State Estimator (SE) Implementation On a Distributed Computer System

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Abstract- **In modern Power Control Centers, the State Estimator application is responsible for determining the actual state of a power network based on the current network model, the available telemetry (analog measurements and digital statuses) and pseudo-measurements (scheduling patterns and data manually entered by the operator). At present each control center runs its own version of a State Estimator. We propose that it is much more economical to run one grid-wide State Estimator at one site and just exchange input and output data with the individual control centers. In this paper we describe the architecture for a Highly Available Distributed RAM (HADRAM) system that can provide the necessary computational power and reliability.**

***Index Terms*- data communication, data management, distributed random access memory, erasure correcting codes, in-memory-databases, network data exchange, power system control, power system modeling, scalable distributed data structure, service oriented architecture (SOA).**

I. Introduction

Power utilities need to run power application functions to monitor the security of their own system. At the core of these power applications is the State Estimator (SE). At present, vendors deliver power application functions for the power utilities; it is rare for the utilities to develop them by themselves. In either scenario, they are heavily customized for every user. As time goes by, many bug fixes or improvements are applied to the software and numerous changes are made. These changes are made always at the individual control centers.

In our paper we want to present a solution where considerable savings can be accomplished by changing the way these functions are deployed and used. We propose that the SE function is installed at a central site and that only input and output data is exchanged between individual utilities. We argue that this solution is technically feasible and much cheaper.

The rest of the paper is organized as follows: In section II we present an overview of typical Power Control Center (PCC) architecture involving computing clusters for distirbution of computing at the level of application functions. Section III describes the details behind our proposal to exploit the concept of running SE in a Highly Available Distributed RAM (HADRAM). In section IV we present an overview of the SE Service Center concept. In section V we describe the implementation of cluster computing using HADRAM architecture for enhanced reliability. We also present experimental results obtained on the prototype system being built at Santa Clara University. In Section VI we present a summary and point out future directions in distributed system development using HADRAM approach.

II. Overview of Power Control Centers

Over the past few decades, the need for solving increasingly more complex analytical problems has driven the evolution of Power Control Centers (PCC) or Energy Management Systems (EMS) into the current highly sophisticated systems. A PCC usually consists of several high performance computers linked via a LAN. These computers are usually organized into two groups to provide adequate reliability at low costs. The first group is dedicated to Supervisory Control and Data Acquisition (SCADA) functions associated with acquiring data and sending out control signals in real-time to equipment distributed throughout the network. This group usually consists of two mirrored systems designated as ONLINE and STANDBY. Should the ONLINE group fail, the STANDBY group will take over the operation. A fast failover from one system to the other is facilitated by having all the SCADA data stored in RAM.

The second group of computers in a PCC is dedicated for various analytical applications. This group consists of as many computers as needed to provide sufficient computing power even when a few of them are unavailable.

The computers in a single PCC are usually located in the same building and are connected via a Local Area Network (LAN), and different PCCs exchange only a very limited amount of data with each other. Thus, every PCC controls its own island of automation in the entire power grid. A simplified schematic diagram of a typical EMS system is shown in Figure 1. The data and information within a control center are structured into a self-contained hierarchy. Measurement values, or process data, are transmitted from lower to higher levels (bottom-up), while the control information is transmitted in the opposite direction (top-down). The applications within the Power Control Centers (PCC) are dependent on the central Supervisory Control and Data Acquisition (SCADA) database. Interconnections to other information systems, such as enterprise information or

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