Inter-Substation Communication leveraging IEC 61850 for wide area substation communications

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Questions

• What are we doing?
• Why are we doing it?
• How are we doing it?
What are we doing?

• Substation-to-substation communications for protection, automation and control
• Horizontal communications for applications such as accelerated transmission line protection schemes
• Vertical communications for applications such as System Integrity Protection Schemes
Ride-Through Capability
Transmission Line Protection
Accelerated Scheme
IEC 61850 Based Accelerated Line Protection

![Diagram of IEC 61850 Based Accelerated Line Protection](image)
SIPS Hierarchy
SIPS Functionality

• SIPS can be considered as systems that have three main types of functional elements:
  – System monitoring elements
  – Protection elements
  – Execution elements
Why are we doing it?

- There are requirements for improving the quality, reliability and efficiency of PAC systems
- Quality: the standard of something as measured against other things of a similar kind.
- Reliability: the ability of an apparatus or system to consistently perform its intended function without degradation or failure.
- Efficiency: the extent to which a resource is used in order to effectively achieve an objective.
Why are we doing it?

• Conventional client-server protocols such as IEC60870-5-101, IEC60870-5-104 and DNP 3.0 as connection oriented and do not meet the performance requirements for many PAC applications
• They do not support high-speed peer-to-peer communications
• The detailed semantical object model in IEC 61850 is not available in other protocols
Why are we doing it?

- IEC 61850 is not just a communications protocol
- It supports a standardized engineering process based on the different System Configuration Language (SCL) files
- Substation-to-Substation communications engineering is based on System interface Exchange Description (SED) files
High bandwidth wide area connection ‘looks like switch’
How are we doing it?

- Use of IEC 61850 GOOSE and sampled values based versus conventional hardwired interfaces
- Using GOOSE over existing communications channel
- Using GOOSE over Layer 2
- Using GOOSE over Layer 2.5
- Using R-GOOSE
GSE Messages:

- **max. Repetition Interval**
- **fast Repetitions**
- **max. Repetition Interval**

new Event: Data Change
Analog GOOSE Applications
IEC 61850 Reports

- IEC 61850-90-1 – Using IEC 61850 for communication between substations
- IEC 61850-90-5 – Using IEC 61850 to transmit synchrophasor information according to IEEE C37.118
SS-SS Tunneling
SS-SS Mechanism

Station A
- Function A1
- Function A2

Proxy B2

Special Communication Mechanism (typically low bandwidth)

Station B
- Function B1
- Function B2

"Teleprotection Equipment" acting as Gateway

IEC 61850-90-1
IEC 61850 Based Accelerated Line Protection

A Distance Protection 1

B Distance Protection 1

A Distance Protection 2

B Distance Protection 2

MPLS

GOOSE
IEC 61850 Based Accelerated Line Protection

A Distance Protection 1

B Distance Protection 1

A Distance Protection 2

B Distance Protection 2

R-GOOSE

IP network

F1

F2

F3
# R-GOOSE Control Block

<table>
<thead>
<tr>
<th>Attribute name</th>
<th>Attribute type</th>
<th>r/w</th>
<th>m</th>
<th>Value/value range/explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoEna</td>
<td>Boolean</td>
<td>rw</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>GoID</td>
<td>Visible-string</td>
<td>r</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>DstSet</td>
<td>Visible-string</td>
<td>r</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>ConfRev</td>
<td>Unsigned</td>
<td>r</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>NdsCom</td>
<td>Boolean</td>
<td>r</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>DstAddress</td>
<td>UDPCOMADDR*</td>
<td>r</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>MinTime</td>
<td>Unsigned</td>
<td>r</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>MaxTime</td>
<td>Unsigned</td>
<td>r</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>FixedOffs</td>
<td>Boolean</td>
<td>r</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>SecurityEnable**</td>
<td>ENumerated</td>
<td>r</td>
<td>o</td>
<td>None, Signature, SignatureAndEncryption</td>
</tr>
</tbody>
</table>

* The definition of UDPCOMADDR can be found in Table 5.
** Additional attribute to be added to the control block.
<table>
<thead>
<tr>
<th>Attribute name</th>
<th>Attribute type</th>
<th>r/w</th>
<th>m</th>
<th>Value/value range/explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIORITY</td>
<td>Unsigned8</td>
<td>r</td>
<td>m</td>
<td>Range of values shall be limited from 0 to 7.</td>
</tr>
<tr>
<td>VID</td>
<td>Unsigned16</td>
<td>r</td>
<td>m</td>
<td>Range of values shall be limited from 0 to 4095.</td>
</tr>
<tr>
<td>APPID</td>
<td>Unsigned16</td>
<td>r</td>
<td>m</td>
<td>As defined in Annex C in IEC 61850-8-1</td>
</tr>
<tr>
<td>TransportInUse</td>
<td>Unsigned8</td>
<td>r</td>
<td>o</td>
<td>Is an enumerated value whose values are: IPv4, IPv6, and DNS assigned.</td>
</tr>
<tr>
<td>IPClassOfTraffic</td>
<td>Unsigned8</td>
<td>r</td>
<td>c</td>
<td>If TransportInUse=IPv4, the value shall represent the IPv4 TypeOfService value. If TransportInUse=IPv6, the value shall be the IPv6 Class of Traffic field.</td>
</tr>
<tr>
<td>IPV6FlowLabel</td>
<td>Unsigned32</td>
<td>r</td>
<td>c</td>
<td>If TransportInUse= IPv4, the value shall be zero (0) and shall be ignored. If the TransportInUse= IPv6, the value shall contain the 24 bits of the IPv6 Flow Label field in the least significant part of the unsigned value.</td>
</tr>
<tr>
<td>IPAddressLength</td>
<td>Unsigned8</td>
<td>r</td>
<td>c</td>
<td>If TransportInUse= IPv4, the value shall be four (4). If TransportInUse= IPv6, the value shall be sixteen (16). If TransportInUse= DNS, the value shall be the length of the DNS string, not including terminating NULL.</td>
</tr>
<tr>
<td>IPAddress</td>
<td>OCTET-STRING</td>
<td>r</td>
<td>c</td>
<td>This attribute shall be 64 octets in size. Any unused octets, based upon the IPAddressLength attribute value, shall be zero (0).</td>
</tr>
</tbody>
</table>
IEC 61850 90-5 Session Protocol
E2E Cryptographic Integrity
Propagation time measurement
Transatlantic GOOSE latency
One way propagation delay Texas - Austria
Two way propagation delay Germany - Austria

![Graph of Propagation Time vs. Packet Size](image-url)