Broadband Access Platforms for the Mass Market
An Assessment

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Abstract.

This paper qualitatively analyzes the suitability of different broadband access platforms to provide intermodal competition for the services provided today by the incumbent telephone operators, cable operators, and satellite operators with a particular focus on the provision of high speed internet access. As a baseline, the paper also presents the quantitative incremental economics for cable companies and telephone companies to provide high speed Internet access as a baseline. This paper is based on the analysis done by FCC Technology Advisory Council's Broadband Access Working Group, which the author chaired[1] as well as updated economics derived from the JP Morgan McKinsey Broadband 2001 report[2].

The approach is to define the services that compete for the consumer's dollar, examine the key economic factors that drive deployment economics, and then analyze the suitability of different platforms to deliver the services. Nine different new technology platforms that are capable now, or will be capable in the near future, of delivering most of the services considered are compared with the baseline of today's cable and telephony. The suitability of delivering these services over the new platforms is a function of technical feasibility, state of development and deployment, and ability to compete with the economics of the existing alternatives.

The conclusion is that any new technology platform will be quite challenged in most markets to compete with the cable operators and incumbent telephone companies for the delivery of high-speed Internet access either on a stand-alone basis or in conjunction with other services. Among the alternative technologies to cable and DSL, terrestrial wireless using either licensed spectrum below 5 GHz or unlicensed spectrum represents the best possibility. Even service providers using these technologies will be challenged to compete broadly for high speed Internet access. Customer acquisition and service and other non-technology costs are considerably greater than the technology costs. Therefore scale and the ability to offer new services on an incremental basis to existing services confer a distinct advantage to incumbents.

Background, Introduction, and Acknowledgements

Chairman Michael Powell of the FCC has stated that "…broadband deployment is the central communications policy objective in America today …" and that " …the primary challenge facing policy makers today is to show we can drive the enormous investment required to turn the promises of broadband into reality" [3]. To drive the investment the FCC's goal is to establish the appropriate policy for broadband access, the so called "first-mile" services (i.e., the connections between the customers' premises and the providers' networks). The FCC must understand if this

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1 "Broadband Access Platforms for the Mass Market: An Assessment" – a presentation with slides by the Broadband Working Group of the FCC Technology Advisory Council, December 12, 2002, www.fcc.gov/oet/tac

2 Broadband 2001: A Comprehensive Analysis of Demand, Supply, Economics, and Industry Dynamics in the U.S. Broadband Market, JP Morgan and McKinsey and Company, April 2, 2001.

3 Written Statement of Michael K Powell, Chairman, Federal Communications Commission, on Competition Issues in the Telecommunications Industry before the Committee on Commerce, Science, and Transportation, United States Senate, January 14, 2003.

market will be fully competitive, or simply a duopoly, or even a natural monopoly in various geographies. The FCC must decide how much to regulate or, if it believes that robust competition will occur without its intervention, the FCC could choose to minimize or eliminate regulation and let market forces rule. There are numerous on-going proceedings in front of the FCC dealing with various aspects of broadband regulation including the UNE (Unbundled Network Element) Triennial Review, the Wireline Broadband Item, the Second Cable Modem Service Order, and the Dom/Non-Dom Proceedings [4]

The Broadband Working Group of the FCC's Technology Advisory Council was ask to address the question of intermodal competition (competition using different technology platforms) for mass-market broadband access as input to the FCC's deliberations. The FCC Technology Advisory Council is an outside group of industry experts that provides technology advice to the FCC.[5] The goal of the Broadband Working Group was to describe the factors affecting the economic and technical viability of all available broadband access platforms to provide the three services – cable, telephony, and high speed Internet access that consumers spend substantive money for today **–** and to analyze the suitability of different broadband access platforms to provide competition, particularly competition to cable and DSL for high speed Internet access. One of the Broadband Working Group's key objectives was to help the FCC to distinguish between promised technology – that may or may not be developed in the future – and reality. By doing so, the FCC can avoid a frequent failing of public policy: decision-making based on technological promises that never come to fruition in the market place.

Today cable modem service from cable providers and Digital Subscriber Line Service (DSL) from telephone companies are the two leading technologies providing high-speed Internet market in the U.S. Cable offers a small amount of competition to telephone companies in the voice market and potentially much more in the future. There is considerable competition between cable and satellite for video services.

There are at least nine other technology platforms that could potentially also be used to provide broadband access to the mass market: Very High Speed Digital Subscriber Lines (VDSL), Fiber to the Premise (FTTP), Broadband Powerline Communications (BPC), Satellite,
Local Multi-point Distributions Systems (LMDS), Low Ghz Licensed Wireless Systems (below 6 Ghz), unlicensed wireless systems(e.g. WiFi) , Stratospheric Platforms, and Third Generation (3G) Cellular Systems. The FCC Technology Advisory Council produced a series of presentations describing these platforms in 2002 to which the reader is referred for detailed descriptions of the technology and obstacles to deployment.[6]

In this paper we first present a methodology for assessing the suitability of broadband access platforms to deliver the aforementioned services. We then characterize the services to be delivered over the broadband access platforms in more detail. The key economic factors that determined the suitability of a platform to deliver the services are presented. The incremental economics of delivering high speed Internet access using cable modems or DSL provide a baseline for assessing suitability. Nine alternative technology platforms are compared with the baseline and conclusions are drawn.

The author gratefully thanks the valuable input and analysis from the members of the FCC Broadband Working Group as well as comments and suggestions from the other members of the

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[4] Written Statement of Michael K Powell, op cit 3

[5] The role and membership of the FCC Technology Advisroy Council, the working papers and presentations produced, and the meetings notes are all available at www.fcc.oet.tac.

[6] April and December 2002 Meetings of the FCC Technology Advisory, www.fcc.oet.tac.

FCC Technology Advisory Council. The author also appreciates the support of Jeff Goldthorpe and Behzad Ghaffari of the FCC, who served as the FCC sponsors of this work and provided excellent guidance. The official record of the FCC Technology Advisory Council and its Broadband Working Group as well as the list of members is on the FCC web site at www.fcc.oet.tac. This author drew heavily on that work but assumes sole responsibility for the presentation in this paper.

Methodology.

We first identify the services that can be offered over a broadband platform that customers purchase today, such as voice, multi-programming video services, and high speed Internet access. These services do not include speculative services that may or may not gain market share in the future but rather just the services that generate substantive spend today. For each service we define the key characteristics.

We then define the key economic factors that determine the suitability of technology platforms for offering the set of service defined above. Typical incremental economics of offering high speed Internet access via either cable modem or DSL are presented.

We then analyze the technical feasibility that each platform can deliver each of the services followed by an analysis of the suitability. The suitability of delivering these services over the new platforms is a function of technical feasibility, state of development and deployment, and ability to compete with the economics of the existing alternatives. This evaluation took into account factors such as deployment status, deployment roadblocks, platform feasibility, and our qualitative assessment of each platform's economics. The assessment was done within the scope of likely competition in the 1 to 5 year time frame, particularly in the 1 to 3 year time frame. This time frame seemed appropriate given that the market for broadband access within 3 years will likely be reaching maturity. Any entrants to the market beyond that time frame will be battling to take market share from entrenched incumbents, a much more daunting proposition that fighting for market share among new subscribers.

Services over Broadband Platforms

Today there are three common services currently provided via BB technology platforms for which customers have broadly demonstrated willingness to pay:

- Voice
- High speed Internet access
- Multi-channel video services.

There are two types of voice service: primary line and secondary line. Primary-line service assumes consistent, high-quality voice signals (e.g. "toll quality voice) with a limited number of service outages – perhaps only one a year. In addition, primary-line services are expected to include a set of features such as call waiting, three-way calling, call forwarding, etc., which customers often take for granted. All of a subscriber's extension lines should continue to function as they do today. One of the more subtle features is the ability for 911 emergency service providers, such as the police, to automatically know the caller's address, even if she cannot speak. With some of the alternative phone services available on the market today, this capability may be lost. Another feature is operator services, including the opportunity to be listed in a directory or to have an unlisted telephone number on request. Many customers are unlikely to be willing to change their primary line to another service provider unless they can port their number to the new service provider.The primary line also typically provides "lifeline" service, in that it does not require electricity to function – making it available even when power lines are cut. (Note that cordless phones require A/C power and thus a household that only has this type of phone will not have voice service in the event of a power outage.) Many people do not realize that their voice service

offers this lifeline feature. However, if competitors enter the market offering services without such lifeline availability, the incumbent will almost certainly promote it to generate awareness and retain customers.Yet another aspect of primary-line service is that it adheres to CALEA (the Communications Assistance to Law Enforcement Act), which states that law-enforcement personnel must have the ability to perform a wiretap on a primary phone line when deemed legally appropriate and to obtain from the telco information such as what calls were made on a given line. Although customers might not want such features, they are a service component that traditional telephone lines are mandated to provide. If CALEA apples to new offerings, such as Voice over Internet Protocol (VoIP), it would impose significant costs on the companies offering those services.
CLASS (Customer Local Area Signaling Services) and customer calling are simply sets of features, such as call-forwarding and caller ID, that are integral to the primary-line offering. Another important feature of primary-line service that is often taken for granted is the way that multiple telephone extensions work together, allowing more than one party to speak with a caller simultaneously, no matter what type of phone is in use (cordless, touch-tone, rotary dial). Customer may well expect all extensions phone to continue to work seamlessly without extensive rewiring or new handsets.

Any technology platform offering primary-line services must take these capabilities into account. Secondary-line service refers not to a second phone line or extension, but to a secondary voice connection that is not relied upon for the same quality, security, and flexibility as a primary line. A wireless phone service may be considered a secondary line, as might a second phone line for dial-up Internet service. We make the distinction between primary and secondary lines because many of the alternative voice technologies will be able to compete quite easily to provide a secondary line but will struggle to provide either the quality or the range of services inherent to primary-line service.

See [7] and [8] for good discussions of the difference between primary line and secondary line and the implications of offering primary line over Voice over IP.

We define high speed Internet access as broadband service that is at least as fast as DSL and cable, i.e. potentially several hundred kilobits (Kbs) per second upstream (to the network) and a megabit or more per second downstream (towards the user) – although the lowest priced offering today are often a little slower.[9] It should also feature low latency. This refers to the amount of time it takes to get information through a network. Both the application used and the network contribute to latency. A commonly used example is when one makes a phone call overseas using a satellite link, which delays the communication for about half a second – creating an annoying perceptible effect on the customer. Low latency is particularly important for two-way real-time communications such as voice, video conferencing, and interactive high speed gaming.
Multichannel video services can simply be defined as today's cable or satellite TV programming services, typically featuring about two dozen basic channels – including local and national over-the-air broadcast networks and additional subscription services for premium packages as well as pay-per-view.[10]

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[7] "Primary Versus Secondary Line Telephony Service" from Ralph Brown of Cable Labs available at www.fcc.oet.tac

[8] Cox Comunications White Paper, "Preparing for the Promise of VoIP, available at www.coxcommunications.com

[9] "DSL-Cable Modem Comparison" from Neil Ransom of Alcatel available at www.fcc.oet.tac.

[10] "Broadband Access for Multiprogramming Video/Audio Services" from Barry Singer of Philips, available at www.fcc.oet.tac.

Key Economic Factors

We now look at the key economic factors that affect the viability of broadband access platforms:

- Revenue generating services supported
- Costs of customer acquisition, equipment and installation
- Operations, billing and customer care
- Network access and transport

Revenue-generating ability is key. Many of the costs associated with serving customers, such as billing, do not increase by much as a provider adds services. Thus, a company that only offers a single service – and captures only a single revenue stream – faces a significant market disadvantage. It cannot apportion fixed costs among different services to capture economies of scope – particularly in customer acquisition, marketing, and SG&A costs. In addition, its customers are more likely to churn to other providers. If a user receives both telephone and high speed Internet service from the same provider, for example, she is less likely to switch to a new provider, because changing both her email address and her phone number at once is more inconvenient. High market penetration, or take-rate, for the revenue generating services is another important factor, as most network providers will experience heavy fixed costs to implement service to a specific area, like a single street in a neighborhood. Therefore, these providers need to serve as many users in a given area – with as many products – as possible if they are to allocate their costs efficiently.Note that some technologies are appropriate platforms for all three of the services we have discussed – voice, high speed Internet access, and multichannel video – and providers can potentially capture multiple revenue streams. Others, such as satellite, are best suited for a single service and are therefore less feasible competitive alternatives except in their current niche.

Customer acqusition including the costs of customer equipment and installation costs are the second major factor in a platform's economics. For example, primary-line telephony requires a piece of equipment at the customer's premises called a network interface device (NID). In a modern digital network with digital service to the home the NID translates the signals between the incoming line and the end-user's equipment, such as the touch-tone and off-hook signals sent by the user's phones. A competitor that wishes to offer an equivalent service must replace the NID with what we call a "smart NID" that can translate the signals from a customer's current equipment into the packet language of the provider's network (and back).
Similarly, digital video services require set-top boxes, usually one per TV. These devices translate the incoming digital video signal into an analog signal, which is the format that most TVs use today. A typical installation cost for telephony is the physical connection of inside wiring at a customer's home to the smart NID or its equivalent. Most customers cannot or do not wish to perform this installation task themselves. As a result, providers usually employ technicians to perform a "truck roll," or visit, to the customer's location if they are offering primary line telephony. For high speed Internet access, PCs must be connected to the provider's network to enable Internet access, which can be a rather complex operation. For instance, if a cable modem is being installed and the cable outlet is not near the PC, the household must be rewired.Installation of wireless services can also be complex, as the operator must determine if it can extend a wireless signal to a given customer. Some wireless technologies require line-of-sight visibility from the transmission point to the customer premises, for example. If it is not present, the provider must either expand its network or inform the customer that it cannot serve him.

Operations, billing, and customer care systems make up another important factor. Typically, it is very expensive for companies to develop support systems to perform these functions. Such facilities can cost upward of $50 million. Furthermore, once a provider has developed a system, it must be readily able to modify it to add the new services and features that will almost certainly be required in this rapidly changing market. A company with limited market share and thus few customers to share this expense would be in a highly unfavorable position. Many competitive local exchange carriers (CLECs) underestimated this expense during the telecom bubble of the late 1990s.

These systems must also be scalable. It is fairly easy for a provider to build a system that can accommodate a small number of customers. A company with a limited number of users and a single service representative who performs all order entries on her PC could build a simple, effective system easily and cheaply. However, such a system clearly would not be appropriate for a company that employs many service representatives serving millions of customers. As a result, building large-scale, robust, scalable operating systems is essential.Network access and transports costs are the final key factor in the economics of BB platforms. These include the cost of adding new customers to the network, physical construction costs such as trenching for fiber optics lines , the cost of rights of way (ROWs) or antenna sites, the cost of concentrating or backhauling signals – a traffic management technique used to reduce expenses – and the cost of resolving other network issues, such as installing more bandwidth or better network capabilities to alleviate the slower download times faced by cable modem users when high speed Internet access was first provided over the shared cable networks and a few customers seemed to be using all the bandwidth.

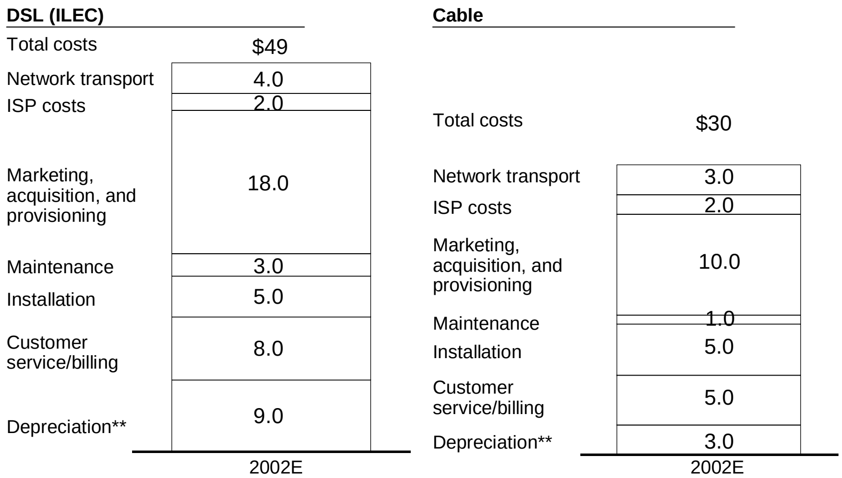
Incremental Economics for High Speed Internet Access using Cable Modems or DSL

The attractive cost structure of high speed Internet access service over cable and DSL presents a challenge to potential competitors. In 80% or more of the U.S. market, customers have at least one choice of high speed Internet access services. Thus, any new technology must compete with at least one existing player. Further, the current service in most areas is offered by a company that provides it as an incremental business to other services: Cable companies offer high speed Internet access as an adjunct to their multichannel video offering; telcos offer DSL in addition to their bread-and-butter telephone services.

Chart 3 provides the estimated monthly costs in 2002 for providing high speed Internet access via DSL for an incumbent telephone company and via cable modem for a cable system operator.

CABLE AND DSL HSI COST STRUCTURE CHALLENGES COMPETITORS

Average BB costs per subscriber* – $ per month in 2002



Caveat: Detailed comparisons depend on many modeling assumptions, including which services are bundled, financial policies, underlying labor costs, maturity of market, % of customers who self-install

CLEC would have to pay an additional $2 to $20 per month for line shared UNE loop or entire UNE loop

* Costs depicted include all period costs averaged over existing subscribers (P&L view of per-subscriber economics)

** Depreciation includes costs for CPE, incremental variable capex per subscriber, and additional high-speed data outside plant build and maintenance

Note: Weighted average of retail and wholesale; includes installation revenues. Columns may not total due to rounding

Source: McKinsey and JPM analysis

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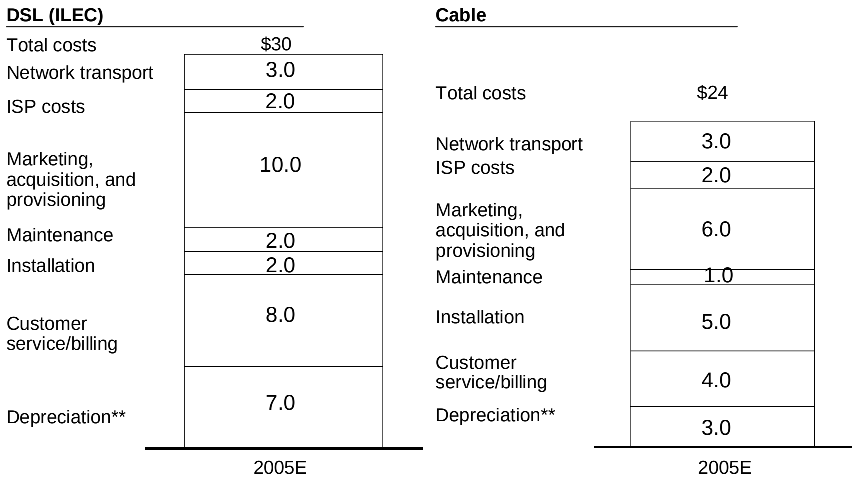
ILECs incur about $49 in monthly costs for each customer subscription to DSL, which includes a depreciation of capex***.*** In comparison, we estimate that cable providers incur about $30 in monthly costs per customer including depreciation. Importantly, only a small portion of these costs are related to the technology employed: Even in 2002 ongoing transport only costs $4 per month for DSL and $3 per month for cable, with depreciation taking $9 and $3, respectively. Marketing and acquisition costs are by far the largest component of the cost structure of both service types. As a result, a new competitor coming into the broadband market – even if it could deliver service of comparable quality, which is not a given for wireless or power-line players – would be severely challenged to compete against incumbent operators, given the latter's attractive cost structures and established customer base. Even if its technology costs were essentially zero, any newcomer would have difficulty building a new network, acquiring customers, and servicing those customers in a competitive way.

By 2005, we expect that monthly customer costs will have decreased even further for both cable and DSL providers. ***as presented in Chart 4.***

AND THE ECONOMICS WILL BE EVEN MORE CHALLENGING IN 2005

Average BB costs per subscriber* – $ per month in 2005



Caveat: Detailed comparisons depend on many modeling assumptions including which services are bundled, financial policies, underlying labor costs, maturity of market, % of customer who self-install.

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** Depreciation includes costs for CPE, incremental variable capex per subscriber, and additional high-speed data outside plant build and maintenance

Note: Weighted average of retail and wholesale; includes installation revenues. Columns may not total due to rounding

Source: McKinsey and JPM analysis

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For cable, we estimate these costs will have decreased to $24, and for DSL to $30. Thus, companies that introduce alternative technologies are likely to face even greater challenges in competing with these incumbent providers.

Comparison of Broadband Access Platforms

***use a Harvey ball (aka phase of moon) format to summarize the suitability of various BB technologies as platforms for each of the services we have discussed*.**

BB ACCESS PLATFORM SUITABILITY

● Suitable
○ Not suitable

● Available now
• In early deployment
· Not available

The TAC had previously supplied the FCC with an analysis of many BB platforms. These analyses were updated, more detailed material was supplied, and one additional platform was added. The key features, advantages, disadvantages, and limitations were addressed. The analysis focuses on serving existing homes and small businesses, not new builds. A separate set of charts has been done for new builds (see supplementary documentation).

Suitable* -------------- Available	Cable	DSL	VDSL	FTTx	PLC	Satellite
Voice – primary line	◕ / Available now	● / Available now	◔ / Not available	◔ / In early deployment	◔ / Not available	◔ / Available now
Voice – secondary line	● / In early deployment	● / Available now	◔ / Not available	◔ / In early deployment	◑ / Not available	◔ / Available now
High-speed Internet	● / Available now	◕ / Available now	◔ / Not available	◔ / In early deployment	◑ / Not available	◑ / Available now
Multi-channel video	● / Available now	○ / Not available	◔ / Not available	◔ / In early deployment	○ / Not available	● / Available now

* Suitable refers to the technical and economic ability to deliver desired services

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BB ACCESS PLATFORM SUITABILITY (CONT.)

● Suitable
○ Not suitable

● Available now
• In early deployment
· Not available

The TAC had previously supplied the FCC with an analysis of many BB platforms. These analyses were updated, more detailed material was supplied, and one additional platform was added. The key features, advantages, disadvantages, and limitations were addressed. The analysis focuses on serving existing homes and small businesses, not new builds.

Suitable -------------- Available	LMDS	Low GHz licensed wireless	Un-licensed wireless	Stratos-pheric platforms	3G
Voice – primary line	◔ / Available now	◑ / Not available	◔ / Not available	◔ / Not available	◑ / In early deployment
Voice – secondary line	◔ / Available now	◕ / In early deployment	◑ / In early deployment	◑ / Not available	◕ / In early deployment
High-speed Internet	◔ / Available now	◕ / In early deployment	◕ / In early deployment	◕ / Not available	◔ / In early deployment
Multi-channel video	◔ / In early deployment	○ / Not available	○ / Not available	◕ / Not available	○ / Not available

* Suitable refers to the technical and economic ability to deliver desired services
** Low GHz wireless refers to portable and fixed wireless systems using licensed frequency below 4 GHz

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The term "suitability" here refers to the technical and economic feasibility of a given platform to provide the service in question (e.g., cable offering primary-line voice). A full moon for a given platform/service combination indicates that at least one provider is now offering it and that its quality and features are comparable to the current standard for that service.

The size of the smaller balls on the charts to the right of the moon indicates availability. A large ball denotes that a given service is currently available on the platform in discussion. A medium-size ball indicates that it is in the early stages of rollout and has not been deployed to the mass market. The smallest ball represents that the service is not available but is potentially deployable on a widespread basis in a three-to-five year time frame. Note that normally it takes three-to-five years for such new services to evolve from the initial trial stage to widespread deployment, despite any provider's or technology vendor's promises to the contrary. Moreover the time from laboratory prototypes to widespread deployment is typically closer to 10 years. For example early prototype trials of both cable modem and DSL technology started in the early '90s. Even the Internet technology which exploded in the '90s dated back to the '70s.Cable, in the first column, offers video, high speed Internet access, and secondary voice services (i.e., over the cable line) today. The last is a relatively new offering and can be offered via the packet cable service defined by Cable Labs or as third party providers such as, Vonage's VoIP product[11]. We gave primary-line voice a three-quarter moon because of the previously discussed Smart NID issue, which requires rewiring a customer's facilities to connect the phones to the cable box. In addition, most cable providers do not deliver lifeline voice services. To do so, an operator would have to implement some type of backup power solution, which would be an additional expense.

Cox and part of Comast's network offer the equivalent of the primary-line service offered by telcos including powering when the commercial power fails. The other cable companies have not designed their networks to provide this level of service, and the upgrade to do so will add significant expensive.
DSL was designed to piggyback on standard telephone service, and it clearly gets a full moon there. It only receives a three-quarter moon for high speed Internet access, because most providers can currently offer it only within about three miles of their central offices on their copper loops, which equates to around 60% of their customer base. To offer DSL to the remainder of the customers, they would need to extend fiber lines to more branches of their network and deploy remote terminals. This can be an expensive proposition if the fiber is not already in place, which is the case in approximately ½ of the remaining customers; the up-front capital cost of such an effort could be over a $1,000 per customer. Even if the fiber to a remote terminal is in place and the remote terminal can accommodate DSL plug-ins, the cost of the DSL installation is more expensive because an extra truck roll to the remote terminal is necessary.As for video services, the inherent design of DSL networks and the platform's technical specifications, particularly the limited bandwidth available for multi-programming video services, do not make this technology suitable to compete with cable or satellite for multi-programming video services.VDSL (very high-speed DSL) could provide all of the discussed services, but it only receives a quarter moon for each because of cost issues. VDSL equipment is considerably more expensive that DSL equipment. Moreover, telcos can only provide VDSL given today's standard International Telecommuncations Union specifications to customers situated within about three thousand feet of their central offices, an area that only contains about 20% of the total telco customer base. To serve more customers using VDSL than they do currently, telcos would need to extend fiber closer to more of their customers' homes, install costly electronics, and spread the expense of this equipment among what would be only a small user base. As a result, we estimate that it would cost telcos about $2,000 to $3,000 per user to provide VDSL to the remaining 80% of their customers.

refers to a fiber optic connection that extends from the provider's central office to the end user. Fiber is an extremely capable medium, and once installed it can effectively deliver all of the services we discuss here (although offering video would require a complex piece of equipment to convert the signal, adding significantly to costs). But FTTP only receives a quarter moon for each service because it would cost approximately $800 per home passed to install fiber in a typical

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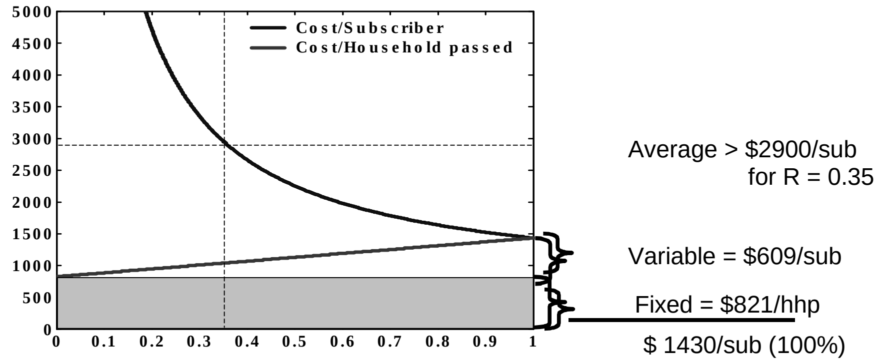
[11] Vonage service offerings are describes at www.vonage.com

residential area and optimistically at least another $600 per home served. At 100% market penetration this represents over $1400 per home served but at a more realistic 35% market penetration, this would represent a costs of over $2900 per home served. (***see chart 11***)

CONSTRUCTION COSTS ALONE MAKE FTTH BUSINESS CASE DUBIOUS



Average cost = $609 + $821 / R

Source: “Corning Cable Systems,” ATT Labs Presentation to FCC Technology Advisory Council

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At the same time, fiber could be a feasible option in situations where incremental construction costs are minimal, such as a new suburban development in which many new services must be installed at once. When trenches are dug to install electrical wires, fiber cable could be installed simultaneously, thus spreading construction costs among services and removing a barrier to the feasibility of fiber as a BB platform. Fiber could also be attractive in dense residential areas with aerial plant.Power-line communications (PLC) refers to the transmission of broadband signals over the electric grid. This concept extends back to the 1800s, but it is still a relatively unproven platform with several significant disadvantages. For example, this platform does not have enough bandwidth for full multichannel video services, nor does it typically offer as much bandwidth for high speed Internet access as cable or DSL over a typcal serving area. In addition, its unproven nature makes its cost structure unclear. Clearly professional installation of any equipment on the commercial power grid will be required. The nature of the U.S. power grid with typically only 4 to 8 customers on the low voltage side of the transformer means that fairly expensive equipment and installation of same may be shared among a very small number of users, particularly under reasonable assumptions about market share among high speed Internet users. Any offer of primary-line telephony would not likely include lifeline services, as the lines would most probably not function in the event of a power outage. Moreover the widespread deployment of this technology raises RF interference issues under consideration in a pending rulemaking. This rulemaking could well be quite contentious leading to regulatory delays and market uncertainty.Satellite technology is clearly a viable platform for video services. It is a suboptimal conduit for high speed Internet access service, however, not only for cost reasons but also because of latency problems inherent to transmitting a signal to a satellite and back. Such issues are not noticeable to a user performing tasks like ordinary Web browsing, but they are significant when doing anything highly interactive, such as online gaming or video conferencing. Latency is also an issue in transmitting voice, because of perceptible delay between speaking and being heard, necessitating pauses between speaker and listener.

LMDS (local multipoint distribution system) is a high-speed, high-frequency – typically in the 24 to 38 GHz range – wireless technology that proclaimed a great deal of promise a decade ago; however, this promise has not been realized. The primary issue has been cost, but LMDS also requires a clear line of sight to work well. Wet trees or heavy rain, for instance, destroy an LMDS signal. Furthermore, this platform only allows transmissions over distances of a few kilometers. Thus, it requires a fairly expensive network, including a high number of base stations and expensive backhaul, to transmit effectively. Moreover, the customer premises equipment is also relatively expensive.

Low GHz licensed wireless includes several low-bandwidth platforms that could use MMDS (multichannel, multipoint distribution system), at around 2.1 to 2.6 GHz or PCS (personal cellular services) at around 1.9 GHz. or some of the new spectrum that will become available such as the UHF TV spectrum (around 700 MHz) that is being returned to the government for auction as part of the conversion to DTV. Many companies have been experimenting with low-GHz technologies and testing them in the market. Incumbent telcos, such as Bell South, and competitors like Clearwire have announced deployments of such platforms. Unfortunately, none of the iterations of this technology has enough bandwidth to deliver video. They all, however, appear to be capable platforms for high speed Internet access, although most require reasonably clear line of sight or near from the tower to the user's equipment. For wireless technologies the ability to do cost effective customer qualification and adequate RF engineering can add substantially to costs. Moreover wireless signals lose considerable strength passing into buildings. Thefore an outside antennae plus cabling to the customer's inside wiring can add considerable costs. This installation either requires a truck roll by the service providers and/or becomes a significant barrier to customer acceptance. As for secondary-line voice, low-GHZ services would probably rely on VoIP technology, earning it a three-quarter moon, while primary-line voice gets a half moon due to lifeline issues and a few other subtleties related to the reliability of a wireless signal. Unlicensed wireless, also known as Wi-Fi (wireless fidelity), has the same issues as low-GHz licensed wireless (not enough bandwidth for video, etc.). In addition, some argue that because it uses a low-power signal and is unlicensed, it might be even more impractical. However, one significant advantage to this technology is that it is on a steep growth curve, with an enormous amount of capital backing it other makets. Corporations are increasingly employing it for enterprise LAN and campus applications; and many consumers are using it for home networking. The rapid deployment of WiFi clients means the customer end of the connection is quite inexpensive. On the other hand WiFi today has relatively short range, thus requiring many base stations and substantive backhaul costs. Various developments are tackling this problem but it is too soon to see how effetive they will be. WiFi was not originally designed to provide voice, and there could be some voice quality problems as a result. At the same time, there have been recent developments suggesting that Wi-Fi using VoIP might actually be a capable medium for voice. Various vendors on making bold claims for the economics of WiFi in relatively dense areas (***see Chart 12)***.

AGAIN, WIRELESS TECHNOLOGIES PROMISE DISRUPTION

But:
- **How good is the coverage within the footprint (dramatically affects cost of customer acquisition)?**
- **What will be the customer churn rate?**
- **Will the quality of service and speed be good enough to compete with cable or DSL?**
- **Can voice or other services be supported so as to spread costs over more revenue streams?**
- **Can the costs of site acquisition and backhaul be effectively managed?**

Analysis presented by Vivato

62,856,600 covered households*
52,425 square miles of coverage
- Wi-Fi switches – 28,330
- Cell sites – 7,083
- Landline backhaul locations – 355

Sufficient throughput capacity to deliver service to >200M subscribers at today's usage levels
- Average busy-hour usage/sub: 3.3kbps**
- Average busy-hour download/sub: 1.5Mbps**

	Switched WiFi	Fixed wireless	Conventional Wi-Fi access point
Network deployment cost	$0.59B	$3.34B***	$2.75B
Equipment	28,330 switches	64,080 radios, 10,680 base stations	476,988 APs
Cell sites	7,083	10,680	476,988

* Approx. 61% of U.S. households
**2001 Dartmouth Campus WLAN study, Kotz & Essien
*** Includes cost of CPE for 5 million subscribers

COMPETING WITH INCREMENTAL ECONOMICS OF CABLE OR DSL IS CHALLENGING!

Source: Vivato (Economics not analyzed by McKinsey)

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However as noted on Chart 12, there are many unanswered questions and the past history of wireless would say the costs are being substantively underestimated. For instance, for a given "footprint," or coverage area, the figures on this slide only begin to be realistic if the wireless signal can reach essentially *all* of the potential customers in the footprint. If the signal is only strong enough to provide service to half of the homes in the footprint, the provider's expenses per subscriber will increase dramatically. And the company will not normally be able to identify which customers will receive an acceptably strong signal and which will not without expensive RF engineering. WiFi also has the same issues about the possible need for an outdoor antenna and subsequent cost of connection to the inside wiring as with the licensed technologies discussed above.Stratospheric platforms would involve stationing some type of unmanned aircraft, such as a blimp, above a metropolitan area. From a technological standpoint, this appears to be a good alternative because it locates an antenna high enough that it can reach a large area, yet low enough that users will not experience latency issues. It could therefore potentially provide video, high speed Internet access, and voice (using VoIP). Unfortunately, there is a substantial degree of risk inherent in such a venture many of them involving the aeronautical problems. This proposition has not moved beyond the venture stage. 3G was originally designed as a voice technology, and we believe that as a platform for high speed Internet access, it has been subject to an inordinate amount of hype. This technology clearly does not offer enough bandwidth for multichannel video, and our analysis shows that it is unlikely to meet high speed Internet access expectations.

Mobile services like 3G can be a substitute for primary-line voice service – essentially replacing the wireline phone. It is not a full replacement since the voice quality of current offerings is inferior to traditional standards, and the need for battery power hinders this technology's ability to serve as a "lifeline."

Conclusion

Any new technology platform will be quite challenged in most markets to compete with the cable operators and incumbent telephone companies for the delivery of high-speed Internet access either on a stand-alone basis or in conjunction with other services. Among the alternative technologies to cable and DSL, terrestrial wireless using either licensed spectrum below 5 GHz or unlicensed represent the best possibility. Even service providers using these technologies will be challenged to compete broadly for high speed Internet access since customer acquisition and other non-technology costs dominate the technology costs.

ADDITIONAL REFERENCES

The following documents are all available on the FCC Technology Advisory Council web site: www.fcc.oet.tac.•FCC Broadband Access Platforms Tutorial, Stagg Newman, April 14. 2002.

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