Network Improvements for Application Support

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The Internet as it really is

• The optical internet backbone
  Gigabit to terabit links

• Access networks
  xDSL, cable modem, ISDN, asynchronous dial
  20,000 instantaneous sessions per GBPS backbone bandwidth
There are more of us out there

- Billions and billions of new Internet devices
- Billions of new Internet users
- Internet available everywhere, all the time (wired, wireless, mobile, ...)
- Convergence of all communication on the Internet (business, personal, entertainment, public services, ...)

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Client/Server Architecture is breaking down

- For web:
  
  Sufficient to have clients in private address spaces access servers in global address space

- Telephones
  
  need an address when you call them, and are therefore servers in private realm
Need an end to end naming and addressing architecture

Implication:
IP Version 6 deployment required for continued development of Internet in Mobile Networks, Developing Countries
IPv6 Innovations
Plug-and-play

- One of the nice things about AppleTalk:
  You can plug the device or computer in, and it just works

- One of the not-so-nice things about IPv4:
  You can plug the device or computer in...
  Configuring, and reconfiguring, can be hard
  DHCP helps a lot, but it requires properly configured servers

- IPv6 allows for
  Significant level of autoconfiguration
  Automated network renumbering
  Arbitrary device addressing within topological limits
Mobility

- **IPv4 Mobility**
  - Permits device to move using same home address
  - All communication through Home Agent
  - Foreign Agent must be a router

- **IPv6 Mobility**
  - Permits device to move using same home address
  - Communication via care-of address
  - No Foreign Agent required
  - Security Issues:
    - Session hijack
    - Duration of Switchover
IPv4 Anycast

- Addressing and Naming of Applications

  One of the nice things about NetWare: Service Location

  Today: DNS lists several addresses for a name, but no information to help select a server
Anycast: what we’d really like to model

- **Model:**
  
  The service looks like one computer reachable through many routers

- **We would really prefer:**
  
  DNS lists one address
  
  Network magically selects the right server instance
IPv6 Anycast

Proposal:
- DNS lists one address,
- Servers are “routers” to that address
  - DNS for service name,
  - Common address for service location
  - Topological address for specific access

Issues:
- Route changes can change which server you use in mid-transaction

Solution:
- Treat server as a *mobile device which is currently stationary*
- Connect to “home address” to select server,
- Thereafter talk to fixed “care-of address”
Security issues

• IPv6 enables end-to-end use of IPsec protocols (because it eliminates NATs),

  Plus for security, although IPsec also exists in IPv4 Internet and is widely used for VPNs
  
  Authentication ("you are the person who knows this key")
  
  Antidote to session hijack ("you are the same person I was just talking with")
  
  Privacy (encryption, using symmetric or public key technology)

• IPsec authentication dependant on key distribution infrastructure, which is not currently a solved problem

  Affects mobility, anycast, secure communication in general
Quality of Service
IPv4 and IPv6
Parekh and Gallagher’s Proof

• INFOCOMM ’93

• One must have at most a predictable amount of traffic in the network

• One must have predictable traffic delay in each network element

• Given these, end-to-end delay of a host to host message is predictable
Premises of QoS Technology

- DSCP: identifies a traffic aggregate
- Policy:
  - Separate from aggregate
  - May identify several characteristics
    - Minimum or maximum rate
    - Jitter (variation in latency)
    - Probability of loss
Network Edge, Network Core
TCP Technology Issues

- Single drops communicate from network to sending host
  “You need to slow down”
- Multiple drops in round trip trigger time-outs
  “Something bad happened out here”
Multiple Drops in TCP

- In the event of multiple drops within the same session:
  Vegas/Reno TCPs wait for time-out
Fast Recovery Phase

- Faster retransmission under multi-drop case

  New Reno “fast retransmit phase” sends one dropped message per RTT instead of one per time-out
Multiple Drops in TCP

- In the event of multiple drops within the same session:
  
  Selective acknowledge may work around (but see INFOCOM ’98)
Still, drops result in timeouts

- Two effects of a drop:
  - ~90% case: wait for timeout before retransmission
    Next RTT sends only the retransmission
  - Wouldn’t it be nice if we could control congestion without dropping traffic?
    Customer desire
    Complaint about Internet
RFC 3168: Explicit Congestion Notification

- Manage congestion without loss
- Supported in Linux 7.1
Assured Forwarding PHB, on the edge

- Rate-limit (MQC Police)
  - Test arrival rate against threshold
  - Conform action is “mark one way”
  - Exceed action is “mark another way”
- External use of WRED required to create actual feedback
  - Clearly identifies the excess traffic
  - Setting WRED min-threshold for excess lower causes it to drop earlier
Assured Forwarding PHB, in the core

- Arriving traffic has been pre-metered
- Traffic belonging to the same PHB (AFx1, AFx2, and AFx3) goes to same queue
- Different min-threshold by DSCP
- Schedule using rate for class
  not priority
Best Effort Service in Simple IP Networks

Line Congested? Drop at Some Rate!
Assured Service in Simple IP Networks

Line Congested and Packet Out of Profile? Drop at Some Rate!
H.323/H.248/SIP/MGCP Voice and Video

- **Voice**
  - Constant bit rate when sending
  - Relatively small messages (44–170 bytes)

- **Video**
  - Generally high variable bit rate
  - Controlled by codec efficiency on picture
  - Message size is generally the MTU
Video: Playback Point

Distribution of Deliveries in Time

Transmission Time

Typical Delivery

Preferred Delivery Interval

Application Buffers Data to Ensure Consistency

Playback Point

Unless it’s Too Late…
But Voice/Video Are Very Predictable

- Codecs generally conform to a dual token bucket scheme, with constant “deadline” from a scheduling perspective (CSZ, SIGCOMM ’92)

- This means that traffic with the *same deadline* can use the same FIFO queue

- Any resemblance to TDMA is purely accidental, but happens to be why ATM voice and IP voice work
The EF PHB, on the edge

- **Rate-limit (CAR)**
  - Tests rate of traffic against threshold
  - Conforming action is accept
  - Exceed action is drop
- **Effects on traffic**
  - For voice/video should not be exceeding allotment
  - For TCP, this has debilitating loss effects
The EF PHB, on subsequent devices

- A device which has no local traffic originators is working with pre-metered traffic.
- It therefore needs only to queue for minimum variation in latency

Classify Messages

Voice

EF Priority Queue

Scheduler
Predictable Amount of Traffic in the Network

• The implication is that we have to control used capacity

  Capacity that individual calls consume
  “If you experience poor quality, use a more compact encoding or a lower frame rate”

  Capacity that total call volume can consume
  “If there isn’t capacity, refuse new calls”
Signaling bandwidth requirements

- Per flow policing
- DSCP marking
- Classify & schedule based on DSCP
- RSVP signalling
IPv6 Conclusions
Is it enough better to justify changing?

• Argument:
  IPv6 doesn’t change routing, trust model, QoS, etc
  It gives us IPv4 Internet with more addresses

• What IPv6 does do:
  Removes address conservation as an issue
  Enables kinds of applications current addressing makes difficult
  Simplifies deployment of new applications
  Eliminates need to kludge around addressing issues
Application models: a choice

- In client/server applications
  - Clients vastly outnumber servers
  - Clients can be addressed on demand
  - Examples: WWW, FTP, X-Windows
- But every application is not client/server
- Peer/peer applications
  - Peer must be accessible and addressed when someone decides to talk with it
- Do we want to limit ourselves to the client/server model?
  - Effect of current IPv4 model assumptions
Conclusions

• IPv6 is addressing the future…

Addresses for new devices, new applications, and new users

Restoring the end to end model, for performance, robustness, security, manageability, and enabling rapid innovation

Significant innovations that help applications

Enhancing IP for next-generation applications: multicast, mobility, plug-and-play, security, and multiple qualities of service
IPv6: Addressing the Future

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