An Empirical Study of RealVideo Performance Across the Internet

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`http://perform.wpi.edu/real-tracer`

Introduction

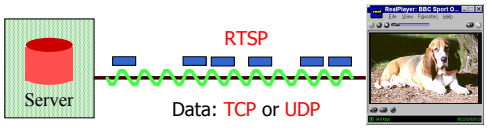
- Streaming Audio and Video is growing
- Traditional Internet studies, but ….
  video is different
  - Bandwidth and response time not enough
    - Care about smooth rate
  - Packet loss rate alone is not enough
    - Often use repair techniques
- RealVideo is big [Jup01]
  - RealPlayer, MediaPlayer, QuickTime

  →Measure RealVideo on Internet

Outline

- Introduction
- RealVideo ←
- Methodology
- Results
- Analysis
- Conclusions

RealVideo Network Characteristics



- Buffering
- *SureStream*
- *Scalable Video Technology*
- Repair

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Methodology

- Build customized RealVideo player (*RealTracer*)
  - Uses RealPlayer core
  - Software Development Kit (SDK)
  - Records performance stats: frame rate, jitter ….
- Select diverse set of RealVideo servers and videos
- Solicit volunteers to run RealTracer
  - Many users to Many servers
  - Friends, colleagues outside of Mass., U.S.
  - `rec.video` newsgroup and `end2end` mailing list
  - 2 weeks in June 2001
- Analyze results

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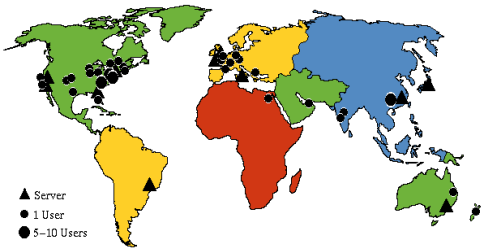
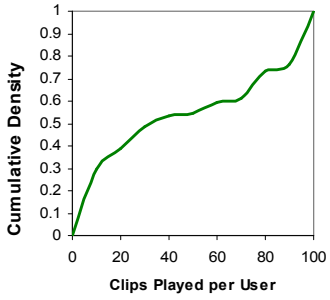
Results

- 11 servers in 8 countries
- 63 users in 12 countries
- 2855 video clips played
- 388 video clips watched and rated
- 10% chance clip unavailable

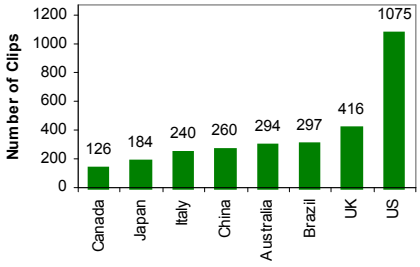
Geographic Location of Servers and Clients



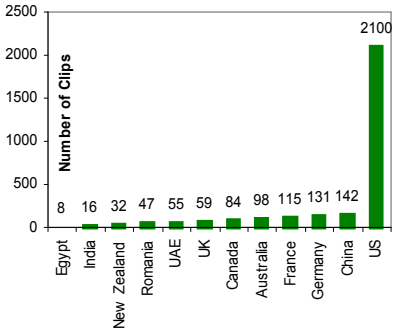
Clips Played per User



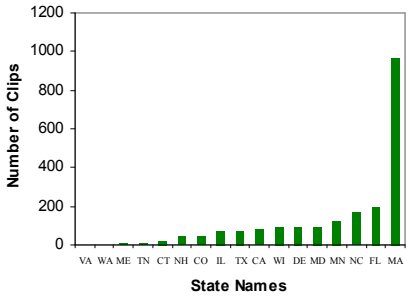
Clips Served per Country



Clips Played per Country



Clips Played per State



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  - Frame Rate ←
  - Jitter
  - Perceived Quality
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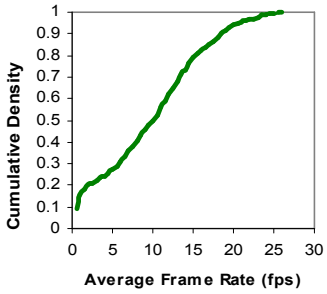
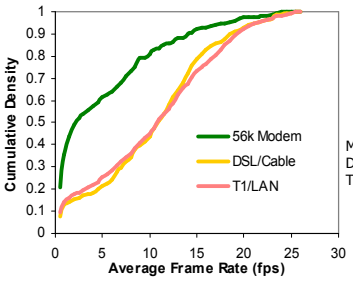
Frame Rate

- Basic video performance unit
  - frames per second (fps)
- Guidelines [Rea00a]:
  - 24-30 fps: full-motion video
  - 15 fps: full-motion video approximation
  - 7 fps: choppy
  - 3 fps: very choppy
  - Less than 3 fps: slide show

Overall Frame Rate

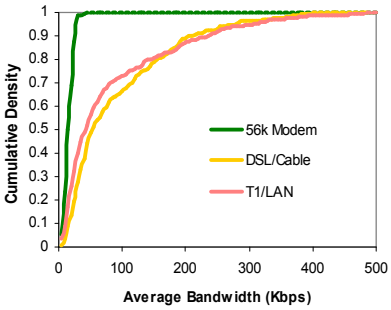


Frame Rate vs. Network Configuration

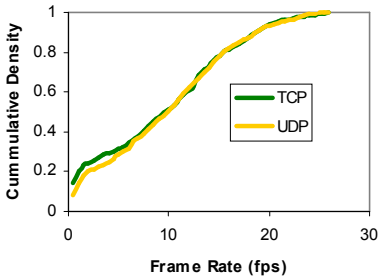


Modem: 19% (550)
DSL/Cable: 30% (874)
T1/LAN: 51% (1468)

Bandwidth vs. Network Configuration



Frame Rate vs. Transport Protocol



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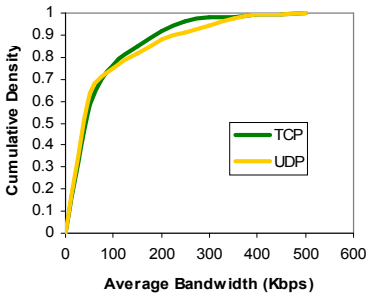
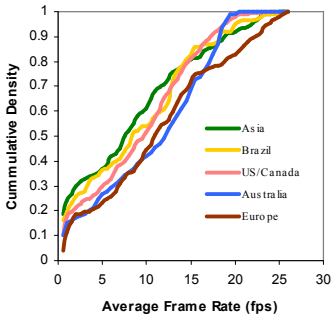
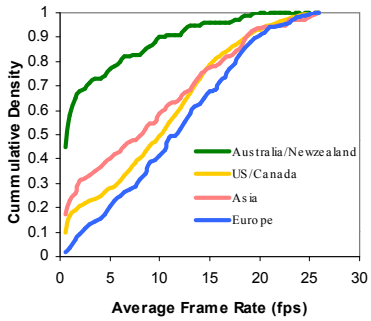


Frame Rate vs. Server Geographic Location

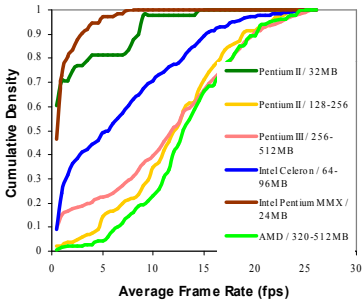


Asia: 344
Brazil: 297
US/Canada: 1201
Australia: 294
Europe: 656

Frame Rate vs. User Geographic Location



Frame Rate vs. PC Type



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  - Jitter ←
  - Perceived Quality
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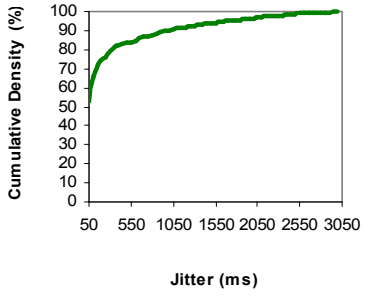
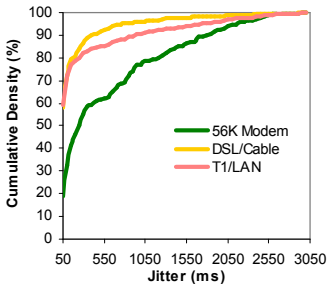
Jitter

- Frame rate alone not enough
  - Also need smooth playout
  - High frame rate but choppy playout can be as bad as frame loss [CT99]
- Variation in frame playout interval called *jitter*
  - Standard deviation
- Buffering can reduce jitter [RKTS94, SJ95]
  - But can still have residual jitter
- Quantitative impact of residual jitter on perceived quality scarce
  - 50 ms imperceptible, 300 ms very rough

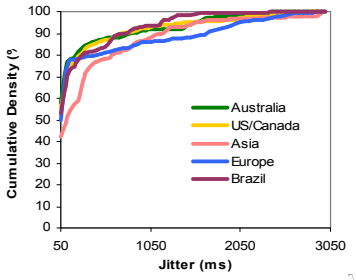
Overall Jitter



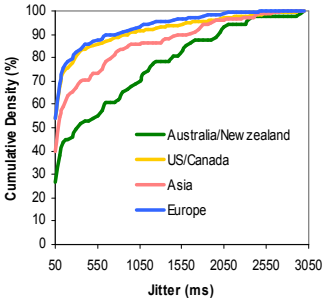
Jitter vs. Network Configuration



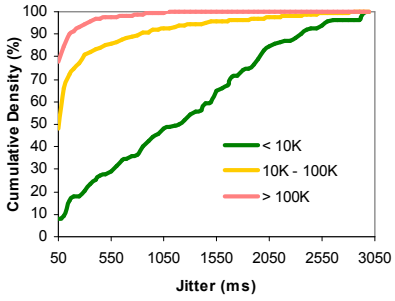
Jitter vs. Server Geographic Location



Jitter vs. User Geographic Location



Jitter vs. Observed Bandwidth



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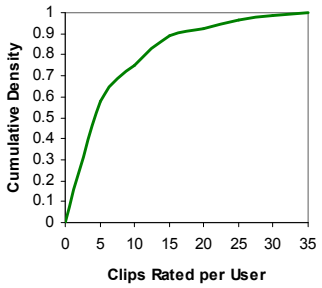
Perceived Quality

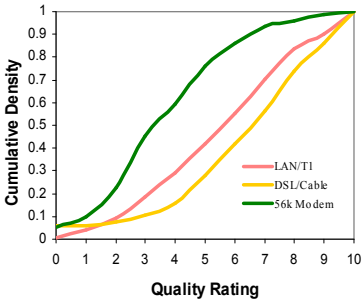
- Frame Rate and Jitter not enough
  - Best frame rate depends upon content [TC01]
    - RealServer varies
  - Effects of jitter depend upon content [CT99]
- Perceptual Quality
  - Numeric rating, 0-10

Clips Rated per User



(388 video clips rated)

Quality vs. Network Configuration



Conclusions

- Average RealVideo clip has good quality
  - 10 frames per second
  - Nearly imperceptible jitter
- Network configuration
  - Modems are a bottleneck
  - DSL/Cable modems pushing bottleneck towards server

Future Work

- RealVideo over UDP
  →TCP-Compatible?
- Perceptual quality of streaming video
- Other streaming players and protocols
  - MediaPlayer, QuickTime
- Effects of caching, CDNs
- Release of customizable *RealTracer*
- Download IP addresses, Playlist, RealTracer
  - From Web page

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