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I believe that at this stage of development of network technologies and intelligent electronic devices, the segments of the process bus and the station bus should be physically separated. For network devices, this is primarily due to economic factors; more expensive switches are to be applied for the process bus than for the station bus. The second point is the human factor; the station bus is connected with automated workstations, laptops for adjustment, and any manipulation can lead to network failures (settling this problem by using VLAN is possible, but in practice, this will also be a problem because of the constant reconfigurations). The third point is the possibility of using a different network architecture (PRP for the process bus and traditional architecture for the station bus) without the use of additional devices such as RedBox (building reliable structures using RedBox is a separate and very complex subject, which cannot be covered in the framework of the comment). From the point of view of IED, two sets of ports (for the station bus and the process bus) allow for sharing the tasks between processors (controllers) and significantly improving the architecture reliability.

As far as data transfer protocols are concerned, it is obvious that MMS protocol should be applied at the station bus level, and Sampled Values, at the process bus level. GOOSE messages are used for different tasks at the facility, and depending on the requirements, they can be transmitted both via the process bus (for example, for the raw data transfer from the discrete merging unit) and the station bus (for example, to organise interlocking). The use of GOOSE at the process bus level gives cause for concern among many experts because of the probability of the so-called 'storms'. However, such collisions are excluded if GOOSE messages are generated only by discrete merging units. In this case, the number of GOOSE messages is known; changes occur only from the primary technological process (i.e., seldom) and there cannot be any cross-connections between devices (when one message can generate another message, leading to an avalanche of traffic). The calculation of such bus is similar to the SV, where the minimum time of the GOOSE message transmission is taken as the transmission interval (as a rule, it is quite large as compared to SV), and the load on the process bus can be accurately calculated.

> « The segments of the process bus and the station bus should be physically separated

To my mind, such a solution is versatile enough for all voltage classes, but the following should be taken into account:

- depending on the substation structure and size, additional network segmentation may be required (physical and logical);
- SV application at the 6-35 kV voltage level has a very dubious sense; SV publisher and subscriber IEDs are usually close, and there are no advantages in using SV. Only incoming feeders' IEDs should be connected to the process bus to arrange the transformers' protection.

As I see it, the problems, the solution of which requires the substation LAN separation by traffic types, have been specified by me, above. I would say not 'problems', but 'factors', and would highlight three:

- technical (perfomance, reliability, etc.);
- economic (final solution cost for the customer);
- organisational (human factors, service regulations, repair regulations, etc.).

The methods may be different, from utilizing VLAN to point-to-point architecture.

My judgments are based on the following experience:

- protocol stack development according to IEC 61850 and designing various software products using such stack;
- IED development and testing;
- integration of various devices according to IEC 61850;
- bench tests (including the 'storm');
- practical experience of implementation of the digital substation technology at one of the hydro power plants in Russian Federation.

Unfortunately, abstract economic research (without reference to a particular facility), as well as outwardly showy technical solutions (with no operating experience in pilot projects) does not always coincide with reality. Different facilities have different lengths and different climatic conditions, and we need a properly executed project with a high quality section related to a feasibility study (FS). Such a project can be implemented only by those organisations that gained experience in the pilot projects related to digital substations implementation (it is important to have this pilot finished; in other words, tests should be performed, the equipment performance should be demonstrated, and the project FS should be compared with real technical and economic results). As a rule, such organisations already have experience in designing 3–5 digital substation projects (not all innovative projects are implemented), conducting a general contract for innovative facilities and their own production (thus, they can assess technical and economic prospects for the serial product introduction).

Equipment cost calculation is another problem. There is equipment for digital substations that is batch-produced (as a rule, this equipment is without the Sampled Values support), and its cost is known. The cost of the equipment manufactured by piece is quite high, and it is not easy to justify the possibility of the cost reduction (especially when they deal not with electronics, but with advanced high-tech materials, for example, optics for measurements).

In any case, it seems that if we decide to master such sophisticated technology, we should do it in a progressive manner, in small steps, with an eye on the experience, without dealing much with loud PR companies and unfounded spectacular solutions; we should also be aware that in case of failure, the energy community can lose its interest in this very promising technology.