Scalable Video Streaming in Wireless Mesh Networks for Education

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ABSTRACT

In this paper, a video streaming system for education based on a wireless mesh network is proposed. A wireless mesh network is a self-organizing, self-managing and reliable intelligent network, which allows educators to deploy a network quickly. Video streaming plays an important role in this system for multimedia data transmission. This new system adopts the scalable video coding scheme that enables the video server to deliver layered videos to different user groups. In addition, a quality control method was developed to automatically change the output data rate based on network conditions. Real implementation test results show the proposed methods are effective.

Keywords: Intelligent Networks, Multimedia Data Transmission, Network Quality Control, Scalable Video Streaming, Wireless Mesh Network

INTRODUCTION

The latest developments in Information and Communication Technologies (ICTs) have serious impacts on quality of education. Radio, television, Internet and satellite have become very popular tools to deliver learner-centered education services to those who are in need, particularly to those who live remotely and are difficult to get access to education resources, or to those who would like to learn at flexible time. Wireless communications, including satellite, mobile communications and WLAN, provide mobility for users and can break the barrier of space to deliver the education resources (Moody & Schmidt, 2004). These technologies are more attractive to those in remote areas or want to learn anytime and anywhere.

WLAN (Bing, 2006), as a low cost, high broadband Internet access technology, and the support for mobile users, is especially appealing nowadays in educational institutions. Most of the universities in western countries are covered by WLAN for teachers and students to get access to the Internet and share resources. However, there are some inherent disadvantages of WLAN technology, i.e. the access points are fixed, the coverage range is short, and the mobility be-

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between access points is limited. These demerits hinder the applications of WLAN in the situation where a network is needed temporarily or mobility is a primary concern.

Recently, a new networking technology has been developed to break the barriers of WLAN. This is wireless mesh network (WMN) (Wang, 2008). WMN is a self-organizing, self-managing and reliable wireless communication network that provides dynamic topology allowing users to join and leave the network automatically. It enlarges the coverage of WLAN and provides full mobility for end users. In addition, it can be deployed wherever battery power or solar power is needed for some special occasions, such as outdoor wildlife observations and sport activities.

Further to previous successful development of WMN in healthcare (Iqbal, Wang, Wertheim, & Zhou, 2009; Wang, Iqbal, & Zhou, 2008), a WMN for education system has been developed in this paper. This new system focuses on video streaming in WMN to provide multimedia education services. It classifies the end users into different communication groups based on the processing ability of the devices and the conditions of network to obtain optimal transmission results.

The rest of this paper is organized as follows: after the brief introduction of the wireless mesh network technology, a framework design of video streaming system in WMN is proposed. Then the details of scalable video streaming techniques in a WMN have been presented. Last quality control of video streaming in the WMN, system implementation and evaluation are presented consecutively.

TECHNOLOGY OF WMN

Other than WLAN, ZigBee (Kinney, 2003), ultra-wideband (UWB) (Yang & Giannakis, 2004) and WiMAX (Vaughan-Nichols, 2004) can also form wireless mesh networks. However, the WMNs based on WLAN are the most widely used technology in commercial environment. That’s why we pay attention to it in this paper. A typical wireless mesh network consists of two types of nodes: the mesh router and the mesh client. The mesh routers, which comprise of the backbone of the wireless mesh network, have the routing function to support the mesh network and some of them work as gateways to connect to the Internet; the mesh clients are the end users of the network. The typical architecture is illustrated in Figure 1.

As shown in Figure 1, the mesh routers form the backbone of the wireless network. Each mesh router has an interface to connect to other routers. In addition, some of them have interfaces that can be used to connect to the Internet, and some others have interfaces to serve the end user. The mesh clients can be static or mobile.

The key characteristics of a wireless mesh network are explained as follows:

1. Multi-hop. With this property, one node can communicate with other nodes out of sight without increasing the radio strength by the relay of neighbor nodes.
2. Self-organization, self-management and self-healing. This characteristic makes the mesh network more robust. When any node in the network fails, other nodes could remove it and establish new routes to maintain the network. Due to the high independence of WMN, the video streaming system can be quickly constructed for outdoor education, which can give educators and students more flexibility.
3. Clients consume less energy. With the help of the mesh router, the client does not need to consume a large amount of energy to routing. This is an important advantage when the end users operate battery supported devices, such as PDA and other mobile devices. In addition, some end users that have more energy support can serve as the mesh router. If there is no condition to construct the mesh router, the video provider can transmit data by virtue of other nodes with routing function to get to the destination.
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