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Abstract

Through this short position paper, we hope to convey our thoughts on the need for free Internet access and describe possible ways of achieving this - hoping this stimulates a useful discussion.

1 Introduction

The Internet is heralded as the eighth wonder of the world connecting 2 billion people around the world. With the profound success of mobile phones (it is estimated that 5 billion people have mobile phones) the "connected" world (the privileged) is expected to get bigger and bigger. Internet has crossed new frontiers with access getting faster and cheaper. New applications and services are being offered. At one extreme, the future Internet is expected to transport applications such as tele-immersion and 3DTV and at the other extreme to connect vast numbers of tiny devices integrated into appliances, sensors, actuators, and a range of previously independent systems forming the notion of "Internet of Things". Sensors have now become all-pervasive and are more and more seen as a solution to large-scale tracking and monitoring applications in particular health monitoring applications. Affordable devices that enable remote health monitoring of patients are available. Using sensors and mobile devices within communities, researchers even understand social structures of communities creating social networks and using these networks to predict epidemic spread within communities [1]. The Internet is now an all powerful medium - information has become pervasive, the entire digital economy relies on the Internet, new models for e-governance have emerged, and it runs the ever growing social networking platform which can even change governments. The world is in one's hands.

On the other end is the notion of the under-privileged society - the other three billion who do not have access to basic services let alone the Internet. It is estimated that epidemic diseases account for more than thirteen million deaths a year for e.g. Influenza alone causes 250,000-500,000 deaths annually [2]. Then there is the notion of Invisible epidemic [3]. Every minute of every day a woman dies of complications in pregnancy or childbirth. Four million babies die worldwide within one month. Most deaths from infectious diseases occur in developing countries. By enabling access to vital health information and remote health monitoring services we may be able to save lives of these people. How would it be if noble hearted voluntary doctors in developed countries monitor remote communities and provide additional support to community health workers in remote communities? How would it be if anthropologists are better able to understand the social structures within these under-privileged communities and establish social relationships that could enable

them to predict epidemic spread within these communities (for e.g. HIV)? By enabling connectivity we could not only save lives, we could also empower individuals and communities (for e.g. see Sugatamitra's Granny cloud [4]) eventually removing the disparity between the privileged and under-privileged worlds.

On one end, we have the developed world where access is getting faster and services being developed to utilize faster access. On the other end, there are people who do not have access to the Internet at all. Some may not be able to get it due to lack of infrastructure support (which accounts to the notion of digital divide problem faced by most people in developed countries). There have been significant initiatives to solve the problem of affordable infrastructure support either through recent academic initiatives (for e.g. [5],[6]), through the industry (for e.g. [7]), through open source infrastructures/initiatives (for e.g. [8],[9]) or through unconventional methods that depart from the norms of the traditional Internet (for e.g. [10]). This paper in particular tries to address the problem of affordability in general i.e. the financial inability to pay for Internet access.

Connectivity costs money! Although several health monitoring devices, medical sensors, mobile phones and even computers can be made available for free through NGOs (for e.g. [11]), transmitting data (either through the Internet or via GSM) costs money to the end user i.e. the under privileged end user. How can we expect them to pay for Internet access when they live on incomes of less than $1 a day? We believe the notion of connectivity for all being governed by the fundamental law of economics is the biggest social barrier in the world today. A similar view was recently echoed by the founder of the Web [12].

Through this paper, we are hoping to break the current mould of thinking that connectivity to all should be governed by law of economics. The disparity between the disconnected and the connected world could be resolved if we can provide free connectivity atleast to access the essential services. We (the privileged society) have the moral responsibility to enable the under-privileged to be connected to the rest of the world. To solve the problem of affordability we may need changes in policy (economic, social and political) to support free Internet connectivity to all. However as a first step, we believe that by driving research into technology that facilitates new access methods we could enable the Internet to be universally accessible to all.

In this paper, we propose access methods based on Less-than-Best Effort (LBE) (also known as the Scavenger Class) Quality of Service (QoS) where network operators and privileged users share their resources (unused network capacity) with the under-privileged communities/users. These access methods ensure that the volunteer (either network operator or user) who is sharing the resource is not affected in terms of performance as well as cost.

2 Potential Solutions

2.1 Distributing the unused capacity for free

How would it be if the network providers pool their unused capacity and distribute it to the under-privileged communities for free Internet access using LBE access? Economic models that facilitate users to use the Internet during less busier times (for e.g. during night time) currently exist. However, these models are still expensive to under-privileged users. We

need to engineer new methods that would allow network providers to distribute their unused capacity. Networks such as two-way satellite (for e.g. Digital Video Broadcasting - Return Channel via Satellite (DVB-RCS)) [13] or WiMAX that are based on Radio Resource Management (RRM) have an inherent ability to provide such a system. These technologies could be useful to provide free access to the rural poor especially when satellite operators are launching next generation two-way satellite services that provide sufficient coverage and capacity to support countries such as Africa and Middle East [14]. The method of asking for capacity and being granted capacity in such RRM-based two way satellite systems provides the feasibility of engineering a system that could provide free access to communities by distributing the unused capacity. The network providers could provide the notion of unsubscribed terminals which can be connected to the satellite network. These unsubscribed terminals can then request for capacity when they have data to send. However, the Network Control Center (NCC) would only grant capacity when there is a portion of the unused capacity that could be distributed over several of such terminals. In such a case, the time between requesting for spare capacity and being granted capacity may be high depending on current usage levels (in the order of several seconds, minutes or sometimes hours) bringing in the notion of a disconnected network. This introduces challenges to most of the current Internet applications that run on TCP as TCP is fundamentally limited by delay. Hence we have to engineer new ways of access to the network (for e.g. Delay Tolerant Networking (DTN) [15]). Although such a system introduces asynchronous connectivity, by utilising existing GSM connectivity (reverse SMS's are usually free), by introducing efficient caching of data (for e.g. news, Wikipedia etc) or location specific caching and by supporting localized Internet access (for e.g. the Haggle architecture [16]), we should be able to provide a communications medium free of cost to the under-privileged until they are in a position to get better access to always-on Internet connectivity.

2.2 Sharing your Internet connection

How would it be if the privileged are allowed to share their Internet connection with the under-privileged (urban poor)? There are couple of schemes that allow you to do this (for e.g. see BT FON [17] and Meraki [18]). However they are for-profit organizations and charge for the hardware and services. However if network operators can support, the privileged users (who could afford and have access to a high speed Internet connection) volunteer to share their Internet connection for free with the under-privileged. Such an approach will allow more opportunities of access enabling digital inclusion without relying on government or network providers to support the needs of the under-privileged users. To ensure that the under-privileged user traffic does not hamper the perceived performance of the privileged volunteer we could explore the possibility of allowing under-privileged users to use the shared home broadband using LBE. It is important that network operators also support this by enabling QoS differentiation to support such access at the Broadband Remote Access Server (BRAS). By enabling LBE, the traffic from the under-privileged users should not affect the volunteer user's traffic which are marked Best Effort (BE) by default. It could be also interesting to see if we could use LBE based transport methods for under-privileged users to access these shared access points (for e.g. Low Extra Delay Background Transport (LEDBAT) [19]). These new transport methods that are currently

being standardized at the IETF would enable users to share a resource without competing for the shared resource. It would be interesting and challenging for the research community to explore and enable applications such as web (which currently need atleast BE service) to work with methods such as LEDBAT and other LBE transport/network access. Another option would be enable these WiFi access points to be DTN enabled. This enables under-privileged users to use asynchronous communication by offloading data into these WiFi access points. The WiFi access points can then wait to see if the connection is idle and then transmit the bundled data either using LBE QoS (if enabled) or use LEDBAT if QoS is not enabled. This also requires that network operators enable their BRAS to be DTN enabled to support these types of access.

However there are several issues to be resolved (security, access control, performance etc) in realizing such a system [20] and hence it is important for the research community to explore these issues. The characteristics of home broadband performance in general have been previously studied in [21]. As a starting point, it would be of real interest to the research community to study how users use these home broadband routers and to understand how much spare capacity is available that could be potentially shared.

A major challenge for both solutions 2.1 and 2.2 could be the perceived performance when a under-privileged user uses a network that either looks like a disconnected network (2.1) or using a LBE or LEDBAT service (2.2). We believe that these under-privileged users (who may have never used an Internet before) would rather appreciate the fact that they have some access rather than no access and this would be a step forward. Understanding under-privileged user expectations would be an interesting topic of study

2.3 Free IP address space for essential services

Assuming there exists an infrastructure, how about creating an IP address system (IPv6) that is free for accessing? This is like the free phone numbers. All essential services such as health, education, government services could be moved on to the free IP address space and they can be accessed for free.

3 Incentives

We need to explore the incentives on why network operators and privileged users should participate in enabling free Internet connectivity. We list down a few possible incentives:

1. Social responsibility: Apart from the charitable act there is a moral responsibility for network operators to be responsive to public needs. The operators not only rely on the government to sell the spectrum licenses but also depend on government help to launch their services. So why cannot the government ask these operators to allocate a small percentage of their capacity to provide free Internet to the under-privileged? The government could also provide incentives to such operators by tax reductions and offering other benefits. There is a mutual benefit for both the government (to show that it is taking care of the welfare of the people) and the operators (who get additional perks).

2. Lower pricing models: The solutions described here could give opportunity for charities/organizations to become virtual network operators by buying services from

wholesale operators at a lower cost for lower quality of service. This provides better utilization of the resources and new avenues for revenues for operators. This also paves way for local councils/municipals to provide free Internet access at LBE without unfairly competing with incumbent providers and thus avoiding any litigious problems [22].

3. Incentives for sharing a user's connection: One compelling justification is that when access (low speed, low quality) is provided, the under-privileged may see new opportunities and realise the benefits of the Internet. They mind find a compelling need to improve on the level of service and which in turn can attract more customers (when they are able to afford). So the network operators can see this as giving free service to trial out their system and build brand loyalty apart from the government perks mentioned earlier. There may be other advantages for the service providers (for e.g. access to more user data for targeted advertisements). This in turn can enable network operators to provide discounts to users who share their Internet connection.

4. The content centric argument: Based on the content centric argument [23], allowing more users to access the Internet enables more efficient caching at the edge nodes which in turn provides faster access to vital data (performance incentive to the user) and also reduces the need for unnecessary transmission of data over the network (cost incentive for the operator).

5. Access to Open Data: The UK government is working on the Open Data Initiative [24] where all the non-personal data that government agencies collect (crime, health, transport, economic stats etc) will be available to anyone who has Internet access. However people without Internet access will be deprived of this democratic right. Hence the government could ensure that the open data could be only available via network operators that also offer free LBE access to urban and rural users on top of their normal higher quality service. This would create an incentive for network operators to deploy LBE access.

4 Conclusion

In summary, we propose the following:

1. Free Internet is definitely not a distant mirage - this could be achieved by identifying and engineering technologies that could enable new modes of access - either by network operators distributing their unused capcity to the under-privileged or by network providers allowing their privileged customers to share their Internet connection to the under-privileged or by provisioning a free IP address space for essential services so that these services could be accessed for free.

2. Through this paper, we propose that the research community should explore the possibility of using LBE QoS in access networks or protocols/methods such as LEDBAT and enable current applications such as the web to work over these protocols/methods. There should also be support for delay-tolerant networking over

these access networks. This would enable transmission of data that would allow a user to use a shared link without affecting or competing for resources of the user who is sharing the Internet connection. Such methods can open up the science to look at new ways of providing free Internet connectivity based on the concept of "I am not affected, so no harm in sharing my connection".

3. Open source technologies should be more widely deployed.

4. We need to encourage donation of old smart phones, devices etc - these devices would be used together with open source technologies to provide access to the needy.

5. NGO's and other organizations (health, education) should support and enable this change to happen.

6. However, it is virtually impossible to provide the notion of free connectivity without fundamental overhaul in the current economic, social, political and most importantly to support new technological innovations. Telecom regulators should support this change. Governments should change their policy to encourage these initiatives - by providing incentives to network providers who distribute their unused capacity or allow their customers to share their capacity.

7. Finally, we would like to stress an important point: as network access speeds increase in the future, today's Less than Best Effort service would be tomorrow's Best Effort service. So it is better for the research community to start thinking about this sooner than later and encourage new initiatives in the directions mentioned in this paper.

There could be more and better ways of doing this. We hope this paper would encourage the Internet community to come out with more ideas that could enable free Internet to the under-privileged a near reality.

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