

**EPRI**

ELECTRIC POWER  
RESEARCH INSTITUTE

## Wide Area Power System Visualization and Near Real-Time Event Replay Using SynchroPhasor Measurement

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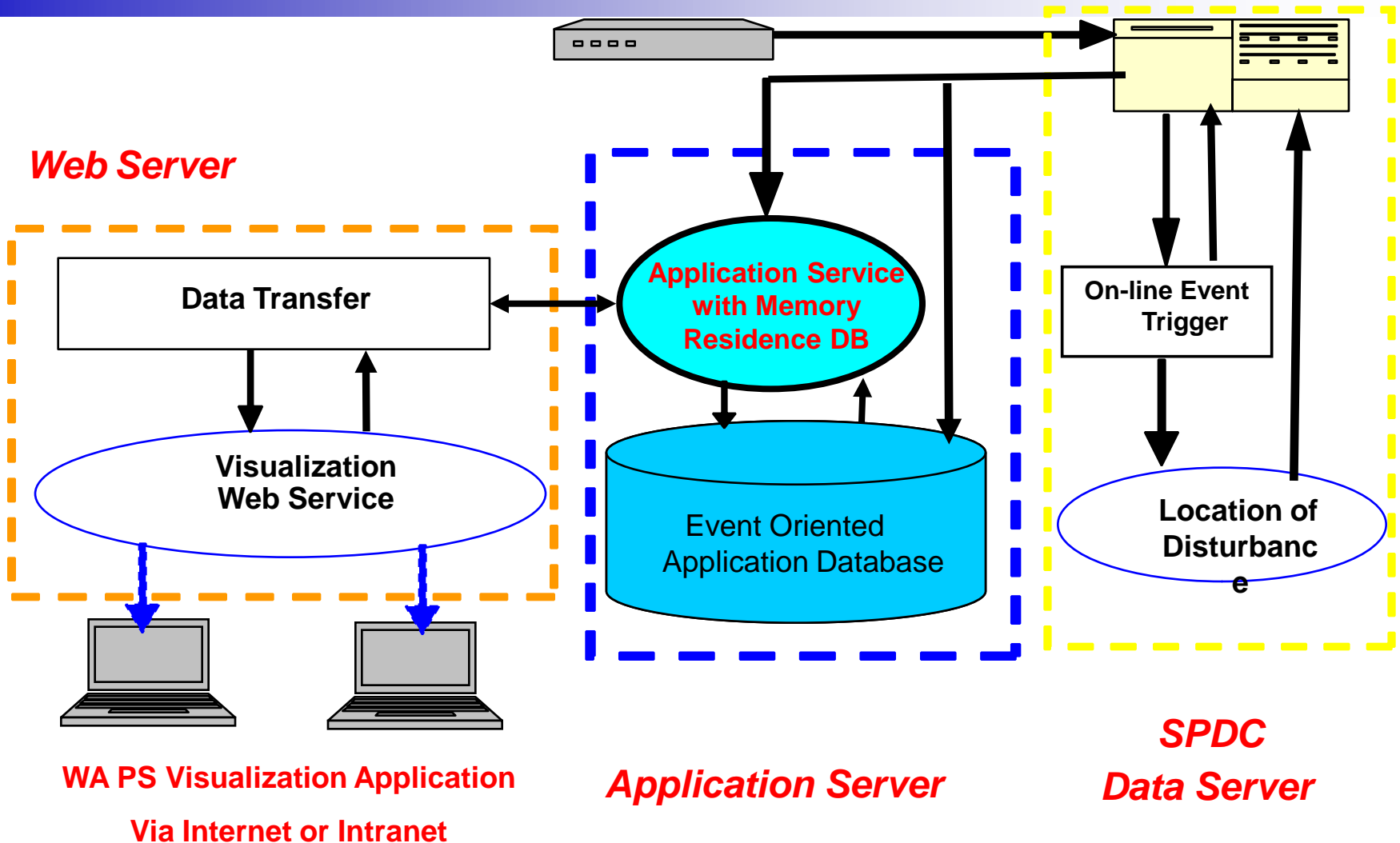
Lisa Beard, Ritchie Carroll and Ryan Zuo, TVA

Yilu Liu, UTK

# Wide Area Power System Visualization Objectives

- Improve operator situational awareness
- Perform wide area power system visualization using real-time synchrophasor measurements for
  - Real-time security monitoring
  - Real-time large event detection
  - Near real-time event replay
  - Location of disturbance
- Perform power system event replay for post event analysis

# System Architecture Overview



# Wide Area Power System Visualization

## Project Status

- Developed wide area power system visualization using new technologies to
  - Efficiently handle large volume of synchrophasor measurements
  - Support large number of users
  - Perform near real-time event replay
- Developed dashboard to allow users to define their own dashboard for security monitoring
- Perform integration and testing at TVA (**in progress**)

# Techniques for Performance Improvements

- Improve performance of real-time reliability monitoring
  - Use memory residence object-oriented database
- Improve performance of near real-time event replay and post event analysis
  - Use event oriented application database
  - Efficiently handle event related synchrophasor data
  - Replay events locally fully utilizing user's computer resources

# Wide Area Power System Visualization

## Main Features

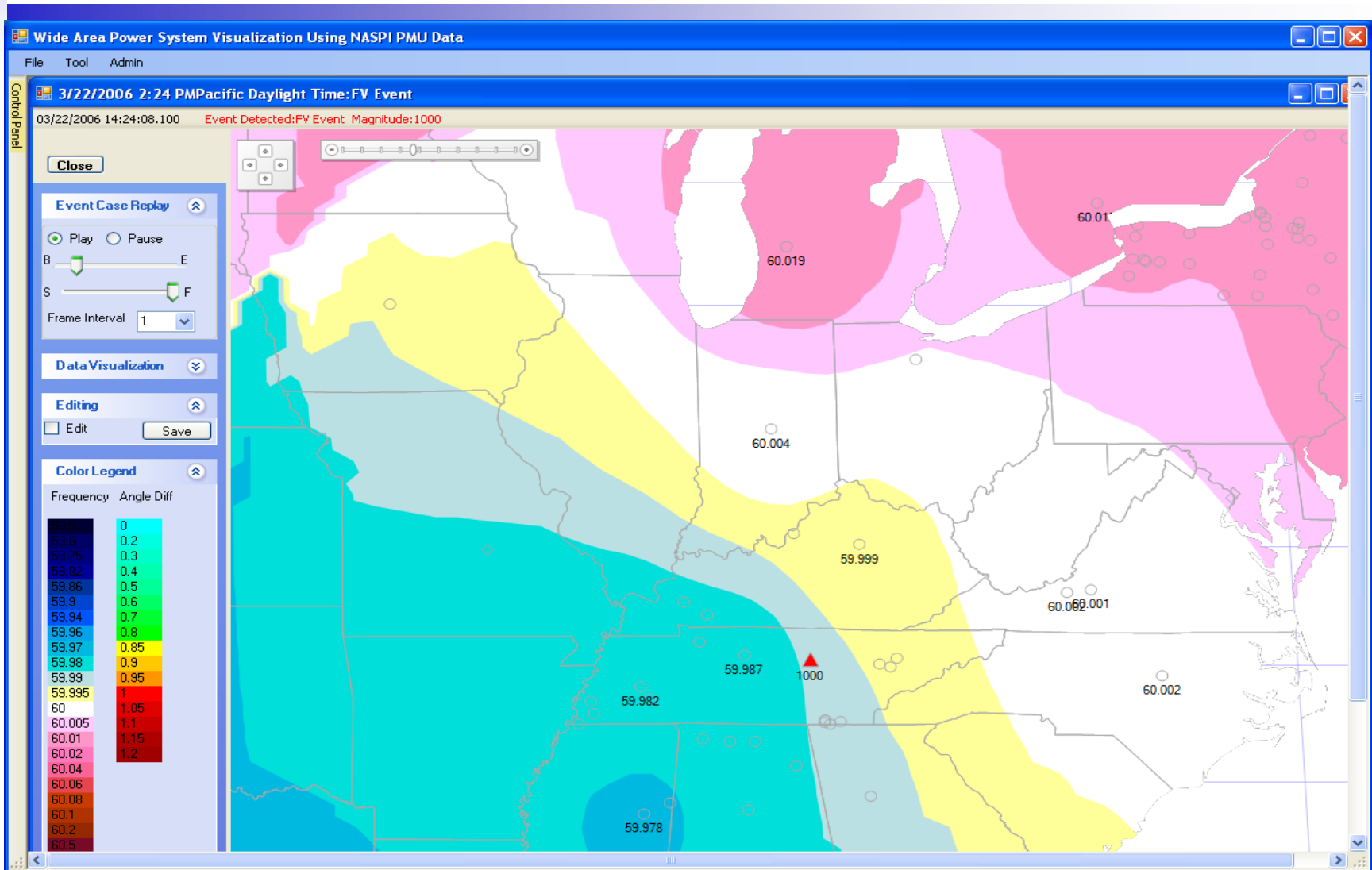
- Real-time security monitoring using real-time synchrophasor measurements
- On-line event detection
- Near real-time event replay
- Location of disturbance
- Post event analysis
- High performance visualization
  - Frequency contour
  - Voltage magnitude contour
  - Voltage angle contour
  - Angle differences
  - Trending charts
  - Dashboards

# Near Real-Time Event Replay Testing Results

## 49 PMUs with 300s event data (about 10MB) Using a Laptop

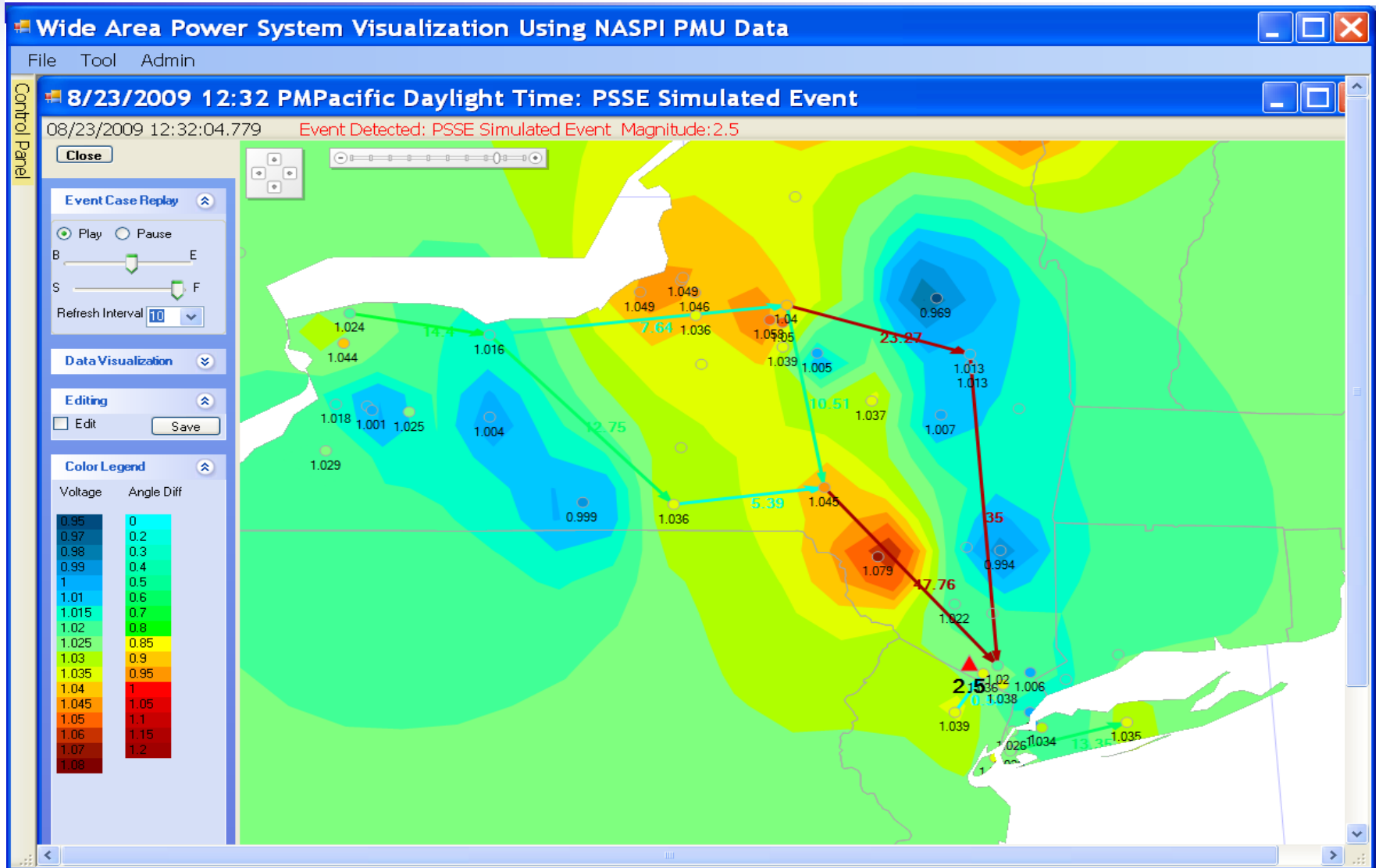
	Traditional Approach (Second)	New Approach (Second)
Insert event data into event database from PMU data server	644	33
Read event data from event database from application server	25	1
Visualization display shows up after event is detected.	858	About 5

# Frequency Visualization Display using 1000 MW Generator Outage Data on March 22, 2006





# Voltage Magnitude Visualization Display with Angle Differences Using Simulated PMU Data





File Tool Admin

Control Panel

## 8/23/2009 12:32 PMPacific Daylight Time: PSSE Simulated Event



08/23/2009 12:32:05.779 Event Detected: PSSE Simulated Event Magnitude:2.5

Close

### Event Case Repla

Play  Pause

B  E

S  F

Refresh Interval 10

### Data Visualization

Show Data Type

Voltage Angle

Contour

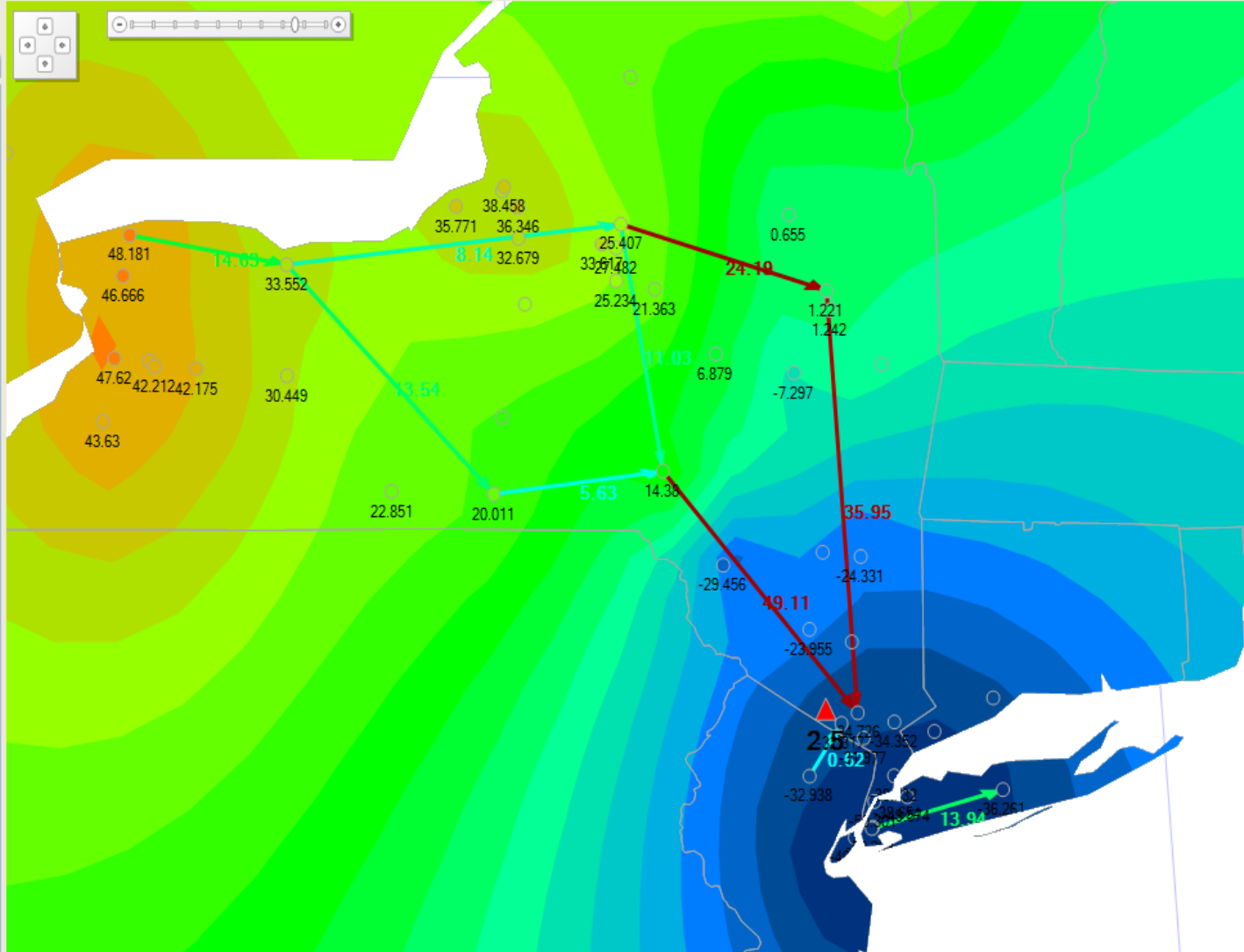
### Editing

Edit Save

### Color Legend

Angle Angle Diff

-40	0
-35	0.2
-30	0.3
-25	0.4
-20	0.5
-15	0.6
-10	0.7
-5	0.8
0	0.85
5	0.9
10	0.95
15	1
20	1.05
25	1.1



# Summary

- Made very good progress in the design, development and integration testing of visualization software
- Developed power system visualization technologies and technical approaches for meeting performance requirements
- Initial testing results for real-time security monitoring and on-line event replay are very encouraging
- Integration and testing at TVA are in progress.

# Summary

- Made very good progress in the research, development and integration testing of visualization software
- Developed power system visualization technologies for meeting performance requirements
- Initial testing results for real-time security monitoring and near real-time event replay are very encouraging
- Integration and testing at TVA are in progress.

# Acknowledgement

## Funding and Technical Support

- The current EPRI R&D projects of wide area power system visualization using synchrophasor measurements are funded by
  - TVA
  - ConEd
  - NYSERDA
  - EPRI Technology Innovation (TI)
- Technical supports: TVA, Virginia Tech, NYISO, NYPA, ConEd and LIPA



# DOE Demonstration of a Novel Synchrophasor-Based Situation Awareness System

- DOE issued the contract on September 30, 2009.
- Project will be completed in 3 years.
- Large scale demonstration using synchrophasor measurements for
  - Real-time reliability monitoring
  - On-line event detection and location of disturbance
  - Near real-time event replay
  - Post event analysis
  - Early warning of potential system problems
- Project teams: EPRI, TVA, Yilu Liu of UTK and HTC Tech