

# Networked Programs

## Chapter 12



Python for Informatics: Exploring Information  
[www.pythonlearn.com](http://www.pythonlearn.com)



# Client



# Server





HTML

AJAX

JavaScript

CSS

HTTP

Response

socket

Request

GET

POST

Python

Templates

Data Store

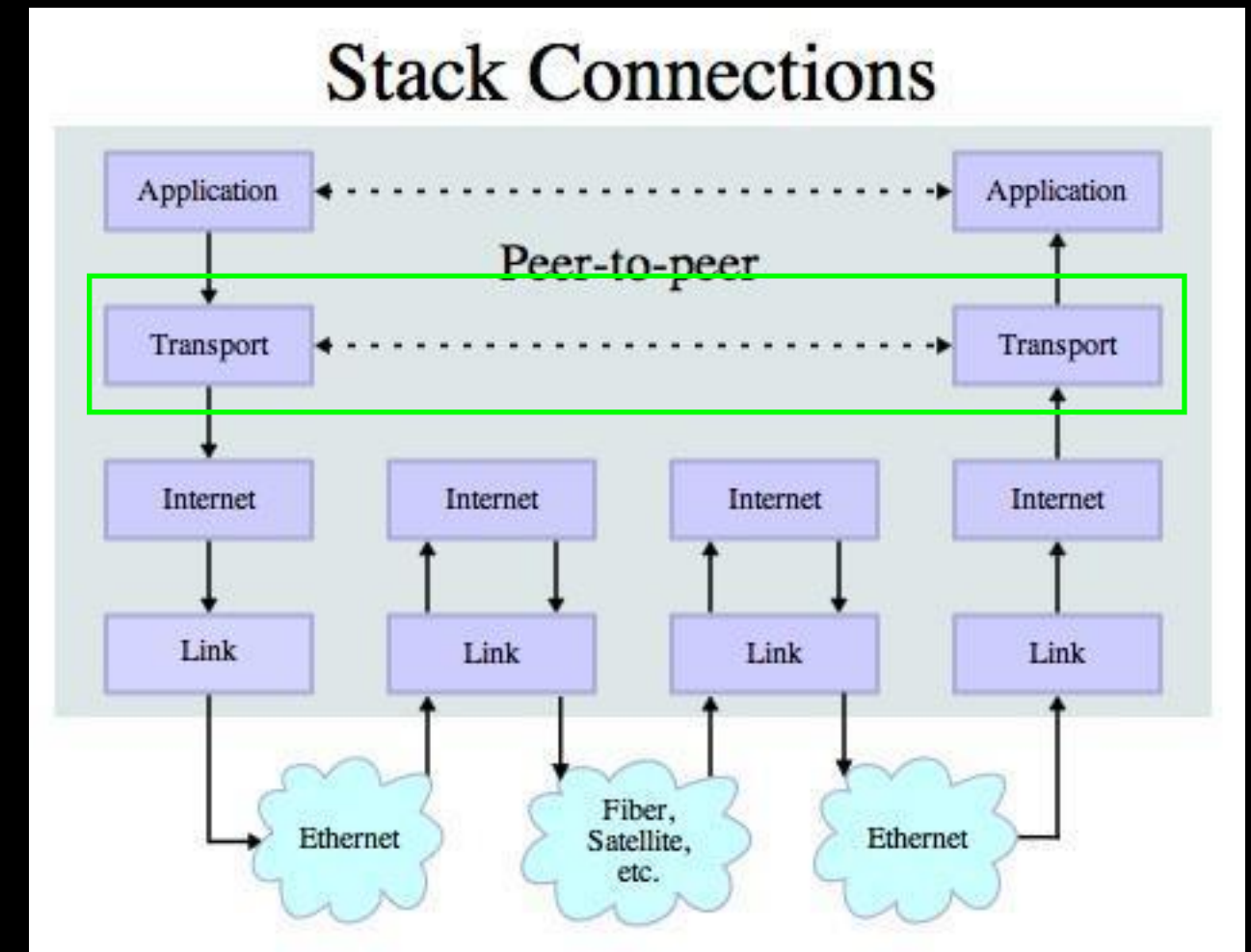
memcache

# Network Architecture....

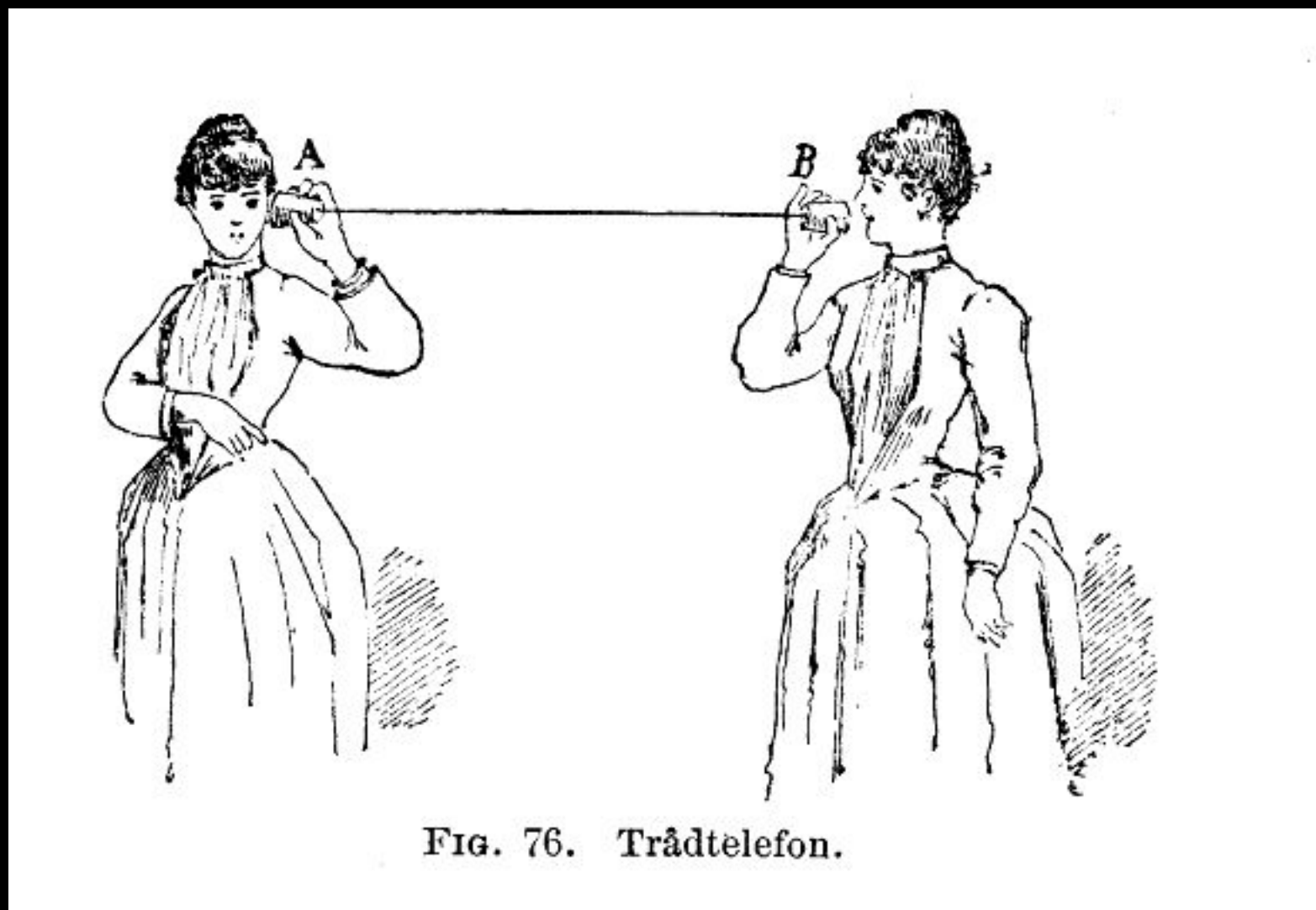


# Transport Control Protocol (TCP)

- 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](http://en.wikipedia.org/wiki/Internet_Protocol_Suite)

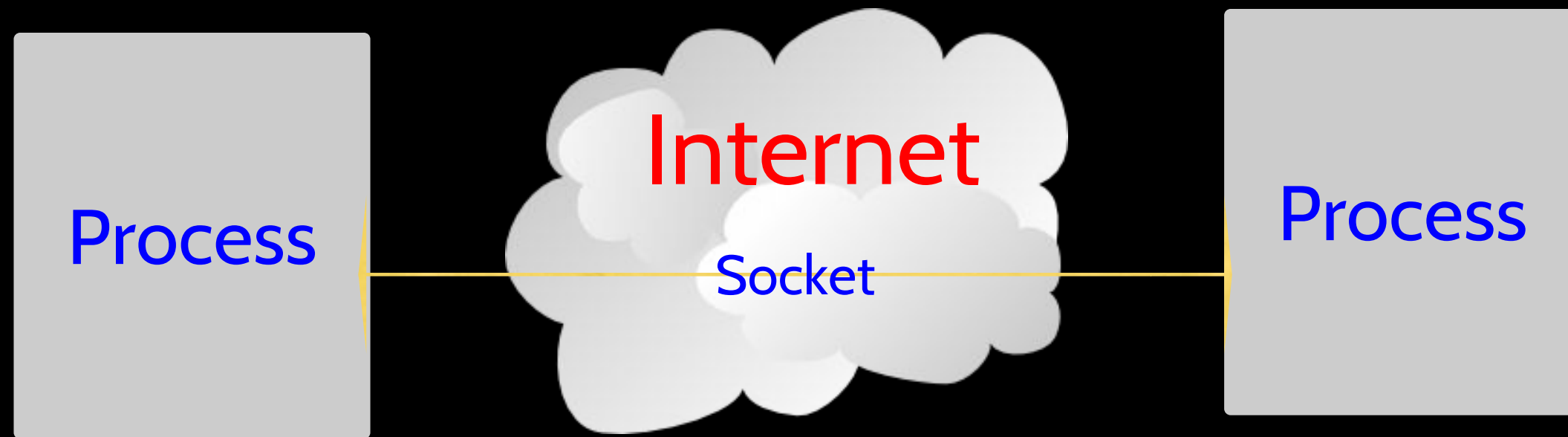


[http://en.wikipedia.org/wiki/Tin\\_can\\_telephone](http://en.wikipedia.org/wiki/Tin_can_telephone)

<http://www.flickr.com/photos/kitcowan/2103850699/>

# 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](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](http://en.wikipedia.org/wiki/TCP_and_UDP_port)



www.umich.edu

Incoming  
E-Mail

25

Login

23

Web Server

80

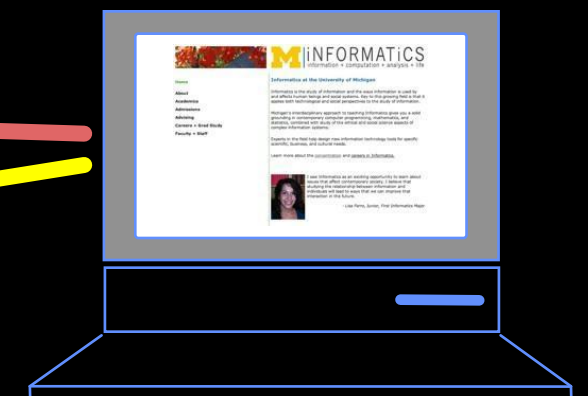
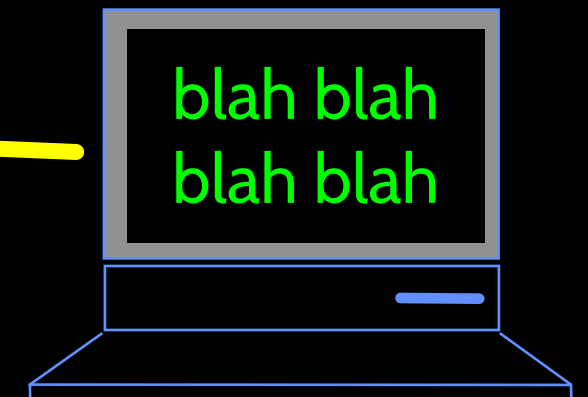
443

Personal  
Mail Box

109

110

74.208.28.177

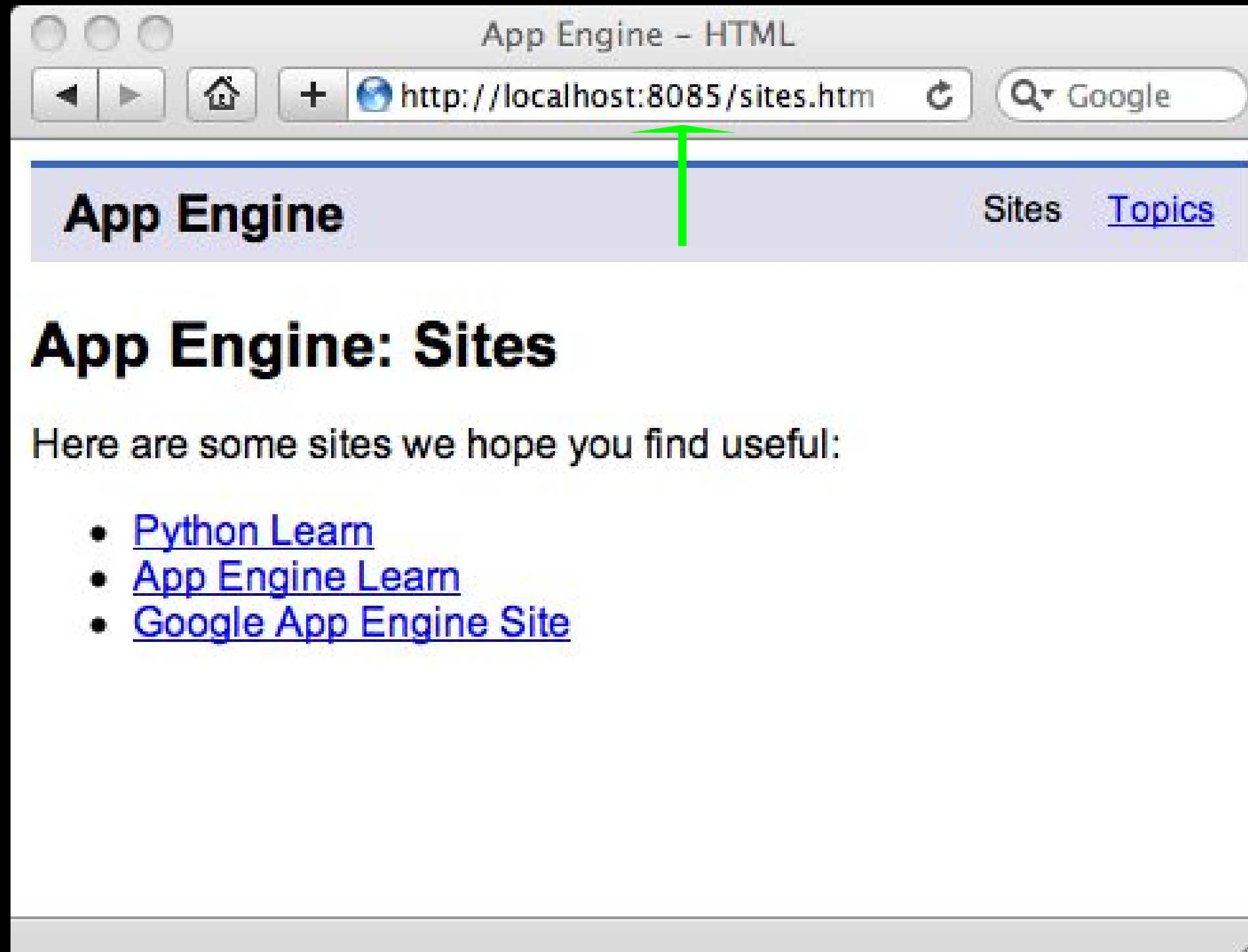


Please connect me to the  
web server (port 80) on  
<http://www.dr-chuck.com>

# 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](http://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers)



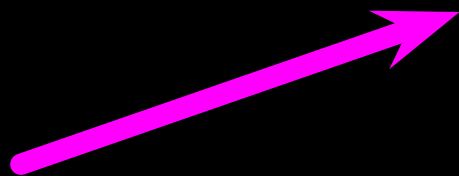
Sometimes we see the port number in the URL if the web server is running on a “non-standard” port.

# Sockets in Python

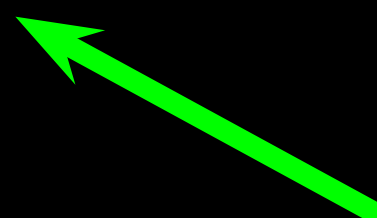
- Python has built-in support for TCP Sockets

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

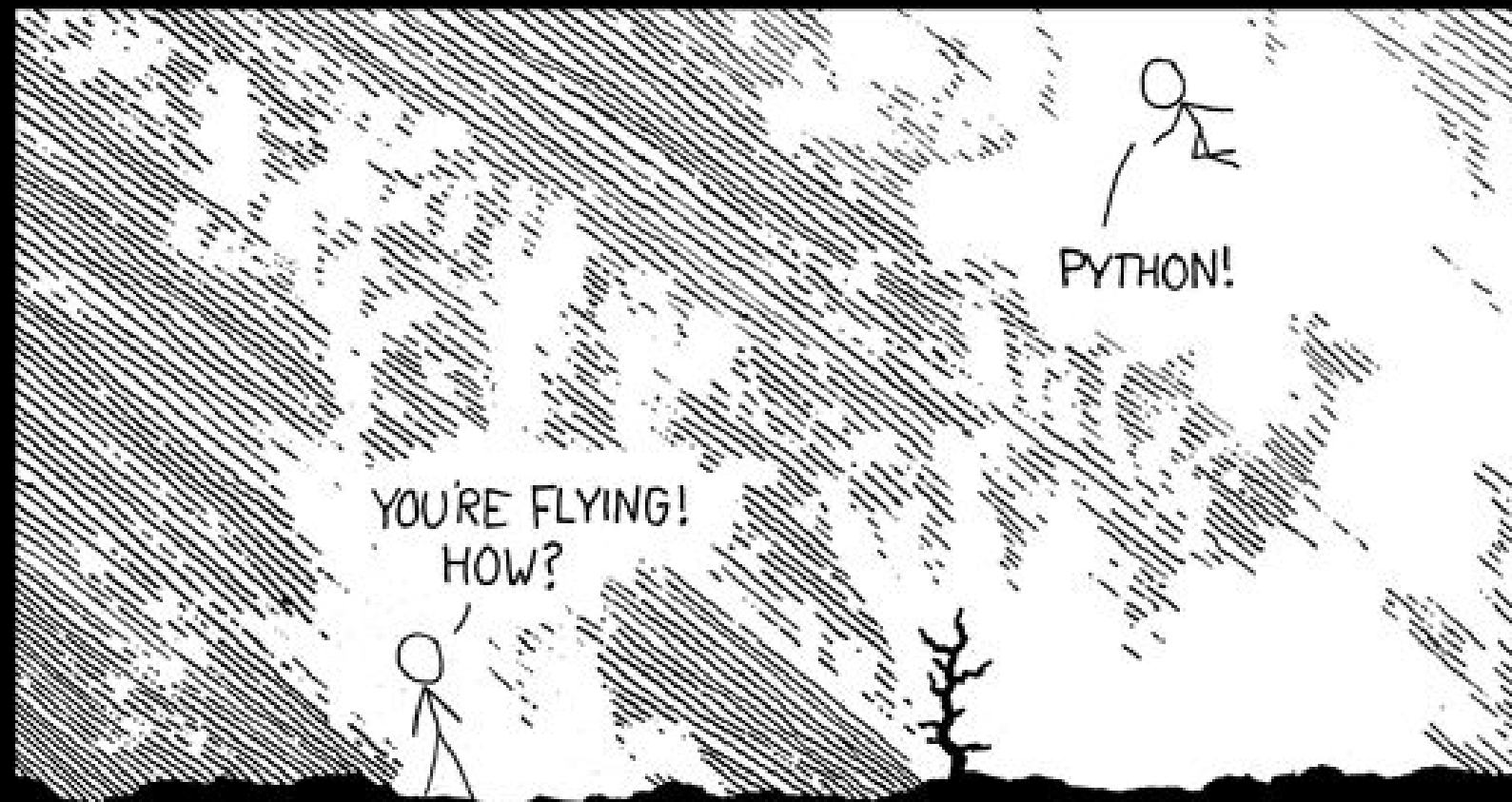
Host



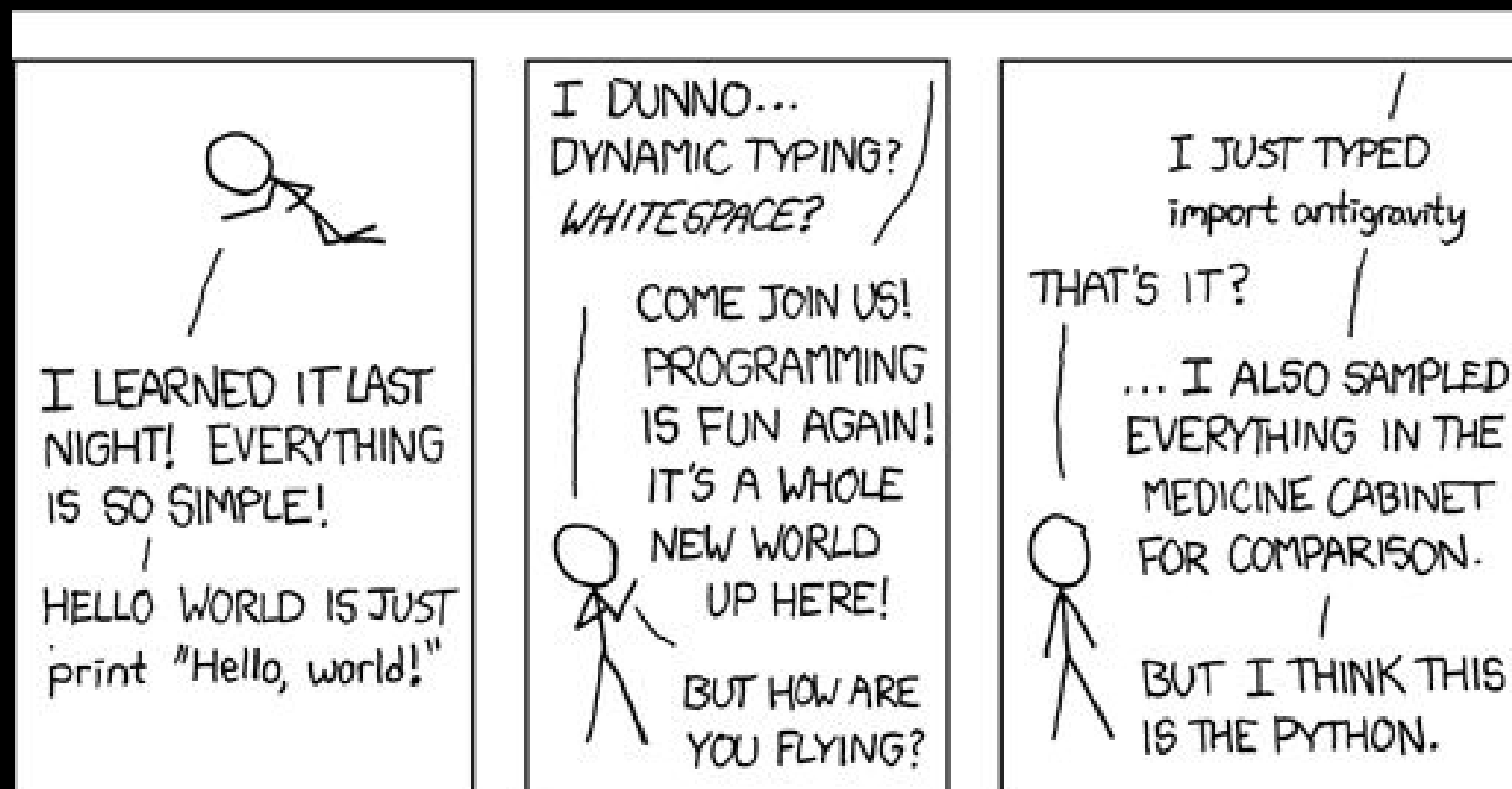
Port



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



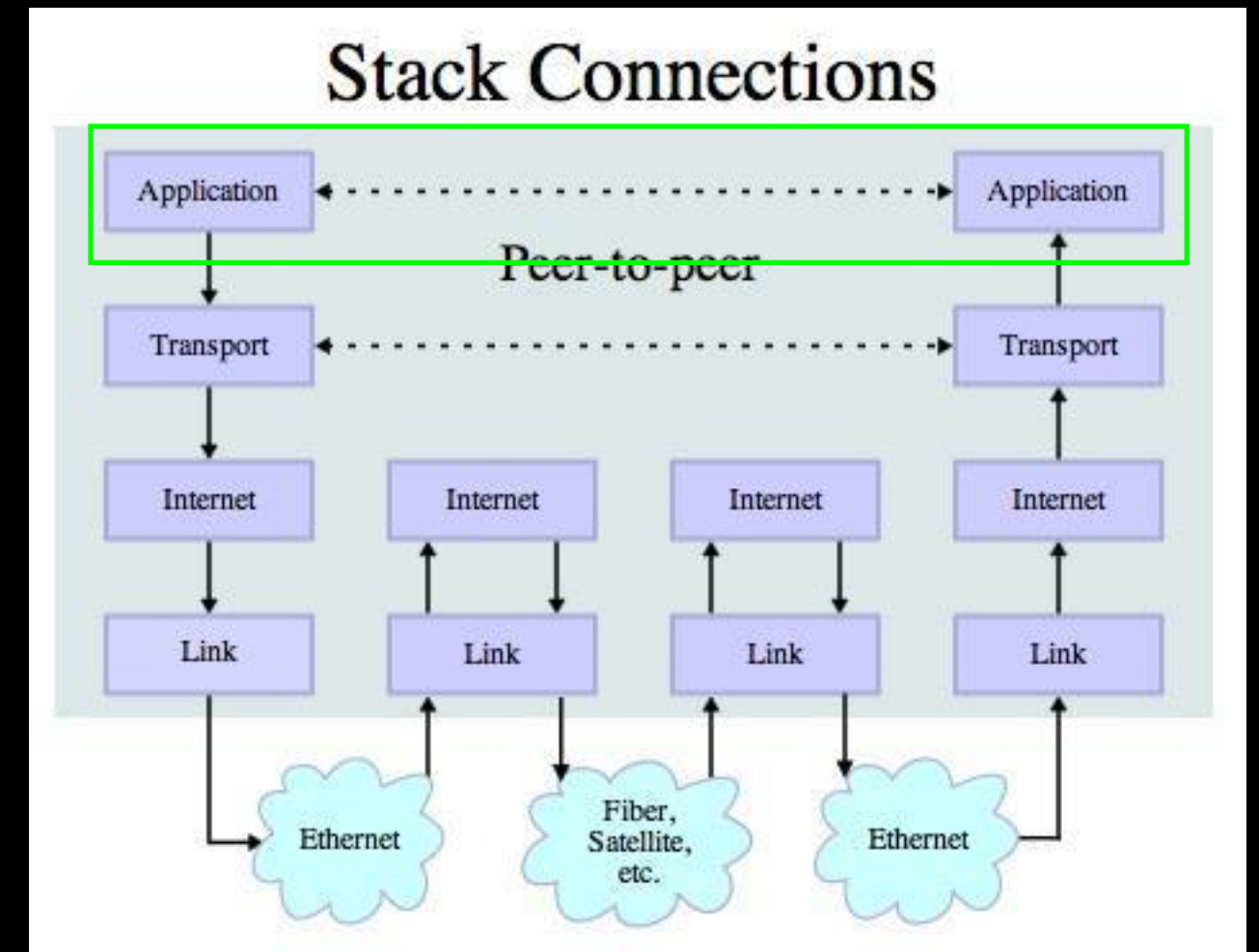
<http://xkcd.com/353/>





# 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://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 **H**yper**T**ext **T**ransport **P**rotocol 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=x2GylLq59rl>

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](http://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>



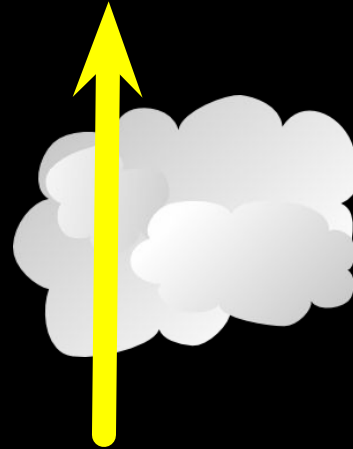


Browser



# Web Server

80



# Browser

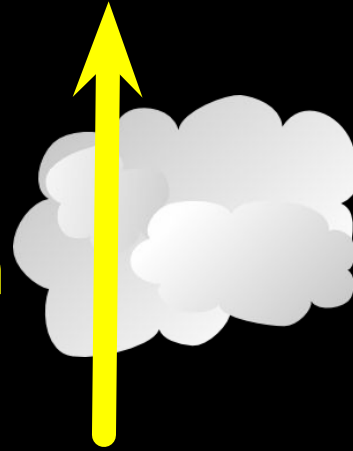




# Web Server

80

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

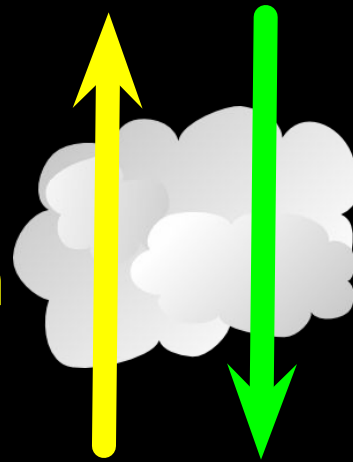


# Browser



# Web Server

80



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

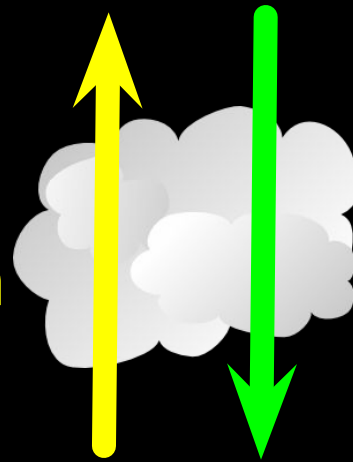
# Browser



```
<h1>The Second Page</h1>
<p>If you like, you can switch
back to the <a href='\"page1.
htm\">First Page</a>.</p>
```

# Web Server

80



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

```
<h1>The Second Page</h1>
<p>If you like, you can switch
back to the <a href='\"page1.
htm\">First Page</a>.</p>
```

# Browser



# 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](http://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

Copyright (C) The Internet Society (1999). All Rights Reserved.

### 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

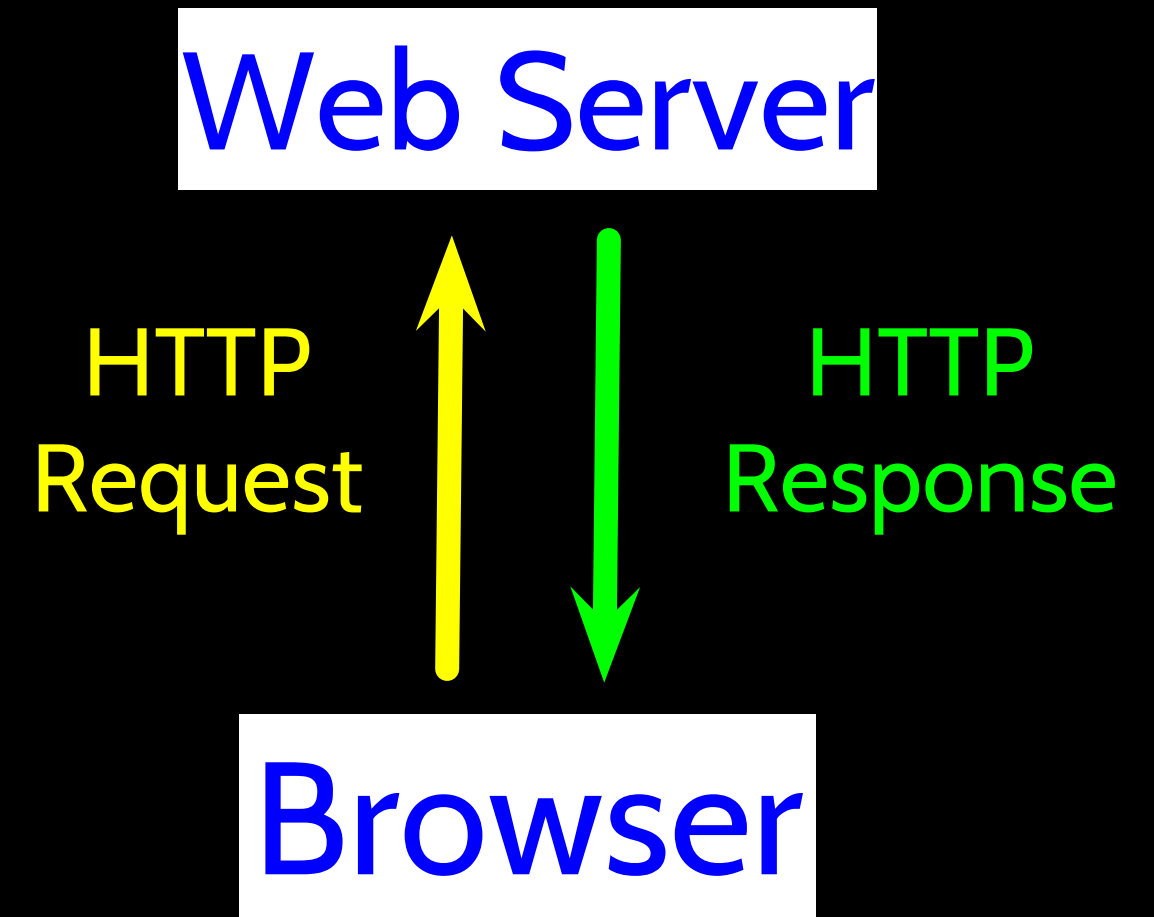
- Connect to the server like [www.dr-chuck.com](http://www.dr-chuck.com)
  - a “hand shake”
- Request a document (or the default document)
  - GET <http://www.dr-chuck.com/page1.htm>
  - GET <http://www.mlive.com/ann-arbor/>
  - GET <http://www.facebook.com>

# “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



# Accurate Hacking in the Movies

- Matrix Reloaded
- Bourne Ultimatum
- Die Hard 4
- ...



```
80/tcp    open      http
81/tcp    open      hosts2-ns
10.0.0.1  [mobile]
11 # nmap -v -sS -O 10.2.2.2
11
13 Starting nmap V. 2.54BETA25
13 Insufficient responses for TCP sequencing (3), OS detection
13 accurate
14 Interesting ports on 10.2.2.2:
44 (The 1539 ports scanned but not shown below are in state: closed)
51 Port      State      Service
51 22/tcp     open      ssh
58
68 No exact OS matches for host
68
24 Nmap run completed -- 1 IP address (1 host up) scanned
50 # sshnuke 10.2.2.2 -rootpw="210H0101"
Connecting to 10.2.2.2:ssh ... successful.
Re Attempting to exploit SSHv1 CRC32 ... successful.
IP Resetting root password to "210H0101".
System open: Access Level <9>
50 # ssh 10.2.2.2 -l root
root@10.2.2.2's password:
[RTF CONTROL]
ACCESS GRANTED
```

<http://nmap.org/movies.html>

```
$ 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.
```

**HOME**

**PROSPECTIVE STUDENTS**

**CURRENT STUDENTS**

**FACULTY & STAFF**

**ALUMNI, DONORS, & PARENTS**



About U-M

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Administration

Athletics & Recreation

Employment

Giving to U-M

Global Michigan

Health & Medical Resources

Libraries & Archives

Museums & Cultural Attractions

News & Events

Schools & Colleges

State & Community Partnerships

web 

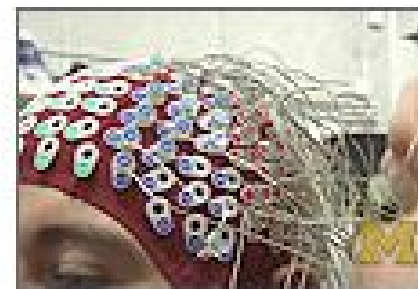
directory 

Search

enter keywords

GO

## IN THE NEWS::



Scientists harness the power of electricity in the brain



Friends with cognitive benefits: Mental function improves after socializing

⇒ Scary chupacabras monster is as much victim as villain

⇒ Video: Fashion, power and politics; Washington Post writer at U-M

## FEATURED SITES



THE  
THOMAS  
FRANCIS, JR.  
MEDAL IN  
GLOBAL  
PUBLIC  
HEALTH



**U-M SPEAKS OUT**



Exposing  
voter  
system  
flaws

*Give online* 



```
si-csev-mbp:tex csev$ telnet www.umich.edu 80
```

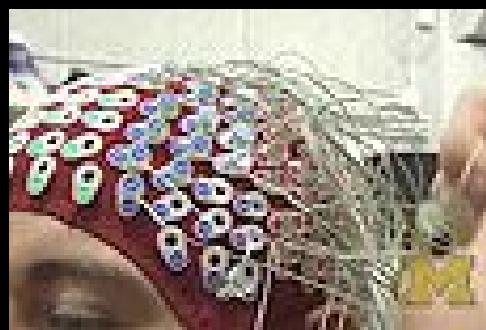
```
Trying 141.211.144.190...
```

```
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">
</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>
```



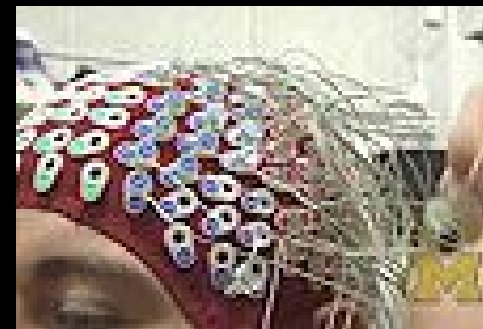
As the browser reads the document, it finds other URLs that must be retrieved to produce the document.

# 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:-876
em;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













# Python for Informatics: Introduction a...

- My previous job: Sakai / CTools Architect
- My research topics: Software For Teaching and Learning, Web Lecture technologies, and High Performance Computing
- I also work in developing standards for learning content interoperability
- Hobbies: Hockey, Off-Road Motorcycle Riding, Video



- 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									
[Red Circle] [No] [Filter] [List] [Preserve log] [Disable cache]									
Name	Method	Status	Type	Initiator	Size	Time	Timeline		
Path		Text			Content	Latency		1.00 s	1.50 s
 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			
22 requests   667 KB transferred									
Console Search Emulation Rendering									

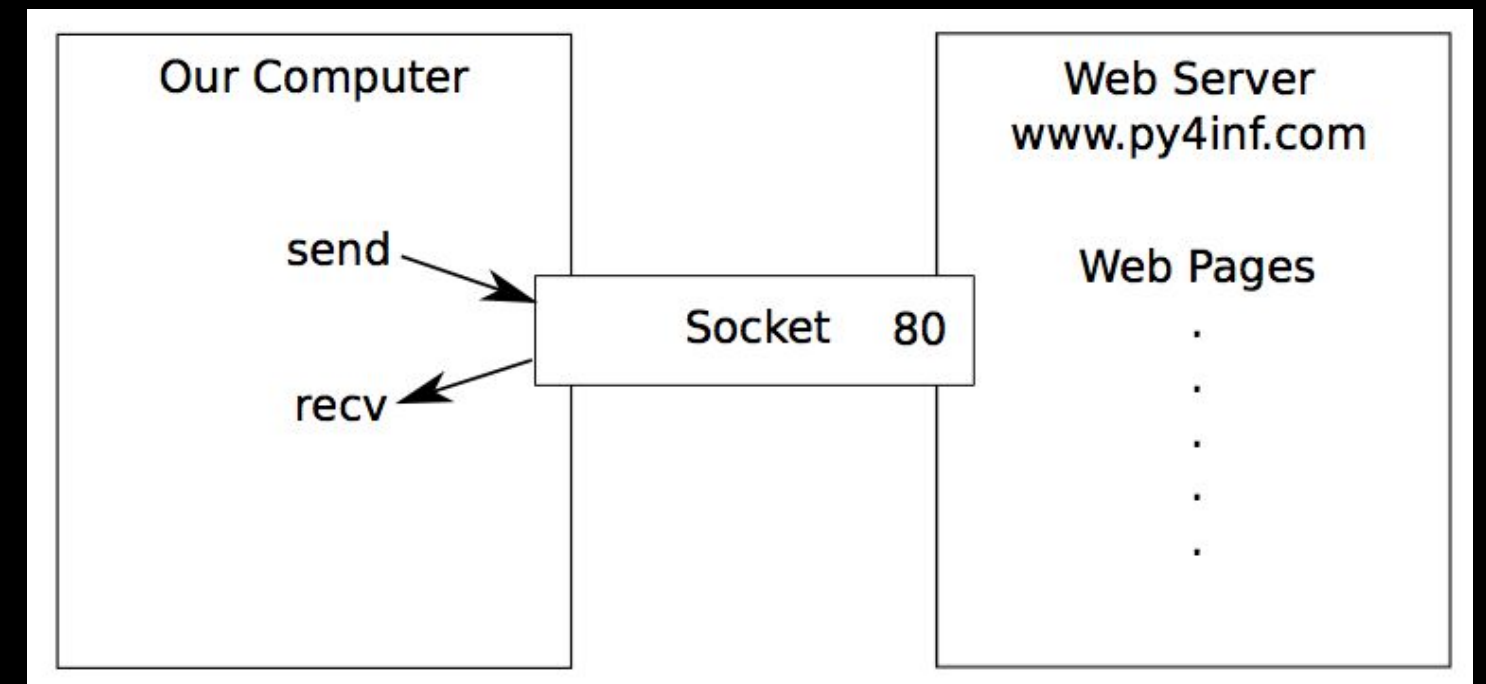
**Let's Write a Web Browser!**

# 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

# 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
```

# 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>
```

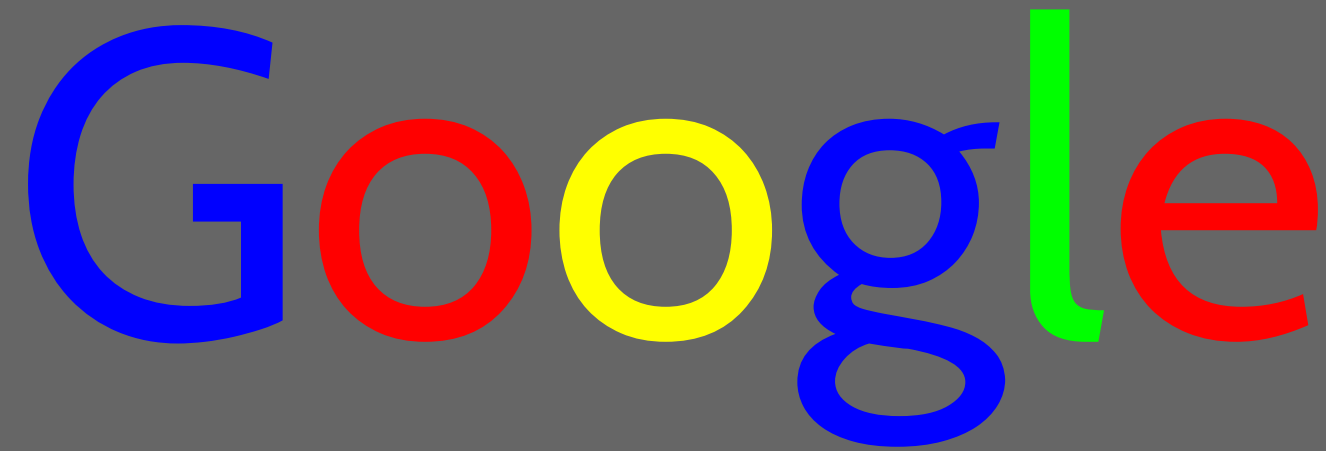
```
<p>
```

```
If you like, you can switch to the
```

```
<a href="http://www.dr-chuck.com/  
page2.htm">Second Page</a>.
```

```
</p>
```



The Google logo is displayed in its characteristic multi-colored font (blue 'G', red 'o', yellow 'o', blue 'g', green 'l', red 'e') centered within a solid gray rectangular box.

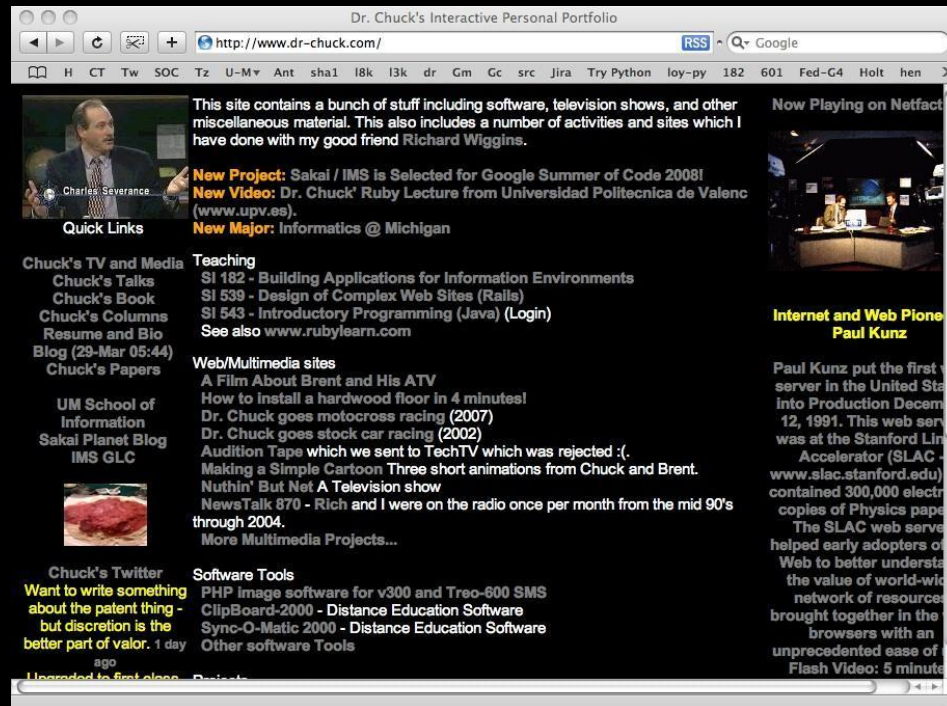
```
import urllib
fhand = urllib.urlopen('http://www.dr-chuck.com/page1.htm')
for line in fhand:
    print line.strip()
```

# **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_scraping)  
[http://en.wikipedia.org/wiki/Web\\_crawler](http://en.wikipedia.org/wiki/Web_crawler)



GET

HTML

GET

Server

```
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



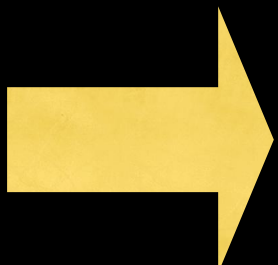
# <http://www.facebook.com/terms.php>

## User Conduct

You understand that except for advertising programs offered by us on the Site (e.g., Facebook Flyers, Facebook Marketplace), the Service and the Site are available for your personal, non-commercial use only. You represent, warrant and agree that no materials of any kind submitted through your account or otherwise posted, transmitted, or shared by you on or through the Service will violate or infringe upon the rights of any third party, including copyright, trademark, privacy, publicity or other personal or proprietary rights; or contain libelous, defamatory or otherwise unlawful material.

In addition, you agree not to use the Service or the Site to:

- harvest or collect email addresses or other contact information of other users from the Service or the Site by electronic or other means for the purposes of sending unsolicited emails or other unsolicited communications;
- use the Service or the Site in any unlawful manner or in any other manner that could damage, disable, overburden or impair the Site;
- use automated scripts to collect information from or otherwise interact with the Service or the Site;





# The Easy Way - BeautifulSoup

- You could do string searches the hard way
- Or use the free software called BeautifulSoup from [www.crummy.com](http://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)
```

```
<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>
```

```
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



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... Insert new Contributors here

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