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

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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.
- Takes the same bandwidth on source host’s network as a single copy.
- No commercial support for multicast routers.

Performance

End-to-End Delay Expression:

\[ D_{\text{end-to-end}}(d \in \text{M}_g) = \sum_{i=1}^{n} D(L_{\text{root} \rightarrow C_i}) + \sum_{i=1}^{n} D(L_{C_i \rightarrow C_j}) \]

Bandwidth Efficiency Approximation:

\[ TB_{\text{end-to-end}}(d \in \text{M}_g) = \frac{(P_{\text{Unicast}})(\text{SoL})}{\left(\sum_{i=1}^{n} D(L_{C_i \rightarrow C_j}) + D(L_{C_j \rightarrow C_k}) - L_D\right)} \]

Formalization of IP Multicast

End-to-End Delay Expression:

\[ D_{\text{end-to-end}}(d \in \text{M}_g) = \sum_{i=1}^{n} L_{C_i \rightarrow C_j} D(L_{C_i \rightarrow C_j}) \]

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

Bandwidth Efficiency Approximation:

\[ TB_{\text{end-to-end}}(d \in \text{M}_g) = \frac{(P_{\text{Unicast}})(\text{SoL})}{\left(\sum_{i=1}^{n} D(L_{C_i \rightarrow C_j}) - L_D\right)} \]

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.

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.

Results
- 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.
- 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.