IJETST- Vol.||03||Issue||09||Pages 4654-4661||September||ISSN 2348-9480 2016

Open access Journal **International Journal of Emerging Trends in Science and Technology**

Impact Factor: 2.838 **DOI:** http://dx.doi.org/10.18535/ijetst/v3i09.13

Internet of Things (IoT) with Cloud Computing and Machine-to-Machine (M2M) Communication

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ABSTRACT

The Internet of Things (IoT) is a new revolution of the Internet. Objects make themselves recognizable and they obtain intelligence by making or enabling context related decisions. They can communicate information about themselves. They can access information that has been aggregated by other things, or they can be components of complex services. The three important factors propelling the IoT forward are Sensing Nodes, Embedded Processing and Communication. This transformation is accompanied with the emergence of cloud computing capabilities supported by an increase in storage capacity and high end processing and the Machine-to-Machine (M2M) communication for data transport with security.

By introducing cloud computing technology, we can make a full call to the storage resource pool and computing resource pool in the cloud computing architecture, and provide high reliability for IoT cloud storage service and efficient cloud computing services to users. The service layer for M2M type of communication will provide a framework for the integration of the different communication technologies deployed in the field of IoT. This M2M service layer will provide the needed services like data transport, security, devices management and device discovery in a harmonized manner across a multitude of vertical domains to the application layer.

In this paper, a brief introduction of IoT is given and the IoT with cloud storage and M2M communication is explained. The main issues of IoT related with storage, requirement of high end devices, security, privacy, data transport can be solved by the combination of IoT with cloud computing and M2M communication. This will also benefit the IoT in its ease of use in day-to-day life and believe to be future in this area which is getting ready for its revolution.

Keywords- *Internet of Things, Cloud computing, Machine-to-Machinecommunication, MQTT, Cloud storage.*

1. INTRODUCTION

The impact caused by the Internet of Things (IoT) to human life will be as huge as the internet has caused in the past decades, so the IoT is recognized as “the next of internet”. A part of the enabling technologies are sensors and actuators, Wireless Sensor Network(WSN), Intelligent and Interactive Packaging (I2Pack), real-time embedded system, mobile internet access, cloud computing, Radio Frequency Identification (RFID), Machine-to-Machine (M2M) communication, Human Machine Interaction (HMI), middleware, Service Oriented Architecture (SOA), Enterprise Information System (EIS), data mining, etc.

The IoT is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment and the confluence of efficient wireless protocols, improved sensors, cheaper processors, and established companies developing the necessary management and application software of the IoT mainstream. Smart environments and Smart Platforms forms a smart web of everything support the citizen in their professional and domestic or public life.

The massive explosion of online services, further inspired by the smartphone and handheld revolution, which made these services highly accessible, has created a demand to leverage technology for M2M communication. It has also created a decline in the cost for adding connectivity capabilities into products. The cloud computing evolution, by an increase in storage capacity, has also brought the ability to scale the amount of data that can be stored effectively and affordably. This is yet another angle in enabling machines to generate and collect large amounts of data on a regular basis.Reduction in cost and mass storage facility with required security of data and quick service is what offered by IoT with M2M communication and cloud computing.

In this paper, first applications where IoT has already been in use is discussed. Then brief overview of some technologies which is used in the field of IoT is explained. Finally, the proposed combination of cloud computing and M2M communication for IoT is explained and through internet facility these will be future drive force for IoT.

2. APPLICATIONS

The application of IoT are in home automation, health sector, food sector, smart city, smart energy management systems. Not only internet of things applications is enhancing the comforts of our lives but also it giving us more control by simplifying routine work life and personal tasks. The rapid rising and aging of population is one of the macro powers that will transform the world dramatically, it has caused great pressure to food supply and healthcare systems all over the world, and the emerging technology breakthrough of the Internet-of-Things (IoT) is expected to offer promising solutions.

2.1 More Internet-connected devices

The number of Internet-connected devices surpassed the number of human beings on the planet in 2008, and by 2020, Internet- connected devices are expected to number between 26 billion and 50 billion as can be seen in Fig 1. Europe has potentially a full eco-system with market leaders on smart sensors (Bosch), embeddedsystems (ARM, Infineon), software (SAP), telecoms (Orange), application integrators (Siemens, Philip), network vendors (Ericsson). There is also hype around Asia and America. This gives hope of IoT revolution globally in upcoming years.

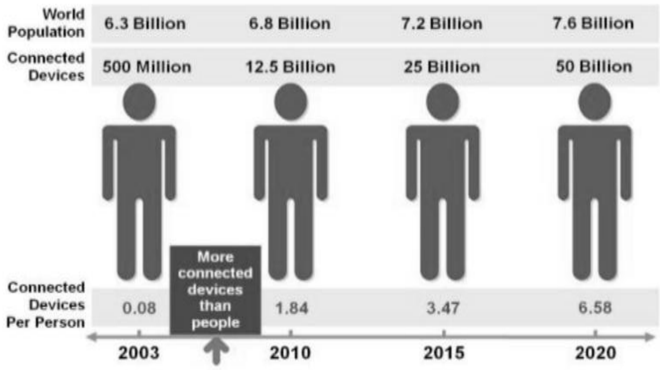

Fig. 1 Number of connected devices by 2020 [1]

2.2 Food

The IoT makes possible a new cooperative between food producers, transportation and hospitality or retail companies who can work together to ensure efficient delivery and food safety. With IoT-based business solutions, companies across the supply chain gain the real-time visibility and enable the automated, intelligent actions needed to ensure food is of the highest quality, delivered on time and prepared in optimal settings.

A typical IoT solution for aFood Supply Chain(FSC) comprises with refer to Fig. 2: a series of field devices (Wireless Sensor Nodes, RFID readers or tags, user interface terminals, etc.), a backbone system (databases, servers, and many kinds of terminals connected by distributed computer networks, etc.); and a series of heterogeneous wired and wireless communication infrastructures (Wi-Fi, cellular, satellite, power line, Ethernet, etc.). Due to its ubiquitous connectivity, all physical entities of M2M communication (field devices and backbone equipments) can be distributed throughout the entire FSC. The vast amount of raw data is extracted and fused into high level and directly usable information for Decision Support Systems (DSS).

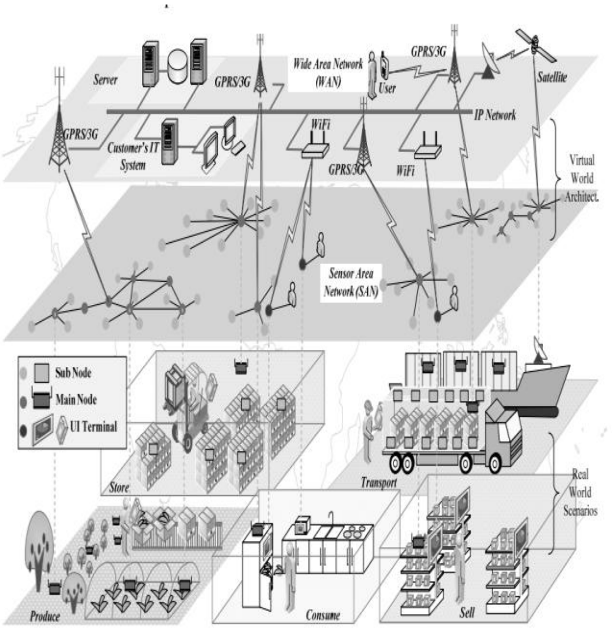

Fig. 2 Food supply chains in the era of Internet-of-Things [6]

2.3 Health

The wearable Networked sensors, those equipped with IoT intelligence, make possible the gathering of rich information (observation and recording of data in home and work environments) indicative of our physical and mental health. Captured on a continual basis, aggregated, effectively mined, and presented to physicians in easy-to-assimilate visualizations, this information can bring about a positive transformative change in the health care landscape.

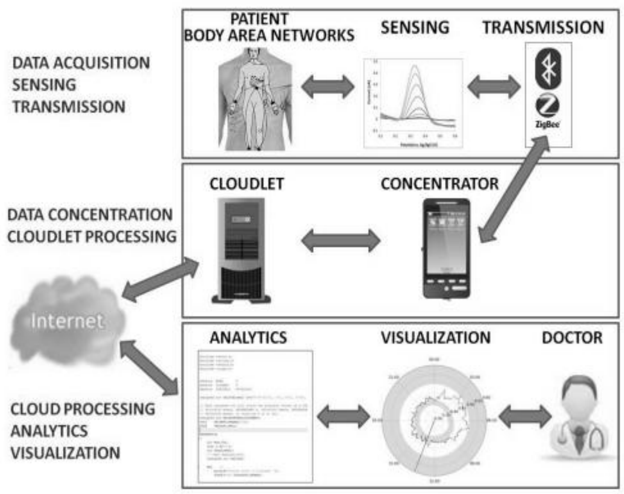

Fig. 3 Components of a remote patient monitoring system that is based on an IoT-cloud architecture [2].

Data Acquisition with refer to Fig 3 is performed by multiple wearable sensors that measure physiological biomarkers and the sensors connect to the network though an intermediate data aggregator or concentrator, which is typically a smart phone located in the vicinity of the patient. The Data Transmission components of the system are responsible for conveying recordings of the patient from the patient's house or any remote location to the data centre with assured security and privacy.

The cloudlet can be a local processing unit (a desktop computer) which is directly accessible by the concentrator through Wi-Fi network. The storage or processing device in vicinity of a cloud let, is used to augment its storage or processing capability. Moreover, the cloudlet can be used to transmit the aggregated data to the cloud in case of limitations on the mobile device such as temporary lack of connectivity or energy.

Cloud Processing has three distinct components: storage, analytics, and visualization. The system is designed for long term storage of patient's biomedical information as well assisting health professionals with diagnostic information. Analytics that use the sensor data along with e-Health records that are becoming prevalent can help with diagnoses and prognoses for a number of health conditions and diseases. Visualization methods that make the data and analyses accessible to them in a readily digestible format are essential if the wearable sensors are to impact clinical practice.

3. TECHNOLOGIES USED IN IOT

The Internet of Things is grouped into three categories: Technologies that enable "things" to acquire contextual information, that enable "things" to process it and that improve security and privacy. The first two categories jointly as functional building blocks and the third is not functional requirement but without which the spread of IoT will be severely reduced.

3.1 Building Blocks of Internet of things

The building blocks are building intelligence into things. There are three important factors propelling the IoT forward.

- Sensing Nodes
- Embedded Processing
- Communication

3.1.1 Sensing Nodes

Sensor is a kind of information gathering tool, it is responsible for collecting the specified information in a specific environment, and then it will carry information with a specific electrical signal from the collected information. It is the data source of the Internet of things, also is the basis for the realization of the Internet of things intelligent and information.

Nowadays, sensor technology is developing towards intelligent direction, intelligent sensor is bound to be an important symbol of the future development of intelligent internet of things. To achieve the real-time adjustment of the storage factors, to ensure the storage quality, the real-time adjustment of the storage factors is required. These nodes contain inimitable identification and through a distant command and organized topology, it can be controlled independently.

3.1.2 Embedded Processing Nodes

The Core element of the IoT is embedded processing. Microcontrollers or microprocessors provided with local processing potential. MCU can offer the real time embedded processing that is a main necessity of the majority of IoT applications.

In the home automation case, for command and control of the whole house all electrical outlets and electrical apparatus; windows, doors and thermostats have straightforward embedded controllers that converse with a master MCU hybrid machine. Consecutively this master machine be capable of converse by means of the Internet with different clients, from the service providers and to gateway that can provide the owner access to distantly control the entire of these connected objects.

The following are some needs that make an MCU superlative for use in the IoT.

- Cost-effectiveness
- Low power
- Quality and reliability
- Security

3.1.3 Communication Capability

The main responsibility of the communication node is to convey information collected by the sensing nodes to the targets recognized by the local embedded processing nodes. Once the new commands are generated and data is distantly processed the communication node gets back the fresh commands to the local embedded processing nodes to carry out a task. This might be as easy as based on energy use sensing a fridge door being left open and without human intervention closing the door using a mechanical mean or produce a warning or it might be as sophisticated as communication to a self-directed vehicle to keep away from an accident.

The inexpensive electronics, the use of the Internet protocol, together with ubiquitous networks and cloud computing now allows any device to be equipped with a communications module. This enables devices to communicate status and information, which in turn can be aggregated, enriched and communicated internally or onwards to other units. The IoT will cover every phase of one's daily life, therefore there is no boundary to the distance for which control and command communication can be used.

3.2 Radio Frequency Identification Technology

Radio Frequency Identification (RFID) is a new automatic identification technology. It takes use of radio frequency signal and through the space coupling to achieve wireless information transmission, and through the transmission of different signals to identify tags within the different information, so as to achieve radio frequency identification. RFID readers sensing the existence of an entity or someone; to indicate a building interruption doors and locks with open or close circuits and for measuring temperature nodes could contain thermostat. The end result is that there could be a lot of unlike variety of sensing nodes, depending on the concerned applications.

These nodes contain inimitable identification and through a distant command and organized topology it can be controlled independently. A smart phone with Radio-frequency identification functionality can move towards individual RFID enabled objects in a house, converse with them and list their position on the network. They assist in the automatic detection of anything they are attached to acting as an electronic barcode. With objects tagged with RFID and paired with an Internet of Things application, consumers can improve their everyday wellbeing and even save time and money in the long run.

3.4 Cloud Computing Technology

Through cloud computing technology, we can use the storage resource pool and computing resource pool, and provide high reliability for IoT cloud storage service and efficient cloud computing services to users. The data that produced by introducing the information technology is unusually large. The cloud computing services first need to build a large number of computing resources servers, and then orderly link them into cloud computing architecture.

The cloud computing technology can distribute the huge data in the distributed computing system. Through deploying cosmically of cloud computing server, we can transfer the workload and the local system can't install a variety of application software or system. The task of running the program is not to be borne by the local computer, we use computer cluster in cloud computing to replace the local computer to complete the task. However, local computer only needs to install an application client, we can through this client and network serve to achieve to realize remote program running and computing functions and so on. On the one hand, we can reduce the cost by this technology, on the other hand, we can improve the efficiency and shorten the schedule time.

Cloud computing technology architecture system as can be seen in fig 4, has divided into the Infrastructure as a Service (IaaS), the Platform as a Service (PaaS), the Software as a Service (SaaS) and the management layer. And the top three layers is a horizontal technology layer of the cloud computing architecture, it is used to provide users with high efficient computing resources and friendly user interface. In addition, management layer provides management support and maintenance to infrastructure, platform and software services.

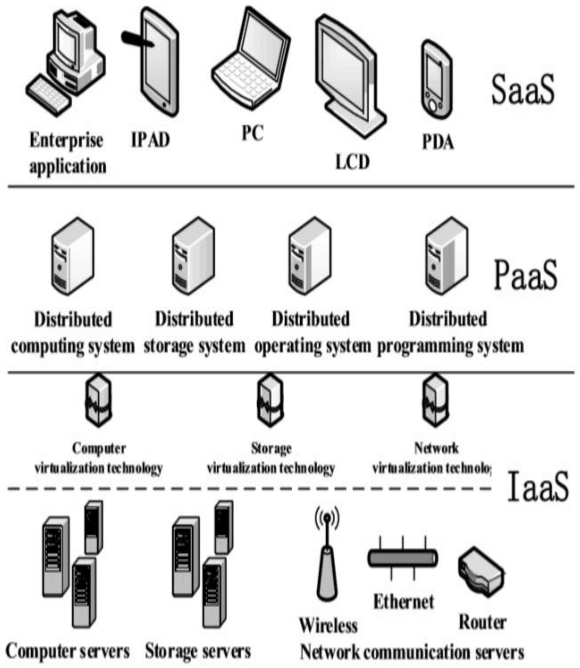

Fig. 4 Cloud computing architecture [3]

IaaS is the basis for the normal operation of the entire cloud computing architecture. It is through the construction of a large number of computer servers, storage servers and network communications server, and call different resource servers by the different users' needs, and provides computing services, storage services, and network communication services to the different users.

PaaS is a virtual computer operating system that provides users with the program development and caching services, and is the middleware part of the cloud computing architecture, and plays a connecting role.

SaaS is based on network communication technology, and it communicates with the cloud computing services with internet technology, and we call the relevant resources from cloud computing architecture shared resource pool, and get the related services, in order to meet the different demands for users.

Cloud computing management layer provides management services for the above three layers, we can make use of the technical maintenance of account management, Service-level agreement (SLA) monitoring, billing management, security management, load balancing and operation and maintenance management to maintain the normal operation of the entire cloud computing system, in order to improve cloud computing efficiency and so on.

3.5 M2M Communication

The M2M communication describes devices that are connected to the Internet, using a variety of fixed and wireless networks and communicate with each other and the wider world. They are active communication devices. Ease of deployment of M2M over wireless and the reuse of the existing infrastructures provide a wide coverage area. Any M2M device, such as a smart utility meter or a traffic monitoring device, can be installed anywhere in the network coverage area without the need for costly wired communication expenses. This facilitates the planning of the smart city and speeds up service delivery.

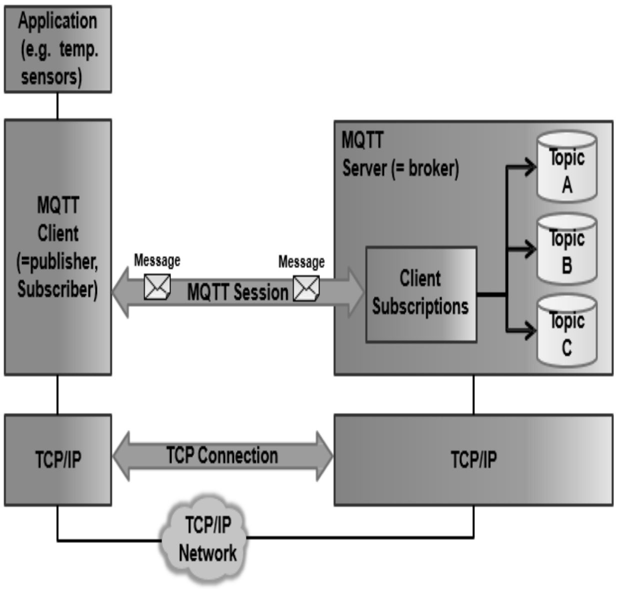

Fig. 5 MQTT model for M2M communication [4]

M2M service layer will provide the needed services like data transport, security, devices management and device discovery [5]. This layer is integral to the IoT architecture and industry chain. The data collected can now be combined and used in a variety of ways. The same data may be used in different contexts. The service platform comprises the following software sets: integrated frameworks, Internet of Things middleware, industry suites, and industry application solutions. The middleware abstracts and implements network and device management, authentication, authorization, and accounts management, data management, and service management. The industry suites are a series of support models, tools, and service sets designed to address sector-specific requirements.

MQTT – Message queue telemetry transport protocol is used for M2M communication. MQTT is a lightweight message queueing and transport protocol. MQTT is suited for the transport of telemetry data (sensor and actor data).

In MQTT, sensor and actor nodes communicate with applications through the MQTT message broker. Messages are the units of data exchange between topic clients. Topics are message queues. Clients subscribe to topics to publish and subscribe messages. Thus subscriber and publisher are special roles of a client. Topics allow clients to exchange information with defined semantics. Application sends an activation message to the actor node through the broker.

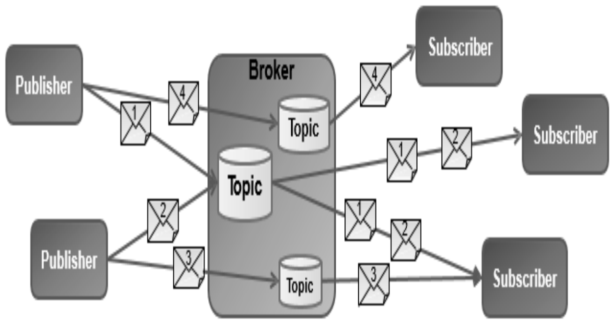

Fig. 6 MQTT model characteristics [4]

4. IOT WITH CLOUD COMPUTING AND M2M COMMUNICATION

The main issues faced by IoT are security and privacy. Poorly secured IoT devices and services can serve as potential entry points for cyber-attack and expose user data to theft by leaving data streams inadequately protected. The Internet of Things privacy issues are related with the ways personal data is collected, analyzed, used, and protected. For example, IoT amplifies concerns about the potential for increased surveillance and tracking, difficulty in being able to opt out of certain data collection, and the strength of aggregating IoT data streams to paint detailed digital portraits of users.

In order to overcome these issues related with security, privacy, data collection, aggregation or analysis we need to incorporate cloud computing and M2M communication along with IoT. This architecture will provide storage for big data collected, high end processing applications for processing these data, secure data transport, less bandwidth utilized, faster response, lesser battery usage and work well in latency network too.

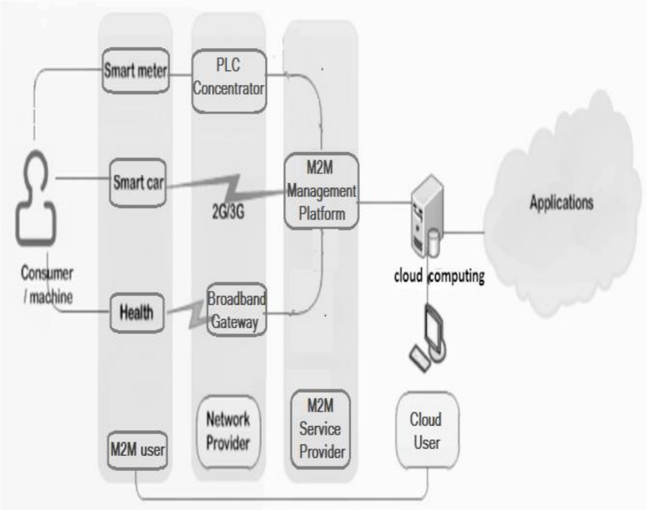

Fig. 7 IoT using cloud computing and M2M service

The data collected needed to be store somewhere and the data generated anytime, anywhere. These huge data given back in raw form back to end user will also consume time, data. Hence the role of cloud computing. The cloud helps to collect and store large data and can also help to analyse it using modern tools.

In fig 7, the main elements of an IoT system and value chain commence with a user or a machine. These devices are controlled by an M2M user. This may be an automobile company, a utility managing drains and sewers and so forth. The end users will need some kind of network to send the data back to their business systems. In between, for example, an M2M management platform that handles device specific tasks, such as fault detection when a device does not respond or management of SIM-cards, an M2M service provider manages the platform. The cloud user will use the data collected in its back office systems. Before reaching user, the data will be aggregated and processed using cloud computing. This can be sent to end user in a visual form rather than big data using cloud or as inputs to an application. Thus M2M and cloud computing can be integrated with IoT for better results.

5. CONCLUSIONS

The Things technology and the characteristics of the internet brought a lot of redundant data and processing on available data fast. Firstly, design the cloud computing, cloud storage, network technology and basic platform module. Secondly, use virtualization technology and network sharing to link various aspects as a linkage system. Finally, M2M communication as communication technology and service management for data transport, improve the efficiency and security.

The architecture including both cloud computing and M2M communication will provide storage for big data collected, high end processing applications for processing these data, secure data transport, less bandwidth utilized, faster response, lesser battery usage or less power consumption and work well in latency network too.

The cloud computing technology can distribute the huge data in the distributed computing system. Through deploying cosmically of cloud computing server, we can transfer the workload. The cloud computing technology provides speedy data processing and assist decision support functions for the networking architecture. This will reduce the time cost bring by redundant data and uncertainties data of unexpected events, shorten the time of developing the requires programs and reduce the loss of life and property caused by unexpected events.

There are many factors that make M2M communication, an attractive medium, such as the relatively low cost of a wireless module, ease of deployment of M2M over wireless and the reuse of the existing infrastructures that provide a wide coverage area. M2M service layer will provide the needed services like data transport, security, devices management and device discovery in a harmonized manner.

There are some drawbacks for IoT in practical scenario, like the high initial investment cost, lack of trust among patients. These will work with help of constant internet connection. The other challenges include requirement for more distributed processing and storage of the massive data as well as cloud functionalities. Since clouds are decentralized (and infrastructure-less), processing capabilities and data positioned closer to users and migration of servers to follow mobile users are fields that require further research.

ACKNOWLEDGEMENT

To all my friends who supported me to prepare this paper.

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