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IT Assignment Sample 1

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# Introduction

The current world is strongly driven by a demand for accessing the internet with the help of mobile terminals thereby pressing the need for inclusion of wireless Local Area Networks (WLAN) and Cellular Communications (CC) into mainstream internet. Where on one hand, WLANs are extremely useful and serve to eliminate the need for a physical and wired infrastructure; they on the other hand raise a variety of performance issues (Fernandes & Karmouch, 2012). WLAN and C systems share most of their characteristics with terrestrial and satellite microwave. These characteristics include high error rates and this makes protocols such as TCP/IP (Transmission Control Protocol) which have been specifically designed for the wired network unsuitable for usage over wireless systems (Wu et al, 2013). Furthermore, wireless systems are also subjected to slow speed issues owing to physical obstructions and terrestrial reflections. Other issues include signal fading, congestion, channel errors, mobility, asymmetry etc.TCP assumes network congestion to be the most prominent cause of data loss and this assumption does not completely hold true in case of wireless networks (Lan & Li, 2012).

With regard to the above discussion, the main aim of this research proposal is to investigate performance issues of TCP/IP protocol over wireless networks. The document will begin by providing an outline of the research background followed by aims of this research, a statement of research problem and a review of literature on the subject. Methodology of data collection shall also be outlined followed by elaborating on potential outcomes of the research, its limitations and ethical considerations which might exist in the context of this research.

# Background of the research

TCP currently is the most reliable, widely accepted, fully duplex and byte stream transport level protocol that is being globally used. TCP was originally developed so as to transmit data packets over reliable communication networks. There are a plethora of network applications which have been built on top of TCP and this will continue to be the case in near future (Wang et al, 2014).

With technological innovation and development of handheld and computing devices capable of operating without being bounded by wired networks, WLANS are gaining exceptional importance. There is a significant increase in the number of evolving combined (wired and wireless) infrastructures and TCP/IP protocol stack is being widely used so as to deploy applications in combined infrastructures (Chen et al, 2013).

One major problem that has widely emerged and has received significant attention in research is the performance of TCP over wireless and mobile links. Research indicates that TCP does not perform particularly well over wireless networks and gives rise to several performance issues. It has also been indicated that TCP was originally designed in line with requirements and characteristics of wired networks and is not suitable for deployment over wireless infrastructures (Kaushik et al, 2012).

The main reason for this performance decrease as indicated in research literature is loss of packets during data transmission in wireless networks. These losses might be caused owing to several reasons including network congestion, noisy channels, interference, disconnection as a result of limited network availability, fading radio signals and host mobility (Francis et al, 2012). Currently, TCP mechanisms do not have the ability to distinguish between packet losses owing to congestion from packet losses owing to any of the other mentioned reasons. This causes TCP to unnecessarily reduce the rate of data transmission and severely degrade network performance (Chen et al, 2013).

Performance of TCP over wireless networks might also suffer a blow owing to the fact that the protocol might not be able to completely use its available bandwidth. This might be attributed to the fact that loss recovery kicks in after the protocol stops detecting losses. This gradually increases the throughput (Kaushik et al, 2012). This is followed by an increase in congestion window (which is clocked by the rate at which acknowledgements arrive). Increase in congestion window also largely depends on round trip time. In other words, in large round trips, the congestion window would decrease frequently owing to multiple and continual losses thereby disabling TCP from reaching its complete bandwidth (Sundararajan et al, 2011).

# Aims of Research

When generally compared to wired links, wireless links are more unreliable in nature with their characteristics subjected to rapid changes and intermittent connectivity. However, TCP’s responses to packet losses other than those due to congestion unnecessarily degrade network performance (Francis et al, 2012). Since TCP’s error detection mechanisms are only capable of confirming that a packet is missing, no recognition is provided to the reason which might have caused a packet loss. As a result, alternate strategies of packet recovery are not available in TCP (Wang et al, 2014).

In order to be successfully deployed in wireless networks in the near future, it would be essential to make improvements to the protocol so that it becomes capable of providing reliability and performance (Sundararajan et al, 2011). In this context, it would first be essential so as to determine the challenges or performance issues faced while implementing TCP/IP over wireless networks.

Therefore, main aim of this research project is to gain an in-depth understanding of performance issues faced while implementing TCP/IP over wireless networks. Ultimate outcome of the project would determine areas in which TCP protocol can be improved so as to provide better reliability and performance.

# Literature Review

## High Delays

This is one of the most commonly encountered themes in research literature and suggests that high transmission delays in a wireless medium are responsible for degrading TCP performance in the medium. (Subramanian et al, 2015) showed that TCP performs in LEO systems by analysing abrupt delay changes in the system. Since variability of these changes is high, an accurate analysis is often not possible thereby affecting performance of the protocol.

## RA Mechanisms in Wireless Networks

(Khademi et al, 2012) served to evaluate the performance of TCP in multi-rate 802.11 WLANs with the help of conventional Rate Adaption Mechanisms (RA). The research concluded by indicating that most conventional RA’s are unable to distinguish frames. Additionally, collision triggered rate might cause downshift of some RA mechanisms even in low noise environments. This in turn would negatively affect the uplink TCP and hence its performance in WLANs causing severe degradation.

## Inappropriate reduction of congestion window

Literature also indicates that transmission errors are the primary cause of performance degradation in TCP based applications over wireless networks. While it might be possible to correct few errors in every packet with the help of FEC codes at low levels, greater number of errors might result in corruption of the packet. Such corrupted packets are simply discarded and are not handed over to TCP (Sundararajan et al, 2011). TCP in turn assumes that the packets were lost due to congestion in the network. Since internal algorithms of the protocol are equipped to deal with network congestion, the protocol reacts by reducing its congestion window. In most cases, errors in wireless networks are not related to congestion thereby resulting in an inappropriate reduction of the window (Sardar et al, 2014). Frequent reduction in the congestion window results in high throughput losses for applications which have been mounted on TCP. Severity of throughput losses might depend on distance between the receiver and the sender and communication bandwidth (Kumar & Chockalingam, 2012).

## Frame Error Rate

WLAN suffers from an approximate frame error rate of 1.55% while trying to transmit over a distance of 85 feet with losses that are clustered. This estimate hold true while 1400 byte frames are being transmitted over the mentioned distance. The measurement of frame error rate might be halved by converting 1400 byte frames into 1100 byte frames. This however results in larger consumption of the bandwidth by overheads (Ramaboli et al, 2012). Furthermore, TCP has been designed to receive acknowledgements for each data packet that it sends. This causes a problem in shared medium WLANs as forward traffic (or data packets which TCP is sending) might collide with reverse traffic (or acknowledgements that the protocol is bound to receive). These collisions would go undetected and serve to increase the rate of error further (Majeed et al, 2012).

Research studies aimed at judging performance of TCP over wireless networks with the help of file transfer tests are indicative of the fact that only a throughput of 1.25Mbps was received while transferring data over a 1.6 Mbps connection. This throughput reduction was caused by frequent invocations of network congestion which was unnecessary in nature (Sardar et al, 2014). Research undertaking this experiment also suggested that it would be possible to increase the throughput to 1.51 Mbps if the errors in the network were evenly distributed instead of being clustered. Other research studies have also confirmed the fact that TCP performance degrades further in networks with clustered losses as compared to networks in which errors are evenly distributed (Majeed et al, 2012).

## Asymmetry

Asymmetry further serves to increase performance issues of TCP protocol. Wireless links between base stations and terminals (which are mostly mobile in nature) are typically asymmetric in nature. Compared to base station from where data packets are being transmitted, independent terminals are limited in their available buffer space, processing capability and power that might be available with the terminals (Sardar et al, 2014). Another asymmetry might come from vast differences between inherent characteristics of wired and wireless links. While wired connections are far more reliable and have large bandwidths, bandwidths of wireless networks are variable and the network is subjected to various errors. Therefore, it is possible that wireless links would become the bottleneck of TCP connections in combined infrastructures (Kumar & Chockalingam, 2012).

## Mobility

Mobility has also been recognised to increase performance issues of TCP over wireless networks. Mobility of devices might result in temporary disconnections thereby causing packet and data losses. This would unnecessarily cause TCP to evoke its congestion control mechanisms and cause performance degradation (Ramaboli et al, 2012). With an increase in the number of handheld and mobile devices, it would be necessary that TCP begins to recognise losses that occur in the network owing to factors other than network congestion. Furthermore, network transmission might drop if users are trying to access the network from a significant distance from the access point (Majeed et al, 2012).

## Channel errors

Wireless networks might be subjected to multipath fading and shadowing owing to presence of physical obstructions. This might cause corruption of data packets which would then be considered as congestion by TCP. Furthermore, intermittent channels might also result in keeping congestion window size of the sender small thereby causing low throughputs of TCP over wireless networks (Kumar & Chockalingam, 2012).

# Research Problem

TCP currently forms the most reliable and widely accepted byte stream transport level protocol around the globe. TCP shall continue to be the base over which applications are mounted in wireless and CC networks in the near future. The protocol however is plagued due to the presence of various issues such as signal fading, asymmetry, inappropriate reduction of the congestion window and high and unpredictable delays (Majeed et al, 2012).

These factors cumulatively prevent TCP from operating over wireless networks with its full capacity. It has been observed that approximately 60% of the available bandwidth remains unutilised thereby causing severe performance degradation in wireless networks (Kumar & Chockalingam, 2012).

The need for improving TCP performance in wireless networks and providing reliability has underlined the need to thoroughly investigate performance issues that are being faced while implementing TCP/IP over wireless networks and determine the extent to which they impact performance.

Most of the research is focussed on determining areas which require immediate improvement so as to provide reliability, speed and consistent performance in wireless networks.

# Research Questions

This research project would serve to consolidate evidence and provide answer to the question that: What performance issues are faced while implementing TCP/IP over wireless networks?

The main research question will be divided into the following sub-questions:

* How does TCP/IP transmit data in wired networks?
* To what extent is TCP/IP applicable for deployment in wireless networks?
* Which factors are majorly responsible for causing performance deteriorations in TCP/IP over wireless networks?
* How can performance issues faced while implementing TCP/IP over wireless networks be solved so as to improve the performance of the protocol?

# Methodology

The research project will use quantitative methods for collecting data for analysis. Primary methods of data collection would involve measuring the performance of TCP/IP over a combination of wired and wireless network in a real-time laboratory setting. The experimentation would make use of a wired server located within the university premises and a mobile client. The client will be allowed to have two interfaces while the server would have only one active interface.

The server would be configured as multi-homed host and will be connected with two Intel Gigabit Ethernet interfaces to two subnets of the university network. A public IP address will be assigned to each of the two Ethernet interfaces. A laptop with built-in wireless interface will be used as a mobile client. He mobile client would be selected such that it has the capability to host two different types of Wi-Fi networks: public Wi-Fi hotspots and private home network. The private home network shall be accessed by linking the wireless interface of the mobile client to a private home network in a residential area. The mobile client would also be provided access to three additional broadband internet interfaces (cellular networks).

Both server as well as the client would be configured to run Ubuntu Linux with the same kernel version. Furthermore, the server would be configured as an HTTP server. Client would be allowed to receive data from all available paths.

So as to minimise interference of other Wi-Fi interfaces to the wireless interface that is currently working, Wi-Fi access to two of the three available cellular networks shall be disabled (so that only one can be used at a time). All devices will be made to run at different frequencies and possible interference between them shall be avoided by extending cellular dongles with the help of USB cables.

# Performance Metrics

Download time: This would be measured as the total duration elapsed from when the client sends out first SYN to the server till the time last data packet is received from the server. Download time of a single file can be compared using single and multi-path TCP.

Loss Rate: Loss rate would be calculated as total number of data packets which might be re-transmitted divided by data packets which might be sent by the server.

Round-trip time: This would be measured as the time duration from when a server sends a packet till the time an acknowledgement for that packet is received.

Out of order delay: This would be calculated as the time elapsed between arrival o data packets at receive buffer to the point in time when its sequence number is in order. It is measured at the receive buffer before packets get delivered to the application layer.

## Data Analysis

Statistical analysis of data will be carried out to compare and contrast performance metrics in single and multi-path TCP in contrast to a wired network. Statistical data for comparison would be directly obtained with the help of experimental measurement.

# Potential Outcomes and Limitations

## Outcomes

Analysis of collected data would provide useful insights into major areas of concern which result in performance degradation of TCP/IP over wireless networks. Analysis would also reveal the extent to which each performance issue serves to deteriorate performance of TCP/ IP over wireless networks. Results obtained would be utilised to provide recommendations regarding areas which need to be addressed on an immediate basis so as to facilitate network reliability, speed and performance.

Results of this research might further be used to:

* Device solutions (in the form of new algorithms) which would improve dependability on TCP/IP in wireless networks
* Develop alternate protocols which are better suited for functioning with lossy wireless networks

## Limitations

Some potential limitations of the study might be acknowledged. The experiment assumes that the interference between different cellular networks is negligible owing to the fact that they have been extended with the help of USB connections. This however might not be true and actual interference in networks might cause result inaccuracies.

Furthermore, the stud presents its findings on the basis of a single experiment. Similar experiments conducted earlier on the subject have not been consulted in the study. Consulting other experimental studies and using their data to support findings of this study would have served to improve findings of this research.

# Ethical Considerations

The research project involves the use of experimentation as selected methodology and this would be carried out with the help of university resources. Therefore, an explicit permission would have to be attained from the university authorities and they would have to be given all details of the experiment.

The experiment ensures that no individual will be harmed during the course of the study and results obtained will only be used for t purpose of this research. Data shall be collected and stored at a secured location and shall not be shared with anyone.

# Conclusion

Constant developments and technological up gradations are making wireless and cellular devices more and more important in nature. TCP/IP however is not well suited to work with lossy networks and will require several improvements before it can be deployed for this purpose. In this context, this research is aimed at determining the major performance issues which are faced while implementing TCP/IP in wireless networks. This would be done with the help of undertaking a comprehensive review of literature and by conducting a real time experiment in which a mobile host will be connected to a wired server. TCP performance shall be measured on the basis of several parameters including download time, roundtrip time, loss rate and out of order delay.

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