Networked Programs

Chapter 12

Python for Informatics: Exploring Information
www.pythonlearn.com

Client

Server

Internet

Internet

HTML

JavaScript

AJAX

CSS

HTTP

Request

Response

GET

socket

POST

Python

Data Store

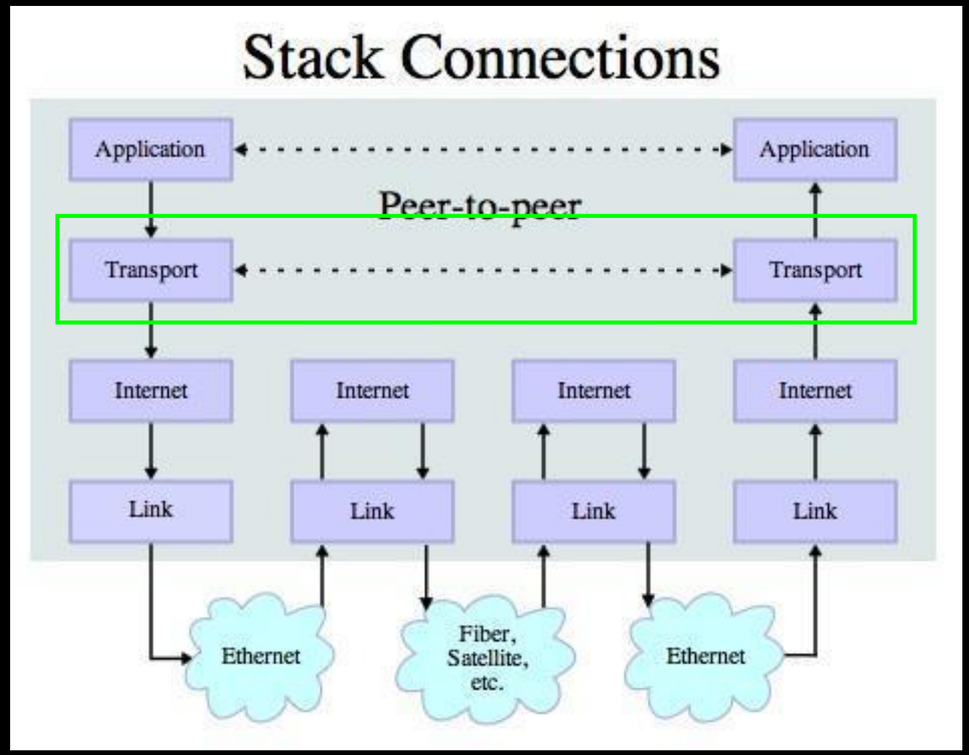
Templates

memcache

Network Architecture....

Transport Control Protocol (TCP)

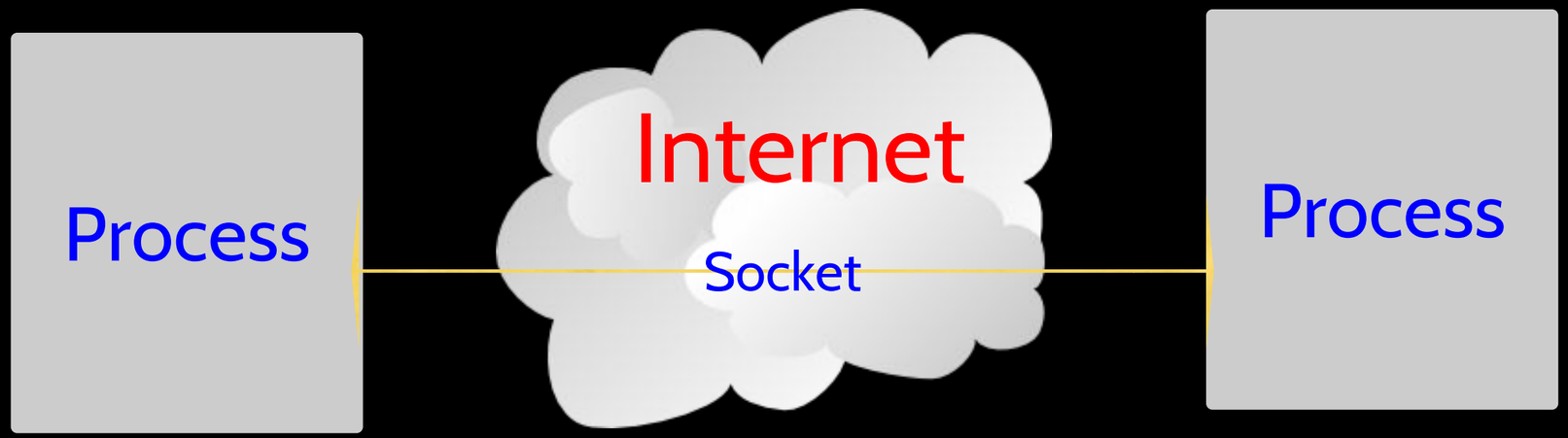
- Built on top of IP (Internet Protocol)
- Assumes IP might lose some data - stores and retransmits data if it seems to be lost
- Handles “flow control” using a transmit window
- Provides a nice reliable pipe



Source: http://en.wikipedia.org/wiki/Internet_Protocol_Suite

TCP Connections / Sockets

"In computer networking, an Internet socket or network socket is an endpoint of a bidirectional inter-process communication flow across an Internet Protocol-based computer network, such as the Internet."

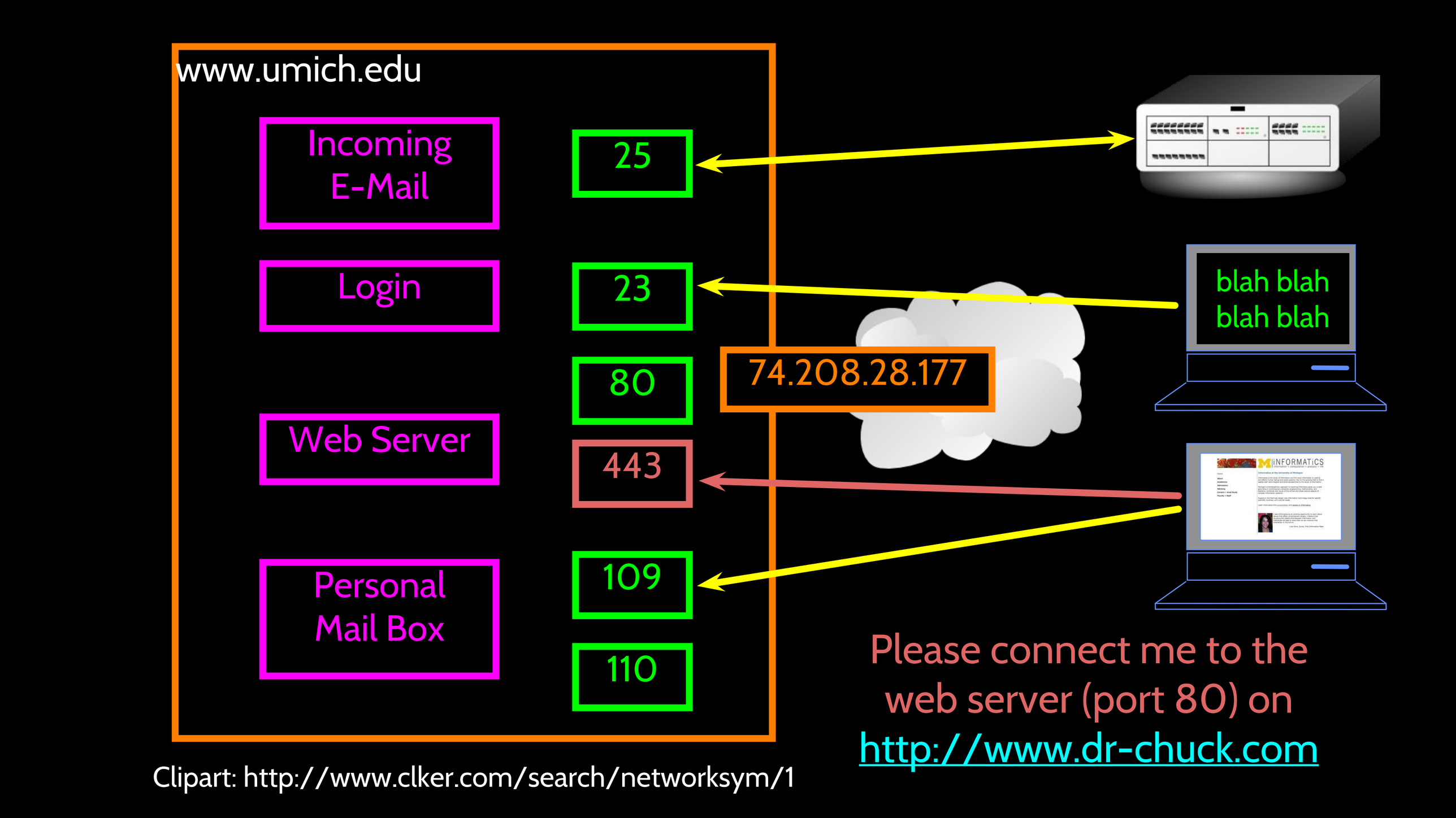


http://en.wikipedia.org/wiki/Internet_socket

TCP Port Numbers

- A port is an application-specific or process-specific software communications endpoint
- It allows multiple networked applications to coexist on the same server.
- There is a list of well-known TCP port numbers

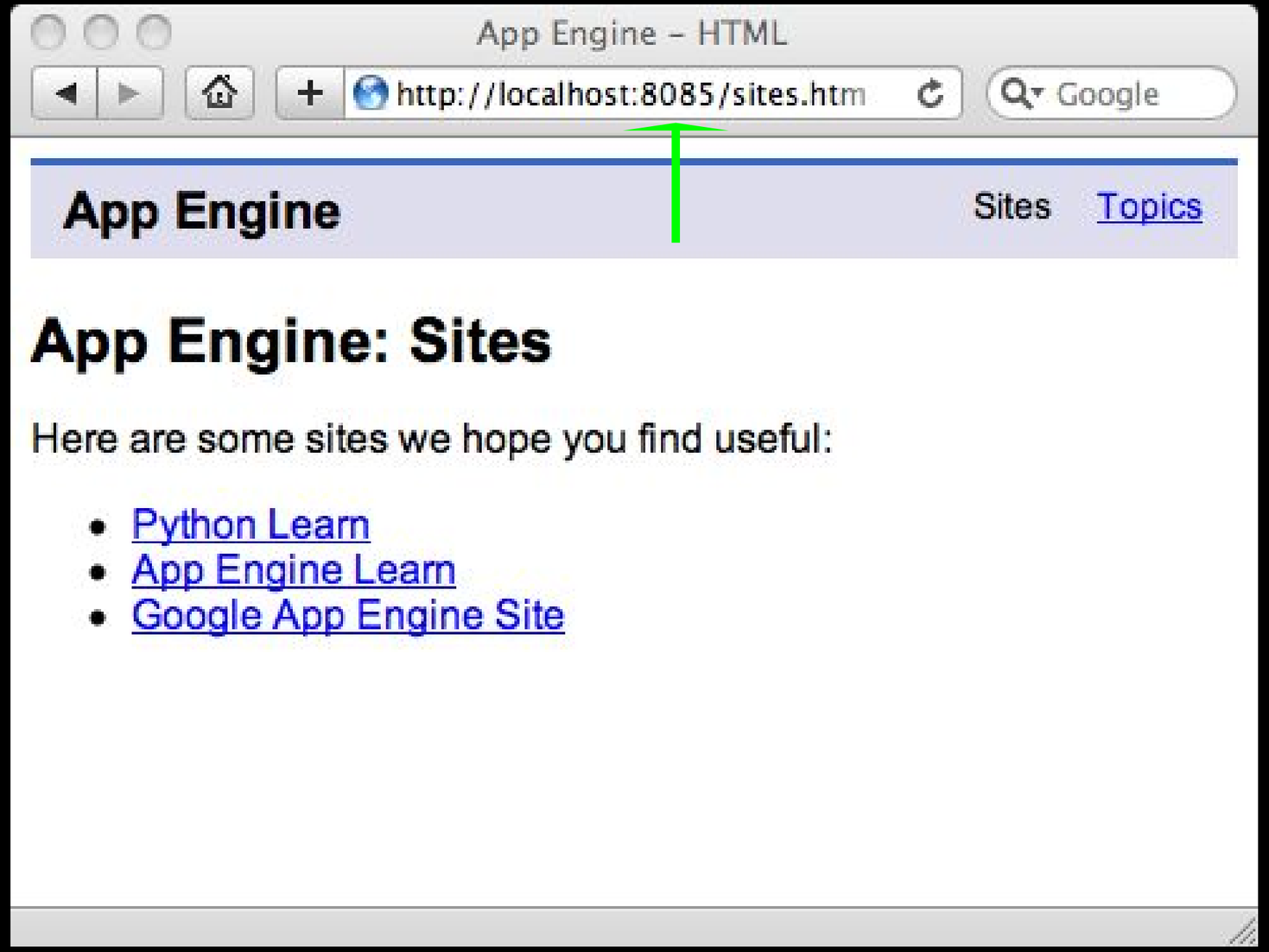
http://en.wikipedia.org/wiki/TCP_and_UDP_port


www.umich.edu
Incoming E-Mail
25
Login
23
80
Web Server
443
Personal Mail Box
109
110
74.208.28.177
blah blah blah blah
Please connect me to the web server (port 80) on http://www.dr-chuck.com
Clipart: http://www.clker.com/search/networksym/1

Common TCP Ports

- Telnet (23) - Login
- SSH (22) - Secure Login
- HTTP (80)
- HTTPS (443) - Secure
- SMTP (25) (Mail)
- IMAP (143/220/993) - Mail Retrieval
- POP (109/110) - Mail Retrieval
- DNS (53) - Domain Name
- FTP (21) - File Transfer

http://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers

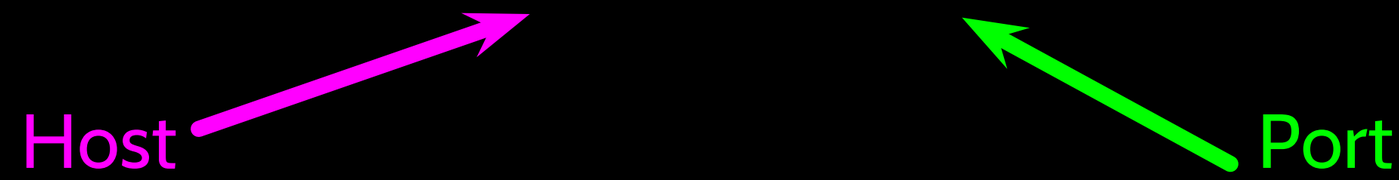


Sometimes we see the port number in the URL if the web server is running on a "non-standard" port.

Sockets in Python

- Python has built-in support for TCP Sockets

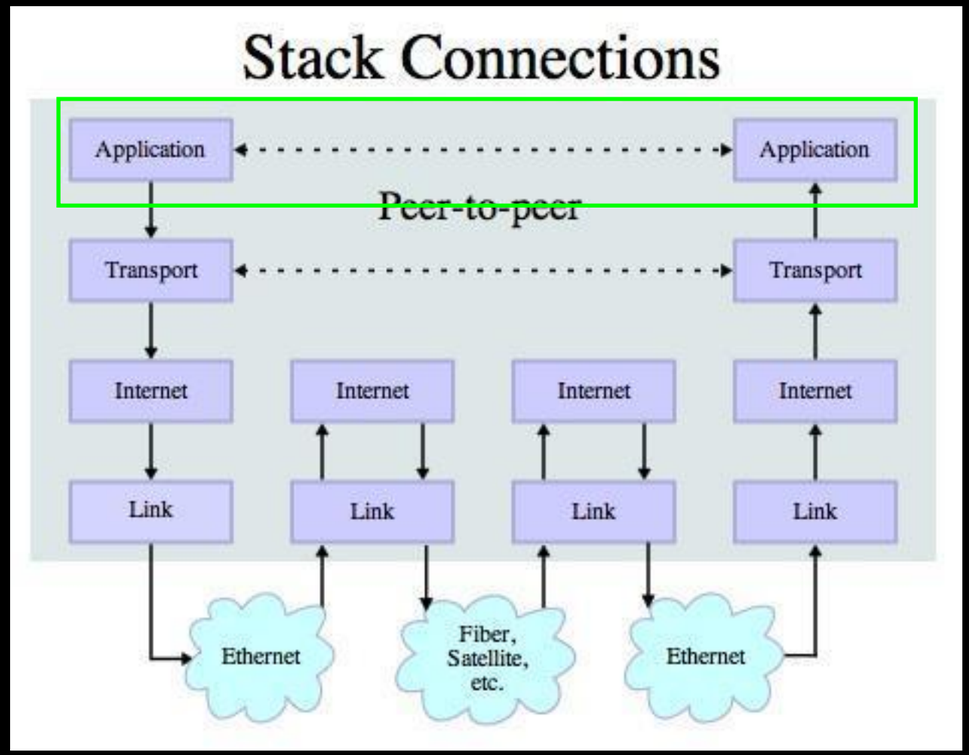
```
import socket
mysock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
mysock.connect( ('www.py4inf.com', 80) )
```



http://docs.python.org/library/socket.html

Application Protocol

- Since TCP (and Python) gives us a reliable socket, what do we want to do with the socket? What problem do we want to solve?
- Application Protocols
  - Mail
  - World Wide Web



Source: http://en.wikipedia.org/wiki/Internet_Protocol_Suite

HTTP - Hypertext Transport Protocol

- The dominant Application Layer Protocol on the Internet
- Invented for the Web - to Retrieve HTML, Images, Documents, etc
- Extended to be data in addition to documents - RSS, Web Services, etc..
- Basic Concept - Make a Connection - Request a document - Retrieve the Document - Close the Connection

http://en.wikipedia.org/wiki/Http

HTTP

The HyperText Transport Protocol is the set of rules to allow browsers to retrieve web documents from servers over the Internet

What is a Protocol?

- A set of rules that all parties follow so we can predict each other's behavior
- And not bump into each other
  - On two-way roads in USA, drive on the right-hand side of the road
  - On two-way roads in the UK, drive on the left-hand side of the road

http://www.dr-chuck.com/page1.htm

protocol host document

http://www.youtube.com/watch?v=x2GylLq59rI

1:17 - 2:19

Getting Data From The Server

- Each time the user clicks on an anchor tag with an href= value to switch to a new page, the browser makes a connection to the web server and issues a “GET” request - to GET the content of the page at the specified URL
- The server returns the HTML document to the browser, which formats and displays the document to the user

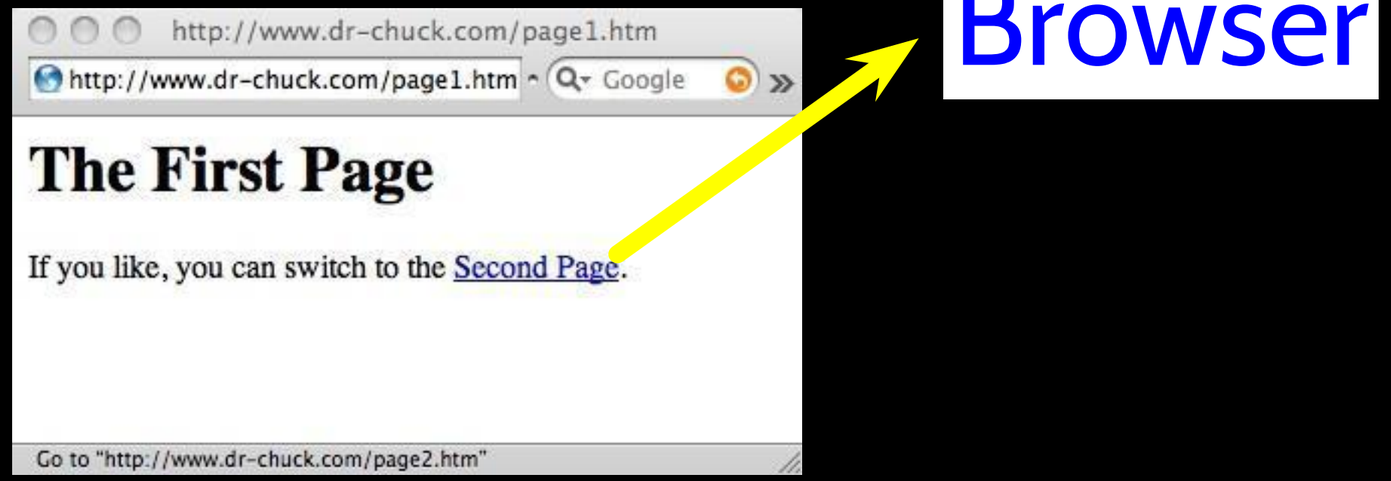
Making an HTTP request

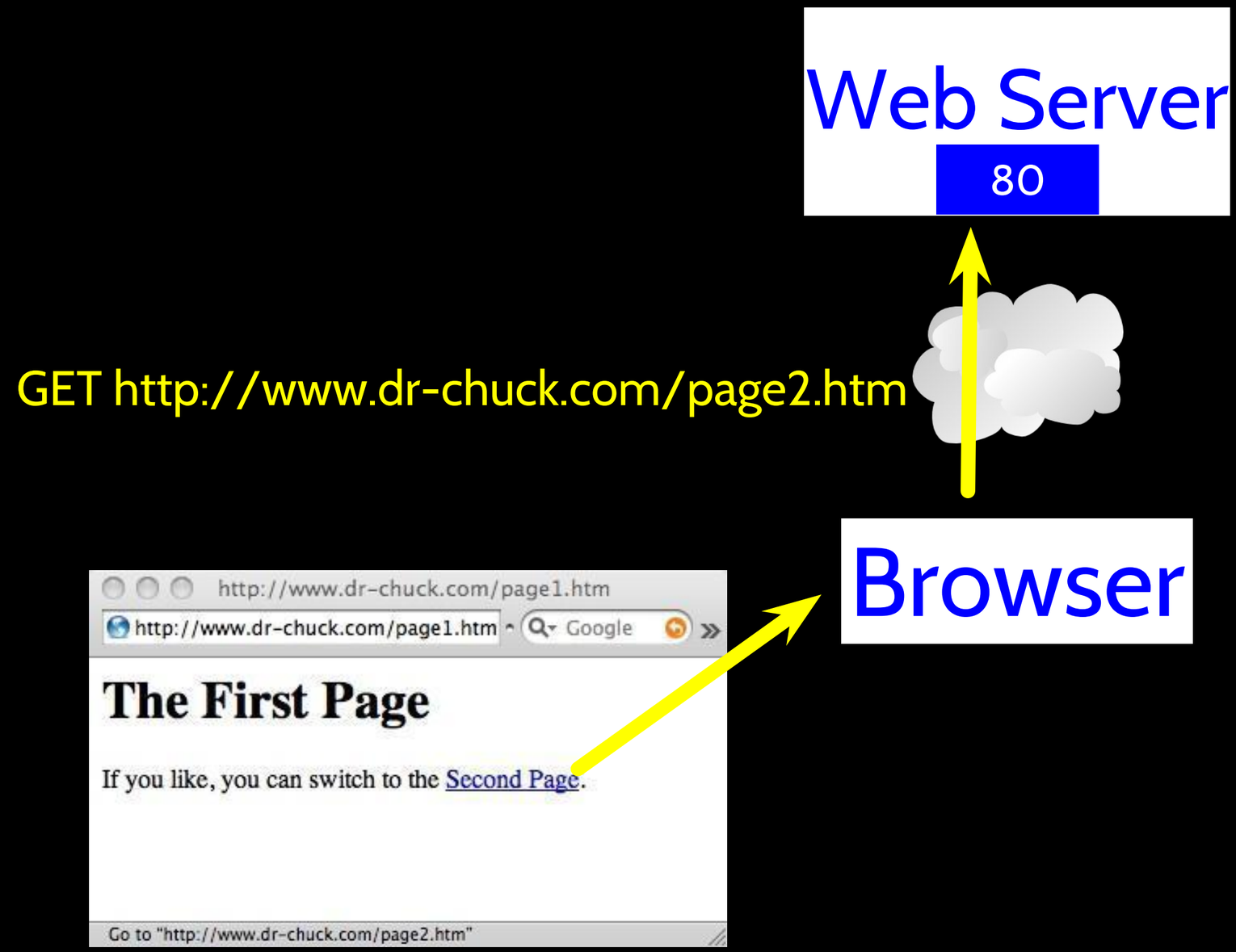
- Connect to the server like www.dr-chuck.com
    - a “hand shake”
- Request a document (or the default document)
    - GET http://www.dr-chuck.com/page1.htm
    - GET http://www.mlive.com/ann-arbor/
    - GET http://www.facebook.com

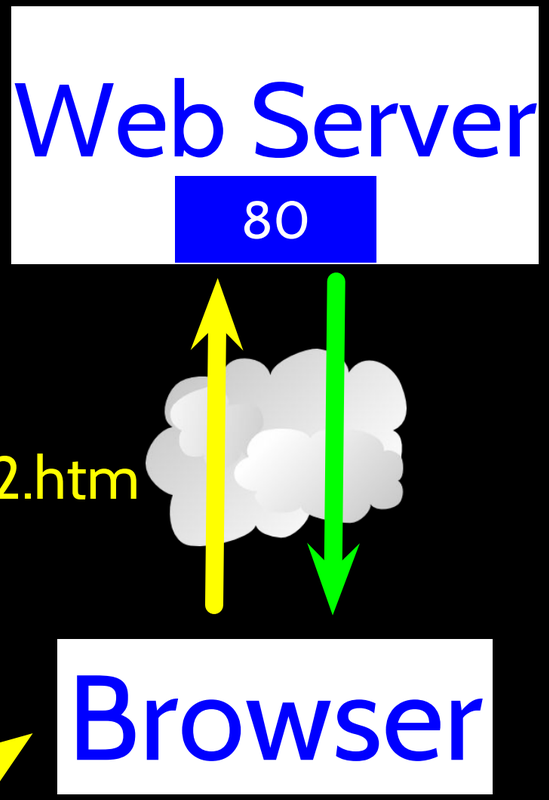

http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page1.htm
Google
The First Page
If you like, you can switch to the Second Page.
Go to "http://www.dr-chuck.com/page2.htm"


http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page1.htm
Google
The First Page
If you like, you can switch to the Second Page.
Go to "http://www.dr-chuck.com/page2.htm"

Browser

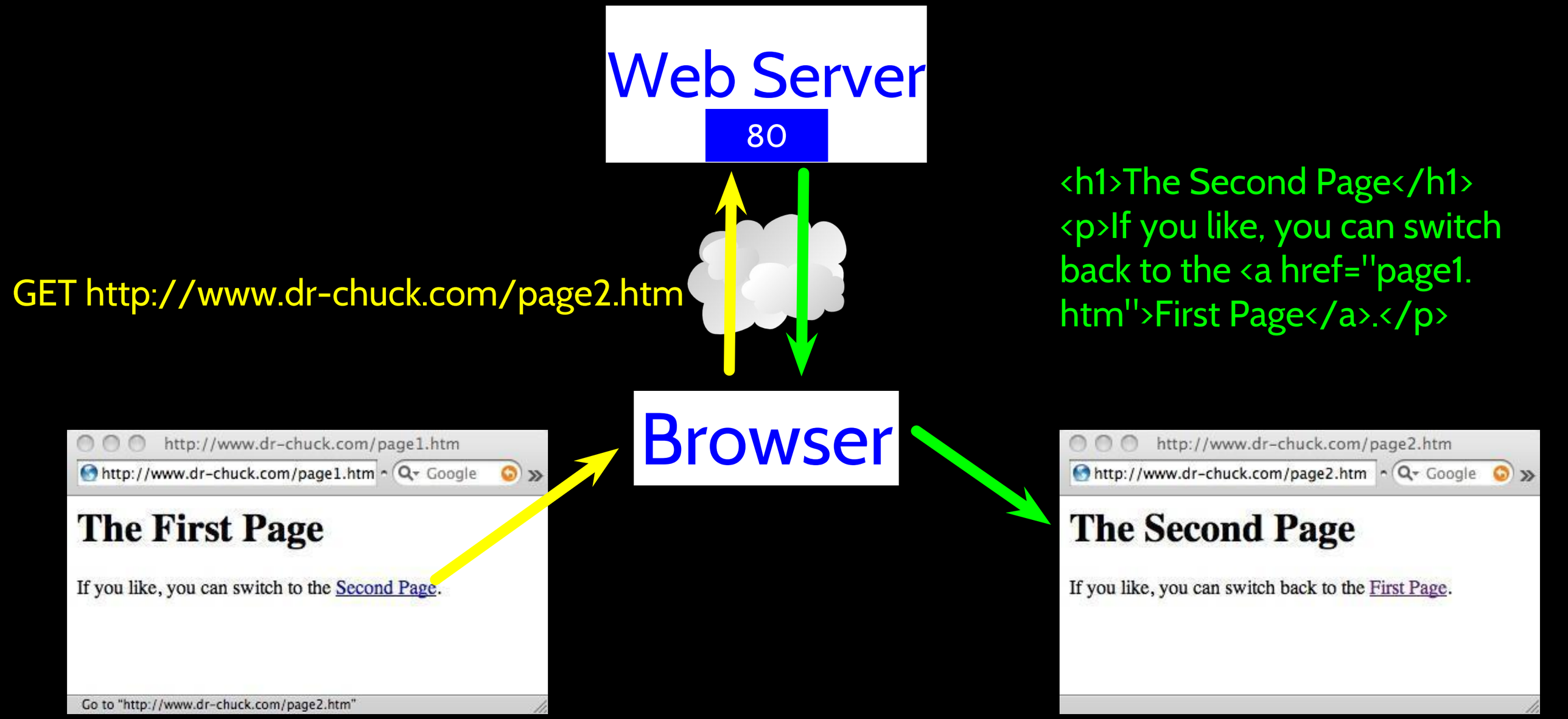

Web Server
80
Browser
http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page1.htm
Google
The First Page
If you like, you can switch to the Second Page.
Go to "http://www.dr-chuck.com/page2.htm"


Web Server
80
GET http://www.dr-chuck.com/page2.htm
Browser
http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page1.htm
Google
The First Page
If you like, you can switch to the Second Page.
Go to "http://www.dr-chuck.com/page2.htm"



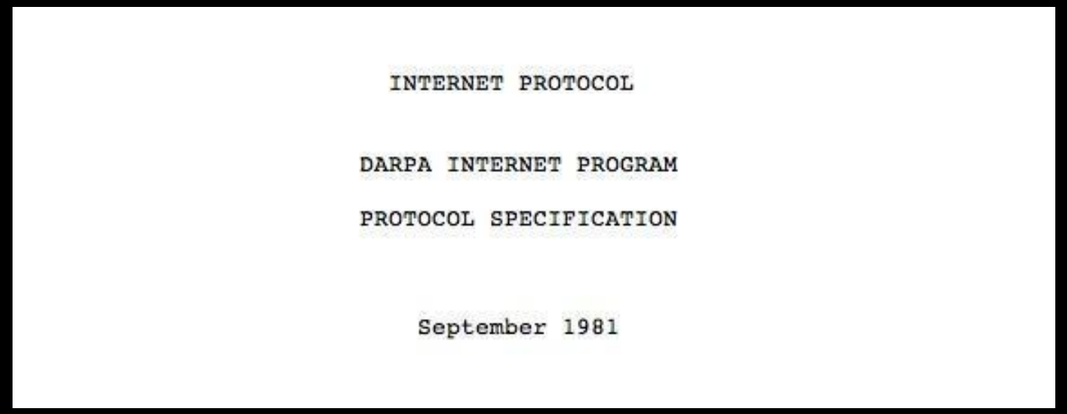
GET http://www.dr-chuck.com/page2.htm

<h1>The Second Page</h1>
If you like, you can switch back to the First Page.


Web Server
80
GET http://www.dr-chuck.com/page2.htm
<h1>The Second Page</h1>
If you like, you can switch back to the First Page.
Browser
http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page1.htm
Google
The First Page
If you like, you can switch to the Second Page.
Go to "http://www.dr-chuck.com/page2.htm"
http://www.dr-chuck.com/page2.htm
http://www.dr-chuck.com/page2.htm
Google
The Second Page
If you like, you can switch back to the First Page.

Internet Standards

- The standards for all of the Internet protocols (inner workings) are developed by an organization
- Internet Engineering Task Force (IETF)
- www.ietf.org
- Standards are called “RFCs” - “Request for Comments”



INTERNET PROTOCOL

DARPA INTERNET PROGRAM

PROTOCOL SPECIFICATION

September 1981

The internet protocol treats each internet datagram as an independent entity unrelated to any other internet datagram. There are no connections or logical circuits (virtual or otherwise).

The internet protocol uses four key mechanisms in providing its service: Type of Service, Time to Live, Options, and Header Checksum.

Source: http://tools.ietf.org/html/rfc791

http://www.w3.org/Protocols/rfc2616/rfc2616.txt

Network Working Group
Request for Comments: 2616
Obsoletes: 2068
Category: Standards Track

R. Fielding
UC Irvine
J. Gettys
Compaq/W3C
J. Mogul
Compaq
H. Frystyk
W3C/MIT
L. Masinter
Xerox
P. Leach
Microsoft
T. Berners-Lee
W3C/MIT

June 1999

Hypertext Transfer Protocol -- HTTP/1.1

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Copyright Notice

Abstract

The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information

5 Request

A request message from a client to a server includes, within the first line of that message, the method to be applied to the resource, the identifier of the resource, and the protocol version in use.

```
Request       = Request-Line              ; Section 5.1
                *(( general-header        ; Section 4.5
                 | request-header         ; Section 5.3
                 | entity-header ) CRLF)  ; Section 7.1
                CRLF
                [ message-body ]          ; Section 4.3
```

5.1 Request-Line

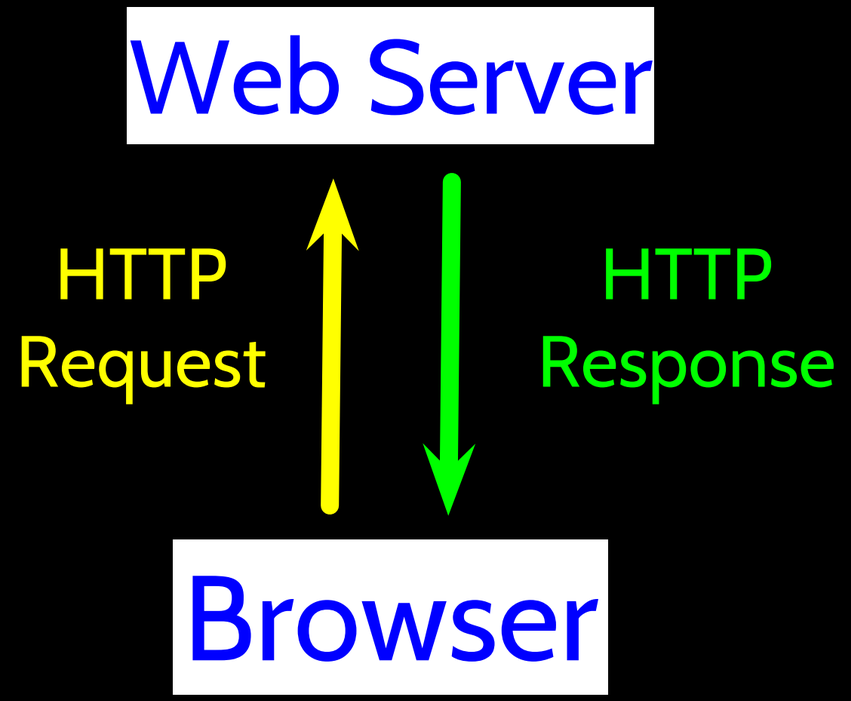
The Request-Line begins with a method token, followed by the Request-URI and the protocol version, and ending with CRLF. The elements are separated by SP characters. No CR or LF is allowed except in the final CRLF sequence.

```
Request-Line   = Method SP Request-URI SP HTTP-Version CRLF
```

Making an HTTP request

- Connect to the server like www.dr-chuck.com
    - a “hand shake”
- Request a document (or the default document)
    - GET http://www.dr-chuck.com/page1.htm
    - GET http://www.mlive.com/ann-arbor/
    - GET http://www.facebook.com

“Hacking” HTTP




```
$ telnet www.dr-chuck.com 80
Trying 74.208.28.177...
Connected to www.dr-chuck.com.
Escape character is '^]'.
GET http://www.dr-chuck.com/page1.htm HTTP/1.0

<h1>The First Page</h1>
<p>If you like, you can switch to the
<a href="http://www.dr-chuck.com/page2.htm">Second Page</a>.
</p>
```

Port 80 is the non-encrypted HTTP port

```
$ telnet www.dr-chuck.com 80
Trying 74.208.28.177...
Connected to www.dr-chuck.com.Escape character is '^]'.
GET http://www.dr-chuck.com/page1.htm HTTP/1.0

<h1>The First Page</h1>
<p>If you like, you can switch to the
<a href="http://www.dr-chuck.com/page2.htm">Second
Page</a>.</p>
Connection closed by foreign host.
```

```
si-csev-mbp:tex csev$ telnet www.umich.edu 80
Trying 141.211.144.190...
Connected to www.umich.edu.Escape character is '^]'.
GET /
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http:
//www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd"><html xmlns="
http://www.w3.org/1999/xhtml" xml:lang="en" lang="en"
><head><title>University of Michigan</title><meta name="
description" content="University of Michigan is one of the top
universities of the world, a diverse public institution of
higher learning, fostering excellence in research. U-M provides
outstanding undergraduate, graduate and professional education,
serving the local, regional, national and international
communities." />
```

```
...
<link rel="alternate stylesheet" type="text/css" href="
/CSS/accessible.css" media="screen" title="accessible" /><link
rel="stylesheet" href="/CSS/print.css" media="print,projection"
/><link rel="stylesheet" href="/CSS/other.css" media="handheld,
tty,tv,braille,embossed,speech,aural" />...  <dl><dt><a href="
http://ns.umich.edu/htdocs/releases/story.php?id=8077">
<img src="/Images/electric-brain.jpg" width="114" height="77"
alt="Top News Story" /></a><span class="verbose">:
</span></dt><dd><a href="http://ns.umich.
edu/htdocs/releases/story.php?id=8077">Scientists harness the
power of electricity in the brain</a></dd></dl>
```

As the browser reads the document, it finds other URLs that must be retrieved to produce the document.

The big picture...


```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
<head>
<title>University of Michigan</title>
....
```

```
@import "/CSS/graphical.css"/**/;
p.text strong, .verbose, .verbose p, .verbose h2{text-indent:-876em;position:absolute}
p.text strong a{text-decoration:none}
p.text em{font-weight:bold;font-style:normal}
div.alert{background:#eee;border:1px solid red;padding:.5em;margin:0 25%}
a img{border:none}
.hot br, .quick br, dl.feature2 img{display:none}
div#main label, legend{font-weight:bold}
```

A browser debugger reveals detail...

- Most browsers have a developer mode so you can watch it in action
- It can help explore the HTTP request-response cycle
- Some simple-looking pages involve lots of requests:
    - HTML page(s)
    - Image files
    - CSS Style Sheets
    - JavaScript files

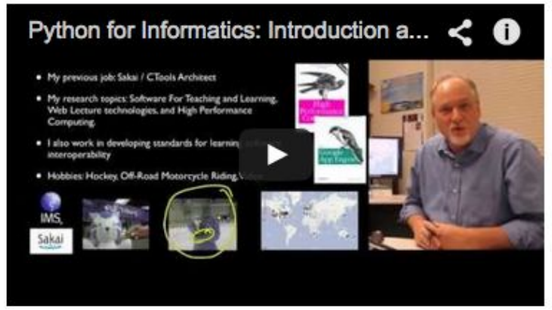
PythonLearn - Exploring D

www.pythonlearn.com

PythonLearn

Book Install MOOC (Korean) Instructor Python About

The goal of this site is to provide a set of materials in support of my Python for Informatics: Exploring Information book to allow you to learn Python on your own. This page serves as an outline of the materials to support the textbook.



You can download the exercises, audio, and video lectures to your local computer so you can play them locally. This can be done with either a Right-Click or a Control-Click in most browsers.

- Welcome Lecture - (YouTube, Download MP4, Audio podcast for all lectures)
- Get your copy of the Python for Informatics: Exploring Information.
- Install the appropriate version of Python and a text editor for your system following these instructions.
- Download Sample code from the book.
- The course slides have been converted to Google drive and are being translated into 30 languages.
- Chapter 1 - Why program? (YouTube, Audio, Video)

Elements Network Sources Timeline Profiles Resources Audits Console

Preserve log Disable cache

Name / Path	Method	Status / Text	Type	Initiator	Size / Content	Time / Latency	Timeline
www.pythonlearn.com	GET	200 OK	text/ht...	Other	11.0 KB 10.7 KB	175 ms 133 ms	
glike.css	GET	200 OK	text/css	www.pythonle... Parser	2.7 KB 2.4 KB	89 ms 40 ms	
ile-main.js api.cloudsocial.org/js	GET	200 OK	applica...	www.pythonle... Parser	117 KB 117 KB	199 ms 88 ms	
UQVK-dsU7-Y www.youtube.com/embed	GET	301 Moved ...	text/ht...	Other	688 B 0 B	149 ms 148 ms	
UQVK-dsU7-Y www.youtube.com/embed	GET	200 OK	text/ht...	http://www.yo... Redirect	9.6 KB 14.3 KB	245 ms 200 ms	

1.00 s 1.50 s

22 requests | 667 KB transferred

Console Search Emulation Rendering

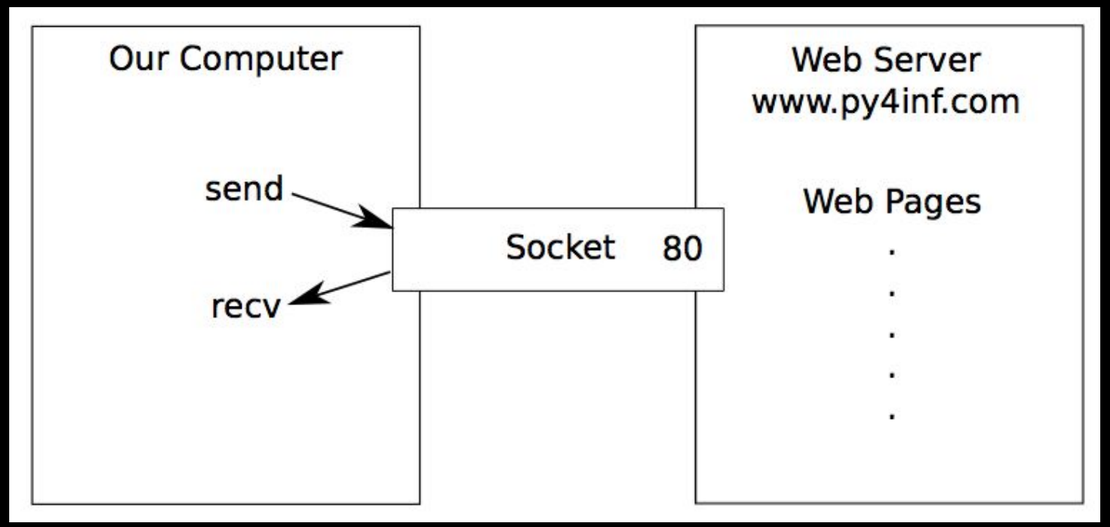
Let’s Write a Web Browser!

An HTTP Request in Python

```
import socket
mysock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
mysock.connect(('www.py4inf.com', 80))

mysock.send('GET http://www.py4inf.com/code/romeo.txt HTTP/1.0\n\n')

while True:
    data = mysock.recv(512)
    if ( len(data) < 1 ) :
        break
    print data
mysock.close()
```



```
HTTP/1.1 200 OK
Date: Sun, 14 Mar 2010 23:52:41 GMT
Server: Apache
Last-Modified: Tue, 29 Dec 2009 01:31:22 GMT
ETag: "143c1b33-a7-4b395bea"
Accept-Ranges: bytes
Content-Length: 167
Connection: close
Content-Type: text/plain

But soft what light through yonder window breaks
It is the east and Juliet is the sun
Arise fair sun and kill the envious moon
Who is already sick and pale with grief
```

HTTP Header

```
while True:
    data = mysock.recv(512)
    if ( len(data) < 1 ) :
        break
    print data
```

HTTP Body

Making HTTP Easier With urllib

Using urllib in Python

Since HTTP is so common, we have a library that does all the socket work for us and makes web pages look like a file

```
import urllib
fhand = urllib.urlopen('http://www.py4inf.com/code/romeo.txt')

for line in fhand:
    print line.strip()
```

http://docs.python.org/library/urllib.html

urllib1.py

```
import urllib
fhand = urllib.urlopen('http://www.py4inf.com/code/romeo.txt')
for line in fhand:
    print line.strip()
```

But soft what light through yonder window breaks
It is the east and Juliet is the sun
Arise fair sun and kill the envious moon
Who is already sick and pale with grief

http://docs.python.org/library/urllib.html

urllib1.py

Like a file...

```
import urllib
fhand = urllib.urlopen('http://www.py4inf.com/code/romeo.txt')

counts = dict()
for line in fhand:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1
print counts
```

urlwords.py

Reading Web Pages

```
import urllib
fhand = urllib.urlopen('http://www.dr-chuck.com/page1.htm')
for line in fhand:
    print line.strip()
```

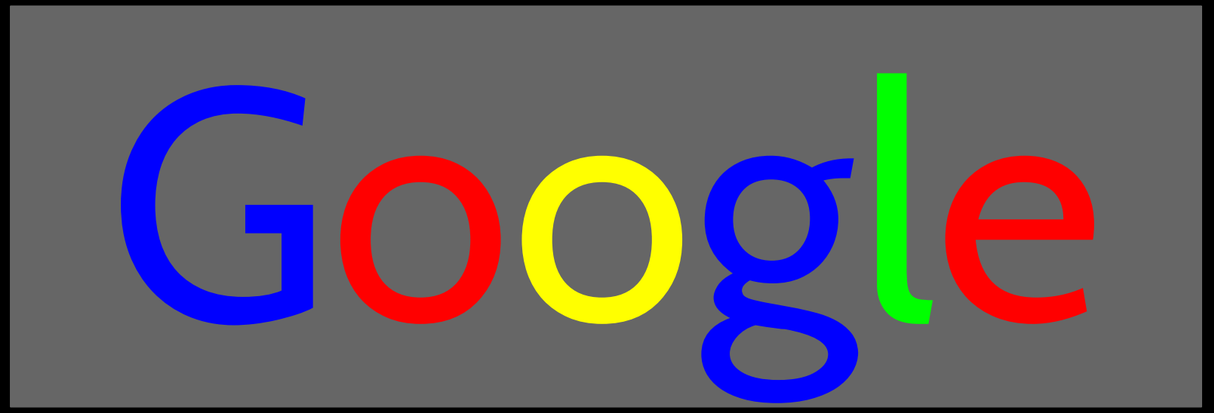
```
<h1>The First Page</h1>
<p>
If you like, you can switch to the <a href="
http://www.dr-chuck.com/page2.htm">Second
Page</a>.
</p>
```

urllib2.py

Going from one page to another...

```
import urllib
fhand = urllib.urlopen('http://www.dr-chuck.com/page1.htm')
for line in fhand:
    print line.strip()
```

```
<h1>The First Page</h1>
<p>
If you like, you can switch to the
<a href="http://www.dr-chuck.com/
page2.htm">Second Page</a>.
</p>
```




```
import urllib
fhand = urllib.urlopen('http://www.dr-chuck.com/page1.htm')
for line in fhand:
    print line.strip()
```

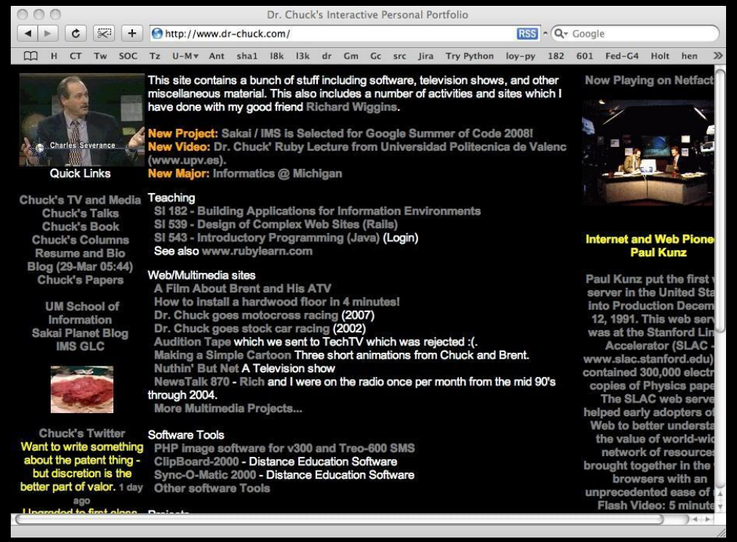
Parsing HTML
(a.k.a. Web Scraping)

What is Web Scraping?

- When a program or script pretends to be a browser and retrieves web pages, looks at those web pages, extracts information, and then looks at more web pages.

- Search engines scrape web pages - we call this “spidering the web” or “web crawling”

http://en.wikipedia.org/wiki/Web_scraping
http://en.wikipedia.org/wiki/Web_crawler



GET

HTML

Server

GET

```
charles-severances-macbook-air:Scraping csev$ python
Python 2.5 (r25:51918, Sep 19 2006, 08:49:13)
[GCC 4.0.1 (Apple Computer, Inc. build 5341)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import urllib
>>> f = urllib.urlopen("http://www.dr-chuck.com/")
>>> contents = f.read()
>>> f.close()
>>> print len(contents)
95328
>>> print contents[0:30]
<html>
<head>
  <title>Dr. C
>>>
```

HTML

Why Scrape?

- Pull data - particularly social data - who links to who?
- Get your own data back out of some system that has no “export capability”
- Monitor a site for new information
- Spider the web to make a database for a search engine

Scraping Web Pages

- There is some controversy about web page scraping and some sites are a bit snippy about it.
  - Google: facebook scraping block
- Republishing copyrighted information is not allowed
- Violating terms of service is not allowed

http://www.facebook.com/terms.php

User Conduct

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The Easy Way - Beautiful Soup

- You could do string searches the hard way
- Or use the free software called BeautifulSoup from www.crummy.com

  http://www.crummy.com/software/BeautifulSoup/
  http://www.pythonlearn.com/code/BeautifulSoup.py

Place the BeautifulSoup.py file in the same folder as your Python code...

```
import urllib
from BeautifulSoup import *

url = raw_input('Enter - ')

html = urllib.urlopen(url).read()
soup = BeautifulSoup(html)

# Retrieve a list of the anchor tags
# Each tag is like a dictionary of HTML attributes

tags = soup('a')

for tag in tags:
   print tag.get('href', None)
```

urllinks.py

<h1>The First Page</h1>
If you like, you can switch to the<a href="
http://www.dr-chuck.com/page2.htm"
>Second Page.

```
html = urllib.urlopen(url).read()
soup = BeautifulSoup(html)

tags = soup('a')
for tag in tags:
    print tag.get('href', None)
```

python urllinks.py
Enter - http://www.dr-chuck.com/page1.htm
http://www.dr-chuck.com/page2.htm

Summary

- The TCP/IP gives us pipes / sockets between applications
- We designed application protocols to make use of these pipes
- HyperText Transport Protocol (HTTP) is a simple yet powerful protocol
- Python has good support for sockets, HTTP, and HTML parsing

Acknowledgements / Contributions

Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors here

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