



Abstract

Introduction to DSL Technology

Digital Subscriber Line (DSL) technology unlocks the potential of conventional copper telephone wire to deliver high-data-rate (“broadband”) digital services. Learn how this technology “turbo charges” the telephone wires available at virtually every business and residence, and how this technology will effect you as a service provider, enterprise customer, and everyday consumer. DSL is one of the leading technologies for bringing “megabits to the masses” in the new emerging age of ubiquitous broadband access. This session includes: introduction to the family of DSL technologies (“**xDSL**”); how DSL technology enables delivery of high-speed data, voice and multimedia over conventional telephone wires; overview of the equipment required to build a DSL network over existing telephony infrastructure; description of value-added services enabled by “mass-market” broadband access.

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Agenda

- **What Is “Broadband”?**
- **Why Is It Important?**
- **What Is DSL?**
- **DSL Technology Overview**
- **Basic DSL Network Design**
- **New World Services**
- **Market Dynamics**

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Life Beyond 56K

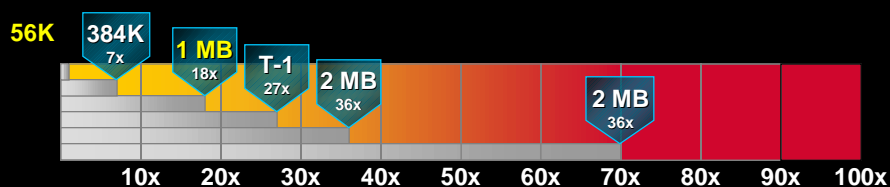
56K Is Too Slow to Provide a Satisfactory Internet Experience

- Our century-old telephone network is designed specifically around the audible frequency range 0–4KHz
- Voice band modems use tones in the audible spectrum and communicate via standard voice circuits—you can hear modems and fax machines “talking” to one another
- 56kbps (“56K”) is the practical limit for voice band modems—actual speeds are lower
- The wire itself is capable of much more
- DSL (**Digital Subscriber Line**) uses inaudible high-frequency signaling to achieve megabit transmission speeds

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What Is “Broadband”?

Broadband = “Megabit” Data Rates



1 Megabit Per Second Is Easily 25 Times Faster Than the Actual Speed of a Typical “56K” Connection

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Broadband Access Technologies

| | |
|--------------------------------------|--|
| DSL (Twisted-Pair Copper) | + Dedicated Wire = Dedicated Bandwidth and Security + Ubiquitous Wiring Infrastructure (Business and Residential) – Digital Broadcast Video Delivery Is a Challenge |
| Cable (Coax) | + Broadcast Video Is Already Present – Current Infrastructure Is Predominantly Residential – Shared Wire Can Slow Performance During “Rush Hour” – Security Is an Issue for Shared Medium |
| Satellite | + Broadcast Video Is Already Present + Great for Remote Locations – Requires Wire-line Return (Preferably DSL) |
| Fixed Wireless | + Great for Remote Locations + Cheaper Than Laying New Cable – Equipment Is Relatively Expensive End-to-end – Subject to Interruption During Heavy Rain |
| Optical Fiber | “Unlimited Bandwidth”—The Holy Grail of Broadband, but Wide-spread Deployment of Fiber-to-the-Home Will Require Huge Investments and Several Decades |

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Why Is Broadband Important?

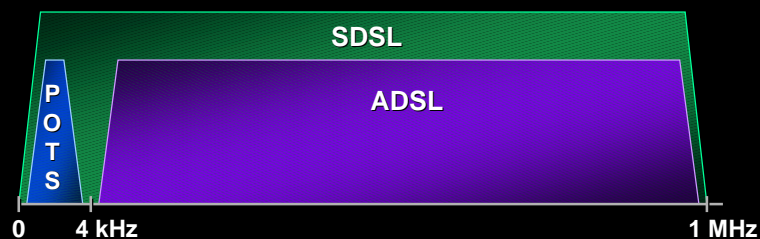
Broadband Unleashes the True Commercial Potential of the Internet

- ✓ Fast—eliminates the “world wide wait”
- ✓ Always on, always available—provides information on-demand
- ✓ Allows transactions on-the-fly
- ✓ Makes “rich content” consumable
- ✓ Enables real-time human interaction
- ✓ Makes business-to-business communication more efficient
- ✓ Makes “network computing” possible (applications and storage)
- ✓ Enables convergence of data, voice, and video

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What Is “DSL”?

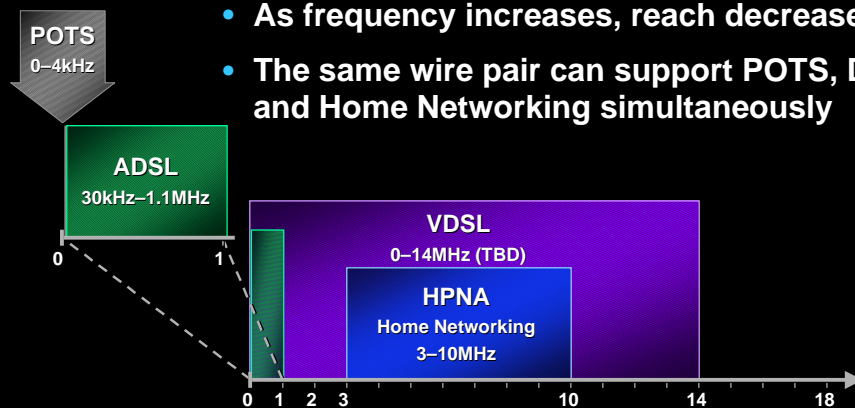
A Family of Access Technologies That Utilize High Transmission Frequencies (up to 1 MHz) to Convert Ordinary Phone Lines into High-Speed Data Conduits



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Spinning Copper Into Gold

- Twisted pair copper can carry much higher frequencies and much greater bandwidth
- As frequency increases, reach decreases
- The same wire pair can support POTS, DSL and Home Networking simultaneously



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DSL Terminology

- **Symmetric (SDSL)**
Same speed in both directions
- **Asymmetric (ADSL)**
“Slow” upstream for low-data-rate requests
“Fast” downstream for bursts of “rich” content and streaming audio/video
- **ADSL variants**
CAP (Carrierless Amplitude/Phase Modulation)
DMT (Discrete MultiTone Modulation)
G.lite (Consumer/Mass-Market DMT)
- **Industry Standards**
ANSI T1.413—Issue 2—“DMT Issue 2”
ITU G.992.1 (G.dmt)—“full rate”
ITU G.992.2 (G.lite)—“consumer”

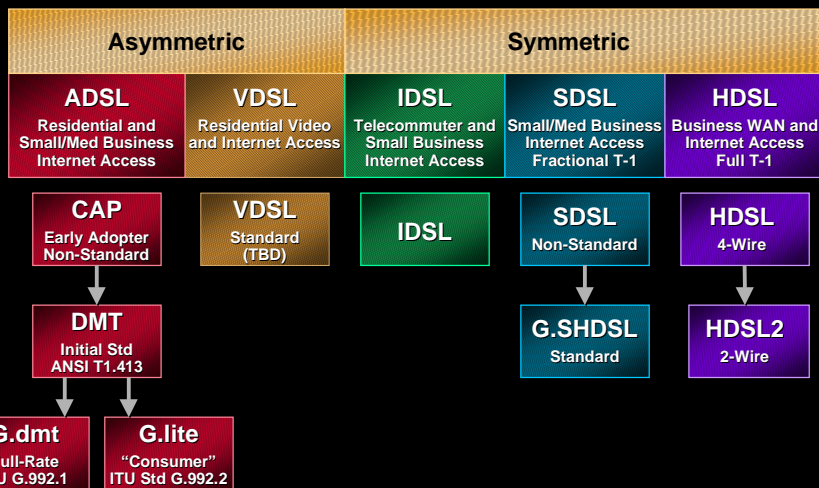
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Symmetric vs. Asymmetric

- **Asymmetry has technical merits in dense wire bundles (“binder groups”)**
- **Typical “consumer” Internet access does not require much upstream bandwidth**
Small requests (a simple URL)
BIG replies (a fancy web page)
Uploading presentations and digital photographs challenges this, as does convergence of data, voice and video
- **Businesses exchange lots of data in both directions, so symmetry is required**
Computer-to-computer data exchange
Two-way digital voice traffic

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DSL Family Tree



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DSL Comparison Chart

| DSL Technology | Max Data Rate Down/Uplink (bps) | Max Reach feet (km) | Key Attributes | Primary Applications |
|--|---|---|--|--|
| ADSL Asymmetric DSL | Full Rate: 8M/1M G.Lite: 1.5M/640K | 18,000 (5.5) | Coexists with POTS Technology of Choice for Residential/Telecommuter | Consumer High-Speed Internet Access |
| IDSL ISDN DSL | 144K Symmetric | 18,000 (5.5) x2 (w/ Repeaters) | Uses Existing ISDN CPE Long Range, but Relatively Slow | Telecommuter Long Reach Fast Internet Access |
| SDSL Symmetric DSL | Up to 1Mbps Symmetric | 22,000 (6.9) | Symmetric Non-standard | Small/Med Business Data and Voice over IP Fractional T1 |
| HDSL 4-Wire High-Bit-Rate DSL | 1.5M-2M (T1-E1) Symmetric | 15,000 (4.6) | Current Technology for T-1 Deployment Req's 2 Pair (4 Wires) | Business WAN Full T1 |
| HDSL2 2-Wire High-Bit-Rate DSL | 1.5M-2M (T1-E1) Symmetric | 15,000 (4.6) | Optimized for Full-rate Replaces 4-Wire HDSL Std Under Development | Business WAN Full T1 |
| G.SHDSL High-Bit-Rate DSL | Up to 2M Symmetric | 26,000 (8.2) | Optimized for Fractional Rates and Long Reach Std Under Development | Small/Med Business Long Reach Fractional T1 |
| VDSL Very-High-Bit-Rate DSL | 52M/6.4M 34M Symmetric 6.5M Symmetric | 1,000 (0.3) 1,000 (0.3) 5,000 (1.5) | Very Fast—Short Reach Co-exists with POTS No Standard Yet | Residential Video and Internet Access |

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DSL Applications

- **Residential and business service from Central Office**

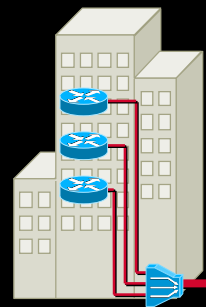
Internet access and corporate interconnects

- **Multibuilding campus networks**

High-speed links over existing phone lines between buildings

- **Multi-tenant buildings**

Hotels, apartment buildings and office buildings



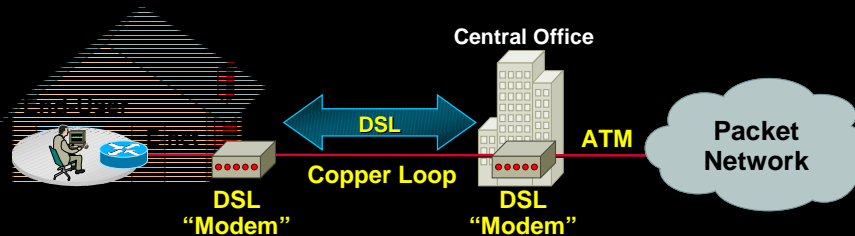
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A Few More Key Points

- **DSL reduces loads on expensive analog voice switches**
 - The switched voice network relies on over-subscription of expensive Class 5 switches based on short conversations
 - Increasing demand for long-duration data connections violates traditional over-subscription models
 - DSL off-loads data connections to the data network
- **DSL dramatically changes the traditional T-1 economic model**
 - Leased Line T-1 (1.5 Mbps) cost more than \$1000 per month
 - Symmetric business-class DSL runs as low as \$200 per month
 - Residential broadband runs as low as \$20 to \$50 per month
- **DSL and Deregulation have energized the CLEC marketplace**
 - High-speed data and low-cost voice is a powerful new bundle
 - Multiple competitive local exchange carriers vying for your \$\$\$
- **DSL paves the way for voice and data convergence**
 - Cheaper to build new data networks than build or lease analog voice networks

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DSL 101



- DSL is a pair of “modems” on either end of a copper wire pair
- DSL converts ordinary phone lines into high-speed data conduits
- Like dial, cable, wireless and T1, DSL by itself is a **transmission technology**, not a complete end-to-end solution
- End-users don’t “buy” DSL—they buy services, such as high-speed Internet access, secure intranet access, packet voice, video-on-demand, etc.

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Basic DSL Network Components

- **CPE**
Customer premise equipment
Subscriber-side interface + DSL interface
PC NICs, bridge/routers, enterprise routers
- **DSLAM**
DSL Access Multiplexer
Concentrates individual subscriber lines from CPE
- **Aggregator/service selection gateway**
Concentrates ATM feeds from DSLAMs
PPP termination, Layer 2 and 3 service selection
Provisions on-demand, personalized services
Accounting and billing

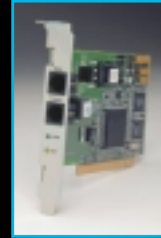


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Residential ADSL CPE



Cisco 677
ADSL Router



Intel Pro/DSL 2100
ADSL NIC



Cisco iHG2000
Internet Home Gateway



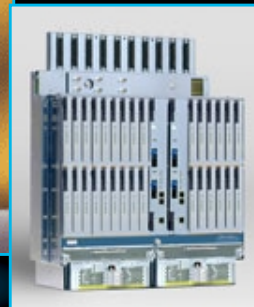
Intel Pro/DSL 3100
USB Modem

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Central Office DSLAMs



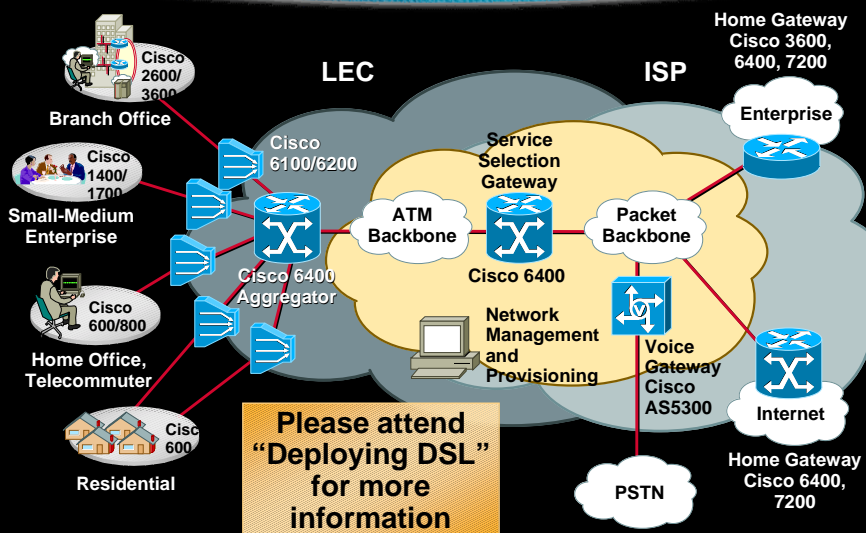
Cisco 6130
DSL Access Concentrator



Cisco 6260
DSL Access Concentrator

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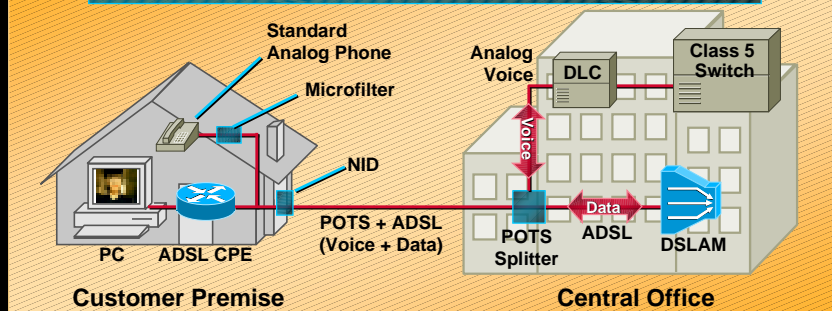
Basic DSL Network Topology



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ADSL and POTS

A Key Feature of ADSL Is Co-existence with POTS



- Permits transmission of both signals on the same wire pair
- "POTS Splitter" at the CO separates analog POTS from data
- "Microfilters" at the customer premise prevent off-hook interference between analog voice signal and ADSL signal

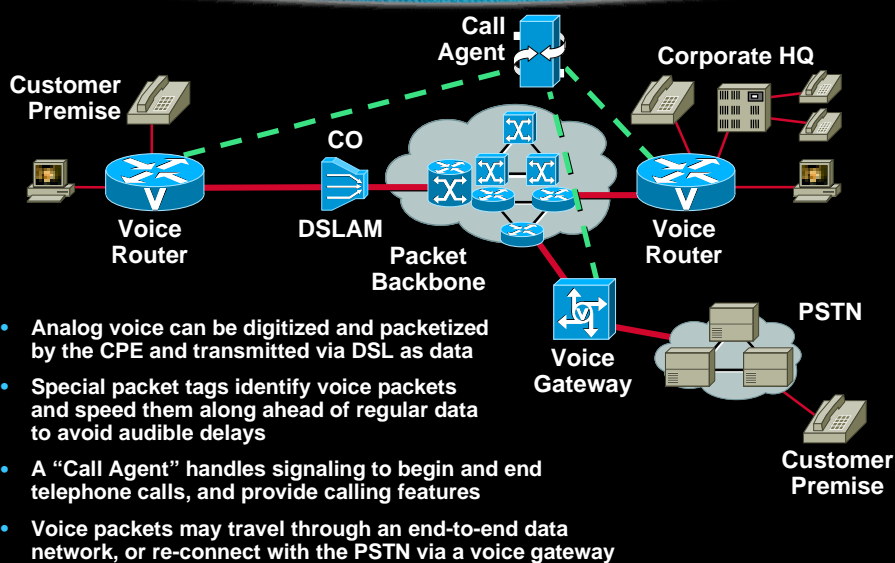
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Real World Considerations

- **Loop quality**
Actual performance (speed/reach/stability) degraded by corrosion, splices, load coils, mixed wire gages, and interaction with other signals in same “binder group”
- **Loop length**
Actual loop length is typically much longer than distance “as the crow flies”
- **Current network topology**
CPE must connect directly to DSLAM in Central Office or DLC Remote Terminal equipped with DSL
- **Interoperability**
Industry-wide effort to assure acceptable loop performance between different DSL chipsets

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Voice over DSL



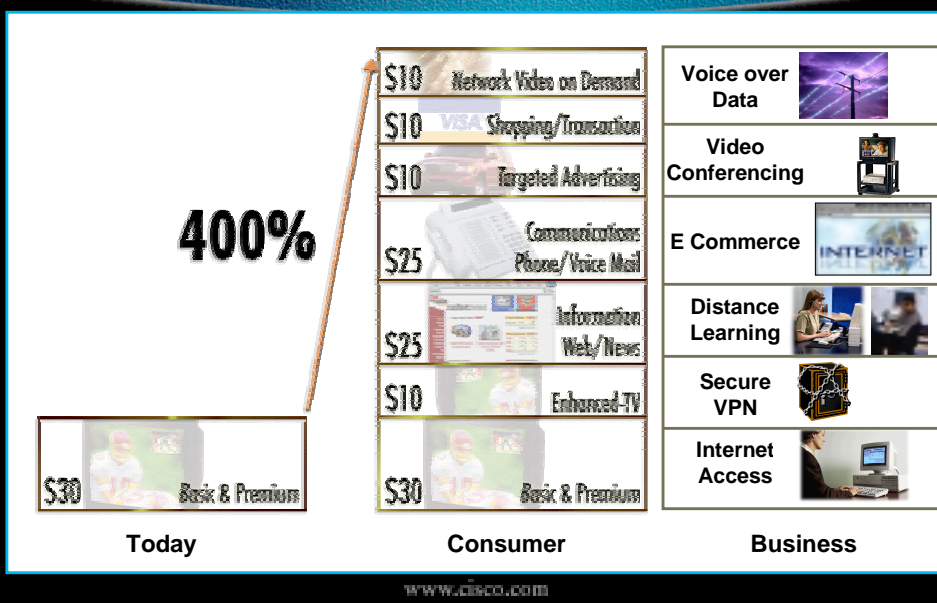
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Video over DSL

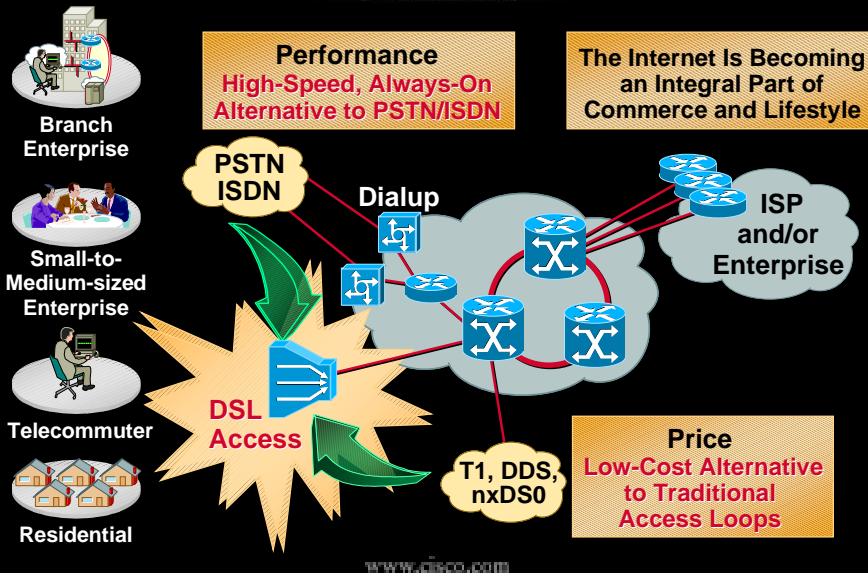
- **Multiple MPEG-4 streams**
Two minimum, preferably three
2 Mbps per stream
- **Tri-media bandwidth budget**
Data: 500 kbps nominal, symmetric
Voice: 4 x 64 kbps max. = 256k symmetric
Video: 2 or 3 x 2 Mbps = 4 or 6 Mbps down
TOTAL:
4.75 to 6.75 Mbps downstream
0.75 Mbps upstream

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New World Services



Exploding DSL Marketplace



DSL vs. the Legacy of ISDN

- **ISDN never achieved significant momentum in the U.S.**
 - The Internet was in its infancy
 - 128K is not fast enough
 - Too complicated to install
 - No competition
- **DSL is in the right place at the right time**
 - The Internet has come of age
 - DSL is faster, simpler and cheaper
 - Competition is intense (CLECs and cable)

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Summary

Life Is Better with Broadband

- DSL is ready for prime time! Mass deployment is underway
- The Internet is driving demand for high-speed access
- CLEC and cable threat are driving accelerated investment in DSL
- Data traffic is eclipsing voice traffic on the public networks
- Convergence of data, voice, and video will decrease end-user aggregate access cost
- Profits in an era of low cost access will come from New World services

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