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Video Streaming Application: Image Quality Analysis of Wireless Ad-hoc Network Routing Protocols

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Abstract: Wireless sensor ad-hoc network usually applied in a monitoring system like monitoring temperature, humidity or even any triggering inputs from a connected peripheral device. The approach of wireless ad hoc network for monitoring video data is under preliminary investigation and development because video streaming requires larger storage, quality channel, less jittering and low packet loss. The mobility of IEEE 802.11 in ad-hoc network increases packet loss due to high link breakages. An efficient routing protocol can diagnose, reduce and improves ad-hoc network for video streaming activity. In this paper the Optimized Link State Routing protocol (OLSR), Better Approach To Mobile Ad-hoc Networking protocol (BATMAN) and the Ad-hoc on Demand Distance Vector Routing (AODV) are evaluated in a testbed setup. The Picture Signal to Noise Ratio (PSNR) and the data throughput analysis are the methods employed to measure the quality of video frames captured in wireless ad-hoc video streaming. The AODV are found less durable compared to BATMAN and OLSR because AODV generates packet loss to 20% but rest are 0% to 5%. The PSNR shows that the BATMAN outperforms than other routing protocols but its performance decayed in a mesh network configuration. The BATMAN routing protocol found to be suitable routing protocol is lesser wireless nodes used in an ad-hoc video streaming application.

***Keywords*— Wireless, Ad-Hoc Network (WAHN), Jitteriness, Data loss, PSNR & Routing Protocols**

I. INTRODUCTION

The multimedia video contents become useful in many applications especially for monitoring or recording unfortunate events or scenes such as catastrophe, accidents, road traffics and etc. Getting real-time video frames are reliable and accurate compare to recorded information which can be manipulated or reconstructed due to losses.

To achieve a video streaming at a modest bandwidth, less jittering and low data throughput will be definitely impossible. Well setting up video streaming of a wireless mobility ad-hoc network will be even more tedious due to high interception and congestion problems but with the prudent and appropriate analysis of the routing protocol can improve the quality of video streaming and have generated many hypotheses for improving the mobility network but fairly few tested on either test bed or on an application to prove the function of pervasive computing in video streaming application [1]. In this research, a test bed is setup to examining the suitable routing protocols in a wireless ad-hoc video streaming. In this investigation, quality of the images are captured during the video streaming and evaluated the PSNR and data throughput to determine the best suitable routing protocol in a wireless ad-hoc network.

II. BACKGROUND

The types of routing protocols that used for these video streaming experiments in the mobility ad-hoc network are; OLSR, AODV and BATMAN. OLSR is proactive and table driven protocol. As long as OLSR is in operation in a node, information of the routing topology that consists of any other OLSR nodes are exchanged and maintained regularly. Any new nodes that join in later will also be added into the routing table of each participating OLSR nodes. Thus, alternative route will be selected without delay if the current route is broken. Also, the current OLSR routing daemon is more user-friendly than other tested routing protocols. However, due to its requirement to select MPRs node, a destination route may not be the shortest path because the sending node has to forward its data packet to its selected MPRs [4].

The AODV routing protocol discovers its direct neighbour by listening to the Hello messages broadcasted by them within a specific time gap. In a situation where a sending node needs to forward the data packets to the non-neighbouring nodes, a RREQ (Route Request) message is broadcasted by it. Upon receiving a RREQ, this node will reply with RREP (Route Reply) if it is the intended destination node and sets up a shortest route reaching the sending node, otherwise it will broadcast the RREQ again to its neighbouring nodes. If the RREQ is expired, a new RREQ is broadcasted with a new ID as well. In the situation whereby the destination of a data packet is not known or neighbouring node is out of range, a RERR (Route Error) message is sent by the affected node to its direct neighbours [2,3,9].

Since AODV is a reactive routing protocol, AODV only establishes its destination route on senders' demand. Such function significantly lowers its regular control message overhead in comparison with OLSR (proactive protocols). Besides, AODV uses less power and thus it is suitable to be implemented on a low powered device such as the computer on module. The shortcoming of such protocol would be the delay for a new route to be setup for usage [4, 9].

BATMAN is a proactive routing protocol like the OLSR routing protocol. However, unlike OLSR, the participating BATMAN nodes only hold information of the neighbours reachable in the next best hop. This is done by having a participating node to broadcast an Originator Messages (OGMs) to its direct neighbours.

The direct neighbours would then forward the OGMs once to their neighbours informing them of the existence of the OGMs' originator node and such process repeats so on and so forth. Each OGMs that broadcasted has a unique sequence number to notify participating nodes should they received duplicate OGMs. In order to discover the next best hop towards an originator node, a participating node (for example, node A) does the evaluation by comparing the OGMs received from its direct neighbors. The OGMs that reach node A in the quickest and most reliable way would be selected as the next best hop.

As nodes in BATMAN routing do not have the knowledge on the global view of the network, the security and robustness of the wireless ad-hoc network is enhanced [5]. Less information is kept and it is more lightweight as compared to OLSR and AODV.

The OLSR protocol is also known as flat routing protocol and it is suitable for homogenous network. Since the MANET offers real time service it is suitable to evaluate the routing protocol performance by metrics like the peak signal to noise ratio (PSNR), packet delay and interruption [2]. Different types of routing protocols are examined in similar methods and 24.37dB considered as optimal value of PSNR to measure the quality of the frames generated over the video streaming [2].

The OLSR routing protocol introduced in wireless ad hoc network for the tourist information delivery system [6]. The IP camera connected to an ad-hoc fixed terminal captures the tourist spots for the observation purpose. This video image can also be viewed by tourists possessing a rental PDA (Personal Digital Assistant) of this system. The proactive OLSR protocol establishes ongoing video streaming in 802.11 ad hoc networks and efficiently controls the bandwidth during the disconnection state of the link [6].

The video streaming activity for vehicle to vehicle is challenging due to the network partitioning. In wireless ad hoc network video data generated from many vehicles and these vehicles collect data randomly with the network partitioning method [7]. Video data arrived at receiver in a uncoordinated manner. Therefore longer buffering needed for continuous playback [8]. OMNET++ a simulation framework used for measuring and testing routing protocols under various and of different network configuration to study the different performance metrics. The output of the studies have created a platform for researchers to select the optional routing protocols most appropriate routing protocol for video streaming applications over WMNs, but also introduced the more efficient hybrid protocols. The optional routing protocols that introduced in this study were proactive and reactive base routing protocols [10].

III. SYSTEM OVERVIEW

A Gumstix is a computer on module (COM) which is a feasibly mobility and can powered by NiCads. This device is easy to install and applicable for remote monitoring like vehicle traffic monitoring system. In this research our focus is to the routing protocol that has impact to the quality of video streaming. The Gumstixs and PCs are installed with the Linux Ubuntu open source operating system and used the VLC video application software for the real time video streaming recording.

3.1 Implementation

The testbed design as shown in figure 1 consists of PCs and Gumstixs with WiFi enabled. The testbed configured to different network configurations. For each configuration video frames are collected in the 60 seconds of video streaming. These video frames evaluated with the PSNR and trace route analysis to determine the frame quality for different types of routing protocols used in the network configuration.

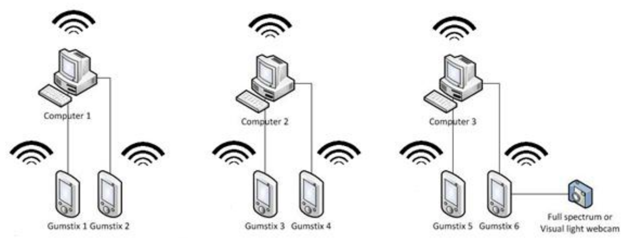

Figure 1: Wireless Ad-hoc Network: Testbed Design

The tested configured to single hop as shown in figure 2, Here the data packets are transferred from the sending node to its immediate neighbor, which is also the receiving node. The double hop, partially connected mesh network and fully connected mesh network are shown in the figure 3, 4, 5 and 6. For the double hop configuration, a Gumstix is added as an intermediary node between sender PC 1 and PC 2. The data packets transferred between them have to pass through a Gumstix. This is done by having PC 1 and PC 2 forcefully drops data packets that are directly transfer between one another. The single and double hop networks are respectively labeled as L1H and L2H.

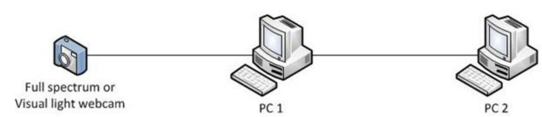

Figure 2: Single Hop Network

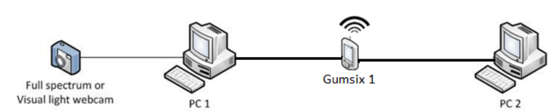

Figure 3: Double Hop Network

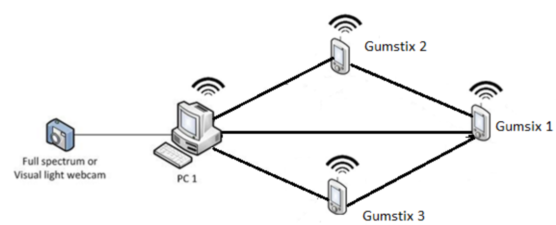

Figure 4: Partially Connected Mesh Network (a)

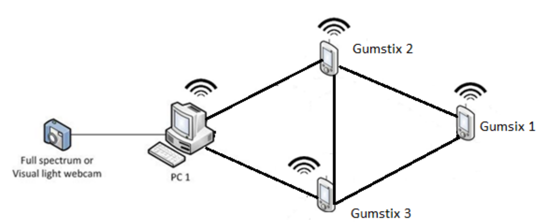

Figure 5: Partial Connected Mesh Network (b)

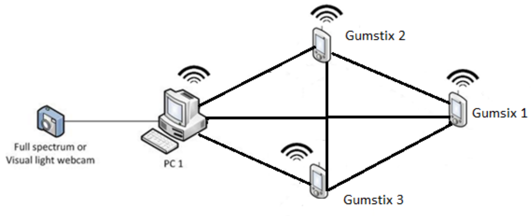

Figure 6: Full Connected Mesh Network

The partially connected mesh network (a) as shown in figure 4 is configured with Gumstixs and a PC. This network structure is respectively labeled as M1. This network configuration shows the creation of alternative route but no dedicated path between the Gumstix 2 and 3. The partially connected Mesh network (b) as shown in figure 5, respectively labelled as M2. In this network configuration PC1 and Gumstix 1 forced to drop data packets that are transferred directly between them but a link is made available between Gumstix 2 and 3. Finally the fully connected mesh as shown in figure 6, labelled as M3. In this network there is no IP table filtering rule is applied. Data packets are freely forwarded in the network without dropping them forcefully upon reaches specific destination route. The following algorithm [3] applied to evaluate the frames of video streaming of different routing protocols;

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right),$$

$$MSE = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left[I_{org}(m,n) - I_{dec}(m,n)\right]^2$$

The ping is applied to measure the round trip time (RTT) in order to trace the jittering and packet losses during the video streaming. The ping request for this testing is run for 20 times and average round trip time in milliseconds (ms) is taken along with the packet loss in %.

IV. RESULT & DISCUSSIONS

The table 1 is the PSNR result for different network configurations with the different routing protocols. Figure 7 illustrates overall comparison between OLSR, AODV and BATMAN protocols. The table 2 is the round trip time analysis of the protocols used in the network structure.

Table 1: PSNR of Wireless Ad Hoc Network Configuration

Network Config	Routing Protocols		
	OLSR	AODV	BATMAN
LIH	28.6407	24.3193	26.5120
L2H	19.4944	20.2728	24.9425
M1	17.9031	15.1699	32.4610
M2	27.2435	18.2788	22.9424
FC	24.5117	23.2791	18.2291

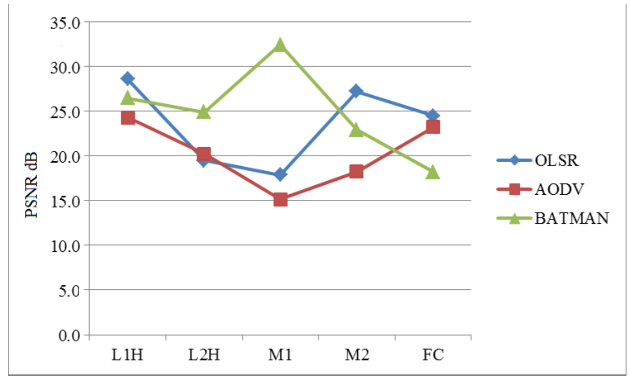

Figure 7: Comparison of Routing Protocols

Table 2: The RTT Measurement of Packet Jitter & losses

Network Topology	Routing Protocol	Average RTT (ms)	Mdev RTT (ms)	Packet Loss (%)
L1H	OLSR	16.735	56.782	0
	AODV	24.821	88.063	0
	BATMAN	0.928	0.284	0
L2H	OLSR	75.686	161.543	0
	AODV	20.590	281.827	20
	BATMAN	3.081	1.011	0
M1	OLSR	21.398	88.713	0
	AODV	1.222	1.053	0
	BATMAN	11.578	44.583	0
M2	OLSR	32.239	89.543	0
	AODV	30.171	41.286	15
	BATMAN	7.105	13.852	0
FC	OLSR	65.444	152.594	0
	AODV	28.810	98.564	0
	BATMAN	20.268	67.098	0

The OLSR has higher PSNR compares to AODV. Its performance exceeded AODV mainly due to the reason that it does not have the delay in setting up communication path between the original sending host and the receiving host. OLSR protocol has outperformed other routing protocols, which is for the fully connected network. However its overall average PSNR is lower as compared to BATMAN due to heavier control traffic and MPRs selection. As mention before, MPRs of a sending node may not provide the shortest route to its destination and heavy control traffic can cause jitters in video streaming of UDP packet transfer.

It is seen that AODV achieved the lowest overall PSNR. This is mainly due to the behaviour of the reactive routing protocol. In reactive protocol design the destination route only established when it is needed, unlike proactive routing protocols. In order for the original sender node to start transferring the UDP packets for video streaming purpose, it has to broadcast the RREQ to its neighbours to identify the destination node. This process causing delay before the video streaming starts. AODV also has highest data loss during the RTT test, which is up to 20%, causing AODV to achieve the lowest average PSNR compared to OLSR and BATMAN.

BATMAN has highest PSNR but its performance is at lowest in the Fully-Connected network topology. BATMAN is also proactive routing protocol which is similar to OLSR. The BATMAN node keeps the information about the next-best-hop for a particular originating sender in their list of originator.

These nodes will decide which direct neighbour is the best next hop by updating this information from time to time. They do not possess all the destination routes throughout the network like the OLSR nodes. It performs well in any other network topology except on the fully connected mesh network. The wireless routing protocol efficacy analysis of the BATMAN protocol shows an outstanding PSNR in the partial MESH network configuration because low traffic can be experience in lesser path connection.

V. CONCLUSION

BATMAN routing protocol is found to be the best for ad-hoc video streaming in comparison to AODV and OLSR. It achieves the highest overall PSNR in all network topologies. However, OLSR is suitable and user-friendly in wireless ad-hoc network than the other two routing protocols. Thus, OLSR suggested for lesser requirements of payload in an ad hoc network. Further research will be on analyzing other routing protocols and the use of Gumstix in vehicle traffic monitoring system in an ad hoc network.

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