Study Committee 35

Secretary
M Monti – EDF RTE
92068 Paris La Défense Cedex 48
FRANCE

2001 Colloquium
5 June
Zagreb
CROATIA

SC35-A-03

POWER SYSTEM NETWORK MANAGEMENT USING TELECOM STANDARDS

by
J.I. Escudero*, S. Díaz, M.C. Romero, F. Pérez
Universidad de Sevilla

(Spain)

1. INTRODUCTION AND OBJECTIVES.

Our main objective in this paper is to suggest a brand new approach to carry out power systems network management, consisting in the adoption of well-established telecom management standards. Although originally developed for this specific environment, we find they are becoming suitable for the non-standardized power systems area, taking into account current trends in this field. Telecom standards provide interconnectivity among hardware devices and interoperability among software applications by means of defining a set of rules to follow for modeling, structuring and accessing management information.

In section 2, we discuss about singularities of both telecom and power systems environments, focusing on the convergence that is taking place between them, according to current trends. Section 3, focusing on ITU-T TMN telecom standard, proposes a mapping from legacy SCADA/EMS physical and functional components to TMN architectural model and management layers. Comments about gradual migration from legacy SCADA/EMS to TMN standard are provided in section 4. Conclusions from the authors are collected in section 5.

2. NETWORK MANAGEMENT IN TELECOM AND POWER SYSTEMS AREAS.

In telecom area, the equipment to manage is very diverse, with many different technologies and vendors in the market. Communication lines in telecom networks are usually fast, typically in the Mbps range. This characteristics lead to open solutions for network management, that allow interconnectivity and interoperability among those different elements – no matter if the protocols used for this purpose are not especially lightweight. These solutions are characterized by basically defining the following:

* Dpto. Tecnología Electrónica (Facultad de Informática). Avda. Reina Mercedes, s/n. 41012 SEVILLA.
Fax: + 34 95 455 2788 e-mail: ignacio@cica.es

- physical and functional architectures,
- a management information model, and
- a protocol for information interchange.

In this framework, we find two widely deployed standards: SNMP and TMN. SNMP (*Simple Network Management Protocol*) is an IETF standard frequently used in computer network management applications, albeit it is considered a simple, short-term solution in telecom management. On the other hand, TMN (*Telecommunications Management Network*) presents a more elaborated, object-oriented framework, developed by the ITU-T over existing ISO standards. For the purposes of this paper, we choose TMN as target telecom standard to develop next sections, because of its more advanced modeling capabilities and structuring degree.

The solution traditionally adopted for network management in power systems is based on the deployment of SCADA (*Supervisory Control And Data Acquisition*) systems, supporting EMS (*Energy Management Systems*) functions. Conceptually, there is no significant difference between telecom and power systems networks, but, under historic perspective, details related to their specific characteristics lead to different solutions. In particular, power systems equipment was not as diverse as in telecom, so openness was not so important. On the other hand, power systems have been using slow communication lines, such as power line carriers (PLC) and radio-relays, for network management. Delays are critical in alarm notification, so protocols became lightweight and efficient to face low transmission rates, but they also got unlayered and, very frequently, proprietary. Effort is being applied to structure and standardize these protocols, aimed to make interconnectivity possible: IEC 60850, IEC 60870-x, EPA, etc. Nevertheless, no standard management information model has been defined, nor even proposed, so interoperability depends on the effort applied in a particular implementation. These difficulties are alleviated by the introduction of state-of-the-art development tools in the market, which simplifies the implementation of a specific solution.

Nowadays, current trends in power systems lead to intelligent RTUs (Remote Terminal Units) which can support broader functionality. This implies more diversity among them, as in telecom case, so openness starts to become a necessity. However, they also can support more workload and, because of it, we think they can cope with the extra work associated to heavier protocols, such as TMN CMIP or SNMP, for the communication with control centers. On the other hand, new physical media (e.g. “wrapped cable”) connecting RTUs and control centers, offer greater communication capabilities, being able to afford the not so efficient but more flexible protocols involved in telecom management, mentioned above. Network management platform and advanced tools exists in the market for telecom, so implementation of power systems network managers should be fairly possible in practice.

3. MAPPING FROM SCADA/EMS COMPONENTS TO TMN ENVIRONMENT.

In this section, we deal with physical architecture mapping, functional architecture mapping and TMN management information model in the next paragraphs.

SCADA/EMS hierarchical architecture fits into “manager of managers” TMN physical model, as shown on figure 1. New TMN-compliant RTUs would manage their respective power network elements, as in legacy SCADA systems, but they would include a software component, named *agent*. The agent maintains management information related to its managed elements, following TMN rules. Since every agent follows the same rules, interoperability is guaranteed among individual information models. This information is structured as a tree, being each node a *managed object*. These objects represent physical or logical network resources. An agent uses CMIP standard protocol for communication purposes, so interconnectivity is guaranteed. RTUs are connected to the control center(s) by means of a *data communications network* (DCN). The

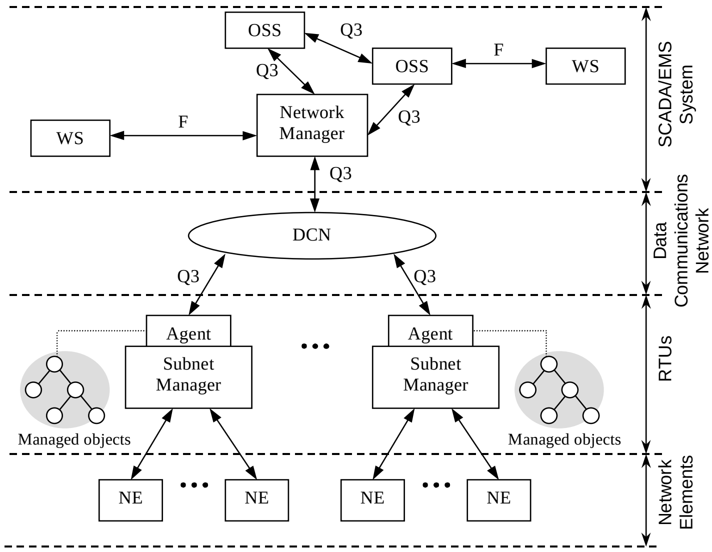

Figure 1. Physical architecture of a TMN-compliant power system management environment.

control center acts as *network manager*, while the intelligent RTUs play the role of *subnet managers*. This network manager has a view of the whole system to manage, so each software management application, implementing SCADA/EMS functions, talks to it to operate the network. In TMN terminology, such management software is named OSS (*Operational Support System*). *Workstations* (WS) are used by operators to monitor, coordinate and control the power system. Different types of *interfaces* have been defined in TMN for the interconnection of the different physical components. The most commonly used is Q3, except for workstations, which need F interfaces.

Power systems management functions can be placed on TMN *management layers*, according to its level of abstraction, as shown in figure 2. In short, lower layers focus on the network itself, while upper ones deal with the services offered and enterprise policies. From another perspective, any function can be located in a *functional area*, according to its purpose: *Fault, Configuration*, *Accounting*, *Performance* and *Security* (*FCAPS functions*). For example, automatic generation control (AGC) function is in configuration area, at service management layer. Although functions may be located at different coordinates in this space, some kind of interaction among them is necessary. Following previous example, AGC depends on economic dispatch enterprise policies, which can be placed on accounting area, at business layer. On the other hand, AGC configuration commands are issued to the SCADA control function counterpart in TMN, located just below AGC, in configuration area, at network layer.

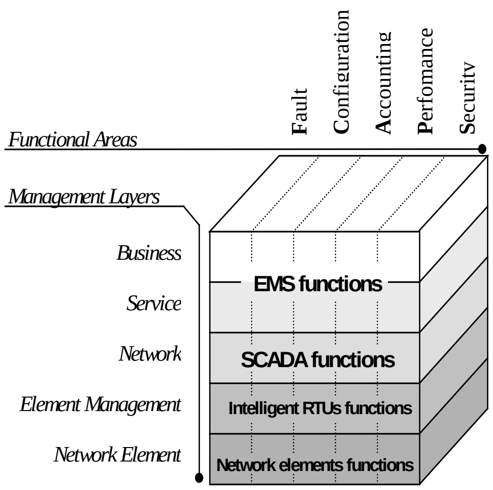

Figure 2. SCADA/EMS functions and TMN management layers.

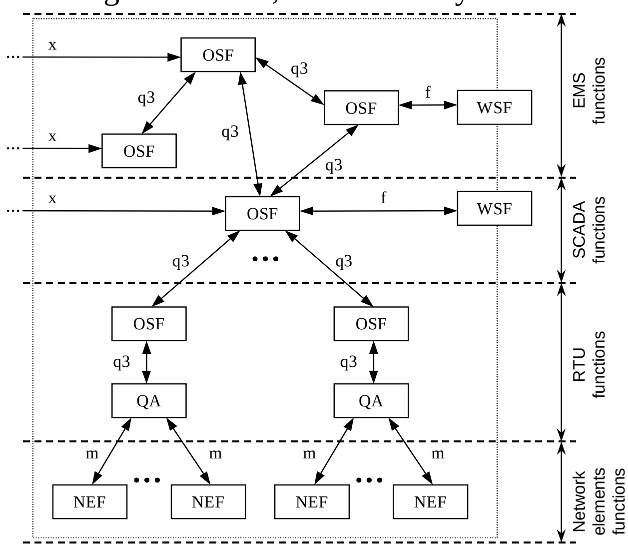

Figure 3. Functional architecture.

This discussion about functional areas and management layer leads us to consider the functional architecture, which shows the functional components involved and the interactions existing among them. In this case, each functional area presents the architecture shown in figure 3.

Note the similarity between physical and functional architecture. Different EMS functions belonging to the same area are represented as separate OSF (*Operation Systems Function*) components. Some of these interact directly with operators, by means of a WSF (*WorkStation Function*). OSFs from EMS layer operate over a consolidated view of the network provided by a network-level OSF, which merges individual RTU domains, inside the functional area we are dealing with. In turn, OSFs implemented in RTUs merge their associated NEFs (*Network Element Function*). Since network elements do not belong to the TMN environment, some kind of translation is needed. This translation is supported by means of QAs (*Q Adapter*). Interactions between components are specified in TMN as *reference points*, logical counterparts of physical interfaces. In particular, x reference points conduct the interaction between OSFs belonging to different functional areas.

TMN management information model is fully imported from ISO standards, which impose an object-oriented paradigm for this purpose. Then, every physical or logical resource is represented as a *managed object*. Relations among objects give rise to a hierarchical, tree-shaped architecture, known as the *containment tree*. Figure 4 shows a containment tree example, including the root node, representing the whole network, the RTU objects and the network element objects. The definition of this tree is placed on a MIB (*Management Information Base*) module, written following standard GDMO (*Guidelines for the Definition of Managed Object*) rules. MIB modules are implemented in agents; actual object instances are maintained in their so-called *MIB caches*. Several types of operations can be applied to managed objects, such as: create/delete object instances, get/set attribute values and invoke object class-specific actions. These are CMIS (*Common Management Information Service*) operations, requested through CMIP (*Common Management Information Protocol*) messages, which work at the application layer in an OSI protocol stack. Also, a managed object can issue notifications when abnormal conditions occur. This framework does add value to RTU-control center interaction in power systems environment, by adopting a standard protocol, which operates over a standard, high-level information model, and thus avoiding the use of proprietary protocols, aimed to deal with low-level data directly. This low-level interaction only remains among RTUs and their respective network elements.

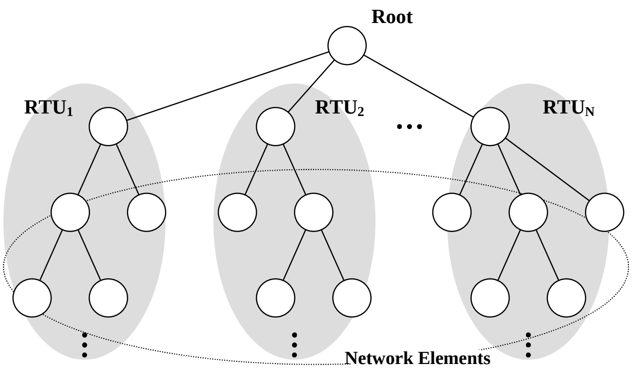

Figure 4. A containment tree simple example for power systems.

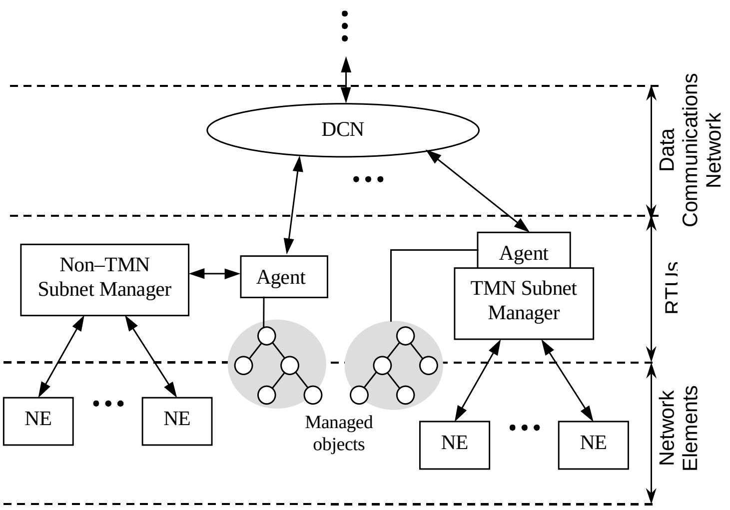

Figure 5. Integrating legacy equipment.

4. MIGRATING TO TMN.

Migration from legacy power systems to TMN should be possible in a gradual manner, because of course it is impossible to replace the SCADA system and all the RTUs with TMN systems in one go. Even when deploying new power systems using TMN as management environment, one could face the problem of what to do with legacy equipment whose TMN-managed counterpart is not yet developed.

If we have a legacy RTU that we want to integrate in a TMN environment, all we have to do is develop an agent for it on our own. This agent will be similar to the one embedded in a TMN-compliant RTU, because it will implement the same Q-adapter function, but it will be deployed in a separate hardware module, as shown on figure 4. Tools for agent development exists in the market, so the hardest work will be the implementation of the communications between the legacy RTU and the agent module.

5. CONCLUSIONS.

Power systems lack a standard whose scope spans the whole management framework. Current standards only deal with communication protocols, proposing some reference models and architectures. Implementations exist, but not yet widely deployed. Anyway, a long way remains for the complete standardization of this sector. So we think it would be more appropriate to adopt a well-known telecom standard, such as TMN, than to develop a brand new one. Recent advances in power communication lines and remote terminal units could support this solution.

In short, the benefits involved by the borrowing of TMN in power systems sector are the following:

- Interconnectivity. This is guaranteed by the standard CMIP protocol. No matter which vendor provides the hardware or software, they can talk to each other.
- Interoperability. Management information is defined following standard GDMO rules and accessed through standard CMIS operations. Then, consistency exists among individual subnet information models, maintained in RTU agents, so they can be effortlessly aggregated to obtain a consolidated view of the whole power system.
- Existence and proliferation of state-of-the-art, TMN-compliant management platforms and development tools in the market.

Hence, integration of diverse equipment is straightforward, provided that they are TMN-compliant. This eliminates every difficulty encountered when enlarging networks or replacing old equipment in legacy power systems.

Nevertheless, the solution we propose here does need fast communication lines and certain computational power in RTUs. On the other hand, the proposal developed here has not yet applied, but the large experience acquired in telecom networks is available to be inherited by power systems.

A. REFERENCES.

[1] G. Chen and Q. Kong, *Integrated Telecommunications Management Solutions* (New York: IEEE Press, 2000).
[2] IEEE Power Engineering Society. *IEEE Tutorial Course: Fundamentals Of Supervisory Systems* (New York: IEEE Press, 1995).
[3] Escudero, J.I. La calidad de las medidas en los sistemas distribuidos. Aplicación a las redes eléctricas. *PhD thesis, University of Sevilla*, 1995.
[4] Working Group 35.13. Telecontrol Protocols And The Importance Of Testing Protocol Implementations Against The Standards. *Électra*, no. 188, 2000, 89-100.