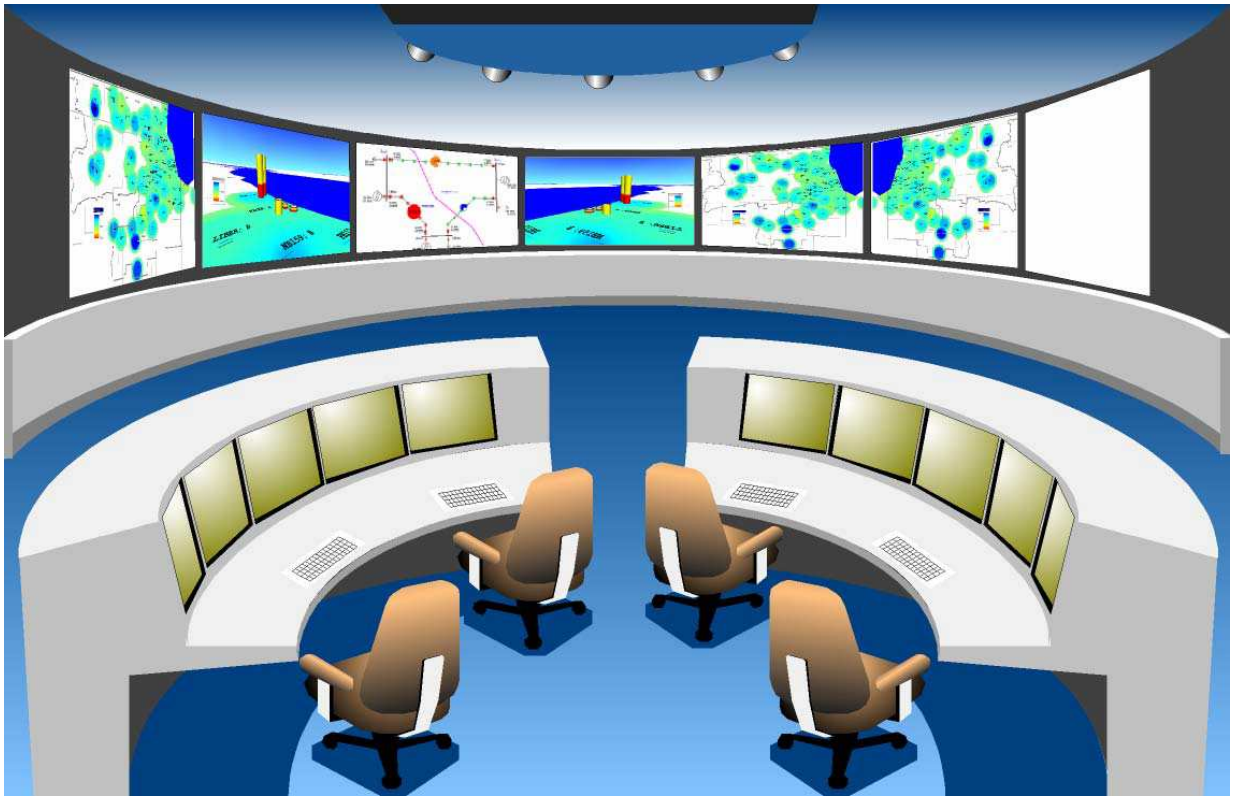
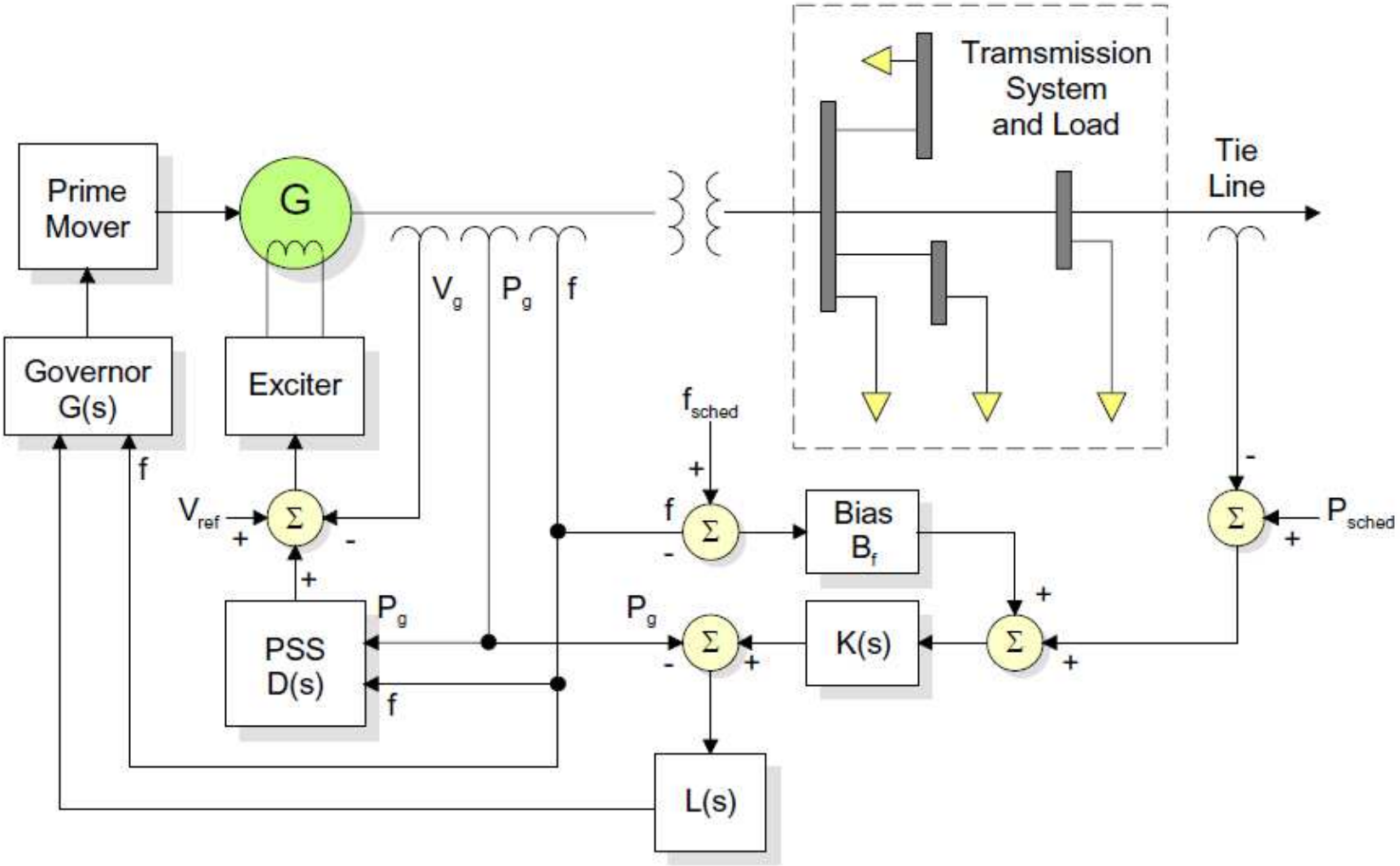
Power System Controls



Control Schemes

Ref: A. P. Meliopoulos, Power System Modeling, 1990-2006



Voltage Control

- The objective of this control loop is to regulate the voltage at the terminals of the generator. It consists of the voltage **regulator** and **exciter** system. Inputs to this control loop are the **reference voltage** V_{ref}, which may be selected by the system dispatcher or automatically by computers (VAR dispatch), and the **actual voltage** at the terminals of the generator V_g.

Power System Stabilizer

- The objective of this control loop is to slow down the oscillations of the generator following a **disturbance**. It consists of a feedback system which injects a stabilizing signal into the exciter system. Feedback quantities may be: frequency, f, real power, P_g, etc.

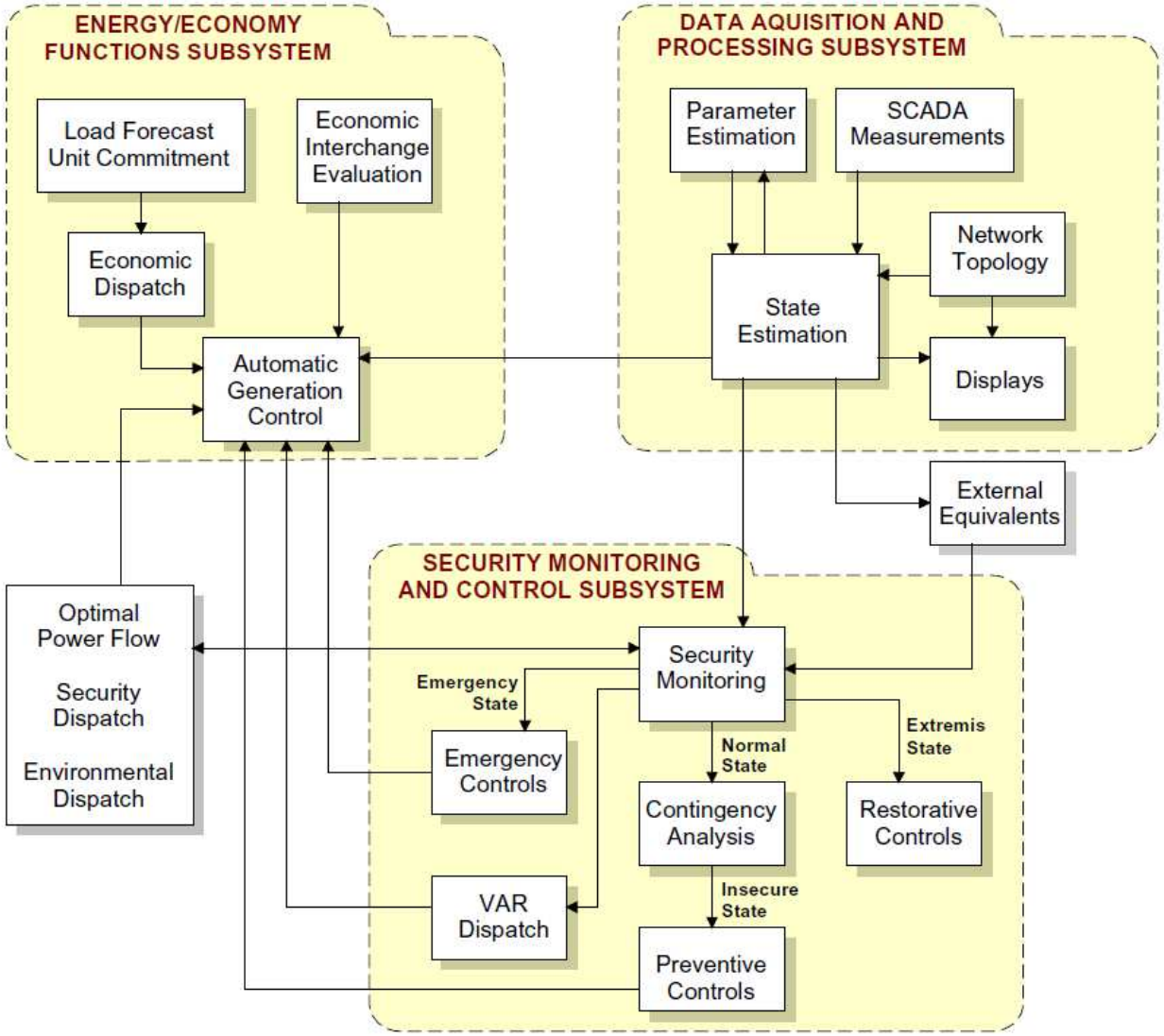
Primary Automatic Generator Control

- The objective of this control loop is to regulate the real power output and the speed of the generator. It consists of the **speed regulator** (governor) of the prime mover. It uses feedback of the generator speed (or frequency) and the real power output of the generator.

Secondary Automatic Generation Control

- The objective of the secondary automatic generation control loop is to regulate the net interchange, unit real power output, and speed (frequency). It consists of a feedback system which injects a signal into the speed regulator (governor).
- The signal, referred to as the Unit Control Error (UCE), is constructed from measurements of frequency, interchange schedule, unit real power output, etc. Reference quantities for this control loop are:
  - Scheduled interchange of real power, P_{sched},
  - Scheduled frequency, f_{sched}, and
  - Scheduled unit real power output, P_{des}. This control loop uses integral feedback of frequency and therefore regulates the system real time (integral of frequency).

Energy Management System



Energy Management and Control Subsystem

- This subsystem manages the energy generation, controls the frequency and the power transactions (net interchange) of the system, and optimizes the operation of the system.

- **Level 1: Load Forecasting**
  - Unit Commitment
  - Economy Purchases.
- **Level 2: Economic Dispatch**
  - Economic Interchange Evaluation
  - Optimal Power Flow
  - Transfer Capability.
- **Level 3: Automatic Generation Control**
  - Frequency Control
  - Power Transaction (Interchange) Control
  - Inadvertent Power Flow Control.

Data Acquisition and Processing Subsystem

- The objective of the data acquisition and processing subsystem is to obtain an accurate (as much as possible) estimate of the operating state of the system. This is achieved with a large number of Remote Terminal Units (RTU) and associated communication network. The system is known as SCADA (**S**upervisory **C**ontrol **A**nd **D**ata **A**cquisition).
- The remote terminal units collect analog measurements (i.e. voltage magnitude, power flows, etc.) and status variables (i.e. status of breakers, switches, etc.) and transmit this data to the computers of the energy management system via the communication network.
- The topology of the network is formed (network configurator) and the state of the system is constructed (on-line power flow or state estimation). The results are displayed in computer monitors, mimic boards, projection systems, etc..

Security Monitoring and Control Subsystem

- Security of an electric power system is loosely defined as the ability of the system to withstand major disturbances without losing synchronism.
- The security of the system is a very complex concept. Experience accumulated over the years indicates that the security of the system can be only insured by continuous monitoring and control of the system.
- Security control comprises the integration of a number of automated and manual control operations, such as:
  - Automatic generation control,
  - Economic dispatch,
  - Generation rescheduling,
  - Voltage control,
  - Coordination with neighboring utilities, and
  - Load control.