Transport Layer Evaluation over 802.11b Wireless Network

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***Abstract*—Nowadays the using limit of wireless network is growing quickly. The reason of not using of data rate at Physical layer completely is dependent only on throughput and size of packets is at Transport layer level. This dependency will be proved and investigated with mathematical analysis. In our experimental work all client computers' (connected to AP) data rates are decreased, when errors are occurred and retransmission is done in one computer. Additionally it is signified that throughput is increased when transmitting packet size is increased while we are analyzing and mathematical modeling on our experiment.**

***Keywords*—DCF, transmission mode, packet, timeslot, frame**

I. INTRODUCTION

In last decade using wireless network has grown exponentially. By installing 802.11 wireless networks in universities, hotels, airports and so on, people can be connected with smart phones, laptops from anywhere in anytime. 802.11 [1] technology has been adding new services and has provided multimedia, security requirements in high level. The wireless networks transmit in two different modes such as PCF (Point Coordination Function) and DCF (Distributed Coordination Function). PCF mode is connected with certain client computer in certain time interval and provides services like multimedia, IPTV that are dependent on delay time and loss of packets. DFC mode shares its environment by CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) protocol and this mode is used in Wireless LAN. Before information transmission CSMA/CA checks the medium. If the medium is busy, it will wait a definitive number of timeslot which one timeslot is equal to 20 µSec. The definitive number is chosen randomly in uniform mode. Those client computers in wireless network will use medium simultaneously so collision will be detected when same time slot is chosen. Therefore the capacity if wireless network will be decreased.

In our work the size of bandwidth is measured by PCATTCP tool and passive traffic measurer in TCP protocol layer, then it is compared with mathematical. The paper organized as follows: In Section II DCF transmission method, in Section III Measurement of Wireless network traffic and its analyze, in IV Mathematical modeling in packet transmitting throughput, finally in Section V Conclusion is described.

II. DCF TRANSMISSION MODE

Data is transmitted in complicated medium using special algorithm with respect to wired network. The 802.11 standard is consisted of two layers: MAC and Physical layer. Types of Wireless network are [1, 2]:

- 802.11b – DSSS band 2.4GHz, data rates 1, 2, 5.5, 11 Mbps
- 802.11g—OFDM band 2.4GHz, data rates 1, 2, 5.5, 11, 22 Mbps
- 802.11a—OFDM band 5GHz, data rates 6, 12, 18, 24, 36, 48, 54Mbps

TABLE I.
802.11 MAC-PHY LAYER PARAMETERS

Type	Data rate (Mbps)	DIFS (µSec)	SIFS (µSec)	SLOT (µSec)	PHY (µSec)
802.11b	1, 2, 5.5, 11	50	10	20	192, 96
802.11g	6, 9, 18, 24, 36, 48, 54	28	10	9	22

Parameters shown in Table I are different according to 802.11 types. Computer will listen to medium for DIFS period of time before its transmission. If the medium is available, packet will be transmitted. If the medium is busy, it will wait for time slot chosen from number generator uniformly. The timeslot called contention window size (CW) increase probability of signal collision. The frame transmission schema in DCF mode is shown in Fig 1.

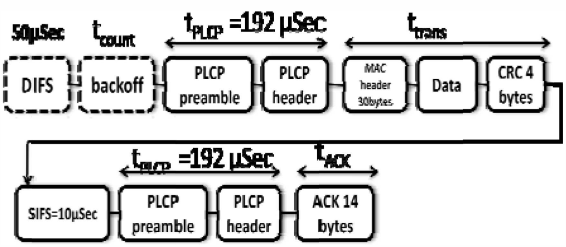

Fig. 1.The frame transmission schema in DCF mode

If signal collision is detected at this moment, the size of CW will be doubled. Then its value will be decreased by one and one and will wait until medium become available. Finally, packet transmission will be started. [0,CW]*Slot is time to implement back off and let the minimum value of CW is equal to 31 ($CW_{min} = 31$) and maximum value of CW is equal to $1023(CW_{max} = 1023)$ [3].

Now if we suppose that the probability of signal collision is equal to **p,** therefore the probability of signal collision would not occur is equal to (**1-p**) [4, 5].

$$W_{avg} = \sum p_i * \frac{(2CW_i - 1)}{2}$$
$$= (1-p) * \left(\frac{2CW_i - 1}{2}\right) +$$
$$+(1-p) * p * \left(\frac{2 * (2CWi - 1)}{2}\right) + \cdots \ldots \ldots$$

We will obtain (1) after some mathematical transformation.

$$p_c = 1 - \left(1 - \frac{1}{CW_{min}}\right)^{N-1} \quad (1)$$

The probability of signal collision is equal to (1).

III. MEASUREMENT OF WIRELESS NETWORK TRAFFIC AND ITS ANALYSE

PCATTCP tool, Wireshark and passive traffic measurer is installed into two notebook those are used to connect 802.11b AP to internet. The connection is shown in Figure 2.

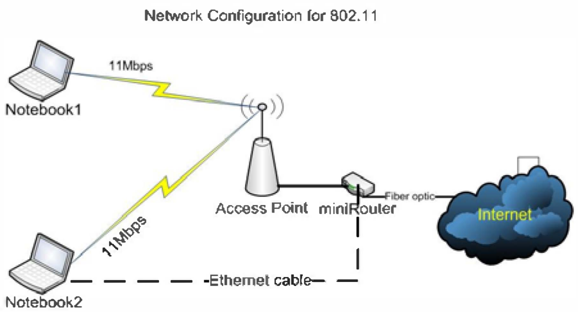

Fig. 2.General schema of wireless network

We installed PCATTCP tool, Wireshark and TTCP passive traffic measurer to two notebook having Windows 7 and UBUNTU 12.04 operating system as shown in Fig. 2.

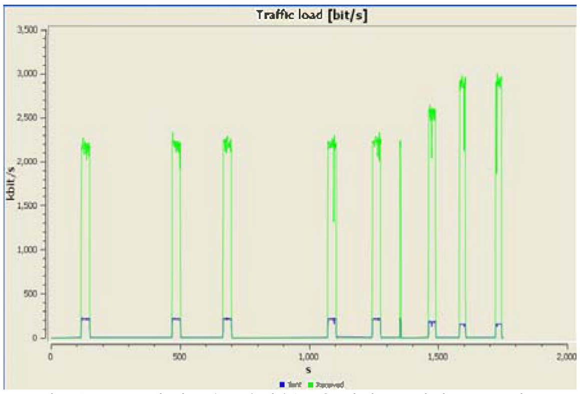

Fig. 3.Transmission bandwidth of WiFi to WiFi connection (250KB)

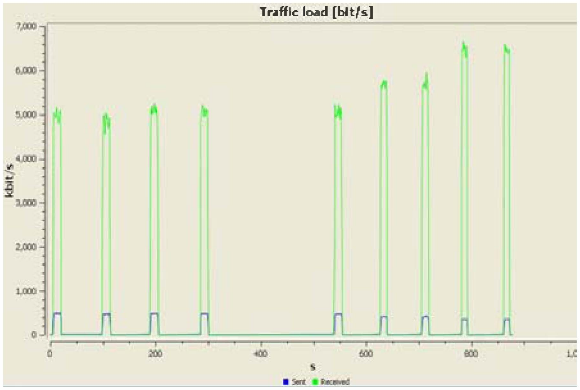

Fig. 4.Transmission bandwidth of WiFi to Ethernet connection (660KB)

We can see from Fig. 3, 4 that the throughput was obtained when data with size shown in Table II is transmitted over two notebooks connected with WiFi 11Mbps data rates. The passive traffic measurer was used for this throughput.

TABLE II.
WIFI TO WIFI AND WIFI TO ETHERNET

№	Byte size	Number of packet	Throughput (KB) WiFi-WiFi	Throughput (KB) WiFi-Ethernet
1	32	262144	244	567
2	64	131072	248	553
3	128	65536	249	580
4	256	32768	247	577
5	512	16384	252	551
6	1024	8192	254	660
7	2048	4096	292	661
8	4096	2048	334	759
9	8192	1024	336	761

We transmitted different number of packets with different size in certain time interval from wireless network to wireless network and from wireless network to wired network with the aid of PCATTCP and passive traffic measurer. As shown in Table II we can see that transmission capacities of WiFi to WiFi and WiFi to Ethernet are different.

IV. MATHEMATICAL MODELING OF FRAME TRANSMISSION CAPACITY

Frames are transmitted in transport layer by schema shown in fig. 5.

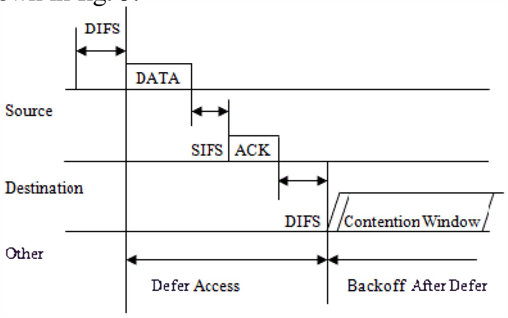

Fig. 5.The structure of the frame transmitting data

A transmitter computer listens to medium when transmits data, if this band if available, it waits for DIFS time, then begins transmitting. Finally the transmitter waits for SIFS time to get guaranteeing ACK packet that is transmitted by the receiver. That is a period of one packet transmitting [6].

We can see the time allocated for transmitting one packet from Fig. 5. [2, 7]:

$$t_{frame} = t_{headers} + t_{trans} \quad (2)$$

$$t_{header} = DISF + t_{PLCP} + SIFS + t_{PLCP} + t_{ACK}$$

As shown in Equation (1), the probability of signal collision is dependent on number of users. So t_{count} will be added to equation (2) and the time allocated for transmitting packet is calculated as follows:

$$t_{frame}(N) = t_{headers} + t_{trans} + t_{count}(N) \quad (3)$$

Here is: $t_{count}(N) = SLOT_T * \frac{1+P_c(N)}{2N} * \frac{CW_{min}}{2}$

$$SLOT_T = 20\mu Sec$$

So throughput is expressed as follows:

$$through\_p = \frac{t_{trans}}{T(N)} \quad (4)$$

TABLE III.
IEEE802.11B OVERHEAD

№	items	Rate and Bits
1	Idle rate	1Mbps
2	Full rate	11Mbps
	PLCP Header	
1	Preamble	128bits
2	SOF	16 bits
3	Speed	8 bits
4	Service	8 bits
5	Length	16 bits
6	CRC	16bits
	Total length=192bits	
	MAC header	
1	FC	16bits
2	ID	16bits
3	Address1	48bits
4	Address2	48bits
5	Address3	48bits
6	SC	16bits
7	Address4	48bits
8	CRC	32bits
	Total length=272bits	

Our aim is to deal with length of IEEE802.11b overhead information as shown in Table III. Now let define utilization ρ of IEEE802.11b technology band.

$$t_{trans} = \frac{l_{frame}}{R}$$

Here l_{frame} is the length of transmitted frame. So the time of signal collision between N couple users:

$$t_{coll_{dev}} = \frac{2}{N} * t_{frame}$$

$$\rho_{frame} = \frac{t_{frame}}{(N-1) * t_{frame} + P_c(N) * t_{coll_{dev}} * N} \quad (5)$$

Let consider that, the time of transmitting one packet is divided by sum of other packets times the time of transmitting one packet and the time of signal collision of N users times the probability of signal collision is equal to utilization. So we can evaluate the throughput using (5):

$$throughput = \rho_{frame} * \frac{l_{frame}}{t_{frame}} \quad (6)$$

Equation (5) is used in (6) and some mathematical transforms is applied, then the throughput becomes as follows:

$$throughput = \frac{l_{frame}}{(N-1)*t_{frame}+P_c(N)*t_{coll_{dev}}*N} \quad (7)$$

Equation (7) evaluates the throughput only in MAC layer. Now let handle the throughput model in TCP layer as follows.Fourth layer-Transport layer (TCP, UDP) has some functions that connecting two final stations, transmitting data without error, controlling network bands, retransmitting packet when error is detected and so on. The transmission is started after the connection is set by 3 way handshaking in TCP layer. But packets are sent first then guaranteed by ACK message in our experiment. Our aim is to obtain a model and to evaluate the throughput in this case. Finally evaluated value will compared with the experimental value [6].

The data segment of TCP:

- DIFS
- The data segment of TCP
- SIFS
- 802.11b ACK frame

ACK packet of TCP:

- DIFS
- ACK packet of TCP

- SIFS
- 802.11b ACK frame

Equation (7) becomes as follows:

$$t_{header} = 2 * (t_{DIFS} + t_{PLCP} + t_{MAC} + t_{IP} + .. + t_{TCP} + t_{SIFS} + t_{MAC\_ACK}) \quad (8)$$

$$t_{trans} = t_{TCP\_DATA} + t_{TCP\_ACK} \quad (9)$$

$$t_{frame} = t_{header} + t_{trans} + t_{count}(N) \quad (10)$$

$$throughput = \frac{l_{frame}}{(N-1) * t_{frame} + P_c(N) * t_{coll\_dev} * N} \quad (11)$$

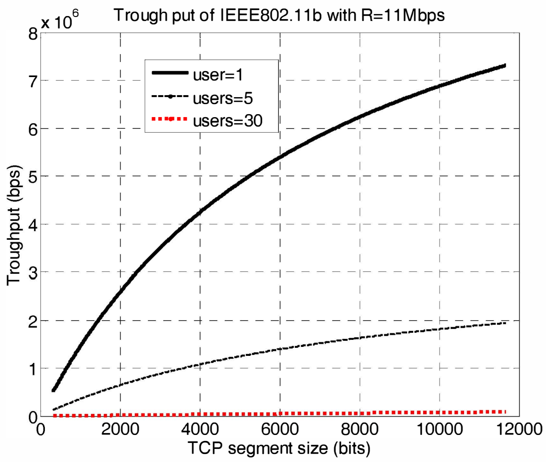

Fig. 6: Throughput (bps)

The throughput related with TCP layer's data packet is shown in Fig. 6. The dependency of throughput on users' number and on TCP data packet is observed in this figure. Throughput is decreased when user's number is increased and the throughput is increased when size of TCP data packet.

V. Conclusion

In this paper, we show that in the wireless network transmission data rate at Physical layer cannot be used completely. Only 50% percent of this data rate is used. The throughput is decreased and the probability of signal collision is increased when users' number is increased. An advantage is obtained that throughput is increased when size of transmitted packet. It is shown in Fig. 6. In future our work can be extended in UDP protocol.

VI. References

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