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Full Length Research Paper

Performance Evaluation of UDSM Network to Deliver Multimedia eLearning Contents: Case of CoICT

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ABSTRACT

The use of technology in education in Sub-Saharan Africa has been reported to be hindered by many factors including inadequate Information and Communication Technology (ICT) infrastructure, low internet speed, and lack of skills to use educational technologies. This paper aim at evaluating how the available ICT infrastructure at the College of Information and Communication Technologies (CoICT) can support, with acceptable Quality of Service (QoS), the delivery of multimedia applications for eLearning services. The evaluation was performed over a network testbed implemented in a computer laboratory for wired and wireless connections. The testbed consisted of five personal computers (PCs) connected via a switch and a router to the internet for the wired connection. The wireless connection consisted of three PCs and a laptop connected through a switch and a router to the internet via a wireless access point. Four different multimedia applications were run through the PCs, and traffic data was mirrored and captured at one of the PC using Wireshark network analyzer. The traffic included streamed and conversational video and audio using YouTube and Zoom applications, respectively; interactive web browsing using web browsers; bulk file transfer, and a mixture of all applications running on the computers. Traffic data captured during the running of these applications were packet loss, delay, jitter, and throughput. The QoS performance parameters obtained were within the acceptable threshold values as per International Telecommunication Union, Telecommunication Standardization Sector (ITU-T) values. Results revealed that ICT infrastructure at CoICT can support delivery of multimedia content for eLearning purposes for both wired and wireless connections. Having the infrastructure capable of supporting multimedia applications with the acceptable QoS implies that instructors are equipped with a conducive environment that supports multimedia application. Hence, they are expected to use and continue using educational technologies to facilitate teaching and learning processes.

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INTRODUCTION

Educational technology (commonly abbreviated as edutech, or edtech) is the combined use of computer hardware, software, educational theory and practices(pedagogies) to facilitate learning. It is a practice of leveraging Information and Communication Technologies (ICTs) to support or facilitate teaching and learning processes (Rumney, 2019). The uptake and use of educational technologies in Higher Education Institutions (HEIs) in Sub-Saharan Africa have been very low despite the availability of thousands of open educational resources (OER) in the public domain (Mtebe & Raisamo, 2014), Massive Open Online Courses (MOOCs) (Liyanagunawardena, 2015), and free and open source systems such as Moodle Learning Management System (LMS) (Reddy & Devi, 2020). These resources can potentially improve teaching and learning processes. Some of the reasons for slow uptake and use of educational technologies have been mentioned in the literature as lack of access to ICT infrastructures such as computers and internet, low internet bandwidth/speed, and lack of skills to create and/or use educational technologies (Mtebe & Raisamo, 2014).

Educational technologies include multimedia systems and content. Multimedia systems combine two or more of the following types of media contents: text, still images, audio, video and animation (Pavithra et al., 2018). To have an effective multimedia system for delivery of learning contents, multimedia applications have certain level of network requirements to ensure service delivery at an acceptable Quality of Service (QoS) (Leszczuk et al., 2016; ITU-T, 2001). The QoS of multimedia content and applications are also affected by performance of the underlying network in which the multimedia contents are transferred (Robitza et al., 2017; Vučević et al., 2007). Multimedia application performance can be measured by using key performance parameters such as throughput, packet loss, jitter and delay (Hillestad et al., 2005). Service quality guarantees are typically achieved via providing one or more of the following four characteristics. A guarantee of delay assures the sender and receiver that it will take no more than a specified amount of time for a packet of data to travel from sender to receiver. A guarantee of loss assures the sender and receiver that no more than a specified fraction of packets will be lost during transmission. A guarantee of jitter assures the sender and receiver that the delay will not vary by more than a specified amount. Finally, a guarantee of throughput assures the sender and receiver that in some specified unit of time, no less than some specified amount of data can be sent from sender to receiver.

Since low internet bandwidth/speed has been mentioned in the literature as one of the reasons that hinders the usage of educational technologies in HEIs, it is inherent to investigate the performance of networks through which educational technologies are connected to be accessible by users in order to establish its effect on the multimedia QoS. Therefore, this paper explores the contribution of network performance as a factor that hinders usage of educational technologies for e-learning. The study evaluated network performance on multimedia QoS over a real wired and wireless network testbed set/implemented for this purpose.

BACKGROUND

Broadband heterogeneous networks are an essential requirement for delivery of multimedia applications. These applications consist of a collection of multiple media sources, e.g., text, graphics, images, sound/audio, animation and video. Multimedia applications are useful for delivering services in different sectors such as education (online and distance electronic learning), business (e-commerce), health (e-medicine/telemedicine), agriculture (e-agriculture), and communication (video conferencing), to mention a few (Mukherjee & Parekh, 2008; Nallusamy et al., 2015; Pavithra et al., 2018; Savov et al., 2019). The quality of multimedia applications, also referred to as quality of service (QoS), is measured in terms of key performance parameters, which are delay, loss, jitter and throughput, hence the quality of multimedia applications rely on the nature and characteristics of the underlying networks over which they are delivered. The acceptable values of the key performance parameters as defined by the

International Telecommunication Unit-Telecommunication Standardization Sector (ITU-T) for each traffic type are as shown in Table 1 (ITU-T, 2001).

Table 1: Multimedia Applications Key Performance Parameters (ITU-T, 2001)

S/N	Traffic type	Medium	Application	Degree of Symmetry	Typical Data rates /Amount of data	Key performance parameters and target values		
						End-to-end one way delay	Delay variation within a cell	Information Loss
1	Conversational/Real-Time Services	Audio	Conversation voice	Two-way	4 - 64 kbps	<150 ms preferred <400 ms limit	<1 ms	< 3% packet loss
		video	Videophone	Two-way	16 – 384 kbps	<150 ms preferred <400 ms limit		< 1 % packet loss
2	Interactive Services	Audio	Voice messaging	Primarily one -way	4 – 32 kbps	<1s for playbacks <2s for records	<1 ms	< 3% packet loss
		Data	Web browsing	Primarily one-way	~ 10 KB	< 4 s/page	NA	Zero
		Data	Transaction services - High priority (e.g., e-Learning, e-Commerce, e-health)	Two-way	< 10 KB	< 4 s	NA	Zero
		Data	Background (Email, (Server Access)	Primarily one-way	< 10 KB	< 4 s	NA	Zero
3	Streaming Services	Audio	Speech, mixed speech and Music Medium to high quality music	Primarily one-way	16 – 128 kbps	< 10 s	<1 ms	< 1% packet loss ratio
		Video	Video clips, surveillance, real time video	Primarily one-way	16 - 384 kbps	< 10 s	<1 ms	< 1% packet loss
		Data	Bulk data transfer/retrieval	Primarily one-way	10 KB-10 MB	< 10 s	NA	Zero
		Data	Still image	Primarily one-way	< 100 KB	< 10 s	NA	Zero

The characteristics of traffic in multimedia applications, that is, varying over time and requiring strict quality levels, present a challenge on ensuring overall QoS of the multimedia applications during transmission over communication networks (Robitza et al., 2017; Vučević et al., 2007; Hillestad et al., 2005). Furthermore, due to the variability of networks via which multimedia traffic are delivered, guaranteeing QoS for multimedia applications or services is a challenging task (Robitza et al., 2017).

QoS of multimedia in wired and wireless networks

With an increasing amount of multimedia applications such as text, images, audio and video being sent over public packet-switched networks, the ability to provide QoS guarantees is important. Hence, research has been carried out to find ways of providing reliable network performance while at the same time efficiently utilizing the network resources (Okpeki et al., 2019; Peng et al., 2018; Akpah et al., 2017).

Reliable network performance has long been an important factor in the quality of many network applications. The challenges associated with providing quality service guarantees are numerous, but the biggest challenge for traditional wired networks has been congestion (Brown et al., 2020; Malhotra et al., 2011). When a network is congested, the end-to-end delay increases because the packet spends more time in the queue at each hop. Loss also increases because if a queue is full, it will start to drop incoming packets. This phenomenon also limits throughput since additional packets sent will just be dropped. Another difficulty involves multi-path routing. When two packets are sent, there is typically no guarantee that they will take the same path to the destination. If one path has more hops than the other or is more congested, the packets will not arrive at the destination at the same time. This uncontrolled routing can cause unacceptable delay or jitter (Mesbahi & Dahmouni, 2016; Pucha et al., 2007). However, in addition to congestion, many more challenges exist for wireless and mobile networks. Multimedia applications' QoS challenge in wireless mobile networks is a severe loss (Mesbahi & Dahmouni, 2016; Marriswamy & Roogi, 2014; Pucha et al., 2007). Loss in wired networks is typically caused by excessive congestion that causes packets to be dropped at routers in the network. A negligible amount of data is lost due to corruption during transmission on a wire. The situation is quite different in a wireless network, which typically suffers much more loss due to data being corrupted during transmission. One cause of loss in wireless transmission is fading, in which multiple versions of the same signal are received at the destination (Popa et al., 2008; Puccinelli & Haenggi, 2006). If these signals are out of phase with each other or Doppler-shifted, they can interfere with each other. Another obstacle in wireless QoS involves propagation delay (Ezdiani & Al-Anbuky, 2015; Krivchenkov & Sedykh, 2015). Some wireless networks span distances that are measured in kilometers. In these networks, propagation delay can be a tremendous burden to all communication, but especially to communication that requires a guarantee on total delay. For this reason, it is important to study separately performance of wired and wireless networks on provision of multimedia application QoS.

Using ICT in Education at the University of Dar es Salaam

The University of Dar es Salaam (UDSM) has strategically decided to adopt and use ICT in providing competitive academic programs, increase institutional reputation, and attract research funding and new partnerships. The move by the university towards greater use of technology in its teaching and learning processes was already envisioned in the university vision 2061 (UDSM, 2014) and the Five-Year Rolling Strategic Plan (FYSRP) 2020/2021–2024/2025 (UDSM, 2020). For instance, the University vision 2061 indicates the university needs to harness the full potential of ICT to transform UDSM into an e-University in terms of IT infrastructure and services. The Five-Year Strategic Rolling Plan identifies technology-enhanced learning as one of the delivery strategies and incentives to be strengthened by June 2023. Recently, the university has also reviewed ICT policy, ICT Master Plan, ICT and ICT Security Policy in order to create a conducive environment for the wider adoption and use of digital technologies.

The University undertook several initiatives and projects to address the challenge that might hinder its mission to become an e-ready University. Some of the initiatives are the significant investment in implementing ICT infrastructures, insisting on the use of ICT in teaching and learning (Technology enhanced teaching and learning processes), and capacity building in ICT literacy. Despite having prior expertise with digital technologies and ICT infrastructure, the University was unable to continue teaching her programs online during the COVID-19 pandemic lockdown because not all academic staff were using digital technologies prior to the pandemic.

Mtebe and Gallagher (Mtebe & Gallagher, 2022) reported an audit conducted in June 2020 on the ICT infrastructure, digital teaching and learning technologies, and instructors' skills gap, which recommended Moodle, the Postgraduate Information Management System (PGMIS), and Zoom conferencing applications as key digital technologies to use for enhancing teaching activities during the pandemic. Following the audit, 340 academic staff were trained to use these tools. Because some staff were already familiar with these tools, the number of Moodle and PGMIS courses grew by 50% after the training (Mtebe et al., 2021). Although regular face-to-face classes resumed when the institution reopened in June 2020, instructors have continued to employ digital tools to supplement face-to-face teaching and postgraduate student supervision. Research reveals that it is common in African universities for instructors to stop using digital technologies or use relatively few features after initial adoption (Bagarukayo & Kalema, 2015; Mtebe, 2015). Therefore, the unwillingness to continue using digital technologies beyond the initial adoption stage is a common phenomenon shared globally (Sørebø et al., 2009).

Because there is a mismatch between the investment being done by the UDSM and the usage of educational technology among instructors, it calls to investigate the reasons that hinder instructors to use and continue using educational technologies. Mtebe and Raisamo (Mtebe & Raisamo, 2014) claimed that lack or limited access to infrastructure, low Internet speed, and lack of skills to create and/or use educational technologies contribute to reasons that hinder instructors from using educational technologies. This study seeks to establish whether the performance of wired and wireless UDSM networks lead to poor QoS of multimedia applications, resulting to low usage of educational technologies by instructors.

METHODS AND MATERIALS

Network testbed setup and implementation

A real-world testbed was implemented, which emulated an all-IP heterogeneous network that included two scenarios: a wired and a wireless network for a Local Area Network (LAN). The LAN consisted of end user PCs and a switch, a gateway/router, and an Internet connection via an Internet Service Provider (ISP).

The following software were used to provide multimedia application traffic and facilitate capturing key performance parameter values for each multimedia traffic type transmitted via the implemented real-world testbed for QoS evaluation:

1. YouTube social media channel was used for audio and video streaming.
2. Zoom web conferencing software was used to facilitate conversational video and audio.
3. Chrome and Microsoft web browsers installed in PC1, PC2, PC3, and PC4 respectively were used to access various web pages interactively.
4. Bulk file transfer was done by downloading a file from the internet

with the size of 21 MB using a web browser.

5. Wireshark, an open-source network protocol analyzer, was used to capture traffic data from the set-up network for the purpose of evaluating network performance in delivery of multimedia applications.

Wired network setup

An isolated network was set up and consisted of five PCs connected using a switch, which connected to the Internet via a router (Figure 1). Each PC is a desktop computer running Windows OS with Intel core i3 processor and 4 GB RAM. Performance measurements were captured using Wireshark installed in PC5, which mirrored multimedia application traffic running in PCs 1-4. The applications were each run for an average of five (5) minutes. The applications included audio and video streaming using YouTube application; conversational video and audio using Zoom meeting application; interactive web browsing using web browsers, and bulk file transfer (download) using web browsers. This type of set-up imitates a typical multimedia application environment such as e-learning in which traffic may consist of a combination of any of the applications. The last experiment consisted of all PCs running all multimedia applications, and traffic was mirrored to PC5 which captured performance data.

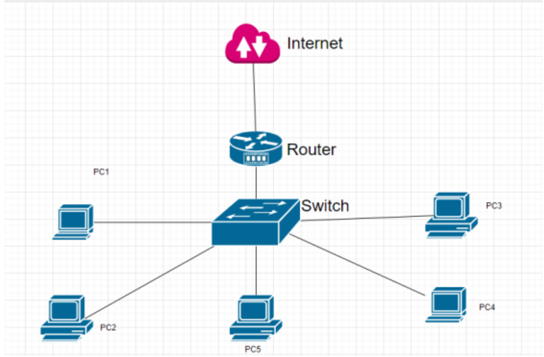

Figure 1: Wired network setup.

Test scenarios included the following applications:

1. Video and audio streaming: PC1 to PC4 were running video and audio streaming simultaneously using a YouTube application. PC5 had Wireshark installed in it and it mirrored the traffic from all PCs (PC1-PC4). Packets were captured for each PC for network performance evaluation.
2. Conversational Audio and Video: PC1 to PC4 were running conversational video and audio using the Zoom meeting application. PC1 is the host to the meeting and all other PCs (PC2-PC4) joined the meeting and traffic from each PC was mirrored to PC5 for packet capture.
3. Interactive web browsing: PC1 and PC2 had Chrome browser installed in them, while PC3 and PC4 had Microsoft Edge browser installed in them. All PCs (PC1-PC4) were accessing various interactive web pages using their respective browsers. Traffic from all PCs were mirrored to PC5 for packet capture.
4. Bulk file transfer: PC1 to PC4 were concurrently downloading the same file of size 21 MB from the Internet via web browsers. Traffic from all PCs were mirrored to PC5 for packet capture.
5. Mixed services: All PCs concurrently joined the zoom meeting application, performed file download via web browsers, accessed Youtube videos and browsed different web pages using web browsers. Traffic from all PCs was mirrored to PC5 for packet capture.

Wireless network setup

A wireless network consisting of three PCs and a laptop was set up. The PCs (PC1-PC3) were desktop computers with Intel core i7 8th generation with 64-bit processor and 4 GB RAM (Figure 2) while the laptop had Intel core i7 3rd generation 64-bit processor with 12 GB RAM. Each PC and the laptop had Wireshark installed, and joined the wireless network advertised by the wireless access point. The same applications used in the wired setup were run in the wireless network. Data capture was done at each PC and the laptop for network performance evaluation.

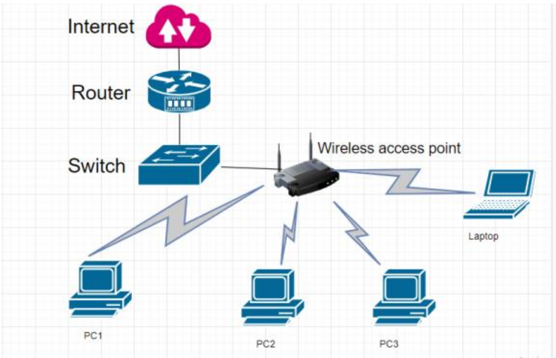

Figure 2: Wireless network setup.

Test Scenarios included the following applications:

1. Video and audio streaming: PC1 to PC3 and the laptop streamed audio and video using YouTube application. With Wireshark installed in all devices, traffic is captured independently in each device for performance evaluation.
2. Conversational audio and video: PC1 hosted a Zoom meeting, and PC2, PC3 and the laptop joined the application. With Wireshark installed in all devices, traffic is captured independently in each device for performance evaluation.
3. Interactive web browsing: All PCs and the laptop accessed various web pages randomly using web browsing, and using Wireshark, traffic is captured independently in each device for performance evaluation.
4. Bulk file transfer: All PCs and the laptop downloaded the same file of size 21 MB from the Internet using web browsers. Traffic was captured in each device for performance evaluation.
5. Mixed services: All PCs and the laptop were running Zoom meeting, downloading a file, streamed audio and video via Youtube, and accessed web pages using web browsers. Traffic was captured in each device for performance evaluation.

RESULTS AND DISCUSSIONS

Tables 2(a) and 2(b) show results of data captured from PC1-PC4 via PC5 for the wired network setup. Parameters captured included packet loss measured in percentage; delay measured in seconds; jitter measured in seconds, and throughput measured in kilobits per second. Tables 3(a) and 3(b) show data captured from PC1-PC3 and the laptop for the wireless network setup. The same parameters were captured for this set up, i.e., packet loss, delay, jitter, and throughput.

Table 2(a): Wired Network Measurements (PC1 & PC2)

	PC1				PC2			
Application	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**
Conversational Video and Audio (Zoom)	2.67	0.00371	0.00623	491	9.26	0.0093	0.0141	384
Interactive Web Browsing	23.99	0.00872	0.01317	348	33.5	0.007	0.018	550

Streaming Audio and Video (YouTube)	5.3	0.00947	0.0147	371	6.99	0.0109	0.0173	291
Bulk Data Transfer	22.69	0.01451	0.03629	191	21.9	0.0202	0.0495	154
Mixed Services	4.44	0.0045	0.00721	828	6.42	0.0059	0.0093	773

Table 2(b): Wired Network Measurements (PC3 & PC4)

	PC3				PC4			
Application	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**
Conversational Video and Audio (Zoom)	10.36	0.00865	0.01298	385	23	0.0135	0.0206	169
Interactive Web Browsing	2.5	0.02047	0.02975	192	31.1	0.0168	0.0241	124
Streaming Audio and Video (YouTube)	8.3	0.00518	0.00823	888	5.98	0.0078	0.0114	508
Bulk Data Transfer	13.7	0.0116	0.02904	258	22.3	0.0129	0.0272	325
Mixed Services	5.18	0.00761	0.03091	585	3.79	0.0036	0.0088	1303

Table 3(a): Wireless Network Measurements (PC1 & PC2)

	PC1				PC2			
Application	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**
Conversational Video and Audio (Zoom)	3.72	0.005444	0.00621	666	17.97	0.007316	0.011564	385
Interactive Web Browsing	19.49	0.008648	0.021383	439	19.31	0.008108	0.012085	441

Streaming Audio and Video (YouTube)	8.92	0.00768	0.01637	521	18.95	0.007529	0.011243	512
Bulk Data Transfer	49.05	0.009645	0.024589	411	36.2	0.00826	0.01214	321
Mixed Services	6.807	0.003081	0.00747	504	12.86	0.007091	0.011123	455

Table 3(b): Wireless Network Measurements (PC3 & Laptop)

	PC3				**Laptop**			
Application	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**	**Loss (%)**	**Delay (s)**	**Jitter (s)**	**Throughput (kb/s)**
Conversational Video and Audio (Zoom)	10.23	0.06378	0.08314	322	14.2	0.00642	0.01201	452
Interactive Web Browsing	18.72	0.00712	0.01152	403	21.3	0.00731	0.03821	362
Streaming Audio and Video (YouTube)	11.2	0.006853	0.01261	580	13.8	0.00653	0.01164	488
Bulk Data Transfer	42.6	0.008361	0.01423	389	38.9	0.00868	0.01843	404
Mixed Services	8.3	0.00586	0.09721	608	12.6	0.00621	0.01452	435

RESULTS DISCUSSION

Table 4 shows the average performance parameters for the wired network in terms of packet loss, delay, jitter and throughput. From the results, the average loss for conversational audio and video, streaming video and audio and mixed services (UDP traffic) is lower than that of the interactive web browsing and bulk file transfer (TCP traffic) applications. This is because during transmission, UDP traffic does not employ flow control as done in TCP traffic, hence TCP traffic experience higher packet loss (Al-Dhief et al., 2018; Gupta et al., 2004; Bolot, 1993). Similarly, the average throughput for conversational audio and video, streaming video and audio and mixed services are higher than those for the interactive web browsing and bulk file transfer (TCP traffic) applications. This can be explained by the fact that the low average packet loss observed for these applications means that most packets reach their destination, reflecting a high network throughput. Results also show that delay and jitter are more or less the same for all applications, which means that even though some packets do not successfully reach their destination, the time for successful arrival of packets is still acceptable.

These results indicate that in delivering multimedia eLearning applications, the use of real time traffic such as conversational video and audio, or video and audio streaming will require more network bandwidth, depending on the amount of traffic sharing the network resources, in order to minimize losses for TCP-like traffic such as file transfer and web browsing.

Table 4: Average performance parameters for wired network

Application	Average packet loss (%)	Average delay (s)	Average Jitter (s)	Average Throughput (kb/s)
Conversational Audio and Video (via Zoom)	11.32	0.01	0.01	357.25
Interactive Web Browsing	22.77	0.01	0.02	303.50
Streaming Audio and Video (via YouTube)	6.64	0.01	0.01	514.50
Bulk File Transfer	20.15	0.01	0.04	232.00
Mixed Services	4.96	0.01	0.01	872.25

For the case of the wireless network setup, the average performance parameters are shown in Table 5. As observed in the wired network case, conversational and streamed audio and video, and mixed services applications, which represent UDP traffic, experienced on average lower packet loss compared to file transfer application. Moreover, the web browsing application experienced a slightly higher packet loss compared to conversational and streamed video and audio, but much lower packet loss than file transfer. The lower average packet loss in UDP traffic is because UDP does not employ flow control, enabling it to be resilient to loss. The higher packet loss in the file transfer application (TCP traffic) is caused by the fact that in wireless networks, the manner in which TCP responds to loss (congestion control and avoidance algorithms) degrades performance (Waise & Dhotre, 2007).

Table 5: Average performance parameters for wireless network

Application	Average packet loss (%)	Average delay (s)	Average Jitter (s)	Throughput (kb/s)
Conversational Audio and Video (via Zoom)	11.53	0.02	0.03	456.25
Interactive Web Browsing	19.71	0.01	0.02	411.25
Streaming Audio and Video (via YouTube)	13.22	0.01	0.01	525.25

Bulk File Transfer	41.69	0.01	0.02	381.25
Mixed Services	10.14	0.01	0.03	500.50

Comparison of performance parameters between wired and wireless network setups is presented in Table 6. Results show that in the wired network, the average packet loss is higher for all applications than in the wireless network, except for web browsing, and more or less the same for conversational audio and video application. This indicates that wired networks generally perform better in terms of packet loss compared to wireless networks. It is interesting to note that the average throughput in the wireless network outperforms that of the wired network for all applications except for the mixed services application. This is attributed to the fact that data capturing was performed via a wireless connection with stationery hosts (PC1-3 and a laptop) and not via mobile devices which experience handoff challenges (Lelescu et al., 2008). Moreover, the access point connected only those devices used in the measurements (via a switch) hence did not face resource scarcity as in the wired network.

Table 6: Comparison of performance parameters between wired and wireless networks

Application	Average packet loss (%)		Average delay (s)		Average Jitter (s)		Throughput (kb/s)	
Transmission mode	**Wired**	**Wireless**	**Wired**	**Wireless**	**Wired**	**Wireless**	**Wired**	**Wireless**
Conversational Audio and Video (via Zoom)	11.32	11.53	0.01	0.02	0.01	0.03	357.25	456.25
Interactive Web Browsing	22.77	19.71	0.01	0.01	0.02	0.02	303.50	411.25
Streaming Audio and Video (via YouTube)	6.64	13.22	0.01	0.01	0.01	0.01	514.50	525.25
Bulk File Transfer	20.15	41.69	0.01	0.01	0.04	0.02	232.00	381.25
Mixed Services	4.96	10.14	0.01	0.01	0.01	0.03	872.25	500.5

These results, when compared with threshold values proposed by ITU-T (Table 1) show that delivery of multimedia application for eLearning services at CoICT can be achieved under both wired and wireless environments. For instance, conversational video and audio, which can be used for online teaching using the Zoom application require bit rates of up to 64 kbps and 384 kbps respectively. Experimental results in this work have shown an average throughput of 357.25 kbps and 456.26 kbps for wired and wireless networks, respectively, suggesting that the network can support such applications.

CONCLUSION

This study has presented performance evaluation of network performance in providing QoS for delivery of multimedia content for eLearning applications at CoICT. The study measured delay, jitter, packet loss and throughput parameters of four multimedia applications that were running simultaneously over a network testbed using wired and wireless connections. Packet data was captured using Wireshark network traffic analyzer. Results from the evaluation suggests that the available infrastructure at CoICT is suitable for delivery of multimedia content for eLearning purposes using both wired and wireless connections. Performance parameters, that is, loss, delay, jitter and throughput, for the different applications are within the thresholds as per ITU-T standards. Having the infrastructure capable of supporting multimedia applications with the acceptable QoS implies that instructors at the CoICT (which can be generalized to UDSM because all academic units are provided with almost similar ICT infrastructure) are equipped with a conducive environment that support multimedia application. Hence, they are expected to use and continue using educational technologies to facilitate teaching and learning processes. Future works will evaluate performance when hosts are connected over wireless connections using mobile devices to reflect real mobility conditions and their performance challenges.

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