CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This chapter enlists the significance of the proposed distributed models for on-line power system applications, the results obtained by the present work and makes suggestions for future research. Before proceeding with the review of the work done, the objectives of the thesis stated earlier in the introductory chapter are recalled.

The primary objective of this research is to investigate the provision of middleware to support various issues related to power system applications in a distributed environment maintaining compliance with distributed standards such as RMI, CORBA and .NET Remoting. A power system data conversion model is developed which represents the power system data in XML as a flat file in order to solve the overheads associated with the interaction of legacy power system applications in a distributed environment. In order to automate the process of power system analysis and to enhance the scalability of the system, it is proposed to develop group communication and active networking models that deviate from the default behavior of the RMI protocol. It is aimed at developing component models to increase the reusability and scalability of on-line power system applications. To reduce the network latency and to provide an uninterruptible service for power system operation and control, it is
proposed to develop an agent-based model. The major areas of power system studies like load flow monitoring, economic load dispatch and dynamic security analysis are being considered for the implementation of the proposed models and their performance evaluation is carried out with respect to Round Trip Time between the request and response.

5.2 CONTRIBUTIONS OF THE THESIS

This thesis offers novel ideas for the development of power system applications in distributed environment using open standards and facilitates the performance evaluation of power system applications in distributed environment.

A brief survey of the literature pertaining to the topics of research considered in this thesis is reported and the motivation for the present work is also brought out in the introductory chapter.

Distributed models for power system applications have been implemented using RMI, CORBA and .NET Remoting technologies. The models that have been developed are based on the concepts of platform, language and location independencies provided by the above core technologies and hence the deployment of power system applications has been achieved in a complete distributed environment. An attempt has been made to standardize the power system data and a procedure to convert the data into an XML form has been implemented. The interoperability among the heterogeneous power system clients in a distributed environment has been achieved through
XMLisation of power system data which provides meaningful solution to the legacy issues associated with power systems.

An RMI based model for load flow monitoring in a distributed environment had been implemented and discussed in detail. This model is enhanced with a client callback mechanism which allows the power system clients to register with the remote load flow server. The load flow server object obtains the load flow data from the registered clients at regular time intervals and sent back the load flow results simultaneously to all the registered clients. In order to achieve secure transmission of power system data and to eliminate the usage of resources by the default RMI registry scheme, a self registry scheme is adopted which binds the load flow server object in the server application. Runtime loading of proxy objects is achieved from a web server through code base with an appropriate security policy file.

A group communication model is implemented where each remote power system client can automate the entire process of power system analysis by generating the sequence of operations in a command list and it is not necessary for every power system client to maintain a separate thread of control. The sequence of power system operations is controlled by the command list which provides independence to each power system client to do its power system analysis in its desired order.

An RMI based active networking model for on-line dynamic security analysis is developed in order to avoid major overhead associated with the group communication model which does not support direct communication between the load flow server and the contingency server. The group
communication model is designed in such a way that every time the contingency server has to depend on load flow server to deliver results for each line outage through power system client. In the active networking model once a load flow data delivered as request from the power system client, contingency analysis for each line outage is calculated by the load flow and contingency servers and the final critical contingency list has been delivered back to the requested power system client.

A location independent model has been implemented to facilitate the power system application integration through heterogeneous environment, which merges RMI with CORBA standardized Internet Inter-ORB protocol. An economic load dispatch model has been implemented in .NET Remoting framework that provides common language runtime for deployment.

The performance analysis of the power system applications that are developed using the above distributed technologies has been carried out by measuring the Round Trip Time with considering the remote object reference lookup time. The performance evaluation method reported in this work is independent of the underlying distributed object models whose results are comparable and does not pose much overhead on the model. Performance analysis has been carried out for different power systems and the results are reported. The variations of round trip time with respect to the number of clients are plotted as graph. RMI based model with callback mechanism performs better than all other models. CORBA based model consumes more RTT because every time the power system client has to search the CORBA service provider for the load flow service in the network.
Component models for power system applications have been successfully deployed to afford portability and strong reusability. An agent based model proposed provides continues Economic Load Dispatch service in a multi client/single server environment. The component model proposed is considered as one of the best possible practical alternatives for on-line power system analysis because of its reusability and modularity.

5.3 FUTURE RESEARCH

The developed distributed models have been tested with IEEE standard 3 bus, 9 bus and 13 bus systems in a LAN environment. The models can be tested with large power systems in real time using the Internet and the performance has to be measured in real time scenario. If a power system client monitors the load flow continuously, the required load flow data can be placed in the cache of the local machine or in the nearby server. This implementation not only saves the time of data transmission but also improves the reliability of the system.

Power system applications like load flow monitoring, economic load dispatch and dynamic security analysis have been considered in this thesis and the core idea of the distributed models can be extended to power system state estimation, stability analysis and coherency identification. Nowadays, Java 2 Micro Edition (J2ME) becomes an emerging trend which supports mobile applications and the models implemented in this thesis can be extended to wireless LAN environment using J2ME technology. The author feels that development of grid architecture for on-line power system analysis is a great enhancement because the grid computing provides a
methodology for sharing the resources and makes the accessible “n” computers in the Internet as a single computer.

5.4 SUMMARY

This research is not confined to a small group of followers. The enhanced distributed models for on-line power system analysis proposed in this thesis are extremely useful for electric power utilities. This thesis explores various issues in deploying power system applications in a distributed environment and will serve the purpose of stimulating interest among power engineers.