Multicast Routing Protocols, Algorithms and its QOS Extensions

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INTRODUCTION

The advancement in optical fiber and switching technologies has resulted in a new generation of high-speed networks that can achieve speeds of up to a few gigabits per second. Also, the progress in audio, video and data storage technologies has given rise to new distributed real-time applications. These applications may involve multimedia, which require low end-to-end delay. The applications' requirements, such as the end-to-end delay, delay jitter, and loss rate, are expressed as QoS parameters, which must be guaranteed. In addition, many of these new applications involve multiple users, and hence the importance of multicast communication. Multimedia applications are becoming increasingly important, as networks are now capable of carrying continuous media traffic, such as voice and video, to the end user. When there is a lot of information to transmit to a subset of hosts, then multicast is the best possible way to facilitate it. This article addresses different multicast routing algorithms and protocols. We have also discussed about the QoS multicast routing and conclude this article with mobile multicasting.

BACKGROUND

Multicast consists of concurrently sending the same information to a group of destinations such that exactly one copy of the packet traverses each link in the delivery tree. Interactive multicast applications include video conferencing, computer-supported cooperative work, and virtual whiteboard applications. Other multicast applications such as remote education require a lesser amount of interaction. A third group of multicast applications are noninteractive, for example mailing lists and some real-time control applications.

In a true multicasting, the least-cost path from the source to each network that includes members of the multicast group is determined. This results in a spanning tree of the required configuration. This is not a full spanning tree, but includes at least those networks containing group members. The source transmits a single packet along the spanning tree. The packet is replicated by routers only at branch points of the spanning tree.

When the same data need to be sent to only a subset of the clients on the network, both broadcast and multiple unicast methods waste network bandwidth by sending multiple copies of the data. Broadcast wastes bandwidth by sending the data to the whole network, whether the data are wanted or not. Broadcast also needlessly slows the performance of client machines. Each client must process the broadcast data, whether the client is interested or not. Multicast falls between these two extremes. It is useful for building distributed pseudo-real-time applications such as videoconferencing and audioconferencing. However, its use is not restricted to these kinds of applications. Any application that involves sending copies of data to multiple places can benefit. For instance, one could distribute network routing tables to all routers in an enterprise, while not burdening all of the workstations with processing these messages. If one has to send audio and video, which needs a huge amount of bandwidth compared to Web applications, multicast is the best possible solution. Multicasting has three advantages over broadcasting, particularly when the recipient group size is significantly smaller than all the possible recipients in a network. First, by routing a message only where it needs to go, multicasting conserves network bandwidth, facilitating more efficient use of the network infrastructural resources. It can result in user toll charges that are lower than broadcast delivery. Second, data transmission can be restricted to only the paying subscribers for services such as video on demand. Third, the dissemination of sensitive information can be limited to a select group of recipients.

MULTICAST ROUTING PROTOCOLS

- Distance-Vector Multicast Routing Protocol (DVMRP) designed to deliver multicast datagrams to a group of hosts across the Internet. DVMRP constructs source-based multicast delivery trees using the reverse-path multicasting (RPM) algorithm. In DVMRP a datagram from a multicast source is initially propagated downstream by a designated multicast router to all other multicast routers, regardless of whether they have multicast group members or not. Multicast routers without downstream or local members send explicit prune messages upstream to remove themselves from the distribution tree. The net effect is a source-specific shortest path tree, with the members forming the leaves of the tree. Once the multicast tree is set up, multicast routers keep track of the reverse path to the multicast source. If an arriving datagram does not come through the interface that the router uses to send datagrams to the source of the multicast, then the arriving datagram is dropped.
- Core-Based Trees (CBT): The CBT protocol was first discussed in the research community and then standardized by the IETF (Ballardie, 1997). The CBT uses the basic sparse mode paradigm to create a single shared tree used by all sources. The tree is rooted at a core. All sources send their data to the core, and all receivers send explicit join messages to the core. CBT uses only a shared traffic tree, and is not designed to use shortest path trees. CBT uses bidirectional shared trees, but PIM-SM uses unidirectional shared trees. Bidirectional shared trees involve slightly more complexity, but are more efficient when packets are traveling from a source to the core across branches of the multicast tree. In this case, instead of only sending "up" to the core, packets can also be sent "down" the tree. While CBT has significant technical merits and is on par technically with PIM-SM, few routing vendors provide support for CBT.
- Protocol Independent Multicast – PIM: PIM provides both dense mode (PIM-DM) (Deering, 1998) and sparse mode (PIM-SM) (Estrin, 1998) group membership. As the name implies, the multicast architecture is independent of the protocol employed for unicast routing. PIM can scale to wide-area networks, and is particularly attractive for sparse multicast group. Essentially PIM can use either the shared tree approach of CBT or the shortest-path approach of DVMRP, with appropriate choice made on a per group or per host basis. The PIM architecture relies upon choosing a suitable rendezvous point (RP), similar to a core in CBT, when constructing the multicast delivery tree for a group. The RP provides a place for multicast sources to "meet" multicast recipients.
- Border Gateway Multicast Protocol (BGMP) (Thaler, Estrin & Meyer, 1998)**:** is a new inter-domain multicast routing protocol that addresses many of the scaling problems of earlier protocols. BGMP attempts to bring together many of the ideas of previous protocols and adds features that make it more service provider friendly. BGMP is designed to be unified inter-domain multicast protocol in much the same way that Border Gateway Protocol (BGP) is used for unicast routing.

MULTICAST ROUTING ALGORITHMS

Different multicast routing algorithms are summarized in this section, both unconstrained and constrained. A taxonomy of these multicast routing algorithms is given in Table 1.

- Shortest Path Tree: A shortest path algorithm minimizes the sum of the weights on the links along each individual path from the source to a receiver in the multicast group. If unit weight is used per hop, the resulting tree is a least-hop tree. If the weight represents the link delay, the resulting tree is a least-delay tree. The Bellman-Ford and Dijkstra algorithms are the two best-known shortest path algorithms. Both are exact and run in polynomial time.
- Minimum Spanning Tree: A minimum spanning tree is a tree that spans all the group members and minimizes the total weight of the tree. The well-known centralized minimum spanning tree algorithm is Prim's algorithm. In Prim's algorithm the tree construction starts from an arbitrary root node and grows until the tree spans all the nodes in the network. Minimum spanning tree algorithms run in polynomial time and can be used to solve tree optimization problems.
- Steiner Tree: The Steiner tree aims to minimize the total cost of the multicast tree, and is known as NP-complete. If the multicast group includes all nodes in the network, the Steiner tree problem reduces to the minimum spanning tree problem. Unconstrained Steiner tree algorithms can be used to solve tree optimization problems. Tree cost optimization for a whole session duration for unconstrained routing algorithm is proposed in Chakraborty, Chakraborty, Pornavalai and Shiratori (1999). Salama et al. (Salama, Reeves & Viniotis, 1997) gave very good reviews on