# The Application Layer: email & SMTP

Smith College, CSC 249
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## Chapter 2: Application layer

- □ 2.1 Principles of network applications
- □ 2.2 Web and HTTP
- □ 2.3 FTP
- □ 2.4 Electronic Mail
  - ❖ SMTP, POP3, IMAP
- □ 2.5 DNS
- □ 2.6 P2P file sharing
- □ 2.7 Socket programming with TCP
- □ 2.8 Socket programming with UDP
- □ 2.9 Building a Web server

## HTTP Recap

- Protocol for the World Wide Web
  - Client-server architecture
  - Pull protocol (you request, "pull," the html file you want, the server does not push it onto you)
  - Steps in an HTTP communication
    - Handshaking and connection set-up
  - Types and format of HTTP messages
    - All in ASCII
- New vocabulary
  - Port number, protocol and processes
- Using telnet

## For Today: Electronic mail

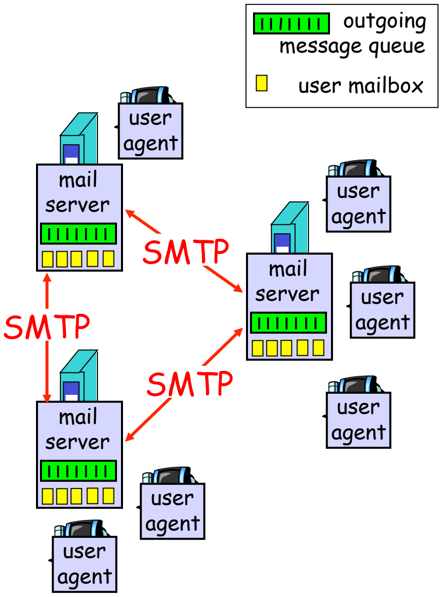
- Major elements of email
- Main protocols (and port numbers)
- Types and format of messages
- Steps for email messages to move from sender to receiver, through the Internet

## Electronic Mail

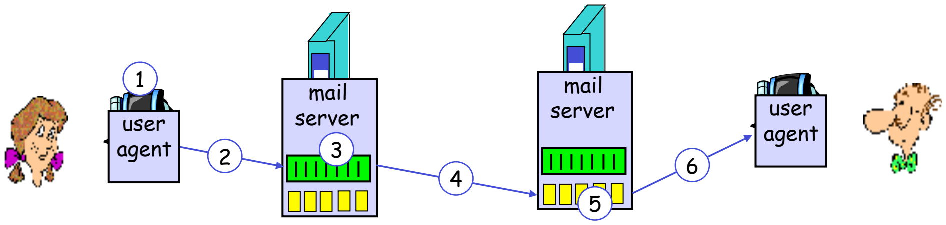
**Three major components:**

1) user agents
2) mail servers
3) SMTP: simple mail transfer protocol

- ❑ (and user access protocols)

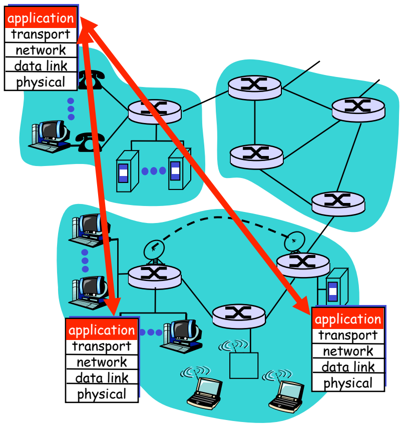


## Scenario: Alice sends message to Bob



# Discussion Question

- ❑ The textbook states "SMTP does not normally use intermediate mail servers for sending mail…"
- ❑ Are devices in the network core used in sending mail? Explain.



# Electronic Mail: SMTP

- ❑ There are three phases in SMTP
  - handshaking (greeting)
  - transfer of messages
  - closure
- ❑ command/response interaction
  - commands: ASCII text
  - response: status code and phrase
- ❑ client and server sides of SMTP run on every mail server
  - Use persistent TCP connections (reliable transfer)
  - Use port 25
- ❑ messages must be in ASCII
  - No binary data can be send – meaning what!?

## Sample SMTP interaction

- In the following interaction with SMTP, which lines are
  - Handshaking
  - Transfer of message
  - Closure

## Sample SMTP interaction

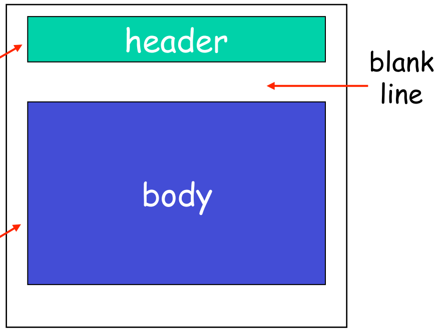
```
   fcapmaster:~ jcardell$ telnet smtp.smith.edu 25
   Trying 131.229.64.236...
   Connected to baton.smith.edu.
   Escape character is '^]'.
   220 baton.smith.edu ESMTP Sendmail 8.14.7/8.13.8; Wed, 31 Jan 2018 11:06:44 -0500

C: HELO jbc.edu
S: 250 baton.smith.edu Hello [131.229.102.128], pleased to meet you
C: MAIL FROM: <judy@jbc.edu>
S: 250 2.1.0 <judy@jbc.edu>... Sender ok
C: RCPT TO: <jcardell@smith.edu>
S: 250 2.1.5 <jcardell@smith.edu>... Recipient ok
C: DATA
S: 354 Enter mail, end with "." on a line by itself
C: Hello Me
C: This is an email message from me as a user agent via telnet
C: .
S: 250 2.0.0 s8GFb0Q4007216 Message accepted for delivery
C: QUIT
S: 221 2.0.0 baton.smith.edu closing connection

   Connection closed by foreign host.
```

## Mail message format

* Example of the actual message - NOT part of the SMTP handshaking process

- header lines, e.g.,
  - To:
  - From:
  - Subject:

  *different from SMTP commands!*
- body
  - the "message", ASCII characters only



## Try SMTP interaction with Smith accounts (using telnet so you can be the user agent)

- Send email without using a fancy email client, but with you doing all the tasks your mail reader usually does for you
  - **`telnet <servername> 25`**
  - You should receive a '220' reply from the server
  - enter HELO, MAIL FROM:, RCPT TO:, DATA, QUIT commands
- Next, include header lines in the actual message
- In Chrome/gmail, compare the message 'properties' of the two messages

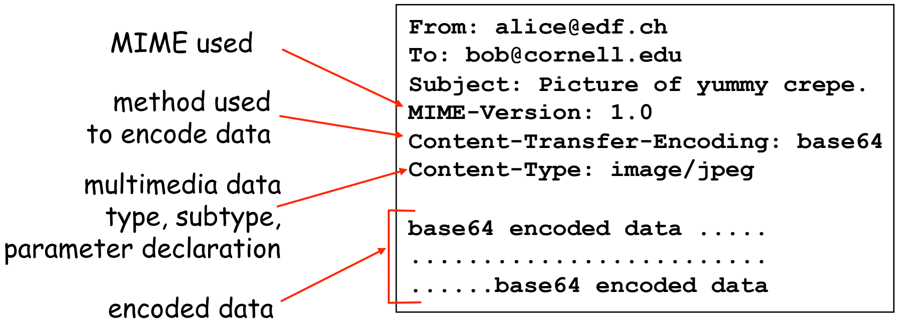
## Back to SMTP → shortcomings

…

- messages must be in ASCII
  - No binary data can be send – meaning what!?

## Message format: multimedia extensions

- MIME: multipurpose internet mail extension
- additional lines in message header define the MIME content


MIME used
method used to encode data
multimedia data type, subtype, parameter declaration
encoded data

```
From: alice@edf.ch
To: bob@cornell.edu
Subject: Picture of yummy crepe.
MIME-Version: 1.0
Content-Transfer-Encoding: base64
Content-Type: image/jpeg

base64 encoded data .....
.........................
......base64 encoded data
```

# Base64 Encoding

| Value | Char | Value | Char | Value | Char | Value | Char |
|---|---|---|---|---|---|---|---|
| 0 | A | 16 | Q | 32 | g | 48 | w |
| 1 | B | 17 | R | 33 | h | 49 | x |
| 2 | C | 18 | S | 34 | i | 50 | y |
| 3 | D | 19 | T | 35 | j | 51 | z |
| 4 | E | 20 | U | 36 | k | 52 | 0 |
| 5 | F | 21 | V | 37 | l | 53 | 1 |
| 6 | G | 22 | W | 38 | m | 54 | 2 |
| 7 | H | 23 | X | 39 | n | 55 | 3 |
| 8 | I | 24 | Y | 40 | o | 56 | 4 |
| 9 | J | 25 | Z | 41 | p | 57 | 5 |
| 10 | K | 26 | a | 42 | q | 58 | 6 |
| 11 | L | 27 | b | 43 | r | 59 | 7 |
| 12 | M | 28 | c | 44 | s | 60 | 8 |
| 13 | N | 29 | d | 45 | t | 61 | 9 |
| 14 | O | 30 | e | 46 | u | 62 | + |
| 15 | P | 31 | f | 47 | v | 63 | / |

# Base64 Encoding

- ❑ Original (binary) bit stream

  100110111010001011101001

  100110 .. 111010 .. 001011 .. 101001

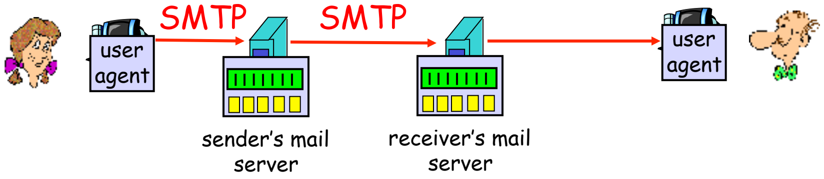
- ❑ Which corresponds to the 6-bit values

  38, 58, 11 and 41

- ❑ Which are encoded as

  m6Lp

# Mail access protocols



- SMTP is a 'PUSH' protocol
- So how do we 'PULL' messages off the mail server?

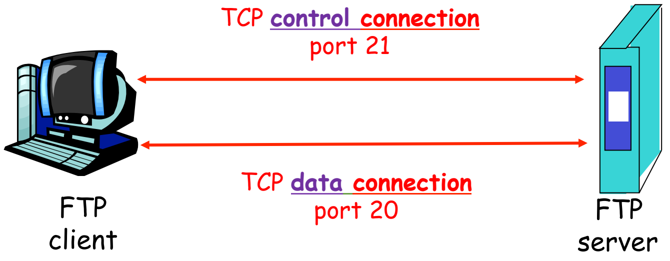
# SMTP: compared to HTTP

- HTTP: pull (you pull info from a server when desired)
- SMTP: push;   POP, IMAP, (HTTP):  pull
- both have ASCII command/response interaction, status codes
- SMTP: multiple objects sent in one message, using encoding as needed
  - SMTP requires message (header & body) to be in ASCII
- HTTP: each object encapsulated in its own response message

# Brief Glimpse: FTP elements

- File transfer protocol
- Two connections
  - Control connection
  - Data connection
- "Out of band"
- The control connection maintains state information

# FTP: separate control & data connections



TCP control connection
port 21

TCP data connection
port 20

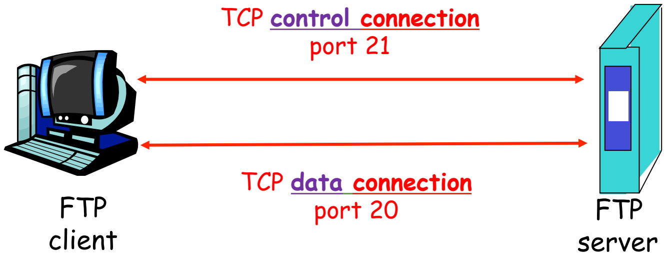
FTP
client

FTP
server

The FTP Client:

- Contacts the FTP server at port 21
- This is a control connection, used to log in
- Commands for file transfer are over this control connection
  - List/Change directory
  - Request to send or receive files …

# FTP: separate control & data connections



TCP **control connection** port 21

TCP **data connection** port 20

FTP client

FTP server

The Server:

- ❑ Listens on port 21 for an incoming connection request
- ❑ When server receives a request, the server opens a separate **data** connection to client

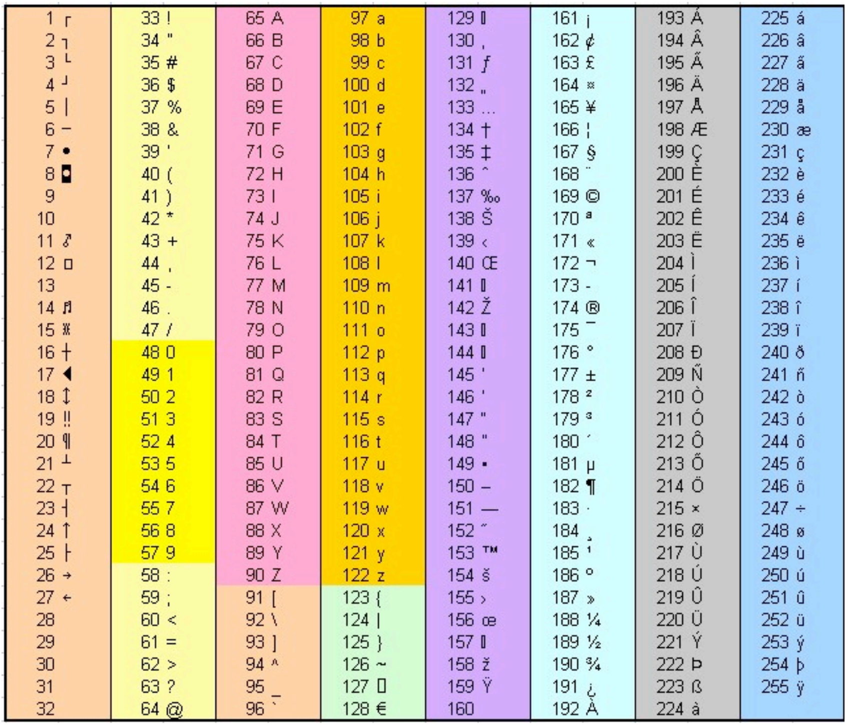
# Port Numbers

- ❑ Can google for list of assigned port numbers:
  - HTTP – 80
  - FTP – 20 & 21
  - SMTP - 25
  - POP - 110
  - IMAP - 143
  - (DNS - 53 over UDP)

## Summary

- ❑ New protocols
  - ❖ SMTP – email delivery and storage
  - ❖ mail access protocols
    - POP3, IMAP, HTTP
- ❑ Using telnet to spoof being
  - ❖ an HTTP client agent
  - ❖ an email client agent
- ❑ Glimpse of FTP – 2 channels

## ASCII



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 ┌ | 33 ! | 65 A | 97 a | 129 ▯ | 161 ¡ | 193 Á | 225 á |
| 2 ┐ | 34 " | 66 B | 98 b | 130 ‚ | 162 ¢ | 194 Â | 226 â |
| 3 └ | 35 # | 67 C | 99 c | 131 ƒ | 163 £ | 195 Ã | 227 ã |
| 4 ┘ | 36 $ | 68 D | 100 d | 132 „ | 164 ¤ | 196 Ä | 228 ä |
| 5 \| | 37 % | 69 E | 101 e | 133 … | 165 ¥ | 197 Å | 229 å |
| 6 ─ | 38 & | 70 F | 102 f | 134 † | 166 ¦ | 198 Æ | 230 æ |
| 7 • | 39 ' | 71 G | 103 g | 135 ‡ | 167 § | 199 Ç | 231 ç |
| 8 ◘ | 40 ( | 72 H | 104 h | 136 ˆ | 168 ¨ | 200 È | 232 è |
| 9 | 41 ) | 73 I | 105 i | 137 ‰ | 169 © | 201 É | 233 é |
| 10 | 42 * | 74 J | 106 j | 138 Š | 170 ª | 202 Ê | 234 ê |
| 11 ♂ | 43 + | 75 K | 107 k | 139 ‹ | 171 « | 203 Ë | 235 ë |
| 12 □ | 44 , | 76 L | 108 l | 140 Œ | 172 ¬ | 204 Ì | 236 ì |
| 13 | 45 - | 77 M | 109 m | 141 ▯ | 173 - | 205 Í | 237 í |
| 14 ♫ | 46 . | 78 N | 110 n | 142 Ž | 174 ® | 206 Î | 238 î |
| 15 ☼ | 47 / | 79 O | 111 o | 143 ▯ | 175 ¯ | 207 Ï | 239 ï |
| 16 ┼ | 48 0 | 80 P | 112 p | 144 ▯ | 176 ° | 208 Ð | 240 ð |
| 17 ◄ | 49 1 | 81 Q | 113 q | 145 ' | 177 ± | 209 Ñ | 241 ñ |
| 18 ↕ | 50 2 | 82 R | 114 r | 146 ' | 178 ² | 210 Ò | 242 ò |
| 19 ‼ | 51 3 | 83 S | 115 s | 147 " | 179 ³ | 211 Ó | 243 ó |
| 20 ¶ | 52 4 | 84 T | 116 t | 148 " | 180 ´ | 212 Ô | 244 ô |
| 21 ┴ | 53 5 | 85 U | 117 u | 149 ▪ | 181 µ | 213 Õ | 245 õ |
| 22 ┬ | 54 6 | 86 V | 118 v | 150 – | 182 ¶ | 214 Ö | 246 ö |
| 23 ┤ | 55 7 | 87 W | 119 w | 151 — | 183 · | 215 × | 247 ÷ |
| 24 ↑ | 56 8 | 88 X | 120 x | 152 ˜ | 184 ¸ | 216 Ø | 248 ø |
| 25 ├ | 57 9 | 89 Y | 121 y | 153 ™ | 185 ¹ | 217 Ù | 249 ù |
| 26 → | 58 : | 90 Z | 122 z | 154 š | 186 º | 218 Ú | 250 ú |
| 27 ← | 59 ; | 91 [ | 123 { | 155 › | 187 » | 219 Û | 251 û |
| 28 | 60 < | 92 \ | 124 \| | 156 œ | 188 ¼ | 220 Ü | 252 ü |
| 29 | 61 = | 93 ] | 125 } | 157 ▯ | 189 ½ | 221 Ý | 253 ý |
| 30 | 62 > | 94 ^ | 126 ~ | 158 ž | 190 ¾ | 222 Þ | 254 þ |
| 31 | 63 ? | 95 _ | 127 ▯ | 159 Ÿ | 191 ¿ | 223 ß | 255 ÿ |
| 32 | 64 @ | 96 ` | 128 € | 160 | 192 À | 224 à | |