SIMULATION TRIAL OF A PROPOSED MODEL APPLIED TO ENERGY CONTROL CENTER'S OPERATION AND MIGRATION STRATEGY

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ABSTRACT

This paper presents the considerations and first simulation trial of a proposed conceptual model for the definition of the current role and functionality of the Energy Control Centers (ECCs) of the Electrical Systems at the Central America region. The results of this trial and further ones are aimed to improve the proposed strategic plan for functional enhancement and eventual technological migration of the ECCs under study. [1]

The simulation is applied to the National ECC at the Empresa Nicaragüense de Electricidad (ENEL) in Nicaragua.

The ECCs are complex systems characterized by a diversity of process and subprocess, where hardware, software and human factors are involved. In addition, habitually the way of describing the ECCs is by isolated definitions or functions of its processes, not well documented relationships amongst them and it is usually understood its role in merely technical definitions.

The model and simulation approach is meant as a tool to provide closer estimates for the current behavior, integral view and further traceable migration strategy of such centers. The acceptance and conclusions coming from the model and simulations are used for defining, in an iterative way, a more *credible* model of the ECCs. The professionals involved in the ECC operation are the main source to validate the results.

The current model and simulation trial is based on the fact that the common attribute amongst the processes at the ECC is: information flow over the organizational structure. Here, SIMPROCESS [2] software is experimented as a dynamic and object oriented modeling and simulation tool to represent the ECC, starting at the information flow to a more detailed, feasible and integral definition of processes, activities, entities and resources.

1. Introduction

1.1 General background about Energy Control Centers (ECCs)

The ECCs are the nerve center of the Power System Network, the main activities of the ECC shall be summarized as follows: Generation–Demand Balance, International energy interchange, Power production control and supervision, Switching procedures, Power network maintenance coordination, Supervision and control of the power network stability, information source of the poweer system behavior.[3]

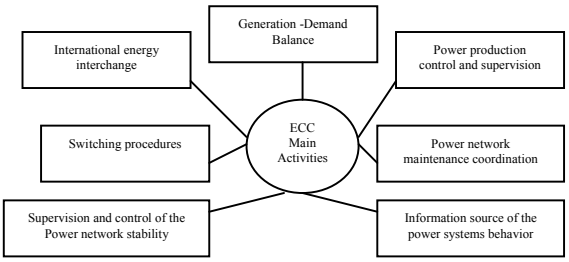

Fig. 1: Main activities of the Energy Control Centers (ECCs).

Despite of the widely accepted missions and tasks, the ECCs in Central America have very heterogeneous levels of maturity in the exploitation, resource capabilities, diverse national and organizational structure, data processing, software applications, hardware standards, operational procedures, etc. In this way, the ECCs becomes a complex systems characterized by a diversity of process habitually described by isolated definitions or functions, not standards documented relationships and its role usually understood merely in technical definitions [4].

In the Central America region, there is a plan of a complete Regional Electrical Interconnection and National Deregulated Power Market evolution. Such dynamic conditions are going to demand to the ECCs a closer interchange of information, standards coordination, and new functionality in general. As a first step facing

such regional coordination there is a Council of Electrification of Central America (CEAC). which main responsibility is to promote multilateral agreements for energy interconnection and optimize the regional energy sources

It is usual that a new functionality definition at the ECC is defined from a merely technical perspective. This procedure is underestimating the organizational impact and the potential considerations as a system of collaborative and interrelated "parts" already doing technical tasks and sub-tasks at the Center [5].

1.2 Methodology

Following the proposed strategic plan, presented in section two, for functional enhancement and eventual technological migration of the ECCs, we need to set up a current model of an ECC. In this case the National ECC at the Empresa Nicaragüense de Electricidad (ENEL) in Nicaragua. Such model was based in the current organizational structure and the information flow amongst the organization. We received a valuable and open help from the professionals working at the ECC.

The work was focus in understanding the information details, interchanged internally at the different *processes* at the ECC. We defined the external boundaries of the model as the *processes* directly receiving or transmitting data or information to/from the ECC.

The current trial, model and simulation, was conformed by the organizational structure as *processes* and the information exchange detailed as: origin, periodicity, feedback, processing procedures, resources used for processing, time of processing and destiny.

It was decided to experiment with SIMPROCESS software as a dynamic and object oriented modeling and simulation tool to represent the ECC. The animation facilities and dynamic modeling flexibility were the most inducing arguments in such decision. Nevertheless, we are studying other software and methods that can better fit in the purpose of the functional model of the ECCs and its complexity.

Presenting the results to the professionals at the Nicaraguan ECC did the validation of the model and the simulation in each stage. From them, it was taken suggestions and clarification of the functionality of the declared processes.

1.3 Outline of the paper

The section two, presents the concept of the proposed strategic plan for functional enhancement and eventual technological migration of the ECCs. The section three presents the considerations about the model and first simulation trial of the ECC in Nicaragua. Finally the section four gives some conclusions and lessons learned in this first trial.

2. A strategic planning approach for functional enhancement of the ECCs.

The planning approach is interpreted as a evolutionary path where the existing ECC is transiting with long-term goals (i.e. a better operational behavior and under needs technological migration of the ECC). Such plan is transformed to short terms iterative phases and objectives in the frame of its main constraints, economical limitations and functional specifications.

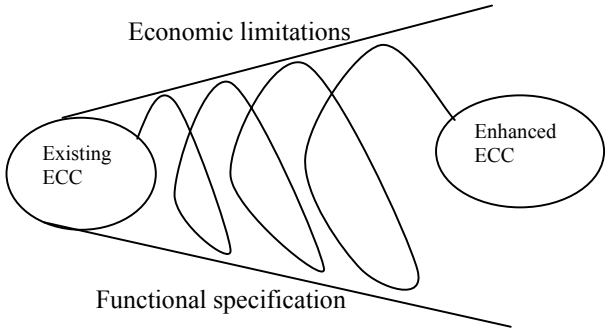

Fig 2:. Evolution path for ECC enhancements

The strategic plan approach is defined in the following phases:

2.1. Understanding and definition of the current role of the Control Center

The first phase of the strategy proposed, and the very core of the whole approach and this paper, is to define the current ECC role and operation as a interrelated system of *processes*[1]. These *processes* must have clear and simple definitions and knowledge of the output, task and sub-tasks, inputs and interrelation to other *processes* and the technical needs[2] for doing the tasks.

This phase will clarify and systematize the typical informal, pragmatic and intuitive knowledge at the Control Center. Facilitating future references and traceable evolution.

[1] Process: office/module/functionality/application software.

[2] i.e.: computing speed, information age availability, accuracy, more information requested from RTUs, resources to be used in general.

2.2. Formal Description of the emerging need

This step must deal with the clear way of defining emerging needs or new functionality to the ECC, in the context of the Utility expansion and evolution. This will be the assessment platform for the reasons inducing some changes (new functionality, performance changes, new application software, etc.) at the ECC.

The emerging functionality or need has to be defined in such way that is comprehensive and coherent with the *process* definitions in 2.1. Understanding and definition of the current role of the Control Center.

In this point we have seen that the new needs reported to the ECCs are increasingly influenced by demanding Management access to information or reports.

2.3. Definition of the effects and the demanded changes of the emerging need

In this phase must be done a trace of the impact, extent of the technical and organizational changes demanded by these emerging needs or new functionality in the current model of the ECC. The new need emerging, is understood in coherency of the *process* definition, will be addressing the changes or necessary improving in functionality and performance standards. (i.e., reliability and capability of the hardware, communication speed, software, interfaces of data, etc.) at the currents *processes* or new *process* of the model of the ECC.

Some restructuring in relations, interchange of operation can be foreseeable as solution. In short, covering the emerging need trying to optimize the resource available, using as a key information the comprehensive models in 2.1 Understanding and definition of the current role of the Control Center confronting it with the definition on 2.2. Formal Description of the emerging need

After the result in this step, it must be a reevaluation to the step 2.2. Formal Description of the emerging need, in order to reconsider the extent of the emerged need or functionality and if this worth all the impact and changes to be faced. It is a common trend to over size the extent of the needs, especially when the cost, time and efforts are not well known.

2.4. Recommendation of the source, requirements and specifications of the solution to the demanded changes from the emerging need

This step is the evaluation stage for taking the decisions about if the solution can be found inside the Control Center it self or in the commercial vendors offers and the decision of the need for consultants.

The most important objective here is define the requirements and specification for integral and open solutions, tunes with standardization trends of the technology available, and avoiding some short vision solutions with proven or foreseeable rapid obsolescence.

Here a reevaluation of the step 2.2. Formal Description of the emerging need, could be done because some added requirements on the solution's demands, as maintainability, efficiency on the solution, portability, reliability, etc., could need some reconsideration on the extent of the defined emerging need.

In this phase it shall be decide how to proceed in the implementation of the work for the fulfillment of the emerge need or *process*, both in the organizational and technical areas.

2.5. Validation and Verification of the solution to the described emerging needs

A validation and verification procedure of the solution to the emerged need must have the final assessment about the solution. This is also a tool for the acceptance and final test on the solution achieved. Once the ECC and the Utilities have the comprehensive declaration of the need, this declaration must have the property of validation and verification.

2.6. Addition of the solution of the emerged need and new functionality to the role of the Control Center

As the model is evolved permanently, whatever instrument choose, has to be defined with flexible properties, in order to update the new *process* structure of the Control Center, once the emerged need or new functionality is implemented. The model, the statements used for the *processes* definition , have to be easily updated and remaining simple and comprehensive.

It is clear that, in the way proposed, the maturity in the exploitation and the understanding of the Control Centers will grow up with better roots on the people and on the real needs, because the changes or additions are taking place step by step and systematically seen.

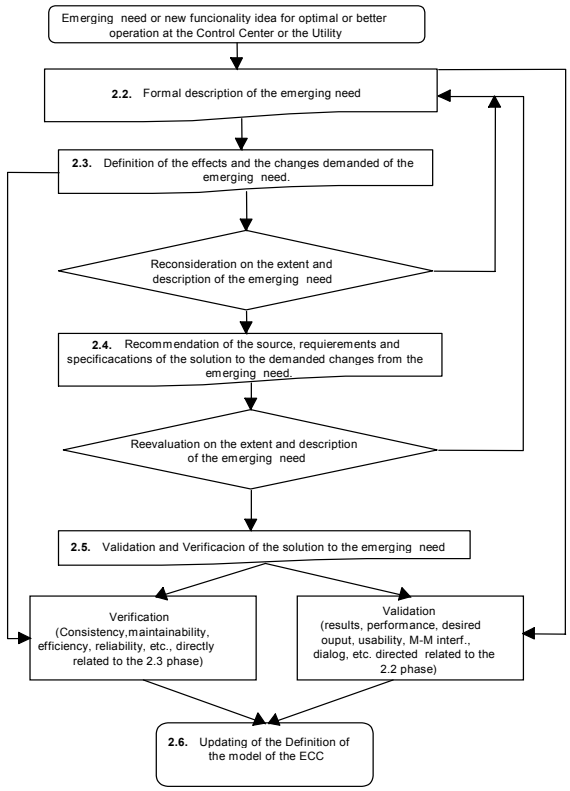

Fig. 3: Summarized procedure of the Strategic Planing Approach proposed. It shall be notice the iterative development characteristic

3. Model of the ECC implemented on SIMPROCESS and consideration of the first simulation essay

As it was said above, the dynamic model of the current operation of the ECC is the core of the strategy proposed. The model here presented have been constructed following the definitions of processes, activities, resources and entities.

A process is a collection of activities and subprocesses, organizing the model network of the system under study. An activity is the basic step in a model, where an operation is performed on an entity with the possible use of resources. An entity or flow objects is the flow of any type of objects (e.g. data, information, reports, commands, SCADA measurements. etc.) from activity to activity. A resource is an agent that is required to perform an activity (e.g. software, computers, engineers, fuel, etc.).

The model of the ECC is created "AS-IS", which reflect the current state of the operation and functionality. Based on the outcomes of various refinements (validations) at the model (more *credible* one after each validation) and simulated scenarios, the "AS-IS" model could be modified to arrive at "TO-BE" model.

For this ECC model we define a set of assumptions:

- The entities are considered deterministic, except for power network failures and alarms coming to the SCADA systems.
- The boundaries of the modeled ECC are the direct connection to the external processes which send or receive entities from any process of the ECC. (i.e: INE, RedEP., GENCA, GTran, GGen, GMantSP)
- The internal processes of the ECC where chosen from the organizational structure of it, following the "As Is" approach.
- All the entities are considered with the time of execution and delays from activity to activity.
- In this first trial, we don't consider financial cost as resource of the activities and entities.
- The understanding process of the ECC was made trough the interview to the professional at the different levels of the organization of the ECC.

The result is a model with processes expressed in layers, where each processes contains a deeper layer of subprocesses and activities. The first layer is showing the ECC external boundaries and relationships.

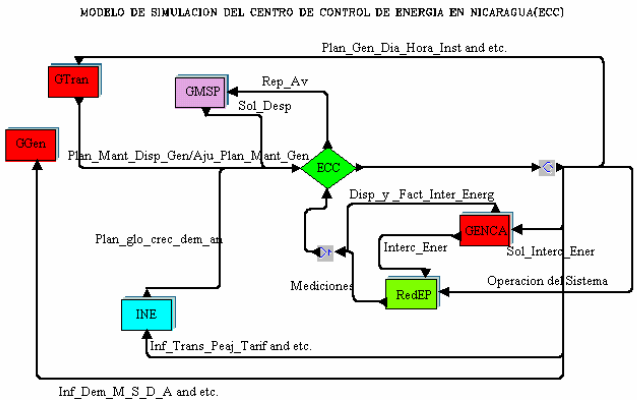

Fig. 4: General structure layer of the model of the ECC and its relantionships with the boundaries processes.

In this general structure layer we can see the various processes which interplay with the ECC trough various paths, interchanging different kinds of entities. Such entities where defined based on the real operational performance from/to the ECC.

The boundaries processes defined here are: INE (National Energy Regulatory Board), RedEP (Power Electrical

Network), GENCA (Energy Generation Plants in the Central America tie-lines), Gtran (Transmission Network Management Authority), GGen (National Generation Management Authority) and GmantSP (Power Network Management Direction).

The ECC itself is, in general, modeled by the next figure.

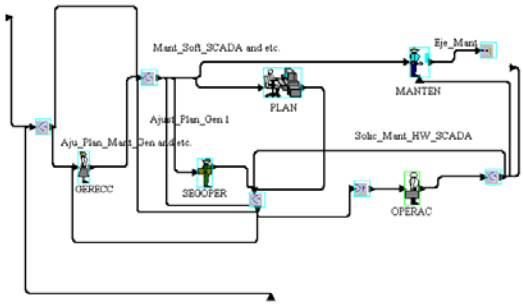

Fig 5. Inner model screen presentation of the ECC

The structure of the ECC consist in five main processes, *GENERAL MANAGMENT*, *SECURITY OPERATION DEPARTMENT, PLANNING DEPARTMENT, HARDWARE MAINTENANCE DEPARTMENT AND OPERATIONAL DEPARTMENT*. Each of these processes consists in subprocess and activities.

In the screen shot presented it can be seen the entities: *GENERATION PLAN BY YEAR, MONTHS, WEEKS AND DAY; ADJUSTMENT TO THE MAINTENANCE PLAN; MAINTENANCE OF THE SOFTWARE OF THE SCADA SYSTEM; MAINTENANCE EXECUTION; INTERNATIONAL ENERGY INTERCHANGE AVAILABILITY; ENERGY INTERCHANGE REGISTRATION and MEASUREMENTS OF THE ELECTRICAL PARAMETERS OF THE POWER TRANSMISSION NETWORK,* flowing from process/activity to process/activity.

During the simulation we observed and measure the performance parameters of each activity and entity, so the whole process. Since it have been defined the resources it can be seen the use of common resources or overload in some of them.

As basic blocks to model the processes we used:

- Generate activities: Generate the arrival of entitities into the model or process. It can have values for arrivals times, quantities,frequencies and ocurrences.

- Dispose activities: Disposes of the entitities when they are finished with processing.

Delay activities: Represents the time consumed or waiting time of an entity to be executed or transformed.

Transform activities: Is an activity that converts an incoming entity into another entity.

Branch activities: Allow us for defining alternatives routings for flow objects or entities. It can be arrange based on a probability or a condition.

Merge activities: Provides a mechnism for merging a number of connectors into a single connector.

Get resources: Provides a mechanism for capturing resources that may be used for a number of donwstream activities or entities.

Free resources: Provides the mechanism for releasing resources that were captured by a Get resource activity.

The current model has thirty five processes, seventy activities, fifty entities and forty resources.

4. Conclusions and lessons learned in this trial

In the validations of the current model, we confirm that the use of an integral tool to view the operation of the ECC is very welcome from the people involved on it. Specially when the model and the simulation are animated and hierarchical presented. The main reason for such *credibitity* is that the current model is attending the ECC "AS IS" and no theoretical neither sophisticated relationship is assumed or presented. The model is accepted as valid in the same magnitude as the entities of each interviewed were seen in action inside of his/her process and the immediate limits. The user can check the topology of the processes and then run a discrete event simulation to evaluate performance measures such as resource utilization.

From this trial, we can notice that when a not integral view is present, the technical systems often stress upon performance and accuracy of individual units. This implies the assumption of independence, that these units contribute separately to throughput and that the contributions can be measured separately.

The concept of information or entities flow was crucial to the smooth understanding of the dynamic nature of the ECC.

We defined an information or entity flow as a collection of coherent sequences of interactions, which complete the various responses that a process can make to an input or

specified function. The information or entity flow has two main features: interaction and sequence.

In this first trial, the interactions were easy to track, the sequence and synchronization of entities or activities was a tremendous obstacle. The current model specification lacks of a reliable entity synchronization at the activities.

The current model also lacks of a deep definition of resources, due mainly that the resources for the activity completions are sometimes used but not fully recognized or documented.

The simulation shows a saturation and overload of the alarm processing and presentation of the current state of the Power Network in the SCADA's man machine interface in the disturbance situations (hundreds of alarms signal from the power system). This obvious result can be seen without a model or simulation, it is a reality already experienced by the personnel at the ECC. Nevertheless, this result validated our first simulation trial. The integral view from some of the personnel of the ECC lead to the conclusion that enough information can be get directly from the modems carrying the alarms signals to the main SCADA system, in order to have in a faster way a representation of the status of the power network. The crew of the ECC designed and installed a listener (SCADITA) for such disturbance situations with a full success.

A more refined model shall be achieved for deeper results and statistical reports, especially about of the use of the resources and synchronization of events. The refined model will take in account the lacks here expressed.

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References

[1] L. Plazaola, "Control Centers' Upgrade in Central America: A strategic planning process approach", IEEE/KTH Stockholm Power Tech Conference 1995. Proceedings on Information and Control Systems, pp 105-110.

[2] SIMPROCESS is commercial software for modeling and simulation registered as trademark of CACI Products Company.

[3] Cegrell T., "Power System Control Technology". Prentice Hall International, 1986.

[4] Plazaola L., "Characterization of the Power Control Centers in Central America. Study Case: Nicaragua",Internal Report, 1992.

[5] S.D. Bird and G.M. Kasper, "Problem formalization Techniques for collaborative Systems", IEEE Transaction, System, Man and Cybernetic. Vol. 25, No. 2, pp. 231-242, 1995.

[6] G.A.Sundstrom and A.C. Salvador, "Integrating field work in system Design",IEEE Trans, System, Man and Cybernetic. Vol.25,No.3,pp.385-389,1995.

[7] SIMPROCESS User's Manual, 1996.

[8] Reportes internos de los centros de control de ENEL (Empresa Nicaraguense de Electricidad), 1985-1996.

Biographies

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