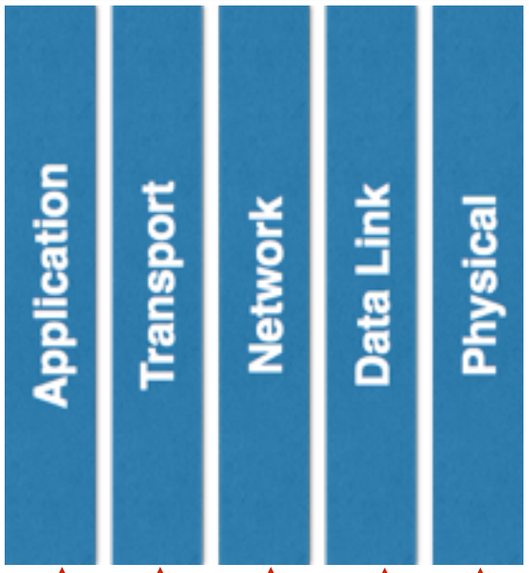
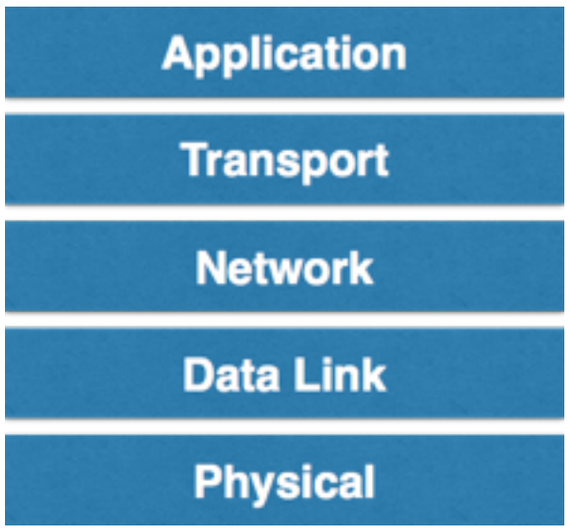
FIT1047 Week 8

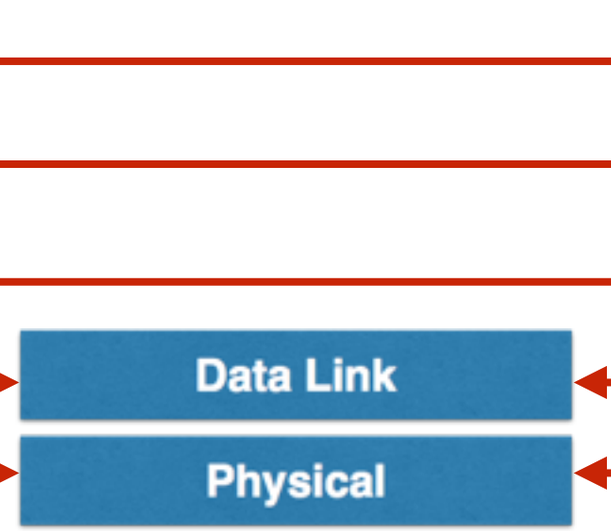
Networks: Application Layer

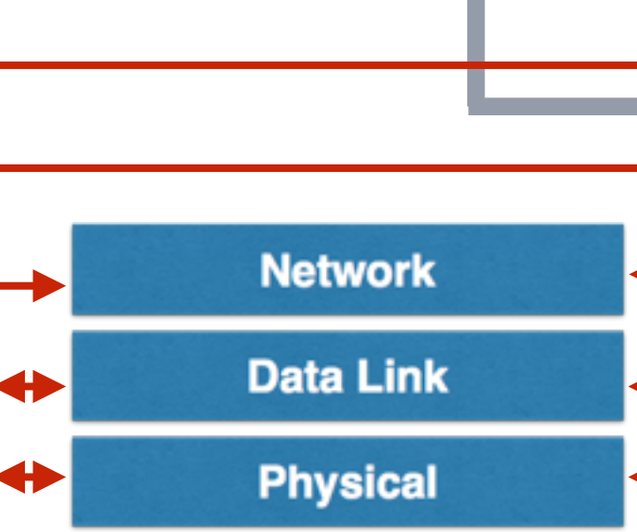
MONASH University

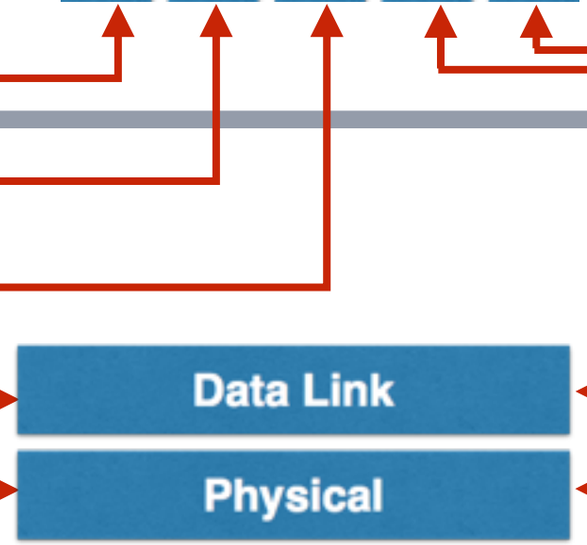
Layers of Abstraction



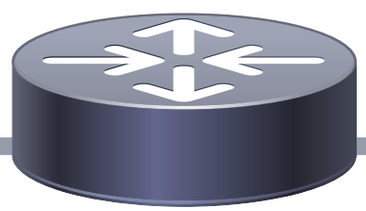








Switch



Router

Switch

Architectures

Application Architectures

Application Architectures

Presentation logic

The user interface. Controls the application.

Application Architectures

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Application / business logic

Defines what the application does.

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Data storage

Where the data is kept, e.g. files or data base.

Application Architectures

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Data storage

Where the data is kept, e.g. files or data base.

Who does what?

Application Architectures

Presentation logic

Application / business logic

Data access logic

Data storage

Who does what?

Server-based Architecture

"dumb" terminal

Presentation logic
Application / business logic
Data access logic
Data storage

Server-based Architecture

"dumb" terminal

Client sends keystrokes to the server, displays text according to server's instructions.

Problems:
Server can become a bottleneck.
Upgrade expensive and "lumpy".

Presentation logic
Application / business logic
Data access logic
Data storage

Client-based Architecture

Presentation logic
Application / business logic
Data access logic

Data storage

Client-based Architecture

Presentation logic
Application / business logic
Data access logic

All the logic is performed by the client.
The server stores the data.

Problems:
All data must travel back and forth between server and client.

Data storage

Client-Server Architecture

Presentation logic
Application / business logic

Data access logic
Data storage

Client-Server Architecture

Presentation logic
Application / business logic

Balance the processing load between client and server.

Data access logic
Data storage

Thin-Client Architecture

Presentation logic

Application / business logic
Data access logic
Data storage

Thin-Client Architecture

Presentation logic

Server handles most of the application logic.

Advantage:
Only one server needs updating.

Application / business logic
Data access logic
Data storage

Multi-Tier Architecture

Presentation logic

Application / business logic

Data access logic
Data storage

Multi-Tier Architecture

Presentation logic

Application / business logic

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Multi-tier architecture

Multi-Tier Architecture

Presentation logic

Application / business logic

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Data storage

Multi-tier architecture


client


server


server

Peer-To-Peer Architecture

Presentation logic
Application / business logic
Data access logic
Data storage

Presentation logic
Application / business logic
Data access logic
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Peer-To-Peer Architecture

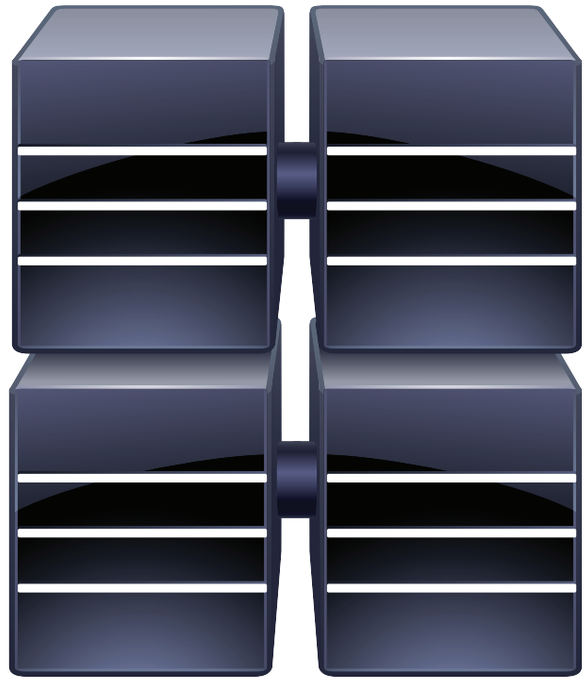
Presentation logic
Application / business logic
Data access logic
Data storage

All computers act as both clients and servers.

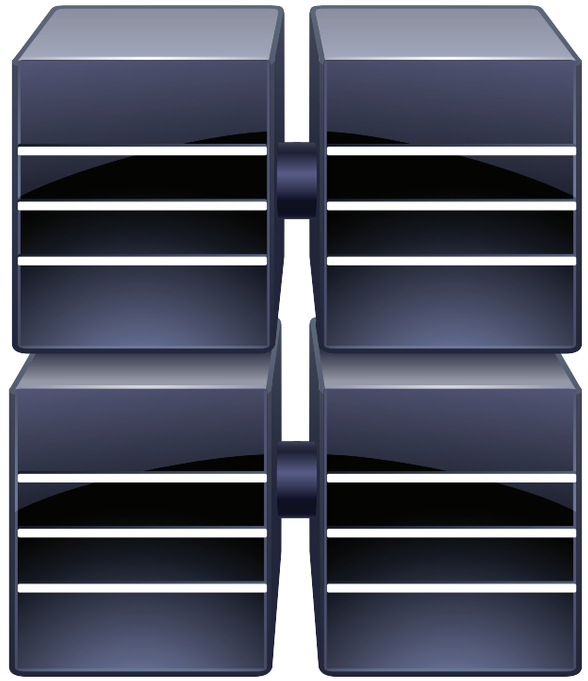
Use local logic to access data stored on another computer.

Presentation logic
Application / business logic
Data access logic
Data storage

World Wide Web



Internet

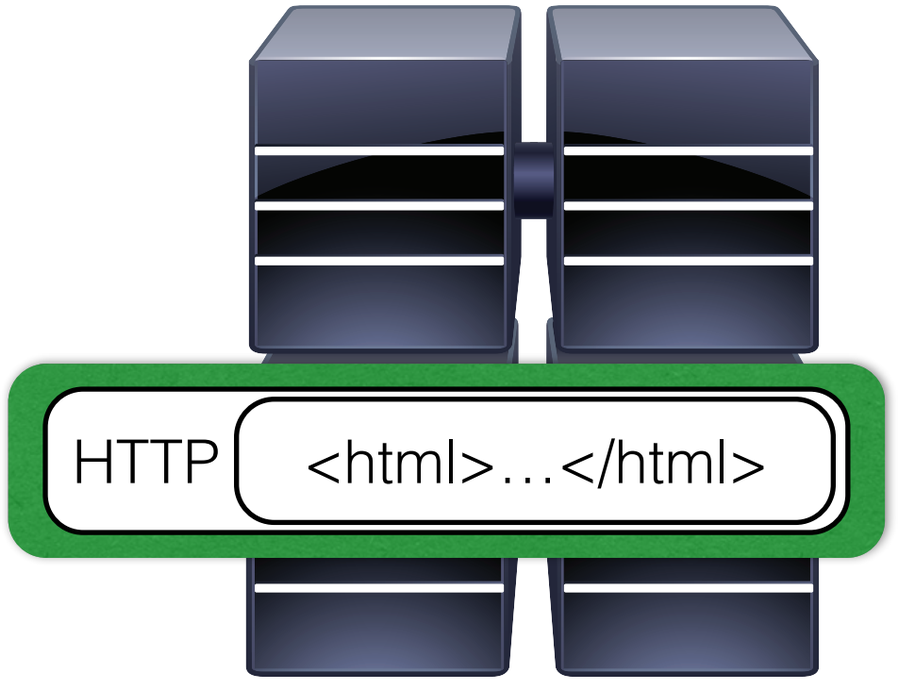


Internet


HTTP
www.youtube.com


Internet


The IT Crowd - Series 3 - Episode 4: The Internet


HTTP
<html>…</html>


Internet


The IT Crowd - Series 3 - Episode 4: The Internet

Internet

What is HTTP?
What is HTML?

Hyper**T**ext **T**ransfer **P**rotocol (HTTP)

- Defines how web **browsers** talk to **web servers**

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  A document containing links to other documents
- **Uniform Resource Locators (URLs):**
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  - **Hypertext:**
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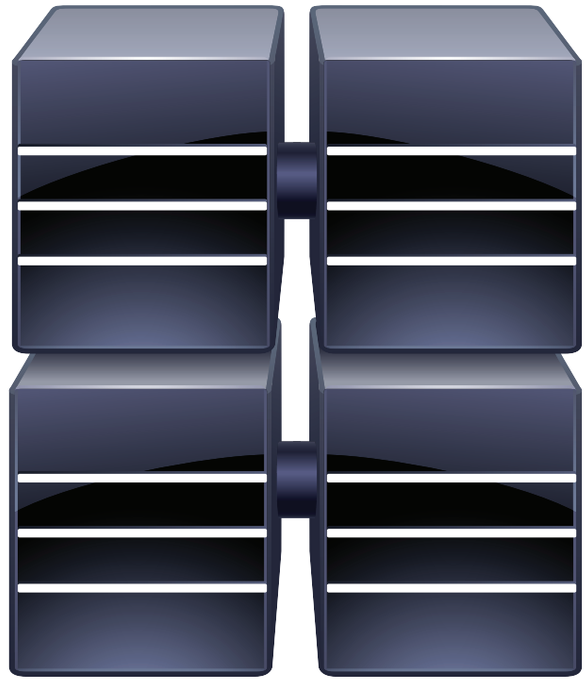
  - **Uniform Resource Locators (URLs):**
    A standard for identifying links to other documents
- HTTP defines **how** documents are requested and transferred

Request - Response-Cycle



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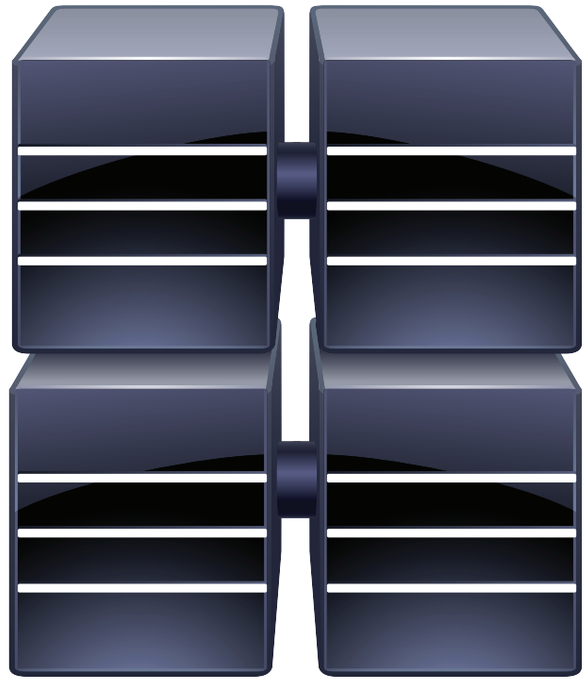

Internet

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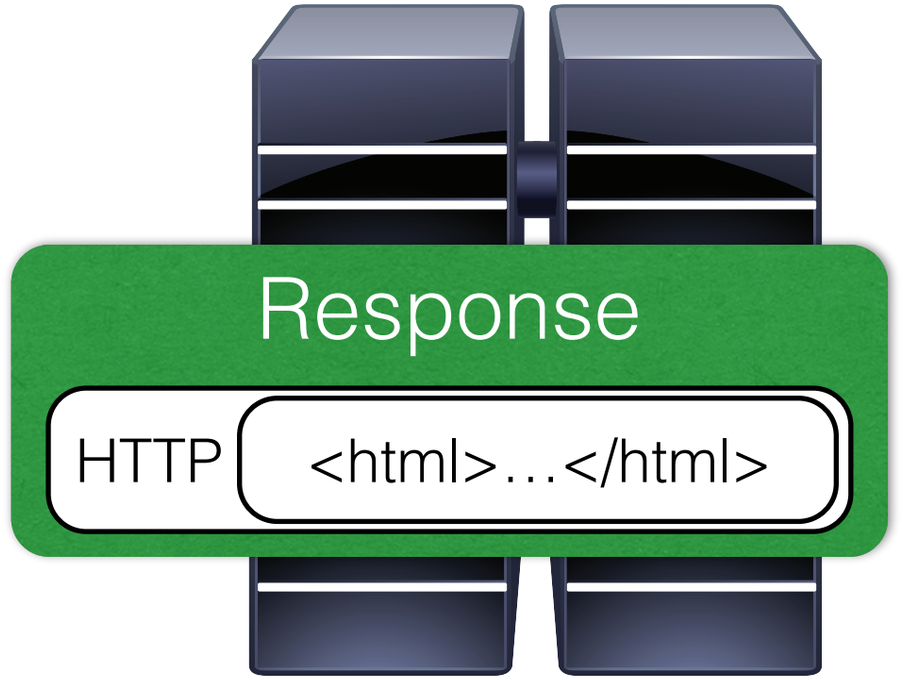

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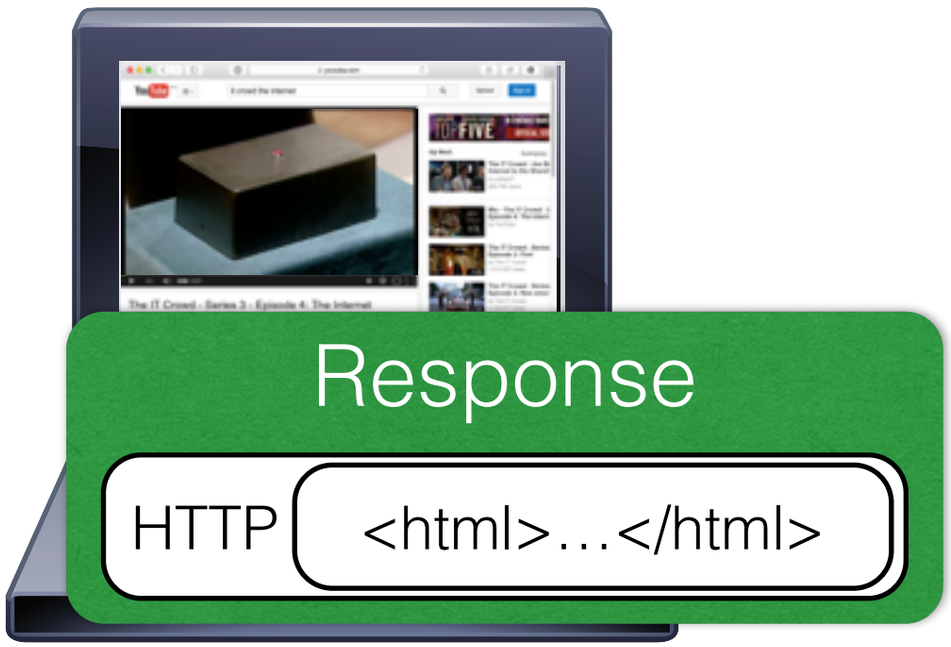

Basic HTTP session

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Host: www.csse.monash.edu
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Request line

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Req. header

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Transfer-Encoding: chunked
Content-Type: text/html

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HTTP/1.1 200 OK
Date: Thu, 05 Mar 2015 08:31:23 GMT
Server: Apache/1.3.26 (Unix)
Last-Modified: Tue, 20 Nov 2012 03:29:22 GMT
Accept-Ranges: bytes
Content-Length: 15681
Content-Type: image/jpeg

JFIFHH@ICC_PROFILE0appl mntrRGB
…
```

HTTP Methods

- GET:
  Retrieve specified URL from server

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  E.g. add a message to a web forum, or an item to a shopping cart. Also retrieves document.

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  Retrieve **only header** for specified URL

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  Add data specified in request body to specified URL

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- Other methods (`PUT`, `DELETE`, `OPTIONS`…) less common

Full HTTP Request

```
POST /~guidot/test_form.php HTTP/1.1
Host: www.csse.monash.edu
Connection: keep-alive
Accept: text/html,application/xhtml+xml
User-Agent: Mozilla/5.0 (Macintosh)
Accept-Encoding: gzip, deflate, sdch
Accept-Language: en-US;en
Content-Type: application/x-www-form-urlencoded
Content-Length: 26

search=data+communications
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Request header

Request body

Request header and body are optional.
HTTP 1.1 requires at least the `Host` header.

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HTTP is stateless

- Each request is an **independent transaction**
- Example: shopping cart
  - *Client* browses online store
  - *Server* responds with web pages
  - *Client* puts item into shopping cart
  - *Client* continues browsing
  - How does the server keep track of **which client** put **which items** into the shopping cart?
    (This is called the **state** of the **session**)

Adding state to HTTP

- Two approaches:
  - Client sends **session identifier** with every request, e.g. encoded in URL or as data in POST
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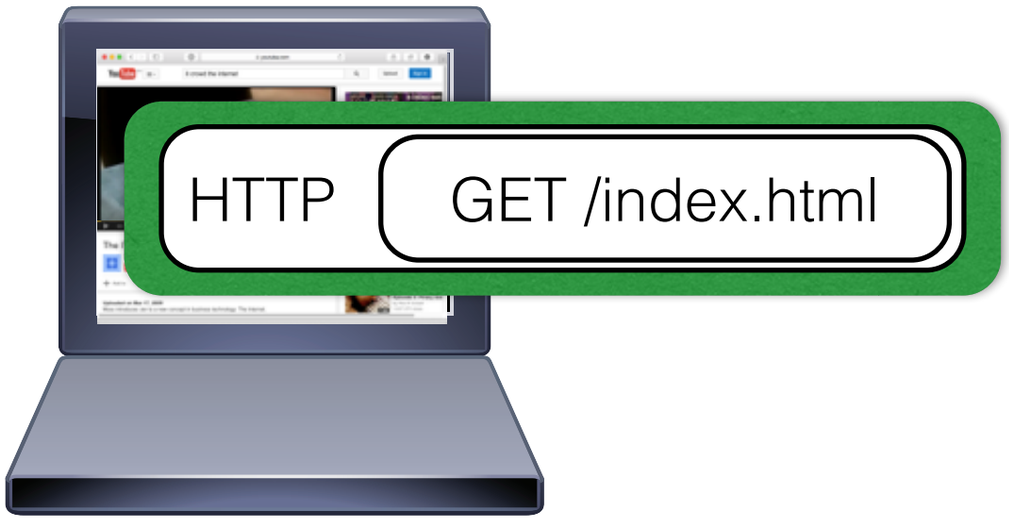

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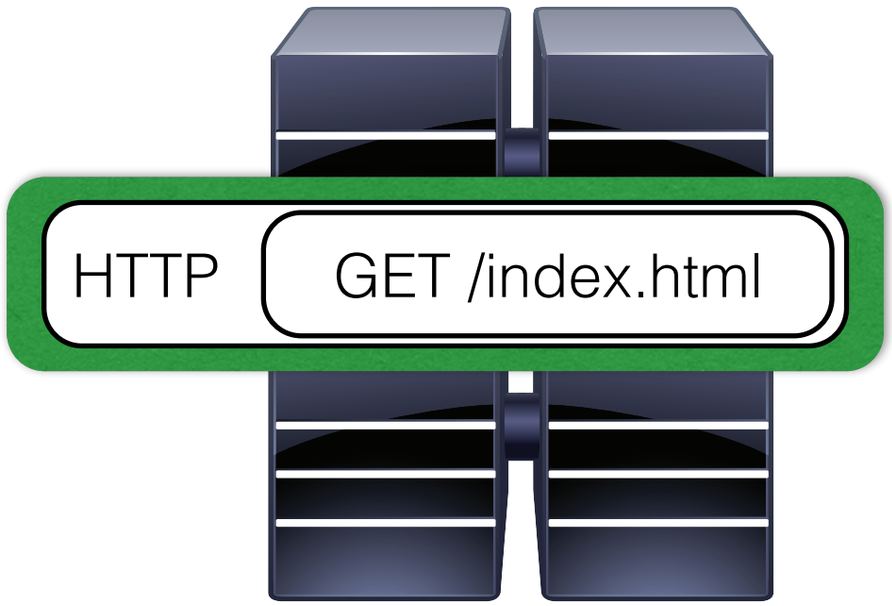

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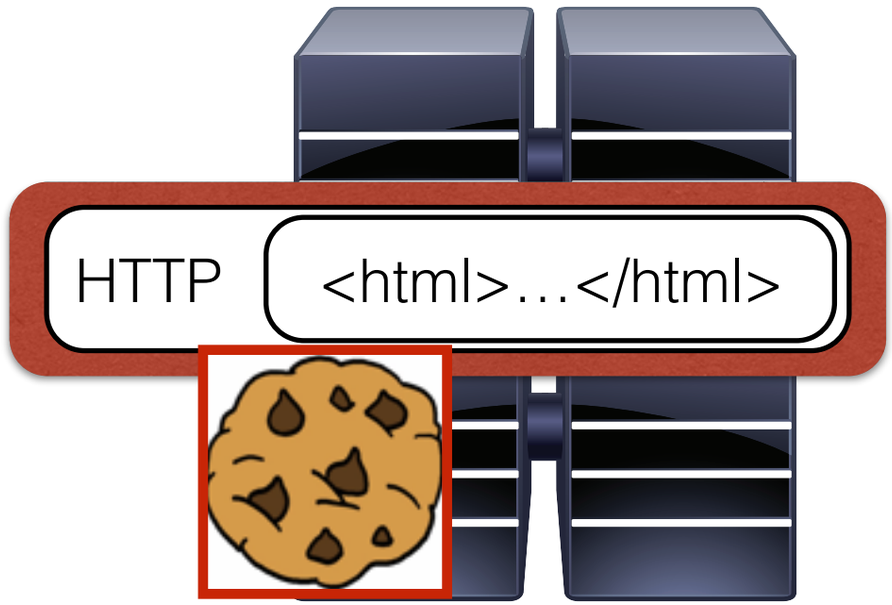

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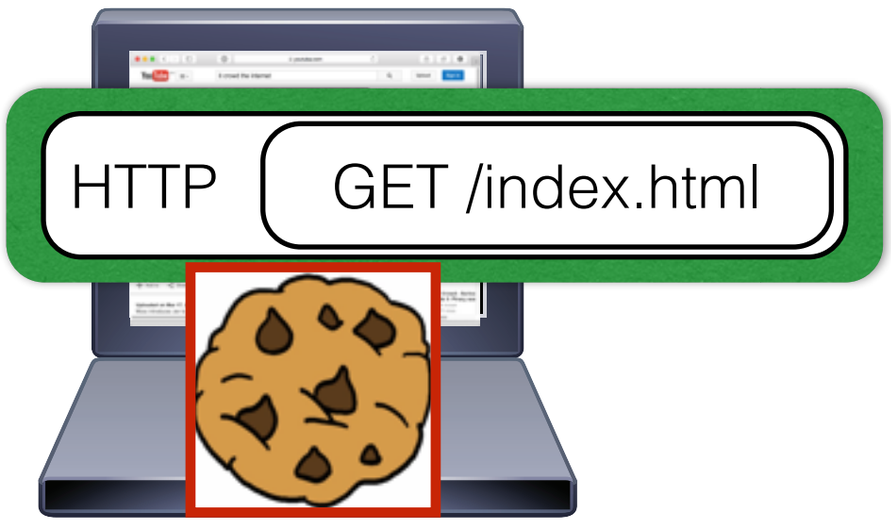
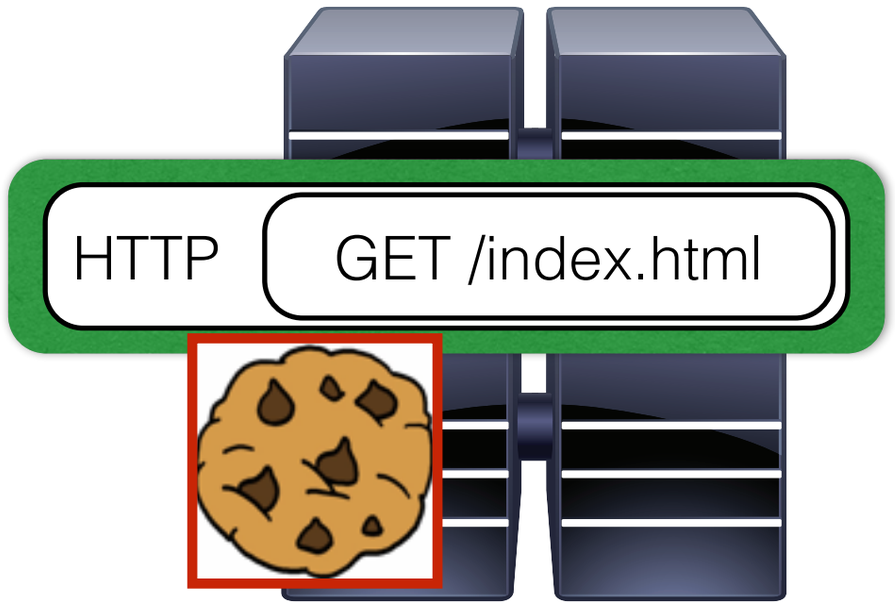


Adding state to HTTP

- Two approaches:
  - Client sends **session identifier** with every request, e.g. encoded in URL or as data in POST
  - Server sets a **cookie,** client transmits the cookie with **every future request**



HTML

- **H**yper**T**ext **M**arkup **L**anguage
- Plain text document *annotated* with *tags* that describe how to format the file
- First version also developed by Berners-Lee in 1990

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- Example:

```
<html>
<body>
  <h1>Guido Tack</h1>
  <img src="images/guido3.jpg">
  <a href="http://www.w3c.org">W3C</a>
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</html>
```

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tag

link to other asset

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</body>
</html>
```

tag

link to other asset

link to other page

HTML

- **Hy**
- Pla w to
  for
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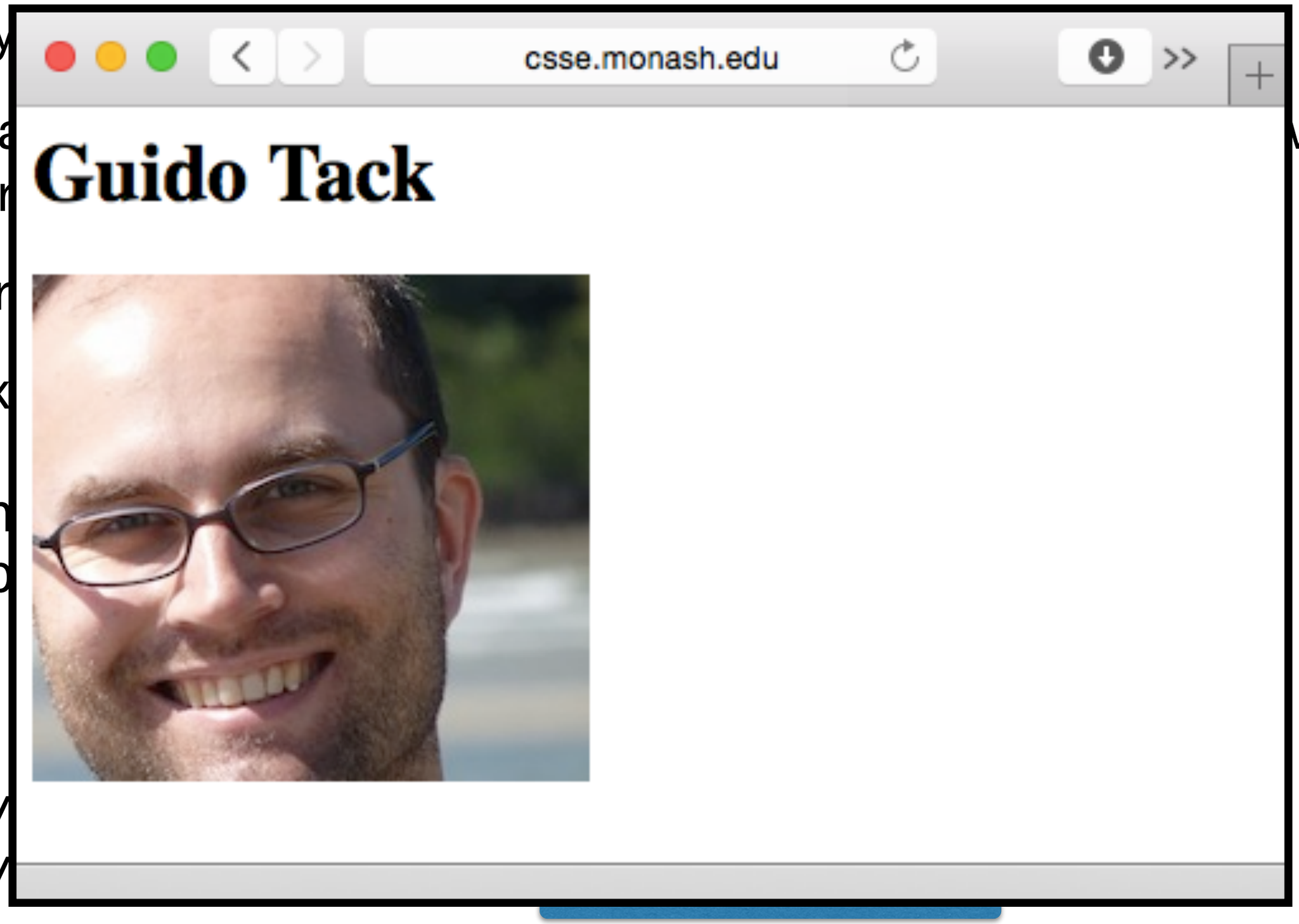
- Ex

<h
<b

</
</



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</html>
```

tag

link to other asset

link to other page

HTML + CSS

- Separation of **structure** and **layout**:
  - HTML defines *what* each element of the page *is*
  - CSS defines *how* each element type should be *displayed*

HTML + CSS

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  - HTML defines *what* each element of the page *is*
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- Example:

```
h1 {
   font-family: sans-serif;
   color: #006020;
   float: left;
}
img { float: right; }
```

HTML + CSS

- Se
  -
  -
- Ex

```
h1

}
im
```

HTML + CSS

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  - HTML defines *what* each element of the page *is*
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- Example:

```
h1 {
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   float: left;
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img { float: right; }
```

Electronic Mail

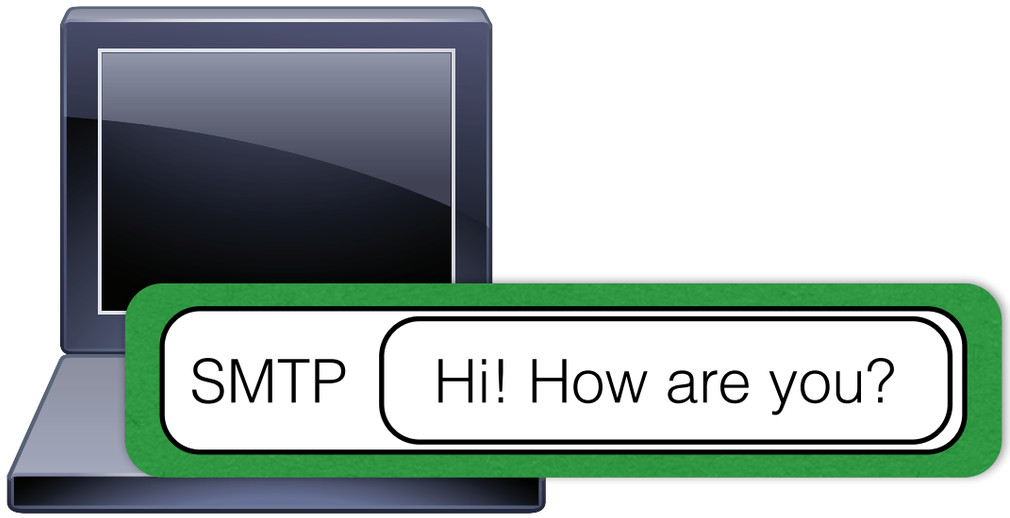
alice@hotmail.com

smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com



alice@hotmail.com

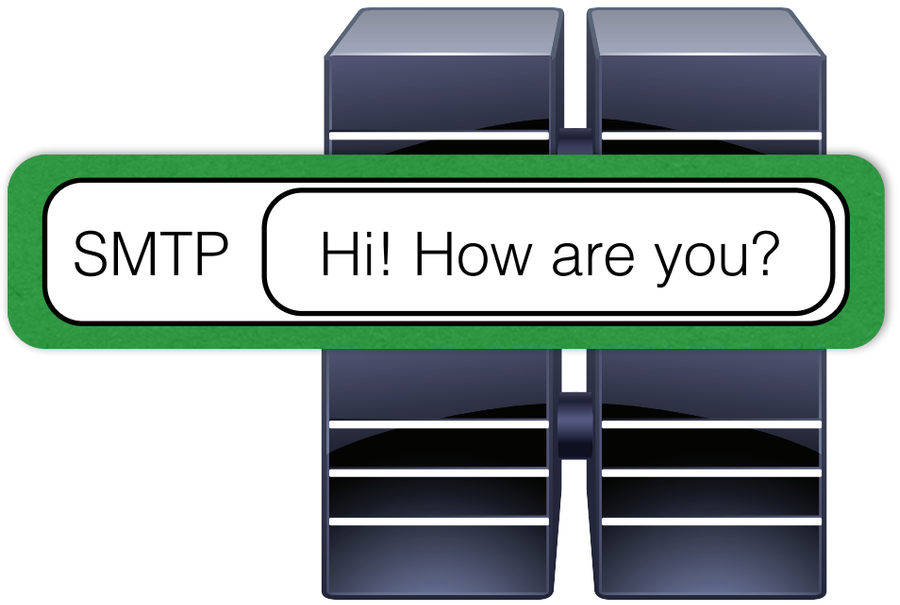
smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com

alice@hotmail.com



smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com

alice@hotmail.com

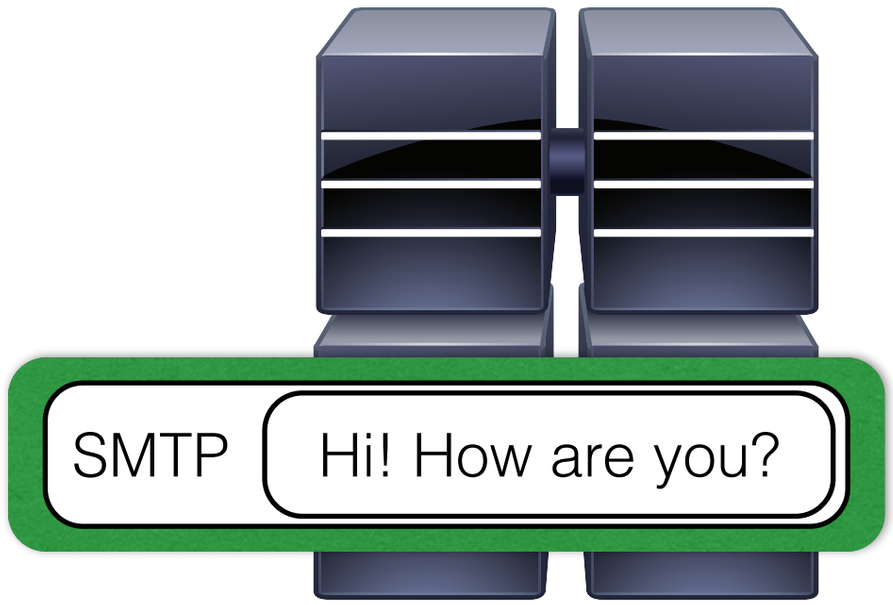
smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com

alice@hotmail.com



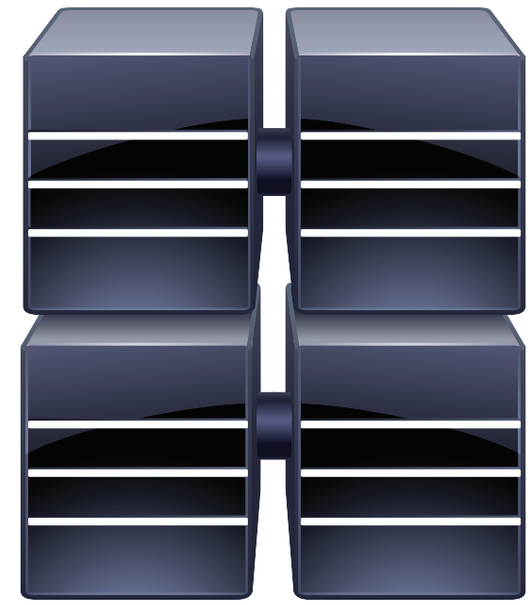
smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com

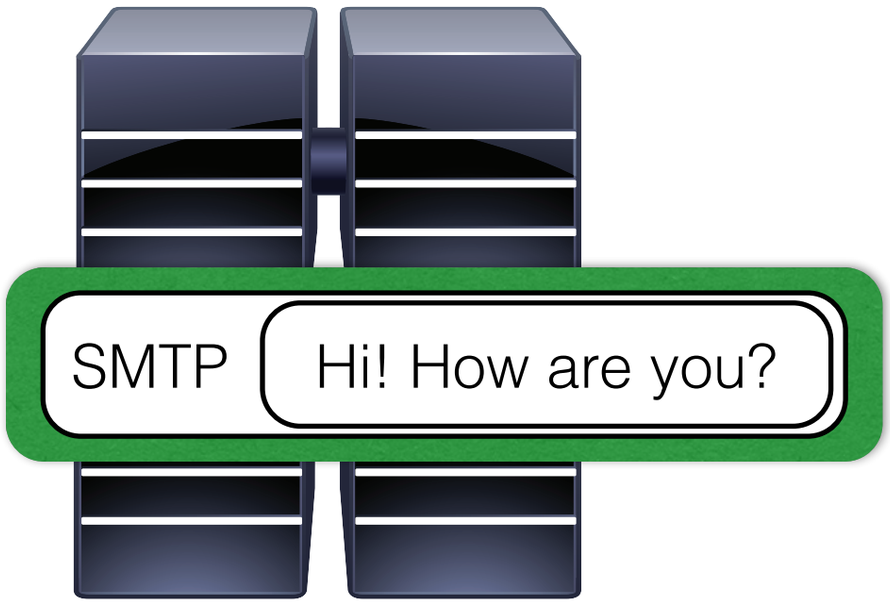
alice@hotmail.com



smtp.live.com

Internet

smtp.gmail.com



bob@gmail.com

alice@hotmail.com

smtp.live.com

Internet

smtp.gmail.com

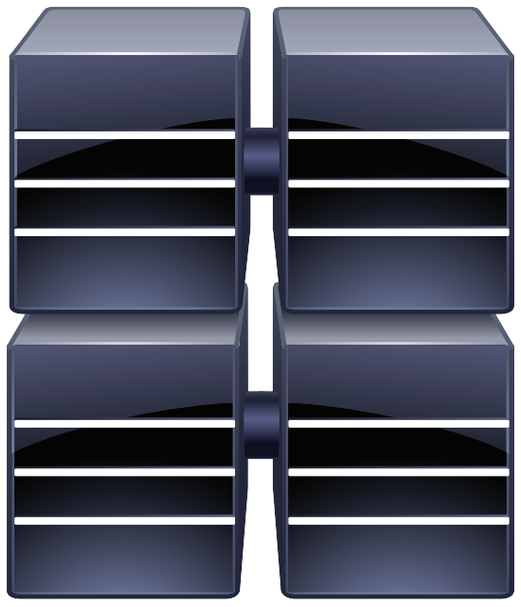
bob@gmail.com

alice@hotmail.com

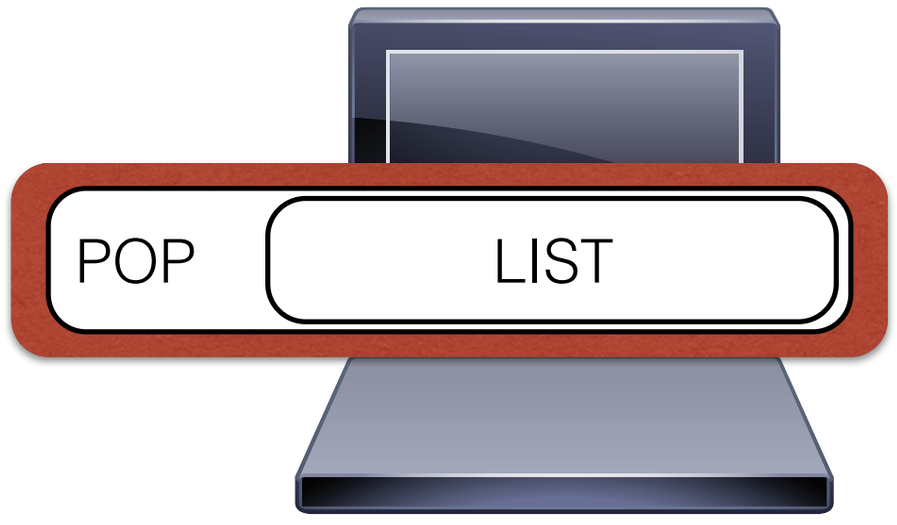
smtp.live.com

Internet

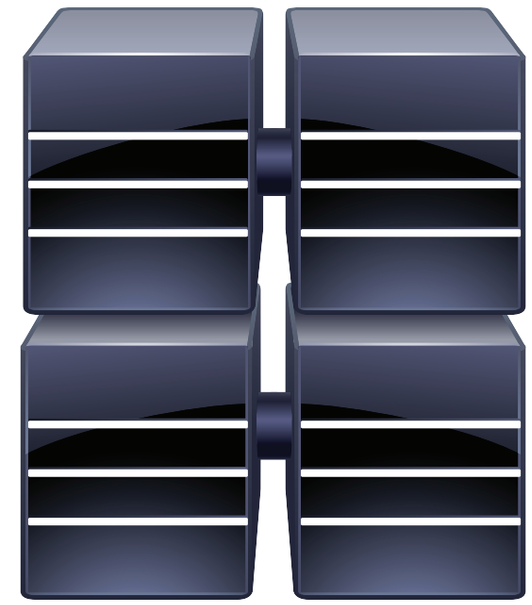
smtp.gmail.com



bob@gmail.com



alice@hotmail.com



smtp.live.com

Internet

smtp.gmail.com

bob@gmail.com

alice@hotmail.com

smtp.live.com

Internet

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bob@gmail.com

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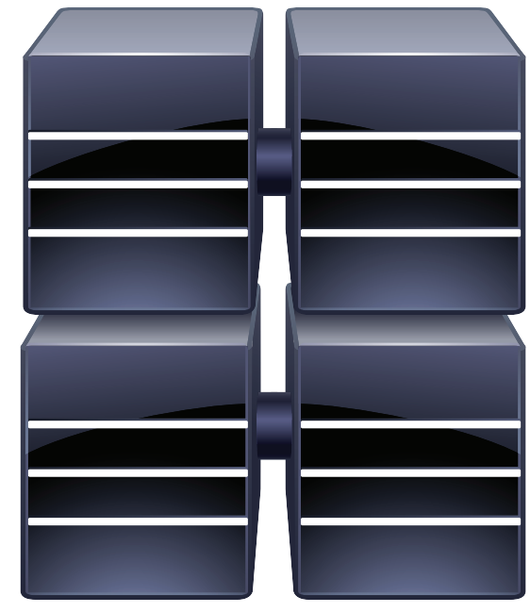

smtp.live.com

Internet

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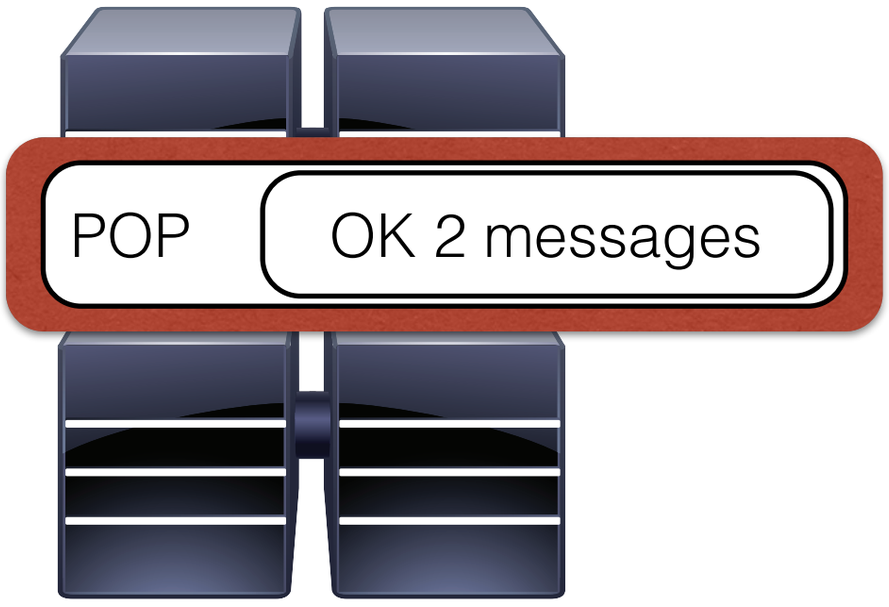

bob@gmail.com

alice@hotmail.com

smtp.live.com

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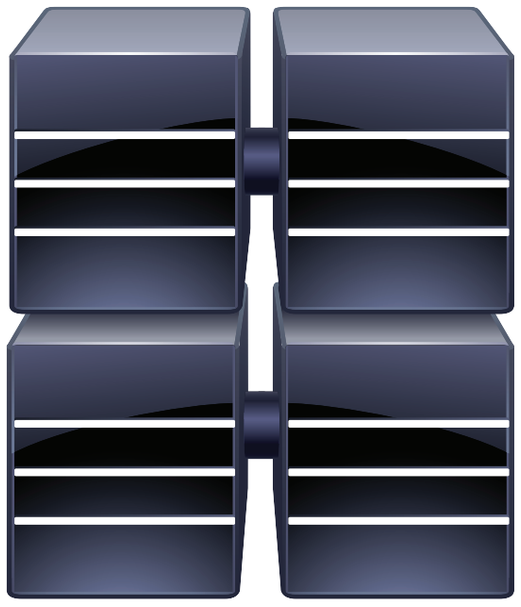

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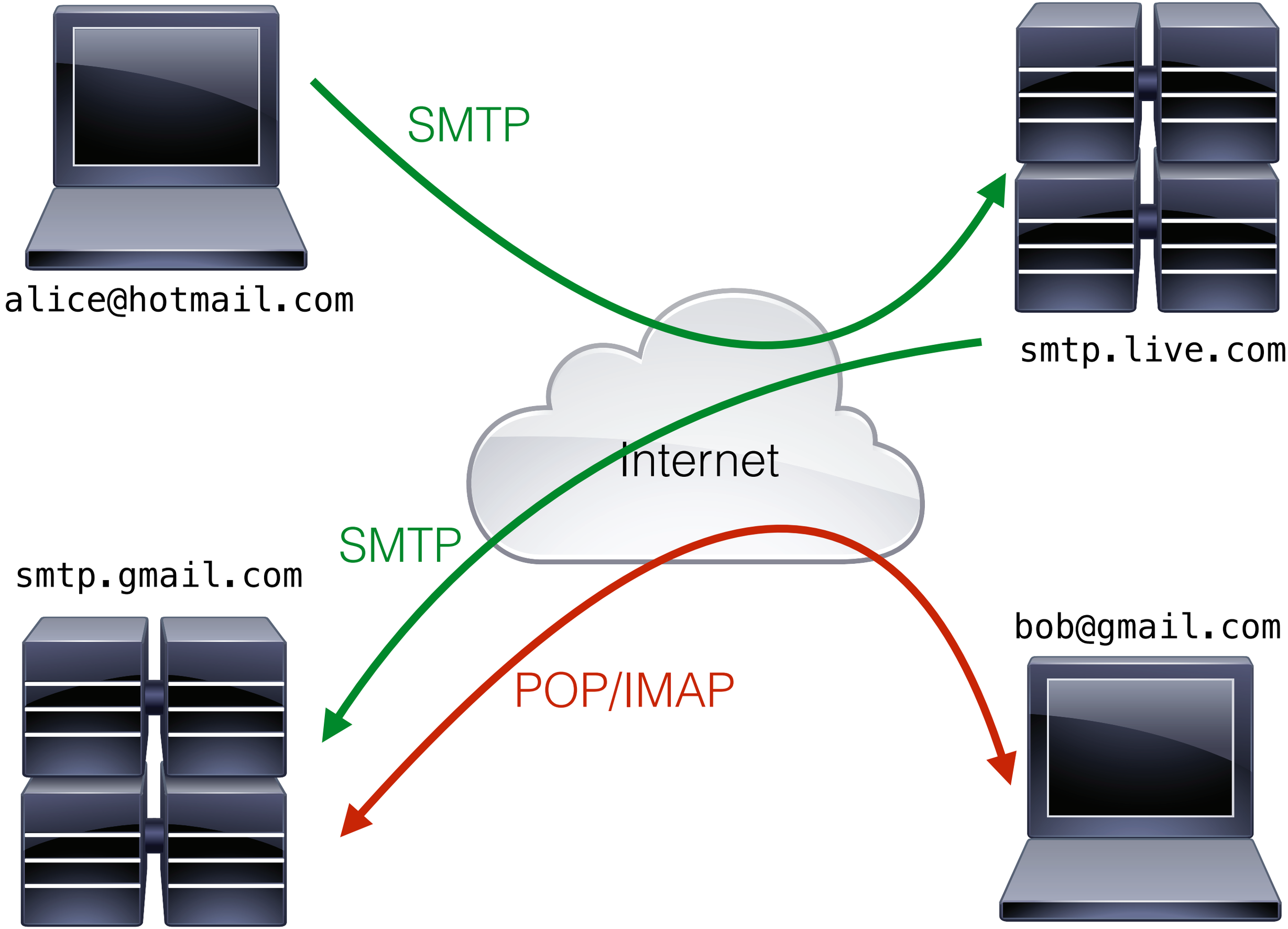
alice@hotmail.com
SMTP
smtp.live.com
Internet
SMTP
smtp.gmail.com
POP/IMAP
bob@gmail.com

Email Protocols

- Simple Mail Transfer Protocol **(SMTP)**
  - Handles transfer of text messages between email client and mail server, and between mail servers

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- Post Office Protocol **(POP)**
  - Messages are downloaded onto client and deleted from server

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- Simple Mail Transfer Protocol **(SMTP)**
  - Handles transfer of text messages between email client and mail server, and between mail servers
- Post Office Protocol **(POP)**
  - Messages are downloaded onto client and deleted from server
- Internet Message Access Protocol **(IMAP)**
  - Messages remain on server
  - Multiple clients can be connected simultaneously to same mailbox

Example SMTP Session

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
```

Example SMTP Session

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220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
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MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
DATA
```

Example SMTP Session

```
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250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
DATA
354 Enter message, ending with "." on a line by itself
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
DATA
354 Enter message, ending with "." on a line by itself
From: "Alice" <alice@mymail.com>
To: "Guido Tack" <guido.tack@monash.edu>
Date: Mon, 09 Mar 2015 19:24:00 +1000
Subject: test message

Hi Guido!
This is just a test.

Cheers,
Alice

.
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
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MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
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250 OK id=1YUBBf-0003Ch-M1
```

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HELO my.laptop
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MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
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To: "Guido Tack" <guido.tack@monash.edu>
Date: Mon, 09 Mar 2015 19:24:00 +1000
Subject: test message

Hi Guido!
This is just a test.

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.
250 OK id=1YUBBf-0003Ch-M1
QUIT
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
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250 OK
RCPT TO:<guido.tack@monash.edu>
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Date: Mon, 09 Mar 2015 19:24:00 +1000
Subject: test message

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This is just a test.

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.
250 OK id=1YUBBf-0003Ch-M1
QUIT
221 MyMailServer closing connection
```

Example SMTP Session

```
220 MyMailServer ESMTP Exim 4.82 Ubuntu Sat, 07 Mar 2015 20:37:24 +1100
HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
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To: "Guido Tack" <guido.tack@monash.edu>
Date: Mon, 09 Mar 2015 19:24:00 +1000
Subject: test message

Hi Guido!
This is just a test.

Cheers,
Alice


.
250 OK id=1YUBBf-0003Ch-M1
QUIT
221 MyMailServer closing connection
```

Header

Example SMTP Session

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HELO my.laptop
250 MyMailServer Hello laptop [192.168.1.5]
MAIL FROM:<alice@mymail.com>
250 OK
RCPT TO:<guido.tack@monash.edu>
250 Accepted
DATA
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From: "Alice" <alice@mymail.com>
To: "Guido Tack" <guido.tack@monash.edu>
Date: Mon, 09 Mar 2015 19:24:00 +1000
Subject: test message

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Cheers,
Alice

.
250 OK id=1YUBBf-0003Ch-M1
QUIT
221 MyMailServer closing connection
```

Header

Body

MIME

- **M**ulti-Purpose **I**nternet **M**ail **E**xtensions
- Remember: SMTP handles **plain text** email

MIME

- **M**ulti-Purpose **I**nternet **M**ail **E**xtensions
- Remember: SMTP handles **plain text** email
- How do you attach other file types?
- MIME specifies an **encoding**
- Supports **character sets** (e.g. Unicode) to send emails with non-latin characters
- Supports **non-text attachments**
- Supports **multi-part** message bodies

MIME Example

```
--Apple-Mail=_DC544A01-B885-421C-B475-2DBBCF2DEE37
Content-Transfer-Encoding: base64
Content-Disposition: inline;
   filename=guido3.jpg
Content-Type: image/jpeg;
   name="guido3.jpg"
Content-Id: <B073584A-EAF2-4A30-9ACC-1368C9C2E846@iiNet>

/9j/4AAQSkZJRgABAQEASABIAAD/4gVASUNDX1BST0ZJTEUAAQEAAAUwYXBwbAIgAABtbnRyUkdC
IFhZWiAH2QACABkACwAaAAthY3NwQVBQTAAAAABhcHBsAAAAAAAAAAAAAAAAAAAAAAAA9tYAAQAA
AADTLWFwcGwAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAtk
c2NtAAABCAAAAvJkZXNjAAAD/AAAAG9nWFlaAAAEbAAAABR3dHB0AAAEgAAAABRyWFlaAAAElAAA
ABRiWFlaAAAEqAAAABRyVFJDAAAEvAAAAA5jcHJ0AAAEzAAAADhjaGFkAAAFBAAAACxnVFJDAAAE
vAAAAA5iVFJDAAAEvAAAAA5tbHVjAAAAAAAAABEAAAAMZW5VUwAAACYAAAJ+ZXNFUwAAACYAAAGC
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AAJWbmxOTAAAACgAAAIYbmJOTwAAACYAAAEEcHRCUgAAACYAAAGCc3ZTRQAAACYAAAEEamFKUAAA
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AG8AIABSAEcAQgAgAEcAZQBuAGUAcgBpAGMAbwBHAGUAbgBlAHIAaQBjACAAUgBHAEIAIAB0AHIA
```

MIME Example

```
--Apple-Mail=_DC544A01-B885-421C-B475-2DBBCF2DEE37
Content-Transfer-Encoding: base64
Content-Disposition: inline;
   filename=guido3.jpg
Content-Type: image/jpeg;
   name="guido3.jpg"
Content-Id: <B073584A-EAF2-4A30-9ACC-1368C9C2E846@iiNet>

/9j/4AAQSkZJRgABAQEASABIAAD/4gVASUNDX1BST0ZJTEUAAQEAAAUwYXBwbAIgAABtbnRyUkdC
IFhZWiAH2QACABkACwAaAAthY3NwQVBQTAAAAABhcHBsAAAAAAAAAAAAAAAAAAAAAAAA9tYAAQAA
AADTLWFwcGwAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAtk
c2NtAAABCAAAAvJkZXNjAAAD/AAAAG9nWFlaAAAEbAAAABR3dHB0AAAEgAAAABRyWFlaAAAElAAA
ABRiWFlaAAAEqAAAABRyVFJDAAAEvAAAAA5jcHJ0AAAEzAAAADhjaGFkAAAFBAAAACxnVFJDAAAE
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MIME Example

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Content-Disposition: inline;
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Content-Type: image/jpeg;
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MIME Example


```
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Two-tier vs Three-tier mail

- **Two-tier:**
  - Client-server architecture
  - Client implements application logic, talks to server using SMTP and POP/IMAP

Two-tier vs Three-tier mail

- **Two-tier:**
  - Client-server architecture
  - Client implements application logic, talks to server using SMTP and POP/IMAP
- **Three-tier:**
  - Thin client accesses **web application**
  - Server handles application logic
  - Client accesses server using HTTP

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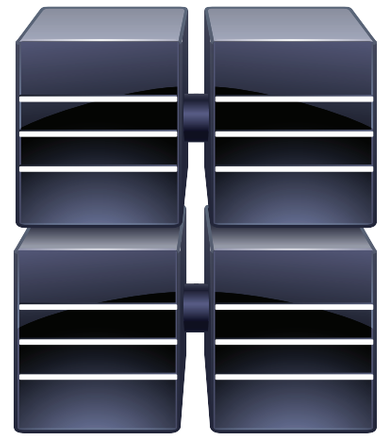

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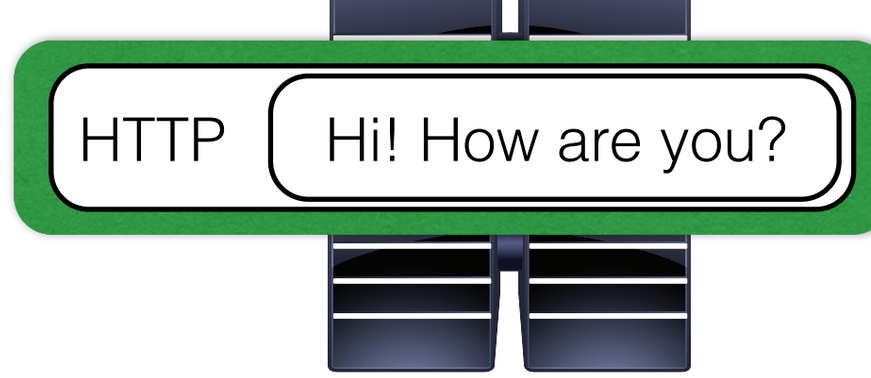

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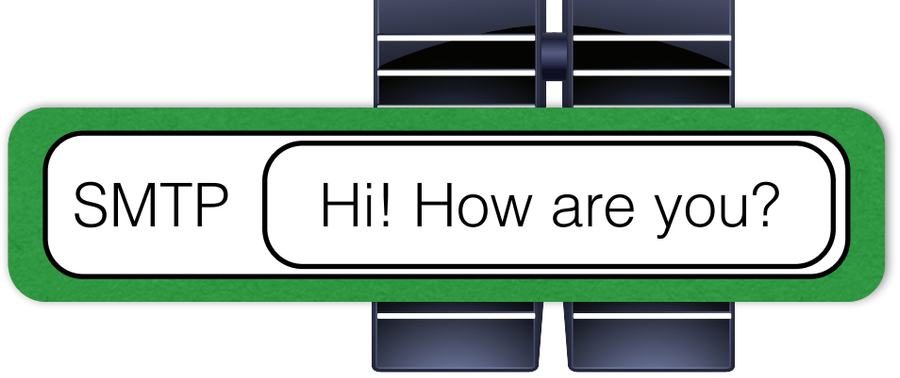

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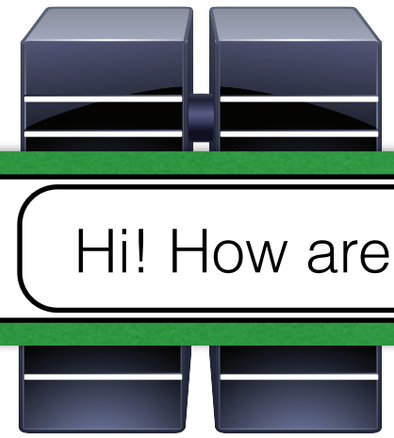

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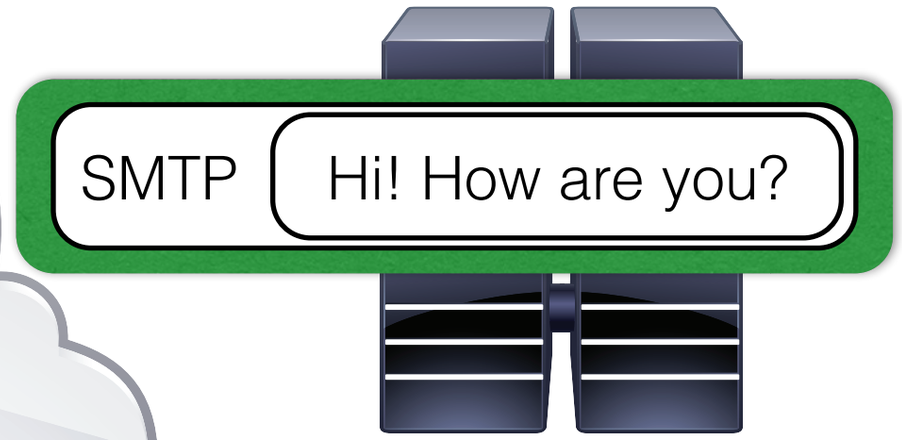

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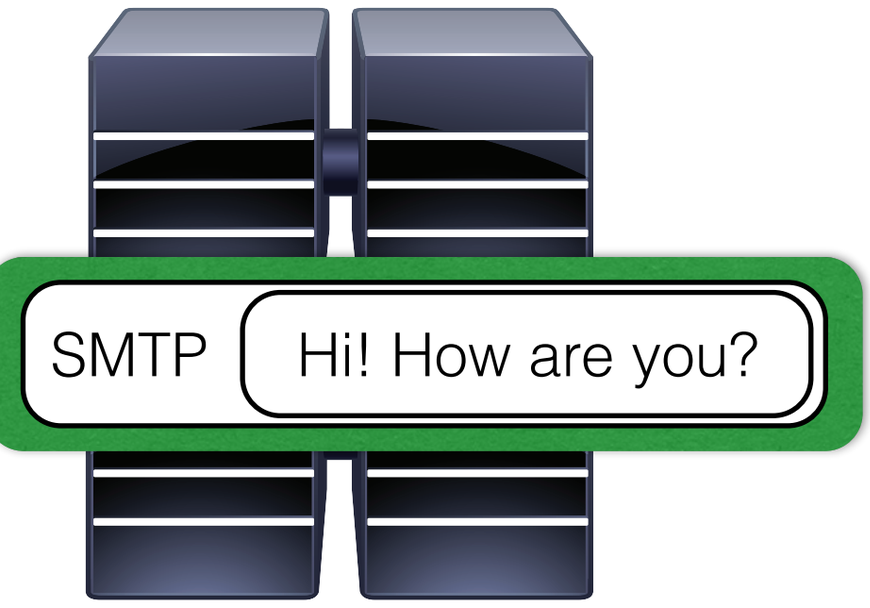

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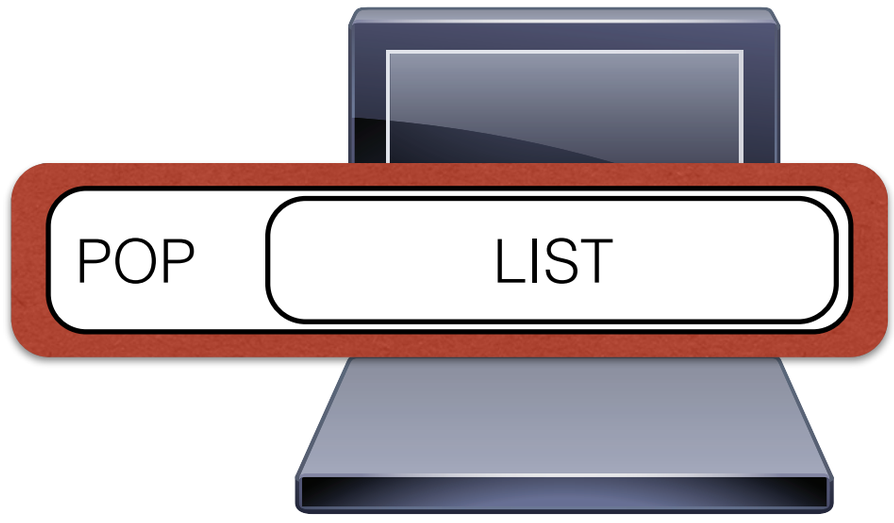

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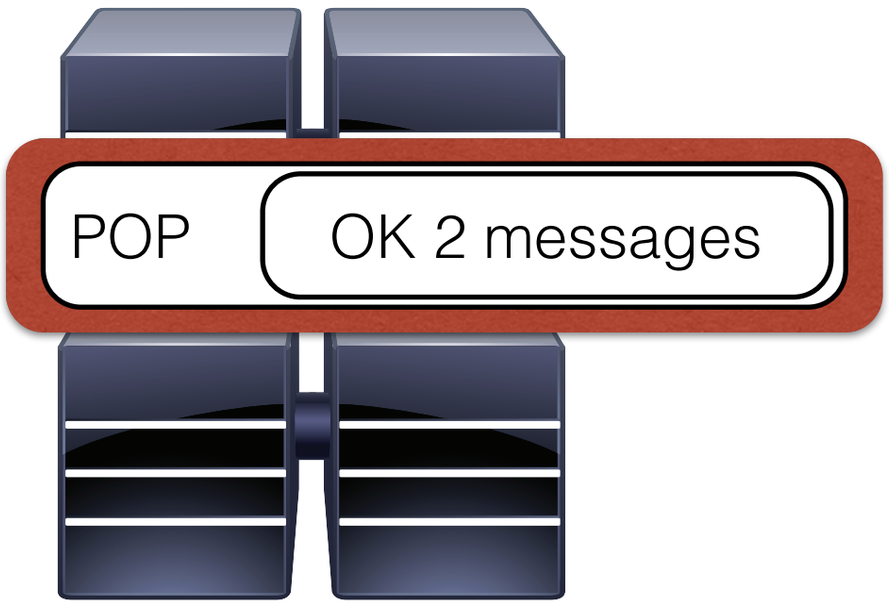

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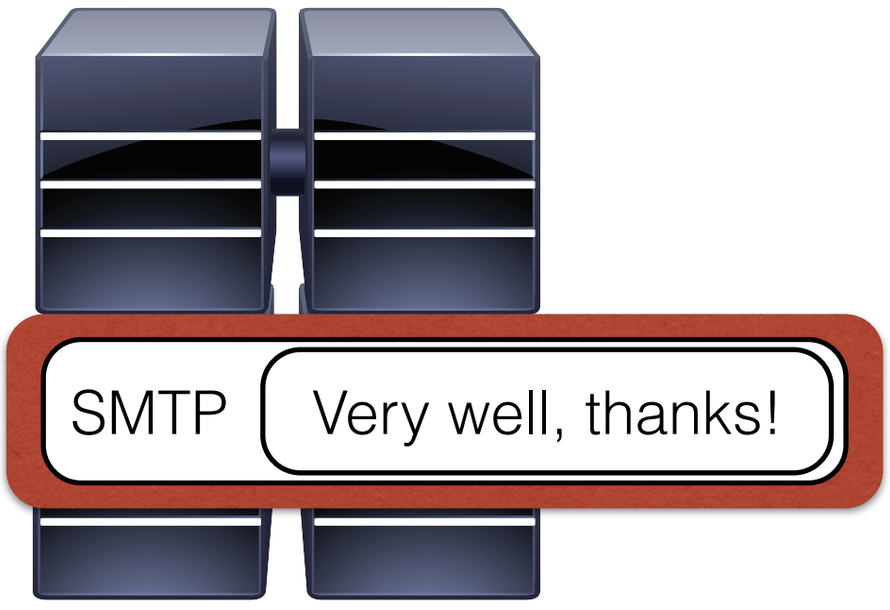

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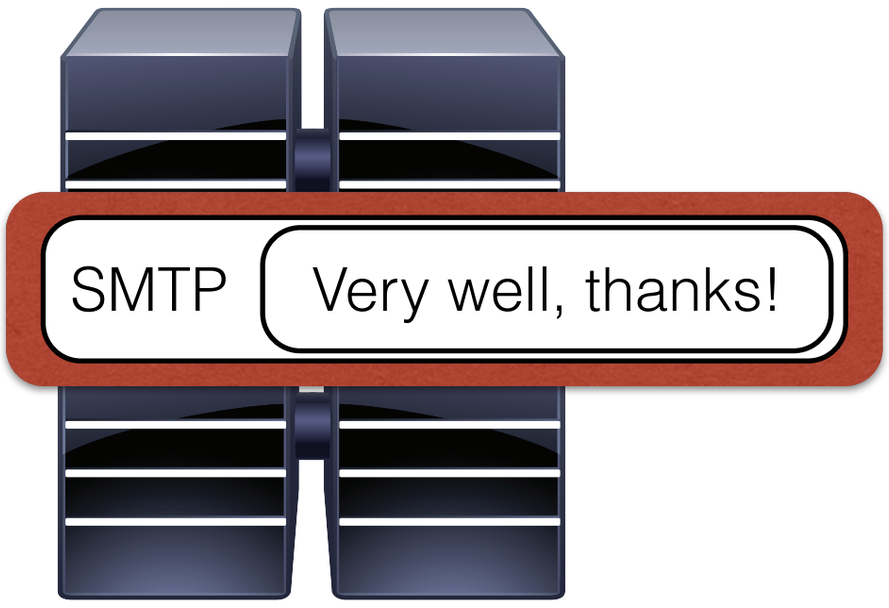

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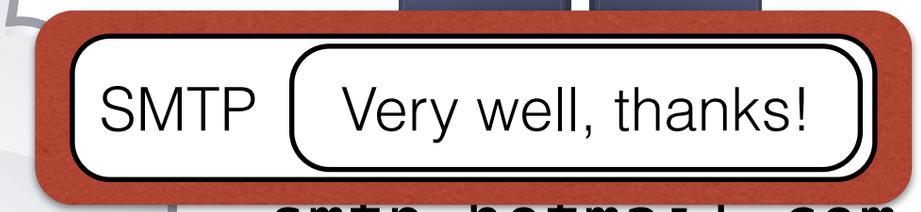

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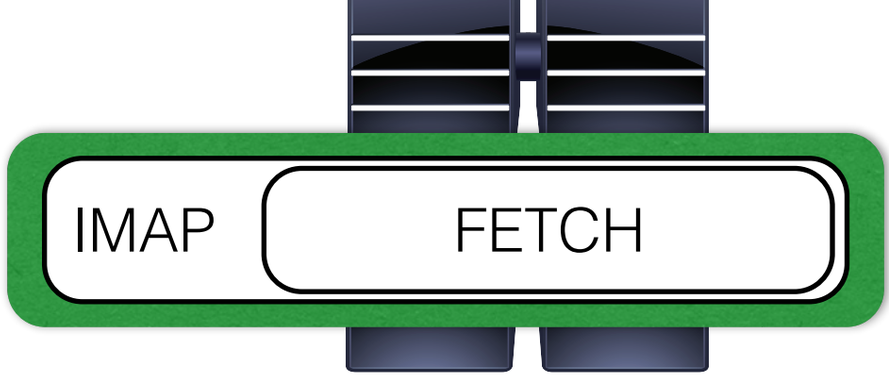

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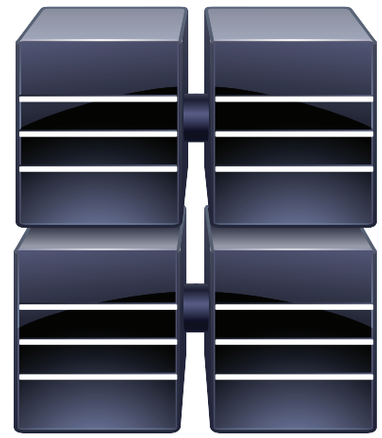

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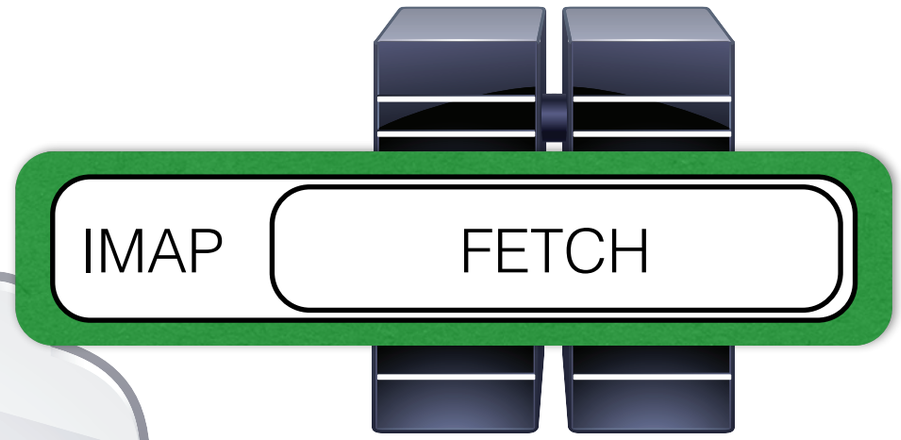

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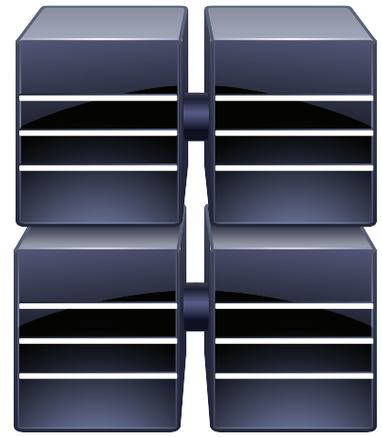

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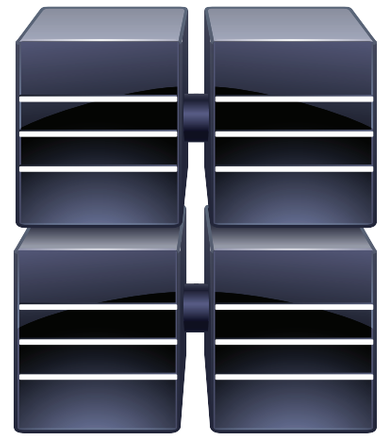

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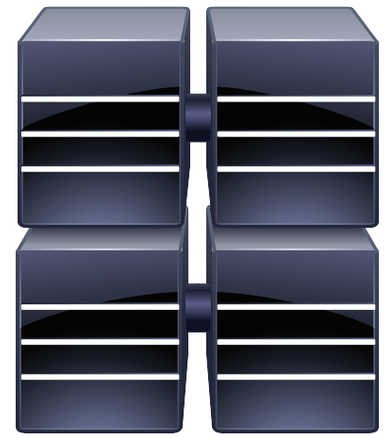

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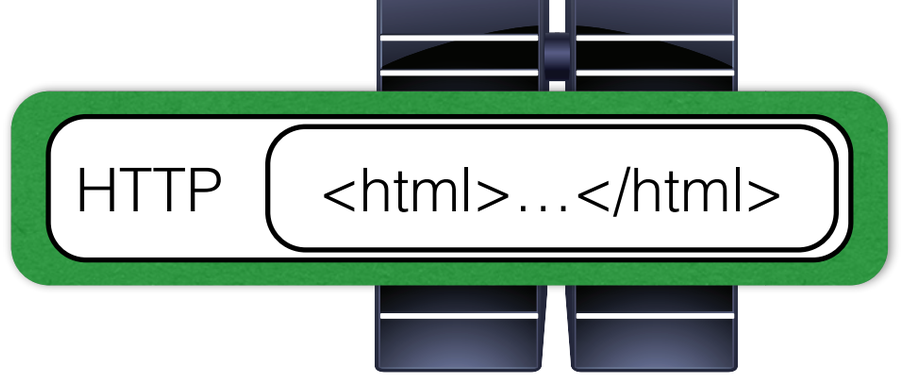

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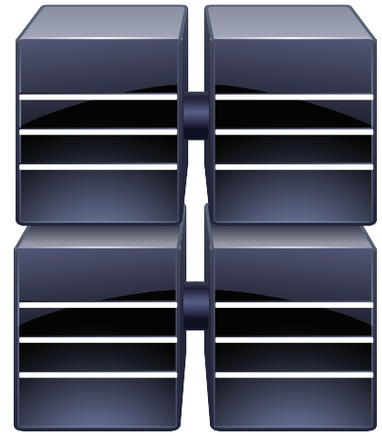

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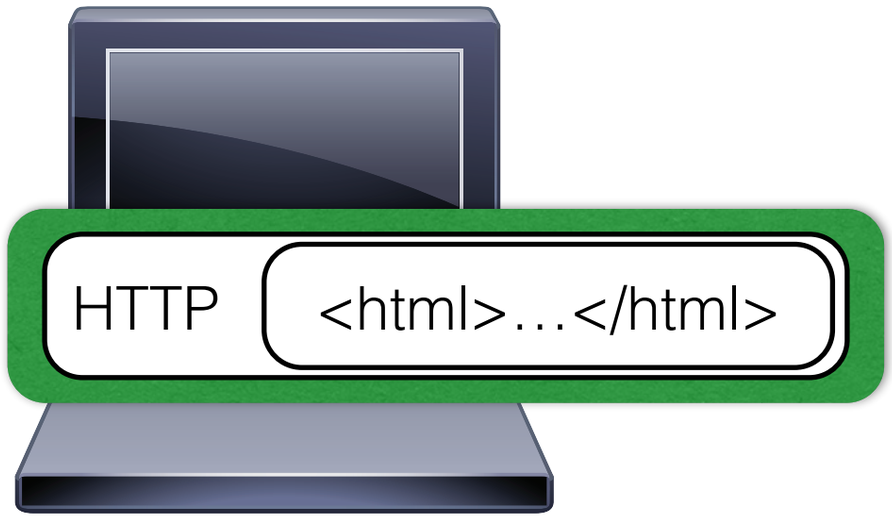

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Summary

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