Multimedia in Networks

Fundamental characteristics:

- Typically **delay sensitive**.
- But **loss tolerant**: infrequent losses cause minor glitches that can be concealed.
- Antithesis of data (programs, banking info, etc.), which are loss intolerant but delay tolerant.
- Multimedia is also called "continuous media"

Classes of MM applications:

- Streaming stored audio and video
- Streaming live audio and video (unidirectional Real-time)
- Real-time interactive video

Multimedia in networks (2)

Streaming stored MM

- Clients request audio/video files from servers and pipeline reception over the network and display
- Interactive: user can control operation (similar to VCR: pause, resume, fast forward, rewind, etc.)
- Delay: from client request until display start can be 1 to 10 seconds

Unidirectional Real-Time:

- similar to existing TV and radio stations, but delivery over the Internet
- Non-interactive, just listen/view

Interactive Real-Time :

- Phone or video conference
- More stringent delay requirement than Streaming & Unidirectional because of real-time nature
- Video: < 150 msec acceptable
- Audio: < 150 msec good, <400 msec acceptable

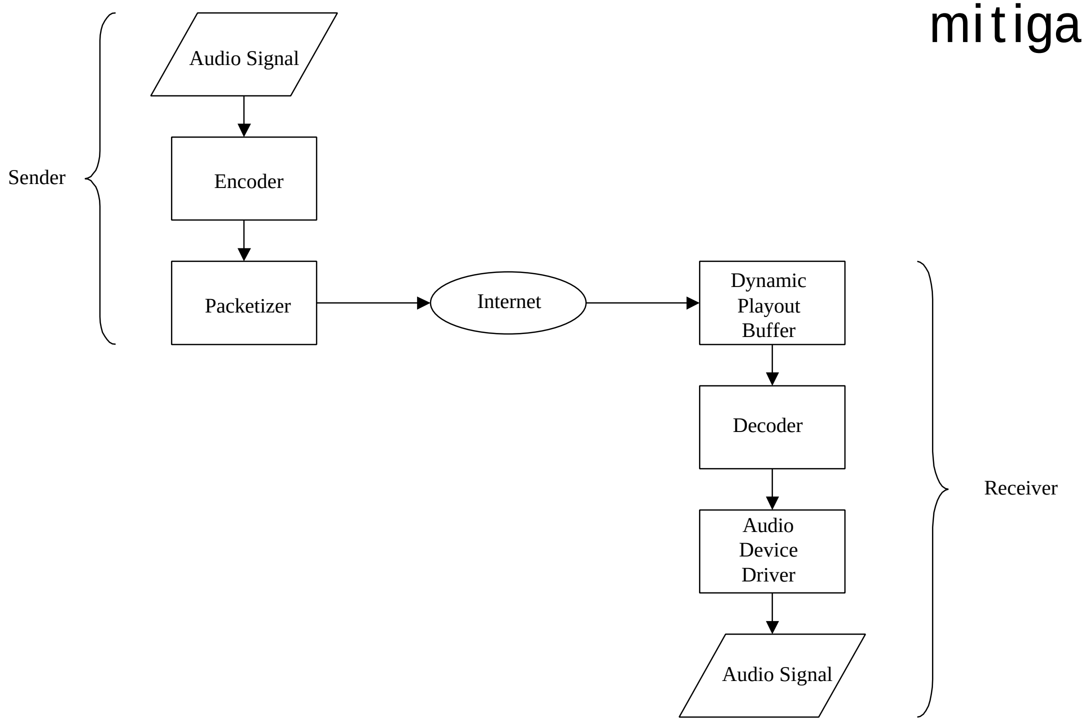
Multimedia in networks (3): challenges

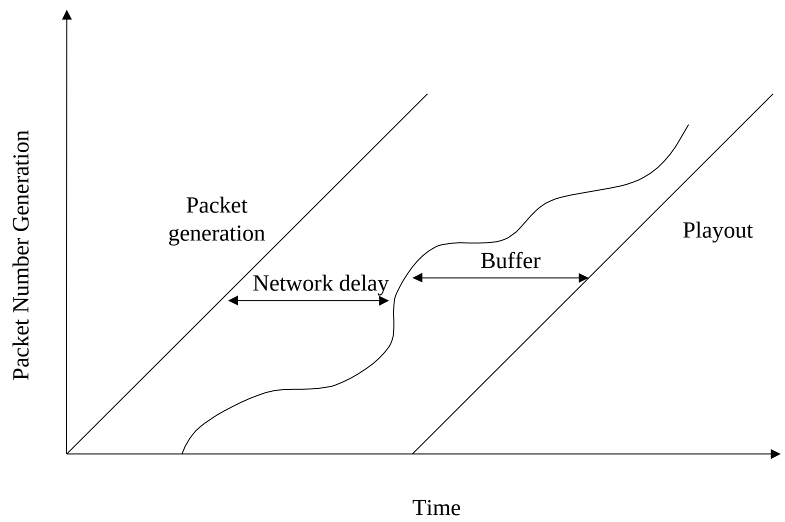
- TCP/UDP/IP suite provides best-effort, no guarantees on delay or delay variation.
  - Streaming apps with initial delay of 5-10 seconds are now commonplace, but performance deteriorates if links are congested (transoceanic)
  - Real-Time Interactive apps have rigid requirements for packet delay and **jitter**.
  - **Jitter** is the variability of packet delays within the same packet stream.
- Design or multimedia apps would be easier if there were class services.
  - But in the public Internet, all packets receive equal service.
  - Packets containing real-time interactive audio and video stand in line, like everyone else.
- There have been, and continue to be, efforts to provide differentiated service.

Multimedia in networks (4): making the best

To mitigate impact of "best-effort" Internet, we can:

- Use UDP to avoid TCP and its slow-start phase…
- Buffer content at client and control playback to remedy jitter
- We can timestamp packets, so that receiver knows when the packets should be played back.
- Adapt compression level to available bandwidth
- We can send redundant packets to mitigate the effects of packet loss.





How should the Internet evolve to better support multimedia?

Integrated services philosophy:

- Change Internet protocols so that applications can reserve end-to-end bandwidth
  - Need to deploy protocol that reserves bandwidth
  - Must modify scheduling policies in routers to honor reservations
  - Application must provide the network with a description of its traffic, and must further abide to this description.
- Requires new, complex software in hosts & routers

Differentiated services philosophy:

- Fewer changes to Internet infrastructure, yet provide 1st and 2nd class service.
- Datagrams are marked.
- User pays more to send/receive 1st class packets.
- ISPs pay more to backbones to send/receive 1st class packets.

How should the Internet evolve to better support multimedia? (cont.)

Laissez-faire philosophy

- No reservations, no datagram marking
- As demand increases, provision more bandwidth
- Place stored content at edge of network:
  - ISPs & backbones add caches
  - Content providers put content in CDN nodes
  - P2P: choose nearby peer with content

Virtual private networks (VPNs)

- Reserve permanent blocks of bandwidth for enterprises.
- Routers distinguish VPN traffic using IP addresses
- Routers use special scheduling policies to provide reserved bandwidth.