Original Research Paper

Engineering

Internet of Things in the Transformation of India Into A Digital Economy

Prof. Ms. Pallavi S. Mane

Department of Information Technology, Karmaveer Bhaurao Patil College, Vashi, Navi-Mumbai.

ABSTRACT

The Internet of Things (IoT) is an all-encompassing term for a network backbone that will host billions of devices and sensors that communicate intelligently. This ecosystem of interconnected things and the technology that manages them is expected to have a market potential of $15 billion by 2020 in India alone. The IoT is in fact the inflection point that is expected to transform the global economy, and specifically those economies that plan around it. The Indian government believes in the tremendous opportunities that the IoT presents, and is planning a close synergy between the Digital India programme and the IoT, and has already drafted it into policy. The IoT will be part of the broadband highway that will deliver a wide range of e-governance and citizen services to all corners of the country. This paper hence provides a comprehensive survey of the enabling technologies, protocols and architecture for an urban IoT

INTRODUCTION

The Internet of Things is *"all about physical items talking to each other."* The Internet of Things is the intelligent connectivity of physical devices driving massive gains in efficiency, business growth, and quality of life. The IoT is an intelligent network which connects all things to the Internet for the purpose of exchanging information and communicating through the information sensing devices in accordance with agreed protocols. Kevin Ashton coined "Internet of Things" phrase to describe a system where the Internet is connected to the physical world via ubiquitous sensors.

IoT helps us interact with things around us in various ways. The things can be systems, machines or static objects. Unlike M2M which is used for machine to machine communication for mere monitoring and control applications. IoT has covered all the industries right from energy, manufacturing, healthcare, telecom and transportation. It has three main aspects such as connectivity, remote management and security. The concept of clouds and mobile app has pioneered the existence of IoT

SCOPE OF IOT IN INDIA

Clearly, the IoT will play a major role in the transformation of India into a digital economy - as the catalyst that empowers our citizens by providing them with transparent governance and services (education, health, legal, financial and safety) at their fingertips. At the heart of this transformation will be a re-engineering and digitising of government processes, using IT and supporting database and cloud infrastructure to simplify, improve and optimise the various government functions.

The private sector's contribution to this transformative undertaking will be indispensable. It brings in the expertise, field experience and thought leadership that is crucial for the successful execution of IoT projects. Digital India projects like Smart Cities are already going forward using the public-private partnership (PPP) model and will showcase IoT-based solutions for almost all aspects of personal and work lives of Indians. For example , smart traffic and parking solutions to address the pressing urban problem of congestion, smart buildings that automatically manage lighting and ambient temperature based on occupancy, and solid waste management using sensor and location intelligence are a few examples of IoT enabled solutions that directly improve the quality of life of citizens.

IoT-based solutions are not just for urban India; they offer rural citizens access to services that were earlier out of reach. On the premise that a well-connected nation is the first step towards a well-served nation, the first objective of the Digital India programme is providing digital infrastructure as a basic utility to all citizens, so educational, health, governance and financial services can be delivered to otherwise underserved areas.

Most patients in rural areas don't have access to medical specialists.

Several large hospitals in Indian metros are now offering remote consulting services to underserved areas, using media-rich network capabilities so their doctors can see and interact with patients in remote telemedicine centres, with the case history and medical data automatically transmitted to the doctor for analysis. Leveraging similar technology, the Karnataka government plans to launch remote education services to supplement Maths, Science and English teaching for high school students.

The penetration of mobile phones in rural areas continues to increase exponentially. The IoT, which encompasses mobile networks, can deliver e-governance and lifestyle-impacting services to these areas. Areas without brick-and-mortar banks, for example, can still be provided with financial services through online and mobile channels. Weather forecasts, news and advisories vital to agricultural can also be provided in a similar fashion.

Empowering rural India is an essential step for the country to move forward on the world stage. Connecting rural India to the IoT provides the much needed bridge between urban and rural India, and is a sure-fire way of channeling the benefits of a digital economy to the largest part of the country. Connectivity offers a host of development opportunities to untapped areas, including manufacturing and e-commerce to market local and traditional products.

Digital channels provide farmers and artisans the ability to directly reach extensive national and even global markets. A host of 'localisation' technologies can help different regions communicate so language is not a barrier.

Relevant information and updates are now provided in local languages and scripts. Rural India has demonstrated it is hungry for technology, and has rapidly and instinctively adopted it as quickly as it is offered.

Complementing the Digital India programme is the Make in India programme to encourage local and foreign companies to manufacture IoT infrastructure in India, to supply local and global markets. Here again lies the opportunity to engage rural India by setting up units in these areas and training the local population to take on the employment opportunities that come with it. Providing local opportunities helps stem the rural-urban migration that results in pockets of overpopulation and the associated urban problems.

The IoT is a very real network that promises to bring together the vast and varied country that we are, so we can all move forward into a digital world without losing what makes us unique both at the individual and regional levels.

5 PROMISING IOT STARTUPS

Tarun have reported that the compressive strength of rubberized concrete can be improve when fine aggregate was fully replaced by

fine crumb rubber. He also indicated that if the rubberParticles have rougher surface or given a pretreatment, the better and improved bonding may develop with the surrounding matrix, and that may result in higher compressive strength.

Internet of Things in India is becoming quite trendy, as a lot of the conversations happening at Bangalore's top tech event. Nasscom Product Conclave showed. There's good reason for that: with 1.5 billion populations expected by 2030, India must create about 1 million new job per month (The Economist). The general opinion on the country is that it lost a decade by postponing key reforms. As a result, India is still ranked 142th for the ease of doing business there. Here are 5 promising startups who pitched on the stage of Bangalore's Product Conclave.

CarIQ: smart driving

CarIQ "makes cars smarter" thanks to a device which records both traditional data from your car, such as mileage and speed, as well as driving patterns. A bit like Waze, it's also connected to a community of peers where you can compare your stats with friends, or with people in the same place, or with the same make and brand of car.

CarIQ- A complete car ecosystem I Available on pre-order: INR 5999

Figure 1: CarIQ

CarIQ was launched in 2012, and the device and software is now available on pre-order for 6000 Indian rupees ($97), including a two year warranty and no additional fees. Among the features offered: towing alerts, battery monitor, social badges for drivers, personalised driving tips and export of all data of your car.

Its founder Sagar Apte shows how it's possible to do this kind of product in India. He is based in Pune, a city which "has a strong ecosystem of automotive domain experts. Pune, being an auto hub, helped us tap into this ecosystem early on".

SenseGiz

SenseGiz has a good pitch. Every day, we spend about 55 minutes to look for things, which is 5 days per year. With small sensors you can apply to any object, the promise of SenseGiz is to give you back this time.
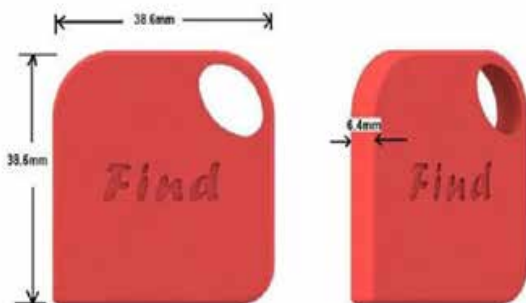

Figure 2: SenseGiz

Figure 2: SenseGiz
So far, the startups have sold 10000 units in 50 countries both for customers directly as well as to retailers. Again, the product is made and manufactured fully in India. Each sensor is a small square of 4 centimetres and half a centimes of width that can be hooked or stuck

to any surface, with removable batteries and Bluetooth communications. Each sensor comes at $29.99, which sounds a bit pricey as it would be better to have a package of 5 units to tag keys , wallets , phones , dog and kids (say).

Entrib ShopWorx

In a drier speech – we're in the industrial internet of things world – Entrib ShopWorx shows how it helps the manufacturing industry to make the shop floor smarter.
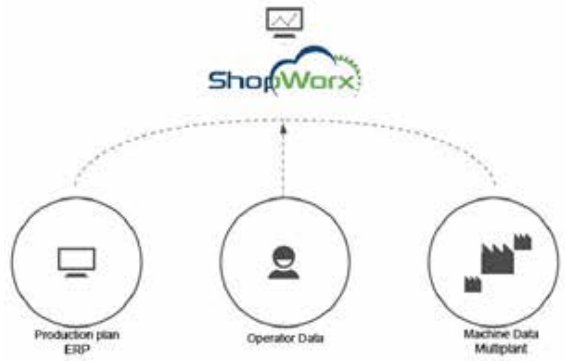

Figure 3: Shopworx model

Figure 4: Entrib-shopworx shop floor plant

The huge number and variety of machines, tools, spaces a manufacturing plant has are not so well connected. It's often one of the guys working there who knows the best where are issues and when to repair , maintain or upgrade the plant . It's of course not scalable to rely on one single person, so the sensors and software shop worx provides connects all of the shop floor to deliver a unified view of how it is run and when to act. So far, the startup works with Indian companies, and has its operations based in Pune.

TeeWe

This connects all your content to your TV.

Figure 6: The TeeWe Device

Figure 6: Concept of teeWe

A simple concept not yet implemented in India: get all your content, from pictures to movies, on your TV through a single device which connects in Wifi to your laptop, phone, remote storage, whatever the OS, the platform. The Teewe companion app makes the smartphone a remote control for browsing. Cost will be 2000 rupees when available ($32).

LifePlot

It is the cheapest and most mobile electrocardiography diagnosis tool. The company is not really a startup, as it's functional since 2009. The product is a connected device which records most of the data of basic medical diagnosis. The device is connected all time, "taking Internet of Things where it should matter". It's currently the lightest electrocardiography (ECG) machine in the world, made handheld for travel .Other features include touch screen, maintenance free, remote diagnosis, paperless, all done in seconds, and it required only 5 to 10 minutes of training.

So there's a LOT happen in India when it comes to Internet of Things. Bangalore and Pune seems to be two cities where you would discover quite a few startups in this field.

As IoT is booming across the world; many Indian companies are working and contributing for the growth of IoT and Big data. IoT is booming market in INDIA due to Indian Government's Digital India programme.

TABLE – 1
MAJOR IOT COMPANIES IN INDIA.

Sr. No.	Company	Product / Service
1	Algo	They help provide operating intelligence for the Engines met masts, wind turbines, solar plants and other IoT systems. They have developed cloud based SaaS platform for Internet of Things Analytics. The other solutions are based on SCADA systems, sensors and smart meters.
2	SenzIT	Enterprise solution provider, working with IBM
3	Azoi	Works on sensor and application based healthcare products. Their latest offering by name 'WELLO' is used as health tracker.
4	Lively	Emergency solutions for elders. The product in the form of Smart watch is connected with lively Hub. The product stays with the users and informs them regularly about medicines and alert them or concerned people when required.
5	Altizon	Their Datonis platform can be used by Systems manufacturers to build connected equipments which will constantly feed operational data to the cloud based platform for aggregation and analysis. Many OEMs are using solutions from Altizon to improve operational efficiencies, remote monitoring as well as predictive maintenance.
6	Neurio	The product by name Neurio can does many things based on power consumption pattern in your home. It is wifi enabled sensor device. It measures flow of electricity and also transfers the information to the cloud. It does calculations based on power data and notify the owner through SMS about many important power related observations
7	RainMachine	The solution forecast sprinkler is developed by the company. It is a wifi enabled touch screen device. This device is placed in the open field. It provides 6 hour weather forecast. This helps manage watering for the garden and also for the crops in the farm. It connects with national oceanic and atmospheric administration. In the case of non availability of internet it makes use of historic data which can be used for maintenance.
8	Cooey	Develops healthcare wearable products which monitors heart rate, temperature, weight etc. and alerts the guardians when needed.
9	CarIQ	CarIQ platform connects car with the internet cloud. This helps both car and driver to make decisions based on real time data about location and route map. condition of the car and credibility of the driver are also few of the factors being analyzed.
10	Toymail	The company has solution (e.g. voice messaging) for kids in the form of toy. This helps one connect with the kid at home while being at work
11	Natalia	The natalia project is inclined to protect human Project rights activists. The project develops IoT gadgets such as IoT wristband. When this wristband is removed forcibly it triggers alarms and send out location information to the network and hence alert nearby members to reach out for that person's help.
12	Altiux	One of the IoT companies in INDIA. It develops M2M and IoT products. The company has expertise in hardware and embedded software domain. They also develop cloud and mobile applications.

RELATIONSHIP WITH IOE

IoE is the networked connection of people, process, data and things. IoE brings together people, processes, data, and things to make networked connections more relevant and valuable than ever before – turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunity for businesses, individuals, and countries. IoT is the "Things" portion. To be clear, by "things" we're really talking about the network of sensors, objects, etc – not concentrating on the devices, themselves.

Figure 7: Relation between IOE & IOT

THREE C'S OF IOC

IoT impacts every business. Mobile and the Internet of Things will change the types of devices that connect into a company's systems. These newly connected devices will produce new types of data. The Internet of Things will help business gain efficiencies, harness intelligence from a wide range of equipment, improve operations and increase customer satisfaction. IoT will also have a profound impact on people's lives. It will improve public safety, transportation and healthcare with better information and faster communications of this information. While there are many ways that the Internet of Things could impact society and business, there are at least three major benefits of IOT that will impact every business, which include: communication, control and cost savings.
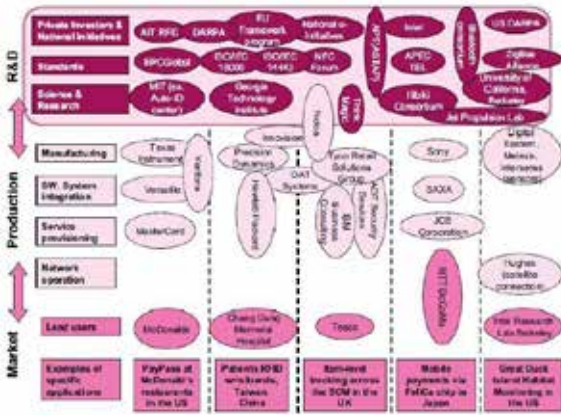
Figure 8: IOT from Idea to Market

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.

IOT ENTITIES

There are two major subsystems involved in the IoT network viz. front end part and back end part. Front end is mainly consists of IoT sensors which are MEMS based. It includes optical sensors, light sensors, gesture and proximity sensors, touch and fingerprint sensors, pressure sensors and more.Back end consists of cellular, wireless and wired networks which are interfaced with IoT devices. The devices will report to the central servers and also interact with databases in the backbone network. Routers and gateways are part of the wireless backbone networks.
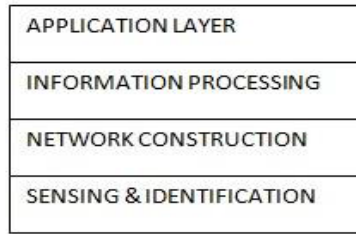

Figure 9: IoT Layers

As the standard has not been finalized for IoT but one can think of IoT having 4 protocol layers as shown in the figure-9. Sensing and Identification include various smart sensor devices based on GPS, RFID, WiFi etc. Network connectivity layer is based on wired and wireless network such as WLAN, WPAN, WMAN, ethernet, optical fiber and more. Other two layers are information Processing layer and application layer. Wireless cellular companies are working towards providing collectivity and enhancement to existing wireless devices to support emerging IoT market.
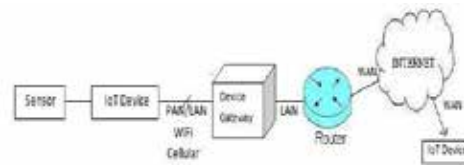

Figure 10: Cellular IOT

The IoT device mainly consists of battery for providing power. It should have long life approx. about 10 years. The parts include interfacing with sensors and connectivity with wireless and wired network. Hence it includes small part of physical layer and also upper protocol layers to interface with application layer. Devices should support both IPV4 and IPV6 based IP protocols. IoT devices must have receiver sensitivity atleast 20dB better than non-IoT devices. The IoT devices should be cheaper.
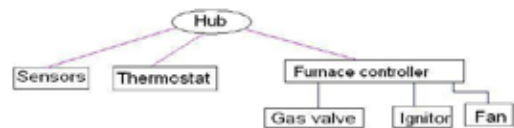

Figure 11: Working of IoT

As mentioned any device, system, person referred as things can be remotely controlled using applications running on smart device (can be smart phone, remote controller etc.). Only need to have IP address assigned to each IoT things. There is no common protocol stack finalized for IoT things. In general First each things should have physical layer to connect with the medium either wired or wireless (wifi,WiPAN,LTE,GSM etc.). Second, each should have layer to interface with backhaul network as per technology the device will be developed for. The third is basic IP address interface. These three basic layers comprise the IoT protocol stack. The figure depicts IoT network comprised of Hub and things. Things can be either controller or things directly. In the case of controller, it is controller which controls the things.

Figure 12: Smart home

1	Bhubaneswar	11	Pune
2	Jaipur	12	Surat
3	Kochi	13	Ahmedabad
4	Jabalpur	14	Vishakapatnam
5	Sholapur	15	Davangere
6	Indore	16	New Delhi
7	Coimbatore	17	Kakinada
8	Belagavi	18	Udaipur
9	Guwahati	19	Chennai
10	Ludhiana	20	Bhopal

Figure 13: Smart Kitchen

IoT devices are used for following applications:

In consumer market for smart home control (lighting, security, comfort), Optimized energy use maintenance.

In Industrial market for smart meters, Wear-out sensing devices, Manufacturing control, Climate control

In Automotive industries for parking, traffic flow control, Anti-theft devices, Location tracking etc.

In Environmental for species tracking, weather prediction and resource management.

In agriculture market for crop management and soil analysis.

In military for resource allocation, threat analysis, troop monitoring etc.

In medical industry for wearable devices, implanted devices and tele-health services.

In retail for product tracking, Inventory control, focused marketing, etc.

Smart cities

Connected cars

Connected Rail Operations

Figure 14: Smart cities

Implementation of smart cities plan will showcase integrated planning. The investment of Rs 50,802 crores has been proposed in selected smart cities and towns during the five-year period. There are five capital cities among the 20 smart cities chosen. A consortium of only Indian companies was chosen for plans of nine cities from the 20 cities chosen. The urban development ministry received proposals for 97 cities from state governments. The selected cities will be equipped with basic infrastructure, efficient urban mobility and public transport, IT connectivity and e-governance mechanisms using IOT. Following is the list of 20 smart cities:

IOT EXPANDS SECURITY NEEDS

Despite its many business benefits, IoT increases security challenges in several ways:

Increased attack surface – Due to the billions of new devices that are now connected

Threat diversity – Due to the variety of objects – many of which are in insecure locations

Impact & risk – More sensitive data is flowing through more connected devices, in more places throughout the world – and BTW, mostly outside the secure embrace of the existing network

Remediation – Need to think differently about security can't necessarily isolate a system, because the cost of shutting it down may be greater than the cost of an infection also, rather than hardening the outside but leaving the inside relatively insecure, need pervasive protection)

Protocols – Security systems need to be considered as a continuous process – in addition to secure access, the system needs to be content-, context-, and threat-aware)

Compliance & regulation – Regulatory compliance organizations are requiring tighter security and privacy controls than ever before, which is affecting a growing number of industries)

Figure 15: IOT challenges

CONCLUSION

The development of IoT in I ndia keeps going forward along scale, collaborative, and intelligent. Promoted by technology, standardization, and application experiences, Indian IoT applications will expand the scale in the different industries, and more enterprises will be attracted to come in. The IoT encompasses several technologies such as information technology, cognitive sciences, communication technology, and low-power electronics. IoT creates a newer information society and knowledge economy. But the challenges from research, industries, and the government will keep pushing and investing.

IoT isn't "science fiction" or something that will happen in the future

– it's real, and it's here now. The inflection point – the point at which the number of connected devices began outnumbering the number of men, women, and children on the planet – happened about five years ago; others in the industry believe that it happened about a year and a half ago. Some believe that the number of connected objects will grow to about 50 billion over the next several years, while others estimate that number at 25, 30, or even as high as 200 billion!

Who's right doesn't really matter … the point is that we all universally agree on two things:

The point of inflection is in the past; and

Gap is expected to widen exponentially over the next several years.

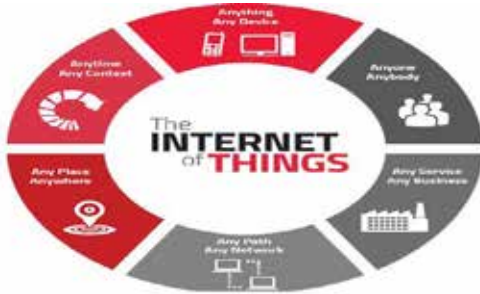So, IoT is here today, and will continue to grow from Indian perspective
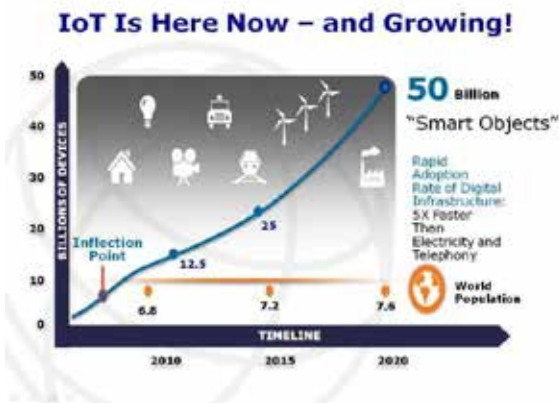

Figure 16: Summary of IoT

 Figure 16: IoT status- today & tomorrow

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