Multicast routing

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- General techniques for routes creation
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What is multicast routing?

Multicast definition

- Multicast *is a network technology for the delivery of information to a group of destinations simultaneously using the most efficient strategy to deliver the messages over each link of the network only once, creating copies only when the links to the multiple destinations split.*

What is multicast routing?

Basic description

- Unicast vs. broadcast vs. multicast
- One-to-one vs. one-to-all vs. one-to-many
- Effectivity is important
- Multicast group
  - Static / dynamic multicast groups
  - Sparse / pervasive multicast groups
- Multicast applications – content delivery

What is multicast routing?

The multi-objective multicast routing problem formulation

- Directed graph $G = (V, E)$
- $(i, j) \in E$ – link
- c_{ij} – cost of the link
- d_{ij} – delay
- $r_i \in R$ – destinations
- s – source
- $T(s, R)$ – multicast tree
- $p_T(s, r_i) \subseteq T(s, R)$ – path between source and destination r_i
- $d(p_t(s, r_i))$ – delay of path $\sum_{(i,j) \in p_T(s,r_i)} d_{ij}$

What is multicast routing?

Objectives

- Path delay (QoS) – maximal / average
- Total cost of the tree
- Maximum congestion (capacity – usage)
- Overhead
- etc.

What is multicast routing?

End of part: What is multicast routing?

General techniques for routes creation

Description

Algorithms can be

- On line
- Distributed algorithms

Unicast tunneling – connecting two multicast enabled segments

General techniques for routes creation

Part 1

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

General techniques for routes creation

Part 1 – Flooding

- Forwarding datagrams from source to other nodes
- Dropping datagram if it was already received
- Easy to implement
- Disadvantage is huge overhead

General techniques for routes creation

Part 1 – Spanning Trees

- Less overhead than flooding
- Easy to implement
- Great deal of experience with minimal spanning trees
- Disadvantage is suboptimality of routes

General techniques for routes creation

Part 1 – RPB & TRPB

- (Truncated) Reverse Path Broadcasting – (T)RPB
- Builds group specific source rooted spanning tree
- The node forwards the packet arriving on the link that is considered shortest to source
- Truncated variant considers group member positions

General techniques for routes creation

Part 1 – RPM

- Reverse Path Multicasting (RPM)
- Same as TRPB, but delivery tree that spans only
  - subnetworks with group members
  - routers and subnetworks along the shortest path to subnetworks with group members
- Leaf routers send prune message if there is no group member

General techniques for routes creation

Part 1 – Core-Based Trees

- Shared single static delivery tree
- Destinations join/prune the multicast group
- Disadvantages are
  - bottlenecks near core routers
  - suboptimality of routes

General techniques for routes creation

Part 2

- Distance Vector Multicast Routing Protocol (DVMRP)
- Multicast OSPF (MOSPF)
- Protocol-Independent Multicast (PIM)

General techniques for routes creation

Part 2 – PIM

- Protocol-Independent Multicast (PIM)
- Uses CBT
- Explicit join mechanism
- Different versions sparse/dense/bidirectional
- IP routing protocol-independent
- It does reverse path forwarding

General techniques for routes creation

End of part: General techniques for routes creation

Steiner tree problem

Description

- Interconnect given a set V of nodes by a network of shortest length
- Expands spanning tree problem with “non-included” edges and vertices
- Most versions are NP-complete, but heuristics available
- Mapping on multicast routing problem
- One of the most studied

Steiner tree problem

Discussion

- Euclidean Steiner tree (polynomial *near-optimal* solution)
- Metric Steiner tree vs. General Steiner tree problem
- Best in situations where virtual connection must be established
- Varying levels of complexity upon the cost and/or criterion
- Is it optimal?

Steiner tree problem

Heuristics

- KMB Heuristic
- Takahashi and Matsuyama
- Wu
- Wang
- None of the algorithms just mentioned is superior in quality to any other

Steiner tree problem

Heuristics – KMB

- Has performance guarantee
- Very good results (5% of optima in real networks)
- Algorithm:
  Construct a complete graph $K(R, E)$
  where $d(i, j)$ is the shortest path from i to j in G
  Find minimum spanning tree T of K
  Replace each edge (i, j) in T by complete path from G
  Compute minimum spanning tree from the result
  Remove all nodes that are not in R

Steiner tree problem

Heuristics – Takahashi and Matsuyama

- Combination of the processes of finding shortest paths and finding a minimum spanning tree
- It is path-distance heuristic
- Procedure is analogous to the one presented by Prim
- Algorithm:
  Initially the tree is composed only from source tree
  Then, at each step heuristic searches for still unconnected destination that is closes to the current T

Steiner tree problem

Steiner Tree Problems with Delay Constraints

- Adding additional requrements to previous definition
- Minimalizing delay – assurance of QoS
- NP-Complete
- Well studied problem – many algorithms available

Steiner tree problem

Steiner Tree Problems with Delay Constraints - Algorithms

- Variations
  - on line
  - distributed

Steiner tree problem

End of part: General techniques for routes creation
Thank you for your attention