Thursday, 14 December 2023

Technical Day- Telecom
AP Transco-Vijayawada

Venu Gopal
Rajesh Verma

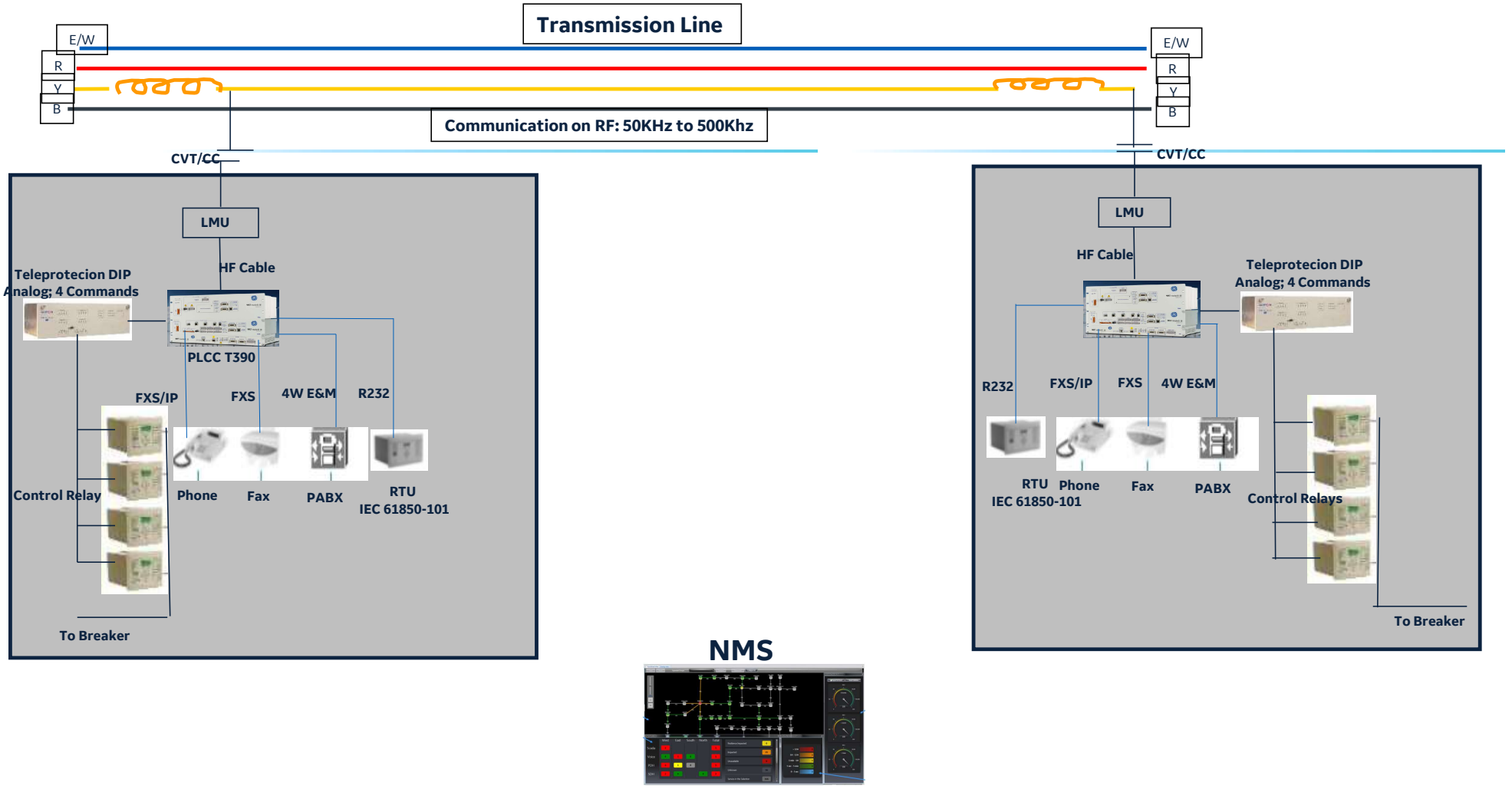
Agenda

1. Introduction

Thursday, 14 December 2023

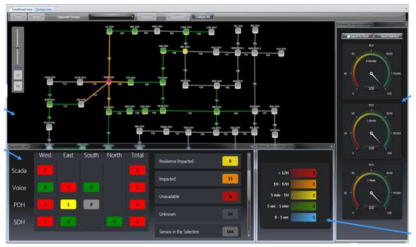
2. Migration of CommunicationTechnology
3. Fundamentals of Protection system
4. Digital & Analog Protection Couplers
5. Next Generation Protection Couplers

PLCC Communication System



NMS

Optical Fiber Communication System



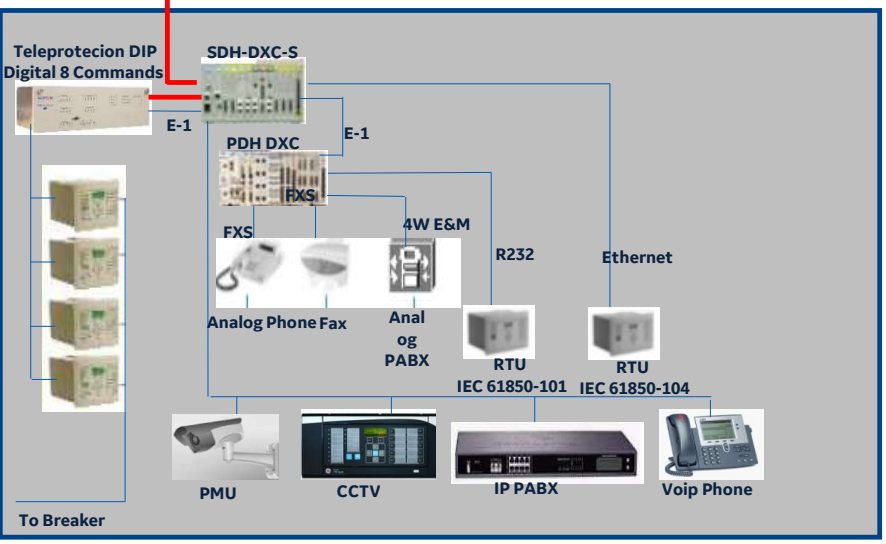
Centralized NMS(Inms+ Sentinel

Transmission Line

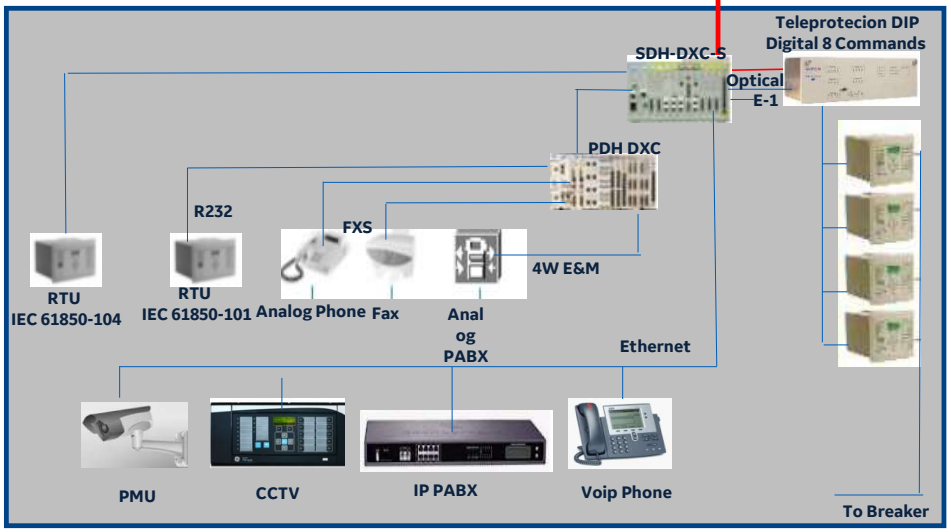
E/W
R
Y
B

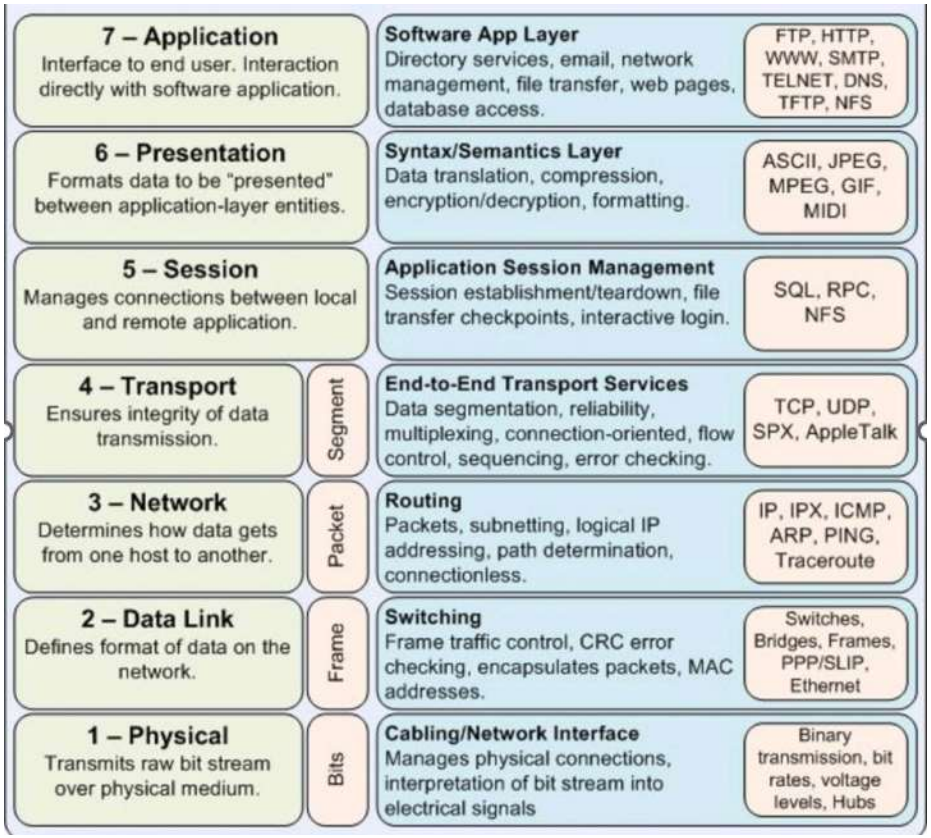
Communication medium: Optical

OPGW

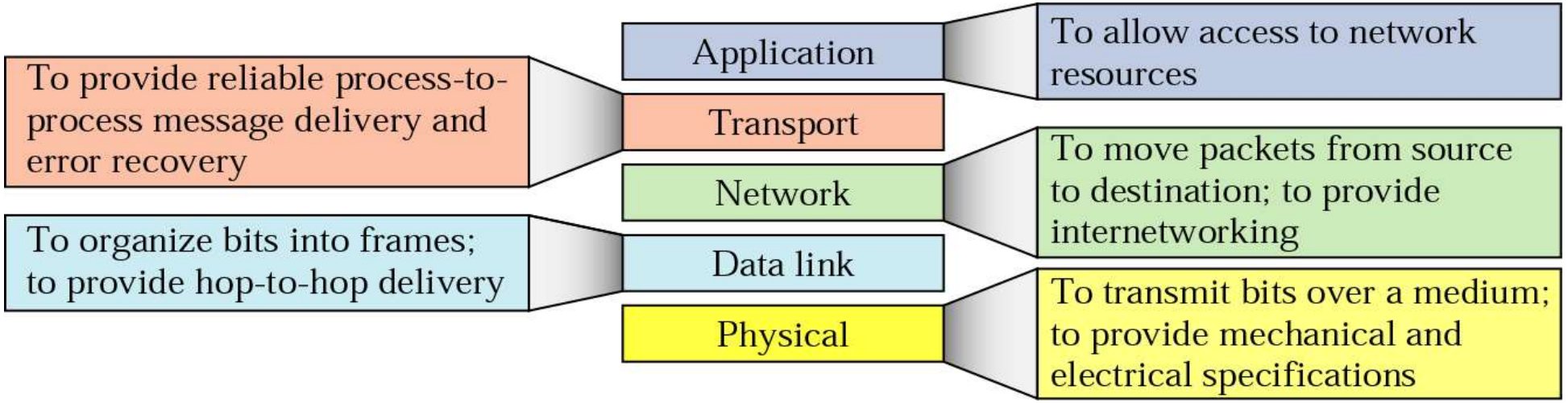


OPGW

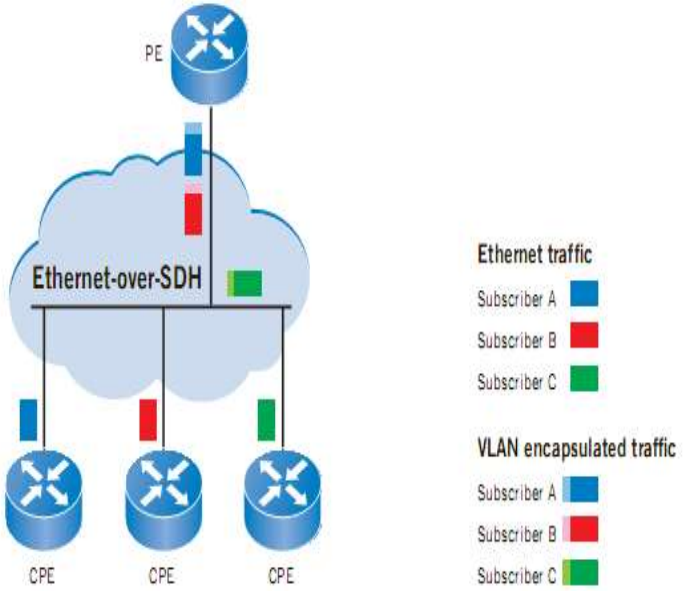


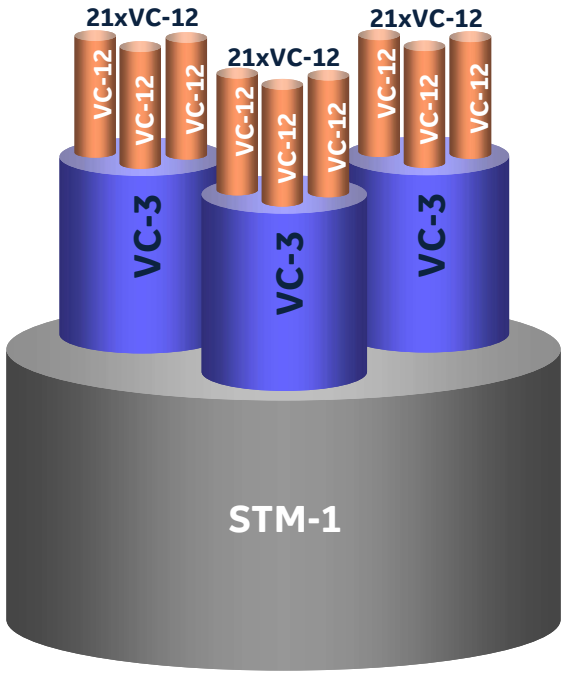


Summary of duties



Digital Communication Technology Basics
EOS(Ethernet Services over SDH)

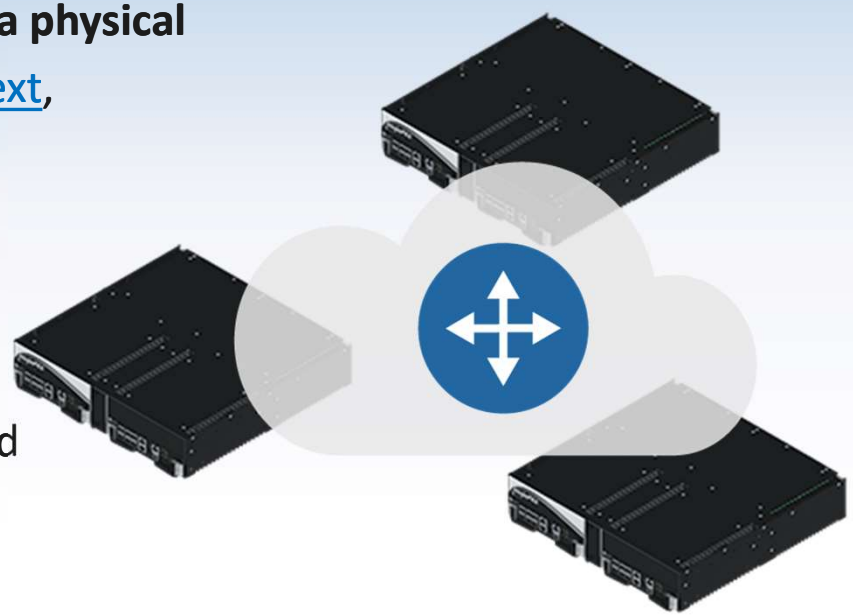




- Ethernet frames (GFP) or TDM circuits can be mapped inside a Virtual Container (VC) for transport across an SDH network
- Each VC can be used to deliver a separate Ethernet or TDM service
- VCAT allows multiple VCs to be bundled together in a logical group for higher bandwidth services
- This allows granular provisioning of services in one VC increments
- Low order VCAT provides VC-12 (2Mbps) level granularity
- LCAS enables dynamic bandwidth provisioning by adding/subtracting VCs in a logical VC group (VCG)

What is MPLS?

Multi-protocol label switching (MPLS) is a collection of standards that define a methodology for **forwarding information across a physical network** so that each application is separated from the next, seeing itself as the sole occupant of that network



Simplifies ‘the network’ to

- A collection of “virtual” switches and routers presented on a “real” Layer 3 architecture

What is MPLS-TP?

MPLS-TP is a connection-oriented, deterministic twist on IP/MPLS

Defined to provide more robust deterministic and measurable management and monitoring of label-switched packet networks

Mpls-Tp

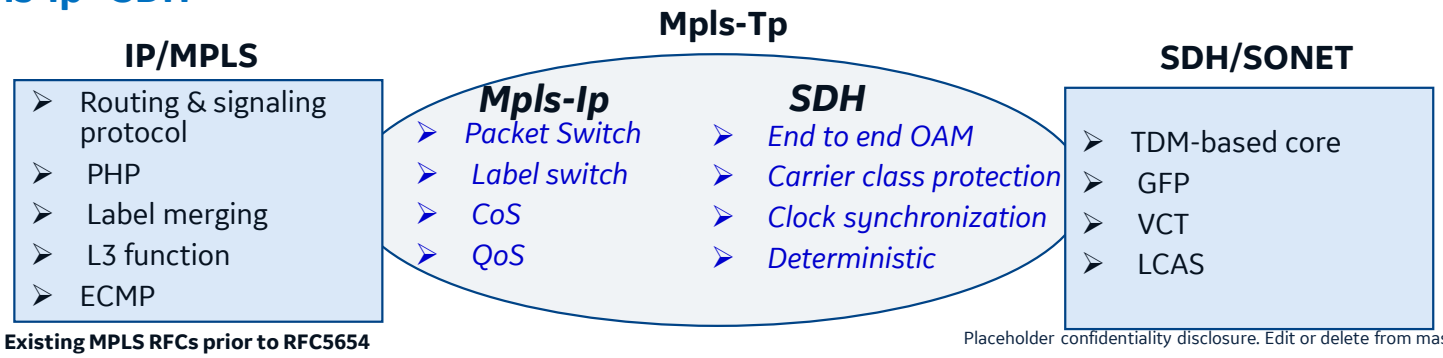
Objectives from RFC5654 and RFC5921

- Enabling MPLS deployment in a transport network with ease of operations of existing transport technologies (SDH/SONET/OTN).
- Enablement of MPLS for supporting packet transport services with a similar level of availability, reliability and OAM as in existing transport networks

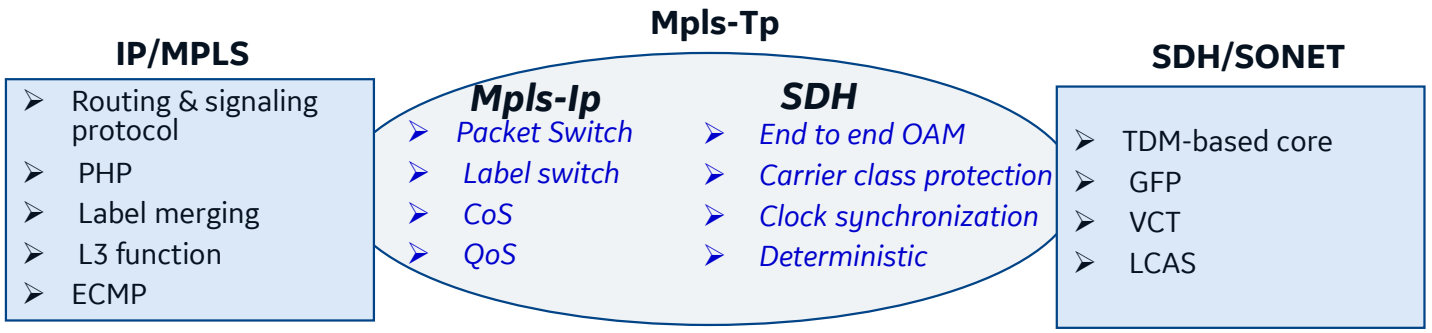
Essential Features(IETF &ITU-T)

- MPLS forwarding plane with restrictions
- No Control Plane only Processing plane through NMS
- Switchover time < 50 msec
- PWE3 Pseudo wire architecture
- Enhanced OAM functionality
- OAM monitors and drives protection switching
- Use of Generic Associated Channel (G-ACh) to support fault, configuration, accounting, performance, and security (FCAPS) functions

Mpls-Tp: Mpls-Ip+ SDH

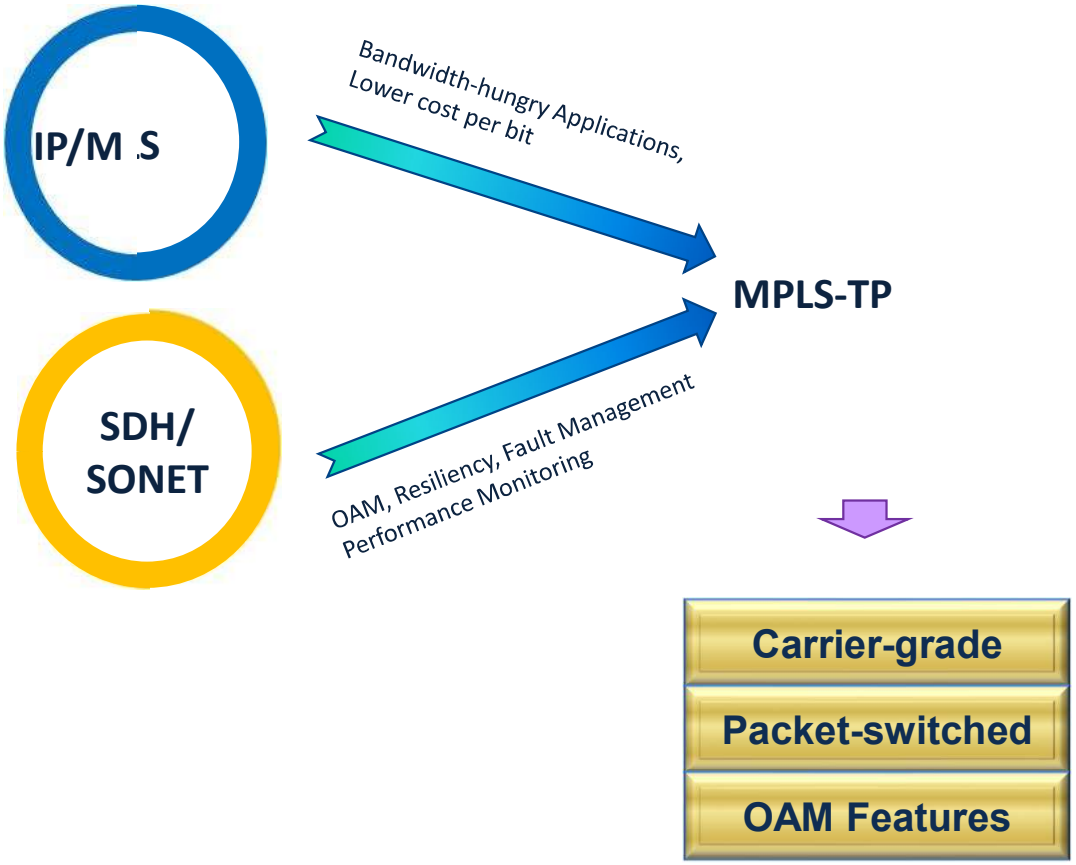


Mpls-Tp Evolution



- Security & Reliability for Teleprotection is similar to SDH
- OAM is exactly similar to SDH
- Network Switching is sub 50 msec
- Latency is sub 10 msec
- Network Topology is similar
- Both use dedicated circuits
- Mpls-Tp have higher bandwidth
- Mpls-Tp supports transport on ethernet over optical fiber supporting legacy interfaces STM-1/4/16, RS 232, FXS,FXO,E&M, C34.94, E-1)

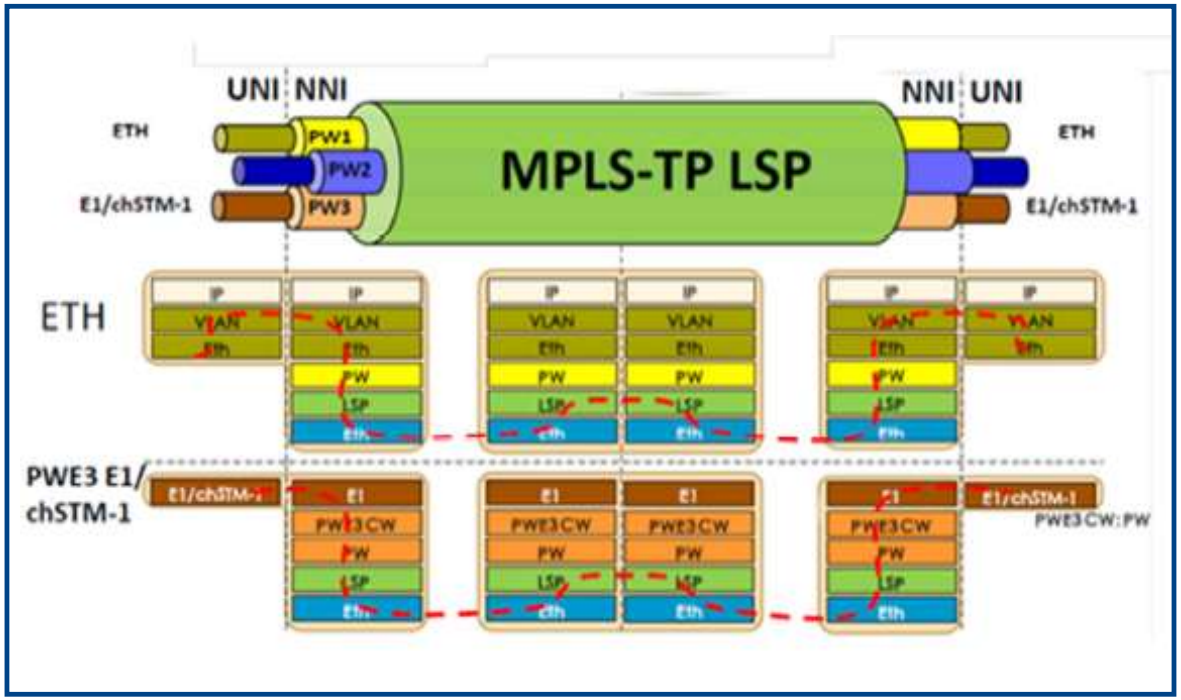
MPLS-TP for Transport Network



Mpls-Tp

MPLS-TP provides a Carrier-Class network stability by eliminating dynamic network factors inside the network. Possible to manage easily and intuitively

Mpls-Tp: Services



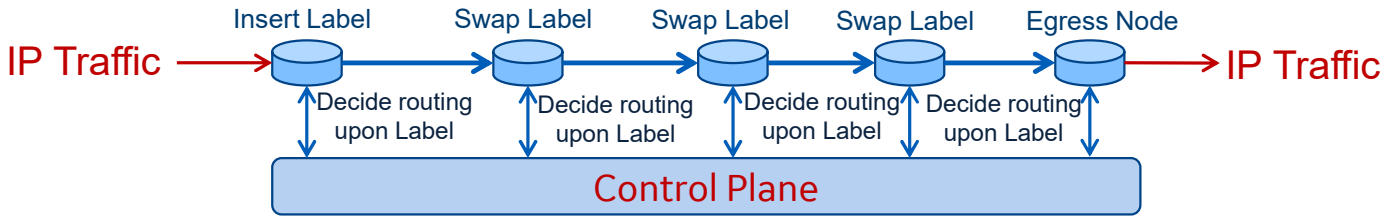
Mpls-Tp: Features

- Mpls-Tp is simplified version of MPLS for transport networks
- Typical MPLS-Ip functions like Penultimate Hop Popping (PHP), Label-Switched Paths (LSPs) merge, and Equal Cost Multi Path (ECMP) are removed
- MPLS-TP does not require MPLS control plane capabilities
- Uses management plane to set up LSPs manually.
- OAM can operate without any IP layer functionalities.

Multi-Protocol Label Switching (MPLS-Ip)

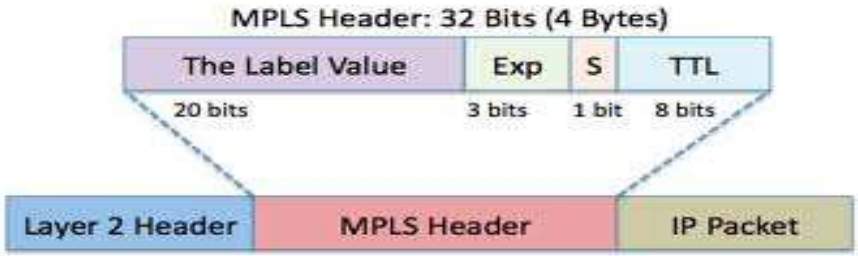
- MPLS allows **Connection-Oriented** operation for IP datagrams using a Unified Control Plane (Label Switched Path, LSP)
- Switching is based on a label, not on the datagram header
- **Unified Multi-service Networks** through L2 / L3 Virtual Private Networks
- Packet Routing decision are made at each node(PHP-Penultimate Hop Popping)
- Uses ECMP(Equal Cost multiple path) for data forwarding
- Diffserve for CoS
- Two planes Data plane & Distributed Control planes are used for traffic provisioning
- Provided same path for forward & return of traffic
- OAM
- Hop-by-hop (e.g. control plane based)
- Out-of-band OAM
- Allows to deploy **QoS** / **Traffic Engineering** (TE)
  - Mapping of Traffic demand (traffic matrix) onto a network topology and the ability to control traffic flows in the network.
  - Measurement, modeling, characterization and control of IP traffic for optimizing the performance of operational networks

Features of Mpls-Ip highlighted in Red are limitation for Transport level



Multi-Protocol Label Switching (MPLS) - Concept

Add Quality of Service and Routing Control to IP Networks



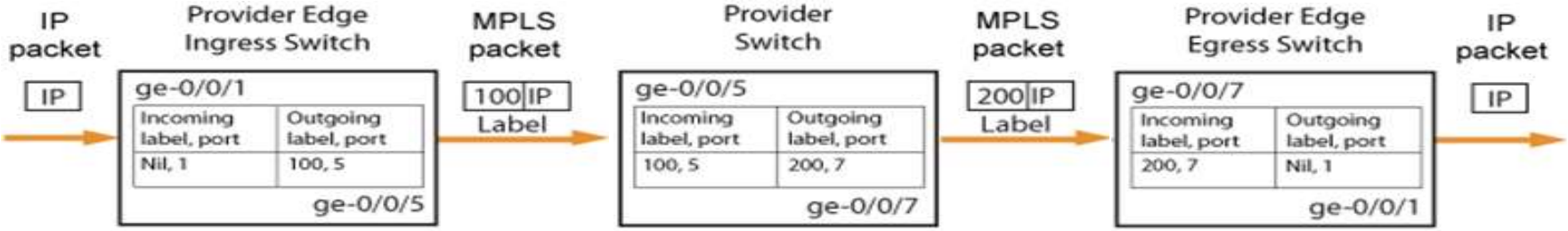
Exp: Experimental (QoS)

S: Stacking bit

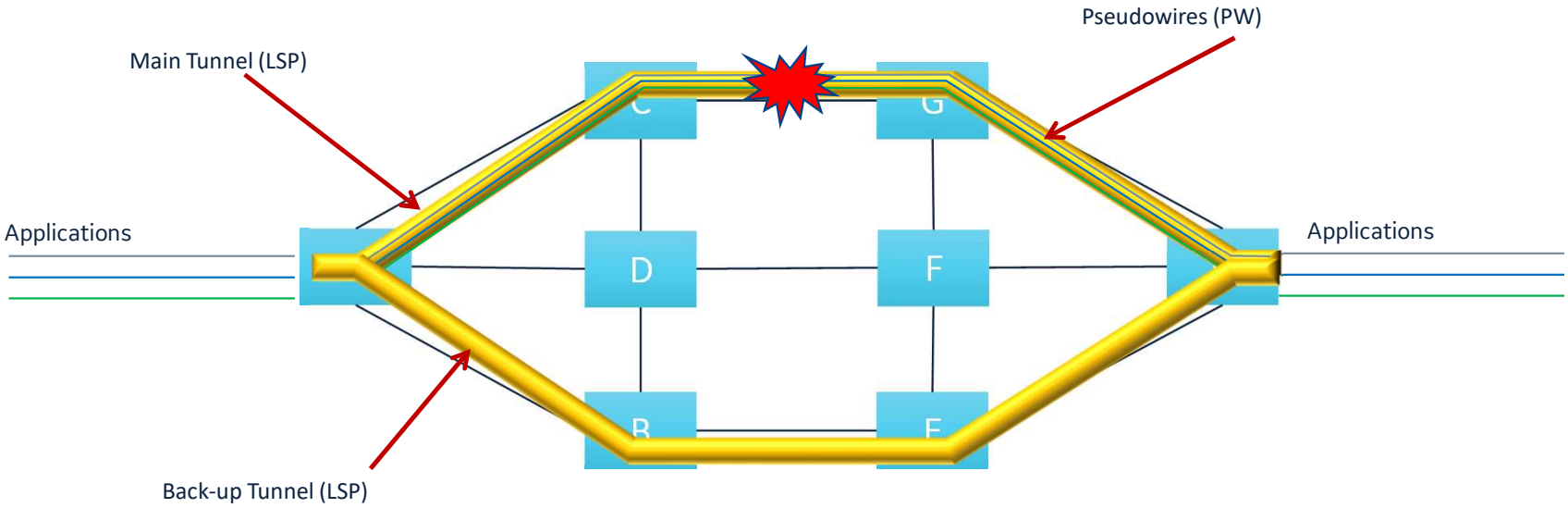
TTL: Time To Live

Forward traffic using labels:

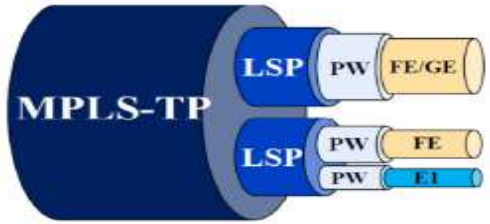
- Adds a Label to each IP packet at the ingress port (Forwarding Equivalence Class) - **PUSH**
- Changes the Label at each node (Label swapping) – **SWAP**
- Remove the Label at egress port to deliver the packet to the end user – **POP**



MPLS-TP Tunnels, Pseudowires and protection



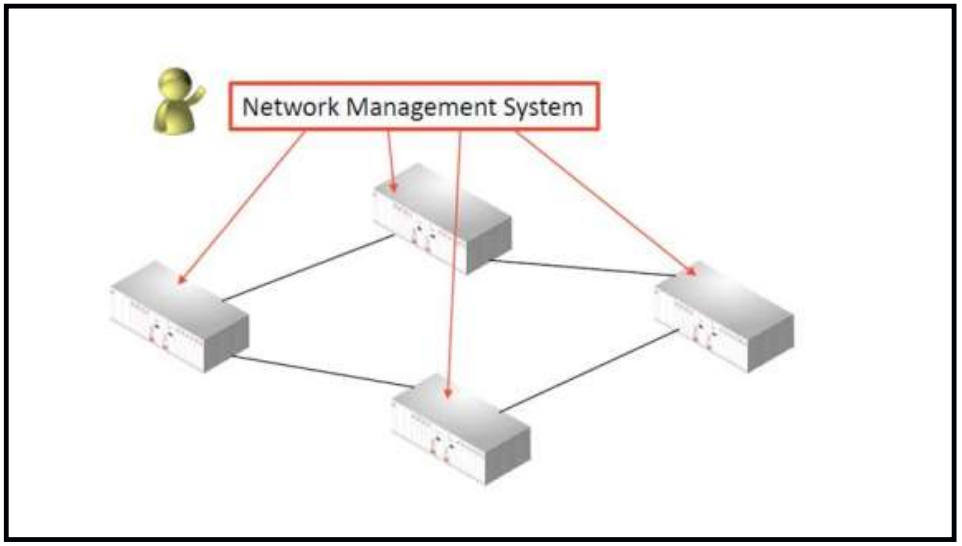
- Linear 1:1, 1+1 linear protection
- Mesh and ring protection
- Trigged by OAM: AIS, RDI…
- Circuit switching and restoration < 50ms
- Revert to working tunnel after fault clearing



Mpls-Tp

Static Configuration

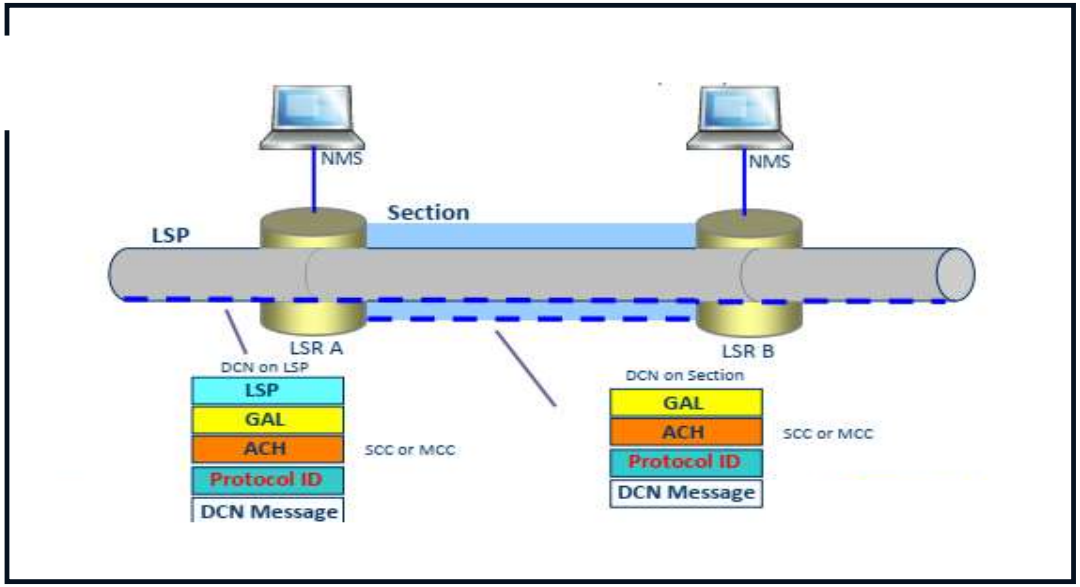
- Decisions are not taken by complicated protocols
- Operator is in full control
- No complexity
- Easy troubleshooting
- Data follow a predefined path



Feature not supported in of Mpls-Ip but Mandatory for Maintenance, trouble shooting of large Telecom

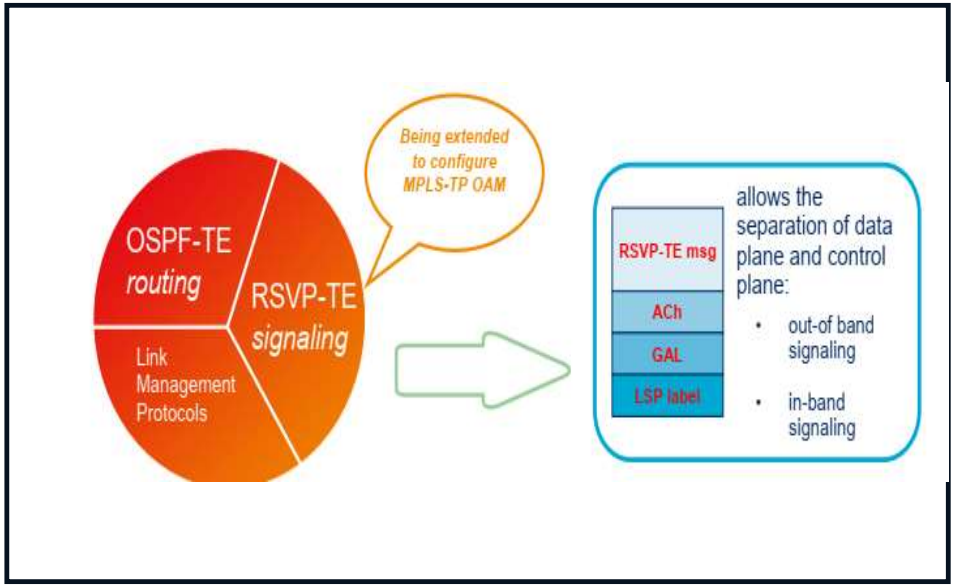
Mpls-Tp

DCN



Carries Management Communication Channel (MCC) or Signalling Communication Channel (SCC

GMPLS

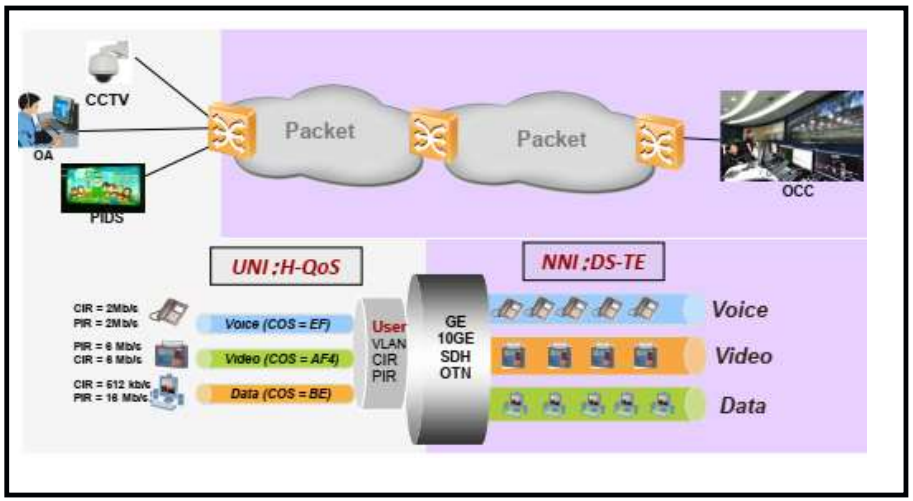


GMPLS is a unified, generalized distributed control plane used for multiple networking technologies and suitable or bidirectional paths

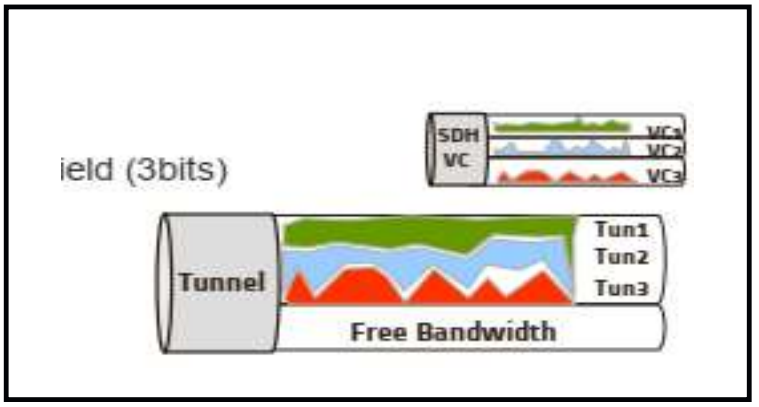
Feature not supported in of Mpls-Ip but Mandatory for Network Management ,Maintenance, trouble shooting of large Telecom

Mpls-Tp

QoS-Quality of Service & CoS- Class of Service



- MPLS-TP supports traffic Classification based on EXP field (3bits)
- Compatible with MPLS QoS,
- Policing and shaping support
- Traffic queuing based on Class of service
- SLA measurement can be performed using Performance Monitoring



SLA not supported in Mpls-Ip

Mpls-Tp

- **Operation**
  - Data plane / control plane independent
  - Operation through NMS
  - Static provisioning
  - Traffic Engineered Control
- **OAM**
  - In-band OAM channels
  - Generic Associated Channel (GACh) generalizes Pseudo wire ACh to also enable OAM on MPLS LSPs & Section Performance monitoring for SLA verification
  - Common tools at PW, LSP and Section level Sub-Path monitoring with multi-level operation
  - Alarms and AIS
- **Resilience**
  - Linear & Ring Protection
  - Sub 50 Msec protection switching

The Capabilities are not supported in Mpls-Ip

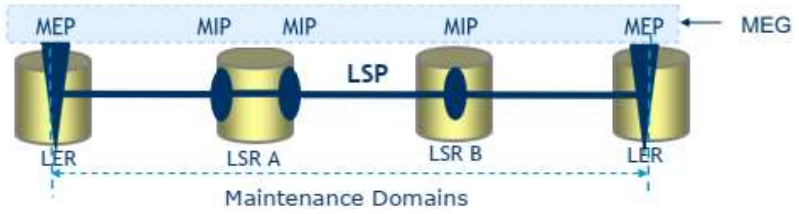
- **OAM(Requirements RFC 5860)**
- **Pro-active monitoring features**
  - Continuity supervision (Integrity)
  - Connectivity supervision
  - Signal quality supervision (packet loss)
  - Alarm suppression (Silencing)
  - Single-ended maintenance
- **Pro-active monitoring applications**
  - Fault management
  - Performance monitoring
  - Protection switching
- **Re-active/On-demand monitoring**
  - Fault localization
  - Signal quality measurement
  - Throughput
  - Ordering and error
  - Transfer delay and jitter
- **Communication channels**
  - Protection switching head/tail-end coordination
  - Network control and management
  - Remote node management
  - Service management

Mpls-Tp

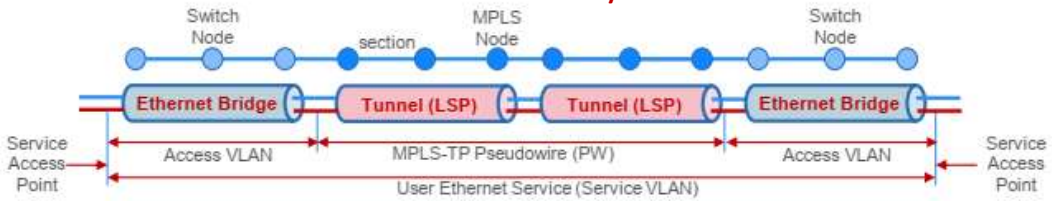
Different levels of OAM **are not supported in Mpls-Ip**

➢ Maintenance

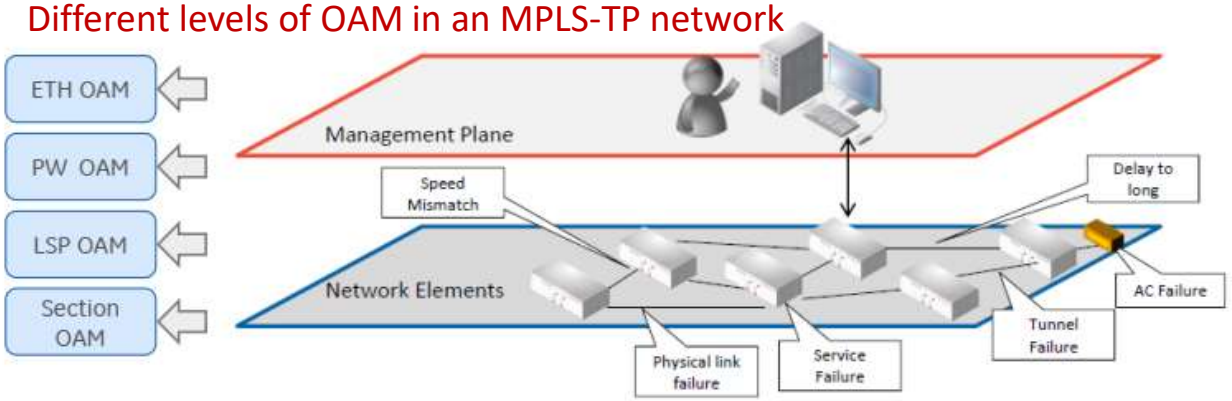
- MPLS-TP uses concept of Maintenance Domains being managed/monitored
- Maintenance End Points (MEPs) are edges of a maintenance domain
- OAM of a maintenance domain must not leak beyond corresponding MEP
- Maintenance Intermediate Points (MIPS) are intermediate elements that can be monitored
- Maintenance Entity Groups (MEGs) comprise all the MEP and MIPs on a given maintenance domain for a pseudo w LSP, or section.



End-to-End Ethernet connectivity and services OAM

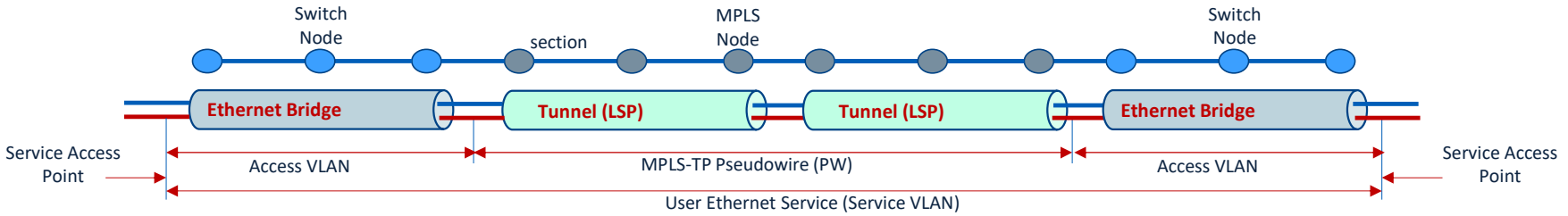


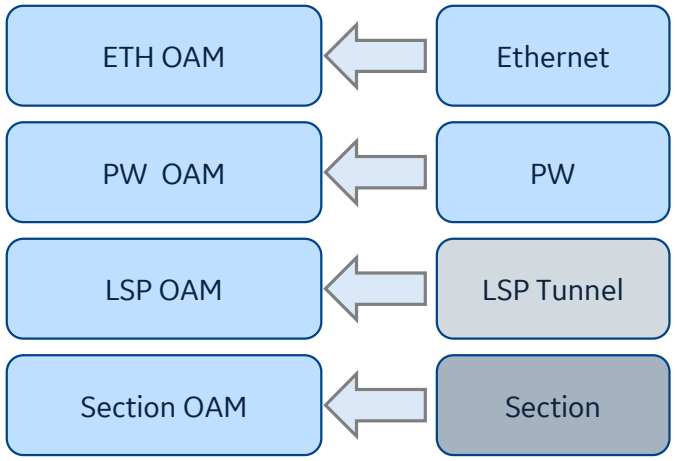
Different levels of OAM in an MPLS-TP network



MPLS-TP OAM functions: IEEE802.1ag / ITU-T Y1731

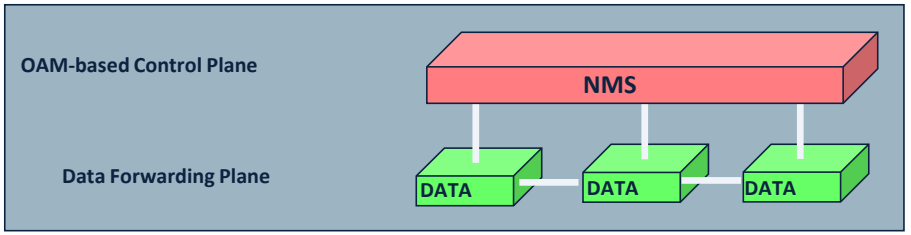
Service level OAM operating on end-to-end Ethernet connectivity and services





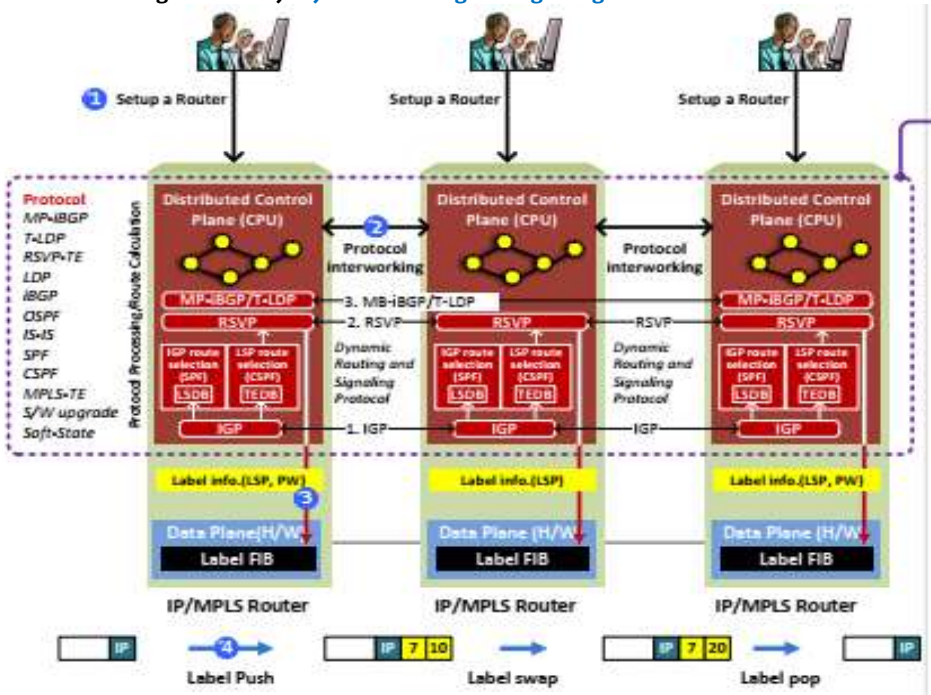
different levels of OAM in an MPLS-TP network

OAM-based control Plane

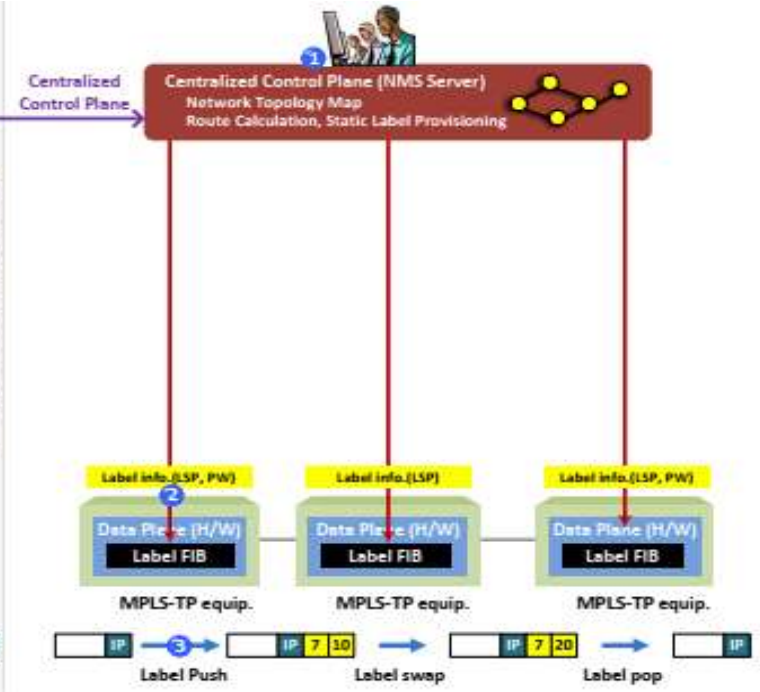


Mpls-Tp Vs Mpls-Ip
Design-Key Differentiator

Create Label Forwarding Table entry: Dynamic Routing and Signaling Protocol



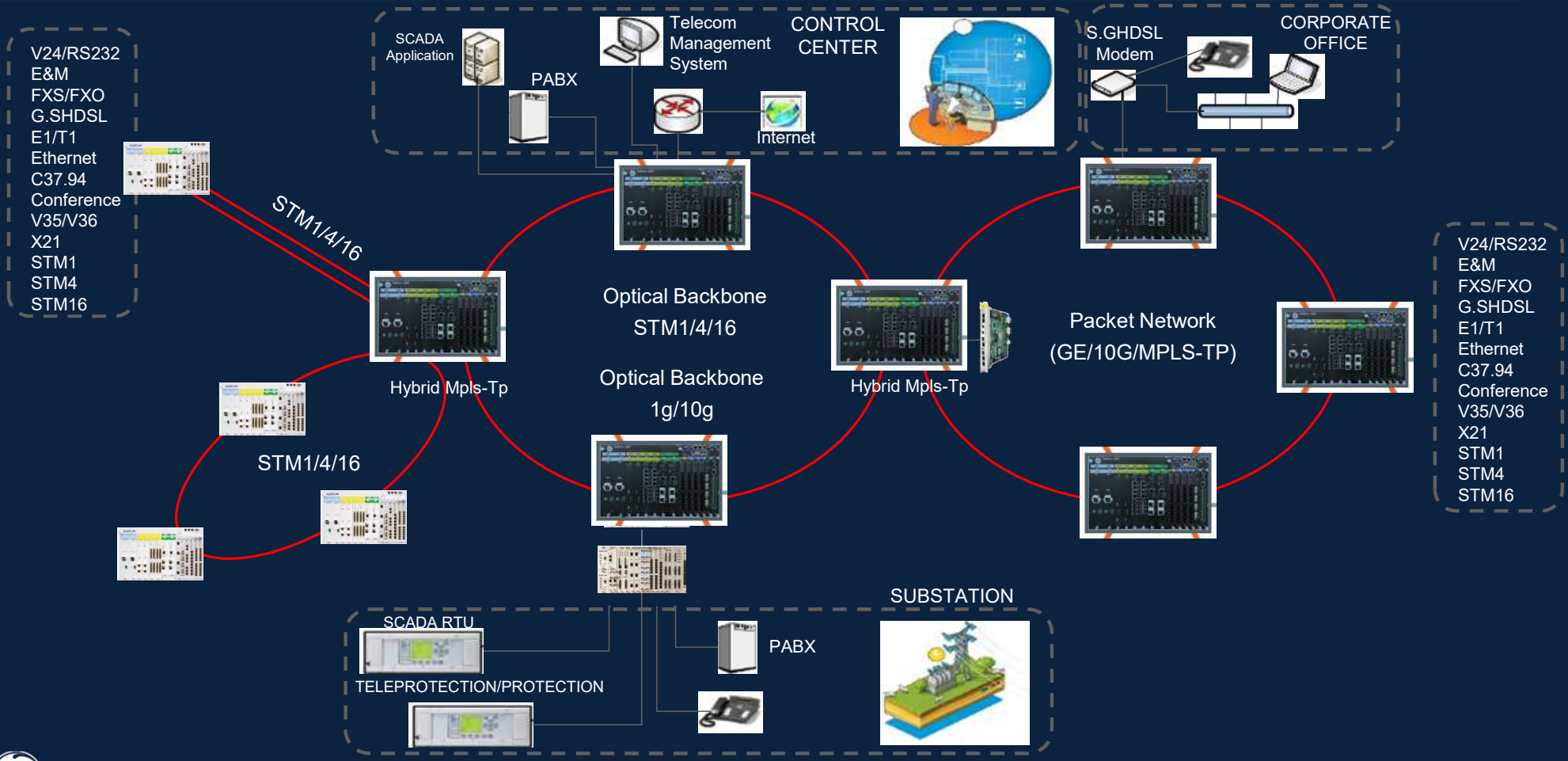
Create Label Forwarding Table entry: Static Provisioning



- Control Plane (IP Routing, RSVP Signaling, SPF, CSPF) inside Routers
- All of routers maintain and manage a network topology through the routing protocols
- Setup a path through RSVP signaling. Set MPLS-TE for path link and node protection
- Configure L3 (vs-lsp)/L2 VPN (pw) using MP-iBGP or T-LDP
- Data plane packet forwarding method: label pop/swap/push
- Potential instability due to the dynamic factors inside routers. High CPU load
- Cost increases in installation (price of system) and operation (labor, training, maintenance, S/W upgrade, power, rate of fault occurrence, etc.)

- Removed Control Plane (no IP routing, no RSVP signaling, no protocol processing)
- No control messages between MPLS-TP equipment's(centralized NMS used for managing a network topology information)
- NMS pre-provisions the primary and secondary path at all the MPLS-TP equipment's statically
- Data plane packet forwarding method: label pop/swap/push
- Provide carrier class-network stability by eliminating dynamic factors inside both network and equipment's
- Cost saving in installation and operation by removing control plane inside equipment

Network Migration



MPLS-TP Strengths Addressing Utility Requirements

MPLS-TP Features	Relevance For Power Utilities
• No control plane required	• Simplifies learning curve
• Fast convergence and no dependencies	• Extremely fast fault recovery
• Control and management planes physically separate from data plane	• Data flow unaffected
• Bidirectional (paths)	• Able to address symmetry
• Ring topologies supported	• Support for legacy topologies without need for complicated network engineering
• Connection-oriented	• End-to-end service guarantees

MPLS-TP Strengths Addressing Utility Requirements

MPLS-TP Features

- Monitor/measure many services or tunnels at same time
- Each OAM session is isolated
- Packets share same fate as existing tunnel or service traffic (in-band, fate-sharing)
- Provides diagnostic capabilities for services, tunnels, and segments of tunnels

Relevance For Power Utilities

- Scalable visibility into multi-service delivery
- Accurate per-service performance metrics
- Know exactly how each application is performing – no ‘estimates’
- Ability to diagnose the service, not just the link it rides on

Differences between IP/MPLS and MPLS-TP

IP/MPLS

- Dependent on interior gateway (routing) protocol - control plane dependency
- Unidirectional (paths)
- Ring support not mandated
- Connectionless
- Out-of-band OAM

MPLS-TP

- No control plane required
- Fast convergence, no dependencies
- Control and management planes physically separate from data plane
- Bidirectional (paths)
- Ring topologies supported
- Connection-oriented
- In-band OAM (fate sharing)
- MPLS-TP 1+1 and 1:1 protection in a ring MUST support switching time within 50ms from fault detection in networks with 16-node ring with <1,200 km of fiber

Mpls-Tp

- **Operation**
  - Data plane / control plane independent
  - Operation through NMS
  - Static provisioning
  - Traffic Engineered Control

- **OAM**
  - In-band OAM channels
  - Generic Associated Channel (GACh) generalizes Pseudo wire ACh to also enable OAM on MPLS LSPs & Section Performance monitoring for SLA verification
  - Common tools at PW, LSP and Section level Sub-Path monitoring with multi-level operation
  - Alarms and AIS

- **Resilience**
  - Linear & Ring Protection
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- **OAM(Requirements RFC 5860)**
- **Pro-active monitoring features**
  - Continuity supervision (Integrity)
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- **Communication channels**
  - Protection switching head/tail-end coordination
  - Network control and management
  - Remote node management
  - Service management

SDH Vs Mpls-Tp: 1/2

COMPARISON OF SDH Vs. MPLS-TP TECHNOLOGY			
S.No.	**Factors**	**SDH**	**Mpls-Tp(Hybrid) (Mpls-Tp with SDH Interfaces & OAM)**
1	Communication (TDM or Packet)	TDM	Packet
2	Application	Speech, Data(Telemtry, SAS, Phasors, SCADA, Surveillinece), Distance Teleprotection	Speech, Data(Telemtry, SAS, Phasors, SCADA, Surveillinece), Distance Teleprotection
3	Bandwidth Granularity (CBR or Burst Traffic)	Rigid(Good for CBR Not Good for Traffic burst)	Flexible (Statististical Multeplexing possible)
4	Bandwidth Efficiency	Fixed Rate Containers	Flexible (Any data rate is possible)
5	Protection Topology	1+1	1+1
6	Flexible Topologies	Flexible topologies (Ring, Linear, Tree, Mesh)	Flexible topologies (Ring, Linear, Tree, Mesh)
7	Ubiquitous Connectivity (How IIOT application or Distribution Co. reequirement can be met?)	IIOT applications: Available through EoS using TD circuits blocking complete channel	IIOT applications : Available through Ethhernet provisoning from 64 Kbps to any number of its multiples
8	Operational Simplicity (Hardware or software requirement for change in bandwidth requirement if any)	Change in bandwidth by change in baord/ SFP(STM-1/STM-4/STM-16/STM-64)	Change in bandwidth by change in board SFP(1g/10g/100g) and STM-1 to STM-16

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SDH Vs Mpls-Tp: 2/2

COMPARISON OF SDH Vs. MPLS-TP TECHNOLOGY			
9	No. of installation & availability spares for future 15 years	Spares becoming obselete & expenssive	Spares available
10	Dependency on OEM	High due to limieted spares	Less due to availability of spares and simplicity of operations and amangement like in SDH network
11	Class of Service (Fixed or Flexible/Multiple)	Only One class of service	Differential class of service Traffic queuing based on Class of service
12	Quality of Service (BER or Packet Loss)	Determined by BER	Detrmined by packet loss
13	Resilience (Teleprotection switching in large network, limit of of nodes is required)	Sub 50 Msec(35-38 msec) protection switching	Sub 50 Msec(35-38 msec) protection switching
14	OAM	In band OAM Channels	In band OAM Channels
15	Latency(ms) wrt Frame Length(Byte) Criteria< 10 msec ITU-TG.114: 400 msec for network	0.06 msec	0.02
16	Frame Loss(Mbps) wrt Frame Length(Byte) Criteria: 0-30% ITU-TG.1050	0	0

Mpls-Ip Mpls-Tp: 1/2

Mpls-Ip Challenges & Limitataions Key considerations for Power Tranmisison Utilities			
Sno	**Function**	**Mpls-Tp**	**Mpls-Ip**
1	Architecture	Single processing platform for services encapsulation and traffic forwarding Services encasulation is done only at ingress(Beginning) equipment and decasulated at egress point(end) equipment. Traffic flows transparently between intermeddiate stations	Two diffrenet platforms for Processing 1.Distributed Control Plane-CPU for services encapsulation 2. Data plane traffic forwarding Complete traffic flows through both CPU & Data plane at all nodes in link. This adds to latency and switching time delays in addition use of IP L-3 complex protocols for decion making at each node(equipment)
2	Determinist circuits	Supported using static provisioning of LSP & PW via NMS (SDH-like). Dynamic Provisoning also supported	Dynamic provisioning
3	Bi-directional path	Supported: ingress and egress LSP are setup in the same time and through the same route	Ingress and egress LSP are provisioned separately and its route may be different. Complex TE function are required keep both on the same LSP
4	QOS	Is implicit(dedicated) and simple to implement Each traffic flow is given a PIR (Peak Information Rate) and can be given a CIR (Committed Information Rate). The network guarantees throughput for critical data streams	Is not implicit Must implement Traffic Engineering (TE) and RSVP (Resource Reservation Protocol) which is very complex and requires prior knowledge of traffic characteristics
5	COS	Pre defined for complete path	Uses Diffserve(Decions is made at each node)
6	Service protection	Linear protection: 1:1, 1+1, (SDH-like) Ring protection (SDH-like)	Additional feature is required like Fast Re-Route (FRR)
7	Control plane	Forwarding table is static with end-to-end alternative path (like SDH) under control of a central NMS – System engineering is similar to SDH (e.g. point and click).	Forwarding tables are established dynamically through the IP-based distributed control plane (each node swaps forwarding labels)
8	Service switching & restoration	< 50 ms (SDH-like)	>200ms Additional feature (FRR) is required for achieveing <50 ms

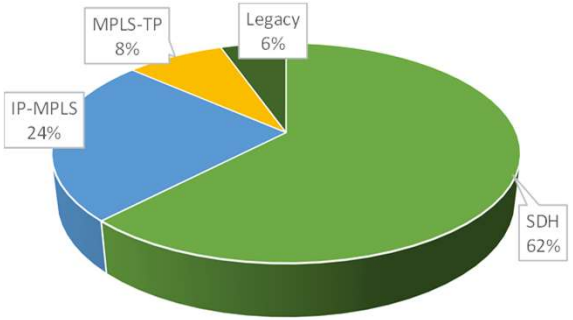
Mpls-Ip Mpls-Tp: 1/2

Mpls-Ip Challenges & Limitataions Key considerations for Power Tranmisison Utilities			
9	OAM - Fault Management	supported -> SDH-like: AIS (Alarm Indication signal), RDI (Remote Defect Indicator), LDI (Link Down Indication); CFI (Connectivity Fault Isolation)	Not supported
10	OAM - troubleshooting	LB (Loop Back), LI (Lock Instruct)**	Not Supported
11	OAM - Continuity check	CC, CV (Connectivity Verification)	LSP ping, BFD (Bidirectional Forward Detection)
12	OAM - Performance	LM (Loss Measurement), DM (Delay Measurement), Throughput Measurement , Delay Variation Measurement	Not supported
13	OAM - Inband	Supported through G-Ach & GAL (SDH-like)	Not supported
14	Processing consumption	Less: no complex process (only Control plane)	More: Complex process (Control plane & Data Plane)
15	Suitable skill	No requirement for IP expertise	High level of IP expertise is mandatory
16	OPEX in power utility	Less cost: Network troubleshooting and operational procedures are SDH-like,	More cost: Network troubleshooting is time consuming, it requires high expertise and staff training
17	Alarm monitoring	All alarms at (equipment & circuit levels) are monitored through NMS. Same like SDH	Equipment level alarms monitored. Circuit levels alarms Monitoring is challenge

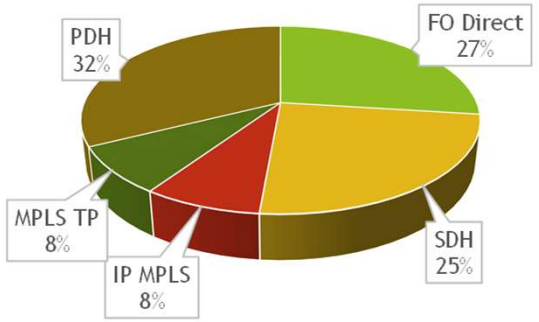
3
2

CIGRE's survey

Survey: State and Roadmap of Telecommunications Technologies in Electric Power Utilities (2020)
Published in Electra in 2021.



Technologies used to carry SCADA traffic



Technologies used to carry Differential Protection

Teleprotection - Introduction

- **What is it ?**
  -> ***Tele***-Communication + ***Protection*** - Signalling
- **Where is it used ?**
  -> Mainly at the higher and highest voltage levels
- **Why is it used ?**
  -> Clearance of faults within the shortest possible time

TPS Standards and Publications

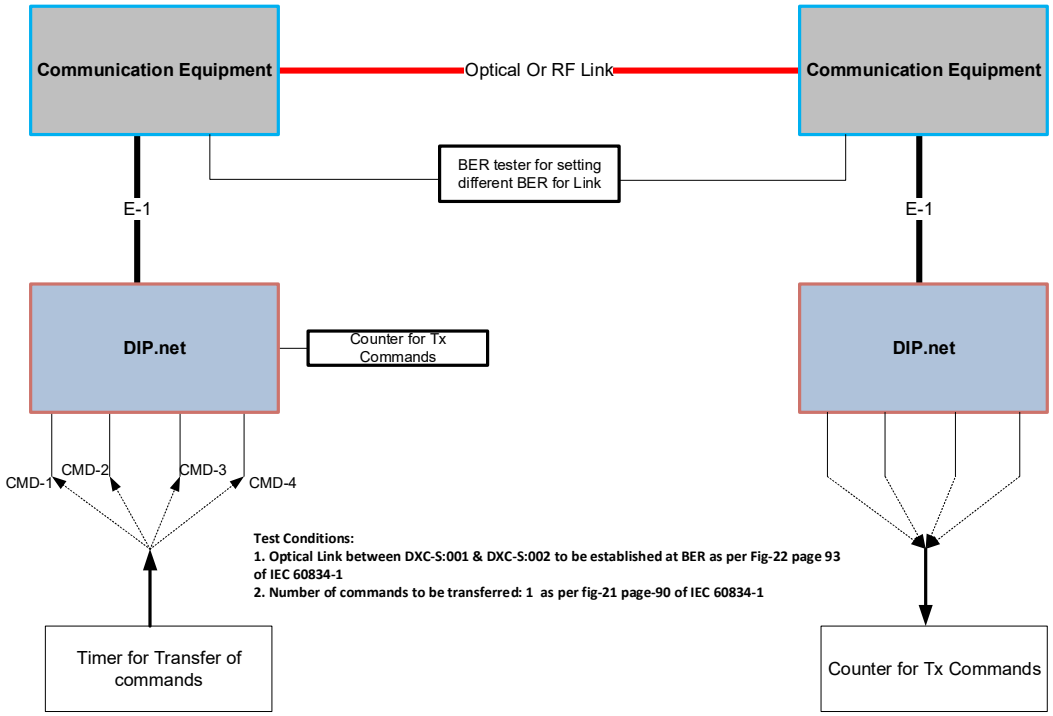
IEC standards:

IEC 60834-1	Teleprotection equipment of power systems - Performance and testing Part 1: Narrow-band systems (First edition, 1988) Part 1: Command systems (Second edition, 1999)
IEC 60834-2	Performance and testing of teleprotection equipment of power systems Part 2: Analogue comparison systems (First Edition 1993)

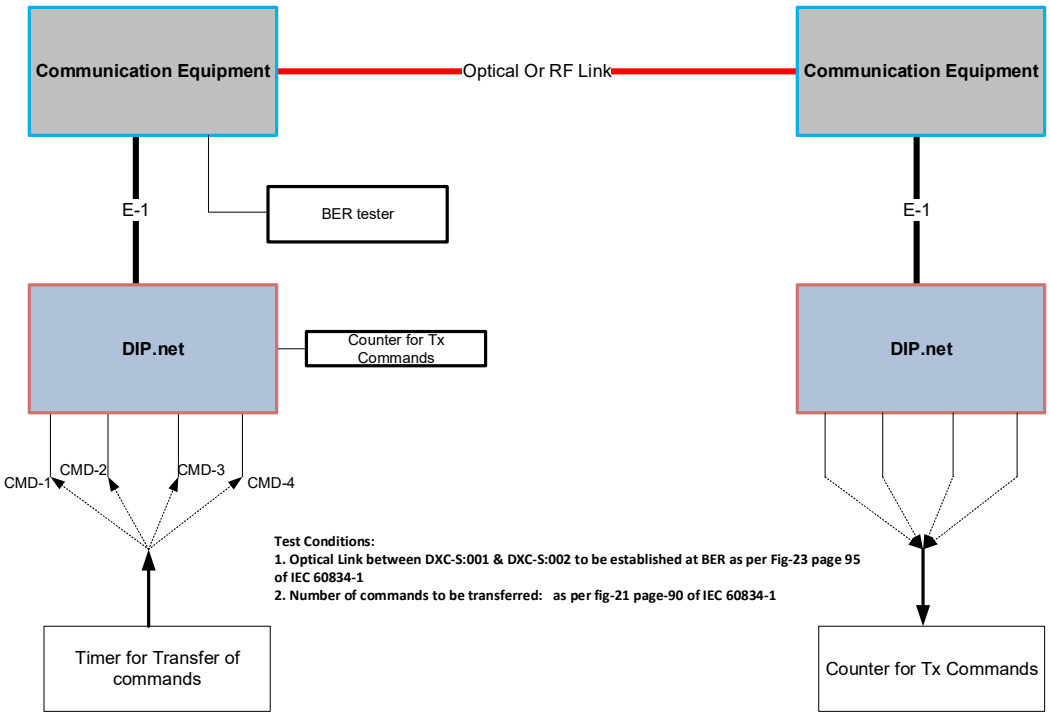
CIGRE publications:

"Teleprotection Guide", Study Committees 34 + 35, Joint Working Group on Teleprotection, 1969;
Revised Version "Protection Systems Using Telecommunication", 1985
Revised Version "Protection Using Telecommunications", 2000 (in preparation)

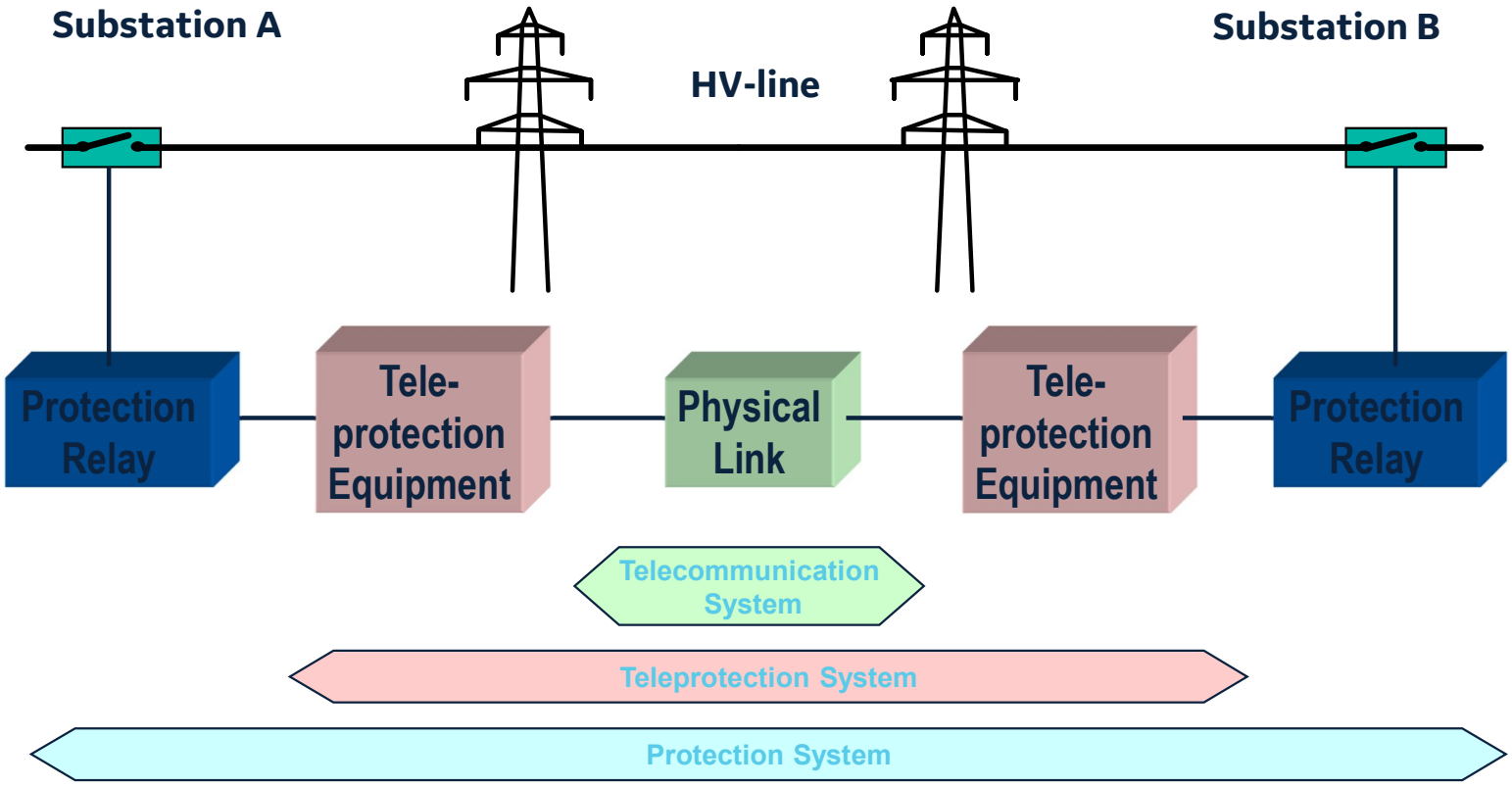
Test Set up for Integrated Security Test
Test Standard: IEC 60834-1 Ed-2,clause 4.3.1.1



Test Set up for Integrated Security Test DIP.net with DXC
Test Standard: IEC 60834-1 Ed-2,clause 4.3.1.1



Protection System Architecture

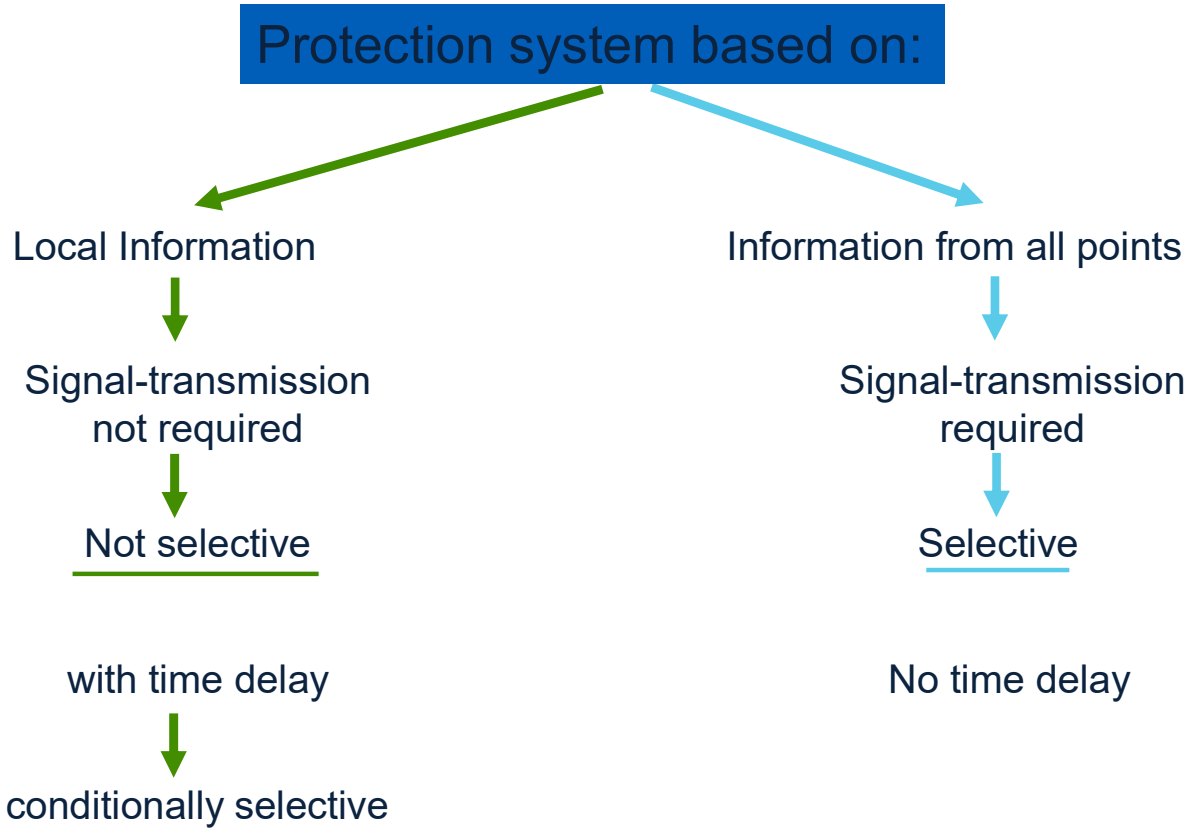


Protection Signal Transmission

Type of Information:

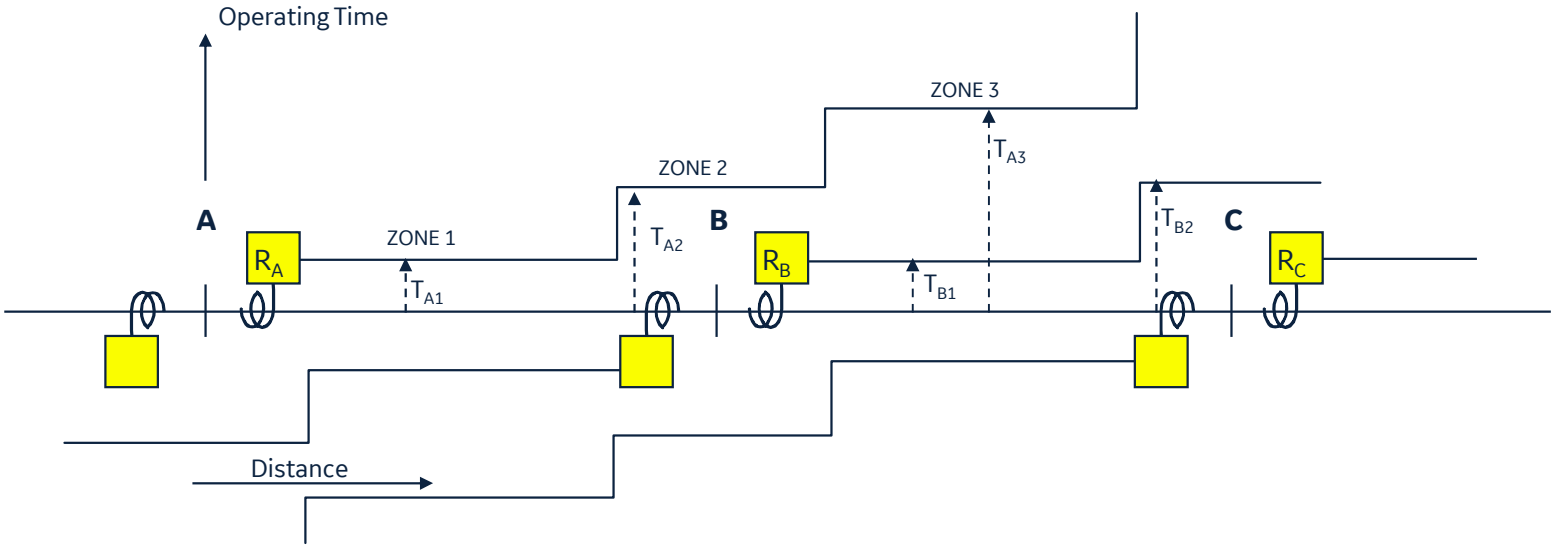
- Continuous signals
  - Magnitude and/or phase of power frequency currents
- Command type signals (on/off)
  - Trip / do not trip

Protection Systems



Distance Protection

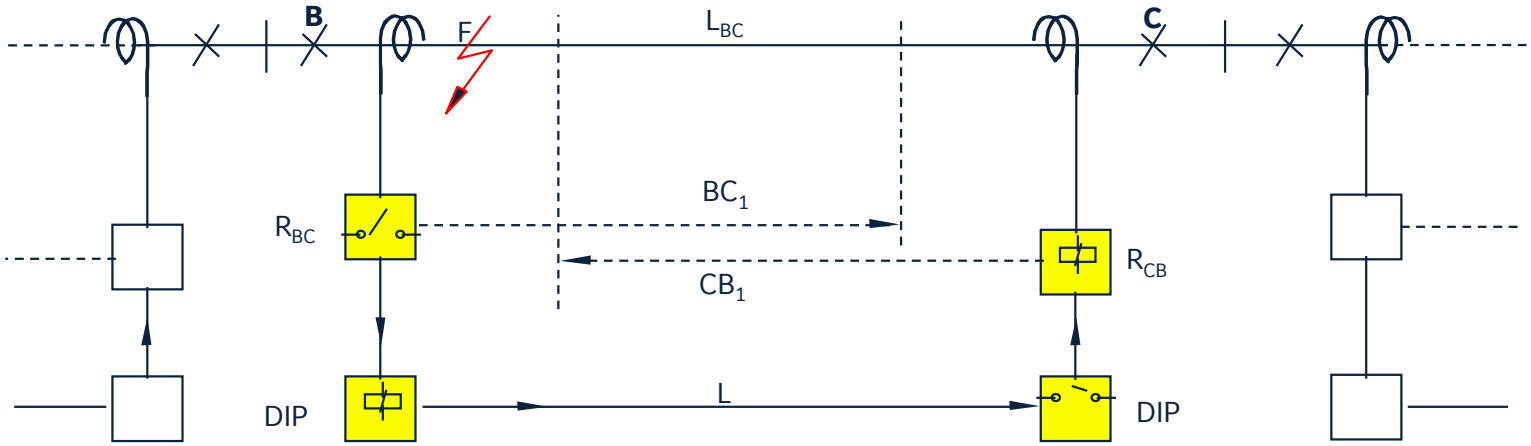
Typical stepped distance/time characteristics



A, B, C	Stations
R_A,R_B, R_C	Protection Relay
T_{A1}, T_{A2}, T_{A3}	Operating Times, Relay A
T_{B1}, T_{B2}, T_{B3}	Operating Times, Relay B

Distance Line Protection

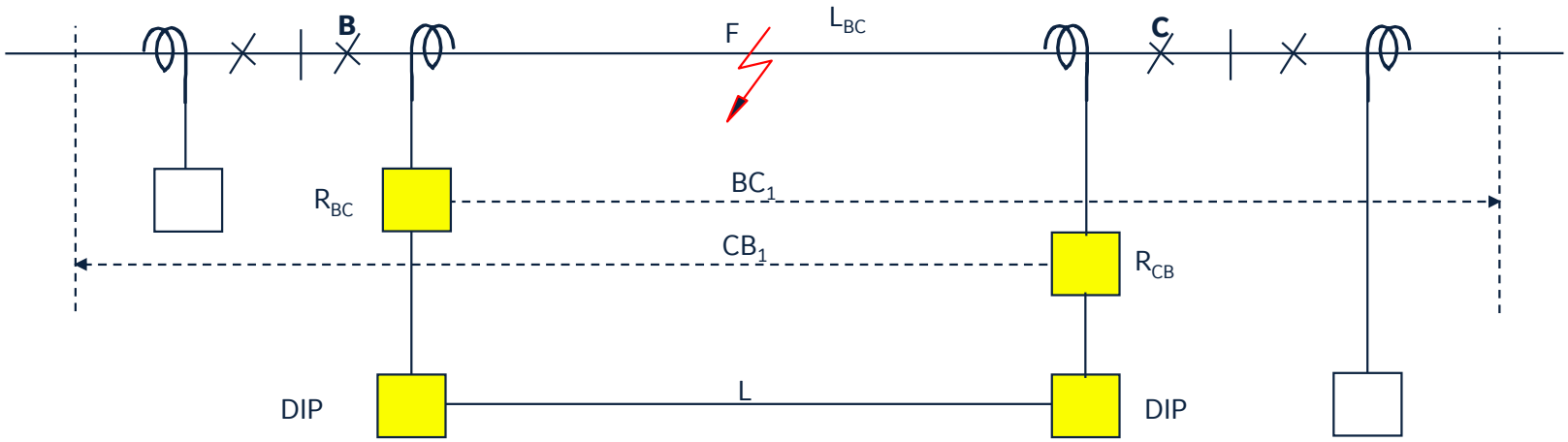
Permissive Underreach Transferred Tripping (PUTT)



B, C	Substations	F	Line fault
L_{BC}	Protected line section		
R_{BC},R_{CB}	Protection relay	L	Communication channel (PLC, Microwave, Cable)
BC_1, CB_1	Zone 1 reach, 85% of line section		

Distance Line Protection

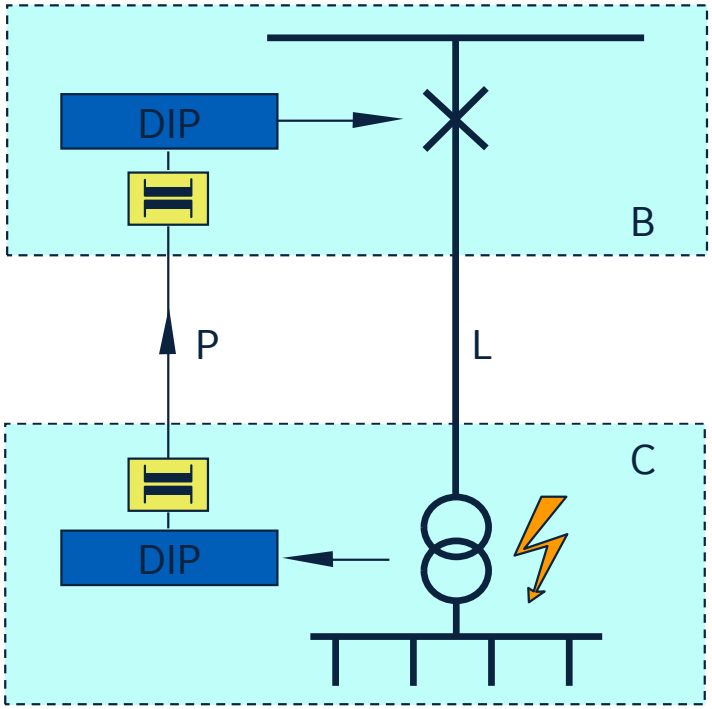
Permissive Overreach Transferred Tripping (POTT)



B, C	Substations	F	Line fault
L_{BC}	Protected line section		
R_{BC},R_{CB}	Protection relay	L	Communication channel (PLC, Microwave, Cable)
BC_1, CB_1	Zone 1 reach, 130% of line section		

Transformer Protection

Example for direct tripping

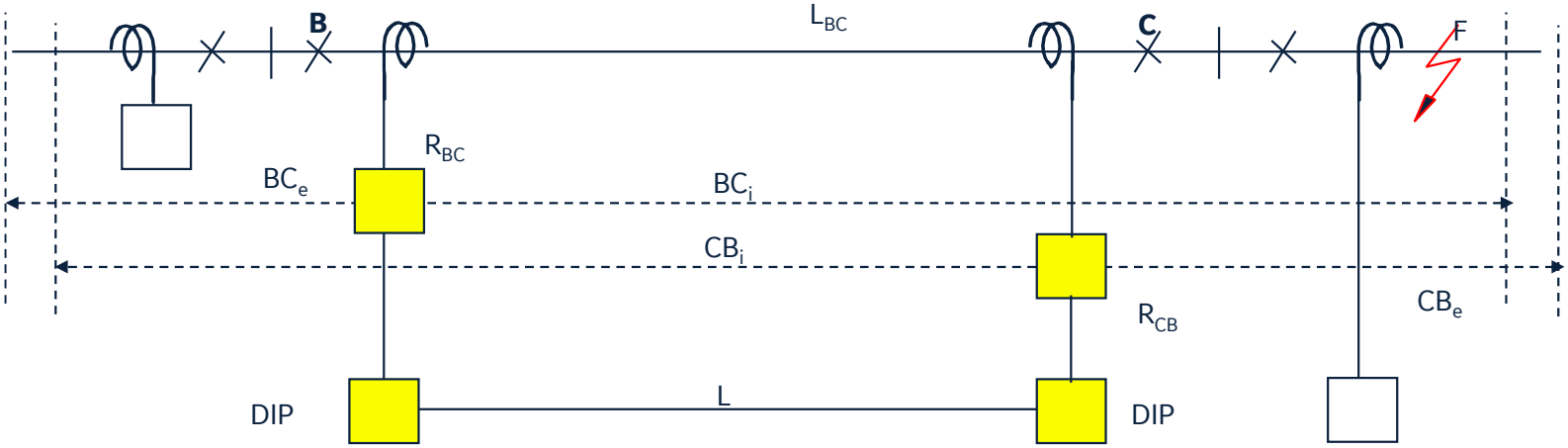


P **Pilot cable**

L **HV Transmission Line or -Cable**

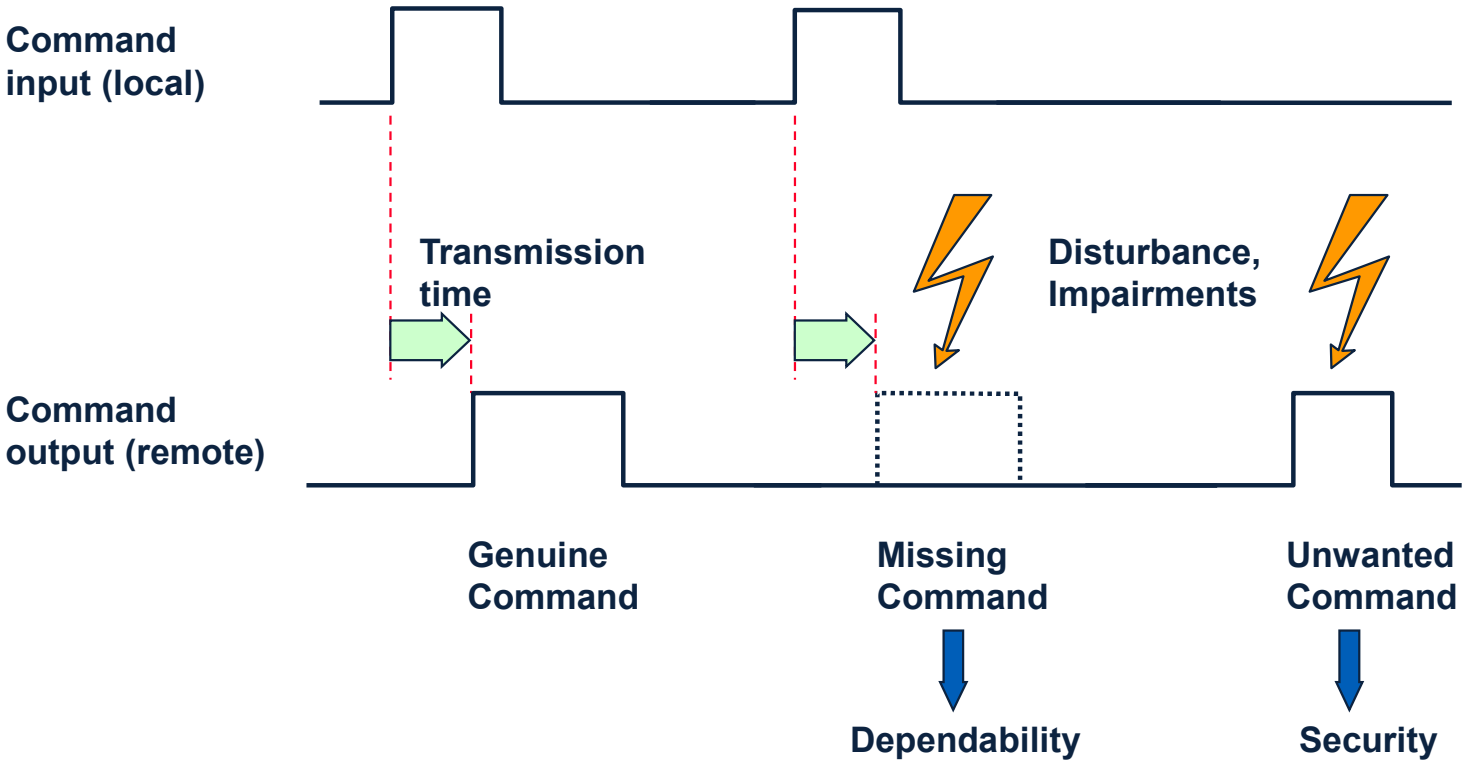
Distance Line Protection

Blocking



B, C	Substations	F	Line fault
L_{BC}	Protected line section	L	Communication channel (PLC, Microwave, Cable)
R_{BC},R_{CB}	Protection relay		
BC_i, CB_i	Zone 1 reach, 130% in direction of the protected line section		
BC_e, CB_e	Range of protection relay in direction of busbars		

Teleprotection command transmission

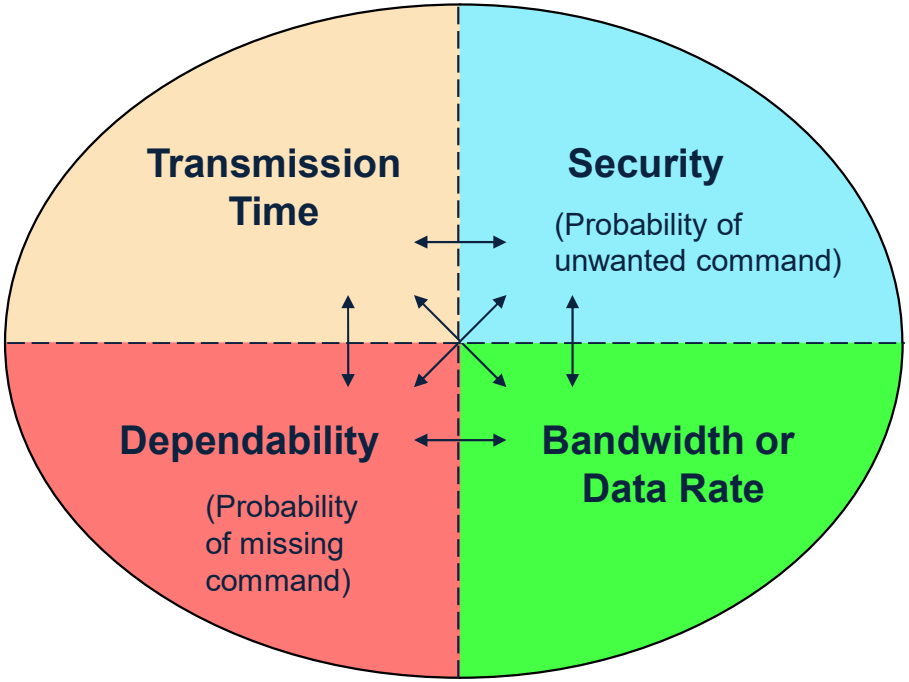


Telecommunication Channel Impairments

- Impairments resulting from interference and noise
  - Isolater / breaker operation
  - 50/60 Hz harmonics (pilot cables)
  - Corona noise (PLC channels)
  - Fading (microwave channels)
  - Jitter (digital networks)
  - Temporary loss of synchronism (digital networks)
  - Signal interruptions
  - etc.

- Disturbed signals may cause protection equipment to maloperate

Performance Criteria for Teleprotection



Optimization / Exchange according to application

Line Protection

Possible Signal Connections Between two Distance Relays

	Designation	Short description	Typical distance relay setting (%) Step 1	Requirements for transmission channel as regards		
				Speed	Security	Dependability
1	Permissive underreach transferred tripping	Starting of distance relay permits tripping	85	M-H	M-H	H
2	Permissive overreach transferred tripping	Directional comparison (signal permits tripping)	130	H	M	H
3	Permissive underreach transferred acceleration	Carrier acceleration by extension of step (*)	85 (130*)	H	L-M	H
4	Blocking (direct overreach, transferred blocking)	Blocking signals are transmitted over healthy lines	130	S	L	H
5	Blocking	Signal inhibits step extension (*)	85 (130*)	H-S	L	M
6	Unblocking	Loss of guard signal permits tripping for limited time only	130	H	M	M
7	Direct underreach transferred tripping	Status of relay at receiving end not taken into account	85	M-H	S	H

L = Low M = Medium H = High S = Very severe requirements

Total Fault-Clearance-Time

- Time delay between fault occurrence and line tripping
- The fault-clearance time results from:
  - Relay-time (fault detection) T_{REL}
  - Command transmission time T_{AC}
  - Switching delay of line breaker T_{BR}
- Typical values:

$\mathbf{T_{Total}}$	=	$\mathbf{T_{REL}}$	+	$\mathbf{T_{AC}}$	+	$\mathbf{T_{BR}}$
75 ms	=	20 ms	+	15 ms	+	40 ms

- Target: $\mathbf{T_{Total}}$ = less than 100 ms, Worst Case
  = 4.5 to 5 cycles max. (50 Hz)

Typical requirements for different applications

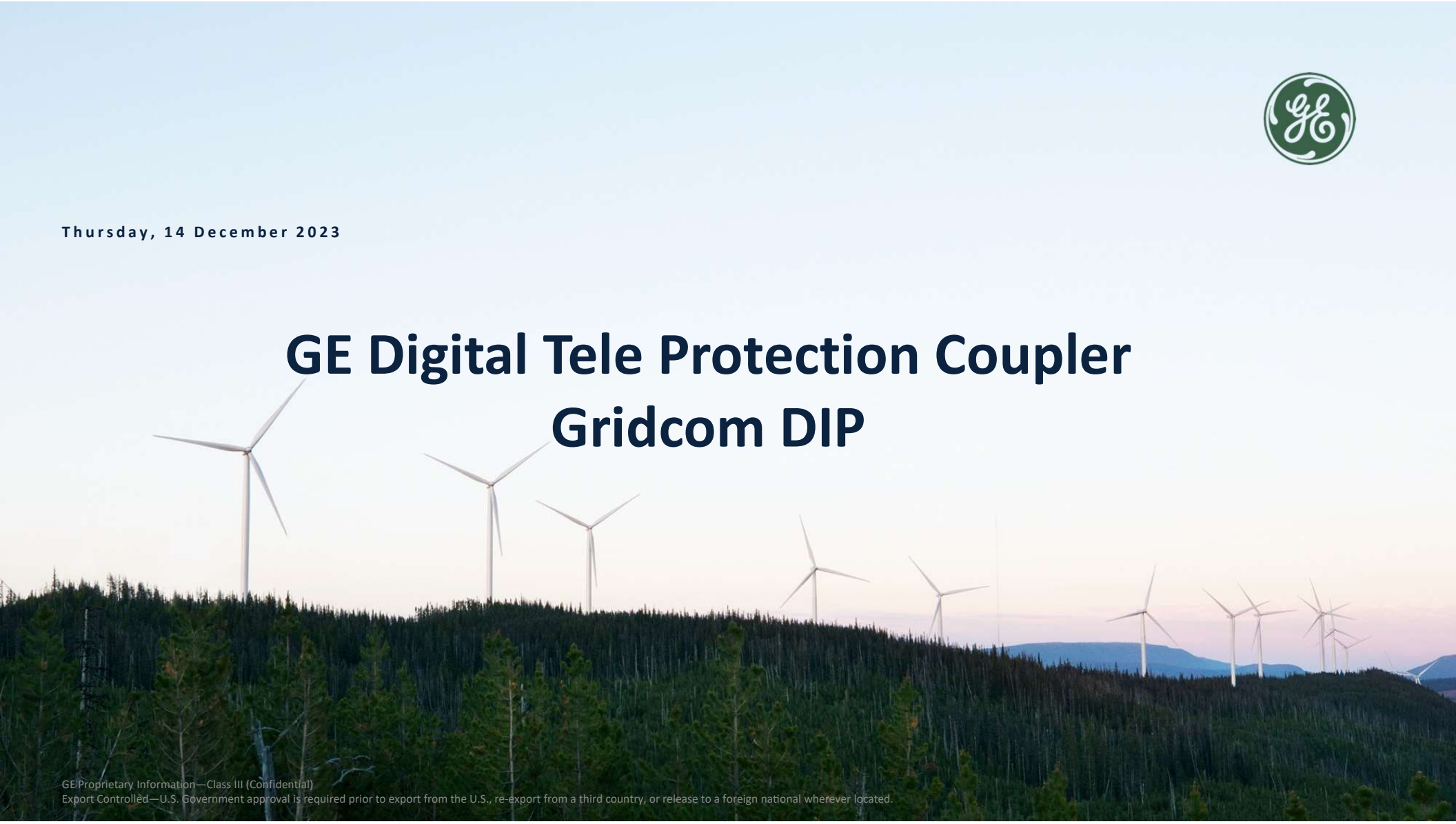
- Line protection with permissive transfer tripping:
  - Transmission time T_0 = 10 ... 20 ms
  - Dependability $P_{\text{lost command}} \leq 10^{-2} \ldots 10^{-3}$
  - Security $P_{\text{false command}} \leq 10^{-3} \ldots 10^{-4}$
- Line protection with blocking system:
  - Transmission time T_0 = 6 ... 15 ms
  - Dependability $P_{\text{lost command}} \leq 10^{-3}$
  - Security $P_{\text{false command}} \leq 10^{-2}$
- Direct transfer tripping (e.g. transformer protection):
  - Transmission time T_0 = 20 ... 50 ms
  - Dependability $P_{\text{lost command}} \leq 10^{-3} \ldots 10^{-4}$
  - Security $P_{\text{false command}} \leq 10^{-5} \ldots 10^{-6}$

Command Systems, Typical Figures

Blocking		*Analog systems*	*Digital systems*	
• short transmission time ms	Tac	< 15 ms		< 10
• moderate security	Puc	< 1E-2		< 1E-6
• high dependability	Pmc	< 1E-3		< 1E-3
Permissive tripping				
• moderate transmission time ms	Tac	< 20 ms		< 10
• moderate to high security	Puc	< 1E-3 ....1E-4	< 1E-6	
• moderate to high dependability	Pmc	< 1E-2 ....1E-3	< 1E-3	
Direct tripping				
• moderate transmission time ms	Tac	< 40 ms		< 10
• very high security	Puc	< 1E-5 .... 1E-6	< 1E-9	
• very high dependability	Pmc	< 1E-3		< 1E-3

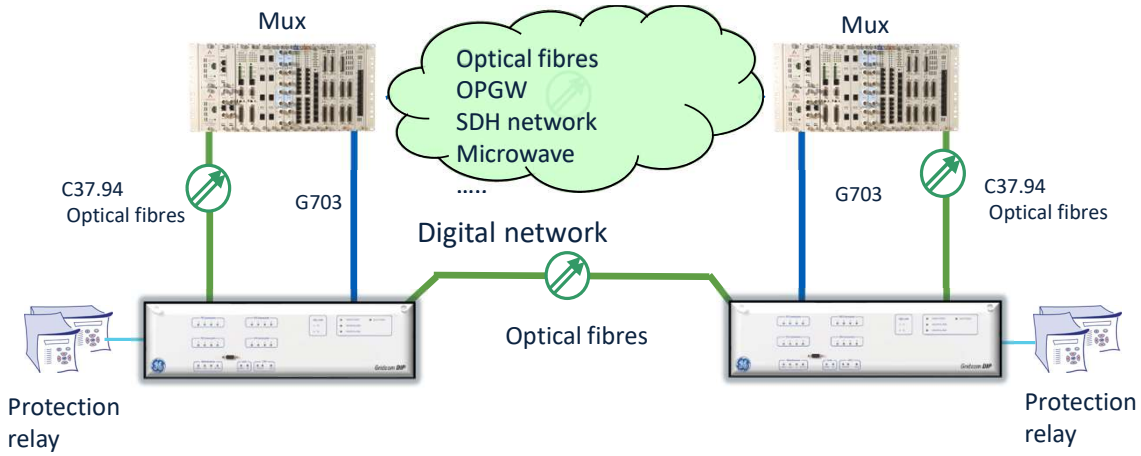
Thursday, 14 December 2023

GE Digital Tele Protection Coupler
Gridcom DIP



Requirement of Gridcom DIP: Intertripping Function

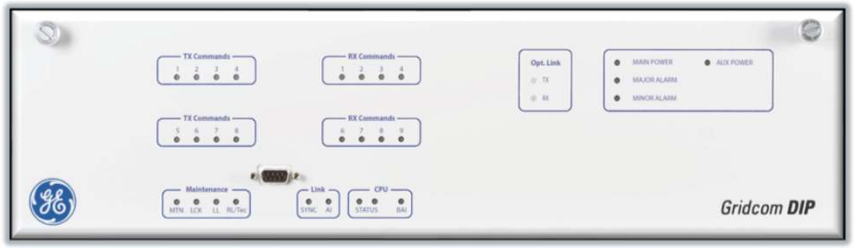
- Intertripping is designed to transfer protection commands originating, in most cases, from distance protection relay contacts to ONE remote location through a communication medium.
- Communication between the inter-tripping equipment is a bidirectional point-to-point communication



General Description of Gridcom DIP

Comprehensive & Versatile

Integrated Modularity



G*ridcom* DIP

Reliable & Secure

Highly Configurable & Customized

Reliable & Secure

Features

- Ultrahigh Reliability degree
- Ultrahigh Security degree
- Very Fast (< 2.5ms)
- Up to 8 independent commands
- Inbuilt measurement and performance functions: BER and Transfer time monitoring
- Logical combination available (AND / OR operation on 2 entries)

Operating Mode: Digital Mode

Principle of digital transmission

- The transmission principle used is that of permanent transmission of a digital frame corresponding to the guard status.
- Closing one or several contacts changes this frame and transmits a command message.

Interfaces available in the digital mode

The architecture and principles used ensure the DIP digital teleprotection equipment can adapt to different transmission media:

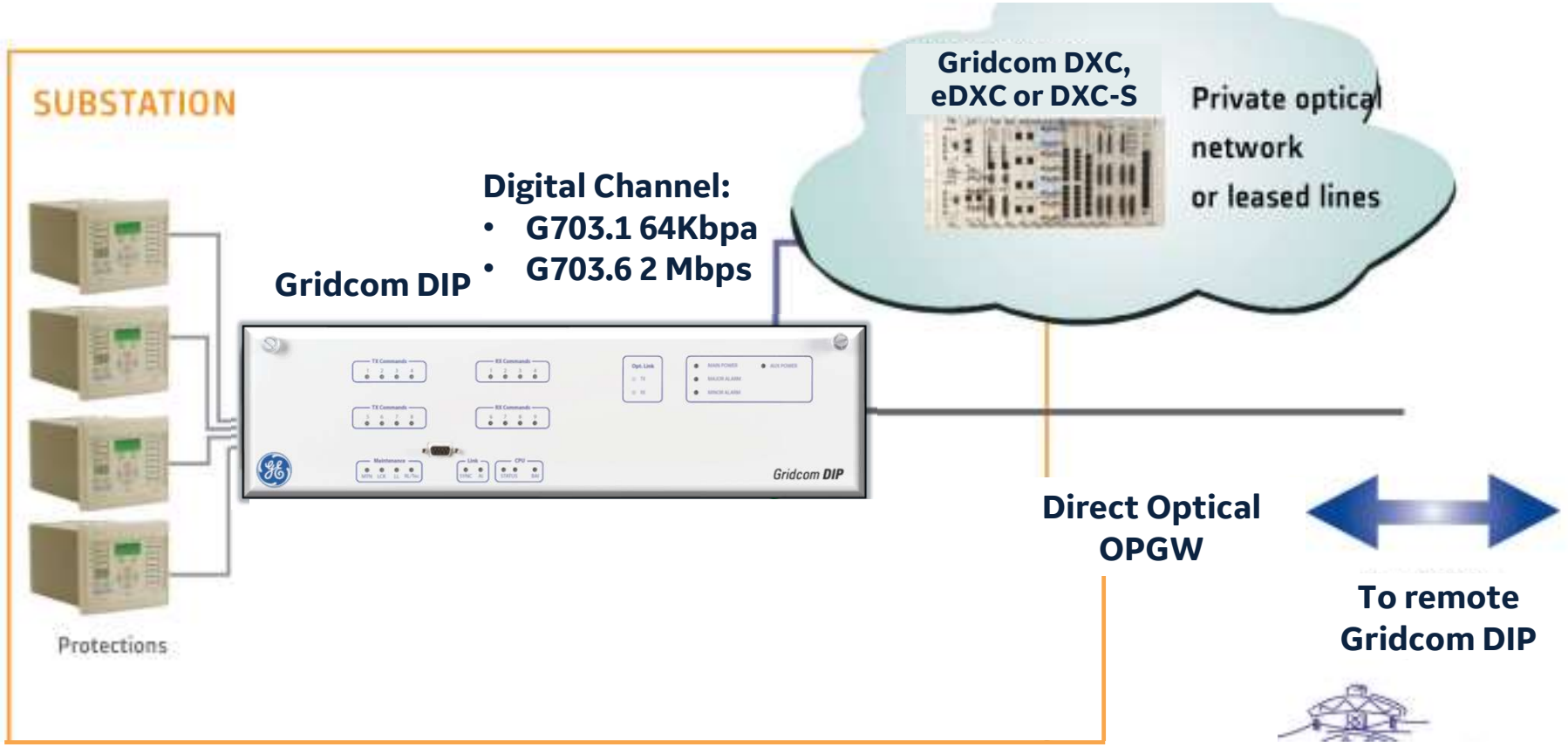
- G703-1 interface at 64 Kbps
- G703-6 interface (E1) at 2048 Kbps. Impedance 75 or 120 ohms
- Interface for single mode optical fiber , rate 256 Kbps
- Interface for multimode optical fiber, IEEE C37-94. Rate nX64 Kbps with n=1 to 8
- Versatile Optical interface with interchangeable SFP module

Software Capabilities

SOFTWARE Capabilities using a PC terminal

- Hardware test
- Remote configuration and test (digital)
- Possibility to lock independently or simultaneously the signal transmission and command outputs
- Local and remote (digital) loop back
- Inputs / Outputs forcing
- transfer time directly measured in event list by clicking (digital)
- 2 counters for each command (received and sent)
- Real time event recorder : 1750 events memorized (1ms accuracy)
- Real time alarm recorder : 1750 alarms memorized (1ms accuracy)

Solution for different communication interfaces

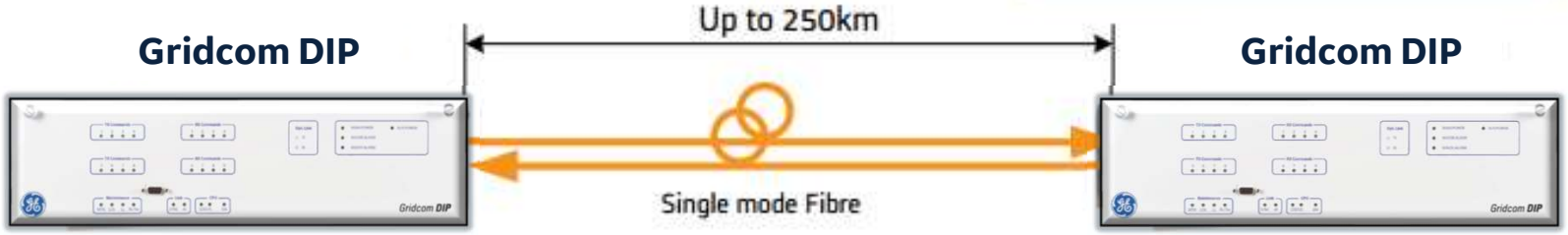


Optical communication interface

Optical communication

- **Ultra long haul communication**

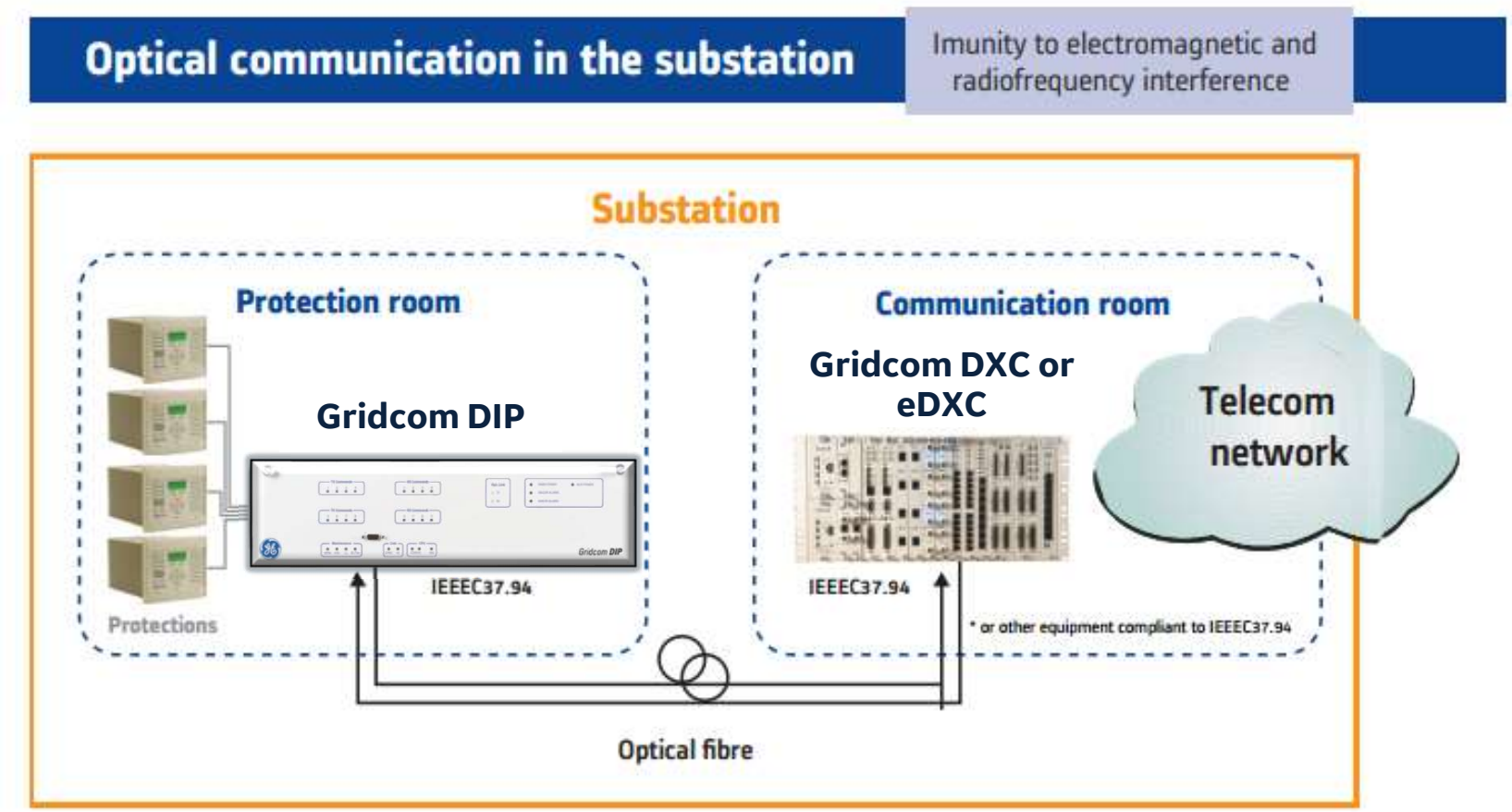
No intermediate device to cover long distance



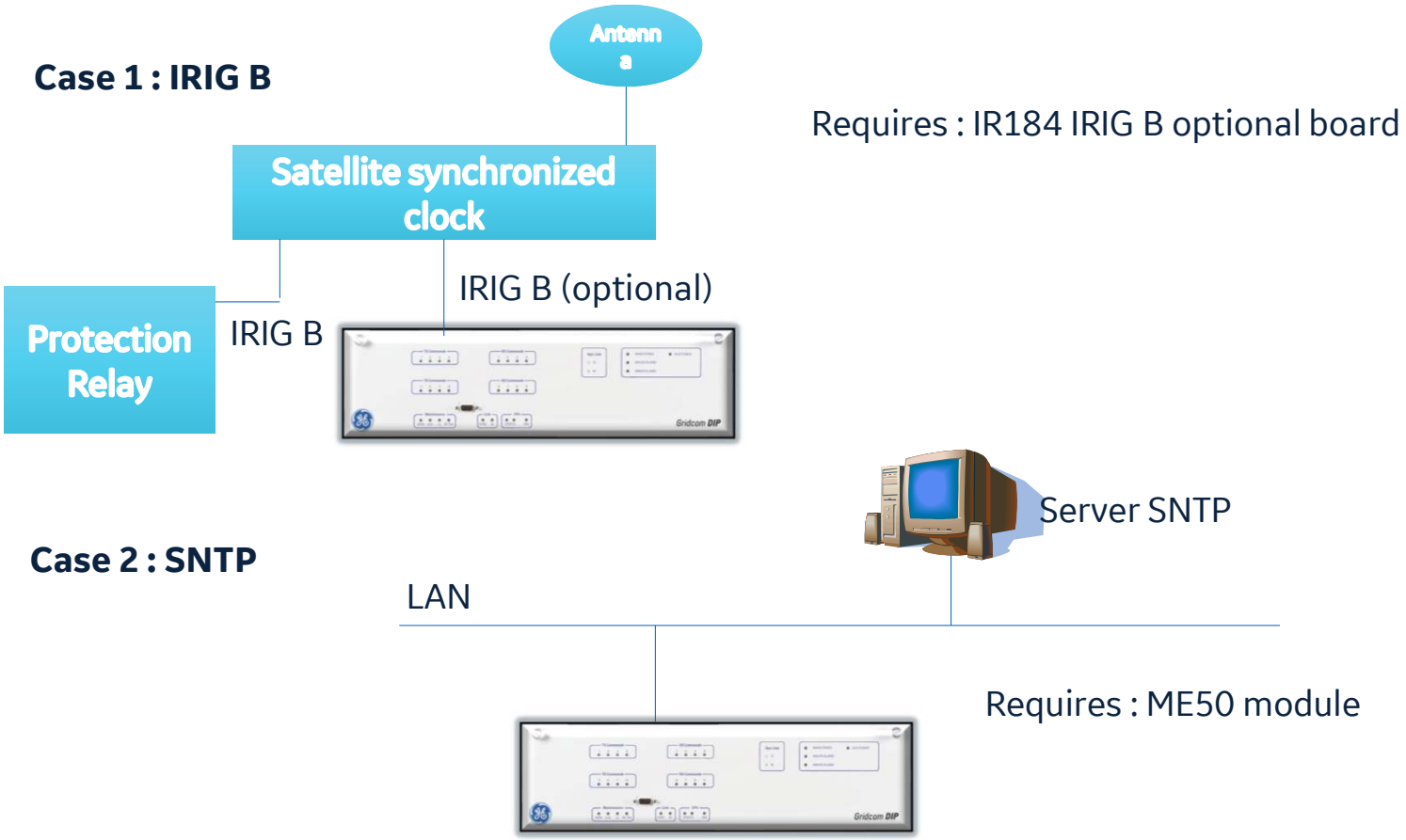
- **Bidirectional communication**

New network architecture design possibilities

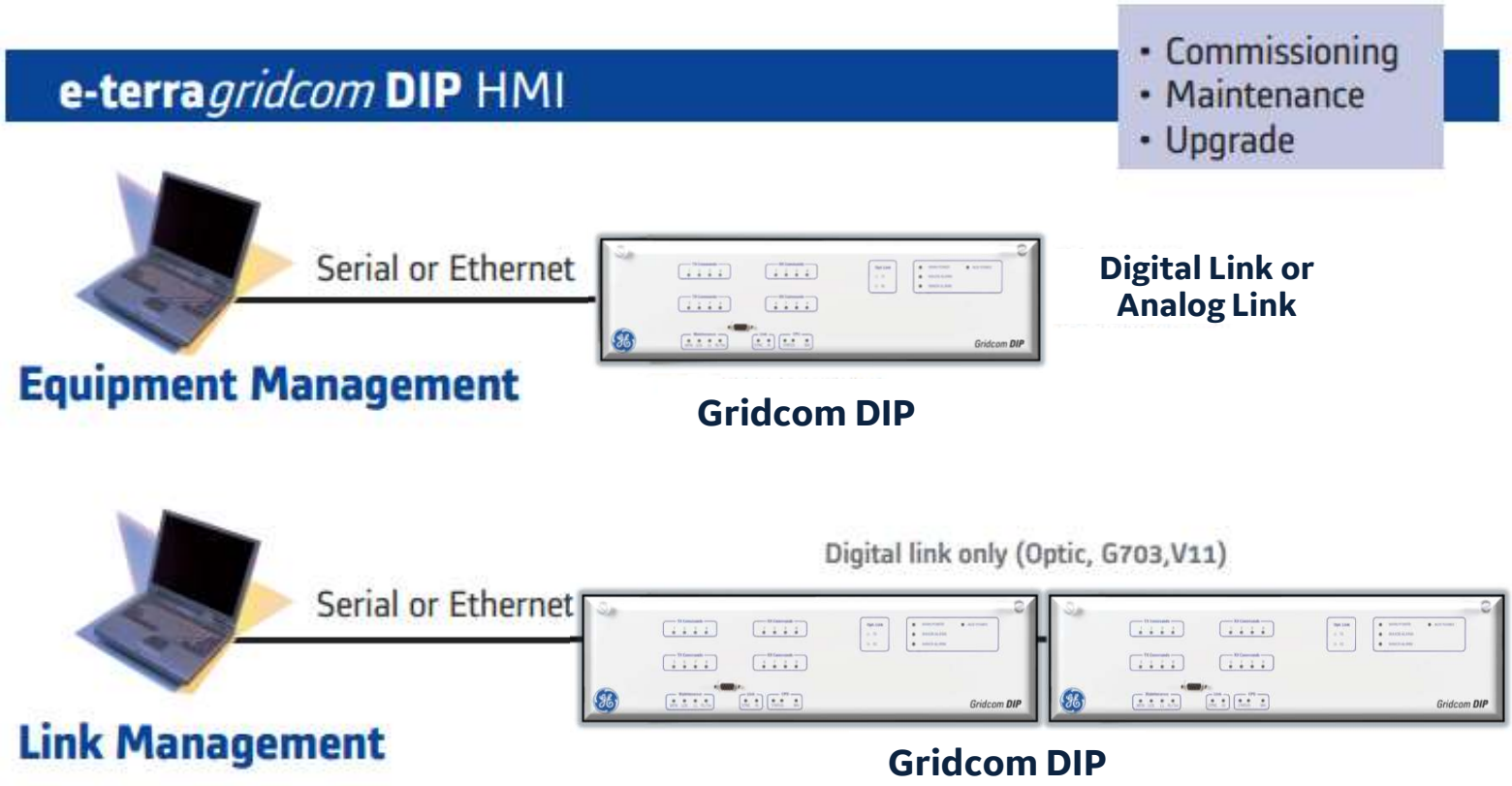
Optical communication interface (IEEE C37.94 interface)



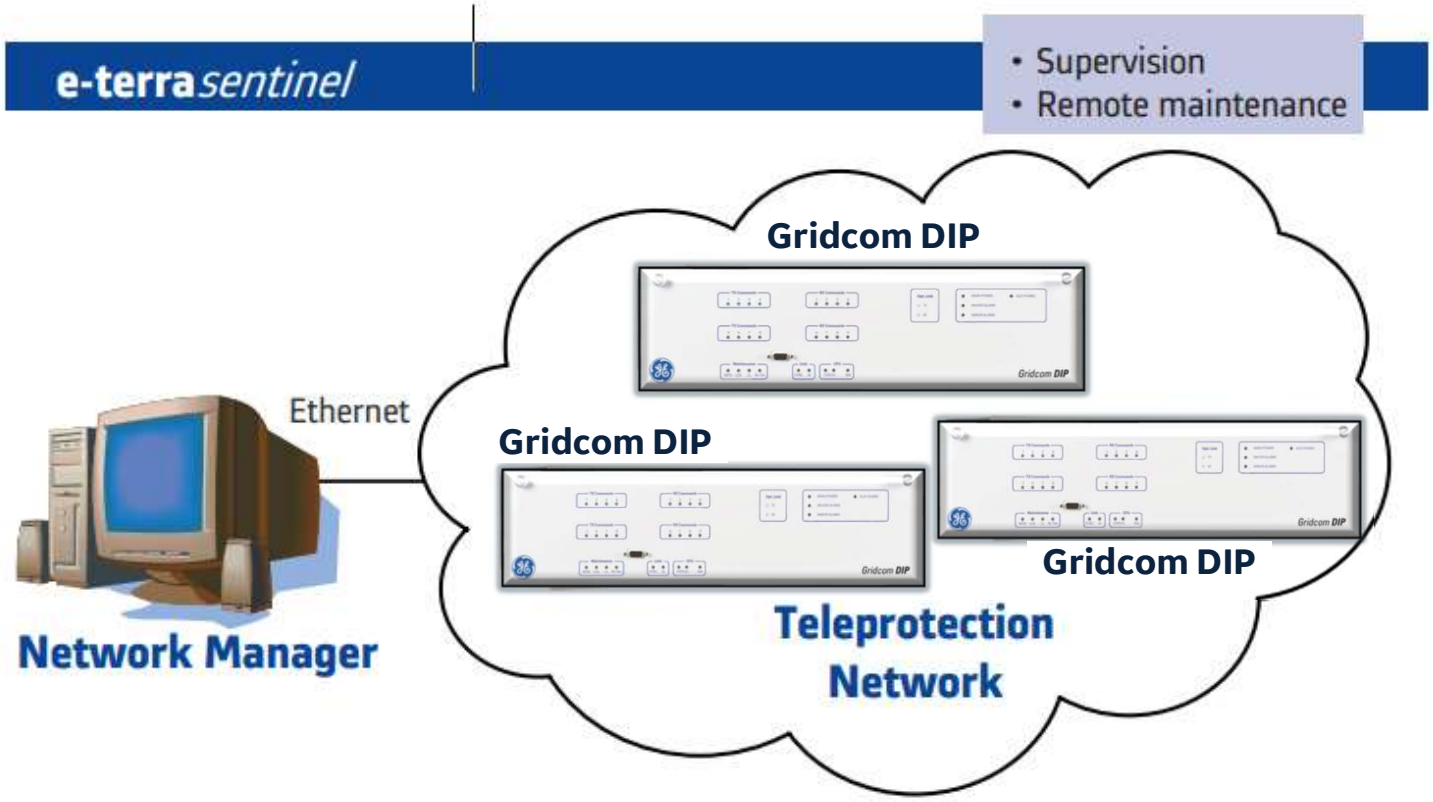
Time synchronization



Serial or Ethernet local or remote communication



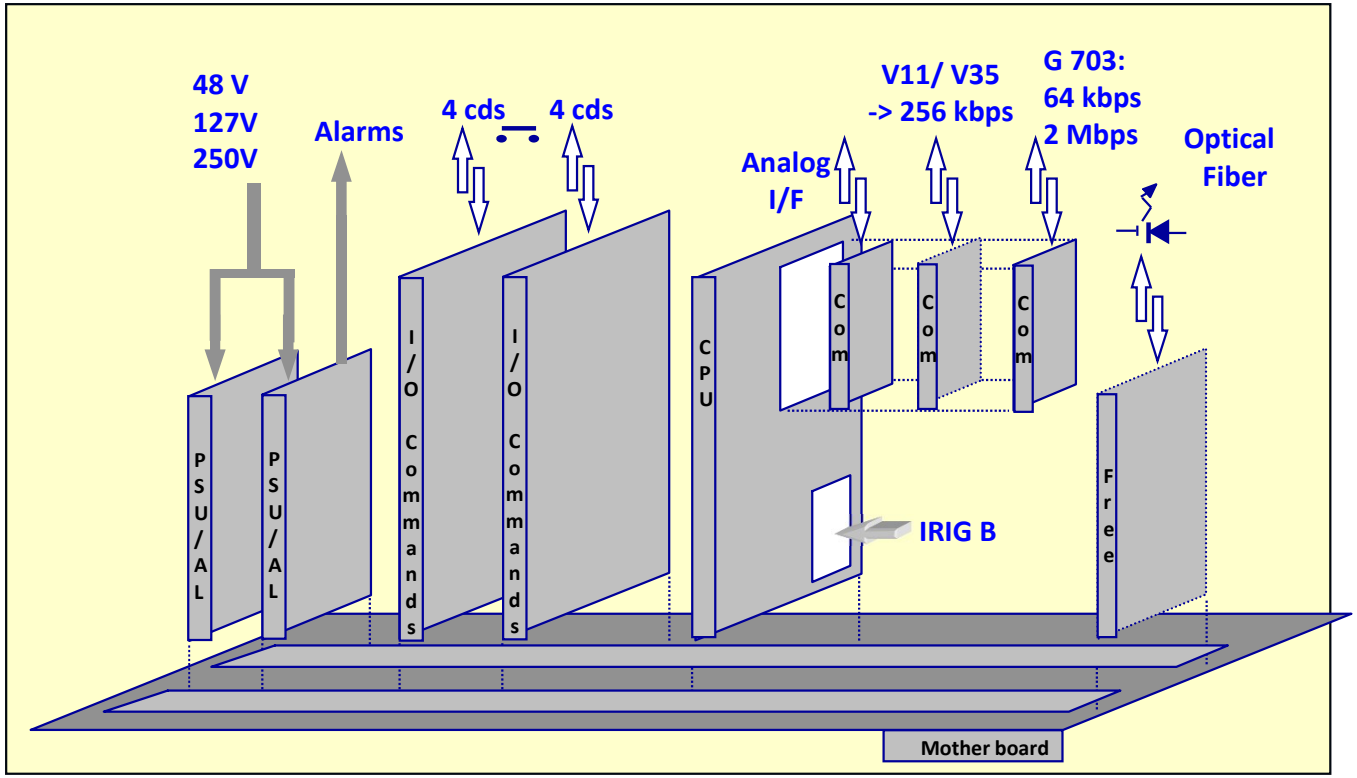
SNMP integrated solution



Certification

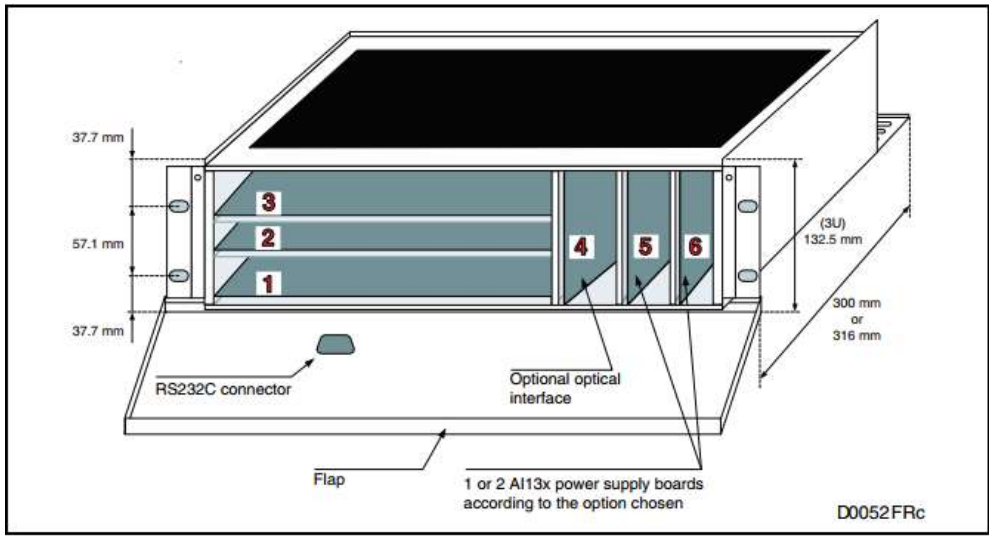
Performance	
IEC 60834-1 digital	Teleprotection equipment of power systems
IEC 60834-1 analogue	Teleprotection equipment of power systems
Electromagnetic Compatibility	
IEC 61000-6-2	**Immunityfor industrial environments**
IEC 61000-4-2 Class 4	Immunity to electrostatic discharges
IEC 61000-4-3 Class 3	Immunity to radiated electromagnetic field
IEC 61000-4-4 Class 4	Immunity to electrical fast transcients/ bursts on input /ouput port
IEC 61000-4-5 Class 3	Immunity to surges on input / output port
IEC 61000-4-6 Class 3	Immunity to conducted disturbances, induced by radio-frequency fields on input/output port
IEC 61000-4-8 Class 5	Immunity to power magnetic field
IEC 61000-4-11	Immunity to voltage dips, short interruptions and voltage variations
IEC 61000-6-4	**Emission standard for industrial environments**
CISPR 16-2-3	Measurement of radiated electric field in shielded room
CISPR 16-2-3	Measurement of radiated electric field in open space
CISPR 16-2-1	Measurement of conducted disturbance on the AC main power port
CISPR 16-2-22	Measurement of conducted disturbance on telecom port
IEC 61000-6-5 + IEC 60834	**Immunity for power station andsubstation environments**
IEC 61000-4-9	Immunity to pulse magnetic field
IEC 61000-4-10	Immunity to Damped oscillatory magnetic field
IEC 61000-4-18	Damped oscillatory wave
IEC 61000-4-29	Immunity to voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests
IEEE C37.90.1 / C37.90.2 / C37.90.3	**IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus**
IEEE C37.90.1	Damped oscillatory wave
IEEE C37.90.1	Immunity to electrical fast transcients/ bursts on input /ouput port
IEEE C37.90.2	Immunity to radiated electromagnetic field
IEEE C37.90.3	Immunity to electrostatic discharges
Safety testing	
EN 60950-1	Safety
Environmental testing	
Climatic	
IEC 60068-2-1	Low temperature during operation
IEC 60068-2-2	High temperature during operation
IEC 60068-2-1	low storage temperature
IEC 60068-2-2	Highstorage temperature
Mechanic	
IEC 60068-2-6	Sinusoidal vibration
IEC 60068-2-27	Shocks
IEC 60068-2-29	Bump

Gridcom DIP Hardware Description: Integrated Modularity



INTERCHANGING BOARDS IN ONE RACK SOLUTION

Gridcom DIP Teleprotection Hardware Description (Main frame)



- Basic configuration of Gridcom DIP is made of:
  - 1 UT148D **CPU board** in position 1.
  - 1 SR200 **I/O board (1)** in position 3.
  - 1 AL137 **power supply board (1)** in position 5.

Module Options

Subrack

AM170D - RACK

Processing

UT 148D - CPU

Power modules

AL140 - 24Vdc

AL137 -48/60Vdc

AL142 -48/60Vdc with NO alarm contacts

AL139A - 110/127 Vdc

AL143 - 110/127 Vdc with NO alarm contacts

AL139B - 220/250 Vdc

Acquisition / restitution

SR114D - I/0 card

SR200 - Enhanced I/0 card

Options

IR184- IRIG B interface

ME50 - Ethernet -SNMP compatible

CD_ROM V23 & PC Cable

Optical communication

IR185 - C37-94 850nm

IR187_with-SFP-MM-20

IR187_with-SFP-S1.1

IR187_with-SFP-L1.2e

IR187_with-SFP-U1.2e

IR187_with-SFP-180-1 /2

IR187_with-SFP-1120-1 / 2

IR187_with-SFP-1200-1 / 2

Electrical communication

IR183 Analogue 4 wires

IR 173 -120 G703-6 2 Mbps 120 Ohms

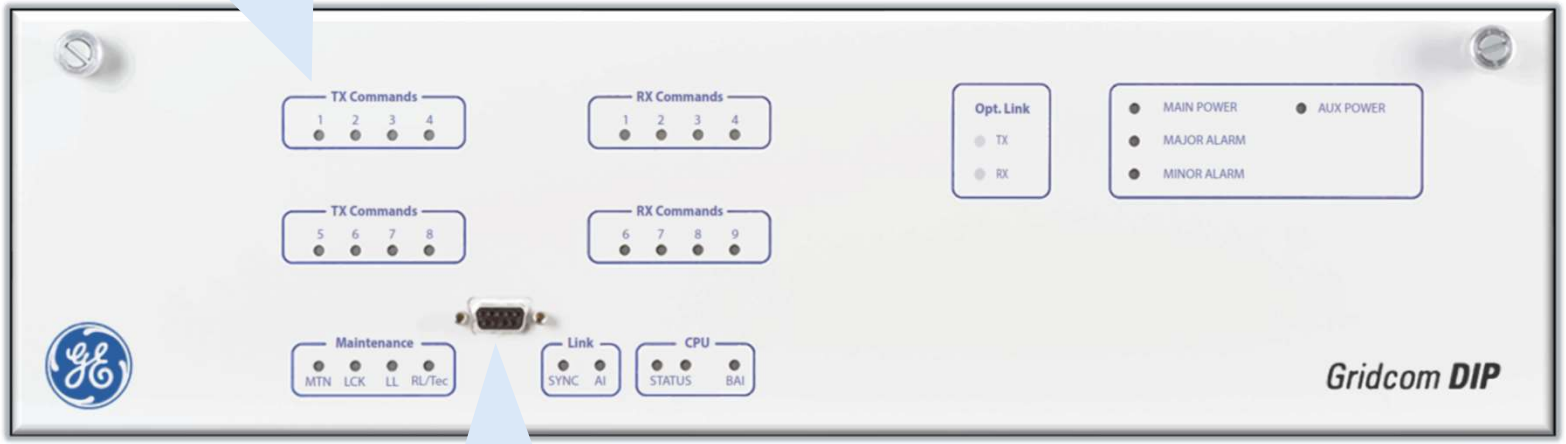
IR 173 - 75 G703-6 2 Mbps 75 Ohms

IR 179 V 11 256 Kbps

IR 180 G703-1 64 Kbps

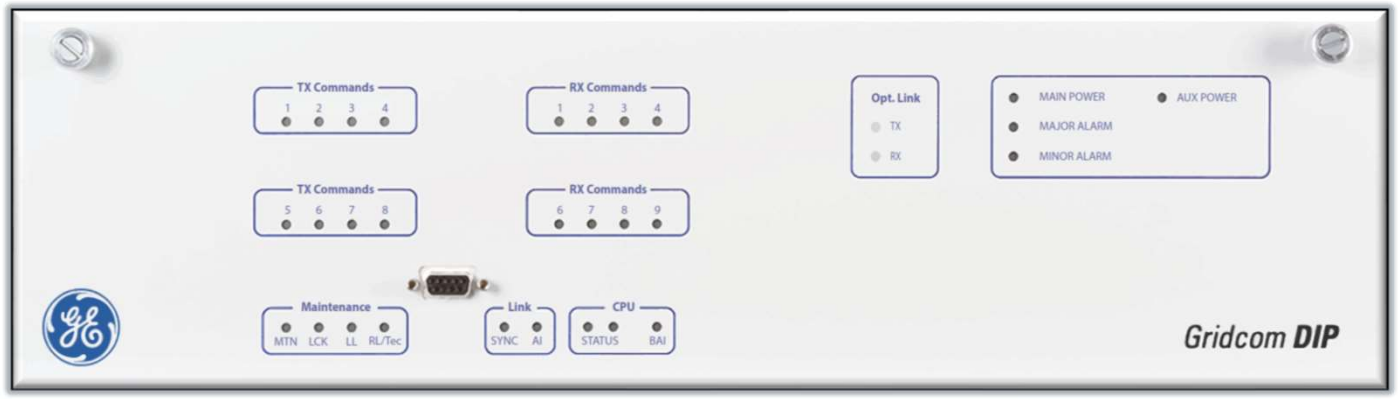
Gridcom DIP Front plate

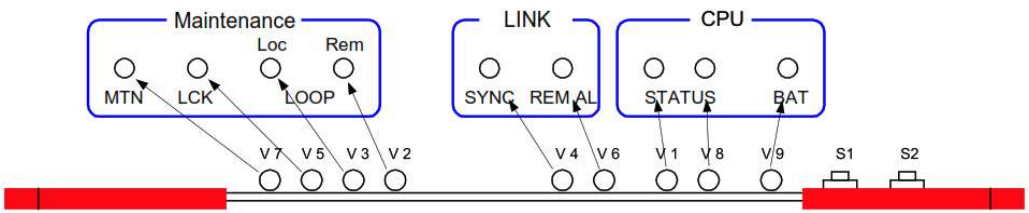
Monitoring LEDs for Power supply ON/OFF status; mayor and minor alarms; status of the comm link, Tx/Rx status ..etc

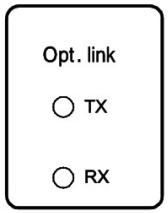


RS232 serial port for local HMI connection and settings

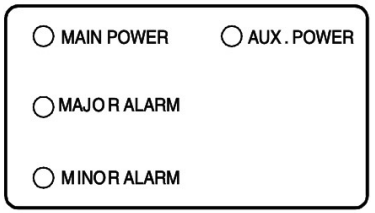
Gridcom DIP Front plate







Optical interface indicator lights



Power supply indicator lights

Gridcom DIP Rare plate

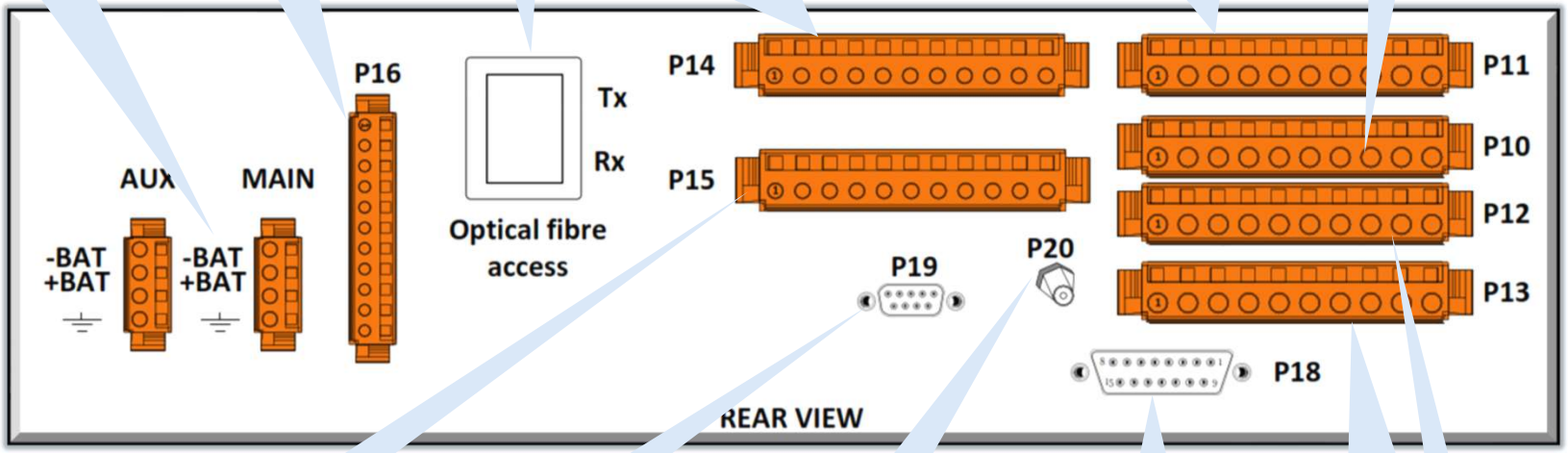
Power supply terminal block for Main and Back up inputs

Distribution loops for major and minor alarms

Tx/Rx Fiber Optic access

Terminal block for transmission copy auxiliary outputs and command restitutions 1 to 4

Terminal block reserved to acquisition/restitution inputs 1 to 4.



Terminal block for transmission copy auxiliary outputs and command restitutions 5 to 8

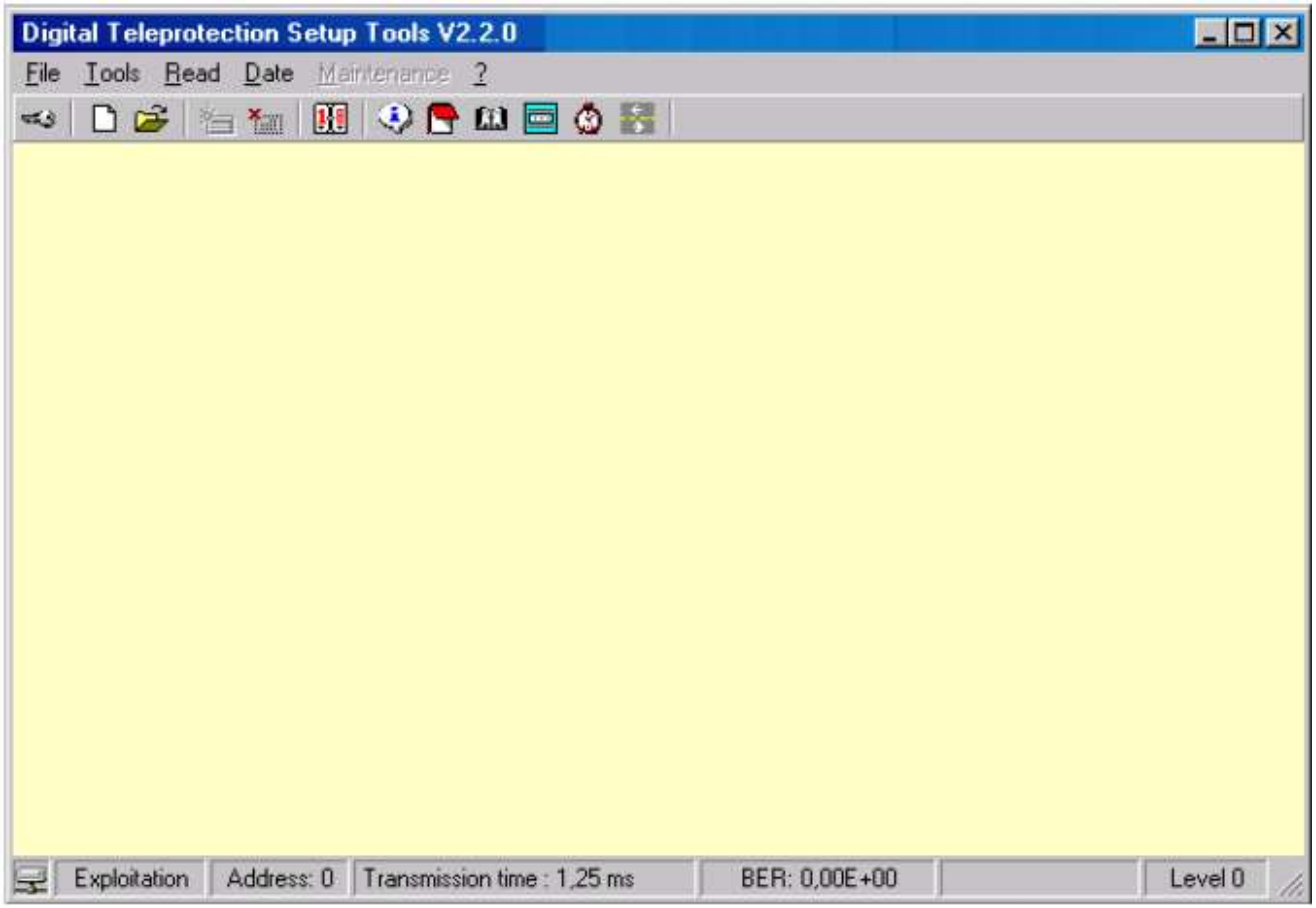
RS232 serial port for local HMI connection and settings

BNC connector for ext. IRIG-B signal

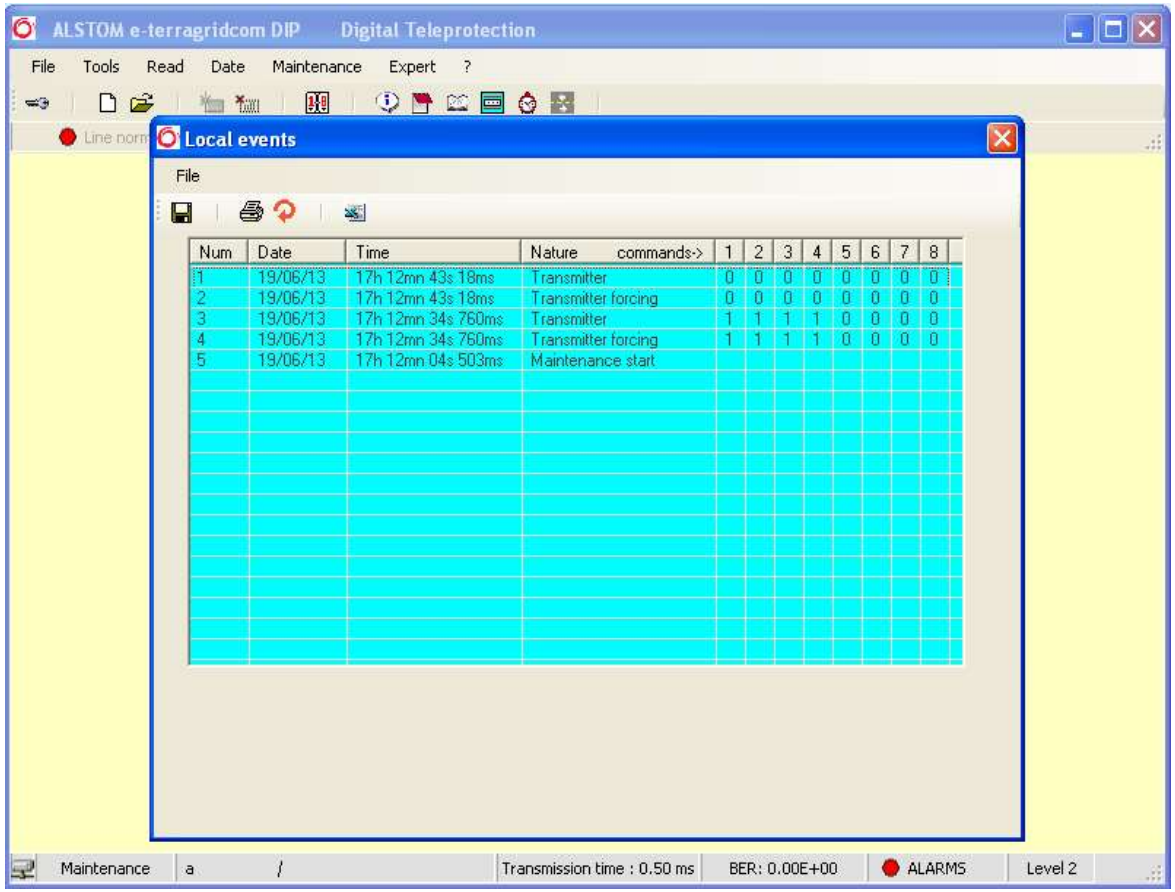
Female connector 15 pins for access to the communication line

Terminal block reserved to acquisition/restitution inputs 5 to 8.

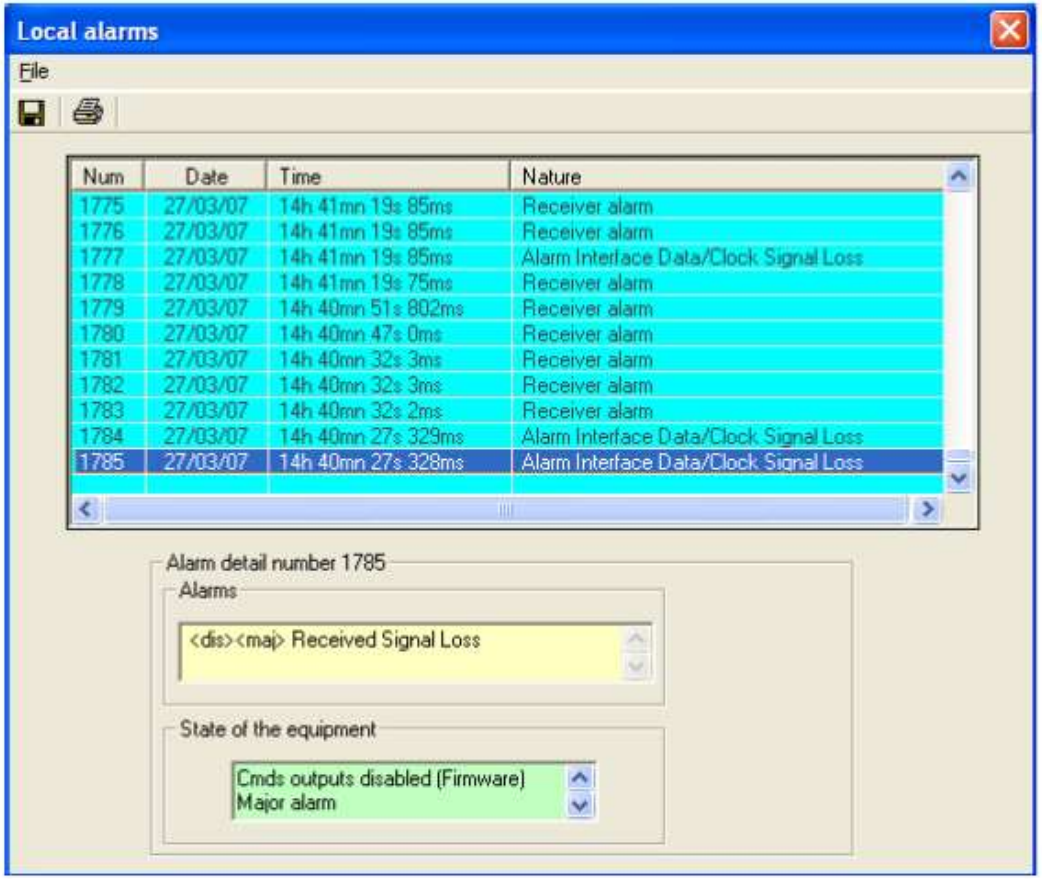
Gridcom DIP Configuration HMI (Digital)



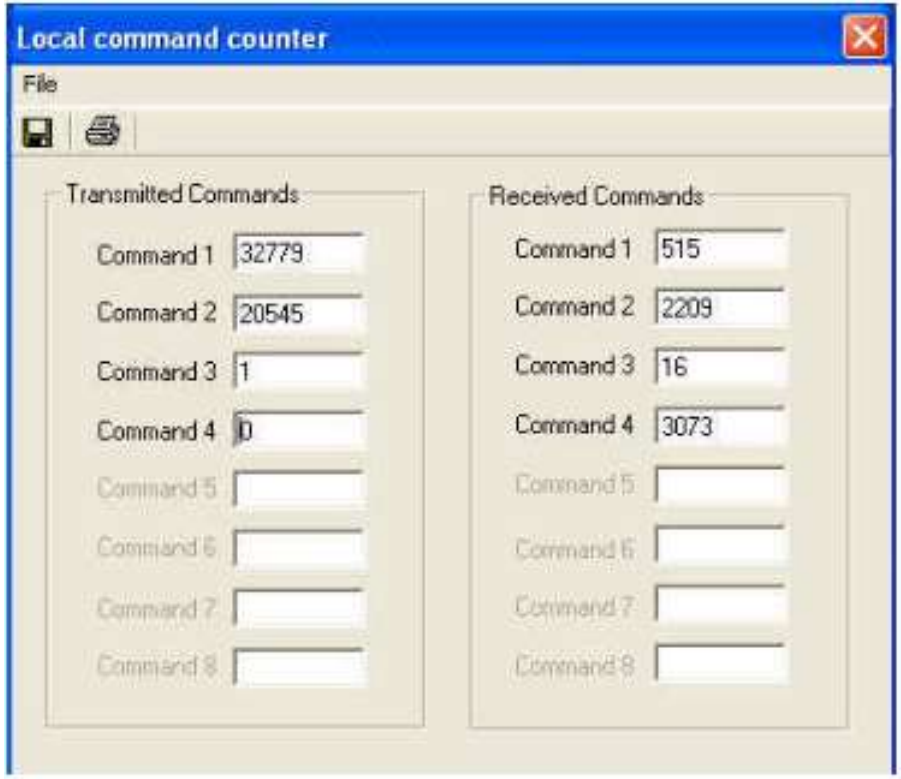
Gridcom DIP - Events



Gridcom DIP - Alarms

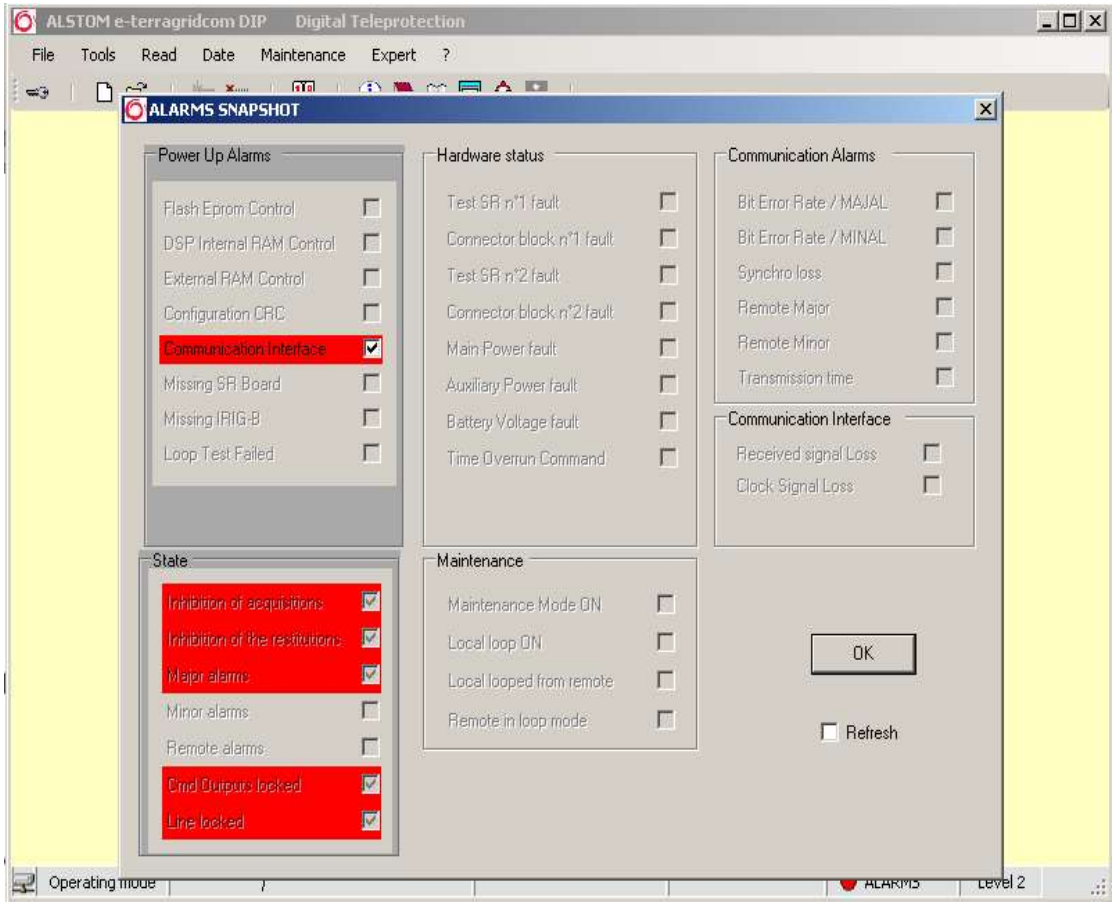


Gridcom DIP - Alarms

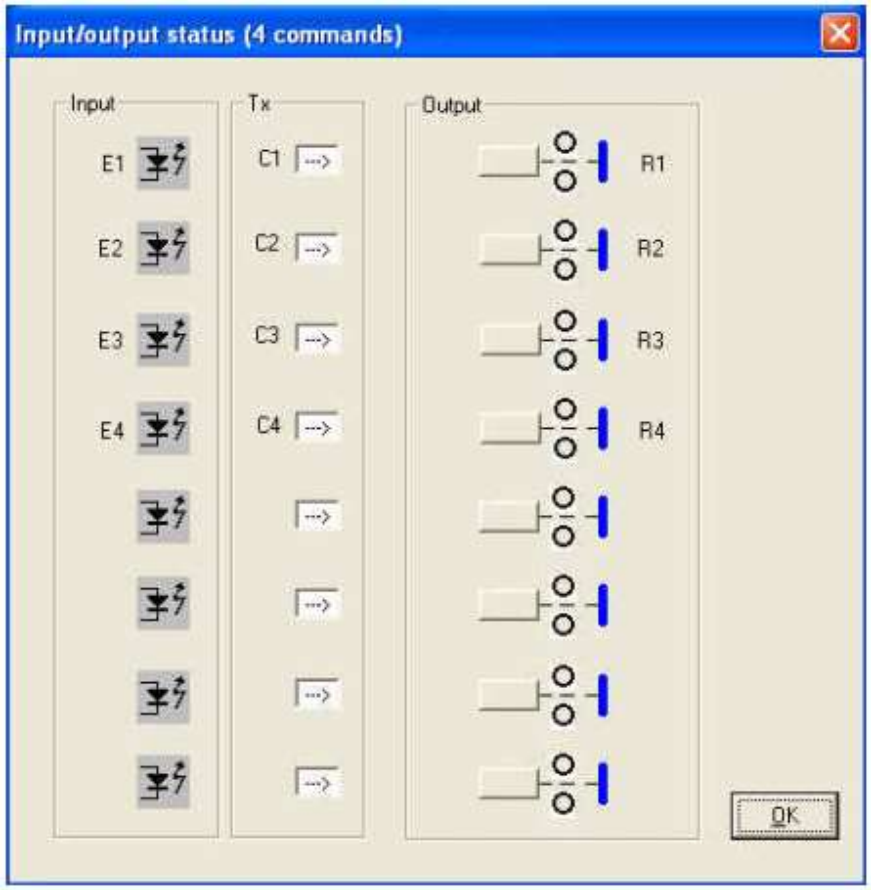


Gridcom DIP Real Time Alarms Snapshot & Input Output Contact Relay Status

Gridcom DIP – Alarms Snapshot



Gridcom DIP – Input / Output States



Thursday, 14 December 2023

Training on
GE Tele Protection Coupler (Analogue, Digital & 61850)
Gridcom DIP.net

GE DIP Teleprotection portfolio & Gradual Migration to Smart Grid Substation

Migration phases	Interface with legacy relays	Step by step migration	Full digital Substation SMART SUBSTATION
	Hard Wire connections with Relays	Hard Wire connections & GOOSE connection with Relays	GOOSE connection with Relays

G*ridcom* DIP

Hard Wire connections with Relays

G*ridcom* DIP.net SLIM

G*ridcom* DIP.net 19” 3U rack

1) Hard Wire connections with Relays
2) Hard Wire connections & GOOSE connection with Relays
3) GOOSE connection with Relays

GE Gridcom DIP.net: Overview

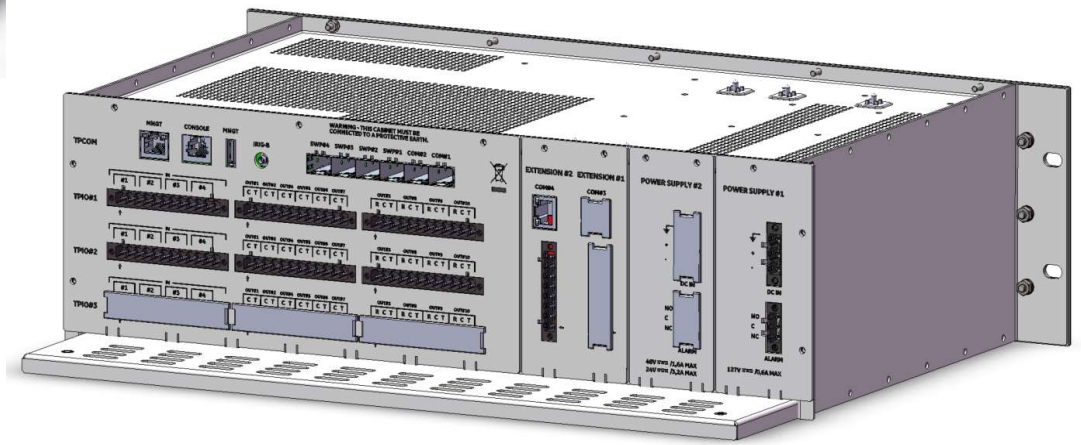
MODULAR & DISTRIBUTED ARCHITECTURE | **REAL TIME MONITORING** | **VERSATILE COMMUNICATIONS INTERFACE** | **COMPREHENSIVE SECURITY** | **COST EFFECTIVE AND FLEXIBLE SOLUTION**

***G**ridcom* **DIP.net SLIM**

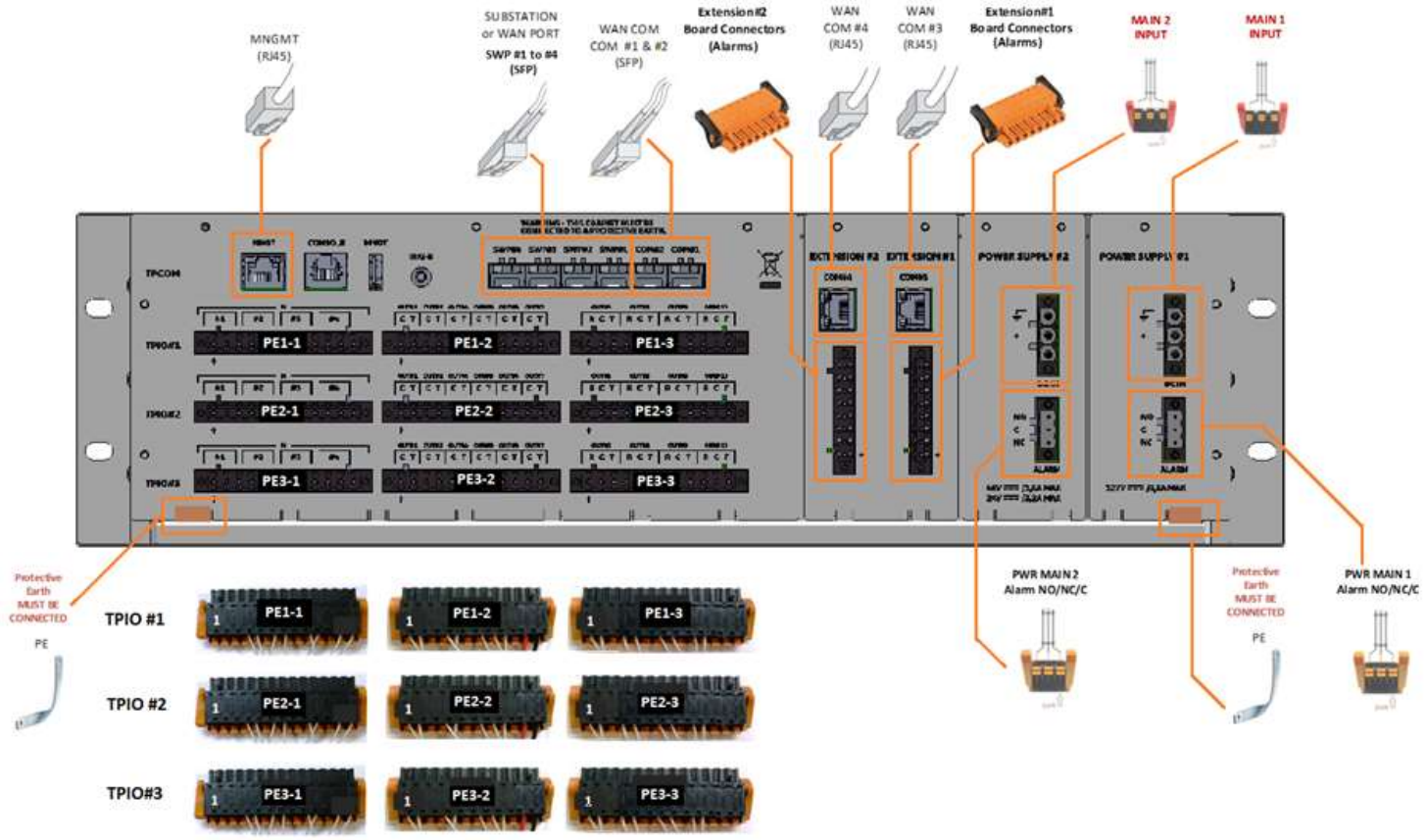
***G**ridcom* **DIP.net 19" 3U rack**

- IEC 61850 native design & Migration from Legacy relay interfaces to Fully Digital Substation over IEC61850
- Enhanced commands management (up to 12 commands in 3U rack & up to 24 commands in SLIM version)
- Cost effective solution (multi-point teleprotection solution)
- Simultaneous I/O hardwiring and GOOSE messages acquisition
- IEC 61850 native design (2nd ed. Compliance)
- PTP 1588-time synchronization (IRIG B, NTP)
- Cybersecurity

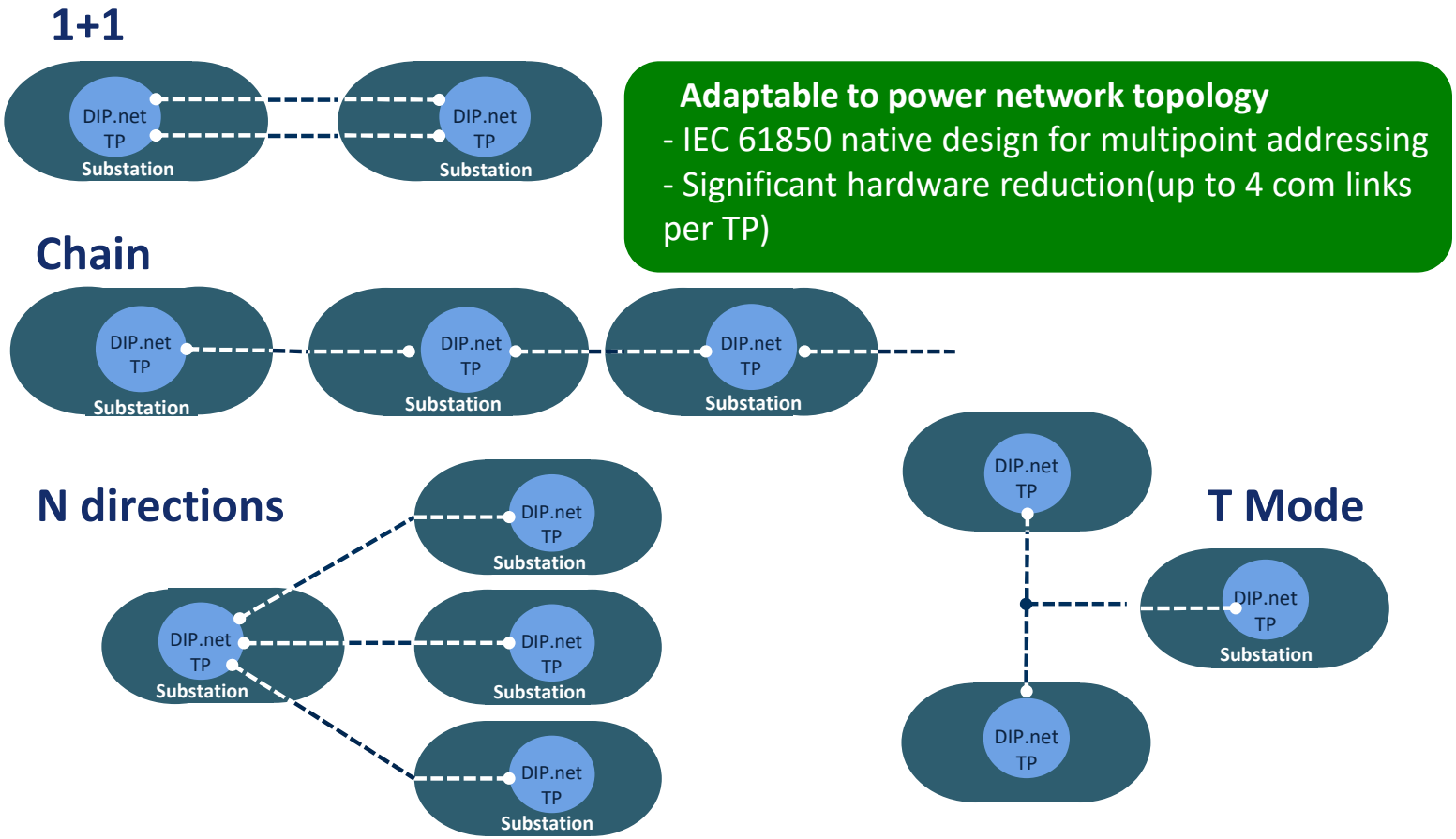
GE Gridcom DIP.net: DIP.net 19” 3U rack Front & Rear View



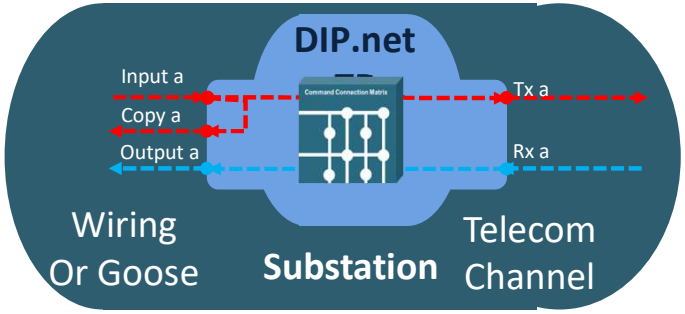
GE Gridcom DIP.net: DIP.net 19” 3U rack Rear View

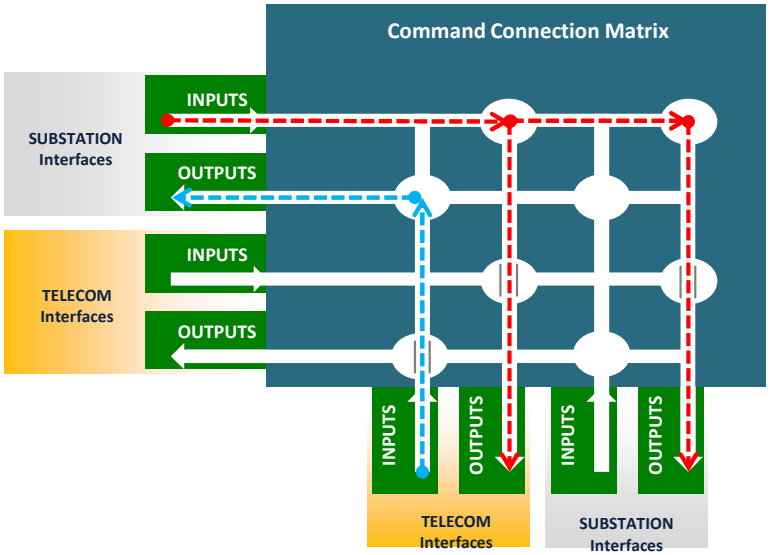


GE Gridcom DIP.net: Adaptability and cost reduction



GE Gridcom DIP.net: Command Matrix Function



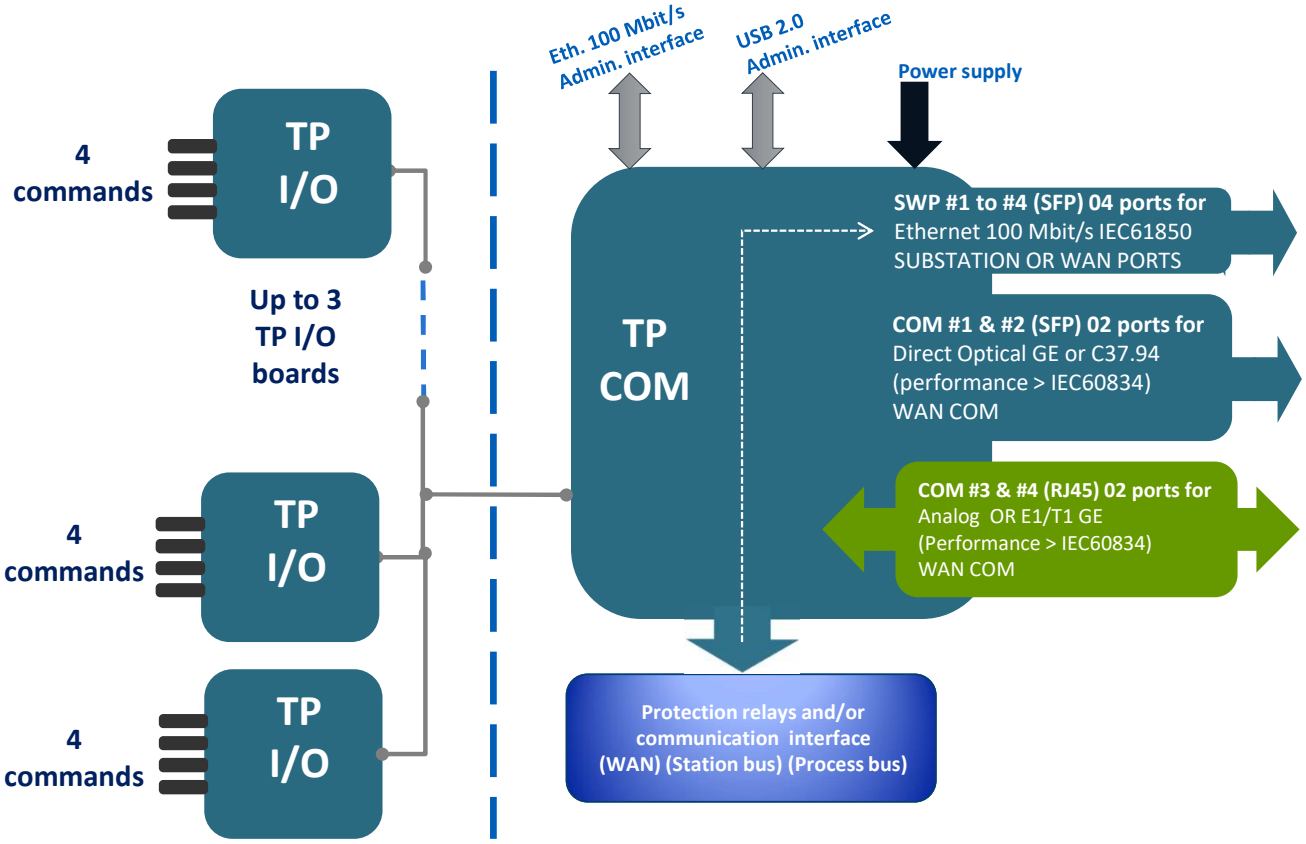


Any Combination between input :
- One or more Output
- Command copy

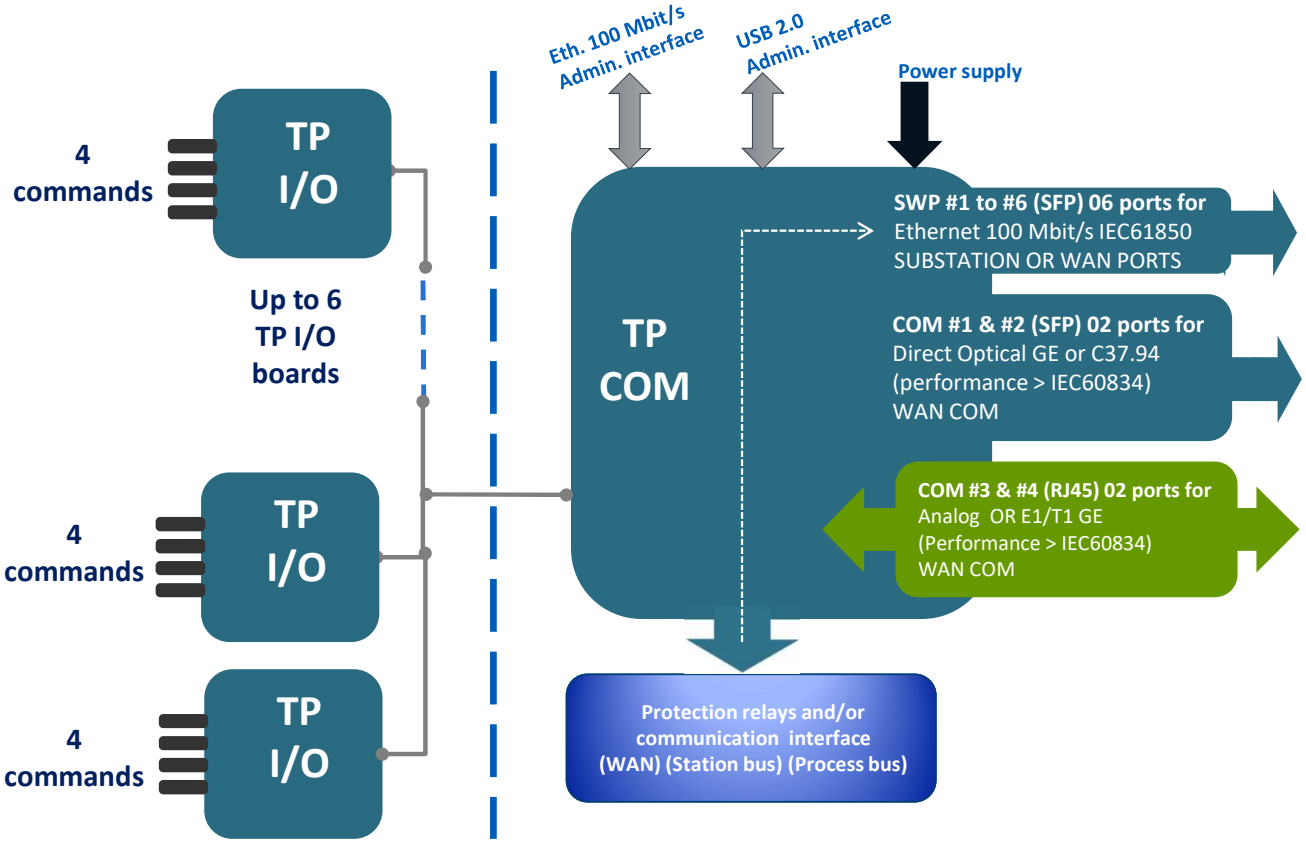
Easy configuration using HMI

Easy installation and maintenance
Less wiring
OPEX Improved

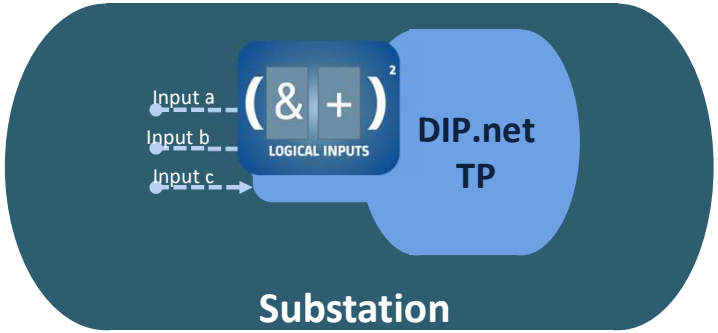
GE Gridcom DIP.net: 19” 3U rack Connectivity



GE Gridcom DIP.net: SLIM



GE Gridcom DIP.net: Logic Programmable functions



Logical complex input operations :

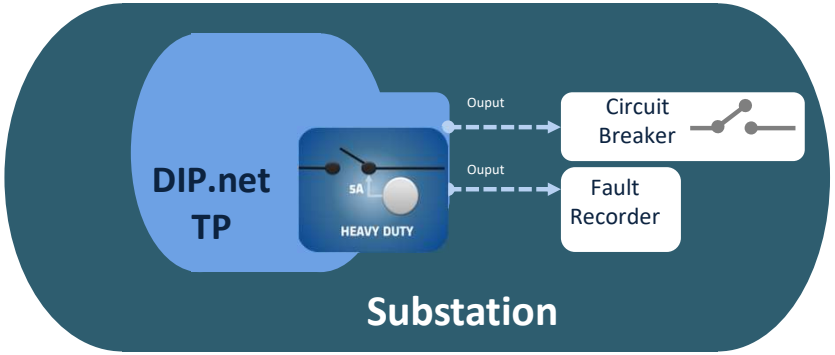
- "And" , "Or" operations
- Complex logical operations
  Ex : (Input . Input b) + Input c

Input Voltage :

- Input voltage from 24vdc up to 250vdc
- Opto-isolation
- Dry contact

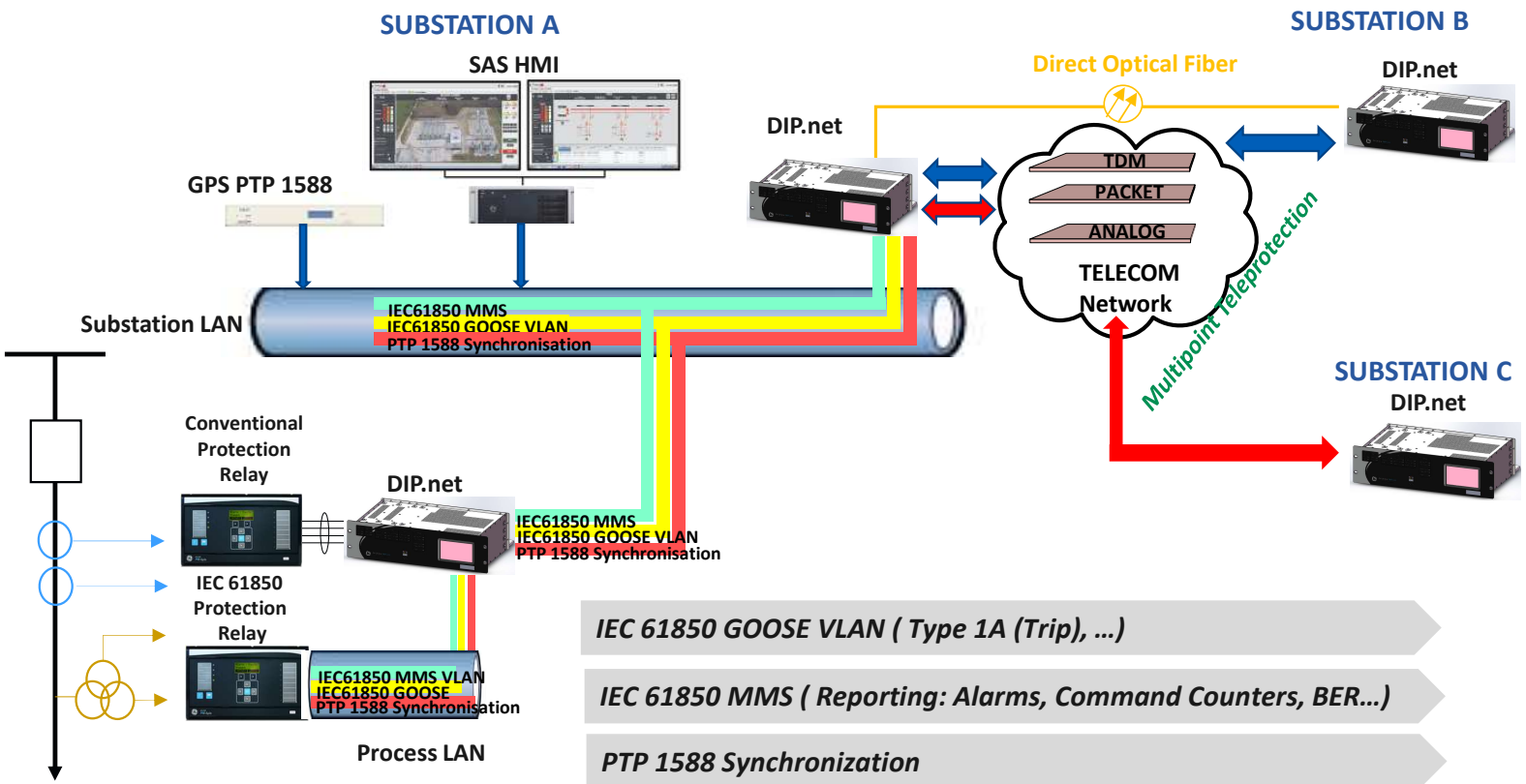
Flexible outputs :

- Heavy Duty Electromechanical relays
- Programmable Functions
  - Command Output
  - Command Copy
  - Alarm



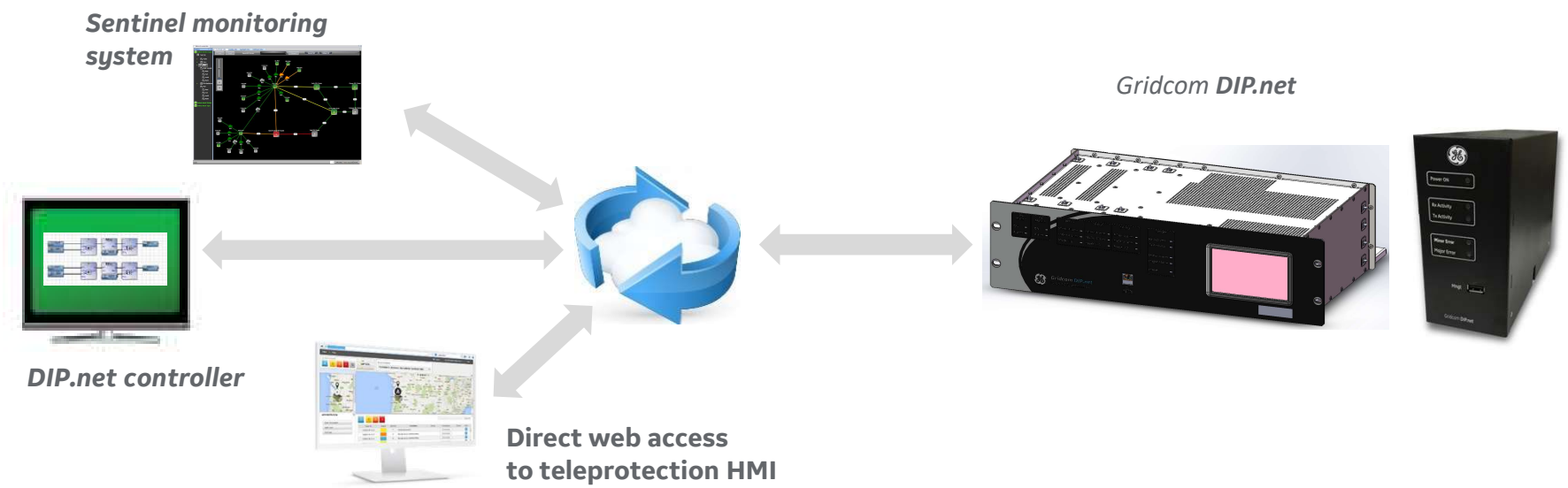
"boolean" combinations avoiding complex wiring. Less risks and installation cost saving

GE Gridcom DIP.net: Simultaneous I/O Hardwiring and GOOSE Messages Acquisition



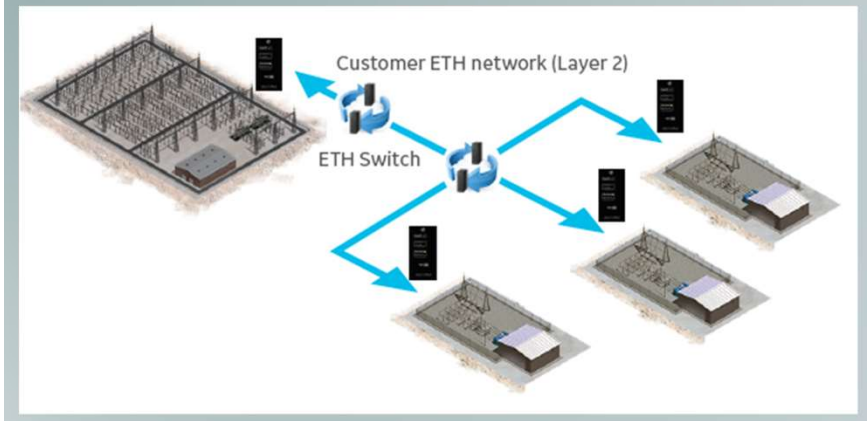
- *IEC 61850 GOOSE VLAN (Type 1A (Trip), …)*
- *IEC 61850 MMS (Reporting: Alarms, Command Counters, BER…)*
- *PTP 1588 Synchronization*
- *User Role Based Access Control (Radius) for WEB-HMI*

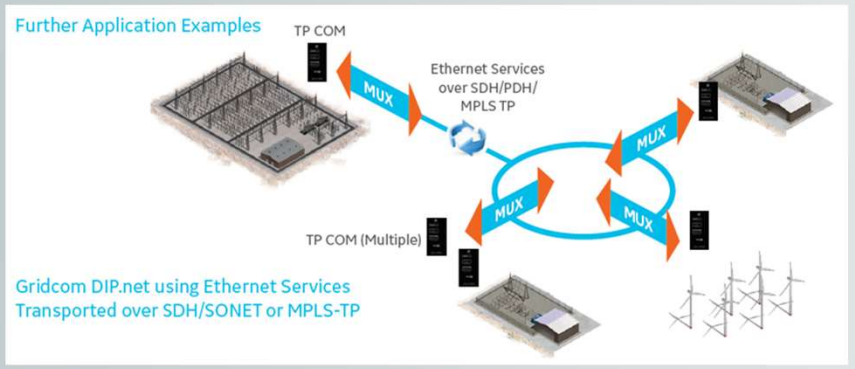
GE Gridcom DIP.net: Real Time Monitoring

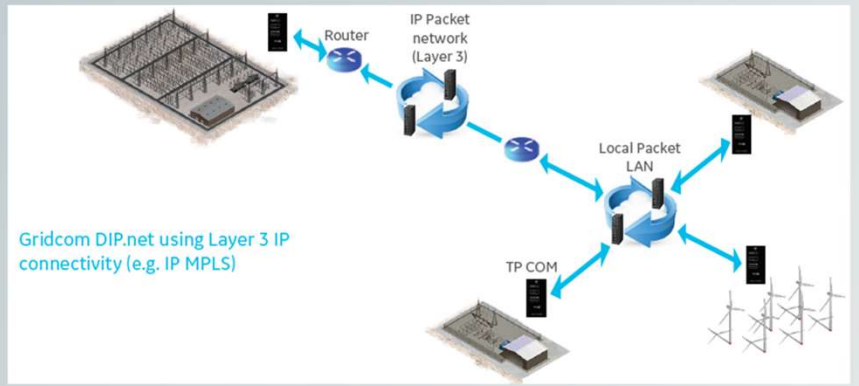


Ready for integration to overall telecom monitoring system
Real time monitoring

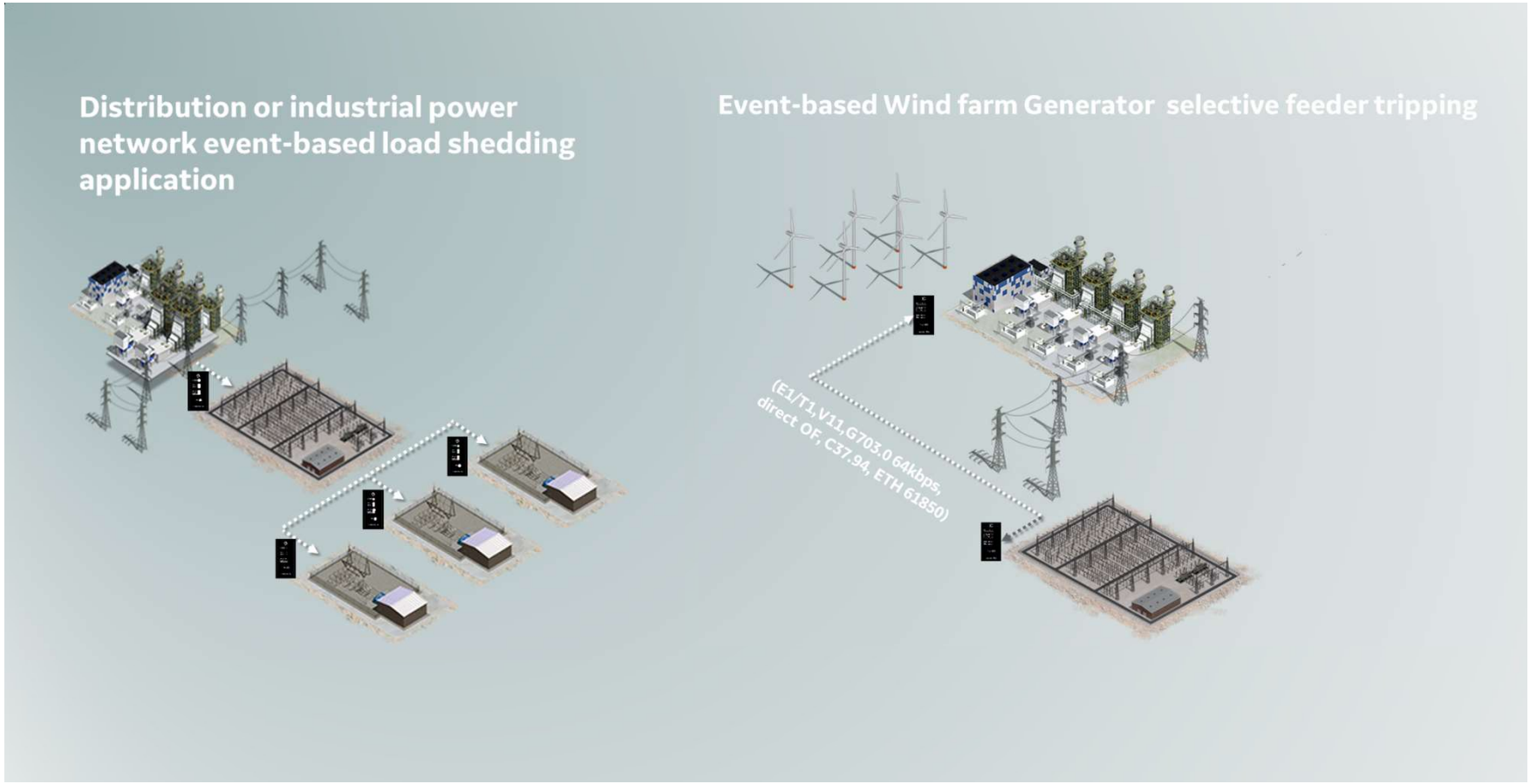
GE Gridcom DIP.net: From Legacy Circuit Network to Ethernet Packet Transport Network







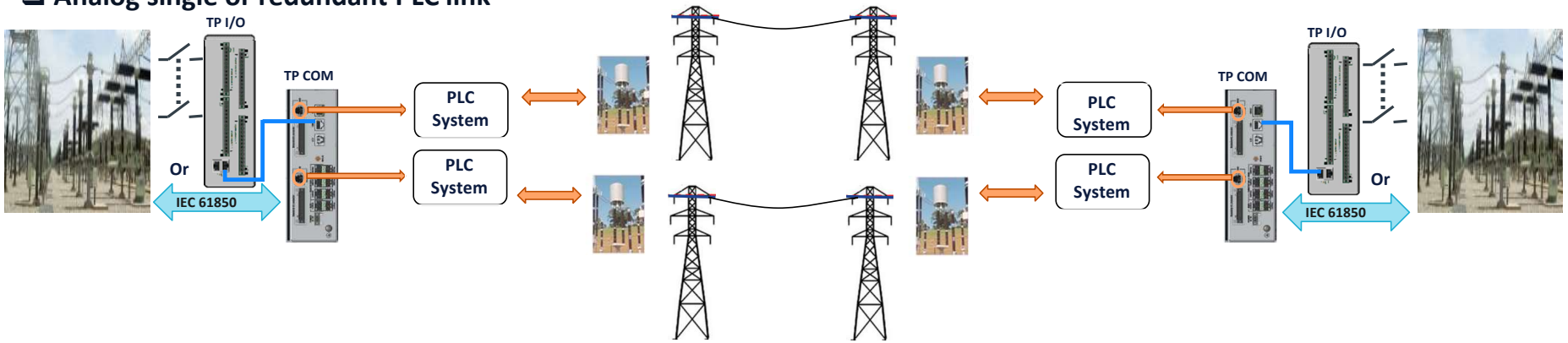
GE Gridcom DIP.net: Load Shedding & Event-Based Automation Schemes



GE Gridcom DIP.net: Application Examples

Analog Communication Link

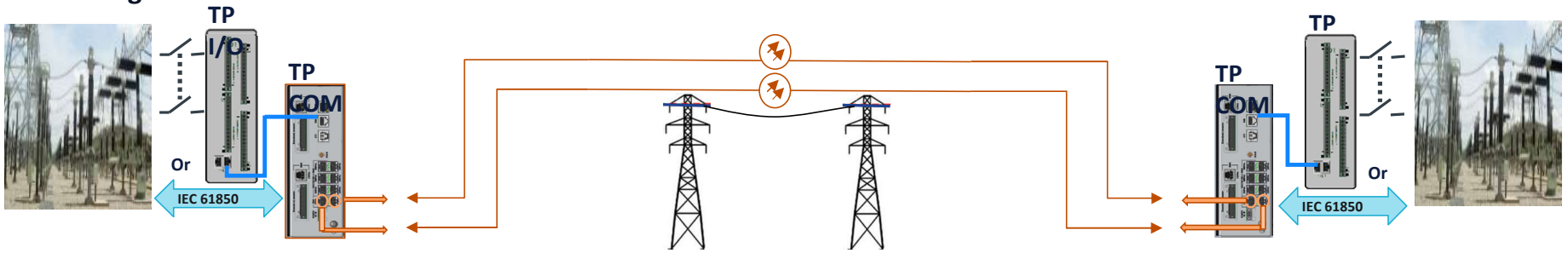
❑ Analog single or redundant PLC link



GE Gridcom DIP.net: Application Examples

Digital Communication Link

❑ Single or redundant Direct OF communication link

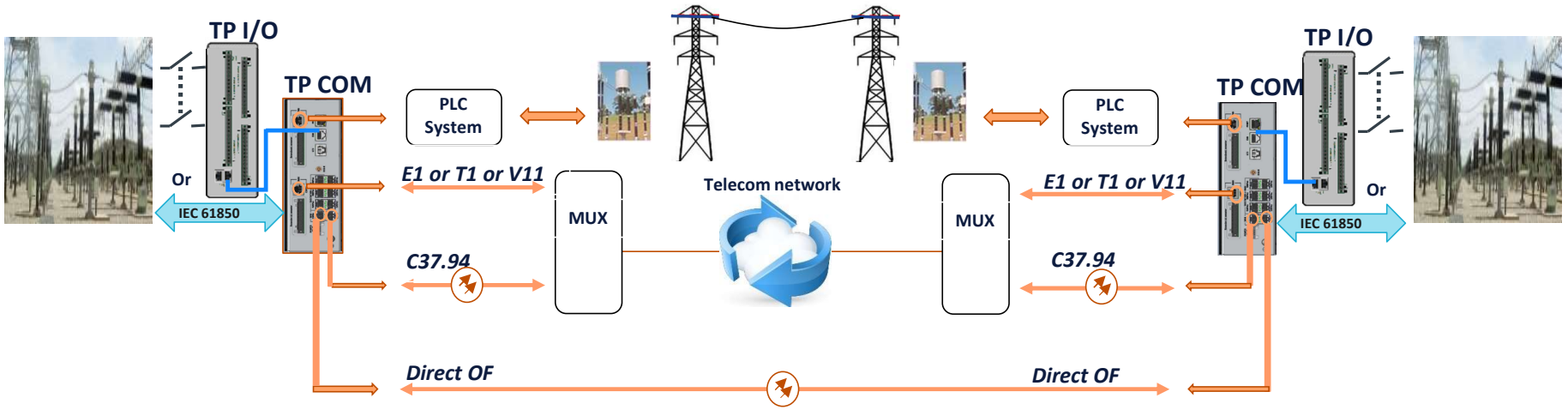


❑ Single or redundant E1 or T1 or V11 or C37.94 communication link

GE Gridcom DIP.net: Application Examples

Heterogeneous (Analog & Digital) Communication Link

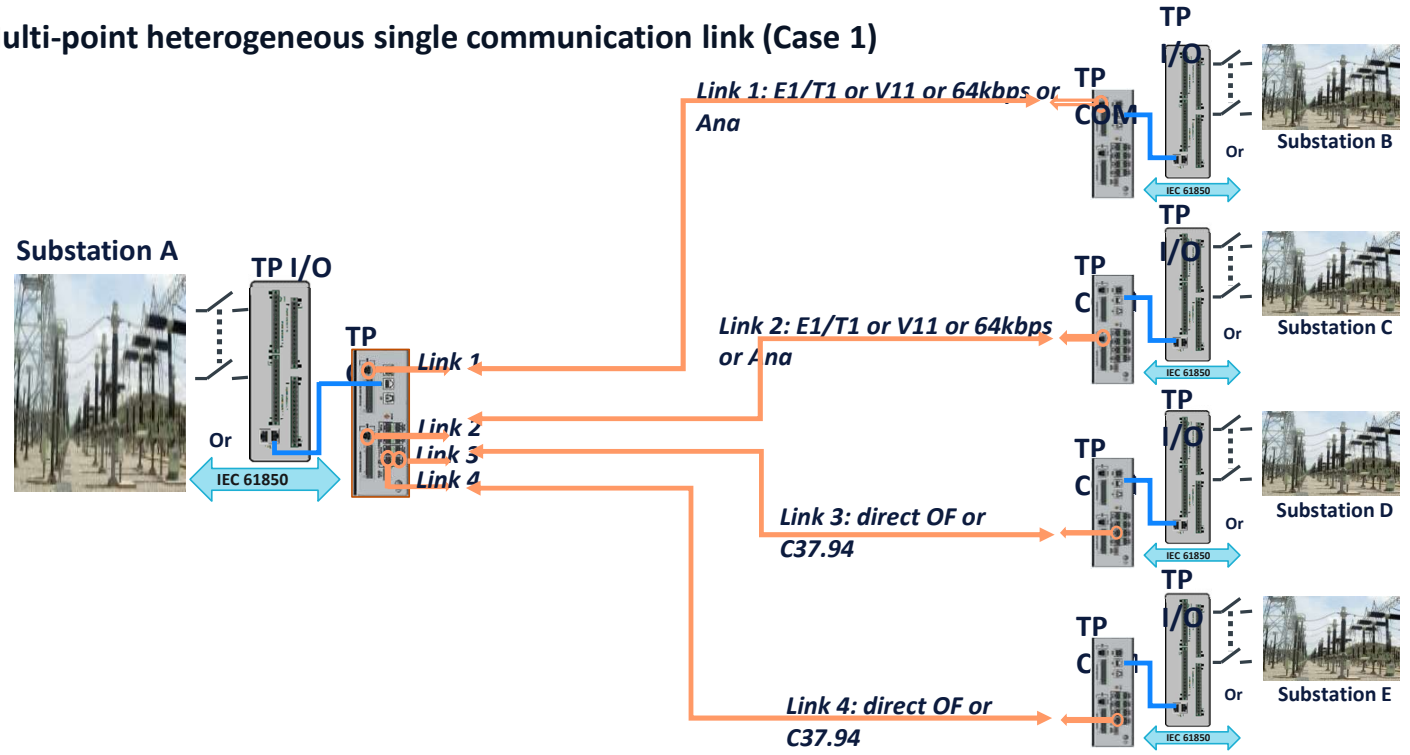
❑ Analog and Digital (or E1 or T1 or V11 or C37.94 or Direct OF) communication link



GE Gridcom DIP.net: Application Examples

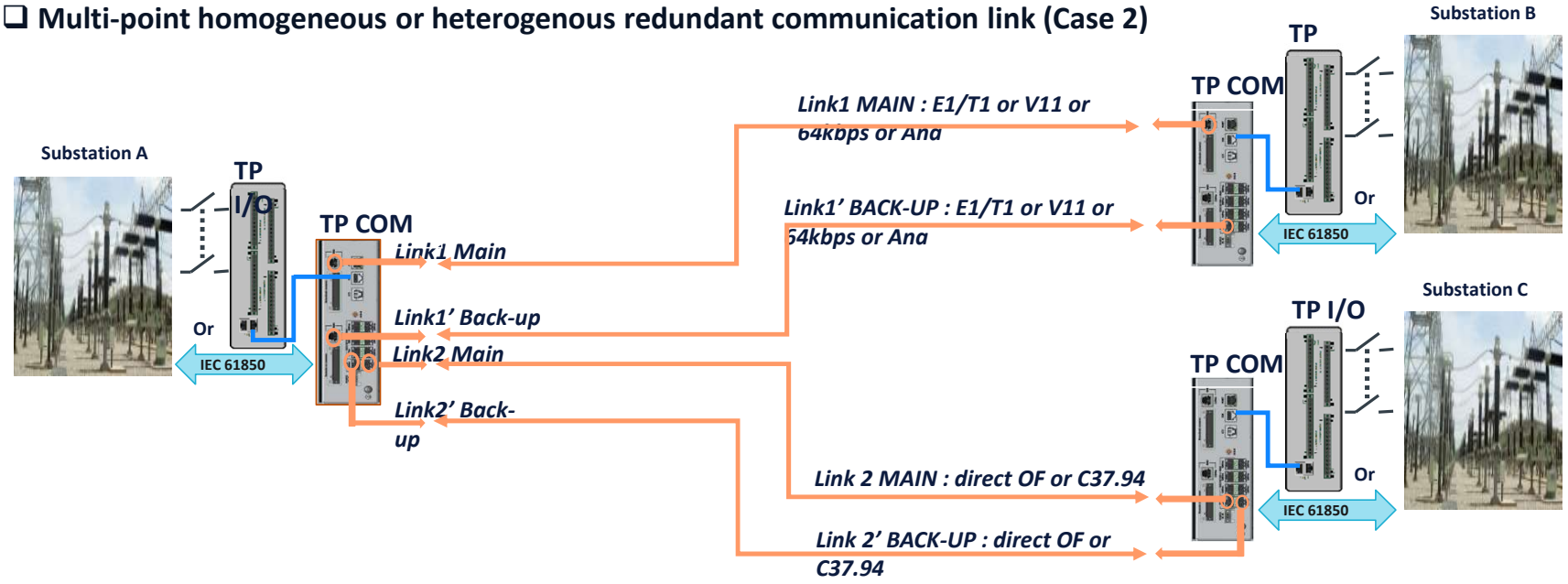
Multi-Point Teleprotection Application Examples

❑ Multi-point heterogeneous single communication link (Case 1)



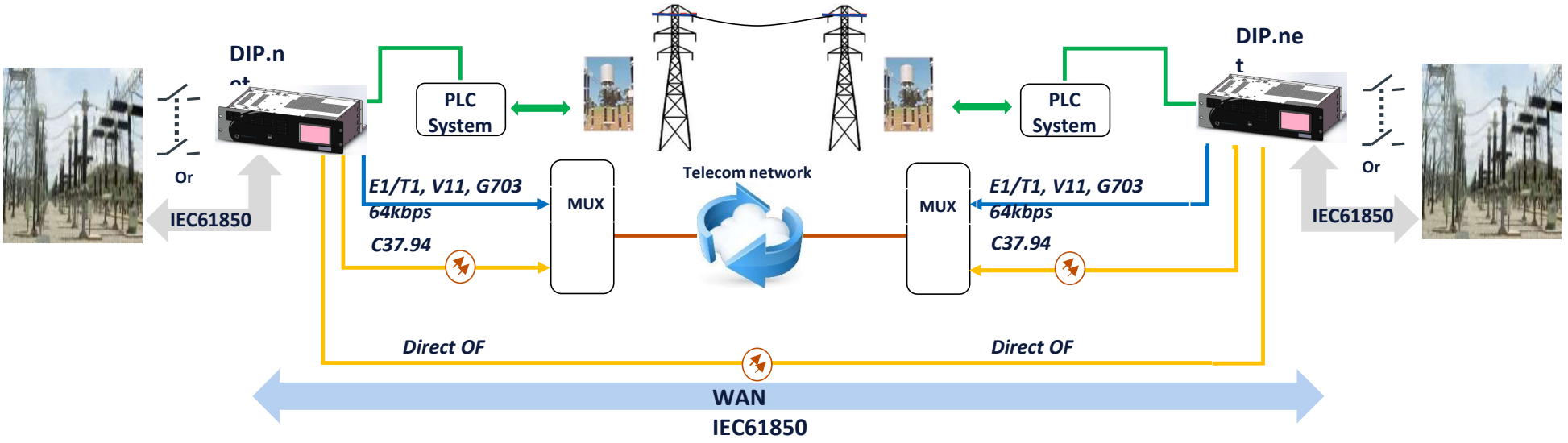
Multi-Point Teleprotection Application Examples

❑ Multi-point homogeneous or heterogenous redundant communication link (Case 2)

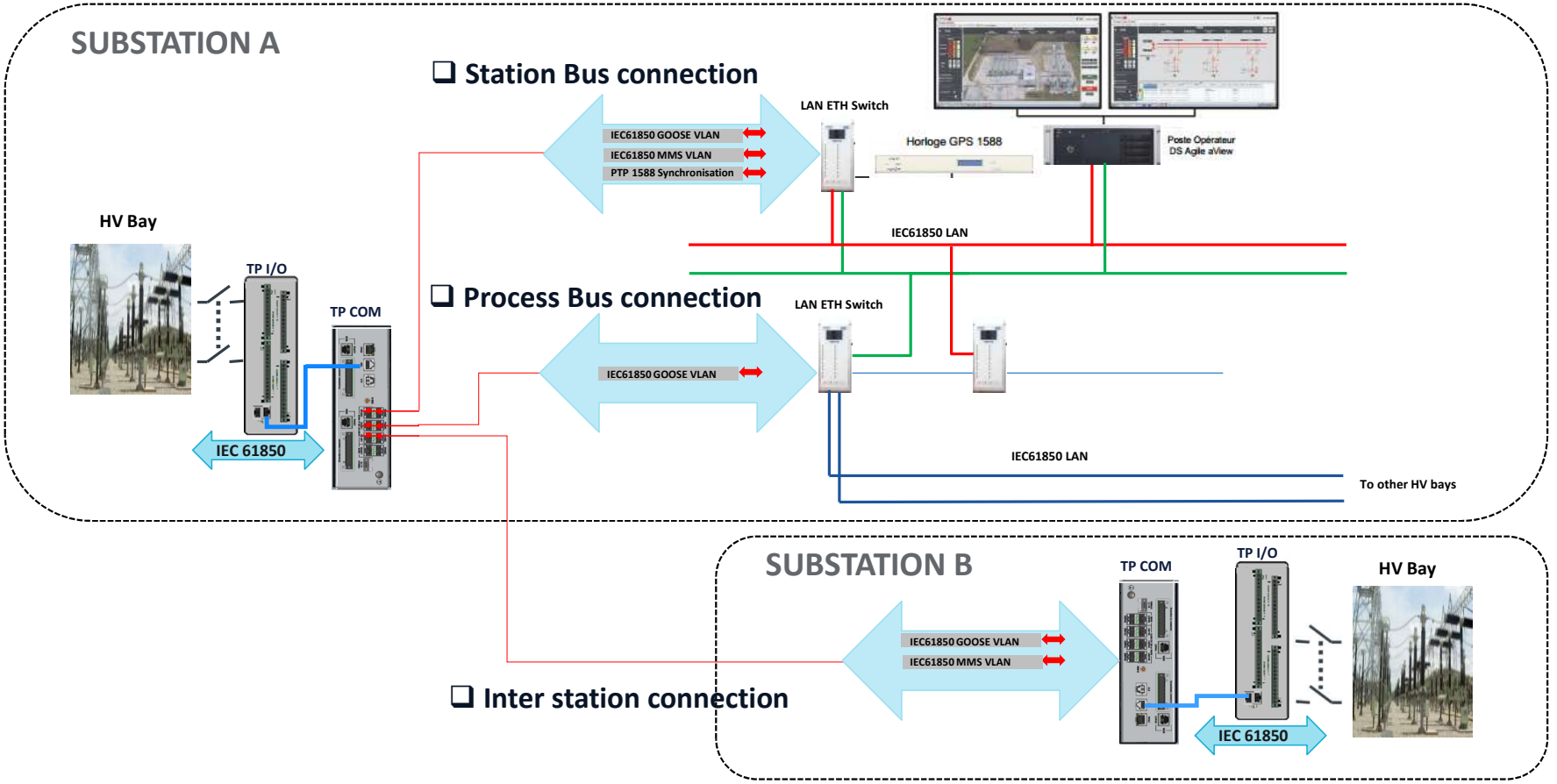


GE Gridcom DIP.net: Application Examples

- Analog and Digital (or E1 or T1 or V11 or G703 64kbps or C37.94 and/or Direct OF) communication link



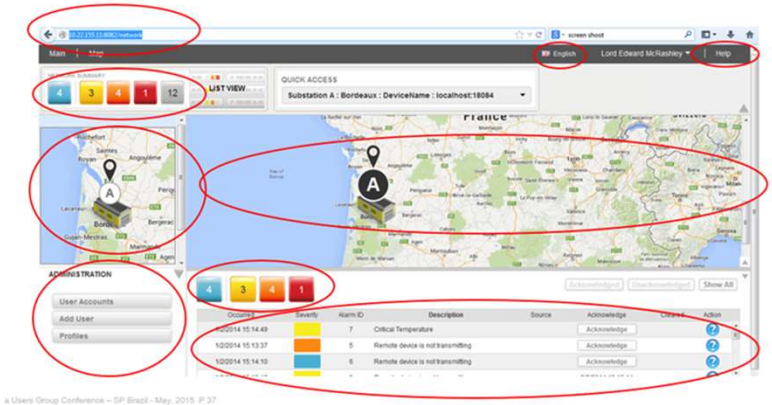
GE Gridcom DIP.net: IEC 61850 S/S Implementation



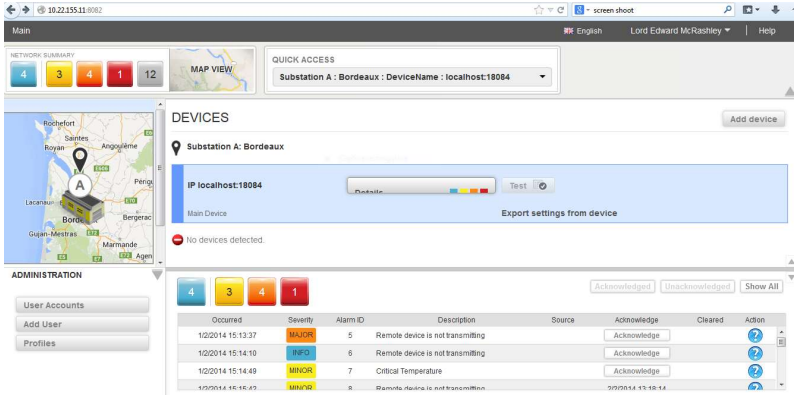
GE Gridcom DIP.net: HMI on Web Browser

GE Gridcom DIP.net: HMI on Web Browser

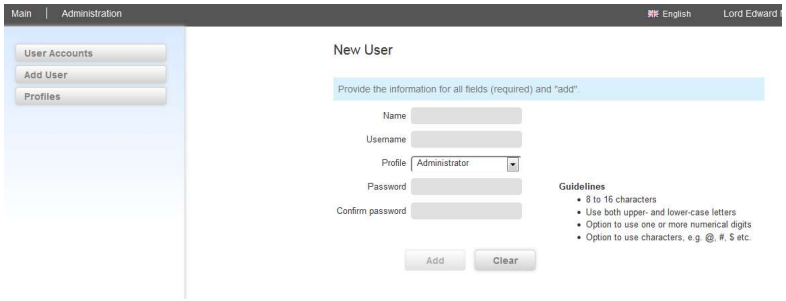
Instantaneous global view of the network, and status



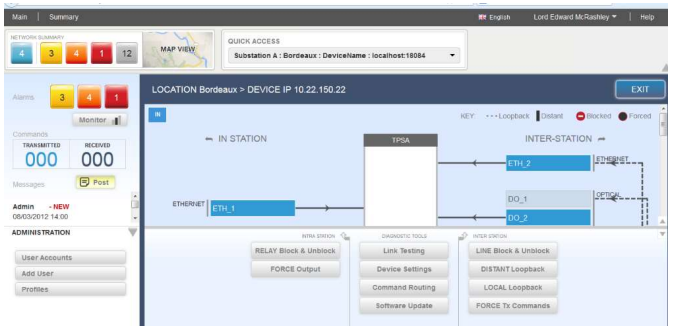
DIP.net HMI provides IP connection access to each equipment after an incident, highlighting the actual event on the module



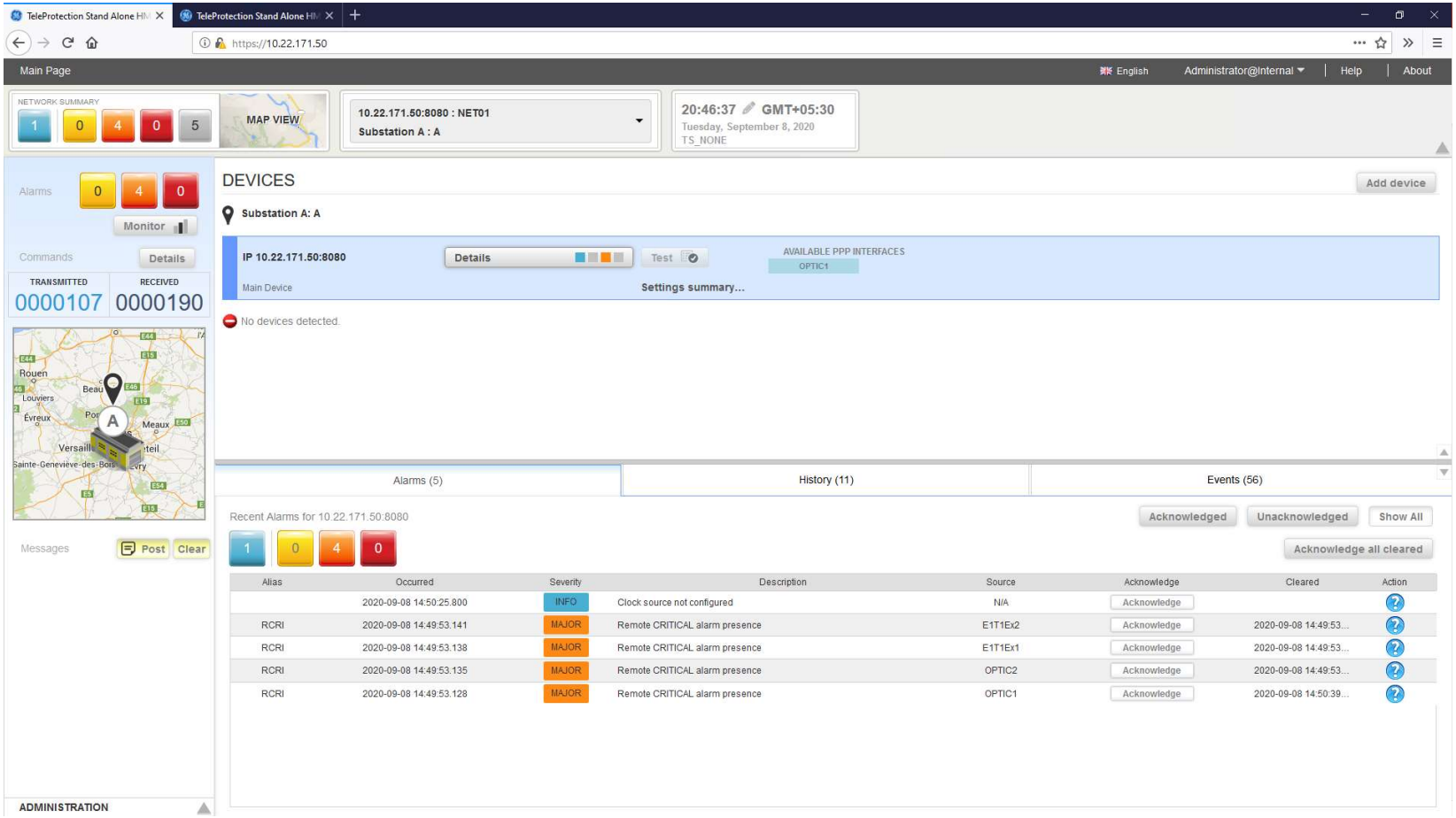
DIP.net HMI users account management.



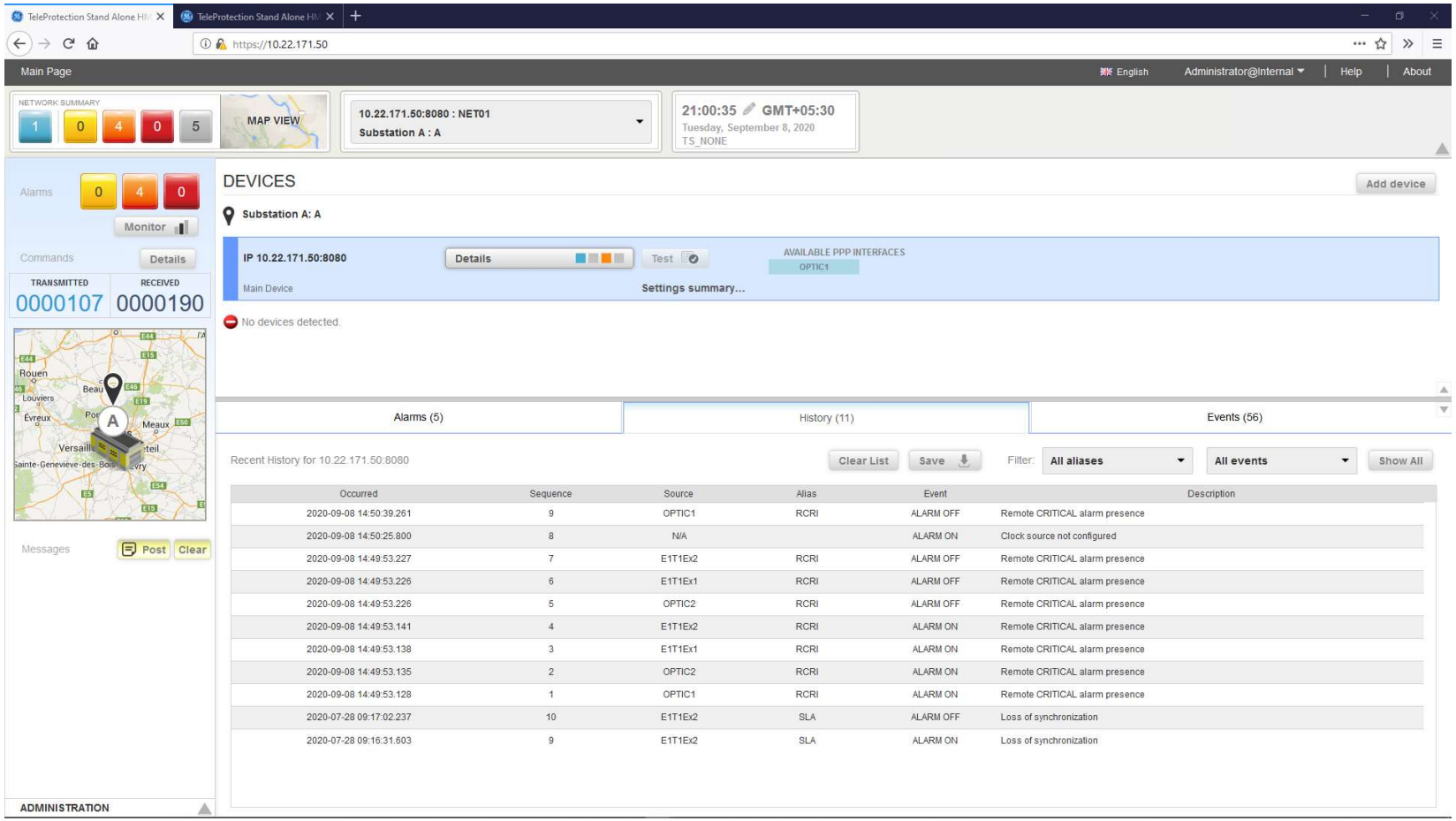
DIP.net HMI flexible inputs/outputs configuration and commands counter



GE Gridcom DIP.net: Alarm, History, Events & Counter

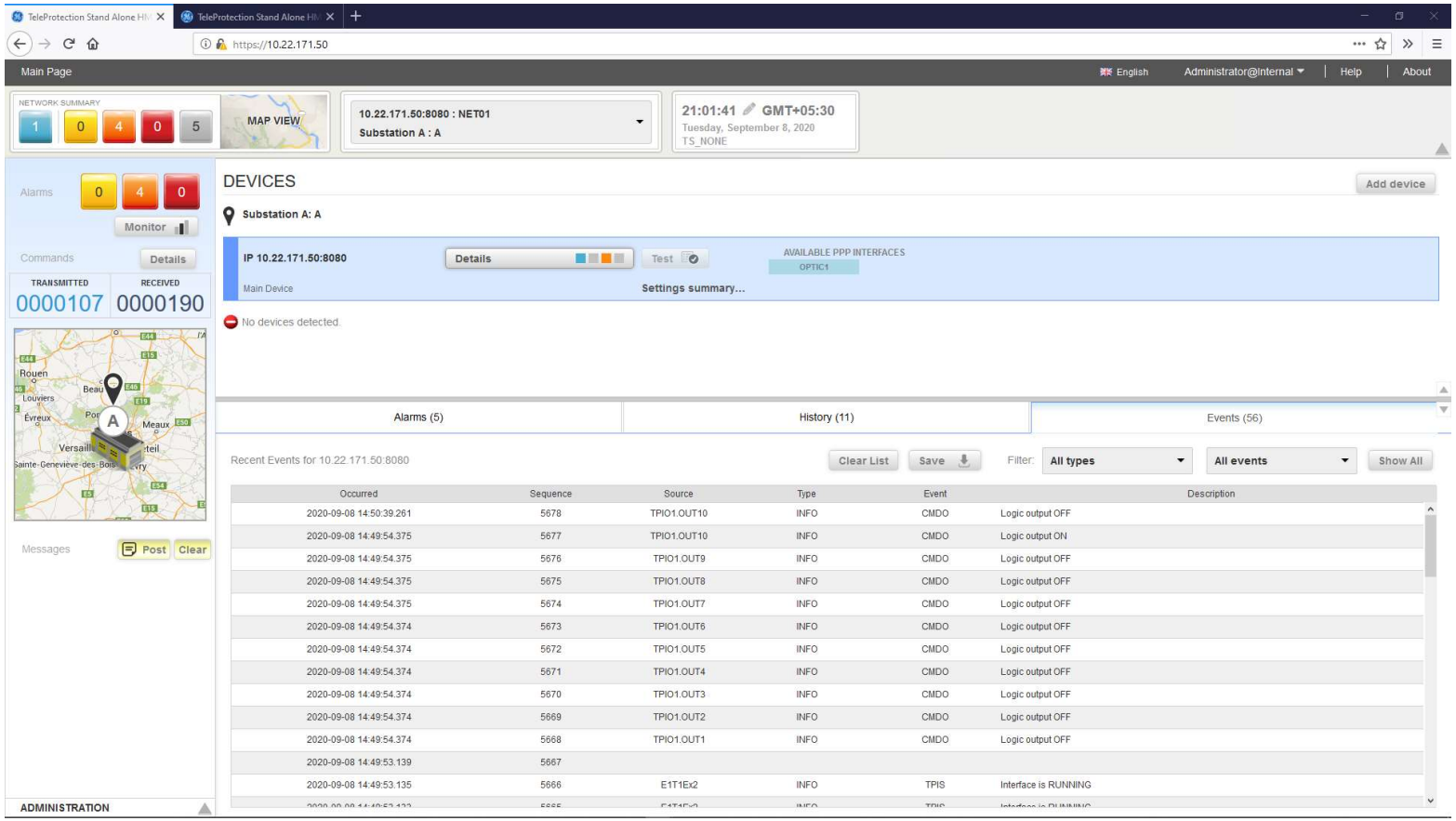


GE Gridcom DIP.net: History logger tab on Main Window

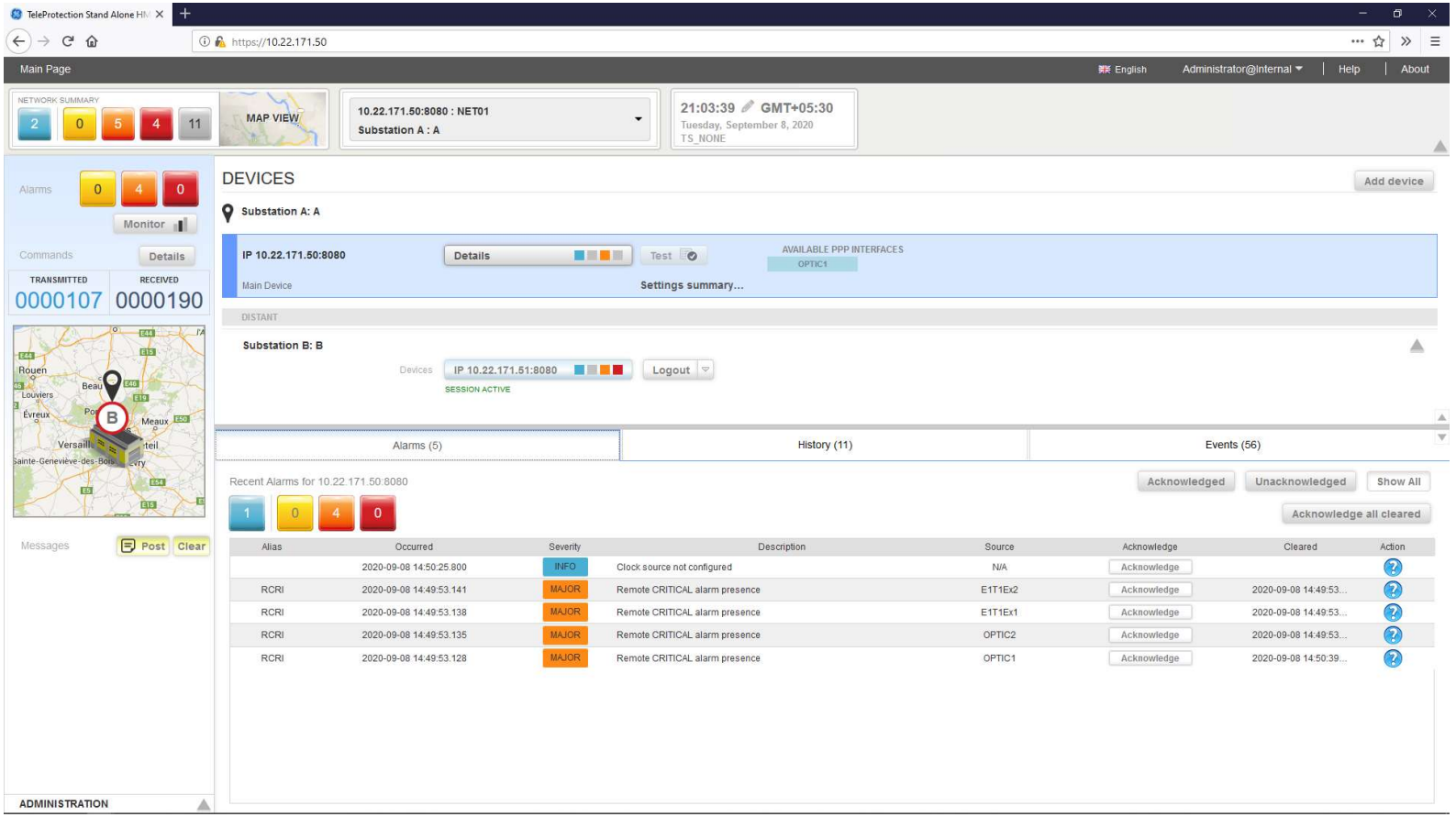


Occurred	Sequence	Source	Alias	Event	Description
2020-09-08 14:50:39.261	9	OPTIC1	RCRI	ALARM OFF	Remote CRITICAL alarm presence
2020-09-08 14:50:25.800	8	N/A		ALARM ON	Clock source not configured
2020-09-08 14:49:53.227	7	E1T1Ex2	RCRI	ALARM OFF	Remote CRITICAL alarm presence
2020-09-08 14:49:53.226	6	E1T1Ex1	RCRI	ALARM OFF	Remote CRITICAL alarm presence
2020-09-08 14:49:53.226	5	OPTIC2	RCRI	ALARM OFF	Remote CRITICAL alarm presence
2020-09-08 14:49:53.141	4	E1T1Ex2	RCRI	ALARM ON	Remote CRITICAL alarm presence
2020-09-08 14:49:53.138	3	E1T1Ex1	RCRI	ALARM ON	Remote CRITICAL alarm presence
2020-09-08 14:49:53.135	2	OPTIC2	RCRI	ALARM ON	Remote CRITICAL alarm presence
2020-09-08 14:49:53.128	1	OPTIC1	RCRI	ALARM ON	Remote CRITICAL alarm presence
2020-07-28 09:17:02.237	10	E1T1Ex2	SLA	ALARM OFF	Loss of synchronization
2020-07-28 09:16:31.603	9	E1T1Ex2	SLA	ALARM ON	Loss of synchronization

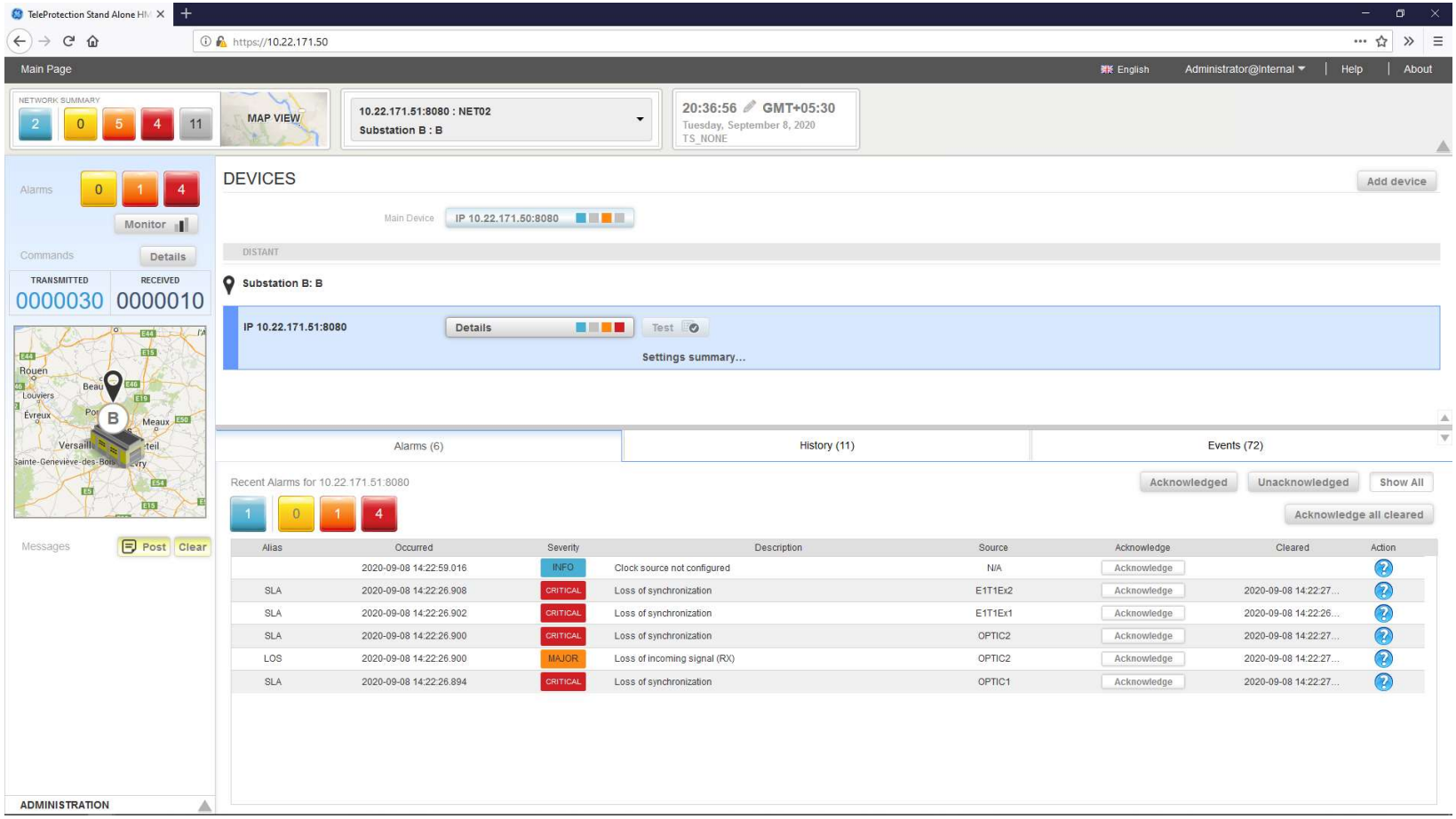
GE Gridcom DIP.net: Event logger tab on Main Window



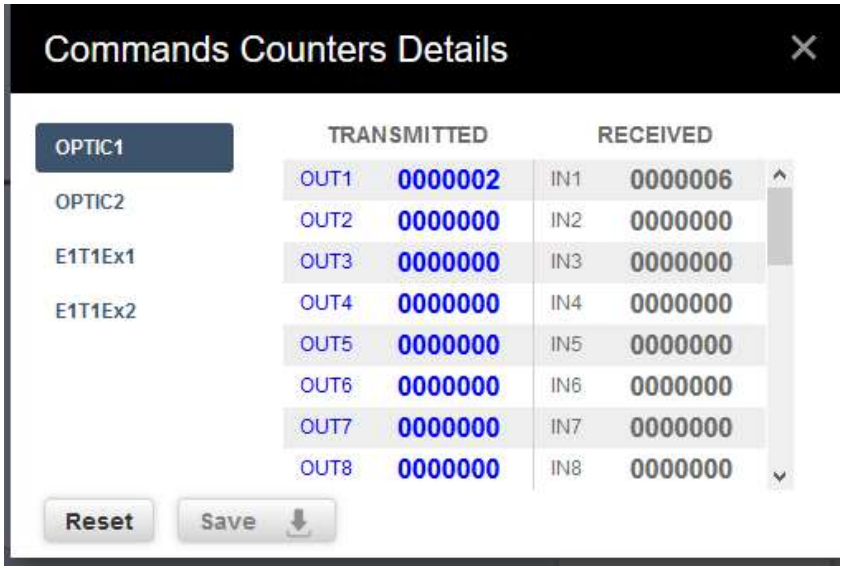
GE Gridcom DIP.net: Manage multiple devices through IP from single Window



GE Gridcom DIP.net: Access other DIP.Net devices in the Network



GE Gridcom DIP.net: Command Counter View for all Communication Channels



GE Gridcom DIP.net: Product Certification

STANDARDS & COMPLIANCE CERTIFICATION

Performance	
IEC60834-1	Teleprotection equipment of power systems
Electromagnetic compatibility	
IEC 61000-6-2	Immunity for industrial environments
IEC 61000-6-4	Emission standard for industrial environments
IEC 61000-6-5 + IEC 60834	Immunity for power station and substation environments
IEEE C37.90.1 / C37.90.2 / C37.90.3	IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
Safety testing	
EN 60950-1	Safety
Environmental testing	
Climatic	
IEC 60068-2-1	Temperature during operation
IEC 60068-2-1	Storage temperature
Mechanic	
IEC 60068-2-6	Sinusoidal vibration, shocks and bump
Digital substation interoperability	
IEC 61850-7-2	Abstract communication service interface
IEC 61850-8-1	Mappings to MMS (ISO/IEC9506-1 and ISO/IEC 9506-2)
IEC 61850-10	Conformance testing