Application Layer

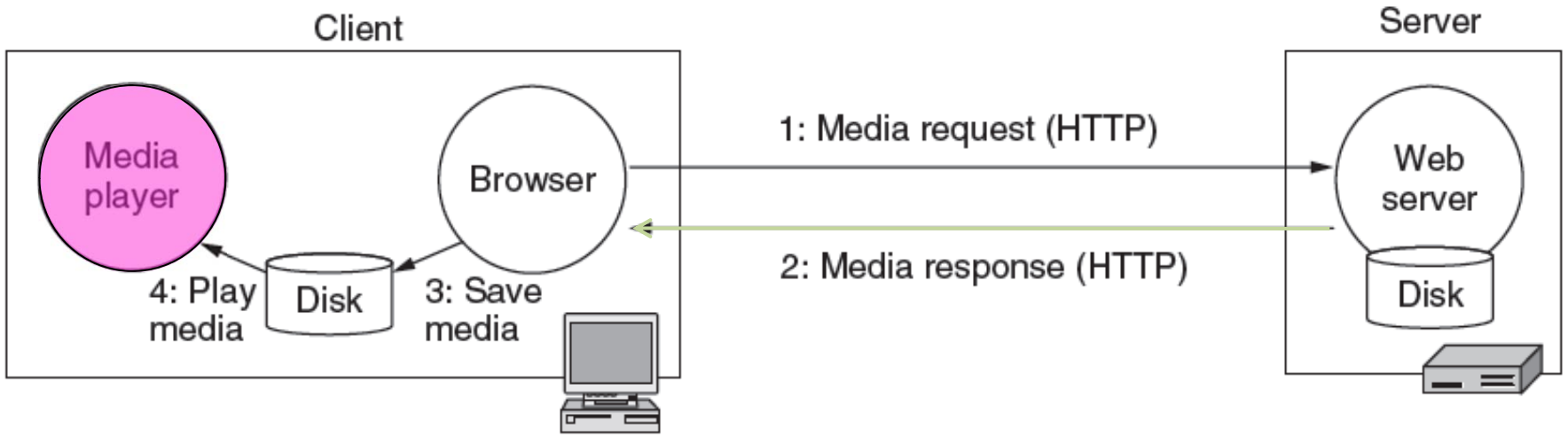
COMP90007

Internet Technologies

Another Key Application Layer App(s)/Data/Protocol/Methods: **Multimedia**

- What is different with Multimedia data?
  - Higher bandwidth requirements
  - Higher QoS requirement, i.e., ***delay sensitivity***
  - Need for new infrastructure and providers
    - Not all communication is one-to-one, quite a bit is ***multicast/broadcast…***
    - …Need separate multimedia servers from web servers: Streaming multimedia service providers are often separated and highly specialised, compared to traditional web hosts

A Basic Model for Multimedia on the Web



Problems with the Basic Model

- **The entire media file must be transmitted over the network before playback starts**
- **Basic model assumes mainly point-to-point media distribution** rather than a point-to-multipoint (broadcast) distribution model
- **Basic model relies on simple browser/plugin/helper** integration and traditional service types which is limited

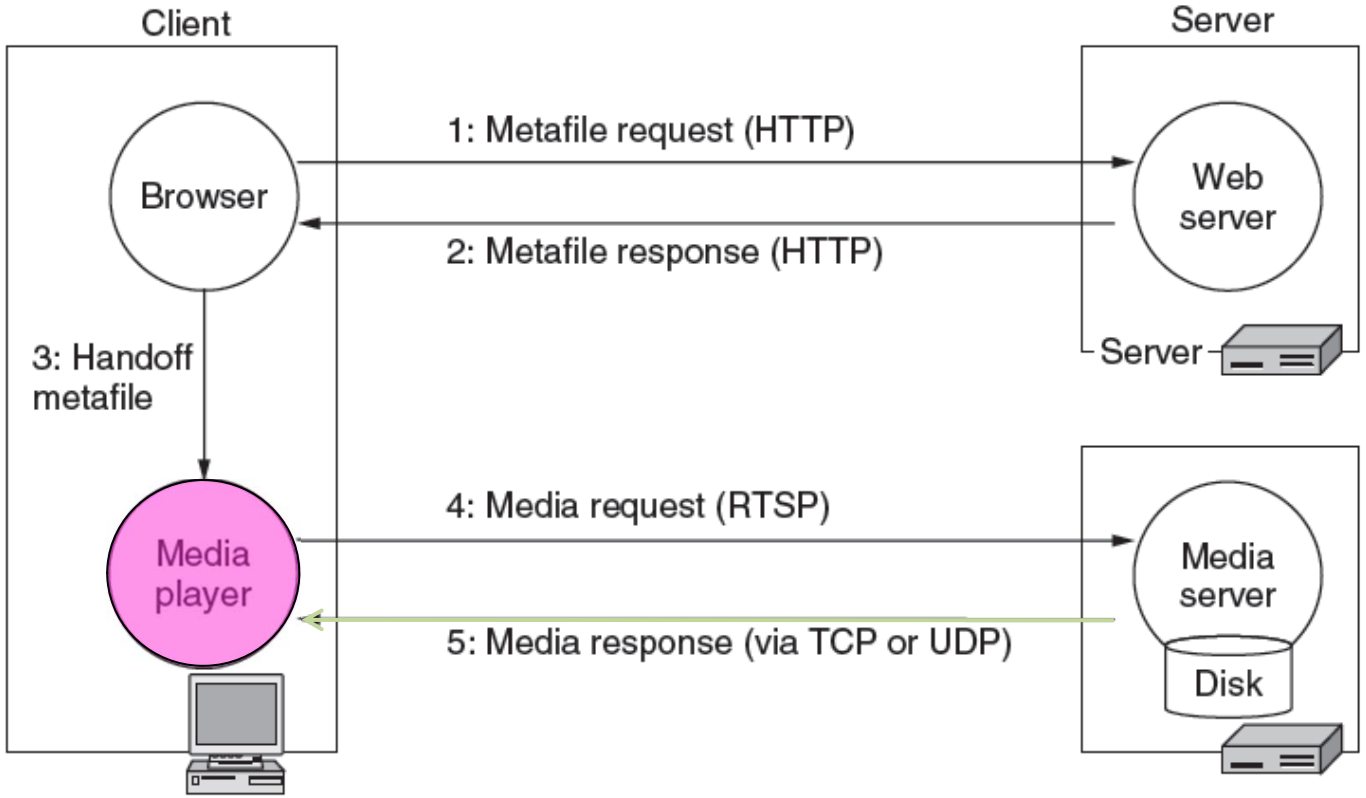
Streaming Media Protocols

- HTTP
- RTP - Real-time Transport Protocol (works over UDP allows for time-stamping etc)
- …
- MPEG-4 (allows for compression)
- …
- Microsoft's Windows Media (closed protocol)
- …
- …***many of these protocols may be used at one time to achieve a successful media stream…***

Specialized Multimedia Software Needed: Not only for display but also in transfer

- 4 main tasks of the multimedia playback software
  - Manage the user interface
    - e.g., volume, playback, next, etc..
  - Handle transmission errors in conjunction with transport protocols
    - Using RTP/UDP errors will likely occur, playback software must manage them gracefully
  - Eliminate jitter
    - Small buffer, quick playback but susceptible to jitter/delay
    - Large buffer, delay at start of playback while buffer fills, but less susceptible to delay/jitter
  - (sometimes compress)/(almost always) decompress the multimedia files

Specialized Model



Handling Errors: A Common Method

Forward Error Correction (FEC) is simply the error-correcting encoding of data.

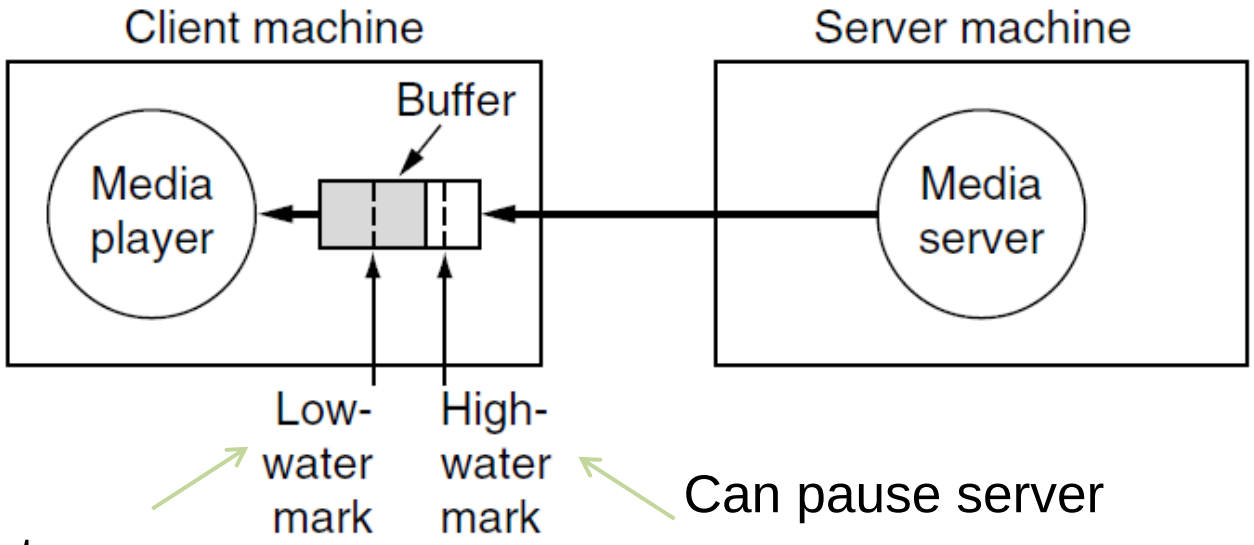
For every X data packets **new packets are added**.

These contains **redundant bits that are used to deal with errors**.

Methods use **parity or exclusive-OR** sums of the bits in each of the data packets.

Jitter Management

Jitters happens because of variable bandwidth and loss/retransmissions. So ***we use buffers***:



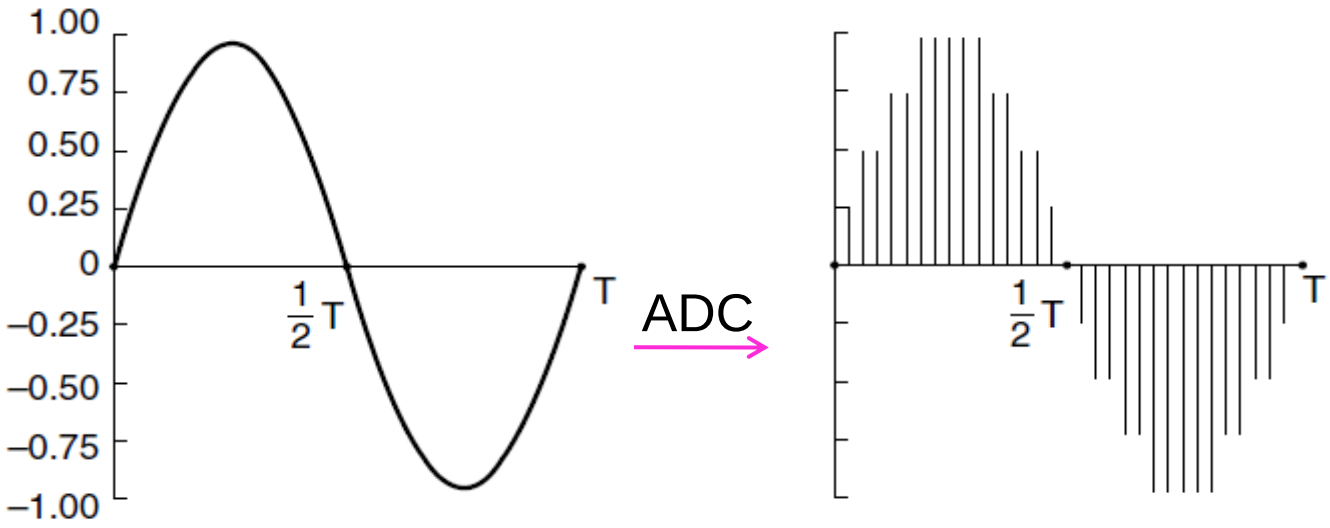
Safety margin, to avoid a stall

Can pause server

Compression:

Not everything needs to be recorded

ADC (Analog-to-Digital Converter) produces digital data, say from a microphone



Continuous audio
(sine wave)

Digital audio
(sampling theory in play)

Example: Audio Compression

- We can use Nyquist and Shannon theorems again to convert analog data to digital first
- Then apply techniques to eliminate some data…
- …for example: **perceptual coding** is that some data can mask other data, e.g., in audio, and at any point such data that are identified can be used in encoding and reduce the size
  - **Frequency masking**: Some sounds mask/hide others so there is no point encoding them
  - **Temporal masking**: Human ears can miss soft sounds immediately after loud sounds, takes time for the ear to adjust, no need to store them either

An Example Format: MP3

- MP3 is MPEG Audio Layer 3
- MP3's compression is **based on perceptual coding**
- MP3 audio compression results in significant **file size savings without a perceived loss of audio quality**
- Typical MP3 audio compression rates for CD quality audio reduce the need for bandwidth **from 1.4Mbps for stereo down to 96-128Kbps**

For Digital Video

- Video is digitized as pixels
  - TV quality: 640x480 pixels, 24-bit color, 30 times/sec ~ 200Mbs uncompressed
- Video is sent compressed due to its large bandwidth
  - Lossy compression exploits human perception
    - E.g., JPEG for still images, MPEG for video
  - Large compression ratios achieved (often 50X for video)

Compression with JPEG

- JPEG lossy compression sequence for one image
- JPEG often provides compression ratios of 20:1
- JPEG compression is **symmetric, decoding takes as long as encoding**
- This is not the case in all types of compression

MPEG

- MPEG - Motion Picture Experts Group
- MPEG can compress both audio and video together
- The evolution of MPEG:
  - MPEG-1: VCR quality at 1.2 Mbps (40:1)
  - MPEG-2: Broadcast quality at 4-6Mbps (200:1)
  - MPEG-4: DVD quality at 10Mbps (1200:1)

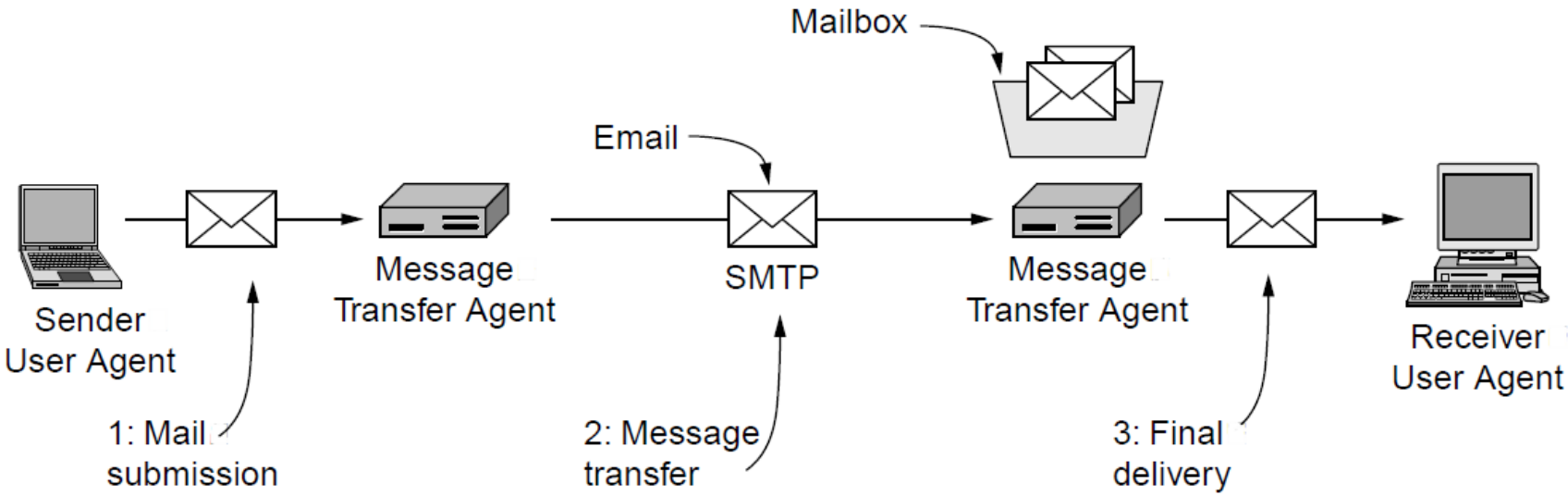
Last Application Layer Showcase…

- **Email** – involves?
  - User Agent: Thunderbird
  - Message Transfer Agent: Exchange
  - Message Transfer Protocols

Email Services

- Email has a long heritage (since 1960’s)
- Standards for Internet-enabled email are based on 2 RFC's
  - RFC 821 (transmission)
  - RFC 822 (message format)
  - RFC 2821 and RFC 2822 (revised versions of earlier RFCs)

Architecture and Services



User agents

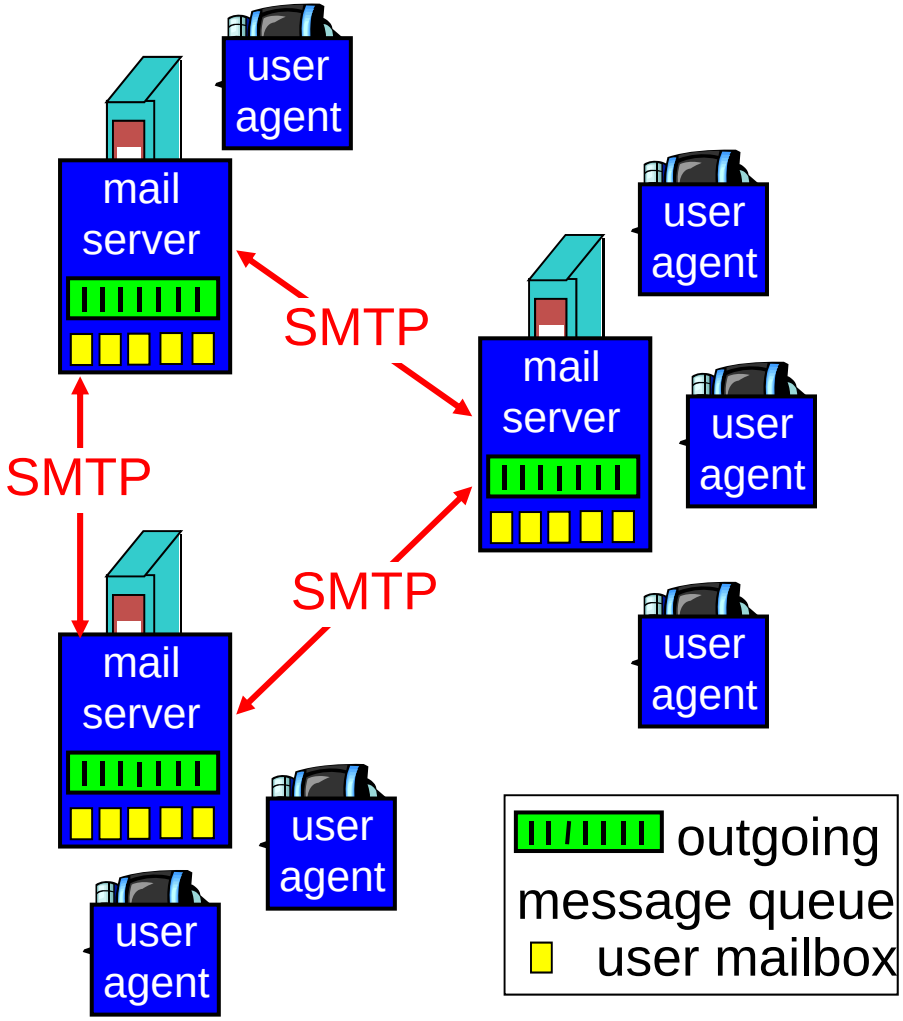
Allow user to read and send email

Message transfer agents

Transport messages from source - destination

Electronic Mail - Overview

- **SMTP (Simple Mail Transfer Protocol)** 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**



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

RFC 822: Message

- RFC 822 doesn't distinguish header and envelope fields
- 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 simple text: **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)

Multipurpose Internet Mail Extentsions (MIME) #2

- **MIME retains RFC822 format but adds** structural elements to the message body and defines encoding rules for non-ASCII messages

- 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 Format

- Typical multipart message containing HTML and audio alternatives is given here

```
From: alice@cs.washington.edu
To: bob@ee.uwa.edu.au
MIME-Version: 1.0
Message-Id: <0704760941.AA00747@cs.washington.edu>
Content-Type: multipart/alternative; boundary=qwertyuiopasdfghjklzxcvbnm
Subject: Earth orbits sun integral number of times

This is the preamble. The user agent ignores it. Have a nice day.

--qwertyuiopasdfghjklzxcvbnm
Content-Type: text/html

<p>Happy birthday to you<br>
Happy birthday to you<br>
Happy birthday dear <b> Bob </b><br>
Happy birthday to you</p>

--qwertyuiopasdfghjklzxcvbnm
Content-Type: message/external-body;
        access-type="anon-ftp";
        site="bicycle.cs.washington.edu";
        directory="pub";
        name="birthday.snd"

content-type: audio/basic
content-transfer-encoding: base64
--qwertyuiopasdfghjklzxcvbnm--
```

Message Transfer

- Transfer
  - SMTP (Simple Message Transfer Protocol)
- Delivery
  - POP3 (Post Office Protocol 3)
    - Download to a single device
  - IMAP (Internet Message Access Protocol)
    - Designed with multiple devices in mind

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

SMTP Steps

- Basic steps SMTP:
  - User agent submits to MTA (mail transfer agent) on port 587
  - One MTA to the next MTA on port 25
  - Other protocols used for final delivery (IMAP, POP3)