Power Delivery Systems

Eugeniusz Rosołowski

Protection and Control of Distributed Energy Resources

Chapter 5

eugeniusz.rosolowski@pwr.wroc.pl

Choose yourself and new technologies

HUMAN CAPITAL
HUMAN – BEST INVESTMENT!

Wrocław University of Technology

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General Considerations

- **The power delivery system is a continuous network linking the end user with the energy generator.**
- **The control requirements have now become more complicated with the separation of generation from the network.**
- **Generation is usually sized, located, and operated within a free market.**

Control Hierarchy

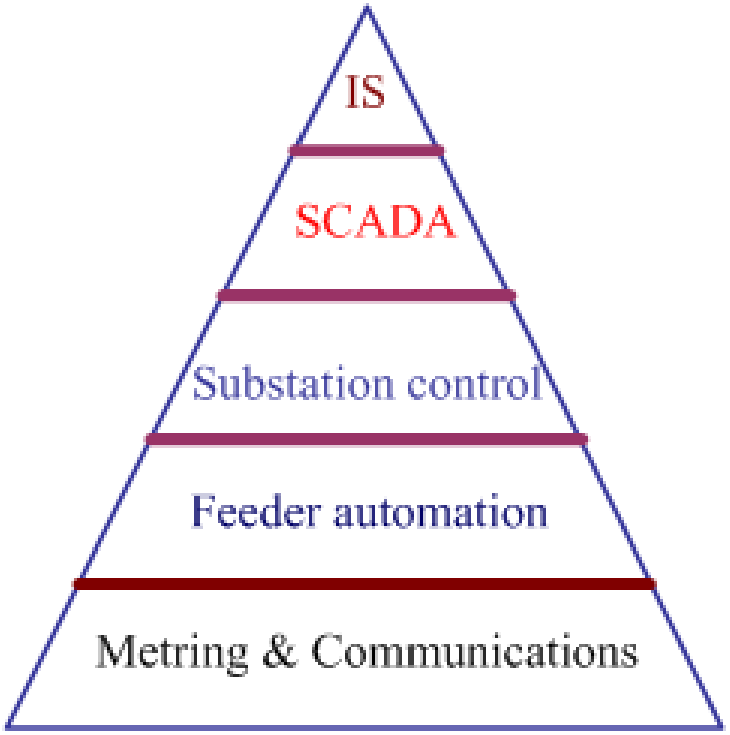
Information System
Geographical IS

Energy Management System
Load Management System

Remote Terminal Device

Intelligent Electronic Device
Distribution Terminal Unit

Load Control Device
Automatic meeter reading



Utility Layer

Network Layer

Substation Layer

Distribution Layer

Consumer Layer

SCADA - Supervisor control and data acquisition

Distribution Automation System

- **A set of technologies that enable an electric utility to remotely monitor, coordinate and operate distribution components in a real-time mode from remote locations:**
  - **Local automation — switch operation by protection or local logic-based decision-making operation;**
  - **SCADA (telecontrol) — manually initiated switch operation by remote control with remote monitoring of status, indications, alarms, and measurements;**
  - **Centralized automation — automatic switch operation by remote control from central decision making for fault isolation, network reconfiguration, and service restoration.**

SCADA systems consist of:

- One or more field data interface devices, usually RTUs, or PLCs, which interface to field sensing devices and local control switchboxes and valve actuators
- A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite, etc., or any combination of these.

SCADA systems consist of:

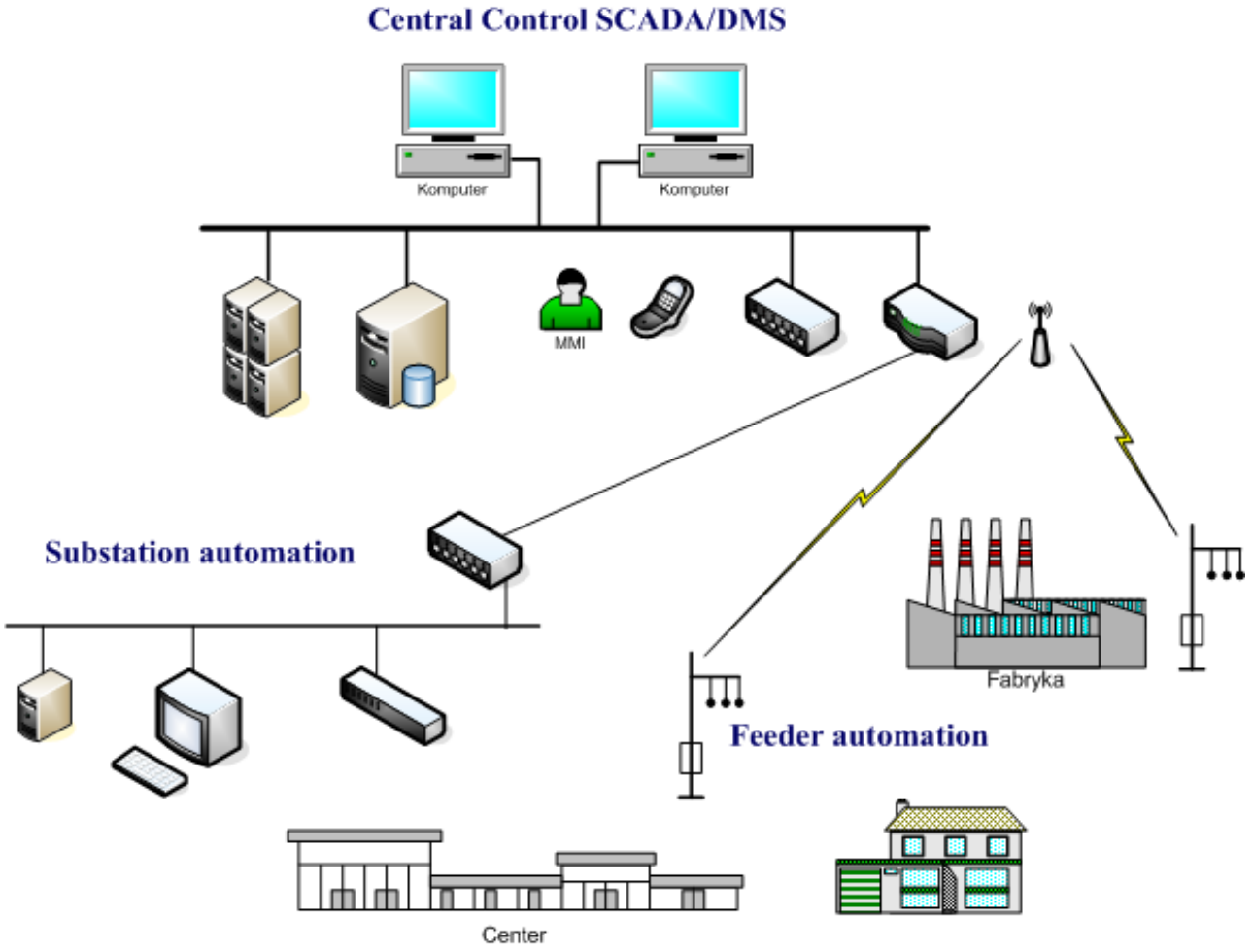
- A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU)
- A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the communications system, and monitor and control remotely located field data interface devices

SCADA System Principles

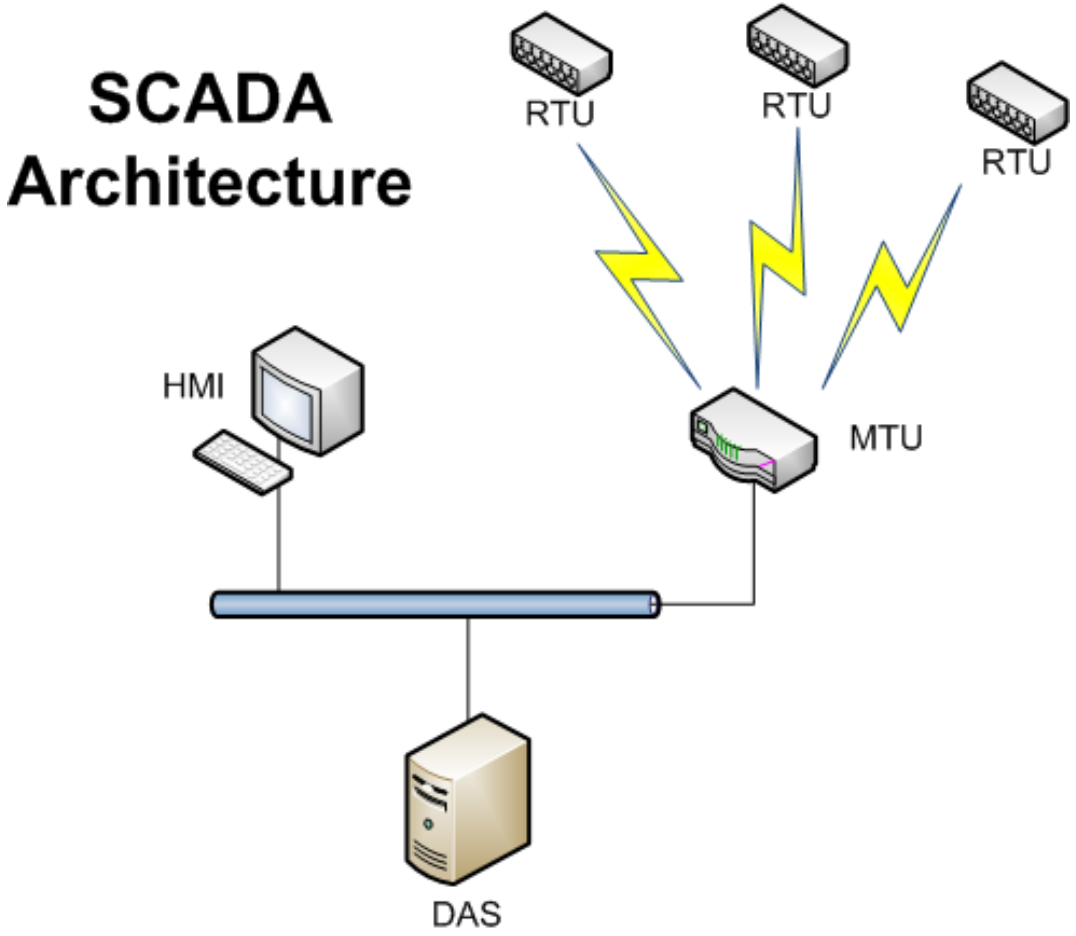
- **Polling principles:**
  - **Cyclic**
  - **Report by exception**
- **Use of Wide Area Networks (WAN) for Data Acquisition**
- **Sending information from the network to the system**
- **Presentation of process state to the operators**
- **Decision support applications**

(Smart Grid System utilizes two direction transmission).

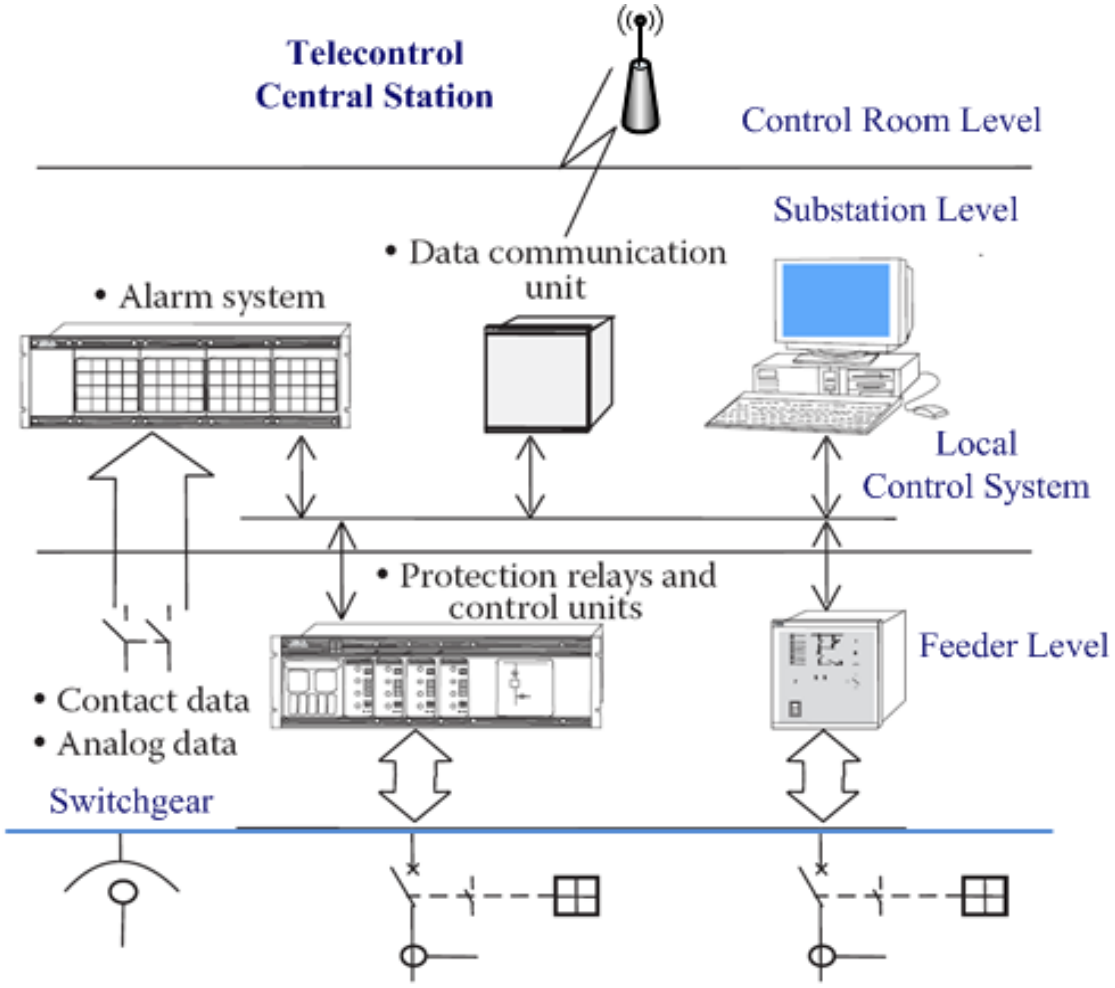
Distribution Automation System



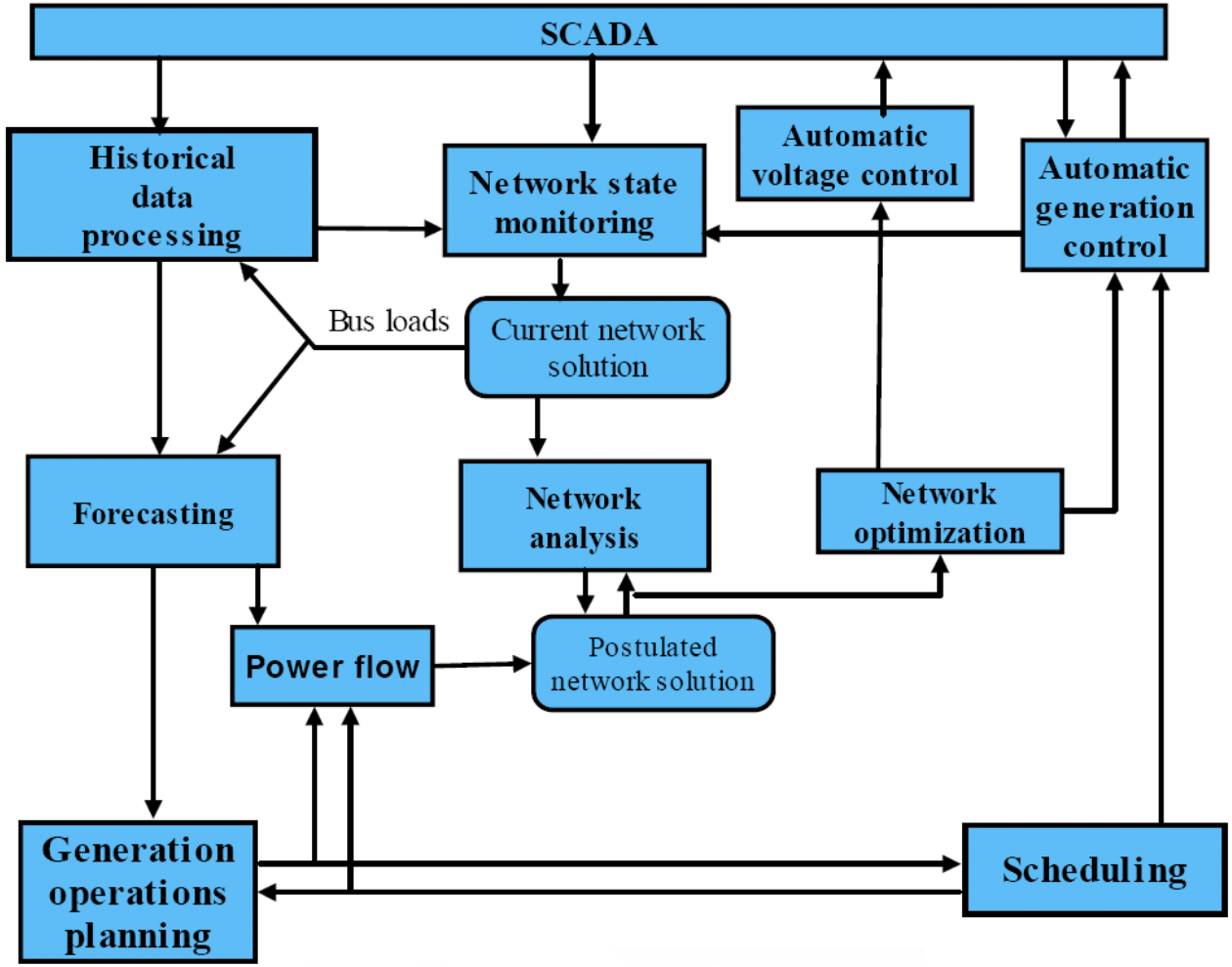
Distribution Automation System



Substation Automation System

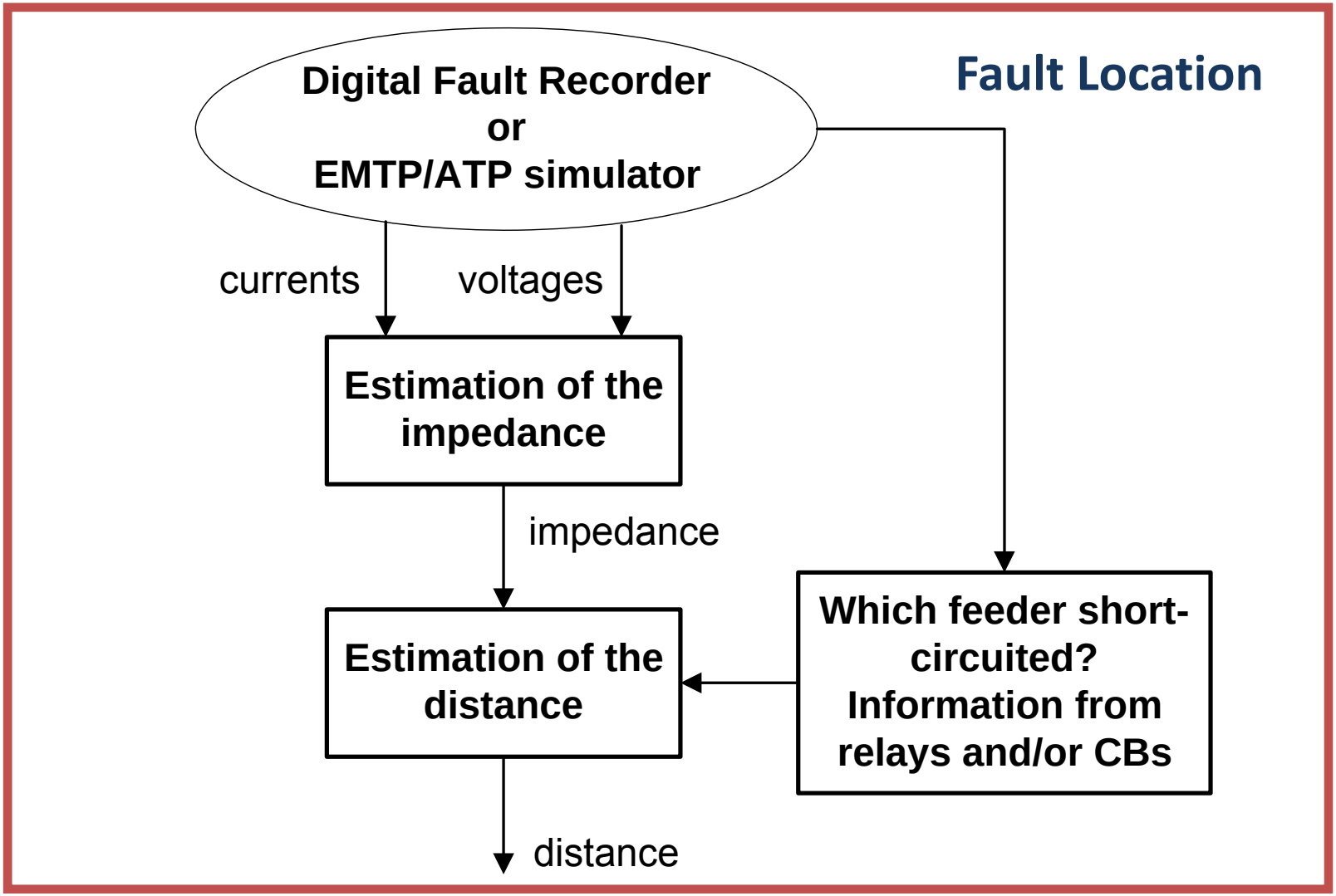


SCADA functions in a Power Systems



Outage Management

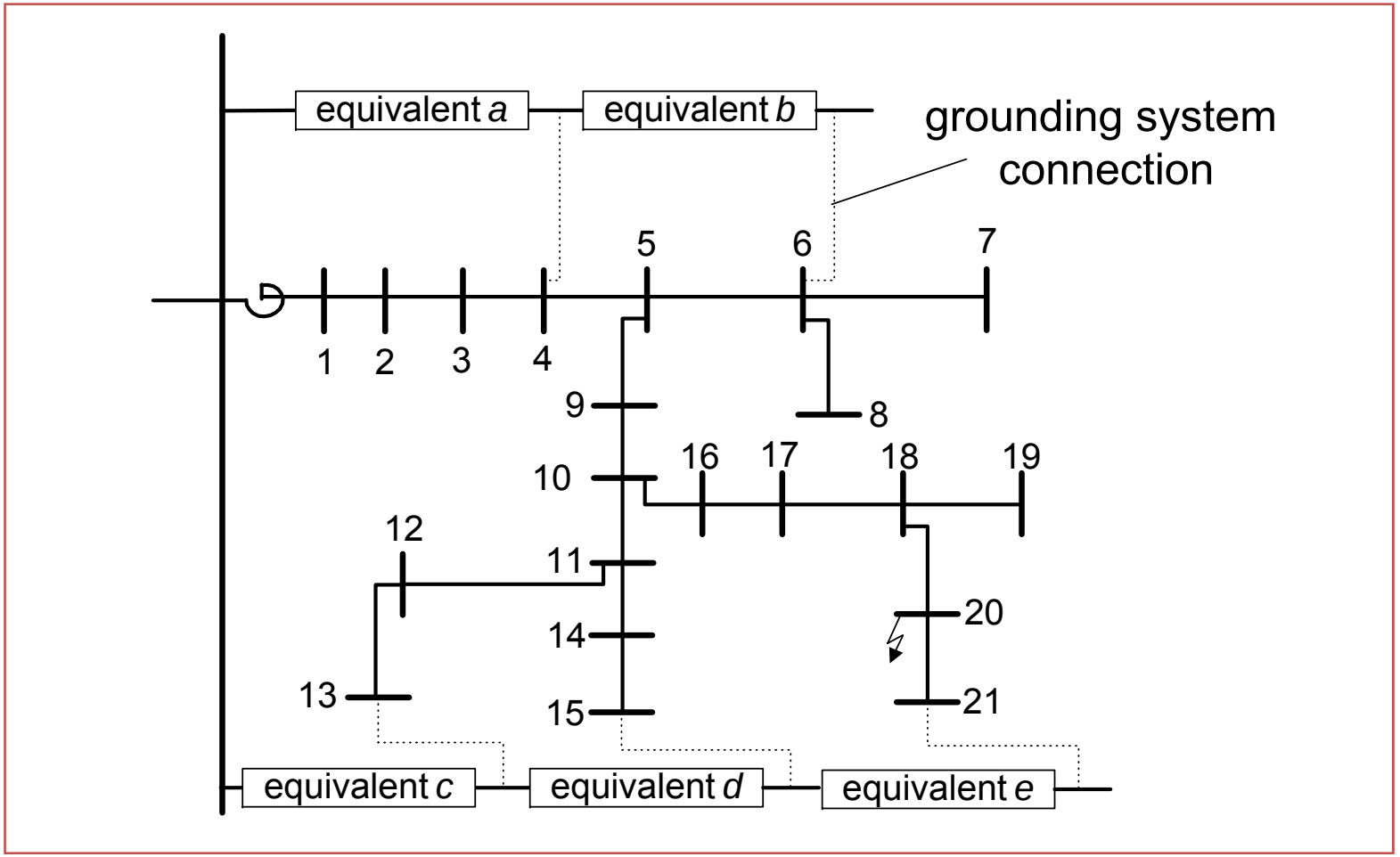
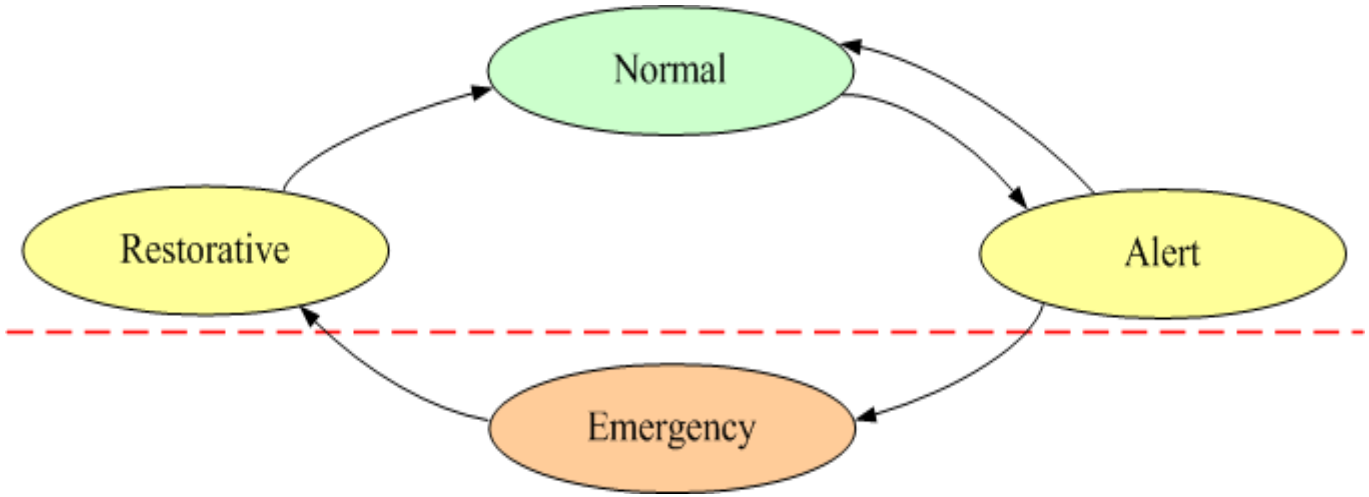
1. Outage Alert
2. Fault Location
3. Fault isolation and supply restoration
4. Presentation of process state to the operators


Fault Location
Digital Fault Recorder
or
EMTP/ATP simulator
currents
voltages
Estimation of the impedance
impedance
Estimation of the distance
distance
Which feeder short-circuited? Information from relays and/or CBs

Fault Location: Basic Assumptions

- Algorithm is based on impedance calculation
- Positive- and zero-sequence fault impedance for feeder nodes are available
- Busbar voltages and currents in the faulty feeder or supplying transformer can be measured
- It is known which line suffers a fault
- Pre-fault condition of the network is accessible

Fault Location: problem with distribution networks



State Modes of Power System Operation