Performance Evaluation of a Flexible Framework Proposal for E-Gov Applications using the Return Path of Digital Television

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Abstract: This paper analyzes three technologies for return path based on a flexible Digital Television framework named CARIMBÓ. The context is based on the investigation and performance evaluation of the viability of an e-government application connecting public doctor's office of the north of Brazil through the DTV return path. The framework presents an alternative way to achieve interactivity on Digital Television according to the local infrastructure resources. The utilization of this resource in areas with no telecommunication infrastructure, like the Amazon region, creates a perspective of integration for the native people to the digital inclusion programs organized by the federal government. In order to evaluate the feasibility of this proposal, a larger scenario was simulated on the Network Simulator (NS-2).

1. Introduction

Digital Television (DTV) is a term adopted by the Federal Communications Commission to describe the specifications for the next generation technology used for televising through diffusion. The main phases of this process are the digital encoding and the digital compression. One of the great innovations brought by the DTV System is the interactivity [12]. This resource allows users, until then passive due to the unidirectional characteristic of transmission of the current model, to directly interact with the system [2]. The implementation of this technology is a challenge for countries like Brazil, with 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 partslice of population, due to the lack of infrastructure in many parts of the country, which is required to support some of these technologies. Alternative measures are needed in order to compensate this lack of infrastructure and to reach users nationwide including those living in remote areas where conventional wired infrastructure is not available as well. This paper presents a flexible framework proposed named CARIMBÓ that is capable to accommodate different technologies in the return path and gives support to regional interactivity. This research has been financed by a Brazilian organ called CNPq (National Council of Scientific and Technological Development)

1.1 – Proposal of Return Path

Considering the dimensions of countries with large areas like Brazil and China, and the specificities of each region, it is necessary to presume the hypothesis that the DTV solutions in these places are heterogeneous and used according to the peculiarities of each region. In the north of Brazil, for example, where there are practically no cable TV infrastructure and the people living in underdeveloped regions still does not have access to the telephonic lines (60% of northern population, that have TV, does not have telephone [7]), one possible alternative would be to provide the return path through technologies such as wireless network or power line communication [8] [1]. The proposal presented in the CARIMBÓ framework will be described in the section 2. It is worth mentioning that the Return Path in Brazilian DTV is currently in the process of standardization.

2. CARIMBÓ Framework

Implement a model that makes interactive applications possible on market implies a great social responsibility to avoid high levels of social exclusion. The opportunities must reach everyone and it can only be guaranteed with the implementation of protective mechanisms for the marginal subsystems. The search for a model that satisfies this relation in a balanced way led us to the creation of a framework called CARIMBÓ, a Portuguese acronym for (Return Channel with Interactivity Mechanism Management by a Continuous Signalization Process Oriented to QoS). The structure of this model, illustrated in Figure 1, prioritizes the interconnectivity for interactivity based on two basic aspects: the infrastructure resources of the area where the system will be installed and the requirements and needs of the user. The components of the CARIMBÓ framework are described below:

2.1 –Digital Television Provider (DTVP)

The DTVP is responsible for the generation of all the programming that will be distributed to the users in diffusion form. Once the grade of information about the programming to be transmitted will be sent through a system of datacasting, known as carousel of data [5], we proposed to send together with it a set of interactivity requirements associated to the current programming. These requirements must be specified by the DTVP in the form of QoS (sensitivity to delay, bandwidth, jitter, blocking probability etc) restrictions. The numbers, in accordance with the minimum standards of QoS supplied by the DTVP, qualify or not the user to participate of the current interactive programming. These values create the basis of a trustworthy admission system, where the possible DTVP will be able to map the relation of possible and/or pretense participants, being able to provide resources to serve the expected demand. This admission model allows adjustments and can be change to already existing proposals such as the one presented in [13].

2.2 –Interactivity Terminal (IT)

The interactive terminal is part of a system located in the user residence. During the transition phase from the analogical to the digital system, the interactive terminal will be represented by an equipment known as set-top-box. The main functions of set-top-box are decoding, decompression and conversion of the signal, which will allow the exploitation of the television infrastructure used in the country during the initial phase of systems

migration. However, as it is an equipment with processor and memory [11], some services can be also added to it.

One of the CARIMBÓ proposals consists in include a module to the firmware of the set-top-box called Media Infrastructure Selector. This module will be responsible for the periodic accomplishment of performance tests with the return channel. The result of those tests will reflect the conditions of the return channel, in terms of QoS requirements. Such data will be used in a comparative process with the minimum requirements of interactivity sent to the DTVP, by means of the system carousel of data. According to this point of view, the model acts as a admission mechanism, allowing only the addition of those users in technical conditions to participate in the interactive process. Moreover, it is possible to provide support resources for the use of administrative tools that map the interactive public target.

2.3 –Return Channel Provider (RCP)

As one of the great goals is to exactly conceive a model of interactivity that creates chances, for the less favored social classes, the framework CARIMBÓ considers the approach of the user through the Return Channel Providers (RCP). A RCP works inside the region of the user and, therefore, it operates with suitable resources with the local infrastructure and the requirements and necessities of its customers. Hence, several RCP can coexist in the same area, focusing on differentiated public. This allows that different arrangements (bouquet of interactive services) are offered. The operationalization of the access technology is under the responsibility of the RCP, which will be used in the last mile for the return channel. Thus, users interested in interactive games in the DTV will associate to the suppliers that offer such services in its bouquet that will have to guarantee technologies in compliance with the applications requirements that they provide. In regions where the perspective of financial return cannot be identified, the government is supposed to take the initiative for providing the bouquet of basic services. In this case, solutions of low cost and without periodic fees must be evaluated, such as the use of infra-structuralized wireless local area networks (WLANs) for the return channel, which will be analyzed in section 3.1.

2.4 –Content Provider (CP)

In the CARIMBÓ framework, part of the services offered by the RCPs is a result of a composition of specialized services offered by the Content Providers (CP). Different RCPs will be able to offer services contracted from the same CP, as long as the adopted access technology supports the requirements imposed by the applications. The CPs, therefore, are conceived with specific goals. Thus, researchers would probably be associated to a RCP that turned the access available to the electronic journal of the IEEE or ACM, in Brazil supported by CAPES (an important entity of research fomentation linked to the ministry of education), adolescents users would search for an RCP that offered interactive games and so on. As several services of content can be added in an RCP, the user will choose one with the best cost-benefit relationship found.

2.5 –Provisioning Resources

As important as providing the return channel in the DTV system is to provide resources to make it possible. CARIMBÓ Framework considers the use of a mechanism of

differentiated services [4] to guarantee priority of traffic between the RCP and the DTVP, on the basis of profiles of interactive applications sensible to the delay, jitter, bandwidth and blocking probability [10]. This control opens a fan set of possibilities amongst which the service of VoIP can mentioned.

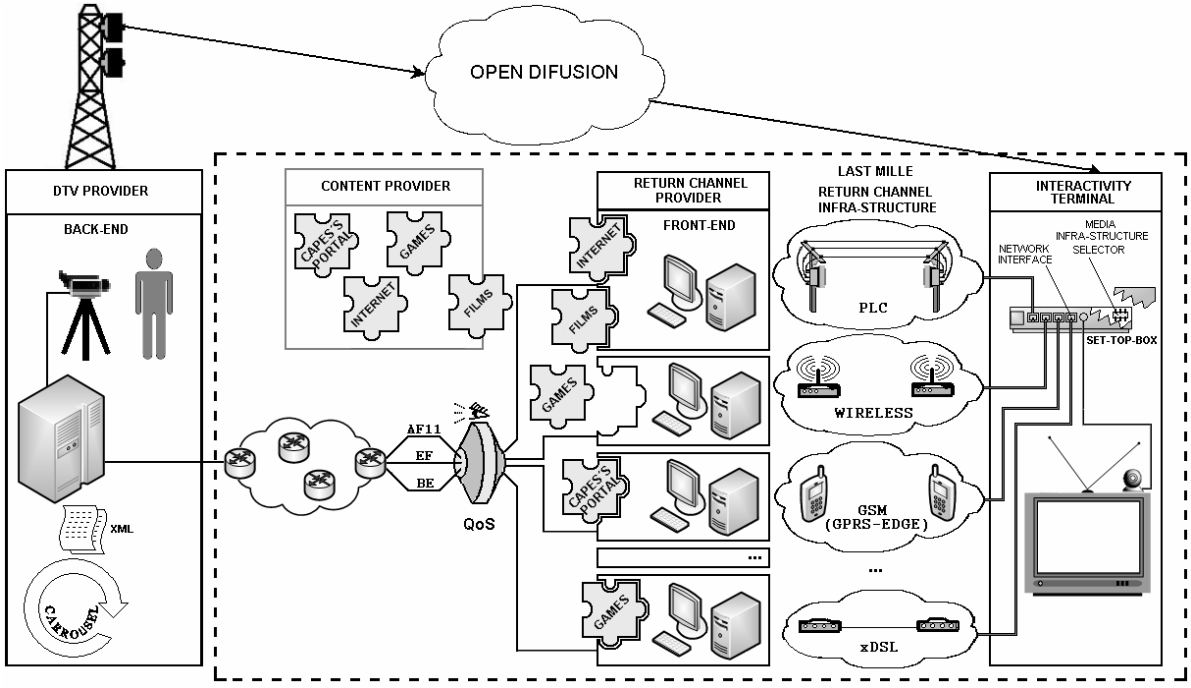

Fig. 1. Carimbó Framework

3. Performance Evaluation

In order to certify the technical viability of the CARIMBÓ framework, three technologies were available from the same application describe in section 3.1 (ADSL, Dial-up and WLAN). To analyze the results in small scale the experimentation technique was adopted. In large scale, a simulation based on the Network Simulator was made. The Network Simulator (NS-2) is a free discrete event simulator directed to network research and linked to VINT Project [15].

3.1 – Application

The context is based on an e-gov application connecting public doctor's offices of the north of Brazil through the DTV return path. The available e-gov application will make the attendance of vaccination process in remote areas allowing that parents and govern monitoring the fulfillment of the vaccination calendar for children from 1 to 5 years old (Figure 2). The application was development in JavaTV library and XLET classes, once it is fit to practically all DTV middleware standards [3]. Usability techniques were adopted to make the application easier to the end user. Two groups of information are requested to the users monthly:

- The evolution of the child's growth through weight, height and cephalic perimeter and;
- Sporadic information as date from the beginning of the introduction of foods, pneumonia occurrence, diarrhea occurrences, etc.

Each child is identified through a code associated to the birthplace. Graphs that compare the curve of the child's growth with the one of a normal child are presented. In cases of danger, explanatory videos or audios are downloaded from the content provider and exhibited. The system consumes a small amount of bandwidth and can fit easily in several access technologies. The performance evaluation [10] was focused in the growth of the number of users connected to the same RCP.

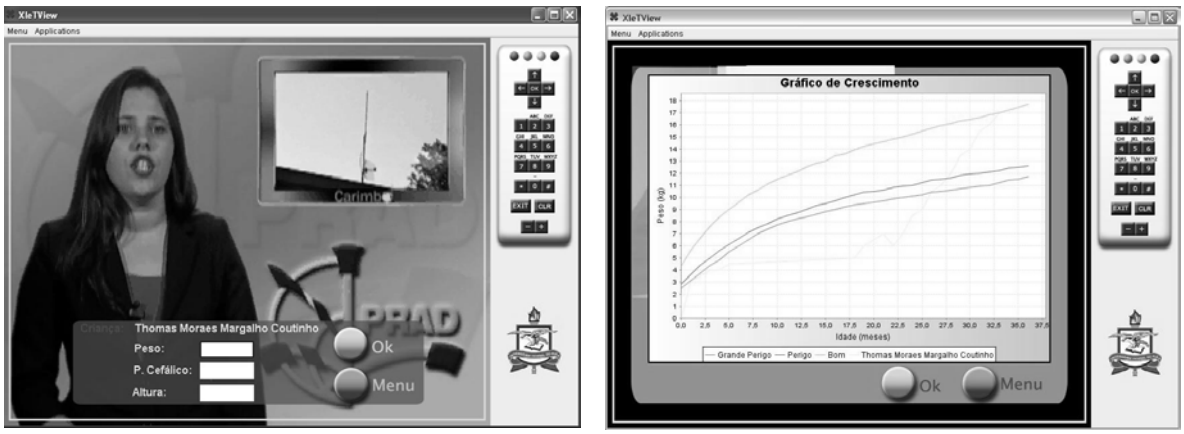

Fig. 2. E-Gov Application

Figure 3 shows a testbed scenario called WLACA where return path are based on IEEE 802.11 networks[8]. To evaluate the performance in reduced scales, WLACA was used. Already, in large scales, the network simulator was configured according to the parameters presented on table 1. The injected traffic in the return channel characterizes the possibility of specialist doctors' intervention, due to the risk verification for the child, using VoIP in the return channel. It was based on an on-off exponential distribution.

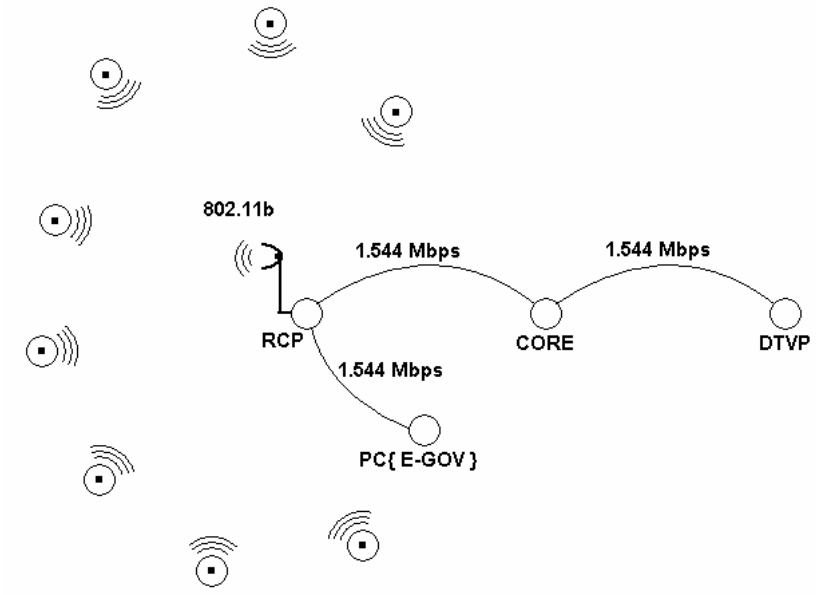

Fig. 3. Testbed available in the experimentation measurement

Table 1. Parameterization of E-Gov experiment

Description	Value
Area (Flat Grid)	500x500 m^2
Number of nodes	40, 50,100
Antenna Gain	18 dBi
Standard	IEEE 802.11b
Path Loss Exponent	2.7
Standard Deviation	5.0
Power transmission	100 mW
Data Rate (Exponential On-Off)	40 Kbps
Packet Size	224 bits

3.2 – Results

Figure 4 shows the average delay based in three technologies: ADSL, Dial-up and WLAN. The average delay in all analyzed cases is less than 400 ms. This limit assures also VoIP applications to be used in accordance with the G.144 ITU-T recommendation [9].

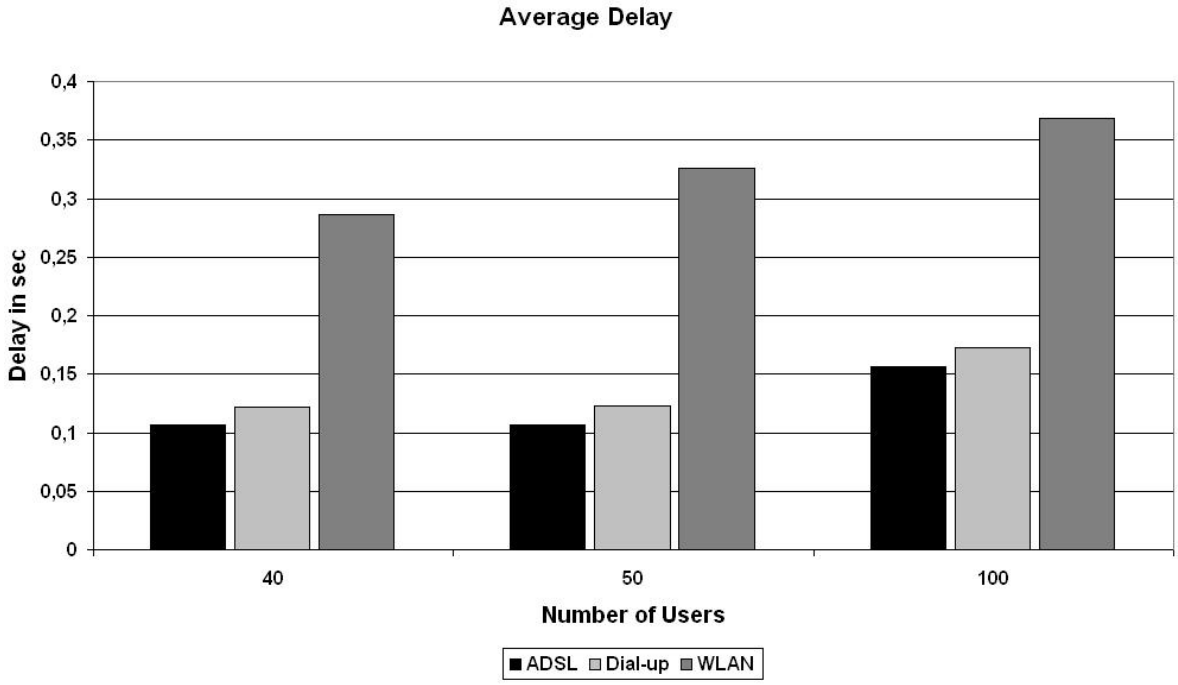

Fig. 4. Throughput of VoiP application

Figure 5 shows the average throughput. The WLAN network is the most affected technology from the growing of the number of users.

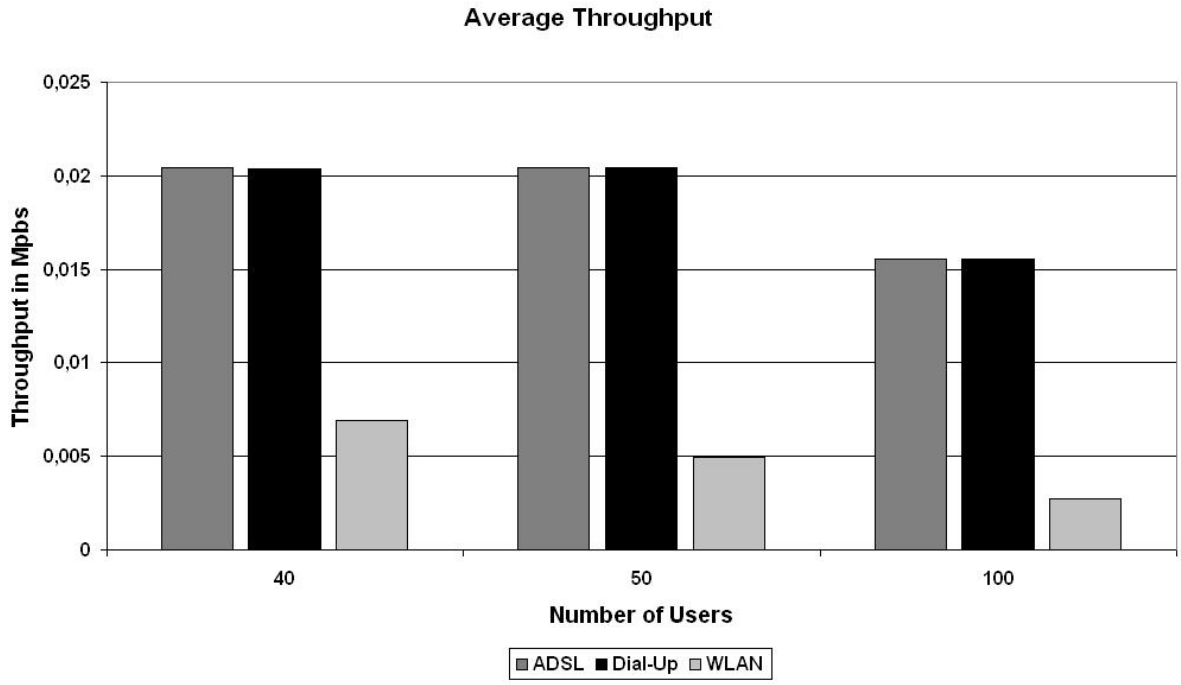

Fig. 5. Average Throughput

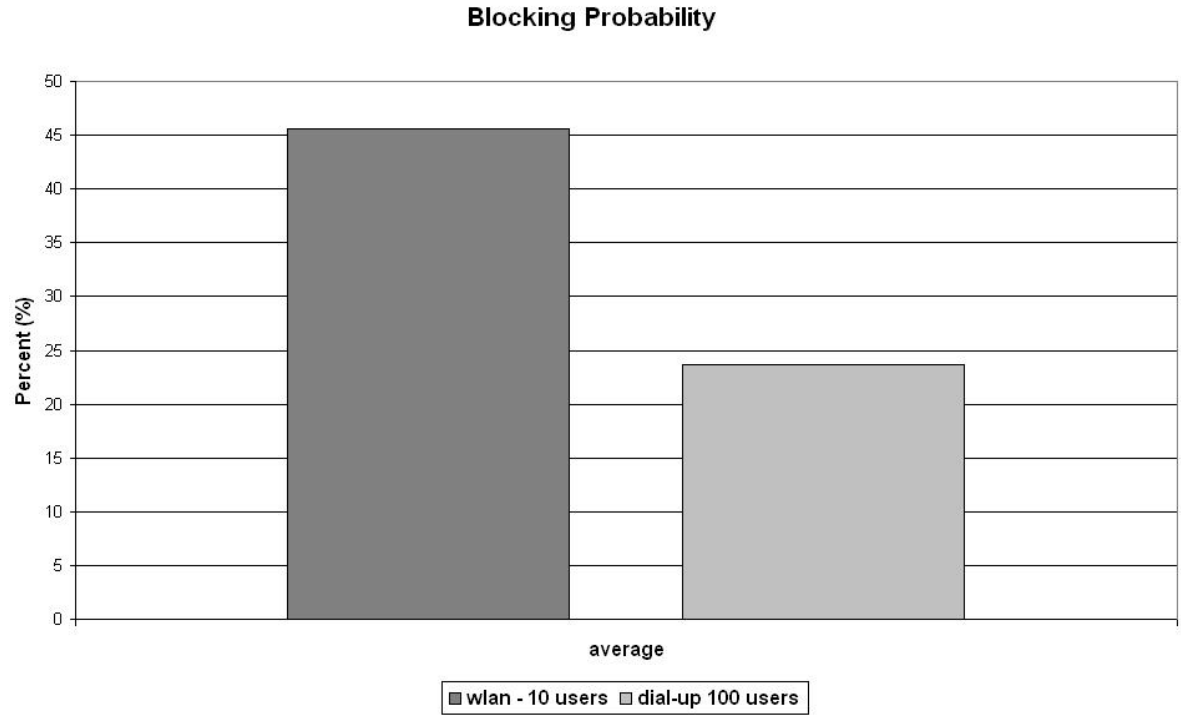

Fig. 6. Blocking probability

The results presented in Figure 6 justify the low rates in WLAN technology as showed in Figure 5. In the case of WLAN, the blocking probability, or the relation between the discarded packets and the sent packets, is around 45% to 10 users while in dial-up technology the value of blocking probability is near 25%.

4. Conclusions

Independently of the standard adopted, flexibility is an essential factor once it makes possible the adaptation of the services to the regional peculiarities. The approach of the user by way of the Return Channel Provider allows compatible solutions with the local infrastructure and the socio-economic situation of the users are adopted. The performance test made in the CARIMBÓ framework showed that it has technical viability for E-Gov applications in places with wired/non-wired infrastructure and can bring an important contribution in the social field. We can also count on a mechanism that allows to predict the demand and to plan the distribution of resources more efficiently, especially on adverse situations. The approach of the management service of the user, through the PCR and PC, allows directed applications to be possible, allowing the government to develop strategies much more efficiently, focused in regional problems. Certainly some challenges still exist to be reached but we hope that the techniques allied of usability the diversity of offered services, as VoIP, will bring an uneven contribution to this work [6] [14]. Thus, this proposal is innovative and, under some points of view, realistic and feasible, and therefore it can strongly contribute to the process of digital/social inclusion to the Amazon region.

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