Cable-Based Network Solutions

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Cisco Systems
Cable-Based Network Solutions

Agenda

• Introduction to Cable Networks
• Cable Modem Technology
• Services
• Q&A
Introduction to Cable Networks

- Introduction to Cable Networks
  The Electromagnetic Spectrum
  Cable Network Architecture
  Fibre-Optic Technology
- Cable Modem Technology
- Services
- Q&A
The Electromagnetic Spectrum

Waves

Almost all digital communication methods work by the manipulation of “Waves”

- A ripple in a pond is a wave in water
- An RF carrier is a wave in electrons
- A beam of light is a wave in photons
The Electromagnetic Spectrum

Frequency

• The number of wave crests that occur in a time period

• Cycles per second = Hertz (Hz)

  1,000 Hz = 1 kHz
  1,000,000 Hz = 1 MHz
  1,000,000,000 Hz = 1 GHz

  1 cycle / second = 1Hz

  2 cycles / second = 2Hz
The Electromagnetic Spectrum

Common Frequencies

- Musical Note A above middle C = 440 Hz
- AM 680 Radio =~ 680 kHz (680,000 Hz)
- FM 102.1 Radio =~ 102.1 MHz (102,100,000 Hz)
- Microwave Oven =~ 2.5GHz (2,500,000,000 Hz)
- Visible Red Light =~ 4.6x10^14 Hz
- X-Ray =~ 3 x 10^19
• RF (radio frequency):

Generally considered to be electromagnetic energy from a few hundred kilohertz to just below infrared light.
The Electromagnetic Spectrum

RF Bandwidth

• RF Bandwidth refers to the \textit{width} of the frequency band used.

• RF Bandwidth does \textit{not} always translate into Bit Rate

\begin{itemize}
  \item The bandwidth used by an analog telephone line is \textit{\sim} 3000 Hz
  \item The bandwidth used by an FM radio station is \textit{\sim} 200 kHz
  \item The bandwidth used by a Television Channel is \textit{\sim} 6 mHz
\end{itemize}
Cable-Based Network Solutions

Television Channels

• Each North American television station uses a 6 MHz wide carrier.
• Each of these signals is modulated to an allocated frequency on the cable network.
• These frequencies are ‘tuned’ to when you select a channel on your television.
# RF Channel Lineup

<table>
<thead>
<tr>
<th>Channel</th>
<th>Over-the-air</th>
<th>Cable</th>
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<tbody>
<tr>
<td>1 MHz</td>
<td>Shortwave</td>
<td>T7</td>
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<td></td>
<td>H a m</td>
<td>T8</td>
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<tr>
<td>54 MHz</td>
<td>TV Ch. 2-4</td>
<td>T9</td>
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<td>TV Ch. 5-6</td>
<td>T10</td>
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<td>FM</td>
<td>T11</td>
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<tr>
<td>108 MHz</td>
<td>Aircraft navigation &amp; communication</td>
<td>T12</td>
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<td>Space research</td>
<td>T13</td>
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<tr>
<td>174 MHz</td>
<td>H a m</td>
<td>5-12 MHz upstream</td>
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<td>216 MHz</td>
<td>Gov't fixed, mobile</td>
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<tr>
<td>216 MHz</td>
<td>TV Ch. 7-13</td>
<td></td>
</tr>
<tr>
<td>432 MHz</td>
<td>Gov't fixed, mobile</td>
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<td>470 MHz</td>
<td>Ham</td>
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<tr>
<td>648 MHz</td>
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<tr>
<td>806 MHz</td>
<td>Over-the-air</td>
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<td>864 MHz</td>
<td>Over-the-air</td>
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<td>UHF TV Ch. 14-69</td>
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<td>Cable</td>
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</table>
Cable Network Architecture

Symmetry

• Cable Networks are asymmetric.
• The available frequency range is un-equally split between “Downstream” (to the subscriber), and “Upstream”
• Frequencies from 54MHz to 850Mhz are used for downstream information. (~125 TV Channels)
• Frequencies from 5MHz to 45MHz are used for upstream information. (Equiv. ~5 TV Channels)
Cable Network Architecture
Cable Network Architecture
Cable Network Architecture

CABLE COMPANY

NETWORK

SUBSCRIBER
Cable Network Architecture

- Major components of a typical cable network:
  - Antenna site
  - Transportation network
  - Headend
  - Distribution network
  - Subscriber drop
• Antenna site:

Exactly what its name implies: A location chosen for optimum reception of over-the-air signals, and sometimes also satellite and point-to-point microwave signals.
Cable Network Architecture
• Transportation network:
  Used where necessary to link a remote antenna site to a headend, or a remote headend to the distribution network. May be microwave, fiber, or coaxial supertrunk.
Here’s a microwave link that’s used to transport TV signals...
Cable Network Architecture

• Headend:

Somewhat analogous to a telephone company’s central office. A facility where signals are received, processed, formatted, and combined for transmission on the distribution network.
And here’s what a headend looks like...
• **Distribution network:**

  In a classic tree-and-branch cable system, trunk and feeder cables comprise the distribution network.

  The trunk is the backbone; it distributes signals throughout the community being served. Typically uses 0.750 inch (19 mm) diameter coaxial cable.

  The feeder branches off of the trunk, and passes all of the homes in the service area. Typically uses 0.500 inch (13 mm) diameter coaxial cable.
Cable Network Architecture

• Distribution network:

In a hybrid fiber/coax (HFC) architecture, optical fiber replaces some or all of the traditional trunk portion of the distribution network.

The network is divided into small service areas, each with from as few as 100 to as many as 2,000 homes passed. Fiber connects between the headend (or hub) and an optical node, where light is converted to RF. From the node, RF signals are distributed throughout the serving area via coaxial cable.
Distribution network

- **Trunk/bridger amplifier; directional coupler and splitter; tap**
- **Line extender amplifier, directional coupler and taps**
- **Standby (battery backup) line power supply**
- **Underground pedestal**
- **Optical fiber node**
Subscriber drop from tap to TV set

Subscriber drops connected to feeder tap

Set top box on top of subscriber’s TV set
Cable Network Architecture

- Tree-and-branch
- Hybrid fiber/coax
  - Fiber backbone
  - Cable area network
  - Super distribution
  - Fiber-to-the-feeder
  - Ring
Tree-and-branch architecture

- Cost-effective “broadcast” architecture
- Con: Cascaded devices
HFC architecture

- Segments network into smaller serving areas
- Use of fiber minimizes cascaded devices
- Improved quality and reliability
- Reduced operating costs
Cable Modem Technology

Agenda

• Introduction to Cable Networks
• Cable Modem Technology
  Overview of DOCSIS
  Network Topology
  Security
• Services
• Q&A
Overview of DOCSIS

Downstream Data

• DOCSIS uses a downstream channel to transmit data from the headend to subscribers.

• Each channel is capable of transmitting up to 38 Megabits/s to the users in a serving area.

• Typical areas have between 200 - 1000 subscribers per downstream.
Overview of DOCSIS

Upstream Data

• DOCSIS uses an upstream channel for traffic from the customer to the headend. There are 4 upstream channels per downstream channel.

• Each upstream can receive up to 10Mbps of traffic from subscribers.

• Each upstream typically serves 200 cable-modem subscribers.
Small cable system topology

- Single box Cable Modem Termination System (CMTS) / Router
- The CMTS is responsible for coordinating timing and security for all cable modems connected to it.
Large cable system topology

- Modem
- Fiber Node
- E/OE/O
- O/E
- E/OE
- CMTS
- HUB Rings
  - 622 Mbit/sec
  - OC-12
- Big Routers
- Ethernet
- Switches
- T1 Links
- VoIP Gateway
- Servers
- Internet
- Phone Network
- 2.4 Gig/sec
  - OC48
- © 2001, Cisco Systems, Inc. All rights reserved.
DOCSIS Security

Baseline Privacy Interface Plus

- BPI+ is a part of the DOCSIS spec. which addresses security in DOCSIS 1.1 networks
- BPI+ includes certificate-based authentication, and 168-bit 3DES encryption for data, and voice.
- Traffic between subscriber and cable operator is encrypted from the home to the head-end.
- BPI+ encryption happens at L2, and does not interfere with IPsec encryption.
DOCSIS QoS

The “Shared” network that isn’t

- DOCSIS implements a robust scheduling mechanism that allows the CMTS to control who gets access to the network, and how much.

- Cable Modems must ask for bandwidth on the network before they are allowed to transmit.

- QoS can be implemented down to an application-level.

- Both priority-based, and guaranteed bandwidth allocation are possible.
DOCSIS QoS

Voice over Cable

• Voice is among the most demanding applications for latency, and jitter.

• DOCSIS 1.1 is designed to be able to transport voice within the strict delay requirements.
Services

Agenda

• Introduction to Cable Networks
• Cable Modem Technology
• Services
  Internet
  VPN
  Future
• Q&A
Enterprise Productivity Challenges

I'm working from home today, call me at 416-444-5678

Can I use the Phone now?

I'll be in Montreal Today. Call me at 514-847-1234
Cable Modem Services

The Obvious… The Internet!

• Internet access from 56Kbps up to 5Mbps/1Mbps

• Business Internet services can give business traffic priority over residential customers.

• Cost Effective ($35/mo. for basic service)
High-Speed Business Internet

Toronto
Corp Office Toronto
416-555-1212

Vancouver
Calgary
Montreal

CMTS
Cable Router

Internet

PSTN

Can I use the Phone now?

Home Office

I’m working from home today, call me at 416-444-5678

Off-Campus Productivity

I’ll be in Montreal Today. Call me at 514-847-1234

I’m working from home today, call me at 416-444-5678

Can I use the Phone now?

Home Office

Off-Campus Productivity
Cable Modem Services
VPN Technologies

VPN Remote Office

- VPN Concentrator at main office.
- VPN Client device at remote offices.
- Leased-Line replacement.
- Secure, and scalable. More offices do not require more links at the main site.
Cable Modem Services
VPN Technologies

VPN Telecommuter

- VPN Concentrator at main office can be the same used for remote workers.
- VPN Client Software is installed on laptops/PC’s of remote workers.
- One-time passwords, and firewall enforcement provide added security.
Mobility and VPN Solutions

VPN Solutions

- Lower circuit cost for branch office connectivity
- Provides teleworkers with “office like” data connectivity
- Rapid deployment of nomadic users - “Instant Office”

Corporation HQ
Toronto

VPN Tunnels

Service Provider

Cable Modem
Home Office
Montreal
Vancouver

Cable Router
Future Services

V3PN

• Voice and Video enabled VPN’s
• Requires QoS and SLA Guarantees in the Service Provider Core
Voice and Video Enabled VPN – V³PN

VPN Tunnels

Branch Office
Teleworker
VPN – Virtual Private Networks

V³PN
Voice Video QoS

HQ
IP Telephony

PSTN
Private IP WAN

V³PN - Voice/Video enabled VPN
Extended Enterprise Mobility
IP Telephony and VPN
Voice and Video Enabled VPN – V³PN

V³PN Solutions

- Lowers costs and increases teleworker productivity
- Cisco Powered Network (CPN) Service Provider partners carry voice/video with toll quality SLA’s
- Same network connectivity at home as in corp office (voice, video and data)

Log into phone and phone takes profile of 416-555-1212

Hello this is John

Corporation HQ
Toronto

Corporation Office TO
416-555-1212

PSTN

QoS enabled VPN (V³PN) over Cable Service Provider

Hello this is John

Home office #
416-555-1212

Montreal

Vancouver
Enterprise Benefits of V³PN
Lower Cost to Network Branch Offices

Before:
Private Frame Relay

TO

Private Frame Relay

Branch Offices

• 23 sites – $38k per month
• Sub T1 access for branches
• 1 month installation time

After:
Voice and Video enabled VPN

TO

Cable Service Provider

Branch Offices

• 23 sites – $24k per month
• T1 access for branches
• 2 week installation time
Teleworker Example
Today

Typical Teleworker Office Setup:
- Uses VPN to dial up corporate data network
- Voice is different phone number and network
- No video facilities

Results:
- Extra phone line charges for voice calls
- Has to expense phone calls back to employer
- Not in corporate PBX or directory – out of touch
- Must remember to check voice mail periodically
Teleworker Example
Tomorrow – IP Telephony Enabled Teleworker

Results:
- Same use of network tools as in Corp office
- Same Phone number and VM as Corp office
- No extra phone line/charges for voice calls
- Increased workday productivity

Hello John speaking

Home Office

Home Office Number 416-526-4000
Home Number 416-555-1212

Corporate HQ

Corporate Number 416-526-4000

QoS Enabled Cable SP

VPN Tunnel

PSTN

I need to call John 416-526-4000
IP Telephony for Teleworker
For Legacy PBX Environments

**How it Works**

1. Analog line configured is same # as Corp Office Legacy PBX Phone
2. Analog line configured to go through gateway and ring teleworker’s home IP phone
3. Corp Office number called – Rings in both Places
4. Possibly no VM light depending on legacy PBX vendor

Corporate HQ

VPN Tunnel (V3PN)

QoS Enabled SP

VoIP GW

PSTN

Corporate Office Number 416-526-4000

CallManager

Legacy/Proprietary Phone Line

Legacy PBX

Home Office

Hello John speaking

Home Office Number 416-526-4000

I need to call John 416-526-4000

Hello John speaking

Fax

VoIP GW

Analog Phone Line Same as Corp Office Number 416-526-4000

Analog Phone Line

Same as Corp Office Phone Line 416-526-4000

I need to call John 416-526-4000

Home Office

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**V³PN (VoIP/Video Enabled IPSec VPN)**

Enterprises Requiring SP QoS

- Service Providers are offering QoS SLA’s today
- Best effort today – SP’s currently developing QoS enabled offerings

**Cisco Powered Network SP Partners**

http://www.cisco.com/pcgi-bin/cpn/cpn_pub_bassrch.pl
Gartner Group Research Results
Facts on Companies that have Installed VPNs

VPNs provide the most cost-effective, flexible and secure network infrastructure for converged voice, video and data

- 85% report higher levels of network security and faster connectivity
- The average ROI is 54% over an 18 month period
- Almost 90% report experiencing cost-savings over their previous solution
- Three hours saved per employee per week
- 70%+ using VPN extranets site improved communications with their customers and partners
- 75% + say that VPNs make supporting remote users easier for IT staff
Only Cisco Delivers End-to-End, Fully Interoperable V^3^PN Network Solution

Cisco Powered SP Partners
Providing QoS SLA’s

Cisco CallManager
Call setup and signaling; Host IDS protection

Core Backbone SP

IP Phone

Branch Office

> T1

SOHO Access SP

Cable/DSL

Teleworker

Cisco IOS VPN Routers
Integrated WAN, VPN, and voice gateway for Head end and remote offices

Cisco IP Phone 79xx
Phone handset with integrated QoS
Cisco Internal V^3PN Deployment

Cisco Private IP WAN

San Jose

SJ SP’s

SJ Teleworker’s

RTP

RTP SP’s

RTP Teleworker’s

Field Office

QoS Enabled SP

VPN Tunnel

Cisco Private IP WAN
Cisco Teleworkers
Current Deployment Examples

Cisco Campus

Clusters

VPN Head-Ends (3660/7200)

Non-QoS Enabled SPs
IPsec VPN

3d-Party Modem

Site-to-Site

Cable

DSL

Site-to-Site

Site-to-Site

PIX Remote Access

Cable
Cisco Internal Requirements

- Many Teleworkers requiring same IP Telephony requirements as in Corp Office
  Development, Tech Writers, Sales etc.
- Lower cost on expensed Home phone bills
- Increased workday productivity
- Edge QoS with a “Best Effort” SP acceptable for benefits gained – Toll Quality >99% of the time
Cisco Internal Teleworker Deployments

Before

- Two PSTN Lines – Home + Work
- Work number different than Corp office
- Work number shared by Fax
- Expensed Work phone bill - $200/month

Home Office/Fax Number
408-555-1111

Home Number
408-555-1212

After

- One PSTN Line – Home
- Work number same as Corp office
- Separate Fax number
- Expensed Work phone bill - $0

Home Office Number
408-526-4000

Home Number
408-555-1212
A Cisco SOHO Site-to-Site VPN Site

- Transparent data, voice and video as if located in San Jose
- Firewall and VPN tunnel termination on IOS router
- QoS configuration
  - LLQ on WAN Interface
  - Service Provider “best effort”
Cisco Internal Deployment Models

Single-Box

Two-Box

Third-Party Modem

9x5

Cable Backbone

To Head-End

DSL

Cable

Single-Box

Two-Box

Third-Party Modem

806/1710

DSL Backbone

To Head-End
3rd Party Cable/DSL Modems
Cisco IOS VPN Router with Traffic Shaping Required

- Traffic shaping to uplink speed
- Avoids uplink congestion
- Ensure that QoS honored
Before

- Two PSTN Lines – Home + Work
- Work number different than Corp office
- Work number shared by Fax
- Expensed Work phone bill - $200/month

After

- One PSTN Line – Home
- Work number same as Corp office
- Separate Fax number
- Expensed Work phone bill - $0
Value of V³PN Solutions from Cisco

Summary

Delivers operational efficiencies by:
- Reducing network infrastructure, bandwidth, and operating costs
- Delivering corporate voice and data network connectivity to more sites and users
- Cost-effectively increasing secure bandwidth to enable new converged applications

Provides greater network security through:
- Encryption of voice and video streams
- Authentication and intrusion protection on network devices
- Stateful inspection of voice and video traffic

Provides an E-Business capable network with:
- Voice and video enabled VPN with end-to-end device interoperability
- Deployment model for service providers and enterprises

Part of the Cisco Multi-Service VPN Solutions Suite
- Delivers voice and video across IP, IPSec, and MPLS
For More Information…

- **V³PN**
  
  www.cisco.com/go/v3pn

- **Cisco VPN Routers**
  
  800, 1700, 2600, 3600, 3700, 7100, 7200, 7400VPN Series Routers
  

- **Cisco Telephony Products**
  

- **Cisco Security Products**
  
  www.cisco.com/go/security
Cisco Cable Products


uBR9xx Cable Access Routers


DOCSIS Spec.’s

CableModem.org http://www.cablemodem.org/

CableLabs http://www.cablelabs.org/