Real Time Simulation of Power Grid Operation & Control

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February 25, 2010

Main Thrusts

Improve Reliability and Security of the Electric Power Grid by developing

- **The new communications and information systems needed to support better automatic controls and operator support tools**

- **The new wide area automatic controls needed for detecting and mitigating oscillations and instabilities**

- **The new operator support tools, like next generation state estimators, for better human decision making**

Assumptions

- **PMUs will increase and phasor measurements at high sampling rates will be ubiquitous**

- **The hardware technologies to move this data in large volumes and high speeds are available**

- **Power control devices (FACTS) will be deployed in larger numbers**

- **The software to manage and move this data is feasible but needs to be developed**

- **The software and algorithms for the next generation control and operation tools need to be developed**

A Critical Missing Piece
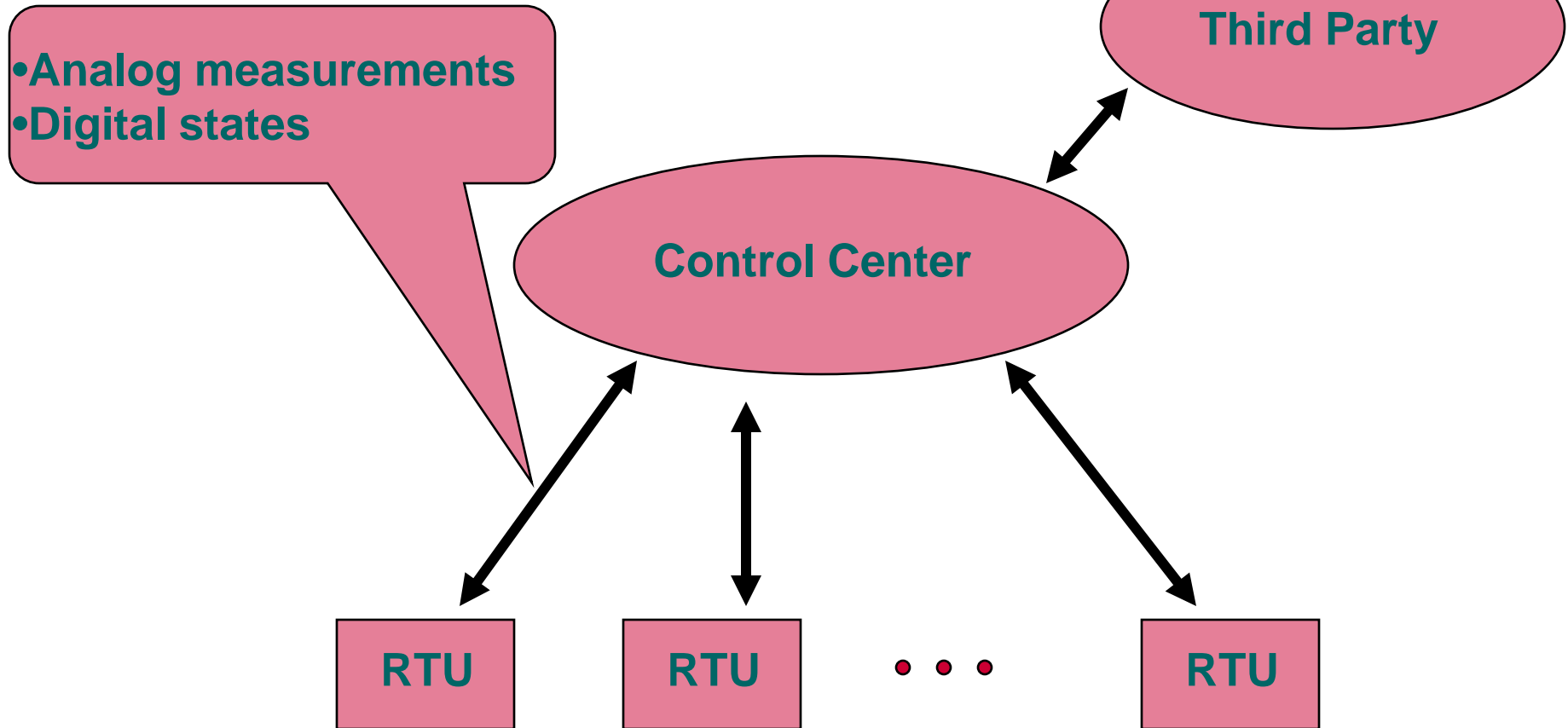
Simulation Test Bed for the Smart Grid
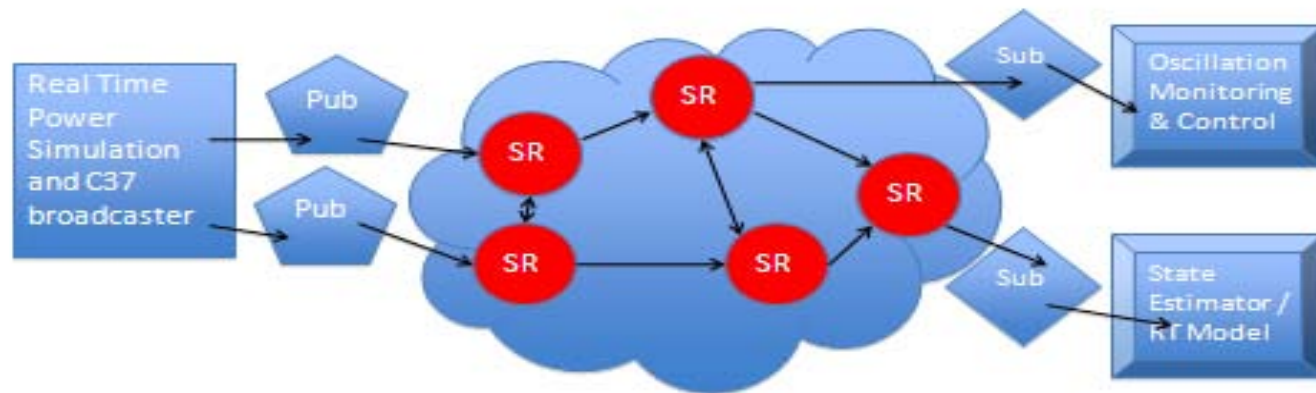
Fast simulation and measurement

- **Real Time Power Grid Simulation**
  - **Use commercial grade transient stability program**
  - **Simulate a large real system in real time**
  - **Replace output file with streaming data**
- **Streaming Measurement Data**
  - **Streaming data needed at PMU locations**
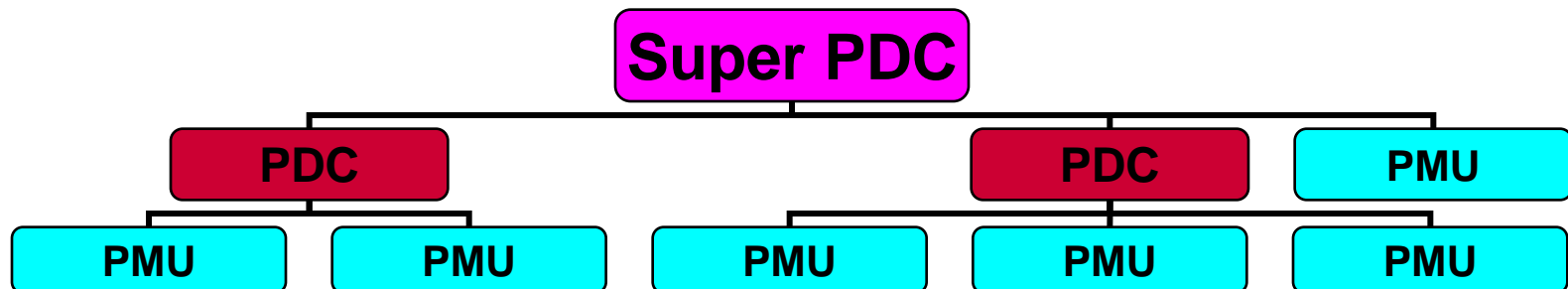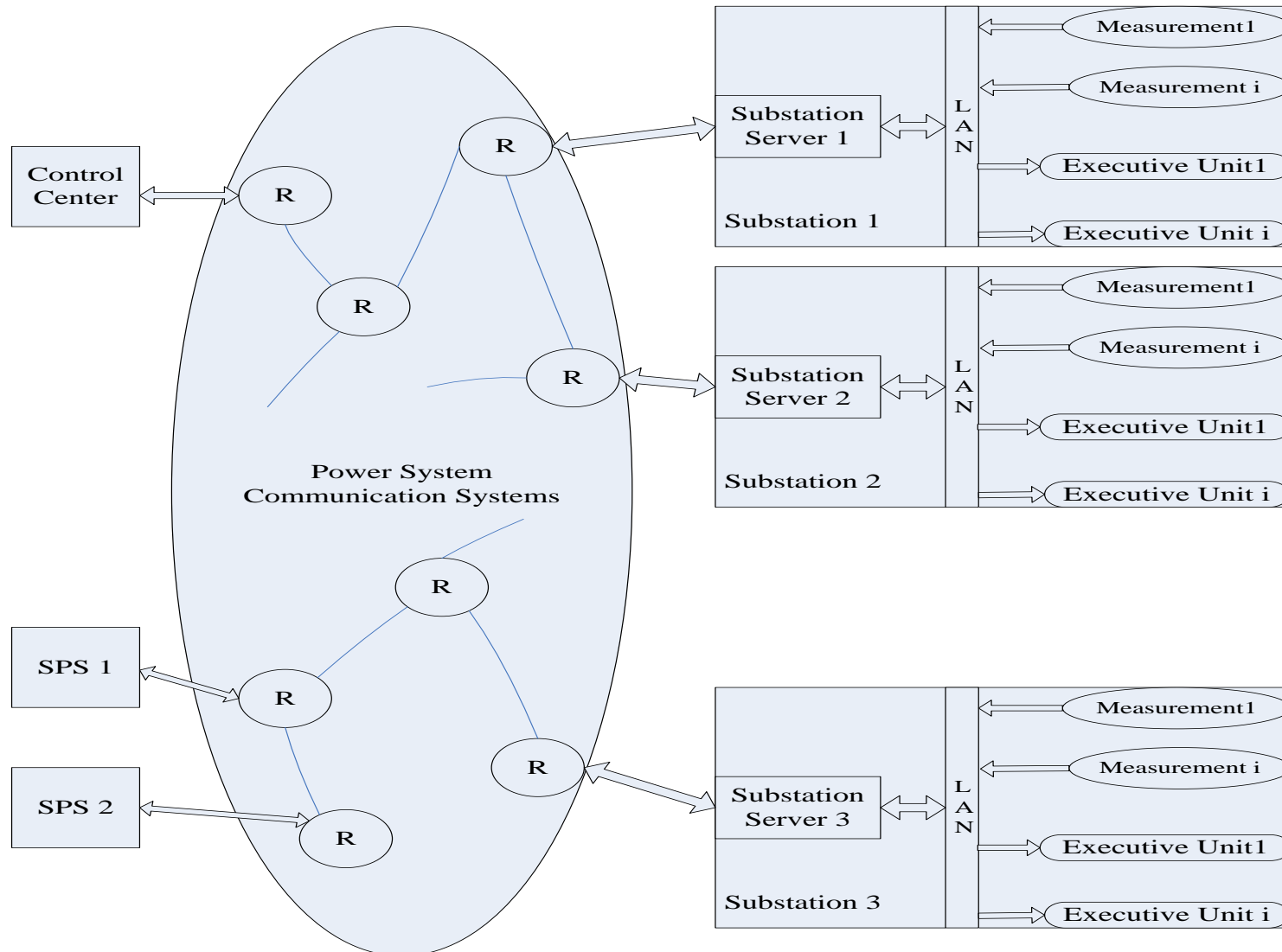 - **Measurement data in IEEE Std. C37-11**

Phasor Measurements

- **Digital substations**
- **Microprocessor based IEDs**
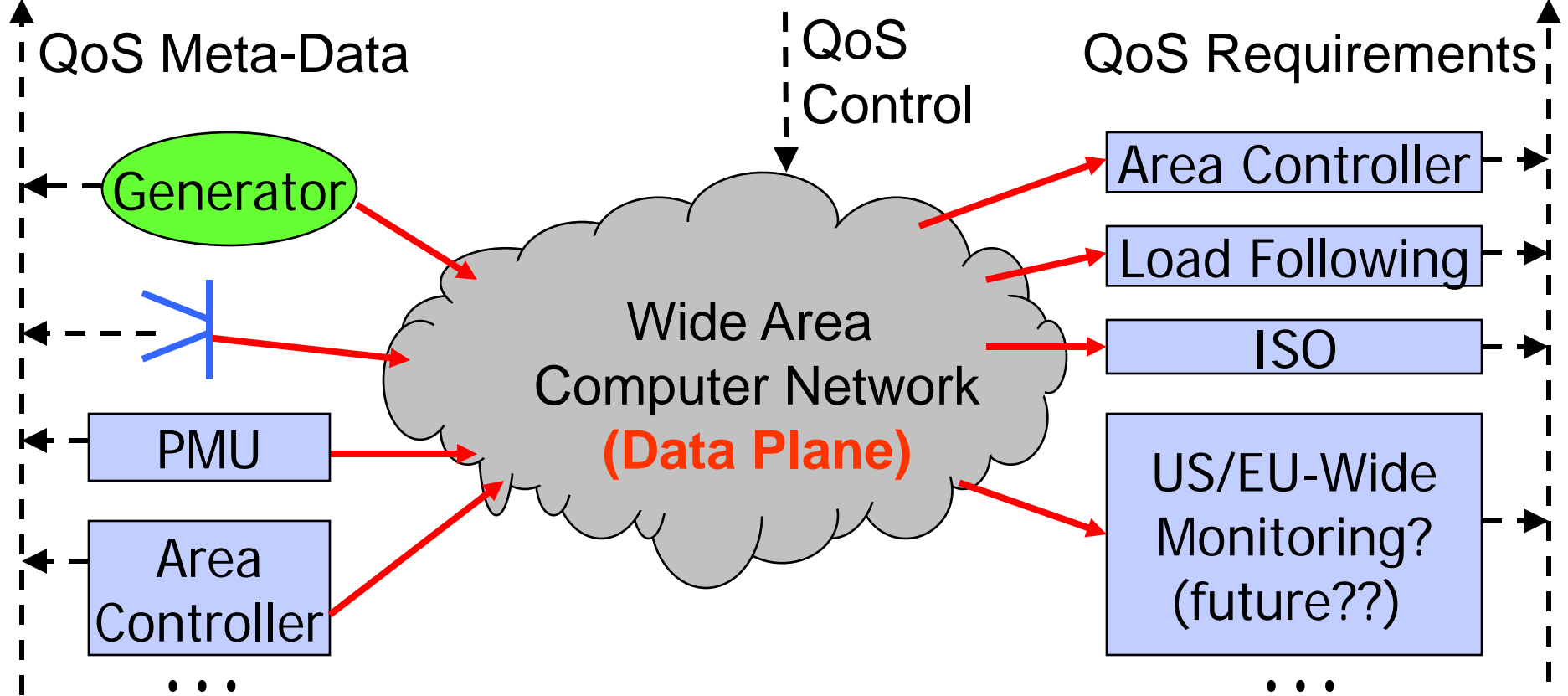- **Measurements 30-60 samples per second**
- **Time stamped by GPS**

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Proposed Communications

Management Plane

QoS Meta-Data

QoS Control

QoS Requirements

Generator

Wide Area Computer Network **(Data Plane)**

PMU

Area Controller

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Area Controller

Load Following

ISO

US/EU-Wide Monitoring? (future??)
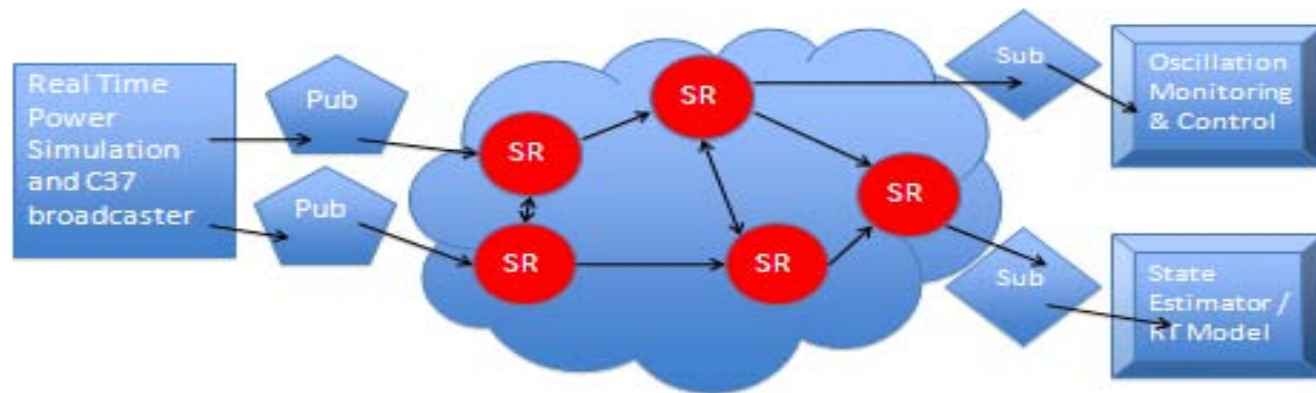
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Publishers

Subscribers

GridStat Function

A Critical Missing Piece

## Simulation Test Bed for the Smart Grid

What is Wide Area Control?

- **Wide area implies 'not local' i.e. input-output signals not confined to one substation**

- **Control implies a controller that uses measurements as input signals to compute output signals for control equipment**

- **Input signals: frequency, currents, voltages, phase angles, watts, vars, switch status, etc.**

- **Output signals: generator output, transformer taps, HVDC, SVC, UPFC, switch status**

Architecture for Two-Level SE
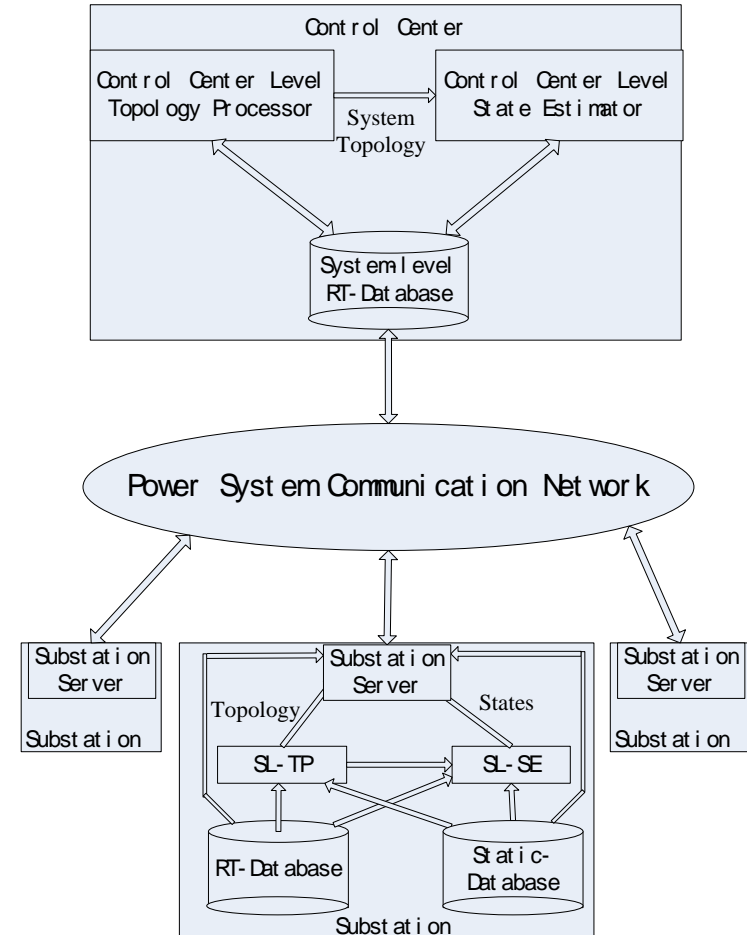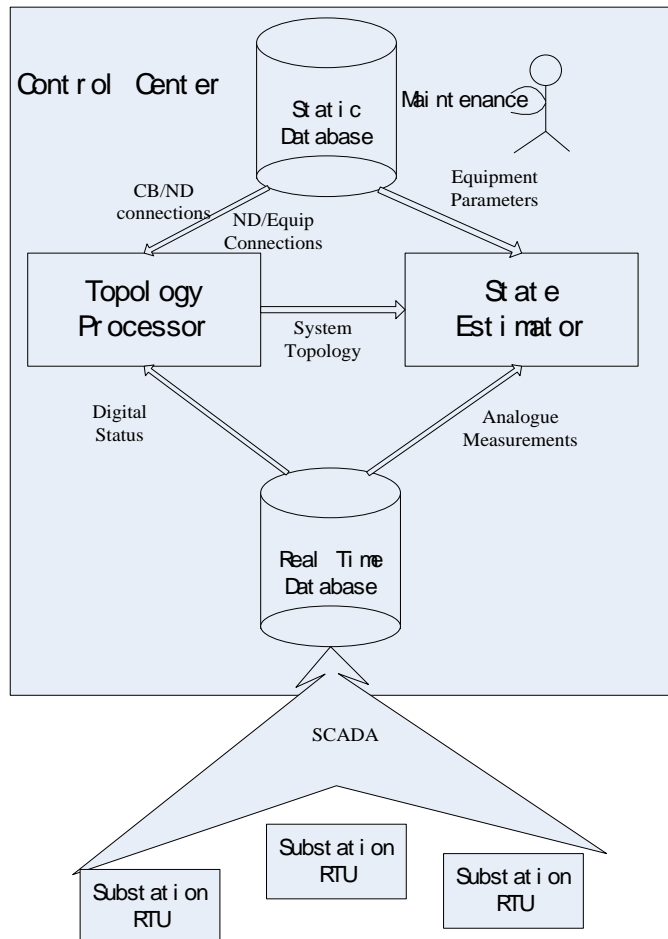
SL-TP: Substation Level Topology Processor
SL-SE: Substation Level State Estimator
RT: Real Time