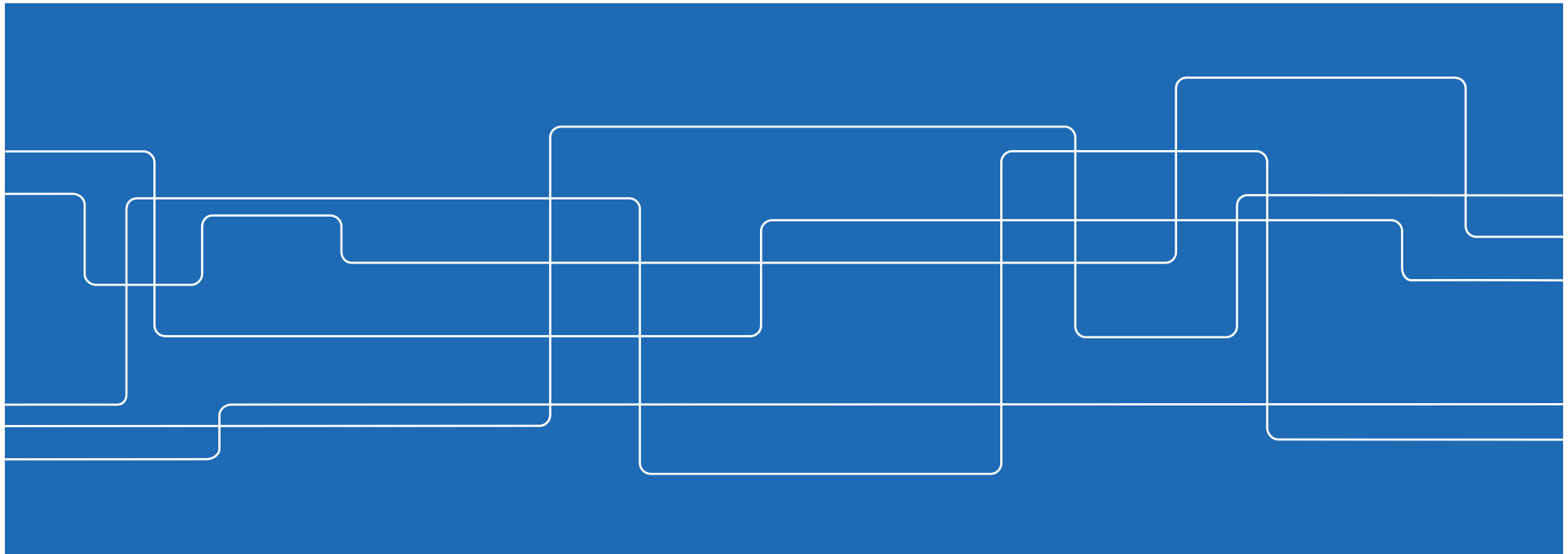# Welcome!

EH2745 Computer Applications in Power Systems
Introductory Course

# Agenda

- Course Overview
  - Course philosophy
  - Course memo walk through
- Computer Applications in Power Systems
  - Repeating and looking ahead

- Hands-on

# Course Philosophy

The course has two (conflicting) aims

1. Develop the student as a programmer
2. Develop the student in Machine learning and data analysis for power system decision making

Why conflicting?

# Course Philosophy

We think you may have taken programming courses before
We think you may know something about information modeling
We think you may know something about data analysis & statistics
**If you do not, we will teach you the basics**



We want you to combine these skills in this applied course

# Course registration

First: Please register for the course on "My Pages" window open now!

If you are not signed-up you cannot register. To sign-up, please contact your student counselor (Studievägledare)

Once registered, you will get access to the Social pages of the course.

# Assessment & Grading

The course has three components for assessment and grading

***Project Assignment #1 & Project Assignment #2***

Performed in pairs, handed in as screencasts.

Can be graded as Fail, Pass or Pass with distinction

***Voluntary test***

To achieve higher grade than E, a 2 hour test will be given at the end of the course covering all topics.
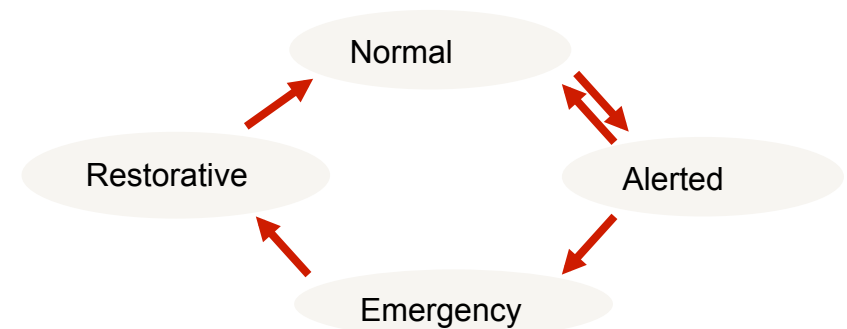
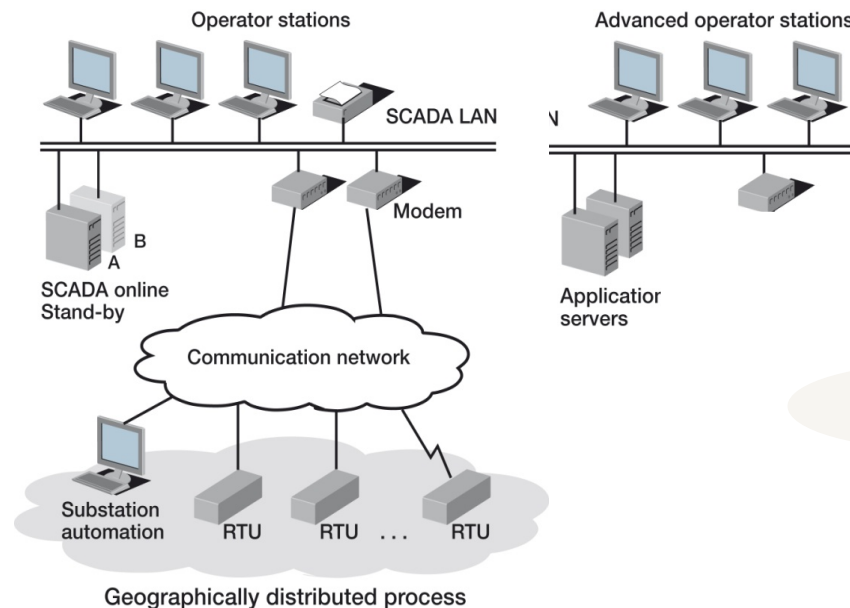# Course Memo Walk-through

# Agenda

- Course Overview
  - Course philosophy
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- **Computer Applications in Power System**
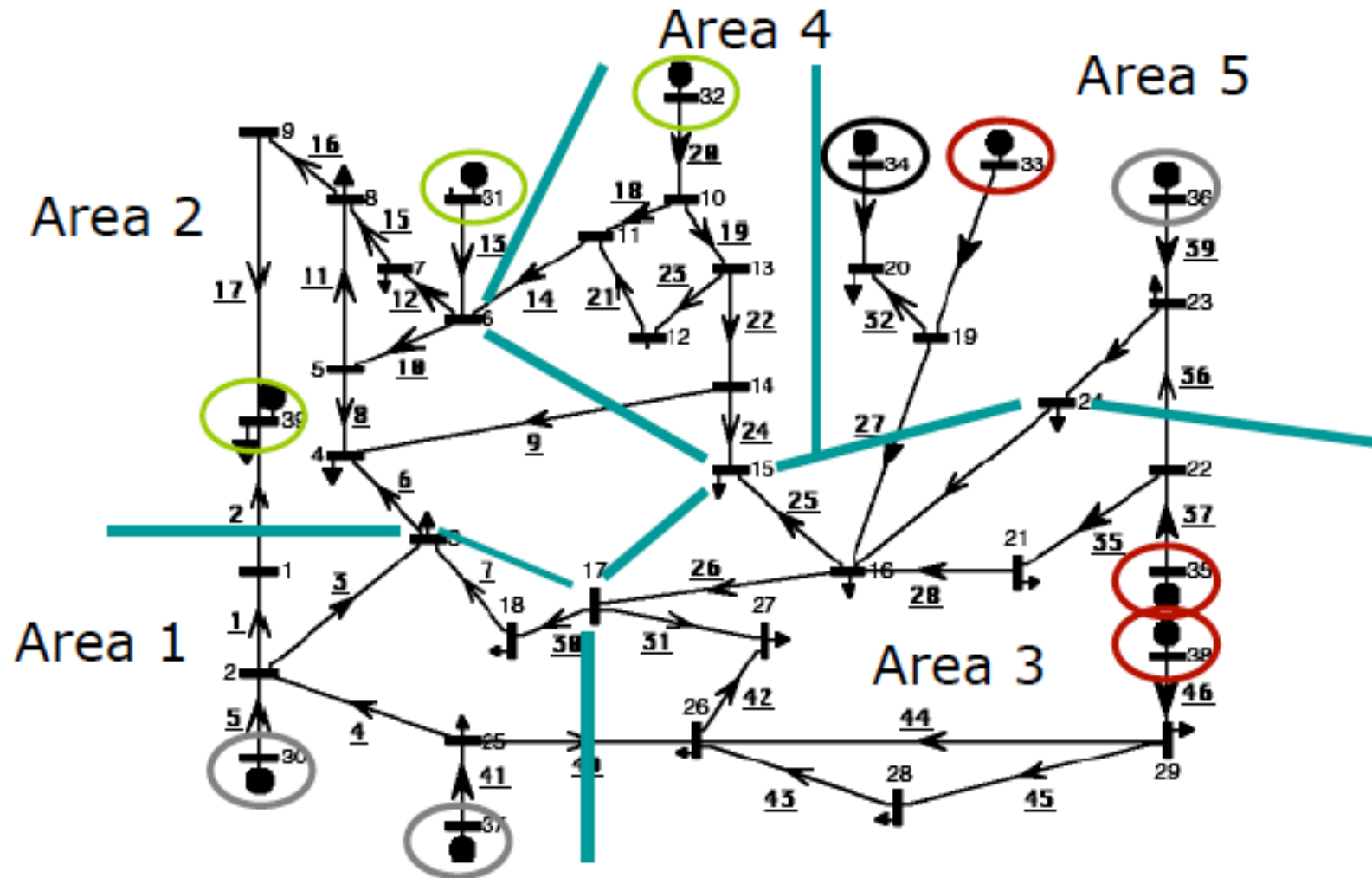  - Repeating and looking ahead

- Hands-on

# Power System Operation

System-wide monitoring, planning & optimisation for reliable and cost efficient operation of the power system

Time scale: seconds to hours.



Operator stations
Advanced operator stations
SCADA LAN
Modem
B
A
SCADA online Stand-by
Application servers
Communication network
Substation automation
RTU    RTU    . . .    RTU
Geographically distributed process



Normal
Restorative
Alerted
Emergency

# Deregulation – in practice

# Coordination between actors

**Transmission System Operators**

**Distribution System Operators**

**Electricity retailers**

**Generating companies**

# Safe and Optimal operation

Each actor wants to optimise their operation within their limitations

Some of the actors have conflicting goals

The safety of the power system must not be jeopardised

Contingencies (unplanned events) must be managed

**Access to data across organsiations is critical for some aspects for this**

**Forecasting and predicting data you cannot get is a valuable replacement**

# Transmission vs Distribution

**Transmission:** backbone of the power systems and its main purpose is to transport energy in large volumes over large distance, from production to consumption center. With a purpose to minimize the resistive losses, the systems are operated at a high voltage levels, 100-400kV in EU.

*Large systems, real-time control requirements*

**Distribution:** deliver electrical energy to the end consumer. The network topology can be meshed but it is also possible to be operated as radial systems. Distribution grid employs all voltage levels between 100kV and 0.22kV.

*Enormous systems, less strict real-time control*
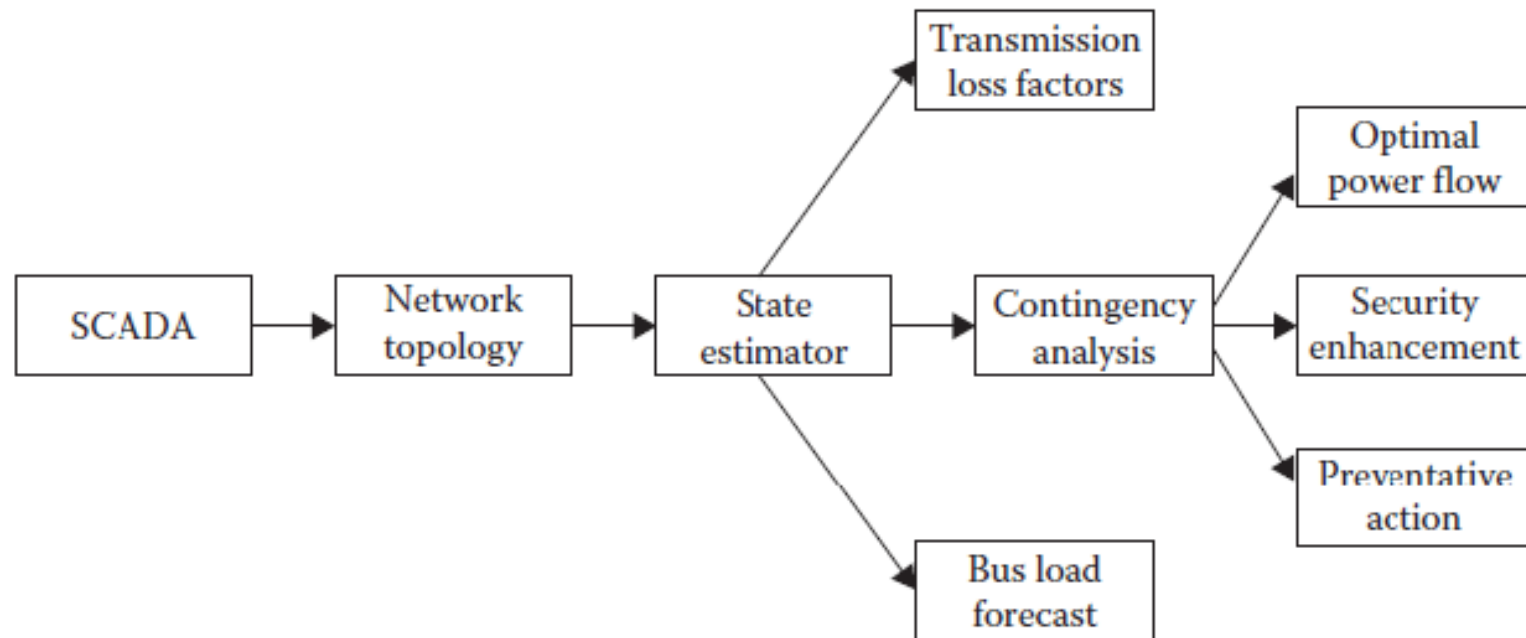
# Coordination structures

In the **United States**, a system of regional transmission organizations is being implemented to help coordinate the activities of individual transmission system operators within larger regional markets. Independent System Operators (ISO) have responsibility for system security and are involved in market operation.

In the **Nordic region**, system operation is undertaken by Transmission System Owners (TSO) in each country with coordination achieved through cooperative agreements that address operational standards and emergency procedures. The Nordic TSOs are involved in electricity market operation

In the **United Kingdom**, system operation is undertaken by a single independent transmission owner, and market operation is independent of the transmission owner.

# Traditional Static security analysis



SCADA → Network topology → State estimator → Transmission loss factors

State estimator → Contingency analysis → Optimal power flow / Security enhancement / Preventative action

State estimator → Bus load forecast

Study network analysis

| Power flow | Contingency analysis | Optimal power flow | Short circuit analysis |

# Wide Area Measurement and Control Systems
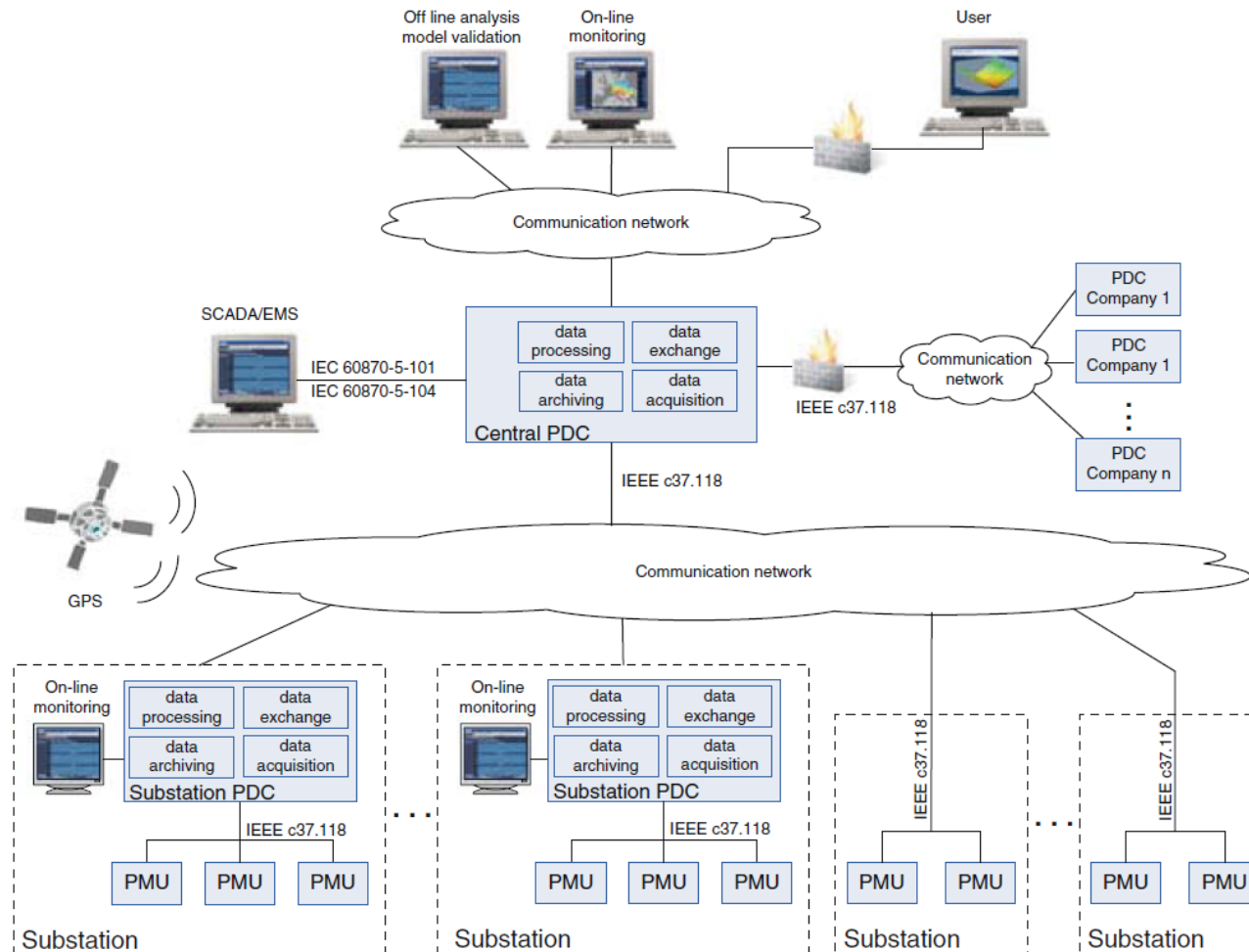
# Transmission System Challenges

**If, when and how the data can be used effectively, it will assist in several diverse fields of control and operation of transmission systems**

- Enhanced contingency analys through the integration of probabilisitic models

- Enhanced day ahead planning incorporating forecasts of renewable production, load variations and grid models

- Real-time dynamic security assessment using Phasor Measurement units

# Responsibiliites of the DSO

The overall aim of a Distribution System operator is to

- Maintain grid quality in terms of reliability and voltage profile while at the same time keeping costs low.

- Considering the monopoly status of a DSO, all partners should be treated fairly.

Traditionally, this has invovled offline optimisation of a stable grid with predictable consumers making the challenge less "electroctechnical" and more administrative in nature.

Changes in production (PV, RES) and consumption (prosumers, EVs) are graudlaly changing this.

# Systems at DSOs for power system control
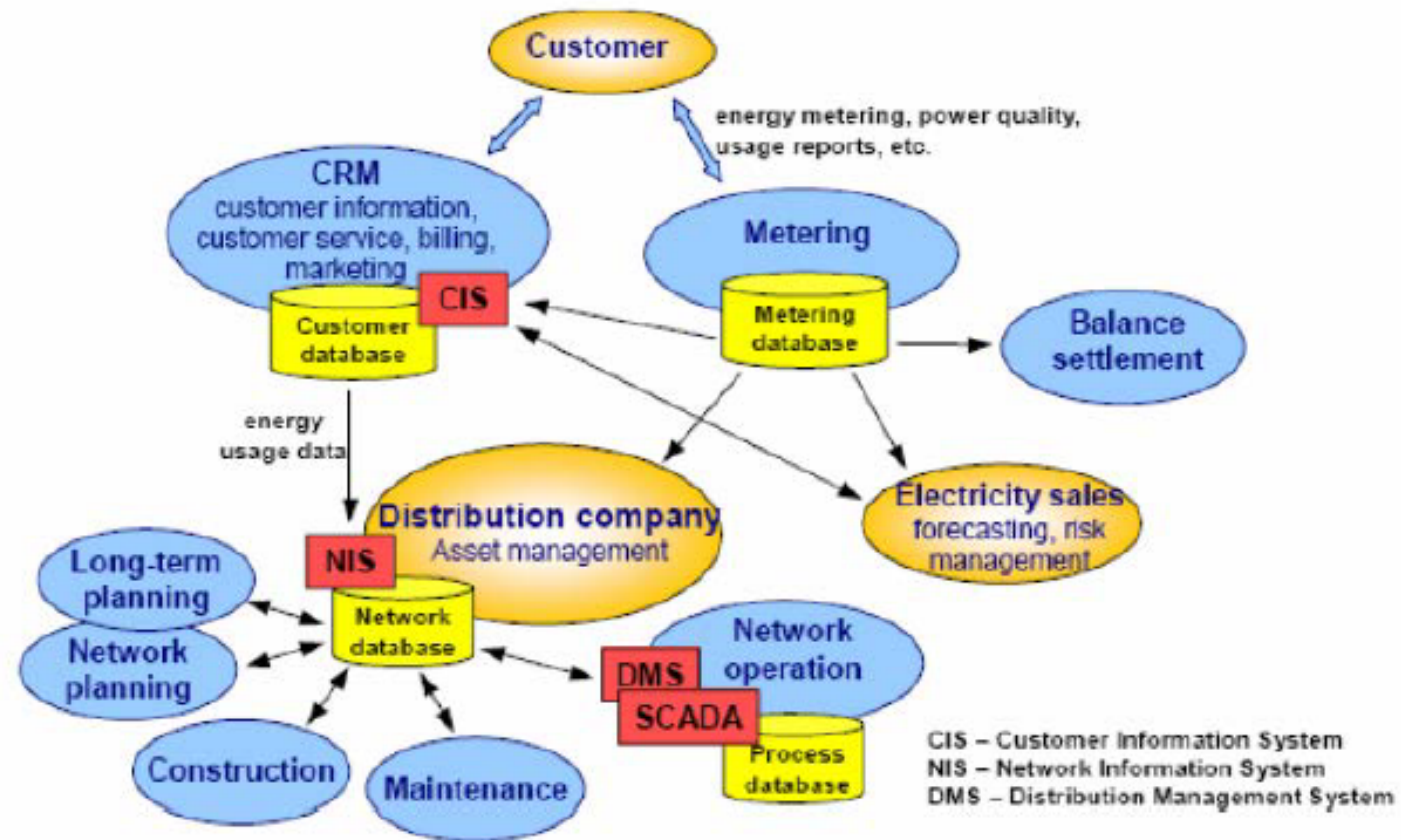
# Automatic Meter Reading
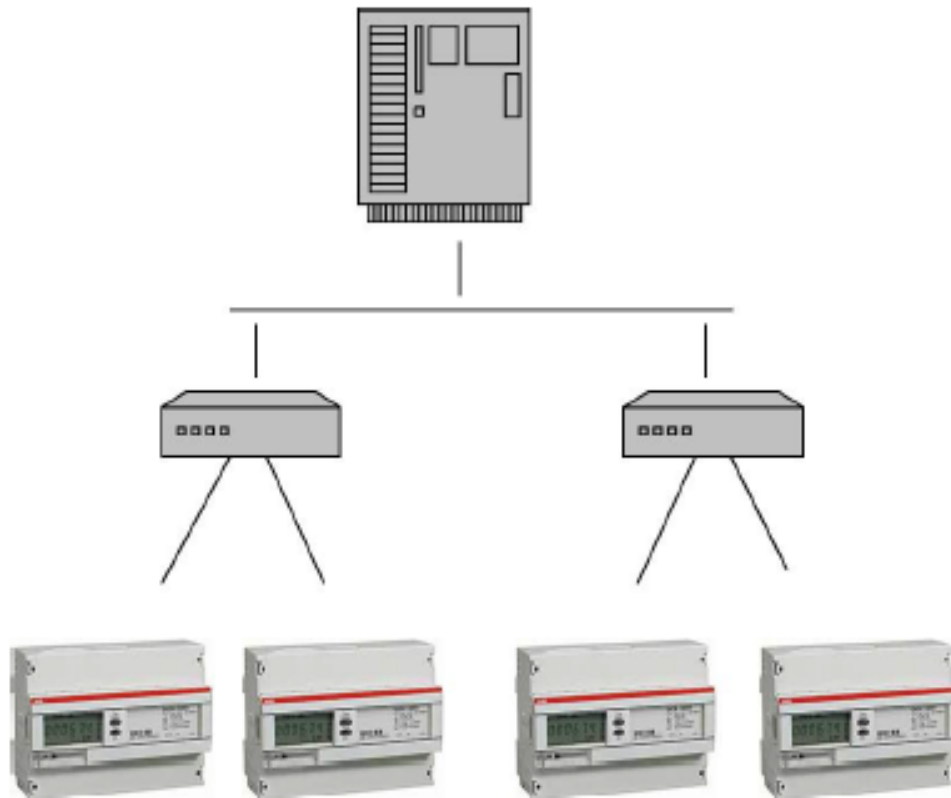


- Consists of
  - Central system
  - Collecting points
  - Intelligent meters
- Communication
  - PLC
  - Radio
  - GSM/GPRS
- Collects meter values cyclically or on request.
  - Hourly, daily, monthly...
  - The data rate is lower than SCADA systems

# Distribution Systems

**And for Distribution system, similarly, if data can be put to work, things like the following can be achieved.**

- Enhanced prediction of production in renewables, and its impact on grid stability
- Enhanced prediction of end-user behaviour, including consumption as well as load
- Enhanced analysis of measurements for support in asset management and condition based maintenance
- Identification of non technical losses and low inteisty faults tjhrough anomaly detection in measurements

# Common Challenges

**Data availability**

How to access data from across different systems and different companies – an interoperability challenge

**Data quality**

How to ensure data is consistently timestamped, checked for accuracy, correctly identified, validated.

**Data management**

How to store and access large amounts of data once stored in a consistent format

**Data Analysis**

How to create useful information for decision support for people, or for decisions by machines

# So, that is why the course contains

*Information modeling*

Common Information model to manage data interoperability and data quality

*Machine Learning*

To develop some (simple) applications that can analyse data to create information for decision support

*Java programming*

To make it real…..

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