Simulation Study Comparison of Throughput Performance between UDP and TCP

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Abstract: User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) are a transportation layer routing protocols which are considered of the core protocols of the internet protocol suite. The behaviour of these routing protocols with different network metrics and scenarios is still not very clear.Also the unfairness problem is keep getting worse because of the greedy nature Transmission Control Protocol (TCP).In this simulation study for evaluating and understanding the unfairness problem in WLANs by investigating the Throughput. by used a very popular simulation tool called Network Simulator 2 (NS2). The simulation tool has used can generalize the effect of TCP and MAC architectural features while maintaining the complex interactions of architectures and algorithms typical of real computer network systems. The used simulation tool is considered an accurate tool for predicting the performance of real world networks.

Keywords: Transmission Control Protocol(TCP), User Datagram Protocol(UDP), Throughput,IEEE 802.11, NS2.

Introduction:

The demand for Wireless Internet access continuously increases, the number of WLANs (also called Wi-Fi hotspot) users have increased explosively. This is obvious since besides laptops and personal digital assistants, many new mobile devices such as cellular phones, camcorders, portable media players, and portable game devices can now support Internet connectivity via Wi-Fi. Therefore, fair service between stations is one of the most crucial concerns for both wireless Internet service providers (WISPs) and subscribers, and so it is imperative for WISP to provide per-station fairness without compromising the overall channel utilization. The authors [1] were dealing with a fairness issue among wireless stations in Wi-Fi hotspots that send/receive TCP traffic under a contention-based medium access control (MAC) protocol, that is, IEEE 802.11 distributed coordination function (DCF). They showed that the service in the current Wi-Fi hotspot is prone to be unfair among wireless stations; the service is biased toward wireless sending stations and against wireless receiving stations. They pointed out that the unfairness problem results from two asymmetric properties: TCP-induced asymmetry and MAC-induced asymmetry. They showed that the TCP congestion control with a cumulative acknowledgment (ACK) mechanism affects the behavior of a TCP flow quite differently, depending on whether it is uplink (from a station to the access point (AP)) or downlink (from AP to a station). This TCP-induced asymmetry makes the service biased toward wireless

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sending stations. On the other hand, they showed that MAC-induced asymmetry exacerbates the unfairness problem. When all the stations communicate through an AP in a hot spot network (infrastructure WLAN), only sending station and the AP participates in the contention to occupy the shared channel, whereas the receiving stations are served by the AP. This MAC-induced asymmetry gives less service opportunity to the wireless receiving stations, hence leading to the unfairness problem. Also, we analyze the interaction between the congestion control of TCP and contention control of MAC and reveal interesting and counterintuitive results: 1) Even when a wireless station has a sufficiently large amount of TCP traffic to send, it is not always allowed to participate in the contention for the wireless medium. 2) As long as packet loss due to buffer overflow in the AP is reduced, both TCP-induced unfairness and MAC-induced unfairness can be mitigated. The reason is that the TCP congestion control adjusts the sending rate of a TCP flow, thus the opportunity for a wireless station to take part in the MAC-layer contention is intrinsically limited by the TCP congestion control.

Eun-Chan et al [1] differentiate between TCP-induced asymmetry and MAC-induced asymmetry and show how these two kinds of asymmetry amplify the unfairness problem. They introduced a cross-layer feedback technique to guarantee the fairness in wireless LANs.

Qian et al [2] have conducted comprehensive experiments using both of test bed and simulation approaches to show the effect of 802.11 MAC protocol and cross-layer interaction on TCP fairness in wireless LANs. They proposed two queue management techniques to ease the unfairness among TCP flows.

Related work:

TCP and UDP protocols are approved to work on transport layer of a network. They handle with the data differently [3].

Network Simulator (NS2)is utilized to evaluate the performance for both TCP and UDP protocols[4],[5].

In [8], a release delay is introduced to achieve fairness; each wireless sending station defers channel access based on the next packet information collected in the AP. Basically, all these MAC-layer schemes [6], [7], [8] try to give more channel access chances to AP than the wireless sending stations in order to compensate wireless receiving stations for less service opportunity. However, these MAC-layer fairness solutions do not necessarily guarantee fairness at the transport layer if TCP is used as a transport layer protocol. The issue of TCP fairness in Wi-Fi hot spot networks has been recently addressed in [9], [10], [11], and [12]. It has been pointed out in [9] that uplink TCP flows are more favored than downlink TCP flows and that this unfairness is affected by the buffer availability of the AP. The approach in [10] alleviates TCP unfairness by performing per-flow scheduling at the AP. To this end, it requires that the per flow queues are maintained for all the TCP flows, which increases implementation complexity. In order to avoid this, the approach in [11] proposed to employ a dual queue in the AP, one for TCP data packets and another for TCP ACK packets, and to schedule these two queues with an appropriate probability. Also, the algorithm in [12] utilizes the IEEE 802.11e [13] service differentiation mechanism to provide TCP fairness. It differentiates the channel access mechanisms for TCP data and ACK packets by using different interframe space, minimum contention window size, and transmission opportunity (TXOP) bursting. These schemes [10], [11], [12] mitigate the TCP unfairness by preferentially serving downlink TCP flows. On the other hand, the recent studies in [14] and [15] have investigated the interplay dependence between TCP and MAC in a Wi-Fi hotspot network. They have shown that the number of active contending stations, that is, the MAC-layer contention level, is regulated by the TCP congestion control mechanism, which has motivated our study.

TCP records the data as a stream of bytes and sending the message as segments. The messages in UDP are sending as datagrams in the network. So, both of TCP and UDP have various approaches of sending and receiving the data [16,17,18].

Problem Overview:

In wireless LAN, the most used architecture is Infrastructure where there are number of wireless stations (STA) communicating with wired stations (STA’) through Access Point (AP). These wireless stations are divided into two kinds, sending stations (UP) and receiving stations (DOWN).

Sending stations send data to their corresponding wired stations through the access point. While receiving station wait for the data coming from their corresponding wired stations to be sent by the access point. The unfairness problem can be understood from this observation: Sending stations and the access point compete to occupy the wireless channel while receiving stations just keep listening to the channel and let the access point to compete on behave of them. This kind of behavior makes sending stations to dictate the wireless channel and do not let receiving stations to have a fair share of the channel because they are not competing to occupy the channel.

To evaluate the problem severity, number of simulation experiments were conducted using NS2 simulator [5].

In this simulation study, I tried to investigate the issue of fairness among stations that send/receive TCP traffic in Wi-Fi hotspots. I would like to show that the current Wi-Fi hotspot provides more services to the wireless sending station compared to the receiving stations, causing the wireless sending stations to dominate the use of network bandwidth while the receiving stations starve.

Methodology:

In this simulation study, I used NS2 [5], which is the second version of Network Simulation (NS). NS is a discrete event simulator targeted at networking research. It provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. It began as a variant of the REAL network simulator in 1989 and has evolved substantially over the past few years. In 1995 NS development was supported by DARPA through the VINT project at LBL, Xerox PARC, UCB, and USC/ISI. Currently NS development is supported through DARPA with SAMAN and through NSF with CONSER, both in collaboration with other researchers including ACIRI. NS has always included substantial contributions from other researchers, including wireless code from the UCB Daedelus and CMU Monarch projects and Sun Microsystems.

I install NS2 in Fedora 9 [4] which is a Linux based operating system that provides users with access to the latest,free and open source software, in a stable, secure and easy to manage form.

Performance Metric:

In my comparison, I have utilized throughput metric among UDP and TCP. This metric are applied to evaluate and analyze protocols performance .

Throughput is defined as the quantity of data being sent/received by unit of time.

Topology:

In figure.1.Shows the topology of the network I used for the simulation study. The network consist of two parts, wireless part and wired part [1].

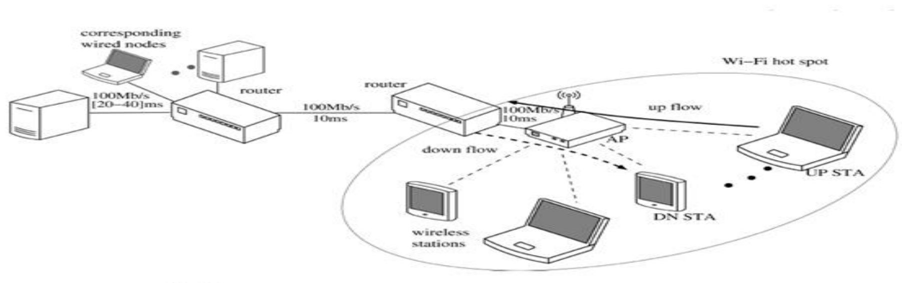

Figure 1.Network configuration of Wi-Fi hot spot

For addressing schemaNS2 does not provide the concept of Access Point (AP), I had to use a hierarchical addressing schema and make one of the nodes act like a gateway between the wireless part and the wired part of the network. The trick is simple, for the wireless stations, if the station does not know the destination address of the packet, it will forward the packet to the gateway station. Then the gateway station will forward the packet to the next wired station.

In hierarchical addressing the topology is broken down into several layers of hierarchy (Domains), I used three domains and in each domain I used only one cluster (Sub-Domain).

In next figure 2, I used the above format to represent stations and these colors have these meanings:

1-Red for Gateway station (called Base station [BS] in the implementation)

2-Green for wired stations

3-Blue for wireless stations

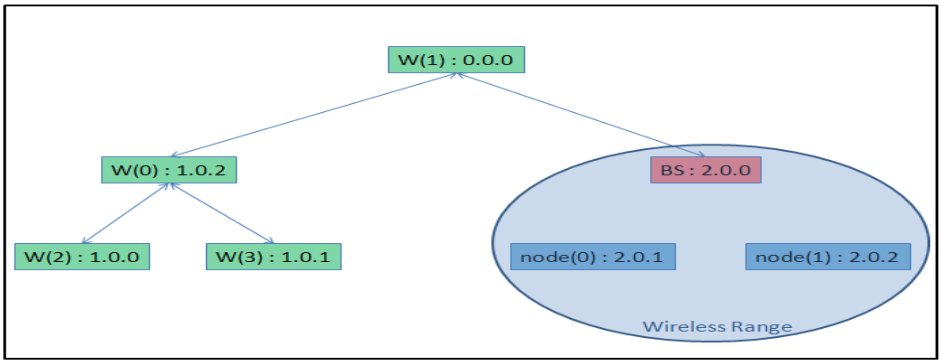

Figure 2.Format to represent stations

SimulationScenario:

In all simulations, I used the same topology so I will start talking about the topology in Tcl since it will be repeated in the all three files.

First, I put the parametervalues of the wireless network an array called opt .

Then I assigned the capacity of wireless networks to 11 Mbps, turned off the RTS/CTS feature and create an object of the simulator .After that, I set up the hierarchical addressing .

In this addressing schema, I have three domains. In each domain, have only one cluster (sub-domain). In the first cluster (first domain), have only one station. In second and third clusters (of second and third domains), have three stations in each one of them. Then, I created the trace files, topology object and General operations director (GOD) objects .Then configure wireless network by using the values in opt array.

And I created the base station and wireless stations and assigned their positions.

Then, I made the connections between the wired stations and the base station.

The next step is to choose the transport protocol and to specify how to calculate the performance metric. Here each simulation file has its own way.

<u>UDP Throughput SimulationSteps:</u>

1.After writing the topology, I created the UDP agents .

2.Created the monitor agents so that I can use them to calculate the throughput .

3.Writing both of finish procedure and the procedure that is going to calculate the throughput and writing it on the trace files (record).

4.The end, I assigned the time for calling each procedure and I ran the simulation .

<u>TCP Throughput SimulationSteps:</u>

1.After writing the topology, I created the TCP and FTP agents .

2.Writingfinish procedure .

3.The end procedure, I used two awk files to filter the information from the general trace file and put this information on the new file. AWK is a general purpose programming language that is designed for processing text-based data, either in files or data streams, and was created at Bell Labs in the 1970s [19].

4.Run of TCP throughput simulation .

Results and Discussion:

Figure 3 and Figure 4 Show the results of simulations, I used Xgraph which a component that came with NS2. These are the graphs that came out:

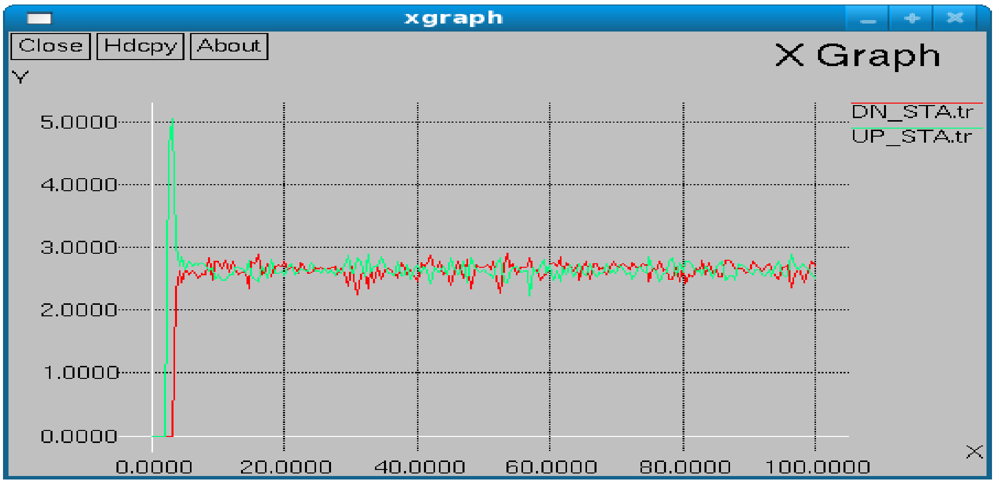

Figure 3. UDP Throughput Simulation

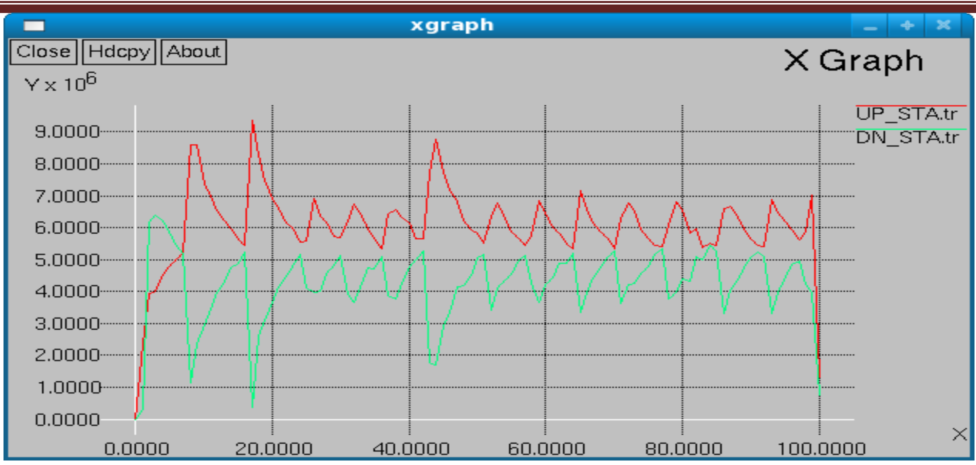

Figure 4. TCP Throughput Simulation

By comparing throughputs of UP_STA (a station that sends data to the AP) and DN_STA (station that receive data from the AP) in the cases of UDP traffic and TCP traffic, I observed a bias toward UP_STA in the case of TCP traffic. When UDP traffic was used (Figure 3 and Figure 4), there was little difference between the throughputs achieved by UP_STA and DN_STA. On the other hand, for TCP traffic, I observed a significant discrepancy between their throughputs. Also, Figures show that the throughput of UDP traffic is almost constant; however, that of TCP traffic fluctuates severely, which is due to the TCP congestion control. The bias toward UP_STA results from the asymmetric behavior of TCP flows responding to packet loss. Note that a TCP connection is bidirectional, which means that a sender transmits a data packet to a receiver and the receiver sends the corresponding ACK packet to the sender. When UP_STA and DN_STA share a wireless channel, the AP transmits two kinds of packets to the wireless stations: data packets to DN_STA and ACK packets to UP_STA. These two different kinds of packets buffer in the downlink queue of the AP. In general, the capacity of a wireless channel is smaller than that of a wired link and it is inevitable that the AP's downlink buffer in a Wi-Fi hotspot easily becomes congested and packets are occasionally dropped due to buffer overflow. In this study, the AP uplink buffer was assumed to be seldom congested when the capacity of wired links connected to the AP is much larger than that of the wireless link. Note that packet loss due to contention may be hidden from the TCP sender because it can be recovered by the 802.11 link-layer retransmission mechanism; however, packet loss due to buffer overflow invokes the TCP congestion control mechanism, and the lost packet needs to be retransmitted by the TCP sender. The TCP flows for UP_STA and DN_STA react to the packet loss due to buffer overflow at the AP's downlink in different ways. When a data packet for DN_STA is lost, a time-out occurs at the sender (wired node), or the receiver (DN_STA) transmits duplicate ACKs to inform the sender of packet loss. Therefore, the throughput of DN_STA decreases when a data packet is dropped in the AP buffer. However, the loss of an ACK packet for UP_STA does not affect its throughput much due to the cumulative ACK mechanism of TCP. Even though an ACK packet is lost due to buffer overflow, the loss does not necessarily invoke the TCP congestion control mechanism of UP_STA. As long as the next ACK packet with a higher sequence number is delivered timely to UP_STA, the cumulative ACK mechanism lets UP_STA tolerate the loss of an ACK packet. Due to this asymmetric behavior in response to packet loss in the AP's downlink buffer, the throughput of UP_STA becomes higher than that of DN_STA.

Conclusion:

In this study, after investigating the throughput of a wireless station in a wireless local area network, I was able to show that the current Wi-Fi hot spot provides more services to the wireless sending station compared to the receiving stations, causing the wireless sending stations to dominate the use of network bandwidth while the receiving stations starve.

Future work:

For the future work, I am planning to extend used (Different Simulation Scenarios and Performance metrics) Comparison between TCP and UDP Protocols, and evaluation of the TCP & UDP with other layer protocols.

دراسة محاكاة لمقارنة أداء (Throughput) بين بروتوكول (TCP) و بروتوكول (UDP)

المستخلص: بروتوكول مخطط بيانات المستخدم (UDP) وبروتوكول التحكم في النقل (TCP) هما بروتوكولا توجيه لطبقة النقل يعتبران من البروتوكولات الأساسية لمجموعة بروتوكولات الإنترنت. لا يزال سلوك بروتوكولات التوجيه هذه بمقاييس وسيناريوهات مختلفة للشبكة غير واضح للغاية. أيضا مشكلة (unfairness) تزداد سوءا بسبب الطبيعة الجشعة لبروتوكول التحكم في الإرسال (TCP). في هذه الدراسة المحاكاة لتقييم وفهم مشكلة(unfairness)في الشبكات المحلية اللاسلكية من خلال التحقيق في الإنتاجية. باستخدام أداة محاكاة شائعة جدًا تسمى (NS2) .يمكن لأداة المحاكاة المستخدمة تعميم تأثير ميزات TCP وMAC المعمارية مع الحفاظ على التفاعلات المعقدة للهندسة والخوارزميات النموذجية لأنظمة شبكات الكمبيوتر الحقيقية. تعتبر أداة المحاكاة المستخدمة أداة دقيقة للتنبؤ بأداء شبكات العالم الحقيقي.

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