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Efficient Internet of Things (IoT) - based Bigdata Analytics Framework

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Abstract: ***Internet of Things (IoT), often known as the Industrial Internet, is a communication model linking a wide array of devices, forming an international network. IoT has garnered substantial interest since the concept's genesis in 1999 by Procter & Gamble's Kevin Ashton, with multifarious global businesses initiating IoT expansion, implying IoT as one of the most promising and substantial areas of forthcoming technology. The concern remains that IoT gadgets yield enormous quantities of data, which is challenging to manage. This paper's primary objective is to illustrate how IoT assists the industry in streamlining said IoT - enabled equipment data by shedding light on the synergy amongst big data analytics, cloud, and IoT, elucidating the protocols applied that produce and uphold this worldwide device communication.***

Keywords: Internet of Things, Bigdata, Cloud Computing, Data Gathering, Analysis, Performance Metrices

1. Introduction

Kevin Ashton was the invertor of Internet of Things (IoT). This term was coming in the market before 16 years but the idea was strike in Kevin Ashton minds since 1970's. This term was also known as "embedded internet" or "pervasive computing". He wants to control and upgrade the physical entities of the world with the help internet and also provide the security features. Basically, IOT is connecting various kind of devices, sensors, entitles, objects with the internet however to do this it will cause various problems like data process, data analysis, task management etc.

Internet of things include hardware or physical objects and embedded software's with are enables to connect and communicate with the external surroundings to make some operation.

In these days, IoT become popular because of wireless telecommunication and it is important for both views i. e., industry and academic. IoT is effectively used in various area for example agriculture, schools, hospitals and metro cities. While working with IoT, main concern is energy conservation because a lot of energy is required to connect different entities with internet to perform desired operations. [1]

IoT significantly increased the device sensorial capabilities. It uses some technology like NFC (Near Field Communication), WSN (Wireless Sensor Network), LEWC (Low energy wireless communication) etc. New communication ways are used in IOT like peer communication to machine communication, machine communication to machine communication, peer communication to peer communication. In this method, Internet of Things has representative with the physical world objects, broadly spread with limited processing capabilities and few storages space that suggests the development opportunities according to integrity, performance, safety and security, confidentiality and reliability. Internet evolution is also shown in IoT where diverse objects or components machines and people are connected with the internet and make a complex network like a web. In every year approximate fifteen million controllers are built to operate IoT and these components are connected with network device so that these devices are available more frequently. [2]

Multilevel architecture is usually combined with IIoT systems in which three layers are used which is known as hardware layer, network layer and upper layer. In upper Layer, there are set of protocols which are used to collect and transmit the data from communication stack. In network layer, there are physical networking devices are used which are may be wired or wireless. In hardware layer, there are set of physical devices like sensors, controllers, actuators and security devices etc.

The constantly rising of connectivity and usage of typical communication protocols, which are used in Industry 4.0 standard and we need to protect these protocols from the cyber - attacks which are frequently occurs on the internet. Nowadays industry access the internet frequently to do operations like production marketing etc., the devices which helps the industry to take control measures are industry control system (ICS) [4].

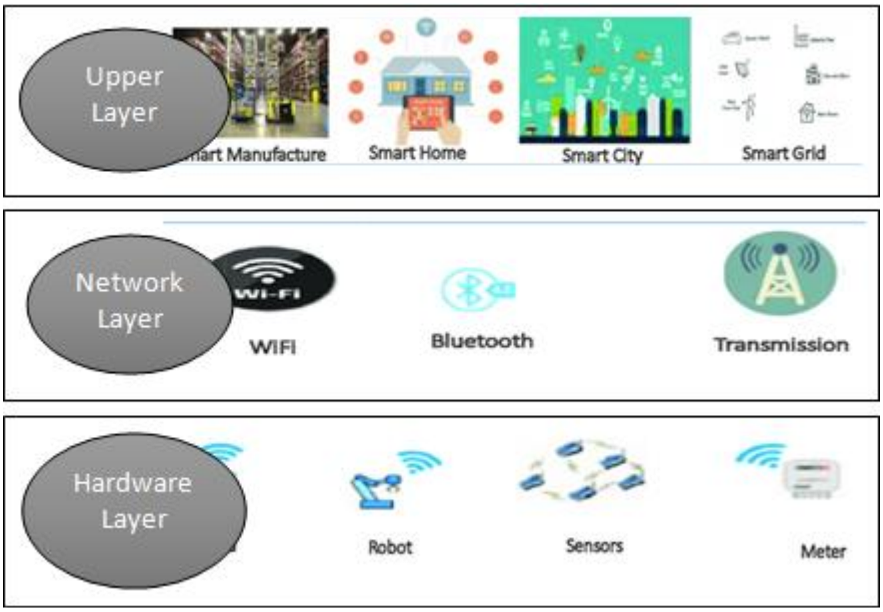

Figure 1: Multilevel Architecture of IIoT

An essential part of IoT is smart connection with existing network devices and framework using network resources. With the uplifted presence of strong network link WiFi, 4G - LTE and 5G wireless internet access, the development toward global information and communication networks is already evident. The Internet of Things demands:

1) To understanding the situation of its users and their devices.
2) Communication network and software architectures to convey and process the relevant information to where it is required.
3) Analytics tool that required for independent and smart behaviour.

With these three points smart network connectivity and context - aware computation can be accomplished.

1.1 IoT Communication Technologies and Protocols

In the case of IoT, there are number of devices are connected over the internet so that devices are able to communicate with each other, so communication between the devices are only possible with the help of protocols. The IoT technology are come into existence if physical world is integrated through several technologies. Various tags are covered by the Radio Frequency Identification (RFID) systems. ZigBee or ZWave are protocols that are used as a low - power RF radio embedded into systems and e - devices and systems These tags are applied on various objects like human or animals by the unique identifiers. The objects are monitored by the RFID in the real time because RFID is a microchip which is attached to antenna and it continuously send a signals and act as a sender and receiver. Another technology is a Wireless Sensor Network (WSN) that also play very crucial role in IoT. WSN is integrated with RFID which helps to keep track on the objects like dimension, movements, temperature and location of the object. Both Sensors and RFID are combined and become another technology is called RFID Sensor Networks (RSN), it has both capabilities like computing or sensing the objects and also send and receive the signals so we can say that it performs network operation more powerfully. Next is LoRa which is used for communication in Long Rangeupto 10 miles without wired connection with low power consumption, in case of IoTLoRa is merged with wide area network and known as LoRaWAN which is used for wireless IoT devices for communication purpose with low energy consumption and able to sense signals within a range of low - to - high signal levels. The main advantage of LoRaWAN is that it helps in bi - directional communication with high security. Another designed network is Narrow Band IoT, which is specially designed network that requires low bandwidth to support huge connection density. It has special security feature which is known as time - tested security. In IoT there is no complete estimation of these protocols together. At the end, the mentioned protocols are well performed in particular environment and scenario. [5]

Table 1: Details of Protocol used in IoT

S. No.	Protocol	Range	Frequency	Technology	Managed by
1	ZigBee	1000 ft approx.	2.5 GHz approx.	Mesh	Bluetooth SIG
2	LoRa	10 miles approx.	T150MHz - 1GHz	Star	LoRa Alliance
3	NB - IoT	20 miles approx.	Below 1GHz	Star	Huawei, Ericsson

1.2 Integration of IoT and Cloud Computing:

New services that come into the existence are based on the cloud computing because with the help of this technology user can access information 24*7 using internet, which eliminates the requirement of particular location and hardware. In IT sector cloud computing services becomes one of the best areas of competition among the global companies. Cloud computing is a technology which is used as a base for IoT. Cloud computing provides various services such as providing platform, storage, testing, infrastructure etc. The main services or features of the cloud computing technologies are co related with the features of IoT for example energy efficiency, services over internet like testing, storage, applications etc. [6]

Amazon released a wed services which is based on cloud platform for IoT named as Amazon Web Services (AWS). The motive of AWS is to enable the connection between the smart devices and provide security. With the use of AWS IoT user can easily user the different services provided by the amazon like Amazon S3, Amazon DynamoDB, Amazon S3, Amazon ML and many more. Nevertheless, AWS IoT also permits various applications to communicate with devices even when they are offline mode. [7]

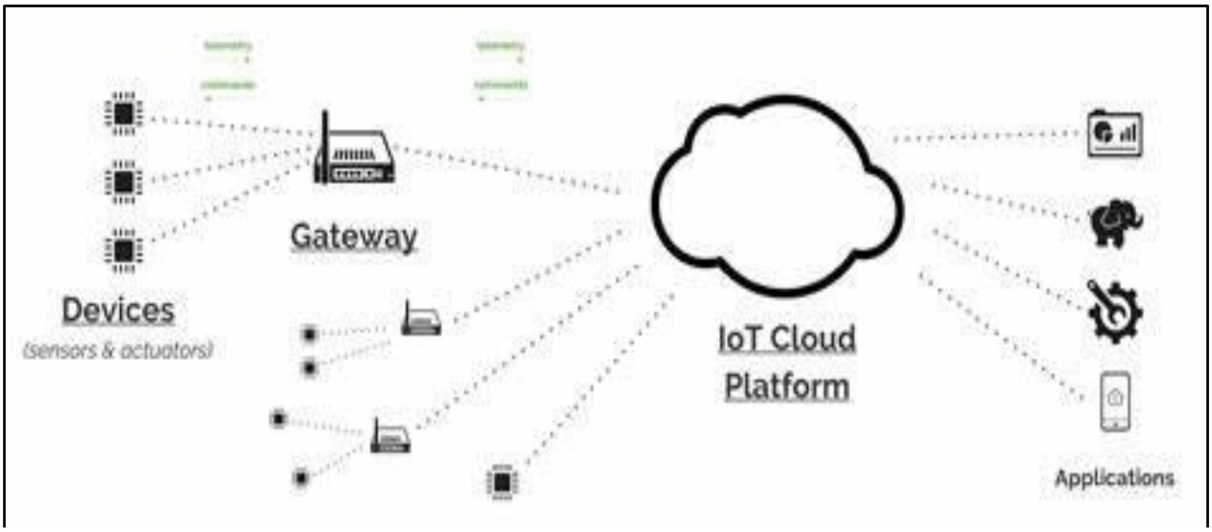

Figure 2: Integration of IoT and Cloud Computing

1.3 Association of Big DataAnalytics with IoT

To improve the decision - making process big data analytics are associated with IoT. The foremost feature of big data analytics is to extract the information about the connecting devices used in IoT. The main function of big data in IoT is to process massive data over the internet and store in various storage services adopted by IoT. The core function of Big Data Analytics is to convert unstructured data into the structured data so that fast processing can be done to make a quick and correct decision.

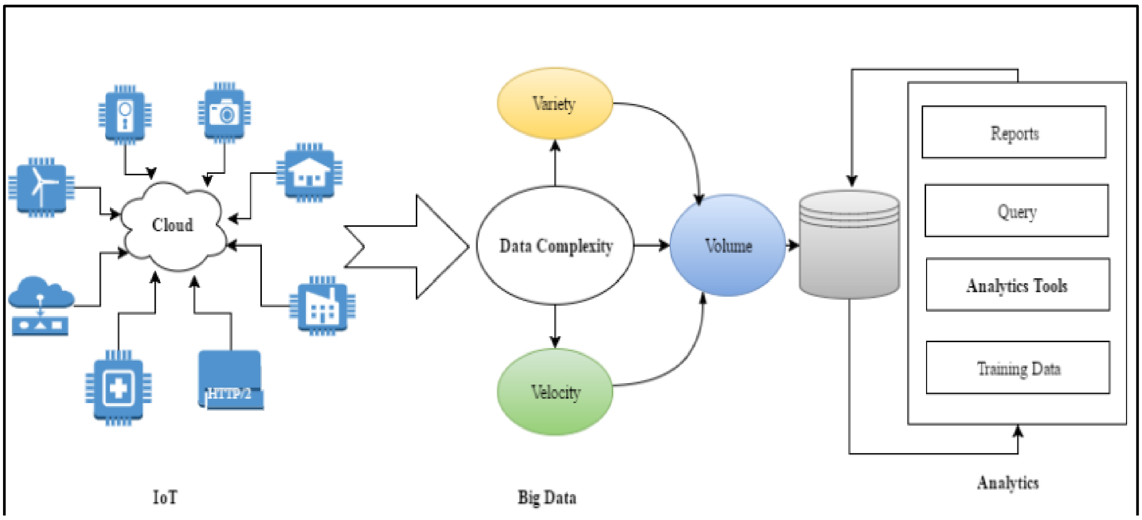

Figure 3: The association of IoT and Big Data Analytics

The main advantage of association the big data analytics with IoT because data over the internet is increasing rapidly so it was difficult to process the data to make a quick decision and extract the relevant information. Now the various applications of the big data technologies in IoT increases the research and business models of the IoT. [8] The association of IoT and big data analytics is shown in figure 3.

The figure 3 contains the three steps i. e., IoT, Big Data and Analytics. In the initial step, IoT data source is available where application uses the sensor devices like CCTV cameras, smart traffic lights, smart home devices etc. to interact with each other and generate massive data with distinct formats. The data can be stored on cloud in low cost. Ain the next step, the produced data from step 1 is called big data, which are based on 3 V's i. e., volume, variety and velocity. The produced data is stored on big data files and shared among distributed databases. In the final step

analytics tools are applied on the data provided by the big data IoT data set. The analytics step is having four levels:
1) Training data (Raw Data)
2) Analytics Tools (MapReduce, Spark, Splunk, and Skytree)
3) Queries
4) Reports.

1.4 Big Data Analytics:

The processes of big data analytics include searching a database, mining, and analysing data dedicated to improve company performance [14]. The main task of big data analytics is to examine huge data set which includes various types of data that contains market trends, liking of the customers, hidden correlations, unseen data or patterns and any other important information. Big data analytics can help the organization to filter the accurate information from the large amount of data collected from the cloud.

Therefore, the main objective of big data analytics is to provide assistance to the business association for better understanding of data so that they can take efficient decision. Big data analytics need various tools and technologies that can convert a huge amount of data (structured, unstructured, and semi - structured) into a more understandable data and metadata format for analytical processes. Various algorithms are used in the analytical tools which helps to find trends, patterns and correlations among various time horizons in the data. Tools represents the data in graphical from after analysing the raw data for better understanding so that analyser can be able to take correct decision. So, we can say that big data analysis is a challenging task for various applications.

1.5 Pillars of IoT

Various applications services provided by the IoT increases the quality life of the human being. There are seven major pillars of IoT system that are Sensing and Actuation, Identification, Communication, Computation, Services, Management and Security [9].

Step 1: Sensing and Actuation
In this step devices collect the various data from the different environment with the help of senor is known as sensing after sensing, the data is processed and analysed by actuation tools to make the correct decision. There are various types of sensors present in the IoT.

Step 2: Identification
In the next step objects, devices or things which is an important source of IoT are identified.
Here device identification is used to identify the things used in IoT application. IoT application
Services are used to operate, monitor and control the object used in IoT. Every device is having its unique identification with any key value.

Figure 3: Pillars of IoT

Step 3: Communication
In IoT, there are two types of communication can be used i. e., wired or wireless. In the present society, the use of wireless communication methods or standards increasing day by day. This step provides short - range and long - range communication standards to establish the connection between various objects or devices.

Step 4: Computation
Processors are used for the computation. Processors are act as a brain of the system. The operating system like Zephy, OpenWrt, Ubuntu Core, Tiny operating system, RIOT, Contiki Operating System, Raspbian etc., are used to develop IoT applications.

Step 5: Services
Services provided by an IoT systems are:
- Monitoring the devices.
- Controlling the devices
- Publishing the various data
- Various device discovery etc.,

Step 6: Management
The core role of management is to manage the users like add user and delete user from the various groups, various roles of the users like admin, normal user or guest etc., and access provided by the IoT services like authorization and authentication. In management, various management services are involved like:
- Device management
- Service management
- User management
- Service management
- Cost management etc.,

Step 7: Security
Security is essential in IoT. It helps to secure the devices, data, server and other important things from unauthorized access.

1.6 Applications of IoT

The emerging technology IoT is having various application domains. These applications can be categorised on the type of network availability, heterogeneity, scale, repeatability, user involvement and coverage. The applications can be categorized into four application areas:

- Home and Personal
- Business
- Resources
- Cell Phones

1.6.1 Home and Personal

As we know smart phones are used as a personal and official purpose for communication along with numerous applications like WiFi, Bluetooth etc., Although there are various applications available in the smart phone like windows, iOS and android operating system that measures various parameters available in the smart phones. Few applications are centralized that can be access by everyone from any location and service is provided by cloud. Nowadays, for an old ages person a personal home monitoring system is created by a personal body area network through which a doctor can monitor the activities of patient from the hospital which helps for hospital cost cutting [12]. Personal home equipment's like washing machines, fans, refrigerators and air conditioners etc., allows user to manage home and energy in a better way.

1.6.2 Business

NoT i. e., Network of thing is similar to IoT is used in companies which is based on enterprise applications. Only owners can use the information collected by such networks abs selective data may be shared with concern members or team. Application named as environment monitoring is implemented to keep track of the number of resources like (fans, lights AC etc.,) and manage the resources within the premises. An integral part of factory setup for weather control, security and automations are sensors, which are swapped by wireless systems to provide flexibility.

1.6.3 Resources

In this application domain, information is provided from the network is used for service optimisation but not for consumer consumption. To optimise the cost and profits for the resources it has been used by the resource management companies. The support network used may lie between satellite, WiFi and cellular communication, these are made up of extensive networks.

Another important IoT application which has been implemented everywhere in the globe is known as smart grid and smart metering [13]. Effective energy consumption can be attained by endlessly monitoring all the electric point around your premises and using collected information to change the way electricity is consumption. Collected information of electricity consumption around the whole city can be used for load balance maintenance within the grid to ensure high quality of service.

1.6.4 Cell Phones

The occurrence of Bluetooth technology (BT) devices imitates the present IoT dispersion in a number of digital gadgets like cell phones, navigation systems, hands - free sets in cars and many more.

Media Access Identification (MAC - ID) number is used to produce unique signals through Bluetooth that can be read by Bluetooth technology sensors within the defined area. Movement of any device can be identified by the readers placed at the various locations. Other data sources like bus GPS, traffic signals, research problems and many more created problems that can be resolved or addressed. There are numerous privacy issues such as usages and digital forgetting is an initial domain of research in IoT where privacy is a concern.

1.7 IoT Security Using FOG Computing

1.7.1 Evolution of FOGfrom Cloud:

There are two independent technologies named as IoT and cloud computing which are having numerous applications. Large number of smart devices and applications are provided by the IoT to the human and cloud service provide the store space to store and manage the data generated by the IoT devices and people can access the data anywhere from the world with the help of an internet. IoT produce massive amount of the raw data on the internet, which produce massive stress on internet infrastructure. The integration of both technologies i. e., IoT and Cloud has introduced pros and cons for storing, processing, securing and managing data generated by the various organizations or peoples. Many organizations try to solve the security issues faced by the integration of these technologies. Researchers observes that there are less benefits and more issues of these technologies, to resolve this issue the concept of FOG computing was introduced by CISCO. Fog computing complements cloud computing rather than replacing it [15].

1.7.2 FOG Computing Architecture

To handle the data generated by IoT devices is the main motive of FOG computing. FOG computing provides the better management so it requires an architecture which is having various layers. It has two frameworks that are FOG cloud device framework and FOG device framework. The layers are arranged according to the computing and storing power. The message can be passed between various layers using communication media, it can be wired or wireless. In FOG - device framework, the FOG nodes give numerous services to the user with involving cloud server. In FOG - Cloud Device framework is simply used to take the decision where as complex decisions are taken by the cloud. The architecture of FOG - Cloud - Device framework is shown below in figure 4. The reduction of data traffic between cloud and network edge is done by FOG computing. Approx 85% traffic is reduced and average response time for a user is approx.25% when researchers compared with cloud - only model [17].

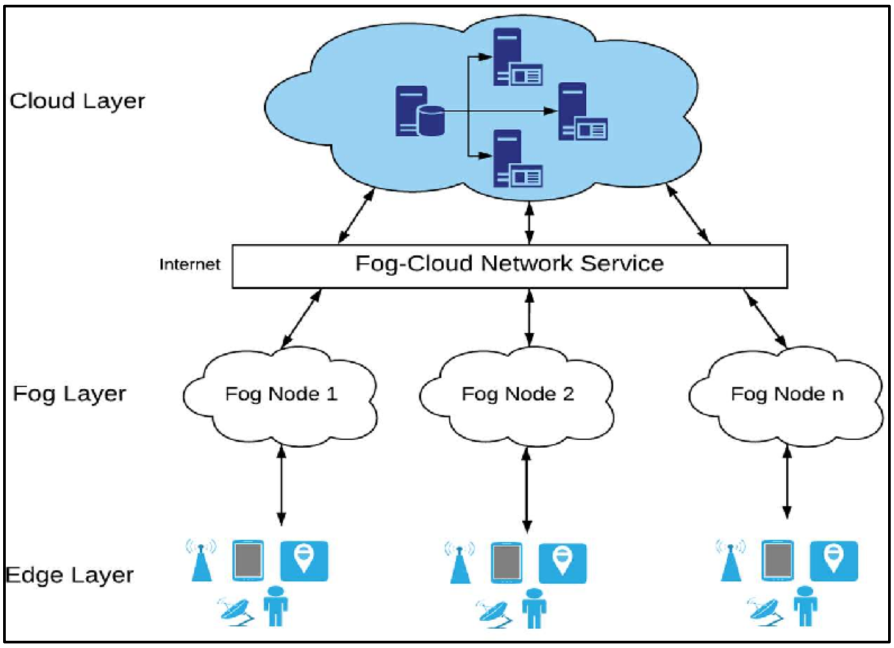

Figure 4: FOG - Cloud - Device framework

1.7.3 FOG'S Benefits Over Cloud:

Every day, IoT devices produce enormous amounts of data. It is not possible to move this data in real time for analysis to the cloud. As a result, the idea of fog computing has been created. Fog computing is the practise of bringing cloud computing and related services out to the network's edge. Time - sensitive data can be efficiently and swiftly stored and processed via fog computing, a dispersed infrastructure for data analysis and processing. Its main objectives are to improve security, stop data theft, reduce the amount of data saved in the cloud, and boost IoT applications' general efficiency. Because the fog layer is positioned significantly closer to the devices than the cloud, the latency in fog computation is lower than that in cloud computation. For long - term storage, only the most pertinent and carefully chosen data is uploaded to the cloud. Applications for fog computing include software - defined networks, smart retail, smart traffic lights, smart homes, smart agriculture, and smart healthcare. It would be expensive and time - consuming to send the massive volume of data produced by IoT devices to the cloud for processing and analysis. Fog computing minimises the frequency of two - way communication between IoT devices and the cloud in addition to lowering network capacity requirements. In a fog architecture, devices called fog nodes collect the data and can analyse 40% of it. It offloads traffic from the core network, reducing IoT device latency. A fog node can be any device with compute, storage, and network connectivity, such as a router, switch, or video security camera. As long as there is a network connection, these fog nodes can be put anywhere, whether inside a car or on a factory floor. Depending on how time - sensitive the data is, it may be sent to the cloud, aggregation node, or fog node. By offering cryptographic computations, fog nodes secure communication in IoT applications. The essential internal resources for that aim are not always present in simple sensors and IoT devices [18].

2. Conclusion

Many researchers do a lot of research on IoT protocols, architectures, functionality domains, tasks and many more. This paper includes all about IoT and its various applications, pillars etc. The main motive of this paper is to merge the four technologies that are IoT, Cloud Computing, Big data and Fog Computing. Cloud Computing helps to store the bulk data generated by IoT devices by using the service i. e., cloud storage as a service and big data helps to analyse and extract the useful data from the data generated by the IoT devices, Fog computing also helps IoT to handle the large amount of data. Its main objectives are to improve security, stop data theft, reduce the amount of data saved in the cloud, and boost IoT applications' general efficiency.

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