On the State and Guiding Principles of Broadband in India

[1, 2] Ashwin Gumaste, [1] Prasad Gokhale and [1] Asheesh Dhar
[1] Department of Computer Science and Engineering, Indian Institute of Technology Bombay
[2] Research Laboratory in Electronics, Massachusetts Institute of Technology, MA, USA, 02139
Corresponding Author email: ashwing@ieee.org

Abstract: India – home to 1.2 billion people and a GDP growth of 9%, has been experiencing flat to modest growth of Internet services in the past decade, this despite the fact that India continues to add 8-10 million cellular connections each month. In this paper, we examine the reasons that affect the high cost of bandwidth in India and steps required to reduce the same. We also argue that the usage based pricing model, which is widely used for billing retail customers in the country, is hampering the growth of local content and services. On the contrary, a flat rate pricing model will spur demand for Internet services and enable content providers to target the local and emerging market. We study the Indian telecommunication scenario from a pricing and technology perspective and understand what the driving forces are for business to prosper. We then discuss the Indian landscape from a metro/access/long-haul networks perspective. The technology choices and the methods of deployment are considered followed by a detailed analysis on the service-centric model adopted by providers. Based on these discussions we outline the problems associated with broadband in India and what needs to be done to absolve these.

I. PRELIMINARIES

Internet usage in India has grown at a modest rate in the past few years quite in contrast to the nearly 9 million cellular lines that are being added per month. While the number of Internet subscribers in India has been growing at about 25% from 2004 to 2007 [3] (see Fig. 1), the actual consumption of bandwidth has been a poor 87 Gbps [1]. This subscriber growth has significantly been lesser than what was expected, and is about 6 % of that of People's Republic of China, and 4 % of the United States [17, 18].

Particularly worrisome is the sluggish growth in the broadband sector for both retail customers and small enterprises. These segments have historically across the globe implied emergence of access users leading to voluminous growth and Internet proliferation thereby achieving e-democracy and e-governance. Penetration of broadband in India remains low and the targets set in the national broadband policy remain unachieved (as shown in Table 1), further shown in Fig. 1.

Year Ending	Internet Subscribers (in millions)		Broadband Subscribers (in millions)	
	Target	Achieved	Target	Achieved
2005	6	5.55	3	0.18
2007	18	9.27 till March 07	9	2.34 till March 07

Table 1. Targets set in the national broadband policy and what was actually achieved [2, 16].

The current demand for Internet bandwidth within the country is driven primarily by software exporters, Information Technology Enterprise Solutions (ITES), banking, software service providers and the finance sector. Most of these industry segments are classified under the umbrella of BPO – Business Process Outsourcing – thereby making broadband a key to the world's back-office – India. Home users only constitute a small share (typically in single digit in terms of usage) of this demand. Applications of broadband in the western world such as healthcare, *telemedicine* and *video-on-demand* are either missing or are in negligible numbers. Even when present, such home-applications are limited by the Service Level Agreements (SLAs) in the last-mile (residential users). The number of Internet subscribers in the country is small and those with a high speed broadband connection is even smaller. Hence, the present market for targeting local content and customized Internet services is negligible – a legacy of the permit policy followed by successive Indian incumbents limiting the gateway and access rights of international bandwidth into the country – submarine landing points.

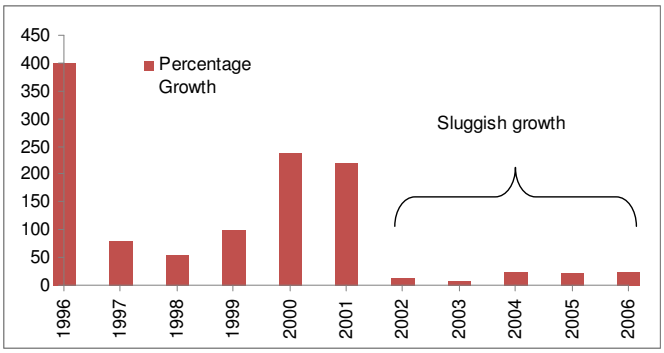

Fig. 1. Percentage growth of Internet subscribers over the years [3].

While the Indian economy is rapidly growing at 9 % per annum resulting in a huge untapped market for ISPs (Internet Service Providers), the retail segment despite its high Purchasing Power (PP), has not blossomed to entail creative, competitive and cumulative business. There is stagnation in the growth of Internet services in India which leads to saturation of broadband needs. Most retail customers have Internet connections that are narrow (<256kbps). This has implied that prevailing applications are restricted to emailing and web-browsing with limited multimedia content. The pricing structure of broadband in India is arguably one of the highest in the world, making it an elite or luxury item, denying the common man the right to information. Surveys and blog [13] entries have suggested that small enterprises and

residential users want better (more) bandwidth at an affordable price. Why does such a broadband scarcity scenario prevail?

II. BANDWIDTH STARVATION – AN ANALYSIS

First, the cost of bandwidth in India is high (see Table 2). Both retail and corporate customers are deterred by this high price of bandwidth in the country [11] primarily due to the near monopolistic policies over the past decade exhibited at landing points of submarine links. Indian enterprises use high-orders of statistical multiplexing catering to a large number of internal users with minimum dedicated bandwidth.

Second, the usage based pricing model that is presently deployed for retail customers dissuades them from extensively using the latest Internet multimedia services like VOIP, video sharing, streaming media and social networking portals. Retail users hence use less bandwidth consuming (intensive) services such as browsing, e-mail and chat.

Third, since the number of users with high speed connections is low, next generation Internet applications, content providers, and data centers that need more bandwidth have been weary of putting shop in India. Though this trend is now somewhat changing with the arrival of Yahoo and Google servers for local use, it would take a long time if all the gap between the content available in the western world and India is to be bridged. This in turn results in consumers not wanting high-speed Internet connections, as they do not use services that need such connectivity. This feedback loop creates the fallacy of local intra-networking which explains the rise, penetration and success of cellular services for both voice and SMS texting applications. The short term benefit and the hype generated by cellular technology is often heralded as a telecom revolution, neglecting the deeper malaise caused by denial to voluminous, dynamic and much-needed information.

Country	*Price per Mbps per month in USD*	*Country*	*Price per Mbps per month in USD*
South Korea	0.34	China	23.18
Sweden	0.65	Thailand	30.36
Germany	5.33	Sri Lanka	40.90
United Kingdom	11.31	Slovakia	51.48
Poland	13.33	India*	88.61
Luxembourg	18.97	Myanmar*	261.75

Table 2. The table shows the price of broadband connectivity as on July 2007 in different countries of the world. Countries marked with * have monthly download limits (eg. 2GB). Source is [13].

Poor Quality-of-Service (QoS) has also been blamed for sluggish broadband Internet services in the country. It was only in 2007 that TRAI (Telecom Regulatory Authority of India) formulated guidelines for ISPs regarding QoS. It is debatable as to how much of these QoS needs are actually implemented at a consumer level. Users have little incentive to switch to a broadband connection if the service provided by the ISP falls short of standards desired for multimedia content.

In most places, though the network is new, and there is available installed capacity, the actual in-use capacity is only a fraction due to stingy CAPEX budget and lack of business foresights. It is worthy to note that unlike the developed world, where providers have in-house research laboratories (AT&T Laboratories, Deutsche Telecom Laboratories etc), not a single provider in India has in its agenda a mission or need for laboratories that focus on telecommunication research. The mantra has all along been to be educated through vendor technical marketing, which as is well established, does not lead to healthy networks with emerging technological innovations.

To make matters worse, a unique provider-vendor business model has emerged, one that brings in the vendor to lease equipment to a provider, thereby sharing profits (between the vendor and the provider). This implies that the network is at the mercy of the vendor in terms of technology roadmaps, as long as the vendor can provide for the basic business needs of the carrier. This also implies that the provider is more focused on its marketing and sales strategies than on the actual ownership of the network. In fact, most of the overheads are in sales and marketing, neither of which is directly responsible for good network planning or vision into technologies of the future.

In the sections to follow we will examine each of the reasons listed above that are key to the sluggish growth of broadband in the country. We will first analyze why bandwidth in India is expensive, even more than countries with lower GDP and lower purchasing power. Subsequently we will discuss the advantages of using the flat-rate pricing model over the usage based pricing model. We will present thoughts on how the flat pricing model should be inculcated and how it could enhance the citizens' lifestyle.

Fig. 2. Landing points of submarine cables in India. Also shown are important Indian cities and major ISPs.

III. INDIA'S NETWORKING INFRASTRUCTURE

Submarine Cable Systems: International connectivity to a country as large as India (7th largest in the world with 6000+

kms of sea border) is primarily provided through submarine optical cable systems. A submarine cable system comprises of optical fiber cables that run through oceans and connect cable landing stations located in different countries. International submarine cables terminate at a *cable landing station*. These cable landing stations are in turn connected to backhaul facilities which link them to a service provider's existing national communication infrastructure / backbone. It must be noted here that a cable landing station is an important "choke point" for an incumbent international operator to thwart competition. According to [1], India had 9 cable systems and 6 cable landing stations with a total design capacity of 18.6 Tbps.

The cable owners may use tactics like *differential pricing* between their associates and competitors; delay or deny capacities required by competitors and obstruct access to facilities and co-location at their cable landing stations. Most of India's landing points till recently were controlled by a single operator, and even now, are controlled by a handful of operators with issues such as conflicts of interests with other local operators. For example if providers A and B control all the landing points into the country, and if further, providers A and B also have business interests in networks within the country (intra-country metropolitan, regional and access networks), then a smaller regional operator C is at the mercy of the pricing policy that A and B dictate. This implies that, even if C would *like* to roll out lower-cost broadband services, it cannot do so, due to the pricing monopoly by A and B who choke bandwidth connectivity to the rest of the world. It is hence not surprising that only a fraction (3.5 % as reported in [1]) of the 18.6 Tbps bandwidth is actually lit-up and made available to the country. Naturally, a large portion of this bandwidth is used for enterprise and institutional customers. Despite an exhaustive search it was found difficult to compute the exact percentage of bandwidth made available to residential users. While of the 18.6 Tbps installed capacity as of 2006, only 655 Gbps has been lit up (provisioned). Of this 655 Gbps available bandwidth, we *estimate* about 500+ Gbps is made available to enterprises and institutional customers, thereby resulting in 155+Gbps capacity to a nation of 1.2 billion people. At an average user-utilization factor of 25 (1 in every 25 users is online at a given time), if we were to distribute this approximate <200 Gbps of bandwidth in the population above the age of 18 (which is about 800 million), each person would get 250 bits per second of net connectivity and 6.25 kbps of shared connectivity (at 1 out of 25 users being active). Given that about 500 million of those individuals have no access to computing resources (falling below or just above the so called poverty line of making around 2USD per day), would imply a net 667 bits per second of net bandwidth – less than 1 kbps, thus allowing 25 kbps or so of shared connectivity. It must also be noted that at the time of this writing developed countries particularly in the Far East and Western Europe have rolled out 50 Mbps of net bandwidth per home/user at price points lower than those available for the 100~256 kbps shared capacity present in India today.

Nationwide, Metro and Access Networks: Domestic traffic within the country is transported on nationwide networks of various telecommunication operators. For example, BSNL (Bharat Sanchar Nigam Limited) the state owned operator has a National Internet Backbone (NIB) which connects more than 71 cities through an MPLS (Multi Protocol Label Switched) core over a WDM optical backbone. Optical fiber networks in India are being rapidly deployed. Table 3 lists the major players in the domestic optical fiber network arena and the length of optical fiber that they have deployed showing the tremendous opportunities for growth. These optical fiber networks offer services like MPLS, IP-VPN, SDH circuits, and Metro Ethernet services. It can be seen that sufficient domestic communication infrastructure exists but is not utilized.

The last mile (connecting end-users to service providers), except in metro cities is primarily non-existent. In metro cities, copper cabling is available which can support lower variants of DSL such as ADSL2. As mentioned in [6] more than 95% of the country's urban copper network is owned by incumbents such as BSNL and MTNL (Mahanagar Telephone Nigam Limited) and was deployed for telephony purposes. Multi-tenant unit (MTU) type homes have implied large distances – of the order of 1000+ feet from the nearest POP, thereby limiting the use of advance variants of DSL such as VDSL which can give 10 Mbps or so of connectivity. DSL (Digital Subscriber Line) remains the most widely used technology to deliver broadband Internet services. For those tier 1 and tier 2 cities without copper infrastructure, some initial deployments of WiMAX have begun. It is debatable as to how deep can WiMAX penetrate into the residential broadband market on account of the following reasons: (1) high cost of basic bandwidth; (2) regulation issues in the 2.4 and 5.2 GHz spectrum; and (3) high cost of Customer Premise Equipment (CPE) of the order of 200 USD per home. In select tier 1 cities the incumbent provider (owned by the government) has begun some basic deployment of FTTH (Fiber to the home) and FTTC (Fiber-to-the-Curb). While this is a good sign, much at par with the happenings in the developed world (South Korea, USA, Japan, UK), the deployments are far too less to make a business impact. The key again is the absence of a comprehensive ROI (return on investment) model, thanks much to the current broadband pricing strategy as a result of bandwidth choking.

Network Operator	*Length of OFC Deployed in Kilometers*
Bharat Sanchar Nigam Limited	550,000
Videsh Sanchar Nigam Limited	40,000
Reliance Communications	80,000
Bharti	70,000
RailTel	30,000
Power Grid Corporation	19,000

Table 3. OFC Networks in India.

The Internet Exchange: Another important component of Internet connectivity in India is the National Internet Exchange of India (NIXI). Four NIXI nodes were originally setup at NOIDA (North India), Mumbai (formerly Bombay), Chennai (formerly Madras), and Kolkata so that ISPs could peer among themselves and route domestic traffic within the country. Peering is an arrangement between two service providers to exchange traffic between their customers. In most cases peering arrangements do not involve either of the service providers paying any money to the other. For peering, service providers need to physically interconnect their networks so that they can directly exchange traffic between their customers. In this way the ISPs avoid paying a transit fee to a third carrier (generally a higher tier ISP) who would have otherwise provided such connectivity. These NIXI nodes have been scantily used for peering purposes. This was an effort that was genuine in conceptualization but failed in implementation.

With this aforementioned background on network structure in the country, we now discuss the broadband costing structure – leading to sluggish broadband penetration in India.

IV. BANDIWDTH WOES

High cost of bandwidth is a major reason for the sluggish growth of Internet in India. The problem is on three fronts: (1) expensive international connectivity through submarine cables, (2) poor network operations by ISPs and (3) an underdeveloped last mile infrastructure.

In the year 2000, a study by NASSCOM (National Association of Software and Service Companies) [12] estimated that India required 5 Gbps of international bandwidth but at that time had an installed base of only 325 Mbps available. In contrast, a large US university alone, in 2001, had more than 500Mbps of connectivity. Till 2003-04 the international bandwidth entering the country remained scarce. This was the main reason why the price of bandwidth in India was high. There was only one incumbent selling bandwidth, and dictating the cost to end-users. However, with the opening up of international bandwidth sector to private players in 2002, the situation today has improved [10], though of course, it lags behind the international market by at least 2 orders of magnitude. By the end of 2006, the cost of international bandwidth had fallen more than 50% than what it was in 2000, but was still about 500% as compared to other developing countries and one order of magnitude higher than that of the developed world [13]. The Telecommunication Regulatory Authority of India (TRAI) has made several attempts to fix international pricing, but has failed to enforce a Quality of Experience (QoE) to end-users as well as enforce penalty to providers that violate SLAs. No study is available on the total penalty that has been levied on providers for not meeting broadband SLAs, though it is commonly known that broadband SLAs are not honored from an availability and reliability perspectives. This monopolistic trend and ability to get away with theft is because competition between submarine cable owners has not matured in India. Some of them continue to engage in monopolistic practices such as, refusal to permit interconnection at their cable landing stations and delay or deny provisioning of bandwidth for competitors. Clearly, the need of the hour is to have an act that would limit companies engaged in submarine intercontinental networks to also deal in intra-country networks. In the very minimum, deregulation must happen as it did in 1996, in the United States of America. International cable operators have also failed to activate additional capacity on their cable systems. This has resulted in artificial shortage of bandwidth into and out of India which has inflated prices. Monopolistic practices by backbone providers must be regulated by unbundling the backbone. Anyone should be able to buy dark-fiber coming into India and light it up. A possible suggestion would be to allow 25% of every submarine fiber (10 wavelength channels) to be used by third parties, sold in an open auction.

The way ISPs operate in India is also a reason for high bandwidth prices. ISPs act as bandwidth resellers rather than network operators [7]. No effort is made to peer with other networks, reach out to content owners or optimize network operations. The network is designed hierarchically for the ISP alone – no gateway traffic with other providers is assumed at the beginning, and as the inter-provider traffic (peering) increases, the pricing for the same rises near exponentially. In a majority of cases, the lack of peering between ISPs results in domestic Internet traffic being routed over international cables only to come back into the country. This wastes precious international bandwidth and incurs huge delays. In fact, to a certain extent NOCs (Network Operation Center) themselves are not aware of this, resulting in erosion of net-profits for the ISPs. It is highly recommended that ISPs interact with content providers and welcome them into their networks. To do so, content providers need to be given a lower pricing model. NIXI was formed so that ISPs could peer among themselves and reduce latency for domestic traffic. However, NIXI's infrastructure remains underutilized [5] as limited number of ISPs have joined it and some of them are not declaring all their routes. So a significant amount of domestic traffic still gets routed internationally, with ISPs paying international rates for domestic traffic. Hence, Indian ISPs are unable to convince owners of popular content and datacenters, to move their services to India, with the commonly used false argument that their users here will experience a better response time. The cost of operating a data center in India is 2 orders of magnitude more than the same cost in the United States. Data centers are critical to host content. This has also meant that it is difficult to create, disseminate and popularize information – thereby creating a digital divide.

ISPs need to demonstrate that they have requisite network operations and peering capability so that national and international content providers and datacenters locate themselves in India. For ISPs this will reduce the costs associated with buying international bandwidth and their networks will also grow.

Merely creating bandwidth will not suffice. There must be efficient means to deliver it to the user. The last mile in India still remains a bottleneck [6]. Creating last mile infrastructure involves huge costs with tangible ROI models that are brought about through good governance, price-points, fair competition and strong customer base.

In urban centers, the existing copper network needs to be utilized as much as possible to offer advance variants of DSL connections to customers. With the incumbents having complete monopoly over the existing infrastructure and reluctant to work with other ISPs, it is difficult for a single provider to meet the needs of urban populations. India accounts for 7 urban cities in the list of top 20 population centers in the world. Sufficing such large requirements implies heavy capital expenditure. The capital expenditure must be justified with short return on investment cycles. With bandwidth being the single largest cost in terms of operating expenditure no single or multiple ISPs can roll out efficient last mile networks. Thus, ISPs are unable to increase their reach and scale operations. The existing copper infrastructure in select cities was built for voice, and is now a good source for tier 2 broadband communications (emailing, web-browsing). However, as energy sources dry up and the need for telepresence, telecommuting, and video-on-demand increase, even the scantily available copper infrastructure would not be able to provide broadband connectivity. Roll out of WiMAX services would temporarily solve the problem, but mass roll out due to CPE pricing and limited bandwidth offered by the wireless spectrum (further statistically shared), would lead to an even bigger crisis. Urban India at that point stands to be one of the biggest centers of the digital divide.

Unbundling of the local loop is necessary for real competition to be brought about in the Indian broadband sector. Just access to the copper network will not solve all problems of the last mile since the quality of the copper, in terms of diameter and age, is also in question. In such a scenario it might be worthwhile a combination of alternatives such as cable, fiber, wireless, in particular in combinations (fiber to the curb + wireless) to provide last mile broadband connectivity. These alternatives also have their own set of problems. For example, cable (CATV) in India is chaotic, disorganized and employs primitive technology. But its reach is vast. There are 78 million cable TV homes in India [15]. If telecom companies tie up with Multi Systems Operators (MSOs) / last-mile cable operators and make proper investments, there is a huge opportunity to roll out cheap broadband services in the country. With wireless technologies such as WiMAX there is always the problem of spectrum allocation, even though it must be noted that wireless has the potential of connecting rural and geographically dispersed areas. In rural areas where incomes are traditionally low, the affordability of broadband (even if it is available) is a problem.

Copper wires have their limitations and must be seen as a temporary short term solution. FTTH and FTTC is the long term solution for broadband services. If “triple play” of voice, data, and video is to be offered to Indian consumers, deploying fiber in the last mile is *inevitable*. Also, there are enough applications to justify its deployment. Applications such as Video on Demand, IPTV, telepresence, and online gaming require high bandwidth – naturally provided by the optical fiber. There is huge demand for video services and IPTV in most parts of India, which needs to be tapped as well as fostered as the key enabler for next generation information access. The cost of deploying FTTC is gradually decreasing and today it is an affordable solution. Moreover unlike in the Western world, where fiber laying costs are astronomical, the per-km fiber laying costs in India are just a fraction of those. Making the decision to roll out fiber in the last mile will prove to be a wise business move for incumbents as well as new service providers. The highly trained manpower in the country would have excellent access to resources through broadband trunk lines facilitated through fiber networks. The operational expenditure in maintaining a fiber based network is far less than that of a copper network. It is important that Indian telecom companies start making major investments in deploying FTTH and FTTC with last inch (from the curb site to the homes, multi-tenant units) using either cable or wireless. This will lead to convergence and propel demand for bandwidth and content. Providers will grow by offering new services through their advanced networks at affordable price-points. A high-speed access network will also make good use of the already deployed, but scantily used metro optical network. The metro network will be a good facilitation of bandwidth to the access. It is important that new service providers emerge and are allowed to do business at international price points. The entire society will benefit from the information highway – the Internet.

As can be understood from the discussion above, high price of Internet in India is mainly due to lack of proper regulation, skewed competition and mismanagement rather than technical constraints.

V. PRICING PHILOSOPHY

We have seen the reasons that have led to the high price of bandwidth in India. What beats the well known demand-supply curve is the basic pricing philosophy. This pricing philosophy defies at a certain level, conventional wisdom – when demand all over the world for broadband is increasing, in India, it is only flat or optimistically growing. This despite the fact that the Indian economy is doing well. The pricing model used by ISPs in India for retail customers is the culprit for this situation [19]. All major ISPs in India, employ a *usage* based pricing model [9] unlike the flat-rate pricing model which is prevalent in most parts of the world.

ISPs in India use a per-megabyte pricing model. For each subscriber, an upper bound is placed on the total data transfer that the customer is allowed per month, for which a fixed fee is charged. For usage beyond the specified limit, the customer is charged for every additional mega-byte of data transfer.

Very few unlimited usage plans are offered by these service providers. Moreover, the price of these plans is high. Usage based pricing model has been an impediment in the growth of Internet related services in India. It deters price conscious users from trying new content and services. It also becomes an obstacle for local Internet technology firms and content providers to role out new products and services aimed exclusively at the Indian market.

The flat-rate pricing model has advantages both for the service providers and the retail customers [9]. Service providers save the overhead of deploying a system for tracking and billing for usage. In fact a system that does implement such a usage based model, in principle can lead to intrusion in privacy – with techniques such as MAC binding and static IP allocations. With a flat pricing model the ISP knows the amount of payments it will receive from its subscribers and can budget accordingly. For retail customers it provides convenience of use and a predictable fee. In the developed world much of content providers and online communities have blossomed through such free-choice of consumers – allowing consumers the freedom in the choices they make without worrying about per-megabit download prices. It can be said that the flat-rate pricing model has been an important factor for the growth of the Internet. It has enabled the Internet to become a kind of an online public library where one can find information for "free". By denying this basic tenet of the Internet, Indian ISPs have pushed further the wedge caused by the digital divide. It is hence an opportune time for the regulatory authority to come in and make an impact by: (a) de-licensing the landing points, thereby making international bandwidth cheap and (b) doing away with usage based models. In fact, due to the presence of state-owned ISPs, the state is in an excellent position to bridge the widening digital divide, thereby setting an example and also lowering price of broadband.

One could also argue against the usage based bandwidth price model, as something that sells information which is available across the Internet for free! The flat price model, is well justified as one, in which the ISP charges the customer for the network (CAPEX and OPEX that the ISP plugs in to maintain the health of the network), and not for the content (or amount of content) through the network.

The data transfer in a usage based model is typically at data-link layer (frame-transfer) – and hence the consumer pays for protocol packets in addition to actual data. This pricing model has its problems. Users may be charged for information they do not want or did not request. For example, spam, pop-up advertisement windows, and video advertisements before the actual video. Also most web sites today have rich graphics and multimedia content which will make the user pay higher access charges.

The prime argument against usage based or the time pricing is that it limits the user from exploring the services and information available on the Internet. A subscriber is less likely to "surf" the Internet when a background counter is ticking. This makes it difficult for content providers to attract Internet users who are shy of using any bandwidth heavy services such as video-on-demand, streaming-media, online-games and teleconferencing, for the fear of being excessively charged. It can be concluded that usage based pricing is jeopardizing the growth of Internet in India as it results in monetary disincentives for producers and consumers of content and services.

VI. CONCLUSIONS

Growth of Internet in India has been impeded because of high prices, a flawed pricing model and weak demand for Internet related services. Artificial shortage of international bandwidth, poor network operations, and difficulties with the last mile have lead to high cost of bandwidth in India despite a decent metro and core networking infrastructure. The usage based pricing model has not allowed content or demand to grow. Localized content is unavailable resulting in low demand for Internet connectivity by retail customers. Hence, we have a scenario where the growth of Internet in general and broadband in particular has slowed down. Unbundling the international cables, better peering by ISPs, and competition through regulation will decrease the price of bandwidth in India propelling the much needed increase in broadband demand. Employing the flat-rate pricing model will increase demand for content and services. These steps will enable acceptance of the Internet to grow at rapid rate in India.

A country that has just added 8.6 million mobile (cellular) [14, 20] subscribers in the month of December 2008 has a very low broadband penetration rate. Likewise 78 million homes have cable TV. These two growth features (cellular and cable) point out clearly that whenever localized operations are possible, the price structure is there to sustain it, while whenever the operations require global interconnection, the pricing structure fails and there is no demand for the same. Cellular pricing in India at 2.5cents a minute, with no pricing restrictions on incoming calls, makes it one of the lowest in terms of cost of ownership. Similarly, most cable users pay less than 5 dollars a month for all cable channels which in the Western world costs 50 dollars per month. Our observation is that urban India is more geared towards the television as an information tool rather than the Internet, implying that choice in terms of content takes a secondary step, quite counterintuitive to the choice offered in the developed world.

The localization and fixed bandwidth transfer of cellular traffic and the in-home availability of cable content allows mobile and cable operators to aggressively price these services thus resulting in unprecedented growth. The question then is why the same cannot be implemented for broadband – a service that is key to the success of the future generations.

While physical infrastructure is hard to improve, it is certainly possible to improve the information infrastructure in particular the last-mile – an investment that would empower broadband in citizen's homes. A fiber based last mile infrastructure coupled with islands of wireless connectivity would ensure cost-effective access to information and

eventually facilitate an increase in the countries' GDP, partially alleviating energy problems through reduced transportation and contributing to growth.

REFERENCES

[1] Telecom Regulatory Authority of India, "Consultation Paper on Access to Essential Facilities Including Landing Facilities for Submarine Cables) at Cable Landing Stations", April 2007.

[2] Telecom Regulatory Authority of India, "Study Paper on Analysis of Internet & Broadband Tariffs in India", November 2006.

[3] Telecom Regulatory Authority of India, "Consultation Paper on Review of Internet Services", December 2006.

[4] Telecom Regulatory Authority of India, "The Indian Telecom Services Performance Indicators April – June 2007", October 2007.

[5] Telecom Regulatory Authority of India, "Consultation paper on Improvement in the Effectiveness of National Internet Exchange of India (NIXI)", October 2006.

[6] S. Arora, "Nothing Broad about it!", http://www.expresscomputeronline.com/20040719/indiatrends01.shtml, July 2004.

[7] Tarun Dua, "Buying corporate bandwidth in India", http://tarundua.net/corporate/bandwidth, March 2007.

[8] Thomas K. Thomas, "India's Net connection slow, unreliable: Report", http://www.thehindubusinessline.com/2008/03/10/stories/2008031050200300.htm, 10 March 2008.

[9] Telephony Online, "Usage-based pricing", http://telephonyonline.com/news/telecom_usagebased_pricing_3/, May 2002.

[10] John C. Tanner, "The rebirth of the wholesale", http://www.telecomseurope.net/article.php?id_article=3437&page=1, January 2007.

[11] "Internet Poll Verdict: Indian Broadband connections are expensive…but why ?", http://trak.in/tags/business/2008/05/12/indian-internet-poll-expensive-broadband-connections-analysis-india-business-blog/

[12] Business Line, "More Bandwidth is NASSCOM Mantra", http://www.hinduonnet.com/businessline/2000/06/02/stories/150239g9.htm, 2 June 2000.

[13] "Global Broadband Cost Comparison", http://www.dailywireless.org/2007/07/09/global-broadband-cost-comparison-2/, July 2007.

[14] Telecom Regulatory Authority of India, "Telecom subscriber growth for the month of May 2008", May 2008.

[15] Telecom Regulatory Authority of India, "Draft Recommendations on Restructuring of Cable TV Sector", 15 July 2008.

[16] Telecom Regulatory Authority of India, "A journey towards excellence in telecommunication 2007", 21 September 2007.

[17] Internet World Stats, "China: Internet Usage Stats and Telecommunications Market Report.", http://www.internetworldstats.com/asia/cn.htm, December 2008.

[18] Internet World Stats, "United States of America Internet Usage and Broadband Usage Report.", http://www.internetworldstats.com/am/us.htm, December 2008.

[19] Online: http://harvardbusinessonline.hbsp.harvard.edu/b02/en/common/item_detail.jhtml?id=704426

[20] A. Gumaste et. al, "Broadband in India: Sparse and Farce," IIT-Bombay Technical Report, 2009.