Internet of Everything – A Literature Review.

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ABSTRACT

"Internet of Things" has become a buzzword of 21st century. The vims and fancy of the human imagination to do things with magic has come into realization. There is greater potential in utilizing the endless possibilities of IoT for a larger good of mankind. Internet of Everything refers to the holistic approach that employs IoT to govern the process driven system. This paper discusses the broad-spectrum coverage of Internet of Everything encompassing IoT applications in public and private sectors. The operational differences between IoT and IoE are highlighted with various case studies in Domestic and Global scenario.

Keywords: IoE, IoT, Edge Computing, Smart Grid, Intelligent Transport System.

INTRODUCTION

Conventionally, "Internet of Things" refers to a colossal scheme of appliances, equipment, objects, animals, humans fitted with devices [that collect the information] called as S*ensors* , the data then drives the devices [that act on the information] called as *Actuators.* This kind of traditional system focuses on "*Things"* and is driven by "*Data"* and may lack legal and ethical standards that protects individuals' privacy and social safety [1].

As per CISCO; [1] who first coined the term "*Internet of Everything*"; IoE refers to interconnected *things* fuelled by *data,* controlled by *processes* and driven by *People.* Drawing parlance to old programming paradigm, IoT is like "*Procedural Programming*" approach where data is global and must be processed in a sequential fashion, the actions are more of reactions to current state of Data[3].

On the contrary, IoE presents an "*Object Oriented approach*" that ensures Data Abstraction (Privacy) and Encapsulation (by processes). Thus IoE is a superset of IoT that is founded on four pillars of Things, Data, Process and People.
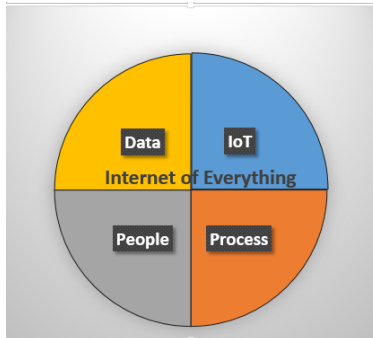

Fig 1: Internet of Everything

IOE ARCHITECTURE

IoT is A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network[4] while IoE is a networked connection between People-to-people (P2P), Machine-to-machine (M2M) and People-to-Machine (P2M) controlled centrally by processes that deliver right information to the right people or machine at the right time. [2] IoE is built on four pillars of People, Process, Data and Things[5].

IoE can be characterized [6] by one or more of the following –
1. Decentralization of Business
2. Data Analytics at the Edge (fog computing)
3. Distributed Ledger (Blockchain)
4. Distributed Information Capture .
5. Decentralization of work backed up by
6. Distributed Network and Cloud services

APPLICATIONS OF IOE

The Applications of IoE are inherently clustering of various applications of IoT maintained by Edge Computing and further controlled by a layer of abstraction of distributed processes managed by People involved in policy and decision making for a larger audience

1 Energy Sector – Smart Grid

Traditionally, an electric grid is a backbone electric network of Power Generation Units, transmission lines, substations, transformers and energy meters that deliver electricity from the power plant to your electric socket, essentially this was built for more than 100 years now and in the modern era, this needs ICT support at every stage of generation, transmission and distribution of Energy.[7] The IoE based smart grid initiative in U.S.A. ensures reliable and efficient energy distribution, reduces frequency, duration and impact of power outages. [8] The Grid is an umbrella of private and public sector operators contributing to distributed supply chain of natural and renewable energy. The Australian Smart Grid project (funded by COAG) based on IoE that embraced Edge Computing and Artificial Intelligence to ensure real-time consumption monitoring, futuristic Energy generation and distribution road-map. [9] The SGSC consumer report highlighted increased awareness and positive consumer (people) engagement which is considered as one of the pillars of IoE. European Union has invested majorly in Smart Grid project and targets to reduce overall energy consumption, increase in renewable energy sources and reduction in green-house gases [12], The Grid needs to adapt to a well-accepted metering standards, and Inter-country distribution policy. In India, [10] Power Grid Corporation of India has come up with a comprehensive plan for integration of renewable (solar and wind) and traditional grid to generate and distribute about 43GW of energy by 2022. The proposed system will work to strengthen Intra/Inter-state transmission and other related infrastructure like dynamic reactive compensation, energy storage, smart grid applications, forecasting of renewable generation, real time monitoring, establishment of renewable energy management center, electric vehicles, investment etc. The union Territory of Puduchchery has implemented smart grid project using IoE technology [11] that ensures grid stability at peak hours, renewable integration, self-healing grid that ensures increased revenue and asset utilization.

2 Smart City

As in 2010, half of the world's population lived in urban areas and this figure is forecasted to rise to 75% by 2050[15] . Due to this ever increasing population thrust, City municipal corporations are forced to adapt to ICT based infrastructure advances through revived economic development policies. According to Forrester [16] - A smart city is the one that uses Smart Computing technologies to make the critical infrastructure components and services of a city — which include city administration, education, healthcare, public safety, real estate, transportation, and utilities — more intelligent, interconnected, and efficient. There are various smart City initiatives implemented through IoE. The initiatives include Intelligent Transport Systems (ITS) which is capable of managing traffic lights, dynamic signage, speed control systems, smart parking, car sharing, and public infrastructure (in terms of streets, roads, cycle paths, public transport stations, parking) management.

In Sii-Mobility, a national smart city project from Florence, Italy [13] the IoE intuitive works on online traffic monitoring of major intersections across city and dynamic routing in congested area. This system also analyses traffic patterns and data analytics fed back to consumers to ensure travel time reduction and hassle-free commute.

IoE based Smart City initiative for Barcelona [14] encourages open Data access to leverage inter-departmental synchronization to better manage public utilities, recreation and other facilities, and to manage open and green spaces. The scheme also leverages new employment opportunities and public housing.
According to Smart City Initiative of Govt. of India [17], there are 100 cities identified to implement various features such as housing and inclusiveness, Open creative spaces and safe neighborhoods, Cheap and round the clock transport, water and other utilities etc.

Pune being one of the smart city have taken IoE based initiative in Smart Street lighting by replacing 77800 conventional street lamps with LED controlled by 300 SCADA panels being monitored and controlled through Integrated Control Center. Lamp-posts are installed with Air-pollution sensors, Wi-Fi access points, CCTV and explicit Panic buttons which are constantly monitored and responded. Another smart initiative is Bio-degradable waste recycling using anaerobic composting to generated Power, Compost and QRDF (Quality Refuse Derived Fuel) based on IoE technology that integrates waste collection, segregation, composting and disposal.

3 HealthCare

IoT enabled wearable, implantable, environmental sensors, wireless health monitoring and record tracking devices have simplified Patient's health-care system to great extent. This has greatly enhanced accuracy in diagnosis, Treatment and considerably reduced costs and failure rates. The high precision automation in reactive and proactive health-care is of utmost importance than any other IoE environment as it directly affects human life [1].

Prescription refills, Dosage monitoring, Imaging, Scanning, Pathological Report tracking, Vital-stats monitoring and Alerting Systems, Universal access to Electronic Medical Records (EMR) Patient-care, assistance and Rehabilitation are some of the major applications of IoT-Cloud Computing based systems [18-19]

The patient health monitoring system 'BSN-Care' [20] proposes a secure and anonymous IoT based sensor response system that uses more secure data transmission, storage at Edge.

CHALLENGES AND LIMITATIONS

IoE by nature is more complex and distributed. The technical challenge lies in setting up thousands of terminal devices (sensors and actuators) at IoE – Edge. Ensuring continuous power-supply/battery back-up. Secure data collection and Aggregation. Compatibility between devices, protocols and applications. Managing the pace with the Big Data generated by these devices, Employing Data Mining Techniques and Artificial Intelligence in Data Analytics, Cyber-security over Cloud. Apart from these, there are more societal challenges like privacy and safety of

consumers, Data Anonymity. Further, the financial requirement of IoE environment requires a strong political will and foresight-full governance.

The scope of research in this paper is limited to literature review of actual implementation of IoE based initiatives in Govt. / private / public sectors, it does not cover technological aspect [Gap Analysis and Proposed Solutions] in detail. The Author has tried to cover the latest Domestic and Global changes and challenges.

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CONCLUSION

It is estimated that 37 billion new things will be connected by 2020 and there will be $4.6 trillion investment in IoE based Infrastructure projects at Domestic and International levels [1]. Securely managing such huge amount of devices and data generated by them is going to pose a high risk and needs well defined processes so that the Wisdom (Generated by Data Analytics) can be used for betterment of humanity.

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