# Blended Technologies
## Operating in the World of HFC, Wireless, DSL, and Other Transport Technologies

Jeff Tokar
High Speed Access Corp.

## ABSTRACT

Now that the standards for DOCSIS compliant cable modems have been finalized and the compliant modems are starting to emerge, cable operators are in a position to expand an early lead in deploying high-speed Internet and data services, establish a significant presence in these new markets, and begin generating revenues in anticipation of competition from telephone, satellite and wireless cable alternatives. Unfortunately a large fraction of the installed cable plant is still either unsuitable for 2-way high-speed communications, or deployed primarily in residential areas bypassing potential commercial markets where these services are highly coveted and have the potential to generate the highest revenues. By expanding upon the technologies within their arsenal, cable operators can take the lead in almost every market today, while gaining the flexibility to expand out the basic hybrid fiber/coax (HFC) technology as revenues and schedules dictate.

## INTRODUCTION

Blended technologies promise to reduce deployment costs, and enable deployment beyond the traditional range of cable plants into many non-traditional markets. They can also provide a time to market advantage so that cable operators can establish a beachhead before the competition has a chance to deploy service. Not only will this improve the chances that cable will become the dominant player in a given market, it will also mean that cable operators will be able to start generating revenues, and gathering operational experience sooner.

As the initial new low-cost high-speed data provider, cable operators will be in a position to demand a premium for their services to help fund the development of the basic infrastructure. Once these costs have been paid, cable operators will be in a better position to face the competition from telcos, satellite providers, wireless cable, and others.

One of the primary limitations of many cable systems is that HFC distributions plants have been built into residential neighborhoods to deliver consumer oriented entertainment, while the business districts represent the highest potential revenues for high-speed data. Even when cable operators decide that that they will build out to business districts and industrial parks, it may prove economical to bring these businesses online and generating revenues within a few weeks, rather than waiting until the cable plant has been extended into the right location.

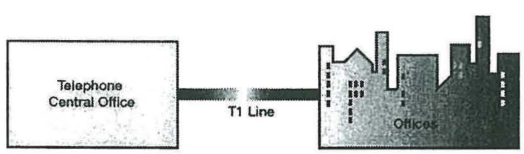
Blended architecture could also play a role in extending services into large office buildings or Multiple Dwelling

Units (MDUs), which may be difficult to wire with coax owing to costs, limited duct space, and/or restrictions on extending the cable plant onto the premises.

## THE DAWN OF HIGH SPEED DATA

In the traditional high-speed access model, businesses have paid high prices for special T1 (1.5 megabit/s) or T3 (45 megabits/s) lines to be brought to their premise. These services have been offered by a combination of local telephone companies, long distance companies and competitive access providers. Prices for T1 lines can average $1000 per month including equipment rental and Internet access, although they tend to be cheaper in concentrated markets such as major cities with significant carrier competition.

**Traditional High-Speed Data**

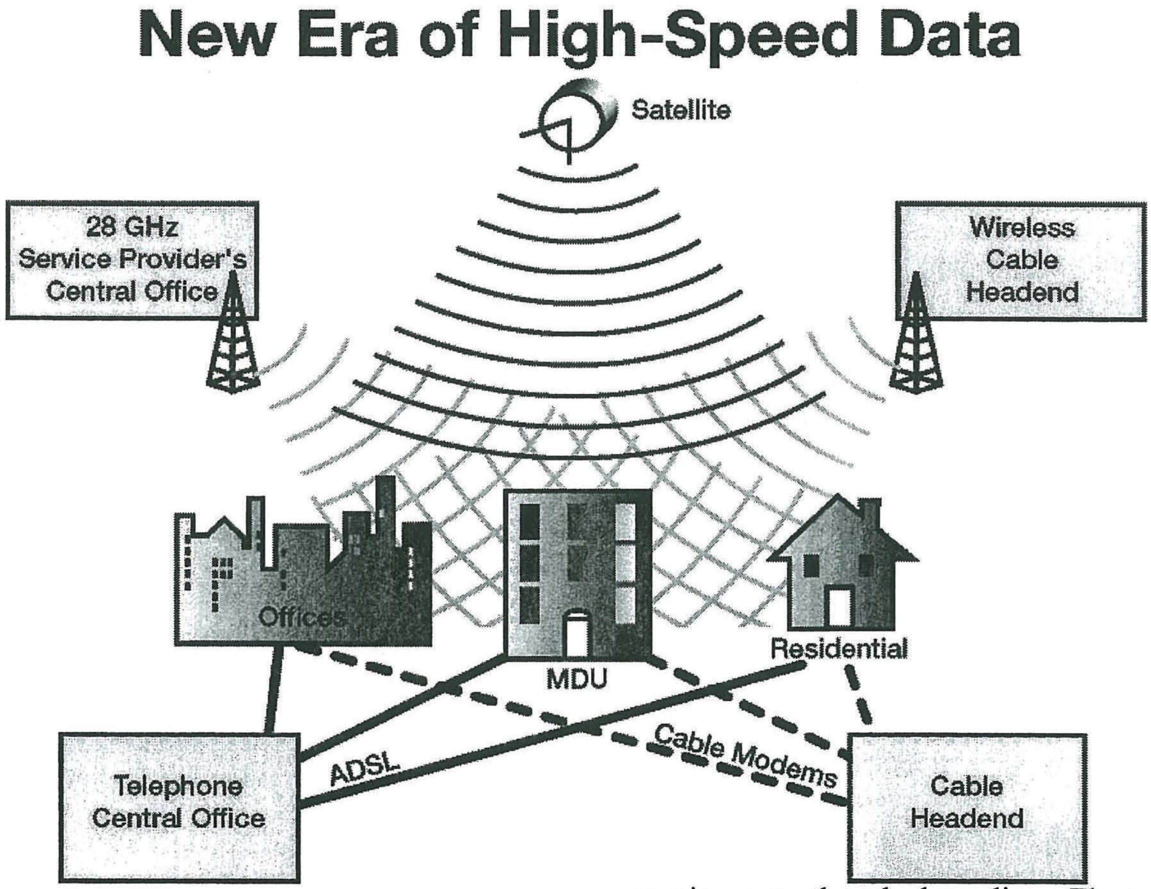



Consumers traditionally have been restricted to much lower speed alternatives that operate over more dated telephone lines. These alternatives have included modems that operate at speeds of up to 56 kilobits/s and more expensive ISDN lines that support speeds of up to 144 kilobits/s (2-B channels at 64 kilobits/s and 1-D channel at 16 kilobit/s). This has restricted consumer oriented Internet access primarily to text, video, and low-quality audio and video applications.

The last mile is in a period of rapid transition thanks to widespread interest in the Internet, and the development and deployment of new technologies for delivering data over cable TV plants, telephone networks, and wireless technologies. This is being paralleled by efforts to develop a high-speed, highly reliable backbone that will be suitable for high-quality telephony, CD-quality audio, video conferencing, entertainment television, and 3D-streaming.

The advent of these new lower cost networking approaches promises to consume the high-cost data services that exist today, and create a new market for higher-speed services which demand a higher quality-of-service. In the future consumers and businesses will regularly take advantage of the Internet for making phone and video calls, watching TV, and being immersed in streaming 3D. Streaming 3D will enable viewers to do things such as watch and replay football games from any angle they choose, or navigate through complex 3D atlases using a novel new type of interface. This technology is not just science fiction. In fact the Web 3D consortium plans to bundle the X3D standard (which is still under development) with the next generation HTML standard that is due out by the end of 1999, and to make this software freely available for incorporation into Web browsers and Internet TV appliances.

Cable operators will be delivering high speed data services over a combination of hybrid fiber/coax, wireless, and telephone wire infrastructure that will generally offer speeds up to 27 megabits/s downstream, and up to 10 megabits/s upstream, which can be shared among multiple users. For cable systems that are not yet equipped to handle bi-directional traffic, the upstream data could be carried over a regular modem. But this would operate at significantly lower speeds and would require the customer to use up a telephone line when connected to the Internet. Although this would still offer consumers high-speed access, it would mean that customer would have to pay for the extra telephone line, which would mitigate some of the added benefit of having a cable modem.




Alternatively, it may be possible to send the upstream signal over some kind of wireless signal, such as unlicensed wireless in the 900 MHz, 2.4 GHz, or 5 GHz bands, which would obviate the need for an extra telephone, and keep the telephone company out of the equation completely.

Cable companies might also run HFC plant to large buildings, such as offices or MDUs, and then use wireless, powerline, or phoneline (over lines owned by customer) networking to provide the last link to the premises.

Another group of Internet Service Providers, which may include the telephone company or others that simply lease out the telco wiring are running Asymmetrical Digital Subscriber Line services over the telephone lines. These technologies will be used by telcos to provide a new type of integrated voice, video and data service. A number of major telcos including AT&T, Sprint, and Cable & Wireless (which acquired MCI's data networking assets in the US after the merger with WorldCom) are planning integrated broadband services using such an architecture.

Wireless cable operators are also breaking into the market for high-speed data delivery by inserting a data delivery channel into an empty TV channel. They will be able to take advantage of some of the work that has taken place in the traditional cable world. For example, Hybrid Networks, which cut its teeth in the traditional cable world, has developed a technology which can send data at up to 10 megabit/s downstream and use either the telephone plant, or wireless at speeds ranging from 256 Kilobits/s to 2 Megabits/s in general and 5 megabits/s upstream for special applications. Data can be transmitted downstream over MMDS, MDS, WCS, and UHF wireless frequencies.

Meanwhile another group of 28 GHz telephone and data service providers is springing up to take advantage of the immense capacity available in this band (1-GHz). Many of these operators, such as Teligent, have already started rolling out commercial service with speeds of up to 45 Megabits/s. Faster speeds are possible due to the 28 GHz band's extremely tight radio waves, which enables the radio energy to be highly focussed, and thus does not create much interference between nearby users.

The satellite operators are also getting into the picture. The Hughes DirecTV venture has launched the DirecPC service, which is already capable of supporting speeds of up to 400 kilobit/s downstream. However, upstream service must go through a traditional analog modem. Teledesic is in the process of creating a low earth orbiting satellite that will support data rates at up to 64 megabits/s downstream and 2 megabits/s upstream for basic service, although a broadband version is planned to support 64 megabits/s in both directions.

The importance in discussing all of these different approaches is that cable operators only have a limited window of opportunity to maximize revenues, and establish new customers. Today cable operators are primarily competing against a relatively expensive technology (T1 lines at $1000 a month), while in the future they will have to compete against a range of technologies that promise to deliver the same bandwidth for as little as $40-100 a month.

It is in the cable operator's best interest to ensure that it is the first and most prominent provider of this next generation of services. If cable operators can be the first to grab major customers such as businesses and small offices, it will be easier to lock customers in -- even when competition offers cheaper services in the future. Businesses and others that grow dependant on them may be hesitant to change providers when the competition emerges due to the hidden costs and uncertainties involved in changing providers in mid-stream.

## APPLICATIONS OF BLENDED TECHNOLOGIES

There are a wide variety of applications in which blended technologies can play a role in expanding the high-speed data business for cable operators. These include providing a time to market advantage, extending the wiring beyond the reach of the core business area, simplifying deployment to MDUs and business districts, reducing the cost of deploying new services, consolidating headends, and reducing the load on the core broadband network.

Time to market

In many cases, blended technologies can take advantage of existing infrastructure to speed the time to market, and the time to revenue, allowing cable operators to make an immediate return on investment while building out the basic HFC plant, and establishing a customer base.

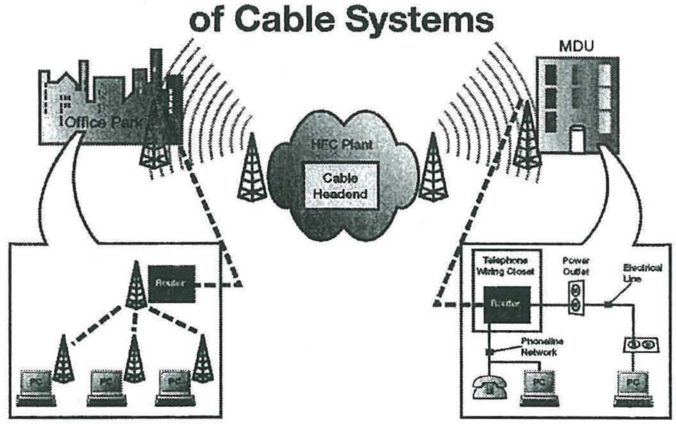
Unlicensed wireless promises to play a role in a number of scenarios. It can enable services to be offered to business parks, office buildings, and large MDUs that are up to 25 miles away from the edge of the HFC network. Short-range wireless could also simplify the deployment of services within large buildings such as offices or MDUs, without requiring any inside wiring.

An emerging new technology called phoneline networking could allow the rapid deployment of new services within a large building without requiring the participation of the local telephone company. Cable operators would simply put a router in the telephone closet, and connect to the individual customers on the customer side of the telephone line of demarcation in the building, which is the part owned by the customer.

Powerline networking can turn the power network in an office building or MDU into a giant Ethernet, which could be accessed by simply plugging into the outlet. The beauty of this approach is that it could be used in every room in the building, even those without phone wiring, or that may be shielded from radio.

ADSL could also be used to extend the reach of cable into new areas. It could be used across spare wires on a large campus without the participation of the telco. Alternatively, it might extend core service outside the range of the core cable network to a large building or office park, which could be shared among tenants. However, this approach would necessitate the leasing of lines from the telco.

**Connecting Beyond Outer Reaches of Cable Systems**




Connecting beyond the reach of the HFC cable system

Alternative transport technologies are cheaper to extend than traditional HFC cable plant. Several of our early wireless plant extensions are based on getting a commercial customer on line quickly while the cable operator extends the plant into the commercial area. This is a prime weapon in getting to the customer before that customer is lost to ADSL, etc.

## Providing service to highly profitable business districts

In many cable systems the business districts have not been targeted because they have not had a great deal of interest in consumer oriented cable programming. However they represent the most profitable opportunity for cable operators since they are accustomed to paying more for high-speed data lines.

Businesses that have traditionally paid $1000 a month for their data connection will jump at the opportunity to have an equivalent or faster service for $200 a month. Many residential consumers are reluctant to pay more than $40-$100 unless they are a small office that can quantify and justify the value added of the expenditure.

The fact of the matter is that businesses can use the network to make money. For many potential residential consumers the Internet is perceived as primarily an entertainment phenomenon and they may be reluctant to spend too much on these services, unless they derive some concrete value like providing junior with an educational lead, or enabling dad to trade stocks with more confidence.

The other aspect of business deployments is that they make a lot more long distance telephone calls during prime-time business hours when rates are more lucrative. As cable expands into the telephony business, these added revenues are sure to play a role in the profitability of the venture. Consumers on the other hand tend to place fewer calls than businesses, and tend to make them more on nights and weekends, when rates are down.

## Simplifying deployment to MDUs

Blended technologies promise to simplify the delivery of interactive services to MDUs. The MDU market has historically been tough to penetrate and hold onto. Cable operators have been required to wire up the whole facility to offer service, which has raised issues involved with management approval. This may involve issues such as expensive business arrangements that appeal to property management, or ownership of the distribution plant inside the property.

Technologies like phoneline networking would allow a cable operator to offer service by simply installing a router in the basement, and hooking phoneline modems to each line, without running a wire anywhere in the building. Wireless technology could enable cable operators to offer service without any management approval since the signal would pass through the open air, and the equipment could be installed outside of the building.

## Reducing the cost of deployment of new services

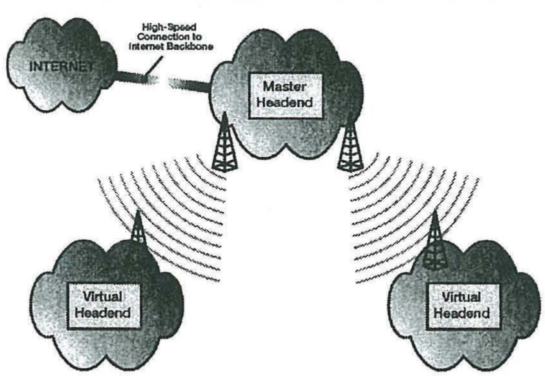
Working with existing infrastructure promises to reduce the need to build new coax plant until the revenues begin to justify the expense. This could enable cable operators to cherry pick the most profitable customers today, regardless of their location.

Blended technology could also extend the reach of cable's infrastructure into remote areas that might otherwise incur long distance tariffs for users. For example, many people are talking about using traditional analog modems to offer a return path for one way networks, or to allow workers to access their email or the web from home. A cable operator could put a virtual Point of Presence (POP) in these remote locations which connects back to the headend via wireless, thus bypassing tariffs for the customer, and hence encouraging usage and acceptance of the service.

Virtual headend consolidation

In some remote areas cable operator have established virtual headends, which simply feed satellite video into the network. Some of these may be in remote areas, which could make the prospect of deploying fiber to the area for accessing the Internet a costly proposition.

**Virtual Headend Consolidation**




Wireless technology could be used to link up these remote headends to a master headend that is closer to the city, and hence easier and cheaper to connect to the Internet backbone.

Different Transport Technologies

Cable operators should embrace the different technologies for extending their network and business as weapons in their arsenal. It is important to understand the basic technologies, their costs and their applications.

HFC

HFC networks provide the core of the cable network enabling the distribution of broadband data to and from the different areas that they serve. With many systems now having a total bandwidth of 450 MHz to 1 GHz, HFC promises to deliver all of the capacity that cable needs to offer a wide range of services including video, voice, and high-speed data.

However it is also one of the most expensive technologies to deploy. Costs typically range from \$15,000/mile for aerial construction to \$75,000/mile for underground construction. In some cases it can reach \$100,000/mile if local regulations require cable operators to replace cobblestones over the cable.

Wireless

Unlicensed wireless is one of the most promising technologies for extending cable's reach into lucrative new areas beyond the reach of the core cable plant. It can be used either for point to point wireless, or over shorter ranges for enabling a single wireless station to communicate with multiple customers.

The FCC has set aside spectrum in several different bands in the 49 MHz, 900Mhz and 2.4 GHz regions for unlicensed applications that do not interfere with others, and which can adapt to interference from other devices.

Services that use unlicensed spectrum promise to be cheaper than those which do not because there is no licensing process to go through, nor spectrum to pay for. However, the growing popularity of unlicensed applications, ranging from cordless phones to Internet access, can lead to interference and impaired performance.

The FCC has also made 300 MHz available for unlicensed National Information Infrastructure devices between 5.15-5.35 GHz, and 5.725-5.825 GHz. When devices that use this spectrum do emerge, they will be able to communicate at speeds of up to 20 megabits/s over short range or several miles with large fixed antennas. The FCC rules allow devices to communicate with up to 200 mW of power between 5.15-5.25 GHz, 1 W of power between 5.25-5.35 GHz and 4 W of power between 5.725-5.825 GHz. These bands coincide with spectrum selected for the European High Performance Local Area Network (HIPERLAN), creating an international market for NII devices.

Some implementations of Europe's HIPERLAN have a throughput of up to 24 megabits/s per channel, and several such channels can be established in each geographic region. Major wireless vendors including BreezeCom, Proxim and Symbionics have developed prototype systems using NII spectrum.

For point to point applications over a long range, technologies such as Solectek's AirLAN Bridge can extend the reach of cable by up to 25 miles at speeds of up to 2 megabit/s.

We have been deploying unlicensed wireless technology from CalAmp that costs $2500 per link for a connection, or a total of $5000 to deliver a T1 equivalent to a customer. With a short range 22 degree aiming variation it has proven highly reliable, on the order of 99.99%, which exceeds AT&T's new standard of 99.95% for data services.

There are several different types of unlicensed wireless communications systems that can operate over a shorter range. For example, BreezeCom's BreezeNET, is a line of wireless radio modems that support Ethernet and can communicate at up to 3 megabits/s. The range of communications varies from 200-600 feet in an office up to 3000 feet between buildings. BreezeNET products start at a cost of under $290 per node and include access points, adapters and mini-hubs. To accommodate even greater speeds, BreezeNET can be installed in a switched Ethernet configuration that supports over 15 megabits/s of aggregate bandwidth.

Metricom has developed the Ricochet service that has already been launched in a number of markets in conjunction with power companies that support it. Ricochet has traditionally been able to support data rates of about 28 kilobits/s in the 900 MHz band. Metricom is working on a new technology, code-named Autobahn, that will support up to 128 kilobits/s. It will use spectrum in both the 900 MHz and 2.4 GHz bands.

Metricom's system is designed to plug into the existing electrical power infrastructure with little construction. It uses a network of radios connected between the solar cell controller and light at the top of many street lamps. Consequently, it is easy for a power company to set up a network. The installer merely unplugs the solar cell from the lamp, and connects the Ricochet radio between them.

WaveRider Communications has developed another wireless wide area technology that uses unlicensed radio spectrum called the Last Mile Solution. The system uses a network of base stations and repeaters, which can be spaced at a maximum of 18-km intervals. The range of the system is up to 7 km between a user and a repeater or base station. Each wireless network access point can accommodate up to 1024 simultaneous users.

The Last Mile Solution can support bi-directional data rates of 40.9 kilobits/s and can be scaled up to 10 megabit/s for high-end users. The system operates in the 902-928 MHz band, which allows unrestricted operation in the US and Canada. It is possible for the modem to operate in any band between 600 MHz and 1.2 GHz for use in other countries. It uses spread spectrum technology, which provides immunity to noise, and security from eavesdroppers.

Another option for wireless network links is to use laser beams. Laser beam communications are not licensed by the FCC because laser beams are coherent, and do not interfere with other laser beam communications. An added benefit of this is that they are substantially more secure than more traditional radio propagation technologies, making it more difficult for hackers to eavesdrop.

Systems, such as the AstroTerra's TerraLink laser can be used for communicating at speeds of up to 622 megabits/s over ranges of up to 5 miles, and 2.5 gigabits/s over ranges of up to 1.5 miles. One of the disadvantages of lasers is that they are more prone to environmental disturbances, such as heavy rain and fog than other technologies.

## ADSL

Although ADSL is typically thought of as a telco only tool, it could play a valuable role in extending the range of cable delivered high-speed data services, particularly in large campuses or office building in which the wiring is owned by the customer or landlord. Typical ADSL speeds range from 1.5 -8 megabits/s downstream and significantly lower speeds upstream. It can operate over a distance of up to 18,000 feet at speeds up to 2 megabits/s and at shorter distances of up to 9000 feet can operate at speeds of 6-8 megabits/s. The downstream bandwidth is enough to provide broadcast quality digital video, which was one of the killer applications initially planned for this technology. But most telephone companies have since dropped plans for digital video and plan to concentrate on Internet access instead.

A low-end version of ADSL, called Universal ADSL or G-lite is capable of delivering speeds of up to 1.5 megabits/s downstream. One of the most appealing aspects of this approach is that it is relatively cheap to implement, and many modem manufacturers are planning on building this into their new analog modems as an optional feature that can be enabled by software. It also will operate without the need to install a splitter on the home, which would eliminate the requirement of sending out an installation technician.

By some estimates there could be as many as 6 million ADSL-lite modems installed in computers by the end of this year, although only a fraction of those will be used for service. These large volumes will make it cheap enough to be used for a variety of applications. This has implications not only for telcos, but for cable operators who may wish to use twisted pair wiring to extend the range of their services by up to 18,000 feet beyond their coaxial infrastructure, if the wiring is available.

Novel variations of ADSL promise far higher speeds. For example, VDSL (Very high-speed Digital Subscriber Line) is capable of delivering 52 megabits/s downstream and 6 megabit/s upstream over a distance of up to 1000 feet.

Phoneline networking

Phoneline networking technology is a new type of network that operates over traditional telephone wiring, without requiring any special wiring architecture. It uses frequency division multiplexing technology to enable it to share the same line voice with no interference. When installed on the consumer premise, past the telco line of demarcation, it does not require permission or coordination with the local telephone company.

It is being promoted by the Home Phoneline Networking Association (HomePNA), which includes Compaq and Intel as driving members. The current standard supports a data rate of 1 megabit/s over a range of up to 2500 feet. Epigram has developed a 10 megabit/s version, which will operate over a range of up to 1000 feet. AVIO is developing a special version that will support a rate of up to 88 megabits/s over a range of up 100 meters over category 5 wiring or 33 meters over regular wiring. Epigram has a 100 megabit/s version in the lab.

Phoneline networking modems are relatively inexpensive, costing as little as $50 per modem when bought in quantity.

Powerline Technology

Powerline technology can turn the power network within a home, MDU, or small office building into a giant LAN that can be accessed by plugging into the wall. It costs on the order of $50 per node. Intelogis has developed a version that will operate at speeds of 350 kilobit/s today over a range of up to ¼ mile, and is planning on a 2 megabit/s version by the end of the year. Enikia has developed a 10 megabit/s version, but it only has a range of 200 feet.

The longer-range technology could be good for office buildings and MDUs. However it has the limitation that everyone on a particular circuit shares the same networking segment. Another limitation is that it cannot operate through a transformer.

Caching

Caches are simply remote servers that can store data that is frequently accessed by a number of users in order to minimize the load on the core network. These caches can be used to deliver frequently accessed broadband content, such as video and streaming 3D.

## Examples of Different Hybrid Architectures

Wireless used to a point miles from cable plant to individual businesses

In this scenario, the range of cable services could be extended by a distance of up to 25 miles past the edge of the cable plant. The connection could use relatively low rate, since the connection would only be with a single business. On the customer's side, the network could be connected into the existing LAN, enabling all of the computers on the network to access the Internet simultaneously.

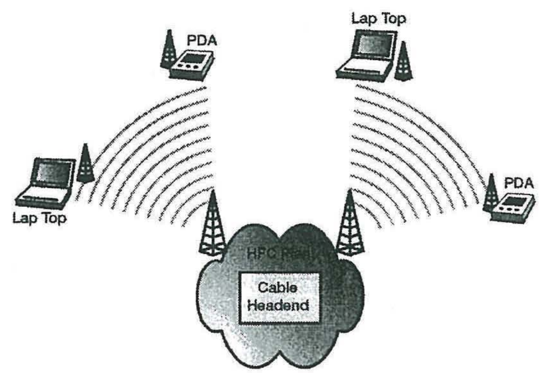
Wireless to remote Points of Presence (POPs)

A wireless link would be extended to a remote office park, office building, shopping center, MDU or small residential community. Once this connection has been established, the network could be extended to each individual business or residence via a combination of low-cost shorter-range wireless technologies, phoneline networking, powerline networking, or a traditional coaxial plant.

HFC to multipoint wireless

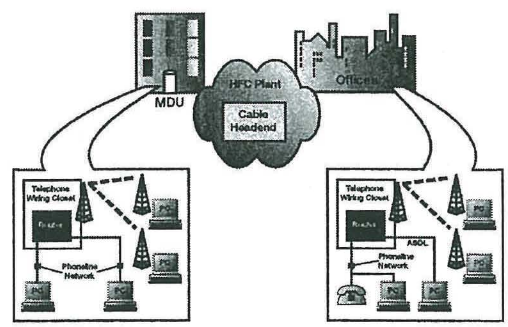
The coaxial network could be extended to a network of wireless transceivers such as Ricochet, which could facilitate communication between users roaming around campuses and office parks. Users could use this network to access the Internet, or office servers using laptops, PDAs, or special appliances such as bar code readers.

### HFC to Multipoint Wireless




Although the data rates on this type of network would be slower than typical high-speed networks, the mobility factor could be important in places such as college campuses where the users may be moving around all day.

### Coax to MDU or Office Building




HFC to office building or MDU

A single HFC connection is made to a large office building or MDU. Data services could be extended throughout the facility using phoneline networking, powerline networking, wireless, or ADSL technology. This would obviate the need to install any new wiring in the facility, enabling a rapid time to market for the service.

## ADSL beyond range of HFC

ADSL could be used to extend the range of service up to 3 miles from the edge of the HFC network. However, it would require that the cable operator had access to a pair of wires with a direct connection to the customer premise. One scenario would be for this deployment to occur on a large campus or office park in which the management had ownership of the wires (as opposed to the telco) and an active interest in the deployment of high-speed data services.

## Remote telephone modem bank

A telephone bank could be installed in a remote area where customers live, to enable them dial-up access to the network without incurring long distance charges. The telephone box could be connected to the core network via wireless technologies.

This type of architecture would make the most sense in remote neighborhoods that only have a one-way cable plant. It could also be used when a cable operator is offering service to a large company with lots of employees who work from home, and need to access the corporate network without incurring long distance charges.

## Conclusion

The future promises a world where high-speed data services will be commonplace and will be offered by a number of service providers including cable, telco, wireless and satellite. Cable operators are in an advantageous position today in that the core technology behind the cable modem is well established. However, they must act aggressively in order to achieve market and mind share, build an embedded base, and to begin receiving the revenues that will enable them to build their service networks out.

Blended technologies promise to give operators the tools they need to offer service in a blitzkrieg-like, yet cost effective manner, while building out their traditional HFC plant as other business and geographical needs dictate.