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Core-selection algorithms in multicast routing - comparative and complexity analysis

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Abstract

The Core-based approach is inevitable in multicast routing protocols as it provides efficient management of multicast path in changing group memberships, and scalability and performance. In this paper, we present a comprehensive analysis of this approach with the emphasis on core selection for the first time in literature. We first examine the evolution of multicast routing protocols into the core-based architecture and the motivation for the approach. Then we review the core-selection algorithms in the literature emphasizing their algorithmic structure and performance. Our study involves an extensive computational and message complexity analysis of each algorithm, and a classification for their deployment characteristics and algorithmic complexities. To the best of our knowledge ours is the first attempt towards providing such extensive comparative analysis of core-based multicast routing protocols.

Keywords: Multicast routing; Core-based approach; Core selection; Complexity analysis

1. Introduction

Multicasting is the simultaneous delivery of data stream to multiple receivers in the domain. Its applications are numerous in group communications including various forms of audiovisual conferencing (discussion forums, live auctions, negotiation systems, white-board applications, online games, chat-rooms), broadcasting (online radios, e-learning systems), mass delivery in digital marketing (software upgrade distribution, news delivery, stock quotes), replicated database applications in various forms of cross-query systems (airline systems, banking applications, cross-catalog search), offline virtual communities (newsgroups, mailing lists), as well as certain search operations of routers to locate counterpart and resources for their own operations in the domain. Group communications on Internet are increasingly pervasive parallel to the wider acceptance of Internet applications.

The objective of multicast routing, in broad terms, is the efficient delivery of the stream to the recipients. Group communications have varying QoS demands on network resources and transmission capacities. In broadband applications, the cost of transmission is significant concern and the packets need to be delivered to their destinations in real-time for the quality of application. The prominent QoS problem broadband multimedia applications is *constrained cost minimization*, delivering the stream to the receivers at minimum cost while meeting a given upper bound for end-to-end delay.

Multicast routing protocols evolved parallel to the growth in Internet size and coverage from broadcast routing that transmits to all but not just a subset of domain nodes. Earlier protocols constructed shortest paths from sources to each receiver in multicast group and hence source-based shortest path trees. Shortest path tree (SPT) still is the design problem in tree construction. In today's protocols, design concern is on core selection into optimization of metrics additional to delay for the improvement of scalability of the protocol especially in today's QoS-sensitive applications.

Multicast routing protocols evolved into core-based approach for improved performance during its operations in distributed networks. Location and structure of routing tree in a group application clearly is the dominant

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determinant on the protocol performance in multicast applications. Core based scheme offered alternative in multicast tree root and thus location to source-rooted tree approach for improved scalability and performance of the protocol. Multi-core trees with multiple cores to serve the group ultimately provided more efficient use of the multicast trees by the group. Selecting the location(s) of the core(s)-the process preliminary to tree construction operations is crucial in this respect for protocol operations, and the lack of an effective core-selection process is likely to degrade the efficiency of the multicast routing protocol to a significant extend.

This paper investigates the core-based approach and core selection algorithms presented in literature. In Section 2, we examine the multicast routing protocols and the motivation for the core-based architecture. In Section 3, we present our review and analysis of core selection algorithms. We first present the terminology and preliminaries to this line of research in Section 3.1. In Section 3.2, we describe a classification of core-selection algorithms for their implementation characteristics. We provide the review of these algorithms in Section 3.3. In Section 3.4, we analyze each algorithm for its computational and message complexity. Section 3.5 includes comparative discussion on the core selection algorithms studied. The final section includes our concluding remarks. To the best of our knowledge, our study is unprecedented for its analysis and coverage of core-selection algorithms in literature to date.

2. Multicast routing protocols

In this section, we overview multicast routing protocols with emphasizing core-based architecture and the current state of these protocols. We distinguish a '*multicast routing protocol*' from '*multicast routing algorithm*' in that the latter refers to merely the tree-building algorithm, parallel to the terminology in the literature. A multicast routing protocol, on the other hand, is the overall suite that includes the multicast tree building algorithm as well as the maintenance of the tree structure in the dynamisms of the multicast environment, packet forwarding, failure discovery and recovery, and other features depending on the protocol specifics. The main architectural component of a multicast routing protocol is the development of the multicast tree not only because it is the structure that directly affects the performance of the protocol, but also is the most demanding one for the development and maintenance. Another major concern in multicast protocol design is the feasibility of the deployment while maintaining high performance in the presence of cost of control overhead to operate and maintain the construct to support that performance. These two are often contradictory goals since a better approximation of the multicast tree for improved performance demands for broader domain knowledge than that available on the nodes, which results in additional overhead for tree maintenance due to changes in the network conditions and group membership dynamics.

In Fig. 1, we present a classification of multicast routing protocols with respect to their path construction and maintenance characteristics. The figure also indicates the time-sequence of the emergence of the protocols with the exception of PIM/DM, which is the dense-mode component of PIM protocol suite appearing in literature along with CBT. Earlier protocols, namely DVMRP and MOSPF assumed source-based multicast trees, i.e. the multicast path is built as a tree rooted as the source of the multicast group. The research later on shifted to core-based trees with the motivation of scalability in sparsely distributed multicast group in a wide domain. Recent trends in multicast protocols include multi-core multicast trees, which allows more than one cores for improved tree accessibility and performance. The assumed problem for tree construction in all multicast routing protocols in Fig. 1 is SPT to minimize end-to-end delay.

2.1. Source-based protocols

In this group of protocols, the multicast tree is rooted at the source of the group with an attempt to minimize delay between the source and each receiver. As we demonstrate in

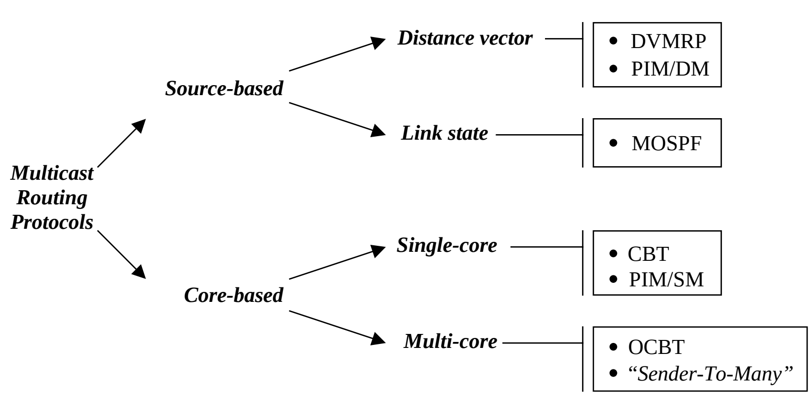

Fig. 1. A classification of multicast routing protocols.