

Favorites  
Sent Items  
Drafts  
Archive  
Inbox

flobo@issp.fr

Inbox  
Drafts  
Sent Items  
Deleted Items  
Archive  
Conversation history  
Junk Email  
Outbox  
RSS Subscriptions  
Scheduled  
Search Folders

Alex Weddell

asw@ecs.soton.ac.uk



Items: 68,234

UNIVERSITY OF  
Southampton  
School of Electronics  
and Computer Science

New login to Twitter from Chrome or W...



Twitter <verify@twitter.com>

To ● Florian B

If there are problems with how this message is displayed, click here to v...

We noticed a recent  
account @flobo69

Device  
Location\*

Chromecast  
Calais, Fra...

\*Location is approximate based on...

If this was you:

Great! There's nothing else you...

If this wasn't you:

Your account may have been...  
should take a few steps to...

# Application Layer 1

ELEC3227/ELEC6255

Twitter

New login to Twitter from Chr...

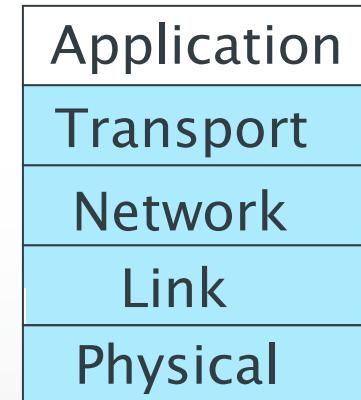
1:17 PM

# Overview

- How the Application Layer fits into the 5-layer model
- Domains and Domain Name Servers
- Email transmission
- World Wide Web and HTTP

# The 5-layer Model

- Application layer is at the **top** of the protocol stack
- “Application” doesn’t necessarily have a user interface
  - Though it does do something useful!
  - May be command-line based, server on network...
  - Email, web browsing, music/video streaming, calls
- Relies on **services** provided by the Transport layer
  - Typically TCP/IP or UDP



# Services Provided by Transport Layer

- Enable data to be transmitted across the network/internet
  - **TCP/IP: Transmission Control Protocol/Internet Protocol**  
Reliable, guaranteed transmission, but significant overheads. Used for file transfer.
  - **UDP: User Datagram Protocol**  
Quick but unreliable protocol, transmissions may not arrive, application must be able to cope with this. Typically used where low latency is more important than accuracy (e.g. video chat, streaming).



Kirk Bater

@KirkBater

Follow

This image is a TCP/IP Joke. This tweet is a UDP joke. I don't care if you get it.

Thread X

iamkirkbater and jkjustjoshing

 **iamkirkbater** Aug 23rd, 2017 at 9:37 AM in #www  
Do you want to hear a joke about TCP/IP?  
 7 replies

 **jkjustjoshing** 5 months ago  
Yes, I'd like to hear a joke about TCP/IP

 **iamkirkbater** 5 months ago  
Are you ready to hear the joke about TCP/IP?

 **jkjustjoshing** 5 months ago  
I am ready to hear the joke about TCP/IP

 **iamkirkbater** 5 months ago  
Here is a joke about TCP/IP.

 **iamkirkbater** 5 months ago  
Did you receive the joke about TCP/IP?

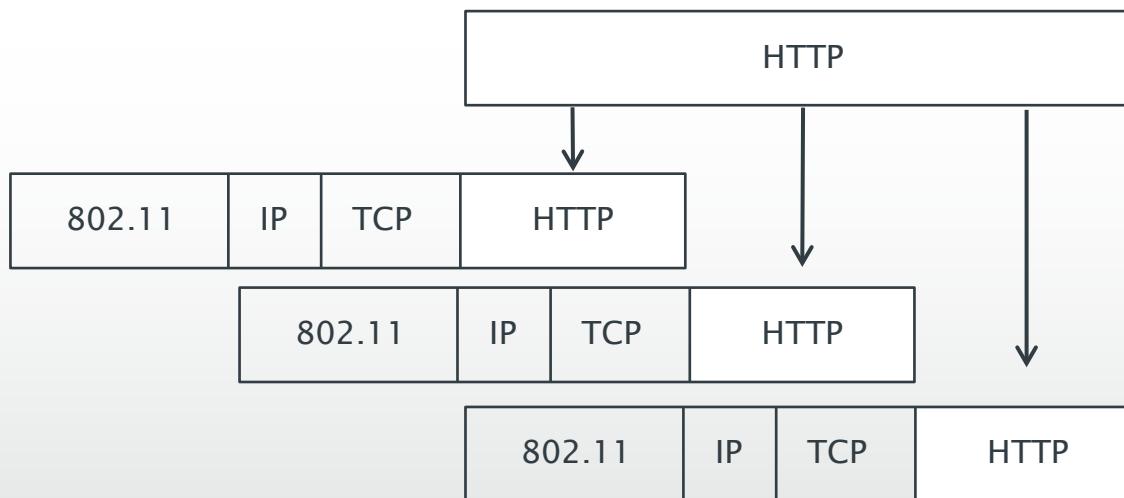
 **jkjustjoshing** 5 months ago  
I have received the joke about TCP/IP.

 **iamkirkbater** 5 months ago  
Excellent. You have received the joke about TCP/IP. Goodbye.

9:01 AM - 17 Jan 2018

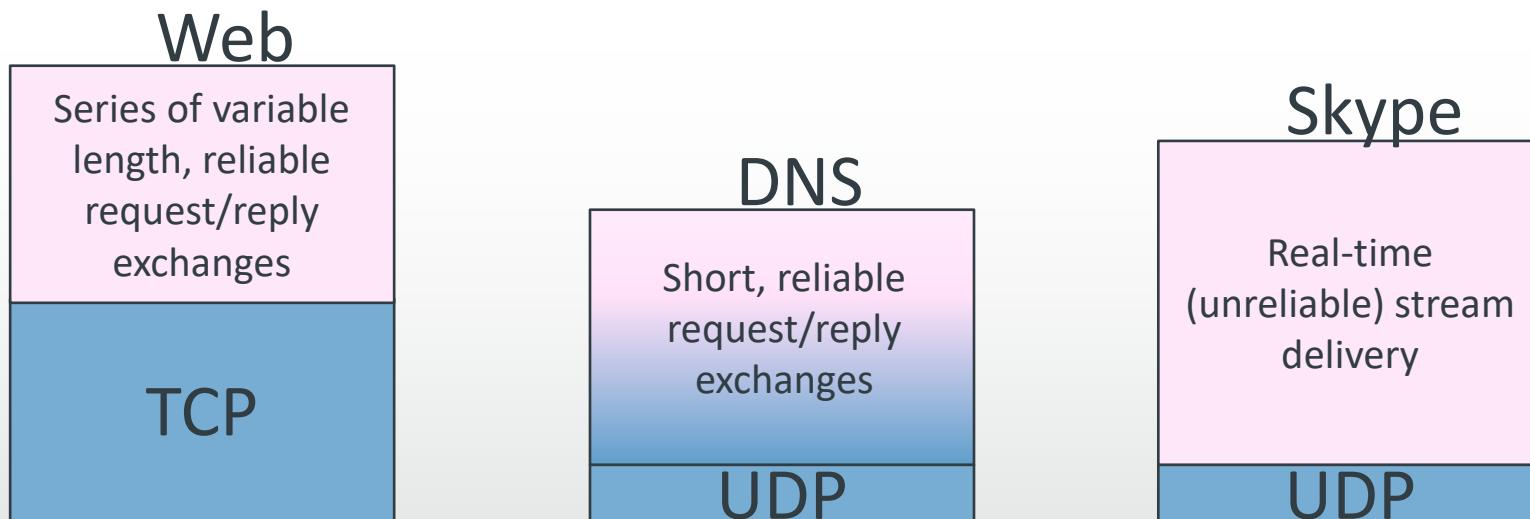
# Message Transmission

- Application layer messages are often split over multiple packets
  - Or may be aggregated in a packet ...



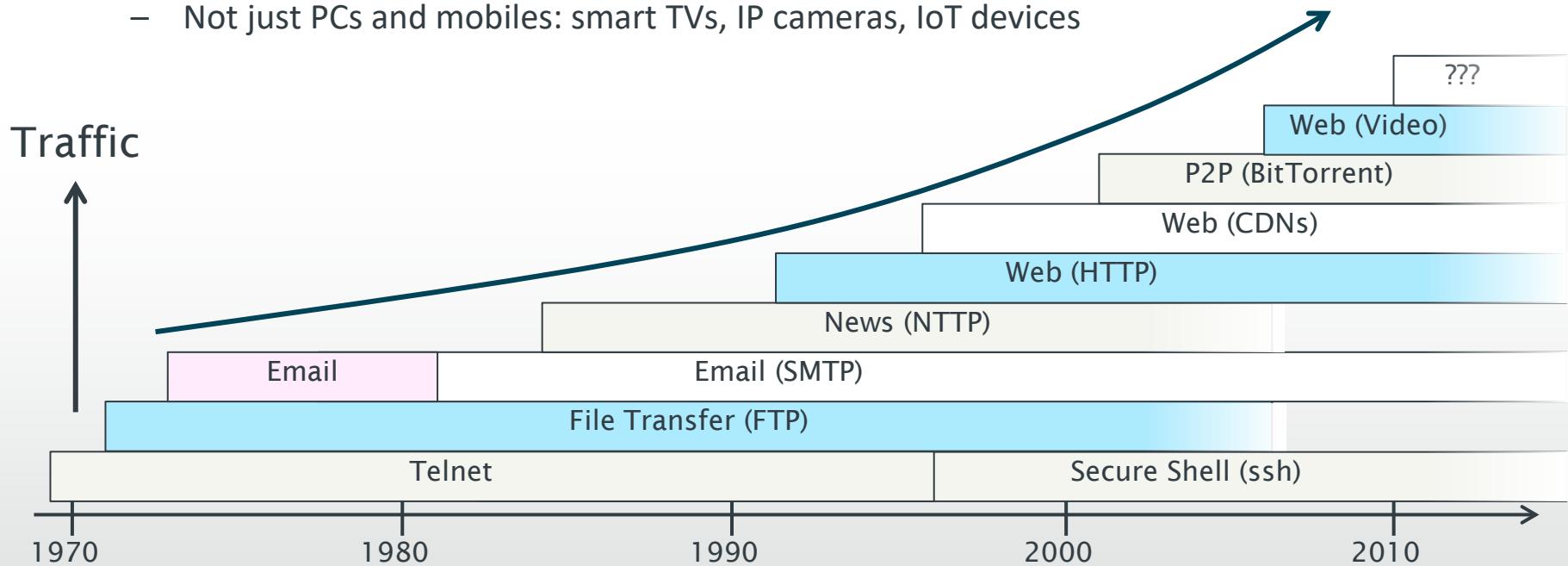
# Application Communication Needs

- Vary widely with app; must build on Transport services



# Evolution of Internet Applications

- Constantly changing and growing...
  - Most traffic is now video
  - Predicted that 33% of IP traffic will be from mobiles by 2021
  - Not just PCs and mobiles: smart TVs, IP cameras, IoT devices

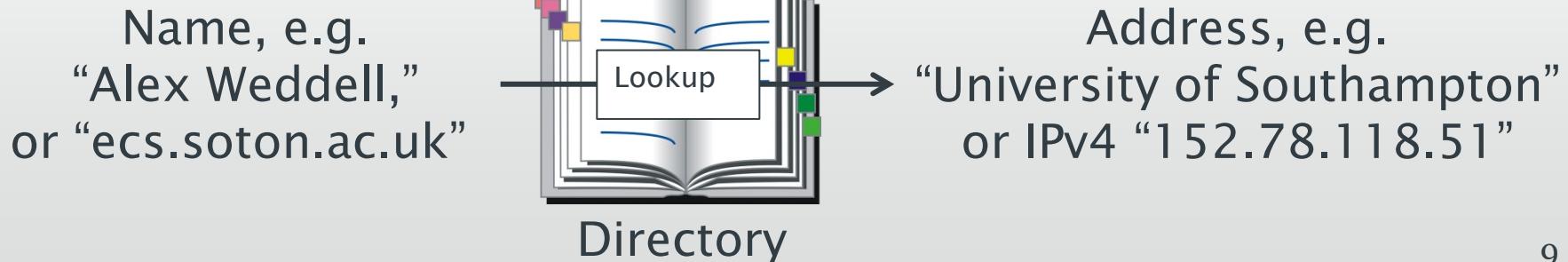
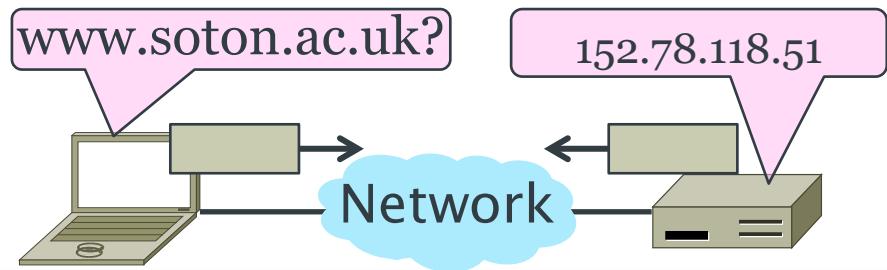


# Domain Name System (DNS)

- Before the DNS – a single text file!
  - Directory was a file HOSTS.TXT regularly retrieved for all hosts from a central machine at the NIC (Network Information Center)
  - Names were initially flat, became hierarchical (e.g., lcs.mit.edu) around 1985
- Neither manageable nor efficient as the Internet (formally ARPANET) grew!
- A naming service to map between host names and their IP addresses
  - www.uwa.edu.au → 130.95.128.140
- Goals
  - Easy to manage (esp. with multiple parties)
  - Efficient (good performance, few resources)
- Approach
  - Distributed directory based on a hierarchical namespace
  - Automated protocol to tie pieces together

# Domain Name System (DNS)

- The DNS (Domain Name System)
  - Human-readable host names
- System of **names** and **addresses**
  - Names are higher-level identifiers for resources
  - Addresses are lower-level identifiers for resources
    - Multiple levels: full name, email address, IP address, Ethernet address...
  - **Resolution (or lookup)** is mapping a name to an address



# DNS Resource Records

- Zone is comprised of DNS resource records, for each domain name

Type	Meaning
SOA	Start of authority, has key zone parameters
A	IPv4 address of a host
AAAA (“quad A”)	IPv6 address of a host
CNAME	Canonical name for an alias
MX	Mail exchanger for the domain
NS	Nameserver of domain or delegated subdomain

# DNS Resource Records

```
; Authoritative data for cs.vu.nl
cs.vu.nl.      86400  IN  SOA   star boss (9527,7200,7200,241920,86400)
cs.vu.nl.      86400  IN  MX    1 zephyr
cs.vu.nl.      86400  IN  MX    2 top
cs.vu.nl.      86400  IN  NS    star                                Name server

star           86400  IN  A     130.37.56.205
zephyr         86400  IN  A     130.37.20.10
top            86400  IN  A     130.37.20.11
www            86400  IN  CNAME star.cs.vu.nl
ftp             86400  IN  CNAME zephyr.cs.vu.nl

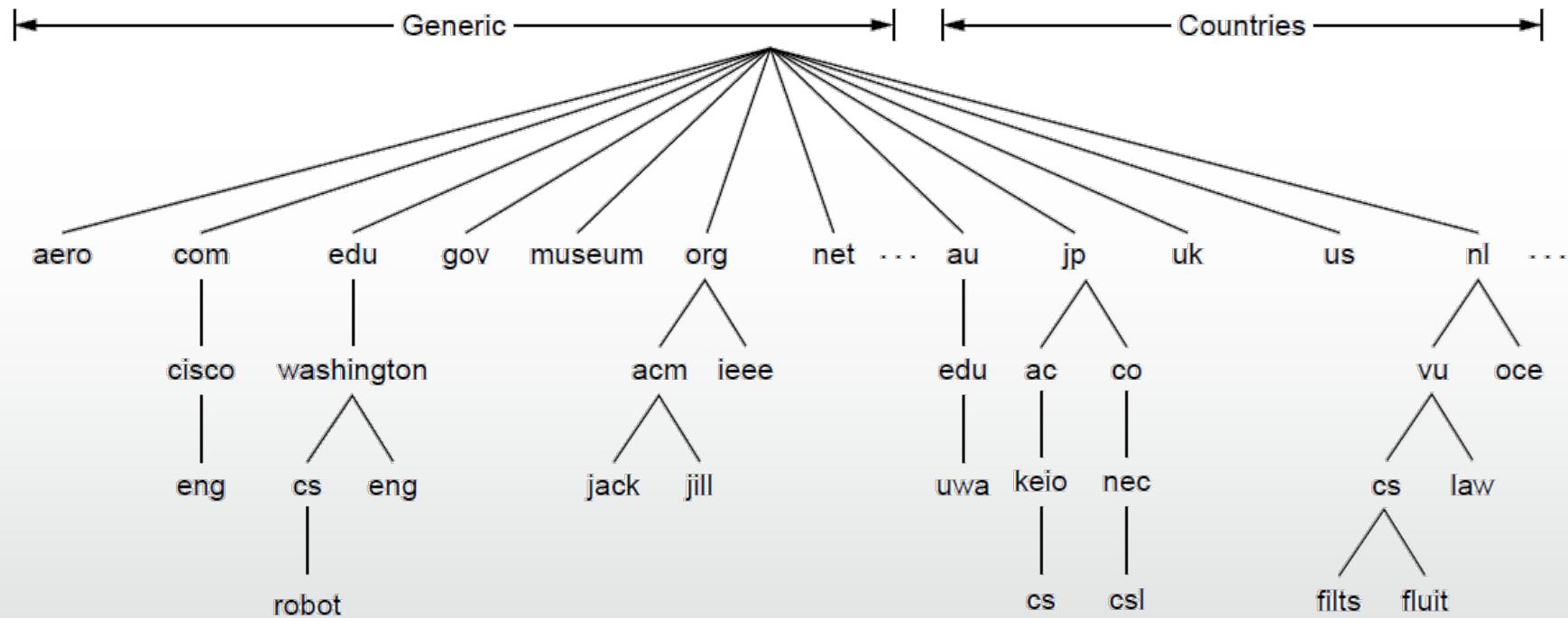
flits          86400  IN  A     130.37.16.112
flits          86400  IN  A     192.31.231.165
flits          86400  IN  MX    1 flits
flits          86400  IN  MX    2 zephyr
flits          86400  IN  MX    3 top

rowboat        IN  A     130.37.56.201
                IN  MX   1 rowboat
                IN  MX   2 zephyr               ← Mail gateways

little-sister   IN  A     130.37.62.23
laserjet       IN  A     192.31.231.216
```

# DNS Namespace

- A hierarchical approach to name management

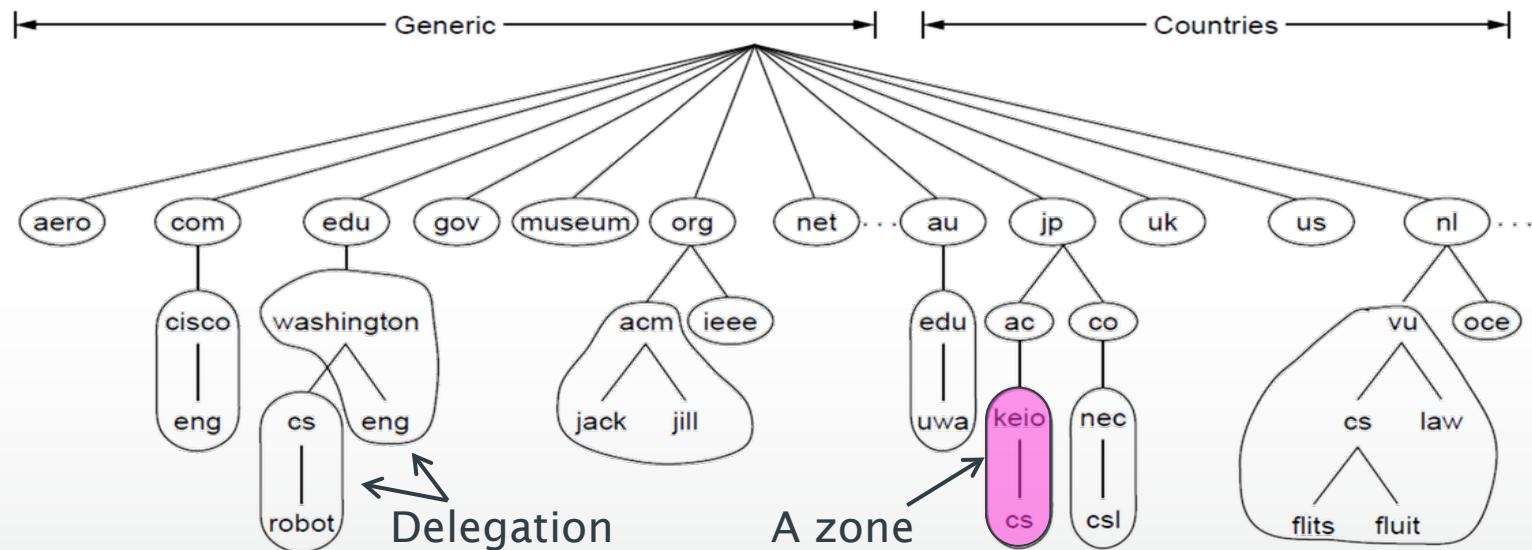


# Top-Level Domains

- Run by ICANN (Internet Corp. for Assigned Names and Numbers)
  - Starting in '98; naming was financial, political, and international
- Up to 2011, there were 22+ generic TLDs
  - Initially .com, .edu , .gov., .mil, .org, .net
  - Added .aero, .museum, etc.
  - Different TLDs have different usage policies
- ~250 country code TLDs
  - Two letters, e.g., ".au", plus international characters since 2010
  - Widely commercialized, e.g., .tv (Tuvalu)
  - Many domain hacks, e.g., instagr.am (Armenia), goo.gl (Greenland)
- Restrictions on TLDs relaxed recently, now >1500 TLDs
  - Need at least \$100,000 and prove competence in running one!
  - e.g. "bargains" "flowers" "guitars" now TLDs!

# DNS Zones

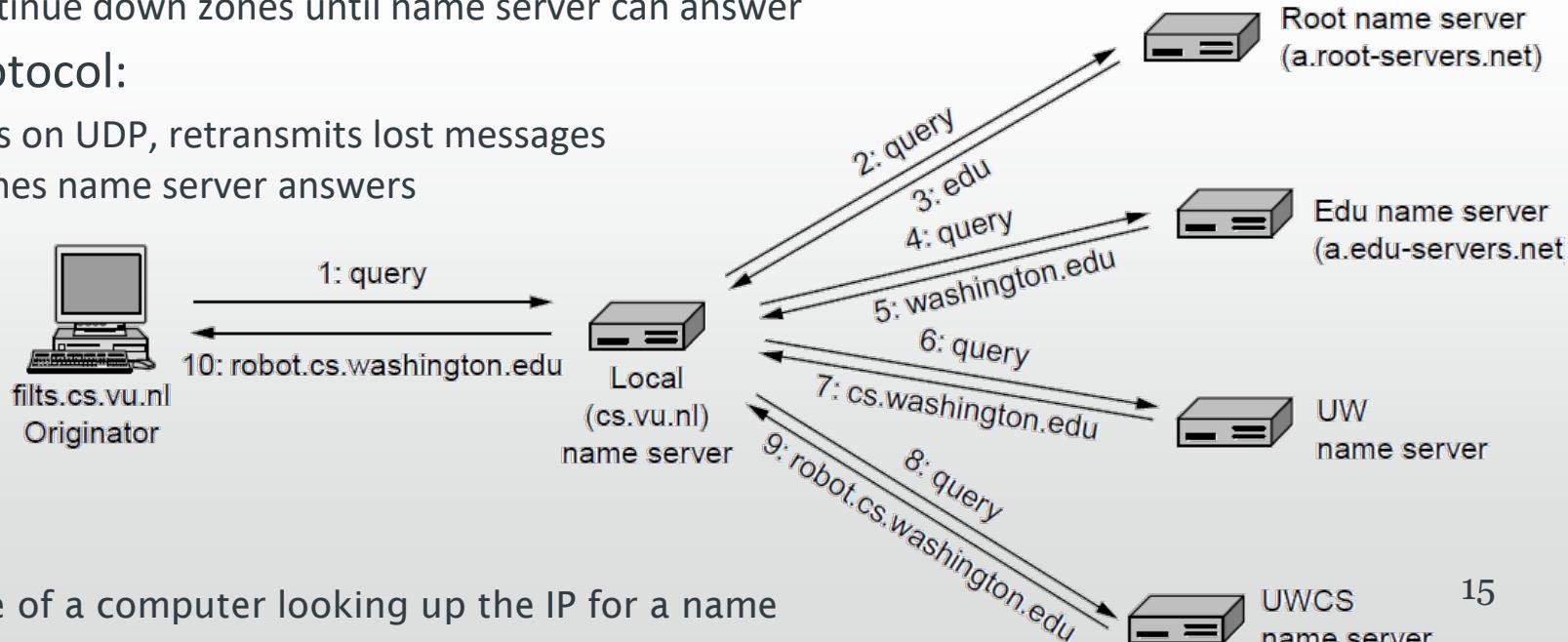
- A **zone** is a contiguous portion of the namespace



- Zones are the basis for **distribution**
  - EDU Registrar administers .edu
  - UW administers washington.edu
  - CS&E administers cs.washington.edu
- Each zone has a **nameserver** to contact for information about it
  - Must include contacts for delegations, e.g., .edu knows nameserver for washington.edu

# Address Resolution

- Finding the IP address for a given hostname is called 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, retransmits lost messages
  - Caches name server answers



Example of a computer looking up the IP for a name

# Uniform Resource Locators

- Pages are named with URLs (Uniform Resource Locators)
  - Example: <http://www.phdcomics.com/comics.php>
  - Protocol: http; Server: www.phdcomics.com; Page on servers: comics.php

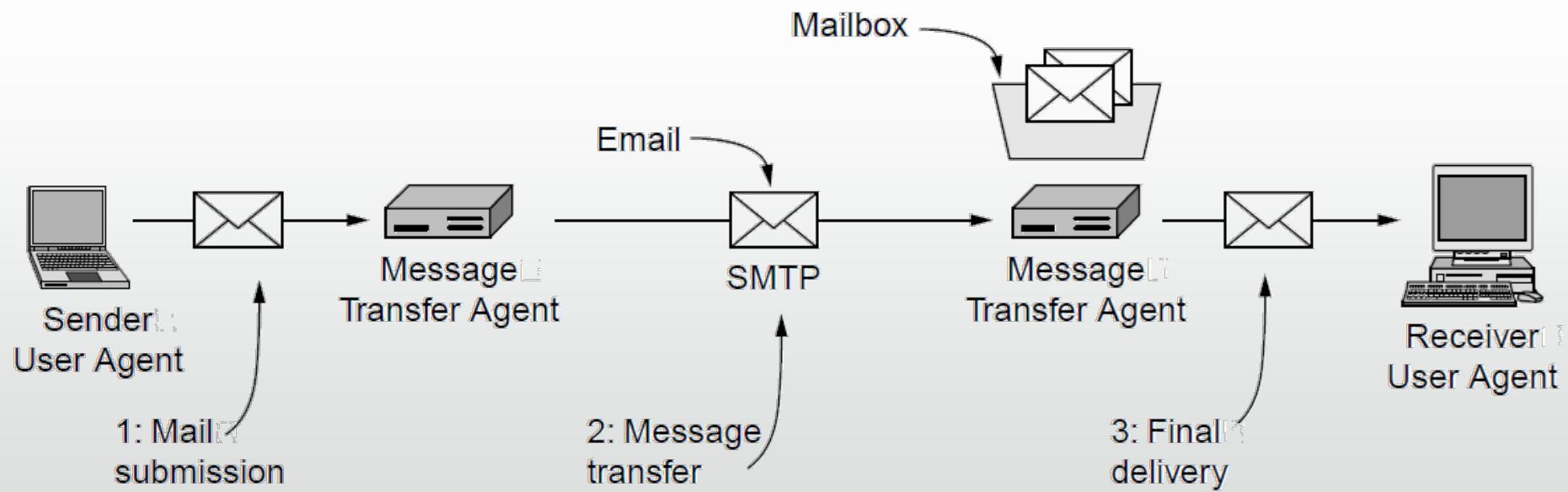
Our focus

Name	Used for	Example
http	Hypertext (HTML)	http://www.ee.uwa.edu/~rob/
https	Hypertext with security	https://www.bank.com/accounts/
ftp	FTP	ftp://ftp.cs.vu.nl/pub/minix/README
file	Local file	file:///usr/suzanne/prog.c
mailto	Sending email	mailto:JohnUser@acm.org
rtsp	Streaming media	rtsp://youtube.com/montypython.mpg
sip	Multimedia calls	sip:eve@adversary.com
about	Browser information	about:plugins

Common URL Protocols

# Email Message Transfer

- Messages are transferred with SMTP (Simple Mail Transfer Protocol)
  - Readable text commands
  - Submission from user agent to MTA on port 587
  - One MTA to the next MTA on port 25
  - Other protocols for final delivery (IMAP, POP3)



# Email Message Transfer

- Header information for message transport; readable text

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

- Other header fields useful for user agents

Header	Meaning
Date:	The date and time the message was sent
Reply-To:	Email address to which replies should be sent
Message-Id:	Unique number for referencing this message later
In-Reply-To:	Message-Id of the message to which this is a reply
References:	Other relevant Message-Ids
Keywords:	User-chosen keywords
Subject:	Short summary of the message for the one-line display

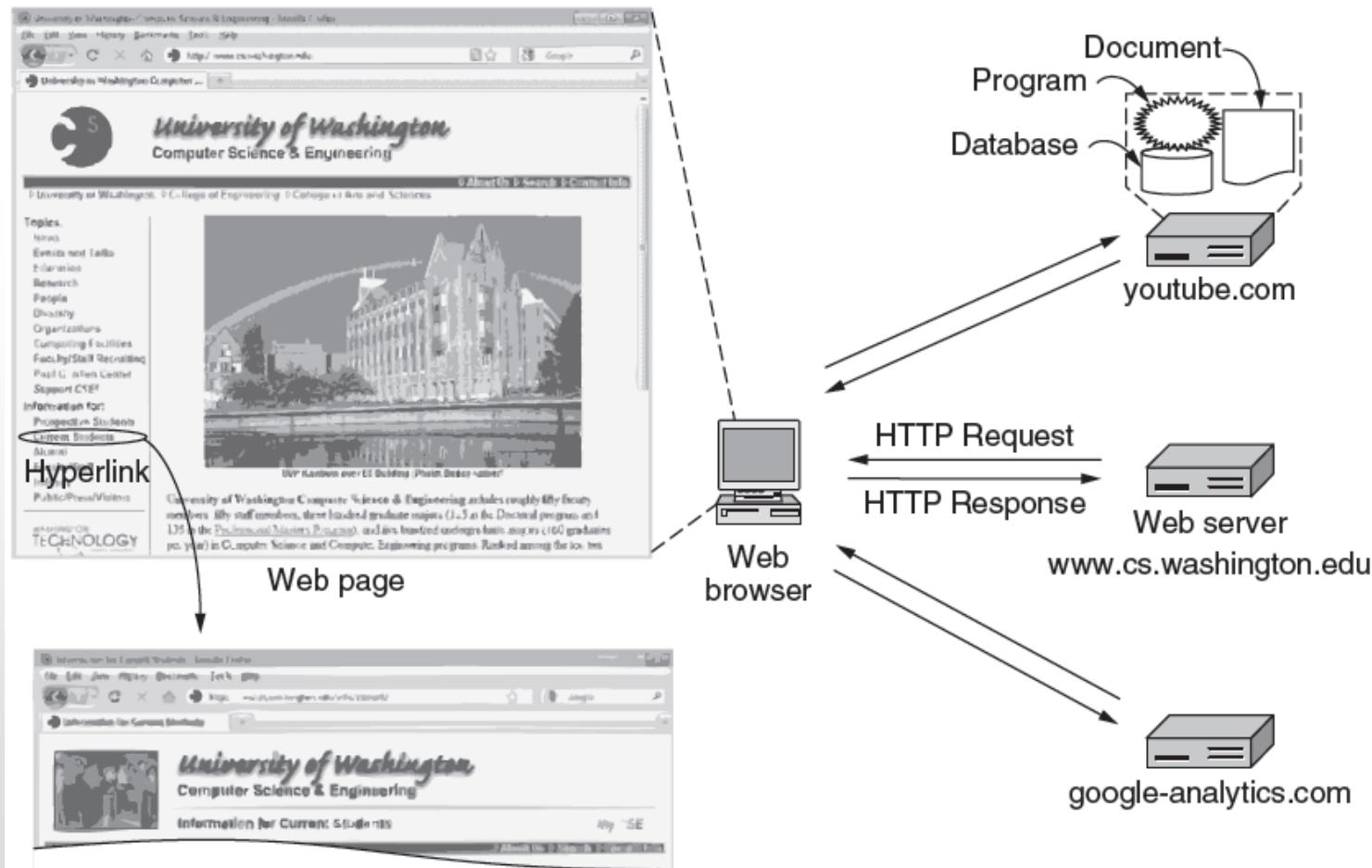
# Email Message Transfer

- Sending a message from Alice to Bob
- SMTP commands are marked [pink]
- Final message delivery uses IMAP, web interface, or proprietary protocol (e.g. MS Exchange)

```
S: 220 ee.uwa.edu.au SMTP service ready
C: HELO abcd.com
S: 250 cs.washington.edu says hello to ee.uwa.edu.au
C: MAIL FROM: <alice@cs.washington.edu>
S: 250 sender ok
C: RCPT TO: <bob@ee.uwa.edu.au>
S: 250 recipient ok
C: DATA
S: 354 Send mail; end with "." on a line by itself
C: From: alice@cs.washington.edu
C: To: bob@ee.uwa.edu.au
C: MIME-Version: 1.0
C: Message-Id: <0704760941.AA00747@ee.uwa.edu.au>
C: Content-Type: multipart/alternative; boundary=qwertyuiopasdfghjklzxcvbnm
C: Subject: Earth orbits sun integral number of times
C:
C: This is the preamble. The user agent ignores it. Have a nice day.
C:
C: --qwertyuiopasdfghjklzxcvbnm
C: Content-Type: text/html
C:
C: <p>Happy birthday to you
C: Happy birthday to you
    • • • (rest of message) • • •
C: --qwertyuiopasdfghjklzxcvbnm
C: .
S: 250 message accepted
C: QUIT
S: 221 ee.uwa.edu.au closing connection
```

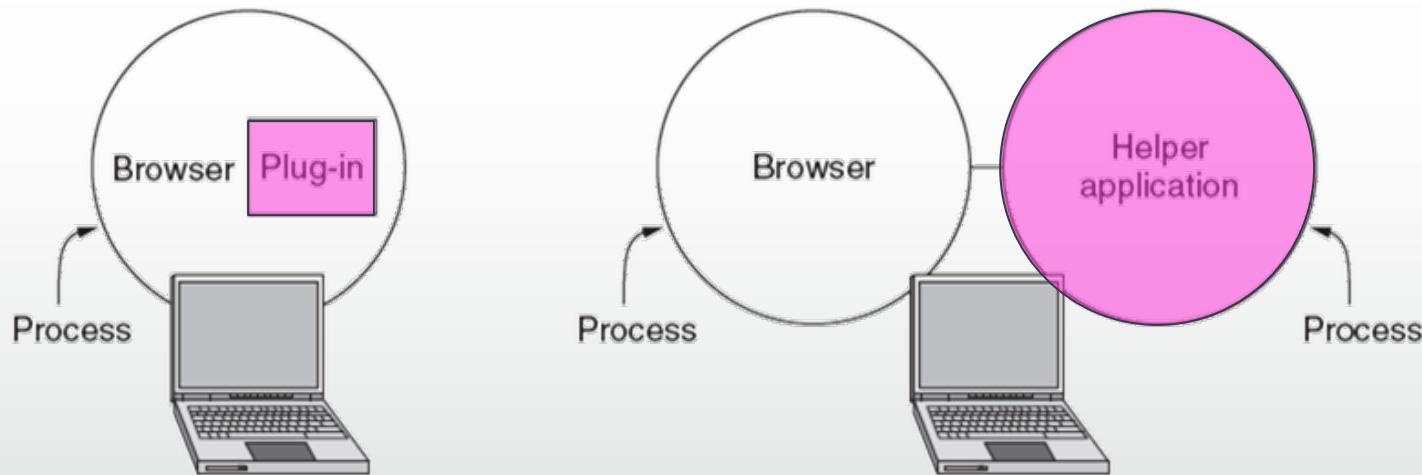
# The World Wide Web

- HTTP transfers pages from servers to browsers



# Handling Files

- Content type is identified by types
  - Browser takes the appropriate action to display
  - **Plug-ins / helper apps** extend browser for new types



# Summary

- How the Application Layer fits into the 5-layer model
- Domains and Domain Name Servers
- Email transmission
- World Wide Web and HTTP