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CSN09101
Networked Services
Week 7: Domain Name Server - DNS

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This lecture

- The Domain Name Service
- Linux BIND configuration
- Capturing a DNS lookup
- Discussions

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DNS

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Basics

- DNS – Domain Name Service
- Translates between machine names and IP.
- Two main types
  - Forward (domain to IP translation)
  - Reverse (IP to domain translation)

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Terminology

- Zone
  - A collection of hostnames and their IPs
- Nameserver
  - The server which responds to DNS queries. A question could be “Give me the IP of grussell.org”.
- Authoritive Nameserver
  - The server which has all the information for a zone stored locally
- Recursive Nameserver
  - If the nameserver is not authoritive for a zone, it is willing to go and ask other nameservers until it has asked an authoritive nameserver for the answer on your behalf. It then tells you the answer to your query.

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- Resolver
  - The part of an OS which sends the DNS questions to nameservers. It's a library which other programs will use. For instance, "ping grussell.org" would ask the resolver to "resolve" grussell.org. It goes on to ask a nameserver for the answer.
- Delegation
  - Sometimes a server does not know how to answer a query, but knows a server that can. The process of delegation effectively says that another server is delegated to answer your query, and you need to speak to them instead.
- Resource Record
  - Part of an answer to a query. An answer could be the IP for grussell.org, but there are other resource records (e.g. for email delivery and delegation).

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WHOIS

- When you register a domain, you have to give information to the registrar.
- This includes a contact name, address, and other contact details.
- You also have to give at least 2 authoritive nameservers.

```
$ whois napier.ac.uk
Registered For:
        Napier University
Servers:
        dns0.napier.ac.uk       146.176.1.5
        dns1.napier.ac.uk       146.176.2.5
Registrant Address:
        Napier University
        C&IT
        219 Colinton Road~Edinburgh
```

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DNS Distributed Database

- By way of an example, consider the following:

  $ ping www.napier.ac.uk

- The resolver in Linux is asked to find out the IP for www.napier.ac.uk
- The resolver contacts its local recursive nameserver and send it a DNS query.
- The resource record needed to translate a domain name into an IP is known as an “A” record.

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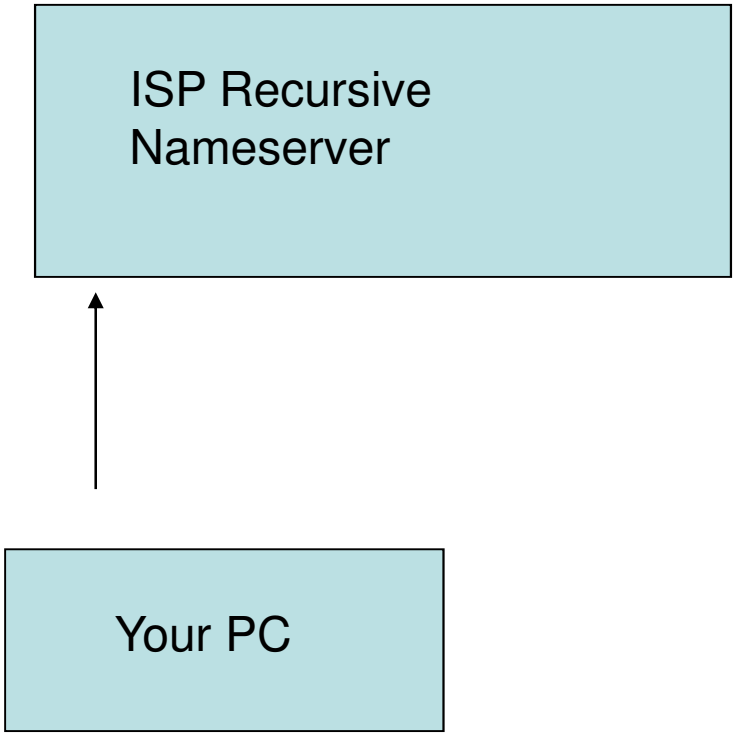
- Step 1: The resolver contacts the local ISP nameserver.
- It is not authoritive. If it has been asked before it might have cached the answer.
- In this case, no cached answer…



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- Step 2: ISP nameserver asks a root server...
- There are more than a dozen root servers.
- Their job is to direct your local nameserver to a nameserver which will help resolve the request.
- The root servers are pre-configured in the local nameserver, with names like:

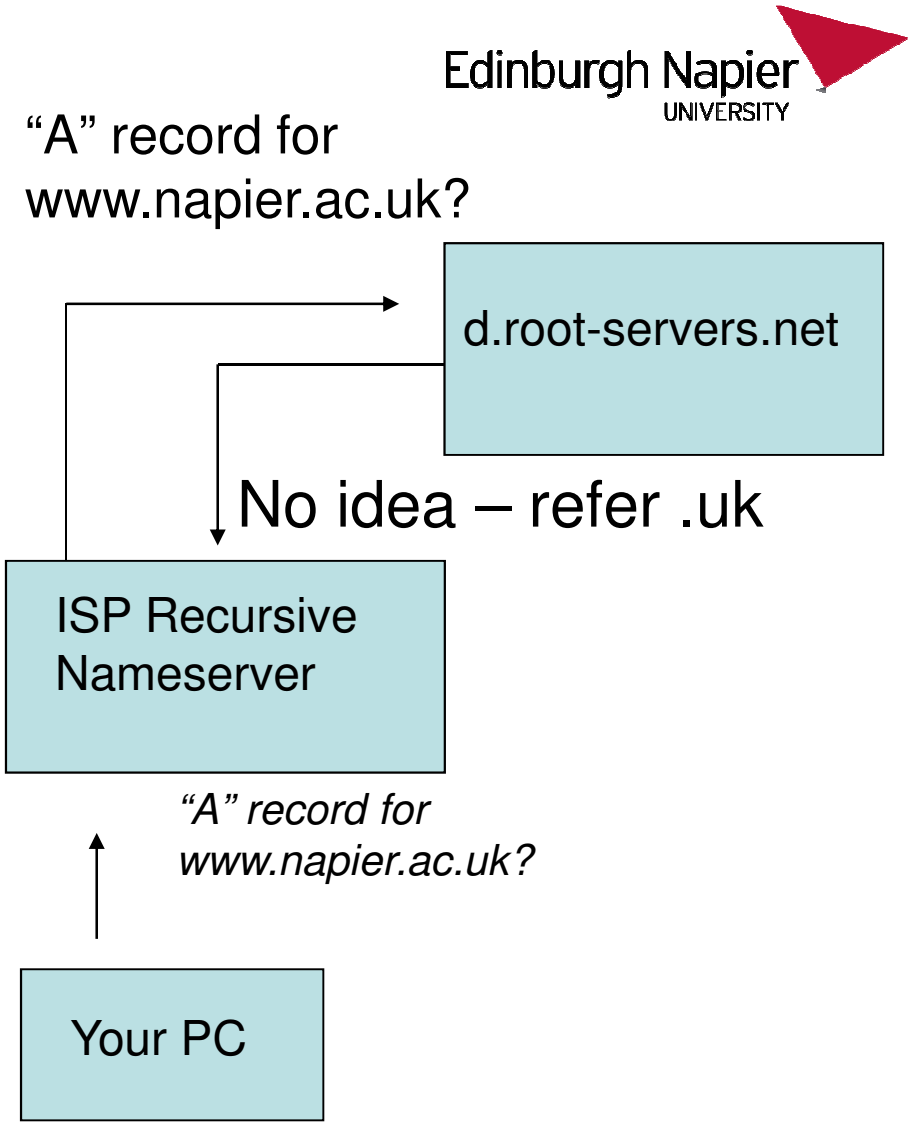
a.root-servers.net.

b.root-servers.net.

c.root-servers.net.

d.root-servers.net.

- Step 2: ISP nameserver asks a random root server...
- It doesn't know either, but offers a referral to nameservers which can help.



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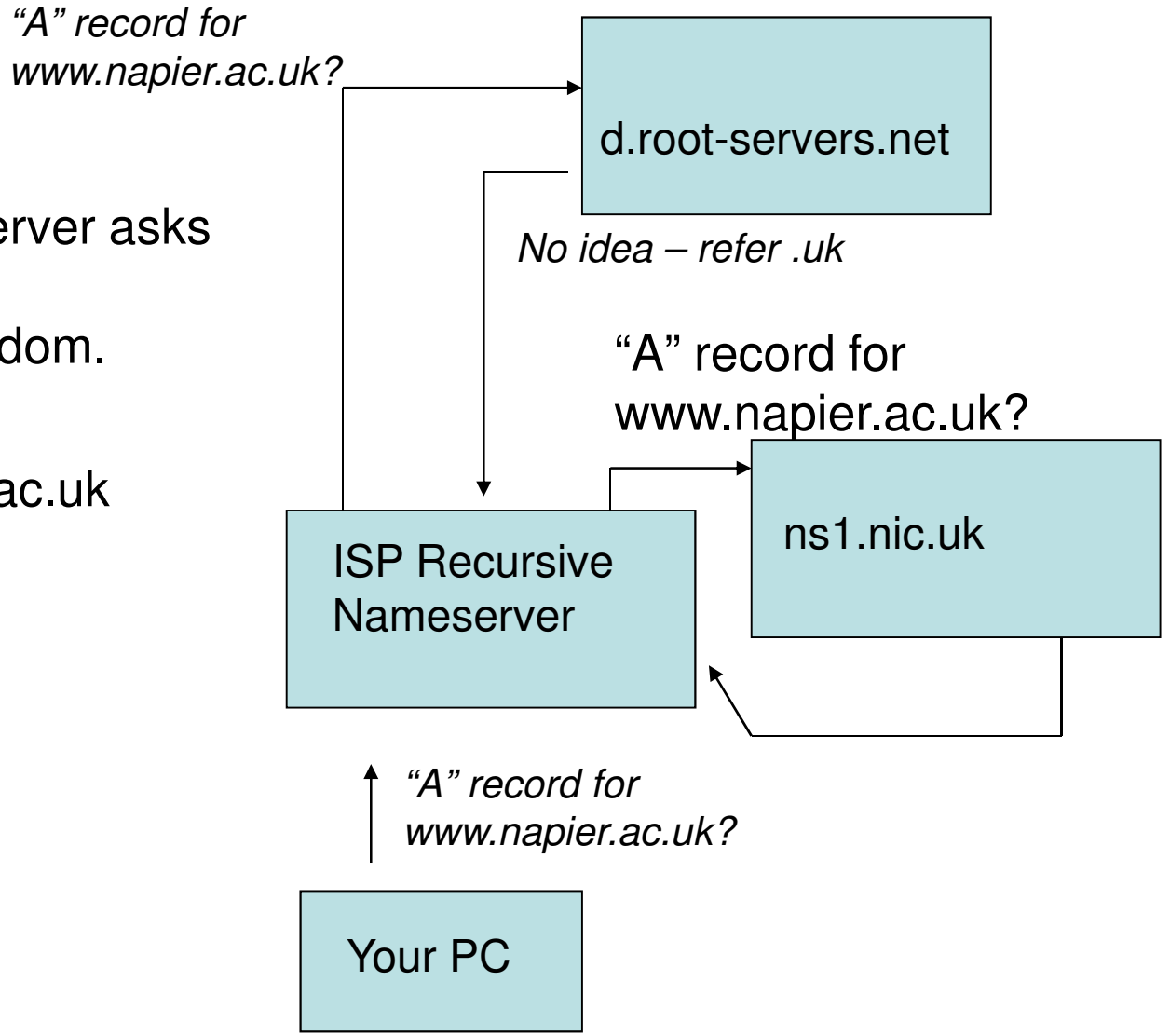
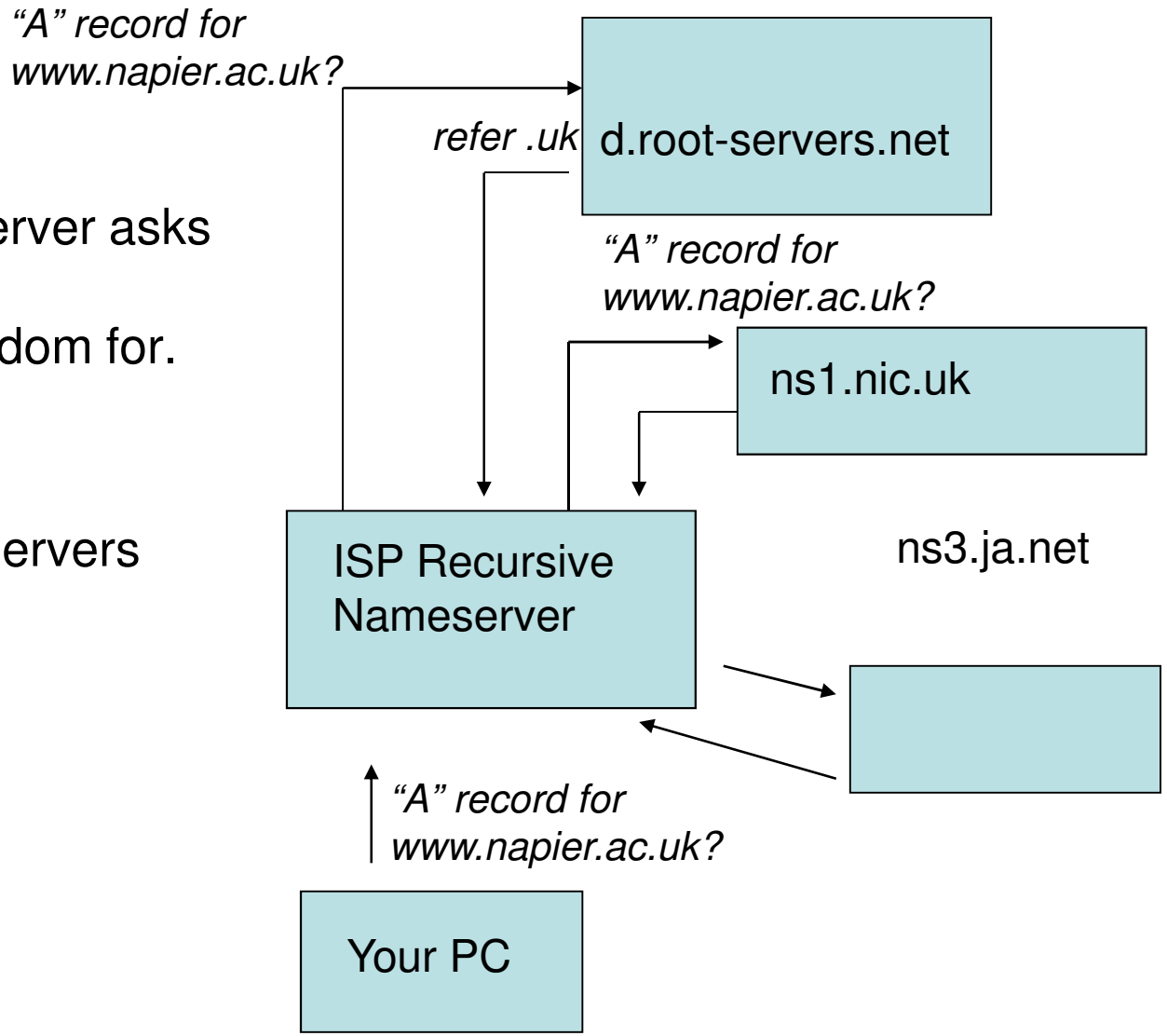
- The root server refers to another set of servers which can answer the query:
- NS are nameserver resource records.
- Note that you also get the A records of the nameservers for free.
- This extra information is referred to as the glue records.
- Without this we would have to look them up with a different query, so this saves time…

```
uk.                 172800  IN      NS      ns1.nic.uk.
uk.                 172800  IN      NS      ns2.nic.uk.
uk.                 172800  IN      NS      ns3.nic.uk.
uk.                 172800  IN      NS      ns4.nic.uk.
;; ADDITIONAL SECTION:
ns1.nic.uk.         172800  IN      A       195.66.240.130
ns2.nic.uk.         172800  IN      A       217.79.164.131
ns3.nic.uk.         172800  IN      A       213.219.13.131
ns4.nic.uk.         172800  IN      A       194.83.244.131
```

- Step 3: ISP nameserver asks one of the referral nameservers at random.
- Another referral.
- Receive NS list for ac.uk nameservers



- Step 4: ISP nameserver asks one of the referral nameservers at random for.
- Another referral.
- Receive NS list for napier.ac.uk nameservers



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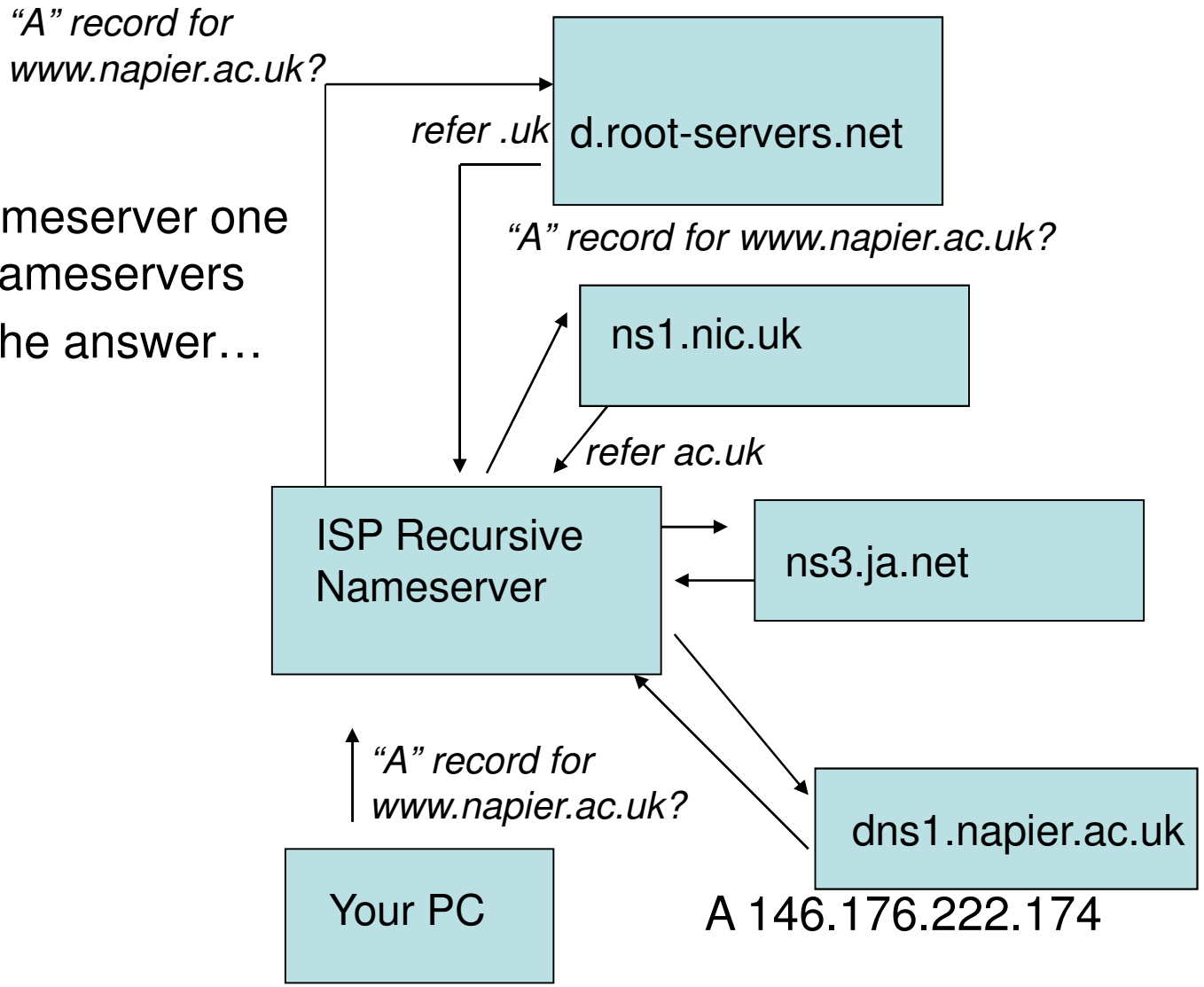
- The ja.net nameserver responded with the authoritive nameservers for Napier.
- The last step is to ask one of the authoritive nameservers for www.napier.ac.uk

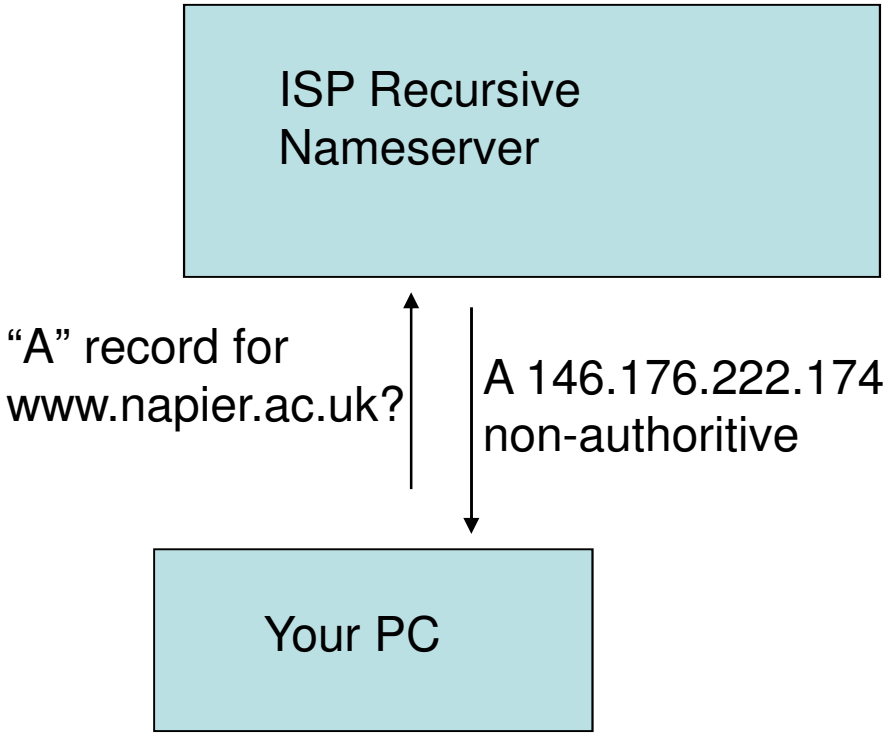
```
napier.ac.uk.        86400   IN      NS      dns1.napier.ac.uk.
napier.ac.uk.        86400   IN      NS      dns0.napier.ac.uk.

;; ADDITIONAL SECTION:
dns0.napier.ac.uk.   86400   IN      A       146.176.1.5
dns1.napier.ac.uk.   86400   IN      A       146.176.2.5
```

- Step 5: ISP nameserver one of the napier nameservers
- Finally it gets the answer…



- The answer from Napier was AUTHORITIVE.
- It is cached in the ISP.
- The cached version is returned to you.
- As it is cached, it is non-authoritive.



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Manual Lookups

- If we are running our own DNS servers, or just having trouble making the resolver work, we can make our own queries using “dig”

$ whois napier.ac.uk
Domain servers in listed order:
dns0.napier.ac.uk 146.176.1.5
dns1.napier.ac.uk 146.176.2.5

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> dig www.napier.ac.uk @dns0.napier.ac.uk

```
www.napier.ac.uk.       86400   IN      A       146.176.222.174

;; AUTHORITY SECTION:
napier.ac.uk.           86400   IN      NS      dns0.napier.ac.uk.
napier.ac.uk.           86400   IN      NS      dns1.napier.ac.uk.

;; ADDITIONAL SECTION:
dns0.napier.ac.uk.      86400   IN      A       146.176.1.5
dns1.napier.ac.uk.      86400   IN      A       146.176.2.5
```

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Reverse Lookup

- Reverse is working out that given 146.176.222.174, the host is www.napier.ac.uk.
- A special domain name is used for IP to Domain Name translation
- The domain is the IP in reverse, ending with IN-ADDR.ARPA
- You need to take the first 3 elements of the IP first to find the right server, then query that server with the full IP.
- The resource record for reverse DNS is PTR.

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```
> dig 222.176.146.IN-ADDR.ARPA
…
;; AUTHORITY SECTION:
222.176.146.IN-ADDR.ARPA. 86400 IN      SOA     dns0.napier.ac.uk.
    root.central.napier.ac.uk. 200808271 28800 7200 604800 86400

> dig 174.222.176.146.IN-ADDR.ARPA @dns0.napier.ac.uk -t any
…
;; ANSWER SECTION:
174.222.176.146.IN-ADDR.ARPA. 86400 IN  PTR     www.napier.ac.uk.
```

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Linux DNS

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Resolver in Linux

- You now know how DNS forward and reverse works. But you do not have to do all the repeated queries yourself!
- The resolver looks after all the lookups.

- As an example, consider a command
  > ping www.linuxzoo.net
- The computer needs to find the IP number…

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$ cat /etc/host.conf

order hosts,bind

- This is the schemes used to translate DNS.
  - hosts – use the /etc/hosts file
  - bind – use dns

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/etc/hosts

- This file is the simplest lookup.
- It is called “host” resolution.
- The file has lines like

127.0.0.1 localhost.localdomain localhost

- It is IP, then hostname, then aliases for the host.
- Its fast and simple, but only lists machines you edit yourself into the file.
- It is good for “kickstarting” finding key machines.

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> cat /etc/resolv.conf

search linuxzoo.net net
nameserver 10.200.0.1

- Not found in /etc/hosts? Check resolve.conf and use bind.
- nameserver – who to ask (our nameserver)
- search – add these to the host if not found.
  - Looking for www.linuxzoo? This search would try “www.linuxzoo”, “www.linuxzoo.linuxzoo.net”, “www.linuxzoo.net”. If still not found then fail.
  - This is a convenience for users.

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> dig www.linuxzoo.net @10.200.0.1

- Ask your nameserver.

1. If nameserver knows the answer, return it.
2. If unknown, nameserver recurses (plus store the answer in a cache).
3. If no one knows after recursion, return a failure.

- If resolv.conf has multiple nameserver entries, each one is tried until all are tried or the answer is returned from one of them.

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Your own nameserver

- You might want to run your own nameserver if:
  - You perform lookups frequently and want to cache the queries locally
  - You want to query the root servers directly without having to talk via a local nameserver.
  - You want to add your own entries to DNS
    - You run your own domain and want to control your DNS entries directly.
    - You have local IPs and want to name them on your own network.

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Nameserver daemons

- The most popular is “named”.
- It is installed on the UML simulations.
- It is part of the bind9 distribution (www.isc.org).
- It is popular, but other services are available.
  - Common systems are often targetting for hacking attacks.
  - NAMED is often cited as a security problem.
  - It needs to be patched often.
  - It should be secured using addition security technology.
    - It can be run in a chroot.
    - It can use SELinux if available.
    - It can use both! In our labs we will use SELinux security.

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What is a chroot

- Many Linux services can be run “chroot”.
- This gives a new “/” directory just for that service.
- It contains only the minimum files and directories.
- The contents are (when possible) owned by a different user than the one who owns the service.
- The service should not be executed as root.
- Service runs as a user who does nothing else but run that service.
- Hack the service and you are stuck in a directory with little contents, you can change very little, with a user which can do nothing… If possible, always run services in a chroot!

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SELinux protection

- In our experiments we will not be using a chroot for additional security.
- Instead we will use SELinux.
  - This gives the kernel a set of rules which named must obey, including what files can be opened and what sort of network connections can be made.
  - Fortunately this is all pre-configured in Fedora and thus completely invisible to us as administrators.

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RNDC

- RNDC allows you to administer NAMED remotely.
- Obviously this has to happen with some security.
- RNCD uses a signed key to validate its security credentials.
- In a non-chroot solution this needs only to be stored in /etc/rndc.key
- If you are (for some reason) using a chroot it must also be copied to /var/named/chroot/etc/rndc.key

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Generate the key

- In a normal installation, you should generate your own key.
- In linuxzoo, you get the key generated automatically. This is a good thing, as generating the key in linuxzoo turns out to be problematic. DON'T.
- However, if you want to generate your own key (ignoring my advice) then:

$ rndc-confgen –a –b 128 –r keyboard

  - -b 128 – Sets the bits to 128 (fast but weak)
  - -r keyboard – Random keys require "entropy". Normally done with /dev/random, but in UML this does not work well. This option asks you to type randomly for a while, and use your keyboard rhythm to generate the random number!
  - The only time you want to do this in linuxzoo is if you deleted the key file!

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/etc/named.conf

- Really two parts – options and zone
  - Options allow run time configurations and global defaults to be set.
  - Zone entries allow us to set up a forward or reverse entry for a domain.

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Master and slave

- There are two distinct types of zone:
  - Master- they have the zone definitions and you can edit that information if you wish
  - Slave- they copy the zone definition automatically from the master. Their copy is read only, so you cannot edit the records on a slave.
- Slave nameservers are needed to give DNS higher reliability and redundancy. You edit on a master and the change is copied to all your slaves. Slave configuration is not considered further here.
- The master is often called a PRIMARY, and any slaves called SECONDARIES. But these names are badly abused, so stick with master/slave.

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```
zone "." IN {
        type hint;
        file "named.ca";
};
```

This tells the daemon to use the root servers listed in named.ca to resolve things not solved by other entries. This can be considered the “default”.

```
options {
        directory "/var/named";
        forward only;
};
```

- Nothing exciting in this part.
- Note that in linuxzoo, DNS requests to the roots (or anywhere else) are intercepted my the linuxzoo filewall and redirected to 10.200.0.1.
- This keeps the load on the root servers down, and makes it harder for people to use linuxzoo to hack the planet…
- Also allows my name service to falsify records – needed to make things work right in the UMLs.

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

- The file localhost.zone gives forward resolving for the domain “localhost”.

```
zone "0.0.127.in-addr.arpa" IN {
        type master;
        file "named.local";
        allow-update { none; };
};
```

- The named.local file give reverse lookups for the 127.0.0.0/24 IP range.

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localhost.zone

```
$TTL    86400
$ORIGIN localhost.
@                   1D IN SOA       @ root (
                                        42              ; serial (d. adams)
                                        3H              ; refresh
                                        15M             ; retry
                                        1W              ; expiry
                                        1D )            ; minimum

                    1D IN NS        @
                    1D IN A         127.0.0.1
```

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named.local

```
$TTL    86400
@       IN      SOA     localhost. root.localhost.  (
                                1997022700 ; Serial
                                28800      ; Refresh
                                14400      ; Retry
                                3600000    ; Expire
                                86400 )    ; Minimum
            IN      NS      localhost.

1       IN      PTR     localhost.
```

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Example : grussell.org, in IP 50.1.1.0/24

- /etc/named.conf zone for this:

```
zone "grussell.org" IN {
        type master;
        file "grussell.zone";
        allow-update { none; };
};
zone “1.1.50.in-addr.arpa" IN {
        type master;
        file “grussell.rev";
        allow-update { none; };
};
```

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> cat /var/named/grussell.zone

```
$TTL    86400
$ORIGIN grussell.org.
@                       1D IN SOA       ns1 admin.grussell.org. (
                                2004101701              ; serial
                                3H                      ; refresh
                                15M                     ; retry
                                1W                      ; expiry
                                1D )                    ; minimum

                        1D IN NS        ns1
                        1D IN A         50.1.1.1
www                             CNAME           grussell.org.
ns1                             1D IN A         50.1.1.10
```

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> cat /var/named/grussell.rev

```
$TTL    86400
@       IN      SOA     ns1.grussell.org. admin.grussell.org.  (
                                1997022700 ; Serial
                                28800      ; Refresh
                                14400      ; Retry
                                3600000    ; Expire
                                86400 )    ; Minimum
        IN      NS      ns1.grussell.org.

1       IN      PTR     grussell.org.
10      IN      PTR     ns1.grussell.org.
```

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MX (Mail Exchange) records

host1	IN	MX	10	host1
	IN	MX	20	backuphost
	IN	MX	30	mx.easydns.com.

- Priority goes to lowest number.
- No dot and end – add the origin.

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Load Balancing

- With 1 server providing a service, only that server can handle requests.
- Multiple servers can handle requests in parallel.
- But how can a single server name be made automatically share out requests to multiple servers?
- Load balancing does this…

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Email server balancing

host1	IN	MX	10	smtp1
	IN	MX	10	smtp2
	IN	MX	10	smtp3
smtp1	IN	A		10.0.0.1
smtp2	IN	A		10.0.0.2
smtp3	IN	A		10.0.0.3

- Equal priority MX records are usually randomly utilised
- Selection mechanism is mail application dependent

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Email server balancing with A

host1	IN	MX	10	smtp
smtp	IN	A		10.0.0.1
	IN	A		10.0.0.2
	IN	A		10.0.0.3

- Chosen using rrset-order (default is random)
- Make sure reverse of .1,.2,.3 -> smtp.domain.com

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Server balancing with A

www	IN	A	10.0.0.1
	IN	A	10.0.0.2
	IN	A	10.0.0.3
ftp	IN	A	10.0.0.10
ftp	IN	A	10.0.0.11

- Chosen using rrset-order (default is random)
- The effect of caching needs to be considered
- The distribution of load needs to be considered

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DNS record types

- SOA – Start of authority, gives params for zone
- A6 – handle ipv6 references
- NS – useful in delegation but basically ignored.
- CNAME – an alias
- HINFO – Hardware and OS being ran.
- RP – who to send emails to.
- TXT – useful text – for instance can be used to certify email server IP number for some span detection software.

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Capturing DNS

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Demonstration of a DNS Query

- To capture packets, use tcpdump.
- It has many options (see man tcpdump).
- Here, we want to capture just packets to do with DNS (port 53), so “port 53”.
- tcpdump likes to translate ips into names, and will generate its own DNS lookups. To stop that use “-n”.

$ tcpdump –n port 53 > dump &

$ dig www.napier.ac.uk

$ kill -9 %1

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Dump file

```
$ cat dump
17:48:54.147146 IP 146.176.162.6.40501 > 146.176.2.5.domain:  6869+
    A? www.napier.ac.uk. (34)
17:48:54.148326 IP 146.176.2.5.domain > 146.176.162.6.40501:  6869*
    1/2/2 A 146.176.222.174 (120)
```

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Discussion

Discussion

- Spot the error(s)

```
$TTL    86400
$ORIGIN broken.net.
@                       1D IN SOA       ns1 admin@grussell.org. (
                                2004101701                  ; serial
                                3H                  ; refresh
                                15M                 ; retry
                                1W                  ; expiry
                                1D )                ; minimum

                        1D IN NS      ns1
                        1D IN A       10.0.0.1
www                     CNAME         broken.net.
ns1                     1D IN A       10.0.0.10.
ns2.                    1D IN A       10.0.0.11.
```

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Discussion

- Here are some mock exam questions you should now be able to answer:

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Question 1

Provide a forward DNS file for the domain test.com. The parameters of the SOA are unimportant. Make sure of the following:

test.com maps to 1.0.0.1
www.test.com is an alias to test.com
email.test.com is 1.0.0.2
A nameserver exists at 1.0.0.10
Email to test.com goes to the email host.

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Question 2

In a server using DNS round robin load balancing across three different A records, discuss what would happen if one of the machines associated with one of the A records failed. How could such a problem be managed?