

## Chapter 7 Conclusions

This chapter summarizes the dissertation and discusses the achievements of objective, the contributions, the limitations, and the future enhancement in the dissertation.

### 7.1 Summary of Dissertation

This dissertation presents simulation on IP Multicast using PIM-DM as the multicast routing protocol. In general, the dissertation begins with an analysis of IGMP and PIM-DM, then the development of IGMP and PIM-DM, and lastly evaluation on the performance of IP Multicast using PIM-DM simulation in different multicast group membership distribution pattern.

A review on IP multicast and computer simulation is done in Chapter 2. The review on IP multicast concentrates on multicast forwarding algorithms and multicast routing protocols, whereas the UMJaNetSim is emphasized in the review of computer network simulation.

In chapter 3, an analysis of IGMP and PIM-DM is done. An implementation of IP Multicast requires IGMP and a multicast routing protocol. The IGMP is required for handling multicast membership between hosts and routers. The PIM-DM, which is a multicast routing protocol, is required for constructing multicast distribution tree to provide multicast packets forwarding. Details in handling of message, table, timers and other special events are discussed for both IGMP and PIM-DM.

In chapter 4 and chapter 5, the development of new simulation components which are integrated into existing UMJaNetSim is discussed. The development of the simulation components includes the design part and implementation part. The design of simulation is implemented by using Java programming language. The classes created for the simulation purposes include *IGMPv2* for IGMP, *PIMDM* for PIM-DM, *IPMulticastApp*

and *MulticastdataApp* for simulation multicast applications, and lastly, *SimParamGroupTable*, *SimParamPIMDMTable* and *SimParamPIMDMNeighbor* for GUI display of IGMP and PIMDM table entries.

Testing of simulation components and performance evaluation of IP Multicast using PIM-DM is discussed in Chapter 6. Testing of simulation components is to validate the correctness of operation for each class created in the project. Besides, it is also used to verify that the algorithm implemented in PIM-DM could provide correct services in IP Multicast routing, and also the distribution tree can be constructed according to dynamic changes of multicast membership condition. In the section of performance evaluation, simulations of PIM-DM in various distribution patterns and multicast membership conditions have been done. The results collected from the simulation are processed and analyzed. Join latency, traffic concentration and protocol overhead are used as a point of reference for the performance of IP Multicast through PIM-DM in both dense distribution pattern and sparse distribution pattern. It is analysed in the simulations in order to evaluate the IP Multicast in densely distribution pattern and sparsely distribution pattern

## 7.2 Achievement of Objectives

The review on IP Multicast lead to a better understanding of multicast address, multicast applications, multicast forwarding algorithms, IGMP, and various multicast routing protocols, especially PIM-DM. An understanding of multicast routing protocol gives a better conceptual view on the operation, strength and weakness for a multicast routing protocol. This could help to find out the limitation and the improvement for IP Multicast. Besides IP Multicast, concept of network simulation is also learned.

The object-oriented IP Multicast PIM-DM simulator is completely developed. The IGMP module, the PIM-DM module and the multicast simulation applications are added into UMJaNetsim. It could provide IP Multicast simulation environment with PIM-DM as the multicast routing protocol. Validation test has proved that the simulator could function correctly. It is used to simulate and evaluate the performance of IP Multicast in two

different membership distribution patterns. Results and analysis of the simulation test is presented in the dissertation.

In short, the objectives of the dissertation are achieved. This dissertation gives the opportunities to study IP Multicast and the relationship of membership distribution pattern with the performance of IP Multicast, especially PIM-DM.

### **7.3 Contributions**

An IP Multicast PIM-DM simulator has been built in the UMJaNetSim. This newly created simulator provides UMJaNetSim with the function of IGMP and PIM-DM. Hence, it can be used for other simulation test on IP Multicast in the future. Besides, it can be used as a reference for further research work on other multicast protocol by providing a reference model in terms of coding, analysis, design and implementation. The implementation of IGMP version 2 in UMJaNetSim is also reusable for other implementation of multicast routing protocol in future.

Various simulation tests have been carried out in UMJaNetSim to evaluate the performance of IP Multicast through PIM-DM in two different membership distribution patterns. It is found that the membership distribution could affect the performance of IP Multicast in join latency, traffic concentration and protocol overhead.

In the join latency test, it is found that the sparsely distributed multicast members have lower join latency than the densely distributed multicast members. For traffic concentration test, dense distribution pattern has lower traffic concentration than sparse distribution pattern. Finally, in the protocol overhead test, the dense distribution pattern has a smaller protocol overhead than the sparse distribution pattern.

## **7.4 Limitations**

Some limitations exist in the simulation due to the prescribe scope of the dissertation and time constraints. Stated below are the limitations.

- The performance of PIM-DM compared to the other multicast routing protocol in dense distribution and sparse distribution of multicast membership is omitted
- The IP multicasting PIM-DM simulator does not support multi-access network and dynamic unicast routing network environment

## **7.5 Future Enhancements**

In conjunction with the limitations above, some enhancements are proposed for further research. These enhancements are summarized as below.

- Comparison of different multicast routing protocol in various of membership distribution patterns
- Provision support of PIM-DM in multi-access network
- Implementing dynamic unicast routing