NASPInet Architectural Issues

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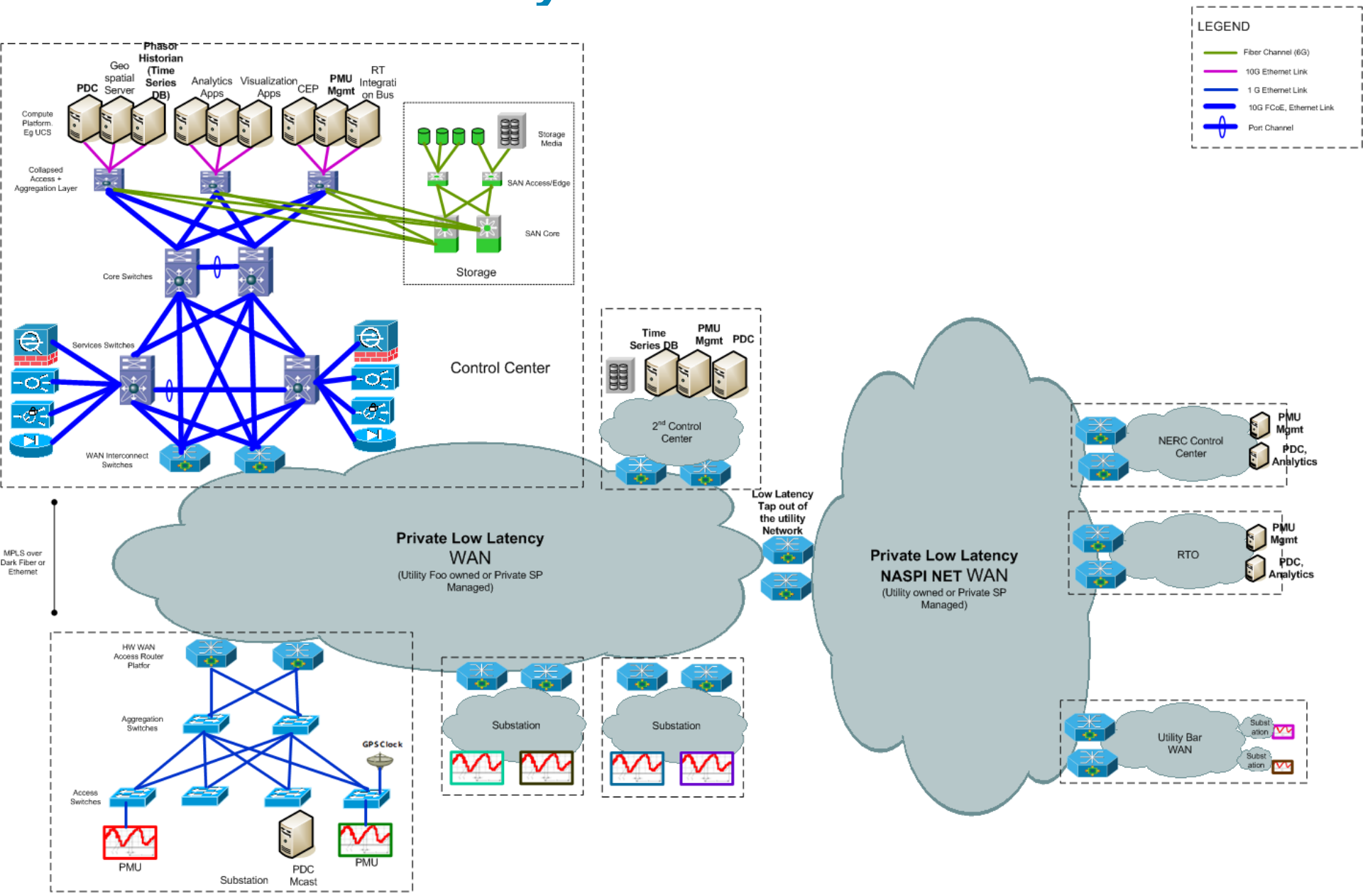
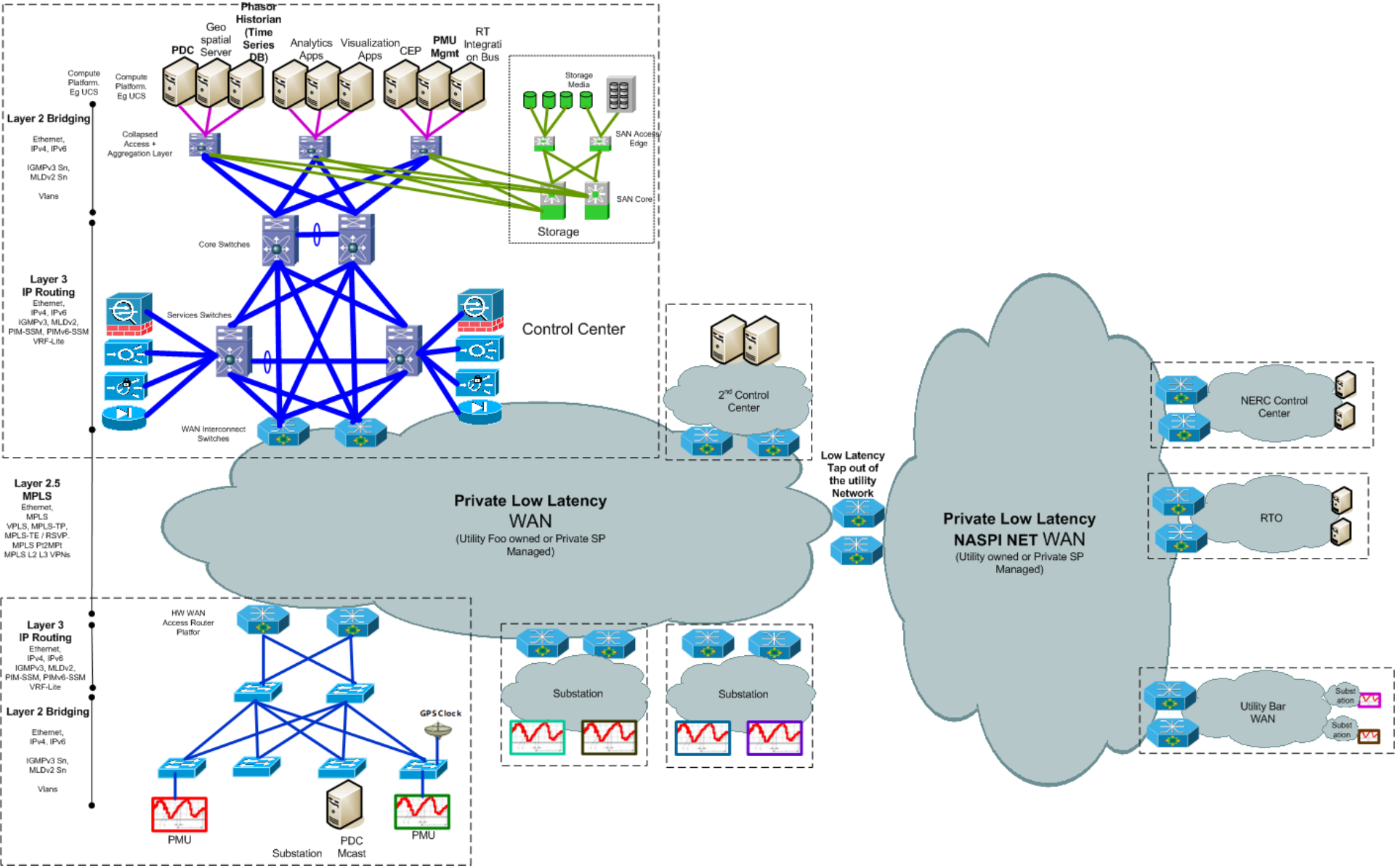
Architectural Principles for NASPInet

- Enable high performance
  - Low latency
  - Security
  - QoS
  - Flexibility and agility
- Use open standards; apply sound architectural principles
  - Allocate functionality to proper places in the architecture
  - Make maximum use of necessary elements
  - Avoid defining new system entities
- Provide upgrade and extension paths (future-proofing)

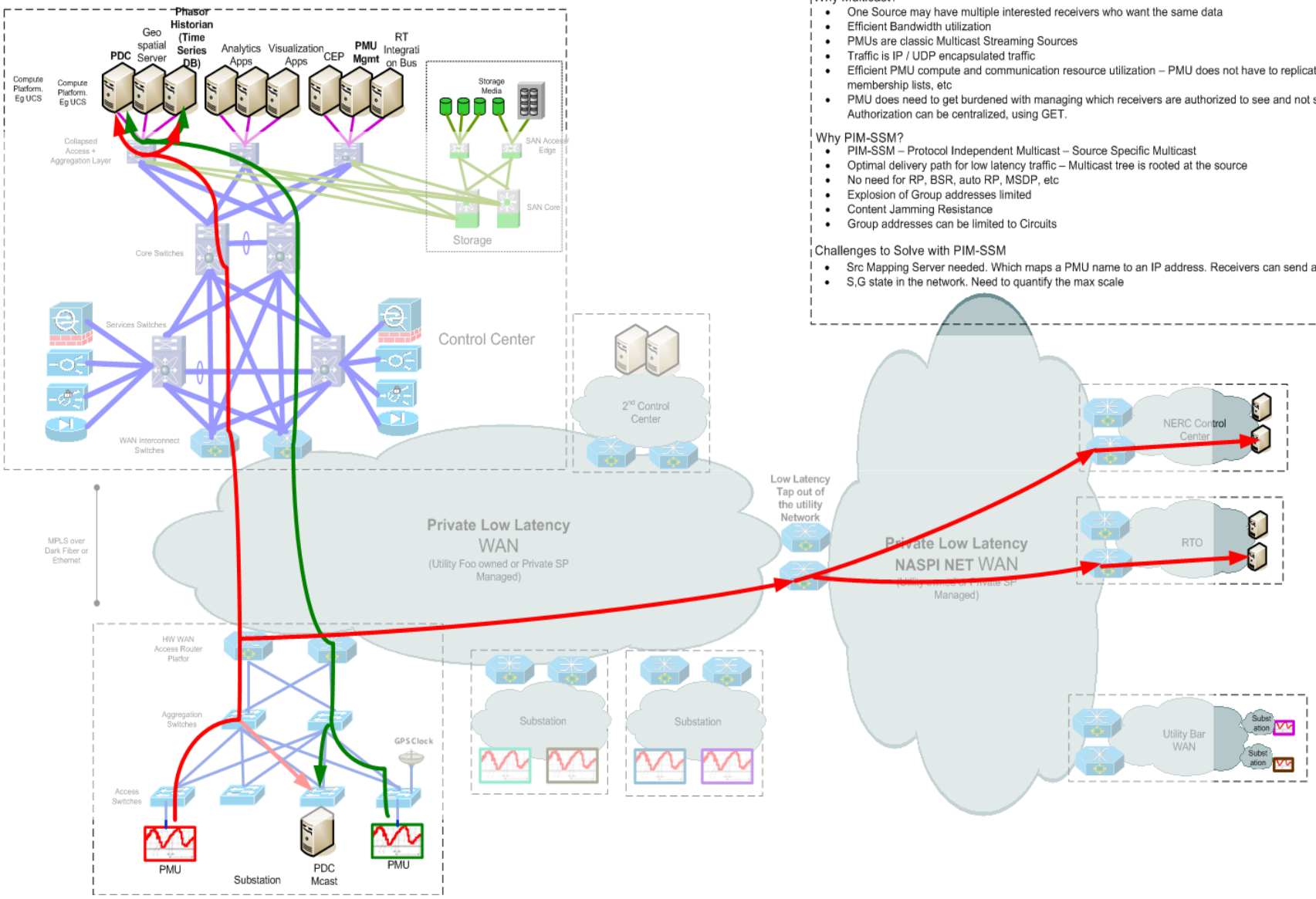
PMU Network Physical Architecture View



PMU Network Protocol View



Multicast for PMU Data (low, predictable latency)



Why Multicast?

- One Source may have multiple interested receivers who want the same data
- Efficient Bandwidth utilization
- PMUs are classic Multicast Streaming Sources
- Traffic is IP / UDP encapsulated traffic
- Efficient PMU compute and communication resource utilization – PMU does not have to replicate traffic, manage interested membership lists, etc
- PMU does need to get burdened with managing which receivers are authorized to see and not see the traffic. Authentication and Authorization can be centralized, using GET.

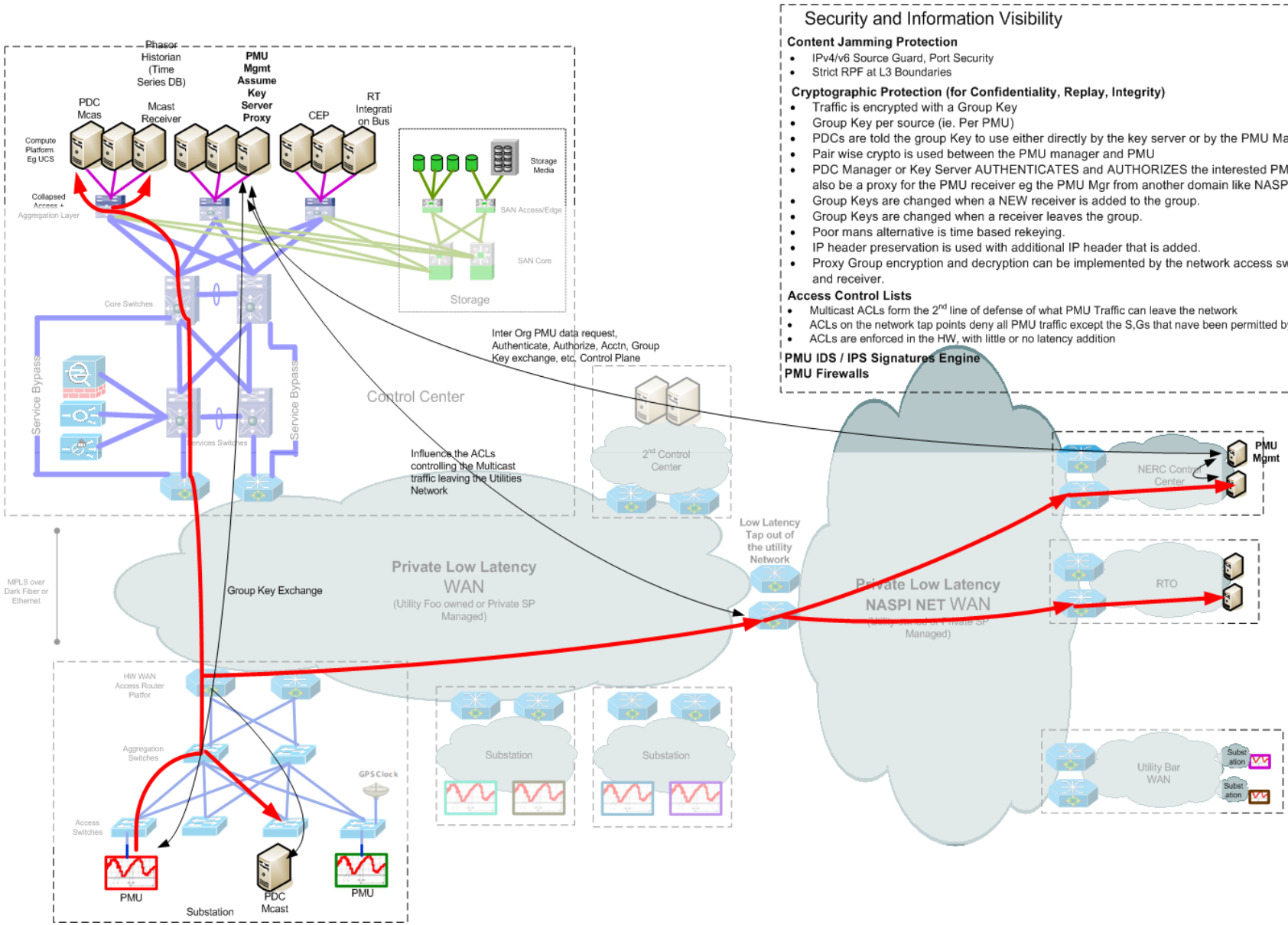
Why PIM-SSM?

- PIM-SSM – Protocol Independent Multicast – Source Specific Multicast
- Optimal delivery path for low latency traffic – Multicast tree is rooted at the source
- No need for RP, BSR, auto RP, MSDP, etc
- Explosion of Group addresses limited
- Content Jamming Resistance
- Group addresses can be limited to Circuits

Challenges to Solve with PIM-SSM

- Src Mapping Server needed. Which maps a PMU name to an IP address. Receivers can send an IGMP/MLD report for (S,G)
- S,G state in the network. Need to quantify the max scale

PMU's and Security



Architecture Issues

- Low Latency Communication
  - End to end hardware forwarding path
    - Application Specific Integrated Circuit (ASIC) forwarding engines
  - Predictable latency Communication
    - “Circuit like” explicit static path setup for maximum control
    - Multiple technology choices
      - MPLS-TE (Traffic Engineering)
      - MPLS-TP (Transport Profiling)
  - Predictable fail-over and network convergence
    - MPLS-TE based fast reroute
    - MPLS-TP based path protection
    - N-1 Network Redundancy
    - Predictable failover after a failure
- MPLS based core WAN network
  - MPLS is a future facing technology, which merges the best of packet switching and circuit switching
- Converged network designed to carry both IP and non IP traffic (eg IEC 61850 GOOSE) even over the WAN; extension to 61850-90-5 will enable IP/UDP-based GOOSE and SV
- Scalable Network
  - Minimizes packet replication; network replicates packets at optimal points
  - Integrates crypto without putting packet replication burden on the end host

Architecture Issues, con't

- End to End QoS for low latency traffic
  - RSVP/MPLS-TE based bandwidth reservation option
  - MPLS-TP/TE based circuit setup
- Cyber security integrated into the design (rather than tagged on later)
  - Low, predictable latency security with no latency penalty
  - Anti content jamming
  - Group crypto protection for traffic
  - PMU owner controls what leaves the network via ACLs
  - PMU data traffic content can be replicated and masked by the network, as an additional service
  - Segmentation and path isolation for PMU traffic
  - PMU-based intrusion protection

Monitoring Center Architecture

- Use modified version of existing three tier architecture
- Make maximum use of network since it must be present anyway
- Avoid data concentrator stacking
- Minimize use of physical gateways

Standard Three Tier Architecture

Presentation tier

The top-most level of the application is the user interface. The main function of the interface is to translate tasks and results to something the user can understand.

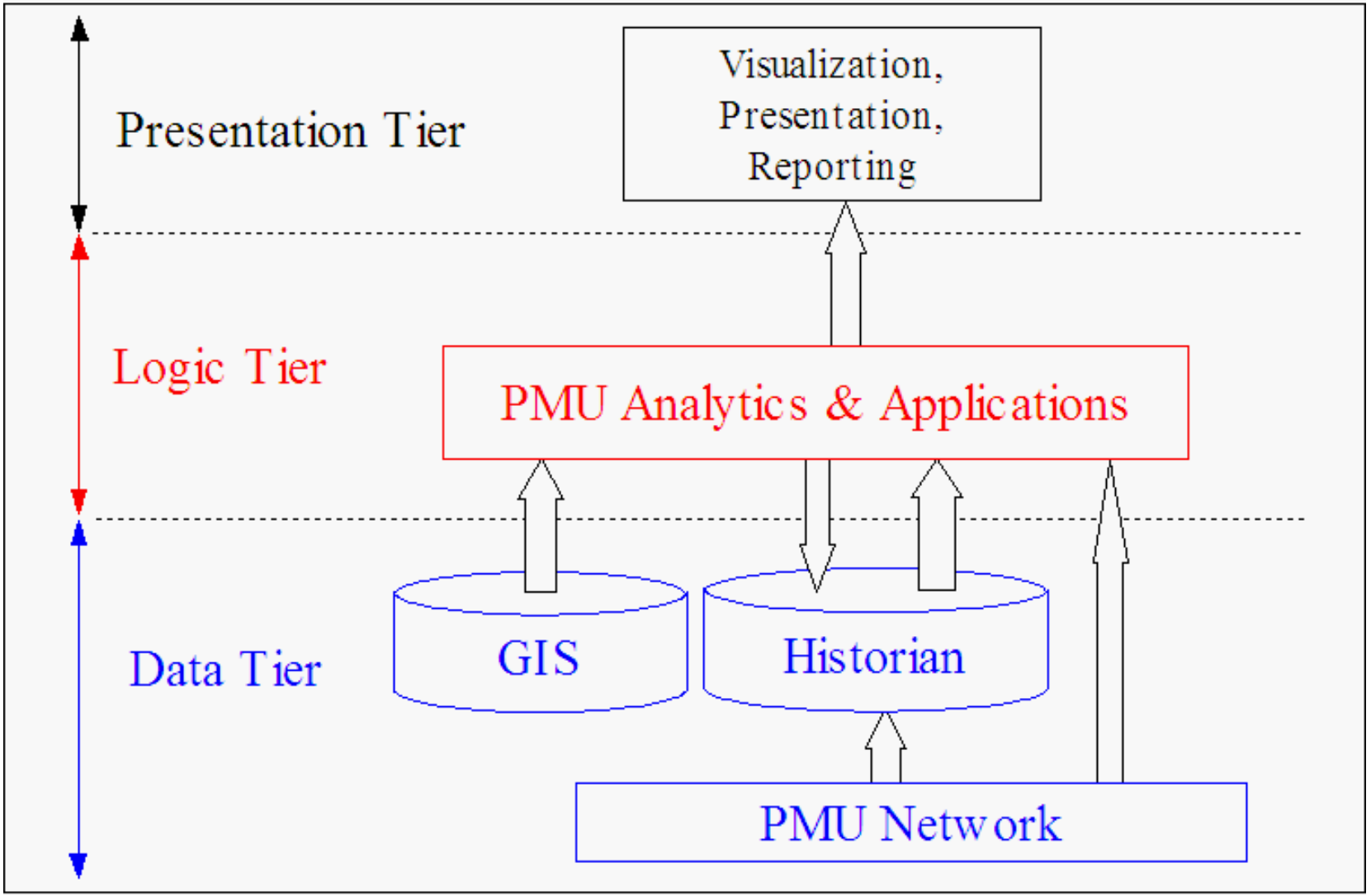
Logic tier

This layer coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the two surrounding layers.

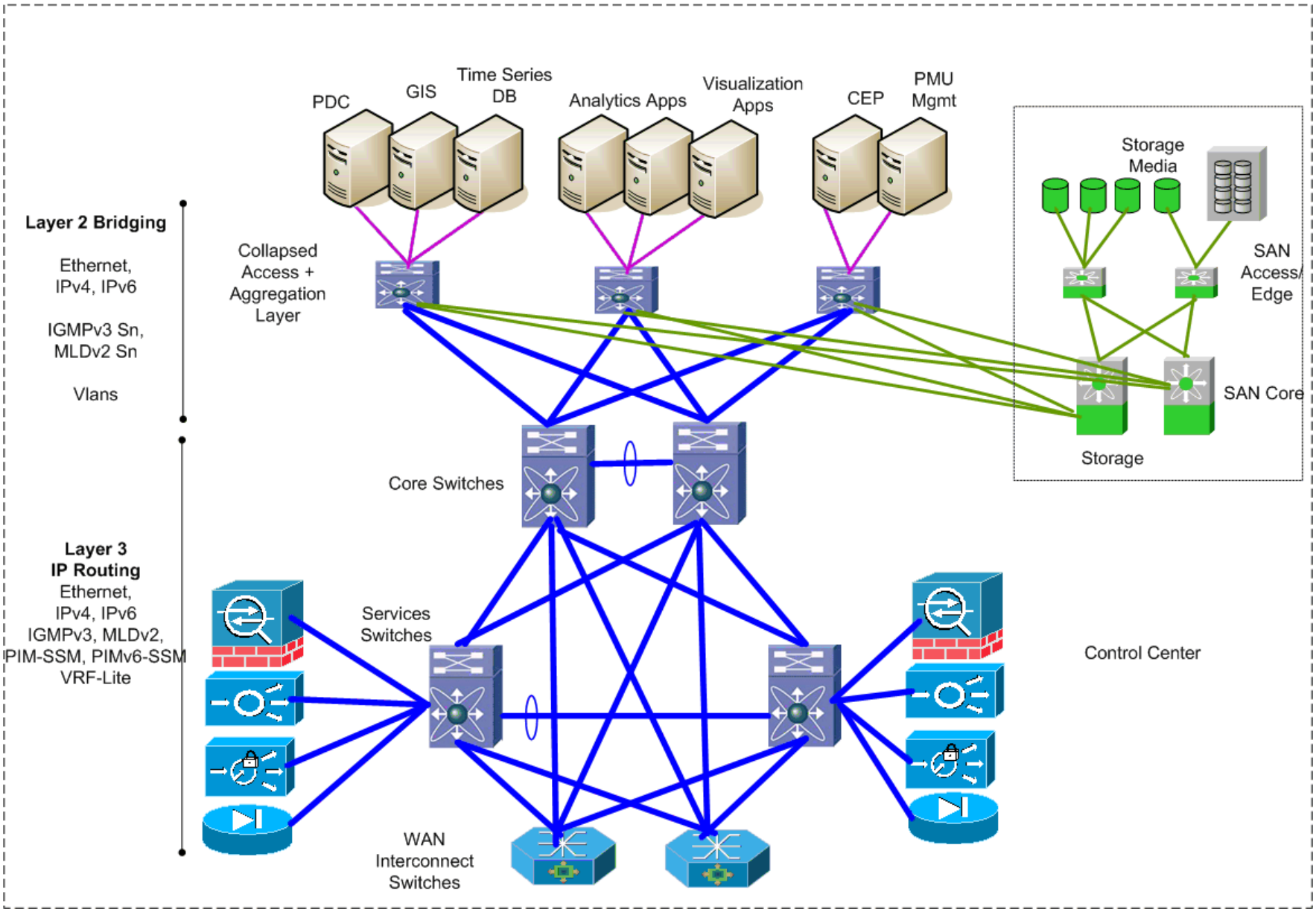
Data tier

Here information is stored and retrieved from a database or file system. The information is then passed back to the logic tier for processing, and then eventually back to the user.

Three Tier PMU Analytics Architecture



Monitoring Center Technical Architecture Example



PMU Gateways and Data Concentration

- Convert PDC and PDG boxes to service abstractions
- Virtualize services and distribute as needed via Service Insertion
- Allow services to reside where needed:
  - Dedicated server
  - Historian
  - Application
  - Network
- Put concentration elements in parallel near applications to avoid stacking
- Workflow management via Service Insertion Architecture and application design

Conclusions/Recommendations

- Implement engineered PMU networks using COTS networking gear
- Use standard protocols and well established methods for security, QoS
- Use the network to maximum advantage since it must be there anyway
  - Advanced architecture based on standard protocols
  - Service abstraction, virtualization, service insertion
- Clean application suite architecture
- Provide forward path compatibility (future-proofing)
- Extension paths for additional complexity where utilities desire it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