Use of IEC-61850 to telecontrol MV grids

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Abstract

To achieve good control over the medium voltage (MV) network is an important step towards developing the Smart Grid, not only for SAIDI (System Average Interruption Duration Index) reductions, but also this network will increase in complexity as new generation sources get in to the network.

It is necessary to find solutions based on off-the-shelf products to allow us enough flexibility and robustness to cover actual and future needs.

It is therefore important to select technologies which allow us to reduce initial deployment costs as well as in operation time costs. These days, IP based communications allow us to separate the telecontrol protocol from the communication medium: sDSL, WiMax, UMTS, GPRS, Tetra or IP radios. This gives us a very high degree of flexibility, but there are considerations that must be taken into account in the telecontrol protocol.

The IEC-61850 is a great tool which can give us very good results also outside the substation. We introduce a scalable and standard solution for remote control of the MV grid without implication for existing control centers.

INTRODUCTION

When selecting the devices involved in a remote control system for medium voltage network we have to take into account certain characteristics that are very different from those required in a substation.

Some of them are:

- The robustness of the devices. Not only is it important to meet the IEC-61850 Electromagnetic Compatibility (EMC) requirements but also the environmental requirements. The modems, routers and Remote Terminal Units (RTUs) are located in places with extreme temperatures and humidity.
- The cost of equipment. The cost of large volumes of equipment should be as optimal as possible.
- And communication technologies to be used to connect the Control Centre to the remote sites. This feature is also key to system reliability.

In this article we will focus on the latter, since the IP networks and IEC-61850 will bring us some benefits to control the secondary grid.

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THE COMMUNICATIONS MEDIA

At this time, companies are under pressure to reduce infrastructure operating costs, and a combination of private and public communication networks will allow investment costs to be balanced depending on the utilities criteria.

The TCP/IP networks allow us to integrate all communications coming from a private network using Ethernet or TETRA (Terrestrial Trunked Radio), and communications coming from public networks which will use GPRS, UMTS, EDGE or any future technology. From the Control Centre's point of view all information is received in same manner, regardless of the media used. Using TCP/IP networks is a future-proofed solution as this ensures the system will adapt to new communication technologies without affecting the Control Centre.

The TCP/IP can support nearly any type of service. In our case the network will transport Telecontrol data, and furthermore we can take advantage of the same network for occasional tasks such as remote maintenance, network monitoring, oscilloperturbograph downloads, etc.

Today, the utilities try to minimize costs in communications infrastructure, and the TETRA network is presented as the cheaper option to implement a private network via radio. Moreover, the GPRS public networks provide high levels of coverage in populated areas, which enable rapid implementation of the telecontrol system without infrastructure costs.

GPRS public networks, in addition to providing some advantages, also carry some problems, such as reliability and cybersecurity. In the latter sense, security enhancements for IEC-61850 have been published as international technical specifications by IEC, like IEC-62351-4 and IEC-62351-6. There have been discussions of the need to secure IEC-61850 not only within the boundary of the substation but communications that extend outside of the substation.

In order to secure communications against cyberattacks the public networks operators offer Virtual Private Network (VPN) services, providing a secure and transparent transfer of data end to end. This greatly simplifies the commissioning task because there is no need to manage keys and certificates that would complicate the system configuration.

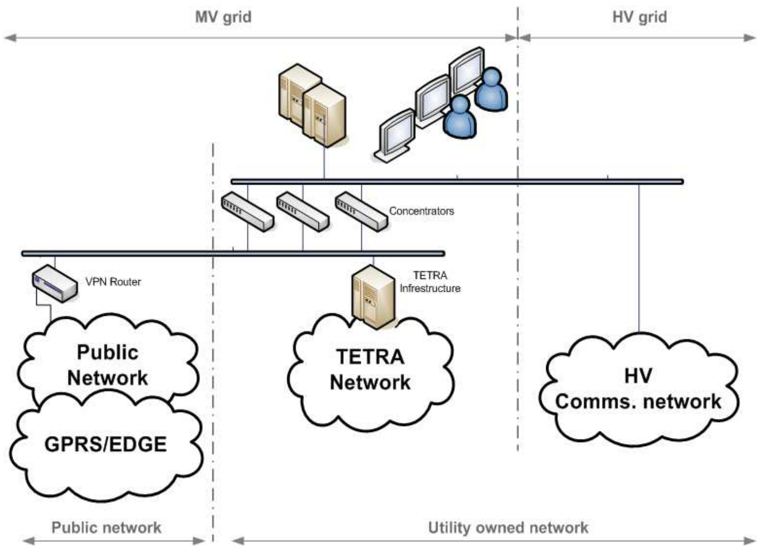

Figure 1. Integration of public and private networks using TCP/IP

WHY IEC-61850?

Initially, the standard IEC-61850 was more focused on transmission and distribution substations. But now, it has expanded beyond substations into new fields such as wind farms (IEC-61400-25), hydro power plants (IEC-61850-7-410), distributed energy resources (IEC-61850-7-420), and takes into account aspects such as communication between substations (IEC-61850-90-1) and communication between substations and the Control Centre (IEC-61850-90-2).

IEC-61850 uses advanced communications techniques to address data management and simplify integration of applications:

- Data from Intelligent Electronic Devices (IEDs) is available to all applications via TCP/IP network.
- Applications and IEDs share common protocols, data format, data addressing and naming conventions, and even the same configuration language, regardless of manufacturer.
- Reduced configuration costs from common naming and automatic point configuration and retrieval.
- IEC-61850 creates a single virtual network between Control Centre and remote sites that eliminates barriers to data access.
- Improved maintainability via use of generic widely available technology
- Now, the standard is more and more adopted by utilities, and many new regions are now starting to adopt it.

To control the secondary grid with IEC-61850 several considerations must be taken into account.

When using WAN networks we need to keep traffic as low as possible, because they are usually networks with low bandwidth or with cost per traffic. Therefore information should be sent in the most compact possible way and with low overhead. This is possible using Manufacturing Message Specification protocol (MMS) and Generic Object Oriented Substation Events (GOOSE), and discourages the use of other communication services like Web Services.

Furthermore, we also encourage that the communications channel is actively monitored. In MMS, as well as in most remote protocols, the outstation remains silently waiting for the connection from the Control Centre. This doesn't allow us to take advantage of telecontrol traffic to perform a test of the communication channel at all the times. Moreover, most communication problems occur at the remote end, and can only be resolved by restarting the communications from there. Therefore, the remote equipment must be responsible for periodically checking the status of communications in a parallel process, and to solve the problem whenever possible.

In the remote control of the secondary distribution grid one is faced with two very different applications with two different IEC-61850 approaches: the remote control of MV switchgears and the over-current fault detection.

REMOTE CONTROL OF MV SWITCHGEARS

The Control Centre needs to act on switchgears, reclosers, disconnectors and capacitor banks. Therefore it is necessary that the Control Centre can monitor the status of the facility and perform commands on it in a reliable way.

In this case, using MMS is best suited for the following reasons:

- Since MMS allows discovering the structure of objects, the Control Centre can verify that the information matches with the Control Centre configuration. This greatly reduces the chance of configuration errors during commissioning.
- Events must be submitted using Buffered Report Control Blocks (BRCB). This ensures that under a communication failure in the Wide Area Network (WAN) the Control Centre will not lose events, as they are stored and sent when communications are restored.

- The measurements must be submitted using Unbuffered Report Control Blocks (URCB). Typically, the Control Centre only cares about the value in the present time. Therefore, when communications fail it is not necessary to keep samples of measures.
- On the other hand, MMS allows the Control Centre to get these measurements on demand, subscribing or unsubscribing to these reports. When the Control Centre is subscribed to a report, it will be sent spontaneously when any measure exceeds a configured deadband, without requiring the Control Centre to make a request. This will reduce the cost of traffic over other protocols implementations.
- Like other protocols of the energy sector, MMS allows secure command through a select-before-operate control model.
- Much other information is also available for the Control Centre and for engineering applications, and it can be accessed at any time by sending simple read requests.

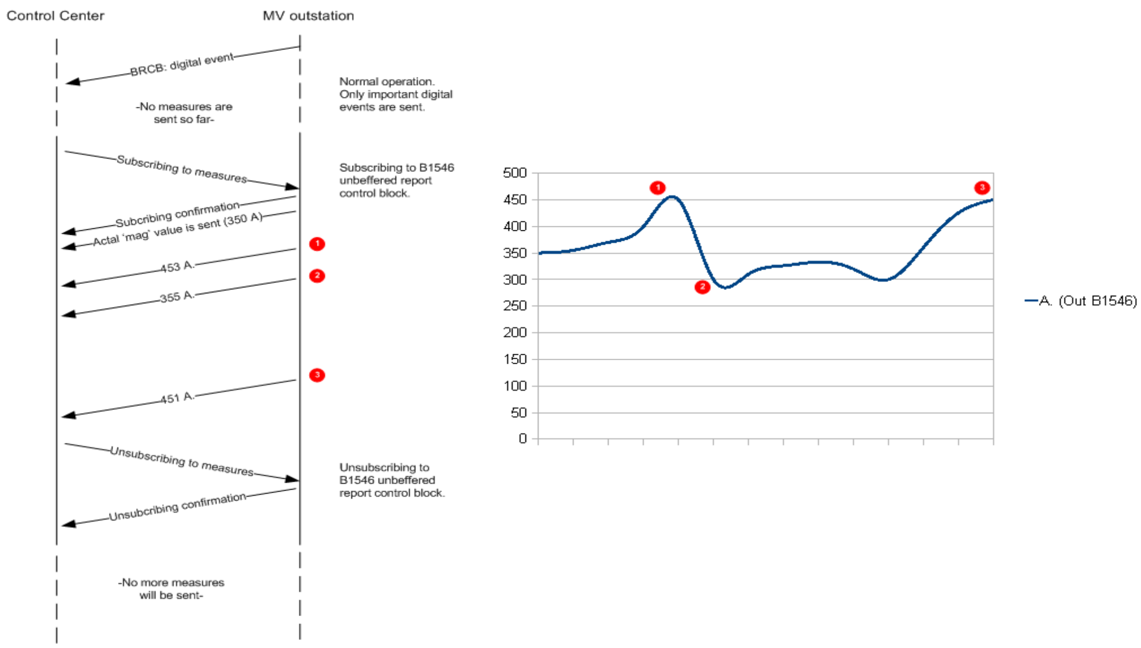

Figure 2. Measures on demand using IEC-61850

To start deploying a remote control system today, we find that:

a) There are many facilities that will require a retrofit using conventional wiring.

b) The price of a MV for secondary relay is significantly cheaper than an equivalent in IEC-61850.

c) In the short term, we don't expect to find Control Centres able to support many concurrent IEC-61850 connections one for each IED in a secondary distribution grid.

All of this means that the most reasonable solution for the time being is to use RTUs capable of concentrating the information received from the relays and wirings, and offer it upstream with IEC-61850.

All information received from different IEDs should be displayed on different Logical Devices (LD) with IEC-61850, one for each IED. It is also necessary to adapt the information received from different protocols (e.g. DNP3, IEC-60870-5-103, Modbus, ...) to the structure of objects and attributes of IEC-61850.

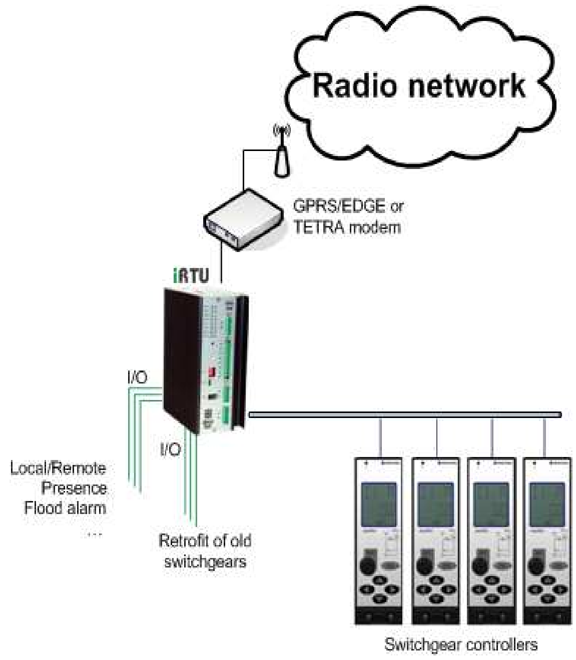

Figure 3. Use of an iRTU to integrate all information collected in a transformer substation.

OVER-CURRENT FAULT DETECTION

The over-current fault detectors allow the operator of the Control Centre to isolate the affected area very quickly.

Performing fault detection requires using specific devices that can detect and indicate over-current conditions through the network. These devices are called passage detectors units and their role is to perform detection of over-current/overload conditions along sections of the MV power grid installed in-between the passage detectors units.

When a faulty condition occurs some of the related passage detectors units installed along the MV power grid (upstream the fault) will sense that condition. Those units which "felt" passage of the fault current through their sensors will report this event to the Control Centre through a small RTU.

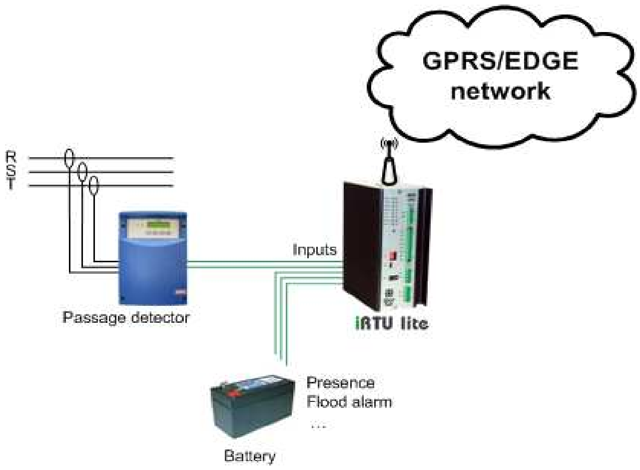

Figure 4. Power grid fault detection using iRTU.

Since the task is quite simple, and many of these units have to be installed, the RTU must be a very optimized for this task at low cost, with a small set of features:

a) 8 digital inputs.

b) Internal GPRS/EDGE modem.

c) GOOSE reports.

Eight digital inputs will be enough to sense all required information for most cases, e.g. homo polar fault detection of three lines, battery charger failure and power supply failure.

Today, the most optimal way to communicate these RTUs with the Control Center is through a public operator network with GPRS or EDGE. Then an RTU with integrated internal modem provides a significant cost reduction.

In this case the use of GOOSE is the best option because its implementation requires little hardware and is enough for sending events. By now, this requires that GOOSE packets are sent through a layer 2 VPN. But in a very near future we may send this traffic through IP, as 61850-90-5 includes new mappings of GOOSE and SMV that can be used for wide area networks using UDP/IP. This will make things much easier.

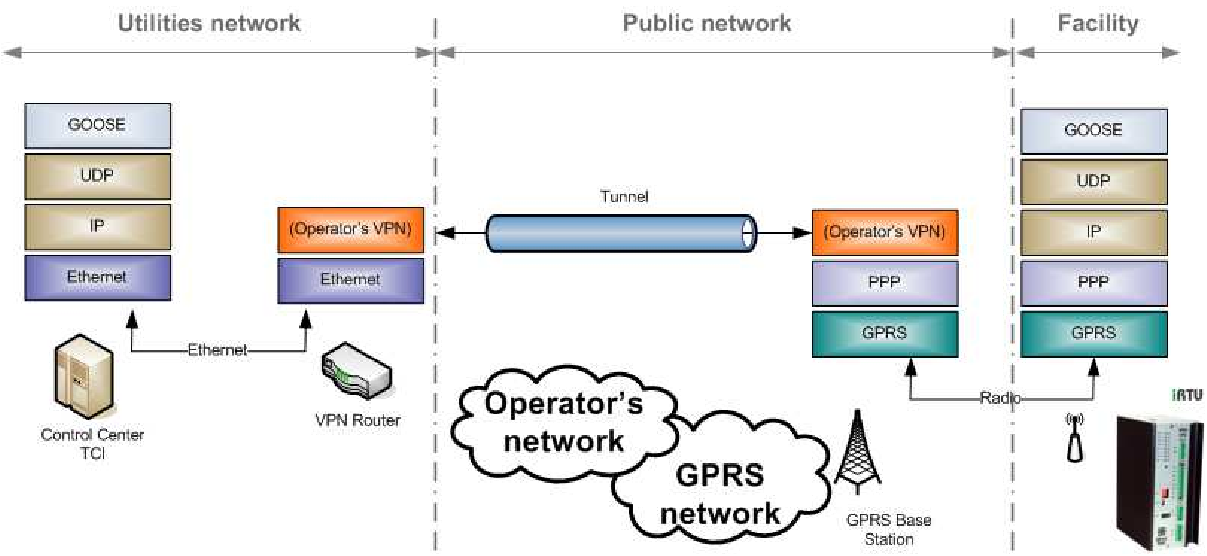

Figure 5. Protocol stacks used for GOOSE on MV.

USE OF DATA CONCENTRATORS

The large number of medium voltage installations generate a high volume of traffic that should not be sent to the Control Centre directly. The Control Centre must be freed from the communications management and pass to it only relevant information, in this case only the information concerning the remote control. It is therefore necessary to always use data concentrators that are handling these communications and provide to the Control Centre all required information to supervise and control the MV network.

These concentrators should be able to connect simultaneously with the main control centre and the backup control centre. Therefore, with a hot-standby configuration, a switch between centres can be performed without losing data.

Today only some small utilities have IEC-61850 enabled SCADAs, and meanwhile, all this information must be translated to other widely used protocols like DNP 3.0 or IEC-60870-5-101/104.

It is worth mentioning that in the case of fault detection concentrator we also benefit from the simplicity of the GOOSE protocol which, given their low hardware and software requirements, allows us to handle a high number of facilities per concentrator.

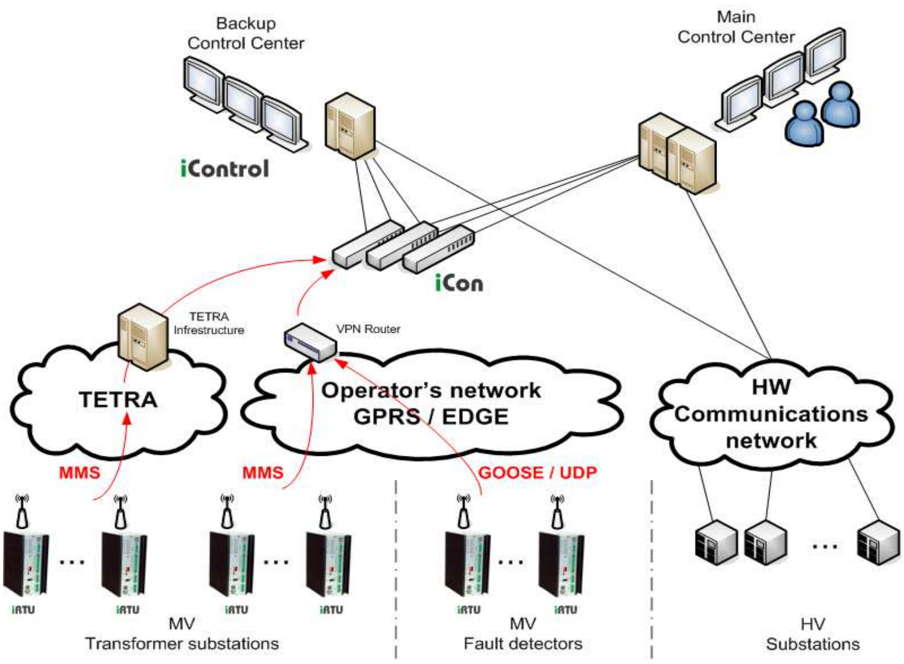

Figure 6. Use of data concentrators for MV information.

CONCLUSIONS

Remote control and monitoring of the MV power grid parameters allows the Control Center operator faster detection and correction of faults.

Use of advanced RTUs provide means for integrating reliable and secure data communication network using private and public IP networks.

When designing a remote control system should always be taken into account to minimize the data traffic. IEC-61850 will help us to keep this low.

For remote control of the MV grid raises two scenarios having different requirements. In each scenario we can apply different parts of the IEC-61850 standard, achieving an optimal solution for each case.

We presented an advanced architecture based on standard protocols and providing forward path compatibility (future-proofing). The iRTU is equipped with a wide range of flexibility that allows integration of such systems by many utilities worldwide.

The IEC-61850 has progress beyond the substation and we can also take advantage of its benefits when use it in WAN networks.

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