Zebroid: Using IPTV Data to Support Peer-Assisted VoD Content Delivery

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Overview

- IPTV Architecture
- Peer-Assisted VoD in IPTV: Considerations
- Research Context
- IPTV Operational Data
- Zebroid – Peer-Assisted VoD
- VP2P Testbed and Experiments
- Summary and Future Work
What is IPTV?

Digital television/multimedia services delivered over IP-based networks managed to support the required level of QoS/QoE, security, interactivity, and reliability.

*Source: ITU-T IPTV Focus Group*

IPTV vs. Internet TV

Best-effort delivery of video content over a broadband connection

- Examples: Hulu.com, iTunes & Apple TV, Netflix “Watch Instantly”
IPTV Architecture: Fiber-to-the Node (FTTN)

- **SHE**: Super Headends (Super Hub Office)
- **VHO**: Video Hub Office
- **CO**: Central Office
- **DSLAM**: Digital Subscriber Line Access Module (192 neighbors within 3000 feet)
IPTV Architecture: Fiber-to-the Node (FTTN)

- IPTV provides
  - Linear Programming Channels: Multicast
  - Video-on-Demand Content: Unicast

- Increasing VoD demands would require either
  - more VoD servers, or
  - increased bandwidth between VoD server and local switches

- Need P2P Solutions that help **IPTV Service Providers**

Cross-community transfer not desirable

\[ B_1N = 1 \text{ Gbps} \]
\[ B_1S = 24 \text{ Gbps} \]
\[ B_0D = 25 \text{ Mbps} \]
\[ B_0U = 1-2 \text{ Mbps} \]
\[ N_{\text{Community}} = 192 \]
Downstream Bandwidth Allocation

25Mbps downstream: 2 HD channels, 2 SD channels, 6Mbps for HIS, and VoIP
Peer-Assisted VoD in IPTV: Considerations

- **Traditional P2P Approaches**
  - Internet as a cloud
  - BitTorrent: tit-for-tat, out-of-order delivery

- **IPTV Environment**
  - Stringent QoS requirement for VoD
  - Centralized control of set-top boxes
    - potential to reserve storage/bandwidth for P2P
    - low failure rates
  - Consideration of physical structure is critical
  - Limited peer upload bandwidth
    - 1-2Mbps
    - can’t use it all for P2P
Research Context

• **Toast (Purdue)**
  - Modified bit-torrent client favors downloading pieces required by the media viewer soon.
  - VoD server as a backup when peers fail to meet the bandwidth requirement.
  - Not easy to find sufficient peers in a community with the requested video to support required bandwidth (HD: 6-7 Mbps).

• **Push-to-Peer (Thomson) and Zebra (AT&T)**
  - Pre-stripe popular VoD content on peer STB’s during idle hours
  - Peer-assisted VoD delivery during peak hours

**Differences**

• Push-to-Peer: peers disconnected from VoD server after striping
• Zebra/Zebroid: anticipates peer failures; residual bandwidth provided by VoD server
Content Striping and Serving

SD: 2 Mbps
10 peers @ 200kbps

HD: 6 Mbps
30 peers @ 200kbps
IPTV Data: VoD Request Distribution

Q: What are the best hours to stripe content?
IPTV Data: STB Availability

Q: How many STB’s that were up during idle hours (2am) will remain active during peek hours (8pm)?

Most communities (across the 40 DSLAM’s) have more 80% of the STB’s that remain active during peek hours (8pm).

Different redundancy ratios can be used based on the STB availability number of each DSLAM.
The Zebroid Architecture

IPTV data constantly collected to help determine Zebroid parameters

• VoD request data
• STB power state data
• Capacity management data
• ...
Zebroid Parameters

<table>
<thead>
<tr>
<th>$Z_N$</th>
<th>total number of videos in the VoD content library</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_n$</td>
<td>number of striped, popular videos; 20% of the videos typically represent 80% of the requests</td>
</tr>
<tr>
<td>$Z_k$</td>
<td>the maximum upload rate from each peer</td>
</tr>
<tr>
<td>$Z_p$</td>
<td>min. no. of stripes required to reconstruct a chunk.</td>
</tr>
<tr>
<td>$Z_c$</td>
<td>number of copies of a striped video</td>
</tr>
<tr>
<td>$Z_r$</td>
<td>erasure coding rate</td>
</tr>
<tr>
<td>$Z_s$</td>
<td>number of stripes for each chunk of the video, $Z_s = Z_p/Z_r$.</td>
</tr>
<tr>
<td>$Z_g$</td>
<td>size of the peer storage (in GB) reserved for P2P content delivery.</td>
</tr>
</tbody>
</table>

Each peer has multiple uploading and downloading threads in the pool. Each thread is limited to 200Kbps ($Z_k$).

$Z_p = 10$ for SD and 30 for HD if $Z_k = 200$kbps
If $Z_r = 5/6$, then $Z_s = 12$ for SD
Average Downlink Bandwidth of Requesting Peers

\[ BW_d = \frac{\# \text{ of supplying peers} \times \text{Peer uplink bandwidth}}{\# \text{ of requesting peers}, p} \]

Constraints: upload @ 1.8 Mbps and download @ 26 Mbps
Average Downlink Bandwidth: Utilization Distribution

Characteristic peaks at multiples of 2Mbps as a result of STBs being situated at different loop lengths from the CO
The Testbed Network Diagram

64 VM’s on 4 MacPro’s started through a network Bootstrap Server (south) and managed by a test controller (north). Individual VLAN connections to the VLAN routers.
Zebroid Values in Experiments:

<table>
<thead>
<tr>
<th>sym.</th>
<th>value</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_N$</td>
<td>1024</td>
<td>can be adjusted based on the real VoD data</td>
</tr>
<tr>
<td>$Z_n$</td>
<td>256</td>
<td>stripe only the top 25% of HD videos</td>
</tr>
<tr>
<td>$Z_k$</td>
<td>200Kbps</td>
<td>rate limit for each upload thread (up to 8)</td>
</tr>
<tr>
<td>$Z_p$</td>
<td>32</td>
<td>for HD video (6.4 Mbps)</td>
</tr>
<tr>
<td>$Z_c$</td>
<td>1</td>
<td>for all popular videos in most experiments</td>
</tr>
<tr>
<td>$Z_r$</td>
<td>1</td>
<td>no erasure coding in the testbed experiments</td>
</tr>
<tr>
<td>$Z_s$</td>
<td>32</td>
<td>for HD video</td>
</tr>
<tr>
<td>$Z_g$</td>
<td>5</td>
<td>5GB each of 64 peers</td>
</tr>
</tbody>
</table>
Zebroid Experiment on the VP2P Testbed

Average Mbps

Total Average Mbps: 3.43

• 4 Zones: 4 Mbps, 6Mbps, 8Mbps, 12Mbps
• Popular files (25%): 256 out of 1024 files
• $B_1N$ throttled at 10Mbps
• In this experiment, Zone 4 has 3 unpopular video requests that need to go back to the VoD server
Average downlink bandwidth of clustered peers

Constraints: upload @ 1.8 Mbps and download @ 26 Mbps

At each peer:
  - Pool of 8 concurrent upload threads (@ 200kbps each)
  - Pool of 32 concurrent download threads (@ 200kbps each)

Peer-assisted HD delivery is possible only for the 8Mps and 12Mbps peer neighborhoods when the number of requesting peers is <= 8.
Summary and Future Work

• **Zebroid Peer-Assisted VoD Scheme**
  - Pre-stripe popular VoD content on peer STB’s during idle hours
  - Peer-assisted VoD delivery during peek hours
  - Anticipates peer failures; residual bandwidth provided by VoD server
  - Uses IPTV data constantly to adjust Zebroid parameters

• **Future Directions**
  - Expand the testbed to hook up to a real VoD server and central office
  - Mobile P2P Video
    - Limited battery power, bandwidth, storage, and communication range
Q & A