Migration of the Protection Data Interface from SDH to MPLS Networks

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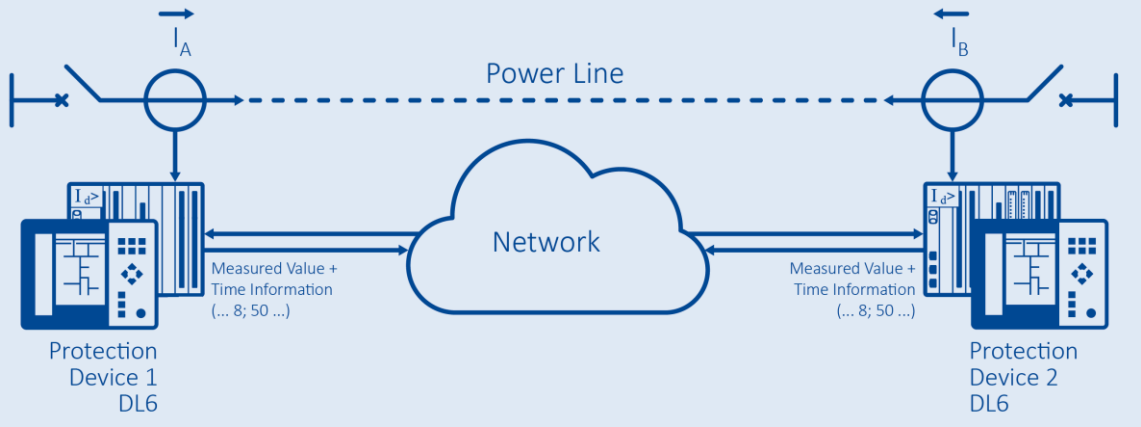
Motivation and Introduction

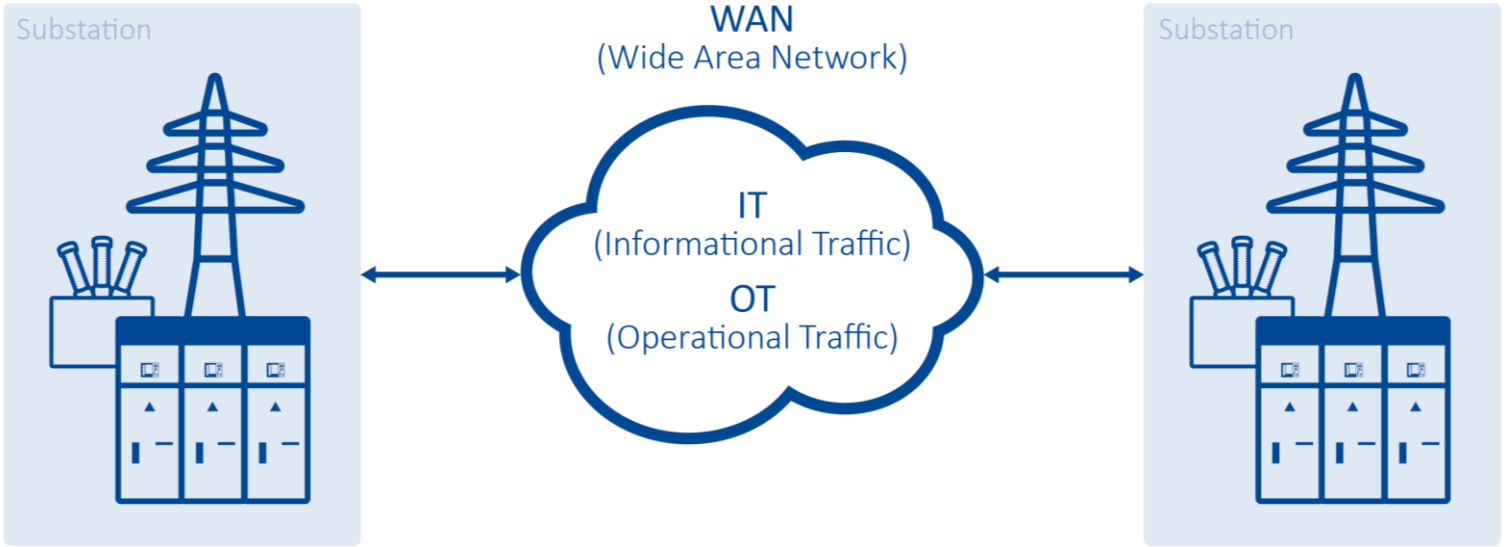
- **Protection Data Interface**

  → Line Current Differential Protection



Motivation and Introduction

- **Inter-Substation Communication**



Motivation and Introduction

- **Differentiation of data by application**
  - Informational Traffic (IT) / Enterprise
    - E-Mail, Communication to data server, Softwareupdates…

  - Operational Traffic (OT)
    - Communication for operation, monitoring and protection application

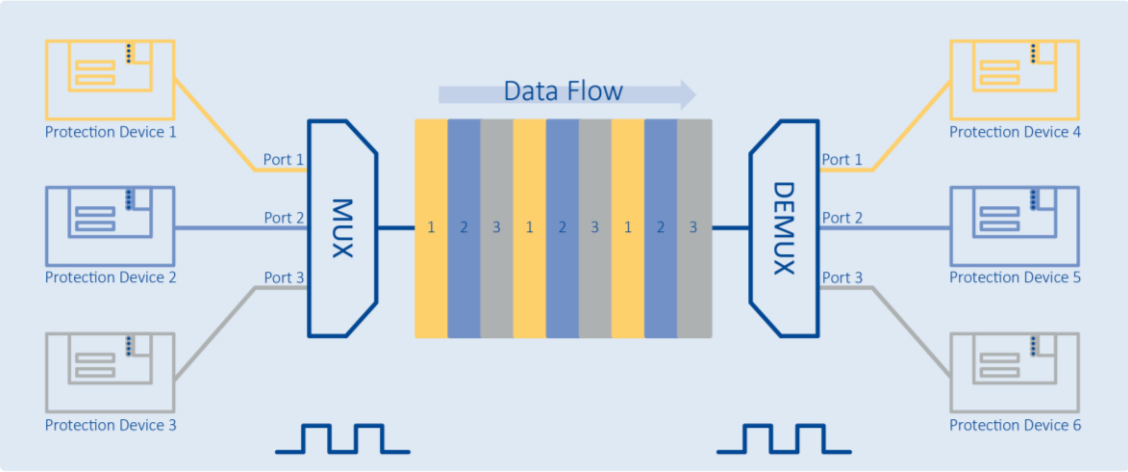
→ **Telecontrol and Teleprotection!**

Motivation and Introduction

- **Communication network type for IT/OT**
  - Enterprise (IT):
    - Ethernet-based
  - Operational (OT):
    - Telecontrol: Ethernet-based
    - Teleprotection: PDH, SDH / Ethernet-based
      - → Protection data interface of line current differential
      - → Signal comparison

IEEE C37.243-2015: 6.1.1 *"… Presently, the use of Ethernet communications has not been widely implemented for line current differential relaying, but is expected in future designs …"*

- **Transmission mechanism**
  - Time Division Multiplexing (TDM) → SDH
    - Fixed assigned time slot for each device
    - e.g. PDH, SDH



→ Inefficient method

Motivation and Introduction

- SDH ➔ Ethernet-based
  - SDH initially designed for voice transmission
  - Subsequently used for general WAN communication
    - ➔ Increase in required bandwidth
  - Inefficient use of bandwidth due to fixed assigned timeslots
    - ➔ Development of packet-switched networks (e.g. Ethernet) was pushed
  - Expansion of the SDH networks declined from around 2000
  - Investment in Ethernet-based solutions increased from around 2005
  - SDH networks reached „End-of-Life“
    - ➔ Development of services to emulate SDH

Ciena Corporation 06.2013:

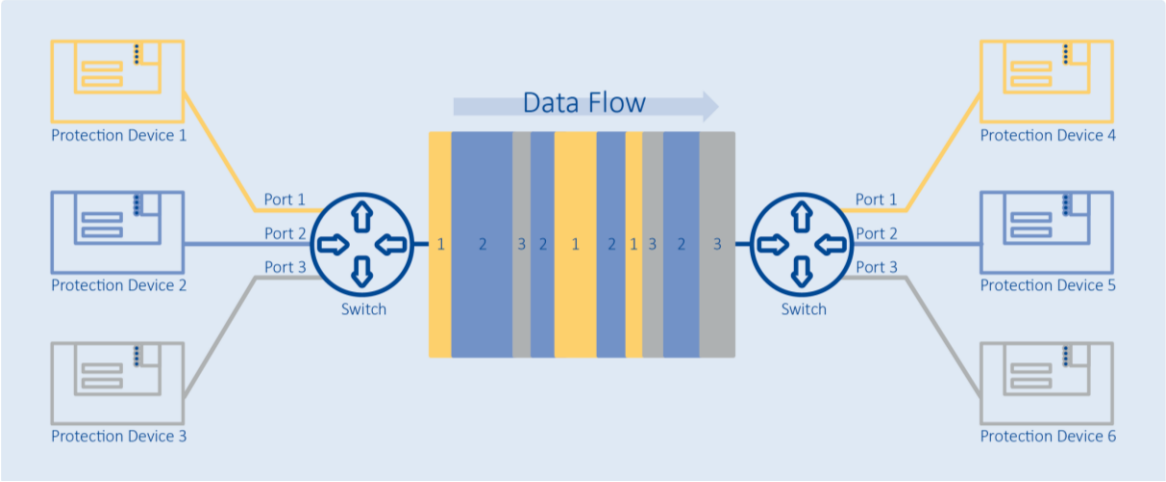
Bo Gowan

Director, Social Media

SONET/SDH is dead – really this time

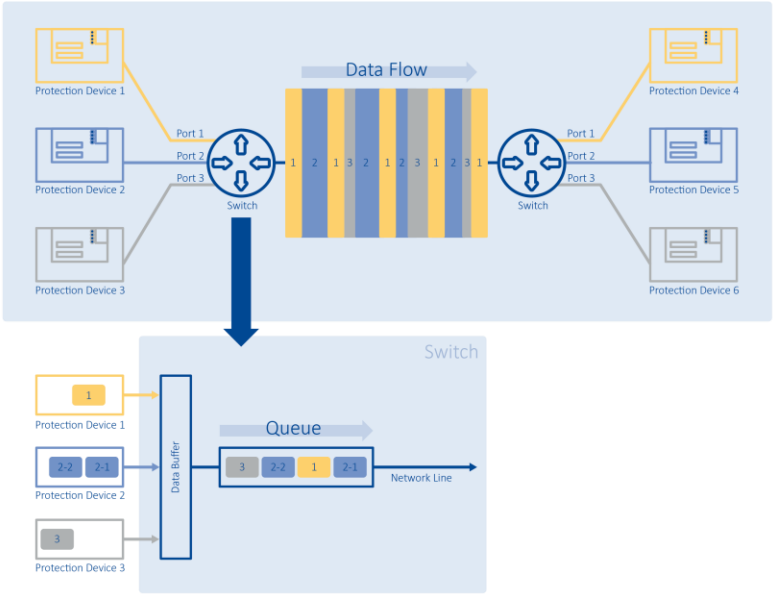
June 19, 2013

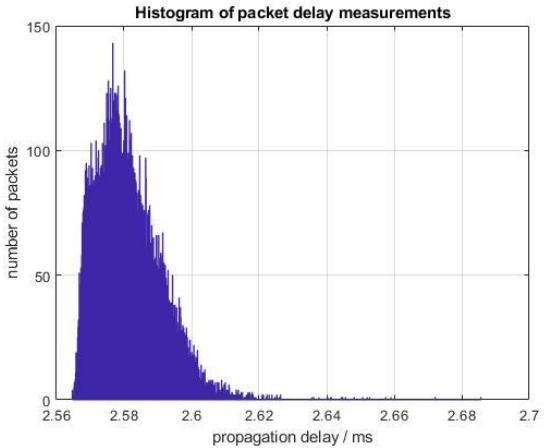
- **Transmission mechanism**
  - Packet Switched Network (PSN) → MPLS
    - Data is sent as needed
    - e.g. MPLS, Carrier Ethernet



→ Efficient bandwidth utilization

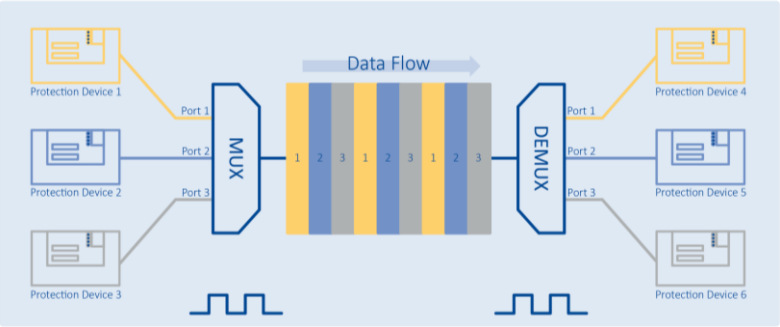
- **Transmission mechanism**
  - Packet Switched Network (PSN) → MPLS
    - Reason for packet delay variation/Jitter



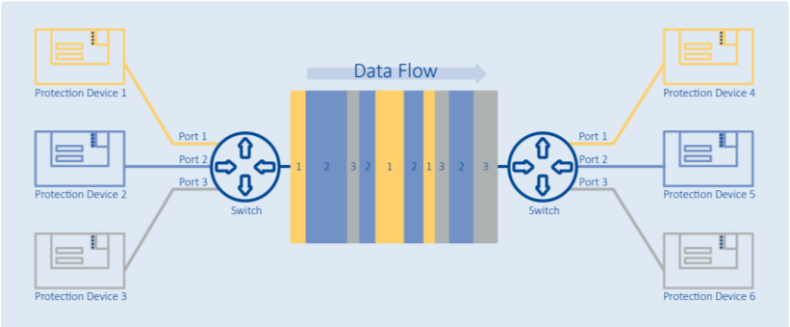


Measurements in an IP/MPLS-Network:
14 Switches and 300 km FO cable

- **Transmission mechanism**
  - Essential difference for teleprotection
    - Deterministic propagation delay?
    - Synchronous data transmission?



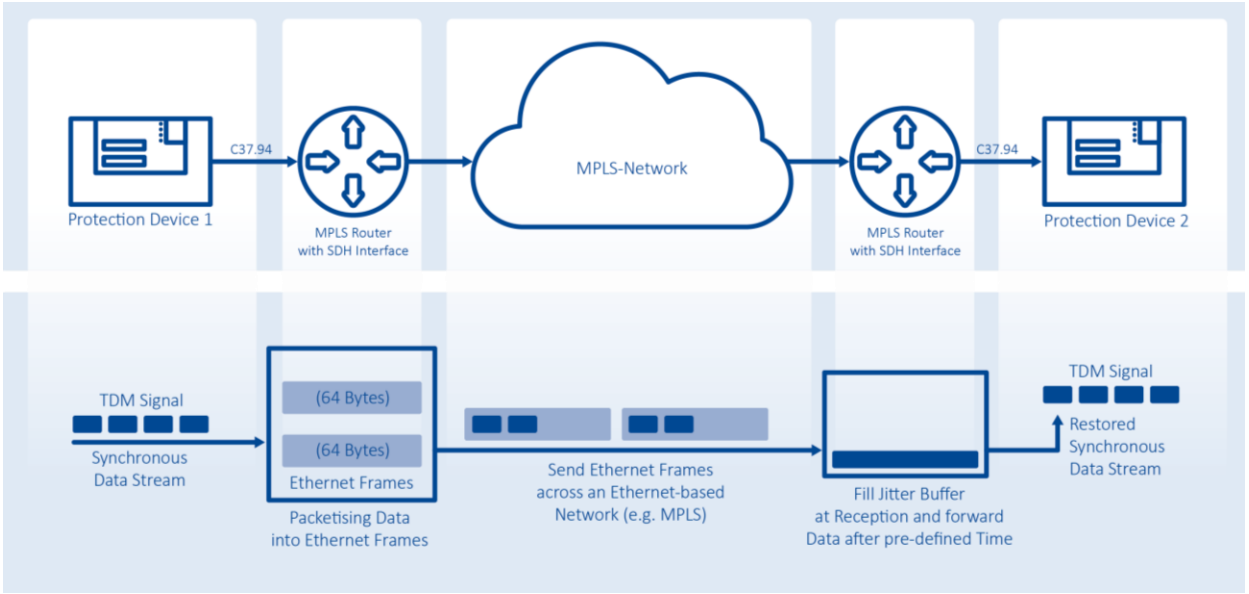
TDM (e.g. SDH)



PSN (e.g. Ethernet)

- **Migration from SDH to MPLS**
  - Use of emulated services for TDM over MPLS
    - Pseudowire connection (CESoPSN, SAToP, …)
  - Direct use of MPLS without additional services
    - Adapt end devices to the transmission properties of MPLS

- **Use of emulated services for TDM over MPLS**
  - Pseudowire connection (CESoPSN, SAToP, …)



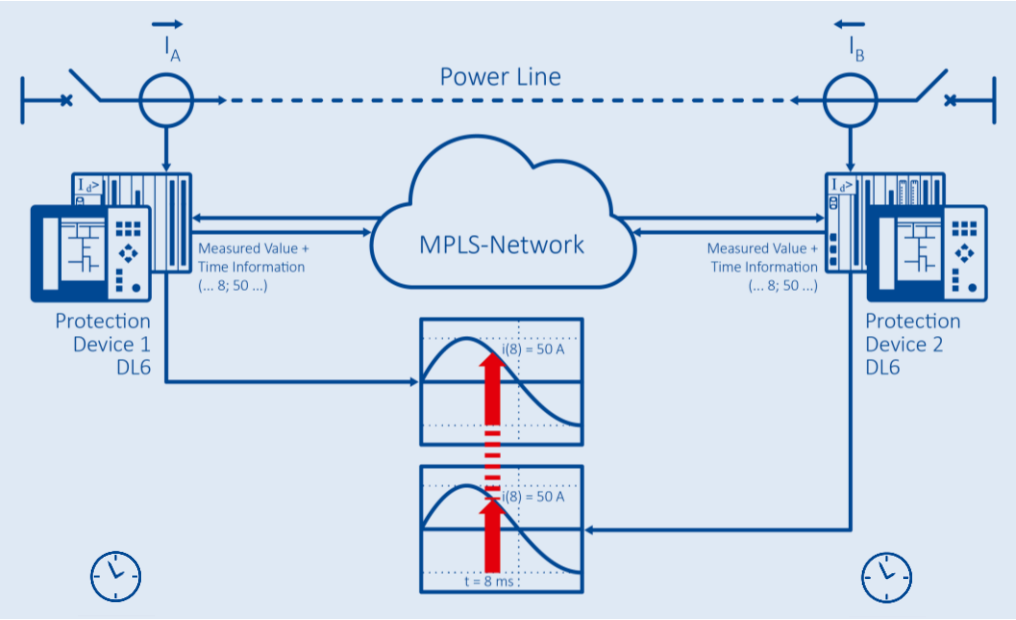
→ Increased propagation delay due to packetization and jitter buffer

→ Increased reserved bandwidth with high priority

→ Limited payload
n x 64 kbps

→ Network device needs to support this service

- **Direct use of MPLS without additional services**
  - Adapt end devices to the transmission properties of MPLS



Synchronized sampling of devices

→ No predetermined limit of data to be transferred

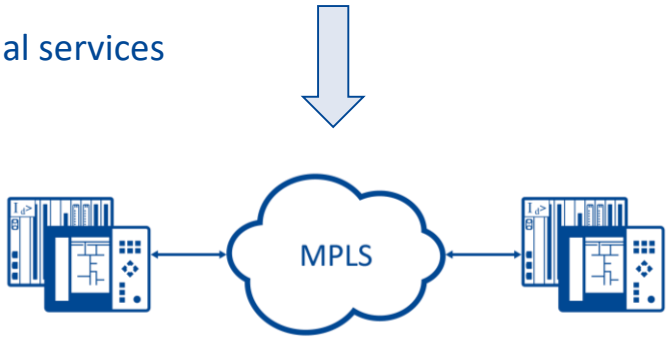
→ Low propagation delay
➔ Especially for Multi-Ended system

→ Established protocols from Ethenet/IP available

Possibilities for signal comparison

- Conventional wiring using an I/O Box
  - **Composition of propagation time – Typical times**
    - Output relay: 5 … 8 ms
    - Signal acquisition: 1 ms
    - **Sum:** 12 … 18 ms

- Communication directly via MPLS without additional services
  - **IEC 61850 R-GOOSE**
  - **Proprietary protocol**



Requirements for the Communication

	Recommendation acc. IEC 61850-90-12 / Table 12	
Characteristic properties of the network	**Analog comparison (Current differential)**	**Command / Transfer tripping**
Propagation delay	< 3 or 10 ms	< 10 ms
Jitter	< 100 µs	Not required
Asymmetry	< 200 µs	Not critical
Recovery Delay	< 50 ms	< 50 ms

- Specific requirement is manufacturer dependent!
  → *not generally definable*

- The resulting accuracy should not depend on the properties of the network!

- **Current technologies for WANs**
  - MPLS – Multi Protocol Label Switching

    → Label contains route description through the network

    - IP/MPLS
    - MPLS-TE

    } IP/MPLS

    - MPLS-TP
  - Carrier-Ethernet

    → Extension of the Ethernet network packet

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- **Characteristics of WAN technologies**

	IP/MPLS	MPLS-TE	MPLS-TP	Carrier Ethernet
General	Initial version of MPLS	Extension of IP/MPLS	“Successor“ of SDH	Extension of Ethernet
Routing mechanism	Comparable to IP-networks; Optimized propagation delay	Optimized channel utilization	Static routing	Optimized propagation delay
Symmetry property	Asymmetric paths may occur	Strict routes are possible	Symmetry properties configurable	Asymmetric paths may occur

Conclusion

- Change of OT networks necessary

- Migration from SDH → MPLS (or Ethernet)
  - **Short- or Medium-term goal**
    - Possible to use emulated connections
  - **Long-term goal**
    - Adapt the concept of the end devices to the properties of the communication
      → **Eficient and advantageous method**

Conclusion

- Advantages of direct communication via MPLS
  - No predetermined amount of data → more possibilities
  - Low propagation delay achievable
  - Use of established Ethernet/IP protocols
- Institutions (IEC, CIGRE, ...) are working on specifications/standards
- Manufacturers already have products or are currently working on solutions

Thank you for your attentiontion!

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References

- IEC 61850-90-1
- IEC 61850-90-12
- CIGRE B5.71 / Chapter 4

- **ELECTRICAL-ENGINEERING.ACADEMY:** *Line Current Differential Protection: Migration Of The Protection Interface From SDH To MPLS Networks*

  https://www.electrical-engineering.academy/posts/line-current-differential-protection-migration-of-the-protection-interface-from-sdh-to-mpls-networks