RESOURCE MANAGEMENT FOR MACHINE TYPE COMMUNICATION AND INTERNET OF THINGS IN MOBILE NETWORKS

Ahmad Khan[1*], Yasir Mehmood[2]

ABSTRACT

Due to the paramount importance of Machine Type Communication (MTC) in many fields, massive increase in (MTC) data traffic is anticipated in future. Different wireless communication technologies can be used for interconnecting MTC devices (MTCDs), but the cellular mobile networks are almost available everywhere and therefore it is considered the best mean for interconnecting MTCDs. The cellular mobile networks are primarily designed for providing broadband services while most of the MTC data traffic is narrowband. Several types MTCDs send data in the form of small packets. It is expected that millions of MTCDs would be deployed in a cell, which would require simultaneous connectivity. This massive data traffic may affect the existing normal data traffic negatively, as it will overburden the system and furthermore spectrum would be utilized inefficiently. This paper proposes a solution for efficient spectrum utilization in mobile networks. The proposed mechanism is intuitive and is based on packet aggregation implemented in intermediary node called aggregation node. Small memory (buffer) is used to held the small packets for some time. When the buffer capacity is achieved the accumulated packet is sent to receiver. Furthermore, a timer mechanism is used for avoiding huge delays of the aggregated packets. Simulation results (graphs) show that significant enhancement in spectrum utilization can be achieved.

KEYWORDS: *IoT, MTCDs, Aggregation, Narrowband*

INTRODUCTION

Indeed, in past times, it was unthinkable that humans would be able to control and remotely monitor devices installed at homes, hospitals, industries and airports etc. In fiction, it was common to depict that a person turns on his air conditioner, refrigerator and electric motor for filling water tank while coming from office, a patient's surgery is conducted through a robot from a remotely area and a car is driven from remote location. Furthermore, it was beyond fantasy in the past that machines and devices would talk to each other intelligently and autonomously without human intervention.

In the present times, Machine Type Communication (MTC) and Internet of Things (IoT) have enabled communications among machines and devices without human intervention (Xia, Nian, & Yang, 2016). MTC is also called Machine-to-Machine (M2M) communication and the end devices used in this type of communication are called MTC Devices (MTCDs). MTC and IoT have proven that anything on earth could communicate with each other for example doors, light bulbs, fans, cars, robots etc. Both the MTC and IoT are new research areas which have attracted researchers to design and implement Things (such as machines and devices) which could communicate intelligently and ubiquitously with minimum human intervention (Saed, Atalla, Shadi, & Tarabeih, 2015).

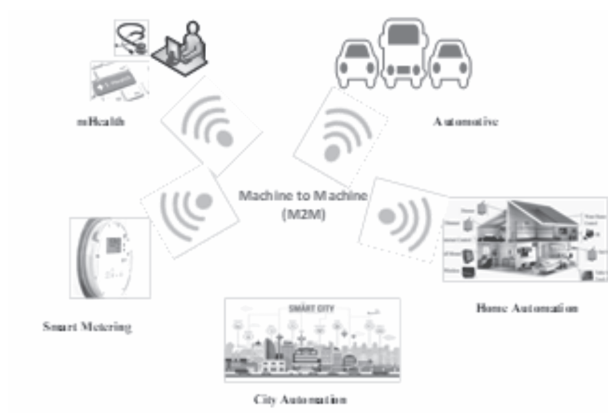

Fig. 1: MTC applications

MTC has greatly improved the development of different systems and has brought revolution in different areas for example Intelligent Transport System (ITS), Smart Grid System, Building & City Automation, Logistics and Mobile health (mHealth) as illustrated in Fig. 1. Due to the importance of MTCDs, they are increasingly being

1 Department.of Computer Systems EngineeringUniversity of Engineering and Technology Peshawar, Pakistan
2 Communication Networks University of Bremen Bremen, Germany ym@comnets.uni-bremen.de
*Corresponding author: ahmadkhan@uetpeshawar.edu.pk

deployed in different areas on daily basis. According to (Cisco, 23 November, 2019) it is anticipated that there would be almost 26.6 billion MTCDs by 2022 and this massive increase in MTCDs would generate massive data traffic in future as well (Cisco, 23 November, 2019).

MTC Applications

In order to communicate, MTCDs require transmission media (wired or wireless). The wireless medium, also called unguided medium, is a convenient option for MTCDs communication. It is less expensive, scalable, easy to install and the most important thing is that there is no cable hampering. Different technologies could be used for this purpose like, Wi-Fi, Bluetooth, HaLow, SUN, 6Lopane, LoRaWAN, SigFox and cellular mobile networks (Silva, Rodrigue, Solic, & Aquino, 2017). Among these technologies the cellular mobile networks have wide coverage and is available almost everywhere. The other technologies like LoRaWAN and SigFox are either not available in most of the areas currently or have very limited coverage, and therefore cellular mobile network is an option for connecting MTCDs and IoTs which offer ubiquitous availability. The general MTC architecture is shown below in Fig. 2.

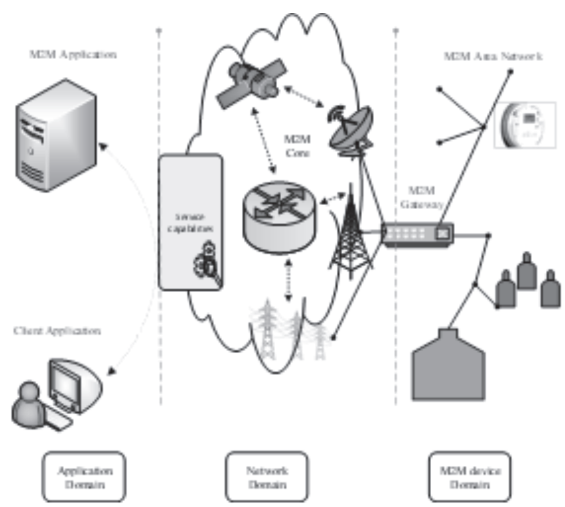

Fig. 2: MTC architecture

MTC Architecture

Cellular mobile networks are basically designed for providing broadband services and human based communication called H2H communication like voice, text, video, file sending and uploading etc. These services require high data rate and low latency systems. Since the beginning of first generation of mobile networks, cellular service providers are primarily focused on increasing the data rates and minimizing the transmission delay. In contrast to cellular communication the MTC applications are mostly narrowband and low bandwidth could be sufficient most of the times.

Evolution in Cellular Mobile Communication Networks

The cellular mobile communication networks emerged in the early eighties. This wireless technology brought revolution both in information technology industry and in social life as well. This technology is in the evolutionary stage since the date of initiation. The first cellular mobile system was lunch by Ameritech (American Telecommunication company) in 1983 in USA and later on in many other countries like Israel in 1986, Australia in 1987, Singapore and Pakistan in 1988 and 1990 respectively. Advanced Mobile Phone System (AMPS) was the first-generation (1G) cellular technology which was an analog system using analog radio signals and analog modulation technique called frequency modulation technique. The spectrum was divided into many channels or frequencies and each user was to be assigned a dedicated channel separately both for uplink and downlink transmission. Voice communication was the only service offered by 1G mobile system. Limited

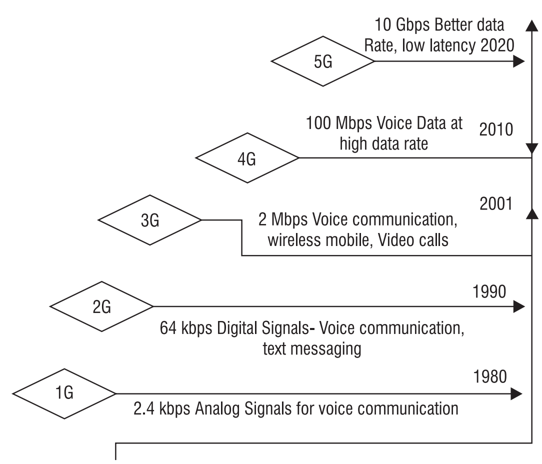

Fig. 3: Cellular networks evolution

number of channels with low capacity and insecure voice communication were the main disadvantages that compelled the researchers to launch second generation (2G) mobile system.

The 2G mobile system was launched by Radiolinja in 1991 in Finland. This system solved the main issues of 1G system by using advanced digital encryption techniques for voice conversation. The radio spectrum in 2G mobile system was comparatively efficiently utilized which enabled more users per channel. Messaging service for mobile users was introduced in the meantime with short messaging service (SMS). Later on, the 2G system was upgraded and General Packet Radio Service (GPRS) with speed of up to 40 Kbits/s and Enhanced Data Rates for GSM Evolution (EDGE) called 2.5G with speed of up to384 Kbits/s was introduced. GPRS and EDGE called 2.7G attracted huge number of customers. With the passage of time and introduction of new services through mobile equipment (device) in businesses and homes, customers felt deficiency in capacity, coverage and data speed. Therefore, third generation (3G) mobile system was introduced to overcome the deficiencies.

The first pre-commercial 3G mobile system was deployed by NTT DoCoMo in 1998 in Japan and was commercially available in 2001. This system offered services at much higher speed of 2Mbits/s with WCDMA/CDMA200 and later on in 2002 HSDPA was defined to achieve 14Mbps data rate in downlink. The data rate was further enhanced in 2004 by introducing MIMO technology achieved 28 Mbits/s with HSPA+ in downlink and 11 Mbits/s in uplink. The 3G system is hybrid (circuit switched and packet switched) the voice communication used circuit switched core network while data services used packet switched core network. With the passage of time the mobile service providers recognized that the data rate offered by 3G system were not sufficient and therefore Long-Term Evolution (LTE) was introduced.

LTE also called 3.9G mobile system, was first time deployed in Oslo (Norway) and Stockholm (Sweden) by TeliaSonera in December 2009 and later on Scartel (Russian Mobile Operator) launched in Kazan in the end of 2010. According to LTE specifications, it could provide services at higher speed of 300Mbits/s in downlink and 75Mbits/s in uplink. Yet, this system could not achieve the requirements that were specified by International Mobile Telecommunication (IMT-2000) in 2008 for 4G systems.

Cellular Networks Evolution

In order to achieve the IMT-2000 requirements, the fourth-generation mobile system was introduced. LTE-Advanced (LTE-A) was the main candidate for being considered a global 4G system. It uses advanced technologies i.e. carrier aggregation, 4x4 MIMO and 256 QAM modulation in downlink and therefore, offers services at a much higher peak speed of 1Gbits/s in downlink and 300Mbits/s in uplink. This is a massive data transfer rate and is sufficient for the present-day needs. But the world is going towards bandwidth thirsty MTC and IoT communication applications and soon this data transfer rate will fall short and therefore, would require more advanced system like 5G to be deployed.

The 5G mobile system has now been tested experimentally in many Labs around the world and is expected to be available commercially by 2021-22. This system would offer services at data rate of 10 to 100 times more than 4G system with much less latency of 1-milisecond (Eldred, et al., 2019). This system would be more energy efficient and will minimize 90 % of energy usage in the network. The 5G system is anticipated to support 1000x number of MTCDs as compared to LTE and LTE-A (4G 5G World, 2019). The detail overview is illustrated in Fig. 3.

Human to Human (H2H) Data Traffic

In this type of communication most of the data flows in downlink and the control information is sent via uplink (Farhan, Marwat, Zaki, Mehmood, & Gorg, 2016). The size of data is mostly very large and therefore require wide bandwidth and high throughput (Chen, Wan, & Li, Feb. 2012). In cellular communication, a cell supports a limited number (like hardly a few hundred) of User Equipment (UEs) because of limited resources. Furthermore, the service requirements for H2H communication are generally identical and the battery life of UEs could be hardly for few days.

MTC Data Traffic

The M2M or MTC data traffic is different than H2H data traffic in term of packet size, bandwidth, capacity and data rate (speed). The data traffic mostly flows in burst form via uplink, the queries and control information are forwarded through downlink (Chen, Wan, & Li, Feb. 2012). The size of data is very small and could be sent in small sizes and therefore, require usually small bandwidth as compare to broadband services. Furthermore, in MTC, one cell can accommodate thousands of MTCDs and the battery life could be more than ten years.

Problem Statement

As discussed in the Introduction section, the cellular mobile networks are an appropriate available option for MTC and IoT data transmission. MTC data traffic holds unique features which cause challenges for cellular mobile communication service providers and researchers as well (Laner, et al., 2015). In the coming years, one of the confronting and challenging issue would be the massive number of interconnected MTCDs per cell and small data traffic generated by these MTCDs. According to (Cisco, 2019), the total mobile data traffic was almost 10.7 Exabytes/month (1 EB= 10^6 Tera bytes) in 2016 and is expected to be 83.6 exabytes/month by 2021. To support and incorporate such increase in massive MTC data traffic is a big challenge for the present cellular mobile systems. In future, it would require connecting thousands and even millions of MTCDs reside in a cell to connect with network simultaneously. As mentioned, cellular mobile systems aim is to provide broadband services and have limited capacity as well. Few hundred of UEs could be accommodated per cell (Alsharif, Mohammed, Nordin, Shakir, & Ramly, 2019). Each user is assigned a resource on demand called Physical Resource Block (PRB) (H. Holma & A. Toskala, 2011). A single PRB comprises of 12 subcarriers which could sent several thousand bits with favorable channel conditions (Jeanette, June 2013). Allocating a single PRB to an MTCD (which normally requires few bytes), would certainly be a wastage of resources. For example, a temperature sensor would require few bytes for data transmission while allocating a single PRB to this MTCD (temperature sensor) is wastage of resource (PRBs). Furthermore, the number of PRBs are also limited (1200 in best case) in LTE and LTE-A. This massive increase in MTC data traffic would overburden the system and would badly affect the normal data traffic as well. In order to enable the cellular system to support MTC data traffic efficiently, it is required to either redesign the 3GPP standard for LTE and LTE-A (which is not possible) or deploy additional hardware (expensive and temporary solution). Therefore, it is required to introduce some other mechanism which is easy to implement and less expensive.

Literature Survey

Spectrum is considered to be among the most important radio resources for wireless communication because of the fact that it is expensive and scarce. This radio resource is normally managed by government (board or agency) in most of the countries. The agency is responsible for allocation and regulation of frequency bands (Mazar, 2009).

Resources could be managed in both networks i.e. core networks and radio networks. Every cellular network provider is assigned a particular radio band for their use. It is the service Provider's job to manage and utilize the allocated band for efficient communication. The radio resource management (RRM) in cellular networks concentrate on enhancing data rates and try to reduce end-to-end delay. While in MTC, the radio resource management requires low energy usage, supporting massive MTCDs and enhancing quality-of-service requirements.

Prior to this work, in literature survey, various studies have addressed radio resource management for MTC in LTE and LTE-A mobile systems. Marwat et al. discussed different uplink scheduling technique for MTC in LTE and LTE-A (Marwat, Weerawardane, Zaki, Goerg, & Timm-Giel, Dec. 2014). Furthermore, they proposed an aggregation scheme for MTC data traffic, but the number of PRBs were kept constant in that research. In other words, the system did not support varying PRB allocation to IoT traffic. Similarly, several studies have focused on access control mechanisms in LTE and LTE-A mobile systems for supporting MTC data traffic (Zhang, Kang, Wang, Guo, & Labeau, May 2015). The authors in (Saleh., 2019) investigated overload issues like random access channel generated due to massive MTCDs and discussed the various access mechanisms to solve them. MAC layer issues and the current research efforts on MTC are discussed in (Orim, Ventura, & Mwangama, Sept. 2019). The authors of (Mehmood, Goerg, Muehleisen, & Timm-Giel, Dec. 2015) discussed the ongoing advancement of MTC applications in home networks, architecture and multiple access technologies.

Liu et al. (Liu, Derakhshani, & Lambotharan, 4-8 Dec. 2017) presented different association algorithms for MIMO, millimeter wave and heterogeneous networks.

The authors, (Dawy, Zaher, Saad, Andrews, & Yaacoub, 2016), categorized existing techniques for radio resource management into different types, for example channel-based schedulers and delay-based schedulers. In the first category, priority is given to MTCDs on the basis of highest signal to noise ratio while in second category the delay budget assigns priorities to different MTCDs for getting resource allocation. But in this case, the system could not differentiate between normal users and MTCDs. Similarly, (Zheng, et al., 2012) suggested to consider channel conditions and maximum delay tolerance when resources are allocated to MTCDs. Generally, the MTCDs require low power for data transmission. The authors, (Yang, et al., 2016) proposed two-phase non-orthogonal schemes for resource allocation among MTCDs, UEs as well as between MTCDs. In first phase, radio resource is assigned to UEs with first priority while in second phase, semi-distributed and centralized scheme is used to assign resource to MTCDs. The semi-distributed scheme possesses no information regarding channel interference while the centralized scheme possesses the complete information of channel gain. The authors, (Tefek, Utku, & Lim, 2017) discussed radio resource allocation between UEs and MTCDS using power control mechanism without disturbing data rates. Dynamic radio resource allocation strategy was proposed which adjust power of MTCDs and UEs if coexist simultaneously (Han, Bin, Habibi, & Schott, 2017). The results obtained for this proposed scheme revealed that MTCDs data rate was enhanced.

In literature survey, to the best of our knowledge, researchers have mostly focused on scheduling in time domain. These scheduling algorithms may work well certainly for very low load (few hundred MTCDs), but when massive number of MTCDs are deployed in a cell, traffic may not be efficiently managed. Furthermore, the normal traffic and MTC data traffic could not be differentiated. For this reason, the resources assigned by eNodeB to normal UE are also assigned to an MTCD reside in the same cell which could cause wastage of resources. The reason is an MTCD require very little bandwidth while the UE require normally huge bandwidth for data transmission.

This paper presents a different solution for accommodating MTC data traffic in MTC cellular networks.

Packets Aggregation

Packet aggregation approach is used in this research work, in which MTCDs are connected with an intermediate node called Aggregation Node (AgN). In other words, the MTCDs send data packets to AgN and not send data directly to eNodeB. This AgN node works according to LTE-A protocol stack. The protocol stack used in LTE-A comprises of different layers like, Physical, Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP). In addition to data compression and decompression, the PDCP layer in AgN node is responsible for collecting small data packets from different MTCDS connected with AgN node.

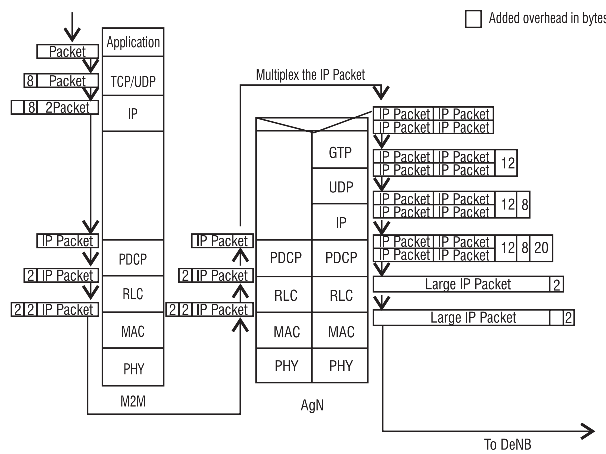

Fig. 4: Packet flow of MTCD, AgN and DeNB (Marwat, 2018)

In the AgN PDCP layer, small memory area called buffer is specified for holding small packets. This buffer depends on the Transport Block Size (TBS) and accordingly small packets are aggregated. To efficiently utilize the PRBs assigned to users, the small data packets are aggregated to form a large packet (aggregated packet). The small packets wait in the buffer until it reaches its maximum capacity. This large packet is forwarded to eNodeB. In the buffer, the aggregated small packets may contain some sophisticated and delay tolerant data, for example, data generated in special cases like accidents, earthquake, flood and big fire caught in buildings. Keeping the aggregated small packets in the memory until the memory size is filled fully, could create delay which might be unacceptable and may not achieve the purpose. Therefore, it is required to hold small packets for a certain period of time which could not affect the purpose for which those data packets were sent for. This is a challenging issue, as discussed in the Introduction section, that MTCDs generate infrequent data and usually send it in burst form. So, in low load when few devices are connected with AgN, it could take large time to fill the buffer capacity. The designed framework supports variable number of PRBs assigned to IoT traffic.

Timer is commenced for solving the mentioned issue. When the first packet arrives, timer is initialized, and packets are aggregated until the memory is occupied fully or the timer expires. Whichever of the condition is satisfied first, the aggregated packet is transmitted immediately, and the timer counter is reset. Fig. 4 illustrates AgN air interface with different protocols. Meanwhile, in the aggregation of small packets into a large packet, the overheads at different layers are also added. The large packet (including small packets and overhead) is sent to eNodeB from the physical layer of AgN as depicted in Fig. 4.

RESULTS AND ANALYSIS

The proposed strategy is modelled in OPNET simulation software, the simulation results for performance parameters like data rate, PRBs utilization and end-to-end delay are divided into five different scenarios. Each scenario contains PRBS in a fashion like 3 PRBs, 4 PRBs, 6 PRBs, 8 PRBs and 10 PRBs. Each scenario further consists of three cases i.e. case-1 (no aggregation), case-2 (aggregation) and case-3 (aggregation plus timer). The first scenario consists of 1000, 2000, 3000, 4000, 5000 and 6000 MTCDs. The number of MTCDs in remaining scenarios are further increased accordingly with 3000, 2000, 2000 and 1000 MTCDs i.e. the number of MTCDs in second scenario ranges from 1000 to 9000, third scenario ranging from 1000 to 11000, fourth scenario ranging from 1000 to 13000 and fifth scenario ranging from 1000 to 14000 number of MTCDs. Simulation parameters are given in Table 1. Each scenario is explained below in detail.

In scenario-1 (3 PRBs), in case of no aggregation (case-1), small data packets which arrives at AgN are sent directly to eNodeB without aggregation and without any wait in the buffer. In other words, as the packet arrives, it is immediately forwarded to eNodeB. Fig. 5, Fig. 6 and Fig. 7 results show data rate, PRBs usage and latency. Data rate is low when the number of MTCDs is small. The results further reveal that data reaches its maximum cell capacity at 2000 and increasing load does not affect data rate. The data rate in case-1, is less than data rate in other two cases i.e. aggregation and aggregation plus timer. The reason is that PRBs are not shared in case-1, while in other two cases, PRBs are shared. As data rate depends on PRBs utilization and hence graphs in Fig. 5, Fig. 6 and Fig. 7 reveal that PRB utilization and data rates are highly correlated. The results of average latency in no aggregation case reveal that in low load, the performance of latency is better until the number of MTCDs reach 6000. The reason has to be that packets arrived at AgN and are sent to eNodeB directly without waiting in buffer.

In case-2, data rate is maximum for low load. Because the packets have to wait in buffer till buffer capacity is achieved, the large packet is then sent to eNodeB. The latency is maximum (because the packets have to wait in buffer) and enhances with increase in load. Because, in high load small packets will frequently arrive and the buffer capacity would be achieved immediately and therefore small packets would not have to wait too much.

In case-3, data rate and PRBs usage is almost the same as in case-1, but latency is more enhanced in low load as compared to case-2. Because, as discussed already in in case-1, packets can wait for long time until buffer capacity is occupied fully while in case-3, due to timer the small packets do not have to wait for much time and when timer expires, the large packet is sent and therefore latency is minimized. Although in high load e.g. MTCDs above 6000 the latency become equal in both cases i.e. case-2 and case-3.

In scenario-2 (4 PRBs), the results of data rate, PRBs usage and latency for 4 PRBs are shown in Fig. 8, Fig. 9 and Fig. 10. In case-1, data rate and PRBs usage is small for low load (because PRB is not shared in no aggregation and packets are sent directly after arrival) and increases with increase in load till 4000 MTCDs while in scenario-1, it achieved the maximum data rate at MTCDs 2000. The reason is increase in PRBs. Further,

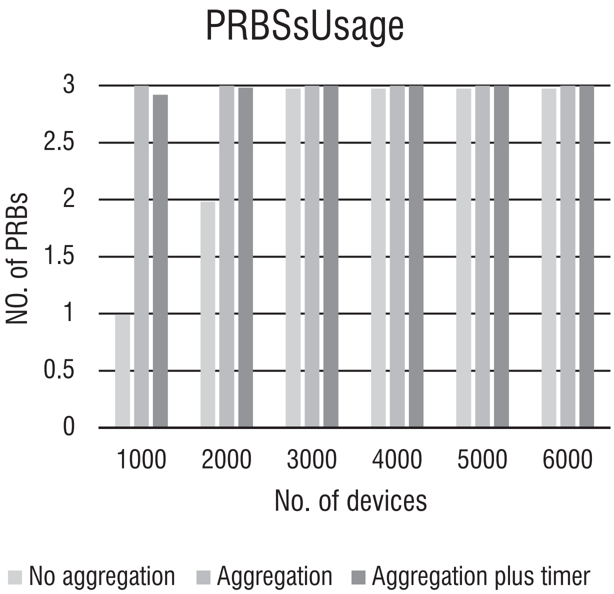

Fig. 5: Data Rate comparision (Scenario-1)

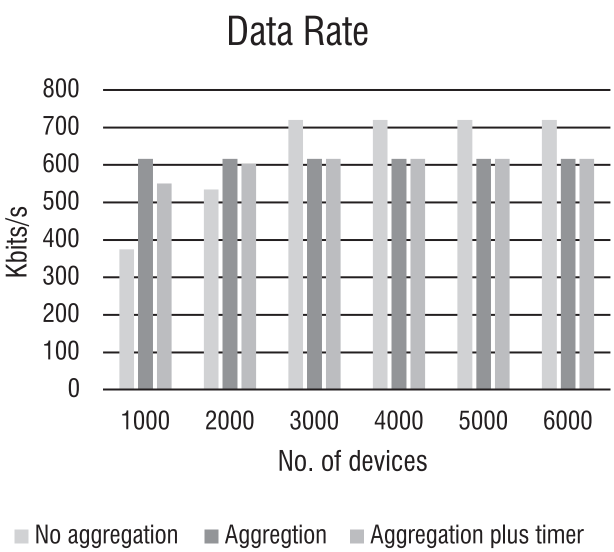

Fig. 6: PRBs usage comparision (Scenario-1)

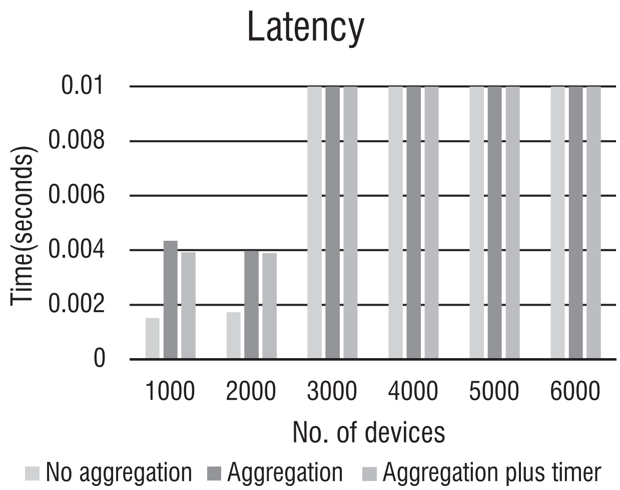

Fig. 7: Latency comparison (Scenario-1)

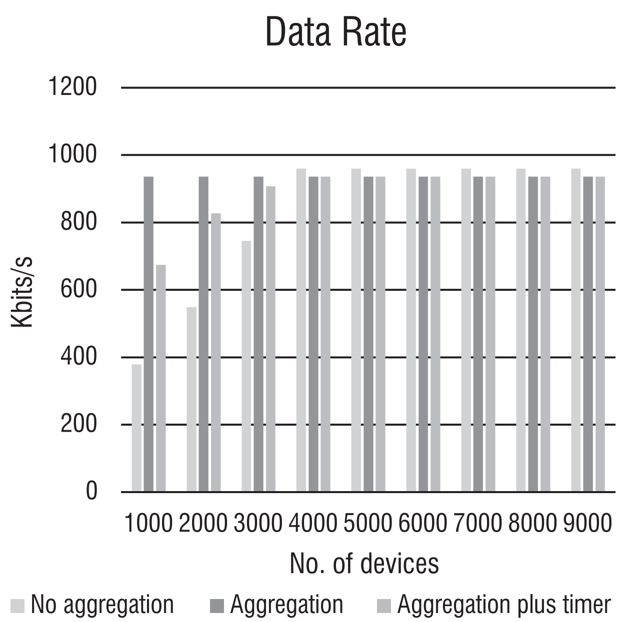

Fig. 8: Data rate comparision (Scenario-2)

increase doesn't affect data rate. The latency is minimum (enhanced) in low load and become high in high load. But, compared to case-1 in scenario-1, where noticeable change occurs in 3000, here noticeable change starts at 5000. It is because of increase in PRB's number. In case-2, the data rate is high for low load, PRBs are not fully utilized in low load and latency is minimum at low load and gradually increases with increase in load. In case-3, the data rate and PRBs usage is more enhanced in low load as compared to all cases in scenario-1, while latency is high in low load and gradually enhances with

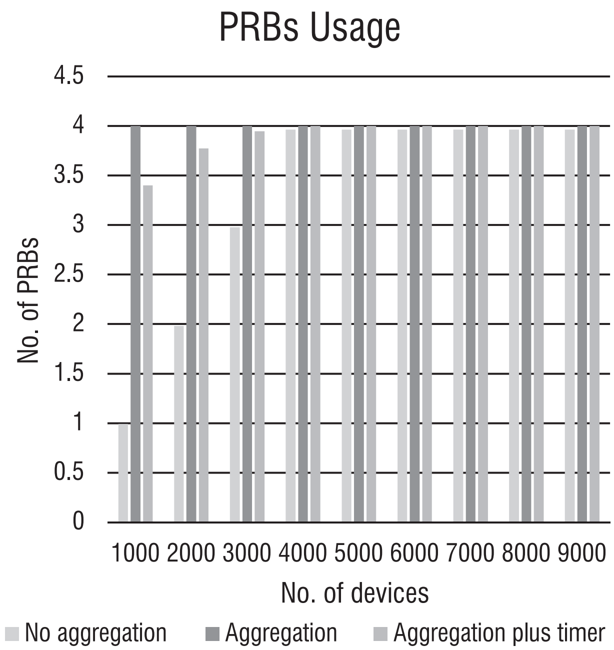

Fig. 9: PRBs usage comparision (Scenario-2)

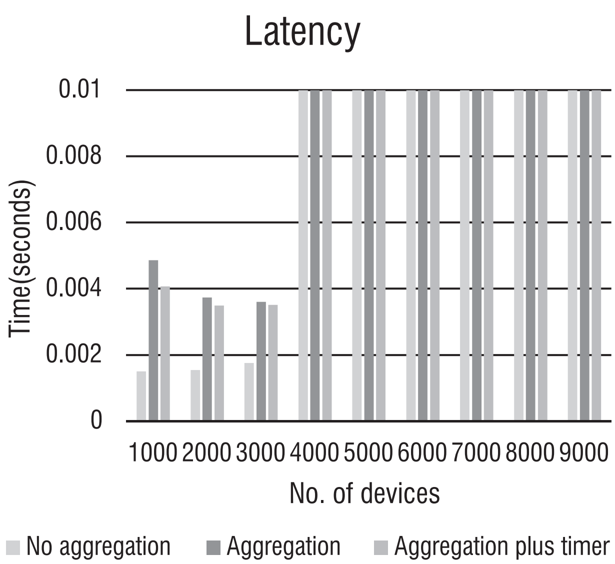

Fig. 10: Latency comparison (Scenario-2)

increase in load.

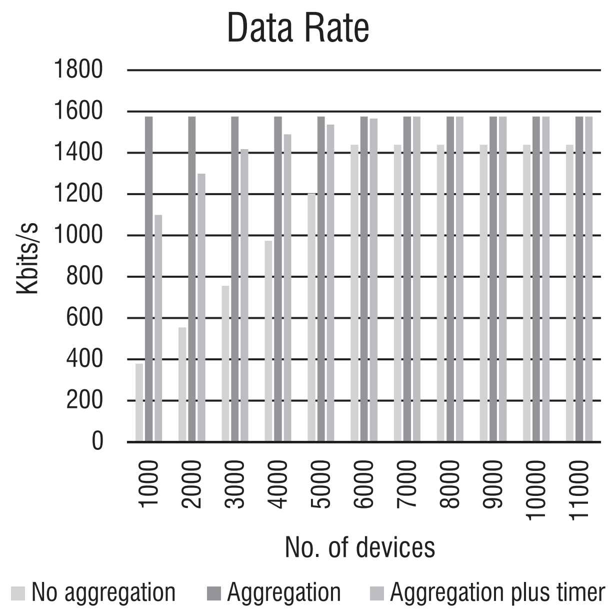

Fig. 11: Data Rate comparison (Scenario-3)

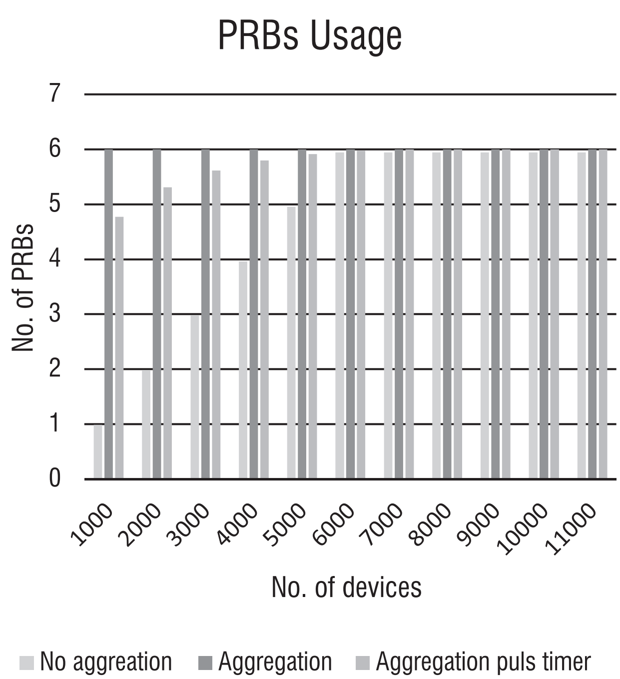

Fig. 12: PRBs usage comparison (Scenario-3)

In scenario-3 (6 BRBs) in case-1, data rate is smaller in low load and gradually increases with increase in number of MTCDs and maximum data rate is achieved at MTCDs 6000 as compared to scenario-1 where maximum data rate was achieved at 2000. This means that in scenario-3, the data rate and PRBs usage is smaller for low load and increase in number of PRBs does not affect data rate as shown in Fig. 11. The PRB usage is decreased in low load as compared to previous scenarios. Maximum PRBs usage is achieved at 6000 as shown in Fig. 12, which could mean that increasing PRBs in low load cannot affect data rate. Although, latency is further reduced as compared to previous three scenarios (Fig. 13).

In case-2, all three performance parameters i.e. data

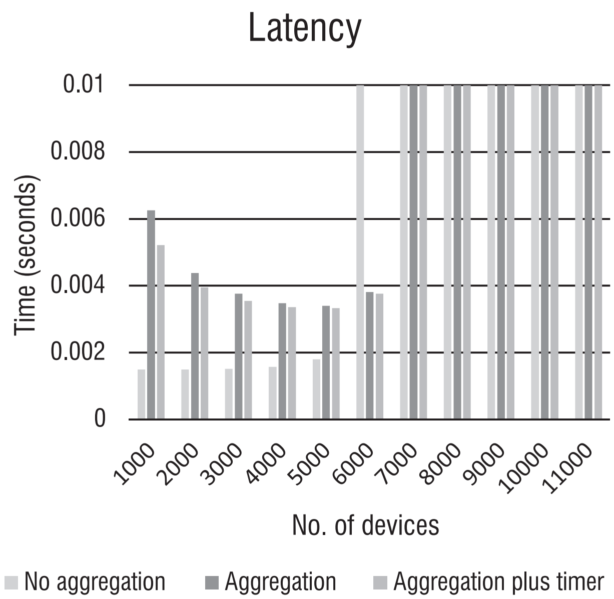

Fig. 13: Latency comparison (Scenario-3)

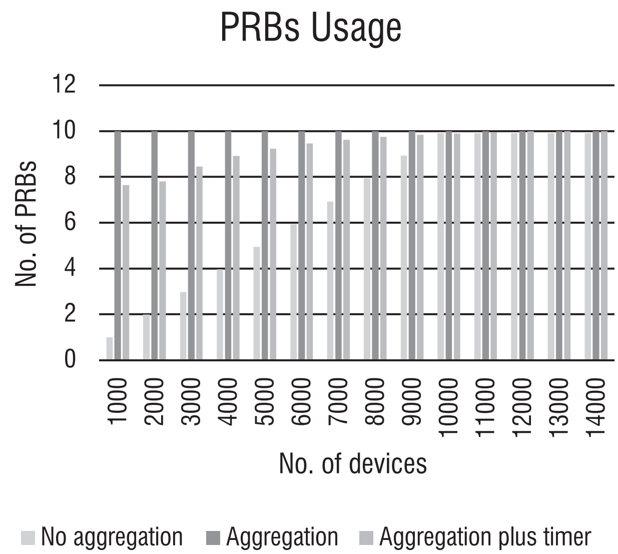

Fig. 15: PRBs usage comparison (Scenario-4)

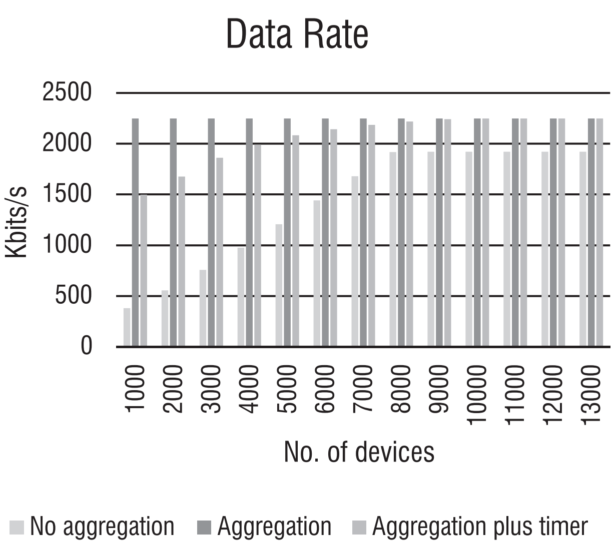

Fig. 14: Data rate comparison (Scenario-4)

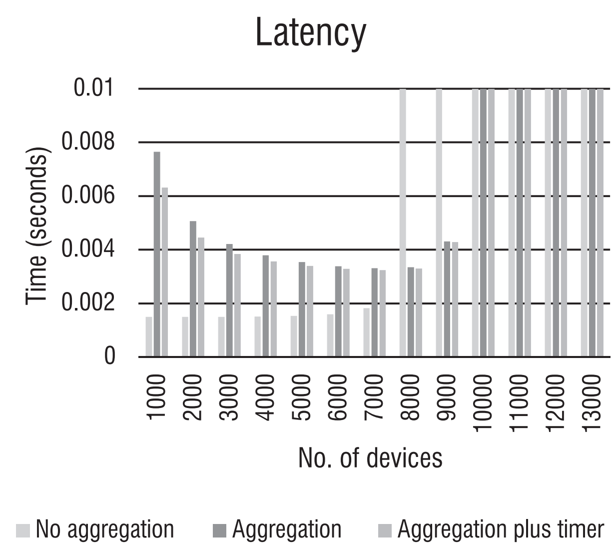

Fig. 16: Latency comparison (Scenario-4)

rate, PRBs usage and latency are further enhanced as compared to previous scenarios and shown in Fig. 12, Fig. 13 and Fig. 14.

In scenario-4 (8 PRBs) in case-1, as shown in Fig.14 and Fig.15, data rate and PRBs usage have the same behavior as in previous scenarios i.e. 1, 2 and 3. The latency is much smaller than previous all scenarios (Fig. 16). In case-2, with increase in number of PRBs, the data rate (Fig. 14) and PRBs usage (Fig. 15) is further enhanced in low load, while in high load both become equal in case-2 and case-3. Similarly, in case-3, the further increase in PRBs increases the data rate (Fig. 14) and PRBs usage (Fig. 15).

In scenario-5 (10 PRBs) case-1, the increase in PRBs does not bring any change in low load situation, although in high load the PRBs are utilized fully (Fig. 18), but the data rate (Fig. 17) is not enhanced. The reason, as mentioned earlier, is that there is no PRBs sharing in case-1 (no aggregation). In case-2, the increase in PRBs enhanced the data rate and PRBs usage (Fig. 18), but the latency is much more increased than any other case

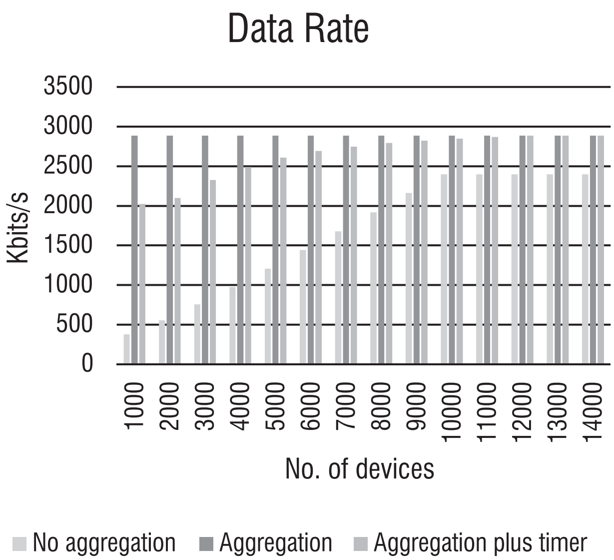

Fig. 17: Data rate comparison (Scenario-5)

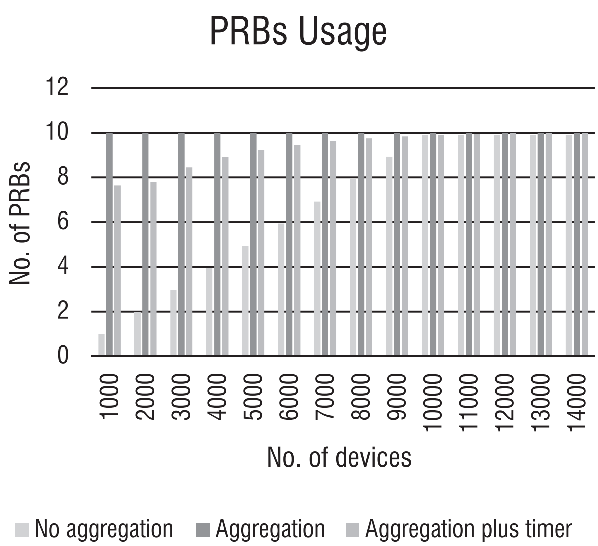

Fig. 18: PRBs comparison (Scenario-5)

in any previous mentioned scenarios. The reason is, the packets wait in buffer till the TBS capacity is achieved. As, TBS depends on Modulation and coding (MCS) scheme and number of PRBs. In case of 10 PRBs, the size of TBS is much greater than any other case in previous all scenarios, because the number of PRBs are less in those scenarios. It takes plenty of time to fill the buffer as compared to any case in previous scenarios and therefore the latency is much greater. In case-3, the same job is performed using less resource (PRBs) and with enhanced latency, as was performed in case-2. PRBs are saved and those spared PRBs could be allocated to other users and therefore spectrum is efficiently utilized.

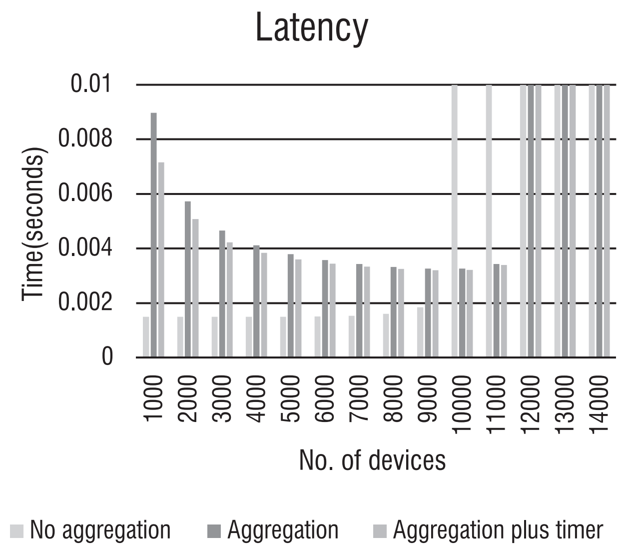

Fig. 19: Latency comparison (Scenario-5)

Table 1: Settings for simulation considerations

Consideration	Setting
Air interface	OFDM
Systems bandwidth	7 MHz
Modulation and coding scheme	16 (3GPP, June 2010)
IoT device transmit power	23 dBm
Channel modeling	Vienna (Ikuno, Wrulich, & Rupp, 16-19 May 2010)
Timer period	10 ms
IoT packet inter transmission duration	1 s
IoT packet size	240 bits
Buffer size	Infinite
Overhead of aggregated packet	352 bits

CONCLUSION

A packet aggregation scheme was proposed in this research work, where small data packets produced by MTCDs are aggregated in memory. A timer technique is also used for managing small packet in memory. These small packets either wait until the memory is full, or timer duration is expired. Using this mechanism can significantly improve the spectral efficiency in mobile networks. Furthermore, the results reveal that increase in number of MTCDs overburden the mobile network, and due to congestion, the system will fail to deliver services. It is also inferred that increasing PRBs is a wastage of resources in low load. The proposed scheme i.e. aggregation scheme enhances the system spectral efficiency.

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