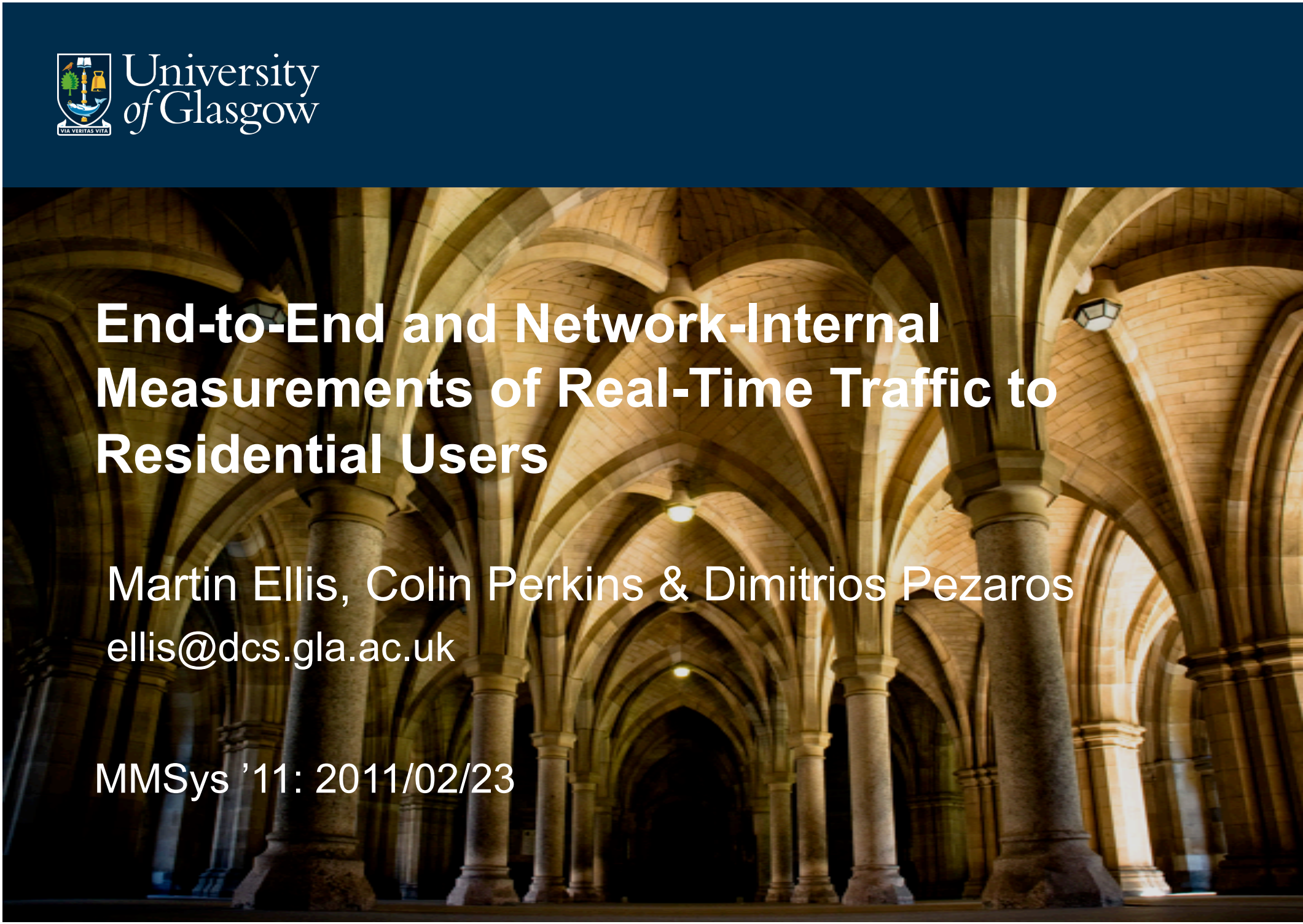

End-to-End and Network-Internal Measurements of Real-Time Traffic to Residential Users

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Motivation (why measure?)

- Internet streaming video increasingly popular
  - UDP streaming already used for intra-domain video/inter-domain VoIP
  - not susceptible to TCP dynamics
- However, little performance data of UDP streaming over residential networks
  - ~90% of residential users use DSL or Cable[1]
  - effect of DSL/Cable edge links not well studied
- This paper describes a dataset showing streaming performance on DSL & Cable
  - *example: make use of data to understand typical packet loss patterns when designing new inter-domain streaming services*

[1] OECD Broadband Statistics, June 2010 (http://www.oecd.org/sti/ict/broadband)

Outline

- Methodology
  - measurement setup
  - trace data overview
- Results
  - packet loss
  - queueing delay

Methodology (how to measure?)

- Using dedicated hardware, placed in participant's homes
  - avoids variation due to differences between home PC setups
  - synchronising using NTP, off-line clock skew correction for relative OWDs
- Measured a range of ADSL and Cable links (one week each)
  - synthetic RTP traffic over UDP/IP (matching MPEG-TS)
  - using a range of standard- and high-definition bit-rates
- Also probing the network within the traces
  - sending some packets with limited TTLs
  - sending some packets as packet-pairs

Challenges

- For over-the-top measurement, need to consider ISP usage restrictions
  - monthly quotas with excess-use fees (e.g., 30GB/month)
  - daily “busy period” quotas with rate-limiting (e.g., 1.5GB/evening)

- To address this, we collected short traces (~5 mins) at various times of day
  - calculated limits on how many traces to take each day, and how much data to send

Trace Data

- Measured 8 ADSL links, 6 Cable (2 in Finland, rest in UK)
  - around 3800 traces in total
  - ~230 million packets captured
- Traces contain send/receive timestamps and sequence numbers for every packet
  - can extract loss, delay statistics
  - also have two-way traceroute measurements taken after each trace

Outline

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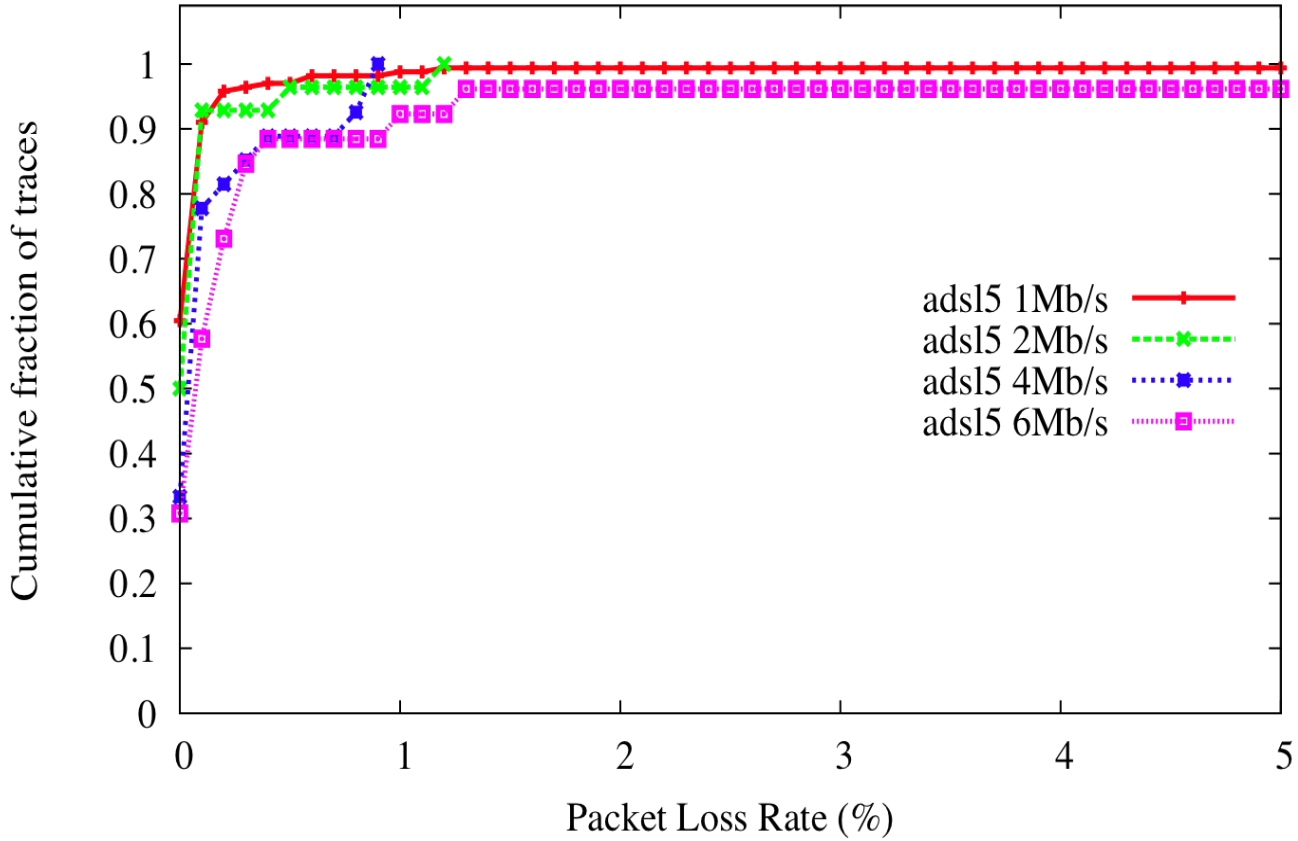
Packet Loss (average loss rates)

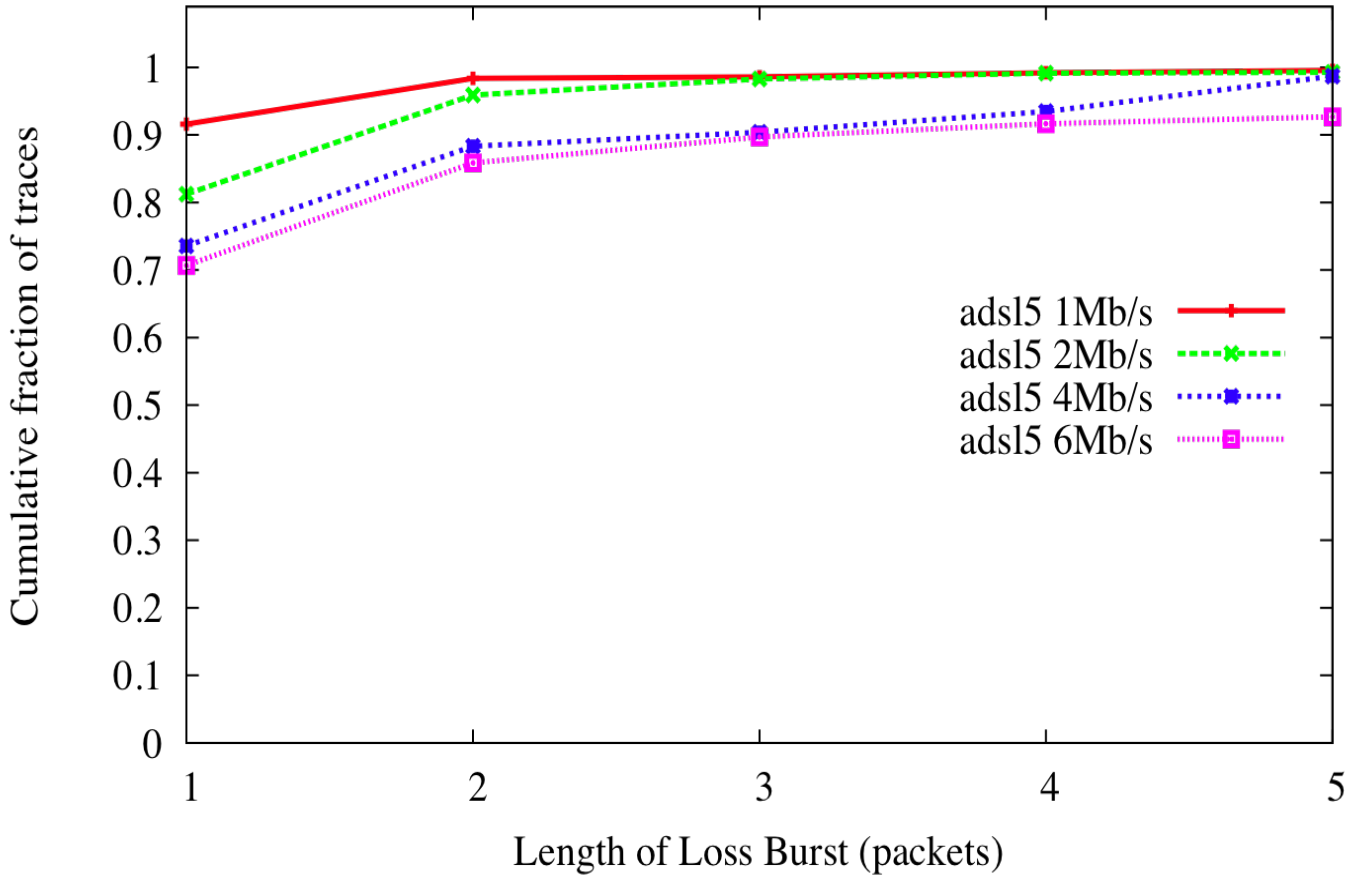
- Overall, loss rates are low:
  - 93% of traces show loss rate ≤ 1%
  - 45% show no loss at all (comparable to [2])
  - loss rates typically rate-dependent



[2] Dischinger *et al.* Characterizing Residential Broadband Networks. In *Proc. ACM IMC '07*

Packet Loss (loss burstiness)

- CDFs show that loss bursts typically just a few packets...

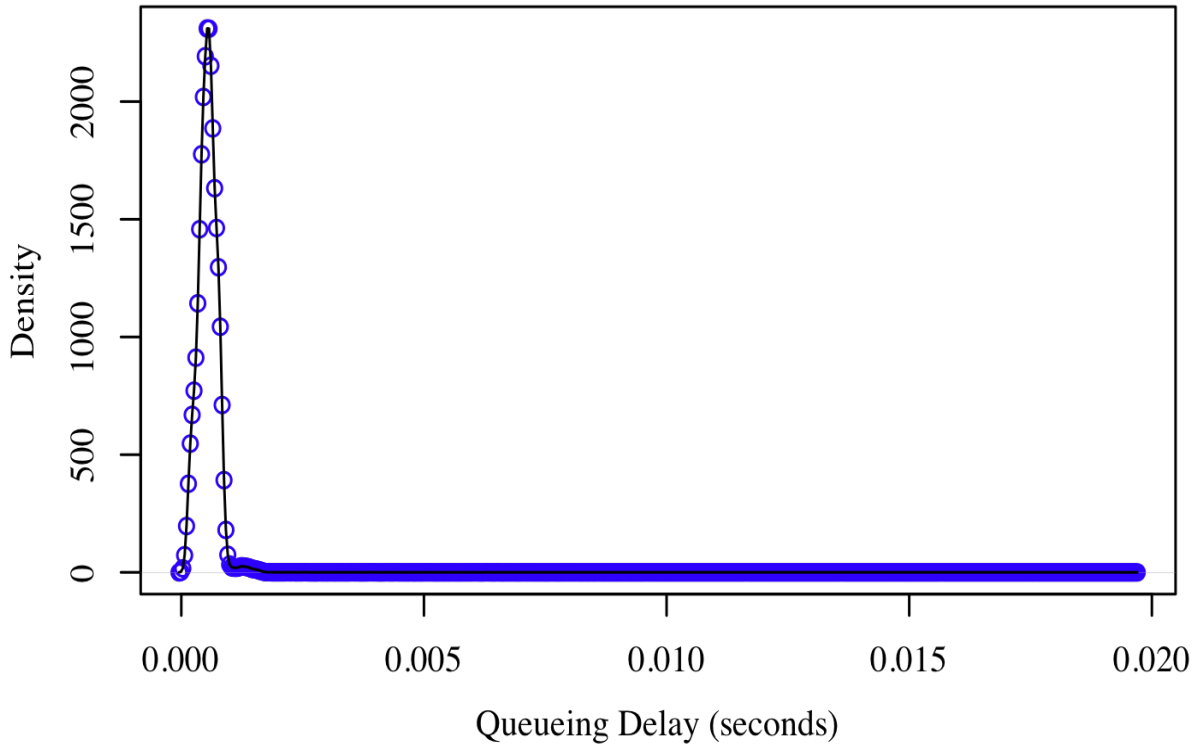


Packet Loss (“bursts of bursts”)

- ...but, inter-loss distance can be short too: “bursts of bursts”

Queueing Delay

- Typically quite stable, roughly around same
- Also see non-negligible number of packets showing higher delay (due to cross-traffic, etc.)
- Some links showing more variability in evenings



Conclusions / Future Work

- Dataset of inter-domain UDP streaming over residential networks
  - gives insight into residential streaming performance
  - available at http://csperkins.org/research/adaptive-iptv/ (and MMSys site)
- Further analysis ongoing to understand effects of residential networks on streaming video traffic
  - also interested in the implications for system design and configuration (e.g., FEC)

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Questions?

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