INTEGRATED INFORMATION ARCHITECTURE FOR THE OPERATION OF ELECTRIC MARKETS

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BACKGROUND

Utility deregulation, restructuring and privatization started in Chile and the United Kingdom in mid and late 1980s, and have become the major driving force in the electric energy sector worldwide. In the United States, the major milestones of this process include the Energy Policy Act (FERC, 1992) and the FERC rulings 888 and 889. In Europe, there has been the Directive 96/92/EC of the European parliament and of the Council of 19 December 1996 concerning the common rules for the internal market in electricity. And every single Latin American country has already issued its own electricity law.

Known under names such as Ley Marco, Ley Eléctrica, Grid Code, Commercial Code, etc., these rules and regulations signal the end of the vertically integrated utility, which has been replaced by generation companies, transmission companies, and distribution companies. A variety of new players have also joined the scene, including power marketers, independent power producers, co-generators, transmission administrators, wholesale and retail market administrators, etc. The entire process is supervised and regulated by regulatory bodies.

In virtually all cases, the restructuring involved both functional disaggregation and the unbundling of services. At least in theory, capacity, energy, reactive power, voltage, frequency, reserves, and regulation capability can now be acquired and priced separately. In addition, transmission operators were required to provide non-discriminatory open access to all suppliers and consumers without consideration of ownership.

An important change took place in operations, where market or trading functions have been separated from the transmission system dispatch functions. The “power system” became an *electric market,* and what used to be called “power system operations” was replaced by the:

- operation of a *power market,* or simply *market,* in which
  - buyers and sellers can participate
  - energy-capacity-transmission transactions between market agents are specified in bilateral contracts or negotiated on the spot market -- in some cases, the size of the spot is regulated to a certain percentage of the market, at least on a interim basis

  - total hourly supply and demand are matched in *merit order*, i.e., by selecting the lowest cost suppliers in sequence until the demand is met
  - market clearing prices are established
  - extensive amounts of information are handled for operational, commercial and auditing purposes
- dispatching of the transmission system, which includes
  - operating the system in real time
  - maintaining the security and integrity of the transmission networks
  - handling congestion if bottlenecks exist

Markets for ancillary services also have appeared and encompass regulation, reactive power, losses, and reserves.

The type, extent and jurisdiction of real-time, same-time, on-line and off-line data and applications required to operate an electric market vary significantly from case to case. As a result, there is no standard information processing solution to support such needs, and each situation needs to be assessed individually.

Nevertheless, an integrated information architecture has been identified which can accommodate both the transmission system dispatch and the market operation. The proposed approach is recommended for small to medium scale electric markets that encompass only one transmission administrator, and where an Independent System Operator (ISO), as it was implemented in the past, may not be economically justifiable.

PREEXISTING CONDITIONS AND RESTRICTIONS

At the outset, a number of preexisting conditions and restrictions need to be recognized:

1. There currently exist many control centers that
   - are critical for power system operations
   - control and monitor the national, regional and/or international interconnections
   - encompass functionality varying from simple SCADA to AGC to a complete range of EMS applications
2. Many of the existing SCADA/EMS installations require immediate upgrading – this process is complex and
   - entails extensive hardware, software and communications replacements and additions
   - requires large implementation schedules

  - ✓ since the operation of an electric market needs to begin as soon as it is enacted, even if, initially, on an interim basis, the market-specific functionality must become available at an early date and, therefore, should not be linked to, or conditioned upon upgrading the existing SCADA/EMS

3. The functions needed to operate a power market lead to specialized applications which, at least at this point in time, are not supported by existing standard, off-the-shelf SCADA/EMS packages

4. The new functionality assigned by law to certain wholesale or retail market administrators overlaps the transmission system dispatch responsibilities and is predicated on the ability to:

   - collect and process real-time data – the immediate example that comes to mind is the responsibility to monitor and maintain the security and integrity of the transmission system which, in turn, requires the ability to collect or, at least, access real-time data, and to perform real-time and study mode network analysis functions

   - send control signals and receive confirmation of control actions – this is the case of market administrators that are responsible for performing AGC and Economic Dispatch

5. The overlapping of functions between the market operation and the transmission system dispatch does not necessarily mean that the same functionality should be implemented on two physically distinct systems. This is because of the need to avoid duplication of resources while maintaining information consistency for subsequent audit and analysis purposes

6. The dispatching of the transmission system, on the one hand, and the operation of the electric market, on the other:

   - are separated -- legally and administratively

   - interact -- physically

     - ✓ the electrical networks are "still" governed by the Kirchhoff theorems ...

   - require extensive exchange of information

7. Most of the national electric markets evolve towards future regional and/or international integration

8. The future, of course, is unpredictable…

MAIN THEME

From a legal, organizational and jurisdictional point of view, the market operation and the system dispatching of an electric market, where, by definition, the power market and the transmission system are separated, are performed via a:

- *Market (Commercial) Operator* – either as a stand-alone business entity, typically known as a wholesale or retail market administrator, or as an operational unit within a larger organization, or perhaps in other business configuration

- *System Operator* – either assigned to a transmission administrator or operating within the same parent organization that handles the market

It is precisely the "system operator" functionality that may cause confusion. In large geographical areas, e.g., in the United States, power pools have evolved into ISOs, whereas the transmission companies (after divesting the generation and distribution) retained their functionality for supervision and remotely controlling their networks. In smaller geographical areas, however, it is quite common for "market operators" to be responsible for both market functions and some limited SCADA/EMS functionality, e.g., AGC, Economic Dispatch, and Network Analysis.

In the later case, the question arises whether it is justifiable to implement two SCADA/EMS solutions – one for the Market Operator, and one for the System Operator. From an implementation point of view, it is both possible and advisable to provide *integrated* information processing support to all the:

- functions that typically belong to the operation of the market
- generation control functions, including automatic generation control and economic dispatch
- network security functions that overlap between market operation and transmission system dispatch
- transmission system dispatch functions, including system monitoring and supervisory control

It is important to re-emphasize that this integration:

- does not affect in any way the institutional separation between the electricity sector players, i.e., the regulatory body, on the one hand, and the market agents, on the other
- does not impact the market structuring into generation, transmission and distribution companies and, in some places, an independent dispatching organization and/or a wholesale or retail market administrator
- refers only to the implementation level of the information resources used by the operators of the transmission system and, respectively, the power market

SCOPE OF INTEGRATED FUNCTIONALITY

SCADA/EMS Functionality Highlights

Traditionally, the transmission system dispatch is responsible for switching operations and generation control, monitoring and maintaining the security and integrity of the transmission network, collecting and structuring historical information, and performing operations support studies.

Accordingly, the SCADA/EMS functionality should include, in addition to real-time data collection, network supervision and supervisory control:

- facilities to define and reconfigure *areas of responsibility*, either locally or on remote consoles -- this makes it possible for the same SCADA/EMS to be accessed, without jurisdictional conflict, by operators reporting to several business units, and even to entirely different organizations
- AGC and Economic Dispatch
- real-time and study mode network analysis
- support for standard communications protocols such as IEC 870-5-101 and ICCP
- information storage and retrieval, also known as Historical Information System (HIS)
- Dispatcher Training Simulator, perhaps configured such that it could be used as a backup control center

And, of course, SCADA/EMS facilities should be designed in accordance with state-of-the-art openness, performance, availability and expandability criteria

Market System Functionality Highlights

In a broad sense, the operation of the power market encompasses MW/MWh transactions, optimum dispatching strategies, overall system security and integrity, settlements and market information.

In the proposed information processing architecture, the Market System and the SCADA/EMS are physically separated, but do exchange extensive amounts of data. The separation of these systems is required by the rules of the electric market, enhances the information security, and provides flexibility to migrate, if needed, to totally disjoint information architectures.

Just like a SCADA/EMS, a Market System performs real-time, same-time, on-line and off-line information processing, but its functional scope is quite different and includes:

- managing the trading activity, i.e., handling demand and energy transactions, including
  - offers from generation companies and power marketers
  - requests from distribution companies and other qualified consumers
- processing such demand and energy transactions to schedule the output of the generating units of the market agents in an economical manner – this particular functionality is explicitly specified in many electricity laws, but it is unclear, at this point in time, to what extent it would be applicable on a regional and/or international scale
- setting energy and demand prices
- monitoring and controlling commercial meters
- providing a broad array of market information management and energy accounting services to the market agents

Proposed Information Architecture

The proposed integrated information architecture that supports both the market operation and the transmission system dispatch is shown in Figure 1. This model:

- is applicable to small and medium scale electric markets, where the integration takes place at "national" level and there is only one transmission provider which is responsible for the operation of transmission grid
- can also be used for large power pools, where the integration takes place at the pool-level and the pool has overall responsibility for the operation of the interconnected transmission system

IMPLEMENTATION ALTERNATIVES

Various approaches have been followed in the past in order to meet the system dispatching and market operation needs.

One model entails *single ownership and operational jurisdiction* and consists of having both the transmission system dispatch functions and the market operation functions performed by a Dispatch Operator, i.e., a dispatching, information processing and communications support entity that is:

- separated from the market
- structured as a non-profit organization that is financially supported by all the market agents.

A minor variation of this model consists of having the transmission system dispatcher and the market operator subordinated to the transmission administrator.

A radically different approach is to have the *ownership and operational jurisdiction assigned to different organizations* and consists of having a wholesale or retail market administrator responsible for the operation of the market, and assigning the transmission system dispatch under the jurisdiction of the transmission administrator.

Either alternative can be accommodated by the implementation architecture depicted in Figure 2. The only difference between one and the other would be the location and functional scope of the workstations that perform remote SCADA/EMS services.

Single Ownership and Operational Jurisdiction

Under this scenario, all the information processing and communications facilities required for system dispatching and market operation belong to, and are under the jurisdiction of a single owner. This model can be implemented either via separate business units of the transmission administrator or under an independent Dispatch Operator, and encompasses a:

- Market System
- SCADA/EMS which

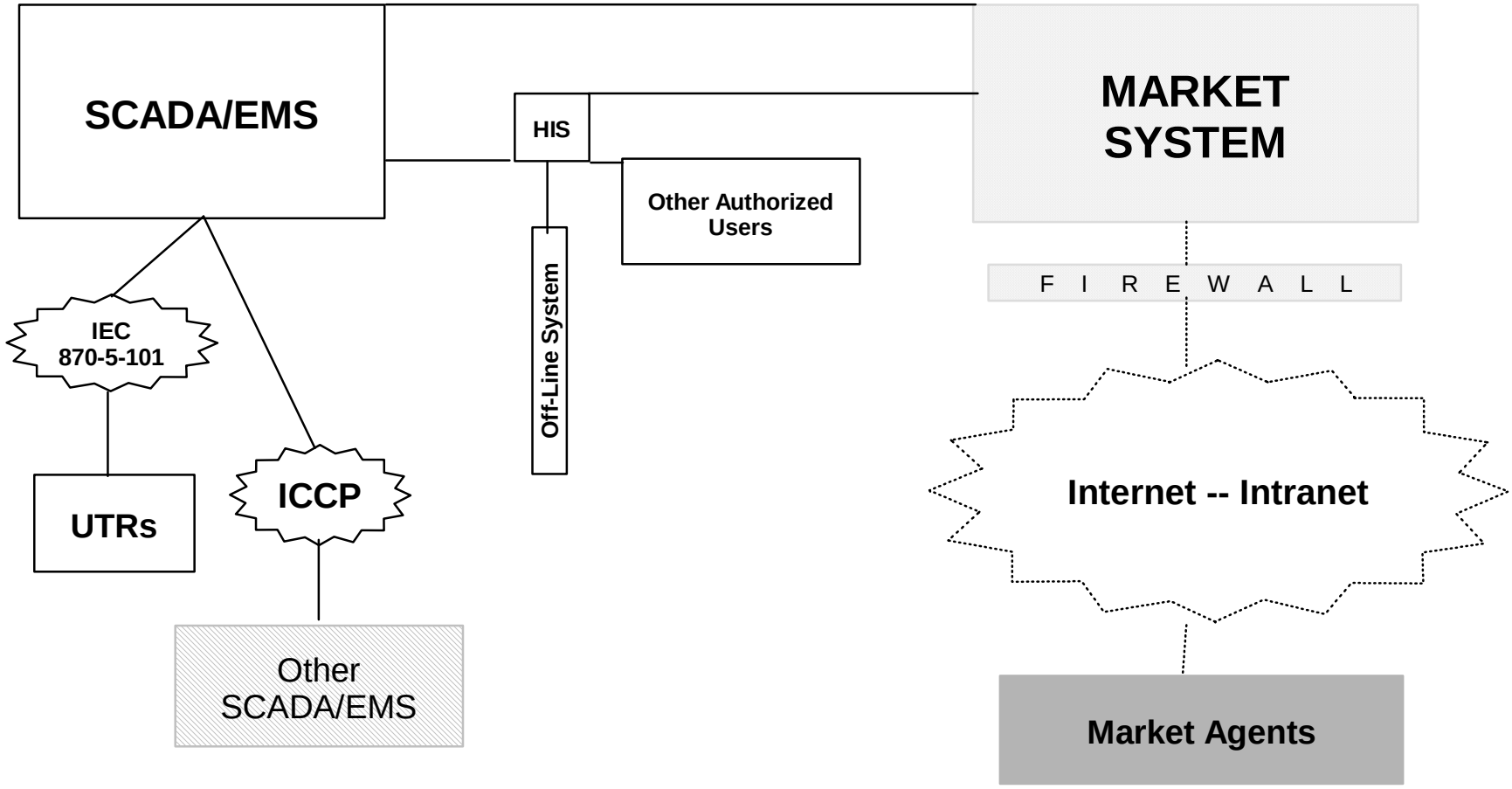

Figure 1 – Integrated information architecture for small and medium scale electricity markets. The "off-line system" refers to computational facilities used to conduct studies and perform support functions and off-line applications. The Information Storage and Retrieval facility, usually referred to as Historical Information System HIS, is part of the SCADA/EMS but is shown separately to emphasize its role in the information dissemination within the entire organization

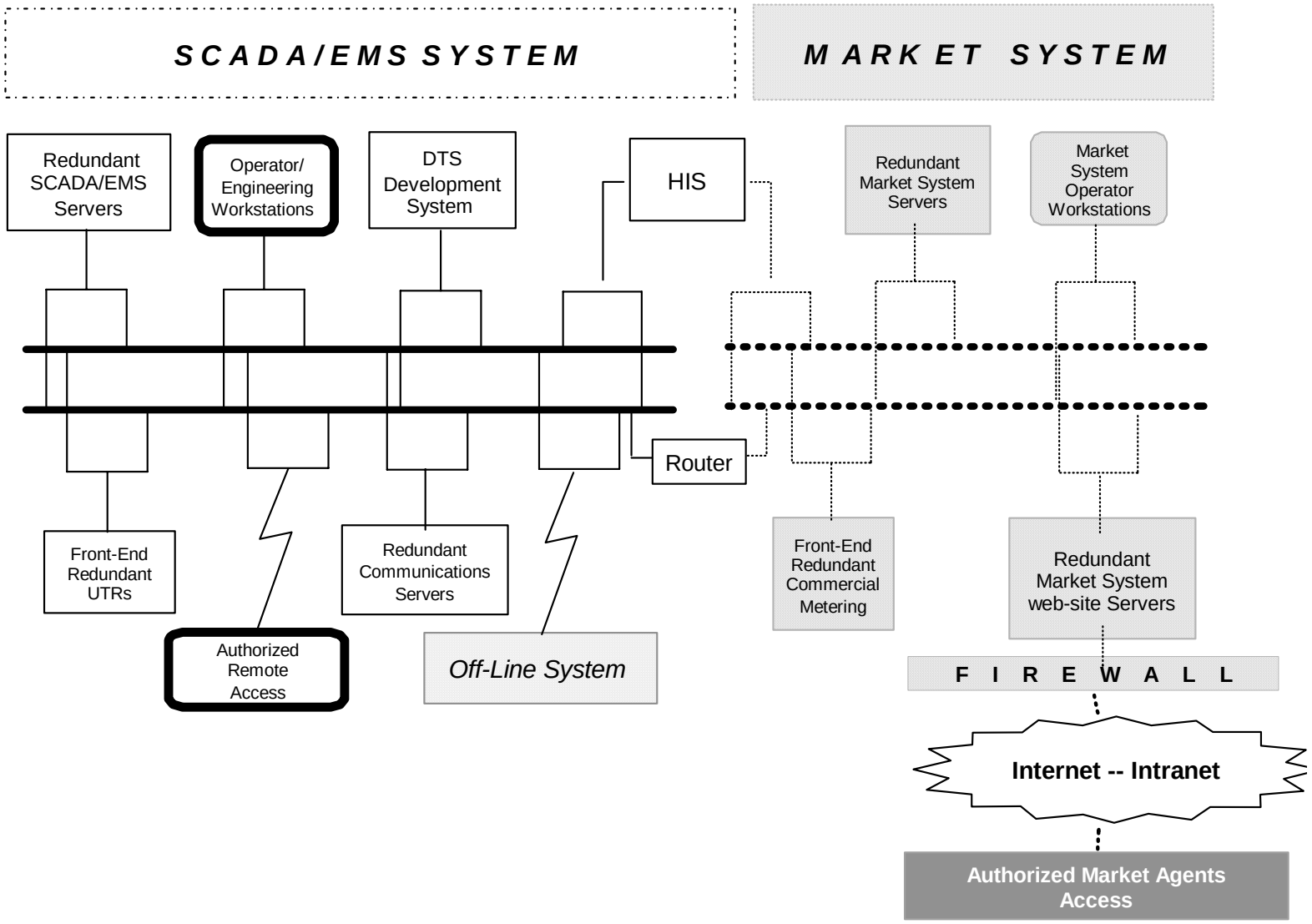

Figure 2 – Example of implementation architecture. The "off-line system" refers to computational facilities used to conduct studies and perform support functions and off-line applications

- performs real-time and study mode network analysis, as well as AGC and Economic Dispatch, on *behalf of the Market System*
- provides *remote SCADA/EMS services* to the transmission operator and, possibly, *remote SCADA services* to distribution companies
- maintains an information storage and retrieval system (HIS) which:
  - ✓ is a critical component in the overall scheme
  - ✓ should be perceived as an *information node* in the entire architecture
  - ✓ can be either implemented as a stand-alone system or seamlessly integrated in the SCADA/EMS LAN

Ownership and Operation by Different Organizations

This model entails a:

- Market System which
  - belongs to the wholesale or retail market administrator
  - performs the full array of market functions
  - accommodates remote workstations, driven from the transmission administrator's SCADA/EMS, for the execution of limited EMS (ISO) functionality such as
    - ✓ real-time and study mode network analysis
    - ✓ congestion management
- SCADA/EMS that
  - belongs to the transmission administrator
  - performs a complete array of transmission system monitoring and control functions
  - provides *remote SCADA/EMS services* to the wholesale or retail market administrator and, possibly, *remote SCADA services* to distribution companies
  - provides information storage and retrieval services, via HIS, both to the wholesale or retail market administrator and to internal clients and market agents with proper access jurisdiction

MAIN CHARACTERISTICS AND BENEFITS

In summary, the major characteristics of the proposed architecture are as follows:

1. A single SCADA/EMS supports both the transmission system dispatch activities and those network security and/or control functions placed by law under the jurisdiction of the market operator.

   The main benefits of this concept include:

- *data consistency and integrity* – since the network model is developed in only one place, both the wholesale or retail market administrator and the transmission administrator use exactly the same power system data. This may not be the case if the network analysis and/or system control functions of the wholesale or retail market administrator were supported by a *physically different* SCADA/EMS, with serious subsequent consequences on auditing and reconstruction of system events

- *significant economic savings* – in the proposed approach, the network analysis and/or system control functions under the wholesale or retail market administrator's jurisdiction are performed via remote workstations driven by the same SCADA/EMS that supports the transmission system dispatch. For small and medium scale electric markets, this is obviously much more economical than implementing an "ISO", which would essentially be a second SCADA/EMS, with, perhaps, a second set of RTUs and within the same geographical area that is served by the transmission administrator

2. One single integrated information processing and communications environment supports the entire electric market.

   The main benefits of this concept include

   - extended, consistent and coherent information reservoir available to meet a wide array of information needs of the market agents

   - flexibility to accommodate new scenarios

   - ability to maintain, from a single point of coordination, the information and communications infrastructure of the market

CONCLUSIONS

This paper advocates the sound and economically viable possibility of accommodating both the transmission system dispatch and the market operation within one single information architecture.

The proposed approach applies primarily to small and medium scale electric power systems that underwent restructuring and deregulation, have been partially or totally privatized, and now face the challenge of operating an electric market. And since this model was synthesized from information processing solutions adopted by a number of power-pools that successfully evolved into electric markets, it is believed that the integrated information architecture described herein can be applied to large scale systems as well, e.g., the regional electric markets that are now emerging everywhere around the globe.

In order to achieve the full array of benefits of the proposed model, the design of the SCADA/EMS, on the one hand, and the Market System, on the other, need to be coordinated to ensure consistency, interoperability, performance and expandability of the overall solution -- and to develop an information processing architecture that will be right for today and ready for tomorrow.