Announcements

• Some people sent feedback, continue to send them
• Exam1 will be returned on Wednesday
• Project1 due on Wednesday
Unicast
Multicast
IP Multicast Model

• Groups
  – Nodes subscribe to a group
  – Messages are directed to a group
Group Management Using IGMP

- Hosts subscribe
- Maintainance
  - Polling by routers
  - Response Suppression

How many poll and response messages per group?
DVMRP

• Flood
• Prune

• How do we discover new nodes?
PIM

- Shared tree
- Rendez-Vous point
- Switch to source-specific trees
- Where is RP?
Challenges

• Billing
  – Who to charge?
  – How many users?
• Secure broadcast
• Address space
• Scaling
EXPRESS

• Channel Model
  – (S,E)
• Subscriber subscribes to (S,E)
• Sender S sends to (S,E)
EXPRESS Service

• Channel Model
  – \( (S,E) \)

• At source
  – Count = CountQuery(channel,countId,timeout)
  – channelKey(channel, \( K_{(S,E)} \))

• Subscriber
  – result = newSubscription(channel, \([K_{(S,E)}]\))
  – count(channel, countId, count)
EXPRESS Advantages

• $2^{24}$ channels per host
  – 232.0.0.0/8

• Source has exclusive transmission access to the channel

• Counting operations available
  – Can be used for accounting

• Subscriber can be selective

• ISP’s know who to bill
ECMP

• Maintain the distribution tree
• Count

• Flood the network with CountQuery
• Subscribers respond with Count

• How can we use Count for
  – Subscription
  – Voting
CountQuery Routing

- Forward the message to downstream routers
- At each hop, set timeout
  - Decrement by $k \times RTT$ to the upstream router
Distribution Tree Maintenance

• Subscribe with unsolicited
  \text{Count(ch,countId,1)}

• Keepalive
  – TCP or UDP

• Unsubscribe with Count(ch,countId, 0)

• Discovery with CountQuery(neighbors)
Multi-source Multicast

- Example
  - Video conferencing application
- Almost single-source multicast application
  - Distance learning
- Session Relay
SR comparisons

• PIM-SM
  – Switch from rendez-vous to source-specific tree

• Why SR?
  – Application control over Relay placement
  – Not much worse than shared tree
Cost and Overhead

• Price for router components
  – Memory, CPU

• State maintenance Overhead
  – Refresh state
  – TCP helps
Proactive Counting

• Send updated count if it is outside the tolerance