Performance of Internet Transport Protocols in 802.11g Wireless Environment

Toni Janevski[1] and Ivan Petrov[2]

Abstract – **Rapid development of wireless communications systems fulfils one of the major challenges in the modern communication era and provides wireless access to Internet. Enabling mobile users to access the vast range of Internet based applications is the next step in wireless communication. Internet connectivity is represented by TCP/IP protocol suite. Performance of the Internet transport protocols may significantly degrade when end to end connection includes wireless links where packets delays and losses are caused by mobility handoffs and transmission errors. In this paper we study the impact of wireless MAC layer design of the native Internet transport protocols during the distribution of multimedia services in realistic outdoor scenario.**

Keywords – **Mobility, Transmission Protocols, Wireless Network.**

I. INTRODUCTION

The need for continuous communication combined with the digital entertainment and the existence of variety multimedia services provided by wireless access communication networks is opening new chapter at the telecommunication market. It is easy to forecast the synergy between wireless access technology and the Internet. This means that remote working, online games, video/music on demand and navigation support are only small part of applications that will be accessible from any palace in any time. Rapid increasing number of active wireless hot spots is providing people to be wireless connected in almost every building and every street they walk and drive in. A large amount of static users are using the IEEE 802.11 g wireless access technology for checking emails, web surfing, video/audio streaming and P2P file shearing.In near future cars will become communication centers enabling us wireless access to Internet. The same scenario will be applicable in the home environment. We know that TCP/IP protocol stack is the most widely used within many applications in the today's computing world. Its parameters were carefully tuned in order to maximize its performance on wired networks where packet delays and losses are caused by congestion [1-6]. In the wireless networks delays and losses are mainly caused by mobility handoffs and transmission errors due to bad wireless channel condition. With the recent developments in mobile wireless networking, the performance of the Internet transport protocols in mobile wireless environment is becoming a topic of interest.

[1]Dr. Toni Janevski is an Associate Professor at the Faculty of Electrical Engineering, Karpos 2 bb, 1000 Skopje, Macedonia, E-mail: tonij@feit.ukim.edu.mk.

[2]Ivan Petrov is with Macedonian Telecom, Key Customers Business Centre, Orce Nikolov bb, 1000 Skopje, Macedonia, E-mail: ivan.petrov@telekom.mk.

We should mention that the protocols for wireless AP's have been designed in order to maximize the utilization of the wireless channel for web browsing and file downloading applications in environment with restricted mobility, which is the main reason why the buffers and the local MAC retransmissions are tuned in a way to maximize the throughput and the reliability for this kind of applications. In this context it is necessary to define and fine tune the technical standards in order to guarantee full interoperability between different digital applications in wireless environment and providing proper wireless/wired interconnection. We focus our attention of the impact of diverse MAC layer and buffer settings of IEEE 802.11g access technology over the Internet native transport protocol during the distribution of multimedia applications in realistic outdoor static and mobile multimedia scenario.

The paper is organized as follows: Section II gives brief overview of the transport protocols, discusses some related work and motivates the need for our approach. It briefly describes the 802.11 MAC protocol. Section III describes our simulation scenario and section IV presents the simulation results. Section V concludes the paper.

II. TRANSPORT PROTOCOLS

Applications can be grouped in two major classes: downloading (TCP) and real-time (UDP). The first class is using reliable data transfer while the second class is based on quick delivery of packets. The performances that are measured by the booth classes of applications are completely different. The first class is measuring the performance in terms of how much time is required to have the whole file transferred that is different from the second one where the performances are measured in terms of percentage of packets that reach the destination within a certain time threshold. We can say that FTP, HTTP, SMTP are applications that for sure are part of the first class and that the interactive on-line games, real-time IP-TV, video/audio chatting, represent examples of applications that are part of the second class. From the statements above we can distinguish the downloading and real-time applications by the employed real time protocol: TCP or UDP. The TCP protocol guarantees the reliable and ordered delivery of every packet sent, to aim this it establishes a session and performs retransmissions of lost packets. We should mention that it employs congestion control functionality. Every TCP flow probes the link with higher and higher data rates eventually filling up the channel. We can be sure that the packets will be queued at the buffer associated with the bottleneck of the link until it overflows causing packet losses. In this situation TCP retransmits the lost packets, and halves its sending rate to diminish the congestion level. Finally, the regular increase of the sending rate is reestablished and so forth. This is not the case with the UDP transport protocol which is much simpler then TCP because packets are immediately sent toward the receiver with a data rate decided by the sender. UDP does not guarantee reliable and ordered delivery of packets but, its small overhead and lack of retransmissions make it less prone to generate delays in the packets delivery. This is the main reason why the UDP transport protocol is mainly used by real-time applications. The first TCP implementations were using cumulative positive acknowledgements and required a retransmission timer expiration to re send a lost data during the transport. They were following the go-back-n model. Without hesitating we can say that the early TCP implementations did little to maintain network congestion. In order to enable good user throughput and to control network congestion a lot of work has been done in order to improve its characteristics and with time TCP has evolved. Today's TCP implementations contain variety of algorithms that enables to control the network congestion and to maintain good user throughput in the wired network. Several variants of TCP can be found in the today's wired networks. TCP Tahoe, TCP Reno, TCP New Reno, TCP Vegas and TCP Sack are few of them that are going to be used in our simulation scenario. We should mention that most used variant of TCP in the real world is TCP NewReno. Every of these TCP variants have unique congestion and flow control mechanisms that differs them. A problem is defined in coexisting of TCP and UDP traffic in a wireless channel, caused by the TCP congestion control functionality. TCP continuously probes for higher transfer rates, eventually queuing packets on the buffer associated with the bottleneck of the connection. The wireless connection can be shared by several devices and applications; it is evident that the connection level and the queue lengths can increase, thus delaying the delivery of packets stuck in queue and jeopardizing requirements of real-time applications. The situation is more worsened by the wireless nature of the link because the wireless medium allows the transmission of only one packet at a time and is not full-duplex as wired links. This means that packets should wait their turns to be transmitted. Interference, errors, fading, and mobility are causing additional packet losses, the IEEE802.11 MAC layer reacts through local retransmissions which in turn cause subsequent packets to wait in queue until the proceeding ones or their retransmissions eventually reach the receiver. The back off mechanism of the IEEE 802.11 introduces an increasing amount of time before attempting again a retransmission. In the recent years, many researchers have studded the problems that TCP and UDP encounters in a wireless environment and have presented their solutions with aim to overcome them [7-15].

III. Simulation Scenario

The network layout of the simulation scenario that is subject of the conducted analyze is presented at Fig. 1.

We can notice that the network topology is consisting of four wired nodes (A0-A3), two wireless base stations (BS0-BS1) and four wireless nodes (n0-n3).

The wireless stations are configured to work according the IEEE 802.11g Standard. Wired connections are configured as stated in Table I.

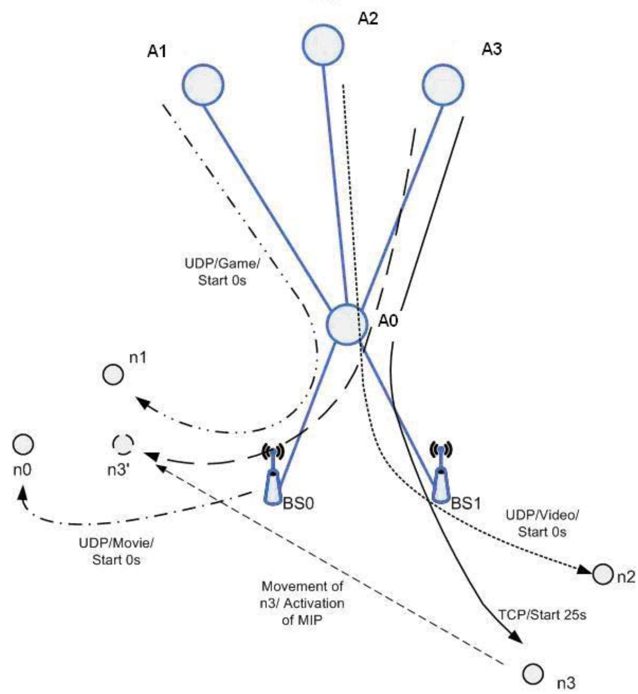

Fig. 1. Simulation Scenario.

TABLE I
Configuration of wired links simulated at scenario.

Node 1	Node 2	Delay	Capacity
A1	A0	10ms	100Mbps
A2	A0	20ms	100Mbps
A3	A0	30ms	100Mbps
A0	BS0	10ms	100Mbps
A0	BS1	10ms	100Mbps

TABLE II
Types of applications and traffic simulated in the presented scenario.

From	To	Type	Transport Protocol	Start	End
BS0	n0	Movie Stream	UDP	0s	110s
A1	n1	Game Traffic	UDP	10s	110s
n1	A1	Game Traffic	UDP	10.1s	110s
A2	N2	Video Chat	UDP	15s	110s
N2	A2	Video Chat	UDP	15.1s	110s
A3	N3	FTP	TCP	35s	110s

Maximum achievable bandwidth rate is 20Mbps instead of 54Mbps as it is declared for IEEE 802.11g standard. The queue size value used in the simulation comes out by multiplying the longest RTT with the smallest link capacity on the path which is represented by the 20Mbps effectively available over the wireless link. In Table II are presented several applications that are used during the simulation. In the simulation are exploited real trace files for video chat and movie traffic. Two VBR H.263 Lecture Room-Cam are used for the Video chat and high quality MPEG4 Star Wars IV trace file is used for the movie. These files can be found in [16]. In this simulation the game events have been generated at the client side every 60ms. At the server side updates were transmitted every 50ms toward the client. The payload generated by the client has been set to 42Bytes and the payload generated by the server has been set to 200Bytes. The rest of the packets were set at 512Bytes.

TABLE III
SIMULATION PARAMETERS.

Parameter	Values	Comments
MAC data retransmissions	1,2,3,4	Default value is set at 4
User-BS distance (m)	50,100	Common outdoor environment
MAC queue size (pkts)	25,50,100	Common values
Velocity (m/s)	4.16,7,14	Random choice
TCP Transport protocol	TCP Tahoe, TCP Reno, TCP Newreno, TCP Vegas, TCP Sack	Commonly used types of TCP protocols in wired networks.

The variable parameters used in this scenario are listed in Table III. A number of simulations have been conducted in order to examine the effects generated by different set of parameters defined in the simulation environment. During the simulation the shadowing model is used with one set of parameters. The shadowing deviation (σ_{dB}) was set to 4 while the path loss exponent (β) was set to 2.7. These parameters are common for outdoor soft partition in urban environment. It is known that the signal attenuation grows with the increase of these parameters so it is expected that the packet losses percentage will be higher over the wireless media. MIPv4 is used as a protocol that handles mobility in the defined scenario.

IV. Result Analysis

We will observe the simulation scenario presented at Fig.1 with configuration of the links defined as in Table I and applications defined as in Table II. We will study the behavior of the TCP applications and the TCP impact of the real time applications in the defined network when node n3 is mobile. The coordinates of the nodes are given in Table IV. During this analysis we should notice that n3 begins to move 55s after simulation starts.

Like we have stated in Table III the mobile node n3 is moving with three different velocities. We will observe scenarios when n3 is moving with speed of 4.16m/s, 7m/s and 14m/s. At Figs. 2, 3 and 4 is presented the change of the average throughput of the TCP traffic achieved in the simulation environment accordantly. From these figures we can evident that if we increase the number of MAC retransmissions the average throughput will increase too. Best throughput values are achieved when the number of MAC retransmissions in set at value of three. From Figs. 2, 3 and 4 we can notice that best performance has been achieved when IFQ is set at value of 50 pkts and TCP SACK is used as a transport protocol.

TABLE IV
COORDINATES OF WIRELESS NODES IN SIMULATION ENVIRONMENT

Wireless node	X	Y
BS(0)	230	230
BS(1)	330	230
n0	171,41	225,85
n1	172,81	230,97
n2	389,2	227,39
n3	338,13	231
n3'	170,01	230,1

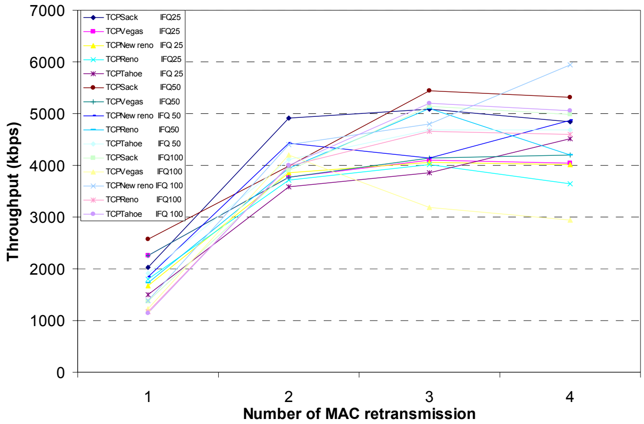

Fig. 2. Average Throughput of the FTP traffic when the node n3 is moving toward BS0 with speed V=4m/s

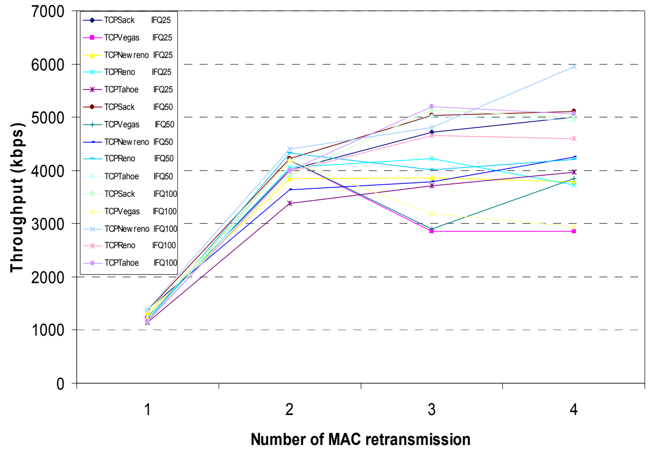

Fig. 3. Average Throughput of the FTP traffic when the node n3 is moving toward BS0 with speed V=7m/s

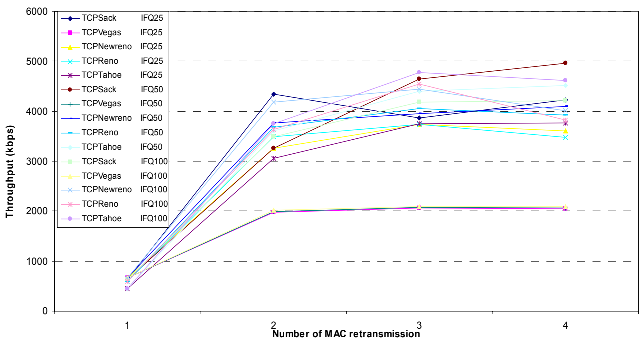

Fig. 4. Average Throughput of the FTP traffic when the node n3 is moving toward BS0 with speed V=14m/s

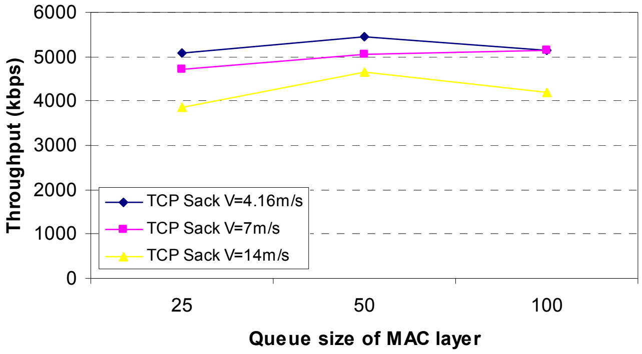

Fig. 5. Average throughput of the FTP flow when the number of MAC retransmissions is set at three and TCP SACK is used as a transport protocol.

We can evident that for smaller speed we are achieving better results when we use queue with size of 50 pkts. This is the case when n3 is moving with speed of 4.16m/s and 7m/s.

In Fig. 5 we have compared the behavior of the average throughput as a function of the MAC queue size when n3 is moving with the defined speed and MAC data retransmissions are set at three. It becomes obvious that the throughput of the flow decreases with increasing of the speed of moving. As TCP transport protocol is used TCP SACK.

V. Conclusions

In the presented work we have analyzed realistic outdoor wireless scenario in which were considered several everyday applications. Traffic analyze was conducted in order to get more familiar with the traffic behavior of different types of applications in wireless environment. We were considering several types of TCP transport protocols in order to observe the behavior of the FTP traffic in realistic wireless environment. After this analyzes we are able to conclude that: distance between nodes directly impacts the FTP traffic flow and its throughput. The throughput decreases as a function of the distance between the nodes in the wireless environment. The number of the MAC layer retransmissions directly influence of the FTP and UDP traffic flow. MAC layer queue size directly affects the traffic flows in the wireless environment especially for shorter distances between the wireless nodes so it has to be carefully tuned in order to be achieved higher traffic flows.

The choice of the TCP transport protocol affects the throughput in the network.

These simulations have shown that in this scenario is best if we set the max number of MAC layer retransmissions at value of three, the MAC queue size at value of 50 pkts. Mobility directly impacts the throughput. Velocity and MAC Layer Queue Size impact at TCP throughput as a function of MAC Layer Retransmissions. The throughput decreases as a function of the speed. In this simulation environment we are able to conclude that best traffic performances are obtained if we use TCP Sack as a transport protocol. During the conducted analyze we should have in mind that the performances of TCP Vegas are degraded when it is incorporated in scenario with the other TCP protocols.

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