NASPInet 2.0

The Evolution of Synchrophasor Networks

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Agenda

- Future Synchrophasor Networks – NASPInet
- Current Network Issues (per Survey)
- Synchrophasor Network Plans (per Survey)
- Next-Gen Networking Applied to NASPInet
- NASPInet 2.0 Recommendations

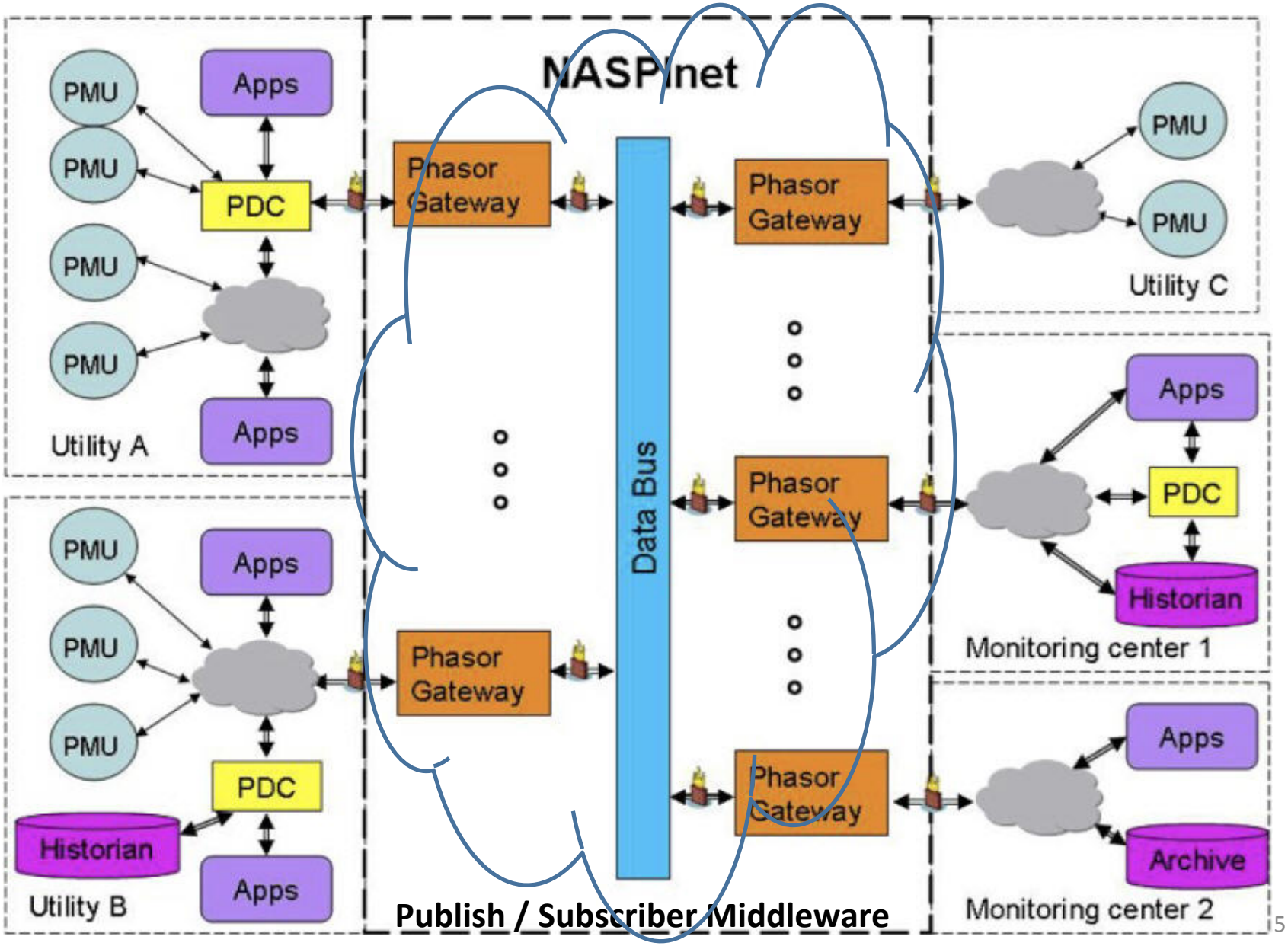
Future Synchrophasor Networks

- Heterogeneous networks, owners, and actors
- Publish/subscribe architecture for data sharing
- Multiple, independent IT administrations
- Internet Protocol (TCP/UDP/IP) for interoperability
- Highly scalable with many PMU's 30-120 samples/sec
- Data time-aligned for proper sequence of events
- Highly secure with centralized security policies

Future Synchrophasor Networks

- High reliability, high availability, low latency, low packet loss
- SLA performance monitoring and logging
- Support multiple types of applications
  - real-time visualization
  - real-time grid protection and closed loop control
  - operator decision support
  - current offline engineering and forensic analysis

NASPInet circa 2009 - Architecture



Source: **Exploring a tiered architecture for NASPInet, IEEE** Innovative Smart Grid Technologies (ISGT), 2010

Synchrophasor Network Issues

(per 2014 NASPI Networking Survey)

- Several use no encryption or network access control for WAN data security.
- A majority…
  - have no (or not aware of) SLA with WAN service provider nor receive alerts if violated.
  - do not use any QoS mechanisms and also don't monitor QoS performance.
  - have no plans to use middleware (e.g. publish/ subscribe, application API's).
  - cannot detect if their time source has been compromised.

Future Synchrophasor Network Plans

(per 2014 NASPI Networking Survey)

- A majority…
  - plan to interconnect with other networks for wide-area communications of PMU data.
  - will shift from offline applications to real-time, mission critical applications (25% plan to use PMU data for closed-loop control).
  - will be transporting other data on the same network (e.g. digital fault recorders and SCADA)

As currently implemented,
PMU networks cannot support these plans!

"Life expectancy would grow by leaps and bounds if green vegetables smelled as good as bacon."

- Doug Larson

"Chokin' down those veggies!"

- NASPInet needs to be adopted, but adoption has been slow.
  "It is a good architecture, but pub/sub with gateways looks like a lot of work!"
- Need real-time visibility into WAN performance.
  "But it's not my network!"
- Need network "awareness" of service-level requirements of applications.
  "And here I thought networks were just dumb pipes!"
- Need "orchestration" of critical services across heterogeneous networks.
  "You mean like a conductor leading an orchestra?"

Synchrophasor networks need some enhancements that:

- realize immediate benefits

- make NASPInet functionality easy to adopt!

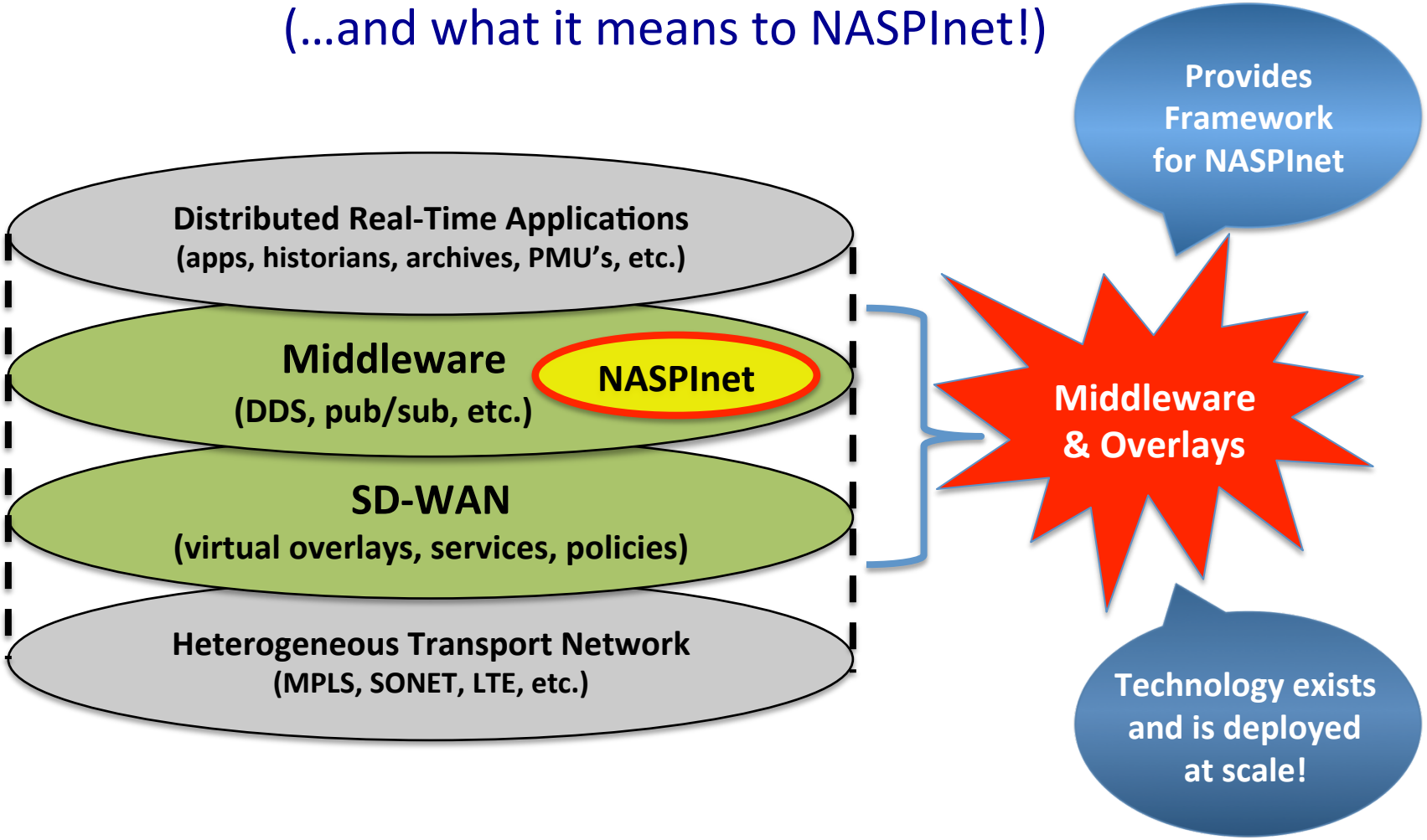
Next-Gen Networking Trends

In high-volume, high-reliability wide-area networks

- "Application-aware" routing and forwarding, independent of underlying transport networks
  - Software-Defined WAN (SD-WAN) – evolved from SDN
  - Service Overlay Networks over heterogeneous transport
  - Network Function Virtualization (NFV) – service chaining
- Secure virtual network segmentation – multi-tenant
- Very accurate, cost-effective timing and synchronization of network services - Single Frequency Network (SFN)
- Centralized policy-driven network and security orchestration

The Next-Gen Network

(…and what it means to NASPInet!)



Existing commercial products can accelerate NASPInet adoption, and provide additional *immediate* benefits!

Benefits of Next-Gen Networking

"Bringin' home the bacon!"

- Secure Routing of traffic based upon application SLA
- QoS is monitored end-to-end and SLA's are strictly enforced
- Path MTU Discovery (PMTUD) and network-edge grooming
- High-level QoS: low to zero packet loss, low delay and jitter, fast restoration, "hit-less" service (no information lost).
- Highly-scalable to thousands of nodes
- High level of security and availability
- ***No change to existing transport networks!***
- ***Easy to configure and deploy!***

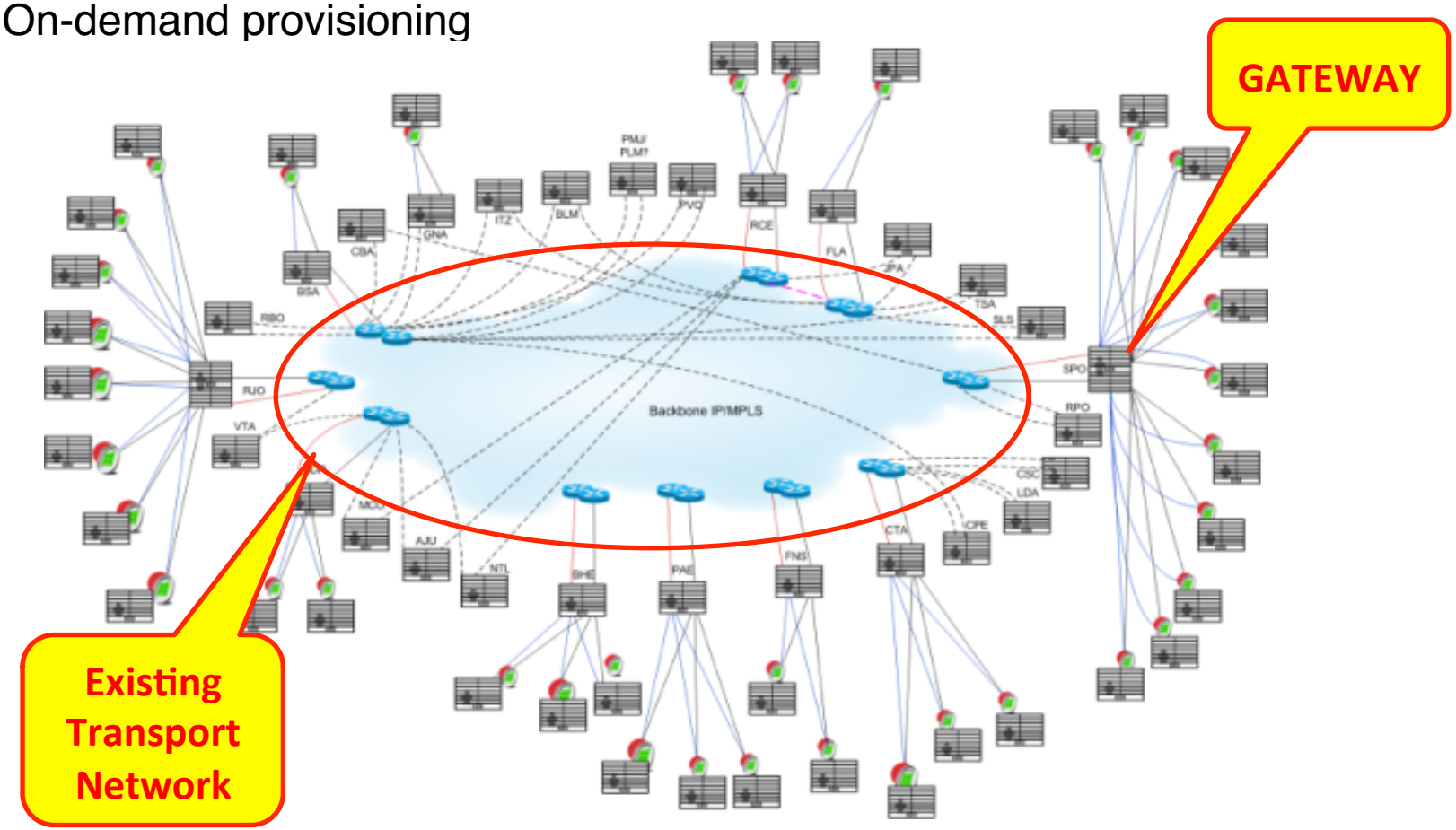
Next-Gen Networking Using Commercial Products

with Parallels to NASPInet

Embratel – Real-time video overlay

National Sports and Event Network in Brazil

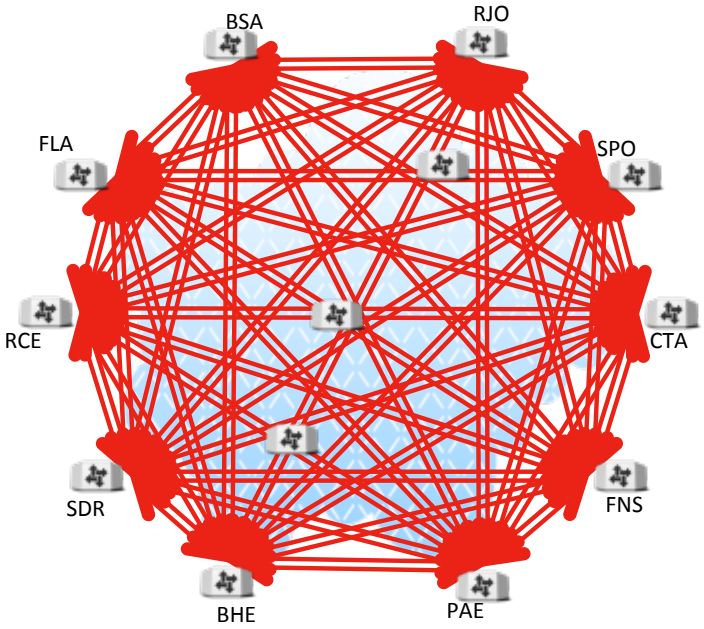
- Sports and event network
- 29 cities with 37 stadiums
- On-demand provisioning
- FIFA WC implementation
- HD with JPEG2000 compression

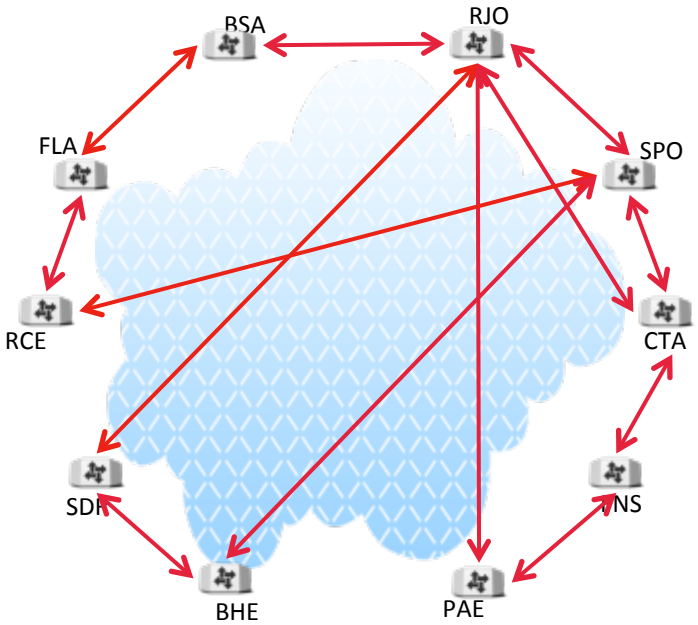


Embratel – Real-time video overlay

Ease of operations and high-level QoS

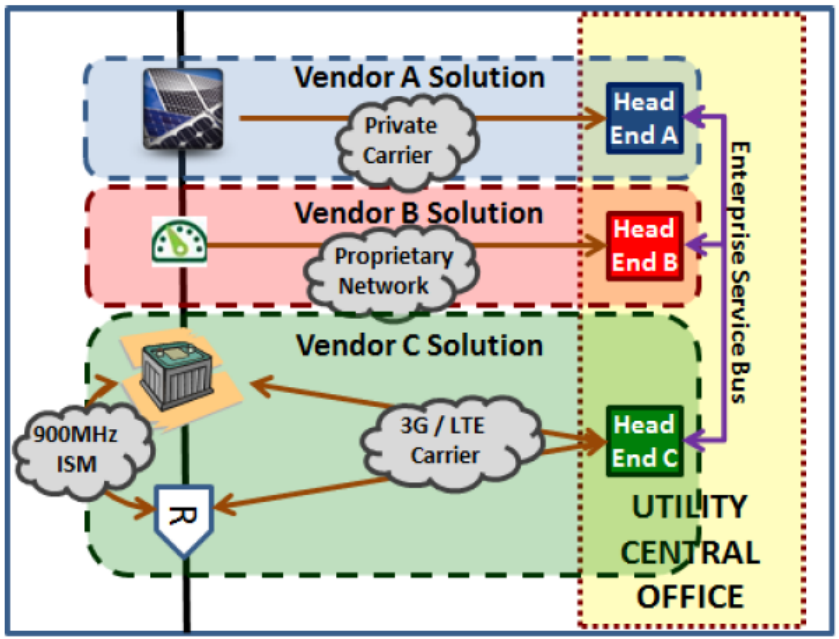
- Live real-time sports broadcast video overlays
- Fewer QoS services to manage in the IP/MPLS core
- On-demand service provisioning independent of core
- Deterministic traffic aggregation/grooming requires less traffic engineering
- Less traffic load in each point – better network utilization
- Lower operational cost and better QoS (equivalent to an SDH/SONET network!)



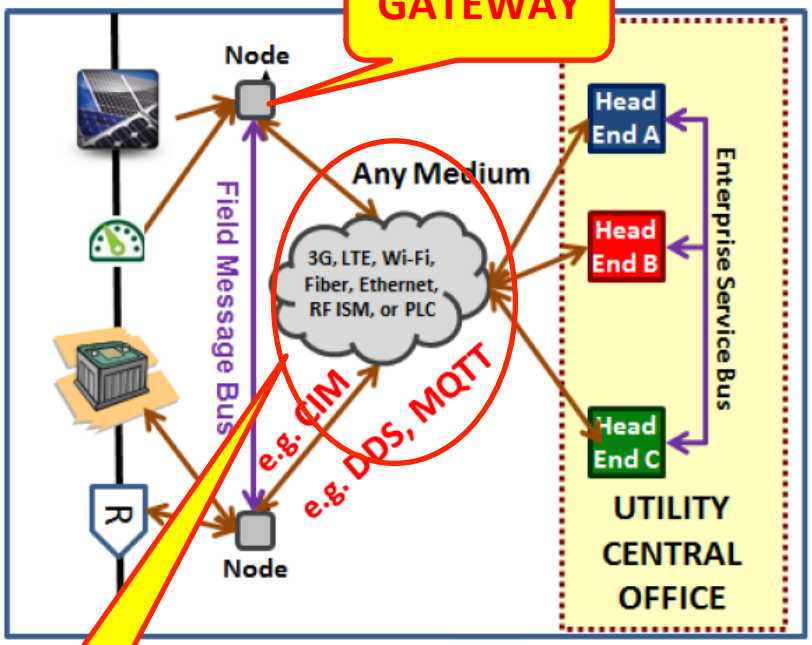


Duke Energy

Open Field Message Bus



Current State – Message Bus at Data Center



Future State – Message Bus in Field and Data Center

Key Observations:

1. Single-Purpose Functions
2. Proprietary & Silo'ed systems
3. Latent , Error-prone Data
4. OT/IT/Telecom Disconnected
5. No Field Interoperability!

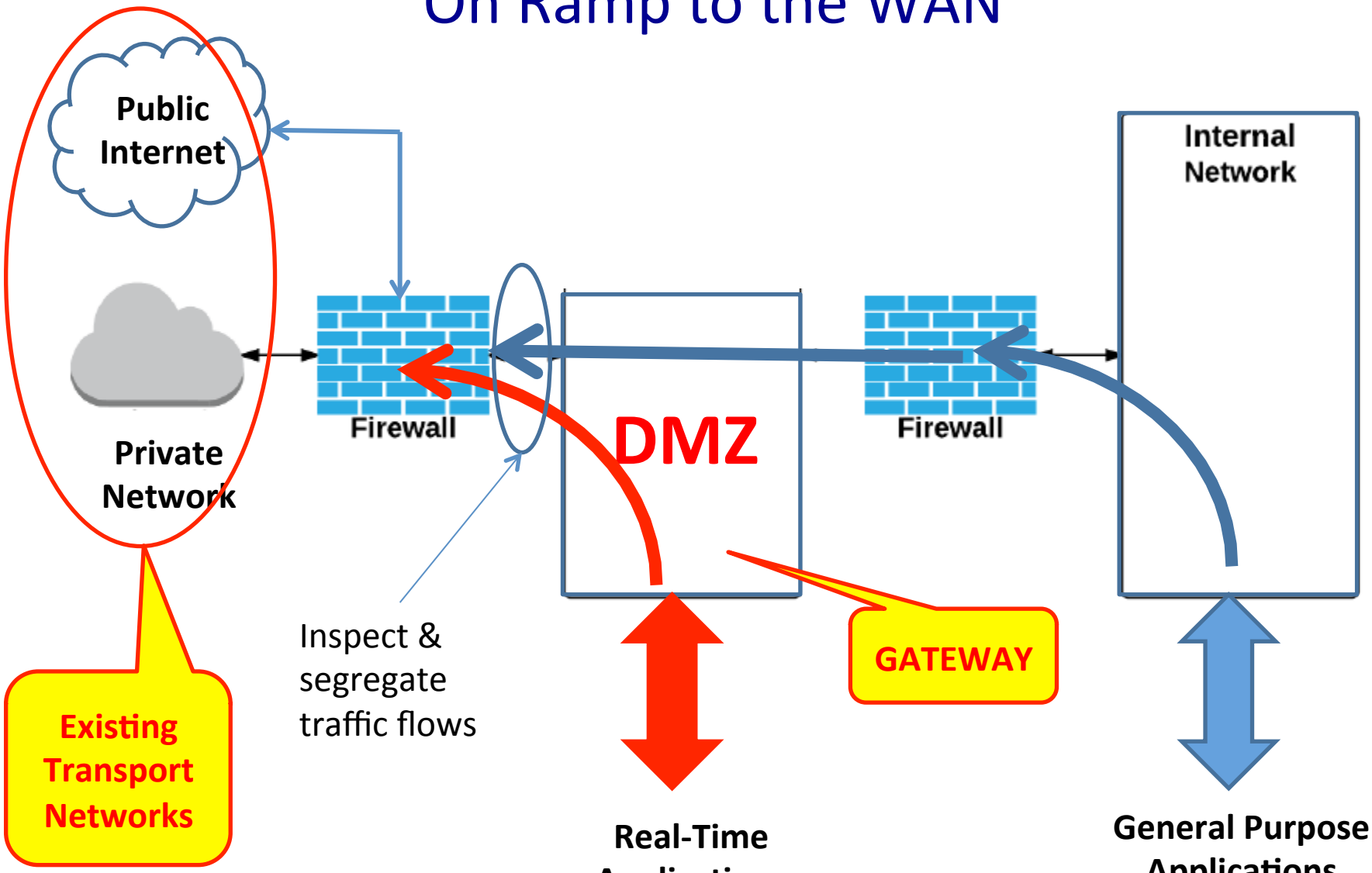
Existing Transport Networks

Key Observations:

1. Multi-Purpose Functions
2. Modular & Scalable HW&SW
3. End-to-End Situational Awareness
4. OT/IT/Telecom Convergence
5. True Field Interoperability!

ESnet's Science DMZ

"On Ramp to the WAN"



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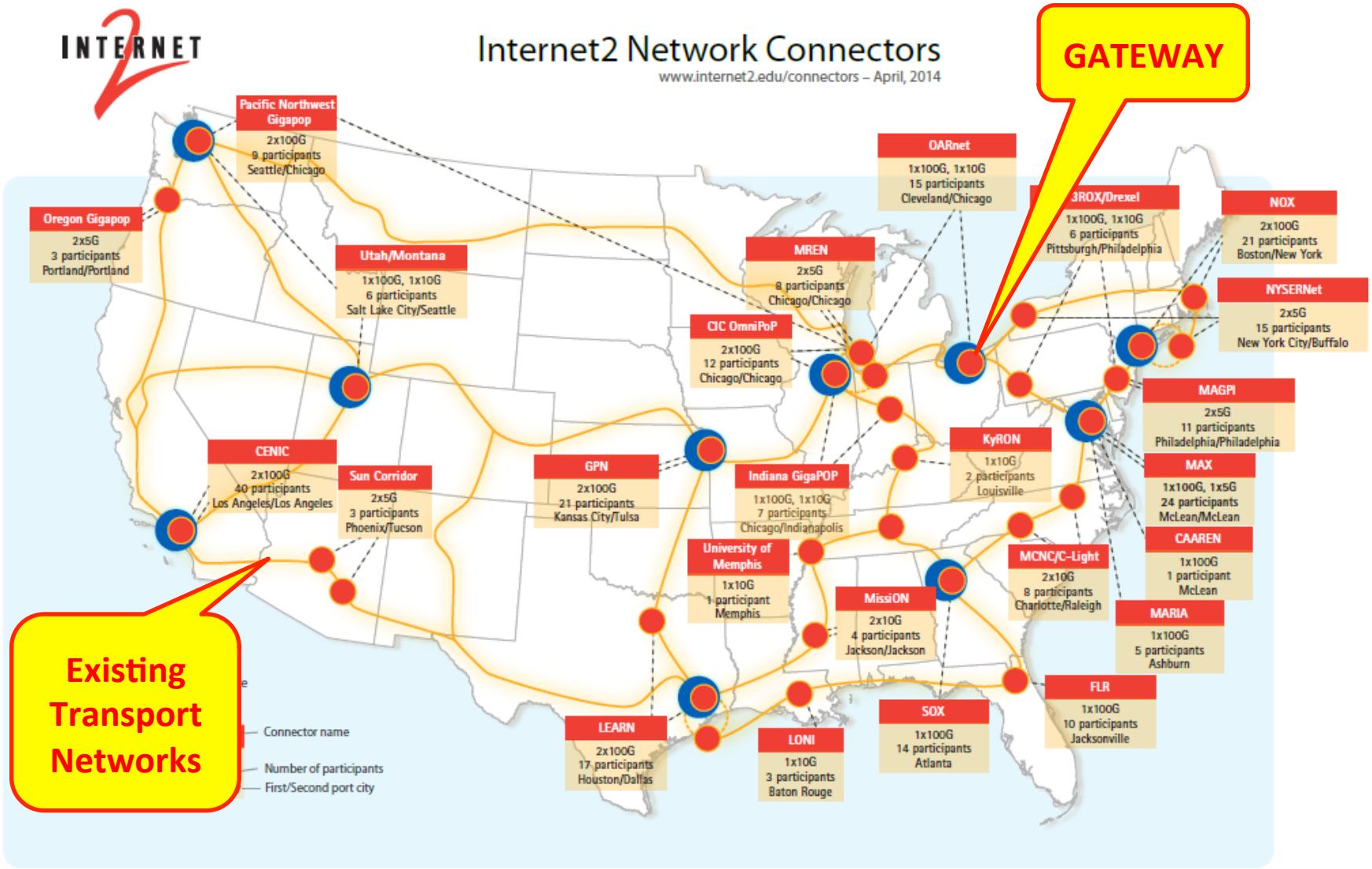
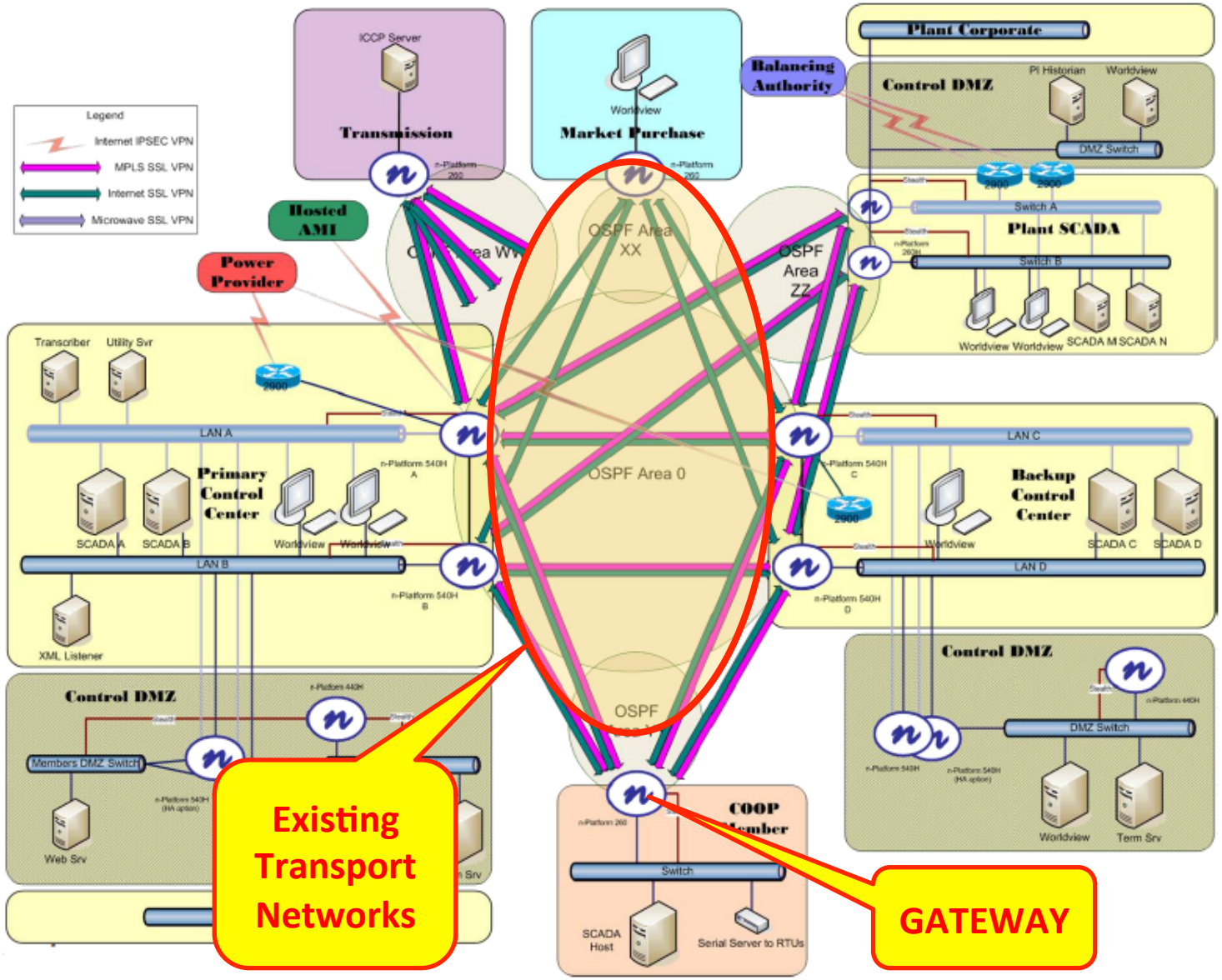


G&T Cooperative - Secure Interconnect



Source: [TCIPG seminar "Experience with Implementing Cybersecurity in a G&T Coop"]

NASPInet 2.0
Recommendations

- Learn from others, i.e. Embratel, Duke Energy, Science DMZ, G&T Coop, etc.
- Update and enhance NASPInet architecture, implementation, and organization
  - Architecture
    - Route application traffic flows via secure virtual network overlays
    - Provide virtual network function service chaining
  - Implementation
    - DDS, Pub/Sub middleware
    - Provide framework for applications to utilize virtual services
  - Organization
    - Centralized orchestration of virtual overlays, services, and security policies
- Implement proof-of-concept with commercially-available products to validate NASPInet 2.0
- Training & Education – Best Practices
- Support

Q & A

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