PRINCIPLES OF RENEWING OF FIELD COMMUNICATION NETWORK OF ELECTRICITY DISTRIBUTION COMPANY

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ABSTRACT

Distribution automation used in electricity distribution network is connected to operation systems with RTU:s and field communication network. The main function of the field communication network has been delivering alarms, controls and measurements between remotely controlled equipment and SCADA. Traditionally, the field communication network is owned and maintained by the distribution company and the communication is carried out using analog links and radio modems in Finland.

This paper will include description of the original status of the field communication network and the requirements set as guidelines for the offer request. In addition, paper includes description of the final technical solution and service concept and analyses expected benefits of the new field communication network.

INTRODUCTION

Development of modern distribution automation equipment, like protection relays and RTU:s has been intense during last decade. Basically, modern distribution automation consists of computers distributed along the distribution network. The functionality and amount of data of the distribution automation equipment has increased a lot, but the performance (i.e. Bandwidth and latency) of the field communication network does not support delivering this information to operating systems.

In Vattenfall Nordic Distribution Networks Finland, most of the main operating systems have been changed since merging six companies into one electricity distribution company in 2000. The field communication networks of the previous companies were left original, even though the SCADA system in the higher level was harmonized. The field communication network was mainly owned and maintained by a partner and consisted mainly of analog links and radio modems that were connected to digital link network. During last few years, some public communication network based connections, like GSM and GPRS, have been utilized for remotely controlled disconnector stations. The communication is carried out by serial communication with polling circles using a variety of protocols and RTU:s. Additionally, several substations have been combined into one polling circle dividing the bandwidth of the analog link network even more.

Strategy for increasing reliability of distribution network of Vattenfall Nordic Distribution Networks Finland has been investing in automation and remotely controlled equipment. During last few years, the amount of remotely controlled disconnectors has been doubled and 2/3 of the primary substations have been equipped with earth fault compensation. Consequently, the scalability of the field communication network has risen as the bottleneck of the distribution automation system. Therefore, a project for renewing of the field communication network was started. The target was to get a cost efficient, reliable, redundant, scalable, high bandwidth and low latency field communication network as a full service provider including equipment, installation, maintaining, fault repairing and communication.

ORIGINAL STATUS OF THE FIELD COMMUNICATION NETWORK

The field communication network for the electricity distribution control automation was mainly built over the past 20 years using private radio link networks and analogue phone modems having very limited data transmission capacity (9600 bps) and expensive to maintain.

On the old days the requirements for electricity network control were mainly to identify major critical faults for which low capacity communication was enough. Since there were not much data to be transferred even expensive minute based public network phone modem services could be used.

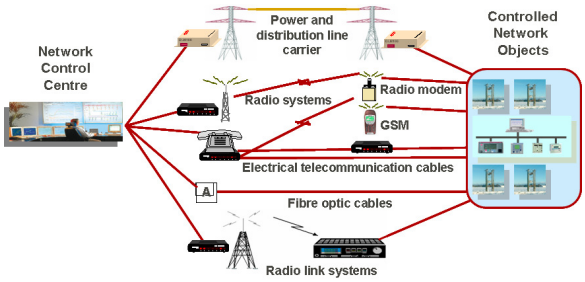

Figure 1: *Old field communication network*

It was quite uneconomical and even impossible to have disconnector stations to be connected to central control although the benefits of that were known long time ago.

Each of the Vattenfall acquired energy company had their own data communication infrastructure with own maintenance, since the old radio link systems were not known by any service company. It was a kind of history based "trap", which must be solved some how.

Since merging of previous companies, harmonization project of operative IT systems was implemented including Network information system (NIS), SCADA, distribution management system (DMS), customer relations management system (CRM), etc. Also, large amount of investments into network automation were made to improve network reliability. These investments include small-scale primary substations, earth fault compensation equipments to primary substations, remote-controlled disconnector stations and reclosers. All these investments included modern automation equipment and required communication link to SCADA system via field communication network. However, the old field communication network was not able to support the new functionality enabled by modern automation equipment.

This heterogeneity of communication led to a planning project aiming to renew communication with today's data capacity possibilities, quality and security options.

REQUIREMENTS FOR THE FIELD COMMUNICATION NETWORK

Vattenfall Nordic Distribution Networks Finland set an invitation of tenders including a list of functional requirements. The requirements that can not be compromised were for

- Safety and Security
- Continuous availability even in major disturbance situations
- Scalability to new remotely operated points
- Future evolution based on smart grid services
- Cost efficiency

Requirements were described for two different levels of communication needs, mainly meaning power stations and disconnector or recloser stations.

The technical solution was deliberately left up to vendor to propose and decide to make vendors think about new kind of solutions not sticking to one specific technical requirement.

Requirements for Power Station Communication

Power stations are the most critical elements in control and management of the distribution network and hence greater value was set for them. Losing connection to power station may lead to long interruptions in wide area affecting lots of customers. Therefore, higher requirements were set to power stations for availability, safety and security.

Availability

- Redundant end-to-end mobile communication connections using different physical routes with 99,96% availability
- It must be possible to use both the routes in parallel.
- Priority classes must be available
- Primary route is for SCADA (min. 20 kbps full duplex, no response time critical, reliable transfer)
- Secondary route is for maintenance and new services like weather stations and video surveillance, VOIP, etc. (min. 512 kbps full duplex, response time critical)
- Automated switch over of SCADA traffic to secondary connection when primary fails

Safety and Security

- The solution must be safe, protected against human and physical disturbances and use of validated security technologies.

Protocols

- TCP/IP
- IEC 104 (Ethernet)

Requirements for Disconnector or Recloser Station Communication

Disconnector and recloser stations are not as critical as power stations, which lightens the requirement. Losing connection to disconnector or recloser station may lead to

longer duration of interruption but in more limited area compared to power station level.

Availability

- Single connections, no redundancy
- 99,96% availability for operative traffic

Safety and Security

- The solution must be safe, protected against human and physical disturbances and use validated security technologies.

Protocols

- TCP/IP
- IEC 101 (RS-232) and IEC 104 (Ethernet)

Requirements for Scada Communication

There are two SCADA-applications in use at different locations, the one being the primary and the other the secondary. Additionally the SCADAs will be connected together with two separate physical connections to assure redundancy.

The SCADA understands both IEC 101 and IEC 104 protocols.

Common SLA Requirements for the Delivery

Taking into account he differences in the communication requirements described the following are common for the communication service and delivery.

SLA

- Service Desk 24/7 email or phone
- 24/7 connection control
- Disconnector and power station connection faults fixed within the next day (Note: At power stations the primary or the secondary connection must be always available)
- Operative availability 99,96% per connection

FINAL SOLUTION OF THE FIELD COMMUNICATION NETWORK

Vattenfall Nordic Distribution Networks Finland received offers from five vendors all providing different technical solutions fulfilling the functional requirements set in invitation of tenders. Out of five offers, a solution that is based on the use of public networks and that satisfies the requirements was selected.

The responsible vendor for the solution based long term service is Emtele Ltd. specialised in machine-to-machine services.

Major components of the mobile wide band communication solution are:

Power Station communication

- Satellite end-to-end connections independent on national network infrastructure
- Flash OFDM 450 MHz (1 Mbps) or 3G depending on the network coverage
- Closed user groups with VPN, i.e. not possible to access from or to outside of the field communication network

Disconnector or Recloser Stations

- GPRS and 3G connections with VPN

SCADA connections

- Fiber

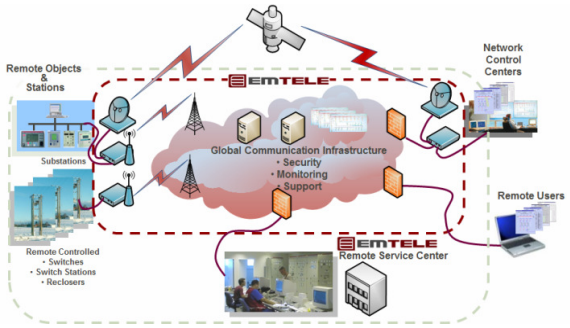

Figure 2: *Current Field Communication Network*

There were the following drivers for the selection of public network based communications instead of proprietary solutions:

- Cost efficiency
- Evolution
- Security

The economical efficiency that is behind manufacturing devices for public networks is much higher than for small amount of proprietary networks.

Major vendors (NSN, Ericsson, Huawei etc.) and standard organisations will keep the evolution ongoing in public networks. For example the next bigger technological step is in LTE (Long Term Evolution) that

has enough band width for even short response time applications. Vattenfall expects that LTE will be a major communication technology for Smart Grids and will scale in price and performance.

Security is one major reason to use generally known technology that includes high security requirements as itself and highly competent communication service provider.

BENEFITS OF THE FIELD COMMUNICATION NETWORK

Vattenfall has got the following benefits from the new field communication network solution:

- Shortening the black out times. With instant access to disconnectors and reclosers it is possible to quickly isolate fault area. Thus the overall quality of service improves considerably.
- It is estimated that with the direct and real-time connection (from Scada) to all the field assets reduces the amount of site visits. The saved amount of driving is 100 000 km per year, which means cost saving and CO2 savings.
- The real-time and wider bandwidth communication allows extract significantly more and faster data from substations, than ever before. This makes it possible to have far more efficient maintenance process (preventive maintenance, and avoidance of breakage).
- There is a lot of new infrastructure in the field, which was not previously used effectively, as there was not a wide band connection to the substation assets.
- With the solution the customer makes it's network Smart Grid enabled. The intelligent communication modules deployed at all levels of the network, makes the network flexible and the customer agile to future changes (eg. addition of micro-generation plants, demand-response systems etc.).
- Customer's communication infra had come to the end of life regarding maintenance, necessary capacity and reliability

CONCLUSIONS

Many international and domestic studies have proven that the role of ICT-systems in electricity distribution will increase towards the future. In addition, the level of automation in the distribution network will rise. One of the most crucial parts of the distribution automation concept is the field communications network. If the communication network is unreliable or insufficient, the benefits in automation are useless.

There are several issues that affect on the communication solution. For example, in what kind of geographical environment the distributions network is located? How wide is the distribution network? What kind of technical properties are required? Perhaps the most crucial question of all is about the reliability of the communication network in major disturbance situations. If there is a large electricity outage situation and it has lasted for several hours, how can we be sure that the communication is working to the field devices? All solutions relating the future communication network tries to pay regard to this dilemma. [1]

One of the requests that Vattenfall Nordic Distribution Networks Finland has is that the communication solution is offered with full service concept from external service provider. That is because the communication management is not the core business of Vattenfall Nordic Distribution Networks Finland.

During the field communication renewal project it was realized that two other projects are reasonable to be arrange simultaneously. The other projects are related to the both ends of the field communication network. The first project is to update the SCADA system to more efficient one. The second is about updating parts of the local automation systems in the substations. The updating of the substations is mandatory because the new system does not support the local automation concept in the substations.

REFERENCES

[1] Koivuniemi H., 2008, *Design Principles for Renewing the Communication Network of an Energy Company* Tampere University of Technology, Tampere, Finland