COPPER MOUNTAIN NETWORKS

DSL ARCHITECTURE AND BUSINESS CASE

VOICE AND DATA SERVICE PROFITABILITY ANALYSIS FOR COMPETITIVE LOCAL EXCHANGE CARRIERS

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OVERVIEW

With the advent of packet voice services, long-heralded voice and data convergence is finally a compelling economic reality. Competitive Local Exchange Carriers (CLECs) can earn substantial return on investment by providing high-speed data service combined with packet voice services to businesses, teleworkers, and residential consumers using Copper Mountain's Digital Subscriber Line (DSL) access equipment and ordinary twisted-pair phone lines.

CLECs should first target businesses and subsidized teleworkers who are paying for higher-priced T1 or Integrated Services Digital Network (ISDN) services for delivery of voice and data. By doing so, the conservative analysis in this white paper shows that a CLEC can pay back its investment in two years. With a penetration of 350 DSL customers per Telco central office (CO), an average monthly price of $60 for DSL data service, plus $36 of local and long distance revenue per subscriber voice line, the lifetime value of a customer with six voice lines is $4,354. As this analysis shows, even if the carrier gives away the data service to the subscriber, the converged voice and data package still produces a lifetime value of $2,194 per customer—a highly attractive return for such compelling service prices.

APPROACH

BUSINESS MODEL

This white paper explores the business model associated with deploying DSL-based voice and data services in ten metropolitan (metro) areas. The economic analysis includes all revenues and costs[1] associated with establishing the metro area networks to deliver voice and data services.

Offering voice service is an option in this model; the "Results" section presents scenarios with and without voice service. Both local and long-distance voice services are included. It is assumed that the CLEC purchases local voice network equipment, with appropriate interfaces for completing off-net local calls. It is also assumed that long-distance services are provided by purchasing wholesale minutes from an inter-exchange carrier (IXC) and reselling the minutes to the end user.

Several cost centers are amortized over a regional or nationwide deployment. For example, billing system, customer service center, and network operations center (NOC) costs are not specific to one metro area.

[1] The economic model herewithin depicts the CLEC's basic cash flow, with recurring and non-recurring revenues representing cash inflows, and capital expenditures and cash operating costs representing cash outflows. All cash flows are calculated and presented on a quarterly basis, with the model extending over four years, or sixteen quarters. The net present value (NPV) is calculated by discounting these future cash flows at an annual hurdle rate of fifteen percent. Thus, any NPV greater than zero indicates that the venture provides a return in excess of fifteen percent.

The model includes a conservative terminal value. Typically, NPV cash flow analysis includes a terminal value that reflects the value of all of the cash flows beyond the time period in the model—in this case, four years. This model's conservative assumption is that the last year's cash flows are repeated for another four years.

The economic model does not include any benefits from unique financing arrangements, nor does it include provisions for income taxes.

MARKET MODEL

The market model is simple. We assume:

- Ten metro areas with twenty COs in each area. The deployment of these metro areas takes six calendar quarters—that is, the CLEC starts deploying slightly less than two metro areas in each quarter. Once the CLEC begins deploying a metro area, it is assumed to take two additional quarters to build out the twenty COs.
- A conservative maximum penetration of 350 DSL customers per CO. (A single CO typically serves an area with roughly 60,000 to 80,000 people, or 25,000 to 35,000 subscriber lines.)
- An "S-shaped" penetration curve reaching the maximum penetration after three years.

BRIEF DSL TECHNOLOGY OVERVIEW

A telephone line providing Plain Old Telephone Service (POTS) carries electrical signals that use only the bandwidth below 4,000 hertz. These frequencies correspond directly to frequencies of sound waves that carry human voices. The telephone converts the air pressure vibrations of the voice into electrical signals that "vibrate" at precisely the same frequency as air. The telephone is connected to a pair of copper wires that lead to a Local Exchange Carrier's (LEC's) CO. Inside the CO, the wires are plugged into a telephone switch, which converts the signal to a digital format. This conversion ignores any frequencies that are out of the voice range, specifically, those that are above 4,000 hertz.

DSL technology makes use of much broader bandwidth, with signals vibrating at hundreds of thousands of cycles per second. This means that a special modem must be used to place the signals on the copper pair. In addition, the DSL signal cannot pass through a traditional telephone switch, since these high frequencies are discarded. Therefore, a DSL access concentrator must be located in the CO, and the copper wires must be unplugged from the phone switch and plugged into the access concentrator to provide DSL service.

Provisioning of packetized local phone service is described in the "Service Delivery Architecture" section.

LOCAL TELECOMMUNICATIONS SERVICES COMPETITION

The Federal Telecommunications Act of 1996 and the subsequent FCC order opened local telecommunications service to competition. Incumbent Local Exchange Carriers (ILECs), such as the Regional Bell Telephone companies, were required to sell components of their networks to competitors at cost plus margin. CLECs can utilize these components to assemble competitive services. The most relevant unbundled network element (UNE) for DSL service is the pair of copper wires, or the local loop, which runs from the CO to the customer premise. To obtain access to these loops, CLECs lease space in the ILEC CO and put their DSL access concentrators in "collocation cages."

Collocation cages are typically 10 x 10 foot spaces, around which the ILEC erects a chain link fence. The ILEC then sets up power, air conditioning, and wiring harnesses. Finally, the ILEC installs equipment racks in the cage. For this setup, the ILEC typically charges the CLEC a one-time installation fee of $20,000 to $30,000; fees vary from state to state.

Another key UNE is interconnection transport service. This service enables CLECs to connect their equipment in these collocation cages to their own data backbone packet switching equipment.

VOICE INTERCONNECTION

Interconnection transport is also used to exchange local voice traffic between CLEC and ILEC local telephony networks. Interconnection transport is usually connected to an ILEC's local network at the toll-tandem switch for each local access and transport area (LATA). However, the ILEC may choose to provide other interconnection points to the CLEC.

There are two pricing schemes available for voice interconnection: "bill and keep" and "reciprocal compensation."

- Bill and keep means that whichever party originates the call keeps all the revenue for that call.
- Reciprocal compensation means that each party must pay the other party to terminate local traffic. For example, if a call originates on an ILEC's network and terminates on a CLEC's network, the ILEC would pay the CLEC a negotiated rate per minute to terminate the call.

If traffic exchanged between the two carriers is expected to be symmetric, that is, the same number of minutes in each direction, then both schemes are cost neutral to the CLEC.

To obtain these UNEs at cost-plus pricing, the CLEC must file with the state regulatory authority to become a licensed telecommunications carrier. The CLEC must then negotiate an "interconnection agreement" that contains the terms and conditions for purchase of unbundled elements.

SERVICE DELIVERY ARCHITECTURE

Figure 1

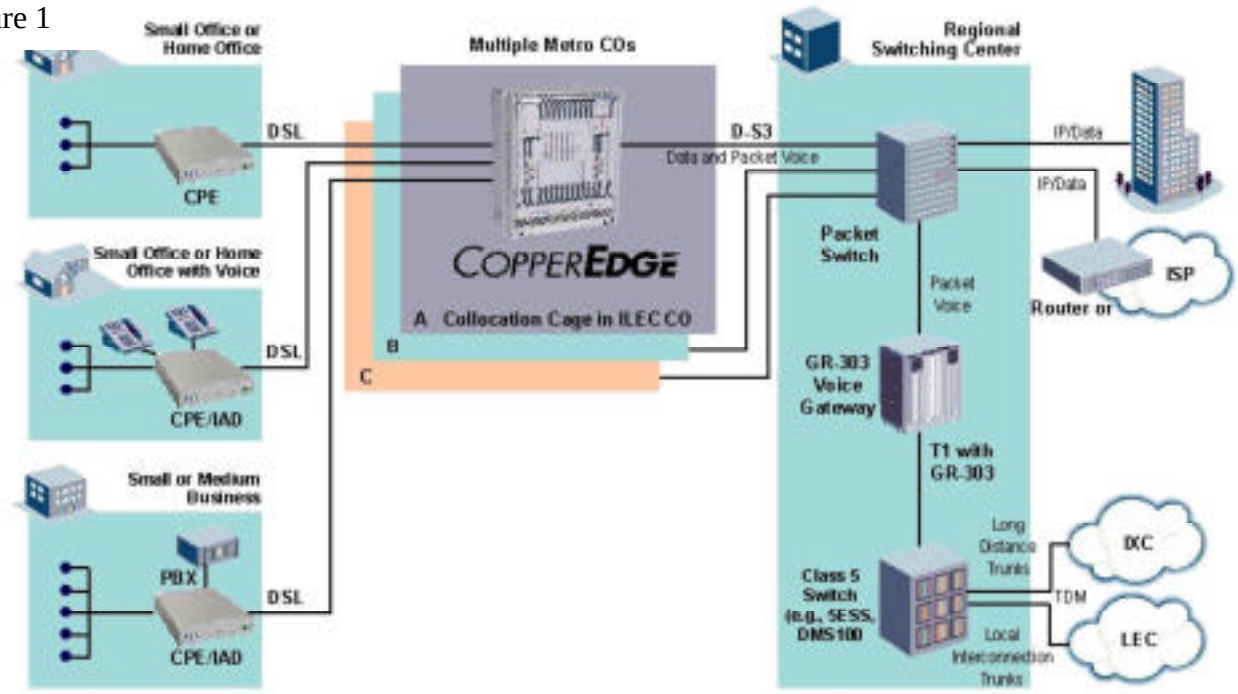


Figure 1 shows the architecture for delivery of Internet service, corporate virtual private network (VPN) service, and voice service.

1) **Subscriber Data Network**. This is typically an existing local area network (LAN) in a small-to medium-sized office. Alternatively, it may be an individual workstation at a teleworker's home. In either case, it is connected to the customer premise equipment (CPE) via standard 10Base-T Ethernet or by a V.35 serial interface.

2) **Subscriber Phone Network**. The customer's phone network can take a number of forms. It can consist of regular analog telephones, a key system, or a private branch exchange (PBX). The phone network is connected to the CPE/integrated access device (IAD) using analog POTS lines or trunks, or using a digital DSX1 interface.

3) **CPE/IAD.** When the CPE interfaces with both the voice and data network, it is often called an IAD. This may be a CopperRocket™ device or a third party CopperCompatible™ IAD. Some IADs have advanced data functionality, such as routing, network address translation, and other functions. IADs may also have advanced voice features, for example, simulating PBX functionality when there is no external PBX. CopperCompatible CPE can prioritize the voice traffic for transmission onto the DSL. Either the CLEC or the service provider sells or leases the IAD to the end user.

4) **Local Loop.** This is a typical local loop, which runs from the customer's RJ-11 wall outlet to the network interface unit on the side of the building and into the CO via aerial or underground cable. The CLEC leases this unbundled local loop from the incumbent LEC for a recurring monthly fee.

5) **CO.** Inside the ILEC CO, the local loop is connected to a main distribution frame (MDF). The ILEC runs a cross-connect from the MDF to the CLEC collocation cage. ILEC COs are distributed geographically throughout a region. Depending on population density, a CO typically serves an area with 60,000 to 80,000 people.

6) **Collocation Cage.** The CLEC rents collocation space, usually a 10 x 10 foot space surrounded by a chain-link fence, from the incumbent. The incumbent provides power, power backup, air conditioning, and equipment racks. Because access to the collocation cage is limited, the CLEC must be able to manage equipment remotely. Cageless collocation can also be used. In this case, the CLEC has a rack in a protected area as opposed to an isolated 10 x 10foot space.

7) **CopperEdge® DSL Access Concentrator.** One or more CopperEdge concentrators are located in a collocation cage in each CO, and the local loop is terminated onto the back of the CopperEdge. The CopperEdge places the voice and data packets onto appropriate virtual circuits, which will then ride on a DS-3 backbone. This concentration function is done at the data frame or packet layer, rather than at the circuit layer. Thus, there can be 350 end users provisioned at 1 Mbps, but they may collectively fit onto a DS-3 wide area network (WAN) pipe, which is 45 Mbps. The amount of WAN bandwidth can be smaller because, statistically, not all users will be simultaneously using their 1 Mbps access. This capability is called "statistical multiplexing." The amount of over-subscription can be carefully monitored and controlled by the CLEC, who purchases and manages the CopperEdge. Having a portfolio of voice and data traffic and a mix of small business and teleworker customers improves the benefit of statistical multiplexing. For example, business voice traffic may be highest during the day, while Internet traffic may be spread into the evening hours.

8) **CLEC Backbone.** The backbone is typically a DS-3 connection from the CopperEdge concentrator in the CLEC CO to the CLEC regional switching center, located in a different building. The DS-3 interconnection service can be purchased from the ILEC as a special CLEC interconnection tariff. Note that even though the CLEC is running Frame Relay or ATM over this DS-3, the ILEC is only providing a pipe and not the actual Frame Relay or ATM service.

9) **CLEC Regional Switching Center.** Each metro area needs a regional switching center. Even for a large metro area, it would be unusual for a CLEC to require more than one regional switching center. The CLEC must equip this machine room with appropriate power and air conditioning and must purchase and maintain the data switch or router.

10) **Packet Switch or Router.** At the regional switching center, the backbone DS-3s terminate onto the CLEC's Frame Relay or ATM data switch. Those CLECs that are also Internet Service Providers (ISPs) may choose to terminate the DS-3s onto a large router instead of a Frame Relay or ATM data switch.

11) **GR-303 Voice Gateway.** Connected to the packet switch using a DS-3 or OC-3 interface, the voice gateway terminates the voice virtual circuits that started at the customer premise IAD. The voice gateway constructs a continuous digital voice signal by taking payloads from the arriving packets and sequencing them back-to-back. In the downstream direction, the voice gateway takes the continuous digital signal from the voice network and cuts it into five- to ten-millisecond time slices. These time slices are placed into a stream of packets, which are sent downstream to the CPE.

In the upstream direction, the voice gateway presents digital circuits to a traditional class 5 voice switch using the GR-303 protocol. GR-303 typically uses T1 facilities, with each T1 able to support twenty-four simultaneous voice calls. GR-303 enables concentration, meaning any subscriber can use any of the voice channels. Because not all subscriber voice ports are used at the same time, there can be substantially more phones than channels on the GR-303 T1s. Depending on usage, concentration ratios are typically from 3:1 to 6:1. This concentration is important to the economics of providing voice services.

Copper Mountain partners with CopperCom, Jetstream, and Tollbridge Technologies to provide voice gateways. These gateways have fifty to one-hundred T1 interfaces to a class 5 switch, supporting 1,200 to 2,400 simultaneous voice calls. With 5:1 concentration, the voice gateways can support 6,000 to 12,000 provisioned subscriber phone ports.

The voice gateway does not have to be located at the CLEC's regional center; the DSL CLEC can also choose to partner with another voice carrier.

12) **Class 5 Digital Switch.** The class 5 digital switch is a circuit switch that provides dial-tone. These are the same kind of switches ILECs use to provide traditional telephone service. In the U.S., the most common switches are the 5ESS from Lucent and the DMS100 from Nortel. For this application, the switch must use a less-expensive GR-303 interface instead of analog voice modules. In this CLEC packet voice model, the CLEC can locate the switch regionally, instead of locating it in each office, and thus enjoy regional economies of scale.

    The class 5 switch has interfaces to connect to IXC long-distance networks as well as the ILEC's local network. These interfaces enable the CLEC to complete off-net long-distance and local calls.

13) **Corporate HQ**. One of the many services that can be provided by DSL is teleworker and branch office connectivity to corporate headquarters. When this service is provided, the corporate HQ is either connected directly to the regional switching center, as shown in Figure 1, or connected to the regional packet or data network. The size of the pipe required depends on the number of teleworkers or branch offices. The pipe would be connected to the corporation's gateway router.

14) **Internet Service Provider.** An ISP purchases a connection to the data switch located in the regional switching center. The subscriber or teleworker data traffic is switched or routed onto virtual circuits (VCs) leading to the appropriate ISP.

15) **CLEC Operations Center.** The operations center (not shown) is not necessarily in the same building with the regional switching center. A CLEC would need only one operations center nationwide, with a possible second for redundancy. It is not necessary to have one in each metropolitan area.

MARKET SIZE AND REVENUE

"AGGRESSIVE COMMUNICATIONS, INC." CASE STUDY

Our model CLEC, "Aggressive Communications, Inc.," will target ten metro areas and will collocate in twenty COs in each of the metro areas. Each CO will be interconnected to a regional switching center using DS-3 circuits. Aggressive's operations center is home to the provisioning and network management functions. One operations center can service all ten metropolitan areas.

"Metropolis" is a typical metro area for Aggressive, with a population of 1.5 million people. It is served by twenty-five COs, with approximately 35,000 access lines in each office. Of the 35,000 lines, 8,000 are business and 27,000 are residential lines. There are approximately 1,100 businesses and 25,000 households in each CO area.

PENETRATION AND VOICE MARKET ASSUMPTIONS

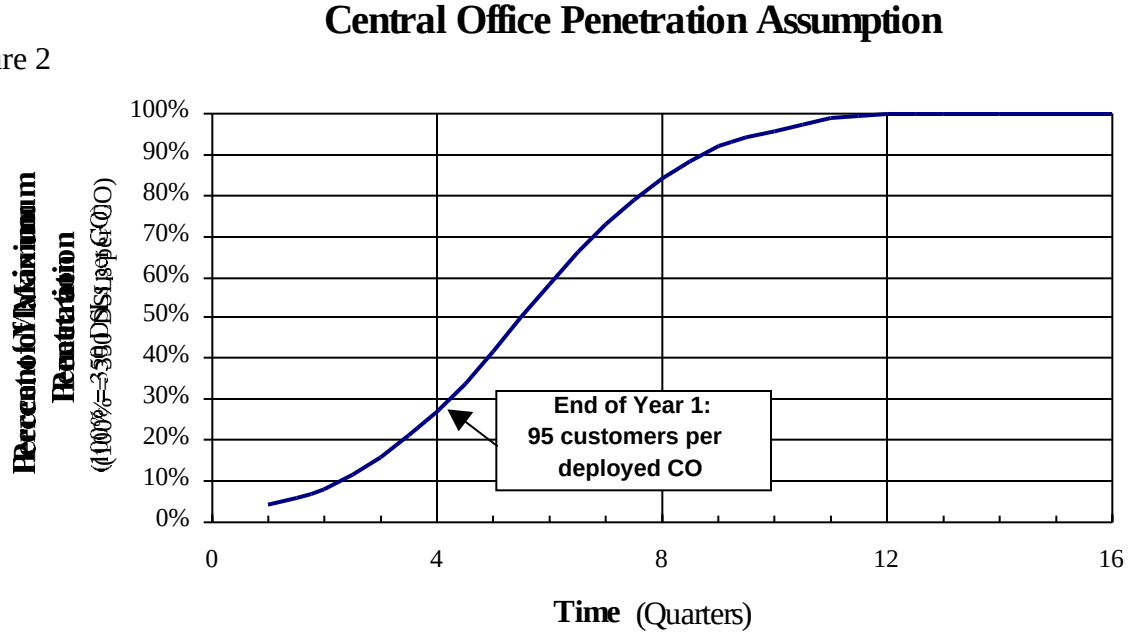
According to Yankee Group, approximately five percent of households nationwide have members that are part of a formal telecommuting program, excluding informal telecommuters and consumers. In the Metropolis area CO, this amounts to 1,250 households in the served available market. Approximately seventy-five percent of small businesses have computers; about fifty percent of businesses have Internet or data connectivity. Essentially all businesses have voice service. However, it is less likely for a business to choose a packet voice service unless that business also has some data services. Assuming that fifty percent of businesses are receptive to DSL service, there are 550 business and 1,250 teleworking households—a total of 1,800 attractive, potential customers per CO.

Our model assumes a maximum penetration of 350 DSLs per CO, covering both teleworkers and small businesses. The model assumes that it takes 2.5 years from deployment to reach this maximum penetration (see figure 2).

There are two scenarios: data only, and converged voice and data. In the combined voice and data scenario, our model also assumes that all customers purchase a package of voice and data services with an average of six voice ports per customer. The average number of long distance minutes per month for each voice port is 200 minutes.

	Data Only	**Converged Voice and Data**
Metro areas	10	10
COs per metro area	20	20
Customers per CO	350	350
Voice services	No	Yes
• Voice ports per customer	0	6
• Long distance minutes per port	0	200

Figure 2



REVENUE: HOW MUCH TO CHARGE?

Aggressive has targeted customers with a demonstrated willingness to pay for high-speed data service. These include business customers and teleworkers subsidized by their businesses and early adopter residential consumers, like those who have ISDN lines. In most cases, the sale is to the business as opposed to a mass-market consumer. Today, users have three high-speed data alternatives for connecting to service providers: Leased Line T1, Frame Relay/ATM, and ISDN dialup.

LEASED LINE (T1)

Leased line service is a point-to-point connection to the service provider. The customer must purchase a T1 channel service unit/data service unit (CSU/DSU) which terminates the circuit. This equipment is analogous to the DSL CPE, and typically costs $700 to $1,200.

The customer pays a non-recurring charge to set up the T1. For example, Pacific Bell charges a one-time fee of approximately $1,200. The total non-recurring cost is approximately $2,000 including equipment.

On a monthly basis, the customer must pay a fixed fee plus a mileage charge. For a leased line spanning ten miles between a customer and a service provider, Pacific Bell charges $600 per month.

FRAME RELAY/ATM

With a Frame Relay committed information rate (CIR) of 128 kbps to 1.5 Mbps, local access will still be via T1. The T1 runs from the customer premise and terminates in the local CO. The service is then carried by Frame Relay to the CO where the service provider's point-of-presence (POP) is located. The service provider must purchase an equivalent access pipe to receive the traffic. There is no mileage charge for the distance between the originating and terminating COs, instead, there is a monthly and non-recurring Frame Relay port charge.

For example, Bell South charges $465 to set up the T1 plus $525 to set up the Frame Relay port for a total non-recurring charge of $990. The monthly fee is $163 for the T1 plus $410 for the

Frame Relay port. Each site, that is, both the service provider and the customer, pays these charges.

The customer must still purchase a CSU/DSU and must also have a device that supports Frame Relay, either a Frame Relay Access Device (FRAD) or a router.

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

ISDN provides a dial-up connection at a maximum of 128 kbps. For businesses, the installation is approximately $100 to $350, depending whether it is a new line or an upgrade to an existing line. Pricing structure varies considerably from region to region. In California, the monthly fee is $33 plus usage. Local usage for each of the two channels is $0.03 for the first minute of a connection plus $0.01 for additional minutes. For calls over twelve miles, however, the toll usage can be $0.05 to $0.15 per minute. Bell South offers a plan that includes 320 hours of local connection time for $90 per month. Additional usage is billed at $0.01 per minute.

For a small office with five to fifteen employees, moderate usage would be a combined total of ten to fifteen minutes per hour. Usage for local connectivity would be about $100 per month; for toll or long-distance connectivity, about $300 per month. Therefore, the total monthly bill is about $100 to $330.

ISDN premise equipment costs between $300 and $750. Therefore the total non-recurring charge is between $400 and $1,100.

TODAY'S BUSINESS VOICE SERVICE

Revenue from a typical measured business line includes a flat monthly access fee of about $15 to $18 per month. Features vary in price, but the first feature usually costs about $3. Local calls are metered at $0.03 for the first minute and $0.01 for each additional minute. Typical local usage of 150 calls at three minutes each produces revenue of $6.50 per month. The ILEC also charges the long-distance carrier between $0.01 and $0.02 for each minute of originating and terminating long distance.

SUMMARY OF EXISTING SERVICE PRICING

Alternative	CPE Equipment	Installation	Monthly Fee	Note
Leased Line	$600-$1,000	$1,000-$1,300	$350-$650	Depends on mileage
Frame Relay	$800-$1,200	$900-$1,100	$575	Each connected location
ISDN	$300-$750	$100-$350	$100-$330	Depends on usage
POTS	--	$45	$23-$29	Excluding long-distance access fee

PRICING OF DSL-BASED VOICE AND DATA SERVICE

Aggressive decides to offer services from 160 kbps to 2.3 Mbps using Copper Mountain Networks technology will charge $250 for installation of the service and will offer combined voice and data packages. For the data-only scenario, Aggressive will price the service at an average of $140 per month. For converged service, Aggressive will price the basic DSL data service at $60 per month. Each provisioned voice port is $20, including local usage and features. Long distance is packaged at $0.08 per minute.

In both scenarios, the DSL subscriber equipment—the IAD—will be sold directly to the end user. It will not appear on Aggressive's books.

MARKET CHURN

We assume a market churn of fifteen percent per year for a data-only service and ten percent per year for a converged voice and data package. This moderately low churn is a result of the "stickiness" of a combined voice-data offering. Actual DSL market experience is indicating unusually low churn rates.

	Data Only	**Converged Voice and Data**
Service Installation	$250	$250
CPE	Sold to subscriber; revenue and cost excluded from this model.	Sold to subscriber; revenue and cost excluded from this model.
Average monthly price of DSL data service	$140 per month	$60 per month
Voice port (a voice line) with local usage and features		$20 per month per port
Long Distance		$0.08 per minute
Churn	15%	10%

CAPITAL DEPLOYMENT

Capitalizable expenses are divided into four areas. These are:

1) Cash outlays to open the operations center
2) Cash outlays to establish each of the ten regional switching centers
3) Cash outlays to set up each CO collocation
4) Cash outlays associated with each incremental end user

OPERATIONS CENTER

This analysis includes start-up expenses for a nationwide operations center. These one-time cash outlays occur in the first quarter of Aggressive's operation. All costs that are a function of metro area deployment are incurred as these areas are deployed.

Item	Amount	Notes
Operations center	$250,000 +$25,000 per metro area	Network management workstations, surveillance equipment, and software
Operational support systems	$300,000 +$25,000 per metro area	Operational support and billing systems

REGIONAL SWITCHING CENTER

Item	Amount	Notes
Regional switching center packet switch (for each metro area)	$65,000 + $3,000 per CO	Cost of Frame Relay or ATM backbone switch (or router for integrated CLEC/ISP). Extra cost per CO is for the extra ports on the switch. At 20 COs per metro area, the switch costs $125,000 for each metro area.

VOICE EQUIPMENT

It is assumed that the cost for the gateway and the class 5 digital switch is incurred on a per-end-user basis. Both pieces of equipment are expandable via line modules. Because one center serves an entire metropolitan area, the voice equipment quickly reaches its economy of scale.

The combined cost of the gateway and class 5 switch is $400 per GR-303 channel, that is, per active voice connection. For example, support of 8,000 simultaneous connections requires a one-time capital outlay of $3.2 million.

CENTRAL OFFICE

Once an ILEC turns a collocation cage over to the CLEC, Copper Mountain's experience indicates that it takes approximately three to four weeks to get a CO up and running. Most of this is waiting time for the ILEC interconnection transport service. It takes approximately two days to install equipment, and another week for testing. This experience also indicates that twenty COs can easily be turned up over a period of six months. All of the non-recurring or one-time cash outlays occur during the initial six months of deployment

NON-RECURRING ITEMS

Item	Cost per CO	Notes
Collocation cage (racks, power, cage construction, etc.)	$35,000	This is paid to the ILEC, can vary widely by territory, and may also be a function of whether there are other collocations in the same CO. The cost per CO is lower for cageless collocation arrangements.
Backbone transport	$2,500	This is the set-up fee for transport to the regional switching center.
CopperEdge DSL concentrator (plus monitoring equipment)	$13,000	This is the DSL access concentrator, plus redundant power, and support equipment for a back-up network management access line.

CENTRAL OFFICE UPGRADE CAPITAL

Maintenance expenditures for repair or replacement of broken equipment are covered in operating costs. Aggressive anticipates needing to upgrade its equipment to take advantage of newly developed features. Starting in the third year, Aggressive will spend three percent of gross (i.e., undepreciated) cumulative capital in each quarter to purchase new equipment.

INCREMENTAL END USER CAPITAL

Most costs associated with serving an end user are covered in the operations section. The DSL modem is shipped directly to the end user by a reseller or the service provider. Aggressive, Inc. does not need to become involved in the sale of CPE.

Aggressive installs DSL modules into the CopperEdge DSL access concentrator in response to end user demand. Copper Mountain offers twenty-four port line cards. For simplicity, this expense is converted into a per-port cash outlay of $350.

OPERATING COSTS

NON-RECURRING OPERATING COSTS

The table below lists non-recurring costs associated with bringing up DSL service. This aspect of the service design hinges on several critical business decisions that can prove disastrous for the CLEC if poor choices are made.

- If the CLEC pursues a mass-market consumer strategy, it will be necessary to undertake an expensive direct marketing and media campaign.
- If the CPE is too expensive, the CLEC will need to subsidize it (similar to the approach taken by cellular carriers with cell phones).
- If the DSL technology is highly sensitive to customer premise wiring, or if the DSL technology requires POTS splitters on the side of the customer premise, there will be an additional $110 to $220 of provisioning expense associated with each customer.
- If the CPE is too complex or requires pre-configuration, provisioning expense can explode with demand for technical support.

Item	Amount per DSL	Notes
Customer acquisition	$120	The CLEC incurs this expense for promotion, telemarketing, direct selling, and advertising. This is similar to consumer long-distance or cellular acquisition costs.
Unbundled copper loop non-recurring charge	$125	This is paid to the ILEC, who must run a "cross-connect jumper" from the MDF to the collocation cage. In addition, the ILEC may have to perform field work to create a connected loop through to the customer premise.
Provisioning expense	$150 (voice and data) $110 (data only)	The CLEC incurs this expense to get the customer's line operating. This covers the operations center labor for setting up the customer account and for configuring the DSL, packet switching, and voice equipment to provide service. It assumes 2.75 hours of labor at a loaded cost of $55 per hour.

RECURRING OPERATING COSTS

The CLEC bears monthly operating costs associated with unbundled customer loops, CO collocation space, and backbone transport to its data center. Furthermore, there are operations and maintenance costs associated with DSL and backbone switching equipment. There is also an ongoing customer service and technical support cost based on the frequency of end user and service provider calls into the operations center.

Item	Amount	Notes
Unbundled loop	$20 per DSL per month	This is paid to the ILEC and is a combination of the monthly lease on the unbundled loop and the monthly cost of the cross-connect from the MDF to the collocation cage. The cost varies from state to state and is generally more expensive in rural areas and less expensive in urban areas. (ILECs are bound by the FCC and the Telecom Act to make this fee cost-based, thus the shorter urban loops tend to be less expensive.)
Collocation cage (rent, power)	$1,400 per CO per month	Paid to the ILEC, this can vary widely by territory.
Backbone transport	$950 per CopperEdge per month	This is paid to the ILEC as a DS-3 interconnection tariff. The $950 cost is for each of the 192 customers. At target penetration of 350 subscribers per CO, the cost is $1,900 per month.
Operations and maintenance	6% of gross capital per year	The CLEC incurs this expense associated with operating and maintaining the physical equipment. It is expressed as a percent of gross (undepreciated) cumulative capital equipment in the switching center and COs.
Customer service and technical support	$6 per DSL per month	This assumes that twenty percent of DSL customers call for technical support each month and use twenty minutes of technical support time at a fully loaded cost of $90 per hour. Note that initial line provisioning is a separate item included under Non-Recurring Operating Costs.
Customer Service and technical support for **voice** service	$2.30 per provisioned voice port per month	Assume that twenty-five percent of DSL customers call for technical support each month and use ten minutes of technical support time, per voice port, at a fully loaded cost of $55 per hour. Note that initial line provisioning is a separate item included under Non-Recurring Operating Costs.
Cost of long-distance	$0.04 per minute	This assumes that Aggressive, Inc. purchases long distance in bulk from an IXC and resells it to the end user.
General and administrative overhead	10% of gross revenue per year	

RESULTS

SCENARIO 1: DATA ONLY

Figure 3 shows the components of the first year's cash flows associated with Aggressive's DSL-based data service. Capital expenditures and capitalizable expenses dominate the first year, with the primary components of capital being the collocation non-recurring cost, regional switching center, packet switch, DSL equipment, and non-recurring cost of backbone transport to the data center. The net cash outflow for the first year is $11.5 million. At the end of the first year, there are 117 COs deployed over six metro areas.

Figure 3

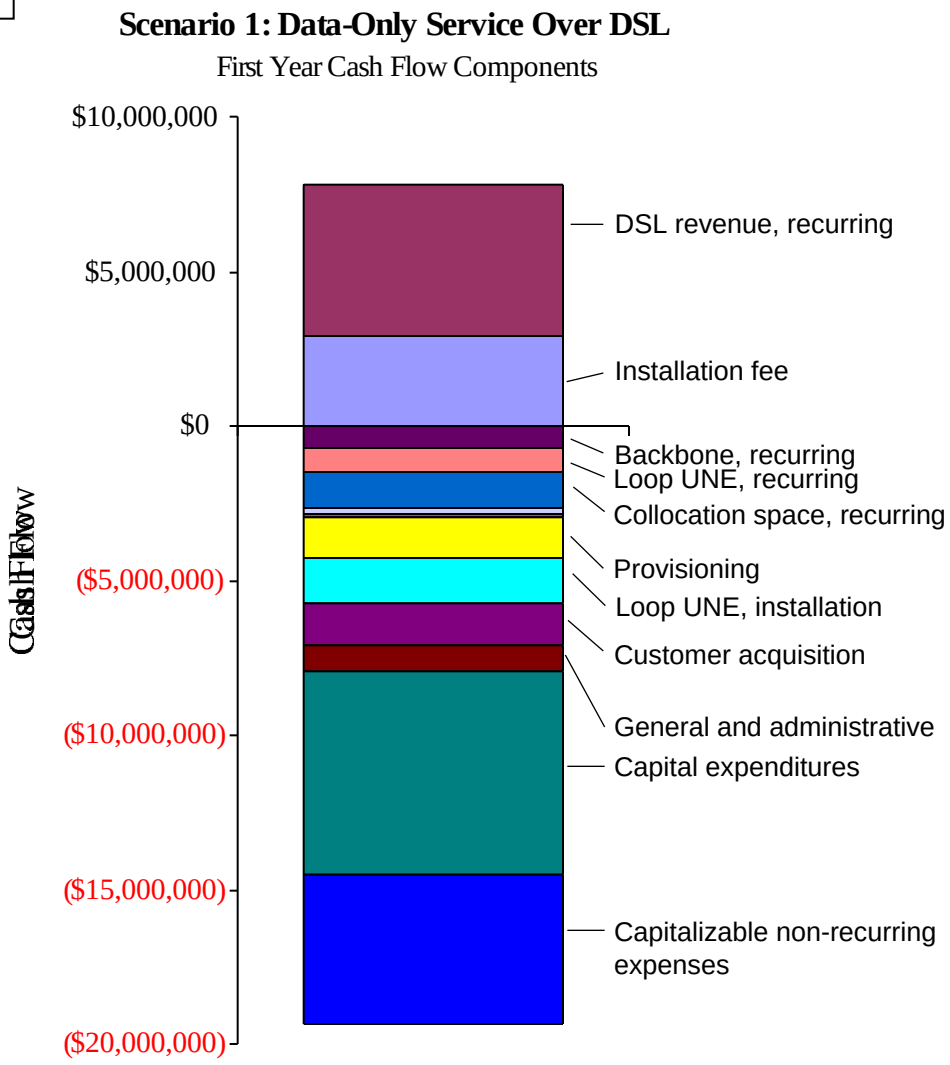
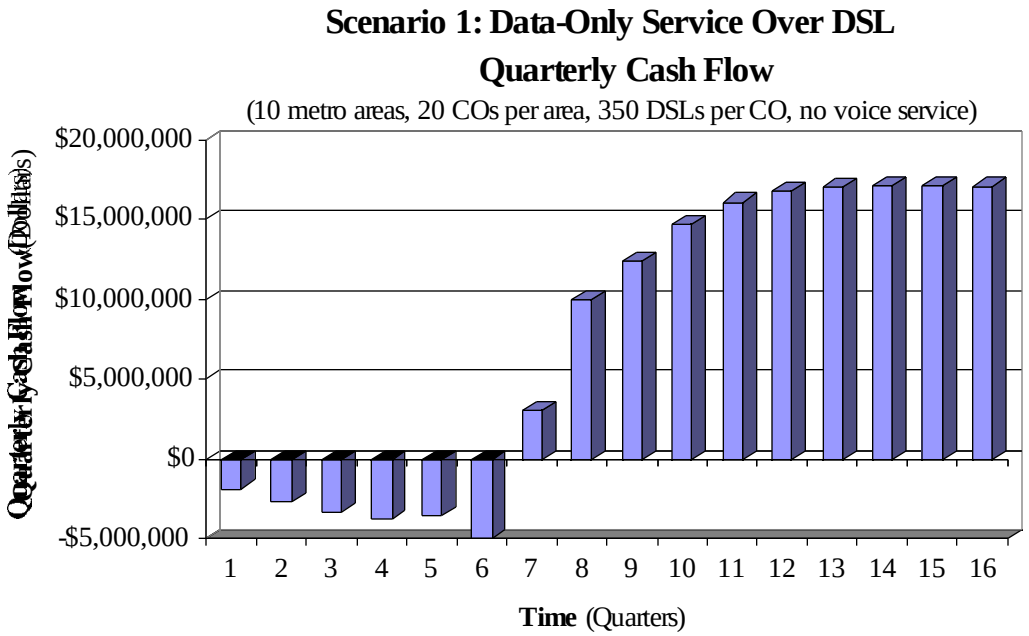


Figure 4 illustrates the total quarterly cash flow for data-only service. The DSL service begins generating positive cash flows in the seventh quarter of operation. The inflection in quarter six indicates investments in additional DSL chassis to meet demand.

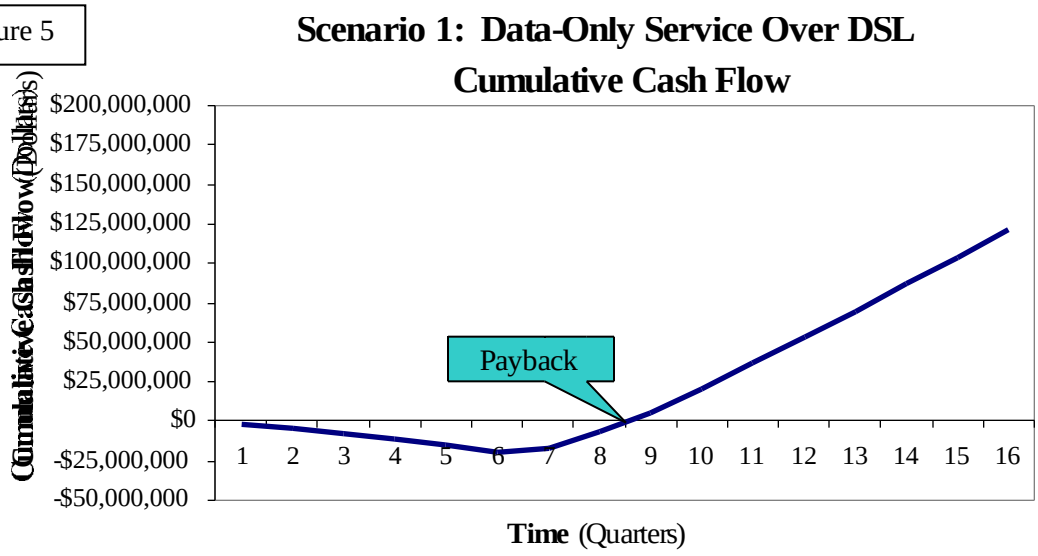
Figure



If the cash flow in figure 4 is discounted at an annual rate of 15 percent, or a quarterly rate of 3.6 percent, and the last year's cash flow is repeated for four more years, the NPV of the cash flow is $187 million. The lifetime value of each customer is $2,665.

Figure 5 shows the cumulative cash flow from the start of the venture. With these undiscounted cash flows, the time needed to pay back the initial investment is eight quarters, or two years, of operation.

Figure 5



SCENARIO 2: COMBINED VOICE AND DATA

Figure 6 shows the components of the first year's cash flows associated with Aggressive's DSL-based voice and data service. Capital expenditures and capitalizable expenses dominate the first year, with the primary components of capital being the collocation non-recurring cost, switching center, and non-recurring cost of backbone transport to the data center. The net cash outflow for the first year is $15.3 million.

Figure 6

Scenario 2: Voice and Data Service Over DSL

First Year Cash Flow Components

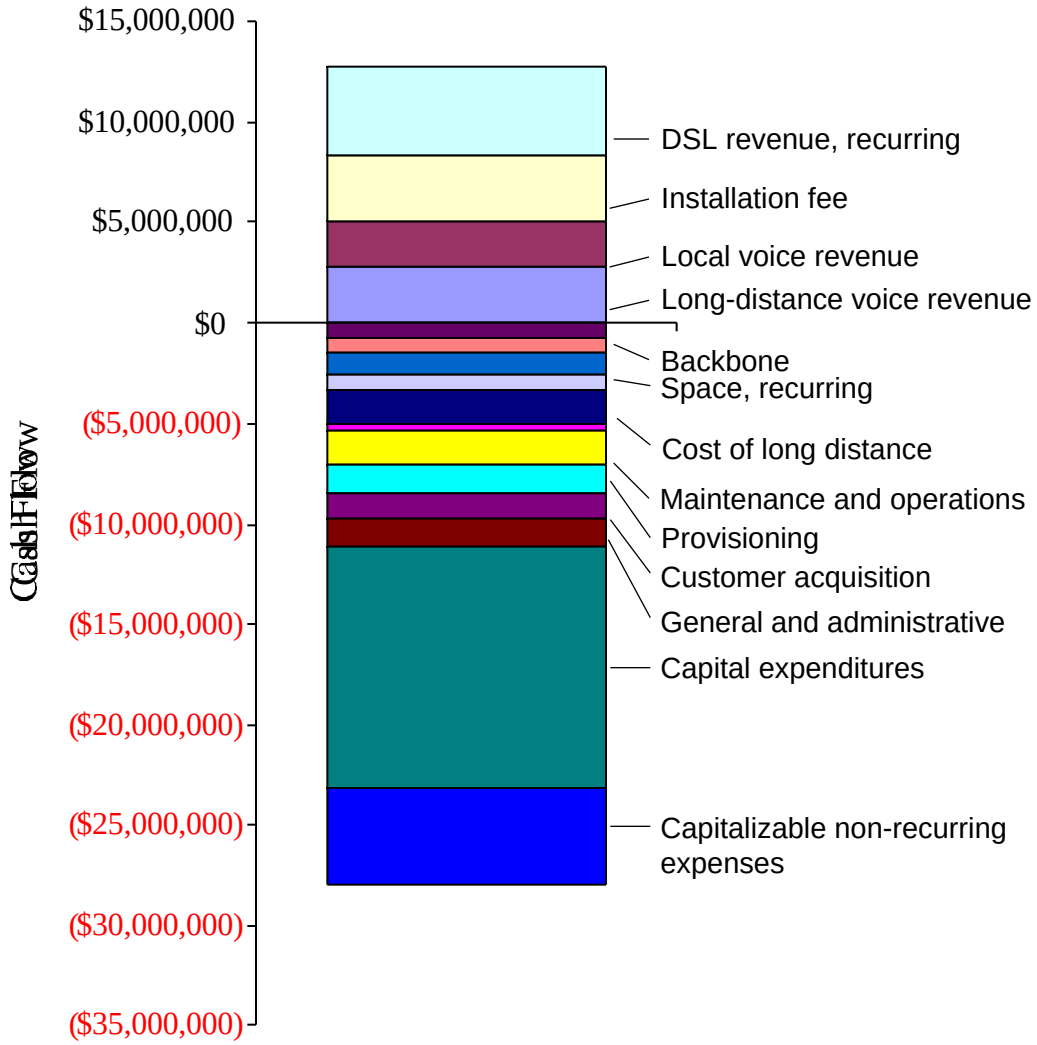
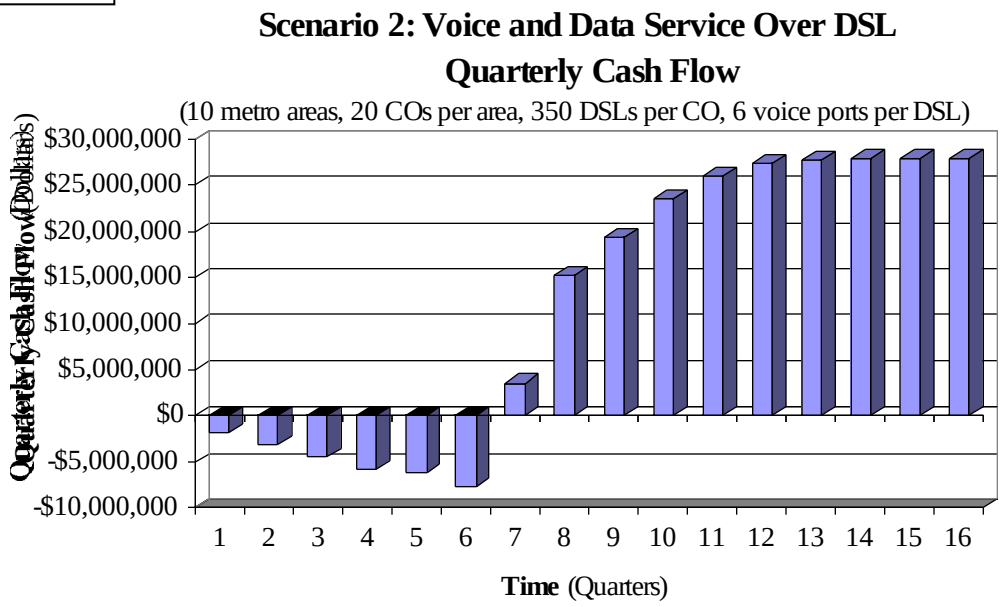


Figure 7 illustrates the total quarterly cash flow for voice and data service. The DSL service begins generating positive cash flows in the seventh quarter of operation.

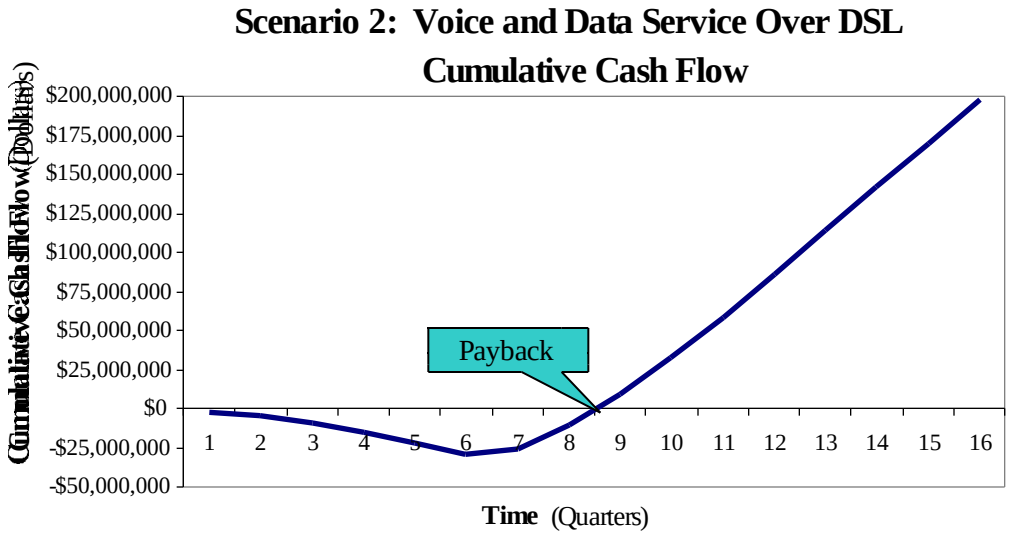
Figure 7



If the cash flow in Figure 7 is discounted at an annual rate of 15 percent, or a quarterly rate of 3.6 percent, and the last year's cash flow is repeated for four more years, the NPV of the cash flow is $305 million. The lifetime value of each customer is $4,354.

Figure 8 shows the cumulative cash flow from the start of the venture. With these undiscounted cash flows, the time needed to pay back the initial investment is eight quarters, or two years, of operation.

Figure 8



CONCLUSIONS

A combined voice and data offering using DSL service to business customers produces attractive returns to CLECs, even when the service is priced well below comparable existing voice and data services.

The lifetime value of the data-only service is $2,665 per customer. For combined voice and data services, the NPV of $305 million for 70,000 customers spread over 200 COs indicates a lifetime value of $4,354 per customer. This conservative estimate does not reflect the growth potential of increasing penetration beyond 350 customers per CO, nor the opportunity to sell more value-added services to the customer base (e.g., multicasting, content, VPN services, etc).

CONVERGENCE IS ECONOMICAL

The data-only service is priced at $140 per customer. With the addition of voice services, the data component can be priced lower—at $60 per month. This is a result of substantial cost-sharing between the two services.

In fact, with six voice lines, it is still a very profitable business to price the data component at $0 per month. Giving away the data service reduces the lifetime value of a customer from $4,354 to $2,194—still a profitable and attractive value, with returns far exceeding business hurdle rates.

Benefits to carriers:	A highly lucrative business enterprise with payback of initial investment in two years.
Benefits to customers:	Voice and high-speed data services at half the price of what customers are paying today.

The combination of compelling customer benefit and a lucrative carrier business model creates an exciting business opportunity. Attractive packages can be created that are still highly profitable for carriers.

GLOSSARY OF TERMS

CLEC	*Competitive Local Exchange Carrier.* A company that files with the state public utility commission to be a competitive carrier. The company then negotiates an interconnection agreement with the ILEC.
CO	*Central Office*. An ILEC building where all telephone wires terminate. Serving a particular geographic region, a typical CO will have 30,000 to 50,000 lines, although some urban COs have more than 100,000 lines.
Collocation cage	A cage in a CO that is erected by the ILEC and rented to a CLEC. CLEC personnel can access and maintain the equipment in the cage.
CSU/DSU	*Channel Service Unit/Data Service Unit.* A device that terminates a leased line. It maintains the timing and continuity of the signal and interprets the voltages into digital data (i.e., bits).
DSL	*Digital Subscriber Line*. A family of technologies for sending high-speed digital data over unshielded, twisted-pair.
GR-303	*Generic Requirement 303.* A specification issued by Bellcore (now Telcordia) that governs the interconnection of loop carrier equipment with class 5 digital switches.
ILEC	*Incumbent Local Exchange Carrier*, such as a Bell Operating Company like Bell Atlantic or Pacific Bell.
Interconnection agreement	A negotiated agreement between a CLEC and an ILEC that sets the terms and conditions under which the CLEC purchases services from the ILEC.
IRR	*Internal Rate of Return.* The rate of return associated with a stream of future cash flows. Typically, the early cash flows are negative (i.e., an investment). IRR is the rate of return on that investment. For example, investing $10,000 in a bank certificate of deposit produces a stream of future interest payments plus the eventual return of principal. Calculating the IRR of this cash stream will yield the bank's advertised interest rate.
ISDN	*Integrated Services Digital Network.* A technology invented in the early 1980s for carrying digital information on the circuit-switched telephone network. The version of ISDN typically purchased by business and residential customers carries two bearer (B) channels of 64 kbps each. These two channels can be combined to transport 128 kbps. Each B channel is circuit switched (the same as a voice phone call); business customers typically pay per-minute usage fees for each channel.
ISP	*Internet Service Provider.* An ISP has a gateway router to which subscribers traffic is sent. ISPs have peering arrangements to connect to the Internet backbone..
IXC	*Inter Exchange Carrier.* A carrier that provides long distance services.

Local loop	A pair of copper wires that run from the customer's premise to the MDF in the CO. The pair of wires runs inside of an aerial or underground cable that may contain thousands of pairs.
MDF	*Main Distribution Frame*. Racks in the CO where the copper loops terminate. The MDF is located in ILEC space.
NPV	*Net Present Value*. The current value of all future cash flows associated with a project. Future cash flows are discounted back to the present based on the required rate of return (also known as the hurdle rate or discount rate). If the NPV is greater than zero, it indicates a good investment.
NRC	*Non-Recurring Charges*. One-time installation fees associated with ordering telecommunications services.
POTS	*Plain Old Telephone Service*. Regular, dial-tone, voice service.
UNE	*Unbundled Elements*. The Federal Telecom Act of 1996 and the accompanying FCC order requires ILECs to unbundle telecommunications services into their component elements. The act further requires that the ILECs sell these parts to competitors at cost plus a reasonable rate of return. One of these unbundled elements is the local loop.
Voice Gateway	An IP or ATM based network element that converts packet voice to circuit voice.