Advance Concept of Automation in Energy Control Centers – A Case Study

R.K.Pandey, P.K.Agarwal and S.K.Garg

Abstract—**The current trend of open and modular architecture in the implementation of current generation SCADA/EMS system is mainly for expansion and integration of systems of different power organizations for efficient online interactive controls among the various sub systems diversely located. However, basic concept of the SCADA/EMS systems is not much different than what was during earlier installations except few additional features for fast communication and control. Conventionally SCADA/EMS system has been designed on the concept of "sending data by RTU on communication line, receiving data at control center and processing and displaying. State estimation has been used for making available the visibility of invisible RTUs. However, in case of outage of large system, state estimator tends to fail in providing complete visibility of the system. Thus making the data unavailable when in need. The hybrid concept of control functions depending on the estimation theory along with the measured information can be a viable option fro automation of energy control centers. The proposed paper is an attempt towards solving the problems of energy control centers experienced at present by suggesting roots and technologies for self healing type and secured SCADA/EMS system. To demonstrate the proposed concept a case study has been done by the way of modelling SAARC countries in an integrated framework which are of varying architecture and technologies.**

Index Terms— **Auto generation of one-lie diagram, Dynamic data linkage, Self-healing configuration, State estimation, Energy economics and market evaluation, integration of SAARC grid.**

I. INTRODUCTION

Conventionally SCADA/EMS system of a utility had been as a isolated, islanded, not-to-expose-to-outside world framework. The real time information available today is limited to analog and status data from the remote terminal units. Information, such as indications of protective control actions, event/fault records, device settings are not available. Protective devices are not considered in steady state or dynamic security assessment. System dynamics are not taken in real time evaluations. Data communicates on PLCC links, microwave/ fiber optic and V-SAT links. In most cases these links are not dedicated.

Economics and market evaluation tools are just emerging. No tool is available to evaluate the impact of market competition and the multi-agent nature on the system vulnerability. Emergency controls such as load shedding do not consider system-wide conditions. Protective relay settings are static – no intelligence is embedded to allow adaptation to the changing system conditions. System restoration relies primarily on human operators and off-line procedures. Present technology serves mainly as a supervisory control and data acquisition tool. Present technologies allow only local, narrowly focused control actions based on measurements at the line or sub-station level.

II. THE TECHNOLOGICAL CHALLENGES

Most significant task in power industry today is the economically effective maintenance and monitoring of power systems to ensure high quality and reliability of electric power supplied to customers. It should also intend to quickly evaluate system vulnerability with respect to cascaded events involving faults, device malfunctions and remedial actions that reflect only local considerations. Minimizing system vulnerability in case of cascaded events can significantly reduce the likelihood of catastrophic failures.

One such case has been shown in Fig. 1 below explaining the basic concept of integration of various modules.

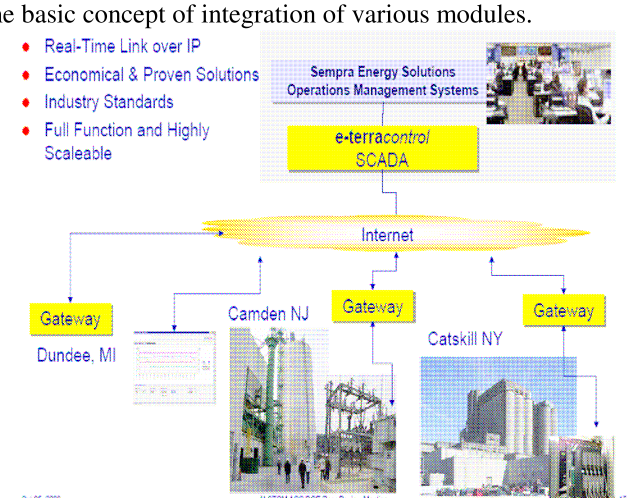

Fig. 1: Basic concept of internet based control centers

R. K. Pandey is with the department of Electrical Engineering, ITBHU, Varanasi, India.

P. K. Agarwal is with Power Grid Corporation of India Ltd. heading the commercial department of Northern Regional Load Despatch Center, New Delhi India. (Telephone 91-11-26851754, pkagarwal@gmail.com)

S. K. Garg is with Power Grid Corporation of India Ltd. heading the hardware section of SCADA/EMS group of Northern Regional Load Despatch Center, New Delhi India. (Telephone 91-11-26851754, skgarg@gmail.com)

These systems should be designed with the ability to reconfigure power networks to minimize insecurity and develop system restoration plans to minimize the impact of disruption base upon system-wide assessment.

- The basic concept is to provide self-healing and adaptive reconfiguration capabilities for electrical grids based on wide-area system assessment. Specifically the automation in electrical grid should able to cope with the dynamically changing scenario of the power network.
- Acquire and interpret extensive real time information from diverse sources, ranging from sensors to satellites.
- Quickly evaluate system vulnerability with respect to catastrophic events in a market environment.
- Adapt the protective device performance based on system-wide assessment.
- Reconfigure the power network to minimize system vulnerability.
- Develop system restoration plans to minimize the effect of disruption.
- Provide secure, dedicated and fastest means of communication to all system elements with capabilities to handle large traffic on WAN.

III. ONE-LINE DIAGRAM AUTO GENERATION

With the increasing growth and complexity of power system, the one-line diagram layout is also becoming complex and need is felt for auto generation tools for one-line diagram generation. Auto generation of the one line diagram contains input data stream stamped with placement and routing for dynamic data linkages. The practical case of integrating the data and establishing the information highway so as to generate the controls can be illustrated by Fig. 2 shown below.

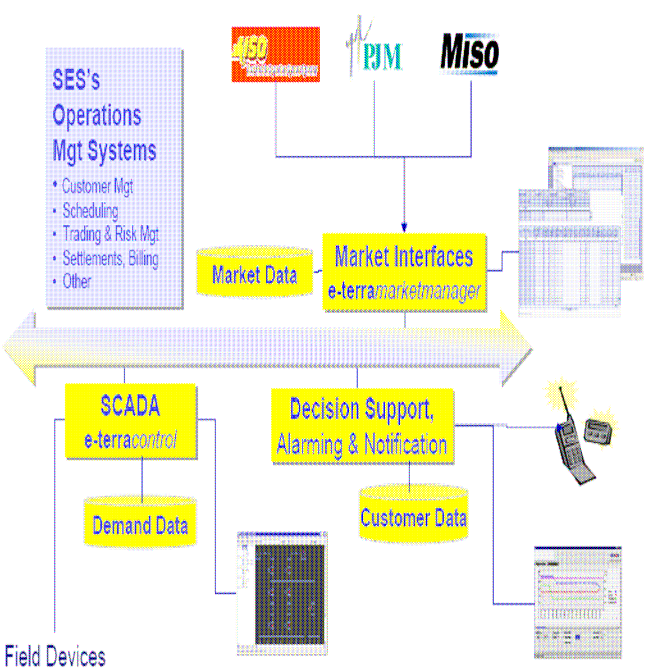

Fig. 2: Building blocks for remotely located hybrid data flow

IV. EVOLUTION

This section focuses the various existing architecture of energy control centers and also the future projection of new technologies in power transmission has been presented in Table I

Table 1 – System Control Center Evolution

Past	Present	Future
Centralized	Client/server and distributed	Distributed and agent based.
Tight integration of hardware and software.	Hardware and software by different SCADA vendors	Off the self hardware and software.
No use of standard	Use of protocols and standard developed by group of vender.	All standards of International Level.
Non or semi-graphical interface	Full graphical interface	Web-based with advance visualization concepts.
Islanded and isolated	Integration with other utilities' system.	Integrated with Internet and business.
Technically oriented operation	Importance of non-technical criteria starts to operate	Economic, commercial criteria become highly important.
Not secure. Secure only due to isolation.	Secure only with trusted connection.	Security standards developed. Secure for public connections.
Life is dependent on hardware obsolesce.	Life dependent on software standards.	Life independent on hardware and software. Addition and replacement possible due to off the self availability.

V. CASE STUDY

SAARC summit in Islamabad on 4-6 January 2004 mandated for creation of concept of Energy Ring. This definitely requires development of a SARRC regional grid, i.e., interconnection of SAARC countries for transfer of energy form one country to other country. To operate such grid, data from all SAARC countries is to be shared amongst them. Though all the data available with SCADA system of a country need not be share/expose to other country but the data related to interconnection and some vital parameters of the grid are essentially to be made available to other country for trouble free exchange of energy. This task may be accomplished by gateway concept for transferring the required data from one country's SCADA system to the shared system.

One more point has to be remembered while designing such system for association of countries is that all countries should have equal right and privileges on this shared system. This is essential to have a well coordinated settlement in changing power transaction scenario along with the legal binding in terms of control generation in case of deviations seen by the network transaction. For this, concept of National Energy Control Center (NGCC) with gateway as shown in Fig. 3 may be implemented. NGCC gets the data from all the regional SCADA systems through a gateway (as shown in the Fig.3) and provides the same to other Distributed Centers (DC) in hierarchical way. These NGCCs of all the countries will form a group for regional cooperation on transfer of energy from one country to the other country.

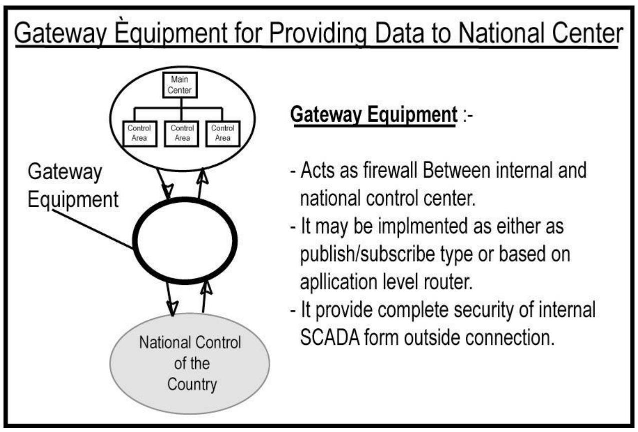

Fig.3: Regional SCADA systems interconnection

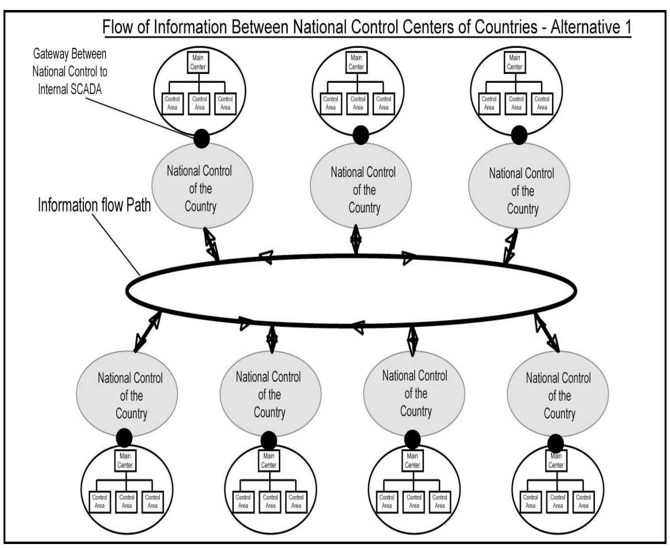

Fig.4: Intercountry SCADA systems interconnection-I

The information flow path and communication channels have to be configured so as outage of any of the NGCC shall in no way affects the availability of data to other operational NGCC. This concept of interconnection and integration of data transfer will enhance the fast information flow for the real time dynamical control of each NGCC of countries concerned in this power pool and thus ensure the reliable power flow dynamics. This has been shown in Fig. 4 and Fig. 5.

Another important issue while designing such system is of security. Since, connectivity is to be exposed to the outside system, proper security measures should be implemented. Public key certificates and cryptography is the answer for this.

Public key certificates are a combination of two technologies – public key cryptography and network directory services. This uses what is known as asymmetric key-based encryption. Two associated encryption keys are generated as a pair, and documents encrypted with one key are decrypted with the other key. Out of the two keys one key is known as Public Key and is available to all and other key known as private key is available to the owner only. This technique accomplishes two important goals: It verifies the integrity of the information in-hand (it must be exact copy of the original) and it verifies the authenticity (only the holder of the private key corresponding to the public key that decrypted the document could have "signed" the original).

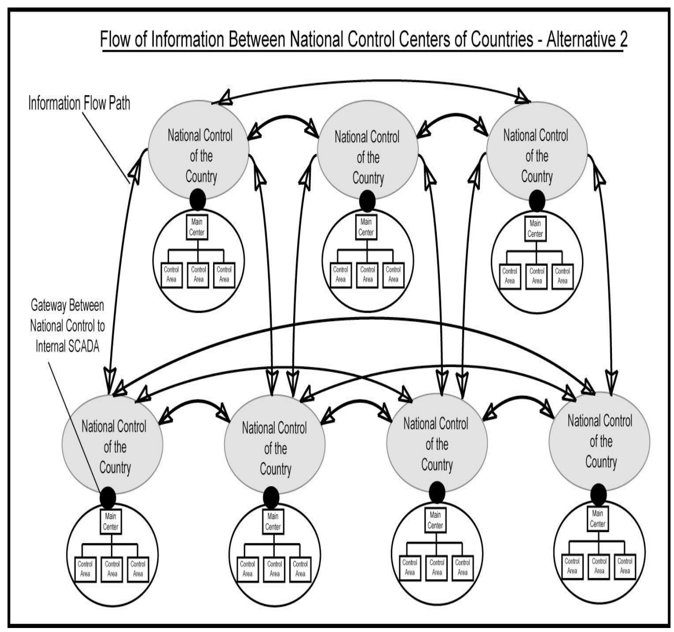

Fig.5: Intercountry SCADA systems interconnection-II

The components of various modules starting from generation to load management can be grouped all together in the complex frame work of one region as shown in Fig. 6 and the modular approach can be adopted for integrating all such regions along with the similar components. The all functions of data acquisitions, market & demand forecasting and other resource monitoring along with scheduling has been grouped and integrated as shown in Fig 6. The functions of each block is well defined and the interface signals are adequately taken based on the on line requirements and dynamical system conditions.

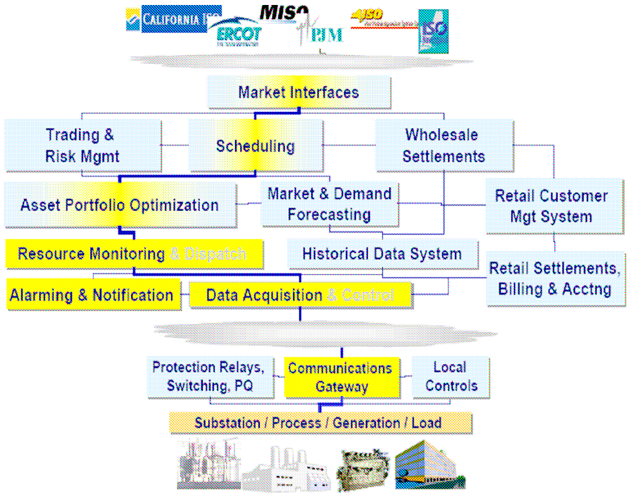

Fig.6: Intercountry/interutility SCADA systems interconnection

Another way of representing the integration of commercial systems, markets of electricity consumption and other utilities all together along with the various protocols and server groups identified for each sub components with SCADA devices are shown in Fig. 7

At country level the schematic of modular connection and information flow diagram can be demonstrated as shown in Fig. 8. The other connections are shown in Figs.9-11.

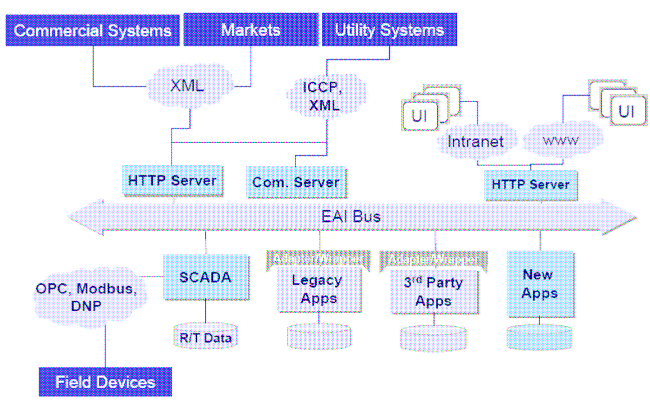

Fig.7: Intercountry intranet & web interconnection

Fig 8: Multi energy company integration concept

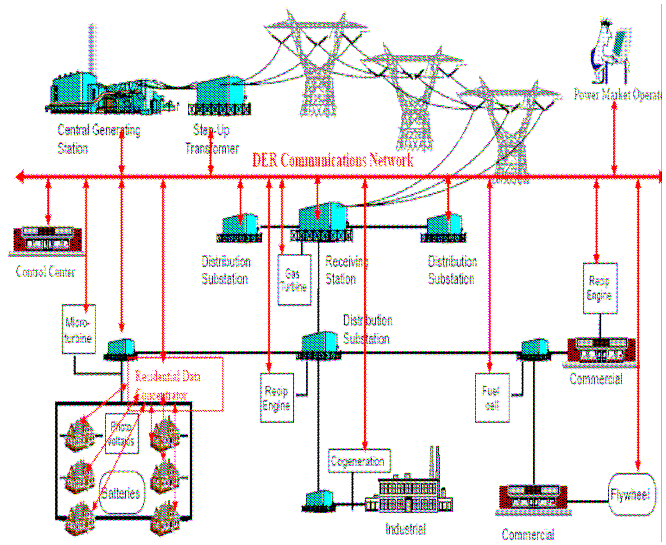

Fig. 9: Regional interconnection modular automation blocks

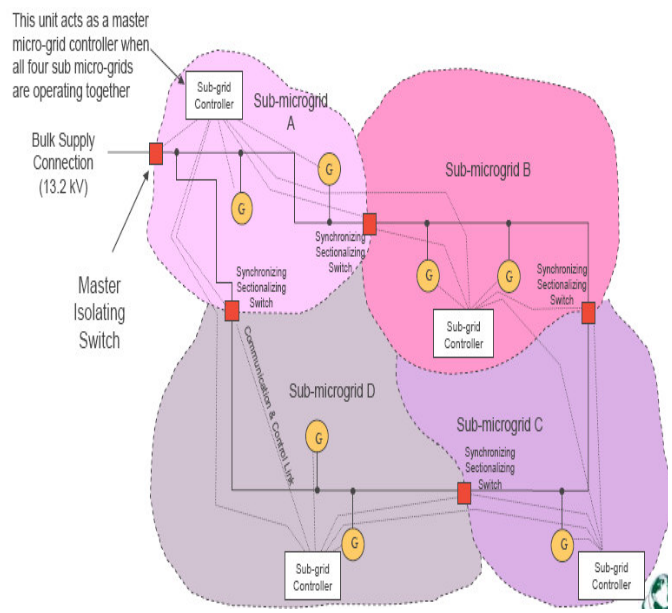

Fig. 10: micro grid interconnection

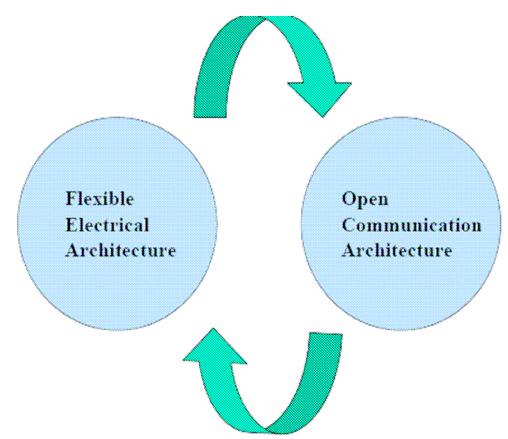

Fig. 11: conceptualization of flexible /open architecture

VII Acknowledgment

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