DIGITAL DIVIDE IN INTERNET ACCESS AMONG LITERATE STUDENTS UNTIL ENTERING UNIVERSITY: A BRAZILIAN PROJECT PROPOSAL

Juliao Braga

FCI

Universidade Presbiteriana Mackenzie
Sao Paulo, SP Brazil
j@braga.net.br

Jeferson Nobre

Institute of Informatics

Federal University of Rio Grande do Sul
Porto Alegre, RS Brazil
jcnobre@inf.ufrgs.br

Ana Leda Silva Moraes

PPG-CC

State Federal University of Sao Paulo
Sao Jose dos Campos, SP Brazil
analedamoraes@gmail.com

Marcelo Santos

Computer Science Department

Federal Institute of Sertao Pernambucano
Salgueiro, PE Brazil
marcelo.santos@ifsertao-pe.edu.br

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ABSTRACT

This work describes a project that aims to reduce the opportunities divide in Internet access in Brazil, but that can be used to meet a similar objective in other countries. Basic education students, living in peripheral communities or in remote locations and participating in rural public schools, among others, have immense difficulties in accessing the Internet. As a result, they no longer participate in the largest repository of knowledge in the world and lose favorable occasions for their personal growth and consequent encouragement to continue to overcome obstacles and continue in the serene construction of a future of their choice.

1 Introduction

This paper describes a project that aims to reduce the opportunities divide in Internet access in Brazil, but that can be used to meet a similar objective in other countries.

Elementary and high school students, living in peripheral communities or in remote locations, and participating in rural public schools, among others, have immense difficulties in accessing the Internet. As a result, they no longer participate in the largest repository of knowledge in the world and lose favorable occasions for their personal growth and consequent encouragement to continue to overcome obstacles and continue in the serene construction of a future of their choice.

This project, called ITER Project (ITER), aims to address this inequality, considering:

- Low implementation and operation cost
- Capillarity
- speed of implementation
- Security

producing actions that make effective:

- the availability of Internet access for students, from literate students until entering University;

- to provide and maintain Internet traffic in public secondary schools;
- provide and keep Internet traffic in public secondary schools, in community settings, and at student homes;
- support for community Internet networks, without direct involvement with the respective operational activities.

ITER proposes to meet the objectives outlined above, with two parallel actions:

1. Facilitate the use of the Internet through the more than 2,600 eduroam locations in Brazil;
2. Use of the immense access capillarity of small, medium, and large Internet Service Providers (ISPs), duly remunerated for this initiative.

To ensure the viability of these objectives, ITER will undergo a test implementation during the period of fifteen (15) months, throughout Brazil. This implementation will be called **Proof of Concept (PC)**. This will happen through a joint effort by Employees and Partners (individuals and companies) recording the lessons learned during **PC** and displaying their results in the smallest details. From these experiences and notes, ITER will be improved. The ITER information repository is available in the **Open Science Framework¹** (OSF).

This paper is a compilation and translation of excerpts from the article [1]. It is based on studies done in Brazil, where there are about 38,450,909 students who should have access to the Internet. Estimates indicate that around 60% do not have this access or have very restricted access. The map in Figure 1 displays this number divided by Brazilian state.

Figure 1: Brazilian students and schools, by state

This work is divided into seven sections, including this Introduction. Section 2 is a summary presentation of **eduroam**. Section 3 presents the topology of ITER and its relationship with **eduroam**, and Internet Access Providers (ISPs) addressing the RADIUS proposal as a solution to the ITER architecture proposal described in Section 4. Section 5 presents ITER's operational strategies, its governance and the participation of multiple stakeholders, characterizing the

¹<https://osf.io/mrkvw/>

institutional support of ISOC Brazil (Brazilian chapter of the Internet Society). Section 6 presents the initial steps to implement the project and to establish the first governance documents. Finally, Section 7 presents a summary of the conclusions and future work associated with the project.

2 O eduroam

eduroam is an initiative created in 2003 and is now operating in more than 100 countries, with a strong academic orientation [2]. Its presence can be seen in Figure 2.

Figure 2: eduroam's presence in the world. Source: <https://www.eduroam.org/wp-content/uploads/eduroam-growing-topology-v2.gif>

It is a technology based on the IEEE 802.1X standard and on a set of servers based on the RADIUS protocol (RADIUS is an acronym for Remote Access Dial In User Service), defined by the Internet Engineering Task Force (IETF), in 1997 described and updated by RFC2865. [3].

Techniques available in RADIUS enable facilities that eduroam explores and that we can see in its operation, as shown in Figure 3 and by the explanations that follow.

Figure 3: How eduroam works. Adapted from: <https://www.eduroam.org/how>

Alice is a student with an ITER ID. She has a name associated with the project domain and a password, which we represent as a pair: [alice@iter.org.br, password]. She was visiting the library of a University in the countryside of Pernambuco and realized that there were eduroam there. This University is the **institution.visit**. Alice picked up the signal on her cell phone and connected to the **institution.visit**'s RADIUS, as shown in the above figure. RADIUS did not recognize **alice@iter.org.br** and forwarded an encrypted message to a RADIUS from the Brazilian eduroam federation, asking if it knew **alice@iter.org.br**. The federation's RADIUS recognized that the institution of the **iter.org.br** domain was ITER and sent the request data to ITER's RADIUS, which is Alice's **institution.home**. This RADIUS reports directly and properly encrypted to the RADIUS of **institution.visit**, the information that Alice is known and that, in addition, her password was correct. Therefore, Alice surfed the Internet! This process took a few seconds...

In Brazil **eduroam** is managed by the National Education and Research Network² (RNP) with more than 2,600 access points available.

3 ITER model

eduroam takes advantage of the techniques available on RADIUS [4] or, more effectively, available on **freeRadius**³ [5]. ITER takes ownership of the facilities provided by **eduroam** and, also, by the techniques provided by **freeRadius**. ITER's explanation follows the display of its model, in Figure 4.

Figure 4: The ITER Project model. Source: [1].

In the purple rectangle on the right are the resources of ITER and the relationship with its users and facilities (such as eduroam), on the left. In addition to Alice, a student registered at ITER, another user appears to understand how ITER works: it is Bob, a character registered only at **eduroam**.

Alice, being registered with ITER, is able to use the Internet both in ITER environments associated with eduroam and in those not on eduroam but available through ISPs partners of ITER. Bob can only access the Internet via an eduroam .visit, several of which are available through ITER. This difference eases Alice's access to Bob since ITER agreed with the providers to use their immense capillarity of Internet signal diffusion. **eduroam** members understand each other because they have RADIUS servers, which allow for strong collaboration and interconnectivity among them. ITER also has RADIUS servers in its infrastructure, which interconnect with the RADIUS servers of the eduroam federation, in Brazil, available through RNP.

These same ITER RADIUS servers are connected to the partner ISPs' RADIUS servers, which provide access to students, such as Alice, through their numerous capillary access points with the IEEE 802.1X protocol.

²<https://www.rnp.br/servicos/alunos-e-professores/colaboracao-a-distancia/eduroam>

³<https://freeradius.org/>

4 ITER Architecture

The ITER ecosystem is very similar to **eduroam** [2], with some special operational features, which can be seen in Figure 5. Actually, ITER architecture uses the best in the structure of **eduroam** and the facilities available through RADIUS.

Figure 5: ITER Architecture: acts only as an Identity Provider (IdP). Source: [1].

- It serves two environments: the *eduroam* environment and the specific environment of ITER itself. The RADIUS servers in both environments are logically presented as a hierarchy similar to the name resolution scheme by the DNS server, wherein each environment there is a root RADIUS. In the case of **eduroam** each country has a root RADIUS.
- Your RADIUS at the top of the hierarchy (remote server) acts only as an Identity Provider (IdP).
- All other RADIUS, both in the **eduroam** environment and in the ISPs environment act as Service Providers (SPs), recognizing a student previously registered with ITER.
- The **eduroam** environment recognizes ITER's RADIUS through its RADIUS server at the Brazilian federation level, under the administration of RNP.
- The RADIUS servers in the ITER environment are managed by the ISPs participating in the ITER Project. They are SPs and act as proxies, in the concept of RADIUS [3]: an ISP's RADIUS server receives an authentication request from a RADIUS (for example, a **Network Access Server** (NAS)) and forwards directly to RADIUS ITER connecting through its domain cite RFC7593.
- The authentication mechanism is a combination of IEEE 802.1X [6]., and the **Extensible Authentication Protocol** (EAP) [7, 8, 9, 10]. This is the authentication process for **eduroam** and also adopted by the ITER environment.
- This authentication mechanism carried out by a RADIUS server acting as a proxy is called **supplicant** and acts equally in any environment using the **trust structure** of **eduroam** using the **Network Access Identifier** (NAI) format (for example, alice@iter.org.br) [11, 12], used by RADIUS. The figure 6 illustrates this behavior, associating it with the EAP and the TLS protocol, inherent to RADIUS cite RFC5246, RFC6614, RFC4279 with the facilities of the **Tunnel Extensible Authentication Protocol** (TEAP). This tunneling method that allows secure communication between a client and a server, using TLS to establish a mutually authenticated tunnel [13].

Figure 6: EAP tunneling. Adapted from RFC7593 [2]

- All attention will be paid to the security issue. Thus, the host of the ITER structure will have to ensure that it follows the recommendations and participates in the **Mutually Agreed Norms for Routing Security**⁴ (MANRS).

5 Operational strategies of the project

To make ITER feasible, a set of strategies is being proposed that culminate in the most important one, named as **Proof of Concept** (PC).

The proposed operational strategies are listed below and described below.

- Governance
- Remuneration of ISPs
- Partial use of **eduroam**
- **Proof of Concept**

5.1 Governance

The ITER project is institutionally linked to ISOC Brazil, which plays advisory and supervisory roles, as well as supporting institutional relations with other entities and seeking sponsorship. But the governance of the project is done by its team, which relates to the multiple stakeholders, generically referred to as entities, intending to make it operational. The organization of the governance structure of ITER is in preparation and the Figure 7 shows the functional relationship between ISOC Brazil, the project Steering Committee and the multiple stakeholders.

Stakeholders are **volunteers**, **collaborators**, **partners** and **sponsoring organizations**. All of them come together to ensure that ITER's objective is realized: serving the students of elementary and high school courses, the main interested party, and called **target**. Grouped in an organized manner by the project's coordination committee, under the institutional shelter of ISOC Brazil, the entities interfere in the organization of ITER, through a process that allows recommendations to change the statutes, similar to the participation of society in Internet policies for Latin America and the Caribbean promoted by the Internet Address Registry Latin America and the Caribbean⁵ (LACNIC).

The **volunteers** are the entities (people, institutions, organizations, etc.) that provide partial or total work to the project, without remuneration. They do this permanently or temporarily. The acceptance and evaluation of volunteers for ITER is the responsibility of the project's Steering Committee.

⁴<https://www.manrs.org/>

⁵<https://www.lacnic.net/1042/3/lacnic/acerca-do-lacnic>

Figure 7: The governance of the ITER Project. with its Steering Committee, the institutional support of ISOC Brazil and the multiple stakeholders. Source: [1].

The **collaborators** are the entities (people, institutions, organizations, etc.) who exercise their skills in ITER demands and are paid for their work. The administration of the collaborators is responsibility of the Steering Committee.

The **partners** are the main stakeholders in the project from an operational point of view. They include schools (public and private) from elementary education to vocational education and also ISPs. The Steering Committee is responsible for calling, registering and providing guidance and, when appropriate, remunerating partners.

The **sponsoring organizations** are responsible for financing ITER, that is, the partners' remuneration, investments and operating costs projected by the Steering Committee.

Entities can participate in one or more interested parties and relate to each other as in Figure 8 becoming uncharacterized, at the intersection of all of them.

5.2 ISPs remuneration

In March 2020, the Brazilian National Communications Agency (Anatel) announced that small ISPs are placing themselves in a comfortable position among the major operators in the sector. This evolution over the years can be seen in Figure 9.

With this, they are, over time, increasing the capillarity, making available access to the Internet, and the most remote Brazilian territory.

For ITER they are the ideal partners and complementary to those of the big providers.

As a way of expanding capillarity more quickly and reaching strategic locations from the point of view of serving the **target** they need and should be adequately remunerated. The Coordination Committee, where a representative of the ISPs will be present, will establish the appropriate and fair remuneration to the ISPs after running the **PC**.

5.3 Partial use of eduroam

eduroam is an opportunity to make immediate access to the internet available to **target** through its more than 2,600 points spread across Brazil. It depends only on understanding with RNP.

5.4 Proof of Concept

Some volunteers are developing protocols to establish a test bed, which is called **Proof of Concept** (PC).

Figure 8: An entity can participate characterized as several stakeholders. So at the intersection it is not characterized. Source: [1].

Figure 9: Evolution of fixed broadband accesses by provider and company size. The 10,405 entities registered with Anatel, produced a total of 34,181,324 accesses, large providers account for 22,249,889 accesses (65.10%) and small providers account for 11,931,455 accesses (34.90%) in July 2020, Source: <https://www.anatel.gov.br/paineis/acessos/banda-larga-fixa>

The **PC** for ITER is the operation for a period of one year, of the integral model proposed in Figure 4. The steps involved in preparing to run **PC** are as follows:

1. Convocation of interested ISPs who have RADIUS in their infrastructure and are willing to participate in this first year of the **PC**, without remuneration;
2. Calling primary and secondary schools, particularly from remote locations but with Internet coverage through an ISP;
3. Convocation of a volunteer to participate in the debates that will establish the technical definitions;
4. Non-governmental institutions that can guide the team of volunteers to establish policies to periphery approach;
5. Convocation of manufacturers and / or representatives of equipment manufacturers adhering to the ITER project, such as the **Network Access Server (NAS)**;
6. **Sponsoring Organizations** interested in participating in the rules that will outline ITER's future and how financial contributions would be made to maintain traffic via ISPs, after **PC**.

6 Schedule of initial activities

Table I identifies the main components needed to leverage ITER and its PC. Like any project, these components change over time, therefore requiring permanent project coordination.

Table 1: Preliminary schedule of the main steps involving ITER.

#	Activity	Responsibility	Start	End
1	Technical project of PC	JB ^a , LL ^b , MS ^c , JN ^d	Sep/20	Oct/20
2	Operation of PC	JB ^a , LL ^b , MS ^c , JN ^d	Nov/20	Oct/21
3	Project ITER operation	Steering Committee	Oct/21	-
4	Marketing Plan	Steering Committee	Sep/20	-
5	Unique Identification (Warranty)	Steering Committee	Sep/20	Oct/20
6	ISPs partnership agreement for PC period	Steering Committee	Sep/20	Sep/20
7	Call Participation for ISP Partners	Steering Committee	Oct/20	-
8	Call for Volunteer Participation	Steering Committee	Sep/20	-
9	First ITER policy document	Steering Committee	Sep/20	Oct/20
10	Policy document change rules	Volunteer Group	Sep/20	Oct/20
11	ITER's Governance Structure	Steering Committee	Sep/20	-
12	19/5000 ITER website	Steering Committee	Sep/20	-
13	Involvement of Sponsoring Organization's actions	Steering Committee	Sep/20	-

Legend:

^a -> Julião Braga

^b -> Luciano I. Lima

^c -> Marcelo Santos

^d -> Jeferson Nobre

7 Conclusions and Future Work

Sponsoring Organizations will only venture to support ITER, if **PC** demonstrates the effectiveness of the results. This indicates the need for special attention during the testing stage, which should have mechanisms to assess direction changes in the face of possible difficulties in current actions.

It is to be expected that one of the major beneficiaries of the reduction of school inequality, in the medium and long term, will be higher education institutions, especially private universities. So they are strong candidates for interested parties like **Sponsoring Organizations**.

One of the concerns that will be part of the **PC** stage is the efficiency of the Radius server (s) available for authentication, since the database will use SQL, a reasonably slow mechanism, mainly in data writing. Additionally, other factors affect the efficiency of Radius servers, which include: availability of main memory, CPU speed, the EAP-TTLS mechanism and the complexity of the implemented policies⁶. A team will be available with the objective of simulating and measuring the efficiency of configurations that should be introduced in the ITER environment in its normal operational activity, which will be able to serve 39 million students – estimated by Brazilian Ministry of Education [14] —, under the AAAA protocol⁷. Radius (and freeRadius) has efficiency simulation features in various scenarios that can be designed with ITER, in the **radclient** tool and in others developed by third parties, such as **RadPerf**⁸. On the other hand, a Radius server can behave as a client to another Radius server, which ensures modular scalability.

Other types of partners will exist and techniques for participation by these new partners will be needed. For example, public and private schools with a navigable Internet band can participate in eduroam, as long as this is permitted by their governance in Brazil or directly at ITER. Such partners use the Internet as a means and, therefore, will not require operational costs from ITER, but technical support.

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⁶<https://wiki.freeradius.org/features/Fast>

⁷Implements authentication, authorization, accounting and auditing services

⁸<https://networkradius.com/radius-performance-testing/>

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