Video Quality Challenges in Wireless Networks

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Abstract
Wireless support is now available in most devices. Streaming video over networks is a big challenge that faced by most companies working in technology development. Giving the best quality and high throughput performance is an ongoing issue. The quality depends on many factors likes bound rates and stringency of the delay bounds and the characteristics of the wireless networks. Wireless networks are exposed to noise and interference and hence cause losses and delays. This paper aims to study the challenges of the video quality in wireless network.

1. Introduction

Video is a sequence of images display at constant rate. Digital image is a ray of pixels, each pixel represented by bits. The expression “streaming” was used early in the 1990s when video on demand over IP networks had just begun [2], using “store then forward” data (stream). Nowadays, video streaming is over all kinds of wireless networks. Streaming content is not like sending text, in which you wait until download, save, and then preview. Video streaming is a continuous flaw of data that plays as arrives in live and real time.

Storage size of a video stream comes from calculating the streaming bandwidth and the length of the media for a single user and file, using the formula (storage size (in megabytes) = length (in seconds) × bit rate (in bit/s) / (8 × 1024 × 1024).For example, if using One hour of video stream encoded at 300 Kbit/s - this was a typical broadband video in 2005 and it was usually encoded in a 320 × 240 pixels window size- will be: (3,600 s × 300,000 bit/s) / (8×1024×1024) requires around 128 MB of storage[2].

Before streaming, the video is first compressed using video codec; the word codec comes from coding/ decoding. Codec can be a device or a program that is used to enable the compression and decompression of a video. With compression, videos encounter some data loss when converted from analogue format to digital format. A codec encodes a data stream for storage or encryption, or decodes it for playback or editing. Analog video represents LUMA (represents the brightness in an image, the "black-and-white" or achromatic portion of the image), so codec encodes videos into digital format by following a few steps. The important step in image compression is representing and storing images in YCbCr color space (also write in YCBCR).Transformation to YCbCr provides two benefits, it improves compressibility by providing decorrelation of the color signals, and secondly it separates LUMA signals. Stored video ratio represented as Y:Cb:Cr to describe LUMA and chroma information which is called Chroma subsampling. Different codecs uses different subsampling as suitable for compression needs. Video compression uses modern coding techniques to reduce redundancy in video data and most video codecs also use audio compression techniques in parallel to compress the separate, but combined data streams as one package [3].

Commonly used video codecs:

There are different compression formats that can be used. Some of which are software as (H.265/MPEG-H HEVC codecs,H.264/MPEG-4 AVC codec, H.263/MPEG-4 Part 2 codecs, Microsoft codecs, Lossless codecs)[3].

This paper studies the challenges of video streaming over wireless networks. It builds on previous studies and tries to contribute to the field. Next section discusses different wireless networks and the technology used to enhance throughput.

2. WIRELESS NETWORKS

Types of Wireless networks:

Wireless network is designed to cover residential areas and small business enterprises to provide internet and other applications without the need for wired infrastructure. Wireless technology depends on two principles: access network and backhaul network. Access networks are principally categorized into two groups, the cellular network group and the broadband wireless access group, widely known as the 802.xx family.

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Many applications have recently been developed such as video on demand services, online video gaming, and video streaming, that requires more network bandwidth and increase the demand for better quality of service. For that reason different IEEE 802.11x (Wi-Fi) and IEEE 802.16x (WiMAX) standards have been developed.

Wi-Fi stands for "wireless fidelity", is a popular technology which allows any electronic device to exchange and transfer data wirelessly over the network giving rise to high speed internet connections, any device which is Wi-Fi enabled (like personal computers, video game consoles, Smartphone, tablet etc.) can connect to a network resource like the internet through a wireless network access point(hotspots), have a coverage area of about 20 meters indoors and even a greater area range outdoors. Wi-Fi suffers from certain shortcomings; it is known to be less secure than wired connections (such as Ethernet) because an intruder does not need a physical connection. An optional feature added in 2007, called Wi-Fi protected setup (wps) was deployed, but it also had a serious flaw that allowed an attacker to recover the router's password. The Wi-Fi alliance has since updated its test plan and certification program to ensure all newly certified devices resist attacks. But security is still a major concern (cam-winget, et al., 2003), (Chandra shekar, et al., 2005-2008).there is three well known 802.11 wireless family standard widely used today [4]:

I- The IEEE 802.11b:

A refined standard for the original 802.11 and was successful due to its high data rates of 11 Mb/s - range of 100 m to a maximum of a few hundred meters, operates on 2.4 GHz unlicensed band. 802.11b is the most widely deployed wireless network within the 802.11 wireless families (Cam-Winget, et al., 2003). It uses the DSSS modulation technique that is more reliable than the FHSS [4].

II- The IEEE 802.11g

The IEEE 802.11g wireless standard also operates on the 2.4 GHz band and has similar range and characteristics as the 802.11b. It has a data rate of 54Mbps (Xu, et al., 2006). The 802.11g has backward compatibility with 802.11b and differs only on the modulation technique; it uses Orthogonal Frequency Division Multiplexing (OFDM). This then makes the 802.11b devices not able to pick the signal from the 802.11g devices (Morrow, 2004) [4].

III- The IEEE 802.11a

It operates in the 5GHz band with a maximum data rate of 54Mbps. The major disadvantage in deploying 802.11a with the other 802.11 standards b and g is that they cannot co-exist as they operate on different frequency bands (ProCurve Networking, 2005). 802.11b/g operates on the 2.4 GHz spectrum. There are some wireless card and access points which are compatible to all the three standards thereby supporting both the 2.4GHz and 5GHz frequencies band (Ransburg, 2006)[4].

IEEE 802.16 (WiMAX):

WiMAX stands for "World Interoperability for Microwave Access". It is a standard typically based on global interoperability including ETSI HIPERMAN, IEEE 802.16d-2004 for fixed, and 802.16e for mobile high-speed data. WiMAX is gaining popularity as a technology which delivers carrier-class, high speed wireless broadband at a much lower cost while covering large distance than Wi-Fi (Cam-Winget, et al., 2003). It has been designed to be a cost effective way to deliver broadband over a large area. It is intended to handle high-quality voice, data and video services while offering a high QoS (Westech Comms Inc., 2010).WiMAX operates in between 10 and 66 GHz Line of Sight (LOS) at a range up to 50 km (30 miles) and 2 to 11GHz non Line-of-Sight (NLOS) typically up to 6 - 10 km (4 - 6 miles) for fixed customer premises equipment (CPE). Both the fixed and mobile standards include the licensed (2.5, 3.5, and 10.5 GHz) and unlicensed (2.4 and 5.8 GHz) frequency spectrum. However, the frequency range for the fixed standard covers 2 to 11 GHz while the mobile standard covers below 6 GHz. Depending on the frequency band, it can be Frequency Division Duplex (FDD) or Time Division Duplex (TDD) configuration. The data rates for the fixed standard will support up to 75 Mbps per subscriber in 20 MHz of spectrum, but typical data rates will be 20 to 30 Mbps. The mobile applications will support 30 Mbps per subscriber, in 10 MHz of spectrum, but typical data rates will be 3 - 5 Mbps. WiMAX applications include: connecting Wi-Fi hotspots with each other and to other parts of the Internet; providing a wireless alternative to cable and DSL for last mile (last km) broadband access. On flexibility, WiMAX can be deployed in any terrain across all geographical areas [4].

The Multicast/Broadcast Service

The Multicast/Broadcast Service (MBS) feature of mobile WiMAX network is a promising technology for providing wireless multimedia because it allows the delivery of multimedia content to large-scale user communities in a cost-efficient manner. In addition WiMAX networks transmit single/multiple video streams encoded in scalable manner to mobile receivers using the MBS feature [5].

Broadcast Service

Broadcast is the term used to describe communication where a piece of information is sent from one point to all

other points. In this case there is just one sender, but the information is sent to all connected receivers [6].

Multicast Service

Multicasting is the networking technique of delivering the same packet simultaneously to a group of clients. IP multicast provides dynamic many-to-many connectivity between a set of senders (at least 1) and a group of receivers [6].

3. CHALLENGES OF VIDEO QUALITY IN WIRELESS NETWORKS

Video streaming over wireless networks is a challenging task due to the characteristics of the video data and wireless channels. In wireless environments, the channel conditions change rapidly over time due to noise, interference, multipath and mobility of the mobile hosts. While video streaming requires a steady flow of information and delivery of packets by a deadline [7], sending signals between transmitter and receiver makes it exposed to more attenuation and more spreading; this let signals incur for more delay and additional bandwidth requirement for video streaming applications [8].

- **Limited Bandwidth**

Although wireless networks are classified into different standards, compared to wired networks, which can support multi-Gega Bytes Per second (gbps), they have more limitations on capacity.

- **Interference**

Interference affects the quality of wireless signals. It is due to operation under unlicensed frequencies which makes other wireless devices interfere with the original signal and generate error rate that prevents the network from achieving its full capacity.

- **Mobility**

Although mobility is an advantage of wireless networks, it introduces a challenge due to locations changing which affects channel and signal conditions between the transmitter and receiver. This may take users out of coverage and make problems when play back videos.

All of these challenges make wireless reality under pressure of how to work with video applications and get high performance using wireless networks. Many papers proposed some solutions to previous challenges and there is some old and recent related work.

4. RELATED WORK

Protocol of Retransmission opportunistically And Time Based Adaptive Retransmission:

Protocol of Retransmission opportunistically (PRO) works with physical layer space. The protocol identifies and retransmits any failed packet transmission in nodes for successful packet delivery. It works as an internal relay. PRO can be used for any type of wireless networks. The advantage of PRO is that it can increase individual throughput as well as network capacity which gives video applications high bandwidth [8].

Time Based Adaptive Retransmission (TAR) uses across layers strategy[9], by which packets retransmission or discarding is decided based on the time (retransmission deadline) of the packet , it reduces the number of late packets and avoids using wireless bandwidth to retransmit unwanted packets [8].

Combination of PRO and TAR is a good solution for high performance, steady flow data and high throughput.

Multicast Video Streaming over Wi-Fi Networks: Impact of Multipath Fading and Interference:

As the wireless quality varies, video transmission rate need to be always adapted. Multicast streaming is a good choice for broadcasting live events, conference, IPTV. While wired networks have a congestion problem, wireless networks have a channel condition problem such as noise and interference. the channel condition can vary in short time ,therefore multicast video streaming over wireless networks is more challenging as compared to their wired network channels counterparts .This study focuses on the impact of interference ,fading signal attenuation on throughput [10].the studies choses key metrics to represent characteristics for all level performance indicators [10].

The Multicast/Broadcast service (MBS):

Streaming multimedia over WiMAX networks (IEEE 802.16 Standard) are commonly used, and supports various network services. One of these services is the multicast and broadcast service which can be used to deliver multimedia traffic to large –scale user communities, like mobile TV service .Video streaming over WiMAX depends on three main entities: content source, base station for WiMAX, and the users or subscribers. This study focuses on a number of scalable video streams that are available at WiMAX base station; each stream is to be broadcasted using (MBS) to a group of mobile subscribers. At WiMAX base station, the MBS module allocates a fixed size data area in the download section of each TDD (Time Division Domain). Each MBS data area can transmit different amount of data depending

on the modulation scheme chosen, which is in turn selected based on the wireless channel condition .Considering that scheduling window composed of a number of MBS data area, data from the video streams are to be allocated to the MBS area in the scheduling window. This study explains how to select the optimal subset of layers from each scalable stream to broadcast over a WiMAX network [11].

5. Conclusion

This paper has studied the challenges of the video quality in wireless network. It highlighted challenges like; limited bandwidth, interference, and mobility.

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