Telemedicine Available Bandwidth Estimation Simulation Model for Effective E-Health Services: Categories, Requirements and Network Application

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ABSTRACT

Available bandwidth is a time-dependent variable that defines the spare bandwidth in an end-to-end network path. Estimating available bandwidth (EAB) is an important and challenging task for providing QoS support in telemedicine networks. The aim of this study is to produce a simulation model that could assist the organization or country in estimating the network bandwidth requirements of its logistics for the telemedicine application, depending on the ability of exchange multimedia data. The study presents the simulation model for estimating the unexploited bandwidth in the system and simulation results of wired and wireless networks for the unused capacity in the normal network and the real network focused on finding out whether the egress rate of the telemedicine packets should be within the ingress rate. The results and the categories of the telemedicine packets the evaluation highlight accuracy that wired network environment provides more estimation available bandwidth comparable measurement to wireless networks.

Keywords: Available bandwidth, simulation model, network, categories, Tanzania

INTRODUCTION

Telemedicine tools enable the communication and sharing of medical information in electronic form. By this means telemedicine facilitates access to remote expertise hence increasing the availability of the expert services and saves lots of life. A physician located far from a reference center can consult colleagues in order to resolve a difficult case. These same tools can also be used to facilitate exchanges between centers of medical expertise and health institutions within countries and across borders.

Table 1. Application completion times at different connection speeds (Little & Venkatesh, 1994)

Application	*Network Download Speed*			
	4 Mbps	*10 Mbps*	*20 Mbps*	*50 Mbps*
Multi–point video conferencing	Not Adequate	Adequate	Adequate	Adequate
Download high–definition video	Not Adequate	Not Adequate	Adequate	Highly Adequate
Server backup (one terabyte capacity)	Not Adequate	Not Adequate	Not Adequate	Highly Adequate
Telecommuting	Not Adequate	Not Adequate	Not Adequate	Highly Adequate
Distance learning	Not Adequate	Not Adequate	Not Adequate	Highly Adequate
Telemedicine	Not Adequate	Not Adequate	Not Adequate	Highly Adequate

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Table 1 examines applications based on the amount of time it takes to complete tasks efficiently with different connection speeds. This information is adapted from research into the bandwidth requirements for a number of business–oriented applications (using the categories of highly adequate, adequate, and not adequate). For a file of any content up to two MBs, 20 seconds is considered highly adequate, 20–25 seconds is adequate, and more than 25 seconds is considered not adequate. For downloading larger files of any content up to two GBs, for example high–definition videos, a time of up to 10 minutes is considered highly adequate, 10–15 minutes is adequate, and more than 15 minutes is not adequate.

Video–Based Applications

One of the reasons advanced and mid–range applications require large amounts of bandwidth are the use of video and audio content. Video transfer is a component in many different applications. The focus here is on two prominent examples of entertainment–oriented applications, downloading media and online multiplayer games, and a business–oriented application, multi–point video conferencing.

Downloading Media

Downloading movies and TV shows is big business for companies like Netflix, Hulu, and Apple. However, all of these companies perform a balancing act between the quality of the video content provided and the amount of bandwidth consumed by the user (Saunders, McClure, & Mandel, 2012). These companies are concerned with bandwidth consumption due to some Internet service providers (ISPs) placing data caps on customers that consume more than a certain data amount each month. Application and software developers dedicate considerable time and resources to compressing video file sizes while maintaining a high level of image quality (Saunders, et al., 2012). The implementation of data caps varies by ISP and is a contentious issue (Fitchard, Olivera, Reckwerdt, & Mackie, 2002). Apple provides customers with a general guide to file sizes and download times of different types of media for the purposes of managing data usage (Apple, 2012). Table 2 provides these file sizes and their download times for different types of media on networks with speeds of 4, 10, 20, and 50 Mbps (Organization et al., 2009).

Table 2. Entertainment media file sizes and download times at different connection speeds (Chand, Breton, Caldwell, & Holburn, 1997)

Media Type and File Size		*Network Download Speed*			
Type	*Size*	*4 Mbps*	*10 Mbps*	*20 Mbps*	*50 Mbps*
four–minute song	4 MBs	7.6 seconds	3 seconds	1.5 seconds	0.6 seconds
five–minute video	30 MBs	57 seconds	22.9 seconds	11.4 seconds	4.5 seconds
nine–hour audio book	110 MBs	3.4 minutes	1.4 minutes	42 seconds	17 seconds
35–minute TV show	200 MBs	6.4 minutes	2.5 minutes	1.27 minutes	30 seconds
45–minute HD TV show	600 MBs	19 minutes	7.6 minutes	3.8 minutes	1.5 minutes
two–hour movie	1.5 GBs	47.6 minutes	19 minutes	9.5 minutes	3.8 minutes
two–hour HD movie	4.5 GBs	2.3 hours	57 minutes	28.6 minutes	11.4 minutes

A few seconds difference might seem trivial, but usability studies suggest each second it takes a user to accomplish a task with an application is a critical factor in user adoption and continued use (Lehto et al., 2008). Often the download times for the larger TV and movie

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files are obscured by the fact that users can view the beginning of the videos while they are downloading. Even then, however, the user might experience a delay or interruption in delivery of the show or movie. This is referred to as network latency and there are many other factors that influence a network's latency in addition to bandwidth, such as the distance a signal travels or the operating system on individual personal computers (PCs) (Yee & Mitchell, 1991). Reduced latency is one of the main benefits of a broadband connection and large amounts of bandwidth are required to limit interruptions in service (Rutter et al., 2011). Latency is a major issue in interactive broadband applications such as multiplayer online gaming and video conferencing, discussed below.

Telemedicine

Application of information technologies to the healthcare field has been slow and relatively haphazard compared to other major industries (Zanaboni & Lettieri, 2011). The size, complexity, and number of stakeholders involved in the healthcare industry make it difficult to develop content and delivery standards for data (Health, 2000). Telemedicine is a general term used broadly to describe the use of any information technologies to provide clinical services to patient for healthcare, such as videoconferencing (Ackerman et al., 2010).

The American Recovery and Reinvestment Act (ARRA) of 2009 amended the Health Insurance Portability and Accountability Act (HIPAA), the main law regulating health information technology, to require the Department of Health and Human Services (HHS) to develop standards, implementation specifications, and certification criteria for health information technologies to achieve wider use of technology in the health care industry, such as through health information exchanges (HIEs) (Health, 2000). To illustrate the speed requirements needed for a health information exchanges, Table 3 provides some applications represent samples of activities typical of healthcare facilities of approximate download times to complete the transmission and download times at different network speeds. The sizes are based upon actual samples; the volumes and transmit and download times are dependent upon is organizational needs. Individual healthcare facilities may use all, some, or none of these in addition to other network uses required for their business operations.

Table 3. File size, transmission and download times at different connection speeds (Akyildiz, Melodia, & Chowdhury, 2007; Campista et al., 2008; Hu, Wang, & Wu, 2006; Huston, 2008)

File type and size		*Network transmission speed*			
Type	*Size*	*4 Mbps*	*10 Mbps*	*20 Mbps*	*50 Mbps*
High Definition Video Conferencing	1.9 MBs	23.8 seconds	9.5 seconds	4.8 seconds	1.9 seconds
TelePathology	3 MBs	2.3 seconds	0.9 seconds	0.5 seconds	0.2 seconds
TeleDiabetic Retinopathy Screening	5 MBs	6.2 seconds	2.5 seconds	1.2 seconds	0.5 seconds
Computerized Radiography (CR)	10 MBs	25 minutes	10 minutes	5 minutes	2 minutes
Digital chest film	20 MBs	38 seconds	15 seconds	7.6 seconds	3 seconds
Mammography	160 MBs	5 minutes	2 minutes	1 minute	24.4 seconds
MRI study	200 MBs	6.3 minutes	2.5 minutes	1.2 minutes	30.5 seconds
Echocardiogram study	4 GBs	2.1 hours	50.8 minutes	25.4 minutes	10.1 minutes

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According to the requirement of telemedicine network as per result obtained of this study should only facilitate learning through the exchange, transfer and distribution of medical information/knowledge, the generation and dissemination of new knowledge about how to collaborate effectively by the use of telemedicine, and the application of this knowledge in telemedicine practice.

DATA ANALYSIS AND MODEL CONSTRUCTION

To ensure the model's flexibility, the following parameters were established; by using them, the model's variables information can be altered, in order to adapt it to the different conditions that could be presented by the region where the program is applied.

Parameters

This parameter considers the number of hours available of unutilized capacity in the system (Bandwidth) especially in the normal network operating base in Nelson Mandela African Institution of Science and Technology. In this parameters shows that as per data obtained from the midnight up to 0600am the TelePathology program it can be operated, form 0700am up to 11am, it is adequate for High Definition Video Conferencing, from 1200am up to 1400pm, also it is adequate High Definition Video Conferencing, from 1500 pm up to 1600pm Not Adequate for the telemedicine services, from 1700pm up to 2300pm it is adequate High Definition Video Conferencing.

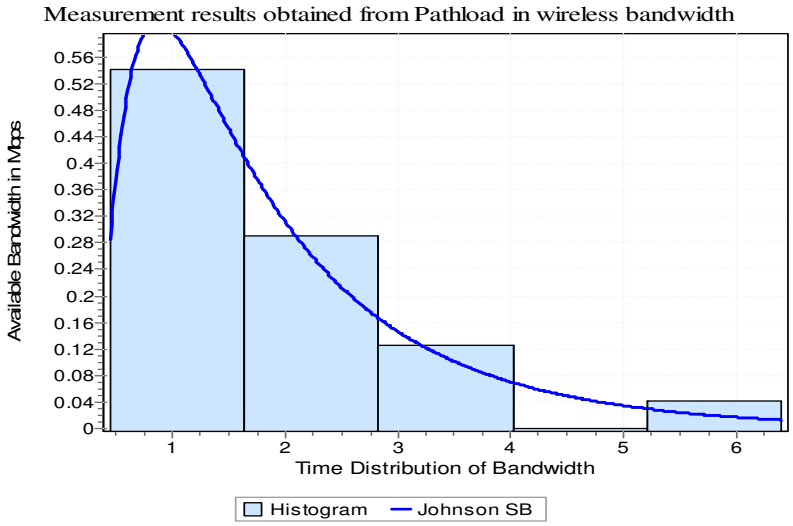

Figure 1. Measurement result obtain from Pathload in wireless bandwidth

The second parameter is the gap model shows that the initial probing gap is a critical parameter when using packet pairs to estimate available bandwidth. Based on this insight, we present two available bandwidth measurement techniques, the initial gap increasing (IGI) method and the packet transmission rate (PTR) method. We use extensive Internet measurements to show that these techniques estimate available bandwidth with the respect to the number of hours, 0600am the TelePathology program it can be operated, form 0700am up to 11am, it is adequate for High Definition Video Conferencing, from 1200am up to 1400pm, also it is adequate High Definition Video Conferencing, from 1500 pm up to 1600pm Not Adequate for the telemedicine services, from 1700pm up to 2300pm it is adequate High Definition Video Conferencing.

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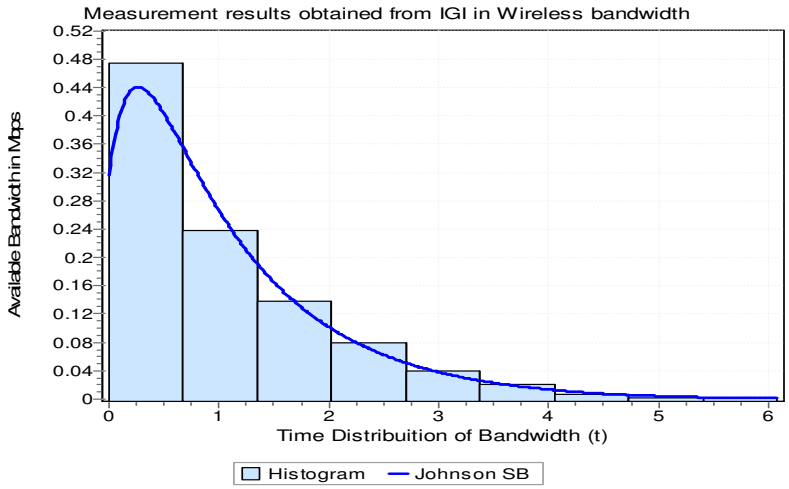

Figure 2. Measurement Result obtain from IGI in wireless bandwidth

This parameter considers the *pathChirp,* a light-weight active probing tool for estimating available bandwidth, Metrics such as round-trip time and tests using small files usually select servers that are two to three times worse than the best server. Inferring the unused capacity *or* available bandwidth.

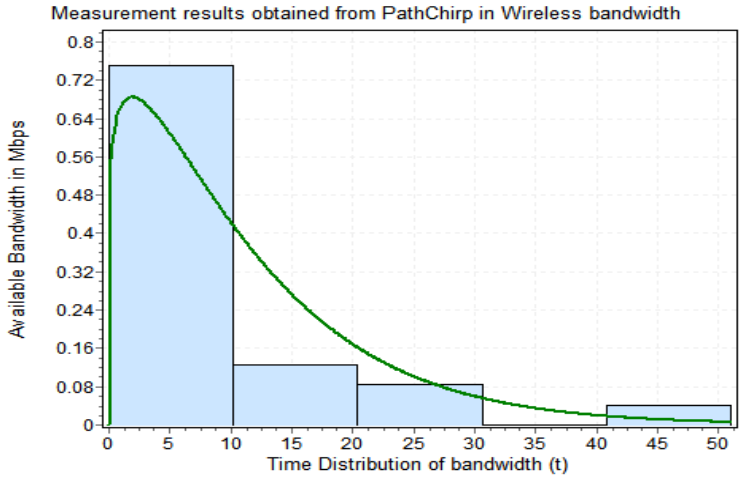

Figure 3. Measurement result obtained from Pathchirp in Wireless bandwidth

A PROPOSED AVAILABLE BANDWIDTH ESTIMATION SIMULATION MODEL

Introduction

Simulation Modeling

It is the procedure of creating and analyzing a conceptual design, engineering, manufacturing, and the ability to virtually explore a complete product before it's built a physical model to predict its performance in the real world. Model is a representation of the construction and working of some system of attention. One reason of a model is to facilitate the analyst to forecast the effect of changes to the system. A model should be a close approximation to the real system and incorporate most of its most important features. The model should not be so complex that it is impossible to understand and experiment with it. A good quality model is a well thought out tradeoff between practicality and simplicity.

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In this dissertation, we introduced the simulation model for estimating the unexploited bandwidth (unused capacity) in the system that could assist the organization or country in estimating the network bandwidth requirements of its logistics for the telemedicine application, depending on the ability of exchange multimedia data.

Related Work

This section reviews the research work related to the simulation model. Much work has been done in the bandwidth estimation area during the recent years but not on the unutilized capacity.

Existing System

There is an importance of understanding the existing system, in this type of network, some of the main or more frequently used networks are DIT, Muhimbili national hospital and Mwananyamala are connected to each other like a mesh network. The Hospital terminals are attached to the main terminal. The topology of the network requires that every terminal be connected to every other terminal in network. This network currently facilitates only learning through the exchange, transfer and distribution of medical information/knowledge, the generation and dissemination of new knowledge about how to collaborate effectively via telemedicine, and the application of this knowledge in telemedicine practice

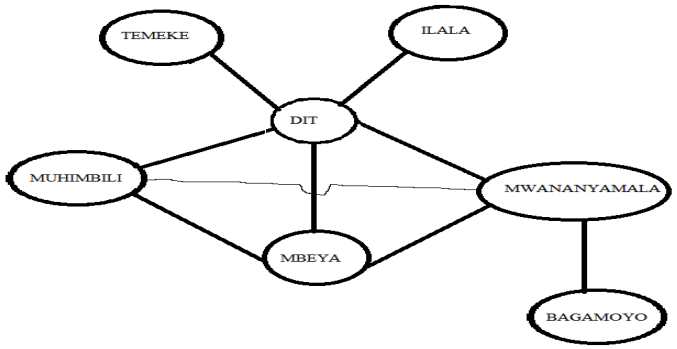

Figure 4. Existing Block Diagram Depicting for Telemedicine Network

The topology incorporates a unique network design in which each hospital on the network connects to every other, creating a point-to-point connection between every device on the network. The purpose of the design is to provide a high level of redundancy. If one network cable fails, the data always has an alternative path to get to its destination, the connection are Muhimbili national hospital, Mwananyamala Regional Hospital, Amana Regional Hospital, Temeke Regional Hospital, Bagamoyo District Hospital and Mbeya Referral Hospital, These are the regional hospitals and referral Hospitals, the services are offered from Muhimbili National Hospital these are the physical findings per a very week, therefore the session is conducted as per time table given below for demonstration and the instruction how to cure that diseases:

Table 1. Muhimbili National Hospital Case Presentation Timetable – Weekwise

Day	*Department Case Presentation*	*Time*
Monday	Surgery	7:00am-9:00am
Tuesday	Internal Medicine	8:00am–9:00am
Wednesday	Cardiac	8:00am -9:00am
Thursday	Emergency Medicine	7:30am- 8:30am
Friday	Pediatric and Child Health	8:00am -9:00am

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The problem of packet loss is modeled as a reduction in available bandwidth have been reported by (Kim & Shin, 2002; Smedley & Cuk, 1995) . Have been reported by (Smedley & Cuk, 1995) and hence, as shown in figure below, lost packets are treated as delayed due to insufficient bandwidth. When bandwidth does become available, delayed packets are sent in bursts at a rate equal to the available bandwidth until the buffer is filled again.

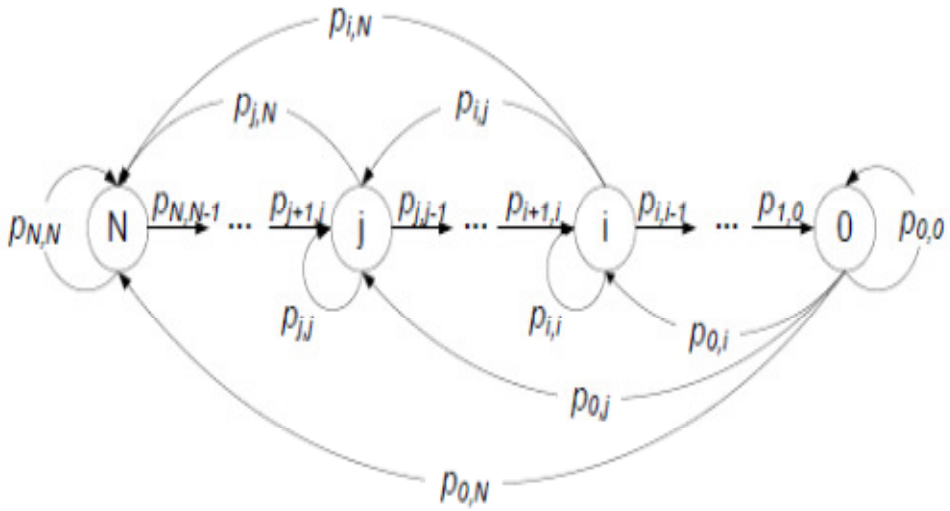

Figure 5. States of Buffer model

The model with the overlay topology was studied by (Zhu, Dovrolis, & Ammar, 2006) for enhancing the reliability and performance of IP networks. It has been reported by (Conklin, Greenbaum, Lillevold, Lippman, & Reznik, 2001) the demonstration based on the allocation model (live or on-demand), the type of the network delivery mechanism (unicast versus multicast), and optimization criteria connected with particular sections of the network (e.g., minimization of distortion for a given connection rate, minimization of traffic in the dedicated delivery), it is possible to identify several models of communication that may require different treatment from both source and channel coding perspectives.

PROPOSED SYSTEM APPROACH TO SIMULATION MODEL

We propose a new approach to estimate the unused capacity of bandwidth in the network by producing a simulation model that could assist the organization or country in estimating the network bandwidth requirements of its logistics for the telemedicine application, depending on the ability of exchange multimedia data.

In order to accomplish the intended objectives, the system must give reliable support for the logistics function in the organization. The system users should be able to get the information they need in a timely manner, hence it should be possible for supervisors to establish a certain level of confidence in the system and its availability and response time. This condition translates into minimizing delays in response time and staying away from bottlenecks and traffic congestion at critical links. Two major indicators provide insight into these aspects of the system behavior: the total delay (the time it takes each message to arrive at the central server) and the utilization of the router link. By observing these two issues in different usage scenarios, the supervisor can get a clear idea about the behavior of the system and the things that have the greatest influence in changing this behavior.

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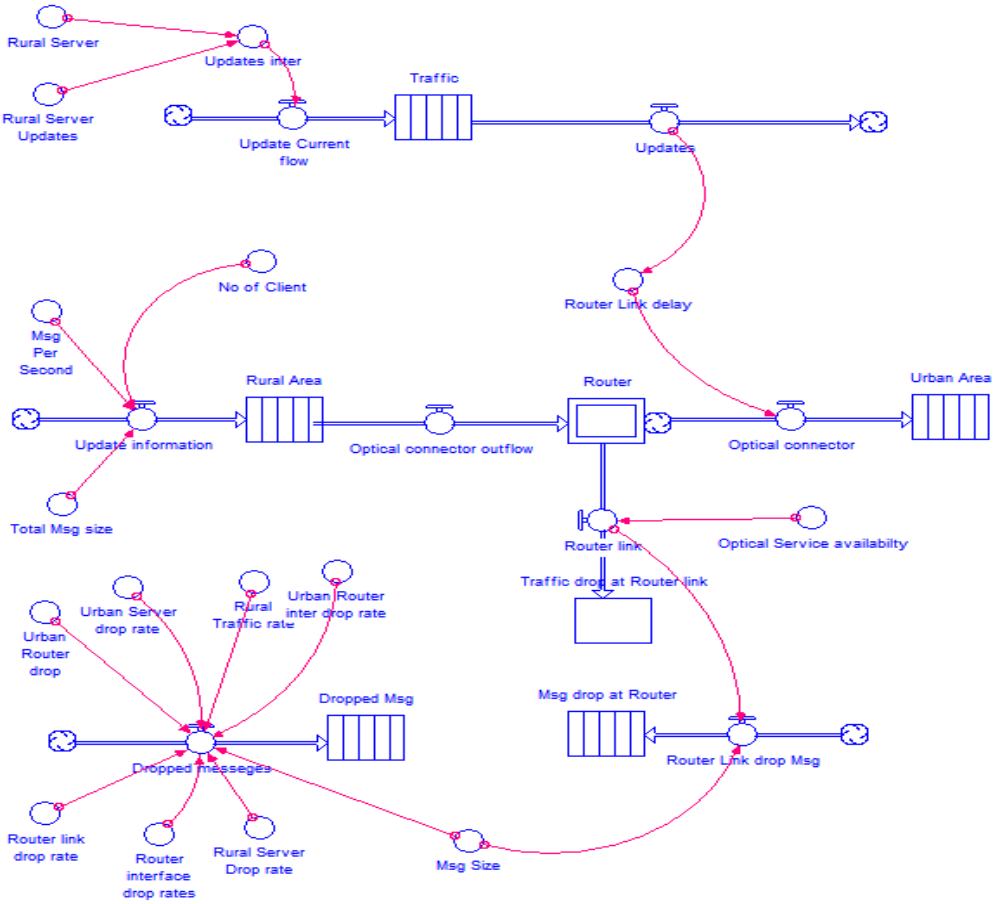

Figure 6. Available Bandwidth Estimation Model

CONCLUSION

Finally, the report presented bandwidth simulation model methods in both wired and wireless networks. To find these distributions the software program Stat Fit was used and Stella version software for simulation model. The model was run several times in order to achieve its stability. In order to validate the model against the actual situation, the results obtained by simulating were compared against the data collected of the experiment in the laboratory. The results of the evaluation highlight accuracy that wired network environment provides more estimation available bandwidth comparable measurement to wireless networks. The logistics could cater implementation of low cost for the telemedicine applications

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