Cloud Transcoder:
Bridging the Format and Resolution Gap between Internet Videos and Mobile Devices

Zhenhua Li, Peking University
Yan Huang, Gang Liu, Fuchen Wang, Tencent Research
Zhi-Li Zhang, University of Minnesota
Yafei Dai, Peking University
About Mobile Devices

• **Mobile devices**
  - more and more popular
  - more than PCs

• **Mobile traffic**
  - only iPad accounts to **10% Internet traffic!**
  - mostly headed for **video streaming**

- iPhone
- iPad
- Android
- Ultrabook
- laptop
- ...
“Gap” Between Mobile and Videos

• Today’s mobile video streaming is still challenging for a number of reasons
  - small and diverse screens
  - low battery power
  - embedded CPU

• Today’s Internet videos
  - mostly PC-oriented
  - single format (soft encode)
  - very limited resolutions

Format and resolution Gap
Local transcoding

- Computation complexity of video transcoding
  - usually as $5 \text{–} 20 \text{ times}$ as that of video decoding (viewing)
  - easily consume up the battery power of a mobile device

- So, today’s mobile users often have to utilize their PCs with auxiliary software
  - iTunes, AirVideo, etc.
  - very inconvenient
Cloud-based transcoding

- Recent years, a worldwide upsurge of cloud service deployments
  - gradually move computation-intensive works from light-weight users onto heavy-weight clouds

- Traditional cloud transcoding solution
  - typically let users upload their original videos
  - work well for transcoding audios and short videos

  - unfit for long videos: 1. asymmetric Internet access (like ADSL), 2. Long videos consume very much computing resource, users need to wait a long time
Multi-format support mobile player

• support full format video (373)
• Cannot not solve the resolution adaption problem
• http://player.qq.com
Cloud Transcoder  TENCNET

Looks simple and straightforward, while works effectively!
Work flow

1. The user only uploads a video request
   <video link; format, resolution, ...>

   HTTP/FTP/RTSP link
   BT/eMule/Magnet link
   User-specified transcoding parameters

2. The cloud caches both original videos and transcoded videos

3. The cloud transfers transcoded videos back to users with a high data rate
   - via the intra-cloud data transfer accelerations
   - detailed described in Cloud Download Paper 2011 ACM MM
Advantages

• **Time Saver**
  – Uploading time
  – Transcoding time

• **Energy**
  – Mobile user *only* consumes energy in the last step
    fast retrieving the transcoded video from the cloud

  – Cloud Transcoder provides **energy-efficient on-demand** video transcoding service to mobile users
Problem and solutions

• Cloud Transcoder moves all the video download and transcoding works from its users to the cloud

• So, a critical problem: how to handle the resulting heavy download bandwidth pressure and transcoding computation pressure on the cloud

• Our solutions:
  - implicit data reuse among users via cloud cache
  - explicit transcoding recommendation and prediction
  - simple but effective: (1) download task cache hit ratio $\rightarrow 87\%$, (2) transcode task cache hit ratio $\rightarrow 66\%$
Real-world system

- Cloud Transcoder
  - deployed since May 2011
  - employs 244 commodity servers
  - across ten biggest ISP networks in China
  - serving ~8600 requests from ~4000 users per day
  - 96% original videos are long videos (> 100 MB)
  - system architecture is planned to serve 100,000 requests per day
System Overview

1. Video request
2. Check cache
3. Transcoding task
4. Download task
4’. Transcoding task
5. Download task
5’. Transcoding task
6. Transcoding task
7. Download
8. Store original video
9. Transfer (with a high data rate)
10. Transfer (with a high data rate)
Transcoding Prediction

• When the average computation pressure \((CPU\ utilization)\) of the transcoders stays below a certain threshold (50%) during a certain period (one hour)

  - Task Manager starts to predict which videos are likely to be requested for transcoding into which formats and resolutions
  - based on the video popularity information

  - Task Manager picks top-1000 popular videos and top-3 popular transcoding parameters to initiate transcoding tasks

  - part of the transcoding computation pressure in “hot” time has been moved to “cold” time for load balancing
Figure 3: Average CPU utilization of the transcoders in one day (with prediction) and the other day (without prediction), respectively.
Cloud Cache

Intra-cloud data transfer acceleration

High data rate!
Cloud Cache capacity planning

- Plan to handle 100K daily requests
  - avg size of original videos: 827 MB
  - a novel video is stored for 12 days
  - avg cache hit ratio of original videos: 87%
  - Original video cache capacity: $C_1 = 827 \text{ MB} \times 100K \times 12 \times (1 - 87\%) = 126 \text{ TB}$

- an original video has 3 transcoded videos in average
- avg size of transcoded videos: 466 MB
- Transcoded video cache capacity: $C_2 = 466 \text{ MB} \times 100K \times 12 \times (1-87\%) = 213 \text{ TB}$

- In total, $C = C_1 + C_2 \approx 340 \text{ TB}$
Cloud Cache replacement strategy

- Trace-driven simulations
- Compare FIFO, LRU and LFU
- LFU performs the best!

(a) For original videos.  (b) For transcoded videos.
Performance Evaluation

- complete running log of Cloud Transcoder in 23 days (Oct. 1–23, 2011)
  - 197,400 video transcoding tasks involving 76,293 unique videos
  - 85% video links are P2P links
  - most popular transcoding parameters: (1) MP4-1024*768 (iPad), (2) MP4-640*480 (iPhone & Android), (3) 3GP-352*288 (Android)
Results

Figure 9: Retrieve duration.
Figure 10: Download duration.
Figure 11: Data transfer rate.

<table>
<thead>
<tr>
<th>Data transfer rate (≈KBps)</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone battery consumption (%)</td>
<td>8.7</td>
<td>8.9</td>
<td>9.0</td>
<td>9.2</td>
</tr>
<tr>
<td>iPad2 battery consumption (%)</td>
<td>4.5</td>
<td>4.8</td>
<td>5.0</td>
<td>5.1</td>
</tr>
</tbody>
</table>
Future work

• **Cloud Transcoder: a novel prototype system**
  - still at its startup stage
  - tend to adopt straightforward and solid designs
  - still considerable optimization space

• **Other cloud transcoding services**
  - mobile web browsers
Q & A