

# The Advanced Internet Project in Costa Rica

## Infrastructure for the New Knowledge Society: A Case Study

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### Abstract

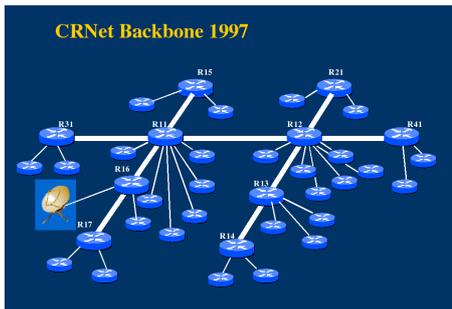
The global Internet is a powerful instrument for the change and development of society. To take advantage of the extraordinary possibilities of modern technologies and accomplish significant progress on fundamental issues such as education, health, e-government and e-commerce, an efficient cyber-infrastructure is required to allow real access to all citizens. Integration of the country's commercial sector to the world economy depends on broad and reliable access to information and communication technologies. Following the deployment in the early 90's of internetworking technologies under the leadership of the academic sector, the Ministry of Science and Technology of Costa Rica proposed an ambitious initiative in 2000, the Advanced Internet Project, to bring broadband access throughout the country using an advanced IP network infrastructure. A pilot project was successfully installed in just a few weeks, on April 2001. However, the large scale deployment of the project, which included the establishment of 100.000 ADSL connections, was postponed for years, causing a considerable delay in the country's technological development. This study presents technical aspects of the project and a brief description of the actual deployment of the Advanced Internet in Costa Rica. It also describes the difficulties of implementing such a large scale project caused by conflicting views on incumbent versus disruptive technologies and the institutional evolution required. Finally, it points out how the new infrastructure will also be used for advanced scientific applications (Internet 2) which require large network capacity.

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# 1 Introduction

By the end of the year 2005 the global Internet will reach 300 million hosts and a billion users [1]. It will exceed the size of the actual global telephone networks and the use of voice over the Internet Protocol (IP) will eventually replace conventional telephony. High bandwidth dedicated links to the Internet will become the norm. Real access to its infrastructure for every citizen becomes a critical element of progress and profound changes of society.



**Figure 1:** CRNet backbone circa 1997. The National Research Network of Costa Rica provided connectivity to most academic and research institutions in the 1990-2000 decade.

As in most countries internetworking technologies were introduced in Latin America by Academic Institutions throughout the continent at the turn of the last decade. The University of Costa Rica (UCR) with the National Research Network of Costa Rica (CRNet) introduced large scale internetworking in the country [2, 3, 4]. In collaboration with the Organization of American States Project RedHUCyT<sup>1</sup>, and Universities in the Central American and Caribbean Region, UCR and CRNet played a crucial role for the region's pioneering interconnections to the Internet and the establish-

ment of Research and Academic Networks in the area during the last decade. CRNet's backbone (Figure 1) provided access to almost all academic and government institutions prior to the PTT's emergence into commercial services. CRNet also provided continuous support, knowledge and experience to almost all sectors. The establishment of a Point-of-Presence (POP) by the National Science Foundation (NSF) in Homestead Florida, allowed peering connectivity with NSF backbone and facilitated south-south IP traffic. Initial interconnectivity in Latin America and the Caribbean was largely based on satellite links.

## 2 Institutional Context

In the past 40 years, the Instituto Costarricense de Electricidad, ICE, the large power and telecommunications state monopoly, has accomplished a remarkable job in providing basic telecommunication infrastructure throughout the country with one of the most dense fixed telephone line infrastructures in Latin America. Public phones were installed in every corner regardless of cost. In the Internet era, with its rapid

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<sup>1</sup>*Red Hemisférica Inter-Universitaria de Información Científica y Tecnológica* [5].

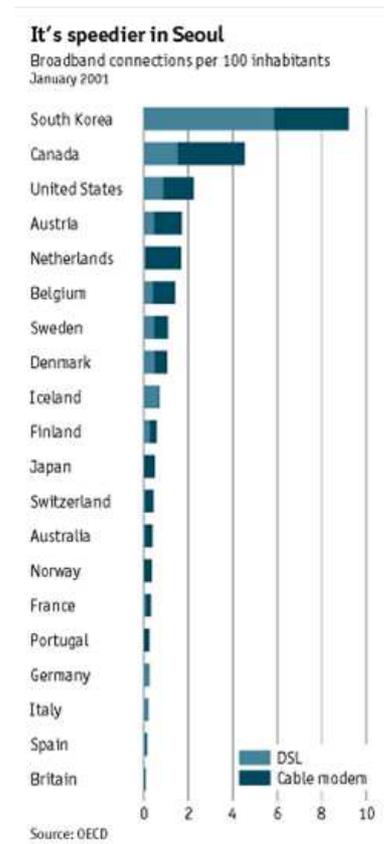
pace of technological change, the telecommunications infrastructure, mainly in the hands of the state-owned monopoly, started to lag behind.

A strong initiative to recover leadership in this critical area was necessary after the notorious failure in opening the publicly owned telecom monopoly, the “ICE Energy Combo Bill” in 2000, resulted in widespread protests. The opening of Costa Rica’s monopolies has traditionally been a particularly sensitive issue.

In November 2000 the Ministry of Science and Technology of Costa Rica (MICIT) proposed an ambitious project, the Advanced Internet Project (RIA), to establish broadband connectivity throughout the country and contributed with the design and implementation of the new communication infrastructure, in collaboration with the Instituto Costarricense de Electricidad [6, 7, 8]. The proposal contemplated the use of existing fiber infrastructure as the network backbone, as well as the copper infrastructure in place for xDSL access, to make possible high speed communication. Connecting the network access nodes to the user premises, the last mile, using fiber could result in a burdensome investment. Consequently, powering the copper infrastructure with DSL technology constituted a rational choice for a simple, low-cost effective alternative to bring broadband connectivity at speeds of several Mbps up to several kilometers, thus covering most of the territory and reaching more than 90 % of the population<sup>2</sup>.

The amount of investment required, in terms of financial resources was marginal and the time required for the deployment of the project was minimal. Implementation of the project required the procurement of giga-routers at the optical backbone level, mega-routers at the network access points, and the equipment required in the network periphery to terminate the xDSL sessions.

Timing and opportunity were excellent, as the Maya I undersea optical cable had just landed in the country. It was technically feasible to implement in few months a state of the art advanced internet system, essentially with the existing infrastructure



**Figure 2:** Broadband connectivity in 2001 from [9].

<sup>2</sup>For a 26 AWG, 0.5 mm, caliber speeds of 1 Mbps are sustained up to 4.5 km by powering the copper wires. Recent DSL technology can transmit data at 25 Mbps up to 1.5 km.

and within the current legal framework. An extraordinary possibility was within reach for Costa Rica to become one of the leading countries in broadband connectivity (Figure 2). With 100.000 DSL lines, Costa Rica would have been placed among the leading countries with 2.5 DSL links per 100 inhabitants.

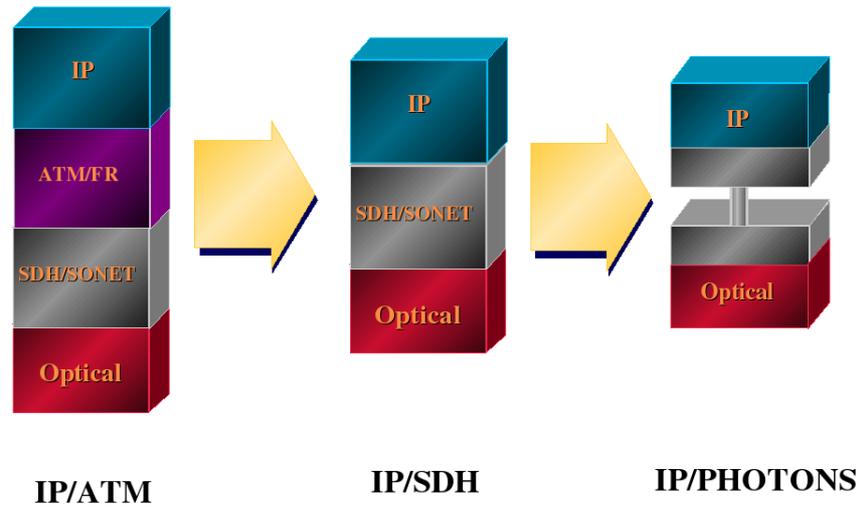
The Advanced Internet Project was designed to support and facilitate economic growth and development in all areas of commerce and in the financial sector, for large and small enterprises, with high bandwidth and low costs, allowing secure transactions over Virtual Private Networks (VPNs) when required. The project was designed to provide a platform for technological innovation and economic competitiveness, leading to increased productivity and better living standards. The project was also designed to cover a very wide geographical area, including remote locations, serving as an instrument to reduce the development gap in different regions of the country. The proposal contemplated the interconnection of all schools and by its nature would be an ideal platform for building e-government initiatives, where distance would no longer be a hindering factor. Implementation of this project would build on Costa Rica's historical effort in maintaining a high level of education, and represented an early opportunity to be fully integrated in the new knowledge based economy of the XXI century. It would give citizens real access to the extraordinary possibilities of modern information and communication technologies for improving health and education, and creating a powerful instrument for research and collaboration in all areas of knowledge regardless where people work or live, or where the information is located.

### **3 The Pilot Project**

The infrastructure of the new project was to the full extent based on the Internet Protocols (IP), integrating other technologies in place, such as ATM and Frame Relay, using multi-protocol label switching (MPLS), a highly scalable and robust switching network architecture, to provide Virtual Private Network VPN/MPLS services. The network design follows the natural technological evolution towards simplicity and efficiency (Figure 3), with lower costs in equipment and avoiding unnecessary delays in the project implementation, as well as assuring the required scalability, flexibility and compatibility with other platforms.

At the time the proposal was presented, user access costs were projected to decrease 20-fold, as compared with the cost of a dedicated link from Radiográfica Costarricense S. A. (RACSA), an ICE subsidiary. The project also contemplated the future dismissal of the phone switchboard system to carry data [7] and eventually voice.

The first phase of the project was successfully implemented in a few weeks in April 2001 with the installation of a high capacity OC-12 optical ring in the metropolitan area and 700 DSL access lines [10, 11, 12]. The pilot project was carried out as an evaluation of concepts and technologies. Concurrently, the Advanced National



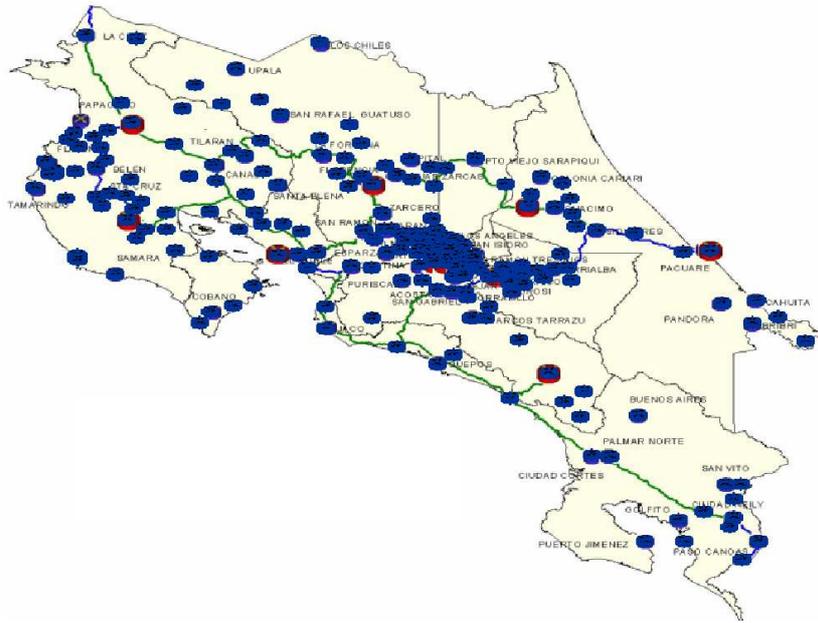
**Figure 3:** Technological evolution in the internetworking architecture from a four-layer IP/ATM (left) to a two-layer IP/Optical design (right). The complex four-layer ATM circuit oriented infrastructure is the platform required to interconnect traditional telephone switchboards, with higher costs, overhead and lack of scalability in high-capacity networks.

Research Network, named CR2Net, was created to provide high capacity traffic to Academic and Research Institutions in the country, using the new VPN/MPLS infrastructure<sup>3</sup>. It appeared that the breach created by the unsuccessful privatization bill had been overcome and that a new path was found to make significant progress in a most important area [13].

## 4 Large Scale Infrastructure

The second phase of the Advanced Internet Project consisted of the large scale deployment of the new network infrastructure supported by a high capacity MPLS/IP optical network. It called for identifying each and every existing fiber, which amounted in total to 5200 km interconnecting 207 backbone ICE nodes or Points-of-Presence in the country (Figure 4). The project included the installation of 100.000 xDSL lines, as well as equipment and network interfaces at each access point to provide high capacity links to industries, government and universities. Due to the limited territorial extent of the country, network repeaters were required in very few places. It was now necessary to identify the bandwidth requirements, and proceed with a detailed network design.

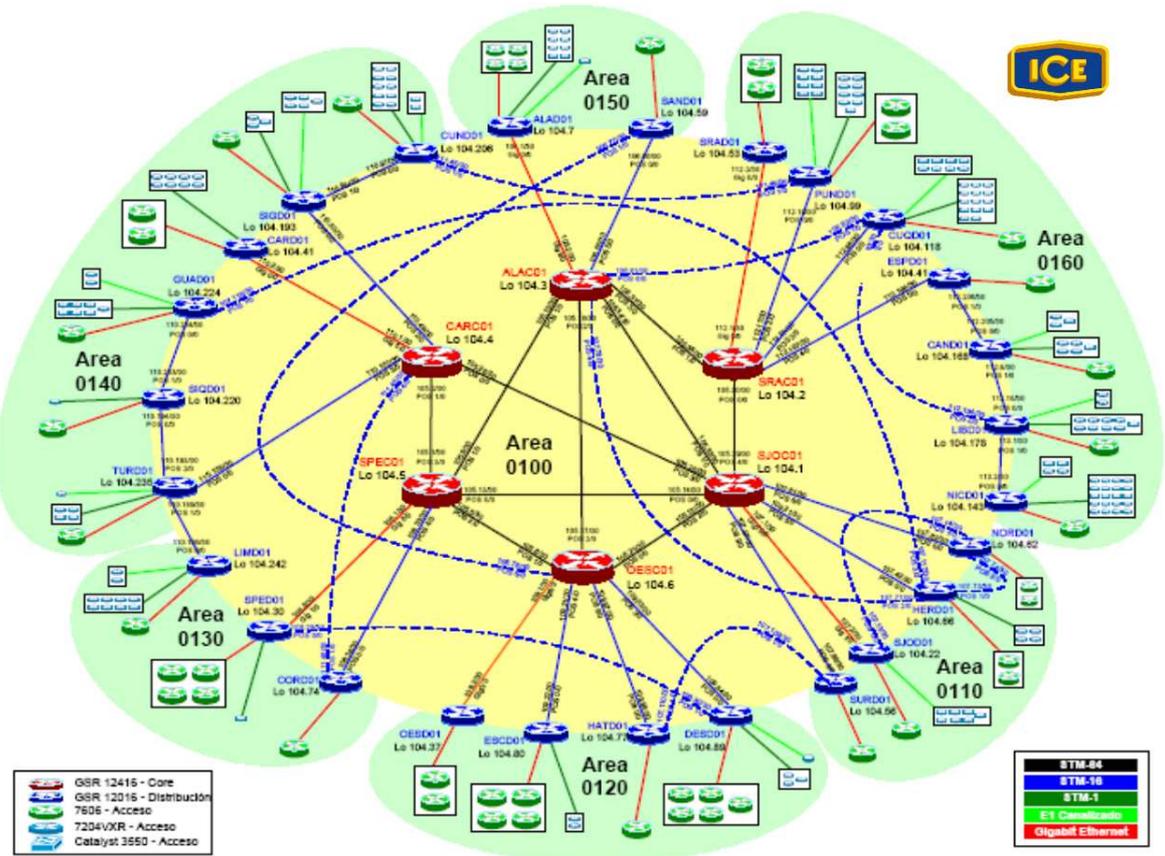
<sup>3</sup>Presidential Decree, MICIT-29431, April 18, 2001.



**Figure 4:** Network backbone nodes of the Advanced Internet in Costa Rica.

The actual design started slowly and the project was delayed for many months because the task was assigned to a team with very little knowledge or experience with internetworking technologies [14]. The impasse was broken at the end of the year when a team with indisputable technical leadership was assigned to the Advanced Internet Project and undertook a network redesign. As depicted in Figure 5, the RIA backbone design consisted of a three layer architecture. An OC-192 mesh core with 6 gigarouters would support most of the traffic with an aggregated throughput of 30 Gbps; an OC-48 redundant distribution layer of gigarouters would cover 26 important locations. Finally a third level, an OC-12 and OC-3 access layer, included 207 network access points, or RIA points-of-presence, distributed throughout the country (Figure 4). The actual backbone design could be scaled to support up to a million DSL lines in the future. As an illustration, a RIA generic distribution node is shown in Figure 6. It is important to highlight that in addition to the DSLAM/DSL access infrastructure, there were also provision for high capacity network access, such as Fast-Ethernet connections for industries or academic and research institutions.

A public bill for the procurement of the routing equipment [15] and xDSL access and energy supply [16] was open on February 2002 [17, 18, 19]. The first contract for the routing equipment was awarded on August 2002 [20]. The contract amounted to \$25 million, 33% lower than the budget. The second contract for DSL access would be awarded few days later, a crucial step to become a fully interconnect country. Further events, unfortunately, unfolded along a very different path.



**Figure 5:** Advanced Internet Project backbone layers: core OC-192, distribution OC-48, access OC-12 and OC-3. The backbone core has an aggregated throughput of 30 Gbps.

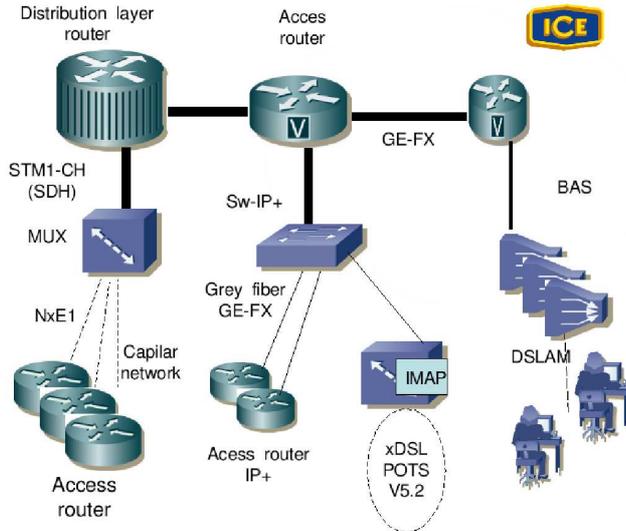


Figure 6: A RIA distribution node.

## 5 Difficulties with the Large Scale Deployment

The Advanced Internet proposal was based on simple and powerful technologies. Similar developments were occurring in the most interconnected countries in the world: Korea, Singapore, Canada, the USA as well as in the advanced research and education networks, such as Geant in Europe and CA3Net in Canada. The pilot project had already functioned flawlessly for almost a year. Moreover, it was demonstrated how the new technologies and concepts could substitute old ones with great advantage. For example commutation within the IP protocols is carried out at the packet level, without using physical switching, and almost unlimited traffic can be carried out over dark fiber without the use of expensive SDH or SONET rings for data transmission.

Each project gigarouter would have a cross-connection capacity equivalent to roughly 100.000 standard phone lines. The project, entirely based on open communication protocols and technologies, constituted a serious challenge to the stronghold maintained by the powerful firms purveying traditional phone equipment to the country [17, 19]. Alternatives to the project based on proprietary equipment, clearly superseded by the new technologies, where much more expensive, difficult to scale and would seriously compromise the country's technological future [18]. A mounting pressure to revert the RIA project to incumbent circuit oriented ATM core technologies was a serious challenge to the project [21].

On September 18, 2002, the Advanced Internet Project was suspended when the Board of Directors of the Instituto Costarricense de Electricidad, ICE, ignoring the

technical criteria of its own body of engineers declares void the public bid for the DSL access [22]. The Board of Directors pays little attention to strong claims by the Government, the press, the Chambers of Commerce, Software, Exports and the Union of Chambers and Private Industry to reconsider their arbitrary decision, which would affect the economy and cast serious doubts on the technological future of the country [23, 24, 25, 26, 27]. The Advanced Internet Project was widely regarded as the most important strategic plan for the technological development of the country [29].

Despite the promising beginning, towards the end of the year, two years after the broadband project was first announced, the contract for the network core was under appeal from one of the telephone switchboard firms, and the bid process for the DSL access stopped by the Board of Directors of ICE [28]. Meanwhile, broadband access in the rest of the world was advancing at a very fast pace.

## 6 Turn of Events

In mid January 2003, the Comptroller General of the Republic, in a 64 page document, rejected the disputant arguments of one of the bidding firms against the contract for the high capacity routing network backbone [30, 31]. A month later, in an unprecedented decision dated February 26, the Comptroller General declared the “absolute nullity” of the move by the Board of Directors of ICE declaring void the process for the acquisition of DSL equipment [32], a pillar of the RIA project. The Comptroller General pointed out that the alleged motifs of the Board are “inexistent”, and against public interest [32, 33]. The Board of Directors of ICE reacted promptly and three days later, on February 28, awarded the DSL contract [34], which was then vacated by the Comptroller General because of technical deficiencies [35].



**Figure 7:** Engineer Abel Brenes, from the RIA design team, configure one of the gigarouters of the backbone core. Photograph: Carlos Leon, El Financiero.

The processes of installing the RIA backbone core was now underway (Figure 7), but twenty months after the public bid to bring broadband connectivity throughout the country was announced, there were still no signs that the DSL contract would be awarded [36]. Finally, a second contract for the procurement of 84.485 DSL ports, the BAS terminal equipment and the power equipment required to give energy to the DSL access system in 207 localities in the country [37] was awarded for \$22.9 million in November 2003. The RIA was again

on track, but the difficulties with the DSL bid process resulted in delaying its deployment for at least a year and a half [38].

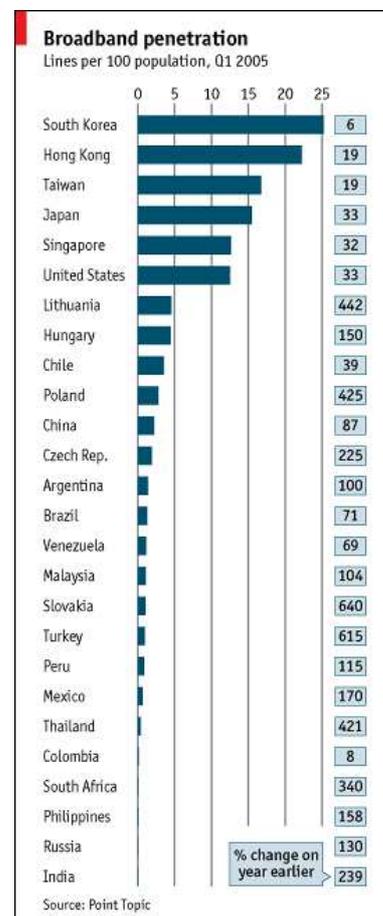
## 7 Final Comments

After more than three years of delay the Advanced Internet Project RIA is now functional [39, 40], with 72.000 xDSL ports installed in June 2005 and 100.000 by the end of the year. The broadband access is distributed throughout the country using a state of the art high-capacity network with 3,366 kilometers of dark fiber, as contemplated in the original design.

It is reassuring some years later, to confirm that the network architecture proposed for the Advanced Internet Project in Costa Rica is the technology of choice of contemporary advanced networks, which allow to combine “traffic from multiple networks on a single backbone” [41]. Multiple Protocol Label Switching (MPLS), a RIA strategic protocol, “allows multiple old-fashioned network services (such as voice, frame relay and ATM traffic) to be carried over a single modern network based on internet protocol (IP)” [41], also carrying voice over IP, VOIP, replacing in the very near future traditional telephony [42].

It is now more difficult to achieve a position as one of the leading countries in broadband connectivity and renewed efforts are required to increase substantially the number of broadband links and new applications. To maintain a leading position in broadband penetration it was necessary, in addition to the prompt installation of the initial 100.000 DSL lines, to install 25.000 additional DSL connections per year from 2002, thus reaching 200.000 broadband links or, 5 DSL links per 100 inhabitants, by 2005 (Figure 8).

New technologies will eventually displace the old ones, sometimes through a hard process. The Advanced Internet Project to bring universal broadband access to Costa Rica is not an exception, but in spite of all the difficulties a powerful and extended



**Figure 8:** Broadband connectivity in 2005 from [43].

network is finally installed and operational with a world class infrastructure.

As a learning experience it is worth recalling that a sound understanding of technologies is required to set definite goals and a clear strategy for the adoption of new technologies, which generally supersedes the old proprietary ones at a fraction of the cost. The independence and competence of those taking crucial decisions is indispensable.

The inherent difficulties of implementing such large scale projects are increased by the unavoidable consequences of the disruptive effects of the new technologies on the incumbent institutions and corporations, which understandably will present fierce opposition to the changes. This should be clear for the proponents of such venture because “the initiator has the animosity of all who would profit by the preservation of the old institutions and merely lukewarm defenders in those who should gain by the new ones” [44]. However, the rewards of implementing such a project are enormous since, regardless of the pattern of past development of a country, the new technological instruments are powerful tools with the potential to transform a society by empowering people and enabling countless opportunities in every field of activity.

*The views expressed in this article are those of the author and do not necessarily represent those of the IDB.*

## Terms and Acronyms

- **ATM** Asynchronous Transfer Mode, a network technology based on the transmission of data in cells of fixed size. The cell used with ATM is relatively small compared to IP packets. The constant cell size allows ATM transmission of video, audio, and data over the same network, creating a fixed route, between two points. This differs from IP, in which messages are divided into packets of different length and each packet can take a different routes from source to destination. ATM makes it easier to bill network usage, but at the cost of network flexibility and scalability.
- **bandwidth** Range of frequencies available for network signals. The term is also used to describe the throughput capacity of a given network.
- **CRNet** National Research Network of Costa Rica.
- **DSLAM** Digital Subscriber Line Access Multiplexer, equipment located at a phone company's central location that links many individual DSL connections to a single high-speed line to the network backbone.
- **Fast Ethernet** A networking standard which supports data transmission rates up to 100 Mbps.
- **Frame Relay** A packet-switching protocol for connecting devices across a network. Telephone companies generally provide Frame Relay service for connections at 56 Kbps to T-1 (1.544 Mbps) speeds. In Europe, Frame Relay speeds vary from 64 Kbps to 2 Mbps. Frame Relay is considered a replacement for old X.25 packet switching protocol.
- **ICE** Instituto Costarricense de Electricidad: power and telecommunication monopoly in Costa Rica.
- **Internet** The largest internetwork which connects thousands of networks worldwide.
- **internetwork** A collection of networks interconnected by routers which functions as a single network, an *internet*.
- **Internet2** Internet2 is a networking environment where universities, companies, and government laboratories work in collaboration to develop advanced Internet technologies and applications such as telemedicine, digital libraries and virtual laboratories. Internet2 members are connected to the Abilene high capacity network backbone. Internet 2 has more than 300 member organizations.
- **IP** Internet Protocol: a network OSI layer 3 communication protocol endowed with addressing information which allows packets to be routed on the internet.
- **Maya 1** A 4500 km undersea cable in the Caribbean.
- **MICIT** Ministry of Science and Technology of Costa Rica.

- **MPLS** Multiprotocol Label Switching, integrates Layer 2 network link information such as bandwidth, latency and utilization, into IP Layer 3 to improve IP-packet exchange. MPLS gives a great deal of flexibility to route traffic around link failures, and congested links. MPLS allows to manage different kinds of data streams based on assigned priorities. Different packets are assigned to corresponding Labeled Switch Paths.
- **NSF** National Science Foundation in the US.
- **OC** Optical Carrier, used to specify the speed of fiber optic networks conforming to the SONET standard. Common OC levels are: OC-3 = 155 Mbps, OC-12 = 622 Mbps, OC-48 = 2.5 Gbps, OC-192 = 10 Gbps.
- **OSI** Open System Interconnection, an international standardization created by ISO. It describes network communication in terms of layers, from the physical layer at the bottom to the user layer on top.
- **packet** A logical grouping of information sent as a unit over a network layer. It includes a header with its origin and destination and other parameters, as well as user data.
- **POP** Point-of-Presence.
- **RACSA** Radiográfica Costarricense, S. A., an ICE subsidiary.
- **RedHUCyT** Red Hemisférica Inter-Universitaria de Información Científica y Tecnológica.
- **RIA** Advanced Internet Project to bring universal broadband access in Costa Rica.
- **router** A dedicated network OSI layer 3 device which forward packets to several possible paths according to optimal metrics. A router also forward packets from one network to another.
- **session** Set of communication transactions between two or more network devices.
- **SDH** Synchronous Digital Hierarchy, a technological standard for synchronous data transmission over fiber optic cables. The U.S. equivalent of SDH is SONET.
- **UCR** University of Costa Rica.
- **VOIP** Voice over Internet Protocol or Internet telephony enables the use the Internet as the transmission medium for telephone calls, by sending voice data in IP packets instead of using the traditional circuit telephone network.
- **VPN** Virtual Private Network, a network which uses public infrastructure to connect nodes or separate private networks. A VPN uses encryption and other security mechanisms to ensure that data cannot be intercepted.
- **xDSL** Refers to all types of Digital Subscriber Line. DSL uses powerful modulation schemes to pack data onto copper pairs. DSL can provide high speed over limited distances.

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