Measuring and Understanding IPTV Networks

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Talk Outline

• Research goals
• Measuring and monitoring IPTV systems
  • Measurement architecture and initial data
  • Implications for IPTV systems
• Future directions
Research Goals

• Measure and understand the impairments affecting IPTV network traffic
  • Packet loss/timing; media aware if possible
  • Intra- and inter-domain flows

• Improve techniques for on-line error repair and off-line network troubleshooting
  • Inform choice of FEC, retransmission, etc.
  • Consider network tomography for management

[Joint with Jörg Ott’s group @ TKK]
IPTV System Model – Interdomain

Monitoring – end-to-end and at domain borders
Repairs – at edges of content distributor network
Feedback Aggregation – inter- and intra-domain

Expected future evolution; deployed IPTV systems a restricted subset – need to understand the end-to-end performance to evolve system
• Expect largely tree-structured access network, more well-connected in the core

• Much access/edge network topology is hidden below the IP layer, but will influence its performance

• Long term goal: infer the edge topology using network tomography, understand and locate problems
Understanding System Performance

- Only limited IPTV measurements available
- Most studies either between well-connected sites or using TCP for media transport
- Little data on UDP-based IPTV performance
  - Interdomain from well-connected servers to residential hosts, to understand end-to-end path
  - Intradomain to understand behaviour of edge networks, evaluate effectiveness of network tomography to diagnose edge problems

- Beginning to collect data – *early interdomain results today*…
Interdomain Measurement Architecture

- Server well-connected on public Internet
- Clients on residential connections
- Inter-domain path from server to client
  - ~15 hops to UK ISPs; choke-point at Telehouse in London
  - Simulates interdomain IPTV scenario
Measurement Architecture – Limitations

- Server on the public network
  - Conceptually acts as a STUN server for NAT traversal
  - Will likely need to implement ICE for peer-to-peer scenarios
- Uncontrolled interdomain path
  - Difficult to separate effect of edge from problems in the core
  - Will measurements to other well-connected hosts let us infer home network performance?
Measurement Platform

- Deploy into home networks
  - ADSL - generally 8Mbps downstream
  - Cable modem
- Expect a mix of users
  - Technical - own Linux/Unix system at home, can run measurement tool
    - But uncontrolled measurement environment; undesirable variation
  - Non-technical - require unobtrusive, low-maintenance, measurement box
    - Soekris net5501 single-board computer with 120GB disk, running FreeBSD 7
    - <10W, silent, size of a book
Measurement Using Test Streams

- Aim: generate test traffic to (roughly) match IPTV flows
  - Measure loss/jitter characteristics
  - Looking to move to real-world streaming IPTV over time

- Input to simulation of repair mechanisms and topology inference
Measurement Plan

• Three phases:
  1. Initial experiment: CBR flows, manually triggered
  2. Simulated VoIP and IPTV traffic, manual control
  3. Simulated VoIP and IPTV traffic, automated tool

• Starting phase 2
## Initial Measurements

### ADSL

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPTV CBR 1Mbps</td>
<td>Hourly at :50</td>
<td>1 min</td>
</tr>
<tr>
<td>IPTV CBR 2Mbps</td>
<td>03:15, 10:15, 15:15, 20:15</td>
<td>10 mins</td>
</tr>
<tr>
<td>IPTV CBR 4Mbps</td>
<td>03:35, 10:35, 15:35, 20:35</td>
<td>10 mins</td>
</tr>
<tr>
<td>VoIP CBR 64kbps</td>
<td>Hourly at :10</td>
<td>1 min</td>
</tr>
</tbody>
</table>

### Cable Modem

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPTV CBR 1Mbps</td>
<td>Hourly at :30</td>
<td>1 min</td>
</tr>
<tr>
<td>IPTV CBR 2Mbps</td>
<td>04:15, 11:15, 16:15, 21:15</td>
<td>10 mins</td>
</tr>
<tr>
<td>IPTV CBR 4Mbps</td>
<td>(not supported by access link)</td>
<td>10 mins</td>
</tr>
<tr>
<td>VoIP CBR 64kbps</td>
<td>Hourly at :55</td>
<td>1 min</td>
</tr>
</tbody>
</table>

Initial trace duration: 1-7 November 2008

~16 million packets
Non-negligible packet loss on ADSL network, unaffected by data rate below some threshold
Packet Loss – Loss Run Lengths

High rate flows: linear plot $\rightarrow$ geometric distribution
Lower rate flows show some evidence of longer tail

Hypothesis: uniform loss probability dependent on data rate with background rate-independent bursty loss?

No clear distinction between ADSL and cable
Packet Loss – Good Run Lengths

Most packets are in long good runs, but most good runs are short.
Packet Reordering

• Packet reordering infrequent
  • 4 packets reordered out of ~16 million sent
    • Worst was out-of-sequence (delayed) by 4 packets
  • 2 flows affected

• Matches expectations: reordering due to route change or misbehaving load balancing at high rates
• Traffic dispersion pattern not unexpected
• Highly dependent on time-of-day
ADSL Inter-arrival Times (24 Hour Trace)
ADSL Inter-arrival Times (1 Week Trace)
Cable Inter-arrival Times

- Slightly worse dispersion than ADSL at busy times, much better at quiet times
Cable Inter-arrival Times (24 Hour Trace)

Temporal profile differs from ADSL: sharper distinction between unloaded and busy times; more residential users?
Cable Inter-arrival Times (1 Week Trace)
Summary of Measurements

• Despite uncontrolled inter-domain path, see clear distinctions between edge networks
  • Analysis just starting...

• Very early results: planning to conduct more measurements
  • Range of different ISPs
  • Multiple users in the same ISP
Implications for Error Concealment

• *If these results are typical…*

  • Most loss bursts short (2-3 packets), but many short good runs $\rightarrow$ small amounts of FEC, but not on adjacent packets

  • Longer bursts infrequent $\rightarrow$ not worth overhead of FEC to protect against these; reactive repair

  • Need more data, from flows reflecting real IPTV traffic, to confirm repair effectiveness
Implications for Network Trouble Shooting

• Eventual aim: network tomography to locate problem areas in access network

• Collecting more data, to understand correlation between receivers in single ISP
  • Expect to be able to trace 2 or 3 receivers in deployed networks without ISP cooperation
  • Not enough to confirm use of tomography, but hopefully sufficient to direct future measurements

• RTCP XR summary reports would be a good proxy for full packet traces, if available
Future Work

• Debugging and deploying measurement tool across a range of ISPs
  • Interest and potential collaboration with other groups for wider data collection
  • Will make traces available once infrastructure stabilises

• Analysis and understanding performance
  • Application to repair and tomography tasks