



ADVANCED COMPUTER NETWORKS

Adhikari, V.K., et al., "Unreeling Netflix: Understanding and Improving Multi-CDN Movie Delivery," *Proc. of IEEE Infocom '12*, Mar. 2012

Netflix Authoritative Nameserver

Used to be UltraDNS

After Oct. 15, 2015 incident that pulled down UltraDNS, it's now handled by Amazon:

```
% dig netflix.com ns
;; ANSWER SECTION:
netflix.com. 171799 IN NS ns-659.awsdns-18.net.
netflix.com. 171799 IN NS ns-1372.awsdns-43.org.
netflix.com. 171799 IN NS ns-1984.awsdns-56.co.uk.
netflix.com. 171799 IN NS ns-81.awsdns-10.com.

;; ADDITIONAL SECTION:
ns-81.awsdns-10.com. 171799 IN A 205.251.192.81
ns-659.awsdns-18.net. 171799 IN A 205.251.194.147
ns-1372.awsdns-43.org. 171799 IN A 205.251.197.92
ns-1984.awsdns-56.co.uk.171799 IN A 205.251.199.192
```

BTW, netflix.com itself resolves to 52.0.171.217, 52.20.41.71, 52.200.137.220, etc.

Netflix Architecture

Why study Netflix?

Sandvine June 2016 Global Internet Phenomena Report:

- 35.2% of traffic on North American (NA) fixed networks
- A/V streaming accounts for 71% of evening traffic in NA
- Cloud storage surpassed file sharing as the top source of upstream traffic in NA
- Bittorrent accounts for < 5% of daily traffic in NA

For the amount of third-party services it employs (or used to employ)

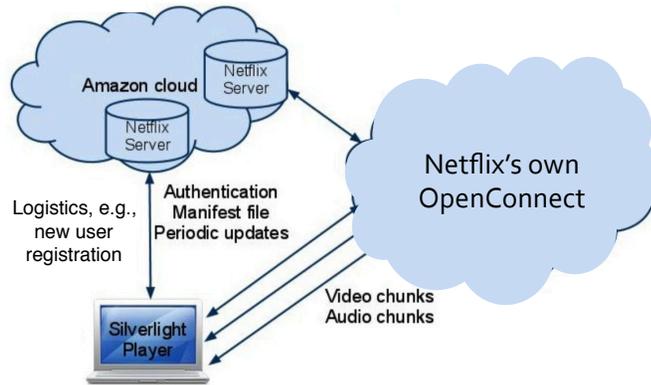
Netflix Architecture

Key Netflix hosts and their maintainers:

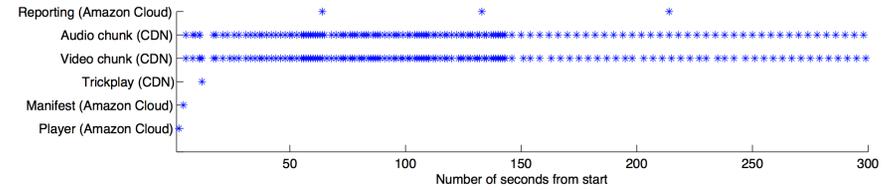
Hostname	Organization
www.netflix.com	Amazon
signup.netflix.com	Amazon
movies.netflix.com	Amazon
agmoviecontrol.netflix.com	Amazon
nflx.i.87f50a04.x.lcdn.nflximg.com	Netflix's own
netflix-753.vo.llnwd.net	OpenConnect
netflix753.as.nflximg.com.edgesuite.net	

discovered by DNS resolution (dig) and looking up WHOIS database (whois)

Netflix Architecture



Netflix Timeline



1. Download player (every time!) and authenticate user
2. Download **client-capability specific** DASH manifest file
3. Download audio/video chunks or trickplay data
4. User experience reporting

Dynamic, Adaptive Streaming over HTTP (DASH)

Server-side:

- divides video file into **multiple chunks**
- each chunk encoded and stored at **multiple rates**
- **manifest** file: provides URLs for different chunks

Client-side:

- request chunks from "closest" server
- periodically measures server-to-client bandwidth
- chooses maximum encoding rate sustainable given current bandwidth
- can choose different encoding rates at different points in time

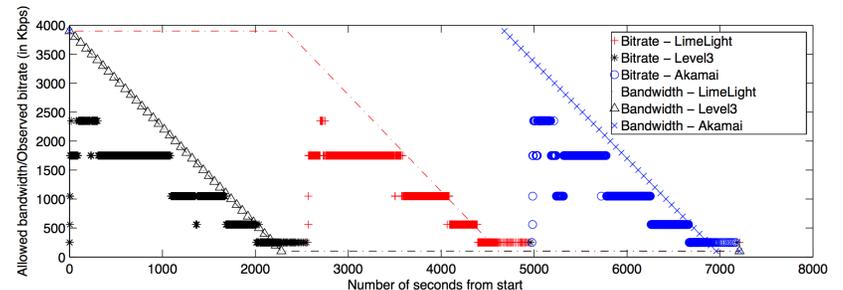
```
<nccp:bitrate>560</nccp:bitrate>
<nccp:videoprofile>
  playready-h264mp130-dash
</nccp:videoprofile>
<nccp:resolution>
  <nccp:width>512</nccp:width>
  <nccp:height>384</nccp:height>
</nccp:resolution>
<nccp:pixelaspect>
  <nccp:width>4</nccp:width>
  <nccp:height>3</nccp:height>
</nccp:pixelaspect>v
<nccp:downloadurl>
  <nccp:downloadurl>
    <nccp:expiration>131xxx</nccp:expiration>
    <nccp:cdnid>6</nccp:cdnid>
    <nccp:url>http://nflx.i.../</nccp:url>
  </nccp:downloadurl>
  <nccp:downloadurl>
    <nccp:expiration>131xxx</nccp:expiration>
    <nccp:cdnid>4</nccp:cdnid>
    <nccp:url>http://netflix.../</nccp:url>
  </nccp:downloadurl>
  <nccp:downloadurl>
    <nccp:expiration>131xxx</nccp:expiration>
    <nccp:cdnid>9</nccp:cdnid>
    <nccp:url>http://netflix.../</nccp:url>
  </nccp:downloadurl>
</nccp:downloadurls>
```

Bit Rate Adaptation

Encoding bit rates:

- SD: 100 and 1750 Kbps, in 12 different rates
- HD: 2350 and 3600 Kbps, in 14 different rates

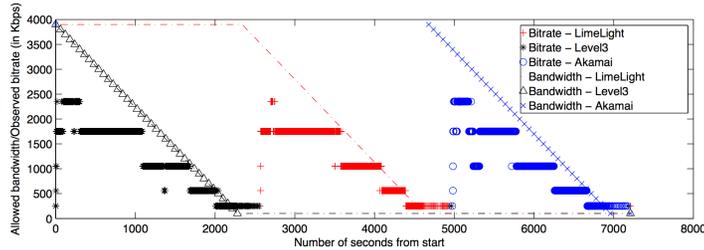
Player starts by probing for available bandwidth
Adapts to lower rate if available bandwidth drops



URL Ranking and Selection

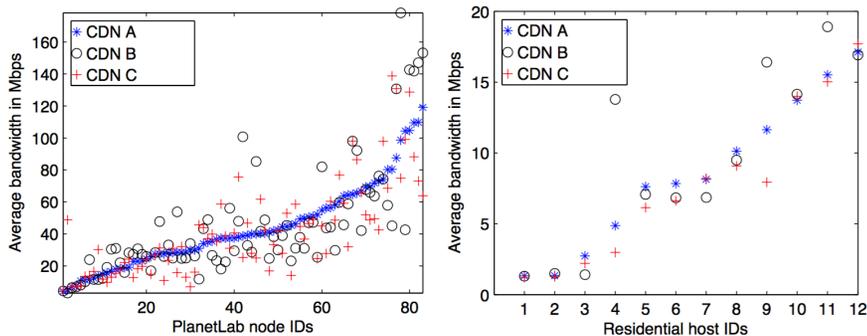
URL ranking assigned to user account is **independent** of available bandwidth and **remains the same** regardless of movie types, computers, time, locations

URL selection changes only when bandwidth from current server goes below the minimal required (motivation?)

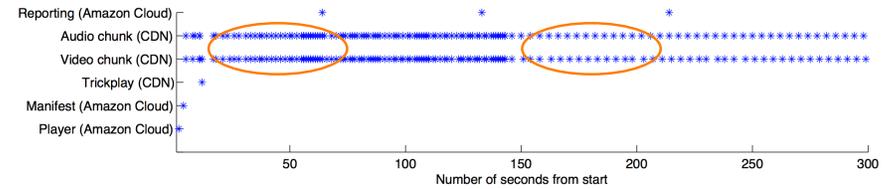


CDN Performance

Some CDN is better provisioned than others
Some clients are better connected than others
(Why hide CDN names?)



Data Download

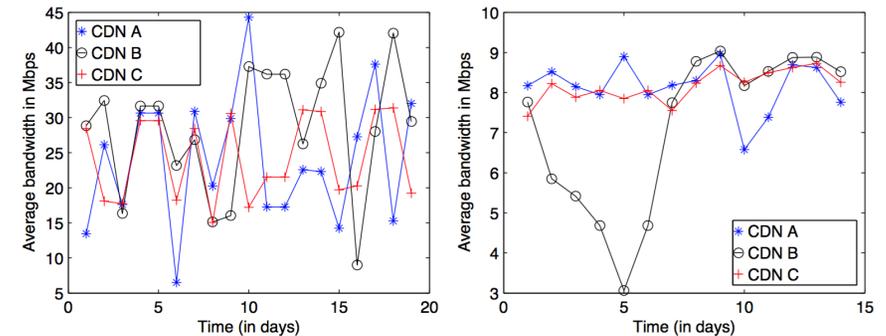


More frequently at the beginning, then becomes periodic, at ~4 secs. apart, the playback length of a typical chunk

Trickplay (FF, RW, Pause, Seek) on digital video requires a different, sampled stream (can't just play back stream at faster rate or backward)
• trickplay info also included in manifest file

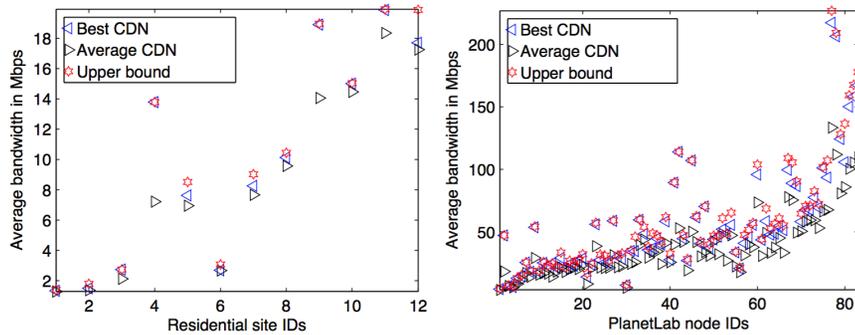
CDN One-day Average Bandwidth at 2 Clients

No CDN is consistently better



CDN Selection: Can We Do Better?

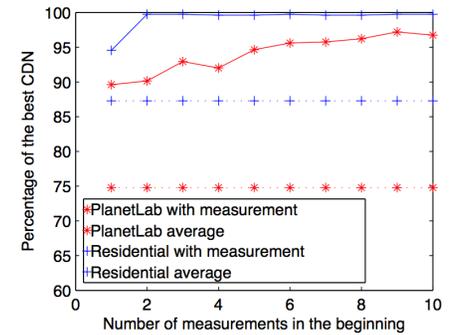
Best CDN: static selection
 Upper bound: adaptive, optimal selection



CDN Selection: Measured Best Static

Client measures for best CDN at the start,
 then stays with CDN for the rest of movie

Applicable to multiple
 URLs of OpenConnect?



Multiple CDNs Simultaneous

Client downloads 3 different chunks in parallel from 3
 different CDNs

Applicable to multiple URLs of OpenConnect?
 Different download schedules for the multiple CDNs?

