IOT and Fog Technology: A Review

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Abstract. The IoT (Internet of Things) is a system to connect devices and collect the data from this device and manipulate the operation of the data and share it to the end user. Internet of Things is a system to connect different devices, actuators, sensors. Internet of Things system to control the number of devices and to provide the connection and with the help of connection from the different devices to communicating the devices and data generated and to save the human efforts and time.

Fog is an emerging technology. Fog technology is used for to storage, computing, networking, and control Internet of Things. Fog computing is an intermediate between IoT and Cloud computing. IoT working environment various problems and issues solve by Fog computing.

This paper presents the overview of IoT and Fog technology, detailed literature survey on IoT and Fog Technology, along with its application.

Keywords: Internet of Things, actuators, sensors, cloud computing and fog.

1 Introduction

Nowadays Internet of Things (IoT) technology is a most popular because things are embedded with the device, sensors, and software to connected and to collect the data and to transfer the data without any intermediate or human efforts are called as Internet of Things. In 1999 Kevin Ashton introduced the concept of Internet of Things (IoT) [1-3].

In Internet of Things, devices or smart devices are connected to the internet services that are embedded to collect the data from the devices and to transfer the data without the human interface as called the Internet of Things (IoT) [1-4]. In the working system of Internet of Things four components are used such as devices/smart devices/sensors, connectivity, data processing and user interface. First component of devices/smart devices/sensors that is a particular device that give the input from the environment and convert this input to data/information and this data can be interpreted by computer system. The second important components are connectivity, in connectivity the number of internet communication protocol and new technology are connected to the system internet. Third component is data processing, in the data processing step which uses the basic raw data, this basic raw data that are converts or transforms into information. In data processing steps numbers of data manipulation techniques are used such as Data Extraction, Data Aggregation, Data classification and Data Analytics. The fourth important component is User Interface. In user interface the processed information is to be shared with the end user by using messages, alarms, alerts, notifications, etc. [1-5].

Now a days as per requirement number devices are connected to the IoT and these devices processes large volume of data generated and send it to the cloud, this large amount of data requires large space for saving, processing and sending data on cloud technology.

Due to bandwidth and latency problem, processing this information on cloud becomes cumbersome. The Fog technology used for this purpose of data analysis, saving and transferring the processed data to appropriate end users. The Fog computing technology act at the middle level of IoT devices and cloud technology [6-16].

2 Related Work/ Literature Review

The following Table-1 summarizes the literature review in chronological order on IoT and Fog Technology. It is mainly focused on the techniques, architecture, and strategies applied by several researchers to address or solve the problem.

Table 1. Important Contribution

Authors	Year	Techniques / Methodology/ Architecture	Contribution
Thomson Christain et. al [1]	2018	Author focused the security architecture, Trust management with RFID, requirement of IoT in security solutions and overall analysis	Author have focused to analyzed overall all security & privacy tin IoT with the help of security architecture, with using RFID Technology how to solve IoT issues and to provide security, privacy and Trust Management.
Madakam, S et. al [2]	2015	Author have focused the Internet of Things in the Time series and describes the IoT technologies and International Telecommunication Union (ITU) Architecture.	Author have present the details concept of IoT, Time series of IoT, In IoT technologies working concept such as Radio Frequency Identification (RFID), Internet Protocol (IP), Electronic Product Code (EPC), Barcode, Wireless Fidelity(Wi-Fi), Bluetooth, ZigBee, Near Field Communication (NFC), Actuators, Wireless Sensor Network(WSN). Author also focused on IoT Forum Architecture and ITU Architecture for IoT working environment.
Ala Al-Fuqaha et al.[3]	2015	Autor have focused the IoT technologies, IoT Architecture such as Three-layer, Middle ware based, SOA based, Five layer. layer, protocols, and IoT application issues.	Author have presented the IoT technologies important in the market and IoT market opportunity. Author have also presented the overview of the IoT concept such as IoT elements, IoT various Architecture, IoT protocols, IoT application that used in smart life. Mainly focused on how the IoT smart autonomic management, data aggregation.

Mung Chiang et. al [4]	2016	Author describes the challenges of fog technology also describes the IoT work in the networking environment and opportunities of IoT and Fog technology.	Author have described the how fog technology to overcome the IoT challenges such as Latency Constraints, Network Bandwidth Constrains etc.
Chun Kit Ng [5]	2018	Author have focused the IoT working elements, also focus on framework, architecture and IoT working in the context of networking communication, management of the IoT data and enabling technologies.	Author have described the framework and challenges of IoT, Current situation of IoT in different applications, Security issues of IoT, application domain of IoT, data & Product management in IoT.
Subhadeep Sarkar et al.[6]	2015	Author have focused on the analyzed the suitability of fog computing within the framework of IoT.	Author have developed the mathematical model of fog computing and access its applicability in the context of IoT. The Model provide enhanced performance of Fog computing both in terms of provisioned QoS and eco-friendliness, fog paradigm as an improved, eco-friendly computing platform that can support IoT as compared to cloud computing paradigm.
F. Bonomi et al. [7]	2014	Author have examined the fog computing and how fog complements and extends cloud computing. Author also described the fog software architecture, highlighting the different technology component necessary to achieve the Fog vision.	Author have proposed a hierarchical distributed architecture that extends from the edge of the network to the core nicknamed Fog Computing and focused on IoT adds to Big Data and Analytics.
Daniel Boos et al. [8]	2013	Author have described the IoT framework in the working of IoT technologies and also describes on supply chains for IoT fast growing.	Author have focused on the IoT theoretical framework that working of IoT to integrated accountability and control the capabilities. Focus on particular supply chains in the context of fast growth of IoT technology. Also described the organization challenges of IoT technology.
Chung-Sheng Li et al. [9]	2018	Author described the outcome-based framework for	Author have the proposed outcome-based framework will contribute

		orchestrating both information and control flows within CIoT systems and solutions based on interconnected cognitive models of these environments.	to the development of emerging services and analytics for Cognitive Internet of Things (CIoT) based solutions, as well as serving as the foundation for enterprises using outcome-based business models for their products and services.
K. Saharan et al. [10]	2015	Author have described the survey and compare the Fog computing and Cloud Computing.	Author have focused the motivation and characteristics of fog computing and provided the Fog and IoT Applications.
N. Peter [11]	2015	Author have described the real time applications of Fog computing.	Author have discussed how the IoT devices generated large volume of data and this large data how to manage and how to solve the problem using Fog computing. Fog Computing using the intelligent platform to solve big data, latency and congestion problem.
C. Puliafito et al. [12]	2017	Author have investigated the fog computing environment and in this environment issue of mobility.	Authors have focused to investigate mobile support IoT devices issue in Fog computing environment. Author have identified three scenarios for the integration of Fog computing and IoT to provided necessary for mobility support.
M. Aazam et al. [13]	2015	Author proposed the Model for resources management and described the research and development in IoT Technology and Fog Technology.	Author have proposed a model that resources management through the fog technology. Model provides the fog computing environment for resources management and described fog technology and cloud service technology environments and point out what are elements or requirements to adapt to the provider of cloud services.
A. Yousefpour et al. [14]	2017	The Author have proposed the framework and model or service in IoT and Fog technology.	Author have proposed the framework for evaluate and understand the IoT and Fog technology services. Described the model for IoT and Fog working environment, service delays and IoT-Fog technology services focus on cloud applications for fast sharing and solve the service problem such as service delays and reduce the load.
Hany F. Atlam et al. [15]	2018	Author Presented the review of Fog computing, Architecture,	Author described the detail review of Fog computing and IoT integration. Also described the difference between FoG

		characteristics, benefits.	computing and Cloud computing, discuss the IoT Challenges in the context of working environment and how the Fog computing to solve the Smart IoT new devices problem.
Purvish R Pandya et. al.[16]	2018	Author have focused the MQ Telemetry Transport protocol (MQTT) for Data Monitoring System	Author have presented the model for IoT based data collection, data processing, data analysis and security. Mainly focused the MQ Telemetry Transport protocol on working of IoT application layer for secure data transmission process.
Hong et al. [17]	2013	Author have focused how the IoT process system are fast in the mobile fog working of IoT applications platform.	Author have purposed the Mobile Fog (MF) that used in IoT application that perform to processing the data locally and load balancing support in IoT platform working.
A. Alrawais et al. [18]	2017	Author have Focused on case study for security and privacy issues solve.	Author have proposed mechanism that used for security enhancement that provide the fog to improve fast processing and IoT devices to provide the security certificate revocation information. These mechanisms to solve the IoT environments security and privacy issues.
Redowan Mahmud et al. [22]	2018	Author has described the Fog Computing taxonomy based on the different challenges.	Author has carried out detail survey of Fog computing based on to identify the various challenges in past developments of Fog computing along with its key future and properties. Author purposed the taxonomy of Fog computing to classify the working system of fog computing based on the Fog nodes configuration, Nodal collaboration, Resource/Service Provisioning Metric, Service level objectives, Applicable network system and Security concern.
Salim Bitama et al. [23]	2017	Author have focused the mobile users to provide the Job Scheduling Algorithm for cost effective and high-performance services by using	Author have purposed the Bees Life Algorithm (BLA) by using Job scheduling for benefits of mobiles users in the Fog computing. Bees Life Algorithm provides the optimization distribution that divided into number of tasks in

		executing fog computing.	fog nodes for fog computing environment.
C. Mouradian et al. [24]	2018	Author has described the survey of Fog computing. The Fog computing main role play in the emerging technology on Tactile Internet.	Author have focused the detailed literature survey of fog computing and discussed the fog computing used in, IoT and CDN based on the number of evaluation criteria of the fog computing.
Yenumala Sankara Rao et al. [25]	2018	Author has described the survey of Fog computing along with security, applications and privacy in the fog computing environment.	Authors have focused on the fog computing application which used in IOT, Security and Privacy problems. Author mainly described the Virtualization technology, this technology used in Cloud and Fog computing to permit the Virtual Machine (VM). Due privacy and security problems the author approaches the VM migration techniques that are used to solve the above problems. Author also purposed the Fog computing application taxonomy.
Wangbong Lee et al. [26]	2016	Author have described the fog computing environment architecture for Wireless Sensors and Actuators Network (WSAN)	Author purposed the gateway based fog computing architecture for Wireless Sensors and Actuators Network (WSAN). Architecture described the slave nodes and master nodes that manage the virtual gateway resources, flows and functions.
S. Khan et al. [27]	2017	Author have described the review of fog computing.	Author have first focused on detailed review of fog computing and its application and also described the fog computing security issues.

The above tables describe the current scenario of IoT and Fog.

3 Application of IoT and Fog Technology:

In today's life IoT with combination of fog technology is use in various products or devices that change human life and easily information provided by IoT smart devices to the human. Following are the IoT with Fog technology applications such as Home, Smart Cities, Agriculture, Environment, Health [1, 3, 15, 19, 20, 21, 28-30].

3.1 **Home:** In home CCTV camera or video camera and safety alarm system to provide secure human home. In home various products or appliances that are used in IoT technology such as refrigerator, washing machine, AC, electric water geyser. In now a new refrigerator come along with LCD screen to inform what are storage in refrigerator, food expiry information etc. The new washing machine user can operate remotely. In smart home to use the IoT and Fog technology to centralize the monitoring and to provide common most platforms for storage and smart secure home appliance with flexible resources. [1,3,15, 20, 21, 28].

3.2 Smart Cities: With the help of IoT technology in Cities Street that used the weather adaptive and intelligent lighting. Intelligent smart IoT devices that are used in highways and roads to inform the warning messages such as accident information, traffic jams, diversions, weather information for smart transportation. By together using of IoT and Fog technology in smart devices for cities properly wastes management and properly clean the cities to become a smart city. IoT with Fog technology also use in Smart Traffic Light System and Smart Connected Pipeline System in Smart Cities [1,3, 15, 20, 21, 28].

3.3 **Agriculture:** Greenhouses uses of the smart IoT devices with Fog technology for controlling the micro-climate temperature to maximize the productivity and high quality of food such as vegetables and fruits [1,19, 20, 28].

3.4 **Health:** IoT devices / IoT chips with using Fog technology are implemented in Hospitals for managing and providing proper services to patients which includes patients reports, medical history monitoring and then providing proper treatment to the patients. By using IoT technology in medical and health provides many benefits such as proper care of patients, remote diagnostic, hospital properly hygiene, hospital equipment's monitoring etc.[1,3.15,20, 21, 28]. Cao et al [29] has developed the fog computing assisted distributed analytics system to control and monitoring the patients fall stroke. Stantchev et al [30] has developed the three-tier architecture for smart healthcare infrastructure and equipment's. In this architecture the fog layer is used for new devices support such as smart mobile, low latency, live location information and security.

3.5 Environment: The IoT smart devices/chips with using Fog computing ae used for tracking system such as GPS/GSM to find out current location and to track the wild animals and to immediately send signals such as messages to coordinates. The IoT smart fire smoke devices are used to alert the forest department, using which it has become easy to control and monitoring fire in the deep forest which is essential to save the wildlife [1,3, 19, 20, 28]. The fog computing to storage of the information and fast processing and sending the IoT devices data to the destination. The use of fog technology can also be deployed in wind farm and smart grid control system [28].

4 Conclusion

Internet of things is a new technology for connecting everyone with everything by means of IoT smart devices which can connect human to devices, devices to devices and human to human for sharing and transforming information and communication fast and easily. Now a days IoT applications are providing support to make human life smart and easy.

Fog is a currently new emerging technology used for storage, computing, networking, and to control Internet of Things. Fog computing can solve various IoT problems such as network bandwidth, data sharing and large storage capacity for saving. By using IoT and Fog computing technology user can transfer and share the proper data everything, everywhere with less response time.

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