Reducing Internet Latency

Mat Ford

Let's have a workshop!

Workshop on Reducing Internet Latency

- **http://www.internetsociety.org/latency2013**
  - London, 25-26 September
  - 30+ submissions
- **Program committee**
  - Mat Ford, Internet Society, co-chair
  - Bob Briscoe, BT, co-chair
  - Gorry Fairhurst, University of Aberdeen
  - Arvind Jain, Google
  - Jason Livingood, Comcast
  - Andrew McGregor, Google
- **Note: we have form**
  - http://www.internetsociety.org/doc/bandwidth-management-internet-society-technology-roundtable-series

Scope

- surveys of latency across all layers
- analyses of sources of latency and severity/variability
- the cost of latency problems to society and the economy, or the value of fixing it
- principles for latency reduction across the stack
- solutions to reduce latency, including cross-layer
- deployment considerations for latency reducing technology
- benchmarking, accreditation, measurement and market comparison practices

Major goals of the workshop

Identify a metric for (access) network latency

Develop an action plan to educate industry

Identify gaps in knowledge

Identify areas of disagreement for further discussion

Outline

Taxonomy

Use cases for a low latency Internet

From measurements to metrics

Congestion control & AQM

Structural issues and public policy considerations

Action plans and deployment challenges

Taxonomy

Sources of latency

- **Generation**
  - Delay between a physical event and the availability of data
- **Transmission**
  - Inherent delay in signal propagation
- **Processing**
  - Computational translation of the signal, e.g. for compression, encryption, etc.
- **Multiplexing**
  - Delays necessary to support sharing a communications medium
- **Grouping**
  - Mitigates some processing latency, but introduces latency of its own

Mitigating sources of latency

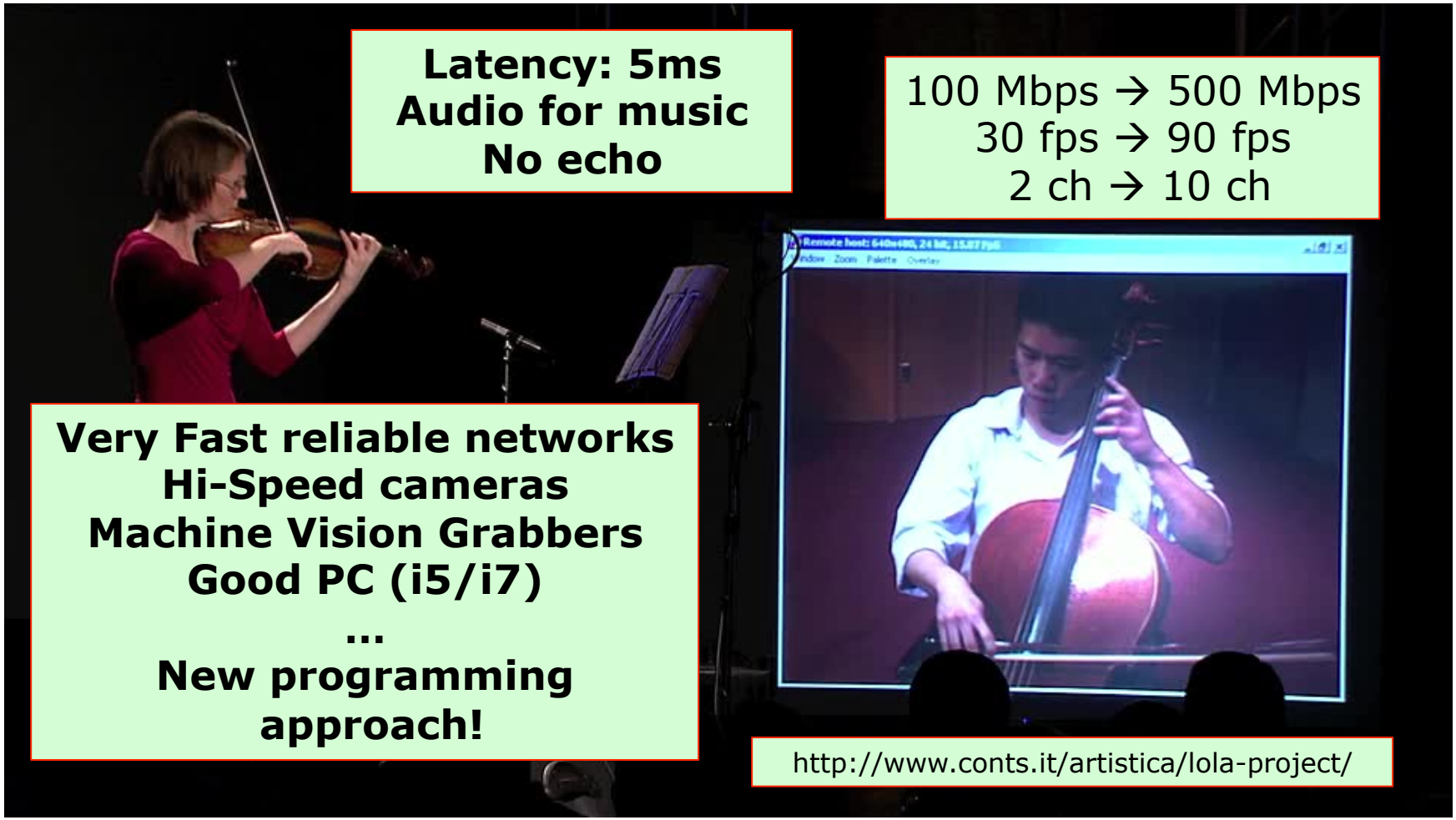
- **Relocation**
  - Move endpoints closer together, thereby reducing the transmission latency
- **Speedup**
  - Increase the number of operations per unit time, thereby reducing the processing impact
- **Dedication**
  - Reserve resources exclusively, thereby reducing the impact of multiplexing latency on the overall cost
- **Partitioning**
  - Split groups into individual components, thereby reducing the grouping latency

Discussion

- **If you care about latency, you have to be very careful and look in a lot of places for potential optimisations, and potential conflicts of those optimisations.**
- **The benefits of Active Queue Management (AQM), for example, are only one part of a much larger picture.**
- **For example – reducing protocol initialization delays can have a profound impact on the overall latency experienced for short flows**

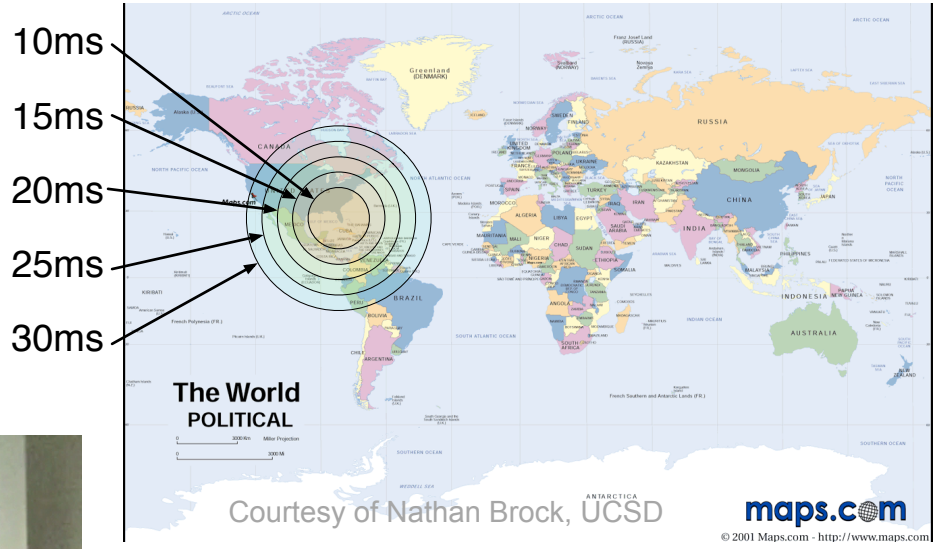
Use cases for a low latency Internet

→ LOLA


Latency: 5ms
Audio for music
No echo
100 Mbps → 500 Mbps
30 fps → 90 fps
2 ch → 10 ch
Very Fast reliable networks
Hi-Speed cameras
Machine Vision Grabbers
Good PC (i5/i7)
…
New programming approach!
http://www.conts.it/artistica/lola-project/

Discoveries with LOLA

Latency:
•~25ms (one way) is the confort limit for most instruments



Sound rendering:
• mixing different ambients;
• reproducing acoustic instruments;

By the way…

All this stuff…

ONLY WORKS ON

- HI-BANDWIDTH,
- UNCONGESTED,
- VERY LOW JITTER,
- ERROR FREE

NETWORK SERVICES!

Discussion

- **Low latency apps can help flush out network issues**
  - Asymmetry, error-protection, TE, badly configured routing protocols
- **For Internet services, improving multiplexing mechanisms of all kinds is at least as important as application optimisations and specialised hardware**

From measurements to metrics

Incentivising the market

- **What is the latency budget required to connect to Internet via given ISP for purposes of comparison?**
  - How to attribute access network portion of overall latency?
  - Design space for such a metric is … large
- **Latency is always additive, and responsibility is cumulative**
  - while an access network may not have direct control of causes of latency at its peers or upstream providers, it does have control over and responsibility for who it peers with, buys transit from, and its routing policies.
- **Basic metrics should be defined in terms of "network physics”**
  - quantities with well-defined measurement methods easily understood by implementors.
- **Metrics used in commerce should**
  - correlate strongly to quality of experience
  - where necessary, be derived/composed of these basic metrics.
  - Multi-dimensional metrics are harder to game

What to measure?

- **Minimum unloaded latency**
  - To where? ISP, nearest exchange, major site(s), E2E?
  - From where? User device(s), CPE equipment?
  - Uni/bidirectional? ICMP, UDP, load a full website?
- **Latency under (saturated) load**
  - Needs reliable method to induce load
  - Really hitting ‘worst case’ probably hard
  - Sampling frequency
- **unloadedLatency:loadedLatency ratio**
  - A ‘load degradation factor’?
  - Logarithmic, linear, normalised?

Some suggestions

- **Easily defined tests which are simple for end users to understand**
  - some relation to **both** latency and bandwidth
  - ease of measurement and alignment with end-user intuition as opposed to simplicity of definition.
    - start-to-finish load time of the front pages of a selection of n of the Alexa Top 500 websites
- **Quantifying queue-related latency**
  - ratio of unloaded latency to latency under load is a useful metric
  - may be applied to devices as well as to paths in the network.
- **Reach out to game companies/networks (e.g. Steam) to do large-scale latency measurements?**
  - Motivate gamers to gravitate towards low-latency, clueful ISPs

Opportunities

- **More discussion is clearly needed**
- **Meantime, initial implementations of well-defined, basic measurements that capture network latency from a given access network customer's observation point would be a start**
  - Expose bufferbloat in the network
  - Enable the consumer to influence latency/bandwidth tradeoff decisions
  - Create incentives for improvement
- **Metrics are about incentivising more research, and changed behaviour, re-engineering etc. – without a metric, we're in the dark**
  - avg. rate / flow size, RTTmin / RTTload, RTTavg to Alexa 500,TCP retransmits
- **Perfect is enemy of the good**
  - alternative to piecemeal metrics is boiling the ocean…

Congestion control & AQM

What's fair anyway?

- Need for latency is application dependent
  - All streams are not the same
- Redundancy and more aggressive retransmissions is a viable option for application-limited streams
  - Use of push anticipation
- Unfairness is not an argument (even if fairness was a valid metric)
  - Application-limited streams are at a disadvantage when sharing resources with greedy streams

- How much redundancy / aggression should we use?
- How much knowledge of application semantics is needed?

What about ECN?

Agreed that it has potential benefits, but current semantics provide insufficient benefit to motivate deployment

Different semantics allowing for earlier and more fine-grained control may improve deployment incentives

Delay-based congestion control

- **Delay signal is a measure of the quantity we are trying to reduce**
- **But it's a noisy signal, and doesn't play well with loss-based CC**
- **Has its uses**
  - in closed environments (e.g. data centres)
  - For scavenger class traffic (e.g. ledbat)
  - Small buffers
  - Incentives for deployment: policing, isolation
  - In combination with other signals
- **DBCC is not *the* solution, but could be *part* of the solution**

Discussion

- **AQM deployment is ‘ballistic’ (i.e. has traction)**
  - TCP capacity allocation problems are going to be exposed
  - We need to avoid deploying AQM that prevents us doing something in the transport layer later on to address capacity allocation
- **Cross layer primitives**
  - Might be something here for a latency research group
  - iOS7 developer documentation - API intended to realise callbacks across all layers so app developers can react appropriately to network events
- **Violent agreement that there is no mark/drop algorithm that always helps and never hurts**
  - Is this in conflict with the desire for a no-knobs solution that ‘just works’?

Further discussion

- **Two orders of magnitude reductions in queuing latency are possible with what we already have today**
- **FQ a pre-requisite for (safe) AQM deployment?**
  - AQM already under deployment without FQ
- **More widespread deployment is challenged by knowing that algorithm X is the correct choice to bake into silicon**
  - Although some industries have already made their choice

Structural issues and public policy considerations

Fundamentals

- **Local content hosting**
  - CDNs are a priority
- **Peering**
  - Keep local traffic local - does this bleed into protectionism?
  - Geolocation can hurt you when physically proximate caches are routed via remote hubs
- **More tools, in the hands of end users, generating more data always preferable to regulatory intervention**
- **Metrics**
  - latency vs. latency under load measures bufferbloat
  - latency vs. distance measures quality of routing
  - both are important components

Roles for regulators?

- **Gathering and publishing of statistics**
  - Several regulatory bodies doing good work today, Ofcom, FCC, IDA
- **Setting benchmarks**
  - Minimum QoS in EU
- **Gaming of metrics, game resistance of metrics**
  - may lead to regulatory requirements

Action plans and deployment challenges

"Everybody talks about the speed of light, but nobody ever does anything about it."

– JT, 1988 (0.79 Gsec ago)

Actions

- **Educational material (video clips, tutorials, whitepapers)**
  - To explain the importance of latency compared to bandwidth and loss
  - Aimed at vendor and operator audiences
  - The RITE project has a relevant deliverable due this year
- **Developing a latency under load metric**
  - Could be pursued in IPPM WG if there was a draft describing what is needed and providing a statement of applicability
  - To be useful, must quantify things that somehow strongly correlate with user-perceived quality
- **Latency/cross-layer interactions research group**
  - needs someone to draft a coherent charter
  - Could include updating host implementation recommendations

Actions continued

- **Routing and topology metric**
  - We need more data on whether this is a problem
  - Geodistance / netdistance -> stretch – could be a useful metric
- **Tooling initiatives**
  - could work with speedtest.net
  - Could work with LMAP WG
- **New definition of meaning of ECN**
  - Intended to improve the potential for ECN deployment
- **Conflict between latency and other priorities**
  - For example encryption
  - These trade-offs could be addressed in an architectural document

Credits

Reducing Internet Latency workshop was sponsored by Internet Society, RITE project, TimeIn project and Simula Research Labs

Several slides in this presentation were borrowed from presentations made at the workshop by Joe Touch, Bob Briscoe, Claudio Allocchio, Salil Banerjee, Anna Brunstrom, Gorry Fairhurst, David Hayes, Piers O'Hanlon, Mirja Kühlewind, and Toke Høiland-Jørgensen.

Other workshop attendees were Lars Eggert, Leslie Daigle, Katsushi Kobayashi, Jim Gettys, Markku Kojo, Lucien Avramov, Brian Trammell, Enrico Calandro, Dave Täht, Luca Muscariello, Andrew McDiarmid, Greg White, Ewan Sutherland, Matt Mathis, David Ros, Andrew McGregor, Ilpo Järvinen.

For more, see http://www.internetsociety.org/latency2013

Mat Ford

Technology Program Manager

ford@isoc.org