

## Address Conversion Functions and The Domain Name System

Refs: Chapter 9  
RFC 1034  
RFC 1035

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## Hostnames

- IP Addresses are great for computers
  - IP address includes information used for routing.
- IP addresses are tough for humans to remember.
- IP addresses are impossible to guess.
  - ever guessed at the name of a WWW site?

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## The Domain Name System

- The *domain name system* is usually used to translate a host name into an IP address .
- Domain names comprise a hierarchy so that names are unique, yet easy to remember.

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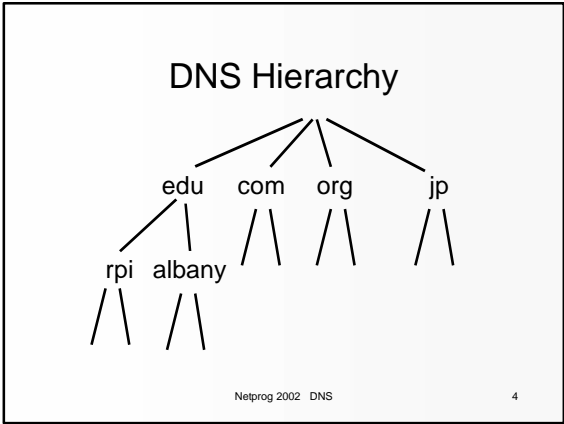
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### Host name structure

- Each host name is made up of a sequence of *labels* separated by periods.
  - Each label can be up to 63 characters
  - The total name can be at most 255 characters.
- Examples:
  - whitehouse.gov
  - barney.the.purple.dinosaur.com
  - monica.cs.rpi.edu

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### Domain Name

- The domain name for a host is the sequence of labels that lead from the host (leaf node in the naming tree) to the top of the worldwide naming tree.
- A domain is a subtree of the worldwide naming tree.

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## Top level domains

- `edu`, `gov`, `com`, `net`, `org`, `mil`, ...
- Countries each have a top level domain (2 letter domain name).
- New top level domains include:  
.aero .biz .coop .info .name .pro

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## DNS Organization

- Distributed Database
  - The organization that owns a domain name is responsible for running a DNS server that can provide the mapping between hostnames within the domain to IP addresses.
  - So - some machine run by RPI is responsible for everything within the `rpi.edu` domain.

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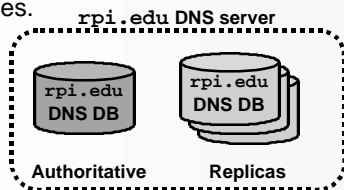
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## DNS Distributed Database

- There is one primary server for a domain, and typically a number of secondary servers containing replicated databases.



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## DNS Clients

- A DNS client is called a *resolver*.
- A call to `gethostbyname()` is handled by a resolver (typically part of the client).
- Most Unix workstations have the file `/etc/resolv.conf` that contains the local domain and the addresses of DNS servers for that domain.

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## `/etc/resolv.conf`

```
domain rpi.edu
128.113.1.5
128.113.1.3
```

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## `nslookup`

- `nslookup` is an interactive resolver that allows the user to communicate directly with a DNS server.
- `nslookup` is usually available on Unix workstations.

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## DNS Servers

- Servers handle requests for their domain directly.
- Servers handle requests for other domains by contacting remote DNS server(s).
- Servers cache external mappings.

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## Server - Server Communication

- If a server is asked to provide the mapping for a host outside its domain (and the mapping is not in the server cache):
  - The server finds a nameserver for the target domain.
  - The server asks the nameserver to provide the host name to IP translation.
- To find the right nameserver, use DNS!

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## DNS Data

- DNS databases contain more than just hostname-to-address records:
  - Name server records           NS
  - Hostname aliases            CNAME
  - Mail Exchangers            MX
  - Host Information            HINFO

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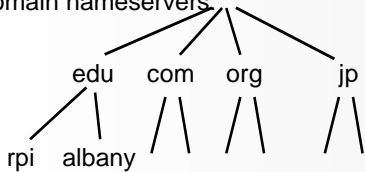
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## The Root DNS Server

- The root server needs to know the address of 1st (and many 2nd) level domain nameservers.



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## Server Operation

- If a server has no clue about where to find the address for a hostname, ask the root server.
- The root server will tell you what nameserver to contact.
- A request may get forwarded a few times.

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## DNS Message Format

<b>HEADER</b>
<b>QUERIES</b>
<i>Response</i> <b>RESOURCE RECORDS</b>
<i>Response</i> <b>AUTHORITY RECORDS</b>
<i>Response</i> <b>ADDITIONAL INFORMATION</b>

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## DNS Message Header

- query identifier
- flags
- # of questions
- # of RRs
- # of authority RRs
- # of additional RRs

16 bit fields

} Response

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## Message Flags

- QR: Query=0, Response=1
- AA: Authoritative Answer
- TC: response truncated (> 512 bytes)
- RD: recursion desired
- RA: recursion available
- rcode: return code

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## Recursion

- A request can indicate that recursion is desired - this tells the server to find out the answer (possibly by contacting other servers).
- If recursion is not requested - the response may be a list of other name servers to contact.

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## Question Format

- Name: domain name (or IP address)
- Query type (A, NS, MX, ...)
- Query class (1 for IP)

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## Response Resource Record

- Domain Name
- Response type
- Class (IP)
- Time to live (in seconds)
- Length of resource data
- Resource data

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## UDP & TCP

- Both UDP and TCP are used:
  - TCP for transfers of entire database to secondary servers (replication).
  - UDP for lookups
  - If more than 512 bytes in response - requestor resubmits request using TCP.

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## Lots more

- This is not a complete description !
- If interested - look at:
  - RFC 1034: DNS concepts and facilities.
  - RFC 1035: DNS implementation and protocol specification.
  - play with nslookup.
  - Look at code for BIND (DNS server code).

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## Name to Address Conversion

- There is a library of functions that act as DNS client (resolver).
  - you don't need to write DNS client code to use DNS!
- With some OSs you need to explicitly link with the DNS resolver library:
  - `-lns1` (`ns1` is "Name Server Library")

**Suns (Solaris) need this!**

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## DNS library functions

`gethostbyname`

`gethostbyaddr`

`gethostbyname2` ← IPv6!

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## gethostbyname

```
struct hostent *gethostbyname(  
    const char *hostname);
```

struct hostent is defined in netdb.h:

```
#include <netdb.h>
```

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## struct hostent

```
struct hostent {  
    char *h_name;      official name (canonical)  
    char **h_aliases; other names  
    int h_addrtype;   AF_INET or AF_INET6  
    int h_length;     address length (4 or 16)  
    char **h_addr_list; array of ptrs to addresses  
};
```

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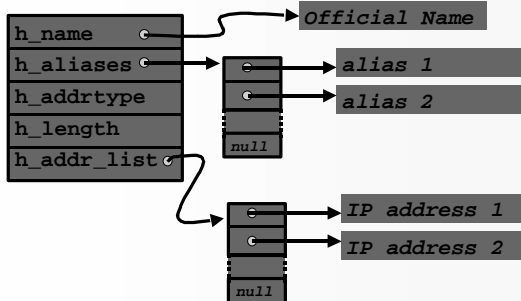
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## hostent picture



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## Which Address?

On success, `gethostbyname` returns the address of a hostent that has been created.

- has an array of ptrs to IP addresses
- Usually use the first one:

```
#define h_addr h_addr_list[0]
```

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## gethostbyname and errors

- On error `gethostbyname` return null.
- `Gethostbyname` sets the global variable `h_errno` to indicate the exact error:
  - `HOST_NOT_FOUND`
  - `TRY_AGAIN`
  - `NO_RECOVERY`
  - `NO_DATA`
  - `NO_ADDRESS`

All defined in `netdb.h`

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Getting at the address:  
`char **h_addr_list;`

```
h = gethostbyname("joe.com");  
sockaddr.sin_addr.s_addr =  
*(h->h_addr_list[0]);
```

This won't work!!!!

`h_addr_list[0]` is a `char*` !

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## Using `memcpy`

- You can copy the 4 bytes (IPv4) directly:

```
h = gethostbyname("joe.com");  
  
memcpy(&sockaddr.sin_addr,  
       h->h_addr_list[0],  
       sizeof(struct in_addr));
```

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## Network Byte Order

- All the IP addresses returned via the `hostent` are in network byte order!
- Repeat after me:  
"Thank you `gethostbyname!`"

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## `gethostbyaddr`

```
struct hostent *gethostbyaddr(  
    const char *addr  
    size_t len, ← sizeof(struct in_addr)  
    int family);
```

*AF\_INET (could be AF\_INET6)*

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## Some other functions

**uname** : get hostname of local host

**getservbyname** : get port number for a  
named service

**getservbyaddr** : get name for service  
associated with a port number

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