Seamless Connectivity for Adaptive Multimedia Provisioning over P2P-enabled IP Multimedia Subsystem

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***Abstract*—The subsystem multimedia internet network (IMS) has been upgraded to support peer-to-peer content distribution services, the peer heterogeneity constraint imposes a challenge that is the guarantee of a certain level of QOS of the video for the different pairs, and the transfer poses a challenge for maintaining quality of service (QoS) in IMS. In this article, we we have extended a scalable Video Coding (SVC) peer-to-peer streaming adaptation model and our extension allows to add another parameter for this adaptation scheme which is the IP address of the peers, so to manage multiple network accesses to a peer when the user changes the type of access, due to a transfer or a loss of connectivity, this model is used to adapt the video quality to the static resources of the peers in order to avoid long start times, and to compare the results obtained for changing the type of network access, we performed two simulation scenarios, one with multiple peers that are connected to the network until the end of the video download by the peers and the other scenario with the change of the address of a peer during the operation of downloading the video sequence by peers. We quantified streaming performance using two metrics of evaluation (peak signal-to-noise ratio (PSNR)) and video quality metrics (VQM)), and also we extracted from the values of PLR (Packets loss rate). Our results show that our model has a better adaptation of the quality according to the network resources of the peers in term of bandwidth available in the network and the performances of the users (CPU, RAM, autonomy of the battery) and also allows a continuity of service in the network by ensuring that the list of peers is updated after each change. The results show a clear quality adaptation with heterogeneous terminals.**

***Keywords*—Next generation networks; NS2; quality adaptation; scalable video coding; peer to peer**

I. Introduction

The Internet Multimedia Subsystem has been standardized by the 3GPP [1] is used today as an architecture for triple-play services: telephony, Internet and video streaming. But streaming video requires a high cost in terms of equipment performance and bandwidth needed for better quality. Streaming in the IMS P2P network often uses data-oriented protocol in which, for example, each node periodically announces to its neighbors the blocks it has. Streaming in this network reduces the cost of infrastructure by taking advantage of customers to make content available and avoid having to set up important structures. The Internet Multimedia subsystem also supports peer-to-peer architecture, In [2] the authors propose to study and design a new content delivery network infrastructure, PeerMob, merging Peer-to-Peer technology with IMS, providing IMS with the scalability, reliability, and efficiency features offered by the decentralized P2P architecture and they put the P2P IMS system under real network conditions and a tough simulation to evaluate the performance of P2P IMS system. In [3] the authors proposed Nozzila a peer-to-peer video streaming service on the IMS network that can be used by IPTV service providers, Nozzila uses residential bridges to create a streaming overlay using the remaining or fixed bandwidth and it also takes advantage of the quality of service and resource reservation enabled by the NGN networks to support a multiple streaming description that improves perceived quality during temporary failures. In [4] the authors proposed virtual communities (VCs) in the IMS network and these virtual communities provide scope for the sharing service between end users in the mobile P2P network and allow them control of sharing. In [5], the authors proposed a framework for evaluating adaptive streaming performance based on SVC encoding, and they evaluated the metrics PLR and FLR versus time. Our research team has developed an algorithm adapting the quality according to the mobile. We could create a simulation of our adaptation model and connect it with the NS2 simulator to perform several simulations on a real flow following an architecture that groups the IMS network with P2P technology and for heterogeneous peers (PC, tablet, mobile), and we chose the use of H.264 / SVC coding that allows for multiplied distribution and adaptive streaming from a single file. On one hand H.264 SVC for Scalable Video Coding allows a video to be encoded with multiple quality layers in the same video file to be decoded gradually depending on the capacity of your internet connection and your device (PC, phone, laptop, etc. ...); With this extension, and into a single file, and in the same stream, are present different layers encoded in different resolutions (spatial) and quality levels (SNR / Quality / Fidelity), frame rate (temporal) and various combinations of these characteristics. SVC coding decodes the stream based on the capabilities of the device used, restriction of bandwidth and the speed of your connection. If we use a low-resolution video device will be decoded in low resolution, if your speed is low only the low-speed layer is decoded, if instead you have a broadband connection and a high-resolution device enjoy the best level of quality And after we decided to extend this model with another parameter that is IP address of the peers to ensure continuity of service and keep the periodic update of the list of peers, and to compare the results obtained for changing the type of network access. We evaluated video packet transmission results. The rest of the paper is organized as follows. In Section II we present the background and in Section III We propose a scalable video streaming architecture in a P2P-IMS network. Section IV describes the simulation set up. In Section V we present the different results of the simulation. Section VI concludes the paper.

II. Background

A. Streaming Video in P2P IP Multimedia Subsystem (IMS)

Video streaming via peer-to-peer (P2P) networks using scalable video coding (SVC) for an NGN over the IP multimedia subsystem (IMS) is possible to implement, among the types of video streaming, there is video on demand and internet protocol TV. The P2P network can contain a heterogeneous architecture such as PC, tablet and mobile phone and can be connected to the network through different networks (LAN, ADSL, Wi-Fi) the constraint of heterogeneity of the pairs imposes a challenge which is to guarantee a certain level of QOS of the video for the different peers, the SVC coding proposes the solution of the coding by layer which makes it possible to divide the main flow into several sub streams while guaranteeing a fidelity to the original video, P2P streaming ensures scalability with existing demand, relying on the user's equipment to contribute their download bandwidth. Therefore, it represents an alternative cost-effectiveness to the client-server paradigm or more scalable architectures.

The objective of the Video Streaming Protocol in the P2P IMS Network is to serve as an enabling technology, taking advantage of the development experiences of existing P2P streaming systems. Its design will allow it to integrate with IETF protocols on distributed resource location, traffic location, streaming control and data transfer mechanisms to create a complete streaming system or a streaming infrastructure.

III. Proposed Architecture

Our proposed architecture is schematized in Fig. 1 and the screen capture of the NS2 simulation nam outpout is schematized in Fig. 2.

The main components of this architecture are: P-CSCF, I-CSCF, S-CSCF, the AS Tracker is an IMS application server that also performs tracker features. Its features include:

Stores a list of pairs and keeps it up-to-date based on the activity of user pairs and network pairs, and the sending of the list of pairs to UE, The AS Tracker collects a set of information from the UE. Our proposed architecture as shown in Fig. 1 is based on [6], we have an IMS network (which contains the P-CSCF, I-CSCF, S-CSCF) a server tracker that is connected to the IMS network and all the signaling messages between them, different peers and the server tracker passes through the IMS network, it is a model defined by 3GPP named P2P CDS architecture, this architecture essentially comprises the CSS entity (Content Source Server (CSS), the purpose of our approach more the technical coordination between IMS, P2P and Scalable Video Coding (H.264/SVC), is to benefit from the advantages of SVC coding to provide adaptive p2p streaming for the IMS network and in a heterogeneous architecture containing different devices (PC, tablet, phone). After the authentication step of the different clients at the level of the IMS network, the multimedia services become possible in the network. Our simulation will include the part of the SIP signaling in the IMS network of the different peers, the creation of a P2P network in our proposed architecture using the Zetasim [7] framework, and the part of the evaluation of the SVC coding using the myevalsvc [8] framework, in order to execute our SVC quality adaptation algorithm, we have developed our algorithm using C++ code, to choose the streamed stream that suits the performance of the peer, then we have to connect our C++ code with the TCL simulation (Tool Command Language) on NS2. Then we use the myevalsvc framework to evaluate the transmission of SVC encoding between two sending and receiving nodes. We use the zetasim framework for the creation of a P2P network and the download management of the video sequence and to simulate adaptive video streaming SVC between peers, the SIP module [9] is used for signaling in the network, where a peer plays the role of a server and other peers play the role of customers. Finally, we have created a complete architecture that can make the identification of IMS P2P users and which also allows the SVC adaptation of quality for heterogeneous devices.

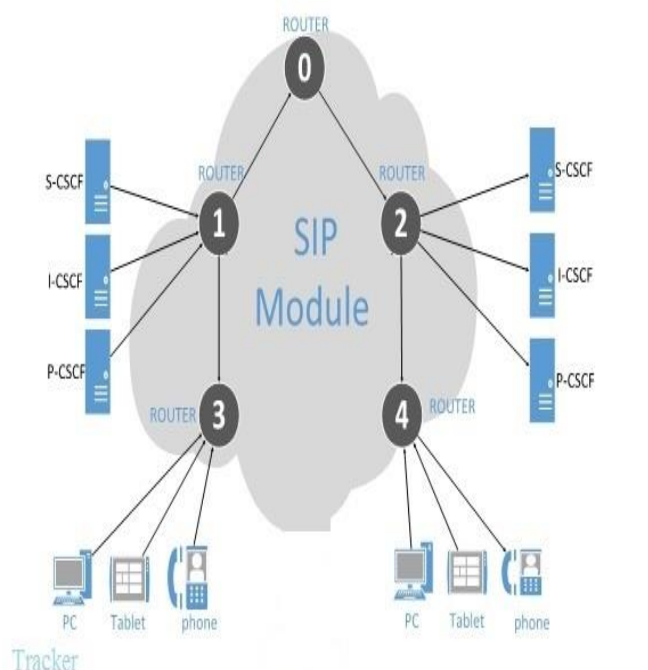

Fig. 1. Proposed Architecture.

Algorithm of adaptation

Algorithm: Selection of the appropriate SVC layer according to customer performance and access type

Input :
di=d0;
tj=t0 ;
qk=q0 ;
d0, t0, q0 represent three types of initial scalability.
Set the initial quality at the layer L0 (di,tj,qk) .
α ; The distribution of the video length in relation to the battery life.
β; Adaptive frame rate.
μ ; Adaptive level of SNR.
φ; Quantization parameter.
£; list of peer belonging to the network
@; address IP of the peer
dm ; Represents the maximum spatial scalability.
tm ; Represents the maximum time scalability.
qm ; Represents the maximum qualitative scalability.
 	
Output :
 	
Fulfill the constraints of the adjusted quality Ll (d,t,q)
 	
Begin
 	
For each level of the layer Ll,dm
If (Ll,di≤ User Preferences.Resolution Display)
then
level_SVC.add {di}
End if
End For
 	
For each level of the layer Ll,(dm,tm)
If ((Ll,(di ,tj) ≤ User Preferences.Taux_Frame)
 	
and (Ll,(di ,tj) ≤ Pair resources.bandwidth)
and (Bitrate(β, φ) ≤ Pair resources. bandwidth))
then
level_SVC.add {di,tj}
end if
end for
 	
For each level of the layer Ll,(dm,tm,qm)
If ((Ll(di,tj,qk) ≤ User Preferences.level_SNR)
and (Ll(di,tj,qk) ≤ Pair resources.Device Power)
and
Complexity (di,tj,qk) ≤ Pair resources. Device Power (CPU)
and (α ≤1))
and @ є £
then
level_SVC.add {di,tj,qk}
end if
end for
 	
if level_SVC.add {di,tj,qk} is not empty
then Return the candidate of adaptive quality{d,t,q}
end if
Return "Error: static resources too low for the base stream"
end

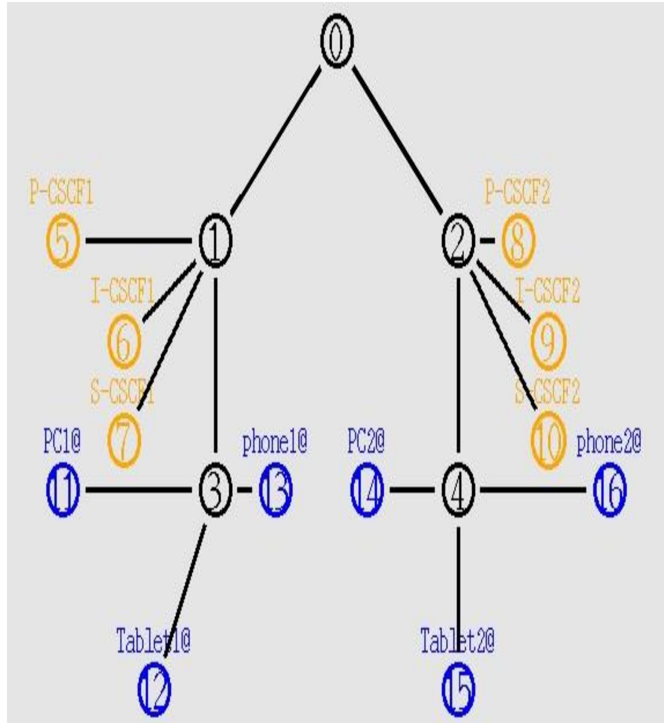

Fig. 2. Screen Capture of the NS2 Simulation Nam Outpout.

In Fig. 3, we present our model of quality adaptation, this model is extended from an existing model [10], by adding another parameter, which is the IP address of the user, in order to guarantee a continuity of service in the IMS P2P network, by ensuring an update of the list of peers after each change of IP address of the users following the model of Fig. 4, and we have created a C ++ code which simulates this model which aims to define the adequate quality (d, t, q) (spatial, temporal , qualitative) with the performance of the user, and we proceed as follows:

1) Executing the spatial adaptation, extracting the SVC levels that have the resolution of the appropriate video for the user according to the resolution parameter of the user's screen.

2) Taking into account the SVC levels already selected in step 1, the model executes the temporal adaptation according to the user requested frame rate and the network bandwidth to extract the levels of SVC respecting these conditions.

3) Taking into account the SVC levels already selected in step 2, does the model perform the qualitative adaptation, according to the user's preferences, does it request that the video be of quality or not, and respect also other more complex parameters that are: CPU performance, RAM, battery life to finally extract a single level SVC adapted to the performance of the user.

4) And taking into account the SVC level adapted to the performance of the user, a check of the IP addresses of the peers in the list of peers is performed, to ensure that the peer that will provide the video sequence is present in the list of peers.

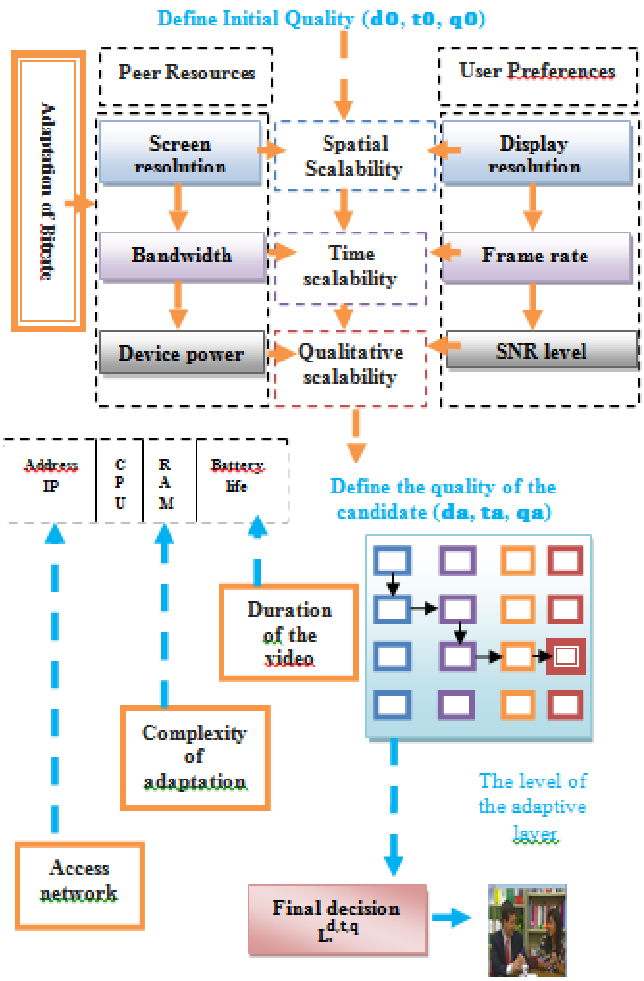

Fig. 3. Scheme of Adaptation Model.

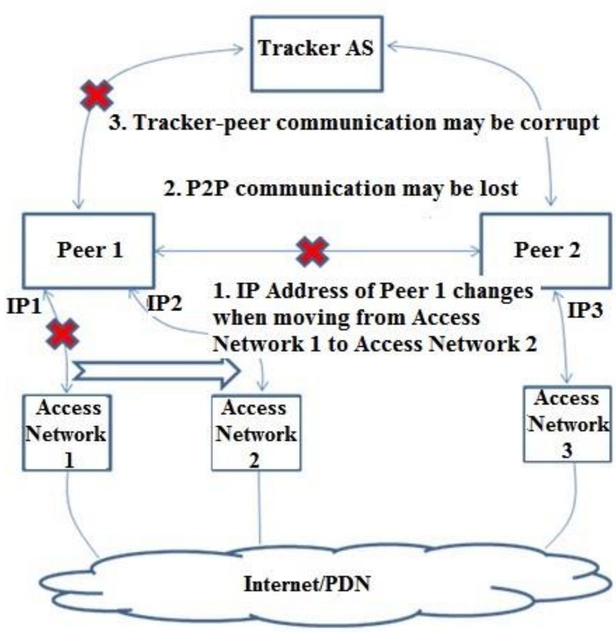

Fig. 4. Diagram Describing the Problem Addressed [6].

IV. SIMULATION SET-UP

We first evaluated two metrics of objective evaluation that are (peak signal-to-noise ratio (PSNR)) and video quality metrics (VQM)). Our test sequences are classified into two classes, PSNR vs. SVC layer level, VQM vs. SVC layer level. Then we simulated our proposed architecture, This simulation allows the SIP authentication of the different users then the creation of the sessions between the different clients, and the creation of a P2P network using the protocol zeta, then the execution of the code C ++ which allows to select the flow so that the peer only receives the appropriate sub stream with their performance and read the video with the appropriate quality, Then we use the myevalsvc framework to evaluate streaming performance in a heterogeneous architecture.

The architecture studied aims at evaluating Packet transmission delay, Packet size by transmission delay, Jitter, PLR (Packets loss rate). This architecture contains, IMS P2P network that contains heterogeneous peers. We will evaluate the video packets, while giving the transition time of these packets, and specifying the time of queuing. The output of the queue and the reception of the packet at its destination, the following results have been extracted:

- Packet transmission delay.
- Jitter by transmission delay.
- PSNR
- VQM.
- PLR (Packets loss rate).

The experiments have been performed on five video sequences and configuration that combining temporal, spatial and SNR scalable layers. Table I shows the configuration described in the main file of the JSVM encoder used for the selected sequences.

The coding parameters are shown in Table II.

TABLE I. TEST OF SEQUENCES

Video Sequence	QCIF Format	CIF Format	Number of frame	Number of layer
paris	176x144	352x288	1000	4
akiyo	176x144	352x288	300	4
Foreman	176x144	352x288	300	4
Hall Monitor	176x144	352x288	300	4
News	176x144	352x288	300	4

TABLE II. CODING PARAMETERS

Number of the layer	4
Base layer and enhancement layer resolution	176x144 ; 352x288
Encoded frames	1000 / 300
GoP size	8
Frame rate	30
Quantization parameter	36 ; 34 ; 30 ; 26
Encoding type	MGS

TABLE. III. CONFIGURATION OF PARAMETERS OF THE SVC VIDEO USED IN THE SIMULATION

Configuration Files	The settings	Values
Main.cfg	FrameRate	30
	FramesToBeEncoded	1000 / 300
	GOPSize	8
	NumLayers	4
Layer0.cfg	SourceWidth	176
	SourceHeight	144
	FrameRateIn	30
	FrameRateOut	30
	QP	36
Layer1.cfg	SourceWidth	176
	SourceHeight	144
	FrameRateIn	30
	FrameRateOut	30
	QP	34
Layer2.cfg	SourceWidth	352
	SourceHeight	288
	FrameRateIn	30
	FrameRateOut	30
	QP	30
Layer3.cfg	SourceWidth	352
	SourceHeight	288
	FrameRateIn	30
	FrameRateOut	30
	QP	26

Table III shows the configuration of the main parameters used for SVC videos by JSVM in the simulation; note that each SVC layer is divided into 4 sub-layers.

V. RESULTS AND ANALYSIS

A. PSNR

We performed the required configuration in JSVM to enable the scalability mode for the tests videos used "paris", “akiyo”, “Foreman”, “Hall Monitor”, “News”, the reconstructed scalable substreams are compared with the original stream containing all the sub-layers. Table IV shows the average of the PSNR coded for each layer level, these values are shematized in Fig. 5.

According to Table V, the scalability in sequences quality takes the three different values of the spatial, temporal and quality named identifiers represented by (D, T, Q) respectively for each SVC level (Sub-layer or index -layer).

TABLE. IV. PSNR BY SUB-LAYERS

Layer level	PSNR average for sub-layer (paris)	PSNR average for sub-layer (akiyo)	PSNR average for sub-layer (Foreman)	PSNR average for sub-layer (Hall Monitor)	PSNR average for sub-layer (News)
0 ;4 ;8 ;12	25,48	24,40	19,93	24,37	20,64
1 ;5 ;9 ;13	26,00	24,40	19,54	23,97	20,39
2 ;6 ;10 ;14	26,57	24,71	19,58	24,16	20,45
3 ;7 ;11 ;15	37,99	33,21	32,55	31,32	31,70

TABLE. V. CODING PARAMETERS

Sub layer	(Lid,Tid, Qid)	Frame Rate	Bit rate (kbps) PR	AK	FR	HM	NW
0	(0,0,0)	3.75	105.2	571.3	1147	1147	861
1	(0,1,0)	7.5	112.4	580.4	1172.4	1166.3	878.9
2	(0,2,0)	15	120.1	582.1	1183.8	1170.3	885.4
3	(0,3,0)	30	127.8	584	1195.6	1174	891.1
4	(0,0,1)	3.75	141.4	572.3	1147.7	1147.7	861.8
5	(0,1,1)	7.5	153.3	582.6	1178.2	1169.1	882.8
6	(0,2,1)	15	167.8	586.1	1197.3	1177.3	894.2
7	(0,3,1)	30	182.5	590.7	1219.2	1185.6	905.9
8	(1,0,0)	3.75	725.1	2632	5734	5734	3989
9	(1,1,0)	7.5	769.8	2686	5917	5898	4099
10	(1,2,0)	15	816.3	2707	6047	6002	4170
11	(1,3,0)	30	860.7	2728	6199	6119	4230
12	(1,0,1)	3.75	1036.3	2634	5735	5735	3990
13	(1,1,1)	7.5	1118.2	2705	6030	6094	4144
14	(1,2,1)	15	1206.5	2747	6316	6434	4281
15	(1,3,1)	30	1294.3	2792	6629	6774	4398

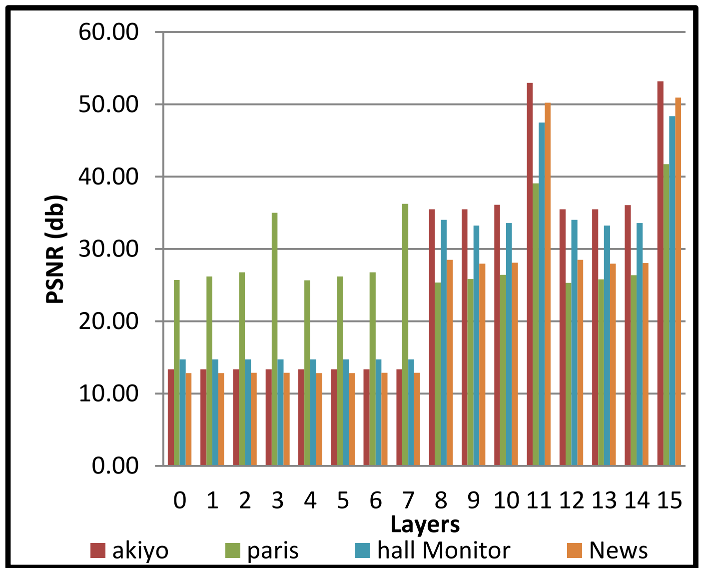

Fig. 5. PSNR (db) Versus Layers.

B. VQM

Our tests sequence was subjected to VQM that makes a comparison between the original video sequence and the distorted video sequence, based only on a set of features extracted independently from each video. The values of VQM are shematized in Fig. 6 evaluates the performance of the zetasim framework, we performed simulations for different numbers of peers (10,30,50 and 70 pairs), based on the simulation parameters of Tables VI and VII and we obtained the results schematized in Table VIII and Fig. 7.

First we calculate the estimated time for a peer to join the P2P network as shown in Table IX, after we performed two simulation scenarios, one with multiple peers that are connected to the network until the end of the video download by the peers and the other scenario with the change of the address of a peer during the operation of downloading the video sequence by peers.

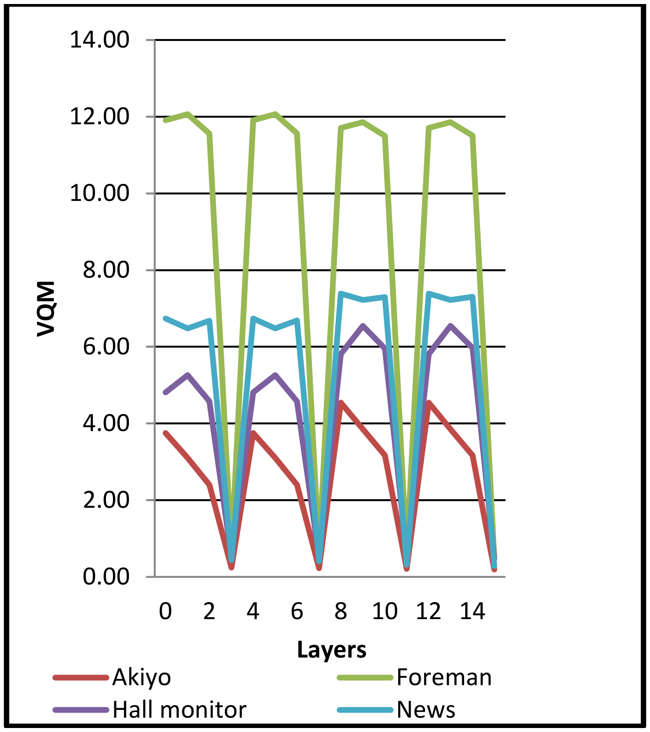

Fig. 6. VQM Versus Layers.

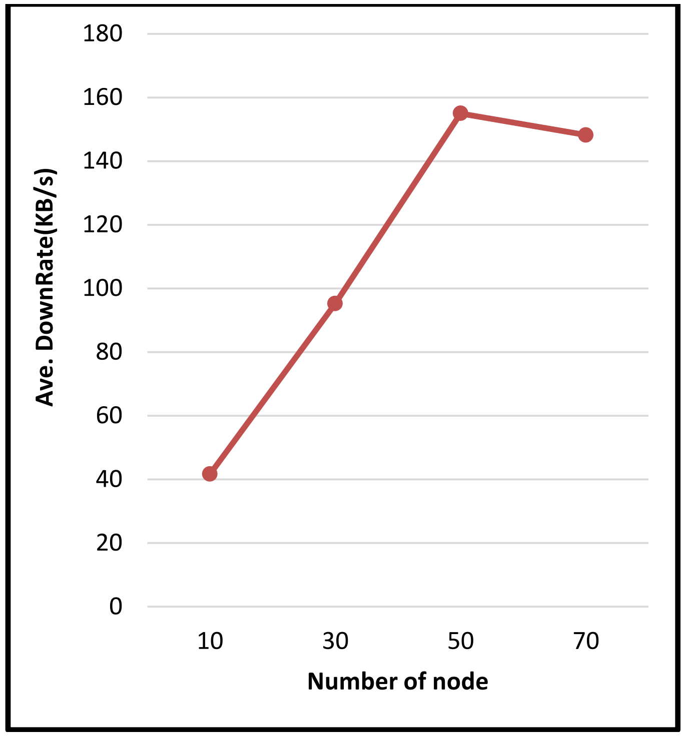

Fig. 7. Averge Download Rate Versus Number of Node.

TABLE. VI. THE SIMULATION PARAMETERS

Simulation parameter	**Value**
Link type	duplex-link
Bandwidth (PC)	10MB
Bandwidth (Tablet)	5 MB
Bandwidth (Phone)	1.5 MB
Queuing time	5ms,2 ms
Packet scheduling type	DropTail

TABLE. VII. THE SIMULATION PARAMETERS

Simulation parameter	**Value**
Tracker	Boot server and tracker
number of bootserver	1
Update peers interval of peer node	0.5 s
tracker_threshold	3
Maximum size NSSocket packet	3
maxUploadSpeed	100kb
code word size	1
block size	20KB
total size of the file	3Mb
threshold to start seeder	0.5
Simulation duration	100

TABLE. VIII. SIMULATION RESULTS FOR DIFFERENT NODES

Number of Nodes	**Ave. Down Rate(KB/s)**	**Ave.Query Time(s)**
10	41,694 KBps	0,03408 s
30	95,236 KBps	0,03408 s
50	154,97 KBps	0,03408 s
70	148,16 KBps	0,03408 s

TABLE. IX. THE ESTIMATED TIME FOR A PEER TO JOIN THE P2P NETWORK

Packet	**Time (s)**
CONNECT_BOOT_SERVER	0,00948
CONNECT_BOOT_SERVER_REPLY	0,009
UPDATE_SHARED_FILES	0,03764
Update Shared Files has been Acked	0,00668
Total	0,0628

Following Fig. 8, the simulation showed that the change of the peer's address allowed an increase of the average download rate in KB/s, which shows the utility of our adaptation model.

Fig. 8. Average Download Rate by One Peer for the Case of Change of Address and Without Change of Address.

The adaptation of the quality can be schematized by the following expression:

$$\text{Bitrate (QP,T)} = B_{max}\left(\frac{QP}{QP_{min}}\right) - a\left(\frac{T}{T_{max}}\right) b$$

Expression I : Adaptation of bitrate.

Where the maximum bitrate is:

B_{max} = Bitrate (QP_{min},T_{max}),**a** and **b** are known and constant parameters dependent on QP_{min} and T_{max}[11].

For simulating streaming video at the NS2 simulator, we used the Soccer sequence which is of type 4CIF (with a resolution of 704x576) (which has duration of 90 seconds) and which was coded in 14 sub-layers and a frame rate 30 fps and 3 level of quality, we compared the transmission results of video packets in and we found the results schematized by the following figures.

From Fig. 9, note that the average of the transmission delay is at most for the number of packets equal to 48, the minimum value of the transmission delay average is for the number of packets equal to 51, between the number of packets 2 and 50, There is a simple change in the values of the transmission delay average and for the packet numbers of 50 or more there are a significant change differences in the mean transmission delay values.

From Fig. 10, note that we have several jitter values for transmission delay of video packets.

To check the performance of our adaptation algorithm, we performed a streaming comparison to a client that has the rate of the SVC 9 level, and we sent to it the global sequence, then we sent to it the appropriate sequence with the level SVC 9, and we extracted the values of PLR of both cases. The results are shown in Fig. 11.

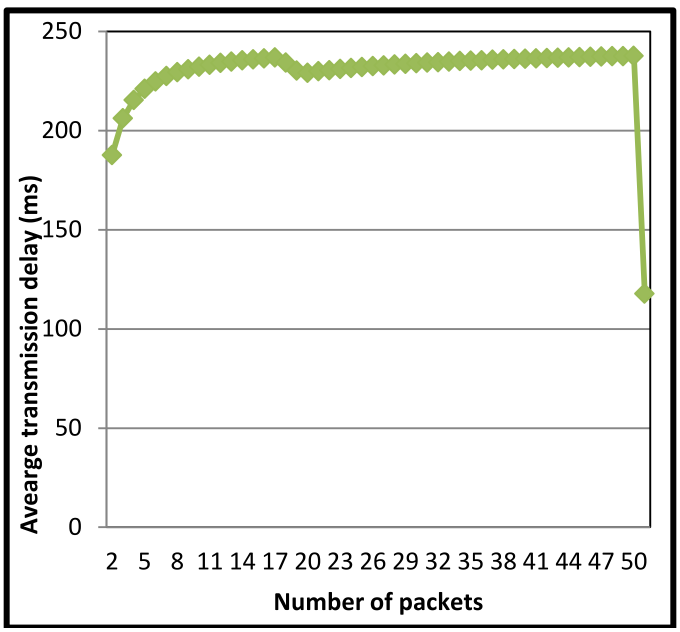

Fig. 9. Average End-to-End Transmission Delay on the Number of Video Packets.

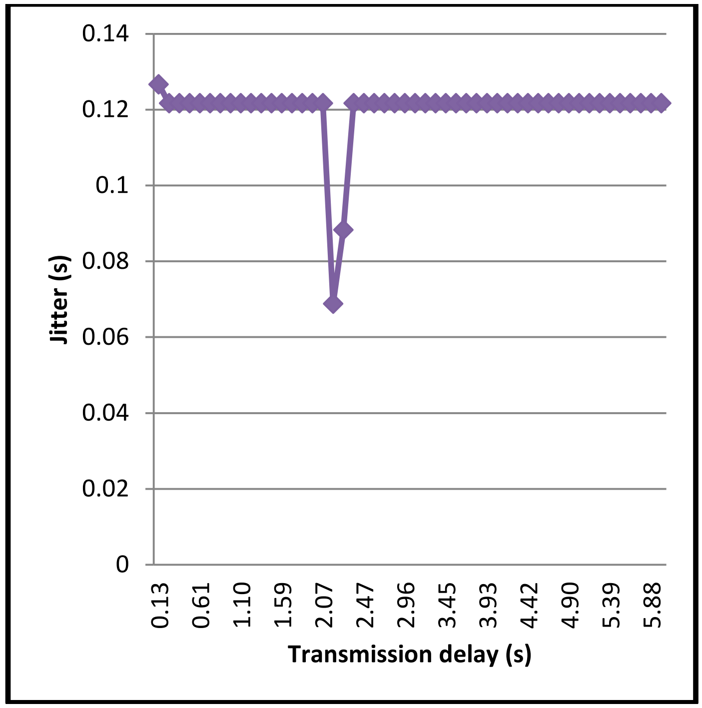

Fig. 10. Jitter on Transmission Delay of Video Packets

From Fig. 11, note that our simulation model allowed a very low level of PLR.

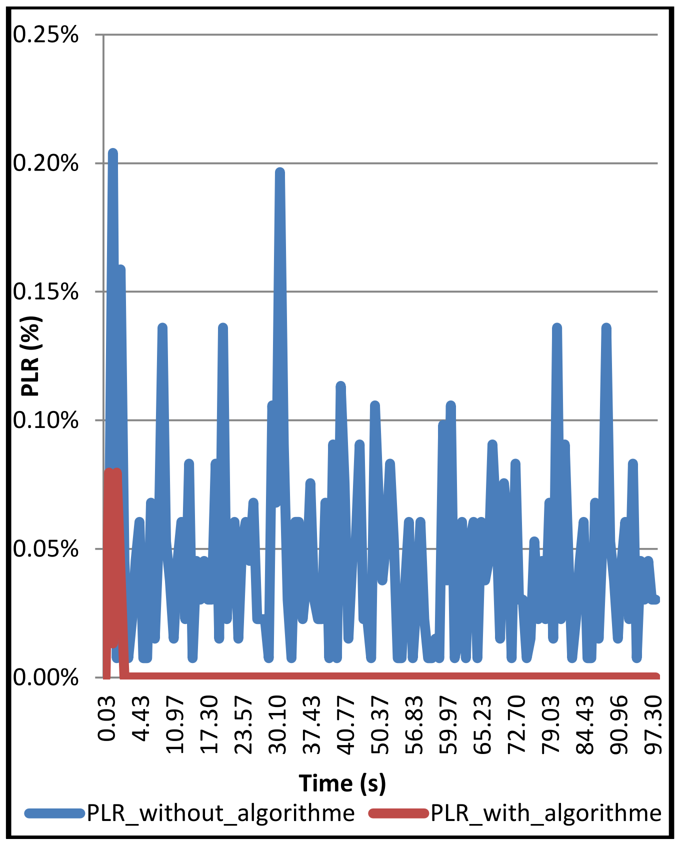

Fig. 11. Comparison between the Rate of Loss of the Packets with the use of the Algorithm of the Adaptation and without the use of the Algorithm.

C. Comparative Analysis with Latest Research Work

To check the performance of our adaptation algorithm, we performed the streaming using the framework avis [5], and we found the results schematized in Fig. 12.

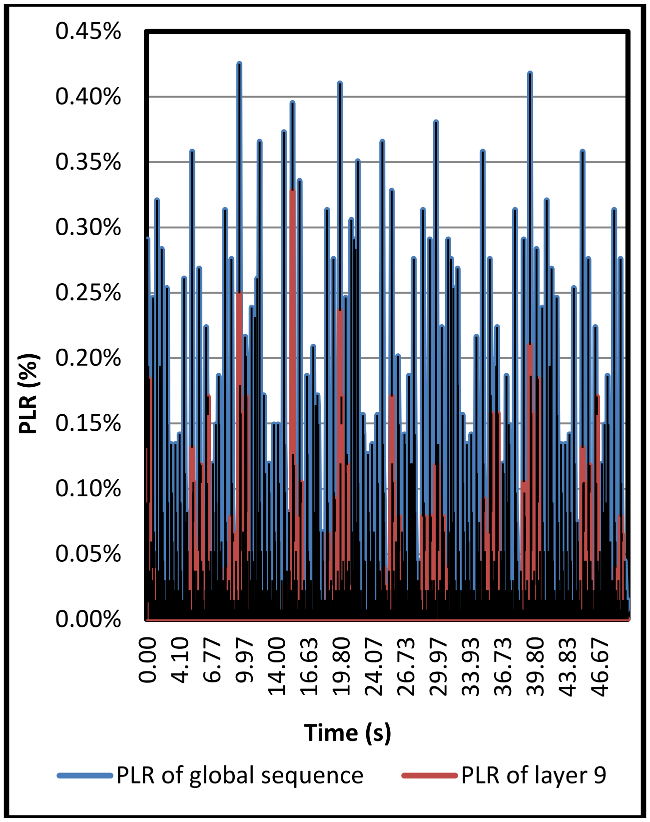

Fig. 12. Comparison between the Loss Rate of the Packets with the use of the AVIS Framework for the Global Sequence Containing All the Layers and the Sequence of the Layer 9.

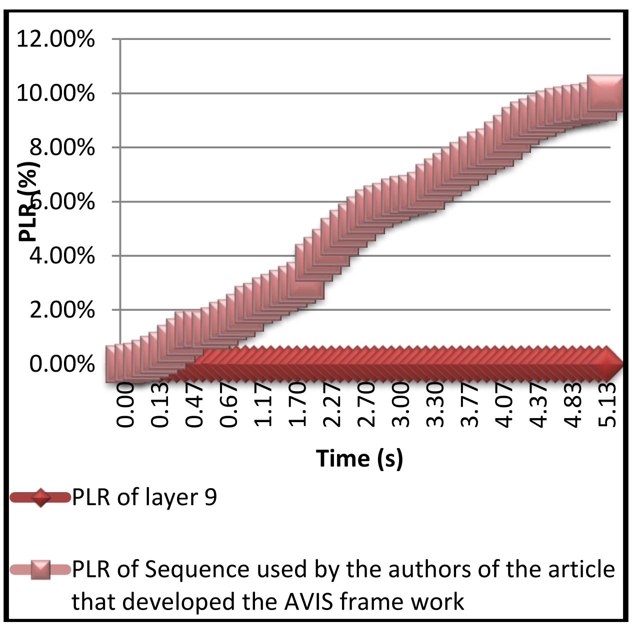

Fig. 13. Comparison between the Loss Rate of the Packets with the use of the AVIS Framework for the Streaming of our Sequence of the Layer 9 and the Streaming of the Sequence used by the Authors of [5].

Our results show that our model has a better adaptation of the quality according to the network resources of the peers in term of bandwidth available in the network and the performances of the users (CPU, RAM, autonomy of the battery), since the rate of packet loss achieved by our adaptation algorithm is less than the packet loss rate achieved by the authors of the article that developed the AVIS frame work as shown in Fig. 13 and also our model allows a continuity of service in the network by ensuring that the list of peers is updated after each change.

The limitation of the study is that we have not tested the performance of our adaptation model in real Internet structure based on a more powerful peer-to-peer protocol that manages gigantic p2p networks.

VI. Conclusion

This paper presented a quality adaptation by scalable video streaming over P2P IMS network. The simulation was tested in NS2 and performed using the code C++ of NS2 SIP, myevalsvc. The results show a clear quality adaptation with heterogeneous terminals, and show the importance of continuity of service for p2p networks. The proposed quality adaptive scheme is also responsive to available network bandwidth and the change of access network of peers.

VII. Future Work

Future work will take into account the advances of H.264 SVC codec in the proposed implementation of adaptive streaming algorithms in both TCL and C++ domains, and the test of the performance of adaptation model in gigantic p2p networks managed by strong peer-to-peer protocol.

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