

Generation of mathematical models for estimating losses generated in an IPTV transmission system using the RTSP protocol

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Abstract—In this article different mathematical models are implemented (using linear regression) in order to estimate or predict the losses that can be produced when delivering television and video content on demand on an IPTV-IMS platform using the RTSP protocols. Several scenarios are evaluated for this. Initially, television is broadcast using the RTSP protocol, switching between wireless and wired networks, and varying the network load. Later this process is repeated when video is transmitted on demand repeating the load conditions and type of network. Each of the proposed scenarios starts with a user receiving the transmission and ends when 10 users are connected. The results of these tests are tabulated, plotted and compared in order to determine how successful the estimation models developed are.

Keyword—Losses on an IPTV system, Mathematical model, IPTV, RTSP,

I. INTRODUCTION

The network structures developed included the implementation of an IPTV system over a wired network structure (see Fig. 1) and over a wireless network topology (Fig. 2).

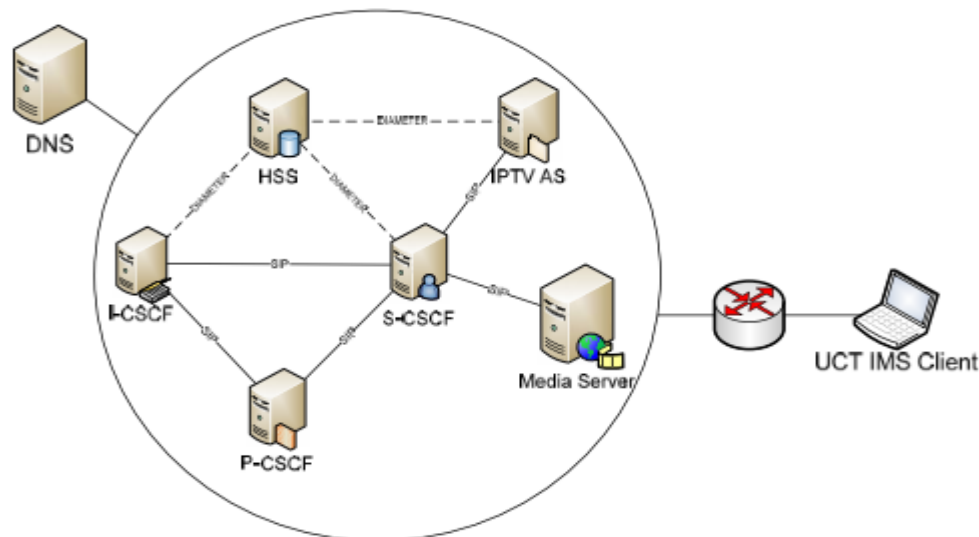


Fig. 1. Scenario used for the implementation of the IPTV system in a wired network [1].

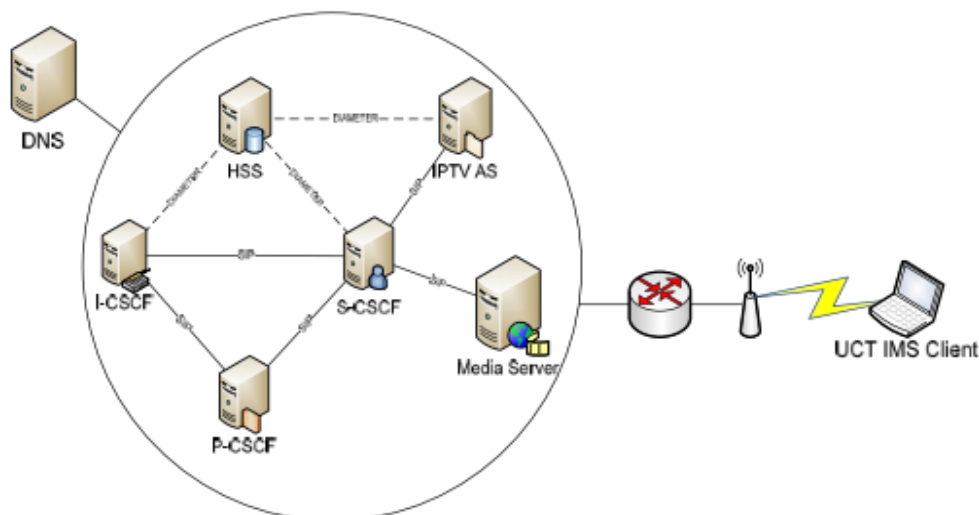


Fig. 2. Scenario used for the implementation of the IPTV system in wireless network [1].

With the network infrastructure already established, the next step is to determine the scenarios to perform the measurement and generation of the behavior of the variable that we want to estimate. Since we intend to estimate or predict the behavior of the variable *losses in reception*, the RTSP (Real Time Streaming Protocol) protocol [2] was used, which generally works on the UDP standard (User Datagram Protocol) of the transport layer. The measurements made were applied independently for the television and video on demand (VoD) services given that the bandwidth consumption may be different. The traffic sent for the tests corresponds to a single video in mp4 format, with a duration of 45 minutes, without high definition and will be used both for television and VoD so that the behavior of the variables is not affected by it. There will also be traffic corresponding to instant messaging although this does not represent a significant load to affect the measured variables.

Initially, each of the users will correspond to a computer with the IMS client [3] installed connected to the wired network. Subsequently, the scenarios will be repeated with the clients connected to the wireless network, which aims to see the effect with respect to the previous case.

Initially, each of the users will correspond to a computer with the IMS client [4] installed and connected to the wired network. Subsequently, the scenarios will be repeated with the clients connected to the wireless network, which aims to see the effect with respect to the previous case.

It is important to note that the implementation of the IPTV platform on Fig. 1 and 2 corresponds to the installation of the selected project (Open IMS Core) [4] with its additional entities, the configuration of each one so that they work on different machines with the domain of the District University and the start-up of each of the proposed scenarios with the respective loss measurements. For this installation, we worked on a data blade of the High Performance Computing Center of the university, for which each of the necessary machines was virtualized using the open source software VirtualBox [5]. In each one Ubuntu 8.04 was installed since the chosen project was designed to work originally under this distribution.

II. MATERIALS AND METHOD

In order to implement the loss model, it became necessary to transmit both television and video-on-demand signals over the network structures of Fig. 1 and 2; the results are shown in Fig 3 to 6.

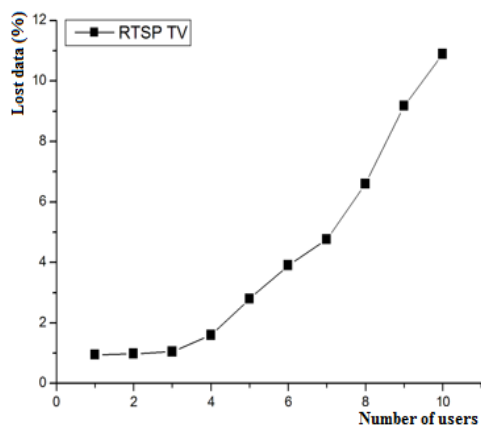


Figure 3. Behavior of the *losses* variable for television signals sent through the RTSP protocol through wireless network.

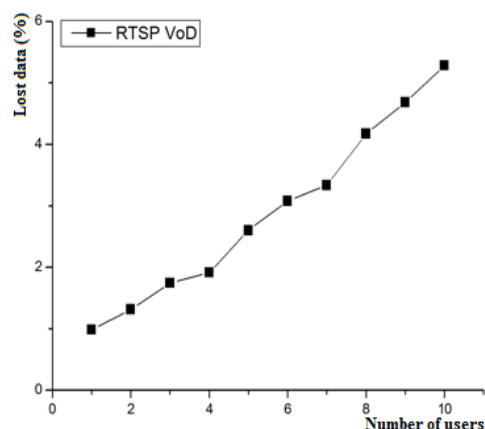


Figure 4. Behavior of the *losses* variable for VoD signals sent through the RTSP protocol through wireless network.

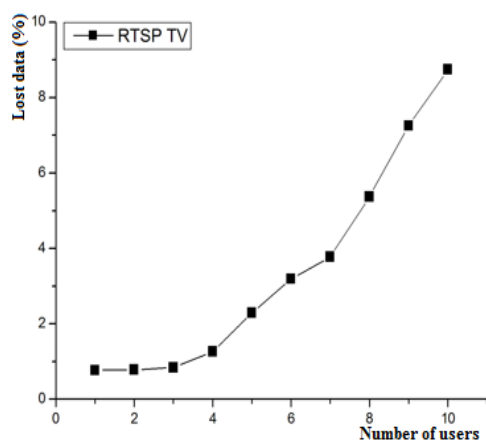


Figure 5. Behavior of the loss variable for television signals sent through the RTSP protocol through a wired network.

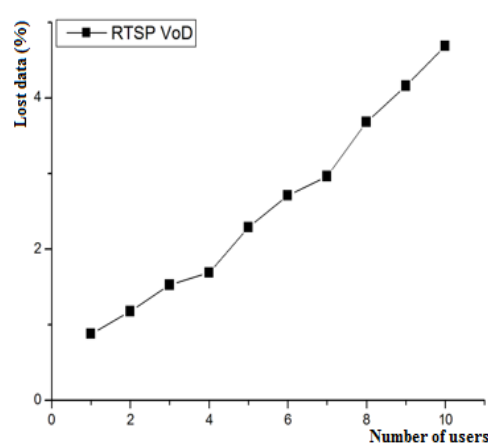


Figure 6. Behavior of the variable *losses* for VoD signals sent through the RTSP protocol through a wired network.

With the loss data already tabulated, we proceeded to obtain a mathematical model that allows us to estimate its behavior having as input parameters the number of users of different types, that is, the number of users connected to the platform through a wireless network, those connected by a wired network and the amount of Set Top Boxes associated with televisions.

It should be noted that the loss models are implemented for each of the services provided (VoD and television) when the data is sent on the RTSP standard, so that in the end there will be 4 different final equations.

Since the data were obtained experimentally, it was decided to use the concept of linear regression to obtain the most accurate approximation possible for each of Fig. 3 thru 6. However, since these do not represent linear functions per se, it is necessary to perform transformations of variables in order to approximate them to linear functions.

There are several methodologies available that can be adjusted to different types of graphics. In order to select the most suitable one, different transformations were made on the data and those that generated a figure close to a straight line were chosen. Later the equation of each case was found and the data of slope (P) and cut point (C) that were used within each model were extracted. The models used for the results obtained are presented in Table I.

TABLE I. Models of Transformation of Variables.

Model	New axes to achieve the straight line with the original dispersion function	Model parameters, taken from the linearized function
$y = ax^b$	$Y = \log_B(y)$ $X = \log_B(x)$	$a = \log_B^{-1}(C)$ $b = P$
$y = ax^b + \delta$	$Y = \log_B(y - \delta)$ $X = \log_B(x)$	$a = \log_B^{-1}(C)$ $b = P$
$y = B^{ax+d}$	$Y = \log_B(y)$ $X = x$	$a = P$ $d = C$
$y = B^{ax+d} + \delta$	$Y = \log_B(y - \delta)$ $X = x$	$a = P$ $d = C$
$y = a_0 + a_1x + a_2x^2$	$Y = \frac{(y - y_1)}{(x - x_1)}$ $X = x$	$a_2 = P$ $a_1 = C - Px_1$ $a_0 = y_1 - Cx_1$
$y = \frac{x}{ax + b}$	$Y = \frac{1}{y}$ $X = \frac{1}{x}$	$a = C$ $b = P$

III. RESULTS

A. Losses model for television signals sent through the RTSP protocol through a wireless network.

For this case, the following transformation of variables is performed:

$$X = xY = \frac{y-y_1}{x-x_1} \tag{1}$$

Where $a_0 = y_1 - Cx_1$, $a_1 = C - Px_1$, $a_2 = P$

The obtained straight line equation is therefore:

$$y = 0,1428x - 0,3087 \tag{2}$$

Now we can proceed to determine the constants.

$$a_0 = 1,254 \quad a_1 = -0,451 \quad a_2 = 0,1428$$

Therefore the final model is given by the equation:

$$\% \text{ lossess} = 1,254 - 0,451 * (\# \text{ wireless users}) + 0,142(\# \text{ wireless users})^2 \tag{3}$$

The data obtained with this model are presented in Table II and its representation in Fig. 7.

TABLE II. Results of the model generated for Television over RTSP through wireless network.

User	Losses (%)	Approximation	Absolute Error	Relative Error
1	0,94560453	0,9456	0	0
2	0,982126573	0,9225	-0,059622	6,07071
3	1,042910924	1,185	0,14209361	13,6247
4	1,5975424	1,7331	0,13556213	8,48567
5	2,7989313	2,5668	-0,2321268	8,29341
6	3,8991423	3,6861	-0,2130378	5,46371
7	4,75813123	5,091	0,3328733	6,99588
8	6,5959313	6,7815	0,18557323	2,81345
9	9,18253134	8,7576	-0,4249268	4,62756
10	10,89060635	11,0193	0,12869818	1,18174
			Average	5,75568

B.Losses model for video signals on demand sent by the RTSP protocol and through wireless network.

For this case, the following transformation of variables is performed:

$$X = xY = \log_B y \tag{4}$$

The obtained straightline equation is therefore:

$$Y = aX + b \rightarrow \log_B y = ax + b \tag{5}$$

And the new y value is determined:

$$B^{\log_B y} = B^{ax+b} \rightarrow y = B^{ax+b} \tag{6}$$

Where $a = P$ y $b = C$

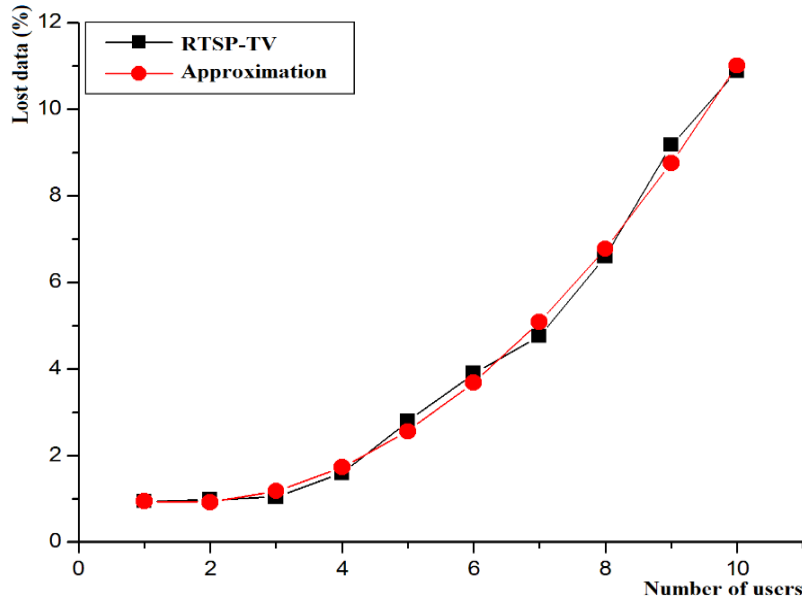


Figure. 7. Approximation for television sent through RTSP protocol through wireless network. - Average relative error 5,75%.

The obtained straightline equation is:

$$y = 0,5197x - 0,0348 \tag{7}$$

Now we can proceed to determine the constants.

$$a = 0,5197 \quad b = -0,0348$$

Therefore the final model is given by the equation:

$$\% \text{ losses} = 10^{0,5197(\# \text{ wireless users}) - 0,0348} \tag{8}$$

The data obtained with this model are presented in Table III and its representation in Fig. 8.

TABLE III. Results of the model generated for VoD over RTSP through wireless network.

User	Losses (%)	Approximation	Absolute Error	Relative Error
1	0,9851454	1,1215018	0,13635645	13,84125106
2	1,3131189	1,3467906	0,03367141	2,564231919
3	1,7453451	1,617335	-0,12801009	7,334371139
4	1,9143244	1,942227	0,02790260	1,457569126
5	2,6015533	2,332383	-0,26916958	10,34649521
6	3,0799135	2,800915	-0,27899804	9,058632478
7	3,3369155	3,363566	0,02665085	0,798667437
8	4,1722551	4,039243	-0,13301195	3,188011023
9	4,686746	4,8506506	0,16390468	3,497195709
10	5,284053	5,8250545	0,54100156	10,23838268
			Average	6,23248

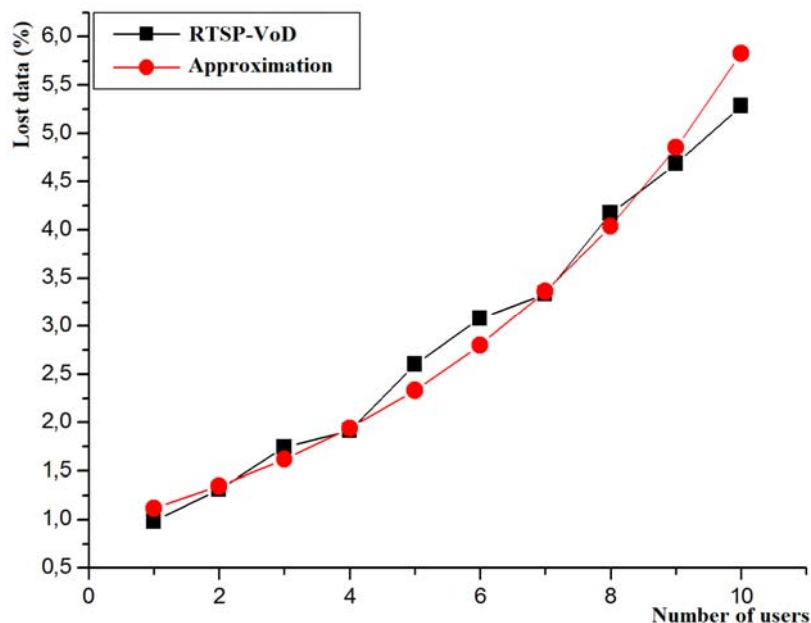


Figure. 81. Approximation for VoD sent via RTSP protocol through wireless network. - Average relative error 6,23%

C. Losses model for television traffic sent through the RTSP protocol and through a wired network.

In this case, the results are lower than those obtained by wireless transmission and according to their graphs, it can be seen that they have very similar behavior. This is consistent since only the transmission medium is being changed to a more reliable one. Given this, since the losses are smaller but have similar behaviors, we verified if these vary in some percentage when using cable as a means of transmission. The results are shown in Table IV below.

TABLE IV. Ratio between losses for television by RTSP via wireless and wired network.

Users	Wireless Network Losses (%)	Wired Network Losses (%)	Ratio (%)
1	0,94560453	0,77201295	81,6423
2	0,982126573	0,783056148	79,7307
3	1,042910924	0,842462075	80,7799
4	1,5975424	1,26401851	79,1227
5	2,7989313	2,291823204	81,8821
6	3,8991423	3,191329872	81,847
7	4,75813123	3,777712212	79,3949
8	6,5959313	5,374938794	81,4887
9	9,18253134	7,257867839	79,0399
10	10,89060635	8,743512012	80,2849

It is easy to appreciate that losses when using cable as a means of transmission correspond approximately to 80% of those obtained when receiving wirelessly, or what is the same, the losses are reduced by 20%. For this reason, the same model generated for wireless transmission will be used multiplying it by 0.8 (see equation 3).

The model in this case will be:

$$\% \text{ losses} = 0,8 * (1,254 - 0,451 * (\#copper \ users) + 0,142(\#copper \ users)^2)$$

The data obtained with this model are presented in Table V and its representation in Fig. 9. (9)

TABLE V. Results of the model generated for television by RTSP through wired network.

User	Losses (%)	Approximation	Absolute Error	Relative Error
1	0,772012	0,75648	0,01553	2,01154
2	0,783056	0,73800	0,04505	5,75342
3	0,842462	0,94800	-0,10554	12,5278
4	1,2640185	1,38648	-0,12247	9,68855
5	2,291823	2,05344	0,23838	10,4013
6	3,191329	2,94888	0,24245	7,59703
7	3,777712	4,07280	-0,29509	7,81138
8	5,374938	5,42520	-0,05026	0,93517
9	7,257867	7,00608	0,25178	3,46912
10	8,743512	8,81544	-0,07193	0,82269
Average				6,108

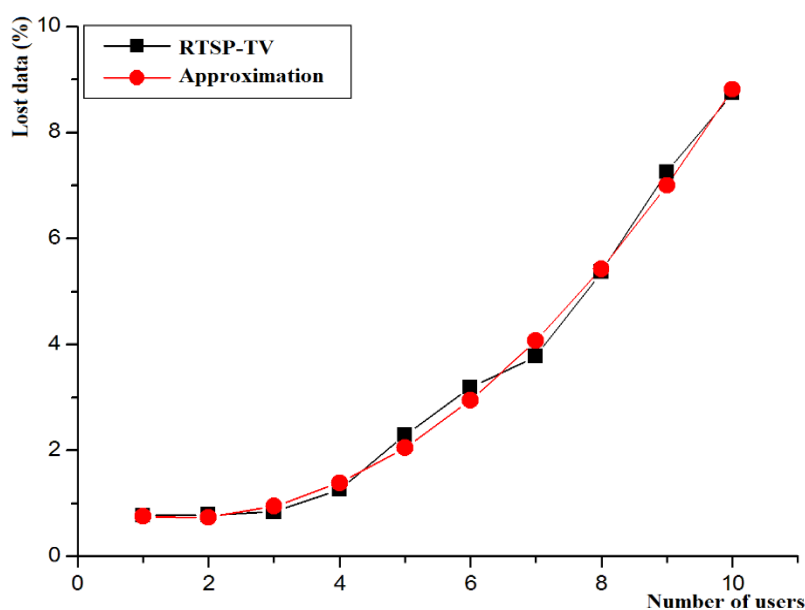


Figure 9. Approximation for television sent through RTSP protocol through wired network. - Average relative error 6,1%.

D. Losses model for video on demand sent through the RTSP protocol and through a wired network.

Carrying out an analysis as in the previous case, we obtain the results shown in Table VI.

TABLE VI. Ratio between losses for VoD by RTSP via wireless and wired network.

Users	Wireless Network Losses (%)	Wired Network Losses (%)	Ratio (%)
1	0,985145414	0,879980167	89,3249
2	1,313118947	1,180691956	89,9151
3	1,745345147	1,52911417	87,611
4	1,914324455	1,689050397	88,2322
5	2,6015533	2,288451119	87,9648
6	3,0799135	2,711741692	88,046
7	3,3369155	2,962890612	88,7913
8	4,17225513	3,682117724	88,2525
9	4,686746	4,160169547	88,7646
10	5,284053024	4,68617418	88,6852

Taking Table VI as a reference, it is concluded that when using cable as a transmission medium the losses are reduced by 12% with respect to the wireless medium, which implies that the model of equation 8 must be multiplied by 0.88 to adjust to the VoD flow

The model in this case would be:

$$\% \text{ losses} = 0,88 * (10^{0,5197(\#copper \ users)-0,0348}) \tag{10}$$

The data obtained with this model are presented in Table VII and its representation in Fig. 10.

TABLE VII. Results of the model generated for VoD by RTSP through wired network.

User	Losses (%)	Approximation	Absolute Error	Relative Error
1	0,8799801	0,986921641	0,10694	12,1527
2	1,1806919	1,185175519	0,00448	0,37974
3	1,5291141	1,423254849	-0,1059	6,92292
4	1,6890503	1,70915981	0,02011	1,19058
5	2,2884511	2,052497667	-0,236	10,3106
6	2,7117416	2,464805601	-0,2469	9,10618
7	2,9628906	2,959938395	-0,003	0,09964
8	3,6821177	3,554533995	-0,1276	3,46496
9	4,1601695	4,268572598	0,1084	2,60574
10	4,6861748	5,126048042	0,43987	9,38663
Average				5,562

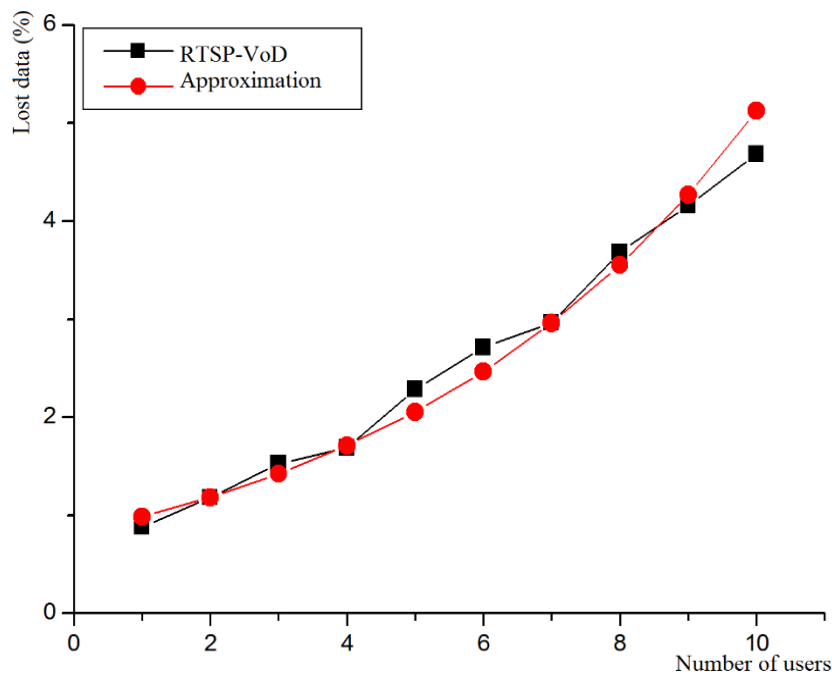


Figure. 10. Approximation for VoD sent through RTSP protocol through wired network. - Average relative error 5,56%.

IV. CONCLUSIONS

Through the use of the concept of linear regression and through the application of transformation of variables, four mathematical models were generated for the estimation of losses in the receivers, with a fairly accurate estimation level in each case since the error was reduced relative to values that oscillated between 5.56% and 6.23248%.

This type of models can be used in the future within IPTV systems in order to estimate in advance the probable *loss of data* that may exist during the transmission of on demand television or video traffic, which may lead to routing protocols having the smart option of re-routing traffic through more appropriate channels.

Future research may involve the implementation of a losses system or model applied to IPTV by applying time series [6] and platforms based on Cognitive Radio Network (CRNs) [7].

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