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# Smart resource allocation for improving QoE in IP Multimedia Subsystems

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ABSTRACT

IP Multimedia Subsystem (IMS) is a robust multimedia service. IMS becomes more important when delivering multimedia services. Multimedia service providers can benefit from IMS to ensure a good QoE (Quality of Experience) to their customers with minimal resources usage. In this paper, we propose an intelligent media distribution IMS system architecture for delivering video streaming. The system is based primarily on uploading a multimedia file to a server in the IMS. Later, other users can download the uploaded multimedia file from the IMS. In the system, we also provide the design of the heuristic decision methods and models based on probability distributions. Thus, our system takes into account the network parameters such as bandwidth, jitter, delay and packet loss that influence the QoE of the end-users. Moreover, we have considered the other parameters of the energy consumption such as CPU, RAM, temperature and number connected users that impact the result of the QoE. All these parameters are considered as input to our proposal management system. The measurements taken from the real test bench show the real performance and demonstrate the success of the system about ensuring the upload speed of the multimedia file, guaranteeing the QoE of end users and improving the energy efficiency of the IMS.

## 1. Introduction

IP Multimedia Subsystem (IMS) is the result of a set of protocols and network architectures, which defined according to (Silverajan, 2017) as a set of specifications that describe the Next Generation Networking (NGN) architecture for implementing IP (Internet Protocol) based on telephony and multimedia services. Moreover, in (IMS, 2017), IMS is described as an integrated network of telecommunication carriers that facilitate the use of IP for packet communications in web services, voice over IP (VoIP), instant messaging (IM), video conference sessions and video on demand (VoD). IMS has taken a very important role in network services which can be achieved by heterogeneous networks and different access technologies. Further, IMS can be used to manage all service related issues such as Quality of Service (QoS), Access Control, User and Services Management, etc. Consequently, in (Chang et al., 2010), authors present a good survey of IMS. It discusses the different impacts.

One of the most challenging issues in IMS is still the reduction of the resource usage and the system energy consumption. Although, in many cases, the lack of their control makes the issue worse. Moreover, the power consumption of IMS also depends on the design of the system architecture and the number of connected end-users to receive multimedia services.

IMS was initially developed as the evolution of next-generation mobile phone and standardized by the Third Generation Partnership Project (3GPP). ETSI-TISPAN working group (Etsi Tispan, 2008), extends its functionality to fixed transport technologies, a network architecture is developed to support IMS and the QoE is guaranteed to the users. One important aspect in IMS is to ensure a good QoE and to design an IP platform that could transport any kind of service to guarantee the QoE (Tsolkas et al., 2017), while the power consumption and the battery life of the devices are reduced (Wuthnow et al., 2009). IMS core networks can be used to assign policies for each service by controlling the different QoS mechanisms (Soldani et al., 2007). Policies can be applied to various bandwidth parameters and codecs for different subscribers.

Session Initiation Protocol (SIP) is used to provide routing and supporting functions in the architectural framework of Internet community (Rosenberg and Schulzrinne, 2002). The IMS specifications widely used SIP for session control signaling. Therefore, User Datagram Protocol (UDP) in the IMS system is utilized to provide greater bandwidth (Zhang and Mouftah, 2003). The use of IMS makes network manage-

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ment easier because it separates the control and transport functions (Bertrand, 2007). Moreover, IMS supports different types of devices, so service delivery is independent of the access technology, thus improving interoperability.

Prefetching/Caching was proposed to improve the performance of concurrent users for streaming on-demand multimedia services (Kim and Liu, 2017). Therefore, Virtual Machines (VMs) were used in data center network infrastructure in order to reduce network traffic burden (Ferdaus et al., 2017). In the one hand, Lyapunov is used to split real time traffic between WiFi and cellular networks to maximize user experience, reduce delay, and balance necessary energy consumption (Abbas et al., 2017). On the other hand, the prediction method was focused as an essential step to allocate workload of applications in (Amiri and Mohammad-Khanli, 2017). According to the prediction results, the sufficient resources allocation were ensured and SLA had better result.

In this work, our proposal uses a smart algorithm that allows associated users to receive an alert message about the updated content. This allows the end-users to watch simultaneously the same video content, which is uploaded by a user who shots the video. Besides, the algorithm is based on QoS parameters and energy consumption which can provide an efficient transmission while guarantees the QoE.

We propose a smart distribution mechanism in IMS, which is based on heuristic decision methods and a probability distribution model for distributing multimedia streaming between the service providers and the upload and download clients. This mechanism takes into to account the energy consumption of the system and the QoE of the end-users.

The rest of the paper is structured as follows. Section 2 shows the state of the art of resource allocation in IMS. Section 3 explains the proposed system and parameters used in our proposal. Section 4 describes the analytical model for smart management in IMS. In Section 5, a smart management system is presented. Section 6 shows the performance test and the evaluation of the system. Section 7, conclusion and future work are presented.

## 2. Related work

This section summarizes the current state of the art of resource allocation in IMS and discusses the recent works that are closest to our approach.

Authors of (Raghavan and Ma, 2011) estimate the energy consumption in Internet. They studied two portions of the Internet's energy consumption. One is the Internet's electricity use, which is the standard metric for energy efficiency. The other is embodied energy (emergy). The estimated energy consumes between 170 GWt (gigawatt thermal) and 307 GWt. They considered that Internet should be more efficient. The motivation of driving the need for energy-efficient communications has been presented in (Zeadally et al., 2012). Several proposed approaches are used to reduce the energy usage. A holistic approach is considered to reduce the energy consumption during the usage stage. They developed innovative, cost-effective and energy efficiency solutions to minimize the energy consumption of ICT technologies and exploit renewable energy sources. Network coding in network layer has been used in (Allouch and Belkasmi, 2013) to improve the throughput, minimize the transmission delay and minimize the energy consumption in IMS networks.

A novel solution is aimed in (Bellavista et al., 2012), which is based on three properties. First, the mobile devices enable decentralized sensed data collection and dynamic control of sensor nodes. Second, it coordinates mobile devices to avoid unnecessary communications. Third, fully compliant with IMS. The experimental results show that it can significantly increased sensor battery lifetime with minimum impact on the freshness of harvested data.

In addition, authors of (Zhang et al., 2013) showed the end users demand exponential growth over wireless networks. The concepts of measures such subjective and objective, qualitative and quantitative, network bandwidth, transmission power and circuit power are used for measuring the QoE. They provided a trade-off between QoE and energy efficiency.

The design of a quality assurance model is presented by (Bester, 2008), which is based on an associated framework for NGN-based IPTV services delivery. The proposed solution is built on the recognized IMS, Resource and Admission Control Subsystem (RACS) and Network Attachment Subsystem (NASS). The proposed framework is aimed to assure enough QoE and QoS due to stricter requirements of real time multimedia IPTV services. In (Khan et al., 2011), authors proposed a QoE-driven scheme over IMS. It was at pre-encoding stage over UMTS access networks. The proposed approach was developed to fully understand the effects of network conditions on perceptual quality adaptation. Also, Mean Opinion Score (MOS) was used to evaluate the video quality. The results demonstrated improvement in users' QoE. The scheme was responsive to manage network bandwidth and congestion. IPTV on IMS standardization suffers from a lack of efficient user-centric network management mechanisms (Arnold et al., 2011), as the end-user may consume IPTV service from different networks. They proposed a platform for delivering IPTV services by introducing new functionalities in IPTV over IMS architecture, which improves the end-users' QoE and the resource utilization of the operator's networks. Authors of (Sterle et al., 2011) proposed an application-based QoE controller. The QoE control was accomplished through context-based QoE modeling. The approach was introduced in the NGN service environment to control QoE session. The service was available to end-users who benefit from QoE optimizations while accessing other available services within their multimedia communication.

Authors in (Saika et al., 2010) proposed the QoS management mechanism of NGN architecture in the IMS transport layer. They tried to reduce the main operations by the MPLS (Multiprotocol Label Switching) protocol in IP Multimedia Subsystem (IMS) architecture. MPLS is used for the transport of the IP datagram and the network traffic. The advantages of MPLS utility in the IMS platforms were to provide guaranteed end-to-end QoS several complex issues of the nature of the NGN environment regarding the quality assurance (Lakhtaria, 2009). Moreover, a service aware policy-based NGN quality assurance was presented. They aimed to demonstrate the resolve of dynamic service-aware end-to-end perceived QoE.

In (Bessis, 2006), the authors analyzed the performance, quantify the benefits and ways of having the SIP protocol in the IMS networks. They showed how to design the IMS network to improve the IMS server co-location. The approach achieves CPU savings of up to 45% and provided clear benefits for performance delay and reliability. In (Hsu et al., 2014), authors proposed a dynamic video streaming quality adaption method for IMS. The video quality was dynamic adjusting according to the network traffic. The aim was to monitor the background traffic by modifying the Multimedia Content Management System (MCMS). It adapts video streaming quality immediately when network loading is increased. The results showed that the proposed method avoids network congestion and enhances QoS efficiently.

The approach presented in this paper is different from other approaches discussed above. The goal is also to guarantee the QoE of the end-users and to maintain the energy efficiency of the system. As a result, we have developed an intelligent management system at the service layer of the IMS architecture. In order to obtain an optimal management result, the intelligent system takes into account different input parameters. At the server level, it includes a CPU and RAM consumption management system which is based on transcoding process, characteristics of the video streaming and the number of connected users. At the network level, it includes the network parameters such as jitter, delay, packet loss, and bandwidth. Finally, at the user level, it includes the characteristics of the devices connected to the server and the type of the access network connection.

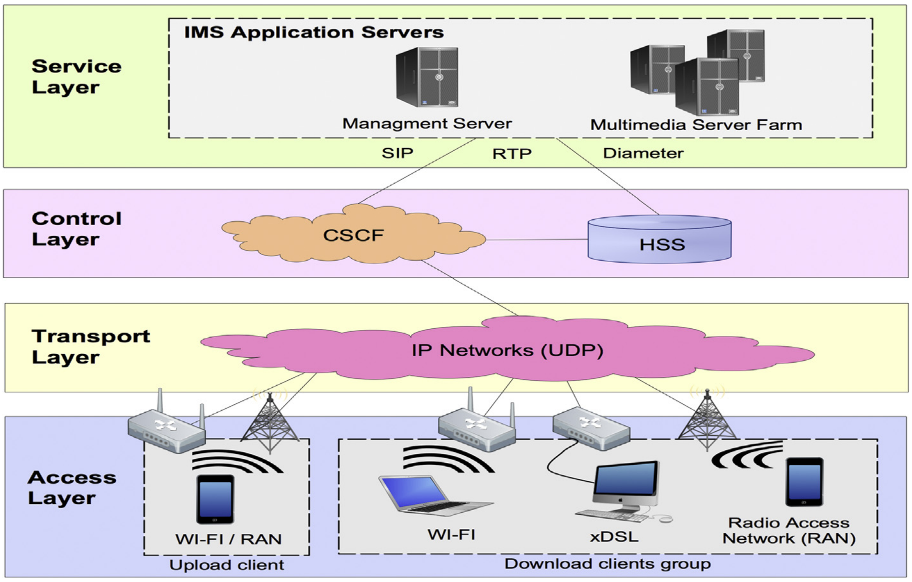


**Fig. 1.** The IMS architecture proposal.

## 3. System proposal

In this section, an IMS architecture is proposed to provide multimedia service which is managed by an intelligent system at the service layer. It is shown in Fig. 1. The system has the necessary hardware to store and process the multimedia files. Moreover, the management mechanism ensures the efficiency of the system.

In the system, we focus on enhancing the following parameters:

(1) Optimization of the upload time for the multimedia files,
(2) Guarantee the QoE of the end-users,
(3) The efficiency of the IMS.

The working procedure of the system is as follow. The multimedia user records a live video content on its smart device (smartphone, tablet, set-top box). Then, the user uploads the video to the servers. The user can select a group of users in its application to allow them to watch the online streaming video. The management system is formed by a farm of servers, which controls the system by sending a message to a set of users of the selected group with a Uniform Resource Locator (URL) link of the multimedia file that permits users to stream the video.

This procedure adds social network features to the system. IMS jointly with the intelligence system guarantees the optimization of the processes. The components of the system are explained in the following subsections.

### *3.1. Upload client*

We define the upload client as an active device which uploads videos to the system. When the device has no connection established with the server using SIP, the IMS application is not running. The upload client connects to the system over SIP and opens the Application Programming Interface (API). The upload client's application allows to record video stream and gives own permission to select members of the group such as family group, friend group, etc.

### *3.2. Manager and download client*

The manager of the system monitors and controls the processes of upload and download videos. It uses an interface to show the state of the performance of the resources and network activity. It also provides alerts according to the resources performance degradation moreover the resources are Memory (RAM) utilization, CPU usage, and the system temperature. The system manager decides whether the communication of the devices is supported or not. If the connection is accepted the system manager determines which server from the farm was able to receive the uploaded video and to send the video to other users. It sends a connection agreement of the specified server to the upload client. The specified server establishes the connection with the upload client in order to stream the video. Once the video is completely sent to the server by the end-user, the server sends a delivery message to the system manager to inform the successful delivery and the availability of the video. Therefore, the system manager sends a message to each member of the group, the message contains the link address of the video information such as server name, video name and the video's format. Accordingly, once the download client clicks on the delivered link the API is launched and a UDP communication is established to receive the video stream. When the communication between the download client and the server set up, the server receives a request "GET" from the client. In the request "GET" the characteristics of the download client 'device' is sent to the server in order to evaluate the device's characteristics. The purpose of having the characteristics is to guarantee the QoE.

As a consequence, the system manager monitors the network activity of the download clients and analyzes the effect of the network parameters such as packet loss, delay, and jitter. Moreover, it evaluates the server status information such as memory, CPU, and temperature.

The system manager provides the optimal transcoding process to ensure the end-user QoE, as mentioned in (Lloret et al., 2011) and (Lloret et al., 2012). The transcoding parameters include the codec, bitrate, and resolution (Garcia et al., 2009).

We have added a server failure detector system. It allows us to include fault tolerance in the approach. When there is a server failure or a server is in the downstate, an alert message is sent to the system manager. The system manager tracks the health of the servers in order to provide the backup server to stream the video to the end-users.

## 4. Theoretical analysis of the intelligent management system

The intelligent management system has the capacity to gather and analyze information about the servers' resources and the media file. The functionality of the intelligent approach has two phases; (1) The decision of selecting a server from the farm of servers to place the uploaded media file (the optimal selection of the server is based on the availability of the servers resource usages such as availability memory usage, CPU and system temperature), (2) Provide an optimum video transcoding system, the intelligent system takes the device's characteristic of the download clients and analyzes this characteristic to provide the appropriate media codec. It sends executions to convert the uploaded media file to the appropriate codec, bitrate and resolution. This provides better QoE to the download clients.

The management system is developed by using probabilistic models as described below.

We define the feature vector as a vector consisting of parameters that have been studied, so that the feature vector is $X$ is comprised of $X = x_0, \ldots, x_n$, $n$ is the total number of features and $x_i$ describes each feature. The relationship between the components which form the feature vector and its influence on the upload time of the media file is determined by next equations.

$$t(\overline{X}) = \sum_{i=0}^{n} x_i \tag{1}$$

The sum of feature components determines the final result. Therefore, the upload time depends on the parameters that have been studied. In order to after an exhaustive empirical study of the influence of these parameters on the final result, we can optimize the function using the following equation:

$$t\left(\overline{X}\right) = \sum_{i=0}^{n} \lambda_i x_i = \lambda_0 x_0 + \lambda_1 x_1 + \cdots + \lambda_n x_n \tag{2}$$

Where the weight ($\lambda$) gives the feature, so the system manager makes decisions, it is based on Eq (2).

Eq. (3) gives a set of input feature vectors, which minimizes the values of the final result.

$$\arg\min_{x} t\left(\overline{X}\right) = \arg\min_{x} \sum_{i=0}^{n} \lambda_i x_i \tag{3}$$

Where $X$ is the feature vector which minimizes the function result.

## 5. Intelligent manager system in the IMS application

In this section, we describe the intelligent algorithm which proposed for the IMS. It has two main tasks: (1) Manage the upload client, (2) Manage the download clients.

The description of the algorithm is depicted in Fig. 2. The algorithm is running as the IMS manager. It listens on a particular port, when the request from the upload client is established, the communication between the manager and the upload client becomes active. This communication is based on sockets connection. The IMS manager initiates the network monitoring and analyzes the server's activity. The communication between the client and the server is performed using SIP. The network monitoring is carried out with SIP messages. A SIP message consists of a plain-text header and its corresponding value. These messages are collected and then the manager analyzes them. On the one hand, from this analysis, we obtain the network parameters such as jitter, delay, packet loss and bandwidth of the links. On the other hand, the manager consults to the servers in order to get the resource parameters values such as memory, CPU consumption, system temperature and the number of connected clients. The values of all these parameters are stored in Home Subscriber Server (HSS). If the manager finds that there are enough resources on the servers, the connection is accepted, otherwise, the connection is rejected. After the activated connection, the manager starts to process the intelligent decisions, which are based on a heuristic model of feature vectors. The components of the vector are the parameters which are listed in the previous section. The outcome of this process provides the optimal server, which can permit the client to upload the media content in the shortest time and efficient transmission. Moreover, the manager sends a message to the upload client indicating the socket of the optimal server. When the connection is held between the server and the client, the client starts to upload the video. Also, there is a consideration of time to upload the media file. If the limitation of the upload time has exceeded from the threshold value, the connection between the upload client and the server is interrupted. If the video is successfully uploaded to the server then the server alerts the manager to execute next phase of the algorithm. After the availability of the uploaded video in the server, the manager sends a message (obtained from the contact information) to the members of the groups. Those members are specified at the beginning of the connection. In this case, the manager looks forward to receiving the requests from the users. When a request is delivered, the manager again starts to analyze the status of the service network and the health of the servers. All these parameters are saved in HSS. The obtained information from the client's request describes the characteristics of the device (device type, which may be a PC (Personal Computer), mobile, laptop or tablet. The obtained information allows the servers to provide the appropriate video transcoding. Thus, the download clients can stream to the proper video, which is suitable to the client characteristics and the client's network connection. Thus, This ensures enough QoE to the download client when it streams the adequate codec, bitrate, and resolution.

## 6. System evaluation

In order to demonstrate the usefulness of the proposed system, it is necessary to evaluate its performance when using different multimedia codecs, when it is required to guarantee the QoE of the connected users, and energy efficiency of the system. The description of the parameters are detailed in the following subsections.

### 6.1. The system and simulation parameters

In this section, we prepare the simulated network testbed in order to apply the experiments. Fig. 3 shows the description of the network topology, which has been used for our experiments.

The upload client is a physical device, which uses an application programmed in Java to connect and to send media data to the server in the IMS system. The other clients downstream the videos using VLC (VideoLAN) media player. The manager in the IMS system monitors and controls the activities in the system. The servers use a SIP java program, which listens to clients requests. Moreover, PHP program is installed on the servers to allow clients to upload the video to the IMS servers. The network simulation is used to simulate the network parameters such as available bandwidth, delay of the packets, the jitter of packets and packet loss. *NETDISTURB* (ZTI Communications, 2017) tool has been utilized to simulate the network parameters. In addition to this, the network traffic simulation in the testbed has been used to the shape available downstream and upstream networking by prioritizing network resources and guaranteeing certain bandwidth based on predefined policy rules. It uses concepts of traffic classification, policy rules, queue disciplines and QoS. This is done in order to shape and control the network's uplink and downlink, delay, jitter and packet loss ratio. Table 1 shows the characteristics of the entire types of equipment.

### 6.2. Upload and download video evaluation

In this experiment, we find the threshold values for the parameters of the resource usages and the QoS parameters, as shown in Fig. 4. The relation between the number of the connected clients and the aforementioned parameters are evaluated in order to obtain the threshold values. In the upload process evaluation, in order to find the impact of the process on the test bench results, all parameters are configured under the unrestricted condition as shown in the figure. In the download process evaluation, we evaluated the download process by using the different type of the devices. We have simulated the connection using Evalvid (EvalVid, 2017). The main reason for using this tool is to give the possibility of calculating the values of the QoE. The

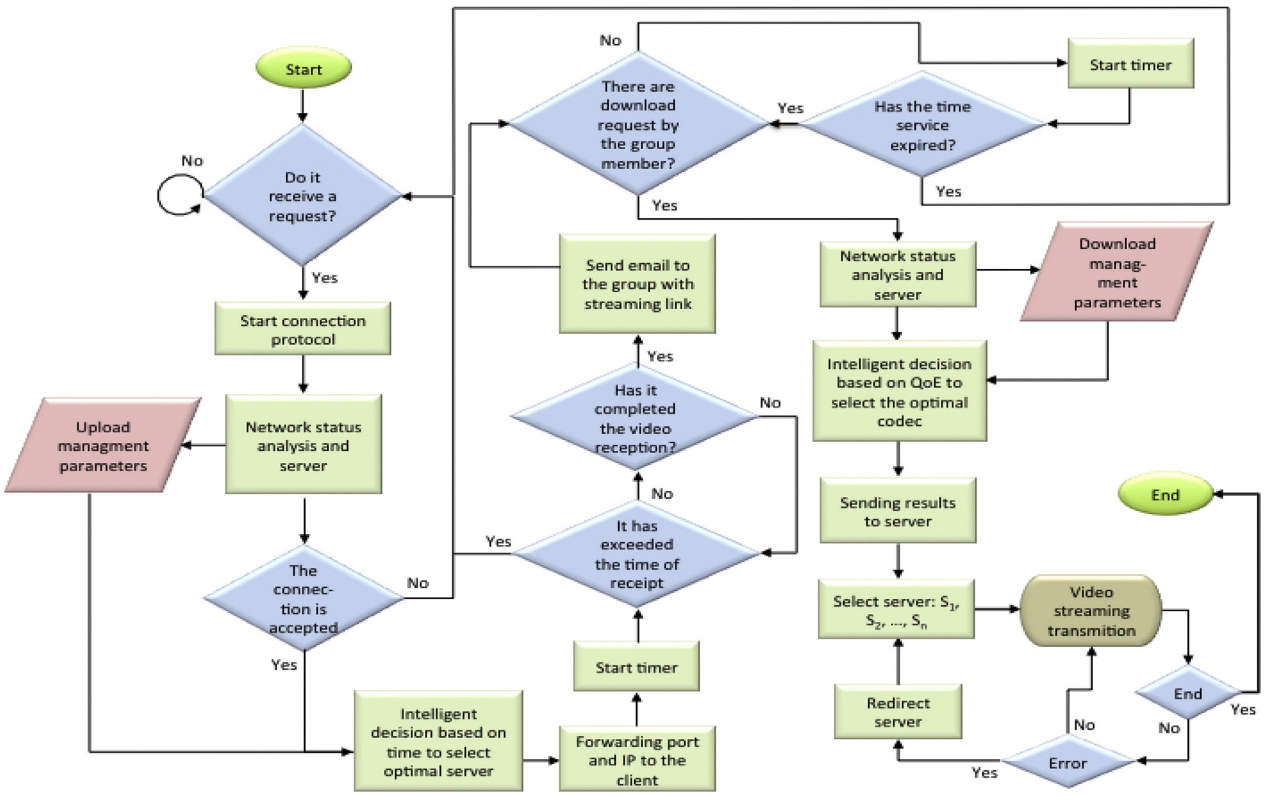


**Fig. 2.** Intelligent manager algorithm in IMS application level.

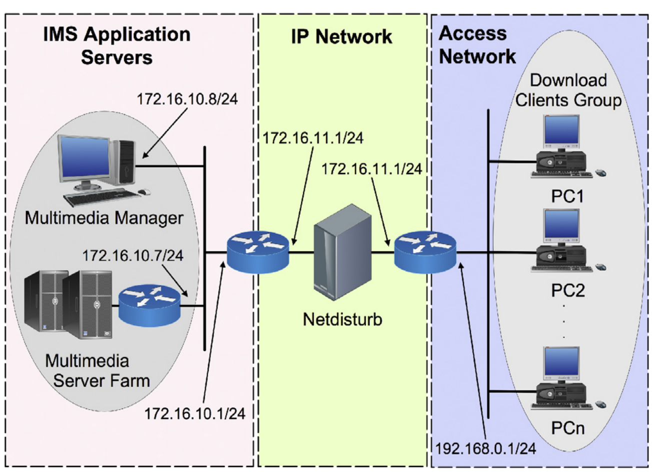


**Fig. 3.** Network topology.

purpose of this analysis is to select optimal encoding process and to ensure QoE in different cases. The video has been encoded in different codecs such as MPEG4, H264, and XVID and several bitrates such as 512 Kbps, 1024 Kbps, and 2735 Kbps and the screen resolutions such as 640 × 480, 800 × 600, and 1024 × 780 are used. The reason for having the different codec, bitrate, and resolution is to analyze the connection of the users from different devices. The manager also takes into account the device's characteristics. From the obtained results, we set our mathematical model.

## *6.3. Evaluation of the IMS application system*

In this section, we present an empirical performance evaluation of the IMS application system, which included the associated resource parameters such as CPU usage, memory, and temperature. In order to evaluate the performance of the system, the important factors are selected such as a number of connected users and the characteristic of the video. Moreover, the characteristic of the video included the static transcode and the dynamic transcode. In the static transcode, the video codec, bitrate, and resolution. In the dynamic transcode, the video is converted to the variable codec, bitrate, and resolution. The impact of the values on the QoS parameters set by the aforementioned decisions are the following ones:

### *6.3.1. Impact of the number of connected users on the system performance*

In this experiment, we include the rate of the usage of resources, which includes the CPU usage, RAM, and temperature. There were 25 connected users. Therefore, in these experiments, the variety of videos are streamed to be played on the client side. We observed the system for 150 samples. The CPU results are shown in Fig. 5. The increasing number of connected users has the huge impact on the performance of the system, the results of the graph show that 90% of the CPU is used for 25 users at 19th sample and 90% of the CPU is used for 10 users at 39th sample. Also, high overload at the sample 57th is recorded for 25 users, and then the raised up the rate forced the system down. Moreover, the figure depicted that, maximum RAM usage is recorded

**Table 1**
Characteristic of the equipments.

| Item | System Manager, Servers, Download client | Upload client |
|---|---|---|
| 1 | Intel(R) Core(TM)2 Quad CPU Q8200@ 2,33 GHz | C110 1 GHz, Cortex A8 Hummingbird Application |
| 2 | Memory RAM: 1,94 GB | 512 MB |
| 3 | O.S.: Microsoft Windows | O.S.: Android 2.2 |
| 4 | Screen resolution(SR): - | (SR):600 × 1024 pixels |

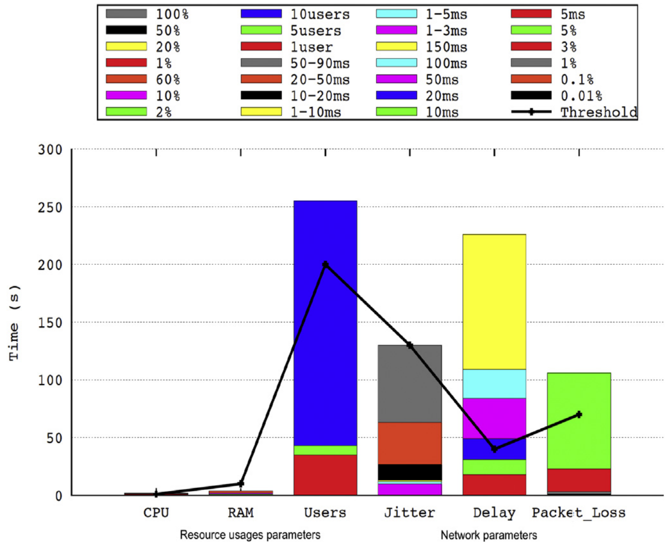


**Fig. 4.** Evaluate the threshold values.

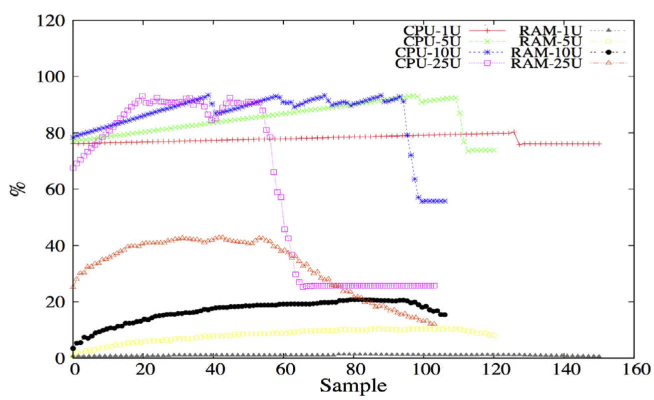


**Fig. 5.** Impact of connected users on the system resources.

between 20th to 60th samples when 25 users are connected to the system. System temperature is depicted in Fig. 6, which includes the temperature produced by the CPU and the system board. The observed results show the peak points at the samples 50 for the CPU and 60 for the system board when the number of the connected users is 25 users.

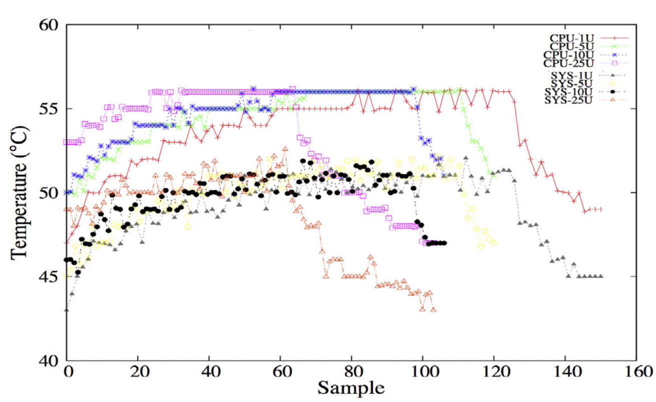


**Fig. 6.** Impact of connected users on the system temperature.

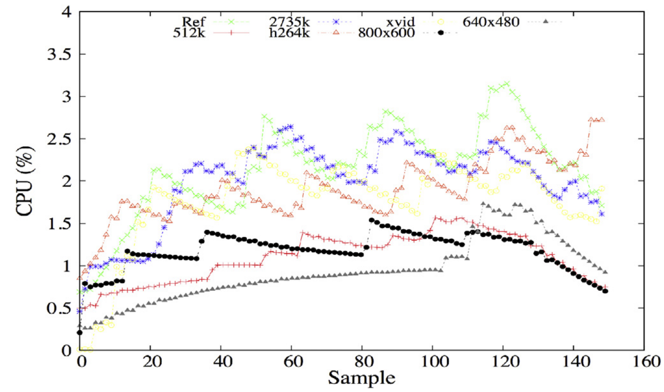


**Fig. 7.** Impact of transcoding on the system CPU.

#### 6.3.2. Impact of the characteristics of the video on the system performance

In this experiment, we analyze the process of transcoding the video. Moreover, we show how the transcoding parameters such as the type of codecs, the rate of the bitrates and resolution size affected on the energy consumption of the system when the transcoding process is performed during the video transmission. In order to demonstrate the effect of transcoding parameters on the video provider in the IMS system, we test the consumption of the CPU usage, the rate of the memory used, the CPU temperature and the board temperature. Fig. 7 shows the results CPU usage when different codecs, bitrates, and resolutions are presented. The performance of the CPU usage has been captured for 150 samples. The codecs XVID and H264 at the beginning of the tests consumed less CPU rate. From samples 20 to 110 the rate of the CPU consumption ranges from 1% to 2%, and at the end of the test, the codec H264 consumes higher CPU rate than XVID as it reaches 2.5%. The bitrate of 2735 Kbps used the height CPU, its range is 2.5% and bitrate 512 Kbps consumed less CPU usage. The resolutions represented by grey color and black color in the figure, the resolution (640 × 480) from samples 110 to 130 had high CPU usage. Those obtained results indicated that the transcoding highly affects the consume energy consumption. Therefore, we measure the impact of transcoding of the video on system's memory as shown in Fig. 8. In this test, we demonstrate the rate of the memory usage for the same video transcoding as mentioned in the previous test. The experimental results show that the maximum memory used is recorded from sample 100 to 110. It leads to having high energy consumption. The temperature of the system is depicted in Fig. 9.

The maximum values of the temperature are recorded between the samples 30 and 110, which greatly affected the performance of the system in the energy consumption.

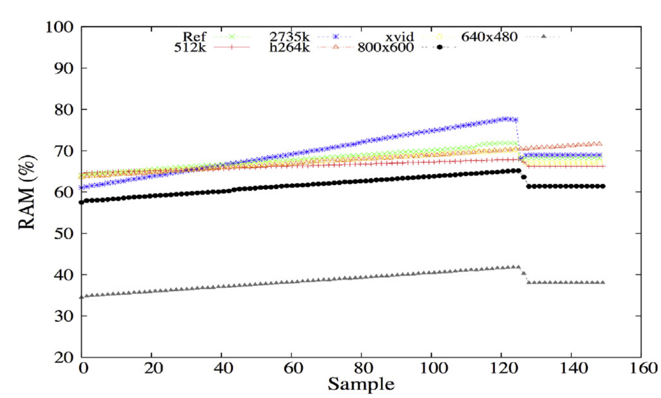


**Fig. 8.** Impact of transcoding on the system memory.

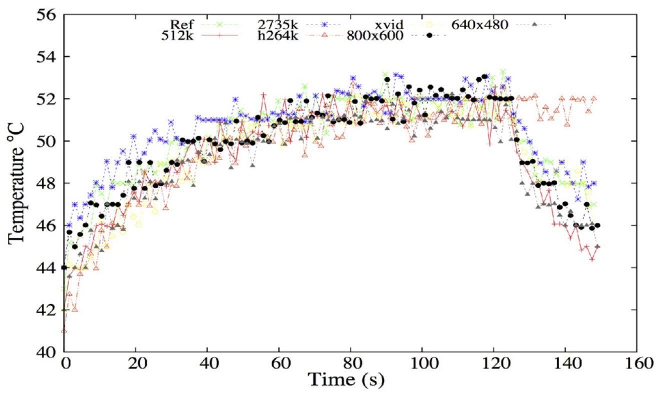


**Fig. 9.** Impact of transcoding on the system temperature.

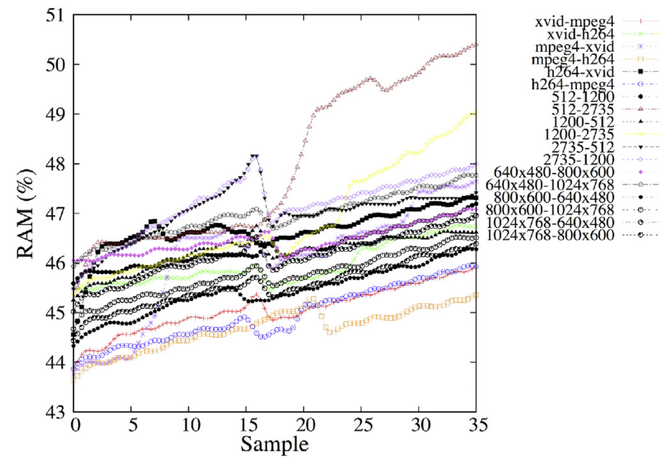


**Fig. 11.** Impact of dynamic transcoding on the memory.

### 6.3.3. Impact of dynamic video transcoding on the performance

We find the impacts of dynamic video transcoding on the resource usage of the system as shown in Fisg. 10–13. The variation between codecs, bitrates, and resolution has the massive impact on the performance of consumption of resources. The rate of CPU usage is high when the process of transcoding is switched from 512 Kbps to 2735 Kbps. However, the switch between the codec H264 to codec mpeg4 consumes minimum rate of CPU usage. The CPU usage increases from XVID to MPEG4, this is because the MPEG encoder is still encoding the video. Conversely transcoding from MPEG4 to XVID consumes low rate of CPU. On the other hand, the maximum rate has been recorded for resolution change from 1024 × 768 to 640 × 480, which reached up to 2.7% of CPU usage. The impact of variation of video transcoding on memory usage is depicted in Fig. 11. The variation of transcoding caused to rise up the usage of memory. It is noted that the switching between codecs 512 Kbps to 2735 Kbps and 2735 Kbps to 1200 Kbps used a high percentage of the memory usage. The brown curve at 15th has 50% of memory used. This happens because the codec at 2735 Kbps uses a high rate of reading and writing on memory. Generally, switches between codecs and bitrates and resolutions move up the temperature of the system, as depicted in Fig. 12.

Results in Fig. 13 shows the board temperature for different video transcoding. The observed results show that the switching between codecs, bitrates, and resolutions in the samples 15, 20, 25 and 35 consumed higher temperature. Accordingly, the results of the dynamic video transcoding show that the variation of video transcoding greatly affected the performance of resources in the IMS system and this conducts to consume high energy.

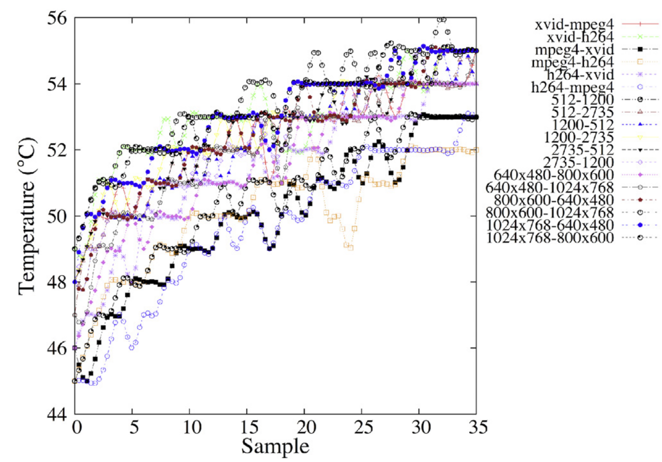


**Fig. 12.** Impact of dynamic transcoding on the temperature.

### 6.4. QoE evaluation

In this experiment, we study the impact of QoS parameters on QoE of the connected users to the IMS system. This allows us to know how the system can provide better QoE to the end-users.

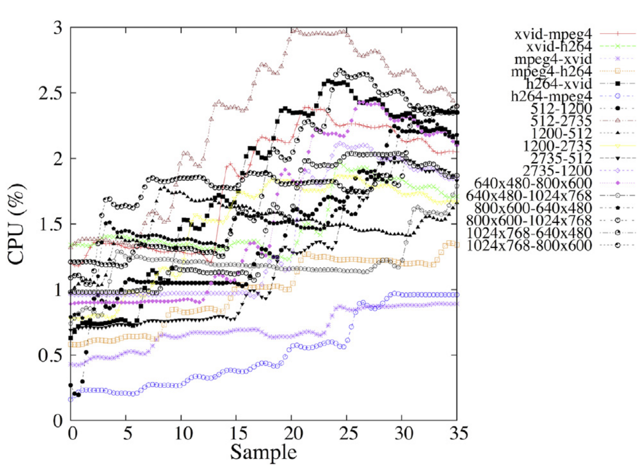


**Fig. 10.** Impact of dynamic transcoding on the CPU.

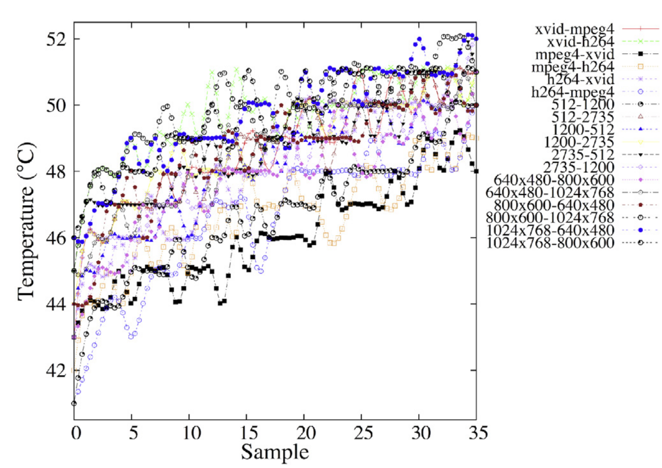


**Fig. 13.** Impact of dynamic transcoding on the system temperature.

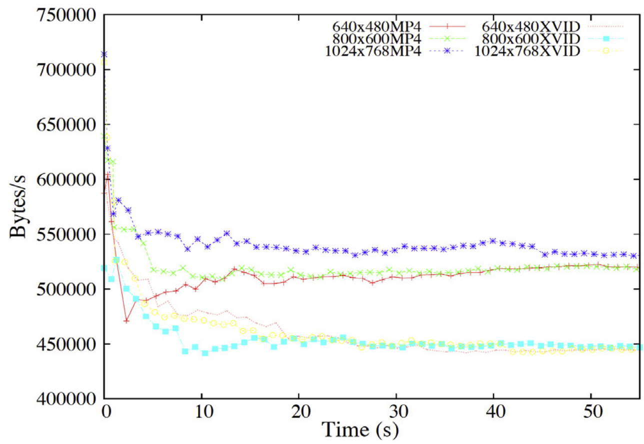


**Fig. 14.** Availability of the video rate in different codecs.

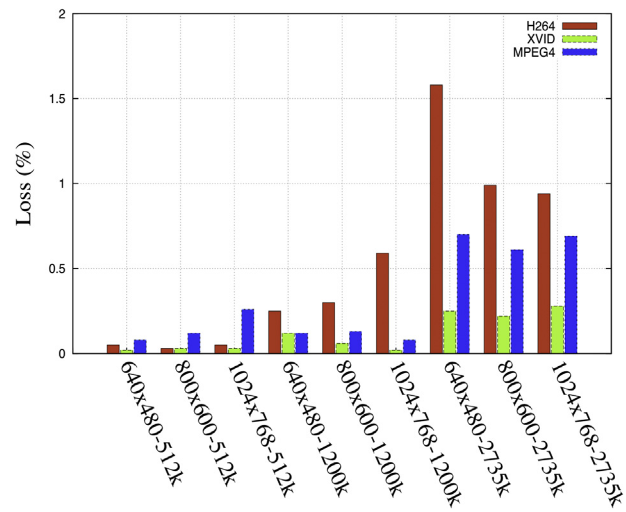


**Fig. 16.** Frames lost for different codecs.

### 6.4.1. QoS impact on transmission rate of end-users

In this experiment, we have carried out the study of network parameters that can influence the QoE, such as the bandwidth used and the loss of packets in order to analyze the impact of QoS on the QoE of the end-users. These parameters impact the perception of the received video by the end user, which can be between negative and positive. Moreover, to check how the bandwidth influences the QoE in the system, we have studied est download rate based on the screen resolution and coding system. In this test, we set a throughput of 100 Kbps between the system and clients. In Fig. 14, the accumulative bit rate for different screen resolutions and codecs with the same rate, 1200 Kbps, for 60 s of transmission is shown.

### 6.4.2. Drop of frames

In this experiment, we show the rate of frames dropped during the encoding and playback in the device. The evaluation depicted two percentages of CPU usage, as shown in Fig. 15, the are 100% and 50%. We observe that frame loss is high when MPEG4 and H264 codecs are used. The rate of frames lost can be estimated from 0.26% to 0.46%. However, the resolution 1024 × 768 of XVID for the peak rate of CPU 100% produces a very low rate of dropping frames.

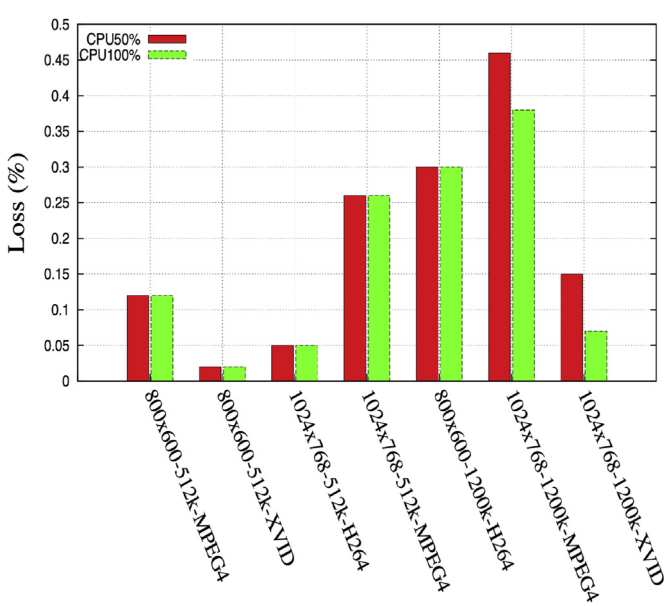


**Fig. 15.** Frames loss.

The other network parameters that have taken into consideration in the analysis of the tests, as a possible influence factor on the QoE, which is rate loss during the downstream. We first studied how the drop of frames effects to screen resolution and the encoding system. The obtained results are shown in Fig. 16. The screen resolutions and the low coding rates, regardless of the used codec, are not affected on the transmission practically, when there are losses, If the resolution is higher (1024 × 768), the MPEG4 codec causes more losses than the other codecs used in the study. If the bitrate is increased, the behavior is different. Then, we can see how the codec H264 generates more losses in the transmission, surpassing the 1.5% of losses when the resolution of the screen is 640 × 480 and there is bitrate of 2735 Kbps.

In general, the XVID codec has a better tolerance when increase both resolution and bitrate are increased. We analyze how the losses of the I and P frames in the video affect independently. Therefore, the rate of I and P frames lost for different codecs of the same video is shown in Fig. 17. Generally, the drop frames of I and P are high in the higher bitrates. Also, *I-frame* of H264 in the case that reached the highest peak 5.8% for the bitrate 2735 Kbps, MPEG4 and XVID gave the lowest values. This is a very important factor since the drop of *I-frames* affect more directly to the QoE than the *P-frames*.

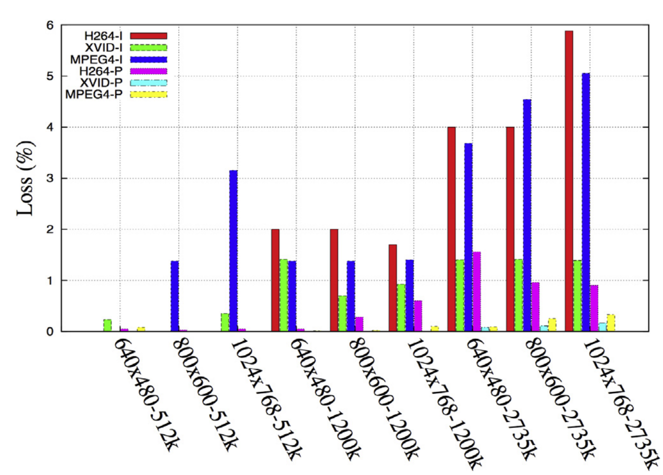


**Fig. 17.** Impact of GOP on the QoE.

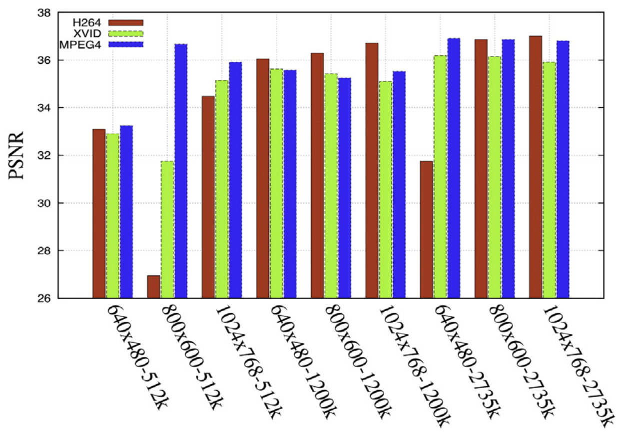


**Fig. 18.** Impact of codecs on PSNR.

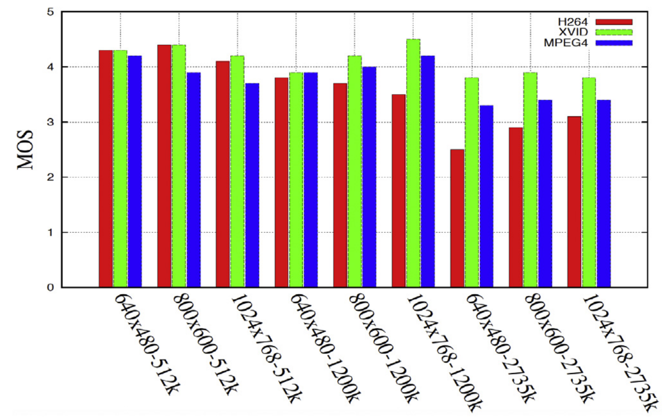


**Fig. 19.** MOS evaluation.

**Table 2**
Mean opinion score scale.

| MOS | Quality | Impairment |
|---|---|---|
| 5 | Excellent | Imperceptible |
| 4 | Good | Perceptible but not annoying |
| 3 | Fair | slightly Annoying |
| 2 | Poor | Annoying |
| 1 | Bad | Very Annoying |

### *6.4.3. Evaluation of PSNR and MOS*

In order to evaluate the perceived quality of the downloaded video by the users, we calculate the PSNR and MOS. We obtain a kind of objective measurement with the PSNR and the subjective measurement with MOS.

In PNSR assessment, the measure of quality reconstruction of lossy compression is found. The PSNR metric estimate the comparison between the original video and the delivered video for different codecs. The Evalvid tool (EvalVid, 2017) (binary PSNR) is used to extract the measures as modeled next.

$$\mathrm{PSNR} = 10\log_{10}\frac{(2^d-1)^2WH}{\sum_{i=1}^{W}\sum_{j=1}^{H}(p[i,j]-p'[i,j])^2} \tag{4}$$

Where $d$ is the bit depth of pixel, $W$ is the image width, $H$ is the image height, and $p[i,j]$, $p'[i,j]$ is the $i$th-row $j$th-column pixel in the original and delivered images of the video respectively. The obtained results can be observed in Fig. 18. Generally, the PSNR values of low bitrates are less than high bitrates. PSNR values of H264 and MPEG4 codecs are higher than the PSNR value of the XVID when bitrate is 2735 Kbps. Thus, H264 in the bitrate 512 Kbps (800 × 600) and the bitrate 1200 Kbps (1024 × 768) presented lower rate than the others codecs. In the last evaluation, in order to obtain the MOS value, we carried out the following process; 50 observers selected to evaluate the quality of the received videos. The assessment based on two criteria. (1) Taking reference of the received video. Table 2 describes the evaluation measures of the rating scale. Although, the video quality is evaluated only by the observers on a scale 1 to 5. (2) The assessment was comparing the source video and the received video. Thus, the observers evaluated the quality of the video received based on the video transmitted. With these 2 measures, as shown in Fig. 19, we extract a mean that will be the definitive value of MOS. In this evaluation, the MOS values are increased in the low bitrates and resolutions. In many cases, the XVID codec has higher MOS than other codecs such as H264 and MPEG4. The MOS value of XVID codec for bitrates 512 Kbps, 1200 Kbps, and 2735 Kbps is higher than the codecs H264 and MPEG4, although both MPEG4 and H264 codecs recorded high perceived video quality as shown in Fig. 18.

## 7. Conclusion and future work

In this paper, we presented an architecture for the IMS system in order to deliver multimedia streaming. The system covered three aspects, the multimedia upload clients, the system manager, and the download clients. The proposed algorithm in the system manager is based on the intelligent media distribution, which decided how the upload user can select the optimal server to upload the media file and then how the group of users can receive the message regarding the updated contents in the IMS system. Accordingly, by taking effective of QoS parameters and the characteristics of the video on the system performance, we described some resource parameters to evaluate the performance regarding the energy consumption and the QoE. The evaluation results depicted that, the increase of the number of connected users had influenced on the performance of the resources such as rate of the CPU usage and the system temperature. In the experiments, we observed that the impact of transcoding is higher especially when the dynamic video was transcoded. Further, we evaluated the QoE in terms of relevant measures such as frame loss, subjective, and objective perceived video quality. The results concluded that MP4 used higher bitrate than XVID and rate of the dropped frames of MPEG4 was 65%, which was higher than the rate of H264. The rate of the *i-frame* of H264 was higher than MPEG4 and XVID for the high bitrate. MPEG4 presented higher PSNR than XVID, and XVID presented better MOS than other codecs.

In future work, we will use a sophisticated approach based on deep learning in order to increase the number of parameters which decide on the performance of the system and QoE. Therefore, we will work on reducing the effects of competing among clients, which leads to improvement of the perceived video quality.

## Acknowledgment

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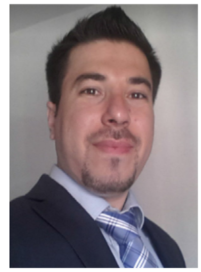

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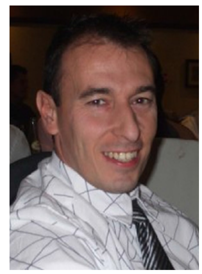

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