Overview on Live P2P Streaming

Mehrdad Moradi
Today’s Talk

- Overview of P2P Video Streaming
- IP Multicast P2P Live Streaming
- Tree-based Overlays
- Mesh-based Overlays
- View-Upload Decoupling (VUD)
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Peer-Assisted Video Streaming

- Peers redistribute video to each other
  - exploit peer uploading/buffering capacity
  - reduces load on server

- Large scale deployments on Internet
  - thousands of live/on-demand channels
  - millions of world-wide users daily

- Leading P2P Video Companies
  - CoolStreaming
  - PPStream
  - PPLive
  - Sopcast
  - UUSee
PPStream (http://www.pps.tv)

#1 P2P Video System in the World

Developed by Liang Lei and Hongyu Zhang (China) in 2005.

350M installations

~12 Million active users each day

Thousands of channels

Num of Channels
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IP Multicast Concept
IP Multicast Challenges

- Routers doesn’t support!
- Native multicast operates at the OSI layer 3 (network)
- requires router support to construct minimal spanning trees
- issues with group and membership management
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- **Tree-based Overlays**
- Mesh-based Overlays
- View-Upload Decoupling (VUD)
Tree-based Overlays (single)
Tree-based Overlays

- suffer greatly from high node transience (also known as churn).
- scarcity and/or uneven distribution of host upload bandwidth.
- deliberate freeloading (that is, exploitation of resources without a proper reciprocation).
- any disruption in the data flow, due to churn, upload shortage, or lack of cooperation at the internal nodes, is propagated to the entire sub-tree rooted at the affected node.
Tree-based Overlays (Multiple)

Just send Descriptions
Tree-based Overlays

- more advanced stream encodings, such as *multiple description coding* (I will explain)
- Each tree is used to deliver a different description
- every node can be required to provide as much bandwidth as it consumes
- it supposes a uniform distribution of resources in the system and a fixed-degree regular tree construction
Multiple Description Coding (MDC)
Multiple Description Coding (MDC)
Multiple Description Coding (MDC)
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- Tree-based Overlays
- **Mesh-based Overlays (ISO)**
- View-Upload Decoupling (VUD)
Mesh-based Overlays (ISO)
Common Features

- **Multiple Channels**
  - Channel Churn

- **Heterogeneous Streaming Rates**

- **Heterogeneous Channel Popularities**
  - Very few viewers in less popular channels.

- **Isolated Channel Design: ISO**
  - Viewer only redistributes channel it is viewing
Problems of Traditional ISO Design

- **Large Channel Switching Delay**
  - Existing P2P video systems: 10-60 seconds

- **Large Playback Lag**
  - Existing P2P video systems: 5-60 seconds

- **Poor Small-channel Performance**
  - Inconsistent and poor performance in small channels.

- *Root causes:* channel churn and resource imbalance
Channel Churn in ISO Design

viewers

Channel 1

Channel 2
**Channel Churn in ISO Design**

**Drawback:** distribution systems disrupted when peers switch channels
Resource Imbalance in ISO Design

- **instantaneous resource index** for a channel of rate \( r \) with \( n \) viewers:

\[
\sigma = \frac{u_s + \sum_{i=1}^{n} u_i}{nr}
\]

- Ratio of **available** upload rate to **required** download rate
  - Channel in trouble if \( \sigma < 1 \)

- Resource index can be **imbalanced across channels**
  - Small channels particularly volatile.
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A Redesign of Multi-Channel System: View-Upload Decoupling (VUD)

New Rule: each peer is assigned to semi-permanent distribution groups; independent of what it is viewing.
A Redesign of Multi-Channel System: View-Upload Decoupling (VUD)

Advantage: distribution swarms not modified when peers switch channels

Channel 1

Channel 2

after channel switching
## Comparative View on ISO Design

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Tree-based</th>
<th>Mesh-based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-Tree</td>
<td>Multi-Tree</td>
</tr>
<tr>
<td>Allow optimization</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Load balancing</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Achievable Transmission Rate</td>
<td>Medium</td>
<td>High</td>
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<td>Control overhead</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Implementation</td>
<td>Easy</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
Advantages of VUD Design Over ISO

- **Channel Churn Immunity**
  - Distribution swarms unaffected by channel churn

- **Cross-Channel Multiplexing**
  - Distribution swarms can be provisioned and adapted to balance resource indexes across channels

- **Structured Streaming**
  - Scheduling and routing can be optimized within the stable VUD swarms
Key Challenges of VUD design

- **VUD Overhead**
  - In ISO, peer only downloads video it is watching.
  - In VUD, each peer downloads its assigned substreams as well as the video it is watching.
  - Solution: **substreaming**

- **Adaptive Peer Assignment**
  - Bandwidth allocation
  - Peer reassignment
Summery

- More insights about P2P Live Streaming.

- I talked about analytic theory for Tree, ISO and VUD streaming.

- More insights about QOS in P2P live Streaming.