International Journal of the Physical Sciences Vol. 5(6), pp. 847-851, June 2010
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 ©2010 Academic Journals

Full Length Research Paper

QoS improvement for multimedia traffic in WLANs with TTN approach

Fatima Bilkis Seeme*, Abdullah Omar Arafat and K. Dimyati

Department of Electrical Engineering, University of Malaya, Kuala Lumpur, Malaysia.

Accepted 07 April, 2010

This study proposes a Time Division Multiple Access (TDMA) based token passing MAC (Media Access Control) protocol, TTN (TDMA based Token Network). In the proposed scheme, the Access Point (AP) assigns time slot to the stations and passes on a token. The stations are allowed to transmit only when they get hold of the token. Through simulation study, it is shown that TTN can perform better in case of throughput, delay performance compared to EDCA (Enhanced Distributed Channel Access) based 802.11e. So TTN can support more real-time traffic streams with satisfactory QoS level.

Key words: MAC, wireless, QoS, TDMA, token, TTN.

INTRODUCTION

The users in today's world demand multimedia traffic transmission with a satisfactory QoS (Quality of Service) level along with reliable data traffic transmission. The real-time applications are strictly time-constraint and require a good throughput level, while slightly unreliable connections are allowed. On the other hand data traffic does not require particularly low delay, but reliability is crucial. These criteria arises the need for a network where all types of traffics can be served with their specific QoS requirements.

Wireless LAN was first introduced with WiFi, then gradually arrived the WiMAX, 3G and even 4G networks like LTE, which are well known for high-speed and wide area coverage. But this paper proposes some enhancement of the earliest technology WiFi, because still today, WiFi is the unbeatable and only solution for low cost deployment over a smaller coverage area.

The first release of IEEE 802.11 WLAN standards arrived at 1997, which supported a low data rate of 1 and 2 Mbps and with no QoS provision for supporting multimedia traffic. The 802.11e (IEEE, 2005) workgroup has modified the Distributed Coordination Function (DCF) of 802.11 and proposed Enhanced Distributed Channel Access (EDCA) as the Medium Access Control (MAC) of 802.11e to provide QoS. However, it causes high overhead, which degrades network performance; thus efficiently serving multiple sources of different types of traffic is still a challenge (Lagkas et al., 2007).

Various MAC protocols proposed for different kinds of network conditions by (Wang et al., 2008; Lagkas et al., 2007; Zen et al., 2008; Xiao et al., 2008; Qing and Yoshigoe, 2008; Chen et al., 2006; Ni et al., 2004; Wang et al., 2008), propose a novel busy-tone based MAC is proposed, (Lagkas et al., 2007) proposes a polling based MAC, (Zen et al., 2008) suggests a token network,(Xiao et al., 2008) introduce a dynamic bandwidth partitioning scheme, (Qing and Yoshigoe, 2008) recommend an admission control scheme. Thus there are numerous propositions to improve the QoS, which cannot be mentioned in this short span and is also out of the scope of this paper. We propose a TDMA based token passing network, TTN (TDMA based Token Network). It assigns time slot to the stations according to their traffic condition and passes token to them. Each station sends data when it gets hold of the token during its allocated time slot, then it passes the token on to next station. It efficiently supports simultaneous real-time and background traffic by taking into account traffic priorities and the buffer load of the stations (Fatima et al., 2010). It should be mentioned that 802.11e has an optional polling protocol called Hybrid Controlled Channel Access (HCCA) (IEEE, 2005) which cannot operate independently and an optional scheme in 802.11e and serves only real-time applications. It cannot

---

*Corresponding author. E-mail: fatimaseeme@siswa.um.edu.my.

Abbreviations: **MAC,** Media Access Control**; AP**, access point; **TDMA**, Time division multiple access**; TTN,** TDMA based token network.

serve background data traffic. So TTN can only be compared to 802.11e EDCA scheme.

IEEE 802.11E MAC

The legacy 802.11 MAC is not capable of supporting real-time traffic with QoS. However, Ni et al. (2004) has proposed some enhancement in 802.11 for providing QoS to some extent. The need for QoS has led to the evolution of IEEE 802.11e. The enhanced MAC mechanism in 802.11e is called HCF (Hybrid Coordination Function) which consists of mandatory EDCA, a contention based scheme and an optional HCCA, which is centralized and based on resource reservation.

EDCA is essentially the same CSMA/CA (Carrier Sense Multiple Access/ Collision Avoidance) based access scheme as DCF. In EDCA, when a station needs to transmit, it tries to sense if the channel is busy by measuring some energy threshold. If the energy measured is above the threshold level, it decides the channel is busy, hence waits until the channel is idle.

If the channel is idle for AIFS (Arbitrary InterFrame Space) interval, the station starts backoff countdown by selecting a random number of slots from a contention window (CW). When it reaches zero, the packet is transmitted and the station waits for an acknowledgement (ACK). If the ACK is not received within a specific period, the station will again start a random backoff countdown and retransmission procedure using a larger window. To resolve the hidden node issue, an additional RTS/CTS (Request To Send/ Clear To Send) handshaking is introduced.

For QoS support, the service differentiation is achieved by categorizing the traffic according to the priority scheme. So in each station there are four packet buffers corresponding to four Access Categories (ACs). Each AC within the stations contends independently for channel access and starts backoff counter after sensing the channel idle for AIFS. Higher ACs are assigned lower value of AIFS and CW. So a high priority packet will probably choose a smaller backoff, increasing its chance to win the channel access.

However, this scheme provides only minimal QoS. The backoff procedure causes huge waste of bandwidth (Lagkas et al., 2007) hidden nodes cause collision despite the backoff mechanism. Even the exposed nodes also can collide, as the backoff is a random number and it can match for any number of stations.

Again, each queue essentially works like its own DCF; hence the collision rate is rapidly increased with growing user number (Zen et al., 2008). RTS/CTS handshake can decrease collision rate while increasing overhead. The performance limitation caused by EDCA overhead is presented in (Wang and Helmy, 2006). Some enhancement of EDCA has been proposed in (Shankar and van der Schaar, 2007; Ge et al., 2007; Hamidian and Korner, 2006; Wang et al., 2006).

TOKEN RING NETWORK

Token ring uses a ring topology where any node can use the network only if it gets hold of the token. So there is no possibility of any two nodes entering the network at the same time. This token serves as a ticket (Mueller and Ogletree, 2004). Figure 1 is an example of a token ring network consisting of 6 nodes. At the starting, a free token is circulating around the network. We assume, node 1 wants to send some data to node 5. So it has to grab the free token at first. Then it embeds its data into the token and then release it. Node 2, 3 and 4 will release the token when they receive it, because the recipient address in the token is not theirs. Node 5 will grab the token and receive the data and embeds acknowledging bits into the token and then release it again. Whenever the token reaches node 1, the node will recognize the ACK bits and takes it as a receipt of data from node 5. However, node 5 is allowed to embed its own data, if it has any, addressing any of the receiver inside the ring network before releasing the token. Thus the token circulates around the network and the nodes utilize it for data transmission purpose.

But our proposed token network is very different from the above topology. We use TDMA with token topology. We also use the token as a ticket. But the token does not include the data here. The token acts as only a ticket to the node, which contains the time slot allocation information. The stations can communicate independently, so they need not embed data into the token. However, they embed their updated buffer status into the token before sending it to the next station.

PROPOSED PROTOCOL : TTN

In our proposed scheme, the stations can transmit only during their allocated time slots. The information of time slot allocation is passed on by the token. AP (Access Point) decides the overall channel sharing. AP keeps track of the buffer status of each station and assigns time slot accordingly to each station.

The AP passes the token to a station and the token is passed on from one station to another. The cycle ends with the token finally going back to the AP. If any station runs out of traffic before completing its time slots, it sends the token back to AP and the rest of the slot is utilized by the AP.

For deciding the cycle time, we take into account the time constraint for conventional multimedia traffic. The delay bound for conversational voice traffic is 150 - 200 ms. So the time cycle is decided to be 110 ms, the rest is kept as a safety margin for additional unwanted codec delays and jitter. The steps are as follows:

(a) Initially the AP is not aware of the buffer status of the stations, so it assigns equal time slots for all stations including itself. Then it passes the token to the first station.
(b) Upon receiving the token, the station checks if it has any buffered packets- if not, it sends the token back to AP. Otherwise it will check its buffer status and send the highest priority traffic first.
(c) After the allocated time slot is finished, it embeds its updated buffer status into the token and passes it on.
(d) The AP is monitoring the token; so it gets the updated

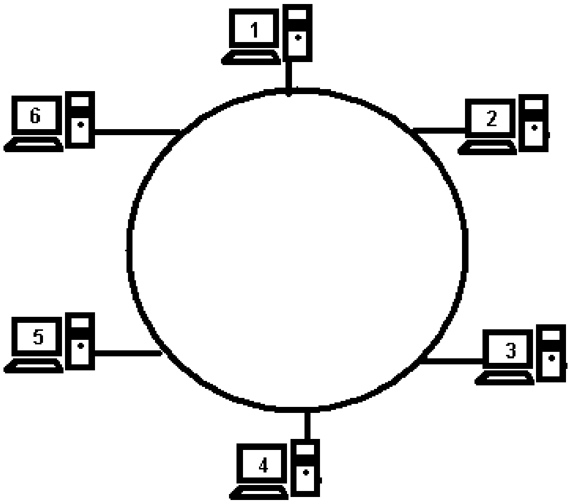

Figure 1. Token ring topology with 6 stations.

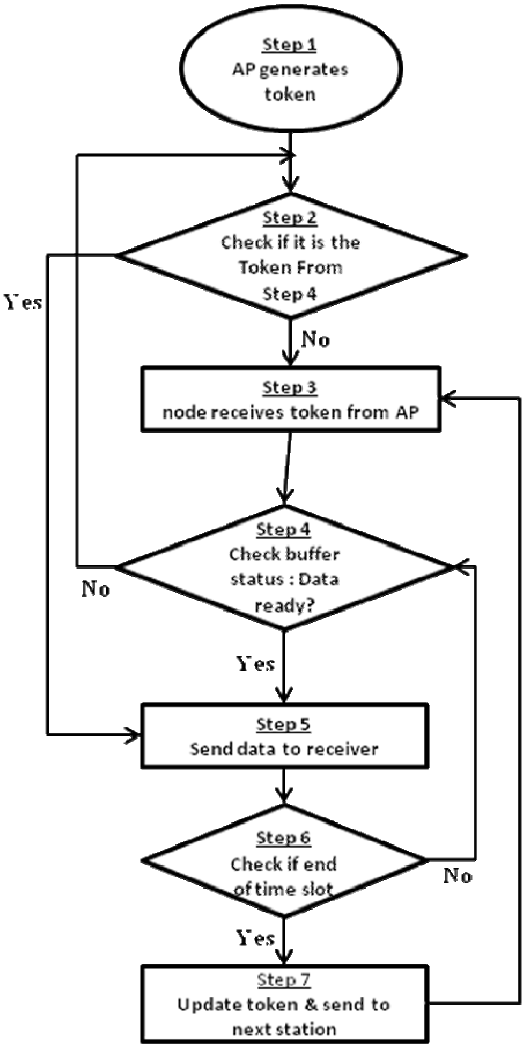

Figure 2. Flowchart for TTN protocol.

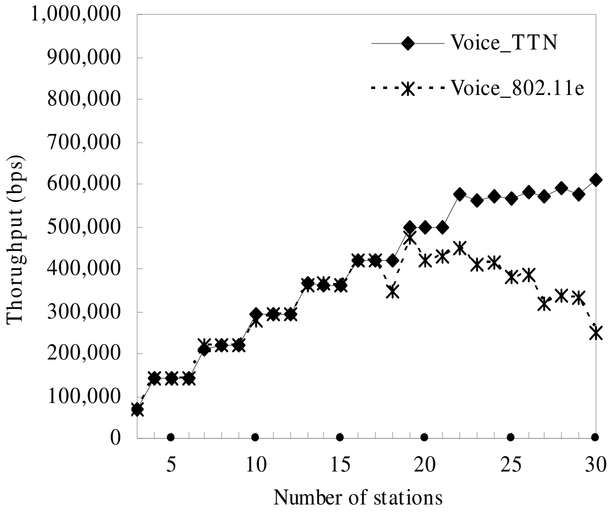

Figure 3. Average throughput of voice traffic.

information of each node's buffer status.

(e) When the AP gets the token, it starts transmitting its own data, except only when it gets the token after cycle completion. After cycle completion, it usually passes the token again to the first station.

(f) If any station runs out of traffic, which happens usually if the data is not ready yet, it will send the token back to AP instead of the next station in cycle. So the remaining time slots are utilized by AP. After that, AP sends the token to the next station as previously scheduled.

(g) When the very initial cycle is completed, then AP is aware of the overall network condition; hence AP allocates time slots according to the requirements and passes the token according to that. The above algorithm can be clarified more with the help of the flowchart presented in Figure 2:

SIMULATION SCENARIO

In our simulation, we have a wireless network with a single AP, where each node is transmitting CBR (Constant Bit Rate) traffic: either voice, video or data. We start with three nodes sending all different types of traffic and then number of transmitting node is increased for each type of traffic until it reaches 30. User Datagram Protocol (UDP) is used for voice and video traffic, while Transport Control Protocol (TCP) is used for data traffic. We use NS2 as our simulation tool.

All types of traffic are modeled based on realistic traffic characteristics. Voice communication is based on G.711 coding standard with packet size of 160 bytes and the inter-arrival time is 20 ms. The packet size and inter-arrival time for video and data are 1280 bytes each 10 ms and 500 bytes each 1.5 ms respectively (Zen et al., 2008). Transmission rate of 11 Mbps is used in our simulation. The results obtained from simulation are compared with that of EDCA based 802.11e (Zen et al., 2008).

SIMULATION RESULTS

Our simulation results show that TTN is significantly better than the legacy 802.11e when all types of real-time and data traffic are transmitted simultaneously. Figure 3 shows

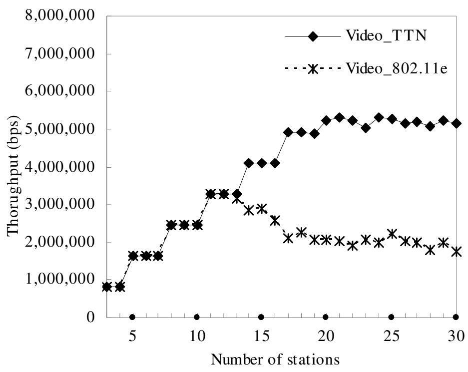

Figure 4. Average throughput of video traffic.

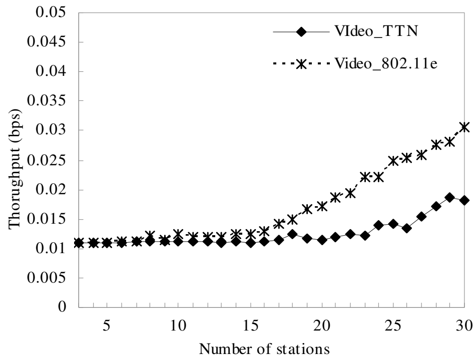

Figure 7. Average access delay for video traffic

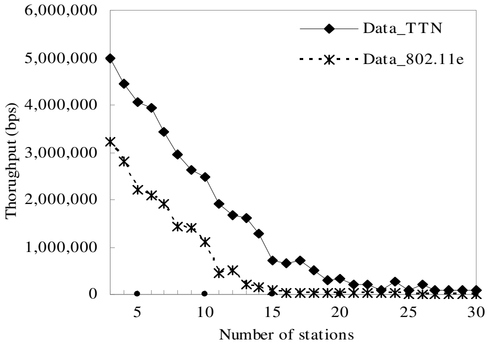

Figure 5. Average throughput of data traffic.

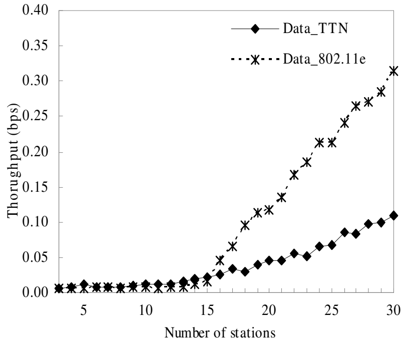

Figure 8. Average access delay for data traffic.

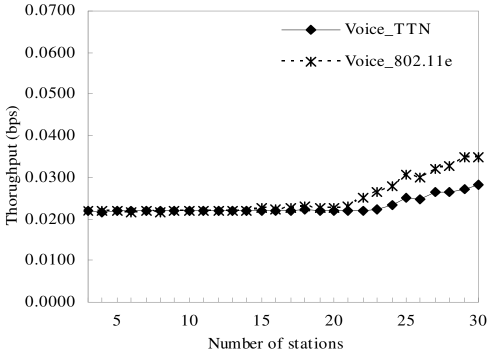

Figure 6. Average access delay for voice traffic.

the average throughput comparison for voice traffic. 802.11e shows a very good throughput until the node number reaches 19. The reason for 802.11e performing so well in case of voice traffic lies in the fact that it facilitates voice traffic to such extent that it deprives the rest.

However, TTN gives good throughput up to 22 nodes. After that no more additional flows can be sup-ported as the throughput level becomes unsatisfactory. For video traffic, as shown in Figure 4, 802.11e tends to drop after 12 nodes. TTN performs better up to 19 nodes where the throughput is around 5 Mbps. Figure 5 shows the comparison of data traffic. In case of 802.11e, data throughput decreases rapidly as the number of real-time flows increases. TTN performs better than 802.11e.

Figures 6, 7 and 8 shows the delay performance comparison of both schemes. Average access delay for voice traffic is increased after 21 nodes in 802.11e and 23 nodes in TTN. For video traffic, the access delay is maintained around 10 - 12 ms for 11 nodes in 802.11e and 17 nodes for TTN.

In case of data traffic, 802.11e shows very high access delay, as it is the lowest priority traffic having the highest backoff and AIFS and prone to collision, which further increases the delay. At 30 nodes, our proposed scheme gives delay around 110 ms.

DISCUSSION

We focused mainly on reducing overhead as much as possible. The reason for the improved performance lies mainly in the access scheme which reduces the collision probability greatly by allowing stations to transmit only when they have the token. As any two stations cannot have the token at the same time, so they cannot transmit at the same time. This way collision probability is essentially zero.

The AP need not contend for channel access as in 802.11e. However, it has to get hold of the token. But as it divides the time slot according to the priority and traffic load of each station, including its own data load, so there is fair sharing of the available resource. Again, any remaining time slot is used by the AP, thus more efficient utilization of bandwidth is achieved. No extra frame is used for stations' status updates; they embed this information into the token one by one. Thus the AP is aware of the network condition without any additional overhead caused by introducing any new control frame for status update.

Conclusion and future work

The proposed TTN scheme can be used as a standalone protocol, or can also be used inside 802.11e in place of EDCA. If TTN is used inside 802.11e along with HCCA, it will show even better performance for real-time traffic. This is essentially a zero-collision-probability scheme. As future work, the network parameters, cycle time can be further tuned and additional call admission control scheme can be introduced for even better performance.

REFERENCES

Chen X, Zhai H, Tian X, Fang Y (2006). "Supporting QoS in IEEE 802.11e wireless LANs," IEEE Trans. Wireless Communications, 5(8): 2217-2227, doi: 10.1109/TWC.2006.1687738

Fatima BS, Arafat AO, Dimyati K (2010). "Providing QoS for joint isochronous and non-isochronous applications over WLANs," ICWN'10 proceedings, in press.

Ge Y, Hou JC, Choi S (2007). "An analytic study of tuning systems parameters in IEEE 802.11e enhanced distributed channel access," Comput. Networks, 51(8): 1955-1980.

Hamidian A, Korner U (2006). "An enhancement to the IEEE 802.11e EDCA providing QoS guarantees," Telecommunication Systems, 31 (2/3): 195–212, doi: 10.1007/s11235-006-6520

IEEE Standard for Information Technology—LAN/MAN (2005). Specific Requirements—Part 11 Wireless Medium Access Control and Physical Layer Specifications, Amendment 8: Medium Access Control Quality of Service Enhancements, IEEE Std. 802.11e WG, Nov. 2005.

Lagkas TD, Papadimitriou GI, Nicopolitidis PAS (2007). Pomportsis, " A novel method of serving multimedia and background traffic in wireless LANs," IEEE Transactions on Vehicular Technology, 57(5): 3263-3267. doi: 10.1109/TVT.912341

Mueller S, Ogletree TW (2004) "Upgrading and Repairing Networks," 4th ed, Que Books, pp. 190-195.

Ni Q, Romdhani L, Turletti T (2004). "A survey of QoS enhancements for IEEE 802.11 wireless LAN," J. Wireless Commun. Mobile Comput., 4(5): 547-566.

Qing H, Yoshigoe K (2008). "Adaptive QoS admission control for IEEE 802.11e network," 5th IEEE CCNC,Jan. pp. 591-595, doi: 10.1109/ccnc08. 137.

Shankar NS, van der Schaar M (2007). "Performance analysis of video transmission over IEEE 802.11a/e WLANs," IEEE Trans. Vehicular Technol., 56 (4): 2346-2362, doi:10.1109/TVT.2007.897646

Wang P, Jiang H, Zhuang W (2006). " IEEE 802.11e enhancement for voice service," IEEE Wireless Commun., 13(1): 30-35, doi: 10.1109/MWC.2006.1593522

Wang P, Jiang H, Zhuang W (2008). "A new MAC shceme supproting voice/data traffic in wireless ad hoc networks," IEEE Trans. Mobile Comput., 7(12): 1491-1503, doi: 10.1109/TMC.2008.73

Wang SC, Helmy A (2006). "Performance limits and analysis of contention-based IEEE 802.11 MAC," in Proc. 31st Annu. IEEE Conf. LCN, pp. 412-425, doi: 10.1109/LCN.2006.322129

Xiao Y, Li FH, Li M, Zhang J, li B, Hu F (2008). "Dynamic bandwidth partition with finer-tune (DP-FT) scheme for multimedia IEEE 802.11e WLANs," IEEE WCNC pp. 3202-3207, doi: 10.1109/WCNC. 559

Zen H, Habibi D, Wyatt J, Ahmad I (2008). "Converging voice,video and data in WLAN with QoS support,"5th IFIP Int. Conf. WOCN'08, pp. 1-5, doi: 10.1109/WOCN 4542485.