Housekeeping

- Exam Friday: open book, open notes, closed neighbor, 50 minutes
- Hauser out of town – Wednesday PM through Friday. Office hours on Thursday are cancelled.
  - I expect to read and respond to email at least once Thursday evening (late)

Project Discussion

- Surprising behaviors
- Experimental techniques
- Debugging techniques
- Best-performance parameters
- Deficiencies of this implementation
- Thoughts about improving the implementation

Multicast

- What is multicast?
  - Contrast: broadcast, unicast
- Why multicast?
- Internet multicast:
  - Simple model
    - Receiver perspective – tell closest router to deliver traffic for a particular group
    - Sender perspective – send IP datagrams (protocol 2)
    - No membership directory, no membership or sender control
    - Not reliable, not ordered

IGMP: Internet Group Management Protocol

- Operates between host and closest router
  - Router sends: membership_query messages
  - Host sends: membership_report
    - In response to membership_query
      - Suppresses response if first hears another host announce membership
    - Spontaneously to join a group
  - Host sends: leave_group
    - Optional – why is this ok?

Multicast Forwarding

- Goal: forward traffic for a multicast group only to networks one or more hosts subscribed to the group – or needed for transit to such networks
- Two approaches
  - Shared tree
  - Source-specific tree
    - Link-state based – optimal for each sender
    - Reverse Path Forwarding

Shared Tree

- Rendezvous Point (center)
  - Optimal choice of center?
- Unicast join messages from edge routers
  - Path of join messages is reversed for delivery of mcast traffic
  - Where is the center?

Source-specific tree

- Link-state based – optimal for each sender
  - Add multicast group membership to link state packets
  - Routers build pre-pruned shortest path trees for each mcast group
  - MOSPF (Multicast open shortest path first)
- Reverse Path Forwarding
  - Forward mcast packets on all interfaces not on the shortest path to the sender
  - Pruning/Grafting (reverse of pruning)
  - DVMRP (Distance vector multicast routing protocol)
    - Available as mrouted

PIM: Protocol Independent Multicast

- No assumptions about underlying unicast routing protocol
- Dense mode – similar to DVMRP
  - Flood mcast traffic unless pruned
  - Used when a tightly connected set of routers are likely to all want to participate in similar sets of groups
- Sparse mode – center-based with source-specific option
  - No mcast traffic unless joined
- Choice of sparse vs. dense?
- switching between sparse and dense?

Between AS's?

- DVMRP
  - Better suited for dense situations
  - Deployed in a sparse situation
- BGMP – Border Gateway Multicast Protocol
  - Under development in 1998
  - Current status?

Multicast Tunneling

- Not all internet routers are capable of supporting multicast
- What to do?
- Encapsulate multicast traffic and routing info in unicast packets between multicast-aware routers
  - Tunneling!
  - Basis of the MBONE – the internet M(ulticast)(Back)BONE
- Tunneling is also the basis of Virtual Private Networks