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Machine to machine communication enabled internet of things: a review

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ABSTRACT

Internet of things (IoT) will be the main part in upcoming generation devices that would not simply sense and report, also will have the controlling capability. It may be a connected vehicle, connected devices, robot, a building automation system, a door lock or a thermostat, these connected machines or devices will provide greater impact on our daily lives. Control data and the operating instructions could be protected to ensure control and autonomy for our safety and security, this could be a critical task. Privacy and security are important consideration in designing the system. With the intense growth of devices or devices with facilities such as computing and communication are carried out using a profound technology known as machine to machine (M2M) communication, which is specially designed for cross-platform integration. In many industries, smart homes, smart cities, smart agriculture, government, connected devices, security, healthcare, education, public safety, and supply chain management. Internet of things (IoT) and machine to machine communication have to be implemented in near future. Also, this paper gives an in depth view about the different M2M techniques with interconnected IoT for truly connected, smart, and sustainable world.

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1. INTRODUCTION

Technological advancement during the recent decade leads to the exponential growth of the "connected devices" which are connected to the internet, due to the number of devices used by everyone gets increasing (e.g. smartphones, iPads, Kindles, and digital television) [1]. Also, the mobile devices are already gets exceeded approximately 6 billion and also users starting to use multiple devices at a time. In connection with that machine to machine (M2M) connections are needed to establish connections.

The innovative technology which capture a real time event from a device and transfers the captured event details to another device using a wire line communication or wireless communication, where a meaningful information is transferred using M2M techniques. More generic entities such as sensors, actuators, smart devices, human beings, and any other objects will able to communicate with other anytime and anywhere is possible due to the availability of internet. These M2M devices are connected through an

innovative internet medium based on technical and societal perspectives [2]. Several economy related business organizations and sectors are expected to disrupt because of the exponential growth in communications industries and the wider global economy, the connected devices, M2M, and the internet of things (IoT). Hence, the growths in traffic generated by M2M devices are rapid. The two important growing technologies M2M and IoT are the trending technology which serve as the base for the future world. This technology tends to occupy within the physical world of anything that of intrigued are to watch, oversee and control by individuals, businesses, or organizations will be associated and will offer administrations by means of the internet. The physical substances could be farmland, common assets like discuss, buildings and individual real-world concepts over the course will work. Due to the increased adaptation of internet and internet protocol and also the decreasing cost of semiconductor components the two technologies are progressing over the last decades in a considerable manner.

Business models with autonomy in different sectors can be created by M2M and IoT, which uses the embedded technologies, and connecting the multitude of different small devices and things to the internet. The contributing techniques in future IoT are machine learning based technologies, large amount of data and cloud and data analytics. Managing big data increases the complexity of information also the automation in actions and control of real-world assets are required. It requires the technological development swhich should go beyond the existing big data [2].

2. SYSTEM MODEL

M2M maybe a computing and communication facility with freed from any human intervention which provides solutions that allow communication between machines or devices. It is almost like an industrial supervisory control and data acquisition systems (SCADA). SCADA is supposed for isolated systems using proprietary solutions, whereas machine to machine (M2M) are meant for cross platform integration. Using machine to machine solutions, end users can obtain data regarding occurrences from assets, such as temperature or inventory levels [2]. The applications of M2M includes such as: i) environmental monitoring, ii) public safety and civil protections, iii) healthcare, iv) energy and utility distribution industry (smart grid), v) intelligent transport systems (ITSs), vi) supply chain management (SCM), vii) automation of building, viii) home networks, ix) agriculture, and x) military applications [3].

M2M solutions, on the other hand, do not typically allow for the broad exchange of data or the connection of devices to the internet. Also, the features of M2M includes sizable amount of nodes or devices, at low cost and low power consumption, traffic is less for small device/machine, huge data collection, intervention less M2M and human response required for operational stability and sustainability. M2M contains three kinds of nodes. They are high, mid and low end nodes [2]. The characteristics of each category of sensor node vary, according that its application environments also differ.

2.1. Architecture of M2M ecosystem

It consists of certain type of providers such as device, internet service, platform, service, and service users. The M2M ecosystem and its service networking are given in Figures 1 and 2 [4]. A generic system solution is given in Figure 3.

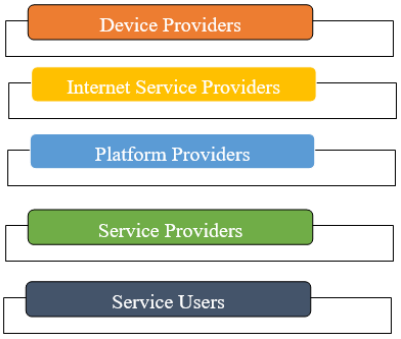

Figure 1. M2M ecosystem

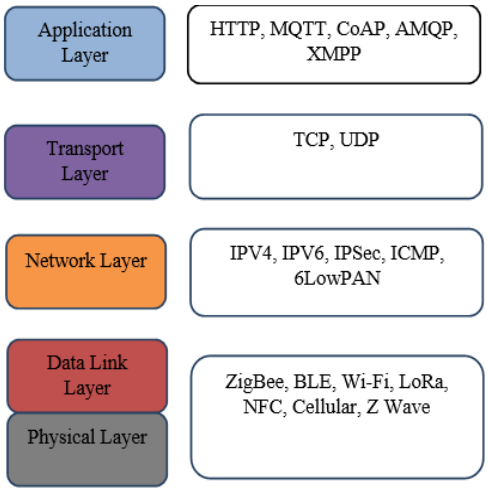

Figure 2. IoT network stack

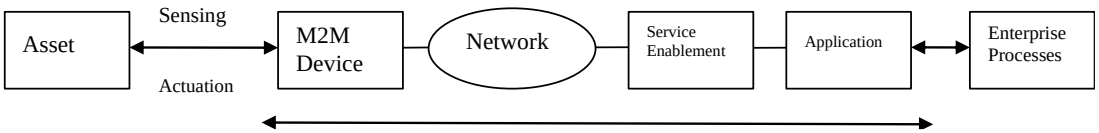

Figure 3. A generic M2M system solution

2.2. M2M device platform

It allows accessing things or devices connected to the web anytime, anywhere. Saved machines or devices are able to create a database which includes managers, users and other services which can easily access the stored data. Manage device profiles, like location, sort of device, address and contour. Also, the authentication and authorization key management functionalities are carried out by this.

2.3. M2M user platform

This platform manages user profiles of the M2M service and provides features such as modification of user registration, recharging and searching. In addition, it interacts with device's platform and handles the complete ban on device, object network, and service user access. An administrative advantage could be provided to Service providers and device managers on their devices or networks as well. The administrators can manage the devices through controlling and monitoring the devices [5], [6].

2.4. M2M application platform

It allows integrated services stand on device collected datasets. Heterogeneous data can be merged from various devices which can be used for creating new services. In addition, it collects data from the control processing logbook for device management by functioning with device platform. Management of the interrelation to an appropriate network is provided for transparent services [1].

2.5. M2M access platform

It provides services through this platform to M2M devices, also provides app management for smart device apps. Application management manages application registration by developers and provides the plotting relationship between applications and the devices. The mapping feature issues a file of applications for suitable machines.

2.6. Overview of IoT protocols

Internet of things ecosystem can a raise not dissimilar to the present web, where ever as devices, networks and application levels are inter linked. Machine to machine communicationtechnologiesare sensor nodes with networks, radio-frequency identification (RFID), mobile internet, wire line and wireless communication network, Bluetooth LE/Smart, IEEE 802.15.4 ((low-rate wireless personal area networks (LR-WPAN); e.g. ZigBee, internet engineering task force (IETF), IPv6-enabled low-power wireless personal area networks (6LoWPAN), routing protocol for low power and lossy networks (RPL), constrained application protocol (CoAP), ISA100.11a, and WirelessHART), M-BUS, Wireless M-BUS, KNX, power line communication (PLC), and IPv4/IPv6. In personal area network (PAN)/home area network (HAN)/local area network (LAN)/field area network (FAN), low power wireless communication technologies such as Wi-Fi, Bluetooth low energy (BLE), ZigBee, and 6LoWPAN, Z-wave may also be used to connect devices to the M2M Gate way node. GSM 3G/4G or fixed bandwidth/FTTH could also be used to connect machine to machine communication gateway node to the main server (See Figure 4).

2.7. IoT protocols

Very small size data are often sent by low-power wide-area network (LPWAN) technologies which include SigfoxandLoRa. Release of 3GPP, it is possible for a cellular operator to design an LPWAN, which they would call EC-GSM-IoT, LTE-M, or NBIoT. Enrolling firms, such as telecom and information technology (ICT) businesses, in IPv6 addressing can present an opportunity to reach billions of devices that can be internet protocol (IP)-enabled and fully addressable over mobile or wired broadband connections. Availability of heterogeneous network in IoT, which has devices that have an IP address and others that do not have an IP address connected through IP gateways. We are getting closer to having the IoT platform connected to the gateways. Some form of batch-level sensor data is generated as a natural consequence of using sensors, and this would necessitate large-scale data analytics, which might be applied to framing intelligence, which could be utilized for several other purposes including planning and operational optimization [7]–[9].

Recently, throughput efficiency was enhanced by the standard IEEE 802.11n. High throughput was obtained by IEEE 802.11ac, focusing in 5 GHz band. IEEE 802.11ah allows number of network device to cooperate greater than 1 GHz (ISM) band. The main focus is to increase the efficiency and also to exploit the collaboration to extend the range. This standard aims in fast development of internet of things and machine to machine application which exploit burst–such as transmissions. They possess similarity as of traditional wireless sensor network (WSN) theories, which includes the technologies namely 6LoWPAN, RPL, and CoAP [10], [11].

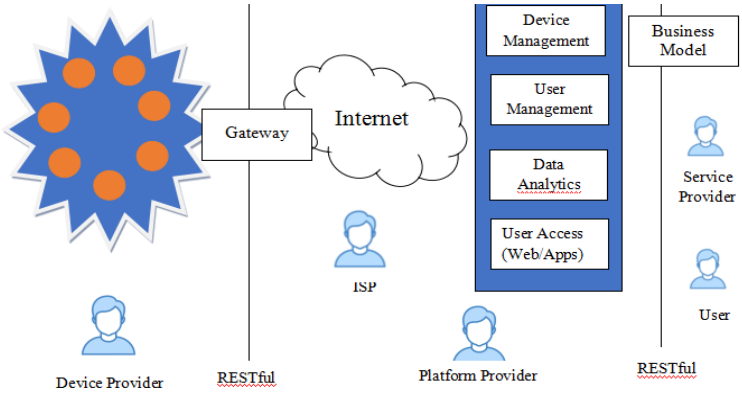

Figure 4. M2M network

2.8. CoAP

The basic structure of CoAP which is already available is free and operable for any kind of IoT device, it stables to be mostly overweight and power consuming for many IoT usage events. CoAPis meant in such how that it meets the wants of hypertext transfer. The IoT built on protocols such as hypertext transfer protocol (HTTP) or user datagram protocol (UDP), which utilizes UDP to ensure that communication between devices is highly secure. Units per transacation UPT, by being open to multi-casting and broadcasting, enables the use of a smaller amount of bandwidth, helping maintain fast communication speeds while also using a minimum amount of bandwidth. This makes it an honest fit for use in resource-constrained M2M applications. On the other hand, CoAP shares similarities with HTTP in that the RESTful framework for appliance endpoints can also enable an invitation/response communication mechanism. In addition, CoAP implements HTTP retrieve, post, post, and delete methods, which eliminates the possibility of misinterpretation in customer communication. It incorporates the datagram transport layer security (DTLS) to enable the transfer of IoT data as well as safe data exchange via the transport layer. The need for a light protocol to meet the demands of battery-powered or low-power devices is satisfied by CoAP, which fully meets these needs. Overall, when it concerns currently utilized web service-based IoT systems, CoAP may be a good fit [1], [12].

2.9. Bluetooth low energy

Bluetooth low energy (BLE) is designed in such a way that it is cost efficient and energy efficient. It is integrated in many smartphones due to its high efficiency. Low Power Networks are considered as another eminent technology which forms the base layer for IoT. IEEE802.15.4 is one of the protocols which is considered as first used protocol in practical experiments and researches in wireless sensors networks.

Low-rate wireless personal area networks (LR-WPAN) can be used in ISM standard at frequency around 433 MHz, 868/915 MHz, and 2.5 GHz. Depending on transmission power level and selected band, the data rates are supported between 20 to 256 kbps. In active modes, the radio transceivers intake power in tens of milli-Watts range which means that they are still insufficient in providing long battery life for continuous operation. During transmission and listening, radio duty cycling manages radio frequency integrated circuit (RFIC)active periods.

2.10. Wireless devices

The more recent derivatives ZigBee IP, ZigBee RF4CE, wirelessHART, ISA 100.a inherit this technology at very fundamental step asIEEE802.15.4 defines the physical layer where numerous of low-energy communications specifications have been created [4].

2.11. Message queuing telemetry transport

Message queuing telemetry transport (MQTT) is defined as a lightweight publication or subscription type (pub/sub) messaging protocol. These are mainly framed for battery-powered devices. The configuration of MQTT is very simple and less weight and also provides very low power consumption for the devices. MQTT is based on a concept of subscriber, publisher, and broker. The publisher's role in this model is to gather information and distribute it to subscribers via a brokerage of brokers. On the other side, the publisher's primary job is to ensure security by cross-checking the credentials of publishers and subscribers. The MQTT will satisfy the wants like consuming less energy, least bandwidth and working over wireless networks, best reliability and tiny handling and high memory resources.

2.12. Wi-Fi

Wi-Fi uses radio waves to transfer data at specific frequencies, such as 2.4 GHz or 5 GHz channels. Multiple channels are found in both frequency ranges, which allow different wireless devices to operate, this distributes the load in such a way that the individual connections of the devices are not disrupted. This often protects the wireless networks from overflowing. The 100 m limit is the standard limit for a standard Wi-Fi connection. However, 10-35 m is the most common range for Wi-Fi [13].

2.13. ZigBee

ZigBee is designed for self-configuration, for use in short-distance radio networks, telemetry systems, various types of sensors, surveillance devices and also in wireless reading of energy and heat meters.

2.14. Bluetooth

Bluetooth technology allows the wireless connection of different electronic devices namely smartphone, headset or speakerphone, keyboard, personal computer, laptop, mouse, palm top, printer, and so on. If you haven't yet created a wiki page-style definition, it's an open standard protocol defined by the IEEE 802.15.1 specification. Its technical specification contains three classes of transmission power, designated ERP 1-3, in the 100 and 10 kilowatt levels, respectively. The second (10 m) class is the most common class as it allows you to connect with the existing devices in various rooms, moreover on the different platforms.

Bluetooth makes use of radio waves within frequency range of 2.4 GHz ISM wave band, therefore the Bluetooth adapter is the gadget that helps in making use of this protocol. As the Bluetooth protocol was upgraded from version 1.0 to 1.1, it could transfer data in batches of packets with 79 channels and an upload speed of 721 Kbps, which is equivalent to the lowest bandwidth and upload speed possible for the oldest Bluetooth 1.0 standard. Compared to the Bluetooth 4.0 specification, which matches the new standard, there are 40 channels with a bandwidth of two megahertz, which guarantees transfer of data up to a maximum of 3 megabytes per second. As new Bluetooth standards are also backward-compatible, quicker data transfer and higher security are ensured.

2.15. Extensible messaging and presence protocol

The availability of real-time organized and extensible data transfer among several network clients is guaranteed with the use of extensible messaging and presence protocol (XMPP). When XMPP was developed, it was generally accepted because it was utilized as a communication protocol. Over time and lightweight XMPP specification: Adding up with the advanced features of XMPP-IoT, it has been used in internet of things (IoT). As an open social support standard, the strengths of XMPP IoT are scalable capabilities and address, making it best suited for consumer-oriented IoT rankings.

2.16. Data-distribution service

Distributed transmission system (DTS) is highly trusted when utilized for the release-subscription model. OMG, in collaboration with DTS, developed DTS-RT for real-time M2M communications, measurable, high-performance and dynamic data transfer between devices independently connected from both hardware platform and software platform. This helps the DTS broker-free design and multicasting to provide high-quality QoS, assuring optimal system performance. Structure of the DTS protocolis predicated on the info center output-subscription layer (TCPS) and therefore the custom data-local reconstruction layer (DLRL). The TCPL is largely responsible for resource-aware, ductile, and efficient data delivery to subscribers, whereas the DLRL provides an interface to the TCPS functions that enable data transmission between IoT-connected items [4].

2.17. Advanced message queuing protocol

Advanced message queuing protocol (AMQP) specification reveals the specifications like sorting, orientation of news, routing (both point-to-point and output-to-subscriber), security, and reliability. Advanced message queuing protocol's primary advantage is its resilient communication mechanism. While AMQP can provide complete transactions, this is not necessarily necessary for IoT applications. Due to AMQP's heaviness, it is not added up for sensor devices with limited power, memory, or network bandwidth, although it are often the sole possible protocol for end-to-end use, including instances of commercial heavy machinery, for personal IoT application cases, or SCADA systems, devices and network significantly more efficient [5], [14]–[18].

IEEE802.15.4g extends the with network coverage of up to tens of kilometers, it is possible to cover enormous areas of terrain with a tiny framework. IPv6 Networking uses internet protocol (IP) to enable the inter-operability which is irrespective of physical layer and also link layer. It is evident that there is only hard requirements needed for embedded device can connect with compatible gateway devices. IETF drives the advances in this technology. 6LoWPAN initially developed by 6LoWPAN working group (WG) of IETF to transport IPv6 over IEEE 802.15.4. Its primary goal is to provide fragmentation, reassembly, and header compression. As a result of the maximum packet size of 127 octets, the protocol data unit has a restricted amount of space. WG developed several ways to handle address auto configuration for network management and mesh networking.

2.18. IPv6 RPL

These networks have huge rate of data losses, low data rates, and instable. Links consists of PLC, IEEE 802.15.4 and low power Wi-Fi but no medium access control technology were specified. In such networks, the traffic flow characteristics were involved in collecting data from many sensing points and from node towards sink, so for the initial development, directed acyclic graph (DAG) was mainly concentrated to the destination oriented DAG (DODAG). Specifically, to RPL network, new ICMPv6 message was defined which consists of DAG information object (DIO), that issues node to find out RPL instance, DAG information solicitation (DIS) allows request for DIOs from RPL node and destination advertisement object (DAO) propagates destination information upwards along DODAG [4].

3. COMPARISON OF IoT PROTOCOL

The analysis of different protocols of IoT for machine to machine enabled communication are given in Tables 1, 2 and 3 with respect to different parameters [2], [19]–[25].

Table 1. Comparison of various protocols

Protocols	CoAP	MQTT	XMPP	AMQP	DDS	REST
Transport layer	UDP	TCP	TCP	TCP	TCP UDP	TCP
Publisher/subscriber	Yes	Yes	Yes	Yes	Yes	
Request/response	Yes	No	Yes	No	No	Yes
Security	DTLS	SSL	SSL	SSL	SSL DTLS	SSL
QoS	Yes	Yes		Yes	Yes	
Low power and lossy network	Exc.	Fair	Fair	Fair	Poor	Fair
Dynamic discovery	Yes	No	No	No	Yes	No
Binary encoding	Yes	Yes	Yes	Yes	Yes	No
Real time	No	No	No	No	Yes	No
Open source	Yes	Yes	Yes	Yes	Yes	No
Architecture style	P2P	Broker	P2P	P2P broker	Data space	P2P
Sponsor	IETF	OASIS	IETF	OASIS	OMG	IETF

Table 2. Comparison of various protocols

Protocols	Application Layer Interoperability among things	Things' representation models	Things' interaction model	Low power and Lossy network	Simplicity	Exhaustiveness and level of detail
RFID, Wi-Fi	Limited to standard (stack layer)	No	No	Fair	NA	NA
Zigbee	Limited to standard (stack layer)	Yes, but limited to specific applications	Yes, but limited to specific applications	Excellent	Good	Excellent
CoAP	Full (delegated to IP protocol)	No	No	Good (UDP)	NA	NA
XMPP, MQTT	Full (delegated to IP protocol)	No	No	Fair (TCP)	NA	NA

Table 3. Comparison of various protocols

Protocols	Frequency	Data Rate	Range	Power Usage	Cost
Bluetooth/BLE	2.4 Ghz	1,2,3 Mbps	-300 feet	Low	Low
802.15.4	Sub-Ghz, 2.4 Ghz	40,250 kbps	>100 square miles	Low	Low
Wi-Fi	Sub-Ghz, 2.4 Ghz, 5 Ghz	0.1–54 Mbps	<300 feet	Medium	Low
Zigbee	2.4 Ghz	250 kbps	-300 feet	Low	Medium

4. CONCLUSION

Business models with autonomy in different sectors can be created by M2M and IoT, which uses the Internet of Things and embedded technologies, by which different kinds of small devices and things get connected to the internet. Implementing anything in a smart way is an attractive factor now a days. The future IoT depends on data, cloud, data analytics and knowledge-based technologies. Huge data handling in big data would increase the complexity and there is a need of automation in handling and managing data. Hence, now we are in need of a new evolving technology to make connected everything with anything that should beyond the Big Data. In this paper, the comparative analysis of different protocols and M2M architecture are carried out which gives an insight knowledge about the importance and technology needed for machine to machine regarding the future internet of things for the initiative of a truly smart, connected and sustainable world.

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