# Performance Modeling of UDP over IP-Based Wireline and Wireless Networks

*A. A. Akintola, G. A. Aderounmu, and A. A. Owojori*
*Obafemi Awolowo University, Ile-Ife, Nigeria*

aakintola69@yahoo.com
gaderoun@yahoo.com
folajori2@yahoo.com

*M. O. Adigun*
*University of Zululand, Kwadlangezwa, Republic of South Africa*

madigun@pan.uzulu.ac.za

## Abstract

The pervasiveness and the seemingly unpopular nature of unidirectional data transfer has greatly necessitated the efforts of this paper. We investigated the performance of User Datagram Protocol (UDP) over IP-based wireline and wireless networks. The conceptual model was developed and tested using Network Simulator 2(NS2) and its bevaviour was monitored over the two networks. The results of the simulation in terms of effective throughput, packet drop/loss, and bandwidth utilization were presented. It reveals that UDP exhibits improved performance degradation on wired networks and that the high throughput is as a result of the fact that UDP does not have flow control protocol as it does not retransmit lost packets.

**Keywords**: IP networks, UDP, connectionless, bandwidth, throughput, packet drop, unidirectional

## Introduction

The ubiquitous nature of IP-based networks has lend credence to the volume of activities and attention accruing to it in the recent times. Driven by the ever-increasing demand for bandwidth and Quality of Service (QoS) guaranteeing, the core of today's network (either wired or wireless) has been evolving. In this research effort, the authors are interested in the behaviour and performance of User Datagram Protocol (UDP) over wired and wireless networks.

UDP is an unreliable protocol because it is unidirectional unlike Transmission Control Protocol (TCP) that is connection-oriented and bi-directional in nature. According to Foster, Kesselman, and Tueke (2001), the rapid increase in network bandwidth and the emergence of new routing and switching technology has made data transfer protocols to become bottlenecks for many applications. Zhang and McLeod (2005) also admitted that the evolving nature of today's Internet has made protocols to be constantly modified in order to optimize performance. Many modifications to the existing protocols have been proposed in the literature to reduce latency. Some of them have been implemented already on the

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Internet like pre-fetching web pages the user is likely to access next, while browsing the current displayed page (Crovella & Bardford, 1998) and avoiding the cost of round trip time (RTT) by reducing the number of HyperText Transfer Protocol (HTTP) connections (Padmanabhan & Mogul, 1994).

## Motivation

Connectionless Data Transfer is not widely understood as TCP/IP (which is connection-oriented data transfer), it is often difficult in the course of developing service and protocol definitions to adduce a rationale for incorporating UDP, and even more difficult to determine appropriate locations for connectionless service within the layered protocol stack. Since UDP is unidirectional as reproted by Xylomenos and Polyzoz (1999), our aim was to compile a comprehensive set of data describing the performance of UDP over wired and wireless networks in terms of packet loss analysis, bandwidth, and throughput.

There is absolutely no guarantee that the datagram will be delivered to the destination host. Not only the datagram can be undelivered, but it can be delivered in an incorrect order. On the basis of the foregoing, there is the need to carry out a critical analysis of UDP/IP connection on any network; be it wireline or wireless.

## Related Research

Network researchers have been improving UDP for many years and have published a series of UDP variations. Although TCP is still dominant in the Internet, the drawbacks inherent in its window based congestion control mechanism prevent its use in high bandwidth-delay product (BDP) environments (Gu, Hong, Mazzuco, & Grossman, 2005). According to Zhang and McLeod (2005), many modifications have been made to the existing protocols in order to reduce latency. Noghani, Kretschmann, and McLeod (2001) suggested the use of multiple TCP connections in conjunction with FTP while the NCSA (”Automatic TCP Window...,” 2005) used better estimating bandwidth-delay products by adjusting TCP parameters. However, none of the above mentioned approaches deal particularly with the bevaviour of UDP over various media. Our work will also extend the published results in Eckhardt & Steenkiste (1996) and Nguyen, Katz, Noble, and Satyanarayanan (1996). He & Gary-Chan (2004) reported that packets aggregation was previously proposed for the Internet with the objective to reduce the number of small packets, e.g., the TCP ACKs for web servers (Badrinath & Sudame, 2000), or Voice over IP (VoIP) packets ( Tounsi, Tountain, & Kamaoun, 2001).

## System Model

In this section, we discuss the conceptual framework for the model of UDP over wired and wireless networks. We also highlighted the model parameters. The model was developed using standard simulation software called Network Simulator 2 (NS2). NS2, an object-oriented simulator, offers the unique capabilities and features required for the system model.

The various networks were defined in NS2 by using nodes and links as building blocks. Nodes are connected by links and contain agents (UDP) and its application CBR (Constant Bit Rate) that are responsible for transmitting and receiving packets. In the process of creating these structures; many of their characteristics are described such as bandwidth, packet drop policy, error rate and other local area network characteristics already present in the simulator. Also, changes that occur in the network at specific times during simulation are scheduled.

The scenario for the Wide Area Network (WAN) model as used in the NS2 environment is as shown in Figure 1. It is worthy of mention that we are only interested in the UDP traffic as shown in the same figure. We abstracted the scenarios of connecting two different networks through wired and wireless means as shown in Figures 2 and 3 respectively. This enabled us to monitor the desired metrics under different conditions.

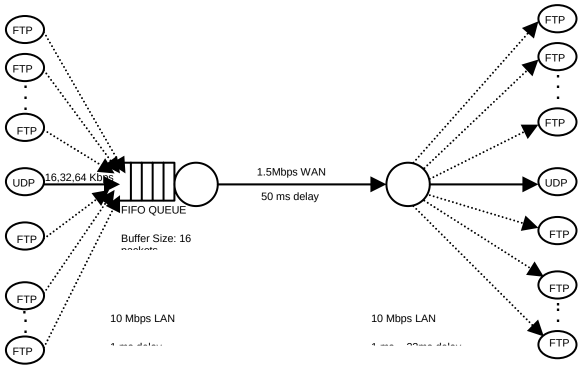


Figure 1: Scenario for Wide Area Network Simulation

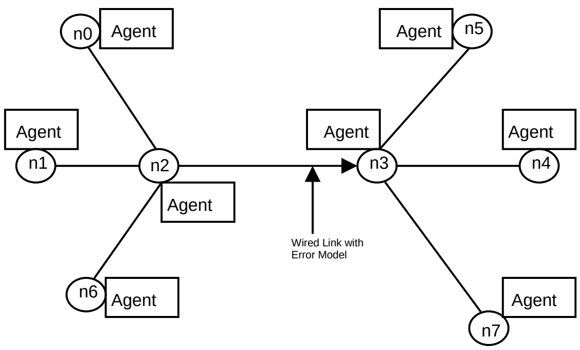


Figure 2: A Model of Two Local Area Networks with Wired Link

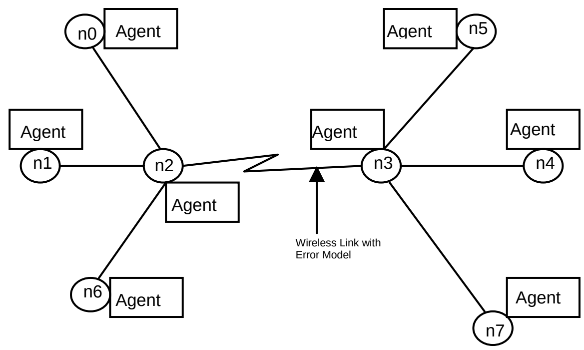


Figure 3: A Model of Two Local Area Networks with Wireless Link

Figure 2 shows a star topology in which n2 and n3 are the main servers between two buildings while the other nodes are located at different points within the buildings. The n2 and n3 are linked together via wired medium. Figure 3 depicts two different networks connected through wireless link; n2 and n3 are the main the servers and are linked via wireless means. The two links; i.e. wired and wireless are with error model.

## *Model parameters*

Here, we specified the model state variables used to describe the abstracted environment in the NS2.

These are:

a) Bandwidth

In this study, it is believed that the bandwidth will be allocated sufficiently to meet the required transmission capacity. In networking, the transmission capacity of a computer or a communication channel is measured in megabits per second (Mbps)

Bandwidth = Packet size / time interval(1)

b) Throughput

This is a measure of the data-transfer rate through a complex communication or networking scheme. Throughput is considered as an indication of the overall performance of the system. In communications, throughput is usually measured as the number of bits or packets processed each second. For the purpose of this work, we used number of packets.

Throughput= Packet (Mb) / time (s)(2)

c) Elapsed Time (sec)

This is the time it takes a packet to travel from the source to the destination;

d) Time Received (sec)

The time at which the destination received each packet sent from the source;

e) Total sent (bytes)

The total packets sent will be determined after the required packets have been sent which will be noted;

f) Total received (bytes)

Due to the features of UDP, packet might be lost during data transfer;

g) Number of packets: total sent / packet size

h) Packet size (bytes)

The packet size will be determined during simulation in which it will be varied;

i) Header size (bytes): header size that the UDP protocol will add to each packet;

j) Total number of packet lost (bytes):

Due to the unreliability nature of UDP, packets could be lost;

k) Packets loss (packets): the system will compute the packet loss through a sink;

l) Percentage received (%): total received / total sent * 100%.

## System simulation and results analysis

The simulation was carried out with NS2 in conjunction with MATLAB 6.1. MATLAB 6.1 provides powerful tools for handling data with wide range of parameters under a graphical user interface that allows its objects to be explicitly described. We also used the MATLAB 6.1 to plot the graphs from the data generated from the NS2.

### *Tracing of Objects*

NS2 produced both the visualization trace in a graphical user interface as well as the ASCII text trace corresponding to the events registered at the network when tracing is used; it inserts four objects to the objects in the link: EnqT, DeqT, RecvT and DrpT as shown in Figure 4. EnqT registers information concerning a packet that arrives and is queued at the input queue of the link. If the packets overflow then information concerning the dropped packets is handled by DrpT. DeqT registers information at the instance the packet that is dequeued. RecvT gives information regarding information that has been received at the output of the link.

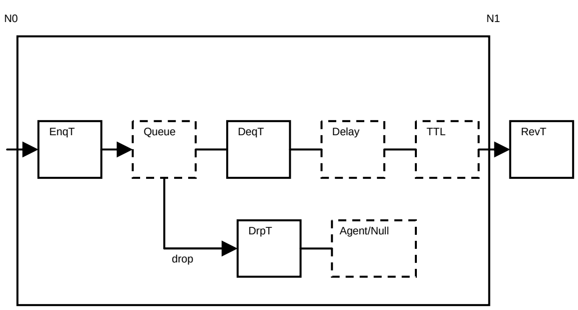


Figure 4: Tracing of Objects

The format of a trace file generated by the simulation follow the sequence below:

- The first field is the event type. It can have the values “r”, “+”, “-”, ”d” for “received”, “queue”, “dequeue”, and “dropped” and “r”, “s”, “f”, “D” for “received”, “sent”, “forward”, and “dropped” respectively;

- The second field gives the time at which the event occurs;
- The third field is the node number at which event occurs;
- The next field indicates the packet type, for instance MAC indicates if the packet concerns a MAC layer, AGT indicates the transport layer (for example, udp) packet, RTR indicates a routed packet and IPQ to indicate events related to the inference priority queue (like drop of packets);
- Then following is dashes, which is followed by the global sequence number of the packet;
- The field following gives more information on the packet type such as tcp, ack or udp;
- After this comes the packet size in bytes;
- Then comes the four numbers in square brackets concerning MAC layer information. The first hexadecimal number specifies the expected time in seconds to send the data packet over the wireless channel. The second number indicates the MAC-id of the sending node while the third is that of the receiving node. The fourth number specifies the MAC type (for wireless);
- The next numbers in the second square brackets concerns the IP source and destination addresses, then the “ttl” (Time To Live) of the packet;
- The third square brackets concern the UDP information: its sequence number.

Another information that is also present in the trace data file if the “Movement trace” is turned on has “M” as the first field, which indicates movement. Then the first number is the time, the second is the node number, then followed by the origin and destination locations and then the speed.

## *Performance Metrics*

The system simulation for the network models developed for both the wired and wireless networks are as shown in Figures 5 and 6 respectively. For the purpose of this work, we have used the following parameters to show the behaviour of UDP over IP-based wireline and wireless networks.

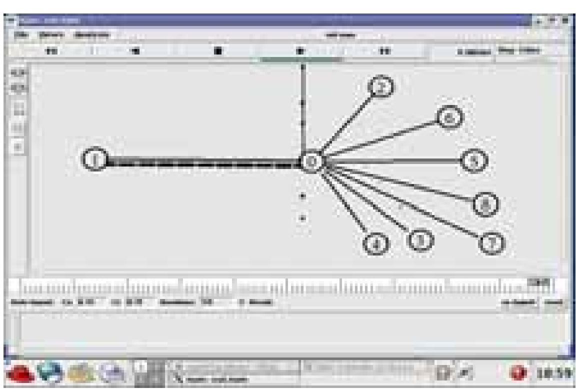

Figure 5: Packet Drop Indication from Wired Network Model

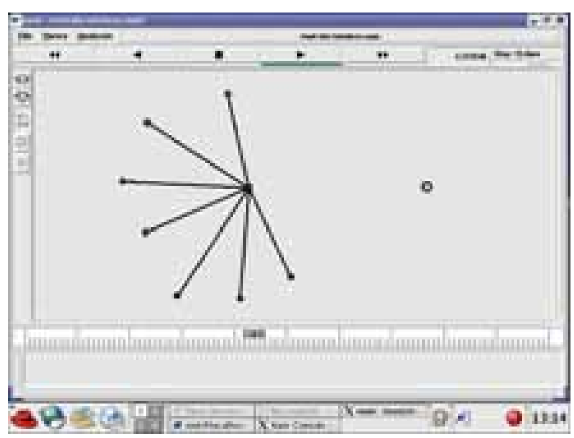

Figure 6: Simulation Interface for a Wireless Network Model

## Throughput/Packet Loss Analysis

Packet losses in the wired and wireless networks considered were obtained by extracting the dropped packets in the trace files generated by the simulations. The time at which each packet dropped was also extracted from the trace file and plotted against the effective throughput, which was calculated from the NS2 package called perl. This is as shown in Figure 7.

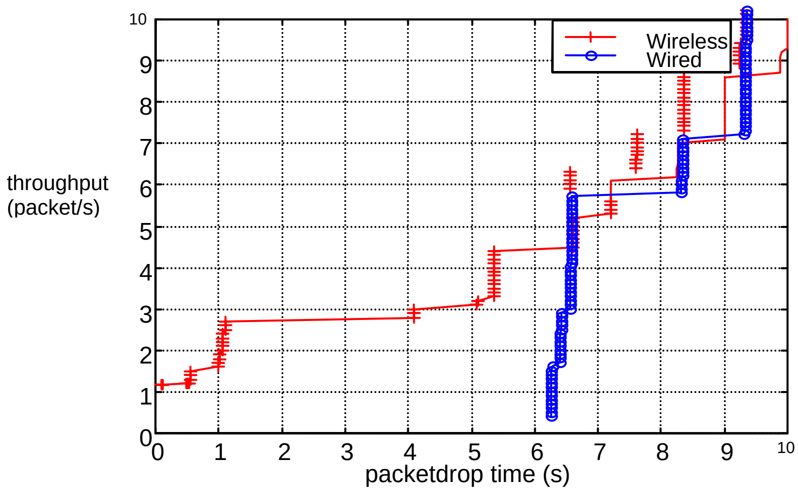


Figure 7: Throughput against Packet Drop on a Wired and Wireless Network

## Throughput/Bandwidth

The bandwidth was varied at intervals (i.e. 5, 10, 15. 20, 25, 30, 40, 50, 80, 100 Mbps) and were allocated sufficiently to meet the required transmission capacity. The following parameters were made constant throughout the simulation: packet size, and queue limit. The mean throughputs at each bandwidth intervals were taken into consideration. Figure 8 shows the graph of the effective throughput plotted against the bandwidth.

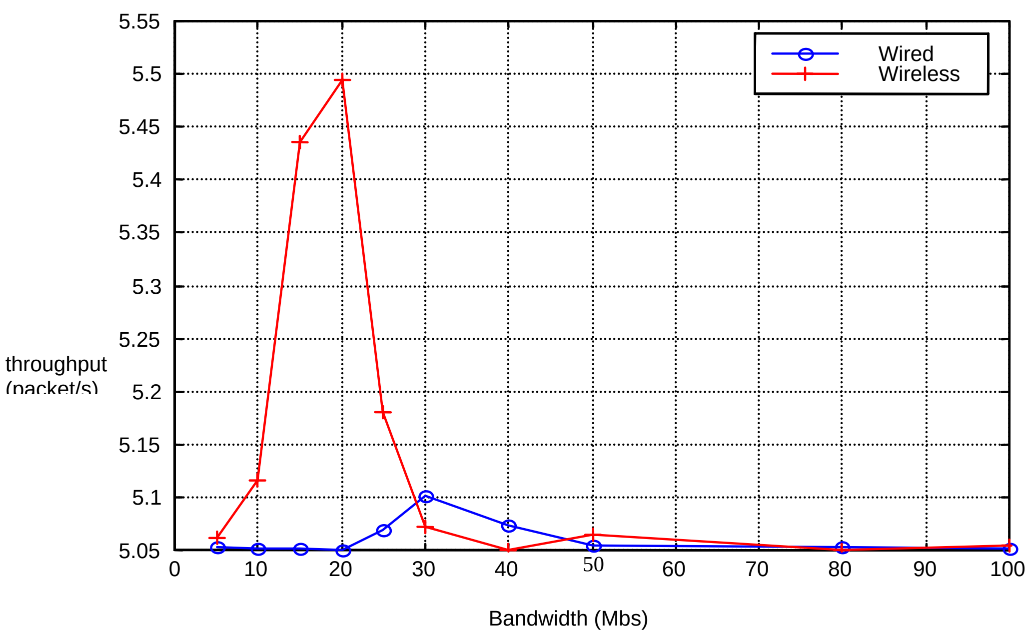


Figure 8: Throughput against Bandwidth on Wired and Wireless network

# Interpretation of Results

## *Effective Throughput vs. Packet drop time*

It can be seen clearly from Figure 7 that the packet drop in the wireless network occurred in the early time of 0.365182076s with a gradual increase while the time it occurred for the packet dropped for the wired network was at 6.805292s and thereafter it increases sharply. This shows that wired network has better throughput in terms of packet drop for connectionless data transfer.

## *Effective Throughput vs. Bandwidth*

Wireless network obtained its most effective throughput at 20Mbps; but as the bandwidth increases, a sharp drop in throughput occurred. Wired network obtained its most effective throughput at 30Mbps and thereafter, a linear drop in throughput as the bandwidth increases is observed as shown in Figure 8. This also shows that on wired link, UDP produces a fairly stable and uniform throughput as the bandwidth increases than the wireless network.

# Conclusion and Future Work

In this paper, we have investigated the performance of connectionless data transfer over IP-based wired and wireless networks using the Network Simulator 2 and MATLAB 6.1. Carrying UDP traffic over wireless networks often leads to severe degradation in throughput. Our results have amply demonstrated the fact that the most effective throughput for the two networks peaked at different times. In the wireless network, it is unreliable due to its sharp drop after it had reached the maximum. We have also found that the high throughput is as a result of the fact that UDP does not have flow control and it does not retransmit lost packets. In future, we will investigate the performance of UDP over Optical Packet Switched (OPS) networks. We will also consider the behaviour of TCP and more performance metrics will be used.

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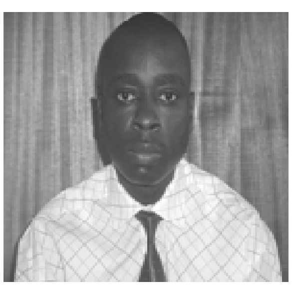
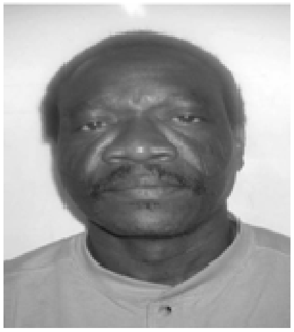
## Biographies

**G.A. Aderounmu** holds a research degree M.Sc./PhD in Computer Science from Obafemi Awolowo University, Ile-Ife, Nigeria (1997 and 2001, respectively). He is a member of the Nigerian Society of Engineers (NSE) and is also a registered computer engineer with Council for the Regulation of Engineering Practice in Nigeria (COREN). He is also a Member of Nigerian Computer Society (NCS) and Computer Professional Registration Council of Nigeria (CPN). He has over 13 years of experience in teaching and research. He is an author of many journal articles in Nigeria and abroad. His special interests include engineering education in Nigeria, curriculum development, and computer communication and network. He is a Visiting Research Fellow to the University of Zululand, Republic of South Africa. He is currently a Senior Lecturer, Deputy Director of the Information Technology and Communication Unit (INTECU) and the Acting Head of the Department of Computer Science and Engineering of the same university.



**A.A. Akintola** obtained his Bachelors and Masters degree in Computer Engineering and Computer Science from Obafemi Awolowo University, Ile-Ife, in 1994 and 2002, respectively. He is a registered computer engineer with Council for the Regulation of Engineering Practice in Nigeria (COREN) and also a member of Nigerian Society of Engineers (NSE). He is an author of many journal articles in Nigeria and abroad. His current research interests are in the areas of teletraffic engineering, mobile/nomadic computing, digital computer networks, hardware system studies, and computer modeling and simulation of streaming video. He is also into the areas of wireless IP networks, error control, and curriculum development. He has over 8 years of experience in teaching and research. He is currently a Ph.D. student and a lecturer at the Department of Computer Science and Engineering of the same university.



**M. O. Adigun** holds a research degree PhD in Computer Science from Obafemi Awolowo University, Ile-Ife, Nigeria which he obtained in 1989. Currently, he is a Professor and Head, Department of Computer Science, University of Zululand, Republic of South Africa. He is an author of many journal articles in Nigeria, Republic of South Africa and abroad. His research interests include Software Engineering, Mobile Computing, Modeling and Simulation, and Performance Analysis of Computer System.

**A.A. Owojori** obtained his Bachelor of Science degree in Computer Engineering from Obafemi Awolowo University, Ile-Ife, in 2005. He is a student member of Nigerian Society of Engineers (NSE). His current research interests are in the areas of computer communications and teletraffic engineering. He is also into protocols design and simulations of wireless communications. Mr. Owojori is currently on National Youth Service.