Basic Internet: Mobile Content Delivery to Everyone

George Suciu
Research Department
Beia Consult International
Bucharest, Romania
email: george@beia.ro

Geaba Alin Nicusor
Telecomm. Department
Politehnica of Bucharest
Bucharest, Romania
email: alin_geaba@yahoo.com

Iñaki Garitano
Enginering Faculty
Mondragon Unibertsitatea
Mondragon, Spain
email: igaritano@garitano.org

Josef Noll
Basic Internet Foundation
University of Oslo/UNIK
Kjeller, Norway
email: josef@unik.no

***Abstract*—The Basic Internet Foundation aims at optimized content delivery for capacity-limited networks, and thus provides free access to basic information to everyone. In this paper we describe the main technological challenges of the content delivery, being *the concept of information*, the remote administration of access points and the inclusion of Internet of Things (IoT) information. Basic Internet aims at offering free access to information on low capacity Internet lines to people lacking Internet coverage or the ability to pay for mobile data. The main contributions of this paper are solutions that the foundation as well as other programs or companies have addressed encouraging digital development and inclusion.**

Keywords–Internet; foundation; broadband; devices; network; information; developing economies.

I. Introduction

There is a constant need for evolution and the only way humanity has surpassed many obstacles and gotten to the point it is today is by using the collective knowledge of different individuals. In that desire to form a connection with others in order to access information you require, the Internet has been developed as the solution for sharing and receiving data and information.

The origins of the Internet date back to the 1960s, when the United States government developed a research program that aimed to build robust, fault-tolerant communication via computer networks [1]. The Internet now links several billion devices worldwide together, and consists of a multitude of networks local to global scope, private or public connected to a broad array of networking technologies [2].

In the 1990s, the Internet had developed into a usable and efficient service that led to a modern human life. As of June 2014, nearly 42.3% of the world's human population has already used the services of the Internet [3]. The necessity of the Internet grew rapidly and it is now used in a large variety of data transfers and downloads for different purposes such as entertainment, business, document and many others. However, the Internet is not accessible for the majority of people in developing economies, mainly due to availability and affordability. As an example, countries like Guinea and Niger have less than 2% Internet usage [3].

The problem that the Basic Internet foundation is trying to solve is that of the economical solution present in many countries. The fact that not all of us are born into the same living conditions is a giving fact, but that does not mean that some of us should be restricted from receiving a proper means of education, including digital competency.

The Internet can be used for multiple purposes, one of them is to promote teacher training. In the case of rural areas, the Internet can have an important role in giving teachers some pointers to a better educational experience, make them a moderator of digital science, and offer them materials for their work [4][5]. By using a network-based training system, teachers can keep in touch with each other or receive support from educators from the best universities.

The Basic Internet Foundation is complementary to Mobile Network Operators, and offers their services to people who can't access or can't afford mobile Internet services. Based on factors such as social conditions, markets or economy the Foundation determines if their interventions are required, and once those factors have evolved satisfactorily, the Foundation will transform its involvement to commercial providers. However, such a transfer of assets will include obligations to continue providing free basis information services. The paper is organized as follows: Section II presents similar solutions from other companies with similar goals, while Section III describes the political involvement in various countries. Section IV presents the current technology challenges, and Section V addresses first results from pilot implementations. Section VI concludes the paper.

II. Related Work

In this section, we provide an overview of existing solutions for Internet distribution in areas with economic issues and present the main challenges. The United Nations' Human Rights Council has unanimously backed the notion of equal rights for every person to be allowed to connect to and express themselves freely on the Internet. All of the 47 members of the Human Rights Council have approved that notion in a resolution on the fifth of July 2012 [6].

A. Nextelco

Nextelco Foundation is a company founded in 2012 by Guy Kamanda and aims at providing Internet to Democratic Republic of Congo (DRC) [7]. The main goal is to provide free information access, which the company considers to be a human right.

The company is using the new concept of user involved service and that of the infrastructure provision. What the real challenge that Nextelco recognized is that mobile coverage is very limited, and costly satellite connection is often the only way of establishing Internet access. In practice, the Internet is only accessible for the well-established people. Nextelcos main purpose is to establish information access as a consumer product in Africa for people of all ages and economical standards. The company has joined forces with Basic Internet to provide hot-spot solutions with free access to basic information like Wikipedia, and voucher-based access to Internet content.

B. WaveTek

WaveTek Nigeria Limited is an innovative company that provides Information and Communications Technology (ICT) solutions that offers customers cutting-edge infrastructure and devices independent of their social area [8]. The Managing Director, Ken Spann advised the operators specialized in ICT to invest more time into developing virtual fiber solutions to deepen Internet penetration thus improving the quality of service. The solution the company has come up with for reducing the cost as an alternative for the fiber circuits is a high-capacity wireless.

The idea is to provide fiber-equivalent connections between different locations. The way to do that is by transmitting data over microwave or millimeter wave frequencies at gigabit speeds, approximately 2 Gigabits per second (Gbps), with the possibility to upgrade it in the future up to 10 Gbps. The reason for its efficiency it that has multiple advantages such as: add/drop data ports and optional wire-speed with an Advanced Encryption Standard (AES) encryption built-in thus making existing fiber network redundant.

C. Internet of Internets

The Next Generation Internet (NGI) consists of a multitude of projects that have the objective of improving Internet performance as well as content quality in different regions [9].

NGI focusses on the research regarding the design, protocols, engineering, and operation regarding the new signal processing techniques in 3G/4G/LTE/B4G [10][11]. Other important researches are that of the Ad Hoc Network and Wireless Mesh Network [12][13], channel allocation [14], Internet of Things (IoT) [15], cloud computing [16], and extensions of the Internet Protocol (IP) [17].

The Multi-Tier Architecture for the Internet of Internets (MTAII) can be separated into two components, Specific Internet Protocol (SIP) and Multi-Tier Internet Protocol (MTIP). SIP isolates IPv4 on hosts from WAN infrastructures while delivering IPv4 traffic through WANs between hosts. MTIP provides a tree-like topology and is used for delivering SIP traffic.

The exhaustion of the IPv4 address space was foreseen more than a decade ago, so many solutions had been suggested [18]-[21]. The problem was that none of them were accepted as a solution so they were all combined into another Internet protocol IPv6 [22][23], leading to a modified protocol stack (Figure 1).

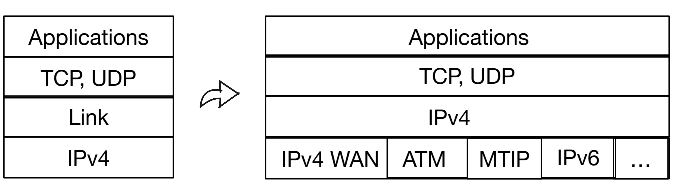

Figure 1. The change in the protocol stack

Internet research assumes sufficient capacity on the link layer, which is not the reality in congested mobile networks or over satellite links. Thus, novel concepts are required with distributed applications supporting these low-capacity links.

III. Political Involvement

Two examples of political involvement are provided, being Germany and Romania. In Germany, the Ministry of Communications has annnounced that every public building should have a free Wifi access in order to foster innovations.

The Romanian Government launched the National Broadband Strategy in order to increase the penetration rate in households of the broadband connection. The broadband coverage remains limited, especially in rural areas among households and companies.

In 2009, the “Government strategy of developing broadband electronic communications in Romania for the period 2009-2015” was adopted. Starting from the provisions of this Strategy, correlated with those of the European Structural Funds Regulations and with the specific state aid, the Ministry of Communications and Information Society has developed a Model for Implementation of projects aimed at developing broadband infrastructure in disadvantaged areas.

The use of Structural Funds available for infrastructure development was decided after analyzing patterns of implementation of broadband infrastructure, achieved through institutional cooperation, consultation and joint communications market profile as well as consultations with representatives of the European Commission. The infrastructure is state property, which is made available to communications operators on a commercial basis, and without restricting access.

The Ministry of Communications and Information Society (MCSI) has distributed in 2010 hotspots in public areas throughout the country. The E-NET initiative consists of building a national broadband infrastructure in deprived areas, by using structural funds. The measure was intended to further the transition process to a modern society, information, based on the increasing number of areas with free Internet access.

These network activities are supported by open-source developments, providing a cost-effective Internet service infrastructure.

IV. Technology challenges

The Basic Internet Foundation aims to deliver optimized content over low-capacity links. The delivery involves several technological challenges, which need further research and development. Currently, the technological department of the Basic Internet Foundation is focused on solving three main challenges: (1) the notification of information, (2) the centralized management of the whole infrastructure, which involves Customer-premises Equipment (CPE), and (3) the dynamic establishment of secure and privacy-aware communication channel for Internet of Things (IoT) devices.

The *first challenge* is related to information provisioning. Information has social, economic, political and cultural roles, depending on the background of the reader. The challenge, we are addressing, is related to the way information is best presented in bandwidth limited systems. Thus, we try to characterize information content related to the amount of bits being used in the communication. Instead of restricting content, we suggest to restrict content types, e.g., to allow text and pictures, but dismiss videos. However, both definition and technological implementations are not straight forward. Taking the example of the resolution and the size of a picture. Depending on the content of a picture, a certain resolution and size is required to provide meaningful information.

The *second challenge*, the centralized management of the whole infrastructure, requires further research and development of protocols such as the Customer Premise Equipment (CPE) Wireless Access Network (WAN) Management Protocol (CWMP), proposed by the Broadcom Forum under the TR-069 report [24]. The CWMP protocol defines the communication between the CPE and Auto-Configuration Server (ACS), together with a framework with several functionalities:

- Auto-configuration and dynamic service provisioning,
- Software/firmware image management,
- Software module management,
- Status and performance monitoring, and
- Diagnostics.

Such functionalities would allow CPE provisioning at the time of initial connection, allowing the distribution of CPE devices with default factory settings. The savings in terms of efforts necessary to configure each device would increase the affordability of the project and push forward the research and development of other technologies.

The *third challenge*, the dynamic establishment of secure and privacy-aware communication channels for IoT devices, involves the design and development of a middleware for both CPE and IoT devices. Being the Basic Internet network open and unencrypted, the middleware would allow the interaction between devices with the platform in order to perform functions such as:

- Establish an encryption algorithm together with a key, and
- Add, update or revoke security certificates,

Furthermore, the middleware would allow the development of CPE applications. Those applications would perform different functions such as conversion of user information into anonymous requests.

Current IoT device vendors suffer the lack of a standard communication channels. Most IoT devices are connected to private or service provider networks preventing them from controlling the communication channel. Moreover, when using mobile operator services, each device needs to be equipped with a SIM card, which depending on the country it will require to be different unless the vendor established an agreement with a multi-country service provider. The costs and challenges associated to communication channels prevent many vendors from developing new IoT devices.

As self-monitoring health care devices evolve, secure- and privacy-aware communication channels become necessary. Home located health-care services, such as Dignio prevent [25], take advantage of new health related IoT devices providing a qualitative service built on top of traditional home health-care services. Gathered health related measures like blood pressure are sent from the end user devices to a central patient monitoring service, and the service will provide a personalise medical advise to the user. Thus, the communication needs to be bidirectional and the channel has to ensure security and privacy.

The development of the middleware would allow the creation of Basic Internet enabled devices. In this way, interested IoT device vendors would be able to associate with the Basic Internet Foundation, being able to use the communication infrastructure and develop their own applications on top of CPE devices.

V. Results and Impact

Though three main challenges are mentioned in the previous chapter, the focus will be on experiences related to challenge one, the information provision.

The Basic Internet Foundation started its activities back in 2010 for developing Internet access in Africa. A series of pilots were established in 2011, amongst others the Internet access for the region and the University of Lisala (DRC). Experiences from these pilots showed that the bandwidth limited and costly satellite link was the biggest hurdle for affordable Internet access.

The main problem that developing countries are facing is related to the high costs for providing Internet services in areas with low availability. The main focus is on getting as much information as possible through a bandwidth-limited link. Some examples of such low-availability links are satellite links and congested mobile networks.

Basic Internet provides solutions for optimizing the stream of information in such a way that a high amount of information can be provided despite the unfavourable conditions mentioned earlier. The Basic Internet network contains in its complete form: a network termination, a distribution network, and a Wireless Fidelity (Wi-Fi) Access Point. In areas where no Internet connection is available, the network termination can be achieved through either a radio link or a satellite connection.

The http archive provides various measures of content of web pages [30]. An average Web page has doubled in size from 2012 to 2015, being 1.09 MB in 2012, and 2.1 MB in 2015. The space used by scripts on web pages is between 15 and 19%, while images account to slightly more than 60%. The raise of video is documented first time in 2015, accounting for 10% of the web size.

TABLE I. WEB SITE GROWTH AND CONTENT

	1Jul2012	**1Jul2013**	**1Jul2014**	**1Jul2015**
av. web site [kB]	1090	1485	1829	2135
Images [kB]	684	909	1159	1348
Scripts [kB]	210	225	293	344
Video [kB]				204

Though the total size has doubled, there are remarkable differences in size. Google.com uses only 90 kB, while Wikipedia uses around 300 kB, both substantially lower than the 3.3 MB used by the NYTimes.com. On thin lines, e.g., a satellite link of 1 Mbps, a web page of 2.1 MB would load in 20 s, and block the satellite capacity for other users.

Thus affordability requires reduction of information, which can be achieved through removing content, content elements, resizing images and compression of the whole web page. Opera Mini is one of the best examples of a browser designed primarily for mobile phones, smartphones and personal digital assistants that can provide a maximum of information, even though it has limited capacity in the network [?][31]. Statistics from Opera point to an average of 340 pages/user, resulting in an average of 4 MByte per month for users in Nairobi [32].

TABLE II. INFORMATION PROVISIONING COSTS

Usage [MB]	Users/1 Mbps	costs/user [US$/month]
4	3996	0.5
20	799	3
50	320	6

Results of a simplified model for providing information over a satellite link are provided in Table II. For simplification, the costs per user are based only on the operational costs of the satellite link. The numbers are based on a 1 Mbit/s (Mbps) satellite link to Africa, with costs of 2000 US$/month, 12 h duty time, and a simplified linear distribution of the traffic. Table I clearly shows the effect of basic information and compression, allowing to provide information at a satellite cost of half a dollar per month, given the average use of compressed 4 MByte per user and month. In comparison, a video transmission of 8 min, accounting to 50 MByte, would cost roughly 6 US$. Using a radio link or a mobile network termination will significantly reduce the cost, and can drop the Basic Internet provision to lower than 0.1 US$/month.

Nowadays, the foundation joined the United Nation's Vision 2030 to ensure optimized content delivery for capacity-limited networks in low-developed countries [29]. The Basic Internet Core Network (Figure 2) is the one responsible for the information optimization and supports traffic shaping, traffic balancing, free access to basic information and voucher-based access to full Internet including video and gaming.

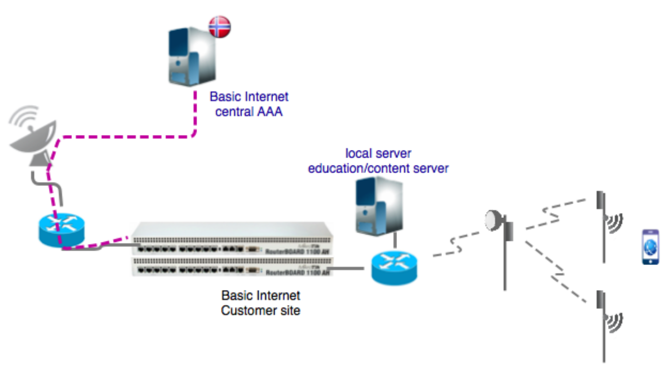

Figure 2. The Basic Internet central AAA and the Customer Equipment

The enhanced infrastructure, as piloted in 4 Universities in Kinshasa (DRC), provides free access to Wikipedia and other educational sides. The customer infrastructure includes a local server, adding free-of-charge educational videos and content. The results of the pilot implementations verify that

- A cost-effective Internet distribution is possible,
- The deployment addresses people not being able to access information,
- Typical target groups are schools, universities, health and community centres, and
- The service offer is complementary to conventional telecom services.

Based on the results of the pilot, we believe that a cost-effective basic Internet distribution worldwide is possible, and will foster digital inclusion.

A high-bandwidth local distribution network represented by a server fully loaded with information freely available for everyone could extend the service offer for education and health information. Such a development includes device and software development specific for the evolving markets such as BRCK [33], as well as low-cost solutions, e.g. USB modem and USB capable MikroTik router [34][35].

Following the principle of the Basic Internet of a low-bandwidth information provision, the focus is mainly on the applications specifically developed for distributing a large amount of collective information without high requirements. Examples that fit these expectations are Wikipedia and a long list of apps on phones and tablets that can work with a minimum bandwidth.

One of the most important development projects refers to health applications that provide information based on the feedback given by a health-sensor. The main idea is to transmit the data about a persons health over the low-bandwidth link together with user-specific information, and to get reliable personalized treatment information back to the user.

Though education and health care are the two dominant areas, digital inclusion will foster local innovation. Business innovation in developing economies will take place by receiving up-to-date information about customers, partners, markets and innovations that can be implemented.

Other actors like Google have dedicated resources for building and helping the development of running wireless networks in emerging markets for connecting more people to the Internet [36]. The main concepts being provided by the Basic Internet Foundation and others are services reaching those who can't access or can't afford wireless Internet services. In that way, the access provision is complimentary to conventional Telecom services. Current activities include the marketing trial in Kinshasa to address potential scalability issues. Upcoming steps are pilots in selected African countries in order to address the ecosystem for digital education. Further steps include global alliances to reach out to countries seeing the need for digital inclusion.

VI. CONCLUSION

In this paper, we presented the development as well as the principles, which the Basic Internet Foundation is based on. The core of the initiative is providing free access to basic information to developing economies using a cost efficient way of network access.

Three main challenges are identified, related to the notification of information, the centralized management of the whole infrastructure, and the dynamic establishment of secure and privacy-aware communication channel for Internet of Things (IoT) devices. The paper addresses the mainly the first challenge, and demonstrates that roughly 4000 users can be supported with free basic access over a thin 1 Mbps satellite link, dropping the connectivity price to as little as 0.5 US$ per person and month. Examples of pilot installations in Africa are presented, pointing out the target groups being schools, universities, health- and community-centres.

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Other initiatives, programs and companies that support the same ideas, as well as their results are presented. A range of solutions for future work envisioned for the purpose of life improvement are introduced. The development of such programs will leave strong results in many areas regarding e.g., data transfer, health, economy, knowledge, business, and entertainment.

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