HANDLING OF LEGACY END DEVICES AND SERVICES ON UTILITY PACKET NETWORKS

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OCTOBER 2018

PRESENTATION OUTLINE

- Utility legacy services use cases
- TDM emulation over Packet Switched Network
- TDM Transport Issues over PSN
- Interface Converters
- Disadvantages of carrying TDM services on PSN
- Legacy migration considerations
- Conclusion
- References
- List of abbreviations

UTILITY LEGACY SERVICES USE CASES

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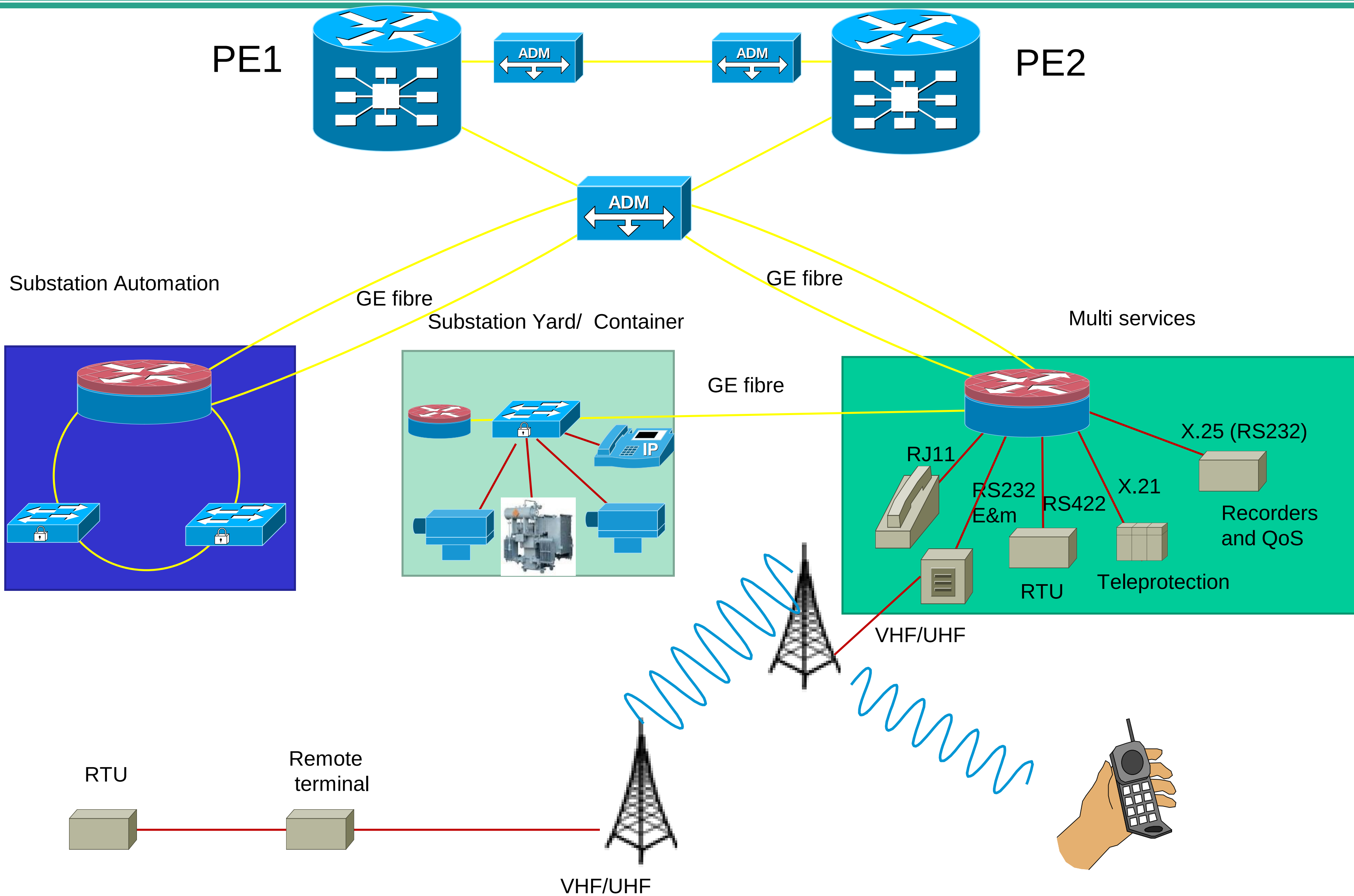


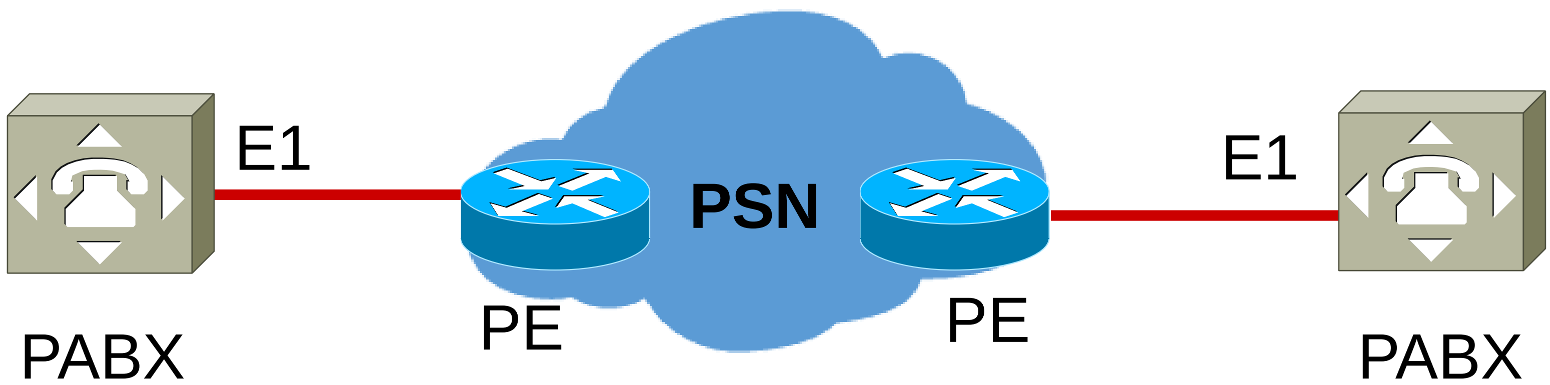
LEGACY SERVICES USE CASES

Interface	Application	Bandwidth
RS232 Asynch	SCADA : RTU and Master	200, 1200, **9600, 19200** bps
X.21 Sync	Teleprotection	64Kb/s
X.21 Asynch	SCADA: RTU and Master	200, 1200, **9600, 19200** bps
RS232 Asynch (X.25)	Disturbance recorders	19200bps
RS232 Asynch (X.25)	Quality of supply	19200bps
FXS/LGS/LGE/FXO/E&M	Telephones	64Kb/s
FXS (PABX)	TWS fault locators	64Kb/s
4 W E&M	SCADA, VHF	200, 1200, **9600, 19200** bps

TDM EMULATION OVER PSN

TDM EMULATION OVER PSN

- TDM Emulation is a method by which a TDM circuit is transported transparently through a Packet Switched Network (PSN)
- ITUT, IETF and MEF have published recommendations for implementing TDM emulation for both PDH and SDH



E1 TDM circuit over PSN

PUBLISHED RECOMMENDATIONS

Organisation	Document	Title	Terminology	Version	Payloads	Transport
IETF	RFC4553	Structure Agnostic TDM over Packet	SAToP	June 2006	T1,**E1,**T3,E3	IP or MPLS
	RFC4842	SONET/**SDH** Circuit Emulation over Packet	CEP	June 2007	STS-n/VC-n VT-n/VC-n	MPLS
	RFC5086	Circuit Emulation Services over Packet Switched Network	CESoPSN	Dec2007	DS0 (nX64Kbps)	IP or MPLS
	RFC5087	Time Division Multiplexing over IP	TDMoIP	Dec 2007	DS0,T1,**E1,**T3,E3,	IP, MPLS or Ethernet
	TSoP	Transparent SDH/SONET over Packet	TSoP	Jan 2015	OC-n/STM-n	MPLS
ITU	Y.1413	TDM-MPLS Network Interworking	Y.1413	March 2004	DS0,T1,**E1,**T3,E3,	MPLS
MEF	MEF3	Circuit Emulation Services Definitions, Framework and Requirements in Metro Ethernet Networks	MEF3	April 2004	DS0,T1,**E1,**T3,E3, STS-n/VC-n, VT-n/VC-n	Ethernet
	MEF8	Implementation Agreement for the emulation of PDH circuits over Metro Ethernet Networks	MEF8 CESoETH	Oct 2004	DS0,T1,**E1,**T3,E3	Ethernet

IETF, ITU and MEF Recommendations [11]

CESoPSN

- For encapsulating structured Time Division Multiplexed (TDM) signals as pseudowires over packet switching networks
- Recognises TDM Structure e.g. G.704 E1
- Can distinguish individual timeslots, enabling packet loss concealment
- Accessibility of TDM signalling
- Bandwidth saving due to support of Nx 64Kbps DS0 circuits
- Supports DS0 timeslot grooming and distributed cross-connect applications.

SAToP

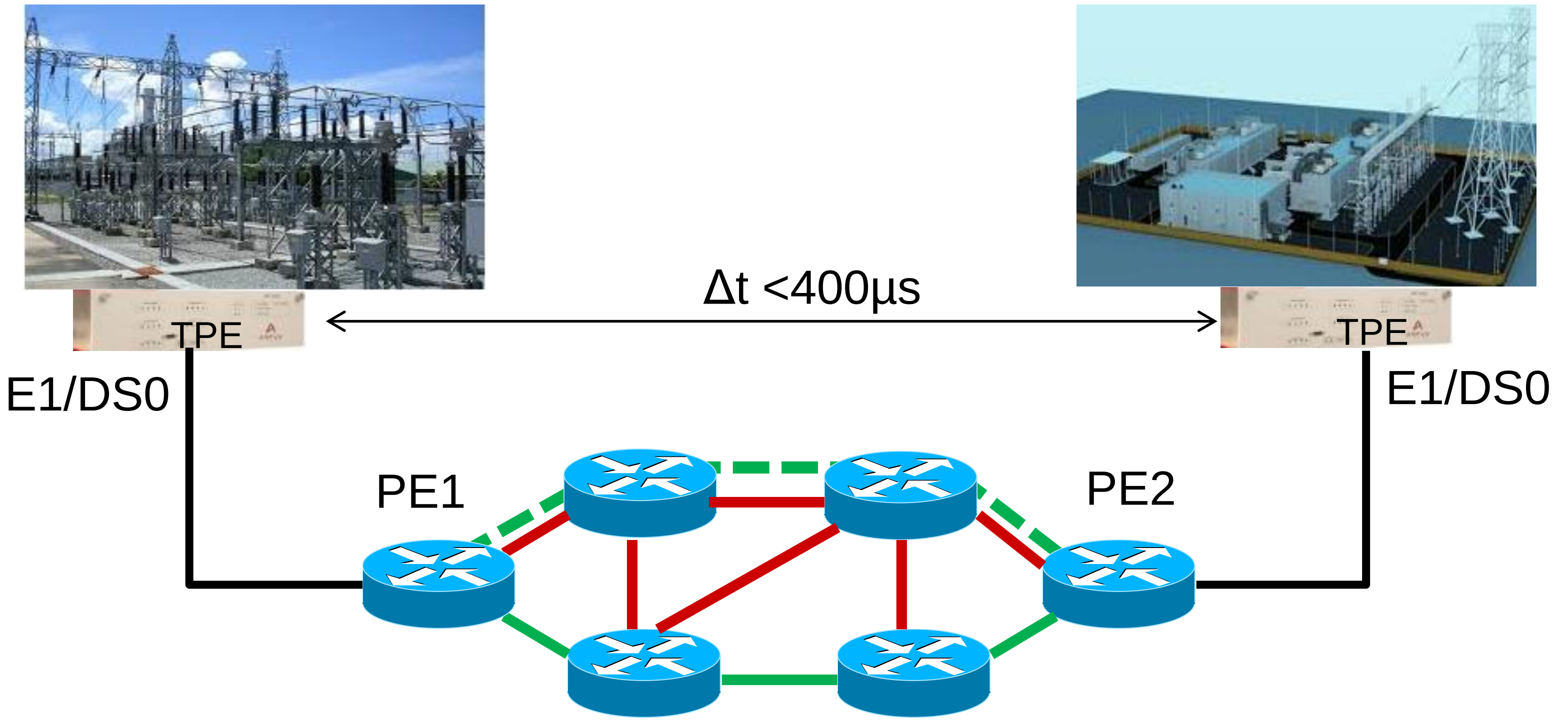
- Structure-Agnostic TDM over Packet (SAToP)
- Pseudowire encapsulation for unstructured Time Division Multiplexing (TDM) bit-streams (E1, E3)
- Disregards any structure imposed by standard TDM framing (e.g. G.704).
- Not suitable for applications where PEs must interpret TDM data or to participate in the TDM signalling

TDM TRANSPORT ISSUES OVER PSN

PACKET DELAY VARIATION (PDV)

- Packet networks introduce a Packet Delay Variation (PDV) called jitter
- High Jitter is not acceptable to PDV sensitive services like differential protection (less than 400µs requirement) and can lead to false trips
- PDV compensation techniques are required for packet networks to carry PDV sensitive services
- It is a requirement of Electric Power Utilities (EPUs) that packet replacement solutions must meet or exceed the performance of the incumbent TDM networks

CAUSES OF PACKET DELAY VARIATION (PDV)



<u>Causes of PDV</u>

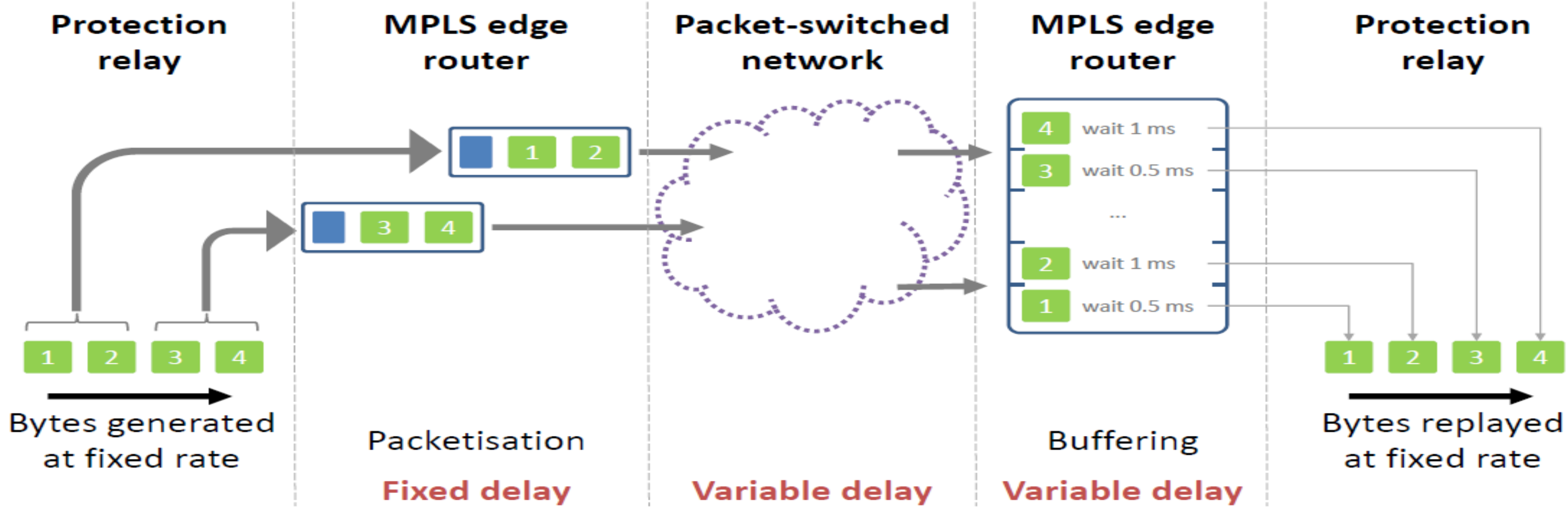
- Network multiple alternative paths
- Network congestions
- Unidirectional label-switched path (LSP)

PACKET DELAY VARIATION (PDV) COMPENSATION

- Jitter buffer compensates for PDV on packet networks
- A jitter buffer temporarily stores arriving packets and then send them to the receiving end at a constant rate, to minimize the impact of PDV.
- PSN solutions offer a configurable (dynamic) jitter buffer size
- Jitter buffer settings can also be preset by the OEM (Static)

JITTER BUFFER

- If packets arrive too late, they are discarded
- A very small jitter buffer does not compensate for PDV, instead it results in an excessive number of packets being discarded, leading to quality degradation.
- If a jitter buffer is too large, additional delay can lead to intolerable latencies



PDV compensation [4]

JITTER BUFFER

- Alcatel Lucent: 2 vs11 Hops, 100Km of fibre

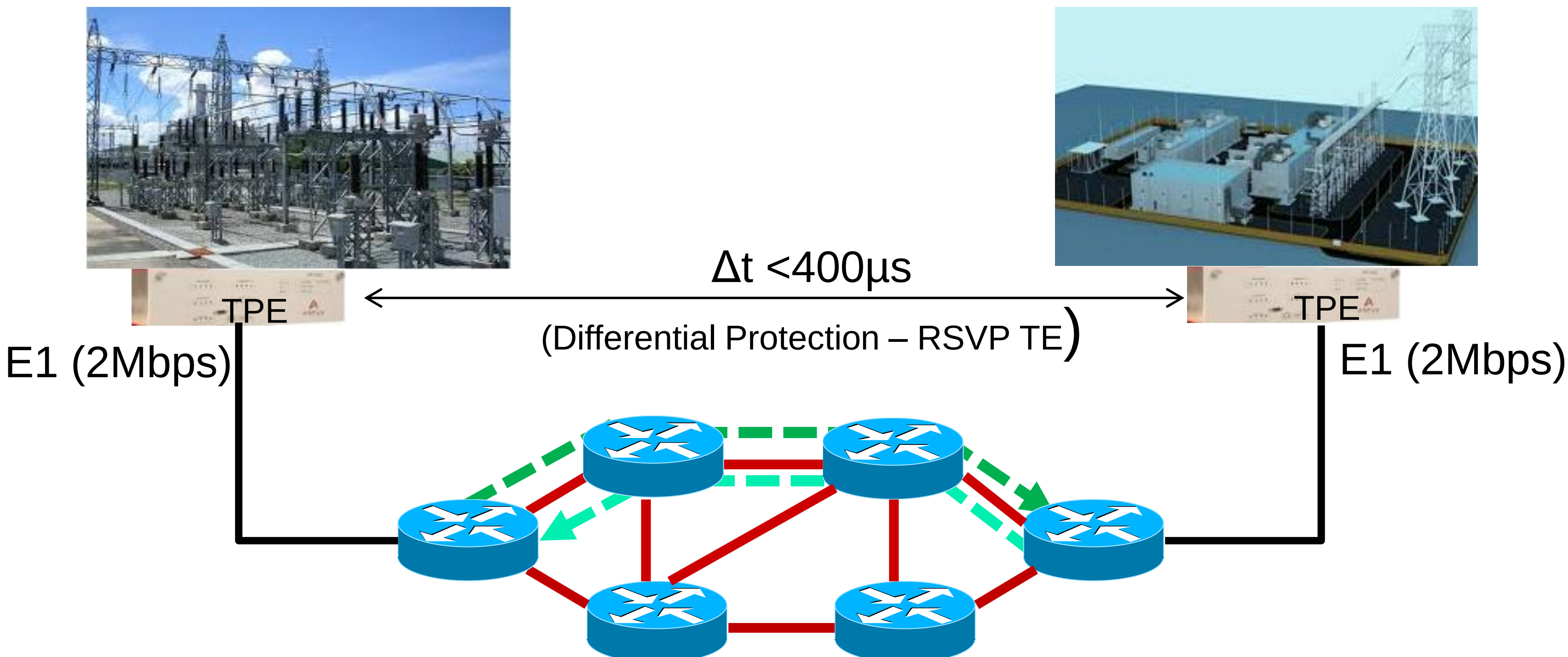
Interface Type	Jitter Buffer (ms)	Payload (bytes)	Latency (ms) 2 nodes path	Latency (ms) 11 nodes path
E1	2	64	1.61	2.29
E1	4	64	2.55	3.3
E1	5	256	3.37	4.12
C37.94	2	32	2.37	3.06
C37.94	4	64	3.87	4.56
C37.94	5	32	3.87	4.56

Impact of Jitter buffer setting size [5]

MPLS SYMMETRY

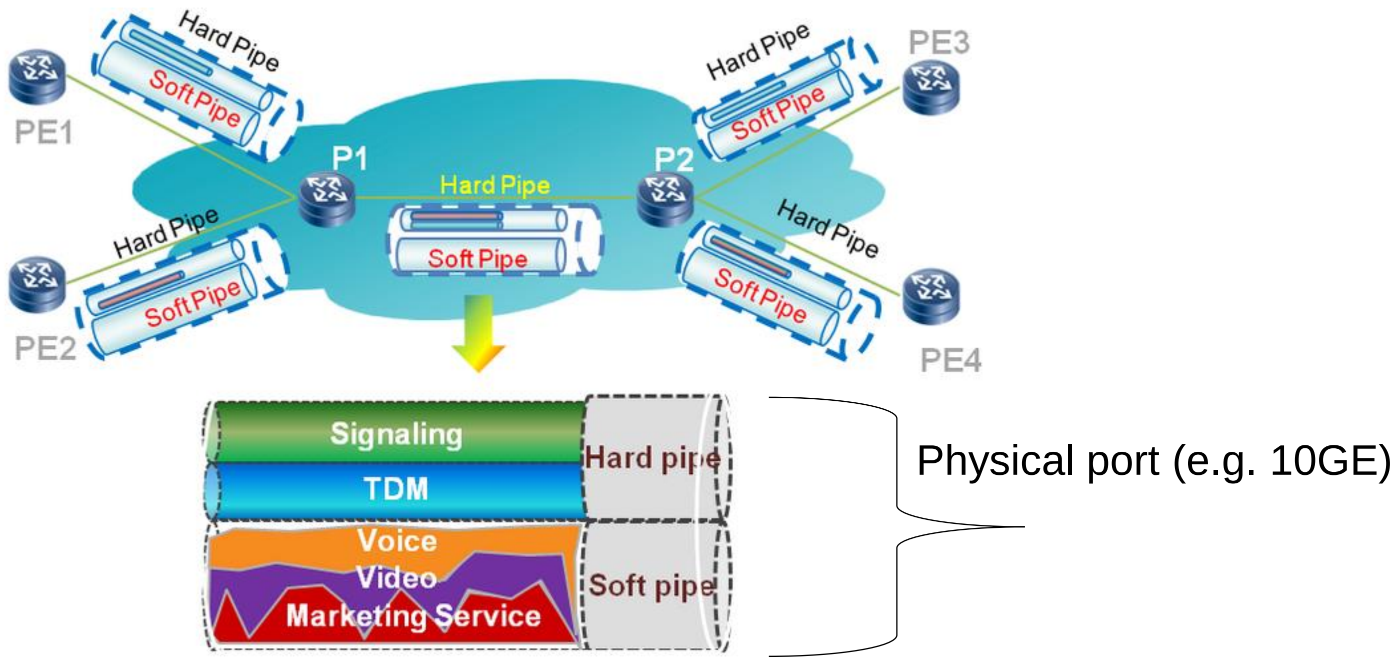
RSVP TE AND TE-FRR

- RSVP TE [6] tunnel compensates the unidirectional LSP on IP/MPLS which causes variations in packet arrival time
- This is done my pinning the sending and receiving LSP on the same path
- TE-FRR [7] protection is used to achieve 50ms recovery against circuit failures



IP HARD PIPE

- Based on IETF RFC 7625 and is designed to achieve low latencies
- Isolates soft and hard pipes by hardware so that the soft and hard pipes have isolated bandwidth.
- Hard-pipe packets are forwarded with the highest priority.

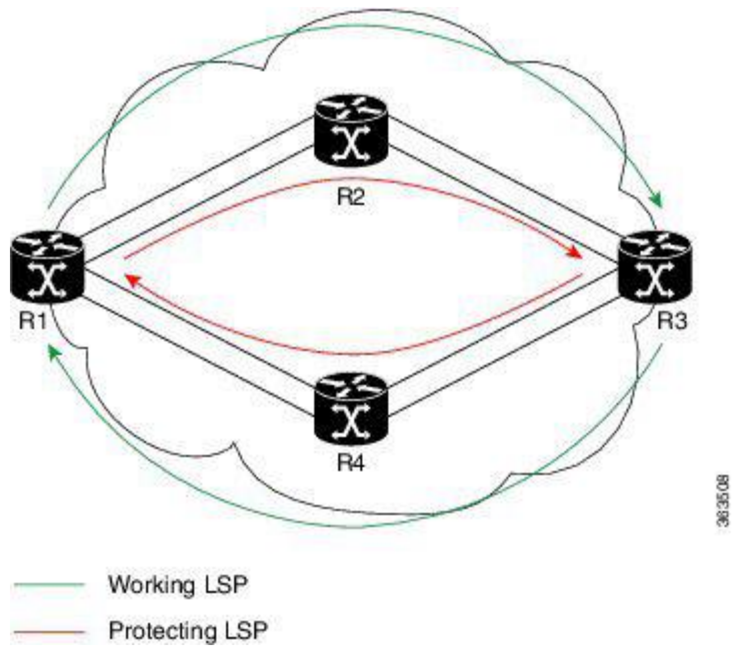


IP Hard Pipe [8] [9]

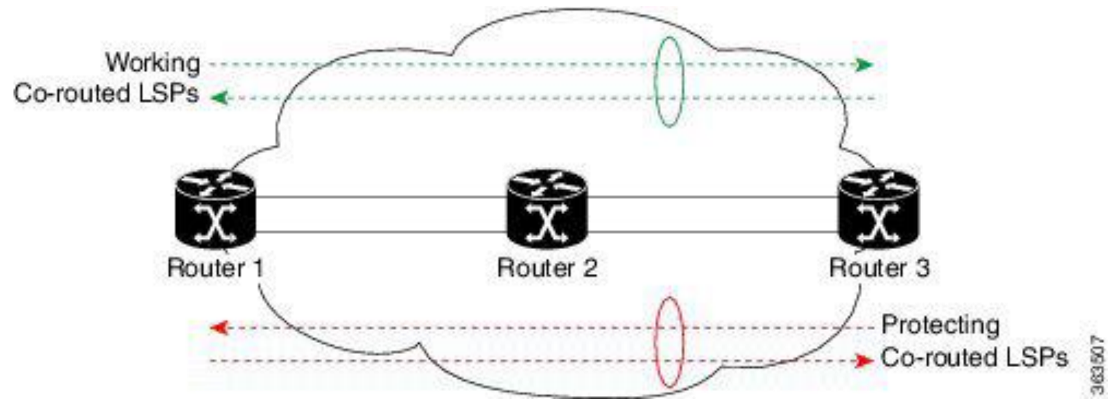
FLEX LSP

- Flex LSP (**Associate Bidirectional LSPs)** is a combination of **static** bidirectional MPLS-TP and dynamic MPLS-TE [10]
- Bidirectional LSPs are **set up dynamically** through Resource Reservation Protocol–Traffic Engineering (RSVP-TE).
- Flex LSP instances where the forward and the reverse direction paths are setup, monitored and protected **independently** and associated together during **signalling**.
- RSVP Association object is used to bind the forward and reverse LSPs together to form either a co-routed or nonco-routed associated bidirectional TE tunnel.
- A protecting MPLS-TE tunnel is associated with either a working MPLS-TE LSP, protecting MPLS-TE LSP, or both. MPLS-TE tunnel to operate with or without protection.

FLEX LSP



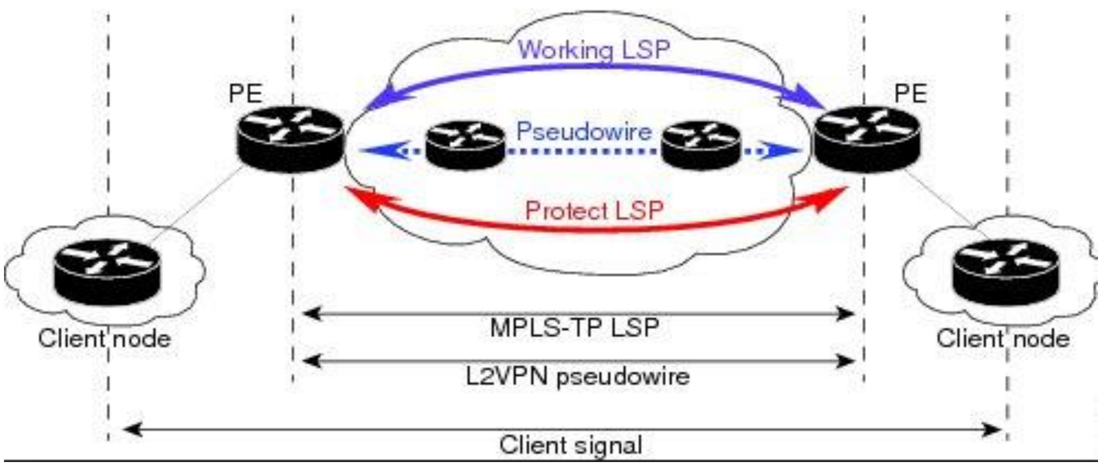
Default non Co-routed LSPs [10]

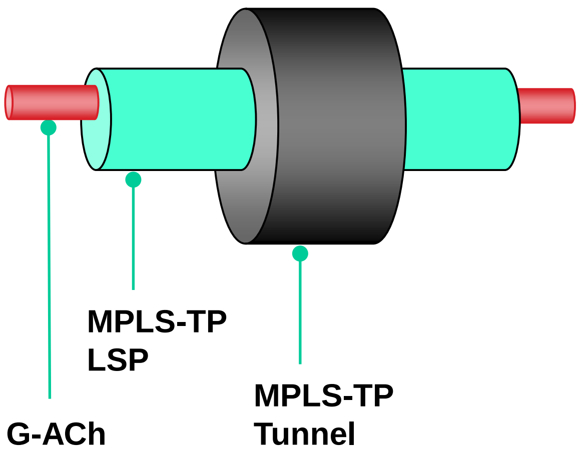


Co-routed LSPs [10]

MPLS-TP

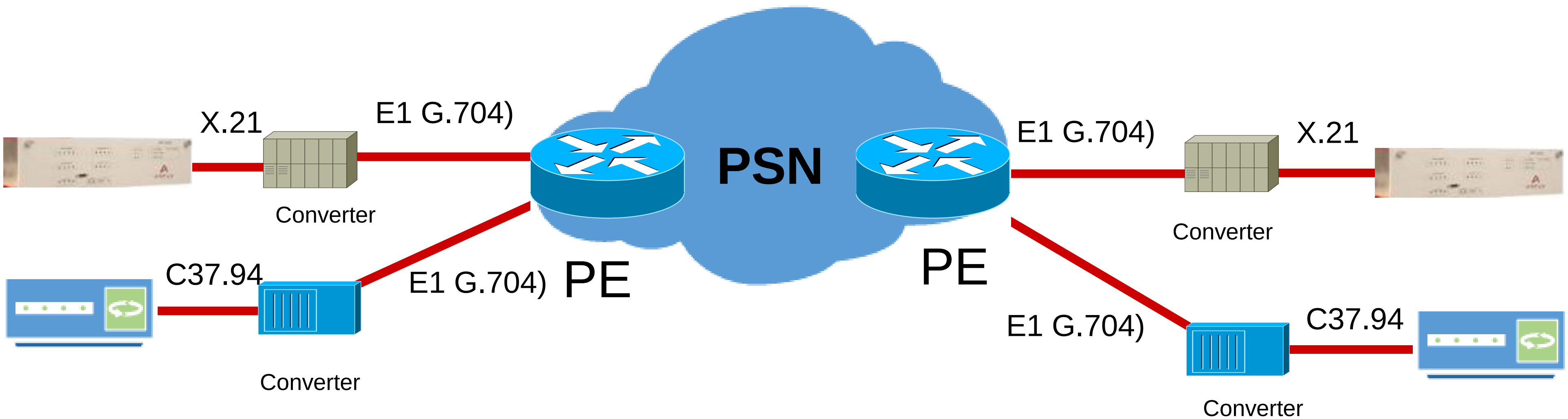
- Offers inband simple and robust SDH like OAM: GACh+Y.1731(ITU-T), extended BFD/LSP-Ping (IETF)
- No Penultimate Hop Label Popping
- Supports LSP protection and less than 50ms automatic protection switching
- Supports Static provisioning of tunnels and pseudowires
- Supports bidirectional LSPs (delay symmetry)



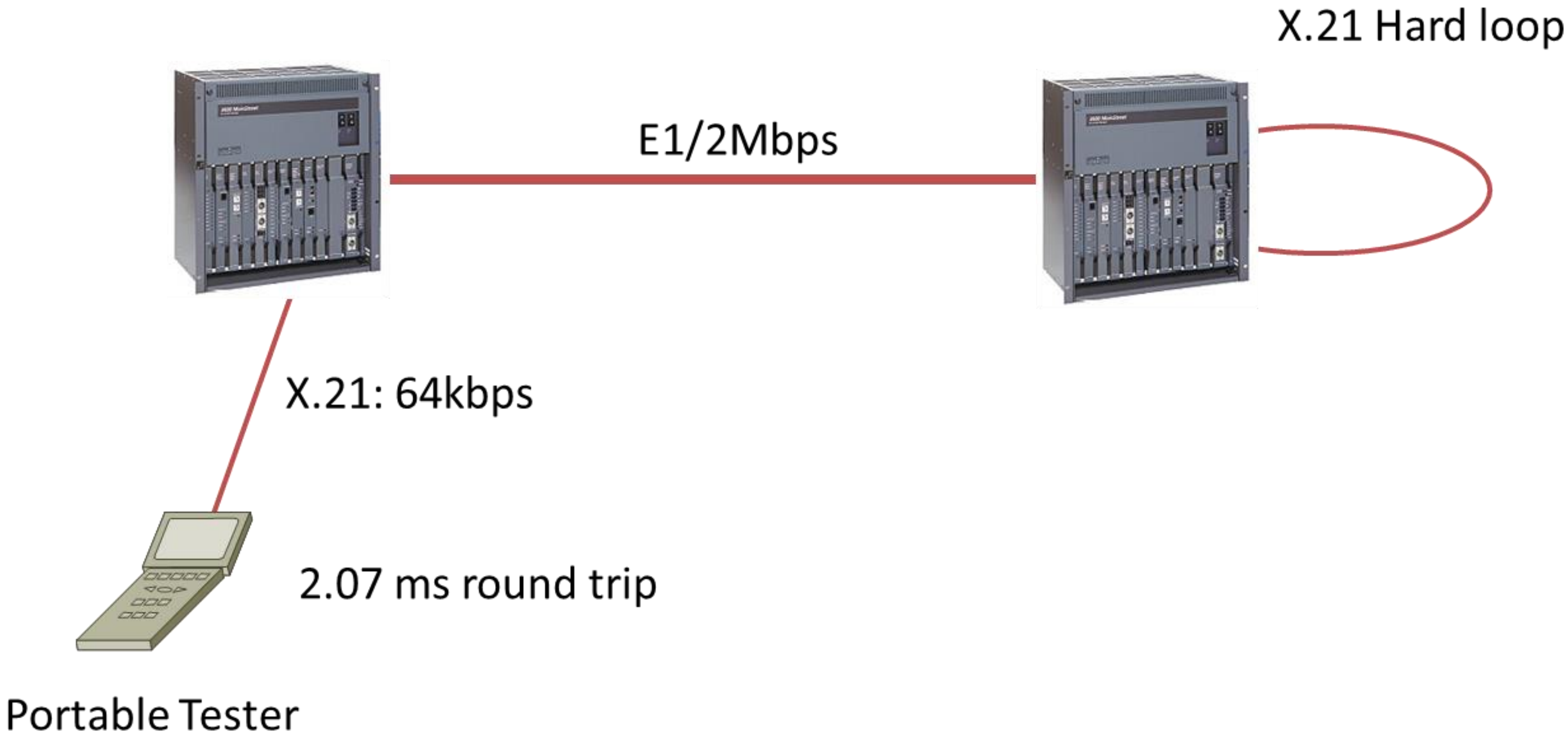


INTERFACE CONVERTERS

- Converters offer flexibility for scenarios where a PSN PE devices do not offer the required interface
- Converters will introduce additional latencies on the circuit
- Converters will mostly not be managed which might have impact on Service Level Agreements (SLAs)
- Existing legacy Muxs can be used as converters during the migration phase

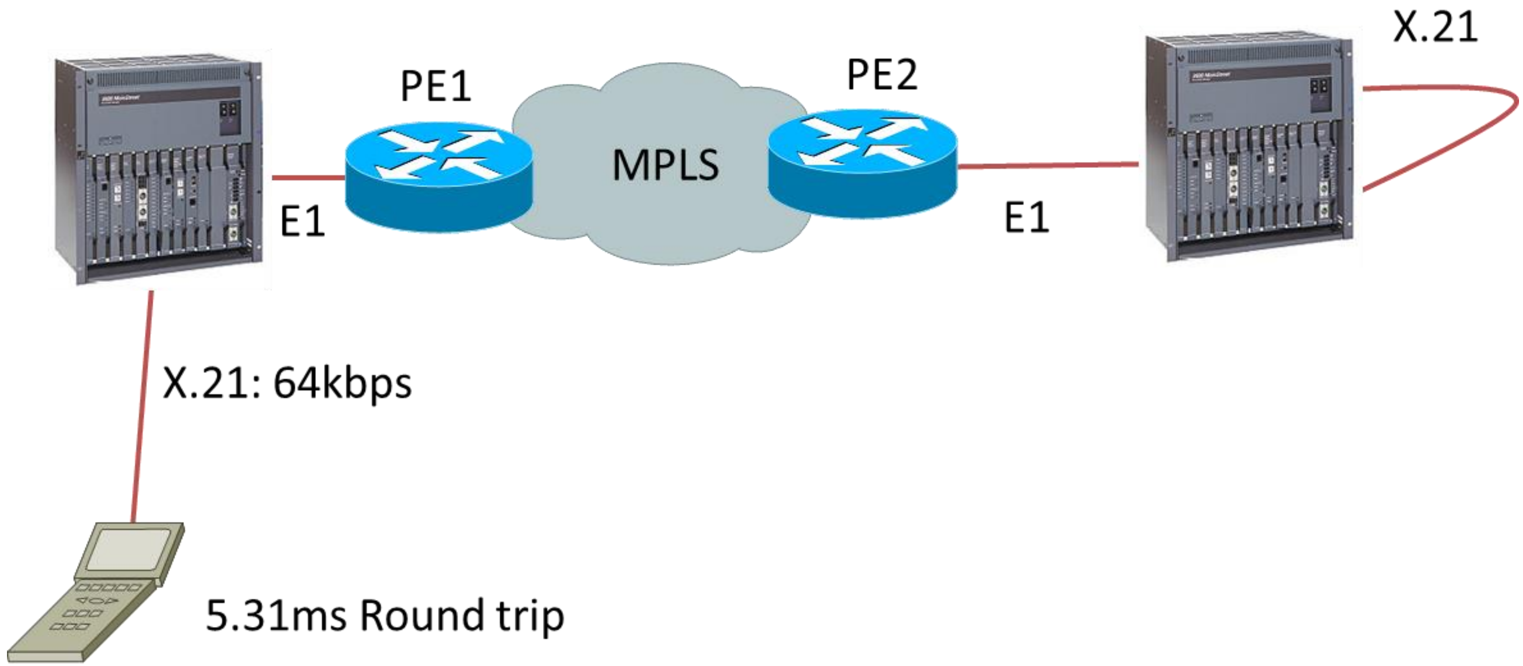


CONVERTERS



Back-to-back 2 TDM Mux nodes (benchmark)

CONVERTERS



TDM + MPLS-TP Latency

DISADVANTAGES OF CARRYING TDM SERVICES ON PSN

- Increases the required number of slots on the PSN PE devices
- More slots = more power = increased cooling and floor space requirements
- Legacy interface modules are costly
- Introduce interoperability issues as the OEMs have different techniques of handling legacy services
- Increased OEM support fees (OEM fees are linked to equipment costs)
- Complicates network configurations.
- The standard IP training does not cover legacy services, making legacy IP skills scarce

LEGACY MIGRATION CONSIDERATIONS

- A strategy that looks only at migrating EPU telecoms TDM networks to IP is not a good strategy, there must also be emphasis on migrating the end devices to IP
- Migrating end devices to IP will ensure that EPUs implement standard solutions with higher levels of interoperability
- EPUs have less risk of being locked to one vendor if they implement standard IP solutions

CONCLUSION

- There are still a lot of legacy services use cases on the EPU networks
- Packet switched networks can handle these services but at a higher cost than if they were IP
- The best approach is to also migrate the end devices to IP
- Use of converters offer another option but it must be taken into consideration that they might not be managed
- It might not be possible to replace legacy IEDs in a short space of time but at least there must be a plan/ a clear roadmap

REFERENCES

[1] https://tools.ietf.org/html/rfc5087

[2] https://tools.ietf.org/html/rfc5086

[3] https://tools.ietf.org/html/rfc4553

[4] The status of communications for power system - Steven Blair, University of Strathclyde, August 2016

[5] Creos Luxembourg - Alcatel Lucent/Nokia, Teleprotection tests

[6] https://tools.ietf.org/html/rfc3209

[7] https://tools.ietf.org/html/rfc4090

[8] https://tools.ietf.org/html/rfc7625

[9] http://e.huawei.com/en/tech-topic/jp/ip-hard-pipe

[10] Flex LSP Overview, Cisco

[11] Trailblazing Legacy Services over Packet Networks, CienaCorp

LIST OF ABBREVIATIONS

- CESoPSN - Circuit Emulation Service over Packet Switched Network
- EPU – Electrical Power Utility
- IED - Intelligent Electronic Device
- IETF - Internet Engineering Task Force
- IP – Internet Protocol
- IP—Internet Protocol
- L1, L2, L3—Layer 1, 2, 3 (of OSI model)
- LAN – Local Area Network
- LAN—Local area network
- MP- Multipoint
- MPLS – Multiprotocol Label Switching
- MPLS—Multiprotocol Label Switching
- MPLS-TP – MPLS Transport Profile
- P2MP - Point-to-multipoint
- P2P – Point-to-point
- PDH – Plesiochronous Digital Hierarchy
- PMU—Phasor measurement unit
- QoS—Quality of service
- SDH – Synchronous Digital Hierarchy
- TDM – Time Division Multiplexing
- UHF – Ultra High Frequency
- VHF – Very High Frequency
- VPLS – Virtual Private Lan Services
- VPN – Virtual Private Network
- XOT – T.25 Over TCP