Multicast routing

state-of-the art, standardisation, open issues and research directions

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Topics

- Classification of multicast routing protocols in Internet with fixed infrastructure
- Optimised and Overlay Multicast Routing
- Inter-domain Routing
- Multicast Routing for Mobile Internet
- Ad hoc multicast routing
- QoS based Routing

Classification of multicast routing protocols in Internet (1)

Classification criteria: Path construction and maintainance
Multicast routing protocols characterised by:
- multicast tree building algorithm,
- maintenance of the tree structure,
- packet forwarding,
- failure discovery and recovery

- Objective of multicast routing
  - Constrained cost minimization delivering multicast data while meeting an upper bound for end-to-end delay
  - Multicast routing algorithms designed according application and group requirements / constraints
- Source based
  - Shortest path multicast tree always routed by the source
  - Delay optimisation during multicast forwarding from source to the receivers, but possible additional tree maintenance overhead for specific group communication models
  - Distance vector: DVRMP, PIM-DM
  - Link state: MOSPF
- Core based
  - Shortest path multicast tree routed at the core
  - Single core: CBT, PIM-SM
  - Multi-core: OCBT, “Sender-to-many”

Classification of multicast routing protocols in Internet (2)

Core based protocols and core selection algorithms

- Choice of core – dependent on
  - Topological location of the multicast group members
  - Delay in data forwarding,
  - Bandwidth
  - Protocol control overhead
- Preferable to source based trees in case of multiple multicast sources
- Core selection algorithms
  - Single core and multiple-core,
  - Constrained and unconstrained
  - Centralized (GREEDY, opt_tree) and distributed
  - Topology based
  - Group based
- Criteria
  - maximum and average distance form the core to group members
  - Diameter of the tree routed by the core
  - Minimum and maximum cost of the tree

Optimised and overlay multicast routing (1)

- Bypass the traditional multicast routing deployment
- Bridging service between several multicast-capable areas running different multicast routing protocols (IPv4 and IPv6)

- Unicast / Multicast Reflector and Punctual Tuning
  - Host having access to unicast routing contacts a reflector (user level gateway between a multicast enabled network and unicast hosts)
  - Limited time and group size
  - UMTP, MTunnel
- Permanent Tunneling
  - Tunneling at router level with IP encapsulation for the whole multicast group
  - Mrouted DVMRP
- Automatic Overlay Multicast
  - Multicast by end-systems implementing the routing approach
  - Overlay topology under complete control and application dependent
  - Underlying topology is hidden
  - Membership knowledge
    - centralised (source), RP or distributed among members,
    - partial and full knowledge
  - “Mesh” and “tree first” distributed algorithms
  - Narada – overlay structure on top of unicast

Optimised and overlay multicast routing (2)

Dedicated multicast strategies

- Gossiping for Peer-to-peer communications
  - Gossiping technique like Scribe can be used for highly robust state distribution
  - Each node increases the group membership knowledge horizon by one hop
  - RP maintains the whole knowledge
  - Technique limited to small data transfer
- Dedicated new group communication routing service
  - Needs for stable networking infrastructures and mobile ad hoc networks
  - Dedicated way to distribute topology (distributed core routers)
  - Scalability support: XCAST, Distributed Core Multicast (DCM), AMRoute (overlay mesh), ODMRP (source crates on-demand a mesh of sources), MAODV (on demand building of shared trees)

Optimised and overlay group multicast routing (3)

Approaches for scalable multicast routing: Routing states reduction

- Reducing the routing states by tunneling and routing state aggregation on top of PIM or CBT
- Encoding of list of destination addresses in a branching node
  - Simple Explicit multicast
- Partially elimination of routing states by using of branching routers in the multicast tree
  - State aggregation: REUNITY, SEM, HBH
- Elimination of routing states completely by explicitely encoding the list of the destinations in the packets instead of using of multicast address
  - Explicit Multicast: Xcast, Gxcast

Inter-domain routing

Multcast routing between domains needs further concepts to support content delivery

- Currently, no scalable solution for inter-domain multicast routing
- Configuration complexity of current connection of different domains for inter-domain multicast based on
  - MBGP (Multiprotocol Extension to BGP)
    - Used to announce different multicast and unicast routers
  - MSDP (Multicast Source Discovery Protocol).
    - Exchange active source information among different domains
- Inter-domain support of emerging multicast applications – on-demand multicast for content delivery
  - Hop-by-Hop Multicast Routing Protocol proposed
    - Source specific channel abstraction
    - Unicast routing asymmetries impact the multicast tree construction

Multicast routing for Mobile Internet

DAIDALOS approach: Integration of IETF standardised multicast group communication and routing protocols (MLDv2, PIM-SM) in Mobile IPv6 architecture

- Mobile Multicast routing in IPv6
  - Source mobility
  - Client mobility
- Mobile Multicast routing in IPv6
  - PIM-SM with context transfer -> DAIDALOS solution
- Optimised routing in MIPv6
  - Candidate access router discovery
- Multicast routing on unidirectional inks
  - Extension of MIPv6 with facilities to handle unidirectional links in interaction with RFC 3077)

Multicast routing in Ad hoc Mobile Networks (1)

MANET protocols: dynamic collection of nodes with sometimes rapidly changing multi-hop technologies (low bandwidth wireless links)

- AODV – Multicast extension of On-Demand Distance Vector
  - Discovers multicast routes on-demand using a broadcast discovery mechanism
  - Builds a shared multicast routes on demand using a broadcast route discovery mechanism
  - Shared bi-directional multicast tree
- ODMRP – On-demand multicast routing protocol
  - Mesh based
  - Forwarding group concept
  - Soft states for maintaining group members
  - Extension of MIPv6 with facilities to handle unidirectional links in interaction with RFC 3077)

Multicast routing in Ad hoc Mobile Networks (2)

Ad hoc wireless protocols

- AMRoute – Ad hoc multicast routing protocol
  - A tree based protocol
  - Bidirectional shared multicast tree
- AMRIS – Ad hoc multicast routing protocol utilising increasing id numbers
  - Establishes a shared tree for multicast forwarding
  - Detects link disconnection by beaconing mechanism
- Heterogeneous mobile ad hoc networks
- Range based mobile Multicast
- CAMP – Core Assisted Mesh protocol
  - Shared meshed stricture
  - Nodes are duplex or simple mebers or no members

QoS based multicast routing

- Goal
  - Finding a path satisfying routing requirements
  - QoS of multicast tree (receiver perceived QoS)
    - Function of group dynamic including
      - ↗ **QoS aware routing**
      - ↗ **Tree rearrangement**
      - ↗ **Core /tree migration (core selection)**
- Multicast resource reservation models
  - Source and Receiver driven QoS reservation
  - Receivers with Heterogeneous QoS
  - Partitioning of multicast requirements into local requests minimising the route tree cost
- QoS driven routing and resource reservation
  - Integration of routing and resource reservation
    - RSVP Integrated Multicast (RIM)

Multicast routing algorithms supporting QoS requirements

- Shortest path tree
- Minimum spanning tree
- Steiner Tree
- Constrained Steiner Tree
- Maximum bandwidth tree
- Trees based on heuristics to meet the delay and inter-receiver delay jitter constraints
  - Tree rearrangement on response to Member Join / Leave

