A High Performance and Efficient TCP Variant

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Abstract – With emergence of the latest technology and deployment of wireless mobile networks for data communication services, the need of the people for faster and robust paradigm has also been increased. There has been a significant effort to tune TCP for these networks. Various TCP variants have been proposed. The performance of TCP is affected due to several factors including congestion window, maximum packet size; retry limit, recovery mechanism, backup mechanism and mobility. These variants are successful in fixed networks but do not yield good results in a mobile wireless network. In this paper, we propose a new TCP variant named TCP University of Bridgeport (UB) by integrating the features of TCP Westwood and Vegas. TCP-UB provides better performance than the other TCP variants from the mobility point of view. We have simulated our algorithm using NS2.28, which shows that TCP-UB achieves superior performance over TCP Vegas and Westwood. The algorithm yields better results in terms of goodput due to effect of the mobility.

Keywords: TCP-UB, TCP Westwood, TCP Vegas, Efficiency and Mobility.

INTRODUCTION

The use of wireless networks in this century has motivated many researchers to study and make exertion for modifying TCP, which was originally designed for fixed wired networks. The result of those efforts shows that TCP in its current structure is not an optimal transport service provider for mobile and wireless networks. Several TCP variants have been intended and implemented in order to optimize the performances, which cause packets loss. However, TCP performs well with these networks by improving the congestion mechanism of the existing TCP variants [5].

First, TCP Vegas is interoperable variant, which augments the throughput performance, reduces packet loss, while it does not affect the fairness. The advantage of TCP Vegas is to calculate the available bandwidth in network. TCP Vegas determines the bandwidth on the basis of difference between expected and actual throughput to avoid packet loss [2].

Second, TCP Westwood gives more significant improvement in wireless networks with lost links [6]. TCP Westwood estimates the bandwidth that is employed by the congestion control algorithm. The bandwidth estimation is performed at the sender side of TCP connection. The slow start and congestion avoidance phases are unaffected during linear and exponential increase of congestion window.

It has been observed that TCP Vegas performed better than Reno with 4.29% to 9.7%, SACK with 1.64% to 4.66%, Tahoe with 4.11% to 9.71% and Westwood with 1.12% to 2.9% & New Reno with 2.01% to 5.6%. On basis of varying mobile nodes and different traffic flows in previous research [10]. Furthermore, the minimum effect of mobility has been analyzed on TCP Westwood. So, the scope of our research is to introduce a new TCP variant to provide better performance based on the above results that we obtained.

In this paper we propose a new TCP variant by integrating the important features of TCP Vegas and Westwood to provide better performance from both efficiency and mobility point of views.

However, in the next Sections we describe the related work, the proposed work, the simulation set up, the simulation results and analysis, discussion of results and finally conclusion.

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RELATED WORK

In [3] a new policy added to TCP Westwood based Concurrent Multipath Transmission mechanism (CMT). This policy makes the process of transmission the data and measuring the bandwidth more efficient. The paper provides the modifying Westwood algorithm (which called CMT-Ww) by adding a new formula to measure the bandwidth with CWND Update for CMT algorithm (CUC) to improve the algorithm of Westwood. However, the paper is using SCTCP-CMT module and updating the congestion control mechanism to apply for CMT-Ww. Moreover, the experiment compared CMT-Reno and CMT-Ww in different paths with setting the bandwidth between each path. The result could improve the throughput. Also, this experiment could show a good adjusting of CWND based on the available bandwidth.

[4] Compares TCP variants: TCP Tahoe, Reno, Lite, New Reno, elective Acknowledgement (sack), Westwood, Vegas and Forward Acknowledgement (Fack) over Mobile Ad-Hoc networks (MANETs) by reviewing the above variants. The evaluation was specific on different congestion control algorithms such as: congestion avoidance, fast recovery, slow start, retransmission, fast retransmission, selective acknowledgment and congestion control. However, the result of this review shows the condition and consumption of the network has an effect on the behavior of the TCP variants. This effect is based on setting the parameters of these variants. Furthermore, each TCP variant has its own solution for network problems.

[7] Proposes a new scheme, which is a Threshold –Based Congestion Control Mechanism on TCP Vegas to solve the progressive performance of Vegas over heterogeneous networks. This research was based on previous research showed TCP Vegas can perform better than TCP Reno over homogeneous networks but not over heterogeneous networks. However, the proposed scheme attains higher throughput than the original Vegas without unfairness. By that, it solves unfairness problem of TCP Vegas for an available bandwidth.

[9] Is based on comparing the performance of both TCP Westwood and TCP Reno over the wireless Ad hoc networks by using NS2 simulator. The experiment used same topology for the two scenarios with setting the transport layer between both sides the sender and the receiver. The result of this experiment shows that Westwood provides a faster recovery mechanism, which can solve the aggressive performance of shrinking. When TCP Reno reduces the congestion window to the half after the three duplicated acknowledgments arrived.

[6] Analyzes TCP Vegas performance based on several exterminates that already proposed over 4th Generation, Long Term Evolution (LTE) using NS2 simulator. The authors used different values of the two parameters (Alpha, Beta) over their experiment. This experiment proves that TCP Vegas can perform better than the other TCP variants when they used different values of the parameters. This provides a great improvement in the throughput.

Some existing TCP Variants over hybrid network are analyzed in [10]. However, the major contribution of this research is to identify the loss of throughput on different mobility ratios and to design mobility-based hybrid network with random waypoint mobility model, where TCP Variants are simulated and analyzed. The authors have shown results that TCP Vegas performs better in Access Point Name (APN) hybrid network where the minimum effect of mobility was analyzed on TCP Westwood.

However, these papers focused on exiting variants when we compare our new proposed TCP-UB with exiting algorithm to find out the fairness.

PROPOSED WORK

TCP-UB Algorithms

The main idea of TCP_UB comes up from TCP Vegas and TCP Westwood. This algorithm behaves in the slow start phase as TCP Vegas exactly and in the congestion avoidance phase behaves as both with adding a new component called (Gama). However, during the Congestion phase, we automatically adjust three threshold values (Alpha, Gama, Beta) as is shown in Figure 1.

The congestion window size (CWND) increases by one since the difference of the expected rate and the actual rate is less than Alpha (a minimal threshold) until it reaches the middle threshold Gama. The reason of that adjustment is the expected throughput is still low as well as we save the bandwidth. Since the difference is less than Gama (a middle threshold) then CWND behaves as TCP Westwood with checking the bandwidth each time to know if the CWND increases or decreases with resetting both the slow start threshold (SSThresh) and the CWND. That continues until it reaches the highest threshold Beta which is (a maximum threshold) then CWND decreases or keeps constant since the expected throughput gets high.

The scope of this section is to show the strength of our algorithm and the ability of efficient usage of Bandwidth.

This algorithm works as given below:

```
If (the Dup ACKs are arrived) then
{
Let Base RTT is the minimum of all RTTs; // RTT: Round Trip Time
Expected Rate= CWND /Base RTT; //Base RTT: the minimum RTT
Actual Rate= CWND/RTT;      // to estimate the flow throughput
Diff = (Expected Rate – Actual Rate) BaseRTT; // Diff: the difference between the expected and actual rate

If (Diff <α) then     // α: Alpha (Minimum threshold)
        CWND+1
else

        If (Diff=δ) then      // δ is a new variable to estimate the congestion possibility (Gama)
                {
                Let ssthresh = (BWE*Base RTT)/ seg_size;   /* BWE: the Bandwidth Estimation; Seg_size: the
                size of the segment*/
                If (CWND > sthresh) then
                CWND=ssthresh
          else

                If (the time out is expired) then
                        {
                        Let CWND=1;
                        ssthresh = (BWE*BaseRTT)/seg_size;
                        If (ssthresh<2) then
                        Ssthresh=2;
                        }
                 }
        else
                If (Diff >β) then   // β: Beta (Maximum threshold)
                        CWND-1;
Otherwise -> CWND;
};
```

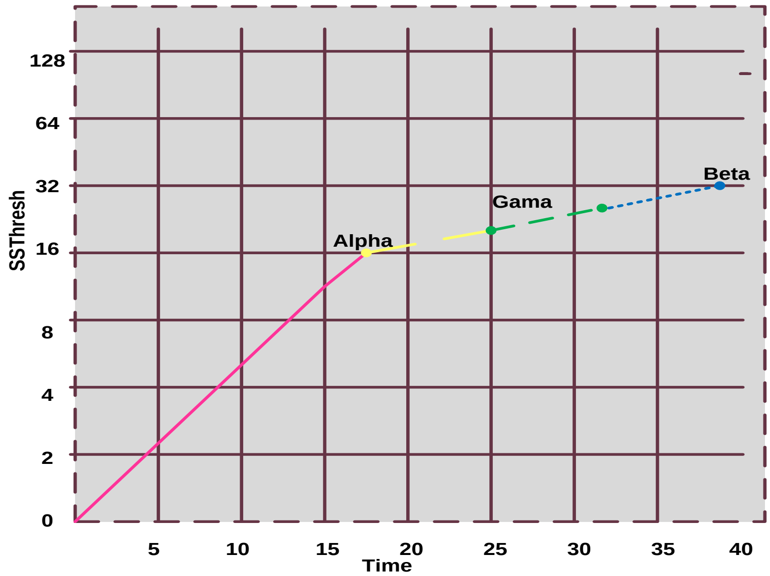

Figure1: The Congestion Control Behavior of TCP-UB

SIMULATION SET UP

The scenarios are simulated using ns2.28 on LINUX Red Hat-9. We have implemented TCP-UB algorithm by Object-Oriented extension of TCL (OTCL). The Implementation of TCP-UB is shown in the Figure 2. We use 1000*1000 squares meters for the simulation area and simulation time is 140 seconds. The transmission range is 250 meter; the nodes cannot transmit after this limit [1]. TCP Westwood and TCP Vegas are simulated and used for comparison to ensure the efficiency of TCP variants with TCP-UB on wireless and MANET. The packet size is 1040 bytes with 40 bytes payload. Each node can send 8packets/sec. The buffer size of the queue is 80 packets. 100 mobile nodes are placed over the networks. Random Waypoint Model (RWM) is imitated for starting nodes' location. We set the pause time for 5 seconds for each 50 seconds. The minimum speed of the mobile node is 0 m/sec and the maximum speed is 35m/sec. By dividing both the minimum and the maximum speed of the node, we can get the moving speed randomly.

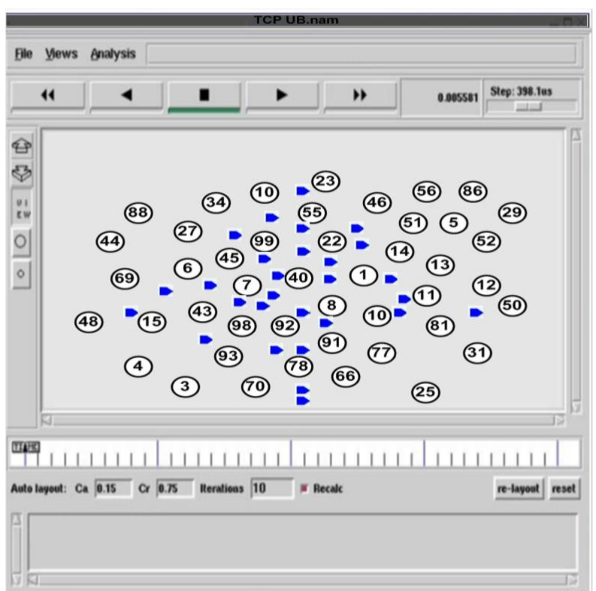

Figure2: The implementation of TCP-UB over Wireless and MANET Networks.

Furthermore, we use the Dynamic Source Routing (DSR) to obtain a goodput performance for routing over the network. We use Contain Bit Rate (CBR) and File Transfer Protocol (FTP) applications, which support TCP and User Datagram Protocol (UDP). Finally, Antenna type is Omni Directional to support the simulation area.

SIMULATION RESULTS AND ANALYSIS

In this section we discuss the simulation scenarios.

A. Efficiency Variance Scenario

In this scenario, we have simulated our network over MANET and wireless segments with NS2 and examined the efficiency of TCP Westwood, TCP Vegas and TCP-UB. For each of above TCP variants, we have collected their acknowledged and received packets. In this scenario, the average speed is 17.5 m/sec for each TCP variants with Random Waypoint Mobility model.

Figure 3 shows the efficiency of TCP Vegas, which steadily decreases for acknowledged packets from 5.8Mb to 4.2Mb over the time. In Figure 4 we can notice that the efficiency of TCP Westwood decreases with almost the same numbers. The reason for this decreasing of packet's efficiency is the mobility. This scenario covers MANET and wireless. In this condition, MANET stays dynamic make radio channel fading and mobility of nodes are main effects.

The mobile nodes take longer time to recover from broken links. The mobility of nodes has an effect on TCP variants due to changes of routing information over the network and can cause longer RTT and repeated timeouts.

In fact, the mobility of nodes can make the receiver getting out of order packets which can affect the acknowledgements. However, that can cause the duplicating acknowledgement and starting retransmission algorithm with reducing in the congestion window [10].

On the basis of efficiency, it is clear that TCP-UB acknowledges more packets than TCP Vegas and TCP Westwood as shown in Figure 5. These data shows TCP-UB received and acknowledges more packets compared with other variants. Furthermore, an important feature of TCP-UB is the stability. The performance of TCP-UB becomes stable during all the simulation time.

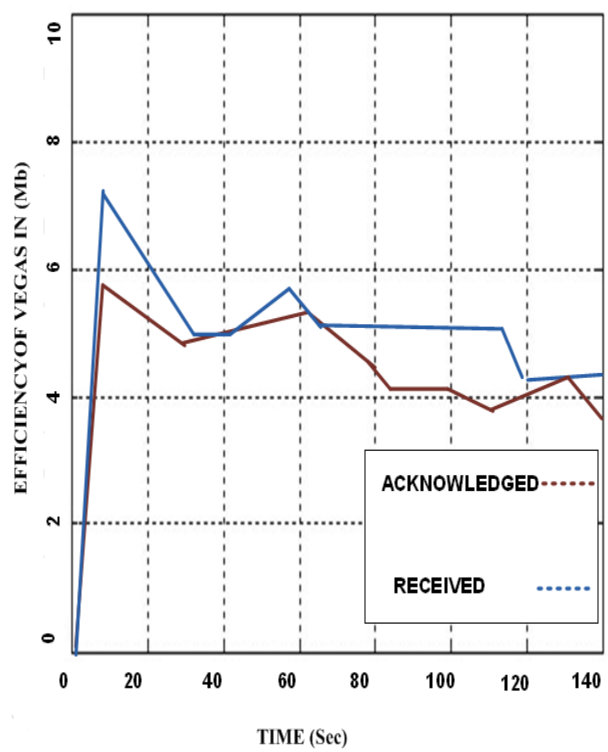

Figure 3: show the performance of TCP-Vegas

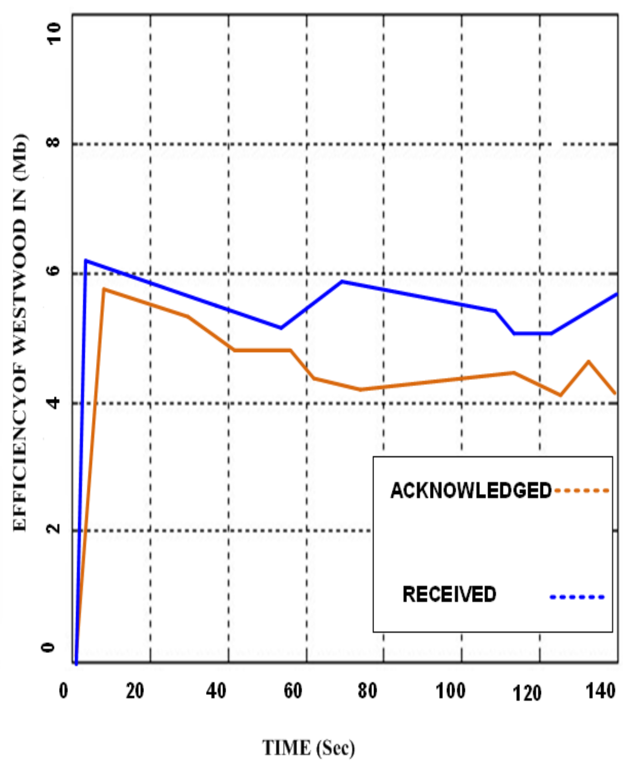

Figure 4: show the performance of TCP- Westwood

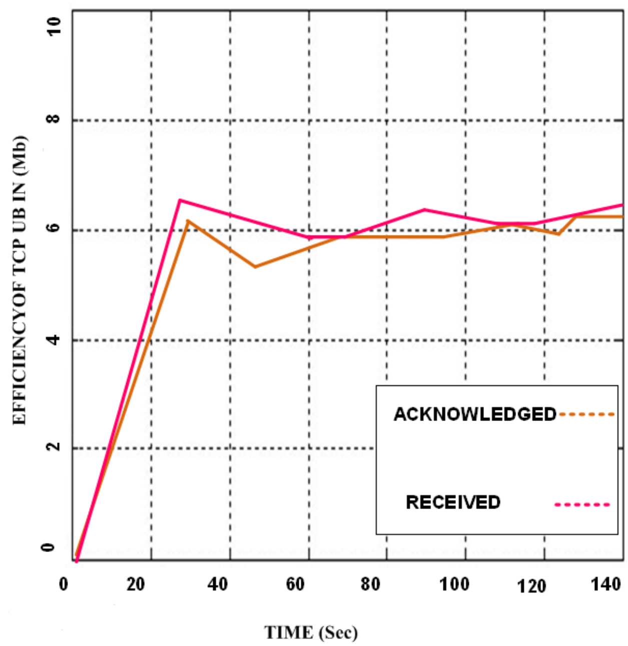

Figure5: show the performance of TCP-UB

B. GoodPut Scenario

We show average of goodput for TCP Vegas, TCP Westwood and TCP-UB from static and mobility point of view as are shown in Figure 6 and 7.

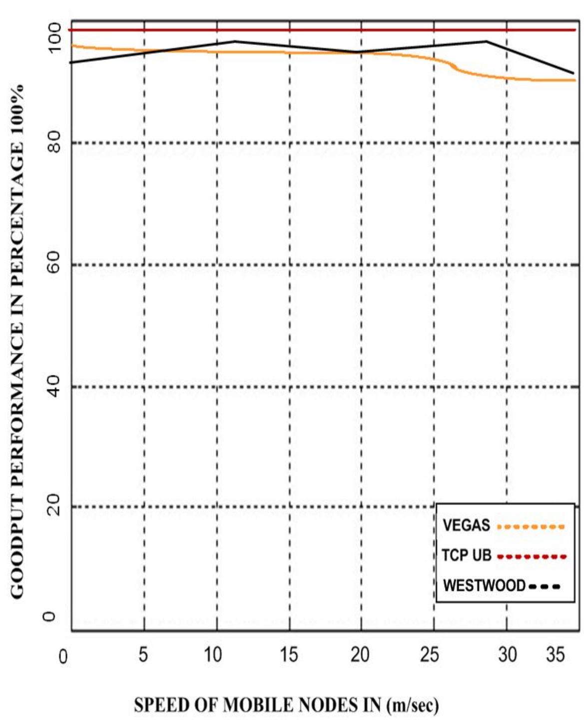

Figure 6: Mobility scenario of Goodput

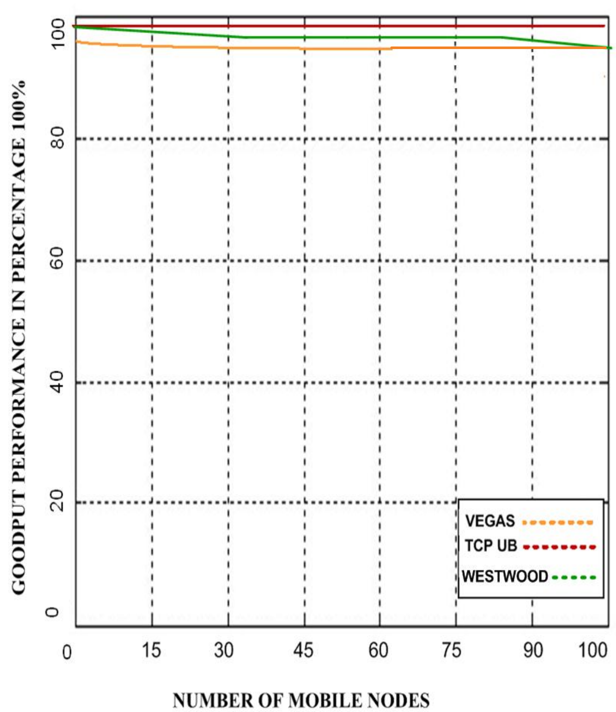

Figure 7: Static Scenario of Goodput

TCP Vegas and Westwood are not stable if the speed increases from 25 to 35m/sec. They show poor performance while TCP-UB the most stable performance throughout changes in nodes' speed. The changes in speed do not affect the performance of TCP-UB because including of Gama, the goodput of TCP- UB is better than other TCP variants.

Another important factor is using Gama for division of congestion avoidance phase into three parts. The partition of congestion avoidance phase provides sufficient time to control congestion window and loss of packets. The behavior of routing protocols also cannot affect Good put performance of TCP-UB.
The performance of TCP-UB, TCP Westwood and TCP Vegas is shown in Figure 6 for Mobility view and in Figure 7 for static view.

DISCUSSION OF RESULTS

We have simulated TCP-UB in NS-2 over MANET and wireless networks by using DSR routing protocol. Two types of scenarios are generated: static and mobility. We mainly focus on mobility based scenario to measure the performance of exiting TCP Vegas, Westwood and our newly TCP-UB. We use varying speed of mobile nodes to examine the real behavior of variants.

In fact, All of TCP variants are affected due to mobility because they do not have completely mobility aware model. However, it has been shown that TCP-UB is better than other TCP variants adding extra component Gama. It gives an excellent result for acknowledged and received packets, and good RTT at different mobile speeds. The reason of producing better performance is to deploy of new component because window does not shrink many times.

Finally, TCP Vegas and TCP Westwood have been designed to achieve excellent results in fixed wired networks but they perform less when compared with the TCP-UB over the hybrid network.

CONCLUSION AND FUTURE WORK

Our proposed protocol can be an advantageous system when it is used for Ad Hoc Networks (MANET) in many applications like military environment, scattered hospitals and industry environments. These applications require data over mobile nodes. We have used the NS2.28 with Random Waypoint Mobility Model to integrate some features of both TCP Vegas and TCP Westwood to provide better performance.

We have used MANET and wireless network to achieve better performance. Furthermore, experimental results show that TCP-UB is not affected by mobility, meanwhile achieves high efficiency and higher delivery of data as compared to TCP Vegas and TCP Westwood. TCP-UB has achieved excellent performance based on the results we validated and measured over several conditions and scenarios.

The implementation of this algorithm shows that there are still more challenges related to TCP variants that can be addressed in the future. We are planning in the future to analyze and evaluate TCP-UB, TCP Vegas and TCP Westwood in MANET and wireless network with respect to bandwidth consumption and congestion control scenario.

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Brief Biographic:

Mrs. Wafa Elmannai is a Master student in the School of Engineering and Computer Science at the University of Bridgeport. She has finished her Bachelor’s degree in Fall2005 at Ben Ashore College for Computer Science. She graduated with highest honors, ranking 4th in her Bachelor degree and awarded merit certificate.

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Dr. Elleithy is the Associate Dean for Graduate Studies in the School of Engineering at the University of Bridgeport. He has research interests are in the areas of network security, mobile communications, and formal approaches for design and verification. He has published more than one hundred fifty research papers in international journals and conferences in his areas of expertise. Dr. Elleithy is the co-chair of the International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering (CISSE). CISSE is the first Engineering/Computing and Systems Research E-Conference in the world to be completely conducted online in real-time via the internet and was successfully running for four years. Dr. Elleithy is the editor or co-editor of 10 books published by Springer for advances on Innovations and Advanced Techniques in Systems, Computing Sciences and Software.

Mr. Abdul Razaque is PhD student of computer science and Engineering department in University of Bridgeport. His current research interests include the design and development of learning environment to support the learning about heterogamous domain, collaborative discovery learning and the development of mobile applications to support mobile collaborative learning (MCL), the congestion mechanism of transmission of control protocol including various existing variants, delivery of multimedia applications. He has published over 30 research contributions in refereed conferences, international journals and books. He has also presented his work more than 10 countries. During the last two years he has been working as a program committee member in IEEE, IET, ICCAIE, ICOS, ISIEA and Mosharka International conference. Abdul Razaque is member of the IEEE, ACM and Springer Abdul Razaque served as Assistant Professor at federal Directorate of Education, Islamabad. He completed his Bachelor and Master degree in computer science from university of Sindh in 2002. He obtained another Master degree with specialization of multimedia and communication (MC) from Mohammed Ali Jinnah University, Pakistan in 2008. Abdul Razaque has been directly involved in design and development of mobile applications to support learning environments to meet pedagogical needs of schools, colleges, universities and various organizations.