A CONCEPTUAL ROLE FOR MODERN INFORMATION SYSTEMS IN MANAGING EMERGENCIES IN ELECTRICAL POWER NETWORKS

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ABSTRACT

The subject paper presents a conceptual scheme for data acquisition, analysis and diagnosis of electric power system disturbances utilizing the high-speed capability of supercomputers. The scheme applies three major parts, namely:

1 -A Supercomputer architecture provided with a data base base management (DBM) system, and placed atthe energy system main(highest control hierarchy) center.

ii -A modern SCADA(supervisory cotrol and data acquisition) system linking the main center with remote (Slave)Stations(power stations or substations)which are provided with RTUS and other elements.

iii -A high speed communication techno logy for data transmission between the main and the slave centers.

The paper provides a rational for deci sion of the most appropriate technology among:

- SIMD(sigle instruction streammultiple data stream) vector machine or MIND (multiple instruction streammultiple data stream) multicomputer system.
- parallel vector machines with single and multiple pipelines.
- The fastest known communication technologies, namely; coaxial fiber-optic cables, or satellite radio system.

At last, the paper draws recommendations for the most promising technologies, from author's point of view.

1- Power Utilities and systems

A power system is always subject to unforeseen disturbances of different kinds covering a wide spectrum raging from small kicks in voltage or frequency up to hazardous accidents leading to partial or even complete blackouts Identification of such disturbances with the appropiate apeed,e.g. on real time base, will undoubtedly contribute to power system service continuity, reliability and hence to the adtional or macroeconomy. Before proceeding further in the subject of power systems disturbances, it is worth noting the main differences between one power utility or system and another. These vary in many respects like:

a) Main system Features: power systems vary according to size(MW interconnection) and geographical coverage.

b) Main structure, i,e,if a utility is centrally situated within a much larger interconnection, or either a utility not interconnected with neighbours or by far the largest partener in an interconnection.

c) Network Sub-Classification i.e.a utility having a multiply meshed transmission system with dispersed generation and demend, or a utility having a lightly meshed transmission system with stability or voltage rather than themal limits.

d) Control structures implemented in various utilites may be classified into six levels:

- SC: Central or coordination center for an internatial interconnection
- NC: National Control Center of a country
- MC:Main Dispatch control center of utility or a group of utilities not covering a whole nation

- RC: Regional Control Center
- AC: Area Control Center

2- A Concept For System Control Scheme

SCADA equipment should be installed at system control center (which may be SC, NC or MC mentioned above, whichever is highest level available in the system). These may include:-

a) A supercomputer architecture for numerical applications. This can be based on either of two major principles;
   - SIMD vector machine

   or - MIMD multicomputer system.

   The supercomputer architecture should also be designed for reception of the high rate data acquisition, besidesother control applications.

b) The system control center should also inrolve the routine equipment like,e.g, two console-mounted master terminals (a main and a stand by), a common console containing a remote (or slave) station simulator, a main-to-stand by processor switch-over, and a station indicator and control panel of uninterruptible power supply (UPS). These besides other I/O devices like multi-colour visual display units (VDUs) with keyboards, chart recorders (dual or multi-pen), a test RTU, printers disk drives (for each processor), ... etc.

3- Conceptiual System's Functions

These may be classified into normal, and additional duties. The latter in turn is subdivided into permanent and occasional.

a) Normal Duties: The function of the system during normal, or non-drastic disturbances conditions is described as follows:-

i - Supervisory Control, Commands can be sent from the SCC (System Control Center) to slave (or remote) station units to open or close circuit beakers, raise or lower taps on voltage regulators or transformers or perform any remote function that can be controlled by one or a series of binary switch openings or closings. It may also include load-shedding feature programmed to operate selected feeders.

ii- Data Acquisition; RTUs accept and transmit to the SCC binary indications both permanent and fleeting, analog values, and pulse accumulator indication. This allows data to be collected on circuit breaker status, and operation, voltage, current, KW KVAR, and KWH.

iii- Monitoring: At the SCC console, the system is to be configured to poll all remote (slave) stations sequentially for data.

IV- Status Monitoring: The displayed status of field devices is refreshed periodically by the master interrogates all RTUs in sequence. Status is stored in the master station's data base (DB), and may be called up for interactive display on to independent CRT/Keyboard operator's consoles.

V- Analog Monitoring: Analog imputs are digitized by the RTUs and reported to the master station. This latter provides automatic scaling of reporoed values into engineering units

VI- Pulse Accumulation: Pulse inputs are accumulated at each RTU, and are frozen and read hourly by the master station.

VII- Display and Record: At the SCC, the outputs may be presented by hardware devices in the operating console like audible alarms in case of uncommanded changes of system state, visual display units to read data on command, besidesreading real time and historical data, Printers which are to be interconnected to the processor and the VDUs, thus logging data reports events in a hardcopy form, a switch to transfer from main to standby processor, a mimic simulator (for slave substations) should be provided to permit the operator manual simulation of tast RTU parameters.

VIII- Θperational Control: At the VDU keyboard, audile alarms will be acknowledged and supervisory - control commands issued as required In sddition to real rime operations the keyboard serves as the user's point of entry for initial system configuration and for DB Programming.

Ix - RTU/Master Communucation: The for mat for communication is :

1-Master interrogation, RTU(slave) response. The master interrogates a giver slave(RTU),then waits a predetermined interval for a response if response received then function preceeds to next RTU.

2-When a potential disturbance occurs, an informal signal is dispatched to the master station(SCC) with the logical scale describing the main features of the disturbance.

3-The master station(SCC)dispatches all RTUS; at each potential change in system's configuration or status; computed values ofequivalent e.m.fs agles and impedances, of the system, reflected at eash station bus.

b- Additional Duties: The technology of power system automation assistance of computers is progressing rapidly. Inspite of this fact, still there is much to be done, especially for diagnosis of disturbances on a realtime base. Actually, this latter idea is the base of our proposal to introduce the supercomputer and this to benefit from its capability in this respect. The function of the supercomputer architecture; which should be situated at SCC; may subdivided into permanent, and occasional(fleeting duties).

b-i) permanent Duties, i.e.,duties to be performed irrespective of existence of disturbances. These include computation of :-

- Equivalent system impedanves(or admittances)reflected at each RTU bus. This covers, positive and zero sequence values.
- Voltage angle at each bus, referred to swing bus.

The above values should be updated at each potential change in system topology, generation value or mix, or damand. The above mentioned be issued to all slave stations. Another duty is to update computations for the moust probable types of disturbances, generate corresponding logical scales which should be classified according to type andloca tion(nearst bus) stored.

b-ii) Occasional Duties i.e., when need calls, mamely after drastic disturbbances in the system. These duties are discribed as follows(with reference to Fig"1") *

1-The SCC collects all logical scales coming from the different stations.

2- The supercomputer sorts these logical scales(L.S) to find out the nearest bus to disturbance

3-It compares; for the nearst bus to disturits computed and observed L.S if this results in 100% coincidence, then the disturbance now is defined; typewise and locationwise. Hence corresponding countermeasures should issued to SCC and slave station.

4-If the 100% coincidence is not realized, then the program should should select the three programs realizing the highest % age of cioncidence, and recompute them; with fresh data (updated) and hence repeat the checking for concidence's procedure. If the 100% coincidence is realized, then repeat process. Otherwise a report should be generated issued to SCC and slave stations. This report should brief:

- The most probable type of disturbance (the above mentioned three programs in descending ordrder of % age of coincidence), and nearest bus to it

*C.M, 3RP designates countermeasures and report of 3 programs respectively.

The corresponding countermeasures versions.

4- A Supercomputer at SCC. Is It a Necessity?

It is well known fact that supercomputers obtain their performance from two contributing factors. Firstly they operate at the highest posible speed technology can provide.

Secondly, additional performance is gained through parallel processing.

If we inspect the conceptual system's function in Sec. (3), we can easily reveal that, to perform both the permanent and occasional duties, the only feasible solution will be the supercomputer with its associated ultra-high processing speed.

5- Software Problems and Adoption of Supercomputer Mode

An algorithm may be generally defined as a partial order of operations, the partial order being determined by the data dependencies between the operations. We call the parallelism of an algorithm explicit if the data dependencies are well - defined by the nature of the data types to be processed, and consequently are known a priori. We call the parallelism implicit if it is not a priori known, but must be determined through data dependence analysis.
Unlike implicit parallelism, explicit parallelism can be exploited with minimal control overhead, using either one of the two strategies known as:-

- The SIMD mode of operation
- The MIMD mode of operation

The decision between the two architectural forms involves a tradeoff between the high cost effectiveness of SIMD mode and the higher flexibility of MIMD mode.

Electric power system application packages are mostly written in FORTRAN. Creating, or even rewriting, these packages in 3- dimensional form will be very laborious task, and needs the cooperation between interested institutes and software houses all over the world.

Historically the parallel processing user has been a rather knowledgeable scientist or engineer who is willing to assume the burden of creating application programs, using rudimentary environments. Detailed architectural and operating system knowledge as well as the intricate ability to manually map parallel algorithms onto a virtual parallel architecture are some of the hurdles such users had to overcome.

But there is a questionnaire that may arise here, that is "which type of supercomputer shall we start with; single pipeline or multiple - pipeline vector machines?

Before answering this, we may cast some light upon programming both types of machines.

- Programming of single pipeline vector machines, usually is carried out in FORTRAN. A number of vectorizing compilers have been developed which map the inner loops of conventional, FORTRAN programs onto the vector operations of the machine.
  The conditons under which such a mapping is possible and the techniques involved have become a well - understood topic.
- Multipipeline vector machines are presently programmed in a multitasking manner. Typically a task is a part of a program that can be run in parallel with some other parts of the program. The work to be done is partitioned into at least as many tasks, or processes; as there are pipelines. The system then maintains a task queue to which an unoccupied pipeline can go in order to find a task to execute.

To conclude this section, one can come to the concluding remarks:-

i - Most of power system disturbances analysis programs are based on linearized models. With this fact in mind, these programs may be considered of the explicit type or in other words, data dependencies are well defined by the nature of the data types to be processed.

ii- In the 1st stages; i.e during the first few years, the power engineers should be involved with creating or even rewriting power packages for parallel processing machines, so it may be wise to assume a SIMD vector machine operating with a few number e.g. up to 4 of pipeline processors

iii- The application programmer is assume to be a knowledgeable system programmer capable of using low level multitasking tools.

6- Adoption of Communication Technology

A wide variety of communication techniques have been investigated to make suc real-time automation possible. 9 potential technologies fall into 4 groups:-

i- Physically connected media, including wire lines, coaxial cable and fiber-optic cable.

ii- Power-line media, including distribution line carrier communication and power frequency communication.

iii- Electromagnetic propagation media, including UHF/VHF radio, AM/VHF radio, and spread spectrum Satellite radio.

IV- Common - carrier media, primarily telephone company lines.

Needless to say, that the highest feasible speed for data transimission is a very essential prerequisite for the success of our proposed scheme.

7- Conclusion and Recommendations

Before concluding this paper, we can summarize our proposals and findings as follows:-

For fast diagnosis, and hence taking the appropriate contermeasures, of power system's disturbances, the following developments are proposed:-

i - Utilization of the high - speed capability of parallel processors. In this respect, we propose the SIMD vector machine, with a few number of pipelines (e.g from 2 to 4), during the early stage of conversion from 2 to 3 dimensional programming. The SIMD computer should be placed in the main control Center (SCC), and should be provided with a power system data base management (DBM) system.

ii- To convert, or create 3 dimensional package, we may advise that the application progrmmer be knowledgeable system programmer capable of using low level multitasking tools.

iii- Beside provision of a modern SCADA system linking the system control center (SCC) with slave, or remote stations, a high speed communication technology should be adopted. We recommend that it may be one of the three variants, namely, coaxial, fiber-optic cables, or Satellite radio. Adoption of any needs a techno-economical feasibility study for each individual case.

IV- A new topic "EGIPT" is recommended to be widely opened for investigators for development.
This topic will be mainly interested in quantitative evaluation of main features of power system's disturbances. These features are integrated into one of predefined categories, and hence a logical scale (an abstract vector) can be compiled. Observed (unknown type of disturbance) and computed (known type of disturbance) logical scales for each slave station are compared, and hence the type of the disturbance can be deduced.

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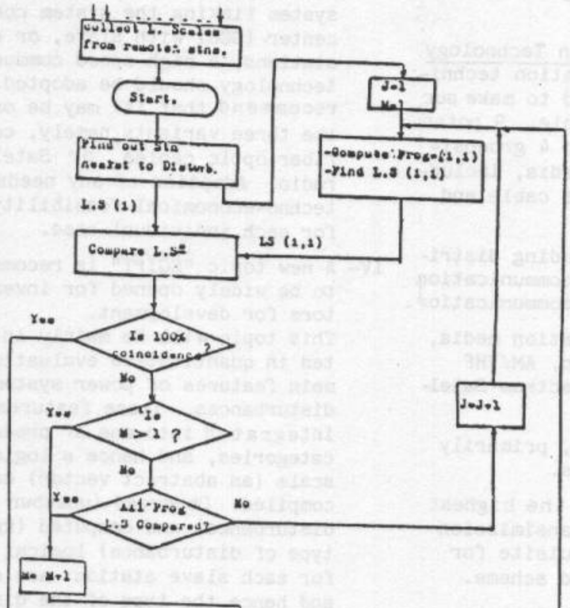

Fig (1): Main Function of the Supercomputer