CAN INTERNET VIDEO-ON-DEMAND BE PROFITABLE?

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Goal

examine a commercial large-scale video-on-demand service

Peer-assisted VoD
Outline
Large-scale operational video-on-demand service

- Traces collected from MSN Video
  - 520M streaming requests
  - 59,000 unique videos
Service growth

<table>
<thead>
<tr>
<th></th>
<th>Apr. 2006</th>
<th>Dec. 2006</th>
<th>Up (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td># of views (million)</td>
<td>41.1</td>
<td>64.7</td>
<td>57.4</td>
</tr>
<tr>
<td># of users (million)</td>
<td>9.03</td>
<td>12.02</td>
<td>33.1</td>
</tr>
</tbody>
</table>

video quality growth

popularity growth

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Service growth (2)

- server rate is billed by the 95\textsuperscript{th} percentile rule
  - measure every 5 mins
  - cut at the 95\% of CDF

<table>
<thead>
<tr>
<th>server bandwidth (Gbps)</th>
<th>Apr. 2006</th>
<th>Dec. 2006</th>
<th>Up (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>server bandwidth (Gbps)</td>
<td>1.23</td>
<td>2.20</td>
<td>78.5</td>
</tr>
</tbody>
</table>
Access bandwidth

- Download BW is measured by Windows Media Server
  - No distinguishing beyond 3.5Mbps
- Upload BW is inferred
  - Very conservative

### Table I

<table>
<thead>
<tr>
<th></th>
<th>modem</th>
<th>ISDN</th>
<th>DSL1</th>
<th>DSL2</th>
<th>Cable</th>
<th>Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td>download</td>
<td>64</td>
<td>256</td>
<td>768</td>
<td>1500</td>
<td>3000</td>
<td>&gt; 3000</td>
</tr>
<tr>
<td>upload</td>
<td>64</td>
<td>256</td>
<td>128</td>
<td>384</td>
<td>768/384</td>
<td>768</td>
</tr>
<tr>
<td>share (%)</td>
<td>2.84</td>
<td>4.34</td>
<td>14.26</td>
<td>23.28</td>
<td>18.0</td>
<td>37.27</td>
</tr>
</tbody>
</table>

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Potential of peer-to-peer

- How much could users upload?

- Demand (D): total download

- Supply (S): potential upload

- Currently, S >> D

- Obviously, P2P can help, but how much exactly?

April 18, 2006
Peer-assisted VoD model

- Guaranteed QoS: always available server
- Performance metric: server bandwidth
- Peers upload what / when they are watching
  - conservative assumption
Assumptions
- peers always start watching from beginning
- VoD: earlier peers upload to later peers

1st policy: no-prefetching
- only satisfy demand for smooth playback
- used by commercial live streaming companies to offer VoD
Prefetching – to utilize remaining upload capacity
- 2nd policy: water-leveling
- 3rd policy: greedy

Lower bound
- allow later peers upload to earlier ones
  - no arrival order constraints
Observations on policies

- Prefetching is crucial
  - “free” to increase video bitrate
  - “balanced mode” is most difficult
    - $S \approx D$

- Greedy policy works best
  - lowest server load
  - very close to bound

Aug. 2007

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Server BW reduction – two videos

- Select top two most popular videos
  - ~800,000 views during April, 2006
- Significant server bandwidth reduction using peer assistance
Server BW reduction — two videos

- select top two most popular videos
  - ~800,000 views during April, 2006
- significant server bandwidth reduction using peer assistance
- less server BW even increase quality 3 times (@3x bitrate)
Server BW reduction – all videos

- 12,000+ videos
- server bandwidth reduction in all categories
  - 1.23Gbps → 36.9Mbps (97%)
  - 1.23Gbps → 770Mbps @3X bitrate (38%)

April 2006
Impact on ISPs

- **Economics of ISP relationships**
  - **sibling relationship**
    - several ISPs belong to same org
  - **peering relationship**
    - mutual beneficial free agreement (to certain extent)
  - **transit relationship**
    - one ISP pays another
Impact on ISPs (2)

Without ISP-friendly

- much more cross sibling than peering boundary
- significant crossing boundary traffic
Impact on ISPs (3)

- Pure ISP-friendly
  - 1 video $\rightarrow$ 5000+ separate distributions
  - still surprising reductions but unnecessarily conservative
- ISP could help by sharing information

<table>
<thead>
<tr>
<th>svr rate (Mbps)</th>
<th>no P2P</th>
<th>sibling partition</th>
<th>peering partition</th>
</tr>
</thead>
<tbody>
<tr>
<td>silver</td>
<td>39.0</td>
<td>19.6</td>
<td>15.8</td>
</tr>
<tr>
<td>top 10</td>
<td>295.2</td>
<td>90.3</td>
<td>75.1</td>
</tr>
</tbody>
</table>

cut cross boundary traffic completely
Peer-assisted VoD is the way to go ...  
Prefetching is important ...  
An ISP-friendly peer-assisted VoD is crucial to build a harmonic society among users, content providers and ISPs ...