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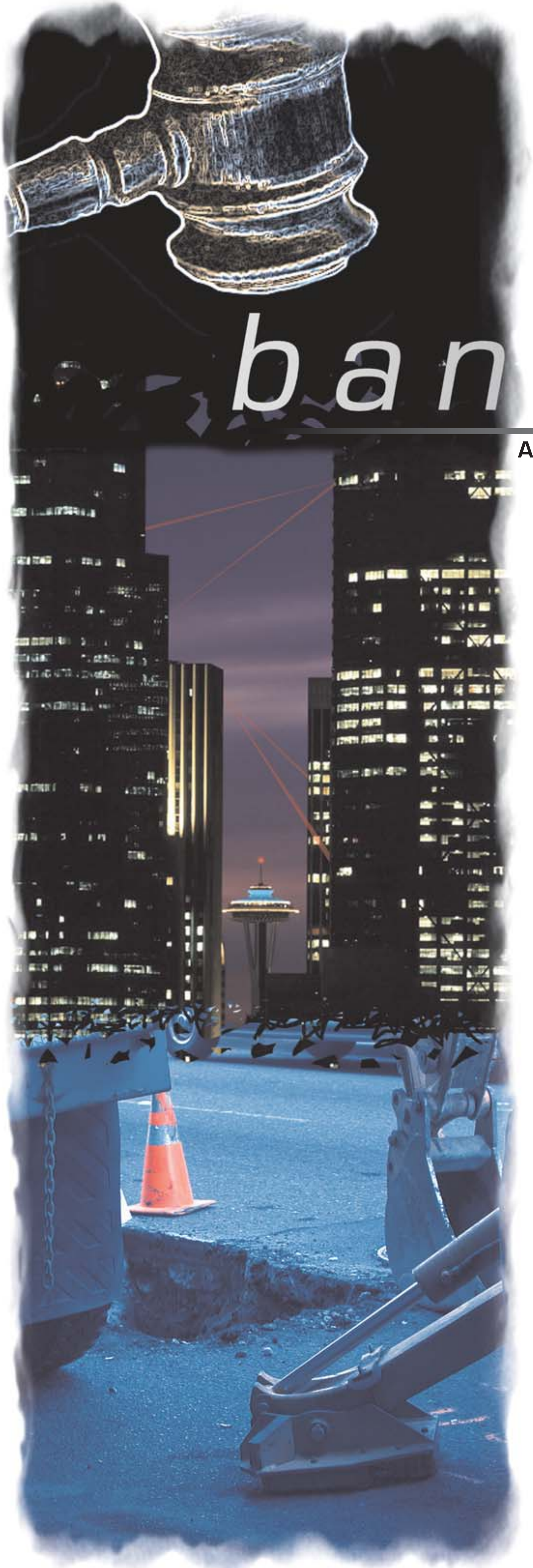

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# Fiber Fables II: The Long Distance Fiber Glut Is Last-Mile Copper Scarcity

By: Senior Fellow John Wohlstetter

Press reports this year have been replete with tales of the great "fiber glut" that leaves long distance carriers with vast unused bandwidth—Merrill Lynch estimates that only 2.5 percent of fiber capacity is currently used.[1] By this reasoning the telecom revolution is drowning in a surfeit of supply and a dearth of demand. But the true story is nearly the polar opposite—yet another example of a telecom fable—a failure to distinguish between unused bandwidth and unusable bandwidth. To grasp this we must venture out into the often arcane world of telecommunications parlance, and translate nerd-speak into plain-speak.

## An Info-Pipe is NOT a Highway

At the root of the "fiber glut" tale of woe is a simple misunderstanding of how bandwidth is measured. The most popular metaphor for the Internet—the "information superhighway"—is a major culprit. On a highway, cars can crawl in traffic but make up for lost time on open road and complete a trip on schedule. Communications capacity simply does not work that way; there is no making up for bottlenecks. What is lost, as a unit of time, is lost forever.

In engineering terms, bandwidth is the instantaneous throughput of an end-to-end connection.[2] Just as a chain is no stronger than its weakest link, a network connection is no broader than the narrowest segment of an end-to-end link. Thus, narrowband connectivity at the end-points—the local loop network segment—is a narrowband connection, no matter how much bandwidth is available in the core long distance network. Users communicating over a 56-kilobit (56,000 bits per second) dial-up circuit cannot do anything with core terabits (trillions of bits per second) except wave at them.

## In Telecommunications, High Speed Travels No Faster Than Slow Speeds

In the world of digital telecommunications speed is used as a proxy for capacity. This is easily misunderstood as well. Speed here does not mean velocity: the digital bits in a 56 kilobit call travel over the network at the same speed as terabits do; it is just that many more bits travel at the same time when terabits are transmitted than when 56,000 bits are sent. This is why one cannot make up time lost if a broadband connection has a narrowband segment. Thus, if two computers are linked to a terabit fiber optic line via 56 kilobit dial-up modems, the speed of the connection is 56 kilobits. Returning to the "highway" metaphor, cars can go 5 mph in traffic and 100 mph on open road; bits cannot.

## Begin With Einstein and Ahab, an Internet Odd Couple….

Some impediments to end-to-end throughput are not capacity-related. The physics of light speed impose a top limit, so long as Einstein remains right (Isaac Newton was right about mechanics for over two centuries, so Einstein still has miles to go to surpass Sir Isaac). Light travels slower through optical fiber's solid glass core than it does in free space; a typical value for light speed over fiber is 70 percent of light's free-space velocity.[3]

Other impediments reflect core network capacity limitations. Most notably, the Internet typically routes calls through 17 "hops"—routing nodes—from origin to destination. The cumulative build-up of delay cuts end-to-end performance, and degrades quality for voice and video transmissions. Thus the joys of IP (Internet Protocol) voice calls that sound like Captain Ahab being dragged under by Moby Dick, and streaming video that barely trickles. DSL and cable modem providers both exacerbate the problem by sharing network capacity—cable from the curb, DSL from behind the central office (the "inter-office" plant segment).

## Add a "Last Mile" that Is Often a "Last Two-Plus" Mile(s)….

Full-speed DSL is rated for 12,000 feet; slower DSL can reach 18,000 feet.[4] But these are in fact marginal systems for many users, as for them the famous "last mile" is more like two, three or even more. Further limiting DSL's geographic reach is that access lines as actually deployed in the local network do not go from central office to residents as the crow flies, but rather via nodes whose location is dictated by overall local loop economics.[5]

This is critical for DSL above all, as DSL technology squeezes capacity out of the high-frequency portion of the old copper wire loop which, unlike cable's broadband coax, is narrowband plant. Cable is solving its capacity problem by pushing fiber closer to the home. At the curbside, optical fiber cable will have vastly greater capacity than at present to apportion among subscribers.

But DSL is not so fortunate. A DSL line runs to the user not from the curb, but from an often-distant central office. DSL is thus severely limited by a fundamental equation of transmission throughput: the distance/bandwidth product. Essentially, bandwidth is inversely proportional to distance traveled. This is why DSL capacity falls sharply after a couple of miles. The solution: either better-performing DSL systems or, better still, driving optical fiber closer to the home.

There is a flip side of the distance/bandwidth equation: as distance decreases, bandwidth increases. Fiber nearer the home can transform today's marginal broadband capability—loading faster the same website pages we load now—to enabling higher-speed applications such as subscription video-on-demand, telemedicine and distance learning. Evidence is mounting that only broadband early adopters consider a faster web connection worth $50 per month.[6]

## Help is on the Way— New Technology (As Usual)….

An example of better DSL is a newer, faster, symmetric (equal speed each way) DSL standard is rolling out in Europe. Dubbed G.SHDSL, it is expected to provide from 2.3 to 4.6 megabit speeds over more than 18,000 feet.[7]

If fiber comes closer to the home, much higher bandwidth applications become viable. Closer means cutting the local loop "last two-plus miles" to well under an actual last mile. The policy goal should become a "last half-mile" (2,640 feet), to make VDSL (Very High Bit-Rate DSL) widely deployable (Qwest/US West already has deployed DSL in Arizona). VDSL can "hold the (networking) fort" u*ntil a technically elegant, economically sustainable* solution to the optical network interface on the user's premises makes true fiber-to-the-home a reality.

VDSL provides 13 megabits per second (Mb/s) over 4,000 feet of copper, 26 Mb/s over 2,000 feet (comparable to the top-end estimated speeds for cable modems) and 52 Mb/s over 1,000 feet. A newer version of VDSL, just announced by Colorado-based VDSL Systems, aims to send 3 to 23 Mb/s over 5,000 of cooper wire, if (in the real networking world, a big if) the copper is in "good condition."[8] Putting these numbers in perspective, the compressed digital HDTV signal transmission standard requires just under 20 (19.43) Mb/s. Thus, laying fiber a half-mile from the end user enables VDSL to carry digital HDTV.

# Opening the Last Half-Mile: Regulation Must Help too

Future investment to upgrade DSL to higher speeds so as to send digital HDTV over the "last half-mile" will be less likely if companies damaged by stranded investment cannot economically make add-on upgrade investment. Thus, new technology investment—notably, fiber placed in the local loop—should be exempted entirely from legacy asymmetric regulation.

The "crow flies" air distance from New York to Los Angeles is roughly 2,500 miles. But if the last 10,000 feet (almost 2 miles) is legacy-network-limited, NY to LA broadband will offer little more than faster web page downloads, and core network "glut" will continue for all save large corporations. Regulatory reform that facilitates deployment of fiber deep enough into the local loop to limit legacy copper wire plant to the last half-mile will open up a vista of true broadband applications, and entice late adopters to take a second look a broadband Internet access. Last half-mile bandwidth abundance will, by stimulating new broadband applications, soak up the core network "glut" in a way that last two-mile copper cannot do.

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[1] How the Fiber Barons Plunged the Nation Into a Telecom Glut, Wall Street Journal, p. A1 (June 18, 2001).

[2] It should be noted that there are two types of connections: physical and virtual. A physical circuit is a complete end-to-end connection, like the circuit switched connection used for voice traffic. A virtual circuit is, in trade parlance, "connection-less"—it does not establish an end-to-end closed link, but instead creates the equivalent of one. Packet switching, used for Internet data calls, is an example: calls are routed sequentially to packet nodes selected according to real-time network traffic conditions, and routed "hot potato" style until they reach their destination; a typical Internet call traverses 17 "hops" in this fashion.

[3] The speed of light through a solid is equal to the reciprocal of the medium's refractive index, i.e., the degree to which light is deflected en route. A typical value for light's velocity through silica, expressed as a fraction of the free-space velocity, is 7/10; the refractive index is the reciprocal, or 1.4. Green, Jr., Paul E., Fiber Optic Networks, p. 43 (Prentice Hall, Inc. 1993). Thus, radio signals travel through space faster than light travels through terrestrial fiber cores. One exception: free space optics such as Seattle-based Terabeam's system, which sends light through the atmosphere rather than over a silica core.

[4] Turning Up the Volume on DSL, Telcordia Exchange, Issue 1, p. 13 (2001).

[5] The author's own DSL line runs 18,400 feet, despite the central office being about a half-mile away.

[6] Bells Make a High-Speed Retreat From Broadband, Wall Street Journal, p. B1 (Oct. 29, 2001).

[7] New DSL Standard Offers Faster Speeds, CNET News.Com, Sept. 21, 2001. http://news.cnet.com/news/0-1004-200-7242800.html?tag=dd.ne.dht.nl-sty.0 G.SHDSL stands for Symmetric High-bit-rate Digital Subscriber Line. The "G" denotes an international standard.

[8] http://www.vdslsystems.com/media/1stgenerele.html

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