
A Study of Netflix and Hulu

STREAMING SERVICES CDN SELECTION STRATEGY ANALYSIS

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PAPER PRESENTED

Measurement Study of Netflix, Hulu, and a Tale of Three CDNs

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OVERVIEW

- **Measurement period: June - October, 2011**
 - **The 3 CDNs used by both services: Akamai, Level3 (Now Lumen), Limelight**
 - **Quality of Experience (QoE) vs. Business Constraints (BC)**
 - **How the CDNs performed & how are they selected for users**
 - **Some possible better strategies that improves QoE while conforming to BC**
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NETFLIX

HOW BIG IS IT?

- **~ 15% of the world's Internet traffic**
 - **> 1 mil paid subscribers**
 - **\$24.9 billion revenue in 2021**
 - **Most people's go-to streaming service**
-

ARCH

TABLE I
KEY NETFLIX HOSTNAMES

Hostname	Organization
www.netflix.com	Netflix
signup.netflix.com	Amazon
movies.netflix.com	Amazon
agmoviecontrol.netflix.com	Amazon
nflx.i.87f50a04.x.lcdn.nflximg.com	Level 3
netflix-753.vo.llnwd.net	Limelight
netflix753.as.nflximg.com.edgesuite.net	Akamai

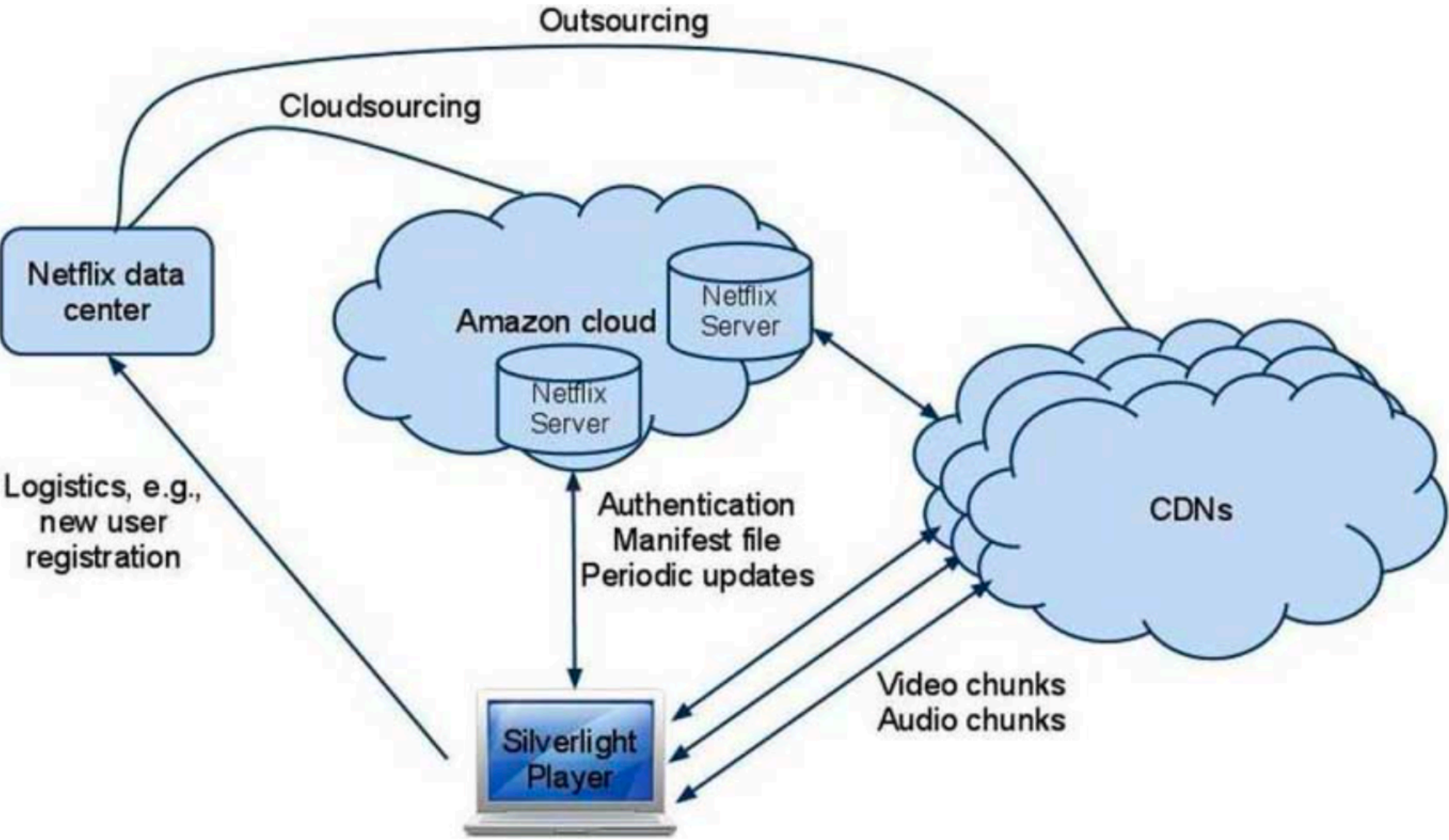


Fig. 1. Netflix architecture.

CLIENT REQUESTS TIMELINE

- Video / Audio divided in chunks under Dynamic Streaming over HTTP (DASH)
- Authentication -> Manifest file -> A/V streaming & periodic reporting

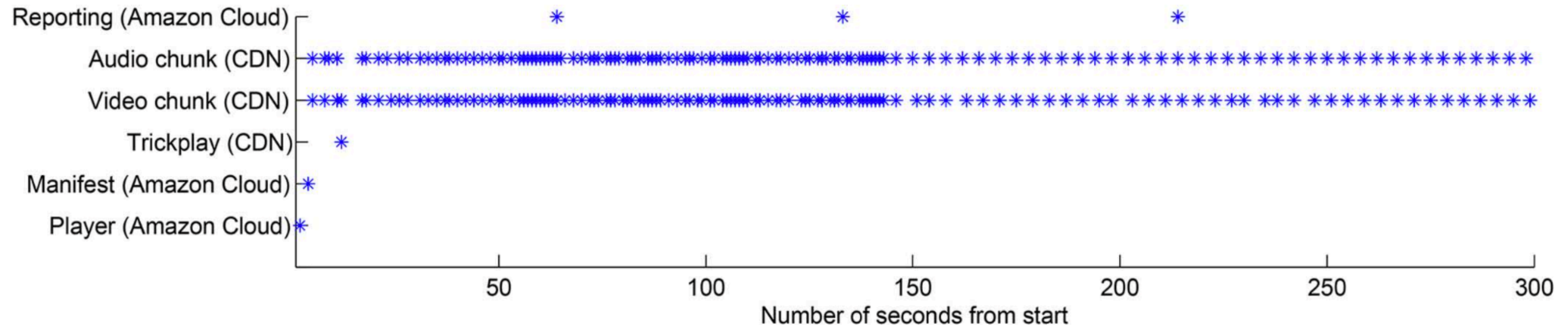


Fig. 2. Timeline in serving a Netflix client.

THE MANIFEST FILE

➤ XML File

➤ CDNs and ranking (*tied to acc*)

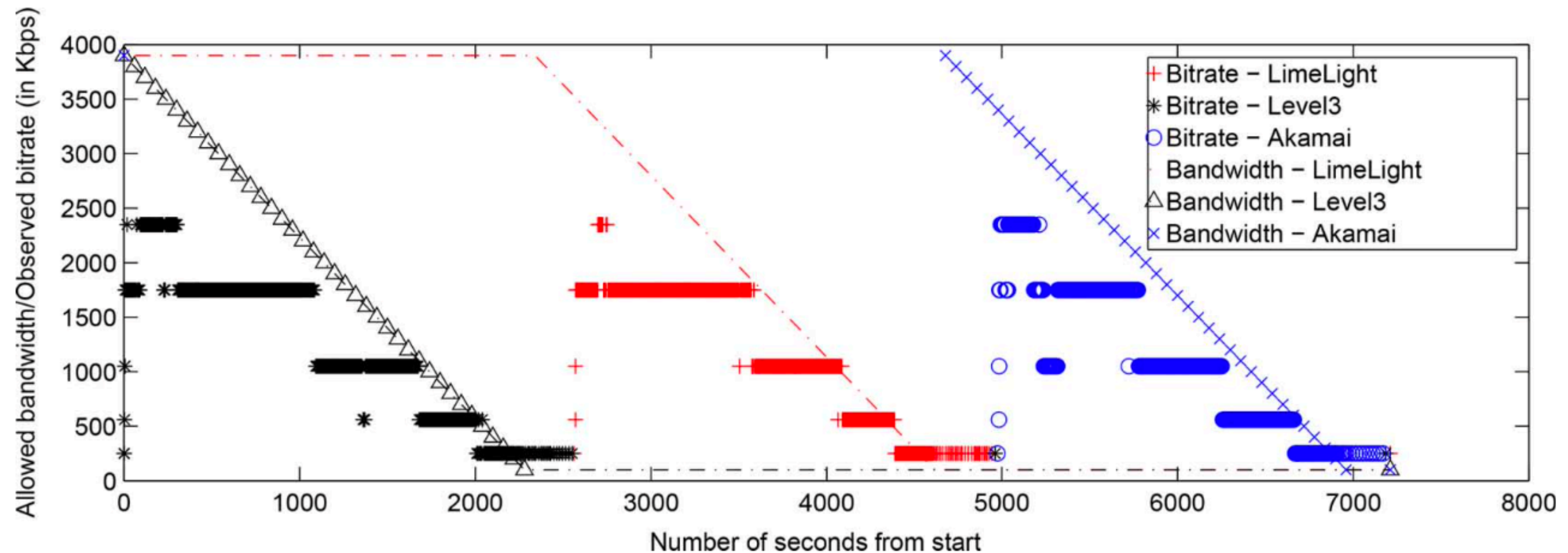
➤ Resource URLs w/ bit rates

```
<nccp:bitrate>560</nccp:bitrate>
<nccp:videoprofile>
  playready-h264mpl30-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:downloadurls>
  <nccp:downloadurl>
    <nccp:expiration>131xxx</nccp:expiration>
    <nccp:cdnid>6</nccp:cdnid>
    <nccp:url>http://nflx.i.../...</nccp:url>
  ,
```

```
<nccp:bitrate>560</nccp:bitrate>
<nccp:videoprofile>
  playready-h264mpl30-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:downloadurls>
  <nccp:downloadurl>
    <nccp:expiration>131xxx</nccp:expiration>
    <nccp:cdnid>6</nccp:cdnid>
    <nccp:url>http://nflx.i.../...</nccp:url>
  ,
```


CDN SELECTION STRAT

- Stay w/ the highest ranked CDN
- Switch to the next CDN only if it cannot support even the very low quality level



HULU

A SIMILAR STORY

- **Protocol: Real Time Mes- saging Protocol (RTMP) / RTMP over HTTP (RTMPT)**
- **Adapted to changing bandwidth by adjusting the bit rates**
- **Switched only when the current CDN is unable to serve the lowest possible bit rate**
- **Reported msgs like “Move up since avg dropped FPS $0 < 2$ and bufferLen > 10 ”**
- **CDN prefs in manifest not tied to account, but conform to certain latent distribution**

```
'tp:cdnPrefs' => 'level3,akamai,limelight',
```

Fig. 7. Section of Hulu manifest file.

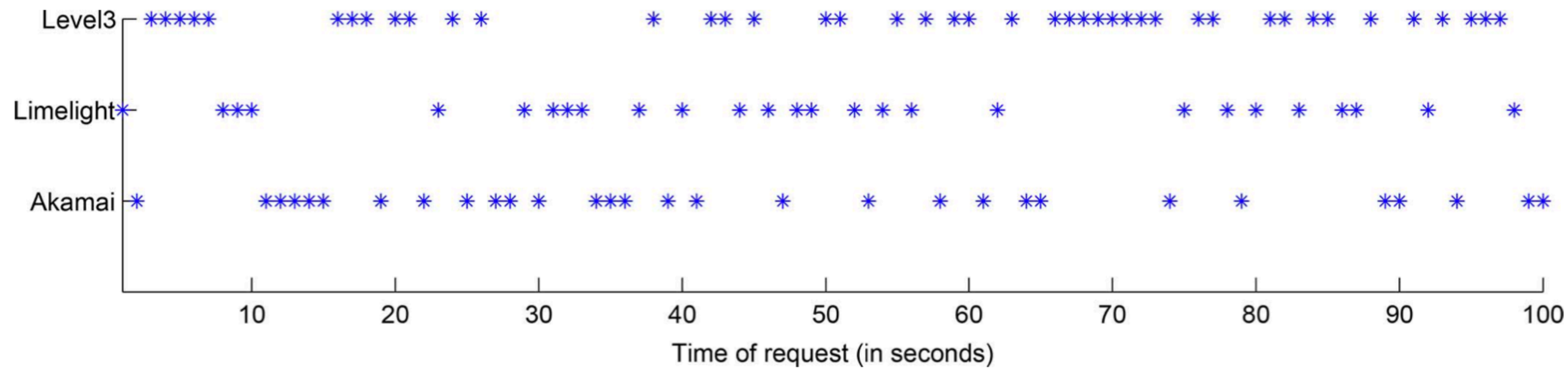


Fig. 8. CDN preference change in a 100-s time interval.

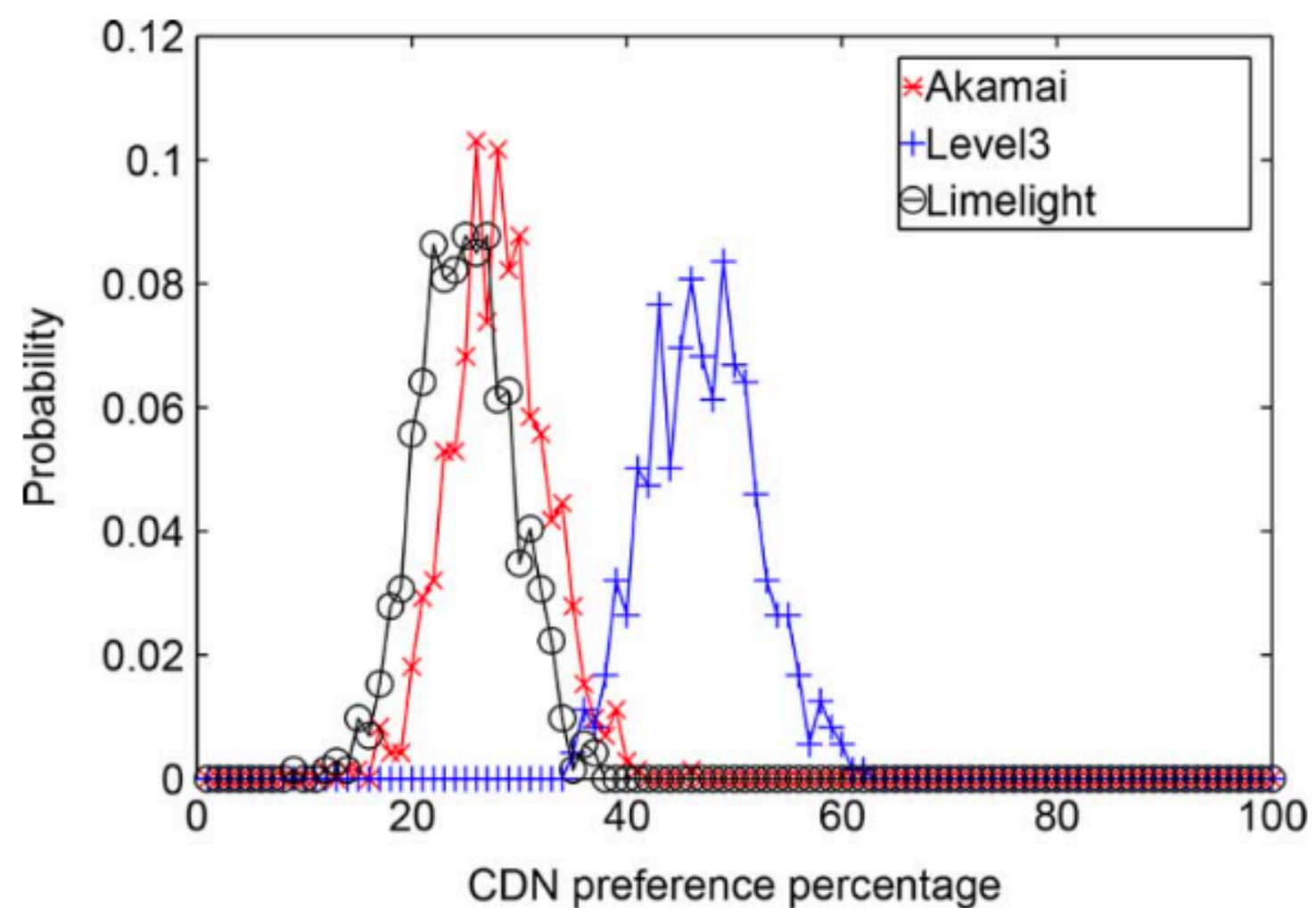


Fig. 9. Overall CDN preference distribution.

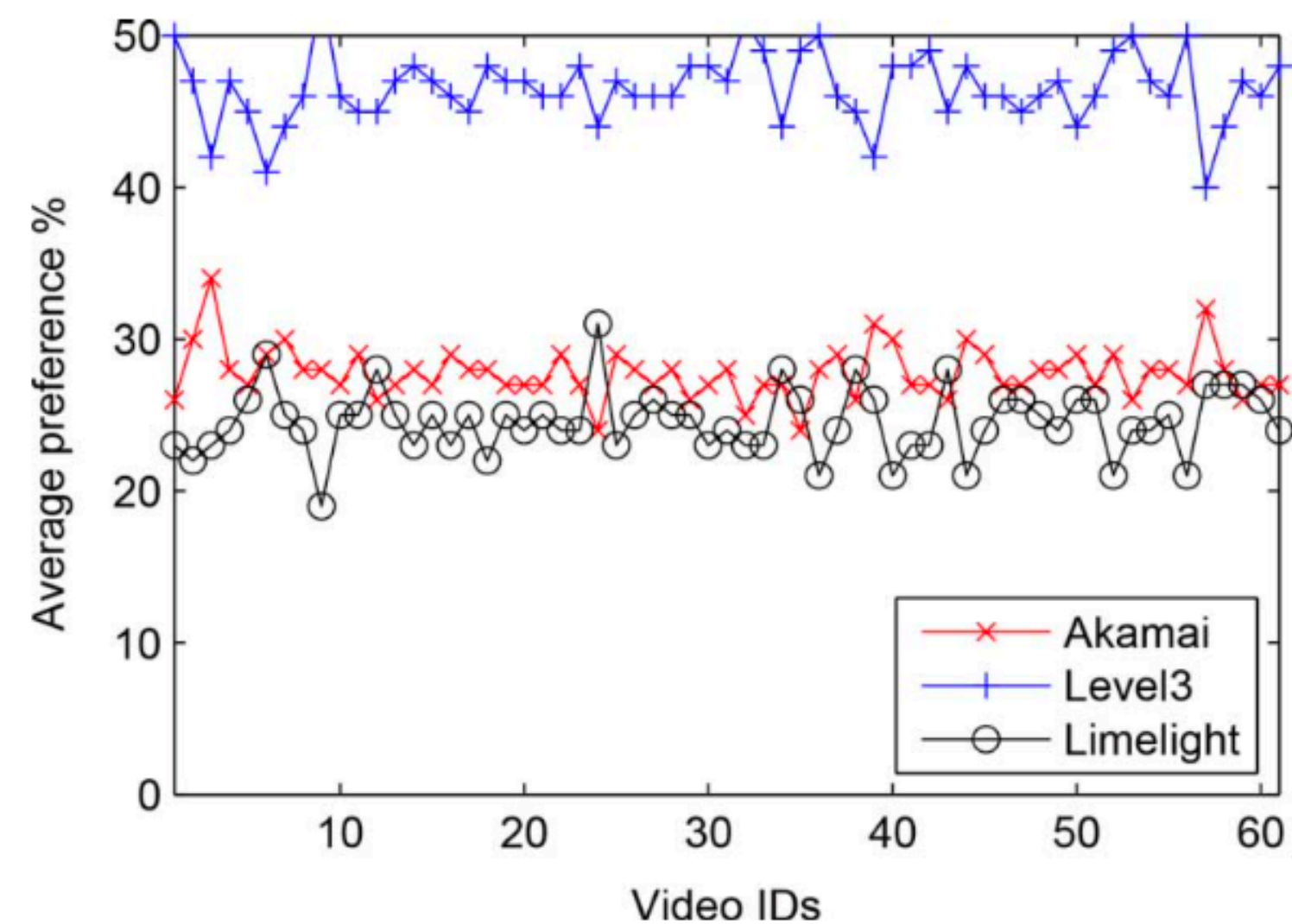


Fig. 11. CDN preference for different videos.

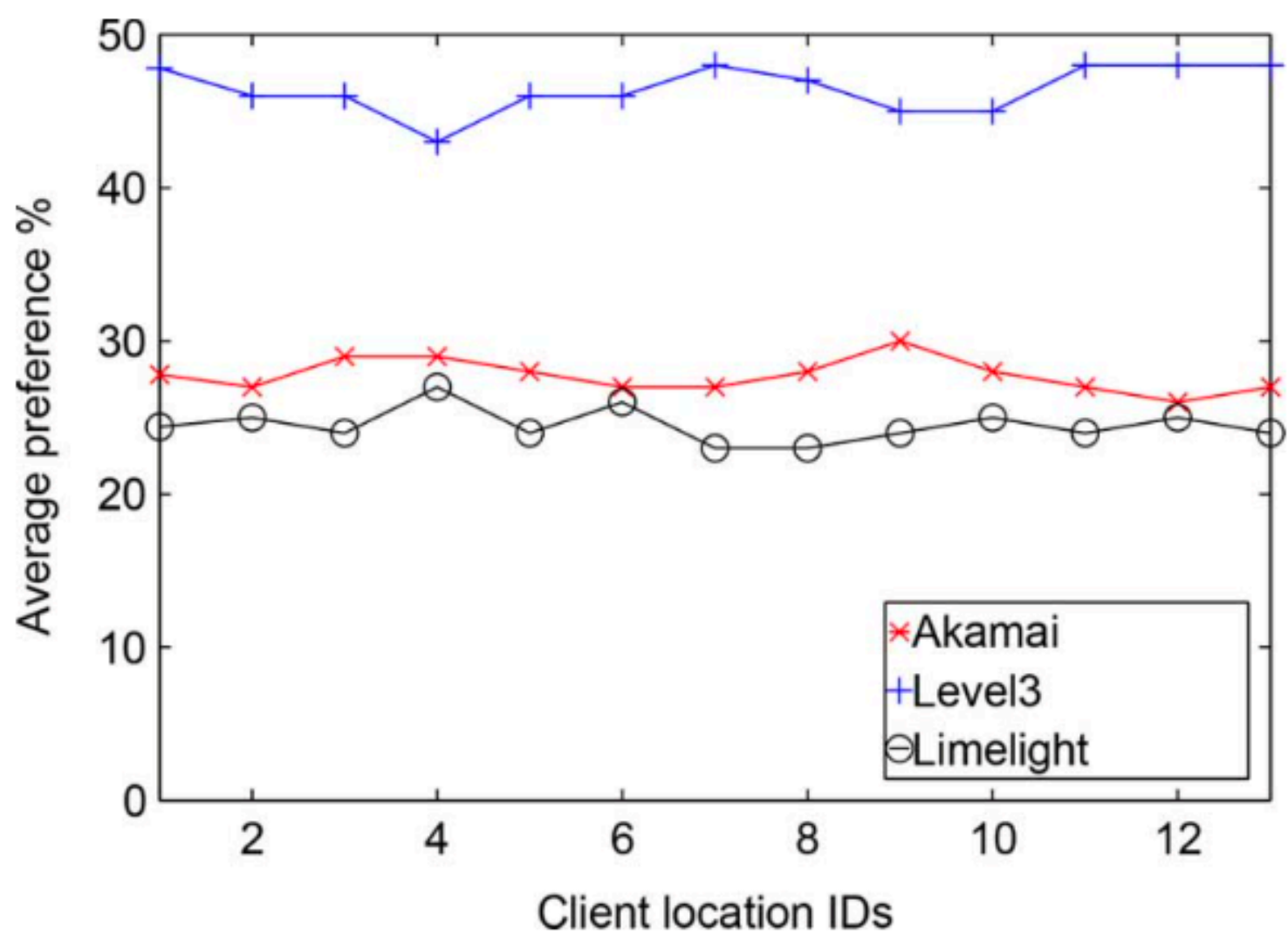


Fig. 10. CDN preference from geographic regions.

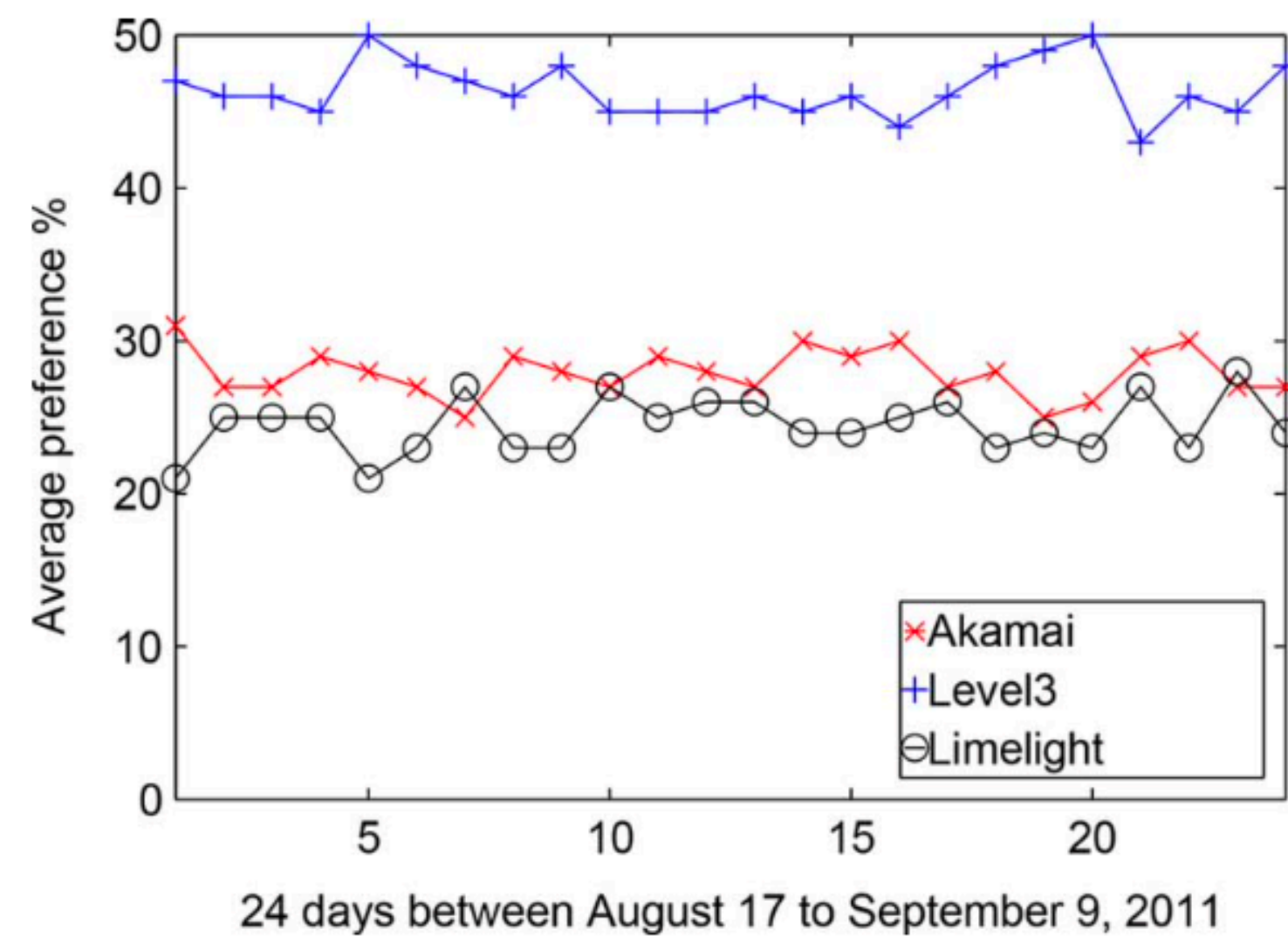


Fig. 12. CDN preference over time.

CDN PERF

QUESTIONS

- **How does each CDN perform?**
 - **Can the selected CDN server consistently support the bandwidth needed for high-quality streaming?**
 - **How do different CDNs compare in terms of performance?**
 - **Is any CDN clearly better or worse than others?**
 - **How far is the current CDN selection strategy from “optimal”?**
 - **Can the strategy be improved to support higher-delivery bandwidth while conforming to the business constraints?**
-

PERF MEASUREMENT

- **Collect resource URLs from the manifest files**
 - **Replay GET requests to the CDNs in a round-robin fasion**
 - **Perform from sites across the globe**
 - **Request only one of the CDNS, or all of them in parallel (byte-range in req header)**
-

FINDINGS

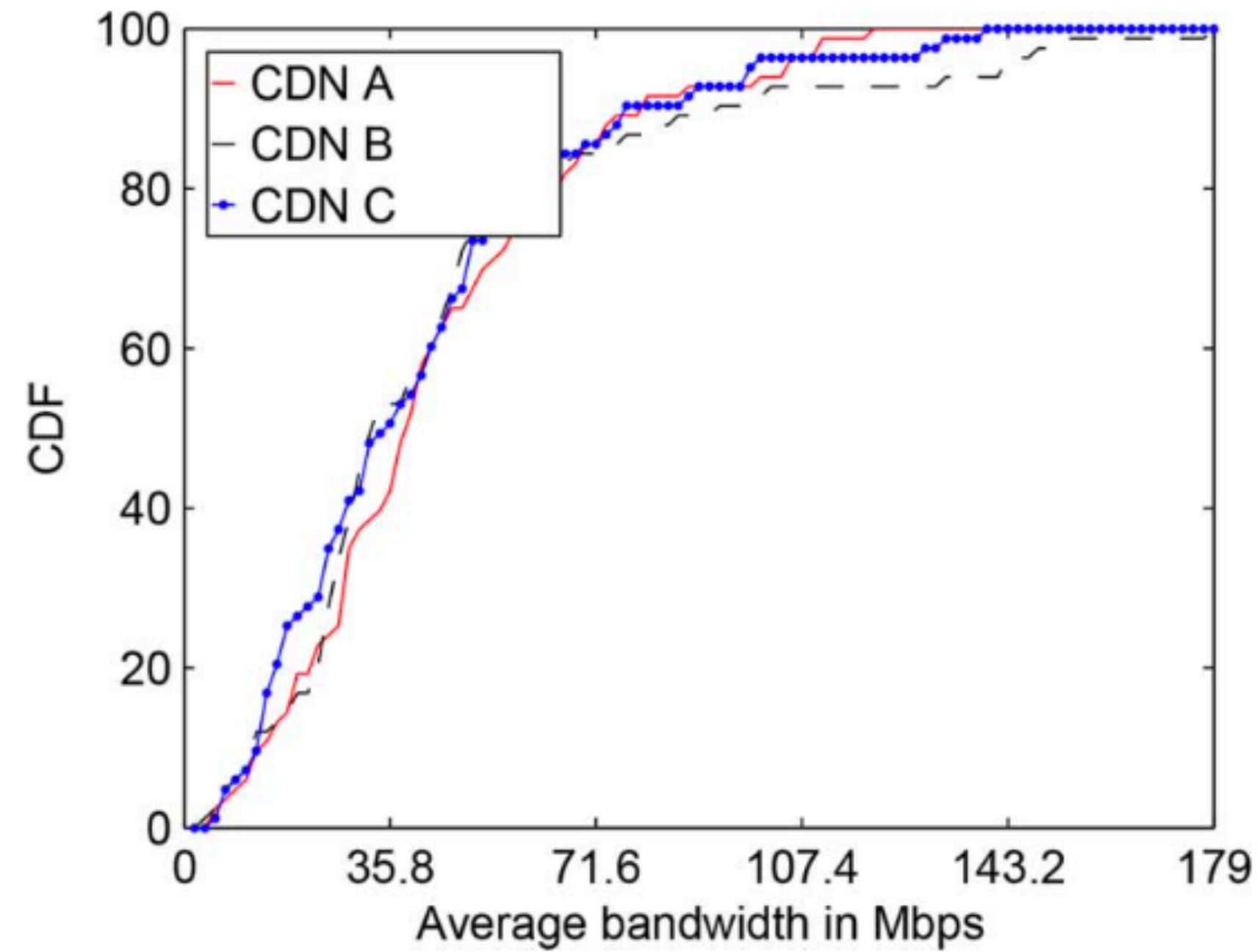


Fig. 14. CDF of average bandwidth at PlanetLab nodes.

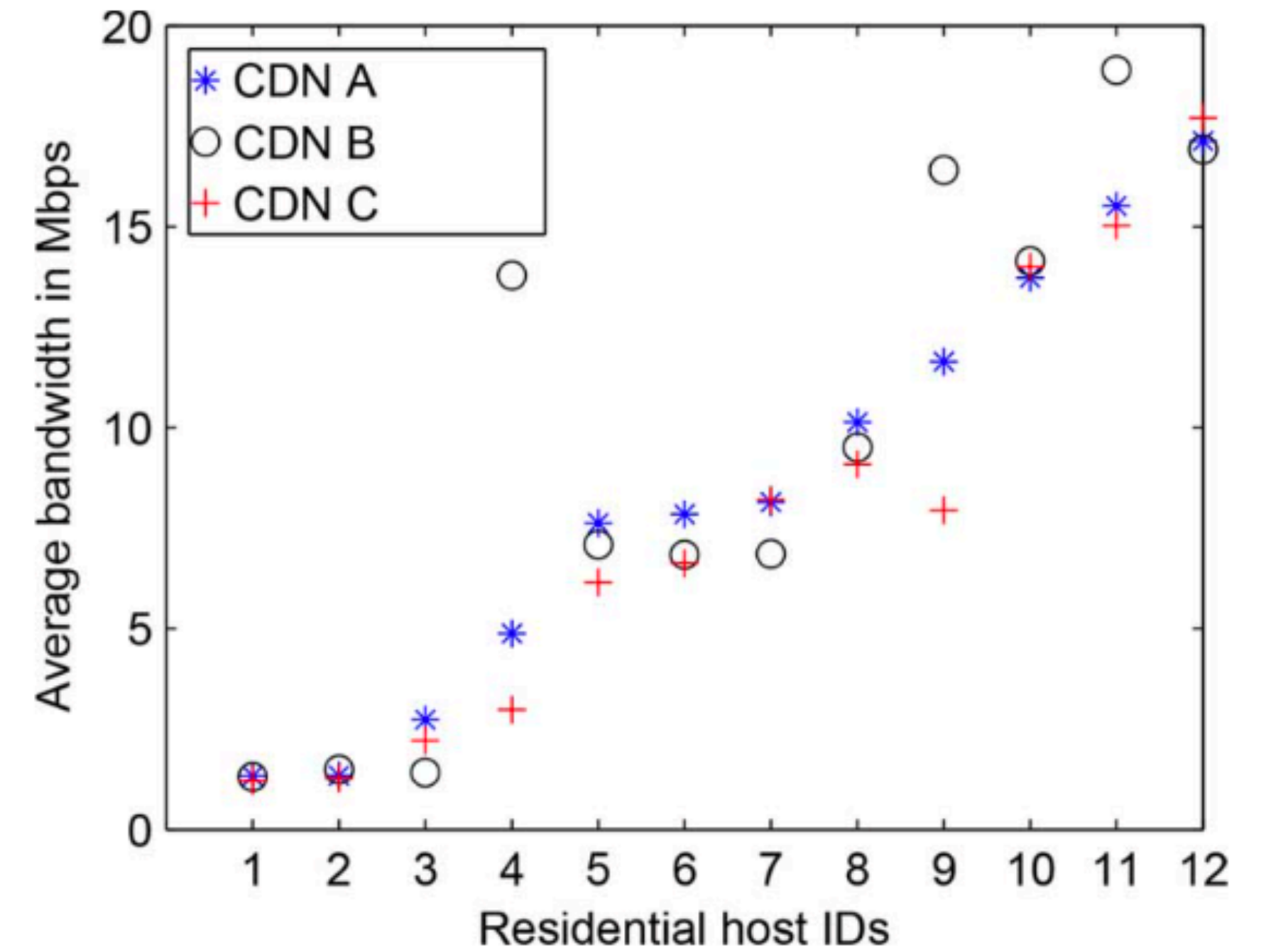


Fig. 16. Average bandwidth at residential networks over the entire period.

BANDWIDTH

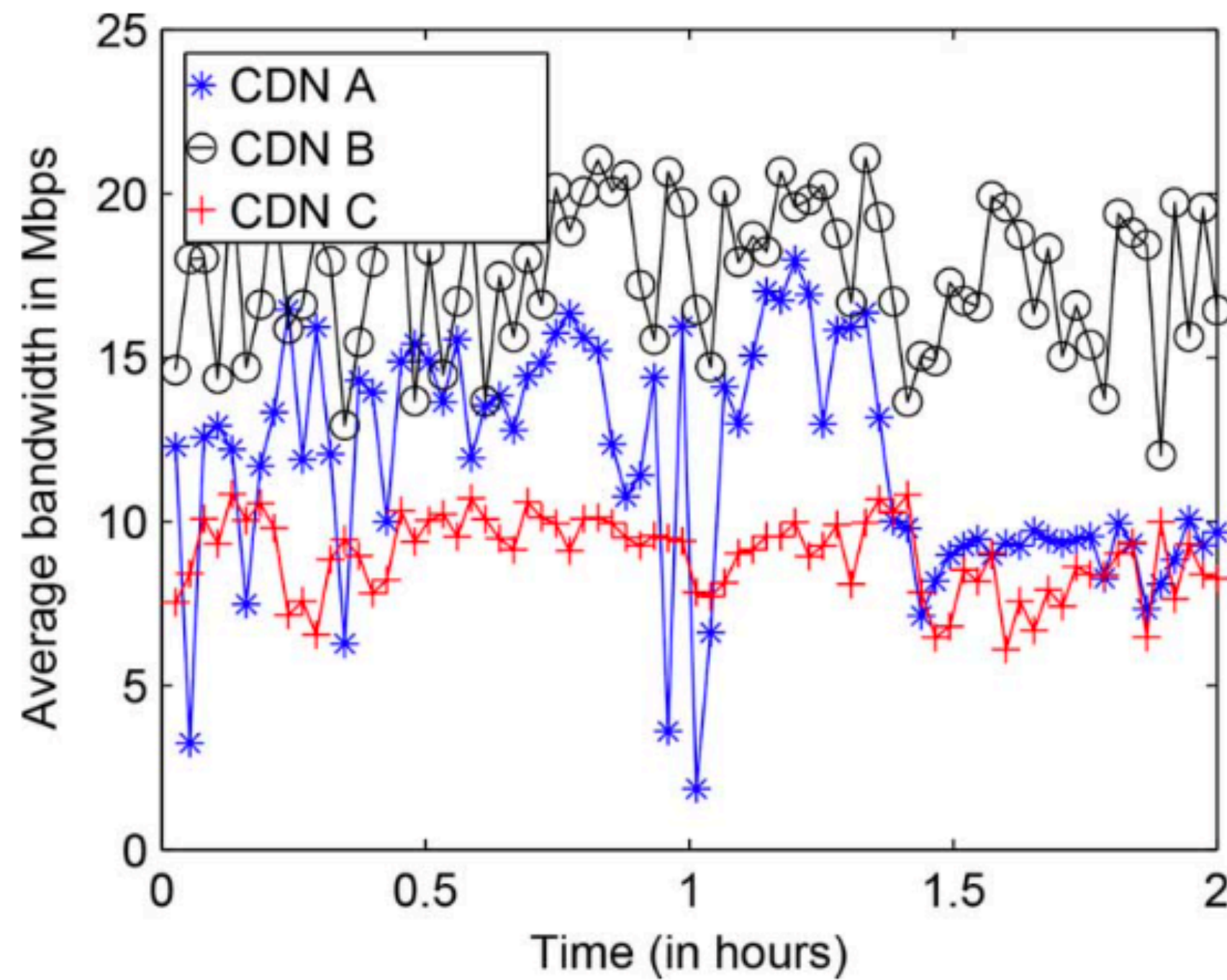


Fig. 22. Instantaneous bandwidth at residential site 7.

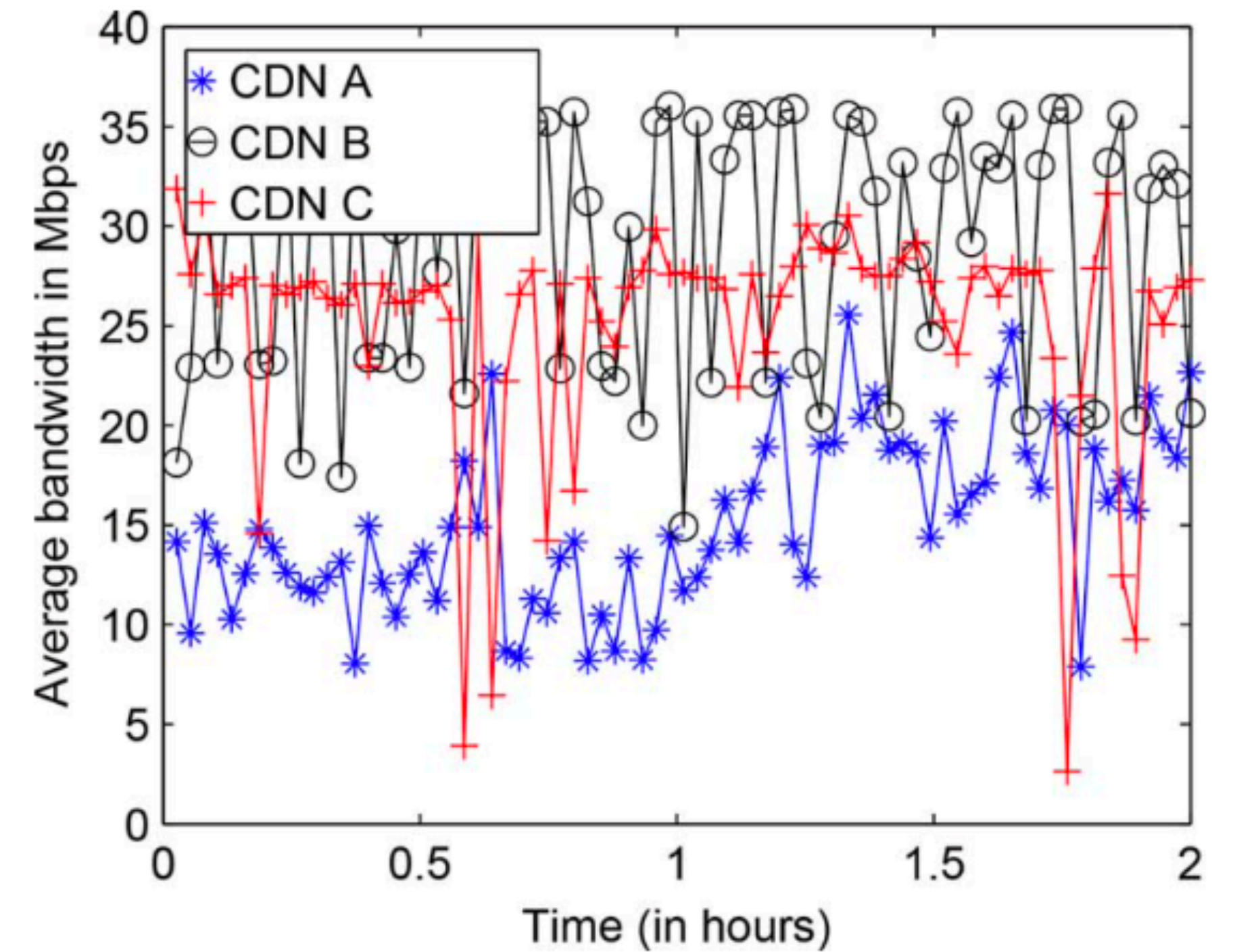


Fig. 21. Instantaneous bandwidth at a PlanetLab node.

BETTER SRATS

STRAT: CHOOSE TOP

- **Choose the top CDN at each point of time (impractical)**
- **Measure before select (> 12% improvement over the static CDN assignment strat)**

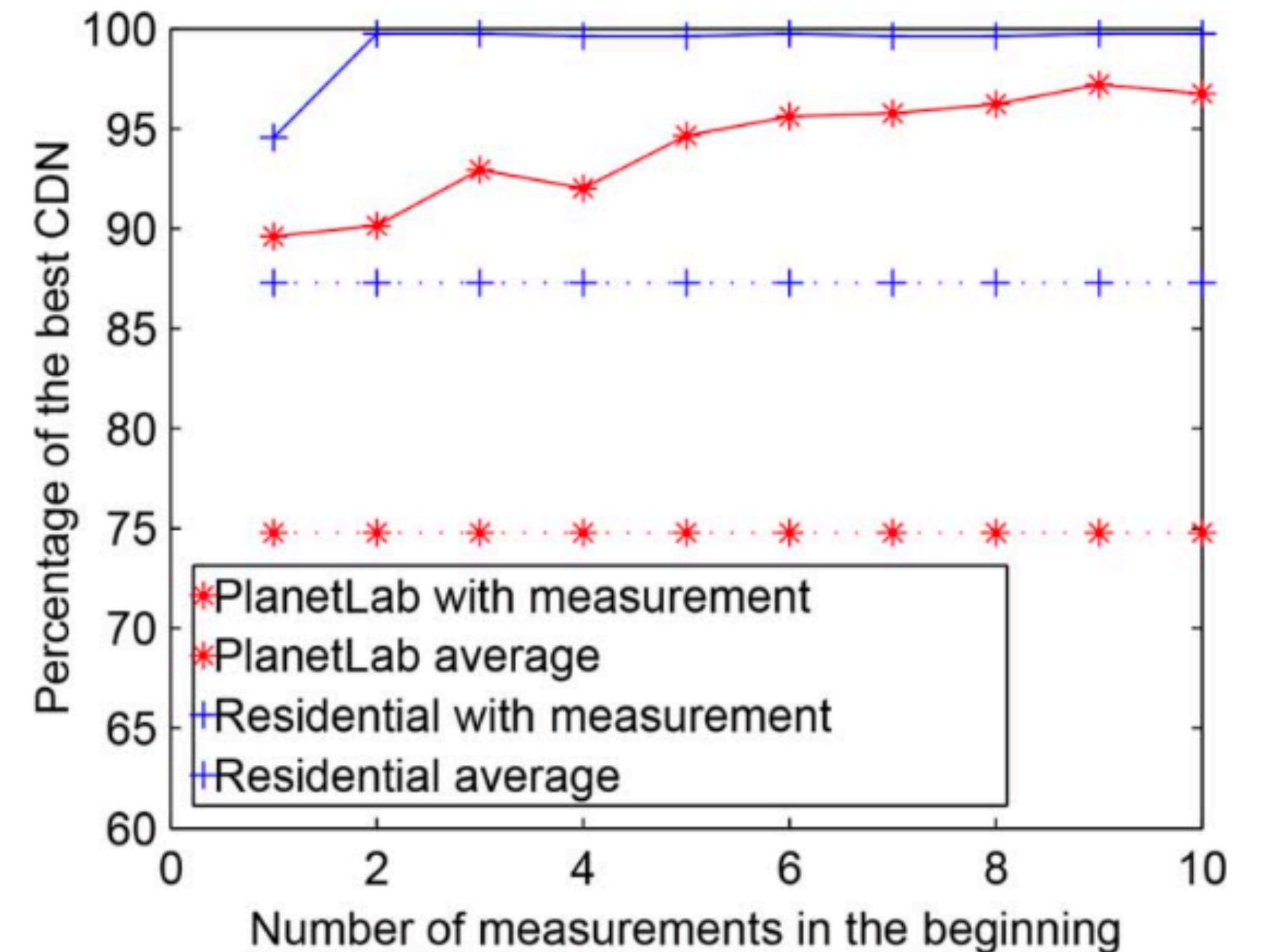


Fig. 26. Effect of number of measurements.

COMBINE 'EM ALL

- **Using Multiple CDNs Simultaneously**
- **Parallel downloads**
- **54%–70% bandwidth boost**

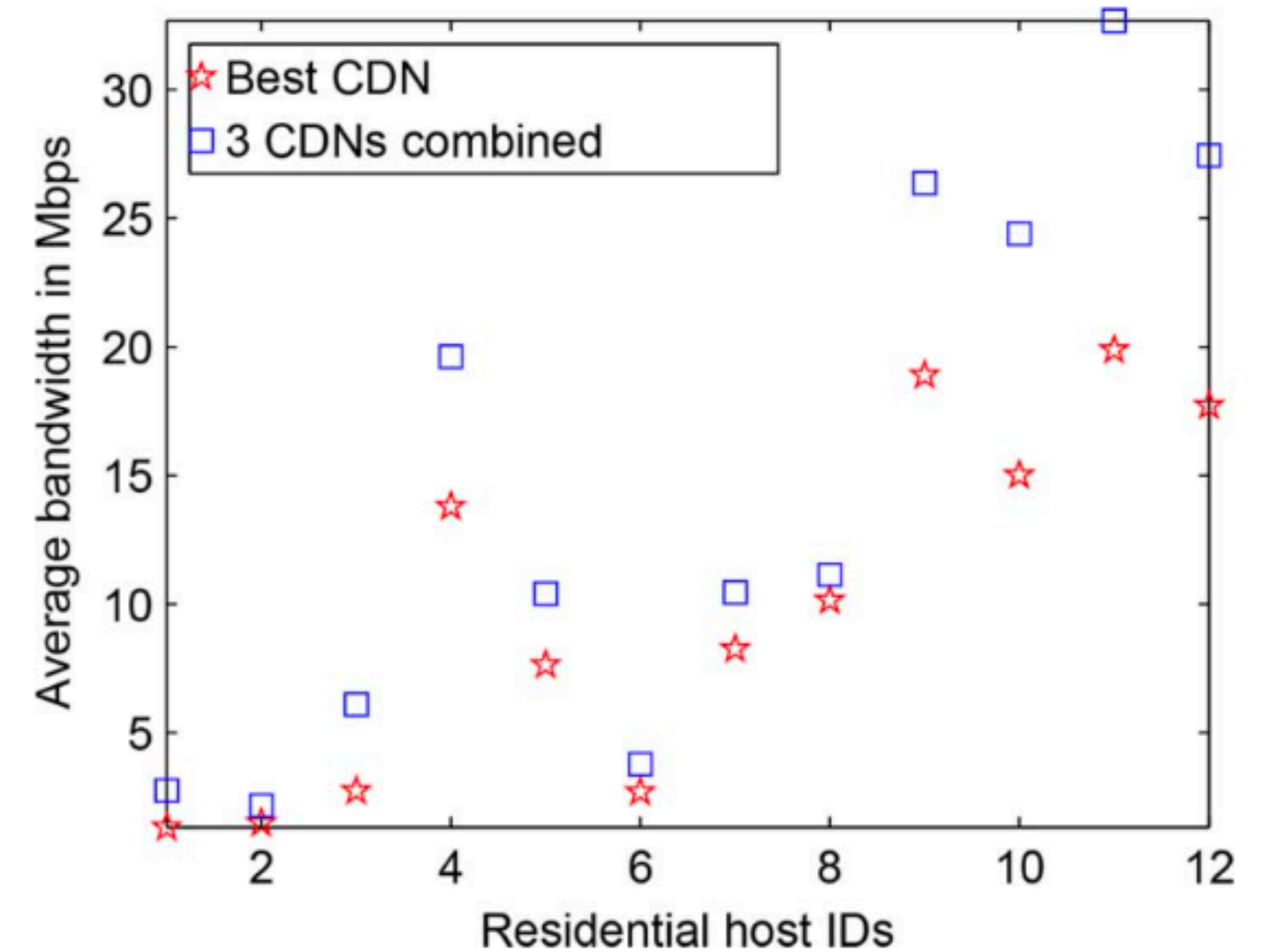


Fig. 27. Best CDN versus three combined CDNs for residential hosts.

PROPOSAL

- **Allow user to select optimal CDN**
- **Better QoE while conforming to BC**
 - **maintain the fraction of overall traffic thru one CDN**
- **Push different CDN profiles to users**
- **Fractions could be maintained**

$$\max_{\{p_i\}} \left(w \cdot p_0 + \sum_{i=1}^3 p_i \right) \quad (1)$$

$$\sum_i s_{i,j} \cdot p_i = f_j \quad \forall j \quad (2)$$

$$\sum_i p_i = 1 \quad (3)$$

$$p_i \geq 0 \quad \forall i \quad (4)$$

Define a *CDN profile* to be a list of candidate CDNs from which the end-user can choose the best one to retrieve the video. Denote by P_i the i th profile. For three CDNs, there are seven valid CDN profiles, $P_0 = [C_0, C_1, C_2]$, $P_1 = [C_0, C_1]$, $P_2 = [C_0, C_2]$, $P_3 = [C_1, C_2]$, $P_4 = [C_0]$, $P_5 = [C_1]$, and $P_6 = [C_2]$,

SUMMARY

SUMMARY

- **Current strategy (2011)**
 - **Static ranking / distribution based, not optimal**
 - **Wouldn't switch unless broken**
 - **Alternative strategies proposed**
 - **Measure before choosing**
 - **Combine 3 CDNs**
 - **CDN profiles - better QoE while conforming to the business constraints**
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