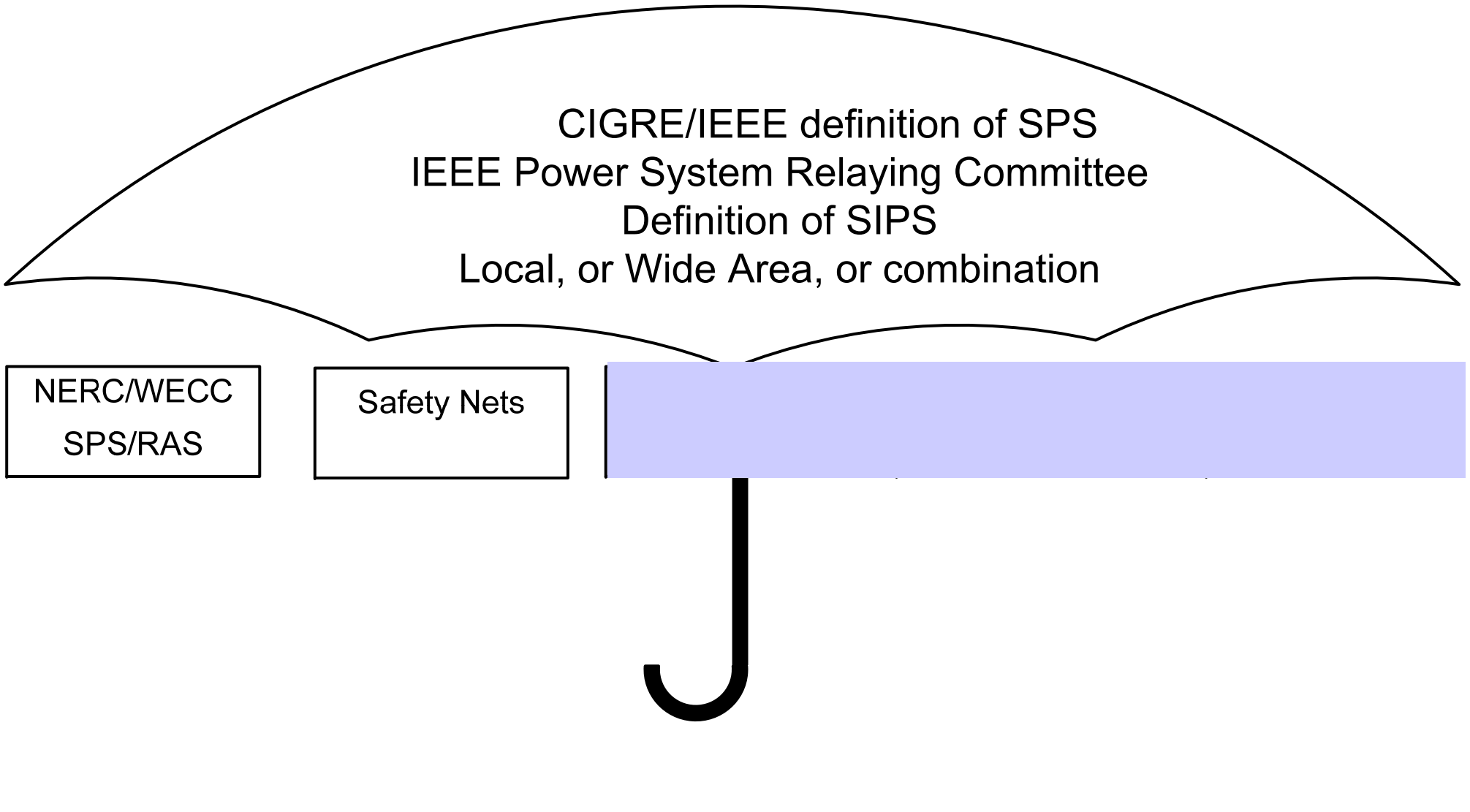
Technological Breakthroughs in Grid Revitalization

Vahid Madani
Pacific Gas & Electric Co.

The Evolving Landscape of Power Systems

PES - Emerging Technology - July 2008

System Integrity Protection Schemes - SIPS

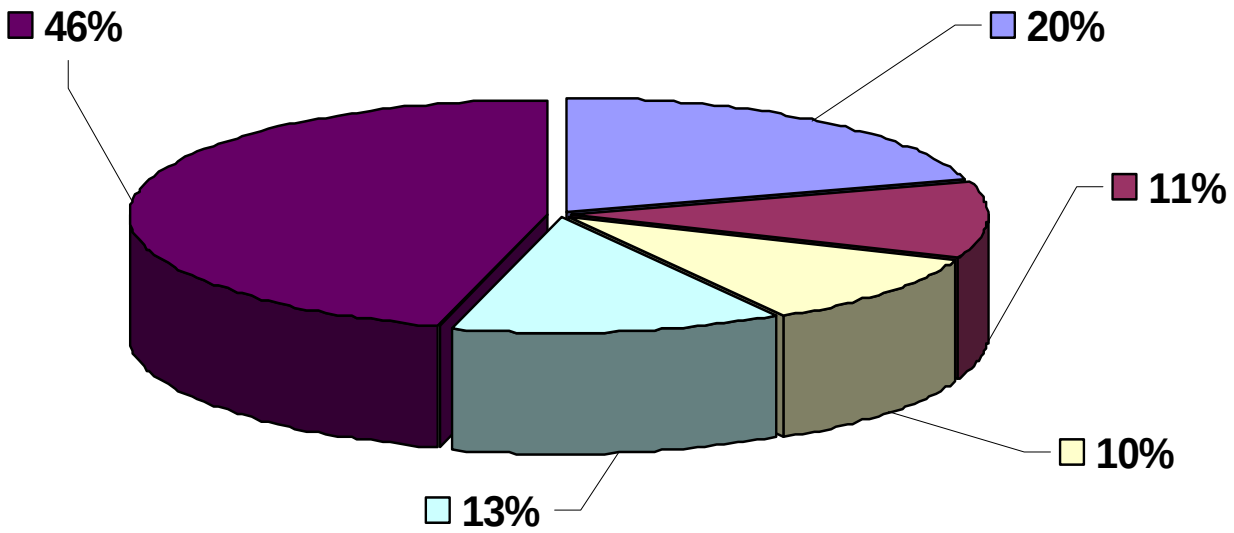


Application Naming

Source: IEEE PSRC WG C-4
Global Industry Experiences with
System Integrity Protection Schemes

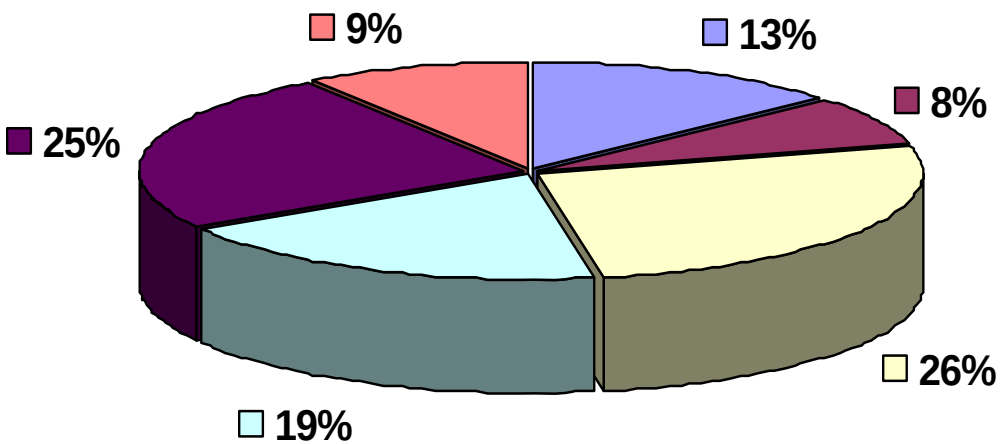
- Generator Rejection
- Load Rejection
- Under-Frequency Load Shedding
- Under-Voltage Load Shedding
- Adaptive Load Mitigation
- Out-of-Step Tripping
- Voltage Instability Advance Warning Scheme
- Angular Stability Advance Warning Scheme
- Overload Mitigation
- Congestion Mitigation
- System Separation
- Shunt Capacitor Switching
- Tap-Changer Control
- SVC/STATCOM Control
- Turbine Valve Control
- HVDC Controls
- Power System Stabilizer Control
- Discrete Excitation
- Dynamic Breaking
- Generator Runback
- Bypassing Series Capacitor
- Black-Start or Gas-Turbine Start-Up
- AGC Actions
- Busbar Splitting

Pie Charts: Classification (422 Entries)



- i. Essential
- ii. Increased Security
- iii. Increased Power Flow Capability
- iv. Important
- v. Normal

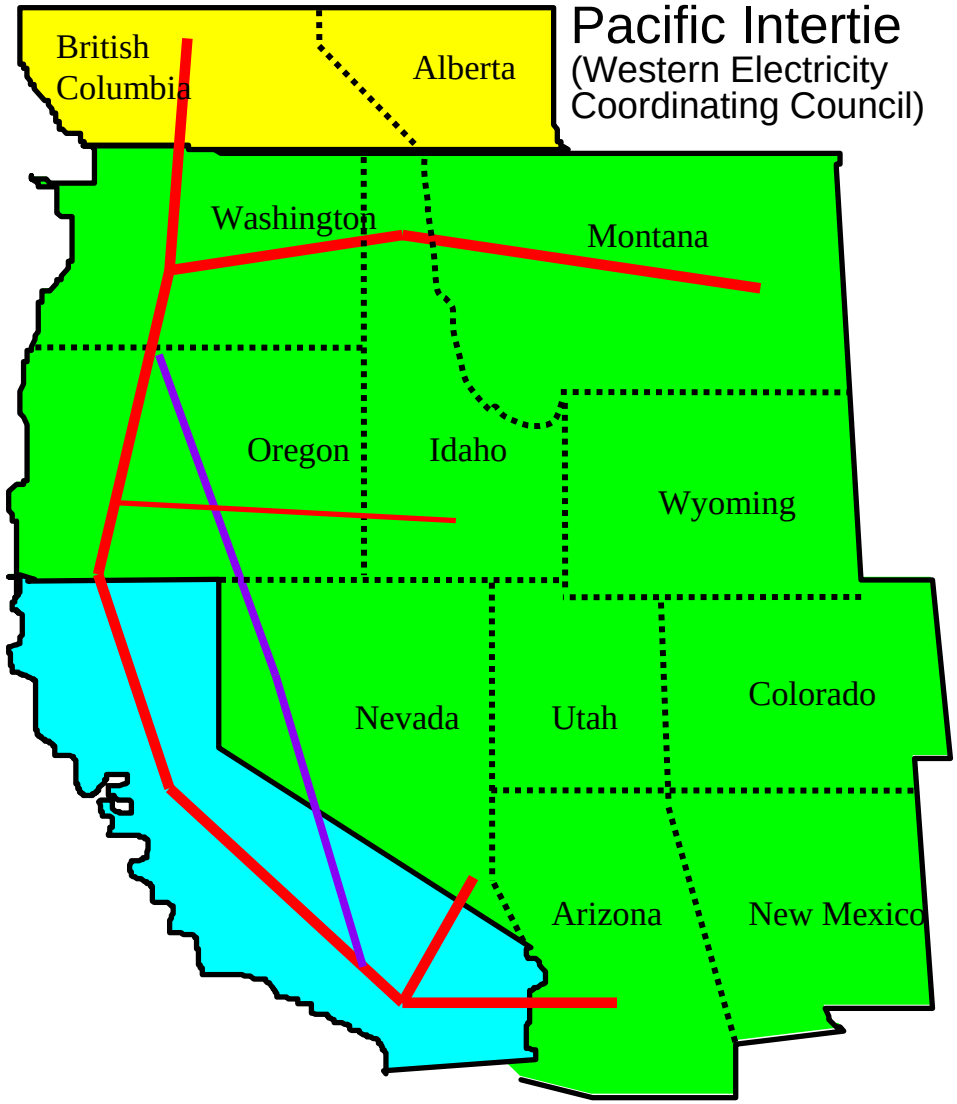
Pie Chart: To provide protective actions against (53 Entries)



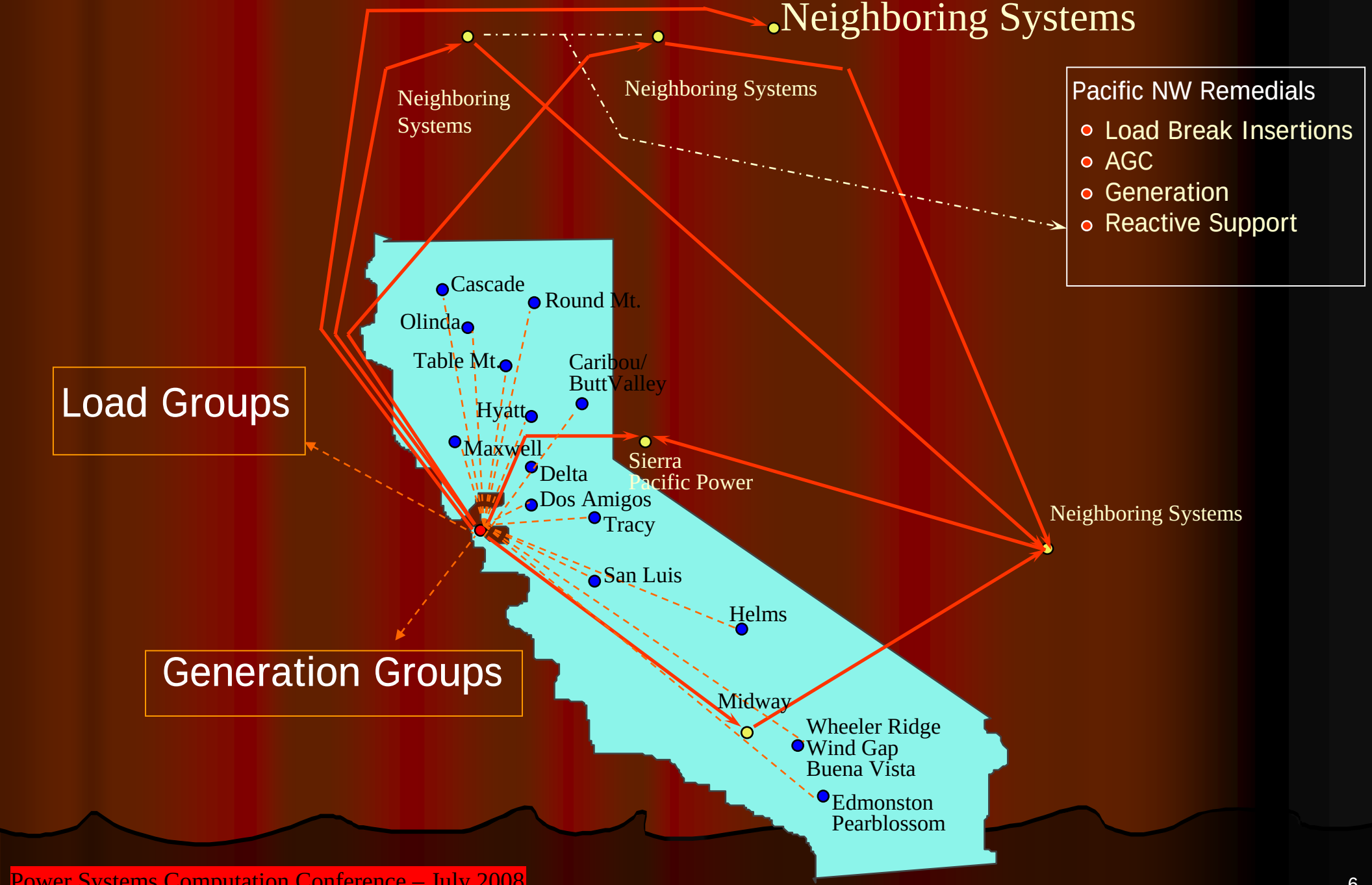
- i. Congestion
- ii. Small-Disturbance Angle Instability
- iii. Transient Instability
- iv. Frequency Instability
- v. Voltage Instability
- vi. Thermal Overloading

RAS or SIPS

- System to protect integrity of power system over a wide area
- Applied to protect system stability, maintain overall system connectivity, and/or to avoid damage to equipments during major system events
- System may require multiple detection and actuation devices, and communication facilities
- Logic, design and actions are driven by the system purpose
- Advanced schemes involve hierarchical architecture with several steps



Large Scale Coordinated SIPS

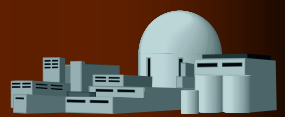


Multiple RAS Control Centers

Existing Control Center

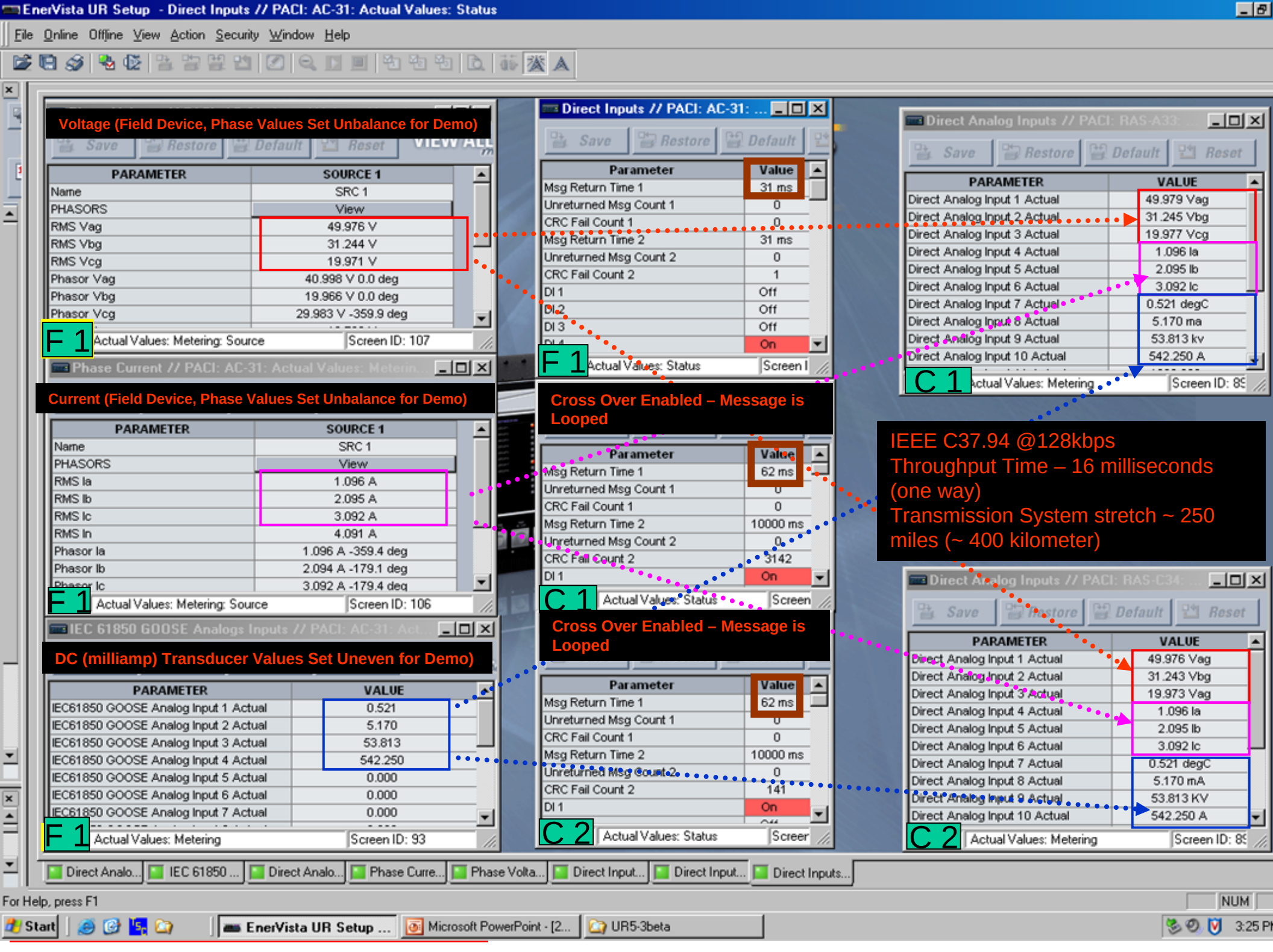
Field Devices - Keep the existing or change to new??

Existing Comms links



New Control Center

New Comms links


EnerVista UR Setup - Direct Inputs // PACI: AC-31: Actual Values: Status
File Online Offline View Action Security Window Help
Voltage (Field Device, Phase Values Set Unbalance for Demo)
PARAMETER SOURCE 1
Name SRC 1
PHASORS View
RMS Vag 49.976 V
RMS Vbg 31.244 V
RMS Vcg 19.971 V
Phasor Vag 40.998 V 0.0 deg
Phasor Vbg 19.966 V 0.0 deg
Phasor Vcg 29.983 V -359.9 deg
F 1
Actual Values: Metering: Source
Screen ID: 107
Current (Field Device, Phase Values Set Unbalance for Demo)
PARAMETER SOURCE 1
Name SRC 1
PHASORS View
RMS Ia 1.096 A
RMS Ib 2.095 A
RMS Ic 3.092 A
RMS In 4.091 A
Phasor Ia 1.096 A -359.4 deg
Phasor Ib 2.094 A -179.1 deg
F 1
Actual Values: Metering: Source
Screen ID: 106
DC (milliamp) Transducer Values Set Uneven for Demo)
PARAMETER VALUE
IEC61850 GOOSE Analog Input 1 Actual 0.521
IEC61850 GOOSE Analog Input 2 Actual 5.170
IEC61850 GOOSE Analog Input 3 Actual 53.813
IEC61850 GOOSE Analog Input 4 Actual 542.250
IEC61850 GOOSE Analog Input 5 Actual 0.000
IEC61850 GOOSE Analog Input 6 Actual 0.000
IEC61850 GOOSE Analog Input 7 Actual 0.000
F 1
Actual Values: Metering
Screen ID: 93
Direct Inputs // PACI: AC-31: ...
Save Restore Default Reset
Parameter Value
Msg Return Time 1 31 ms
Unreturned Msg Count 1 0
CRC Fail Count 1 0
Msg Return Time 2 31 ms
Unreturned Msg Count 2 0
CRC Fail Count 2 1
DI 1 Off
DI 2 Off
DI 3 Off
On
F 1
Actual Values: Status
Cross Over Enabled – Message is Looped
Parameter Value
Msg Return Time 1 62 ms
Unreturned Msg Count 1 0
CRC Fail Count 1 0
Msg Return Time 2 10000 ms
Unreturned Msg Count 2 0
CRC Fail Count 2 3142
DI 1 On
C 1
Actual Values: Status
Cross Over Enabled – Message is Looped
Parameter Value
Msg Return Time 1 62 ms
Unreturned Msg Count 1 0
CRC Fail Count 1 0
Msg Return Time 2 10000 ms
Unreturned Msg Count 2 0
CRC Fail Count 2 141
DI 1 On
C 2
Actual Values: Status
Direct Analog Inputs // PACI: RAS-A33: ...
Save Restore Default Reset
PARAMETER VALUE
Direct Analog Input 1 Actual 49.979 Vag
Direct Analog Input 2 Actual 31.245 Vbg
Direct Analog Input 3 Actual 19.977 Vcg
Direct Analog Input 4 Actual 1.096 Ia
Direct Analog Input 5 Actual 2.095 Ib
Direct Analog Input 6 Actual 3.092 Ic
Direct Analog Input 7 Actual 0.521 degC
Direct Analog Input 8 Actual 5.170 ma
Direct Analog Input 9 Actual 53.813 kv
Direct Analog Input 10 Actual 542.250 A
C 1
Actual Values: Metering
IEEE C37.94 @128kbps
Throughput Time – 16 milliseconds (one way)
Transmission System stretch ~ 250 miles (~ 400 kilometer)
Direct Analog Inputs // PACI: RAS-C34: ...
Save Restore Default Reset
PARAMETER VALUE
Direct Analog Input 1 Actual 49.976 Vag
Direct Analog Input 2 Actual 31.243 Vbg
Direct Analog Input 3 Actual 19.973 Vag
Direct Analog Input 4 Actual 1.096 Ia
Direct Analog Input 5 Actual 2.095 Ib
Direct Analog Input 6 Actual 3.092 Ic
Direct Analog Input 7 Actual 0.521 degC
Direct Analog Input 8 Actual 5.170 mA
Direct Analog Input 9 Actual 53.813 KV
Direct Analog Input 10 Actual 542.250 A
C 2
Actual Values: Metering
Direct Analo... IEC 61850 ... Direct Analo... Phase Curre... Phase Volta... Direct Input... Direct Input... Direct Inputs...
For Help, press F1
NUM
Start
EnerVista UR Setup ...
Microsoft PowerPoint - [2...
UR5-3beta
3:25 PM

Throughput Timing – 128kbps

(Excludes Controller Time ~ 10-12 msec)

- Distributed Intelligence and Central Processing
- Very inefficient to transport all of the raw data only to combine the various values after the data arrives at the control center
- Amount of raw data can overwhelm the bandwidth
- Methods to reduce the amount of raw data by pre-processing it prior to transmission
- If the mathematical combination and simplification can be done at remote sites, the required communication bandwidth is reduced
- Local subsystems be designed for station-to station communication
  - For local coordination

- Total measured time Device to Device - 16 milliseconds for one way, 250 miles (~ 425 km)

- Field Device (3 milliseconds)
- Central Controller Device (3 msec)
- Channel bank field, 1.5 msec
- Channel bank central device, 1.5 msec

- Propagation Time = [16 - (3+3+1.5+1.5] ~ 7 msec for 250 miles

- For 500 miles (~850km), it is safe to say < 14 msec

Thank You

Participate:

- NASPI - North American Synchronized phasor initiative Performance Standards Task Team (PSTT)
- IEEE Power System Relaying Committee (PSRC) - Survey WG C-4 (Global Industry Experiences with SIPS)