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INTEGRATION OF IOT, CLOUD AND BIG DATA

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ABSTRACT

In the present day Internet of Things (IoT) based on cloud computing and Big data concepts has become a new area of research. Novel concepts and implementations are being researched every day. The paper presents an overview of trending technologies in cloud computing and IoT applications. Discussion on these concepts also includes major advantages, concerns and risks that need to be mitigated.

Keywords: *Internet of things, IoT, cloud computing, Big data.*

I. INTRODUCTION

In modern world, cloud is an important technology for many IT operations and many industries make use of technologies such as big data and IoT (Internet of things) for many of their applications for an efficient management of the company. Various concepts and definitions are discussed below.

Internet of Things: Future internet will be mainly based on IOT.As the name indicates Internet of Things is nothing but interconnected network of things which are embedded with sensors and actuators. The thing may be any real world object. These objects have the capability to collect data from the environment with the help of sensors and hence they are termed as smart objects. Large amount of data will be collected by such smart objects, which will be useful in future analysis.

Cloud computing: Cloud computing is the realization of utility computing where, resources are provided by the service provider and the client will pay as they use the resources. User can access the cloud via thin client. Cloud also provides memory for large amount of data to store and allows computation. Hence lot of user can rely on cloud as it reduces the infrastructure cost that the user needs to invest.

Cloud of Things: Introducing IOT into the internet results in lot of smart objects gets connected to the internet. These objects generate large amount of data that cannot be handled by normal databases. If the objects have very simple interface then they cannot even perform small amount of computation that might be necessary. Hence cloud concepts are integrated with IOT so that storing and computation is done in the cloud. Managing huge amount of data can be easily done by combining IOT with cloud.

II. LITERATURE SURVEY

John Soldatos et. al.[8] specifies design principles for IOT cloud environment and also introduces a framework for converging computing models with emerging IOT infrastructure. The paper has described that future internet is mainly based on IOT and hence integrated smoothly with the services such as Internet of Services (IOS) and their standards. Management of IOT based cloud environment is not easy and hence this paper introduces main building block of a middle wear framework. With this framework service providers can efficiently handle end user requests by deploying cloud utility based infrastructure. The paper also explains the design principles for framework. OpenIOT is developing a framework which bridges the gap associated with differences and conflicting properties among the IOT and Cloud. The OpenIOT middle wear has properties such as autonomic, utility based, open source and royalty free, dynamic, scalable, optimal and self-managing, standards based and Interoperable with other IoT architectures. The authors also talks about specification of service requests with the support of Semantic Sensor Network (SSN) ontology. Lu Tan et. al.[12] discusses about the concepts of Internet of things. Every object in the internet can be connected and it is called Internet of Things. At present main communication in the internet is between humans and in future things will be exchanging information on behalf of the people. To develop IOT architecture some supporting technologies are needed. To connect the object in the internet they must be identified. This identification is done with RFID technology which uses Radio frequency for detection. Sensors establish connection between physical world and information world. This paper also explains the application of IOT in college, with examples which are already successful applications in different fields such as retail, food, logistics, transportation etc., When lot of things are connected to the internet traffic will be increased. This should be handled properly. The huge amount of data produced in the network should be stored and managed. This is done with the help of Cloud technology. One more problem is interoperability. Coordination layer has been introduced as a

solution. The other issues with IOT are security and privacy. Jayavardhana Gubbia et. al.[17] discusses about visions as well as motivations for IOT, different application domains in IOT and a new way of defining them. It also throws light on IOT realization, problems or challenges involved and also future trends and scope in Cloud centric Internet of things. The paper describes how the internet is influenced by the internet of things. Future generation of Internet will be based on IOT and as all objects can be connected to the internet huge data will be generated. To handle large amount of data, IOT seeks the help of Cloud computing. Users and service providers can access application from anywhere. An introduction to ubiquitous networking is given. Convergence of micro-electro-mechanical systems (MEMS) technology, Wireless communication and digital electronics has resulted in the development of small devices which have the ability to sense, compute and communicate. A smart environment can be devised with the help of sensor-actuator-internet framework. This paper further gives definition of things, a smart environment, IOT and also defines the trends in IOT. Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), addressing schemes, data storage and analytics and visualization concepts are explained in detail. Applications which are impacted by the introduction of IOT are listed. The paper gives conceptual IOT framework and a detailed description about Aneka cloud computing platform. Open challenges such as privacy, interoperability, participatory sensing, data analytics, GIS based visualization, security protocols and Quality of Services are mentioned.

Lu Kai et. al. [21] has proposed to mix static binding, SLAAC, DHCPv6, four kinds of IPv6 addressing strategy methods and verification method for the legality of the source address. With these four types of IPv6 addressing methods authenticity and reliability for IP address can be realized with a less network cost. The paper discusses how IPv6 solves the interoperability problem, as the IPv4 addressing method cannot satisfy many application requirements. The development of IPv6 made IPv6 to play a key role as interconnection of things need lot of IP addresses and cloud computing provides support for the storage data calculations and in turn support IOT. But whenever IPv6 addressing is safety and reliability must be considered. The paper describes what a new generation of internet consists of. In new generation internet, object information can be accessed from any place and time with the help of sensors, two-dimensional code, RFID etc. The paper gives an idea about different address formats of IPv6 which includes unicast, multicast and anycast addressing. Addressing strategy such as static address binding and verification mode, SLAAC address allocation and verification mode, DHCPv6 address allocation and verification mode and *SLAAC and* DHCPv6 combined with address allocation scheme are well explained in detail. IPv6 packets are divided and reorganized, effective routing algorithms are introduced. To reduce the overhead in IPv6 the header of IPv6 packets are compressed. Dimosthenis Kyriazisa et. al. [23] describes management mechanism which is not centralized for IOT-based systems in order to exploit several devices and also explains an architecture in which things learn based on others experience. The paper discusses the realization of the IOT based applications based on the enhancement of IOT technology. Humans communicate with each other and sharing of information in turn results in development. By enabling IOT applications to collect large amount of data, which together form the information helps in development. Furthermore it explains that more importance is currently put on sustainable and green smart city applications. The paper explains challenges and enablers under which five different concepts are explained. Here Objects will be able to learn and adapt to different situations. Privacy aspects are very important in IOT as the data may be sensitive and the physical environment may affect the data through deployed sensors and actuators. Privelets are introduced to preserve privacy. As the network contains millions of devices centralized management of things would be inefficient and hence decentralized autonomous management of network of things is a better idea. The paper further proposes a conceptual architecture to enhance the sustainability of the IOT applications. In this architecture, an environment for IOT applications is provided through cross-platform channels. These channels support technologies for data management, information, things and decentralized management of the network. FahimKawsar et. al. [24] discusses a novel modeling technique for pervasive systems based on high level models of human activities. It presents a flow driven distributed software framework. A foundation for discovery, adaptation and execution of flows in real time matching the dynamics of real world activity is provided by this framework. The paper explains the definition of IOT and development of IOT in past few years. It also addresses the two challenges given as 1) lack of technology-independent and transferable models of human work activities 2) design of distributed and embedded interaction techniques and user interfaces to effectively support people in demanding work environments such as hospitals and industrial plants which ensure spatial and temporal consistency. Situated flow is a novel approach to model high level human activities that can drive seamless interaction in pervasive work environment. The paper describes the design issues for the coordination across physical objects. In the architecture section, the flow driven coordination framework for interactive spaces is explained with several examples that can be implemented. Future work of the paper may be some issues that could be handled are support for rich context, dynamic refinement, spatial interface and state management.

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Geoffrey C. Fox et. al.[4] discusses the architecture of IOT cloud framework and the different APIs available to the users. There are several technical problems involved in the IOT development and can be listed as interoperability problem, security, deployment problem, management problems etc. The paper describes the IOT architecture which has components such as IOTCloud controller, Message broker, Sensors and Clients. IOTCloud controller is the one which is responsible for controlling system components and providing SOAP messages. Message broker is responsible for routing of messages. Sensors are used to collect the data and which is used by clients. The paper describes different types of message broker, sensors and clients and their functionalities. It also describes about Future Grid. With Future Grid Complex research problems in computer science related to the use and security of grids and clouds. Huijuan Wang et. al.[6] discusses the concepts of cloud computing and IOT. Both cloud and IOT has its own advantages. Combining them will lead to a better performance. The ways in which both the technology combined are as follows.

a. Single center, multi terminal: In such model, terminal treats cloud center as data center where data is unified and sent to the center of the cloud and there it is processed.
b. Multicenter and large number of terminals: For a large business application it is useful. Here more than one cloud is used as data center and these cloud centers can share the information via the network.
c. Information, application layer in hierarchical processing massive terminal: The data such as Game, video processing etc., based on the application requirement can be processed is more important, then next section discusses.

The problem that should be dealt while integrating cloud and IOT are with the communication standards and the cost of the implementation. Gilberto Taccari et. al. [7] discusses how cloud of things can be used to tackle emergency situations. Emergency is any occasion which requires action to save lives and protect property, public health and safety. Emergency management provides an important role. This paper aims at defining a framework by which the heterogeneous resources and data can be combined along with the capabilities provided by physical objects such as sensors and actuators. There should be collaboration among the organizations that are involved in the management of emergencies. Organizations will be having capabilities to share different resources. To save human life and limits injuries when an emergency occur. Different actions need to be taken, like evacuating people and moving them towards safe areas or other emergency related operations. Mohammad Aazam et. al.[9] discusses the IOT, Cloud Computing and the issues involved in integrating these two technologies. Now, there is a demand for integration of IOT and the cloud. In IOT things refer to any object which is connected to the internet. The architecture of IOT consists of 5 different layers. The number of devices that are connecting to the internet is increasing and hence it increases the data as well. Storing and handling the data in local storage devices is not possible anymore. More processing of data is not possible with the limited resources at the IOT end. These problems can be handled by Cloud Computing. The author mentioned that IOT alone cannot manage the huge amount of data cloud is integrated. This is termed as Cloud of Things (COT).Cloud Computing provides a platform to process and manage the data. Thin clients can be used at the IOT end which does not have high processing ability. But there are many issues involved. Different things which are connected to the internet may use different protocol. As any number of devices can be connected to the internet, this results in lot of data communication and hence it consumes lot of power. Resource allocation, IPV6 deployment, security, privacy etc. are some other issues which are addressed in this paper. Salvatore Distefano et. al.[10] discusses about the design of an architecture where new generation services collects the data from the outside environment and different management strategies are applied to them. It mainly focuses on the implementation of the architecture based on COT. This paper explains ICT scenario in which number of devices connected to the network is growing which also includes sensors and actuator networks. To coordinate the interaction between computing, storage and sensing a proper methodology is needed. Other issue that should be considered is heterogeneous resource mashup which is used to implement wide ranging cloud infrastructure. The authors have described SAaaS (Sensing and Actuation as a Service) module architecture which has following three modules.

a. The Adapter: It allows the communication between sensing and actuation devices directly and also keeps track of resources and their connectivity
b. The Node Manager: It manages sensing-actuation resource operation and also involves in enforcement of policies.
c. The Abstraction and Virtualization Unit: This module exposes functionalities of the node in the form of services.

This paper further explains architecture of volunteer framework which aims at consolidating different resources and services in a cloud environment. This framework has components such as Reward Systems, QOS manager, LA manager which is explained in detail. Finally TaaS (Things as a Service) architecture is explained which comprises

of four main parts such as the Cloud Driver, the High Level Manager, the Things Abstraction and Virtualization and the Frontend.

Pritee Parwekar [11] discusses the services offered by IOT on Integration with Cloud Computing. IOT has tiny devices called sensors as well as actuators which are used to collect the data. These sensors sense the changes in the environment and produce very large amount of data. These devices are embedded to physical objects. Modern society has got many data constraints. This problem can be reduced by fast transfer and retrieval of data or information. With the help of cloud computing, the things with less capacity can perform high computation. But in current IOT providing security is a difficult task and there is no interaction between services and events.

The paper gives information about different services the IOT provides. They can be listed as follows.

a. Identity related services
b. Information aggregation services
c. Collaborative aware services
d. Ubiquitous services

The paper discusses about the limitations of the deployment of IOT on cloud. There might be connectivity problem, scalability problem, interoperability, security, bandwidth availability etc. George Suciu et. al.[13] proposes an architecture to exchange information through the internet. The main goal is to achieve customized services and non-intrusive behavior. The paper concentrates mainly on explaining different frameworks existing for IOT, cloud and interoperability among them. Cloud Framework has several interoperable specifications and standards to provide basis for cloud computing such as AJAX, REST, JSON, SOAP etc. The main challenge will be management of SLAs for services as well as applications deployed in cloud. The IOT FrameWork concept mainly came from the Radio Frequency Identification (RFID) technology. The necessity for standard protocols, architecture and APIs are explained to facilitate interoperability between smart objects. The paper explains an architectural overview of central elements of cloud computing. Different roles found in cloud computing such as service user, developer and provider are also explained. Carlos Dores et. al.[18] discusses the different technologies that can be used for the development of future internet platforms. By combining different technologies such as Cloud Computing, IoT and Wireless Sensor Networks, different systems can be developed that provides services to the people and in turn improves the quality of life.The paper describes different technologies that can be used to make the future internet a reality. It describes about Next Generation Networks (NGNs) which is a concept that makes network architecture more flexible and new services can be easily added to the network. It also describes IP Multimedia subsystem (IMS) architecture, Internet of Things (IoT), Wireless sensor networks (WSN's), Body Sensor Networks (BSN's) and also about Cloud Computing. The paper also discusses about a conceptual platform which is still under development called Skynet which focuses on Machine to machine communication. Qiao Ying et. al. [25] compares brain with the internet and discusses designing a data center based on the IOT of Smart Cloud Computing Data Center. The architectural part explains how data solution is given based on IOT concepts. Virtual brain is assumed as Cloud computing by changing virtual sensory organs into the IOT sensor and by changing virtual internet nervous system into ubiquitous network of IOT. Further it explains the design of Smart Cloud computing and data center design. The different hardware layers are listed as follows

a. The core hardware layer of SCCDC: This layer consists of super computer servers, massive data storage devices, routers and core switches.
b. The ubiquitous network terminal of SCCDC: This layer manages all the sensor and executive agencies such as camera, microphone, temperature and humidity sensors etc.
c. The ubiquitous user terminal of SCCDC: This layer includes equipment's such as virtual brain equipment's, consciousness control system, reflector etc.,
d. The ubiquitous network of SCCDC: The ubiquitous network layer consists of optical fiber, wireless network, telephone lines, cable television network, and coaxial cables.

The software layers can be further listed as follows.

1. The operating system of SCCDC: Different Operating system includes Windows, UNIX, Linux, mac OS etc., which are applied to PCs and other OS such as Palm OS, Symbian, windows CE etc., are applied to mobile and handheld devices.
2. The application software of SCCDC: Allows the user to perform specific applications.

The paper concludes by stating that to handle massive data produced by the IOT one must rely on Cloud Computing.

Jason C. Hung et. al.[1] introduces a concept of smart travel design which intends to help the traveller capture the moment emotion memory and process the data. This paper also explores the possibility to develop tourism and introduces a new ubiquitous tourism system based on concepts such as SNS, IOT and UGC. This travel information can be accessed in new ways using smart phones, GPS, Google Maps which brings novel experience for users. The

paper explains challenges faced in tourism industry and how technology plays a major role to handle these challenges. Services provided to tourists can be improved by the advancement in technologies. The concept of smart -travel is explained with a figure with its purpose and project history. In the smart-travel overview details of the system are explained by categorizing into three sub groups such as real-time travel search, personal demand, and task service etc., Further these subgroups are explained well with examples. This smart-travel system explains the interdependency of these subgroups and working of the system as a whole. In conclusion, the paper suggests the usage of the technology to improve the connection between machine and the user in the near future and hence it opens a new opportunity for business models. Xiao Ming Zhang et. al.[2] proposes an open, secure and flexible platform which is based on the concept of IOT and Cloud Computing. To address interoperability short distance ambient communication protocols for medical purpose are discussed. To solve different security issues Secure Socket Layer (SSL), authentication and auditing are taken into consideration. In dynamic environment streaming quality should be improved and in order to do that an adaptive streaming QoS model is used. This paper explains about current trends of IOT in the field of health care through telemedicine and ambient aiding living. This is intended to increase patient autonomy and confidence. Telemedicine is a practice of medical care using interactive audio visual data communications. But there exists few problems such as IOT interoperability, system security, streaming quality of service and dynamic increasing storage which is explained in detail. Further major technologies used in the architecture are discussed including interoperability of IOT gateway, adaptive streaming, system secure, elastic archiving with the help of examples and schematic diagrams. In conclusion, it states that IOT and Cloud Computing will be supporting technologies for telemedicine and ambient aiding living, in which an open secure and elastic architecture is introduced and several technologies are identified and researched. Yifan Bo et. al.[3] discusses the application of IOT and cloud computing, how that can be applied to agriculture and forestry. Forest pest forecasting can be done based on the collected information about the pests which can be done with the help of sensors. The data which will be collected is very huge and this can be handled by cloud. Grass-root department can use the service provided by the cloud as all its requirements will be satisfied by the service provider. The safety of agricultural product is necessary. Example is food safety. Internet of Things provides an application called Food Safety Traceability System which helps in this regard. Information about climate, humidity, atmosphere, pH etc. is collected sing sensors which helps the farmers. Problems involved are implementation of IPV6 for IOT, Security, risk and the data centers need to be more reliable. Zaheer Khan et. al.[5] discusses ICT tools for a smart city deals with different application domains such as land use, transport, energy and provides integrated information. This information is beneficial for smart cities but which requires software tools and several technologies to collect, store, process and analyze the data. This paper proposes a theoretical perspective which focuses on big data processing and analysis. This paper explains about how the urban management and better planning can be done with the help of ICT tool for smart cities. So urban management based on ICT can be considered as a step towards making cities into smarter ones. With ICT, the citizens are given with necessary information for the better management of their surroundings. Urban planners can also make necessary decision with the intelligence given by these tools for urban development. Further it explains data management and analysis for variety of smart city applications in Cloud environment. This paper gives an example use case of Smart town center and also proposes an architectural design for cloud based big data analysis. Architecture is explained with diagram which is divided into three tiers. Lowest layer is data acquisition, analysis and filtering layer. The next layer is resource data mapping and linking layer and the top layer is interactive explorer layer. These layers described with their objectives in this section. System architecture is also based on following design principles such as system scalability, Low latency, open system principles, data acquisition and management and processing, analysis and use. Existing tools such as system and database management, web resources extraction, data analysis tool etc., are used to support the architecture. Diego Gachet et. al.[14] has introduced the concept of "Virtual Cloud Carer" (VCC), by a Spanish national R&D project. Its main purpose is to create new health service for dependents and chronic elderlies using the technologies such as IOT and Cloud Computing. The paper discusses issues faced by many developed countries with effective health services and quality of care in context to population ageing. Different statistical data obtained from agencies are discussed in detail. To tackle the issues involved VCC project is used. Hence the objective is achieved with different approaches given below.

a. Technological Oriented Objectives: To design and build a tele-monitoring and telecontrol platform for dependent people and their caretakers, in home as well as outside, the system should be easy to use independent of the underlying technology. Use of interfaces between users and computers brings the concept of IOT and Cloud computing.

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b. Social Oriented Objectives: this attempt to fill the gap that prevents elderly and people with chronic diseases to have minimum quality of life, by permitting people to do daily activities knowing their health status in all moments.
c. Health Oriented Objective: This objective aims at providing health- oriented goals that help elderlies to keep active through physical training exercises and also assist medical staff in the task of monitoring the treatment of these people from homes.

The technological platform's architecture is explained which implements the use of web browser, design of mobile devices etc. Finally, it discusses the expected results from the point of view of development and implementation of the functionality of the framework.

Ying Leng et. al.[15] discusses methods to solve the traffic problems. Improper management of traffic with the help of traditional management system posed a serious problem. IIOVMS is an intelligent system in which vehicle can choose the way where the traffic is less. Video supervising subsystem in IIOVMS, records the video and by which transportation administrative management can monitor the traffic. IIOVMS uses IoT, cloud computing, WSN and other modern techniques. Private cloud provides platform that can only be accessed and supervised by authorized staffs. Public cloud data provides information for the general users. WSN are used to collect the information about the traffic. Xi Yu et. al.[16] discusses a framework for Intelligent Urban Traffic Management System. It is an application of cloud computing and IOT. Intelligent monitoring and management of urban traffic is done by cloud computing. The paper describes the architecture of the proposed framework. Intelligent Urban Traffic Management system has three different layers: Perception layer is nothing but sensors and sensor gateways and its main function is to collect information along with object identification. Network layer receives the information from perception layer, processes it and transmits to application layer. It is constituted of network, network management system etc. The paper describes how intelligent computing is done. Collection, trimming mass data, deleting error data, useless data and unified data format made ready for further calculations. Prahlada Rao B. B et. al. [19] discusses about Big data issues and Sensing as a Service (SnaaS). The main challenge is handling huge data with available traditional database. So cloud is integrated with IOT. The paper discusses about the sensors which detect and respond to electrical as well as optical signals. SnaaS and SEaaS (Sensing Event as a Service) are the terms used to describe sensor data and events. Large number of sensor networks is integrated to form sensor cloud. The paper describes the different features of sensor cloud and sensor cloud infrastructure. In service model, service providers prepare service templates as catalogue. The service requestor requests for particular service from the predefined catalogue. The paper also discusses the challenges of the sensor cloud. Complex applications which require high bandwidth and low network latency. But to get access to resources applications have to wait. Kevin O Mahony et. al. [20] describes real-time information profiling for smart objects. The paper explains about internet of things concepts and smart objects which comprises of sensors and actuators which collect the information. It is very challenging to determine interaction standards and the APIs required for the user interaction with smart objects. This paper describes different information profiling methodologies which are based on Information Profile Acquisition and Modeling procedures. Smart objects are defined as objects embedded with sensing, processing and communication abilities. In Vision based application profile identification is done based on QR tag. QR tag method provides a better way for identification of various objects. Physical objects can be configured by using Information profiling concepts. Information profiling concepts consists of two parts. i.e., Application context profile and behavioral profile. The paper describes System architecture and interface design. Interface design is done with the help of existing development framework called PhoneGang. George Suciu et. al. [22] proposes a new platform for using cloud computing capacities for provision and support of ubiquitous connectivity and real time applications and services for smart cities need. This is achieved by combining two critical technologies which are cloud computing and internet of things. The cloud provides a large scale and long lived storage and processing resources for the personalized ubiquitous application that are delivered through IOT as well as important backend resources. The paper discusses about implementation of both the technologies which has led to a range of multiplicative benefits. Multisensor applications need to perform complex computations and hence it uses cloud computing along with IOT. This paper discusses the conceptual framework of integrating the cloud for the delivery of real time data coming from sensor devices.

III. CONCLUSION

This paper discusses the future internet concepts and how IOT has its influence on future internet. Architecture of IOT, Various applications which can be built with IOT and concept of Cloud integrated with IOT leading to new technology called COT are also discussed here. The problems involved for implementing this technology could be a research area.

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