

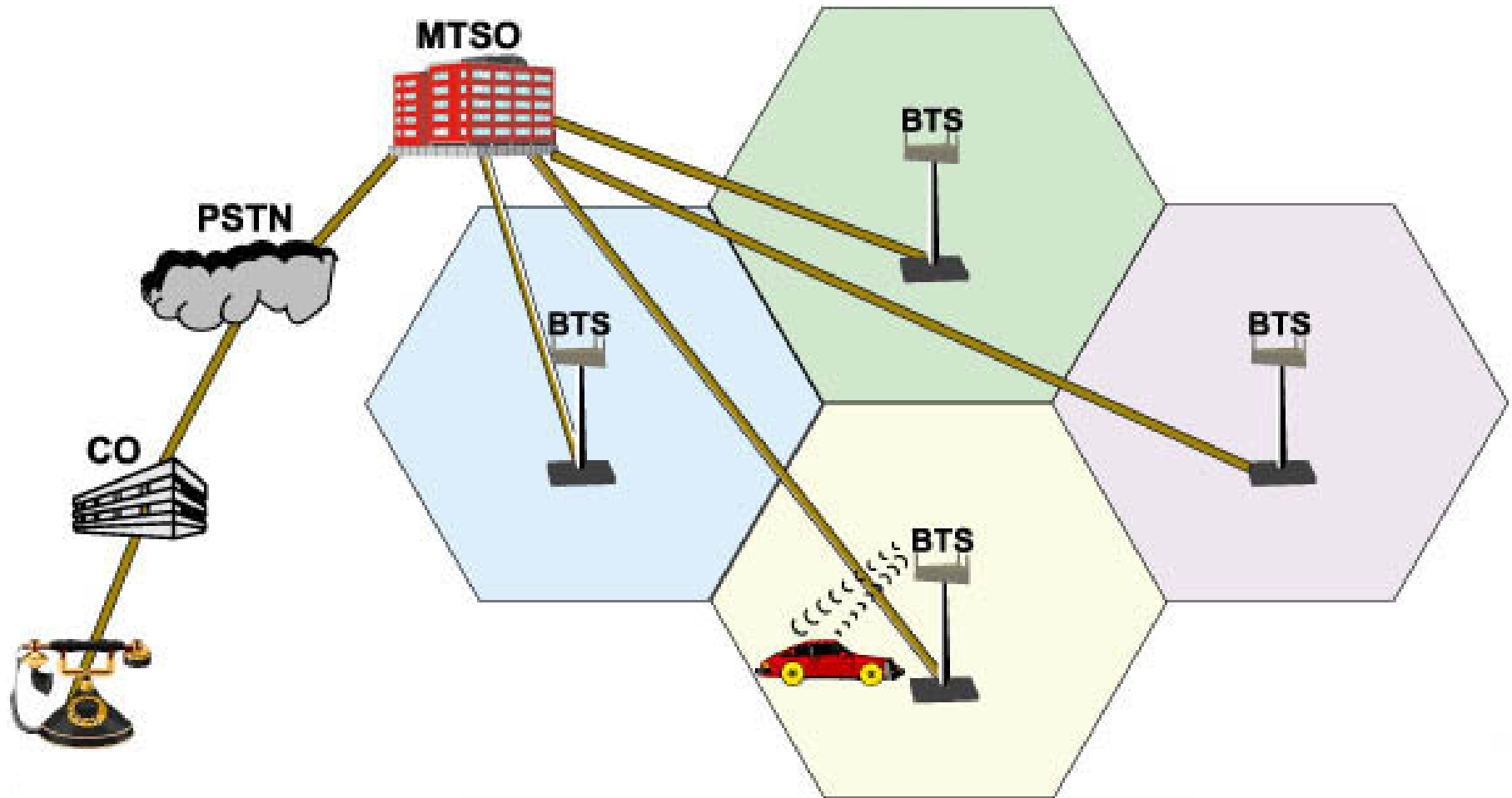
# CORNING

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Solutions

## Can You Haul Me Now?

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Market Development Manager  
18 March 2009  
Piedmont SCTE

# What is Cellular?



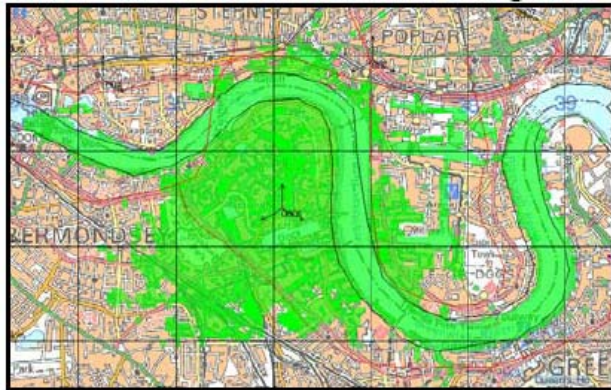
# Wireless Evolution

- 2G
  - Digital communications aka PCS
    - GSM (TDMA- AT&T, T-Mobile)
    - CDMA One
    - iDEN (Nextel)
- 2.5G
  - Packet switching for 2G nets
    - GPRS and EDGE for GSM operators (AT&T, T-Mobile)
  - Better than 2G, but not even close to 3G
- 3G
  - Packet Switching
  - Layered Services
  - UMTS (AT&T, T-Mobile)
  - EV-DO (Verizon, Sprint)
    - 2Mbps maximum per user download speed
- 4G
  - LTE
  - WiMax
  - Better utilization of 3G infrastructure
    - Up to 100Mbps download speed per user



# Wireless Evolution and Network Density

## GSM Voice Coverage



2G Voice Only

## Coverage at 64 kbps



2.5G Voice & Data

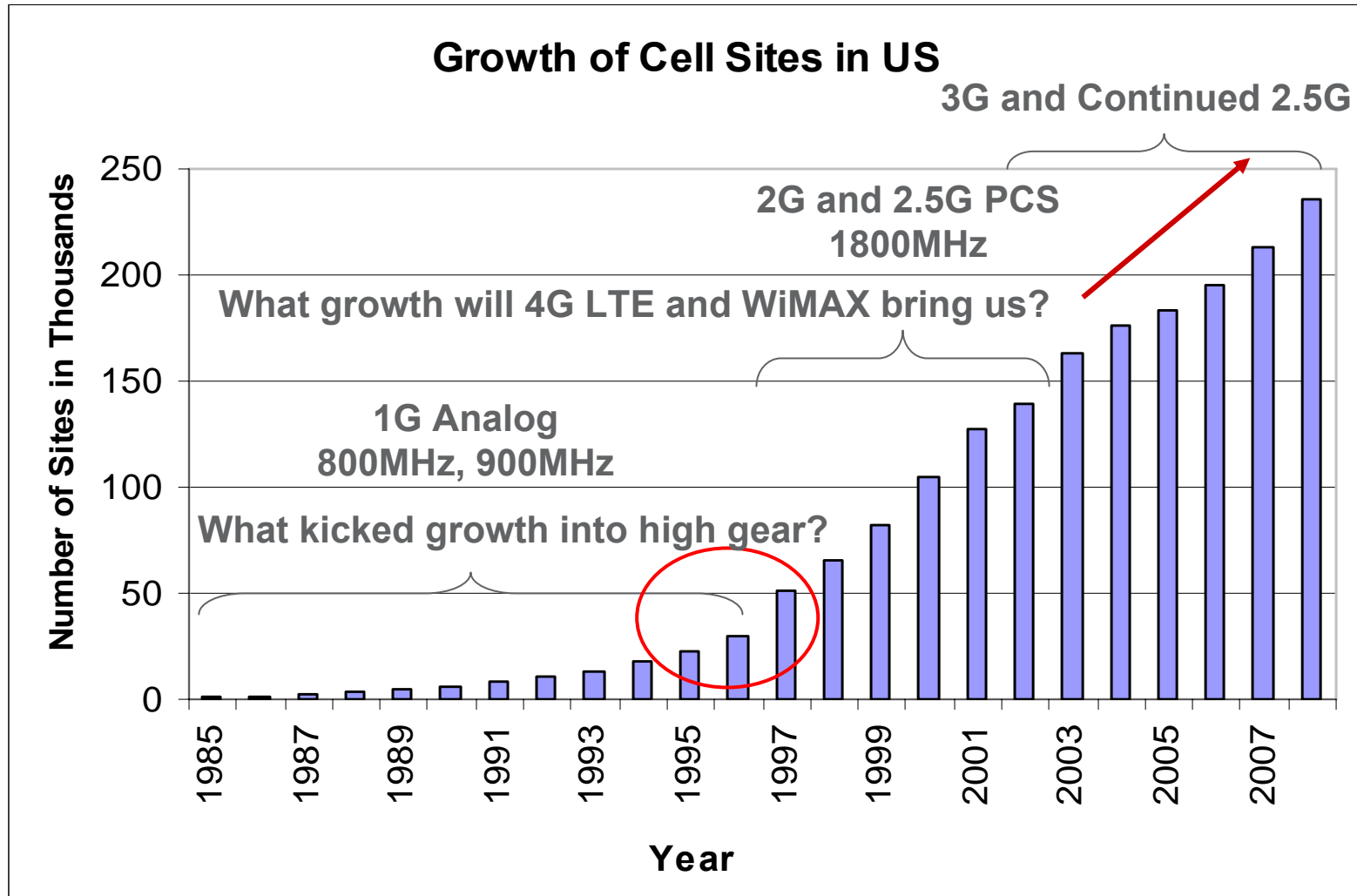
## Coverage at 384 kbps



3G Voice & Data

Source: Crown Castle International

# Cell Site Proliferation

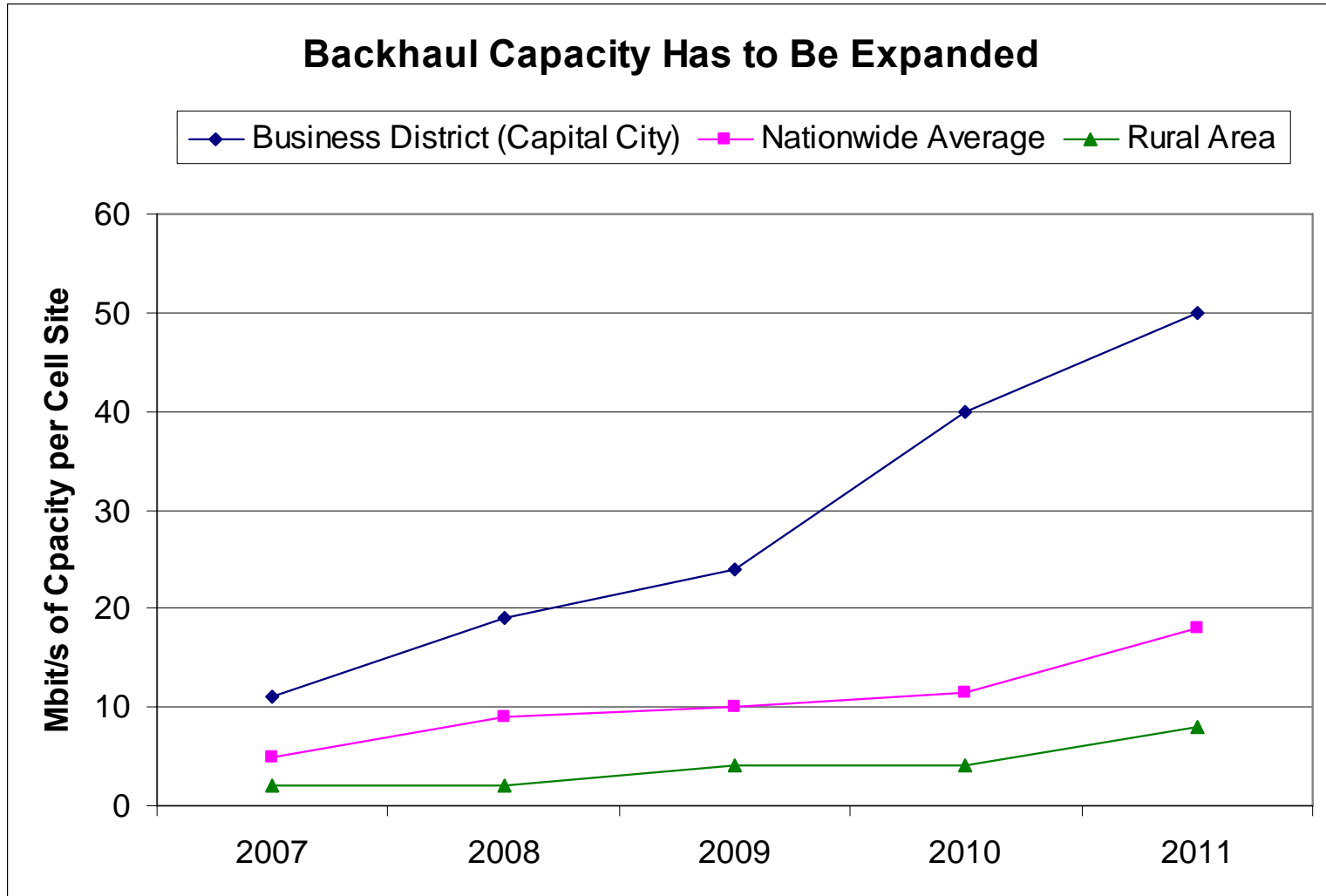


# Mobile Internet

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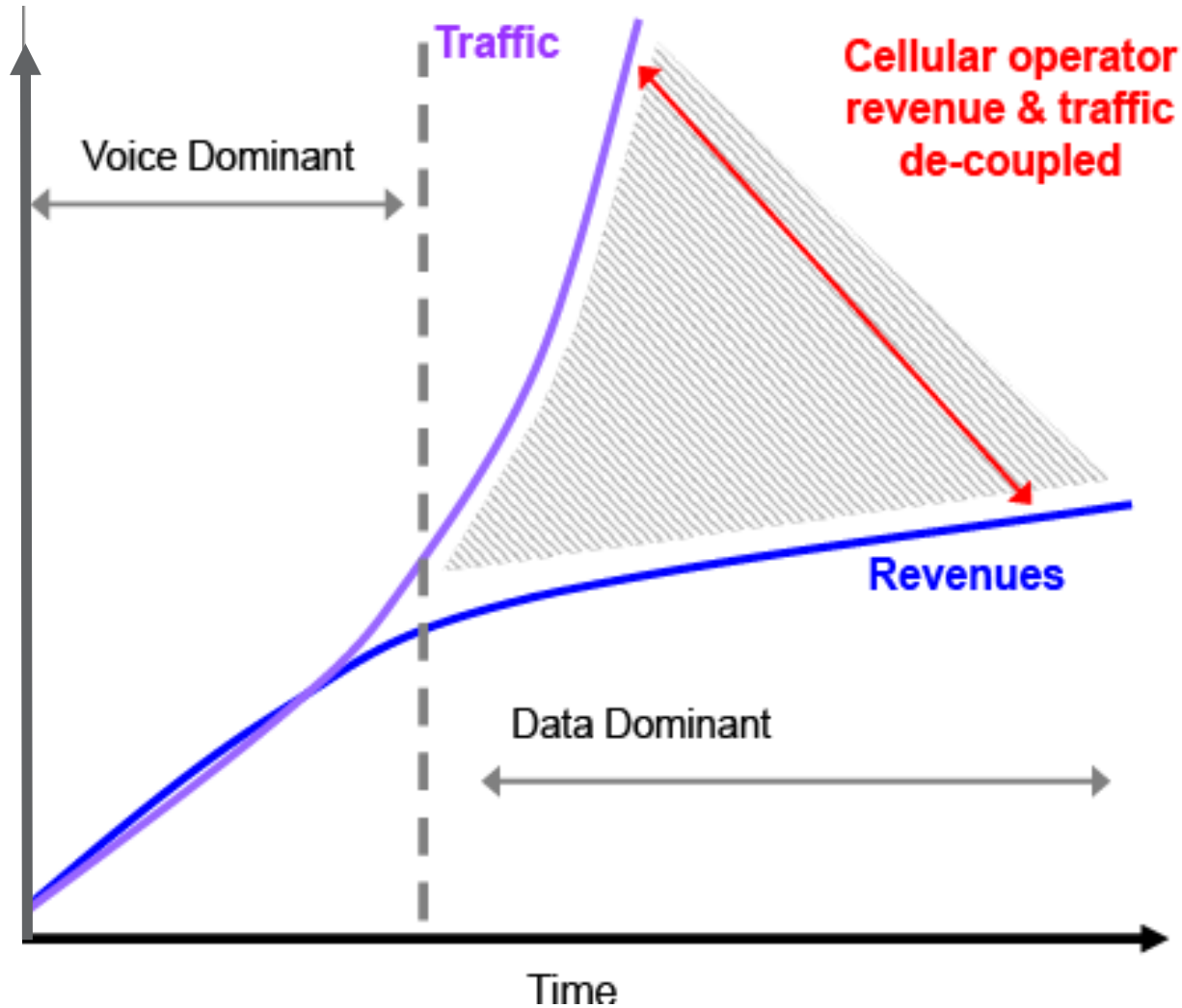
- Moore's Law (computing power)
  - Processing ability doubles every 18 months (60% growth curve)
    - To realize improved capabilities, a consumer need only buy the component and install it
    - Instant gratification
- Nielsen's Law (bandwidth growth)
  - Internet user connections increases in speed at about 50% annually
    - To realize improved capabilities, a consumer must purchase the necessary equipment **and** the provider must also upgrade their equipment and/or infrastructure

# How Much Is Enough?



Source:  
Heavy Reading

# Traditional Cellular Backhaul Does Not Scale Well



Source:  
Heavy Reading



# An ounce of prevention.....

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- What steps should be taken today to ensure infrastructure is prepared to scale with tomorrow's expectations?
  - 3G only about 50% built
    - TDM (T1/E1, DS3, SONET) backhaul requirement
    - Still a voice system capable of transmitting data
  - 4G build will begin in earnest in 2009
    - Minimum 100Mbps per sector at the cell site
      - Normally three sectors per BTS
    - Most backhaul providers are already provisioning for 4G
  - Circuit emulation is a work-in-progress
    - T1-over-Ethernet, etc
      - Technology developing, carriers familiar with TDM for reliable clock
      - Latency problems; not your regular ethernet QOS
      - May not scale well in ten years
        - » Particularly if part of a PON

# Cell Site Basics and Commonality

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- One to eight wireless operators lease space at the site
- Legacy equipment will require T-1 interface at the BTS
- Within fence is a controlled access area
  - Some service providers terminate service outside the fence
- Cellular redundancy with adjacent cells
  - Diverse path is beneficial
- Remain as passive as possible
  - Low latency, jitter, and differential latency are critical factors
  - This is why Ethernet backhaul is not yet standardized
- Turn-up time averaging several months today
  - Less than one month within three years

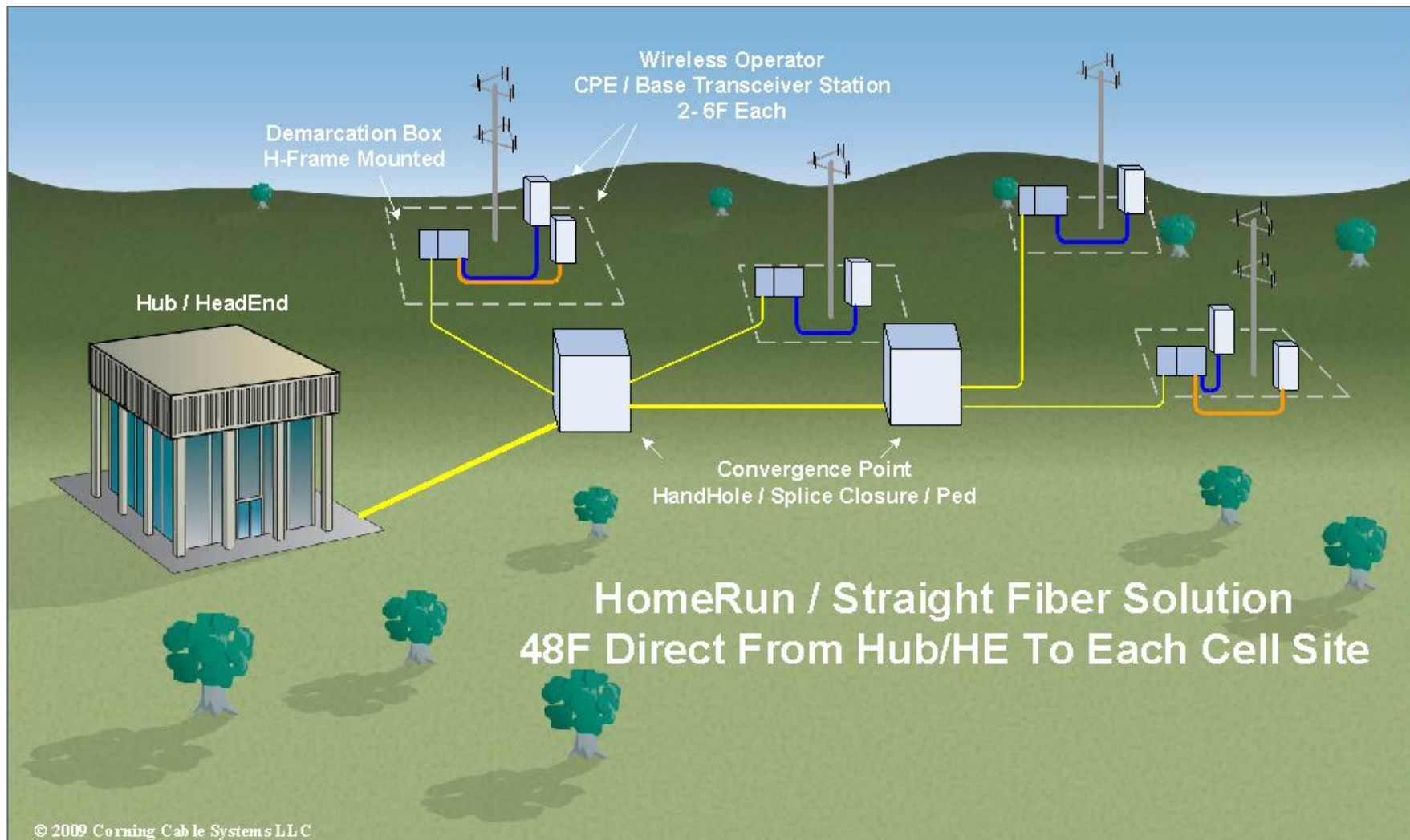
# Cellular Backhaul Solutions Overview

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## 1) Straight Fiber – 2) PON – 3) WDM

- Best suited to backhaul providers utilizing SONET, or other Wide Area protocol
- Simplest solution to install and maintain
- Sector demarcation box protects feeder cables
  - Backhaul provider terminates service in a locking demarcation box, each wireless operator connects at this point
- Similar to existing backhaul infrastructure, familiar to wireless operators
  - SONET gear can be co-located at cell site, or in Headend / Hub some distance away
- Provides most flexibility for future upgrades or bandwidth requirements

# Home Run / Straight Fiber Solution Diagram

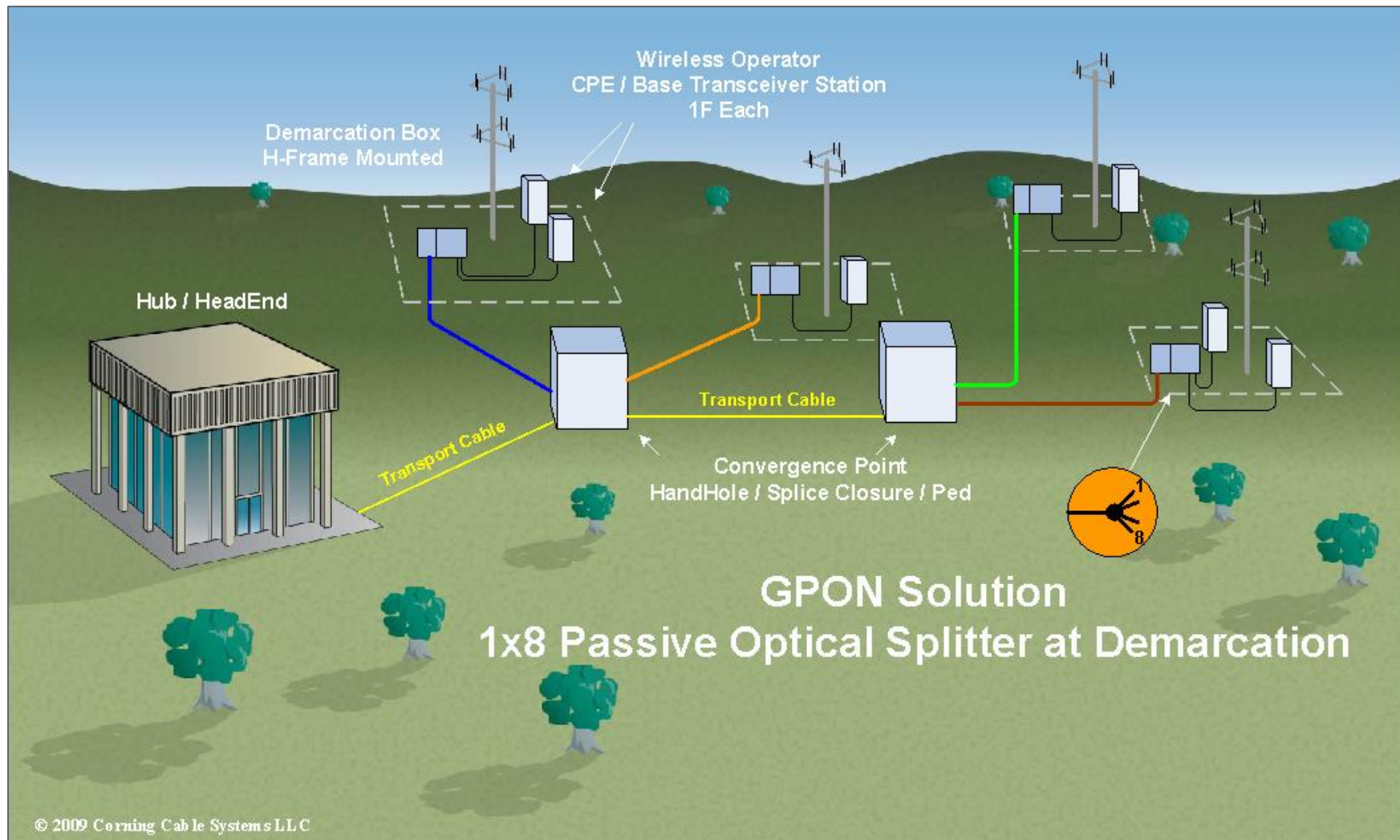


# Cellular Backhaul Solutions Overview

## 1) Straight Fiber – 2) PON – 3) WDM

- Virtually identical to FTTH networks being deployed in North America
- Can be convenient to connect a wireless operator as a subscriber to existing PON
  - 4G (LTE/WiMAX) requires 100M per carrier sector at the BTS
    - 300M per wireless operator nominal
  - Backhaul through PON architecture could reduce OLT utilization
    - GPON designed for 1:32 split ratio cannot deliver 100M unless ratio is reduced to accommodate towers
  - Data-only content may extend range beyond video limitations
    - Depends on OLT/ONT vendor and video transmission method
- In general, an entire OLT port should be provisioned per site
  - 1x8 splitter at the fence provisions 125Mbps per leg ( $1G \div 8 = 125M$ )
  - For network resilience, operators would not allow multiple towers on a single point of failure (OLT Card)
  - Circuit emulation is a serious concern; latency and jitter; carrier dependant
    - GSM clocking derived from TDM Circuit
    - CDMA clocking synchronized by GPS receiver
    - GPON networks utilize fixed 8KHz clock, providing possible synchronization source

# GPON Solution Diagram



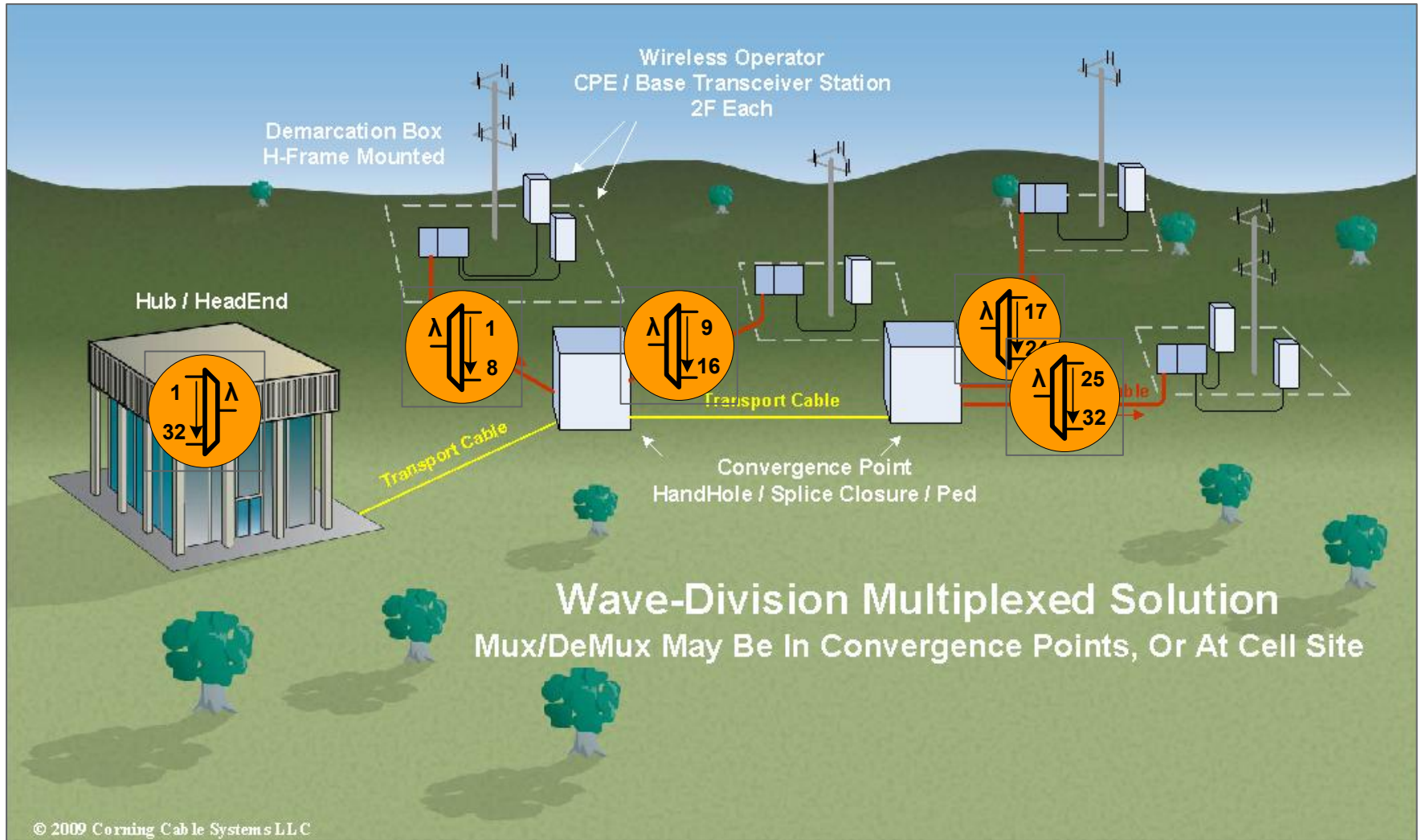


# Cellular Backhaul Solutions Overview

## 1) Straight Fiber – 2) PON – 3) WDM

- Ideal solution for utilizing existing infrastructure with insufficient dark (unused) fiber
  - WDM components may be less expensive than complete system overbuild
- Optimal solution for MSOs as they already deploy and operate WDM technology
  - Solution is conceptually very similar to PON except that instead of using a 1x8 split, the customer would use one or two wavelengths for each customer
    - One wavelength Tx, One Rx
      - 2F or ring solution would allow Tx and Rx on same wavelength
    - Using CWDM technology, up to four carriers per fiber (eight for 2F and/or ring)
      - Many more possible with DWDM
- First customer build includes bulk of infrastructure, additional customers may be added with additional WDM modules on each end
  - CWDM most convenient in 4-ch modules
  - DWDM allows greater utility
    - DWDM and CWDM can coexist provided 1530 and 1550 skipped in CWDM
- BTS equipment may not utilize colored SFPs, so translation equipment may be required

# WDM Solution Diagram

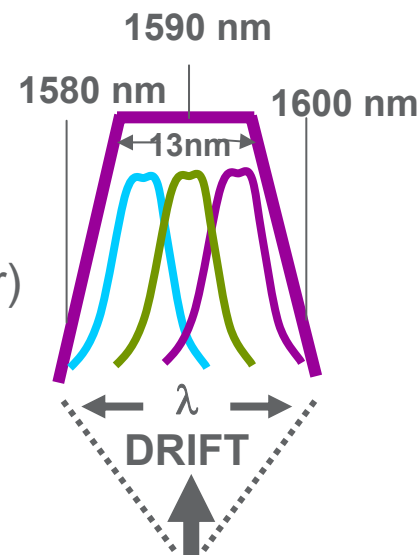




# Comparison of CWDM & DWDM

## CWDM Advantages

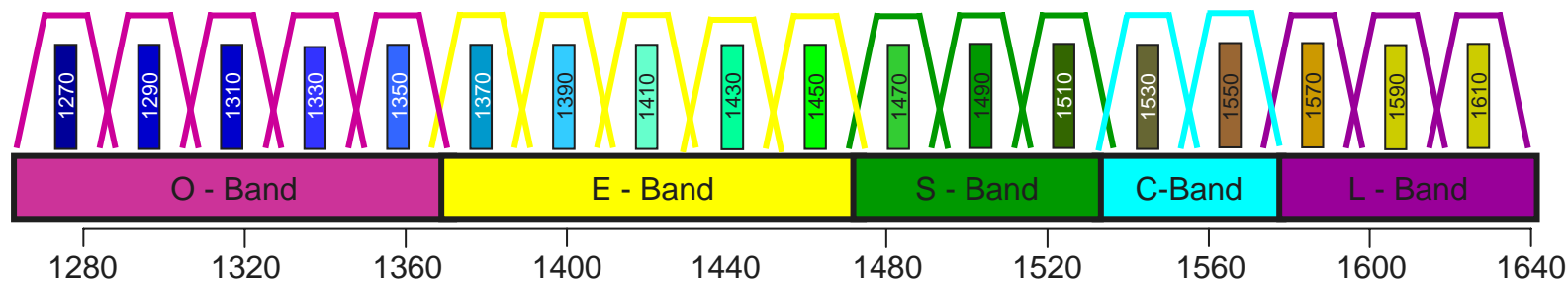
- Uses lower cost, lower power, uncooled lasers
- Due to large wavelength spacing can tolerate 6–8 nm of thermal drift (outside plant temperature ranges)
- 13 nm passband ideal for linear AM applications
- Limited to 8-10 channels with standard 1310nm (Non LWP fiber)
- ITU-T G.695 Specifies Interoperability of CWDM Equipment



## DWDM Advantages

- 100+ channel counts: 100+
- Amplifications allow for greater distances
- Allows for a transparent metro/access DWDM network
- Uses single filter device for MUXing multiple channels simultaneously

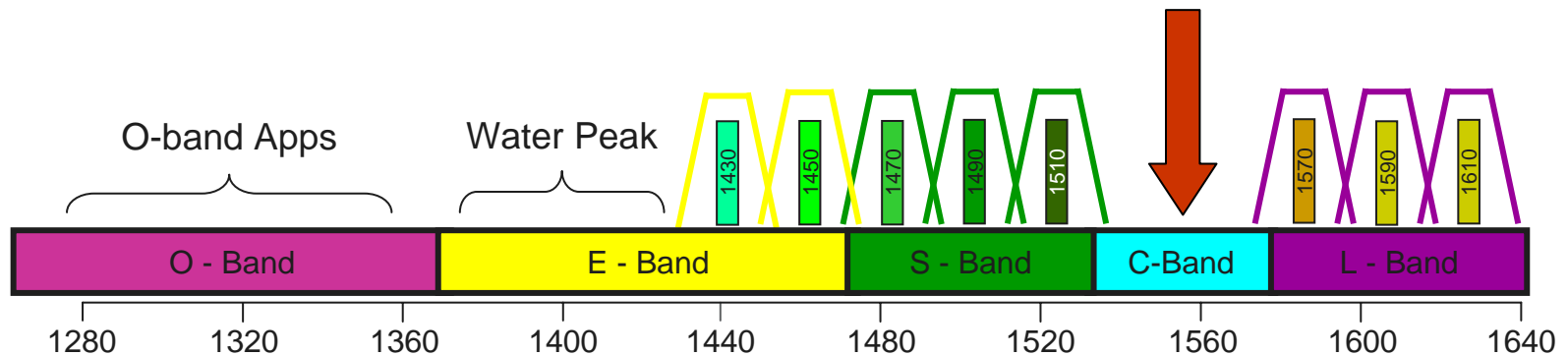
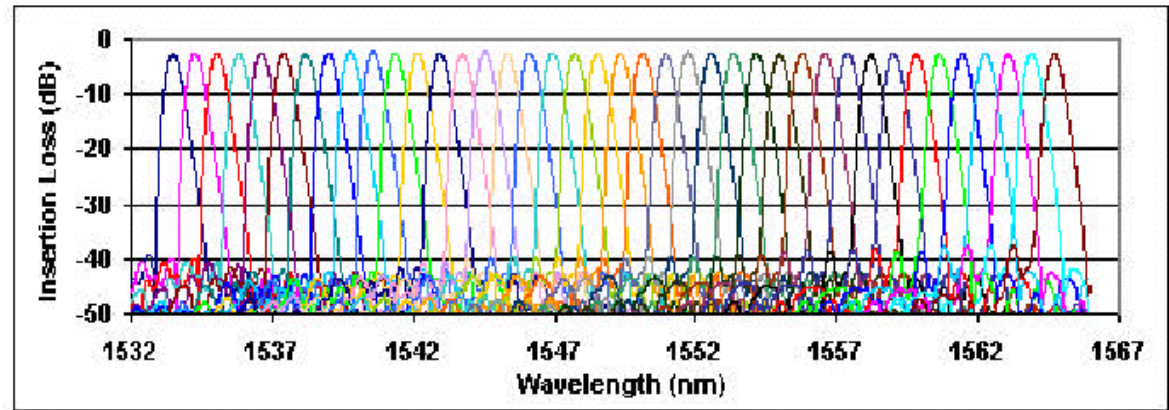
## ITU-T G.694.2 CWDM Channel Plan (approved June 2002)



# CWDM Mux/Demux with DWDM Upgrade

Operator deploys a CWDM (up to 8 channel) system today and then overlays a DWDM (40+ channel) system in the future!

32 nm gap = 40+ DWDM CH  
in C-band (0.8 nm spacing)



# Summary

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- Wireless business will remain strong despite economic downturn
- Optimum coverage areas shrinking due to capacity concerns
- Bandwidth demand grows at nearly 50% annually
  - Exponential
- Traditional Time Division Multiplexed circuits don't scale well
  - 4G and beyond will be a packet-based protocol
- Home-running fiber from HE / Hub provides best insurance your network will accommodate future demands
- Passive Optical Splitters and GPON can be used for backhaul, with some limitations
- WDM can extend the life of your existing infrastructure
  - CWDM, DWDM, CWDM / DWDM overlay

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