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The Paradigm of CloudIoT: Applications and Challenges

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Abstract*: *The convergence of Internet with the Radio Frequency Identification devices, sensors and other smart devices is termed as Internet-of-Things (IoT). In this concept, the present internet is extended to accommodate every such device which can be powered up or down. The future seems to be drowned in such sensing devices. IoT is seen as a whole new world in which most of the devices are connected and transmit information from one process, place or people to another. Such information could be processed and analyzed to provide understanding and insights. The basic idea of IoT is that it is virtually possible for every physical object in this world to become a computer. The recent advancements in technology have seen the shift of society towards an always connected paradigm that basically realizes the idea of "Internet of Everything (IoE)". This article explores various aspects associated with Internet of Everything fuelled by Smart Sensor Technology. Further, the emergence of CloudIoT paradigm and various challenges associated with it have been discussed. The impact of COVID-19 on CloudIoT market has also been discussed in brief.

Keywords* : *Internet of things, RFID, Smart Sensors, CloudIoT.

I. INTRODUCTION

The exponentially increasing worldwide adoption of Internet of Things (IoT)[2] has led to the integration of people, processes, data and things connected over public or private networks into a much wider paradigm called Internet of Everything (IoE)[1]. The backbone of the interfaces between the people, processes, data and things of IoE are sensors which facilitate a variety of monitoring and control based applications such as smart grids, battlefield surveillance and situational awareness and other scientific experiments. The associated technology is termed as smart sensor technology.

There are various kinds of sensors (Figure 1) such as audio sensors, infrared/electro-optical, temperature sensors, bio-sensors, radiation and chemical detectors, RF detectors, Molecular sensors, laser, cameras, RFID, Geolocalization, engine monitoring, NVG, thermal imaging, performance monitoring. But, what makes them smart? When a raw sensor is integrated with computing capabilities and is packed together with a CPU, it is termed as a "smart sensor"[3].

This integrated sensor is adaptive and reacts to the environmental conditions to facilitate decision making. These are applicable in various domains such as healthcare, smart cities, smart homes and smart metering, video surveillance, smart mobile systems, smart energy grids, logistics, environmental modeling etc. With the emergence of location based technology, transportation and travel industries have also been strongly benefitted from smart sensing devices that could relay back locally processed information to the central stations for integrated processing and analysis.

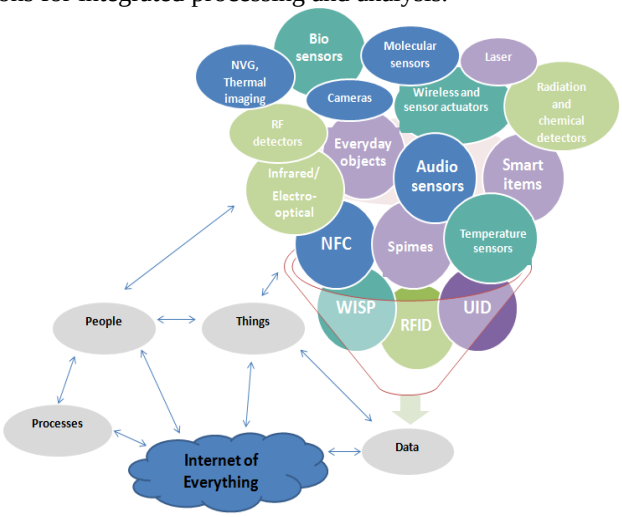

Figure 1: Paradigm of Internet of Everything (IoE)

II. APPLICATIONS OF SMART SENSOR TECHNOLOGY

The advancements in smart sensor technology have led to the emergence of various application-specific sensing devices such as smart bicycle pedals, autonomous bus sensors, smart parking sensor lights, telepathic communication devices, autonomous food delivering robots, self-driving car sensors, sensor-packed electric scooters, mobile meal-sharing communities, pet passenger trackers, honking traffic sensors, smart walking aids, autonomous flying cameras, vandal-detecting projects, Bluetooth traffic sensors, cyclist traffic light sensors, crop monitoring robots, etc[4].

Other instances of smart sensor technology have been summarized in Table-I. Imagine a world where all these domains will be interconnected, that will be everything of "Internet of Everything".

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Table-I: Applications of Smart Sensor Technology [5]

Application	Smart Sensor Technology
Smart Cities	Smart parking systems, Structural health monitoring capabilities, mapping the urban noise levels, detecting smartphones and EM field levels, monitoring traffic congestion, smart lights, management of waste, smart roads
Smart Environment	Detecting forest fires and air pollution levels, Monitoring snow cap levels, preventing landslides and avalanche, early detection of earthquakes
Smart Water	Detecting chemical leakage in rivers, water monitoring, remotely measuring swimming pools and pollution levels in sea, water leakage, floods and river water pollution monitoring [22]
Smart Metering	Smart grid system, Monitoring levels of tanks, installations of photovoltaic systems, measuring water flow and calculating soils stock.
Security & Emergencies	Access control in perimeters, detecting presence of liquid, measuring radiation levels, explosives and hazardous gases
Retail	Controlling supply chain, Intelligent shopping applications, managing smart products.
Logistics	Shipment quality measurement, Searching location of Items, detecting incompatibility of storage, Tracking fleet.
Industrial Control	Mobile to mobile applications, Indoor Air Quality and temperature monitoring, Ozone presence detection, Indoor location analysis, auto-diagnosis of vehicles, vibration measurement and bearing fault detection[23]
Smart Animal Farming	Hydroponics approach, care of offsprings, tracking animals, monitoring toxic gas levels
Smart Agriculture	Enhancing wine quality, controlling green house gases, dry areas selective irrigation, meteorological station network
Smart Home	Energy and water usage, Appliances controlled remotely, Intrusion Detection systems, preservation of art
Healthcare	Automatic falls detection, medical fridges, care of sportsmen, Surveillance of patients, measuring effects of ultraviolet radiation, falls detection in a residential aged care environment[21]
Smart Devices[24]	Gait, balance, and range of motion analysis

III. CLOUD-IOT: INTEGRATION OF INTERNET OF THINGS WITH CLOUD COMPUTING

Cloud computing has been defined by the National Institute of Standards and Technologies (NIST)[6] as an enabler of ubiquitous, convenient, on-demand access to various resources like networks, applications, storage and servers. The main idea is the rapid provisioning of such access with minimal amount of support required from the management or the service providers.

Cloud computing model makes the processing capabilities faster and effective at low costs and provides unlimited virtual storage with high availability so that the virtualized resources could be provided in an on demand manner [7]. Technology giants like Amazon, Google, Facebook, etc. have widely adopted this paradigm to provide faster real-time services over the Internet thereby achieving social, economic and technical benefits.

The two important terms of this decade i.e. "Cloud" and "IoT" have seen a rapid and independent evolution. The unlimited capacities and resources of cloud can benefit the IoT and compensate its technological constraints such as storage, processing, communication. For example, Applications and services can exploit the benefits of cloud for their effective implementation and management [8].

On the other hand, IoT can also prove beneficial for the Cloud by providing extended scope to face the real world things in a dynamically distributed manner[27]. As a case basis, things and applications can be separated by an intermediate level called Cloud, so as to provide abstraction by hiding the complex and functional details. The development of future applications can be hugely impacted by bringing about new challenges in information gathering, transmission and processing in multi-cloud environments [9,10].

CloudIoT gave rise to various new smart services and applications that have the potential to strongly impact everyday life. But these application domains address different set of challenges which need to be addressed by thorough research. Table-II provides a comparative analysis of such application domains discussed in various studies in the light of CloudIoT.

Now-a-days various companies are providing their own CloudIoT solutions containing the complete set of tools required to perform various operations on data. Therefore a whole market of CloudIoT is on the rise. However, due to COVID-19 outbreak, there has been a huge impact on this market according to a new Study on "2020-2026 Internet of Things (IoT) Cloud Platform Market Global Key Player, Demand, Growth, Opportunities and Analysis Forecast"[28] due to lockdowns imposed all over the world, the closing of restaurants, offices, flight ticket cancellations etc. The global tech giants should now come up with innovative ways to mould their solutions to the new normal during these times.

Table-II: Application Domains of CloudIoT and associated challeges

Application Domain(s)	Benefits	Identified Challenges
Healthcare[11,12,13]	• Improvement in healthcare services • Ambient assisted living • Accumulation of vital data of patient using a sensor network connected to the medical devices • Delivering the data to cloud for storage and processing • Medical data sharing as electronic health records (EHR) • m-health: monitoring student stress levels in fog-Cloud IoT environment[25]	• Security and privacy of healthcare information • Reliability of the results from sensor based devices • Enhancement of medical data security • Keeping the services available by ensuring redundancy
Smart Cities and Communities[14]	• Capturing information from different sensing infrastructures and accessing different geo-locations and IoT technologies • Representation of information uniformly (e.g., through a map which is dynamically annotated). • Sensing as a service • Providing and supporting pervasive connectivity • Supporting real-time applications for smart cities	• Harnessing the collaborative power of information and communication technology networks. • Secure, Reliable, Heterogeneous and timely data delivery • Transparency in providing computing capabilities for huge volume of heterogeneous and customized data • Setting up and deployment of sensors and effective integration of new sensors in the sensing environment
Smart Home[26] and Smart Metering[15]	• Improvement in power use habits by monitoring the power use of smart devices. • Management of air conditioning, lighting and heating • Intelligent remote control and Automation	• Limitation of reliability • Lack of standards • Web-enabled household devices should provide uniform interaction. • Quality of service is variable. • Devices are not always available and reachable, may fail at times. • To make the appliances easily discoverable, recognition routines are required.
Video Surveillance[16]	VSaaS: Implementation of complex analysis in the cloud and provisioning of ubiquitous access to video recordings	• The camera connection and control sometimes fail due to mismatch between enabling technology and tools. • There is a limitation of properly defined standards and schemes which leads to incompatibility and heterogeneity between various smart devices
Smart Mobility and Automotive Industry[17]	• Road safety can be increased. • Traffic congestion can be reduced • Traffic monitoring and safe parking can be done • Warranty analysis can be performed effectively • Car recommendations for maintenance and servicing.	• System could not be scaled effectively due to large number of vehicles and change in their number dynamically. • Quality of service, Reliability and performance is affected due to movement of vehicles at various speeds. • Authorization and authentication is also affected due to limitation of established infrastructure.
Smart Energy and Smart Grid[18]	• Consumption and distribution of energy can be managed intelligently and effectively. • Response in demand can be monitored. • Generation, distribution and quality of electricity can be analyzed	• The enforcement of security is quite costly. • Size, volume and velocity of data, its heterogeneous nature and collection rate are other concerns. • Latency dynamics • Ensuring privacy and security is important • If the data is exposed to attacks for longer durations, it can be devastating. • Data having varied owners can be integrated. • Public and private data can be aggregated.
Smart Logistics[19]	• The starting and ending points of consumption can be connected via an automatic route for flow of goods, which makes the process much easier. • Track goods while in transit (geo-tagging technologies)	Resource sharing and Dynamic allocation
Environmental Monitoring[20]	• The water levels in lakes, streams, sweages and other water bodies can be continually monitored for long terms. • The laboratories and deposits have gas concentration which can be monitored. • Bridges and damns inclination can be checked. • Humidity in soil and other characteristics can be checked. • Landslides monitoring and prevention • Detecting intruders in dark places by lighting conditions. • Fire or animal detection using Infrared radiation	• The infrastructures are massive in scale • The computational resources are limited to cope with changing environment conditions.

IV. CONCLUSION

The Internet of Everything facilitated by Smart Sensor technology has marked the onset of an everything-connected world. There are numerous applications where smart sensors could revolutionize decision making by making the processes simpler, efficient and faster. The integration of the Cloud Computing and Internet of things into CloudIoT is another big leap towards a smarter world. But the effective and secure implementation of IoE and CloudIoT paradigms require addressing several challenges associated with them. In this article, such application specific challenges have been identified to provide an insight for further research.

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