of Nest Labs by Google with their very popular *Nest Thermostat* in market, Samsung's *Smart Things kit , Home Kit* by Apple, all are real examples which can control your home devices with a simple tap to see all your dumb objects become connected, sending signals to each other and alerts to your phones. All these products are the direct gateway for Smart appliances to take over your kitchen, bedroom in the most helpful and satisfying manner.

4.2. Impact on Health sector

IoT has come up with many advanced solutions for diagnosing the health conditions. Sensor-enabled medical instruments allow sensors to monitor the health state of a person from body weight and mass, sleep conditions and daily activities. Watches, wristbands and many wearable devices can track sleeping 00patterns, heart rates of elderly people and transfer data to their Smartphone in their pocket via Bluetooth. This phone can transfer report to the base station (Medical centre) via internet where the doctor can take any emergency action/support if needed.

4.3. Impact on Environment

Sensor enabled IoT devices can prove to be a boon for clean and pollution free environment. Be it taking care of personal garden to city garbage collection, deforestation, water and air pollution, IoT can address all of these issues. It can help people in reducing waste, getting warnings regarding any structural failure of dams and bridges [18].

4.4. Impact on Industry sector

Supply chain management and logistics are the areas where IoT is likely to have the maximum impact. It can provide ability to view, track and monitor inventory and replenishing items by remotely monitoring data from sensors [20]. Usage of RFID technology can result to satisfactory and fast shopping experience for customers. It can also give rise to new business models, extend the life of machine by years and also reduce the maintenance cost.

4.5. Impact on Employment sector

With all our daily activities getting automated with the use of IoT devices, its natural this may create a employment shortage in the society. There will be fewer requirements of human resources, especially maids and workers.

4.6. Impact on Social life

In the present circumstances we are very much dependent on technology, especially younger generation who are most isolated from their social relations, family and relatives. Due to IoT, this dependency is expected to spread amongst generations and in the daily routines of users which will have direct implications on social life

4.7. Impact on Business Operations

The concept of IoT is like a complex network where internet connection is of prime importance for smart machines to work and communicate. Any failure in the software or hardware or lost in network connectivity can cause ongoing operations stand still. Even power failure can cause serious consequences e.g. After every power cut, a bug in the printer software restores all the data and automatically orders a new ink cartridge for your printer whereas you have already ordered one. Also Privacy and security will be a major concern for companies implementing IoT applications as most of the applications would be consumer driven.

5. CONCLUSION

IoT has been fascinating our lives, by enlightening technological changes for making life simpler and more comfortable. A surge in IoT may lead to an industrial revolution throughout the world thus India should not miss this inevitable wave. At the beginning, the paper portrays evolution of Internet in India and how it has

grown in an incremental fashion. Being the second largest country after China, in terms of internet users, with many enterprises moving to cloud computing and sophisticated analytics software, India has a potential to adopt this radical change. A robust technology needs an understanding of its architecture. IoT's framework as proposed here comprises of major building blocks which are Sensors, Smart objects, IoT Gateway, strong & reliable internet connectivity and Cloud solution for efficient and secure data storage which are needed to build any real time application. The uniqueness of IoT lies in the identification and deployment of these varied smart objects to its respective application in the real world. Thus classification of smart objects based on characteristics such as functional capability, bandwidth capability and human interaction capability has also been discussed. The climax of the paper investigates all possible positive and negative future impacts of IoT in various sectors at both consumer and commercial space. Introducing such a concept in India, which is technologically advanced, may be innovative but achieving social and economical benefits by diffusing this technology is the main challenge ahead.

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