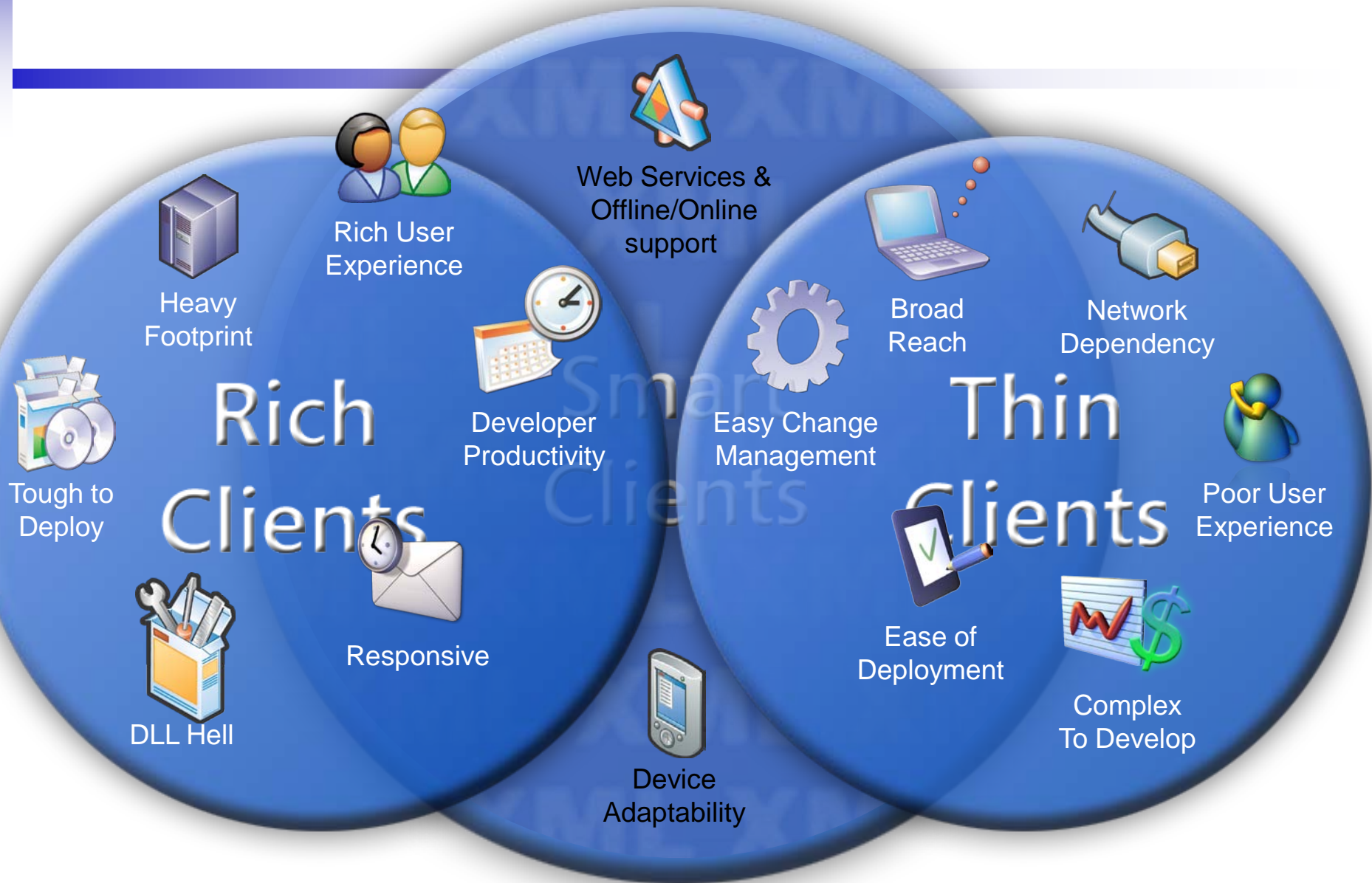# Wide Area Power System Visualization and Location of Disturbance (LOD) Using PMU Data

Guorui Zhang, EPRI
Lisa Beard, TVA
Ritchie Carroll, TVA
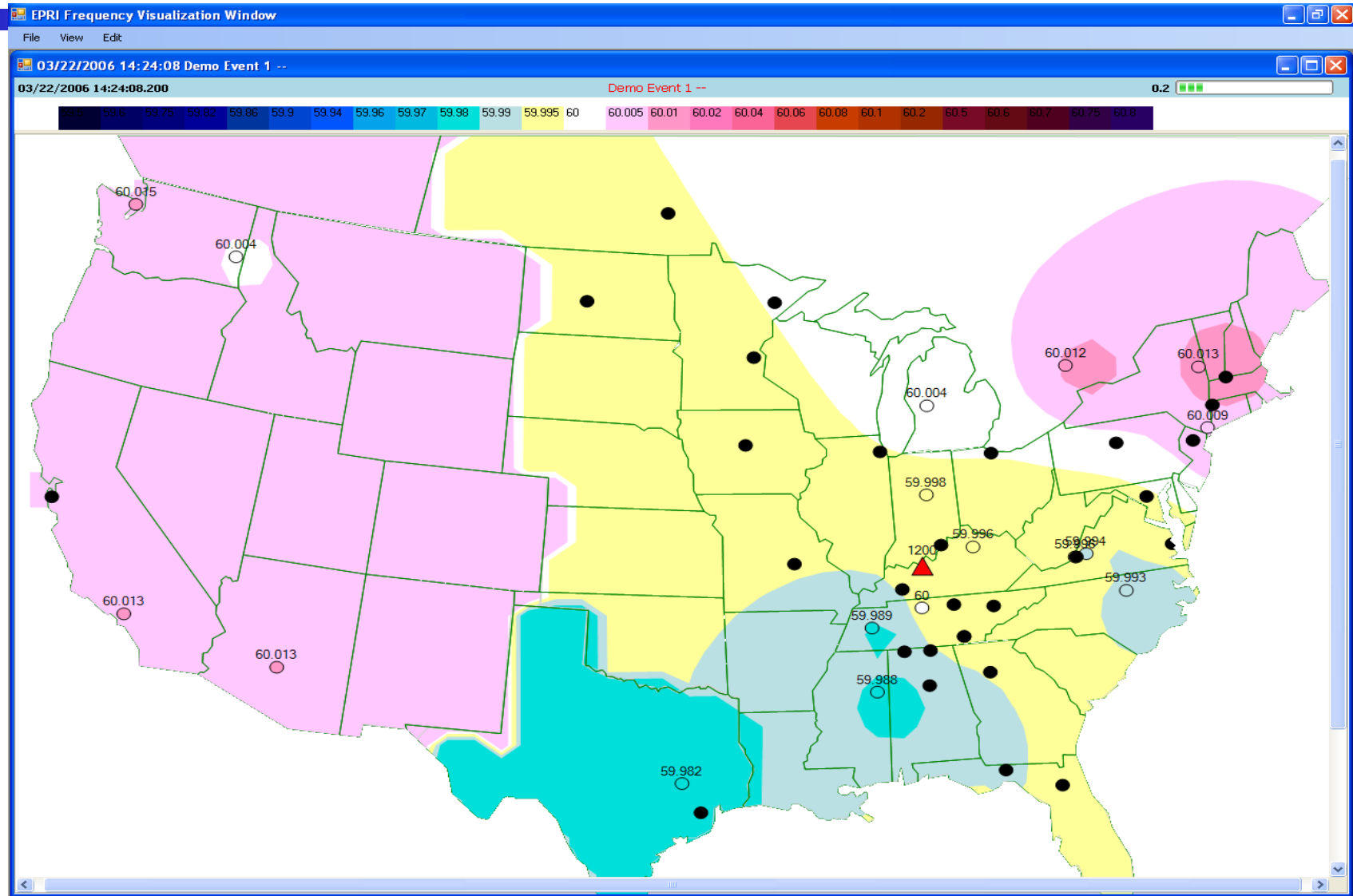*Yilu Liu, Virginia Tech*

Wide Area Power System Visualization Objectives

- Improve operator situational awareness
- Demonstrate wide area power system visualization and location of disturbance using real-time synchronous PMU measurements
- Demonstrate power system event replay for post event analysis
- Allow all authorized users to use this visualization for real time security monitoring and event replay

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Smart Client Presentation from Microsoft

Rich Clients

- Heavy Footprint
- Rich User Experience
- Tough to Deploy
- DLL Hell
- Responsive
- Developer Productivity

Smart Clients

- Web Services & Offline/Online support
- Device Adaptability
- Easy Change Management

Thin Clients

- Broad Reach
- Network Dependency
- Poor User Experience
- Ease of Deployment
- Complex To Develop

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Real-Time Frequency Visualization Display Using a Generator Outage Event Data

4

Wide Area Power System Visualization
PMU Data Processing Challenges

- Process large volume of real-time PMU data

- Identify and filter bad or invalid real-time PMU data

- Insert large volume of PMU data for a event

- Handle malfunction PMUs or missing PMU data

- Filter real-time PMU data not used for power system visualization

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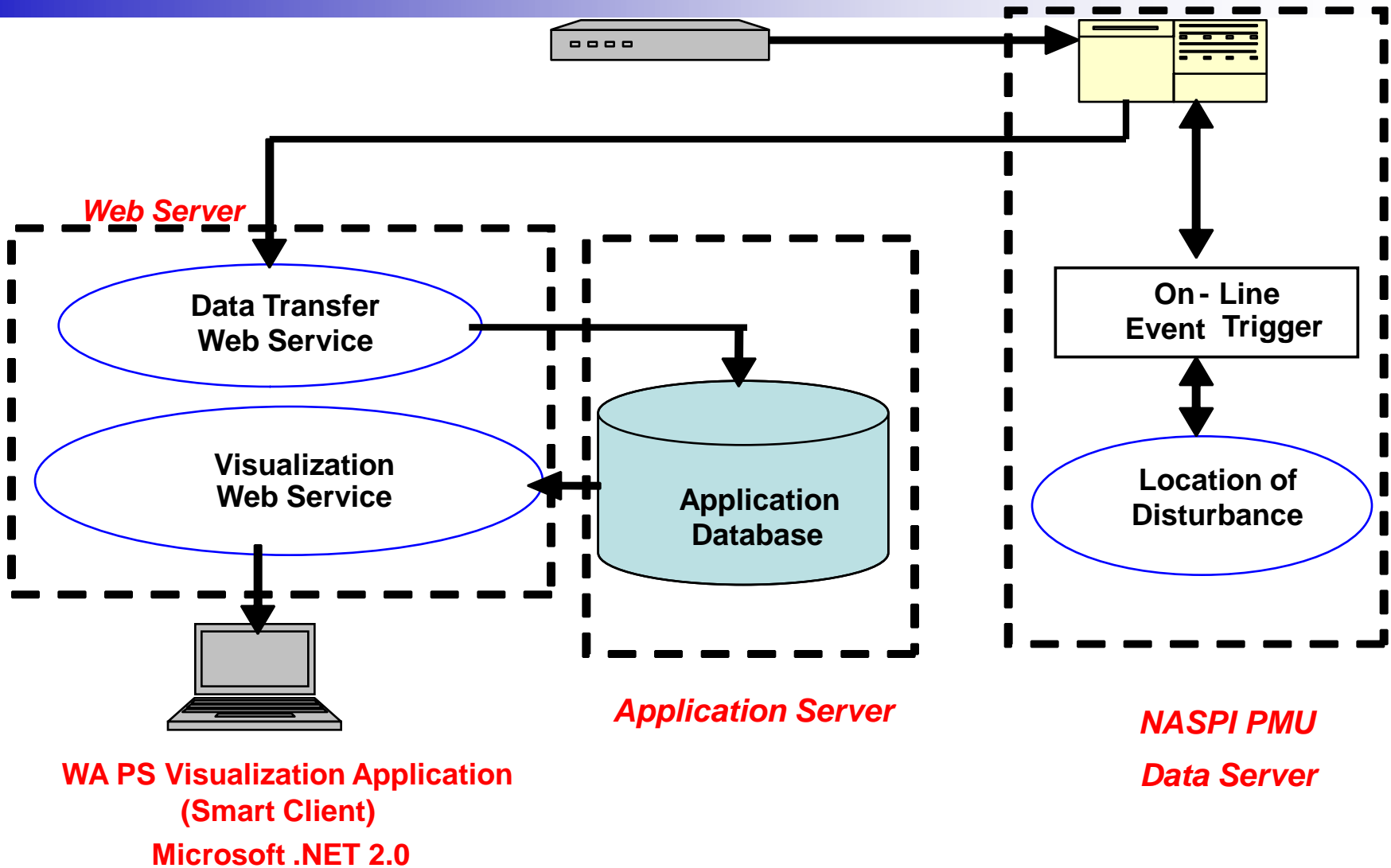
Wide Area Power System Visualization
Main Performance Challenges

- Efficient handling large volume of real-time PMU data and large number of users.

- Efficient handling of large volume of PMU data related to an event for post event analysis

- Efficient handling large number of users when they are replaying different events

- Fast calculation of frequency or voltage contours in event replay mode

- Coordination of real-time monitoring and event replay

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Wide Area Power System Visualization
Performance Enhancements

- Improve performance of real-time security monitoring
  - Transfer reduced set of PMU measurements required for visualization
  - Transfer one or two samples per second
- Transfer event related PMU data in full resolution (20 to 30 samples per second) only when an event is detected
- Use event oriented application database
- Coordinate real-time security monitoring and event replay
- Replay event locally fully utilizing user's computer resources
- Enhance data communication between data server to application server
- Enhance data communication between application server to large number of users

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Wide Area Power System Visualization System Architecture

Web Server

Data Transfer
Web Service

Visualization
Web Service

Application
Database

On - Line
Event Trigger

Location of
Disturbance

Application Server

NASPI PMU

Data Server

**WA PS Visualization Application
(Smart Client)**

Microsoft .NET 2.0

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Wide Area Power System Visualization Integration Tasks

- Integrate on-line event trigger and Location of Disturbance (LOD) with PMU / FNET data server at TVA (Virginia Tech and TVA)

- Integrate Wide Area Power System Visualization Application with PMU / FNET data server at TVA (TVA and EPRI)

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Wide Area Power System Visualization Integration Approaches

- Use PMU data parser program developed by TVA to process real-time PMU / FNET real time data to speed up integration

- Filter PMU data items not used for visualization to improvement performance and reduce the computer and communication requirements

- Filter PMU data items not used for on-line event trigger and location disturbance application

- Use Remote Procedure Call (RPC) to transfer PMU / FNET data from PMU data server to application server

- Install wide area power system visualization application (Web server, database server, application server) at TVA

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Wide Area Power System Visualization
Main Components

- PMU Data Server

- Location of System Disturbance developed by Virginia Tech and funded by EPRI, TVA and Entergy

- On-line Event Trigger developed by Virginia Tech

- EPRI Wide Area Power System Visualization Application

- Application interfaces for transferring PMU data and event data from PMU data server to application data server

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Wide Area Power System Visualization
Main Features

- Perform real-time security monitoring using PMU data
  - Frequency contour
  - Voltage contour
  - Phase angle contour
  - Phase angle differences
- Identify and show location and magnitude of large disturbances
- Replay current or previous system disturbances
- Show PMU data trending

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Wide Area Power System Visualization
Potential Users

- Power system operators at EMS or ISO

- Reliability coordinators

- Regional reliability coordinators

- Operational planning engineers and managers

- Government agencies

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Conclusion

- It is critical to quickly identify and show the location and magnitude of an large event using real-time PMU measurements

- It is very challenging to perform wide area power system visualization and event replay using PMU data and supporting large number of users

- Smart client is very suitable for real-time monitoring and post event analysis

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