A CONFIGURABLE SOFTWARE PLATFORM FOR THE DISTRIBUTION NETWORK RESEARCH

D. VOIRIN, O. JEANNIN, P. HABERSTICH
Direction des Études et Recherches
Électricité de France
1, Avenue du Général De Gaulle, 92141 Clamart (France)
Tel : 01.47.65.43.21

SUMMARY

Whether concerned with medium voltage or low voltage, those responsible for distribution network planning must integrate a great many constraints: technical and economic optimisation, recent developments in voltage waveform regulations, diverse requirements by customers and authorities with regard to quality of the electric supply. Furthermore, the arrival of new protagonists, particularly the independent producers, makes the problem more complicated.

The approach undertaken by EDF aims to provide the research leader with a sample group of interfaced tools which covers all the current technical constraints and which is also able to respond to future problems. From the user point of view, this software platform must integrate several essential requirements: unification of the input, homogenisation of the interfaces, easy exploitation of the results, advanced openness and configuration, but also scalability and adaptation to different technical contexts. The tools recently created on the basis of such specifications have enabled EDF to construct an exportable offer in terms of distribution network planning systems.

After presentation of the computing solutions adopted to develop this group of tools, the article clarifies the results obtained to date and gives a detailed explanation of the potentials of one tool from the range.

INTRODUCTION

The investments devoted to the networks constitute one of the levers available to the distribution companies for improving the quality of the electricity supply, both in terms of LV and HTA: the use of this potential calls for the implementation of a sophisticated system of technical and economical rules, which has led EDF to gradually equip its research leaders with a whole range of decision-aid tools.

The software systems developed by EDF are today designed from a single technical consistency environment which incorporates different requirements: unification de data input, homogenisation of the interfaces, easy exploitation of the results, advanced openness and configurations, but also scalability and adaptation to different technical contexts. The refining of this computing consistency environment has been the subject of the MOSAIC project and from now on enables better control over the cost and leadtime components in the development of distribution planning tools.

In parallel, new requirements are emerging. Faced with low growth in demand, the focus is less on dimensioning new installations than on the quality constraints (break times, slow variations in the voltage, etc.), which are increasingly restricting.
The arrival of independent producers further complicates this problem, since the technical impacts are great. In particular, it is advisable, before setting up any production on the network, to check that this will not alter the quality of supply (voltage profile, in normal or emergency diagrams) as well as the safety of the installations (observance of the thermal stresses, adjustment of safety systems, short-circuit powers). Furthermore, the development of low voltage networks, the prime purpose of which is to control the slow voltage variations, must incorporate several new constraints, whether it is a matter of a recent change in the regulations or of requirements strongly confirmed by customers and authorities. The ESTERE tool developed around MOSAIC makes it possible to respond to this problem.

This article presents, firstly, the MOSAIC project and its results, then deals with the example of ESTERE.

ANALYSIS OF THE REQUIREMENT

In 1995, an analysis of EDF's software offer in terms of distribution network research highlighted the following assessments:

1 – Heterogeneity of the support platforms (Unix, DOS/Windows). The various planning products were using different man-machine interfaces for dialoguing with and displaying the network and were showing a number of redundancies in the functionalities, such as calculation of the electrical status of the network.

2 – Need for significant upgrades from the functional point of view. Some tools were becoming obsolete through their operating platform. At the same time, new requirements were appearing (see examples above).

3 – Lack of integrating architecture.
This led to a specific architecture for the product requirements not designed with a view to participation in a wider system for a job area: control, cartography, etc...

THE TARGET SELECTED

The analysis above led Electricité de France’s Study and Research Division [Direction des Etudes et Recherches] to consider a “guiding principle” for its future software developments, which has been divided up into multiple objectives :

A uniform offer...
To have a range of tools equipped with a standardised man-machine interface, enabling the user to quickly take things in hand.

A consistent offer...
To have a range of tools which interact with one another, and respond to complementary, non-redundant requirements.

An open-ended offer...
To envisage each development by way of an “insertion into the company information system” logic, whether it is a matter of EDF or of foreign companies.

A scalable offer with reduced costs and leadtimes...
To allow the addition of functionalities to an existing product without fundamentally undermining its architecture, or to create new products by using all or part of the products already developed.

The site owner thus sees a reduction in costs and production, upgrading and maintenance times. The user can more efficiently operate the different tools and optimise his studies. The architect can make his developments cost-effective and reliable. The distributor can offer an integrated system of network research products.

These different development principles have been given concrete expression in the form of a project called “Mosaic”, which lasted three years and was completed at the end of 98.

THE MOSAIC PROJECT

The fundamental objective of the MOSAIC project is to define a technical consistency environment for the development, upgrading and maintenance of network research products developed on PC under Windows in C++. Such a consistency environment may be divided up according to two main complementary lines: the development line and the communication line.

1. The development line

Objective: to define a development and integration architecture for making the developments in network research tools consistent and to define a target offer;

Result: a Windows PC development platform (C++ programming language) providing the developer with development assistance tools (for modelling, programming and tests) and with libraries of reusable components; a Windows PC test and integration platform enabling the product to be validated and accorded the MOSAIC label.

The *reusable software components* themselves are based on business C++ libraries. The development of a research system consequently amounts to assembling blocks, services and elements of a specific code (see figure 2, and definition of the blocks below).

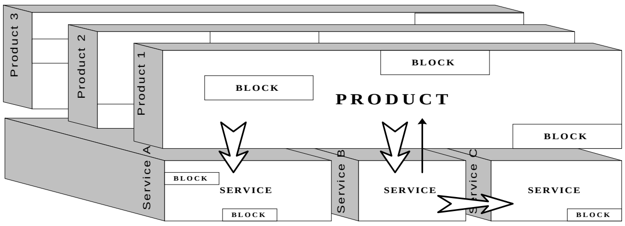

Figure 2 *– Principle for reusing software components*

The reusable components cover the following requirements:

- modelling of generic graph,
- modelling of electricity network,
- graphic network representation,
- management of the consistency between the logic model and the graphic model (representation server),
- network editing and cartographic editing functions,
- electrical calculation codes.

The identification and specifications of these functions, the list for which is not exhaustive, was the subject of a study completed in 96. The functional perimeter of Mosaic was not fixed for all that: new components are built into the Mosaic architecture as and when required (e.g.: calculation code for the “Criter” short-circuit powers in 98).
As a whole, these basic tools make it possible to quickly and more cheaply build an application framework onto which the calculation codes and specific Man-Machine interface are grafted. The developments produced from the building blocks take full advantage of the encapsulation and inheritance object designs, which guarantee scalability and openness.

Figure 3 shows the different software layers making up MOSAIC. They can be distinguished as:
1 – the lower layers, known as “blocks”: these are functions, or APIs (Application Programming Interfaces), for use by the development teams. They handle the graph and electricity network modelling, graphic representation, and making the graphics and application model consistent.
2 – the upper layers, known as “services”. These are either APIs (e.g.: calculation code) or software tools common to the software programs in the range (symbol editor, network editor, cartographic editor, control module for a table to be digitised).

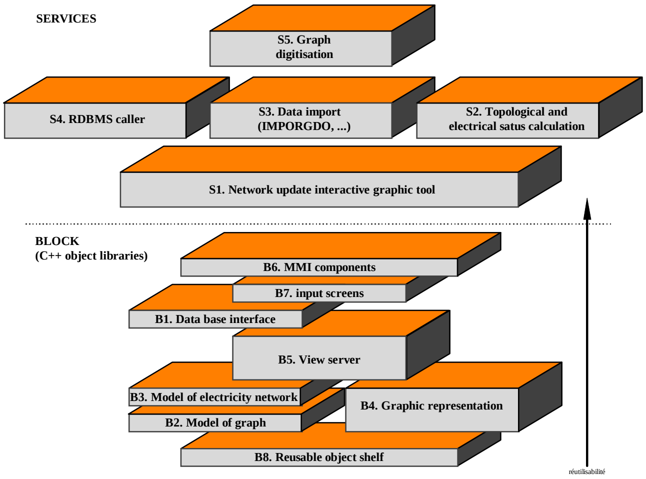

Figure 3 : MOSAIC software layers

2 - The communication line

The choice of a **communication architecture** is based on the following considerations:

- developing, using and organising the blocks and services described earlier as elements of focused target systems;
- integrating the existing components into the target systems as far as possible, without detracting from the homogeneity whilst retaining the scalability of the system;
- adhering as closely as possible to the most commonly used market technologies, with the same approach towards continuity of the system;
- to take advantage of existing software packages, by developing links with these systems.

Figure 4 shows an example of communication architecture, based on two frames of reference: the technical frame of reference and the geographical frame of reference. This architecture is inspired by the one that exists at EDF.

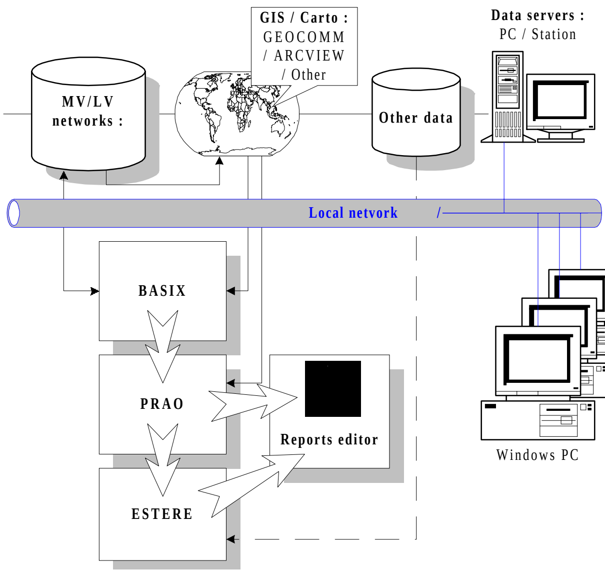

Figure 4 : Communication architecture

We are able to note on this figure:

- The communication [interaction] between tools: this is provided via a local network by direct communication with the data server (such is the case with the BASIX product, an updating and consultation tool in the technical data base) or by file swapping. The format adopted is the original format used for PRAO (decision-aid tool for MV investment choices). This format is built into all the range's products (PRAO, BASIX, ESTERE) ;
- The use of standard office automation tools (EXCEL® type) for presenting the results of the different research products. The facility for directly incorporating the product results into the reports is much appreciated by users;
- The connection to the GIS (Geographic Information System) world.

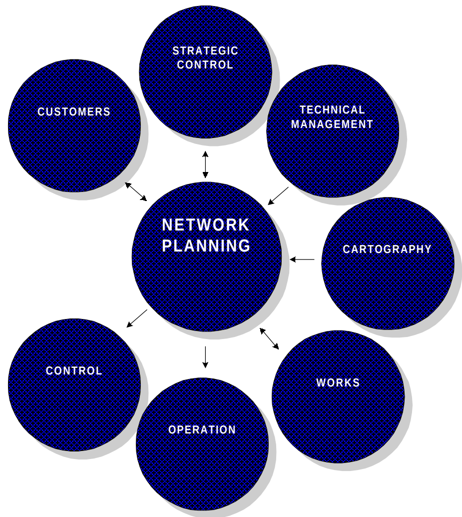

Figure 1: the areas connected with the network planning

On the matter of communication, the expectation of users relates above all to the openness of the tools to the areas of GIS, control and customers.

The GISs (Geographic Information Systems) contribute much more than just the plan production. They are increasingly found at the centre of the technical information system of companies and enable different data sources to be matched up with one another or with the site. Two business tools operating off NT are currently being studied within the framework of the MOSAIC project: they will be placed downstream of the technical information system (BASIX) and make it possible to implement a set of themes or the plan production.

The same concern relates to the **information arising out of the "control" and "planning" areas** (all the distribution company's technical and financial management comes under this term). Not being identical, the data bases associated with these two areas are, in practice, not connected and do not interact. Links are prototyped in order to join up the BASIX technical information system with the “remote-control” data bases produced by EDF (IN-PACT project) or by private manufacturers (SEVME or MORS).

Finally, links with the customer management bases make it possible to avoid duplicating inputs, a source of errors and a waste of time.

The present works are laying the foundations of what will be a future DMS (Distribution Management System) offer.

MOSAIC: THE RESULTS

MOSAIC has been used in the development of a number of software programs concerning the distribution networks:

- an MV works manager (BASIX), today sold on the international market.
- a voltage adjustment optimisation tool and planning tool for connecting producers to the HTA network (ESTERE V1 and V2),
- tools for updating MV, LV and gas technical data bases at EDF Centres (PANTER tools, in the process of being developed). They will make it possible to take advantage of standardised interfaces.

The following figure gives an idea of the gains afforded by MOSAIC with regard to the software production costs.

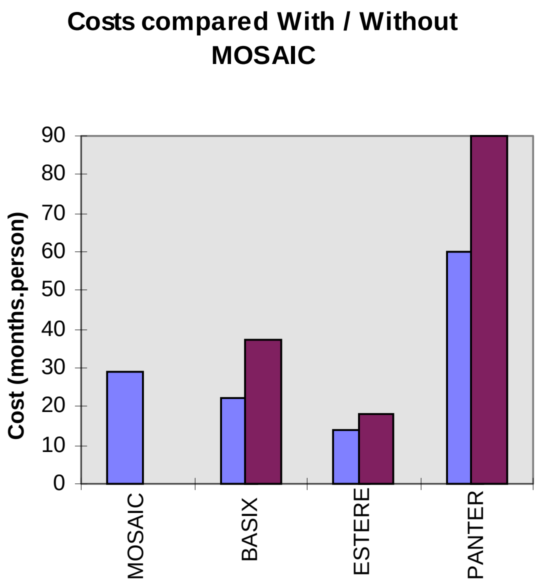

Figure 4 : Costs compared With/Without Mosaic

We see a gain of some 25% against the development costs, making it possible to recoup the initial investment (first column).

MOSAIC is not a fixed tool. The appropriateness of integrating such and such a service into the MOSAIC package is systematically analysed. If it is potentially reusable, it will be integrated into it. There remains the question of cost: a software component reputed to be reusable does not share the same development standards as a specific code (in terms of specification, documentation or tests). Going by experience, it is estimated that the “reusability” cost is up to 50% greater than a specific code cost. This cost is then recouped by the gains realised when coding the finished products.

A MOSAIC PRODUCT: ESTERE

Two problems led to the writing of the ESTERE tool: on the one hand, optimisation of the distribution network voltage plan, on the other, the introduction onto the network of decentralised producers.

Optimisation of the voltage plan

Context: the quality of the voltage is an important component in EDF’s reference offer and is divided up into two aspects as far as the slow voltage variations are concerned:
The French decree of 29 May 1986, applicable as from June 1996, raises the nominal LV voltage to 230 V and restricts the range of its variations to + 6 % / - 10 % around this value. The former contractual tolerances of 220 V + 10 % / -10 % thus become obsolete and the variation range for the LV voltage falls by 4 %.
With HTA, the Emeraude contracts in the process of being brought into widespread use commit EDF to deliver, in terms of a normal diagram as well as an emergency configuration, a voltage with a range of +/-5 % around a duly specified level (instead of +/- 7 % in the experimental Emeraude contract).
This reduction in the voltage variation tolerance (- 4 %) would result in a not insignificant financial effort on the part of EDF if only the conventional solutions for strengthening the HTA and LV networks were implemented.

Objectives: to offer a tool making it possible to optimise the adjustment of the LV voltage, based on the co-ordinated method for calculating the HTA and LV voltage plan.

Study of decentralised production

Context: we are witnessing a general trend, being the growth in requests for connecting up groups engaged in decentralised production over the networks. In France, this trend is association with the obligation to purchase renewable energies and energy produced by means of cogeneration (as well as at the ruling purchase rates), and could accelerate in the future with the opening up of the electricity market.
But so far the operators of distribution networks are relatively powerless to ascertain the constraints laid down by the connection of this or that producer to the HTA network or LV network. A decision-aid tool could, as a result, be extremely useful for making the right choices and saving precious time in terms of tedious calculations.

Objectives:

To discover the feasibility or otherwise of connecting a given decentralised producer at a given point. In order to determine the possibility of such a connection, the knowledge of the producer's P_{max} power and the minimum tgφ value he may have at his terminals are essential input data. In addition, the parameters of the voltage regulation at the source substation are also study input data. Two types of regulation are possible at the producer's terminals: a regulation for maintaining an active power P and voltage V set-point (PV regulation), or a regulation for maintaining an active power P and reactive power Q set-point (PQ regulation). The lack of a regulation is taken into account in respect of the asynchronous machines. In the event of connection proving impossible, the software must provide the operator with the data to enable him to confer with the producer, particularly in terms of induced constraints (thermal, straining [overvoltages], PCC, adjustment of the safety systems) on the network. The user will, if he wishes, also be able to determine the maximum power able to be connected at that point.

This requirement can be divided up according to the following question:

Is it possible to connect up a given producer at a given point, and what are the constraints? If not, what does the producer's maximum power need to be in order to be able to connect him?

Relevance of Mosaic

The relevance of integrating the development of ESTERE into the Mosaic project became necessary for the following reasons:

- the "conventional" modelling of the distribution network, enabling the direct reuse of the Mosaic components,
- the need to link ESTERE to PRAO. Thanks to a joint exchange format, PRAO's editing functions are directly exploitable in ESTERE, at no additional cost. The adaptation of ESTERE to the international market is made easier,
- the homogenisation of the graphic interface.

Feedback

The tool is currently in operation at EDF, awaiting its adaptation for the international market. Feedback at this time makes it possible to provide the following information:

Quick prototyping: A prototype created in a month has enabled the choice of Mosaic to be validated.

Controlled development: The coding phase for the product belonging to MOSAIC has been carried out in confirmity with expectations.

Validation of the relevance of MOSAIC: The structure proposed by MOSAIC has proven to be suited to the product. The same version of MOSAIC is used in a number of tools, which reduces the maintenance costs and enables greater stability of the code.

CONCLUSION

The development of the tool at the most effective cost initially undergoes a precise assessment of the requirements and validation of the specifications by the future users. But this is not enough. The project carried out by DER has enabled gains in developments by banking on the reusability of the codes (thanks in particular to the object techniques) and communication between tools, whether they are developed in-house or not.

Products such as BASIX, ESTERE and PANTER take advantage of these technical trends, to be benefit of the users, but also of the site owners. The developments produced have laid the foundations for a DMS (Distribution Management System) project complementing the EDF offer in terms of software programs.