Chapter 1 Introduction

Today, the Internet is undergoing rapid growth in all aspects, including topology size, number of users and number of applications. One of the popular applications available in the Internet is multicast application. Multicast application is introduced to link multiple users together so that users could share and receive the same information. As a result, some new protocols have been designed in order to implement multicast application. Protocol Independence Multicast – Dense Mode (PIM-DM) is one of the protocols that has been developed for the implementation of IP Multicast.

In this dissertation, a network simulation and performances evaluation on IP Multicast using PIM-DM as the multicast routing protocol was carried out. Hence, a discussion on the dissertation is going to be presented in this report.

In this chapter, an introduction to IP Multicast is presented in the first section. The following section is an introduction to computer simulation. This is followed by objective of the project in third section, and scope of the project in the forth section. Finally, a brief description on the organization of the whole report is presented.

1.1 Introduction to IP Multicast

IP Multicast is a communication pattern, which involves either one or multiple sources to multiple receivers, where only one IP packet is sent from one source at a given time. [1] It is very different from the conventional multiple destination communication. Before the implementation of IP multicast, multiple copies of the same packet are sent out by unicasting to multiple destinations or flooding the entire network by broadcasting. Both techniques consume a lot of network resources. Hence, it causes a waste in network bandwidth.

Nowadays, there are many multicast applications running on the Internet. Some of these applications are video conferencing, audio conferencing, video-on-demand, web TV casting, and distributed application. In the future, more multicast applications will be introduced. Hence, IP Multicast will become an important communication in IP networks.

Basically, there are three important components in IP Multicast: sender, receiver and multicast router. Senders are applications, which send multicast packets to multicast groups, while receivers are also applications, which must express an interest in joining a particular multicast group in order to receive multicast packets. In the meantime, multicast routers are responsible for exchanging routing information to construct multicast trees so that multicast packets can be forwarded from senders to receivers. [2]

In IP Multicast, similar to IP Unicast, an IP address is assigned to the address field of IP multicast packets so that the packets could be delivered to the members of the multicast group. However, the address used in multicast is a group address. This means all members in a particular multicast group are sharing the same multicast group address. As long as they are members of the group, each of them will receive a copy of packet that is multicast to this group, from every sender. [3]

To support IP Multicast, components in the network must be multicast-enable. These components include the sending and receiving hosts as well as the network infrastructure between the nodes, such as intermediate routers. [1] To be multicast-enable, Internet Group Management Protocol (IGMP) is needed in every hosts and leaf routers, while a type of multicast protocol is required to be implemented in every intermediate routers. The function of IGMP is to manage the joining and leaving process of multicast group members. Multicast protocol is used to exchange multicast routing information among intermediate routers so that these routers are able to forward multicast packets to their group members.

1.1.1 Internet Group Management Protocol (IGMP)

IGMP is designed to help a multicast router identify the hosts that are members of a multicast group. [3] In a subnet, one selected multicast router must take the responsibility to check whether members exist for every multicast group. This is done by sending out query periodically in the subnet. IGMP will subsequently notify multicast routing protocol in the router if there is a multicast group member exists in its subnet.

On the other hand, if a host is interested in joining a particular multicast group, it will report its membership for the group to the router through IGMP. When leaving a multicast group, a host will also use the IGMP to notify the router.

1.1.2 Multicast Routing Protocol

Multicast routing protocol is used to construct multicast trees for the purpose of multicast packet forwarding. [4] When a multicast packet arrives at a router, the router will find out the forwarding paths to distribute the multicast packet to the desired recipients. The forwarding paths are created based on the result produced by the multicast routing protocol.

Multicast routing protocol is developed based on multicast forwarding algorithms. In general, there are several defined algorithms. The algorithms are listed below.

- Flooding
- Spanning Trees
- Reverse Path Broadcasting (RPB)
- Truncated Reverse Path Broadcasting (TRPB)
- Reverse Path Multicasting (RPM)
- Core-Based Trees (CBT)

Normally, a multicast routing protocol is developed by combining some of the algorithms. There are many multicast routing protocol available now. Below are some of the general multicast routing protocols.

- Distance Vector Multicast Routing Protocol (DVMRP)
- Multicast Extension for OSPF (MOSPF)
- Protocol-Independent Multicast - Dense Mode (PIM-DM)
- Protocol-Independent Multicast – Sparse Mode (PIM-SM)
- Core-Based Trees (CBT) multicast routing protocol

1.2 Introduction to Computer Simulation

Computer simulation is the process of designing and executing experiments with a model of actual or imaginary system by using computer. The main objective of computer simulation is to experimentally test and analyzes a system without building an actual system. In general, computer simulation is divided into three categories based on the simulation approach. [5] These simulation approaches are stated below.

- Monte Carlo
- Continuous
- Discrete Event

A simulation process is divided into three main fields. [6]

- Model Design
- Model Execution
- Model Analysis.

Computer simulator is developed using a programming language. Two programming approaches used to develop a simulator are procedural approach and object-oriented approach.

1.3 Objectives of the Dissertation

This dissertation undertakes a detailed study on Internet Group Management Protocol (IGMP) and Protocol Independent Multicast – Dense Mode (PIM-DM), with emphasis on developing a simulation environment for testing and evaluating of IP Multicast using PIM-DM. The objectives of the dissertation are summarized as below.

- To study and explore IP Multicast.
- To study and explore the IGMP and PIM-DM multicast routing protocol.
- To build an object-oriented IP Multicast PIM-DM enabled simulator by adding new modules into the existing event network simulators, the UMJaNetSim, using Java programming language.
- To create a simulation environment for IP Multicast with PIM-DM as the multicast routing protocol.
- To evaluate the performance of the IP Multicast through PIM-DM in different membership distribution patterns.

1.4 Scope of the Dissertation

The scope of the dissertation in accordance with the objectives is summarized below.

- The brief study on advantages and application of IP Multicast, multicast address and several multicast forwarding algorithm, such as Flooding, Spanning Trees, Reverse Path Broadcasting (RPB), Truncated Reverse Path Broadcasting (TRPB) Reverse Path Multicasting (RPM), and Core-Based Trees.
- The brief study on IGMP, with concentration on IGMP version 2.
- The brief study on several multicast protocols, such as DVMRP, MOSPF, PIM-SM and CBT. Detailed multicast routing protocol is analyzed only for PIM-DM protocol. Further studies for the others are beyond the scope of this dissertation.
- The IP Multicast PIM-DM simulator is implemented on a point-to-point link network. It is developed based on the Internet-draft of "Protocol Independent Multicast Version 2 Dense Mode Specification". Mechanisms that involved multi-access network in PIM-DM are not implemented.

- The simulator implements IGMP version 2. It is developed based on RFC 2236. Mechanisms that involved multi-access network for IGMP version 2 are not implemented.
- The discussion on development of PIM-DM simulator is focusing on the new designed and implemented modules.
- The routers in the simulation are running on IGMP version 2.
- The IP Multicast PIM-DM simulator is implemented on non-dynamically changing unicast routing environment.
- The simulation multicast applications used in the simulation environment involve only one-to-many communication pattern.

1.5 Organizations of Dissertation

There are total of seven chapters in this dissertation. The dissertation is organized as below.

- **Chapter 1 Introduction**

  This chapter presents an introduction of the dissertation. Here, IP Multicast and computer simulation are first introduced. Then, the objectives and scope of the dissertation are defined.

- **Chapter 2 Literature Review**

  This chapter provides a discussion and review on IP Multicast and computer simulation. A review on IP Multicast includes a brief introduction to the basic IP Multicast and the elements that are involved in IP Multicast, such as multicast address, IGMP, multicast forwarding algorithms, and multicast routing protocols. On the review of computer simulation, besides an introduction to the computer simulation, programming approach used in computer simulation and Java programming language are also discussed. In addition, an analysis on UMJaNetSim in terms of architecture and Application Programming Interface (API) are also presented.

- **Chapter 3 Analysis on IGMP and PIM-DM**

  This chapter explores the elements and mechanisms involved in IGMP version 2 and PIM-DM. These include message type, table of entries, timers and the events that occurred in both protocols.

- **Chapter 4 System Design**

  This chapter details the design element in IGMP, PIM-DM and simulation multicast application. The system architecture and object classes for both protocols are concerned. Furthermore, the important attributes and methods in each element are illustrated.

- **Chapter 5 Implementation**

  This chapter covers the implementations detail for IGMP, PIM-DM, and the simulation multicast applications. Assumption and exclusion of the implementation are discussed here.

- **Chapter 6 Testing and Performance Evaluation**

  This chapter illustrates the analysis and result of the testing and simulation for the validation test and performance evaluation test. Here, the objective, brief procedures, result and analysis for testing and simulation are presented.

- **Chapter 7 Conclusions**

  This chapter summarizes the dissertation. The concentration is also focused on the achievement of the objectives, the contributions, the limitations and the future enhancements.