

**IT 609**

**Network and System  
Administration**

**WAN Technology**

Thursday October 28, 2021

# WAN Technology

## WAN Technologies

*Going the distance...*

# WAN Topics

- 1.What is a WAN?
- 2.SOHO WAN services
- 3.WAN technologies and terminology
- 4.Advances in fiber optic networks and how that affects the WAN in the future
- 5.UNH's WAN story

# Wide Area Networks (WAN)

WAN links span distances

Generally the connection is not owned by the company using it - leased from a telecom provider

Usually only one network (layer 3) protocol used

Require routers to connect the LAN to the WAN link

Usually slower than the LAN

# WAN Design

**Goals:**

Sufficient WAN bandwidth

Costs

Maximize the effective service to the end users

Generally, you get 2 of 3, but not all

# SOHO WAN Options

## **DSL** - Digital Subscriber Line

Max speed  $\approx$  50 Mbps, often less, dedicated

## **DOCSIS** - Data Over Cable Service Interface Specification (aka Cable Modem)

Max speed  $\approx$  2 Gbps, 20-100 Mbps often, shared

## **FTTP** - Fiber to the Premises

Max speed  $\approx$  10 Gbps, 1 Gbps often, dedicated

# DSL

**DSL - Digital Subscriber Line**

Voice and networking over phone lines

Collection of newer standards, affordable

xDSL (ADSL, HDSL, SDSL, etc)

Dedicated connection

# DOCSIS

**DOCSIS - Data Over Cable Service Interface Specification (aka Cable Modem)**

**Networking over cable television lines**

**Shared bandwidth**

**Current standard is DOCSIS 3.1; up to 10 Gbps**

**Usually sold as tiered speeds**

# Fiber To The Premises (FTTP)

Best known as Verizon FIOS service

See also Google Fiber

Tiered speeds

Dedicated connection

Sold as packages of voice, TV, data

# SOHO Speeds

DSL	1.5 Mbps to 50 Mbps
Cable	10 Mbps to 2 Gbps
FTTP	50 Mbps to 10 Gbps

# WAN Technologies

Continued development over the last 20+ years

Move from copper to fiber

Progression of technologies on fiber-based networks

B-ISDN

Frame Relay

MPLS

# ISDN

Integrated Services Digital Network

Replacement for Plain Old Telephone System (POTS)

Uses copper wire Public Switched Telephone Network (PSTN)

Digital Signal levels

DS0 - one voice channel, 64Kbps

DS1 - 1.544 Mbps (24 DS0's)

DS3 - 44.736 Mbps (672 DS0's)

T1/T3 - a communications channel that communicates at DS1/DS3 speeds

# Broadband ISDN

Next generation phone/networking system

**SONET - Synchronous Optical Network**

A fiber optic network standard - Layers 1/2

OC1 - 51.84 Mbps

OC3 - 155.52 Mbps

OC12 - 622.08 Mbps

OC48 - 2.488 Gbps

OC192 - 9.953 Gbps - can interoperate w/ 10Gb Ethernet

**ATM - Asynchronous Transfer Mode or**

**MPLS - Multiprotocol Label Switching on top**

# 10G Ethernet

10 Gigabit Ethernet specifications include both LAN and WAN applications

WAN PHY (10GBASE-W)

Interoperate with OC-192 SONET

Used for point-to-point connections only

No contention or collisions possible

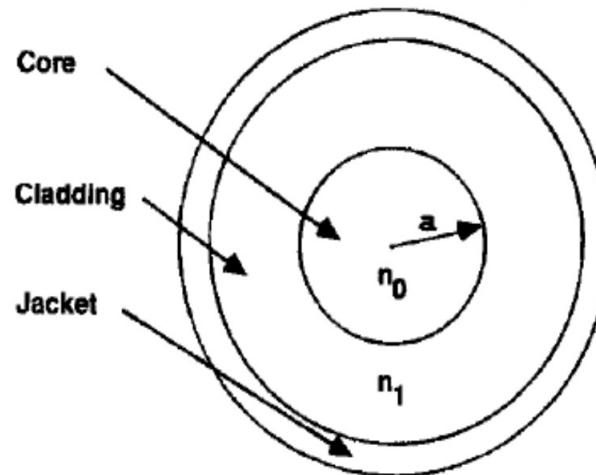
# Optical Fiber

What is an optical fiber?

A glass or plastic fiber that has the ability to guide light along its axis.

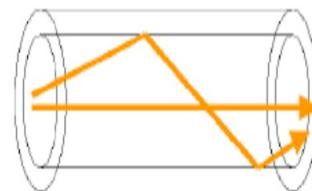
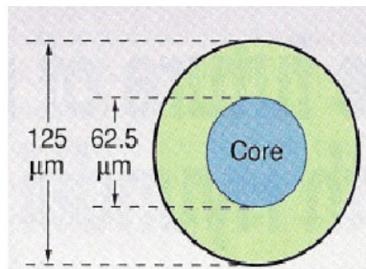
A fiber cable consists of three layers:

core,  
cladding,  
jacket.

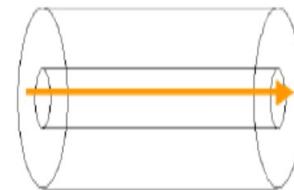
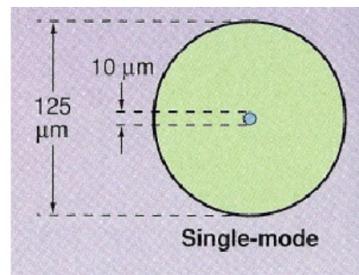


# Fiber Types

**Multi-Mode:** supports hundreds of paths for light.



**Single-Mode:** supports a single path for light



# Multi- vs Single- Mode

	<b>Multi-Mode</b>	<b>Single-Mode</b>
<i>Modes (paths)</i>	Many	One
<i>Distance</i>	Short	Long
<i>Bandwidth</i>	Low	High
<i>Typical Application</i>	Access	Metro, Core

# Fiber Advantages

True broadband medium

The fiber is immune to virtually all kinds of interference

A fiber optic cable is much smaller and lighter in weight than a wire or coaxial cable with similar information carrying capacity

Fiber optic cable is ideal for secure communications

Low production cost (~\$/km)

# Fiber Problems

Cost of termination

Relative fragility vs. copper

Signal degradation

Attenuation

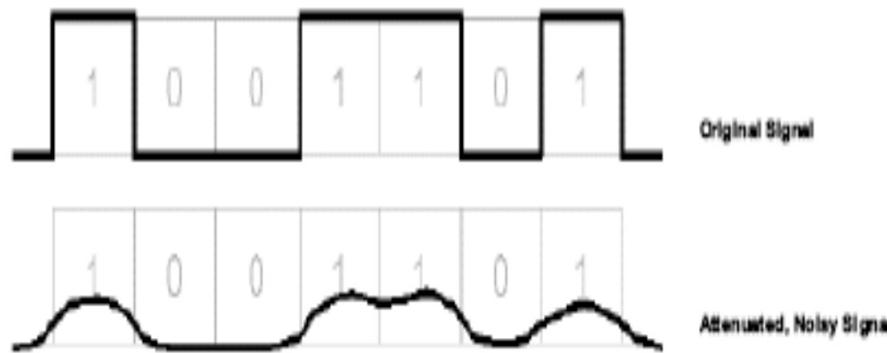
Dispersion - Multimode, Chromatic,  
Polarization

# Attenuation

Reduction of light power over the length of the fiber

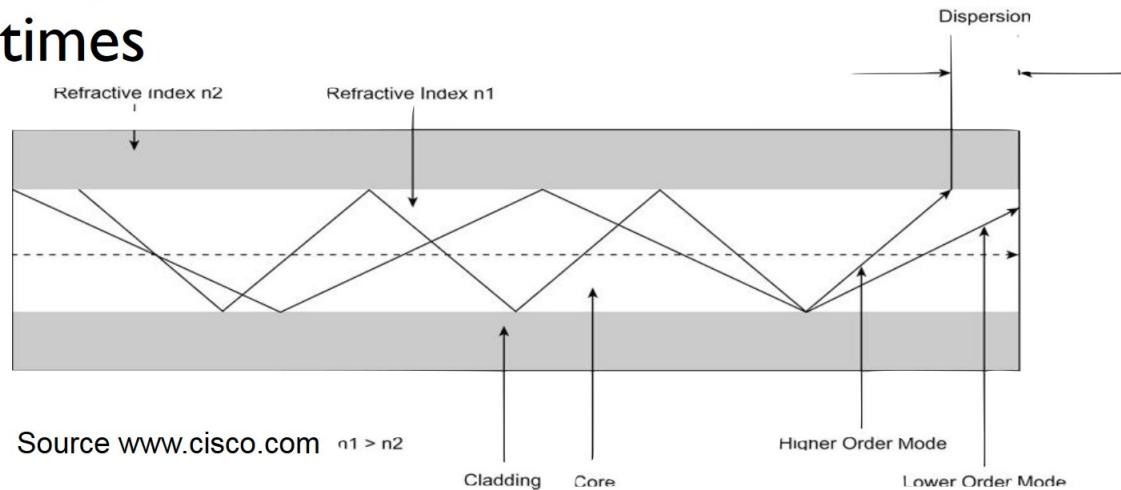
Mainly caused by scattering

Depends on the transmission frequency



# Dispersion

Light rays are transmitted from the source at a variety of angles and arrive at the receiver at different times



Also effects from different colors or polarizations spreading out over transmission

# Multiplex the same Fiber

TDM (Time Division Multiplexing)

- Slotting of channels for simultaneous users

- Achieve maximize utilization of given bandwidth

WDM (Wavelength Division Multiplexing)

- Use of optical fibers to achieve higher speeds

- Utilize wavelengths to multiplex users

- Allow continuous channel allocation per user

- Increases the effective bandwidth of existing fiber

# Limitations

## TDM

Dependency of Mux-Demux on bit rate

Limitations on bit rates

How fast can we go? (Decides how small the time slots can be)

## WDM

Inefficient usage of full capacity of the optical fiber

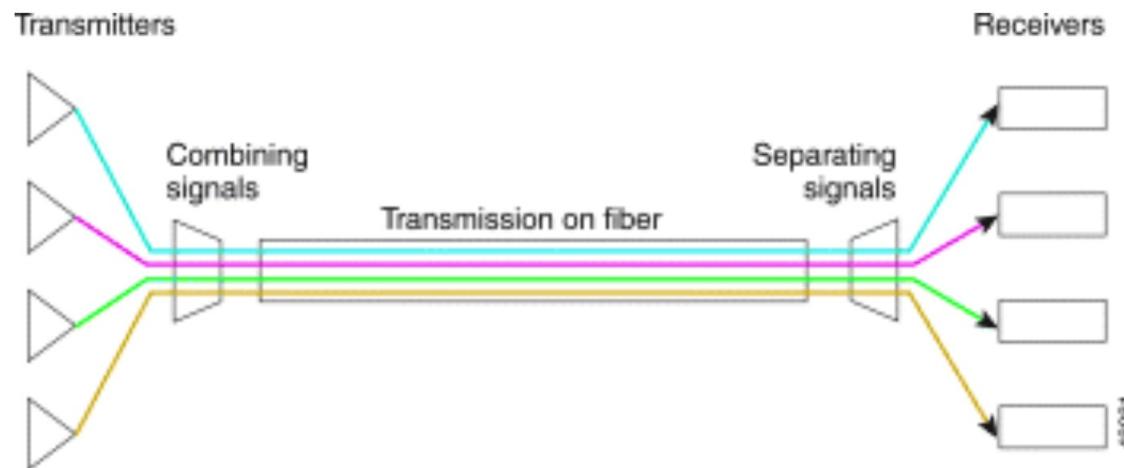
Capability of carrying signals efficiently over short distances only

# DWDM

Dense Wavelength Division Multiplexing

Narrow band lasers send multiple colors at the same time

Got fiber and want more speed? Change the equipment at either end to send more channels at once



# DWDM

Up to 80 (and theoretically more) separate wavelengths on a single optical fiber

Each channel carrying 2.5 Gbps, means 200+ Gbps in one optical fiber

Different data formats being transmitted at different data rates can be transmitted together

Internet (IP) data, SONET data, and ATM data can all be traveling at the same time within the optical fiber

# DWDM Frequencies

In the (1529-1536) nm region called BLUE BAND (C),

8 channels 100 GHz spaced

16 channels 50 GHz spaced can be multiplexed

In the (1542-1561) nm region called RED BAND (C) ,

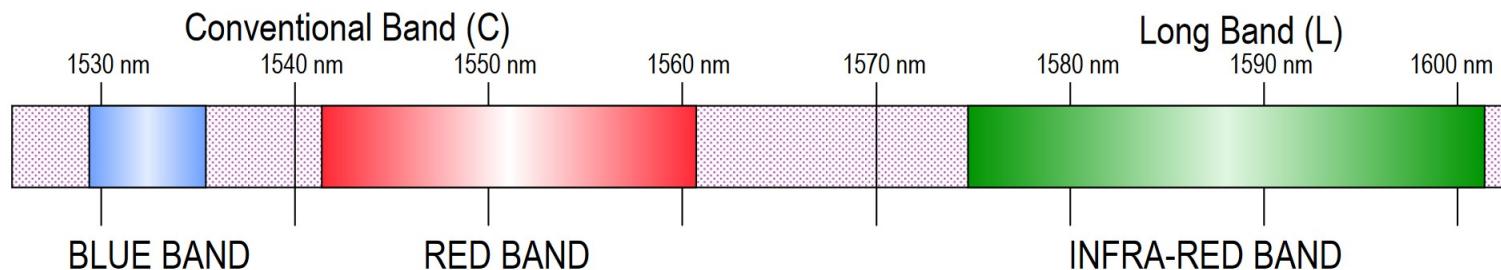
24 channels 100 GHz spaced

48 channels 50 GHz spaced can be multiplexed

In the (1575-1602) nm region called INFRA-RED BAND (L),

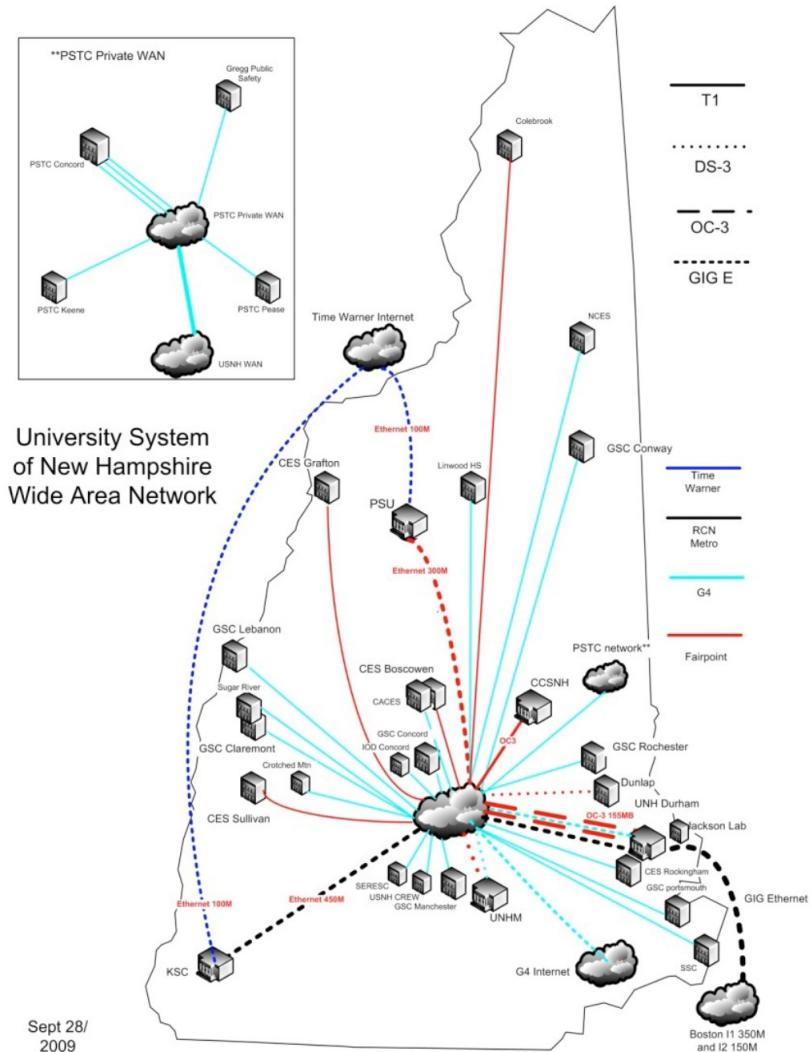
32 channels 100 GHz spaced

64 channels 50 GHz spaced can be multiplexed

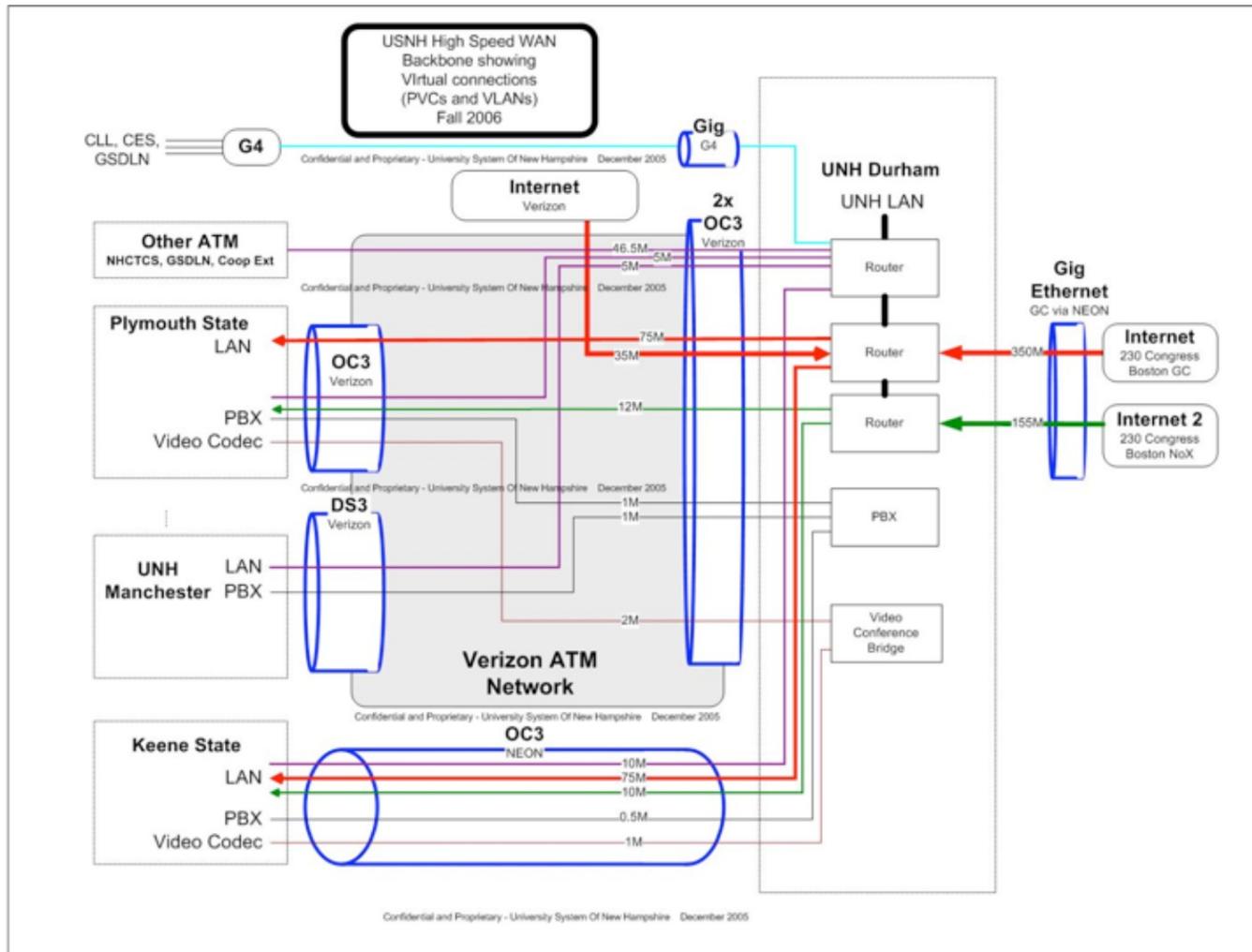


# USNH WAN 2009

Hub-and-Spoke  
Network across NH  
  
Not ideal to tackle the  
Next Generation  
connectivity required  
for collaborative  
research



# USNH WAN

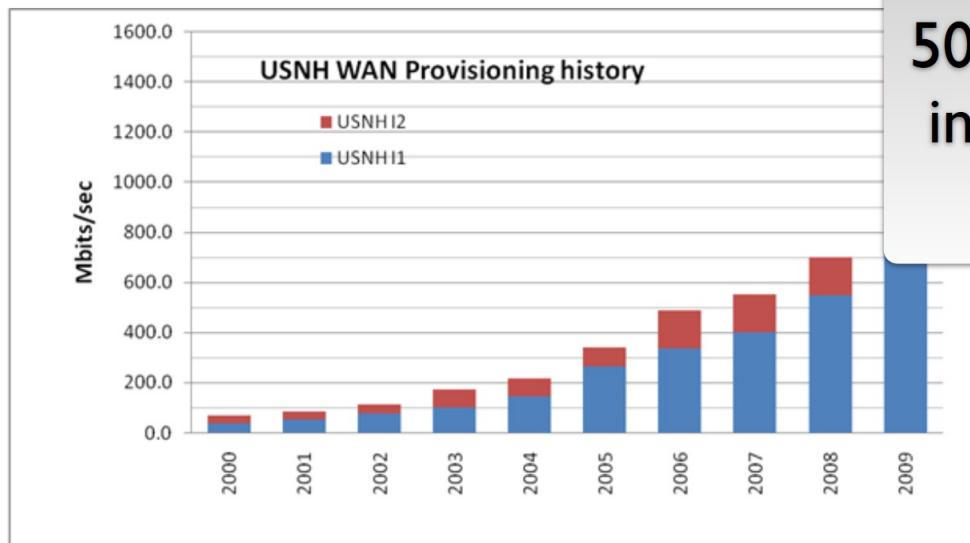


# USNH Bandwidth Needs

USNH trend indicates continued growth

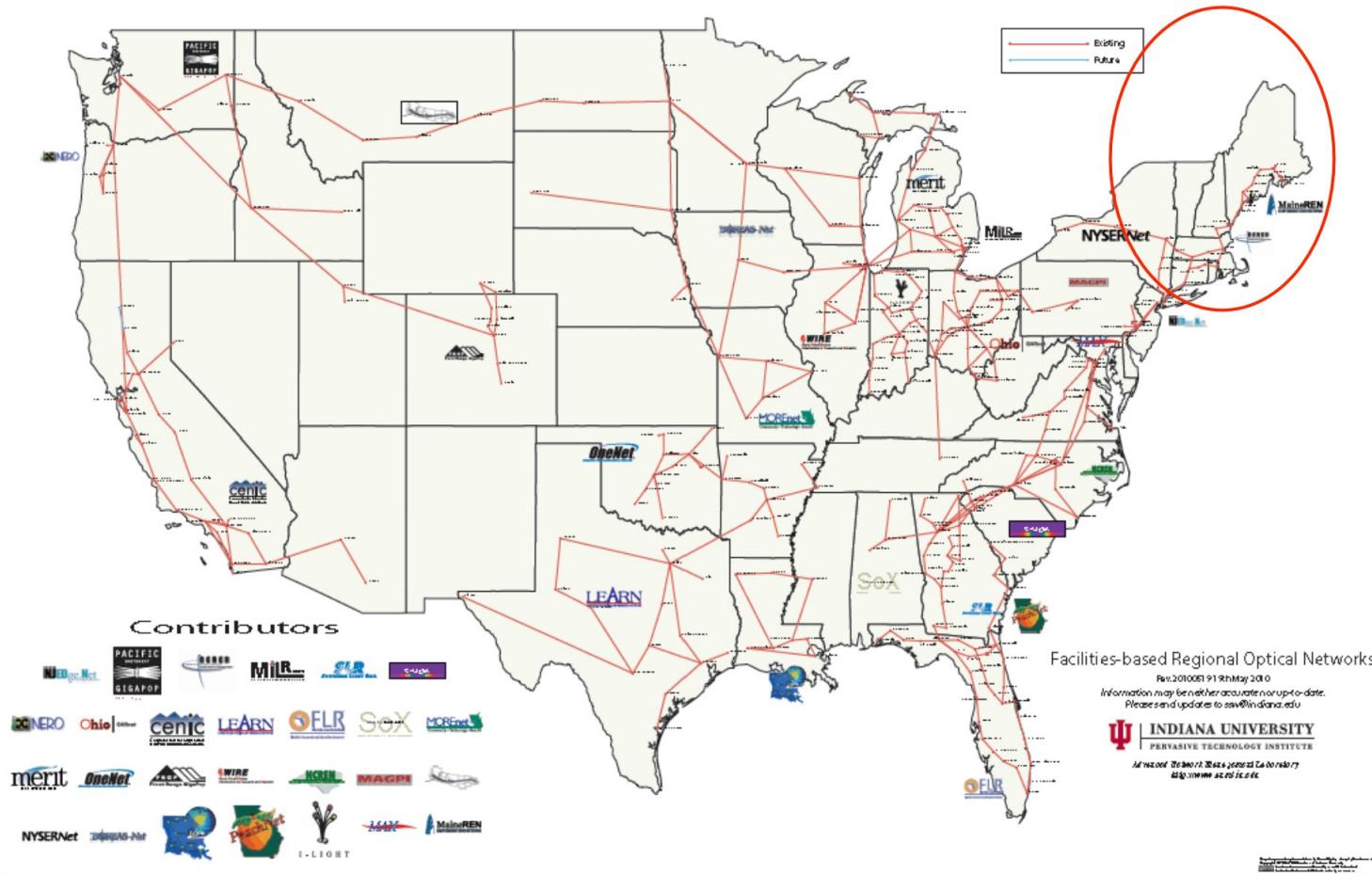
Increasing “rich content” uses (video)

Bandwidth Management reduction



UNH - Fall  
2017  
500% increase  
in bandwidth  
use!

# Higher Education Broadband Networks - 2010



# Higher Education Broadband Networks - 2010



# Why a Regional Optical Network?

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Magnitude leap in capacity (bandwidth)

Access to Internet and Internet2

Disaster recovery and application redundancy

Enable research collaboration

Improve state infrastructure and facilitate economic development

Compete nationally and globally for faculty, students, and grant funding

Stabilize costs

# Middle Mile Fiber

The Middle Mile fiber routes will be acquired through:

New Construction

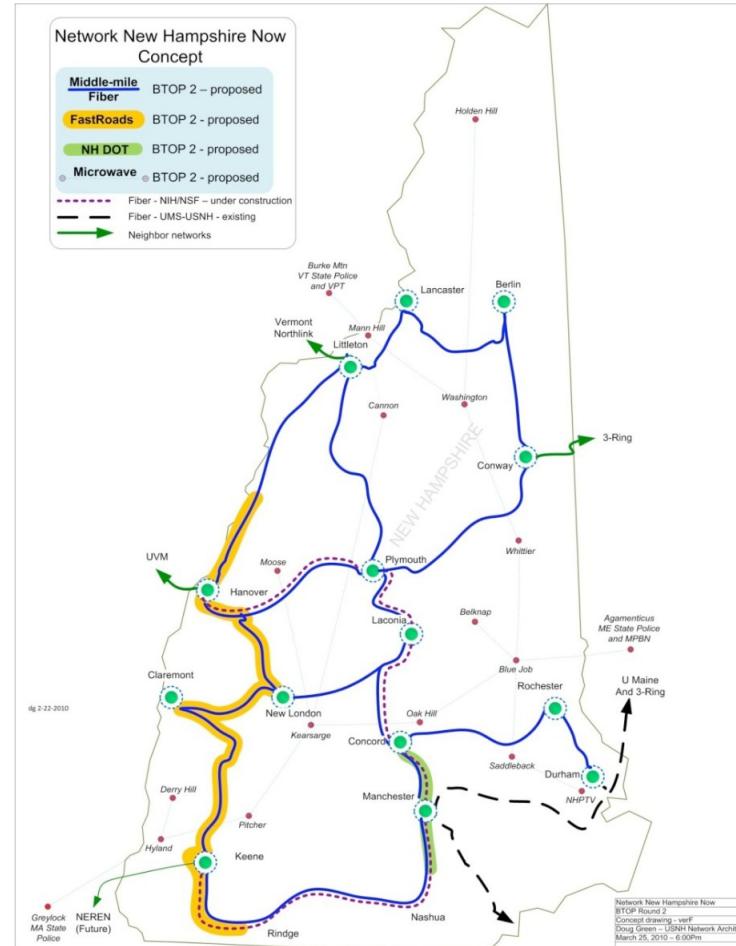
Existing Fiber Leased

Lit Services Lease

Other Creative Solutions

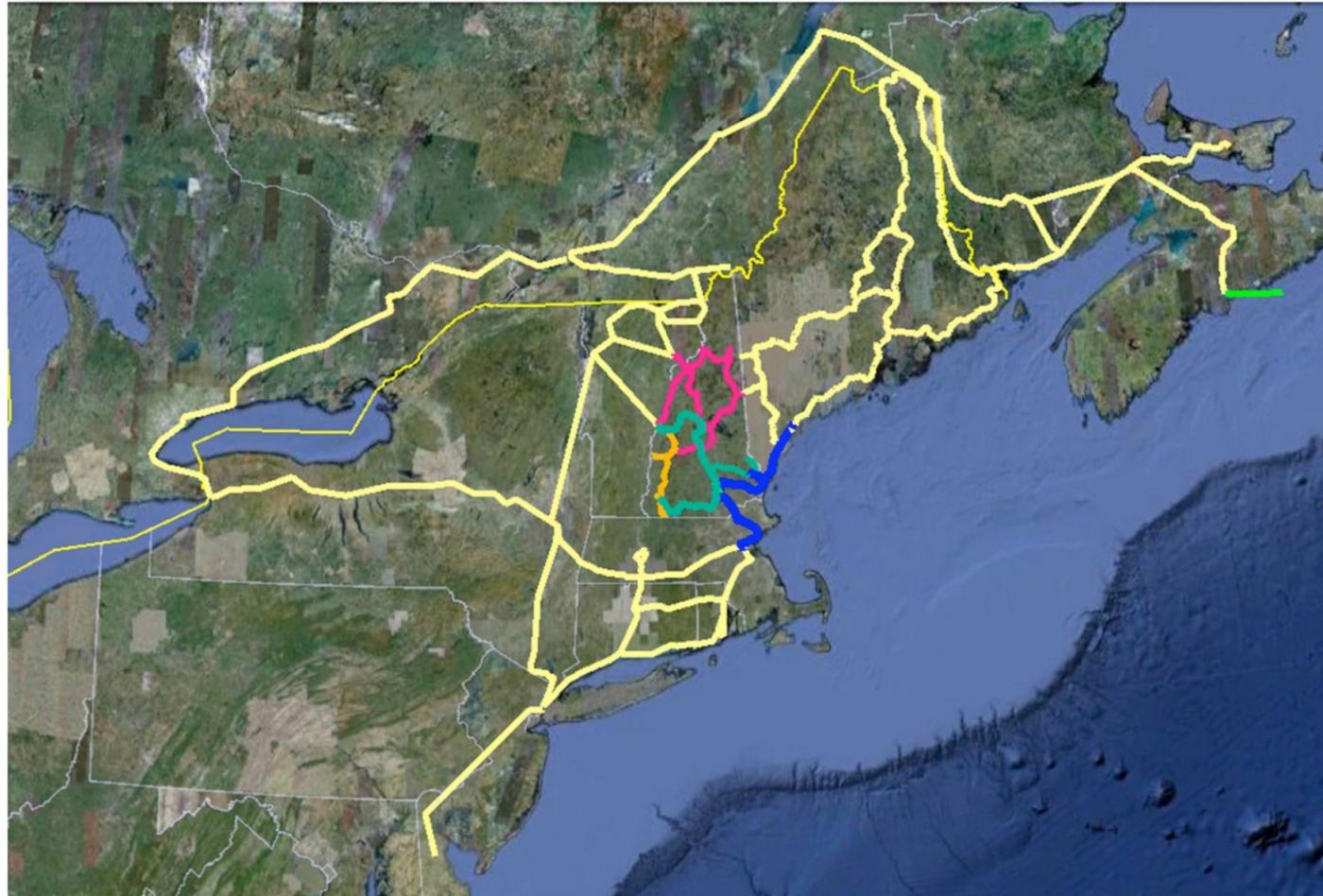
RFP for construction released on 9/28/10

The DOT route is designed & under DOT jurisdiction as part of statewide, comprehensive ITS



# Atlantica

# Vision For New England



# USNH WAN Today

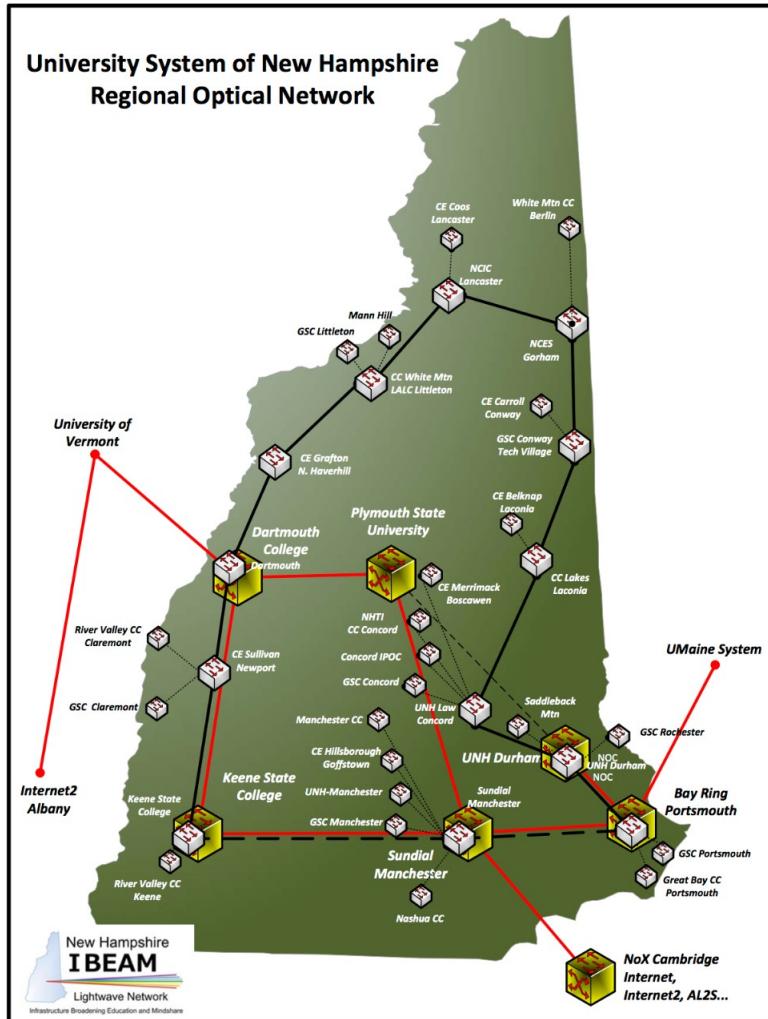
Network NH Now completed in 2013

USNH leases the fibers back at very low cost for 20 years

USNH puts whatever equipment we want on both ends of the fibers

Upgrade equipment as more bandwidth is needed, not redo the fiber

400 Gbps DWDM main ring to main sites & Internet2; also 20 Gbps Carrier Ethernet ring to partners



# Acknowledgement

Thanks to Scott Valcourt for sharing his presentation, parts of which have been reused here.



USNH Wide Area Network,  
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Network New Hampshire Now,  
Atlantica and  
The Technologies They Use

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