An Assessment of Pricing Mechanisms for the Internet--A Regulatory Imperative

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1 Introduction

This paper argues that however much of an anathema the notion of regulating the Internet may be, there is a strong need to start putting the appropriate regulatory structures in place as the commercialized Internet moves incrementally towards a usage-based pricing system. Various factors such as new bandwidth-hungry applications; the massification of the net; the concerted entry of the telephone, cable, and software companies; and the proliferation of electronic commerce all imply unimaginable potential growth rates for the Internet and a resultant scarcity of bandwidth, thus making it imperative to put a pricing system in place that would effectively ration scarce bandwidth.

As has been argued by many, a usage-based pricing system seems to be an innovative way to effectively ration scarce bandwidth. In this context, this paper examines the Precedence and the Smart Market models of Internet pricing. We note that (a) the perceived homogeneity of the Internet's load, and (b) the threat of market-power abuse through artificial creation of a high network load by those who control the bottleneck facilities, remain the fundamental weaknesses of usage-based pricing. However, given that usage- based pricing is inevitable, and that the Smart Market mechanism does present an innovative and a potential solution, it is important to consider the appropriate safeguards that need to be put in place. In this context, the paper argues that a usage based, free market pricing system needs to be combined with some form of regulatory oversight to protect against anti-competitive actions by the firms controlling the bottleneck facilities and to ensure non- discriminatory access to emerging networks.

2 The Different Dimensions of Growth

The Internet, which has hitherto been restricted as a resource for high level researchers and academics, is "expanding to encompass an untold number of users from the business, lower-level government, education, and residential sectors" (Bemier, 1994, p. 40). Studies done by Merit Network Inc. [1] [#n1] indicate that the Internet has grown from 217 networks in July 1988 to 32,370 networks in May 1994. The number of hosts have increased from 1,000 to over two million over the same period, with about 640,000 of these located at educational sites, 520,000 at commercial sites, 220,000 at governmental sites, and the remaining 700,000 at non-US locations. Traffic over the NSFNET backbones increased by 10 times in three years, from 1,268 billion bytes in March 1991 to 12,187 billion bytes in May 1994. The traffic history of packets sent over the NSFNET shows similar exponential growth trends. As against 152 million packets in July 1988, 60,205 million packets of information were sent over the system in May 1994; an increase of almost 400 times. [2] [#n2]

These stunning growth figures are just a precursor to the boom in Internet traffic that is expected to take place in the near future. As will be laid out in this paper, a set of factors in combination are threatening to dwarf even these exponential growth rates in the near future.

3 The Causal Model of Internet Congestion

As illustrated in the chart, a set of forces working together are threatening to create unprecedented levels of congestion on the Internet. It is argued that three main factors—incompatibility of the newer applications with the Internet's architecture, massification of the Internet, and privatization and concomitant commercialization of the Internet—are responsible for an inherent change in the Internet's dynamics, thus mandating a reexamination of the economic system that surrounds the Internet.

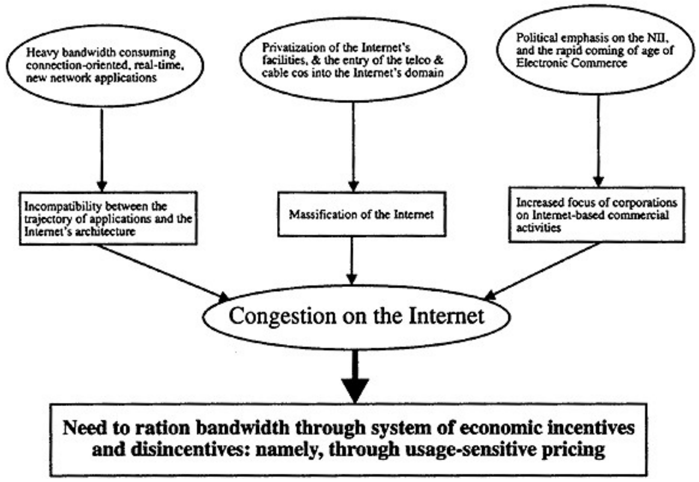

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Figure 1

3.1 Incompatibility issues

New network applications are all tending to require heavy bandwidth in near-real time. As Bohn et al. note, "one may argue that the impact of the new, specifically real-time, applications will be disastrous: their high bandwidth- duration requirements are so fundamentally at odds with the Internet architecture, that attempting to adapt the Internet service model to their needs may be a sure way to doom the infrastructure" (p . 3).

Their technical characteristics and, consequently, their demand on the network are very different from the more conventional, traditional electronic communication and data transfer applications for which the Internet has been designed. [3] [#n3] While conventional electronic communication is typically spread across a large number of users, each with small network resource requirements, newer applications such as those with real-time video and audio require data transfers involving a continuous bit stream for an extended period of time, along with network guarantees regarding end-to-end reliability. Even though the data-carrying capacity of the networks is constantly being enhanced through upgrades in transmission capacity and switching technology, current developments in communication software, especially those related to multimedia, are creating network applications that can consume as much bandwidth as network providers can supply (Bohn, Braun, Claffy, & Wolff, 1994).

Multimedia Netscape applications, Internet fax, and Internet radio are becoming large users of resources (Love, 1994). Russell (1993) reports that while only 2.4 kbps are required for communication of compressed sound, 3840 kbps are required for CD quality stereo sound. Real-time video needs bandwidth ranging from 288 kbps to 2000 kbps, while studio quality non-real time video could require up to 4000 Kbps. HDTV requirements range from 60,000 to 120,000 Kbps. [4] [#n4] Bohn et al. (1994) report that many videoconferencing applications require 125 kbps to 1 Mbps. Although compression techniques are being developed, the requirements are still substantial CUSeeMe, developed at Cornell University uses compression, yet its requirements are in the region of l00 kbps.

In essence, the trend is towards applications that are, first, heavy bandwidth consumers and second, require near real-time transmission—both characteristics that are essentially incompatible with the inherent architecture of the Internet.

3.2 Privatization, Commercialization, and Massification

Simultaneously, we are witnessing a privatization of the Internet's facilities, increasing commercialization of the net, and a political agenda promoting the rapid deployment of the NII. All these are resulting in a massification of the Internet, as it becomes easier to get "wired" in. The bottom line implication is that the demand for bandwidth is possibly rising beyond current levels of supply.

Prior to 1991, the net's physical infrastructure was government-owned and operated. On December 23,1992, the NSF announced that it will cease funding the ANS TS backbone in the near future. The Clinton Administration's thrust on private-sector investment in the NII implies that very soon, possibly by 1996, the Internet's facilities will be largely privatized. In 1994, the NSF announced that the developing architecture of the Internet would utilize four new Network Access Points (NAPS), and the contracts for operating them were awarded to Ameritech, PacBell, MFS, and Sprint. In addition, MCI has been selected to operate the Internet's new very high speed backbone (vBNS).

The traditional telecommunication companies operating in a nearly saturated and increasingly competitive domestic market, are turning their focus towards advanced data services, a market where the "number of data relationships is growing at more than four times the number of voice relationships" (Campbell, 1994, p. 28). Spurred on by the promise of the NII, a variety of communication companies are getting into the act. "(T)elephone companies, cable companies, information service companies, television networks, film studios, and major and software vendors are all maneuvering to ensure that they are well positioned to profit from the NII in general and the Internet in particular" (Business Editors, 1994).

Of all these players, the telephone, software, and cable companies are in a position to strongly affect one critical aspect of market: accessibility. User-friendly software, enhanced services, and marketing skills are together likely to have a dual effect: one, allow computer literate users who have been to date outside the periphery of the net the opportunity to connect, and two, drive the development of user-friendly tools of navigation, which would have a multiplier effect on both network usage and the number of people who would be able to navigate through the Internet effectively and access desired information bases productively .

Bernier (1994) reports that the telephone and the cable companies have already rolled out their plans for the Internet. In March 1994, AT & T announced a national InterSpan frame relay service and Internet Connectivity options, both dial-up methods for accessing the Internet. MCI offers access over its frame relay services. Sprint, which offers a nationwide Internet access service along with providing international Internet connections, is now offering ATM access to the net. Several Bell regional companies are getting into the act. US West offers end users access to two Internet providers via its frame relay services. Pacific Bell in collaboration with InterNex Information Services, now offers Internet connections, while Ameritech has won a contract to be one of the four Network Access Providers. They plan to offer Internet protocol pipes over their frame relay, switched multi-megabit data service. Many cable operators are also getting into the market. Continental Cablevision and Jones Intercable are using cable modems hooked onto their coaxial lines to bring broadband Internet connections to businesses and homes. Continental, a Boston- based cable company, launched a service in M arch in collaboration with Performance Systems International, the national Internet access providers, to bring high bandwidth service to residences and businesses in Boston. [5] [#n5]

The bottom line implication is that the number of Internet users is going to increase manifold, as opportunities to interconnect with the network become ubiquitous through the efforts of the telephone, software, and cable companies, and as user-friendliness and utility of the applications develop further.

4 Implications & Key Issues

The implication of these forces—the incompatibility of the new bandwidth hungry applications, infusion of new users, and the privatized and commercialized nature of the Internet—is that the demand on network resources will increase exponentially, and will possibly be much more than the supply of bandwidth. As network resources become scarcer and as the system is driven towards a free-market model, resource rationing through a change in the pricing system is inevitable.

The key issue is that the pricing mechanism should be able to (a) preserve the inherent discursive nature of the net, (b) send the right signals to the marketplace, and also (c) be flexible and adaptive to changes brought about through technology, political initiatives, and software development.

4.1 Pricing Alternatives

The major fear in some quarters is that the present system of flat-rate, predictable pricing for a fixed bandwidth connection will be replaced by some form of vendor preferred, usage-based metered pricing Users feel that the Internet should continue to function primarily as a vast, on-line public library from where they can retrieve virtually any kind of information at minimal costs.

According to some, a transition to metered-usage would make the NII "like a Tokyo taxi, so that for every passenger who takes a ride on the national data superhighway, the first click of the meter will induce severe economic pain and the pain will increase with each passing minute" (Judith Rosall, International Data Corporation's Research Director quoted in Business Editors, 1994).

Consumer advocacy groups opposing metered pricing usage of the Internet [6] [#n6] feel that the NSF should create a consumer advisory board to help set pricing and other policies for the network to ensure that the free-flow of information and democratic discourse through Internet listserver and fileserver sites is preserved and enhanced. In addition to the fear that a popular discussion would have to pay enormous amounts to send messages to its members, it is feared that usage based pricing would introduce a wide range of problems regarding the use of ftp, gopher, and mosaic servers, since the providers of the "free" information would be liable to pay, at a metered rate, the costs of sending the data to those who request for it. This would have a negative effect on such information sites, and would eliminate many such sources of free information.

In essence, the argument is that usage based pricing would imply severe economic disincentives to both users and providers of "free" information, and would therefore destroy the essentially democratic nature of the Internet.

4.2 The Arguments against Flat-rate Pricing

The paper argues that flat-rate pricing in the current context of the Internet is likely to run into severe problems. Paradoxical as it may sound, the continuance of flat rate pricing is likely to severely impair the current discursive nature of the Internet.

The basic role of a pricing mechanism is to lead to an optimal allocation of scarce resources, and to give proper signals for future investments. The mechanism in place should lead to the optimization of social benefits by ensuring that scarce resources are utilized in such a manner as to maximize productivity in ways society thinks fit. As Mitchell (1989) notes, "in a market economy, prices are the primary instrument for allocating scarce resources to their highest valued uses and promoting efficient production of goods and services'' (p. 195). One critical issue however is the basis on which an appropriate pricing scheme can be designed.

Given that the marginal cost of sending an additional packet of information over the network is virtually zero once the transmission and switching infrastructures are in place, marginal cost pricing in its simplistic form is inapplicable. Cost-based return on investment (ROI) pricing is both not feasible, given the multiplicity of providers who would have to chip in to bring about an end-to-end service, and inefficient, given the chronic problem of allocating joint costs. [7] [#n7] A "what the market can bear" policy would be likely to have unforeseen implications, especially if the markets are not competitive in each and every segment of the network.

The principle that is most likely to be effective in this scenario is a modified version of the marginal cost approach, where the social costs imposed by the scarcity of bandwidth—the bottleneck resource—is taken into consideration. Bandwidth being the speed at which data is transmitted through its networks, its scarcity implies delays due to network congestion. This then is the social cost that needs to be incorporated into any efficient pricing scheme.

4.3 The Costs of Congestion

The packet-switching technology of the TCP/IP protocol embedded in the Internet has an essential vulnerability to congestion. A single user, overloading a sub-regional line that connects to the regional level network, can overload several nodes and trunks, and cause delays or even data loss due to cell or frame discarding for other users. The specific manner in which the problem manifests itself depends on the protocols used, and on whether the network is simply delaying or actually discarding the information (Campbell, 1994). Since backbone services are currently allocated on the basis of randomization and first-come-first-served principle, users now pay the costs of congestion through delays and lost packets (Varian & MacKie-Mason, 1994). [8] [#n8] The problem is likely to become even worse as Power PCs such as a $2000 Macintosh AV combined with a $500 camcorder would enable an undergraduate to send real-time video to friends on another continent, by pumping out up to 1 megabyte of data per second onto the Internet, thus tying up a T l line (Bohn et al., Love).

The cost of congestion on the Internet is therefore a tangible problem, and not merely the pessimistic outpourings of a band of dystopians. Some have argued that it does not matter if users fill up their leased line, and even less the manner in which they do so (Tenney, telecomreg, 4 May 1994, 18:42:09). However, the Internet is not designed to allow most users to fill their lines at the same time. Also, as new applications such as desktop videoconferencing and new transport services such as virtual circuit resource reservation come in, it will become more and more necessary for the network to provide dedicated and guaranteed resources for these applications to operate effectively (England, telecomreg, 7 May, 1994 08:04:26). In the Internet system, which is essentially designed for connectionless network services, the requirement of bandwidth reservation implies that an incompatible class of service needs to be provided over it, thus necessitating costs in developing added functionality to its edges (Pecker), and in decreasing its overall efficiency.

In essence, the changing nature of network traffic implies a social cost, largely due to this inherent incompatibility between new applications and the Internet architecture. There is a social cost imposed by those who are making unlimited use of the newer bandwidth-hungry, incompatible applications. This cost is being borne by others in the form of delays and data dropouts while making use of the more traditional applications such as email, ftp, and gopher. [9] [#n9] The flat-rate pricing mechanism is therefore inefficient in sending out corrective signals to minimize social costs and as a resource allocator since it can hardly be argued that the social benefits of a democratic discourse are less beneficial to society than an undergraduate sending out real-time video to his friends. [10] [#n10]

There is a potential danger here. Continuance of the current pricing system may result in a situation where the new applications drive out traditional uses. The inherent bias of flat-rate pricing, whereby heavy users are subsidized by light users, is a threat to the more traditional forms of net usage as applications requiring heavy bandwidth are coming of age. It is however clear that a new form of pricing scheme needs to be developed in order to ensure that the net retains part of its original character as it evolves into a more potent and futuristic medium of communication.

4.4 The Pricing Options

At the far end of the spectrum is pure usage-based pricing. Given the shortfalls of the flat-rate based scheme, it seems certain that there will eventually be "prices for Internet usage, and the only real uncertainty will be which pricing system is used" (Love).

4.4.1 The Telephone Pricing Model

One form of usage based pricing would be to use the system of posted prices as in telephony. One way to do this would be to adopt the telephone model of computing interLATA prices, where the cost of Internet usage is based on the distance between the sender and the receiver, and on the number of nodes through which data need to travel before they reach their destination. This however would be difficult to implement given the inherent nature of the connectionless net technology, which is based on redundancy and reliability, where packets are routed by a dynamic process through an algorithm that balances load on the network, while giving each packet alternative routes should some links fail (Varian & MacKie-Mason, 1993, p. 3). The associated accounting problems are also enormous. In addition, the sender would prefer that packets are routed through a minimum number of nodes in order to minimize costs, while the algorithm in the Internet would base its calculations on the concept of redundancy and reliability, and not necessarily on the fewest links or the lowest costs.

The telephone model of pricing is not likely to work for another reason. Posted prices are not flexible enough to indicate the state of congestion of the network at any given moment (Varian & MacKie-Mason, 1993, p . 19). As we have seen earlier, congestion in the network can peak from an average load very quickly depending on the kind of application being used. Also, time-of day pricing means that unused capacity at any given moment cannot be made available at a lower price whereby it would be beneficial to some other users. Conversely, at moments of congestion, the network stands to lose revenue because users who are willing to pay higher amounts than posted rates are being crowded out of the network through the randomized first-in-first-out (FIFO) process of network resource allocation.

In essence, the system of posted fixed prices implies multiple problems: while it does not allow for revenue maximization under the "market can bear" philosophy or lead to optimal capacity utilization, it also does not address the social costs of congestion because it cannot allow for prioritization of packets. It is thus clear that the answer to the Internet's pricing problem does not lie at either ends of the pricing spectrum defined by flat-rate pricing and pure usage based pricing, but possibly in an innovative approach.

4.4.2 Innovative Pricing Models

Two innovative pricing schemes have been suggested recently. Bohn et al. have proposed the "Precedence" model, while Varian & MacKie-Mason have developed the "Smart Market" mechanism.

4.4.2.1 The Precedence Model

The Precedence model proposes "a strategy for the existing Internet, not to support new real-time multi-media applications, but rather to shield ... the existing environment from applications and users whose behavior conflicts with the nature of resource sharing" (Bohn et al., p. 4). The authors propose that criteria be set to determine the priority of different applications, which will then be reflected in the IP precedence field of the different data packets. Packets would receive network priority based on their precedence numbers. In the event of congestion, rather than rely on the current randomized decision, the Precedence model presents a logical basis for deciding which packets to send first and which to hold up or drop. While noting that their proposed system is vulnerable to users tinkering with precedence fields, the authors feel that this approach would "gear the community toward the use of multiple service levels, which ... (is) the essential architectural objective" (p. 10).

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