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A Simulation of a Networked Video Monitoring System Using NS2

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Abstract

The work presented in this paper has focused on the simulation of video streaming over a hybrid (wired-wireless) network for the purpose of monitoring. A simulation scenario has been designed and implemented using the network simulator (NS2) to realise the network system. The system consists of 5 nodes, 3 of which are video cameras that play two major roles. First of all, capturing moving objects within a radius of 20 metres and secondly to work as a wireless routers within the network. Furthermore, the two nodes have different purposes; the fourth node works as an access point to connect the cameras which are wirelessly connected together and with the access point. However, the fifth node performs the job of a server which is wired-connected to the access point and has the video encoding/decoding and quality of service (QoS) calculations routines.The system has been implemented and tested under simulation environment and two types of assessment have been performed. The first assessment was to measure the quality of service from a networking point of view for which three factors have been used; namely: Packet Loss, End-to-End Throughput and Jitter. The second assessment was to measure the quality of the received videos using Peak signal to Noise Ratio "PSNR" measure. For simulation purposes 3 videos of type H.264 have been used to represent the 3 cameras streams. Evalvid framework is used to transform them into a streaming format to facilitate the evaluation of video streaming over a simulated network. The simulation process has shown a promising results in both network's QoS and video quality with the average packet loss of 0.04%, average time delay of 0.9sec and average jitter of 0.001951. More after, the video quality has shown an average "PSNR" of 30.13 when 1530 frames have been transmitted with STDV of 6.85.

Keywords: Network simulation, wireless network, wired network, video coding, QoS, video monitoring.

1- Introduction

The recent years have shown increasing interests in video applications over wireless networks in both industry and academic institutions. Many researches have been conducted to study the feasibility of using wireless network architecture as a medium for video applications. Furthermore, more researches have proposed methods and solutions for video encoding problems over a networked environment.

Maloth et el. [1] Proposed a cross-layer algorithm for video coding over a WiFi network. They used different access strategies for IEEE 802.11e categories. A multi view video coding standard have been studied to evaluate the system quality of services (QoS).

A simulation study of MPEG-4 requirements with a predefined experimental model has been introduced by [2] to measure the video performance under different parameters over a wireless sensor network (WSN). The authors had evaluated three parameters that affect the performance of video encoding and assumed that the simulation results would be used as a bench mark for future studies.

A multilevel video streaming techniques has been demonstrated in [3]. The simulation results have shown that multi-layers techniques would over perform the traditional single layer streaming in terms of video quality and network performance.

I. Overall System Layout

The system is designed as a mixed wired/wireless network with three types of nodes as follows:

- Three video cameras to capture objects within predefined dimensions.
- An Access point which is connected wirelessly to the video cameras.
- A server which has the encoding and monitoring software installed in it and wired connected to the access point and the monitoring station.

Figure (1) shows an overall system diagram; the distances between cameras are measured carefully to enable the system to cover as much as possible space within the available resources.

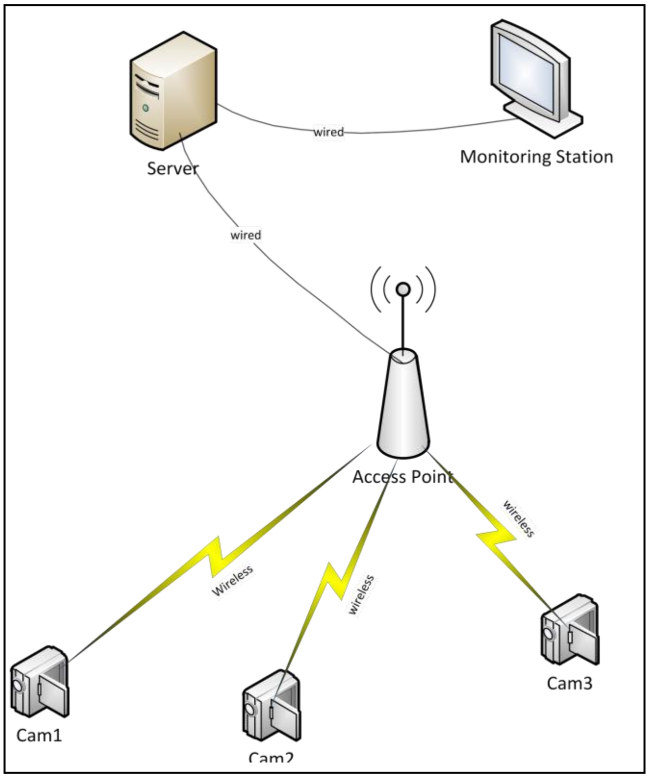

Figure (1) Overall System Layout

II. Simulation Setting and System Configuration

A. Network settings

The simulated environment has been created using the Network Simulator 2 (NS2)[4]. NS2 is a discrete even simulator which enables programmers to design networks of different types and perform network traffic streams as needed. Furthermore, NS2 supports number of standards protocols and applications. More after, using NS2 different kinds of connections and connections' setting can be created.

NS2 employs programming language like OTCL and C++ which enable researchers and developers to add more functionalities and investigate new networking concepts by adding new protocols and applications to the object classes of the simulator. In addition, TCL script is used to create network topologies and connections as well as running simulations for a predefined time stamps.

In general, a networked system consists of the following:

- Node: is the main building block in NS2 and can be created using the TCL script set *n0 [$ns node]*.
- Protocol: *"set udp_sender [new Agent/UDP]."*
- Connection: "*$ns duplex-link $n0 $n1 1Mb 50ms DropTail."*
- Application:" *set cbr [new Application/Traffic/CBR]"*

"*$cbr attach-agent $udp_sender"*

"$cbr set packet_size_ 1000"

Where Node represents cameras, access point and servers in the context of this paper. UDP, is the transmission protocol (User Datagram Protocol)[5] which is used in this research for the reason of speed and simplicity. After that, the connection is used to connect to nodes using a duplex links of 11 Mbps speed and Drop tail queuing algorithm. Application is used to create traffic between nodes of type "CBR" (Constant Bit Rate)[5].

B. Video Settings

The video files have been set as H264 [7] video which has been converted to "YUV" format then encoded using Evalvid[6] encoder for simulation purposes as shown in figure (2).

Evalvid framework will be used to investigate and evaluate the quality of streaming video across the simulated network. Figure(2) describes the scheme of evaluation framework which has been used in our implementation.

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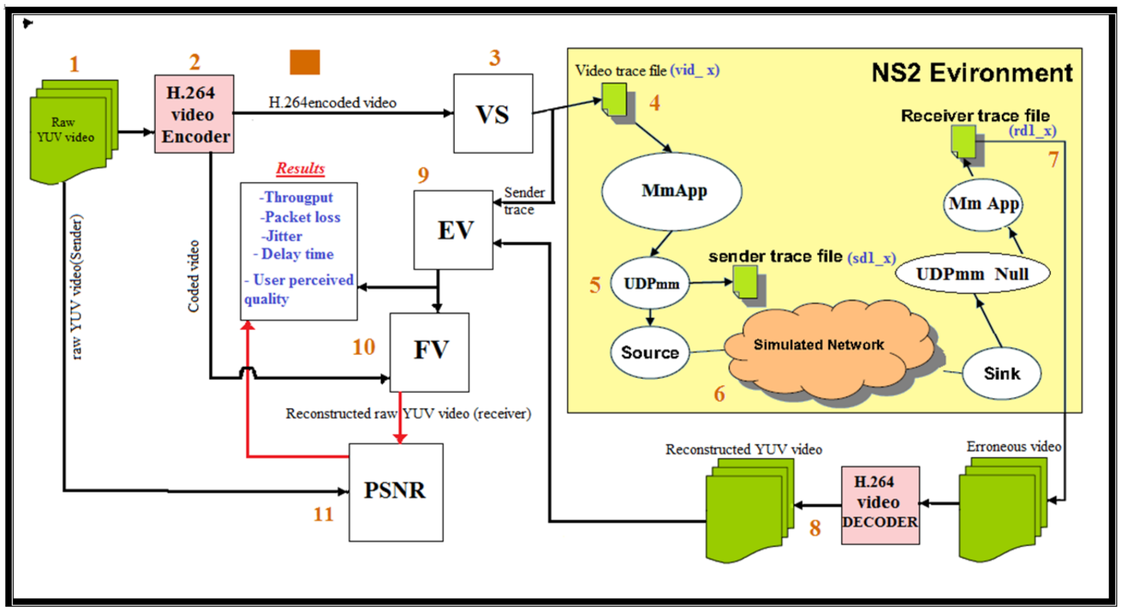

Figure (2): Evalvid for H.264/AVC.

The operation flow procedure of Evalvid with H.264 codec is explained as the following:

1- Input video file in "YUV" raw sequence format with "YUV" CIF (352 x 288) formats, shown in table (1) in system configuration section.

2- H.264 Encoder is converting the input raw "YUV" video file format into H.264 format with smaller size (from 38Mb to 13.6 Mb).

3- Video sender (VS) receives the encoded video file from theH.264 encoder, and brake down each encoded video frame into smaller segments .After that, it creates two trace files, sender trace file and video trace file. Both files will be used later for video quality evaluation.Sender trace file contains information about every packet generated for transmission; the following table (1) illustrates the format of sender trace file.

Time stamp (sec)	Packet ID	Packet Type	Payload Size (bytes)
0.033333	0	udp	29
0.066666	1	udp	1000
0.066666	2	udp	1000
0.066666	3	udp	1000
0.066666	4	udp	36
0.099999	5	udp	659
0.133332	6	udp	357
0.166665	7	udp	374
...	...	...	...

Sender Trace File

Table (1) a Snapshot of the Sender Trace File

4- Video trace file contains information about frames, as it can be clearly seen in table (2).You may note that "I" frame has a higher frame size because it relies only on the information that contained in its frame and decoded without any reference to other frames. Moreover, in the encoder side, I-frames are inserted in regular intervals in which are used as a reference to P-frames and b-frames.

Frame Number	Frame Type	Frame Size	Number of UDP-packets	Sender Time
0	H	29	1 segment at	33 ms
1	I	3036	4 segments at	67 ms
2	P	659	1 segment at	99 ms
3	B	357	1 segment at	132 ms
4	B	374	1 segment at	165 ms
...	...	...	...	...

Video Trace File

Table (2) a Snapshot of the Video Trace File

5- "MmApp" agent first receives the video trace file (vid_x) from the video sender (VS), and then a connection creates between "UDPmm" and "MmApp" agents. "UDPmm" agent receives segments which created from (VS) and records packet payload size, and the packet id in the sender trace file (sd_x), as shown in the figure (2)

6- "UDPmm" transmits packets via "UDPmm" packets over the simulated network.

7- At receiver side ,"UDPmm_x null" agent receives erroneous packets and pass them to "MmApp". At this point we have received erroneous trace file called (rd1_x) trace file.

8- H.264 decoder is first converting the erroneous encoded video into raw "YUV" video file format, then send this file to (ET)

9- Evaluate Trace (ET) has two inputs, from the output of the decoder with erroneous decoded video and sender trace file which from video sender. In this stage, packet loss, jitter, delay time, "PSNR", and throughput can be calculated by using these trace files.

10- Fix Video (FV) compares the total number of original encoded video frames with the total number of received video frames. When a frame lost, the (FV) inserts the last successfully decoded frame instead of each lost frame.

11- Finally, compare video quality ("PSNR") between the raw YUV video (sender) and reconstructed raw "YUV" video (receiver) pixel by pixel in each frame, in order to calculate the "PSNR" (the quality of video) to each frame.

IV. Experimental Results

To simulate the reality, a video stream is transmitted through the three cameras (to be equal to capture video through these different cameras). In addition to that, a wireless connection between each camera and the receiver will be setup using 802.11a wireless technology to transmit the video streaming for a specific period of time. The following figure (3) illustrates the implementation of the hardware system. To monitor the transmission performance, the quality of service as well as the video quality parameters will be setup at the receiver side. The simulation scenario as shown in figure (3), a wired-wireless network environment is used to show the implementation of three fixed cameras[node (2), node (3), and node (4)] and also fixed wireless access point[node (1)], which are wirelessly connected and implemented as a fixed network.

The server Node (0) is connected wirily to the Access point with 10Mb bandwidth and 2ms delay.

At Cam 1 , video_1 starts to send video to “MmApp_1” application which contains group of pictures or frames, then “UDPmm_1” transport protocol packetize each frame to many packets ,and send them to the access point,

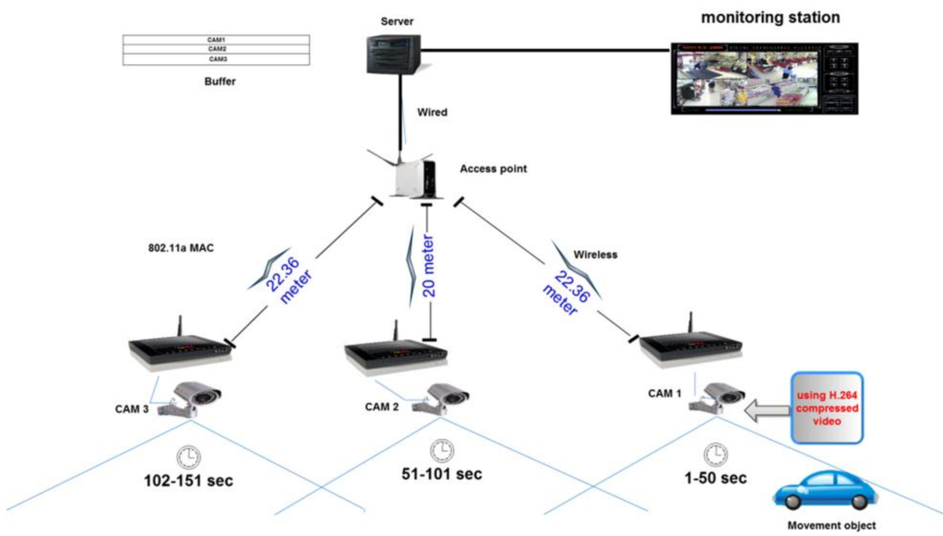

Figure (3): discretion of the implementation of hardware system

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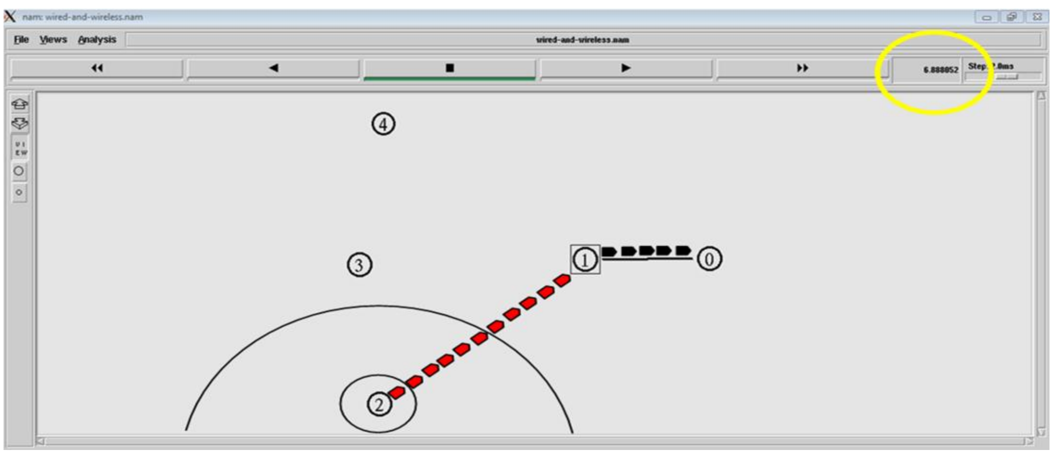

Figure (4): Routing between Cam (1) and the Access point.

Starting with Cam 2 ,starting between 51 and 101 sec, during this period packets are delivered by using "UDPmm_2" transport protocol after received video_2 from "MmApp_2" agent, as shown in figure (5).

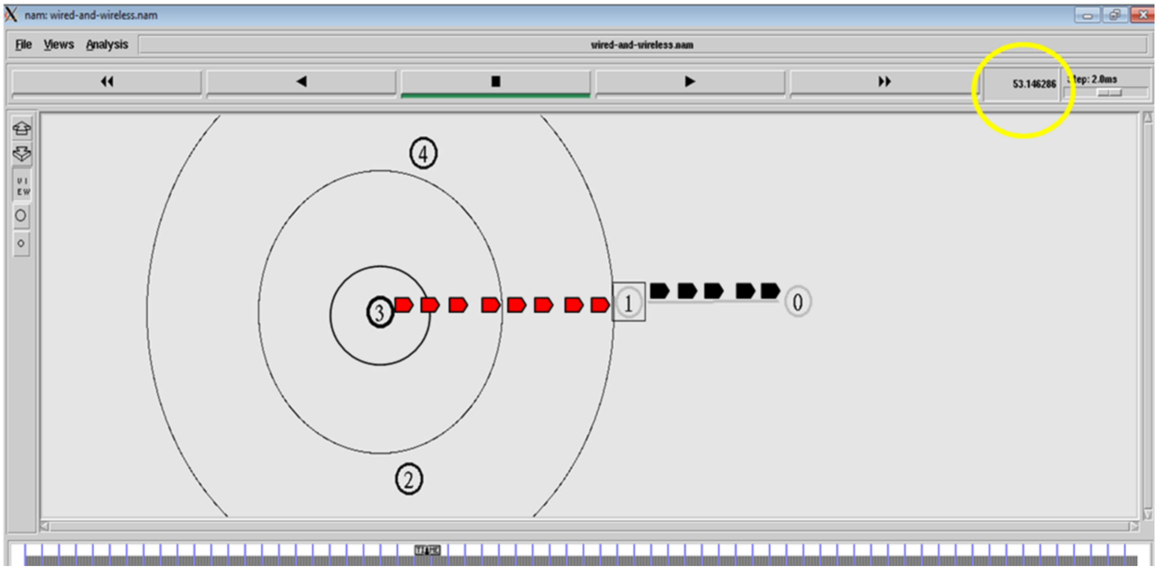

Figure (5): Routing between Cam(2) and the Access point.

In the cam(3), the elapsed time will start with 102 to 151 sec. Firstly, Vedio_3 will stream the video to "MmApp_3"application,then "UDPmm_3" packetize the frames video to packets and send these packets to the access point as showed in figure (6).

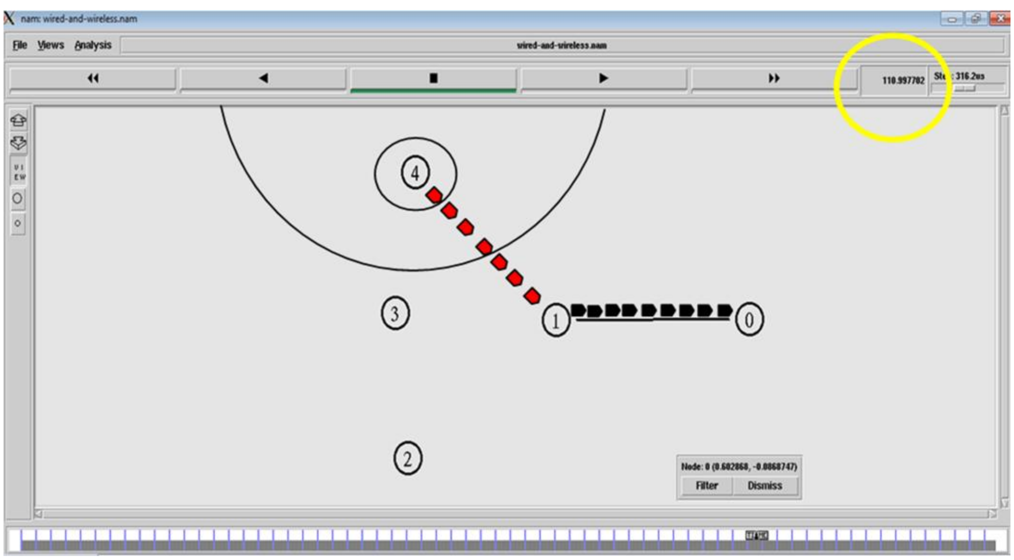

Figure (6): Routing between Cam(3) and the Access point.

V. Network and Video Performance Measures

To evaluate the performance of the simulated scenario, three different factors have been studied as follows:

- Delay: the average amount of time in seconds which has been required for a packet to transfer from the source node towards the destination.
- Throughput: the amount of data in bits which has been exchanged over the network in one second.
- PSNR: is the Peak Signal to Noise Ratio which computes the error between the original frame and the received one.

Figure (7) shows the average delay over 1000 simulation cycle. It does show that longer simulation time would increase the average delay. The analysis and observation showed that when the system is running for longer time the number of messages increase due to the increase in the traffic volume.

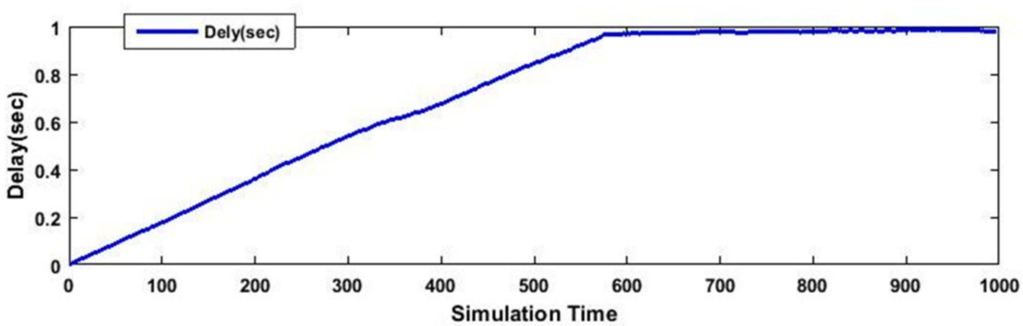

Figure (7) The Average Delay (sec) Over 1000 Simulation Cycle

Furthermore, the other performance measures have been demonstrated in table (3) for three different videos which are transmitted from the three cameras as explained in figure (3). The results in table (3) show that "video1" of 1530 frames has been transferred over the network in 31.0113 seconds which produces an average throughput of 5601 bits/sec. The quality of the received video has been calculated for each corresponding frame and the results have been averaged by dividing them over the number of received frames and yielded a PSNR of value = 30.13 dB. More after, the same process has been repeated for two other videos and produced relatively close results as demonstrated in table (3).

For trace files (video1 and video2) the system has experienced more delay after the time slice around 80 seconds which in turn affects the average throughput. The delay effect explained the decreased in the value of the average throughput. However, the received videos quality was relatively the same of 29.78 dB and 29.51 respectively.

Trace File Name	Number of Frames	Throughput			PSNR(dB)	
		Total	Average	Sending period	Average	STDV
Video1	1530	173706928	5601	31.01163 sec	30.13	6.85
Vidoe2	1530	170123168	2097	81.114768 sec	29.78	6.75
Vidoe3	1480	172117848	1312	131.14419 sec	29.51	6.81

Table (3) System Performance under Three Different Performance Measures

VI. Conclusions and Future Works

The work presented has studied a simulation scenario for a video monitoring system which consists of three cameras that capture a moving object. The cameras are wirelessly connected to an access point using WiFi connection. Furthermore, the access point is wired connected to a server which performs the video encoding/decoding process and quality calculations. The server is connected to a monitoring station(s). A well-known network simulator NS2 has been used to implement the suggested scenario to realise the network while "Evalvid" video evaluation software has been used to simulate the video functions. In this paper H264 compressed high definition video format is used to simulate the cameras outputs which then encoded using "Evalvid" software to produce a text oriented output file. The simulation results have shown that using NS2 with "Evalvid" to implement the suggested paradigm is feasible with some limitations. First of all using H264 format is costly as the video is in high definition format which produce a relatively large output file which in turn produces heavy network traffic. From a video point of view the simulation has demonstrated good video quality even with some packets loss caused by the network traffic.

Currently, we are working on improving the system performance by adopting different network scenarios and different network simulators that facilitates more video encoding/decoding algorithms.

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نظام محاكاة شبكة مراقبة فيديوية بأستخدام NS2

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المستخلص :

العمل المقترح في هذا البحث يركز على محاكاة تصميم نظام شبكي لغرض المراقبة. النموذج المقترح تم تصميمه وتنفيذة باستخدام برنامج محاكاة الشبكات NS2. يتكون النظام من ٥ عقد شبكية ثلاث منها عبارة عن كامرات فديوية تلعب دورين مهمين بالنظام هما: التقاط صور للاجسام المتحركة ضمن نصف قطر ٢٠ متر. الدور الثاني هو العمل كروتر لاسلكي ضمن الشبكة. العقد الاخرى وظيفتها كالاتي: العقدة الرابعة تعمل كنقطة وصول. اما النقطة الخامسة فتعمل كخادم مرتبط سلكيا مع نقطة الوصول(العقدة الرابعة) وايضا تحتوي على برامج الترميز وفك الترميز.

تم تنفيذ النظام و فحصه ضمن بيئة محاكاة (NS2) و تم استخدام نوعين من التقييم للنظام، النوع الاول من التقييم لحساب كفاءة الشبكة. حيث تم استخدام ثلاث عوامل لدراسة النظام هي: مقدار فقدان البيانات، معدل البيانات المتبادلة ضمن النظام ونوعية الفديو الواصل.

لاغراض دراسة النظام تم استخدام ثلاث ملفات فديو من نوع H.264 لتمثيل الكامرات الثلاث. تم استخدام برنامج محاكاة الفديو Evalvid لتحويل ملفات الفديو الى صيغة رقمية يمكن التعامل معها برمجيا لتسهيل عملية تقييم عمل النظام. عملية المحاكاة اظهرت نتائج مشجعة من حيث كفاءة الشبكة ونوع الفديو المستلم ونوعية الخدمة.

حيث كان معدل فقدان الحزم % 0.04 ومعدل التأخير 0.9 ثانية ، من ناحية اخرى فأن نوعية الفيديوا سجلت PSNR= 30.13 عندما تم ارسال 1530 صورة بمعدل انحراف معياري 6.85

الكلمات المفتاحية : محاكاة الشبكات ، الشبكات اللاسلكية ، الشبكات السلكية ،ترميز الفيديو ،كفاءة الخدمة ،المراقبة فيديوية .