(World Wide) Web

- **a way to connect computers that provide information (servers) with computers that ask for it (clients like you and me)**
  - uses the Internet, but it's not the same as the Internet
- **URL (uniform resource locator, e.g., http://www.amazon.com)**
  - a way to specify what information to find, and where
- **HTTP (hypertext transfer protocol)**
  - a way to request specific information from a server and get it back
- **HTML (hyptertext markup language)**
  - a language for describing information for display
- **browser (Firefox, Safari, Internet Explorer, Opera, Chrome, …)**
  - a program for making requests, and displaying results
- **embellishments**
  - pictures, sounds, movies, ...
  - loadable software
- **the set of everything this provides**

Web history

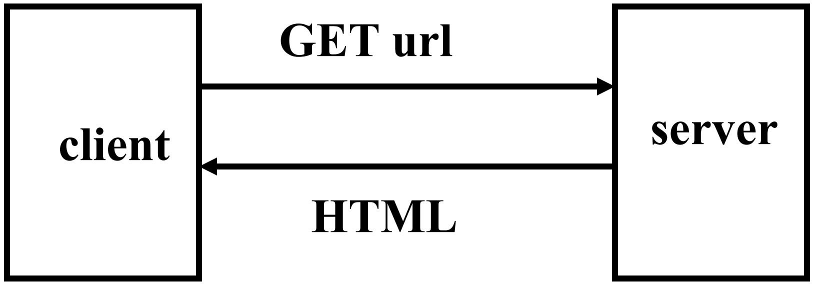
- **1989: Tim Berners-Lee at CERN**
  - a way to make physics literature and research results accessible on the Internet
- **1991: first software distributions**
- **Feb 1993: Mosaic browser**
  - Marc Andreessen at NCSA (Univ of Illinois)
- **Mar 1994: Netscape**
  - first commercial browser
- **technical evolution managed by World Wide Web Consortium**
  - non-profit organization at MIT, Berners-Lee is director
  - official definition of HTML and other web specifications
  - see **`www.w3.org`**

HTTP: Hypertext transfer protocol

- **What happens when you click on a URL?**
- **client opens TCP/IP connection to host, sends request**

```
    GET  /filename  HTTP/1.0
```

- **server returns**
  - **header info**
  - **HTML**



- **since server returns the text, it can be created as needed**
  - can contain encoded material of many different types (MIME)
- **URL format**

```
    service://hostname/filename?other_stuff
```

- ***filename?other_stuff* part can encode**
  - data values from client (forms)
  - request to run a program on server (cgi-bin)
  - anything else

Embellishments

- **original design of HTTP just returns text to be displayed**
- **now includes pictures, sound, video, ...**
  - need helpers or plug-ins to display non-text content
    - e.g., GIF, JPEG graphics; sound; movies
- **forms filled in by user**
  - need a program on the server to interpret the information (cgi-bin)
- **cookies to remember information on client**
  - HTTP is stateless: server doesn't saveanything from one request to next
  - cookies are a way to remember information at the client
- **active content: download code to run on the client**
  - Javascript
  - Java applets
  - plug-ins
  - ActiveX

Forms and CGI programs

- **"common gateway interface"**
  - standard way to request the server to run a program
  - using information provided by the client via a form

- **if the target file on server is an executable program**
- **and it has the right properties and permissions**
  - e.g., in /cgi-bin directory and executable
- **then run it on server to produce HTML to send back to client**
  - using the contents of the form as input
  - output depends on client request: created on the fly, not just a file

- **CGI programs can be written in any programming language**
  - Perl, Python, PHP, Java, Ruby, …

Cookies

- **HTTP is <u>stateless</u>: doesn't remember from one request to next**
- **cookies intended to deal with stateless nature of HTTP**
  - remember preferences, manage "shopping cart", etc.
- **cookie: one chunk of text sent by server to be stored on client**
  - stored in browser while it is running (transient)
  - stored in client file system when browser terminates (persistent)
- **when client reconnects to same domain,**
  browser sends the cookie back to the server
  - sent back verbatim; nothing added
  - sent back only to the same domain that sent it originally
  - contains no information that didn't originate with the server

- **in principle, pretty benign**
- **but heavily used to monitor browsing habits, for commercial purposes**

Cookie crumbs

- **fetch a page from xyz.com**
  - it contains <img src=http://doubleclick.com/advt.gif>
  - this causes a page to be fetched from DoubleClick.com
  - which now knows your IP address and what page you were looking at

- **DoubleClick sends back a suitable advertisement**
  - with a cookie that identifies "you" at DoubleClick

- **next time you fetch any page that contains a DoubleClick.com image**
  - the last DoubleClick cookie is sent back to DoubleClick
  - the set of sites and images that you are viewing is used to
    - update the record of where you have been and what you have looked at
    - send back targeted advertising (and a new cookie)

Advertising marketplace

- **advertising exchanges**
  - Yahoo Right Media, Doubleclick Ad Exchange, Facebook Atlas ...
- **a person uses a browser to request a web page**
- **web page "publisher" notifies exchange that advertising space on that page is available**
  - publishers are typically portals or entertainment and news sites
  - publisher provides information about the person: past online activity, viewing and shopping habits, geographic location, demographics

    probably not actual identity (?)
- **advertisers bid on the ad space**
  - amount depends on person's attributes and location, advertiser's budget, etc.
- **winner's advertisement is inserted into the page**
- **elapsed time: 10-100 milliseconds**

- **this happens for multiple advertisements on one page**

Cookies are not the only tracking mechanism

- **web bugs, web beacons, single-pixel gifs**
  - tiny images that report the use of a particular page
  - these can be used in mail messages, not just browsers
- **Flash cookies ("local shared object")**
  - cookie-like mechanism used by Flash
- **"super cookies"**
  - e.g., Verizon's X-UIDH HTTP header on cellphones
- **HTML canvas fingerprinting**
  - uses subtle differences in browser behavior to distinguish users

- **defenses:**

  addons like AdBlock, FlashBlock, Cookie Monster, Ghostery, NoScript

Plug-ins, add-ons, extensions, etc.

- **programs that extend capabilities of browser, mailer, etc.**
  - browser provides API, protocol for data exchange
  - extension focuses on specific application area

    e.g., documents, pictures, sound, movies, scripting language, ...
  - may exist standalone as well as in plug-in form
  - e.g., Acrobat Reader, Flash, Quicktime, Windows Media Player, ...

- **scripting languages interpret downloaded programs**
  - Javascript
  - Java

    compiled into instructions for a virtual machine

    (like the Toy machine on steroids)

    instructions are interpreted by virtual machine in browser

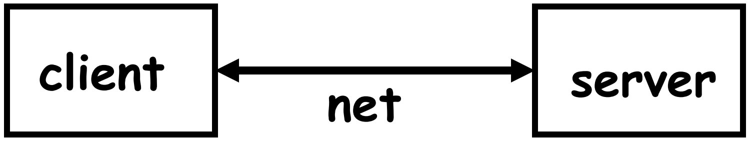
ActiveX (Microsoft)

- **write programs in any language (C, C++, Visual Basic, ...)**
- **compile into machine instructions for PC**
- **when a web page that uses an ActiveX object is accessed with Internet Explorer**
  - Internet Explorer downloads compiled native machine instructions
  - checks that they are properly signed ("authenticated") by creator
  - runs them

- **each ActiveX object comes with digital certificate from supplier**
  - can't be forged
  - run the program if you trust the supplier
- **more efficient than an interpreter**
- **no restrictions on what an ActiveX object can do**
  - no assurance that it works properly!

- **the most risky of the active-content models (but Microsoft only)**

Potential security & privacy problems



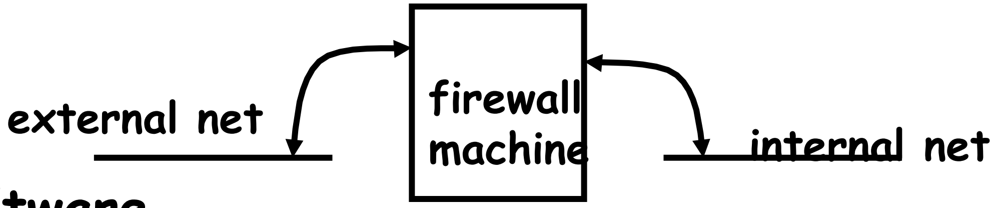
- **attacks against client**
  - release of client information
    - cookies: client remembers info for subsequent visits to same server
  - adware, phishing, spyware, viruses, ...
    - spyware: client sends info to server upon connection (Sony, …)
    - often from unwise downloading
  - buggy/misconfigured browsers, etc., permit vandalism, theft, hijacking, ...
- **attacks against server**
  - client asks server to run a programs when using cgi-bin
    - server-side programming has to be careful
  - buggy code on server permits break-in, theft, vandalism, hijacking, …
  - denial of service attacks
- **attacks against information in transit**
  - eavesdropping
    - encryption helps
  - masquerading
    - needs authentication in both directions

Privacy on the Web

- **what does a browser send with a web request?**
  - IP address, browser type, operating system type
  - referrer (URL of the page you were on)
  - cookies
- **what do "they" know about you?**
  - whatever you tell them, implicitly or explicitly (e.g., Facebook)
  - public records are really public
  - lots of big databases like phone books
  - log files everywhere
  - aggregators collect a lot of information for advertising
  - spyware, key loggers and similar tools collect for nefarious purposes
  - government spying is everywhere
- **who owns your information?**
  - in the USA, they do
  - less so in the EU

Defenses

- **use strong passwords; don't share across important accounts**
- **cookies off, spam filter on, Javascript limited**
- **turn off previewers and HTML mail readers**
- **anti-virus software on and up to date**
  - turn on macro virus protection in Word, etc.; turn off ActiveX
- **run spyware detectors**
- **use a firewall**
- **try less-often targeted software**
- **be careful and suspicious all the time**
  - don't view attachments from strangers
  - don't view unexpected attachments from friends
  - don't just read/accept/click/install when requested
  - don't install file-sharing programs
  - be wary when downloading any software


external net
firewall
machine
internal net