DNS/DNSSEC Workshop

DNS Refresher

UNIVERSITY OF OREGON

NSRC
Network Startup Resource Center

Overview

- Goal of this session
- What is DNS ?
- How is DNS built and how does it work?
- How does a query work ?
- Record types
- Caching and Authoritative
- Delegation: domains vs zones
- Finding the error: where is it broken?

Goal of this session

- We will review the basics of DNS, including query mechanisms, delegation, and caching.
- The aim is to be able to understand enough of DNS to be able to configure a caching DNS server, and troubleshoot common DNS problems, both local and remote (on the Internet)

What is DNS ?

- System to convert names to IP addresses:

  nsrc.org. => 128.223.157.19

  www.afrinic.net. => 2001:42d0::200:80:1

- ... and back:

  128.223.157.19 => nsrc.org.

  1.0.0.0.0.8.0.0.0.0.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
  d.2.4.1.0.0.2.ip6.arpa. => www.afrinic.net.

What is DNS ?

- Other information can be found in DNS:
  - where to send mail for a domain
  - who is responsible for this system
  - geographical information
  - etc…
- How do we look this information up ?

Basic DNS tools

- Using the host command:

  # host nsrc.org.

  nsrc.org. has address 128.223.157.19

  # host 128.223.157.19

  19.157.223.128.in-addr.arpa domain name pointer nsrc.org.

Basic DNS tools

- Host with IPv6:

```
# host www.afrinic.net
www.afrinic.net has IPv6 address 2001:42d0::200:80:1

# host 2001:42d0::200:80:1
1.0.0.0.0.8.0.0.0.0.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
d.2.4.1.0.0.2.ip6.arpa domain name pointer www.afrinic.net.
```

Basic DNS tools

- Try this yourself with other names – first lookup the names below, then do the same for the IP address returned:

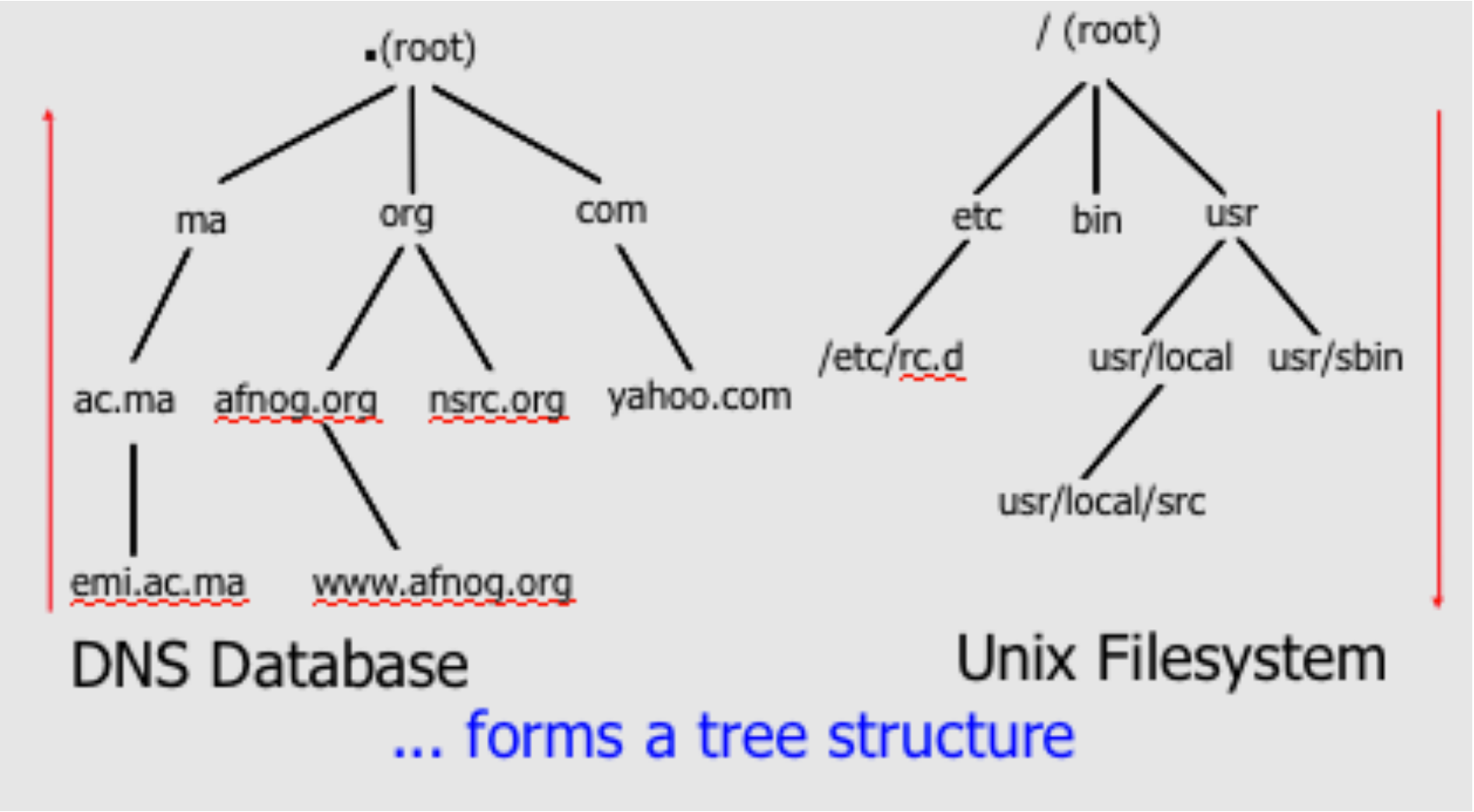
  www.yahoo.com

  www.nsrc.org

  ipv6.google.com

- Does the lookup of the IP match the name ? Why ?
- Where did the 'host' command find the information ?

How is DNS built?



How is DNS built?

- DNS is hierarchical
- DNS administration is shared – no single central entity administrates all DNS data
- This distribution of the administration is called delegation

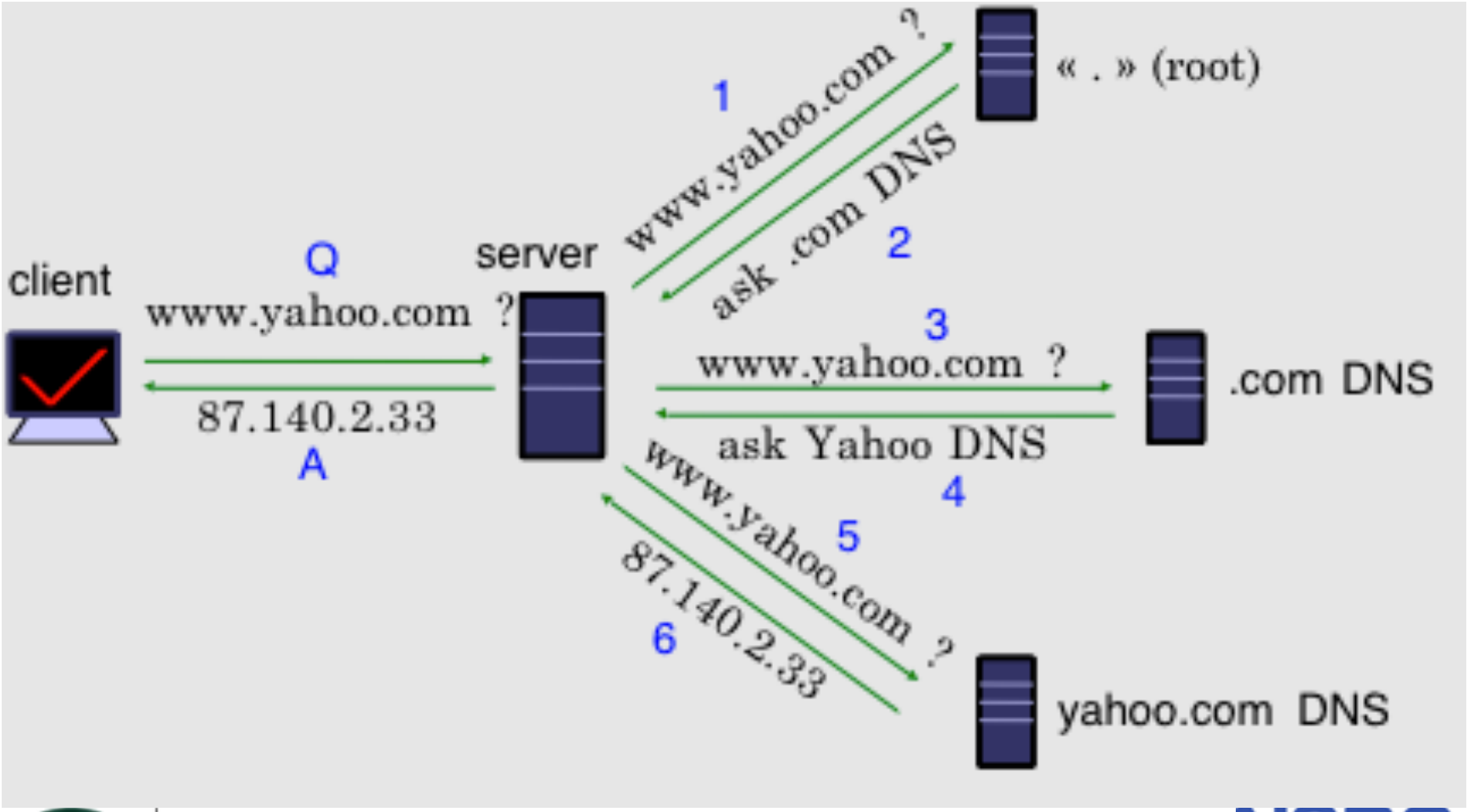
How does DNS work ?

- Clients use a mechanism called a resolver and ask servers – this is called a query
- The server being queried will try to find the answer on behalf of the client
- The server functions recursively, from top (the root) to bottom, until it finds the answer, asking other servers along the way - the server is referred to other servers

How does DNS work ?

- The client (web browser, mail program, ...) use the OS's resolver to find the IP address.
- For example, if we go to the webpage www.yahoo.com:
  - the web browser asks the OS
    "I need an IP for www.yahoo.com"
  - the OS looks in the resolver configuration for details of the server to ask, and sends the query
- On UNIX, /etc/resolv.conf is where the resolver is configured

A DNS query


client
Q
www.yahoo.com ?
87.140.2.33
A
server
1
www.yahoo.com ?
2
ask .com DNS
« . » (root)
3
www.yahoo.com ?
ask Yahoo DNS
4
.com DNS
5
www.yahoo.com ?
6
87.140.2.33
yahoo.com DNS

Query detail with tcpdump

- On the server, run tcpdump as root:

  $ sudo tcpdump –s 1500 -n port 53

- In another window/screen do:

  $ host circa.ecs.vuw.ac.nz

  circa.ecs.vuw.ac.nz has address 130.195.5.10

  circa.ecs.vuw.ac.nz mail is handled by 0 kaukau.ecs.vuw.ac.nz.

Query detail – example output

18:14:03.723243 IP 103.10.233.88.38541 > 130.195.6.10.53: 31507% [1au] A? circa.ecs.vuw.ac.nz. (48)

18:14:03.724492 IP 130.195.6.10.53 > 103.10.233.88.38541: 31507*- 1/4/3 A 130.195.5.10 (198)

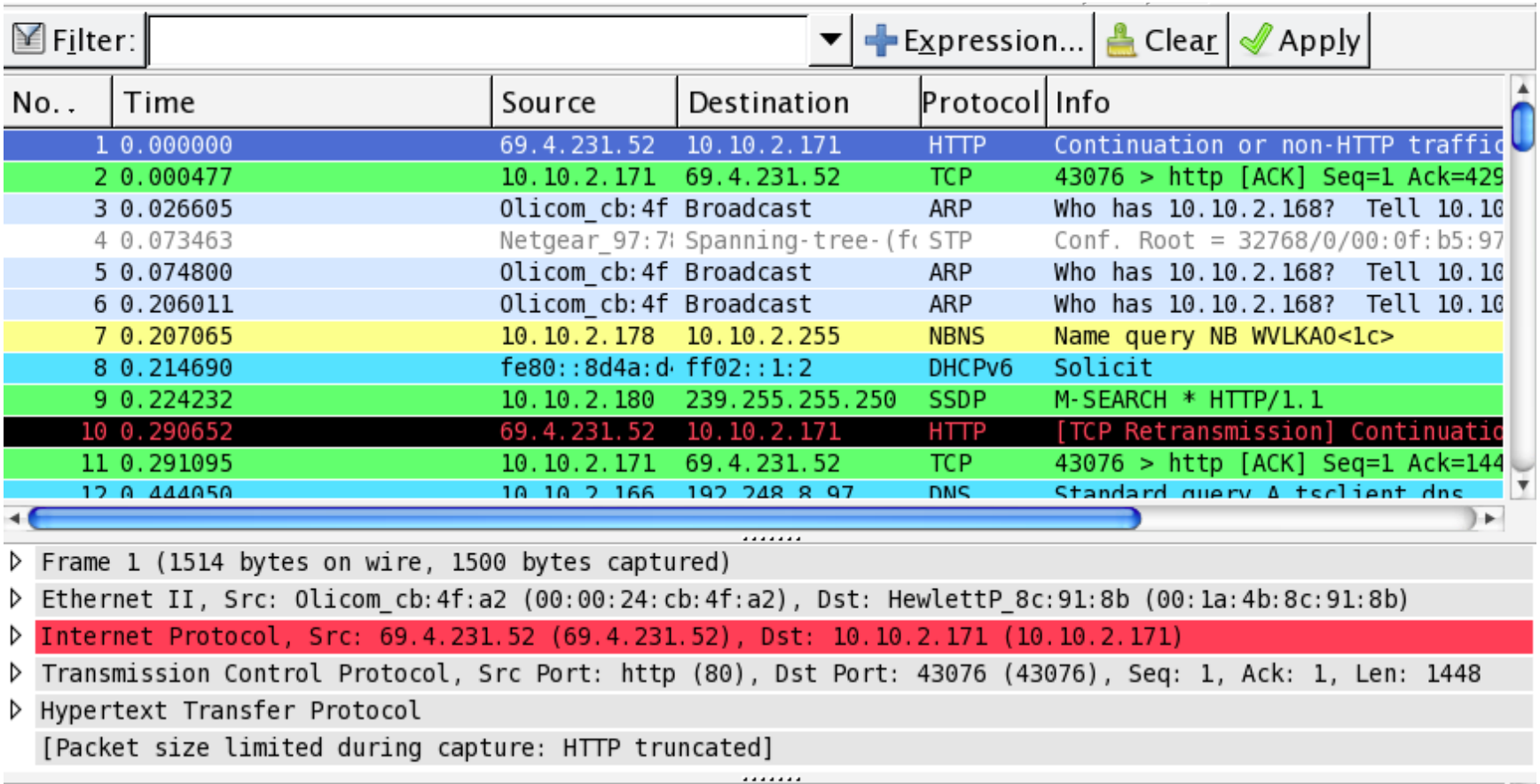
18:14:03.725216 IP 103.10.233.88.13650 > 130.195.5.12.53: 45724% [1au] AAAA? circa.ecs.vuw.ac.nz. (48)

18:14:03.726586 IP 130.195.5.12.53 > 103.10.233.88.13650: 45724*- 0/1/1 (93)

18:14:03.726951 IP 103.10.233.88.40996 > 130.195.5.12.53: 60113% [1au] MX? circa.ecs.vuw.ac.nz. (48)

18:14:03.728569 IP 130.195.5.12.53 > 103.10.233.88.40996: 60113*- 1/4/4 MX kaukau.ecs.vuw.ac.nz. 0 (221)

Query detail with wireshark



Resolver configuration

- So how does your computer know which server to ask to get answers to DNS queries ?
  - On UNIX, look in /etc/resolv.conf
- Look now in the file, and verify that you have a 'nameserver' statement of the form:

  nameserver a.b.c.d

  or

  nameserver ip:v6:ad:dr:es:ss
- ... where a.b.c.d is the IPv4/IPv6 of a functioning DNS server
- Why can't this be a "domain name"?

Finding the root...

- The first query is directed to one of the thirteen root nameservers e.g.

  192.112.36.4 (g.root-servers.net.)

- How does the server know where to reach the root servers ?
- Chicken-and-egg problem
- Each nameserver has a list of the root nameservers (a – m.root-servers.net) and their IPv4 and IPv6 addresses
  - In BIND, named.root

Using 'dig' to get more details

- The 'host' command is limited in its output – good for lookups, but not enough for debugging.
- We use the 'dig' command to obtain more details
- dig shows a lot of interesting stuff...

dig nsrc.org - gives more details

```
; <<>> DiG 9.8.3-P1 <<>> nsrc.org
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 38112
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 3, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;nsrc.org.                      IN      A

;; ANSWER SECTION:
nsrc.org.               84851   IN      A       128.223.157.19

;; AUTHORITY SECTION:
nsrc.org.               58315   IN      NS      phloem.uoregon.edu.
nsrc.org.               58315   IN      NS      ruminant.uoregon.edu.
nsrc.org.               58315   IN      NS      rip.psg.com.

;; Query time: 0 msec
;; SERVER: 127.0.0.1#53(127.0.0.1)
;; WHEN: Sat Feb 14 18:32:18 2015
;; MSG SIZE  rcvd: 133
```

```
noc# dig www.afrinic.net any

; <<>> DiG 9.4.2 <<>> any www.afrinic.net
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 36019
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 6, ADDITIONAL: 10

;; QUESTION SECTION:
;www.afrinic.net.          IN   ANY

;; ANSWER SECTION:
www.afrinic.net. 477      IN   AAAA     2001:42d0::200:80:1
www.afrinic.net. 65423    IN   A        196.216.2.1

;; AUTHORITY SECTION:
afrinic.net.      65324   IN   NS       sec1.apnic.net.
afrinic.net.      65324   IN   NS       sec3.apnic.net.
afrinic.net.      65324   IN   NS       ns1.afrinic.net.
afrinic.net.      65324   IN   NS       tinnie.arin.net.
afrinic.net.      65324   IN   NS       ns.lacnic.net.
afrinic.net.      65324   IN   NS       ns-sec.ripe.net.

;; ADDITIONAL SECTION:
ns.lacnic.net.    151715  IN   A        200.160.0.7
ns.lacnic.net.    65315   IN   AAAA     2001:12ff::7
ns-sec.ripe.net.  136865  IN   A        193.0.0.196
ns-sec.ripe.net.  136865  IN   AAAA     2001:610:240:0:53::4
ns1.afrinic.net.  65315   IN   A        196.216.2.1
tinnie.arin.net.  151715  IN   A        168.143.101.18
sec1.apnic.net.   151715  IN   A        202.12.29.59
sec1.apnic.net.   151715  IN   AAAA     2001:dc0:2001:a:4608::59
sec3.apnic.net.   151715  IN   A        202.12.28.140
sec3.apnic.net.   151715  IN   AAAA     2001:dc0:1:0:4777::140

;; Query time: 1 msec
;; SERVER: 196.200.218.1#53(196.200.218.1)
;; WHEN: Tue May 27 08:48:13 2008
;; MSG SIZE  rcvd: 423
```

dig output

- Some interesting fields:
  - flags section: qr aa ra rd
  - status
  - answer section
  - authority section
  - TTL (numbers in the left column)
  - query time
  - server
- Notice the 'A' and 'AAAA' record type in the output.

Record types

- Basic record types:
  - A, AAAA: IPv4, IPv6 address
  - NS: NameServer
  - MX: Mail eXchanger
  - CNAME: (alias) Canonical name
  - PTR: Reverse information

Caching vs Authoritative

- In the dig output, and in subsequent outputs, we noticed a decrease in query time if we repeated the query
- Answers are being cached by the querying nameserver, to speed up requests and save network resources
- The TTL value controls the time an answer can be cached
- DNS servers can be put in two categories: caching and authoritative

Caching vs Authoritative: authoritative

- Authoritative servers typically only answer queries for data over which they have authority
  - i.e. data for which they have an external copy, from disk (file or database)
- If they do not know the answer, they will point to a source of authority, but will not process the query recursively.

Caching vs Authoritative: caching

- Caching nameservers act as query forwarders on behalf of clients, and cache answers for later.
- Can be the same software (often is), but mixing functionality (recursive/caching and authoritative) is discouraged (security risks + confusing)
- The TTL of the answer is used to determine how long it may be cached without re-querying.

TTL values

- TTL values decrement and expire
- Try repeatedly asking for the A record for www.yahoo.com:

  # dig www.yahoo.com
- What do you observe about the query time and the TTL ?

SOA

Let's query the SOA for a domain:

```
# dig SOA <domain>
...
;; AUTHORITY SECTION:
<domain>. 860 IN SOA ns.<domain>. root.<domain>.
                     200702270          ; serial
                     28800              ; refresh
                     14400              ; retry
                     3600000            ; expire
                     86400              ; neg ttl
...
```

SOA

- The two fields highlighted are:
  - ns.<domain>
    - the SOA (Start Of Authority), which the administrator sets to the name of the « source » server for the domain data (this is not always the case)
  - root.<domain>
    - the RP (Responsible Person), which is the email address (with the first @ replaced by a '.') to contact in case of technical problems.

SOA

- The other fields are:
  - serial: the serial number of the zone: this is used for replication between two nameservers
  - refresh: how often a replica server should check the master to see if there is new data
  - retry: how often to retry if the master server fails to answer after refresh.
  - expire: when the master server has failed to answer for too long, stop answering clients about this data.
- Why is expire necessary ?

Running a caching nameserver

- Running a caching nameserver locally can be very useful
- Easy to setup, for example on FreeBSD:
  - add named_enable="YES" to /etc/rc.conf
  - start named:

    /etc/rc.d/named start
- What is a good test to verify that named is running ?

Running a caching nameserver

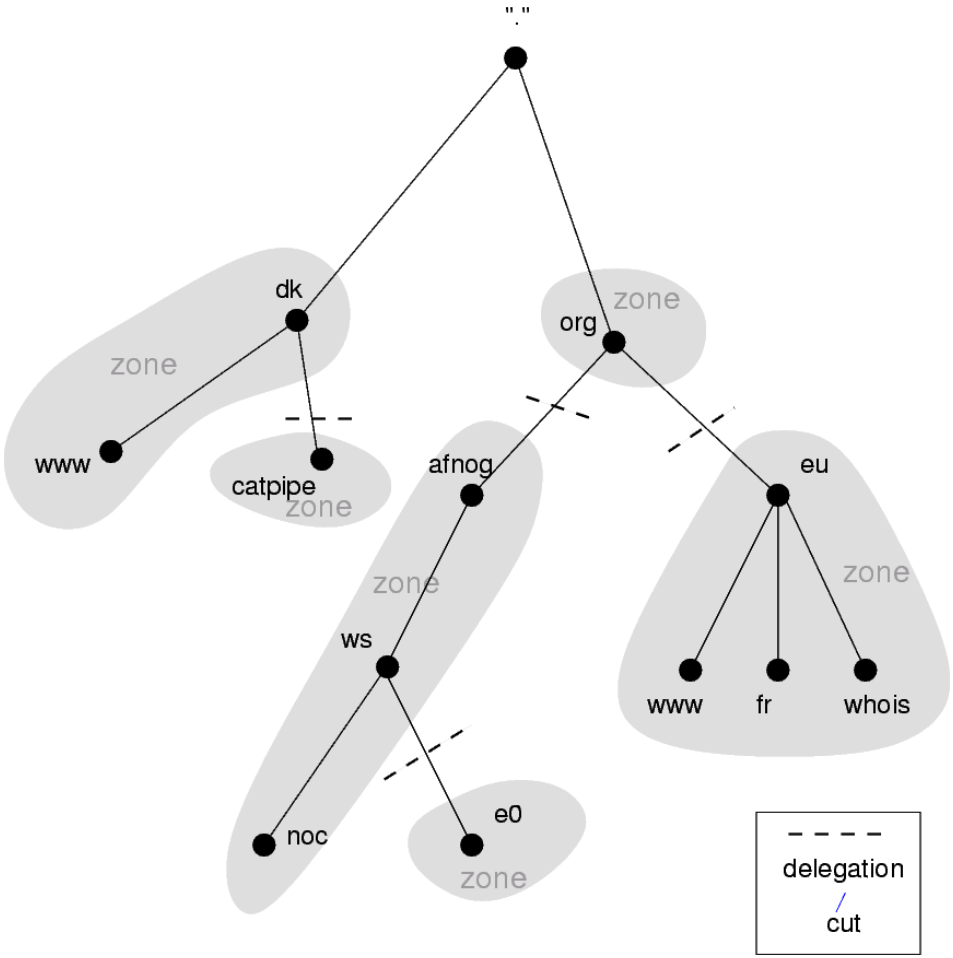
- When you are confident that your caching nameserver is working, enable it in your local resolver configuration i.e.
  - /etc/resolv.conf

    nameserver 127.0.0.1

Delegation

- We mentioned that one of the advantages of DNS was that of distribution through shared administration. This is called delegation.
- We delegate when there is an administrative boundary and we want to turn over control of a subdomain to:
  - a department of a larger organization
  - an organization in a country
  - an entity representing a country's domain

Delegation

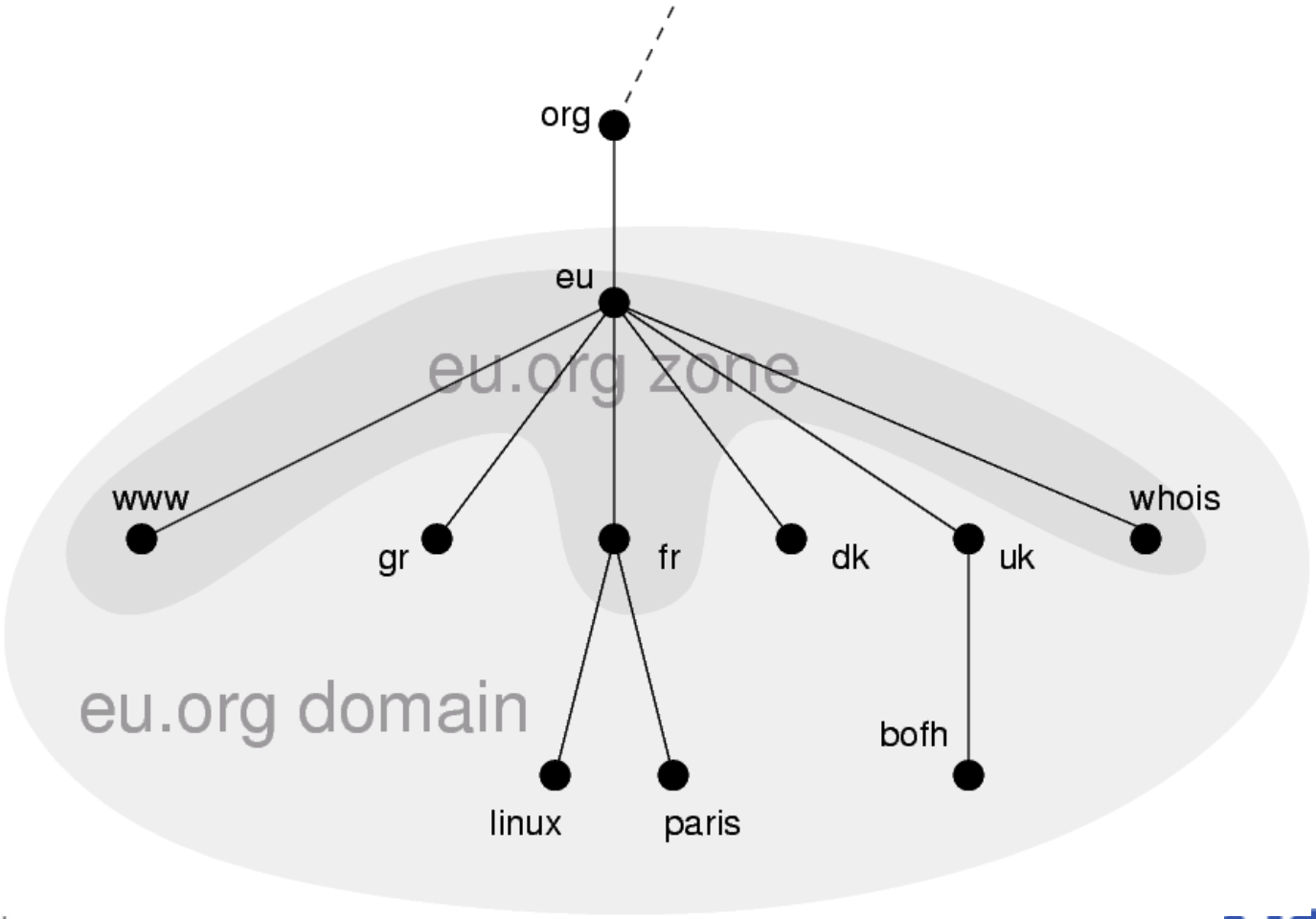

"."
dk
zone
www
catpipe
zone
org
zone
afnog
zone
ws
noc
e0
zone
eu
zone
www
fr
whois
delegation
cut

Delegation: Domains vs Zones

- When we talk about the entire subtree, we talk about domains

- When we talk about part of a domain that is administered by an entity, we talk about zones

Delegation: Domains vs Zones



Finding the error: using doc

- When you encounter problems with your network, web service or email, you don't always suspect DNS.
- When you do, it's not always obvious what the problem is – DNS is tricky.
- A great tool for quickly spotting configuration problems is 'doc'
- /usr/ports/dns/doc – install it now!
- Let's do a few tests on screen with doc...

Conclusion

- DNS is a vast subject
- It takes a lot of practice to pinpoint problems accurately the first time – caching and recursion are especially confusing
- Remember that there are several servers for the same data, and you don't always talk to the same one
- Practice, practice, practice!
- Don't be afraid to ask questions...

Questions?

?