Internet of Things – A Survey for IOT opportunity for the Indian Railways

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ABSTRACT: The Internet of Things [IOT] is the next big wave to revolutionize the technology world. It's a place where every object equipped with identifying, sensing, networking and processing capabilities is connected to the other objects over the Internet to provide services to the users. The IOT has a huge potential to develop new intelligent applications in almost every field; one such field where the IOT is dramatically accelerating its pace of innovation is the transportation industry. This paper discusses the emergence of the IOT, its ecosystem, platforms and the application domain with emphasis on the significant impact and challenges of diffusing IOT in the railway industry especially in India to develop safe and sound transportation system for the consumers.

KEYWORDS: Internet of Things, IOT, Indian Railways, IOT Platforms, Tri-Netra.

I.   INTRODUCTION

The Internet of Things is the next big wave to revolutionize the technology world. It is a concept that is gaining interest because it has the potential to impact our everyday lives by giving us more control to simplify routine work life and personal tasks. The thumb rule is: any object that can be connected, will be connected to the Internet. These objects can be a person, an animal, houses, vehicles or any other physical device that can be assigned an IP address [1] and has the ability to transfer data over the network. Gartner Inc., an information technology research and advisory firm, predicts that in the next three years 26 billion devices will be connected to the Internet to harness the enormous intelligence which will add values to the life of every human being on this planet.

The below image shows that in the year 2003, when the world population was 6.3 million, the number of connected devices were 500 million and the connected devices per person was 0.08. After seven years, the world population was 6.8 billion and the connected devices were 12.5 billion with 1.84 connected devices per person. In the year 2015, the connected devices almost doubled and as per predictions in the next three years the world population will grow to 7.6 billion with 50 billion connected number and almost 7 connected devices per person.
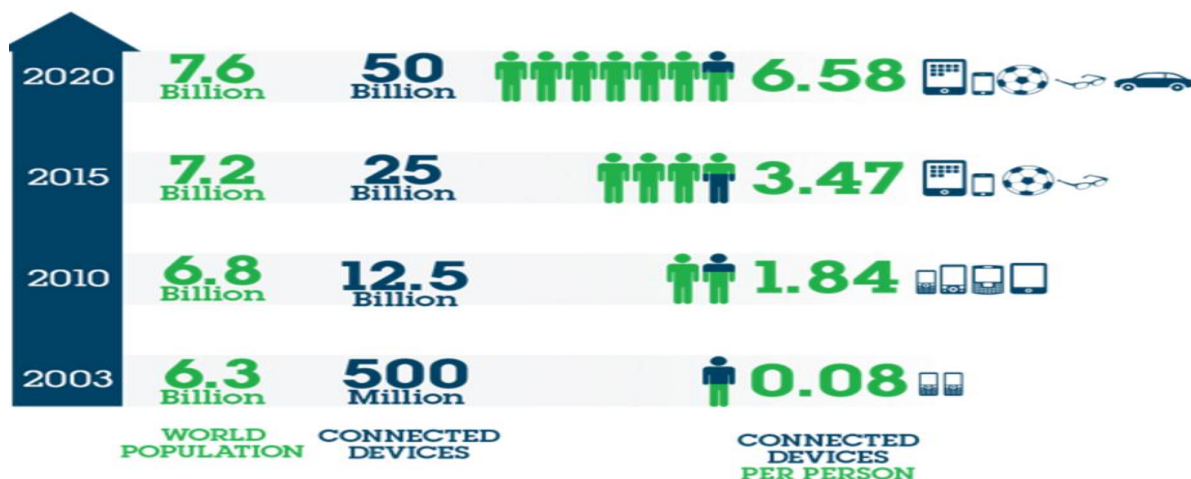

Image courtesy: Cisco IBSG, April 2011

The IOT opens the door to virtually endless opportunities and connections. Here are the few examples that clearly portrays the potential value that theIOT holds in a day to day life: An alarm clock connected to the coffee machine can instruct the machine to start brewing coffee when it rings, adjustment of the brightness of lights through mobile phone, refrigerators that inform the user on the status of the supplies, vehicles that are aware of the user schedule by accessing the calendar and can take the best possible shortest route, garbage bins that can alert the municipality when they need to be emptied.

The world is seeing the rapid adoption of theIOT technology where the objects can both sense the environment and communicate over the network without having any human intervention. The data generated by the Internet of Things will have an inherent value which will provide every industry with new opportunities to improve life for customers.

II. RELATED WORK

In [1], the author looks for the implications of IOT in human life and how it will transform the world to a world of web where in future apart from assigning IP addresses to almost all the physical objects, one might get assigned a unique IP address too. In [2], the author addresses the Internet of Things and its enabling factor which is the integration of several technologies and communication solutions. In [3, 4, 7], the authors discussed that in the last few years, the IOT has had an effect on education, communication, tradeand the public administration. It represents a paradigm: an innovationthat creates value, a range of technologies that provide objects with intelligence,making sure that they communicate with humans or with other machines, providing a

new level of interaction or information compared with the environment in which theseobjects can be found. In [5, 8], the authors present a survey of technologies, applications and research challenges for IOT, its huge potential and the major issues that need to be tackled to devise innovative technical solutions. In [6], the railway minister proposes the budget for the Indian Railways and in [9], the current IOT system "Tri-Netra" is being extensively tested to avoid calamity in the Indian Railways. In [10], the author presents the vision of the Hon'ble Prime Minister Sh. Narender Modi for empowerment of the Indian society. In [11], the author lists all the major rail accidents in India. In [12, 13], the authors find the IOT categories used to build smart enterprises and discusses how Fortune 500 companies may use various IOT applications to innovate their business models. The authors' analysis reveals that there is a significant relationship between the type of IOT applications and the IOT adoption rate and there is also a significant relationship between the type of business model innovation and the IOT adoption rate. Finally, five implementation strategies for smart enterprise development are discussed.

III. IOTECOSYSTEM

Government, Businesses and consumers are the main entities ofthe IOT ecosystem as shown in the below figure:
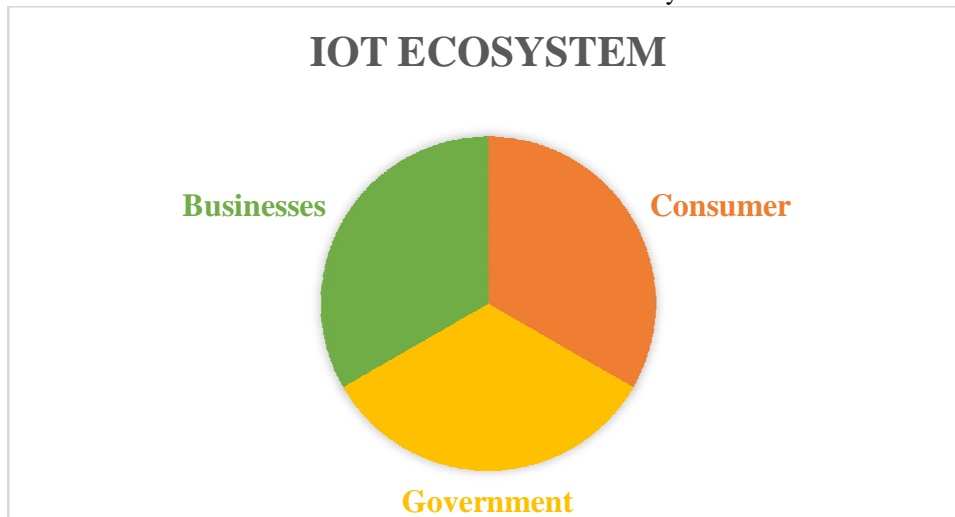
In recent years, the IOT has attracted great attention and is used in various sectors worldwide. Opportunities offered by the IOT make possible the development of a large number of applications [9].Following are the that will leverage the potential of theIOT.

- Agriculture
- Manufacturing
- Banks & PSUs
- Food Services
- Healthcare
- Defence
- Buildings
- Oil, gas and mining
- Hospitality
- Utilities
- Retail
- Logistics

IV.   IOT INDUSTRIES

A brief look at the organisations which are currently providing the IOT enabled services to the consumers:

- Apple
- IBM
- AT&T
- GE
- Honeywell
- Hitachi
- FitBit
- Google
- Skyworks
- Sierra Wireless
- Silver Spring Networks
- Nimble Storage
- Microsoft

and many more.

V.   IOTPLATFORM

The IOT applications generate huge volumes of data which require massive data storage, huge processing speed to enable real time decision making, and high-speed networks to connect to the cloud. The data have to be stored and used intelligently for analytics for which a centralized infrastructure support is required, so use of a middleware is an ideal option. Middleware is a software layer between the technological and the application levels. The presence of middleware simplifies the development of new applications and services [2].As of date, cloud computing provides an ideal solution for handling huge volumes of data and to process them for numerous IOT applications [3, 7, 13].
Some of the IOT platforms providing cloud based services in the market are:

- Microsoft Azure
- IBM's Watson
- Cisco IOT Cloud Connect
- ThingWorx IoT Platform
- Amazon Web Services
- Oracle Integrated Cloud

VI.   IOT APPLICATION DOMAIN

The Internet of Things has huge potential to develop new intelligent applications in almost every field. These applications aim at enhancing the quality of life and will have a profound impact on the economy and the society at large. Following are the typical examples of the IOT application domains:

Smart Environments:
If the heating of the rooms in the office or the homes are adjusted according to our preference, if the electrical equipment are switched off automatically when not in use, if burglary is avoided or dangerous incidents are averted by monitoring through alarm systems then our life would be much more comfortable due to the intelligence of these objects [2] in such a smart environment. Home appliances such as washing machines, air conditioners, heaters, refrigerators and many other devices can be controlled very efficiently to provide better home and energy management [3].

Healthcare
In the healthcare sector, the IOTcan offer variety of smart solutions to measure, monitor and diagnose patient's health depending on its stage. Smart devices can help patients to track their weight, BMI, sleep patterns and daily activity rate. The data collected from these smart devices can be used to track down the patient's condition in a very efficient manner. Remote monitoring of elderly is also possible and rapid response and emergency services can be deployed when needed. For example, fall detection application can help elderly or disabled people live more independently [4, 5].The rapid development of smart mobile devices and health applications creates a huge market for IOT products. Individual mobile health applications have been developed so that a patient can monitor his glucose and blood pressure level [8].

Smart Farming
The Internet of Things (IOT) can transform the agriculture industry and enable farmers to deal with with the enormous challenges they face. The farms can leverage IOT by deploying sensors that can detect condition of the soil, crop growth, livestock feed levels. These sensors can be managed remotely to control smart connected harvesters and irrigation equipment. The data collected from the sensors can be used for analytics for quick remedial solutions and improved decision making.

Security and Emergency
Internet of Things can enhance security and help government in the emergencies. Devices can alert the authorities of the possible outbreak of a natural disaster. Ambient sensors can be used to monitor the presence of dangerous chemicals or explosives. Sensors can also be used to monitor the behaviour of people to assess their involvement in the act of suspicion [5].

Smart Transportation
Smart transportation helps to realize better traffic management [4] with the data obtained by counting vehicles on the road, calculating travel time and displaying available slots in the parking. Real-time monitoring and tracking of the moving objects can be guaranteed by attaching RFID tags or sensors to the objects to bring accuracy and efficiency to the entire supply chain process.

VII.   IOT IN INDIAN RAILWAYS

The current state of the Indian Railways is best captured in the words of the railway minister Mr. Suresh Prabhu during the presentation of the 2016-17 Railway Budget[6]:
"Railway facilities have not improved very substantially over the past few decades. A fundamental reason for this is the chronic underinvestment in Railways, which has led to congestion and over-utilisation. As a consequence, capacity augmentation suffers, safety is challenged and the quality of service delivery declines, leading to poor morale, reduced efficiency, sub-optimal freight and passenger traffic, and fewer financial resources. This again feeds the vicious cycle

of under-investment. This cycle must be put to an end. The mission, is to "reorganise, restructure, rejuvenate Indian Railways".

Given the size of an organisation as huge as the Indian Railways, the mission of the Railway Minister is not going to be easy without resorting to the Internet of Things. The Internet of Things (IOT) holds a promising future in India and the push for its growth comes from the digital India initiative [10] of the Hon'ble Prime Minister Sh. Narender Modi which aims at transforming India into digital empowered society. One such initiative is to provide support to Indian railways to leverage the power of IOT to make it more safe and reliable, to maximise its services and to provide great customer satisfaction.

Indian Railways has always been the most convenient mode of long distance transport for the passengers. It plays a significant role in development and growth of industries. Over the years, the Indian Railways have shown tremendous progress both in terms of quantity and quality, however, it battles some major problems and one such problem is safety for which Indian railways have been in the news for wrong reasons. With the tremendous increase in passenger and goods traffic, the frequency of train accidents is also increasing. Below is the list of worst train accidents in India which starkly reminds the dilapidated condition of the railways [11]:

21 January 2017 – 41 deaths and 68 injured among the 600 passengers on board when a passenger train *derailed* in Kuneru.

28 December 2016 - 15 coaches of the Ajmer-Sealdah Express *derailed* near the Rura railway station while crossing a bridge, resulting in 44 injuries

20 November 2016 - Nearly 150 people died when 14 coaches of the Indore-Patna Express *derailed* near Pukhrayan station in Uttar Pradesh.

6 May 2016 - *Side collision* for the Chennai central – Thiruvananthapuram central superfast and a suburban train. Seven Injured

23 July 2014 - A school bus was hit by a Passenger train at an *unmanned railway crossing*. The bus was dragged by the train for about 200 meters. 16 students aboard the bus, the bus driver and his help died in the accident.

26 May 2014 - At least 25 killed and over 50 others injured when Gorakhdham Express *collided* with a stationary goods train.

30 July 2012 - One of the coaches of the Tamil Nadu Express *caught fire* leading to the death of 47 passengers.

2 January 2010 - Three accidents involving five trains took place in Uttar Pradesh due to *dense fog conditions*.

By far, the highest number of accidents are because of derailments & accidents at unmanned crossings. The other types of accidents include low visibility in dense fog and collisions but their number is relatively low. In times of advanced technology, frequent rail mishaps and deaths on the tracks are not acceptable. The railway system needs a generational change.

VIII.   IOTIN ACTION

IOT holds the promise to alleviate the existing shortcomings of the Indian Railways. There is a huge potential in deploying IOT devices on the trains. These devices communicate through the clouds to transmit data among themselves, send and receive instructions from the control centres, provide data on track status, water table levels and much more. Indian Railways is regressively testing an IOT based advanced system called "Tri-Netra" - Terrain imaging for diesel dRivers INfra-red, Enhanced opTical & Radar Assisted system[9] to overcome the challenges faced by the drivers during dense fog, heavy rains and in night. Tri-Netra system is made up of high-resolution optical video camera, high sensitivity infra-red video camera and a radar-based terrain mapping system which capture images and displays a composite image in front of the driver to spot any obstruction on the track. With Tri-Netra, the driver can apply the brakes well in time, maintain speed in poor visibility and avoid arrival delays.

In addition to the Tri-Netra, deployment of infrared sensors up and down the railway tracks can monitor air and track temperature and send the alerts, the sensors when onboard, can monitor equipment for signs of wear and tear, microphones can be placed along the trackside to record any unusual noises from wheel bearings, on the board monitoring systems can display the train velocity on the screen in front of the drivers and wayside signaling system can regulate the train speeds and command to halt if there is a presence of other train on the track. Fibre optics laid down across the length of the tracks will provide network connectivity to enable the devices to send and receive the data remotely from the control centres.

The data collected from the smart sensors can be used to significantly reduce accidents, track inventory, manage assets, improve driving performance, optimise energy consumption, reduced costs and better customer service. By employing these preventive and predictive measures there could be tremendous increase in the passenger and revenue volumes for the Indian Railways.

IX. CHALLENGES

The Internet of Things will bring a paradigm shift in the operations of the Indian Railways. However, addressing the existing issues and opening up the new possibilities requires to deal innovatively with its associated challenges:

1. Being a developing country, India lacks the Internet infrastructure. So, for the IOT to progress impressively it is imperative to have a robust Internet connectivity across the length and breadth of India.
2. Indian Railways have done substantial investments in the legacy systems which are not designed to connect and communicate. The challenge lies in connecting these legacy systems with the IOT systems to keep the replacement costs at the minimum
3. IOT is a very complex heterogeneous network of networks[8]. To tie all the subsystems of the IOT together, we need to have an infrastructure that supports Big data storage. Current computer systems or sensors do not have enough storage to keep all this data [12]. The amount of data that will be occurred by billions of connected objects will increase incredibly and we need complex and efficient analytics to work on this data to assist decision making.
4. Interrelated with the issues of safety and connectivity is the matter of security and with such an enormous amount of relevant data, it is vital to keep it safe and secure from the outside interference and intrusion.

X. CONCLUSION

Internet of Things is dramatically different than the Internet that we use today. It is the evolution of the Internet and has the potential to reshape the world by playing an important role in the future emerging technologies. Given the Prime Minister's resolve to make India a digital country, it is obvious that the future of IOT in India is a promising one. The need is to apply data analytics to the huge volumes of data churned out which encompass all aspects — millions travelling long or short distance at any given time, ticket reservations, point of sales of various items in stations; locomotives and freight cars, loading and unloading of freight, repairs and services, vendor management and thousands of employees behind the scene.The government is fully backing the effort to develop better infrastructure, companies are coming out with innovative products, and industries understand the benefits that IOT provides. With more time and resources, IOT progress in the Indian Railways could prove to be impressive on a large scale.

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