

Wide-Area Control and Protection

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**Next Generation Analytics
for the Future Grid**

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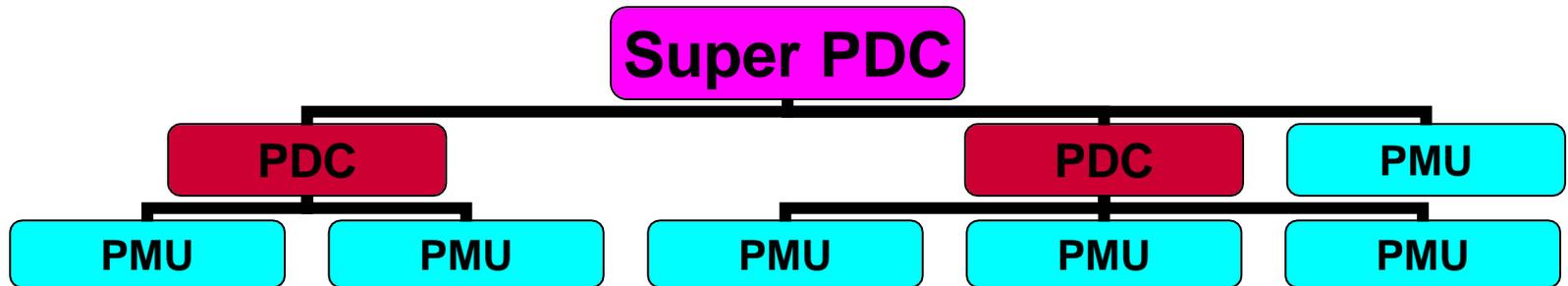


Control of the Power Grid

- **Frequency Control (AGC)**
 - **Area-wise – ONLY WIDE-AREA CONTROL**
 - **Slow (secs)**
- **Voltage Control**
 - **Local and regional**
 - **Slow to fast**
- **Protection**
 - **Mostly local, few special protection schemes**
 - **Fast**
- **Stability Control**
 - **Local machine stabilizers**
 - **Remote special protection schemes**
 - **Fast**



Phasor Measurements



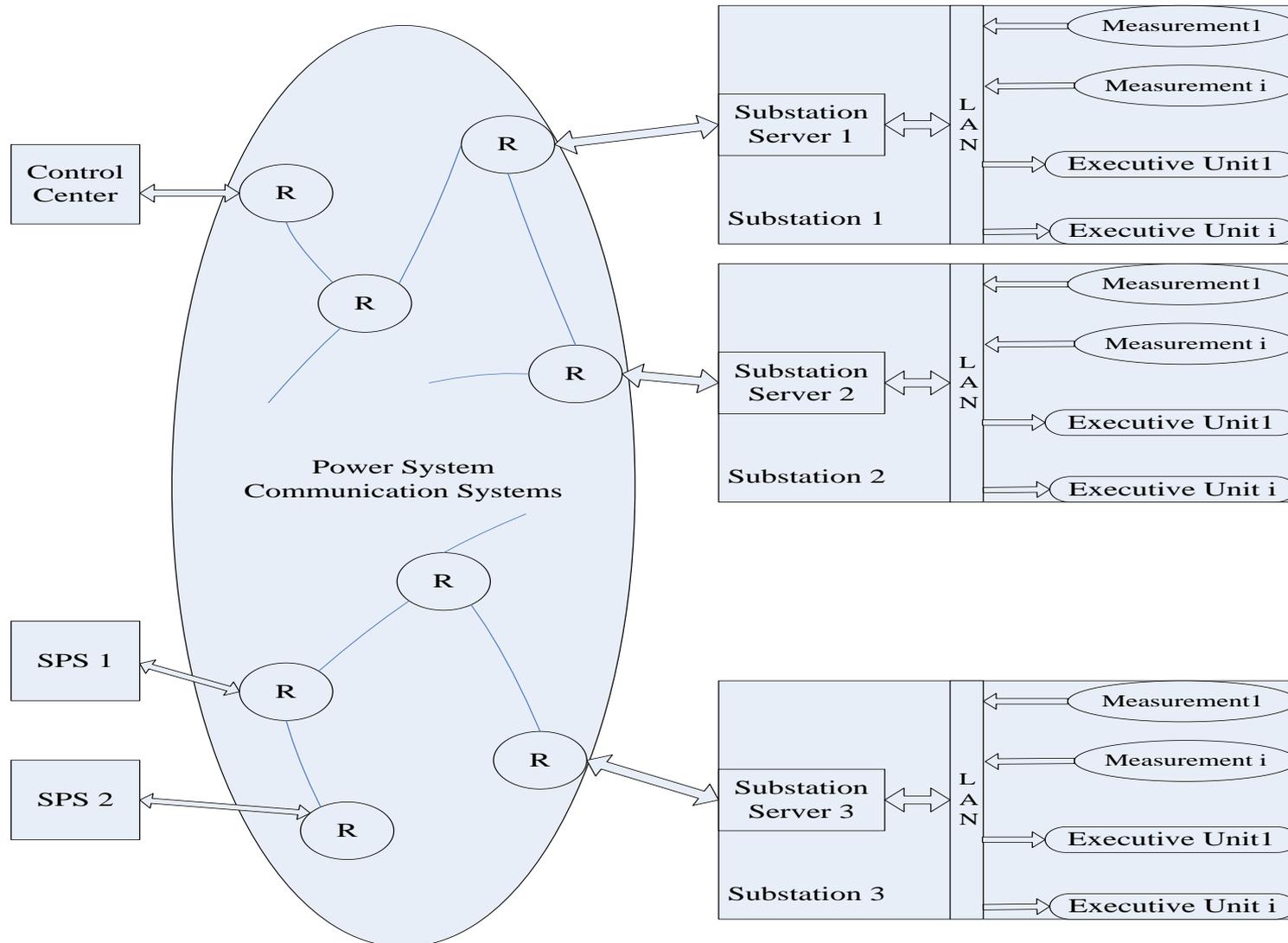


What is Wide-Area Monitoring, Protection and Control?

- **Wide-Area Monitoring Systems (WAMS)**
 - First installation of PMUs was called WAMS
- **Wide-Area Protection**
 - Event driven
 - Logic processing of non-local inputs/outputs
 - Switching
 - Now called SPS or SIPS
- **Wide-Area Control**
 - Multiple non-local input/output
 - Analog input/output



Proposed Communications





Data Base Issues

- **Real time data base must be distributed**
 - **Large amounts of calculated data must be part of this data base**
- **Static data base must be distributed**
- **Historical data base will require still another design**
- **Substation data bases and system level data bases have to be coordinated**
- **All data bases in the same interconnection will have to be coordinated**
- **Standards will be key**



What WACs are feasible?

- **Slow control (10-seconds)**
 - **AGC**
 - **Regional voltage control**
 - **Phasor measurements not needed**
- **Oscillation control (seconds)**
- **Transient stability control (sub-seconds)**
- **Model based control**



Oscillation Control

- **Oscillation detection already implemented**
- **Loop has been closed in experimental systems for actual oscillations**
- **Damping control feasible and being considered (already being done manually)**



Transient Stability Control

- **Event based wide area protection (SPS)**
- **Event based wide area control of FACTS**
- **Measurement (PMU) based protection or control of FACTS**
- **Measurement based calculated control**
- **Event based (faster than real time) calculated control**



Model Based Control

- **Real Time Model is updated by State Estimator**
 - **Static model updated in minutes**
- **Hundreds of Contingency scenarios studied**
 - **Operator is alerted**
- **Remedial Action can be calculated by OPF**

Can the loop be closed?

- **Faster update of Real Time Model is needed**



State Estimator and PMUs

- **Present**
 - **PMU measurements added to traditional SE**
 - **Marginal improvement in accuracy**
 - **No improvement in update frequency**
- **Future**
 - **PMU-only SE (observability required)**
 - **Linear, sub-second updates, higher accuracy**
 - **Substation level/Area level**



Closing the Loop

- **SE can update faster than SCADA data today**
- **Use SE output for monitoring**
 - **Operator visualization**
 - **Alarming**
- **Calculate Preventive Control and close loop**
- **Calculate Corrective control**
 - **Is it fast enough to close loop?**