Domain Name System (DNS)

Session-1: Fundamentals

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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

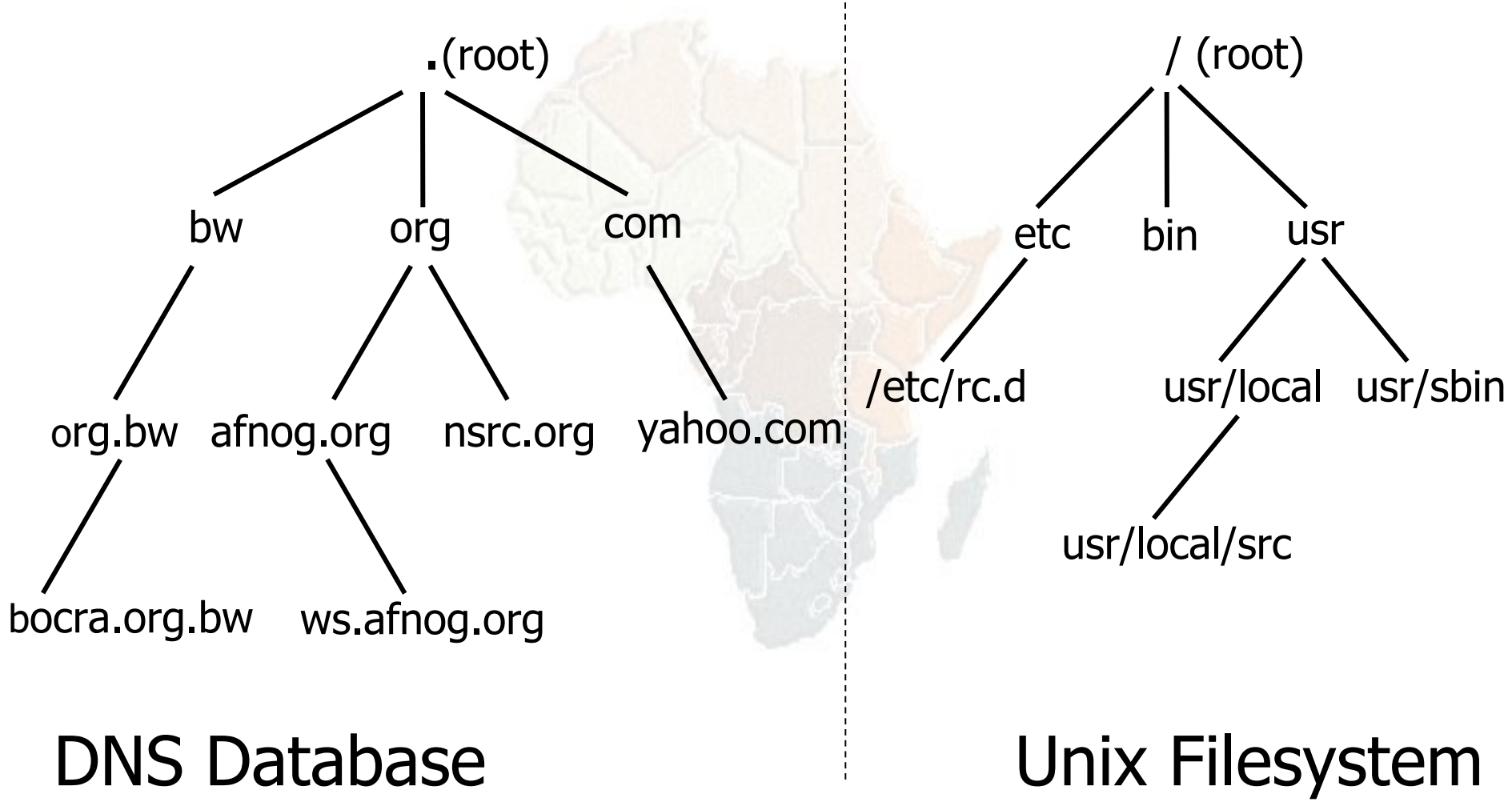
hosts.txt does not scale

- ✗ 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- ✗ Always out of date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



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 zero or more RESOURCE RECORD SETS (RRSets)
- There are different RRTYPEs 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 Record Types (RRTYPEs)

- 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 a mail 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 a set of 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 RRSets 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")
  - You are 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.***

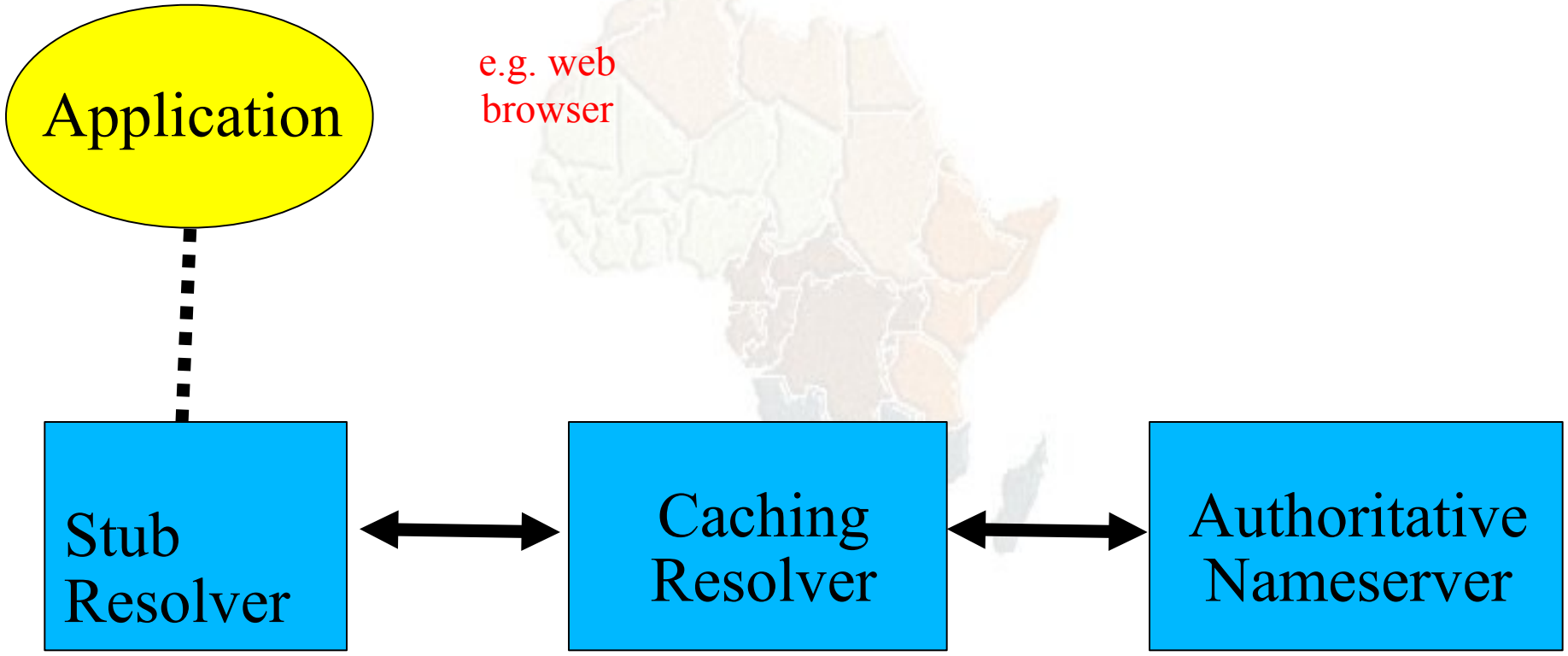
Known as a "reverse DNS lookup" (because we are looking up the name for an IP address, rather than the IP address for a name)

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 large responses (not just 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



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 its name?)
- Good idea to configure more than one recursive nameserver, in case the first one fails
  - But failover between them might not be quick

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

- Must have PERMISSION to use it
  - e.g. recursive resolver at your ISP, or your own, or a deliberately-public one
- Prefer a nearby recursive resolver
  - 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 recursive resolver
  - Perhaps your own?

Stub resolvers can be configured with search 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