

# Introduction to the DNS

---

AfNOG 2010  
Kigali, Rwanda

# 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:

`www.ws.afnog.org` → `196.200.223.1`

`www.afrinic.net` → `2001:42d0::200:80:1`

- ... and back:

`196.200.223.1` → `noc.ws.afnog.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.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 noc.ws.afnog.org.
```

```
noc.ws.afnog.org has address 196.200.223.1
```

```
# host 196.200.223.1
```

```
1.223.200.196.in-addr.arpa domain name  
pointer noc.ws.afnog.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.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`

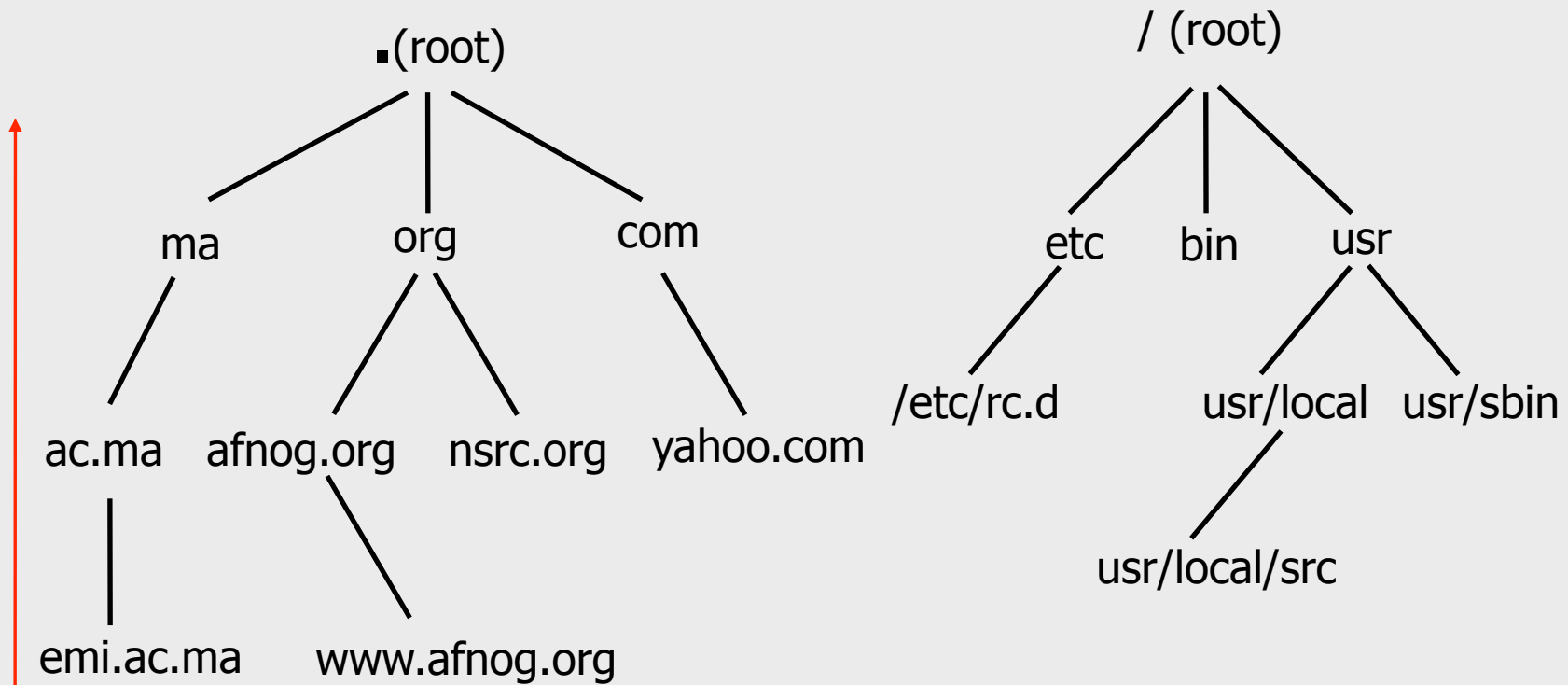
`www.nsrc.org`

`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?



DNS Database

Unix Filesystem

... forms a tree structure

# 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?

---

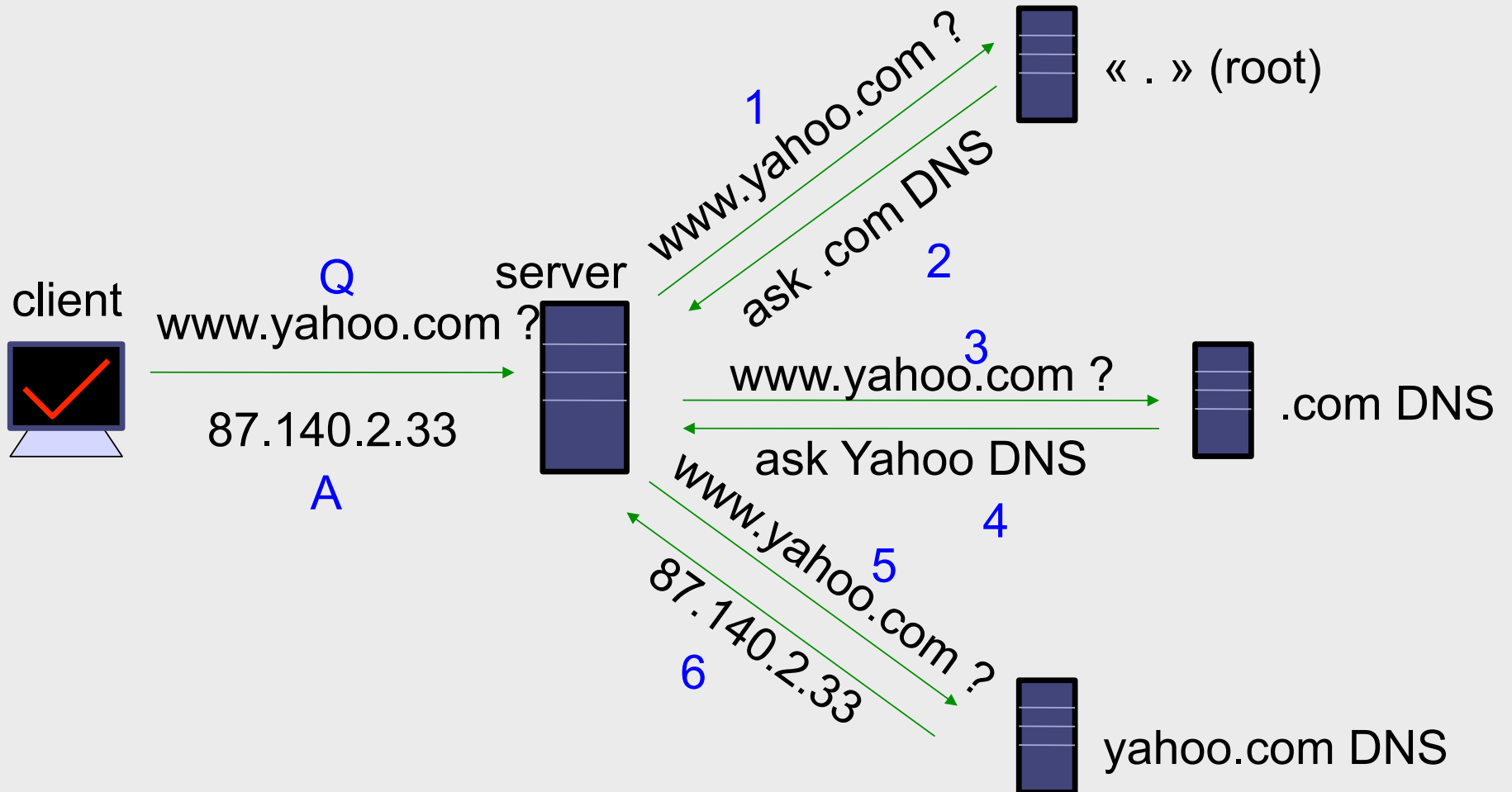
- **Clients** use a mechanism called a **resolver** and ask **servers** – this is called a **query**
- The server being queried will try to find the answer on behalf of the client
- The server functions recursively, from top (the root) to bottom, until it finds the answer, asking other servers along 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 the IP for `www.yahoo.com` »
  - the OS looks in the resolver configuration which server to ask, and sends the query
- On UNIX, `/etc/resolv.conf` is where the resolver is configured.

# A DNS query



# Query detail with tcpdump

---

- Let's lookup 'h1-web.hosting.catpipe.net'
- On the server, we do:

```
# tcpdump -n udp and port 53
```

- In another window/screen do:

```
# host <something>
```

# Query detail - output

- 1: 18:40:38.62 IP 192.168.1.1.57811 > 192.112.36.4.53: 29030  
[1au] A? h1-web.hosting.catpipe.net. (55)
- 2: 18:40:39.24 IP 192.112.36.4.53 > 192.168.1.1.57811:  
29030- 0/13/16 (540)
- 3: 18:40:39.24 IP 192.168.1.1.57811 > 192.43.172.30.53: 7286  
[1au] A? h1-web.hosting.catpipe.net. (55)
- 4: 18:40:39.93 IP 192.43.172.30.53 > 192.168.1.1.57811: 7286  
FormErr- [0q] 0/0/0 (12)
- 5: 18:40:39.93 IP 192.168.1.1.57811 > 192.43.172.30.53:  
50994 A? h1-web.hosting.catpipe.net. (44)
- 6: 18:40:40.60 IP 192.43.172.30.53 > 192.168.1.1.57811:  
50994- 0/3/3 (152)
- 7: 18:40:40.60 IP 192.168.1.1.57811 > 83.221.131.7.53: 58265  
[1au] A? h1-web.hosting.catpipe.net. (55)
- 8: 18:40:41.26 IP 83.221.131.7.53 > 192.168.1.1.57811:  
58265\* 1/2/3 A 83.221.131.6 (139)

# Query detail - analysis

---

- We use a packet analyser (wireshark / ethereal) to view the contents of the query...



# 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 IP/IPv6 of a functioning DNS server (it should).

# Finding the root...

---

- The first query is directed to:

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 IP address
- 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...

# Using 'dig' to get more details

```
ns# dig @147.28.0.39 www.nsrc.org. a

; <<>> DiG 9.3.2 <<>> @147.28.0.39 www.afnog.org
; (1 server found)
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 4620
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 4,
ADDITIONAL: 2

;; QUESTION SECTION:
;www.afnog.org.                IN      A

;; ANSWER SECTION:
www.afnog.org.                14400   IN      A      128.223.162.29

;; AUTHORITY SECTION:
afnog.org.                    14400   IN      NS     rip.psg.com.
afnog.org.                    14400   IN      NS     arizona.edu.

;; ADDITIONAL SECTION:
rip.psg.com.                  77044   IN      A      147.28.0.39
arizona.edu.                  2301    IN      A      128.196.128.233

;; Query time: 708 msec
;; SERVER: 147.28.0.39#53(147.28.0.39)
;; WHEN: Wed May 10 15:05:55 2007
;; MSG SIZE rcvd: 128
```

```
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 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:** Canonical name (alias)
- **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 of which they have an external copy, i.e. 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 first two fields highlighted are:
  - 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)
  - 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 (`/etc/resolv.conf`):

```
nameserver 127.0.0.1
```

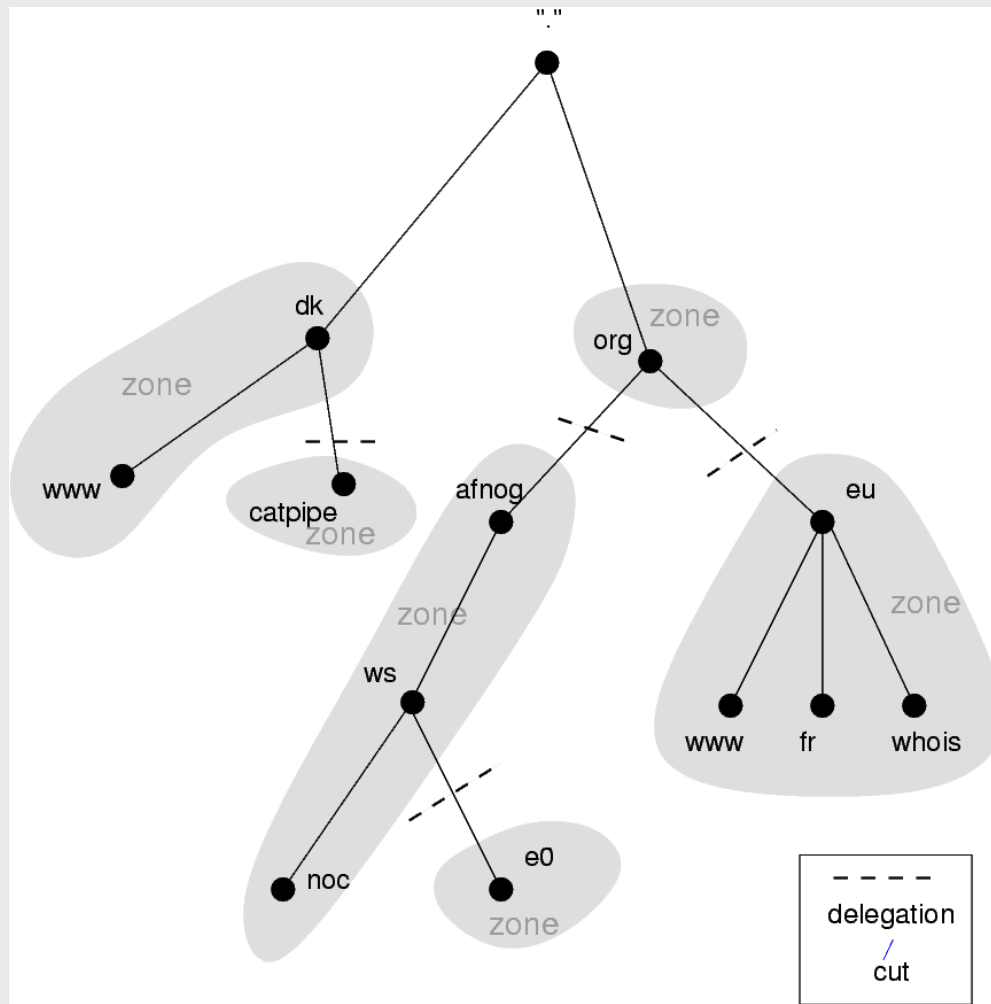


# Delegation

---

- 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

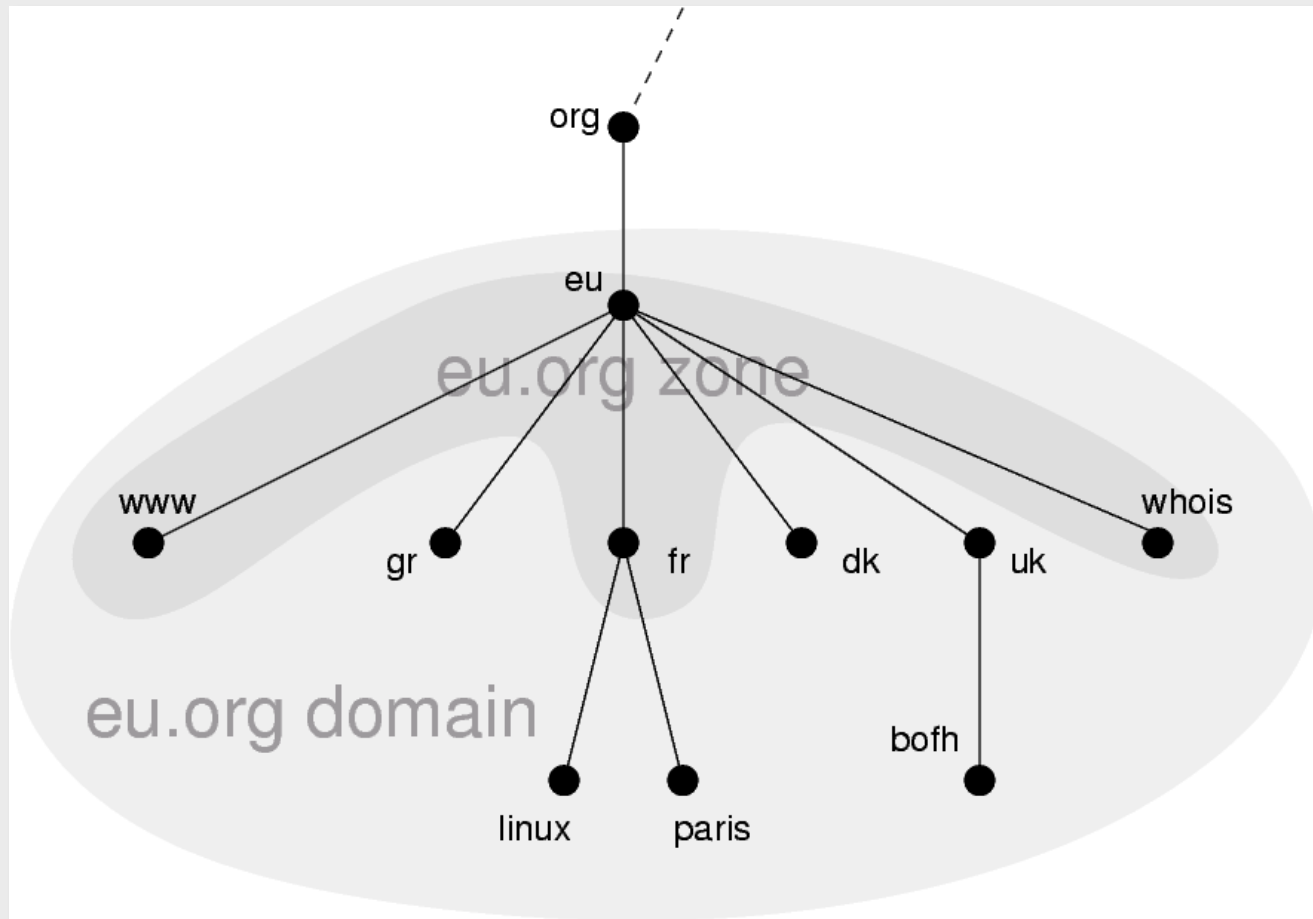


# Delegation: Domains vs Zones

---

- 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 ?

---

?