Cloud-based PMU Data Sharing and Analytics Platform

Panel: Best Practices in Sharing Big Data in Power Systems
AMPS – Big Data Analytics

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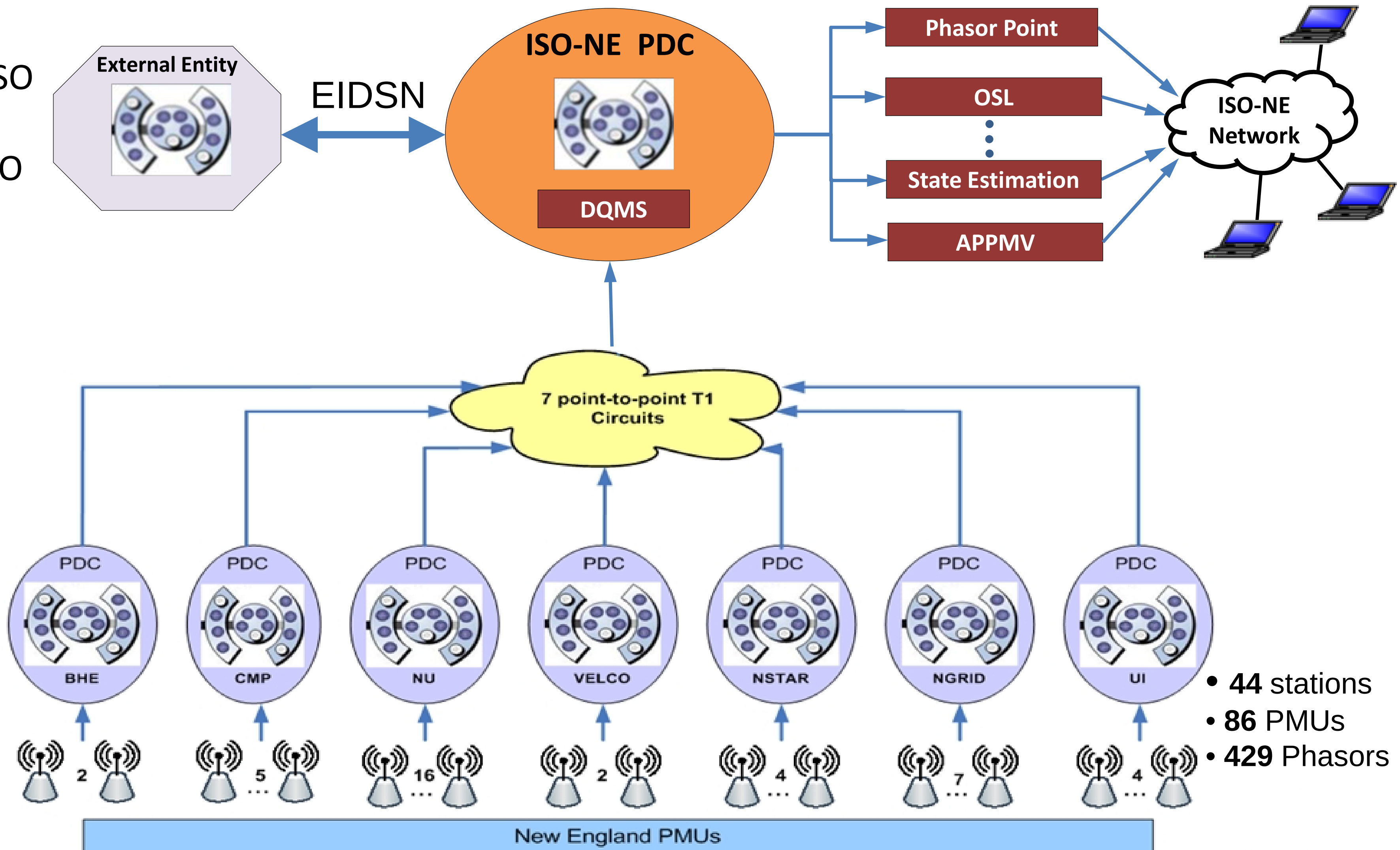
Outline

- Overview of the Synchrophasor Infrastructure at ISO New England
- Motivations to a cross-regional platform for PMU data collection, storage, and exchange
- Cloud-hosted Wide Area Monitoring System
- Cloud-hosted big data analytics
- Conclusions

New England Synchrophasor System

- NYISO
- PJM
- MISO



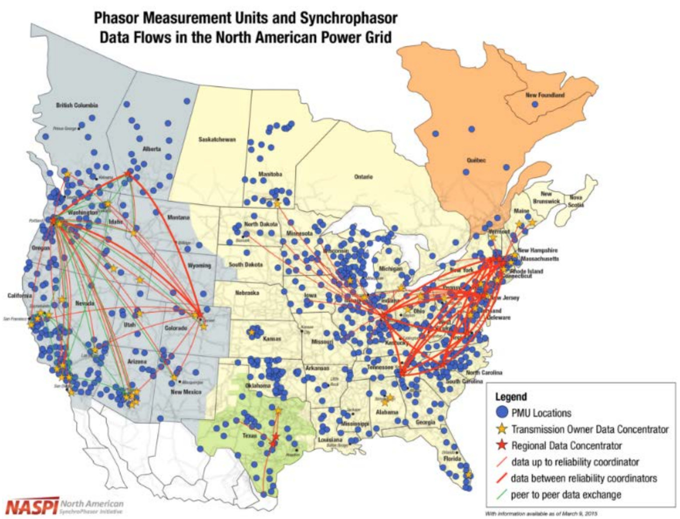
- **44** stations
- **86** PMUs
- **429** Phasors

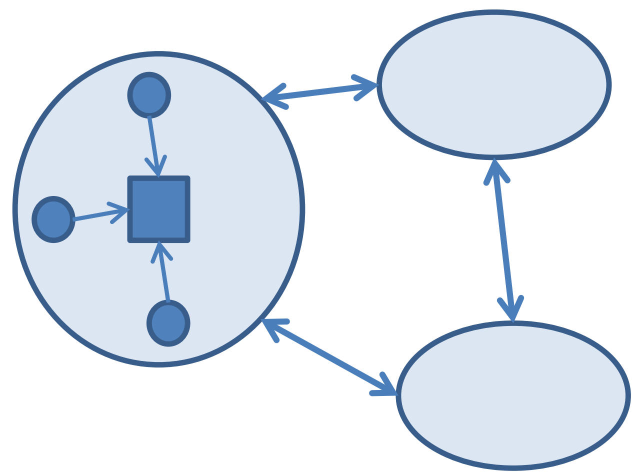
New England Synchrophasor System

- Established regional PMU data exchange with NYISO, PJM, and MISO via EIDSN, started in Q1 2017.
- Approved Operating Procedure 22 changes (effective Dec. 2017) to require new PMU installations by Transmission Owner (TO):
  - Point of Interconnection (POI) with generation interconnections above 100 MW, both new and existing generating units
  - All new TO 345 kV stations, or new elements at existing 345 kV stations
  - Other TO locations as designated by ISO, mainly for IROL and SOL monitoring
- OP 22 changes will double the existing number of PMUs in the next five years.

Wide-Area Monitoring System (WAMS)

- Monitoring wide-area power system conditions in real time is key to operational situational awareness
  - Large scale PMU deployment in Eastern Interconnection due to SGIG
  - Information beyond the operational region is crucial
  - Current practice
    - ISOs collecting data from Transmission Owners
    - PMU data exchange among regions





Challenges of the Current PMU Data Collection and Sharing

- Latency
  - Bottom-up tree structure
  - Chained-PDC network which has unnecessary time alignment and accumulation of time delays
- Point-to-point data exchange structure
  - Multiple bilateral data streams: network cost, performance
- Raw PMU data exchange
  - Large data volumes
  - High maintenance
  - Lacks coordination

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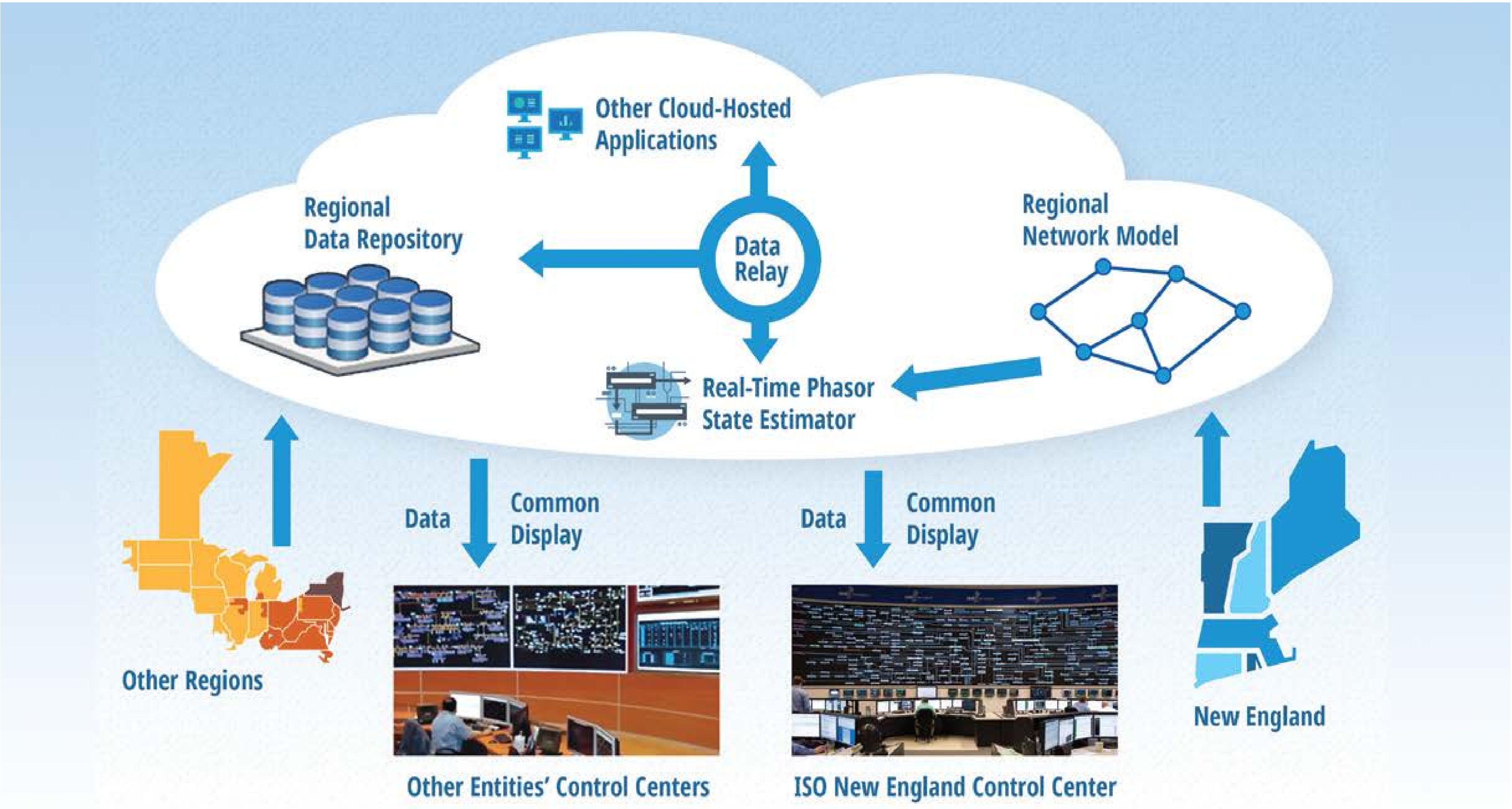
Needs of a Cross-Regional Common Platform

- PMU – “Big Data”
- Efficient data collection and exchange
- Interconnection wide monitoring and situation awareness
- Better collaboration among regional grid operators
- Elimination of multilateral data exchange

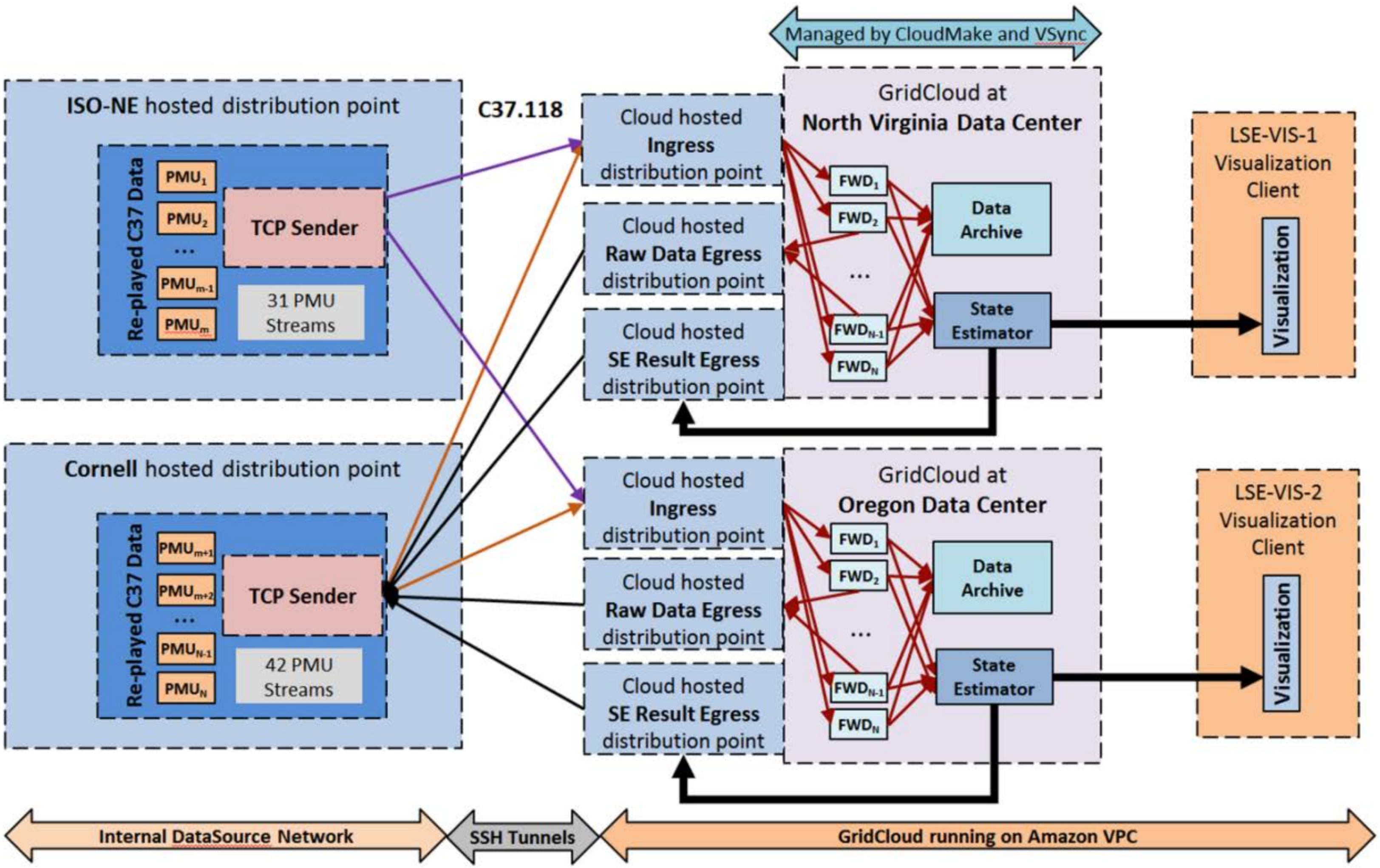
Proof-of-Concept Cloud Hosted WAMS

- Objective: demonstrate a cloud-hosted distributed platform for real-time PMU data collection, storage, processing and dissemination to achieve wide-area monitoring
  - Security
  - Network latency
  - Fault tolerance
  - Data consistency
  - Cost
- Project collaboration among
  - ISO New England Inc.
  - Cornell University
  - Washington State University
  - New York Power Authority (Phase II)

Proof-of-Concept Cloud Hosted WAMS



Cloud Hosted WAMS Deployment



Key Findings

- The latency due to encryption of data in transit and at rest (cloud archive) was satisfactory
  - Around 15ms between EC2 classic and VPC
  - SSH tunnels added less than 2ms
  - AES 256 encryption has no impact on performance (noise level)
- The average round-trip time, from the ISO-NE in Massachusetts to the Phasor State Estimator in the cloud and back to Cornell, was 350 milliseconds via the Virginia data center and 425 milliseconds via the Oregon data center

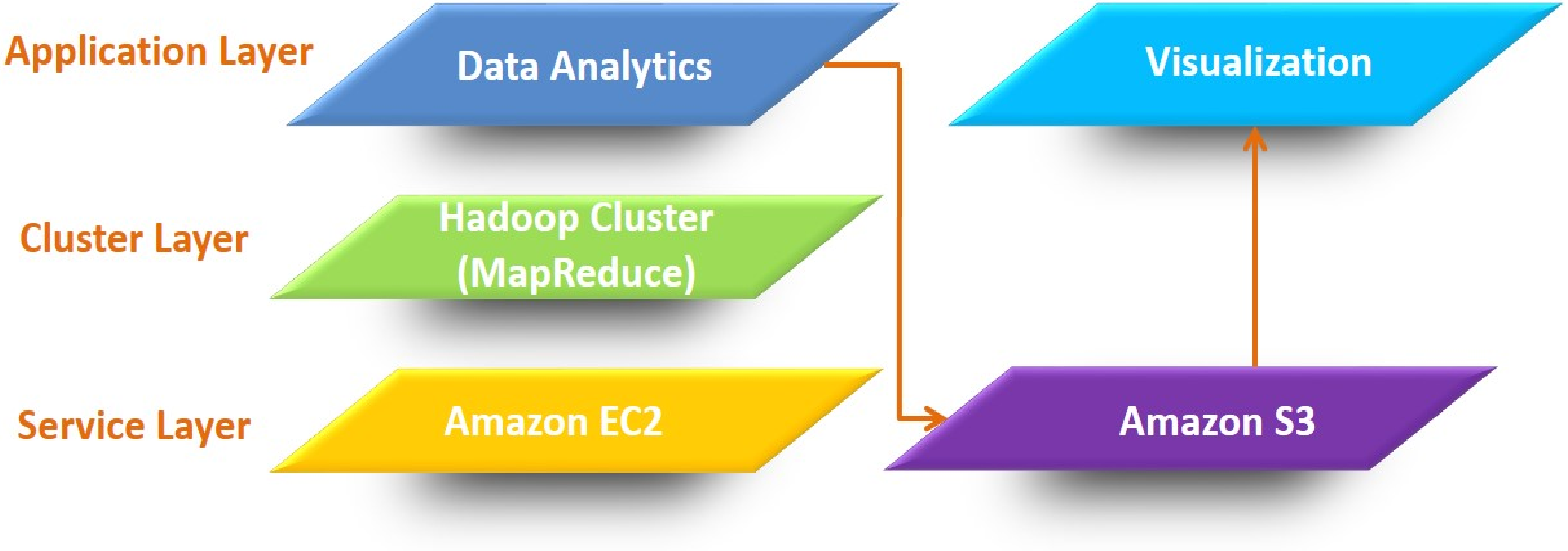
Key Findings

- Data consistency (PMU raw data and state estimator results) was confirmed between the two data centers
- Each data center had 13 cloud instances, with a total average cost of $2.47 per hour per data center
- Full back-up redundancy was restored within 5 minutes after data center shutdowns.

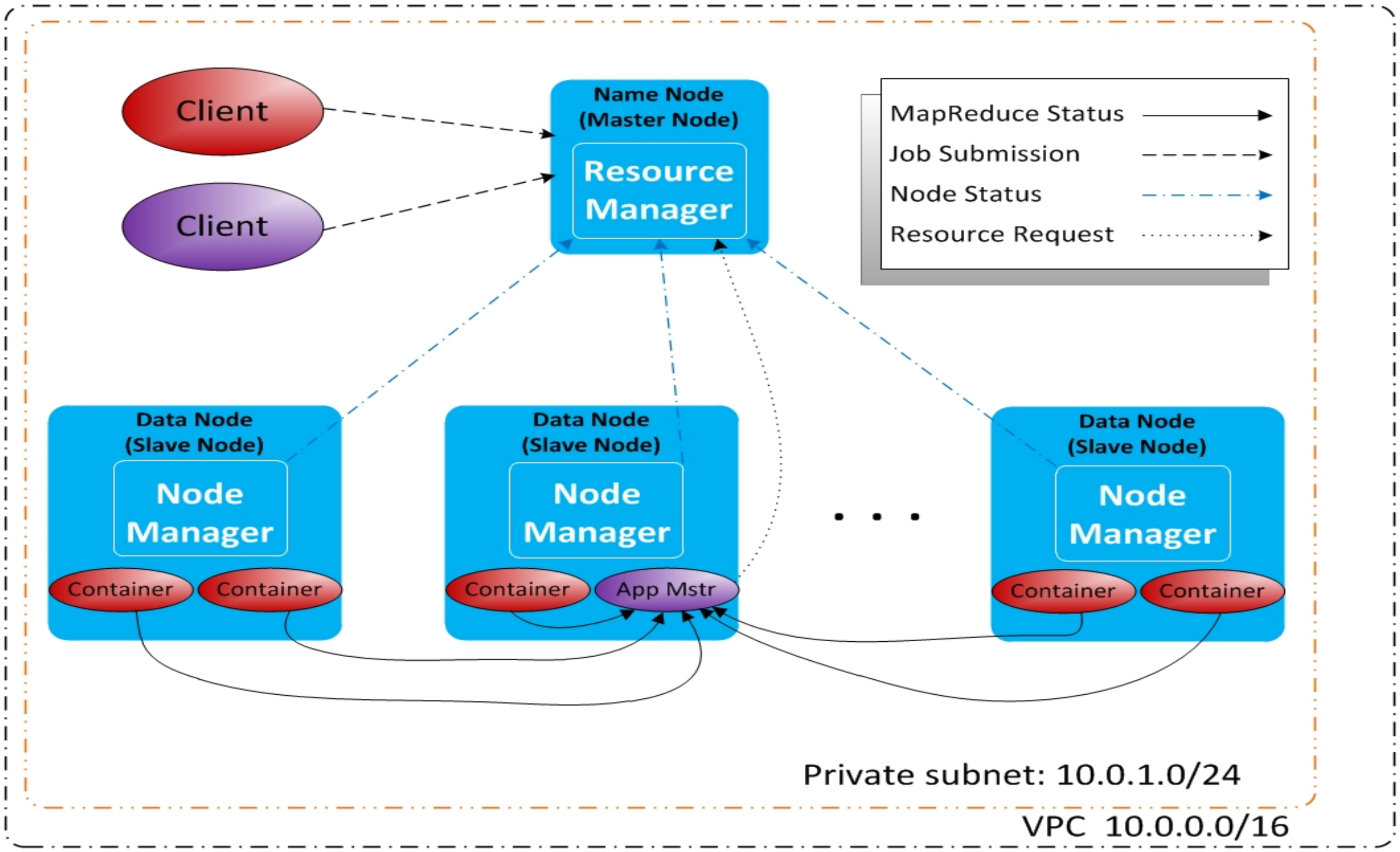
PMU Frequency Excursion Analysis

- Balancing Authorities must ensure generator governor response to frequency deviations exceeding 36mHz
- UTK's FNET email notification for large generator trip event across the Eastern Interconnection
- Operations are also interested in slow frequency change events
- PMU data is ideal for identifying the frequency event and generator governor response

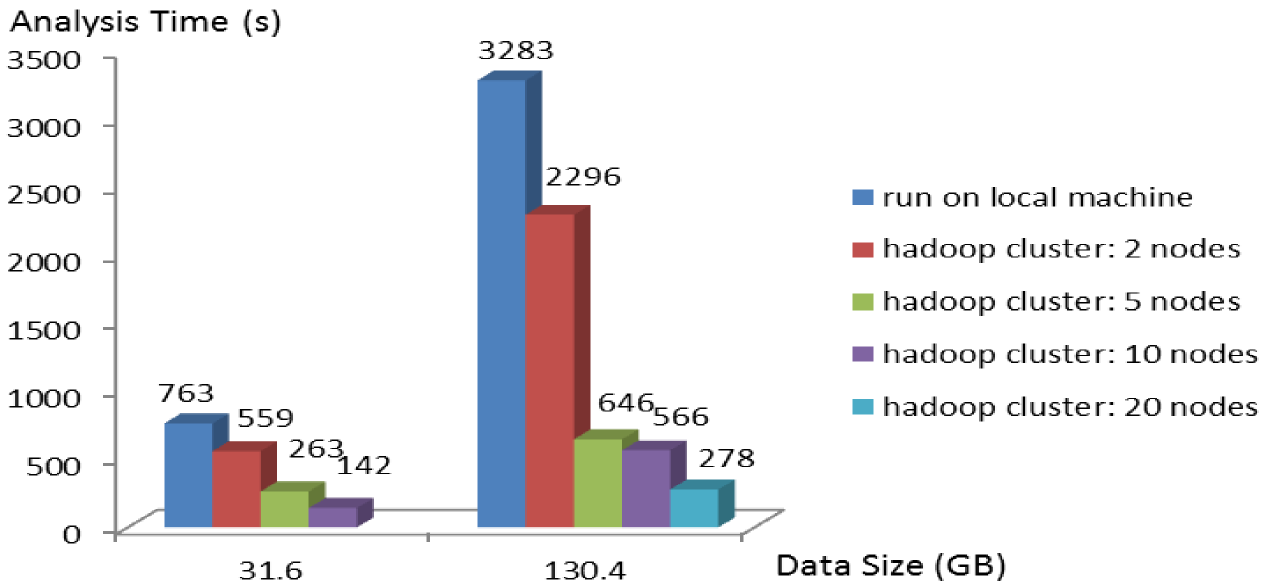
Cloud-Hosted Big Data Analytics



Hadoop-Cluster Overview

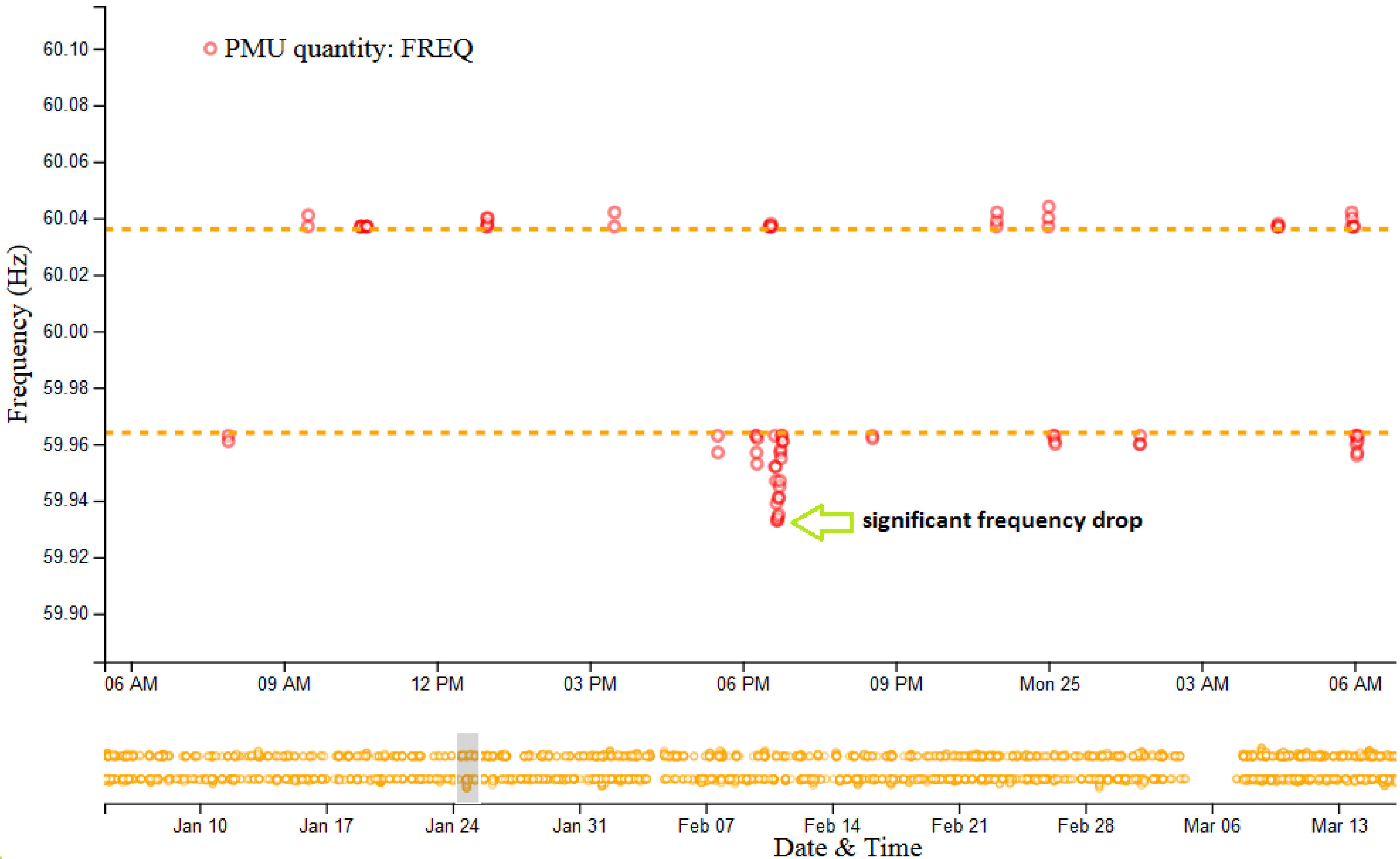


Performance and Cost



Number of data nodes	On-demand price per hour ($/hr)	Cost ($)	
		1st test	2nd test
2	1.26 = 0.42*(2+1)	1.26	1.26
5	2.52 = 0.42*(5+1)	2.52	2.52
10	4.62 = 0.42*(10+1)	4.62	4.62
20	8.82 = 0.42*(20+1)	N/A	8.82

Visualization of Analysis Results



Conclusions

- Cloud computing is a paradigm shift
  - Servers, storage, database, networking, software, analytics, etc.
- Power industry has been slow in adopting it
  - Offline and real time applications
- Cloud-hosted platform is ideal for PMU “big” data collection, storage, exchange, and analytics
- Much more streamlined architecture for wide-area collaboration and monitoring
- Early adoption of the cloud technology has successfully shown the ability of secure implementation