Availability, Usage, and Deployment Characteristics of the Domain Name System

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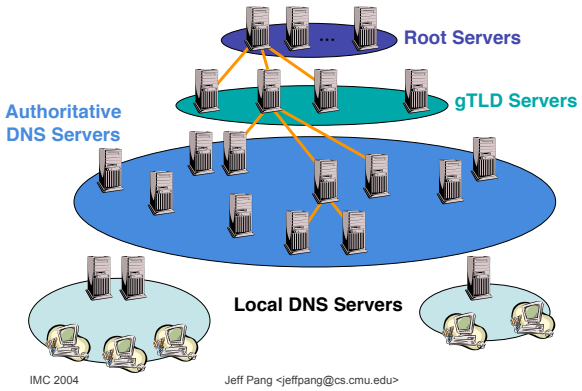
Why Characterize DNS?

- Critical and Understudied
  - Internet "stops working" when DNS goes down
  - Example of federated deployment styles
  - Much unknown and to be improved
  - Proposed DNS Modifications: CoDoNS [Ramasubramanian04], CoDNS [Park04]
- Guide to Future "Planetary-Scale" Services?
  - Largest, most robust distributed system today
  - PlanetLab, Overlays, DHTs, CDNs, and more!

The Domain Name System



Related Studies

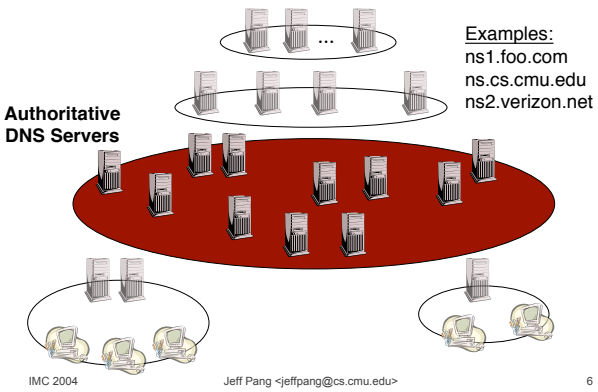
- Workload on the Root & gTLD servers [Brownlee01]
- Lame-delegation, diminished server redundancy, and cyclic zone dependencies [Pappas04]
- Bottleneck gateways [Ramasubramanian04]
- Local DNS failures [Park04]

- We focus on "raw" DNS server characteristics
- Compare local vs. authoritative servers

Overview

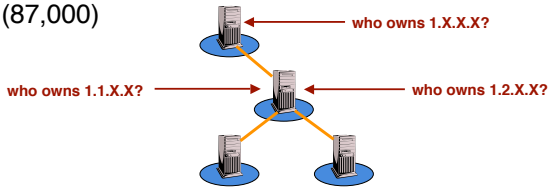
- **Methodology**
  - How to obtain representative samples of DNS servers?
- **Load**
  - How many users are serviced by DNS servers?
- **Availability**
  - How often are DNS servers unavailable?
- **Deployment Styles**
  - How do organizations deploy DNS servers?

Authoritative DNS (ADNS) Servers



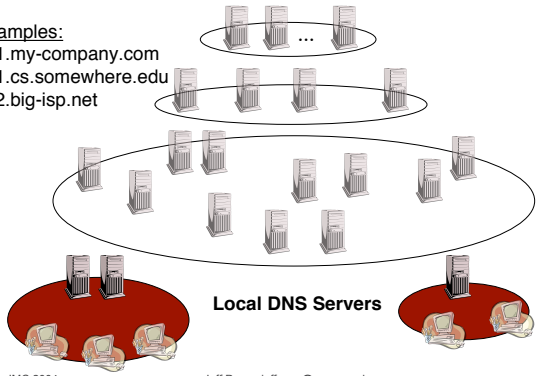
Sampling ADNS Servers

- Servers for domain names in web cache logs (NLANR) (85,000)
- Reverse name map of DNS hierarchy (87,000)



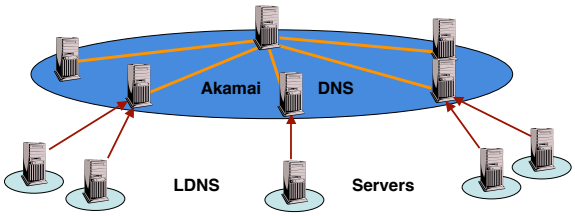
Local DNS (LDNS) Servers

Examples:
ns1.my-company.com
ns1.cs.somewhere.edu
ns2.big-isp.net



Sampling LDNS Servers

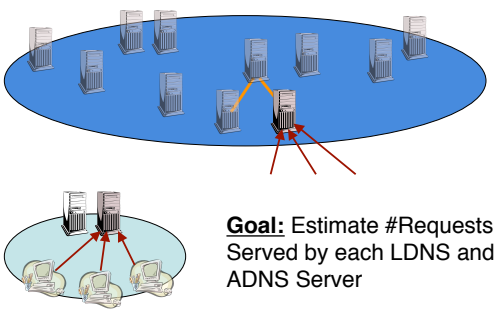
- Sample servers that access Akamai's DNS
  - Handles DNS for ~26 of top 100 websites
  - 274,000 LDNS servers in 49 different countries



Overview

- Methodology
- **Load**
- Availability
- Deployment Styles

Server Load

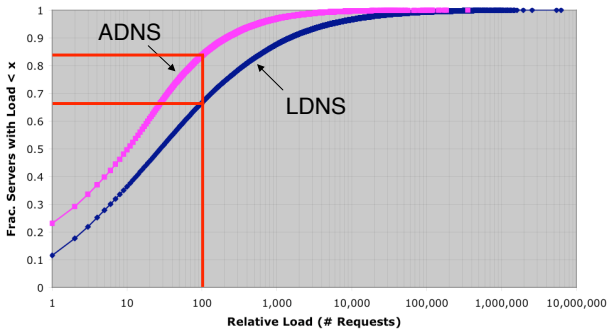


Goal: Estimate #Requests Served by each LDNS and ADNS Server

Estimating Relative Load

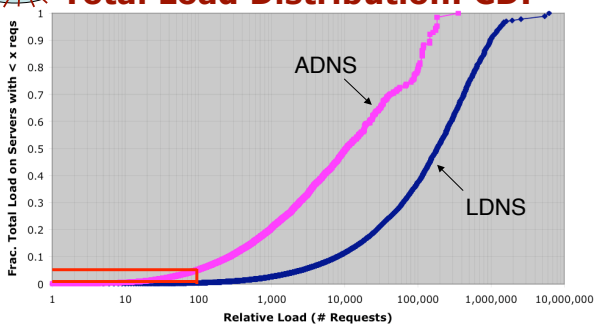
- ADNS
  - # HTTP reqs to websites served by DNS Server
  - Coarse-grained relative estimator
  - (1 week)
- LDNS
  - #DNS reqs sent to Akamai hosted websites
  - Estimated 14% of all web reqs go to Akamai
  - Akamai DNS records have low TTLs (20 sec)
  - (1 week)

Relative Server Load: CDF



- Most servers are relatively lightly loaded.

Total Load Distribution: CDF

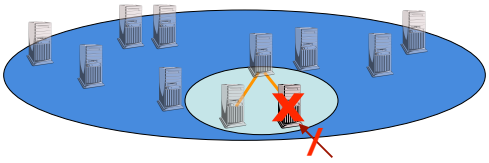


- Most Requests come from the highly loaded servers.
- Not quite Zipfian: weight not all in tail

Overview

- Methodology
- Load
- **Availability**
- Deployment Styles

Server Availability



Goal: Estimate how often servers can not serve requests, and how long they are unavailable.

Estimating Availability

- Active Probes from one vantage point
  - Poisson sampling with mean interval 1 hour
  - Both DNS requests and ICMP pings
  - $\frac{\text{\# probe failures}}{\text{\# total probes}}$ estimates availability
  - Took steps to avoid counting local failures
  - (2 weeks)

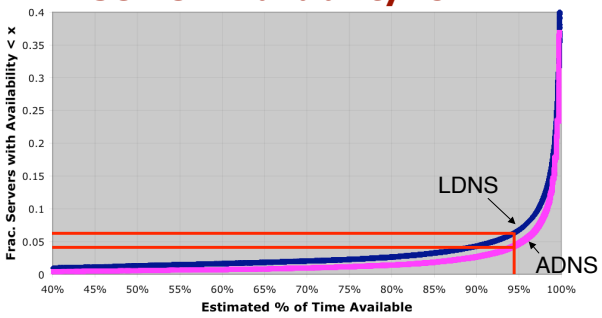
Non-Responsive Servers

- Which Servers are Responsive?
  - Sent “test” probe immediately after a server sent a DNS request to Akamai
  - More likely server is “up” when initially probed
- LDNS Server Responsiveness
  - 76% responded to either DNS or Ping
    - 35% respond to both
    - 21% only respond to Ping
    - 20% only respond to DNS

Distinguishing Dynamic IPs

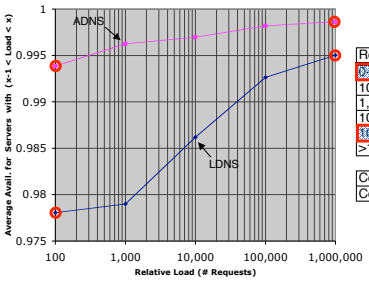
- Impact of Dynamic IPs
  - 6-8% of LDNS servers or more are probably on dynamic IPs (Surprising?)
  - Incorrect estimate of availability
  - Overestimate number of distinct DNS servers
- We choose to be conservative
  - Only analyzed servers on non-dynamic IPs
- Identifying non-dynamic IPs (one technique)
  - Conjectured that dynamic IP pools have similar host names:
    `cust-0-1-2-3-3.isp.net` (IP Address: `1.2.3.3`)
    `cust-0-1-2-3-4.isp.net` (IP Address: `1.2.3.4`)
    `cust-0-1-2-3-5.isp.net` (IP Address: `1.2.3.5`)
  - Example: for 1.2.3.**3**, compare with 1.2.3.**2** and 1.2.3.**4**
  - Correctly flags over 98% of a SPAM RBL dynamic IP list

Server Availability: CDF



- Perfect availability: 62% LDNS, 64% ADNS
- Mean availability: LDNS 98%, ADNS 99%

Relative Load vs. Availability



Relative Load	Mean Avail. LDNS	ADNS
0-100	0.978	0.993
100-1,000	0.979	0.996
1,000-10,000	0.986	0.997
10,000-100,000	0.992	0.998
100,000-1,000,000	0.995	0.999
>1,000,000	0.998	

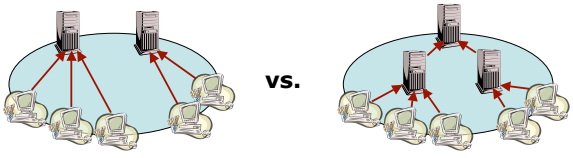
Correlation(load, avail)	0.017	0.007
Correlation(log load, avail	0.041	0.043

- Minor but non-trivial positive correlation
- Sidenote: web cache ADNS sample set had ~1% higher mean availability than “reverse crawl” sample set

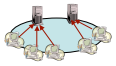
Overview

- Methodology
- Load
- Availability
- **Deployment Styles**

Deployment Styles

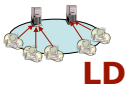


Goal: Determine common “styles” of LDNS deployment within different organizations.

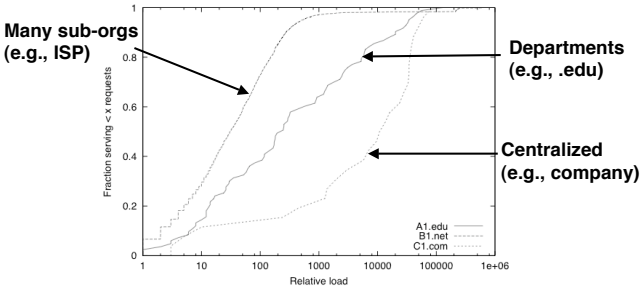


Deployment Styles

- Grouped LDNS servers by domain name
  - Coarse-grained approximation of organizations
- Characteristics examined:
  - Load distribution within an organization
  - Number of servers deployed [see paper]



Deployment Styles: LDNS Load Distribution CDF



- We observed three common patterns in LDNS load distribution among servers in a domain.

Summary

- Load Distribution
  - Many idle LDNS and ADNS servers
  - But most requests come from/to a few busy ones
- Availability
  - Majority of servers are highly available
  - Small positive correlation between load and availability
- Deployment Styles
  - Conjecture that there are 3 basic profiles for LDNS distribution in organizations
- ADNS vs. LDNS
  - ADNS slightly more available
  - LDNS servers more diverse: dynamic IPs, etc.

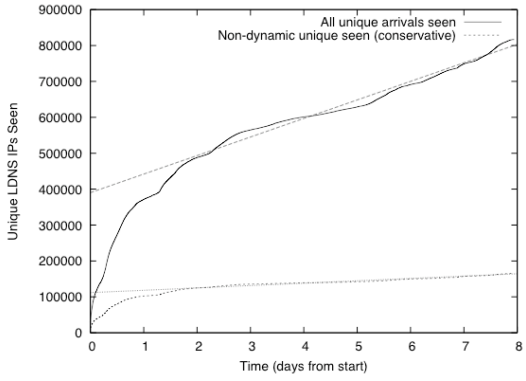
Questions

Extra Slides

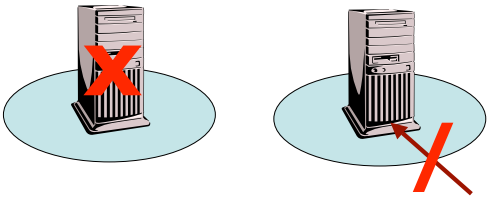
Limitations

- Probing from single vantage point
  - Limited impact of local connectivity issues [see paper]
  - Rough estimate of failures related to network: 15%
- Probing granularity
  - Performed smaller 5-min granularity experiment
  - Similar results
- Accounting for “Middle-boxes”
  - Probes may not actually be to actual DNS server
- Sample Bias
  - Web cache vs. Reverse-crawl ADNS sample sets show sampling method is important

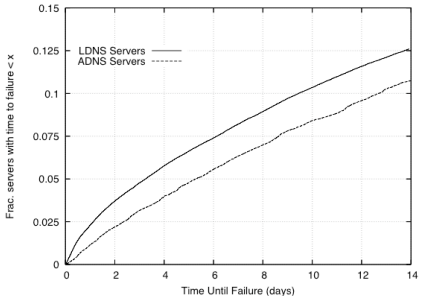
Dynamic LDNS Arrival Rate



Server Availability

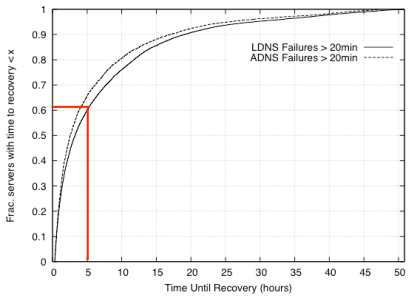


Time to Failure: CDF



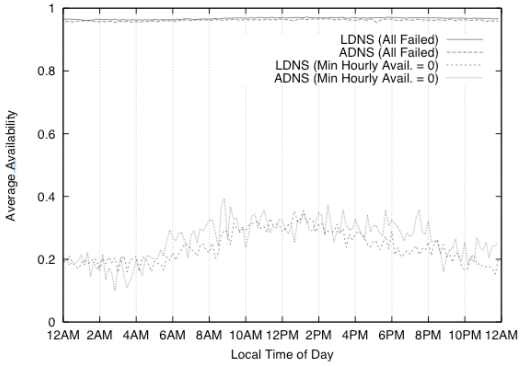
- Time to failure is likely to be on order of days, weeks, or longer.

Time to Recovery: CDF

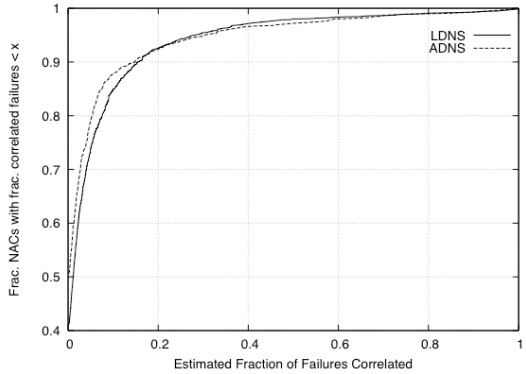


- Time to recovery is likely to be on the order of hours.

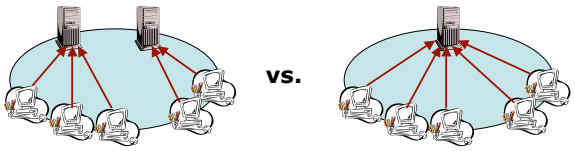
Time of Day Effects

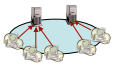


NAC Correlated Failures

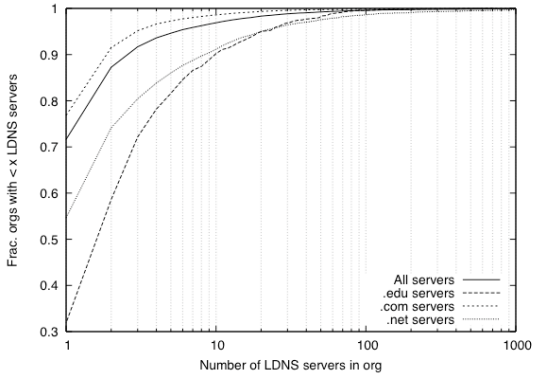


Deployment Styles





LDNS Server Count



Relative Server Load