Access management and Data path prediction for securing cloud-based services and enhancing cybersecurity solutions

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Abstract
Next decade will evidence the emergence of a new dawn of communications, where the machines communicate to each other without or with minimal human intervention. The existences cellular and ad-hoc networks infrastructure and recent advanced LTE technology encourage researchers to exploit to build a coexist communication between human to human (H2H) and machine to machine (M2M). The purpose of this research is that a cloud platform schema by adopting getaway (Access Point) as a mediator to separate between M2M and H2H communication to alleviate the traffic congestion and random access on cellular networks is introduced. As a method, the proposed model composes three stages: initialization stage, where machines register to the system and gain unique identifier. Classification stage, in this stage the mediator getaway classifies the data type and work to separate H2H communication and MTC. Finally, in the third stage, based on stage classification decision will take either to store those date into the cloud or give high priority to send those data to the cellular network. Early results allow us to show the performance of the data path prediction through this proposed research in which the decision then will be based upon predefine QoS and priority or emergency cases. Our novel proposed cloud platform can preserve high throughput and low latency. Obviously, traffic congestion has been mitigated. Low hit ratio to LTE network has also been achieved.

Keywords:
Machine to machine communication, Machine type communication, Cyber Security, Internet of things.

1. Introduction

Nowadays, M2M and Internet of things (IOT) become popular abbreviations, which refer to Machine to Machine communication and Internet of Things [1] [2], respectively. Recently, massive academic researchers have also been conducted to study their advantage [3] and influence [4] [5] [6] upon existing communications type. The advantage that gains from M2M communication and applications encourage academic, and industry filed to adopt Machine type communication (MTC) and implemented in different approaches [7]. When those machines try to connect to cellular networks, which already known as congestion might lead to the deterioration of cellular networks. To gain the maximum benefit from these promising technology we have to study their characteristics [8] that will guide us to exist cellular infrastructure and resources to provide them with their exact requirements. Current communication networks are designed and implemented to support H2H communication, without considering for MTC [9] [10]. So, implanting MTC on current communication may produce huge traffic congestion and access delay [11] [12]. Therefore, deep study and analyze M2M traffic characteristic will be a better solution before going further implementation without considering their impact.

The current studies estimate that the total number of devices is growing rapidly, assuming it will reach 50 billion devices in 2020. So, the challenge appears here is how we will be able to manage this massive number of devices and provide them the same opportunity to access network while preserving two main factors (high throughput and low latency), also guarantee their QoS requirements. As we know that there are a lot of heterogonous devices each has its own characteristic and producing different data type which related to their dedicated purpose. So, our concern is whether the exit communication networks can achieve those M2M communications requirements without leaving any impact or influence on H2H communication or not.

A lot of access management solutions have been proposed [13] [14] [15] in this domain to diminish the traffic congestion and access delay. Several surveys have also been conducted on M2M connectivity issue upon different network layers. Some of them concentrated on MAC layer issue and protocols [16] [17] [18], also security and privacy on M2M communications gain a lot of researchers interesting and several of contributions have been introduced to address security and privacy related issues on M2M communications [19] [20] [21] [22] [23] such as; data encryption, integrity, and authentications.

Seemingly, the Wireless Ad-hoc and Sensor Networks will be allocated to no predefined infrastructure. Consequently,

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exploiting existing cellular networks infrastructure to exchange machines generated data seem to be highly potential. This will cause more cellular networks congestions and overload in the worst case it may lead to gradual deterioration in the performance of the network. Based on the above information, deep studying, analyzing, performance modeling and evaluation of Wireless Ad-hoc and Sensor Networks led us to build a perfection environment for machines generated data by deploying an infrastructure that is most suitable for this kind of Wireless Ad-hoc and Sensor Networks.

Wireless Ad-hoc and Sensor Networks aim to have a perfect infrastructure to exchange data with them. Toward this end, three different domains are combined to produce a perfect communicate between machines; device domain, application domain, and network domain.

The proposed cloud platform schema is divided into three stages; initialization stage, classification stage, and decision stage. Consequently, our contribution in this paper can be summarized as follows:

- Cloud platform to elaborate direct communication to
- cellular networks.
- Adopt gateway (access point) as a mediator that aim to manage, control and classify M2M and H2H communication and distinguish between different machines priority and quality of service.
- The cloud platform consists of three stages; initialization stage, where machines register to the system and gain unique identifier. Classification stage, in this stage the mediator getaway classifies the data type and work to separate H2H communication and MTC. Finally, in the third stage, based on classification stage, the decision will take either to export machines generated to date to the cloud or upon machine generated data QoS and priority export those data to the cellular network then to the in charge users.

The reset of the paper is organized as follows. Section 2 discusses the literature review and related works on M2M communications. The proposed cloud platform schema is discussed in section 3. Experimental results are highlighted in section 4. Finally, the paper will be concluded in section 5.

2. Related Work

Massive researches have conducted and published on M2M access management. On this domain, a literature review has discussed variant and different solutions to address random access issues. For instance, Laya [24] et al. study the Random Access limitation to handle the demand for a massive number of machines communication from two perspectives: access delay and energy consumption. Using beta and delta arrival distributions, they perform the experiment to show the bulk arrival conditions. Based on their experiment result, exist access mechanism are not capable of handling this massive number of machines requests. Also, they prove that long period spent on machines to establish RA connection will cause a lot of energy consumption. Chen [25] et al. also proposed a model that aims to reduce packet loss rate and to preserve M2M wireless networks lifetime. In this study, Sub-spider web size has been dynamically adjustment to meet different data traffic. Potsch [26] et al. study the M2M influence on cellular networks, when massive and tremendous of machines want to communicate to LTE networks directly, they also investigate the impact of increasing M2M traffic. Toward this end, M2M traffic characteristics such as; packet size, low data rates, numerous end points with frequent connect request have also been studied. The simulation results of several scenarios infer that M2M traffic will leave a significant impact on LTE regular data performance. In [27] Christoph and et al. proposed a system model to evaluate the performance of cellular networks considering M2M presence. LTE behavior to different traffic characteristics has been estimated. Also, different access managements have been simulated to deduced M2M impact on existing cellular networks. In [28] a survey on random access channel for MTC on LTE and LTE-A has been conducted by Laya and et al. Different alternative random access method and their strengths and weakness have been introduced. Energy efficiency also has been considered. Rajandekar [29] et al. to fully utilize M2M communication, show that all network layer should meet their service requirements. In this paper, a survey concentrates on MTC requirements, technical challenge and ongoing work on MAC layer to support M2M communications. Efficiency, scalability and fair channel access for M2M communication related issues have also been covered. As M2M communications have various characteristics, this survey aims to study, evaluate and assess existing MAC protocols and their capability to meet M2M communication requirements such as; data throughput, scalability, energy efficiency, low latency, coexist and cost effectiveness. A taxonomy of different M2M proposed MAC protocols have been introduced and evaluated, to deduce their strength and weakness. Chen [30] et al. conducted a survey on M2M technologies for home networks architecture. Different aspects of researches domain in M2M communications and its pertaining architecture have been illustrated. Two type of communication architecture; cellular M2M communications, where all machines are directly connected to cellular networks; and capillary M2M communications, in this type a gateway has been adopting as a mediator

between machines and cellular networks. Several radio communication technologies for short range data also exchange have been introduced. Tavana [31] et al. proposed a new adaptive access class barring schema for congestion control. Depending on different metrics such as; the number of unused preambles in each time slot, the number of successful transmissions and the total number of MTC machines competing in RACH. Based on system dynamic, Kalman filter has been adopted for further estimation accuracy enhancement and refine. In [32] Jiang and et al. discuss the potential security threat to M2M communications considering different aspects; data encryption, integrity, authentication, unauthorized access and physical attacks. In [33] Elkhodr and et al. aim to study the challenge that will increase exposure to new promising technologies in term of architecture, connectivity, efficiency, security, and services provision. Automated invasion attack which deemed new attack model also has been introduced. In [34] A survey on existing communication technologies that can be adopted for M2M communication in smart grid has been introduced. ZigBee has been chosen among other communication technologies such as UWB, Wi-Fi, and Bluetooth to enable M2M communications in the smart grid. Some enhancement and improvements on exist ZigBee technology have been also suggested.

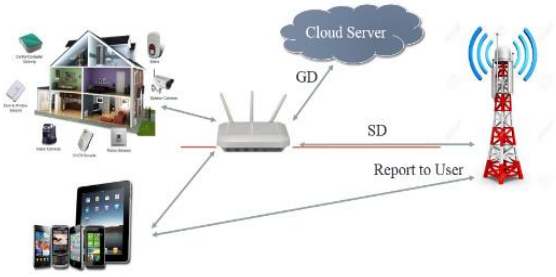

Fig. 1 Cloud Platform Schema Architecture

3. System model and problem formulation

The proposed system model falls under three tier architecture. Fig1: shows cloud platform schema architecture which consists of three components;(1) Client: which be either M2M or H2H communication type; (2) Gateway which locates as a mediator between the client and cloud server\LTE networks. In this case, we assume that the channel between the client and the gateway is a secure channel, therefore, how to secure this channel is beyond the scope of this paper; (3) Finally, the cloud server to store, manage and further processing for machines generated data or LTE networks. GD and SD in the fig1 refer to the general date and sensitive data, in our cloud platform schema general data means no high priority of machines generated data. Where sensitive data means a high priority. Therefore, SD export directly to LTE networks.

A. Problem formulation:

In this paper, we aim to identify the problem regarding when massive of heterogeneous machines desire to have directly communicated to LTE network. We also define the frontier of our proposed model.

1. Heterogonous machines:

Tremendous and various machines required various applications which generate different data types related to their dedicated tasks. Consequently, those heterogeneous machines require different communication types to the cellular network. Nowadays, some of MTC application appears in a different domain such as; surveillance and monitor, health care, smart home, smart city, transportation and logistics. Therefore, different machines belong to different categories, generate different data type and requires different communication types. Towards this end, deep studying and analyzing for machines heterogeneous characteristics lead to provide them with their exact and real communications requirements.

2. Direct communication with LTE networks:

Current LTE networks infrastructure which dedicated to server H2H type communication facing many issues such as; high latency, low throughputs, energy consumptions and network overload. So, when the new promising MTC technology appears and wants to communication directly to LTE networks. Obviously, the direct communication will lead to more issues on existing cellular networks infrastructure. Some of the literature reviews study the MTC characteristics to infer their implications upon H2H communication. The study concludes that some of the machines produce low data volume and request frequent communicate to LTE networks. Other contributions aim to manage the random access to cellular networks. In this paper, we aim to mitigate unnecessary direct MTC to cellular networks. Toward this end, we adopt cloud server to store, manage and for further processing purpose on machines generated data traffic.

3. Cloud platform schema frontier:

Well known that the LTE networks broadcast 64 preamble channel for random access channel (RACH) as depicted in fig2. Therefore, if any machine collects one of this (RACH), this channel will be used and dedicated for machine data transfer. As aforementioned some of the contributions which related to access management studied the random

access to LTE networks and concluded the influence of MTC random access on existing infrastructure and H2H communications. Our contributions to this paper are proactive steps to determine, classify and predict machine data path. Obviously, cloud platform schema diminishes unnecessary direct MTC to LTE networks. By adopting cloud server, we aim to store and manage machines generated data for further processing rather than export them directly to cellular networks.

Fig2: shows the proposed model frontier, which can be pointed as follow:

- Classify MTC and H2H.
- Determine QoS and priority.
- Eliminate unnecessary direct connection to LTE networks.
- Convert MTC data path to cloud sever instead of export them directly to LTE networks.

B. Cloud platform schema:

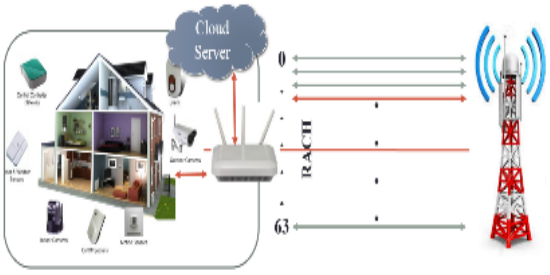

Fig. 2 Cloud Platform Schema frontier

Fig3 depicts cloud platform schema flow chart. Where machines consider as a system input. First, the proposed model determines machines type, either H2H or M2M communication. It's clear that from the flow chart all H2H communication directly export to LTE networks. Then if the input is M2M communication, we come to face the first barrier that denied direct MTC to LTE networks. In the second, barrier steps the proposed model determines the priority and quality of service, upon the predefined priority and QoS for each machine. The cloud platform schema classifies and determines machines generated data path, either export them directly to LTE networks or store them on a cloud server. Without fail, the proposed model will not totally eliminate all machines to communicate to LTE network, but it's obviously that we almost achieve low hit ratio to LTE networks and high hit ratio to the cloud server. Consequently, the main goal of our proposed model has been achieved. The proposed model consists of three stages; initialization stage, classification stage, and decision stage. We will discuss each stage in details within next subsections.

1. Initialization stage:

This stage considers as handshake stage between machines and gateway, and it's also can be considered as preliminary registration stage. In this stage, we aim to have full information about any machines that involve in MTC and

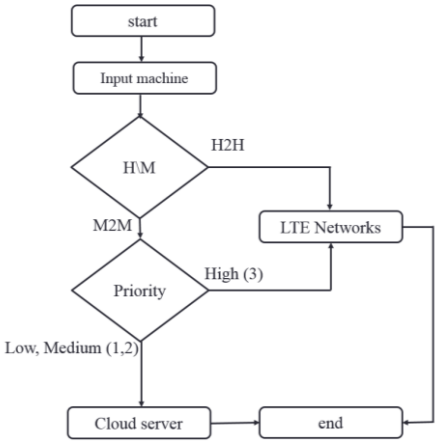

Fig. 3 Cloud Platform Schema flow chart.

envisaged to be a part of M2M communications. All gathering information at this stage will be stored and analyzed for further processing. This stage is carried through several processes as follows:

- Define machines categories (M_cat).
- Define machines unique identifier (M_id).
- Define machines data type (M_dt).
- Define potential quality of service for each machine (M_qos).

As aforementioned, initialization stage is a preliminary stage that aims to determine and classify machines categories, priority, and quality of service.

2. Classification stage:

After determining and classifying machines categories, priority and quality of service in the former stage. Classification stage comes to work in machines generated data as a traffic classification. This stage also is carried through several processes as follows:

- Classify H2H communication.
- Classify M2M communication.
- Determine the potential quality of service for each machine.
- Define a separate path for each classification H2H and M2M communication.

3. Decision stage:

Based on the pervious stage (Classification) decision will be taken as follows:

- Determine and define machine priority and quality of service.
- Determine and define cloud data path (C_dp).
- Determine and define cellular networks data path (CNW_dp).

Table (1) shows the system abbreviations.

C. M2M Influence on cellular networks:

Table 1: Cloud Platform Schema abbreviations.

Abbreviation	Description
GD	General Data
SD	Sensitive Data
RACH	Random Access Channel
M_id	Machines ID
M_cat	Machines Categories
M_dt	Machines data type
M_qos	Machines quality of service
C_dp	Cloud data path
CNW_dp	Cellular networks data path

Massive of published contributions in MTC domain proved that the new promising technology (M2M communication) definitely would impact on current LTE infrastructures, causing dramatically deterioration on regular cellular networks performance. Unless, an optimal improvements and enhancements mechanism for MTC access management has been introduced. Cellular networks ubiquities encourage MTC to exploit them exist infrastructure to connect machines to each other without or with minimum human intervention. This direct communicate to LTE networks will cause more network interferences and networks overload. Although packets size of MTC is small, it's necessary to analyze their impact on cellular networks. Because the main MTC feature is frequent communication.

4. Experiments and Results evaluation

As we are aiming to mitigate direct MTC to LTE networks, we adopt cloud platform schema to evaluate the proposed model by conducting several experiments and compute the average results. Most of the proposed contributions on M2M communicate aim to study and analyze the random access (RA) to LTE networks. Our cloud platform schema considers as a proactive step to reduce the quantum of massive machines that desire to communicate with LTE networks directly. We evaluate the proposed model based on the following aspects:

A. Determine and classify M2M and H2H communicate:

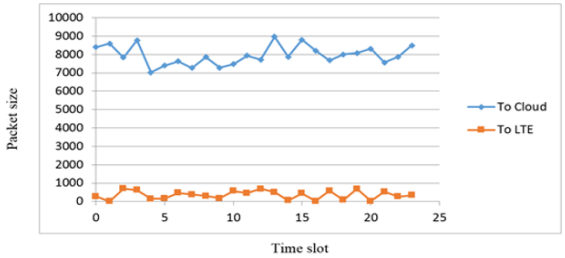

Fig. 4 The optimal case

Existing LTE infrastructure is deployed to serve H2H communication type. However, once the new promising M2M technology appears to communicate with LTE networks, this process could be the lead to more congestions and networks overload. Current LTE networks infrastructure is not capable of handling and manages this tremendous number of MTC unless enhancements and improvements have been formed. The process of determined and classified data types, priority and QoS for MTC considers as a proactive step to diminish unnecessary direct communicate to LTE networks. The initialization stage in cloud platform schema can determine and classified M2M and H2H data types, priority and their QoS which support for further processing. Table (2) shows the parameters of the experiment.

B. Specify generated machines data path:

After determined and classified by the MTC data type, priority and QoS the machines generated data have two paths either export the data into cloud severe for further processing or export them directly to the LTE networks. As aforementioned in the initialization stage, the proposed model can distinguish between M2M and H2H data. However, at this stage, we determined the priority and QoS for each machine generated data. Therefore, our cloud platform schema has the capability to specify the data path for each machine either to the cloud sever or LTE networks. We

Table 2: Experiment parameters.

Parameters	Value	Unit
Machines No.	2 – 100,000	-
Categories	1 - 10	-
Priority	Low- Medium -High	-
Time Slot	0 -24	Hours

conduct several experimental for our proposed model with a different scenario to observe, infer and analyze different results. Table (3) shows Machines categories, quantum, priority and packet size.

C. Cloud server hit ratio:

We achieve the main contribution for this paper by achieving high hit ratio to cloud server rather LTE networks.

That means most of the generated machines data are exported to the cloud server.

D.Experiment setup:

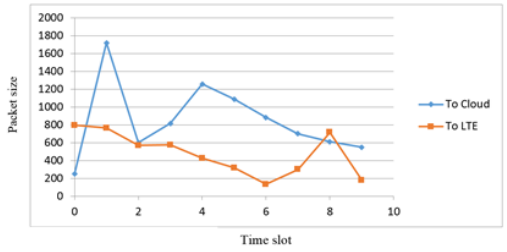

Fig. 5 The normal case

We implement our simulation using JAVA; the experiment has conducted on DELL Laptop with following specifications: Intel CORE i5 vPro. 8GB RAM memory. Window 7 X 64 Enterprise operating system. The proposed cloud platform schema simulates three different scenarios; Optimal, Normal, and the worst scenario. To distinguish between machines generated data priority within same categories, separate machines have been dedicated to high priority cases. Consequentially, we may found recur machine in same categories; some machines for low and medium priority and others for high priority. Table (3) shows the machines categories used in our experimental.

E.Experiment results:

Table 3: Machines categories, quantum, priority and packet size.

Categories Name	No. of Machines	Priority	Packet size
Heal Care	1 – 1000	1-3	100 -5000
	1 – 5000	1-3	100 -5000
	1 – 10,000	1-3	100 -5000
Surveillance	1 – 20,000	1-3	100 -5000
	1 – 30,000	1-3	100 -5000
	1 – 100,000	1-3	100 -5000
Alarm	1 – 1000	1-3	100 -5000
	1 – 2000	1-3	100 -5000
	1 – 3000	1-6	100 -5000

Fig4: shows the optimal case for the proposed cloud platform schema where vast majority machines generated data have low or medium priority. Consequently, in this case, we achieve high cloud server hit ratio which can be considered one of the major contributions on our proposed cloud platform schema. While LTE networks are getting low hit ratio.

Fig5: shows another scenario for the proposed cloud platform schema, where machines generated data are equivalent and hit ratio for both cloud server, and LTE

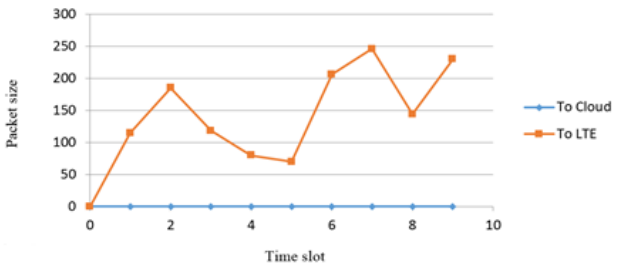

Fig. 6 The worst case

network seems mediator. However, in this case, the most of the machined generated data are exported to cloud server as it illustrated in fig2.

Fig6: shows the worst case for the proposed cloud platform schema where the vast majority of machines generated data are exported to LTE network rather than store them on a cloud server. Based on the experiment result, this scenario rarely to occur, but it's necessary to consider it. So, we are ready to deal and handle such case if it occurs.

5. Conclusion and future work

Recently, M2M, IOT, and MTC become a hot topic for both academic and industrial communities. Also, it gains a lot of researchers interesting. Numerous of contributions have also been conducted in this domain which considers as one of the most active research domains. Most of the conducted research concentrate on how to manage massive random access of MTC to cellular networks. As known that cellular networks have a limited quantum of permeable dedicated to random access, the current situation is almost facing congestion issues even before deploying MTC. Consider how the congestions situation will be when MTC coexist with H2H and communicate to cellular networks.

The proposed cloud platform schema considers as a proactive step that aims to manage, classify and predict MTC generated data path to mitigate unnecessary direct MTC to cellular networks. The experimental results show three different scenarios; optimal case, normal case, and the worst case. In the optimal case where there is no high priority for the machines generated data, therefore, most of the generated data path if not all are exported to cloud server rather than export them directly to LTE networks. In the normal case, the machines generated data path export also to the cloud server. Where the vast majority of machines generated data has high priority, consequently, data path export directly to LTE networks. Which consider the worst case in our scenario. The proposed cloud platform schema, obviously elaborate unnecessary direct MTC to cellular networks.

In future work, we plan to measure the energy consumption for each machine from the initialization stage to final stage. Based on this measurement, we will evaluate and access enhancement management mechanism to achieve high throughput and low latency while preserving low energy consumption. As aforementioned, our cloud platform schema frontier is considered as a proactive step to mitigate direct MTC to LTE networks. Also, as its shown form the experiments results that some machines have directly communicated with LTE networks. Therefore, for the future works we aim to manage the random access to those machines which have the direct communicate to LTE networks.

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