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Analyzing Video Streaming Quality by Using Various Error Correction Methods on Mobile Ad hoc Networks in NS2

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ABSTRACT
Transmission video over ad hoc networks has become one of the most important and interesting subjects of study for researchers and programmers because of the strong relationship between video applications and frequent users of various mobile devices, such as laptops, PDAs, and mobile phones in all aspects of life. However, many challenges, such as packet loss, congestion (i.e., impairments at the network layer), multipath fading (i.e., impairments at the physical layer) [1], and link failure, exist in transferring video over ad hoc networks; these challenges negatively affect the quality of the perceived video [2].This study has investigated video transfer over ad hoc networks. The main challenges of transferring video over ad hoc networks as well as types of errors that may occur during video transmission, various types of video mechanisms, error correction methods, and different Quality of Service (QoS) parameters that affect the quality of the received video are also investigated.
Keywords - ad hoc, automatic repeat request, congestion, forward error correction, link failure.

I. Introduction

Recently, many applications over wireless mobile ad hoc networks (MANETs) have been used for video calls, video gaming, and video conferencing; these applications are used in military operations and civil protection, education, and emergency response [3]. Various types of wireless connectivity standards and technologies have emerged. These technologies enable people to use various computing and telecommunication devices easily and simply, without the need to buy, carry, or connect cables. Thus, the wireless ad hoc network together with its various applications have become among the most important networks. Providing high-quality video over MANET has become one of the most popular subjects of study; however, this issue is complex because of the nature of this network, which undergoes frequent link failure and congestion [4].

II. Related works

Numerous works related to streaming video over MANETs have been published.
Panahi [5] proposed a new design that depends on sending video packets over two separate paths by using buffering technique in different network nodes. In each path, one node is selected as cache node. The selection of these nodes in the network is based on an agreement between the sender and the receiver of video. Alternatively, this selection is based on network topological condition. The main tasks of these nodes are to recognize different types of packets, store important video packets, eliminate forward traffic rate while discovering loss in the network, as well as manage and overcome the high loss rate of video packets. This scheme reduces end-to-end delay in the network and increases the quality of service over the application layer.
Shen et al. [6] proposed collective multiple description coding (MDC) with multipath video streaming in wireless ad hoc networks. A new algorithm for path construction and aggregation is used to increase the number of video receivers. The simulation results indicate that the proposed algorithm can reduce time delay and increase the quality of the received video.
Ibrahim et al. [7] analyzed the effect of using different routing protocols, such as DSR (Dynamic Source Routing Protocol) and AODV (Ad- Hoc On-Demand Distance Vector), , on the video conferencing quality. In addition, the researchers proved that the coverage area of AODV is better than that of DSR. Moreover, the delay of AODV is acceptable and the packet loss is significantly low.
Shalini et al. [8] compared video quality by using MDC, MDC with feedback based on split multipath routing, and MDC with feedback based on ad hoc on-demand multipath distance vector (AOMDV) routing. The results were simulated by using an NS2 simulator. The results proved that the quality of video that used MDC with feedback-based AOMDV is

higher than the quality of the video that used other types of algorithms.

Saranya et al. [9] studied the problem of congestion in streaming video over MANETs and proposed a new routing algorithm to supply the best route for transferring video over an ad hoc network. This new algorithm is better than all the existing algorithms in terms of signal strength. This algorithm can also be used to improve video quality.

aswant et al. [10] used various routing protocols (i.e., ZRP, AODV, AOMDV, and DDIFF) and studied the most suitable protocol for video streaming over an ad hoc network. Different routing protocol parameters such as average throughput, end-to-end delay, and packet delivery ratio were analyzed. Jaswant et al. concluded that DDIFF is the best routing protocol that can provide the best video stream quality.

III. Video Transmission over Wireless Networks

Over the previous decades, wireless technologies have progressed significantly, particularly technologies that aim to develop personal communications and mobile applications. These applications have been modified from a simple voice call into several multimedia applications. With these developments, mobile multimedia has become one of the most essential aspects of new technology; thus, the main issue is improving the quality of the received media [11].

Fig. 1 illustrates that the general system of transferring video over an ad hoc network consists of many stages. The two main parts of the process are the sending side and the receiving side. The sending side involves transmitting the video in any type of format. Then, the video is encoded to the number of frames by using a software encoder (e.g., MPEG, MPEG-2, MPEG-3, MPEG4, H.263, and H.264) to form video packets that are ready for streaming. The environments of MANET cover one of the wireless standard suits (e.g., IEEE802.11a, IEEE802.11b, and IEEE802.11n). The ad hoc mobile nodes are distributed within the specific area of MANETs with different speeds and locations. The receiving side receives the video stream at the destination node, and the received packets are decoded by using a software decoder to reconstruct the output video at the receiver node.

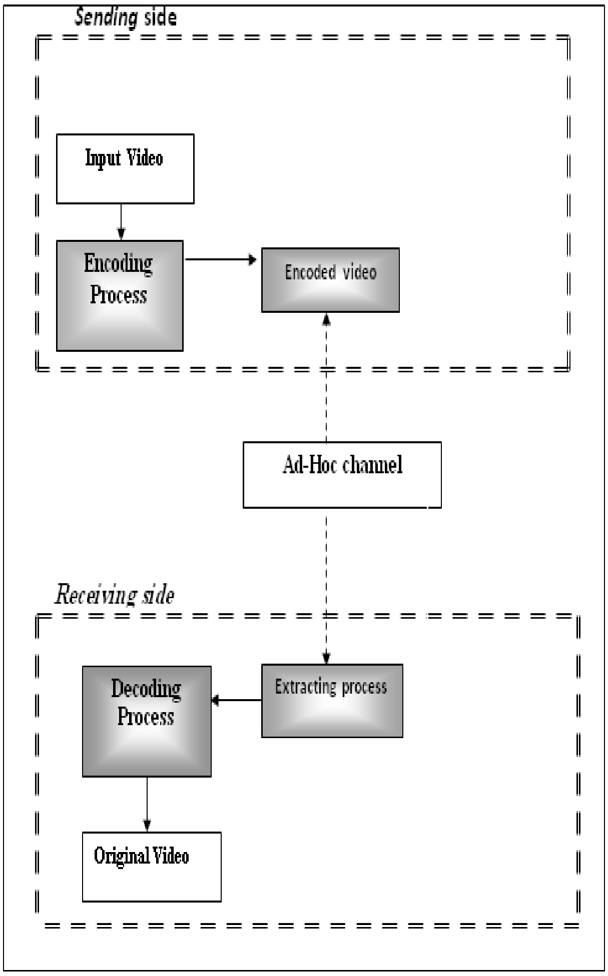

Fig. 1 General system of transferring video over an ad hoc network

IV. Challenges of Video Transmission over MANETs

Real-time multimedia transport has stringent bandwidth, delay, and loss requirements. This application is considerably difficult to support in wireless ad hoc networks, where wireless links are frequently broken and reestablished because of mobility. With respect to these challenges, channels may also be severed from congestion. The following types of errors may occur during video transfer over ad hoc networks:

- Link failure errors: These errors occur because of the changes in link states as well as because of the nature of the wireless links and network nodes that are constantly characterized by instability and mobility.
- Congestion errors: These errors occur because of the changes in channel states [12]. TCP assumes that the loss of packet refers to congestion errors rather than link failure errors [13].

V. Video Transmission Mechanisms

Many mechanisms use decreasing delay, damage packet elimination, and repair of broken links of ad hoc networks. These mechanisms can be reflected positively in video streaming performance. These mechanisms include single description coding (SDC) technique, multi description coding (MDC) technique, and layered description coding (LDC) technique.

5.1 single description coding (SDC)

This mechanism is the simplest technique used to generate video streams by encoding the specific video into a single stream. Then, that stream is distributed onto several paths. This technique is easy to implement, but it does not exhibit high performance because the streams on one path depend on the streams on another path. Thus, the quality of the received video is low when this technique is used in transferring video, as illustrated in Fig. 2.

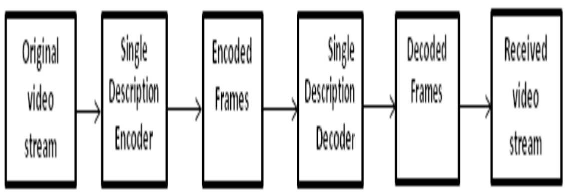

Fig. 2 SDC Technique

5.2 Multi description coding (MDC)

Fig. 3 illustrates that MDC divides the original stream into several descriptions. All descriptions have the same importance. Then, the decoder rebuilds the received video from any group of descriptions. The quality of the video is directly proportional to the number of correctly received descriptions. Any description can be used to reconstruct the original video with basic characteristics of quality, and any newly generated description is used to further improve the video quality [14].

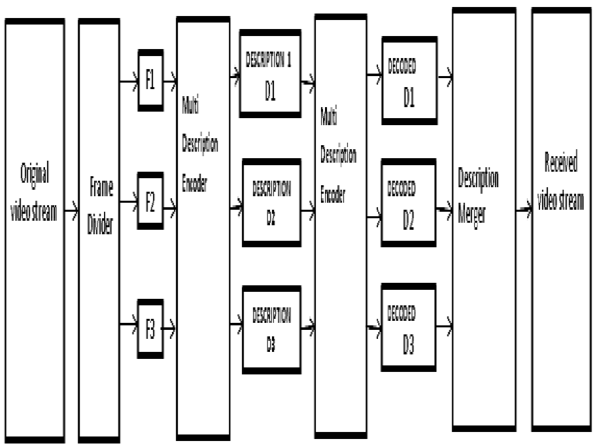

Fig. 3 MDC Technique

5.3 layered description coding (LDC)

Fig. 4 illustrates that this technique involves encoding a video frame into two layers: base and enhancement. The base layer is decoded independently of the enhancement layer, whereas the enhancement layer is used to refine the quality of the base layer. Moreover, using the enhancement layer alone is ineffective. Thus, the base layer is considered the most important part of the LDC technique; the retransmission of the damaged packets occurs by using the enhancement path, thereby leading to less delay [15].

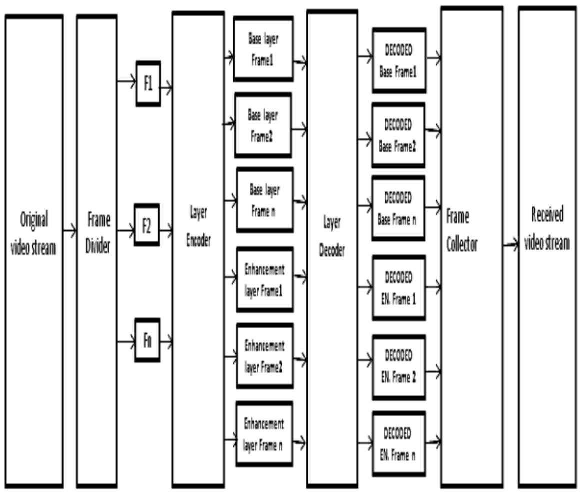

Fig. 4 LDC Technique

VI. Error Correction Methods

Two basic methods are commonly used to correct damaged packets in the ad hoc network: forward error correction (FEC) and automatic repeat request (ARQ).

6.1 Forward Error Correction (FEC)

FEC is an error correction method that permits the sender side to add extra data into original messages; thus, the receiver is aided in correcting a specific number of errors in the received data without the need for any retransmission [16].

Two schemes are used to design FEC and prevent damage to data packets. These schemes are called media-dependent FEC and media-independent FEC.

- Media-dependent FEC: This type of FEC design prevents packet loss by sending each packet more than once. When one of the packets is damaged, one of the additional packets restores the damaged packet.

- Media-independent FEC: This type of FEC design does not need to know the content of each stream because a full block of mathematical codes is sent to repair the damaged packets [17].

6.1.1 FEC Classifications

FEC could be classified into two classes based on how the extra information is added to the original data:

- Static FEC: extra information is inserted into original data in a fixed rate. The main advantage of this type of FEC is ease of implementation. However, the disadvantage of static FEC is that this type is not sufficiently flexible; thus, it cannot adapt to network changes.

- Dynamic FEC: Extra information is dynamically inserted in different rates depending on network variation. The main advantage of dynamic FEC mechanism is adapting to network changes, thereby leading to high system performance [18].

6.2 Automatic Repeat Request (ARQ)

This type of error correction method requires less overhead than FEC does because retransmission occurs only when needed.
This method involves the use of a received acknowledgement (ACK) and not received acknowledgement (NACK) messages with resending techniques to ensure reliability and to receive data in optimal form.
In this method, if the sender does not receive an acknowledgement within a specific time, the request is automatically repeated until an answer is received.

6.2.1 ARQ Classifications

The two main ARQ strategies are stop-and-wait and go-back-N:

- Stop-and-wait ARQ strategy: This type of ARQ strategy is used to ensure correct delivery of data with few errors. Fig. 5 illustrates that the sending side sends only one frame at a time. The sender does not send another frame until the answer (ACK) is received at the receiving side. If the receiver does not receive an answer (ACK) from the sender in a specific time, the sender resends the undelivered frame

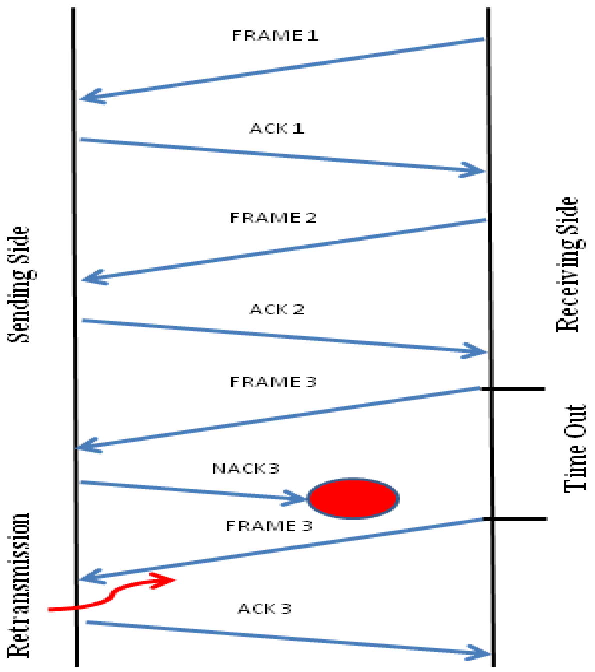

Fig. 5 stop-and-wait ARQ strategy

- Go-back-N ARQ strategy**:** As shown in Fig. 6, the sending side continues to send a specific number of frames even when no acknowledgement (ACK) is received at the receiving side. The sender retransmits all frames, starting from the first frame that was not returned (ACK) until the last frame [19].

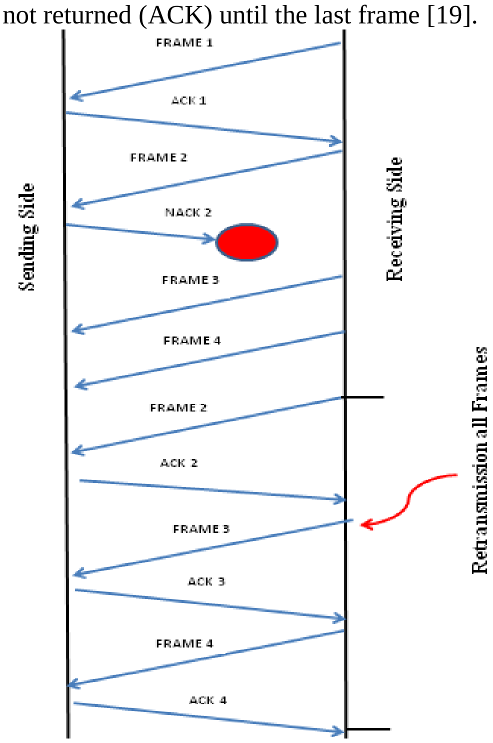

Fig. 6 Go-back-N ARQ strategy

VII. Network Simulation

This study involves measuring the effect of FEC and ARQ on video stream quality. These error correction methods are analyzed based on QoS parameters, such as average throughput, end-to-end delay, peak signal-to-noise ratio (PSNR), and packet delivery ratio. The simulations were performed by using a network simulator (i.e., NS2) with continuous bit rates as a traffic source. Source-destination nodes were moved randomly over the network. Mobility model used a square area of 1000 m × 1000 m with 20, 40, and 60 nodes. Simulation time is 150 seconds. The model parameters employed in this study are shown in TABLE1.

Table.1 Simulation Parameters

Simulation Parameters	**Value**
Simulator	NS-2.29
Routing Protocol Type	DSDV
Simulation Time (sec)	150
Simulation Area (m)	1000 × 1000
Node Number	20, 40, 60
MAC Type	802.11n
Name of Traffic	CBR
Simulation Model	Shadowing
Packet Size (bytes)	512
Channel Type	Wireless Channel

VIII. Performance Metrics

- Average throughput: This parameter is defined as the ratio of the received data to the simulation time. These data may be transferred over a logical or physical network node. Alternatively, these data may be pushed through a network node. Average throughput is always measured in bit/second or data packets/time slot.

$$\text{Average Throughput} = \frac{\sum \text{Received Data}}{\text{Simulation Time}} \quad \text{.....(1)}$$

- End-to-end delay: This parameter is defined as the time taken by data packets to reach the destination nodes. End-to-end delay can be calculated by dividing the sum of all time differences between sending and receiving of packets. Low end-to-end delay average in the network is a good indicator of network performance.

$$\text{End-to-End Delay} = \sum (T_{s1} - T_{r1}) + (T_{s2} - T_{r2}) + \ldots\ldots\ldots + (T_{sn} - T_{rn}) \ldots\ldots(2)$$

given that

- T_{s1} is the time received packet
- T_{r1} is the time sending packet

- PSNR: This parameter is defined as the ratio between the power of the original signal to the power of the noise. A high PSNR value indicates high network performance.

$$\text{PSNR} = \frac{\text{Power of Original Signal}}{\text{Power of Noise Signal}} \ldots(3)$$

- Packet delivery ratio: This parameter is defined as the ratio between the total delivered data packet number and the sent data packet number. This ratio is used to illustrate the level of delivered data to the destination node. The performance of the network is good when the packet delivery ratio is large [20].

$$\text{PDR} = \frac{\sum \text{Total number of packets received}}{\sum \text{Total number of packets sent}} \ldots.(4)$$

IX. Simulation Results

- Average throughput: In the FEC model, the throughput increased when the number of nodes increased. However, in the ARQ model, the throughput decreased when the number of nodes increased. Thus, the highest throughput can be obtained in a large number of nodes in the FEC model, as shown in TABLE 2 and Fig. 7.

Table.2 average throughput using FEC and ARQ

Number of Nodes	**FEC**	**ARQ**
20	470.20	340.25
40	610.52	320.98
60	670.98	310.54

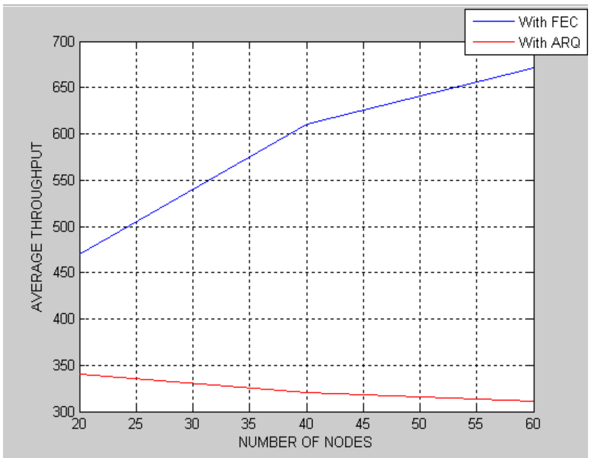

Fig. 7 Average throughput for FEC and ARQ

- End-to-end delay: TABLE .3 and Fig. 8 demonstrate that in both the FEC and ARQ, end-to-end delay increased as the number of nodes increased and vice versa. However, the results show that the FEC model exhibits the least end-to-end delay when FEC is compared with ARQ

Table.3 average end-to-end delay using FEC and ARQ

Number of Nodes	FEC	ARQ
20	110.38	215.56
40	180.32	270.54
60	197.01	310.98

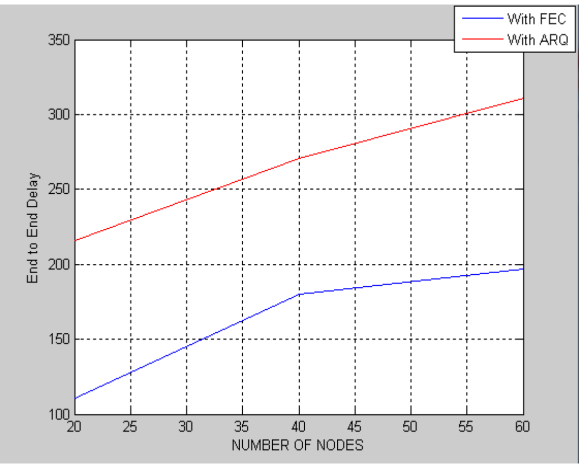

Fig. 8 End-to-end delay for FEC and ARQ

- PSNR: In both the FEC and ARQ model, the signal is decreased as the number of nodes increased and vice versa. However, the value of the PSNR in the FEC model is greater than that in the ARQ model, as demonstrated in TABLE .4 and Fig. 9.

Table.4 PSNR using FEC and ARQ

Number of Nodes	FEC	ARQ
20	40.32	25.32
40	36.21	21.36
60	34.89	19.38

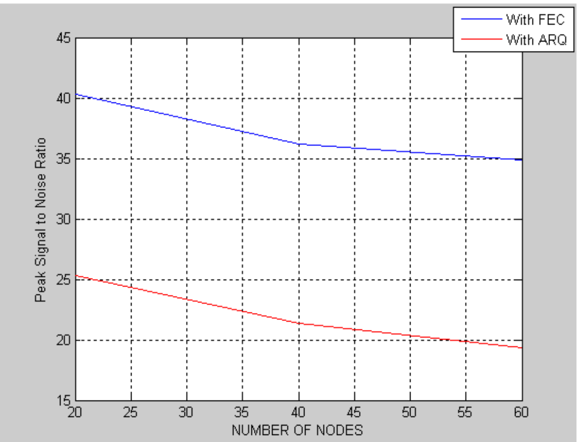

Fig. 9 PSNR for FEC and ARQ

- Packet delivery ratio: Both the FEC and ARQ models demonstrate that the packet delivery ratio increased when the number of nodes increased. However, the performance of FEC in packet delivery ratio is higher than that of ARQ, as shown in TABLE. 5 and Fig.10.

Table.4 Packet delivery ratio using FEC and ARQ

Number of Nodes	FEC	ARQ
20	94.20	86.50
40	95.88	89.01
60	96.98	90.25

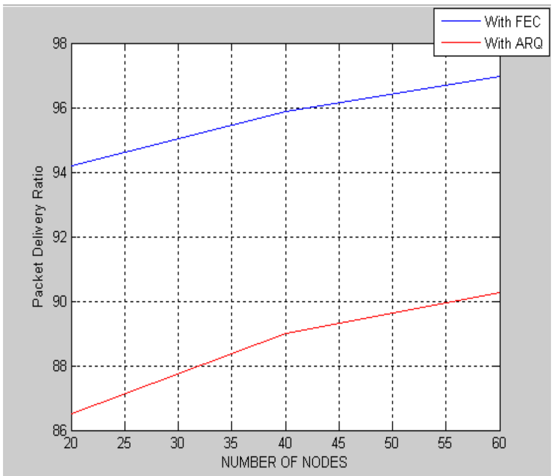

Fig.10. Packet delivery ratio for FEC and ARQ

X. Conclusion

This study aims to analyze the quality of video over ad hoc networks by using two error correction methods, namely, FEC and ARQ. The simulation results have demonstrated that the type of error correction method has a significant effect on video quality. Thus, this study concludes that FEC can improve video quality by increasing the average throughput, PSNR, and packet delivery ratio. FEC can also improve the video quality by decreasing the end-to-end delay. Furthermore, the performance of FEC in correcting errors for video over MANETs is better than that of ARQ.

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