Introducing the Specifications of the MEF

MEF 54: Ethernet Interconnection Point (EIP):

An ENNI Implementation Agreement

April 2016

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://www.mef.net/carrier-ethernet/technical-specifications

Outline

- Approved MEF Specifications
- Implementation Guide Overview
- About MEF 54
- In Scope / Out of Scope
- Terminology / Concepts
- Key Companies That Made This Possible
- Project Review
- Summary

Approved MEF Specifications*

Specification	Description
MEF 2	Requirements and Framework for Ethernet Service Protection
MEF 3	Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks
MEF 4	Metro Ethernet Network Architecture Framework Part 1: Generic Framework
MEF 6.2	EVC Ethernet Services Definitions Phase 3
MEF 7.2	Carrier Ethernet Information Model
MEF 8	Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks
MEF 9	Abstract Test Suite for Ethernet Services at the UNI
MEF 10.3	Ethernet Services Attributes Phase 3
MEF 11	User Network Interface (UNI) Requirements and Framework
MEF 12.2	Carrier Ethernet Network Architecture Framework Part 2: Ethernet Services Layer
MEF 13	User Network Interface (UNI) Type 1 Implementation Agreement
MEF 14	Abstract Test Suite for Traffic Management Phase 1
MEF 15	Requirements for Management of Metro Ethernet Phase 1 Network Elements
MEF 16	Ethernet Local Management Interface
MEF 17	Service OAM Framework and Requirements

***Current at time of publication. See MEF web site for official current list, minor updates and superseded work (such as MEF 1 and MEF 5)**

Approved MEF Specifications

Specification	Description
MEF 18	Abstract Test Suite for Circuit Emulation Services
MEF 19	Abstract Test Suite for UNI Type 1
MEF 20	User Network Interface (UNI) Type 2 Implementation Agreement
MEF 21	Abstract Test Suite for UNI Type 2 Part 1: Link OAM
MEF 22.2	Mobile Backhaul Phase 3 Implementation Agreement
MEF 23.1	Class of Service Implementation Agreement Phase 2
MEF 24	Abstract Test Suite for UNI Type 2 Part 2: E-LMI
MEF 25	Abstract Test Suite for UNI Type 2 Part 3: Service OAM
MEF 26.1	External Network Network Interface (ENNI) – Phase 2
MEF 27	Abstract Test Suite For UNI Type 2 Part 5: Enhanced UNI Attributes & Part 6: L2CP Handling
MEF 28	External Network Network Interface (ENNI) Support for UNI Tunnel Access and Virtual UNI
MEF 29	Ethernet Services Constructs
MEF 30.1	Service OAM Fault Management Implementation Agreement Phase 2
MEF 30.1.1	Service OAM Fault Management Implementation Agreement Phase 2
MEF 31	Service OAM Fault Management Definition of Managed Objects

Approved MEF Specifications

Specification	Description
MEF 32	Requirements for Service Protection Across External Interfaces
MEF 33	Ethernet Access Services Definition
MEF 34	Abstract Test Suite for Ethernet Access Services
MEF 35.1	Service OAM Performance Monitoring Implementation Agreement
MEF 36	Service OAM SNMP MIB for Performance Monitoring
MEF 37	Abstract Test Suite for ENNI
MEF 38	Service OAM Fault Management YANG Modules Technical Specification
MEF 39	Service OAM Performance Monitoring YANG Modules Technical Specification
MEF 40	UNI and EVC Definition of Managed Objects Technical Specification
MEF 41	Generic Token Bucket Algorithm Technical Specification
MEF 42	ENNI and OVC Definition of Managed Objects Technical Specification
MEF 43	Virtual NID (vNID) Functionality for E-Access Services Technical Specification
MEF 44	Virtual NID (vNID) Definition of Managed Objects Technical Specification
MEF 45	Multi-CEN L2CP Technical Specification
MEF 46	Latching Loopback Protocol and Functionality Technical Specification

Approved MEF Specifications

Specification	Description
MEF 47	Carrier Ethernet Services for Cloud Implementation Agreement
MEF 48	Service Activation Testing Technical Specification
MEF 49	Service Activation Testing Control Protocol and PDU Formats Technical Specification
MEF 49.0.1	Amendment to Service Activation Testing Control Protocol and PDU Formats
MEF 50	Carrier Ethernet Service Lifecycle Process Model Guidelines
MEF 51	OVC Services Definitions Technical Specification
MEF 52	Carrier Ethernet Performance Reporting Framework
MEF 53	Carrier Ethernet Services Qualification Questionnaire
MEF 54	**Ethernet Interconnection Point (EIP): An ENNI Implementation Agreement**
MEF 55	Lifecycle Service Orchestration (LSO): Reference Architecture and Framework

MEF 54 Implementation Agreement Overview

MEF 54: Ethernet Interconnection Point (EIP): An ENNI Implementation Agreement	
Purpose	A guideline document providing Ethernet Operators practical advice to help them on their journey towards creating MEF standardized Carrier Ethernet Interconnections with other Operators. These Interconnections are what the MEF calls "ENNIs." If an Operator cannot create an ENNI, the Guideline provides instruction on how to create a non-standard interconnection known as an "NNI." The guideline covers myriad topics covering key areas such as current market assessment, where the market is heading, technical expectations, obstacles that may be encountered, and the need for an Operator to be "bi-lingual" until the market moves to MEF standardized Interconnections.
Audience	All Ethernet Operators who wish to interconnect their network with another Operator to create EVCs spanning two Operators.

MEF

Overview of MEF 54

Ethernet Interconnection Point (EIP):

An ENNI Implementation Agreement

About MEF 54

- **Purpose**
  - This presentation is an introduction to MEF 54 – Ethernet Interconnection Point (EIP): An ENNI Implementation Agreement.
- **Audience**
  - Operators who buy wholesale Ethernet services from other Operators and interconnect their networks for the purpose of E-Access.
  - e.g. – Operator 1 buys an Ethernet UNI (ENNI) from Operator 2 and uses this UNI (ENNI) to reach multiple customers located within Operator 2's footprint.
- **Other Documents**
  - MEF 26.1 - Technical specifications for External Network Network Interface (ENNI) – Phase 2 (Provider Bridging)
  - MEF 33 - Ethernet Access Services Definition
  - MEF 51 - OVC Services Definitions Technical Specification

MEF 54 - In Scope/Out of Scope

In Scope

- This version of the Implementation Agreement (IA) used the most basic Ethernet E-Access configuration possible so that the six Operators performing interoperability testing could interconnect and create Ethernet Private Line (EPL) service spanning two Operators.

Out of Scope

- Ethernet Virtual Private Line (EVPL), Access EVPL
- E-LAN, E-Tree, E-Transit
- Any service with an Excess Information Rate (EIR)
- Class of Service (CoS) Medium and Low

Terminology & Concepts

Key Terminology

- **ENNI** = External Network to Network Interface
- **E-Access** = Ethernet Access
- **NNI** = Network to Network Interface
- **TPID** = Tag Protocol Identification
- **S-Tag** = An Ethertype with a value of 0x88a8
- **C-Tag** = An Ethertype with a value of 0x8100
- **Q-in-Q** = Non-standard double tagging method commonly used in the industry. Uses two C-Tags.

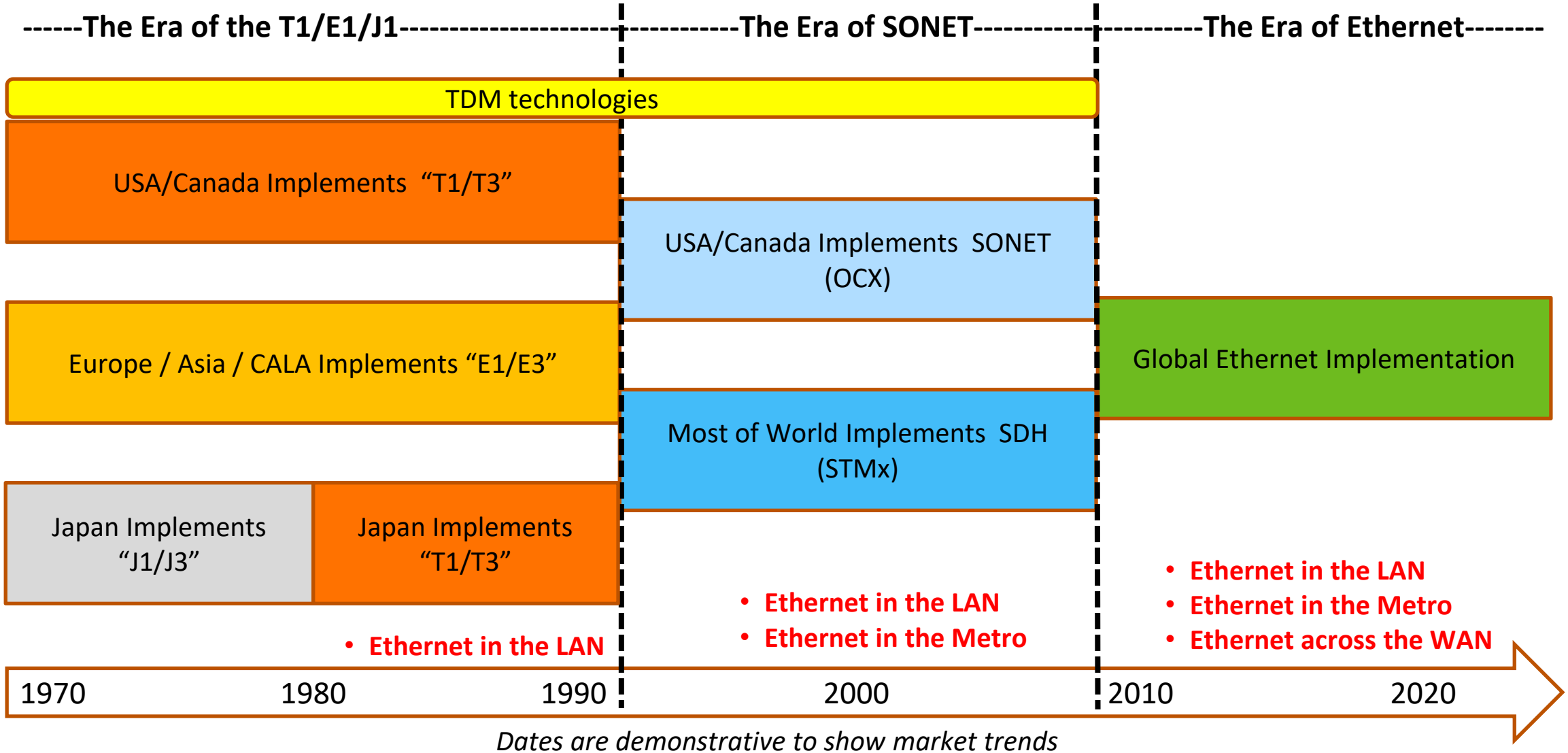
New Terminology

- **Bilingual Operator** – An Ethernet Operator that can create Ethernet Interconnections using either a non-standard NNI or the new ENNI
- **Rapid Prototyping** – Quick interoperability testing between Operators at the University of New Hampshire

Key Companies That Made This Possible

- This project relied heavily upon the six Operators who donated time, talent, and a spirit of mutual respect and cooperation to moving the industry forward (AT&T, Frontier, CenturyLink, TelePacific, Verizon, Windstream) – Thank you!
- This Project relied heavily upon the testing (rapid prototyping) conducted at the University of New Hampshire's Interoperability Lab – Thank you!
- This project relied heavily upon the equipment vendors who donated time and equipment to facilitate the testing at UNH Lab (Accedian, Alcatel-Lucent, Canoga Perkins, Ciena, Cisco, Juniper, RAD) – Thank you!
- This project relied heavily upon Veryx technologies to measure performance between Operators during testing – Thank you!

Global Era of Ethernet



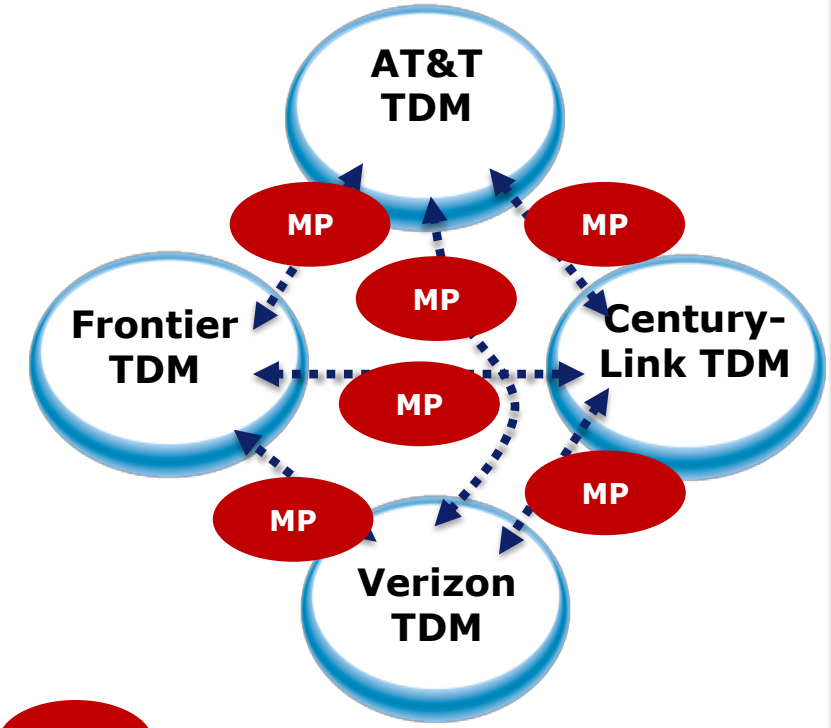
Dates are demonstrative to show market trends

Multi-Carrier Interconnection Capability: TDM vs. Ethernet

1970 - 2020

Current TDM Interconnection Capability

Standardized TDM Meet Points enabled mass scalability of Private Lines (T1) and were the foundation of the Internet and the digital explosion (~1990-2010)

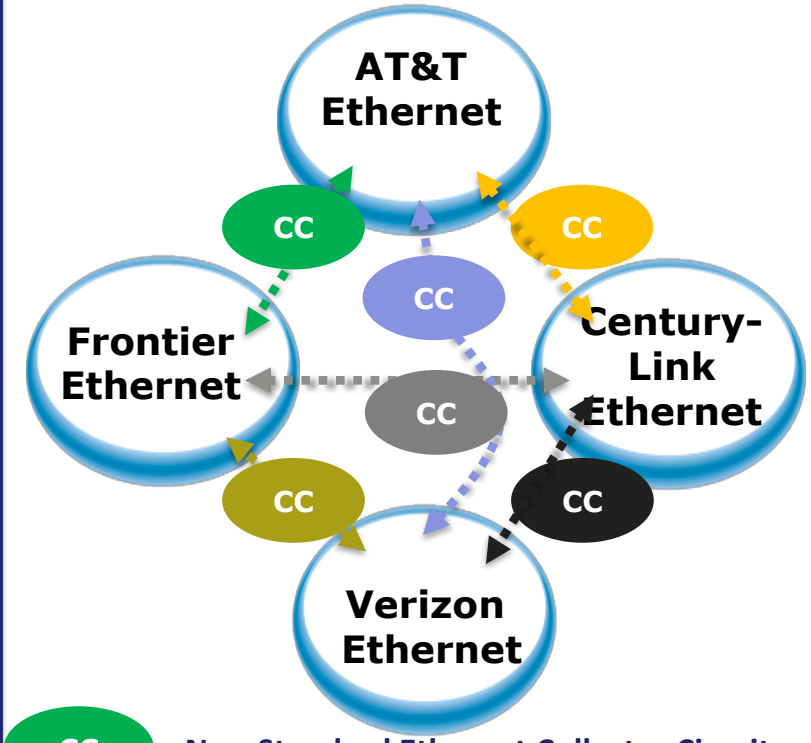


MP = Standardized TDM Meet Point

2005 - 2020

Current Ethernet Interconnection Capability

Lack of standardization is hindering Ethernet growth. This gets worse as more customers demand Ethernet. Solution is getting the industry to use the MEF standard (ENNI)

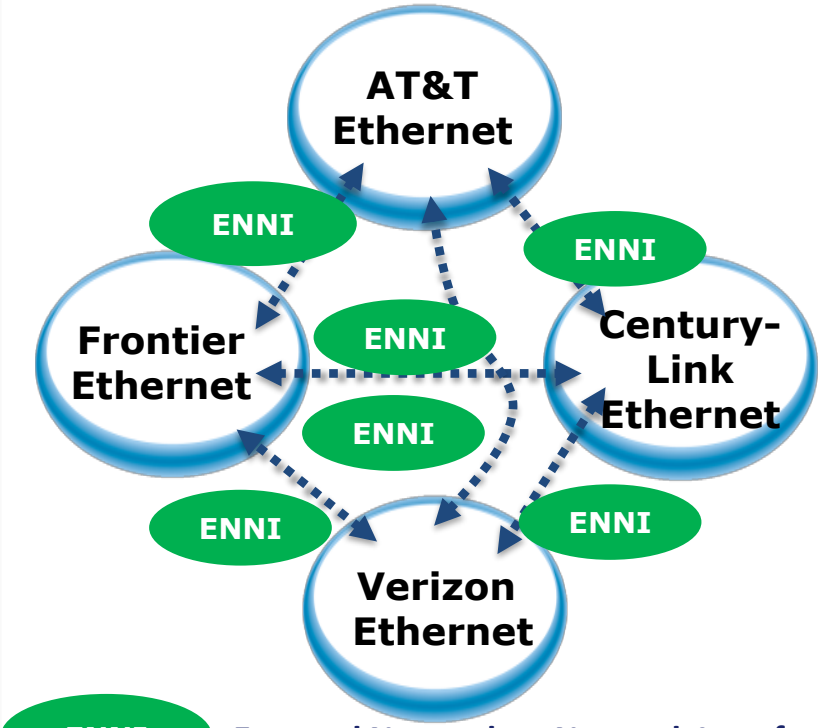


CC = Non-Standard Ethernet Collector Circuit

2020 - Forward

Future Ethernet Interconnection Capability

As MEF standardized Ethernet Interconnections take hold, (ENNIs) Ethernet availability becomes as ubiquitous as TDM



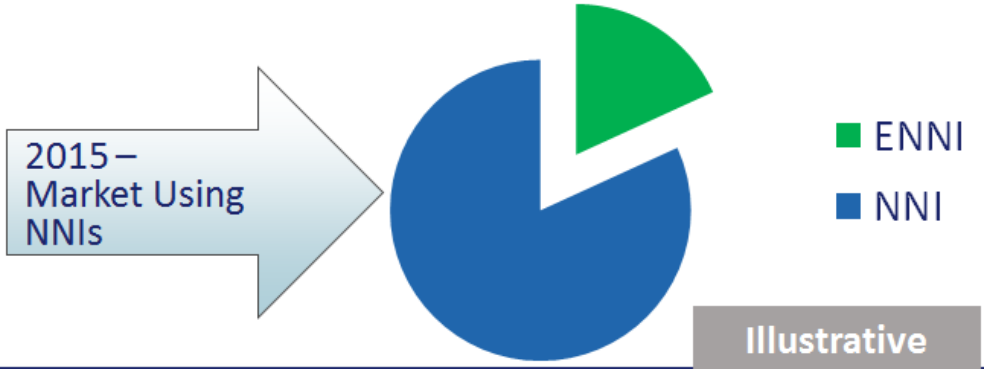
ENNI = External Network to Network Interface

Interconnection Landscape – From NNI to ENNI

- **Most Ethernet interconnections in the market today are custom built between Operators and are typically referred to as "NNIs" (Network-to-Network Interconnections)**
- **Since NNIs are custom (non-standard), there are many versions, which prevents the market from scaling. The industry needs to build the same MEF standardized interconnection (ENNI) to rapidly scale and reduce complexity.**

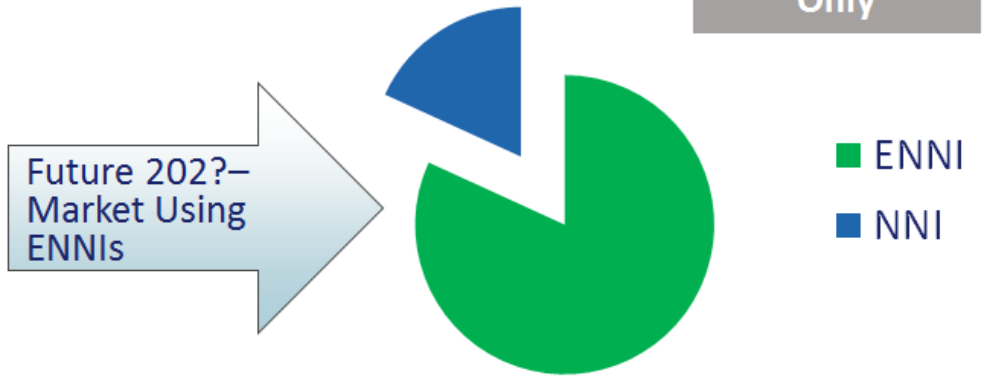
NNI

1. Not scalable
2. Long provisioning cycle times
3. Individual certifications / operator
4. Harder to trouble shoot
5. High complexity
6. High cost



ENNI

1. Easier to scale
2. Shorter provisioning cycles
3. No need for operators to certify each other
4. Easier to trouble shoot



MEF Specifications and Possible Obstacles

- **MEF 26.1 documents a *Technical* Industry Standard Called an External Network-to-Network Interface (ENNI).**
- **MEF 33 defines E-Access Services which use an ENNI defined in MEF 26.1**

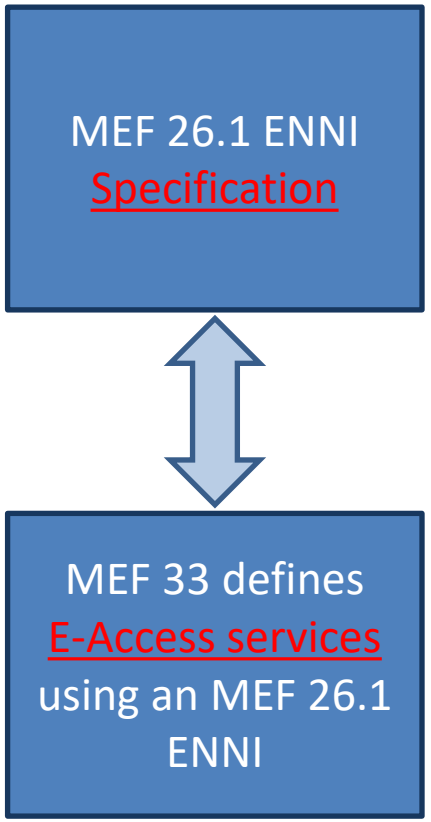
Obstacles Operators Can Encounter When Implementing MEF 26.1 and MEF 33

Network Hardware Cannot Support the Technical Configurations (Switch and/or Card and/or Operating System)

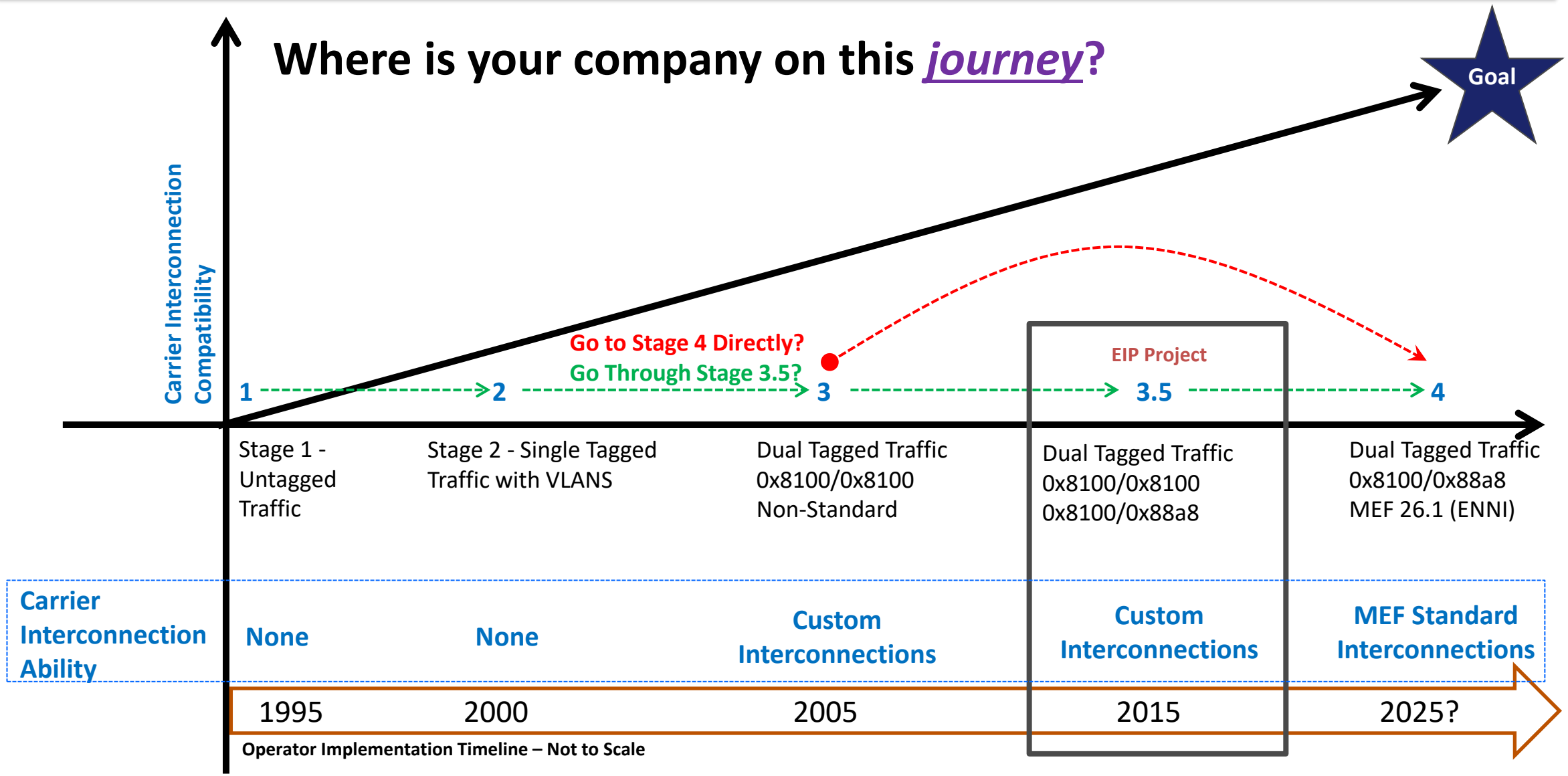
- **Dual tagging with TPID of 88a8**
- **Color awareness**
- **CE-VLAN ID preservation**
- **Etc….**

IT Systems

- **Internal Operator IT systems cannot support the quote-to-cash capabilities for E-Access and ENNI configurations**
- **Examples: Support for OVCs / S-Tag preservation at ENNI**

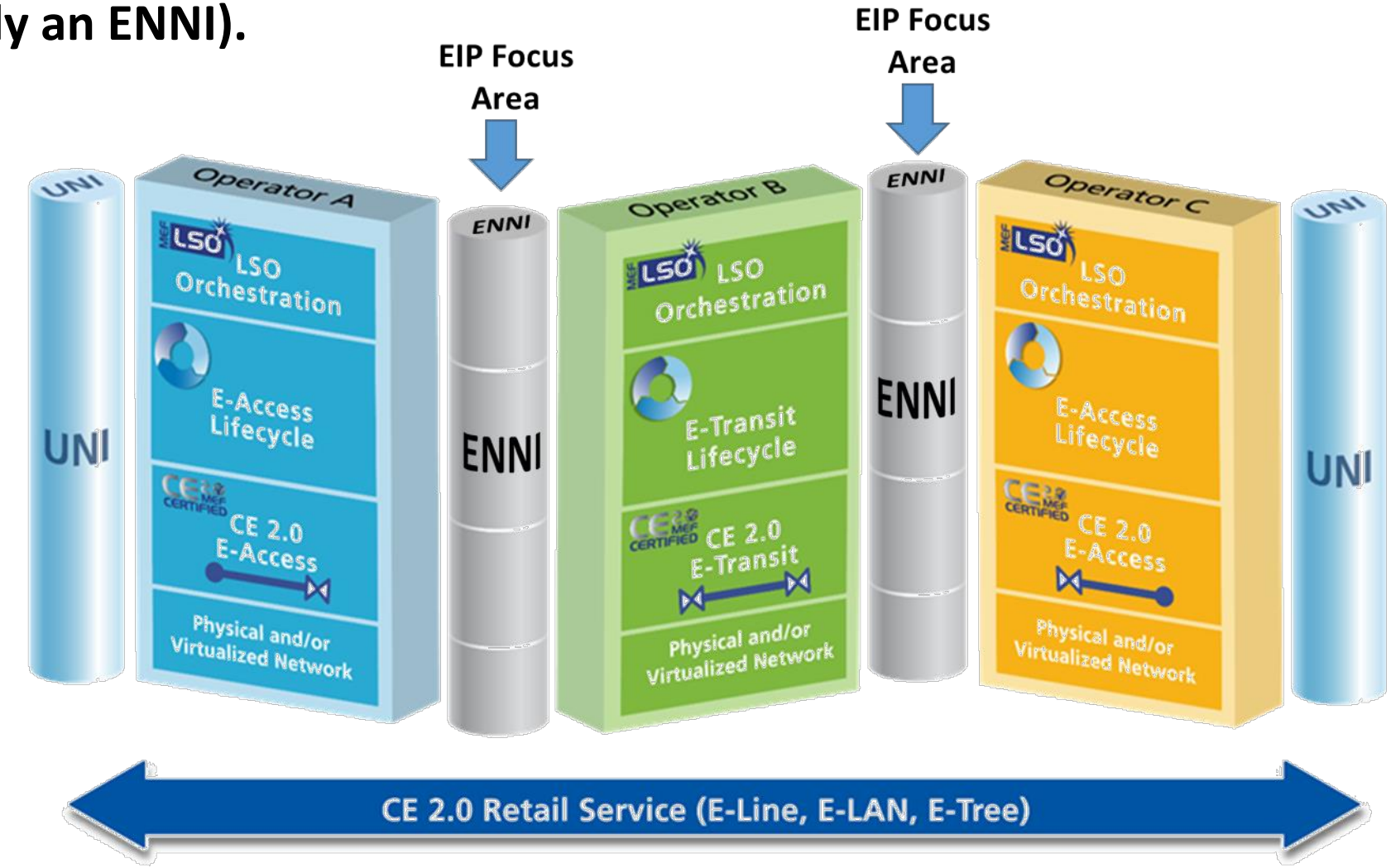


Evolution of Tagging & TPIDs – It's a Journey



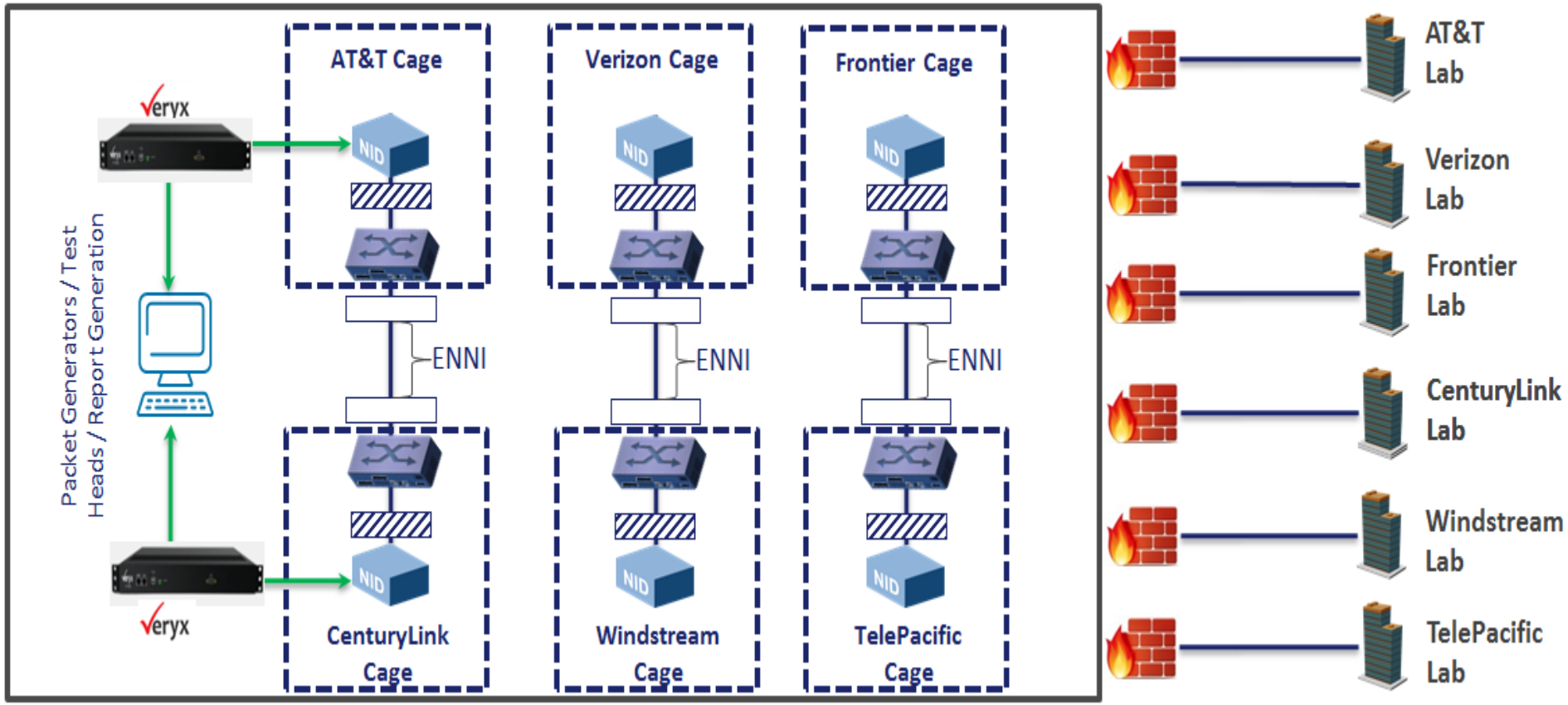
EIP Project

Goal: Help operators make informed decisions on taking the next step on their interconnection journey (e.g., creating a non-standard interconnection (NNI), or preferably an ENNI).



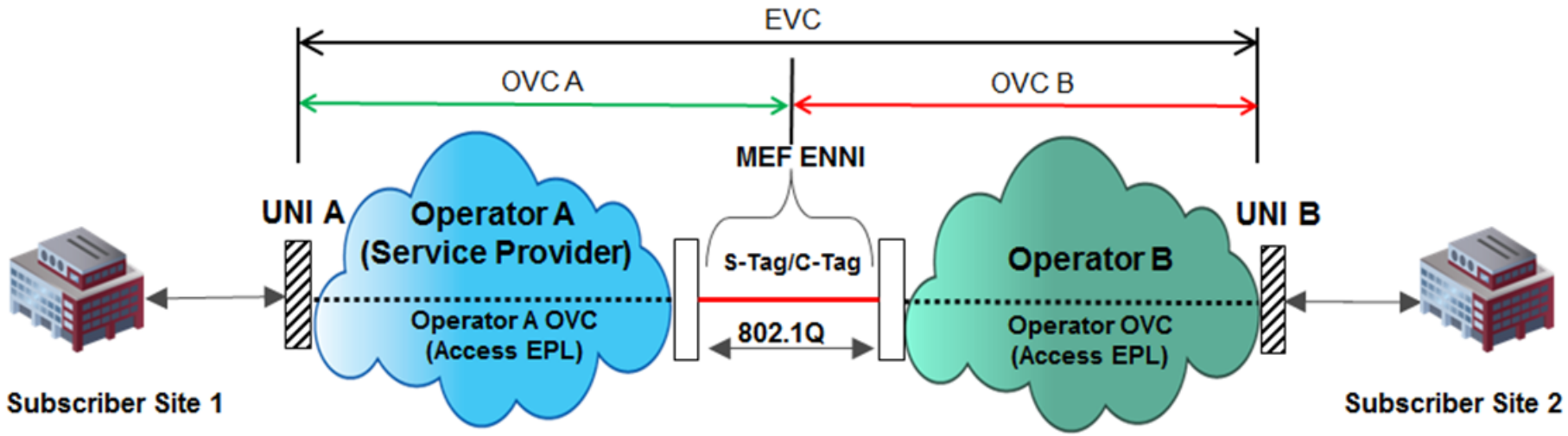
Rapid Prototyping at UNH IOL

The University of New Hampshire's Interoperability Lab (IOL) is hosting an industry first test-bed allowing six large Operators to perform ENNI interconnection testing. All six Operators are being tested with each other. Results are being fed directly to their respective Labs via a secure connection. Only the University of New Hampshire knows the results and configurations of each provider.



Overview of Connection Tested at UNH

The UNH interoperability testing is simulating the network configuration depicted below. A customer has two sites they wish to connect with an EVC. One of the sites is located in another Operator's territory. In order for this connection to be made the two Operators must interconnect their networks using either an NNI or an ENNI. Depiction below is of an ENNI.



Subscriber Point of view:

- Ethernet Private Line (EPL) with Port-based (all-to-one bundle) UNIs
- UNIs Port Speed: 1,000 Mbps
- CIR Speeds varied based on the Test Case: 5, 50, 100, 500 Mbps
- CoS Label H

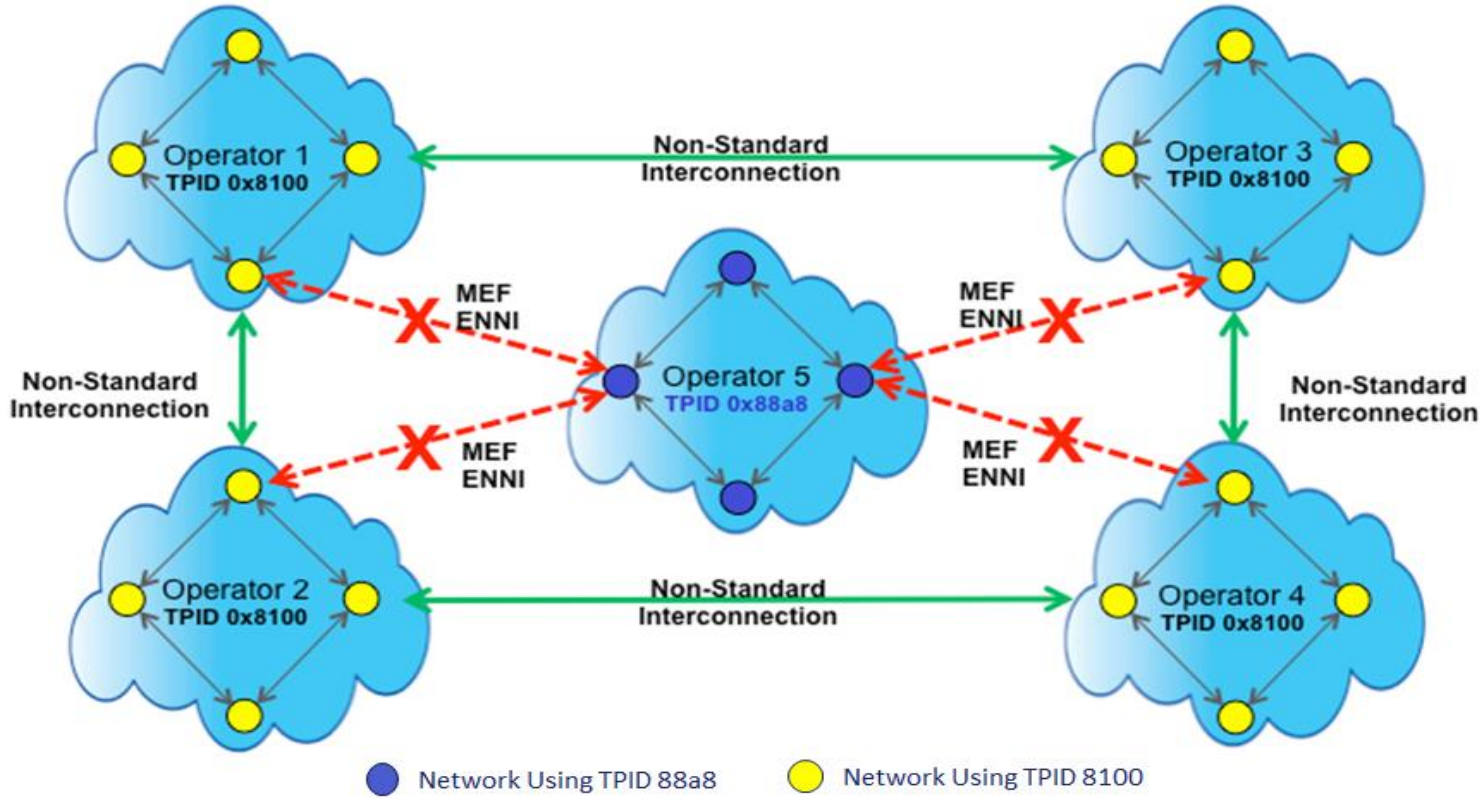
Summary of Test Results

The testing at UNH yielded clear and immediate results. As predicted, the most salient technical challenge to overcome when interconnecting Operator Ethernet networks is ensuring that the TPID of the outer tags, mapped at the ENNI, match at the interconnection point (EIP). There was no way to configure an Ethernet service operating with a TPID outer tag value of 0x8100 to work with an Ethernet network operating with a TPID outer tag value of 0x88a8.

Test Cases	Results with All Operators Using TPID 0x88A8	Results with All Operators Using TPID 0x8100	Results with Some Operators Using TPID 0x88a8 and Some Using 0x8100
1. Frame Format	Passed	Passed	Failed
2. Service Mapping and CE-VLAN ID Preservation	Passed	Passed	Failed
3. CE-VLAN CoS Preservation	Passed	Passed	Failed
4. Unicast, Multicast, Broadcast Frame Delivery	Passed	Passed	Failed
5. Service and ENNI Maximum Frame Size – Minimum Value Supported	Passed	Passed	Failed
6. Service and ENNI Maximum Frame Size – Maximum Value Supported	Passed	Passed	Failed
7. Service and ENNI Frames Exceeding the Maximum Size Supported	Passed	Passed	Failed
8. Service OAM CCM Transparency	Passed	Passed	Failed
9. Service OAM Multicast LBM Transparency	Passed	Passed	Failed
10. Service OAM Unicast LBM/LBR Transparency	Passed	Passed	Failed
11. Service OAM LTM/LTR Transparency	Passed	Passed	Failed

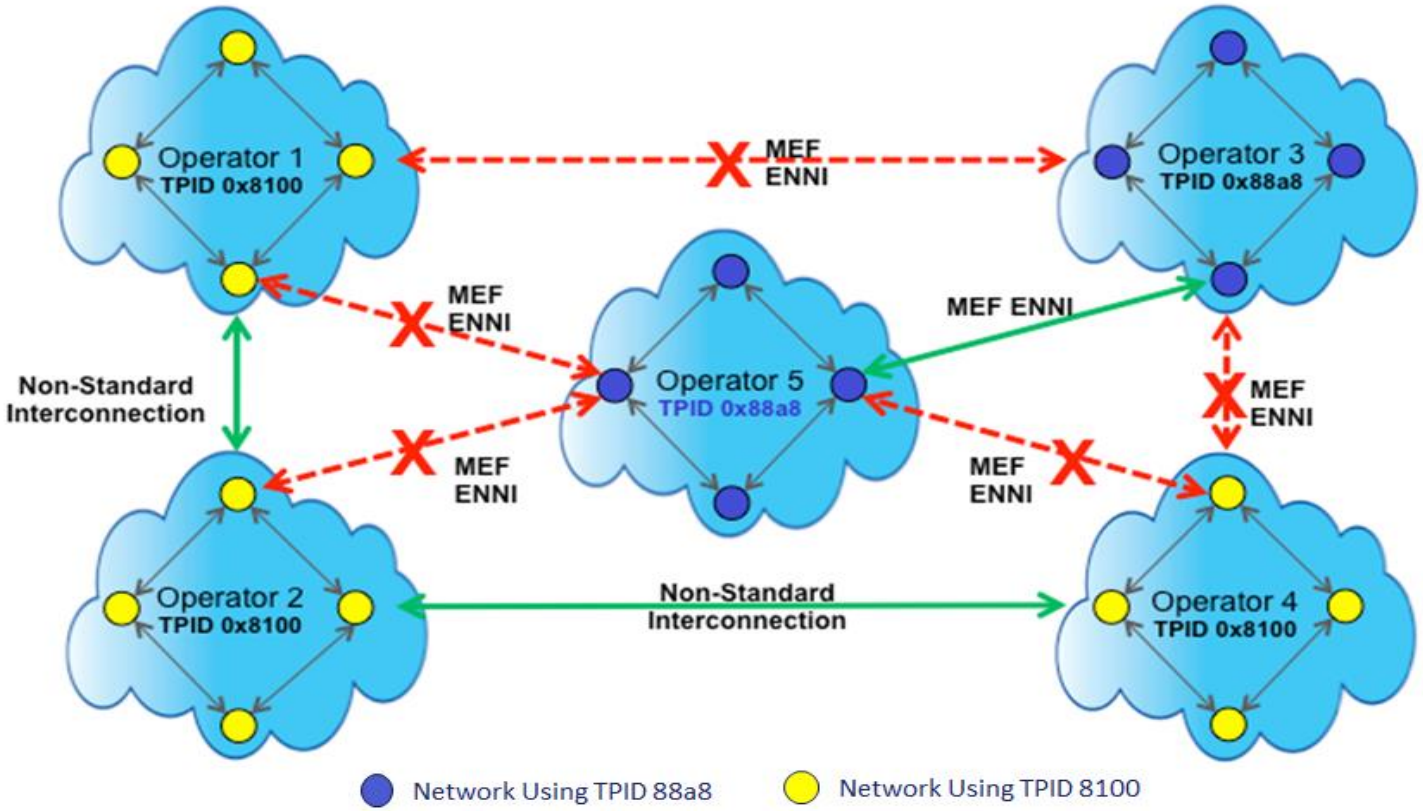
TPID Mismatch - Operator Becomes Completely Isolated

In the figure below, Operator 5 moved to using a standard S-Tag encapsulation at the ENNI (TPID 0x88a8) but the other operators adjacent to its footprint did not. While Operator 5 moved to the new correct "industry standard" (MEF 26.1) they are now isolated from connecting to the Operators around them. Operator 5 is now an "Island" and cannot interconnect with other Operators to create end-to-end services. In this instance, moving to the MEF standard actually diminished their capacity to expand their Ethernet service.



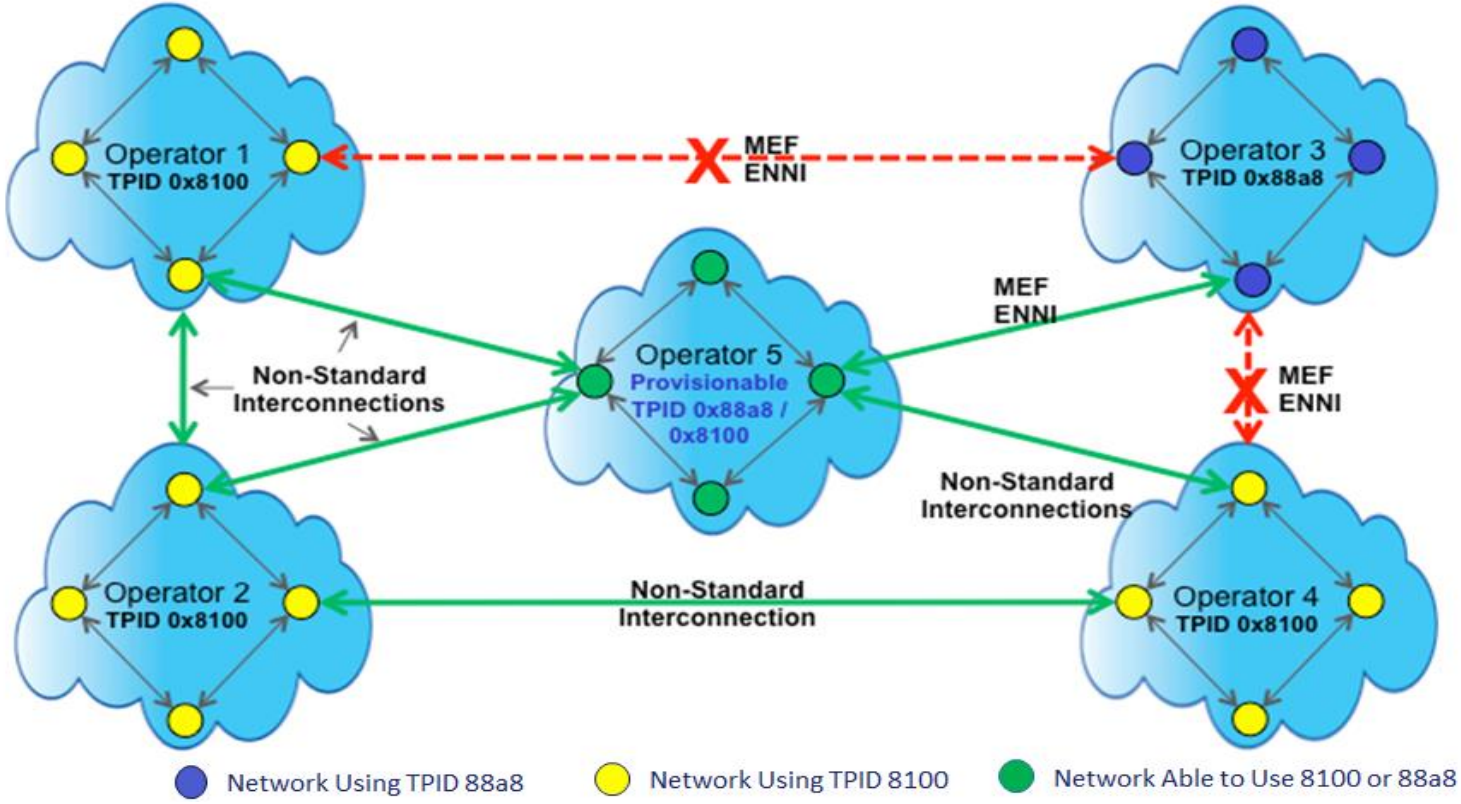
TPID Mismatch - Operator Becomes Partially Isolated

In the figure below both Operator 5 and Operator 3 have moved to the new MEF standard and can now interconnect in an industry standard fashion and enjoy the benefits of MEF 26.1. However, they are still unable to connect with all the other Operators using non-standard interconnections.



TPID Match - Operator Becomes “Bilingual”

In the figure below Operator 5 is able to create both MEF ENNIs (TPID 0x88a8) and non-standard interconnections (TPID 0x8100) with the Operators adjacent to its footprint. Operator 5 has become "bilingual" and has the greatest capacity to conduct business with Operators who use non-standard interconnections, or the ones who moved to ENNIs. This is the best position for an Operator to be in while the market transitions to Ethernet. Over time, as more and more operators adopt the MEF standard, Operators will stop creating non-standard interconnections. NOTE – An Operator cannot be “bilingual” on the same network port. A port can only be provisioned as an ENNI or an NNI – Not both. However, the same network card can have an ENNI port and an NNI port (depending upon HW).



Overcoming Obstacles

Obstacle Encountered	Remediation	Result
One Operator is Color Blind and the Other Operator is Color Aware	We used CIR only service	All frames are either marked green or red - no need for color awareness
One Operator has an MTU size larger than the Other Operator	We sent traffic with the minimum MTU supported	Picking the minimum MTU ensured that all the Operators passed all their frames in both directions (ingress and egress)
How do you ensure that both Operators use the same value for the outer VLAN at the Interconnect Point?	During the testing at UNH, UNH tester selected the VLAN value for outer tag and communicated it to both Operators; each Operator configured the outer VLAN value	Since both Operators have assigned the same outer VLAN value ("21" for example) the frames flowed across the ENNI (or Non-Standard Interconnection) to the other Operator
Operators did not support the same set of CIR speeds so how do we deliver requested CIR for customer EPL service?	UNH tested common set of customer EPL CIR values supported by both Operators access services	Customer gets the requested CIR, or a CIR that's acceptable for their needs

Operators Need to Know…

As Operators continue their journey towards MEF standardized interconnections (ENNI) there are other non-technical items they will want to consider. Section 11 of the Implementation Agreement is meant to act as a "thought provoker" to help ensure all aspects of Ethernet interconnections are being considered. Topics include:

1. **Where to build an EIP?**
2. **How many EIP's are needed?**
3. **How to determine what Ethernet services are available outside an Operator's footprint?**
4. **What should an Operator know about ordering Ethernet services?**
5. **Physical equipment considerations**

Summary

MEF 5X - EIP

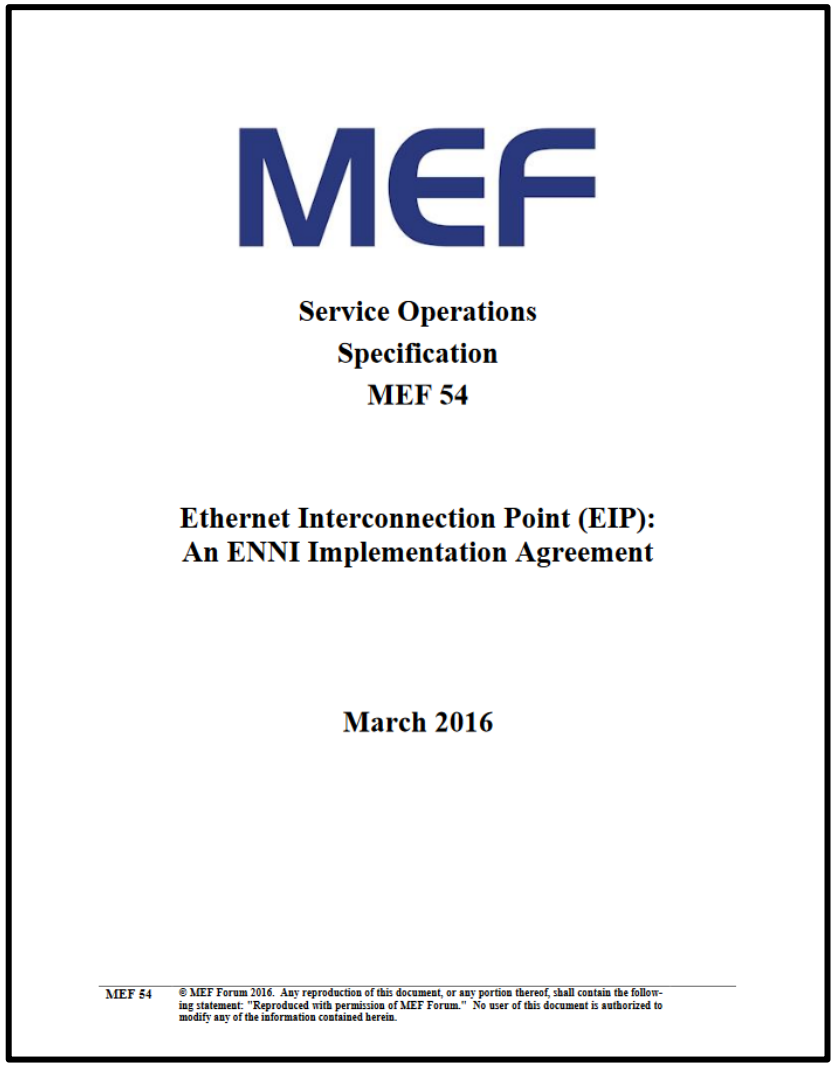
Summary MEF 54

- All Operators who offer TDM-based services, whether they know it or not, are on a journey away from TDM towards Ethernet
- All Ethernet Operators (Telecom, Cable, CLEC, ILEC) are on a Journey towards MEF standardized interconnections (ENNI)
- Testing performed in this project demonstrated Operators with different TPID values cannot interconnect
- Operators should become “bilingual” to ensure they can interconnect with other operators on their boarder
- Operators should consult the EIP Implementation Agreement to help them begin, or take the next step, on their journey towards MEF standardized interconnections

For Full Details …

- **Visit http://www.mef.net Select "Specifications" and select MEF 54 to access the full Implementation Agreement**

- **Visit the EIP site at: www.mef.net/eipproject**


MEF

Service Operations
Specification
MEF 54

Ethernet Interconnection Point (EIP):
An ENNI Implementation Agreement

March 2016

MEF 54

How to Perform ENNI Testing and Certification

- **Operators who wish to perform their own Interoperability testing – whether using TPID 0x88a8 (ENNI) or 0x8100 (NNI) are encouraged to contact the University of New Hampshire's Interoperability Lab. Visit: https://www.iol.unh.edu/**

- **Operators who are ready to create, or can already create, an industry standard ENNI using TPID 0x88a8 as per MEF 26.1 should get MEF certified for "MEF 33 E-Access services." They will then appear on MEF's "Certification Registry." Doing so allows other Operators, who boarder their network, to understand where the Operator is on its interconnection journey. It also allows retail customers with large RFPs to view an Operator's capabilities. Visit: https://www.mef.net/certification/services-certification-overview**

Related Documents

- MEF 26.1 - External Network Network Interface (ENNI) – Phase 2
- MEF 33 - Ethernet Access Services Definition
- MEF 51 - OVC Services Definitions Technical Specification

MEF

Accelerating Worldwide Adoption of Carrier-class Ethernet Networks and Services

MEF.net