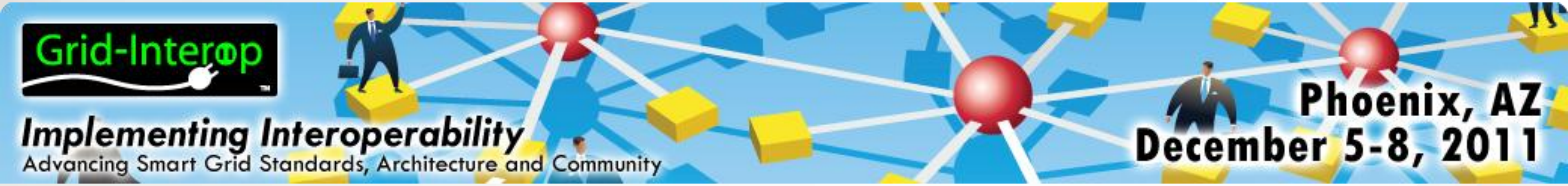


Grid Communications Protocol Interoperability on Converged Virtual IP networks

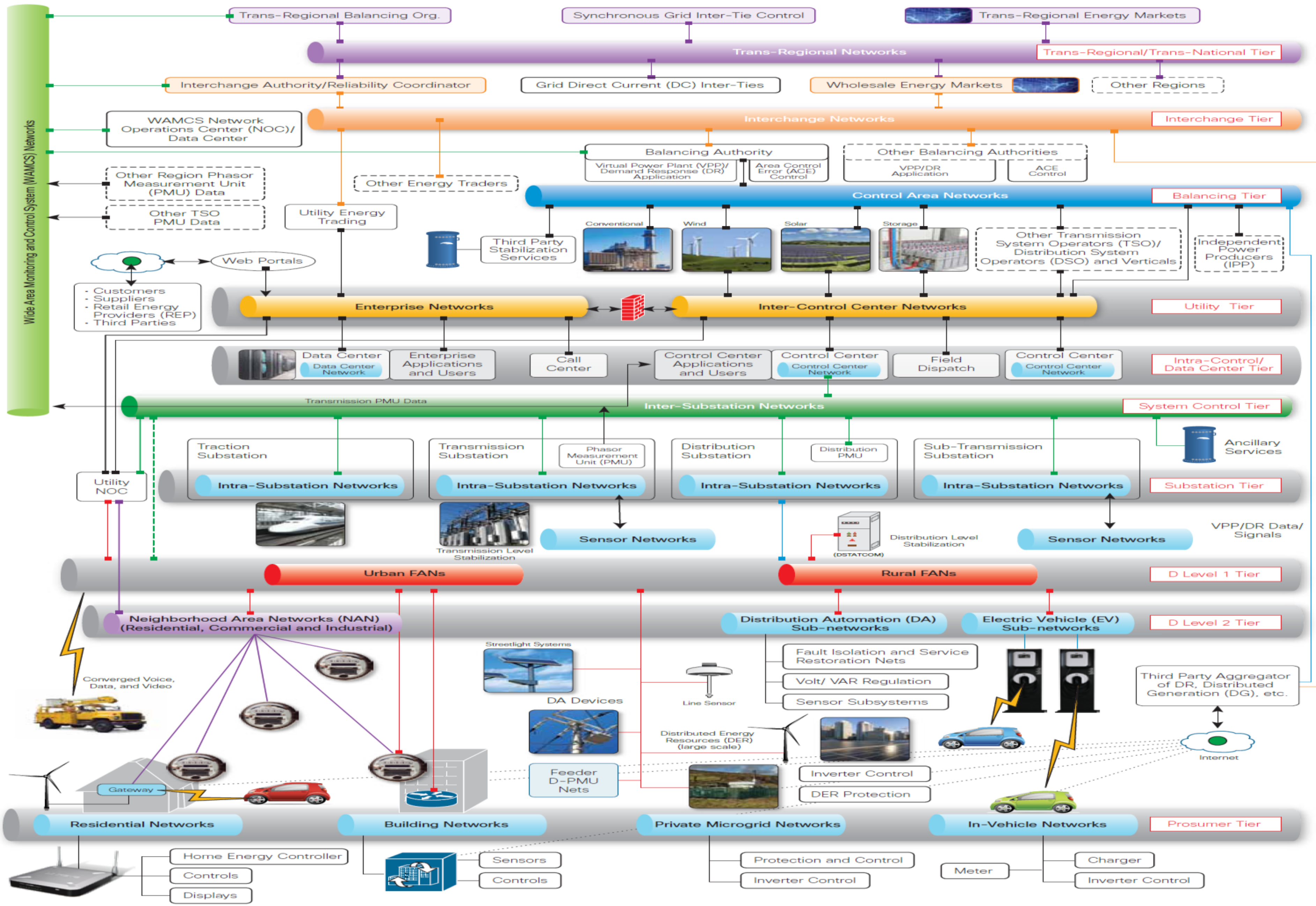
Eruch Jal Kapadia

Sr. Solutions Architect, Cisco Systems Inc.

Agenda

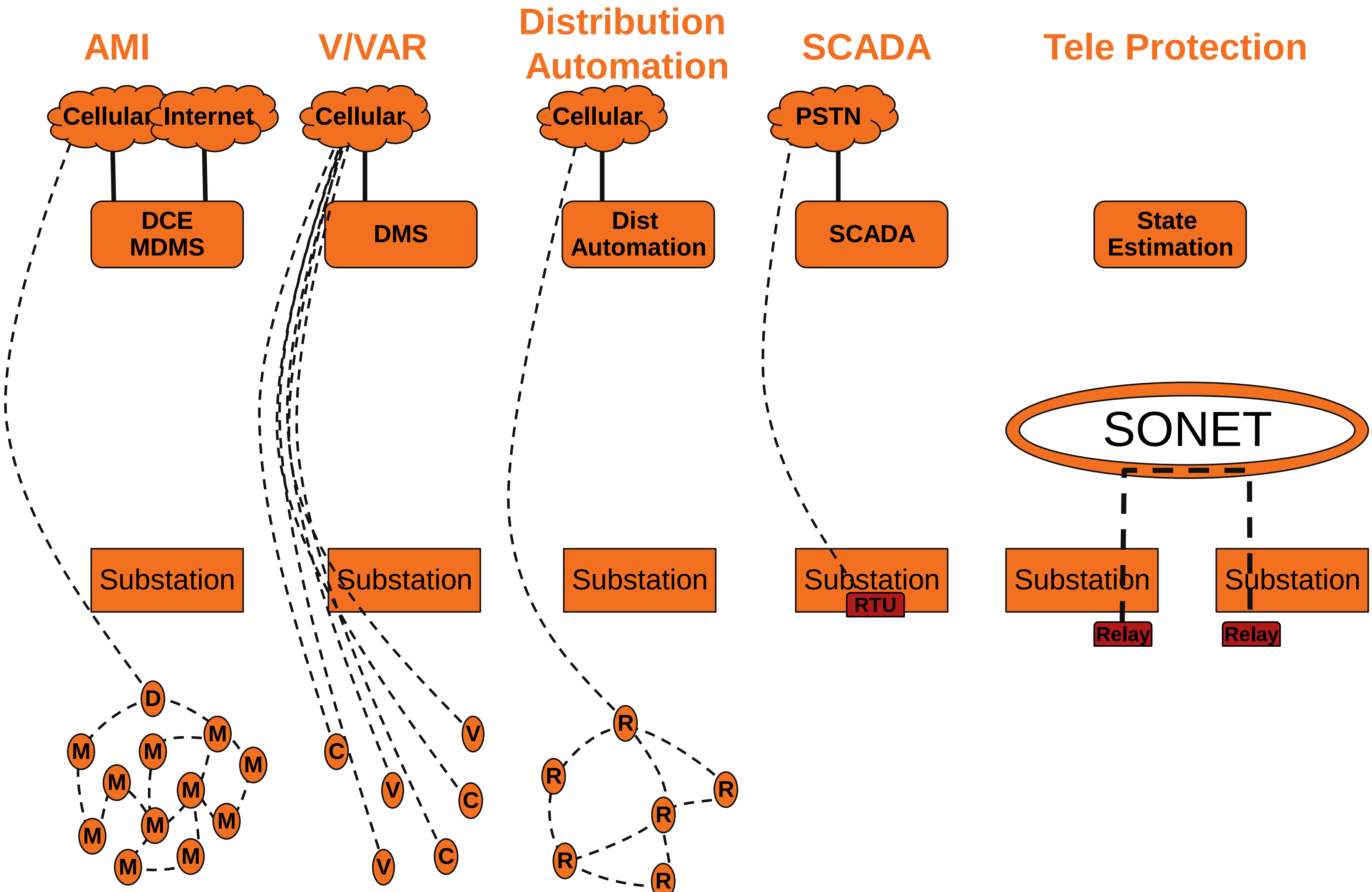
- Architecture
    - Reference Model
    - Building a Converged Architecture
- Converging on IP
- Architecture Discussion
    - Converged WAN
    - Transport MPLS-TP
- Protocol Interoperability

Cisco GridBlocks™ Reference Model



The Legacy Approach to Grid Apps

Promotes Multiple Silo'd Networks/Systems



Building a Converged Architecture

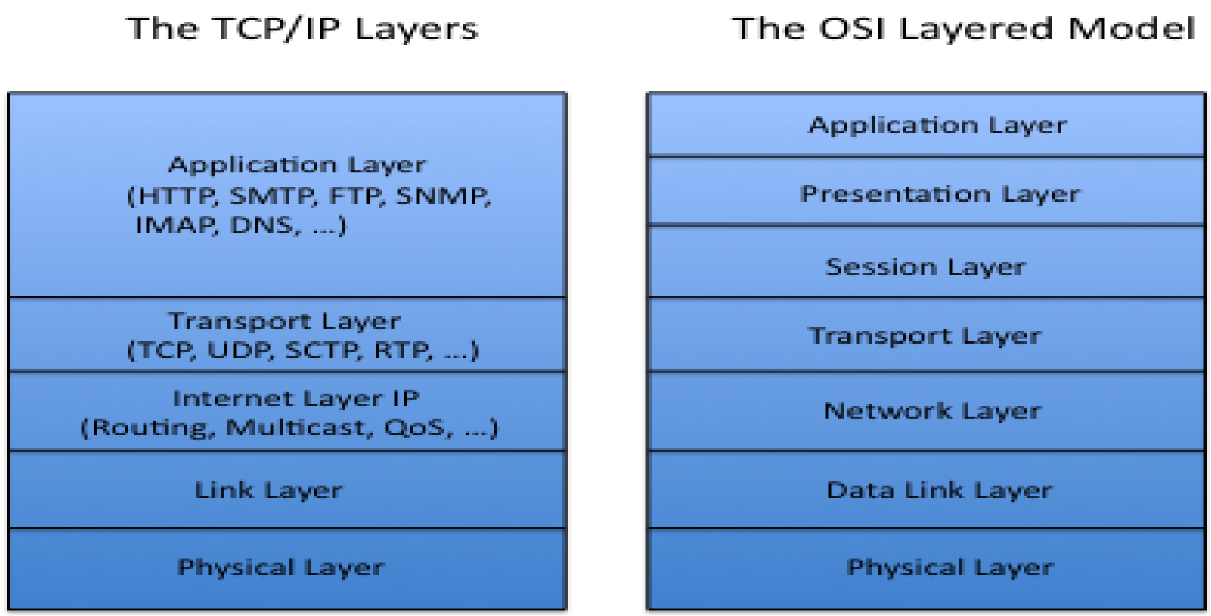
A Converged Communications Architecture Is One which Brings Together a Diverse Set of Functions to Share a Common Set of Resources, Driving Down Cost, and Synergistically Creating New Efficiencies by Increasing Interaction Between Them.

Traditional View		+	New Interpretation	
Transport Convergence	• Using the same underlying transport to meet communications requirements for multiple types of traffic		Intelligence	• Allow elements (including apps) to analyze information, make collaborative decisions and exercise control cutting across domains to which they belong
Protocol Convergence	• Allowing elements talking diverse protocols to communicate with each other		Services	• A uniform set of service (such as security) policies spread across the environment adhering to overall business objectives
Technology Convergence	• Multiple technologies (voice, data etc.) over the same underlying infrastructure		Design	• Architectural development in a manner which allows modularity as well as architectural leverage across networks

Converging on IP

IP is not just a protocol but an architecture

- Architecture

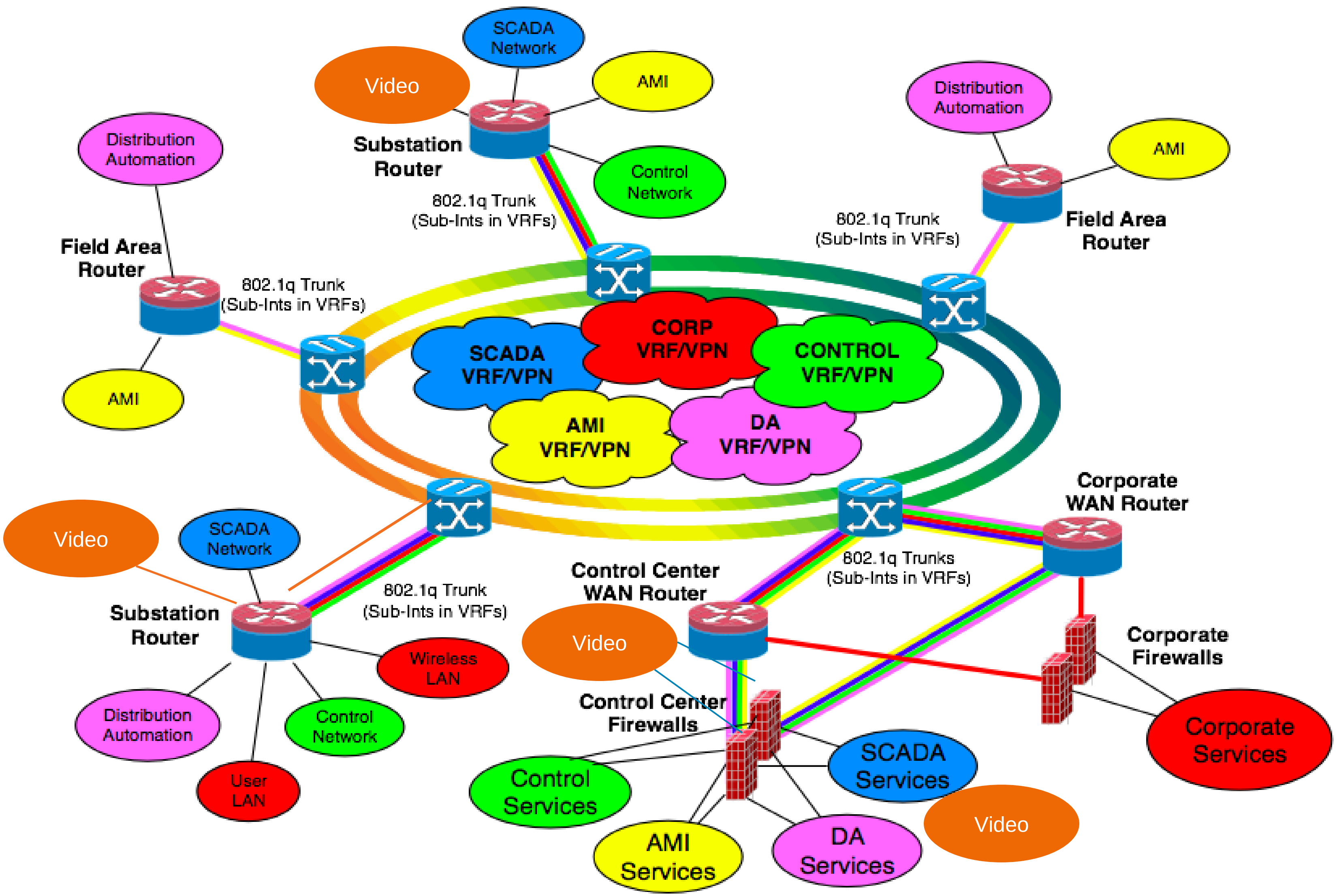


- Seeking a *global* optimum *NOT Local* excellence
- Jack of everything but not optimized for anything

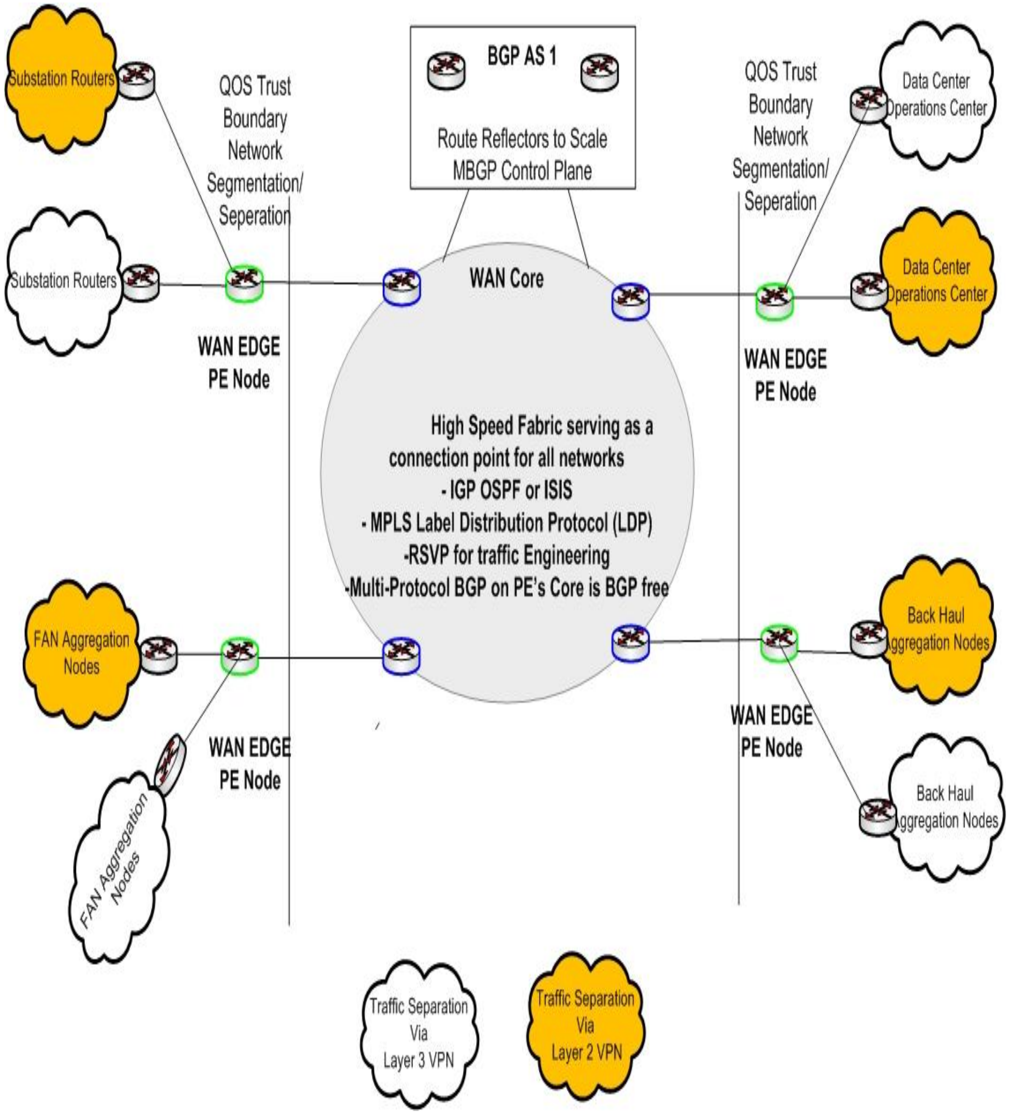
WAN – Converge with IP/MPLS

Converged WAN

Virtual Segmentation in the Core



WAN Architecture: MPLS Single Core



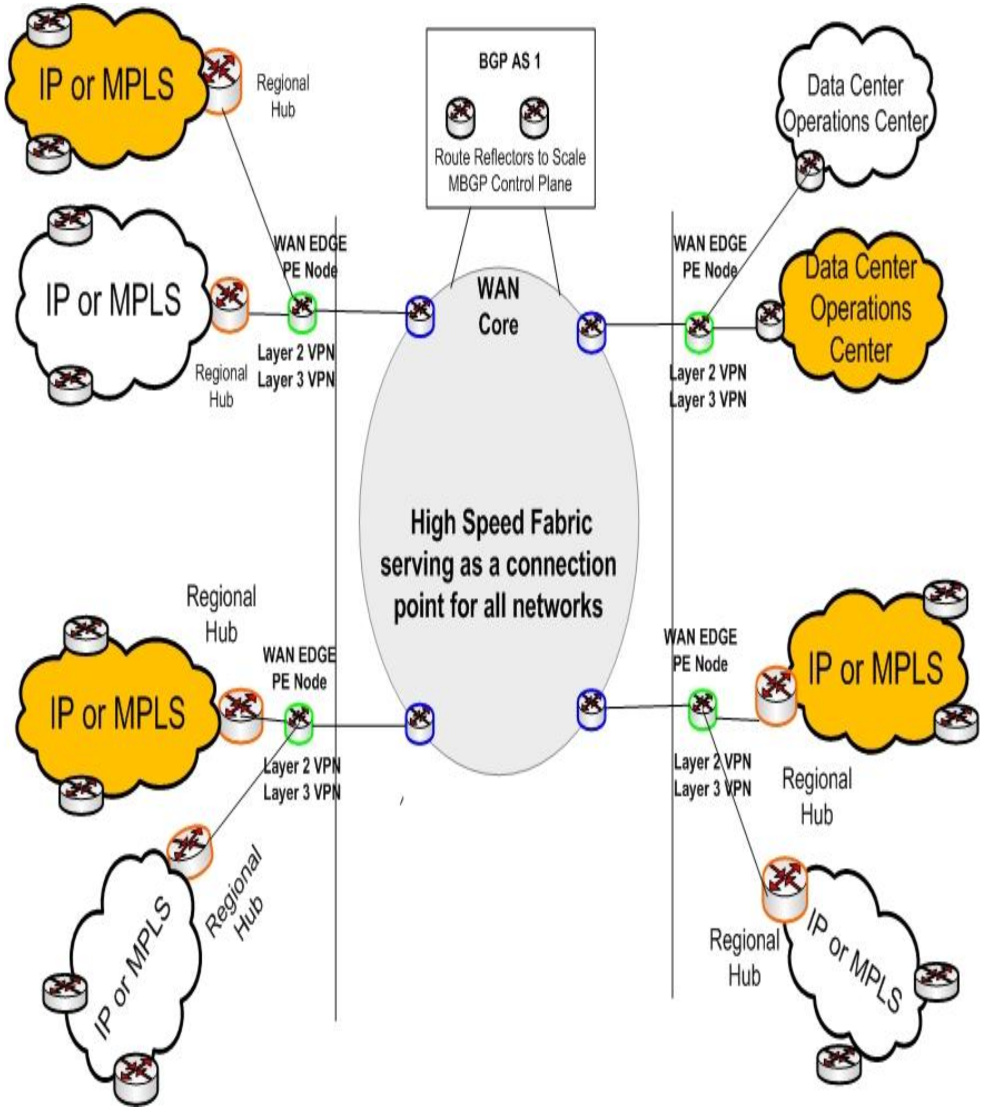
Model Characteristics

•Single core, Layer 2 & 3 VPN services

• Segmentation: Layer 3 VPN offers layer 3 controlled policy based segregation enabling multiple zones. Layer 2 VPN to provide layer 2 transport for utility applications e.g. 61850

• Convergence: MPLS TE with fast reroute to achieve <50 ms link failure recovery in core and sub-second recovery for node failure

WAN Architecture: Regionalized Domains



Model Characteristics

- Extends the single core Model
- Regionalized MPLS Core w/ Layer 2 and Layer 3 VPN services

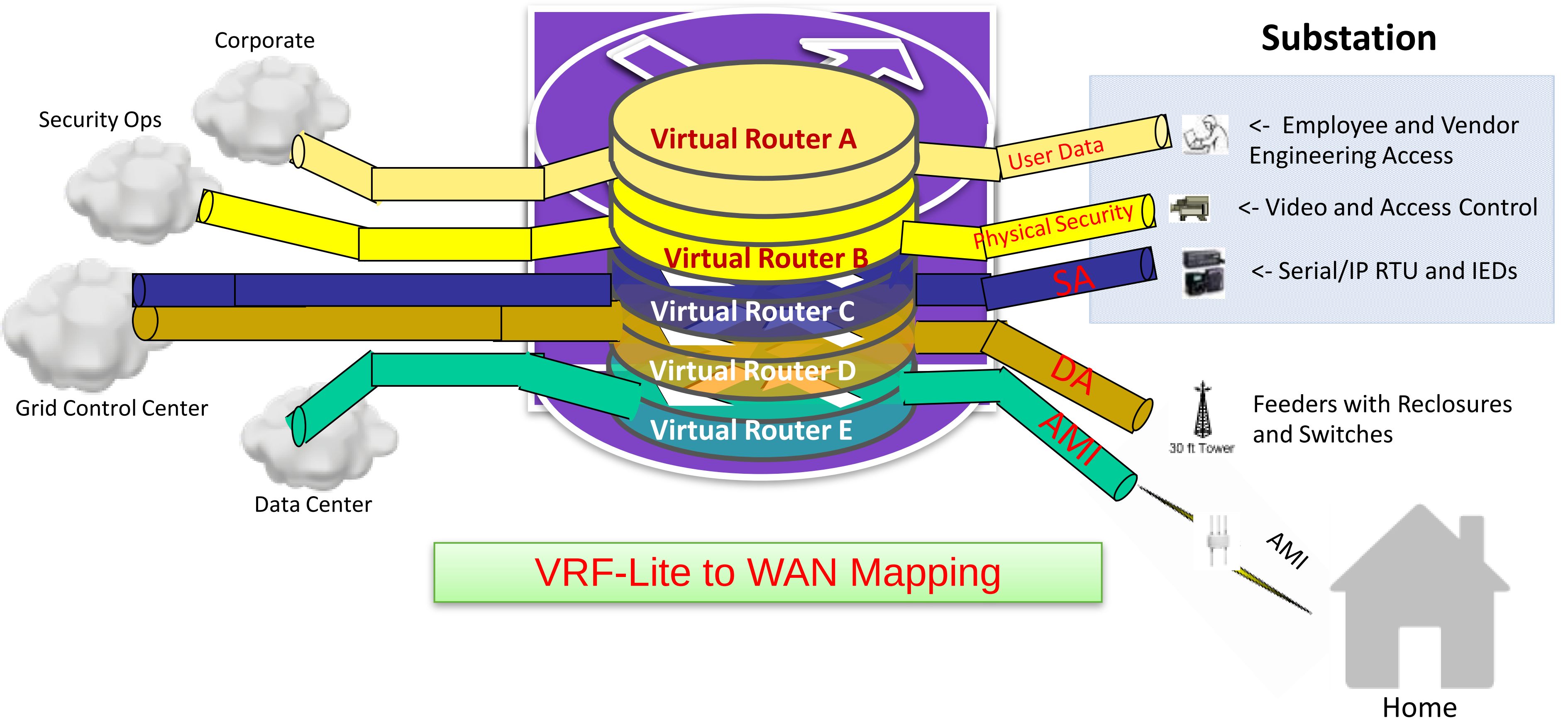
Segmentation:

- Multiple utility domains based on service level or regional boundaries.
- Domain can be IP or IP/MPLS
- Shared resources like Control or Data Centers are directly connected to inner Core.

QoS

- Defined at the edge and for the MPLS domain. MPLS QoS for all domains is similar to assure transport of the QoS parameters through the MPLS core

WAN Edge Segmentation with VRFs

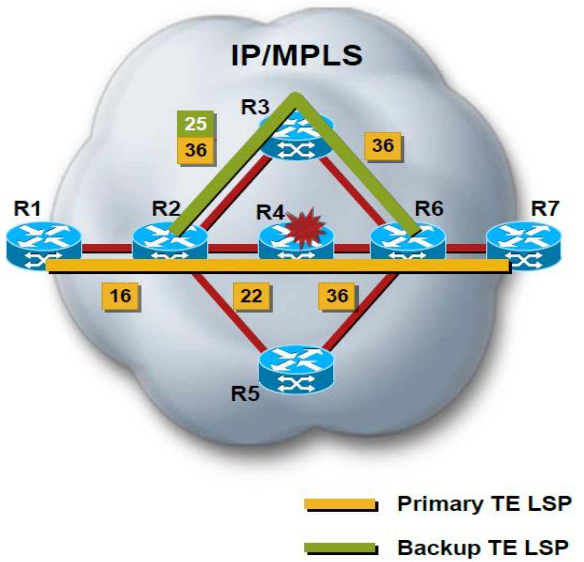


VRF-Lite to WAN Mapping

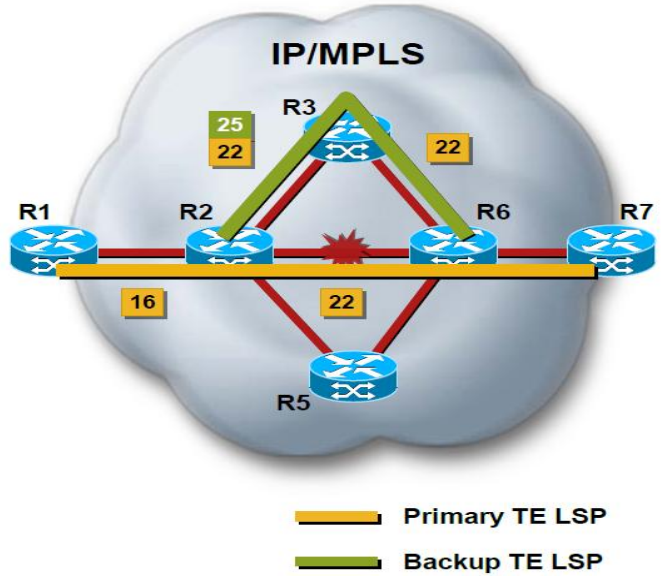
IP/MPLS perception Corrected

- IP/MPLS may take too long to converge to meet the requirements of utility operational requirements.
- Solution: Use the Fast Reroute capability to achieve <50 ms Link failure recovery and sub-second recovery times for node failures.

Node Protection



Link Protection



Transport

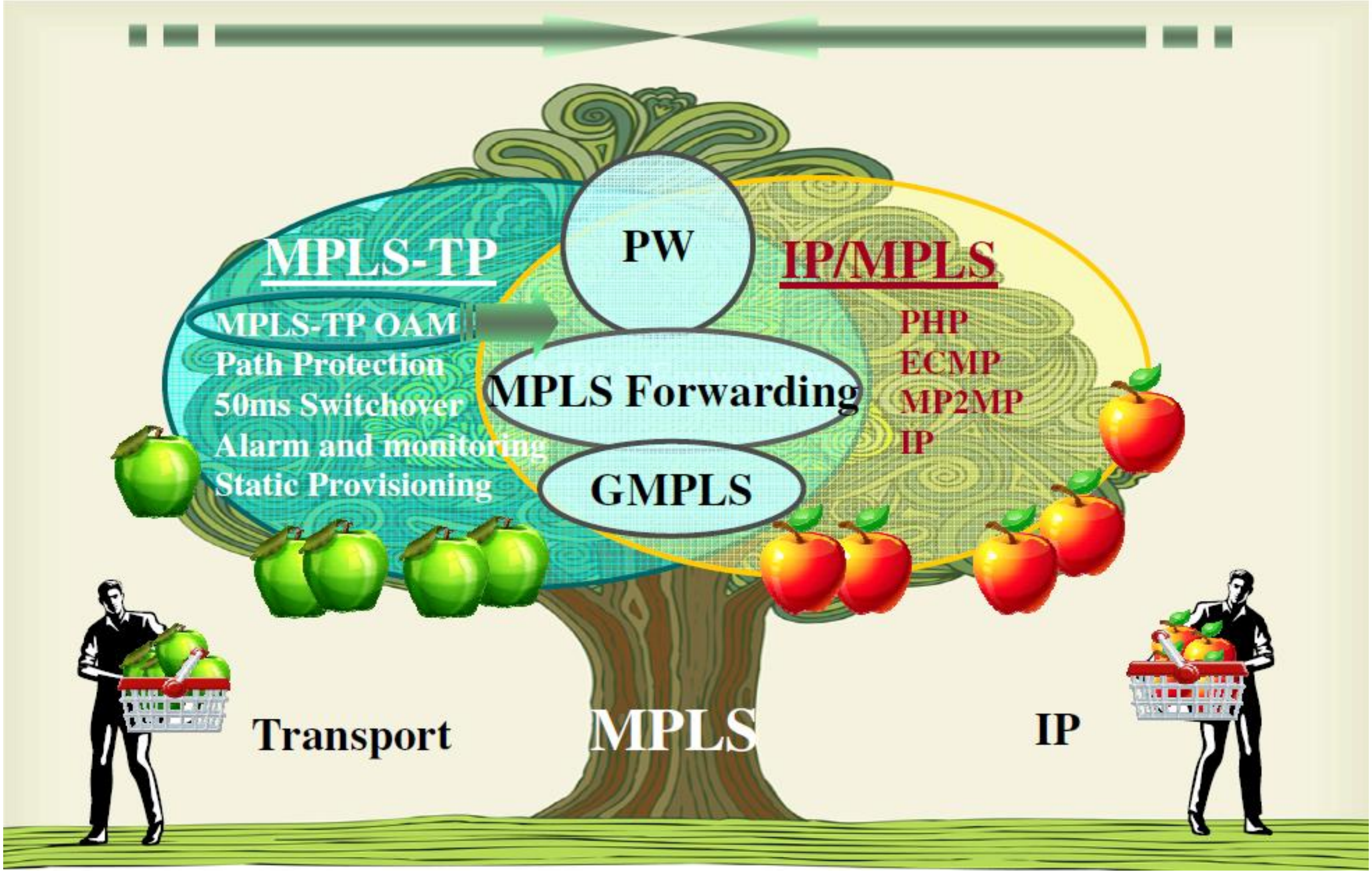
SONET perception

- SONET is the only preferred transport choice for utilities due to it resiliency, convergence and OAM (management)

Reality:

- Future is all packet. Past – TDM, Today – TDM & Packet, Future – All Packet
- Forcing packets into Sonet/SDH framing is an inefficient means of transport; operators had no other choice but to transport packets over Sonet/SDH to use its management, resiliency, and reliability functions.
- MPLS-TP and OTN incorporate the OAM, resiliency and are more scalable
- In addition, there is tremendous momentum around 100G transport as the next-gen core transport rate. Yet, the Sonet/SDH standards have been capped at 40G rates (256 VC-4 in SDH or 768 STS-1-SPE in SONET).

Transport and IP convergence

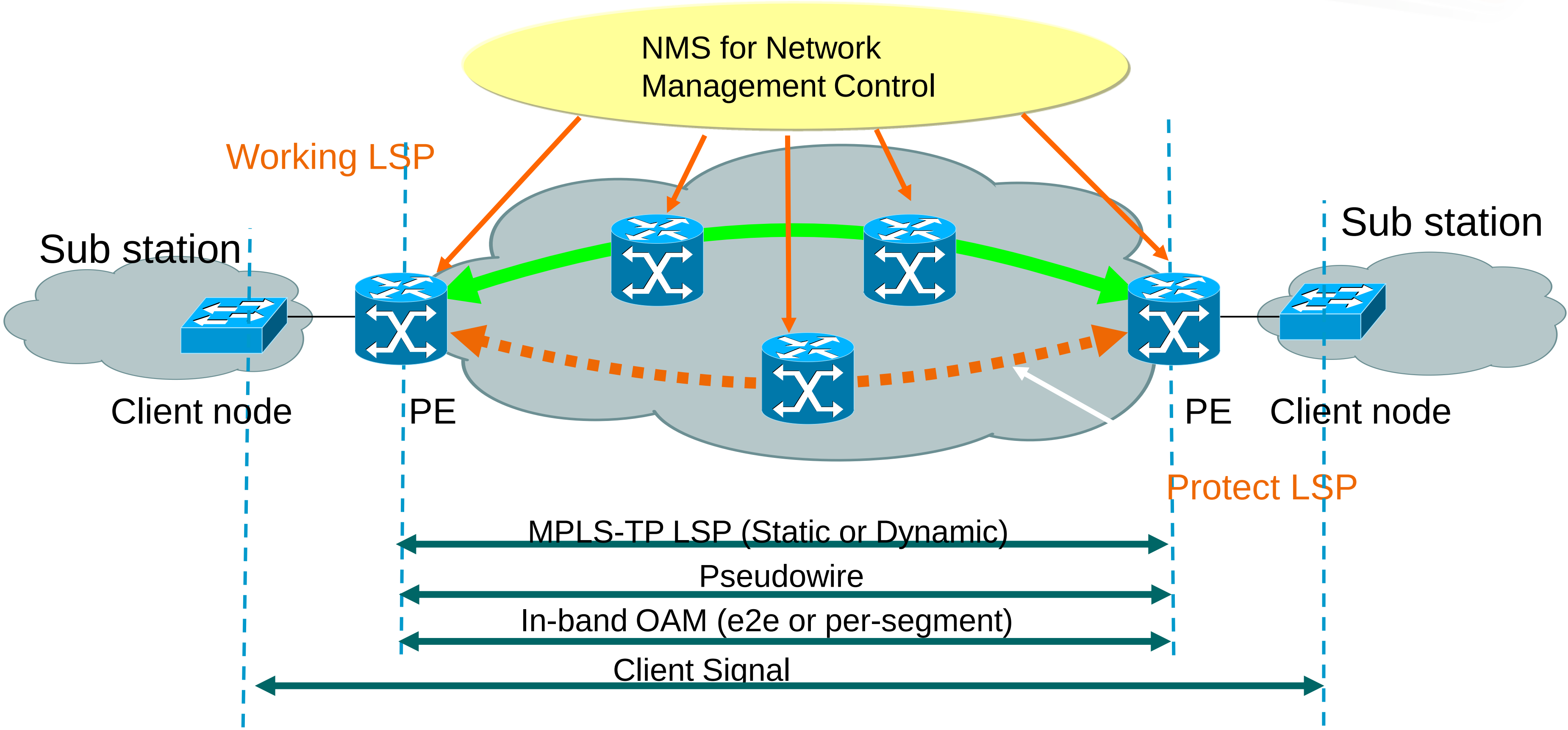


Take the Best of Both World

	TDM Transport	Packet Data Network
Connection mode	Connection oriented ★	Connectionless (except TE)
OAM	In-band OAM ★	Out-of-band (except PW, TE)
Protection Switching	Data Plane Switching ★	Control plane dependency
BW efficiency	Fixed Bandwidth	★ Statistical multiplexing
Data Rate Granularity	Rigid SONET hierarchy	★ Flexible data rate
QoS	One class only	★ QoS treatment

Packet Transport

MPLS-TP Enabled Cloud



- Connection Oriented, pre-configured working path and protect path
- Transport Tunnel 1:1 protection, switching triggered by in-band OAM
- Phase 1: NMS for static provisioning

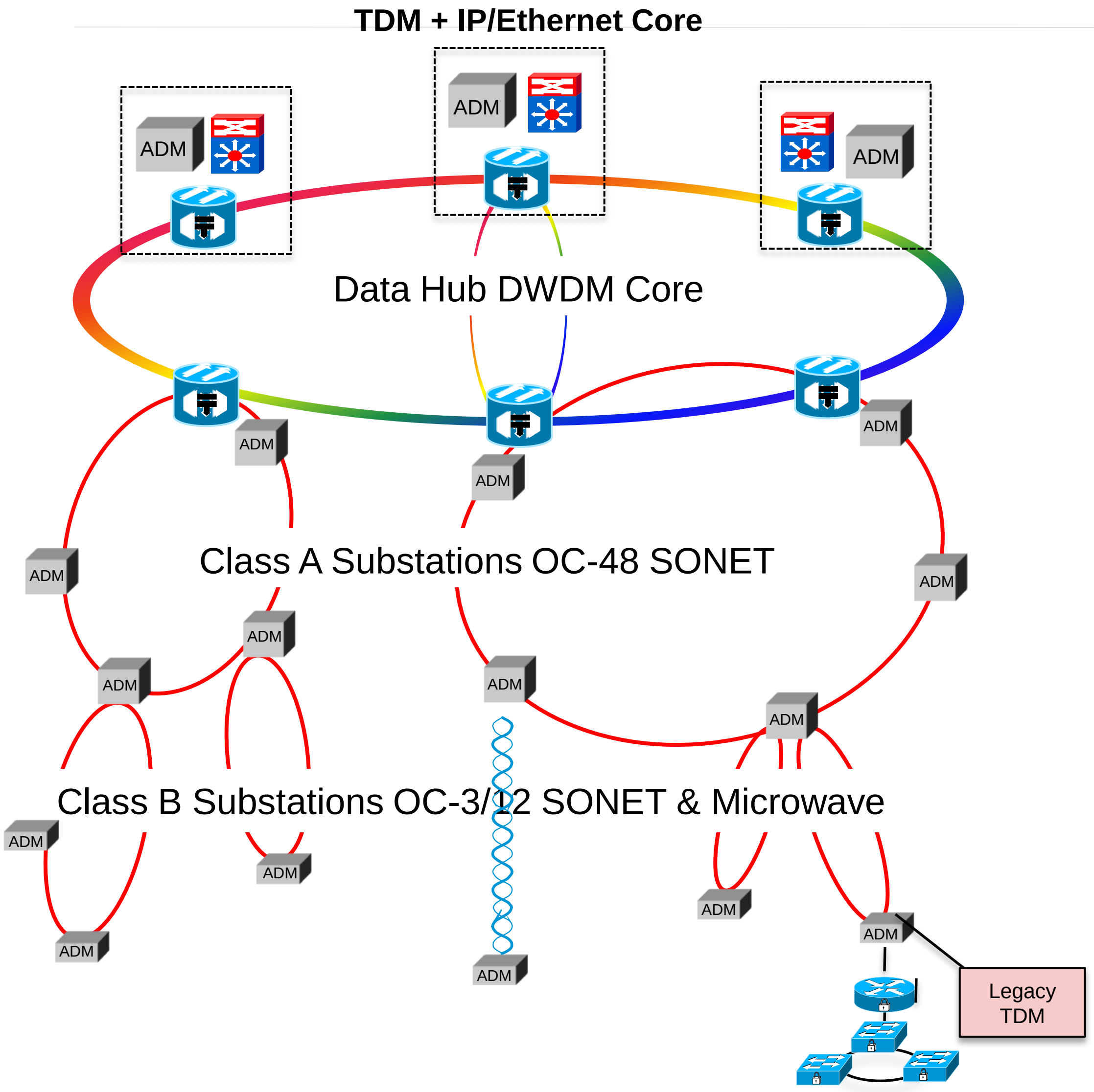
Connection Oriented Ethernet
Transport Evolution to MPLS-TP

- Multiprotocol Label Switching – Transport Profile
- Based on IETF Standards
- Service Flexibility/Scalability of MPLS
- No forwarding dependence on IP routing protocols
- Graceful extension of IP/MPLS Core into Access & Aggregation

Benefits to the Utility

- Transport operational model, Connection Oriented, Deterministic, Point & Click Mgmt.
- SONET/SDH like OAM&P (operations, administration, maintenance & provisioning)
- Highly Scalable (10G/40G/100G, Statistical Multiplexing)
- Support for Legacy TDM Interfaces (DS1, DS3), Synchronized Ethernet (1588, SynchE)

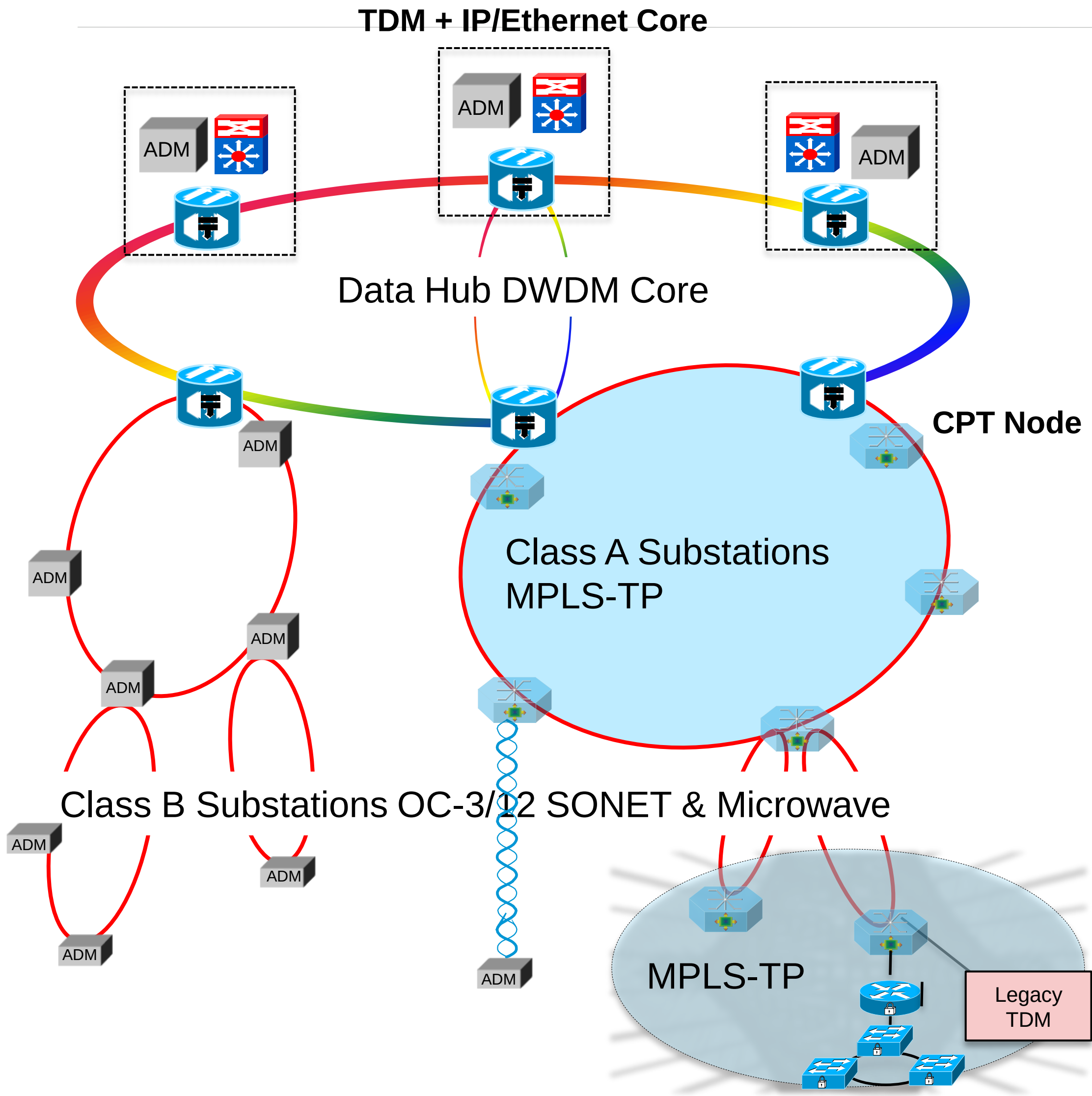
SONET Aggregation Solution - Today



Existing SONET Aggregation

- Fixed BW Assignment
- No Statistical Multiplexing
- No Multi-point Support
- Capped at 2.5G or 10G

Packet Transport Aggregation Solution

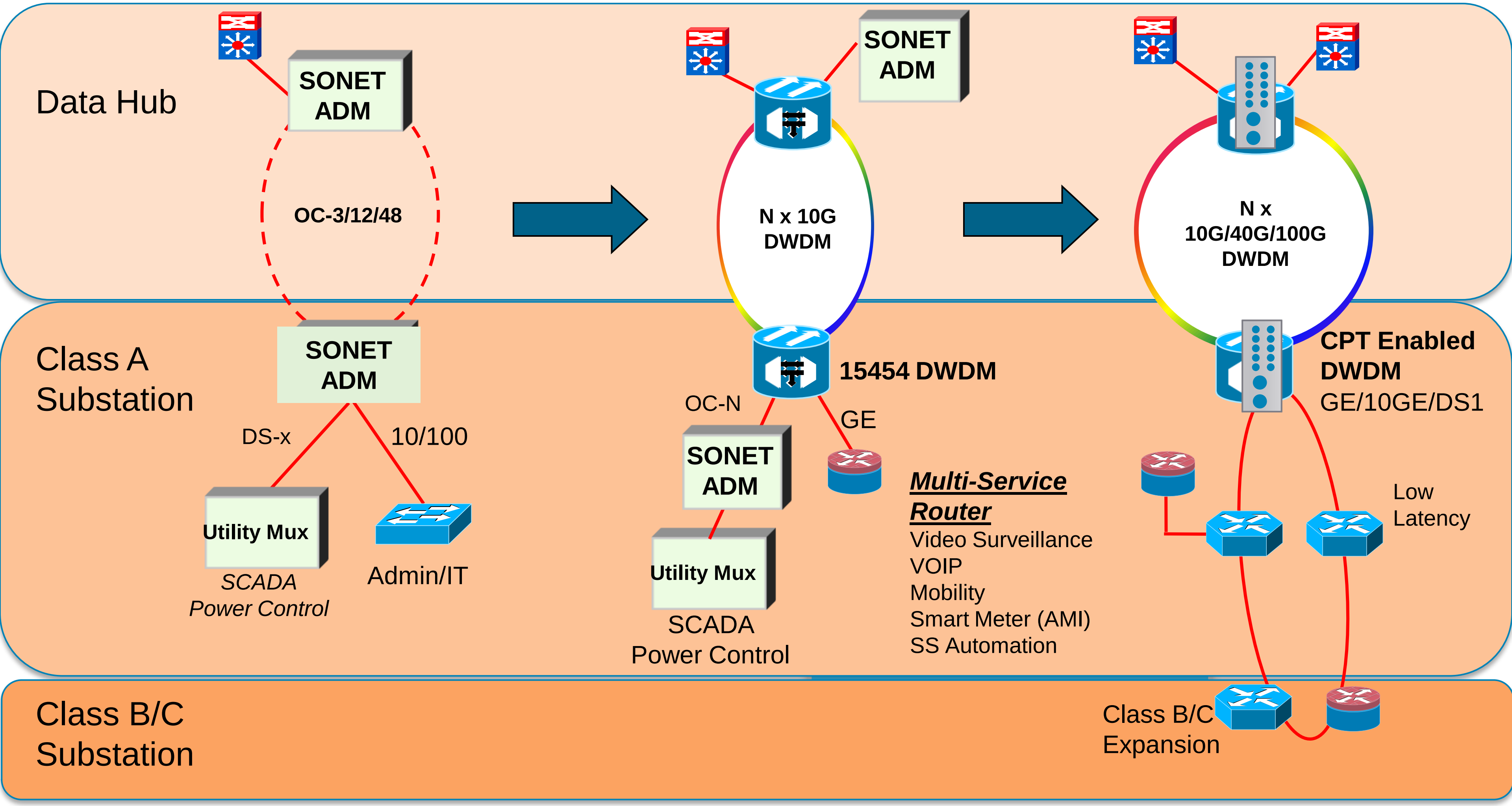


Next Gen Transport

- Ethernet over SONET to MPLS-TP
- Scale to 10G and Beyond
- Legacy Interfaces via DWDM/Circuit Emulation over Packet (CEoP)
- SONET like Operational Model

Substation Transport Evolution

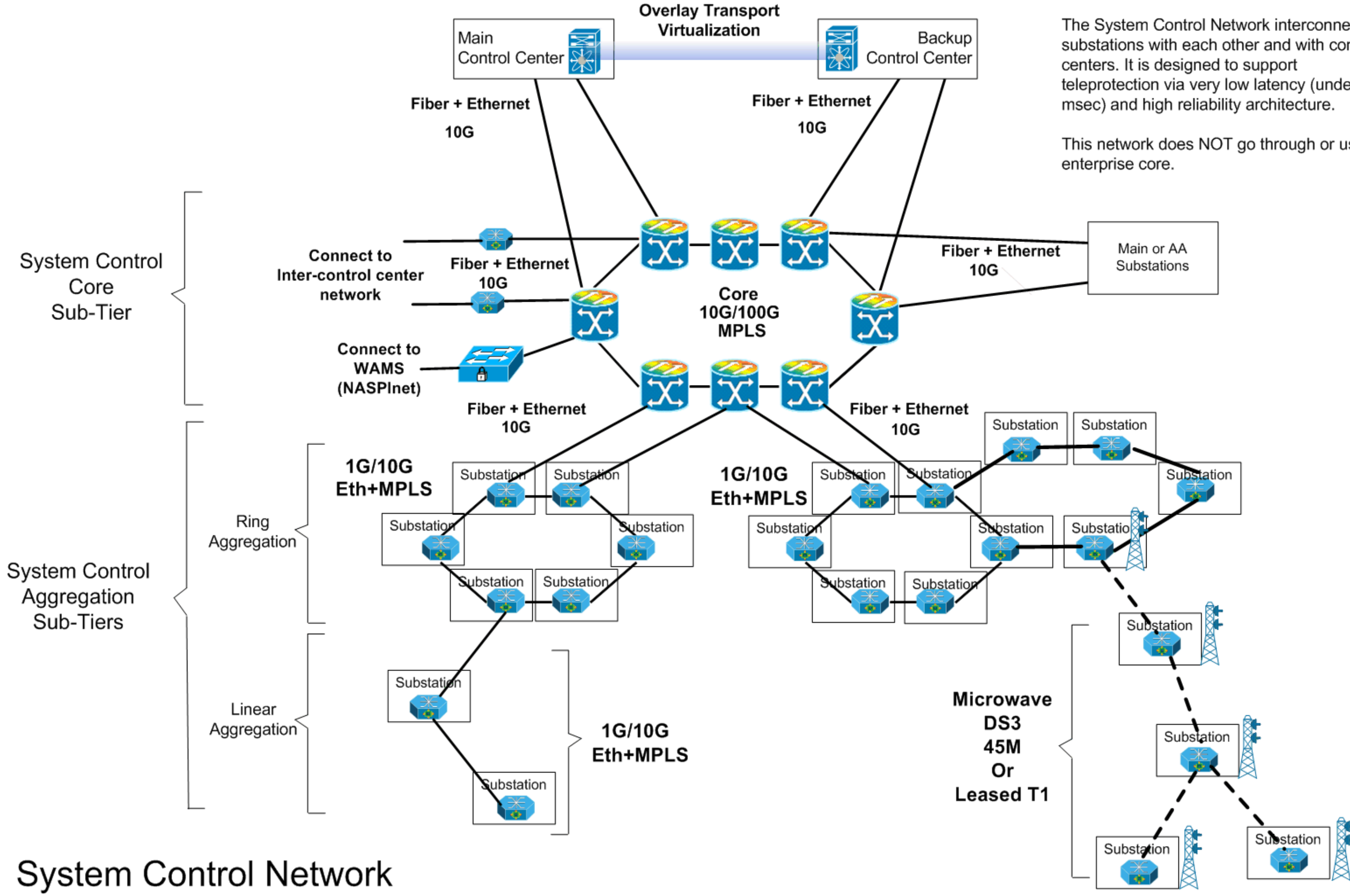
Current	Phase 1	Phase 2
IP with SONET Transport	Extend DWDM Footprint	End to End Packet Transport



System Control Network – IP MPLS

The System Control Network interconnects substations with each other and with control centers. It is designed to support teleprotection via very low latency (under 5 msec) and high reliability architecture.

This network does NOT go through or use an enterprise core.



System Control Network

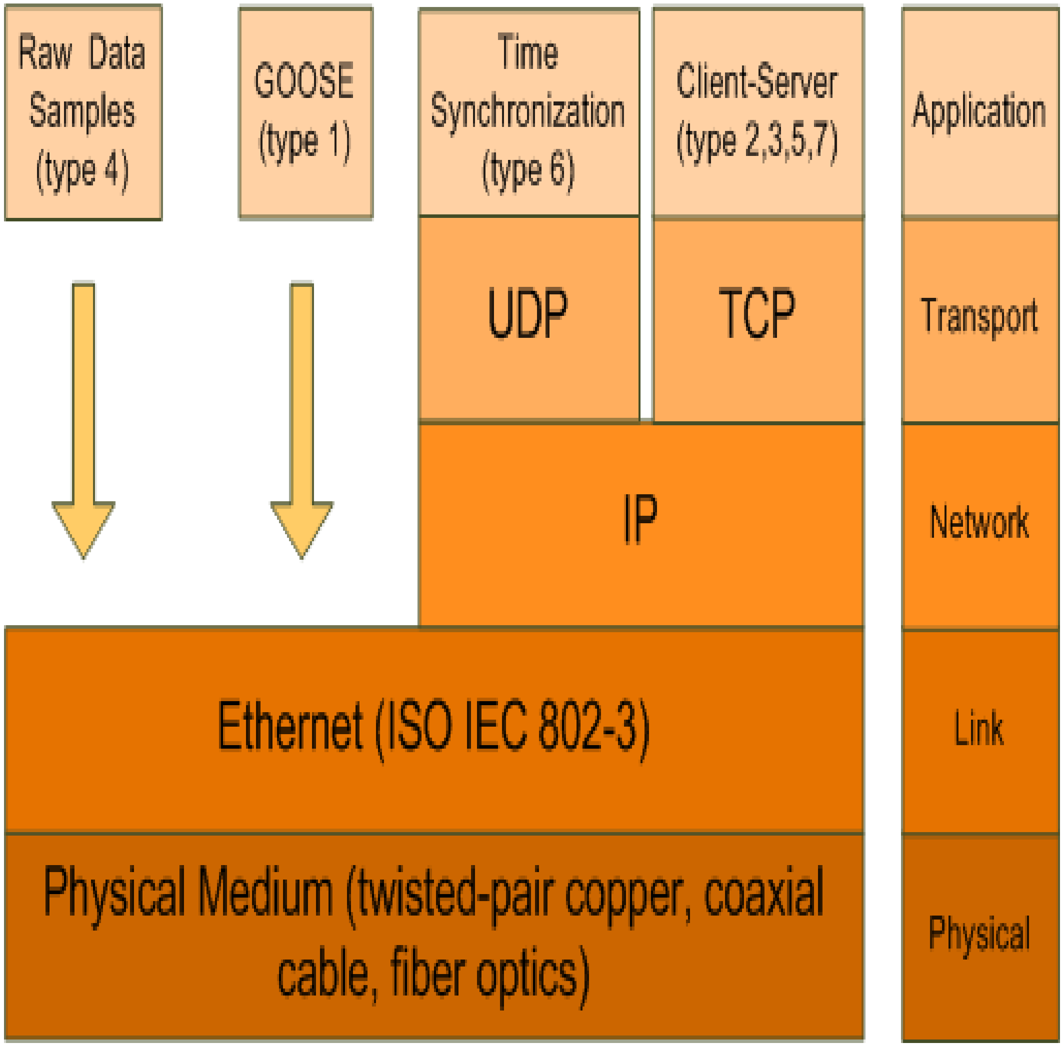
Protocol and IP interoperability

IEC 61850 GOOSE and SV over the WAN

Challenges and Solutions

61850 Overview

Need IPv4 and IPv6 profiles for GOOSE and SV



- CRAS, distance tele-protection, WAMS require sending GOOSE and SVs between substations and to control Center.
- The raw data sample values (SV) type 4 and GOOSE type 1 messages are time critical and mapped to Ethernet.

Issues Inside Substation:

- Inefficient Multicast Traffic Distribution
- Cyber security
- Scaling broadcast domain

Issues outside the Substation

- Ethernet is NOT routable and not built for WANs.
- Large Ethernet bridge domains can cause instability

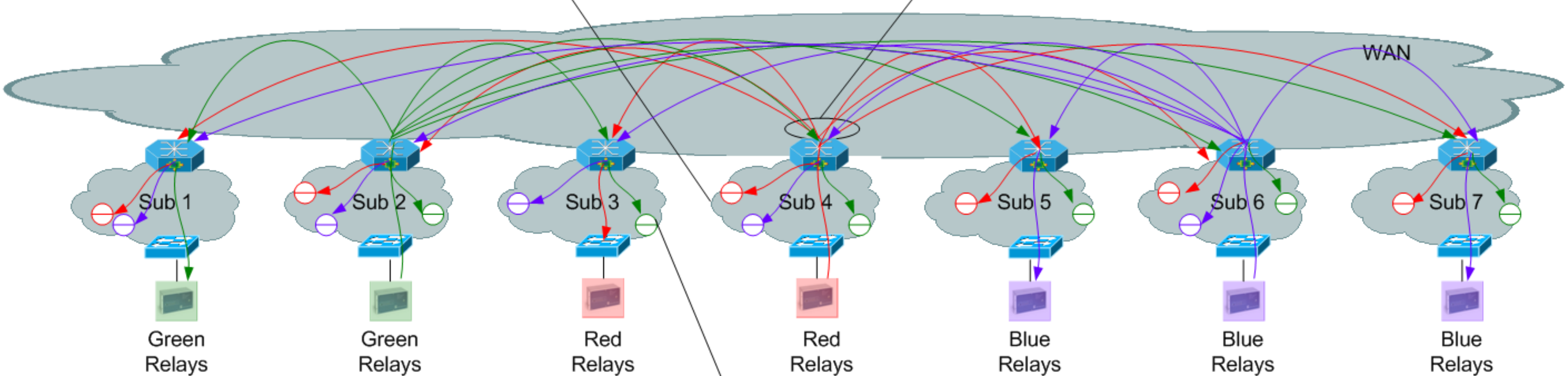
IEC 61850-90-1 Solution to Carry GOOSE/SV over the WAN

- Tunnel. Example
  - Layer 2 Tunneling Protocol (L2TP / L2TPv3) – RFC 3931
  - Generic Routing Encapsulation (GRE) Tunneling - RFC 2784
- Gateway
  - Example Proxy Gateways
  - GWs Must Terminate Protocols
  - GWs must Understand Applications and configuration changes in the application
  - Latency and Jitter addition, especially when GWs are implemented in software
- Tunneling or Encapsulation is the more realistic option
  - MPLS, VPLS, PWs are examples of Encapsulation technologies

Problem: Layer 2 GOOSE / SV over the WAN – Implications on Scaling, Security, Replication, Flooding, etc

1. Fault in the Vlan spread across Substations
2. Traffic flooding inside the substation vlan
3. Info security leak

1. Multicast Replication Inefficiently done. Replication per Tunnel.
2. Blind flooding of Ethernet Multicast traffic wastes BW in the WAN and in the other substations
3. Tunnel Scaling of the solution is limited
4. Inefficient forwarding of traffic in the WAN (due to tunnel encapsulation)
5. Higher MTTR as the tunnel has to do live ness checks, to detect tunnel failures
6. Weaker Security – Flooding sends data to unneeded/unwanted places… information leakage



Un interesting Traffic

Issues:

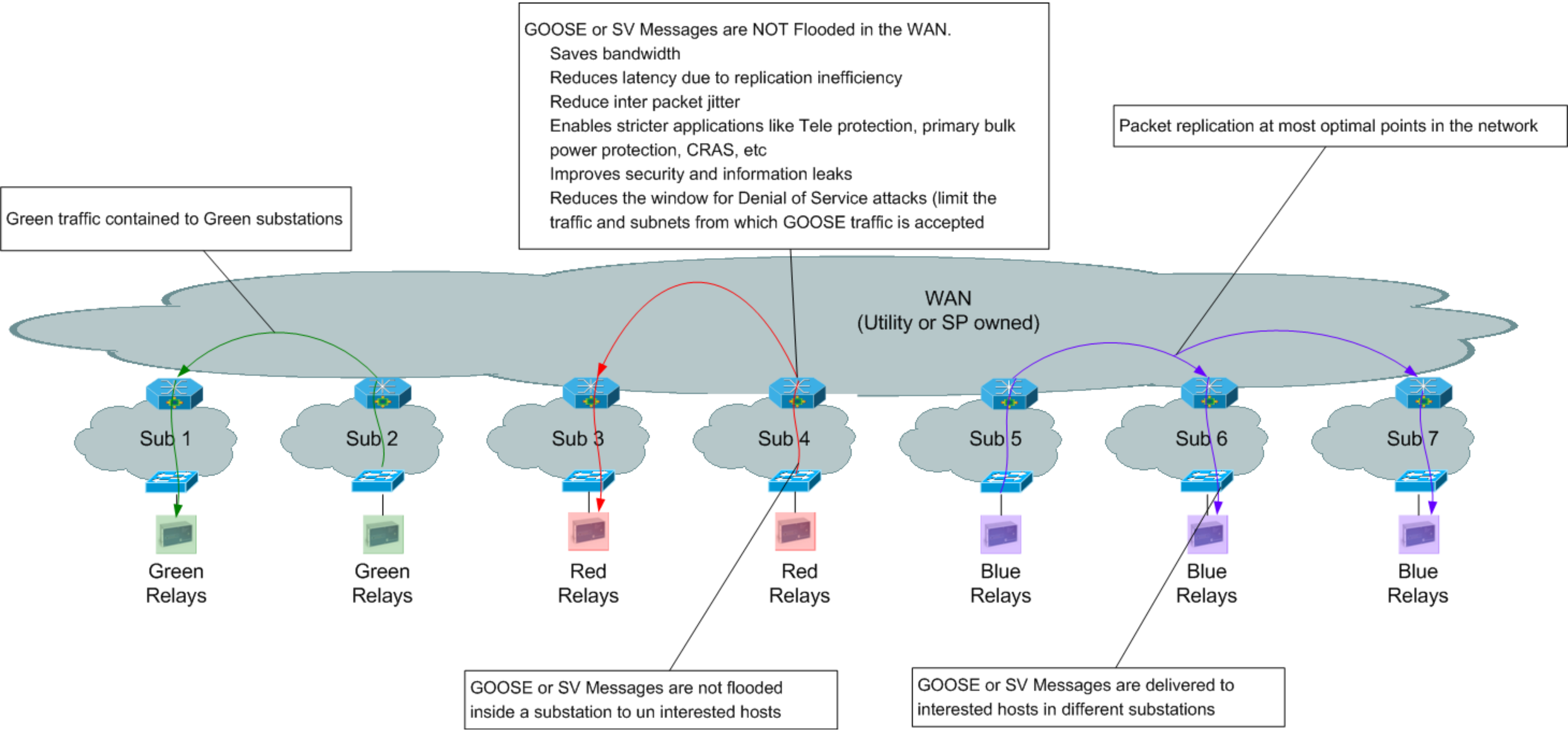
- Intra Substation Replication
- Inter Substation Replication
- Information Leakage – Security Implications
- Wasted Bandwidth
- Limited Scale
- …

VPLS : Packet replication and the amount of address information are the two main scaling concerns for the provider edge device. When packets need to be flooded (because of broadcast, multicast, or destination-unknown unicast address), the ingress provider edge needs to perform packet replication. As the number of provider edge devices in a VPLS increases, the number of packet copies that need to be generated increases.

Solution: IEC 61850 with IPv4/v6 profile provides - Scalability, Security, etc

GOOSE/SV on IPv4/v6 routable protocol

- Scalable
- Low (in usecs) Latency – All HW forwarding Path
- Low (in usecs) Jitter
- Cyber Security benefits
- Easy to trouble shoot and manage over WAN – proven model
- …



IP profiles for all 61850 messages!!!

- IEC 61850-90-1 extended the 61850 beyond the substation but did not address the challenges of extending tele-protection controls beyond the sub-station.
- IEC 61850-90-5 for PMUs is working on a 61850 profile to carry GOOSE / SV over TCP/IP[v4v6] stack
- IP profiles being developed above must Not only be restricted to PMUs, but also to other all relays and applications!!!!

Protocols Communication Architecture

Feature	60870-5-101	60870-5-104	DNP3	60870-6-TASE.2	61850
Application	SCADA	SCADA	SCADA	Control Center to Control Center	Substation automation, Substation to Control Center and other domains
Communication	V.24/V.28 or X.24/X.27	TCP/IP over ethernet 802.3 or X.21	V.24/V.28 or X.24/X.27; TCP/IP over Ethernet or X.21	TCP/IP and OSI over Ethernet 802.3 or X.21	TCP/IP and OSI over Ethernet 802.3 or X.21; Ether-type for GOOSE and SV
Layering	3 layer	7 layer (TCP/IP)	4 layer (serial) or 7 layer (TCP/IP or UDP/IP)	7 layer and Object library	7 layer (TCP/IP and OSI) and logical node and object library
Routing	N/A	IP	IP (TCP or UDP)	IP, OSI NP	IP, OSI NP
Transport Protocol	N/A	TCP	Pseudo Transport over serial, TCP or UDP over IP	TCP, OSI TP	TCP, OSI TP
Open support for encoding (XML etc.)	N/A	N/A	N/A	N/A	HTML and XML coded messages products
Open Service support (HTTP, CORBA, SOAP etc.)	N/A	N/A	N/A	N/A	IEC 61400-25-4 defines a webservice protocol for IEC 65180-7-2

Thank you.

MPLS-TP Encapsulation