Assessing Affinity Between Users and CDN Sites

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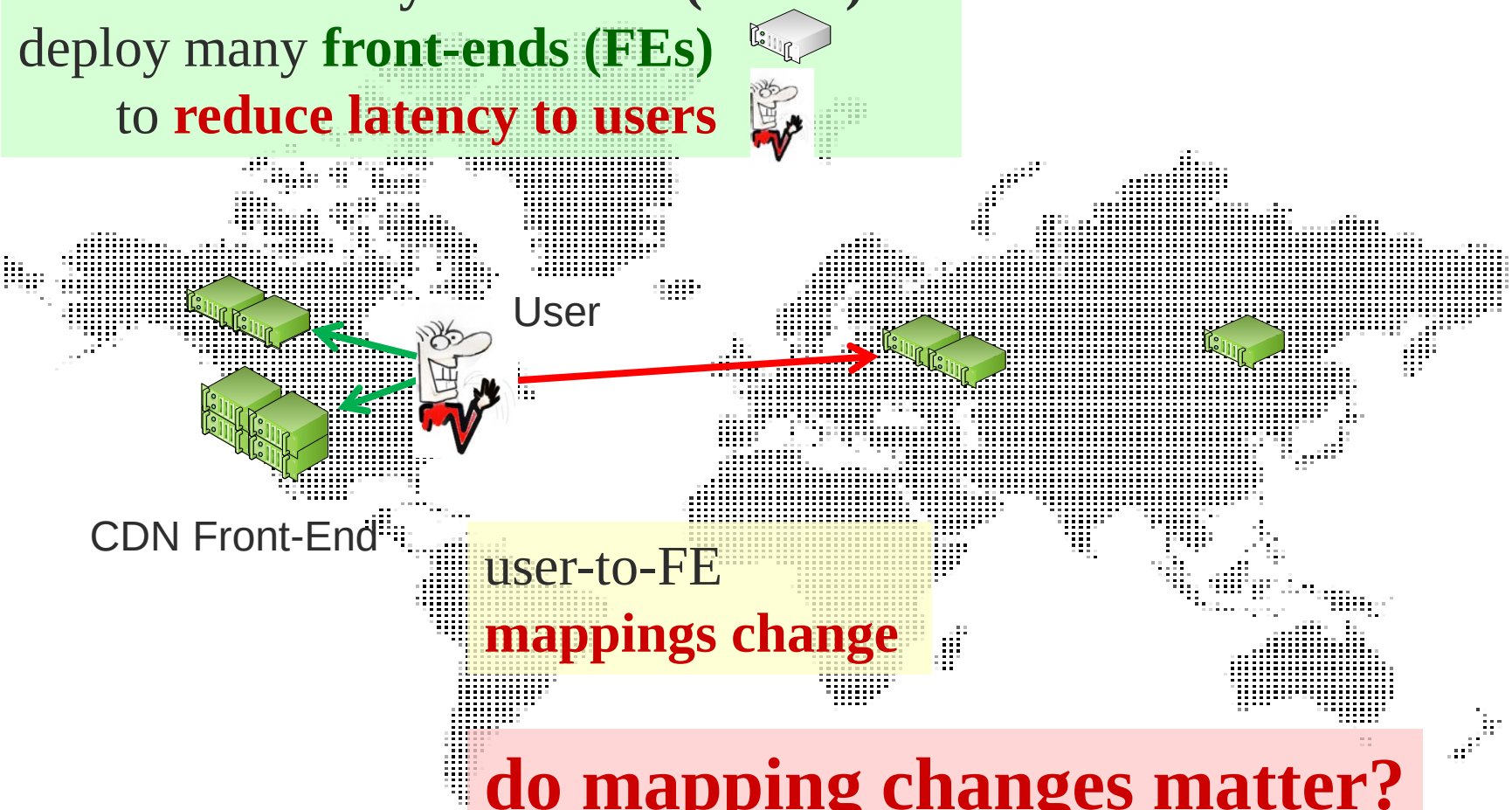
2015-04-24

This research is sponsored by the Department of Homeland Security (DHS) Science and Technology Directorate, HSARPA, Cyber Security Division, BAA 11-01-RIKA and Air Force Research Laboratory, Information Directorate under agreement number FA8750-12-2-0344, and contract number D08PC75599. The U.S. Gov't is authorized to reproduce and distribute reprints for Gov't purposes notwithstanding any copyright notation thereon. The views herein are those of the authors and do not necessarily represent those of DHS or the U.S. Gov't.

Content Delivery Networks (CDNs)
deploy many **front-ends (FEs)**
to **reduce latency to users**



user-to-FE
mappings change

do mapping changes matter?
to performance? security?
how often? how much?

When Does User-to-FE Mapping Matter?

- for users
  - performance effects?
  - where does my data go? (legally)
- for governments
  - does data go abroad? (national policy)
- for CDN operators
  - how do other CDNs work?

Contributions

- evaluating user-to-FE maps from **many places**
- **performance effects** of user/FE map changes
- evaluation of **geographic footprint** users see

Contributions

- evaluating user-to-FE maps from **many places**
  - 32k user prefixes (/24), 180 countries, 5158 ASes
- **performance effects** of user/FE map changes
  - sometimes large latency!
- evaluation of **geographic footprint** users see
  - many prefixes see several countries per month

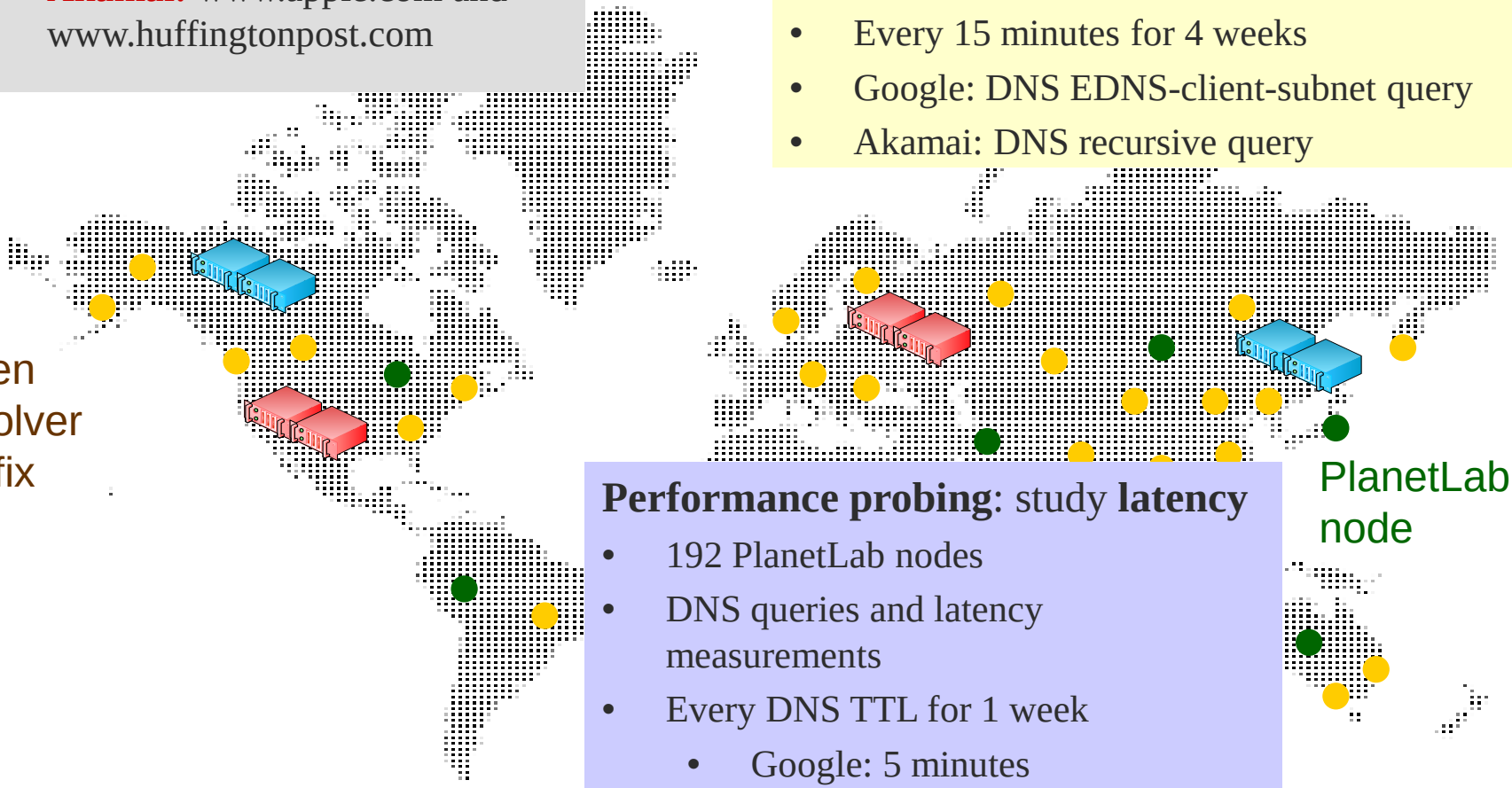
Data Collection

targets: **two large CDNs**

- **Google:** www.google.com
- **Akamai:** www.apple.com and www.huffingtonpost.com

Broad probing: study **mapping changes**

- 32k open resolver prefixes
- Every 15 minutes for 4 weeks
- Google: DNS EDNS-client-subnet query
- Akamai: DNS recursive query



Open resolver prefix

PlanetLab node

Performance probing: study **latency**

- 192 PlanetLab nodes
- DNS queries and latency measurements
- Every DNS TTL for 1 week
  - Google: 5 minutes
  - Akamai: 20 sec

Reuse Existing Clustering and Geolocation

- Clustering: RTT-based fingerprinting
  - group FE IP addresses into *FE Clusters*
  - FE Cluster := *one* physical and network location

- Geolocation: Client-Centric-Geolocation
  - find each FE cluster's latitude and longitude
  - uses client locations

- from [Caldar et al, ACM IMC 2013] (our prior work)

Identifying Mapping Changes

Observations (every 15 min) →

user prefix	10:00	10:15	10:30	10:45
1.2.3.0/24	1 (FE Cluster ID)	1	1	1
1.2.4.0/24	2	2	3	3

find **mapping changes**

and their **switching pairs** (or **switches**):
clusters before and after change
(here: 2 and 3)

Performance: Latency

- estimate client performance with latency
  - RTT (ping latency)
  - patch fetch time
- only from 192 PlanetLab nodes (needs app support)
- after **mapping change**, check **current *and* prior** cluster

user prefix	10:00	10:15	10:30	10:45
1.2.4.0/24	2	2	3	3
target	**2**	**2**	**3 *and* 2**	**3**
RTT	20ms	22	62 (and 22)	60
page fetch	50ms	54	135 (and 58)	132

Is Our Evaluation Complete?

	Google		Akamai -Huff	
Total IPs	24,150	100%	9,492	100%
Clustered	22,679	94%	8,843	93%
Un-clustered	1,471	6%	649	7%
Geolocated	22,101	92%	7,953	84%
Un-geolocated	2,049	8%	1,593	16%
Clustered and Geolocated	20,861	86%	7,953	84%
Total FE Clusters	983/1100		1,195/1200	

cover most clusters **~70%** **~100%**

we see only some servers, but *many clusters*

estimates of complete from: [Caldar et al] and [Zhao et al], both ACM IMC '13

Results

- Are there many mapping changes?
  - Mapping changes are common
- Do mapping changes affect user performance?
  - Many prefixes see distant switching pairs
  - Distant switching pairs are not rare
  - Distant switching pairs are more likely to cause large latency changes
  - A few prefixes stay on large latency FE Clusters for long
- Are users mapped abroad?
  - Many prefixes are mapped to FEC in different countries/regions
  - Geographic footprint of user prefixes

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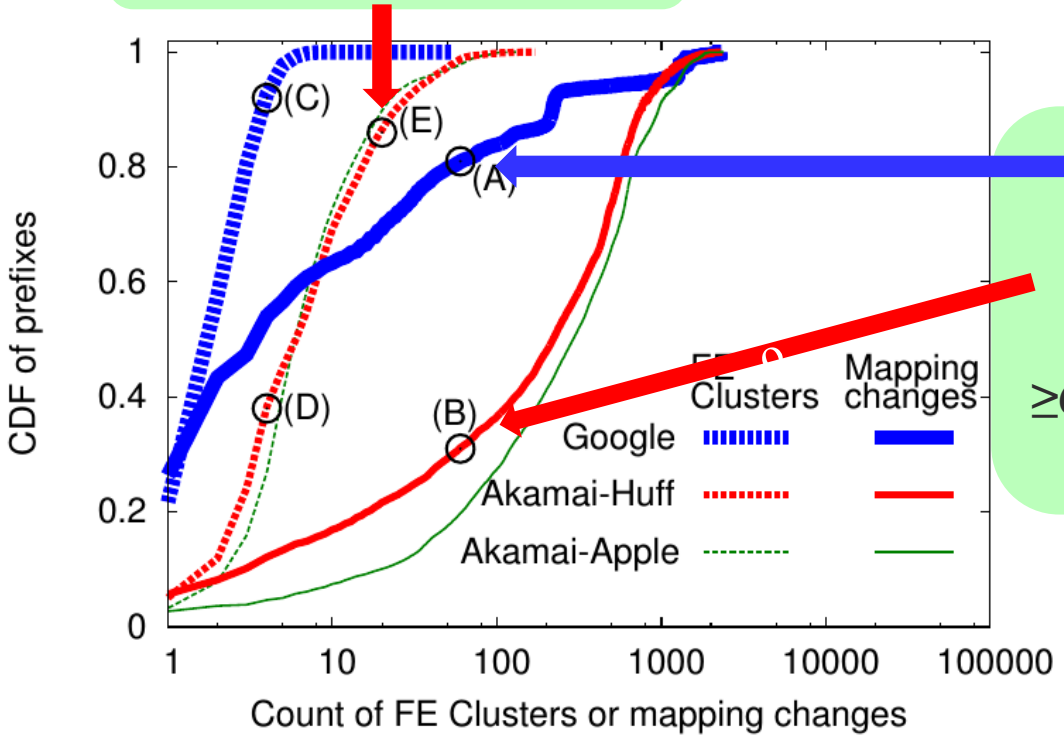
Are There Many Mapping Changes?

14% of prefixes
see **≥20 clusters** (Akamai)



20% (Google)
and
70% (Akamai)
see
≥60 mapping changes
per month

Mapping changes are common!

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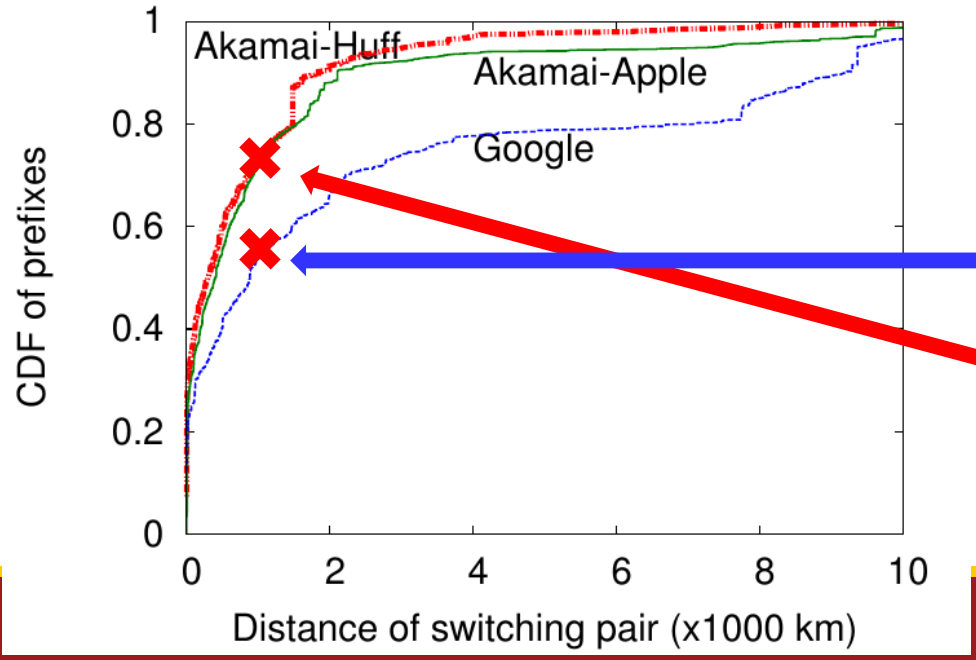
Switching Pairs are **Often Distant**

- why do we care distant switching pairs?
  - move users between very different FEs
  - one side is likely higher latency
- metric: distance of first switching pairs after random time



switching pairs often distant (≥1000km) often **≥ 50% (Google)** and **≥ 30% (Akamai)**

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  - **Distant switching pairs are more likely to cause large latency changes**
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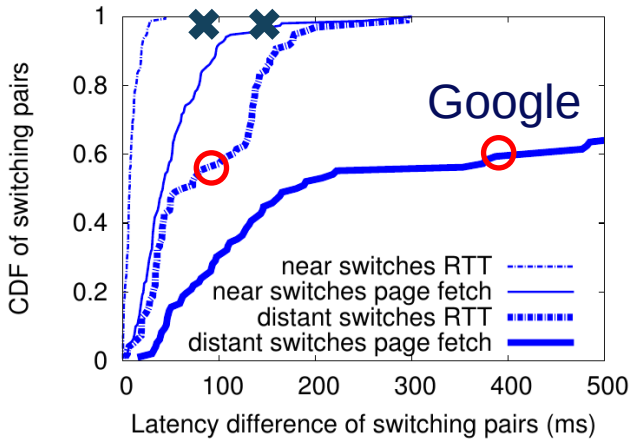
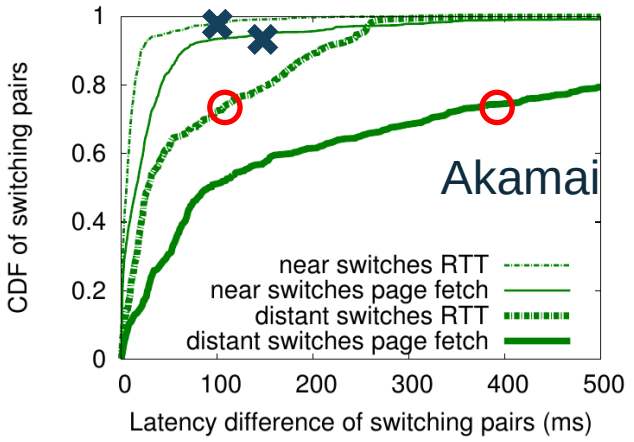
Distant Switches => **Large Latency** Changes

- **X: near switches** (<1000km)
  generally (at least 90-98% of time Google and Akamai)
  see smaller performance changes (<50ms RTT, <150ms page fetch)
- **O: distant switches** (>1000km)
  sometimes (>40% Google, >28% Akamai)
  see large performance changes (>100ms RTT, >400ms page fetch)





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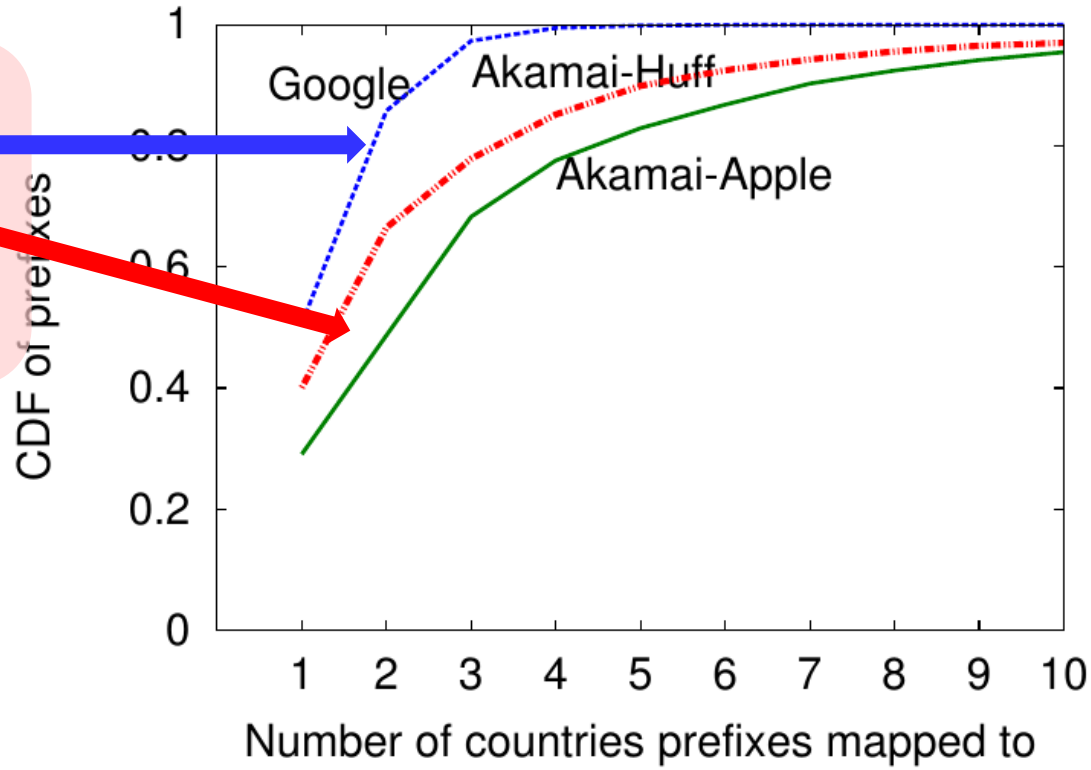
Many Prefixes Go Abroad

many prefixes
20% (Google)
or **40-60% (Akamai)**
leave their
originating country



Geographic Footprint **May Matter** to Some

- metric: how often does a prefix go abroad and where does it go?

source country	Google non-domestic %	1st	2nd	3rd	Akamai-Huff non-domestic %	1st	2nd	3rd
us (United States)	11%	be (4%)	nl (4%)	de (3%)	98%	ca (38%)	gb (27%)	fr (27%)
kr (S. Korea)	97%	jp (58%)	us (19%)	cn (18%)	99%	tw (99%)	jp (6%)	nl (3%)
ru (Russia)	99%	us (35%)	be (6%)	nl (5%)	96%	se (74%)	no (43%)	de (40)
jp (Japan)	55%	us (30%)	nl (9%)	be (7%)	100%	cn (92%)	us (67%)	vn (9%)
br (Brazil)	48%	nl (18%)	be (17%)	us (14%)	83%	us (78%)	cl (53%)	ar (35%)
tw (Taiwan)	45%	us (24%)	be (9%)	nl (9%)	99%	cn (74%)	us (72%)	vn (48%)
	%	us (27%)	nl (11%)	be (11%)	99%	jp (93%)	us (89%)	gb (67%)
	%	us (40%)	de (19%)	fr (5%)				
	%	us (40%)	nl (19%)	be (8%)				
	%	us (24%)	nl (18%)	be (11%)				
hk (Hong Kong)	–	–	–	–	9			
tr (Turkey)	–	–	–	–	91%	it (82%)	se (46%)	de (23%)
fr (France)	–	–	–	–	99%	pl (69%)	gb (57%)	es (56%)

Brazil considered requiring domestic hosting (none today!)

some see service from countries with strong dometic content restrictions

Conclusions

- first to evaluate user-to-FE mapping changes from many VPs
- where you go can matter:
  - longer distance => higher latency
  - going abroad => what is your policy?

- Our data is free upon request: http://www.isi.edu/ant/traces/mapping_cdns