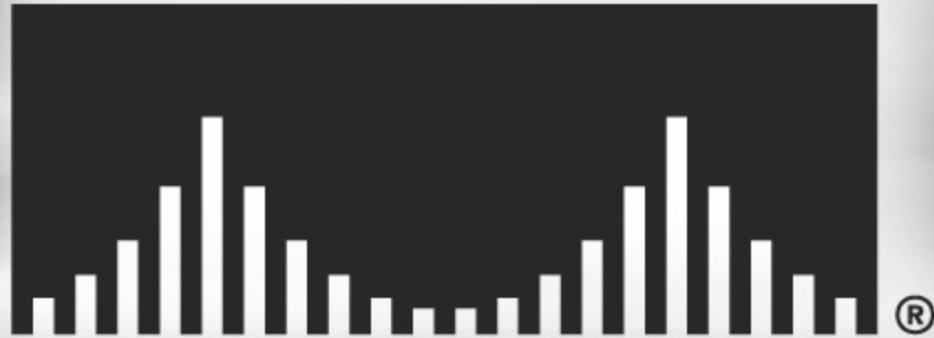


# CISCO SYSTEMS



# Cable-Based Network Solutions

**Patrick Toal**

**Systems Engineer**

**Cisco Systems**

# Cable-Based Network Solutions

Cisco.com

## Agenda

- **Introduction to Cable Networks**
- **Cable Modem Technology**
- **Services**
- **Q&A**

# Introduction to Cable Networks

Cisco.com

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



# The Electromagnetic Spectrum

Cisco.com

## 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

Cisco.com

## Frequency

- The number of wave crests that occur in a time period
- Cycles per second = Hertz (Hz)

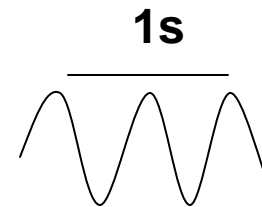
1,000 Hz = 1 kHz

1,000,000 Hz = 1 MHz

1,000,000,000 Hz = 1 GHz



1 cycle / second = 1Hz



2 cycles / second = 2Hz

# The Electromagnetic Spectrum

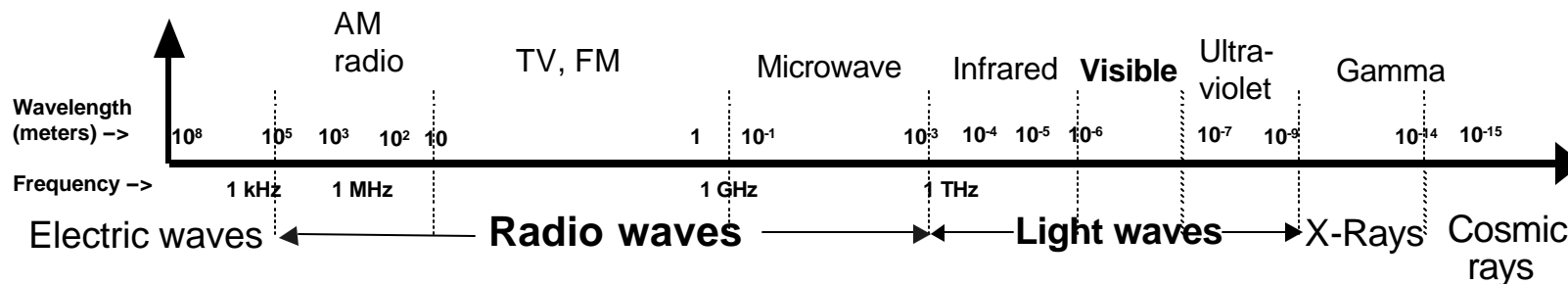
Cisco.com

## 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 =~  $4.6 \times 10^{14}$  Hz**
- **X-Ray =~  $3 \times 10^{19}$**

# The Electromagnetic Spectrum

Cisco.com



- **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 width of the frequency band used.
- RF Bandwidth does not always translate into Bit Rate

The bandwidth used by an analog telephone line is ~3000 Hz

The bandwidth used by an FM radio station is ~200 kHz

The bandwidth used by a Television Channel is ~6 MHz

# Cable-Based Network Solutions

Cisco.com

## 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.**

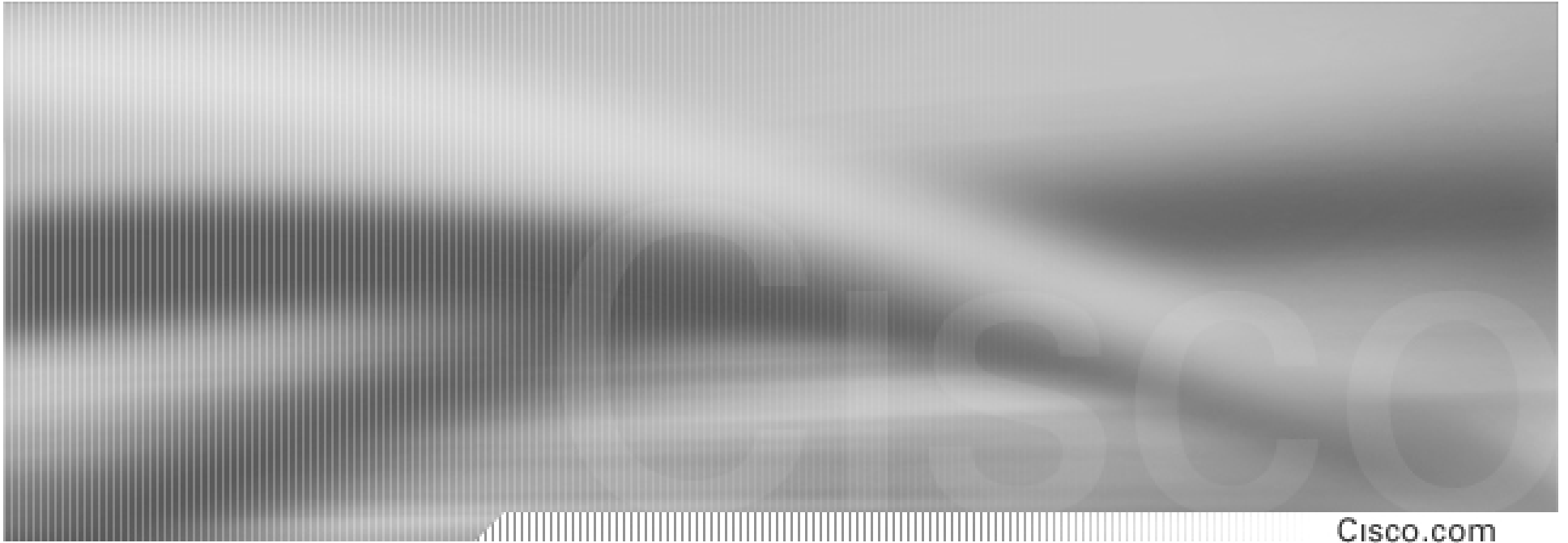


# Cable Network Architecture

## Symmetry

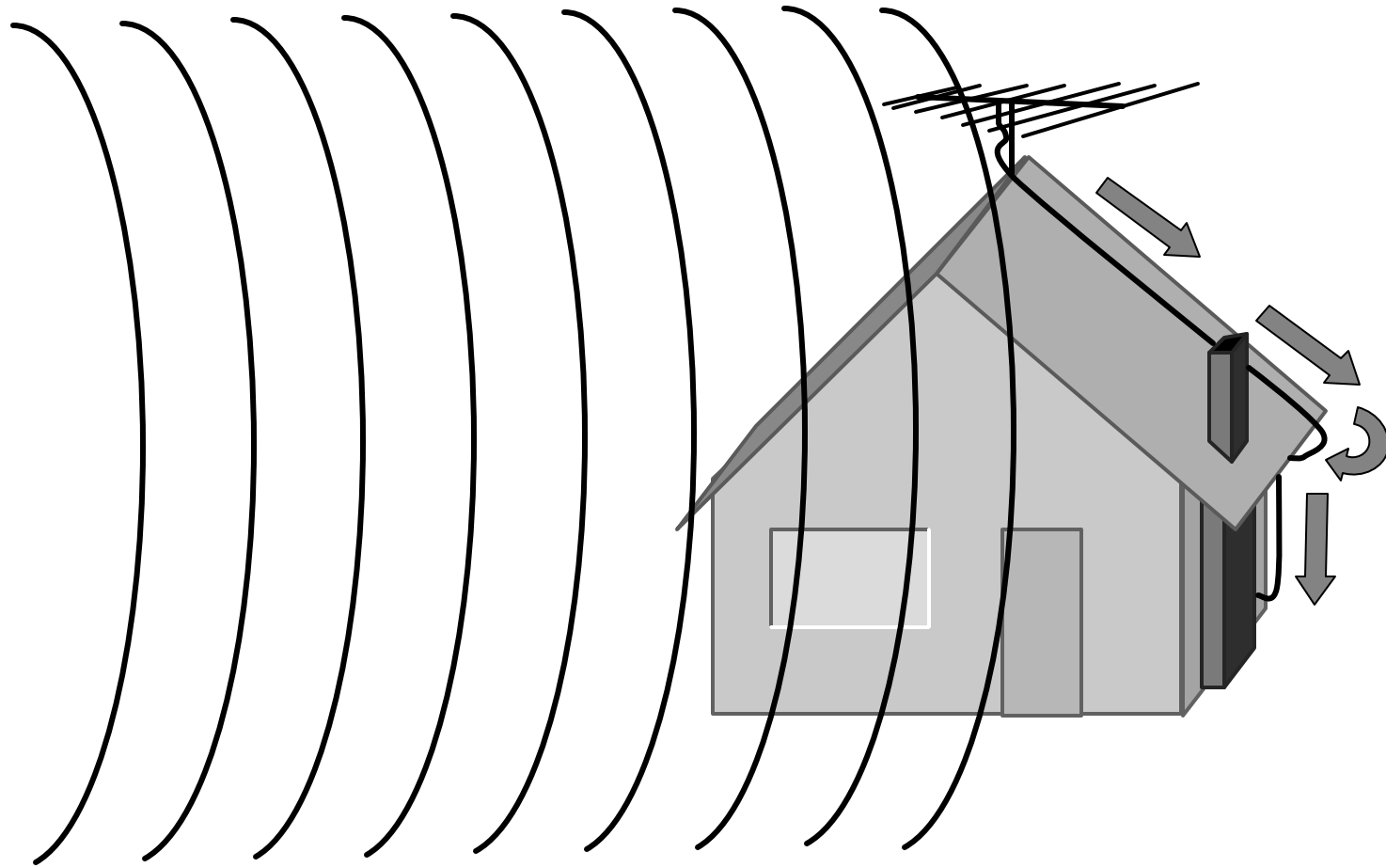
- **Cable Networks are asymmetric.**
- **The available frequency range is un-equally split between “Downstream” (to the subscriber), and “Upstream”**
- **Frequencies from 54MHz to 850Mhz are used for downstream information. (~125 TV Channels)**
- **Frequencies from 5MHz to 45Mhz are used for upstream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





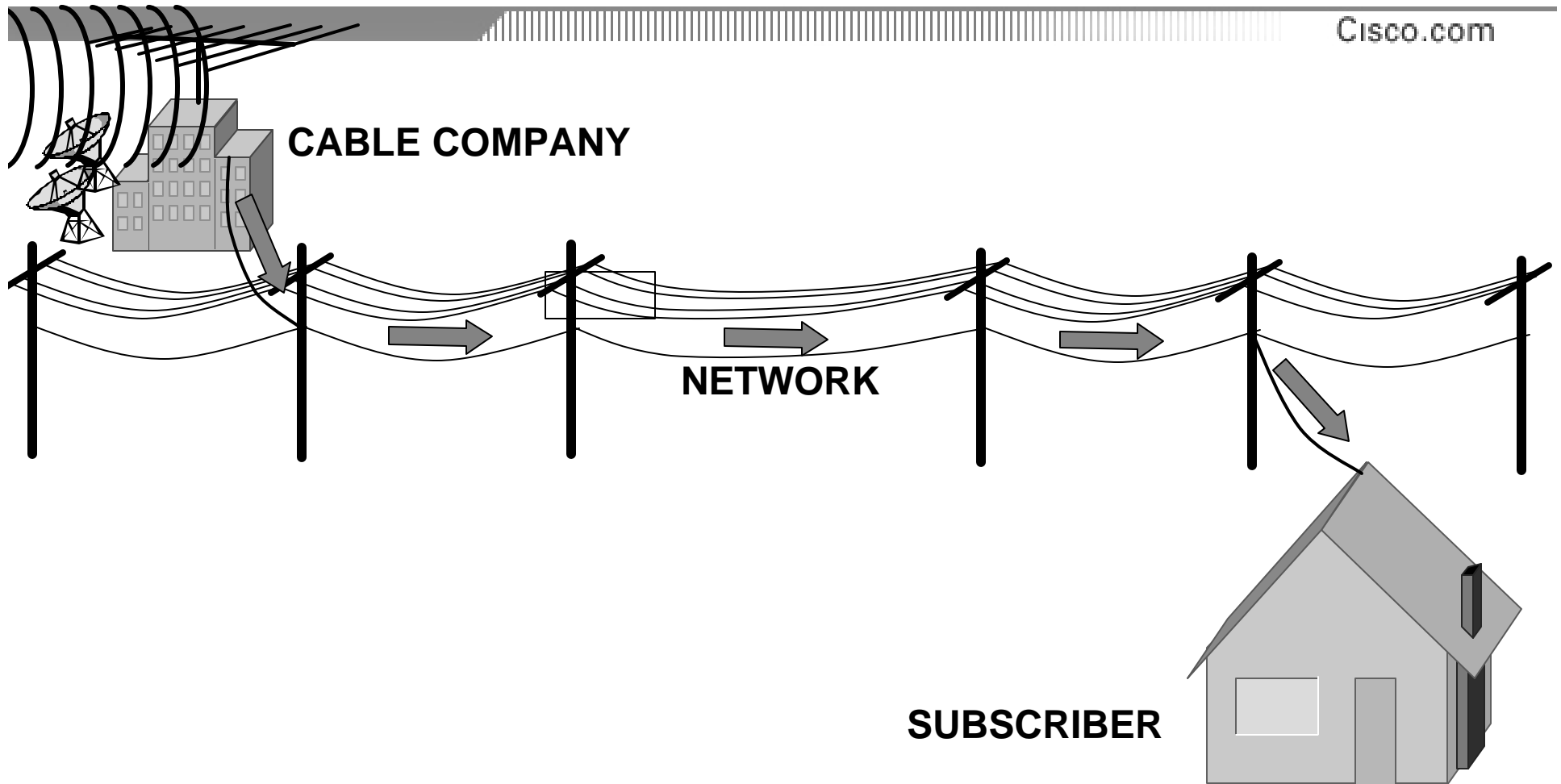
# Cable Network Architecture

# Cable Network Architecture



# Cable Network Architecture

Cisco.com



# Cable Network Architecture

- **Major components of a typical cable network:**

**Antenna site**

**Transportation network**

**Headend**

**Distribution network**

**Subscriber drop**

# Cable Network Architecture

- **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

Cisco.com



# 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...

Cisco.com





# 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...

Cisco.com



# Cable Network Architecture

- **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:**

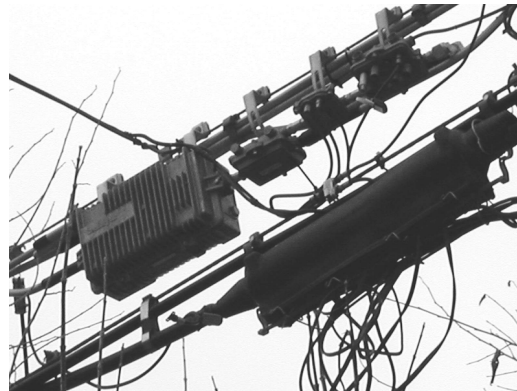
**In a hybrid fiber/coax (HFC) architecture, optical fiber replaces some or all of the traditional trunk portion of the distribution network.**

**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**



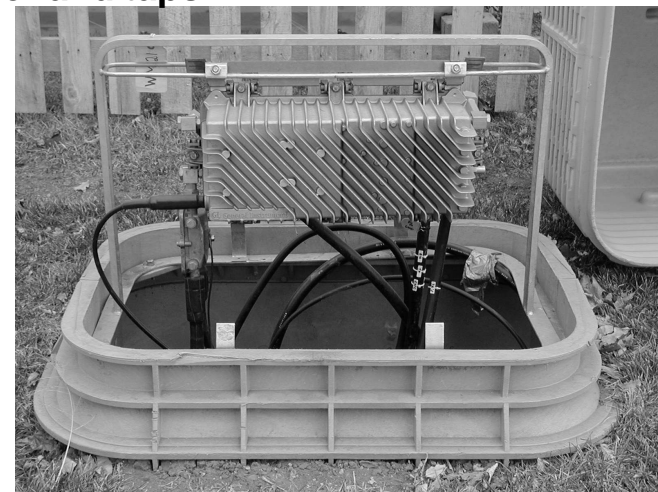
**Line extender amplifier,  
directional coupler and taps**



**Standby (battery backup)  
line power supply**



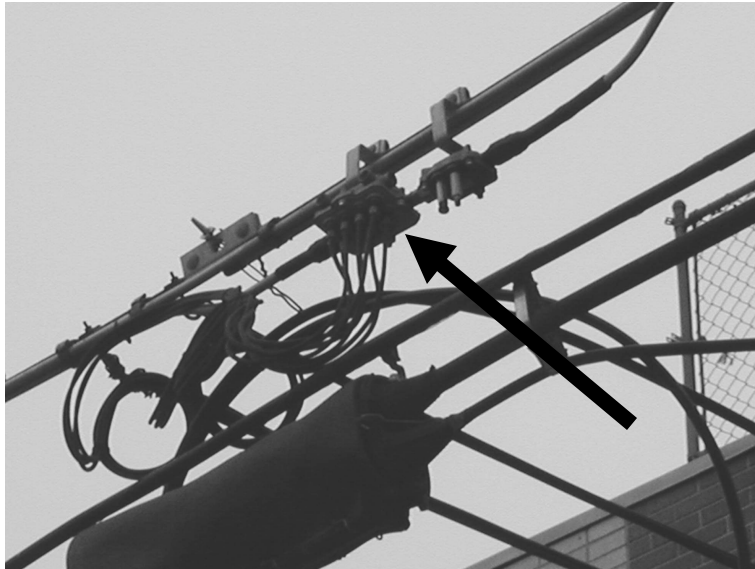
**Underground pedestal**



**Optical fiber node**

# Subscriber drop from tap to TV set

Cisco.com



**Subscriber drops connected to feeder tap**

**Set top box on top of subscriber's TV set**

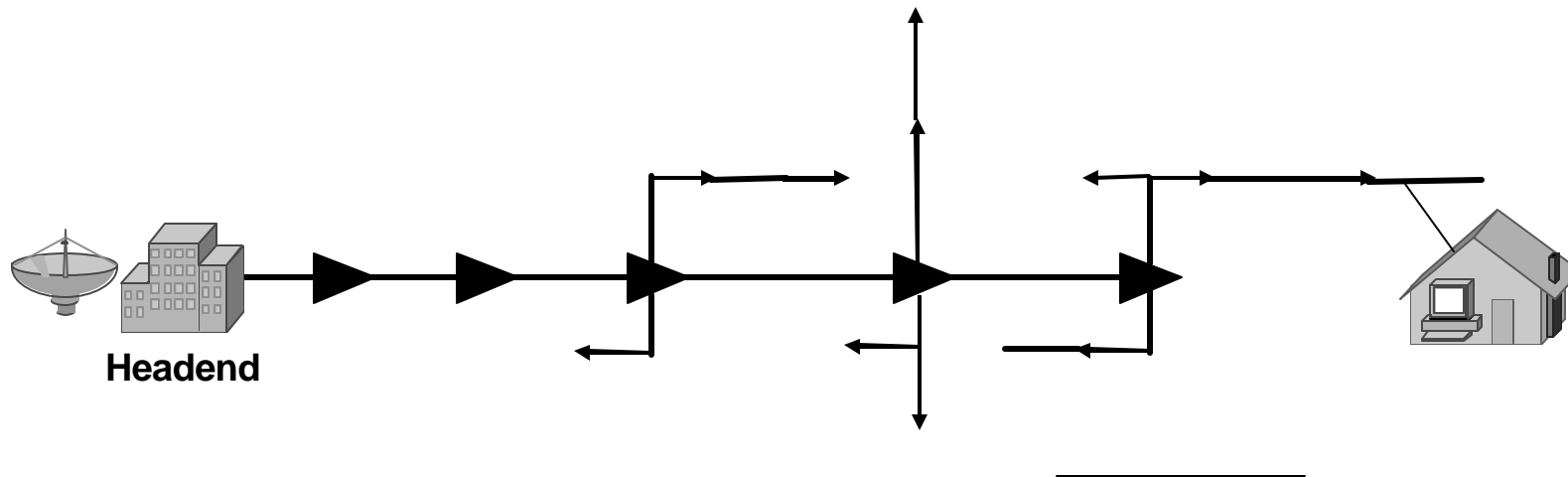


# Cable Network Architecture

Cisco.com

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

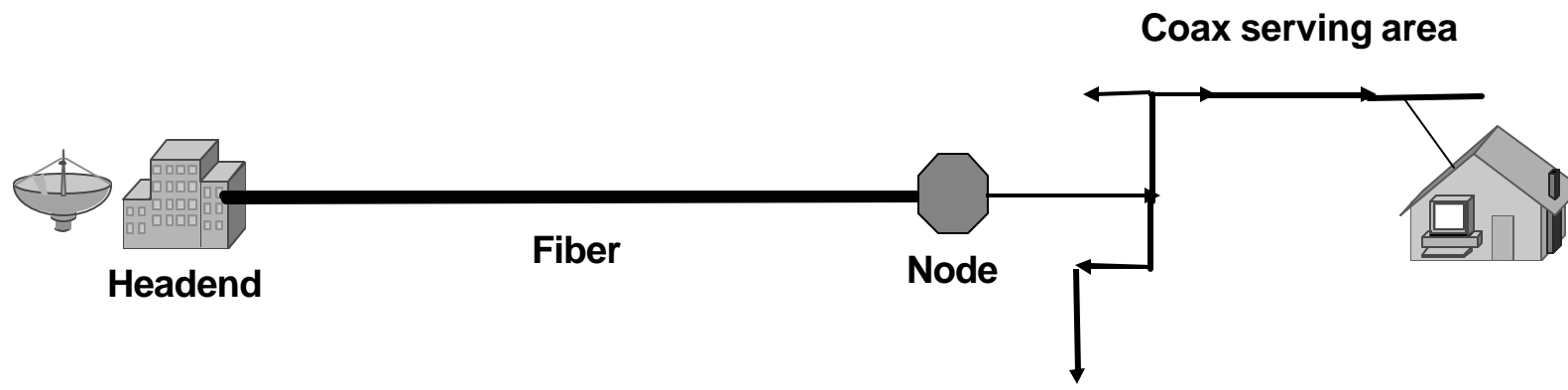
# Tree-and-branch architecture



- **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

Cisco.com

## 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.**

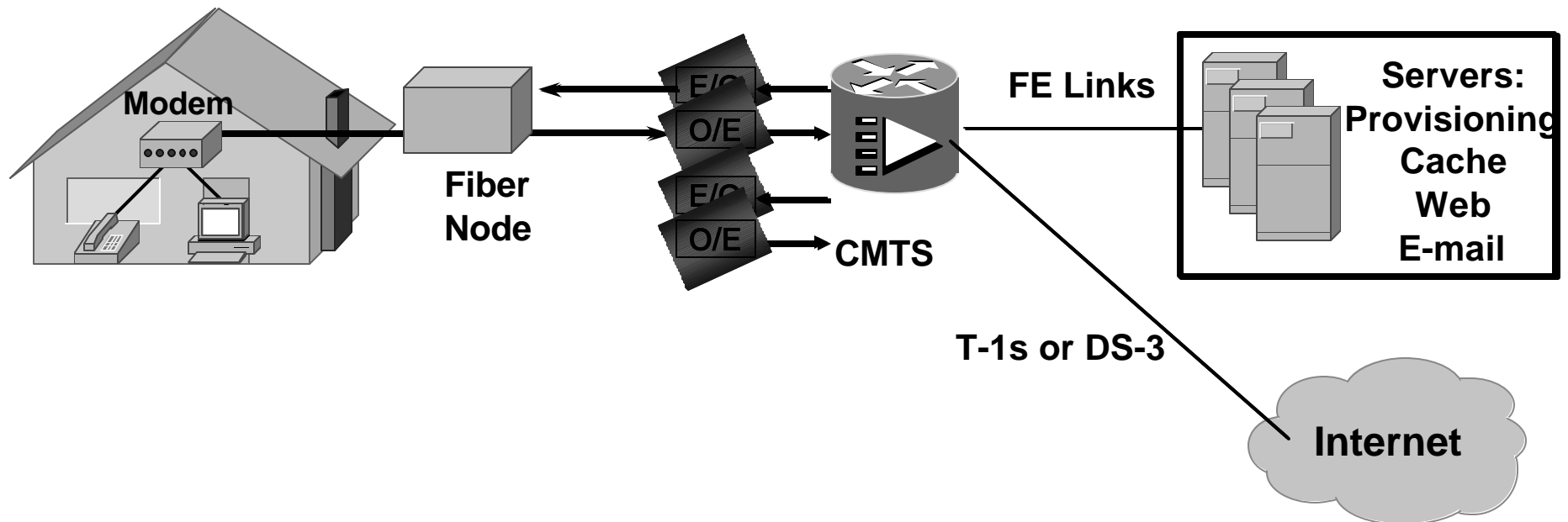
# Overview of DOCSIS

## 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

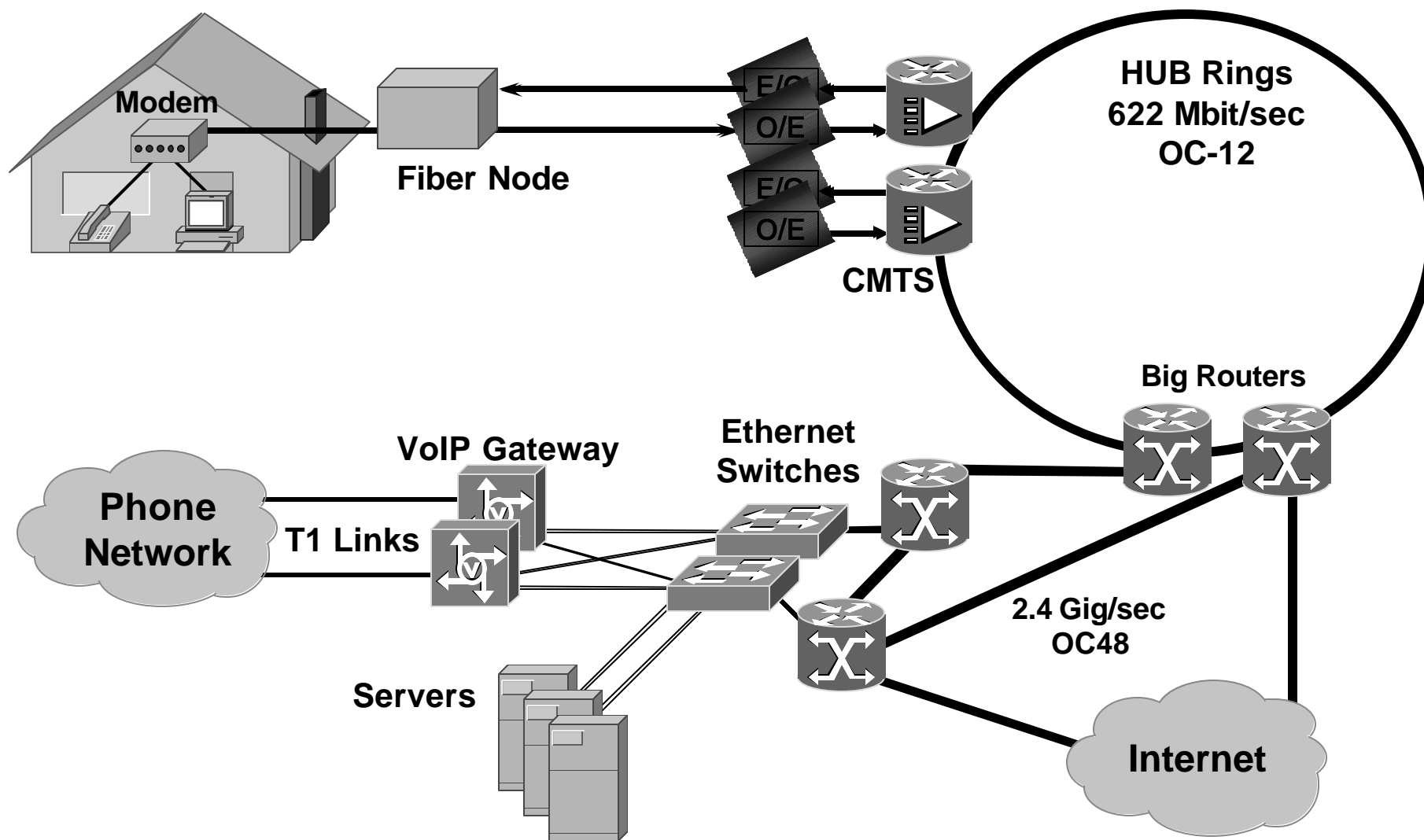
Cisco.com



- 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

Cisco.com



# DOCSIS Security

Cisco.com

## 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

Cisco.com

## 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

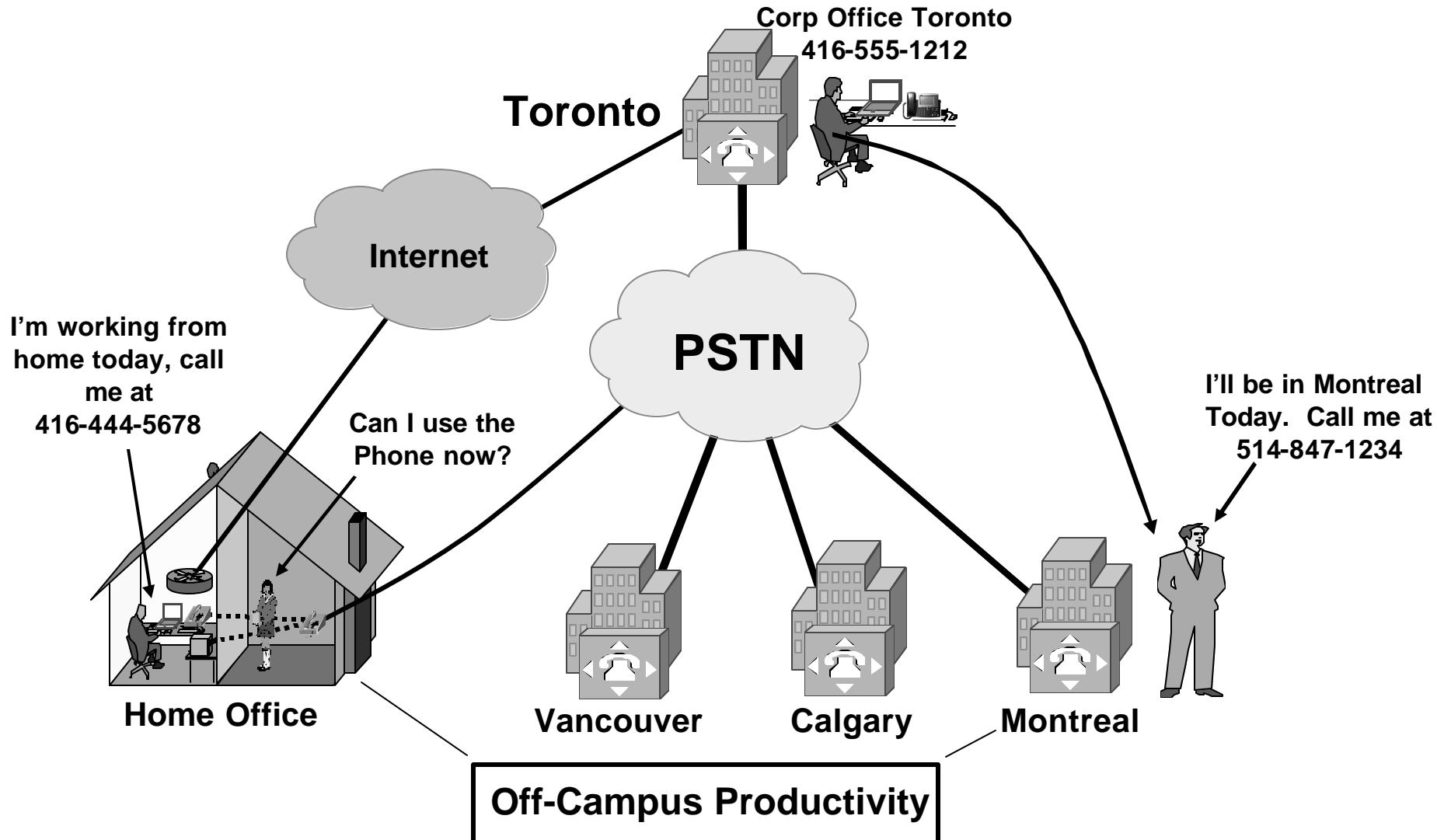
Cisco.com

## Agenda

- **Introduction to Cable Networks**
- **Cable Modem Technology**
- **Services**
  - Internet
  - VPN
  - Future
- **Q&A**

# Enterprise Productivity Challenges

Cisco.com



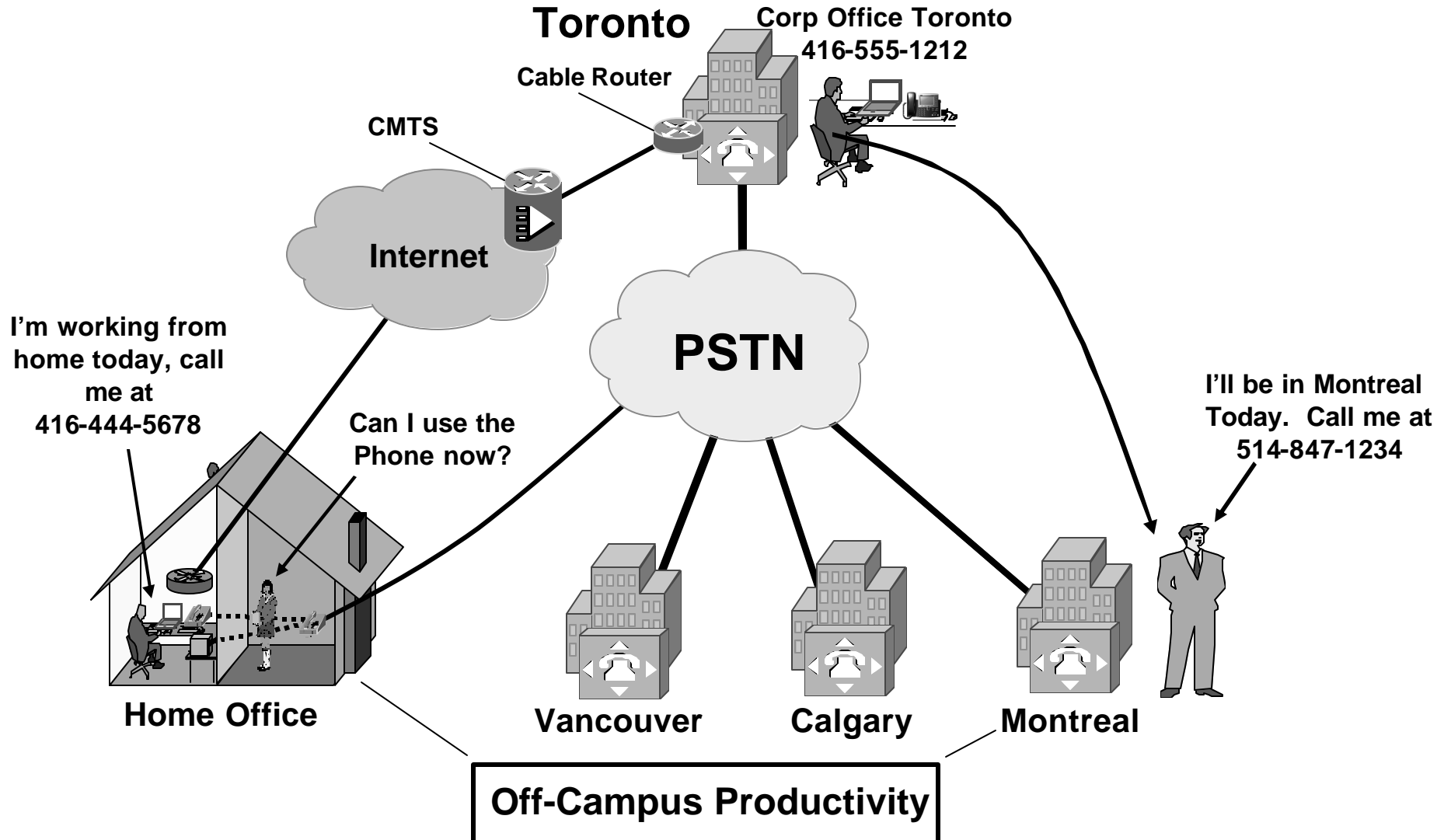
# Cable Modem Services

Cisco.com

## 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



# Cable Modem Services

## VPN Technologies

Cisco.com

### 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

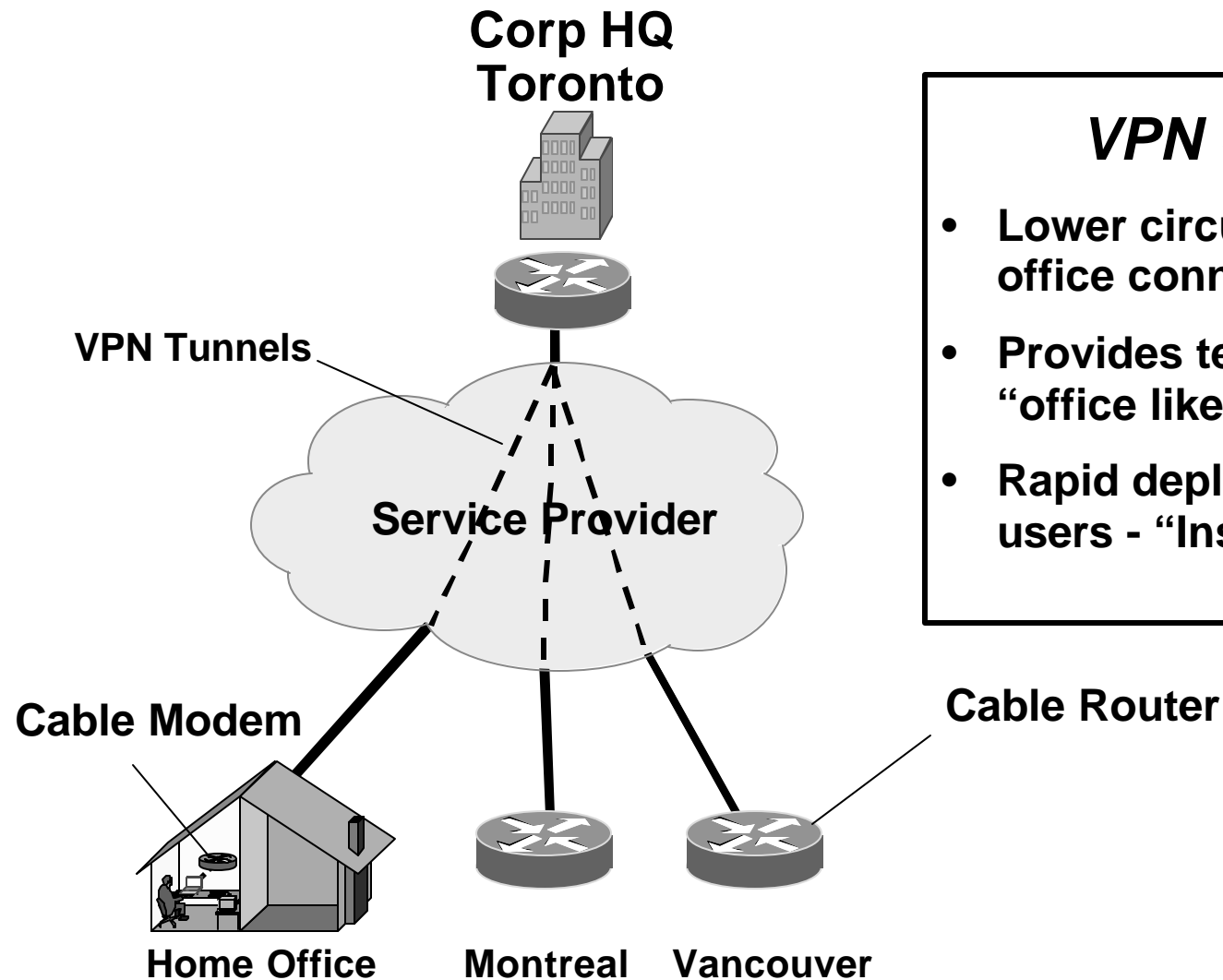
Cisco.com

### 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

Cisco.com



## *VPN Solutions*

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



# Future Services

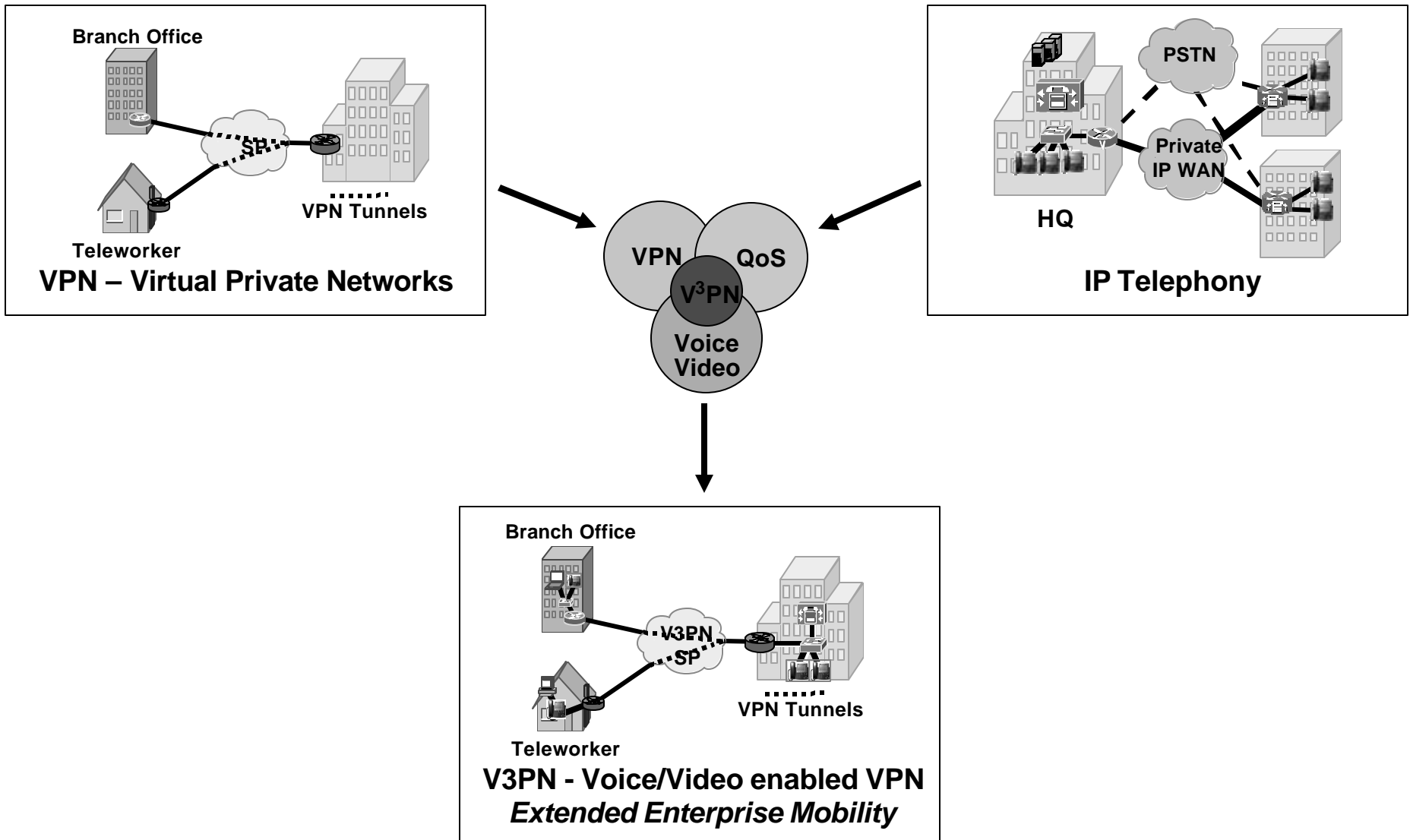
Cisco.com

## V3PN

- **Voice and Video enabled VPN's**
- **Requires QoS and SLA Guarantees in the Service Provider Core**

# Voice and Video Enabled VPN – V<sup>3</sup>PN

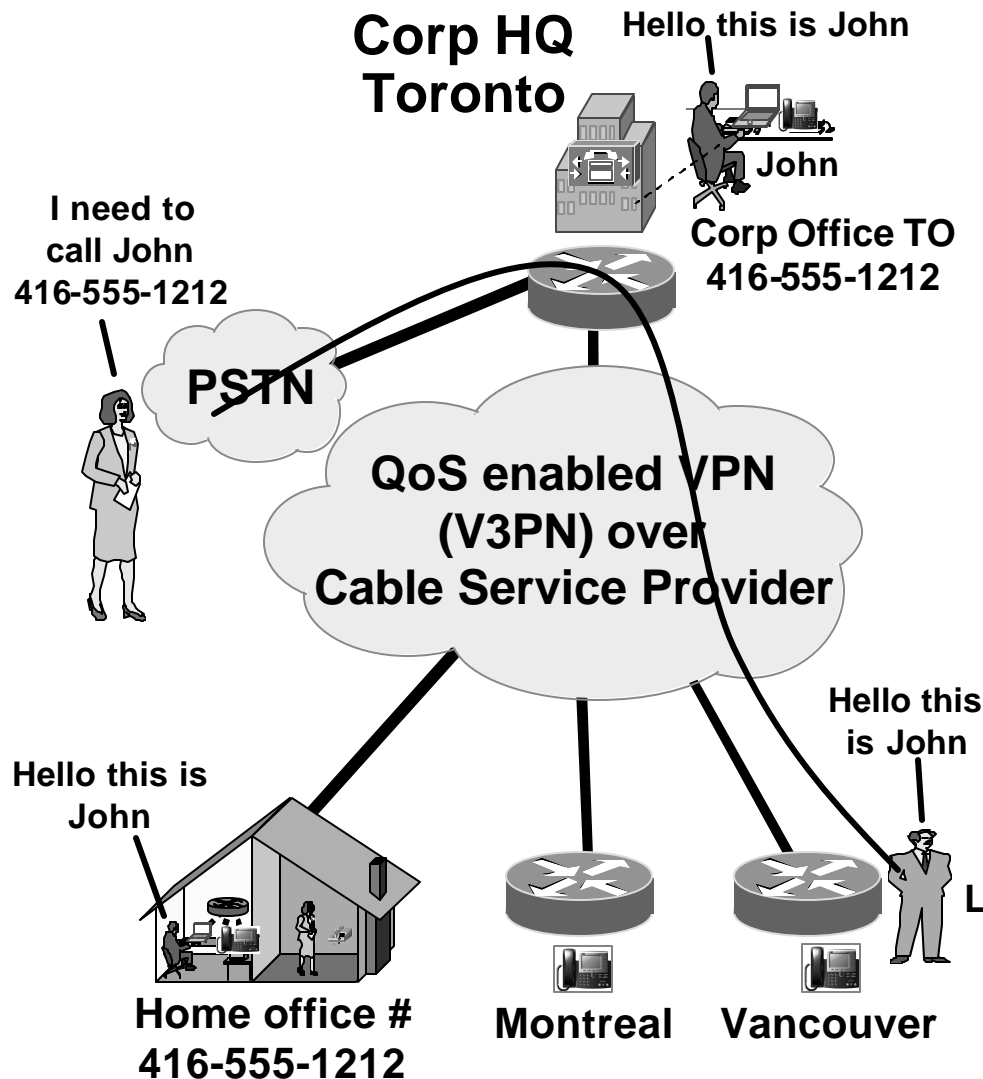
Cisco.com



# IP Telephony and VPN

## Voice and Video Enabled VPN – V<sup>3</sup>PN

Cisco.com



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

### V3PN Solutions

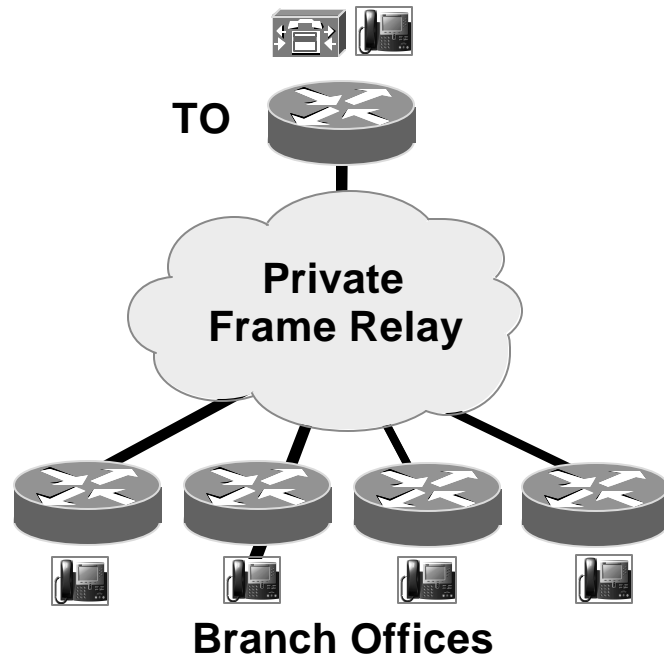
- Lowers costs and increases teleworker productivity
- Cisco Powered Network (CPN) Service Provider partners carry voice/video with toll quality SLA's
- Same network connectivity at home as in corp office (voice, video and data)

# Enterprise Benefits of V<sup>3</sup>PN

## Lower Cost to Network Branch Offices

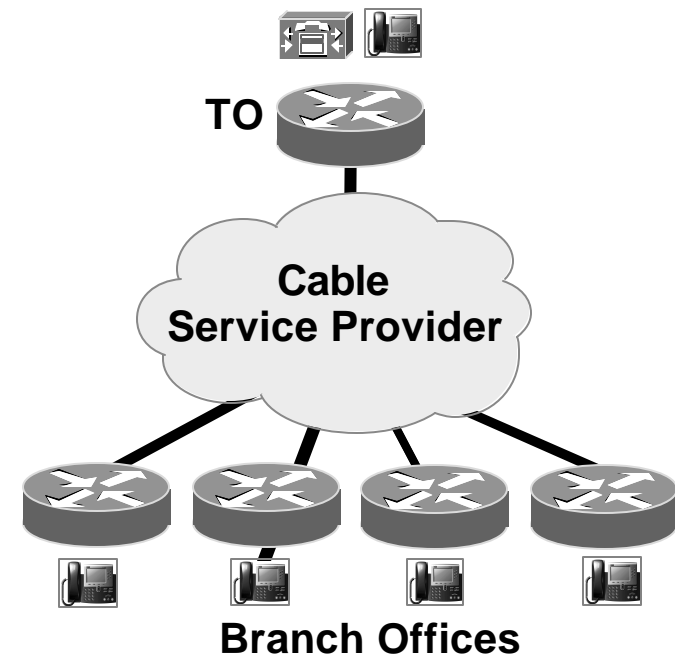
Cisco.com

### Before: Private Frame Relay



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

### After: Voice and Video enabled VPN

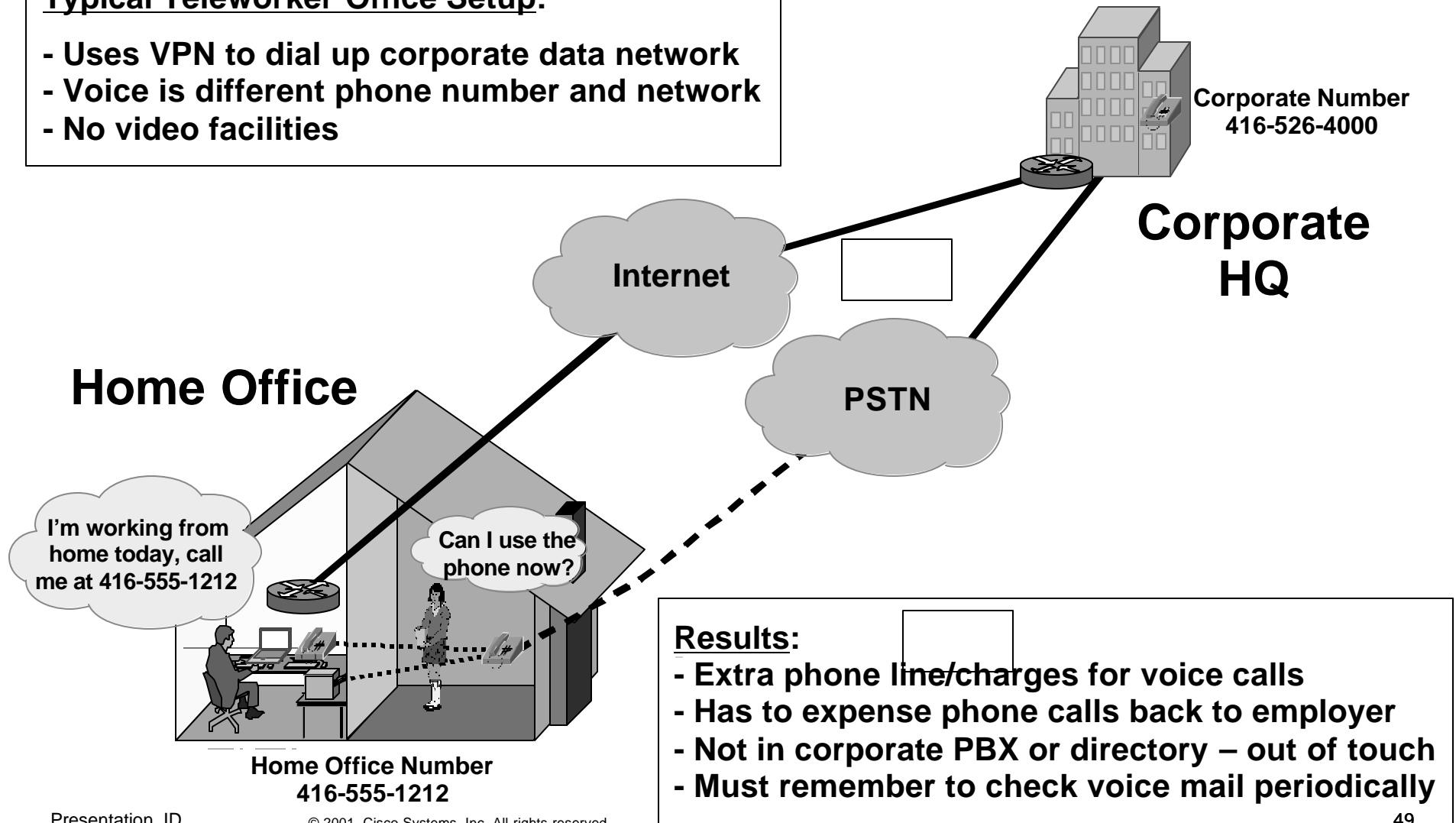


- 23 sites – \$24k per month
- T1 access for branches
- 2 week installation time

# 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

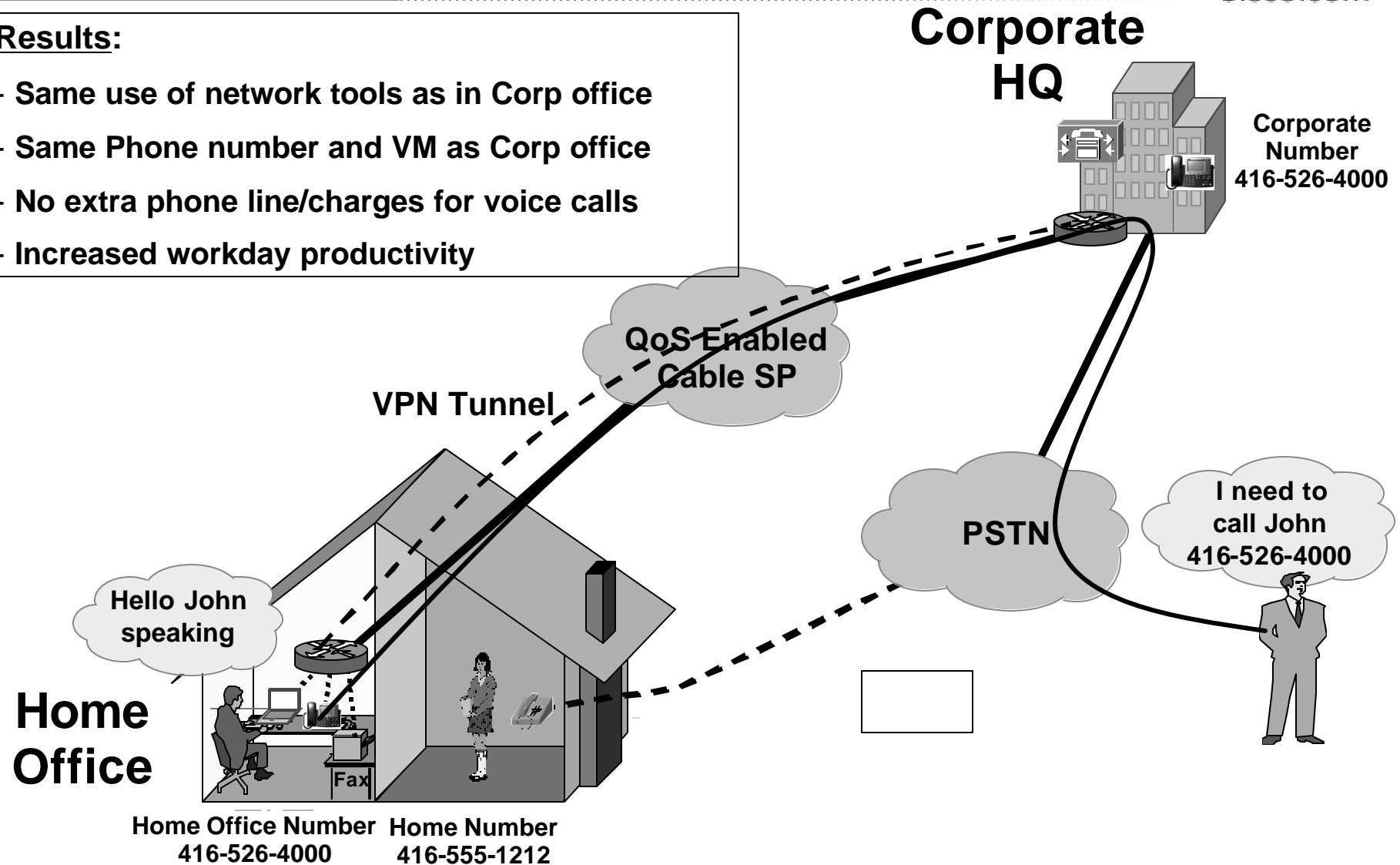
# Teleworker Example

## Tomorrow – IP Telephony Enabled Teleworker

Cisco.com

### 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

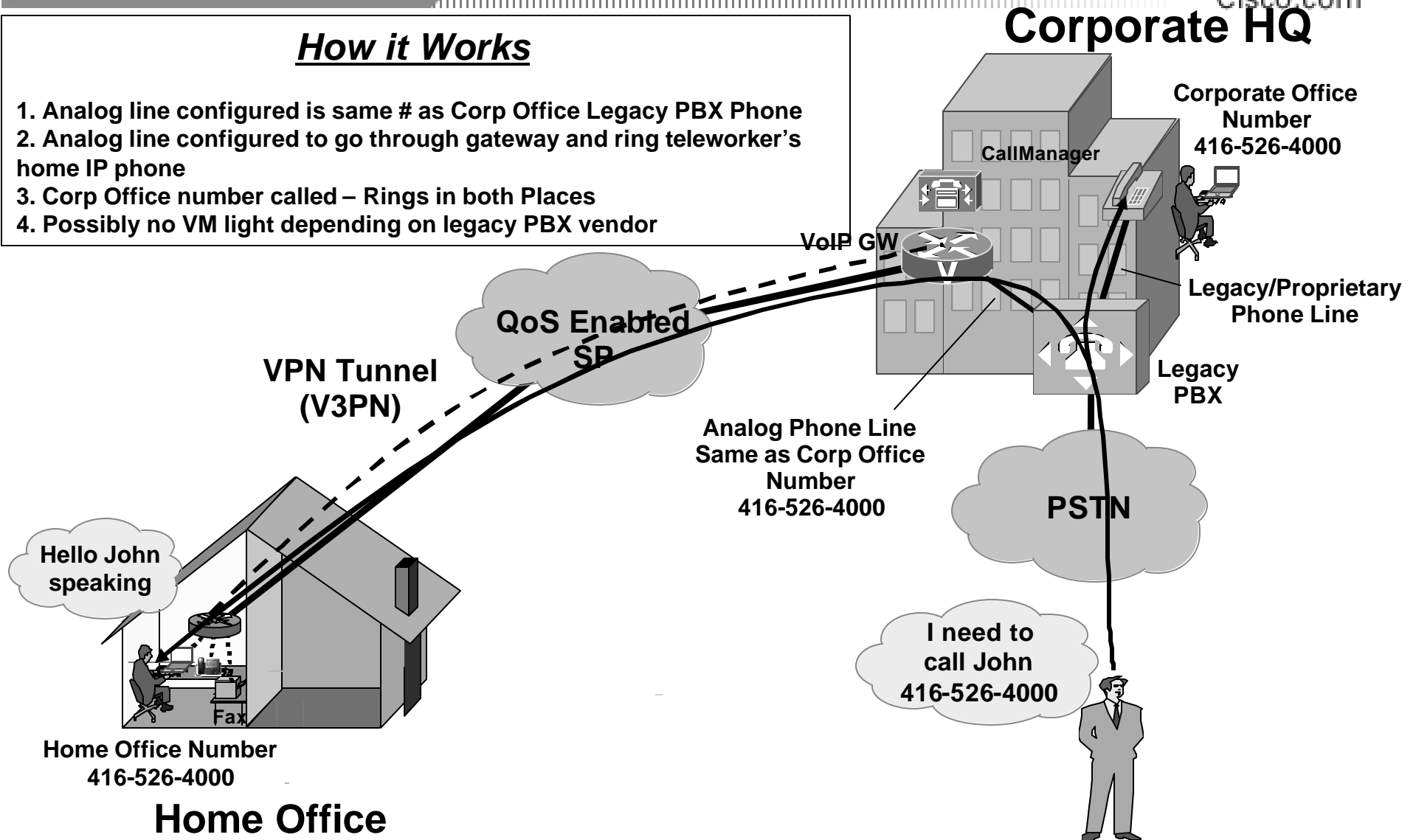


# IP Telephony for Teleworker For Legacy PBX Environments

Cisco.com

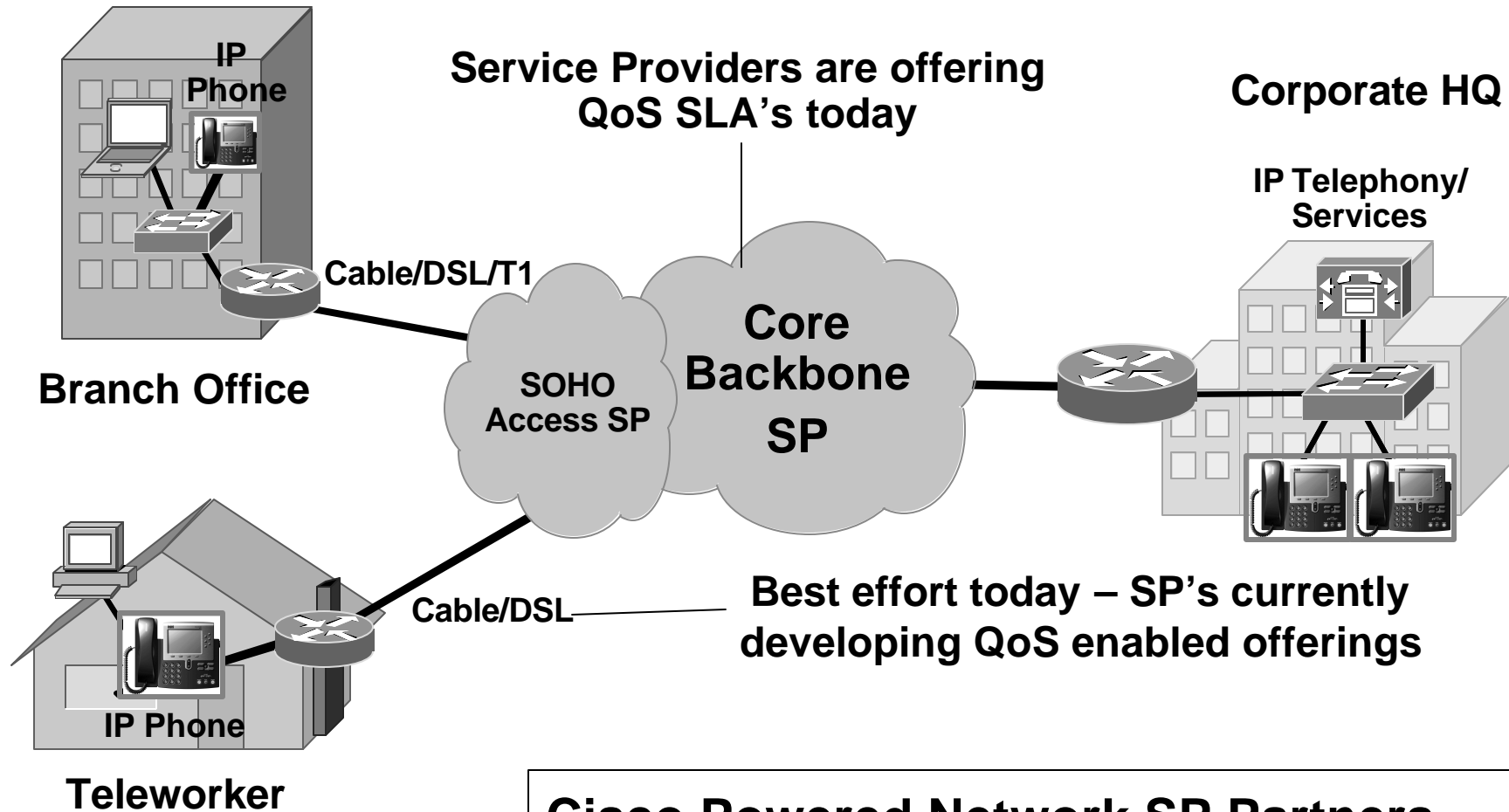
## How it Works

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



# V<sup>3</sup>PN (VoIP/Video Enabled IPsec VPN) Enterprises Requiring SP QoS

Cisco.com



**Cisco Powered Network SP Partners**

[http://www.cisco.com/cgi-bin/cpn/cpn\\_pub\\_bassrch.pl](http://www.cisco.com/cgi-bin/cpn/cpn_pub_bassrch.pl)



# ***Gartner Group Research Results***

## **Facts on Companies that have Installed VPNs**

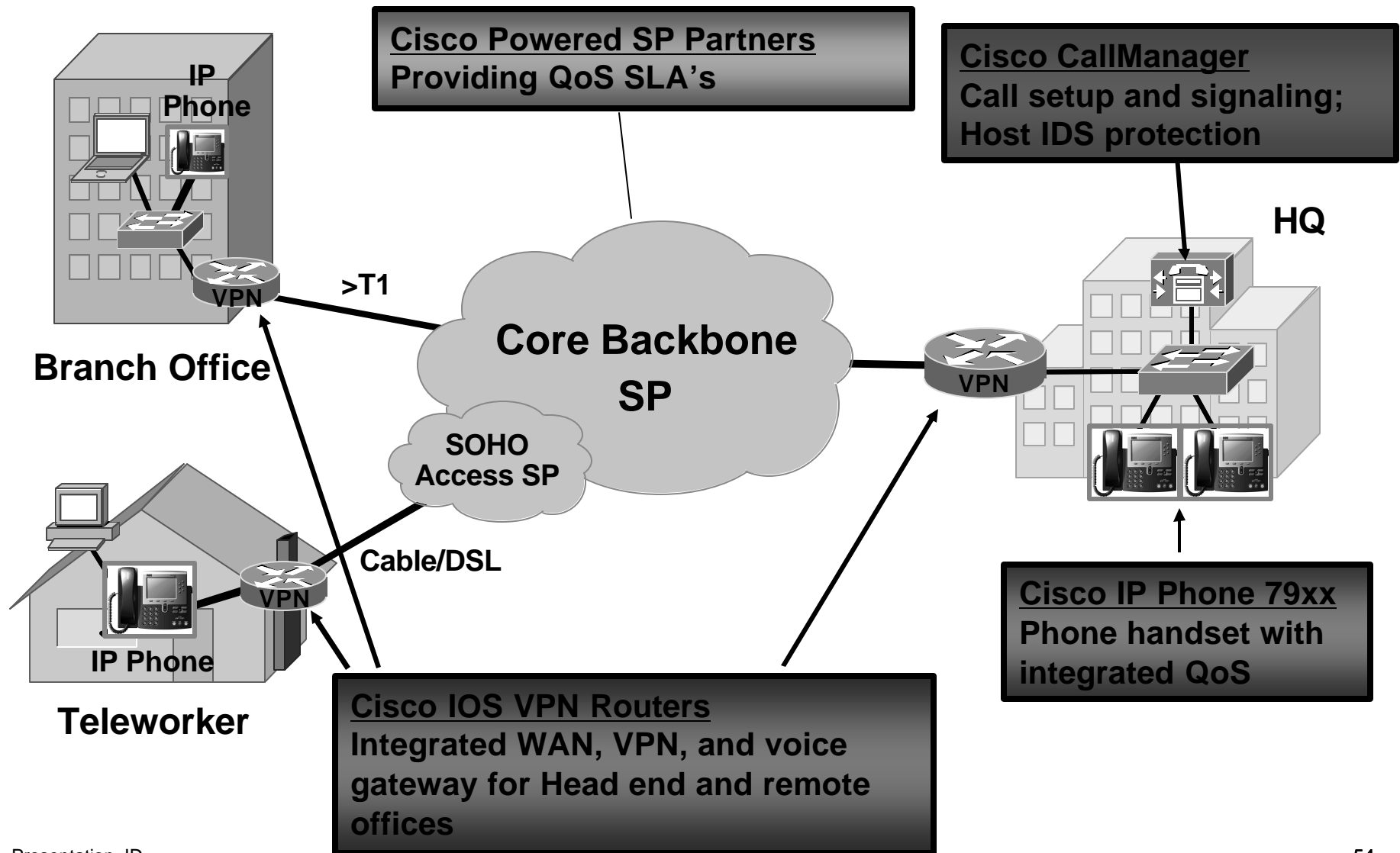
Cisco.com

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

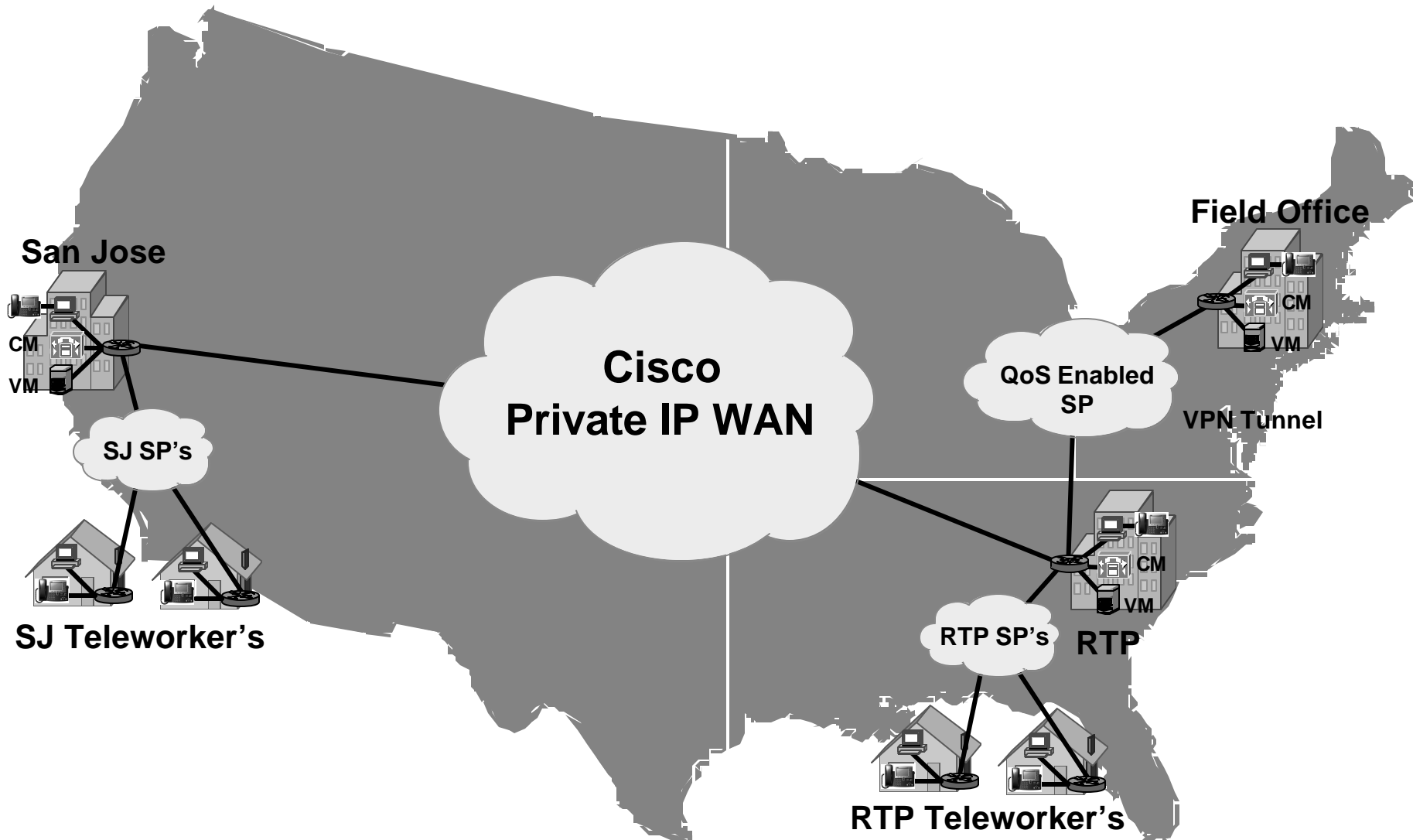
- **85% report higher levels of network security and faster connectivity**
- **The average ROI is 54% over an 18 month period**
- **Almost 90% report experiencing cost-savings over their previous solution**
- **Three hours saved per employee per week**
- **70%+ using VPN extranets site improved communications 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<sup>3</sup>PN Network Solution

Cisco.com

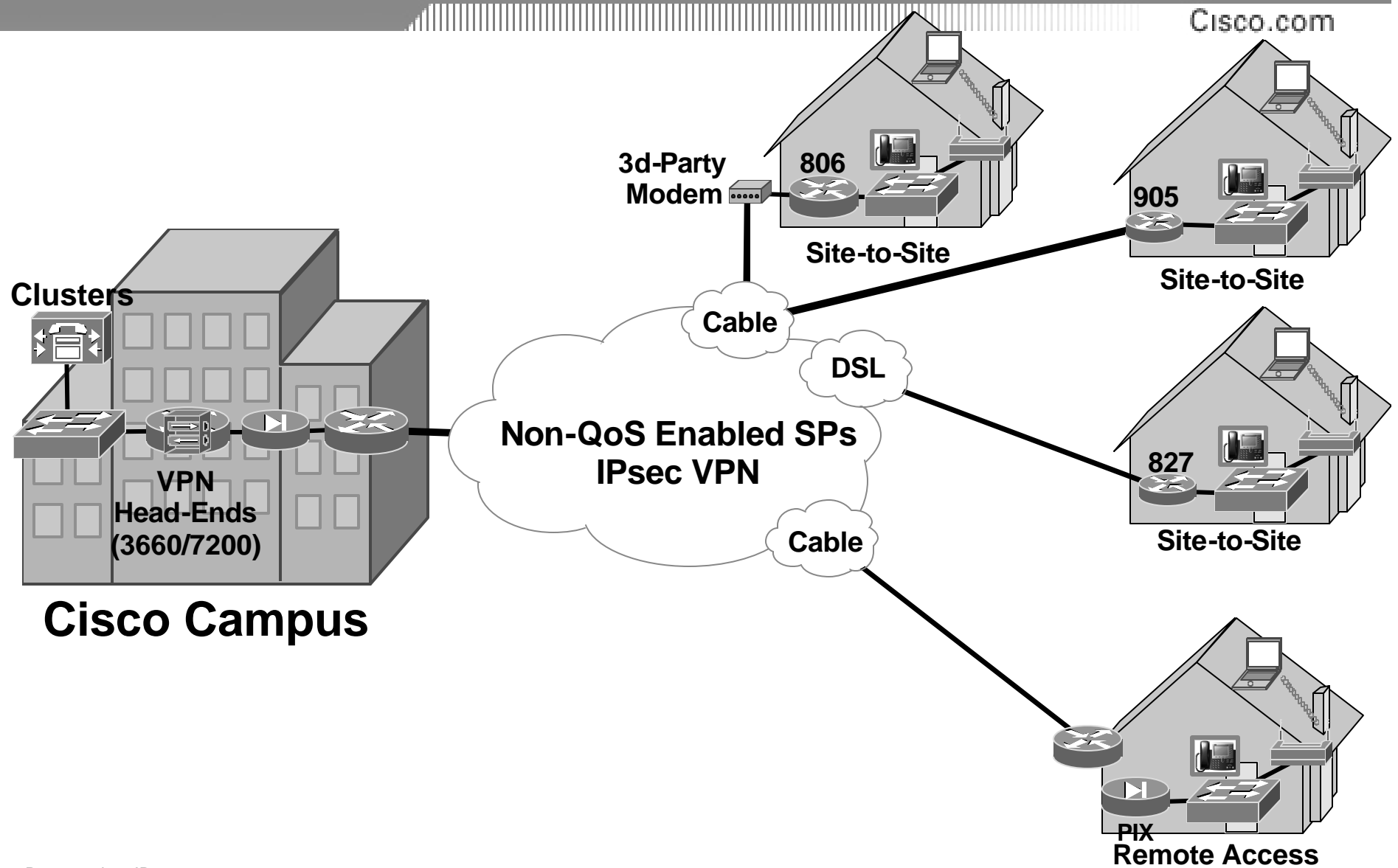


# Cisco Internal V<sup>3</sup>PN Deployment



# Cisco Teleworkers

## Current Deployment Examples



# ***Cisco Internal Requirements***

Cisco.com

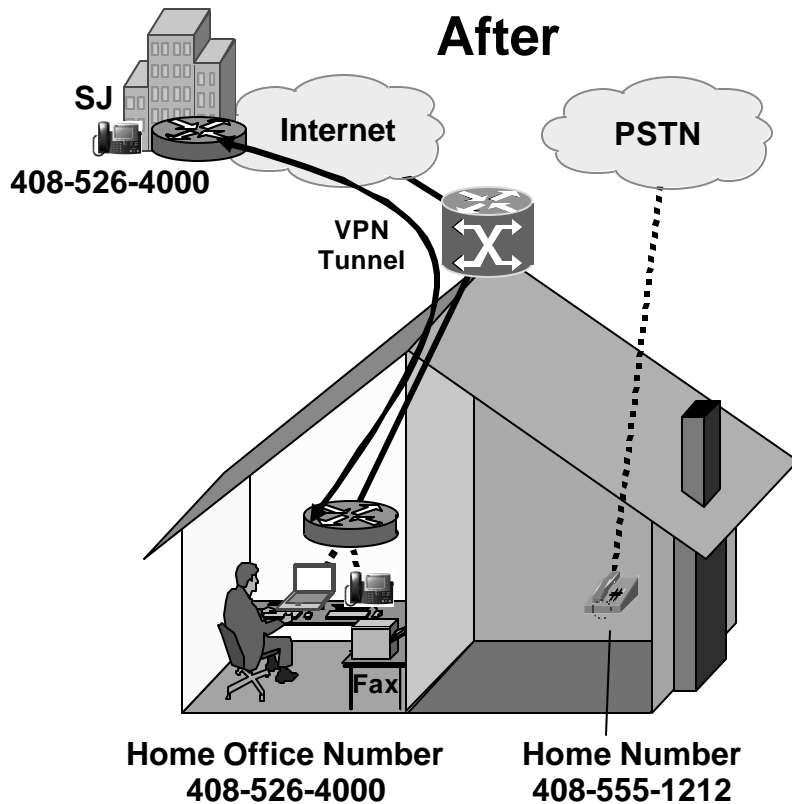
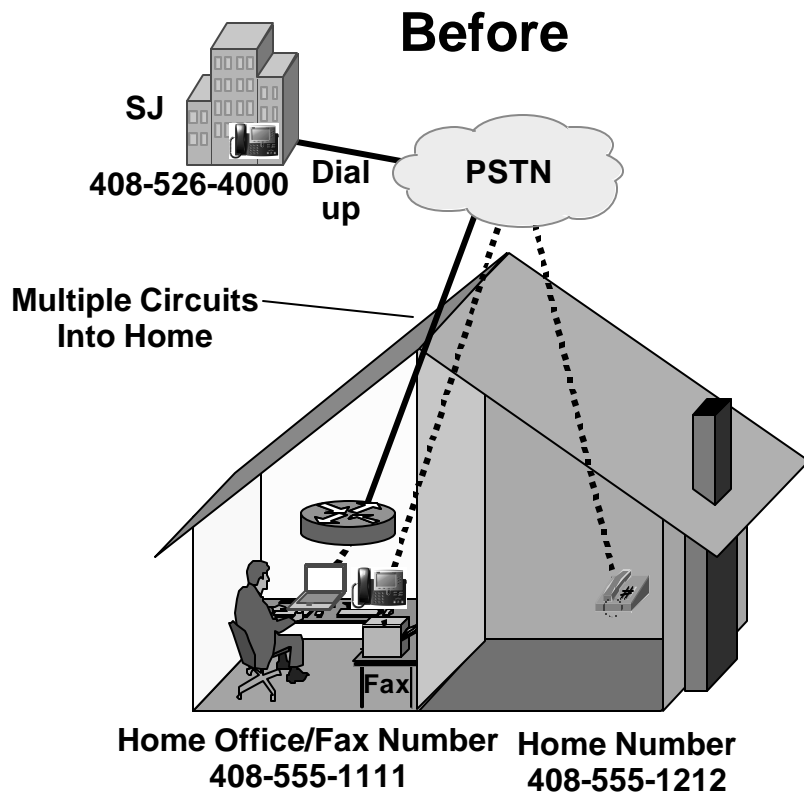
- **Many Teleworkers requiring same IP Telephony requirements as in Corp Office**

**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

Cisco.com



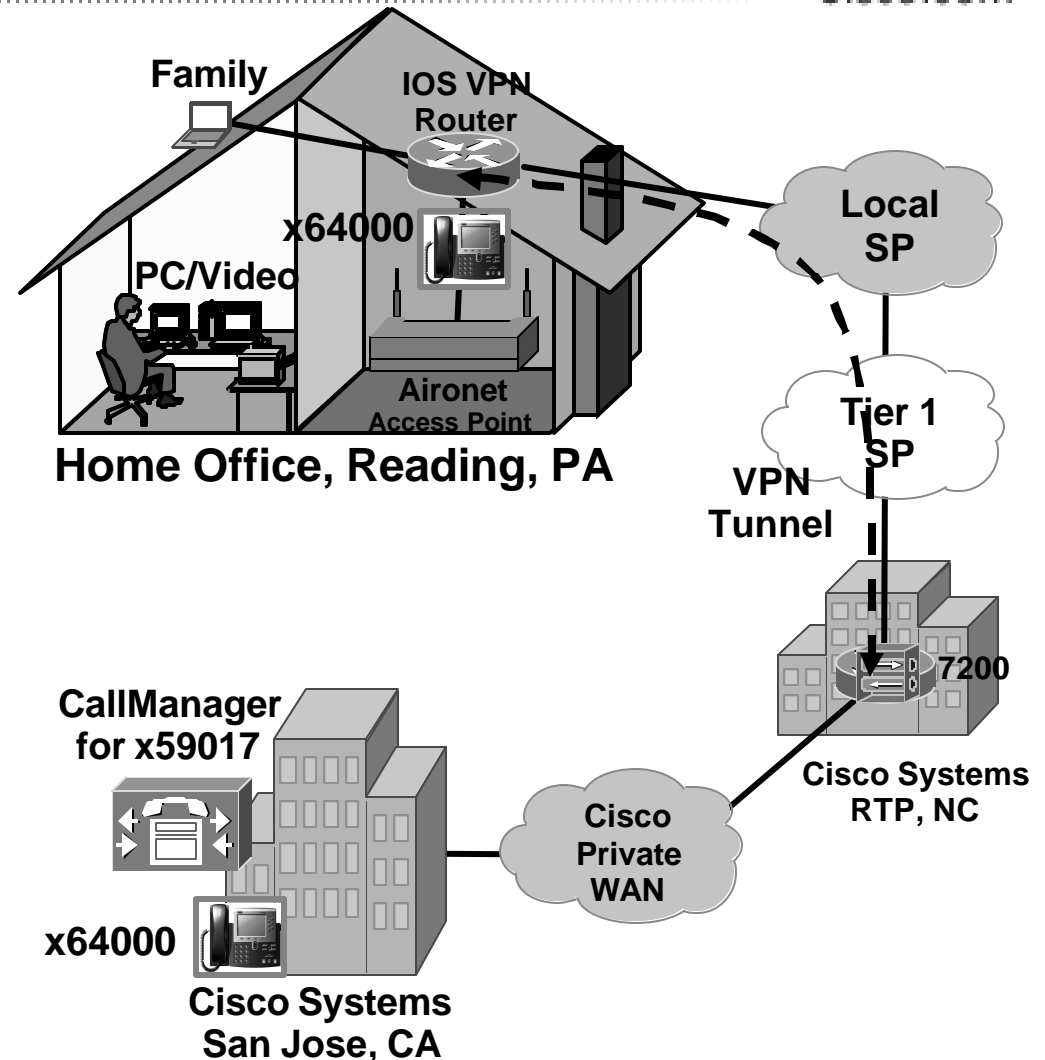
- Two PSTN Lines – Home + Work
- Work number different than Corp office
- Work number shared by Fax
- Expensed Work phone bill - \$200/month

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

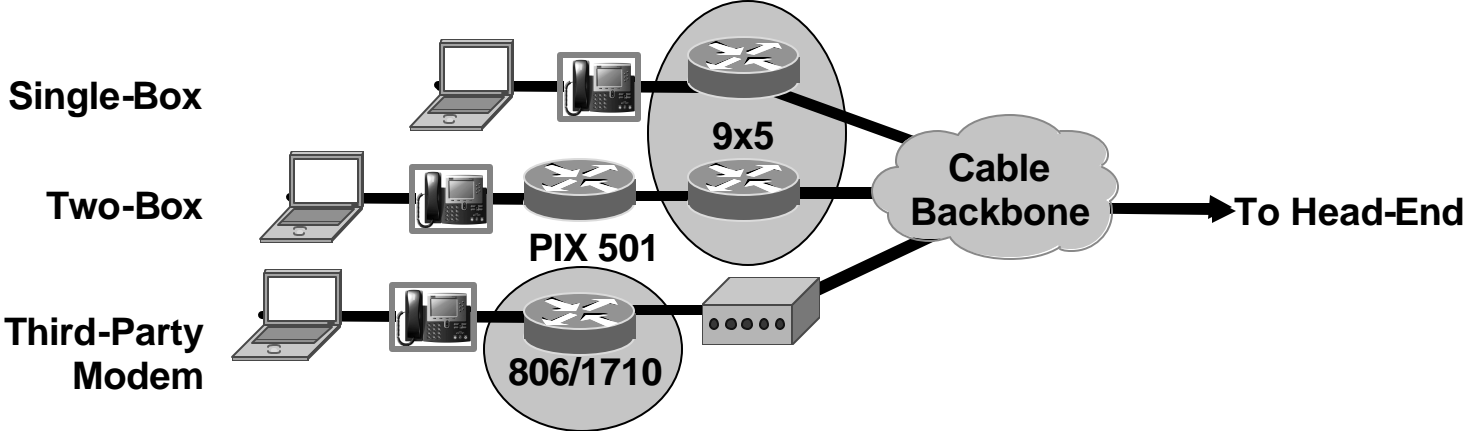
# A Cisco SOHO Site-to-Site VPN Site

Cisco.com

- 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”

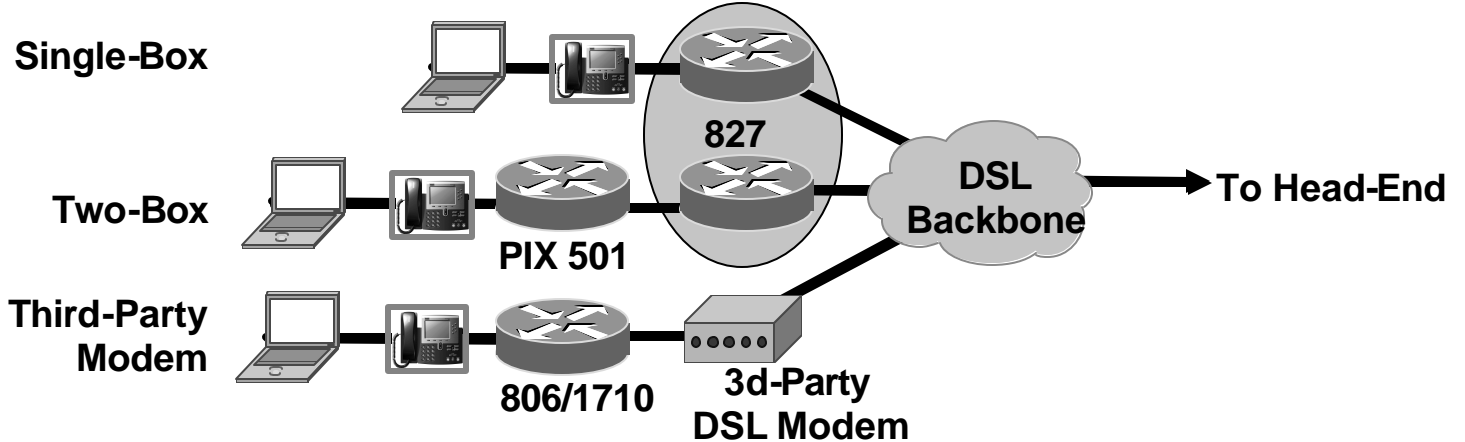


# Cisco Internal Deployment Models



## DSL

## Cable

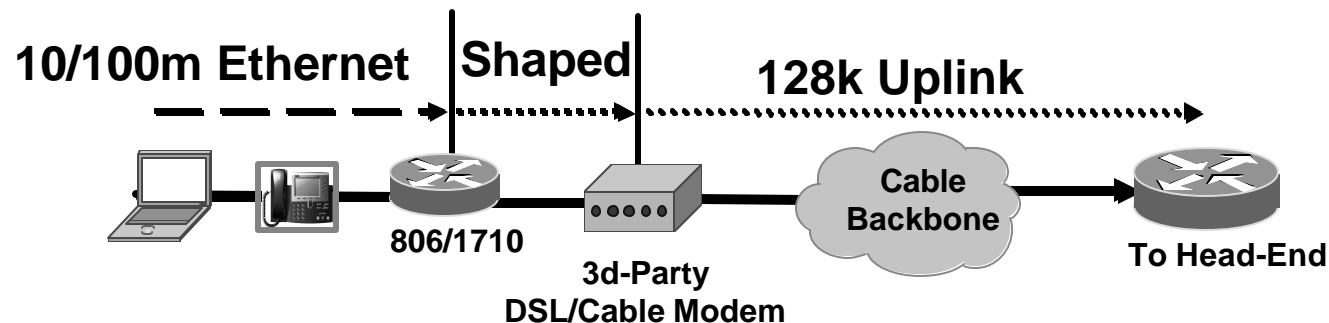




# 3<sup>rd</sup> Party Cable/DSL Modems

Cisco IOS VPN Router with Traffic Shaping Required

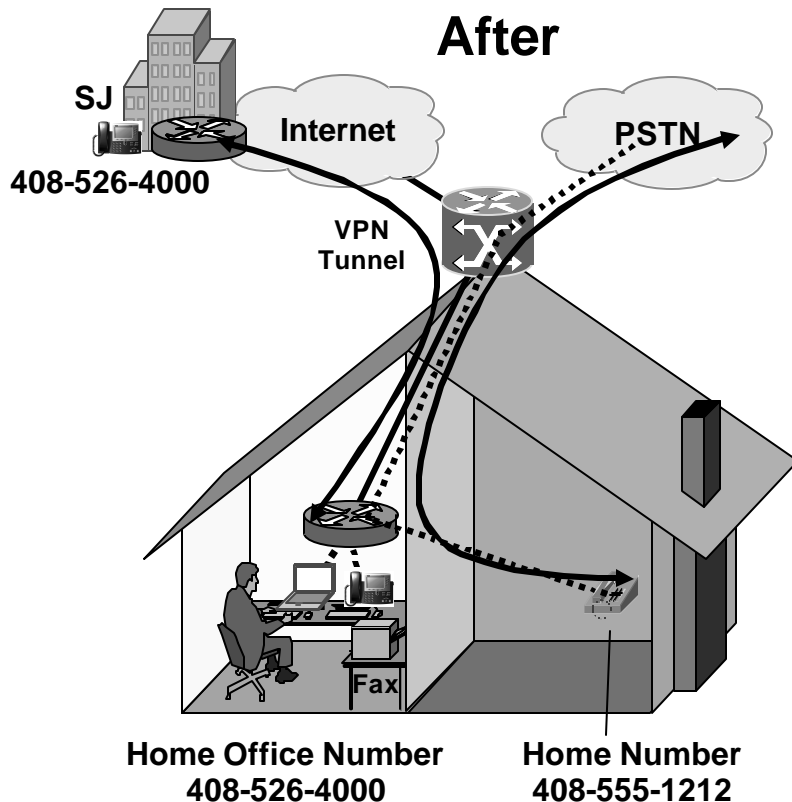
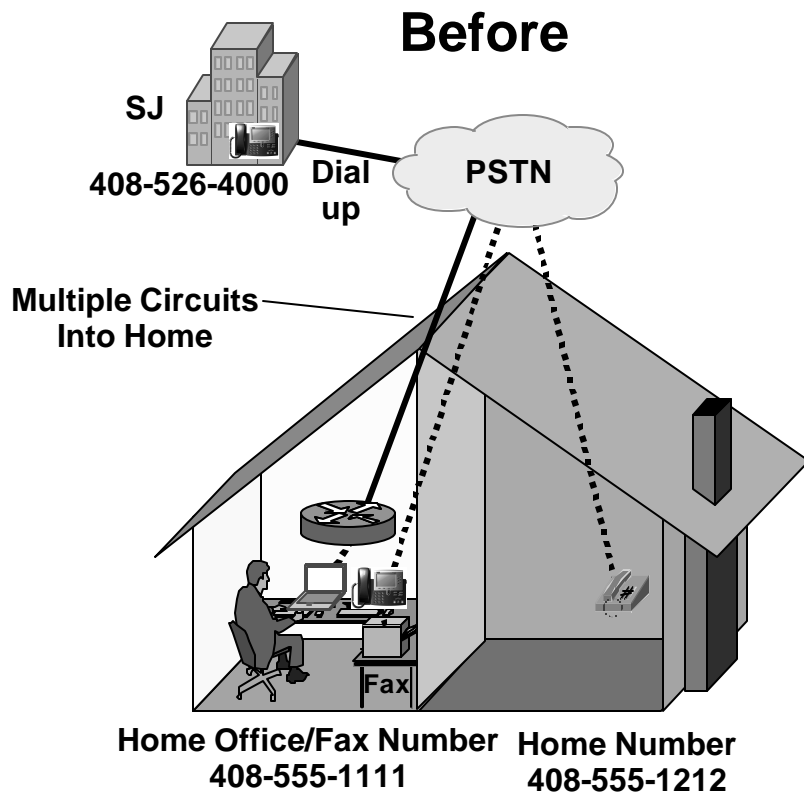
Cisco.com



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

# Cisco Internal Teleworker Deployments

Cisco.com



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

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

# ***Value of V<sup>3</sup>PN Solutions from Cisco***

## **Summary**

Cisco.com

### **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...*

Cisco.com

- **V<sup>3</sup>PN**

[www.cisco.com/go/v3pn](http://www.cisco.com/go/v3pn)

- **Cisco VPN Routers**

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

<http://www.cisco.com/warp/public/779/largeent/learn/technologies/vpn/site2site.html>

- **Cisco Telephony Products**

<http://www.cisco.com/warp/public/779/largeent/learn/technologies/voice.html>

- **Cisco Security Products**

[www.cisco.com/go/security](http://www.cisco.com/go/security)

# *...For More Information...*

Cisco.com

- **Cisco Cable Products**

<http://www.cisco.com/warp/public/779/servpro/solutions/cable/>

uBR9xx Cable Access Routers

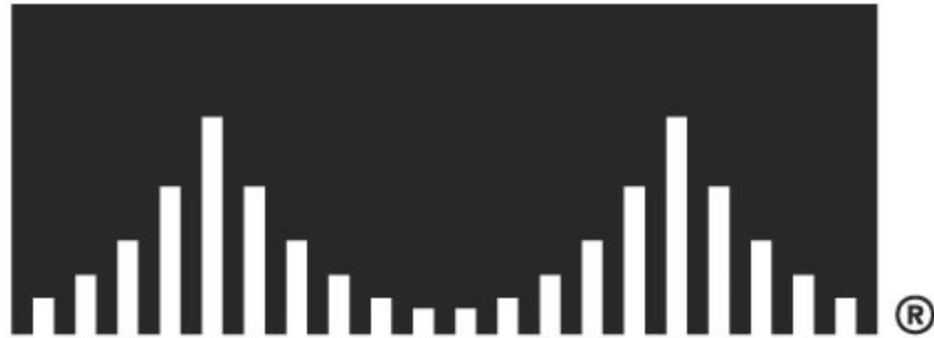
<http://www.cisco.com/en/US/products/hw/cable/ps2221/index.html>

- **DOCSIS Spec.'s**

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

CableLabs <http://www.cablelabs.org/>

# CISCO SYSTEMS



EMPOWERING THE  
INTERNET GENERATION