Bandwidth and End-to-End Delay Analysis of IP and End System Multicast (ESM)

Syed S. Rizvi and Nathan D. Showan

College Of Information Sciences & Technology, Pennsylvania State University, Altoona PA

Motivation

- Develop analytical and the mathematical models for formalizing the *end-to-end delay* and the *bandwidth efficiency* of both ESM and IP multicast system.

What is ESM?

- ESM is a promising application-layer scheme for implementing multicast routing.
- ESM is considered as a practical alternative to the IP multicasting.
- All multicast functionality is shifted to the end users.

Potential Problems?

- Limitation in bandwidth
- Message needs to be forwarded from host-to-host using unicast connections which can increment the end-to-end delay

What is Needed?

- Require a sound understanding of the multicasting schemes such as IP multicast and ESM before deployment

Who will Benefit?

- Communication entities supporting high-speed real-time applications such as live streaming multimedia, videoconferencing, distributed simulations, and multiparty games

IP Multicast

Our Considerations

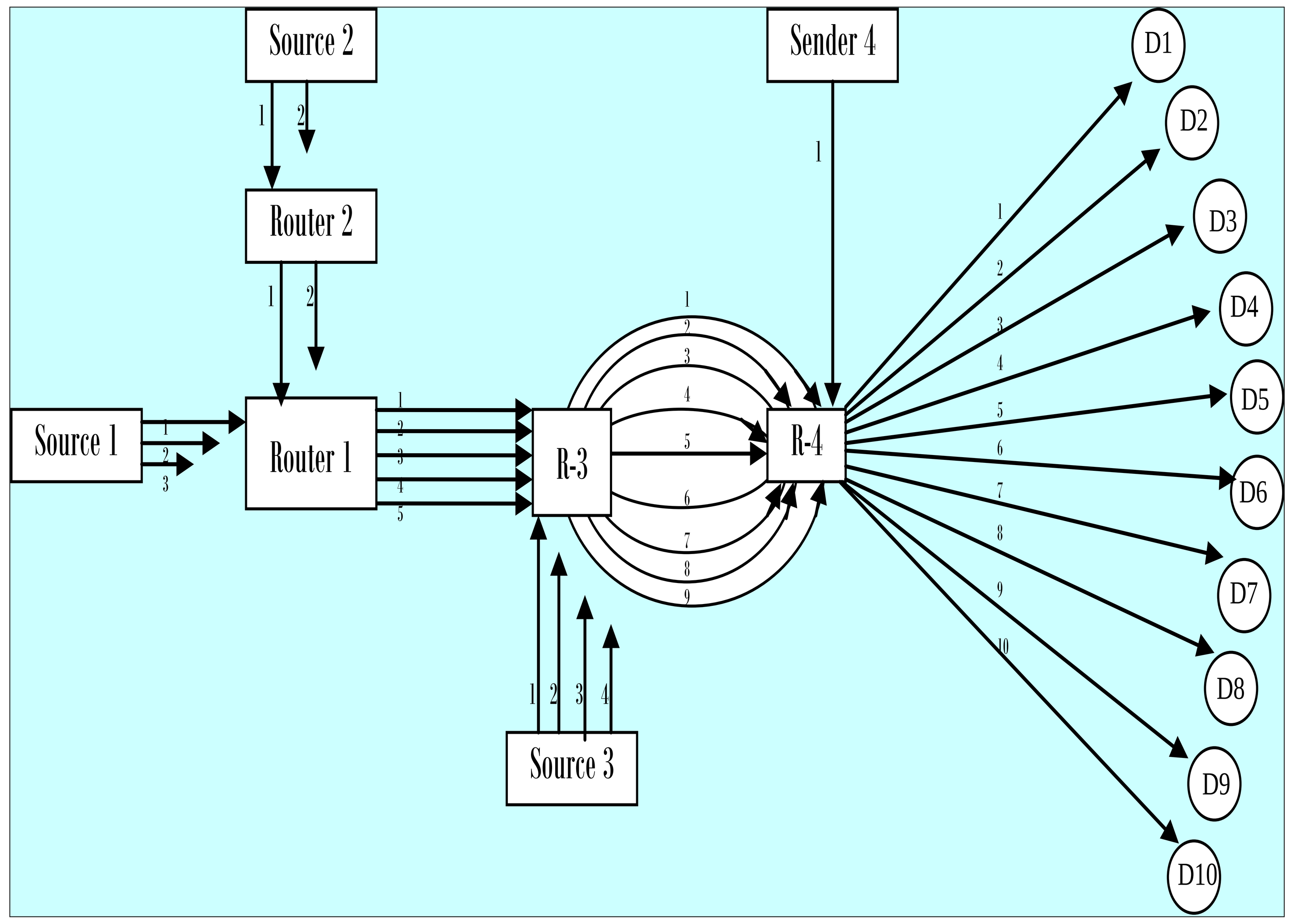
- IP multicast capable routers are considered in our analysis.
- In IP-multicast, we use a source-rooted tree with the members of the multicast group.

Performance

- Takes the same bandwidth on source host's network as a single copy.

Problem

- No commercial support for multicast routers.



Formalization of IP Multicast

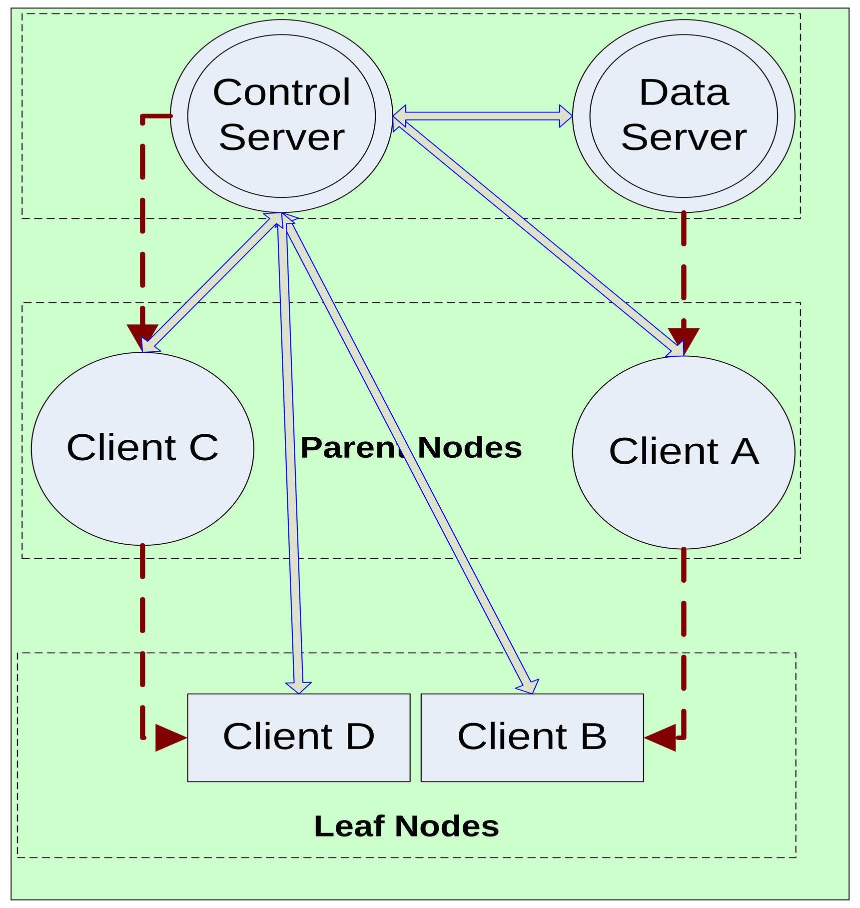
End-to-End Delay Expression:

$$D_{\langle s \longrightarrow (d\in M_G)\rangle} = \sum_{L_{n,Z}\in R_T(s,d)} D\left(L_{n,Z}\right)$$

*where $L_{n,Z}$ represents the total number of links (i.e., $Z \in R_T$) that a packet needs to traverse to reach the specific destination **d** along a path of R_T within the tree **T***

Bandwidth Efficiency Approximation:

$$TB_{W\langle s \longrightarrow (d\in M_G)\rangle} = \frac{(P_s)(SoL)}{\left|(SoL)\left\langle \sum_{L_{n,Z}\in R_T(s,d)} D\left(L_{n,Z}\right)\right\rangle - L_D\right|}$$



Analysis of ESM

- ESM is built on top of the unicast services provided by network on transport layer.
- The membership and replication functionality is performed by the end receivers, which connect together over unicast channels to form a multicast tree, rooted at one data source.

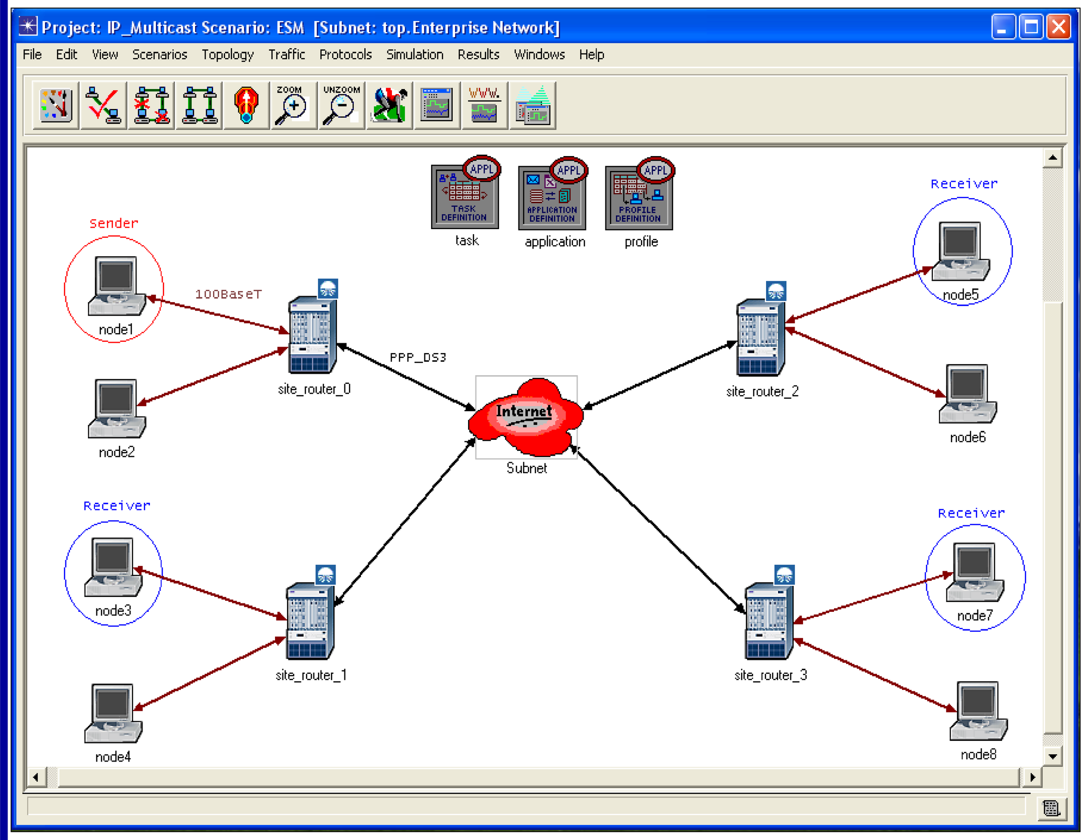
End-to-End Delay Expression:

$$D_{\langle s \longrightarrow (C_n)\in\{s,P_nUN\}\rangle} = \sum_{i=1}^{n} D\left(L_{i(s\longrightarrow P_n,C_n)}\right) + \sum_{i=1}^{n} D\left(L_{i(P_n,C_n)}\right)$$

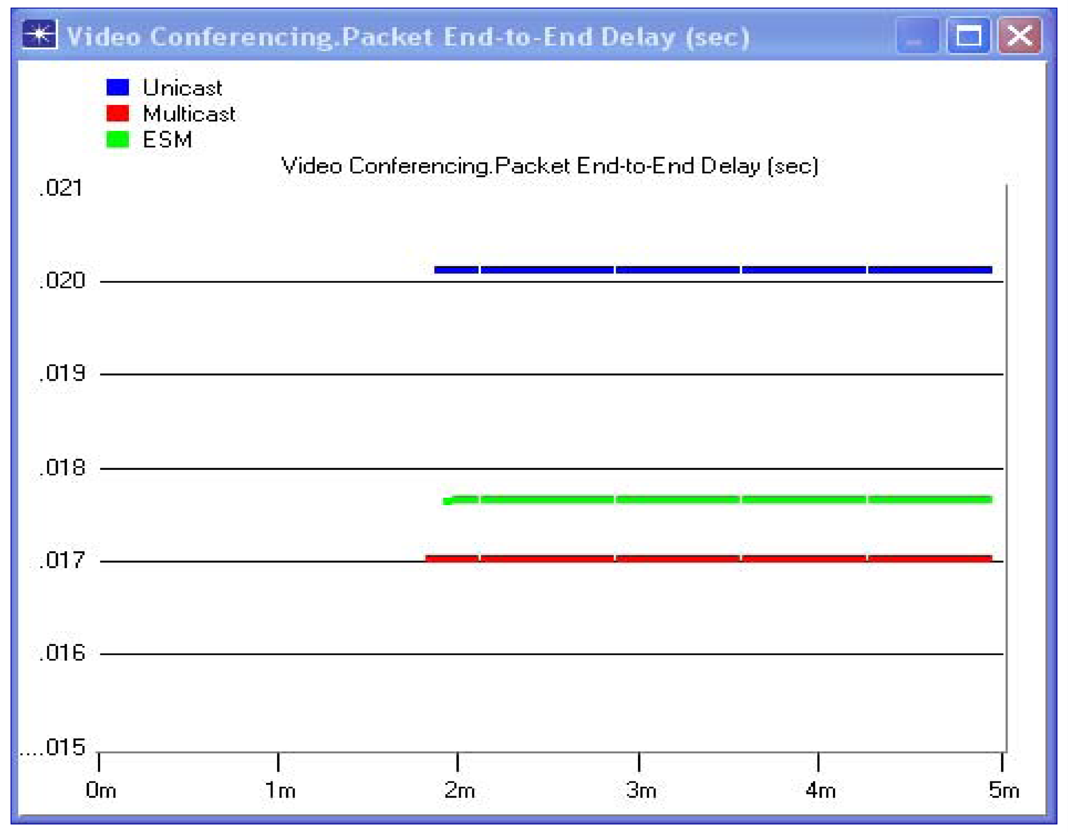
Bandwidth Efficiency Approximation:

$$TB_{W\langle s \to (C_n)\in\{s,P_nUN\}\rangle} = \frac{(P_s)(SoL)}{\left|\left\langle \sum_{i=1}^{n} D\left(L_{i(s\to P_n,C_n)}\right) + \sum_{i=1}^{n} D\left(L_{i(P_n,C_n)}\right)\right\rangle (SoL) - L_D\right|}$$

Model for Multiple Unicast, IP Multicast and ESM Video Conferencing Transmissions



Average End-To-End Packet Delays for Multiple Unicast, IP-Multicast and ESM simulations.



- ✓ Simulations are performed using OPNET to examine the performance of Multiple unicast, IP multicast, and ESM schemes.
- ✓ ESM packets transmission provides comparatively good performance than the Unicast but not as impressive as the IP multicast.

Results

- ✓ We show that the IP-multicast demonstrates some good bandwidth efficiency characteristics than the other multicast schemes.
- ✓ Our formalization of bandwidth efficiency suggests that the ESM is a feasible alternative for sparse, medium size group.