Delay Sensitive Multipath Routing with Bandwidth Guarantees for Video Transmission in Wireless Mesh Network

D.Jeyasutha† and N.Fareena††,
† ME CSE(Final Year), Anna University of Technology, Tirunelveli.
††Assistant Professor, Anna University of Technology, Tirunelveli.

SUMMARY
Wireless mesh networks have drawn significant attention from academia and industry as a fast, easy, and inexpensive solution for broadband wireless access. One of the most important issues is how to efficiently support the video communications, which is expected to be the killer application for future wireless networks. To solve this issue, the proposal is to employ multipath routing in WMN, so that the traffic can be uniformly distributed across the network. It is important to find the multiple paths with minimum joints to achieve good traffic engineering performance in WMNs. The main objective of this work is to provide an enhancing framework for video transmission in Wireless Mesh Network. To support video communications in an efficient way a new framework that is the multipath routing for Multiple Description (MD) video delivery over IEEE 802.11e based Wireless Mesh Network with enhanced version of Guaranteed-Rate (GR) packet scheduling algorithm has been proposed. This gives video traffic high preference in multiservice environment.

Keywords
Wireless Mesh Network, Video communications, multipath routing, Multiple Description, Packet scheduling, Mac 802.11 e.

1. INTRODUCTION
Wireless mesh networking has recently emerged as a promising technology for the next-generation wireless networks. They provide ubiquitous and reliable broadband network services. One of the most important issues is finding the method to efficiently support the video communications, which are expected to be the killer application for future wireless networks.

Wireless mesh networks (WMNs) are dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. WMNs deliver wireless services for a large variety of applications in personal, local, campus, and metropolitan areas. WMNs are comprised of two types of nodes: mesh routers and mesh clients. Other than the routing capability for gateway/bridge functions as in a conventional wireless router, a mesh router contains additional routing functions to support mesh networking. In multi-hop communications, the same amount of coverage can be achieved by a mesh router with much lower transmission power. To further improve the flexibility of mesh networking, a mesh router is usually equipped with multiple wireless interfaces built on either the same or different wireless access technologies. Mesh routers have minimal mobility and form the mesh backbone for mesh clients [2]. Thus, although mesh clients can also work as a router for mesh networking, the hardware platform and software for them can be much simpler than those for mesh routers.

Video applications in WMN are usually Internet oriented and thus the traffic is either from end user to Internet gateway (IGW) or vice versa. In most WMNs deployed today, the routing protocol focuses on finding a single best possible route from the source to the destination. Consequently, certain links could be heavily loaded while many others are significantly underutilized. Such a phenomenon is a breach of traffic engineering principle and could deteriorate the overall performance of the network. To solve this problem multipath routing in WMN is proposed, so that traffic can be uniformly distributed across the network. Fully disjoint paths are not always available in the network.

It is clear that multipath routing will have a better traffic engineering performance if a WMN can shorten the delay of video transmission. The reason is lower video transmission delay means more qualified candidate paths. It investigated on the multiservice environment, where video traffic can coexist with other types of traffic in WMN.

To reduce the delay of video traffic MDC video streams send via multiple paths using AOMDV routing protocol it uses IEEE 802.11e MAC layer with enhanced version of Guaranteed-Rate (GR) packet scheduling algorithm, namely virtual reserved rate GR (VRR-GR), to give video traffic high preference in multiservice environment. The fundamental difference between VRR-GR and conventional GR is that the former employs virtual reserved rate instead of real reserved rate to calculate the Guaranteed-Rate clock value.

The paper is organized as follows: Section 2 briefly describes the related previous techniques. Section 3 contains methodologies for video transmission. Section 4 shows the implementation results to demonstrate the advantage of the proposed framework. Section 5 discusses the conclusions.

2. RELATED WORKS
Researchers have proposed many techniques to enhance the video transmission. Danjue Li et.al,[5] describe a multi-source multipath video streaming system to support concurrent Video-on-Demand (VoD) services over Wireless Mesh Networks (WMNs), and approach the route selection problem for such a system using rate-distortion optimized framework. By taking wireless interference into consideration, it captures the characteristics of wireless networks with a more realistic networking model. Based on that, it mathematically formulates the route selection problem, and solves it heuristically using a genetic algorithm. Wei et.al,[10] propose a novel multi-path selection framework for video streaming over wireless ad hoc networks. The framework uses heuristic interference-aware multipath routing protocol based on the estimation of concurrent packet drop probability of two paths, taking into account interference between links. The advantage of proposed protocol is, the performance of the proposed protocol is close to that of the optimal solution, and is better than that of other heuristic protocols.

Chen et al [4] describe Multiple Description Coding (MDC) as a way of coding video information into multiple bit streams and is useful in a number of scenarios including peer-to-peer video streaming and video transmission over error-prone networks. Biswas et. al [3] proposes a modified tree structure for 3D-SPIHT that is more efficient for MD coding. Also propose a branch-pruning technique to generate multiple descriptions. It then shows how rate-distortion optimization can be incorporated into the MDC framework to develop an efficient MD video coding system.

Pawan Goyal and Harrick M. Vin [6] describe a class of generalized Guaranteed Rate (GR) scheduling algorithms that includes algorithms which allocate variable rate to packets of a flow. It defines work- conserving generalized Virtual Clock, Packet-by-Packet Generalized Processor Sharing and Self-Clocked Fair Queuing scheduling algorithms that can allocate variable rate to the packets of a flow. It also defines scheduling algorithms suitable for servers where packet fragmentation may occur. Nenad Koji et. al, [7] represent a WMNs as a type of mobile ad-hoc networks. These networks are very important in providing the Internet access to fixed and mobile terminal equipment. This paper presents one type of packet routing in wireless mesh networks based on Hopfield neural network. Artificial intelligence is used for path optimization. Distribution of local routing information and routing table updates is realized by mobile agents.

Zhang Lili et.al, [11] describe the fault-tolerant and transmission delay in the wireless mesh networks by topological property of undirected graph. The method provides a measure to analysis the performance of wireless mesh networks. Despite recent advances in wireless mesh networking, many research challenges remain in all protocol layers.

3. PROPOSED FRAMEWORK

Wireless Mesh Network still has to face many challenges to support video communications. An existing frame work is not considering multipath routing in Wireless Mesh Network. Routing protocol focuses on finding a single best possible route. Mesh topologies of WMNs provide a good basis for fully disjoint paths but fully disjoint paths are not always available in the network. In real time video applications are have stringent delay requirement. To overcome this problem a new framework is proposed. The architecture of proposed framework is shown in Figure 1.

The design of the system consists of three modules such as, i) Multiple Description Coding (MDC), ii) Multipath Routing and iii) Delay Reduction. In MDC, multiple equivalent substreams (or descriptions) are generated from a video source for transmission. After the video is MD coded, the multipath routing scheme constructs multiple paths from the source to the destination. Video traffic is then delivered with each path carrying one sub- stream. At the receiver, any received subset of these descriptions can be combined to reconstruct the original video [8].

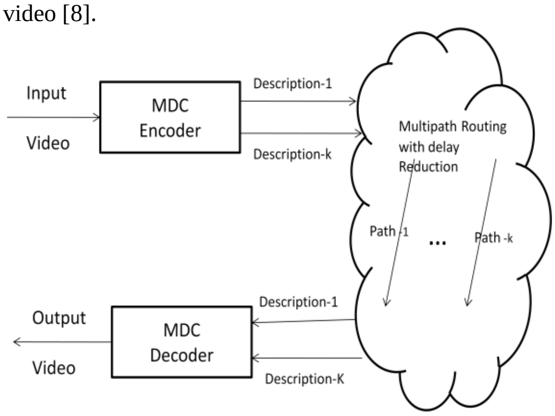

Figure 1 Proposed Framework for video Transmission

EvalVid framework is used for evaluation of the quality of video transmitted over a communication network. The structure of the EvalVid framework is shown in Figure 2. The video source can be either in the YUV QCIF (176 x 144) or YUV CIF (352 x 288). MPEG4 Encoder and MPEG4 Decoder is used for video coding. Video Sender(VS) reads the compressed video file from the output of the video encoder. MyTrafficTrace agent extracts the frame type and the frame size of the video trace file generated from the traffic trace file. MyUDP agent specifies the output file name of the sender trace file and it records the timestamp of each transmitted packet, the packet ID, and the packet payload size. MyUDPSink is the receiving agent records the timestamp, packet ID, and payload size of each

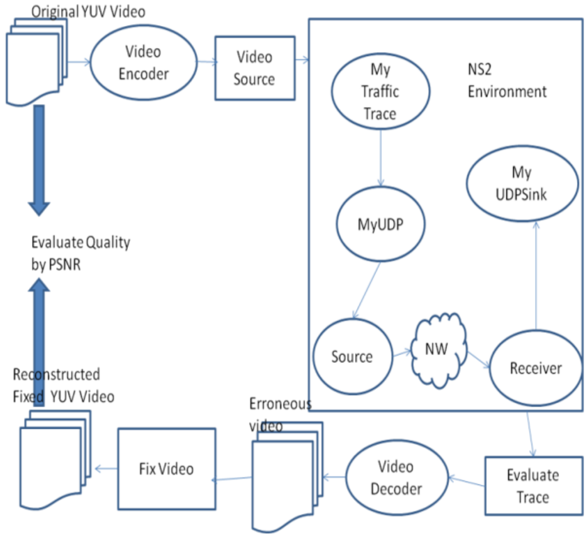

Figure 2. EvalVid Framework

received packet in the user specified receiver trace file. Based on the original encoded video file, the video trace file, the sender trace file, and the receiver trace file, the ET (Evaluate Trace) component creates

a frame/packet loss and frame/packet jitter. In FV (Fix Video) the digital video quality assessment is performed frame by frame. The total number of video frames at the receiver side, including the erroneous frames must be the same as that of the original video at the sender side. FV component inserting the last successfully decoded frame in the place of each lost frame as an error concealment technique. PSNR (Peak Signal Noise Ratio) assess the application-level QoS of video transmissions. PSNR measures the error between a reconstructed image and the original one. MOS (Mean Opinion Score) is a subjective metric to measure digital video quality at the application level ranges from 1 (worst) to 5 (best). Finally, the reconstructed fixed YUV video can be compared with the original raw YUV video to evaluate the end-to-end delivered video quality.

Multipath routing is the routing technique of leveraging multiple alternative paths through a wireless mesh network. Figure 3 shows Multipath routing framework for MD coded video communications over WMN. Other than the routing capability for gateway/bridge functions as in a conventional wireless router, a mesh router contains additional routing functions to support mesh networking.

On-demand Multipath Distance Vector Routing is an adhoc (AOMDV) routing protocol. Every node maintains a monotonically increasing sequence number for itself. It also maintains the highest known sequence numbers for each destination

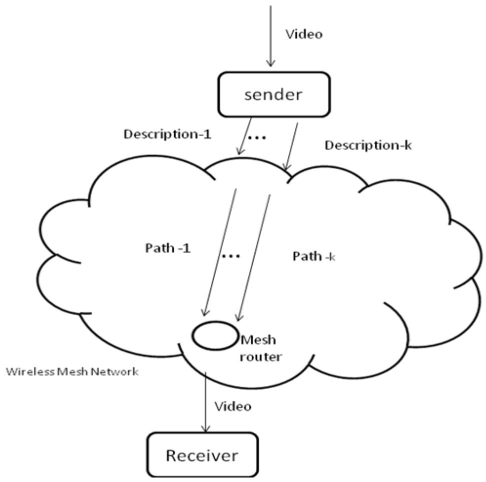

Figure 3 Multipath Routing Framework over WMN

in the routing table (called "destination sequence numbers"). Destination sequence numbers are tagged on all routing messages, thus providing a mechanism to determine the relative freshness of two pieces of routing information generated by two different nodes for the same destination.

The AOMDV protocol maintains an invariant that destination sequence numbers monotonically increase along a valid route, thus preventing routing loops. A node can receive a routing update via a RREQ or RREP packet either forming or updating a reverse or forward path. The routing updates received via a RREQ or RREP as "route advertisements" are referred.

Delay Reduction is the technique to reduce the packet delay in WMN which is mainly caused by MAC layer latency and packet scheduling latency. Distributed coordination function (DCF) is the most popular IEEE 802.11 MAC protocol in use. DCF is based on the scheme of carrier sense multiple access with collision avoidance (CSMA/CA), which does not differentiate traffic types. As a result, a station might have to wait for an arbitrarily long time to send a packet, and multimedia services may suffer intolerable delay and jitter.

To solve this problem, IEEE 802.11e proposes EDCA as an enhanced version of DCF. EDCA supports the QoS by introducing four access categories (ACs). Each packet arrives at the MAC layer with a priority from higher layer, and is mapped to an AC according to the priority. AC3, AC2, AC1, and AC0 are for voice, video, best effort data, and background traffic, respectively. To differentiate the traffic types, EDCA grants AC i (i = 0, ..., 3) a set of specific parameters, including minimum contention window (CWmin[i]), maximum contention window (CWmax[i]), and arbitration inter-frame space

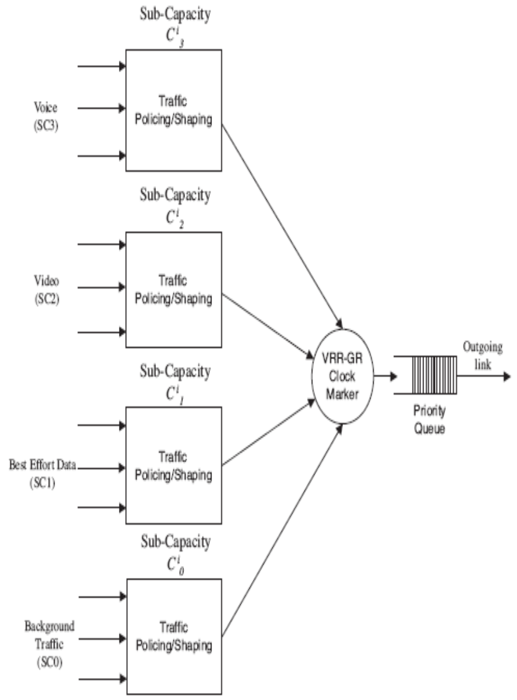

Figure 4 Architecture of VRR- GR Packet Scheduling

(AIFS[i]). With above parameters, the support of QoS can be achieved by differentiating the probability of channel access among different ACs[9].

EDCA has shortened the MAC layer latency of video transmission, but there still remains a problem to reduce the packet scheduling latency. To overcome this difficulty, a new approach of virtual reserved rate GR (VRR-GR) has been used to give video applications preference during packet scheduling process in multiservice environment [1]

A virtual reserved rate GR (VRR-GR) scheduling algorithm is used to determine the Guaranteed-Rate clock value of each flow in the priority queue of Figure 4. The major difference between VRR-GR and conventional GR is that the former uses virtual reserved rate instead of real reserved rate to calculate the Guaranteed-Rate clock value. Here, the virtual reserved rate comes from the concept of virtual sub-capacity. VRR-GR algorithm aims to integrate multiple service levels into one packet scheduling architecture.

In this architecture, VRR-GR has the responsibility to prioritize video service by deriving the Guaranteed-Rate clock value from virtual reserved rate rather than real reserved rate. Bandwidth and delay bound are two important issues when designing VRR-GR algorithm. Real sub-capacity decides the bandwidth that a flow finally obtains, whereas virtual sub capacity decides the induced delay during packet scheduling. Using conventional GR as a reference, virtual offset-capacity explains the additional reserved rate that VRR-GR grants to a flow during packet scheduling. It is worth noting that virtual offset-capacity is introduced to influence the delay bound but not the bandwidth of a flow.

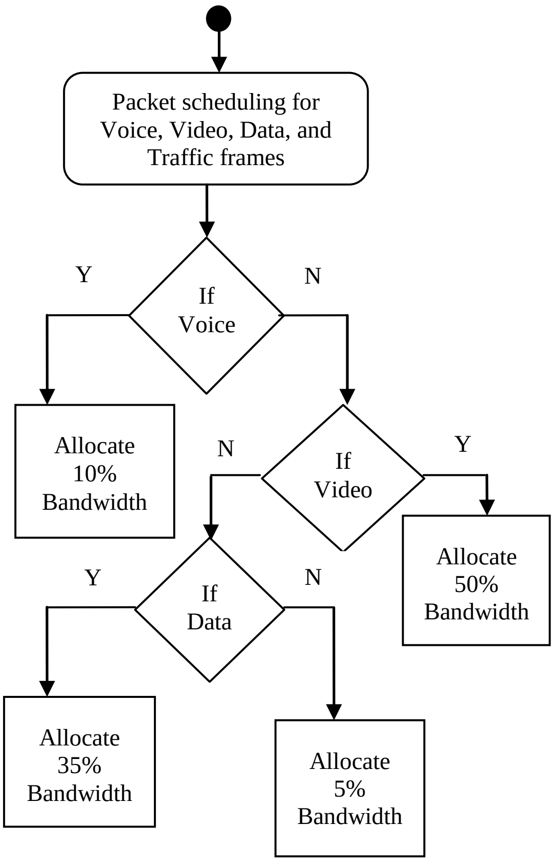

Figure 5 Flow diagram of Packet scheduling

4. IMPLEMENTATION AND RESULTS

The proposed framework has been implemented using Network Simulator 2.34 to evaluate the performance of VRR-GR through a line of N nodes (mesh routers in WMN). The work has been implemented and evaluated on the well known video streams [13]. Figure 5 illustrates the percentage of bandwidth allocation in packet scheduling. It checks the four traffic sources (T3, T2, T1, T0), allocate the percentage of bandwidth for each traffic sources. The traffic sources generate packets according to special profiles, with (T3, T2, T1, T0) representing the source of voice, video, best effort data, and background traffic, respectively.

The *N* VRR-GR nodes are programmed to be identical and to schedule the packets using VRR- GR scheduling algorithm according to the configuration.

In this scenario, the flow diagram in Fig.6 is characterized with the following features. Total capacity of 600 Mbps, with 10% allocated to SC3, 50% allocated to SC2, 35% allocated to SC1, and 5% allocated to SC0.

Table 1 shows the throughput of video sources.

Table 1 Throughput (bytes)

Video Streams	Voice (T3)	Video (T2)	Data (T1)	Traffic (To)
Stream1	25399	139591	100281	12993
Stream2	23247	138190	100218	12986
Stream3	23102	83411	67534	8698

The traffic sources tranfer packets according to the allocated bandwidth. The table 1 shows for the first test video stream 9.56% of voice packets, 50.36% of video packets 35.42% of data packets and 4.66% of Background Traffic have been delivered.

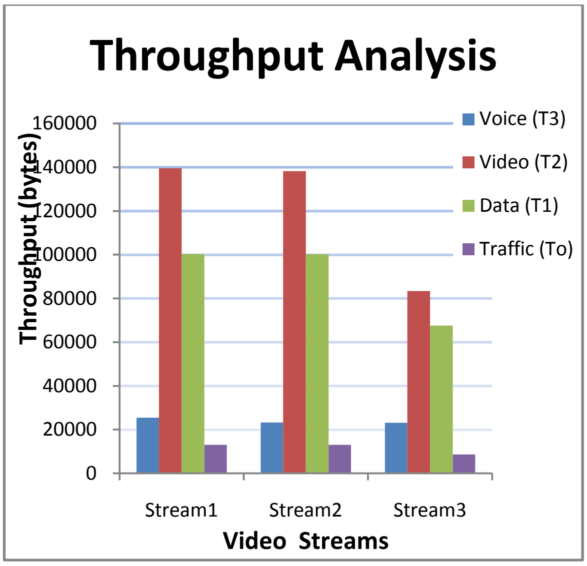

Figure 6 Overall Throughput analyses

Figure 6 shows the overall throughput analyses between Video, Voice, Data and Background Traffic. Also it shows the proposed framework provides video packets high preference during multiservice environment and also achieves good traffic engineering performance in WMNs.

5. CONCLUSION

This paper describes the objectives, the literature survey of the topology maintenance protocol, detailed design methodologies, implementation of multipath delivery of MD coded videos over IEEE 802.11 based WMN using NS2. The strict delay requirement of video applications is the major obstacle hindering the performance of our proposed scheme. To solve this problem, the new framework is developed to give video traffic high preference during packet scheduling process. Simulation study shows that the proposed approach can shortens the packet delay of video communications and achieve satisfying load balancing performance in WMN.

6. REFERENCES

[1] Bo Rong, Yi Qian, Kejie Lu, Rose Qingyang Hu and Michel Kadoch, "Multipath Routing over Wireless Mesh Networks For Multiple Description Video Transmission" ,IEEE Communications Journal, VOL. 28, NO. 3, APRIL 2010

[2] I. F. Akyildiz, X. Wang, "A survey on wireless mesh networks," IEEE Commun. Mag., vol. 43, no. 9, pp. S23-S30, Sept. 2005.

[3] M. Biswas, M. R. Frater, J. F. Arnold, "Multiple description wavelet video coding employing a new tree structure," IEEE Trans. Circuits Syst. Video Technol., vol. 18, no. 10, pp. 1361-1368, Oct. 2008.

[4] J. Chen, C. Tian, S. Diggavi, "Multiple description coding for stationary Gaussian sources," IEEE Trans. Inf. Theory, vol. 55, no. 6, pp. 2868-2881, June 2009.

[5] Danjue Li, Qian Zhang, Chen-Nee Chuah, S. J. Ben Yoo "Multi-source Multi-path Video Streaming Over Wireless Mesh Networks ",IEEE, pp.698-701, 2006.

[6] P. Goyal and H. M. Vin, "Generalized guaranteed rate scheduling algorithms: a framework," IEEE/ACM Trans. Netw., vol. 5, no. 4, pp.561-571, August 1997.

[7] Nenad Koji_, Marija Zajeganovi_-Ivan_i_, Irini Reljin, Branimir Reljin "Packet routing in wireless mesh networks" IEEE, pp.155-158, 2010

[8] G. Sun, U. Samarawickrama, J. Liang, C. Tian, C. Tu, T. D. Tran,"Multiple description coding with prediction compensation," IEEE Trans. Image Process., vol. 18, no. 5, pp. 1037-1047, May 2009.

[9] P. Wang, H. Jiang, and W. Zhuang, "IEEE 802.11e enhancement for voice service," IEEE Wireless Commun., vol. 13, no. 1, pp. 30-35, Feb.2006.

[10] Wei Wei and Avideh Zakhor, "Interference Aware Multi-Path Selection for Video Streaming in Wireless Ad Hoc Networks", IEEE, 2006.

[11] Zhang Lili, Wang Huibin, Xu Lizhong, Xu Zhuoming, Li Chenming, "Fault Tolerance and Transmission Delay In Wireless Mesh Networks", IEEE Wireless Commun., vol. 13, no. 1, pp. 30-35, Feb.2006.

[12] YUV :http://en.wikipedia.org/wiki/YUV

[13] trace :http://trace.eas.asu.edu/yuv/