Peer-Assisted Content Distribution in Akamai NetSession

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Content Distribution Network

- A large distributed system of servers deployed in multiple data centers across the internet

- Peer-to-Peer CDNs
  - Inexpensive, Easy to scale
  - Security problems, Low quality of Service

- Infrastructure-based CDNs
  - Expensive to set up and scale
  - Predictable Quality of Service
Hybrid CDN Design Space

• Potential benefits
  • better quality of service
  • reduced reliance on peer contributions
  • more reliable delivery
  • less legal exposure
  • better security
  • higher efficiency
  • lower cost
  • global coverage

• Potential risks
  • need for revenue
  • less transparency
  • heterogeneity,
  • multiple administrative domains
  • NATs and firewalls
  • impact on ISPs
Akamai NetSession

- A peer-assisted Content Distribution Network (CDN)
- More than 25 million users in 239 countries
- Infrastructure provides a central point of coordination and add resources
- Peers provide resources and scalability
The NetSession System Design Goals

- A substantial fraction of the content should be delivered by the peers
- Peer-assisted delivery QoS should be comparable to that of infrastructure-based delivery
  - Downloads should be no less reliable
  - Downloads should not be much slower
- The system should offer reliable accounting for services provided

Two explicit Non-goals:

- The system need not be more reliable than an infrastructure-based CDN
- Peers need not contribute equally
The NetSession System Architecture

- Infrastructure of *edge servers* that are operated by Akamai
- A number of user-operated peers that have special software, the *NetSession Interface*
- Infrastructure also have NetSession control plane

*Figure 1: Overview of the NetSession system.*
The NetSession Interface

- Available for Windows and Mac OS
- A background application that runs whenever the user is logged into their system
- Maintains a control connection to the control plane
- Control connection used to query control-plane for other peers, configuration updates and for reporting usage statistics
- Each peer has a unique GUID, chosen at random during installation
- Use HTTP (HTTPS) connection to download from edge servers
- Use swarming protocol like BitTorrent to download from peer
- No incentive mechanism
Edge Servers

- To ensure content integrity
  - Generate and maintain secure IDs of content and secure hashes of the pieces of each file
  - IDs and hashes are provided to peers to validate content

- Authorization
  - A peer must authenticate to edge server over HTTP(S) connection
  - Yields an encrypted token that can be used to search for peers
  - Prevent user from downloading unauthorized content

- Configuration and reporting
  - Policies to download or upload a file and other configuration options
  - To prevent accounting attacks
The NetSession Control Plane

Connection Node (CN)
- Endpoints of the persistent TCP connection to control pane
- Receive and collect usage statistics
- Handle queries for objects the peers want to download
- Tell peers to connect to each other to facilitated content sharing

Database node (DN):
- Maintains a database of which objects are currently available on which peers and connectivity of these peers
- Peers appear only when
  - Uploads are explicitly enabled on the peer
  - Peer currently has objects to share
The NetSession Control Plane

STUN:

- Peers periodically communicate with STUN components over UDP and TCP to determine details of their connectivity and to enable NAT traversal

Monitoring Node:

- Peers upload information about their operation and problems to these nodes
- Process these logs to monitor the network in real-time, to identify problems, and to troubleshoot specific user issues
NetSession Peer Selection

- Peer query closest available CN for an object, CN asks local DNs to identify suitable peers
- DNs use locality-based peer selection based on the geo-location of each peer
- Each peer belongs to multiple sets, based on public IP and AS
- CN/DN system is interconnected across regions
- CN returns the information about these (default 40) peers to the querying peer
- CN instructs both the querying peer and the chosen peers to initiate connections to each other
- Peers control the number and utilization of their connections based on current resource availability
Measurement Study
Number and location of the peers

<table>
<thead>
<tr>
<th>Customer</th>
<th>US East</th>
<th>US West</th>
<th>Other</th>
<th>India</th>
<th>China</th>
<th>Other</th>
<th>Europe</th>
<th>Africa</th>
<th>Oceania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer A</td>
<td>2%</td>
<td>1%</td>
<td>12%</td>
<td>6%</td>
<td>6%</td>
<td>18%</td>
<td>51%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Customer B</td>
<td>13%</td>
<td>6%</td>
<td>15%</td>
<td>1%</td>
<td>8%</td>
<td>3%</td>
<td>45%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Customer C</td>
<td>22%</td>
<td>21%</td>
<td>6%</td>
<td>2%</td>
<td>1%</td>
<td>3%</td>
<td>48%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Customer D</td>
<td>5%</td>
<td>3%</td>
<td>8%</td>
<td>2%</td>
<td>1%</td>
<td>28%</td>
<td>48%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Customer E</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Customer F</td>
<td>8%</td>
<td>3%</td>
<td>12%</td>
<td>2%</td>
<td>8%</td>
<td>20%</td>
<td>51%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Customer G</td>
<td>6%</td>
<td>4%</td>
<td>7%</td>
<td>4%</td>
<td>2%</td>
<td>20%</td>
<td>51%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Customer H</td>
<td>5%</td>
<td>2%</td>
<td>18%</td>
<td>–</td>
<td>15%</td>
<td>7%</td>
<td>57%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Customer I</td>
<td>42%</td>
<td>24%</td>
<td>14%</td>
<td>–</td>
<td>5%</td>
<td>11%</td>
<td>51%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Customer J</td>
<td>7%</td>
<td>4%</td>
<td>11%</td>
<td>3%</td>
<td>2%</td>
<td>20%</td>
<td>46%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>All customers</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 2: Global distribution of downloads for the ten largest content providers.

- One month trace of October 2012
- Contains 26 million distinct GUIDs
- On a typical day, between 8.75 and 10.90 million of the GUIDs connect to the control plane
- Connections from 239 different countries and territories across all continents
- A truly global system

Figure 2: Global distribution of peers.
choice, despite its mention in the NetSession user agreement. This tendency is well known in UI design: most users simply stick with whatever the default setting is. Despite this, Do the peers contribute resources? Peer-assisted CDN, NetSession can avoid the first problem because its content is centrally controlled and vetted, and tent providers can control on a per-file basis whether or not peer-to-peer downloads are allowed. In our trace, we found that peer-to-peer downloads were enabled initially...
Benefits

• Do the peers contribute resources?

<table>
<thead>
<tr>
<th>Uploads initially...</th>
<th>Nodes</th>
<th>Number of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disabled</td>
<td>15,913,255</td>
<td>99.96% 0.03% 0.01%</td>
</tr>
<tr>
<td>Enabled</td>
<td>7,395,867</td>
<td>98.11% 1.80% 0.09%</td>
</tr>
</tbody>
</table>

Table 3: Observed changes to the setting that enables content uploads.

<table>
<thead>
<tr>
<th>Customer</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>p2p (%)</td>
<td>&lt;1</td>
<td>20</td>
<td>2</td>
<td>94</td>
<td>2</td>
<td>45</td>
<td>47</td>
<td>&lt;1</td>
<td>91</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Table 4: Fraction of peers that have content uploads enabled.

• How much can be offloaded to the peers?
  • Peer to peer downloads are enabled for only 1.7% of the files, but these accounted for 57.4% of the downloads bytes overall.
  • The average peer efficiency for peer-assisted downloads was 71.4%
Benefits

- Are peer-assisted downloads slower?

Figure 4: Edge-only vs peer-assisted download speed in two large ASes.
Benefits

- How many peers are needed for good performance?

Figure 5: Number of registered file copies vs. peer efficiency

Figure 6: Impact of the number of peers on peer efficiency.
Benefits

- Are peer-assisted downloads reliable?

![Figure 7: Downloads of larger files are terminated more often.](image-url)
Benefits

- Do peers improve global coverage?

Figure 8: Peer contributions in different regions (for one exemplary content provider).

Note: Countries where the infrastructure serves bytes more than the peers (circle), between 50% and 100% of the peers (plus), or less than 50% of the peers (square.
Risks
Do ISPs suffer from NetSession?

- Which ASes are sending the most?

Figure 9: Traffic balance results.

(b) Contributions of different ASes
(c) Distinct IP addresses per AS

Figure 10: P2P bytes uploaded vs. downloaded for an AS. Only the bytes which cross AS boundaries are considered here.
Risks

- How balanced is the traffic?

Figure 10: p2p bytes uploaded vs. downloaded for an AS. Only the bytes which cross AS boundaries are considered here.

Figure 11: Traffic balance on AS-to-AS links.

Note that we have only considered the origin and the destination ASes that are not carrying very much NetSession traffic. This cost depends on a variety of other factors as well, including the business relationships between the ISPs. Nevertheless, it is likely that a large traffic imbalance would still exist between pairs of ASes, and not the cost that this particular problem does have on ISPs. Our data only describes the traffic, and not the cost that it has on ISPs.

Unlike

How strong is the mobility-related churn? 20,922 new connections per minute. The DNs must update their directories to keep track of this mobility, but the corresponding balance results.

Our data only describes the traffic, and not the cost that NetSession’s traffic has on ISPs.
Risks

- Impact of user-managed machines
  - How strong is the mobility-related churn?
  - Can malicious peers do damage?
  - GUID cloning and re-imaging

Figure 12: Expected sequence of secondary GUIDs (left) and common nonlinear patterns.
Conclusion

- NetSession is able to deliver the key benefits of a hybrid architecture.
- NetSession can offload a high fraction (70-80%) of the traffic to peers.
- NetSession offers good performance and reliability.
- NetSession faces some problems inherent to hybrid architecture like security and manageability.
- Hybrid architecture is an attractive design point for CDN.
Thank You
Any Questions???