Future proof Communication networks for power utilities
Agenda

- Why do we talk about transition to Packet Switched Networks (PSN)?

- How will fiber optical networks develop?

- Why ABB communication solutions?

- What is the role of PLC in transmission networks today?
What has changed in Telecommunication?

- Traditionally wide area networks (WAN) are build on circuit oriented network (PDH/SDH)

- New market requirements in public telecom:
  - In Telecommunication main application changed from voice to data (e.g. Tripleplay service – High speed internet, Television, Telephone)
  - Strong growth on bandwidth demand (e.g. Video on demand)
  - Source of revenue → overbooking (e.g. no bandwith guarantee for end-users)

- Use of Packet Switched Networks in public telecom segments (Ethernet/IP-MPLS)
Why does it affect operational networks?

Public Telecom networks
- Shift to Packet Switched Networks (IP/MPLS)
- Market 4.3 trillion USD
- Defines technology standards
- Very competitive market

Operational Utility networks
- Circuit oriented networks (SDH/PDH)
- OT/IT Market 5 billion USD (0.1%)
- Follows the telecom industry
- Niche market

Telecom suppliers push into operational utility networks
- Telecom suppliers promote IP/MPLS in utilities
- Some Telecom suppliers outphase PDH/SDH

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Will operational networks also be based on IP/MPLS?

- According a current CIGRE report:
  - IP/MPLS is **not an optimal** solution for operational utility networks. IP/MPLS is …
    …“neither cost-effective nor effort-reducing”
    …“very heavy burden in terms of processes”\(^1\)
  - Circuit oriented networks are still the main solution in operational utility networks
  - Customers are unsure and need security of investment
  - **Also today SDH technology is implemented in newly released products from different vendors**
  - Guarantees long life time of PDH/SDH

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\(^1\) **CIGRE 2012**: Line and System Protection using Digital Circuit and Packet Communications, JWG D2B5.30
Packet Switched Networks Applications
IEC61850 – an evolving standard

IEC 61850
IEC 61850-90-2
IEC61850 information exchange between Network Control Center

IEC 61850-90-1
IEC61850 information exchange between Substations

IEC 61850-80-1
exchange IEC61850 information via IEC60870-5-101/104

IEC 61850-8-1
IEC61850 information exchange In Substations

IEC 61850-80-1
IEC61850 information exchange between Control Center

IEC 61850-90-1
IEC61850 information exchange between Control Center

IEC 61850-80-1
IEC61850 information exchange between T&D Substation

IEC 61850-80-1
IEC61850 information exchange between T&D Substation

IEC 61850-7-410
IEC61850 information exchange for water

IEC 61850-7-420
IEC61850 information exchange for solar

IEC 61400-25-x
IEC61850 information exchange for wind

IEC 62271-3
IEC61850 information exchange from primary apparatus in Substations

Modeling according to IEC61850 for distributed generation

Available standard
Not yet issued
Technology change
The battle for the “future WAN”

- **TDM**
  - PDH / SDH / SONET (Circuit Switched)
  - “Next Gen. SDH” (EoS)

- **PACKETS**
  - “Carrier Class” Ethernet (Packet Switched)
  - GbE Switches
  - S/S Ethernet Switch

- **IP/MPLS Routers**
  - Data-centric networks (IT)

- **LAN**
  - Industrial Ethernet

- **MEF**
  - Carrier Ethernet
  - Provider Backbone Bridging (PBB)

- **IEEE / IEC**

- **ITU-T**

Additional optical ITU-T technologies
- CWDM/DWDM (Coarse/Dense Wavelength Division Multiplexing)
- OTN (Optical Transport Networks)
Cyber security - the drawback of PSN

- PSN networks & applications are affected by cyber security
- Beside the challenges of PSN technology and implementation there is a big challenge for cyber security
- Standards focus on customer organization, supplier organization or on supplier products
- Utility industry has not yet consolidated view
What will change in future for operational networks?

- Also operational networks will also grow to Packet Switched Networks. The exact way and timeline is still unclear.
- CIGRE names MPLS-TP as a promising technology, which is still under definition (OAM)\(^1\)
- Integration of installed base is an important aspect. Platform has to interwork with existing (SDH) network.
- Because of demanding utility application requirements specific features are required (e.g. low jitter, bidirectional switching, EMC, temperature)
- A utility should not rush into new technologies. A utility should use well established and «utility proven» technologies.

\(^1\) CIGRE 2012: Line and System Protection using Digital Circuit and Packet Communications
Will we see only one type of product?
What are the specific utility requirements

Utility Grade means…

- High levels of Electromagnetic Immunity
- Wide variation in environmental influences (temperature, vibration, shock etc.)
- External Type Testing and intensive application testing
- Sustainable product lifecycle strategy
- Allowing redundant network structures in terms of media, path diversity, network resilience and hardware duplication
- Utility standards (e.g. IEC 61850)
**Will we see only one PSN network in utilities?**

What are differences between IT/OT

<table>
<thead>
<tr>
<th>Administrational networks (IT)</th>
<th>Operational networks (OT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT environment</td>
<td>OT environment</td>
</tr>
<tr>
<td>High data volume</td>
<td>Medium data volume</td>
</tr>
<tr>
<td>Constant network changes</td>
<td>Few network changes</td>
</tr>
<tr>
<td>driven by organisation</td>
<td>driven by infrastructure</td>
</tr>
<tr>
<td>Maintenance during night</td>
<td>Maintenance during day</td>
</tr>
<tr>
<td>Today pure IP environment</td>
<td>High diversity of (legacy) protocols</td>
</tr>
</tbody>
</table>

Although both networks will be based on PSN

These networks will stay separate
ABB active participation in defining future solutions
Why ABB for utility communication solutions
Active participation in defining future solutions

- ABB has experts in all relevant organisations defining future solutions and standards for power utility environment such as:
  - CIGRE (Working groups B&D)
  - IEC (Working groups for IEC61850)
  - IEEE (e.g. 1588v2)

- ABB is very much committed to integrate future standards into the product portfolio

- ABB has a long term commitment for the utility communications market
Why ABB for utility communication solutions
IEC & CIGRE - ABB Power Systems participation

- **6 active members in CIGRE Working Groups**, e.g.:
  - D2.23: The use of Ethernet Technology in the Power Utility Environment
  - D2.28: Communication Architecture for IP-Based Substation Communication
  - D2.35: Scalable Communication Transport Solutions over Optical Networks
  - JWG D2B5.30: Line and System Protection using Digital Circuit and Packet Communications

- **13 active members in IEC working groups**, e.g.
  - Members in all relevant working groups of TC57 Standardization of IEC61850
  - TR: Use of IEC61850 for the communication between substations
  - TR: Use of IEC61850 for communication between substations and control centers
  - TR: Network Engineering Guidelines for substation LAN
  - Several members in other working groups
Application requirements
Utilities mission in the focus

- Power utilities need to reliably transmit and distribute electrical energy
- Various applications help the utility to ensure the reliable energy transmission and distribution
- Some of them are mission critical
  - Requiring real time communication
  - Requiring predictable and constant communication channels

- The utility communication network helps to achieve reliable energy transmission and distribution and accordingly it needs to fulfil the requirements defined by the applications without compromise
## Application requirements

Overview about various applications

<table>
<thead>
<tr>
<th>Service</th>
<th>Data rate</th>
<th>Acceptable latency [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice</td>
<td>2.4 – 100 kbit/s per channel</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>Telecontrol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• SCADA</td>
<td>0.05 – 64 kbit/s</td>
<td>&lt; 1000</td>
</tr>
<tr>
<td>Distance Protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Blocking</td>
<td>&lt; 64 kbit/s</td>
<td>&lt; 4 - 8</td>
</tr>
<tr>
<td>• Permissive</td>
<td>&lt; 64 kbit/s</td>
<td>&lt; 5 - 10</td>
</tr>
<tr>
<td>• Intertrip</td>
<td>&lt; 64 kbit/s</td>
<td>&lt; 8 - 16</td>
</tr>
<tr>
<td>Line Differential Protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) EHV (Extreme High Voltage)</td>
<td>64 kbit/s – 2 Mbit/s</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>1) HV (High Voltage)</td>
<td>64 kbit/s – 2 Mbit/s</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>1) MV (Medium Voltage)</td>
<td>64 kbit/s – 2 Mbit/s</td>
<td>&lt; 40</td>
</tr>
<tr>
<td>Video Surveillance</td>
<td>256 kbit/s – 10 Mbit/s</td>
<td>&lt; 1000</td>
</tr>
<tr>
<td>Other operational data</td>
<td>64 kbit/s – 100 Mbit/s</td>
<td>&lt; 1000</td>
</tr>
</tbody>
</table>

1) Line Differential Protection is very sensitive to Jitter (time accuracy) and asymmetrical delay
Application requirements
SCADA systems

- Various protocols and technology used
  - IEC 60870-5-101/ 104, DNP3, Modbus, …
  - Special communication structures possible

- Typically point to multipoint structure
  - SCADA server needs to talk to all outstations
  - Outstations need to talk to SCADA server only

- Redundant Server configuration possible
  - Point to point link between servers
  - Connectivity from each outstation to both Servers

- High availability of communication channels required
  - Redundant channel routing
  - Guaranteed service under any network condition
Application requirements
Differential protection

Protection functionality based on comparison measured values
- Difference means that there is a fault current existing
- Comparison of similar measurement values important
- Variation of transmission time “looks” like a fault current for the protection relay
  - Sensitivity depending on time accuracy (jitter) of compared values
  - Bigger jitter than expected can lead to unwanted trip signals
Requirements for utility communication
EMC/EMI

Substation environment faces:

- Very high voltage levels
- Very high current levels (specially in case of short circuit)

→ **Strong electrical- & magnetic fields**

- Utility communication equipment must withstand this stress without any influence on communication
- **IEEE 1613 defines EMC/EMI** requirements for substation environment
Power utilities environment
Life time cycle

- Equipment in substation/ utility environment will be operating much longer in comparison to public telecom operators network
- Very high MTBF of the equipment required to guarantee correct operations over total life cycle
- Long time availability of spare parts & extension material required
FOX615
Hybrid multiservice access/ transport multiplexer
FOX615 Concept
Universal Equipment providing SDH and GbE Services
Requirements for utility communication
Operational excellence through multiservice networks
FOX615 Packet Switched Backbone Applications
FOXMAN-UN – Network Management System Functionality

**Fault Management**
- Status supervision
- Alarm documentation

**Configuration Management**
- Equipment configuration
- Network configuration

**Account management**
- Providing information for accounting

**Performance Management**
- According to ITU-T G.826

**Safety Management**
- Access / Intrusion Control
  - Software
  - Physical intrusion
ABB FOX515/ FOX615 solutions

- **FOX615 is...**
  - prepared for future packet switched backbone networks
  - fully integrated into the FOXMAN-UN

- **FOX615 provides...**
  - full interoperability to FOX515
  - similar TDM access interfaces as FOX515 including utility specific interfaces such as Teleprotection
  - support of SDH technology until 2020 and beyond
  - significantly enhanced Ethernet/ IP interfaces & services

- **FOX615 is a utility grade equipment** (enhanced temperature range, EMC/ EMI) based on well proven FOX515 experience

- **FOX615 provides investment protection because of:**
  - Full interoperability with huge installed FOX515 base
  - Future upgradability to Packet Switched Networks
Utility Communication – Power Line Carrier
Components of a PLC link

Transport of electrical energy

Substation A

HV-line

Substation B

Transmission of data, speech and protection signal
Power Line Carrier (PLC) System
ETL600 R4 System Overview

Multi-service equipment
ETL600 integrates all the applications that are critical for electrical utilities

- Data
- Telephony
- Teleoperation
- Teleprotection

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Power Line Carrier Systems

**Pro’s**
- Uses existing high-voltage AC or DC power lines (33 … 1000 kV)
- No extra media required
- Long distances without repeater (up to 1000 km)
- Excellent solution for line distance protection
- Fully under the control of the utility
- Normally used for pure operational applications – no cyber security problems
- License-free

**Cons**
- Narrowband medium < 256 kbps (line dependent)
- Weather (rain, ice) influences performance
- Subject to EMI (Corona noise, switchgear operation, line faults)
- Not suitable for line differential protection

- Provides bandwidth for Operational Network requirements
- Provides redundancy for fiber optical links
- Acts as insurance for the utility
Teleprotection - NSD570
Connection interfaces to communication channels

A wide range of interfaces supporting almost any transmission medium

Redundant configurations for ultimate reliability
Wireless Broadband for the Smart Grid
TROPOS Network Architecture
Automatic reclustering

Network automatically reclusters to take advantage of additional backhaul.
Routers provide communications for many applications
Secure, high-speed, low-latency

- Routers provide secure broadband wireless connections to nearby infrastructure, people and vehicles
- One network supports many applications and user groups
- Routers support industry standard security
  - AES encryption
  - Integrated firewall
  - Integrated IPsec VPN
Abu Dhabi Electric & Water Authority (ADWEA)
Efficient resource management, emirate-wide

- Over 1 million smart power and water meters in urban, suburban and rural areas connected by Tropos network
- Tropos network spans >3,000 square miles
- Built to support multiple Smart Grid applications simultaneously
  - Advanced Metering Infrastructure (AMI)
  - Real-time SCADA substation control
  - Distribution automation (DA)
  - Mobile workforce connectivity
  - Substation video security
  - Street light control
Utility Communication - an integrated network
ABB Communication Networks group
Portfolio Overview

**Distribution**

- Fibre optic: FOX family (SDH/PDH, Ethernet/IP, legacy)
- VHF/UHF radio: AG100, ...
- Meshed radio solutions - Tropos

**Transmission**

- Power Line Carrier: ETL600
- Teleprotection: NSD570
- Fibre optic: FOX family (SDH/PDH, Ethernet/IP, legacy)
- MW radio

**Smart Grid**

- Meshed radio solutions - Tropos
- Advanced metering infrastructure

**In-Plant**

- Ethernet/IP/Legacy: FOX family
- CCTV, telephone systems
- Public address System
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