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Artificial Intelligence for Supervisory Control

Amit Shrivastava[1], Dr Anand Khare[2]

[1] Research Scholar, CSE, Bhagwant University,
Ajmer, Rajasthan, India

[2] Research Director, the MRPC Company
Hyderabad, Andhra Pradesh, India

ABSTRACT
Four models have been developed which cover important aspects of the power industry i.e. Generation, Transmission, Distribution and HMI (Human Machine interface) based on SCADA architecture. The models simulate power grid network which generates database on scaled down parameters and can converted back to real time values of the power industry. The data obtained from the model can be used for load forecasting and analyze different critical situations arising and their solutions. Primarily the research attempts to develop new computer based dynamic Information and control systems that can introduce efficiency by automating the tasks in power industry with engineering products to operate successfully, provide profitability, employment and serve humanity.

Keywords: HMI, SCADA, Grid network, Neural Network

INTRODUCTION
Here the automation project is to manage the power industry at the generator, transmission and distribution stations to supply power to various parts of cities. Power may trip if load increases which leads to blackout or brownout. Therefore to avoid power failures a hardware and software model on Neural Network is proposed which is based on back propagation technique for predicting the future loads. These predicted values help the software in taking intelligent decision during increase or decrease of any load then automatically the other loads are altered or disconnected accordingly as per the program. The main benefit which can be derived is maximizing the power utilization with least capital investment.

[4] Author has proposed a method for evaluating SCADA system reliability in absolute cost terms. This cost enables a direct, quantitative comparison of alternative SCADA system options. In the first of two examples, alternative Area SCADA architectures were applied to the IEEE reliability test system. The reliability analysis revealed that the centralized option was *5.5* time more “expensive” than the distributed option.
The second example comprised a case study of an actual system implemented by Trans Power. In this case it was found that the annual reliability worth was relatively small. This suggests that Trans Power has incurred only a minor increase in liability as a result of changing Area SCADA architectures.

[5] Author has highlighted the need of stronger SCADA security. To analyze the security risks and develop appropriate security solutions for the systems he has proposed a modeling simulation tool which would enable the simulation of SCADA systems with the benefit of testing different attack and security solutions. This paper proposes a simulation tool for building SCADA simulations that supports the integration of external devices and applications. A key benefit of this tool is the ability to test the effect of attacks on real devices and applications, even though using a simulated environment.
He used SCADASim which is built on top of OMNET++ , a discrete event simulation engine. OMNET++ consists of modules that communicate with each other through message passing. Modules can also be combined in a hierarchy of levels making possible to build complex simulation components. It also provides a set of tools for designing network topologies. With the help of results he had shown that SCADASim closely simulates the realistic behavior of actual SCADA devices.

[6] This paper proposed a survivability quantification model that takes into account, service heterogeneity and interdependencies to compute the survivability of SCADA systems. The proposed model uses network traffic to compute the information diversity score, which is used as a metric to define services states. The services are aggregated into a Bayesian network that is used to

compute the final survivability score of the overall system.
The paper further demonstrated through a case study, and by using a combination of information diversity and service interdependence, one could probabilistically evaluate the survivability of SCADA systems under undesired events such as malicious attacks.

[7] Here the performance model of data exchange on the Internet is established, and a quantitative analysis of the data exchange delay is presented. Simulation and experimental results have indicated that the Internet provides a convenient way for inter control center data exchange and, by using state estimation (SE) accurate complete network models, can be obtained for practical security and available transfer capability analyses.
In this paper, a C&C network modeling technique for analyzing transfer delays via the Internet is presented. Two measurement treatment schemes are also proposed to minimize time delay effects in the network modeling.

[8] In this paper, a new forecast method called *FCS* method by the Author is proposed. The FCS method adopts a fuzzy neural network combined with a chaos-search genetic algorithm and simulated annealing and is found to be able to exploit all the conventional methods advantages.
The proposed method is next applied to load forecasting, as an example test, in an actual Taipower power system and demonstrates an encouraging degree of accuracy superior to other commonly used forecasting methods in several time-period cases.

[9] In regard to the influence of real-time electricity prices on short-term load, Author has proposed a model to forecast short term load by combining the radial basis function (RBF) neural network with the adaptive neural fuzzy inference system (ANFIS). The model first makes use of the nonlinear approaching capacity of the RBF network to forecast the load on the prediction day with no account of the factor of electricity price, and then, based on the recent changes of the real-time price; it uses the ANFIS system to adjust the results of load forecasting obtained by RBF network. It has been shown in this paper with the help of factual data that this integrated approach has improved forecasting accuracy.

[10] Here Author have shown how weather ensemble predictions can be used in ANN load forecasting for lead times from one to 10 days ahead. They have used the 51 ECMWF ensemble members for each weather variable to produce 51 scenarios for load from an ANN. For all ten lead times, the mean of the load scenarios was a more accurate load forecast than that produced by the traditional procedure of substituting a single point forecast for each weather variable in the ANN load model. This traditional procedure amounts to approximating the expectation of the ANN nonlinear function of weather variables by the same nonlinear function of the expected values of the weather variables. The mean of the 51 scenarios is appealing because it is equivalent to taking the expectation of an estimate of the load pdf.

PROPOSED MODELS

Four models have been developed

1. SCADA Power System Monitor
2. SCADA Power Grid
3. Neural Network Model for Load Forecasting
4. SCADA with Artificial Intelligence for Supervisory Control

MODEL 1 – SCADA Power System Monitor

The SCADA Power System Monitor simulates power grid network. It comprises three generators, loads and transmission lines which can be interconnected to form a power-grid.
Experiments on power flow with and without UPFC show efficient management of power and logging records of power drawn from loads during peak and normal period has been simulated for study. For more details see ref [1].

MODEL 2 - Micro Grid Model

The Micro Grid model simulates the power system network and has all necessary features of SCADA automation to study its advantages and finally implement it in real system. For more details see reference [2]

Both Models first and second are used for practical study of power grid networks working on scaled down voltages to represent generator, transmission lines and distribution of power to simulate the real time electrical power industry. The SCADA system on the model transmits the data to computer software that is generated at Generator station, Transmission Lines and Loads, and controlling of hardware components that is by changing rotary switch positions to switch ON/OFF and circuit connection/disconnection on the model through and wireless arrangement.

MODEL 3 - Neural Network for Load Forecasting

With this, intelligent Software was designed to record the parameters of energy consumption at load side of each day and after sufficient database records it is capable of estimating the average future required loads. This intelligent software is called Neural Networking; it has a self learning technique which is used for Load forecasting. For more details see reference [3]

MODEL 4 - SCADA with Artificial Intelligence for Supervisory Control - HMI

This software Model has been designed for controlling first and second models and has been developed in Lab View software.

WORKING OF THE FOURTH MODEL

This model is an artificial intelligence based software build with first and second model to exercise supervisory control over model one and two by using third Models' predicted values.

The model one and two generate the data of a Grid system involving three Generators, three Transmission lines and three Loads reading all parameters (V, I, W, PF, VARS, VI). Then the third model takes in to account the generated data logs from the model 1, 2 and 3 then it creates an intelligent analysis for load forecasting which eventually are input details for model four. The fourth model reads the data file rendered by model three. This file is in a "aa.dat" format which enables the model four to act accordingly in implementing and monitoring the required power supply during the recorded time and location.

The Lab View HMI program reads the file aa.dat which contains the predicted Peak Loads on hourly basis. The HMI Program then sets the three generator stations as per the Load. Assuming each generator can bear a load of 3000 MVA maximum, so the logical decision program then distributes the required power to the loads and disconnects when in excess. In the table 1 it can be seen that loads are changing hourly.

This SCADA artificial intelligent controlling software is designed to take appropriate decision to switch on and off the generators to meet the loads. For example the Load is 8967MVA then logic distributes the load like this – 3000MVA for 1st generator, 3000MVA for 2nd generator and 2967MVA for 3rd generator.

SCADA Software (front end)

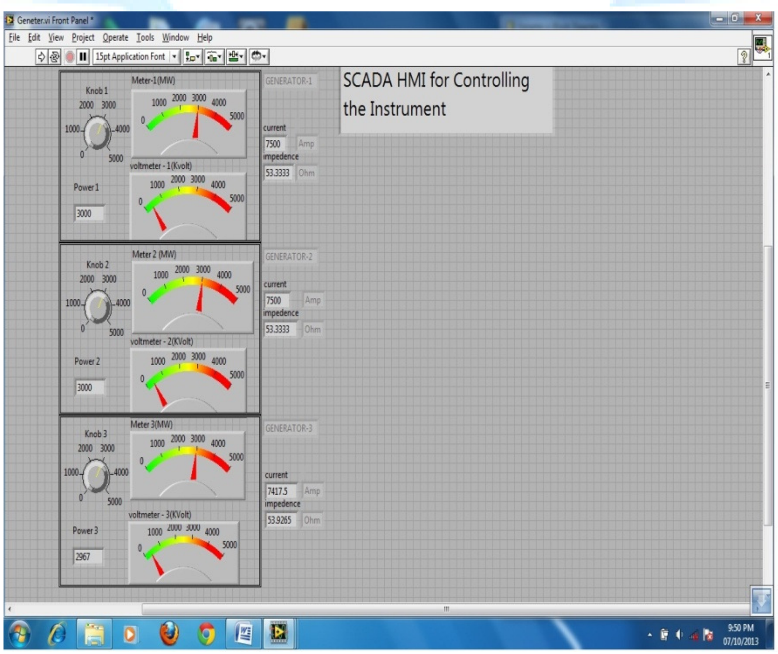

Figure 1- Main Page for Data Acquisition

The Predicted Load File (in "aa.dat" format) Generated by Neural Network Model - 3

Time	Predicted Load (In MVA)
01:00	2897
02:00	3895
03:00	9000
04:00	8000
05:00	7000
06:00	6390
07:00	5783
08:00	6751
09:00	8329
10:00	3000
11:00	4500
12:00	5600
13:00	8700
14:00	9000
15:00	5000
16:00	2000
17:00	7000
18:00	6000
19:00	2000
20:00	4500
21:00	8967
22:00	7680
23:00	6783
12:00	5341

Table 1: Hourly Load Records

Snap Shot of Front End Design of the SCADA Artificial Intelligent Software

There are two sets of Program

1. First program takes in to account the predicted load values into a file "aa.dat"

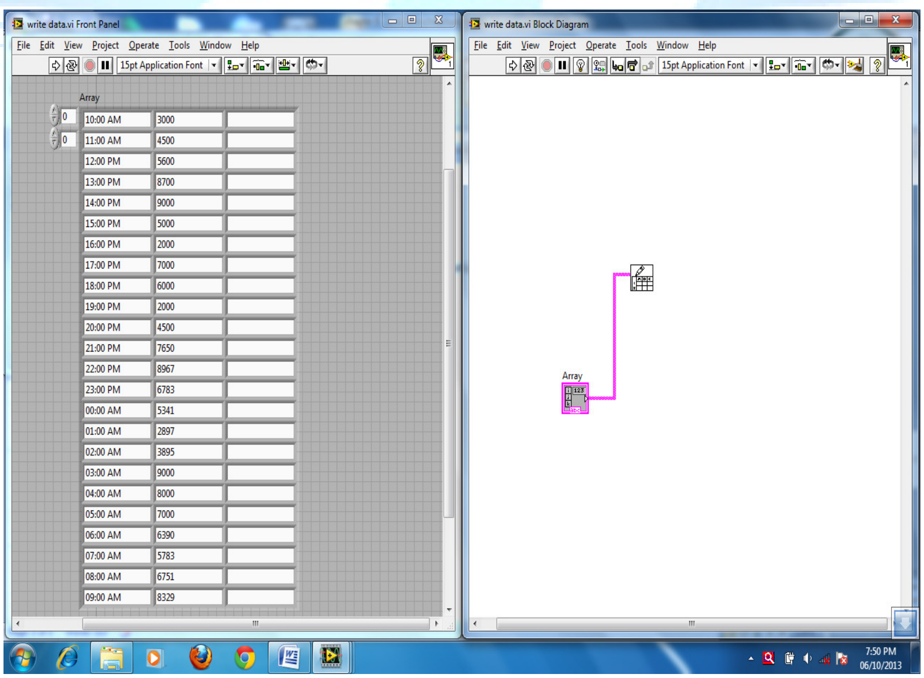

Figure 2 – Extracting data from "aa.dat" file

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2. Second Program processes the data from figure2 and creates logical decisions

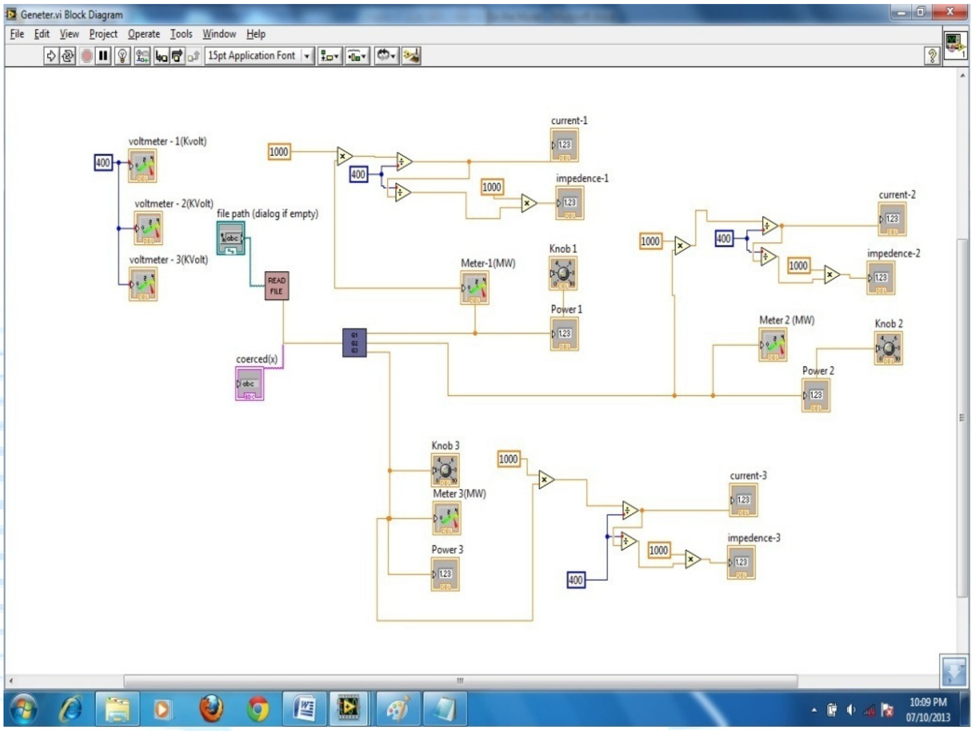

Figure 3 – Program generating the logic of figure 2.

Sub VI / Subroutine

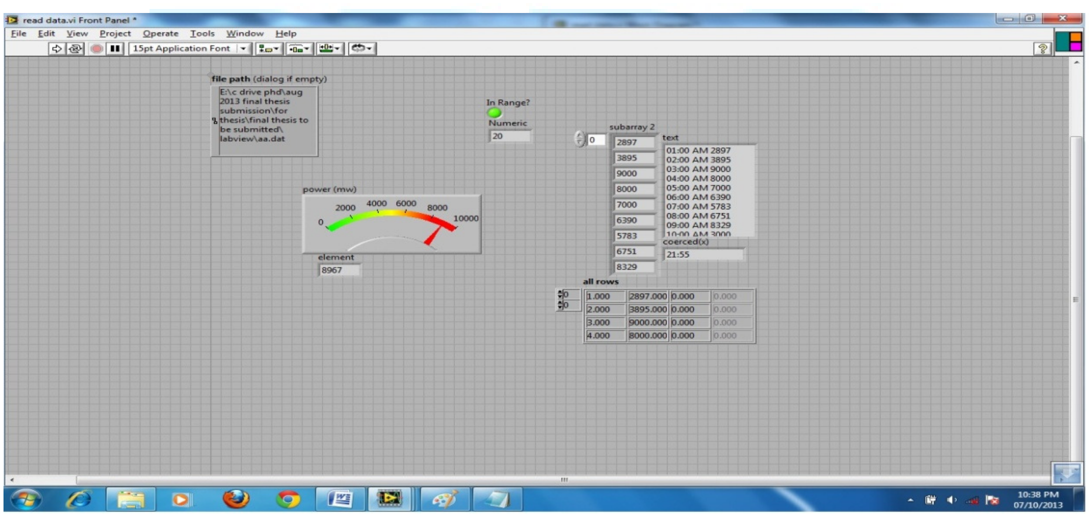

Figure 4 – Sub VI reads the details of individual components

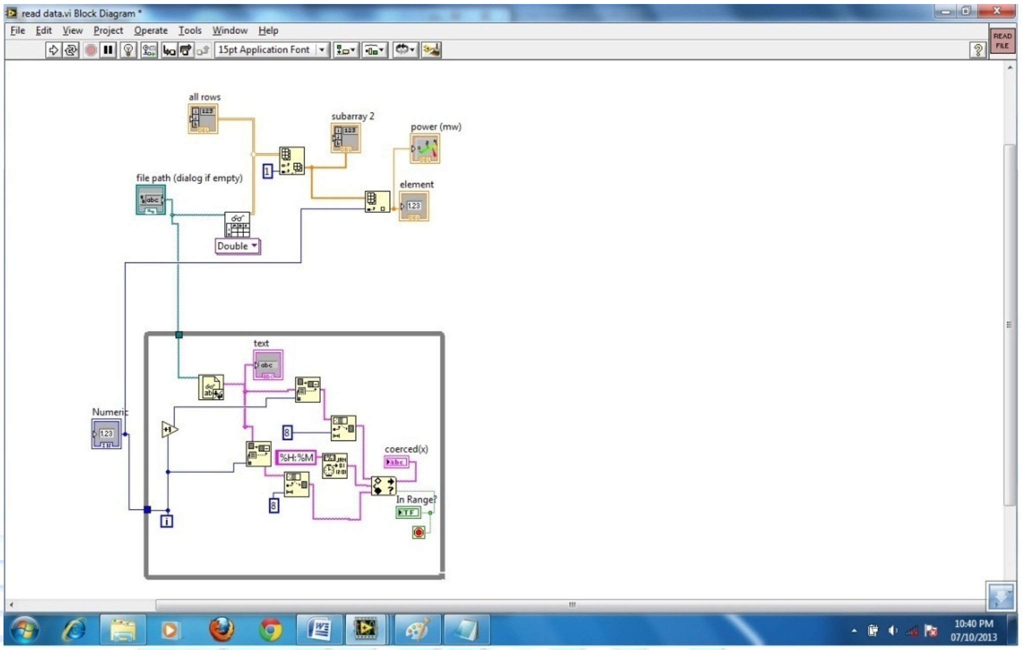

Figure 5 – Sub VI Block Diagram / Program for reading the details of individual components

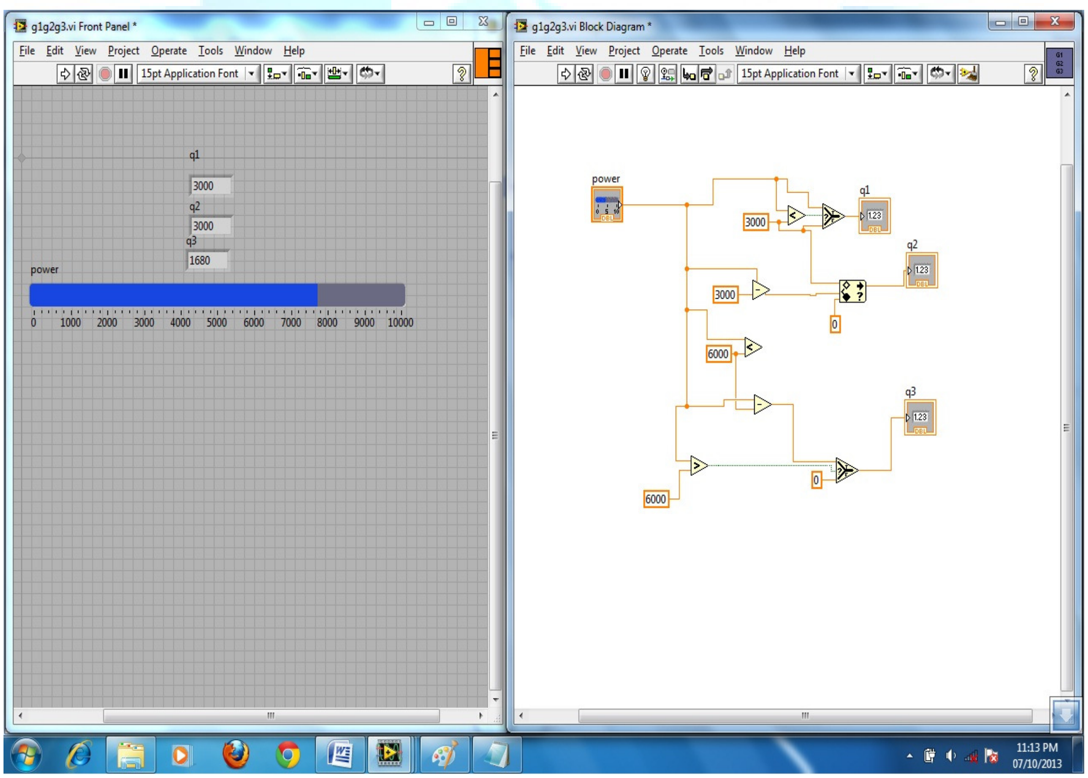

Figure 6 – Sub VI Generator logic File Front Panel and Program

CONCLUSIONS

The scope of this algorithm is limitless as it is low cost and versatile for all type of Supervisory Control required in automation for different industries as this algorithm automatically sets the operational limits of control. The software can be included as a apart of the main software as an additional feature. Here the data is provided for 24 hour activity which can also be easily altered to vary its schedule for different days.

The complete automation of small, medium and large units using artificial intelligent software is economically feasible. Through the attempted research it can be concluded that the methods adopted in this paper and papers [1], [2] and [3] give new insights on this subject of artificial intelligence for Supervisory Control and its economic viability. This topic of research has future scope and further studies can be made to achieve artificial intelligence at a cheaper cost.

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THE AUTHOR

AMIT SHRIVASTAVA has obtained BE (1999), M.E (2006) in Computer Science from DAVV University, Indore India. His interests are in Computer Applications in Power Generation and Transmission Industry. Presently he is submitting thesis for his PhD at Bhagwant University, Ajmer Rajasthan India. He has published two research papers on the topics of SCADA Automation in Power-Industry.

Dr. Anand Khare has obtained MSc (Electrical) from Wales and PhD (Electrical) from London. Presently he is a Director at MRPC Company, Hyderabad. Formerly he was a Faculty member at Indian Institute of Science Bangalore and Hest Ham College London.