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Reducing DNS Caching

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Reducing DNS Caching
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1. **The DNS zero TTL challenge**
2. Experiment configuration
3. Observations and analyses
4. Round-up

Motivational example: mobility in ILNP

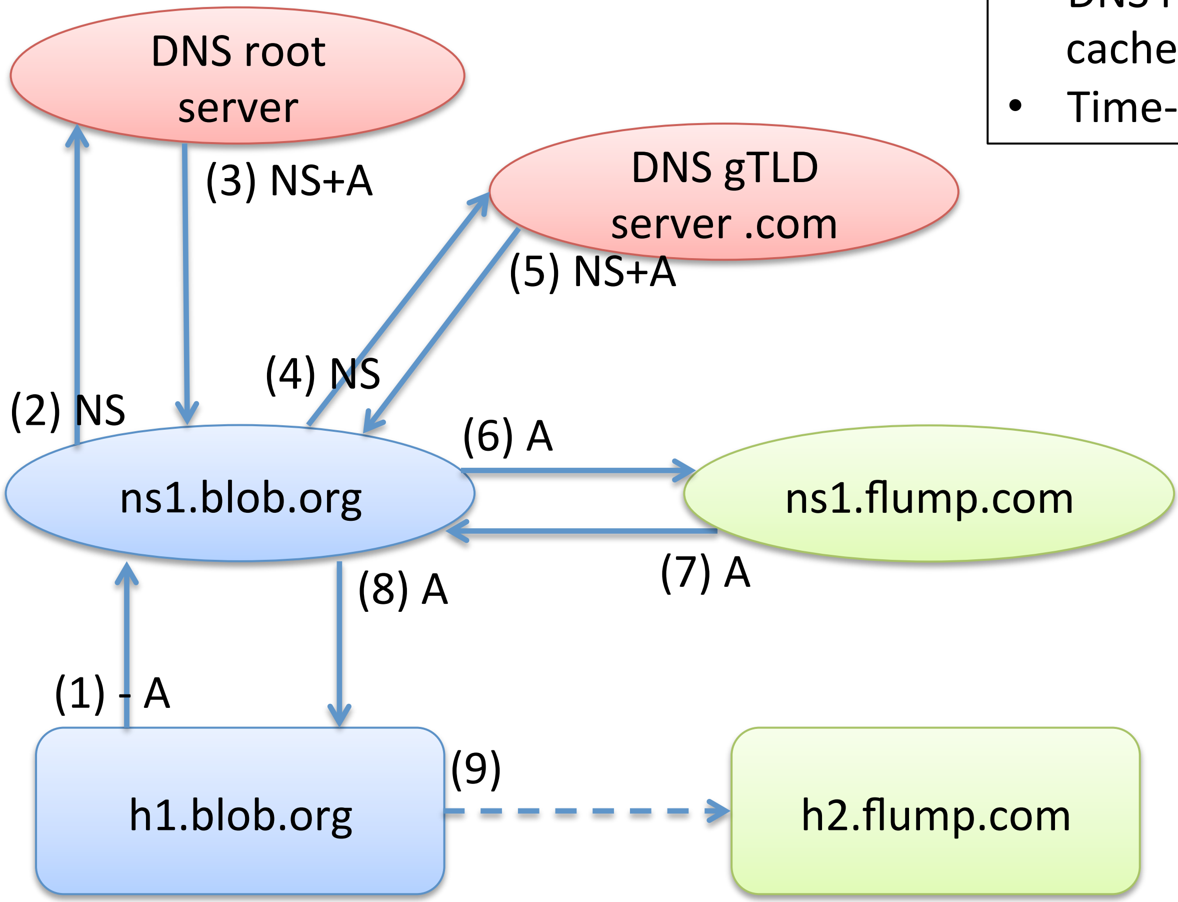
- ILNP – http://ilnp.cs.st-andrews.ac.uk/
- ILNP nodes update (topological) Locator value in DNS as they move to different IP networks.
- Movement could happen at any time, so cached Locator values could become stale.
- We need to reduce caching of such values, ideally to zero, so there are no stale values.
- **Is zero caching practical?**
  Test with A records – nearest equivalent for ILNP.

DNS – a summary [1]

- Scaling – architecture mechanisms:
  - Hierarchical name-space
  - Administrative zones across the name space
  - Delegation of lookups across zones
- Scaling – engineering mechanisms:
  - Administrative **zones** organised around naming hierarchy
  - DNS protocol permits **redirection** (**referral**) to another **name server** for resolving a name
  - Returned results are **cached**
- **Administratively organised, spatio-temporal caching hierarchy**

DNS – a summary [2]

h1.blob.org to lookup h2.flump.com



- DNS resource records (RRs) can be cached for different times.
- Time-To-Live (TTL) value for each RR.

NS RRs (and associated A RRs) returned at steps (3), (5) and (7) can have different TTLs to the A RR returned at step (8).

DNS data

App. data

DNS caching recommendation

- RFC1034 (STD13) on TTL values, p13:

```
… the realities of Internet performance
suggest that these times should be on the
order of days for the typical host.
```

- Today, TTLs generally have large values, e.g.: www.sjtu.edu.cn uses TTL of 43200s (12h)
- Small TTL values (i.e. a few seconds or lower) considered “bad” (some exceptions …)

(Non-)Effectiveness of DNS caching

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- Jung, J., Sit, E., Balakrishnan, H., and Morris, R. 2002. *DNS performance and the effectiveness of caching*. IEEE/ACM Trans. on Networking. Vol. 10, No. 5 (Oct. 2002), pp. 589-603.
- DNS caching has reduced effectiveness for edge sites:
  - trace-driven emulation (no experiments)
  - **A records could have low TTL (e.g. below 1000s)**
  - **such low TTL would have low impact on DNS load**

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DNS experiments at StA [1]

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- Experiments in Q4/2009
- Modify TTL values of records in operational DNS server at School of CS, St Andrews
  - 4 DNS servers: Windows ActiveDirectory
  - ~500 DNS clients: Windows, Linux, MacOSX, BSD
- TTL values for successive 7-day periods during normal semester:
  - changed DNS TTL on ActiveDirectory
  - TTL values used: 1800s, 30s, 0s
- Configured clients not to cache.

DNS experiments at StA [2]

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- Passive collection of packets via port mirror:
  - *tcpdump(8)* targeting *port 53*
  - Captured all DNS packets
- Results shown on following slides are for:
  - A record requests for servers only during the capture period (relevant to ILNP, and less 'noisy' data)
  - using 1 second buckets
- Basic statistics:
  - on time-domain data
- Spectral analysis:
  - examination of request rates
- Analysis: home-brew *python* scripts, NumPy package

2009 data-sets: overall meta-data

Data set name	TTL [s]	Duration [s][1]	Total DNS packets captured[2]	Number of A record requests for 67 servers[3]
dns1800	1800	601,200	41,868,522	2,004,133 (4.8%)
dns0030	30	601,200	71,105,247	2,648,796 (3.7%)
dns0000	0	601,200	55,868,573	4,501,590 (8.1%)

[1] from tcpdump timestamps, rounded to nearest second, 7 days = 604,800 seconds, less 3600s temporal guard band for TTL value changes = 601,200 seconds

[2] includes all request and response packets to/from port 53 (TCP and UDP), including erroneous requests, retransmissions etc

[3] servers that were active during the 3 weeks of data capture

2009 data-sets: internal meta-data

Data set name	TTL [s]	Duration [s][1]	Total DNS packets captured[2]	Number of A record requests for 67 servers[3]
dns1800-i	1800	601,200	29,486,362	792,339 (2.7%)
dns0030-i	30	601,200	54,097,231	951,485 (1.8%)
dns0000-i	0	601,200	30,555,305	1,419,782 (4.7%)

[1] from tcpdump timestamps, rounded to nearest second, 7 days = 604,800 seconds, less 3600s temporal guard band for TTL value changes = 601,200 seconds

[2] includes all request and response packets to/from port 53 (TCP and UDP), including erroneous requests, retransmissions etc

[3] servers that were active during the 3 weeks of data capture

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dns1800-i: A queries TTL=1800s

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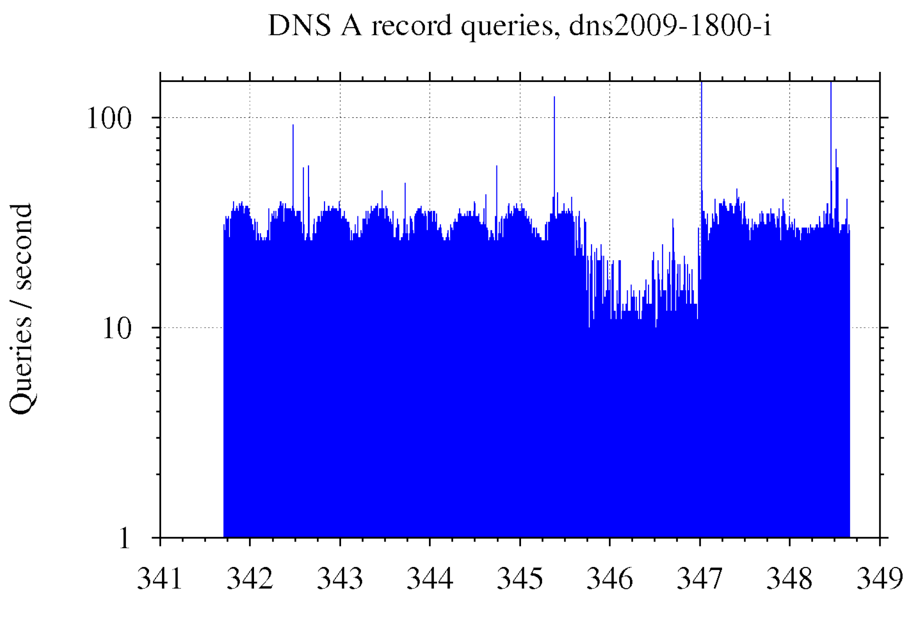
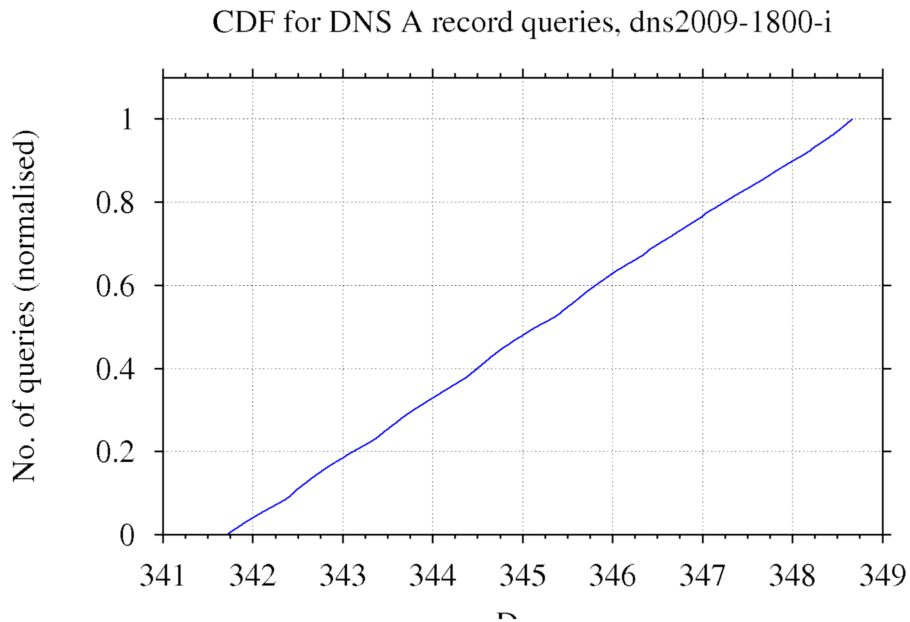
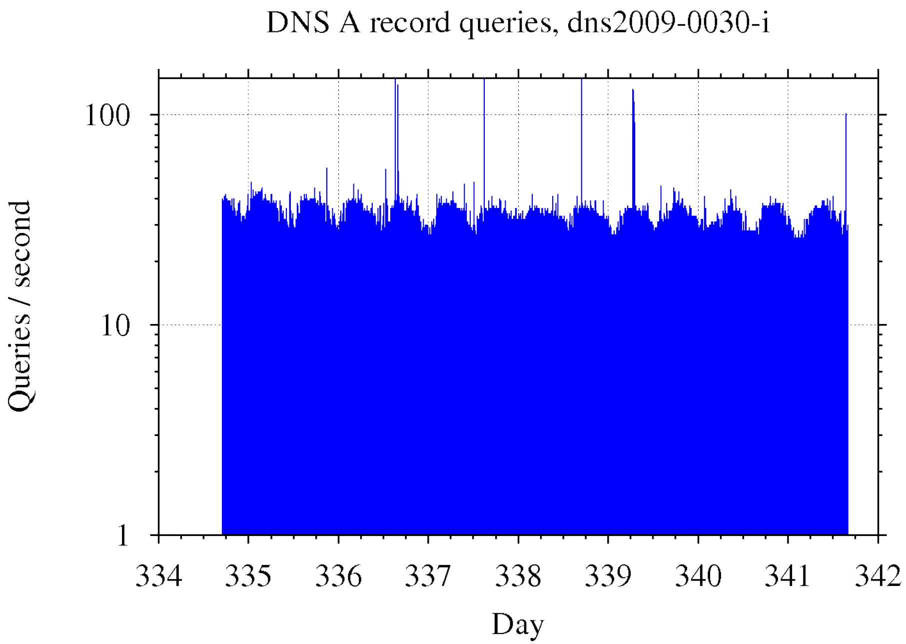
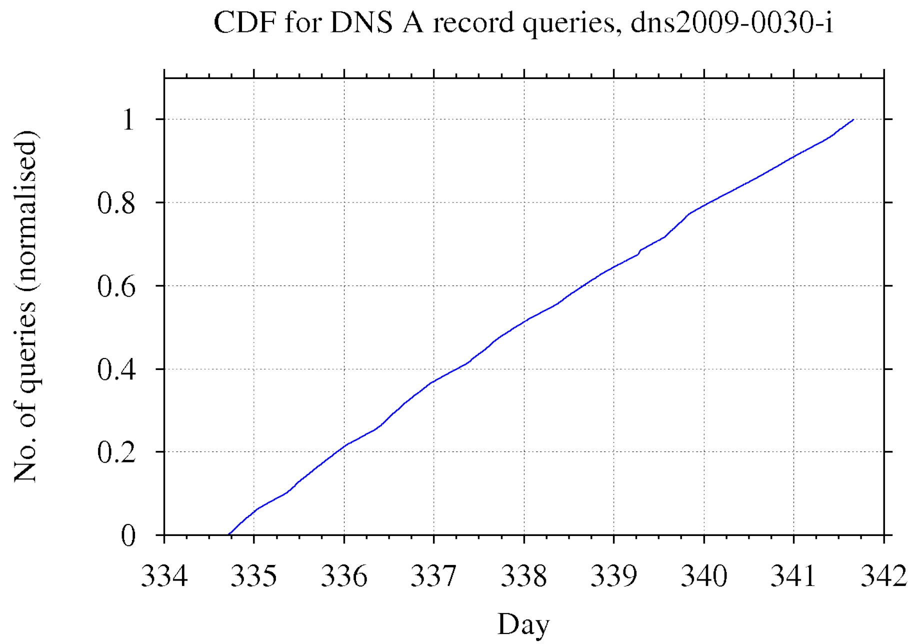




Mean: 1.31 request/s
Std Dev: 2.98 requests/s
Max: 176 requests/s

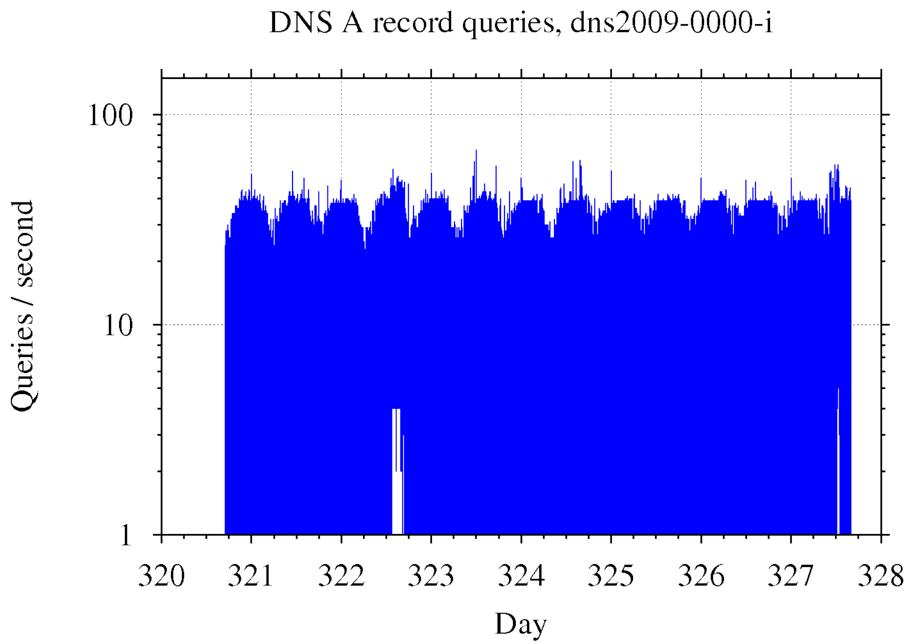
dns0030-i: A queries TTL=30s

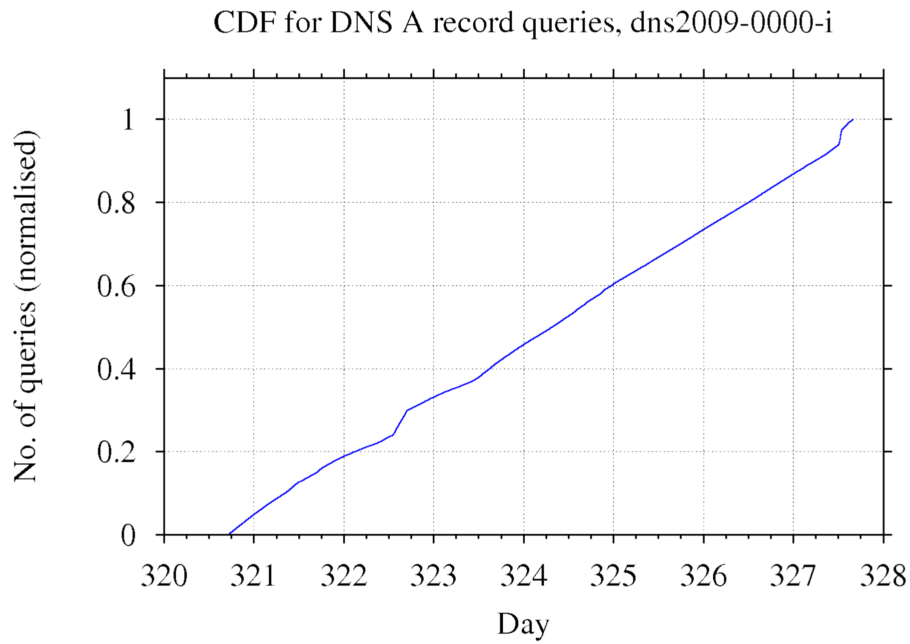




Mean: 1.58 request/s
Std Dev: 3.57 requests/s
Max: 168 requests/s

dns0000-i: A queries TTL=0s





Mean: 2.36 request/s
Std Dev: 3.48 requests/s
Max: 68 requests/s

2009 Summary of basic statistics

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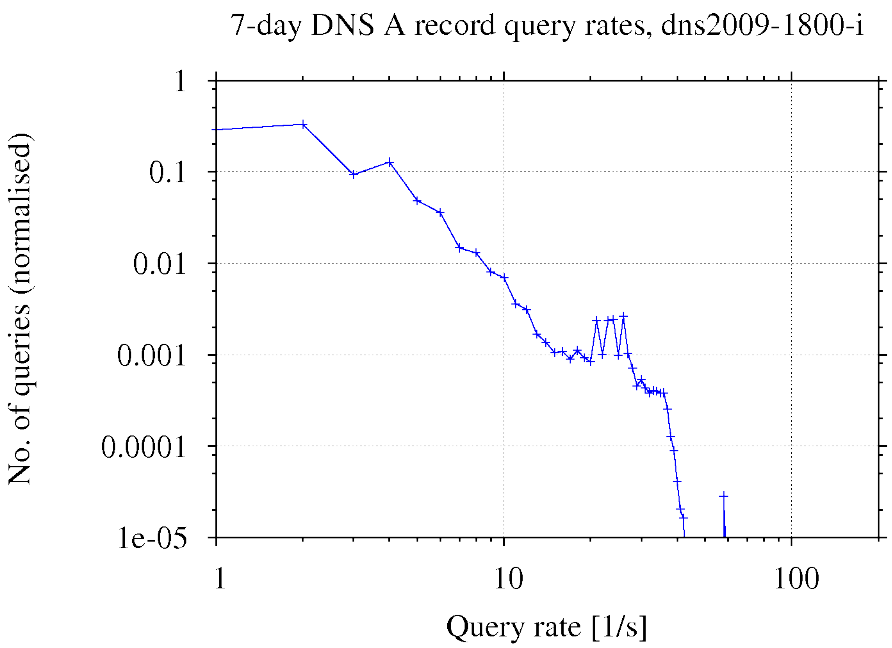
Data set name	Mean [reqs/s]	Std Dev [reqs/s]	Maximum [reqs/s]
dns1800-i	1.31	2.98	176
dns0030-i	1.58	3.57	168
dns0000-i	2.36	3.48	68

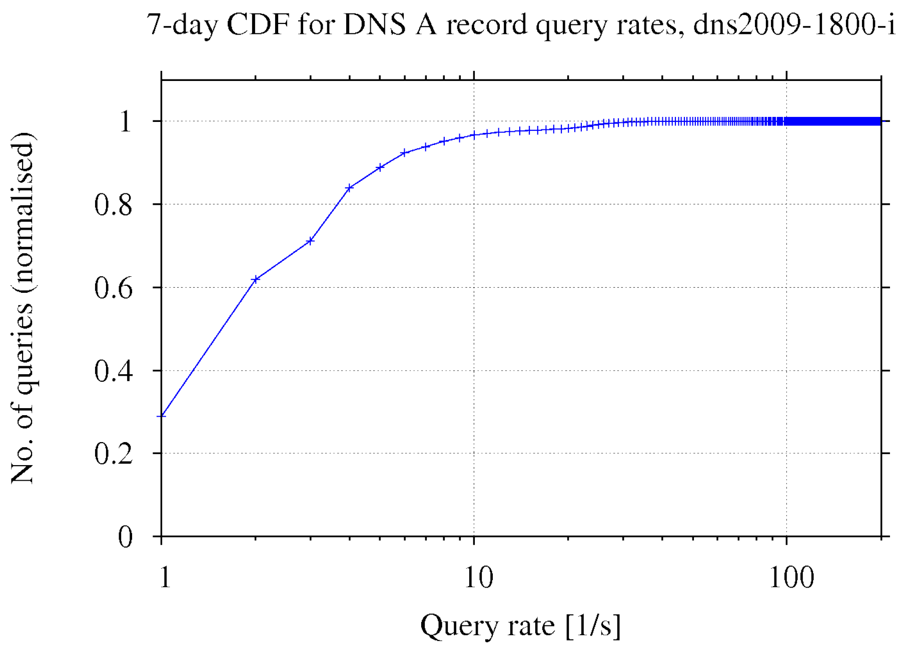
60x drop in TTL values results in
⅓x increase in A record requests.
0 TTL gives ~**2x increase.**

2009 Basic spectral analysis

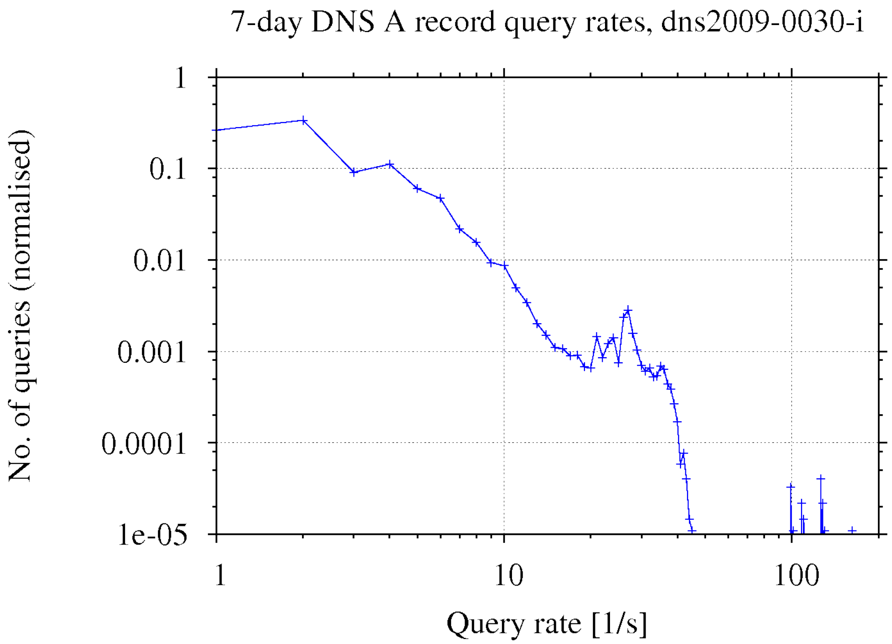
- Create approximate periodogram by counting occurrences of bucket sizes:
  - have used 1s bucket
  - so size of bucket, *n*, is number of requests/s
  - count occurrence of buckets of size *n*
- Comparison of periodogram:
  - shows changing dynamics of request rates
  - gives a better view of the trends in request rates

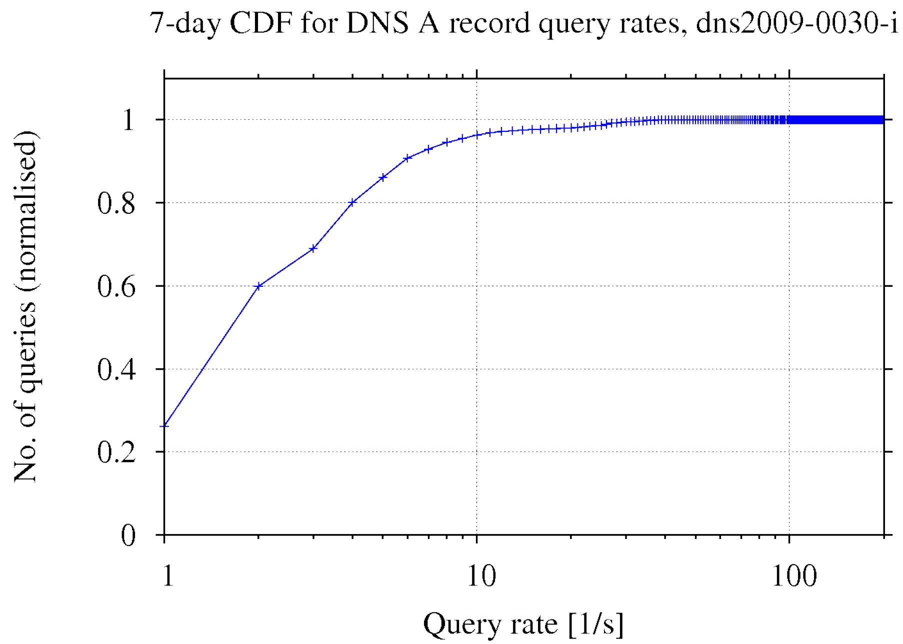
2009 periodograms: 1800s



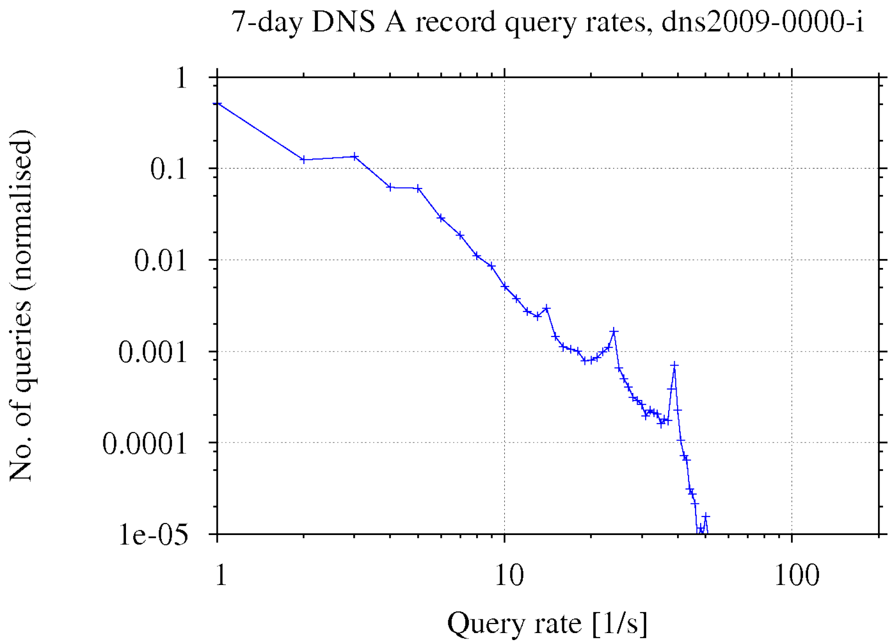


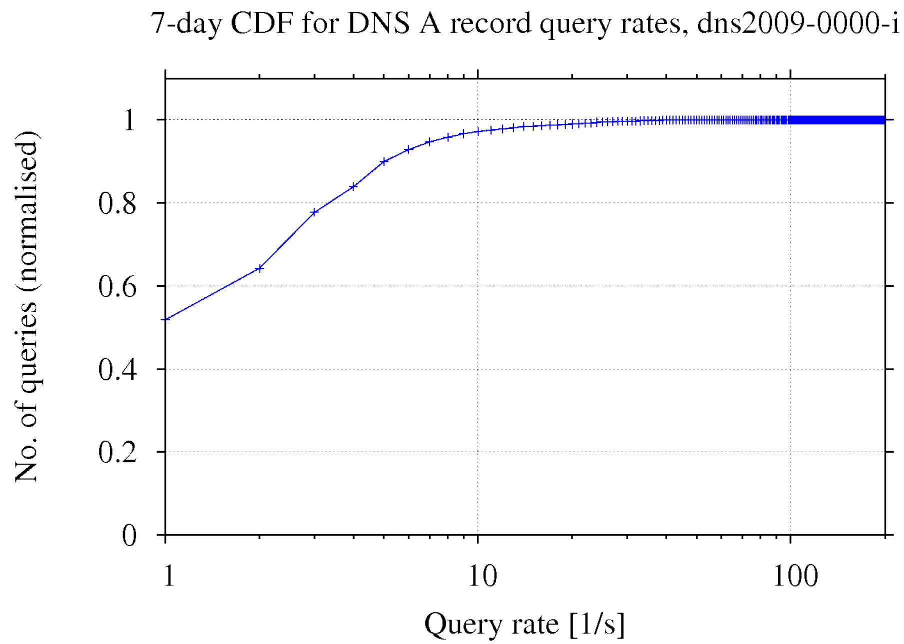
2009 periodograms: 30s





2009 periodograms: 0s





2009 Summary of basic statistics

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Data set name	Mean [reqs/s]	~95% [reqs/s]	~99% [reqs/s]
dns1800-i	1.31	8	22
dns0030-i	1.58	8	24
dns0000-i	2.36	8	15

~95% centile is the same and is of a low value (8 reqs/s)

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Who would set DNS TTLs so low?

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- Real A record values for some services:
  - TTL = 60 seconds: yahoo
  - TTL = 20 seconds: akamai
  - **TTL = 0 seconds: St Andrews, Computer Science**
- Note that a site would **NOT** set low TTLs for:
  - Its own NS records, which identify its DNS servers.
  - The A records related to its NS records.
  - A, CNAME, PTR records for services, e.g. email MX
  - A (mobile) site can make remote some or all of its authoritative DNS servers; some sites do so today.

Future work

- More in-depth analyses of traces:
  - possibly some controlled experiments
- Repeat experiments at other sites
- For mobility:
  - Secure DNS Dynamic Update
  - DNSsec (authenticated responses)
- Have started some discussions with various industrial collaborators.

Summary and Conclusion

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- Summary:
  - Zero TTL values for edge-site DNS A records possible
  - DNS load with zero DNS TTLs seems manageable
  - (Indeed, 1s TTL is good, perhaps better than zero)
- Conclusion:
  - DNS A records with very low TTL seems practical

Acknowledgements

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