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A Scalable M-learning Systems for the National Open University of Nigeria Using Multimedia Data Transmissions Technologies

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ABSTRACT

In this paper, we present the development of a Scalable M-learning Systems for the National Open University of Nigeria Using multimedia data transmissions technologies. This platform is based on wireless ad-hoc networks and can be used to provide high quality m-learning. The platform consists of a set of nodes that are connected by wireless links. In this network the nodes are free to move and the topology of the network may therefore change. The nodes can forward data for each other in multiple hops and the path between two nodes is set up dynamically depending on the connectivity between the nodes and without the support of any central coordinator. The coverage of this network is increased when more users are added to the network. This type of network is very robust since nodes can be added or removed from the network dynamically and the routing will adjust rapidly to the new conditions. Even though the capacity for end to end communication is decreased when data is forwarded in multiple hops. Experimental findings from our efforts showed that the capacity provided by the ad-hoc network is high enough to enable real-time video communication. This platform for provides a practical and reasonable priced communication network for M-Learning for the National Open University of Nigeria.

Keywords: M-learning, National Open University of Nigeria, Multimedia Data Transmissions, Systems, Technologies.

1. INTRODUCTION

Sending real-time video over wireless ad-hoc networks is a challenging problem. Video is very sensitive for packet loss and wireless ad-hoc networks are error prone due to node mobility and weak links. The most popular routing protocols today for ad-hoc networks, for example Dynamic Source Routing (DSR) (David, 1996) and Ad-hoc On Demand Distance Vector (AODV) (Perkins, 2003) are reactive routing protocols that are focused on scalability for very large networks and to reduce the routing load (Perkins, 2001). The major problem when sending real-time video over reactive routing protocols is however the long interruption in packet delivery when a route breaks and a new route has to be established. This is a drawback of the reactive design.

To achieve high robustness for real-time video over ad-hoc networks issues like the delay and packet delivery ratio are very important. We have developed a preemptive routing protocol by adding some extensions to standard DSR. We call this version of DSR for real-time DSR (RT-DSR). There are basically two problems with the standard DSR that this new routing protocol solves. The first problem is that DSR will not search for new routes until a route breaks. During the time it takes to discover new routes no data can be delivered. This is an unacceptable delay for the real-time video. The other problem is the gray-zone problem (Henrik, 2002). The standard DSR routing protocol often discovers routes that contains very weak links. The route packets are broadcasted and they are relatively small compared to the data packets. We start with the most basic form of DSR.

The following optimizations were removed from DSR:
• Automatic route shortening
• Caching overheard routing information
• Replying to route requests using cached routes
• Overhearing of packets
• Adding routes to intermediate nodes
• Gratuitous Route Replies
• All nodes process all of the Route Error messages they receive

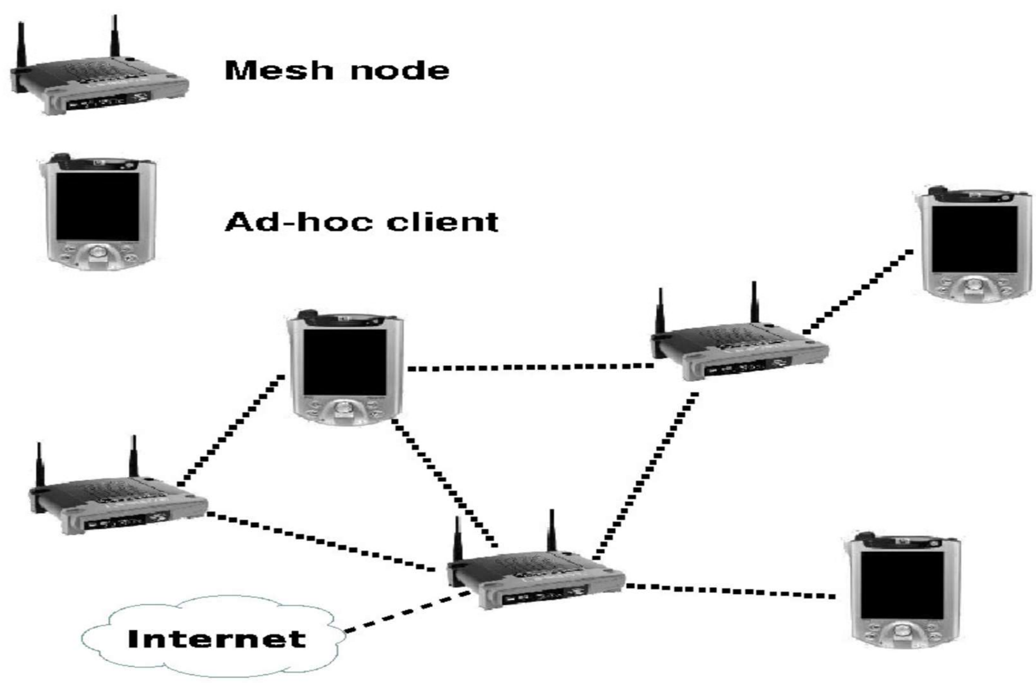

Figure 4.1: An overview of a network consisting of mesh nodes and mobile ad-hoc clients.
(Johannes, et.al, 2009)

If the event of routes that are about to break can be discovered it is possible to establish and start to use new routes before the old routes break. By simply monitoring the signal strength for each data packet we can detect if a route is about to break. To avoid using very weak links when establishing new routes the Route Request (RREQ) packets are filtered based on received signal strength. The following two extensions were added to DSR: • Send a special "weak RERR" packet when a data packet having low signal strength is routed • Signal strength threshold for RREQ packets. The modifications to the data structures, packet formats and algorithms are described in the following sections.

Our network is built up using two different types of nodes, see Figure 4.1. One type of nodes is the ad-hoc clients in the network. These nodes can be for example a laptop equipped with an IEEE 802.11 wireless interface, a mobile phone equipped with WiFi or a Tablet. This type of nodes can relay traffic for other nodes, but also be sink or source for traffic. They are both routers and hosts. These nodes are mobile and can also be switched on and off randomly thus creating fast changes in the network topology. The other type of nodes is mesh nodes that will only relay traffic for other nodes. They are needed to guarantee connectivity even at times when the number of mobile clients is few. These nodes can be located at rooftops or other positions providing a high level of coverage.

2. MESH NODES

The requirements for the mesh nodes are a CPU capable of running the routing protocol, a wireless communication interface, possibilities to harvest energy from the environment, and a battery to compensate for the variation in energy collected from the environment. The node should be able to operate even if there is no available connection to a power line.

Figure 4.2: A picture of a deployed mesh node (Johannes, et.al, 2009)

The mesh nodes used in this test-bed are built using a Linksys WRT54GL router, a solar panel and a battery, see Figure 4.2 for a picture of a deployed mesh node. All components are high volume consumer products to keep the cost for a node as low as possible. The Linksys WRT54GL router has a 200MHz Broadcom 5352 CPU, 4MB Flash, 16MB RAM and an IEEE 802.11 b/g wireless chipset. It is capable of running a Linux distribution enabling the possibility to add customized ad-hoc routing protocols. It uses a switched power regulator and at 12v the measured current was 240mA.

Ad-hoc clients

For the mobile ad-hoc clients node several suitable products are in the market. The "One Laptop Per Child project", OLPC, delivers a laptop suitable for education at the cost of 100 USD. These laptops have a 7.5" TFT display, a VGA camera, and a wireless network card capable of creating an ad-hoc network even when the CPU is off. The Classmate PC from Intel is also developed for the same purpose. Also Mobile Phones with Wi-Fi and Tablets can be used.

3. DATA STRUCTURES

When the source node receives information about a weak link on a route this route should still be used until new routes have been discovered. The old routes must however be removed after the new routes have been discovered. If this is not done, the old routes will be continued to be used until a packet is dropped on the route. We therefore add a 1-bit flag, weak Signal, to the route cache. This flag is used to mark the routes to be deleted after new routes have been discovered. The old routes must however be removed after the new routes have been discovered. If this is not done, the old routes will be continued to be used until a packet is dropped on the route. We therefore add a 1-bit flag, weak Signal, to the route cache. This flag is used to mark the routes to be deleted after new routes have been discovered.

Packet formats

A control packet is used to inform the source of the route when a weak link on the route is detected. If we use a regular RERR packet all intermediate nodes and the source node receiving the RERR packet will remove all routes in its route cache containing the weak link. This should not happen until new routes have been discovered. Instead of creating a complete new control packet a weak Signal flag is added to the RERR packet. The RERR packet has an 8-bit Error Type field and a 4-bit reserved field that can be used for this.

Route maintenance

A RERR packet with the weak Signal flag set is initiated every time a node receives a data packet having signal strength below −80 dBm. When the source or intermediate node receives this RERR packet they will not delete any routes in the route cache. When the source receives this RERR packet it will first set the weak-Signal flag for all routes in the route cache for this destination. The source node will then initiate a route discovery by sending a Route Request (RREQ) packet. When the node receives a Route Reply (RREP) it will remove all routes in its route cache having the weak-Signal flag set for the given destination.

Route discovery

When a route discovery is performed it is desired to avoid discovering routes containing weak links. Because the control packets are small and broadcasted they are less error prone than the data packets. If all RREQ packets are forwarded it is likely that many of the discovered routes will contain links having a very high packet loss. This is referred to the gray-zone problem in wireless ad-hoc networks. We therefore discard RREQ packets received with signal strength below −80 dBm.

3. SIMULATIONS

The GloMoSim 2.03 (Karlsson 2002) network simulator is used in our simulations. This is an event driven network simulator developed at the UCLA parallel computing laboratory. There is a version for the original DSR routing protocol and another version for the modified RT-DSR routing protocol. We also compared our results with the AODV (Perkins, 2003) routing protocol.

For all the simulations we used the following settings:

Table 1. Settings for all the network simulations (Johannes, et.al, 2009)

PROPAGATION-LIMIT -111.0
PROPAGATION-PATHLOSS
TWO-RAY NOISE-FIGURE 10.0
TEMPARATURE 290.0
RADIO-TYPE RADIO-ACCNOISE
RADIO-FREQUENCY 2.4e9
RADIO-BANDWIDTH 11000000
RADIO-RX-TYPE SNR-BOUNDED
RADIO-RX-SNR-THRESHOLD 10.0
RADIO-TX-POWER 15.0
RADIO-ANTENNA-GAIN 0.0
RADIO-RX-SENSITIVITY -91.0
RADIO-RX-THRESHOLD -81.0
MAC-PROTOCOL 802.11

The two-ray path loss model was used (3). This is the maximum of the plane earth (1) and the free space path loss (2),

$$P = \frac{d^2}{t \times r} \quad (1)$$

$$S = \frac{4 \times \pi \times d}{\lambda} \quad (2)$$

$$T = \max(P, S) \quad (3)$$

Where d is the distance between the sender and receiver, t is the tx antenna height, r is the rx antenna height and λ is the signal wavelength.

In GloMoSim both the rx and tx antenna height is 1.5 meters and the wavelength in this simulation was set to 0.125 meters. When the distance is 356 meters the received signal strength will be −80.01 dBm and the link will be detected as a weak link. When the distance is 377 meters the received signal strength will be −81.01 dBm, this is below the radio rx threshold and the packet will be dropped. In our simulations we used the theora video codec and the ogg container format. We used two different videos in our simulations. One was the commonly used foreman video sequence in qcif resolution (176x144 pixels).

The original video clip was 400 frames at 30 frames per second and we looped this sequence 45 times to create a 600 second and 18 000 frames long video clip. The other video we used was the first 600 seconds from the opening session of the biomedia course given within the ICT-LEAP consortium. This course is given for five universities over video conferencing networks. We used the recorded video from a video conference session and encoded the video from one of the parties at qcif resolution. For both of the video clips the video was encoded using a target bitrate 100 kbit/s, keyframe interval 120 and 30 frames per second. The actually encode bitrate, including the ogg headers, was 157.1 kbit/s for the foreman sequence and 101.4 kbit/s for the biomedia course sequence. First a trace file was created. This file contained the size of each packet and the time for transmission. This file was used in the GloMoSim simulations and the lost packets were recorded. This information was then used when the video was decoded. If a packet was lost or had a delay of more than 50 ms the packet was dropped at decoding.

The error concealment method used at the decoder was to copy the previous successfully decoded frame if a frame was lost. To compare the new routing protocol to AODV and standard DSR we run three different simulation scenarios. In each simulation we recorded the number of lost packets, the average PSNR, the number of frames having a PSNR below 30 dB and the total number of routing packets transmitted. An error free transmission had an average PSNR of 34.87 dB for the foreman video sequence and 40.79 dB for the biomedia course video sequence. The foreman video sequence had much more motion, including camera motion, compared to the video sequence from the biomedia course and since the video was coded using constant bitrate the encoded quality of the forman video was lower.

4 RESULTS AND ANALYSIS

4.1 Roaming node

In this scenario we forced a number of route breaks at the last hop. We used a total of seven nodes. The nodes were placed on a row having a distance of 200 meters between them, see Figure 4.3. The source and the destination node had the same initial position. The destination node was then moving along the row of nodes at a speed of 2 m/s until it was located 200 meters to the right of node six. First there was a one-hop link between the source node and the destination node. When the destination node was located between node two and node three the one-hop route was lost and a two-hop route had to be established. Similarly the two-hop, three-hop, four-hop and five-hop route was lost. Finally before the destination node reached its final destination 200 meters to the right of node six the five-hop route was lost and a six-hop route had to be established. There were a total of five route breaks in this simulation. The simulation time was 600 seconds and we run the simulation ten times for each video sequence with different initial seed.

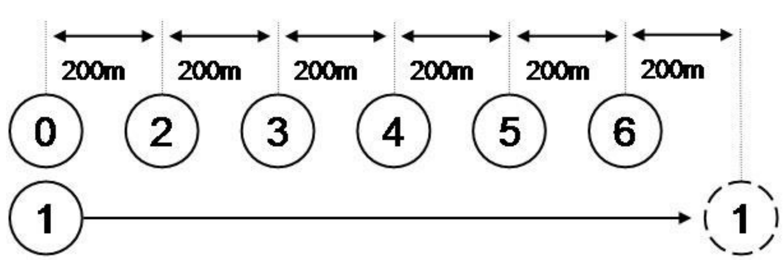

Figure 1: The roaming node scenario. (Johannes, et.al., 2009)

In table 2 and table 3 we can see that RT-DSR had much lower packet loss compared to standard DSR for both video sequences. Most of the packet losses when DSR was used occurred at the last route breaks. The RT-DSR routing also outperformed the AODV routing protocol for both video sequences, the difference was however much smaller compared to DSR

Table 2: Route Performance in the Roaming Node Scenario and the Foreman Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.00%	11.07%	0.32%
PSNR (dB)	34.76	25.78	34.23
PSNR < 30dB	0.00%	14.27%	1.31%
Control packets	160	5035	64

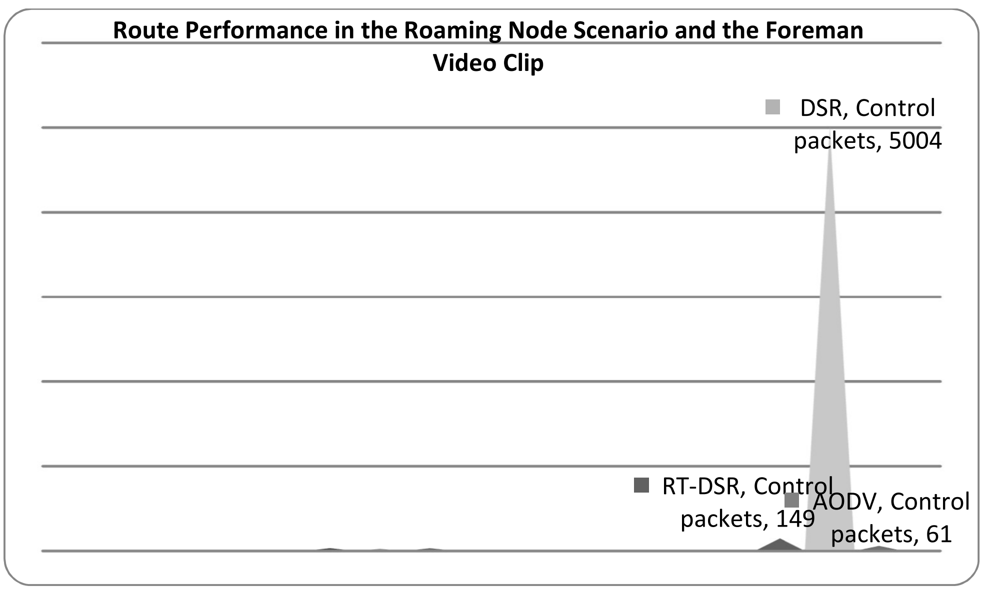

Figure 2: Histogram illustrating the Route Performance in Roaming Node Scenario and the Foreman Video Clip

Table 3: Route Performance in the Roaming Node Scenario and the Biomedia Course Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.00%	12.53%	0.32%
PSNR (dB)	40.82	30.79	41.29
PSNR < 30dB	0.84%	12.89%	0.89%
Control packets	151	5225	63

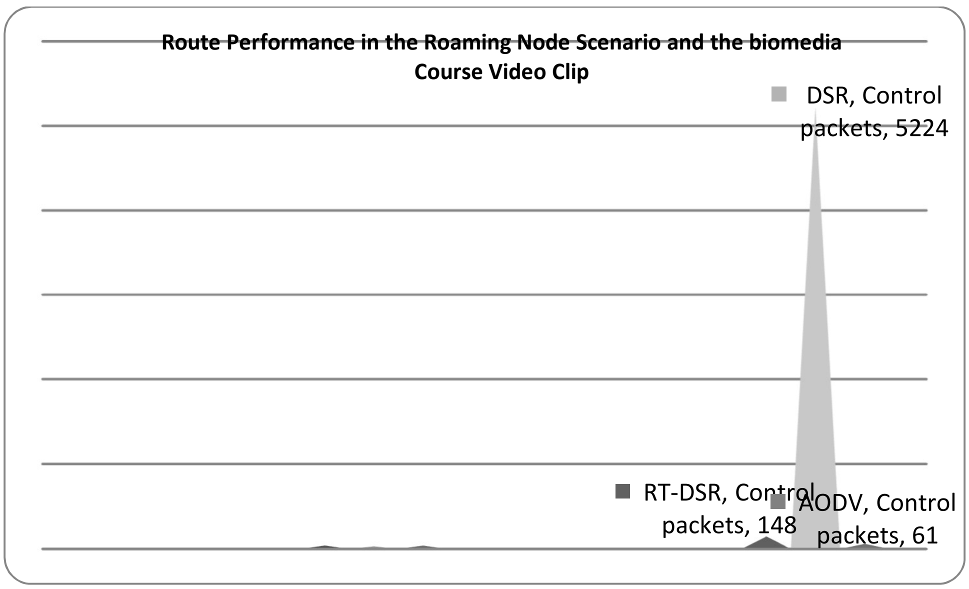

Figure 4.5A histogram illustrating the Route Performance in Roaming Node Scenario and the Biomedia Course Video Clip

In both figures 4 and 5 in the Roaming Node scenario for both video sequences, the DSR Routing Protocol had much higher control packets when compared to the other two Routing Protocols this implies a higher packet loss for DSR in this scenario.

4.2 Intermediate break

In this scenario we forced link breaks at intermediate nodes. Five nodes were located on a row having a distance of 200 meters between each node, see Figure 6. This created a four-hop path between node zero and node one. When the simulation started node five was located in the middle of the path. It then moved at the speed of 4 m/s away from the path until it was located 400 meters from its original location. At the same time node four was moving to node fives original location. After this both node four and node five moved back to its starting locations at a speed of 4 m/s. This was repeated three times and a total of six route breaks was generated.

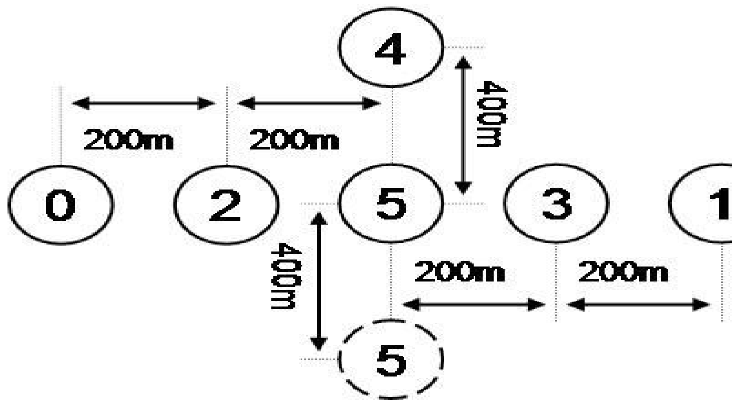

Figure 4.6. The intermediate node break scenario. (Johannes, et.al, 2009)

The total simulated time was 600 seconds and we repeated the simulation ten times for each video sequence with different initial seed. In this simulation the route was first established by sending a data packet before the video transmission was started. In tables 4 and 5 we can see that all routing protocols, especially DSR, performed much better compared to the roaming node scenario. As expected the RT-DSR has the highest number of routing control packets.

Table 4: Route Performance in Intermediate Break Scenario and the Foreman Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.00%	0.01%	0.00%
PSNR (dB)	34.87	34.81	34.87
PSNR < 30dB	0.00%	0.06%	0.00%
Control packets	194.7	52.6	60

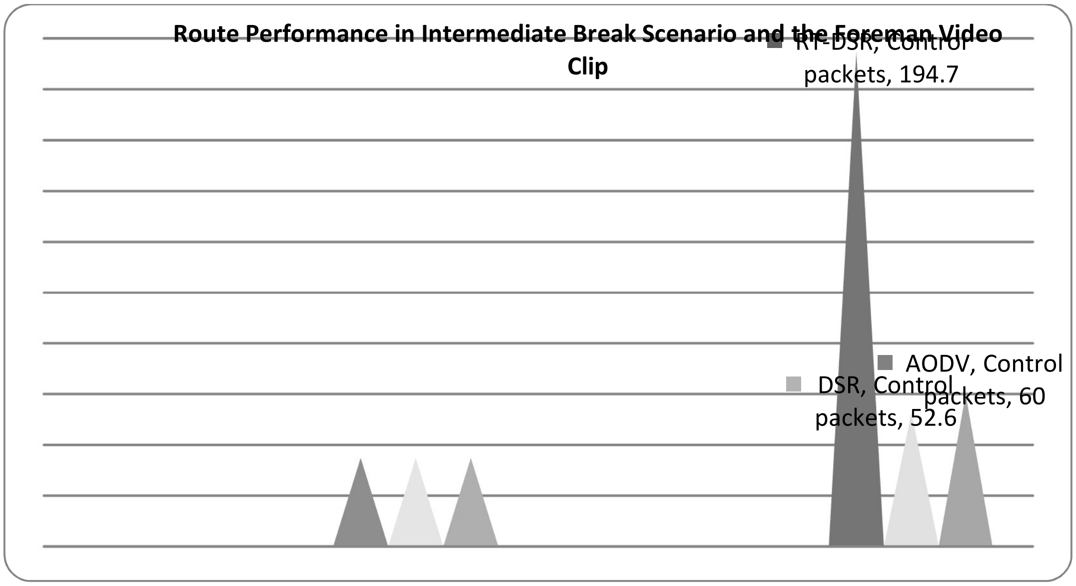

Figure 7: A histogram illustrating the Route Performance in Intermediate Break Scenario and the Foreman Video Clip

Table 5: Route Performance in Intermediate Break Scenario and the Biomedia Course Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.00%	0.00%	0.00%
PSNR (dB)	40.79	40.79	40.79
PSNR < 30dB	0.81%	0.81%	0.81%
Control packets	185	52.7	60

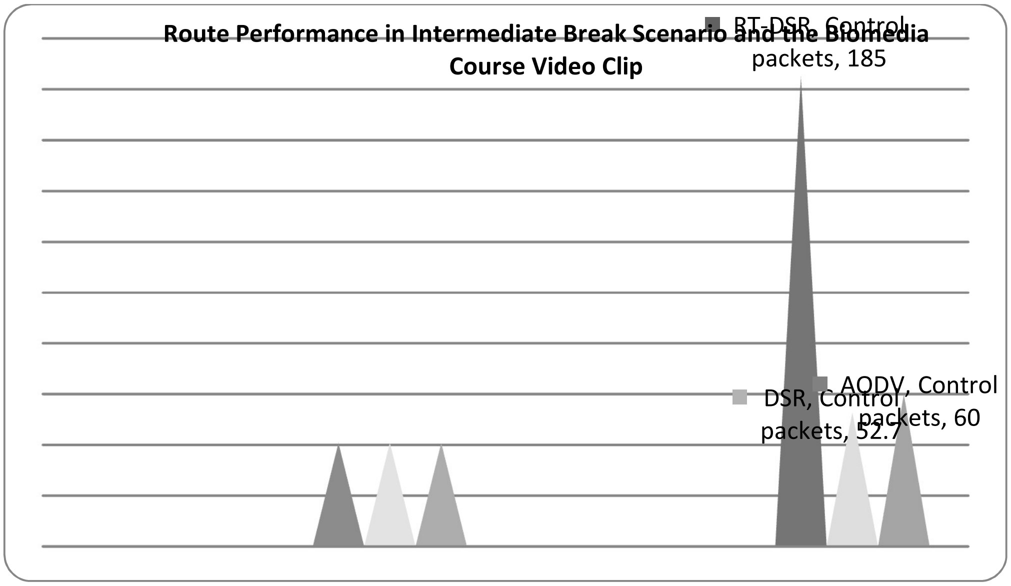

Figure 4.8: histogram illustrating the Route Performance in Intermediate Break Scenario and the Biomedia Course Video Clip

In figures 4.7 and 4.8, both charts for the Intermediate Break Scenario, the Foreman and biomedia Video Clip charts, we see that the RT-DSR has the highest number of routing control packets when compared to the other routing protocols.

4.3 Random waypoint

In this simulation we let a number of nodes move randomly within an area. We used a very high node density to make the network connected with high probability. This is because we did not want to have dropped packets because there were no routes available between the source and the destination. We used 60 nodes distributed within an area of size 1000x1000 meters. The nodes were initially distributed using uniform node placement. The mobility model used was random waypoint. Both the max and min speed were set to 4 m/s. The waypoint pause time was set to 1 second. The simulation was run for 600 seconds and each simulation was repeated ten times for each video sequence with different initial seed. In tables 6 and 7 we can see that the RT-DSR had less dropped packets compared to both DSR and AODV. Though we used high node density it is likely that some of the packets were lost because no route existed between the source and the destination. The RT-DSR routing protocol had much higher routing overhead compared to both DSR and AODV in this simulation

Table 4.6: Route performance in the Random Waypoint Scenario and the Foreman Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.04%	3.25%	0.15%
PSNR (dB)	34.77	31.05	34.37
PSNR < 30dB	0.26%	4.72%	1.03%
Control packets	1483	751	382

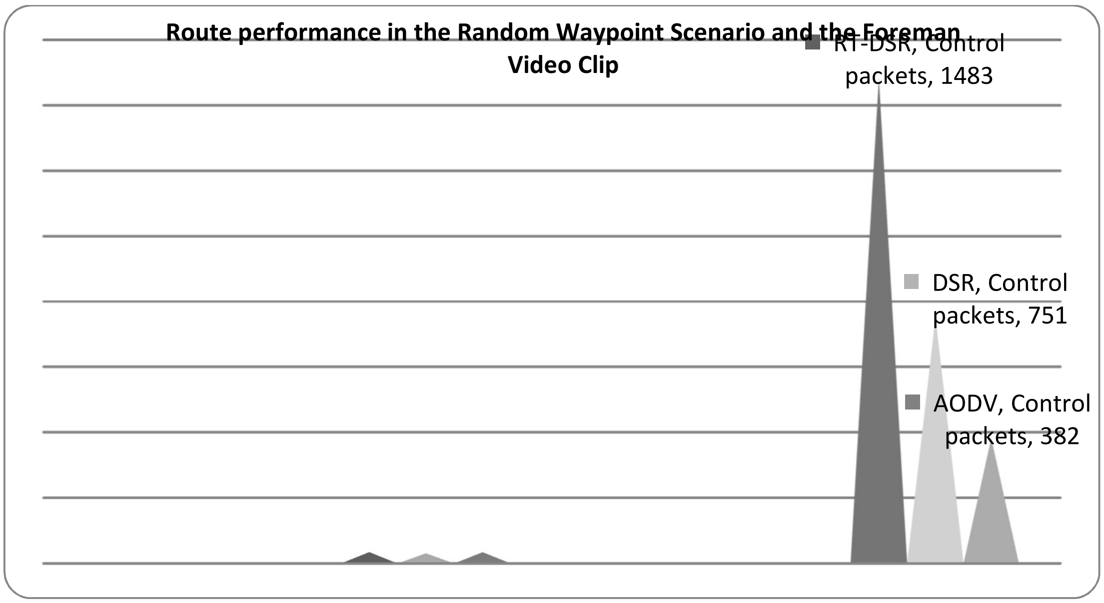

Figure 4.9: histogram illustrating the Route performance in the Random Waypoint Scenario and the Foreman Video Clip

In figure 9 we see that the RT-DSR had higher control packets than the DSR and much more than the AODV this implies less dropped packets compared to both DSR and AODV as shown in Table 4.6.

Table 7: Route performance in the Random Waypoint Scenario and the Biomedia Course Video Clip

	RT-DSR	DSR	AODV
Lost packets	0.04%	2.72%	0.18%
PSNR (dB)	40.72	38.10	40.19
PSNR < 30dB	0.83%	2.88%	0.98%
Control packets	1779	839	424

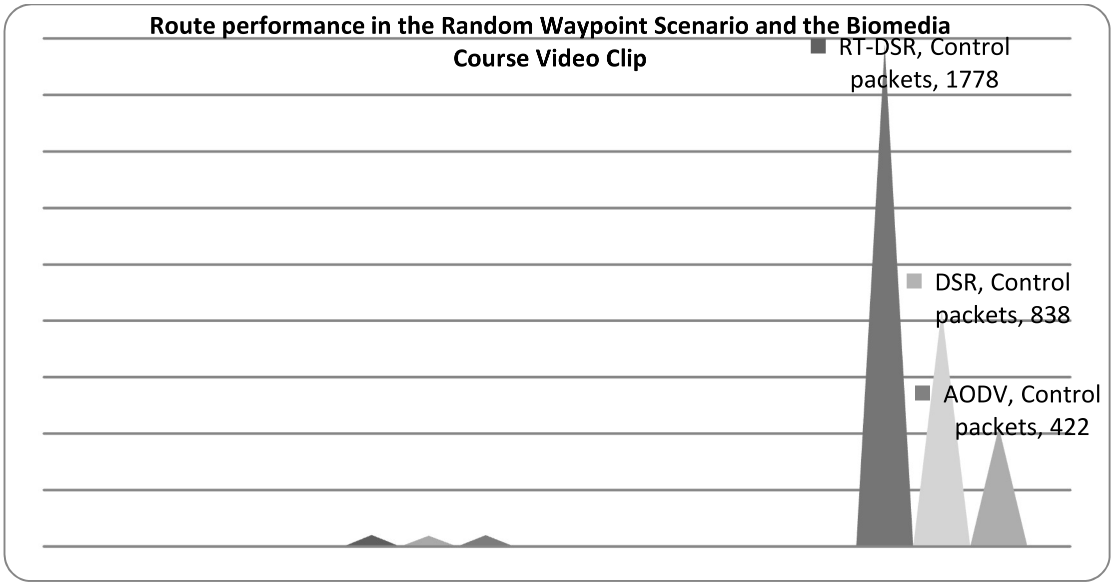

Figure 4.10: histogram illustrating the Route performance in the Random Waypoint Scenario and the Biomedia Course Video Clip.

In figure 10 we see that the RT-DSR had higher control packets than the DSR and much more than the AODV this implies less dropped packets compared to both DSR and AODV as shown in Table 7.

5. CONCLUSION

mLearning is a combination of mobile technology and its affordances that create a unique learning environment and opportunities for learning that can span across time and place. Mobile technology is growing at a rapid rate around the world, and becoming ever more accessible. Technology is emerging and closing the gap towards being a viable tool for mobile learning. It's a social platform that creates environments for communication, understanding, and transfer of information. Its ability to cater for varying learning styles through various features, its link to communication and its social context make it a very attractive tool for learning. The main characteristics that have been identified with mobile technology are nomadicy, ubiquity, context sensitivity, personalisation, and interaction. It is important that mLearning exists within pedagogy and that designers have an understanding of the contexts that learners exist in. mLearning can cater for various learning styles through varying delivery methods. In this paper, we present the development of a Scalable M-learning Systems for the National Open University of Nigeria Using multimedia data transmissions technologies. Our platform for provides a practical and reasonable priced communication network for our target learning environment.

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