CARIMBÓ – A Flexible Framework Proposal for the Return Path in Brazilian Digital Television

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Abstract. This paper proposes a framework to the return path on the Brazilian digital television. It presents an alternative way to achieve user based interactivity by utilizing the existing Wireless Distribution System resource (WDS) The utilization of this resource in areas with no infrastructure of telecommunications, like the Amazonian region, creates a perspective of integration for the native people to the digital inclusion programs organized by federal government. In order to evaluate the feasibility of this proposal the Network Simulator (NS) was used.

Keywords— performance evaluation, wireless, wds, digital television, digital inclusion.

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1. INTRODUCTION

Digital Television (DTV) is a term adopted by the Federal Communications Commission [4] to describe the specifications for the next generation technology used for televising transmissions through diffusion. The main phases of this process are the digital encoding and the digital compression [18]. One of the great innovations brought by the DTV System is the interactivity [2]. This resource allows users, until then passive due to the unidirectional characteristic of transmission of the current model, to directly interact with the system. The implementation of this technology is a challenge for countries like Brazil with such a vast territorial extension, and a diverse climate, topology, demographic density, socioeconomic situation, etc. The establishment of a single option for the return path can exclude from this process a considerable part of population, due to the lack of infrastructure in many parts of the country which is required to supports some of these technologies. Alternate measures are needed in order to compensate to this lack of infrastructure and to reach users nation wide including those users living in remote areas where conventional wired infrastructure is not available as well. This paper proposes a flexible framework capable to accommodate different technologies in the return path, also making use of the IEEE 802.11b standard with resource of wireless distribution system (WDS), allowing an effective growth of the covering area.

1.1 PROPOSAL OF RETURN PATH

1.1.1 General Considerations

Considering the dimensions of the Brazilian territory and the specificities of each region, is necessary to consider the hypothesis that the DTV solutions in countries like Brazil, are heterogeneous and used in accordance with the peculiarities of each region. In the north of the country, where there are practically no cable TV infrastructure and the poor population still does not have access to the telephonic lines (60% of the north region population, that have TV, does not have telephone [8], one possible alternative would be to provide the return path through a wireless network once that specter for solutions based on VHF/UHF is already congested enough, generating a problem in the introduction of new services. Worth mentioning that the Return Path or Interactivity Path in Brazilian DTV is currently in the process of standardizations . [6].

The proposal presented in this paper makes use of the framework described in the section 1.1.2, which eases the use of many technologies in accordance with the technological availability of each region.

1.1.2 Framework

Figure 1 shows the model of one flexible framework inspired on [3] named CARIMBÓ[1] which allows the use of many technologies to constitute a return path more appropriated to each region. The framework is split up into four main modules:

1) The Interactive Terminal that will be resident in the user's home. It is composed by the following elements:

a) The set-top-box that is a component responsible for the tasks of encoding and decoding of digital signals. It´s also capable, to host secondary memory what implies in the possibility of the transmission of video on demand (VoD);

b) The Media Infrastructure Selector that has the function of a filter that will act as a threshold, limiting the use of applications according to the technology adopted in return path. Applications that require a high level of QoS in the return path, such as audio and video, will be allowed if the chosen technology supports these applications. For example, interactive video applications won't be allowed in dial-up return path due to their limited bandwidth;

c) The network interface defines the type of physical media adapter used for the return path and establishes the interface with the environment. In the case of wireless, for example, this implies a WLAN adapter 802.11 standard [20].

2) The interconnectivity gateway is associated with the Return Channel Providers (RCP) and will act as the Front-End between the end users and the Digital Television Provider (DTVP). It's a solution for the last mile that presents to the user the available services, according to the limitation of the media. Occasionally, some services may be granted by their local RCPs instead of the DTVP. The choice is made based on which services are available at the RCPs at a particular time. For example, interactive games between users of the same RCP or access to electronic libraries hosted on the Content Provider, like the collection of scientific periodic on the portal of the CAPES (an important entity of research fomentation linked to the ministry of education in Brazil). Another function of the RCP is to transport the data to the DTVP. In many cases there are the possibility of aggregation with others technologies allowing more flexibility to the model. This resource can be useful, for example, in scenes such as aboriginal tribes, where one system of wireless can collect the return path and converge to a single point for being multiplexed and directed, by satellite or winmax (described in section 1.1.5) to the RCP. This process would make possible the interactivity in the entire village.

3) The Content Provider is a media repository. A place where specific content are stored and, eventually, commercialized. This repository is linked to RCPs and can either be: Integrated to the DTVP or act as an independent module.

4) Finally the Digital Television Provider where the data flows are submitted to a dynamic QoS [10]marker called Matrix [16]. The Matrix scans the incoming data flows and, based on specific characteristics of them, classify each to the appropriated priority level of QoS. After this, the data are stored, processed and eventually used to define the sequence of the programming. It's possible that, at this point, proposals like COSMOS, fit perfectly to CARIMBÓ using the carrousel technique describe in [14].

1.1.3 Return Path

The return path constitutes on of the instruments that makes possible the interactivity in the DTV. Through it, the user interaction plays a big role once that new spaces are opened to applications of the most varied purpose maximizing the user's benefits.[18]

[1] The carimbó is a folkloric dance of the state of Pará in the Brazilian Amazon, in the area of the Marajó Island.

1.1.4 WDS (Wireless Distribution System)

WDS is a terminology used to characterize a system that interconnects Basic Service Sets (BSS)[7]. The majority of the wireless networks require more than one Access point (AP) to provide an adequate signal of radio frequency to enable the roaming between the multiple APs and to connect them to the wired network. If no cable is used and the connection between the APs is established through a radio signal one WDS link will be created.[9]

The main benefits of a WDS system are:

a) Cost effectiveness, once an AP link is established, adding another WDS link simply requires the configuration of new AP.

b) Flexibility, because the expansion of the covering area is possible without the necessity of investment in additional wired infrastructure and the topology allows adjustments of positioning when it required.

c) Multiplexing of channels, if required all the APs involved in a WDS infrastructure can be configured to operate on the same channel.

The use of the WDS system was proposed in CARIMBÓ framework for two reasons. First: the use of a reusable energy source in order to power each remote Access Points (like solar or eolic energy). There are lots of places where the population does not have electrical energy. They watch television using a recharge battery. Second: to expand the area covered some Access Points (AP) manufactures allow the use of six of them through a WDS scheme.

1.1.5 Winmax

Winmax is the acronym to Worldwideweb Interoperability for Microwave Access. The standard that defines winmax is the IEEE 802.16a [11]. This new standard, approved by the Winmax Forum [22] in January of 2004 for use in Metropolitan Area Networks, allows more than sixty users connected simultaneously to the same base station in velocities greater than 124 Mbps. The protocol used in this new model, W-OFDM, allows the satisfactory communication in distances up to 6 Km without line of sight.

1.1.6 Alternative Proposal of Return Path

The model presented in this paper uses the framework considered in section 1.1.2. A wireless network is used in order to provide interactivity for remote regions lacking a conventional wired infrastructure. Two applications forms of this proposal are presented below[15]:

a) Use in urban areas: The application of the proposal for urban areas implies in the use of the mobile telephony infrastructure and suggests the installation of APs IEEE 802.16a standard in the Cellular Base Stations (CBSs), seeking the collection of the return signal. For such, the antennas installed in the CBSs must be dual band, receiving not only the cellular operator’s frequencies, but also the defined for the Digital TV return path, without the necessity of new cables installation. The signals would be differentiated using a duplex filter, before being delivered to the controlling equipment of the CBS, adapted to process both the signals, cellular and radio, and to send them to the Central of Commutation and Control (CCC). Once that there is already a convergence of links from CBSs to CCC, will have the necessity of installation of only one additional link between the CCC and the Digital TV Provider, responsible for the data processing, so that the return path would be established.

b) Use in rural areas with low demographic density: It has places of the Amazonian region, where the population is found dispersed throughout a vast territorial area. Some of these places are half-flooded and located on plain areas, what makes rather difficult the installation of a wired infrastructure. In this case the installation of a IEEE 802.11 WDS system, coupled with several directional antennas, is capable of covering an area of several kilometers with a relatively low cost. Any device of telecommunications can be used to direct the signal to the DTV provider. Moreover, this wireless infra-structure can be used, like hot spots by tourists, in time of idleness of the system.

Regarding the user, it would be necessary a device equipped with a transmitting radio, with a wireless card attached, and an external antenna, what would make possible the sending of the return data to the AP. The Brazilian legislation, supervised by the ANATEL, allows the use of ISM (Industrial, Scientific and Medical) networks through SCM service (Multimedia Communication Service) for community ends, since the providers preceded their registration on a regulating agency, and use homologated equipment. [1]

The graphic showed in figure 2 presents the relation between the bandwidth capacity of different technologies of return path.

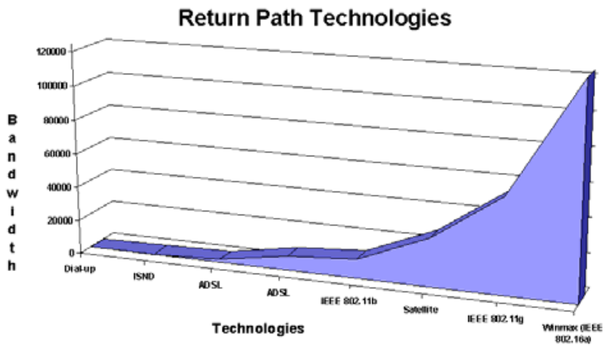

Figure 2 - differences between the main technologies of return path

2. METHODOLOGY

The methodology used to evaluate the model was based on simulation. The NS (Network Simulator) was adopted motivated by the acceptance in the international scientific community. Developed from the VINT project (Virtual InterNetwork Testbed), the NS is a discrete events simulator [21] with support to a wide variety of researches that include the stack of TCP-IP protocols, LANs, WANs, and satellite networks.

The NS is open source code and free, what has attracted several researchers, making the simulator robust and reliable. One of those contributions, made by the Monarch group of the Carnegie Mellon University [17], was responsible for the incorporation of the module of wireless mobile networks on the NS.

A support tool denominated NAM (Network Animator) allows a better visualization of the simulation through a graphical interface. The evaluation of the results begins with the analysis in a trace file generated in the simulation process.

The version used in this work was the 2.27, released on January 2004. The operating system was Linux with the kernel version 2.4.

3. RESULTS

To evaluate the performance [12] [13], a scenario of a typical remote area secluded in the middle of the Amazonian region was used, with low demographic density and area of 80.000 square meters, where the residences are equipped with a set-top-box.

Figure 3 presents a snapshot of the simulation generated by the module NAM (Network Animator) of the NS. [21]

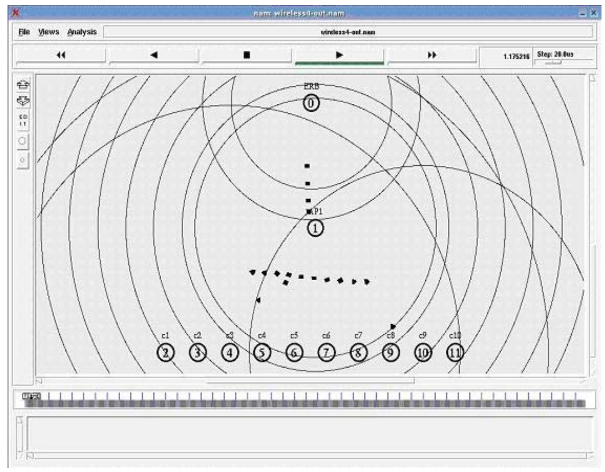

Figure 3 –CARIMBÓ Simulation with WDS

The first experiment simulated intended to evaluate the behavior of the system facing the growth of the number of users. For such, simulations with 5, 10, 15, 20, 25 and 30 users were accomplished. This limit exists due to the current average capacity of AP configured in simulator, which support up to 30 users connected simultaneously. The graphs of figures 4 and 5 show the performances of the outflow system facing the growth of the number of users. Two types of flows were transmitted with a rate of 64 Kbps throughout 100 simulation units: CBR [19], which characterize a constant transmission rate, and another based on a statistical distribution of Pareto [5], which characterizes transmission in burst, typical in the Internet.

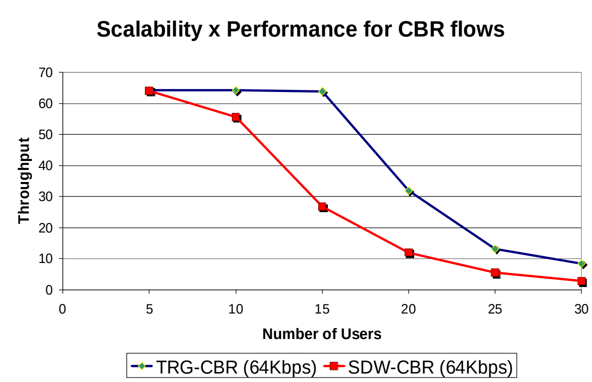

Figure 4 – Scalability from Two Ray Ground and Shadowing models based on CBR Flows

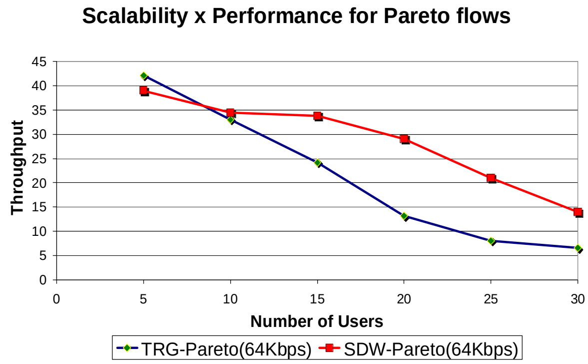

Figure 5 - Scalability from Two Ray Ground and Shadowing models based on Pareto Flows

It can be observed that the more accentuated drop of performance happens when the system has more than 15 users.

Once that the system performance presents an accentuated drop from the fifth user, and considering that additional APs could extend this capacity without larger problems, then the others performance dimension was based in the proportion of 15 users for each AP.

The graph of figure 6 shows the evolution of the throughput from the average of 15 CBR flows transmitted throughout 100 simulation units. The values are presented with and without the confidence interval (64,94 ± 0,59 Kbps).

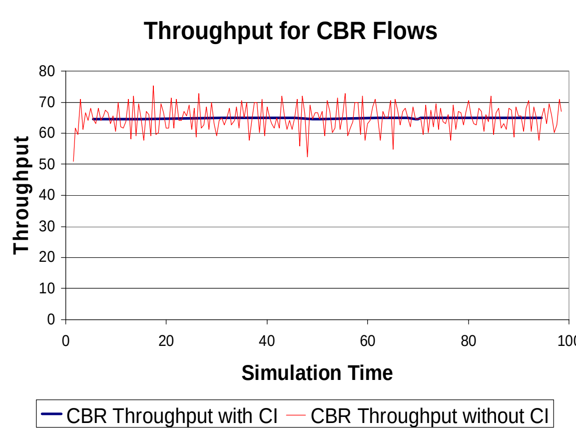

Figure 6 – Throughput versus Simulation Time

The graph of figure 7 show the average values of delay inherent to the simulation made with and without the confidence interval (0,14 ± 0,00147), where it can be verified that the delay levels are below 150 milliseconds, which constitute the minimum requirement for multimedia applications.

If the confidence interval was used, the average delay decreases to nearly 136 milliseconds.

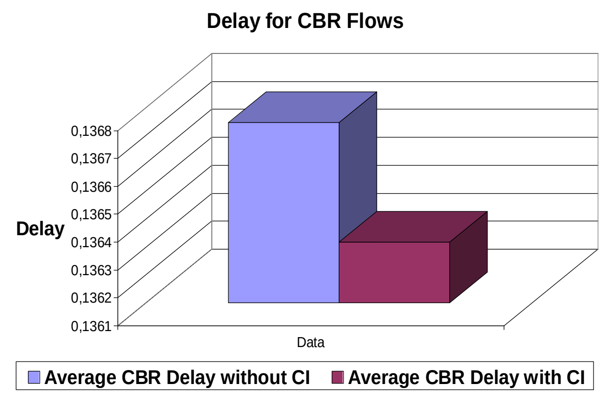

Figure 7 – Delay of Flows

Another performance measure is the jitter, which constitutes the statistics variation of the delay. Transmissions with many variations of jitter can compromise the quality on the reception, if the flows in question are multimedia. The graph of figure 8 shows the average values of jitter inherent to the simulation made with and without the confidence interval (0,14 ± 0,00147).

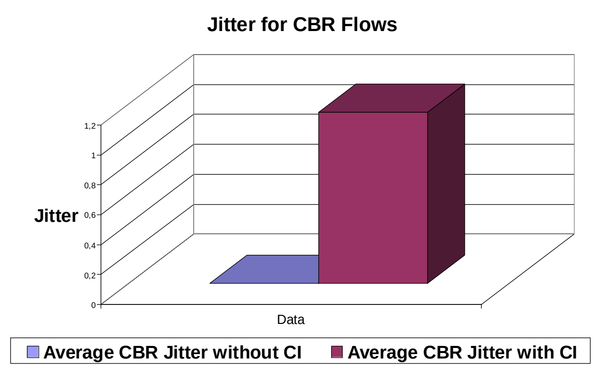

Figure 8 – Jitter of Flows

4. CONCLUSIONS

The adoption of the CARIMBÓ framework in areas with no infrastructure of telecommunications will certainly benefit a significant portion of the population, once different kinds of infrastructure technologies can be composed. The definition of one specific technology for return path can exclude lots of people of the digital inclusion process, once there are many places without infrastructure in countries like Brazil. Futhermore, the results achieved through simulation indicate the technical viability of the return path based on WDS proposal, which can be implemented with a relatively low cost while contributing to the overall social benefit of the community. Some applications, such as Distance Learning, would allow the process of digital inclusion to happen not only in urban centers with certain level of development, but in regions of difficult access, where there are no perspective of higher technological investments. In fact, another questions need to be investigated in futures works. Aspects like secuity and interference need to be discusess in specifcs work groups. This is really one initial contribution to be ripened and further improved.

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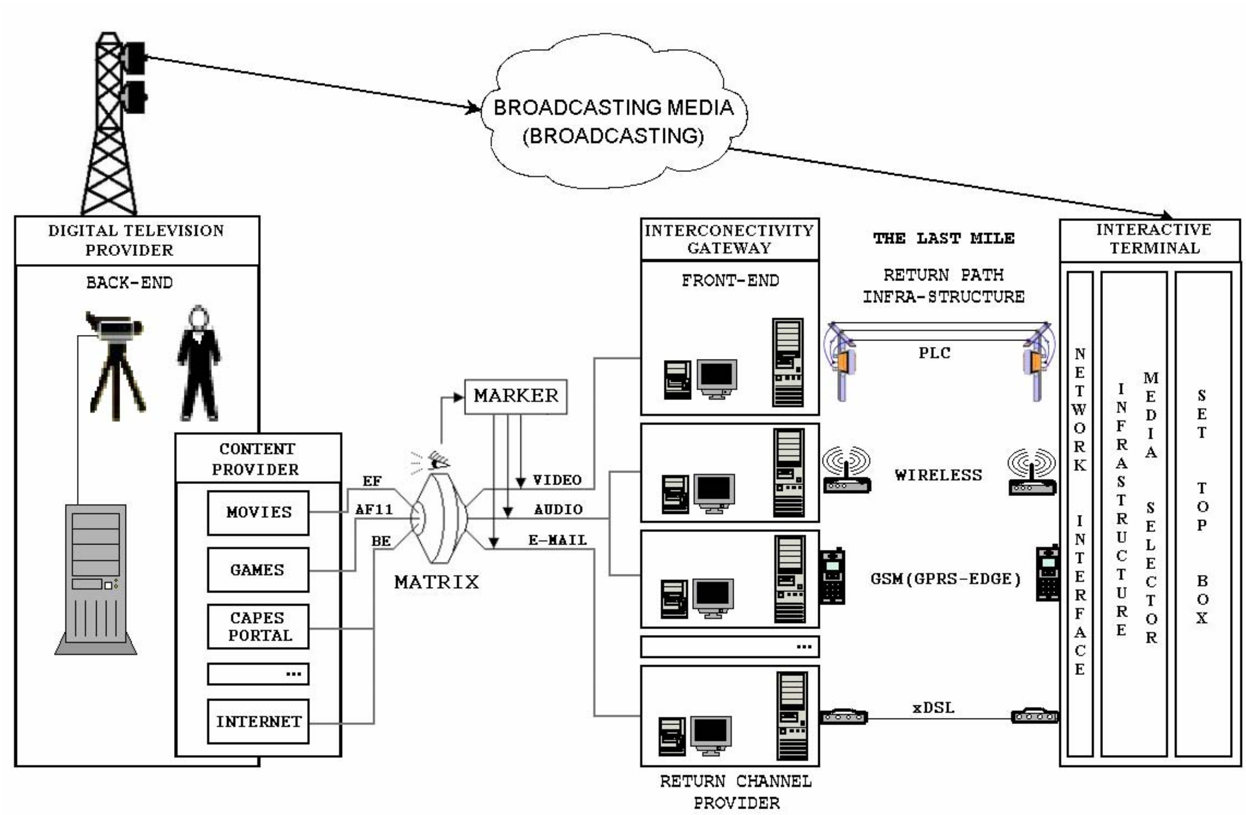

Figure 1 – Carimbó Framework