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Question 2.01: What are the challenges in the development of digital substations and how to address the problems caused by the digitalization?

Digital Substations Challenges

Developing and deploying digital substations pose a wide range of challenges to end-customers, operators, as well as solution providers. Challenges range from organization aspects on customer side, including required know-how ramp-up and challenges when transferring existing specifications to cover digital substation aspects, to technical aspects on product and system design.

The contribution focuses on two aspects, that are often discussed in the context of digital substations with IEC 61850 process bus:

1. Time synchronization

To achieve adequate accuracy of substation functions, including revenue metering, the synchronization of sampling at physically disperse locations must be accurately synchronized. IEC 61850-5 requests synchronization accuracy of 4 microseconds for synchronized sampling and 1 microsecond for highly synchronized sampling, as e.g., used for wide area applications. IEEE 1588 standardizes the precision clock synchronization protocol and IEC/IEEE 61850-9-3 specifies the profile to be used in power automation. Interoperable device in substation automation networks shall therefore follow the profile definition. To ensure adequate availability of the protection, automation and control system (PACS), device and system design need to fulfil a couple of requirements, as for example:

- The PAC system shall be synchronized by multiple grand-master capable clocks. For optimum robustness, it makes sense to distribute the time sources and e.g., distribute the precise time synchronization across the utility WAN. This can be instead of, or in addition to GPS clocks on site.
- The IEDs in the substation shall be master capable and participate in the Best Master Clock Algorithm (BMCA), in order to synchronize the system in case of loss of global (e.g., GPS synchronization)
- Using link layer redundancy (HSR or PRP) in the critical networks for process and time data avoids single points of failure in the communication networks
- Finally, it is a must, that the protection and control IEDs intrinsically behave correctly in case of bad quality or missing time synchronization. This means that the devices shall automatically block affected protection functions, if data that would require synchronization is not anymore synchronized, while keeping those functions running, that do not depend on the missing time synchronization.

2. Documentation

By replacing copper wires with fibre-optic communication networks and transmitted sets of data, conventional system documentation loses its purpose. The documentation is therefore replaced or extended with two types of additional documentations:

- **SCL based documentation**
 - ✓ As built SCD file, the single source of truth
 - ✓ Rich of content, e.g., including substation section and topology

- Requires tool support to interpret and represent
- **Human readable documents**
 - ✓ List based documents, exported from system and IED configuration tools
 - ✓ Simple to read for non-specialists, e.g., communication tables resembling today's wire connection lists
 - Limited content, risk to be out of date

Both are required for documentation and enable efficient maintenance. With the SCD file being the ultimate as-built documentation, it is important that it is as complete as possible, for example including the substation section, even if this might not be absolutely required during the engineering and deployment of the PAC system.