Power Transmission and Distribution
Energy Automation

Secure and reliable electricity network operation

Siemens AG, PTD SE PT, 2006
The electrical network from source-to-sink
Changing energy market environment

- Change of energy market environment, e.g. industry restructuring, competition
- Business process optimization, e.g. new communication channels, Web
- Pressure on prices and cost together with the trend to more automation
- Increased value of information, especially with regard to real-time information
- Stronger customer focus
- Technology innovation
Focus of an innovative energy management

**Quality of supply**
- Minimum interruptions & high product quality
  - Comprehensive network monitoring
  - Automation
  - Quality management
  - On-line network security analysis
  - Sufficient reserve scheduling for power plants

**Customer satisfaction**
- Good offerings (Product, Quantity, Quality, Price, Services)
  - Outage management
  - Optimal Load Management
  - Network analyses and optimization
  - Single Point of entry for multiple resources

**Economy & efficiency**
- Low costs & sustainable profit
  - Network automation
  - Optimal energy production and trading balance
  - Mobile operation
  - Optimized operation (Workflow, …)
  - Efficient IT integration and usage
  - Optimal Total Cost of Ownership
Workflow from day-ahead preparation to settlement

**Day-Ahead -Actions**
- Forecast demand
- Forecast market price
- Planning of maximum profit
- Deal Entry
- Financial and Risk Checks
- Fix Generation Schedules

**Intraday -Actions**
- Intraday Market participation
- Control delivery of net power and ancillary
- Monitor obligatory or agreed reserves
- Emergency counter measures
- Archive Schedules & Delivery Values
- Perform settlement calculation

**Day-Before -Actions**
- Day-Ahead Actions
- Intraday Actions
- Day-Before-Actions
- Forecast demand
- Buy (allocate) reserves
- Control energy balance
- Emergency counter measures
- Intraday Market participation
- Archive Schedules & Delivery Values
- Perform settlement calculation
Modular component architecture

UI – Domain
Web Infrastructure

Application Domain
- Archive
- Load Management E/G/W/DH
- Forecast & Scheduling Applications
- Distribution & Transmission Network Analysis
- System Services

Base System Domain

Communication Domain
- OPC Interface
- Process Interface: IEC, DNP, 61850, ...
- ICCP

Real-Time Domain
SCADA-Functionality

Data Management Domain
- Data Model (CIM based)
- Configuration Parameter (HW / SW)

Control Center Desktops
Decentralized Desktops
System Management
Data Management

OPC Interface
Automation Technology

Process Interface
IEC, DNP, 61850, ...

ICCP

CIM
Common Information Model
DNP
Distributed Network Protocol
ICCP
Inter-control Center Communications Protocol

OPC
OLE for Process Control
OLE
Object Linking and Embedding
SCADA
Supervisory Control and Data Acquisition
Application portfolio and addressed market segments

- **ET** Energy Trading
- **RM** Risk Management
- **ES** Energy Sales, Customer Management
- **CFE** Communication Front-End
- **CA** Communication Apps
- **SCADA** Supervisory Control
- **MS** Multi-site
- **ITS** Interchange Transaction
- **SA** Scheduling Applications
- **PA** Power Applications
- **TNA** Transmission Network Applications
- **DTS** Dispatcher Training Simulator
- **BS** Base System
- **SDM** Source Data Management
- **UI** User Interface
- **DW** Data Warehouse
- **HFD** Historical and Future Data
- **FA** Forecast Applications
- **DNA** Distribution Network Application
- **VVC** Volt/Var Control
- **FISR** Fault Isolation/System Restoration
- **OMS** Outage Management
- **CMS** Crew Management System
- **TCS** Trouble Call System
- **OFR** Optimal Feeder Reconfiguration
- **NTLO** Non-Technical Losses
Supervisory Control and Data Acquisition (SCADA)

- External Communication
- RTU, ICCP, ELCOM 90, OPC
- Applications
- Historical Information System
- Energy Accounting
- Wireless Alarming
- Alarming Telecontrol Monitoring
- SCADA

Applications
Historical Information System
Energy Accounting

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Supervisory Control and Data Acquisition (SCADA)

Functions

- Control Device operations
- Data Acquisition
- Event & Alarm Processing
- Limit Monitoring of analog and counter values (8 limits)
- Interlocks Processing
- Real-time Data Calculations
- Marking & Tagging
- Real-time Accumulator Processing (RAP)
- Control Execution Monitoring
- Switching Procedure Management (SPM)
- Source Value Selection
- Topology Processing
- Supervisory Control
- Marking & Tagging
- Real-time Accumulator Processing (RAP)
Transmission services

- Transmission Grid Analysis Applications
  - Dispatcher Power Flow
  - State Estimator
  - Network Parameter Adaptation
  - Security Analysis
  - Outage Scheduler
  - Security Analysis Look-ahead
  - Fault Calculations
  - Network Sensitivity

- Transmission Grid Optimisation Applications
  - Optimal Power Flow
  - Voltage Scheduler
  - Security Constrained Economic Dispatch
Distribution Services

Distribution Management System (DMS)
Generation Services

Power Applications

- Load Frequency Control
- Production Cost Monitoring
- Economic Dispatch
- Reserve Monitoring

Control Area

Generation Area

Consumers

Generating Units

Schedules

Schedules
Generation Services
Load forecast functions

Diagram showing the flow of information from historical data, engineering data, and historical load and weather data to short-term load forecast (STLF) and current forecast, leading to current operating plan (COP).
Generation Services
Planning and Trading Horizons

- **Stochastic**
  - 5-20 years: Expansion Planning
  - 1-5 years: Long-Term Planning, Long-Term Bilateral Trading
  - 1-2 years: Short-Term Planning, Day-Ahead Trading
  - 1-7 days: Short-Term Planning
  - 1-15 minutes: Dispatch, Real-Time Trading
  - Online: Control

- **Deterministic**
  - 5-20 years: Maintenance Scheduling
  - 1-5 years: Resource Optimization
  - 1-2 years: Hydro Thermal Coordination
  - 1-7 days: Trade Optimizing Scheduler
  - 1-15 minutes: Short-Term Trade Evaluation
  - Online: Economic Dispatch, Automatic Generation Control

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Power Transmission and Distribution
Multiple Energy Resource Optimization (MERO)
Example of a German utility

Primary Resources
- Coal
- Gas
- Oil
- Electricity

Secondary Resources
- Electricity
- Gas
- District Heating
- Potable Water

Boiler
- 40-100 [t/h]
- Waste heat Boiler
- HP: 30-60 [t/h]
- LP: 4-8 [t/h]
- 45-100 [MW]

Steam turbine
- 10-75 [MW]
- 5-25 [MW]

Generator

Gas turbine
- 15-25 [MW]

Heating

House load

Water pumps
- Potable Water

Example of a German utility
Energy automation system services

System management functions:

- Start-up and Shutdown functions
- Redundancy and System Recovery functions
- Backup & Restore functions
- User Administration and Security
- Project Data Management functions
- License Management functions
- Diagnosis functions
Communication Solutions
Communications Front End (CFE)

Base Functions

- Data Acquisition
- Data Preprocessing
- Time Processing
- Error Messages and Quality Flags
- Start-up Procedure
- Line-Level Redundancy
- Listening Mode
- Connection of Data Concentrator
**Communication Components**

Spectrum PowerCC
( SCADA, Applications)

**Telecontrol:** RTUs

**Industry Automation:** SIMATIC S5, -S7

**Station equipment:** Protection, ...

Substation Process: Switch Gear, Infrastructure, Protection, ...

CFE  Communication Front End
DDS  Data Distribution Service
ELCOM  ELectricity utilities
ICCP  Inter-control Center
OPC  OLE for Process Control
RTU  Remote Terminal Unit

From/to other CCs

Parallel Interface to Process

Different Telecontrol Protocols

IEC 101, 104, SINAUT8-FW, others

Automation protocols
(SIMATIC NET via TCP/IP for long distance, Profibus only for short distance)

Other Protocols

Telecontrol Protocols

Profibus
Station bus

IEC 101, 104, SINAUT8-FW, others

Automation protocols
(SIMATIC NET via TCP/IP for long distance, Profibus only for short distance)

Other Protocols

Telecontrol Protocols

Profibus
Station bus
Communications Front End (CFE)

Spectrum PowerCC Communication Example

- Power System Object Server (PSOS)
- Real Time Server
- UI Client
- Spectrum PowerCC LAN
- Communications Front-End 1 (CFE 1)
- Communications Front-End 2 (CFE 2)
- Real-Time Data LAN
- Router
- WAN
- Configuration with 2 redundant CFE subsystems and different RTU interface connections
Communication Services
Protocols

Communication Protocols (Standard)

- IEC 60870-5-101 (Master) IEC 60870-5-104 (Master)
- DNP 3.0 / DNP 3.0i
- CDC Type II Siemens SINAUT 8FW
- L&G TG 800 L&G TG 8979
- L&G TG 065
- IEC 61850 IEC 60870-5-103
- INDACTIC 35 Modbus
- L&G TG 6000 RP 570/571

Communication Protocols (Project-specific)

- Conitel 2020 INDACTIC 33
- Siemens FW 535 SEAB-1F
Elcom Interface (ELC)

Spectrum PowerCC ELCOM (ELeCttricity uLtiLiies COMmunication), an Open and Standardized Protocol for Process Data Exchange between remote control centers (ELCOM as introduced standard in more Nordic countries)

Highlights

- Internationally accepted de facto standard for inter control center communication services
- Real time data exchange
- Multi vendor supported
Protocols
ELCOM-90 (Electricity utilities communication) (IEC 870-6 TASE.1)

ISO layer model:

Application layer: ELCOM-90
Presentation layer: ELCOM-90
Session layer: empty
Transport layer: TCP
Network layer: IP
Link/physical layer e.g.: IEEE 802.2 / IEEE 802.3, Ethernet, Token Ring, X.25, ATM, Frame Relay
Protocols
ICCP (Inter-control Centre Communication Protocol) (IEC 870-6 TASE.2)

Open and Internationally Standardized Protocol for Inter Control Centre Communication with real-time data exchange

**ICCP Data Exchange**

![Diagram showing the relationship between different control centers and utilities through the ICCP protocol, including Spectrum PowerCC (Local Control Center), Spectrum PowerCC (Remote Control Center), Other Utilities (Non-Siemens System), Non-utility Generators, Power Pools, Regional Control Centers, and WAN (or permanent lines).]
OPC - The universal and flexible Interface

Client / Server Architecture

- **OPC-Client**
  - Application
  - Communication Device
  - OPC-Interface

- **OPC-Server**
  - OPC-Interface
  - Device specific Protocol
  - Communication Device

Communication Device

COM / DCOM (external via TCP/IP)
Benefits of communication standards

Communication standards to ensure interoperability, efficient engineering, commissioning and secure operation

Current communication standards

Goal for future communication - Use of different physical and link layers
IEC 61850 and its mapping opportunities

IEC 61850 is the up to date, world wide accepted communication standard
Mapping the data model and the services to different ISO/OSI layers

Key features of the standard:

1. Separation of data and communication technology
   - keep the information (application) free from any information exchange method and communication network

2. Communication stacks may be exchanged following the state of the art in communication technology
   - one specific mapping defined to MMS and Ethernet TCP/IP
   - generally the standard is open for other transmission media like PLC or radio transmission

3. Information models can be easily extended
   - further extension planned i.e. for wind power plants, distributed power stations, and water power stations
IT integration concept
Fully integrated and extended WinCC Graphics Designer
- MS Windows look and feel
- World map concept with a 32 layer drawing pane for vector-oriented display design
Typical redundant Spectrum PowerCC System Configuration

- **CS**  Communication System
- **RTS**  Real-time (SCADA) Processing
- **CFE**  Communication Front End
- **AAS**  Advanced Application Server e.g. HIS Archive
- **PSOS**  Real Time Database
- **UI-Client**  Operator Workstation
- **TS**  Terminal Server
The traditional "Plug-Compatibility" as Key for IT-Integration in Utilities

"Integration Bus" = Middleware + Meta Data Model …
I would like to invite you to a discussion about

- Requirements
- Deficits
- Trends
Different Levels of security mechanism

Control Centre Level

Protection and Interlocking

Station Level

Field Level

Device Level

Substation 1

Substation 2