
Application Layer : DNS and SMTP

COMP90007

Internet Technologies

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Outline

- Domain Name System
 - ❑ Division of Name Spaces
 - ❑ Services
 - ❑ Domain Name Properties
 - ❑ Resolving Domain Names
 - ❑ Name Servers

Application
Transport
Network
Link
Physical

DNS (Domain Name System)

■ Problem?

- IP address (32 bit), e.g., 121.7.106.83 – used for addressing datagrams
- “name”, e.g., www.yahoo.com – used by humans

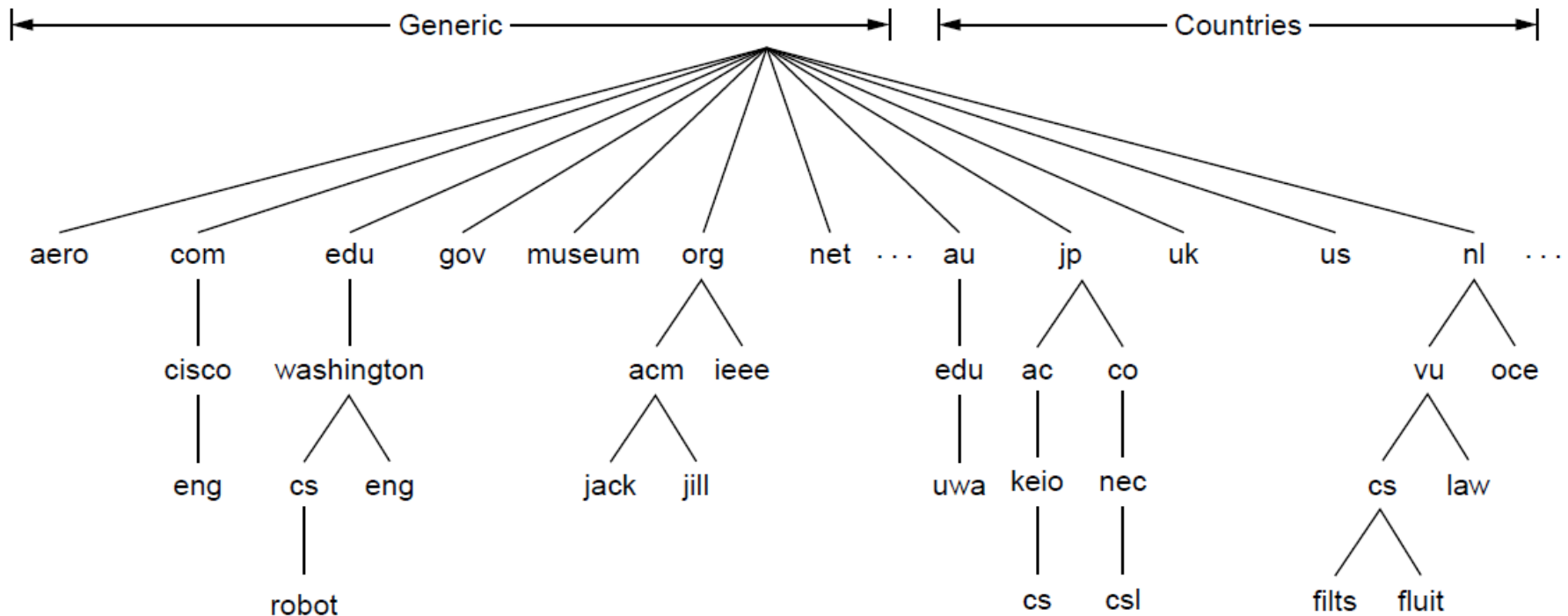
■ Q: how do you map between IP address and name, and vice versa?

■ Domain Name System:

- *distributed database* implemented in a hierarchy of many *name servers*
- *application-layer protocol* that allows a host to query the database in order to *resolve* names (address/name translation)
- used by other application-layer protocols (http, ftp, smtp)

Conceptual Divisions of DNS Namespace

- A hierarchical naming convention; the top of the hierarchy is managed by ICANN (The Internet Corporation for Assigned Names and Numbers).



The computer *robot.cs.washington.edu*

Name Space

- Internet is divided into over 250 top-level domains (TLD).
- Generic top-level domains are given next.

Domain	Intended use	Start date	Restricted?
com	Commercial	1985	No
edu	Educational institutions	1985	Yes
gov	Government	1985	Yes
int	International organizations	1988	Yes
mil	Military	1985	Yes
net	Network providers	1985	No
org	Non-profit organizations	1985	No
aero	Air transport	2001	Yes
biz	Businesses	2001	No
coop	Cooperatives	2001	Yes
info	Informational	2002	No
museum	Museums	2002	Yes
name	People	2002	No
pro	Professionals	2002	Yes
cat	Catalan	2005	Yes
jobs	Employment	2005	Yes
mobi	Mobile devices	2005	Yes
tel	Contact details	2005	Yes
travel	Travel industry	2005	Yes
xxx	Sex industry	2010	No

Why not centralize DNS?

- Single point of failure
- Traffic volume
- Distant centralized database
- Maintenance

Doesn't scale!

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DNS Services

- hostname to IP address translation
- host aliasing – alias names for canonical names
 - e.g., canonical `relay1.westcoast.enterprise.com` aliased to `www.enterprise.com`
- mail server aliasing
 - e.g., `Bob@relay1.westcoast.hotmail.com` aliased to `Bob@hotmail.com`
- load distribution
 - busy sites are replicated over multiple servers
 - a set of IP addresses is associated with one canonical name
 - DNS server rotates the order of the addresses to distribute the load

Domain Name Characteristics

- Domain names:
 - ❑ Are case insensitive
 - ❑ Can have up to 63 characters per constituent
 - ❑ Can have up to 255 chars per path
 - ❑ Can be internationalised (since 1999)
- Naming conventions usually follow either organisational or physical boundaries eg.
 - ❑ au.ibm.com / uk.ibm.com (for email)
 - ❑ ibm.com.au / ibm.co.uk (for web)
- Absolute domain names ends in a “.”
- Relative domain names partially specify the location and can be used only within the context of an absolute domain name

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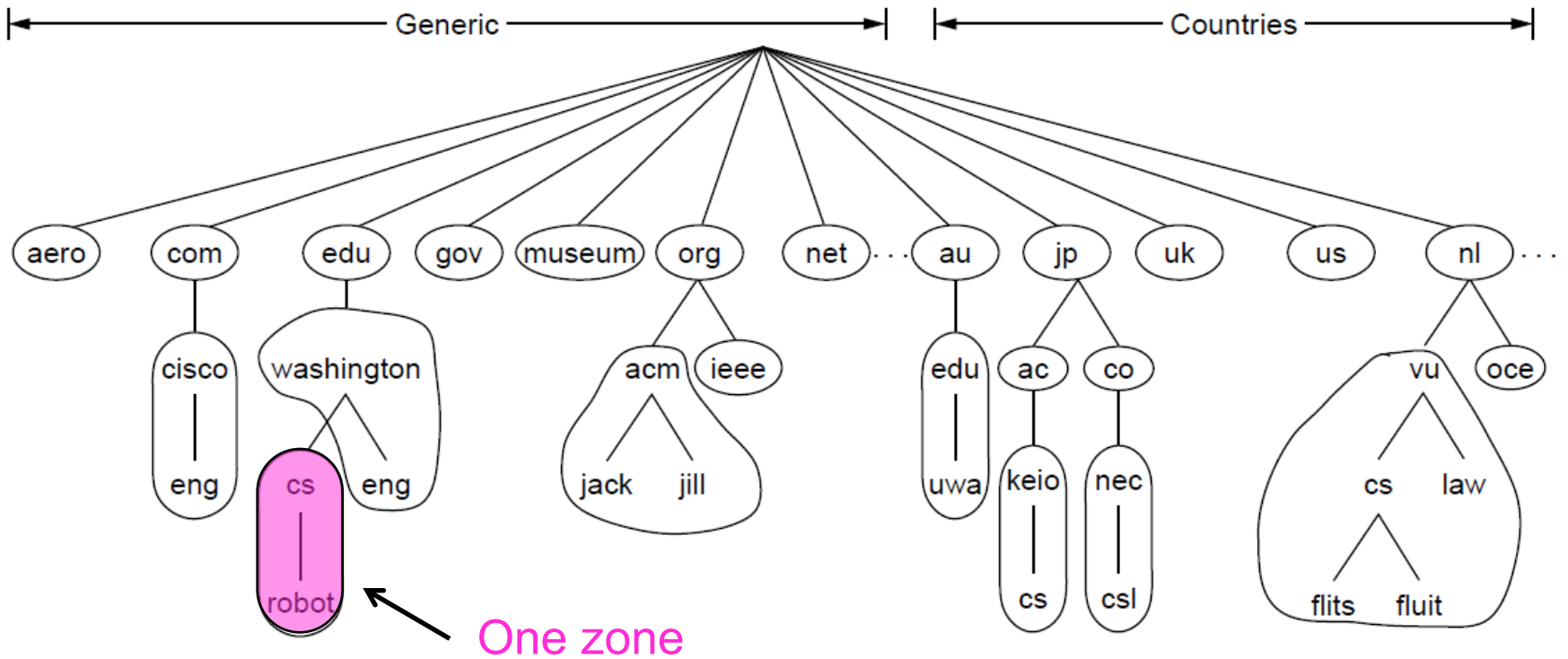
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Zone Name Servers

- DNS namespace divided into non-overlapping zones
- Each zone contains a part of the DNS tree and also name servers authoritative for that zone -
 - usually 2 name servers for a zone (called the primary and secondary name servers),
 - sometimes secondary is actually outside the zone (for reliability)
- Name servers are arranged in a hierarchical manner extending from a set of root servers

Name Servers

- The DNS name space is divided into nonoverlapping zones; each circled contains some part of the tree.



Root Name Servers

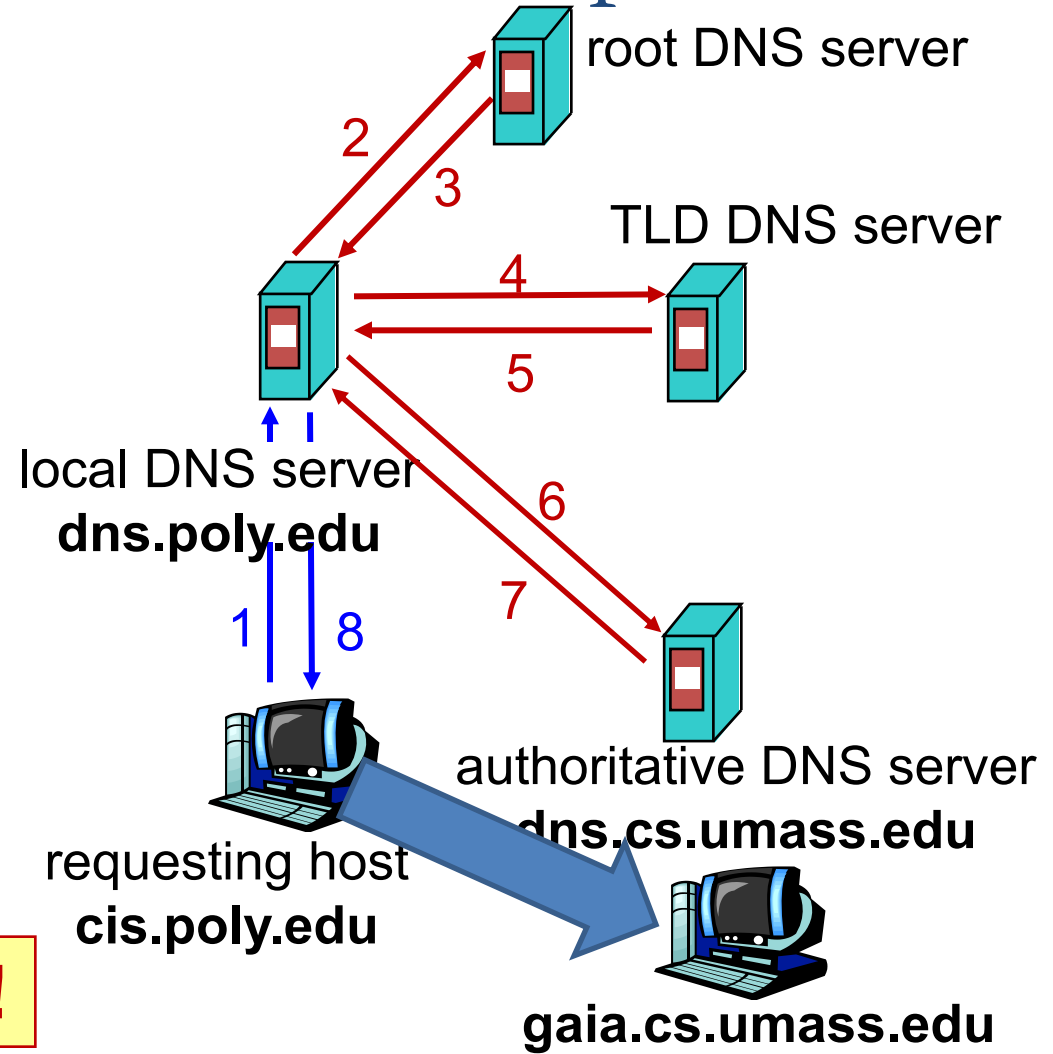
- The root servers form the authoritative cluster for enquiry in the event of locally-unresolvable name queries
- There are 13 root servers globally
 - ▣ In some cases, a root server is a cluster of servers that are in the anycast IP space

DNS In Action

- Finding the IP address for a given hostname is called name resolution and is done with the DNS protocol.
- Resolution:
 - ❑ Computer requests local name server to resolve
 - ❑ Local name server asks the root name server
 - ❑ Root returns the name server for a lower zone
 - ❑ Continue down zones until name server can answer
- DNS protocol:
 - ❑ Runs on UDP port 53, retransmits lost messages
 - ❑ Caches name server answers for better performance

DNS Name Resolution: Example

- host at cis.poly.edu wants IP address for gaia.cs.umass.edu
- iterated query:
 - contacted server replies with name of server to contact
 - “I don’t know this name, but ask this server”
- recursive query:
 - server obtains mapping on client’s behalf



Lots of network traffic!

DNS: Caching and Updating Records

- Once (any) name server learns a mapping, it *caches* the mapping
 - IP addresses of TLD servers typically cached in local name servers
 - ➔ root name servers not often visited
 - Cache entries timeout (disappear) after some time

DNS Software

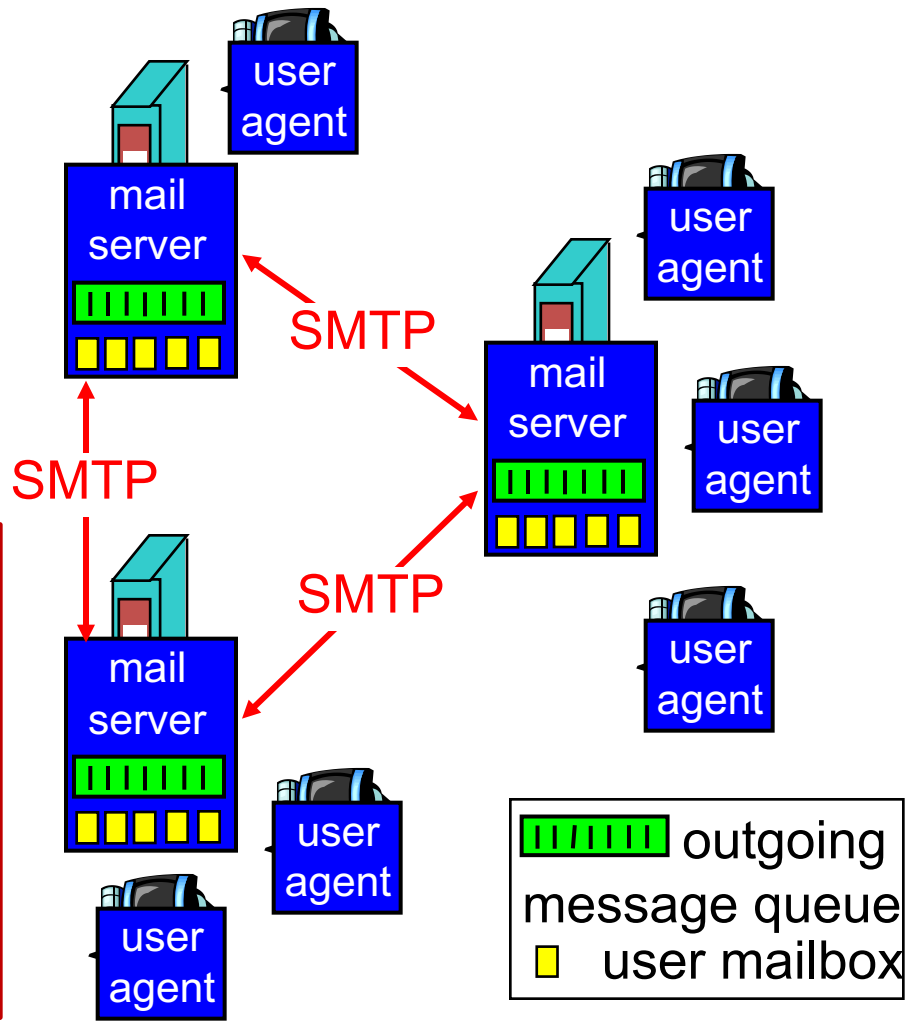
- DNS Server Software
 - ❑ BIND
 - ❑ djbdns
 - ❑ Microsoft Domain Name Server
- DNS Query Tools
 - ❑ nslookup
 - ❑ dig

Electronic Mail - Overview

- ❖ Three major components:
 - User agents
 - Mail servers
 - Simple Mail Transfer Protocol: SMTP

SMTP is used to **send** messages from the sender's

- **mail server** to the receiver's **mail server**
- **user agent** to the sender's **mail server**



The User Agent

- Basic functions: compose, report, display, dispose
- **Envelope** and **contents**: encapsulation of transport related information
 - Envelope - destination address, priority, and security level, all of which are distinct from the message itself
 - Mail servers use the envelope for routing
- **Header** and **body**: header - user agent control info; body for human recipient
 - contains control information for the user agents
- User must provide message, destination, optional other parameters
- Addressing scheme **user@dns-address**

Message Formats

- Message =
 - RFC821 envelope
 - Header fields (line of ASCII text with fieldname:value syntax)
- Blank line delimiter
- Message body

RFC 822: Message Header

- RFC 822 headers related to message header

- ❑ Date:
- ❑ Reply-To:
- ❑ Message-Id:
- ❑ In-Reply-To:
- ❑ References
- ❑ Keywords:
- ❑ Subject:

Header	Meaning
To:	Email address(es) of primary recipient(s)
Cc:	Email address(es) of secondary recipient(s)
Bcc:	Email address(es) for blind carbon copies
From:	Person or people who created the message
Sender:	Email address of the actual sender
Received:	Line added by each transfer agent along the route
Return-Path:	Can be used to identify a path back to the sender

- RFC 822 allows users to invent new headers for private use but they must start with X-

Multipurpose Internet Mail Extensions (MIME) #1

- In the early days of email, messages were in English and used only ASCII – RFC822 was enough for these simple constraints.
- In time the inadequacy of RFC822 became apparent
 - ❑ Languages with accents (French, Spanish)
 - ❑ Non-Latin alphabets (eg Cyrillic)
 - ❑ Non-alphabetic language (eg Chinese, Japanese)
 - ❑ Messages with content other than text (audio, images)
- As a result, MIME (RFC 1341) was written (later updated in RFCs 2045-2049)

Header	Meaning
MIME-Version:	Identifies the MIME version
Content-Description:	Human-readable string telling what is in the message
Content-Id:	Unique identifier
Content-Transfer-Encoding:	How the body is wrapped for transmission
Content-Type:	Type and format of the content

Multipurpose Internet Mail Extensions (MIME) #2

- MIME retains RFC822 format but adds structural elements to the message body and defines encoding rules for non-ASCII messages - thus leverage existing infrastructure for RFC822 services, and leaving MIME functionality changes to the user agent
- MIME has 5 additional message headers:
 - ❑ MIME-Version: identifies the MIME version
 - ❑ Content-Description: human readable describing contents
 - ❑ Content-Id: unique identifier
 - ❑ Content-Transfer-Encoding: how body is wrapped for transmission
 - ❑ Content-Type: type and format of content (e.g., text/plain, html, video, etc..)

MIME Types and Subtypes

Type	Example subtypes	Description
text	plain, html, xml, css	Text in various formats
image	gif, jpeg, tiff	Pictures
audio	basic, mpeg, mp4	Sounds
video	mpeg, mp4, quicktime	Movies
model	vrml	3D model
application	octet-stream, pdf, javascript, zip	Data produced by applications
message	http, rfc822	Encapsulated message
multipart	mixed, alternative, parallel, digest	Combination of multiple types

Message Transfer

- Transfer
 - SMTP
- Delivery
 - POP3 (Post Office Protocol 3)
 - IMAP (Internet Message Access Protocol)

SMTP

- Simple Message Transfer Protocol
- Simple ASCII protocol, operating on TCP port 25
- RFC 821: Simple Mail Transfer Protocol
- RFC 2821: Extended Simple Mail Transfer Protocol
- RFC 2821 delineated by HELO vs EHLO, new features of 2821

SMTP Steps

- Basic steps SMTP(Simple Mail Transfer Protocol):
 - ❑ Employs readable text commands
 - ❑ User agent submits to MTA (mail transfer agent) on port 587 (Preferred RFC 4409)
 - ❑ One MTA to the next MTA on port 25
 - ❑ Other protocols for final delivery (IMAP, POP3)

Internet Message Access Protocol (IMAP)
Post Office Protocol 3 (POP3)

Message Transfer

```
C: telnet servername 25 ← establishing connection
S: 220 hamburger.edu
C: HELO crepes.fr
S: 250 Hello crepes.fr, pleased to meet you
C: MAIL FROM:<alice@crepes.fr>
S: 250 alice@crepes.fr... Sender ok
C: RCPT TO:<bob@hamburger.edu>
S: 250 bob@hamburger.edu ... Recipient ok
C: DATA
S: 354 Enter mail, end with "." on a line by itself
C: From: alice@crepes.fr
C: To: bob@hamburger.edu
C: ... message ...
C: .
S: 250 Message accepted for delivery
C: QUIT ← closing connection
S: 221 hamburger.edu Closing connection
```

application-layer

handshake

end of
message

Email Software

- UA's
 - Outlook (+Express), Eudora, Pine, Mutt, elm, Evolution, Thunderbird
 - Agent Middleware (User -> Server)
 - Pop3d, qpopper, fetchmail
 - MTA's
 - sendmail, Qmail, PostFix, Exchange, MDaemon, IMail
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Summary – Core Internet Applications

- DNS
 - Describe operation of DNS lookup
- Email
 - Explain which functions should be performed in Message Transfer Agent or User Agent