



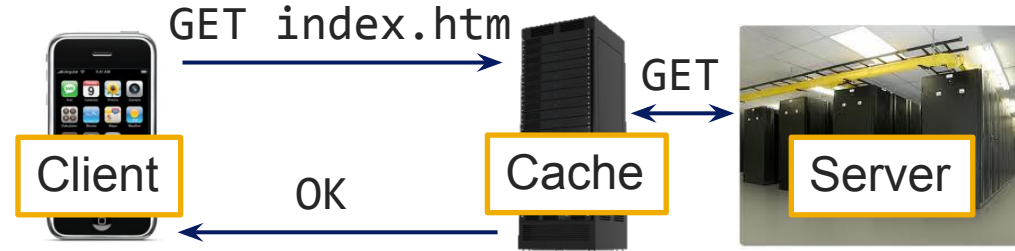
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Chapter 2

Content Delivery Networks (CDNs)

Client side data: Caching

- Problem
 - HTTP is stateless
 - Resending server data wastes bandwidth
- Caching
 - Save previously delivered data
 - Subsequent requests served from cache on the browser, or in the access network
- Applications
 - Reduce response time for client request
 - Reduce ISP traffic costs
- Content distribution networks
 - Distributed caches
 - Web objects addressed to CDN server
 - CDN server fetches from content provider on first access

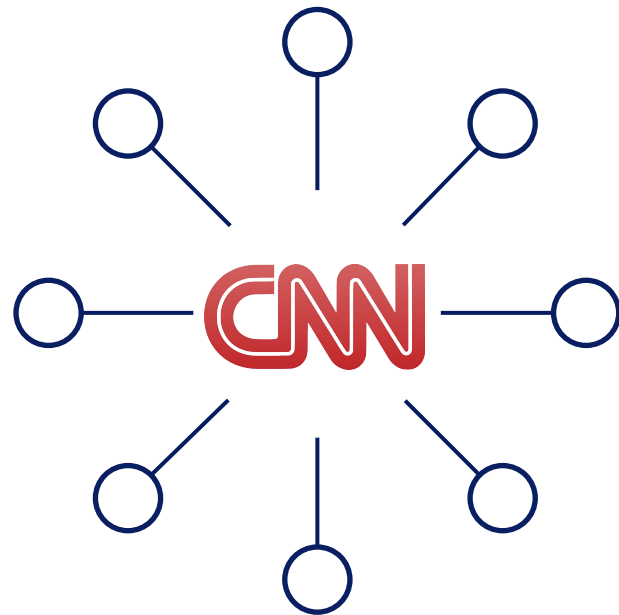


- Conditional GET
 - Cache: specify date of cached copy in HTTP request
If-modified-since: <date>
 - Server: response contains no object if cached copy is up-to-date:
HTTP/1.0 304 Not Modified

Why is sending a conditional GET all the way to the server still faster, than a non-conditional GET?

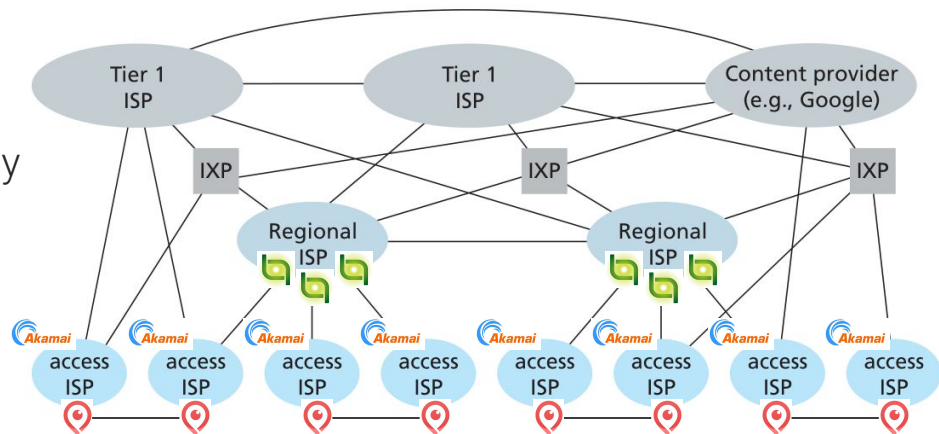
Content delivery networks (CDNs)

- Challenge:
 - How to stream content to millions of users?
- Option 1:
 - Single mega-datacenter
 - Pros: Simple
 - Cons:
 - Single point of failure
 - Point of network congestion
 - Long path to distant clients
 - Multiple copies of video sent over outgoing link



Content delivery networks (CDNs)

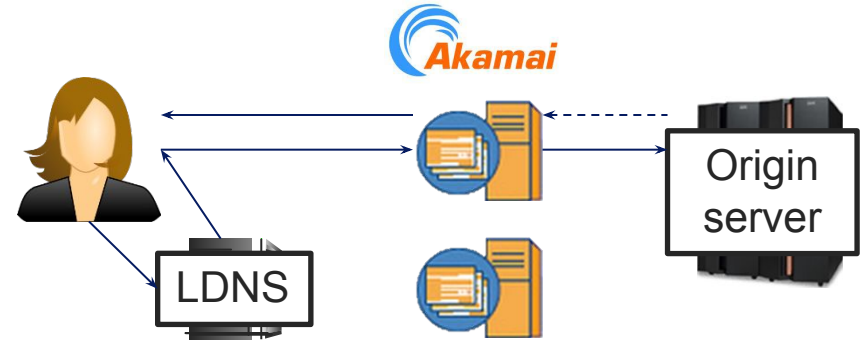
- Option 2:
 - Store/serve multiple copies of videos at multiple geographically distributed sites
 - **Enter deep:** push CDN servers deep into many access networks
 - Close to users
 - Used by Akamai, 1700 locations
 - **Bring home:** smaller number (10's) of larger clusters in POPs near (but not within) access networks
 - Used by Limelight
 - **P2P:** stream data from clients themselves
 - Based on BitTorrent (not really a CDN)
 - Used by Kankan (in China)



CDNs have limited impact on dynamic content. Why?

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facebook



Mike Wittie

http://profile.ak.fbcdn.net/hprofile-ak-snc4/41671_1062307220_4094_q.jpg

```
[mwittie@esus ~]$ host profile.ak.fbcdn.net
profile.ak.fbcdn.net is an alias for
profile.ak.facebook.com.edgesuite.net
profile.ak.facebook.com.edgesuite.net is an
alias for a1725.1.akamai.net
a1725.1.akamai.net has address 92.122.50.192
a1725.1.akamai.net has address 92.122.50.184
a1725.1.akamai.net has address 92.122.50.162
a1725.1.akamai.net has address 92.122.50.147
```

Ubiquity of CDNs



34 DNS lookups

204 HTTP requests

520 KB of data downloaded



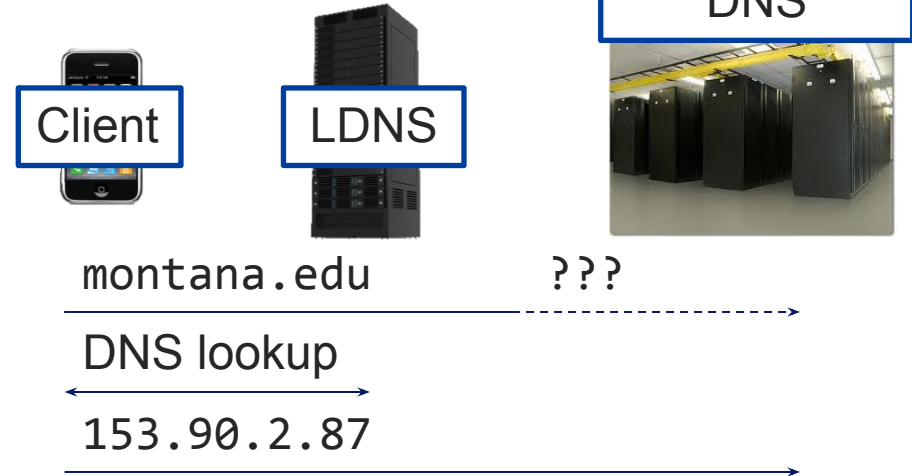
56% of domains
resolve to a CDN

- Challenge: how does CDN DNS select “good” CDN node to stream to client
 - Pick CDN node geographically closest to client’s local DNS
 - Pick CDN node with shortest delay (or min # hops) to client (CDN nodes periodically ping access ISPs, reporting results to CDN DNS)
 - IP anycast – have routers choose shortest path to replicas advertised under the same IP address

Domain Name System (DNS)

- People like names
 - Ex. montana.edu
- Routers like fixed width addresses
 - Ex. **153.90.2.87** (32 bits)
- How to map between the two?
- Domain Name System:
 - Database of mappings between host names and IP addresses
 - Application layer protocol
 - Hosts communicate with DNS to resolve names
 - Lookups over UDP on port 53

- Example:



What if the LDNS is far from the Client?

Extension mechanisms for DNS

- Idea
 - Avoid impact of remote DNS by changing localization approach
 - Directly provide client location to CDN
- Implemented as an **EDNS0** extension
- DNS resolver adds client's IP prefix to request
- Approximate client location approach typically sufficient
 - /16 prefix enough for Google and EdgeCast CDNs

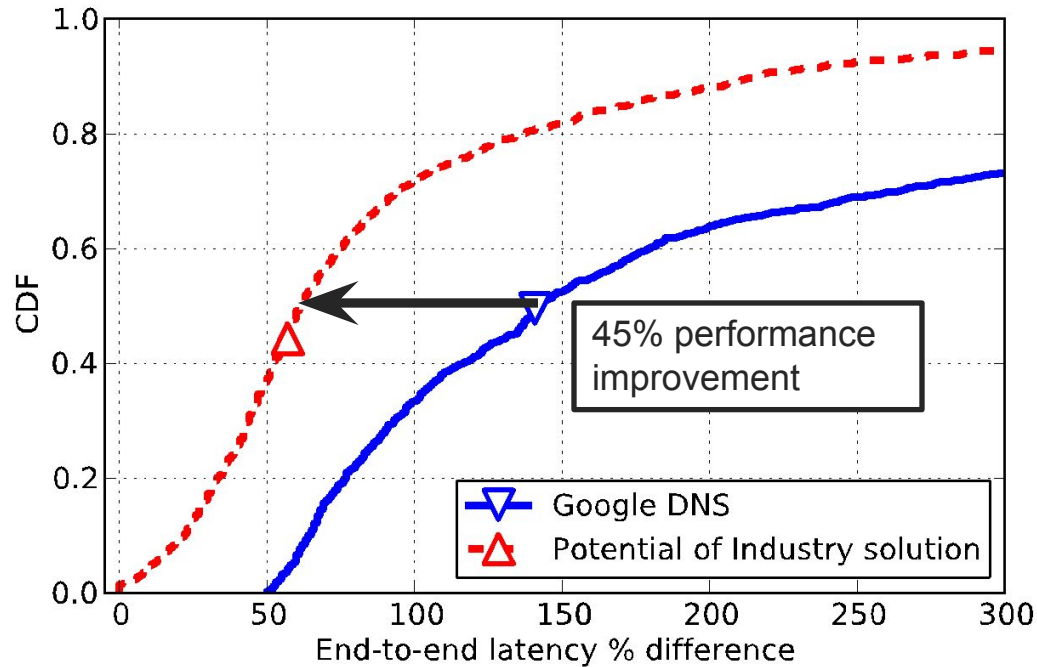
Identification	Flags
Number of questions	Number of answer RRs
Number of authority RRs	Number of additional RRs
Questions (variable number of questions)	
Answers (variable number of resource records)	
Authority (variable number of resource records)	
Additional information (variable number of resource records)	

```
;; OPT PSEUDOSECTION:  
; EDNS: version: 0, prefix: 128.111/16
```



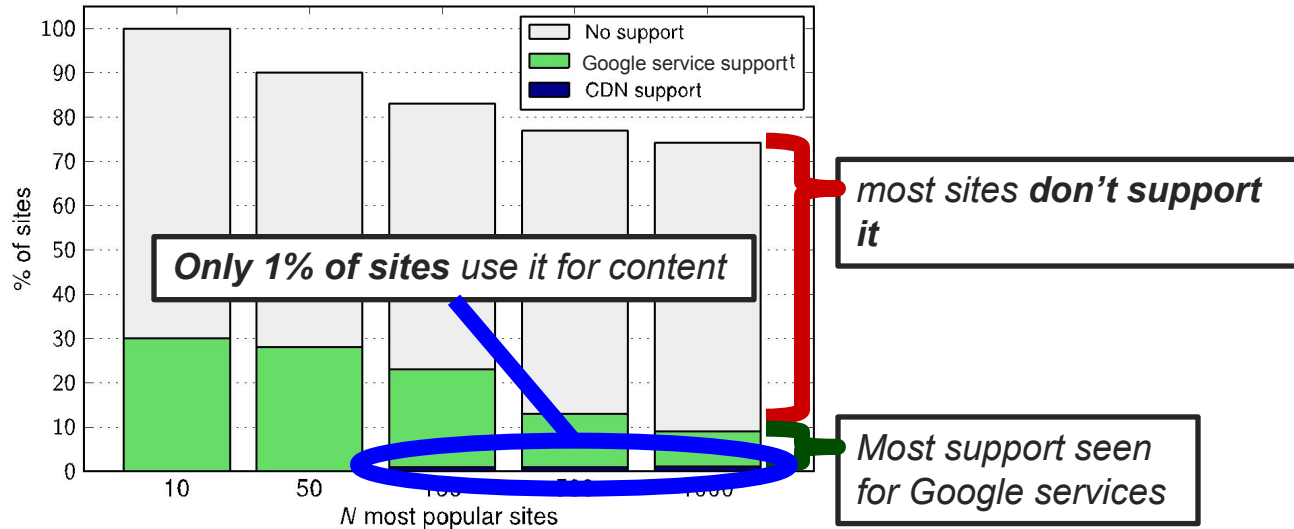
Evaluating the DNS extension

- Focus on places where remote DNS affects performance



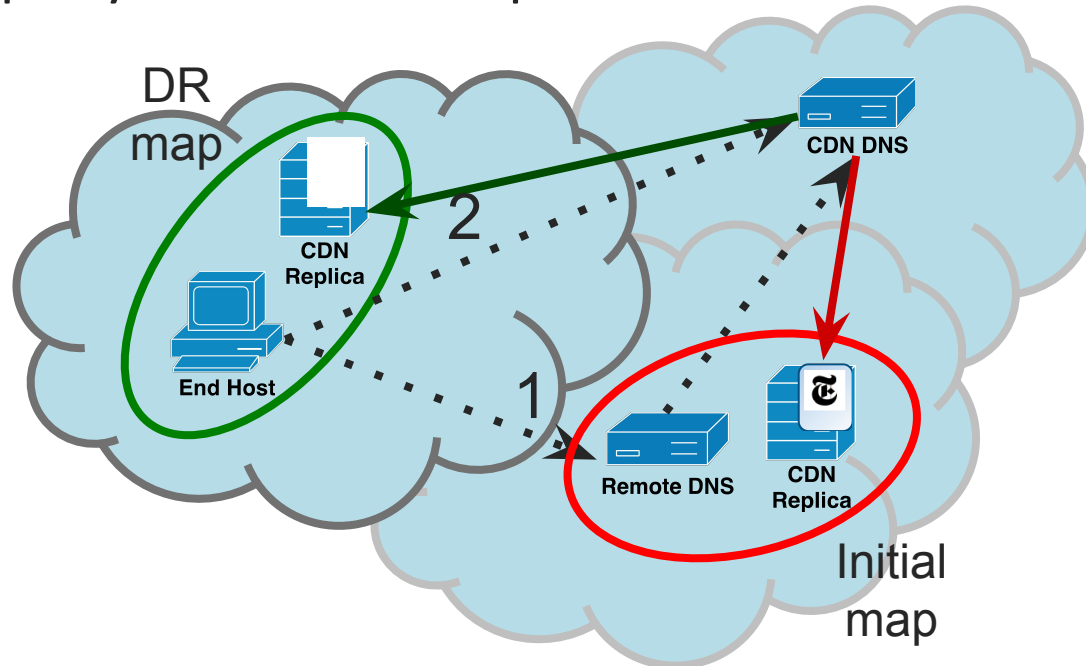
DNS extension adoption

- Minor issue – both DNS and CDN services must support it

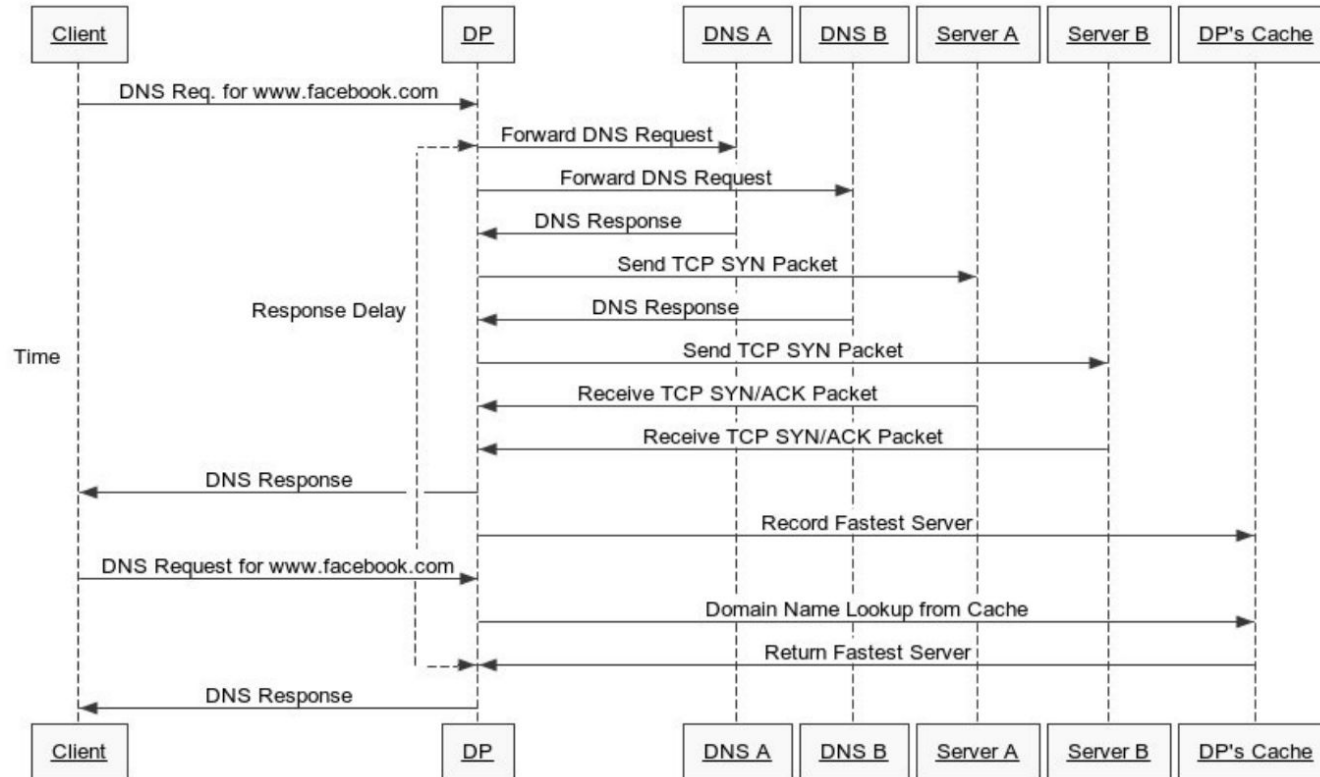


Direct Resolution approach

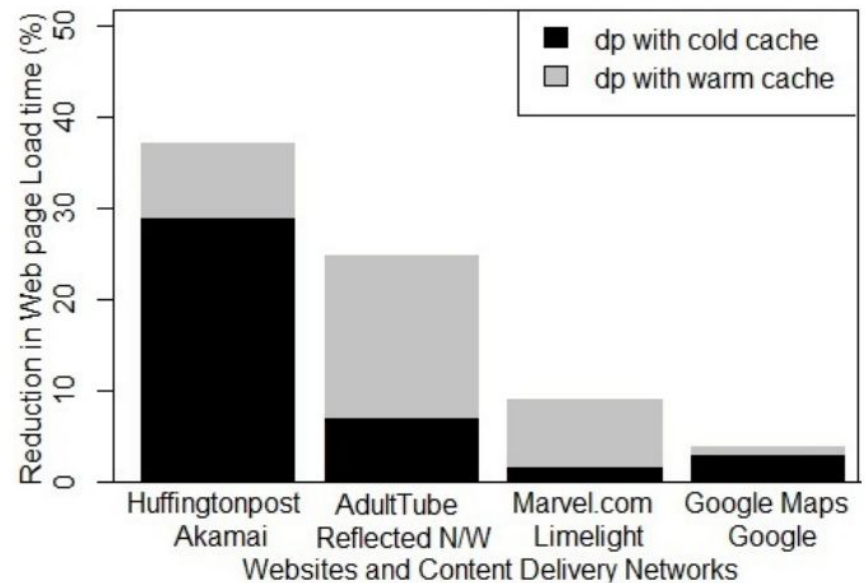
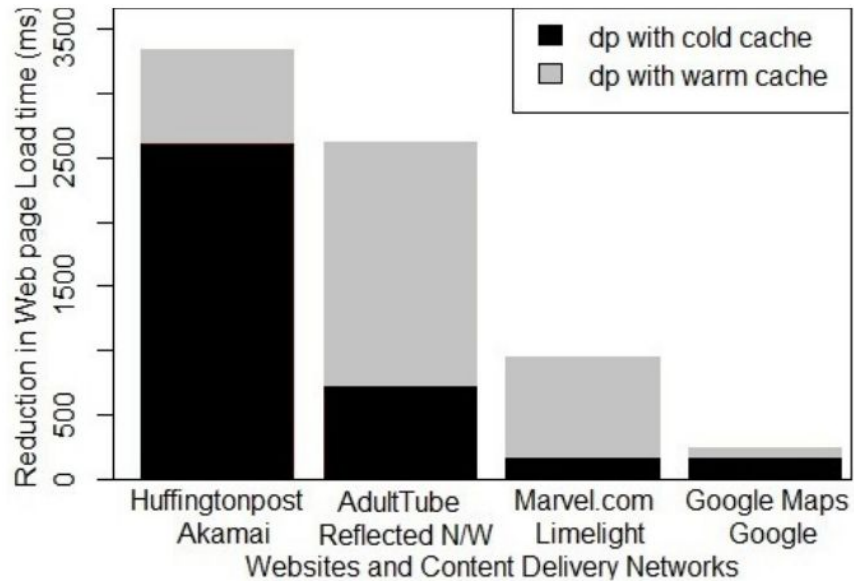
- Step 1: typical DNS query to recursive resolver
 - Use recursive DNS to translate customer name to CDN
- Step 2: directly query CDN for an improved redirection



DNS proxy



DNS proxy



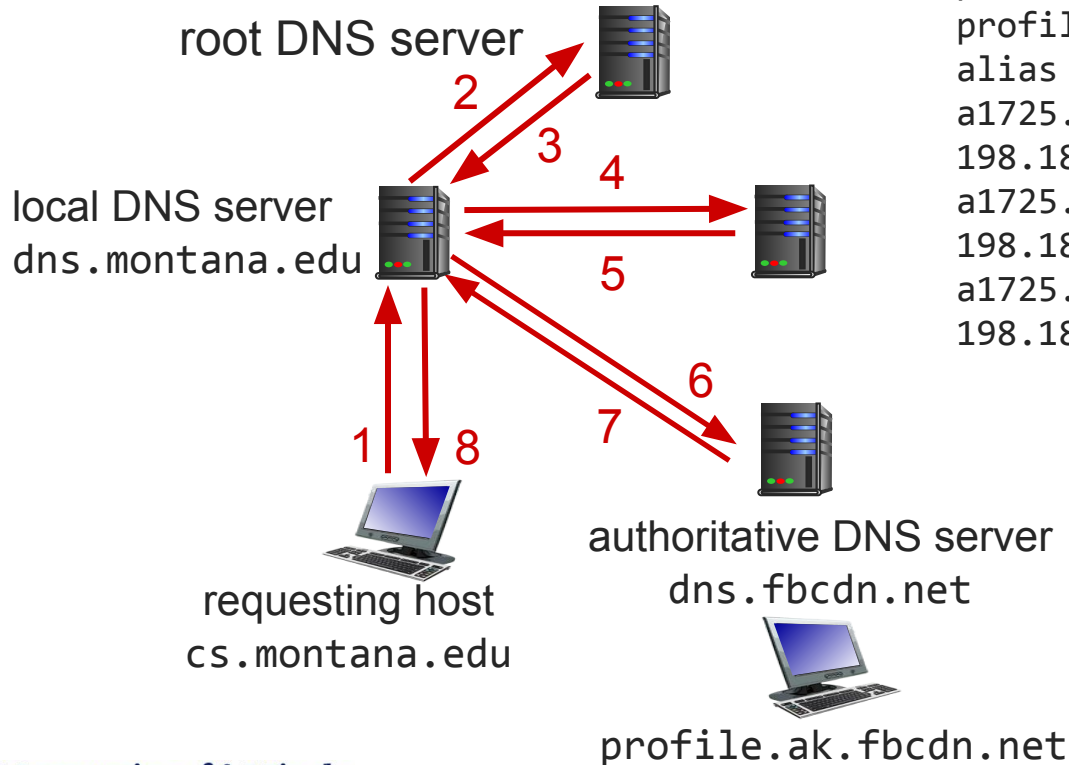
Replica Selection

- Given a set of datacenters, how to direct users to replicated logic and content?
- Metrics:
 - Latency
 - Server load
 - Storage overhead
 - Inter-DC communication costs
- Approaches to replica selection:
 - DNS IP-based
 - Client IP-based
 - IP anycast
 - Centralized logic

DNS redirection

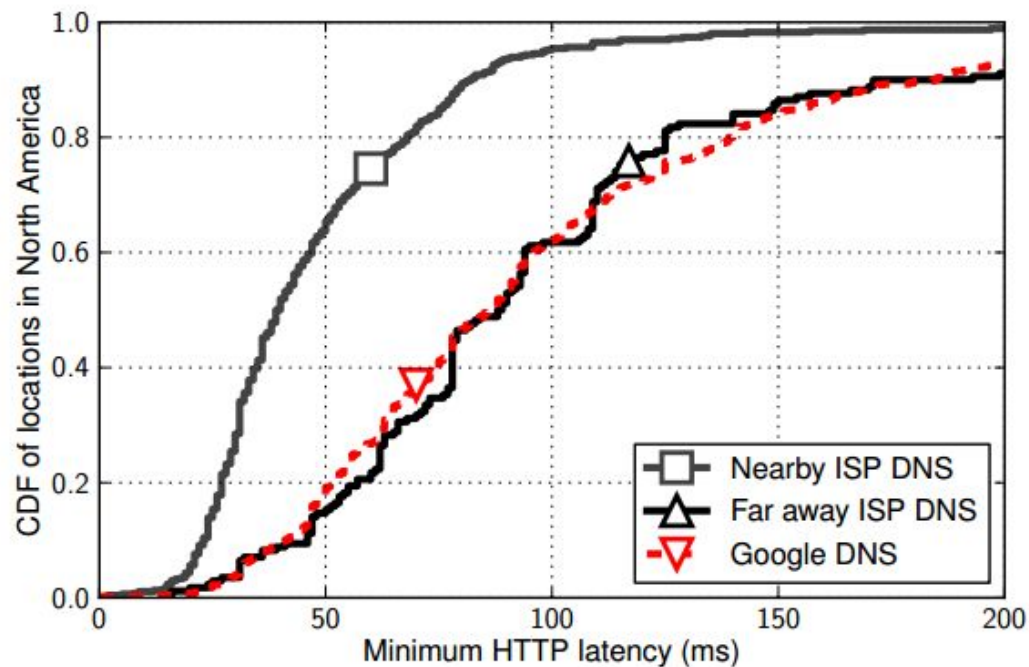
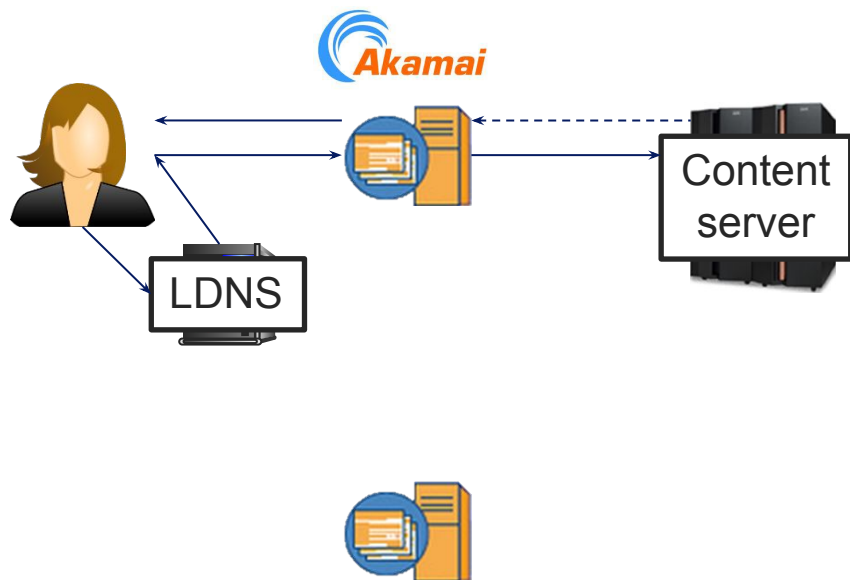
`http://profile.ak.fbcdn.net/hprofile-ak-snc4/41671_1062307220_4094_n.jpg`

```
>host profile.ak.fbcdn.net
profile.ak.fbcdn.net is an alias for
profile.ak.facebook.com.edgesuite.net.
profile.ak.facebook.com.edgesuite.net is an
alias for a1725.dspl.akamai.net.
a1725.dspl.akamai.net has address
198.189.255.223
a1725.dspl.akamai.net has address
198.189.255.199
a1725.dspl.akamai.net has address
198.189.255.216
```



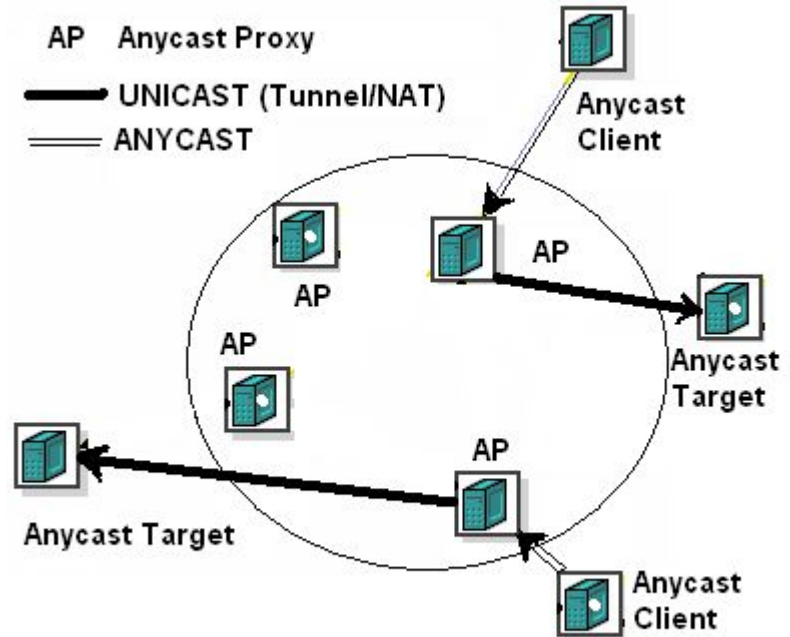
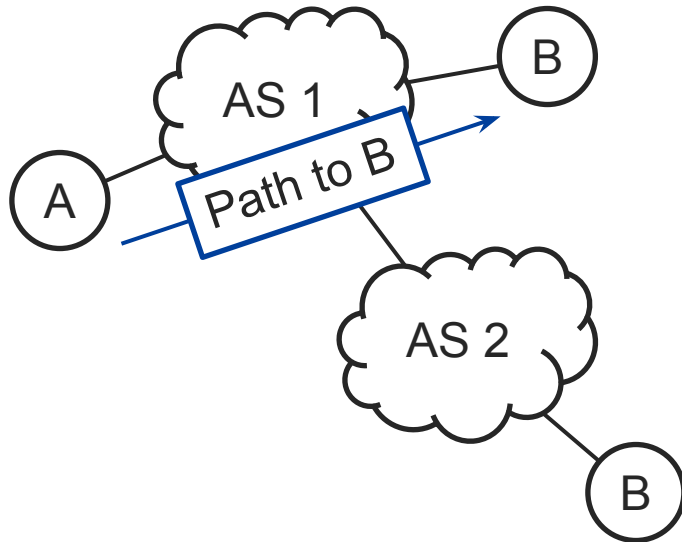
How are these IP addresses determined?

LDNS problem



Anycast

AS 1 gets advertisements for IP address B from two eBGP announcements





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