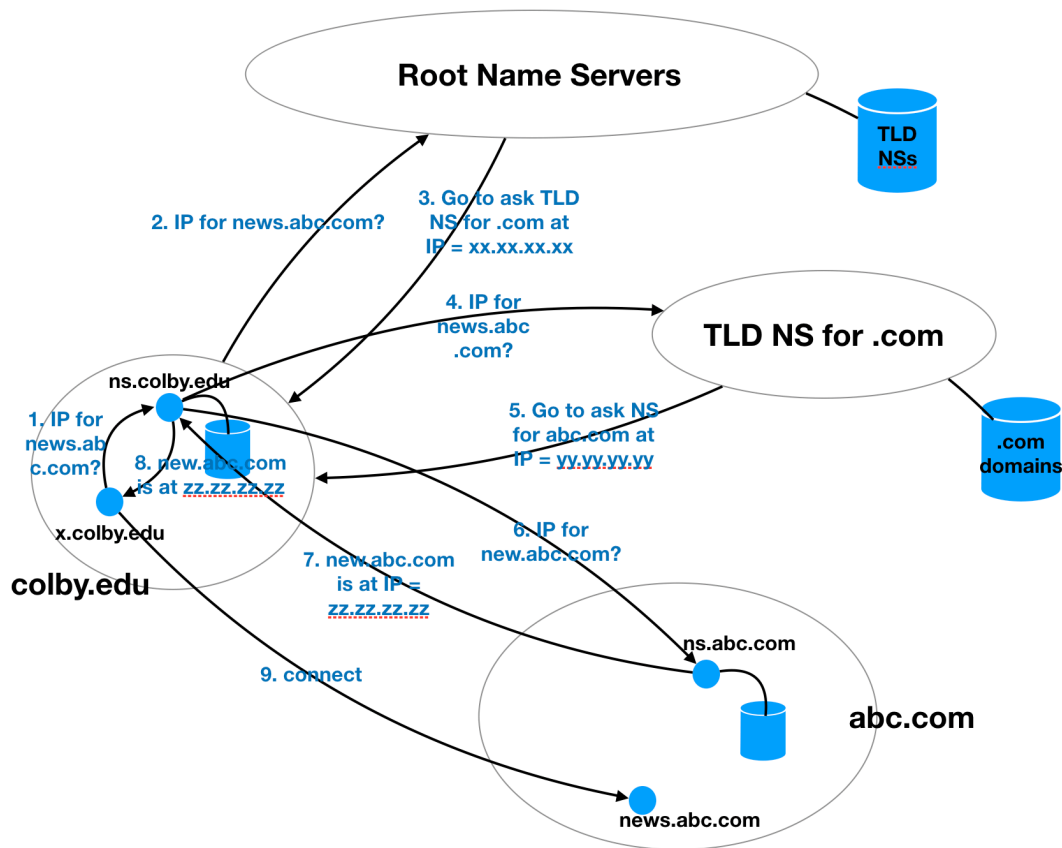


Application Layer (III)

Domain Name Service (cont.)

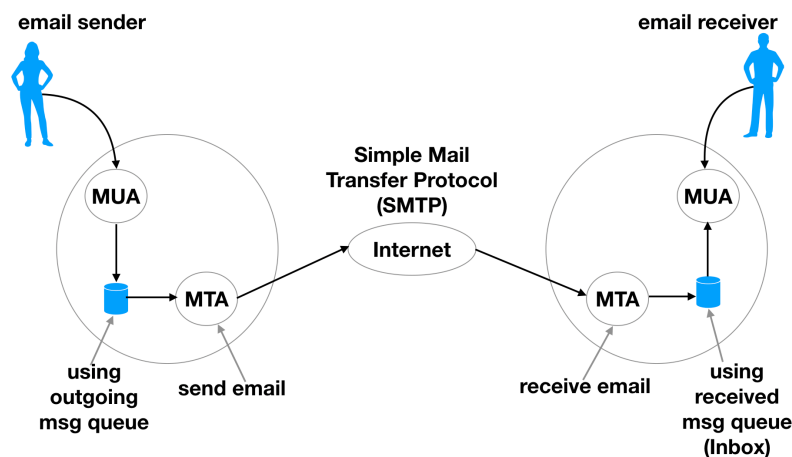
- Example: Non-local Domain Name Resolution
 - If we are at Colby and want to open abc.com. This will lead to a recursive domain name resolution.



- DNS tools:
 - `nslookup google.com` (brief)
 - `dig google.com` (medium)
 - `whois google.com` (detailed)

Electronic Mail — SMTP

- Designed for **asynchronous** message delivery
 - This means that messages can be delivered to the other end of the network, and receivers can **read** the messages **when** they are **available**.
 - It **puts** a message **in a** message **pool** and **doesn't require immediate response**.
 - Robustness and reliability should also be considered in the design.
- Two types of agents
 - Message Transfer Agent (**MTA**)
 - A software **transfer** a **message** from one computer to another computer **using SMTP**
 - They are also called mail servers and often keep mailboxes for email.
 - Has two queues: outgoing message queue, received message queue (inbox)
 - Message User Agent (**MUA**):
 - A computer program allow users to read, reply to, forward, save, and compose message
 - They are **mail clients** and can be on the same host as MTA or not.



- From the above figure, we can observe that there are **two types of interactions** (and protocols) between these two types of agents
 - MTA to MTA (SMTP/ESMTP)
 - MUA to MTA (POP-3/IMAP)

MTA to MTA

- A protocol support MTA to MTA interaction is Simple Mail Transfer Protocol (**SMTP**): port 25
 - If the mailbox of the message recipient is not hosted locally, the message is forwarded to another MTA. Each relaying MAT adds a Received trace header field to the top of the message header.
 - SMTP is not built with no encryption nor authentication. Since the MUA was hosted on the same host as MTA, it could rely on the system authentication for user access.

- Therefore, a “not so simple” mail transfer protocol is needed. **ESMTP** (extended SMTP) addresses the authentication problem, which is adopted by many current emails, and **TLS**(Transport Layer Security) (port 587) is used to address encryption.

SMTP Example

- We use `gloin` to demonstrate a SMTP communication. In this example, we transmit a message from `gloin` to itself. The MUA is on the same host. We will use the program `mail` to check the received email.

```
gloin:~> nc localhost 25
220 gloin.cs.colby.edu ESMTP Postfix (Ubuntu)
helo gloin.cs.colby.edu
250 gloin.cs.colby.edu
mail from: yingli@gloin.cs.colby.edu
250 2.1.0 Ok
rcpt to: yingli@gloin.cs.colby.edu
250 2.1.5 Ok
data
354 End data with <CR><LF>.<CR><LF>
subject: SMTP test
this is a test
.
250 2.0.0 Ok: queued as 1DD9C7C007F
quit
221 2.0.0 Bye

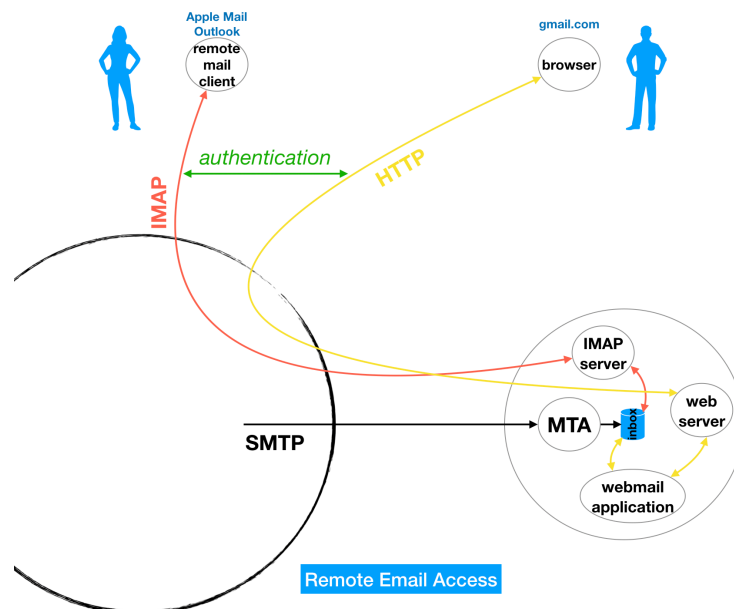
gloin:~> mail
Mail version 8.1.2 01/15/2001. Type ? for help.
"/var/mail/yingli": 1 message 1 new
>N 1 yingli@gloin.cs.c Mon Sep 30 12:27 14/552 SMTP test
& more 1
& quit
Saved 1 message in /personal/yingli/mbox
gloin:~>
```

- The red texts above are the responses from the mail server. The number in each response indicate the status of the mail server.
 - 220: The server is ready
 - 250 Ok: The prior request is completed
 - 354: The server is ready to receive data
 - 221: end the interaction
 - 550: you may receive 550 after rcpt, which means the address is not existed or it's returned by recipient's firewall.
- The green texts are the requests sent by users. The SMTP commands are:
 - helo: reach out the the server
 - mail from: followed by sender's address
 - rcpt to: followed by recipient's address

- data: let the server know that you are going to send the message
- subject: email subject
- .: email body ends with a . on a newline by itself.
- quit: end the interaction

MUA to MTA Communication

- MUA and MTA on the same host in the past
 - MUA and MTA communicate using files
 - use of host's authentication methods
- MUA and MTA communicate over a network in nowadays
 - SMTP was not designed for retrieving messages
 - it can push message to the server, but **cannot pull the message from the server**
 - **retrieving** mail: **POP-3** and **IMAP** (include authentication)
 - **POP-3** (post office protocol - version 3): port 110
 - manage messages **locally**, cannot access messages/folders from different machines
 - **IMAP** (Internet Mail Access Protocol):
 - significantly more complex
 - **enable manage and organize** message **on the MTA**, so **can access folders across machines**
 - obtain components of messages, useful for low bandwidth



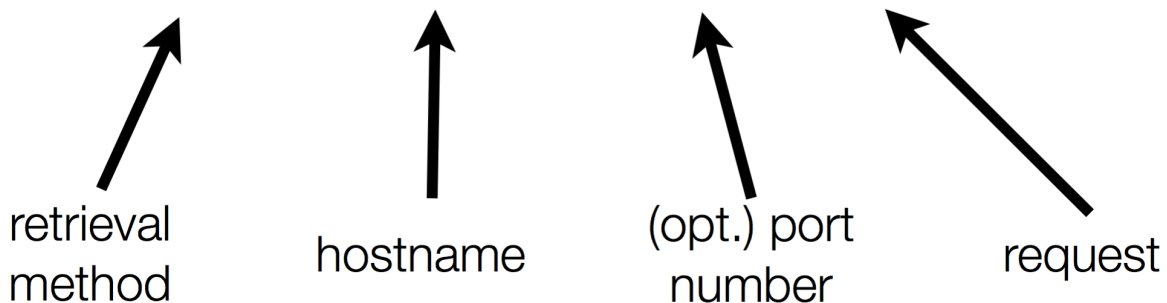
MIME

- **Problem:** SMTP was designed to deliver limited length, English text only
- **Solution:** MIME (Multipurpose Internet Mail Extensions) (but can be use for HTML)
 - make everything look like text
 - package the message (including text, characters, images, icons, audio, video, etc.) and mark it with content type so it can be unpacked and rendered on the receiving end
- Emails are transmitted via SMTP in MIME format.

HTTP Overview

- URL (Universal Resource Locator)

<http://cs325.colby.edu:80/dir/file.html>



- Web page
 - A html file references to various objects such as images, movies, etc.
- HyperText Transfer Protocol (HTTP)
 - defines how web clients request web pages from Web servers and how servers transfer Web pages t clients.
 - Client and Server architecture
 - Client side - web browser
 - Server side - web server (Apache, Microsoft Internet Information Server)
 - TCP underneath
 - stateless protocol
 - servers maintain no information about the client
 - this means if you take an online survey or purchase online, it's not the http server keeps your answers or ordered items, but other techniques do that for you.
 - Non-persistent and persistent connections
 - Non-persistent
 - set up a TCP connection for each object on a html page
 - those connections may be sequential or parallel. The browser controls the degree of parallelism. (Default 5-10 parallel connections)
 - Persistent (default)

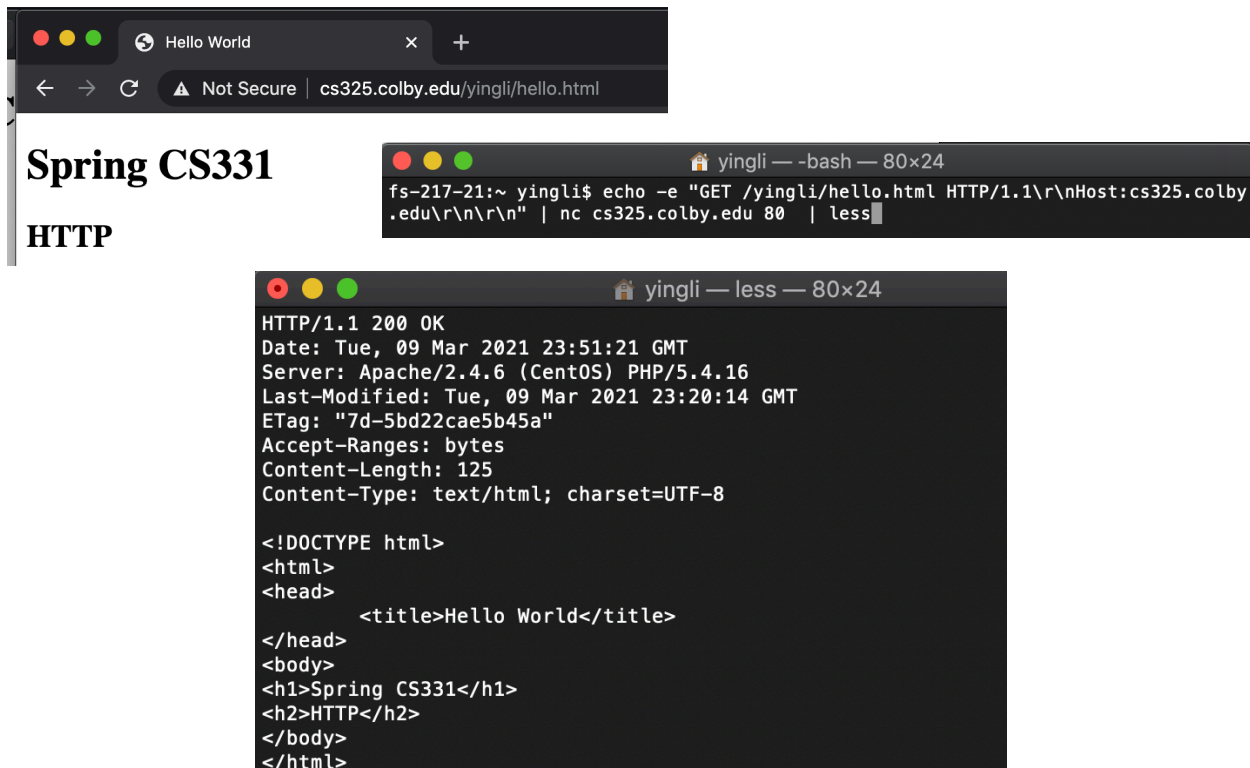
- HTTP/1.1 persistent connection, the server leaves the TCP connection open after sending a response, and close a connection when it isn't used for a certain time (configurable). Allow back-to-back objects/requests transmission.
- HTTP/2 allows multiple requests and replies to be interleaved in the same connection, and has mechanism for prioritizing HTTP message requests and replies within this connection. (<https://www.digitalocean.com/community/tutorials/http-1-1-vs-http-2-what-s-the-difference>)

HTTP GET Method

- GET
 - let a client requests data from the server
 - e.g., open a website

GET Examples

- In this example, we use nc coupled with a well formatted GET request to retrieve the following webpage on the terminal and investigate the HTTP response.



The image is a composite of three screenshots. The top-left screenshot shows a web browser window with the title 'Hello World' and the address bar displaying 'cs325.colby.edu/yingli/hello.html'. The top-right screenshot shows a terminal window with the command: `fs-217-21:~ yingli$ echo -e "GET /yingli/hello.html HTTP/1.1\r\nHost:cs325.colby.edu\r\n\r\n" | nc cs325.colby.edu 80 | less`. The bottom screenshot shows the output of the command in the terminal, displaying the HTTP response headers and the HTML body content.

Spring CS331

HTTP

```
HTTP/1.1 200 OK
Date: Tue, 09 Mar 2021 23:51:21 GMT
Server: Apache/2.4.6 (CentOS) PHP/5.4.16
Last-Modified: Tue, 09 Mar 2021 23:20:14 GMT
ETag: "7d-5bd22cae5b45a"
Accept-Ranges: bytes
Content-Length: 125
Content-Type: text/html; charset=UTF-8

<!DOCTYPE html>
<html>
<head>
  <title>Hello World</title>
</head>
<body>
<h1>Spring CS331</h1>
<h2>HTTP</h2>
</body>
</html>
```

Disclaimer: Notes adapted from the textbook and online resources.