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Going the distance

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As with most things in life, telecom is subject to fads and cycles. Several years ago, it was fashionable to talk about two wire to the home fiber local loop buildouts by cable TV operators and incumbent local exchange carriers. (Remember Goldman Sach's Communicopia?)

Wireless was relegated to high-priced, low-volume mobile specialty status. This was supported by the then-new Negroponte Flip, posited by Nicholas Negroponte, director of MIT's Media Lab, who argued that over the long term, wireless would be used for narrowband voice and data, and fiber would become the primary vehicle for broadband, flipping the historical paradigm of wired telephones and over-the-air TV.

The stampede toward fiber, however, was never absolute. Even in those days, futurist George Gilder championed the concept of a bandwidth-unlimited Ethersphere based on high digital multiplexing and capable of supporting wireless broadband service. Clearly, though, Gilder was in the minority.

The fiber broadband infrastructure was never built, and the fashion cycle has shifted substantially. The buzz about terrestrial wireless broadband local loop now is growing louder.

The market capitalization for WinStar, a broadband wireless service provider with 38 GHz licenses in 21 metropolitan statistical areas (MSAs), rose from $348 million to $1.42 billion-16 times revenues, during the past year.

In late November, Teligent, a point-to-multipoint provider with 24 GHz licenses in 74 MSAs, raised $400 million in an initial public offering and debt offering. Teligent's market capitalization reached $1.53 billion, or 464 times annualized 1997 revenues of $3.3 million.

However, this wireless fashion trend has limits. In March, the FCC completed its auction of radio spectrum in the 28 GHz band for local multipoint distribution service (LMDS). The results were disappointing, with total revenues of $660 million vs. previous Strategis forecasts of $4 billion.

And AT&T's C. Michael Armstrong, after experiencing difficulties commercializing the carrier's narrowband Angel wireless local loop technology, recently said that broadband wireless commercialization is years away.

Who is right? WinStar, Teligent and WNP-the largest bidder in the LMDS auction-all with big bets in wireless broadband? Or AT&T, MCI, WorldCom, Sprint and the Bell regional holding companies, which were LMDS auction no-shows?

The RHCs were prohibited from bidding on licenses in their service territories but were allowed to bid out-of-territory. AT&T hedged its bets by buying Teleport Communications Group, which through TCG's prior acquisition of BizTel owns 38 GHz licenses in a number of MSAs.

So to what extent do the new wireless technologies represent serious competition for fiber-based wireline alternatives, both in the near term and long term? Do we believe in the Ethersphere, the Fibersphere or both?

Broadband wireless vs. selected wireline options An economic model helps answer the question by comparing the capital requirements of wireless broadband networks with a benchmarked fiber alternative.

The wireline benchmark is TCG, the No. 2 competitive LEC after MFS, which has installed a 9470 mile fiber network in 65 MSAs (Table 1). This sounds like an extensive network, and indeed, in January AT&T agreed to pay $11 billion to own it-or $1.2 million per fiber mile.

On the other hand, when the aggregate statistics are divided into per-MSA numbers, what is striking is how limited the TCG footprint is-in the average MSA, TCG is hooked up to only 77 buildings (Table 2).

That's not much compared with the approximately 14,000 commercial buildings in the average MSA (Table 3). TCG, with its 77 buildings per MSA, has a 0.5% penetration level of overall commercial buildings.

TCG's low penetration results from the high cost to reach and connect buildings using fiber technology. The carrier's gross network plant at the end of 1997 was $1.72 billion. After subtracting $205 million for the 41 switches at roughly $5 million each, the net outside plant cost is about $1.5 billion. In other words, it costs TCG $112,000 in capital to pass a single building and $303,000 to hook up a single building.

At these costs, TCG must be selective in the buildings it passes and connects. The issue is not the cost of the opto-electronics in the basement of the buildings to which TCG chooses to connect. If that can be done for $20,000 to $40,000 per building connected for DDM-2000 multiplexers, the aggregate customer premises equipment cost is approximately $100 million to $200 million, leaving about $1.5 billion for the fiber transport system. Against 9470 route miles, this translates into $150,000 per route mile, with an average of 0.5 buildings connected per route mile.

Once a carrier's line passes a building, the marginal connection cost is fairly low if the occupants can use OC-3 (156 Mb/s) capacity-about $20,000 to $40,000.

That isn't much on a DS-0 equivalent if the throughput is needed. For example, $40,000 for a 2016 voice-grade-equivalent OC-3 connection-excluding fiber transport cost amortization-translates into $20 per DS-0. This compares favorably with an incumbent LEC's legacy of $600 to $700 outside capital cost per access line.

But the cost of extending fiber networks to pass new buildings-for example, if $303,000 is added for each new building connected, the capital cost per DS-0 rises to $170-suggests that fiber won't be a universal service solution for some time.

Point-to-point beats the numbers Until recently, the only viable broadband wireless technology has been point-to-point microwave, in which a dedicated transmitter-receiver pair links a telecom provider base station to a customer premises. The point-to-point pairs can transmit up to three miles at a link availability of 0.99999 and up to 30 miles at lower levels of availability, as long as direct line-of-sight is maintained.

The capital cost for two state-of-the-art point-to-point systems can be compared readily. The first is a transmitter system with 16 T-1s of capacity supplied by companies such as Innova and P-Com. The cost of this system is $8000 for a fully loaded transmitter/receiver pair (Table 4), which we estimate will decline 40% in two years to $4800.

This translates into $20.83 per DS-0, declining to $12.50-compared with $20 per DS-0 marginal cost for fiber and $170 per DS-0 fully loaded, including transport. Thus, on an equivalent full-cost basis, a 16 T-1 point-to-point system involves far lower cost per building passed ($0 vs. $112,000), per building connected ($8000 marginal cost vs. $20,000 to $40,000), and per DS-0 ($21 vs. $170 full cost).

The capital costs for a higher-capacity OC-3 radio system manufactured by Triton-with 84 T-1s of capacity-also can be compared with fiber. The two-way cost of an OC-3 system is $26,000, declining to $16,600 by 2000. Although the marginal cost per building connected rises from $8000 for a 16 T-1 system to $20,000 for an OC-3 system, the unit cost per DS-0 equivalent is only $12.90, dropping to $8.23 by 2000.

So point-to-point looks attractive compared with fiber:

* Upfront cost is close to zero, compared with $112,000 per building passed for fiber.

* Point-to-point's marginal cost per building connected is as low as $8000, compared with $20,000 to $40,000 for fiber.

* Point-to-point's marginal cost per DS-0 equivalent is as low as $13, compared with $20 for fiber.

Point-to-multipoint: better still In the past year, the FCC has permitted the upgrading of point-to-point licenses to point-to-multipoint. Point-to-multipoint permits a single high-capacity base station to interface with multiple customer premises radios.

The advantage is clear. Provisioning a point-to-point network of 100 buildings with 16 T-1s of capacity each would require 100 antennas and modems. But a point-to-multipoint system might use a single antenna to interface with all its customers.

Furthermore, to the extent that 1600 T-1s of customer demand is a peak load figure, a service provider could reduce the number of transmitters, modems and other equipment to reflect a lower predicted service level.

Alternately, even if the 1600 is treated as a guaranteed minimum service level, the service provider can share unused non-peak load capacity among all subscribers on an as-available basis, making the effective non-peak load capacity significantly higher.

To test the economics of point-to-multipoint, a set of network cost figures can be set up using cost estimates for equipment produced by companies such as Innova, P-Com, Digital Microwave Communications and Ensemble. Key underlying assumptions include:

* 1150 MHz available capacity-equal to an LMDS A band license

* One bit per hertz in 1998, improving to 2 bits per hertz by 2000

* Base station power amplifiers/carriers, each transmitting over 25 MHz

* A maximum of 64 power amplifiers and carriers per base station in 1998, increasing to 128 in 2000

* 60 degrees (6x) sectorization with frequency reuse factor of two. This reflects Ensemble's prospective on tradeoffs. Other companies such as Digital Microwave Communications, Triton, Innova, P-Com and Lucent Technologies are looking at other approaches-typically 90 degrees (4x) sectorization with a frequency reuse factor of four.

With these assumptions, overall base station capacity is quite high- 1.6 Gb/s in 1998, rising to 6.4 Gb/s by 2000. The quadrupling capacity is due to a doubling in bits/hertz from digital signal processing improvements and a doubling in the number of amplifiers per base station because of miniaturization and reduction in power consumption.

The assumptions on unit base station and CPE costs are shown in Table 5. The customer CPE, at $5230 per unit, is slightly more than a 16 T-1 point-to-point transmitter.

Compared with an equivalent OC-3 capacity point-to-point transmitter, a point-to-multipoint system costs substantially less. It uses newer PC-based technology and interfaces directly with copper without a multiplexer. As a result, point-to-multipoint CPE has a lower cost at higher capacity levels.

Additional savings occur on the base station side where a station with 1.6 Gb/s capacity-forecast to rise to 6.4 Gb/s by 2000-costs $300,000 now and should drop to $190,000 by 2000. That price breaks out to $187.50 per T-1 or $7.81 per DS-0. Importantly, most of the costs, even at the base station, are driven by variable demand levels and are not incurred in advance of signing up customers.