KTH ROYAL INSTITUTE
OF TECHNOLOGY

Lecture #13
SCADA Systems

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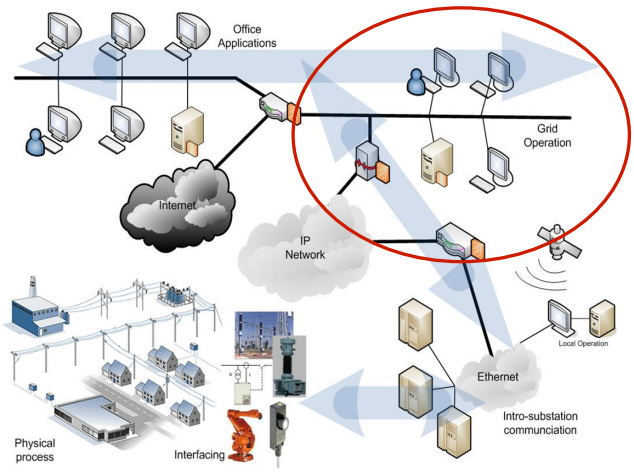
Course map



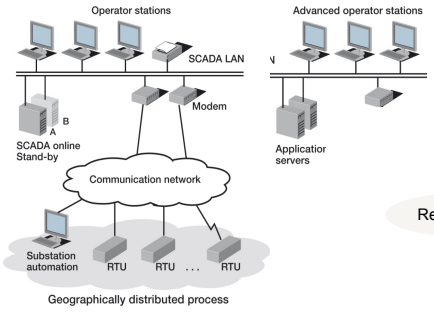
Outline of the lecture

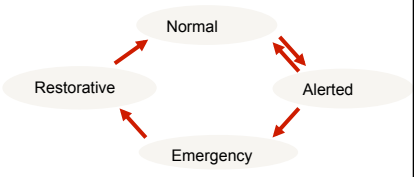
- Power System Operation
- SCADA System functions
- SCADA Components & Architectures

- Project Assignment Q&A

Power System Operation

System-wide monitoring, planning & optimisation for reliable and cost efficient operation of the power system
Time scale: seconds to hours.





Control room & SCADA system

Supervisory Control and Data Aquisition

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What is SCADA?

Supervisory **C**ontrol **A**nd **D**ata **A**cquistion

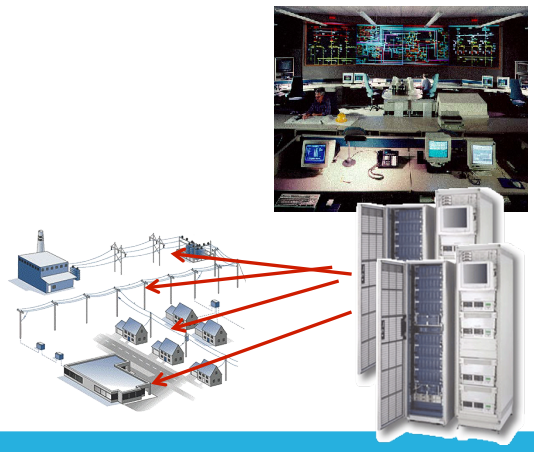
- Collect measurements and status data from the process
- Remotely intervene in the process
- Centralized system platform
- Based on distributed I/O

Applicable Processes

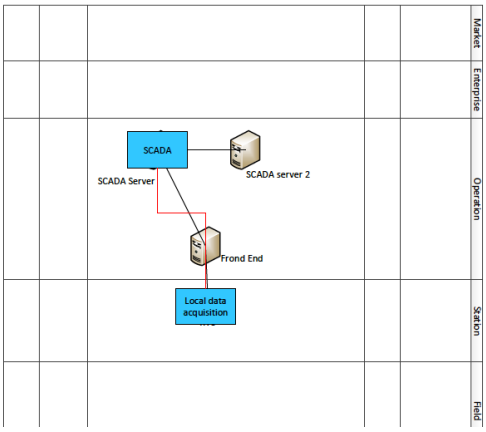
- Oil or Gas prodcution facilities
- Piplelines for gas, oils, chemicals or water.
- Railway/Transportation Process
- Nuclear, Gas, Hyrdo generation plants

What is controlled by SCADA

- Tap changers
- Switching devices
- Shunt capacitor/reactor
- Generator setpoints
  - Excitation & power output
- Sequential control



The SGAM perspective



SCADA functions

- Data acquisition
  - Analog and discrete values
  - Event and alarm processing
    - Events vs alarm
- Control
  - Tap changer
  - Shut capacitor/reactor
  - Switching devices
  - Generator excitation
- Data storage, archiving and analysis

- + Data Engineering

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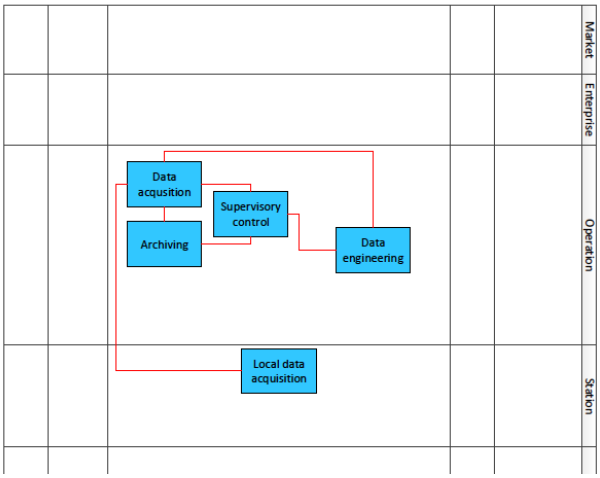
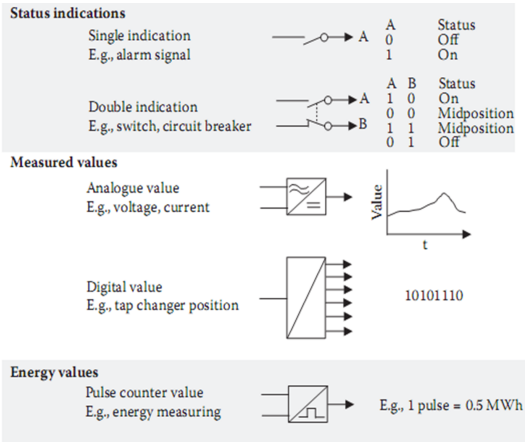
A more detailed SGAM View



SCADA: Data acquisition

- Points
  - Measured values
- Pseudo points
  - Derived values
- Scan
  - process by which data acquisition system interrogates RTU/IED
- Scanning rate
  - 1 sample/2-5 seconds
- Time skew
  - elapsed time between the first measurement and the final measurement is taken



Reference: North-Corte Green Control & Automation of Electric Power Distribution Systems

SCADA: Data Acquisition (Cont.)

Measurements and Status Indications Collected are stored in a Real Time Database.

The Values are Time tagged in the database.

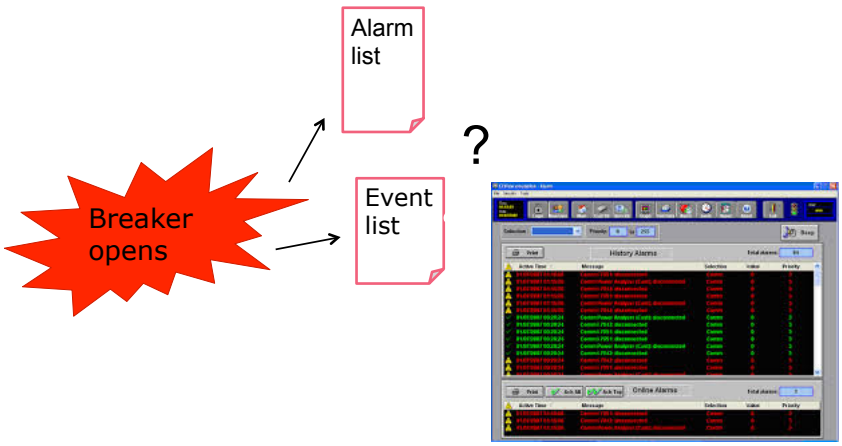
As new Values come in from the RTUs/IEDs old values are overwritten (or archived).

Data Aquisition: Performance Requirements

	Typical measurement services performance requirements							
Enterprise/function	**Example measured elements**	**Update periodicity (s)**	**Accuracy (%)**	**Unavailability (h/mo)**	**Latency (s)**	**Resolution (%)**	**Time skew substation (s)**	**Time skew SCADA (s)**
Tier 1								
Substation operator indications	Voltage, Bus	5	0.3	4	1	0.1	1	1
Switching and tagging	Voltage, Line	5	0.3	4	1	0.1	1	1
End element control	Real and Reactive Power, Line	10	1.0	4	5	0.2	1	1
Low-priority alarm	Real and Reactive Power, Equip	10	1.0	4	5	0.2	1	1
High-priority alarm	Current, Line	5	0.3	4	1	0.1	1	1
System restoration	Current, Equip	5	0.3	4	1	0.1	1	1
	Frequency/Phase Angle	1-5	0.3	4	1	0.1	1	1
	Position, Regulator/valve	10	1.0	4	5	0.2	1	1
	Ancillary value	10	1.0	4	5	0.2	1	1

Reference: C37.1-2007 IEEE Standard for SCADA and Automation Systems

SCADA: Alarm and Event Management



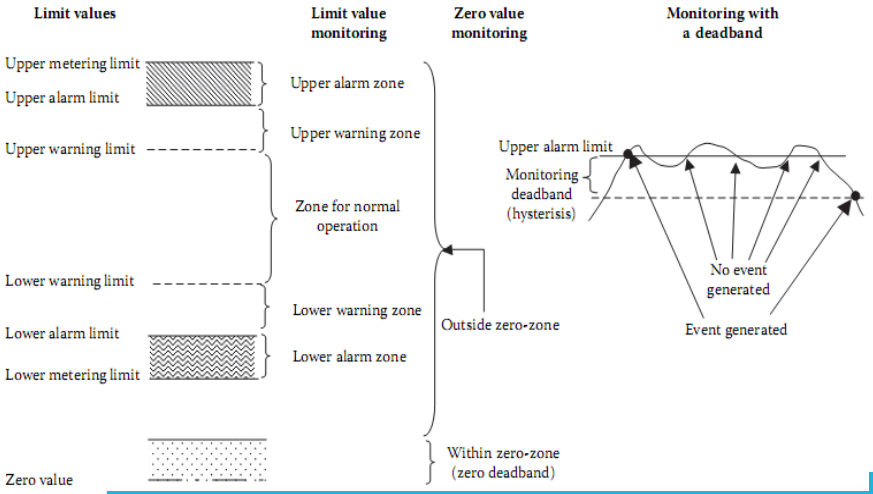
SCADA: Event & Alarm Processing

•Events
- Changing positions
  - Breaker / Disconnector opens or closes
  - Value above/below a threshold
- Equipment activated
  - Reactor or capacitor engaged
- Automatic changes
  - On load tap changer changes state

•Alarms
- Critical events

It is a matter of definition

Alarm & Event Processing (cont.)



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SCADA: Control Functions

•Individual Device Control
- Direct open/close commands to individual devices
- **C**heck-**b**ack **b**efore **O**perate function.

•Control Messages to Regulating Equipment
- E.g. Raising or lowering tap changer taps

•Sequential Control
- E.g. in the case of a set of sequential switching steps to restore power through predefined backup configuration.

•Automatic Control
- Triggered by an event of lapse of specific time period that invokes a control actions
- E.g. automatically changing load tab changer due to voltage set point violation

SCADA: Data Storage, Archiving and Analysis

Data Collected from the process is sometimes archived, this due to many reasons:

- Regulations
- Billing
- Future Load planning
- Performance Audits
- Post Mortem Review, in case of disturbances or interruptions in the process.

- Changed Values are "archived" at cyclic intervals, the interval depends on the importance of the values. Examples of cyclic intervals are: every scan interval, every 10 seconds or every hour.

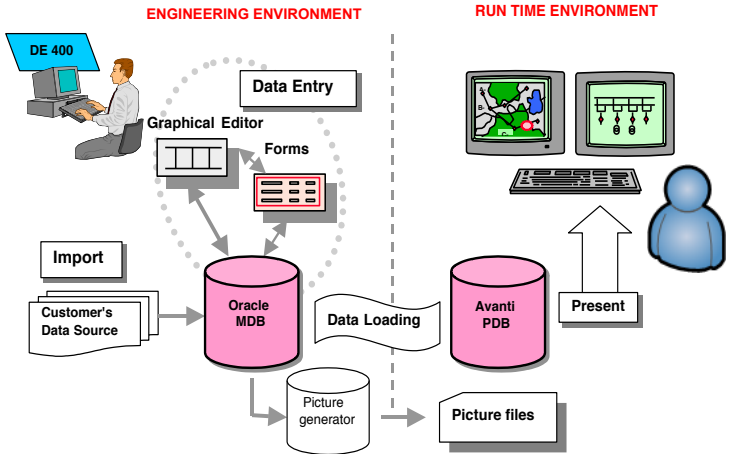
Time stamping

Sequence of events is often important in analysis of chains of events

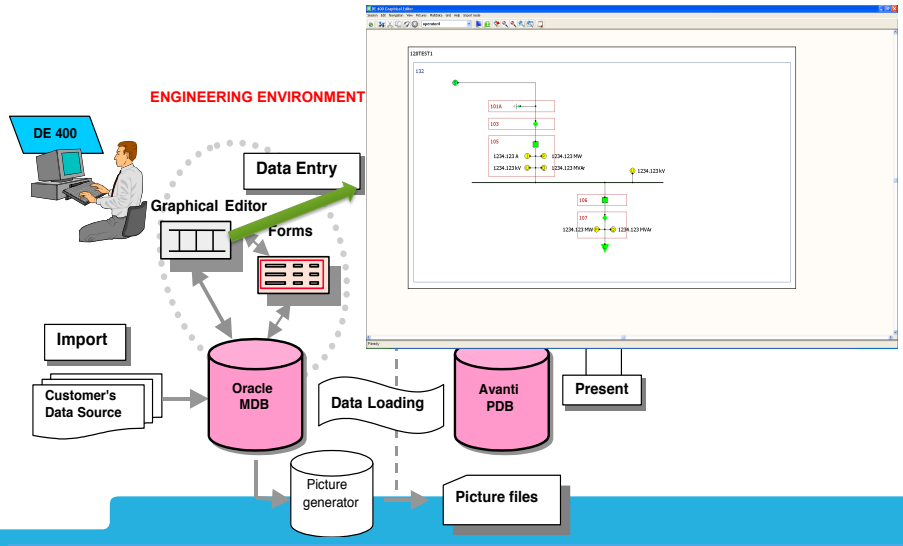
Time stamping of Events

- As close as possible to the source. For example the IED that collected the measurement
- Requires time synchronisation of distributed devices
- Additional Time-stamp at SCADA Front-End

SCADA ”Function”: Data Engineering



Data Engineering



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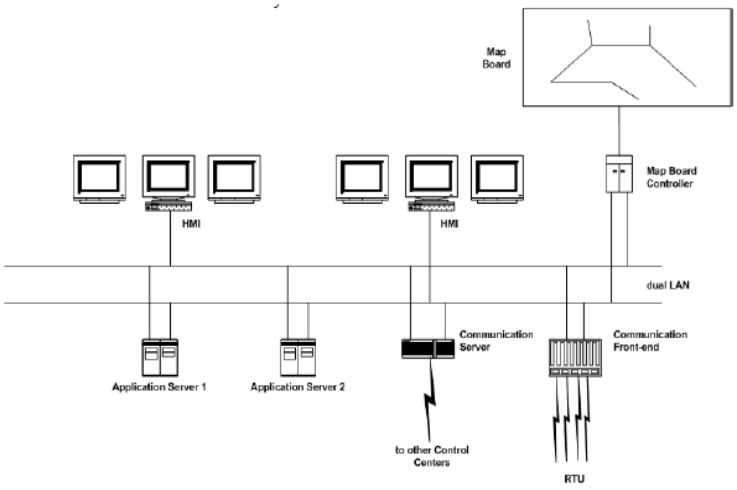
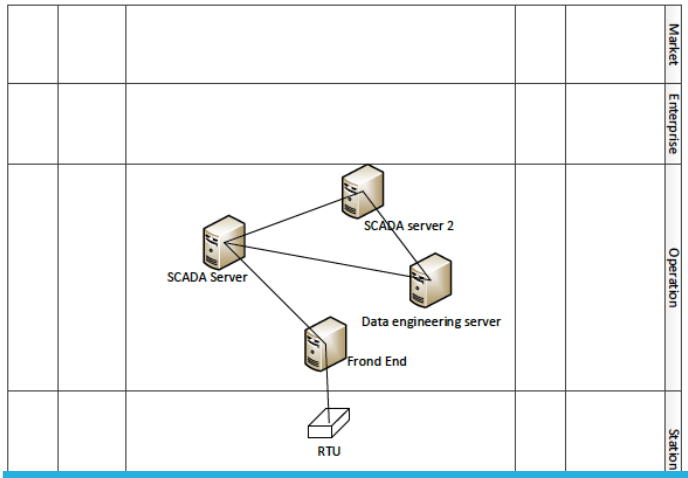
SCADA architecture



Simplified SGAM component layer



SCADA Components
Human Machine Interface - HMI

Communication between operator and machine

Input

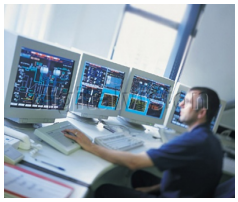
- Mouse, keyboard, touch screen

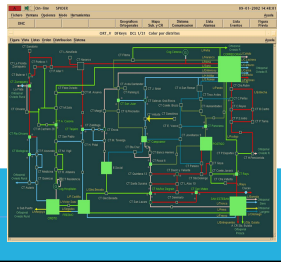
Output

- Screen, audio, print-outs or mimic board

A weak link

- Information overload/misinterpretation





SCADA components

Application Servers

Application servers provide the computing platform for the SCADA System, included servers are:

- Real-time database
- Historical database
- Energy Management applications
  - State Estimation
  - Optimal/Dispatcher Powerflow
  - Voltage Stability Assessment
  - Etc….
- Geographic Information Systems
  - Distribution Management

SCADA Components

System Configuration Servers

Allows configuration of the SCADA system environment, typical servers include:

- Data engineering of the SCADA system providing manual data entry into the SCADA topology database including lidnes, circuitbreakers, stations, …..

- Substation Device configuration, such as IED configuration tools and databses of IED configuration. Remote access tools for configuration

SCADA components

Communication Servers

Variety of servers for communication

- Communication to other Control centers using ICCP
- Communication to office applications
- Communications to field devices (RTUs) – Front End

SCADA components

Communication Front End

Manages communication with the field devices

Supports communication with variety of protocols

Cyclic polling and event based communication, provides messages queuing

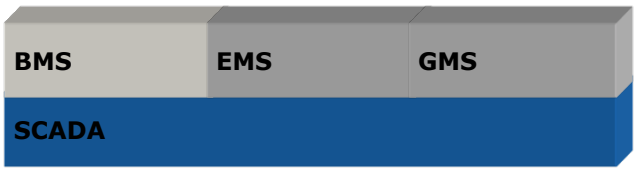
SCADA Components
Remote Terminal Unit - RTU

A remote terminal unit (RTU) is a microprocessors-controlled electronic device that interfaces objects in the physical world to a distributed control systems or SCADA by transmitting telemetry data to the system, and by using messages from the supervisory system to control connected objects.

Power System Control Center Functionality

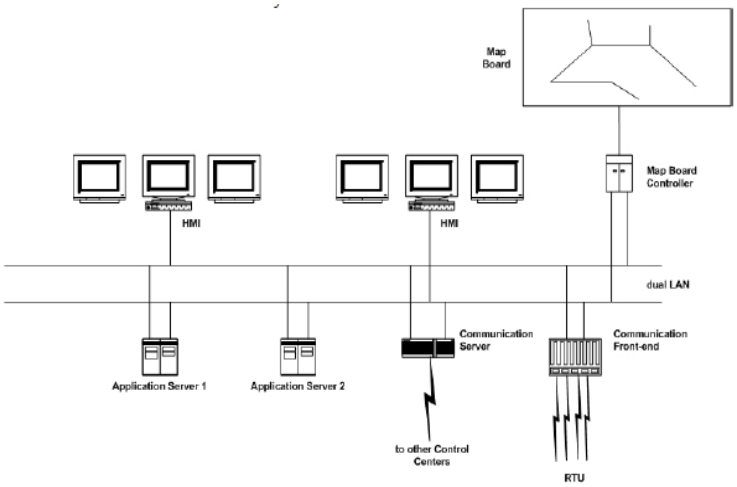
Three groups of further functions rely on SCADA

- Business Management
- Energy Management
- Generation management

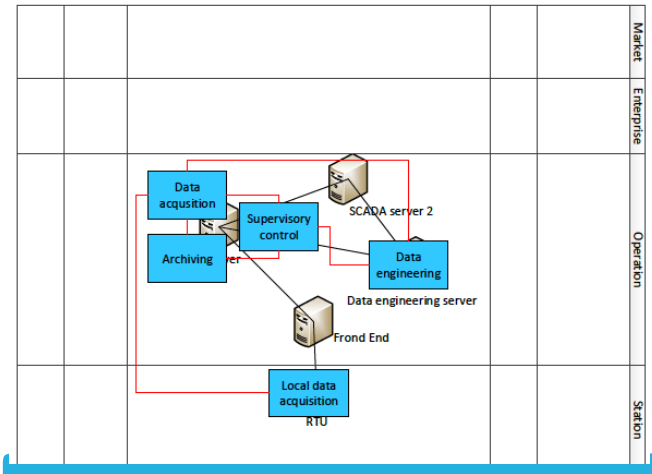


That is Part 3 of the course!

SCADA architecture



Slightly more complete SGAM view



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Project assignment Q&A

Workflow

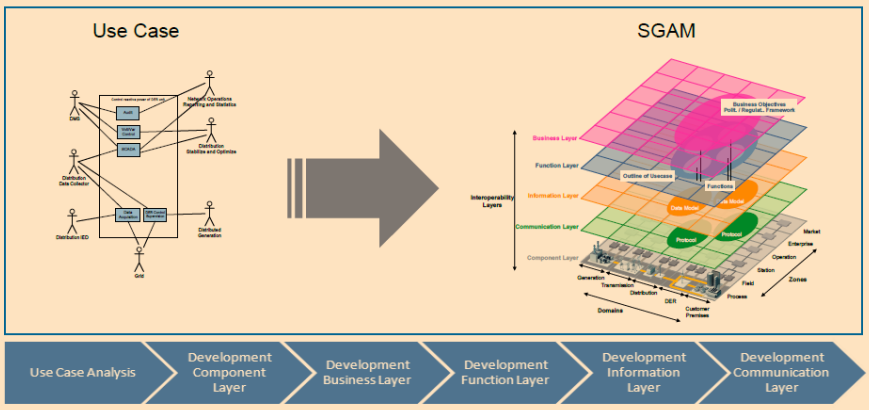

Figure 12: Use case mapping process to SGAM