Journal of Scientific Research and Development 2 (14): 26-32, 2015
Available online at www.jsrad.org
ISSN 1115-7569
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Effect of Node Density and FEC Packet Size on Video Quality over Heterogeneous Networks

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Abstract: Video transferring over Heterogeneous Networks has been considered as one of the most important subject to study since this process is used in a great number of modern applications, where the number of the users using for this type of network has increased. Transferring video may be suffered from many problems such as fading, connection failures, network traffic overload, storage capacity, and so on, which reflected in reducing the quality of the perceived video. There are many parameters that must be determined accurately in order to ensure the correct reception of delivered video, This paper study the effect of using different node density (number of nodes) and different Forward Error Correction (FEC) packet size on perceived video quality. The FEC method is selected because it is considered the most important method among all of the available methods. This method is used with different packets size that affect the network overhead thus the packet deliver ratio(PDR) and the number of dropped packets will also be effected, Hence, the way of selection the accurate FEC packet size is very important. This study has analyzed the video transmission over heterogeneous network using Network Simulation-NS2. The main errors which have occurred during video transferring and types of video transmission techniques error correction methods are studied. Various performance parameters such as the packet delivery ratio, throughput, and peak signal to noise ratio which affect the quality of the delivered video are also calculated with respect to different node density and FEC packet size in order to get the ideal density and FEC packet size.

Key words: Heterogeneous network; Error correction methods; Forward Error Correction (FEC); 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 the accurate error correction method to solve these problems is highly necessary, and select the accurate number of nodes and accurate FEC packet size for the network is also a very important task. 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 and select which number of the nodes and FEC packet size can improve the quality of the received video.

2. Related works

A new algorithm for the selection of routes in networks was developed by Danjue (Danjue et al., 2006). This new algorithm used multiple sources and paths to provide high-quality video on demand over wireless mesh networks and utilizes FEC to correct errors. The algorithm was simulated using opnet and the results showed a great gain in the peak signal-to-noise ratio, which is reflected in the high quality of the video. (Peng et al., 2008) suggested a new FEC algorithm that depends on the cross-layer design in streaming MPEG-4 video over wireless networks.

This algorithm utilized 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 showed 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 et al, 2008) that

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used multi description video coding algorithm. 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. (Morten et al, 2010) 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 occurred in transferring videos and determined the main techniques to solve these problems.

(Harsharndeep et al, 2012) analyzed the impact of routing overhead, delay, throughput, and packet delivery ratio (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 showed that this technique can decrease the routing overhead and increase the PDR, which reflected positively in the video quality.

3. Video transmission over heterogeneous networks

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 necessary (Cranley and Murphy, 2009). The general system of video transmission over heterogeneous networks is as shown in Fig. 1. It consists of two sides: the sender and the receiver.

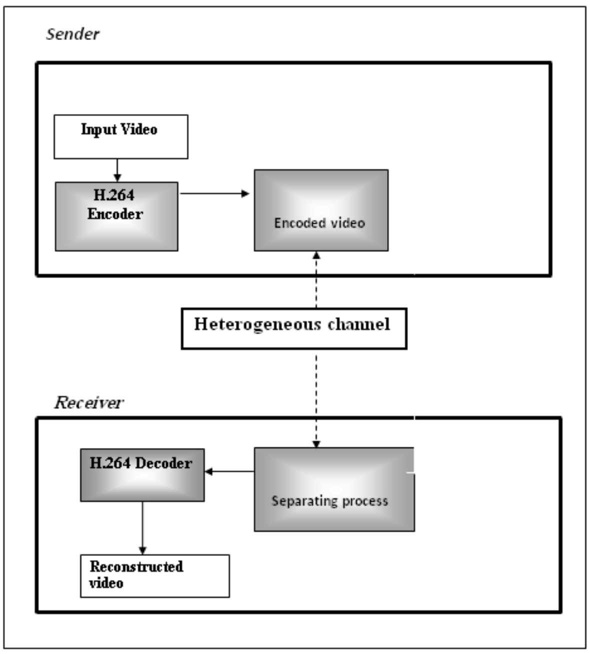

Fig. 1: General system of video transmission over heterogeneous networks

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 are the Single description coding (SDC), Multi description coding (MDC), and Layer description coding (LDC) techniques.

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 Fig 2.

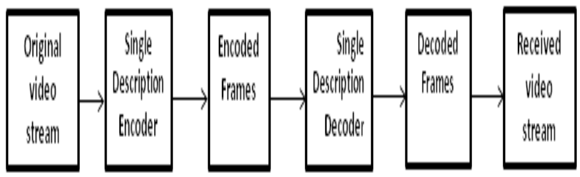

Fig. 2: SDC technique

4.2. Multi description coding (MDC)

This second type of video transmission technique divides a given stream into a 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 characteristics of quality, and any newly produced description can be used to further improve the video quality (Vaidya et al., 2010) as shown in Fig. 3.

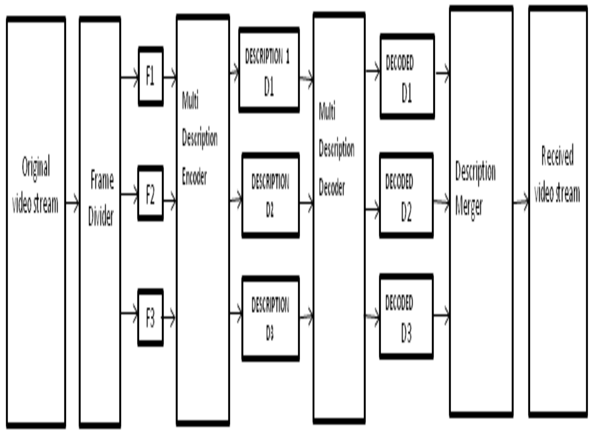

Fig. 3: MDC technique

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 delay (Magnus, 2008), as shown in Fig. 4.

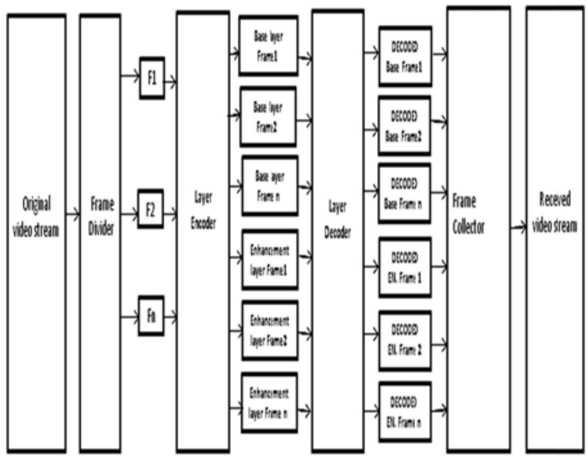

Fig. 4: LDC technique

5. Forward error correction (FEC)

FEC is the main method uses 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 packets (Shiwen et al., 2001). The procedure of adding extra data and how such data are constructed at the receiver is as shown in Fig. 5.

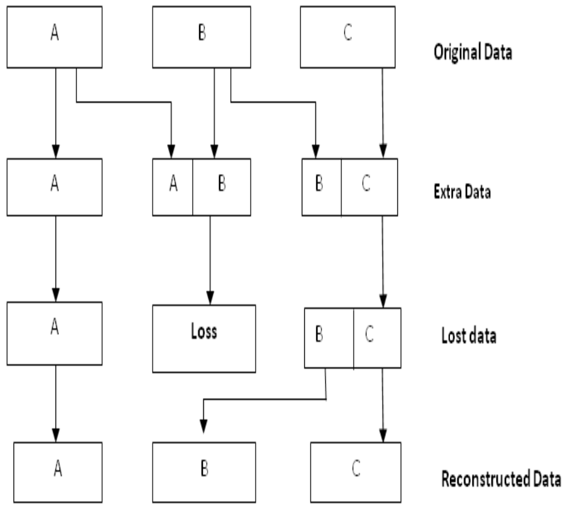

Fig. 5: The procedure of adding extra data and how such data are constructed at the receiver

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 Fig. 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 data (Chakareski et al., 2005).

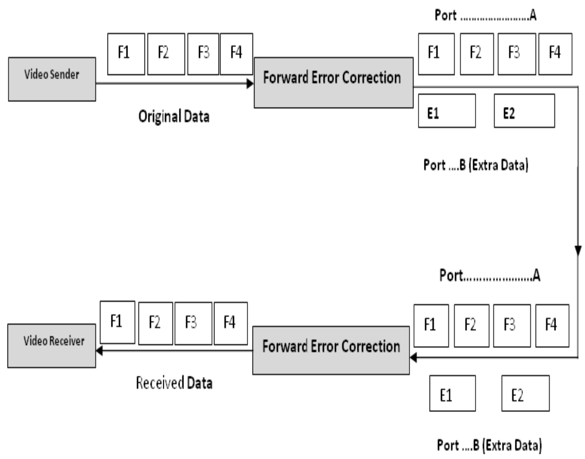

Fig. 6: FEC formula construction

5.1. FEC classifications

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

5.1.1. 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.

5.1.2. 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 performance (Kliazovich et al., 2010).

6. Network simulation

This study analyses the impact of two error corrections algorithms which are: FEC and ARQ on the quality of the transferred video. The performance parameters that are calculated including packet delivery ratio, throughput and peak signal-to-noise ratio and all of them are measure with respect to speeds.

The simulations are modeled using the network simulator NS2. The continuous bit rate (CBR) is used as a traffic pattern, and the video quality is evaluated based on two different scenarios to determine the effect of node density and the FEC packet size on the perceived video quality. The first scenario is to examine the effect of number of nodes on Packet Delivery Ratio, throughput, the number of dropped packets and Peak Signal to Noise Ratio of the perceived video. However, the second scenario is to examine the effect of the different FEC size on same parameters and get the best value. 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, 10 (m/sec). All parameters of the models are as shown in Table 1.

Table 1: Simulation parameters

Simulation Parameters	Value
Number of nodes	30,70,100,150,200
FEC packet size	600,800,1000,1200,1400
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

7. Performance parameters

7.1. 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. 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.

7.3. Number of dropped packets

When a packet reaches a network layer, it is sent to the destination node if a correct route is identified. Otherwise, the packet is buffered until the appropriate route by which to reach the destination node is discovered. If the buffer is full, then the packet is dropped (Nor et al., 2009).

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 Peak signal to noise ratio is a good indicator of high video quality (Chakareski et al., 2005).

8. Results and discussion

The quality of the delivered video is measured based on two different scenarios: the effect of the node density and FEC packet size on the quality of the received video.

8.1. First scenario: Effect of node density:

This scenario is applied to measure the PDR, throughput, number of dropped packets, and peak signal to noise ratio of the received video quality without using any type of error correction methods like FEC. The simulation results are as follows:

PDR: When the number of nodes has increased the packet delivery ratio of the received video will be increased, as shown Table 2 and Fig.7. This mean that the high number of nodes will be contributed in forwarding the video from one node to another until it reached to the receiver, so the ratio of the received packets will be increased with respect to the sent packets, which reflected in producing high quality video. Therefore, the highest video quality in terms of the PDR can be obtained for 150 and 200 nodes.

Table 2: PDR for two ray ground model and shadowing

No. of Nodes	PDR of the delivered video
30	89.20
70	90.88
100	92.98
150	94.32
200	94.62

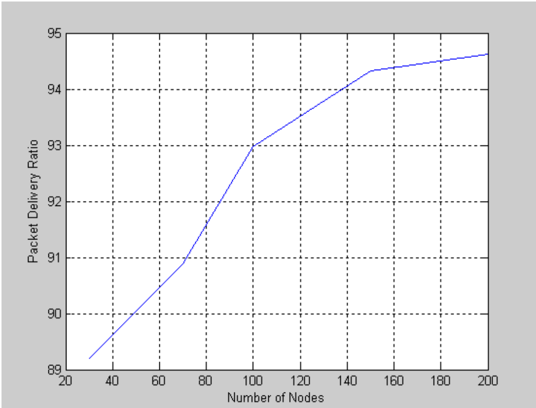

Fig. 7: PDR for Two Ray Ground model and Shadowing

Throughput: When the number of the nodes increased, the total number of the received video on the specific time will be reduced, as shown in Table 3 and Fig. 8. However the results are slightly different in case of increasing the number of nodes into more than 30 nodes. The quality of video is also increased but in small amount, so the higher video quality can be obtained in terms of throughput for 30 nodes.

Table 3: Throughput for two ray ground model and shadowing

No. of Nodes	Throughput
30	532.65
70	425.36
100	409.23
150	401.65
200	389.78

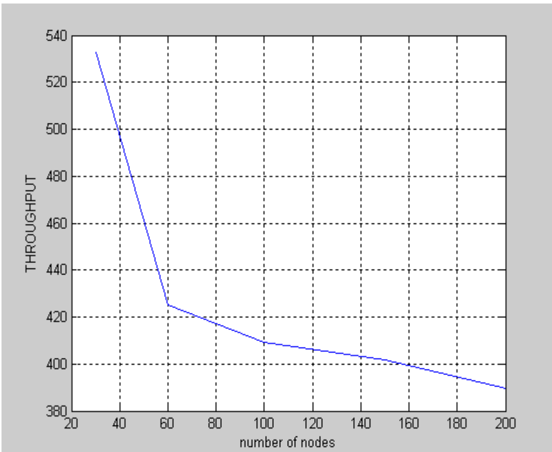

Fig. 8: Throughput for two ray ground model and shadowing

Number of dropped packets: When the number of the nodes increased, the total number of dropped packets will be increased, as shown in Table 4 and Fig. 9, for 30 and 70 nodes. However, when the numbers of nodes become greater than 70, the number of dropped packets will be approximately the same value, which means in the condition of this study, when the total number of nodes exceeded the specific ranges, the total value of the dropped packets will be decreased.

Hence, the quality of the received video will be increased in terms of the number of dropped packets as the density of the nodes is more than 70 nodes.

Table 4: Number of the dropped packets for two ray ground model and shadowing

No. of Nodes	Number of dropped packets
30	**21**
70	25
100	19
150	15
200	14

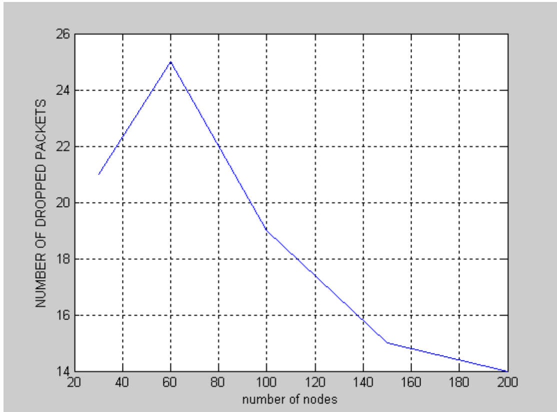

Fig. 9: PDR for two ray ground model and shadowing

Peak Signal to Noise Ratio: For the case of 30 and 70 nodes, the quality of the original signal as it compares with the quality of the received signal is high, as shown in Table 5 and Fig. 10. However, when the number of nodes is increased more than 70, the quality of this signal becomes less due to the decreasing in the power signal as it transferred and the effect of the topology noise. This difference is very slight, so that the quality of the received video is slightly different as the number of the nodes is increased more than 70 nodes.

Table 5: Peak signal to noise ratio for two ray ground model and shadowing

No. of Nodes	Peak Signal to Noise Ratio
30	35.23
70	34.52
100	32.94
150	33.05
200	31.25

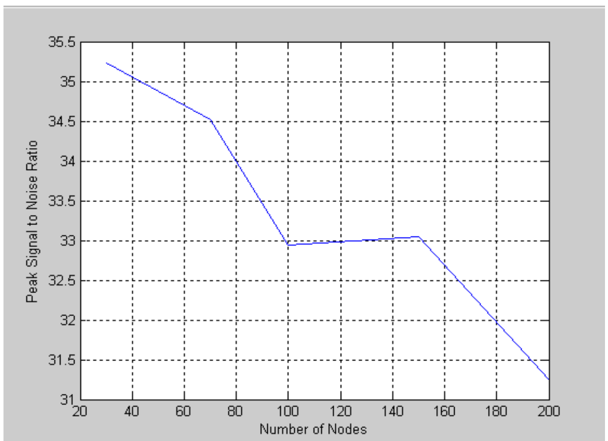

Fig. 10: Peak signal to noise ratio for two ray ground model and shadowing

8.2. Second scenario: Effect of FEC packet size:

This scenario is applied to measure the PDR, throughput, number of dropped packets, and the peak signal to noise ratio of the receive video quality using FEC error correction method. The packet size of FEC is changed to get the benefit of FEC, and the optimum value of FEC packet size is determined. The simulation results are as follows:

PDR: FEC method can increase the number of received packets in the correct form in a great ratio, as shown in Table 6 and Fig. 11. This improvement is nearly (3-6%) which is considered a very high increment in terms of PDR. However, in the case of packet size of 600 and 800 bytes, when the packet size of FEC increases, the packet delivery ratio of the received video will decrease. This mean that these two values of packet size will be contributed in decreasing the ratio of the received packets with respect to the sent packets, but the highest PDR can be obtained in packet size of 1200 bytes which produced the highest video quality when compares with the other values.

Table 6: PDR for the two ray ground model and shadowing

FEC packet size	PDR
600	94.49
800	93.25
1000	92.32
1200	96.35
1400	90.62

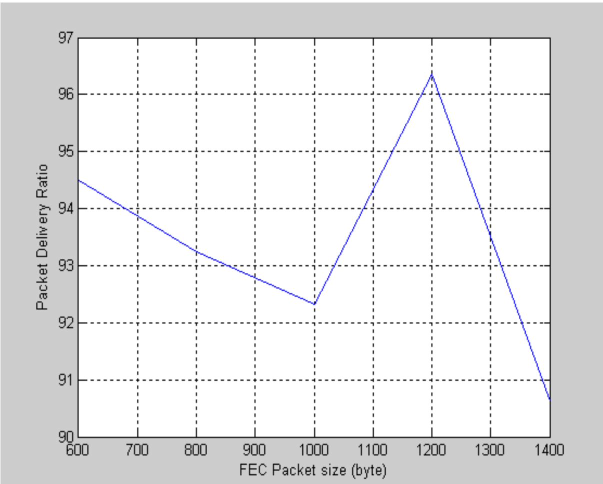

Fig. 11: PDR for two ray ground model and shadowing

Throughput: In the case of 600 and 800 bytes, when the size of FEC has increased the total number of the corrected received video on the specific time will be reduced as shown in Table 7 and Fig. 12. However, this result is different for packet size 1200 byte, which increases the throughput in nearly 50-60 bytes as it compared with the previous case. These results reduce in 1400 byte, so the higher video quality can be obtained in terms of throughput in 1200 bytes.

Number of dropped packets: In the case of 600 and 800 bytes, when the number of nodes increased, the total number of the dropped packets will be increased, as shown in Table 8, Fig. 13, and Fig. 7. However, when FEC packet size becomes greater than 800 bytes the number of dropped packets will be approximately the same value. For the condition of this study, the quality of the received video is approximately the same in terms of the number of dropped packets as the FEC packet size is more than 800 bytes.

Table 7: Throughput for the two ray ground model and shadowing

FEC packet size	Throughput
600	550.23
800	535.23
1000	501.21
1200	603.32
1400	504.28

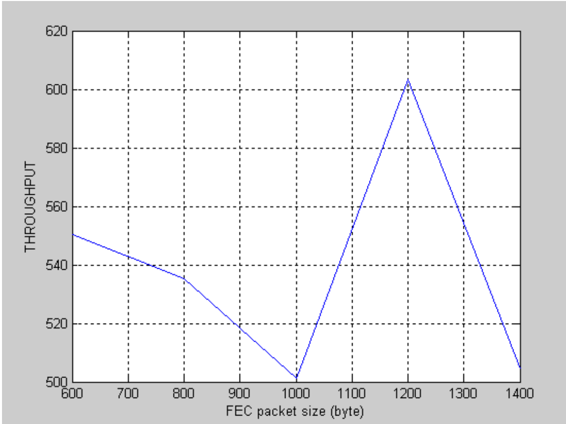

Fig. 12: Throughput for two ray ground model and shadowing

Table 8: Number of the dropped packets for the two ray ground model and shadowing

FEC packet size	Number of dropped packets
600	18
800	19
1000	21
1200	21
1400	22

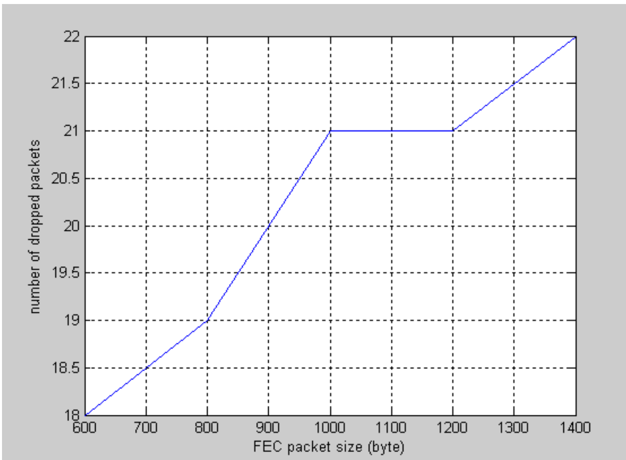

Fig. 13: Number of the dropped packets for two ray ground model and shadowing

Peak Signal to Noise Ratio: The quality of original signal as it compares with the quality of the received signal is increased as the FEC packet size is increased, as shown in Table 9, and Fig. 14. This improvement is due to the effect of FEC method in reducing the noise effects, but these differences is very minimum and the highest quality of the received video is obtained in 1200 and 1400 bytes of FEC packet size.

Table 9: Peak signal to noise ratio for two ray ground model and shadowing

FEC packet size	Peak Signal To Noise Ratio
600	32.25
800	35.29
1000	35.87
1200	37.21
1400	37.79

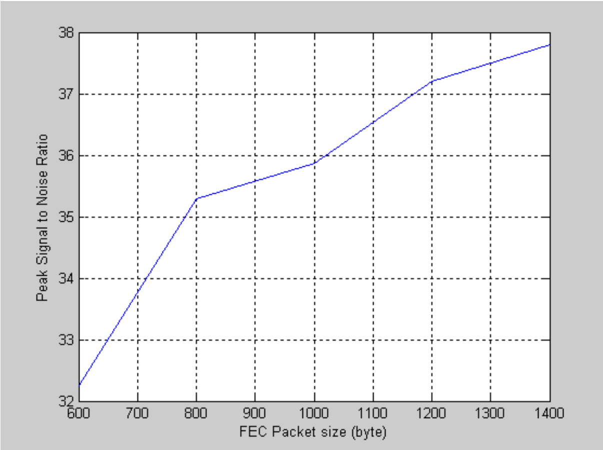

Fig. 14: Peak signal to noise ratio for two ray ground model and shadowing

9. Conclusions

Video transferring over Heterogeneous Networks and the effect of using different node density (number of nodes) and the effect of different Forward Error Correction (FEC) packet size on perceived video quality are analyzed. Different performance parameters such as the packet delivery ratio, throughput, number of dropped packets, and peak signal to noise ratio are used for the measurement, which affected on the quality of the delivered video. The simulation results proved that the ideal number of nodes has a direct effect on the perceived video quality and when all considerations are taken into account the ideal number of nodes in the topology network is 150 nodes. It can be concluded that the ideal density and FEC packet size is 1200 bytes.

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