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Title of Thesis: Performance Analysis of Wide Area Measurement and Control Systems

ABSTRACT

The analysis of geographically distributed wide area measurements in a power grid for control and analysis purpose is termed as a Wide Area Measurement and Control system (WAMC). The purpose of this research is to investigate the performance of WAMC systems. Various aspects have been considered for performance evaluation of WAMC:

Exploring IEEE Standard C37.118 for Synchrophasor: Measurement of precise synchronized voltage and current values are paramount in power system. Through synchronisation it is possible to locate phasors, taken at different locations, on the same phasor diagram, which is helpful in analyzing, monitoring and controlling the power systems during dynamic and transient state. Principle features of further revised versions of IEEE standard **C37.118** for the synchrophasor measurement and data exchange have been described in this thesis.

Performance Analysis of Wide Area Measurement and Control Systems: WAMC performance is the function of its communication infrastructure, the performance of which is broadly defined in terms of latency and utilization of links. This thesis develops a model for overall communication latency and explains its basic constituents such as propagation delay, queuing delay, packet delay etc. Link capacity and utilization parameters of communication have been studied.

Latency Reduction Techniques in Communication Network of Wide Area Measurement and Control System: Based on comprehensive analysis of delays, new communication architecture for Indian WAMC is proposed and designed in OPNET. This architecture is analyzed in the context of data latency and comparison with dedicated and shared topologies is carried out. Performance evaluation of the proposed architecture shows the trade-off between latency and reliability. Hence, different methods are discussed to reduce the latency values

of WAMC in general. Use of protocols in latency reduction is presented. Different types of protocols for different topologies for normal operating and link failure scenarios are suggested. .The role of the PDC timeout settings in reducing the communication delay is also presented.

Reliability Evaluation of Wide Area Measurement and Control System: The reliability analysis WAMC, is presented based on a Markov graph theoretic approach. Initially, PMU is considered wherein a state-space model is used to denote state transitions due to various component failures. This model is then expanded to include different common cause failures and component redundancies. Further the impact of the nature and type of communication network of the complete WAMC on the overall system reliability is investigated.

Application of Wide Area Measurement and Control System in power system: Identification of Fault location in Overhead Transmission line: The synchronized measurements are obtained from PMUs installed at the two terminals using two different phasor extraction techniques. The impedance of the system at the time of fault is obtained using sudden change in positive sequence components of voltage and current which in turn results from the sudden change in phasors of current and voltage. This system impedance is utilized in the calculation of the distance to fault.

The research work can be summarized as: "WAMC is the latest addition to intelligent power system which provides high speed real time information of power system. High data sampling rate contribute to various challenges in WAMC implementation in electrical networks. This thesis attempts to overcome some of these challenges by exploring the associated data latency and reliability concerns in WAMC. Need and importance of IEEE standard C-37.118 for data transfer in WAMC systems is given. New communication architecture for WAMC network of Indian power sector is proposed for data transfer using these standards. Use of protocols and cut down in time -out settings of one of the WAMC components especially PDC is suggested for reducing latency. Reliability and ageing concerns in WAMC network are also addressed and effect of common cause failure on reliability are shown. Finally fault distance estimation of transmission lines is accurately carried out using WAMC to enunciate on use of WAMC for different power system applications