ABSTRACT

The Long Term Evolution (LTE) cellular technology provides higher data rates than its predecessor technologies. This advancement paves the way for more data services, including improved multimedia services. Three-dimensional (3D) video transmission is one such service that can benefit from LTE deployment. For a positive uptake of 3D video transmission, the network must provide a good Quality of Service (QoS). In this paper the authors evaluate the LTE network's performance when transmitting Multi-view Video Coding (MVC) using simulcast and inter-view prediction coding. Furthermore, the authors evaluate the system using both the H.264/AVC (Advanced Video Coding) and the more recent High Efficiency Video Coding (HEVC) and their MVC extensions. Results show that, in an urban environment, LTE can accommodate a maximum of 93 users per cell, with adequate QoS, when transmitting 3D HEVC video at Common Intermediate Format (CIF) resolution. Moreover, cross-layer techniques can be used to reduce the QoS degradation as the user moves away from the eNodeB by transmitting lower resolution video.

Keywords: 3D Video Transmission, Long Term Evolution Networks, Multi-View Video Coding, Quality of Service

INTRODUCTION

Transmission of multimedia content has been increasing over the years demanding more bandwidth from the telecommunication networks. Recent surveys (CISCO, 2014) indicate that Internet Protocol (IP) video traffic will reach around 79% of all the consumer generated Internet traffic in 2018. IP TeleVision (IPTV) is gaining popularity and is now a feasible option for service providers to offer multimedia services. Standardization has played an important role in the success of IPTV with standards being developed by the Digital Video Broadcasting

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(DVB) project (Schäfer, 2006), the International Telecommunication Union (ITU) (ITU, 2013), the European Telecommunications Standards Institute (ETSI) (ETSI, 2008, and 3GPP, 2013), and the Alliance for Telecommunications Industry Solutions (ATIS) IPTV exploratory group (ATIS, 2008). The Set Top Box (STB) of an IPTV system is designed to operate in limited bandwidth scenarios and only receives the content requested by the customer. This contrasts with traditional broadcasting networks where all the content is transmitted to each customer all the time, thus limiting the number of video streams available to the maximum the channel capacity can hold. Most of the work found in literature is devoted to the transmission of IPTV on fixed networks but studies like Perry et al. (2009) and Song and Lee (2010) suggest that the technology can easily be used in broadband wireless networks. There is also some limited work that looks into the transmission of 3D video content using IPTV, such as Ikuta et al. (2011) and Farin et al. (2008).

Most of the 3D multimedia experiences until recent years have been limited to specialized cinemas and controlled environments, mainly due to the high investments needed and bandwidth demands. However, lately, technologies have advanced to a state where stereoscopic video is being transmitted over satellite, Blu-Ray™, and Internet technologies (Vetro et al., 2011). These transmissions are intended for stereoscopic displays and the user has to wear special glasses that filter the content towards the correct eye of the viewer so that the brain reconstructs the image with the intended 3D perception. The user experience can be improved by transmitting more views, using more cameras to capture the same scene, together with the depth information. This allows for higher fidelity 3D TV using autostereoscopic displays and Free-viewpoint applications, where the latter allows the viewer to arbitrarily decide from which angle to view the scene (Ho & Oh, 2007). To stream all this data in limited bandwidth channels requires adequate coding. The increase in importance of multimedia has been pushing network operators to increase their services and the infrastructure bandwidth. This investment was necessary to avoid congestion and hence degradation of customers’ satisfaction. The latest advancements saw the development of Long Term Evolution (LTE) technology, which offers more promising performances compared to other technologies, for example Worldwide Interoperability for Microwave Access (WiMAX), and legacy networks. LTE is a packet-switched network system and thus allows for easy development and deployment of new applications and services (Cox, 2012).

In this paper we extend the work in Ellul and Debono (2014) in evaluating the feasibility of transmitting 3D IPTV using the LTE technology. This is done to identify the limitations of the current technology in providing 3D video services in the mobile environment. The Quality of Service (QoS) parameters obtained from the LTE network are used as an indicator to identify the maximum number of users supported. The evaluation is done using both simulcast and inter-view prediction coding of the Multi-view Video Coding (MVC) streams and for different content resolutions, representing different portable devices. The results obtained show that LTE is a promising technology that can support the transmission of multi-view video if the number of users within a cell is limited. Furthermore, a cross-layer solution is proposed to reduce the impact of throughput degradation and increase in packet loss as the user moves away from eNodeB.

The paper is divided into five sections. The next section gives some background information on the technologies used in this work. A section describing the implementation of the system and another one presenting the results obtained follows this. At the end, a conclusion is given.

**TRANSMISSION OF VIDEO OVER WIRELESS NETWORKS**

The use of multimedia applications and services has been increasing throughout the years. This has led to continuous improvements in telecom-
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