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Challenges and Benefits of a Unified Synchronism Network
CASE CHESF

by

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SUMMARY

The next years are supposed to bring great challenges to the electric sector companies. Some factors will have important impact to telecommunications among these companies, such as:

- The presence of the Smart Grid;
- The remote control for the electro-energetic system;
- The diversification of the energetic matrix;
- Renewable Generation Plant
- The expansion of the electro-energetic system

During the last years there have been technological changes in the telecommunications. All the communication tends to be supported by an IP platform. The electro-energetic system is evolving to respond to the IEC 61850 standard, with local Ethernet Networks and communication protocols based on the IP. These factors command the necessity to have a new and careful multi-annual planning.

The creation of a Telecom Director Plan for Chesf, the largest generator of electricity of the Brazil, looks towards serving not only to the demand for the company's future services and internal application, but also to enable new converging telecommunications systems to escalate, become more available and secure, combining their necessities to the operating business, becoming even more competitive throughout the national electric scenario.

The Business Plan considered the transformation of the several systems in compliance with all requirements of Electric Sector and of the new services, including the Synchronism Network.

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A new synchronism network is projected, considering, besides the current clocks type SSU (Synchronization Supply Utility), the implementation of new clock distributors, in each locality, who will substitute the current GPS, responding to the new needs of the systems (particularly regarding the integrated management and the possibility to distribute synchronism in interfaces Ethernet, according to IEEE 1588 PTP standard, corresponding IEC 61850 standard, referring to the substations automation). Although the main function for the new system is to guarantee the telecommunication system's synchronism, it could also be used by other clients from the electro-energetic control system (including by de PMU measurers, by the line protection applications and differential protection, etc), substituting the various GPS that are often used by those customers.

This paper demonstrates a overview of the Telecom Director Plan with focus in the Unified Synchronism Network, operated by the telecommunications area, modern and appropriate to the needs of telecommunications (TL), information technology (TI) and operational of the electro-energetic sector. The main challenges and Benefits for implementation of this new Synchronism Network will also be presented, including functional structure of the company.

KEYWORDS

CONVERGENCE , OTN, IEEE 1588 PTP, SSU, GPS

1.0 - INTRODUCTION

In the Electric Power Generation and Transmission Enterprises, it's common to had the necessity of interconnecting all the substations, power plants and other dependencies, over a telecom system.

The area of telecommunications of Chesf is believed to have in its platform a level of Quality of Service (QoS) in compliance with the requirements of its electric operation, and with the Electric System National Operator (ONS). However, new administrative and operational applications request a greater capacity of bandwidth and better signal processing, which makes us need to plan ahead to design the expansion and transformation of this new platform, implementing new technological trends, expanding the backbone with the goal to enable it to this new generation of services, which are being demanded:

These demands command the necessity to have a new and careful multi-annual planning. The expansion of applications (remote presence, administrative video), the intense use of video cameras, supporting the electro-energetic system's operation and the unified communications with voice migration to the IP platform, would promote a drastic increase in demand for bandwidth. Also, as part of the equation, are increasing operation automation, and the consequent increase of reach and in the volume of the transported data.

The Telecommunication Director Plan considered the transformation of the several systems in compliance with all requirements of Electric Sector and of the new services demands.

Some systems are listed below:

- Transport Network
- Wide Area Network
- Synchronism
- Unified Communications
- Video Surveillance
- Wireless Network
- Security
- Quality of Service

The objective of the planning was to elaborate the guidelines for the upcoming years, regarding the expansion and modeling of Chesf's telecommunications system, considering the company's particular characteristics, in both aspects: its role as an enterprise, whose main goal is the generation and transmission of electric energy, as well as its importance and significance in the national context, its business structure and its development path, predicted for upcoming years.

2.0 PLANNING DEVELOPMENT

This chapter will present an overview of the Telecom Business Plan, with horizon 2018.

2.1 Basic Premises

Due to the critical significance of the information that flow through Chesf's telecommunications network, the main guiding criteria for all the planning was the need for total security and reliability in the telecommunications system.

Based in premises, a study of the existing networks at Chesf and the current and future services, was done, and led to a needs forecast, which guided the planning of objectives for the new communications network at Chesf. In parallel, a study about the prospective markets, studies of adopted solutions in similar companies in Brazil and abroad, studies of the available technologies and equipment, as well as proposed solutions by the various manufacturers and vendors, currently acting in Brazil, through consultations, studies of technical materials, and several meetings.

Based on these actions, it was designed the new communications network architecture of Chesf.

2.2 Transport Network

The new telecommunications transportation networks will utilize high capacity optical systems. In the high traffic regions, the transmission backbone will adopt the OTN (Optical Transport Network) technology, at 10 Gbit/s. This technology has the advantage to support long distances and high speeds, with no modification in the existing fibers and directly transports Gigabit Ethernet signals, besides transporting isochronic signals. For the lower traffic demand regions, the optical backbone will have a 2,5 Gbit/s. The IP charge will be transported through Carrier Ethernet services, over barring done with the NG-SDH (Next Generation SDH) techniques.

Considering these premises, the transportation platform was projected to provide the closing of the optical rings, covering several working areas of the company, creating an integrated system, with survival protection and offering integral services, even in the presence of simple failure in any part of the ring, responding to the propagation of information throughout them, even under different working conditions, as it may be observed by Figure 1.

For a high level protection, at the optical transport layer, the ring configuration allows for the implementation of a protection line, according to the MS-SPRing or ODU-SPRing protocols, preferably at four fibers. In the SDH trajectory layer, and even in the ODU trajectory layer, and additional protection according to the SNC-P model may be implemented. Regarding the transportation services of statistics signals (Ethernet), protections may be implemented, foreseeing an automatic recovery of the services, in tens of milliseconds, similar to the SDH protection, using the new functions of the Ethernet layer. Naturally, the normal router topology protections, including the fast protections in the range of tens of milliseconds, will also be implemented.

FIGURE 1 - Transport Network

2.3 Long Distance Network

In order to respond to news needs, it's proposed to develop Chesf's long distance data network, utilizing the *Metro/Carrier Ethernet* technology, with larger band width characteristics, and capacity to provide this width in flexible increments, and an excellent support for voice, video and data. This technology also presents low implementation costs, operation facility and advanced quality service resources (QoS), protection and security, becoming simpler and more efficient.

The projected network is expected to extend the Ethernet standard to the long reach metropolitan networks, using a flatter network topology, with the use of more intense of level 2 networks (Bridged Ethernet), allowing the reduction of latency and costs. This network consists on a Multiservice Platform, based on Metro Ethernet technology, combined with IP/MPLS with TE (traffic engineering), divided in 3 layers (Aggregation, Distribution and Access).

The Service Nucleus located in the COS (System Operation Center) represents the core, who's interlinked to the distribution layer, constituted by the regional management, responsible for the concentration and orientation of all the traffic generated by the two network presence points. In every regional management, it's predicted the implementation of 2 (two) switches type Carrier Class, in order to offer total redundancy of the concentration of the access rings, in each regional and charge balance. Each access ring should be initiated by one of the switches, and should have its end in another equipment. The switches interconnection core topology between the regional, is in a ring, due to the use of transmission and resilience resources' optimization, inherent to the Ethernet networks, configured in this topology. For this layer, it's proposed the use of the MPLS (Multi Protocol Label Switching) technology, looking for better protection resources, QoS, service provision, among other options offered by this technology.

2.4 Video Surveillance

The new video surveillance system will serve two important purposes:

- ✓ Provide patrimonial and telecommunications control rooms' security, with the installation of surveillance cameras in all the Chesf's localities, complying with the most recent criteria of quality, storage policy, safety and dada transfer;
- ✓ Respond to the electro-energetic system controlling necessities, with the installation of cameras who allow the operators to visually confirm, remotely, the way commands emitted by the electric dispositive are behaving throughout the control system (similar to the way real sectional keys and protection dispositive work).

The System Operation Center is responsible for managing all the system, and will have total hardware redundancy, guaranteeing the required trust.
It is predicted to have integration between the video surveillance with the electric system's operation, named *SAGE*, responsible for the supervision and control of the electric network.

Studies indicate the need to acquire around six thousand cameras and *codecs*, besides dispositives for recording, also furnishing video surveillance subsystem operation rooms with equipment, integrating the SAGE with all the distributed managing system.

2.5 Synchronism Network

The design of a current synchronism network for a power company must use a global focus synchronism in order to build a hierarchical network synchronism that meets the needs of telecommunications, control and others, which may provide one reliable service, managed and universal of frequency and time. This network must optimize resources and should be an infrastructure present in all operational areas of the Company.

In the next chapters will be covered in detail the new network synchronism designed.

3.0 - CONSIDERATIONS OF SINCRONISM PROJECT

The traditional form of synchronization of frequency of networks is to install primary reference nodes and distribute the reference frequency from these nodes using their own telecommunications network. The primary nodes are performed with the use of GPS (Global Positioning System) - getting your referral network of global positioning satellites - and primary atomic clocks (cesium, aided by rubidium oscillators).

On the other hand, currently, not enough syncronize in frequency the network elements of telephony, PDH and SDH, it is also necessary to have a service syncronism time (ToD, Time of Day), which must be supplied by a hierarchical network referenced the primary clocks and that provide time stamps precise and accurate for IP-based services. This need becomes more critical as new applications, such as the synchronization process management, distributed processes, billing, routing decisions and many others are increasing in scope and importance.

The traditional syncronism phase and time (ToD or Time of Day) follows a hierarchical scheme similar - mains sites, distribution of reference between sites and distribution intra-building. In the electricity sector, it is usual that the services that require this type of syncronism had on dedicated GPS receivers connected to distributors in each site, which leads to a variety of devices that are not always managed remotely. And the distribution interfaces only meet current standards (mainly IRIG-B) required by the control devices and automation.

This scenario should now be treated systemically. With the advent of optical networks (OTN standard, which has not wrap synchronous) and direct transport of Ethernet signals, set up the need to use Ethernet to distribute time and frequency references as between sites (WAN) as within of site itself (for LAN). The new recommendations of the ITU-T describes an alternative that consist in to create a new interface Synchronous Ethernet (Sync Ethernet), in which the line signal is encapsulated in a wrapper synchronous that allows transference exact oh the information of frequency, and a second alternative which consists in transporting time stamps high precision by Ethernet (also described in IEEE 1588v2, PTP precision time Protocol). Is worth mentioning that accurate time stamps from the PTP allows the recovery of not just syncronism exact of phase as well as frequency, and therefore the method described in IEEE 1588v2 also allows frequency remote synchronization for several areas.

For the transparent transport of highly accurate time stamps that allow the transport of information of syncronism of frequency and time (phase) described in the new syncronism transportation methods, OTN networks are equally transparent and appropriate. The networks based in switches level 2 (Ethernet switches) need to be planned appropriately to allow the passage of time stamps without harming informations of syncronism of phase and frequency, even if the intermediate nodes do not participate in the process (see Recommendation G.8265 and ITU-T G.8265.1, for example).

In the electricity sector, the problem must also consider the specificity of the sector, particularly with respect to implementation of the IEC 61850 standard across the network. A syncronism modern structure, therefore, must be equipped to attend the criteria of distribution of timing information (frequency synchronization) and exact time (time stamps distribution).

4.0 – DESIGN OF SINCRONISM SYSTEM OF CHESF TELECOM DIRECTOR PLAN

The first consideration in the design is that the synchronism system must be as robust as possible, since all systems depend on information of phase and frequency correct and high availability for its correct working. To ensure this premise, the project must involve multiple redundancies and clock distribution devices for high availability.

The second consideration is that in the project should be included the needs of the telecommunications system, since the main client and most urgent of the new synchronism system are their own telecommunications. However, the system must be prepared and able to provide the information of time and frequency also for the electric devices of power system. Adopting an Synchronism Unified Network across the network, there will be a high availability of exact syncronism with all formats and interfaces that eventually can come to require all subsystems, as of telecommunications (2 MHz, 2 Mbit/s and PTP IEEE 1588v2 Telecom Profile), as TI (NTPv4, Network Time Protocol) as of the electro-energetic control system (currently, particularly in the format IRIG-B and, in the future, in the format PTT IEEE 1588v2 Power Profile).

4.1 Description of the Architecture of the Synchronism Network

The synchronism network consists of network elements responsible for distributing the clock at each site (intra-site synchronism) and a system for the distribution of references among network sites (intersite synchronism).

For intra-site system will be adopted distributors clock (Substation Clock) with carrier class hardware (duplicate sources, duplicate oscillators without single point of failure) with output interfaces sized according to the customers present in the site (PTP, IRIG-B, 2Mbit / s, NTP and 2MHz). Must be provide availability appropriate interfaces for controlling network elements of the electric power system, for the case of the integration of all clients of syncronism in the same network infrastructure. In case of multiple LAN segments within the site, the standard IEC 61850 provides for the installation of master clock PTP duplicate.

The main distributor of synchronism, working as Grandmaster Clocks, at each site, must be equipped with a GPS (Global Positioning System) and that takes as its primary reference clock. In this case, the GPS system, consisting of a set of satellites with atomic primary clocks with high precision directly traceable to the world standard of time, provides a direct reference to local distributors. However, in the event of a failure in the local GPS, the system must previse availability of external references reliable. As new networks tend to be packet networks, the method indicated is to get the reference by site neighbors, using the protocol IEEE 1588v2 Telecom Profile, carried by the transmission network and available inEthernet interfaces, and in this case the distribuitor shall operate as Boundary Clocks. Soon, the line signals received are alternative references for each site.

Therefore, in this project each site has a GPS receiver that takes as main reference and can consist in alternative reference to sites adjacent to which are connected by the transmission of any type that transports Ethernet signals (OTN, SDH, PTN, Ethernet physical on fiber, microwave, etc.).

The case of total failure of the GPS system is foreseen in the system. The project will provide a network of clock distribution from two different points of the network. In case of GPS system breakdown, or there is a position to leave the GPS reference for strategic reasons, these two central points are to serve as the main reference and alternative to the entire network.

In the latter case, to ensure that the quality of the clock signal arriving at any point in the network has the quality and stability and resiliency necessary, will be need to design the network of clock distribution traditionally, ie using SSUs distributed, with rubidium clocks or quartz in thermal camera double. The SSUs have two functions. The first is retime the references received from distant points, to eliminate the effects introduced by the transmission. The second is to provide an exact syncronism when, a failure in the transmission, not receive an external reference. The architectural design of the network inter-site shall include the respective norms and standards, as well as the maximum number of hops in the cascade distribution until the next SSU regarding definition of oscillators each SSU. Finally, it is noteworthy that the SSUs are synchronized from GPS receivers (main reference) and line signals (whose type is chosen according to availability) and should provide syncronism signals of the type IEEE 1588v2 PTP Telecom Profile for distributors of sites that do not have SSUs.

Finally, the two main sites that will assume the syncronism of the entire network should be installed in geographic redundancy. Can have atomic clocks (Cesium primary clocks in comply with Recommendation ITU-T G.811) to get total independence from any other synchronism system.

The network should receive syncronism signals alternative of quality from other sources, such as public carrier that have, themselves, reliable syncronism systems and that can deliver signals of quality appropriate to the power company.

The basic architecture designed for CHESF synchronism network is illustrated in Figure 1.

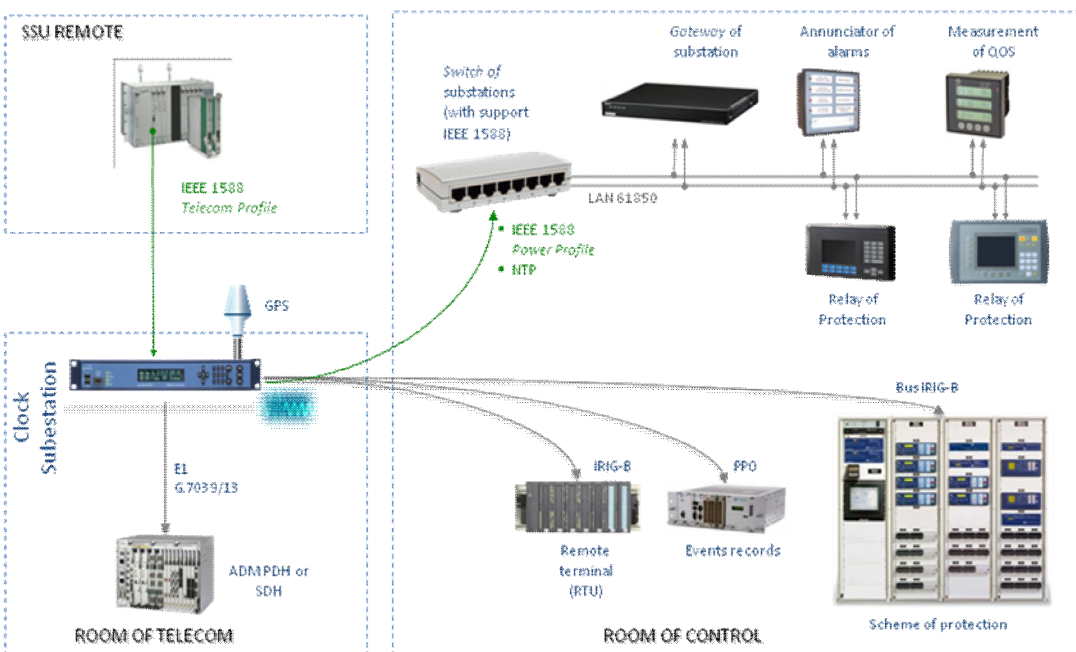

FIGURE 2 – Recommended architecture for the synchronism system

4.2 Considerations about Syncronism of Electric Power System

The synchronism of the electric power system will serve the need of activities such as:

- Management of the frequency of the grid;
- Computer of control center and remote terminals (RTUs);
- Measurement of quality of supply;
- Measurement of energy (different rates);
- Phasor Measurement (PMU) synchronized in time (synchrophasors);
- Troubleshooting for wave propagation (traveling waves);
- Monitoring rays;
- Units junction (sample values).

For option of timing distribution to the electric power system, the profile IEEE 1588v2 Power Profile (IEEE C37.238) is adequate. Emphasizes the need to specify clock distributors that meet not only the needs of telecommunications devices as well as the electric power system devices in order to allow the existence of a unified synchronism system in the future.

4.3 Syncronism for Cabana of Relays

The function of generation of IRIG-B signals by substation clock to attend the legacy control devices located in Cabana of Relays can be performed directly by the IRIG-B optical or electrical signal of local distributor or alternatively by equipment that generates IRIG-B signals from timestamps PTP Power Profile and that distribute the IRIG-B signal recovered, as industrial switches.

4.4Platform Management

The synchronism system must be equipped with an integrated management system for the whole platform with redundant servers to be sure that the synchronism system is constantly available and reliable, based on the new requirements assigned to the operation of electric power system and administrative management of the Company.

5.0 BUSINESS CHALLENGES

The implementation of this solution designed has many challenges to overcome, such as the functional structure of the company that owns the telecommunications and control area, protection and systems engineering area and the area of information technology on three separate directors which makes it very difficult the convergence of a unified syncronism solution, mainly, due to the modus operandis to be implemented.

In second place with the publication of the Provisional Measure No. 579/12 by the government, subsequently converted into Law No. 12.783/13, which authorized the extension of concessions for over 30 years, reducing energy tariffs that were being overcome, causing immediately the reduction of budget resources of the company, considering the reduction in revenue coming from the measure.
As a guideline of the Eletrobras Group, companies, among them CHESF, need reduce 30% their operating costs to maintain financial balance and generate profits for its shareholders, however, this measure may be an opportunity for the telecommunications group enable this project considering the benefits of a unified network synchronism.

6.0 - BENEFITS

The new synchronism network is based on providing greater reliability to the current synchronism system in operation in the company by setting up a solid, robust, managed and of high availability as well as create an infrastructure of synchronism that can be utilized by other areas of the company (Electric Power and Information Technology Sectors).

Adopting an Unified Synchronism Network across the network, in addition to the obvious advantages of having a managed network and high quality to suply all the needs of time and frequency, there will be a high availability of exact synchronism with all formats and interfaces that eventually can to require all subsystems, as of telecommunications (2 MHz, 2 Mbit/s and PTP IEEE 1588v2 Telecom Profile), as TI (NTPv4, Network Time Protocol) as of the electro-energetic control system (currently, particularly in the format IRIG-B and, in the future, in the format PTT IEEE 1588v2 Power Profile), can provide synchronism the various subsystems with reduction of investments

7.0 - CONCLUSION

The creation of a Telecommunications Director Plan for Chesf looks towards serving not only to the demand for the company's future services and internal application, but also to enable new converging telecommunications systems to escalate, become more available and secure, combining their necessities to the operating business, becoming even more competitive throughout the national electric scenario.

Due to the need of telecommunications of an syncronism integrated network to work correctly, it is suggested that the synchronism network operated by telecommunications can also be used, with clear advantages for other sectors of the company, and be prepared to attend the new requirements imposed by the standard IEC 61850, by measuring PMU and synchrophasors, by the transducer of interfaces, by automation of the electric power system and other functions of control of the system, with optimization of investment, improvements in the operation and sharing maintenance of the network, and consequent cost reduction .

8.0 - BIBLIOGRAPHY

[1] Planejamento Estratégico Eletrobras 2010-2020. Eletrobras. Rio de Janeiro/RJ. 2009.
[2] Planejamento Empresarial Chesf 2010-2015. Chesf. Recife/PE. 2010.
[3] Several Recommendations and Technical Standards of ITU-T, IEEE, MEF, ITEF and various information into internet and with vendors.
[4] Plano Diretor de Telecomunicações Chesf com Horizonte 2018. Chesf. Recife/PE. 2011.

9.0 - BIOGRAPHIC INFORMATION

Rodrigo Leal de Siqueira was born in Recife in 1977, graduated in Electronic Engineering at the Federal University of Pernambuco (UFPE) in 2000. Received his Masters in Electronic Engineering, with concentration in Telecommunications in 2004, at the same institution. Received an MBA in Projects Management by the *Fundação Getúlio Vargas*, in 2009 and since 2006, has been an Engineer at the Telecommunications Systems Expansion sector, at CHESF. During the period of 2000-2006 he was Projects Manager for a Consulting Firm. Published a technical paper at the IEEE Vehicular Technology Conference 2006 in Melbourne, Australia. Published e participated in several other national and international events.