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EFFECT OF NODE MOBILITY AND HANDOFF ON THE PERFORMANCE OF TCP VARIANTS IN MOBILE CELLULAR ENVIRONMENT

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Abstract: TCP is the most common and important transport layer protocol and its performance in the wireless environments is characterized by two path characteristics not normally present in wired environments: packet losses due to corruption and mobility.. In this research, we have used the perfect cellular model to model the wireless packet losses due to mobility and handoff in order to get the real performance of TCP. In this paper, we have investigated the behavior of TCP Tahoe, Reno, New Reno, Sack and Vegas in a Cellular Mobile network and tried to find out the impact mobility and handoff of mobile node on the behavior of these TCP variants and which TCP variant has the best performance among all the TCP variants considered in this research.

Keywords: TCP; Mobility; Handoff; wireless; Cellular

I. Introduction

Due to the rapid and aggressive development of mobile wireless and data net, the demand in use of integrated (wired-cum-wireless) net is increasing day by day. The situations and demands are totally different in third generation (3G) and the emerging fourth generation (4G) wireless nets. The main issue of these two generation is to provide reliable data services over wireless links using handy and portable devices, such as mobile phone, laptop etc. Because the demand for providing Internet services over the wireless links has grown rapidly in the recent years. As an example in Japan more than 40 million people access the Internet from the mobile phones [2]. Transmission Control Protocol (TCP) [7] is the most common transport layer protocol used in the Internet. It was primarily designed for the wired nets and performs very well as expected for the wired net. However, the introduction of the mobile wireless net to the internet changes the situation rapidly. The environment of the wireless net violates many assumptions that are made by conventional TCP that are designed for the wired nets. So, the challenges that the traditional TCP has to face, when in wireless environment are high and time varying bit error rate, variable delay, mobility (handoff), and interaction with lower layer protocols [1]. Because, congestion control in the wired link of the Internet is based on the assumption that the packets that are lost in the wired link only due to congestion [3]. But packet losses in the wireless links are normally due to three particular reasons, one is due to congestion and others are due to wireless link errors (random packet loss) and mobility, which are more frequent than the first one. According to the design specification of the TCP's congestion control algorithm, TCP can't differentiate the loss caused by the congestion or by wireless link error (random packet loss) and mobilityType Style and Fonts

II. Features of Wireless Environment

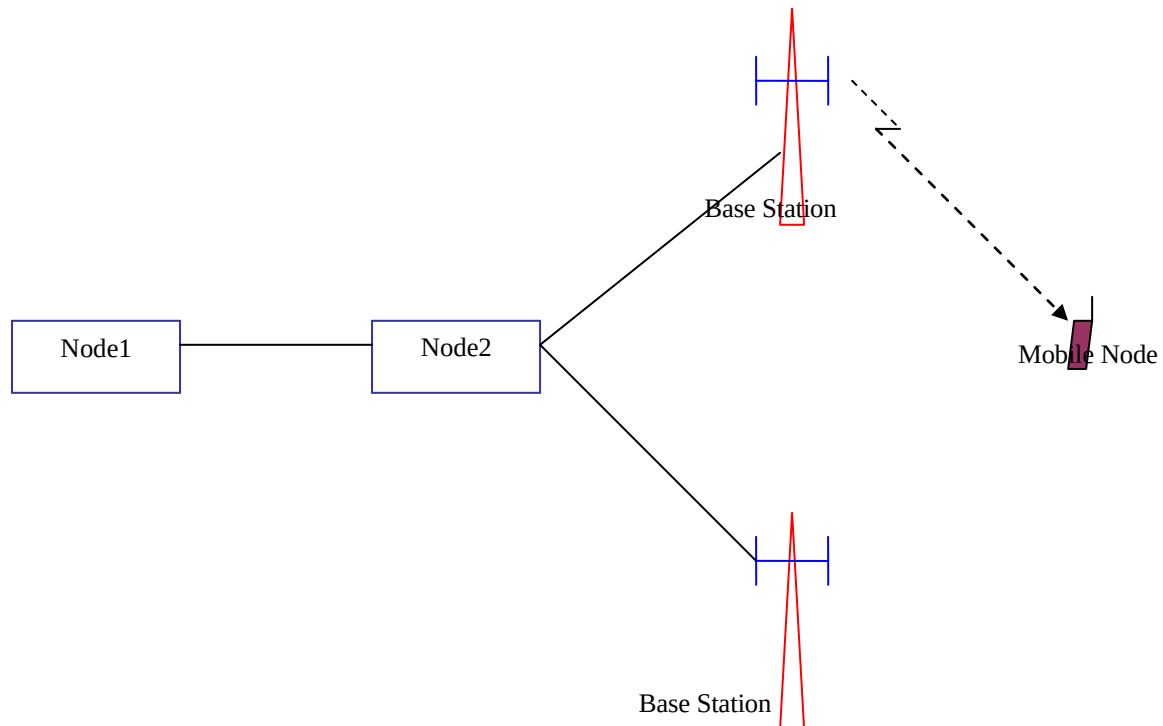
In recent years there has been a strong interest in extending the Internet access technologies to wireless and satellite links. There are many advantages in using these technologies. For example they enable user mobility and net access anytime from anywhere. When using wireless links it needs to be considered that they have quite different characteristics to wired links. They can have a high bit error rate (BER), often combined with fading, can be asymmetric in nature (different forward and return channel bandwidth) or have a high propagation delay[6] etc. Not all of these characteristics might be present in any given link but all of them, or even a subset of them, pose difficulties to the traditional TCP protocol. There are several characteristics that are unique to the wireless environment that make it challenging to adapt TCP to effectively in this environment. The major factors affecting TCP performance in cellular mobile environment are [4]:

- a. Limited Bandwidth
- b. Long Round Trip Times
 - i. Slow congestion window growth
 - ii. Longer time to detect and recover from losses
- c. Random Losses

d. User Mobility

III. Simulation Model and Parameters

NS-2 is used for this simulation [5]. The simulation model (net topology) used in the simulations is shown in figure 1. As shown in figure, there are five nodes: two fixed host (FH): Node1 and Node2, two base stations (BS): Base station1 and Base station2, and a Mobile station (MS). Each base station includes a finite buffer drop-tail gateway. In this research only bulk data transfer are concerned from a Node1 to a mobile station. In this research FTP is used as an application layer protocol. It has been assumed that TCP segments are transmitted towards the wireless terminals from the wired terminal, and ACK segments are in the reverse direction. Here two ray ground propagation model is used as a propagation model and Omni directional antenna is used as specified in NS-2.29.

Figure 1: Simulation Scenario

The topology boundary is defined as 700 X 700 and the mobile station is allowed to move within this boundary, going from the coverage of one base station to the coverage of another base station at a specified speed. MobileIP is used in order to perform handoff between the two base stations. We use the IEEE 802.11 MAC layer for the wireless net. This choice is based on the availability in the NS-2 simulator and because most of the research that we refer to in the research uses it. Table 1 shows the list of simulation parameters.

Table I Shows the Simulation Parameters

Wired link capacity	10 Mbps
Wired propagation delay	20 ms
Wireless link capacity	2 Mbps
Wireless propagation delay	2 ms
TCP packet size	1040 byte
TCP ack packet size	40 byte
Buffer size of each base station	50 packets
Coverage of each base station	250 meters
Speed of the Mobile station	0 to 50 meter/second

To evaluate the performance of the different TCP clones in mobile environment, the following performance metrics are used:

- Number of Handoffs: The number of times the mobile station moves from the coverage of one base station to another base station.

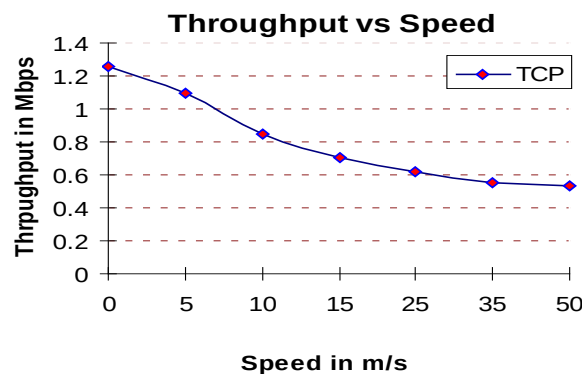
➤ **Speed:** The speed at which the mobile station moves.

Setting these parameters, we have measured the throughput (Which is defined as, the amount of data the receiver receives without retransmission in a unit time) and also see the congestion window dynamics of different TCP clones to analyze their behavior in the presence of multistate error in cellular mobile environment.

IV. Simulation Results and Discussion

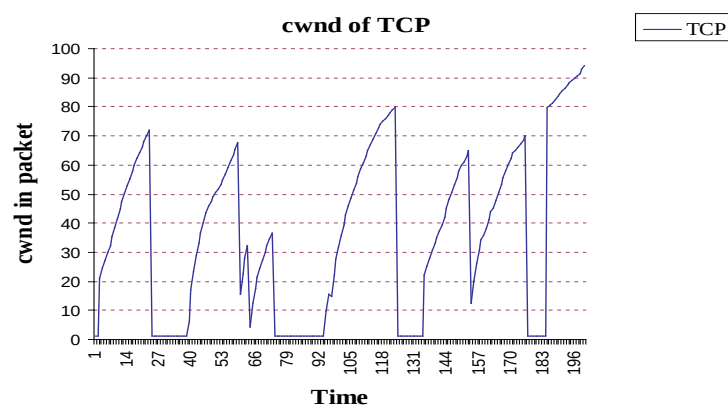
The handoff event in the wireless net is mainly happened due to mobility of the mobile station. Hence simulation is performed to analyze the effect of mobile station's speed with incorporated handoff on the performance of TCP. The speed of mobile station is varied from 0 meter/second to 50 meter/second. And the simulation is run for 200 seconds. Here we only consider the unmodified TCP. The result is plotted in Figure 5. From the figure 5 it can be shown that throughput has been severely degraded with increasing speed.

Figure 2: The graph of throughput vs. speed of the mobile station exploring the performance of TCP during the mobility of mobile station.



Simulation is also carried out to investigate the behavior of regular TCP in presence of mobile handoff. To simulate the handoff performance on TCP, four handoffs are generated.. For each handoff the mobile station shifts from the Home Agent (Base Station1 of Figure 1) to the Foreign Agent (Base Station2 of Figure 1) and vice versa. Figure 6 shows the Congestion window dynamics for four handoffs. It can be shown that whenever a handoff occurs congestion window is reduced to its minimum value, i.e., $cwnd=1$.

Figure 3: Congestion window dynamics of unmodified TCP in presence of mobile Handoff (Speed 10 m/sec).



V. Conclusion and future work

In this paper we have took a close look on the important characteristics of the wireless net, mobility and their effect on TCP performance. Mobility is considered by generating handoffs when a mobile station switches from its serving base station (Home agent) to another base station (Foreign agent) and vice-versa. We have also considered the speed of the mobile station, where the mobile station moves freely at different speed at different times throughout the whole area that is considered in this research. The effect of mobility (with incorporated Handoff) on the performance of TCP has been simulated. From the analysis, it is seen that the throughput of TCP degrades with increasing the speed of the mobile station. We have also analyzed the behavior of these five TCP clones in the presence of both high bit error and handoff. From the analysis, it is observed that the

throughput of these five TCP clones seriously degrades because of heavy packet losses due to both handoffs and high bit error and it is also mentioned that Sack has the best performance.

There are several key areas for extension of our current research.

- The first important area is to simulate two types fading, such as small scale fading (Multipath delay spread and Doppler Effect) and the large scale fading (Shadowing effect) that are normally found in mobile cellular environment and also analyze their effect on the performance of TCP.

The second is to analyze behavior of TCP in cellular mobile environment considering coverage, battery power, and other impacts that are found in cellular mobile environment.

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