The Case for Deploying "Big Broadband" Through Open Advanced Fiber Networks (AFNs)

Executive Summary

The U.S. is far from being the leader in deploying the rapidly evolving IT and Telecom infrastructures of the world. As of early 2004, it is behind countries including South Korea, Sweden, Canada, and Japan; ranking eleventh internationally. Under current trends, it is likely to rapidly fall further behind. Yet expert observers widely recognize that the IT/Telecom infrastructure will determine the relative performance and productivity of the knowledge goods sector of the U.S. economy -- and in turn, of the entire U.S. economy.

The U.S. is unlikely to return to a leadership position in IT/Telecom -- unless it rapidly deploys open, advanced fiber networks (AFNs) -- Ethernet networks over Fiber infrastructures capable of gigabit speeds. In turn, these networks must be open to multiple, competing suppliers of content, application and services (CAS). We call such networks "Big Broadband."[1] They offer prodigious advantages that can be ensured only when their infrastructure is owned/controlled: 1) by the end-user, or 2) by users-together, acting for themselves through surrogates such as their municipalities.

The paper introduces sufficient basic economic analysis to establish that the domain of an AFN network embodies an incipient "natural monopoly." (See Appendix B, page 38.) In its body the paper establishes further that the key determinant of the performance of networks such as AFNs, is whether those who own the network infrastructure have incentives to activate the incipient natural monopoly for their profit, or as end-user-owners, have incentives to block the potential negative impacts of the natural monopoly by containing it; i.e., leaving it dormant -- since it makes no sense to exploit yourself. Nor does it make sense to close your network arbitrarily to potential service providers.

1Term coined by Reed Hundt, former FCC Chair; used by him at the New America Foundation in December, 2003. See: http://www.newamerica.net/Download_Docs/pdfs/Pub_File_1431_1.pdf

On 08-21-03 the FCC entered a rulemaking. This rulemaking was part of a complex series of changes that would provide U.S. Incumbent Local Exchange Carriers (ILECs) with incentives for regional monopoly-control affecting both transport and content over their telecommunications infrastructures that the FCC classifies as "broadband" technologies and we call, "Little Broadband." (See extended footnote 1, pages 4 and 5.) The attempts by the FCC to provide regulatory certainty to the decision makers of MSOs, ILECs, and CLECs to encourage their build-out of "broadband", have resulted in the opposite: great uncertainty prevails. This uncertainty is unlikely to be resolved except through further court action, perhaps even at the U.S. Supreme Court level. Such an environment of uncertainty inevitably slows investment and innovation by regulated (or soon-to-be regulated) entities. This further suggests that even deployment of "Little Broadband" in the 1 to 10 Mb range by incumbent suppliers in this country is likely to languish at a time when progress toward Big-Broadband deployment is accelerating among our economic and technological rivals.

On the other hand, if the FCC were to achieve its stated objective of facilitating "Little Broadband" and foreclosing "common carriage," over ILEC infrastructures, the activation of regional monopolies would have profound negative impact on the competitiveness of the U.S. on the world stage, and for-certain would result in creation of a prodigious "digital-divide" separating users into "haves" and "have-nots" at home. (See table 1, page 14.) And it would imply that the network providers could and would exert limitation and control not only over transport, but also over "CAS" provided over their infrastructures to the end-users.

Further deleterious effects that arise from activating the natural monopoly, especially under regulatory procedures that effectively endorse closed, regional monopolies, are presented in detail in the paper. One such effect is that, given their fiduciary responsibilities, managers of the regional monopolies would have no choice but to pursue profit-maximizing strategies to the benefit of their stockholders -- strategies that would simultaneously undermine the productivity

and profitability of end-users in their regions and virtually foreclose the evolution of the Internet into the Big Broadband era.

Of even greater importance, the paper demonstrates that the sole mechanism for ensuring that the incipient natural monopolies remain dormant is through End-User-Ownership of their AFN infrastructures. Only then will it be possible to avoid the negative trade-offs and achieve the myriad benefits available through deploying AFNs. Extensive deployment of end-user-owned AFNs can obviate negative outcomes, result in open-systems networks, create virtually costless transport over the networks and greatly encourage peering, while facilitating the rapid evolution of the Telecommunications infrastructure -- and the Internet -- into the "Big Broadband" era.

The process of deploying open AFNs is a challenging one especially for municipalities serving as surrogates for their end-users. Fortunately, there are organizations that have resources and a commitment that can greatly facilitate the process.

HighSpeed America (HSA) is one such organization that can serve as a pilot. It was established by "alumni" of AOL. It seeks to be recognized as a comprehensive source of "outsourced modules" in support of open AFNs. The presence of such an organization also provides an institutional structure through which coordination of the activities of multiple AFNs can be accomplished.

It is especially important to note that today's incumbents also are well-situated to compete in these emerging businesses should they choose to reorient some of their energies and resources in this direction. In fact, incumbent ILECs and MSOs offering Internet services have resource-endowments, even greater than those of HAS, that can be reprogrammed to such tasks. The incumbents can transform themselves into direct participants in this new, rapidly emerging arena of businesses should they choose to do so.

The analysis in the paper leads to the following conclusions:

1. **Even the most optimistic and complete deployment of "Little Broadband" envisioned under the auspices of the FCC over the next three to five years would be insufficient to an acceptable competitive positioning of the U.S. in the global economy. We in the U.S. are behind many other nations now; such an outcome would imply that we would continue rapidly to fall behind them and still others, while greatly increasing the difficulty of our catching up at some point in the future.**

2. **Rapid deployment in the immediate future of advanced fiber networks (AFNs) throughout the U.S. -- that is, Ethernet networks over fiber infrastructures capable of gigabit speeds -- is vital, but not sufficient to the competitive positioning of the U.S. in the global economy.**

3. **Monopoly or duopoly control of the AFNs thus deployed also must be avoided. The current experiences of Korea and Japan confirm that either market structure can default into a nationwide monopolized structure. Such a monopoly of either transport alone or transport plus content would be subject to the abuses shown in Table 1, page 12 infra, with unacceptable economic and social consequences.[2],[3]**

4. **Only through end-user owned/controlled AFNs can the U.S. control the potential instability, keep the natural monopolies dormant and leapfrog its competitor nations to reinstate a U.S. leadership position in the development and delivery of rapidly evolving knowledge goods in the global economy.**

5. **The process of deploying open AFNs is challenging, especially for municipalities serving as surrogates for their end-users. Fortunately, there are organizations that have resources and commitment that can greatly facilitate the process. HighSpeed America (HSA) is one such organization that can serve as a pilot. Incumbent ILECs and MSOs offering Internet services have resource-endowments, even greater than those of HAS, and are in a position to transform themselves for direct participation in this new, rapidly emerging arena of businesses, should they choose to do so.**

6. **Such a fundamental transformation of the IT/Telecom infrastructure of the U.S. would represent an enormous market opportunity for both current and future product and service suppliers to the industry; and, as in the case of South Korea (Appendix A), represent an enormous potential stimulus for the entire US economy.**

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[2] The table demonstrates that distortions introduced by even regional monopoly market structures are myriad and pervasive and subtle. The experience of decades has shown that regulation is such a slow and blunt instrument and so open to political manipulation through the three "L's" -- Lobbying, Litigation and Legislation -- that "regulation" as a remedy to monopolization is unlikely to represent an acceptable alternative. This is especially the case when there is a simple, straight-forward alternative, End-User-Ownership, so readily available.

[3] See the works of Lawrence Lessig, Professor of Law at Stanford Law School, and Founder of the Stanford Center for Internet and Society.

The U.S. faces the greatest urgency for achieving extensive, rapid deployment of end-user-owned Advanced Fiber Networks, networks that we call, "Big Broadband." Fortunately, such deployment is reasonably within the nation's capability.

The Case for Deploying "Big Broadband" Through Open Advanced Fiber Networks (AFNs)

Introduction

Future patterns of Telecom Deployment can move toward open, interconnected, advanced fiber networks (AFNs); that is, Ethernet networks over fiber infrastructures capable of gigabit speeds. Further, AFNs call for a new paradigm of ownership: end-user-ownership of the infrastructure of their AFN. These conclusions emerge from analyses of the fundamental characteristics of AFN technology, the economic realities implicit in deploying that technology and the conditions of ownership of its infrastructure. The analyses were undertaken by a joint task force of the IEEE-USA and Cornell University through their Workshop, "**U.S. National Policy for Accelerating Broadband Deployment**," in 2002 with follow-on multifaceted analyses in 2003 and 2004.

The U.S. is far from being the leader in deploying the rapidly evolving IT and Telecom infrastructures of the world. As of early 2004, it is behind countries including South Korea, Sweden, Canada, and Japan; ranking eleventh internationally. Under current trends, it is likely to continue rapidly to fall behind. Yet we recognize that the IT/Telecom infrastructure will determine the relative performance and productivity of the knowledge goods sector of the U.S. economy -- and in turn, of the entire U.S. economy. The U.S .is unlikely easily to catch up -- unless it stimulates truly high-speed broadband deployment and also turns to a new paradigm of network ownership.[1]

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[1] At this writing (early 2004) the regulatory process in relation to the deployment of broadband connectivity to end-users in the United States is in a muddled state. The FCC has attempted to make significant changes in the regulation of suppliers of "high speed" Internet access over cable modem and other wireline facilities and has limited the extent to which the ILECs are required to provide unbundled network elements (UNEs) to potential competitors.

In a declaratory ruling entitled "*In the Matter of Inquiry Concerning High-Speed Access to the Internet Over Cable and Other Facilities Internet Over Cable Declaratory Ruling ...*," GN Docket No. 00-185, CS Docket No. 02-52, (rel. March 15, 2002), the FCC determined that Internet access, when offered as a combination of data transport and the capability of searching, storing, processing, editing and otherwise using information, is an "information service" and not a "telecommunications service" or a "cable service" as these terms are defined and used in the

Communications Act. In *Brand X Internet Services v. FCC*, 345 F.3d 720 (9th Cir., October 6, 2003), a three-judge panel of the Ninth Circuit overturned the FCC's declaratory ruling, holding that Internet access is *both* an "information service" and a "telecommunications service." The FCC has asked the Ninth Circuit to reconsider the panel's decision *en banc.*

Nearly from its inception, the U.S. cable operators have portrayed and positioned themselves as "First Amendment speakers" -- and therefore not subject to the rules of "common carriage;" of Title II of the Communications Act; or of regulated prices, investment, and services. The policy rationale was based on the initial legal posture of the cable business as a retransmission service of broadcast television; and broadcast television, of course, enjoys all the First Amendment protections that were designed for newspapers. Three factors have recently made the regulatory status of the cable operator subject to additional regulatory and policy interest: (1) their *de facto* (regional) monopolies in the provision of multi-channel video programming; (2) their application of new technologies to exploit cable's investment in broadband access– including satellite and microwave systems, distant-signal importation, Internet access services, and, most recently, voice telephony access services; and (3) their success in rivalry with the ILECs by using these new technologies in innovative ways.

Shortly before issuing its cable modem declaratory ruling, the FCC issued a *Notice of Proposed Rulemaking* to develop a legal and policy framework for Internet access provided over domestic wireline facilities, such as Digital Subscriber Line (DSL) facilities. *In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities …,* CC Docket Nos. 02-33, 95-20, 98-10, *Notice of Proposed Rulemaking* (rel. February 15, 2002). In the *Notice*, the FCC said that it had tentatively concluded that Internet access over wireline facilities should also be classified as an "information service" rather than a "cable service" or a "telecommunications service." It was widely understood from statements by Michael Powell, FCC Chairman, that he sought "regulatory parity" for ILECs providing broadband DSL etc. with cable modem MSOs providing broadband Internet services.

In its UNE (for "Unbundled Network Element") Triennial Review, the FCC addressed the core issue of whether removing the requirement for UNE access to the ILEC networks would "impair" the ability of CLECs to provide broadband services in competition with ILECs, Cable modem MSOs and other competitors. The Triennial Review order was adopted in February of 2003 and released in August of that year. In its order, the FCC freed ILECs from a duty to offer to competitors, unbundled access at wholesale rates to most of the ILECs' broadband facilities, particularly to facilities used to provide fiber to the home.

As noted above, the Ninth Circuit issued its *Brand X* decision on October 6, 2003. This decision not only applies to the FCC's cable modem ruling, but it also undermines the FCC's rationale for classifying Internet access over wireline facilities as an "information service." As a result, the FCC is not expected to announce a decision in the wireline proceeding until the *Brand X* case is finally resolved.

If the FCC ultimately loses the *Brand X* case, it may attempt to achieve the same result by relying on its authority to forbear from imposing regulatory requirements that it believes to be unnecessary and contrary to the public interest. While this course would itself be problematic in various ways, it would at least have the virtue of being forthright and consistent with the FCC's existing body of decisions

Had the FCC achieved its objectives in the cable modem and wireline broadband proceedings, both cable modem suppliers of broadband access and ILEC suppliers of access over their infrastructures would effectively be removed from regulation by the FCC including any requirement for providing, common carriage. The significance of these developments to the current paper is a de facto endorsement by the FCC of the dubious proposition that "duopoly" competition between incumbent cable and telephone monopolists will result in low prices, quality service, and innovation even in the absence of common carriage requirements for either.

The Emergence of the New Paradigm of Network Ownership

The AFN emerged from the evolution of Ethernet technologies on campus-like network infrastructures of universities, commercial heavy-users of information technology, and providers of information technology software and products. In the course of operating their on-campus Ethernet networks, potential end-users discovered that purchasing, integrating, and operating Ethernet components can be achieved with great simplicity and with great operational efficiency by an enterprise that seeks to deploy a network at gigabit speeds over a fiber-optic infrastructure. They've found that the simplicity makes it possible for their organization to consider acquiring/owning/controlling its own telecom infrastructure -- something that would have been unthinkable given legacy telecom costs and operational complexity. They then determined that the investment required to deploy the Ethernet components over fiber to support gigabit speeds is so much less than has been the case for earlier broadband technologies (such as point-to-point carrier-provided circuits, digital subscriber line, cable modem, or satellite), that these efficiencies make the AFN infrastructure attractive for the enterprise to seek to own/control as assets of its own. Capital expenditure (CAPEX) for an AFN -- a network capable of gigabit speeds -- is lower than for alternatives for achieving such capabilities.

The result of the experience and experimentation of this group of users is the AFN, the advanced fiber network. It is a network that, as a result of a series of (continuing) innovations made to simple, standards-based Ethernet technologies, can be propagated for a hundred miles without "regeneration", as compared to tens of yards that was the maximum possible in the recent past. The AFN approaches a difference in kind as compared to traditional telecom transport networks.

Deploying the AFN

Once the owner of the AFN has paid for deploying the infrastructure and for bringing the network to a fully operational level, transport over the AFN can be sustained simply by covering its low, on-going operational costs. Those costs are virtually independent of the bandwidth used;

hereinafter this characteristic will be referred to as "costless" transport.[2] Given the incentives to the end-user-owner, the availability of transport at a cost that approaches zero can be expected to be passed-through to the internal users of that network as a "no-fee" price -- with many concomitant savings in administering and operating the AFN.

AFN networks under end-user-ownership represent a New Paradigm of Telecommunications Infrastructure deployment. They are not intended to generate explicit revenues for their owners. These networks reduce the costs for carrying out the activities of the network users and they improve the productivity of the parent organization.[3] These elements that contribute to the profitability (or success) of the organization are the elements that constitute the "Business Plan" for AFN networks deployed under end-user-ownership.

Further, AFN users report that in contrast to the specialized training and "care and feeding" required for the cables of cable systems or the complex operational, administrative and maintenance requirements of ATM/SONET systems, once the AFN network is in place, operational requirements are minimal. These facts further reduce (relative) operational expenditures (OPEX) for AFNs; enterprise profits are increased from the savings implicit in the use of such networks flow-through to the organization's bottom-line. As we see below, together these factors also have powerful implications for likely future network market structures.

Ensuring that Bandwidth is "Not Scarce"

As a requirement for transport over a network to approach being "costless" as suggested above, the bandwidth deployed over the network must be "not scarce:" congestion must be avoided. In

[2] This situation is analogous to the use by end-users of internally-owned computer system infrastructures.
[3] Again the analogy holds. What price do you pay to your organization for each use of your desktop or laptop computer? What price do you pay for each use of the LAN that provides internal connectivity for your desktop or laptop computer? And what explicit revenues do you or your organization expect to generate from use of either of these infrastructure elements? More generally, what is the Business Plan" for generating explicit revenues from the use of any element(s) of the internally-owned, computer systems infrastructure?

turn, this requires that "enough" bandwidth, including switching/forwarding capacity, be present to meet transport needs. To drive this idea home we say that at any given moment, only having "bandwidth-to-spare" meets the requirement of "enough bandwidth." In practice, the objective of avoiding congestion on an AFN infrastructure is proving to be achievable, within a reasonable approximation, through simple network management policies and monitoring of network use.

Another way of saying that bandwidth is not scarce and therefore transport over the AFN can approach being costless, is to say it the way economists do: "the marginal cost of use of the AFN (that is, the cost of one more unit of use over the network -- e.g., one more email message) approaches zero."[4] This formulation of wording proves to be powerful for this analysis since it is closely aligned with key elements of basic economic theory. One tenet of that theory states that a natural monopoly exists under conditions in which marginal cost is everywhere below average cost. (For succinct graphical and mathematical discussions of the characteristics of a natural monopoly, please see the analysis in Appendix B.)

(Very) roughly translated into more familiar language, the average cost (e.g., per unit of use of a network) takes into account both CAPEX (fixed costs) and OPEX (operational costs). If the marginal cost of use of the AFN approaches zero, then average cost must be declining as use increases, (since CAPEX effectively is being divided over more and more users) but since average cost includes CAPEX, it must be above zero for all quantities of use: thus marginal cost is everywhere less than average cost in the AFN. And as explained more fully in the next paragraphs, these are the conditions that identify a natural monopoly.

[4] Municipalities and we in the general public are intimately familiar with other forms of infrastructure; e.g., roads, bridges, etc.; that once constructed have a marginal cost of use that approximates zero. It costs the municipality nothing for one more car to drive over the road, or cross the bridge. We are all familiar with what municipalities charge us the next time we drive to work or go to the grocery store: the marginal cost to the municipality is zero so the price to citizen-users for using the road or bridge is the "no-fee" price of zero.

Natural Monopoly Conditions Exist, But Are Contained

By definition, therefore, the conditions for a "natural monopoly" of transport and the predicate for a monopoly of transport plus content are intrinsic to the AFN (as with many other networks for which congestion has been controlled, as above). Entry of another network supplier would mean duplicating the capital investment and splitting the transport "load," and thus the average cost to each supplier would rise, implying higher costs to users. A single supplier (a monopolist) can minimize the *cost* of the network, thus the term "natural monopoly."

If the natural monopoly of transport were exploited, however, then users (and productivity) would lose because of monopoly pricing, despite the presence of transport that is costless. Fortunately, given that the end-user-owner of an AFN *owns* its infrastructure, it can avoid the possibility of its users being subject to monopolistic exploitation. (One does not exploit one's self.)

In relation to operational costs (OPEX), the power of end-user-ownership/control of its own infrastructure is three-fold. The end-user-enterprise itself 1) directly benefits from "no-fee" transport over its network to its end-users, and 2) since it owns/controls the network, it obviates the potential for exploitation of its end-users under the natural monopoly. Additional benefits accrue from 3) other lower, on-going network operating costs once the AFN has been installed. In addition to these matters that impact OPEX, as analyzed and emphasized strongly below, there are powerful additional incentives for end-user-owned networks to be open networks with all that that implies.

Nothing in the above analysis should be taken to imply that an ILEC (or other LEC) cannot deploy AFN technology. That is, LECs have the same opportunity as do end-user-owners to approach costless transport over their networks and to use more simple and efficient network technologies, such as the Ethernet over fiber infrastructures capable of gigabit speeds.

On the (economists' ubiquitous) "other-hand," this does not imply that users of the services of an AFN deployed by an ILEC are likely to face the same "prices" (as compared to costs to its suppliers) as users of an AFN deployed by end-user-owners (i.e., in terms of prices to them for network use) or that the AFN deployed by an ILEC would have comparable industry or economic development impact as an AFN deployed by an end-user-owner. As discussed below, the ILEC is very likely to operate its AFN as a monopoly in both transport and content. One way to illustrate the differences that are likely to emerge from differences in ownership is through a sequential comparison (such as that presented below and summarized in Table 1) of expected impacts of the two approaches.

The Evolution of End-User-Owners of Enterprises Deploying Their Own AFNs

End-user-owners began investing into AFNs when the costs for Ethernet hardware plummeted as a result of increasing equipment capability and decreasing prices for optoelectronic components (particularly lasers). In business enterprises and on campuses, end-users began deploying more fiber optic cables of their own. In addition, increased access to public support structures (conduit, poles, rights-of-way, etc.) made it possible for end-users with sufficient need for truly high speed connectivity to make a substitution: rather than "renting" circuits from ILECs, they discovered that they could more efficiently deploy and own/control their own fiber optic cables.

The substantial benefits that flow from an AFN deployed through an enterprise as end-user-owner include "no-fee" transport over the network. In turn, this implies that there is no need for complex tracking hardware and/or software; simple rules and monitoring systems will suffice to avoid congestion. Experience has also shown that networks of this sort, once deployed are stable and relatively easy to manage.

Of greater consequence: in relation to content, applications, and services; the end-user-owners of an AFN have an interest in maximizing the feasible numbers of content, applications, and service providers and in enabling the availability of diverse content, applications, and service offerings among which they -- the end-user-owners -- can select based on "competition on the merits." It

is in the end-user-owner's interest to have maximum, open competition as to content -- and therefore likely rapid innovation in content, applications, and services on their network.

Benefits to the Internet -- and thus to Innovation -- from Open-Networks

> **Open competition among content, application and service providers over open networks consistent with wide deployment of AFNs under end-user-ownership would virtually guarantee the evolution and enhancement of the Internet. Through its evolution from the old -- narrowband, dial-up, copper-based technologies -- to the new – broadband, fiber-based technologies -- innovation and technological development horizons would essentially be unlimited. Note: It is the *openness of the network* and the *openness of competition* over the network, not the presence of fiber in the network that permits evolution and enhancement of the Internet.[5]**

The ILEC Model of Deploying AFNs

As in the case of the end-user-owner, transport over the ILEC's AFN can approach being costless through the same mechanism of ensuring that there is bandwidth-to-spare. As in the prior case, this also implies that the conditions for a natural monopoly will exist in the AFN-domain deployed by the ILEC. In contrast to the prior case, however, it is in the interest of the ILEC to take advantage of the natural monopoly conditions if it can do so. The resulting market power can be used to support transport over the network of the ILEC under a "monopoly-fee" structure. It is important to emphasize that, despite the fact that transport over the network can approach being costless (to the ILEC), it is in the interest of the ILEC and its stockholders to charge customers monopolized-fees equal to "what the traffic will bear." Nearly-costless transport just serves to enhance their profit margins. Monopolized-pricing to maximize total fees requires costly hardware and software to support analysis, testing, monitoring and billing. In turn, this implies both CAPEX and OPEX greater than required for an AFN deployed by an end-user-owner. Also in contrast to the end-user- owner-AFN, it is in the interest of an ILEC-AFN to limit, control, even censor and/or vertically- tie a business relationship to content, applications, and service providers as part of a profit-maximizing business plan. A likely objective of the ILEC-AFN owners in doing so would be to extend the monopoly power in the network to other

[5] Lessig, op,cit.

Table 1: Implications of Different Ownership/Market Structures for the AFN

The End-user-owner Model of Deploying the AFN	The ILEC Regional Monopoly Model of Deploying the AFN
Results in costless transport that simultaneously implies natural monopoly conditions exist.	Also results in costless transport that simultaneously implies natural monopoly conditions exist.
But with end-user-owner, natural monopoly is contained. One doesn't exploit one's self.	Here natural transport monopoly is exploited as a mechanism to permit transport fees at monopolized levels.
• Leads to "no fee" transport • Facilitates peering	Transport still "costless" to ILEC, but leads to fee levels at "what the traffic will bear".
Requires only simple rules and monitoring to avoid congestion.	Strategy implies need for complex, costly monitoring to maximize fees.
Therefore: • CAPEX smaller • OPEX approaches zero • Ethernet network infrastructure has lower on-going operational cost	Therefore: • Increases CAPEX • Increases OPEX
The end-user-owner AFN is open to a maximum feasible number of competing content, applications, and service providers selected by the AFN-owner on the basis of "competition on the merits," creating open-networks that extend the Internet to dimensions with gigabit speeds.	Access to AFN can be monopolized, i.e.,: • Limited • Controlled • Censored • Vertically-tied
Peering offers multiple, new opportunities; new long distance transport and widespread connectivity; true "end-to-end" networking.	Forecloses user free-choice of content application and service suppliers creating "closed-networks," blocking Internet innovation. Monopoly power can extend into the higher layers carrying content application and services.
Extensive deployment of Customer-Empowering Networks required to prevent or overcome a "Digital Grand Canyon".	Deployment follows market-based business model: 3-year maximum payback; maximizing monopoly return; implies "cherry picking" locations for deployment.

network layers. It is in their interest to be the "gate-keepers" -- monitoring and controlling access by content, applications, and service providers to the AFN in the interests of stockholders -- rather than being providers of open-access to end-users in the interests of end-users.

The FCC's Triennial Review and Associated Order 03-36 of 08-21-03

The Triennial Review order FCC 03-36 was adopted February 20, 2003 and released August 21 of that year. This rulemaking that limited the extent to which the ILECs are required to provide unbundled network elements (UNEs) to potential competitors, provided U.S. ILECs with incentives for regional monopoly-control (affecting both transport and content) over their U.S. broadband telecommunications infrastructures under government sanction. It consecrates old rules for old, narrow-band technologies, and essentially few rules if any for new, broadband technologies -- effectively mandating that regional-monopoly incentives be followed by ILECs. By turning their AFNs into closed-networks, however, the ILECs are likely to limit -- even to foreclose -- the Internet itself to a new generation of innovation that otherwise, through open access to true, Big Broadband capabilities, would most likely take place.

Through the mechanisms just described, the activation of the regional monopolies in response to mandated government sanctions and incentives would have profound negative impact on the competitiveness of the U.S. on the world stage; it would imply limitation and control by the network provider of: content, application and services made available over the infrastructure to the end-users; and, for-certain as, noted above, it would result in creation of a prodigious "digital-divide" separating "haves" and "have-nots."

The Consequence of the Closed-Network

Deployment of the AFN as a closed-network consistent with a monopolized structure would virtually guarantee the limitation of the Internet at most to the old -- narrowband, dial-up, copper-based technologies -- it uses today. Monopolized networks have incentives to foreclose the Internet to the new -- broadband fiber-based technologies -- the thereby tragically limiting its technological development horizons.

The implications of what the FCC has ruled with its Triennial Review and associated Order 03-36 are: consecrating old rules for old, narrow-band technologies, and essentially no rules at all for new, broadband technologies – effectively mandating regional-monopoly incentives that must be followed by the managers of ILECs.

Further Implications of ILEC Monopoly-Control

There are other implications of ILEC ownership and control of the AFN. Since the breakup of AT&T in 1984, deployment of innovations to end-users in the context of U.S. ILECs' monopolization of the "last mile" of connectivity has indeed been sparse. Study after study undertaken by parties who are close to the ILECs (and are familiar with their business practices) documents the lack of incentive (and the legal and business disincentives) for managers to deploy beyond the limits implicit in their business models. This pattern is likely to continue: as profit-making firms, the ILECs generally follow a market-based model of deployment with high ROI targets and short target "payback periods" of three years or less for investments.

The costs of deploying an AFN infrastructure in rural areas and in congested, urban residential districts (of likely lower monetary return) are significantly higher than the costs of deployment opportunities that ILECs have tended to accept in the past. Their business models imply that the ILECs will build-out first in those areas that promise to maximize the monopoly return to their stockholders -- rather than benefits for network end-users -- for investment deployed. In fact, the constraints on the decision-makers of the ILECs and of the cable-modem providers (MSOs, or multiple-system operators), are even stronger, as discussed below.

It is highly likely that a very large portion of the U.S. population would find itself in areas that do not meet a monopoly-ILEC's investment criteria**.**

> **Comment 1: A first-cut comparison between end-user-owned-AFNs and ILEC-owned AFNs (even when both are of essentially identical "Big-Broadband" technology); shows vast, important differences in incentive structures that arise strictly from the difference in ownership -- and the market structure differences that are likely to evolve there-from.**
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> **Comment 2: By bestowing government-sanctioned market power on the regional ILECs to match the market power already accrued by the regional cable modem service providers (MSOs) -- and implicitly validated by the FCC -- the FCC through its (intended) rulemakings would require monopoly strategies for these companies. The immediately preceding analysis, as summarized in the right-hand column of Table 1, establishes the strategies necessary to be followed by each regional monopoly -- and their likely consequences.**
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> **Comment 3: Given the intended FCC rulemaking, neither the ILECs nor the cable-modems' managers would have a choice of whether or not to follow monopoly-**

strategies. Each would have to pursue the interests of its stockholders. Failure to do so would violate management's fiduciary responsibilities and expose the managers to litigation.

<u>Comment 4:</u> Under these conditions, it would be likely that what is perceived as a digital-divide today could well evolve into a "Digital Grand Canyon" for citizens residing in areas that are not economically attractive to decision-makers who are required to avail themselves of monopoly incentives.

Areas of Agreement Between IEEE-USA/Cornell Workshop Report and "Googin's Law"

Key areas of analysis from the IEEE-USA/Cornell Workshop Report[9] are supported by the analysis of Roxanne Googin, a leading investment analyst who focuses on the telecom industry. Further, the validity of these key areas of agreement between the Workshop Report and of Googin's analysis is being demonstrated in the world's leading broadband marketplace, South Korea, the largest of the "Asian Tigers." A similar validity test is likely to be on-going in the world's second largest economy, Japan, in the immediate future.

Googin's analysis is succinctly captured in what has come to be known as "Googin's Law," as stated in **bold** in a paragraph below. In keeping with the viewpoint of her profession, Ms. Googin frames her comments from the perspective of an investor seeking to develop and own a network similar to an AFN and then to generate revenue from customers for transport-services over that network. In effect, Googin's Law implies that an organization such as an ILEC cannot provision a network similar to an AFN and expect to achieve sustainable revenues from transport over that network unless the ILEC is a monopoly supplier of the bulk of that transport. If the ILEC faces effective competition, then, as in any competitive market, its price for transport will be competed down to its marginal cost. And with the AFN and similar networks, that marginal cost approaches zero.

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[9] "Report from the Workshop: This Decade's (R)evolutionary Telecommunications Paradigm": http://www.ieeeusa.org/committees/CCIP/Broadband03report.pdf ;
see also:
http://afn.johnson.cornell.edu/referencedocuments.php#WSR

In capturing Googin's Law, The Cook Report[10] states:

> **"Consider Googin's Law: the network transport mechanism can be operated either as a valuable monopoly, or a valueless commodity.**
>
> **"Googin states that 'ownership is indeed all or nothing. Either you own a very valuable [monopoly] conduit, or you compete in a total [competitive] quagmire.'…"** (Bracketed words added.)

The analysis of the pattern of end-user-ownership of the AFN infrastructure in the Workshop Report is in full agreement with Googin's Law, except for a small shift in semantics and perspective. The Workshop Report includes discussion of the Boeing Company that owns its own metropolitan area networks (reproduced on page 19 infra); Quebec school districts that each owns its own AFN LAN (See page 26 below for greater detail on Quebec); and Burlington, Vermont's public utility that owns the municipal network. The implications of this form of ownership contrast sharply for those with ILECs as the network owner.

What from the end-user-owner's perspective is called "no-fee transport over the network," Googin from a supplier's perspective (e.g., an ILEC's) calls a "valueless (as a source of revenue) commodity." Furthermore, Googin's "total [competitive] quagmire" reflects the Workshop's conclusion that competition under nearly zero marginal cost will drive prices to nearly zero and foreclose any profits. Both under the Workshop Report, and under the strictures of Googin's Law: in the absence of monopoly power, such an LEC cannot "make money" from transport-services over its AFN. Only by activating the incipient natural monopoly in the network and thus exploiting the monopoly power over the prices it charges to end-users for transport of signals over the network (including those charged to content, application and service providers), can an organization such as an ILEC or ELEC (for "entering local exchange carrier") "make money" from transport over its AFN. Appendix A represents a real world test of the hypotheses just stated.[11]

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[10] The Cook Report, page 98, April-June 2003.

[11] All three phases are based on the authoritative ITU study, "Broadband Korea: Internet Case Study," of March, 2003 as augmented by news reports.

South Korea: The Test Case

In Appendix A, a brief, three-phase history of South Korea's strategy for recovery from its deep recession of 1997 (the "Asian Crisis" as it impacted South Korea) is presented. Phase I chronicles the positive macro economic impact of their approach of focusing development of its economy on its high tech sector.

Phases I and II

Beginning in 1997, the South Korean Telecom Industry was privatized (starting with its preexisting government-owned monopoly provider, Korea Telecom) as "KT". Further, competition was introduced by licensing several other private LECs as new entrants in competition with KT proving them with government-facilitated funding. (As noted above, we call these entrants "ELECs" for "entering local exchange carriers," to distinguish them from CLECs, "Competitive Local Exchange Carriers" in the U.S.: CLECs did not achieve significant entry.) The goal was to stimulate and transform the South Korean economy through the introduction of advanced technologies that would foster rapid economic growth. As reported in Appendix A, that objective of South Korea's strategy was resoundingly achieved over Phases I and II. The South Korean economy grew rapidly at approximately 8% during Phase II stimulated by the build-out of the ELECs (that drove KT's market share of broadband below 50% and forced KT to respond with its own new technology) drove the IT sector of its economy to 13% of it GDP and established South Korea as the world leader in deploying broadband reaching 70% of the population of the country.

The clear implication under both the Workshop Report and of Ms. Googin's analysis, however, is that a policy such as that undertaken by South Korea would result in cut-throat competition among the ILECs and ELECs in its telecom industry. ELECs competing with the ILEC in South Korea could imply ELECs (most likely) being driven into bankruptcy through price wars as the transport over each competing network would be driven closer and closer to marginal cost; a marginal cost that approaches zero.

Phase III

By the year 2002 South Korean telecom industry reached Phase III. And indeed that is what happened.

The number three player, Korea Thrunet, was already in bankruptcy. The number two player, Hanaro Telecom, in spring 2003 saw its CEO resign in disgrace because of the continuing huge losses experienced by his firm. KT had seen its market share forced below 50% by the new entrants, but as of mid-2003 anticipated "consolidation," as its competitors were going out of business. Think through what these developments might imply for KT in the not too distant future. Will KT again solely dominate?

That which was predicted is currently taking place! Could the negatives have been avoided? Can the situation be recouped?

Japan: another Emerging Test Case?

For their part the Japanese have responded to the South Korean introduction of advanced technology and its resulting world broadband leadership by also facilitating the entry of new ELECs in competition with their dominant, now privatized, telecom player, NTT (Nippon Telegraph & Telephone now split in two as NTT East and NTT West. The leading new competitor, Yahoo BB (for broadband), by 2003 had already achieved a 35% market share of broadband, but at the price of accepting a huge debt burden. While by 2002 the South Koreans had deployed VDSL with eight megabit-bandwidth, the Japanese suppliers had already moved to twelve megabit VDSL. They stated their intention to double their bandwidth in 2004 to 24 megabits. Already by mid-2003 in Tokyo individual competitors were widely advertising immediate availability of 100 megabit-bandwidth to the end-user for under $50 per month, seeking to re-establish their position of technological leadership in relation to South Korea.

Rather than building their own networks, as in South Korea, most Japanese competitors are sharing (leasing) NTT's infrastructure, especially final connectivity to the home. Yahoo BB is an exception, it has done both: it has built an AFN of its own creating what we call "an AFN-domain," but it still connects to the end-user at the final stage through UNEs, unbundled network

elements; of NTT's infrastructure. Yahoo BB provides its users with very inexpensive VoIP (Voice-over-Internet Protocol) as a part of its offerings. Customers of Yahoo BB are able to communicate with each other without additional charge over the Yahoo BB: anywhere in Japan, for as long as they wish, through VoIP. Yahoo BB's CEO, Masayoshi Son, states that the voice quality of their VoIP can exceed that of NTT's POTS (Plain Old Telephone Service).[12] The clear implication is that this can be achieved because the bulk of the transport of VoIP messages takes place through the fiber in Yahoo BB's AFN-domain, with only final connectivity through NTT's copper VDSL.

Several studies in 2003 attributed much of the success of Yahoo BB to steep discounts mandated by the Japanese regulators for line sharing, co-location and powering at co-location sites. Line sharing is reportedly mandated at a tariff as low as $1.50 per month per line, while in the U.S., the FCC's Triennial Review had just ordered line sharing to phase-out completely over the next 3 years.

The jury is still out on whether Yahoo BB will achieve break even, or as predicted by many, will follow the path of South Korea's ELEC competitors. What are the implications -- especially for NTT -- of a possible telecom consolidation in Japan where competing players currently share NTT infrastructure's connectivity to end users? What would happen if the ELECs were to go out of business?

Once again, full dominance for NTT? Could it be avoided?

Evolution of FTTH

Having established in earlier sections the great attractiveness of end-user-owned AFNs and shown the likelihood in South Korea, of undesirable reversion to monopoly ownership, in this section, we now trace a gradual evolution that can lead to ubiquitous Fiber to the Home (FTTH). As noted there, one of the most attractive factors is the fact that the direct benefits that accrue

[12] Fat Pipe Dream, Wired, August 2003. http://www.wired.com/wired/archive/11.08/pipedream_pr.html

from deploying an AFN can be captured by the enterprise that can "internalize" the payoffs to the parties directly associated with its AFN.

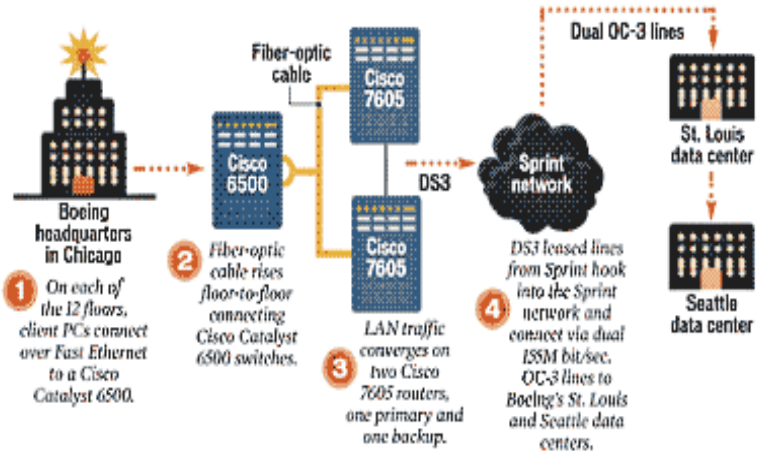
As demonstrated above, the technological characteristics of the Ethernet over a Fiber infrastructure capable of Gigabit speeds drive the economics of the AFN. Then, the combination of technology and economics drives the decision-making of the enterprise owners leading them to "do it by themselves, for themselves." That is, they choose to own/control the assets of the infrastructure that supports their AFNs.

Roadmap for End-User-Owned AFN Deployment

As opposed to the ILEC paradigm of AFN ownership, where infrastructures are built only when very rapid cost-recovery is feasible, it has been shown that the deployment of end-user-owned AFN infrastructures can occur in a series of phases that successively lower the costs of connectivity while increasing connectivity until the end-user-ownership paradigm can be fully established.

Phase 1: Enterprises Accrue Internalized Benefits through AFN Build-Outs

The illustrative "enterprise AFN-owner" network featured on page 2 of the IEEE-USA/Cornell Workshop Report is the Boeing Company is reproduced below. Boeing has Metropolitan Area



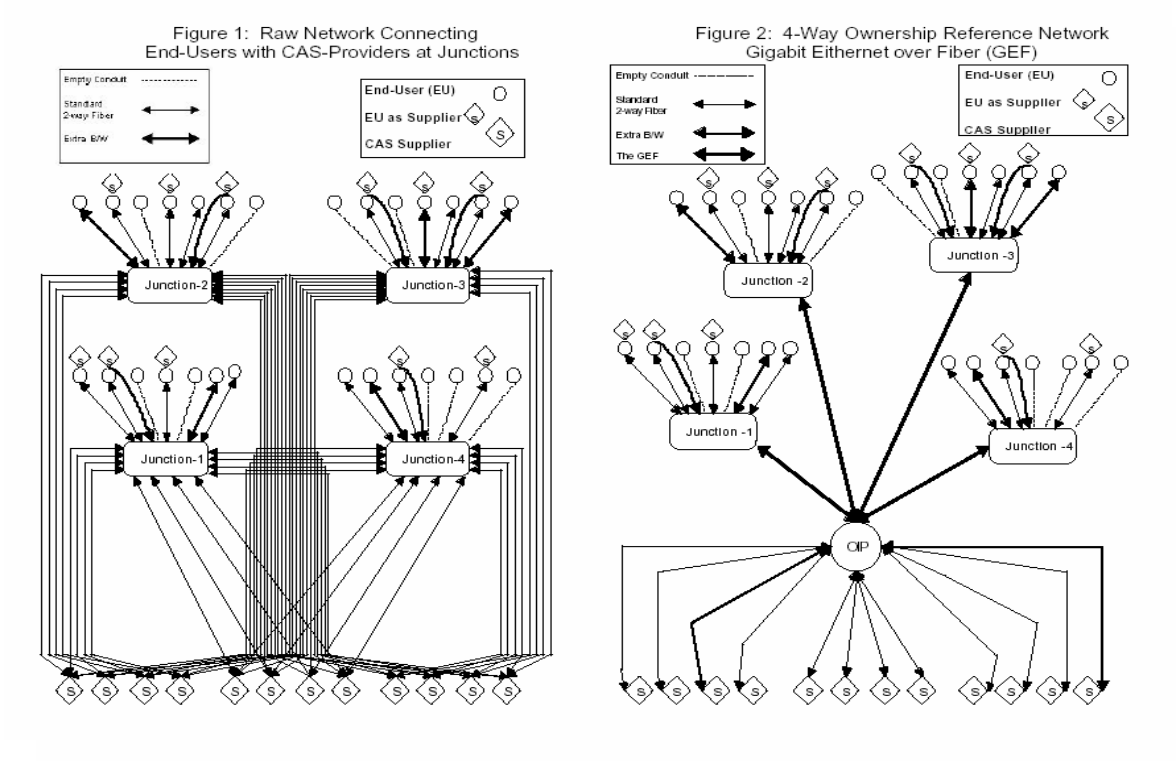
Source: www.computerworld.com, July 30, 2001

Diagram 1. Boeing owns its own AFN-LAN (Chicago) and AFN-MANs (Seattle, St. Louis) that connect multiple LANs to the Legacy Network at 45, 155, and 155 Mbps, respectively.

Networks (MANs) in Seattle and St. Louis integrating several gigabit-speed-AFN Local Area Networks (LANs). It also has an AFN LAN in Chicago. The same incentive structure, though at different scales, presents itself to other large firms and to many firms of medium size.

It is important to recognize that many not-for-profit and public sector activities are also carried out through organizations that are properly characterized as "enterprises." They include large research universities, each with its own ubiquitous Ethernet local area networks and sub-networks. As noted above, many of these organizations today have deployed full-fledged AFNs. Many have multiple gigabit-speed local area nets integrated across their campuses by a metropolitan area network-style AFN capable of 10 Gbps through each wavelength deployed over its fiber. In the United States, literally hundreds of such deployments are served by the Internet2 (I-2) public-private backbone in support of the research activities of affiliated universities.

Reduce the barrier to entry for FTTH; create a plethora of network junction points



(Figure 2 is discussed further on page 22).

Each public sector "enterprise" faces an incentive structure similar to those of private sector enterprises. Each is capable of internalizing the benefits achievable by deploying its own AFN to itself, and for itself. These entities include municipalities, school systems, hospital complexes, and affiliated library groups, among many others.

Phase 2: Enterprise Networks Create a Plethora of Junction Points

In a given geographic region, a condominium build-out by several of the enumerated enterprises -- each owning its own fibers within the resulting local or metropolitan area network -- would be making available "junction points" at which an end-user could potentially connect to the
In turn, the cost of closing the gap would sequentially decline. Nonetheless, the gap would remain.

Phase 3: End Users Create and Own Connections to Junction Points

The benefits from the deployment of an AFN can be internalized to an enterprise from the moment the AFN becomes operational. This is in contrast to the situation that exists when a neutral player -- perhaps a municipality -- builds-out an AFN network all the way to the end-user in the home or small businesses. In the latter situation, benefits again accrue immediately to all parties to the network, including the end-users at their homes or SOHO businesses, but not all of those benefits can be immediately internalized to the entity that deploys it. With deployment to homes and small businesses, a significant portion of the benefits accrue to the end-users, but are not immediately capturable by the entity that deploys the network as direct measurable benefits within the entity. In the latter case some benefits occur outside the boundary of the entity and accrue only over time through network effects; community growth impacts, increased property values and property and sales tax receipts. This structural difference has represented a major impediment to the deployment of AFNs to end-users in homes and small businesses. Despite the obvious fact that these benefits exist and that they make significant contribution to the end-users' value propositions, their benefit to the network deployer is, at best, delayed.

Bill St. Arnaud, one of the lead technologists of the CANARIE organization, has coined a phrase that is appropriate to this situation. He refers to such networks as "Customer Empowered Networks." Perhaps the phrase, "Customer Empowering Networks," would capture the meaning even more precisely.

If the reward-function to the deployer of the Customer Empowering Networks could immediately recognize the benefits to the end-user implicit in the words "Customer Empowering," then that reward could help justify the extension of AFNs to homes and small businesses. In time, these benefits do prove to have "externalities," consisting of pay-backs to the deploying agency as noted through increased property values, through increased property taxes, through an enhanced sense of community, through the reality of an enhanced community, and so forth. One way for the AFN-deploying agent to be able to recognize the value of the extension of the network to end-users would be for the latter as individuals or as groups to make an immediate monetary contribution to that agent.

Prerequisites for E-U-O AFN Deployment

For FTTH to be deployed through the end-user-ownership paradigm, a number of prerequisite conditions must be fulfilled. These are suggested below.

Open Networks through Four-Way Ownership Model

Appendix 1 to the IEEE-USA/Cornell Workshop Report lays out a "Four-way ownership structure" to facilitate the deployment of an AFN through the congruence of the interests and incentives of four parties: (1) the end-user of the AFN, (2) the content application and service providers to the AFN, (3) the neutral player, and (4) the entity deploying and operating the AFN. The analysis of Appendix 1 was focused on joint-ownership of the AFN with each particular party owning particular elements of the network as a way to provide incentives to the [participating] parties as a group such that any potential or predisposition toward monopoly exploitation of the resulting AFN would be blocked. In other words, this combination of owners jointly would foreclose the potential realization of the natural monopoly. The analysis required pro-active deployment of "support structures" by the neutral player, as we rehearse below.

One likely locus of monopoly power in an AFN would be in (1) the connectivity of the individual end-user of the network. To foreclose this as a possible choke-point, it was recommended that the end-user effectively own/control (perhaps through out-sourcing) its own connectivity to the network. This would represent a way for the end-user both to internalize the benefits of that portion of the AFN and to pay directly for it. It would remove those costs from

the total that the network supplier would need to recover. Also by themselves assuming this portion of the costs (both the CAPEX and the associated carrying costs) of the network, the end-users would thereby reduce the costs necessary to be assumed by the other parties.

In the context of our current analysis, this element takes on even greater significance. Connectivity to the end-user is the final link in the chain of the evolution of the AFN as provider of Fiber to the Home. End-users for whom connectivity to the MAN (that is likely to have been deployed in its community) was most beneficial, could accept the opportunity to deploy-and-own that connectivity. (Of course, as end-users currently do, they could carry this out perhaps through a general contractor or by acting as their own contractor for particular expertise to be supplied by the appropriate expert agent).

Affordable End-User Price Points

For end-users to own their own connectivity to competitive junction points, the infrastructure costs must be affordable. Such a development would not be as unusual as one might think. It is being done in "Greenfield" real estate developments in many parts of North America. After a few institutional changes, it could well be possible for any end-user-owner to include the cost of such connectivity in its mortgage. Alternatively, the end-user could negotiate a home equity loan that could cover this investment. Either way, the ultimate end-user-owner's investment in its productivity and quality of life could be financed and amortized over the life of a mortgage of up to 30 years -- in a mortgage whose interest payments are tax deductible (in the United States). This form of financing would greatly reduce the effective monthly cost to the end-user while simultaneously substituting the end-user's financing for this portion of the CAPEX required for the AFN. The connectivity, once completed, is likely to increase the market value of the home or office. Further, the process of connecting ultimate users is likely to lead to the externalities mentioned above-- including economic growth -- locally, regionally, and at the macro-economic level of the economy.

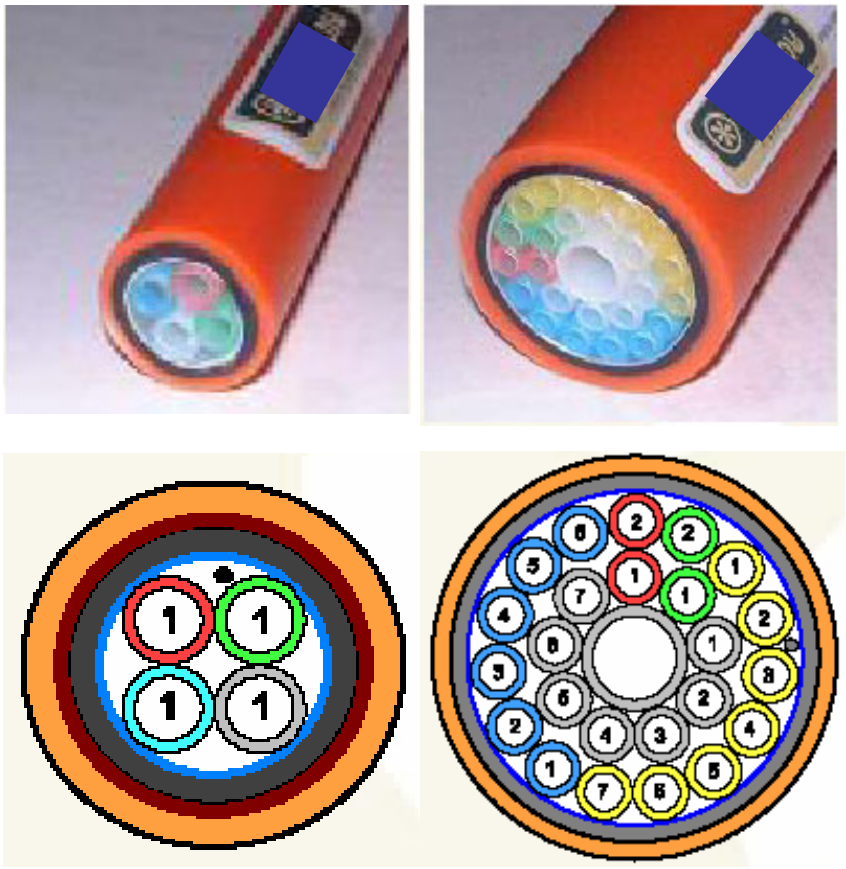
Micro-conduit

Also in the analysis of Appendix 1 of the Workshop Report, there is a great deal of emphasis placed on support structures (conduit, poles, rights-of-ways, etc.). The neutral party, party 3, acts pro-actively to provide support structures that ensure that competition at junction points

exists through easy entry and ensure that player 4, the AFN provider, feels the incentives of a "contested market" in its activities after it has deployed the AFN. The third party, the neutral player, might well deploy a powerful new form of support structure, micro-conduit, to each potential end-user in its community. In the presence of ubiquitous micro-conduit available to end-users as a result of such a build-out, the end-user would be greatly facilitated in "owning its own connectivity to the junction point." Then each end-user seeking connectivity to the AFN could merely select customer premises equipment (CPE) appropriate to the bandwidth it requires, "blow" its appropriate fiber (or cable) from its home or business through the micro-conduit to the selected junction point, and join the network.

Micro-conduit clearly has a long useful life. It does not deteriorate, is easily maintained, and has no active elements. The fiber itself and the CPE available at the endpoints of the fiber are likely

Reduce the barrier to entry for FTTH: provide micro-conduit;
"blow" fiber from the home to a junction point at low cost



to have shorter useful lives: the life of the CPE could be 3 to 5 years, while the physical life of the fiber might match that of the conduit, although its effective technological life might well be shorter. Both the fiber and the CPE would be readily replaceable. Each could be deployed and effectively depreciated over an appropriate expected useful life.

Community Equity Loans

Note that the cost to the network deployer would be diminished to the extent that the end-user took direct responsibility for either the fiber (or cable) that it chose to "blow" through the micro-conduit to the junction point, as well as for the in-house CPE and the end-user's portion of the cost of CPE at the junction point. Under this scenario, a municipality could also stay in the support structure business rather than engaging in the telecommunications business.

Many municipalities are "biting the bullet" with full FTTH deployments to ensure the long-term viability of their communities. Their AFN-domains can be considered as collectively embodying end-user needs. Traditionally, such activities are funded from what can be looked upon as, "Community Equity Loans," i.e., municipal bonds.

The community network is an asset to the community that can be amortized over 20-30 years. Its operation is not profit-driven. Any surplus would be temporary and would, perhaps through decreased "hook-up" fees for customers of the networks or get reinvested in the community. It would not be transferred to investor's accounts outside the community (except indirectly). Gains in economic development, quality of life, local pride and well-being enhance the business case for such networks. This is especially true if the likely alternative for the community happens to be economic oblivion--as faced by many remote, small communities today.

New Business Opportunities Intimately Tied the Introduction of AFNs

HighSpeed America (HSA) is a newly emerging firm established by "alumni" of AOL. The principals of HSA are the persons with technology and operations expertise who took AOL from its inception to the point that it became a huge player on the Internet, first through standard telecom dial-up, but also through cable modems, to achieve a position of hegemony. They thus have a deep understanding of both current Internet delivery systems.

Having spent their careers dedicated to the mission of empowering people by connecting them to networks, they've now turned their attention toward the task of accelerating the spread of networks similar to today's AFNs by forming an entity devoted to facilitating the build-out of these networks as open networks. HSA seeks to be recognized as a comprehensive source of outsource-modules. The range and depth of these modules is intended to provide whatever capability and skills are necessary to complement, and thus complete the creation and operation of multiple, discrete, open AFNs. Simultaneously, today the presence of such an establishment provides an institutional structure through which coordination of the activities of multiple AFNs can be accomplished.

The Challenge

In a speech delivered in December 2003 at the New America Foundation, Reed Hundt, former chairman of the FCC, sketched what can be looked upon as competing scenarios for the future deployment of the telecom infrastructure in the United States. We characterize these "scenarios" as the build-out of (1), "little broadband" and of (2), "big broadband," respectively. It is clear that Hundt prefers the build out of big broadband. Implicit in that choice, however, is the presence of a "Schumpeterian innovation through creative destruction." That is, for big broadband as endorsed by Hundt to be implemented, would require a virtually complete transformation of the telecommunications infrastructure of this country.

A Role for the Incumbents?

This raises the question, "Would there be a role for today's incumbents in the world of big broadband?" **The answer is a resounding, "Yes!"** As with any fundamental shift in a major infrastructure, there are huge opportunities for all. As a group, the incumbents have essentially the same intellectual, technical and technological resources available to them as does HSA, and HSA has established a prototype in-being for types of service businesses that many of the incumbents are fully capable of emulating.

Further, the incumbents have assets such as rights-of-way that they control, support structures necessary for deploying big broadband, expertise that would be required in the operation of AFNs. The incumbents could become pro-active providers of rights-of-way to newly established AFNs. Similarly they could be proactive providers of support structures on a strategic or opportunistic basis. No doubt, their pre-existing resources would have to be extended to make them especially useful to a given client, but that could easily be done.

The reprogramming of existing rights-of-way and support structures of incumbents can be accomplished through their "mining" the copper in their support systems for recycling of various kinds, as well as to free those structures to be used to facilitate the build-out of particular AFNs.

Much of the early effort involved in re-programming the existing infrastructure of the incumbents to new business activities, and proactively making its elements available to those seeking to build-out big broadband, is labor-intensive work. It would therefore produce lots of jobs! Although they are likely to be low-paying at first, these jobs are in support of a high technology infrastructure and therefore are likely to offer the opportunity for simultaneous or sequential training and education of workers for higher productivity work teams in the future.

Again, the answer to the question, "Would there be a role for today's incumbents in the world of big broadband?" **is a resounding, "Yes!"**

AFNs Present Enormous Business Opportunities for Product and Equipment Suppliers

There is no question about **OBVIOUS and AXIOMATIC roles for** today's and tomorrow's **product and equipment suppliers** in the world of big broadband. As with any fundamental shift in a major infrastructure, the **business opportunities are enormous.** There are opportunities for all, especially for those providers of telecom equipment and services that are alert in responding to the new and virtually limitless needs implicit in the change-over to the AFN, big broadband world.

Complementary Wireless Connectivity

At multiple times in the build-out of AFNs to permit Fiber-To-The-Home, it may be desirable to achieve initial connectivity through wireless technologies. The rapid developments in both Wi-Fi technology and in point-to-point wireless connectivity suggest that wireless can become an early, complementary connector. It can also become an extender of AFN connectivity to otherwise economically-unreachable destinations or a sequential participant in a combination of all the above.

Case Study: End-User-Ownership by Quebec School District

The roadmap for deploying end-user-owned infrastructure can be illustrated in the deployment of fiber optic connectivity to 1000 urban schools in Quebec, Canada in 2001. The success of that activity led to the adoption of a program to expand end-user-ownership across the Province.

Powerful Evidence of Enterprise Build-Out

The CANARIE organization of Canada is a public-private activity dedicated to making it possible for Canada to become the "world's leading deployer of information technology networks." CANARIE explicitly seeks to ensure that Canada becomes the lead player in this arena, much as the U.S. has been the lead player in the development and deployment of the Internet. In the year 2001, CANARIE presented its annual award to what was then IMS Experts-Conseiles (now Xit Telecom) that had been instrumental in the build-out of AFN infrastructures to 1000 mainly-urban schools in the province of Quebec through condominium build-outs.

The enterprise owners in the condominia supporting these school districts included TELUS Quebec (the #2 Telco in the province of Quebec), the RISQ network (the network serving higher education throughout Quebec and the first such network in the Canadian provinces), plus other organizations on an ad-hoc basis. Using innovative strategies to mobilize themselves and their allies, these organizations together were able to achieve low-cost build-out of AFN networks to 1000 schools. More important, these build-outs proved to be achievable at an effective cost that many economists would characterize as "free." That is, virtually every school district discovered that its pre-existing budgets for telecommunications, when combined with other savings that the AFN produced, were sufficient to cover the cost of deploying and operating its AFN. In some instances, the full pay-out was achieved in a matter of months; in others, it was achievable within 3 to 5 years.

The costs (prices) that the schools paid before and after deployment of the AFN were essentially the same; there was a difference, however, in what the schools received. In place of telephone connectivity (voice service and limited-speed data service), they were able to offer VoIP and achieve fiber-connectivity capable of gigabit speeds to each school.

Follow-on Achievements: Brilliant Policies at the Quebec Provincial Level

The CANARIE award for 2001 was presented to the firm that is now known as "Xit Telecom" in recognition for significant achievement on behalf of the 1000 schools in Quebec. For the remaining, more-rural schools of Quebec, however, the achievement represented an invidious comparison leading to their inevitable question to the provincial government, "What about us?"

The phrase, "… leave no child behind …" appears to have significant meaning in Canada. In response to the questions above, the legislature of Quebec endorsed a program called "Villages Branchés", roughly translated as "connecting the towns." Villages Branchés was designed to make it possible for the other schools in Quebec also rapidly to achieve AFN connectivity capable of gigabit speeds. The legislature decided to extend what Xit telecom had catalyzed, and to speed the process by contributing provincial funding to assist in the deployment.

The Villages Branchés program established a key requirement for participation by each school district: in order to apply to the program, the school district must contract with its municipality for the simultaneous planning and build-out of AFNs to serve them both. The program requires condominium build-out as a mechanism for minimizing the cost of fiber build-out to these rural schools. Each school-municipality partnership was also required to enlist as many additional local partners as possible in their respective build-outs. Only when the condominium-plans were complete would the Quebec government agree to provide cash to the school district in the amount of two-thirds of its portion of the cost of the build-out. Under similar conditions, Quebec would agree to pay cash to the municipality in the amount of two-thirds of its portion of the cost of the build-out made for appropriate municipal purposes. This program was launched in October, 2002; to date (early 2004), no municipality approached by a school district has refused to join in condominium partnership with its appropriate school district.

The heading of this section included the words, "Brilliant Policies at the Quebec Provincial Level." Indeed, that is what the Villages Branchés program represents. It is a program whose implementation promises to "leave no child -- in Quebec -- behind."

Some Implications

South Korea's Success for its Macro Economy

At a macro level, as noted in Appendix I immediately below, South Korea's experience during Phases I and II, that took place before the financial difficulties experienced by the competing ELECs, strongly demonstrated the power of focusing on modern, advanced information technologies as a driver for growth of the macro-economy of their country.

Beginning in 1997-98, before the dot-com bubble, and extending even after the bursting of the bubble (2000-02), South Korean economic policies moved that nation out of the recession that followed the Asian crisis, at a rapid pace of approximately 8 percent per year (until slowed when their North Korean neighbors began rattling their nuclear arms). For South Korea, the "externalities" that accompanied rapid deployment of infrastructures to support knowledge goods, indeed, have proven to be powerful drivers for national economic growth.

A similar combination could also drive the macro-economics of the U.S. economy.

The U.S. Analogy

We have already made reference to the apparent similarity in the objectives of the U.S. Telecom Act of 1996 and South Korea's objectives in relation to telecom and other high tech industries. The South Koreans set out to create a competitive, private sector telecom structure. As noted, they were spectacularly successful through Phase I and Phase II to date. Also as noted, the U.S. has been spectacularly unsuccessful in similar efforts to date.

What appears to be actively sought by the FCC and the U.S. Administration is what has befallen South Korea in Phase III and is impending in Japan -- possible, even likely return to a monopoly structure. The FCC's preliminary rulemaking of February 20, 2003, confirmed on August 22nd 2003, called for the removal of common-carriage requirements for broadband from the U.S. ILECs. In effect the interconnect requirements arrived at under earlier FCC rulings, known as "computer II" and "computer III", effectively would be rescinded.

As noted in footnote 1, one objective of the FCC is to achieve "regulatory parity" between the cable modem suppliers of Internet connectivity and the ILECs of the telecom industry. Since cable modem suppliers, even when providing two-way communications services, are not (yet) required to open their infrastructure to be shared by others, nor are they subject to common carriage requirements, the FCC has stated their intention to remove these requirements from the ILECs as well as the requirement for common carriage. Recall that Canada's CRTC has also acted to provide regulatory parity, but has done so through opposite rulings: both its ILECs and MSOs are subject to opening their infrastructures through which they provide two-way services such as internet or broadband connectivity and to act as common carriers. Further, as stimuli to broadband build-out, the FCC proposed (1) removing the requirement for open sharing with competitors through unbundled network elements (UNEs) of any portions of the networks of the ILECs that offer speeds greater than 200 kbps (the FCC's definition of "broadband") and (2) that broadband no longer be regulated.

These rulings have been blocked by the decision of the Ninth Circuit. Had they not have been, the result would have been effective grants of unregulated, regional monopoly status to each of the nation's ILECs. The stated rationale for doing so was two-fold. First, it is the position of the FCC that broadband telecom in the United States is provided under competitive conditions through facilities-based competition. That is, since both the cable modem suppliers and ILECs have similar "broadband" offerings (that are currently within the asymmetric range of 1.5 megabits downstream and several -- a few -- hundred kilobits upstream) this represents effective competition. Second, in the presence of effective competition the FCC has no reason to regulate.

This rationale appears to ignore the implications of Metcalfe's Law for the broadband marketplace. Should either a regional ILEC or a cable modem supplier achieve dominance in a region, it is likely that under Metcalfe's Law, the "network effects" would result in the party achieving perhaps even an early plurality, then quickly sweeping to establish a dominant market share: the resurgence of monopoly is the likely result. To date, Chairman Michael Powell has been silent on such an eventuality.

As in the case of South Korea, where ELECs broke the ISDN monopoly of its then-dominant firm, Korea Telecom, by offering ADSL and later VDSL connectivity plus Internet connectivity,

there is a new technology available in North America (and elsewhere) to facilitate breaking monopoly positions in the U.S. It is the advanced fiber network (AFN) offered especially by enterprises as the end-user-owners of a network. That technology is already in the early stages of deployment. From Table 1, it is possible to see distinctions and comparisons between the "plain vanilla" AFN deployed by an enterprise as end-user-owner, and even-AFNs owned by ILECs as regional monopolies deployed for use by others. The right hand column of Table 1 documents the effects of business plans that are rational under, and consistent with, the monopoly status an ILEC regional monopoly implicit in the intended FCC rulings.

Squaring the Circle: Migrating to End-User-Ownership from other ownership models

What Table 1 and the analysis that surrounds it establish is that end-user-ownership of the AFN -- and only end-user-ownership -- is fully congruent with the maximum potential of that network to provide benefits to its owners; to the activities in which its owners engage; to the communities in which the networks are deployed; to the productivity of all; the end-users, the enterprises, and to their communities; but most importantly, to the productivity and thus the international competitiveness of the economy in which the AFN is deployed.

Currently South Korea, following its spectacular progress as a result of focusing on deployment of interactive broadband and other information technologies as driver for its economy, is experiencing the dysfunctional side of attempting to deploy AFNs through ILECs and ELECs in competition with each other.

Japan appears to be embarked on the same path. Masayoshi Son, the CEO of Yahoo BB, states his intention effectively to drive NTT out of the telecom business[13]. Whether he achieves this ambitious goal or his firm, Yahoo BB, itself follows the apparent path of South Korea's ELECs, the result would be the same for both countries: transport over competing LECs would prove to be a "valueless commodity". Unless, that is, a dominant firm re-establishes an effective monopoly position. As discussed immediately below, such a monopoly position would be likely to be short-term.

[13] Fat Pipe Dream, Wired, August 2003. http://www.wired.com/wired/archive/11.08/pipedream_pr.html

Neither South Korea nor Japan appears to have taken seriously the negative learnings of the IEEE-USA/Cornell Workshop Report and of Googin's Law. Neither appears to be aware of the positive message of the Workshop Report as extended through this paper:

There is another way!

Evidence to date suggests that, if, indeed, competitive AFN transport is a valueless commodity to the ILECs, then the only way effectively and sustainably to deploy the AFN and capture its prodigious benefits -- to the individuals, to the firms, to the enterprises, to the communities and to the economies in which it is widely deployed -- is to deploy the AFN through end-user-ownership of the network or through its closely-aligned surrogate, the customer-empowering-network.

It is through such a strategy that the U.S. and its North American companion, Canada, can "accentuate the positive of the AFN while eliminating the negative of its accompanying potential for natural monopoly," and thereby re-establish the technological leadership for North America in this vital arena, and the vibrant high-tech sectors of our respective economies.

Conclusions

In addition to the immediately preceding, unsurprising observations, the analysis in the paper leads to these conclusions on the likely future US role in global competition:

1. **Even the most optimistic and complete deployment of "Little Broadband" envisioned under the auspices of the FCC over the next three to five years would be insufficient to an acceptable competitive positioning of the U.S. in the global economy. We in the U.S. are behind many other nations now; such an outcome would imply that we would continue rapidly to fall behind them and still others, while greatly increasing the difficulty of our catching up at some point in the future.**

2. **Rapid deployment in the immediate future of advanced fiber networks (AFNs) throughout the U.S. -- that is, Ethernet networks over fiber infrastructures capable of gigabit speeds -- is vital, but not sufficient to the competitive positioning of the U.S. in the global economy.**

3. **Monopoly or duopoly control of the AFNs thus deployed also must be avoided. The current experiences of Korea and Japan confirm that either market structure can default into a nationwide monopolized structure. Such a monopoly of either**

transport alone or transport plus content would be subject to the abuses shown in Table 1, page 14 infra, with unacceptable economic and social consequences.[14],[15]

4. **Only through end-user owned/controlled AFNs can the U.S. control the potential instability, keep the natural monopolies dormant and leapfrog its competitor nations to reinstate a U.S. leadership position in the development and delivery of rapidly evolving knowledge goods in the global economy.**

5. **The process of deploying open AFNs is challenging, especially for municipalities serving as surrogates for their end-users. Fortunately, there are organizations that have resources and commitment that can greatly facilitate the process. HighSpeed America (HSA) is one such organization that can serve as a pilot. Incumbent ILECs and MSOs offering Internet services have resource-endowments, even greater than those of HAS, and are in a position to transform themselves for direct participation in this new, rapidly emerging arena of businesses, should they choose to do so.**

6. **Such a fundamental transformation of the IT/Telecom infrastructure of the U.S. would represent an enormous market opportunity for both current and future product and service suppliers to the industry; and, as in the case of South Korea (Appendix A), represent an enormous potential stimulus for the entire US economy.**

The U.S. faces the greatest urgency for achieving extensive, rapid deployment of end-user-owned Advanced Fiber Networks, networks that we call, "Big Broadband." Fortunately, such deployment is reasonably within the nation's capability.

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[14] The table demonstrates that distortions introduced by even regional monopoly market structures are myriad and pervasive and subtle. The experience of decades has shown that regulation is such a slow and blunt instrument and so open to political manipulation through the three "L's" -- Lobbying, Litigation and Legislation -- that "regulation" as a remedy to monopolization is unlikely to represent an acceptable alternative. This is especially the case when there is a simple, straight-forward alternative, End-User-Ownership, so readily available.

[15] See the works of Lawrence Lessig, Professor of Law at Stanford Law School, and Founder of the Stanford Center for Internet and Society.

Appendix A: The South Korean Saga

The South Korean government chose a strategy for moving its economy out of the deep recession that followed the Asian financial crisis. That strategy called for focusing on information technologies as the driver for development of the economy. South Korea undertook a policy similar to that apparently intended under Telecom Act of 1996 in the United States. The major difference was that in South Korea, the strategy as initiated, worked. In the United States, it did not work, although a great number of false starts contributed to activities perceived as the dot-com boom.

In the United States, the two phenomena, the Telecom Act and the dot-com bubble, reinforced the rapid deployment of Telecom infrastructure by CLECs -- (intended) "competitive local exchange carriers" -- to compete with the ILECs and other players, a competition that proved not to take place.

The needs of the "dot-com boomers" were expected to cost-justify the Telecom build-outs. The economic realities of the dot-com experiment had a double-barreled impact in the U.S. The bursting of the dot-com bubble exposed as fantasy the anticipated increase in demand for Telecom infrastructure just at a point that the new competitive local exchange carriers players were saddled with maximum borrowings. The result was the Telecom crash; a crash that took place before there was any significant impact on the prior monopoly position of the ILECs in the local market. There were pronounced impacts in the long-distance markets with the capacity-over-supply of dark fiber. Against this backdrop, the South Korean approach can be seen to have achieved a number of importance successes.

Three Phases of South Korea's Telecom Strategy

At the depths of its recession in 1997, the dominant player in the Korean Telecom industry was the government-owned Korea Telecom (KT). KT had a well-developed and lucrative infrastructure of ISDN technology. The bandwidth available through ISDN was attractive to many customers and greater than what was broadly available to U.S. customers and many others throughout the world.

Phase 1: Privatization and Competition

The strategy of South Korea's government called for and implemented, (1) the privatization of KT; it was spun out as a private company, KT Corporation. (2) The government issued licenses and provided financial support for other potential suppliers of Telecom services to engage in competition with KT. Herein after these entering firms are designated "ELECs", entering local exchange carriers.

At this early period, South Koreans made very little use of the Internet. What use they did engage in was 85% in English; only 15% in Korean. There were stand-alone start-ups that offered Korean language content, but their penetration of the market was relatively low. The strongest initial entrant into the South Korean market, Hanaro Telecom, considered the ISDN monopoly of KT to be unassailable. Its managers recognized that for Hanaro to be a successful entrant, it would have to offer a differentiated product. They noted also the low level of Internet use at that time. Hanaro took advantage of the geographic concentration of Korea's population, with 95% of the population within 2 km of one of Korea Telecom's central offices. Under the government's new rules, Hanaro could, and did, deploy its own network with higher bandwidth, initially of ADSL (Asymmetric Digital Subscriber Line) connectivity to its potential customers. Further, it included Internet connectivity as a part of its package offering.

Phase 2: Customer Response; Industry and Economic Impacts

Customers responded rapidly to this new technology and to the opportunity to have broadband access to the Internet. The independent suppliers of Korean content recognized the opportunity to reach a much larger customer base through the Internet and quickly shifted their offerings to that medium. Interactive video games began to proliferate and to lead increasing numbers of customers to shift to Hanaro and other ELECs.

Initially, KT was slow to respond, apparently feeling secure in its ISDN monopoly cash cow, but came to recognize the threat represented by their ELEC competitors. KT saw its market share rapidly declining (something that did not occur in the U.S. in response to the Telecom Act of 1996). With the market shares of its ELEC competitors climbing rapidly, Korea Telecom took a bold step. It abandoned its ISDN base and committed itself to compete with the new entrants

with their DSL technologies and Internet connectivity. KT did retain its Plain Old Telephone Service (POTS) copper connectivity.

South Korea's domestic-language content offered over the Internet grew at an astounding rate. By 2003, Korean-language content represented 85% of rapidly expanding total content with non-Korean content making up the remainder. Competition among DSL providers led to rapid improvement in the service offerings of all parties, including KT. By the year 2000, ADSL services had evolved into much higher bandwidth, 8 megabit DSL offerings throughout the country. Further, these offerings were available to approximately 90% of the total population with over 70% of the population opting for broadband connectivity. Over the competition-inspired period of broadband build-out, the information technology sector -- the target of South Korea's national policy for economic development -- rapidly grew and by 2002 had reached 13% of the nation's total GDP. Over the period from the initiation of its IT focus, South Korean economic growth proceeded at a phenomenal rate of 8% per year. South Korea's statistics show that fully 50% of that growth in the economy occurred in the information technology sector.

With the availability of networks with greater bandwidth in both directions[16] than before, traffic patterns changed radically in South Korea and interactive usage exploded. Traffic upstream from the end-user now exceeds downstream traffic in their networks. Women contribute more than 45% of total traffic. 8.7% of total retail trade is now e-commerce-based and is expected to double within the year 2003. Computer games do represent a very substantial portion of traffic, but so does distance learning with many students at virtually all levels of education using Internet connectivity for significant portions of their education. KT's market share was competed back by the new entrants to less than 50% (again, in contrast to what occurred in the U.S.). Hanaro has reached a 35% market share, a phenomenal showing for a new entrant. Korea Thrunet, the third player, also achieved significant share.

To this point, South Korea's national policies had been a resounding success. South Korea is the world leader in broadband penetration of Telecom. Its patterns of Internet use are more

[16] It is not clear if the VDSLs of Korea and Japan are fully symmetric. In any case, they have sufficient relative up-stream capacity to facilitate a high degree of interactive connectivity and usage.

advanced than those of any other country. Its infrastructure is at 8 Megabits and is fully capable of 40 Megabits and even 50. New patterns of network use and family involvement have emerged. Enormous experiential-learning is taking place throughout Korea.

Currently, similar patterns of learning cannot be conceived of much less achieved in the U.S. It will be years before South Korea's bandwidths-of-today can be matched in the U.S.-of-the-future. Where will South Korean's and the Japanese have progressed to by the time the U.S. catches up to the South Korea of today and the Japan-of-tomorrow?

Phase 3: ELECs and Price Wars

The South Korean telecom industry has reached a very fragile point. Competition among its ILECs and ELECs is severe. Korea Thrunet has been driven into bankruptcy as a result of the price wars that have broken out; Hanaro's CEO resigned in disgrace, as a result of the huge continuing losses, experienced by his firm. All industry observers including the chief executive of KT predict rapid consolidation of the supplier industry. He is quoted as saying that perhaps the government made a mistake in creating the competitive structure with financial support for the multiple ELECs that KT had faced.

In all likelihood the consolidation of the supplier industry in South Korea will see a reemergence of monopoly power to KT. It is not clear whether any of the ELEC competitors will be able to survive. The South Korean economy has also experienced an additional shock that, from the risk and uncertainty introduced by the nuclear threat orchestrated by their neighbor, North Korea.

An Interpretation of the Developments in South Korea

There are a number of prominent features of the brief history of South Korean telecom traced above. Korea Telecom's ISDN monopoly position was essentially unassailable by competitors. Yet major competitors were able to enter the market. They did so only by deploying superior technology, broadband technology, and opening new avenues for end-users through the packaging of internet access with their broadband offering.

KT responded with unusual force and insight by abandoning its ISDN "fortress." It was clear that KT's survival depended on its ability to adopt, match and hopefully to exceed the

technology and attractiveness of its upstart competitors. The competitors have awakened a giant. KT has mobilized its resources to fight back and, "The result has been manic competition in…South Korea [leading to] excellent [VDSL] service offerings at crazy prizes…"[17] This comment attests to both the severity of the Korean price war and the severity of the competition in quality-service offerings.

The rapid technological build out in South Korea is the result of the conscious policy of the South Korean government which has clearly borne fruit. Unfortunately, it is likely the case that an unintended and unexpected result (by South Korea, though predicted – and predictable – after the issuance of the Workshop Report and publication of Googin's Law) has overtaken that process. Barring new insights and innovative policy it appears likely that in the future the South Korean domestic telecom industry will settle back into a more comfortable, less simulative, less innovative monopolized structure. Competition with Japan for the mantel of "Broadband Technology Leader," however, is very likely to continue. (See below.)

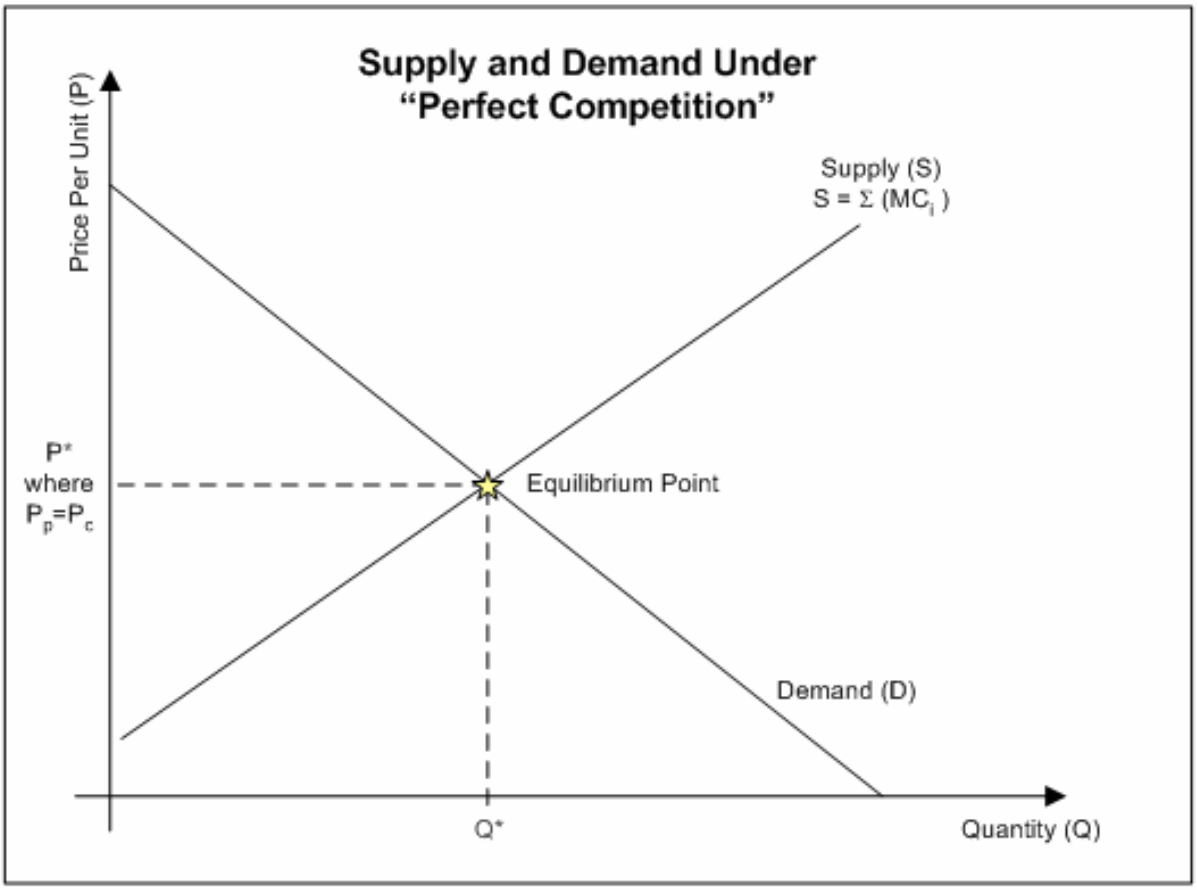
Spillover to the Japanese Market

The Japanese government and its telecom industry appear to be very sensitive to the new prominence of the South Korean telecom industry in the deployment of broadband capability. Their reaction appears to be further stimulated from the natural rivalry influenced in large part by their mutual history. The Japanese strategy response has paralleled that of South Korea. It may well result in a similar outcome – plus continued rivalry with South Korea.

[17] Michael Phillpott, "Avoiding the Risks of the Asian DSL Model," Ovum, http://www.ovum.com/go/content/019234.htm

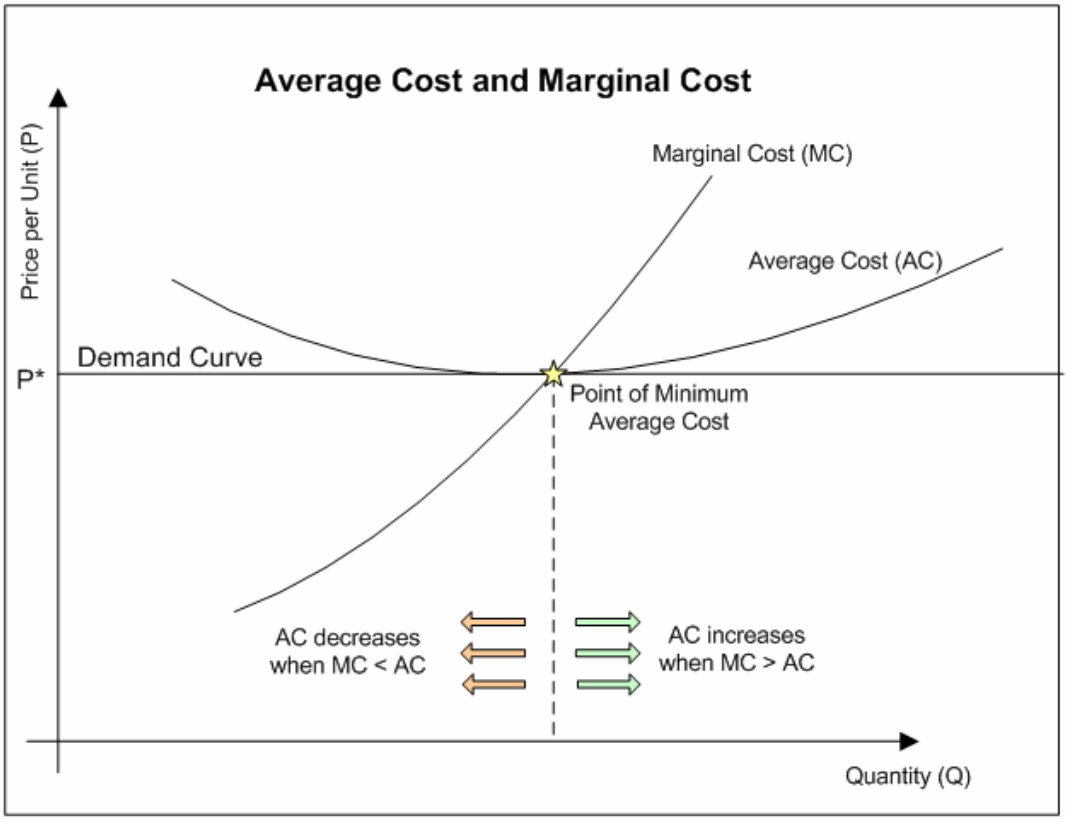
Appendix B: Natural Monopoly and the AFN

I. Competitive Market



Under perfect competition, the quantity supplied equals the quantity demanded, Q*, and price is symmetric: the price to the consumer equals the price to the producer: The price to the producer at equilibrium includes a "normal profit." A normal profit is a profit attractive enough to permit this supplier to remain in business, but no more.

II. The Firm at Equilibrium



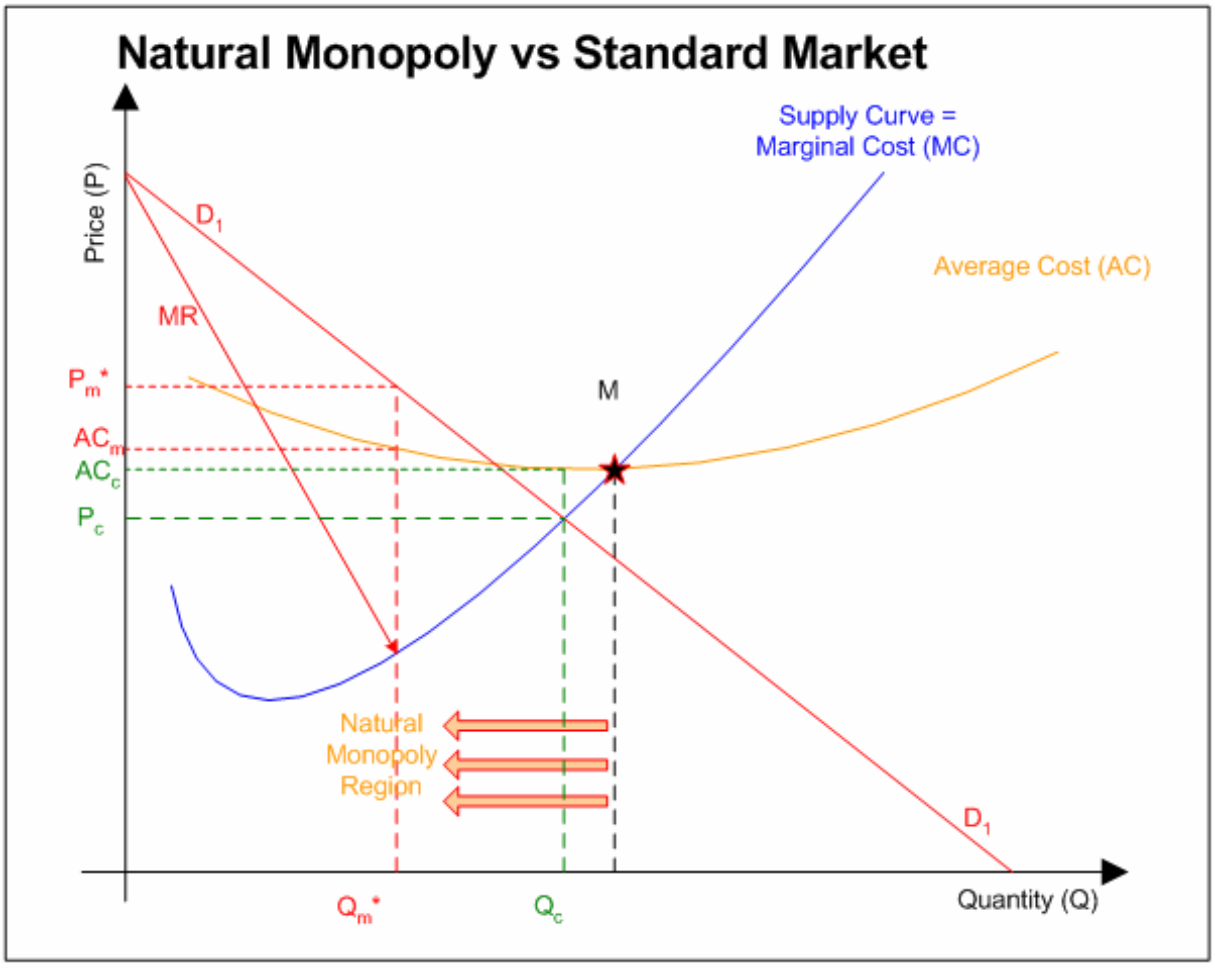
All firms in a market are "price takers:" no firm is large enough to significantly shift the supply curve for the market. That is, each firm treats the market price (P*, determined in Graph 1) as its demand curve and as a given. A demand curve for the firm, then, can be represented by the horizontal line at the equilibrium price, P*, established in figure 1. At equilibrium, this horizontal line will pass through the minimum average cost point for the firm.

For any given quantity Q, Average Cost is determined as the sum of marginal cost up to that Quantity divided by Q:

$$AC = \sum_i \frac{MC_i}{Q}$$

Therefore AC increases or decreases depending on whether MC is greater than or less than AC at that particular quantity-point.

III. Natural Monopoly vs Standard Market



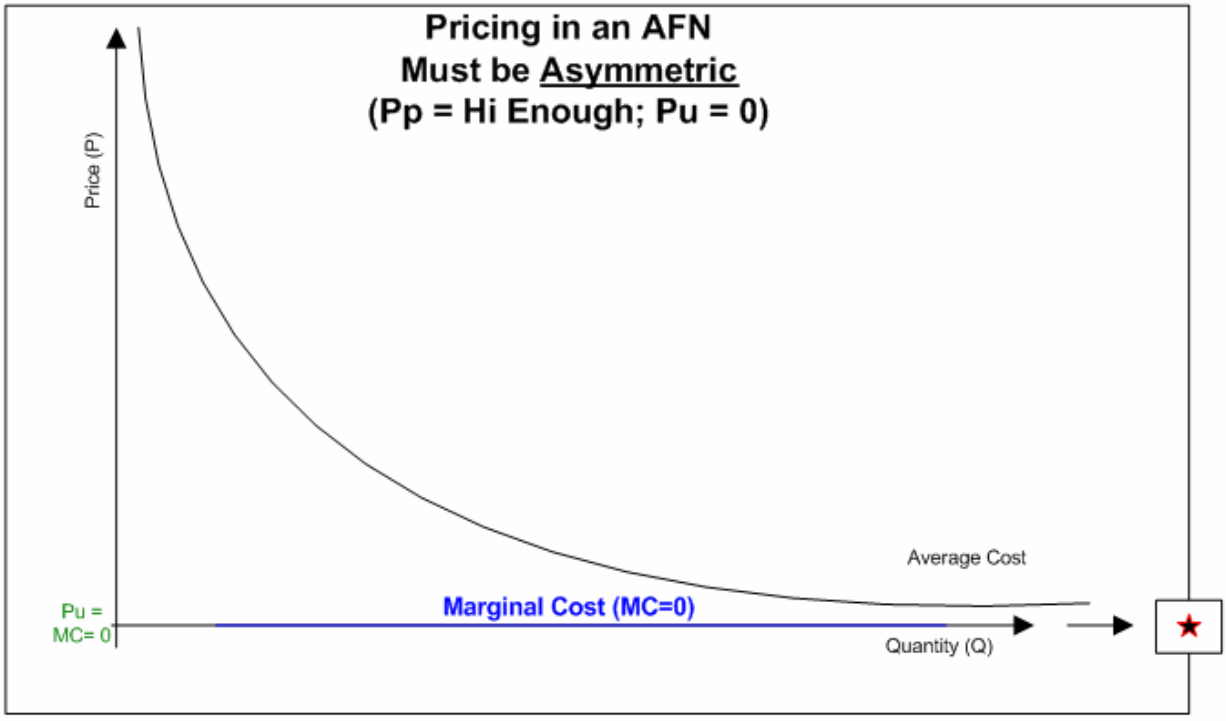
In a market in which the total quantity demanded can be supplied by a single firm whose marginal cost is everywhere less than its average costs constitutes a natural monopoly. That is, the product can be supplied to the market at a cost that is everywhere declining.

Should a second firm enter in competition with the initial firm, the cost to society would rise; each firm would face a lesser demand, and each firm's output would occur at a higher average cost than that possible to the single firm supplying total demand.

Under a Natural Monopoly, the firm would not cover its costs were it to set P* = MC. If left free to maximize its profit (Π), it would do so by setting MR = MC. This would occur at Q_m* and at a price of P_m* as shown in the figure.

(Why? See Appendix A)

IV. Pricing the AFN



An AFN market is an instance of Natural Monopoly for which Marginal Cost < AC everywhere, as suggested in this figure.

Pricing is asymmetric: The price is to the user is different from the price that must be paid to the producer. The price to the user is zero; the effective price to the producer must be high enough to get the AFN produced in the first place.

$$P_u = MC = 0$$

$$P_p = P_p = High \quad Enough$$

Equations for Optimizing Monopoly Profit

In a monopoly situation, the monopolist's goal is to maximize profit and he does so by choosing to produce only the quantity for which marginal cost will be equal to the marginal revenue for that output.

The reason for this is detailed in this appendix.

$$\pi = R - C \qquad (1)$$

where π is profit, R is revenue, C is total cost and Q is quantity. The maximum point for profit is at:

$$\frac{d\pi}{dQ} = 0; \qquad \text{i.e.} \qquad \frac{dR}{dQ} - \frac{dC}{dQ} = 0; \qquad (2)$$

or:

$$\frac{dR}{dQ} = \frac{dC}{dQ}; \qquad (3)$$

the quantity at which marginal cost is equal to marginal revenue; MR = MC. The equations for deriving the marginal revenue (MR) curve are as follows:

Assuming that the demand curve is a straight line crossing the Price axis at P_0 and the Quantity axis at Q_0, the equation for the demand line (or price line) is then,

$$D = P_0 - \left[\frac{P_0}{Q_0}\right] Q \qquad (4)$$

Revenue is equal to price times quantity:

$$R = P*Q = \left(P_0 - \left[\frac{P_0}{Q_0}\right]\right)*Q = P_0*Q - \left[\frac{P_0}{Q_0}\right]*Q^2 \qquad (5)$$

Marginal revenue is the first derivative of revenue:

$$MR = \frac{dR}{dQ} \qquad (6)$$

$$MR = P_0 - 2\left(\frac{P_o}{Q_o}\right)*Q \qquad (7)$$

This equation is similar to the equation for the demand curve (or price line), except that the slope is twice as steep. Therefore, it intercepts the Price axis at P_0, and the Quantity axis at $(1/2)*Q_0$, which implies that it bisects the angle that the demand line makes with the price axis.
The marginal cost (MC) curve is the supply curve for the monopolist in diagram 3.
MC = MR occurs at the intersection between these two curves.

Appendix C: Glossary

Item	Definition
ADSL	Asymmetric digital subscriber line
AFN	Advanced Fiber Network
Average Cost	Total cost divided by number of units produced.
Bandwidth to Spare	Enough bandwidth, including switching and forwarding capacity, to meet current and anticipatable transport needs.
Big Bandwidth	Networks capable of 1-10 Gbps to every business and 100-1000 Mbps to every home
CAPEX	Capital expenditure
CLEC	Competitive local exchange carrier
Costless	A situation in which marginal cost is zero. No additional cost is associated with an additional unit of production.
CPE	Customer-premises equipment
CRTC	Canadian Radio-television and Telecommunications Commission
Depletable	A resource for which the total supply available diminishes when it used.
DSL	Digital subscriber line
DSLAM	Digital Subscriber Line Access Multiplexer.
ELEC	Entering local exchange carrier
EUO	End-user owner(ship)
Excludable	Where the use of a resource by one individual excludes its use by others.
FCC	United States Federal Communications Commission
FTTH	Fiber to the home
Gbps	Gigabits per second
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ILEC	Incumbent local exchange carrier
ISDN	Integrated services digital network
IT	Information technology
ITU	International Telecommunications Union
KT Telecom	The privatized entity that succeeded South Korea's government-owned ILEC, Korea Telecom
LAN	Local area network

Item	Definition
LEC	Local exchange carrier
Little Broadband	Networks capable of 1-100 Mbps to every business and <1-10 Mbps to every home
MAN	Metropolitan area network
Marginal Cost	The increase in total cost given one additional unit of production.
Mbps	Megabits per second
MSO	Cable television Multiple-System Operator
No Fee	A situation in which no price is charged.
Not Scarce	A resource that is neither depletable nor excludable.
NTT	Nippon Telegraph & Telephone Co.
OPEX	Operating expenditure
POTS	Plain old telephone service
RAN	Regional area network
Scarce Resource	A resource that is both depletable and excludable.
SONET	Synchronous optical network
VDSL	Very high speed digital subscriber line
VoIP	Voice over Internet Protocol

Table of Contents