Distributed Systems of Control Specialists for Power System Operations

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EDRC 18-29-92

DISTRIBUTED SYSTEMS OF CONTROL SPECIALISTS FOR POWER SYSTEN OPERATIONS

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Abstract

Keywords:

INTRODUCTION

In its operations, every electric utility must deal with exogeneous phenomena which it can neither controll nor predict with certainty. These phenemona include certain customer demands, transactions with neighbouring utilities and sudden disturbances or failures (called contingencies). To counteract the ill effects of these pheneomena, utilities use a mix of proactive (feedforward) and reactive (feedback) strategies for the real-time control of their networks. These strategies work very well and have allowed U.S. utilities to provide their customers with service of exceedingly high quality. The question is: when, if ever, will the existing strategies require a major renovation?

The operating environment for U.S. utilities is in the beginning of a period of rapid change. Some of the indications are:

- Customer demand is growing faster than system capacity. As a result, equipment usage is increasing and energy is being shipped over greater distances.
- The unbundling of services being required by deregulation will cause profound changes in operating practice. For instance, the familiar notions of costs and losses will have to be replaced by the unfamiliar and more complex notions of revenues and profits as operating objectives.
- NUGs (Non-Utility Generators), load management technologies and other additions to the and other artifacts of deregulation are proliferating.

• Environmental concerns are increasing in importance and will will play a larger role in operations.

We feel that the best way to adapt to the growing complexity is to restructure the computer-based decision support system used in energy management systems. In the succeeding material we will elaborate on this theme. Emphasis on dealing with contingencies

DECISION MAKING CELLS

The real-time control of power systems is too difficult to be handled by one human or computer-based tool. Rather, it requires an organization of many and humans and tools. We can, without any loss of generality, think of such an organization as an interconnection of cells, each of which contains a human and some tools (Fig.1).

Current structure: tools are numeric and primarily for monitoring or analysis, like state estimators, load flows, etc. (knowledge-based programs are present but in vanishingly small numbers), prescriptive tools, like AGC,are definitely in the minority; interconnections among tools are "hard wired";-----

Disadvantages:

• inflexibility: getting a new tool in, like a new state estimator, can take months of effort (especially new type of tool)

• limited expandability: no intelligent supervision of numeric tools except that provided by the human. Therefore, we cannot insert more tools than the human can supervise. For example, no point in putting in two different optimal power flows unless the human learns how to choose between their recommendations when these recommendations are different.

• information overload: numeric tools tend to produce numeric results in enormous amounts--human has difficulty comprehending such results--example: bursts or alarms, long lists of constraint violations from contingency evaluations.

• mostly analysis and predictions from tools, prescription is left to the human

• no capacity for automatic learning: the only learning that is done is by the human.

ORGANIZATIONAL ALTERNATIVES

How can we eliminate the disadvantages? Need a different scheme for organizing tools. Some sources of ideas: human organizational theory, animal and insect societies, biological models such as neural nets, AI-developed models for cooperation such as blackboards. We do not have the space to describe all the alternatives these sources suggest. Instead, we will outline a taxonomy of organizations for computer-based tools. This taxonomy consists of a number of dimensions, each denoted by a double whose entries are the extremes of the dimension. Thus, the double: **[symbolic, numeric]**, means a dimension stretching from symbolic tools through intermediates such as neural nets to numeric tools.

The dimensions, divided into six categories and with some very brief explanatory notes, are listed below.

- **tool type**

1. [symbolic, numeric]

2. [autonomous, non-autonomous]

By "autonomous" we mean a tool that is completely independent, that decides when and what to do and has the resources to implement these decisions.

- **architecture**

3. [tree, hetrarchy]

By " architecture" we mean both the supervisory structure (who reports to whom) and the communication structure (how tools exchange data). By "tree" we mean a hierarchy whose lines of authority and communication are coincident and form a tree. Thus, a tree allows for no direct communications between members in the same level. By "hetrarchy" we mean a leaderless group all of whose members are of equal status, such as a neural net or a school of mackrel. Thus, the only communications in a hetrarchy are between members in its one and only level.

- **control**

4. [serial, asynchronous parallel]

5. [synchronous, asynchronous]

By "control" we mean how tasks are to be performed. A synchronous parallel process is one in which all the steps and the order in which they are to be performed are predetermined. In an asynchronous parallel process, tools interact spontaneously or opportunistically. To illustrate the difference, consider the pair of equations:

$$x = f(x, y)$$
$$y = g(x, y)$$

A synchronous algorithm for iteratively solving these equations is:

$$x_{n+1} = f(x_n, y_n), \quad n=0,1,\text{-----}$$

$y_{n+1} = g(x_n, y_n)$, n=0,1,-----

An asynchronous algorithm for iteratively solving the equations is:

$x_{m+1} = f(x_m, \underline{y})$, m=0,1,-----

$y_{n+1} = g(\underline{x}, y_n)$, n=0,1,-----

where x and y are the latest available iterates of x and y. In the asynchronous algorithm, the computations of x_{m+1} and y_{n+1} are allowed to proceed independently and one cannot, in general, predict exactly when they will exchange data. Therefore, asynchronous parallel processes cannot be simulated on single processors, as synchronous processes can. For further details see EPRI report.

A-TEAMS

Our goal is to develop organizational schemes for extending the performance, function and flexibility of tool-kits. By "performance" we mean the speed, reliability and accuracy of computations. By "function" we mean the sorts of computations that can be made. By "flexibility" we mean the ease with which the kit can be changed, that is, tools added, architectures modified, or new mechanisms for task and information handling included.

Unfortunately, there are no systematic ways to design or analyze organizations. Therefore, the selection of an organizational scheme is largely a matter of intuition. Our intuition leadsus to seek performance through distributed processing,

to _tool type: mixed (symbolic, numeric and sub-symbolic, if necessary)

_ architecture: loosely coupled, modular hierarchy (semi autonomous tools)

_control: distributed, asynchronous, opportunistic

advantages/disadvantages

CONTINGENCY TREES

_need

_brief description of CQR--addition of knowledge based programs to security assessment scheme

_ use: copies of CQR asynchronously updating contingency tree

PLANS

- control specialists

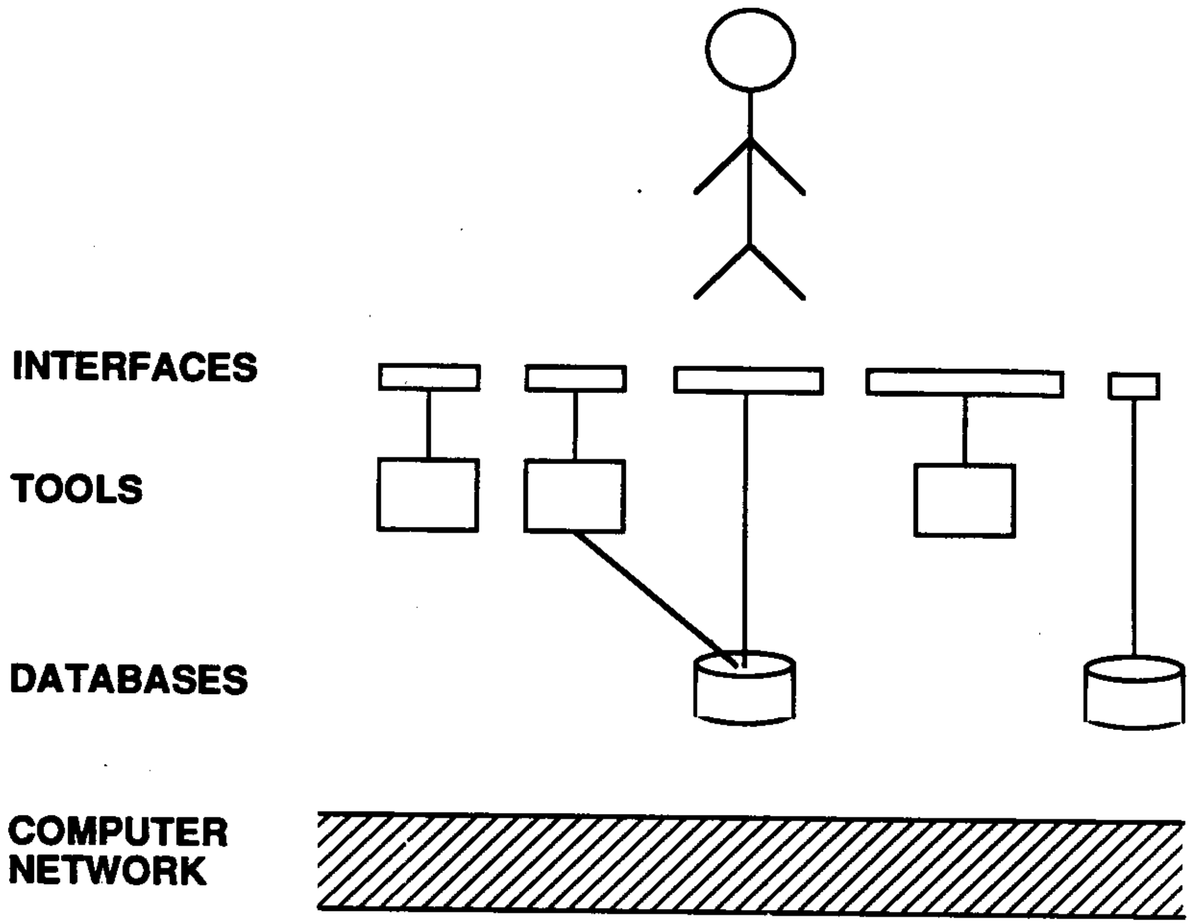

Fig. 1 A decision making cell

Current decision-support facilities (Fig. 1) tend to be stand-alone tools with little interaction with each other. Many of these have their own output interfaces (even if their displayed on the same console), leading to potential distraction of the operator during critical circumstances. Such tools thus have poor communicating mechanisms, both between themselves and with the operator. Many of these are custom-built numerical tools which are black-boxes as far as the operator is concerned. Thus, such tools are highly inflexible, and have very limited rationality. Also, these tools have no potential for incorporation of automatic learning capabilities. These failings are largely organizational failings, and we will discuss alternatives in the next section.

CONCLUSION

REFERENCES

[1] Richard D. Christie, "An expert system for on-line power system security assessment", PhD thesis, CMU, July 1989.