A Survey on MAC protocols for Fully-Connected MANET

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Abstract—MANETs are continuously self-configuring, infrastructureless network of mobile devices that are connected wirelessly. Each and every device in MANET is free to move in any direction independently and will therefore change its link to other devices frequently. All nodes cooperates in distribution of the data in the network. In this paper, we will decide on the quality of the service employed for the fully connected Mobile Ad-hoc Networks. We also deal with the protocols involved in transferring the data in this paper. And the traffic load management of data when it is being transferred. The major disadvantage in MANET is that its channel utilization and performance degradation when network traffic is high. So we discuss about the protocols that can manage the traffic in varied network load conditions. Techniques from other research papers are also taken into consideration and a mechanism is introduced in this research to counter the various network traffic load management and channel utilization. This mechanism maintains the Quality of Service QoS and manages the data that is being transferred.

Keywords—MANET; Traffic Load; Protocols; Channel utilization; QoS

I. INTRODUCTION

With the emerging technology in wireless networking, it will allow the users to access the information and the services electronically. Wireless networks can be classified into two types. They are Infrastructure and Infrastructureless networks. In this paper, as we deal with Mobile Ad-hoc Networks, which is considered under the Infrastructureless Network. A mobile ad hoc network is a self-organizing system of wireless nodes that requires no fixed communications infrastructure. The wireless mobile devices such as Laptops, smart phones are interconnected and they can communicate with each other in a distributed manner with a single-hop or multi-hop mode. As the MANETs has infrastructureless characteristics and with simplified implementation, they provide cost effective communication services in areas such as tactical networks and disaster areas where the conventional communication cannot be implemented easily.

The number of mobile devices and technology is increasing and the data can be transferred from anywhere, irrespective of the geographic location. Each node in the MANET act as routers and they can move while communicating. The key issue is identifying when nodes are allowed to access the channel that is to transmit a packet, for which a decision is made by Medium Access Control (MAC) protocol. The primary challenge in building a mobile ad-hoc network is that it has to equip each device to properly route traffic and continuously maintain the information required to be transferred.

II. RELATED WORK

Ping Wang, et al [1] discusses about the unique characteristic of the wireless mesh backbone that is, all the routers are located at fixed sites into consideration. The proposed MAC reduces the control overhead in comparison with conventional contention based MAC schemes (e.g., IEEE 802.11). The proposed MAC achieves much higher resource utilisation than contention based MAC by eliminating collisions, reducing control overhead, and achieving maximal spatial reuse.

Hai Jiang, et al [2] proposed a new distributed channel access scheme with the minor modifications to EDCA. The real time voice traffic has guaranteed priority over data traffic. But data traffic has certain service time. Also, short-term fairness enhancement is provided to data traffic. To serve voice traffic and
to achieve data throughput, analytical models are used to calculate the percentage of time. The effectiveness of our proposed scheme demonstrate both analysis and simulation.

Lei Lei et al [3] proposes DT-MAC, a dynamic TDMA based MAC protocol. It is designed to provide QoS in fully connected ad-hoc networks. In DT-MAC, the time frame is partitioned. Each partition has synchronization, request, assignment and data slots. The number of slots and their lengths in each time frame are dynamically adjusted according to the number of nodes and their services in the network. To provide synchronization guarantee for the nodes in the network, a frame synchronization method is introduced. To dynamically allocate the slots, a manager node is generated for each time frame according to the QoS requirements of the services that is sent by the nodes in the request slots. Also, the request slot is used to enable the nodes to join or exit from the network without conflicts, thus accommodating the change of network scale. DT-MAC protocol performs better in providing QoS guarantees as per the simulation results and compared to conventional TDMA-based MAC protocols, it accommodates the change of network scale.

Chlamtac, A. Farag, et al [4] proposed a Dynamically Adaptive Protocol for Transmission (ADAPT) for ad-hoc network. This combines a collision-free allocation based protocol and a contention based protocol while retaining the advantages of each. Contention mechanism is used by ADAPT at low loads as it reuses the bandwidth which would be otherwise wasted by a pure allocation based protocol. ADAPT provides bounded delay guarantees at high loads by dynamically changing its operation to that of its allocation based protocol and avoids the instability problem associated with pure contention based protocols. Thus, according to the prevailing network conditions, ADAPT self-adjusts its behavior. As per the analysis and simulation results, two protocols interact in a positive way. Therefore, without suffering from their drawbacks, it is possible to combine advantages of two fundamentally different design philosophies.

Weihong Hu, et al [5] proposed a hybrid protocol referred as Load- Adaptive MAC (LA-MAC) protocol for MANETs. LAMAC achieves high channel utilization under both high and low contention by adaptively switching its running mode between CSMA and TDMA. Implementation of LA-MAC is reported on a MANET testbed. It is formed by a collection of Multiple-Input Multiple-Output (MIMO) Universal Software Radio Peripheral (USRP) software defined radio nodes. Physical layer of USRP nodes is programmed using GNU Radio and LA-MAC is integrated with Physical layer implementation of USRP. Performance improvements of LAMAC compared to CSMA and TDMA is demonstrated through experimental studies. ShengmingJiang, et al [6] extends the classical centralized and slotted packet reservation multiple access (PRMA) scheme to a simple distributed PRMA (D-PRMA) as an MAC scheme for MANETs. It has emphasis on voice application support. The major efforts of D-PRMA includes a simple slot reservation mechanism for voice traffic. It does not rely on any central entity. D-PRMA also includes a simple solution for the hidden and exposed terminal problems uniquely present in wireless ad-hoc environments.

MarekNatkaniec, et al [7] proposed a comparison of protocols for the reader’s convenience. It has been provided with the indication of important features and supported mechanisms. This was done in order to help the reader more broadly to understand how the presented MAC protocols differ from each other. Furthermore, we have given short descriptions of current and evolving standards related to QoS provisioning at the MAC layer in ad-hoc networks and devoted a separate section to the most probable future research directions.

Akimitsu Kanzaki, et al [8] proposed that a node which joins the network, a protocol is designed to assign one of the unassigned slots to the node. If no unassigned slots are available, our proposed protocol generates unassigned slots. It deprives one of the multiple slots assigned to a node or enlarges frame length of nodes. This can cause collision with each other. Collision-free packet transmission is provided by our proposed protocol by setting frame length as a power of 2 slots among the nodes with different frame length. As per the simulation results, our proposed protocol improves the channel utilization dramatically when compared with the conventional protocols.

HomayounYousefizadeh, et al [9] describes the design of LA-MAC protocol. Also, reports on its implementation in a MANET testbed. A collection of MIMO USRP SDR nodes forms the MANET testbed. Multiple-Input Multiple-Output (MIMO), Universal Software Radio Peripheral (USRP), Software Defined Radio (SDR). The performance of LA-MAC is compared with that of CSMA and TDMA under different traffic conditions through analytical and experimental studies. Improvements achieved by LA-MAC in comparison with other alternatives is shown in the results.

RanaEjaz Ahmed, et al [10] discuss on the time slots in a frame that are dynamically assigned to TDMA or non-TDMA that is slotted ALOHA modes which depends upon the decision made at the end of previous frame. The TDMA mode ceases in next
frame, if the number of un-used slots in a TDMA frame exceeds a pre-defined threshold value and the nodes transmit packets in slotted ALOHA mode in the next frame. The mode of operation changes back to normal TDMA only when there is a collision in the previous frame. A simulation study for the protocol was done in order to study the effect on system performance by the variation of several parameters. It is shown that, by properly choosing threshold value, the system automatically adapts to the traffic load variations such that at low traffic intensities the protocol behaves similar to slotted ALOHA; while at high traffic intensities the protocol performance approaches to TDMA. The proposed protocol is simple to implement, adaptive, robust and stable. It has the potential for use in LAN/ MAN and wireless communication environments.

III. PROTOCOLS USED IN MANET

The main drawback in MANET is the traffic load management. MANET should achieve high network performance and satisfied quality-of-service should be maintained. To achieve this, medium access control (MAC) is required. MAC protocol is a mechanism that co-ordinates the nodes’ access to the wireless medium for transmitting the packets. Dynamic traffic load and distributed network operation makes the challenge in developing a MAC protocol in achieving consistently high performance. CSMA/CA - Carrier sense multiple access with collision avoidance based distributed coordination function (DCF) contention MAC scheme is most widely used in the current MANET implementation. As the network traffic load increases, there is performance degradation experienced by DCF due to increase in control overhead for the packet collision resolution. When the traffic load is high, channelization-based TDMA schemes are used to achieve high resolution utilization than DCF by avoiding packet transmission collision among the nodes. When the traffic load condition is low, the channel utilization of TDMA is inferior to DCF as the distributed time slot acquisition in TDMA consumes considerable amount of channel time for information exchange locally among the neighboring nodes.

Therefore, at a specific network traffic load, two MAC protocols would be having the same performance. This specific traffic load is referred to as MAC switching point. Based on this point, performance of DCF and TDMA protocols are calculated. Performance of DCF is higher before the traffic load reaches this point and the situation reverses after this point.

Because of this performance related issues between contention based MAC protocol and channelization based MAC protocol, for efficient use of network resources, adaptive MAC schemes which combines CDMA/CA with TDMA in hybrid frame pattern that switch between MAC frame structures periodically by adapting to varying network traffic load is used. To maximize network performance, the adaptive MAC solution determines the MAC switching point.

IV. ADAPTIVE MAC SOLUTION

MAC protocol adapts to changing traffic load conditions in MANET. At each network traffic load condition, MAC protocol should be selected to achieve the better performance based on throughput and delay. This is the key element to determine the MAC switching point.

By comparing the performance of MAC candidates with respect to small network, MAC switching point can be calculated. By comparing the average packet delay between MAC candidates, MAC switching point can also be determined. Since a higher throughput corresponds to lower packet delay, this is expected to generate the similar results. On when the packet arrival rate is less than service rate, average packet delay can be evaluated in theory. Thus, when the MAC switching point locates a value at a node where network traffic is high, MAC switching point could be calculated either by candidate MAC protocol or average packet loss delay.

As there is node mobility in MANET, the number of nodes may fluctuate around switching point. When the nodes move relatively fast MAC switching cost is undesired. Performance gain should be higher than the switching cost in order to benefit from MAC switching.

V. DRAWBACK IN ADAPTIVE MAC PROTOCOL

The disadvantage of Adaptive MAC protocol is as follows:

- Inefficiency under low contention level
- Inefficient collisions control, control overhead
- Performance degradation when the collision rate of packets is high
- Channel utilization is inferior when the network traffic is high
- Existing performance evaluations rely on numerical methods which are complex to conduct a performance comparison
The major disadvantage of contention protocol is collision and its inefficient usage of energy. When any two packets are transmitted at the same time, they might collide and become corrupted and must be discarded. This results in corruption of packets or packet loss. This does not solve all the problems of Medium access control in wireless network. IEEE 802.11 devices consume large amounts of energy due to the high amount of time spent listening without receiving messages. To handle the collision possibilities, collision avoidance or collision detection methods should be employed.

Analytical and the simulation results of MAC switching point demonstrates the accuracy of analytical model to determine the MAC switching point in both high and low traffic load conditions. This is best suited for homogeneous network. However, in heterogeneous network in a fully connected MANET where both real-time voice and non-real-time best-effort applications are used, adaptive MAC solution does not favor as expected in a fully connected MANET.

<table>
<thead>
<tr>
<th>Ref No</th>
<th>protocol</th>
<th>SPS</th>
<th>TCs</th>
<th>ETC</th>
<th>R/S</th>
<th>SO</th>
<th>QoSRT</th>
<th>OCRT</th>
<th>Comments</th>
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<tr>
<td>[1]</td>
<td>DPRMS</td>
<td>No</td>
<td>2</td>
<td>no</td>
<td>yes</td>
<td>medium</td>
<td>slow</td>
<td>slow</td>
<td>First mini-slot winner may use remaining mini-slots for data transmission</td>
</tr>
<tr>
<td>[10]</td>
<td>Multi-mac[10]</td>
<td>yes</td>
<td>2</td>
<td>yes</td>
<td>yes</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>Channel reservation phase composed of two parts: contention of real-time users and contention of data traffic users involves multiple channels</td>
</tr>
</tbody>
</table>
VI. CONCLUSION

The large number of mechanisms and protocols described in this survey reflect the importance of QoS-related research. This area of study is mostly challenging in the context of ad-hoc networks because of their frequently changing network topology, unstable channel conditions, station mobility, limited battery and computational power, etc. All these issues have been identified and commented in this survey. TSAMAC is improving the throughput of the communication channel for the unlicensed user. This method will facilitate to decide and allocate free channel to secondary user without interfering with primary user. The protocol ensures that there is no slot that is left vacant. This guarantees full use of the available spectrum. The protocol includes the provision for Quality of Service (Qos), where real-time and safety critical data is being transmitted with highest priority and delay is less.

References


