MEF

METRO ETHERNET FORUM

Mobile Backhaul, Circuit Emulation Services, MEF Certification and MEF 18 Update

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http://www.metroethernetforum.org

Agenda

- Mobile Network Evolution
  - RF innovations
  - Business and service trends
- Mobile Backhaul Implementation Agreement
- Circuit Emulation Services - CES
  - MEF 3 and MEF 8 overviews
- MEF Certification Program Overview
- MEF 18 Technical Specification
  - Abstract Test Suite for Circuit Emulation Services over Ethernet, based on MEF 8

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Mobile Network Evolution

Our Wireless Future

Voice, email, surfing → Photos, music, video download → Mobile TV

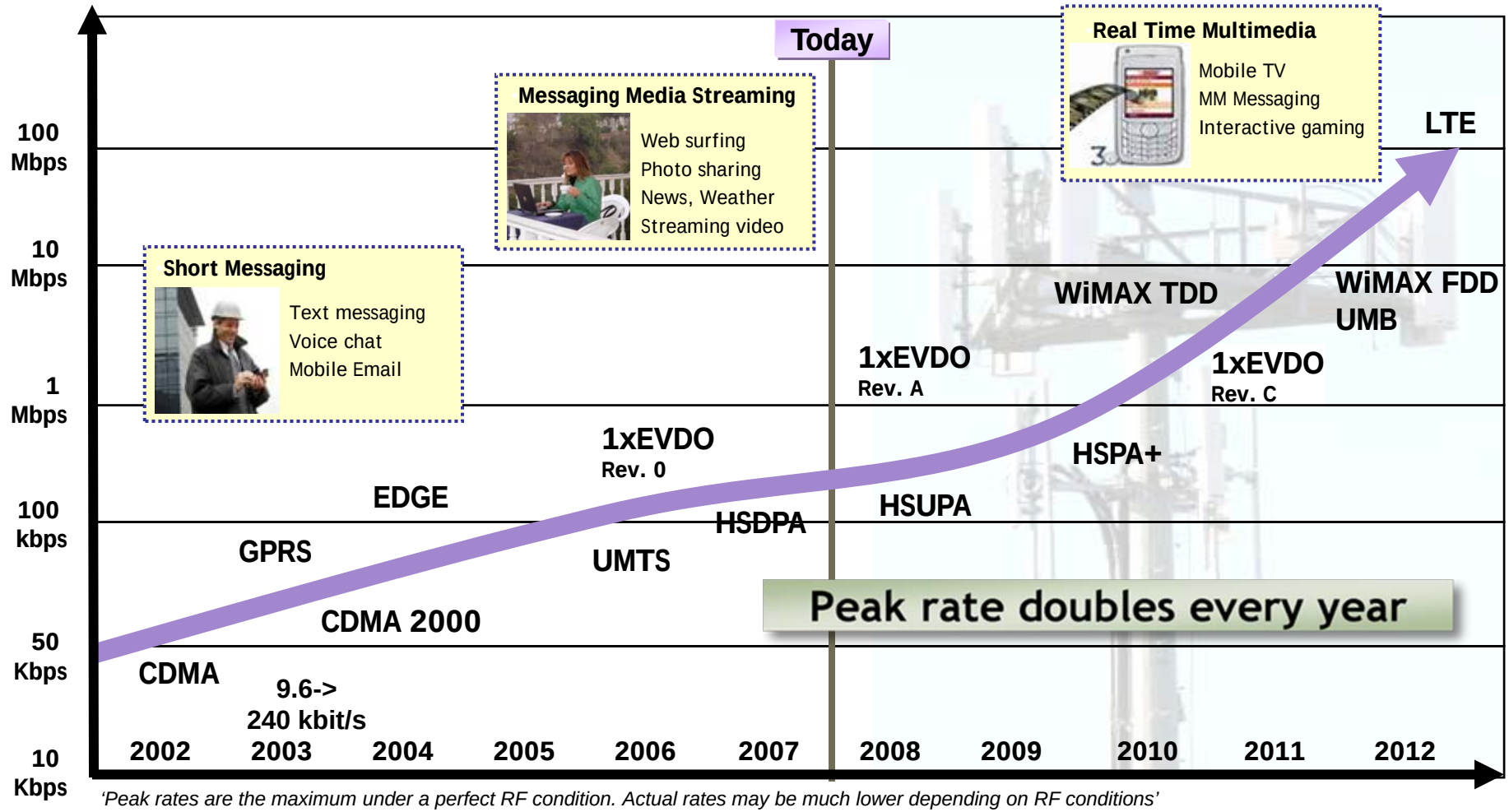
mobiTV · Google · FOX SPORTS MOBILE · fon · skype · YouTube · myspace.com · MTV · ESPN MOBILE PRODUCTS

Ubiquitous Narrowband → Ubiquitous Broadband

Growing number of devices connected
17 Billion devices by 2010

RF Innovations and New Multimedia Applications

Drive Mobile Network Bandwidth Requirements and Evolution



'Peak rates are the maximum under a perfect RF condition. Actual rates may be much lower depending on RF conditions'

As throughput becomes ever faster and cheaper, ubiquitous broadband coverage becomes a reality, creating real change for all...

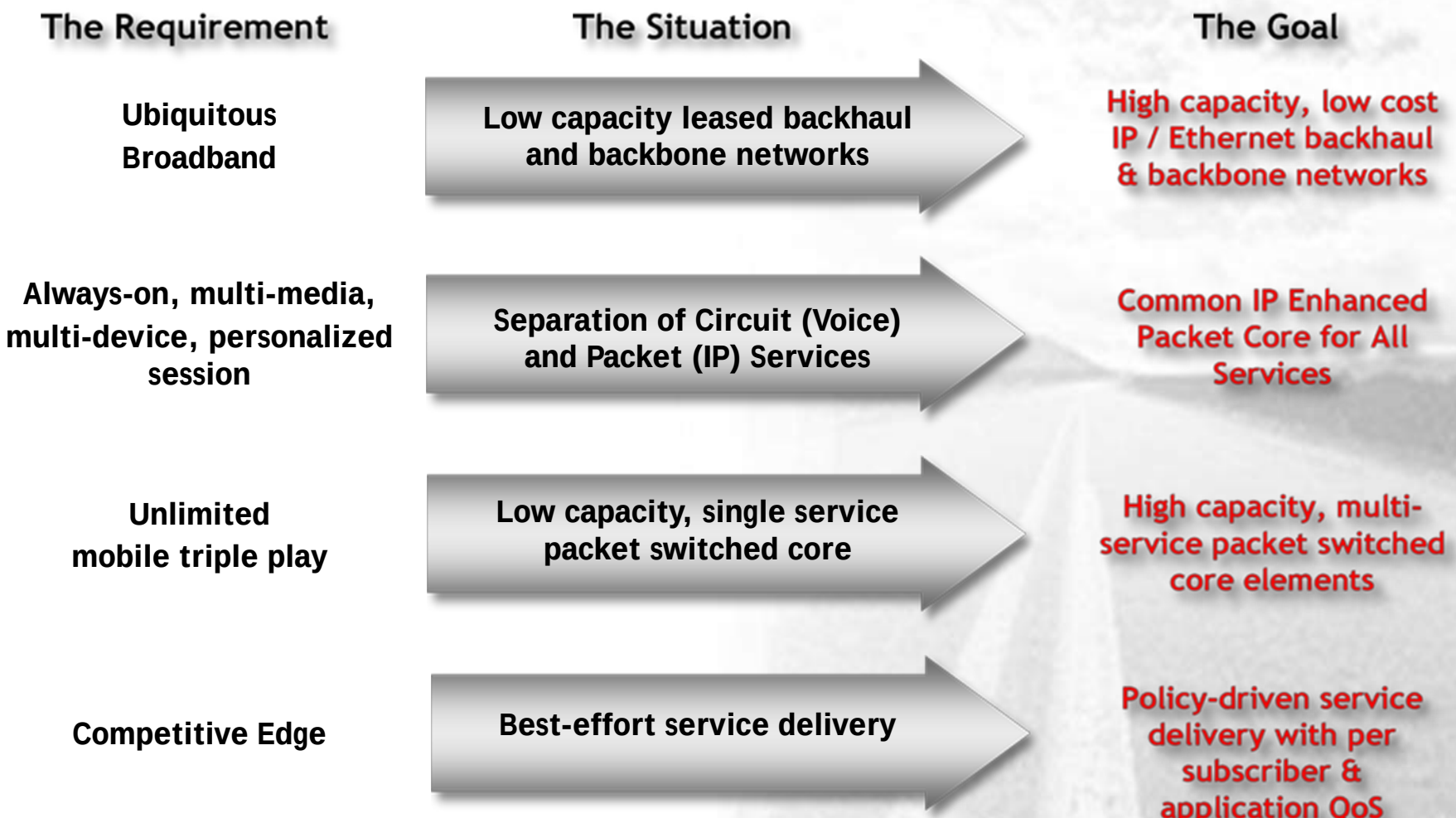
Business & Service Trends

Drive Mobile Network Evolution . . . . .

Narrowband	REACH	Broadband
Voice-centric and SMS	SERVICES	Data-centric, rich multimedia
Connectivity	CORE BUSINESS	Connectivity, context[1] and content
Pay-as-you-go	PRICING MODEL	Unlimited mobile triple-play

[1]personalization, advertising

. . . Which Require Fundamentally Different Network Infrastructures

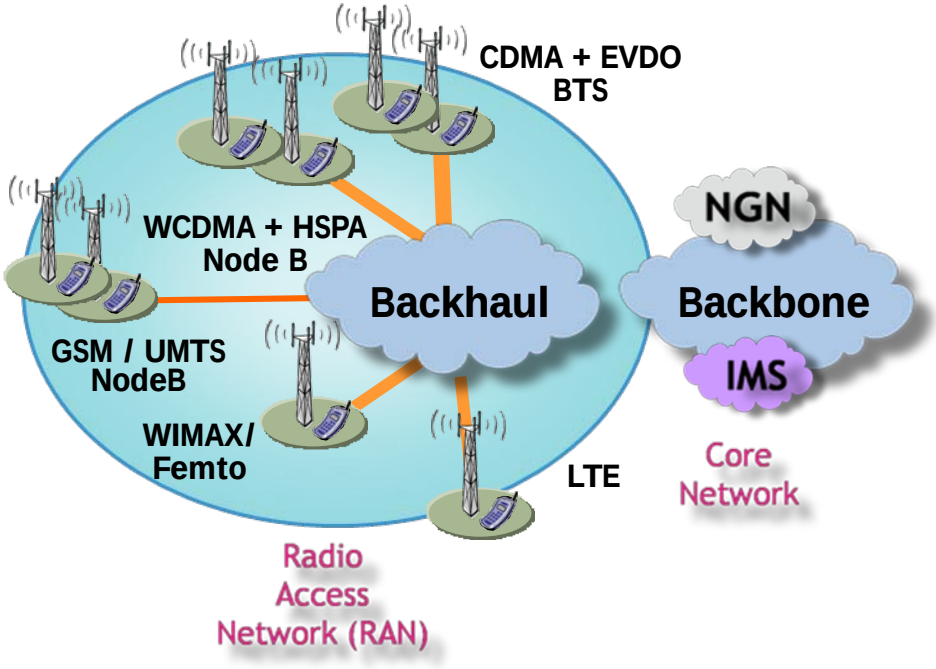


Mobile Network Evolution

- **Simplify the Network**
  - Consolidate on a single Ethernet IP transport network
  - Efficient migration from TDM to packet

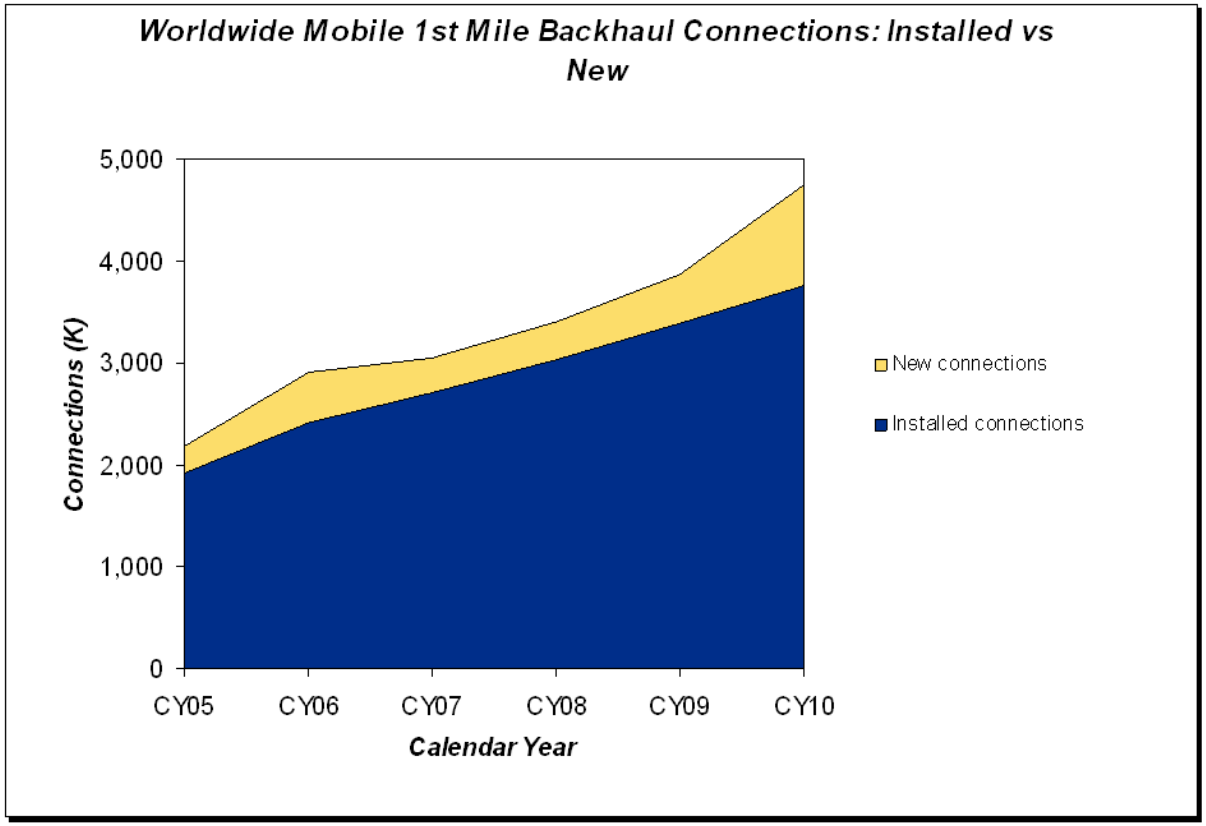
- **Increase Revenue - ARPU**
  - Deliver new services faster
  - Drive value with personalized services

- **Decrease Costs - Opex**
  - Increase transport capacity (bw) at less cost with Ethernet
  - Improve operational agility with common transport



Mobile backhaul transport networks are evolving to **Ethernet/IP** to support more capacity at lower cost

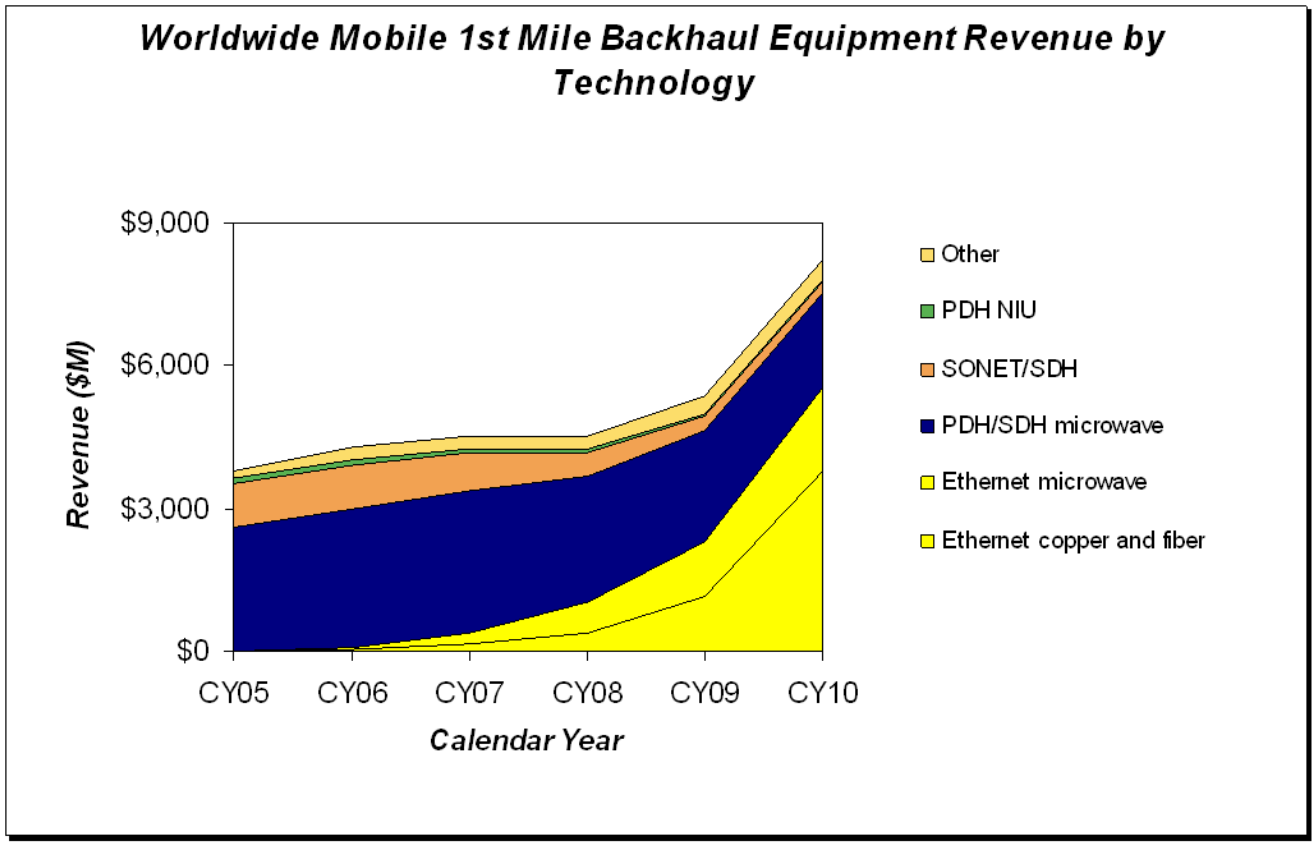
Worldwide Cell Site Backhaul Connections Growing



Source: Infonetics Research Mobile Backhaul Equipment, Installed Base & Services, 2007

- Worldwide installed backhaul connections
  - 2006 = 2.9 million
  - 2010 = 4.8 million
- Ethernet fastest growing through 2010
- Mobile operators pay incremental charges for 2x to 10x bandwidth
  - New options solve major problem for operators

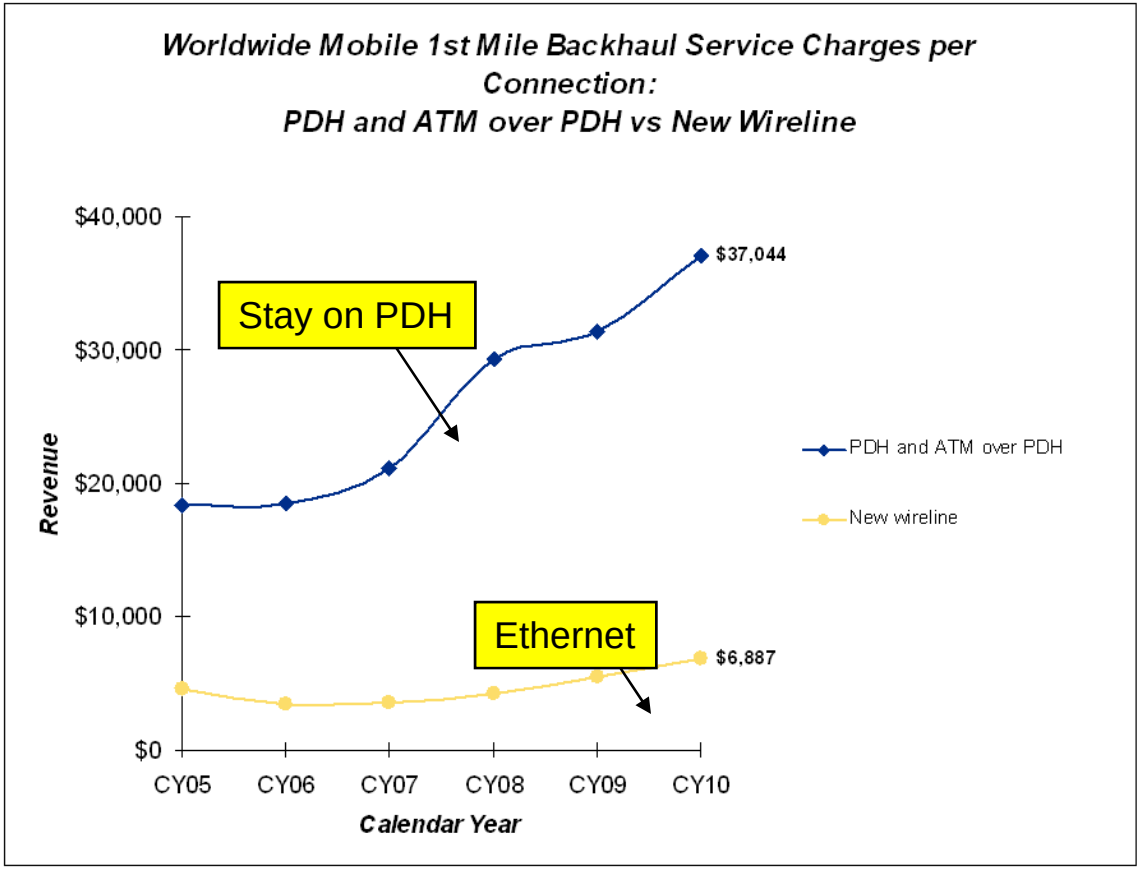
Mobile Backhaul Equipment Market Opportunity



Source: Infonetics Research Mobile Backhaul Equipment, Installed Base & Services, 2007

- Ethernet fastest growing
  - wireline
  - microwave

Ethernet Solves Backhaul Cost Problem

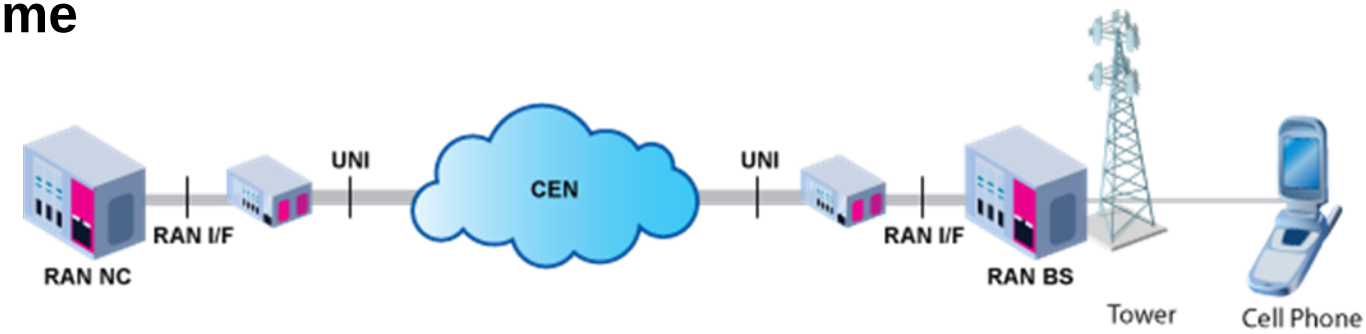


Source: Infonetics Research Mobile Backhaul Equipment, Installed Base & Services, 2007

- PDH (T1/E1 etc.) costs climb directly with bandwidth
- Ethernet wireline costs grow gently with large bandwidth increases (Eth, DSL, PON, cable)
- New IP/Ethernet wireline options to satisfy the #1 investment driver: operational cost savings

Key Reasons for Carrier Ethernet in Mobile Transport Networks

- **Carrier Ethernet**
  - Economically meets exploding bandwidth requirements currently constrained by the prohibitive costs of legacy networks
  - Leverage rapid move to Carrier Ethernet for wireline traffic enabling a single integrated wireline and mobile backhaul network
- **Most mobile traffic is broadband/IP centric**
  - Carrier Ethernet is optimized for packet data traffic
- **Overcomes TDM (T1/E1) services scalability**
  - Unlimited scalability and ubiquity
- **Smooth transition from legacy networks**
- **Protects investment and seamlessly bridges from TDM to Ethernet over time**



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Mobile Backhaul Implementation Agreement

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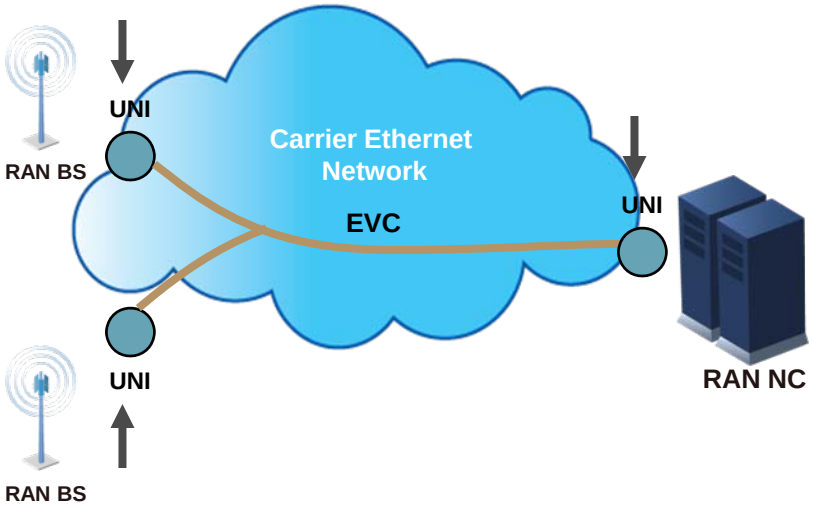
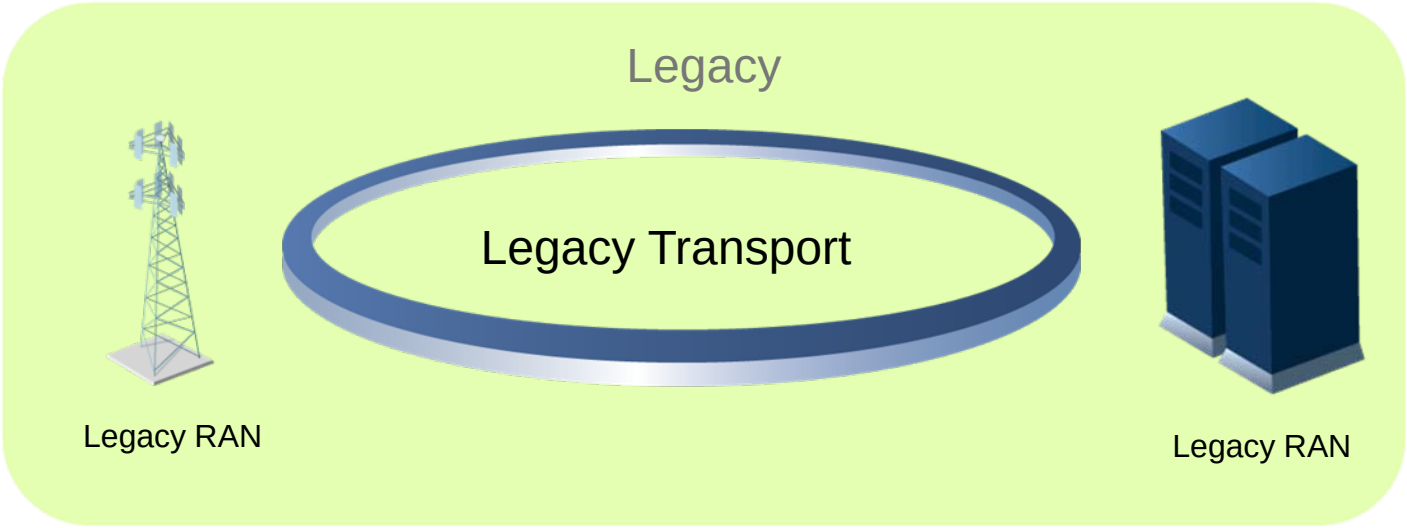
Mobile Backhaul Implementation Agreement

- **The structure of the document provides generic guidelines for several mobile technologies – specific guidelines for a given mobile technology may also be specified**
- **MEF Goals**
  - Standardized services
  - Certification
  - Interoperability
- **UNI Requirements**
  - Ethernet OAM (Link OAM and Service OAM)
  - Protection and Fault Recovery Requirements
- **Service Requirements**
  - CoS Requirements
  - Service Definitions
  - Synchronization



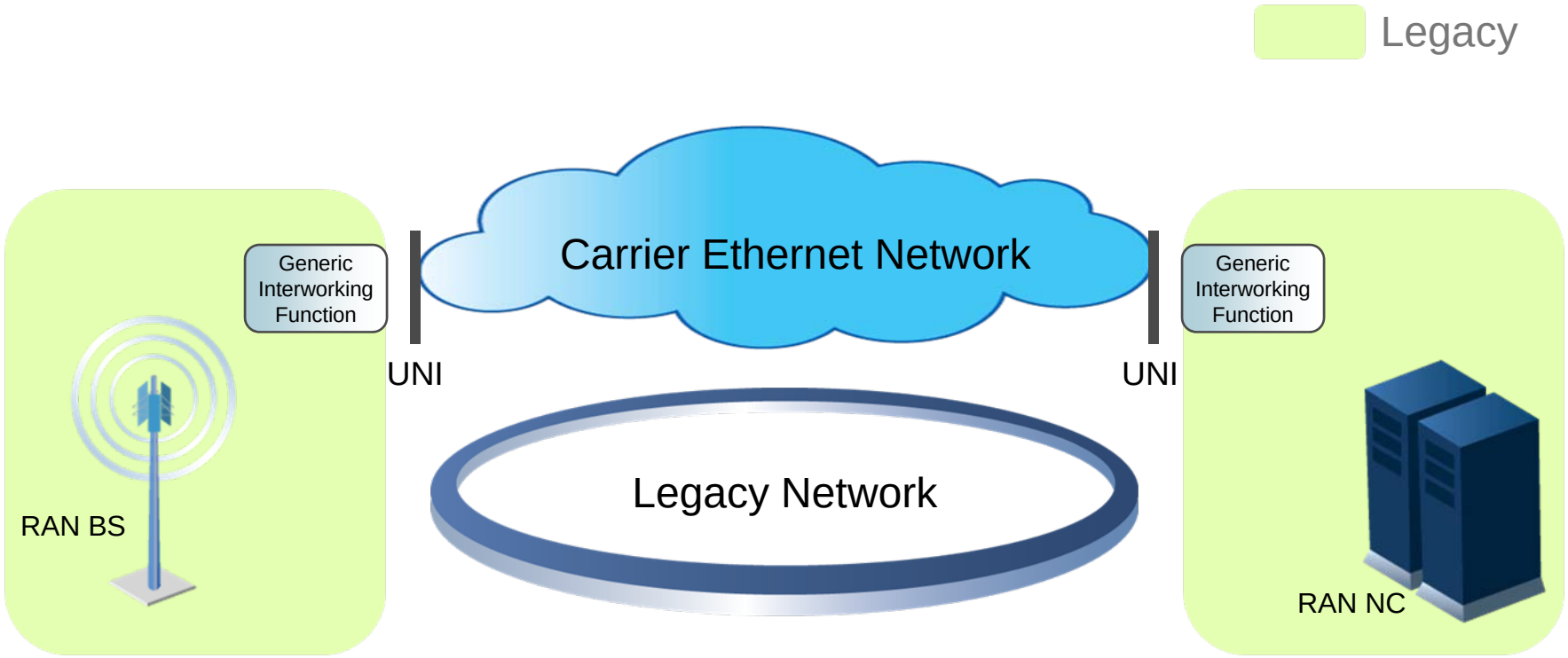
Today's Mobile Backhaul and MEF Use Cases

- The Implementation Agreement identifies four generic deployment scenarios that capture the main short term and long term deployment possibilities



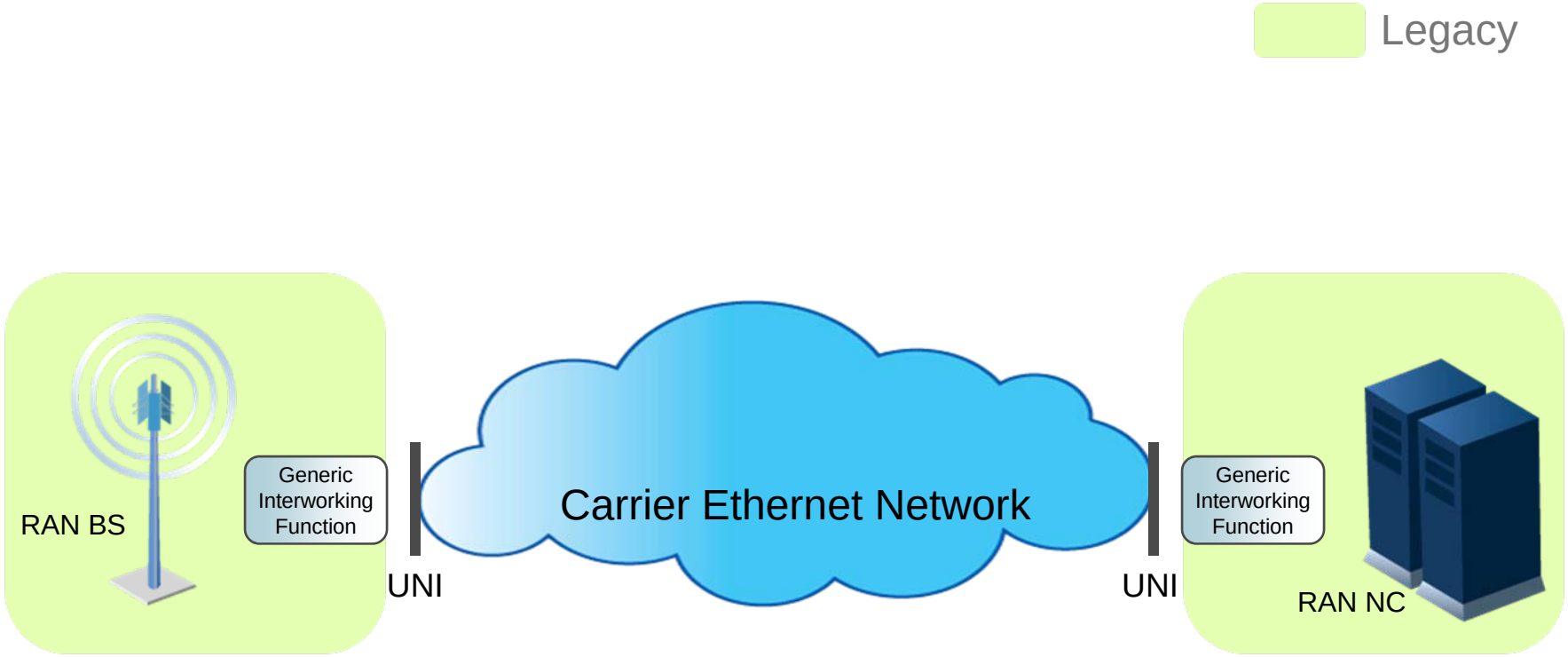
Legacy = "non-packet RAN" and "non-packet transport"

Packet offload over carrier Ethernet – 1a



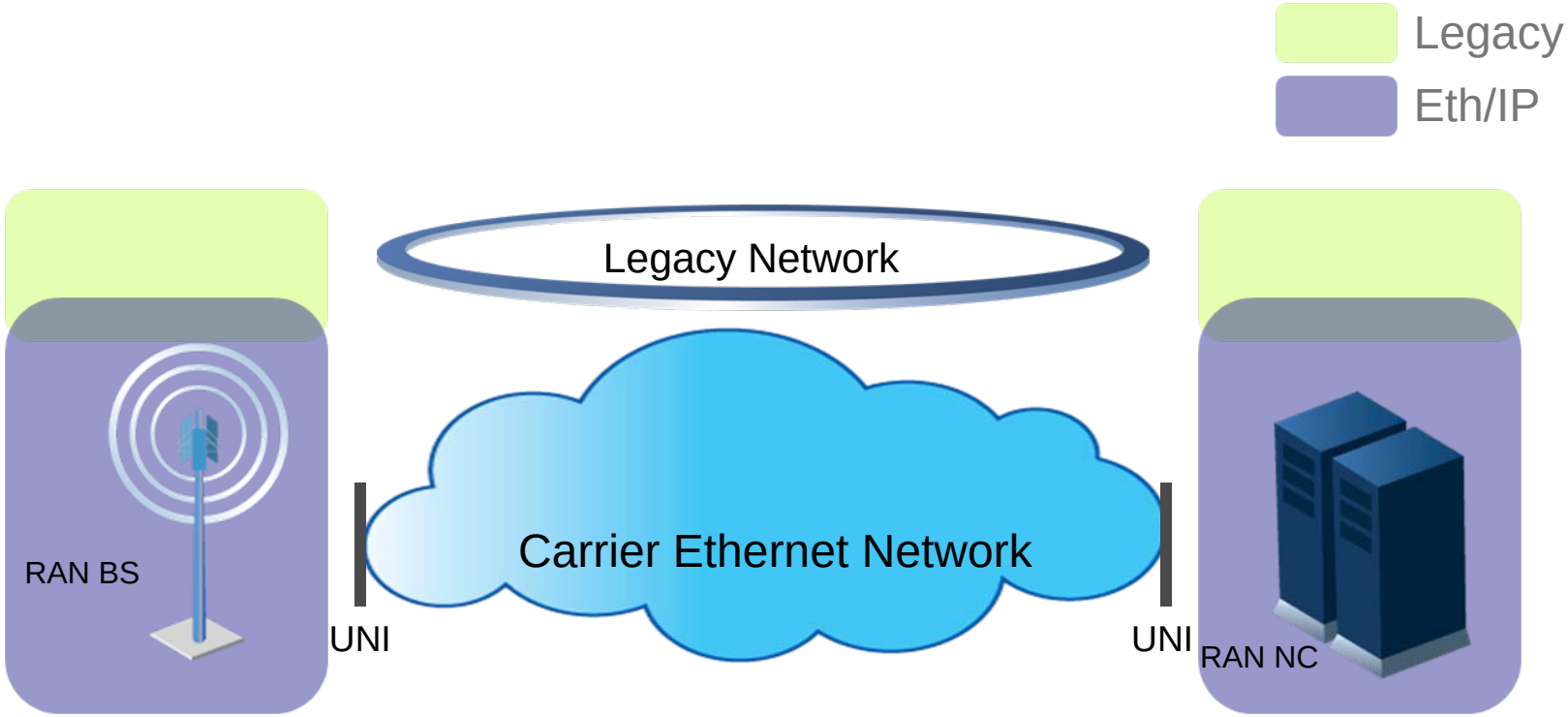
- Overlay MEN does bandwidth offloading onto Ethernet services
- Legacy network continues to transport voice and deliver timing

Emulation over Carrier Ethernet – 1b



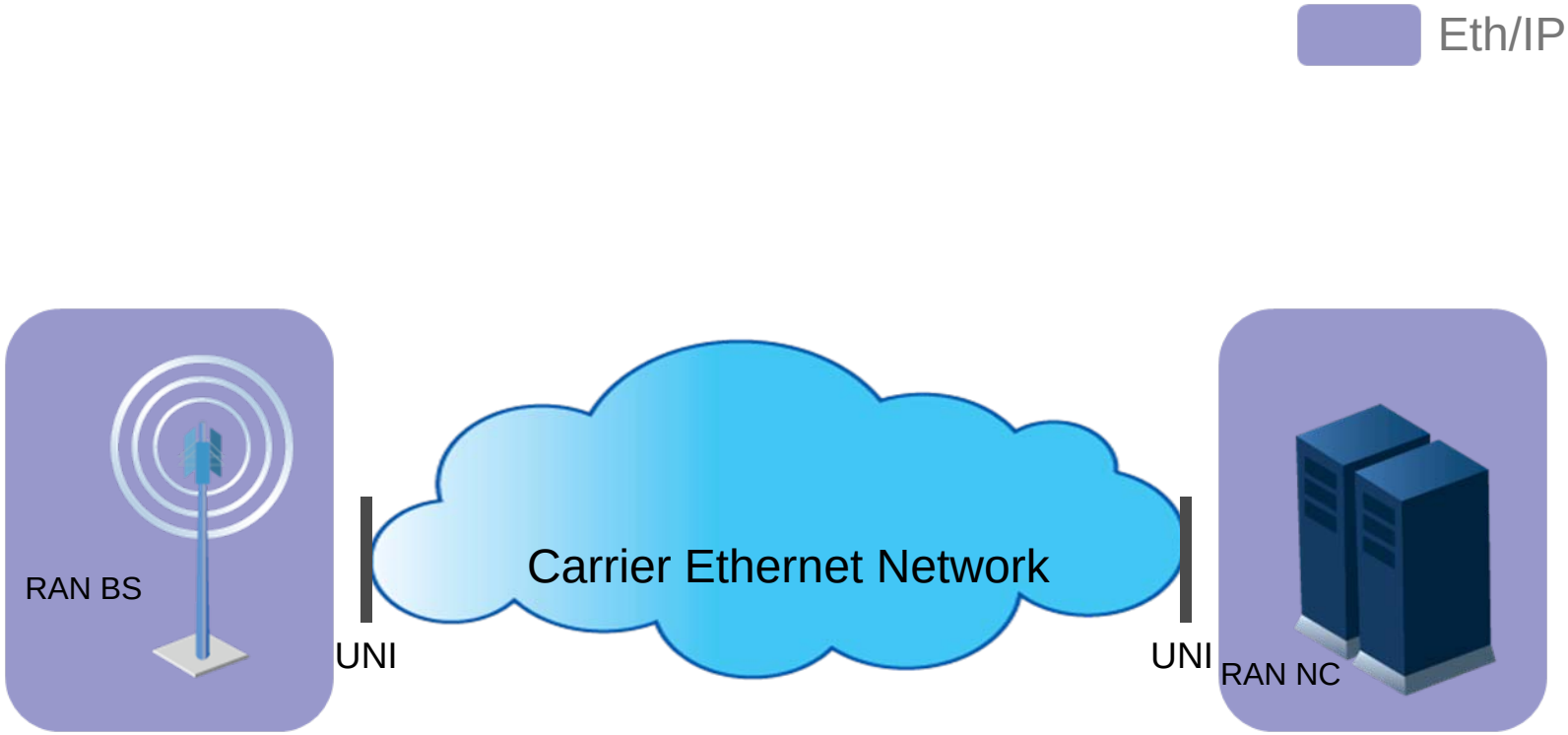
- RAN nodes with legacy interfaces transport all traffic over Ethernet services using emulation technologies

RAN dual stack – 2a



- RAN nodes are equipped with Ethernet and legacy interfaces
- Overlay legacy network transport voice and delivers sync; MEN is used for BW offloading

Full Ethernet – 2b



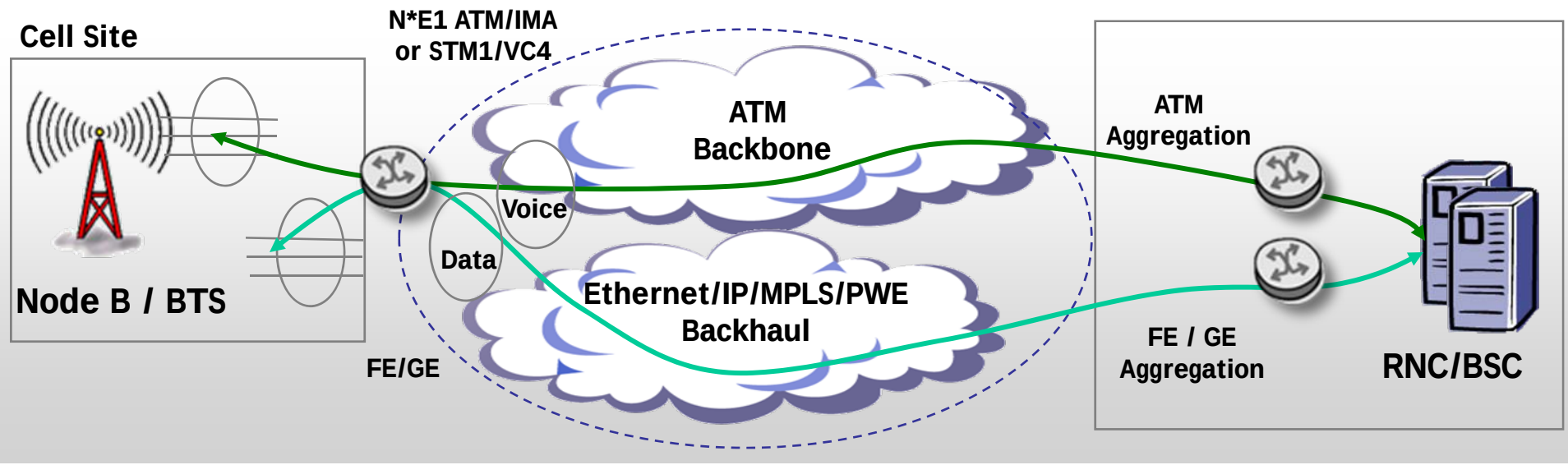
- New RAN nodes with native Ethernet interfaces
- All traffic is transported over Ethernet services

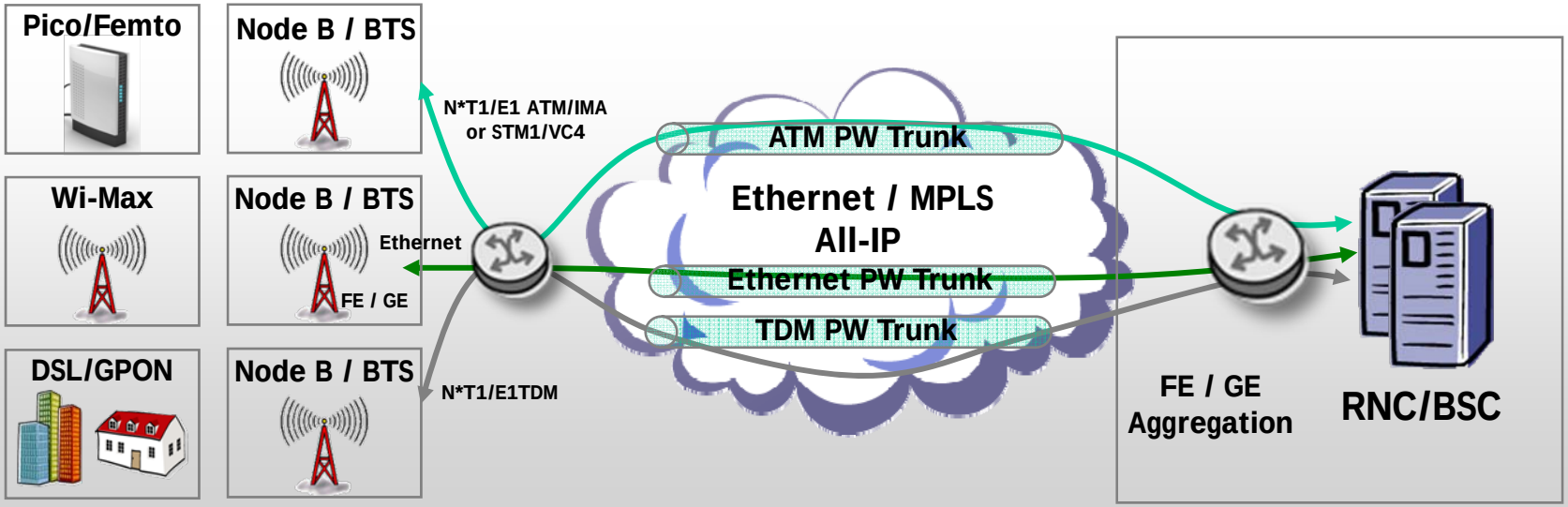
Additional requirements for mobile IA

- Ethernet OAM
- Protection and fault recovery
- Traffic separation
- Services
- Synchronization

Must consider existing deployments and their restrictions while looking at the possibilities available for future deployments

Separation of Voice and HSPA Data Evolves to All-IP over Ethernet





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Circuit Emulation
MEF 3 and MEF 8

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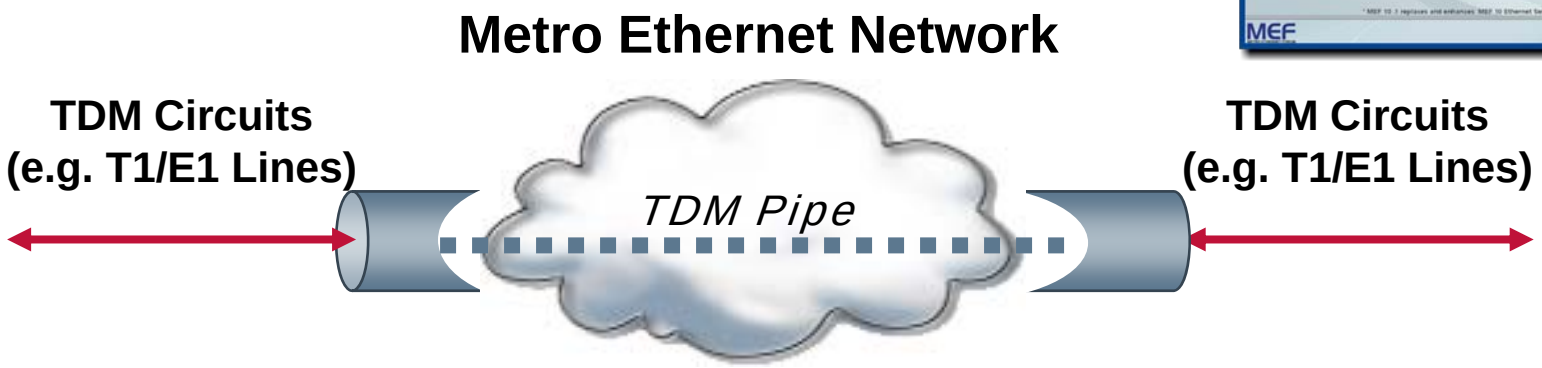
Future-Net

MPLS, ETHERNET AND BEYOND

What is Circuit Emulation Service over Carrier Ethernet?

- Circuit Emulation Service “tunnels” TDM traffic through a Metro Ethernet network
  - Packet network “emulates” a circuit-switched network, re-creating the TDM circuit at the far end
  - Transports TDM services over Carrier Ethernet services
  - Invisible to TDM source and destination equipment
  - Runs on a standard Ethernet Line Service (E-Line)
  - MEF 3 and 8 were designed to meet these challenges
  - MEF 18 is designed to certify conformance



MEF Specifications Overview

MEF 3	**Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks**
Purpose	Circuit Emulation Service “tunnels” TDM traffic through a Metro Ethernet network allowing inclusion of legacy networks within a Carrier Ethernet environment
Audience	Equipment Manufacturers supporting devices that provide Circuit Emulation over Carrier Ethernet Services. Useful for Service Providers architecting their systems.

Technical Committee Service Area

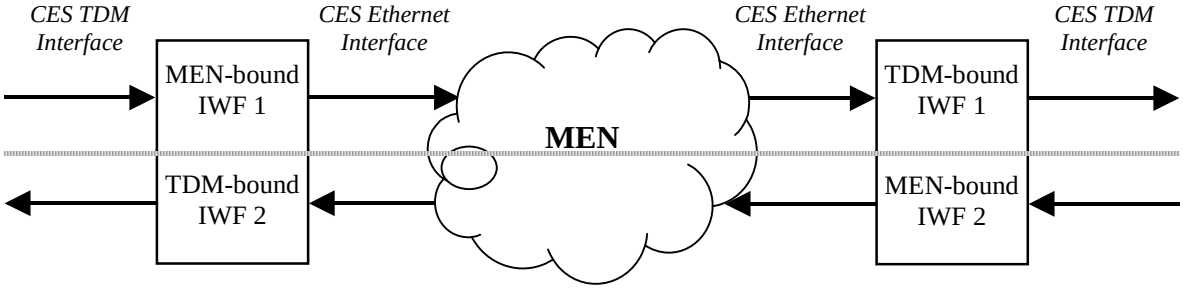
MEF 8	**Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks**
Purpose	Gives precise instructions for implementing interoperable CES equipment that reliably transport TDM circuits across Metro Ethernet Networks while meeting the required performance of circuit emulated TDM services as defined in ITU-T and ANSI TDM standards
Audience	Equipment Manufacturers supporting devices that provide Circuit Emulation over Carrier Ethernet Services. Useful for Service Providers architecting their systems.

Technical Committee Service Area

MEF 3: CES Framework & Requirement
MEF 8: CES Implementation Agreement

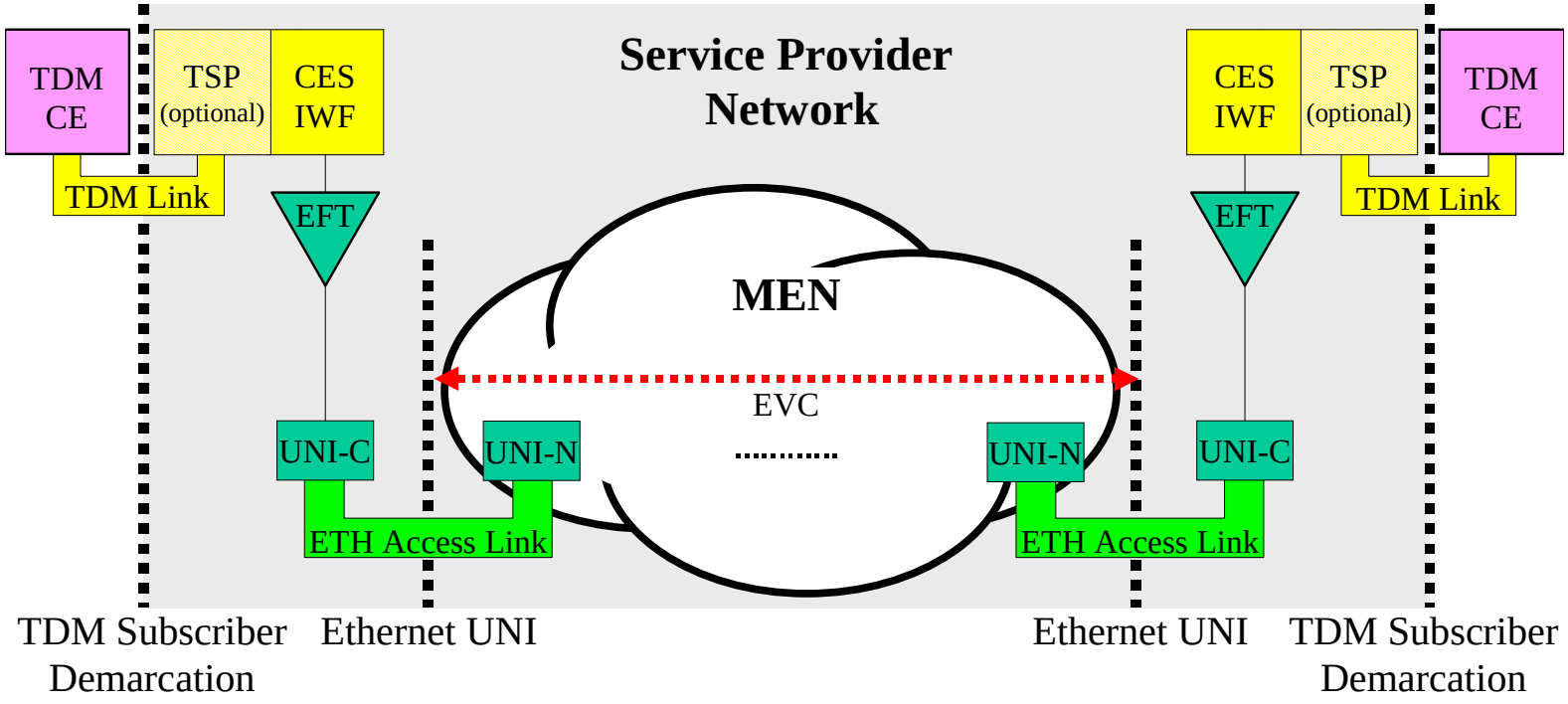
- **Services description**
  - Types of TDM services offered over Metro Ethernet,
  - PDH and SONET/SDH
  - DS1E1, DS3/E3, OC-3/STM-1, OC-12/STM-4
- **Requirements document**
  - Comprehensive CES requirements for providing TDM services over Ethernet
  - SLA service quality parameters as specified by the ITU for TDM services
- **Implementation agreement for Ethernet**
  - Practical agreement as to how to implement the CES over Ethernet
    - Connectivity
    - Timing
    - Signaling
    - MEN performance criteria
    - MEN services OAM

MEF 8 CES Terminology



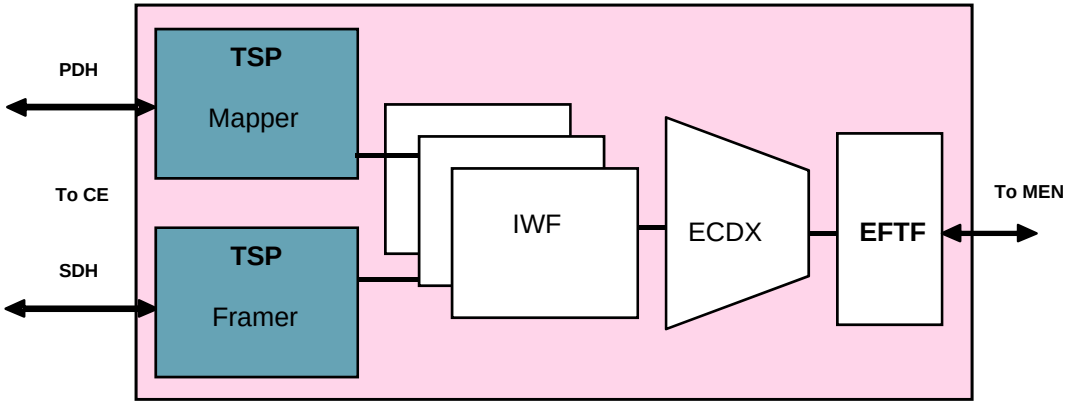
- A circuit emulation service is a bidirectional service consisting of two symmetrical data flows in opposite directions. For each direction of the emulated circuit, there is a pair of CES interworking functions. The MEN-bound IWF handles the packetization of the TDM data, encapsulation into Ethernet frames and forwarding into the Ethernet network. The corresponding TDM-bound IWF extracts the TDM data from the Ethernet frames, and recreates the TDM service.

Circuit Emulation Services Relationship to the Metro Ethernet Network



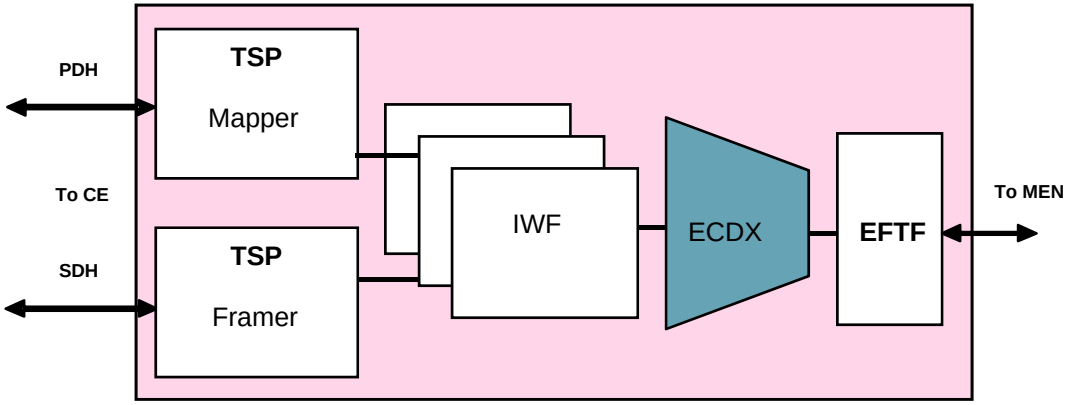
- **CES functions in relation to those specified by the MEF for the MEN**

Functions Defined



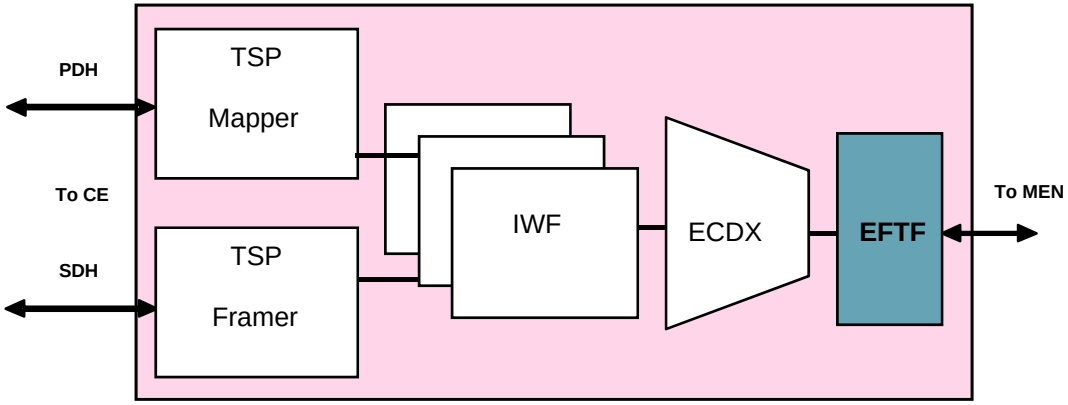
- **TSP – TDM Service Processor**
  - Optional TDM mux/demux function –prior to Ethernet interworking
  - The TDM Service Processor is an optional component that operates on the TDM Service Interface to produce the service that is to be emulated across the MEN (and vice versa). For example, it may terminate framing overhead, or multiplex several customer TDM services into a single service to be emulated. It operates in the TDM domain, and may make use of standard or proprietary techniques. The TSP is considered part of an equipment vendor's own value added function, and its operation is not covered by this implementation agreement.
  - The interfaces to the TSP consist of the following:
    - TDM Service Interface (the TDM service handed off to the customer)
    - CES TDM Interface (i.e. DS1, E1, DS3, E3, or N x 64 kbit/s)

Functions Defined



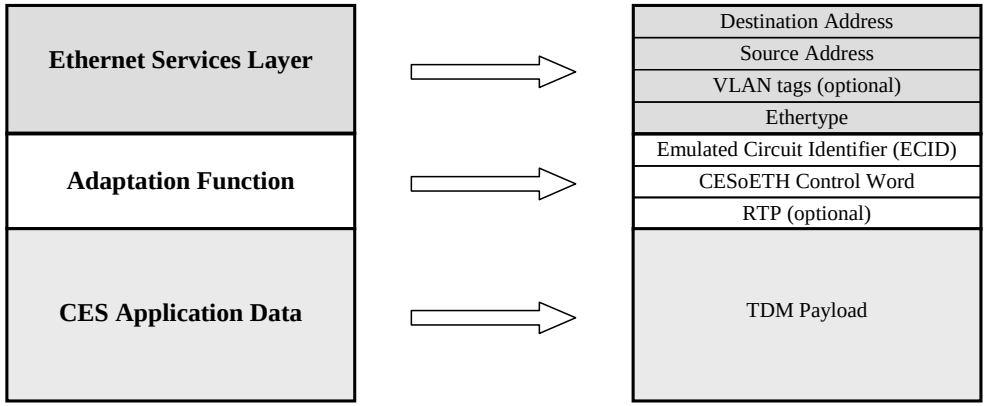
- **IWF - Interworking function of TDM to Ethernet frames**
- **ECDX - Emulated Circuit De/Multiplexing Function**
  - The Emulated Circuit De-multiplexer (ECDX) is a function, operating in the packet domain, that in the MEN-bound direction:
    - Prepends to every Ethernet frame sent to the MEN an Emulated Circuit Identifier (ECID) attribute that is unique to the TDM-bound CES IWF.
    - Assigns the Ethertype field to each Ethernet frame sent to the MEN.
  - In the TDM-bound direction, the ECDX:
    - Determines the destination CES IWF of each Ethernet frame from the ECID value
    - Strips the Ethertype and ECID fields, before handing off the CES Payload to the CES IWF.
  - The interfaces to the ECDX consist of the following:
    - CES Payload (i.e. packetised TDM payload, CES control word, optional RTP header (see RFC 3550)
    - Adapted Payload (i.e. the CES Payload, plus the ECID and Etherype fields)

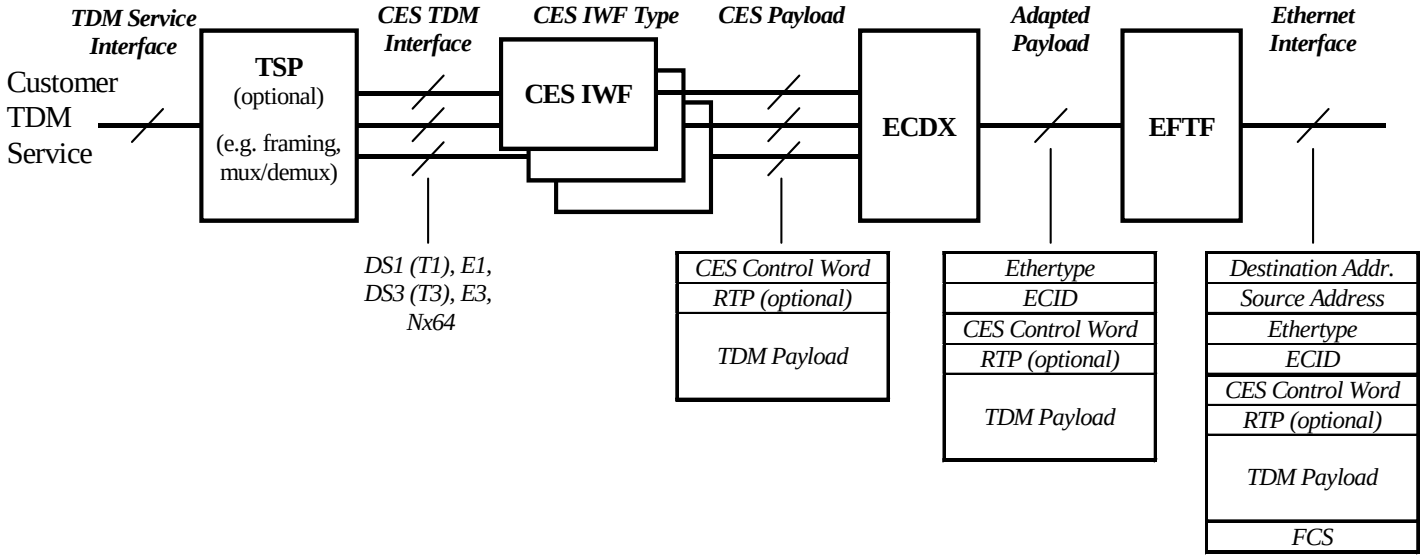
Functions Defined



- **EFTF - Ethernet Flow Termination Function**
  - In the context used here, an Ethernet Flow Termination function takes an adapted payload from the ECDX (the MAC client information field), along with an Ethertype attribute describing it as CES payload. It then adds:
    - the MAC Destination and Source addresses
    - optional VLAN tag (if required) and associated Tag ID and User Priority information
    - any padding required to meet the minimum Ethernet frame size
    - the frame check sequence (FCS).
  - In the TDM-bound direction, the EFTF takes in an Ethernet frame from the MEN, and checks the FCS, discarding the frame if it is incorrect. It determines whether it contains CES payload from the Ethertype field, and forwards it to its associated ECDX function, for passing to the appropriate CES IWF.
  - The interfaces to the EFTF consist of the following:
    - Adapted Payload (i.e. the CES Payload, plus the ECID and Ethertype fields)
    - Ethernet Interface (standard IEEE 802.3 interface)

Functional layering and mapping onto encapsulation headers

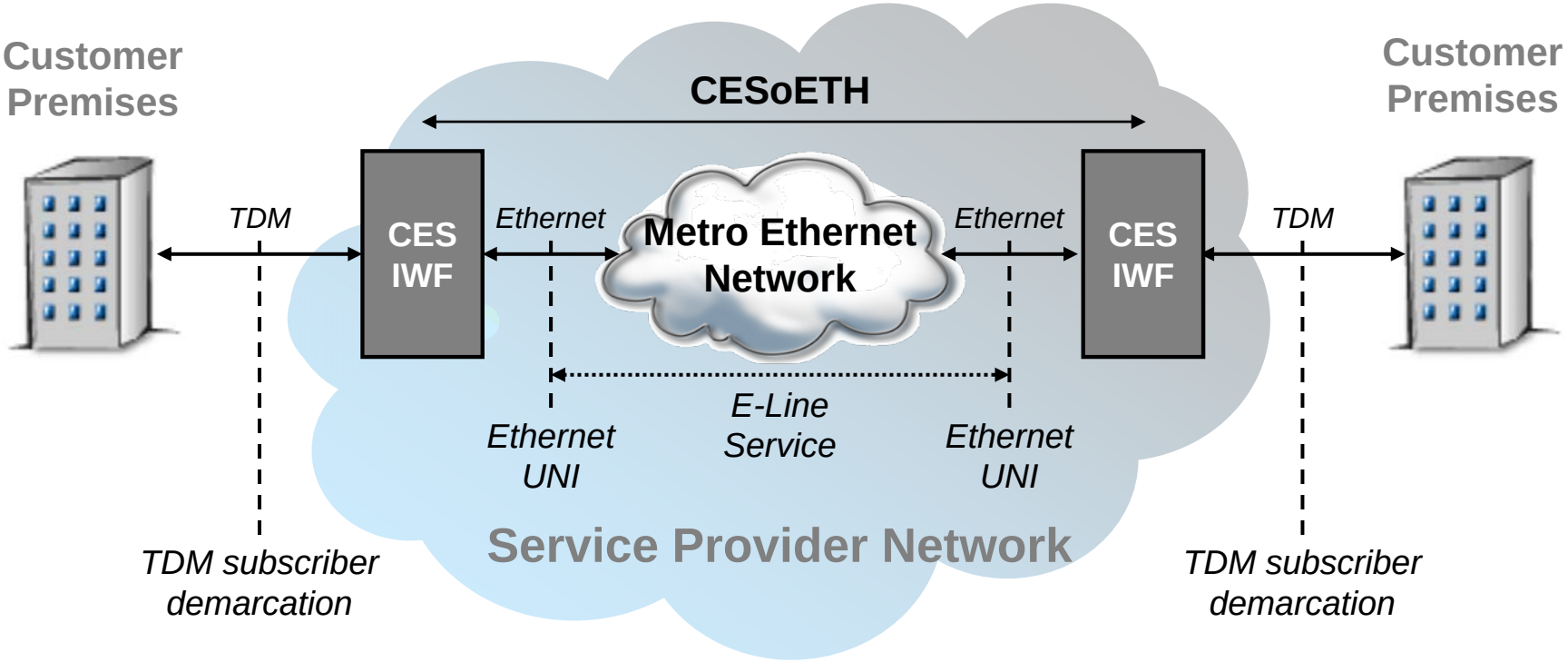




ECDX as shown is effectively a multiplexing function allowing multiple CES circuits to share a single EVC

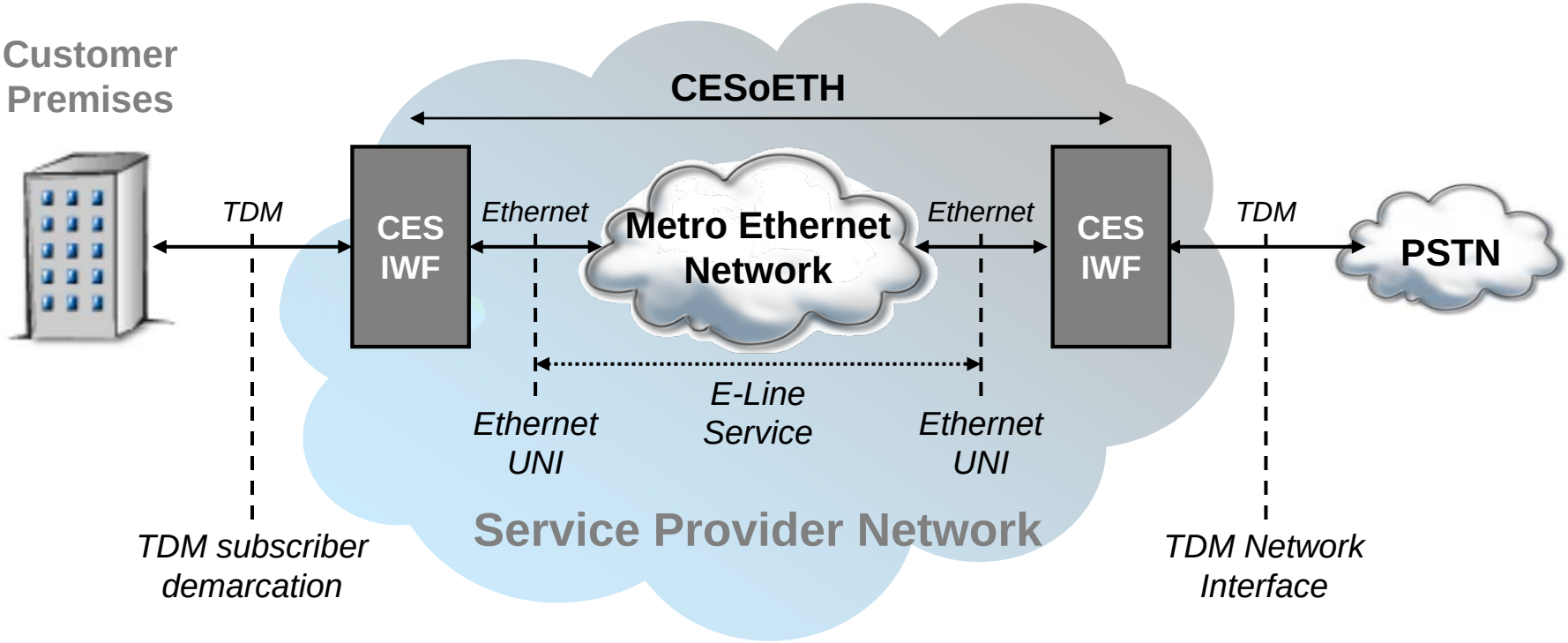
MEF Service Definitions

- **TDM Line Service (T-Line):**
  - Application: Leased line replacement



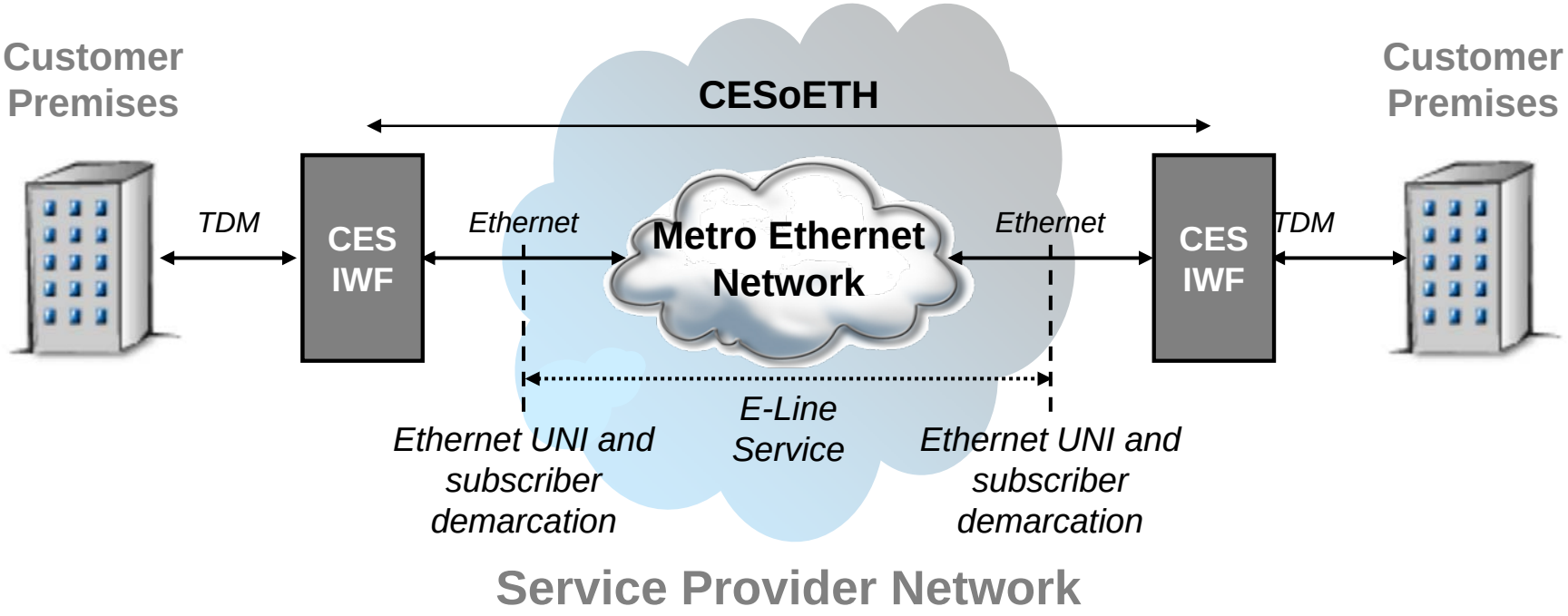
MEF Service Definitions

- **TDM Access Line Service (TALS):**
  - Application: Access to a remote network (e.g. PSTN)



MEF Service Definitions

- **Customer-Operated CES:**
  - Application: Toll-bypass



Similar work in other bodies

- **ITU-T: Recommendation Y.1413**
  - Very similar to MEF8, but for MPLS networks rather than Metro Ethernet
  - Payload and encapsulation formats are identical
  - Equipment supporting Y.1413 should also be capable of supporting MEF8
- **IETF: draft-ietf-pwe3-satop-01.txt, draft-ietf-pwe3-cesopsn-02.txt, draft-ietf-pwe3-tdmoip-03.txt**
  - Very similar to MEF8, but for IP and MPLS networks rather than Metro Ethernet
  - As with Y.1413, payload and encapsulation formats are identical
  - Equipment supporting Y.1413 should also be capable of supporting these IETF drafts

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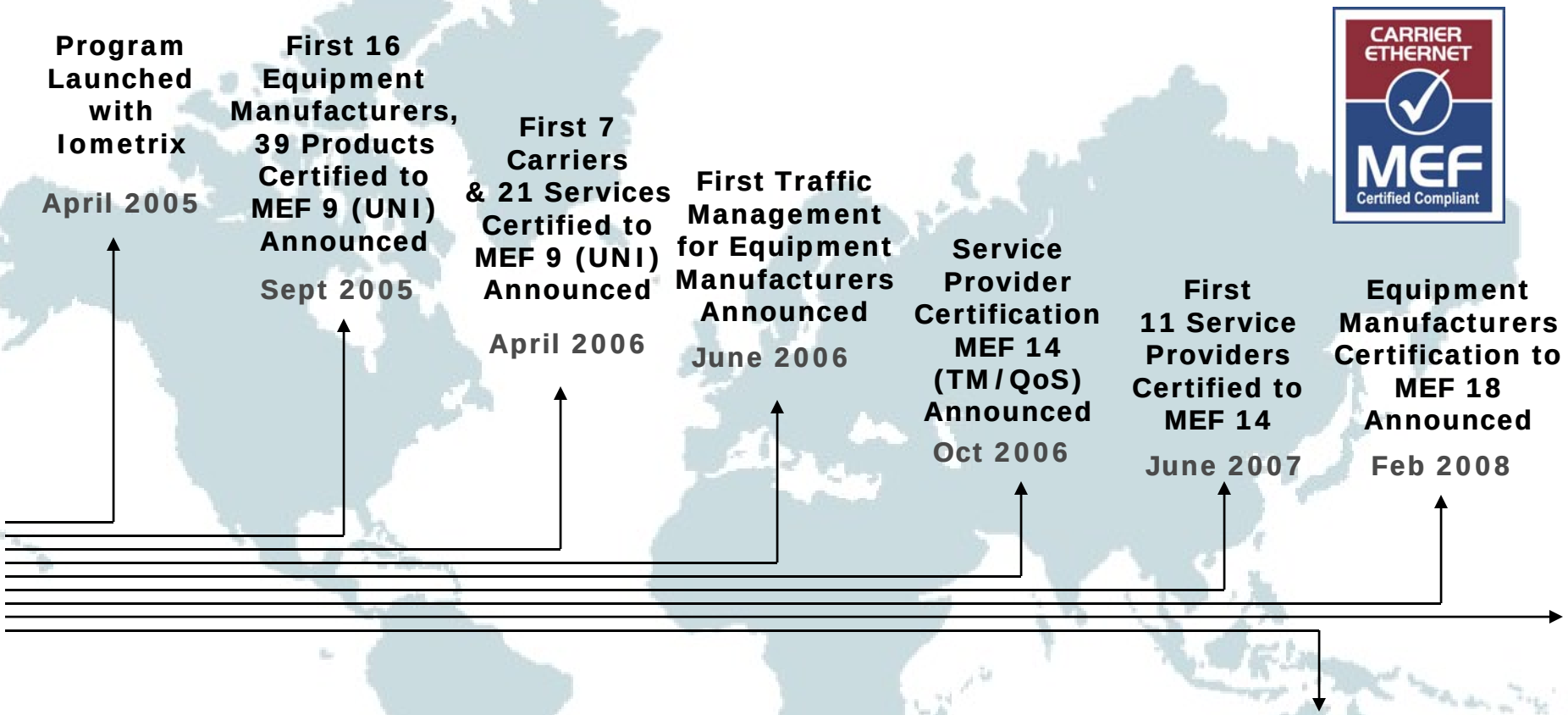
Overview of the MEF Certification Program

The MEF Certification Program

- **Background**
  - Worldwide Ethernet Services based on large populations of multi-vendor equipment yet delivering a single set of services must be carefully engineered
  - From user perspective, services must be plug and play
- **This is facilitated by the Certification Program**
  - The program consists of a series of thorough tests providing evidence for end-users, service providers and manufacturers alike, that products and services are compliant to published MEF specifications

The MEF Certification Program: Rapid Progress Achieved



Program Totals March 2008:

385 Systems, 56 Equipment Manufacturers, 19 Service Providers Certified

1000s Tests Conducted, 750 Certifications Granted

MEF Certified Companies March 2008

Growth Continues: 70+ Certified Services, 385+ Certified Systems, 1000s tests

19 Service Providers Certified

CARRIER ETHERNET MEF Certified Compliant™

MEF Certification Lab

iometrix THE STANDARD FOR TESTING

56 Equipment Manufacturers Certified

Accelerating Adoption Through Certification

- **Current Certification Program Comprises**
  1. Service Certification to MEF 9 for Equipment Manufacturers
  2. Service Certification to MEF 9 for Service Providers
  3. Traffic Management Certification to MEF 14 for Equipment Manufacturers
  4. Service Certification to MEF 14 for Service Providers
  5. ***Circuit Emulation Services over Ethernet to MEF 18 for Equipment Manufacturers***
- **Approved Certification Lab**
  - MEF does not conduct certification directly
  - Certification is via MEF approved lab: Iometrix Inc.
  - Cooperation with leading test manufacturers
  - Implements state-of-the-art test methodologies

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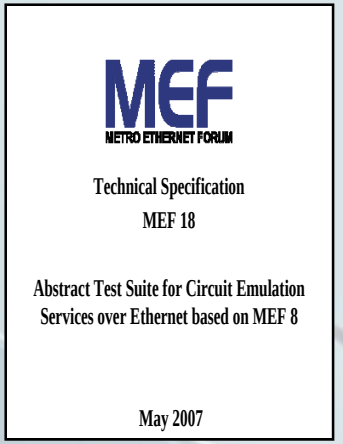
MEF 18 Abstract Test Suite for Circuit Emulation Services over Ethernet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Technical Specification
MEF 18

Abstract Test Suite for Circuit Emulation Services over Ethernet based on MEF 8

May 2007

Certification Announced February 2008

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MEF 18 Certification

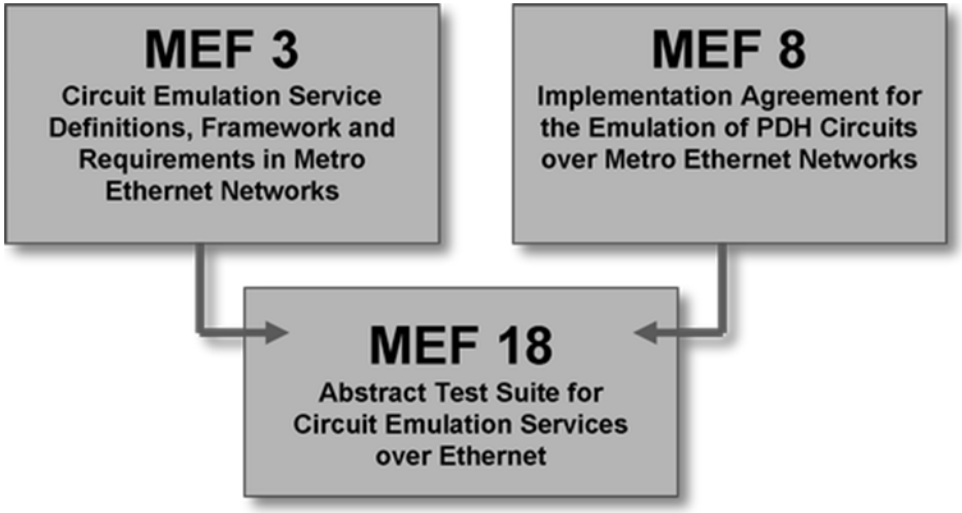
- **MEF 18 provides standard testing of Circuit Emulation Services over Ethernet**
  - Speeds implementation and enables full inter-operability
  - 334 ground breaking tests and certifications in the suite
  - MEF 18 has many applications but is key to Mobile Backhaul migration strategies
    - Lead by strong service provider demand
    - Industry first impairment testing brings first test of emulation of clock recovery
    - Raise the level of confidence that clock recovery will meet the stringent requirements of mobile backhaul.

- **Comparison with ITU 8261**
  - ITU 8261 does not define a profile that allows a deterministic and repeatable test
  - MEF 18 Certification: the first test bed to produce repeatable results

Why CESoETH Certification?

- **CESoETH is a major step in industry's progression toward entirely packet-based networks**
  - Converged networks for data, video and voice have been a dream of the industry
  - Technical challenges to combine TDM and data are not trivial
  - CESoETH is a standard to overcome the technical challenges

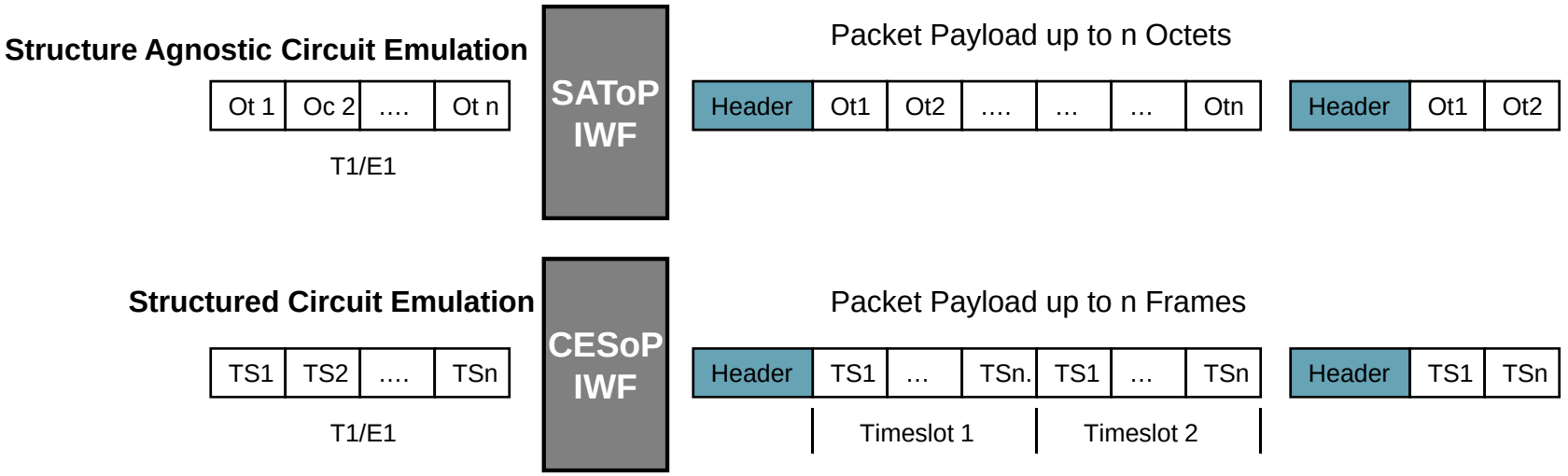
- **Major applications relying upon CESoETH**
  - Mobile backhaul
  - TDM services over Ethernet
  - PBX Interconnect



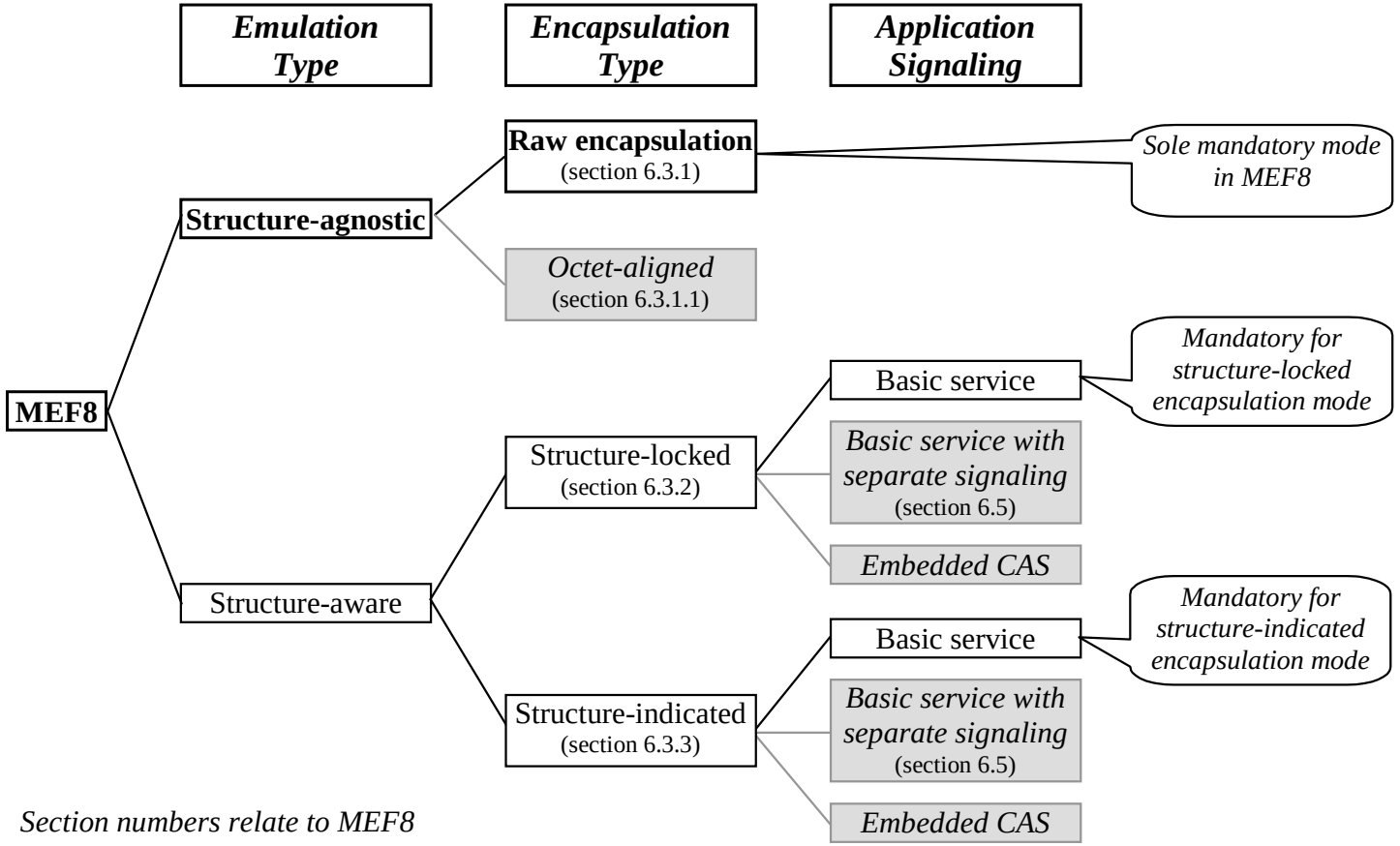
Structured vs Unstructured CES

- **SAToP** (RFC 4553)
  - TDM pseudowire technology that differs from TDMoIP and CESoPSN in that it treats the TDM traffic as a data stream and ignores the framing or the timeslots(DS0). It provides functionality similar to TDMoIP in its unframed mode.
- **CESoPSN**
  - TDM pseudowire technology supports framed and channelized TDM services over packet switched networks. The main difference between TDMoIP and CESoPSN is the way CESoPSN packetizes the TDM data. Where TDMoIP packetizes TDM data in multiples of 48 bytes, CESoPSN uses multiples of the TDM frame itself.

TDM PW Type	TDM Service Support	Advantages	Limitations & Disadvantages
SAToP	Unframed	Low overhead Lowest end-to-end delay Flexible packet size	TDM service is more susceptible to frame loss and re-sequence No DS0 grooming can be performed
TDMoIP	Unframed, Framed, Channelized	Complete support of TDM services in one protocol	Higher delay when transporting several time slots due to n x 48 byte frames
CESoPSN	Framed, Channelized	Lower packetization delay when transporting several time slots (DS)	No support for Unframed, must use SAToP



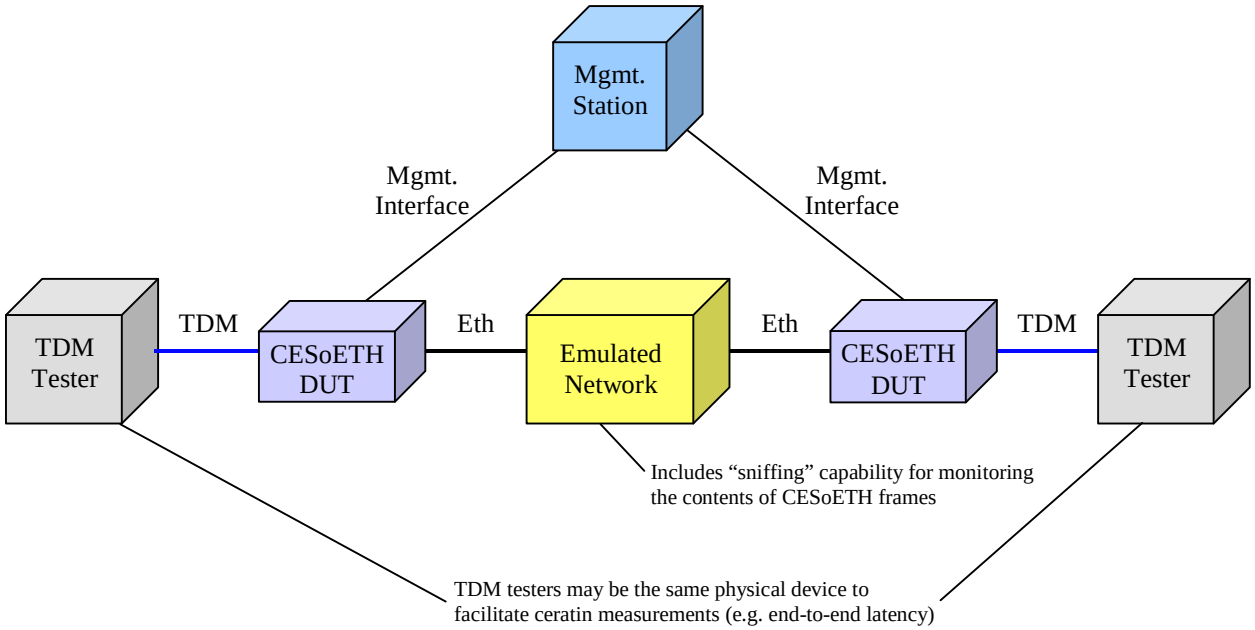
MEF 8: Modes and Conformance



Section numbers relate to MEF8

- MEF 8 describes several operating modes for the implementation of CESoETH
- Only one mode is mandatory to claim conformance with MEF 8
  - **Structure-agnostic emulation using a raw (i.e. non-octet-aligned) encapsulation.**
- Several optional operating modes are described in MEF 8
  - **Structure-aware emulation modes and different signaling types.**

MEF 18 CES Test Set Up



- **The second generic test bed consists of equipment for generating and receiving TDM services (e.g. DS1, E1, DS3 or E3 circuits), two identical devices to be tested, and equipment representing an Ethernet network. The devices under test are controlled by a management station, connected via a management interface. The nature of this interface will be specific to the device under test.**

MEF 18 Conformance Tests

- Section 6: Tests for Mandatory Requirements
  - 6.1 Encapsulation Layers
  - 6.2 Payload Format
  - 6.3 Synchronisation
  - 6.4 Defects, Performance Monitoring and Management
- Section 7: Tests for Dependent Requirements
  - 7.1 Octet Aligned Payload of DS1 Circuits
  - 7.2 Structure-Locked Encapsulation
  - 7.3 Tests for Structure-Indicated Encapsulation
  - 7.4 TDM application signaling

CES MEF 18 Test Case Examples

ABSTRACT TEST CASES FOR CESoETH IMPLEMENTATION AGREEMENT	
Test Name	**Test Case 1**: Emulated Circuit Identifier and Sequencing
Test Definition ID	MEF8.R1,R17-R18
Reference document	MEF 8
Test Type	Conformance
Test Status	Mandatory
Requirement Description	R1. Each TDM-bound IWF at a given MAC address MUST have a unique ECID value. R17. The SN field MUST be incremented by one for every CESoETH frame transmitted into the MEN with the same ECID value, including those frames that are fragments of multiframe structures. R18. The initial value of the SN field on setup of an emulated circuit SHALL be random.
Test Object	Determine that the attached device operates with a valid ECID attribute and sequencing function.
Test-Bed Configuration	Generic Test Bed 1, with at least one CESoETH IWF connected at the MEF UNI. Each IWF is configured for Structure-Agnostic emulation of E1, DS1, E3 or DS3.
Test Procedure	TDM testers generate circuits for emulation by the CESoETH IWFs. Ethernet Tester monitors the CESoETH service frames at the ingress UNI, and used to verify that data frames associated with the same CES flow use the same destination MAC address, have the correct CESoETH Ethertype, have the proper ECID attribute, and that the sequence number increments correctly every frame. Where multiple CESoETH IWFs are connected (e.g. in the case of a DUT that is capable of emulating several TDM circuits simultaneously), the Ethernet tester must also verify that the number of different ECID's received from the tested CESoETH device is equal to the number of CESoETH IWFs connected at the MEF UNI. Each IWF must be torn down and re-established several times, to verify that the initial value of the sequence number is random.
Units	Value of Sequence Number
Variables	Multiple CESoETH IWFs per DUT
Results	Pass or Fail
Remarks	

ABSTRACT TEST CASES FOR CESoETH IMPLEMENTATION AGREEMENT	
Test Name	**Test Case 2**: 'R' bit of the CESoETH Control Word and its Usage
Test Definition ID	MEF8.R4-R7
Reference document	MEF 8
Test Type	Conformance
Test Status	Mandatory
Requirement Description	R4. A TDM-bound IWF SHALL enter a Loss of Frames State (LOFS) following detection of a locally preconfigured number of consecutive lost (including late frames that are discarded) CESoETH frames. R5. A TDM-bound IWF SHALL exit the Loss of Frames State (LOFS) following reception of a locally preconfigured number of consecutive CESoETH frames. R6. An MEN-bound IWF SHALL set the 'R' bit to 1 on all frames transmitted into the MEN while its local TDM-bound IWF is in the Loss of Frames State (LOFS). The 'R' bit SHALL be cleared at all other times. R7. On detection of a change in state of the 'R' bit in incoming CESoETH frames, a TDM-bound IWF MUST report it to the local management entity.
Test Object	Verify that the CESoETH IWF device sets the 'R' bit to 1 on frames transmitted into the MEN while its local TDM-bound IWF is in the Loss of Frames State (LOFS). Verify that the CESoETH IWF device sets the 'R' bit to 0 at all other times.
Test-Bed Configuration	Generic Test Bed 2 as shown in **Error! Reference source not found.**. Network emulator required. Each IWF is configured for Structure-Agnostic emulation of E1, DS1, E3 or DS3.
Test Procedure	Valid CESoETH flow set up in both directions between the two CESoETH IWFs (known as the "left" and "right" IWFs for the purposes of this test). Verify that frames received back from both IWFs are valid, and contain 'R'=0. Network emulator is used to stop traffic flow in the left-to-right direction for a period larger than the pre-configured number of consecutive frames defined in R4. Verify that the frames received back from the right-hand IWF have the 'R' bit set to 1. Verify that the management station for the left-hand IWF correctly reports the 'R' bit being set in frames received. Network emulator re-enables the traffic flow in the left-to-right direction for a period larger than the pre-configured number of consecutive frames defined in R5. Verify that the frames received back from the DUT now have the 'R' bit cleared again. Verify that the management station for the left-hand IWF correctly reports the 'R' bit being cleared again in frames received. Test repeated using different threshold numbers for R4 and R5, and blocking frames in the right-to-left direction.

CES MEF 18 Test Case Overview and References

Requirement	Description	Level (mandatory/ dependent/ optional)	Test Case No.	Test reference	Comments
MEF8.R1	ECID attribute	Mandatory	1	MEF8.R1,R17-R18	
MEF8.R2	ECID reserved field – transmit	Optional		None	
MEF8.R3	ECID reserved field – reception	Optional		None	
MEF8.R4	LOF State entry	Mandatory	2	MEF8.R4-R7	
MEF8.R5	LOF State exit	Mandatory	2	MEF8.R4-R7	
MEF8.R6	R bit setting conditions	Mandatory	2	MEF8.R4-R7	
MEF8.R7	R bit change of state detection	Mandatory	2	MEF8.R4-R7	
MEF8.R8	L bit setting conditions	Mandatory	3	MEF8.R8,R10,R14	
MEF8.R9	L bit setting conditions	Optional		None	
MEF8.R10	L bit clearing conditions	Mandatory	3	MEF8.R8,R10,R14	
MEF8.R11	L bit payload suppression	Optional		None	
MEF8.R12	L bit reception actions	Optional		None	
MEF8.R13	L bit reception actions	Optional		None	
MEF8.R14	M field support	Mandatory	3	MEF8.R8,R10,R14	
MEF8.R15	M field support	Optional		None	Depends on DUT capability
MEF8.R16	M field reception	Mandatory	4	MEF8.R16	
MEF8.R17	Sequencing	Mandatory	1	MEF8.R1,R17-R18	
MEF8.R18	Sequencing	Mandatory	1	MEF8.R1,R17-R18	
MEF8.R81	Jitter Buffer Overrun	Optional		None	
MEF8.R82	Facility Data Link	Optional		None	
MEF8.R83	Facility Data Link	Mandatory	12	MEF8.R83	
MEF8.R84	Frame Error Ratio	Optional		None	
MEF8.R85	Bandwidth provisioning	Optional		None	Requirement on MEN
MEF8.R86	MEN Specification	Optional		None	
MEF8.R87	MEN-bound Statistics	Optional		None	
MEF8.R88	TDM-bound Statistics	Optional		None	

- Section 8: Requirements status and test summary
  - 88 separate tests
- Section 9: References

Reference	Reference Details
RFC 2119	"Key words for use in RFCs to Indicate Requirement Levels", RFC 2119, S. Bradner, March 1997, http://www.ietf.org/rfc/rfc2119.txt
RFC 2833	"RTP Payload for DTMF Digits, Telephony Tones and Telephony Signals", RFC 2833, H. Schulzrinne, S. Petrack, 2000, http://www.ietf.org/rfc/rfc2833.txt
MEF 3	"Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks", MEF 3, April 13, 2004, http://www.metroethernetforum.org/PDFs/Standards/MEF3.pdf
MEF 8	"Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks", MEF 8, October 2004, http://www.metroethernetforum.org/PDFs/Standards/MEF8.pdf
G.823	"The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy", ITU-T recommendation G.823, March 2000
G.824	"The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy", ITU-T recommendation G.823, March 2000
G.8261	"Timing and Synchronisation aspects in Packet Networks", ITU-T recommendation G.8261, June 2006

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