Shifting to Wireless Broadband Infrastructure: Why OPEX Functions Rule the Last-Mile Dilemma

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Abstract

Propagation of DSL (digital subscriber link) technology and a burgeoning consumer demand over the past five years has posed a double-edged sword for service providers. The allure of raising an ARPU (average revenue per subscriber unit) value in a steady state of decline holds mass interest to carriers of all sizes, but this effort comes at a steep burden of rising internal costs. And faced with the effects of stiff competition by local exchange carriers and commoditization of voice services, top-line growth becomes nearly impossible to achieve without the presence of parity between reasonable profits and scalable cost curves. The chieftain premise of our research concludes that broadband service providers (BSP) continue to lose money because the reality of OPEX (operational expenditures) burden exceeds the economic yield. In other words, the marginal profit generated by DSL services is quickly eroded by the internal overhead associated with creation and maintenance requirements.

> LAST MILE SOLUTIONS HAVE DIMINISHED THE MARGINAL REVENUE PRODUCTIVITY (MRP) FOR MANY DSL SERVICE PROVIDERS.

Carriers recognize that the bright future of telecommunications hinges on a successful convergence of data and voice services—with an upward trend line of consumer interest that is difficult to refute. Moreover, the recent financial initiatives designed to curb costs speak to the contrary of ensuring profitable services. A focus on reducing CAPEX (capital equipment expenditures) outlays and reeling in the qualification loop length for new subscribers poses a dangerous passage through weak economic times. And coupled with increased churn by DSL connections based on QoS (quality of service) issues, the multiplying impact of cost recovery is further exacerbated.

This research effort unveils some of the key bodies of descriptive statistics and feasibility measurements that we observed by modeling the constraints of DSL service delivery within the environment of a wired carrier network. From the simple computation of an average cost of a truck roll to the determination of loop length impairment, we applied real-world network data to solve for the economic variables that worsen the profit yield. Our scope extended to encompass broadband networks not only in the United States but also those in Europe and the Asia-Pacific where DSL expansion is showing significant adoption. The net result of this work shows how movement to a wireless infrastructure clears the path for profitable service generation through a conserved OPEX position and CAPEX spending that synchronizes more accurately with subscriber demand.

A DSL Economics Framework

Shifting subscribers from slower 56Kbps analog dial-up service to high-speed broadband access was a relatively simple value proposition. Greater line speed implied faster downloads of traffic utility. And the *utility*—or productivity gain—made a premium payment sense to teleworkers, digitally centric users, and those requiring a distinct advantage in connection quality. The lapse of sensibility, however, happened within the carrier's strategy itself. Costly equipment, slower than expected adoption rates, technical limitations, and obsolescence worked against an ambitious plan to deliver broadband everywhere.

The technology boom of the late 1990's and its early turn into the next century did not implore a notion of restraint on service provider spending. CAPEX dollars continued to outpace the nominal increase of subscriber ARPU, and shortly thereafter 2001, the brakes on DSL expansion came to a sudden stop. Upstream providers like Covad (OTC: COVD.OB) and NorthPoint found themselves immersed in bankruptcy proceedings; consumer ISP giants like AOL and Earthlink found difficulty in provisioning DSL access to many requesters. What started as a promising revolution in connectivity experience was finding its path of disappointment widening with the smear of poor financial returns. Economic profit to this day is still difficult to assess, despite that vast improvements made since 2002 with regard to more accurate loop qualification and steady expansion of subscriber rolls.

Carriers accept the fact that a fundamental impairment to profitable DSL exists for one of many reasons. First, the average subscriber selling price (ASSP) for ADSL (asynchronous) service is declining on par with a rate of 9.7% for the past calendar year (2003), and a stabilized price floor is not yet in sight for the coming two years. SBC Internet Services (NYSE: SBC) lowered their ASSP for basic-grade DSL service from $29.95 per month to $26.95 per month with assurance of 12-month service agreements; Verizon (NYSE: VZ) added significant network improvement features while following a similar price suppression strategy. Other competitive local exchange carriers (CLEC) knowingly compete for new enrollments based upon razor-thin margins and hope that subscribers eventually will add premium services to their line connection. In our sample of representative DSL populations, less than 9.4% of any given metropolitan statistical area (MSA) has adopted tiered service enhancements beyond initial order entry. The lower propensity of consumption for these services can be explained by the notion that subscribers view broadband access as a commodity service, and therefore treat spending habits with price discrimination.

> **The average subscriber selling price (ASSP) for ADSL service is declining on par with a rate of 9.7% for the past calendar year (2003).**

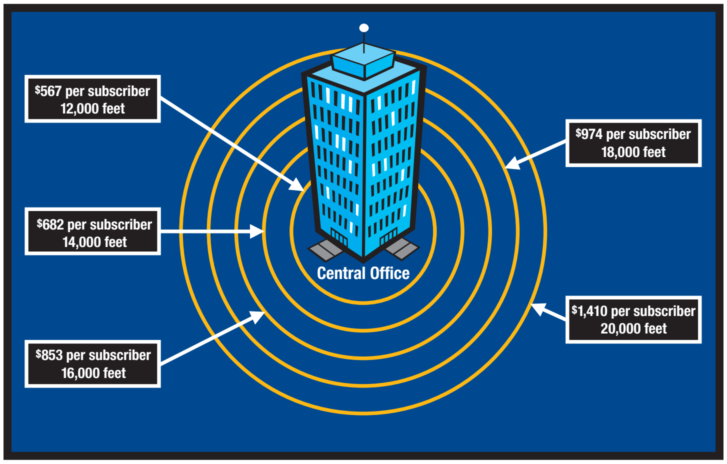
Second, in the face of consistent price erosion mirrored by a lack of subsidy through profitable enhancements, the costs of maintaining these networks continue to rise due to OPEX drag being imposed by a contingency of external factors. For instance, as loop length is extended beyond 12,000 feet from the central office (CO) facilities, signal attenuation and line quality is markedly decreased. Outside plant repair and cable pair health play a critical role in determining how much care and feeding is required to sustain minimum performance standards. The farther distance from the CO results in a higher frequency of technician visits—both to a customer's premises and often ahead of the neighborhood junction terminal.

> **CAPEX COSTS HAVE DECLINED ON AVERAGE BY 37.2% SINCE Q4 OF 2000; OPEX COSTS FOR THE SAME SUBSCRIBER BASE HAVE RISEN ON AVERAGE BY 24.8%.**

Obviously, not every subscriber resides within the demarcation of reliable loop length service. A third issue affecting the profitability of DSL comes from an incremental cost of adding remote terminal (RT) facilities to bridge the distance gap between acceptable signal strength and performance standards. And these RT facilities can be extremely expensive—average cost for one carrier was computed to be $630,000 (USD) for the equipment, construction costs, fiber installation, and real estate acquisition or lease. Beside the expansion costs of a DSL network with RT infrastructure, the number of subscribers served in a green field area of the RT may be too low to support the cost step function. Prominent service providers have since abandoned many of their previous plans to extend DSL qualification through RT deployment due to weighing the respective returns on capital investment.

Lastly, a fourth issue impacting DSL profitability is the marginal physical cost (MPC) of adding each new subscriber to the network—which varies in apportionment based upon the distance from the CO of service origination. Within 12,000 feet of the local loop, the average cost of provisioning a new subscriber is $567 (USD) at the time of generating the order. This figure includes the cost of adding new line cards, modification to DSLAM equipment, power and sparing, line conditioning, and a host of other CAPEX payments. The elusive toll, however, is the allocation of these costs over a given density of connections. That means some areas show drastically different results in terms of capital intensity and the viability of profitable service creation. And factoring subscriber churn (service disconnection) into the mix, some carriers may never recoup their investment of turning on service at the outset.

One of the observed statistics within our study of trends impacting DSL deployment was the underserved population of subscribers that could not attain service within high-density urban markets. Using a modeling technique that uses regression of subscriber variables, we found that the demand for DSL broadband services exceeds the capability to provision service in 74.2% of generally classified urban markets. Think of this figure as a quotient for the number of people who would subscribe to regularly available ADSL service but can not connect—either by error in the loop qualification database or by lack of transmission by CO facilities. Many communities throughout the Bay Area in the heart of Silicon Valley are still waiting for service availability in any form. Most of the shunned have turned to meet their broadband needs through an offering of cable MSO (multiple systems operator) solutions that deliver digital content over coaxial wiring infrastructure. In fact, the mainstay competition to DSL has been cable modem access (CMA), but this trend is waning due to limited success of bundling voice services with data by domination of the regional bell operating company (RBOC) network.



Provisioning costs per subscriber increase with distance from the central office facility

But shocking as it may be that demand exceeds network capacity, and carriers continue an uphill struggle to make DSL profitable on the balance sheet, there is a bright future for DSL to turn the corner on profitable service creation. The answer combines matching the CAPEX investment with predictable subscriber adoption and reliable operation of service equipment that equalizes market demand. What this implies is a scalable economy of returns (payments) for service that more suitably fits a given region and at a lower cost of entry. The popular saying that 'the last mile is the toughest' clearly demonstrates the economic impasse of the carrier: *profits are being lost in stretching the network to meet the subscriber at their closest point of termination.*

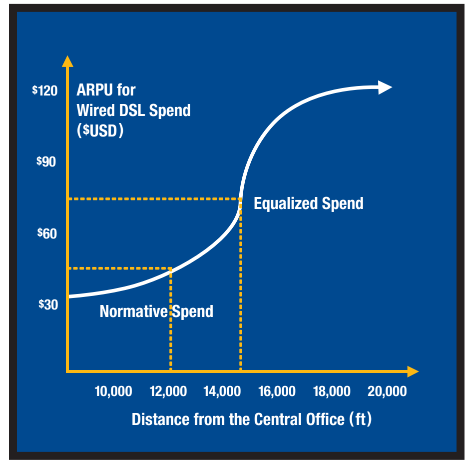
THE AVERAGE COST OF PROVISIONING A NEW SUBSCRIBER IS $567 AT THE TIME OF GENERATING THE SERVICE WITHIN 12,000 FEET OF THE LOCAL LOOP.

Top Reasons Why DSL Needs Wireless Innovation

With so much at stake in making DSL affordable to the consumer, profitable to the network provider, and simultaneously reliable to both sides, the time for an alternative to traditional DSL deployment is more apparent now than ever before. Coupling the elasticity for broadband service with a feasible infrastructure solution can only be accomplished by moving beyond the transport medium itself. Namely, wired access over copper line pairs has its unique set of limitations—and imposition of costs.

Restrictions on loop length mean considering the cost of extending service beyond a point where marginal increases eventually carry significant penalties of OPEX burden—not to mention customer dissatisfaction. Trying to tap growth areas of incremental subscriber revenue without the appropriate and economically scalable technology is a foolhardy attempt on all counts. Rather, our research shows a global trend toward a common need for applying wireless innovation as a core solution to addressing the basic issues of user demand, provisioning costs, and lifecycle maintenance of the service environment. The rationale is fairly straightforward and supported by a number of the following conclusions.

1. ***Cost of Market Entry***—the MPC of traditionally adding each new wired subscriber is likely to exceed the total lifetime revenue of the customer and is especially dependent on the density of markets.
2. ***Uneven Demand Cycles***—each subscriber may desire the purchase of services at different intervals of time and across a varied point elasticity of price.
3. ***Infrastructure Leveling***—the greatest impediment to reliable service is the trap between outside plant equipment and the customer premises itself.
4. ***Just-in-Time Provisioning of Application Services***—like the pay-per-view model of cable MSO networks, subscribers share increasing interest in voice and data applications that turn-on with minimal effort and flex to meet their changing needs.
5. ***Network Intelligence***—the formidable challenge at the time of order entry is the insight into the network's health and faults caused by systemic failures.
6. ***Reduced Labor***—the equivalent of high automation in manufacturing, service generation in the wireless approach requires less labor inputs in cable maintenance and premises technician visits.
7. ***Marginal Revenue Productivity***—the capability to upgrade soft-switch infrastructure to coincide with demand for new service orders is pivotal to establishing a profitable subscriber base on a per instance basis.



Subscriber spend propensity for DSL as a function of availability and distance from the central office facility

DIRECT COMPETITION TO DSL SERVICES INCLUDE (AND RELATIVE PERCENTAGE OF USERS):

- *Cable (28.2%)*
- *ISDN (4.7%)*
- *Wi-Fi 802.11x Hotspots (2.6%)*
- *Alternative Frame Relay Sharing in Multi-tenant Units (1.6%)*

In review of terrestrial data samplings in various MSA communities around the world, we sought to understand the meaningful clusters of subscriber populations that have acquired—or would otherwise acquire—DSL broadband services. As part of their economic schema, the cost of reaching these subscribers could be modeled to extract insight into their propensity of spend (willingness in dollar currency) next to the carrier's expenditure to deliver the DSL connection. And what we uncovered in the research process seemed consistent with our general hypothesis: *the greatest level of consumer demand was either inside dense urban markets or just outside the requisite loop length of non-service markets.*

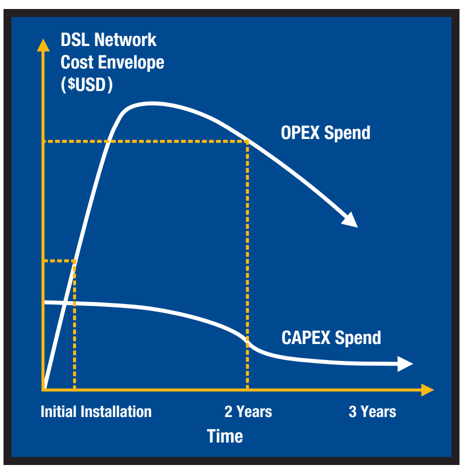
On a normal distribution of given subscribers for a particular MSA, those within the urban cities and relative proximity to the CO were more likely to pay a premium for DSL service than those already consuming DSL service in mid-density areas such as single-family home communities. Alternatively, those outside the prescribed loop length were the most affluent and also willing to pay a higher premium for broadband access. Notably, the suburban homes were the most rapid adopters of alternative access through cable MSO offerings and satellite connection. But on each end of the distribution tail, the costs were determined to be prohibitive in technical feasibility by the carrier and ongoing surveys are being conducted to explore DSL growth solutions on a per community justification.

However computed, the end result is still the same in the essence that subscribers with the highest per capita incomes are still without DSL service. And the gap appears to be closing as metropolitan service providers are extending cable modem platforms and PCS (personal communication systems) carriers begin to offer a hybrid of wireless voice and data service plans.

The Makeup of MPC and Significant Sources of Cost Variation

Cost accounting for DSL represents an opportunity for carriers to evaluate the real transaction cost basis for provisioning new subscriber service within their existing network. One of the contemporary arguments of late says that wired DSL service is becoming less expensive because the subordinate cost structure of CAPEX requirements is declining each quarter. True to some forms, the nominal CAPEX investment is following a steady downward slope of improved cost performance, but the upslope side of the OPEX maintenance burden is actually worsening (increasing) across many MSA communities. Even where network service providers have attained saturated subscriber populations, the marginal cost of physically adding each new subscriber increases as expansion beyond the 12,000 foot loop length is experienced. In effect, the further distance from the CO to the subscriber, the higher the cost of starting service because of OPEX constraints.

THE AVERAGE OPEX ESTIMATOR PER SUBSCRIBER IS APPROXIMATELY 3.62 TIMES CAPITAL INVESTMENT AS A MULTIPLIER.



Weighing the costs of CAPEX and OPEX over time

In our course of studying the range of MPC charges associated with provisioning, an average cost value of $567 (USD) was derived consistent with service creation inside the 12,000 foot loop. Stated previously, this value incorporates the aggregated subordinate cost structures of line cards, DSLAM equipment, power and sparring, line conditioning equipment, and other outside plant facility charges. At first glance, the normalized MPC basis seems reasonable given the moderate retrofit of CO facilities and network expansion. However, adding an OPEX factor of roughly 3.62 times the initial CAPEX investment gives a total cost of inputs that can take years to recharge with subscriber revenues.

And outside the United States public switched telephone network (PSTN) infrastructure, these costs can fluctuate upward by as much as 37.45% in Europe and 15.73% in Japan due to capitalization of copper-based facilities and the recent investment in necessary fiber plant. On a per port basis, many carriers morph these costs by distributing CAPEX and OPEX loads evenly across a wider installed base of analog voice customers as they upgrade their networks to handle switched data. The resolution of amplified costs in this approach goes down, and the outlook for DSL becomes much better against the backdrop of bottom-line operations.

> **Approximately 46.7% of the subscriber base disconnected or switched their service within 36 weeks (or 9 months) of initial enrollment.**

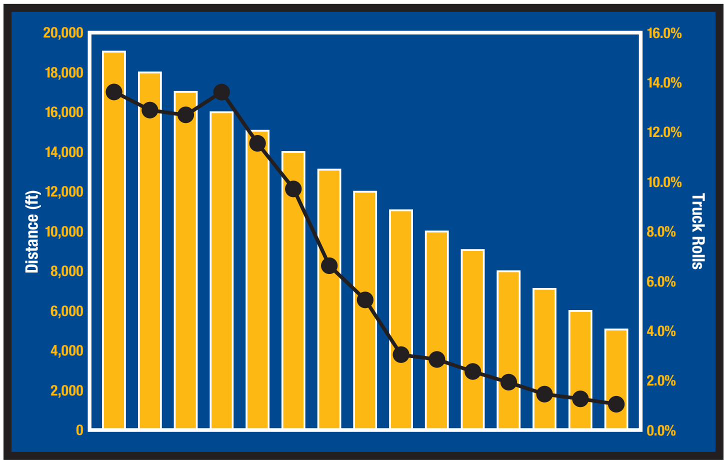
Customer Churn: A Question of Survival for DSL Providers

As DSL finally came to the residential foreground of many communities in 1999, and the word about its revolutionary speed became known, an outcrop of dissatisfaction began to build among a consensus of the user population. Like the latest propagation of cellular technology and its inherent persistence of spot voice coverage, early DSL users started to notice quirks in connection, speed variance, and cost of service as they talked amongst themselves. When initial subscribers were free to choose between providers, many selected the lowest-price or elected to subscribe through their ISP network. Less than a year later, bankruptcy of these CLEC carriers made headlines and so did the millions of subscribers left in the dark by unplugged providers that failed to issue a disconnect order. So, as dissatisfaction tends to breed negative buyer sentiments, a new set of expectations were cast as customers no longer felt any particular loyalty to a single carrier and elected to order DSL service elsewhere.

Such was the magnitude of this continuing shift that caused us to look inside the customer management data and service history records of a well-branded Chicago network provider last September. In a subset of the total subscriber population, we observed several stark trends with regard to subscriber churn:

1. Approximately 46.7% of the subscriber base disconnected or switched their service within 36 weeks (or 9 months) of initial enrollment.
2. QoS was the primary reason stated for the service change; price was the secondary reason by only 13.2 basis points of difference.
3. Switching to cable MSO service was stated by only 9.7% of the subscribers indicating an alternative broadband transition.

These figures and the resultant analysis of the case data show that network providers are pressured to find ways to ensure long-run satisfaction with DSL while retaining monthly service annuities to cover initial line connection costs. Looking at the average MPC of a subscriber, the minimum breakeven position would be slightly longer than 13 months, while the historical cost recapture is more closely 19 months. And with attrition being stimulated by downward pricing tactics and comparable serving offerings on the competitive local market, the mandate for retention is not only critical to the network provider's success, but it is required to sustain reasonable market penetration.



Percentage of truck rolls per year as a function of distance from the central office

The Future of Self-Installation

By the close of 1999, DSL installations realized the worst nightmare in telecommunications repair history—less than 4.2% of initial line connections were accomplished without the involvement of technician assistance at the customer premises. Even with test and measurement equipment improving alongside the sophistication of customer premises equipment (CPE), the overhead of field installation and a high number of truck rolls to complete each order was sapping the growth potential for every network provider. And these costs were difficult to pass through to the customer, although many network service providers established caveats on the expense limits with basic installation. Still, the extra wiring at the customer premises, subsidy of the CPE technology, and mounting trouble with cable quality lead to the current direction of edge-aware devices that boost self-installation performance levels.

Nearly 35.6% of all ADSL installations are being accomplished by self-installation methods in 2003.

Today, the picture is steadily improving with nearly 35.6% of all ADSL installations being accomplished by self-installation methods in 2003. That translates to approximately one out of every three installations is being completed by the end consumer without a technician visit to the premises. Data across the five-year span shows marked efficiency in 2002 when the self-configuring DSL router and modem technology became a mainstay approach to allowing customers the ability to "plug-and-play" their devices while the CO controlled the firmware on a signal basis. The continuous improvement with self-installation is promising, but may reach a plateau as most of the line trouble still requires cable maintenance in the field (especially those areas with high mechanical splicing and aging copper facilities).

To achieve less truck rolls and a diminishing number of cable action requirements, the OPEX factor could be further improved by a "configure-once" hub approach as is common to wireless base station deployment on a given frequency spectrum. This applies modulation at the base while the CPE nodes act as intelligent edge devices in an auto-configuration mode. Defective CPE devices can simply be exchanged through a retail means and no longer would the technician be required to gain access at the premises itself. The technical efficiency savings alone offers substantial improvement to lowering the requisite number of field technician personnel in a given MSA and enables the network provider to ensure higher levels of customer service through the gains of edge intelligence.

Percentage of self-installation service connections

1999	4.2%
2000	13.1%
2001	15.7%
2002	24.1%
2003	35.6% (estimated)

Percentage of truck rolls per installation

1999	99.3%
2000	95.8%
2001	94.2%
2002	76.5%
2003	63.1% (estimated)

Historical values of self-installation and technition truck rolls for DSL provisioning

AN AVERAGE COST OF DISPATCHING A DSL FIELD TECHNICAL SPECIALIST TO THE CUSTOMER PREMISES IS APPROXIMATELY $642 (USD) PER INCIDENT.

Help Desk and Repair: Why Traditional DSL is Expensive

When self-installation does go awry, the first line of defense is the call center for order quality assurance and technical support. Within our data set, we found the average cost of a telephony-based technical support call to be $82 (USD) for an estimated duration of 35 minutes. This value reflects a burdened call center resource and its apportionment of marginal costs. Important to note, the approximate frequency of calls placed for each new installation averaged 2.6 times, with a 12-month frequency of 0.4 calls while service is classified as operationally stable. Call centers for each of the major service providers have expanded considerably to accommodate the inflow of subscriber assistance calls, but the cost of this support method has been somewhat elusive on a per subscriber reporting instance.

And despite the fine-tuning of call center troubleshooting techniques, often times a truck roll is still necessary to accomplish the DSL order completion process and move the customer's service to an operationally stable state of presence. Contrast to the much lower cost of a call center resolution, an average cost of dispatching a DSL field technical specialist to the customer premises is approximately $642 (USD) per incident. Included in this figure are the nominal technician labor cost, allocation of vehicle expense, service and test equipment, dispatch labor, field supervision labor, miscellaneous field service inventory, and other cost derivatives associated with inside wiring and network connection. If the customer premises can be avoided—meaning that the trouble condition is located within the cable span between the CO and the immediate junction—the value is lowered to an average of $389 (USD) per incident to reflect a similar cost accounting, less the components of field service inventory and wiring support at the premises.

Infrastructure Leveling

Practices of changing the transport medium to support next generation networks are nothing new. However, most of the signaling upgrades and outside plant installations (e.g. fiber) have proven costly—and more technically burdensome—beyond the basic business benefit. As carriers turn to the consideration of RT facilities in their expansionary deployment of DSL service, the same issues of feasibility and technical continuity rise to the surface. But new fiber networks and optical rings—given their high speed advantages—are less the culprit than the copper infrastructure that already exists today.

Our research into DSL metropolitan areas of Boston, Chicago, Los Angeles, and the San Francisco Bay Area lends cause to the issues spawned by copper plant and an appreciation of the maintenance overhead for cabling that dates back nearly fifty-plus years. When establishing service for DSL subscribers in these seemingly modern communities, the given condition of the cabling infrastructure is often wrought with splice repairs and far below minimum standards for data usage. This problem only worsens with further distance from the CO and the closer to the customer premises that the signal is carried.

And within the walls of the subscriber's business or residence, the internal wiring configuration leaves much to be desired at the point of termination. Today's customer premises environment is filled with secondary noise that degrades the data signal carried within the structure; telephone answering devices (TAD), alarm equipment, hybrid telephones, and competing radio frequency equipment work against line quality. Wired carriers continue to dampen the effects of secondary noise and the impact of consumer equipment interference (EI) on DSL through the use of filter technology and by installing clean wiring pairs to combat the issue. Often is the case, most of these extended wiring installations cause subsequent service disruptions that require multiple technician visits and consume valuable resources in the field.

Coupled with deteriorating and many times overloaded cabling that reaches the premises, the solution to solving the error instances imposed by infrastructure is to level the DSL environment. That implies taking away the unknown variable of wiring faults in the subscriber's walls and disconnecting the metallic faults of cabling within the ground. Setting the environmental control through wireless transmission is one of the few ways to accomplish the task on delivering a quality DSL signal without the token issues of copper burden.

THE NEXT QUANTUM LEAP IS MAKING THE CONNECTION BETWEEN APPLICATIONS, TRANSPORT, AND SECURITY.

Future Proofing the Network: Broadband Wireless Applications Adoption

What counts the most in delivering profitable service is lowering the OPEX equation.

A survey of current DSL subscribers by an Asia-Pacific carrier shows a moving interest toward a propensity of consumption level for broadband applications—and namely those in the wireless context of ubiquitous computing devices. These data point to a positive rise in the slope of purchased functionality and the notion of modulated supply for broadband access. In other words, subscribers are increasingly willing to pay marginally more for uniquely differentiated service functions. Where network providers have since concentrated on the elementary foundation of reliable service, the next quantum leap is making the connection between *applications*, *transport*, and *security*. Consumers of next generation DSL service appear to be moving quickly into the wireless realm and seeking solutions that marry their interests across each of these three dimensions.

The economic explanation for the movement toward wireless DSL solutions is primarily driven by a shift in *preferences* and an offering of *complementary services* that increase a subscriber's overall utility. When basic DSL began in the late 1990's, the fascination was about speed at a cost displacement of ISDN network services (at a comparatively slow 128Kbps). Not to mention the speed boost, subscribers realized that they could accomplish access without adding new lines or buying expensive equipment. Yet, as many of the early adopters of ISDN service realized that transport speed was just one part of the benefit, the real value came in simplifying voice and data on a single line while lowering the monthly line cost significantly. Then along came advances in wireless networking, and the subscriber audience has begun to accept that wired solutions are limiting. What is demanded, at least according to the Asia-Pacific survey data, is a unified blend of Internet functionality within a secure framework.

Summary

The business of providing consumer and business-grade DSL service is more akin to a linear production function of capital inputs, the configuration of operational centers, and the additive of technology to optimize the service solution. What counts the most in delivering profitable service is lowering the OPEX equation toward achieving marginal revenue production in each new subscriber. Unfortunately, the best improvements with traditional wired DSL service have left millions of subscribers without the positive benefits of high-speed access, and carriers continue to ignore significant revenue streams because of capacity issues.

One company of interest to watch in the wireless DSL marketplace is SOMA Networks, Inc., headquartered in San Francisco, California. In the end-to-end scope of wireless last-mile solutions, the firm has uniquely positioned its spectrum technology to enable network providers of all sizes to enrich their offering with a deployment of voice, data, and application services. Inside the envelope of scalable feasibility, the cost per subscriber is constrained against the levy of otherwise high CAPEX investments and uncertain subscriber growth. More information about SOMA Networks can be found on the company's website at: www.somanetworks.com

Demand for broadband DSL services exceeds provisioning capacity in 74.2% of domestic urban markets.

Methodology Endnote

Conclusions and various perspectives contained within this appraisal integrate the latest economic data pertinent to the network operations of diverse carrier and service providers around the globe—covering CO facilities within the domestic United States, Europe, and Asia-Pacific. Our sample data populations were derived from real carrier operations, including network switch data, operational support systems (OSS), billing support systems (BSS), and customer relationship management (CRM) records. Beginning with the compilation of these data concerning network economics and DSL utility, the initial task involved applying multivariate analyses for logistic regression and CHAID (chi-square detection) relationships. We expanded our modeling exercises to concentrate an understanding of the relationship between factors influencing the cost of wired DSL operations and the chained revenue growth of such service offerings in various MSA populations. A digest of these findings first appeared in the September 1, 2003 issue of *America's Network* magazine (Advanstar Publications).

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About the Author

Frank J. Bernhard is a technology economist and the managing principal of the Supply Chain and Telecommunications practice at OMNI Consulting Group LLP in Davis, California. His research focuses on emerging network technologies and the econometric models that explain market phenomena in the past decade.

Regarded as a pioneer in the subject of technology economics, his writing appears across many different industry and trade media sources, including *America's Network, Intelligent Enterprise, Red Herring, Telephony, Technology Investor* and the *Wall Street Journal*. He may be reached at 530.750.5199 or via email at fbernhard@ocg-us.com.

vision
beyond
technology

OMNI Consulting Group LLP, Davis, CA 95616
Tel: 530.750.5199, Fax: 530.750.3710, Email: information@ocg-us.com, Online: www.omniconsultinggroup.com