DNS Session 2: DNS cache operation and DNS debugging

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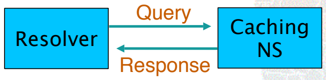
AfNOG 2007 workshop

How caching NS works (1)

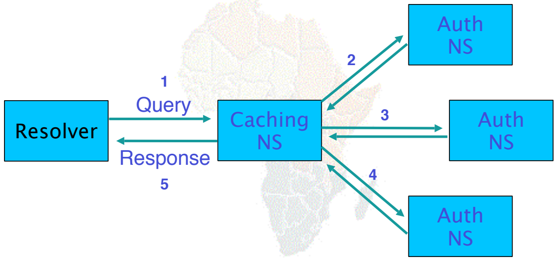
- If we've dealt with this query before recently, answer is already in the cache - easy!



What if the answer is not in the cache?

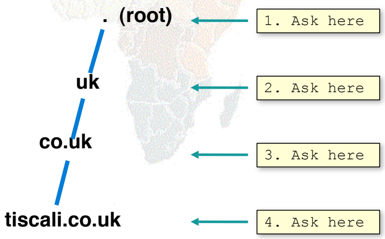
- DNS is a distributed database: parts of the tree (called "zones") are held in different servers
- They are called "authoritative" for their particular part of the tree
- It is the job of a caching nameserver to locate the right authoritative nameserver and get back the result
- It may have to ask other nameservers first to locate the one it needs

How caching NS works (2)



How does it know which authoritative nameserver to ask?

- It follows the hierarchical tree structure
- e.g. to query "www.tiscali.co.uk"



Intermediate nameservers return "NS" resource records

- "I don't have the answer, but try these other nameservers instead"
- Called a REFERRAL
- Moves you down the tree by one or more levels

Eventually this process will either:

- Find an authoritative nameserver which knows the answer (positive or negative)
- Not find any working nameserver: *SERVFAIL*
- End up at a faulty nameserver - either cannot answer and no further delegation, or wrong answer!
  - Note: the caching nameserver may happen also to be an authoritative nameserver for a particular query. In that case it will answer immediately without asking anywhere else. We will see later why it's a better idea to have separate machines for caching and authoritative nameservers

How does this process start?

- Every caching nameserver is seeded with a list of root servers

/etc/namedb/named.conf

```
zone "." {
        type hint;
        file "named.root";
}
```

/etc/namedb/named.root

```
.                       3600000      NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.     3600000      A     198.41.0.4

.                       3600000      NS    B.ROOT-SERVERS.NET.
B.ROOT-SERVERS.NET.     3600000      A     128.9.0.107

.                       3600000      NS    C.ROOT-SERVERS.NET.
C.ROOT-SERVERS.NET.     3600000      A     192.33.4.12
;... etc
```

Where did named.root come from?

- ftp://ftp.internic.net/domain/named.cache
- Worth checking every 6 months or so for updates

Demonstration

- **`dig +trace www.tiscali.co.uk.`**
- Instead of sending the query to the cache, "dig +trace" traverses the tree from the root and displays the responses it gets
  - `dig +trace` is a bind 9 feature
  - useful as a demo but not for debugging

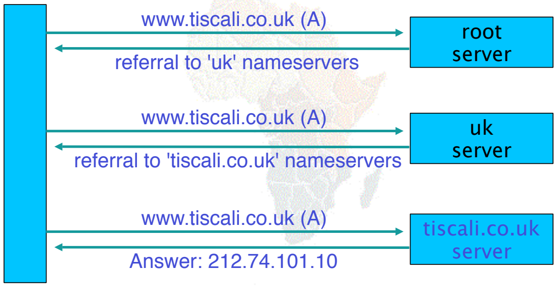
Distributed systems have many points of failure!

- So each zone has two or more authoritative nameservers for resilience
- They are all equivalent and can be tried in any order
- Trying stops as soon as one gives an answer
- Also helps share the load
- The root servers are very busy
  - There are currently 13 of them (each of which is a large cluster)

Caching reduces the load on auth nameservers

- Especially important at the higher levels: root servers, GTLD servers (.com, .net ...) and ccTLDs
- All intermediate information is cached as well as the final answer - so NS records from REFERRALS are cached too

Example 1: www.tiscali.co.uk (on an empty cache)



www.tiscali.co.uk (A)

root server

referral to 'uk' nameservers

www.tiscali.co.uk (A)

uk server

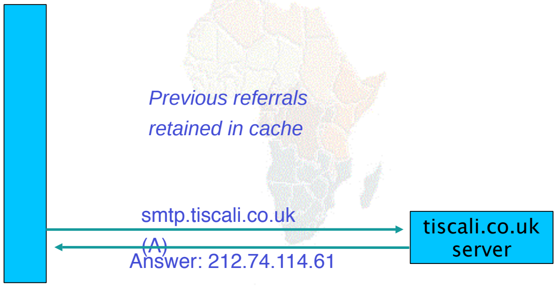
referral to 'tiscali.co.uk' nameservers

www.tiscali.co.uk (A)

tiscali.co.uk server

Answer: 212.74.101.10

Example 2: smtp.tiscali.co.uk (after previous example)



Previous referrals retained in cache

smtp.tiscali.co.uk (A)

tiscali.co.uk server

Answer: 212.74.114.61

Caches can be a problem if data becomes stale

- If caches hold data for too long, they may give out the wrong answers if the authoritative data changes
- If caches hold data for too little time, it means increased work for the authoritative servers

The owner of an auth server controls how their data is cached

- Each resource record has a "Time To Live" (TTL) which says how long it can be kept in cache
- The SOA record says how long a negative answer can be cached (i.e. the non-existence of a resource record)
- Note: the cache owner has no control - but they wouldn't want it anyway

A compromise policy

- Set a fairly long TTL - 1 or 2 days
- When you know you are about to make a change, reduce the TTL down to 10 minutes
- Wait 1 or 2 days BEFORE making the change
- After the change, put the TTL back up again

Any questions?

?

What sort of problems might occur when resolving names in DNS?

- Remember that following referrals is in general a multi-step process
- Remember the caching

(1) One authoritative server is down or unreachable

- Not a problem: timeout and try the next authoritative server
  - Remember that there are multiple authoritative servers for a zone, so the referral returns multiple NS records

(2) *ALL* authoritative servers are down or unreachable!

- This is bad; query cannot complete
- Make sure all nameservers not on the same subnet (switch/router failure)
- Make sure all nameservers not in the same building (power failure)
- Make sure all nameservers not even on the same Internet backbone (failure of upstream link)
- For more detail read RFC 2182

(3) Referral to a nameserver which is not authoritative for this zone

- Bad error. Called "Lame Delegation"
- Query cannot proceed - server can give neither the right answer nor the right delegation
- Typical error: NS record for a zone points to a caching nameserver which has not been set up as authoritative for that zone
- Or: syntax error in zone file means that nameserver software ignores it

(4) Inconsistencies between authoritative servers

- If auth servers don't have the same information then you will get different information depending on which one you picked (random)
- Because of caching, these problems can be very hard to debug. Problem is intermittent.

(5) Inconsistencies in delegations

- NS records in the delegation do not match NS records in the zone file (we will write zone files later)
- Problem: if the two sets aren't the same, then which is right?
  - Leads to unpredictable behaviour
  - Caches could use one set or the other, or the union of both

(6) Mixing caching and authoritative nameservers

- Consider when caching nameserver contains an old zone file, but customer has transferred their DNS somewhere else
- Caching nameserver responds immediately with the old information, even though NS records point at a different ISP's authoritative nameservers which hold the right information!
- This is a very strong reason for having separate machines for authoritative and caching NS
  - Another reason is that an authoritative-only NS has a fixed memory usage

(7) Inappropriate choice of parameters

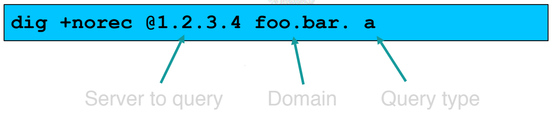
- e.g. TTL set either far too short or far too long

These problems are not the fault of the caching server!

- They all originate from bad configuration of the AUTHORITATIVE name servers
- Many of these mistakes are easy to make but difficult to debug, especially because of caching
- Running a caching server is easy; running authoritative nameservice properly requires great attention to detail

How to debug these problems?

- We must bypass caching
- We must try **all** N servers for a zone (a caching nameserver stops after one)
- We must bypass recursion to test all the intermediate referrals
- "dig +norec" is your friend



```
dig +norec @1.2.3.4 foo.bar. a
```

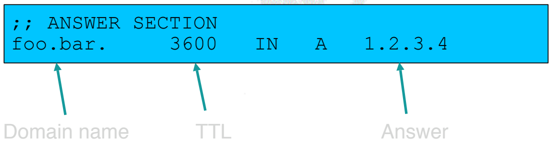
Server to query

Domain

Query type

How to interpret responses (1)

- Look for "status: NOERROR"
- "flags ... **aa**" means this is an authoritative answer (i.e. not cached)
- "ANSWER SECTION" gives the answer
- If you get back just NS records: it's a referral



```
;; ANSWER SECTION
foo.bar.      3600   IN   A   1.2.3.4
```

Domain name

TTL

Answer

How to interpret responses (2)

- *"status: NXDOMAIN"*
  - OK, negative (the domain does not exist). You should get back an SOA
- *"status: NOERROR"* with zero RRs
  - OK, negative (domain exists but no RRs of the type requested). Should get back an SOA
- Other status may indicate an error
- Look also for *Connection Refused* (DNS server is not running or doesn't accept queries from your IP address) or *Timeout* (no answer)

How to debug a domain using "dig +norec" (1)

1. Start at any root server: [a-m].root-

```
dig +norec @a.root-servers.net. www.tiscali.co.uk. a
```

Remember the trailing dots!

1. For a referral, note the NS records returned
2. Repeat the query for **all** NS records
3. Go back to step 2, until you have got the final answers to the query

How to debug a domain using "dig +norec" (2)

1. Check all the results from a group of authoritative nameservers are consistent with each other
2. Check all the final answers have "flags: aa"
3. Note that the NS records point to names, not IP addresses. So now check every NS record seen maps to the correct IP address using the same process!!

How to debug a domain using "dig +norec" (3)

- Tedious, requires patience and accuracy, but it pays off
- Learn this first before playing with more automated tools
  - Such as:
    - http://www.squish.net/dnscheck/
    - http://www.zonecheck.fr/
  - These tools all have limitations, none is perfect

Practical

Worked examples

Building your own caching nameserver

- Easy!
- Standard software is "bind" (Berkeley Internet Name Domain) from ISC: www.isc.org
- Most Unixes have it, and already configured as a cache
  - FreeBSD: in the base system
  - Red Hat: "bind" and "caching-nameserver" RPM packages
- Question: what sort of hardware would you choose when building a DNS cache?

Improving the configuration

- Limit client access to your own IP addresses only
  - No reason for other people on the Internet to be using your cache resources
- Make cache authoritative for queries which should not go to the Internet
  - localhost Õ A 127.0.0.1
  - 1.0.0.127.in-addr.arpa Õ PTR localhost
  - RFC 1918 addresses (10/8, 172.16/12, 192.168/16)
  - Gives quicker response and saves sending unnecessary queries to the Internet

Access control

/etc/namedb/named.conf

```
acl mynetwork {
    127.0.0.1;
    192.188.58.64/26;
};

options {
    directory "/etc/namedb";
    recursion yes;              # this is the default
    allow-query { mynetwork; };
    # note: use 'allow-recursion' instead if your
    # nameserver is both caching and authoritative
};

zone "." {
    type hint;
    file "named.root";
};
```

localhost -> 127.0.0.1

/etc/namedb/named.conf

```
zone "localhost" {
    type master;
    file "master/localhost";
    allow-update { none; };
};
```

/etc/namedb/master/localhost

```
@       SOA     localhost.    root.localhost. (
                2004022800    ; serial
                8h            ; refresh
                1h            ; retry
                4w            ; expire
                1h )          ; negative TTL

        NS      localhost.
        A       127.0.0.1
```

127.0.0.1 -> localhost

/etc/namedb/named.conf

```
zone "0.0.127.in-addr.arpa" {
    type master;
    file "master/localhost.rev";
    allow-update { none; };
};
```

/etc/namedb/master/localhost.rev

```
@       SOA     localhost.    root.localhost. (
                2004022800    ; serial
                8h            ; refresh
                1h            ; retry
                4w            ; expire
                1h )          ; negative TTL

        NS      localhost.
1       PTR     localhost.
; Don't forget the trailing dots!
```

RFC1918 reverse lookups

/etc/namedb/named.conf

```
zone "168.192.in-addr.arpa" {
    type master;
    file "master/null.zone";
};
zone "10.in-addr.arpa" {
    type master;
    file "master/null.zone";
};
# repeat for 16.172.in-addr.arpa
#     ... to  31.172.in-addr.arpa
```

/etc/namedb/master/null.zone

```
@       SOA     localhost.    root.localhost. (
                2004022800    ; serial
                8h            ; refresh
                1h            ; retry
                4w            ; expire
                1h )          ; negative TTL

        NS      localhost.
```

FreeBSD caching nameserver

- `named_enable="YES"`   *# in /etc/rc.conf*
- *For improved security, by default named is run inside a "chroot jail" under /var/named*
  - *accesses to /foo are actually to /var/named/foo*
  - *There is a symlink from /etc/namedb to /var/namedb/etc/namedb to make life easier*

Managing a caching nameserver

- `/etc/rc.d/named start`
- `rndc status`
- `rndc reload`
  - After config changes; causes less disruption than restarting the daemon
- `rndc dumpdb`
  - dumps current cache contents to `/var/named/var/dump/named_dump.db`
- `rndc flush`
  - Destroys the cache contents; don't do on a live system!

Absolutely critical!

- `tail /var/log/messages`
  - after any nameserver changes and reload/restart
- A syntax error may result in a nameserver which is running, but not in the way you wanted
- bind is very fussy about syntax
  - Beware } and ;
  - Within a zone file, comments start with semicolon (;) NOT hash (#)

Practical

- Build a caching nameserver
- Examine its operation