

UNIVERSITY OF
Southampton
School of Electronics
and Computer Science

Application Layer 1

ELEC3227/ELEC6255

Alex Weddell
asw@ecs.soton.ac.uk

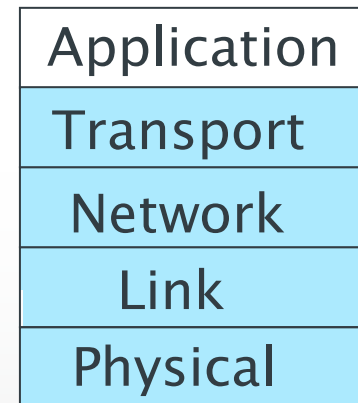
https://mispoweruser.com/dark-mode-finally-hits-the-reading-pane-in-office2019/

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 ×

iamkirkbater and jkjustjoshing

 **iamkirkbater**  Aug 23rd, 2017 at 9:37 AM
in #www

Do you want to hear a joke about TCP/IP?

 7

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.

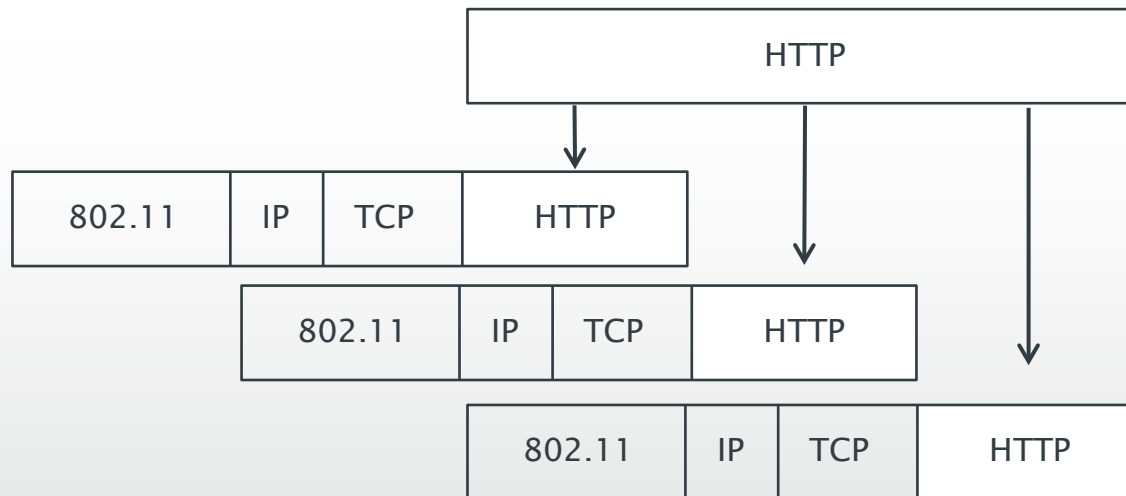
 **iamkirkbater**  5 months ago
Did you receive the joke about TCP/IP?

 **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.

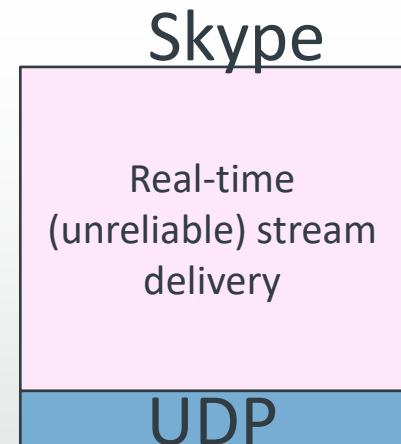
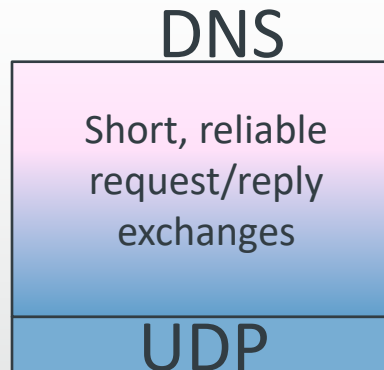
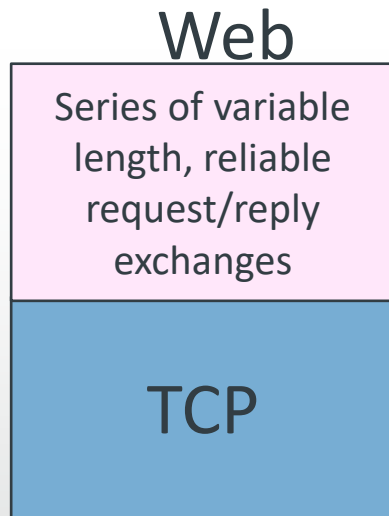
Message Transmission

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



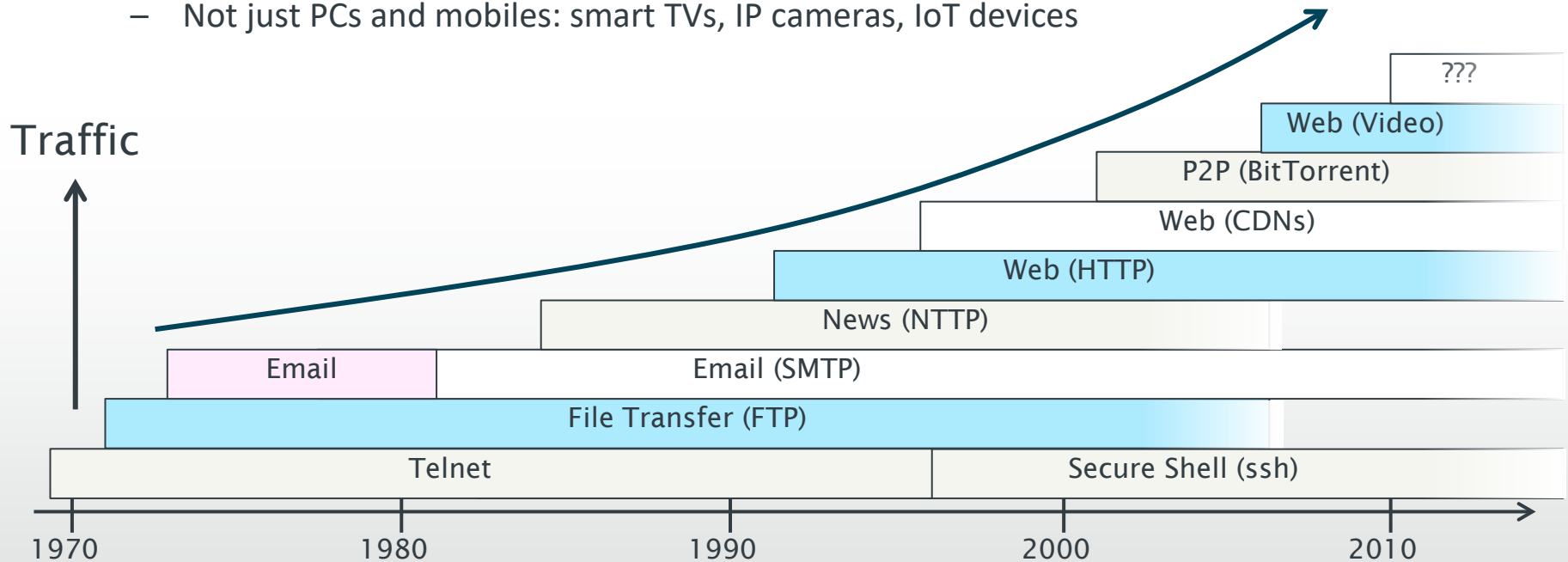
Application Communication Needs

- 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



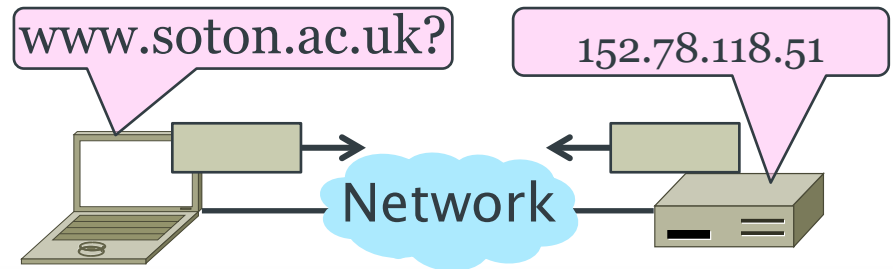
Domain Name System (DNS)

- 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)

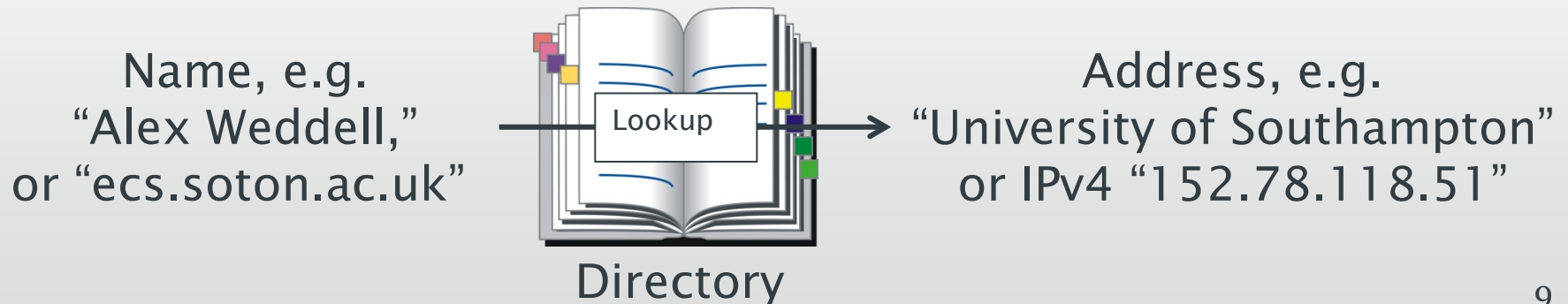
- The DNS (Domain Name System)

- 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	

IP addresses of computers

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	

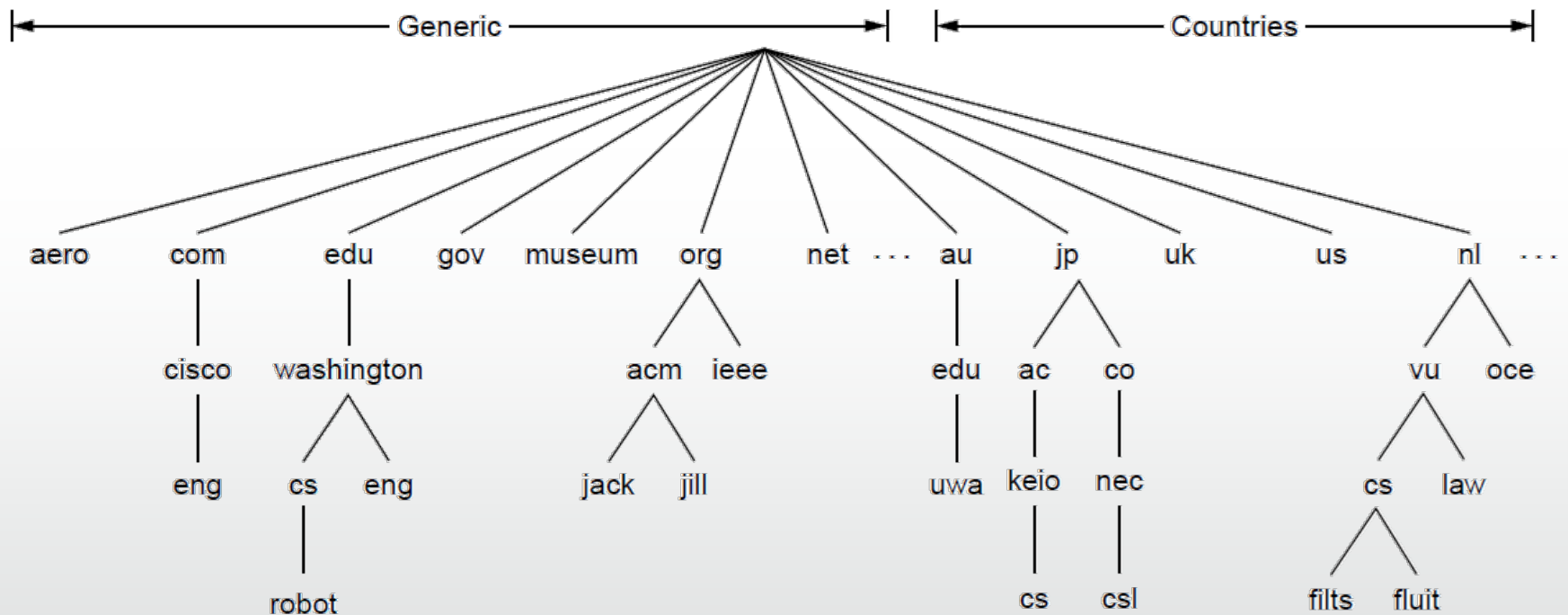
rowboat		IN	A	130.37.56.201	
		IN	MX	1 rowboat	
		IN	MX	2 zephyr	← Mail gateways

little-sister		IN	A	130.37.62.23	
---------------	--	----	---	--------------	--

laserjet		IN	A	192.31.231.216	
----------	--	----	---	----------------	--

DNS Namespace

- A hierarchical approach to name management

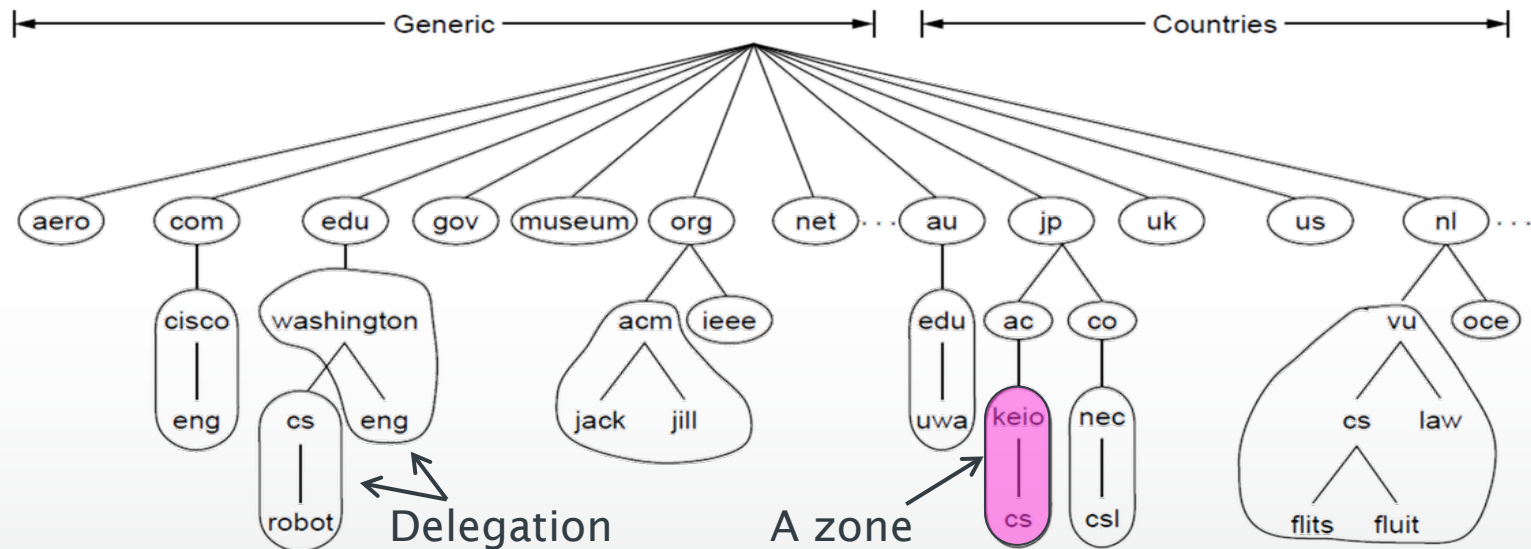


Top-Level Domains

- 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

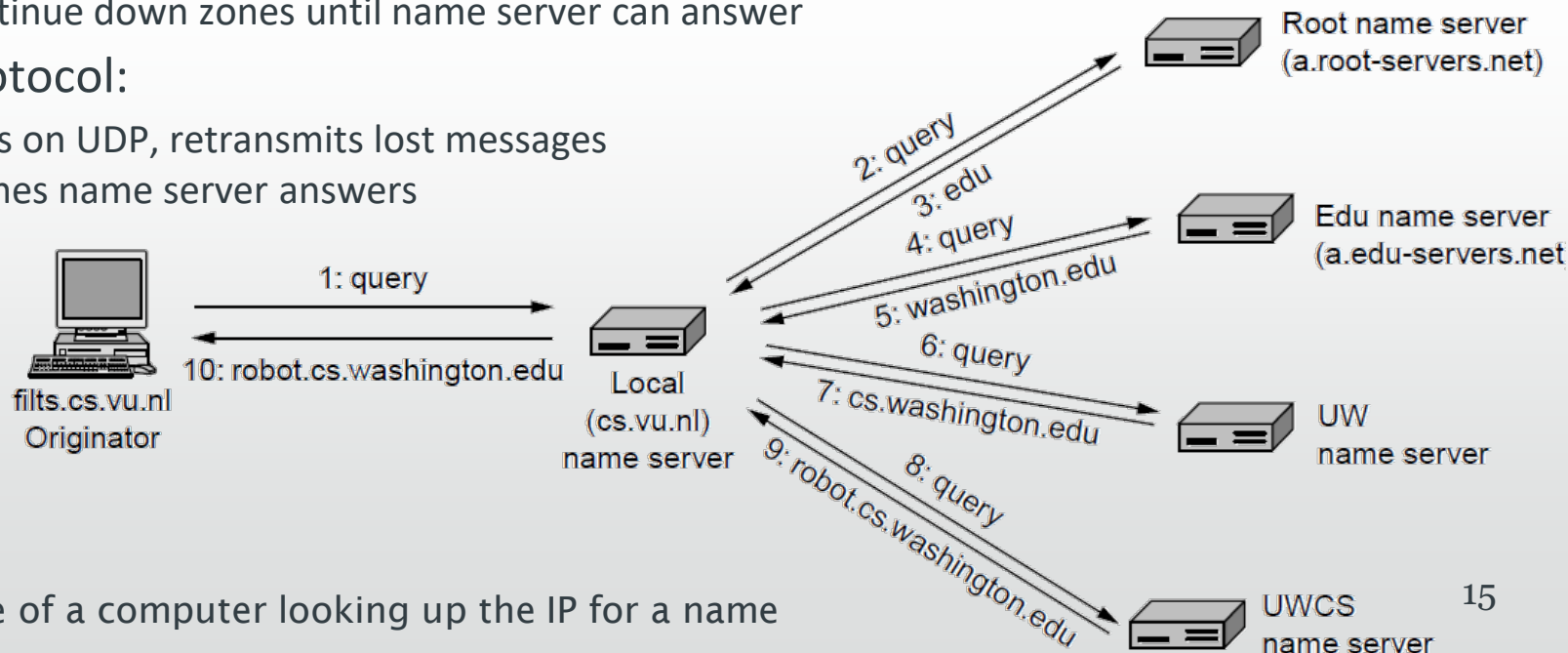
- A **zone** is a contiguous portion of the namespace



- 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

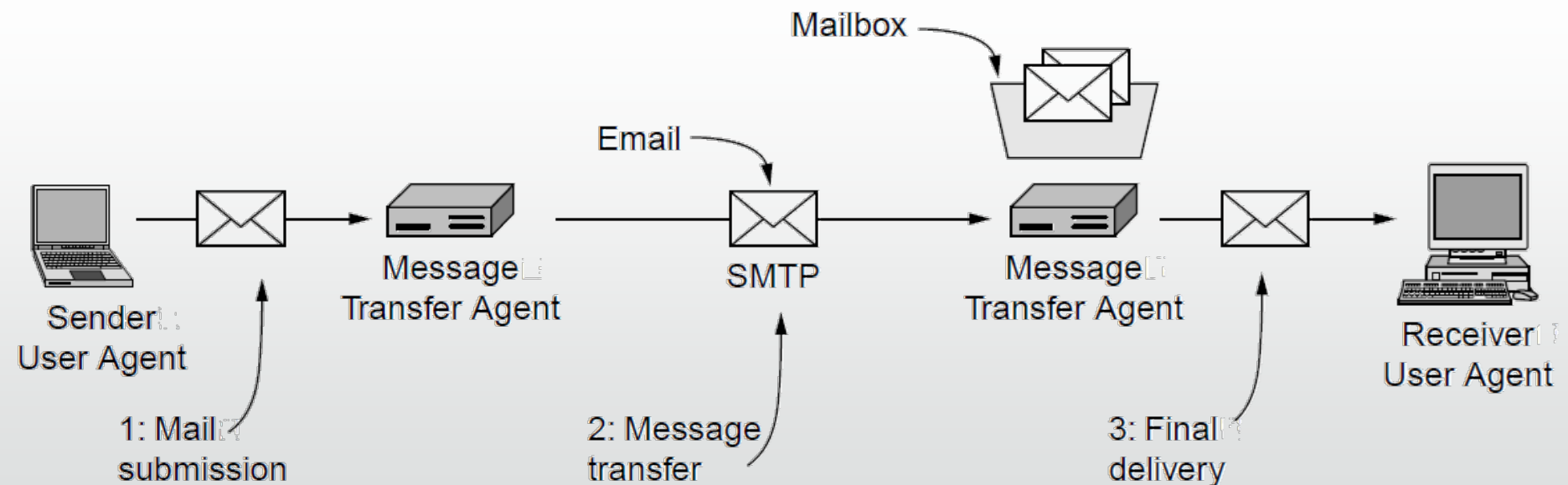
Our focus →

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

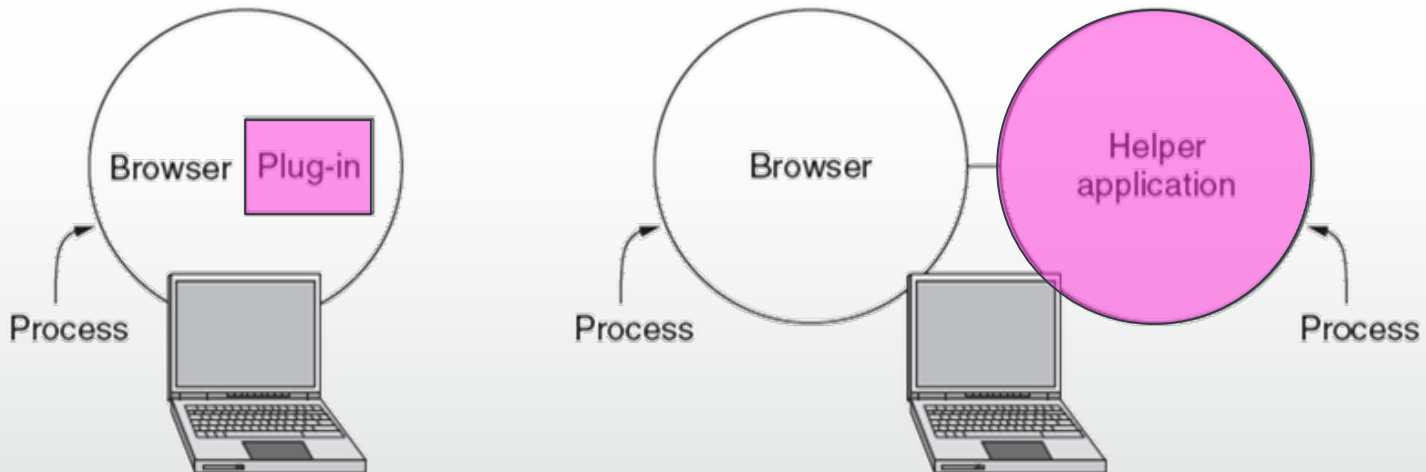
- Sending a message from Alice to Bob
- SMTP commands are marked [pink]
- Final message delivery uses IMAP, web interface, or proprietary protocol (e.g. MS Exchange)

```
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
C:
C: ■ ■ ■ (rest of message) ■ ■ ■
C: --qwertyuiopasdfghjklzxcvbnm
C: .
S: 250 message accepted
C: [QUIT]
S: 221 ee.uwa.edu.au closing connection
```

-
- The diagram illustrates the interaction between a web browser, a web page, and various web services. On the left, a screenshot of a web browser shows the University of Washington Computer Science & Engineering website. A red circle highlights a 'Hyperlink' on the page, which points to a 'Web page' (another screenshot of the same website). To the right, a 'Web browser' icon is shown. Arrows indicate the flow of data: an 'HTTP Request' is sent from the web browser to a 'Web server' (labeled 'www.cs.washington.edu'), which returns an 'HTTP Response'. Additionally, the web browser interacts with 'youtube.com' and 'google-analytics.com' via bidirectional arrows. A dashed line connects the web browser to the top-left screenshot of the website.

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