Hybrid Medium Access Control Scheme for Large Machine to Machine Networks: A Review

Akshat A Mokashi
ME Student,
Rajiv Gandhi Institute of Technology,
Mumbai, India

B.M. Patil
Asst. Prof.,
Dept. of Computer Engg.,
RGIT, Mumbai, India

ABSTRACT
This paper first discusses the machine to machine (M2M) domain architecture which becomes the basic model for hybrid Medium Access Control (MAC) protocols for large M2M networks and also it sets the background for hybrid MAC scheme. A review of the contention based and reservation based MAC protocols used in M2M networks is then made.

General Terms
Hybrid Protocol, M2M.

Keywords
Contention Protocol, Hybrid MAC, M2M domain architecture, Reservation Protocol.

1. INTRODUCTION
M2M networks are growing at fast pace in the Internet of Things (IOT) industry. It therefore becomes important to address the massive connectivity of various devices to M2M communication. Hybrid MAC protocols are needed to provide this massive access to every device in fair way [1].

Organization of this paper is as follows. Section 2 reviews the literature. Section 3 discusses the domain architecture for M2M networks which then forms the basic model. Section 4 reviews the various MAC protocols used in wireless M2M networks. Section 5 addresses related results and discussions. Section 6 provides the conclusion.

2. RELATED WORK
Many hybrid schemes are reviewed in literature. One such hybrid scheme is Zebra-MAC (Z-MAC) [2] used in the context of wireless sensor networks. In this scheme, in case of CSMA, when the contention is low, the channel utilization is high and latency is reduced and in case of TDMA, when the contention is high, the channel utilization remains high with reduced collision between two hop neighbors. Another hybrid scheme involves streaming of video over wireless networks [3].

3. MACHINE TO MACHINE DOMAIN ARCHITECTURE
Fig. 1 shows domain architecture for M2M communication. It consists of three domains, M2M domain, network domain and application domain [4]:

3.1 M2M Domain
The M2M network comprises of many intelligent devices or nodes with sensing capability and gateway. These devices send their data packets through single hop or multi hop patterns to gateway devices. The gateway devices then forward these data packets to back-end server via network domain, which can be either wired or wireless.

3.2 Network Domain
This domain provides reliable data packets delivery from M2M domain to application domain via a cellular link or a wired link.

3.3 Application Domain
In this domain the back-end server is the point of integration of all data packets coming from M2M domain. This information is then used by M2M applications for carrying out various tasks.

This architecture then forms the basic model to aid the understanding of working of hybrid MAC protocols as discussed in the next section.

4. MAC PROTOCOLS FOR WIRELESS M2M NETWORKS
Medium access control Protocols are divided into three broad categories:

4.1 Contention Based
Contention based protocols are the simplest protocols in which nodes contend for the channel in various ways, but are not scalable due to collisions [5]. Random access mechanism includes protocols like pure ALOHA, slotted ALOHA initially developed at university of Hawaii. As the throughput of both the protocol is 18% and 36% [6] and also protocol suffered from collision of packets, Carrier Sense Multiple Access (CSMA) protocol came into existence. CSMA protocol suffered from two major problems hidden terminal and exposed terminal which later on was solved by introducing single channel solution called multiple access with collision avoidance (MACA) [7]. It was incorporated with RTS-CTS-DATA-ACK control signal information. In [8] authors have proposed adaptive traffic load slotted MACA that is an improvement over slotted MACA.

4.2 Reservation Based

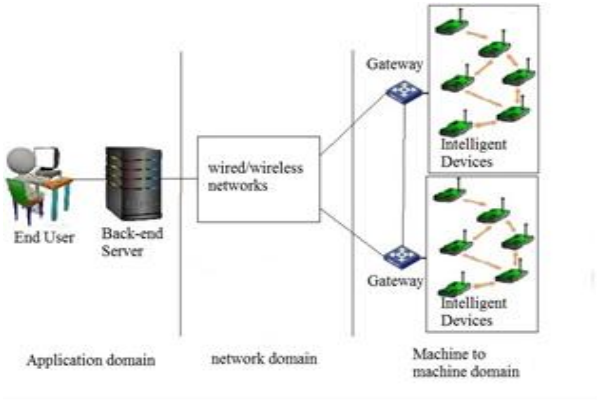

Fig 1: M2M Domain Architecture

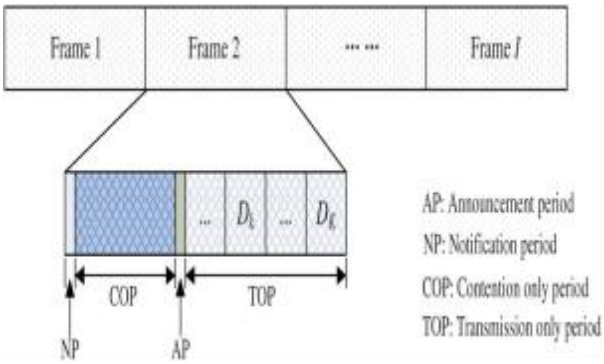

Fig 2: Time Frame Architecture [10]

One solution to avoid collision is provided by reservation based scheme which uses Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), and Code Division Multiple Access (CDMA) [5]. However TDMA protocol has limited scalability [9]. It is also subject to clock synchronization failures, time varying channel conditions, topology changes, and physical environmental changes [2]. Due to these factors it is insufficient to use these protocols for large M2M networks.

4.3 Hybrid Protocols

Hybrid protocols combine the advantage of contention based protocols and reservation based protocols for M2M networks. Fig. 2 shows Time frame architecture [1] which consists of 4 periods i) Notification Period NP: where base station or gateway notifies the start of contention to its nodes. ii) Contention only period COP: where the devices having data to transmit contend for reserving a slot for transmission. iii) Announcement Period AP: where the base station or gateway broadcasts announcement messages to nodes and the successful nodes enter in transmission period whereas other nodes go in sleep mode. iv) Transmission Only period TOP: where the successful nodes transmit data during their time slot.

Another hybrid MAC scheme is evaluated by the authors in [11]. It is an improvement over the above scheme. The basic RTS-CTS-DATA-ACK (a four way handshake mechanism) is introduced in the above scheme to overcome the TDMA clock synchronization failure in order to avoid the communication failure.

5. RESULTS AND DISCUSSIONS

5.1 Throughput, Average Transmission Delay, and Energy Consumption

Throughput is defined as number of bits transmitted per unit time. The above hybrid MAC scheme with the integration of IEEE 802.11 Distributed Coordination Function (DCF) mechanism achieves better aggregate throughput as compared to traditional slotted ALOHA and TDMA with N equals 10 % M (where N denotes successful machine devices during contention and M denotes total number of machine devices.) [11].Also they have evaluated the average transmission delay with respect to their proposed scheme taking into consideration the sending of control information signals [11]. In [10] the authors have measured average transmission delay by increasing the number of nodes; they also evaluate the energy consumption in Joule with respect to the number of devices for each period in the frame.

6. CONCLUSION

A reviewof the hybrid MAC schemes for large M2M networks that combine the advantage of contention based scheme and reservation based scheme has been made. Two such protocols for scaling the network have been studied. The first one includes four periods for each frame [1], [10] and the second one integrates IEEE 802.11 DCF mechanisms in each TDMA slots for robustness [11].The domain architecture is also discussedin context of M2M networks which becomes the basic model to understand the hybrid MAC protocols.

Future work try to further optimize the problem of control overhead by introducing coordinated sleep mechanisms, allowing hybrid protocols to adapt to heavy traffic load to save more energy, avoiding Request-To-Send Clear-To-Send packet losses, minimizing delay due to high packet failure rates.

7. REFERENCES

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