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MULTI INTERFACE TCP FOR HANDOVER IN NEXT GENERATION WIRELESS NETWORKS

Dr.K.LakshmiNadh[1], Dr.S.SivaNageswara Rao[2], G. Sambasiva Rao[3]
[1]Assoc.Prof, Narasaraopeta Engineering College, Narasaraopet, Andhra Pradesh, India
[2]Assoc.Prof, Narasaraopeta Engineering College, Narasaraopet, Andhra Pradesh, India
[3]Assistant.Prof, Narasaraopeta Engineering College, Narasaraopet, Andhra Pradesh, India
drklmn7@gmail.com,
drssnr@yahoo.in,
sambasiva.gumma@gmail.com

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Abstract

Multi interface network environment provides a TCP session between two hosts connected with wired or wireless channel. If the two mobile hosts are connected to the core network through homogeneous access networks, the speed will be maintained uniformly, otherwise the difference in bandwidth of two end channels leads to asynchronous service environment. This paper describes various approaches of TCP handover in asynchronous manner and connected design issues. Further these design issues are addressed using the concept of dynamic buffer. At the end of this paper performance evaluation mechanism for dynamic buffer approach is also addressed.

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1 Introduction

Mobility is the most important aspect of today's wireless environment. Mobility can be attained by handover mechanisms in wireless networks. Handover is the process of changing the channel associated with the current connection while a call is in progress [1].In wireless environment, the handovers are classified into two main streams

1.1 Horizontal Handover

Horizontal handover involves a device to change their point of attachment with Access Point (AP) within the same type of network to maintain connectivity [2]. It can be further classified into Link-layer handover and Intra-system handover. Horizontal handover between two AP, under same foreign agent (FA) is known as Link-layer handover. In Intra-system handoff, the horizontal handover occurs between two BSs that belong to two different FAs and both FAs belongs to the same system and hence to same gateway foreign agent (GFA).

1.2 Vertical Handover

Vertical handover (VHO) refer to the spontaneoushandover from one technology to another in order to maintain the connectivity among the nodes [3].The vertical handover allows a terminal device to change networks between different types of networks (e.g., between 3G and 4G networks) [2].There are three important phases [4], [5] in vertical handover,those are system discovery, vertical handover decision, and vertical handover execution. In the system discovery phase, the mobile terminal regulates which networks can be used. These networks can announce its parameters such as supported data rates and Quality of Service (QoS). In VHO decision phase, the mobile terminal determines whether the connections should continue using the current network or be switched to another network. The decision may depend on various parameters or metrics including the type of the application,bandwidth and delay required by the application, access cost, transmit power, and the users preferences. During the

VHO execution phase, the connections in the mobile terminal are re-routed from the current network to the new network in a seamless manner. This phase includes the authentication, authorization, and transfer of a users context information [6].

The aim of handover management is controlling the change of APs in order to maintain the connection with the moving device during the active data transmission. The problem is exacerbated by the presence of APs adopting different technologies. Hence handover procedures between APs of heterogeneous technology, should be taken into account [7]. In this paper, we intend to review numerous schemes which tackled the handover at transport level, and define some of the advantages and drawbacks of each solution. The Asynchronous handover approaches are discussed in section 2. In section 3, we present Multi Interface TCP which provides service continuity. Section 4 presents dynamic buffer approach which provides consistent data flow in multi interface environment. In section 5, the performance evaluation for existing and proposed mechanisms is presented. Finally, section 5 presents the conclusion.

2 Asynchronous TCP Handover Approaches

Different wireless access networks such as IEEE 802.11(WLAN), IEEE 802.16 (WiMAX), GPRS, UMTS using the Internet Protocol (IP) having different characteristics, which offer a different range of high data rate multimedia services to users. Providing consistent and continuous reliable services is the most challenging issue, while considering QoS requirements during the mobility between two different access networks. However, make service continuity in multi interface environment is a complex task due to frequent bandwidth changes and temporary loss of connectivity.

Only providing handover management mechanism for a TCP connection during handover is not fare. Due to the change of link properties such as bandwidth and propagation delay after handover in multi interface environment creates issues on performance of TCP. When a Mobile Node (MN) switches from one access network to another access network with different link layer technologies there is a need to perform vertical handover of TCP session.

There are variety of solutions have been proposed at transport level to overcome the problem of throughput degradation after asynchronous handover. In this section some of the solutions have been discussed:

2.1 Slow Start TCP (SS-TCP)

SS-TCP [8] is a new TCP variation for the vertical handover between heterogeneous networks. In a SS-TCP approach, the TCP sender and receiver uses the handover option field (HO) in TCP header to recognize in implementing handover and a complete handover. After vertical handover TCP sender tries to update its flow of data rate in short time by resuming the data transmission with slow start mode because the new network has various characteristics.

2.2 Vertical handoff Aware TCP (VA-TCP)

VA-TCP [9] [10] is prepared for TCP much good working in multi interface wireless environment. It is a complete mobility management protocol which also tries to improve TCPs performance after vertical handover. When moved into a different network, VA-TCP potentially calculates bandwidth, delay and bandwidth delay product in the new network. Secondly depending upon the expected bandwidth delay product, VA-TCP will have a slow start threshold, congestion window, retransmission timeout and RTT) properly fit into the new network environment. RTT is estimated by sending pair of packets going forth and coming back. Bandwidth capacity is estimated by sending packet-pair and its duration of to and fro. Delay Product (BDP) is calculated by:
BDP = Bandwidth*estimated RTT

By this the TCP sender gets bandwidth delay capacity and sets the size of congestion window and sends data in the required proportion. Thus the TCP sender maintains the constant throughput.

2.3 TCP ACK-Pacing

TCP ACK-Pacing [11] [12] is a receiver determined technique to prevent throughput reduction after vertical handover. No changes for TCP sender. In this method the TCP receiver regulates the transmission rate of ACKs depending upon the network situations prior and post of the vertical handover. The Delay Product (BDP) is calculated by:
BDP = Bandwidth*estimated RTT

The calculation of bandwidth in the new network depends on ICMP. In this method the receiver wanted the information of cross layer, network and datalink layers. In case of upward vertical handover Mobile Node makes multiple ACKs for one segment to increase the CWND immediately. Sender after receiving ACK increases the CWND and gets access to the high bandwidth network effectively. If it is downward vertical handover then MN returns duplicate ACKs to the sender and senders CWND will be made half when it received three duplicate ACKs.

2.4 Freeze Dead Line

Freeze Dead Line (FDL) [13] method is improved version of Freeze-TCP (F-TCP). F-TCP [14] is a method for improving throughput in a handover situation. If a node is aware that handover has occurred, it sends a message to the server that sets the window size to be 0. After receiving window size to be 0, the server stops sending packets. When handover ends, the node sends a message to the server that sets the window size to the value it had before handover. However, Freeze-TCP causes some adaptation problems. In upward handover, the node should wait to use full bandwidth. In downward handover, the node loses packets because of low bandwidth.

The use of Freeze-TCP has addressed many handover problems of the transport layer in wireless networks, because Freeze-TCP is designed for horizontal networks, other problems occur when Freeze-TCP is used in heterogeneous wireless networks. These problems mainly involve the timing of the freezing and unfreezing of the networks.

The FDL method is used to solve this type of handover problems. In the FDL, it assumes that the bottom layer sends messages that have a handover start time and handover end time.

The cross layer methods are used to calculate the handover start and times. FDL is a time at RTT/2 before the hand-off end time in current networks. It is described by the following equation:
$FDL_{time} = T_{handoverEnd} - (RTT_{current}/2)$

Mobile nodes gather other network parameters and monitor the handover. If handover occurred, mobile node calculates the hand-off end time using past information, and sends a freeze request message to the server before the FDL. This is because the packet of the freeze request remains alive and safely arrives to server. FDL shows better performance than other fast freeze methods. Comparison of different types of vertical handover mechanisms are listed in the below table.

Table 1: Comparing different handover mechanisms

Handover Approach	Estimate Bandwidth	Approach	Drawback
SS-TCP	Slowstart	Sender/ Receiver	Slow start degrades throughput
VA-TCP	Packet pair	Sender/ Receiver	Needless overhead, computation
TCP ACK-Pacing	ICMP messages	Receiver	Needless overhead, computation
FDL with F-TCP	Slowstart	Sender/ Receiver	CWND reduces the throughput

3 Multi Interface TCP

Next Generation Networks (NGN) supports multi interface environment to the end users. In NGN environment a mobile with multi interface is allowed to move freely and very flexibly in the region. Mobile while moving will be connected to the core network through different interfaces at different times. NGN is aimed to provide synchronous and consistence service with assured end to end quality delivery.

TCP plays a key role to assure end to end quality service. In wireless environment, mobiles have a dynamic connectivity to the network and it changes the point of connection to the core network very dynamically through different interfaces at different times. Conventional TCP and existing wireless TCP mechanisms will not work properly in multi interface environment. It is very much essential to develop multi interface TCP to cope up the requirement of NGN.

The handover process is basically consists of channel changing and continuation of existing services. To assure end to end quality in multi interface environment it is very much essential to handover TCP session to different access networks which is most significant and important.Multi interface TCP is capable of providing TCP handover among mobile nodes. The TCP handover requires freezing of existing TCP session, creation of Transmission Control Block (TCB) at mobile end, reconfiguration of fixed end TCBs and re-initialization of TCP sessions. These mobile nodes are connected to core network through multiple interfaces sometimes in such a way that a TCP session may be established between two hosts with one is connected to higher bandwidth channel and other is connected to lower bandwidth channel. This leads to asynchronous in service providing to the nodes. The issues related to these things are addressed in Multi interface TCP using dynamic buffer approach. Estimation

4 Dynamic Buffer Approach

This section proposes dynamically variable size buffer for both ends of TCP session to address the issue of asynchronous nature of service in multi interface environment. The design changes required modifications in TCB. Fig1 illustrates the concept of TCB creation in dynamic environment.

The TCB having sending buffer and receiving buffer separately, because the sending and the receiving processes may not be write or read data at the same speed, so TCP uses buffers available in TCB. In the dynamic buffer approach, the buffers sizes may vary based on the heterogeneous access networks capacity. The dynamically allocated size of buffer is related to the maximum congestion window size. When the CWND size is increases the size of buffer is decreased, when the CWND size decreases the size of buffer space is increased in order to maintain consistence data flow in multi interface environment. The message exchanges in mobile and network initiated handover procedures in the case where the mobile node handover from one access network to another access network (Wi-Fi to the 3G cellular network/WiMAX to the 3G cellular network/Wi-Fi to WiMAX)

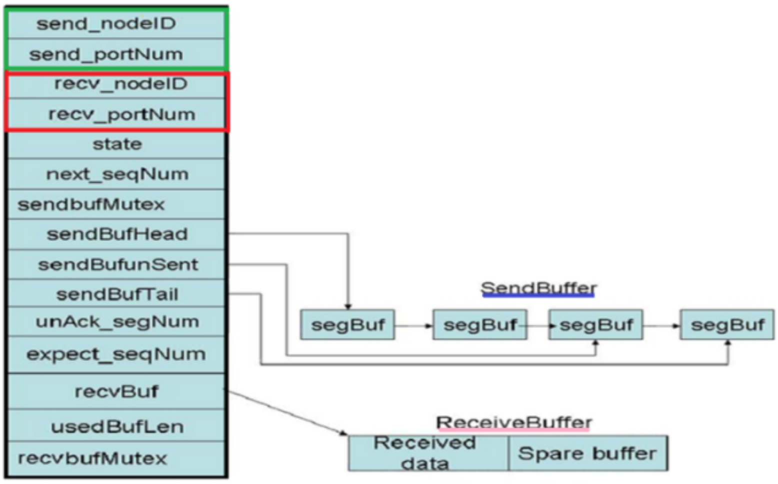

Figure 1: TCB with send buffer and receive buffer

as shown in Fig2.

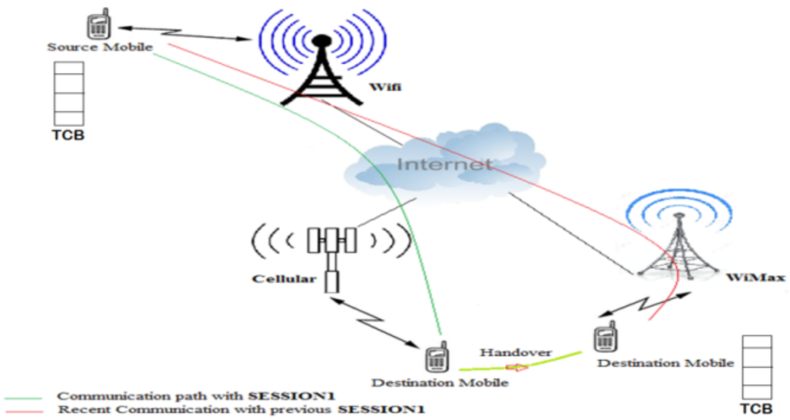

Figure 2: Handover in Multi interface Environment

When the handover is identified, the mobile node gets the static information about the surrounding networks. The mobile host sends freeze message during the handover procedure. After handover the mobile host sends defreeze and networks capacity information as a return message to end hosts. The response indicating the capabilities of the two networks is returned to the mobile node. After receiving this information, mobile node adopts which network to handover to, based on policies and the output of its network, the buffer size and CWND size is changed using dynamic buffer approach.

5 Performance Evaluation Mechanism

The performance of Multi Interface TCP can be measured using Throughput and Flow size. The contributed model is show in Fig3 as the fundamental concept to implement Multi Interface TCP simulation. The performance can be measured using Throughput and Flow size. The handover occurs when a mobile hosts connection changes from one access point to another. The simulation represents various types of handovers. Results of the Mobile Host (MH) handover in different access networks are shown in Fig4, Fig5 and Fig6.

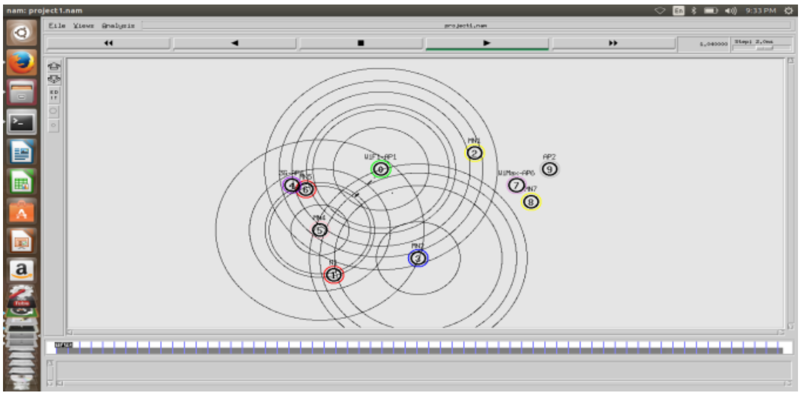

Figure 3: Multi Interface TCP Experiment setup

Now we consider the first Fig4, the MH gets handover from access network WiMAX to access network Wi-Fi. The throughput is reduced and the flow size of ACK packets also reduced. When the sender gets handover the sender buffer at TCB location is increased by decreasing the CWND size from 10656.7 kbps to 346.8 kbps. If we consider the second Fig5, the MH gets handover

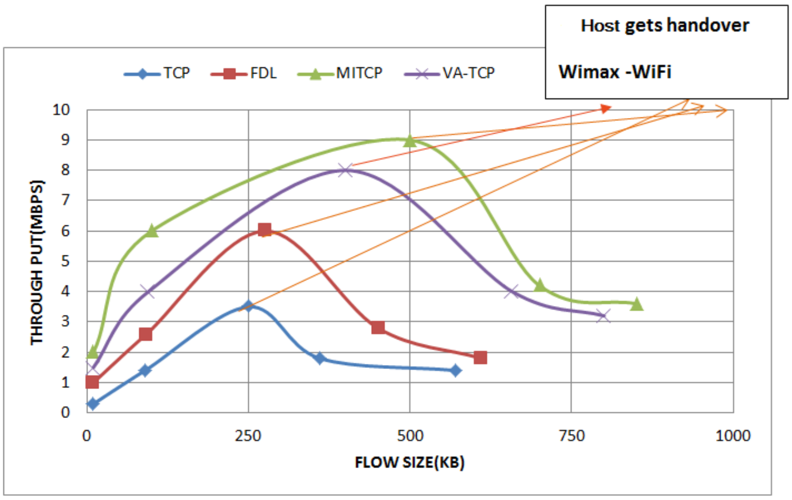

Figure 4: Host initiates handover from WiMAX to Wi-Fi

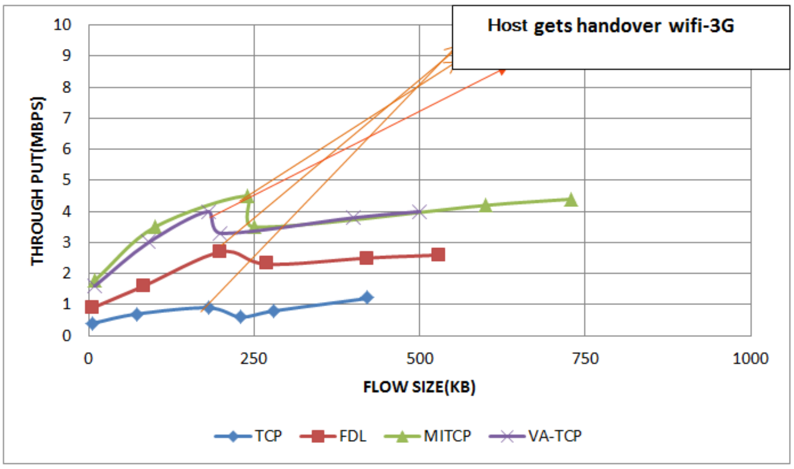

Figure 5: Host gets handover from WiFi to 3G

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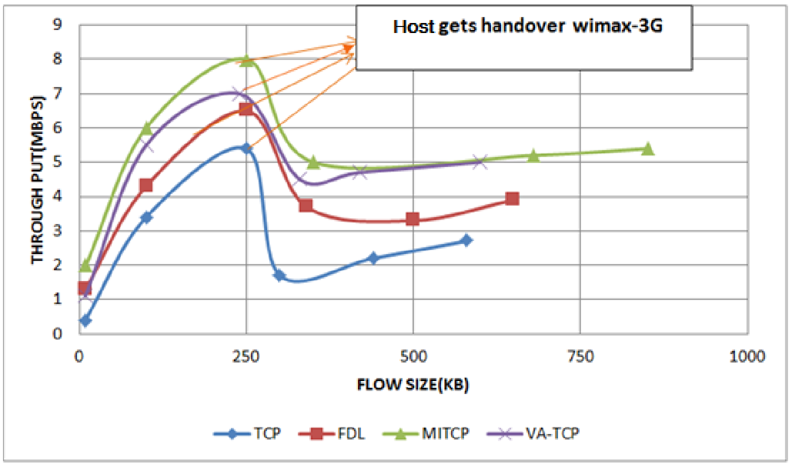

Figure 6: Host initiates handover from WiMax to 3G

from access network Wi-Fi to access network 3G. The throughput is increased and the flow size of ACK packets also increased. When the sender gets handover the sender buffer at TCB location is decreased by increasing the CWND size from 346.8 kbps to 10656.7 kbps. If we consider the third Fig6, the MH gets handover from access network WiMAX to access network 3G. The throughput is slightly decreased and the flow size of ACK packets also decreased. When the sender gets handover the sender buffer at TCB location is increased by increasing the CWND size from 10656.7 kbps to 11468.7 kbps. Finally Multi Interface TCP can get the better performance compared to VA-TCP, FDL and TCP under similar scenarios.

6 Conclusion

TCB plays a key role in handover of TCP session in particular in multi interface environment. When a TCP session has established between two nodes connected to different access technologies having significant difference in bandwidth leads to asynchronous service among the nodes. And service performance will drastically reduced. The concept of dynamic buffer resolves this problem by maintaining dynamically variable buffer at the both the ends of TCP session, to overcome asynchronous situation and to provide an illusion of synchronous service.

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