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CÉDRIC COSANDEY HEAD OF ABB UNIVERSITY SWITZERLAND & COMMUNICATION NETWORKS LC MANAGER

# FOX615 MPLS-TP technical presentation

Hybrid Multiservice Platform – the way to MPLS based operational WAN



# Traditional PDH/SDH based communication

Guaranteed performance for critical applications



Operational networks have been based on PDH/SDH technology

PDH/ SDH technology guaranteed performance required even by most critical applications

- Deterministic communication channels
- Symmetrical communication channels
- End to end channel supervision
- Fast redundancy switching (down to  $\ll 50$  ms)
- Performance not influenced by traffic load any type

→ The same is need from Packet switched networks

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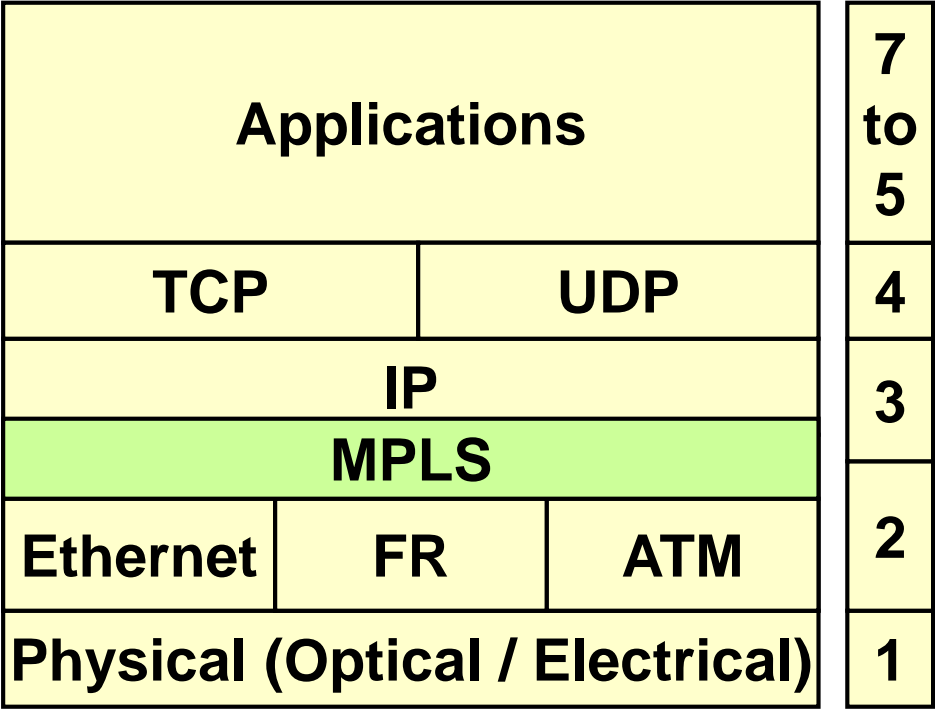
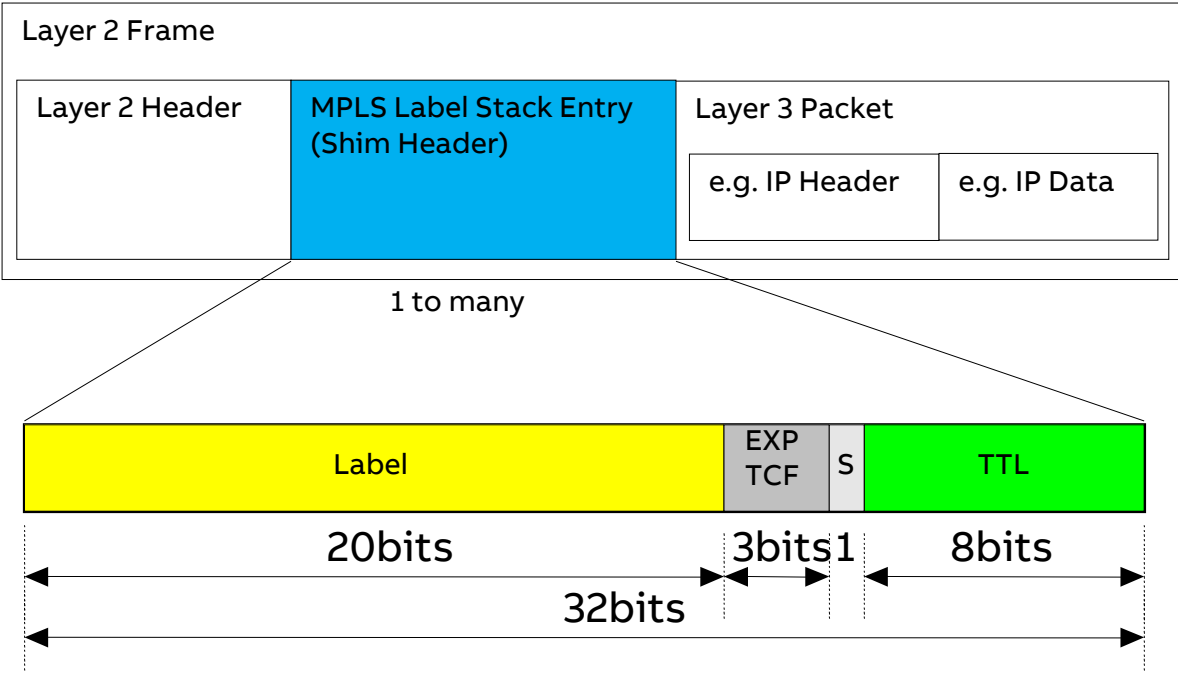
# MPLS-TP Networks Basics

Multi-Protocol Label Switching – Transport Profile

# Utility MPLS Networks Basics

## MPLS and OSI Model

### MPLS and OSI Model

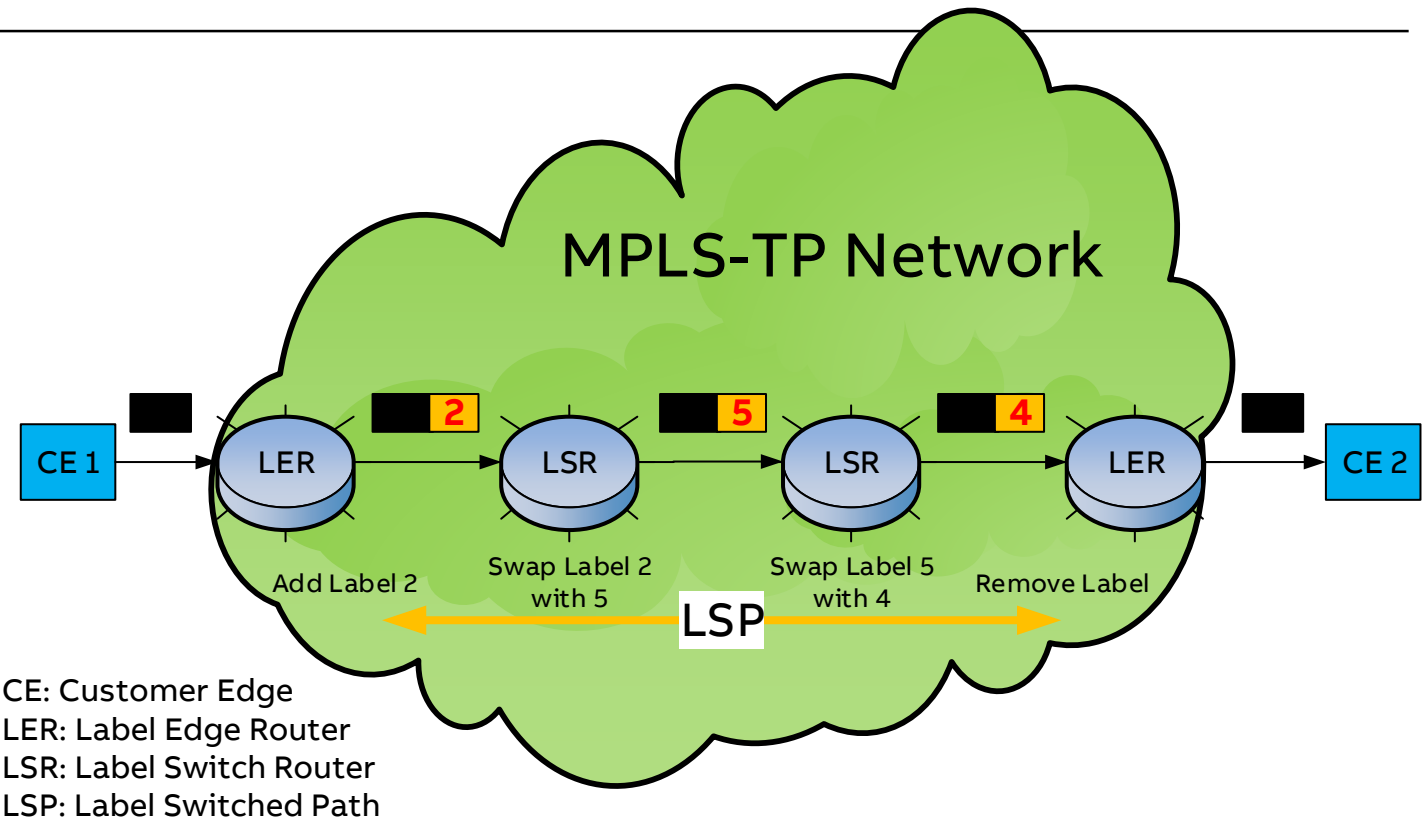


# Utility MPLS Networks Basics

## Multi-Protocol Label Switching – Transport Profile

### MPLS-TP LSP

1. Packets from CE arrives at ingress LER
2. Ingress LER identify egress LER and corresponding LSP
3. Packet is sent with Label corresponding to LSP to next switch router
4. Based on received label, LSR selects label for the next leg of the LSP and forward packet to next switch router
5. Egress LER remove MPLS header and forward packet to CE

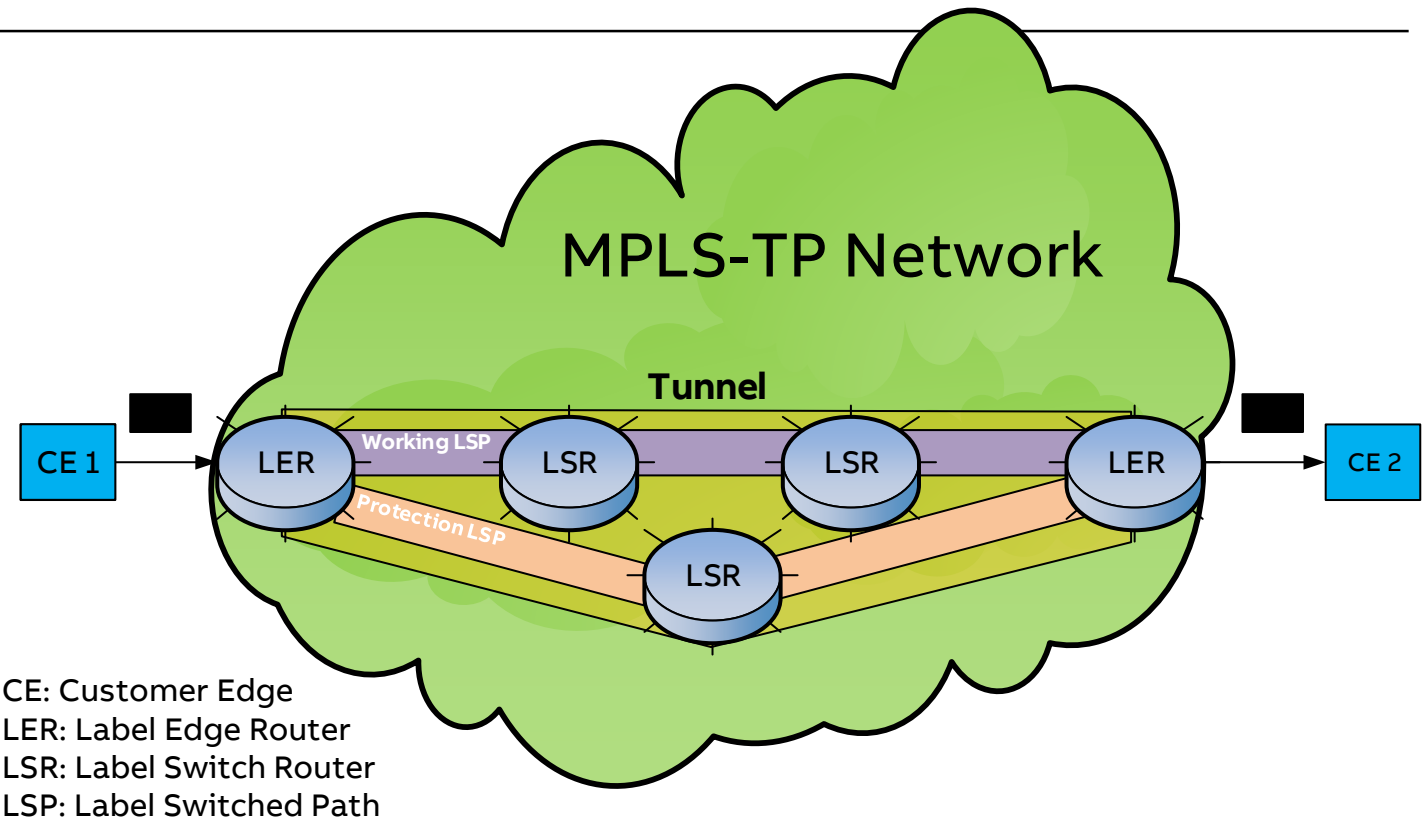


# Utility MPLS Networks Basics

## Multi-Protocol Label Switching – Transport Profile

### MPLS-TP Tunnel

An important element within MPLS-TP is the tunnel. It is a connection which is provided across a working and a protection LSP.





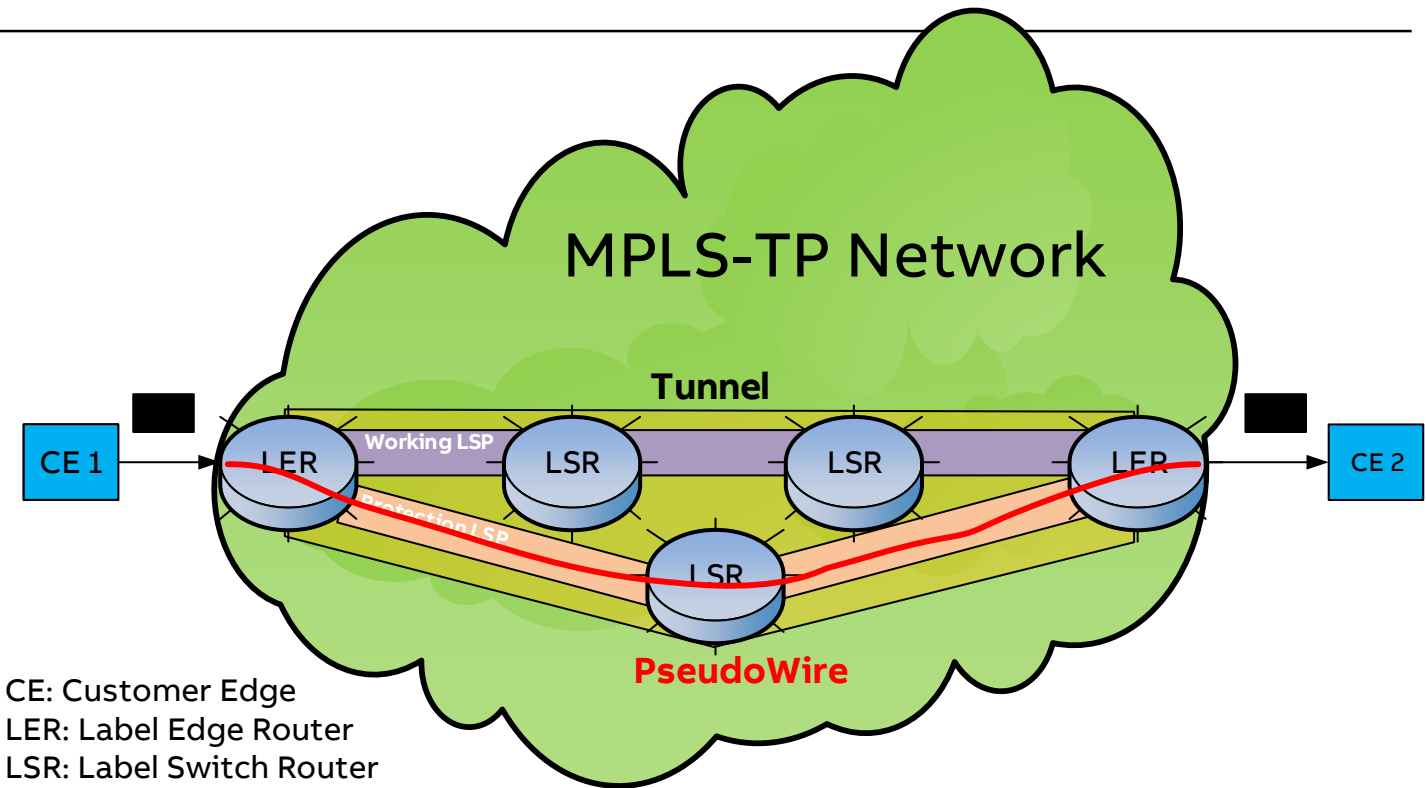
# Utility MPLS Networks Basics

## Multi-Protocol Label Switching – Transport Profile

### MPLS-TP PseudoWire

The MPLS-TP framework document specifies Pseudowire (PW) as a construct to perform all aspects of service-specific transport of data across an MPLS-TP tunnel.

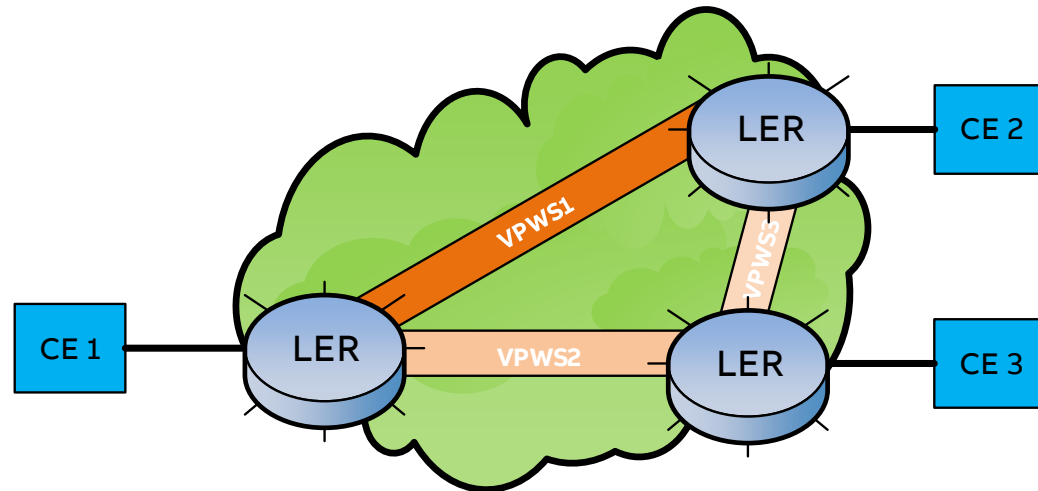
PW is a mechanism to emulate the attributes of a service over a packet-switched network. The user of a service that is configured perceives the PW as if it were an unshared link or a circuit of that service (within certain bounds).



# Utility MPLS Networks Basics

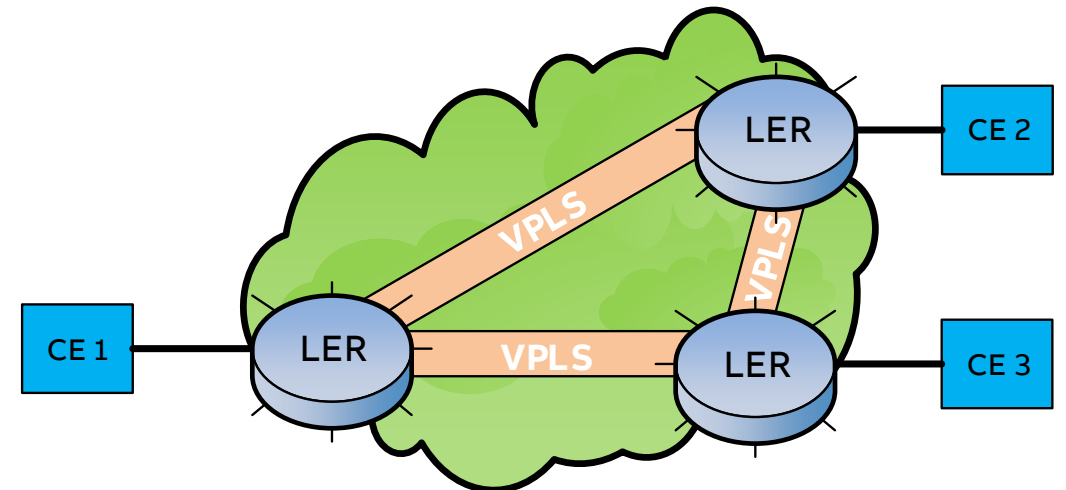
## Multi-Protocol Label Switching – Transport Profile

### MPLS-TP Services



**Virtual Private Wire Service (VPWS)**

CE: Customer Edge  
LER: Label Edge Router



**Virtual Private LAN Service (VPLS)**



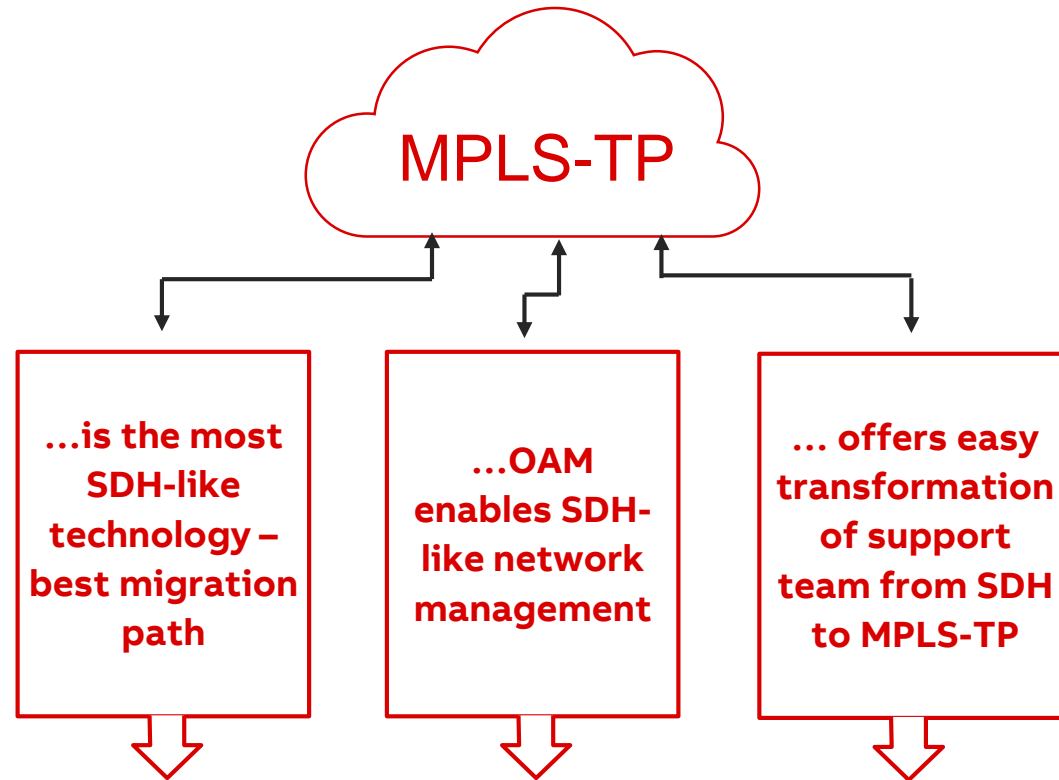
# Utility MPLS Networks Basics

## Technology Migration: IP/MPLS versus MPLS-TP

IP/MPLS	MPLS-TP	SDH
Dynamic, network defined channel routing	Static, user defined channel routing	Static, user defined channel routing
<b>Unidirectional</b> communication channels	<b>Bidirectional</b> communication channels	<b>Bidirectional</b> communication channels
<b>Link wise</b> channel supervision	<b>End to end</b> channel supervision	<b>End to end</b> channel supervision
Routable protocol (security issue)	Non routable protocol	Non routable protocol
CLI common	GUI for configuration typical	GUI for configuration typical
Without special measures <b>none deterministic</b> data channels	If network is planned properly <b>nearly deterministic</b> data channels	<b>Deterministic data channels</b>
Local switchover, without special measures >> 50 ms	< 50 ms end to end channel switchover guaranteed	< 50 ms end to end channel switchover guaranteed

# Utility MPLS Networks Basics

## Multi-Protocol Label Switching – Transport Profile



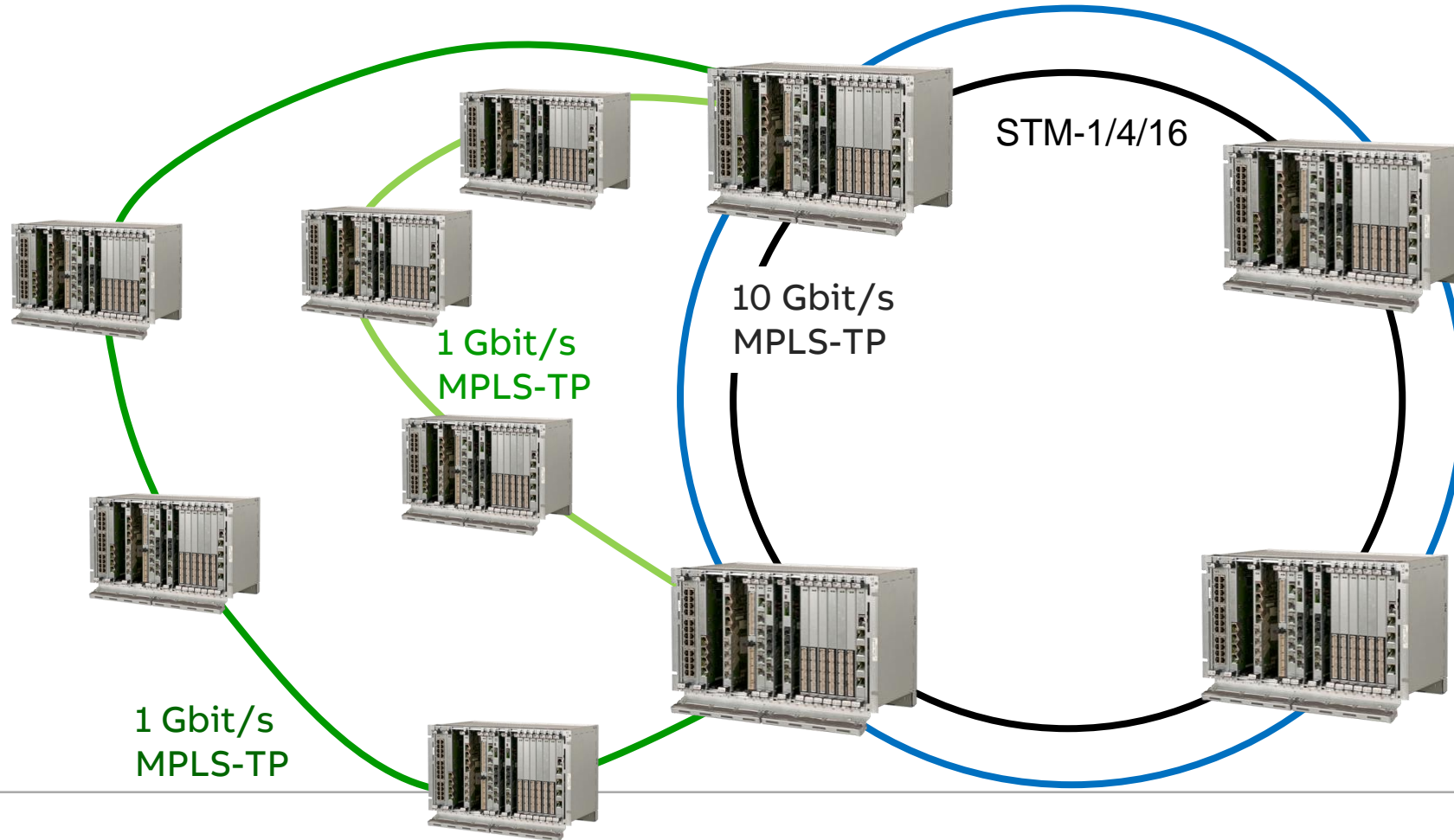
**MPLS-TP is the most logical migration path**



# The FOX615 MPLS-TP solution

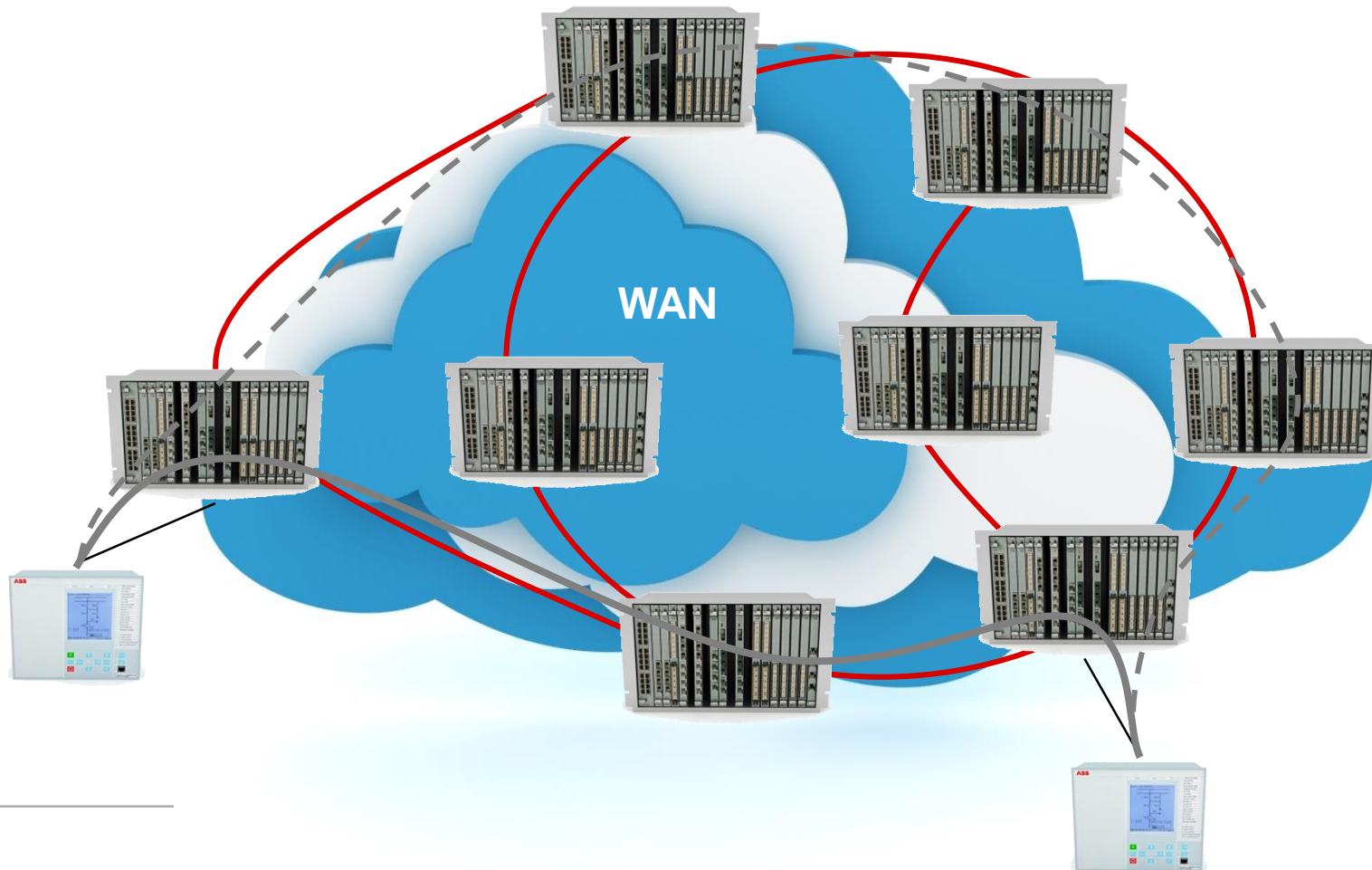
# The FOX615 MPLS-TP Solution

Enabling MPLS-TP backbone



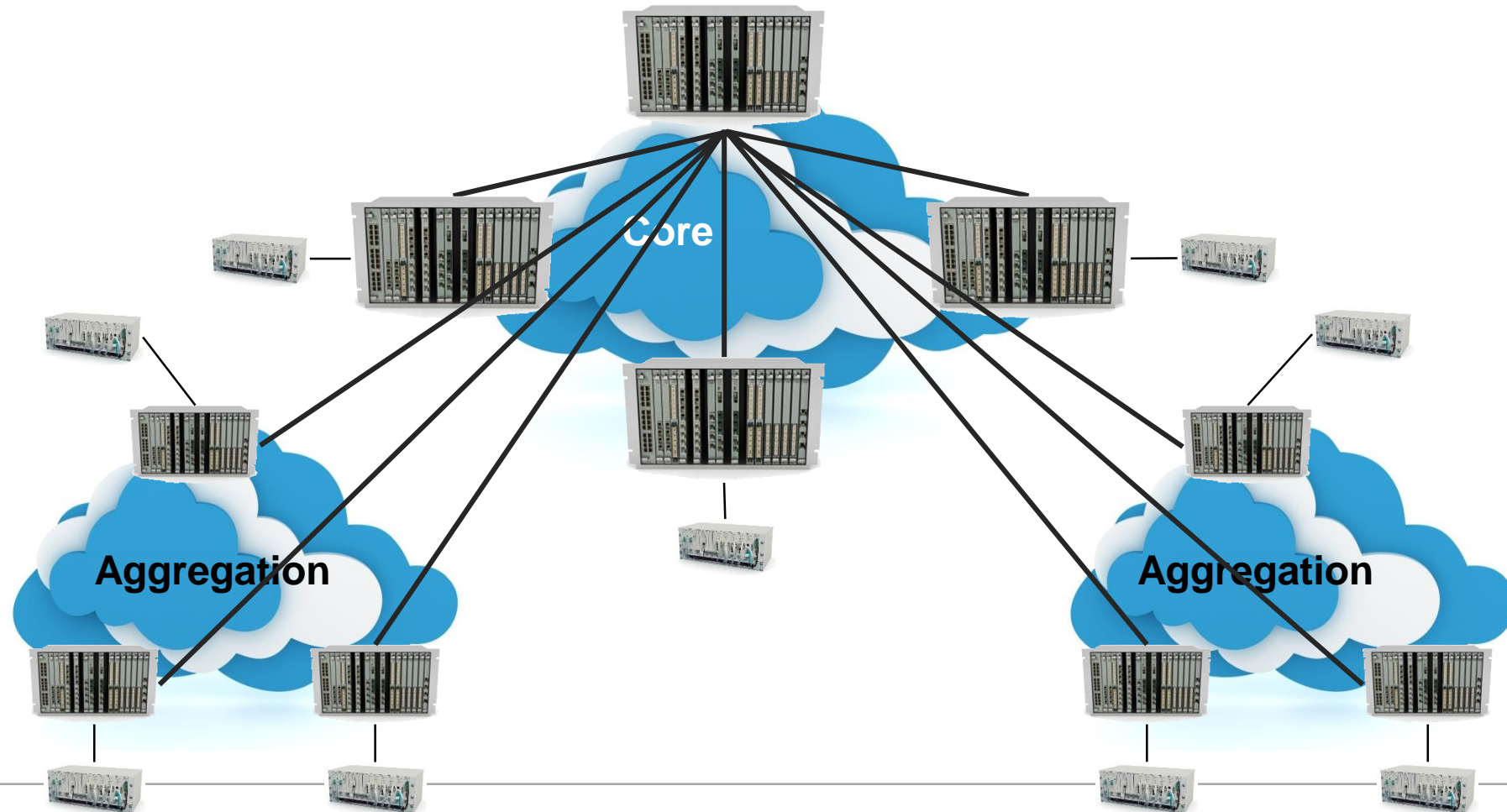
# FOX615 MPLS-TP capabilities

Point to point services (VPWS)



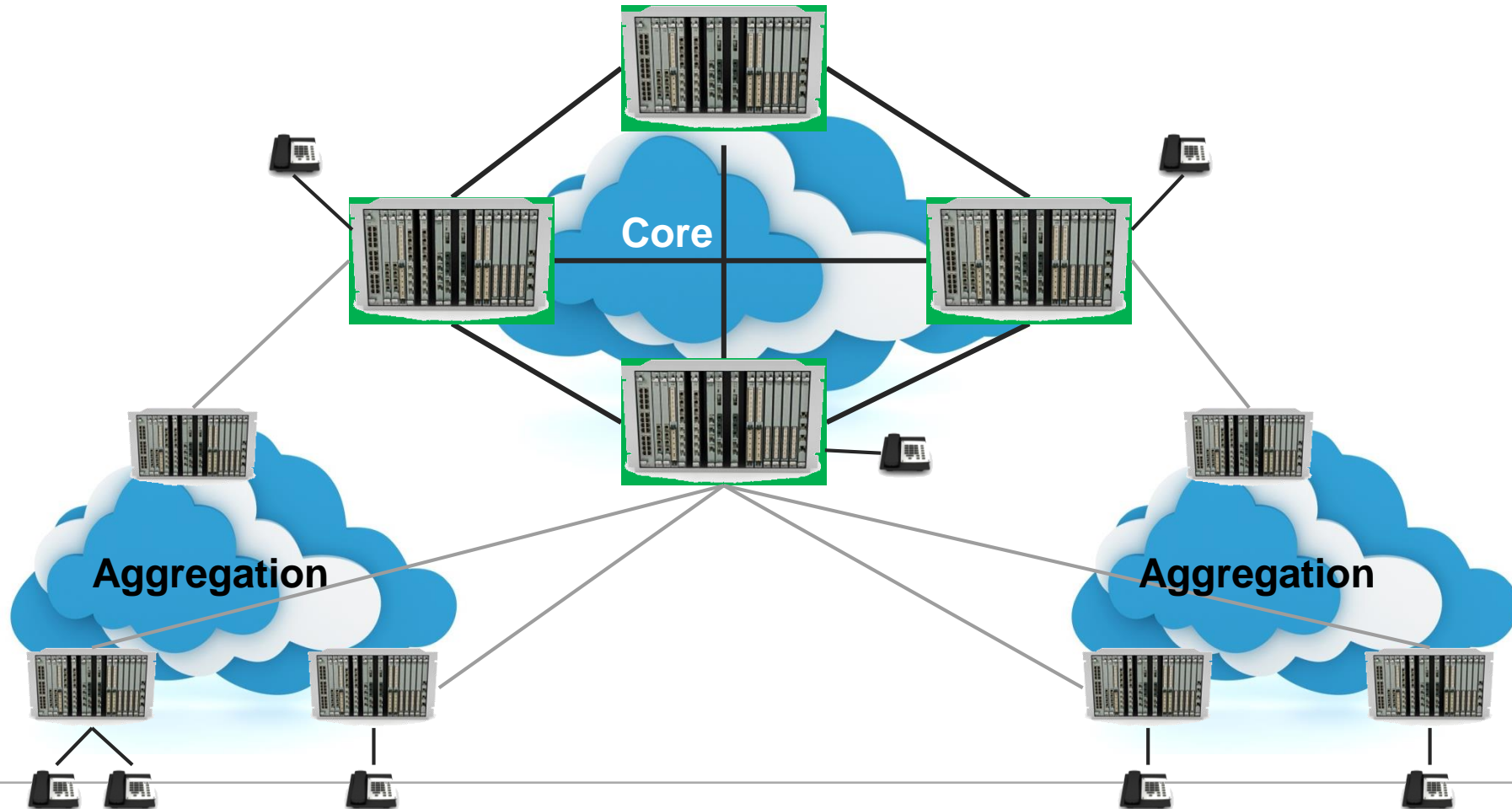
# FOX615 MPLS-TP capabilities

Point to multipoint applications (E-Tree services)



# FOX615 MPLS-TP capabilities

Any to any services (VPLS/ H-VPLS services)





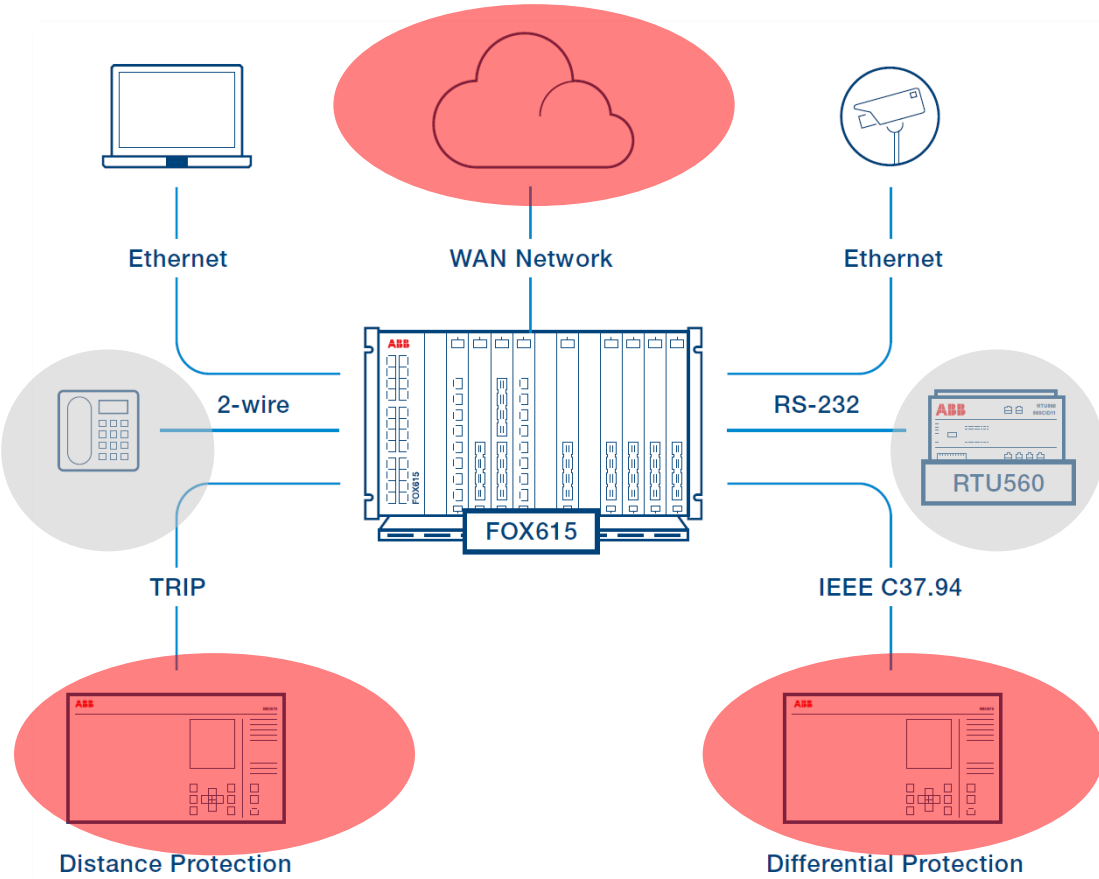
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# How to migrate an operational network?

ABB's approach to migrate power utilities operational networks from TDM (PDH/SDH) based technology to packet switched technology (MPLS-TP)

# Migration to Packet Switched

## Key Questions



- How to deal with installed base?
- How to offer communication to legacy applications?
- How to deal with protection applications requiring hard real time communication performance?
- How to guarantee Teleprotection standard requirements (e.g. dependability as per IEC 60834-1)?
- How to ensure data integrity?

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## Key aspects

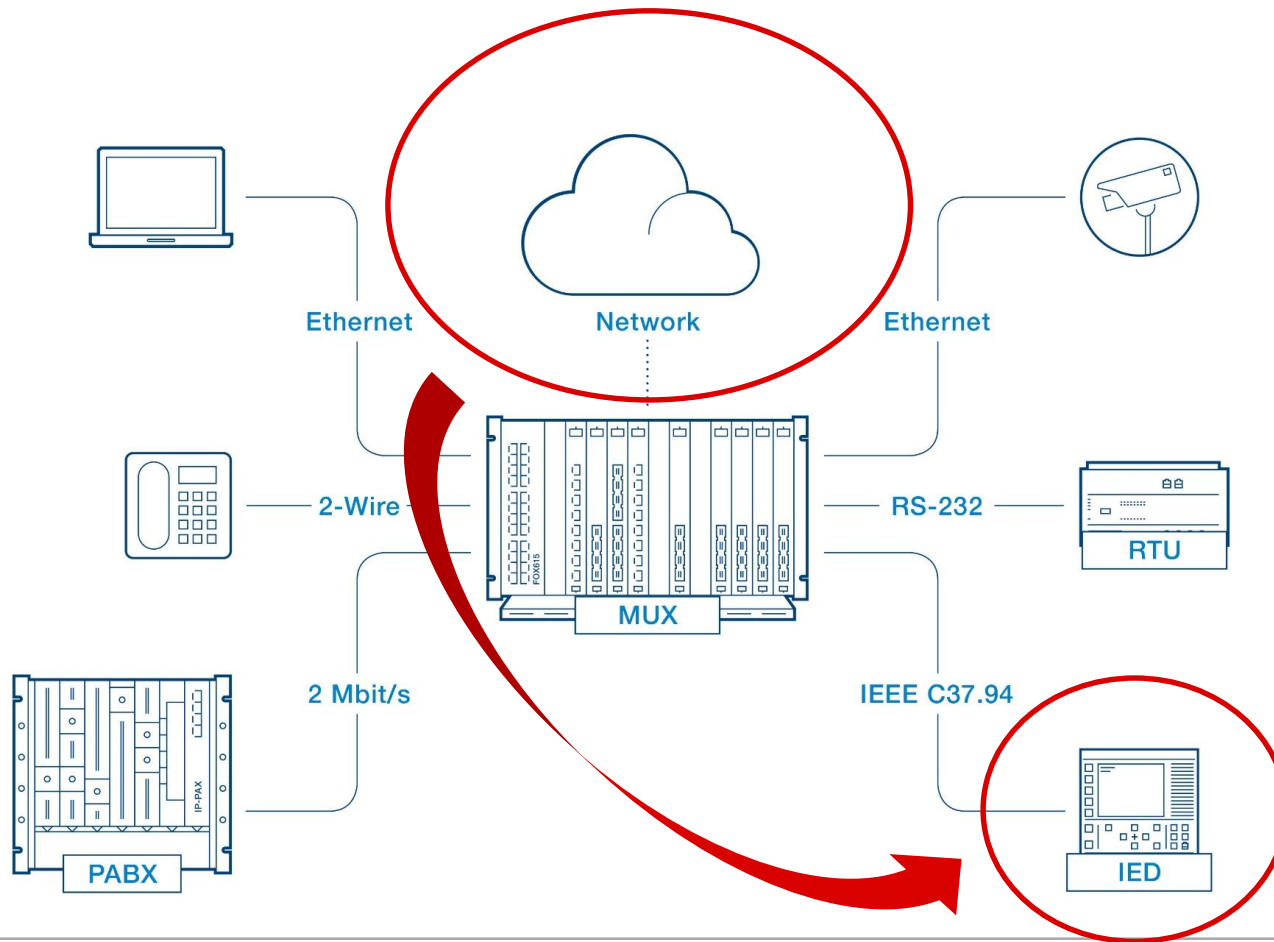
- **Guaranteed performance for mission critical applications such as protection applications**
- **Application specific solution**
- **Smooth transition from TDM based networks to Packet Switched Networks**

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# FOX615 – guaranteeing performance for mission critical applications

# Many applications needed for reliable electrical grid operation

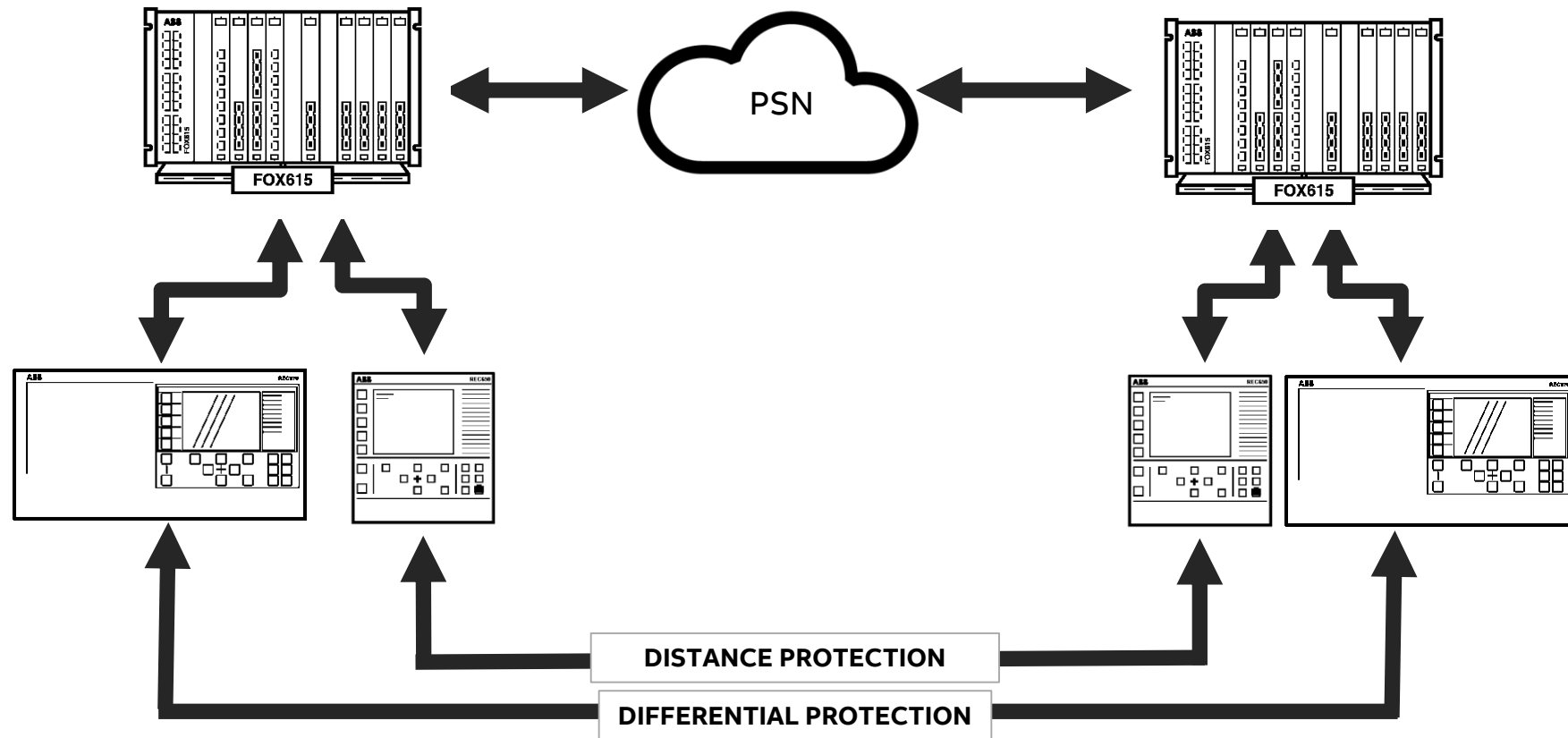
Critical applications need special attention



- Reliable grid operation requires many applications working together
- Communication networks solution has to fulfill diverse requirements
- Critical applications have stringent requirements on communication channel performance
- Solutions have been optimized to communication network technology
- Communication network technology is evolving to packet switched solutions – creates new challenges, also on cyber security

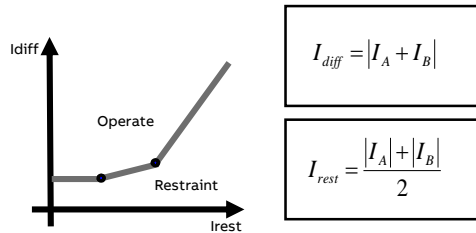
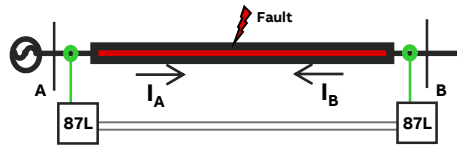
# Migration of teleprotection services

FOX615 – enabling protection application via PSN



# Line protection solutions

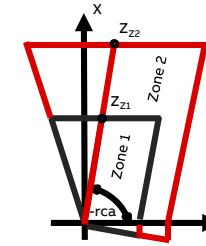
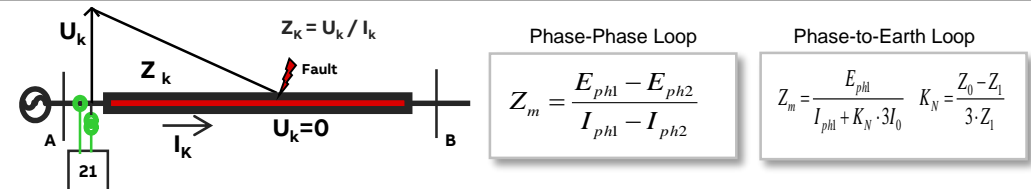
## Line differential protection



### Characteristics:

- Excellent tripping time <25 ms
- Extremely stable for external faults
- Very good sensitivity for internal faults
- **Fully dependent on communication between line ends**
- **High requirements on communication channel (latency, summary)**

## Line distance protection



**Protection**  
Full scheme  
Phase selection  
Power swing  
Teleprotection

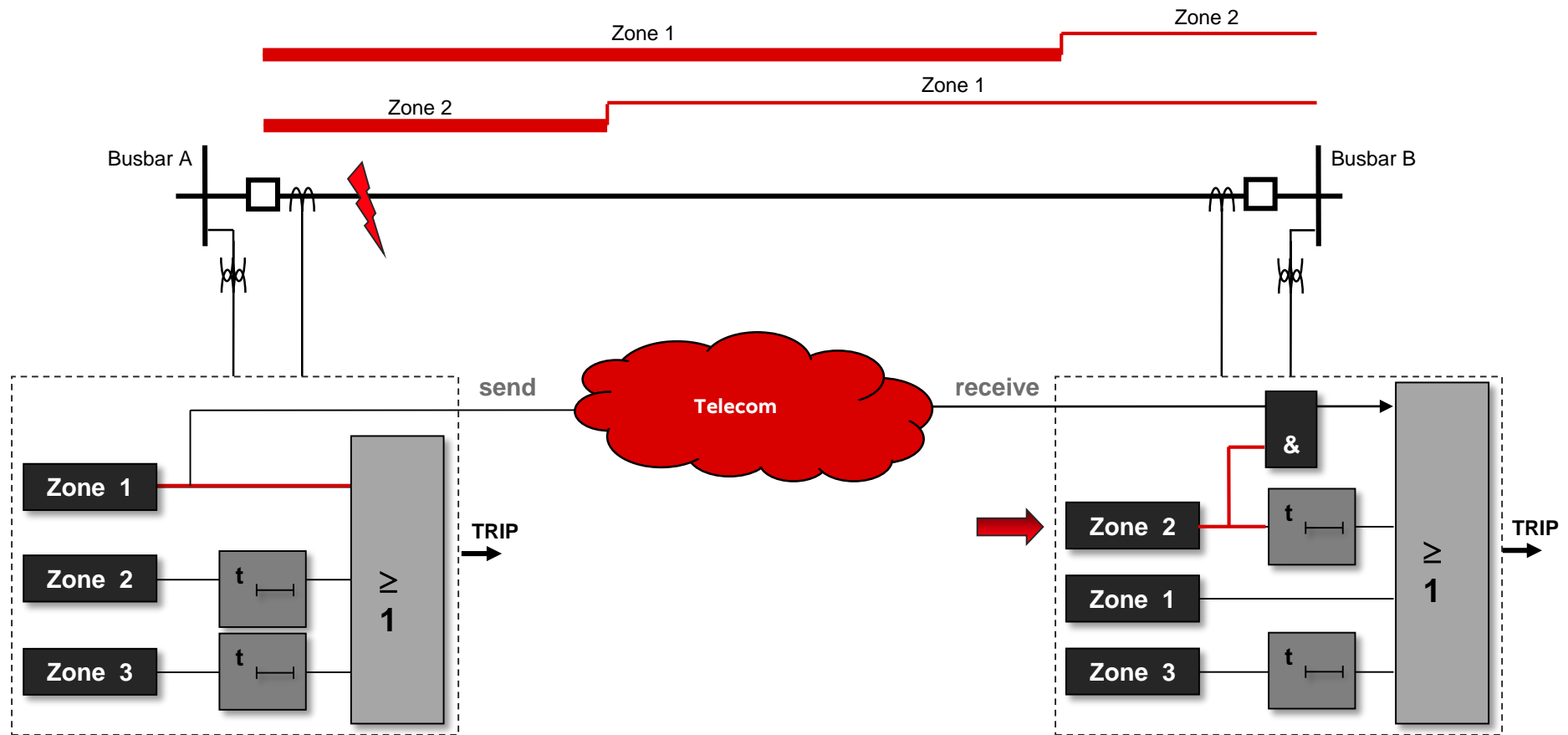
### Characteristics:

- Most used protection solution for overhead lines
- Good performance for long lines
- Difficult configuration for short lines and heavy load or power flow change
- **Data exchange between line ends improves the performance**

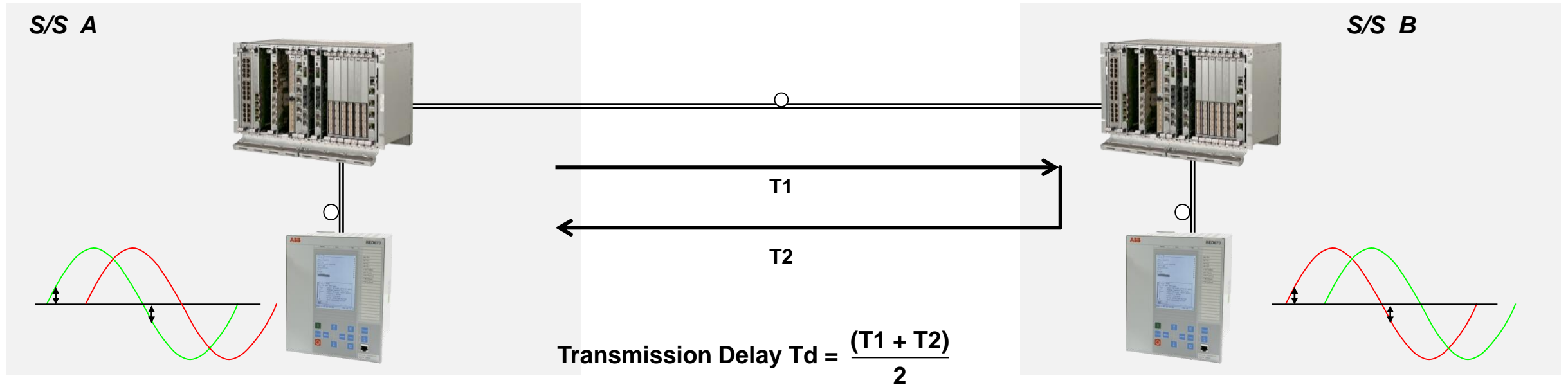
**Both line protection solutions required real time communication to fulfill the tripping time requirements**



# How does distance protection work?



# Differential protection – how does it work and communication needs

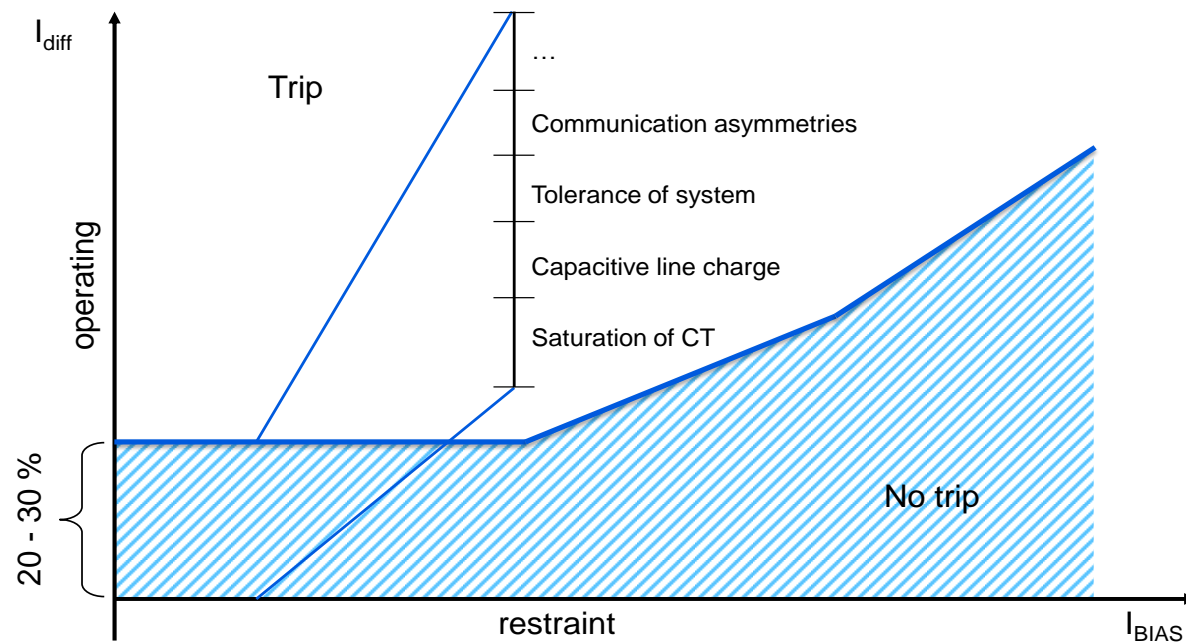


## Variation of transmission time “looks” like a fault current for the protection relay

- Sensitivity depending on time accuracy (jitter) of compared values
- Bigger jitter than expected can lead to unwanted trip signals

# Specific requirements of differential protection

## Differential Protection



- Differential protection application is dependent on reliable high performing communication channels for correct operation
- Due to nature of differential protection deterministic communication channel required
- Jitter & Wander as well as asymmetries lead to “virtual” fault current (e.g. 0.4 ms  $\rightarrow$  3.6° or 6.3% @ 50 Hz or even 4.32° / 7.5% @ 60 Hz)

# Specific requirements of distance protection

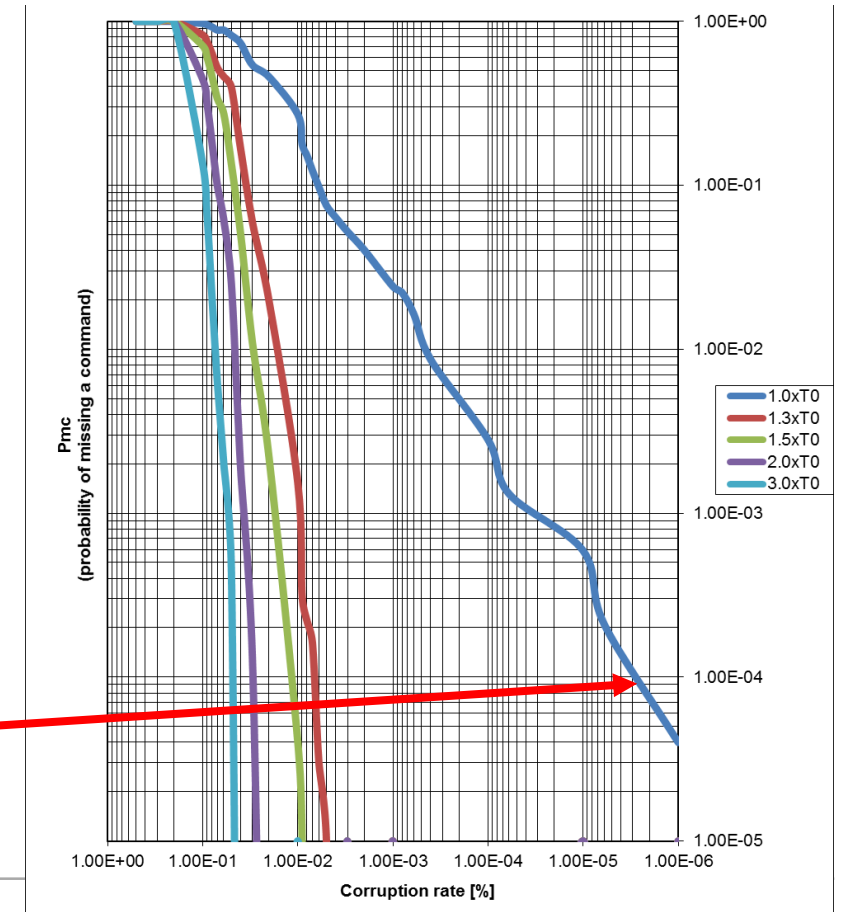
IEC 60834-1 standard compliance ensures correct operation of protection system

Protection scheme	Trip time ( $T_{ac}$ )	Dependability ( $P_{mc}$ )	Security ( $P_{uc}$ )
Blocking	< 10 ms	< $10^{-3}$	< $10^{-4}$
Permissive underreach	< 10 ms	< $10^{-2}$	< $10^{-7}$
Permissive overreach	< 10 ms	< $10^{-3}$	< $10^{-7}$
Intertripping	< 10 ms	< $10^{-4}$	< $10^{-8}$

Requirements defined in IEC 60834-1 for a BER of  $10^{-6}$

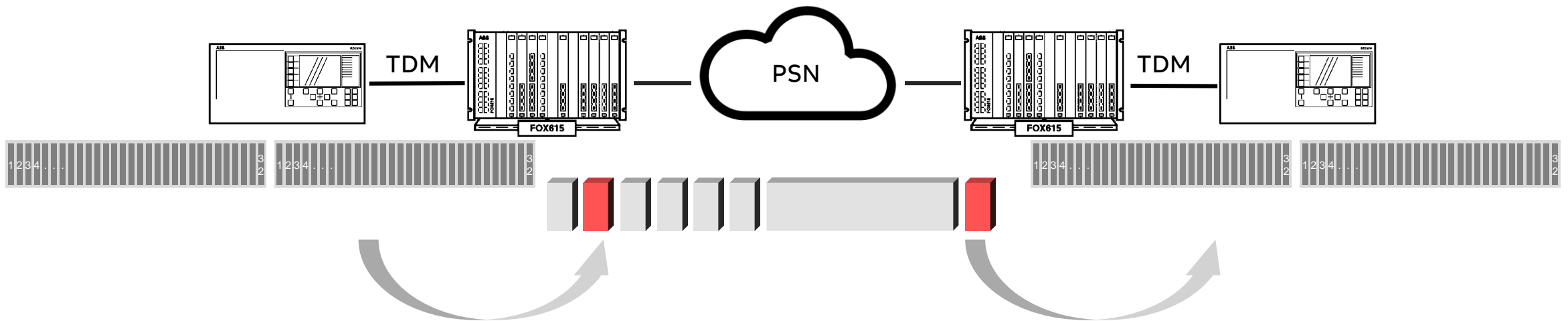
Solution is compliant to IEC 60834-1 requirements

Example of TDM based system (FOX615 with TEPI1)



# Challenge: Technology migration from TDM to PSN

The need for an interworking function



- Protection relays typically send and expect commands or TDM data streams to/ from the wide area network
- If WAN is packet based conversion to packets needs to happen for transmission
- Relay on remote side again expects original signal structure/ protocol → conversion from packets to TDM required
- Communication channel behavior is completely different if TDM or packet based network provides service

# What needs to be done for WAN technology migration?

Teleprotection in packet switched networks – the need for an interworking function

## Two possible scenarios for Teleprotection over packet switched wider area networks:

1. Migrate existing Teleprotection solution to new WAN technology by using an interworking function (IWF) mapping traditional TDM data into packets (standard based IWF)
  - Structure agnostic circuit emulation (SAToP) as per RFC4553
  - Structure aware circuit emulation as (CESoPSN) per RFC5086
2. Use of new solutions providing application specific interworking functions mapping the protection signals directly into packets (specific IWF) optimized for the specific requirements (OPIC2, TEPI2)

**How does this change critical Teleprotection performance parameters?**

# Implications of WAN technology migration on Teleprotection systems

Teleprotection systems using standard based CE

## Change on latency

Contributions:

- Packetization delay, can be optimized by just putting one frame into a packet in stead of multiple frames
- Jitter Buffer on receiver side allowing a limited packet delay variation (PDV tolerance) on the packet switched wide area network

Additional latency ~ Packetization delay + PDV tolerance

Additional ~ 4.125ms latency due to packetization\*

## Change on bandwidth

Contributions:

- TDM timeslot needs to be put in a Ethernet packet → Ethernet packet has a large overhead
- Minimum packet size needs to be achieved (64 bytes), additional VLAN Tag, MPLS and Ethernet headers are added, leading to 86 byte total length
- Optimized performance is achieved by mapping 1 frame into 1 packet

$$Bandwidth = \frac{(Payload+Overhead)*2048}{Payload} \left[ \frac{kbit}{s} \right]$$

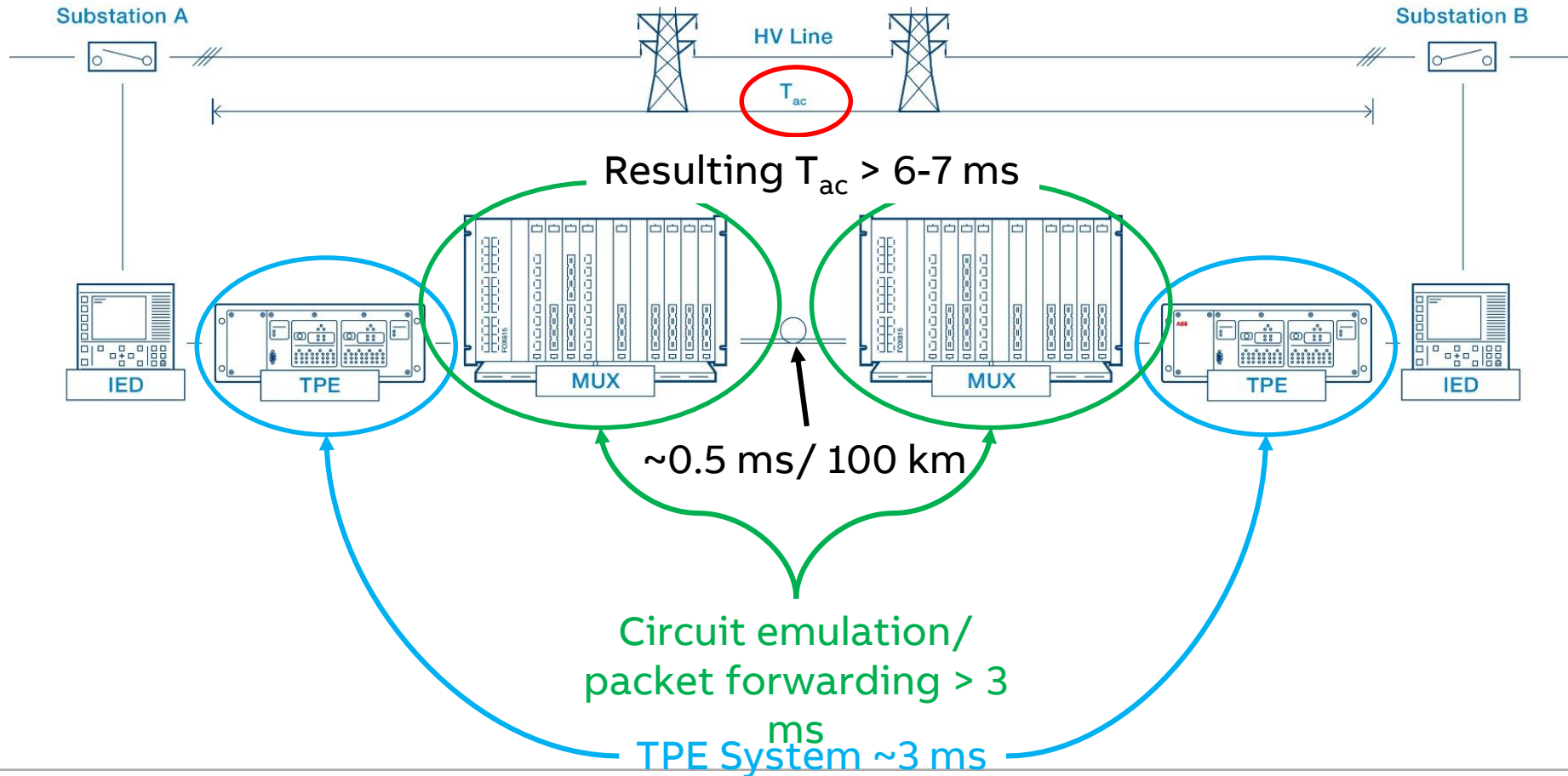
64kbit/s TDM data results in 5.5Mbit/s PSN\*



# Distance Protection

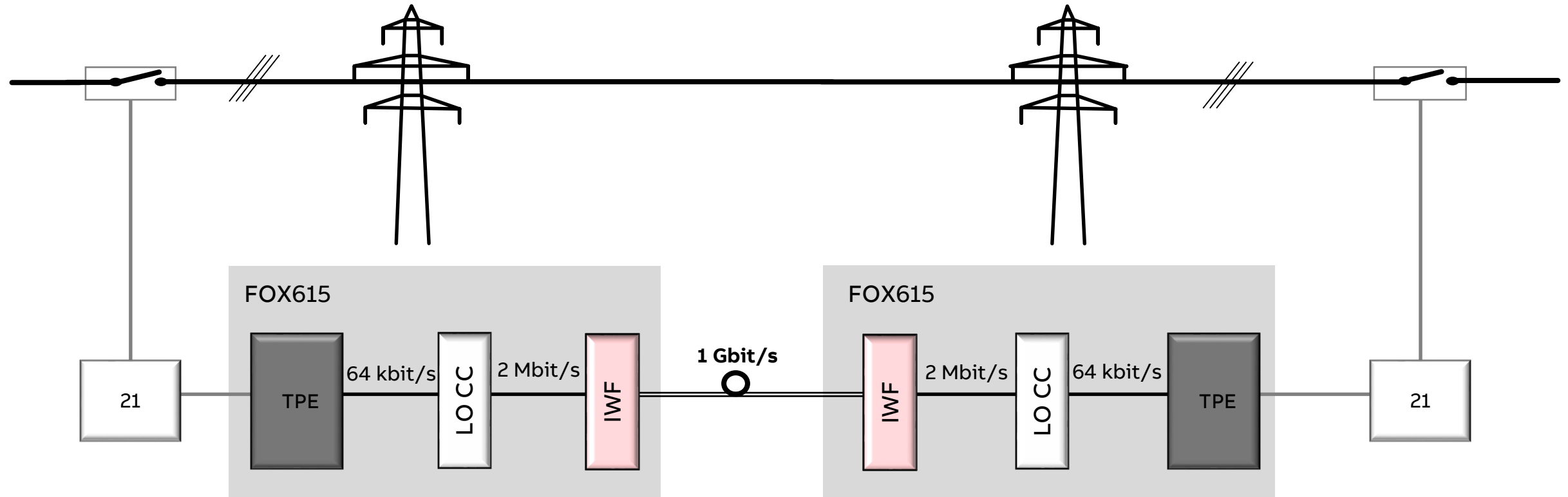
## Where does latency come from?

$T_{ac}$  is critical for protection performance



# Comparison of solutions for distance protection

Same Teleprotection solution used



Packet switched system using standard base CE as IWF

# Command based Teleprotection systems using standard based IWF

## Implications on Teleprotection System

### Probability of a missing command in TDM and PSN using standard based CE

	TDM solution	Standard based CE solution via PSN
BER	$7.27 \times 10^{-6}$	$7.27 \times 10^{-6}$
$T_{ac}$	6.9 ms	7.3 ms
$P_{mc}$	$< 1 \times 10^{-5}$	$6.3 \times 10^{-2}$
Bandwidth	64 kbit/s	5504 kbit/s

Same BER

Comparable latency

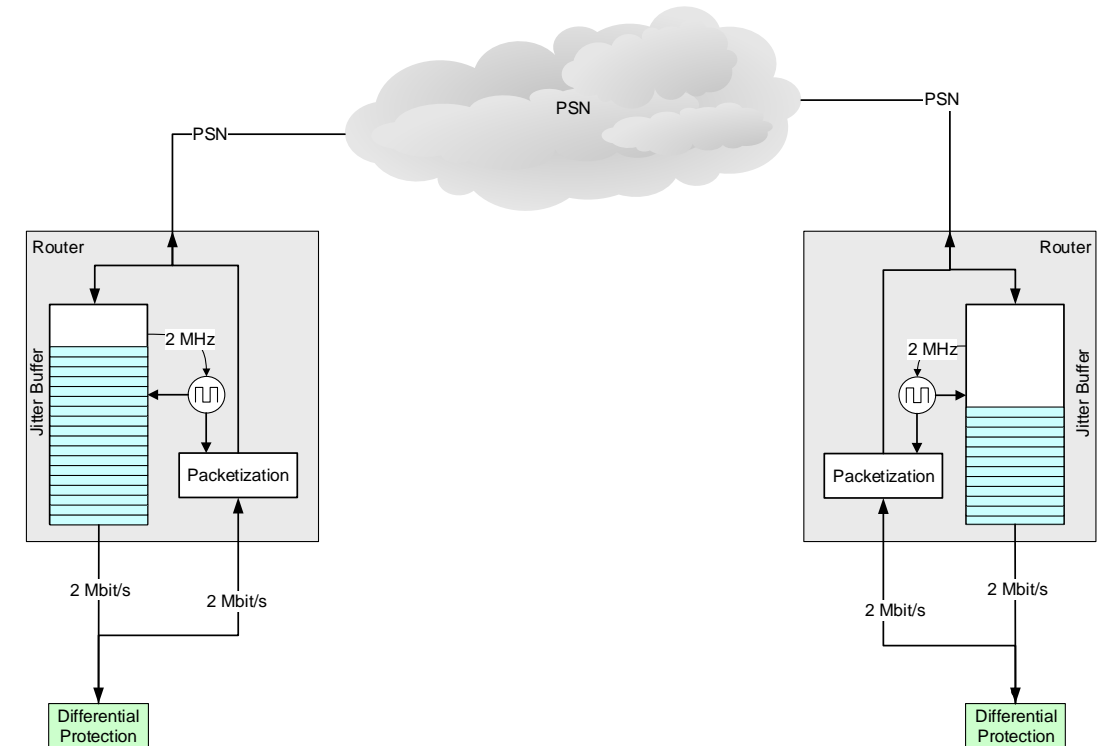
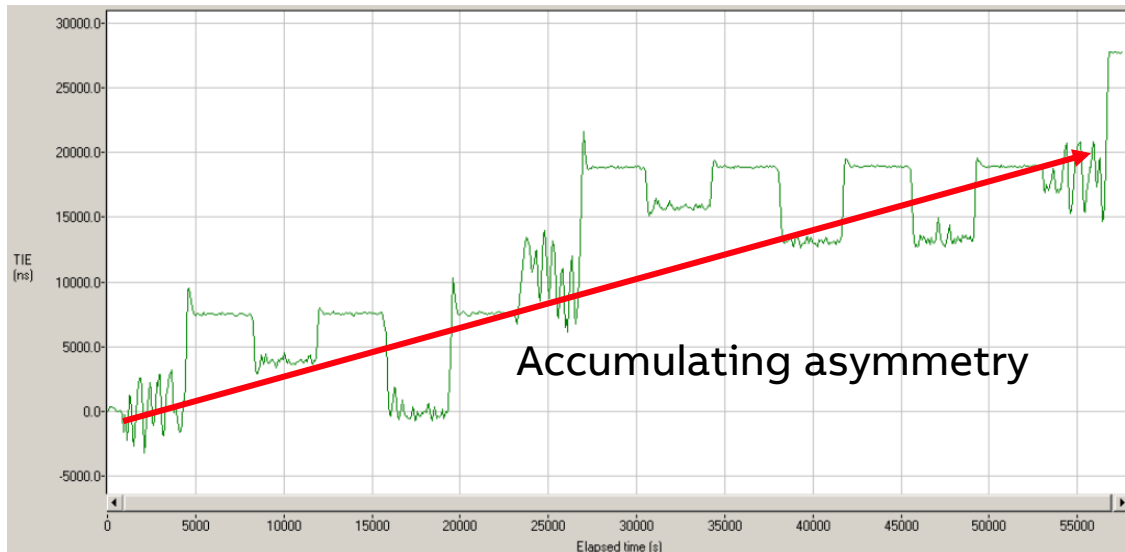
Probability to miss a command more than a factor 1000 higher than in TDM network

> 80 x on Bandwidth

# Implications of WAN technology migration on Teleprotection systems

## Jitter, Wander and Symmetry

### Standard based IWF (with frequency recovery)



- Standard based IWF is not suitable for differential protection, accumulating asymmetry can lead to mal operation of the protection relay.
- Redundancy switching to redundant paths can even in frequency synchronized schemes (e.g. through SynchE) cause wrong trips

# Teleprotection systems using standard base CE

The need for an application specific solution

## Result of migrating conventional Teleprotection using standard based circuit emulation:

- Significantly slower command transmission due to packetization delay and packet delay variation tolerance
- Massive bandwidth increase
- Critical Teleprotection data is not secured at all (e.g. against data modification or replay attacks)

## Differential protection problems

- Probability of wrong trip exists due to unspecified maximum jitter, wander and asymmetry values

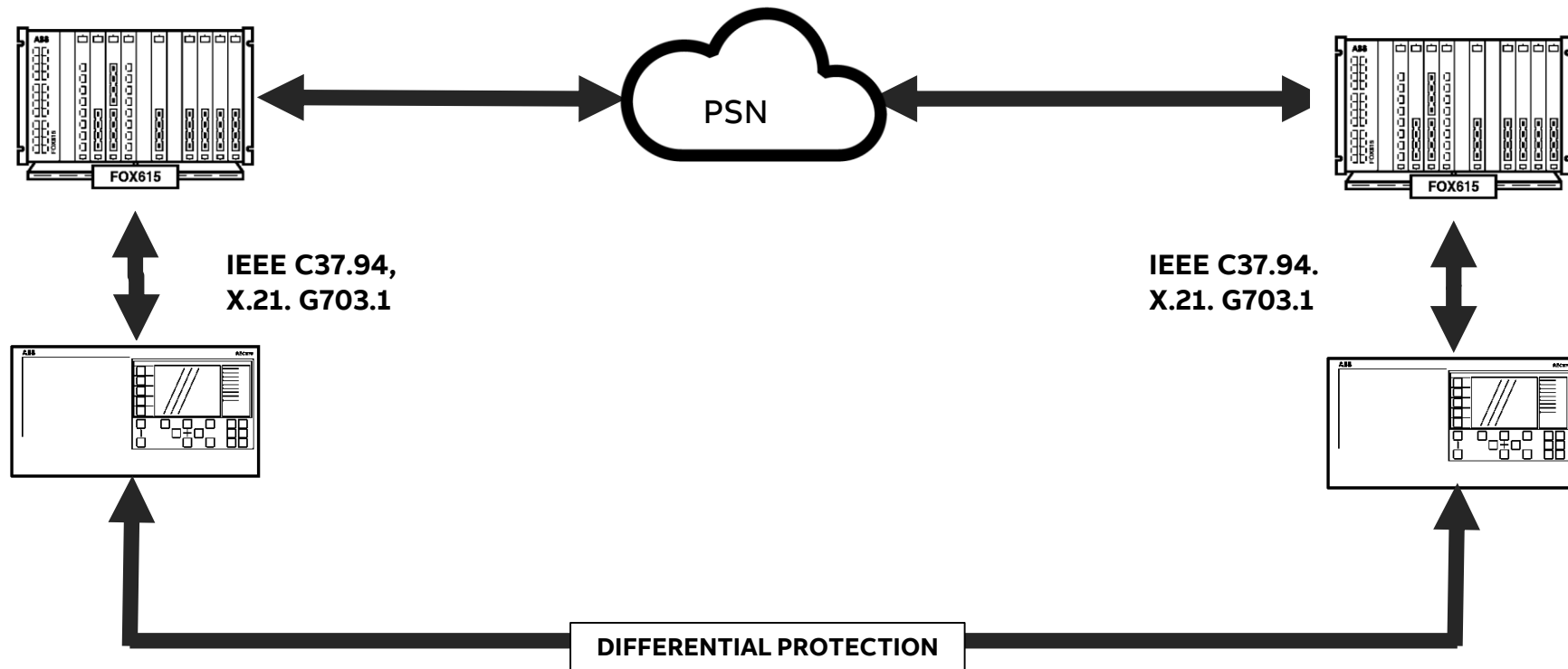
## Distance protection

- Significantly higher probability of losing a command due to bit failures

**Or in other words, we get much worse protection system performance and cyber security risk at higher costs (bandwidth)**

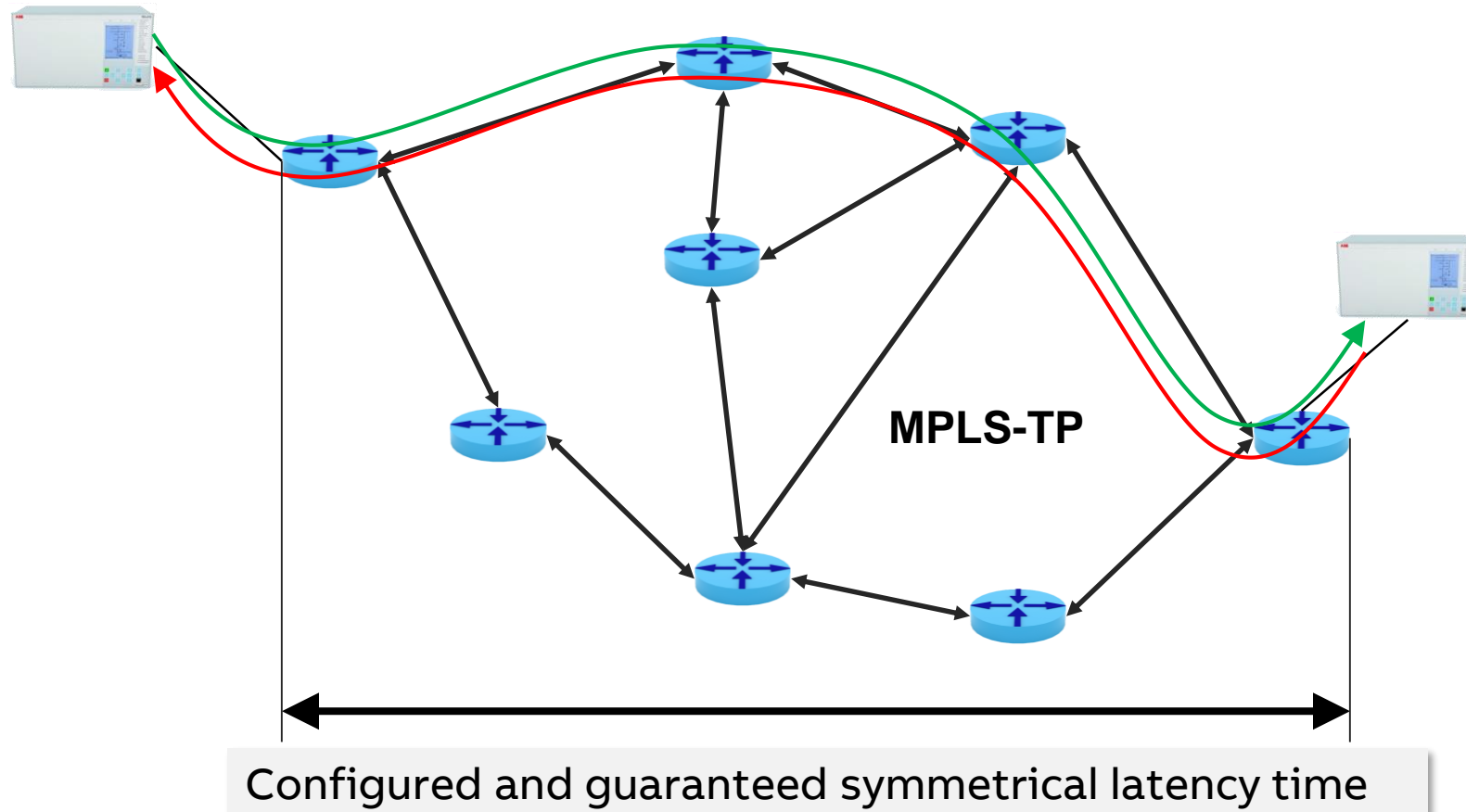
# Differential Protection

FOX615, OPIC2 – enabling protection application via PSN



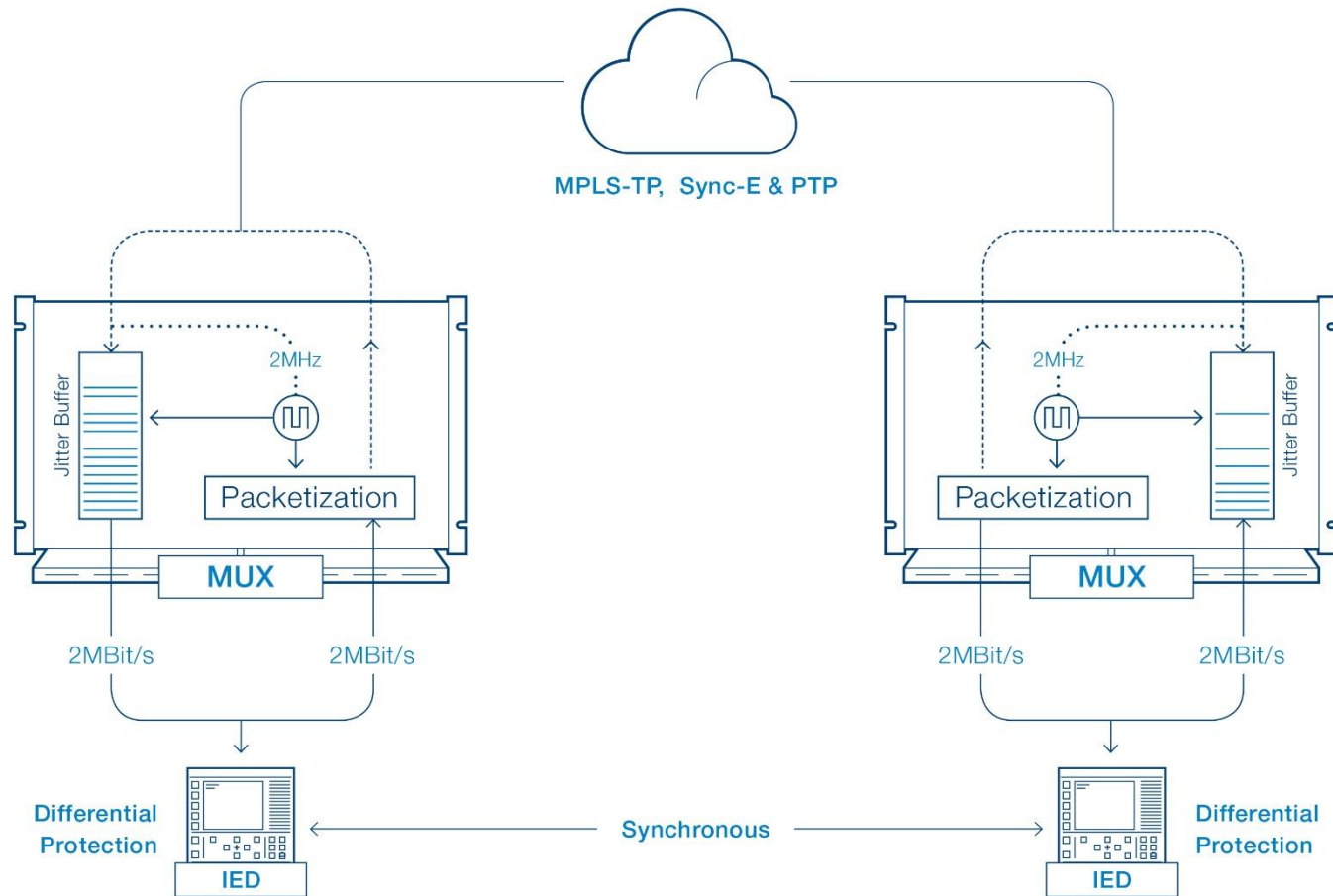
# Application oriented configuration

OPIC2 - fix defined latency times





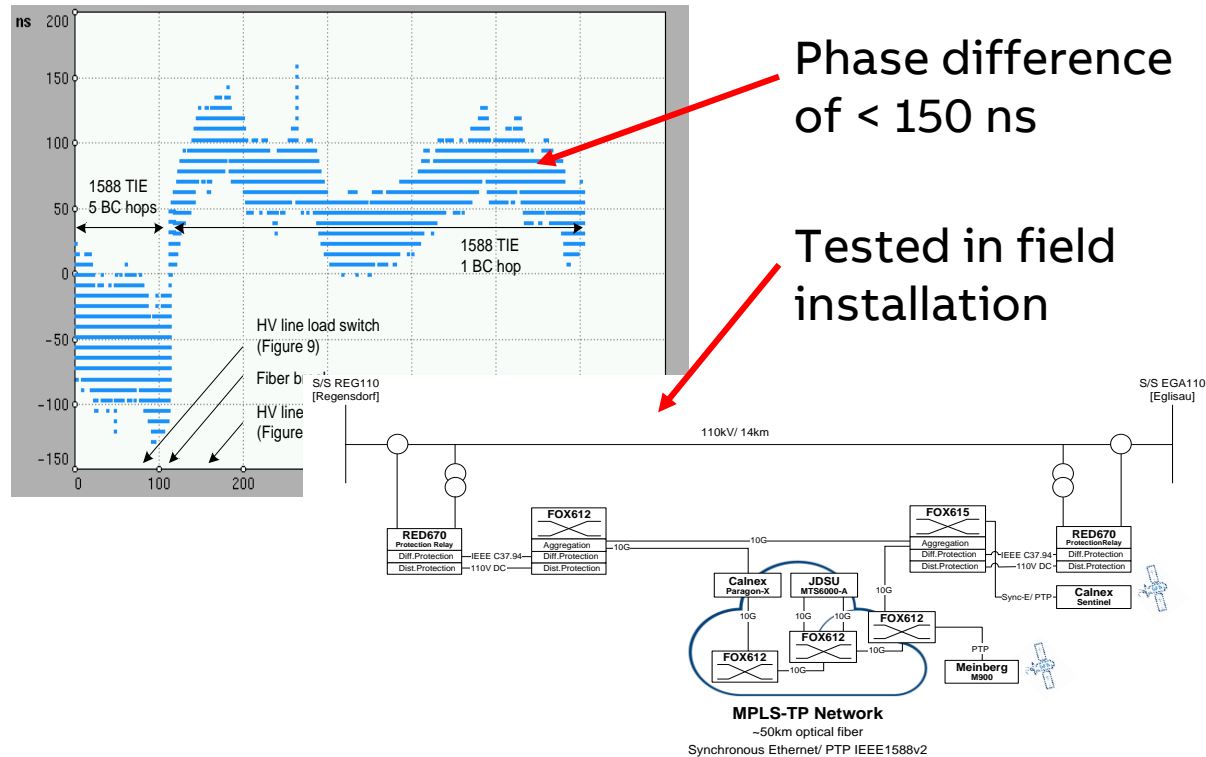
# FOX615 & OPIC2 – a novel approach for differential protection signal transmission over PSN



# Application specific IWF for differential protection application

OPIC2 in FOX615

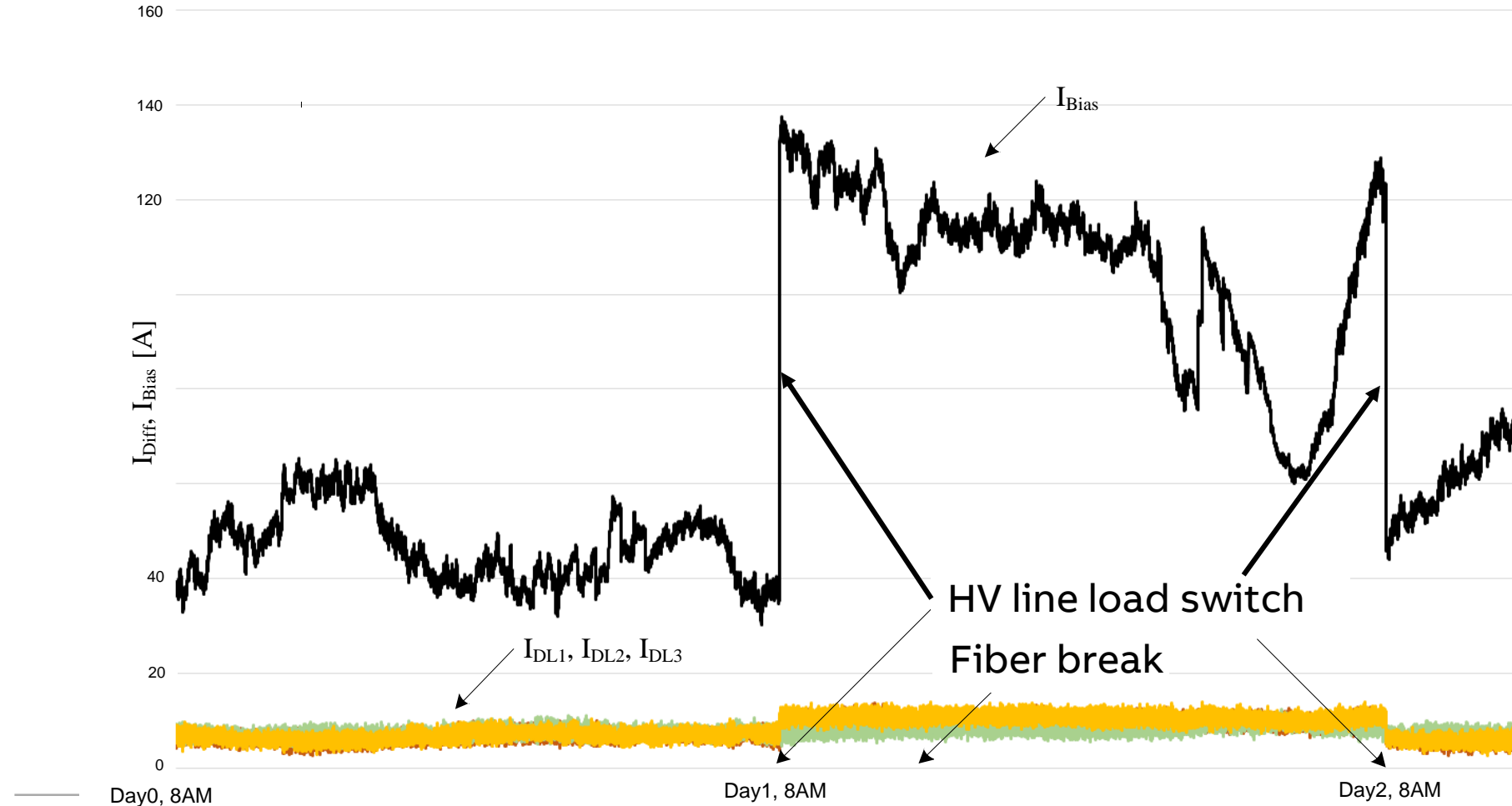
## Specific IWF for differential protection



- Specific IWF providing frequency and phase synchronized communication channels focusing on application requirements
- Robust operation ensured by combining various different synchronization technologies and application know-how
- Fully tested, under worst case conditions with route switching and network resynchronization
- Controlled stop of application when risk exists for out of specification asymmetries or jitter & wander

**No wrong trip due to communication problems in the network**

# Results of field test



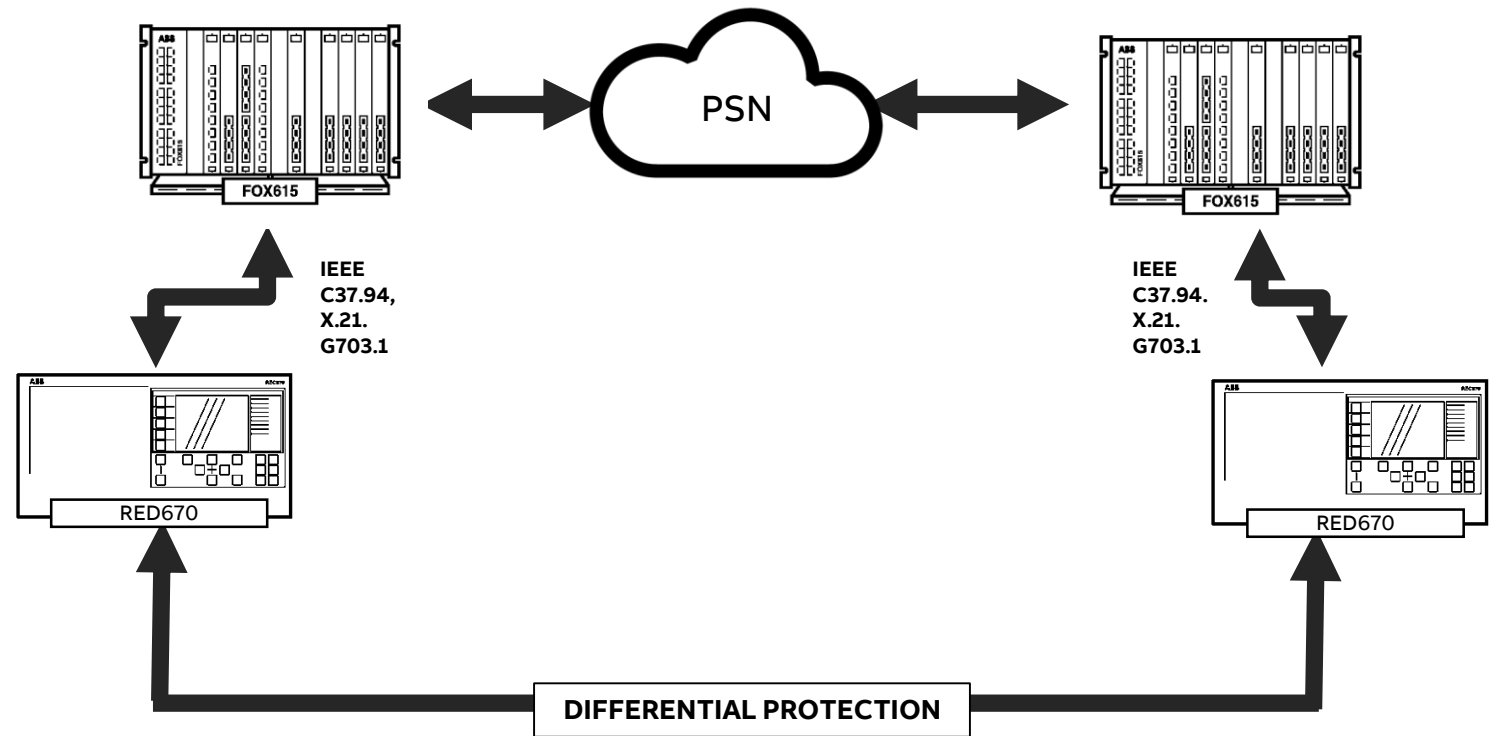
No change  $I_{diff}$  of protection relay due to PSN link

# FOX615 & OPIC2 enabling differential protection via PSN

Requirements for reliable operation

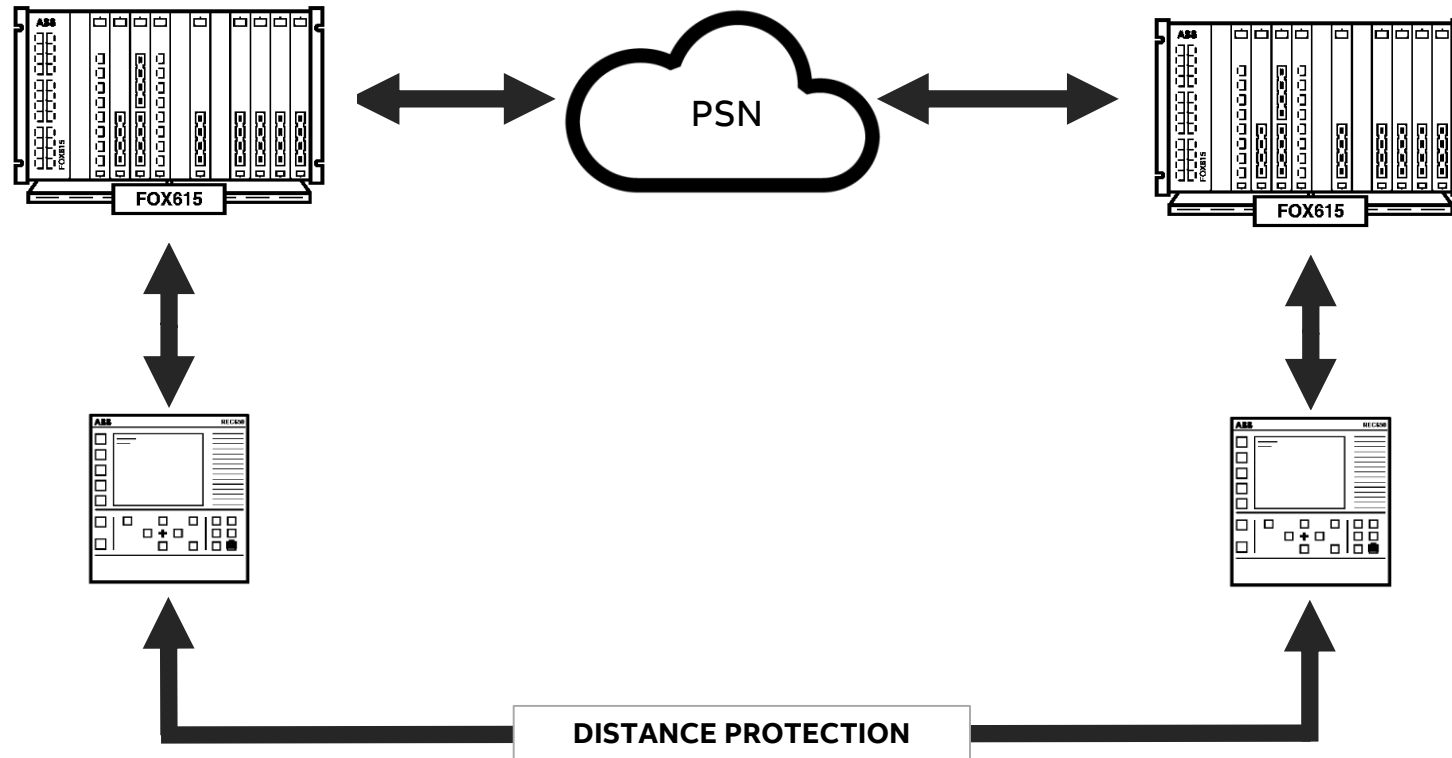
## Differential Protection via PSN

- Reliable transmission of current, voltage or phasor measurements
- Guaranteed latency time of  $< 10$  ms
- Ensured that no wrong tripping is caused due to communication problems
- Guaranteed symmetry of data channel of  $< 150$   $\mu$ s
- Guaranteed jitter/ wander of  $< 150$   $\mu$ s
- Ensure data integrity of trip signals in packet based wide area networks
- Ensure availability of  $> 99.999\%$  for mission critical applications
- End to end channel supervision and centralized alarming in NMS



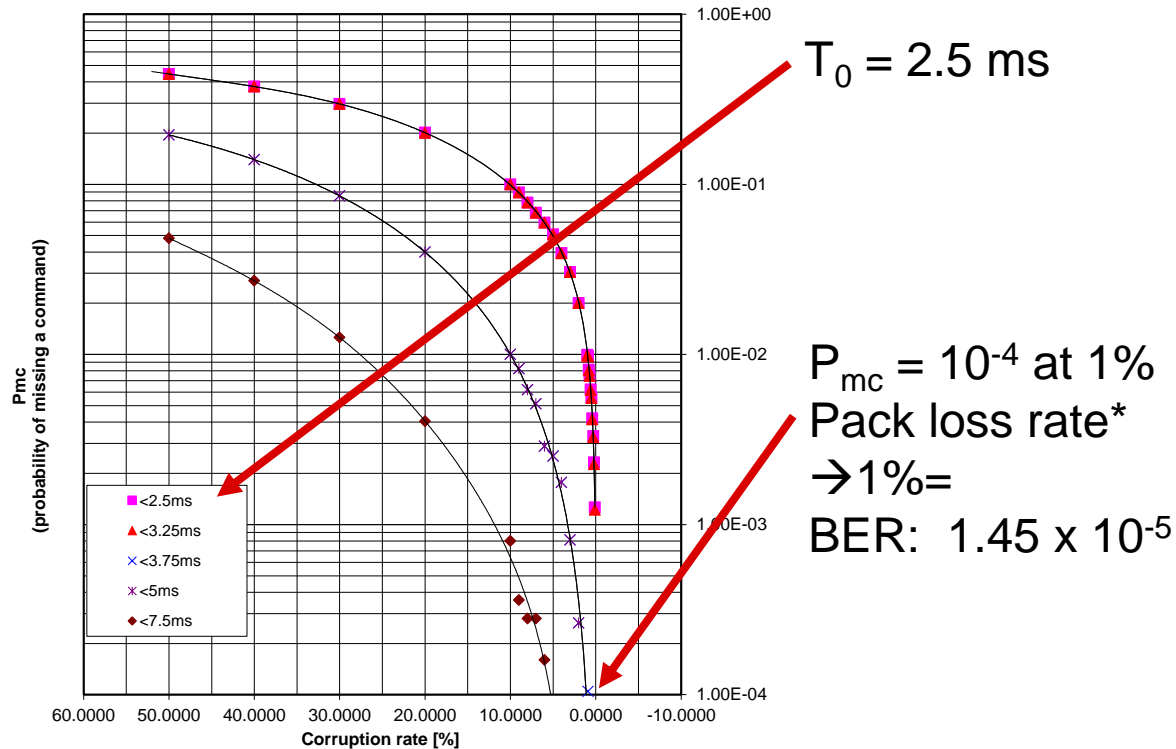
# Distance Protection

FOX615, TEPI2 – enabling protection application via PSN



# Application specific IWF for distance protection provides outstanding performance (TEPI2)

Specific IWF based  $P_{mc}$



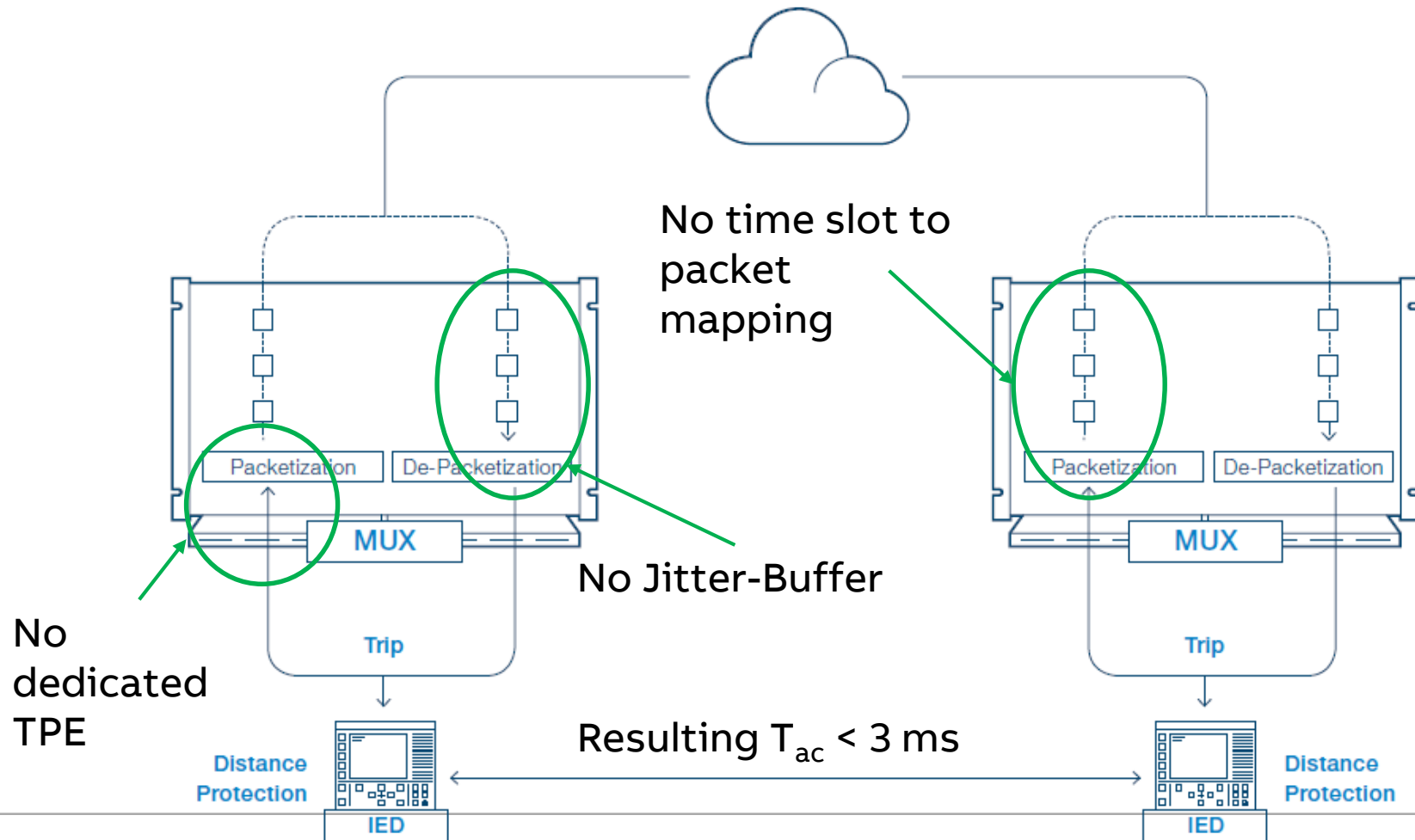
Specific IWF focusing on the application requirements optimizing delay, dependability, security and bandwidth

## We are back in the race!

- Even faster command transmission times than in TDM solution
- Even lower probability of missing a command than in TDM solution
- Authentication of data done preventing replay attacks or data modification

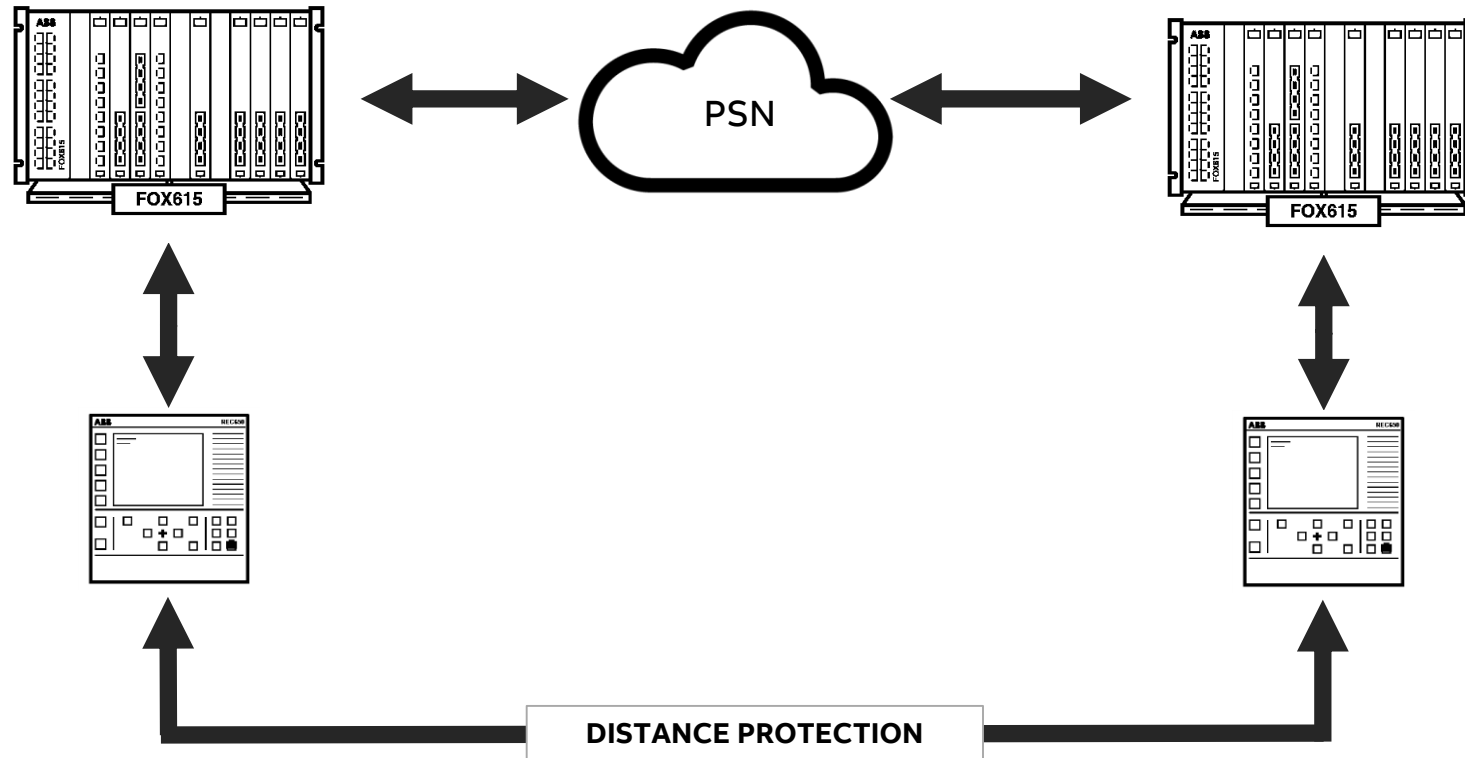
# FOX615 - Protection application

TEPI2 - fully integrated Teleprotection solutions



# Distance Protection

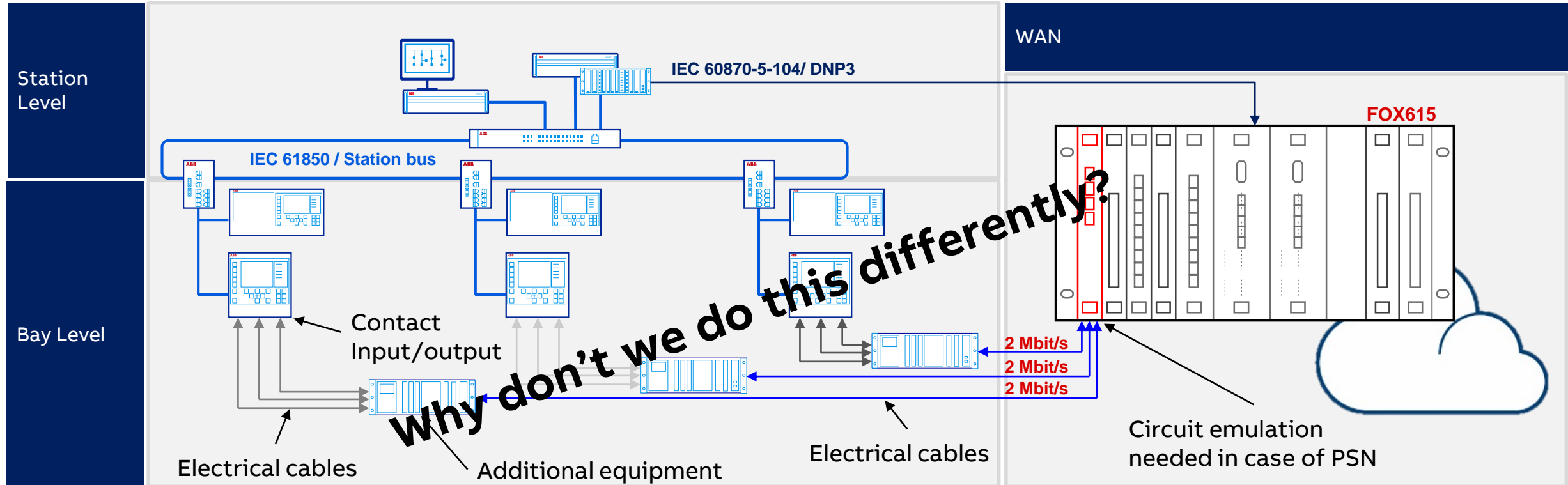
FOX615, TEGO1 – enabling GOOSE and SV based protection





# Line protection today - how is it really done?

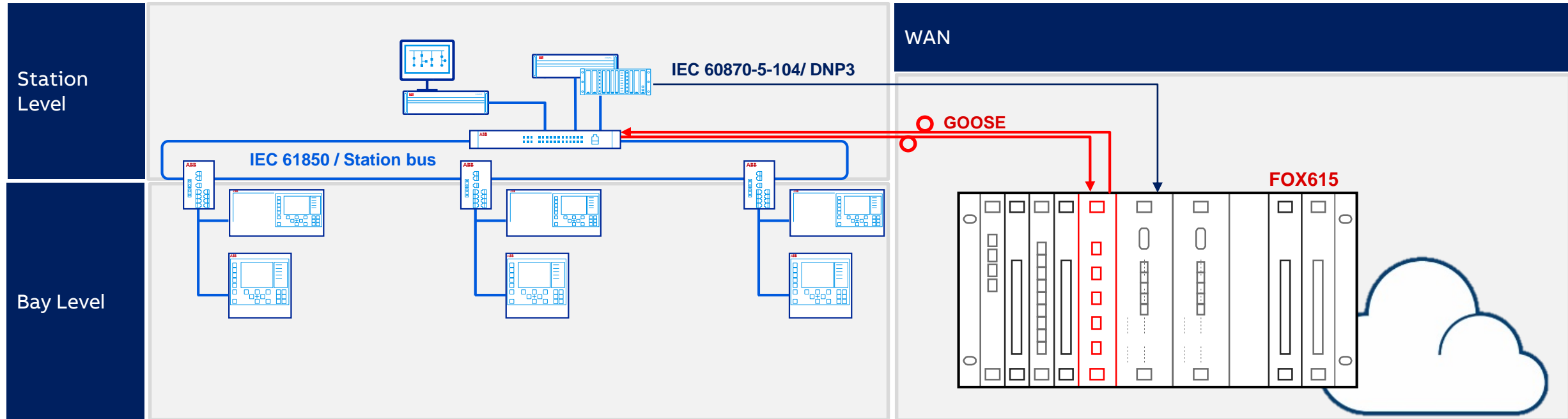
Integrated teleprotection solution (e.g. TEPI2)



Conventional Teleprotection setup is based on hard wired commands, adds complexity and latency, reduced availability

# Line protection using IEC 61850 GOOSE

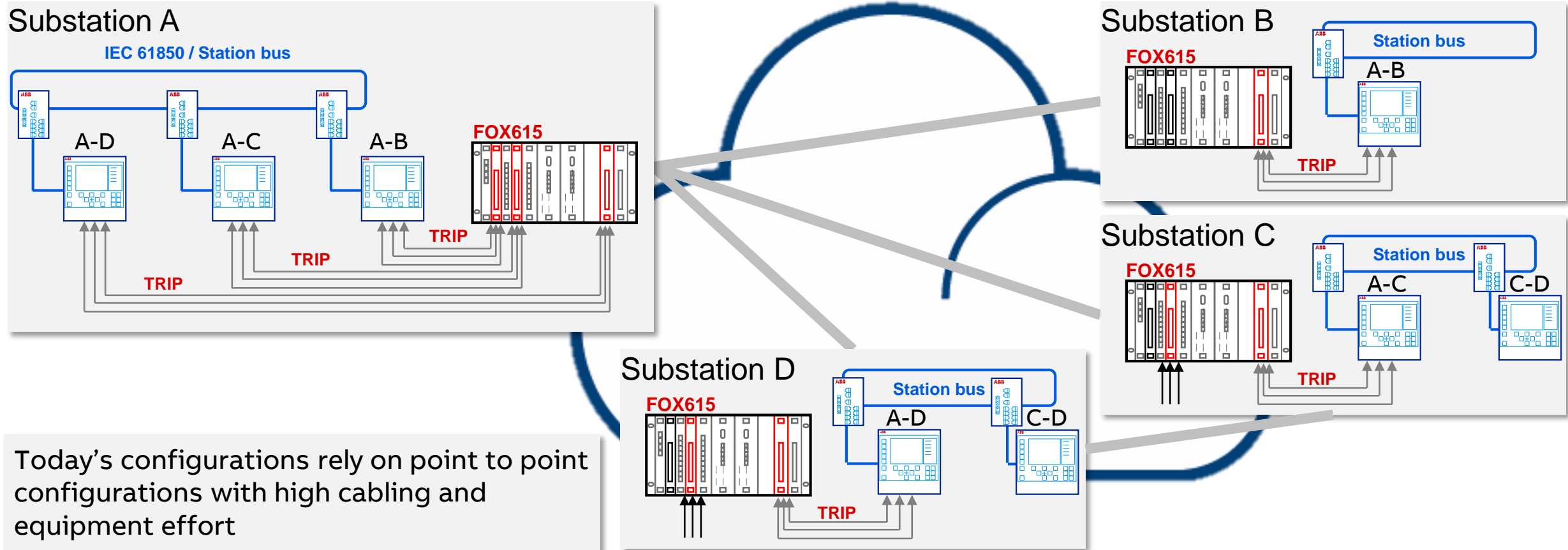
Reduction in cabling and installation complexity



- Significant reduction of installation and cabling complexity
  - All copper cables (typically 3 per powerline) are replaced by 2 fibres
  - 1 Interface card can cover multiple powerlines
- Increased availability of solution

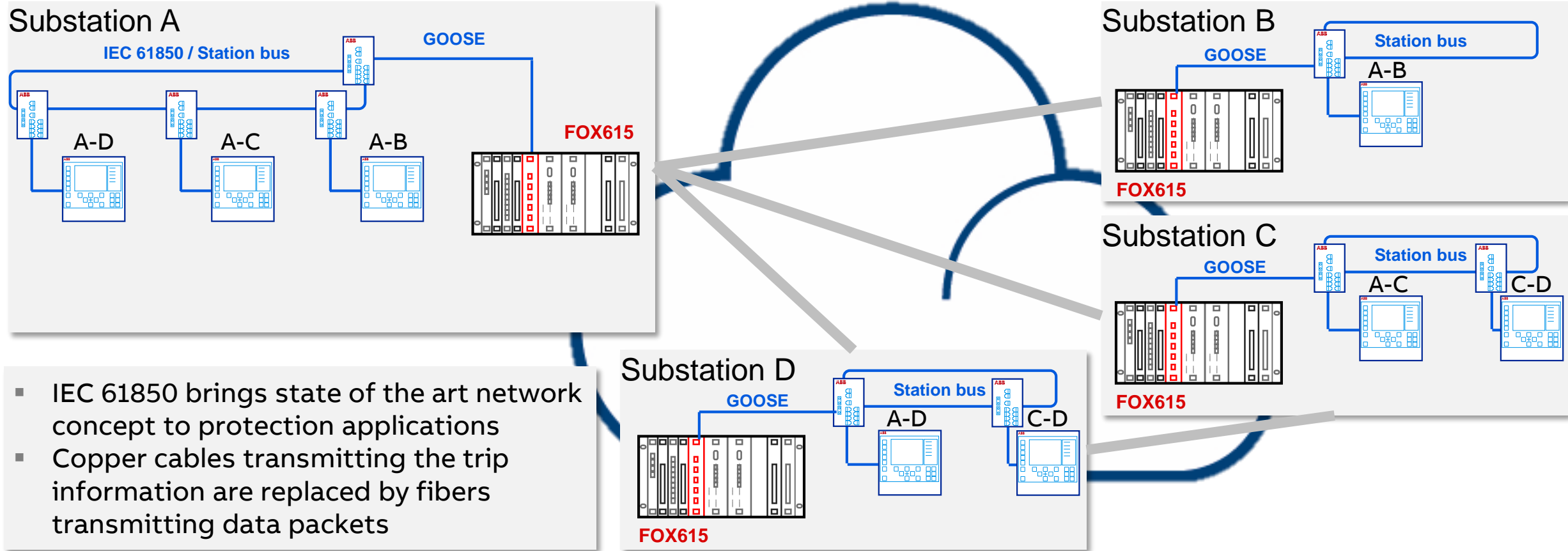
# What would change?

## Configuration of conventional teleprotection solution



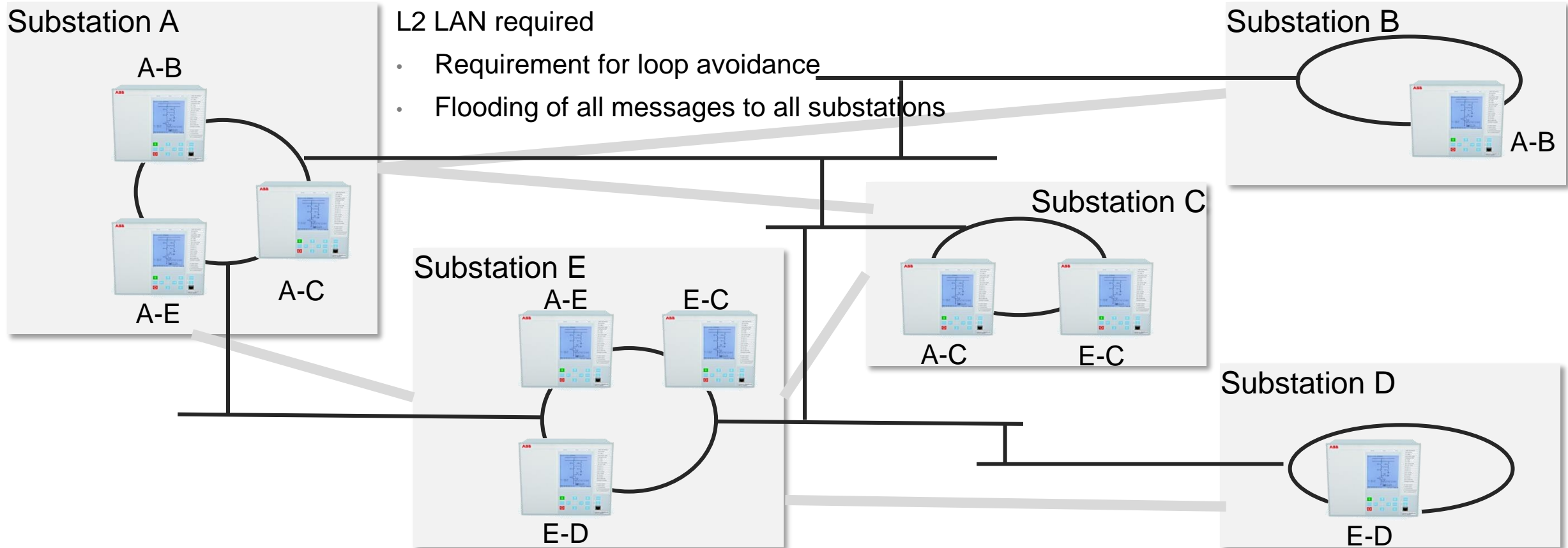
# What would change?

## Configuration of IEC 61850 based teleprotection solution

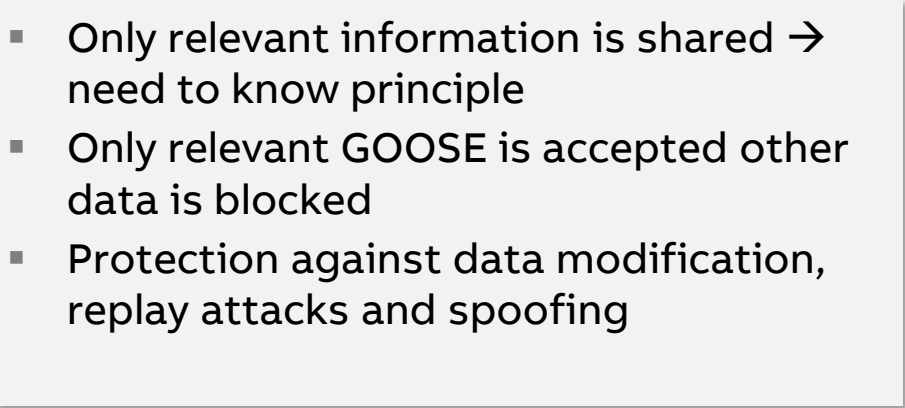


# Problems arising by this change

## Flooding of information



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# TEGO1 performance comparison

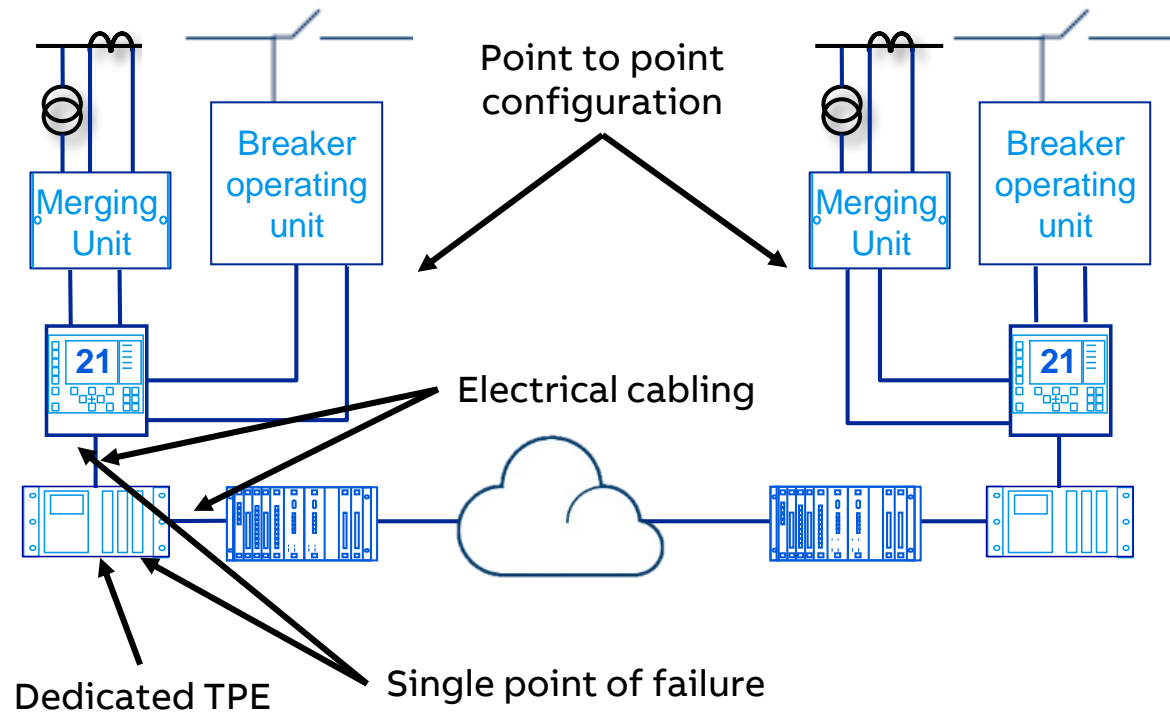
## Performance of Protection system



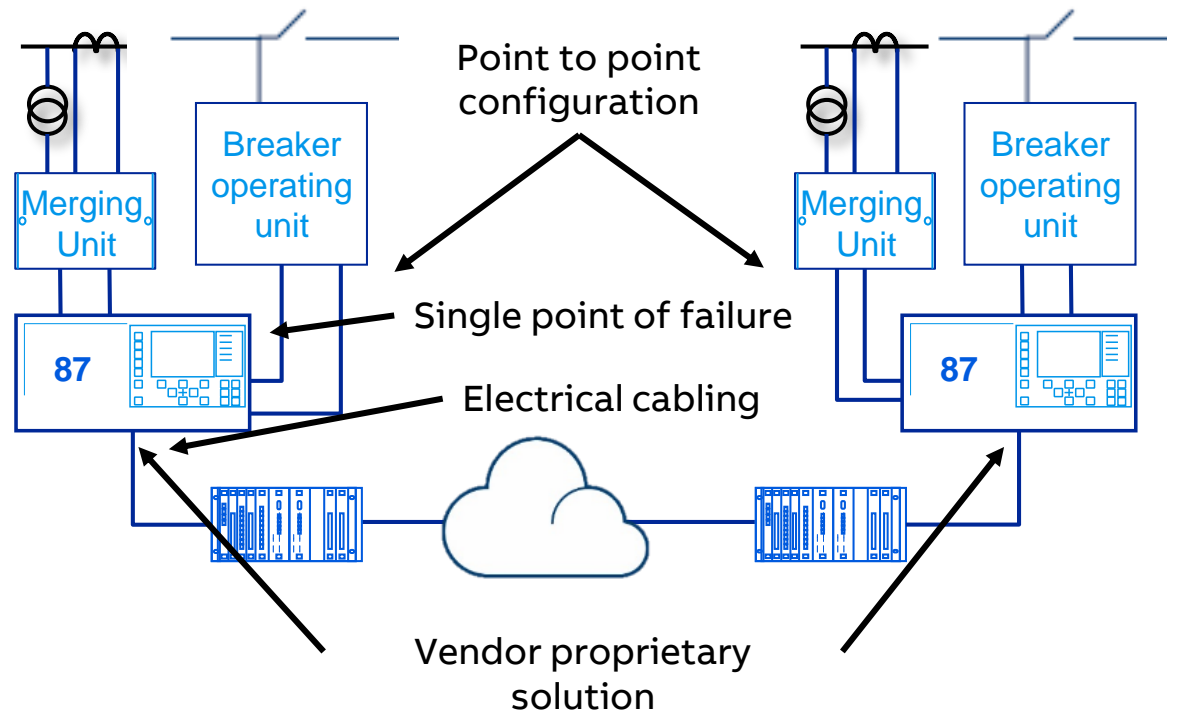
Performance increase of protection system using GOOSE based Teleprotection is ~5 ms  
Back to back delay introduced by TEGO1 is ~180  $\mu$ s

# Conventional protection systems and its limitations

## Distance protection



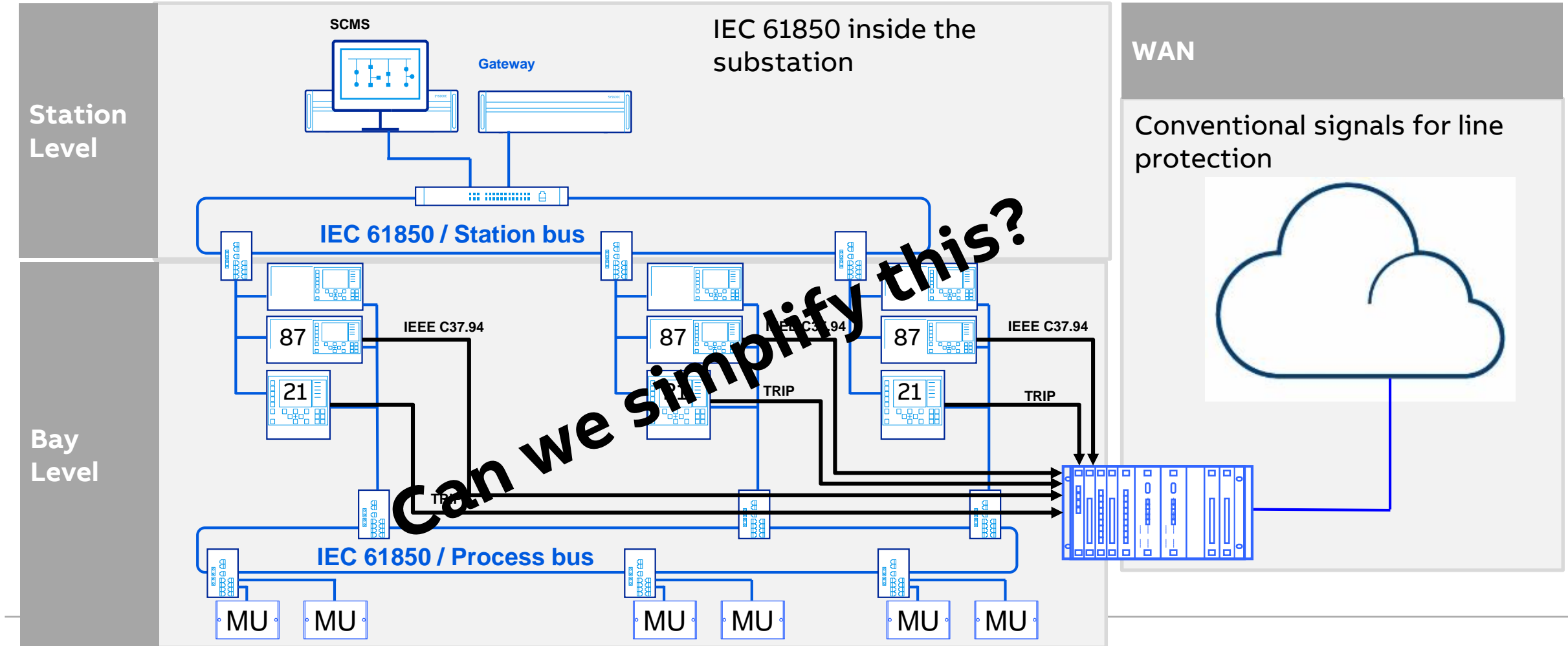
## Differential protection



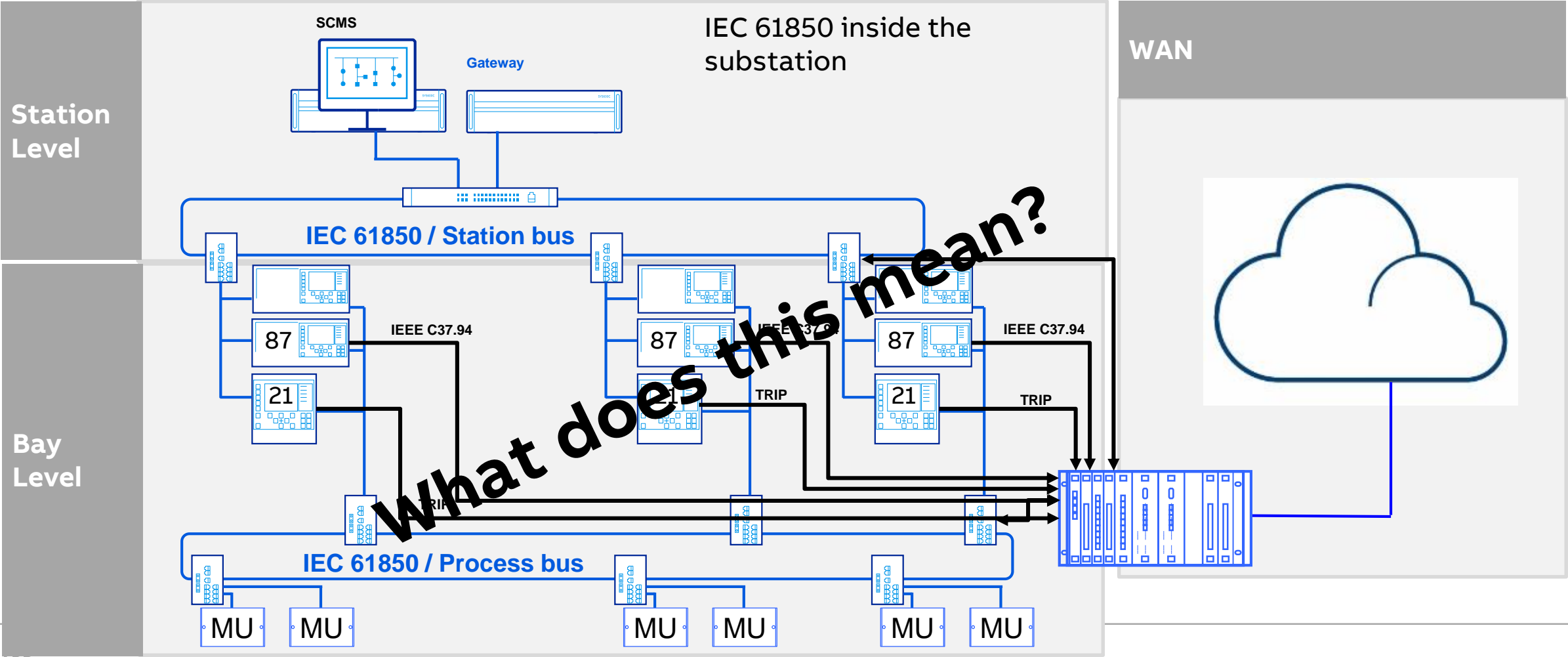


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Technology breaks, causing problems especially with migration to packet switched technologies

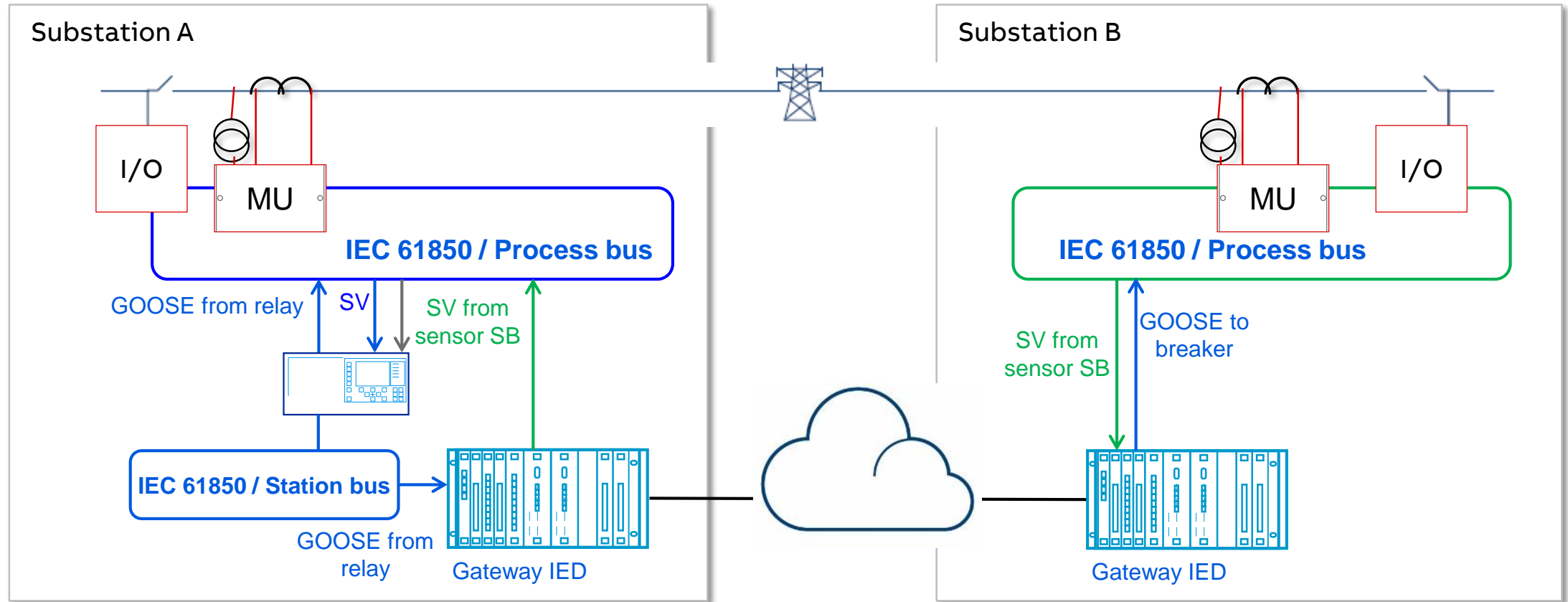


# Conceptual setup using IEC 61850

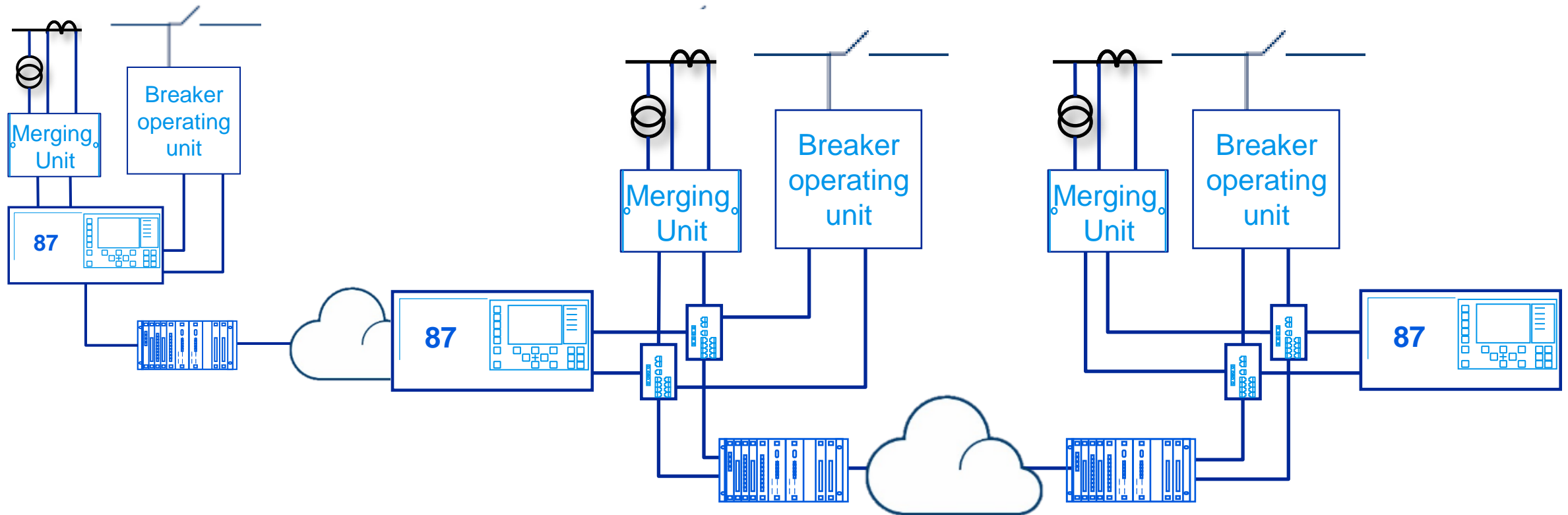




# Applying new concept - communication flow of future SV based line differential protection systems (principle)



## Function blocks of future SV based solution

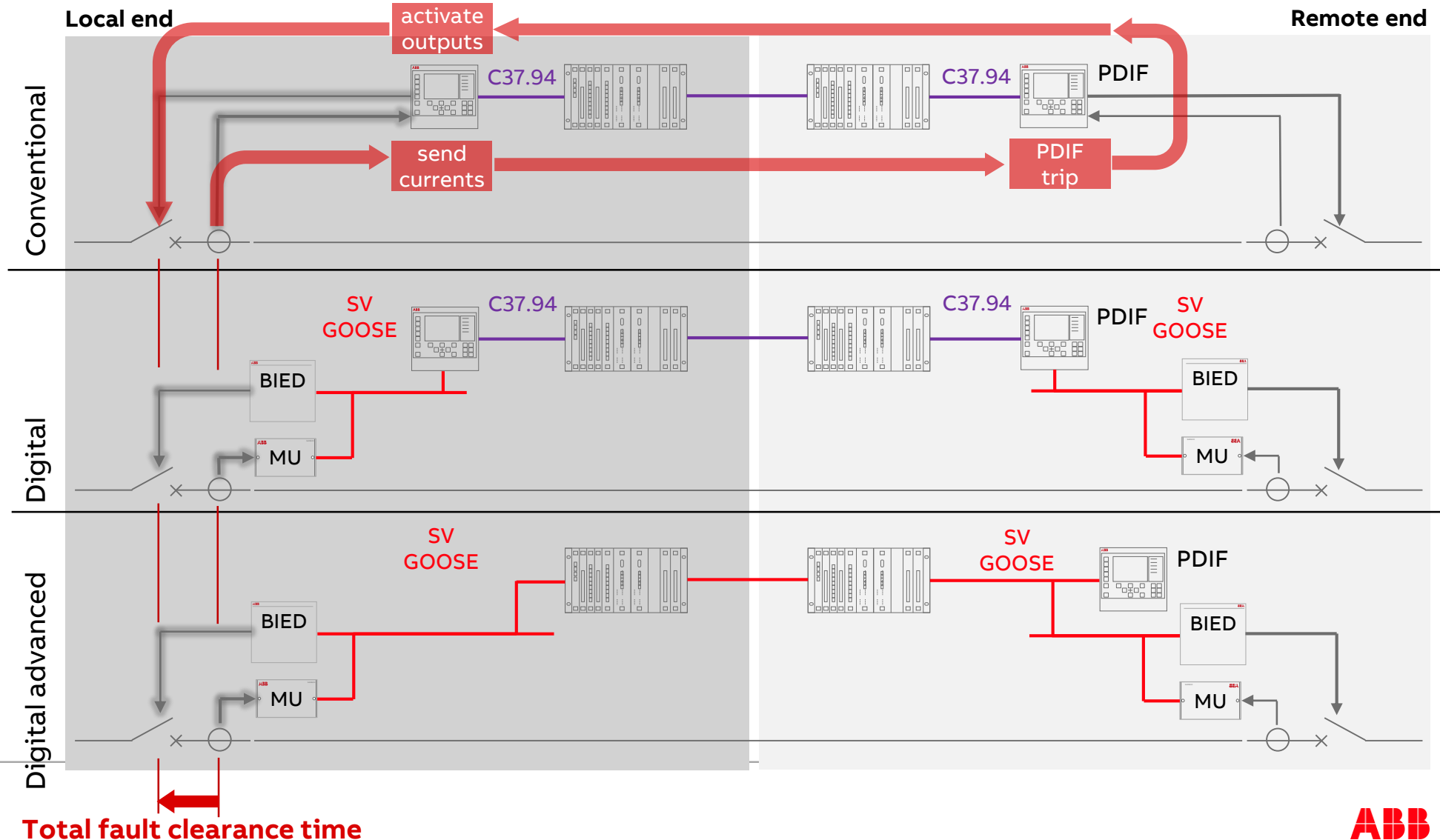


- Signal is directly taken from source, no processing by relay required
  - Performance increase of protection application
  - Interoperability between different relay providers
- Redundancy as used in substation possible (e.g. PRP)
- Increased availability can be achieved with less devices involved

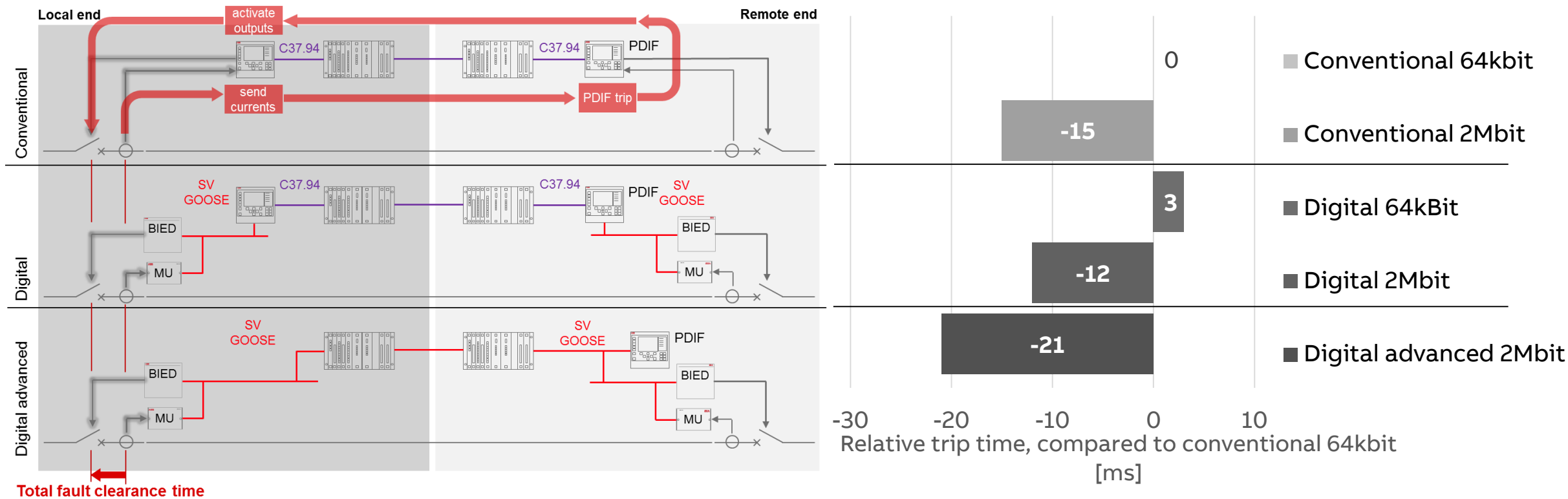
# Performance comparison of line differential protection implementations

## Comparison of 3 scenarios:

- **Conventional** with C37.94 between PDIF IEDs
- **Digital** with MUs, sampled values & GOOSE but C37.94 between IEDs
- **Digital advanced** with sampled values and GOOSE directly between process and remote end IED



# Performance comparison - Results



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# New applications possibilities

Being able to distribute real-time measurements and commands across wide area networks, opens unseen opportunities

## Example applications

- Automatic voltage regulation  
by using remote measurements to optimally adjust tap-change settings
- Integration of renewable generation  
share measurements between grid connection points and remote generation locations, e.g. off-shore wind turbines
- Power System Protection Scheme (PSPS) or Remedial Action Scheme (RAS)  
using real-time measurements to perform system wide protection functions



# More information available

Enabling Teleprotection via packet switch wide area networks with guaranteed performance

R. BÄCHLI<sup>1</sup>, A. FREI, M. KRANICH

ABB Switzerland Ltd.  
Switzerland

Presented at the annual Western Protective Relay Conference 2018  
Spokane, WA  
October 15-18

GCC Power 2018

Paper No. P-SPA-628

Kuwait

IEC 61850 real-time communication between digital substations enabling new protection and automation concepts

Ramon Baechli<sup>1</sup>, Adolf Frei, Stefan Meier

ABB Switzerland Ltd.  
Switzerland

 <http://www.cigre.org>

CIGRÉ-64

2018 CIGRÉ Canada Conference  
Westin Calgary Alberta, Canada, October 15-18, 2018

Implication of WAN technology on Teleprotection systems

 CIGRÉ-GCC P-SPA-372

<http://www.cigre-gccpower.com>

2017 CIGRÉ-GCC  
Villa 279, Street 850, Doha  
Muscat, Sultanate of Oman, October 16-18, 2017

A. FREI, M. KRANICH

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Switzerland

IEC 61850 GOOSE based inter substation protection

R. BÄCHLI, M. KRANICH, R. CHOWDHURY, M. HÄUSLER

ABB  
Switzerland  
Y. Al Jassasi  
Oman Electricity Transmission Company SAOC (OETC)  
Sultanate of Oman

variety of applications working together seamlessly  
the various applications have completely different  
bandwidth, availability and data path symmetry. Fail-  
ure of visibility, the ability for remote control or  
operational losses and reputation damage.  
Grid stability has become the most demanding

**SUMMARY**

IEC 61850 has become the standard protocol inside substations and is the basis for new digital substation architecture concepts. Among many other aspects IEC 61850 standardizes the substation internal communication between intelligent electronic devices (IEDs) for critical signals (e.g. trip signals or sampled measurements). The GOOSE based trip signals have been used by many utilities for years and with the stringent requirements given by IEC 61850 under normal but also under stress conditions considering various different failure scenarios. Another important aspect considered are the implications for the design of high voltage power line protection schemes, with the consequences for installation efforts, availability as well

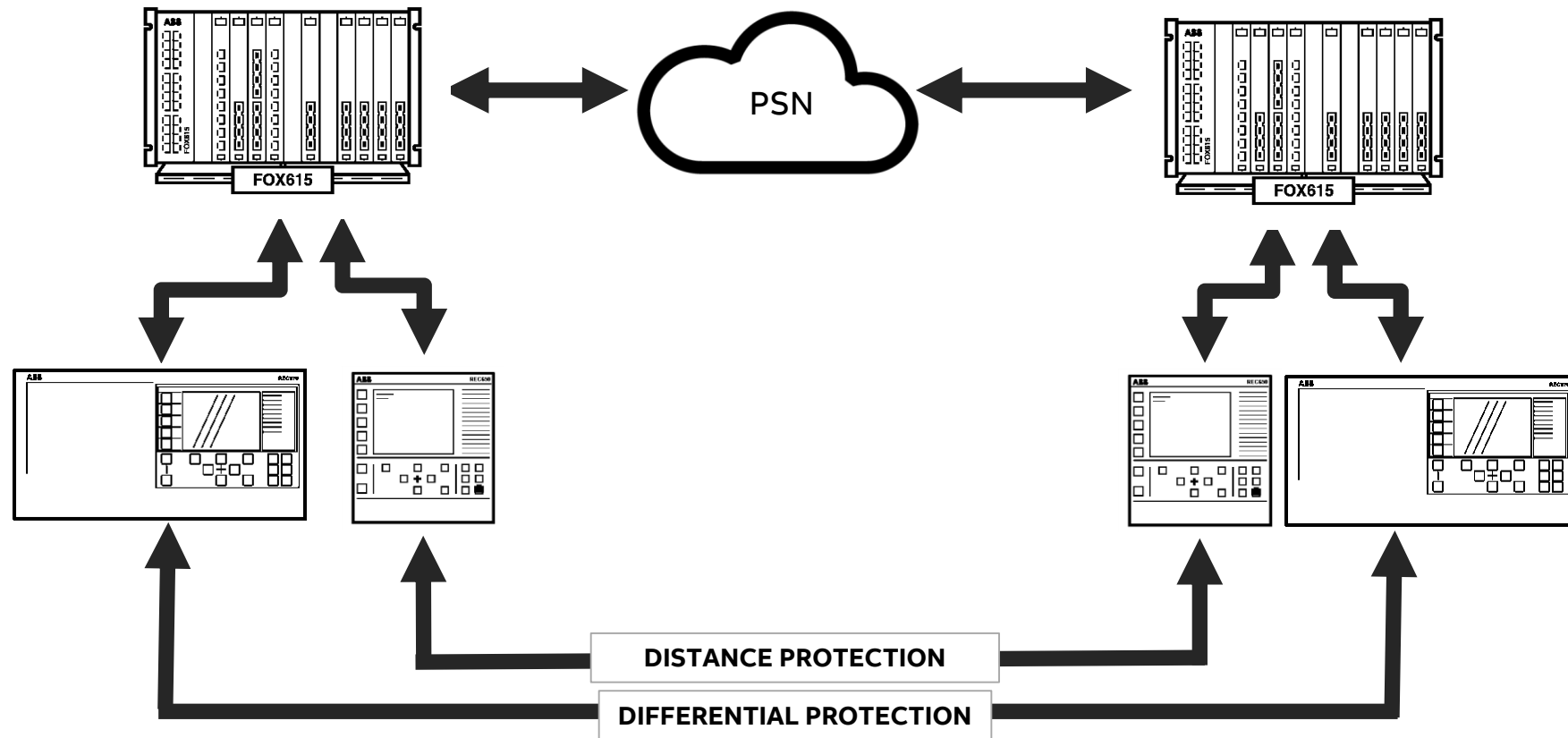


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# FOX615 – application specific migration solutions

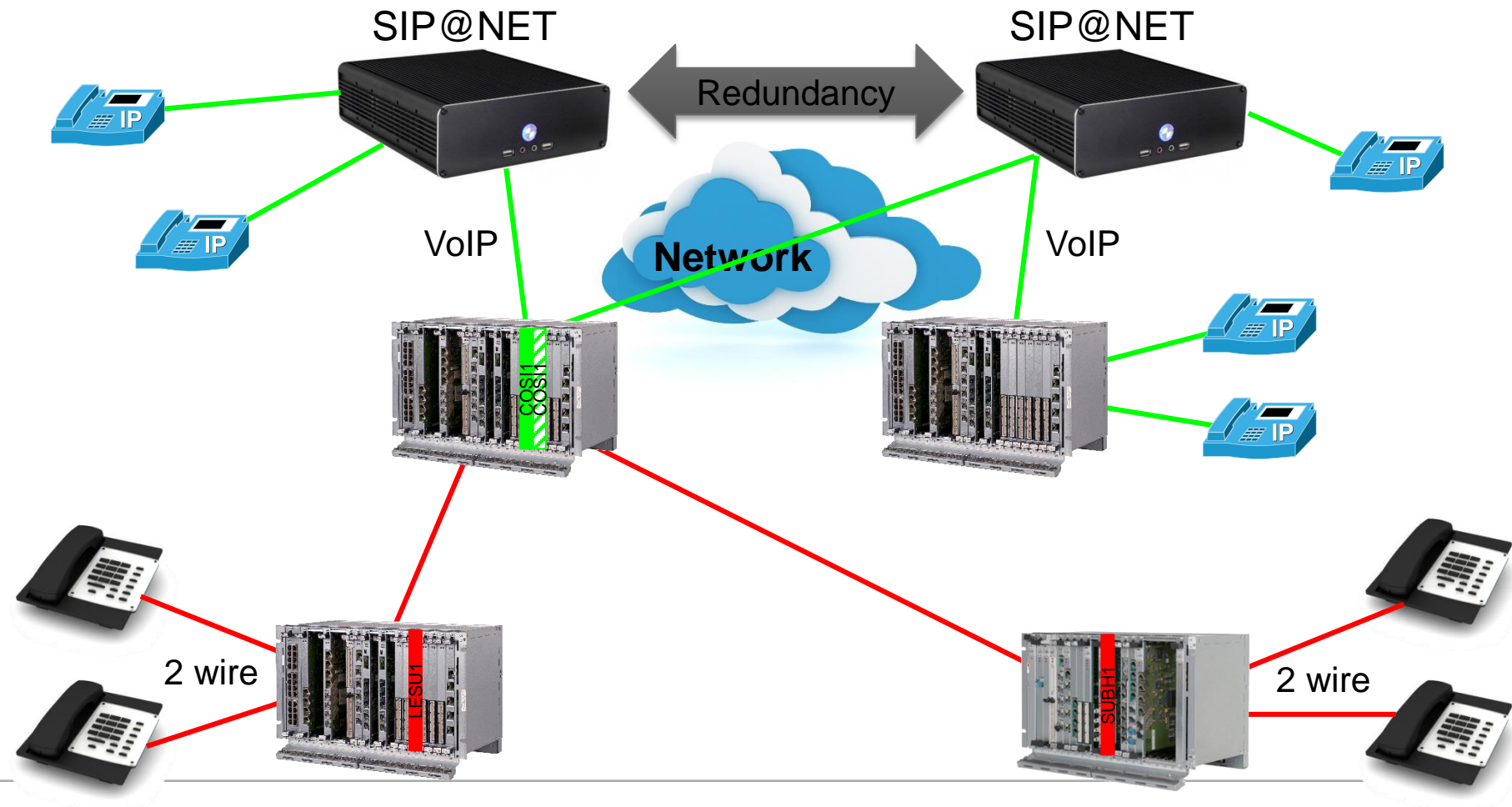
# Migration of teleprotection services

FOX615 – enabling protection application via PSN with TEPI2 and OPIC2



# Migration of voice services

COSI1 – integrated 2w voice – VoIP conversion



# Migration of traditional TDM data

CEPI1 - 2 Mbit/s ITU-T compliant circuit emulation interface



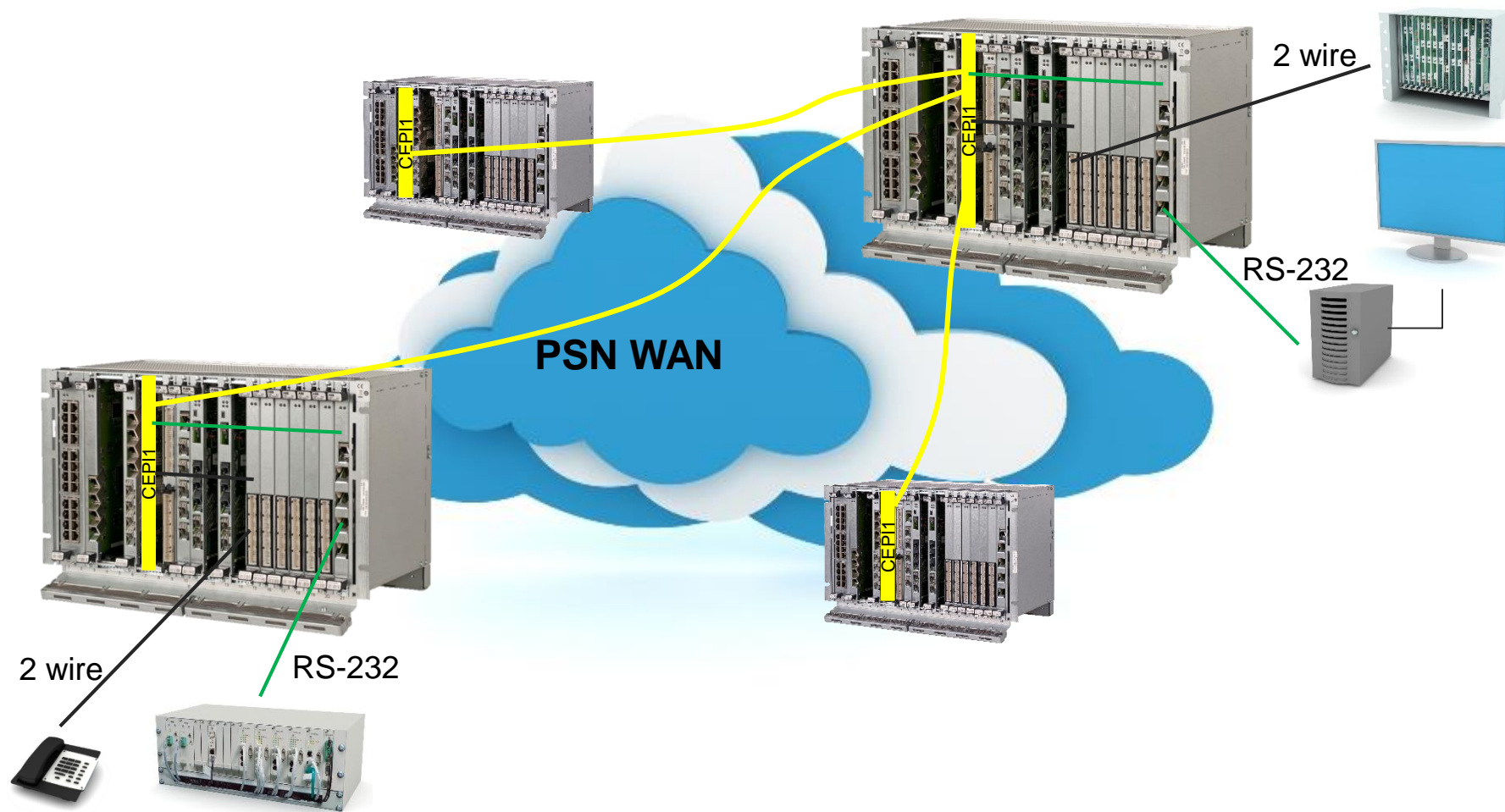
Standard circuit emulation for TDM data

- 2 Mbit/s G.703/ 704 interface
- 8 x 2 Mbit/s front ports
- 8 x 2 Mbit/ TDM backplane connectivity
- Support of Satop or CESoPSN
- 8 circuit emulation instances
- Allows interconnection of traditional TDM services through packet switched networks

→ This interface can not be used for protection signal transmission via PSN

# CEPI1 – use case

Integration of legacy signals

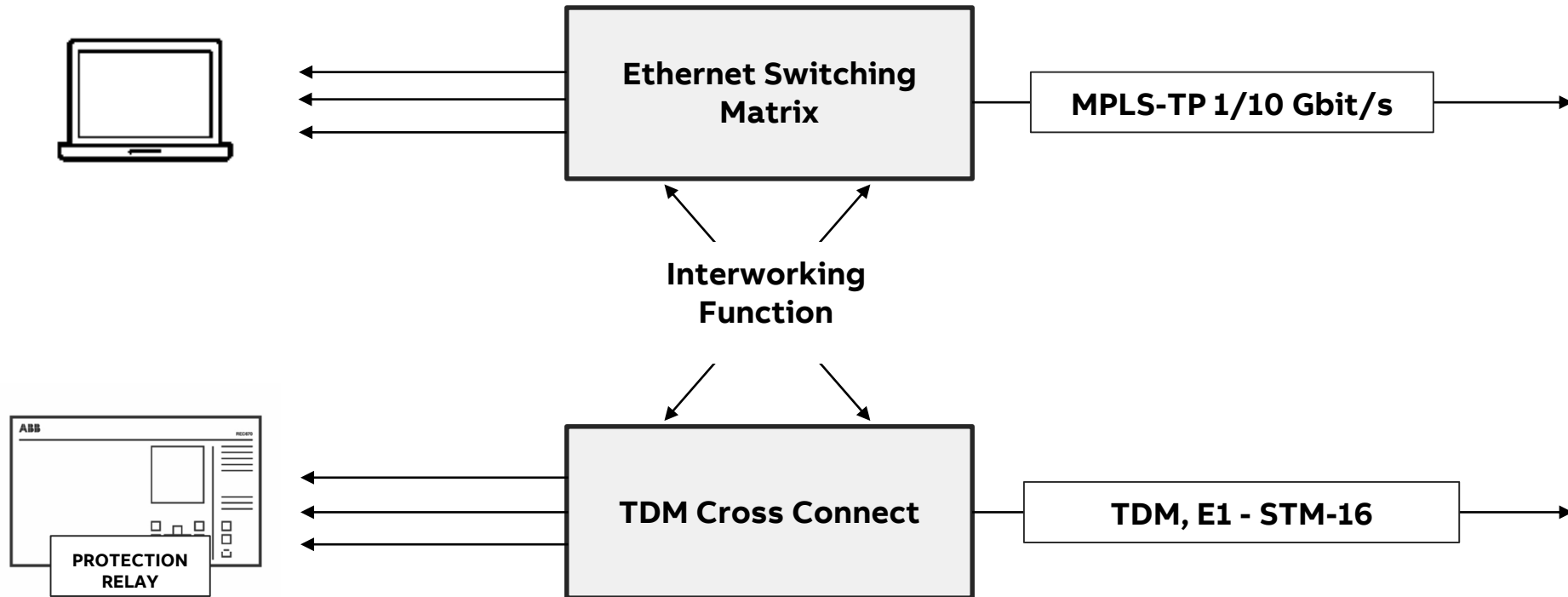


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# Smooth transition from TDM based networks to Packet Switched Networks

# FOX615 multiservice hybrid platform

Offering simultaneous native TDM and PSN technology

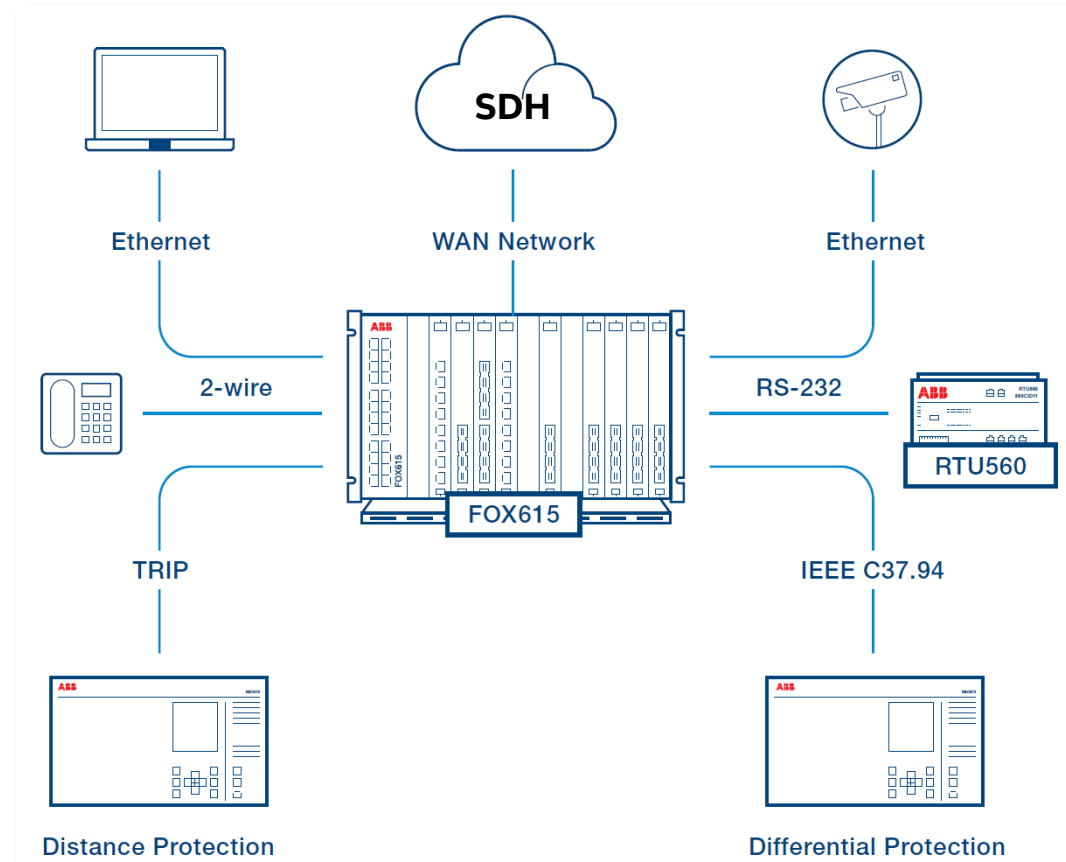


**FOX615 – Ready for the challenges of tomorrow**



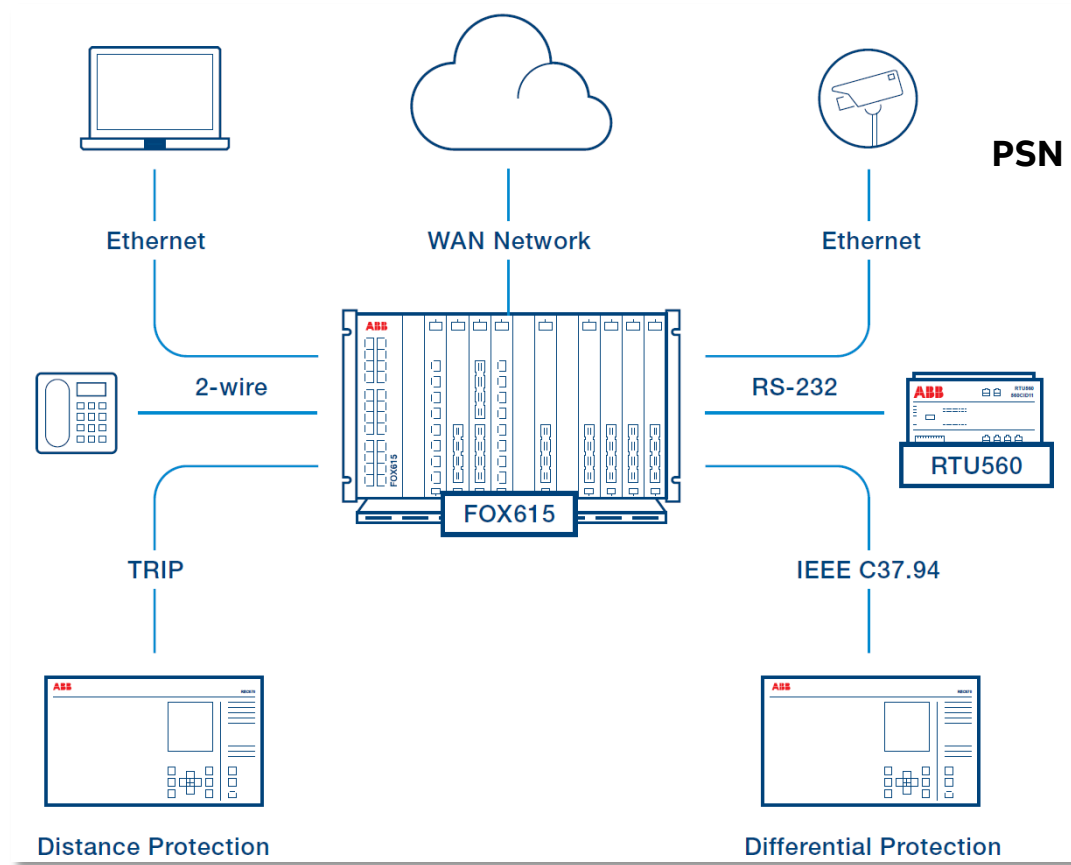
# FOX615 multiservice platform – hybrid platform

From SDH...



# FOX615 multiservice platform – hybrid platform

... to MPLS-TP



# FOX615

Allowing stepwise migration from SDH to MPLS-TP with guaranteed performance

## SDH

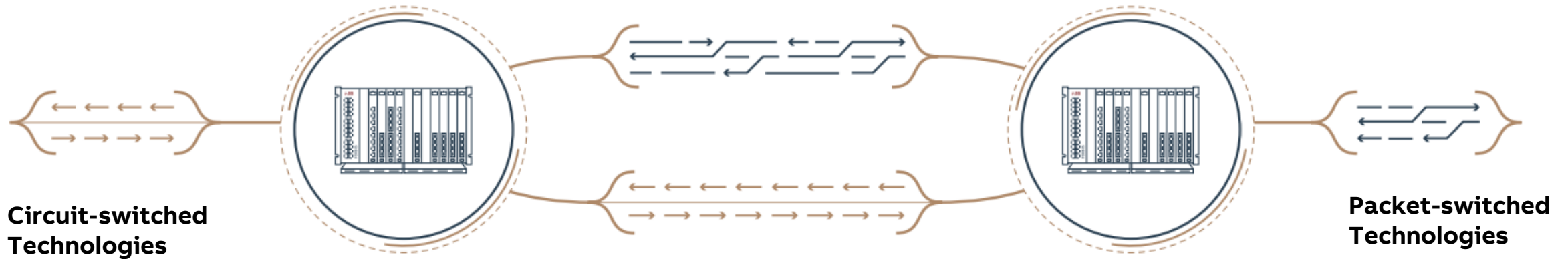
Supported  
Network

## Hybrid

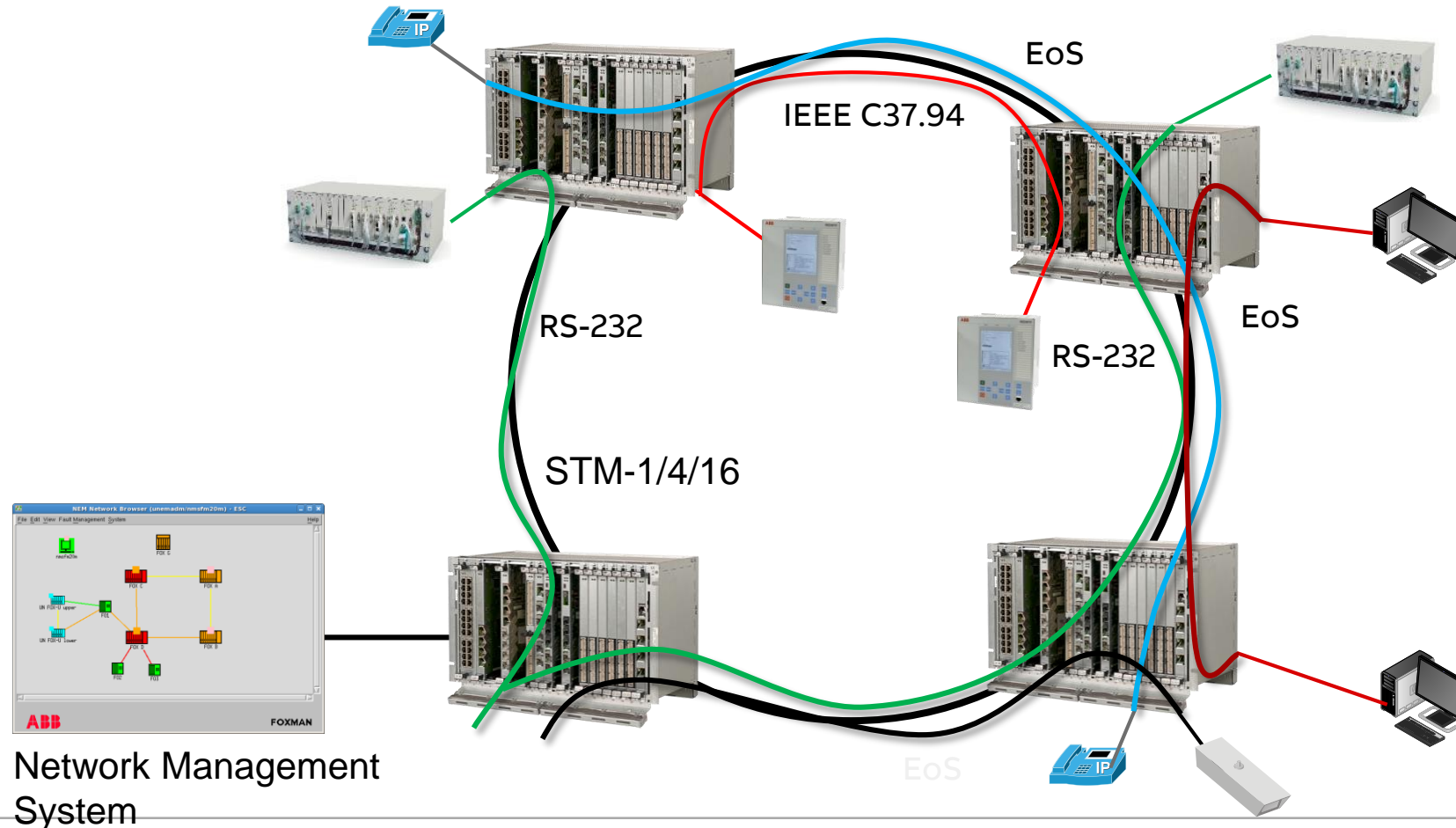
Combined  
Networks

## MPLS-TP

Future Networks

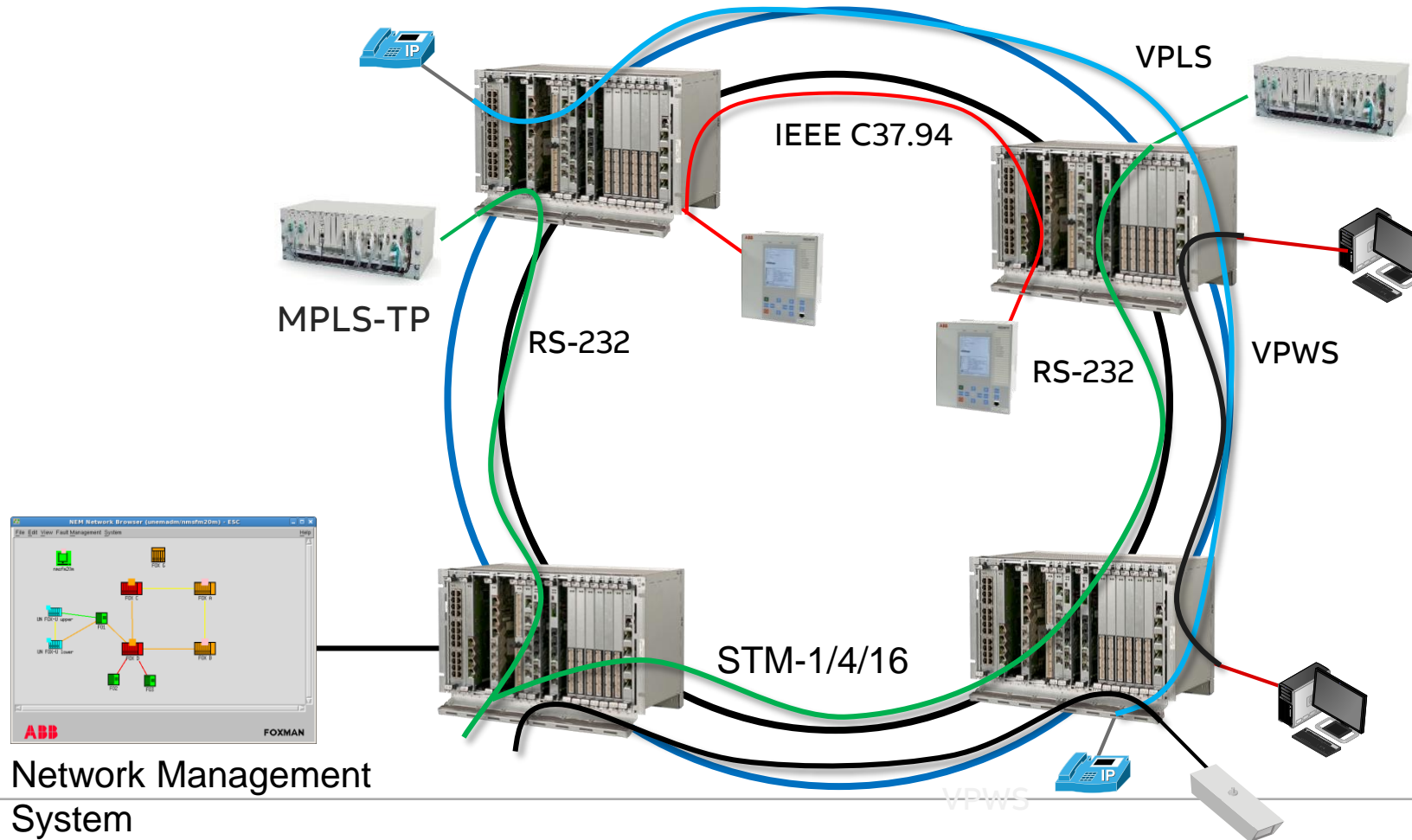


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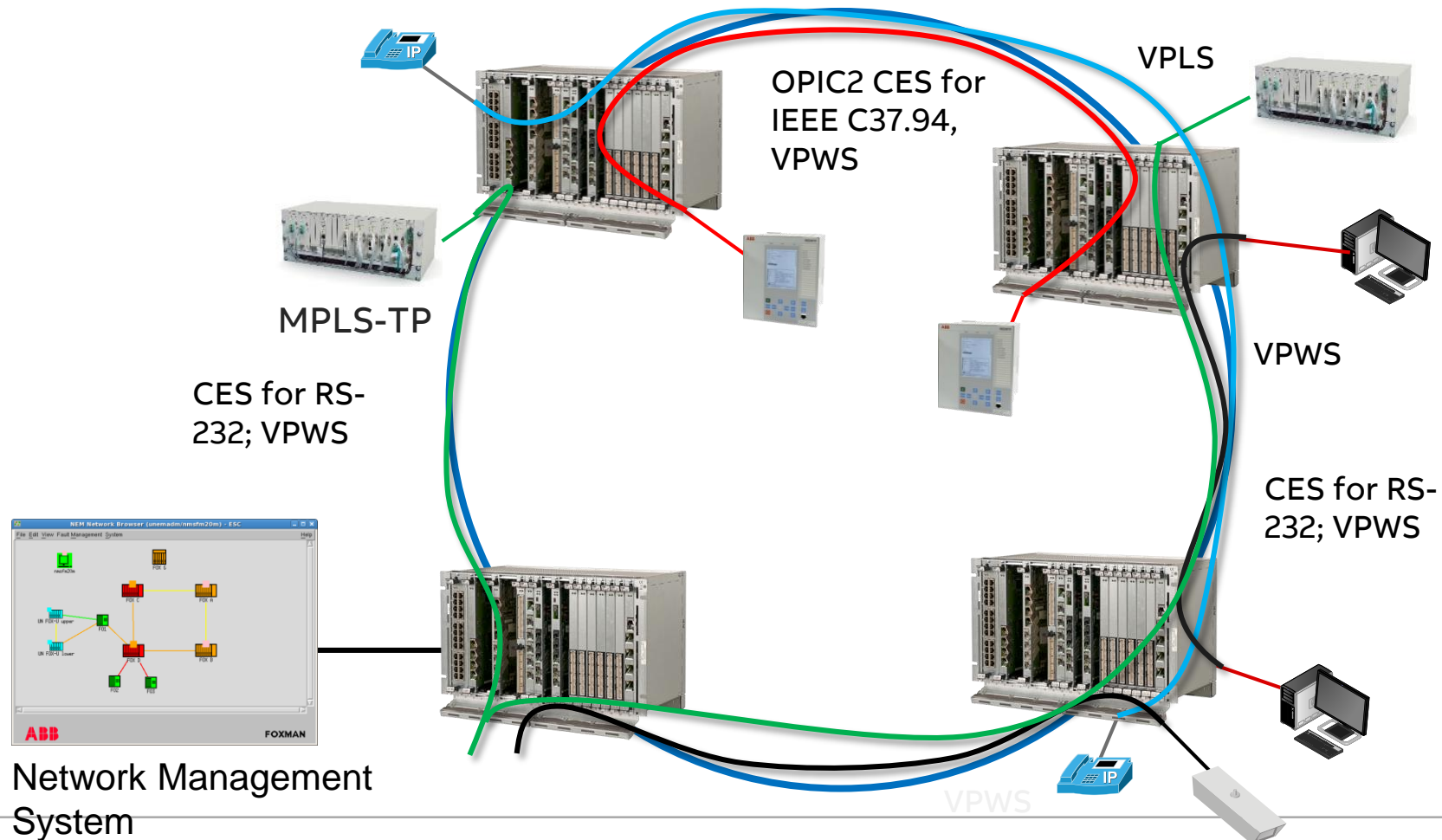
# FOX615 the way to packet switched networks

Hybrid network

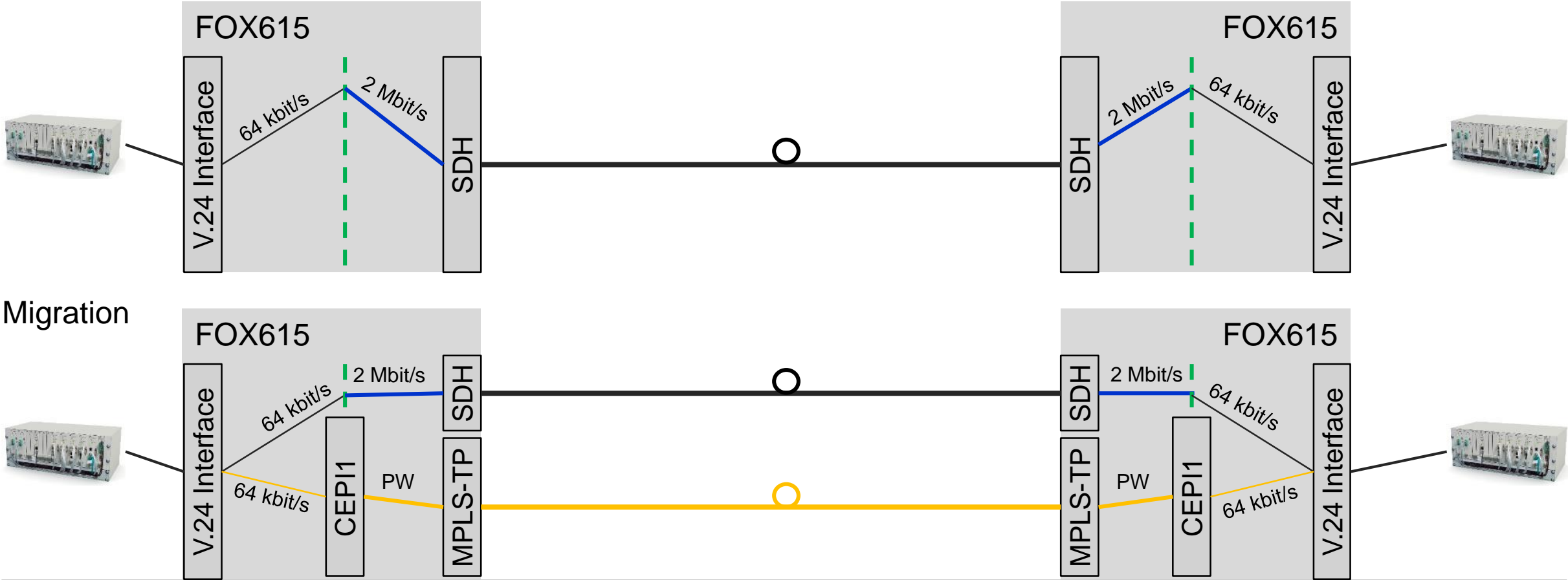


# FOX615 the way to packet switched networks

Hybrid network



# Details on smooth technology migration



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# FOX615 and cyber security



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## Cyber Security

### Definition

“Measures taken to protect substation automation systems and communication networks against unauthorized access or attack”

# FOX615 and cyber security

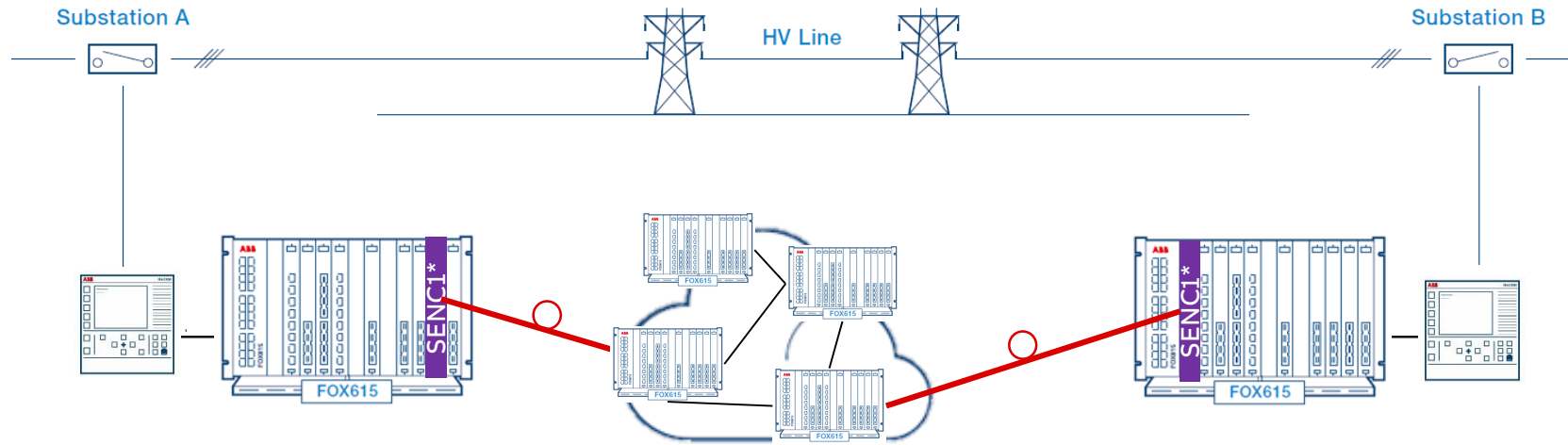
Many features supported

Cyber Security Feature	FOX615 R2
System Time	SNTP, PTP
SYSLOG	YES
Management protocols	Proprietary on top of TLS SNMPv3 IPsec
Management accounts	RBAC, RADIUS
Management VLAN	yes, dedicated
Rate limiter (BC, MC, UU)	YES
Flow control	YES
OSPF authentication	MD5
Internal firewall towards management port	YES
Authentication of critical data	YES (OPIC2/ TEPI2/ TEGO1/ SENC1)
L2 firewall for critical data	YES (TEGO1)
Traffic encryption, including system protocols	YES



# SENC1 – Line encryption unit

End to end service encryption

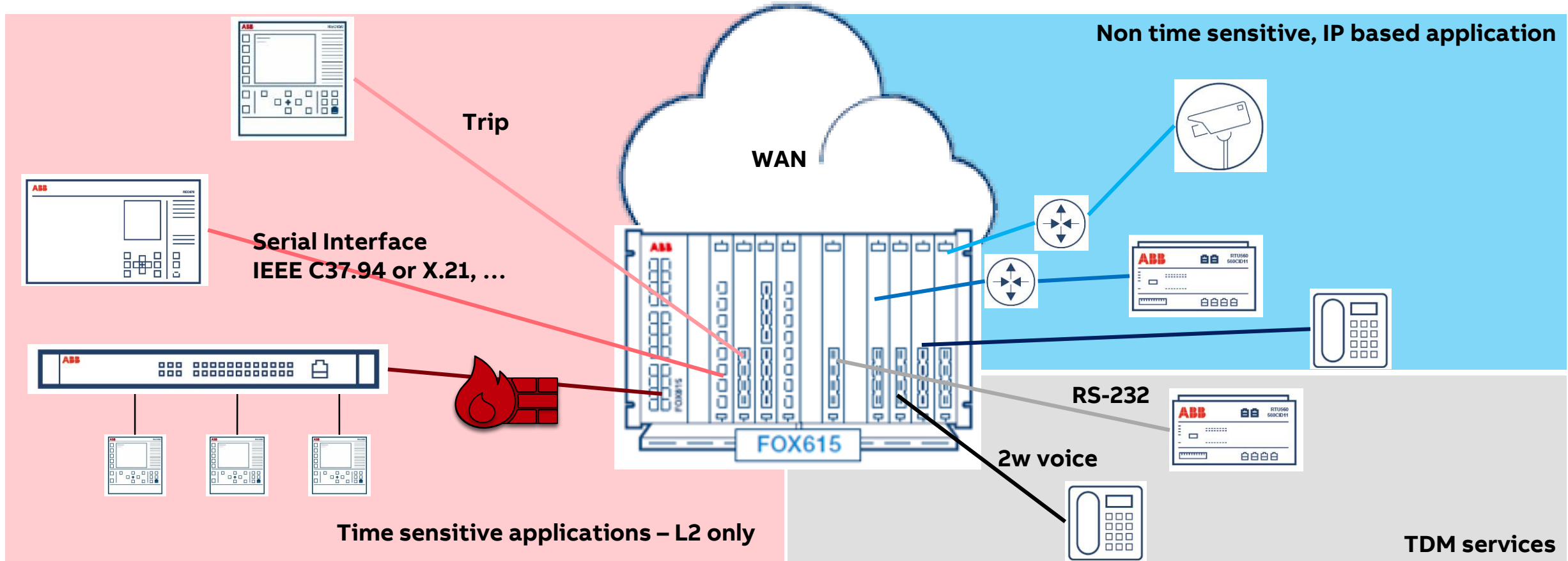


- End to end **service** encryption/ encryption and authentication
- Up to 1024 services per port can be encrypted at wire speed, up to 10 Gbit/s
- Suitable for **critical services, extremely low jitter/ wander injection** by encryption solution
- Encryption of **mission critical data** (protection) and **system protocols possible** (PTP, ECC)
- Configuration of encrypted channels through FOXMAN-UN-ENP
- Key handling consisting of **session** and **master** keys
- Session key generated based on **real randomness**

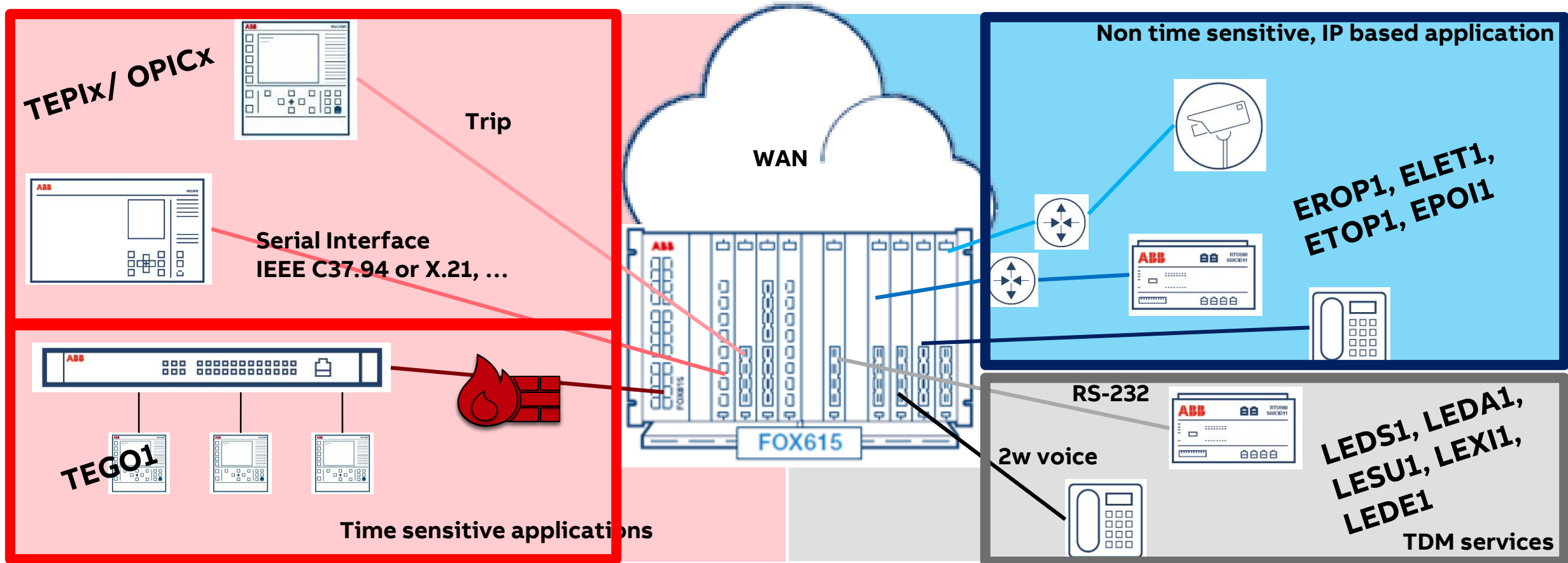


# Summary

# Multiservice approach with FOX615



# Multiservice approach with FOX615



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# FOX615 the solution for technology migration

## Summary

FOX615 offers true hybrid functionality with native TDM and PSN functionality

FOX615 offers different migration scenarios from TDM to PSN

- Leaving the decision on when and how to do it to the utility and not creating pressure caused by technology or equipment availability
- Allows to get experience with the new technology not abandoning the established technology
- Enables extremely simple ways of service migration from TDM to PSN within the same equipment
- Adapts the migration scenario/ solution to the specific application requirements in order to guarantee required performance parameters

**→ FOX615 is the most flexible solution adapted to individual needs available with guaranteed long term support**

---

**FOX605**

**We are securing the past in a fast moving future**



# FOX605

We are securing the past in a fast moving future

**Made for the  
utility  
environment**



- Fanless design
- Extended temperature range
- Redundancy

**Ideal mix of  
interfaces**



- Traditional interfaces (serial, 64kbps, E1)
- LAN services incl. PoE
- MPLS-TP & L2 on el. & optical GE
- STM-1 & ANSI T1 / OC-3 via SFP

**Secure and  
reliable  
communication**



- Service-based Enhanced L2 MACSec encryption
- SyncE / 1588v2 incl. timing interfaces
- Integrated into ABB's Network Management Suite

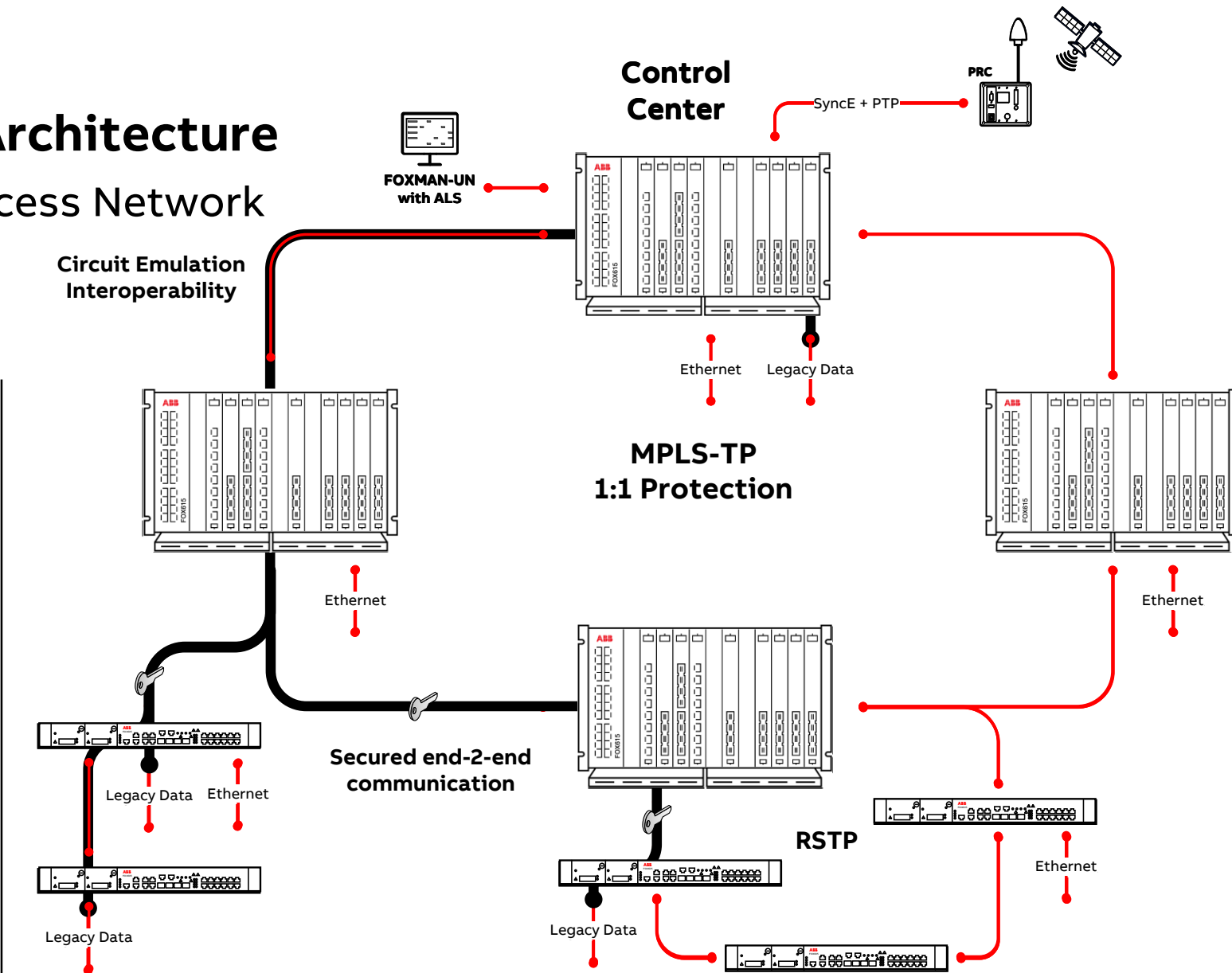


# FOX605 & FOX615 Network Architecture

## MPLS-TP Core Network & Layer 2 Access Network

### Highlights

- Legacy Data (E1/ V.24/ V.11/ RS-485/ 64k)
  - Circuit Emulation interoperability using MEF8 (CES over ETH)/SAToP (RFC4553)
- Protection
  - 1:1 Linear Protection (PSC) – MPLS-TP
  - RSTP – Layer 2
- Synchronization: SyncE and PTP (IEEE 1588v2)
- Ethernet Services
- Quality of Service (QoS)
- Enhanced MACSec (end-to-end encryption)
- Management: FOXMAN-UN with ALS



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# **NSD570 Teleprotection Equipment**

## **Ethernet WAN Interface G3LE**

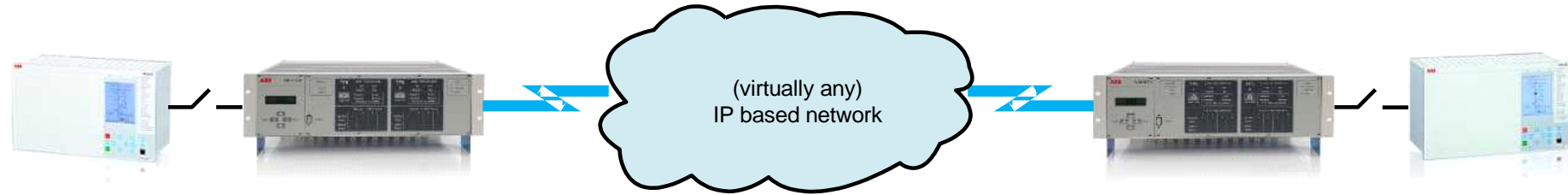
# NSD570

## Can it be used in Ethernet/IP networks?

- NSD570 supports direct Ethernet/IP connectivity (using Ethernet line interface G3LE)
- NSD570 supervises the delay and raise an alarm if certain limits are exceeded (delay, packet loss rate)
- NSD570 can take advantage of the QoS mechanisms provided by the network. It can however **not** improve the performance of the IP network!
- It is the **user's responsibility** to ensure that the IP network delivers the requested performance, like
  - Guaranteed end-to-end delay under all network load conditions
  - Guaranteed end-to-end bandwidth (min. 1 Mbps)
  - Guaranteed service- and/or port prioritization
  - Fast switchover times in case of route failures

# NSD570 Ethernet WAN Interface G3LE

Transmission of protection commands over Ethernet/IP networks

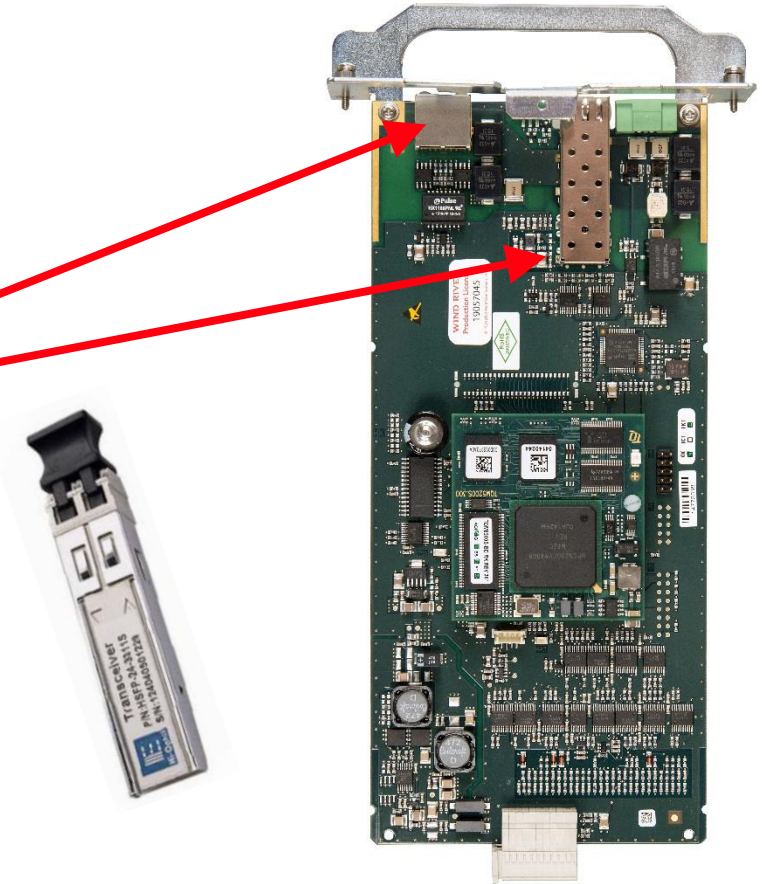


- Transfer of up to 8 simultaneous/independent commands (Nominal transmission time  $\leq 4$  ms back to back)
- Continuous channel supervision (packet loss rate, actual transmission time)
- Alarms / warnings in case of bad channel quality or end-to-end delay too high
- Security mechanisms to prevent attacks, e.g. use of secure message coding algorithm SHA-256
- Support of Ethernet/IP network traffic management (message prioritization):
  - VLAN tagging on Ethernet layer 2 (ID and priority setting)
  - Type of Service field on IP layer 3 (ToS / DiffServ setting)
- Low bandwidth requirements (0.5 Mbit/s max. in command state)
- All NSD570 teleprotection features supported (event recorder, unblocking, etc.)

# NSD570 Ethernet WAN Interface G3LE

## Module overview

- Plug-in line interface module for NSD570
- 400 MHz PowerPC Architecture
- On board interfaces (only one usable at a time):
  - 10/100Base-TX – electrical interface with fix mounted RJ45 socket
  - Cage for exchangeable SFP\* transceiver modules
    - 100Base-FX (optical Ethernet) for different distances:
      - 850 nm, MM, > 0.5 km, up to 1 km, or
      - 1310 nm, SM, > 30 km, up to 50 km
      - same SFPs and optical fibers as G1LOa

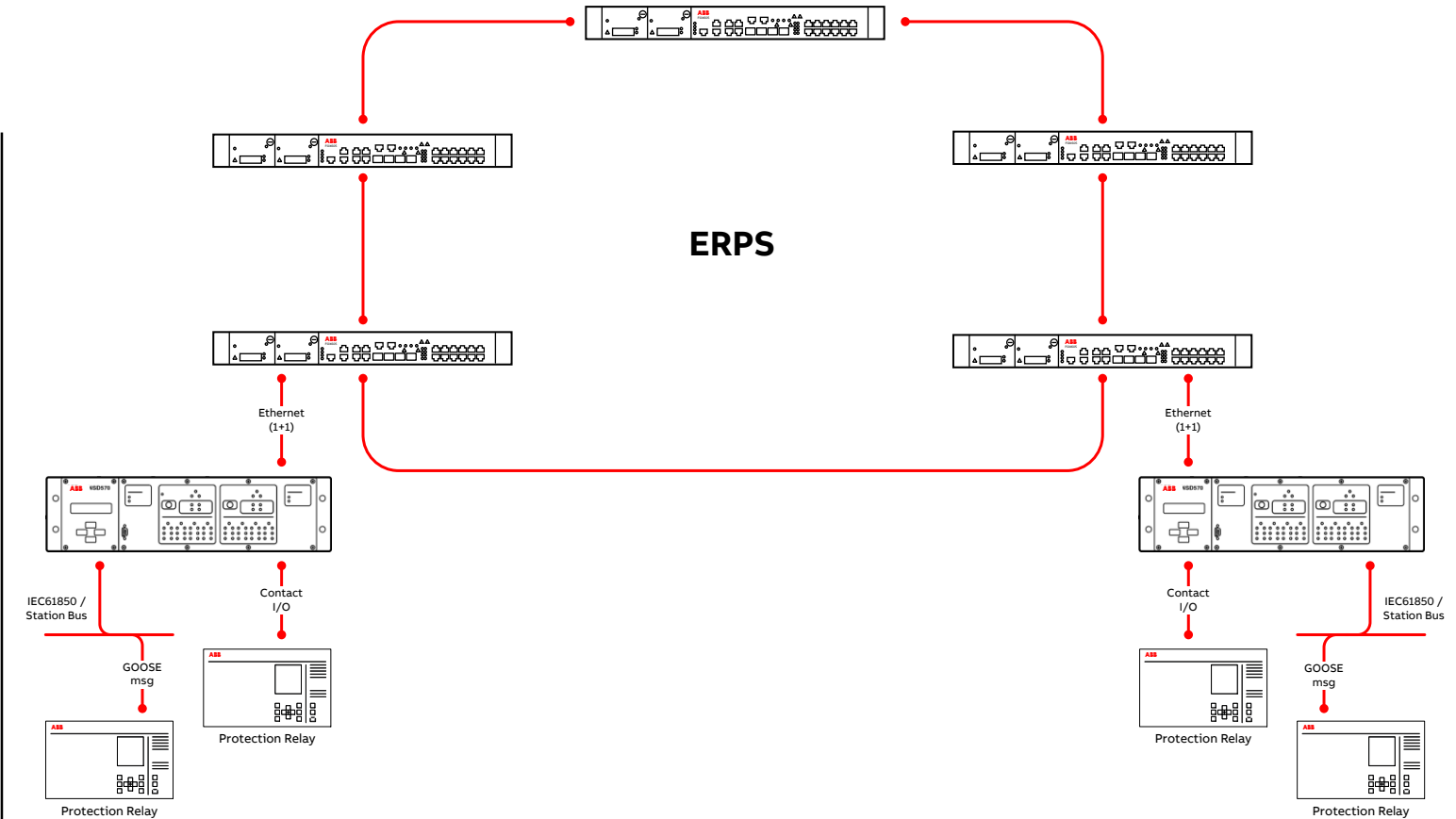


# Teleprotection with FOX605

## Solution with NSD570

### Technical Details

- NSD570 equipped with Ethernet Line Interface (G3LE) and connected to FOX605
- GOOSE (IEC 61850) and contact type commands can be signalled over NSD570
- Redundant Path Protection (1+1) can be provided on NSD570 (2x G3LE)
- FOX605 network also provides redundancy (ring topology) with fast and reliable switchover times (e.g. with ERPS)
- Appropriate network engineering/design is required in order to achieve reliable teleprotection performance (VLAN ID & priority setting, Quality of Service, fast protection scheme (such as ERPS), etc)

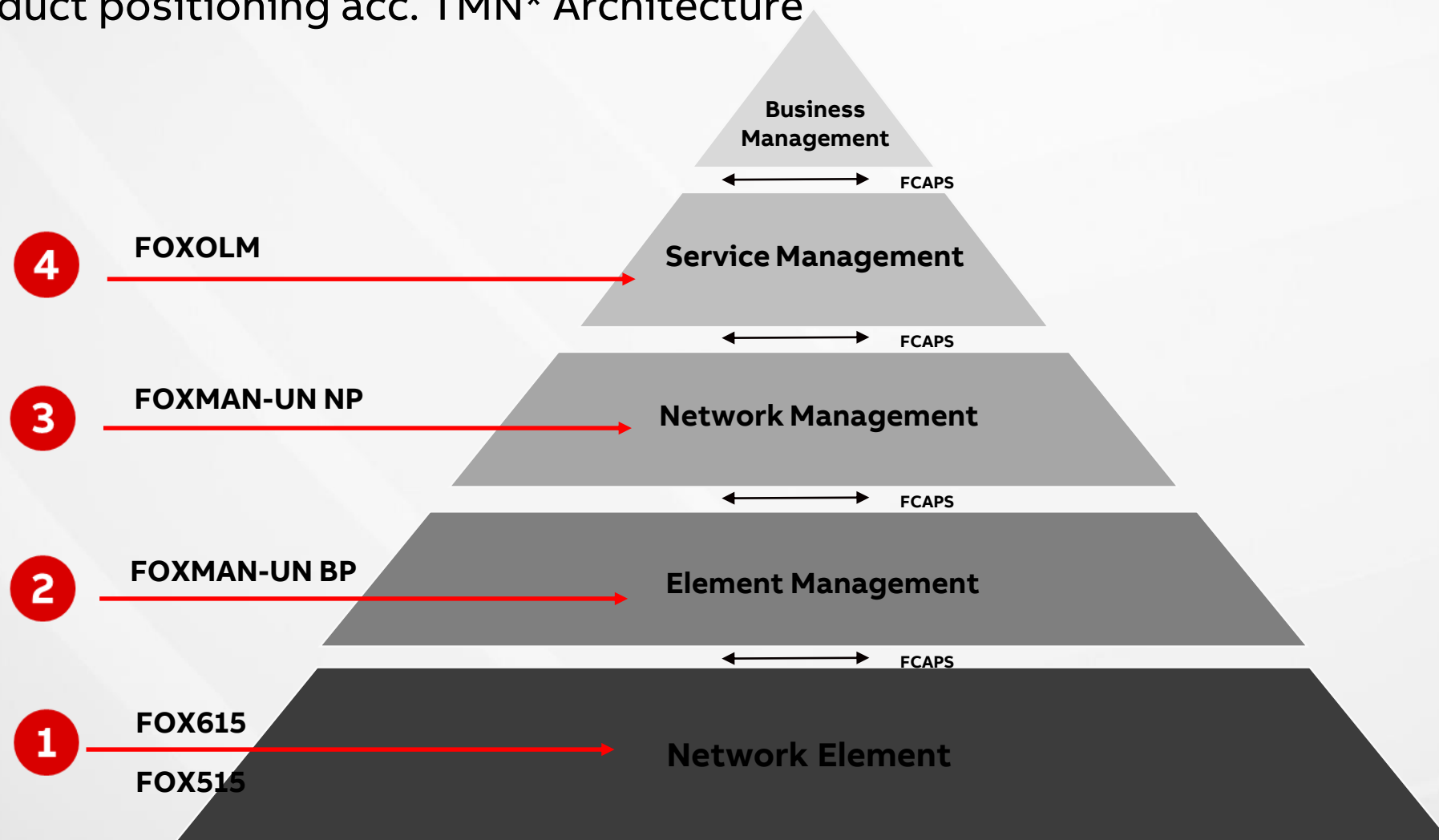


# — **FOXOLM – Overlay Management System**



# Network Management Systems

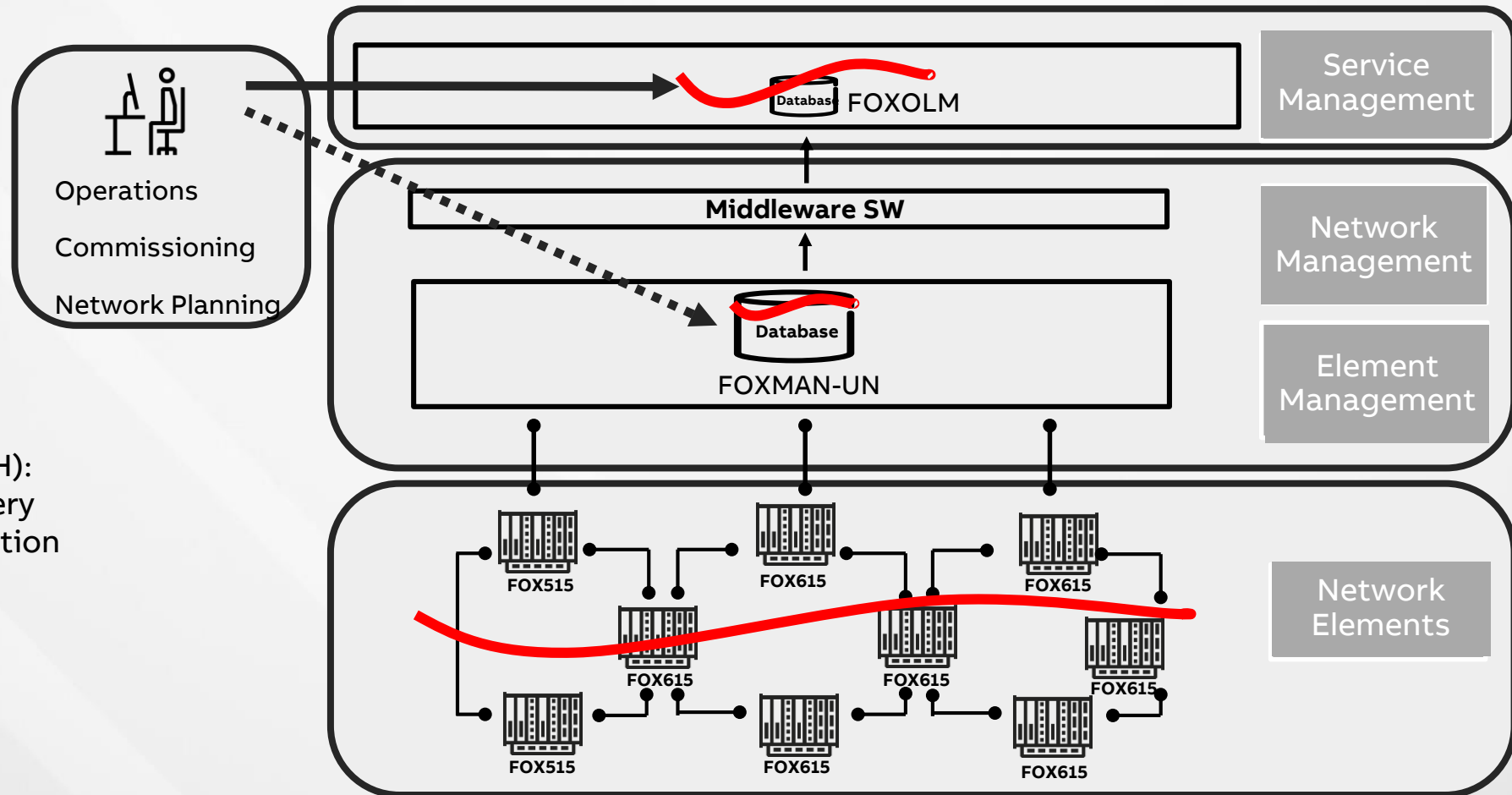
ABB Product positioning acc. TMN\* Architecture



- Based on the OSI management specifications in ITU-T Recommendation series X.700
- BP = Base package
- NP = Networking package

# FOXOLM – Use cases

Integration with FOXMAN-UN R9C & FOXMAN-UN R11A SP01\*



Main features (PDH/SDH):

- E2E Network Discovery
- Network Documentation
- Capacity & Inventory Analysis
- Network Analytics
- Network Planning

\*Release planned for H2 2018

# FOXOLM

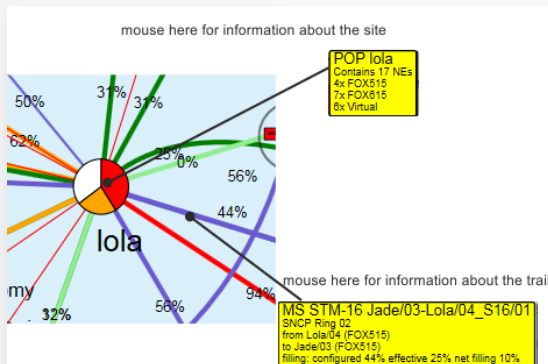
## Summary & benefits



### Network documentation

Increase in operational productivity and user experience

- Comprehensive view of multi-layer networks
- Accurate network documentation through automated data upload
- Reduce operational workload with recurring reporting tasks



### Inventory & capacity

Optimize network inventory and strategic plan capacity

- Efficient and accurate inventory of physical & logical resources including statistical utilization & reporting
- Easy detection of capacity bottlenecks and optimize areas of overcapacity
- Generate input for inventory and capacity utilization benchmarks



### Network analytics

Pro-active risk assessment against misconfiguration

- Ensure main & backup path diversity through route protection analysis
- Eliminate service downtime in event of equipment unavailability and infrastructure
- Eliminates financial loss due to planned outages

Details for NE WATANI 132kV\_FOX515H\_1

NE type: FOX515H  
Resource Status: Planning (Planned)  
Site: WATANI 132KV (Site)  
Manufacturer: Unknown

Shelf	Card	Port	Port Type	Port Name	Port Description	Port Status
01	Card	Port	Port Type	Port Name	Port Description	Port Status
02	Card	Port	Port Type	Port Name	Port Description	Port Status
03	Card	Port	Port Type	Port Name	Port Description	Port Status
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100	Card	Port	Port Type	Port Name	Port Description	Port Status

### Network planning

Detail planning & traceability for network deployments

- Optimize resource availability & capacity for network extensions
- Document & plan new physical and logical resources interconnections and services
- Automatic reconciliation between planned resources versus discovered resources

**ABB**