DNS Delegation

UNIVERSITY OF OREGON

NSRC
Network Startup Resource Center

Summary

- DNS is a distributed database
- Resolver asks Cache for information
- Cache traverses the DNS delegation tree to find Authoritative nameserver which has the information requested
- Bad configuration of authoritative servers can result in broken domains

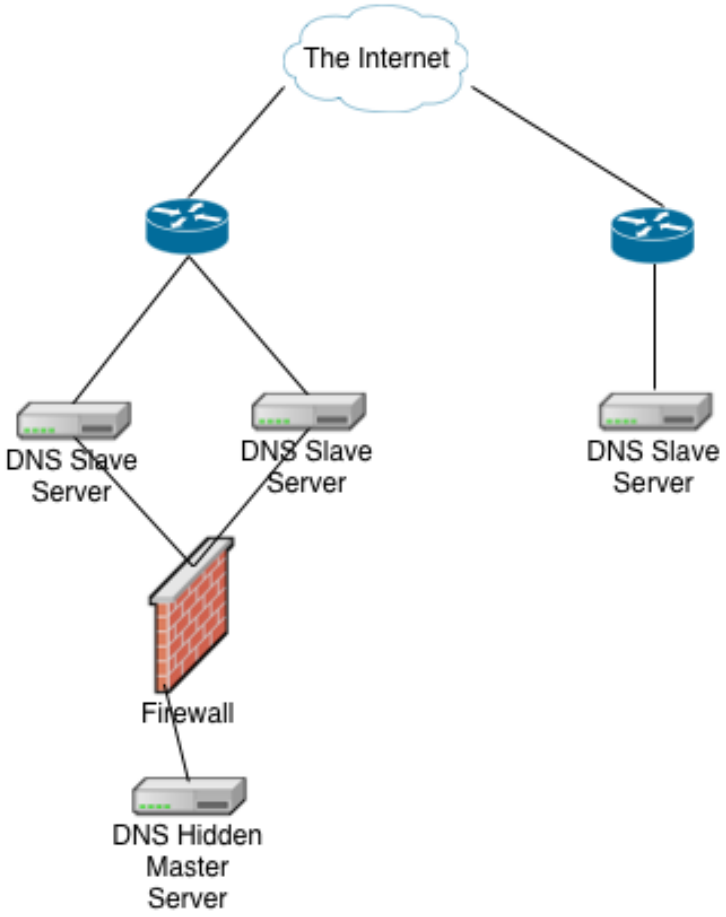
DNS replication

- For every domain, we need more than one authoritative nameserver with the same information (RFC 2182)
- Data is entered in one server (Master) and replicated to the others (Slave(s))
- Outside world cannot tell the difference between master and slave
- NS records are returned in random order for equal load sharing
- Used to be called "primary" and "secondary"

Hidden master server

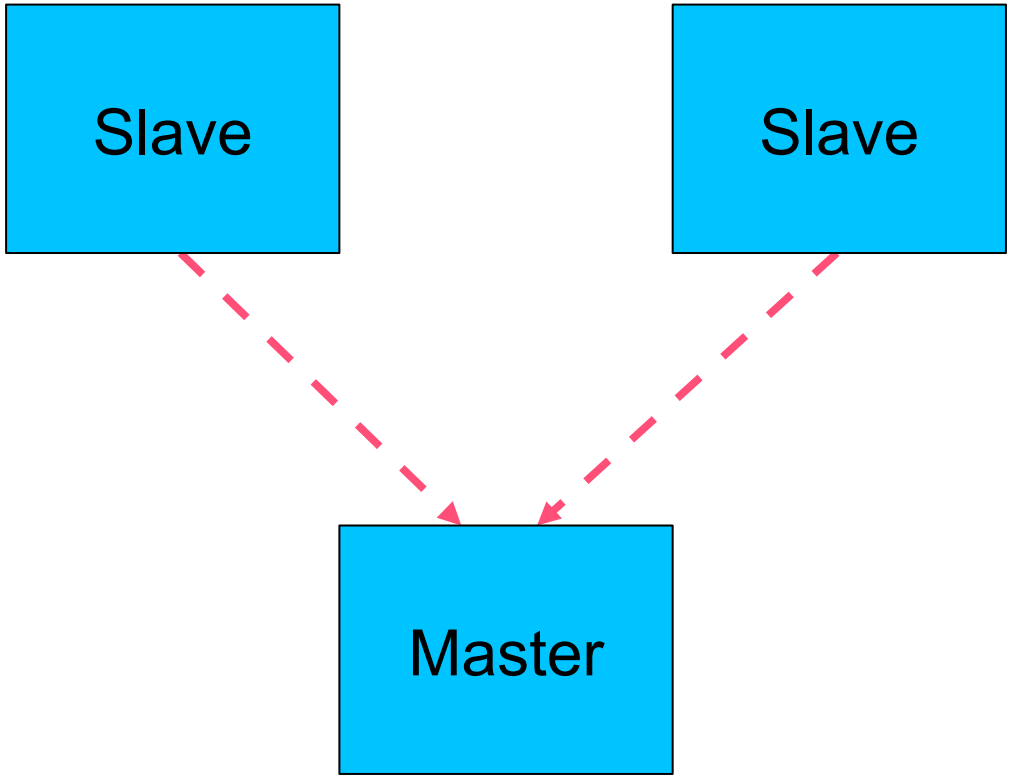
- Traditionally we set up a master and one or more slave servers
  - These are then all visible to the world
- A better architecture is to have a DNS master server which is not globally visible
- Slave servers replicate the data and serve it to world

Nameserver architecture



- DNS Slave servers:
  - different subnets on a campus
  - geographically separate
- DNS Master server:
  - Only visible to Slave servers
  - Not listed publicly as a nameserver

Slaves connect to Master to retrieve copy of zone data



When does replication take place?

- Slaves poll the master periodically - called the "Refresh Interval" - to check for new data
- Originally this was the only mechanism
- Master can also notify the slaves when the data changes
- Results in quicker updates
- The notification is unreliable (e.g. network might lose a packet) so we still need checks at the Refresh Interval

Serial Numbers

- Every zone file has a Serial Number
- Slave will only copy data when this number INCREASES
  - Periodic UDP query to check Serial Number
  - If increased, TCP transfer of zone data
- It is your responsibility to increase the serial number after every change, otherwise slaves and master will be inconsistent

Recommended serial number format: YYYYMMDDNN

- YYYY = year
- MM = month (01-12)
- DD = day (01-31)
- NN = number of changes today (00-99)
  - e.g. if you change the file on 5th March 2004, the serial number will be 2004030500. If you change it again on the same day, it will be 2004030501.

Serial Numbers: Danger 1

- If you ever decrease the serial number, the slaves will never update again until the serial number goes above its previous value
- RFC1912 section 3.1 explains a method to fix this problem
- At worst, you can contact all your slaves and get them to delete their copy of the zone data

Serial Numbers: Danger 2

- Serial no. is a 32-bit unsigned number
  - Range: 0 to 4,294,967,295
- Any value larger than this is silently truncated
- e.g. 20040305000 (note extra digit)
  - 4AA7EC968 (hex)
  - AA7EC968 (32 bits)
  - 2860435816
- If you make this mistake, then later correct it, the serial number will have decreased

Configuration of Master

- /etc/namedb/named.conf points to zone file (manually created) containing your RRs
- Choose a logical place to keep them
  - e.g. /etc/namedb/master/tiscali.co.uk

```
zone "example.com" {
        type master;
        file "master/example.com";
        allow-transfer { 192.188.58.126;
                         192.188.58.2; };
};
```

Configuration of Slave

- named.conf points to IP address of master and location where zone file should be created
- Slave zone files are transferred automatically
  - Don't edit them!

```
zone "example.com" {
        type slave;
        masters { 192.188.58.126; };
        file "slave/example.com";
        allow-transfer { none; };
};
```

Master and Slave

- In a traditional DNS master/slave setup it's perfectly OK for one server to be Master for some zones and Slave for others
- It's good practice to keep the files in different directories
  - /etc/namedb/master/
  - /etc/namedb/slave/
    - the slave directory must have appropriate permissions so that the daemon can create files

allow-transfer { ... }

- Remote machines can request a transfer of the entire zone contents
- You can control who is allowed to transfer a copy of the zone.
- By default, only nameservers of the zone can (as declared in the zone)
- You can set a global default, and override this for each zone if required

```
options {
    allow-transfer { 127.0.0.1; };
};
```

Structure of a zone file

- Global options
  - $TTL 1d
  - Sets the default TTL for all other records
- SOA RR
  - "Start Of Authority"
  - Housekeeping information for the zone
- NS RRs
  - List all the nameservers for the zone, master and slaves
- Other RRs
  - The actual data you wish to publish

Format of a Resource Record

www	3600	IN	A	212.74.112.80
Domain	*TTL*	*Class*	*Type*	*Data*

- One per line (except SOA can extend over several lines)
- If you omit the Domain Name, it is the same as the previous line
- TTL shortcuts: e.g. 60s, 30m, 4h, 1w2d
- If you omit the TTL, uses the $TTL default value
- If you omit the Class, it defaults to IN
- Type and Data cannot be omitted
- Comments start with SEMICOLON (;)

Shortcuts

- If the Domain Name does not end in a dot, the zone's own domain ("origin") is appended
- A Domain Name of "@" means the origin itself
  - e.g. in zone file for example.com:

```
@    means    example.com.
www  means    www.example.com.
```

If you write this…

```
$TTL 1d
@                               SOA  ( ... )
                                NS   ns0
                                NS   ns0.as9105.net.
; Main webserver
www                             A    212.74.112.80
                                MX   10 mail
```

it becomes…

```
example.com.          86400   IN   SOA  ( ... )
example.com.          86400   IN   NS   ns0.example.com.
example.com.          86400   IN   NS   ns0.as9105.net.
www.example.com.      86400   IN   A    212.74.112.80
www.example.com.      86400   IN   MX   10 mail.example.com.
```

Format of the SOA record

```
$TTL 1d

@   1h   IN   SOA   ns1.example.net. hervey.nsrc.org. (
                    2004030300      ; Serial
                    8h              ; Refresh
                    1h              ; Retry
                    4w              ; Expire
                    1h )            ; Negative

          IN   NS   ns1.example.net.
          IN   NS   ns2.example.net.
          IN   NS   ns1.othernetwork.com.
```

Format of the SOA record

- ns1.example.net.
  - hostname of master nameserver
- hervey.nsrc.org.
  - E-mail address of responsible person, with trailing dot - the first '.' maps to an '@'
  - in newer versions '.' can be written as '@'
  - what about fred.bloggs@example.com?
- Serial number
- Refresh interval
  - how often Slave checks serial number on Master
- Retry interval
  - how often Slave checks serial number if the Master did not respond

Format of the SOA record (cont)

- Expiry time
  - if the slave is unable to contact the master for this period of time, it will delete its copy of the zone data
- Negative Cache
  - indicates how long a cache may store the non-existence of a RR
  - old software used this as a minimum value of the TTL
- RIPE-203 has recommended values
  - https://www.ripe.net/publications/docs/ripe-203

Format of NS records

- List all public authoritative nameservers for the zone
  - master and slave(s) or
  - slaves only if using a hidden master
- Must point to HOSTNAME not IP address

```
$TTL 1d
@  1h  IN  SOA  ns1.example.net. brian.nsrc.org. (
             2004030300      ; Serial
             8h              ; Refresh
             1h              ; Retry
             4w              ; Expire
             1h )            ; Negative

       IN  NS  ns1.example.net.
       IN  NS  ns2.example.net.
       IN  NS  ns1.othernetwork.com.
```

Format of other RRs

```
IN   A       1.2.3.4
IN   AAAA    2404:2000:3F:AB::32
IN   CNAME   host.example.com.
IN   PTR     host.example.com.
IN   TXT     “any text you like"
IN   MX      10 mail.example.com.
```

- The MX number is a "preference value”.
  - Mail is delivered to the lowest-number MX first
  - Must point to HOSTNAME not IP address

When you have added or changed a zone file:

- Remember to increase the serial number!
- named-checkzone example.com \
  /etc/namedb/master/example.com
  - bind 9 feature
  - reports zone file syntax errors; correct them!
- named-checkconf
  - reports errors in named.conf
- rndc reload
  - or: rndc reload example.com
- tail /var/log/messages

These checks are ESSENTIAL

- If you have an error in named.conf or a zone file, named may continue to run but will not be authoritative for the bad zone(s)
- You will be “lame” for the zone without realising it
- Slaves will not be able to contact the master
- Eventually (e.g. 4 weeks later) the slaves will expire the zone
- Your domain will stop working

Other checks you can do

- dig +norec @x.x.x.x example.com. soa
  - Check the AA flag
  - Repeat for the master and all the slaves
  - Check the serial numbers match
- dig @x.x.x.x example.com. axfr
  - "Authority Transfer"
  - Requests a full copy of the zone contents over TCP, as slaves do to master
  - This will only work from IP addresses listed in the allow-transfer {...} section

So now you have working authoritative nameservers!

- But none of this will work until you have delegation from the domain above
  - That is, they put in NS records for your domain, pointing at your nameservers
  - You have also put NS records within the zone file
- The two sets should match

Any questions?

?

TOP TEN ERRORS in authoritative nameservers

- All operators of authoritative nameservers should read RFC 1912
  - Common DNS Operational and Configuration Errors
    - http://www.rfc-editor.org/info/rfc1912
- And also BCP 16 or RFC 2182
  - Selection and Operation of Secondary DNS servers
    - http://www.rfc-editor.org/bcp/bcp16.txt

1. Serial number errors

- Forgot to increment serial number
- Incremented serial number, then decremented it
- Used serial number greater than 2^{32}
- Impact:
  - Slaves do not update
  - Master and slaves have inconsistent data
  - Caches will sometimes get the new data and sometimes old - intermittent problem

2. Comments in zone files starting '#' instead of ';'

- Syntax error in zone file
  - Master is no longer authoritative for the zone
  - Slaves cannot check SOA
  - Slaves eventually expire the zone, and your domain stops working entirely
- Use "named-checkzone"
- Use "tail /var/log/messages"

3. Other syntax errors in zone files

- e.g. omitting the preference value from MX records
  - Same impact

4. Missing the trailing dot

```
; zone example.com.
@   IN   MX 10   mailhost.example.com

becomes

@   IN   MX 10   mailhost.example.com.example.com.
```

```
; zone 2.0.192.in-addr.arpa.
1   IN   PTR     host.example.com

becomes

1   IN   PTR     host.example.com.2.0.192.in-addr.arpa.
```

5. NS or MX records pointing to IP addresses

- They must point to hostnames, not IP addresses
  - Unfortunately, a few mail servers do accept IP addresses in MX records, so you may not see a problem with all remote sites

6. Slave cannot transfer zone from master

- Access restricted by allow-transfer {...} and slave not listed
- Or IP filters or firewalls not configured correctly
- Slave will be lame (non-authoritative)

7. Lame delegation

- You cannot just list any nameserver in NS records for your domain
  - You must get agreement from the nameserver operator, and they must configure it as a slave for your zone
- At best: slower DNS resolution and lack of resilience
- At worst: intermittent failures to resolve your domain

8. No delegation at all

- You can configure "example.com" on your nameservers but the outside world will not send requests to them until you have delegation
- The problem is hidden if your nameserver is acting both as your cache and as authoritative nameserver
- Your own clients can resolve:

  www.example.com
- but the rest of the world cannot

9. Out-of-date glue records

- See later!

10. Not managing TTL correctly during changes

- e.g. if you have a 24 hour TTL, and you change www.example.com to point to a new IP address, then there will be an extended period when some users hit one machine and some hit the other
- Follow the procedure:
  - Reduce TTL to 10 minutes
  - Wait at least 24 hours
  - Make the change
  - Put the TTL back to 24 hours

Practical

- Create a new domain
- Set up master and slave nameservice
- Obtain delegation from the domain above
- Test it

Advanced delegation

Summary: How do you delegate a subdomain?

- In principle straightforward: just insert NS records for the subdomain, pointing at someone else's servers
- If you are being careful, you should first check that those servers are authoritative for the subdomain
  - by using "dig +norec" on all the servers
- If the subdomain is managed badly, it reflects badly on you!
  - and you don't want to be fielding problem reports when the problem is somewhere else

Zone file for *example.net*

```
$TTL 1d
@   1h   IN   SOA   ns1.example.net. hervey@nsrc.org. (
                    2007112601      ; Serial
                    8h              ; Refresh
                    1h              ; Retry
                    4w              ; Expire
                    1h )            ; Negative

         IN   NS    ns1.example.net.
         IN   NS    ns2.example.net.
         IN   NS    ns1.othernetwork.com.

; A delegated subdomain
subdom   IN   NS    ns1.othernet.net.
         IN   NS    ns2.othernet.net.
```

There is one problem here:

- NS records point to names, not IP addresses
- What if zone "example.net" is delegated to "ns1.example.net"?
- Someone who is in the process of resolving (say) www.example.net first has to resolve ns1.example.net
- But in order to resolve ns1.example.net they must first resolve ns1.example.net !

In this case you need "glue"

- A "glue record" is an A or AAAA record for the nameserver, held higher in the tree
- Example: consider the .com nameservers, and a delegation for example.com

```
; this is the com. zone

example             NS   ns.example.com.
                    NS   ns.othernet.net.

ns.example.com.     A    192.0.2.1       ; GLUE RECORD
```

Checking for glue records

- dig +norec ... and repeat several times
  - Look for A records in the "Additional" section whose TTL does not count down

```
$ dig +norec @a.gtld-servers.net. www.as9105.net. a
 ...
;; flags: qr; QUERY: 1, ANSWER: 0, AUTHORITY: 2, ADDITIONAL: 1
;; QUERY SECTION:
;;      www.as9105.net, type = A, class = IN

;; AUTHORITY SECTION:
as9105.net.          172800  IN    NS        ns0.as9105.com.
as9105.net.          172800  IN    NS        ns0.tiscali.co.uk.

;; ADDITIONAL SECTION:
ns0.as9105.com.      172800  IN    A         212.139.129.130
```

Practical

- Delegating a subdomain

DNS: Summary

- Distributed database of Resource Records
  - e.g. A, AAAA, MX, PTR, ...
- Three roles: resolver, cache, authoritative
- Resolver statically configured with nearest caches
  - e.g. /etc/resolv.conf
- Caches are seeded with a list of root servers
  - zone type "hint", /etc/namedb/named.root
- Authoritative servers contain RRs for certain zones (part of the DNS tree)
  - replicated for resilience and load-sharing

DNS: Summary (cont)

- Root nameservers contain delegations (NS records) to gTLD or ccTLD servers (com, uk, ae, jp etc)
- These contain further delegations to subdomains
- Cache finally locates an authoritative server containing the RRs requested
- Errors in delegation or in configuration of authoritative servers result in no answer or inconsistent answers

Further reading

- "DNS and BIND" (O'Reilly) - 2006
  - http://shop.oreilly.com/product/9780596100575.do
- Internet Systems Consortium
  - https://www.isc.org/downloads/
  - BIND 9 Administrator Reference Manual
  - includes FAQ, security alerts
- RFC 1912, RFC 2182
  - http://www.rfc-editor.org/