Study Committee D2

Information systems and Telecommunication

Paper 11052_2022

DESIGN OF A DARING IP NETWORK ARCHITECTURE IN REE FOR THE UNAVOIDABLE CONVERGENCE OF SERVICES

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Motivation

To correctly achieve its functions and responsibilities as Transmission and System Operator (TSO) in Spain, REE has developed a wide area telecommunication network based on its own facilities.

The Physical network is established mainly on Optical Ground Wire (OPGW) deployed in REE overhead lines. REE telecommunication network has about 30,000 fiber kilometers and around 800 Synchronous Digital Hierarchy (SDH) nodes in substations.

This network has derived to a mesh topology with impressive levels of reliability. Upon this optical layer, there is an SDH transmission layer, which supports respectively an IP layer based on routers and switches. These routing devices are interconnected by means of Ethernet over SDH, TDM links, or directly with fiber connections.

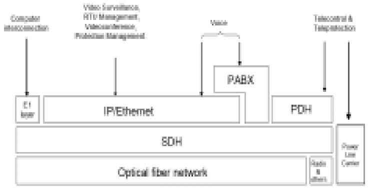
The scheme of the network is shown.

Objectives

- Establish a robust secure multiservice network
- Integrate old and new services.
- Deal with real-time issues.

Actual Service Model

The model of actual provisioned services is a mix of TDM and packet services that need to be integrated.



MPLS

- MPLS is a networking technology that routes traffic based on "labels" rather than network addresses, to handle forwarding over private wide area networks.
- Switching times and resources are lower than in an IP network because it is not necessary to re-evaluate the route at each intermediate point in the path.
- It is the chosen technology for the present deployment.

Provision

The services are to be integrated with three provision techniques:

- Virtual Private Wire Service (VPWS): Acts as a simple point-to-point connection between two nodes of the network, emulating an Ethernet connection or a TDM connection such as a E1 circuit.
- Virtual Private LAN Service (VPLS): It is a layer 2 multipoint service that is used to interconnect more than two locations. From the client's perspective, VPLS looks as though a LAN switch.
- Virtual Private Routed Network (VPRN) It is a layer 3 service which interconnect two or more locations.

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Proposed evolution

When facing a technology migration project, many challenges must be considered but overall, a deep strategic analysis as well as a rigorous risk assessment focused on both the technology chosen but also the current portfolio of the services and their future evolution.

The technology implemented should allow a smooth evolution from TDM services to IP services, considering that the network should be prepared to transport all the legacy interfaces and services based on switched circuits (TDM, SDH, PDH), as well as the IP traffic which will be the most representative soon. The network must be a powerful tool for the internal departments of the company therefore it shouldn't force any technology migration not included in the investment planification.

Deployment

In each substation, equipment is installed to provide connectivity to substation services. Design is to be made specifically for each substation.

As a general criterion, at least two devices are always considered inside a substation with a wide area coverage.

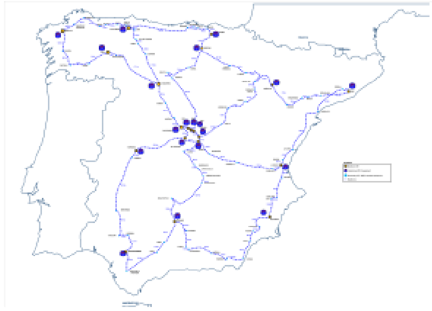
Overall Architecture

The overall architecture of this network can be described with a three-layer model:

- An access layer in each substation with local switches.
- A long-distance transport layer made with IP infrastructure.
- A distributed switching core.

The whole design criterion in this wide area network is an extrapolation of the N-1 Criterion established by the European Network of Transmission System Operators for Electricity (ENTSO-E) to the telecommunication world. The significance is that any breakdown in a single element must have no impact in the overall performance.

In the routing aspect, design was made in accordance with company organization, number of users and applications, and geographical distribution of facilities and operational areas. A simple hierarchical structure has been established, with a backbone and several subnets while keeping the number of the subnetworks as low and similar in size as possible.



When designing the topology of this IP network, the following guidelines and rules were employed:

1. Connection of every substation with at least two physical different paths;
2. Avoiding links with excessive traffic load;
3. Enhancing simplicity by making IP network reflect as much as possible the subjacent physical transmission network. Additional considerations, considering traffic patterns, were also employed. The overall physical architecture is shown in Figure.

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Services & Sychronization

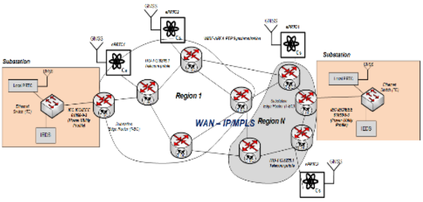
The new IP-MPLS network has been designed to transport and distribute frequency, phase and time synchronization from a synchronization clock hierarchy to substations.

The protocol uses in all nodes of the network for distributing accuracy time and frequency is IEEE 1588V2 Telecom profile as per ITU-T G.8275.1 “Full Timing Support”. This profile allows timing accuracy <1 microsecond with a high stability when the network links or nodes failure. This performance is suitable in the digital substation applications such as synchro phasors, Sampled Values and current differential line protection. The nodes of network also can convert the telecom profile to IEEE 61850-9-3 (Power Utility Profile) to provide time for the substation IEDs.

The clock hierarchy is composed by several ePRTC located at strategic places of the network. Several synchronization regions are created and each one is attended by two ePRTC. This type of clock provides a high level of accuracy (Accurate to within 30 ns or better to UTC provides by GNSS) and delivers a higher level of reliability to ensure the required time and frequency service performance for long periods regardless of the availability of GNSS.

Inside the substation, a backup Picture Transfer Protocol (PTP) system is being evaluated. This system, formed by a local Clock locked to GNSS and connected to LAN substation, is designed to provide precise time during disruptions on the WAN synchronization.

The REE synchronization architecture is shown in the following figure.



Conclusions

Introducing a new technology in a running company is not an easy task, and there are processes to consider when change is attempted.

Above all, lack of systematic planning must be averted, and implementation must be considered as a whole, avoiding parallel practices that could lead to a loss of clear approach.

The process of leaving well known technologies in which the activities are currently properly provided to the moment could sometimes generate concern while accommodating to partially unknown techniques.

Key points are:

- Clear objectives.
- Correct evaluation of efforts needed.
- Risk management strategy.
- Plan for reversing to the prior stage