DESIGN AND DEVELOPMENT OF THE TECHNICAL INFORMATION SYSTEM FOR ELECTRICITY UTILITY OPERATIONS AND MAINTENANCE SUPPORT, Phase I

PROJEKTOVANJE I RAZVOJ TEHNIČKOG INFORMACIONOG SISTEMA ZA PODRŠKU RADU I ODRŽAVANJU ELEKTROPRIVREDNOG PREDUZEĆA, I faza

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Abstract: To be able to take competitive technical and commercial decisions at different hierarchical levels at the electricity utility, as well as at different locations, utility employees that are at the different decision making positions need numerous adequate and timely process and maintenance data from all company segments in generation, mining and electricity distribution, on the regular basis. Now days this is in most part done locally with limited IT support, and with almost no integration between applications/systems. To improve effectiveness of the current operation and maintenance processes, new technical information system was designed and its first phase developed and implemented at national utility. The scope of this phase is limited to the extensive utility technical data base, and basic applications for its creation and maintenance, together with the two main applications for shift/daily operations reporting at all of the utility segments. IT technologies selected and applied are state of the art, based on commercial ORDBMS, web application server as a middleware core and Java applications, within the three tier architecture. In this paper the system architecture, functional scope, data model and applied information technologies will be described. These will be illustrated in the paper with the HMI samples from the recent project.

Key words: technical information systems, DSS, operations & maintenance, generation, coal mining, distribution.

1. INTRODUCTION

Today’s electricity supply industry is characterized with liberalization and re-regulation, where new players (IPP, GenCo, traders) are active on the market and where concurrency is gaining in importance. A power system and its operation complexity increases due to increased energy transfers, inadequate transmission capacity in some cases, and numerous technological improvements as well.

On the other side new generation capacity building is typically slowing down and fuel prices generally increase, thus, business technical and commercial aspects are getting more stringent for those that run assets and make decisions, resulting in pressure to reduce production cost (€/MWh).

Also, increased requirements on environment protection (emission of CO2, SOx, NOx...) are in place, especially in the EU. Increased threats to security should not be overseen. Several other

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important issues can be identified: older and older equipment/plants require best possible O&M practice, older workforce, with valuable knowledge base, that can be easily lost.

An electricity companies (GenCo, DisCo, Coal mining Co.) and/or independent power producers (IPP’s) to be able to take competitive technical and commercial decisions, apart from nameplate type equipment technical data, need numerous valid and timely process, operations and maintenance-related data from the power plants, transformer stations/substations (at different voltage levels) and coal mines, on a regular basis. At the generating company level now days (typically at their control centers) different IT-based Generation Management System (GMS) are used to perform functions related to SCADA, resources scheduling, load forecasting, and generation control [1,2]. Similarly, at distribution companies DCC are equipped with the SCADA/DMS systems. Also at the electricity (Generation/Distribution/Mining) Company level of hierarchy different decision support systems/applications are needed, for example technical performances of the individual plants/units should be followed and analyzed together with the activities on coordination of power plant maintenance. To do all of that, numerous power plant and substation data are required (technical, operations and maintenance, process historic, real-time and non-real time). Between them on-line/real-time unit efficiency and unit production cost (as €/kWh, based on the unit heat rate) are of the prime importance.

The existing IT and control support within the power plants is typically limited to production unit distributed control systems (DCS) and used almost entirely just for real-time monitoring and control of the production unit. Thus acquired data are rarely used outside the unit control room due to their relative closeness.

Similar situation arises at the company level (HQ and control centre) where there is a need for data integration from different heterogeneous data sources that are in different power plants.

These problems are also common to many generation companies and utilities worldwide, especially those with the older power plants that were recently refurbished and modernized, as it is the case in the SEE region.

Existing solutions are no so numerous and typically come from large vendors [3-5]. Except in their process control system interface parts, that are custom designed, this solutions use general purpose IT solution and equipment. The approach proposed here is based on centralized data base concepts [6] that look competitive for data integration purposes as well as for their flexibility.

To overcome some of these constraints, and to enable opening of energy companies data silos, the IT project (named PROTIS) based on object relational data base was initiated and its I phase successfully concluded in Serbia [7]. The system PROTIS main goals are to: 1. Establish at the electricity company HQ level centralized data base with the O&M data collected from the individual PP and SS 2. Serve as a platform for different applications that will use mainly operations and process data from the PP/mines/distributions, and 3. As a communication gateway towards the GMS (or SCADA/DMS) at the GenCo (or DisCo) control center (CC), that also supplies data to the Company’s upper hierarchy decision support levels.

In this paper, after short introduction, functional scope of the IT system is briefly described. Then relevant applications to collect and maintain operations and maintenance data, and those to query and visualize integrated data, will be described too. The information architecture and system interfaces are also outlined there. Finally, information technologies employed in implementation will be specified, one that correspond to the situation within the EPS used as an practical example for the solution presented in the paper.
2. FUNCTIONAL SCOPE OF THE “PROTIS” SYSTEM

Business (functional) architecture for the target system PROTIS was developed early during the project. It is intended to cover most of the daily operations and maintenance activities within the thermal, hydro power plants, at coal mining companies and distribution companies, as well as management support functions and maintenance coordination functions that are performed at the upper hierarchical decision making levels, typically at the company HQ location. The hierarchical information pyramid, in its base has numerous process data, acquired typically through process acquisition and control systems (like DCS, SCADA), that are introduced in the system PROTIS through suitable interfaces (API), or entered manually, during the project initial I phase.

Having in mind the scope and limitations of this project here we shall limit our scope to the information system application architecture, one that in principle implements required business functionality, as an equivalent one, one that defines the application structure for system PROTIS.

From the spatial-business domain point of view, global architecture of the system, in its full extent includes all the business domains (generation, coal mining and electricity, hot water, steam and coal distribution) and all relevant EPS business entities, as shown in Fig. 1.

![Figure 1 Global target architecture, business domain scope of the system PROTIS](image)

Where abbreviations stand for:

- TE = TPP - Thermal Power Plant
- HE = HPP - Hydro Power Plant
- RUD = Coal Mining company/entity
- ED = Electricity distribution

3. THE “PROTIS” SYSTEM APPLICATION ARCHITECTURE

The system structure defined in the project is planned as modular, and might be treated as an application architecture (where software module = application). This structure is compactly represented in Fig.2. More detailed representation of the application architecture, having four levels of detail, is given in the project documentation [7].

In the sequel in Fig.2 depicted is the information system PROTIS target application architecture where maintenance management systems (MMS) and business ERP systems will be centralized.
Compact description of the application subsystems and applications for the whole system is described in the sequel.

The core part of the system PROTIS is its technical data base (DTB). The application architecture proposed is composed of DTB, and several application subsystems that implement operations management (i.e. operations process control) functionality, and maintenance management (i.e. maintenance planning and control). It is planned for the system PROTIS to have in its final stage application functionality (on level 1) shortly described:

TDB – technical data base
VOI – operations reporting
OP – operations data configuration
POD – operations events tracking/recording
PSP – operations state tracking/recording
PSU – data from different (real time, process) control systems
PMP – process material flows (fuels and residuals)
EOV – energy accounting and valorization
ORO – maintenance works safeguarding / safety measures

Figure 2. Global target application architecture of the system PROTIS
System PROTIS applications overview

Within the system global architecture the following main application subsystems were defined:

- Plant/station data management
- Operations process management
- Maintenance management
- Technical and specific reports
- Technical documentation management
- System user privileges/rights administration

**Plant/station data management (UPP)** subsystem represents a central part of the IT system PROTIS. This system consists from different modules that manage client definition, plants to include, module functions configuration, and content maintenance and visualization. This subsystem contains also modules that enable creation, maintenance and visualization of content in the TDB.

The core of this system is a technical data data base (TDB) that contains all relevant operations and process data within PROTIS, including user plant/equipment data from all domains.

**Operations process management (UOP)** subsystem is one of two key application subsystems. Its main functions are: to register, process and visualize operations & maintenance data from different parts of the company. At the final stage this subsystem includes the following applications:

- Operations reporting
- Operations data configuration
- Operations events tracking/recording
- Operations state tracking/recording
- Process material flows
- Energy accounting and valorization
- Maintenance works safeguarding / safety measures
- Data from process control systems.

**Maintenance management (UO)** is another key application subsystem. Its main functions are: recording, processing and visualization of maintenance data related to plants/equipment in different parts of the company. Thus it provides efficient support to maintenance processes, like preparation of preventive maintenance activities. At the final stage this subsystem includes the following applications:

- Work order generation/creation
- Maintenance planning
- Maintenance analysis
- Stock/warehouse processing and evaluation

**Technical and specific reports (TPI)** represent separate subsystem whose function are: generation and visualization of technical and another reports for selected categories of users (like technical management and executive staff). This subsystem dill with evaluation, control and analysis of different operations data, and in the final stage includes the following applications:
- Report generation
- Technical efficiency

**Technical documentation management (UTD)** is a separate subsystem whose function is to provide electronic storing of technical documents of different type (scanned documents, textual doc, drawings, digital photos, etc.) from all parts of the EPS.

This subsystem also has to provide for entry and visualization of the electronic documents, with clear and unified document classification, as well as efficient e-document storing.

Based on the defined application requirements and interfaces to process control system (SCADA/DCS) and other relevant systems, to be implemented in follow on phases, it was possible to propose target application architecture of the system PROTIS. Based on previous research, it was defined along the centralized systems principles.

The architecture proposed is depicted in Fig.3, with the assumption that where existing MMS and ERP type systems will be centralized too during the follow on project phases. This assumption was supported by the Investor.

![Figure 3 Target application and interface architecture for system PROTIS (for future centralized environment)](image)

4. **THE DATA MODEL**

On the other side, system information architecture provides insight focused on the data that describe the enterprise (electricity utility company). In the case of system PROTIS these are the data that describe EPS generation-distribution system.

Within the system target architecture it is foreseen that the largest part of these data will be provided automatically, through suitable interfaces, from the existing process information-control systems of DCS/SCADA type. The lesser part of the data will be entered manually.
In this moment only one part of the whole data from the target system PROTIS is specified. Thus in this moment it was possible to specify just information architecture for the system I phase covering information needs of the applications from this phase. Detailed data model content and unified class diagram for the system PROTIS in this phase are contained in respective Project documentation [7].

5. THE SYSTEM INTERFACES

For its successful operation, system PROTIS will require several interfaces, as towards process data sources, as well as towards its business environment. From the direction of data transmission point of view, it is possible to distinguish two types of interfaces, so called one way, and two-way interfaces.

The first one represent interfaces that are ”one-way”, and transfer data from the data source (typically process measurements and signalizations) towards PROTIS, and will be implemented on the as-needed base. In its operation system PROTIS will use multitude data sources, like:

- Process DCS/SCADA systems at TPP units
- Process DCS/SCADA systems at HPP aggregates
- Information system (IS) of the fuel supplier (coal, oil, gas)
- IS for measurement of fuel and residual quantities
- LIMS (Laboratory Information Measurement System)
- IS for environment monitoring (atmosphere, soil, water)
- IS for remote/communal/industry heating
- Meteorological IS
- SCADA systems in the SS/SY of PP
- Monitoring and control system at the coal mines
- SCADA systems at the ED companies
- Hydrological IS
- Manual data entry by the operation and maintenance shift personnel

Another, ”two-way” interfaces, that enable data interchange in both directions, will be designed and implemented toward:

- Business IS (before all, of ERP type)
- Systems for support of maintenance management (MMS) which are sometimes integrated within the ERP type systems
- Resources scheduling system

As a result, basic PROTIS interfaces, depicted in Fig. 3, relative to the dominant data nature, and a type of the systems to be connected with, might be divided/aggregated in several groups:

- Interfaces toward process-control systems (DCS, SCADA, etc.);
- Interfaces toward business management information systems (of ERP, MMS type);
- Interfaces toward other (mostly technical) software systems.

6. THE INFORMATION TECHNOLOGIES APPLIED

Defining system technology architecture includes, defining the necessary technologies, and software tools when possible, and also defining the configuration of the computer (servers, workstations) and communication hardware and software equipment that is needed.

Defined general requirements towards IT technologies and tools for the system PROTIS implementation include:

- Application solution is web oriented. Middle tier must use standard model for components, which interact with HMI thus enabling simple and efficient way of work. The user interface should
enable fast and simple application layer, freed from complex logic and processing, based on programming frameworks from leading vendors.

- The IT chosen must enable changes and/or upgrades of individual tiers independently of other tiers. Also IT chosen must yield high level of software flexibility and portability.
- High reliability of the system.
- The unified application solution for the whole EPS, that will support needs of all the functional domains.

In this respect, and with the goal to satisfy these requirements, it was necessary to define technologies and tools in all main segments, and with the following results:

1. Computer hardware with redundant main components (LAN, DB server, Application Server)
2. Operating system (OS), Linux, Windows
3. Data base management system (DBMS), Oracle 11g
4. Middleware (middle tier) that integrates different tiers, Oracle Fusion MW, Web Logic AS
5. Tools/environments for application logic and UI development, JDeveloper, ADF.

It’s worth saying that, when analyzing and specifying technology solutions and tools needed, one has to have in mind that the issue is about target technology architecture of the system that will have many ten’s of applications/modules, where some of them jet to be designed, and developed, the system that will be in design/implementation for the next 3-5 years. At this time horizon there is no point to specify now the software tool versions. Based on above, proposed technology architecture of the target system PROTIS is depicted in Fig. 4.

Figure 4. System target technology architecture, in case that MMS and ERP are centralized too
7. THE IMPLEMENTATION EXAMPLE

Here as an example we shall outline PROTIS I phase application scope: TDB related apps (AEO, EOP, AA, KFG, OP, RUOP, KMP) and those from UOP subsystem: VOI, POD. Model size is also impressive, it contains about 130 tables.

Apart from a specific application business function, that implements real business flow in some specific segment, basic functions needed for data entry, their modification, deleting and their visualization and printing, are also developed and available to the user.

As an illustration of the EOP application, sample HMI at central PROTIS system is presented in Fig 5.

Figure 5. The application EOP HMI example

As an illustration of the KMP application, sample of HMI is presented in Fig.6.

Figure 6. The application KMP HMI example
8. CONCLUSION

To improve effectiveness of the current operation and maintenance processes within the electricity utility, new technical information system was designed and its first phase developed and implemented at the national utility. The scope of this phase is limited to the extensive utility technical data base, and basic applications for its creation and maintenance, together with the two main applications for shift/daily operations reporting at all of the utility segments. IT technologies selected and applied are state of the art, based on commercial ORDBMS, web application server as a middleware platform and Java applications, employed within the three tier architecture.

9. REFERENCES


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