ADVANCED MANAGEMENT TECHNOLOGIES FOR DISTRIBUTION PLANNING AND OPERATION — A PORTUGUESE-BRAZILIAN COOPERATION PROJECT

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ABSTRACT

The paper reports the main objectives and results of a Portuguese-Brazilian project on advanced management technologies for distribution planning and operation. Technologies for management of planning studies and scheduling of real-time switching were developed based on a powerful analysis, simulation and optimisation system: DPlan. The main functionalities of the management technologies are reported and illustrated and their relation to other corporate systems, namely SCADA and GIS, are described.

INTRODUCTION

Power distribution systems are naturally complex — the large dimension of the system and the variety of equipment and possible network configurations make the problems of investment planning and the real-time operation formidable optimisation problems. Much attention has been devoted to these problems in the last ten years, including by the authors [1-6]. New algorithms have been proposed and new technologies have been developed to handle some of these problems in a satisfactory manner. More progress is expected in this regard. However, the scope of this paper goes beyond the particular optimal solution for a given investment study and beyond the particular reconfiguration solution for a given operation problem. The paper deals with a hierarchically-higher problem, one of providing efficient technologies for managing the various planning studies and also managing the various scheduled operation reconfigurations.

This paper reports on a project involving companies of the EDP Group both in Portugal and in Brazil. The corresponding distribution networks have many similarities but also some differences. In Brazil, loads are often unbalanced, the network is often unsymmetrical, transformer stations are more frequent (less power per unit), and there are differences in system configuration and voltage support as well. These similarities and differences, and the corresponding engineering experiences, when put together and thoroughly analysed result in a mutual benefit: a clarification of the requirements for technologies that can bring added value to investment and operation. Innovative and robust solutions are sought and they must be delivered in an efficient timely manner and should facilitate the supervisory management.

In addition to some interesting aspects of applied optimisation, the paper focus on two new, advanced technologies. One is an Investment Study Manager (ISM), and the other is a Switching Schedule Manager (SSM). ISM facilitates the management of all investment studies. SSM facilitates the management of all switching programmed activities.

The integration of both ISM and SSM within the corporate information system, including GIS and SCADA are also addressed in the paper.

A BINATIONAL PROJECT

The EDP Group comprises several companies in different continents. In Portugal, the distribution company is EDP Distribuição (EDPD). In Brazil, the group owns five companies, including three distribution utilities, shown bellow.

Each Brazilian utility has specific characteristics that are severely influenced by geography, native population and economic factors. A major challenge of the Group has been to standardize processes and procedures in order to achieve cost reduction and asset optimization.

The technical systems available at Bandeirante, based on mainframe architecture developed in the late eighties, had become obsolete and surpassed. That was the reason for Bandeirante to start a new corporation-wide project in 2002. The project, named Sistema de Informações Técnicas (SIT), comprised the development of a modern Geographical Information System based on the GESmallworld platform: GESmallworld Core, PowerOn, PSS/PTI power flow and other integrated tools. SIT started at Bandeirante in 2002 and was successfully completed in 2005. In 2006 the group engaged in a project whose main purpose was to adapt the Bandeirante solution to Escelsa and Enersul requirements and the three companies are nowadays ready to use the

same technical system.
Nevertheless, the dispatching environment has been facing a major deficiency: the lack of a powerful tool to support both scheduled and real time switching. Thus, a new project is born – DPlan Brazil.
The goal of this new project is to evaluate and install DPlan as used by EDPD, with all its functionalities, to support the companies of the Energias do Brasil Group. DPlan has become very useful in the solution of problems that concern operational planning and expansion planning of power systems. EDPD has used DPlan to analyze three phase symmetric networks with balanced loads. The principal benefits of using DPlan are as follows:

- Reduces losses, thus decreasing energy operation costs
- Improves reliability, thus bettering the quality of supply
- Improves configuration according to desirable patterns, thus decreasing staff operation cost
- Optimises investments, thus decreasing investment costs
- Provides high-quality technical information to support strategic decisions
- Reduces labour effort and speeds decision making

As pointed out earlier, the distribution networks of the companies of the EDP Group both in Portugal and Brazil have many similarities but also some differences. To adapt DPlan to the type of network that exists in EDP Brasil companies, it was necessary to implement algorithms capable of dealing with unsymmetrical networks and unbalanced loads. To promote the same technical culture and support the best management practices for investment planning and switching schedule, the ISM and SSM systems have been developed based on DPlan technology, as described next.

INVESTMENT STUDY MANAGER

The Investment Study Manager provides for the following activities:

1. Repository of all studies
2. Updating of previously submitted studies
3. Distribution to qualified users
4. Advanced geographical and schematic viewing
5. Comparison and analysis of cases

The comparison of cases is a very interesting aspect of ISM. The facilities for comparison include geographic viewing and schematics, queries and filters for detecting additions, deletions and other differences together with an immediate analysis of their effects. All this amount of information is available and ready for running the distribution planning optimisation modules. When a study is uploaded, all results — and not only the ones selected by the planner — are readily available to the manager and other qualified users.
Fig. 1 shows a view of the ISM including a geographic view of the areas of study (rectangles) with intervention areas (irregular polygons within the rectangles), a master window with the list of uploaded studies, a subwindow corresponding to the "set permissions" command.
Fig. 2 is a data flow diagram for ISM. There is a "Repository of studies", which runs on a server and includes all studies uploaded by the users, and a set of functionalities whose end results are the updating of the repository, the distribution of each study to selected users, and the sending to the "Design Manager".
The activities of the user are hence as follows:

1. Do local studies with DPlan to propose new investments and a different network configuration

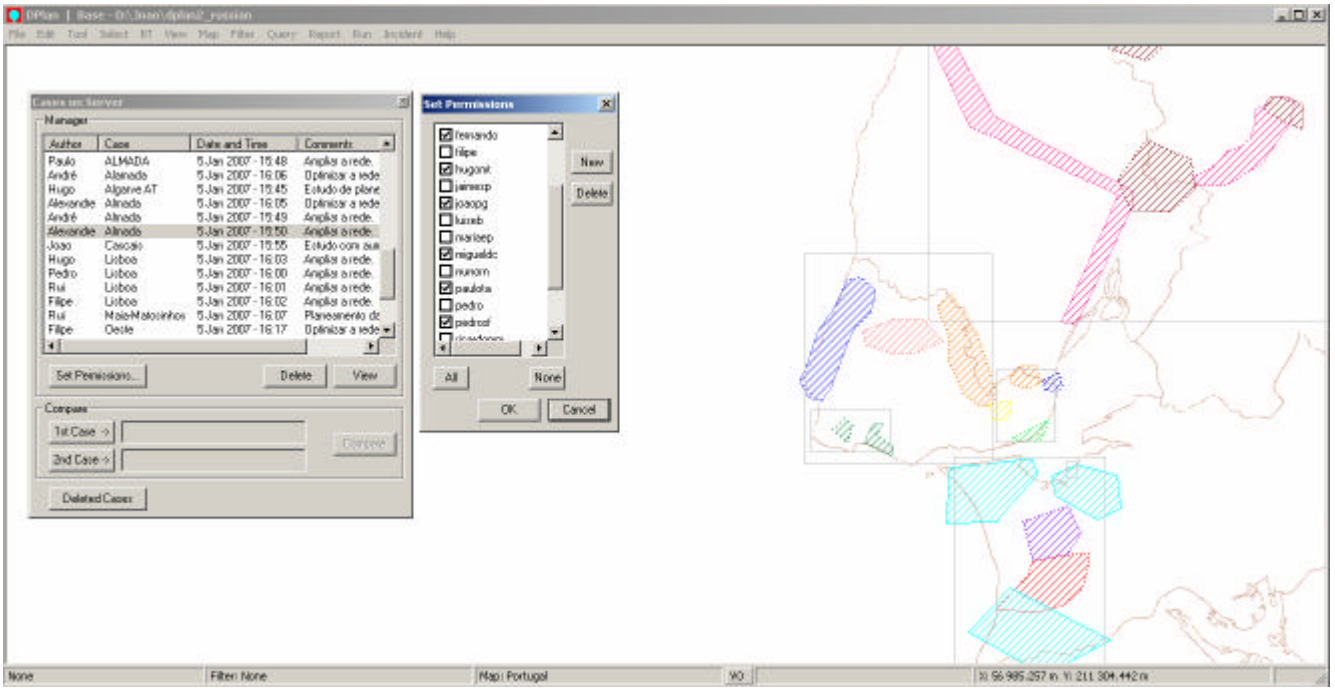

Fig. 1. Snapshot of the ISM window.

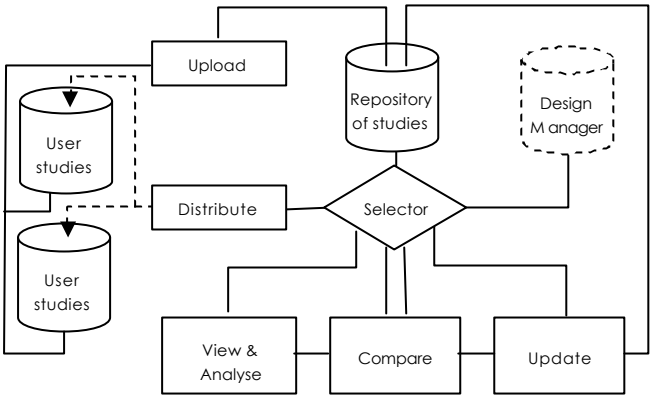

Fig. 2. ISM dataflow diagram

2. Compare with reference case, previous studies, and other studies he has access to
3. Upload the local study onto the server

The activities of the study coordinator are hence as follows:

1. Overview of all studies
2. Select view by area, by user and by date in accordance with the interest of his activities as coordinator
3. Select one study and view the progress made with respect to the reference or previous studies; the "Compare" functionality automatically generates a progress report as well as displays geographically all changes made
4. Analyse the study in detail with DPlan
5. Select users to have permission to download study
6. Send approved study to SIT's "Design Manager"

SWITCHING SCHEDULE MANAGER

The Switching Schedule Manager (SSM) provides for the following activities:

1. Real-time repository of all programmed switching activities, including the record keeping of all schedules and reschedules
2. Updating of previously submitted activities
3. Logging and record keeping of all schedules and reschedules
4. Availability to all dispatchers and other qualified users
5. Simulation for any point in time of the activities

The simulation is a very important feature of the system. This includes the facilities for analysing the system in all details for the estimated nodal daily load profile and in accordance with actual switching status and programmed switching scheduled for that time. The user can also analyse the security state of the system and use DPlan's contingency switching technology to rapidly respond to network contingencies to restore the service.

Fig. 3 shows a view of a SSM window with the actual configuration, a "switching status" subwindow, a "future switching" subwindow. There are two subwindows on the foreground: one shows the switching inside a substation and the other a view of the quantities related to one of the transformers. The "view branch" displays the quantities for the selected time and the amps corresponding to the 24 hour profile.

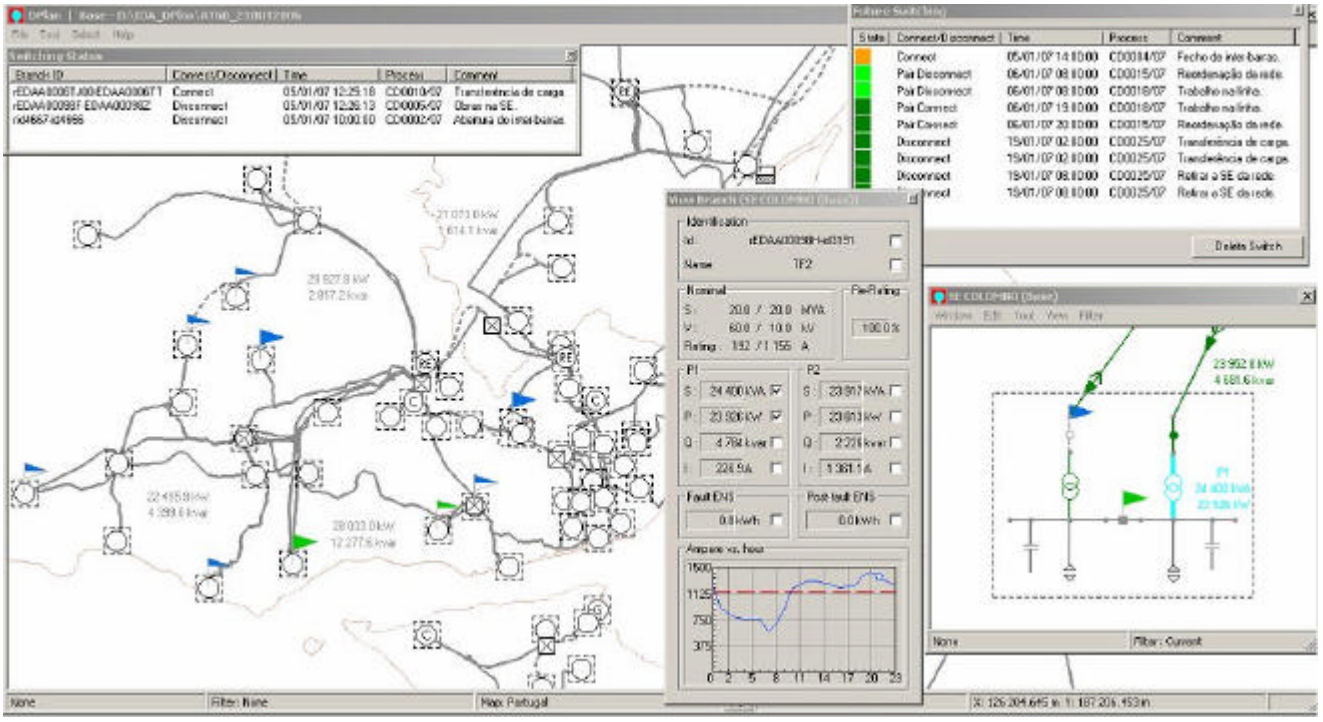

Fig. 3. Snapshot of the SSM window.

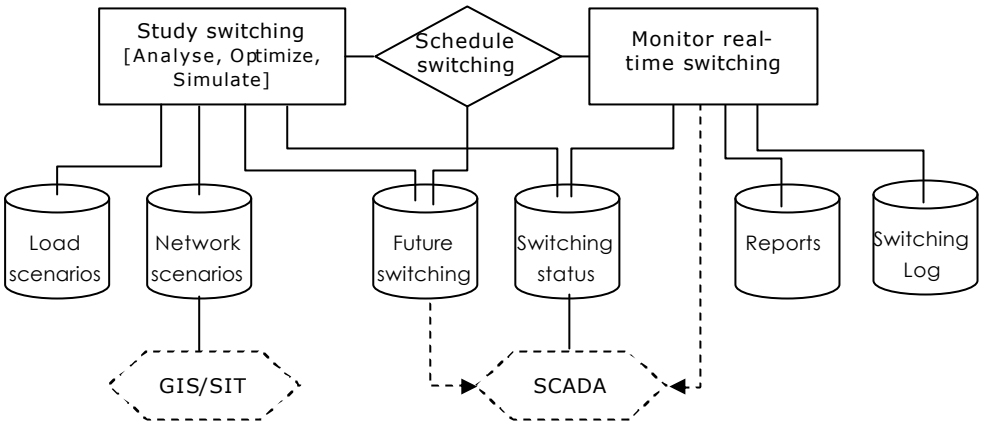

Fig. 4. SSM dataflow diagram

All changes with respect to the normal configuration are flagged. Full flags signal current switching status. Half flags signal future switching schedule. Flags are colored according to a specific operations code.

Fig. 4 is a data flow diagram for SSM. Scheduling new switching activities requires four types of data: expected load info, network info, current switching status and the already scheduled switching activities. Optimal scheduling requires powerful study capabilities as provided by DPlan. Monitoring network current status requires info on current switching status and info on programmed switching activities to analyse and simulate the immediate future.

The activities of the user are hence as follows:

1. View real-time network analysis in a geographic, schematic, friendly interface; results include topology, currents, voltages, contingency severity and reconfigurability, etc, as given by DPlan
2. Simulate the immediate future and view 24-hour ampacity diagrams for lines and transformers; display 24 hour results for all active filters and window reports
3. Review and reschedule switching plans based on the new info available
4. Study near future to schedule new switching activities

CONCLUSION

A Portuguese-Brazilian technology project for distribution planning and operation has encompassed many dimensions: one is the development of a management tool for investment studies; another is the development of a tool for management of switching schedules; another is the interface and communication with other corporate systems such as SCADA and GIS (SIT); and a most important dimension is the mutual enrichment that a successful binational project brings forth.

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