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data integration/exchange

part 2: future technical and business opportunities

IN THE UTILITY INDUSTRY, LIKE in many other major industries, it is becoming more and more clear that data and information are powerful assets. But, it is still not recognized how the value of data and information can be fully utilized in defining a successful business strategy. To illustrate this point, the following issues related to data integration and information processing infrastructures used for monitoring and controlling power systems are rather important:

- ✔ The impression that more data is not desirable is a misconception; it is only important where, when, and how the information is extracted and shared. Introduction of substation automation systems, as reported in the March/April 2003 issue of *IEEE Power & Energy Magazine*, clearly contributes to more data becoming available as the intelligent electronic devices (IEDs) are being locally integrated and better interconnected with the control centers. At the same time the ability to process data and extract information is tremendously enhanced. However, the new users who will benefit from this capability are still not clearly identified.
- ✔ The traditional approach of allocating the data and related information processing into separate legacy infrastructures does not make full use of data and information. As the integration capabilities are becoming more prominent, the issue of defining multiple uses of data and information is emerging as the pressing objective. How to fully utilize this capability yet remains to be an open question.
- ✔ New users want the information produced as accurately and as timely as possible while avoiding the complexity of data handling issues. The transparency of related infrastructures for collecting, processing, and communicating data and information is the key to a successful business strategy. How to make the process of integrating data and extracting information fully automated while

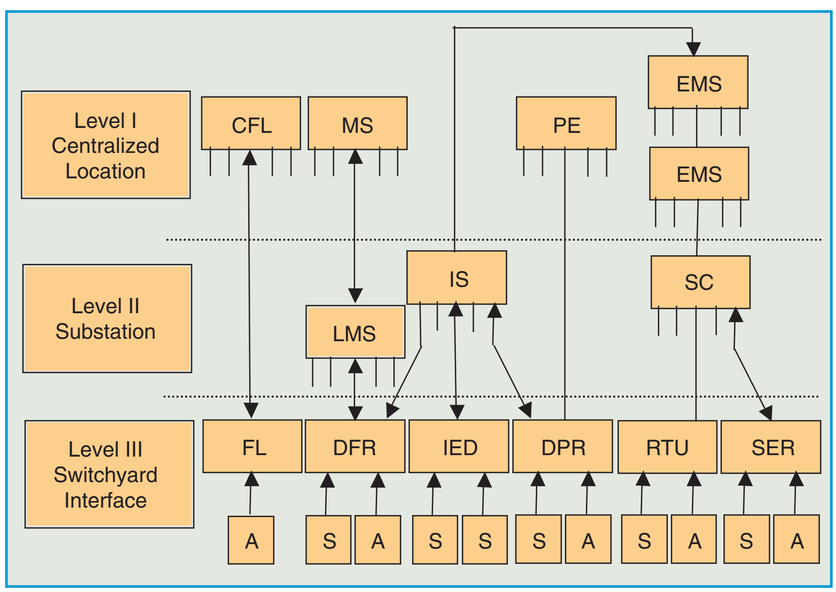

figure 1. Layout of the typical substation equipment (monitoring, control, and protection). FL: fault locator, DPR: digital protective relay, DFR: digital fault recorder, RTU: remote terminal unit, IED: intelligent electronic device, SER: sequence of events recorder, EMS: energy management system, PE: protection engineer, SC: substation control, IS: integrated system, CFL: central fault location, LMS: local master station, A: analog, S: status.

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creating a major business advantage remains a challenge.

How to establish the value of data and information and how to make the whole process of integrating the data and extracting the required information as efficient and as transparent as possible remain as two of the major concerns in the utility industry today. To support the argument that the technical and business value of data and information still needs to be fully understood and appreciated, further analysis of the issue is provided using the example of the traditional versus future view of the data integration and information exchange.

Existing Infrastructures for Collecting and Processing Field Data

One typical setup of the infrastructure is shown in Figure 1.

A cursory analysis of Figure 1 identifies a major property: each infrastructure component serves a specific utility group and related data collection and processing is aimed at extracting the information of interest to the selected group. This can be easily identified based on the following observations:

- ✔ The dispatchers use remote terminal units (RTUs) in substations and supervisory control and acquisition system (SCADA) at the control center to perform energy management system (EMS) functions.
- ✔ The protection engineers use dedicated fault locators (FLs), digital protective relays (DPRs), and digital fault recorders (DFRs) to capture data and extract information to analyze faults and performance of related fault-clearing equipment
- ✔ The substation operation personnel uses sequence of event recorders (SERs), and lately the integrated systems (ISs), to capture operating conditions of a substation and to execute local control and monitoring functions through dedicated substation control (SC) solutions.

Investigating further this common legacy approach from the viewpoint of identifying the future value of data and information, several issues come to the front:

- ✔ Is it possible to utilize the same data to produce additional information that will make the mentioned utility groups more competitive and cost-effective? If so, what needs to be done regarding data integration and information exchange?
- ✔ Is it possible to identify new users of the mentioned data, and if so, what information the users would like to see extracted? Is this information going to make the users more competitive in their decision making?
- ✔ Is the "wealth" of the substation data going to affect the performance of both local SC and EMS functions, and if so, how? Is this

approach going to affect the new paradigm for power system security, and what information extracted from the data contributes to achieving the expected benefits?

To illustrate some of these points, future approaches that will be producing new value of data integration and information processing are discussed next.

Future Approaches to Data Integration and Information Exchange

To allow for new functions to be implemented, it is very important to recognize that the substation automation and enhanced communications are very important "ingredients" but not a solution, per se. Development and implementation of new functions is needed to accommodate the new approach. One approach to implement the new functions of comprehensive fault analysis and two-stage state estimation, as discussed in Part 1 of this tutorial, is illustrated in Figure 2.

To simplify the discussion, only a subset of substation equipment is considered. The following major properties are very important in implementing new applications:

- ✔ Power system tracking capability. During the integration of data, it needs to be recognized that data sources (IEDs) have quite different properties and hence the data need to be preprocessed. This may be done using a function designated as verification of substation data base (VSDB). In addition, it may be recognized that the topology data and associated measurements are changing dynamically as the substation operation takes place. A function designated as substation switching sequences verification (SSSV) may have to be implemented to make sure that each time a switching sequence is executed, the verification of topology is performed. The two-stage state estimation (TSSE) module is needed to provide the substation data for the new state estimation function described earlier.
- ✔ Automated analysis. This function may be implemented using data from individual IEDs, such as digital fault recorders (DFRs), digital protection relays (DPRs), circuit breaker monitors (CBMs), and PQMs shown in Figure 2. After the individual data is processed and relevant information is passed on to the relevant groups, a comprehensive fault analysis and fault location (FAFL) function described earlier in the article may be implemented using both the substation data as well as the outcomes of analysis functions associated with individual IEDs.

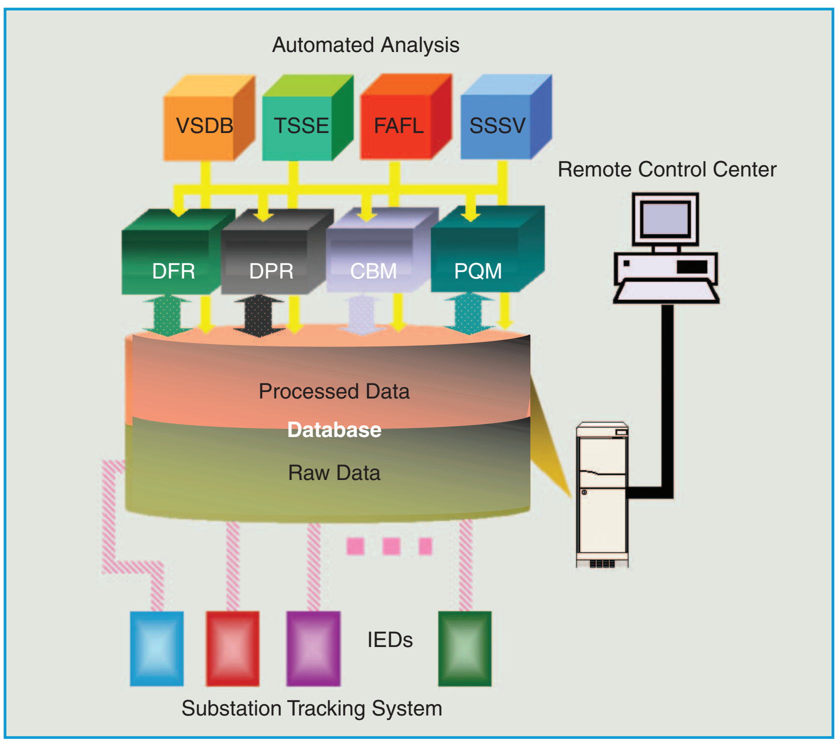

figure 2. One example of new substation functions supporting new applications. VSDB: verification of substation database, FAFL: fault analysis and fault location, TSSE: two-stage state estimation, SSSV : substation switching sequence verification.

Once the understanding of the new approaches to data integration and information exchange at the substation level is achieved, it becomes important to discuss the broader trend in the future development of the infrastructure for collecting and processing the data and extracting and exchanging the information.

Future Infrastructure Developments to Support the New Paradigm

In the context of reliability and security of power system operation and associated value of data and information, one can envision future trends as represented in Figure 3.

The main developments indicated in Figure 3 relate to:

- ✔ Improving data acquisition. The present practice where each IED may have unique data acquisition properties, some of which are illustrated in Table 1, makes the data integration and information exchange efforts pretty involved. To avoid the tedious task of preprocessing the data coming from different IEDs to make it consistent across the substation, the whole process can be tremendously simplified by designing the IED front-end processing to be of a high performance and rather consistent. Using a high sampling rate (over 10 kHz), high A/D resolution (16

table 1. Typical data acquisition properties of different classes of IEDs.

equipment	sampling synchron.	A/D resolution (in bits)	sampling rate (kHz)	signal coverage
DFR	synchron.	10–12	3–5	substation
DPR	synchron.	12–16	1–3	line
SER	synchron.	N/A	1–3	substation
FL	synchron.	12–16	1–20	line
RTU	scanning	8–12	1–3	substation

bits), and synchronized sampling capability (with GPS receivers connected to all IEDs), the data coming from different IEDs can be easily integrated.

- Automating local information extraction. Since the new concept assumes an increase in the field-collected data, it is critical that a local information extraction capability is provided so that the data transfer from a substation to a control center is kept low. Since most of the analysis and control actions are time critical, it is a necessity that the local data processing is automated. This also implies that the analysis and control may be viewed in a hierarchical way where some actions are initiated at the substation while some more centralized actions are initiated at the control center.
- Introducing new IEDs. As the value of data and information gets better defined in the future, there will be a need to define new data acquisition and control IEDs. As an example, a new class of dynamic disturbance recorders (DDRs) is shown in Figure 3. This class of recording IEDs will be aimed at monitoring dynamic stability oscillations of the power system across a region. This type of monitoring IED can be implemented by developing new devices such as phasor measurement units (PMUs) or by retrofitting the existing recorders such as DFRs to provide the recording accuracy required.
- Interfacing substation systems to control centers. It is clear that the processing power of substation automation systems has to increase in the future. Having a strong processing capability in a substation will lead to different data processing and data extracting strategies: performing substation-wide applications, executing a preprocessing for the centralized system functions, redistributing centralized functions to

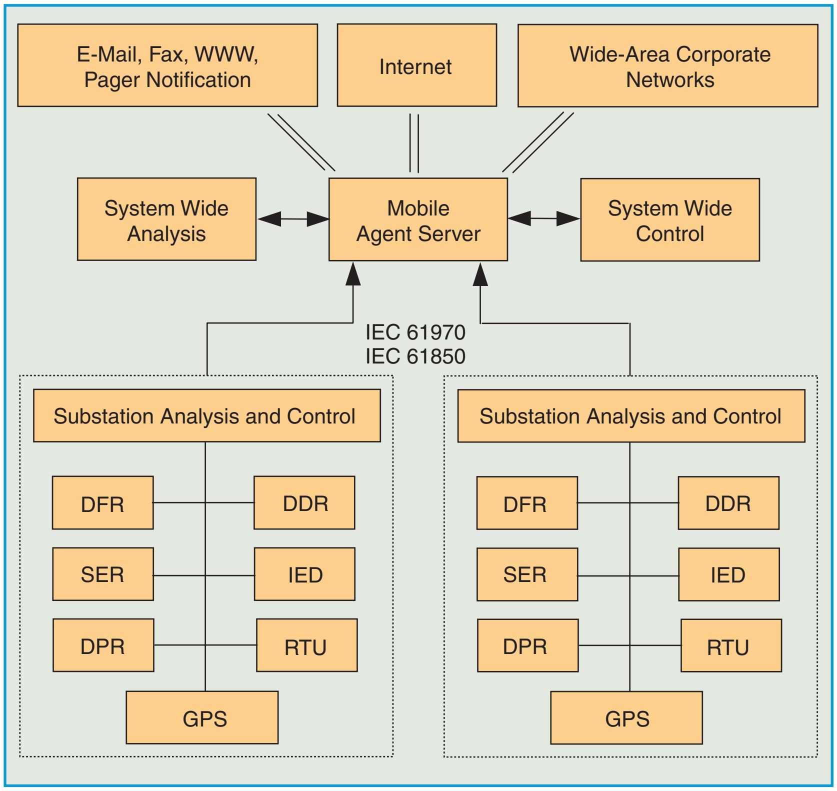

figure 3. Future infrastructure supporting data integration and information exchange.

substations using distributed processing. In all of these instances the substation equipment interchange standard communication protocols (for example, IEC 61850) will have to be harmonized with EMS database interfacing standards (for example, IEC 61970).

- ✔ Allowing an easy exchange of application programs and access to the required databases. This requirement is rather obvious if a flexible data integration and information exchange is to take place. To illustrate this trend, one of the rather promising technologies, namely mobile agents, is indicated in Figure 3. In this example, various applications can be executed at different locations (substations, regional centers, EMS, etc.) selected based on the availability of relevant data. By organizing the applications in forms of agents, and providing them with a mobility feature, the applications can be made truly transparent regarding the specific data acquisition and processing architecture, and the entire data integration and information exchange concept can be optimized regarding such criteria as speed of operation and cost of implementation.

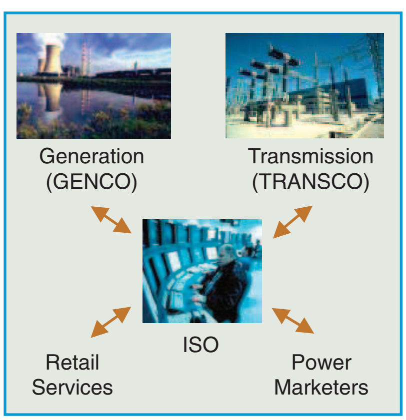

figure 4. Global view of data integration and information exchange.

- ✔ Enabling enterprise-wide dissemination of results and reports. Interconnecting IEDs and substation automation systems across the entire system is a necessary condition for unlocking the value of data and information in the future. To achieve this goal, a variety of present and future technologies will have to be used. Typical examples of the technologies of interest are Internet, embedded Web applications, pagers, wireless devices, e-mail and net meeting capabilities, etc. The main purpose is to allow multiple user access to the information extracted and packaged from the common pool of data.

New Business Paradigm for Establishing the Value of Data Integration and Information Exchange

Instead of drawing a definite conclusion based on the example used in Part 1 of this article (new paradigm for power system operational security), a broader view of the data and information value is offered. It is clear from the examples provided in the previous discussions that unlocking the value of data and information creates a major improvement in the operating capabilities while reducing the overall investment. The concept can be extended to any situation where the data may be integrated and information shared across different business entities and for whatever purpose. An example of a scenario where quite diverse entities may benefit from the new concept is shown in Figure 4. Let us assume for a moment that the data and information can be defined as commodities that may be exchanged, traded, shared, leased, etc. To illustrate how the business value of such commodities may be defined and utilized, we offer a few final examples:

- ✔ Coordination of maintenance schedules among GENCOs, TRANSCOs, and ISOs. Each entity may have its own data relevant for scheduling the maintenance, but information required for coordinating the overall schedule may be *exchanged* to facilitate automated scheduling optimization.

- ✔ The power marketers may wish to have more detailed insight into the performance indices describing historical market trends. The ISOs may collect such data and package the information to meet the interest of the power marketers. This information may be *traded* and made available to all the marketers for a fee.
- ✔ The network conditions including sudden contingencies may be reported in real time by TRANSCOs. In that case all the market participants may have access to this information that is *shared* on a regular basis through common communication means.
- ✔ Some of the retailers may wish to obtain data from the equipment owned by the DISCOs or TRANSCOs to develop their own value-added business services. An example is the use of metering data to provide energy billing services to the users in a given retail area. In this case the companies owning the equipment for data collection may *lease* data for this purpose.

Conclusion

In conclusion, the approach reported in this part of the tutorial has identified a new paradigm for assigning a business value to the data and information produced in the course of processing the energy. Integrating the data and exchanging the information may define several new business opportunities. The approaches of using the data and information may be revisited in the context of the goals of deregulation and more competitive, customer-focused industry. The resulting strategies may offer some new benefits and more efficient and versatile uses of data and information in the future.

For Further Reading

M. Kezunovic and A. Abur, "Data Integration and Information Exchange: Impact on Future Substation and EMS Applications and Related Implementation Requirements," EPRI Technical Report, Project #055434, 2004.

M. Kezunovic, A. Abur, A. Edris, and D. Sobajic, "Data integration/exchange Part 1: Existing technical and business opportunities," *IEEE Power Energy Mag.*, vol. 2, pp. 14–19, Mar./April 2004.

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Biographies

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