

# MEF

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## Carrier Ethernet Access Extending Ethernet into the First Mile

**MEF Reference Presentation  
October 2011**

# MEF Reference Presentations

- **Intention**

- These MEF reference presentations are intended to give general overviews of the MEF work and have been approved by the MEF Marketing Committee
- Further details on the topic are to be found in related specifications, technical overviews, white papers in the MEF public site Information Center:  
<http://metroethernetforum.org/InformationCenter>

- **Notice**

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# Topics

- **Overview**
- **TDM Over Ethernet**
- **Overview of Carrier Ethernet over ...**
  - Direct Fiber, WDM Fiber, HFC ( COAX and Fiber), Bonded Copper, TDM, PON, SONET/SDH, WiMax
- **Carrier Ethernet over Packet Wireless**
- **Carrier Ethernet and Active Line Access**

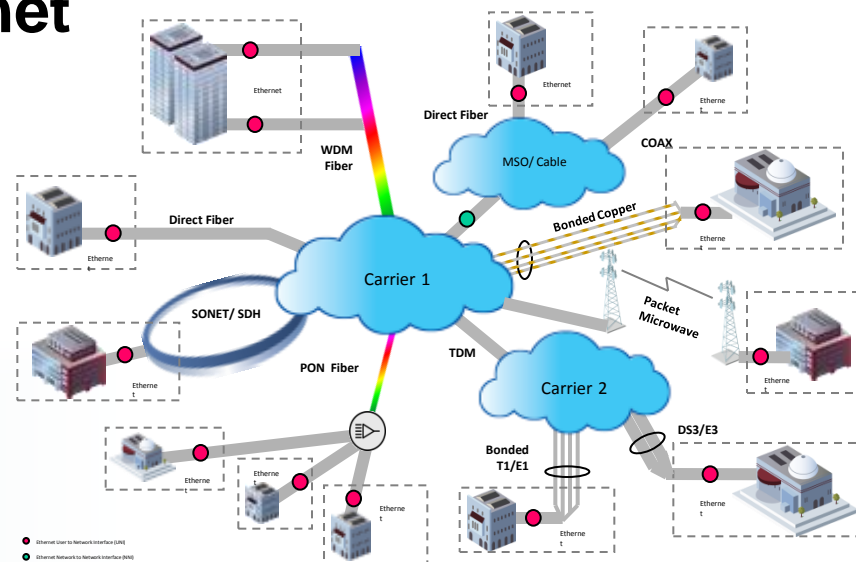


# Introduction: Extending Carrier Ethernet into the First Mile

## A key benefit of Carrier Ethernet

is its ability to provide consistent, cost-efficient, high-performance services delivered to users ...

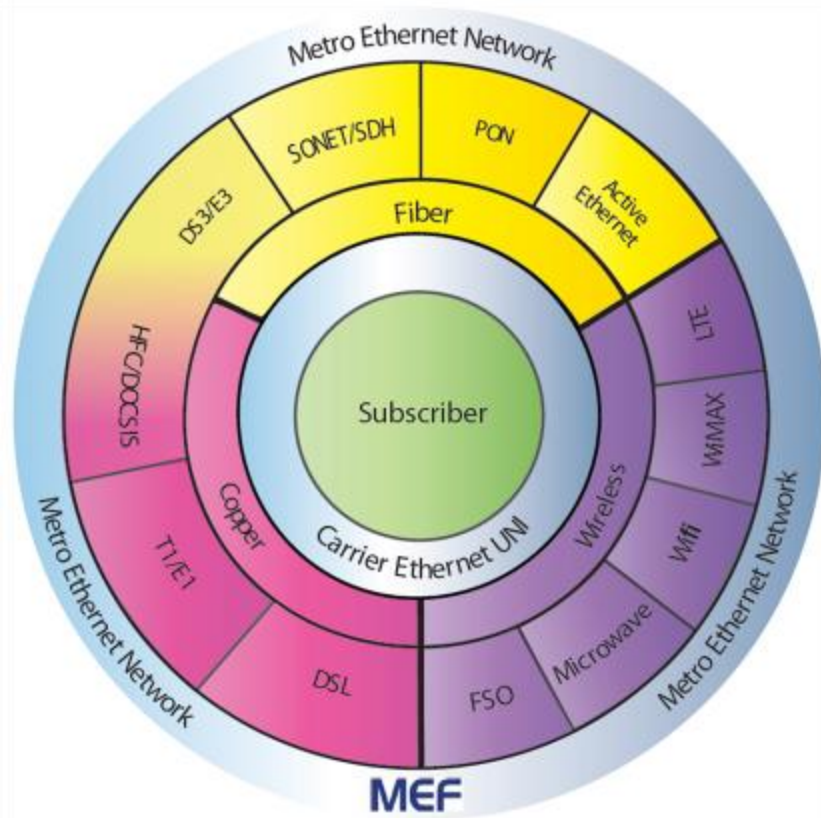
**connected over the widest variety of access networks in any location**



## This presentation

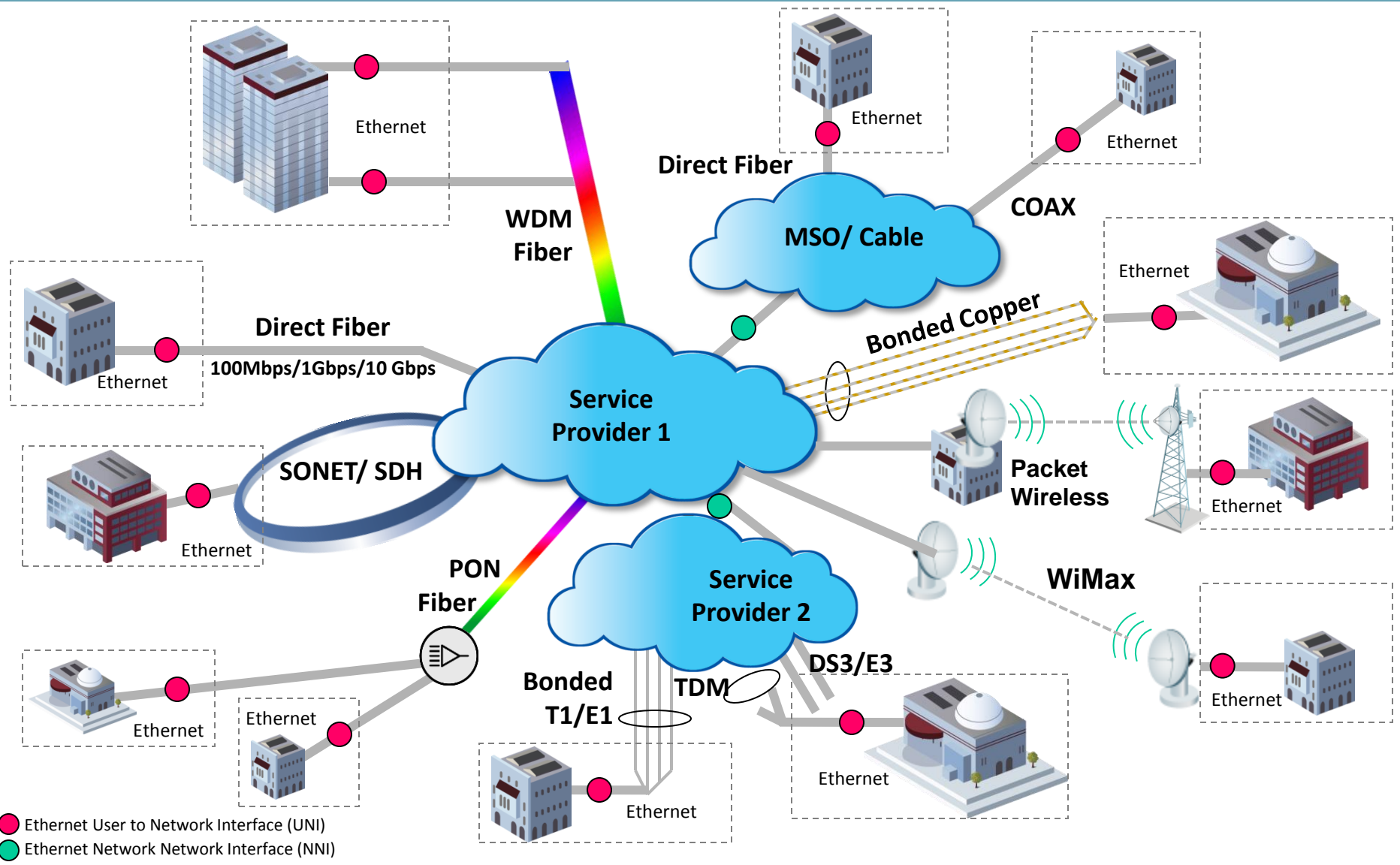
Describes how each access technology enables delivery of these and other Carrier Ethernet benefits to users connected to the world's access networks

# Introduction: Extending Carrier Ethernet into the First Mile



**Ubiquity** requires multiple **access technology solutions** from the End-User **Subscriber** to the **Carrier Ethernet Network**

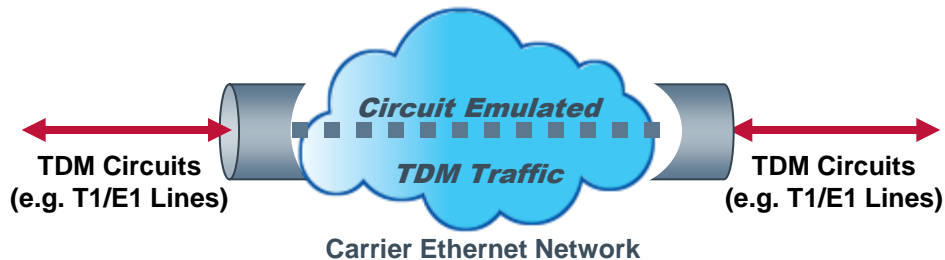
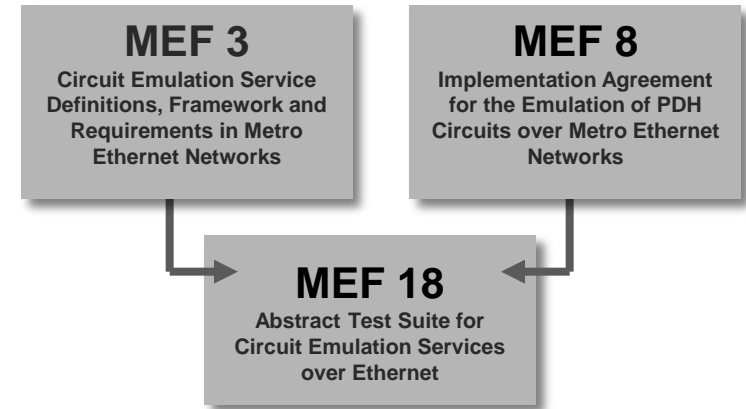
# Ethernet Access for a Multi-Site Enterprise



# MEF Standards for TDM Over Ethernet

## Circuit Emulation Services over Ethernet (CESoETH)

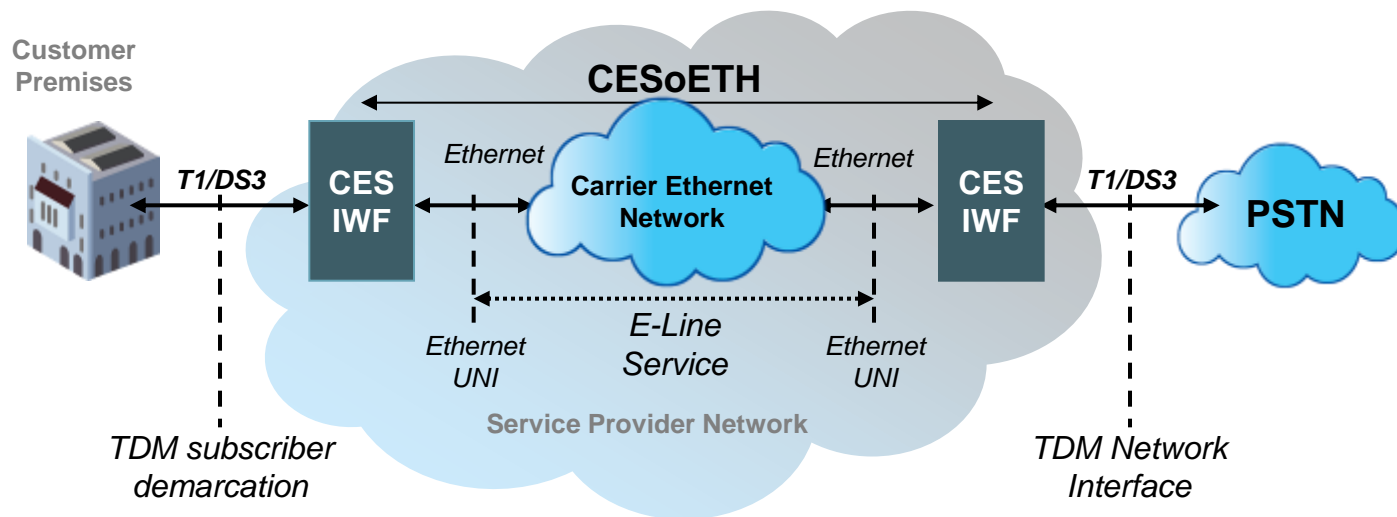
- **MEF 3**
  - Requirements for TDM transport over Ethernet Access
- **MEF 8**
  - Delivery of TDM (T1/E1, DS3/E3) transport over Ethernet Access
- **MEF 18**
  - Tests for compliance of CESoETH system
  - 334 tests for T1/E1 and DS3/E3 including tests of clock recovery



## Primary applications

- Mobile backhaul
- Business services delivery
- PBX Interconnect

# What is Circuit Emulation Over Ethernet?



- Industry's first formal definition of CES standards over Ethernet
- CESoETH “tunnels” TDM traffic through a Carrier Ethernet network
  - Packet network “emulates” a circuit-switched network, re-creating the TDM circuit
  - Invisible to TDM source and destination equipment
  - Runs on a standard Ethernet Line Service (E-Line)
- Treats the CEN as a “virtual wire” between two TDM networks

**CESoETH can be delivered over any Ethernet access technology!**



# Ethernet Over Direct Fiber

## Longest Distance

- Distance up to 140 Km with no bandwidth loss

## Highest Bandwidth Capacity

- Bandwidth Capacity of 100 Mbps, 1 Gbps, 10 Gbps, 40 Gbps, and more.
- WDM enables multiple data streams per fiber link

## Security

- Physically secure medium with no EMF emission; nearly impossible to tap lines

## Scalability

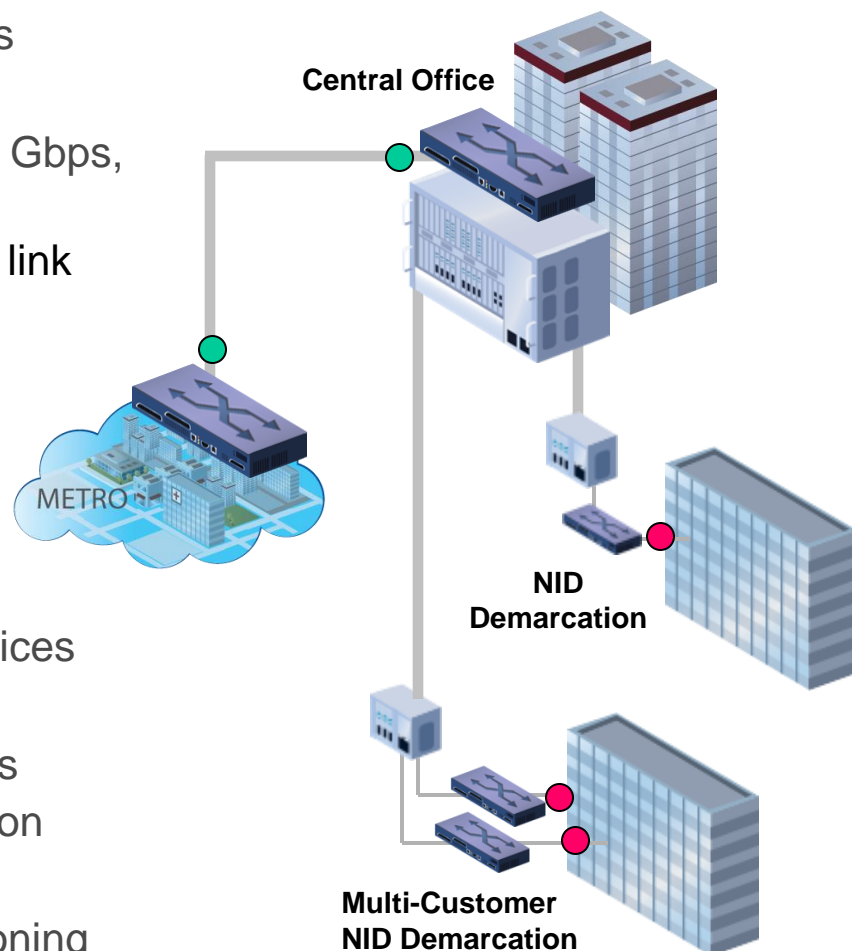
- EVC / E-Line / E-LAN using Q-in-Q VLAN\*  
\*Requires extension for s\_tag UNI
- High capacity enables rate limiting tiered services

## Reliability

- Protection with redundant links & resilient rings
- OAM performance monitoring & fault notification

## Secure Service Management

- 802.3ah OAM IP-less management & provisioning
- NIDs provide securely managed demarcation



# Ethernet Over WDM Fiber

## Future Proof

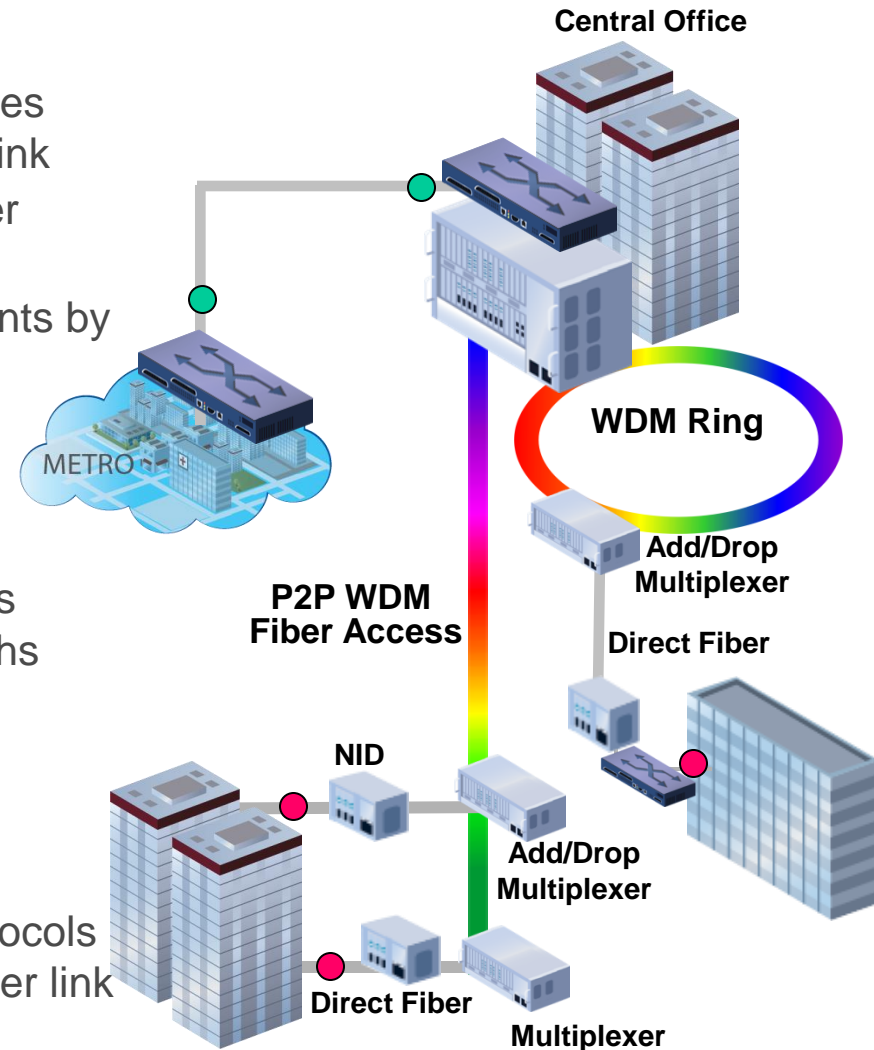
- Wavelength division multiplexing (WDM) enables multiple data streams (wavelengths) per fiber link
- CWDM supports up to 18 wavelengths per fiber access link, more with WDM
- Add/Drop multiplexers provide new access points by splicing into the WDM fiber link

## Cost Effective

- Increase fiber access capacity and minimize installation of new fiber links
- Small form pluggable transceivers, multiplexers and media converters enable WDM wavelengths with existing infrastructure equipment

## Scalability

- Quickly implement new fiber access with off-the-shelf hardware
- Wavelengths can deliver different network protocols to mix Ethernet and TDM services over one fiber link



# Ethernet Over HFC (Coax & Fiber)

## Cable uses a Hybrid Fiber Coax (HFC) network

- Network extends fiber to a node
- Coax is used for lower bandwidth sites while fiber is still used for large bandwidth sites
- Coax-fed and fiber-fed sites are integrated into a single network

## Cost effective alternative to Fiber

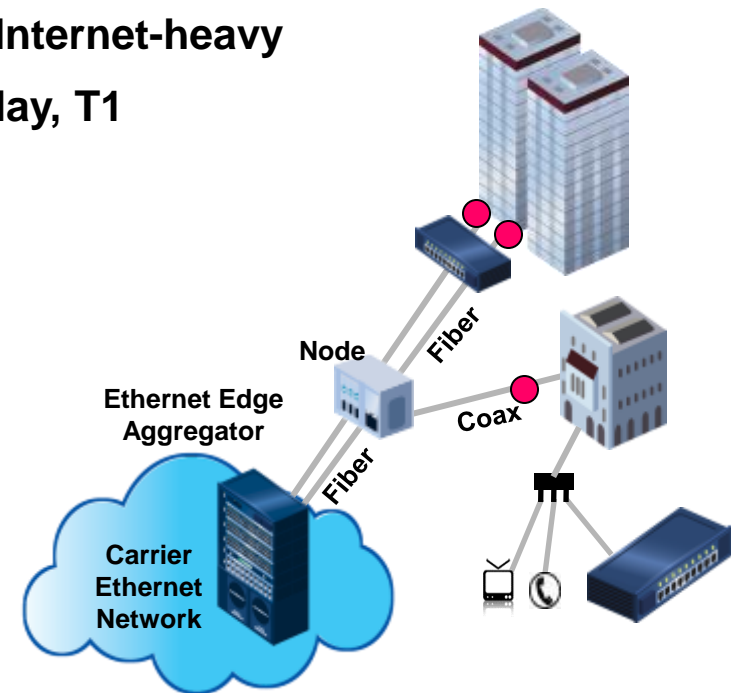
- Up to 100 Mbps with DOCSIS 3.0 implementation - scalable in 1 Mbps increments

## Typical Customer is Regional Business, Multi-site, Internet-heavy

## Alternative to Legacy Technologies ATM, Frame Relay, T1

## Typical Applications

- Branch office interconnectivity
- Dedicated Internet access
- Disaster recovery / business continuity
- Distance learning
- PACS images
- Automatic teller machine (ATM)
- Security cameras
- Point of sale (POS)
- Teleworker / remote employees



# Ethernet Over Bonded Copper

## Copper Pairs are Bonded to Create a Single Ethernet Pipe

- Long reach 2BASE-TL delivers a minimum of 2 Mbps using G.SHDSL
- Short reach 10PASS-TS delivers a minimum of 10 Mbps over VDSL

## Leverages Existing Copper to Fill Fiber Gap

- Only 22% of US and 15% of European businesses have access to fiber
- Nearly 100% of businesses have enough copper pairs to get up to 100 Mbps (reach permitting)

## Fast Service Turn Up, Fast Pay Back

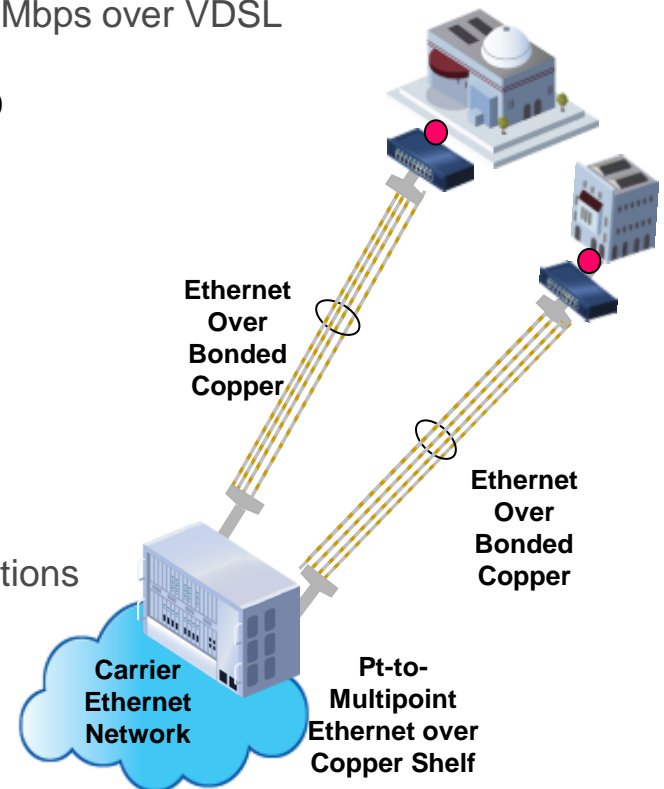
- Deploys in days or weeks
- Requires minimal CapEx

## High Bandwidth and Reliability

- Up to 10x more bandwidth than legacy copper solutions
- Pair failover capability ensures fiber service level agreements are met or exceeded

## Enables Ubiquitous Service Offerings

- Provides services out to reaches that cover majority of providers' serving area



# Ethernet Over TDM

## Ubiquitous Access

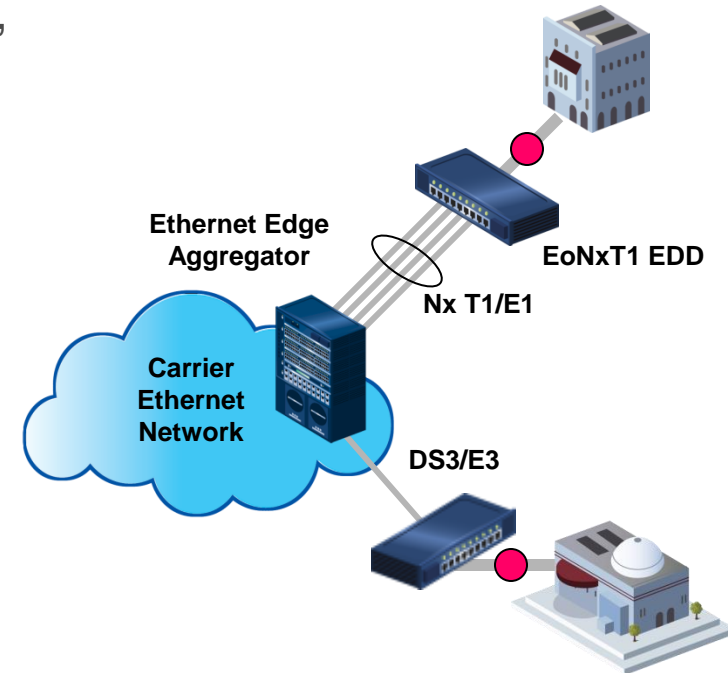
- T1 and E1 circuits are universally available, even when fiber is not
- No distance limitations

## Rapid service turn-up

- Leverages existing infrastructure
- Well understood provisioning and billing for off-net applications

## Flexible and resilient bonding

- Service stays up even if one link breaks
- Add and delete links hitlessly



	Available Service Bandwidth	Standard Encapsulation Technologies	Standard Circuit Bonding Technologies
Ethernet over T1/E1	1.5 Mbps (T1) up to 16 Mbps (with bonding) and 2Mbps(E1)	PPP, GFP, HDLC, G.998.2	MLPPP, PDH VCAT G.998.2
Ethernet over DS3/E3	34 Mbps up to 130 Mbps (with bonding) and 45Mbps (E3)	X.86, GFP, G.998.2	PDH VCAT, G992.2, LAG

# Ethernet Over PON

## PON Simplifies Business Park Coverage

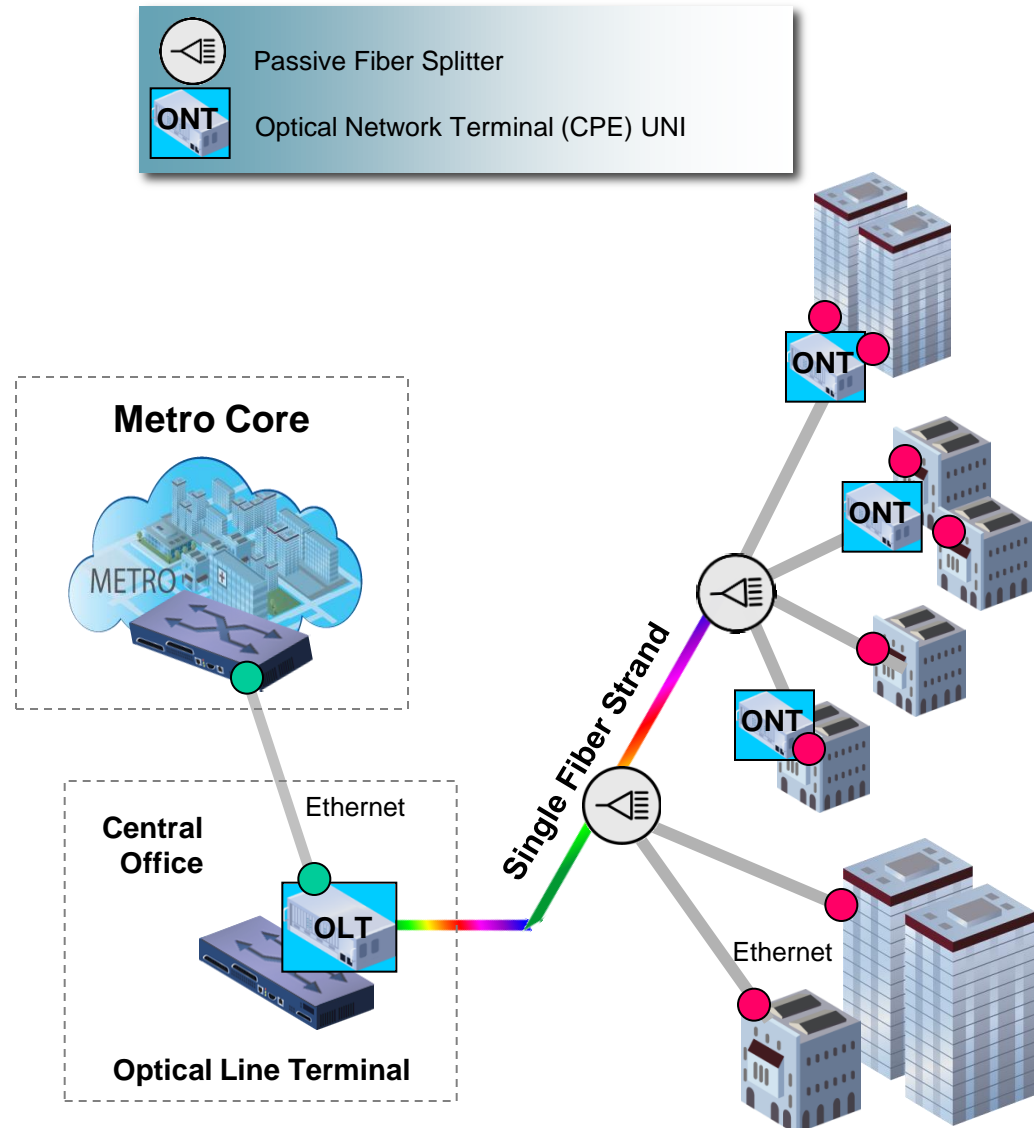
- 1 Fiber strand is split at business parks
- Splitters: pole mounted or on cables
- Passive splitters serve multiple ONTs
- ONT can be mounted outside
- PON prevents fiber exhaust
- Quick new customer adds

## OPEX Savings & Lowest first cost

- Remote ONT activation
- Each ONT serves multiple drops
- Minimal outside plant maintenance
- No power or permits needed
- Affordable "Managed UNI" demark

## Embedded Service Layering

- E-LANs (MEF9)
- T1 & E1 backhaul ports
- IP-POTS ports



# Ethernet Over PON

## OPEX Savings

- **Passive outside plant lowers costs**
- No power or maintenance of active equipment
- Affordable “Managed UNI” demark
- **Up to 10Gbps per PON**

## Lowest First Cost for Fiber

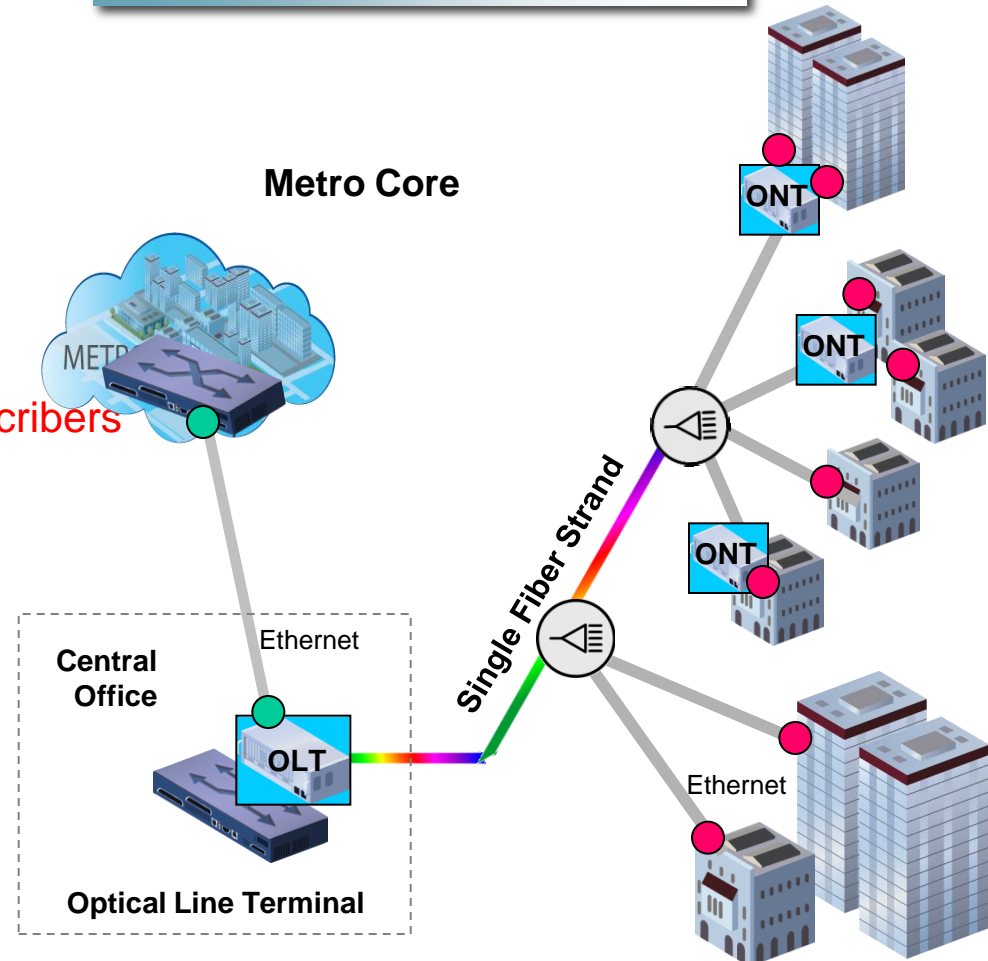
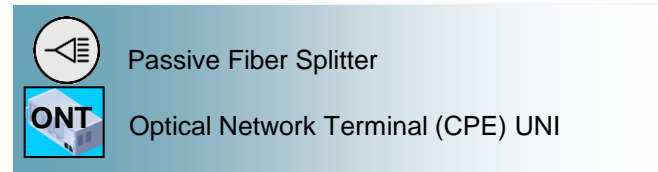
- **Most fiber efficient access technology**
- **Conserves existing fiber**
- **Minimizes need for new fiber**

## PON Simplifies Coverage

- 1 Fiber strand is split among **up to 64 subscribers**
- Splitters: pole mounted or on cables
- Passive splitter serve multiple ONTs
- ONT can be mounted outside
- PON **addresses** fiber exhaust
- Quick new customer adds

## Embedded Service Layering

- **Supports E-LINE, E-LAN, E-Tree**
- T1 & E1 backhaul ports
- IP-POTS ports





# Ethernet Over SONET/SDH

## Rapid service turn-up

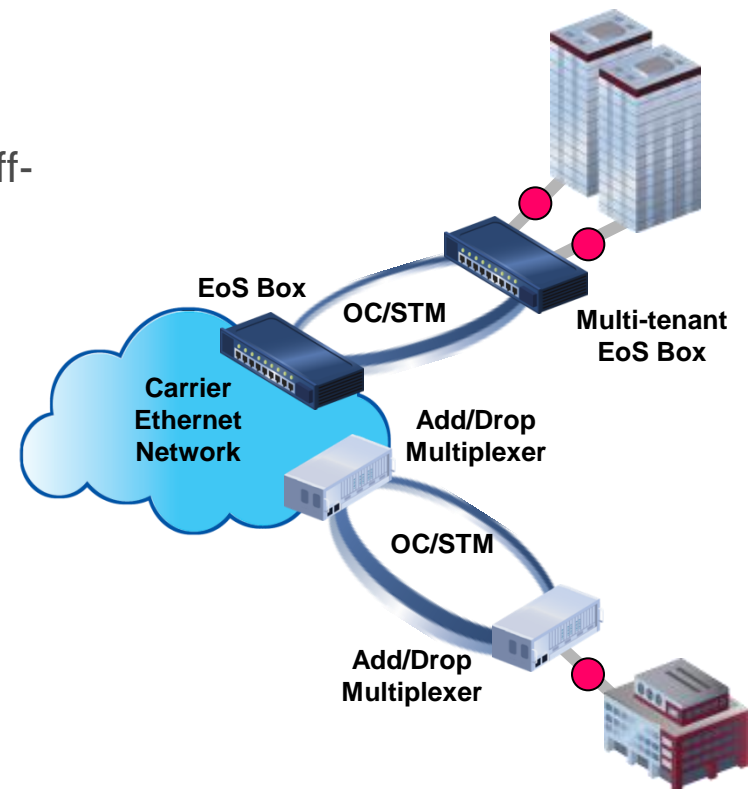
- Leverages existing equipment and fiber plant
- Ubiquitous availability world wide
- Well understood provisioning and billing for off-net applications
- Ethernet enable on-net buildings

## Highly resilient and secure service

- Sub-50ms resiliency
- Secure multi-tenant services
- Legacy TDM circuits supported natively

## Flexible bandwidth options

- OC-3/STM1 up to OC-192/STM64 physical
- Sub-rate and Nx OC/STM are available with VCAT bonding
- Each channel carries one or more EVCs



	Available Service Bandwidth	Standard Encapsulation Technologies	Standard Circuit Bonding Technologies
Ethernet over SONET/SDH	155 Mbps up to 1 Gbps)	X.86, GFP	VCAT, LAG



# Ethernet Over Packet Microwave

## Packet Microwave Technology

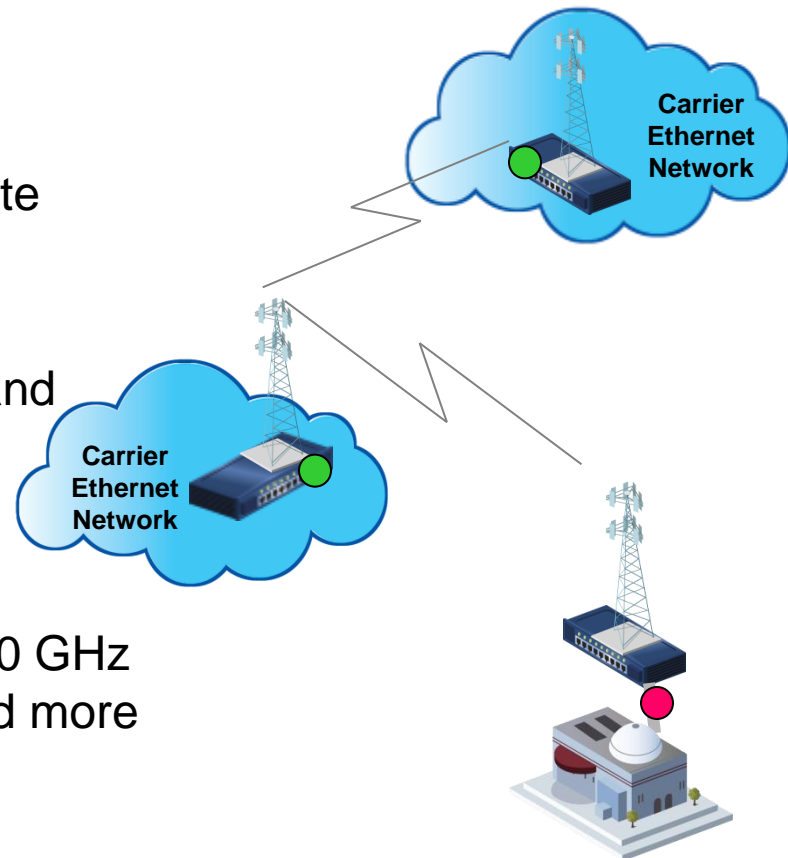
- Cost effective solution
- Rapid service deployment to virtually any site
- Independent of existing wired infrastructure

## Deployment Scenarios

- Complementary and alternative to access and aggregation fiber networks
- Mobile Backhaul networks
- Used in green field deployments, for network expansion and/or upgrades
- Typically used frequency bands from 6 to 40 GHz
- Distances of several 100m up to 150km and more

## Carrier Grade Technology

- Mature, widely deployed solutions
- Scalable throughput up to several Gbps
- Established radio planning and dimensioning methods for highest availability requirements



- User to Network Interface (UNI)
- Network to Network Interface (NNI)

# Packet Microwave - MEF perspective

- **Packet microwave receiving much attention in with many proprietary definitions**
- **Industry definition from recent MEF paper [1]:**
  - “Packet Microwave converges the Ethernet and Non-Ethernet (e.g. TDM, ATM) traffic over a single packet transport layer called the multiservice aggregation layer. This is done using industry standard Pseudo-Wire and Circuit Emulation technologies e.g.
    - CESoE (MEF-8) SAToP, CESoPSN, ATM PWE3; and others”.

[1] MEF, “Microwave Technologies for Carrier Ethernet”, January 2011,  
[http://metroethernetforum.org/PDF\\_Documents/MEF\\_Microwave\\_Technology\\_for\\_Carrier\\_Ethernet\\_Final\\_110318\\_000010\\_000.pdf](http://metroethernetforum.org/PDF_Documents/MEF_Microwave_Technology_for_Carrier_Ethernet_Final_110318_000010_000.pdf)

# Packet Microwave - Building Blocks

- **An interworking function that assures the encapsulation of legacy non-packet traffic at the ingress into packet streams**
  - Non-Ethernet (legacy) traffic is handled through circuit emulation services, as CESoE (MEF-8), SAToP/CESoPSN, or pseudowires
  - Standard Ethernet interfaces, either on the access or network side
- **A Carrier Ethernet switch**
- **A Microwave Aware Transmission function**

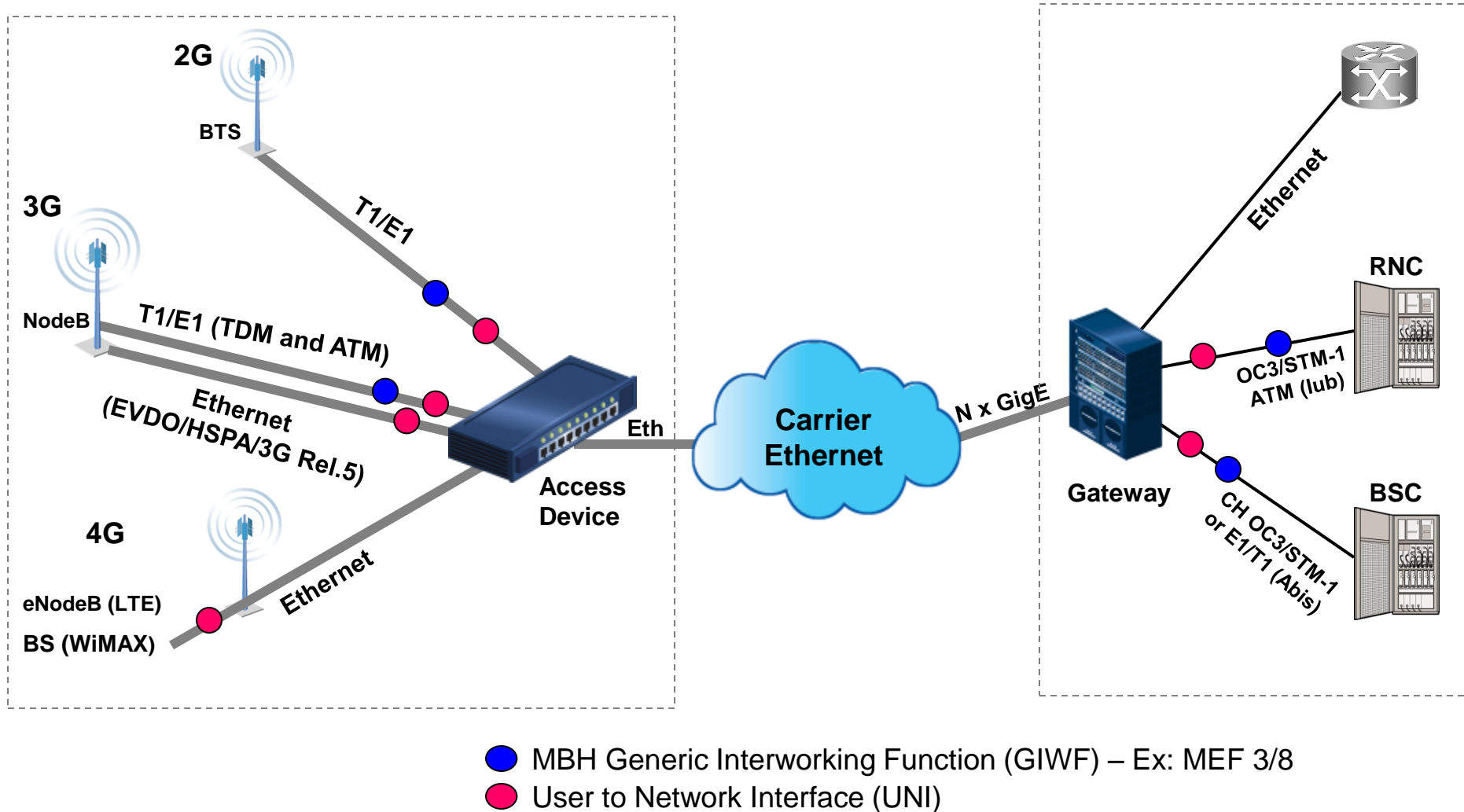
# MEF

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**WiMax in Mobile Backhaul  
and other Wireless Backhaul/Access Transport**

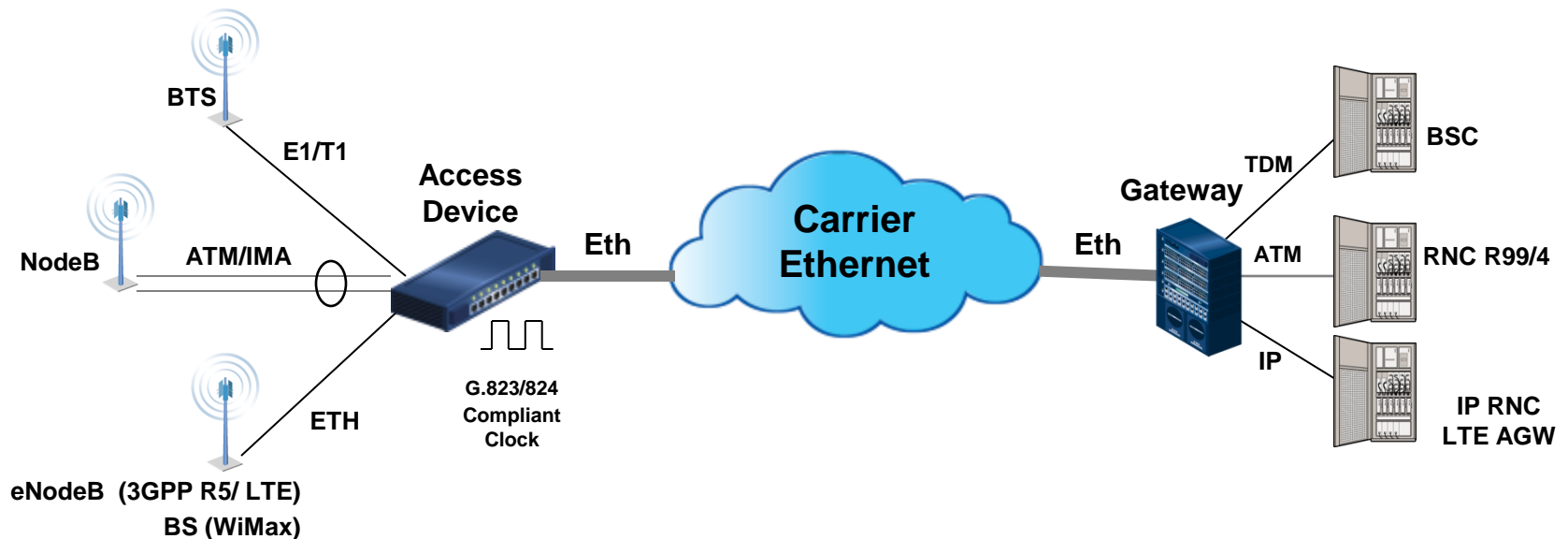
**Also see MEF Mobile Backhaul  
Reference Presentation**

# Multiple Generations of Mobile Backhaul



# Next-Gen RAN Transport Network

- Carrier Ethernet can be supported over different physical transports
- Carrier Ethernet supports backhaul of all mobile generations over a single pipe
- Carrier Ethernet enables high, scalable, and flexible bandwidth at lower cost
- Five-Nines availability, redundancy, and OA&M supported using Carrier Ethernet
- Carrier Ethernet positions the RAN for WCDMA, LTE, and WiMAX backhaul



# Ethernet / TDM Services at the RAN

## **Backhaul is migrating from legacy TDM/ATM to Ethernet**

- The introductions of all IP technologies like EVDO, WCDMA R.5, LTE, and WiMAX require IP backhaul in addition to the legacy TDM/ATM.

## **Ethernet is the right choice for growing data services**

- The introductions of All-IP technologies like EVDO, WCDMA R.5, LTE, and WiMAX require IP backhaul in addition to the legacy TDM/ATM.

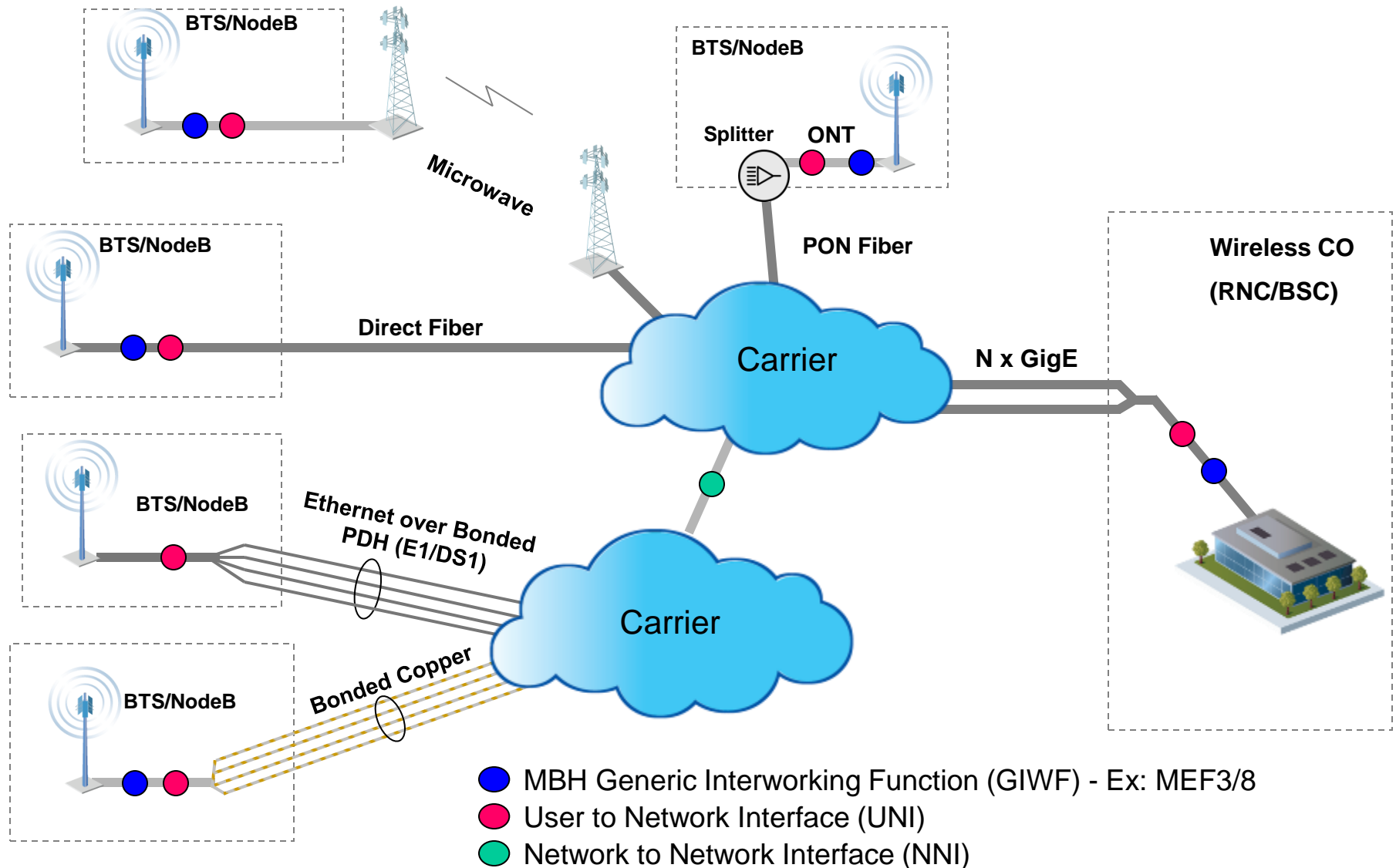
## **Multiple access technologies are available**

- A Carrier Ethernet RAN (Radio Access Network) can be achieved using a combination of different physical transport technologies based on availability. Examples: Fiber, Copper Bonding, Circuit Bonding, and Microwaves.

## **All RAN traffic can be supported on single Carrier Ethernet connection**

- The MBH Generic Interworking Function (GIWF) enables the backhaul of any combination of 2G, 2.5G, 3G, Evolved-3G and 4G voice and data traffic over a single Carrier Ethernet RAN.
- The MBH GIWF allows a combination of Ethernet, MEF 3/8 based CESoPSN/SAToP, and IETF based ATM/Frame Relay/HDLC PWE3 over a single pipe.

# Multi Physical Transport Mobile Backhaul





# Service Convergence for Multiple Generations

Wireless Generation	Cell Site Interface	RNC/BSC Interface	Supported Service
GSM, CDMA	TDM: T1/E1, DS3/E3, OC3/STM-1	TDM: T1/E1, DS3/E3, OC3/STM-1	MEF 3/8 (Emulation of PDH Circuits over Metro Ethernet Networks) based CESoPSN/SAToP
WCDMA based UMTS R.99/4, HSDPA,	ATM & ATM IMA: T1/E1, DS3/E3, OC3/STM-1	ATM: T1/E1, DS3/E3, OC3/STM-1	MEF 3/8 based CESoPSN/SAToP IETF based ATM PWE3 (RFC4717)
CDMA2000: 1xRTT, 1xEVDO	HDLC: T1/E1, DS3/E3	HDLC: T1/E1, DS3/E3, OC3/STM-1	MEF 3/8 based CESoPSN/SAToP IETF based HDLC PWE3 (RFC 4618)
iDEN	FR: T1/E1, DS3/E3	FR: T1/E1, DS3/E3, OC3/STM-1	MEF 3/8 based CESoPSN/SAToP IETF based FR PWE3 (RFC 4619)
WCDMA/UMTS R.5, EVDO, WiMAX, LTE	Ethernet: Fast Ethernet	Ethernet: GigE	Ethernet Services May based on IETF based Ethernet PWE3 (RFC 4448)

# MEF

## NICC Ethernet Active Line Access



## Potential Additional Business Opportunities

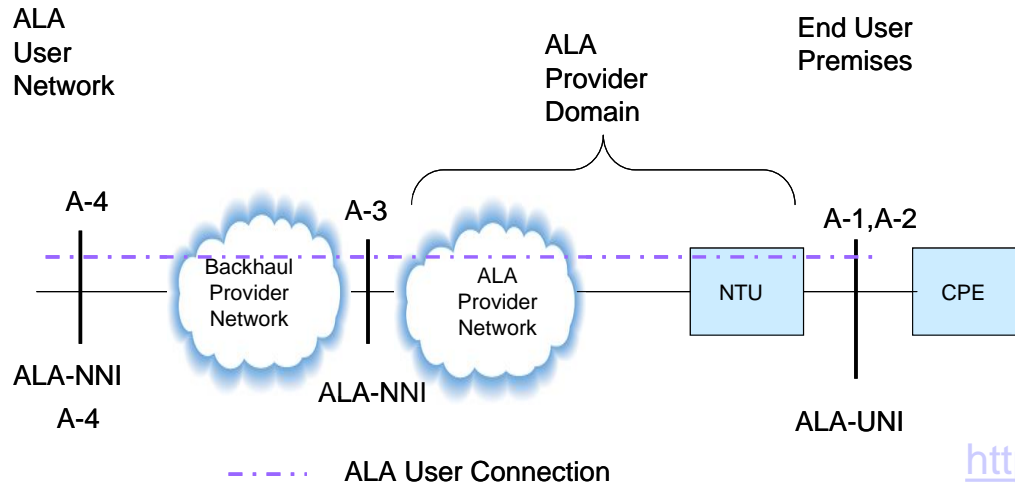
- **Why this is of Interest**

- Carrier Ethernet is designed for business class services delivery
- ALA allows consumers access to multiple service providers from a single low cost NTU device

- **E-Access with ALA**

- Potentially enables low cost delivery of business class services to SOHO and tele-worker users
- **Opens up a large new market for Carrier Ethernet Services**

# NICC Ethernet Active Line Access



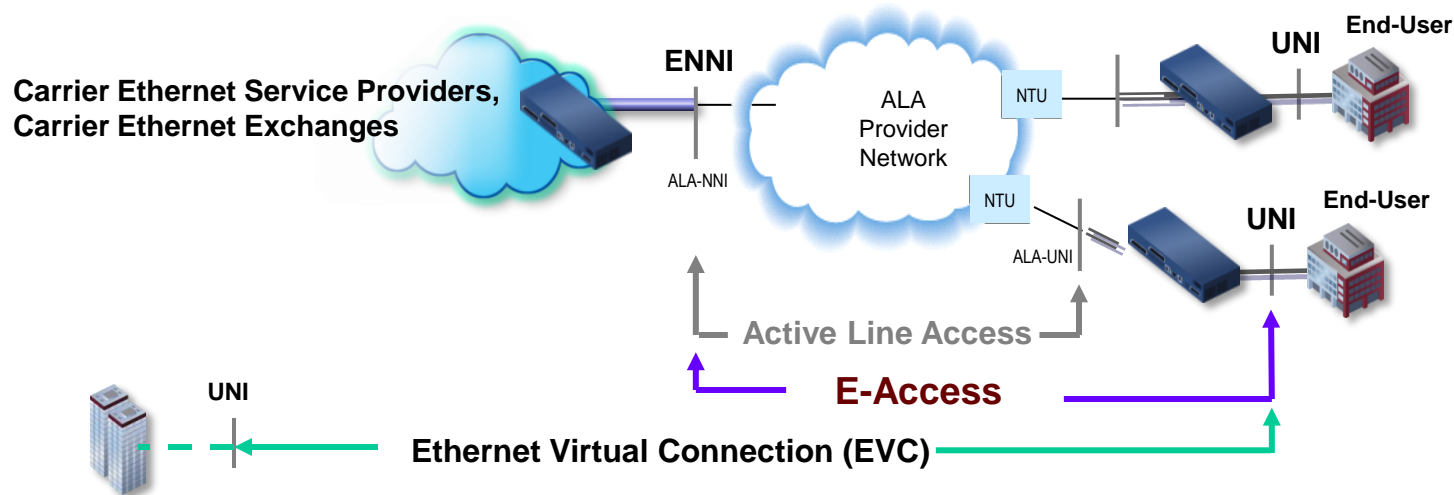
<http://www.niccstandards.org.uk>

- **Developed by NICC from UK regulator initiative (OFCOM)**
- **Supports multiple service providers on equal basis**
- **Access to any (served) end user site**
- **Ethernet is the unifying layer - MEF ENNI interfaces**
- **Agnostic to underlying technology**
  - GPON, xDSL, Active Ethernet, WDM-PON etc.

**Ethernet based Wholesale Access Services for smaller premises**

# E-Access delivered over NICCC ALA

- **Many infrastructures can be used for E-Access (MEF is agnostic)**
  - ALA likely to be applied mostly in SoHo and SME areas
- **Access Operators' business case enhanced:**
  - ALA for MEF business services
  - ALA for BBF residential services
- **Various deployment options to suit local markets**
  - Access technology
  - Local Access or Local Access + Backhaul



# Access Methods & Speeds

Access Method	Speed
Ethernet over Active Fiber	10 Mbps, 100 Mbps, 1 Gbps, 10 Gbps, 40 Gbps, 100 Gbps
Ethernet over PON	1 Gbps with EPON 1.25 Gbps upstream & 2.5 Gbps downstream with GPON
Ethernet over SONET/SDH	155 Mbps to 1 Gbps
Ethernet over HFC/DOCSIS	Up to 100 Mbps with DOCSIS 3.0
Ethernet over DSL	Minimum of 2 Mbps using G.SHDSL Minimum of 10 Mbps over VDSL Up to 100 Mbps (asymmetric)
Ethernet over T1/E1	1.5/2Mbps to 16 Mbps with bonding
Ethernet over DS3/E3	34/45 Mbps to 130 Mbps with bonding
Ethernet over Packet Microwave	1 Mbps to >1Gbps
Ethernet over WiMax	Varies with distance: Up to 1Gbps. <70Mbps at 50km

# Access Methods & Applicable Standards

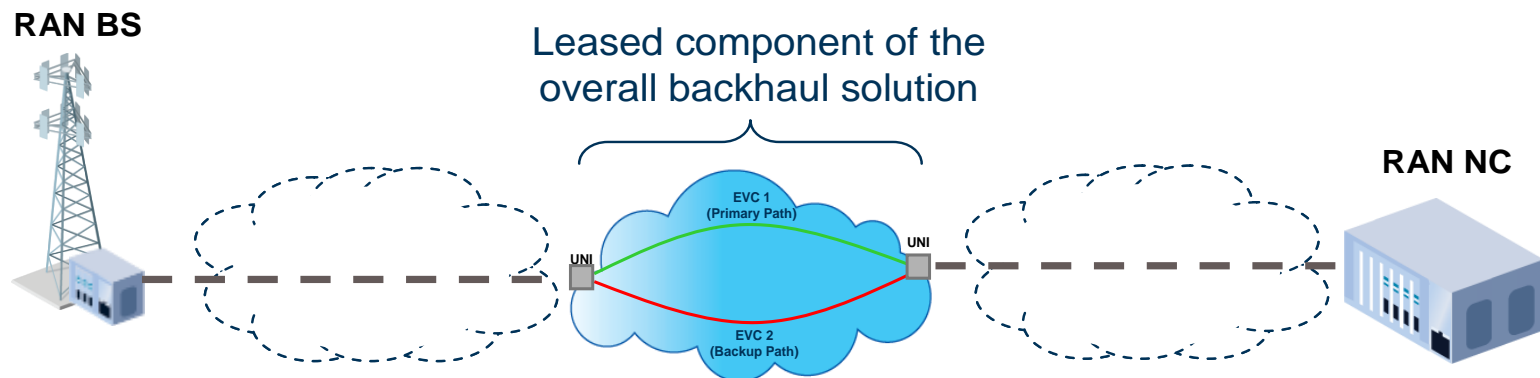
Carrier Ethernet Access Method	Technology	Applicable Standards
Fiber	Ethernet over Active Fiber	IEEE 802.3-2005
	Ethernet over SONET/SDH	TU-T X.86 encapsulation ITU-T G.707 and G.7043 (GFP-VCAT)
	Ethernet over Passive Optical Network	IEEE 802.3-2005 (EPON) IEEE 802.3av (10GEAPON) ITU-T G.984 (GPON) Broadband Forum WT-156, WT-167
	Ethernet over HFC/DOCSIS	DOCSIS 1.x, 2.x, 3.0, EuroDOCSIS
Copper	Bonded T1/E1	RFC1990 (Multilink PPP) and RFC3518 (BCP) ITU-T G.7041 and G.7043 (GFP-VCAT) ITU-T G.998.2 (G.bond)
	DS3/E3 and bonded DS3/E3	ITU-T X.86 encapsulation with optional link aggregation ITU-T G.7041 and G.7043 (GFP-VCAT) ITU-T G.998.2 (G.bond)
	2BASE-TL	IEEE 802.3-2005 2BASE-TL using ITU-T G.991.2 (G.SHDSL.bis) Broadband Forum WT-201
	10PASS-TS	IEEE 802.3-2005 10PASS-TS using ITU-T G.993.1 (VDSL)
Wireless	Packet Microwave	IEEE 802.3-2005 user interface
	WiMAX	IEEE 802.16
	Free space optics	IEEE 802.3-2005 user interface
	WiFi	IEEE 802.11
	LTE	3GPP LTE Release 8

# Resiliency/Protection

- **MEF Service Specifications augment industry standards**
- **In totality, they address port and service protection, fault detection and restoration**
  - At the UNI ports
  - At the ENNI (for direct and Exchange connections)
  - For UNI to UNI (EVCs)
  - UNI-ENNI OVCs

Protection
✓ 1+1 APS
✓ LAG (802.1ax LACP)
✓ Dual Homing
✓ Ring (G.8032)
✓ Linear Protection (G.8031)

- **The following is one option for Mobile Backhaul showing Active/Standby**





# MEF Reference Presentations

## MEF Reference Presentations Covering the Principal Work of the MEF

<b>Overview presentation of the MEF.</b>	This presentation gives basic and most up-to-date information about the work of the MEF. It also introduces the definitions, scope and impact of Carrier Ethernet, the MEF Certification programs and describes the benefits of joining the MEF.
<b>Overview presentation of the Technical Work of the MEF</b>	Includes a summary of the specifications of the MEF, structure of the technical committee, work in progress and relationships with other Industry Standards bodies. For PowerPoint overviews of individual specifications: <a href="#">click here</a>
<b>Carrier Ethernet Services Overview</b>	This presentation defines the MEF Ethernet Services that represent the principal attribute of a Carrier Ethernet Network
<b>Carrier Ethernet User-Network Interface</b>	This presentation discusses the market impact of MEF 20: UNI Type 2 Implementation agreement
<b>Carrier Ethernet Access Technology Overview</b>	This presentation describes how the MEF specifications bring Carrier Ethernet services to the world's Access networks (with examples of Active Ethernet (Direct Fiber), WDM Fiber, MSO Networks(COAX and Direct Fiber), Bonded Copper, PON Fiber and TDM (Bonded T1/E1, DS3/E3))
<b>Carrier Ethernet Interconnect Program.</b>	This is the latest presentation from the Carrier Ethernet Interconnect Working Group which acts as a framework for all presentations given on this topic.
<b>Carrier Ethernet OAM &amp; Management Overview</b>	This presentation describes the management framework and the OAM elements for fault and performance management expressed in terms of the life cycle of a Carrier Ethernet circuit
<b>Carrier Ethernet for Mobile Backhaul</b>	A comprehensive marketing and technical overview of the MEF's initiative on Mobile Backhaul that has lead to the adoption of Carrier Ethernet as the technology of choice for 3G and 4G backhaul networks
<b>Carrier Ethernet Business Services</b>	A comprehensive presentation aimed at business users
<b>The MEF Certification Programs</b>	A presentation of the MEFs three certification programs: Equipment, Services and Professionals. These programs have been a cornerstone of the success of Carrier Ethernet and its deployment in more than 100 countries around the world.

# MEF

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**End of Presentation**