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A Study on Emerging IoT: Technologies, Recent advances and Applications

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ABSTRACT: As everyone now a days are aware that the hype around the Internet of Things (IOT) is huge. Day to day, new IoT based product get released into the market making human life more comfortable. Based on emerging technologies and smart sensor, IoT provide large application in various fields. The future is Internet of Things, which will transform the real world objects into intelligent virtual objects. In this paper, IoT has been defined by its major characteristics; also various technologies which go hand in hand with IoT are listed. This paper mainly focuses on several recent advancements that are made with IoT leading to comfortable life with minimum or without human intervention; also application of IoT in various domains has been mentioned in this paper. However, the content of this manuscript will be helpful for the new researchers to innovate more ideas in the field of IoT.

KEYWORDS: Internet of Things (IoT), NFC, RDIF, IoT sensors, Data analytics, MQTT protocol.

I. INTRODUCTION

The Internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The rapid development of information technology (IT) has brought forward a hyper connected society in which objects are connected to mobile devices and the Internet and communicate with one another [1].In the 21st century, we want to be connected with anything anytime and anywhere, which is already happening in various places around the world. The core component of this hyper connected society is IoT, which is also referred to as Machine to Machine (M2M) communication or Internet of Everything (IoE).

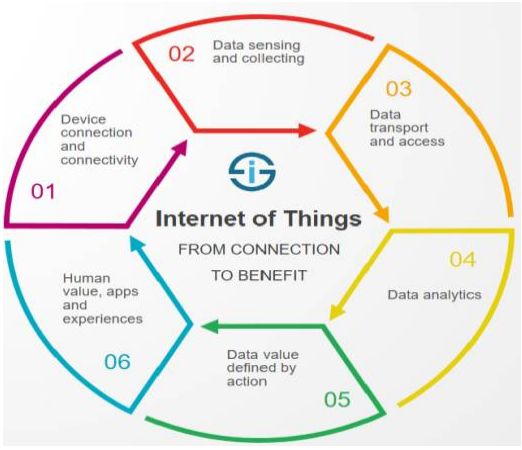

Figure: Defining Internet of Things

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Internet of Things represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where it can be processed and utilized for various interesting purposes.
IoT can be briefly explained with its 6 characteristics shown in the above figure [2]:
1)*Device Connectivity:* Internet connectivity is either available within the device itself or can be provided by a hub, smartphone or access point (base station). If connectivity is provided by an access point then it is most probably collecting data and operational information from a range of sensors for a specific device and then communicating with the cloud to relay this information.
2)*Sensing and data collection:* The communication infrastructure in an IoT environment is enhanced using sensors attached to every device. Each sensor node is connected to each other using a wireless sensor network. A sensor node is used to detect various parameters such as temperature, pressure, motion and light .
3)*Data transport and access:* Data transport is certainly one of the more critical pieces of IoT development, providing data stream support and data flow control and ensuring that messages arrive reliably. Devices must communicate with each other (D2D). Device data then must be collected and sent to the server infrastructure (D2S). That server infrastructure has to share device data (S2S), possibly providing it back to devices, to analysis programs, or to people. Some of the protocols used: MQTT,XMPP,DDS and AMQP.
4)*Data analytics:* Big data technology, such as Hadoop and NoSQL, provide the ability to rapidly collect, store and analyze large volumes of disparate IoT data. The data collected in the cloud is analysed by Big Data analytics strategy to examine patterns of interest as data is being created – in real time and evaluating thresholds to predicting future scenarios .
5)*Data value defined by action:* Depending on the data value and threshold value generated at the analytics edge ,corresponding action taken through sensors , tags and Apps.
6)*Apps and Experience:* At the user end Web Application designed using HTML,PHP and other languages and Mobile application developed in Android is designed to provide a smart GUI acceding data from user and sensors, providing the results either in action or data value.

In recent years, the concept of the Internet of Things (IoT) is gaining momentum due to the development of the wireless networking technologies, such as Long Term Evolution Advanced (LTE-A), Wireless Fidelity (WiFi), Bluetooth, Zig-Bee, and so forth. Conventionally, these network technologies are utilized for establishing communication from the Person to Person (P2P) or the Person to Machine (P2M) perspectives. However, due to the diversification of the network equipment, Machine-to-Machine (M2M) communication is also utilized in numerous circumstances, such as inside homes, commercial buildings, schools, hospitals, and factories. The development of smaller and less expensive wireless devices enables not only smart-phones, tablets, and personal computers but also cars, home electrical appliances, and so forth, in order to connect them to the Internet. For example, electric lights, air conditioners, and water heaters can be connected to the network inside a building, and thus, they may be controlled for optimizing the environment inside the building with minimum power consumption.

II. LITERATURE REVIEW

As early as 1832, IOT was conceptualized when an electromagnetic telegraph was made by Russian Scientist Baron Schilling. Similarly in 1833, Carl Friedrich Gauss and Wilhelm Weber developed a code to send communication signals over 1200 meter distance in Germany and this started a development towards the IOT. As early as 1982, a concept of smart devices was discussed at Carnegie University in USA where Coke machine was reformed to be first machine connected onto internet and thus created the smart device based first application of IOT.
As of 2016, the vision of the INTERNET OF THINGS or INTERNET OF EVERYTHING or INTERNET OF OBJECTS has advanced due to merger of technologies. This means that the embedded computer systems, wireless sensor grids, control devices and systems, automated machines and its applications used in home and building automation or all such options enable IOT and work on the concept of IOT. [1][2] The IoT is a technological revolution that represents the future of communications and computing technology, and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology.

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A. *Technologies:*

The IoT communication technologies support heterogeneous smart devices or smart objects to communicate to each other providing smart services. These smart devices should work efficiently with low power consumption and high battery life. There are many Short-range M2M wireless technologies or protocols are used in IoT are listed below:

i)*RDIF:*

RDIF are wireless microchips that use electromagnetic fields to transfer data of automated identification and tracking of tags attached to the objects[4][5].These RDIF system consists of tags and readers. As shown in the diagram below, the tag contains all the details of the object including unqiue IDs and using the RDIF reader ,details of the object is read and transferred through antenna to enterprise systems, thereby it tracks the location of object without the requirement of line of sight.

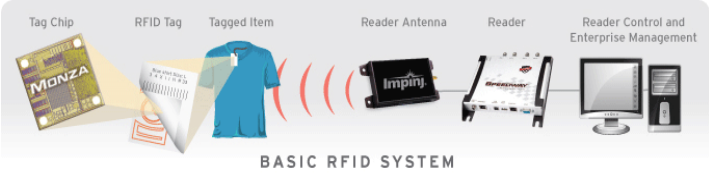

Figure: RDIF tag and RDIF reader

ii) *IP:*

The Internet Protocol (IP) is the principal communications protocol in the Internet protocol suite for relaying datagrams across network boundaries. Its routing function enables internetworking, and essentially establishes the Internet.

IP has the task of delivering packets from the source host to the destination host solely based on the IP addresses in the packet headers. For this purpose, IP defines packet structures that encapsulate the data to be delivered. It also defines addressing methods that are used to label the datagram with source and destination information.

Historically, IP was the connectionless datagram service in the original Transmission Control Program introduced by Vint Cerf and Bob Kahn in 1974; the other being the connection-oriented Transmission Control Protocol (TCP). The Internet protocol suite is therefore often referred to as TCP/IP.

The first major version of IP, Internet Protocol Version 4 (IPv4), is the dominant protocol of the Internet. Its successor is Internet Protocol Version 6 (IPv6). Internet Protocol version 4 (IPv4) was the first major version of IP. This is the dominant protocol of the Internet. However, iPv6 is active and in use, and its deployment is increasing all over the world.

iii) *Barcode:*

A barcode is an optical, machine-readable, representation of data; the data usually describes something about the object that carries the barcode. Originally barcodes systematically represented data by varying the widths and spacings of parallel lines, and may be referred to as linear or one-dimensional (1D). Later two-dimensional (2D) codes were developed, using rectangles, dots, hexagons and other geometric patterns in two dimensions, usually called barcodes although they do not use bars as such. Barcodes originally were scanned by special optical scanners called barcode readers. Later applications software became available for devices that could read images, such as smartphones with cameras.

iv) *Wi-Fi:*

Wi-Fi or Wireless Fidelity is a technology for wireless local area networking with devices based on the IEEE 802.11 standards. Devices that can use Wi-Fi technology include personal computers, video-game consoles, Smartphone's, digital cameras, tablet computers, digital audio players and modern printers. Wi-Fi compatible devices can connect to the Internet via a WLAN network and a wireless access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometres achieved by using multiple overlapping access points. Wi-Fi most commonly uses the 2.4 gigahertz (12 cm) UHF and 5 gigahertz

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(6 cm) SHF ISM radio bands. Having no physical connections, it is more vulnerable to attack than wired connections, such as Ethernet.

v) *Bluetooth:*
Bluetooth is a short-range wireless technology which connects various devices such as notebook PC's, handheld PC's, PDA's, camera's., etc in the range of 10-100meter.Bluetooth uses the specification of IEEE 802.15.1 standards and can communicate at the speed of 1Mbps.bout 2-8 devices can connected to each other forming a piconet and share data such as text, picture, video and audio.

vi) *Radio Protocols:*
ZigBee, Z-Wave, and Thread are radio protocols for creating low-rate private area networks. These technologies are low-power, but offer high throughput unlike many similar options. This increases the power of small local device networks without the typical costs.
ZigBee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations.
ZigBee technology builds on IEEE standard 802.15.4 which defines the physical and MAC layers. Above this, ZigBee defines the application and security layer specifications enabling interoperability between products from different manufacturers. In this way ZigBee is a superset of the 802.15.4 specification.
Z-Wave devices are deployed for smart home automation and for business automation etc. Z-Wave supports 30meters P2P communication and operates at 900MHz frequency and allows data transmission range 40kbps to 200kbps.

vii) *NFC:*
Near Field Communication (NFC) is a set of short-range wireless technologies, typically requiring a distance of 4cm or less to initiate a connection. NFC allows you to share small payloads of data between an NFC tag and an Android-powered device, or between two Android-powered devices.
Tags can range in complexity. Simple tags offer just read and write semantics, sometimes with one-time-programmable areas to make the card read-only. More complex tags offer math operations, and have cryptographic hardware to authenticate access to a sector. The most sophisticated tags contain operating environments, allowing complex interactions with code executing on the tag. The data stored in the tag can also be written in a variety of formats, but many of the Android framework APIs are based around a NFC Forum standard called NDEF (NFC Data Exchange Format)

viii) *WSN:*
A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes (see Figure 1). The wireless protocol you select depends on your application requirements. Some of the available standards include 2.4 GHz radios based on either IEEE 802.15.4 or IEEE 802.11 (Wi-Fi) standards or proprietary radios, which are usually 900 MHz.

ix) *Actuators:*
An actuator is something that converts energy into motion. It also can be used to apply a force. An actuator typically is a mechanical device that takes energy — usually energy that is created by air, electricity or liquid — and converts it into some kind of motion. That motion can be in virtually any form, such as blocking, clamping or ejecting. Actuators typically are used in manufacturing or industrial applications and might be used in devices such as motors, pumps, switches and valves. Actuators are mainly of 5 types: Hydraulic, Pneumatic, Electric, Thermal and Mechanical.

x) *LTE-A:*
LTE-A, or LTE Advanced, delivers an important upgrade to LTE technology by increasing not only its coverage, but also reducing its latency and raising its throughput. It gives IoT a tremendous power through expanding its range, with its most significant applications being vehicle, UAV, and similar communication.

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III. RECENT ADVANCES

A. *Smart clothing with NFC tag:*

A micro-NFC chip which is waterproof, dustproof and light proof is embedded within the clothes. The chip has a unique Id encrypted and written into it during manufacturing itself. The manufacturer will create a new entry with his side of details for the Id and fills the table data. The retailer, after selling the product will fill a few more additional details about the date of sale, date of purchase from the manufacturer, billing details, MRP, offers valid .,etc. In the user side, the tag will be scanned by the Mobile Application; the Id will be decrypted and read which is cross referenced with the database and retrieved[6][7]. The user will fill the remaining fields such as name, skin tone, reference number, etc before using the cloth.

A single relational database with a number of tables and fields is stored in the cloud environment. This database is used to serve the queries of the manufacturers, retailers and end users. A mobile application based on android platform is developed which acts as a interface between the end user and interactive clothes. This application acts as a personal stylist which suggests a colour, type of outfits., based of users input for particular occasion, skin tone, climatic conditions. It also lists number of times cloths was washed, used and recommends type of wash for the fabric.

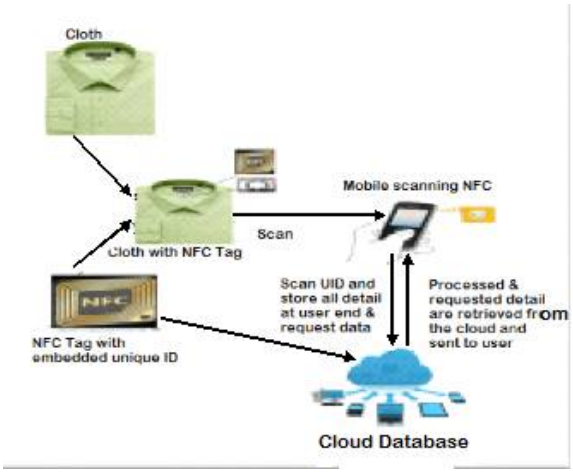

Figure: NFC chip embedded within the cloth

B. *Smart home with IoT sensors:*

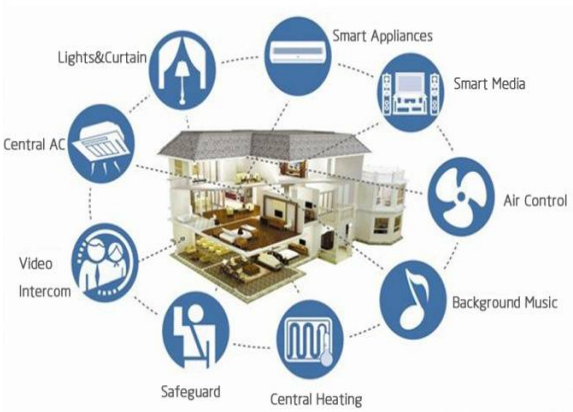

Figure: Smart sensors embedded in home appliances

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The home can be made smart by using IoT technology which 3 components: Server, Network gateway and Smart devices. This smart devices are sensors which are embedded into curtains, appliances (AC, fans, DVD players.. Etc), TVs, background music system as shown in the above figure[3]. Depending on the sensors data the particular device or appliances are operated automatically, for example the sensors embedded in the curtains senses the light from outside through window, if it senses more light then it automatically opens the curtain or if light reduces gradually and reaches some threshold value then it automatically closes the curtains .This technology make the home smarter by less human work and interferences.

C. *Smart Parking with IoT:*

Smart parking can be implemented with IoT reducing the time of the user to search for the vacant parking area/slot. This system includes several components giving a major contribution in their own role.

The sensors like infrared-used to indicate vehicle presence with red and empty area with green, ultrasonic sensor-used in the parking slot to indicate whether the parking slot is vacant or not.[8][9] The data collected from these sensors are sent to the Raspberry pi processor using ESP8266 chip. The data is then sent from Raspberry pi to the MQTT server through MQTT (message queue telemetry transport) protocol, which is the stored on cloud. The server hosted o the cloud acts as a database storing all the information regarding no. of parking slots, vacant slots, registered end user, car number, duration of parking (in hours),amount paid ,mode of payment .,etc. A mobile application is created I android and iOS platform with JSON format; this acts as a intermediary between end user and server. The end user can install the app in his mobile, register himself, search for the vacant slot around his destination, book for the vacant slot, pay the parking charges and finally confirm the occupancy through his app. So, with this designed automatic smart parking system which is simple, economic and provides effective solution to reduce the risk of finding the parking slots in any parking area and also it eliminates unnecessary travelling of vehicles across the filled parking slots in a city.

D. *Safe driving using IRIS scanner:*

It was based on research that about 40% of road accidents were caused due to drowsiness of the driver .There were many R&D carried out on this and in IEEE paper by F. Fabian and B. Yang titled as "Drowsiness monitoring by steering and lane data based features under real driving conditions", Signal Processing, pp. 209-213, 2010 stated that accidents caused due to drowsy driving should be detected and visual or auditory warning should be given to the driver. The tools such as Volvo 2020 and IoT Alarm clock which works with support of IoT based software takes the signals given by the sensor. This sensor monitors the driver's alertness or drowsiness and alerts the driver through alarm.

Another paper [10] proposed additional technique based on IoT of using IRIS scanner in the vehicle and alarm embedded in music system .This IRIS scanner scans the drivers eyes continuously ,if the driver closes his for 2sec, the scanner activates the alarm and rings loudly. With this the driver becomes conscious and drives ahead safely .The driver is given a option of switching on/off the functionality of this system, by switching on this system it ensures the safe driving and thereby saves lives.

E. *Smart crop-field monitoring and irrigation with IoT:*

Agriculture plays major role in the country, here IoT is used to make agriculture smarter to increase the productivity, to minimize the waste and to effectively get rid of pests. The Indian farmer has adopted various traditional techniques which has resulted in either excessive use of pesticides or less water supply or many more issues leading to less crop production.

So many modern techniques have been implemented to improve the irrigation such as well water irrigation, tank water irrigation, inundation irrigation and many more. In recent research [11][12],the use IoT system has the irrigation more easier to the farmer yielding more crop production. In this system the use sensors to the soil moisture, humidity, temperature are used to monitor the crop all the time and send the data to the web server using NRF23LO1 transmitter, receiver and Ethernet connection at receiver side. These data stored in server is checked with the threshold value of moisture, humidity and temperature. Depending on the value checked with threshold value motor will be switched ON or OFF. [13][14]The web page designed using PHP and HTML inserts the sensor data in mysql database when it receives request from the GPRS/GSM modem and uses JSON (JavaScript Object Notation). The mobile application developed using android can be operated anywhere to monitor and control the field ,thereby making the farmer tension free and also yield more crop which feed millions of people in the growing population.

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Table: Threshold value compared with the sensors data

Parameter	*Condition*	*Minimum value*	*Maximum value*
Input Voltage	-	3.3V	5V
Output value	Dry Soil	0 Ω	300 Ω
	Humid soil	300 Ω	700 Ω
	Water	700 Ω	950 Ω

F. *Smart city with Waste management system using IoT:*

An efficient solid waste management system has become the need of the hour in many major cities. There already exists some waste management and smart garbage bins implemented but with drawbacks as it uses GSM modules and SIM cards used in garbage bins. Due to this, recent advances were made for solid waste management using IoT.

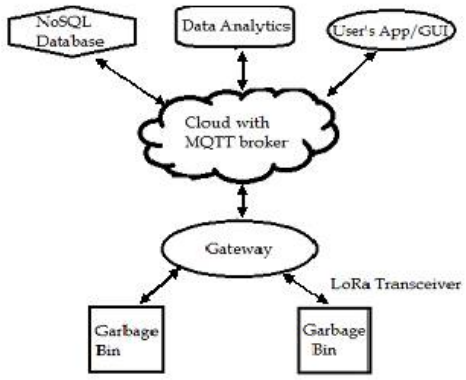

Figure: General structure of IoT waste management

In this system[15] ,all the wet waste(biodegradable),plastic, glass bottles, dry waste will be segregated into separate bins, each of these garbage bins will be attached with a IR sensors to detect the level of garbage, gas sensors and load sensor for estimating the weight of garbage bin. All the data from various garbage bins are collected by these sensors and actuator will be transmitted through a microcontroller to the gateway by LoRa transceiver module. This data will sent to cloud via TCP/IP with MQTT protocol and managed in the NoSQL database which is further handled by the data analytics. Reports generated by data analytics will be used by authorities through GUI to monitor the entire process.

IV. APPLICATIONS

As everyone nowadays are aware that the hype around the Internet of Things (IOT) is huge. Day to day, new IoT based product get released into the market. Based on emerging technologies and smart sensor, IoT provide large application in various fields. Applications are not restricted, but depending on its usability, it can be classified into following sectors:

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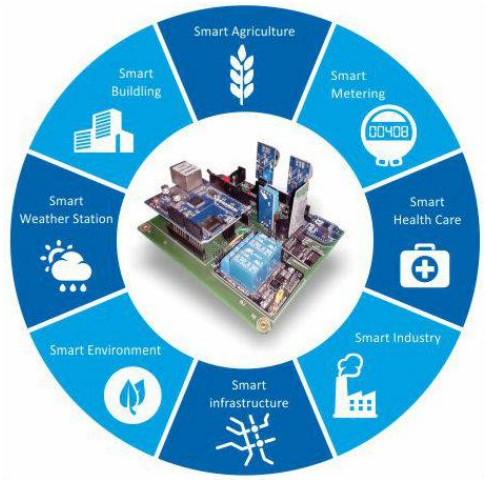

A. *Smart building/home:*
In our daily lives, IoT provides a personalized experience from the home to the office to the organizations we frequently do business with. A smart home application permits its users to develop/modify and control home environment for better security and cost-effective energy management.
The sensors embedded in TV, light, curtains, AC senses temperature, humidity and human motion are adjusted automatically. Also at the door ,the sensor embedded at the door recognises person entering the house along with time and date providing more comfortable and safety for the people at home.

B. *Smart Agriculture:*
Today's sophisticated commercial farms have exploited advanced technology and biotechnology for quite some time, however, IoT introduces more access to deeper automation and analysis. Much of commercial farming, like weather monitoring, suffers from a lack of precision and requires human labour in the area of monitoring. Its automation also remains limited.
IoT allows operations to remove much of the human intervention in system function, farming analysis, and monitoring. Systems detect changes to crops, soil, environment, and more[11-14]. They optimize standard processes through analysis of large, rich data collections. They also prevent health hazards (e.g., e. coli) from happening and allow better control.

C. *Smart metering:*
The concept of a smart grid, and the smart meters that are used to measure it, predated the Internet of Things. If we think about IoT as simply the networking of physical devices to allow them to exchange data, then energy & utilities companies building smart grids could be considered leaders of the early IoT movement focusing on meter-to-cash process(M2C).[17][19] Most smart meter initiatives have centred around capturing operational savings first, and are now moving into providing customers with data and transparency on energy consumption. This by itself should reduce consumption, but we predict that combining smart meters with IoT innovations in the home will magnify energy efficiency. For example, smart thermostats are becoming ubiquitous but there is no consistent IoT platform for connecting these devices with smart meters.

D. *Smart wearable's:*
Wearable devices, such as the Apple Watch, and a host of other smart devices by other companies, such as Samsung, Google, Jawbone, Fitbit, Adidas, Pebble, Motorola, Johnson & Johnson, etc., [16]will drive the market for the IoT. They mainly are aimed to provide fitness, health and entertainment requirements. These include ultra-low power processors, accurate, low-cost, ultra-low power mobile sensors, and low-power wireless connectivity.

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E. *Smart industry:*
Applications of IoT in these areas include improving production, marketing, service delivery, and safety. [18]IoT provides a strong means of monitoring various processes; and real transparency creates greater visibility for improvement opportunities.
The deep level of control afforded by IoT allows rapid and more action on those opportunities, which include events like obvious customer needs, nonconforming product, malfunctions in equipment, problems in the distribution network, and more.

F. *Smart Marketing:*
IoT functions in a similar and deeper way to current technology, analytics, and big data. Existing technology collects specific data to produce related metrics and patterns over time, however, that data often lacks depth and accuracy. [18]IoT improves this by observing more behaviours and analyzing them differently.
This leads to more information and detail, which delivers more reliable metrics and patterns.
It allows organizations to better analyze and respond to customer needs or preferences.
It improves business productivity and strategy, and improves the consumer experience by only delivering relevant content and solutions.

G. *Smart weather station:*
The goal of this project is to make a temperature/humidity monitor that wirelessly logs the temperature and humidity to a remote server.[20] Arduino Uno (or clone), a DHT11, and ESP8266 sensors are used to measure wind, wind gusts, wind direction, rain, atmospheric pressure, temperature and humidity. The station creates a web site that monitors temperature, dew point, humidity, pressure, light index, and rain. All these data collected at the local station is stored in the server through network.

H. *Smart Health:*
IoT pushes us towards our imagined future of medicine which exploits a highly integrated network of sophisticated medical devices. Today, IoT can dramatically enhance medical research, devices, care, and emergency care. The integration of all elements provides more accuracy, more attention to detail, faster reactions to events, and constant improvement while reducing the typical overhead of medical research and organizations.

V. CONCLUSIONS

IoT has gradually brought many technological changes in our daily lives making it more simple and comfortable. In this paper, we have discussed about various technologies of IoT and few recent advances in the field of Smart clothing, Safe Driving, Smart home, agriculture and Waste management in cities applying modern technologies is also mentioned. The advancement of IoT is limited to this, since each day an new invention in this field is emerging. The paper concludes by listing various application of IoT in several fields. We hope for many more advances of IoT in future.

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