

Improving Video Transmission over Heterogeneous Network by using ARQ and FEC Error Correction Algorithm

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Abstract

Video transferring over Heterogeneous Networks has been considered as one of the most significant subject to study because this process involve in a great number of new applications, which contributed in increasing the number of the users for this type of network. Transferring video in this type of network may suffer from many problems such as connection failures, weakness in the network layer, fading, network traffic overload, storage capacity, and so on. This study involves analyzing video transmission over heterogeneous using Network Simulation-NS2, the main errors which have occurred during video transferring, the types of video transmission techniques error correction methods, and various performance parameters such as the packet delivery ratio, throughput, normalized overhead control, and peak signal to noise ratio. The effect on the quality of the delivered video are calculated, and the results show that the quality of video transmitted over heterogeneous networks has improved using the proposed algorithm.

Keywords: Adaptive Repeat Request ARQ, Forward Error Correction (FEC), Heterogeneous Network, Video Transmission Techniques

1. Introduction

In the last few years, video transmission over heterogeneous networks has become one of the most important issues. This process involves in a great number of modern applications including video on demand, video conferencing, and many new mobile social network applications. However, providing this type of application in such networks is not simple because these networks pose many challenges such as link failure, congestion, fading, bandwidth capacity, storage management, and so on. Thus, finding an accurate error correction method to solve these problems is highly necessary. There are two

types of strategies, which are used to correct corrupted transferred packets in heterogeneous network that are Automatic Repeat Request (ARQ) and Forward Error Correction (FEC). These two strategies has been studied and discussed, and the results are analyzed to ensure the correct reception of the video packets.

2. Related Works

Danjue et al.¹ developed a new algorithm for the selection of routes in networks. This new algorithm uses multiple sources and paths to provide high-quality video on demand over wireless mesh networks and utilizes FEC to correct

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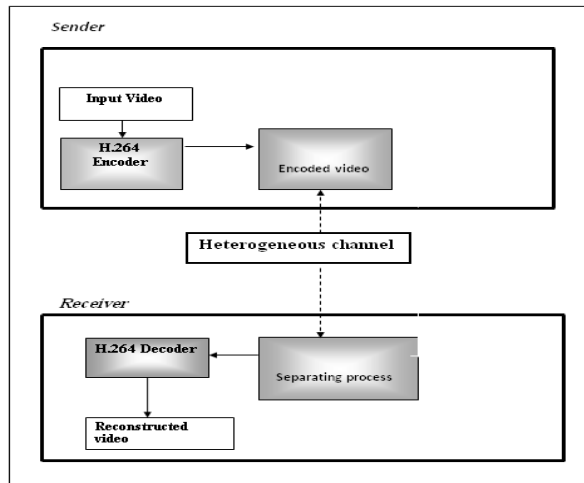


Figure 1. General system of video transmission over heterogeneous networks.

errors. The algorithm was simulated using opnet and the results show a great gain in the Peak Signal-to-Noise Ratio (PSNR), which is reflected in the high quality of the video. Peng et al.² suggested a new FEC algorithm that depends on the cross-layer design in streaming MPEG-4 video over wireless networks. This algorithm utilizes Poisson operation to anticipate the status of the network, which forms the basis of changes in the rate of sending the video frame. The simulation results show a clear gain in video quality in terms of minimum delay and number of loss packets.

A new error correction method was developed by Naccari that uses multi description video coding algorithm³. This study determined and estimated the ratio of loss in the transmission channel and corrected the error according to this status. The practical results of this method, relative to those of all the previous methods, exhibit a high quality in the perceived video. Omar et al.⁴ studied the effect of using different FEC packet sizes on reducing the ratio of packet loss in the perceived video quality. This study used Ns2 simulator to simulate the network environment, and the simulation results yielded the best values for the FEC packet size that must be used in any wireless environment to increase the efficiency of the whole network. In⁵, Morten determined the main difficulties in video streaming over mobile ad hoc networks. This study identified the cross-layer design and the main parameters and factors that have the most significant effect on the quality of the video stream and the main restrictions on wireless resources. It also summarized the main problems that occur in transferring videos and determined the main techniques to solve these problems.

Harsharndeept et al.⁶ analyzed the impact of routing overhead, delay, throughput, and Packet Delivery Ratio

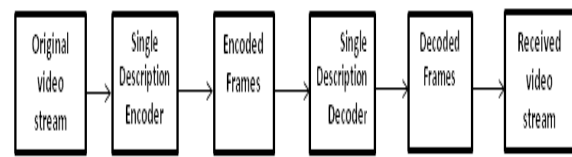


Figure 2. SDC Technique.

(PDR) on the ad-hoc on-demand multipath distance vector routing protocol. This study also suggested a new technique of transferring videos and adapting them to the network status. The simulation results show that this technique can decrease the routing overhead and increase the PDR, which reflected positively in the video quality.

3. Video Transmission over Heterogeneous Network

In the last few years, heterogeneous technology has been developed enormously, such that the personal and social applications of the heterogeneous device have also been developed and transferred from simple communication to multimedia applications, with the result that improving and increasing the quality of these media have become necessary⁷. The general system of video transmission over heterogeneous networks is as shown in Figure. 1. It consists of two sides: the sender and the receiver.

On the sender side, the video is transferred in any kind of video format (e.g., MPEG, MPEG2, MPEG3, MPEG.4, H.263, H.264, and so on). In this study, H.264 is used to encode and decode the video. The video is encoded into a number of packets using software encoder based on the type of the transferred video format. The encoded packets are passed through a specific channel (i.e., wire and wireless channels). The receiver side extracts the packets and decodes them using the software decoder to rebuild the receiver video at the receiver node.

4. Video Transmission Techniques

Many techniques can be employed to eliminate the delay, renovate the damage packets, and maintain destroyed links in heterogeneous networks. All of these mechanisms help to increase the quality of video streaming. Examples of these techniques include the Single Description Coding (SDC), Multi Description Coding (MDC), and Layer Description Coding (LDC) techniques.

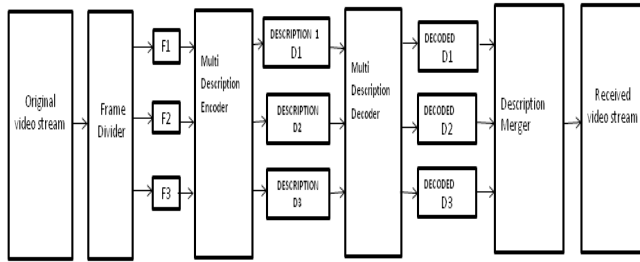


Figure 3. MDC Technique.

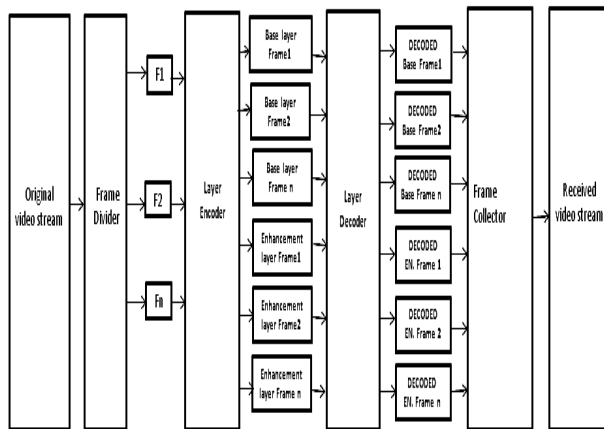


Figure 4. LDC Technique.

4.1 Single Description Coding (SDC)

This technique is regarded as the easiest technique used in video transmission. It can be implemented by encoding a certain video into only one stream. This stream is then divided into a number of encoded frames, which are distributed into multiple paths. The main disadvantage of this technique is that the streams on one path will depend on the streams on another path. Thus, the received video quality is unsatisfactory, as shown in Figure 2.

4.2 Multi Description Coding (MDC)

This second type of video transmission technique divides a given stream into the number of frames. These frames are then directed into a multi-description encoder, which produces a number of descriptions that have the same significance. The decoder then reconstructs the received video from any group of received descriptions. The quality of the video is determined by the number of descriptions that are received correctly. Any description can be used to reconstruct the base video, with the main character-

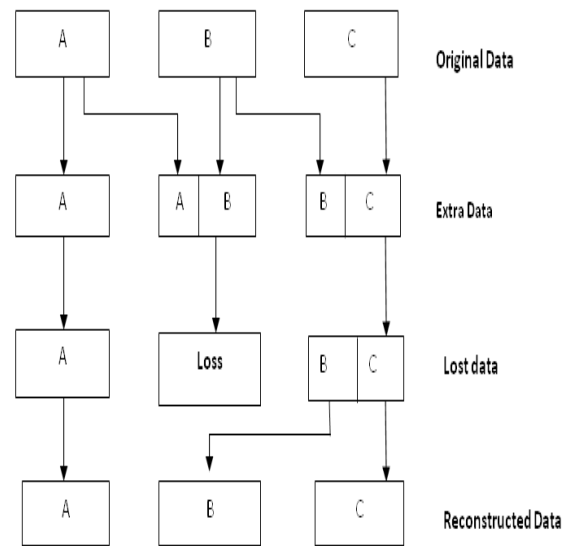


Figure 5. The procedure of adding extra data and how such data are constructed at the receiver.

istics of quality, and any newly produced description can be used to further improve the video quality, as shown in Figure 3⁸.

4.3 Layer Description Coding (LDC)

In this type of video transmission technique, each video is divided into a number of frames. These frames are then encoded into two layers: the BL and EL. These layers are encoded and decoded independently of each other. The BL contains the video with the basic characteristics, while the EL is used to increase the quality of the BL. In this technique, using only the EL is inefficient. Thus, the BL is the main part of the LDC technique. Lost packets are resent using the enhancement path, so that this technique decreases the delay⁹, as shown in Figure 4.

5. Error Correction Strategies

Two basic strategies are usually applied to correct the errors in heterogeneous networks which are Automatic Repeat Request (ARQ) and Forward Error Correction (FEC).

5.1 Automatic Repeat Request (ARQ)

Automatic Repeat Request (ARQ) techniques are usually used by a packet switching data system to reserve an

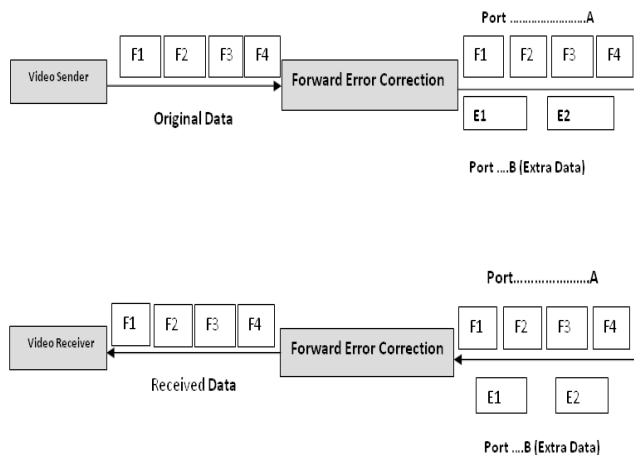


Figure 6. FEC formula construction.

error-free communications link between stations. The ARQ technique guarantees suitable data quality with different types of link status. This type of strategy supplies a minimum network overhead because retransmission of the packets execute when it needs only. This will depend on the utilization of the received Acknowledgement (ACK) and the not received Acknowledgement (NACK), with retransmission technology to guarantee the packets delivering in optimum 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.

5.1.1 ARQ Classifications

The two mainly ARQ can be categorized into two types which are Stop-and-wait and Go-back-N ARQ strategies:

A-Go-back-N ARQ strategy: In this strategy, the sender node continuously sending a fixed number of packets even when there is no reply with Acknowledgement (ACK) from receiver node.

B-Stop-and-wait ARQ strategy: This type of ARQ is applied to guarantee the correct reception of sent data. In this strategy, the sender node sends only one data packet at a time, and waits for receiving a reply with (ACK) from the receiver node, after this it will transfer another data packets⁸.

5.2 Forward Error Correction (FEC)

FEC is the main method used in correcting errors in packets. FEC allows the sender of packets to incorporate

additional data into the main packets. This capability will help the receiver of packets to correct a certain number of errors in the delivered packets without the need for any retransmission.

Retransmission results in a greater gain in bandwidth relative to Automatic Repeat Request (ARQ), which is considered as the second type of error correction method. The main difference between FEC and ARQ is that the latter depends on the retransmission strategy in correcting errors in received packets¹⁰. The procedure of adding extra data and how such data are constructed at the receiver is as shown in Figure 5.

The extra data in FEC are also transferred, so that the received message can be rebuilt with high quality, particularly when any loss in the original packets occurs, as shown in Figure 6. In any FEC, the main formula of the original and extra data is determined by $E = M - F$, where E is the extra data, M is the FEC block size, and F is the original data¹¹.

5.2.1 FEC Classifications

FEC can be classified into two categories, depending on the means by which extra information is added to the main data:

A-Static FEC:

In this type of FEC, a constant number of extra information is inserted into the original data regardless of the status of the network. This FEC is regarded as the simplest type of FEC in terms of execution. However, the disadvantage lies in its inability to adapt to changes in the network traffic.

B-Dynamic FEC:

In this type of FEC, a number of extra data is dynamically inserted at different rates depending on the changes in the network traffic. The main advantage is its ability to adapt to variations in network status, which in turn results in a high network performance¹².

6. Network Simulation

The impact of two error corrections algorithms that are FEC and ARQ on the quality of the transferred video are simulated. The performance parameters such as packet delivery ratio, normalized overhead control, throughput, and peak signal-to-noise ratio are calculated, which are measured with respect to speeds.

Table 1. Simulation Parameters

Simulation Parameters	Value
Speeds(m/sec)	3,6,10,13
Number of Nodes	100
Simulation Area (m)	1500 × 1500
Simulation Model	Two Ray Ground Model
Packet Size (bytes)	512
Mac Type	802.11
Simulator	NS2
Simulation Time (sec)	150

The models are simulated using network simulator NS2, where the Continuous Bit Rate (CBR) is used as a traffic pattern. The packet size of CBR is 512 bytes, and this package is transferred in one second. The source and destination nodes are randomly distributed in a specific area of the network. The mobility model uses a square area of 1500 m × 1500 m with speeds of 3, 6 and 10 m/sec. The simulation time is 120 seconds. The parameters of the model are shown in Table 1.

7. Simulation Parameters

7.1 Packet Delivery Ratio (PDR)

Packet delivery ratio is defined as the ratio between the total number of data packets delivered and the number of data packets sent.

7.2 Normalized Control Overhead

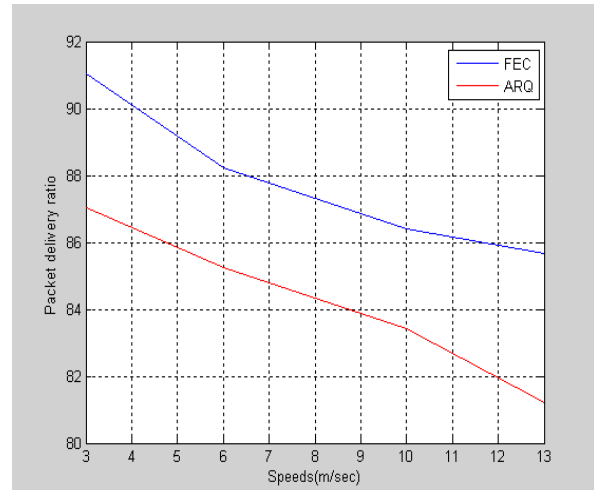
It is calculated by dividing the total number of packets transmitted under protocol control by the total number of delivered data packets¹³.

7.3 Throughput

Throughput is defined as the ratio of the correctly received data to simulation time, the units of this parameter are data packets/second or data packets /time slot.

7.4 Peak Signal to Noise Ratio

This parameter is determined by comparing the quality of the original signal with that of the received signal. The qualities of the signals are compared by calculating the ratio of the power of the main transferred signal to the power of the effected noise on the transferred signal. A high value of PSNR is a good indicator of high video quality¹⁴.

**Figure 7.** Packet delivery ratio for FEC and ARQ.**Table 2.** Packet delivery ratio for FEC and ARQ

Speed (m/sec)	FEC	ARQ
3	91.02	87.02
6	88.24	85.24
10	86.42	83.42
13	85.65	81.20

8. Analysis and Results

8.1 Packet Delivery Ratio

Packet delivery ratio for both FEC and ARQ increases as the speed of the node decreased, as shown in Table 2 and Figure 7. However, the packet delivery ratio for FEC is greater than that of ARQ, which means that FEC can minimize the number of corrupted data packets because of its sufficient strategy in correction the damaged packets, which is reflected in enhancing the quality of the received video.

8.2 Normalized Overhead Controller

For both FEC and ARQ, the normalized overhead controller increases as the speed of the node increased, as shown in Table 3 and Figure 8. However, FEC shows a low normalized overhead controller value. The main reason for this result is that FEC has a minimum number of con-

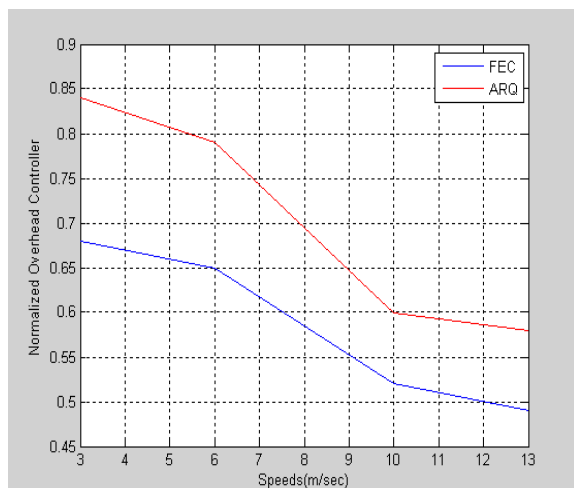


Figure 8. Normalized overhead controller for FEC and ARQ.

Table 3. Normalized overhead controller for FEC and ARQ

Speed (m/sec)	FEC	ARQ
3	0.68	0.84
6	0.65	0.79
10	0.52	0.60
13	0.49	0.58

trol packets which are used in the source, in contrast with ARQ which used a great number sent packets, in order to ensure the correct reception of the acknowledgement. Hence, FEC reduces the number of control packets so that the network overhead is also reduced, and the number of dropped packets decreased. As a result, the quality of the video which is recovered by FEC is higher than that of ARQ.

8.3 Throughput

The throughputs for both FEC and ARQ decrease as the speed of the node increases, as shown in Table 4 and Figure 9. This decrement is due to the increment in speed which increases the distance between the nodes. Thus, the number of the packets received in the destination node is minimized. However, FEC is registered higher throughput value than ARQ which means that FEC can increase the number of successful delivered packets in a specific time, that reflect in a video with high quality.

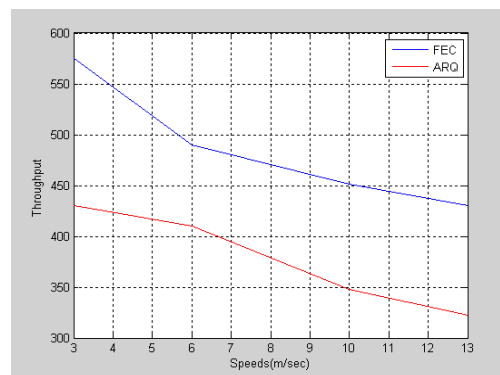


Figure 9. Throughput for FEC and ARQ.

Table 4. Throughput for FEC and ARQ

Speed (m/sec)	FEC	ARQ
3	575.23	430.25
6	490.23	410.36
10	450.98	347.98
13	430.21	322.14

8.4 Peak Signal Noise Ratio

For both the FEC and ARQ models, as the speed of the node is increased, the strength of the transmitted signal will be reduced, and vice versa. This is as shown in Table 5 and Figure 10. However, the value of the PSNR in FEC is higher than that in ARQ. The main reason for this improvement is that the number of the adaptively added FEC packets increase as the number of the corrected received packets is increased, which resulting in a high PSNR value.

9. Conclusions

This study analyses the effect of using various type of error correction algorithms in improving the quality of video transmitted over heterogeneous networks. The simulation results have shown that the type of error correction method has an important effect on received video quality, and it proved that FEC is efficient in improving the quality of videos with an increased in their PDR throughput and PSNR, and decreasing the Normalized overhead controller of the received video stream. Thus, in conclusion the performance of FEC in correcting errors for video over MANETs is better than that of ARQ.

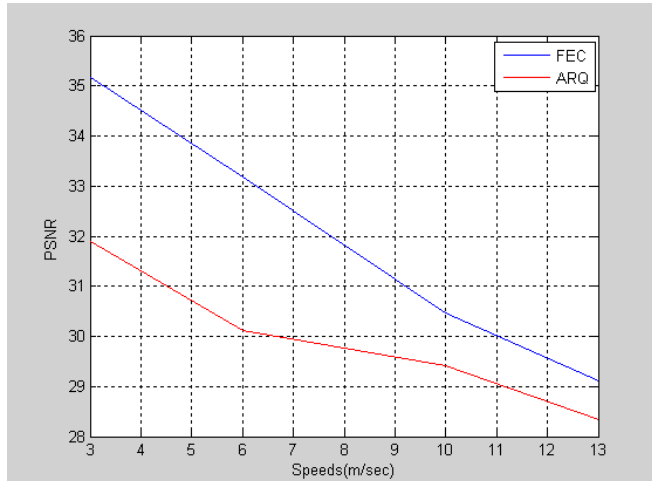


Figure 10. Peak Signal Noise Ratio for FEC and ARQ.

Table 5. Peak Signal Noise Ratio for FEC and ARQ

Speed (m/sec)	FEC	ARQ
3	35.17	31.89
6	33.18	30.12
10	30.47	29.41
13	29.10	28.33

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