Characterizing a Meta-CDN

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Motivation - What is a Meta-CDN?

- Content Delivery Networks
  - Key component in the Internet, high availability and low latency

- But is one CDN enough?
  - Varying performance, cost model (quota, time depending)
Motivation - What is a Meta-CDN?

- **Content Multihoming**
  - Distribute content via multiple CDNs
  - Select CDN with best performance and/or low costs

- **Meta-CDN**
  - Multi-CDN, CDN selector or broker
  - Offers request routing service
    - E.g., Conviva for video delivery

- **User Perspective**
  - Higher availability and (possibly) improved performance

- **CDN Perspective**
  - Challenge for business model → traffic harder to predict
Detection - Why Cedexis?

- **DNS measurements at our institute**
  - Stability of mappings

```
dig www.download.windowsupdate.com
...;
;; ANSWER SECTION:
www.download.windowsupdate.com.  2853 IN CNAME 2-01-3cf7-0009.cdx.cedexis.net.
2-01-3cf7-0009.cdx.cedexis.net.  239 IN CNAME fg.download.windowsupdate.com.c.footprint.net.
fg.download.windowsupdate.com.c.footprint.net.  229 IN A 8.253.208.112
fg.download.windowsupdate.com.c.footprint.net.  229 IN A 8.248.99.254
...
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Thu Mar 08 11:05:08 CET 2018
```

```
dig www.download.windowsupdate.com
...;
;; ANSWER SECTION:
www.download.windowsupdate.com.  3395 IN CNAME 2-01-3cf7-0009.cdx.cedexis.net.
2-01-3cf7-0009.cdx.cedexis.net.  239 IN CNAME download.windowsupdate.com.edgesuite.net.
download.windowsupdate.com.edgesuite.net.  831 IN CNAME a767.dspw65.akamai.net.
a767.dspw65.akamai.net.  19 IN A 2.21.242.189
a767.dspw65.akamai.net.  19 IN A 2.21.242.196
...
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Thu Mar 08 11:05:27 CET 2018
```

- **Characterize a Meta-CDN**
  - Operational principle, global view on infrastructure and customers
Cedexis - Operational Principle

- **DNS-based redirection**
  - Transfer requesting user via CNAME to authoritative nameserver

```bash
dig www.download.windowsupdate.com
...;
;; ANSWER SECTION:
www.download.windowsupdate.com. 3395 IN CNAME 2-01-3cf7-0009.cdx.cedexis.net.
2-01-3cf7-0009.cdx.cedexis.net. 239 IN CNAME download.windowsupdate.com.edgesuite.net.
download.windowsupdate.com.edgesuite.net. 831 IN CNAME a767.dspw65.akamai.net.
a767.dspw65.akamai.net. 19 IN A 2.21.242.189
a767.dspw65.akamai.net. 19 IN A 2.21.242.196
...
```

- **Cedexis CNAME structure**
  - 2-01-3cf7-0009.cdx.cedexis.net
    - $C_{ID}$ $A{PP}_{ID}$
  - Customer can configure different profiles (applications)
    - E.g, `images.domain.tld`, `download.domain.tld`
Cedexis - Operational Principle

- CDN selection options
  - Cedexis offers three components: Radar, Fusion, Openmix

- Radar
  - Community-driven measurements via embedded JavaScript
    - Once page is loaded, requests probe instructions from Cedexis
  - Private (own performance) and Community probes (measure others)
    - Results reported back to Cedexis

- Fusion
  - Gather statistics from CDNs itself, e.g., traffic share, quota, or performance

- Openmix
  - Enables customers to program DNS resolution
  - Based on Radar and Fusion measurements
Cedexis - Operational Principle

- **CDN selection options**
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- **Radar**
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- **Openmix**
  - Enables customers to *program* DNS resolution
  - Based on Radar and Fusion measurements

Dynamic traffic routing, thus harder to predict for CDNs
Cedexis Customers - Measurement

- **Via DNS resolutions and Domain lists**
  - Enumerating $2-01\cdot C_{ID}\cdot APP_{ID}.cdx.cedexis.net$ (limit $APP_{ID}$ to $256 \rightarrow 16.8M$)
  - Resolve $A$-records based on domain lists $\rightarrow$ CNAME $*.cedexis.net$
    - E.g., Alexa 1M, .com/.net/.org, .fi/.se/.nu

- **$(C_{ID},APP_{ID})$ tuples**
  - 84% via enumeration, 11.2% enum. and domain lists, 4.8% only in lists
  - 55 (20) customers with 1 (2) apps, 1 customer with 84 apps
  - 62.7% of $(C_{ID},APP_{ID})$ behind a single domain
    - 31 (6) $APP_{IDs}$ managing more than 10 (100) domains
## Cedexis Customers - Classification

### Manual Classification and evolving set of categories

- Automated Alexa Web Information Service not practical
  - Classifications only exist for 17% of domains
  - Errors, e.g., secure-m.ibis.com → .../Materials_and_Supplies/Wafer

#### Top 10

| Type     | Share |
|----------|-------|
| Business | 17.7% |
| IT       | 12.1% |
| News     | 11.3% |
| Gambling | 11.3% |
| Shopping | 8.1%  |
| Games    | 8.1%  |
| Unknown  | 8.1%  |
| Goods    | 5.6%  |
| Automotive| 5.6% |
| Advertising | 3.2% |

| Service    | Share |
|------------|-------|
| Web        | 62.7% |
| Unknown    | 15.6% |
| Assets     | 12.9% |
| Media      | 5.4%  |
| API        | 2.3%  |
| Bulk       | 1.1%  |
• Authoritative DNS Deployment
  ▶ Managing *.cedexis.net
  ▶ 4 servers configured in .net zone
    ■ flip{a,d,g,m}.cdxcn.net

• Measure latency (ping)
  ▶ ~ 870 RIPE Atlas probes
  ▶ 4 server locations
    ■ US, South America, Europe, Asia
    ■ Anycast deployment

• Performance of DNS
  ▶ Register own Cedexis account
  ▶ Directly return an A-record
Infrastructure - Active Measurements by Cedexis

- **Radar Community Probes [1]**
  - Embedded JavaScript
  - Different metrics and infrastructures
    - throughput, latency, availability
    - Cloud, CDN, ISP
  - Different levels of severity
    - minor, medium, major

- **Definition of anomaly and severity by Cedexis**
  - E.g., confirmed CDN medium throughput event
    - Witnessed by 5 ISPs (AS) for ≥ 5 mins
    - Throughput drop of 75% - 90%, compared to rolling average of last 5h

[1] https://live.cedexis.com
Analysis of captured events

- Capture feed of website
- 9th Oct. 2017 – 8th Jan. 2018

Allows to infer location of visitors

- Reported via probes
- Hints at user base of customers
  - Coincides with DNS deployment

Reported Events (as observed)

- Confirmed after ~ 9 mins
- Most events concern CDNs
  - CacheFly outage during study
Measurement Setup

- **Probes**
  - 35 PlanetLab nodes (AU, BRA, CA, CHN, CZE, JP, POL)
  - 6 RPis in 6 distinct German ISPs (DE)

- **Measurement**
  - Resolve *each* domain every 15 mins
  - In addition, capture (ping) latency
  - Capture CNAME redirection to determine used CDN
    - If new domains discovered, include in set
How customers utilize Cedexis?

- **DNS Time-To-Live**
  - CNAME mapping from Cedexis to subsequent entry
  - No country specific settings

- 67% ≤ 20s, faster reaction to change
- Compare to TTLs set by CDNs

**Figure 5:**
DNS TTLs experienced among Cedexis-enabled domains. For a) mappings from Cedexis to the subsequent entry and b) the CDNs used for the final delivery.

- Increase between 200% and 500% is considered as medium severity. We find most of the reported events to concern CDN, followed by ASes. The high amount of major availability events concern CacheFly CDN outages during our measurement period.

**Takeaway.**
We observe visitors of Cedexis-managed sites from almost every country. Yet, its anycast DNS platform is suggested to be based in the US, Europe, and Asia. Users in other countries can be subject to higher DNS query latencies.
How customers utilize Cedexis?

- **DNS Resolution Time**
  - Cedexis to CDN to A-Record
  - Indicates good DNS deployment
    - Regarding vantage points
  - However, adds one additional step

- **CDN Usage of Customers**
  - Most customers 1-2 CDNs
  - Most regions behave the same
    - Minor exception for CHN
  - Contrast to Mukerjee et. al. [2]
    - Analysis of Conviva
  - Extend analysis to open resolvers (161 countries)
    - For 67% same CDN in every country, 30% have two, 3% use three

[2] M.K. Mukerjee et. al. *The Impact of brokers on the future of content delivery*, ACM HotNets 2016
Latency Perspective

- Evaluate choices made by Cedexis
  - Compare latency of all configured CDNs to selected CDNs
    - ICMP ping instead of HTTP requests to not generate costs

- Inflation evaluation
  - When choice was not optimal
    - Difficult to assess the quality, routing metric not known
  - 50% only small relative distance & only small absolute difference
  - Apart from BRA (& JP), 90% are within 20ms
Conclusion

- Analysis of Meta-CDN concept by the example of Cedexis
  - Operational principle, customers, infrastructure, and performance

- Potential to steer large portions of traffic
  - Customers with users across the globe
  - Enables *arbitrary* routing decisions
    - Radar, Fusion, Openmix platform

- Future Work
  - Quality of Meta-CDN’s own measurement
    - Do they reflect the actual performance?

- Interested in more stuff that we do?
  - Visit https://netray.io

Thank you for your attention!