Machine-to-Machine Communication - A Survey and Taxonomy

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Abstract

Machine-to-Machine (M2M) communication has become an attractive topic due to the rapid evolution of the wireless communication system and the potential market size of the Internet of Things. It is not only the influential technology of 21st century but also caused resilient prospect in the industry and academia. M2M communications emerge to autonomously operate to link the interaction between the internet cyber and physical world. It can offset the overhead cost of conventional operations, thus promoting their wider adoption in fixed and mobile platforms equipped with embedded processors and sensors/actuators. In this paper, several fundamental key aspects of M2M communication are discussed related to technologies and challenges. In addition, we have presented detail taxonomy of the classification of M2M based on their network and communication pattern. Moreover, we reviewed existing home network projects to better understand the real world application of these systems. This survey contributes to the better understanding of the challenges in existing M2M networks and further sheds new light on future research direction.

***Keywords**: Machine-to-Machine communication, Network and communication pattern*

1. Introduction

Machine-to-Machine communication is the communication between multiple devices in multiple ways at multiple scales without human interventions. In recent years, human-to-human communication has leads leading us to the new terminology of human-to-machine communication and machine-to-machine communication, where we are standing now. In a broader aspect, M2M comprises various devices i.e. sensor nodes, mobile equipment and other capillary devices that senses or receives data from various other devices. The sensed or received data is then relayed towards its destination through multiple hops which accomplishes end-to-end connectivity in the wired or wireless network.

M2M communication provides various applications, such as environmental monitoring, security purpose i.e., civil and public safety, Supply Chain Management (SCM), energy & utility distribution industry (smart grid), Intelligent Transport Systems (ITSs), healthcare, automation of building, military applications, agriculture, and home networks [1, 9]. These applications create groups of new business and opportunities. The characteristics and features of M2M are rather different than those of traditional networks [1-3]. Since M2M networks are composed of a hefty number of nodes (say machines or devices) which can be anything around us. In order to achieve communication between a large number of machines, the cost of machines as well as of the communication should be low. Since the majority of machines are operated on batteries in which the energy conservation techniques are the challenging task. In case, if a machine receives data from other machines or senses from the physical environment (e.g., sensors or mobile equipment), the overall traffic per machine is small enough to accommodate. On the other hand, M2M establishes communication without intervention of humans. However, sustaining the established connection is the challenging task.

In the early 1980's, supervisory control and data acquisition (SCADA) [4] introduced the early form of M2M. SCADA tries to focus on the similar functions as similar to M2M. However SCADA consists of some out-of-the-way systems which make their technology more complex and expansive. In the

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beginning, SCADA started to unbolt their new propriety protocols and bring out protocol specifications. However, it was a transition from the proprietary system to consistent technologies having low-cost. Recently, various other models have been proposed which are similar to M2M, which are Device-to-Device (D2D), Machine Type Communication (MTC) [3, 8], Internet of Things (IoT) [4, 5] and Ubiquitous Sensor Network [9].

In the majority of the research platform, the M2M solutions do not address some of the main issues i.e., service and application development [7], as the majority is focused on energy conservation techniques, networking (MAC, routing, transport) and other protocols [8]. However, we believe that there is still much space left to provide solutions and cope with the issues of services and applications. In addition, the M2M service and application platform is a comparatively new area of research. Apparently, several authors compared several M2M service and application platforms based on their scope that focuses only on platform among people, object's environment and enterprise systems [7, 9]. In addition, a comparison is being made for the requirements of M2M platforms based on standard, adaptability and scalability. In contrast, as special intention is required to classify the existing M2M platform and architecture based on their network architecture and protocol design. The following topics are required to be transaction with M2M classifications: classification of existing work, architecture design, communication and networking, cellular system, and mobility and management of devices and network for sustainability. The main purposes of such classifications are (i) to facilitate the design of new architecture and protocol for M2M communication, and (ii) to manage of devices and user efficient.

Therefore, we have planned the rest of the paper as follows. We present the survey of recent M2M work and their issues. In classification of M2M network and their functionality, we first highlight the M2M architecture and their communication pattern. After this, we present a taxonomy of existing work in M2M communication. Than we discuss various challenges in the existing work of M2M communication and networking protocols.

The rest of paper is organized as follows. In Section 2, we briefly explained the system architecture of M2M. In Section 3, we briefly described various taxonomies of M2M communication. In Section 4, we describe the major challenges faced by M2M. Finally, Section 5 briefly concludes this article.

2. Machine-to-Machine Communication - Network Architecture

There are several other possible architectures available in literature based on IP connection to M2M application server i.e., the device connected to application server directly or via IMS. However, we are considering one of the example architecture based on the cellular system [10]. Figure 1 delineates the connection of the third party M2M server with the intermediate application server. This connection is established by internet protocol i.e., Hypertext Transfer Protocol (HTTP). The function of the intermediate server is to translate the internet protocols into the short messaging system (SMS) which are buffered and sent out to M2M terminals when they are in an active state. A home subscriber server (HSS) is used inside the 3G network which assists the network by providing security. In addition, it also provides some other information which is essential to allow the message to be propagated in the 3G base station for transmission in the M2M device. The job of the HSS server is to check whether the device is in reach or not. If so, it directs all the incoming data to M2M devices. However, if these devices are unreachable, then HSS stores the incoming data and forwards it when the device is in reach.

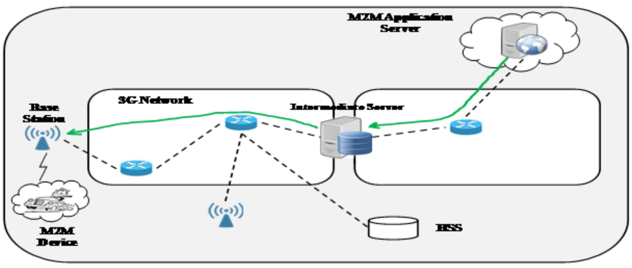

Figure 1. Cellular M2M Communication

2.1. Cellular M2M Communications

When we say ‘cellular network’, several elements are included, such as mobile devices, gateway devices and other nodes. Gateway devices apportion the bandwidth as well as the network resources to all ~~the~~ devices in the cellular network. As shown in Figure 1, various communication models are considered among the three elements described as follows [22].

Gateway nodes communication: As these devices apportion bandwidth to the devices in the network. Therefore, this transmission required licensed spectrum. This type of communication establishes bi-directional data transmission that shares resource allocations when needed to evade or lessen the interference.

Gateway device communication: As these devices have different data rates as well as frame structure. However, gateway nodes are used to allocate bandwidth which is then utilized by these devices to establish an efficient communication channel. In addition, it is preferred to have a short distance communication path between the two devices.

Device communication: In cellular M2M communication, all the devices directly communicate with other devices uses exiting frequency spectrum. However, radio signals also exist in the network. Therefore, a scheme is required to avoid signal interference ratio along with congestion on the devices.

2.2. M2M Standardization in Cellular Networks

Recent wide range of applications for M2M is likely to be vertical applications which focus on the current market of transport and automotive [10]. The European Telecommunication Standard Institute (ETSI) is focusing on identifying a level of architecture which provides a specific baseline to extend new applications of M2M [11]. This level of architecture includes horizontal protocol layers approved by either ETSI or other customary bodies. The following Table 1 shows customary bodies targeting various aspects of M2M communications.

Table 1. Standard bodies operating in M2M Space [10]

Aspect	Standard bodies
Service	ETSI, TIA, IETF, (CoRE)
Access and network	TISPAN, 3GPP, 3GPP2, DSL, forum, WiMAX forum
Gateway	ETSI, IETF (6LoWPAN)
PAN	Zigbee Alliance, IETF (6LowPAN), KNX, ZWave Alliance, RFID
Smart metering (vertical App)	ISO, ANSI, CENELEC. IEC

In the M2M cellular system, the service requirements are identified by the working group of SA1. In addition, SA1 and SA2 have identified some of the aspects such as reachability of the devices used to connect to the cellular network, optimization of signals and low power consumption. The above aspects are mulled over within the Release 11 timeframe. With the advancement of the system improvements for M2M, high level architecture along with the possible solutions are proposed by SA2 which were previously identified by SA1 [12]. Release 10 resides some specification changes in LTE along with UMTS were implements to deal with network surplus challenges that are caused by M2M. In LTE, low cost M2M devices are also been proposed which intend to study the methods of how to reduce the cost of the LTE devices, that allows LTE to be in support with M2M having same coverage area along with bandwidth. Interested readers should refer to article [10] for more details.

3. Taxonomy of M2M Communication

In this section, we first discuss the first level taxonomy based on the architecture and communication pattern in Figure 2. The rest of the taxonomy, along with concrete examples is presented in the rest of the sections.

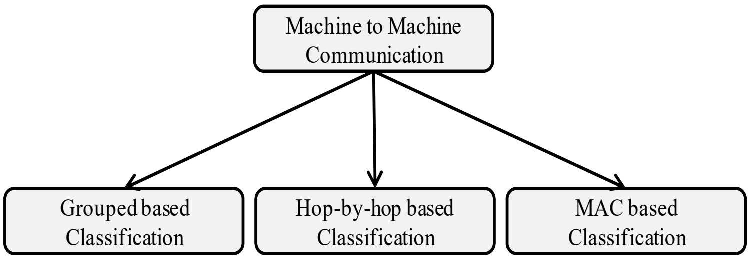

Figure 2. Taxonomy of M2M Communication

3.1. Grouped based taxonomy

According to Figure 3, grouped based communication is achieved through three different schemes. From one side, data is collected through aggregated scheme, which is a type of data aggregation technique. The second is to organize M2M device in a cluster, whose aim is to collect data from various devices with the help of a sink node. And the last is to cope with requirements of extremely low power operation and easy deployment on top legacy systems. This is achieved by grouping the devices along with the grouphead node. In the subsequent sections, we will present a fruitful discussion on each of these.

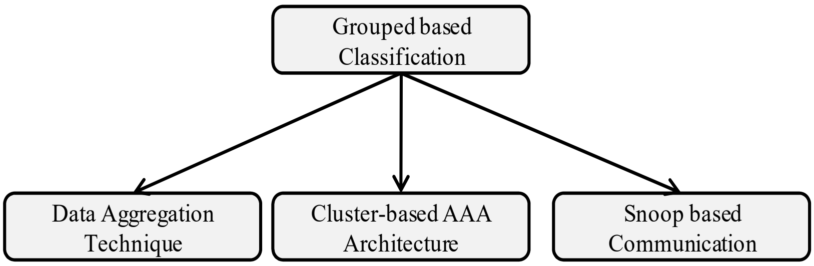

Figure 3. Taxonomy of Grouped based classification of M2M communication

3.1.1. Data Aggregation Scheme

Machine-to-Machine (M2M) communication technologies provide capabilities for various devices to communicate between each other through wired and wireless systems. In M2M networks, applying data aggregation to reduce the energy consumption is an efficient way. In data aggregation there are three significant issues i.e. choosing aggregation points, routing algorithm in data aggregation and the expiration conditions (e.g., the buffering time in time-based aggregation mechanism). A significant amount of transmission overhead can be observed in M2M devices as the size of M2M networks becomes exceptionally large (e.g., the gas sensor in [13]). In order to prolong the lifetime of M2M network data aggregation is an efficient way because M2M devices have the capability of retrieving the sensing data from the same kind of devices [14]. To exploit data aggregation, we need to exercise message buffering in M2M devices. Therefore a time based mechanism utilizes message buffering in M2M devices. In addition to that, if the message buffering time expires, M2M devices aggregate them into a new message upon retrieving data collected during the buffering time. Aggregate volume in a message and energy efficiency is improved when the device extends the buffering time; however from sources to application server (or M2M gateway) the transmission delay increases. To address this issue, a scheme is designed on using data aggregation method to improve the transmission delay and energy efficiency [15].

In this section we have detailed study of time-based aggregation mechanisms in M2M network. As shown in Figure 4, the M2M device in its located area collects the sensed data. Via the M2M gateway, the collected data is sent to the application server. In Figure 4, M(0) and M(k) represent the source node and the M2M gateway respectively. M(0) senses data e_0 which is delivered to the application server through the routing path M(0) → M(1) → · · · → M(k). In the proposed scheme, time-based

M2M aggregation mechanism is implemented in each M2M device, M(i), $0 \leq i \leq k - 1$. It works as follows:

Step 1. Node M(i) receives a message containing the sensing data e0 from M(i − 1), and M(i) deposits the received message in an aggregation buffer.

Step 2. M(i) starts an aggregation timer of period T, if the aggregation buffer is empty, .

Step 3. M(i) retrieves the buffered messages and aggregates the collected sensing data into a new message, When the aggregation timer expires.

Note that M(i) sends the new message to M(i + 1) when the aggregated message contains sensing data e_0.

M(k) REFRESH the sensed data to store in the application server after the sensing data e0 arrives at the M2M gateway M(k). To reduce signal overhead in the core network, after a time period τ, the M2M gateway might update the M2M server. This technique is called a delayed REFRESH operation and it has been widely used in 3GPP core networks [16-17]. Based on the discussion above, the performance metrics of the time-based aggregation mechanism includes: Expected delivery delay E[ts]: the average time period between the data that is received at the M2M application server and the data e0 that is sensed at the source M(0). Expected aggregated volume E[N]: the expected number of sensing data aggregated in a message.

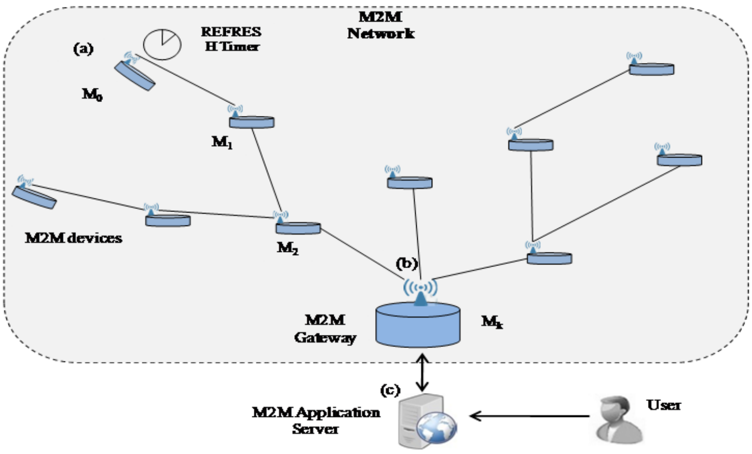

Figure 4. M2M Architecture

3.1.2. Cluster-based AAA Architecture

In the domain of communication industry, M2M is considered to be the next limit. In order to expand their revenue based on the wireless network operators that are gearing up extensive efforts to support M2M Services in their networks. For M2M network WiMAX is one of the 4G broadband wireless access technologies that have ~~a~~ tremendous potential to play market driver role in realization. WiMAX is a strong contender because of its relatively low licensing and deployment costs. In order to accommodate the huge diverse sensor deployment, numerous architectural designs are proposed in WiMAX backhauled sensor networks. Major issues in the design problems are the functionality of AAA. AAA is responsible for WiMAX operator for revenue generation and subscriber profile management. For large sensor networks this scheme provides a functional architecture to accommodate AAA functionality. The scheme is based on Cluster Based Authentication of sensor nodes. The purpose of this scheme is to reduce the signaling load by authentication entities in the network.

In WiMAX core this solution is already deployed aiming to be economical with minimal modifications. The architecture is proposed with the core aiming to keep the modification cost low for already deployed WiMAX Networks. For conventional commercial WiMAX subscribers the solution is designed to be fail-safe to minimize the risk of network outage. A cluster-based scheme is introduced to handle the design problem of AAA [18]. This scheme is not only economical and flexible but it also requires minimal adaptations to WiMAX Access Service Network (ASN) and Connectivity Service Network (CSN). For example, Bridgewater Service Max 500 for WiMAX networks a popular integrated AAA solution which can scale up to 100,000 subscribers. To accommodate AAA functionality without the cost of extensive capacity addition, a mechanism has to be defined. In addition, AAA mechanism must be cheap, flexible and efficient with minimal re-authentications and procedural repetitions since the node battery conservation is paramount in WSN design. Minimal modifications are done in previously deployed WiMAX networks for AAA functionality in WSN. Depending upon the requirements and constraints either symmetric or asymmetric key solutions could be deployed for the sensor nodes. In WSN, once a node is authenticated and attains the network entry, the node presence is reported to a dedicated AAA system for accounting and billing to the corresponding subscriber account [19].

In the proposed architecture for proving backhaul connectivity for conventional clients, 802.16 BSs act as Mesh routers to form an infrastructure [18]. With the help of different radio technologies such as 802.16, the user or subscriber becomes capable to establish the connection. The entire network consists of WSN area, WiMAX with AAA servers and WSN Company's Server (WCS).

WSN are classified into a set of clusters where each cluster has a number of wireless sensor nodes as depicted in Figure 5. Through Wi-Fi/ WiMAX Border Gateways (XBG) each cluster head is connected, and XBG is connected to Base Station (BS)/Access Point (AP). XBG is a border gateway with WiMAX CPE and other functionalities.

The above scenario consists of wireless sensor nodes and each wireless sensor node is considered as a Cluster Node (CN). A cluster is a collection of CNs and each cluster has a Cluster Head (CH) which acts on their behalf and represents all the CNs. As shown in Figure 6, CNs can communicate to the outer world through CHs which are connected to XBG. For transmission it uses Mesh under and IP-based routing/forwarding. In order to form a packet at the final destination, these fragments are reassembled. Thus, our proposed architecture is less expensive and optimized to serve the numerous number of sensor nodes and also uses a conventional AAA server for subscribers. The proposed scheme uses a dedicated AAA server for Wireless Sensors Networks (WSN). XBG is a border gateway for wireless sensor networks with WiMAX CPE functionalities and other functionalities furthermore XBG is connected to CHs as well as Base Station (BS)/Access Point (AP) as shown in Figure 6. On using 802.15.4 technologies XBG is connected to the cluster head and further on using 802.16 technologies it is connected to BS/AP of WiMAX networks. CH initiates Network Entry Request (NER) and forwards to XBG that includes the authentication request. In our proposed scheme XBG is upgraded to forward the CH NER requests to ASW. ASW maintains the record for all billing accounts, privileges and charging policies. In Figure 7, the detailed procedure of generic flow of the network entry process is explained.

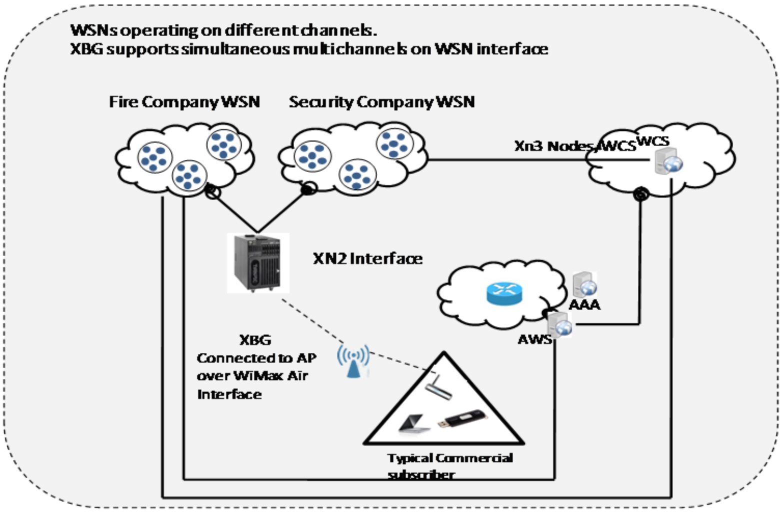

Figure 5. Cluster-based AAA Architecture

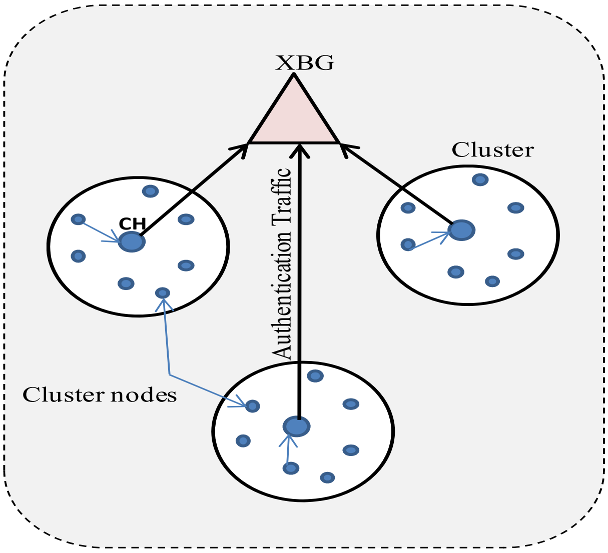

Figure 6. Cluster nodes communication via cluster head

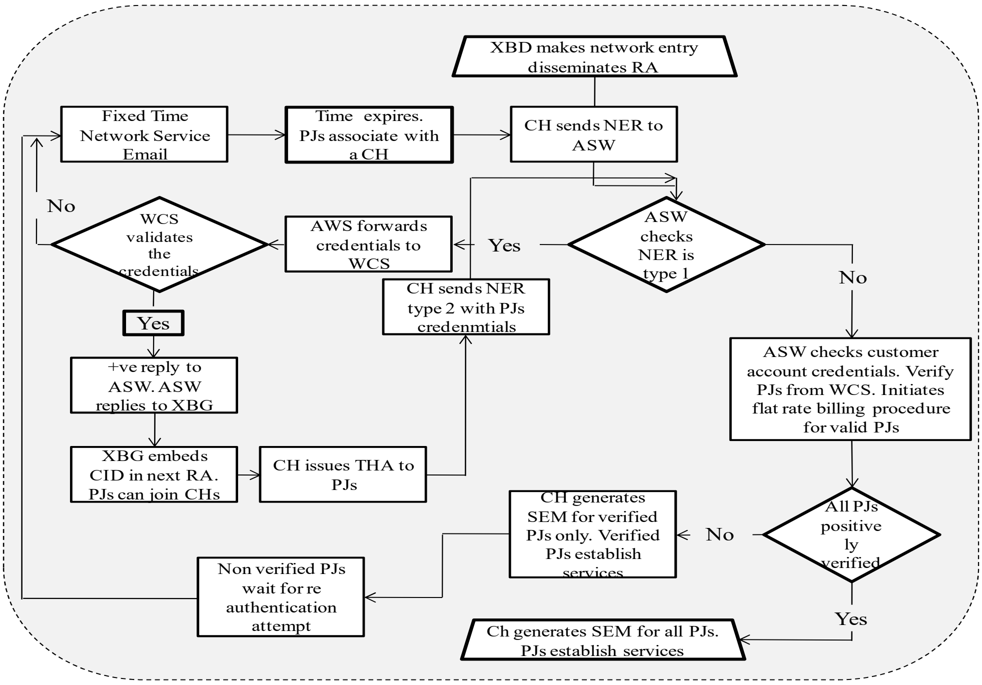

Figure 7. Generic flow of network entry process

3.1.3. Snoop based Group Communication in Cellular M2M

In M2M communication there are some major requirements such as extremely low power consumption of devices and mass device transmission. A novel snoop based relaying method in cellular M2M communications is presented in order to meet the above requirements. The proposed scheme consists of two methods; I) group member assignment based on link quality or location and snooping group formation including group head selection, II) snooping and relaying packets to or from group members.

By employing the group based operation the requirement of extremely low power consumption can be met where a number of devices can be grouped together based on application type and/or geographical location in the cell. Also on behalf of group member devices the group head can relay packets to/from the base station. In order to get an efficient group based communication, a direct link between the group head and group members should be provided as shown in Figure 8. However, this requires a new air interface standard with new radio frame structure. It is expected that for existing cellular networks the M2M system will be an add on feature such as the WiMAX 1.0 system based on IEEE 802.6 -2009 [20] or for the WiMAX 2.0 system based on IEEE 802.16m [21].

A novel solution based scheme on snoop based group communication is proposed in order the cope with requirements of extremely low power operation and easy deployment on top legacy systems. The proposed systems consist of two methods i.e. i) snooping group formation with group members assignment and group head selection based on link quality or location, ii) snooping and relaying packets to/from group members.

In order to access the cellular system all M2M devices must be authenticated by the network during the network entry procedure. The base station is able to formulate M2M groups based on the application type and geographical position of M2M devices after the network entry of the M2M devices.

In the proposed scheme since listening does not require much power consumption when the group members communicate with the base station in the downlink (DL). On the other hand in the case of uplink (UL), on using the resource allocated by the base station, the group members transmit packets with limited power, which is notified by the base station during the network entry. The group head is able to snoop the packet transmission of group member devices and relay the snooped packets to the base station because the group head selection based on geographical location in the cell. Due to limited transmission power the resources allocated by the base station can be reused in the cell, by exploiting special multiplexing mass device transmission can be achieved. The proposed scheme improves the capacity in the UL transmission and the low power operation. However, in M2M communication in UL the M2M clients report the measurement to the M2M server, the proposed scheme improves the performance of low power operation and the capacity to accommodate mass device transmission.

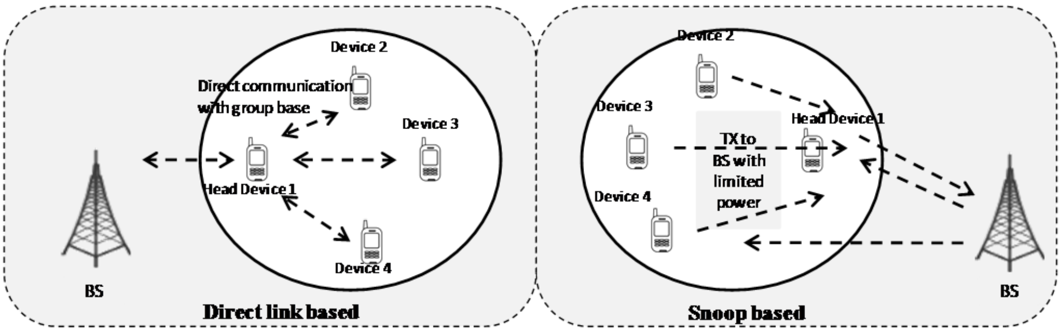

Figure 8. M2M group based communication methods

3.2. Hop-by-hop based taxonomy

As shown in Figure 9, Hop-by-hop communication is achieved through multi-hop communication in M2M networks. In such networks, all the devices are sparsely deployed and the sink node is used to aggregate data through a hop-by-hop manner. In such schemes, all the devices are involved in the data transmission process. This kind of data transmission usually degrades network lifetime, since all the nodes are involved. Therefore, it is required to design a scheme to avoid excessive multi-hop communications which results in enhancing network lifetime.

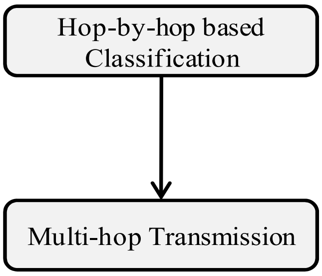

Figure 9. Taxonomy of hop-by-hop classification in M2M Communications

3.2.1. Multi-hop transmission in M2M Communication

M2M multi-Hop transmissions an Emerging machine-to-machine communication scenarios imagined to cope with more rigorous quality of service demands. This is in view of outage and latency requirements. For example, for critical messages quite different than for traditional applications. Besides machine-to-machine communication, systems are widely accepted that need to be energy-efficient because of the widespread use of battery-powered devices, and also due to their huge deployment numbers. Therefore in the proposed scheme, the author focused on some basic queries i.e. in order to transmit a packet of a certain size from a source to a destination, what is the minimum energy required and on the other hand violation of end-to-end outage probability constraint taken care of, at the same time the transmission meets a given deadline. We study these queries widely with respect to multi-hop forwarding from a source to a destination. In this framework, we study these queries with two different approaches: Forwarding the packet moreover based on average Channel State Information (CSI) or, instead, based on instantaneous CSI. On the first scenario for payload transmission, the entire time span is available from source to destination, while when using instantaneous CSI, the channel states have to be obtained first.

The consumed time and transmit power i.e. energy for present nodes, has its own merits for packet forwarding. In order to achieve the QoS requirements, the nodes are able to invest as much power on transmission as necessary, and hence it avoids power over-provisioning and wasting energy. Based on convex optimization, the numerical study shows the comparison between various schemes since the authors have developed an optimal allocation of transmitting power along a multi-hop route for both the cases. In case of exploiting instantaneous CSI than the duration of the channel acquisition phase has a big impact on the energy consumption. In addition, for more demanding transmission scenarios (large packets, short deadlines, and high reliability requirements) from working with instantaneous CSI, the energy savings scenario is quite large (up to a factor of 100). Finally from source and destination, numerical results show that for a given distance, there is an optimal number of hops to use with respect to minimizing transmit energy. There will be significant increase in the consumed energy if the optimal number of hops is underutilized.

We consider a scenario from a source to a destination a packets of size D is transmitted over a set of n links (n - 1 intermediate nodes). All nodes in the system are static. We focus only on a single packet transmission where the packets belong to a flow. This single packet transmission is limited by QoS parameters. I.e. we defined the required success probability of the transmission as P, and the associated deadline is defined by T. An effectively transmitted packet implies that it reaches the destination within the time span T error-free. On the other hand, it leads to outage occurrence (late arrival, bit errors). For packet forwarding all the transceivers use certain resources. Initially there are n links in the multi-hop route, for forwarding the packet to the next node. Each node can utilize a specific bounded time. As follows, we refer a time unit as a slot. During its own slot to forward a packet node i utilizes the transmitting power of P_i. Finally, all nodes utilize the same bandwidth of B in Hz. The random behavior of the wireless links along the path is due to the major source of unreliability in the network stems. Forwarding link i ϵ {1,..., n} (from node i to i + 1) is categorized by an instantaneous channel gain h_i^2. This instantaneous channel gain is a combination of a random fading component as well as an average channel gain h'^2_i. The average channel gain h'^2_i is comprised of a path loss factor and a random (but constant) shadowing factor.

For the path loss, we assumed a straightforward model in which d_i is the distance between the transmitter and the receiver of link i and the gain is given by $d_i^{-\alpha}$ .Link lengths d_i are arbitrary and connect the total distance d. In case of shadowing component, we assumed a log normal distribution with standard deviation δ_{SH} and a mean of $\delta_{SH} = 0$. For an instantaneous channel due to random small-scale fading gain sample h_i^2 deviates from the average gain. Hence this fading is modeled by a stationary Rayleigh process such that the instantaneous Signal-to-Noise Ratio (SNR) γ_i is an exponentially distributed random variable with mean.

$$E[\gamma_i] = \gamma'_i = P_i \cdot h'^2_i / \sigma^2 \quad (1)$$

Where, noise power is denoted by σ^2. We assume a slowly varying block-fading process the instantaneous channel gains remain constant over the time span T. Because of fading, a packet transmission is potentially leads to errors. We account the transmission errors by a threshold error model if the transmitter i does not have information about the instantaneous channel state γ_i [24].
Given the corresponding error-free transport capacity c_i of the link is a random variable and the SNR is γ_i. The instantaneous transport capacity is given by taking the slot duration T_s into account is,

$$c_i = T_s B \log_2[1 + \gamma_i \beta] \quad (2)$$

Transport capacity denotes the amount of data (in bits) which can be sent error-free for an SNR of γ_i over the corresponding link and depends directly on the applied transmit power P_i. At any time $c_i < D$ for the transmission of a packet of size D, the packet is lost on the link i. Based on our definition of transport capacity and the stochastic SNR model, they derive the success probability p_i, which is the probability of the random transport capacity being bigger than the packet size D. To determine the exponential distribution of the link SNR, we first need to derive the probability density function (PDF) of c_i.

3.3. MAC based taxonomy

As shown in Figure 10, reliable and energy efficient based communication is achieved through IEEE 802.11 in the M2M network. In such networks, all the devices are sparsely deployed and the sink node is used to aggregate data through the hop-by-hop manner. In such schemes, all the devices are involved in the data transmission process. This kind of data transmission usually degrades network lifetime, since all the nodes are involved. Therefore, a design of a scheme is required to avoid excessive multi-hop communications which results in enhancing network lifetime.

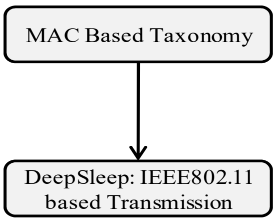

Figure 10. MAC based Classification

3.3.1. DeepSleep: IEEE 802.11 Enhancement

M2M devices can be powered from external sources rather than batteries through an emerging technology called Energy harvesting. Cost-effective and energy efficient, it allows devices to independently harvest and supply energy for their power use. The renewable energy harvested to power devices for a long duration of time that requires ambient energy which comes from external sources like solar, mechanical, heat or wind. In M2M application the property meets the demands for structural health monitoring, whose devices are hard to access after deployment. Therefore, for wireless devices operating in industries, the recent advance in energy harvesting technology has shown great potential [23].

The capability of IEEE 802.11 PSM to save energy in a wireless network of mostly because of uplink traffic is limited. During the backoff procedure, there is much more energy wastage from overhearing and idle listening when the number of devices increases. In order to shorten the backoff procedure, there is an option is to lower the contention which leads to higher collision probability. On considering the fact that energy-harvesting devices are characterized by their various energy levels which also vary in time. To improve the overall network performance, it provides a better energy expenditure scheme by favoring the low energy devices. Hence the novel scheme DeepSleep is proposed i.e. MAC (Media Access Control) enhancement scheme on IEEE 802.11 PSM [25]. For deploying energy harvesting devices in M2M network, DeepSleep is designed, which can also adapt to high contention levels caused by a large number of wireless devices.

The Energy-Aware Sleeping algorithm and High Priority algorithm is the first part of the DeepSleep scheme. Concerning the overall collision probability and duration of overhearing and idle listening, first our focus is on the value of CW_{min} in the backoff procedure of IEEE 802.11. In order to reduce overhearing and idle listening probability to save energy, the authors intentionally allow some devices to use lower CW_{min} value to transmit packets, their priority will be higher than others. Too many devices allowed to use lower CW_{min} at a given time will make the contention level too high, leading to much more retransmission, degrading energy-efficiency. Based on the scenario, higher channel accessing priority is granted for the devices short of energy, after sleeping for a while to drop out channel access.

The device constantly checks its battery level E in the Energy-Aware Sleeping algorithm. The battery level E is decremented below $E_{DeepSleep}$, threshold higher than the usable energy level E_0, and then the device goes to sleep, marking bool_High Priority true, and skipping nBP beacon frames. In case of the High Priority algorithm, it checks the value of bool_HighPriority when the device wakes up to transmit packets. If the value is true, the device sets its CW_{min} as a smaller value $CW_{DeepSleep}$ and sets the bool_HighPriority false. On the other hand, the devices sets its CW_{min} back to the default value $CW_{minOriginal}$.

The second part of the proposed scheme is Random Deferring. The Random Deferring is based on the observation in the baseline scheme, from the beginning of the beacon period if the buffer is not empty. The devices wake up at the same time and try to transmit packets. Some idle listening, overhearing states, and finally the data transmission and ACK reception are the composition of the whole packet delivery procedure. If the number of devices increases, the contention level also increases, which leads to longer idle listening and overhearing time in the backoff procedure. Predominantly until their own buffer is empty. Most devices are awake for a long duration. The energy wasted in the backoff procedure can be reduced if we can defer the wake up time for part of the devices. Before the device's packet transmission turns into a sleeping state, this can be considered as switching the preceding part of idle listening and overhearing states. In the meantime, due to the less number of devices contending at the same time, the channel contention level can be reduced. AP broadcasts beacon frames containing the sleep probability $P_{DeepSleep}$ and deferring time $T_{DeepSleep}$ to the devices using Random Deferring. The device will make the sleep decision according to the $P_{DeepSleep}$, when the device wakes up to transmit packets after receiving the beacon frame. The device will wake up after the $T_{DeepSleep}$, once the device decides to go sleep.

4. Challenges in Machine-to-Machine Communication

The schemes discussed above consider either group based, hop-by-hop or MAC based communication which aims to provide efficient and reliable communication. However, some schemes are required that guarantee the resource constraints i.e. energy conservation techniques, Quality of Service (QoS), Cost and group management.

First, various devices (sensor nodes, mobile equipments) might have priorities, since installation could be made with different kind of machines and could be deployed in different geographical locations. Therefore, these devices can generate received data with different characteristics having diverse priorities with respect to bandwidth allocations. However, most of the existing schemes do not consider these kind of priorities since their aim is to achieve reliable communication, not efficient communication.

Secondly, the majority of the existing M2M communication schemes are based on single path communication techniques. Those scenarios which consist of multipath communication is not yet considered. For example, considering multipath communication might lead to congestion in those devices which are near the base station or access points, a problem would be: how a parent device and their child devices should adjust its own sending rate. The problem can be even more severe in scenarios where some devices follow the multipath communication while others do not.

Thirdly, the majority of physical layer challenges are like coverage, devices battery and incurable cost problems. Various devices in M2M are less lenient to deprived coverage since the majority of these devices are stationary (e.g., sensors). These devices cannot change their position where they might have better coverage. While considering the M2M network that consists of tracking or portable e-health devices should be powered by battery. However, it will be a fatal problem if there is a need to recharge these batteries. In such scenarios, a scheme is needed due to which they can conserve their battery power. Furthermore, to reduce the cost of each device, there is a need to abridge radio frequency (RF) signals. This phenomenon will not only reduce the RF bands but also the baseband complexity [10].

Various challenges need to be addressed in M2M. However, the solutions required for Human-to-human communication can be applicable to M2M scenarios. The following Table 2 shows some of the other major challenges faced by M2M communications [10].

Table 2. M2M Challenges

Challenges	Issues
Device battery	Minimize network lifetime
Stationary devices	Reduce coverage area and increase cost of M2M network
Security	Security is required which is as same as for human communications
Multicasting	M2M devices effectively multicast
Group management	M2M devices can be easily move in a group e.g., in a car
QoS	Wide range of QoS
SIM	Can be easily to change the operator
Cost	Cost can be reduced by employing radio signals

5. Conclusion

This article has presented an overview and survey of the existing M2M schemes. We first classified M2M communication services on the base of architecture, applications and functionalities. We surveyed and analyzed various existing schemes and came up with the limitations in ideal M2M techniques i.e. to achieve flexible reliability, conserve energy, and an optimized mobility pattern that is application dependent QoS. In addition, we also discussed the challenges and issues of various M2M platforms that address communication pattern, mobility pattern, battery power and cost. In order to establish a M2M communication, we should consider the following problems i.e. i) how should we assign priorities to various devices in the M2M network? The effective mechanism should help the device to generate received data having diverse characteristics and priorities w.r.t bandwidth and reliability, ii) How can we guarantee reliable communication? It is worth addressing to have multipath communication in M2M in order to ensure reliable communication. iii) M2M network should be platform dependent i.e., there should be an individual standard platform for home based M2M, cellular based M2M and heterogeneous based network.

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