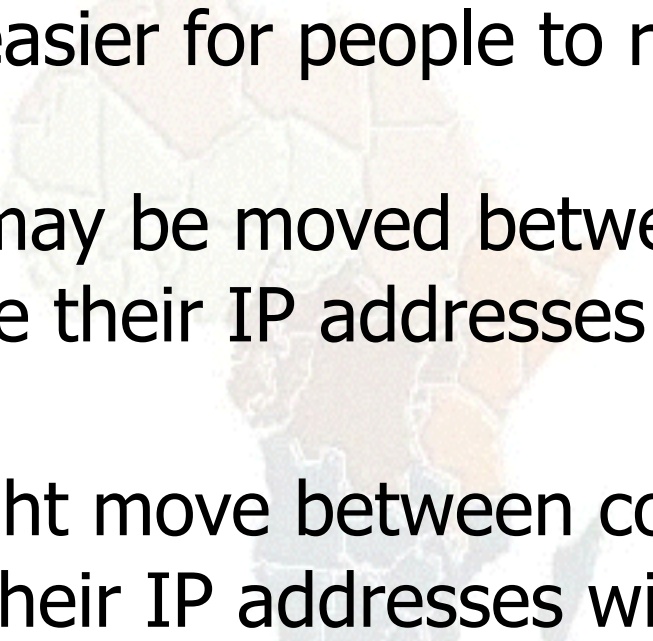# Domain Name System (DNS)

## Session-1: Fundamentals

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AfNOG Workshop, AIS 2015, Tunis

# Computers use IP addresses.
# Why do we need names?

- Names are easier for people to remember

- Computers may be moved between networks, in which case their IP addresses will change.

- Services might move between computers, in which case their IP addresses will change.

# The old solution: HOSTS.TXT

- A centrally-maintained file, distributed to all hosts on the Internet

- *SPARKY*          *128.4.13.9*
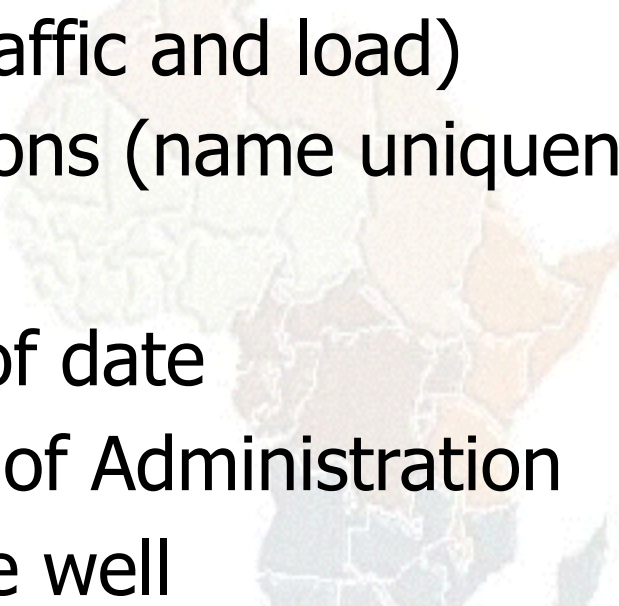- *UCB-MAILGATE*      *4.98.133.7*
- *FTPHOST*         *200.10.194.33*
- `... etc`

- This feature still exists:
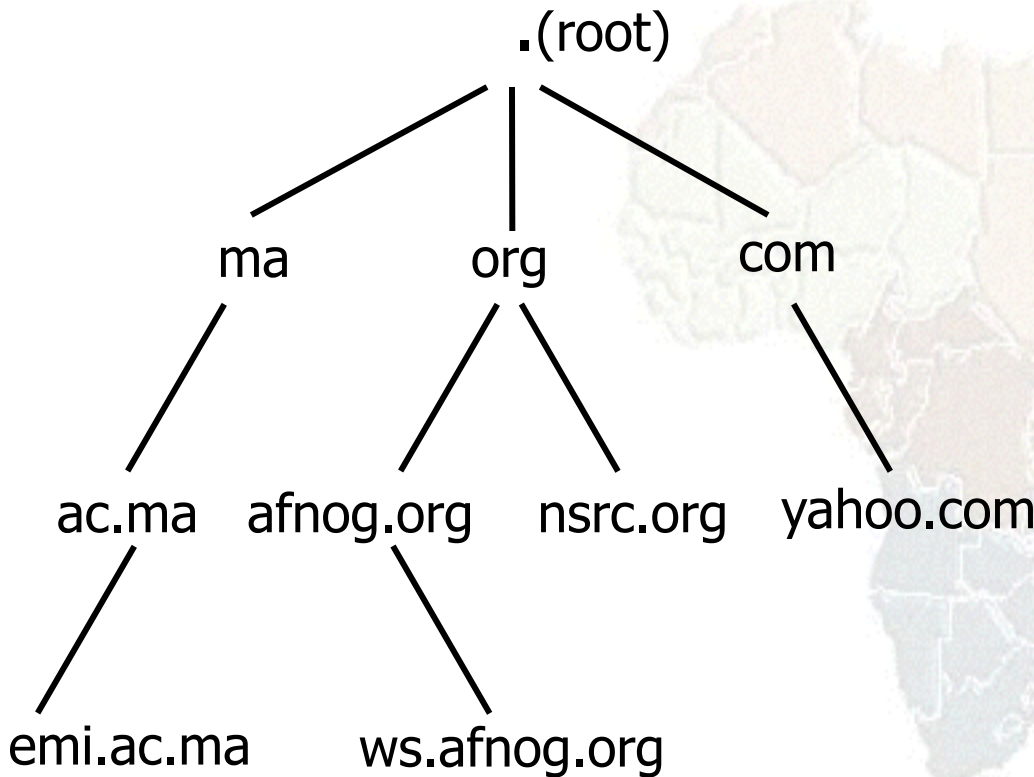  - /etc/hosts (UNIX)
  - c:\windows\hosts

# hosts.txt does not scale

✗Huge file (traffic and load)

✗Name collisions (name uniqueness)

✗Consistency

✗Always out of date

✗Single point of Administration
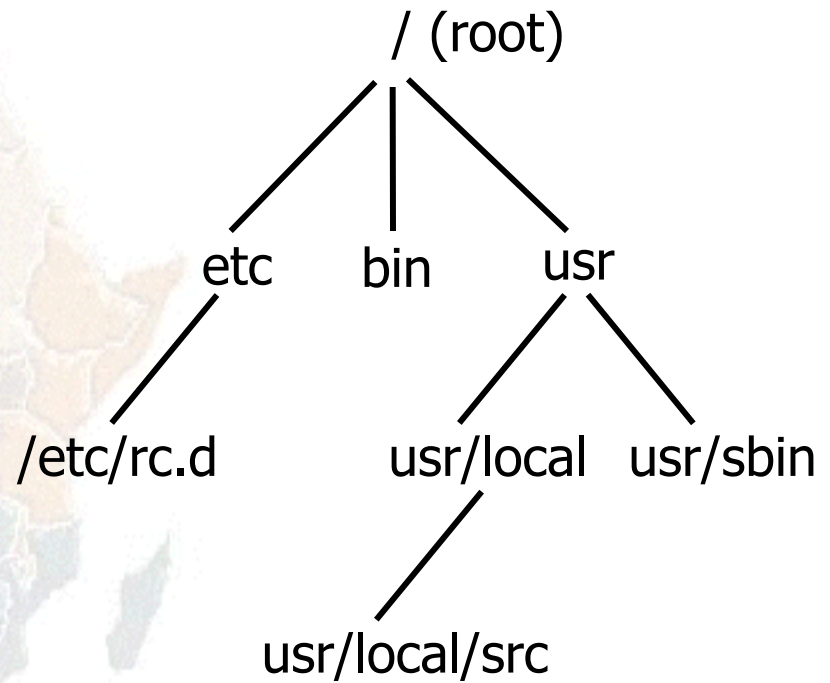
✗Did not scale well

# The Domain Name System was born

- DNS is a distributed database for holding name to IP address (and other) information
- Distributed:
  - Shares the Administration
  - Shares the Load
- Robustness and improved performance achieved through
  - replication
  - and caching
- Employs a client-server architecture
- A critical piece of the Internet's infrastructure

# DNS is Hierarchical



.(root)

ma    org    com

ac.ma    afnog.org    nsrc.org    yahoo.com

emi.ac.ma    ws.afnog.org

/ (root)

etc    bin    usr

/etc/rc.d    usr/local    usr/sbin
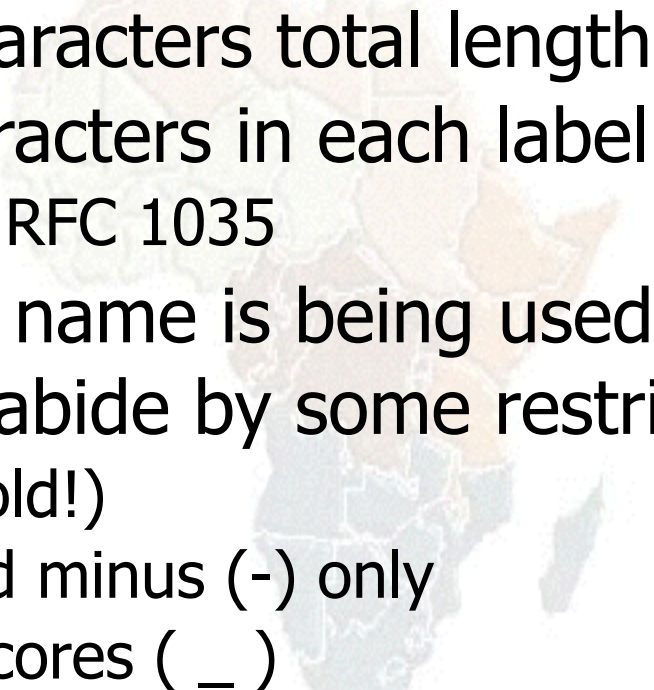
usr/local/src

DNS Database

Unix Filesystem

Forms a tree structure

# DNS is Hierarchical (contd.)

- Globally unique names
- Administered in zones (parts of the tree)
- You can give away ("delegate") control of part of the tree underneath you
- Example:
  - org on one set of nameservers
  - afnog.org on a different set
  - ws.afnog.org on a different set

# Domain Names are (almost) unlimited

- Max 255 characters total length
- Max 63 characters in each label
  - RFC 1034, RFC 1035
- If a domain name is being used as a host name, you should abide by some restrictions
  - RFC 952 (old!)
  - a-z 0-9 and minus (-) only
  - No underscores ( _ )

# Using the DNS

- A Domain Name (like www.ws.afnog.org) is the KEY to look up information
- The result is one or more RESOURCE RECORDS (RRs)
- There are different RRs for different types of information
- You can ask for the specific type you want, or ask for "any" RRs associated with the domain name

# Commonly seen Resource Records (RRs)

- A (address): map hostname to IPv4 address
- AAAA (quad A): map a hostname to IPv6 address
- PTR (pointer): map IP address to hostname
- MX (mail exchanger): where to deliver mail for user@domain
- CNAME (canonical name): map alternative hostname to real hostname
- TXT (text): any descriptive text
- NS (name server), SOA (start of authority): used for delegation and management of the DNS itself

# A Simple Example

- Query: **www.afnog.org.**
- Query type: **A**
- Result:

**www.afnog.org.    14400    IN    A    196.216.2.4**

- In this case a single RR is found, but in general, multiple RRs may be returned.
  - (IN is the "class" for INTERNET use of the DNS)

# Possible results from a Query

- POSITIVE ("NOERROR")
  - the name exists, and has zero or more RRs associated with it
- NEGATIVE ("NXDOMAIN")
  - the name does not exist
- SERVER FAILURE ("SERVFAIL")
  - server is having bad hair day
- FORMAT ERROR ("FORMERR")
  - the query you sent was broken in some way
- REFUSED ("REFUSED")
  - not allowed to query the server

# How do you use an IP address as the key for a DNS query

- Convert the IP address to dotted-quad
- Reverse the four parts
- Add ".in-addr.arpa." to the end; special domain reserved for this purpose

**e.g. to find name for 193.194.185.25**

*Domain name: 25.185.194.193.in-addr.arpa.*

*Query Type: PTR*

*Result: ashanti.gh.com.*

***Known as a "reverse DNS lookup"*** (because we are looking up the name for an IP address, rather than the IP address for a name)

# Any Questions?

# DNS is a Client-Server application

- (Of course - it runs across a network)
- Requests and responses are most frequently carried in UDP packets, port 53
- DNS can also use TCP transport, port 53
  - for very large responses e.g. zone transfers
  - because you want to exchange more than one query/response on a single session
  - because a response you received told you to with TC=1
  - because UDP is being aggressively rate-limited or blocked (e.g. to mitigate a reflection attack)

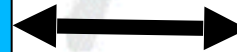# There are three roles involved in DNS

Application

e.g. web browser

Stub Resolver ↔ Caching Resolver ↔ Authoritative Nameserver

# Three roles in DNS

- **STUB RESOLVER**
  - Takes request from application, formats it into UDP packet, sends to recursive resolver
- **RECURSIVE RESOLVER**
  - Returns the answer if already known
  - Otherwise searches for an authoritative server which has the information
  - Caches the result for future queries
- **AUTHORITATIVE NAMESERVER**
  - Contains the actual information published in the DNS by the domain owner

# Three roles in DNS

- The SAME protocol is used for stub<-> resolver and resolver <-> auth nameserver
- It is possible to configure a single name server as both a resolver and an authoritative server
- But it still performs only one role for each incoming query
- Common but NOT RECOMMENDED to configure in this way (we will see why later).

# ROLE 1: THE STUB RESOLVER

- A piece of software which formats a DNS request into a DNS message, sends it to a resolver, and decodes the response when it arrives

- Usually a shared library (e.g. libresolv.so under Unix) because so many applications need it

- EVERY host needs a stub resolver - e.g. every Windows workstation has one
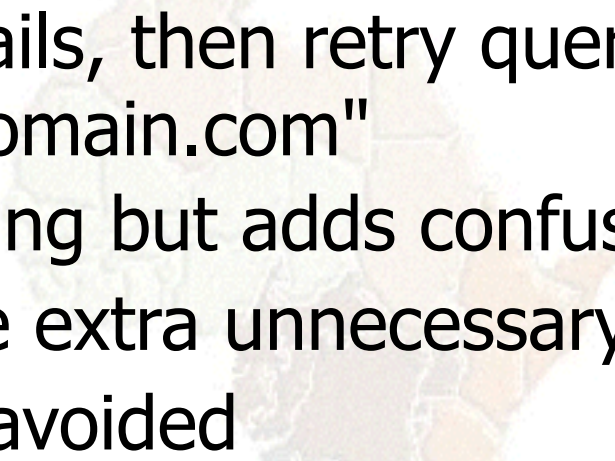
# How does the stub resolver find a recursive nameserver?

- It has to be explicitly configured (statically, or via DHCP etc)

- Must be configured with the IP ADDRESS of a cache (why not name?)

- Good idea to configure more than one cache, in case the first one fails

# How do you choose which recursive resolver(s) to configure?

- Must have PERMISSION to use it
  - e.g. cache at your ISP, or your own, or a reliably public one
- Prefer a nearby cache
  - Minimises round-trip time and packet loss
  - Can reduce traffic on your external link, since often the cache can answer without contacting other servers
- Prefer a reliable cache
  - Perhaps your own?

# Stub resolvers can be configured with default domain(s)

- If "foo.bar" fails, then retry query as "foo.bar.mydomain.com"
- Can save typing but adds confusion
- May generate extra unnecessary traffic
- Usually best avoided

# Example: Unix stub resolver configuration

/etc/resolv.conf

```
search sse.ws.afnog.org
nameserver 196.200.219.200
nameserver 196.200.223.1
```

*That's all you need to configure a resolver*

# Testing DNS

- Just put "www.yahoo.com" in a web browser?
- Why is this not a good test?

# Testing DNS with "dig"

- "dig" is a program which just makes DNS queries and displays the results
- Better than "nslookup", "host" because it shows the raw information in full

```
dig ws.afnog.org.
```
   -- defaults to query type "A"
```
dig afnog.org. mx
```
   -- specified query type
```
dig @196.200.223.1 afnog.org. mx
```
   -- send to particular cache (overrides
      /etc/resolv.conf)

# The trailing dot

```
# dig ws.afnog.org.
```

- Prevents any default domain being appended
- Get into the habit of using it always when testing DNS
  - only on domain names, not IP addresses or e-mail addresses

```
[field@term /usr/home/field]$ dig @zoe.dns.gh. downloads.dns.gh. a

; <<>> DiG 9.3.1 <<>> @zoe.dns.gh. downloads.dns.gh. a
; (1 server found)
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 34963
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 3, ADDITIONAL: 0

;; QUESTION SECTION:
;downloads.dns.gh.                    IN       A

;; ANSWER SECTION:
downloads.dns.gh.         3600       IN       CNAME    zoe.dns.gh.
zoe.dns.gh.               3600       IN       A        147.28.0.23

;; AUTHORITY SECTION:
dns.gh.                   3600       IN       NS       zoe.dns.gh.
dns.gh.                   3600       IN       NS       mantse.gh.com.
dns.gh.                   3600       IN       NS       snshq902.ghanatel.com.gh.

;; Query time: 275 msec
;; SERVER: 147.28.0.23#53(147.28.0.23)
;; WHEN: Sat May 24 00:17:53 2008
;; MSG SIZE  rcvd: 145
```

# Understanding output from dig

- STATUS
  - NOERROR: 0 or more RRs returned
  - NXDOMAIN: non-existent domain
  - SERVFAIL: cache could not locate answer
  - REFUSED: query not available on cache server
- FLAGS
  - AA: Authoritative answer (not from cache)
  - You can ignore the others
    - QR: Query/Response (1 = Response)
    - RD: Recursion Desired
    - RA: Recursion Available
- ANSWER: number of RRs in answer

# Understanding output from dig

- Answer section (RRs requested)
  - Each record has a Time To Live (TTL)
  - Says how long the cache will keep it
- Authority section
  - Which nameservers are authoritative for this domain
- Additional section
  - More RRs (typically IP addresses for the authoritative nameservers)
- Total query time
- Check which server gave the response!
  - If you make a typing error, the query may go to a default server