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A Novel Hybrid-MAC Protocol for Densely Deployed Adhoc Machine-to-Machine Networks

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Abstract: *This paper contains a new hybrid MAC framework, an instantiation related to medium access systems based on contention and reservations. We suppose that this instantiation is a framework consisting primarily of two parts. These are containment interval 'CI' & information interval 'DTI.' The length of CI follows the p-persistent CMA system. This facilitates channel access by M-2-M appliances. The effective systems gain slots of time & transmit packets of information after a dispute during DTI. In this suggested MAC-Hybrid protocol, the DTI period follows the Time-Division-Multiple-Access (TDMA) mechanism, enabling each M-2-M instrument to operate IEEE 802.11 DCF. A transmission system communicates within every TDMA time slot with its respective one-hop remote storage unit using the DCF protocol of IEEE 802.11 to reduce the different constraints of TDMA. The suggested hybrid-MAC protocol considerably enhances performances compared with slotting-ALOHA, p-persistent CSMA, and TDMA systems in the field of overall throughput, median delivery delay, channel supply, and power consumption.*

Here the also suggestion of a new MAC protocol to enable more devices in every TDMA time slot is given. This protocol works with a single channel and transceiver, allowing spatial reuse to allow multiple M-2-M appliances to access the channel concurrently and considerably improve the hybrid MAC protocol's performance. This MAC protocol inserts extra entry distances (AAIs) between control packet injection (RTS / CTS) and information packet transmission (DATA / ACK). If, in every time-slot during the 'DTI of the hybrid-mac frame,' M-2-M devices communicate with one another using this proposed MAC (instead of IEEE 802.11 – DCF suggested as in previous cases), a series of RTS / CTS interchanges between the device in the vicinity of the transmission / receiving device allowing potential concurrent data transmissions. This leads to important improved hybrid-MAC image performance relative to the IEEE 802.11 - MAC protocol.
Finally, with the number of simultaneous transmissions increasing within one TDMA slot of hybrid MAC-protocol, this results in the interference among M-2-M appliances in the local geographically interacting region. To reduce the interference and accommodate the more M-2-M appliances in a hybrid MAC framework, Multiple Beam Array-Medium Access Control (MBAA-MAC) interact mutually with the use of a MAC-protocol in every TDMA Time Slots of the hybrid MAC framework. This also makes the hybrid-MAC frame scalable and increases further, compared with IEEE 802.11 MAC-protocol; the output of hybrid-MAC frame.

Keywords: *TDMA, MAC Protocol, TDMA, open-system-interconnection, and distinctive service quality*

I. INTRODUCTION

The next large thing on the technology front is M2M (Machine to Machine) communication & for leveraging the potential of this technology, many development activities are happening worldwide. M-2-M is an evolving technology in the area of telecom systems. M-2-M relates to technology for wireless and wired systems with other equipment with the same capacity. M-2-M utilizes the devices (e.g., a sensor or meters) to collect an event that converts a captured event into significant data by network 'wireless, wired or hybrid'. It is heartening worth noting that comprehensive plans to adopt the M-2-M communication from concept to practical application have been made worldwide, focusing on the communications segment, which is essential to the success of M-2-M. It is extremely important to have open standards and interoperability to ensure that M-2-M systems proliferate to provide effective, citizen-centered services in different industries. The significance of M-2-M communication is enormous; as roll-out spreads across different industries for consumers, enterprises, citizens, and governments, M-2-M can bring significant and tangible social and economic advantages. For different industries like Smart-City, Intelligent Grid, Intelligent-Transportation, Smart-Health, and many more. M-2-M is the foundation for automatic data exchanges between equipment and control centers. Through various standards initiatives, the government of India recognized and stressed the potential of M-2-M.

II. MACHINE-TO-MACHINE COMMUNICATIONS

The M-2-M communications should play an important part in improving the interaction between machines and computers in different industries through a reduction in the human interface. In bringing intelligence to the field level in various industries, making it easier to transform M-2-M communications and ICTs into intelligent sectors through a reduction of human-machine interface. M-2-M communications will revolutionize the efficiency of different industries, companies, and services by offering automation and intelligence not imagined. M-2-M can bring considerable social and economic tangible advantages. Apart from M-2-M, many other phrases are also used to define communication like 'Internet of Things (IoT), Internet of Everything, Embedded wireless, smart systems' with few distinct characteristics for related phrases. IoT is an N/w of many associated embedded devices that can communicate with M-2-M without a human interface. M-2-M Communication is "Smart" in comparison with cloud and remote logic. M-2-M can bring considerable social and economic tangible advantages.

Since the last few years, several initiatives have been taken towards M-2-M facilities, but the strategy remained extremely fragmented and isolated in the respective industries. Efforts are, however, being made to develop different criteria, regulatory requirements, and the industry approach to M-2-M. Almost all countries worldwide have taken the lead in creating M-2-M product systems and standards. Our focus is on M-2-M interaction components, concentrating on interoperable industry-wide standards, policies, and laws. M-2-M / IoT will be the world's next big, and there will be many worldwide acts. M-2-M has enormous potential to bridge the digital gap in the country. It will also place India in a favorable role as M-2-M technology can be used in upcoming technologies. Many M-2-M / IPC-based applications are potentially extremely important for energy, infrastructure, transport, logistics, transport, healthcare, and smart-city industries, many more.

The future development of M-2-M communication will include deep interactions with all M-2-M Eco-System contributors, including all stake-holders like Academia, Chip-Set OEM Vendors, Industry, Consultants, Solutions providers, companies, international and national standardization bodies & government. M-2-M communication will provide intelligent use of minimal technology in non-communications products and services across various industries. Close coordination and telecoms experience is necessary for the smooth implementation of the same. An Apex coordination body between different industries is suggested to meet these demands. It is noteworthy that Standards and Regulatory guidelines are being formulated and finalized after intensive consultation with relevant stakeholders, including industry associations and industry, by embracing the realistic approach while including the significant inputs. There have been attempts to incorporate all related inputs, tools, and experiences gained during the last one and a half years since the beginning of the activities. This paper is hoped to be an important milestone in the acceptance and deployment of M-2-M's intelligent infrastructure and services in various economic sectors.

The government of India has acknowledged the significance of IT/ITeS/ESDM sector and has initiated the Digital India and Make-in-India campaign. The success of such campaigns will lead to tremendous M-2-M penetration. M-2-M / IoT will provide multiple pieces of equipment on this network that improve ordinary people's quality of life and result in socio-economic development in India. This is advantageous for India because intelligent device capabilities can be used in infrastructure projects to make it effective and offer enormous possibilities. Increasing the country's socio-economic development is potentially possible by adopting applications based on M-2-M in fields such as healthcare, tele-education, intelligent-metering, intelligent grid, intelligent building, intelligent city, etc. A great plan can produce an advantage that may ensure that many elements can be shared, leading to economic growth in the infrastructure segment. One of the requirements to boost M-2-M deployment is favorable standards and norms.

M-2-M is a new paradigm with various major challenges regarding present networks for communication and are first optimized and used in personal communication. This includes handling several different devices and resources that allow for appropriate QoS, etc. Consequently, M-2-M communications must be endorsed with minimal impact on personal human communications. To meet the key scalability, energy efficiency, reliability and quantitative variability requirements of M-2-M communication, new M-2-M alternatives are needed. In addition, to support M-2-M communications and the coexistence networks of M-2-M devices and H2H clients, an optimization of the distinct parts of the ISO-OSI model protocol pad needs to be done. It is also projected that cognitive M-2-M (C-M-2-M) messages will be essential in the M-2-M era.

In the next ten years, mobile network operators (MNOs) will experience one of the most important problems for M-2-M and IoT governance. M-2-M levels of traffic should represent only a tiny percent of the network quantities, but steady changes are a challenge for mobile network operators to plan and optimize their networks to meet fresh requirements and distinctive service quality (QoS) needs. Many linked systems will pose a significant spectrum insufficiency challenge, as expected for M-2-M communications. Not only does C-M-2-M increase spectrum use, but it also leverages additional range possibilities by introducing vibrant spectrum access capacities in M-2-M networks. C-M-2-M is also primarily designed to address the instrument's heterogeneity, power effectiveness, and intrusion control.

This study aims mainly to address various problems in the capillary and mobile M-2-M fields and create fresh protocol improvements so that M-2-M devices can efficiently access the channel. Special emphasis is placed on M-2-M networks that use Carrier-Sense-Multi-Access (CSMA) technology, Multi-access Time Division (TDMA), and DCF (MAC) technologies for capillary M-2-M. The M-2-M protocols must be developed from an executive viewpoint. Therefore, this paper focuses on intelligent houses and intelligent buildings, two of M-2-M communication's fastest-growing applications. Furthermore, the objective of this dissertation is to investigate evolving frontiers in M-2-M communications.

Till now, not much has been done to unite these parts and find the existing gaps in standards. Besides, M-2-M apps require the incorporation of various techniques across various company areas.

Table 1: M-2-M networks Key radio technologies

Standards	**Characteristics (like Data Rate / Range / Applicability**
Wi-Fi	Wi-Fi networks used in Local Area Networks (LANs) having high data rate i.e. 'for 802.11a (max up-to 54Mbps), for 802.11b (max up-to 11Mbps), for 802.11g (max up-to 54Mbps) & for 802.11n (more than 100Mbps)'. Wi-Fi range is up-to 150feet (i.e. 46m) for indoor & 300feet (i.e. 92m) for outdoor in 802.11b/g/n. Also, this is approximately one third (1/3) in case of 802.11b/g/n and for 802.11a. Laptop-connectivity, smart metering etc. are some of its applications.
802.15.6	IEEE 802.15.6 standard used in Body Area Networks (BANs) has low data rate from 10kb/s to 10MB/s. It has a range of 2 to 5 mts. It has its application in the field of e-healthcare.
UWB (Ultra-Wide Band)	UWB (Ultra-Wide Band) has applications in Personal Area Networks (PANs) with a high data rate beginning from 480mbps - 1.6gbps. It has range till some mts. All live videos are one of its examples.
Bluetooth	Bluetooth network is mainly used in Personal Area Networks (PANs). Having a low rate of data as 250 kbps. Bluetooth networks have a reach of up to 10 mts. Music, video file sharing, etc., are some of its applications.
ZigBee	ZigBee standard is used in Personal Area Networks (PANs) with a low rate of data as 250 kbps. It has reached as min 10mts to max100 mts. Appx. This technology is useful in automatic control.

M-2-M standards

Several standardization activities globally have been initiated to promote the development of M-2-M eco-systems. Criteria concentrated on the inclusion and support of applications via unsafe platform interfaces as reported by QD. Vo, J.P. Choi, H.M. Chang & W.C. Lee (2010), R. Yu, Y. Zhang, Y. Chen, C. Huang, Y. Xiao & M. Guizani (2011), M. Sneps-Sneppe & D. Namiot (2012) and B. C. Villaverde, R. De Paz Alberola, A.J. Jara, S. Fedor, S.K. The European Institute set das & D. Pesch (2014) for Telecommunications Standards Technical Committee for Machine-to-Machine (M-2-M) reported by BC. Villaverde, R. De Paz Alberola, A.J. Jara, S. Fedor, S.K. Das and D. Pesch. ETSI TC in M-2-M cooperates closely with the 3 GPP mobile standardization and activity ETSI Next Generation Network (NGN). The latter included communication machine support as demonstrated by V. Galetic, I. Bojic, M. Kusek, G. Jezic, S. Desic, and D. Huljenic (2011), A. Rajandekar and B. Sikdar (2015) in Release 10, which enabled the use of large M-2-M apps by 3GPP mobile networks. The TR-50 engineering committee set IoT Access Standards for Agnostic Interface Systems at the Telecommunications Industry Association (TIA). For the IPv6 protocol (e.g., integrated devices), the IETF workforce (ROLL) produces a routing architectural framework that resource limits. Routing through the working group for the low energy and loss network. The Working Group on Resource Funding Apps, operating on a resource-restricted network, is formed by IETF CORE (Constrained Restful Environments).

Our paper shows significant attempts to standardize several SDOs, technology-based partnerships and implementation-oriented partnerships, a distinct system model, their key distinctions, and particular goals.

Connection-mode and Connectionless-mode

It is now discovered that two main kinds of services exist. The first is modeled on how telephones operate and are called a connection-oriented service, whereas the second is modeled on how a postal service operates. Interestingly, the connectionless system is older; namely, a telegraph system which was used before the telephone was invented, but the connection-based system is more predominant and was the only form to be used before the introduction of digital computers.

The main difference is that an entity using the low-level connection service must first establish a connection, i.e., communicate with the other end without any information being transferred. The first step is to provide a connection. This is known as the connection build-up stage. Besides, the user has to explicitly break the communication channel with the peer organization in the other end when the user terminates the transfer or communication of information. Between these two stages, data is transmitted.

To generate connection-mode-based service from a connectionless-based service, the open-system-interconnection (OSI) required for the protocol supplying the connection-mode must be sent through connection-free mode. This leads to a clear question of whether the open interconnection scheme (OSI) comes into the correct sequence. The choice of protocol procedures, resilient to these events, shows the answer. A typical illustration is provided by the ISO-Class-4 Protocol, meant for use under these cases using a 3-way handshake for connection building.

Point-to-point (P2P) and Multi-peer

Applications ideally suitable to P2P implementation are those where centralization is not feasible or necessary, significant scalability is desired, transitory or ad-hoc relationships, resources are widely distributed, and its quality or output is desirable to increase with the involvement of more nodes in the network. For P2P, we need Uniform peer addressing, which can be established by providing Peer IDs and implementing Dynamic peer domains using peer groups. We would also need to implement Uniform resource representation and Virtual communication channels. Peer devices are any networked device that implements one or more protocols. The devices can be PC, server, PDA, cell phone, etc. Peer devices shall operate independently, asynchronously, and shall be able to Spontaneously discover each other on the network using Transient relationships or Persistent relationships (peer groups). Peer groups are created or used to Create secure and protected domains. They can also ensure and define the scope of peer operations such as Discovery, search, communications. Peer groups also provide a "group" identity apart from sharing a common interest. More importantly, peer groups also Enable monitoring of the devices. Accordingly, We can readily say that the communication network's topology determines what we want to accomplish and only sets out which sides may or may not send to others directly. Furthermore, the protocol should consider the option of master-slaves operating at various speeds, and we should therefore identify time-out periods to match a slower slave. Even at the end, we can guarantee that the protocol takes care of one or more participants' mistakes while still properly performing for each other.

Simplex and Duplex

This system consists of two linked parties or devices that interact in one or two directions with each other. Two systems may be simple, medium, or full-duplex, communication between two devices. Simplex: One way is to communicate. Simplex communication allows all signals to flow in only one direction. These schemes are often used in broadcast networks, where no information must be returned to the transmitter/broadcaster by the receivers.

A duplex is a system that consists of two linked parts or devices that interact in both directions with each other is the duplex communications system. Half-Duplex: Typically, this system setup communication towards both directions and allow one direction at the same time. After any receiver starts to collect any signal, the transmitter needs to wait before the answer. For example, a full-duplex "walkie-talkie" schema allows communications on both sides and allows simultaneous communication instead of a half-duplex system.

There are many different practical applications that are supported by simplex and duplex communication. Applications of Simplex Communication primarily are 'TV broadcasting, AM and FM radio broadcasting, Digital Radio and television, Cable television, Wireless remote control, Internet of Things (IoT), Navigation and direction-finding services, Telemetry, Surveillance, Music services, Internet radio, and video.' Primary duplex communication applications are 'Telephones, Two-way radio, Radar, Sonar, Amateur radio, The Internet, LAN, MAN, and WAN.'

Multiplexing and Demultiplexing

In almost every protocol architecture that has ever been created, multiplexing and demultiplexing services are given. It includes two unique areas in the header, the first being the port number of the source & the other one being the port number of the destination. The UDP and TCP carry out demultiplexing and multiplexing activities. Multiplexing is usually referred to as gathering information from various sender implementation procedures called multiplexing by enveloping and transmitting the information with the header to the expected recipient. During multiplexing, received sections are delivered on the receiver side for the right application layer. The sender should be aware of the destination IP address & the number of application ports (related to the destination part) in which data are worth passing as part of transmitting and receiving data from an application on the sender side to an application on the target side.

We are aware of the multiplexing and demultiplexing of the service supplied by the OSI model's Transport layer. As described in the following methodology, multiplexing and demultiplexing procedures are carried out. As the principal requires, the sender must know the destination IP-address & number of the port associated with an application (on the target side) to which they wish to transfer data for sending data from an application on the sender side to an application on the target side. Suppose A is the sender and B the recipient. Suppose A would like to send messages to B. A must specify B's IP address and the target port number for transmitting the signal via its implementation.

In the latter event, A must also indicate B's IP address and the destination port number when sending the email. Messages from both applications are now embedded in the suitable headers (like source & destination IP address, source & target port number, target). This method is referred to as multiplexing. The received message is unwrapped at the location, and the relevant documents are sent to the suitable implementation by looking at the port number at the location. This technique is known as demultiplexing. Similarly, B can also send messages to A.

III. SEGMENTATION, FRAGMENTATION AND REASSEMBLY

The technique of dividing the packet into smaller units before transmission and reassembling the packet in the right order at the end of the communication is the Packet Switched Telecom, segmentation and reassembly network (SAR), sometimes known as segmentation. Packets are decreased to velocity through the network and, in particular, because of specified packet size constraints in a particular path. SAR is performed in the Open Systems interconnection (OSI) model on both sides of the transport layer. The size of one of the networks involved in the packages' conveys and segments determines the size of the smallest PDU.

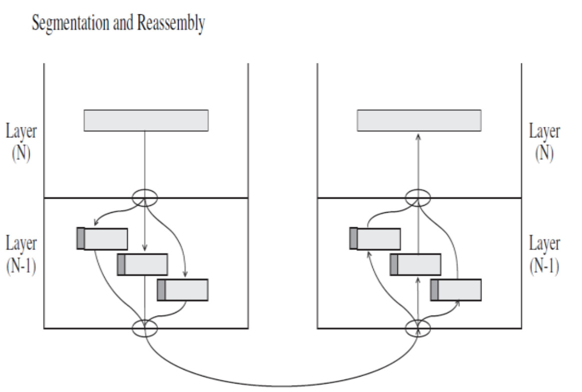

Fig1: Segmentation and Reassembly

The segmentation technique is performed before data is transmitted through the network, pre-storage in the periphery device. Segmentation becomes vital due to what is called packaged communication that is used by today's communication systems. The cutting of data in segments provides different uses. After segmentation, parts are called protocol data units. The packets are built-in with these PDUs. Several paths can send packets towards the destination. It enhances effectiveness as well as the speed of data moving over the network. Packets travel through the switched network of the packet without linking any communication circuit. Therefore, numerous conversations in various parties can share the same communication link. When an incident of packet loss takes place, the entire debate may be resubmitted rather than restarted. One example of segmentation would be transferring a completed Protocol Data Unit from TCP to PDI (Internet Protocol), which is stamped using an additional sequence number, source & locale port number & then one calculated checksum. This is when a transmission control (TCP) is cut into the segment, encapsulated by the segment having remote and locales TCP port numbers. Fragmentation is how larger parts of data are cut into smaller parts. Fragmentation usually takes place at a hardware level, and when the data is cut in bits, it is called a frame. Fragmentation happens to allow the transmission of data over a connection without overwhelming the memory buffer on either side of the link. Fragmentation makes it possible to coordinate the transmission of information between machines connected to a common medium. Reassembly is segmentation's opposite. Protocol Data Units are reassembled to reassemble a data stream in its initial form in the right order.

M-2-M Communication Protocol Classification

There are three main protocol types:

1. **Service-oriented Architectures (SOA)**: For example, soft real-time information transfer between programmable programming controls and information control and data acquisition (SCADA) systems is carried out in industrial automation technologies with the help of SOA.
2. **Representational State Transfer (REST):** The architecture type of representative state transfer (REST) describes restrictions on used parts, connectors, and information elements.
3. **Message Oriented Protocols:** Message-oriented protocols support the transfer of asynchronous information between the systems distributed.

Also, there are two main models used for M-2-M communications, according to the interaction paradigms:

1. **The model Request / Answer:** This Model is frequently used in the distributed system to exchange data via transmission from sender to recipient. Clients demand data from a server, and the server reacts appropriately to these demands. E.g.: HTTP, CoA
2. **Publish / Subscribe system:** This model relies on an Event Broker for copies of sending (publisher-related) status (notifications) to interested customers (subscribers). For instance: MQTT, AMQP

IV. PROPOSED WORK

The related transmitting systems are referred to as primary transmitter devices and primary receiver devices. One of the most important pieces of information for setting up simultaneous transmissions is data on previously scheduled transmissions in the network's vicinity. To record this data, the device maintains an Active Neighbouring Devices List (ANDL) in the FTDMA-based MAC protocol. After the RTS / CTS primary transmission is completed, ANDL related to the primary device does not become empty; due to this is expected that it retains its ANDL depended upon packets of overheard control during EAIs. Based on the available data on the nearby primary transmission, transmission related to DATA & ACK packet related to other planned transmissions should be changed. Therefore, these are referred to as secondary transmissions & corresponding participating devices referred to as secondary transmitter & secondary receiver units.

After RTS / CTS control packets have been successfully exchanged between the primary sender and the primary receiver system, the recipient devices do not transmit the DATA packet immediately, like the case in IEEE 802.11 'DCF' protocol. Rather, EAI interval is started, facilitating devices in vicinity regarding the sending / receiving device, exchanging their control packets, and scheduling simultaneous transmission of data with-out defying currently planned transmissions. This EAI interval is expressed as follows:

$$EAI = Duration_{RTS} + Duration_{CTS} + SIFS \qquad (1)$$

Where $Duration_{RTS}$ is referred to as like time interval needed in case of successful transmission regarding RTS, $Duration_{CTS}$ is the time interval required for the successful transmission of CTS while SIFS denotes small inter-frame spacing(SIFS). In contrast to the IEEE 802.11DCF protocol and the other existing approaches stated by P. Karn (1990), E.S. Jung & NH. Vaidya (2005) and Y. Lei, F.J. Shang, Z. Long & Y. Ren (2008), the proposed MAC doesn't employ the RTS/CTS packets to make the neighboring devices quiet. Instead, the control packets carry the information about the previous transmission. The possibly interfering devices in the proximity of a sending/receiving device use this information, in addition to the received signal strength of these packets, to dynamically decide if it is likely to schedule their transmission. ACKdelay, as stated in equation-2, is the time required for the primary sender for transmitting the data packet. This is determined based on prior experience. Control packets of the primary transmitter and receiver provide this information to all the secondary transmitter & receivers.

FTDMA based MAC uses an approach to delay the ACK packets of concurrent secondary transmissions. This is undertaken to avoid the collision of various transmissions between the ACK packets and the DATA packets. The information regarding previous transmissions calculates this delay, means a total time of transmission (total_transmission_time) and a number of the packet transmitted during this time from control packets.

$$ACK_{delay} = \frac{total\_ransmission\_time}{N} \qquad (2)$$

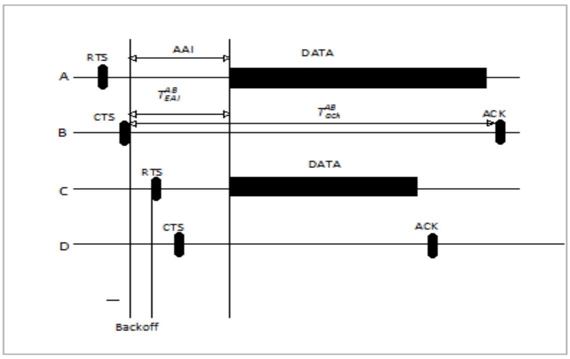

Fig. 2: Basic mechanism of FTDMA based MAC

We focus on two concurrent transmissions, i.e., A to B and C to D, as shown in Fig.2. To start with Device A transmits an RTS packet for device B. The RTS packet contains information like start times according to the device A DATA packet and ACK packet of device B. These values have determined concerning receiving time regarding related control packets to shut the need regarding synchronized clocks. Device B replies to device A with a CTS packet, which includes similar information. For a device in the vicinity of A or B, this information is required to find out whether it can simultaneously receive a data packet from another device while A transmits data to B or not. After the RTS/CTS packets exchange is over, the device A defers from transmitting the data packets in the duration of the EAIs. Devices C and D will interchange control packets & arrange the transmission in case of need during EAIs. In the case of transmission between Device C & Device D arranged successfully, all transmissions will take place simultaneously & the start time related to Device C's DATA packet is equivalent to the DATA packet of Device A. As shown in Fig., the system C DATA packet is smaller than the device A packet. The DATA packet length of corresponding primary transmission (DP_len_{PT}) must always be equal to or more than the data packet length related to a secondary transmission (DP_len_{ST}).

$$DP\_len_{ST} \leq DP\_len_{PT} \quad \textbf{(3)}$$

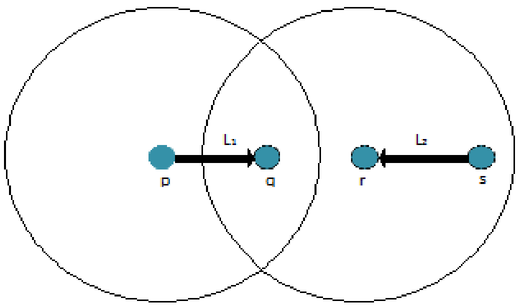

Fig. 3: Collision between ACK and DATA packets

Furthermore, an issue with the MAC layer is that in addition to interference between the concurrent transmission DATA packets, the concurrent transmission DATA packets and ACK packets may be overlapped with each other, as shown in Fig.3. Even if DATA packets related to transmissions A to B & C to D may be transmitted simultaneously without collision, both transmissions may still not be successful as a reason for collision between DATA packets & the ACK packet. Besides, if the packet duration remains lesser to length of the packet, the ACK packet will be transmitted by the device r before device q stops receiving their packets. By default, system q interference as a reason for the transmission of the device is greater than that due to the device s transmission. As a result, when the ACK packet is transmitted from device r, receiving the DATA packet at device q may not work properly.

To complete simultaneous transmissions, we use an ACK packet delay method. The primary transmission ACK packets and all associated secondary transmissions are transmitted synchronously in sequence. As a result, chances of collisions in between ACK packet themselves or in between simultaneous transmission DATA and ACK packets are significantly reduced. The whole process is the following. As soon as a secondary transmission is computed, It delays the start time related to the ACK packet toward the finishing point for the ACK packet of all planned transmissions nearby to the secondary transmitter/receiver system. Since ACK packet size is set and the same for all devices and the scheduled transmissions are stored in the ANDL, finding its own is easy for the secondary transmission. Sequencing related to ACK packets distinguishes DATA/ACK packets & the other ACK packets, allowing more simultaneous transmissions. Meanwhile, it makes the FTDMA-based MAC protocol considerably simpler because it only considers possible collisions in between DATA packets. Since ACK packet size for all devices is extremely small & equivalent, performance is only affected to some degree.

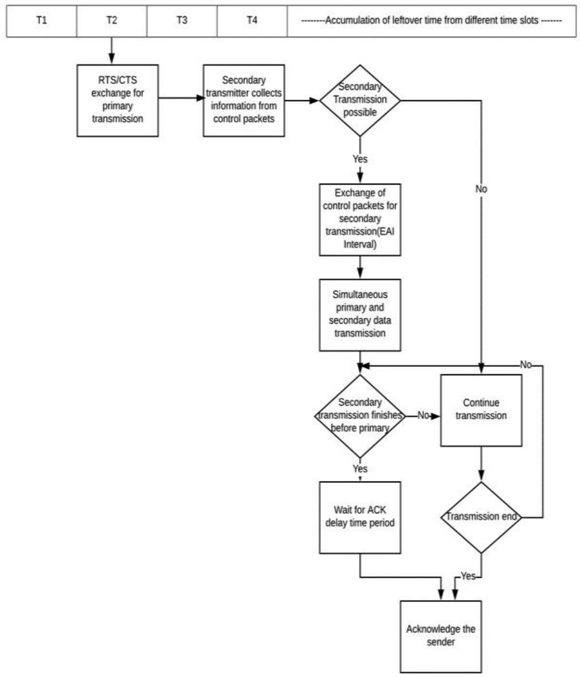

Fig. 4: Flowchart for FTDMA based MAC

V. RESULTS AND DISCUSSION

Simulator ns-2 is used to evaluate the performance related to proposed 'FTDMA based MAC protocol' by simulating our scenario in the, and by comparing our simulation results with IEEE 802.11 standard. We implemented the proposed hybrid-MAC protocol by extending the TDMA protocol available in the ns-2 simulator. Table 2 shows the parameters of the simulation.

Table 2: Simulation Parameters

Propagation model	**Two Ray Ground**
Data Rate	2 Mbps
SINR	6 db
Transmission Range	400 m
The range for Carrier Sense	800 m
Sensitivity of the Receiver	-94dBm
Receiver Threshold	-82dBm
Frame interval	1500ms
Transmission interval (for M-2-M device)	2.5ms
Message duration for transmission request	22.5 µs
Contention notification message duration	10.5 µs
Time-slot announcement message duration	10.5 µs
Acknowledgment message duration	8 µs
Short inter-frame space duration	2.5µs

Simulation Results

We study the performance of FTDMA based MAC protocol under different topologies – Random grid topology, random topology, and cluster topology.

Random Grid Topology

Firstly we have formed a random grid topology where devices are deployed in 800 square meters. This area is further divided into n*n significantly smaller squares, wherein one unit is placed arbitrarily in a small square. We presume that m transmission pairs (2 m devices) are available, and the transmitter is utilized fully. The corresponding receiver devices are only a hop back from all transmitter devices. Since the devices belong to each other's carrier sensor range, the IEEE 802.11 DCF protocol can transmit single transmission. Simulation results for control gap optimal size for different values of m is 256B (m=2), 448B (m=3) & 640B (m=4) as shown in the Figure-5, Figure-6 & Figure-7. The simulation results show 29%, 29%, and 39.31%, respectively for m= 2, 3, and 4. The simulation results clearly show that device density significantly affects the throughput of the network w.r.t. our proposed hybrid-MAC methodology. As the devices' density increases, the average distance between the transmitter and receiver decreases as the receiving device is located in its respective transmitter system's neighboring grids. Subsequently, the average distance between devices with different transmissions is increasing.

Consequently, the number of scheduled simultaneous transmissions increases, which results in an improvement in network output in terms of throughput. Besides, contending transmissions in the network often affect network performance at any time. This is because as there are more contending transmissions are present; more simultaneous transmissions will take place. We can see that more contending transmissions result in better results for our proposed hybrid-MAC protocol.

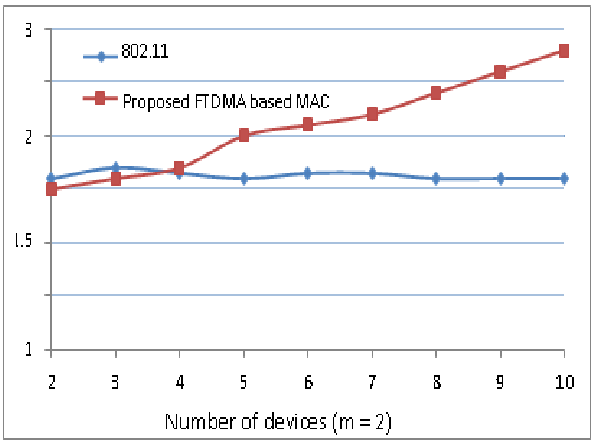

Fig. 5: Throughput of FTDMA based MAC where m=2

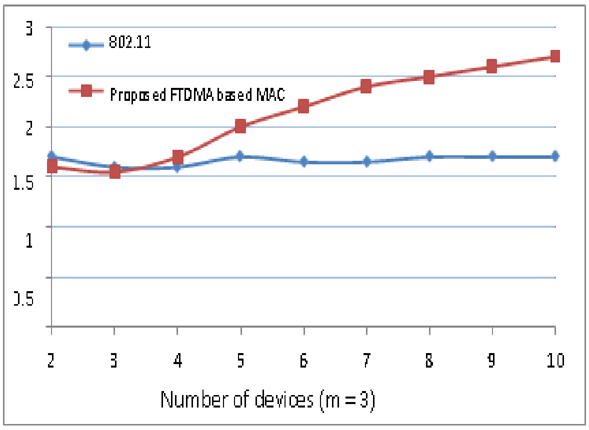

Fig. 6: Throughput of FTDMA based MAC where m=3

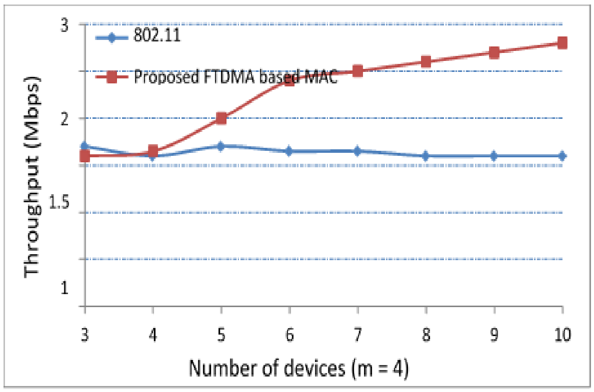

Fig. 7: Throughput of FTDMA based MAC when m=4

Random Topology

Secondly, we used ns for the performance evaluation of the proposed FTDMA based MAC protocol by simulating random topology. For this purpose, we have considered an area of 1000m within all 100 devices arranged randomly. Assuming m flows presence in the network and randomly selecting the sender and receiver devices of each flow and ensuring that the transmitter device is saturated and active for each flow. After that, it was decided to keep the size of the control gap used in the simulation as 640 B since we started the simulation keeping m = 4. The obtained results from the simulation are shown in Fig. 7. It was noted that when m is small, our proposed FTDMA based MAC protocol overpowers this problem and gives an almost comparable performance as that of the IEEE 802.11DCF scheme. However, with the increase in value of m, the chances for concurrent transmissions increase. Therefore, our proposed FTDMA based MAC protocol performs better and gives a throughput improvement of nearly 10% compared to that of the IEEE 802.11DCF scheme. We can easily infer that as the value of m is increased, there is further improvement in our proposed protocol.

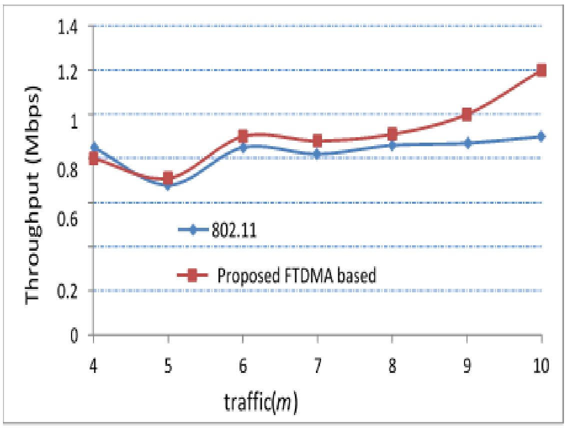

Fig. 8: Throughput comparison of FTDMA based MAC and 802.11 protocol (random topology)

Cluster Topology

Thirdly we considered 400*400 m^2 area to establish cluster topology. We group 16 devices into four different groups, each of which covers an area of 100* 100 m^2 in one corner of the whole considered area. The transmitter device may communicate with its identified receiver device; this receiver device is selected using another cluster having a p probability or using the same cluster having a 1–p probability. Simulation of four transmissions on the network was performed, with packet generation rate as n packets/second related to every transmitter device. In this condition, all transmitter devices are in each other's transmission range, resulting in only one transmission at a given point when the scheme IEEE 802.11 is used.

We set EAI's value to 3, resulting in 3 (three) secondary transmissions together with 1 (one) primary transmission. In figures 9 and 10 in one group, devices interact with other group devices with a probability of 0.25, and within the same group, devices interact with a probability of (1-p), i.e., 0.75. Consequently, only one transmission occurs between two groups out of a total of four simultaneous transmissions. The remainder of the communications happens among the same group's devices. Consequently, the average distance between concurrent transmissions increases in the current case in comparison with the situation shown in Fig. 9. Hence, concurrent transmissions are likely to occur more, as in Fig. 4.6; this results in enhanced throughput with comparison to the scenario shown in Fig. 9. In the case IEEE 802.11 DCF protocol is applied, the probability of only one transmission occurs. This may happen in between the inter-group devices in different groups or intra-group, i.e., same group devices. The throughput increases nearly linear, having less than 30 packets per second packet sending rate & then becomes saturated. According to Fig. 9, the performance of FTDMA based MAC protocol and IEEE 802.11 DCF is compared assuming a value of p = 0.25. The proposed FTDMA based MAC may accomplish nearly 30% enhancement in throughput upon IEEE 802.11 DCF standard in case of network traffic. In case p = 0, the proposed MAC performs excellent while attaining nearly 90.60% greater above IEEE 802.11 DCF scheme.

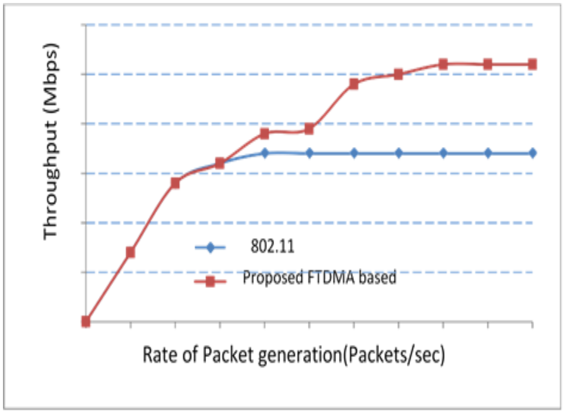

Fig. 9: Performance of FTDMA based MAC and IEEE 802.11 DCF Protocols, when p = 0.25

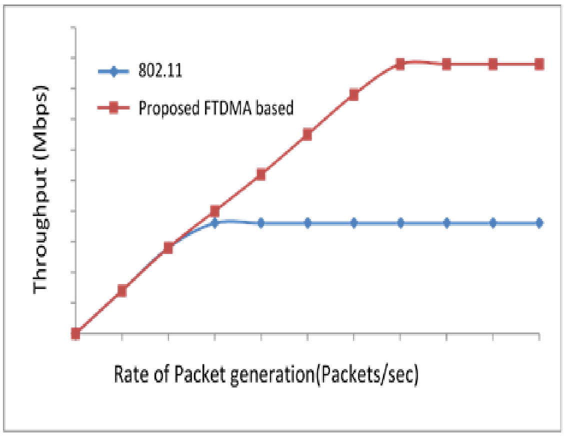

Fig. 10: Performance of FTDMA based MAC and IEEE 802.11 DCF Protocols, when p = 0.75

VI. CONCLUSION

For densely deployed M-2-M networks, we have suggested a novel FTDMA oriented MAC protocol. This makes spatial reuse easier and enables many broadcasts simultaneously. The EAI protocol introduces the transmission of order sequences and data packets during each TI time-slot. To plan feasible numerous simultaneous data transmission within each time-space during TI, a range of RTS / CTS interactions between secondary transmission and receptor can occur. An ACK succession mechanism is also implemented for eliminating necessary interference between DATA packets & the finished transmission's ACK streams. The main benefit of the suggested MAC protocol is that the chance of further simultaneous transmissions also improves as quickly as the amount of units rises. This leads to more devices transmitting DATA packets in an interval of transmission. When our suggested FTDMA-based MAC protocol is being used within each FTDMA-slot, simulation findings indicate a significant performance increase compared to IEEE 802.11 MAC protocol.

The high-throughput MAC (HT-MAC) protocol proposed to accommodate more M-2-M devices within each time slot between DTI duration significantly improves the entire M-2-M network. The design of efficient HT-MAC protocol enabling concurrent transmission in every TDMA time slot related to hybrid MAC frame structure is achieved through spatial reuse using an antenna for accommodating more devices in a single hybrid-MAC frame and insertion of extra distances of entry (AAIs) between control packet routing (RTS / CTS) and information packet transmission (DATA / ACK). When M-2-M devices share data in every time slot during DTI using HT MAC protocol, a series of RTS / CTS exchanges between devices nearby for transmitting/receiving devices are allowed for scheduling possible simultaneous data transmissions. A fresh ACK sequence system was used to prevent the feasible interference in DATA packets & ACK streams. The most significant benefit of this protocol is that the chance of concurrent broadcasts also improves as the number of appliances per time slot during DTI rises. This, in turn, makes our protocol hybrid-MAC more scalable. Simulation findings showed a significant increase in performance when our suggested hybrid-MAC protocol relative to the IEEE 802.11 MAC protocol is used.

Finally, the simulation findings showed that protocol provides greater performance owing to numerous concurrent signals using another planning system, namely various MAC (MBAA-MAC) beam antenna arrays in every time slot in DTI. MBAA MAC protocol promotes a single transceiver, operates upon single transmission energy & for information and control streams. This protocol can therefore be used in most current software goods. The suggested hybrid-MAC protocol's efficiency is assessed through comprehensive simulation and contrasted to the IEEE 802.11 DCF mechanism. The general network throughput also improves in the situation of random grid topology in the case of the amount relating transmission pair rises. AAI value narrows throughput representing the number of concurrent broadcasts depending on the number of entry slots. The delay also improves as AAI's importance rises, which eventually devalues the advantages obtained by concurrent broadcasts.

Furthermore, it is evident in the event of random topology if the amount relating flows 'value of m' rises, performance improves. Therefore, the throughput is directly proportional related to the number related to flows running within the network in four hop distances compared to the source device at any given time. Finally, the simulation findings showed that the Hybrid MAC protocol proved best than IEEE 802.11 DCF protocol in cluster topology and considerably increased the general network throughput. At the same moment, it retains IEEE 802.11 DCF's collision prevention property.

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