INVESTIGATION OF INTERFACING NPP SIMULATORS WITH PSCAD SOFTWARE

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Abstract

This paper demonstrates a new method of interfacing a NPP simulator with the PSCAD software so that the interaction between the plant dynamics and the grid dynamics can be studied. Through this method, data extracted from NPP simulator, as an object, will be communicated to a server running PSCAD software. This paper will illustrate the use of Remote Procedure Calls (RPC) as a distributed, client-server based application used to establish a connection between NPP simulator running on UNIX server and PSCAD running on a PC. Using this method, the called procedure need not exist in the same address space as the calling procedure. Communication protocols available in the NPP simulator are used to export data from the simulator.

I. Introduction

With the increasing role of nuclear power as a vital source of world energy, it is expected that more nuclear power plants will be constructed in the near future. In order to increase the efficiency of the power generation and transmission, it is important to study potential impact of nuclear power plants to the transmission grids. This is particularly true in load-following mode of operation. The variable load represents the electricity usage provided by the power generation unit. Since the electricity usage fluctuates over time, a real-time mechanism is required to adjust the power production with respect to these changes.

Despite the wide range of practical applications in research and development of nuclear power plants, NPP simulators mostly operate as an isolated unit without considering the dynamics of the transmission lines. The objective of this paper is to create a software environment where the dynamics of a nuclear power plant can be jointly studied with that of the electric transmission systems with connection to other generation units. The software engineering aspect of interaction between the nuclear power plant simulators and power system simulators is studied in order to establish a dynamic connection and management communication between the NPP simulators and power system control tools. Utilizing this network

communication, the NPP simulator can be represented as an object for power system control tools in order to dynamically adjust the power generation with respect to the variable load.

II. Methodology and Procedure

In order to establish communication between the nuclear power plant simulator and the power system simulation software, a network configuration is designed in such a way that the power system simulator represents the variable load of the outside world and the NPP simulator simulates the actual power plant which interacts dynamically with the variable load.

In order to simulate the variable load, a power system simulator is required. The simulator chosen for this purpose is PSCAD, a virtual power system simulation tool. This virtual power system is required to have a network connection with the NPP simulator. In addition to physical and logical connection between the simulators, a specific method should be used to establish communication between them. The required connection is established through a client-server application technique called Remote Procedure Calls (RPC).

A desktop NPP training simulator is used in this study. This simulator provides a reasonably accurate simulation tool for Darlington nuclear power plant. This simulator is used in order to represent the NPP with variable load capability. OPG NPP simulator has dedicated communication protocols used to establish connections to the outside of the plant.

III. Brief Description of PSCAD

PSCAD (Power Systems CAD) is a powerful and flexible graphical user interface to the world-renowned, EMTDC solution engine for power system studies. PSCAD enables the user to schematically construct a power system, perform simulations, analyze the results, and manage the data in a completely integrated, graphical environment [1].

In this design the PSCAD simulator plays the role of a variable load which will control the power generation level of the simulated nuclear power plant. In the client-server method used for this communication, PSCAD software is considered the client which dynamically communicates the variable load and controls the power system.

The simulated nuclear power plant communicated to the PSCAD through the network represents a power generator as a part of the entire power generation system. Figure 1 shows a power generator simulated in PSCAD environment.

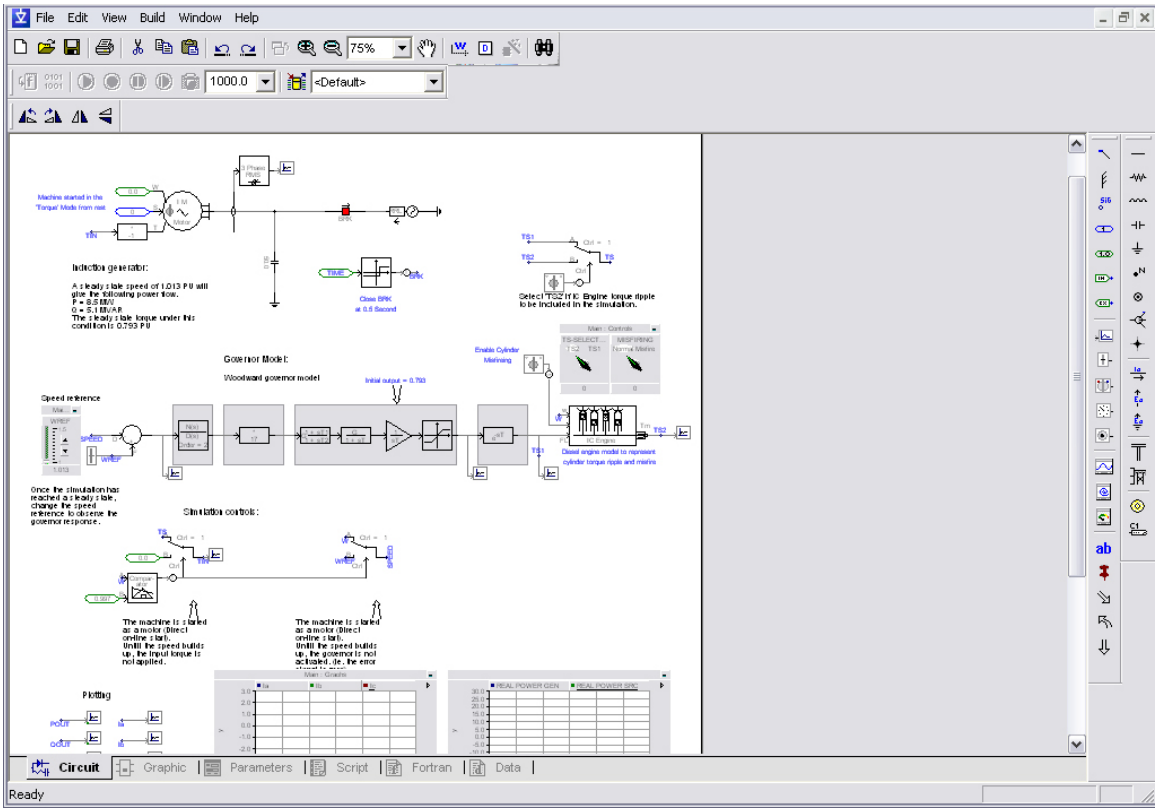

Figure 1: PSCAD simulation environment of a power generator

IV. Remote Procedure Calls (RPC)

RPC is a powerful technique for constructing distributed, client-server based applications. It is based on extending the notion of conventional or local procedure calling, so that the called procedure need not exist in the same address space as the calling procedure [4].

This technique allows two dependent processes to run in separate machines with network connections. The unique characteristic of this method is that the transport independence of RPC allows the communication to be established regardless of physical and logical network specifications and protocols.

An RPC is analogous to a function call. Like a function call, when an RPC is made, the calling arguments are passed to the remote procedure and the caller waits for a response to be returned from the remote procedure. The client makes a procedure call that sends a request to the server and waits. The thread is blocked from processing until either a reply is received, or it times out. When the request arrives, the server calls a dispatch routine that performs the requested service, and sends the reply to the client. [2]

The PC running the PSCAD simulator acts as the client. The client's procedure call is a request from the server to the NPP simulator. The NPP simulator running on the UNIX operating

system plays the role of the server and runs the appropriate dispatch routine. Finally, the server sends a reply to the client with respect to its new state.

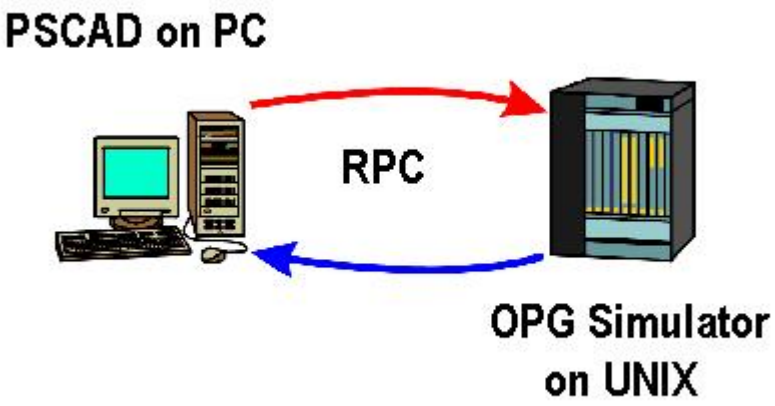

Figure 2: Remote Procedure Calls

V. Network Configuration

The establishment of connection between the client and the server which are the two simulators included in the control system combination requires creation of physical and data link layer configuration of OSI network model.

Both machines are required to have a Network Interface Card (NIC) in order to establish the communication. The PC running the PSCAD is connected to the UNIX machine through a 10-Base-T cross-over cable.

Ethernet is used for the physical and logical connectivity between the client and the server. Since the RPC application is a transport-independent technique, Ethernet as well as other protocols can be used as the infrastructure of the connection between the two machines.

Manchester encoding method is used before data transmission when using the Ethernet protocol. This method uses a synchronous clock encoding technique which makes the protocol “self-clocking” and therefore prevents the need to use synchronization methods in higher layers.

VI. Brief Description of a Desktop NPP Simulator

In order to accurately simulate the real-time response of a nuclear power plant, a desktop simulator from OPG is used. This simulator software provides realistic emulation of a fully operational CANDU power plant. The OPG simulator is capable of accurately simulating the Darlington nuclear power plant in real-time.

The OPG CANDU simulator is running on a Hewlett Packard DS25 Alpha Server running version 5.1B of the Tru64 UNIX operating system. This machine includes the Ethernet interface required for the network connection.

VII. Discussions and Conclusions

The connection of a nuclear power plant simulator with a power system simulator is investigated in this paper. The methodology of the network connection in this proposal consists of two major components: RPC connection of the PC client to the UINX server and the interaction between the OPG CANDU simulator and the UNIX operating system.

The process of Remote Procedure Calls' implementation is a well documented process which utilizes pre-defined functions in order to establish the desired connection. However, an additional interaction between the OPG CANDU simulator and the UNIX operating system is required to allow the communication between the simulator and the outside world. In this project the mentioned task is accomplished by designing a C-programmed module which interacts with the simulator. The module is compiled as a standard C object file. A new simulator configuration is created which includes the new module and can be loaded by the simulator.

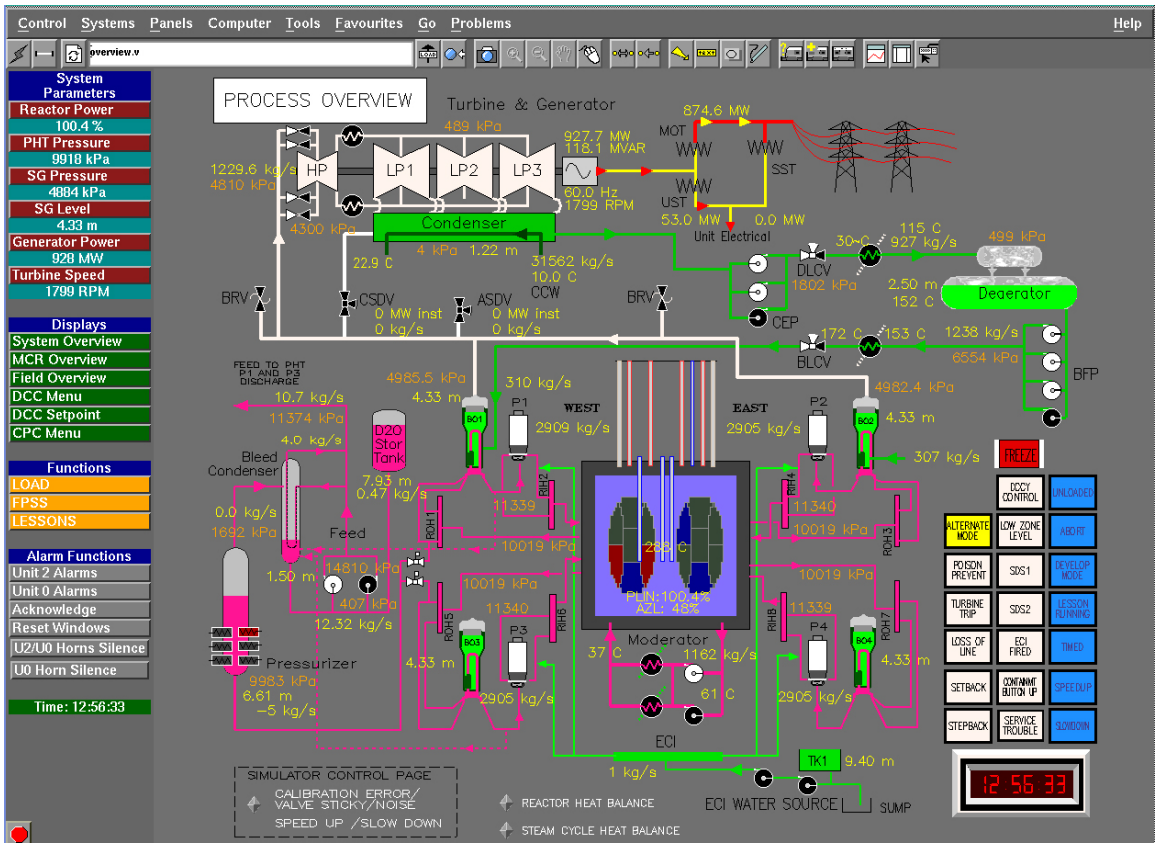

Figure 3: Ontario Power Generation's CANDU simulator (Darlington, Overview)

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References

[1] Paul Wilson, *User's Guide on the use of PSCAD (Power Systems Computer Aided Design)*, **Manitoba HVDC Research Centre**, Winnipeg, Manitoba, Canada, June 2004

[2] R. Boult, *Third Generation System Controls Nuclear Power*, **Control Engineering**, August 1998

[3] R.M. Lepp and L.M. Watkins, *Control and Instrumentation Systems for the 600 MWe CANDU PHW Nuclear Power Plants*, **Atomic Energy of Canada Limited.** Chalk River Nuclear Laboratories, Chalk River, Ontario, 1982

[4] Dr. A.D. Marshall, *Remote Procedure Calls (RPC)*
<http://www.cs.cf.ac.uk/Dave/C/node33.html>

[5] Kenneth E. Foote, University of Clorado, *Teaching with GIS in the Liberal Arts*
<http://www.colorado.edu/geography/foote/si/figure01.gif>