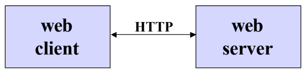
Lecture 7

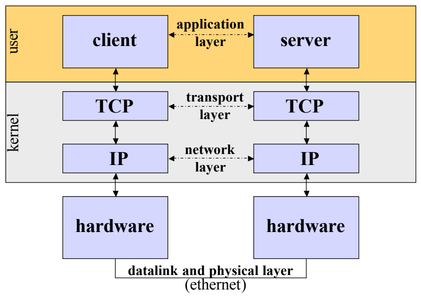
Networking, HTTP, CGI

Network Application

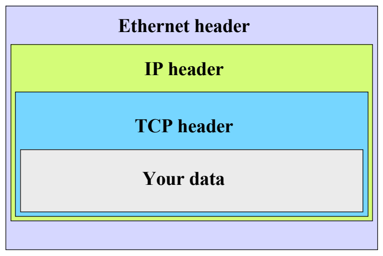
- Client application and server application communicate via a network protocol
- A protocol is a set of rules on how the client and server communicate



Internet Protocol Suite



Network Packet



TCP/IP

- TCP and IP were developed as a standard networking protocol to connect a diverse set of networks
- Two layers:
  - **IP** – determines routing of packets of data from sender to receiver. Uses 32-bit addresses (e.g. 128.122.20.15)
  - **TCP** – connection-oriented protocol for reliable delivery of data. Acknowledgements, sequencing, retransmission, timeouts

Ports

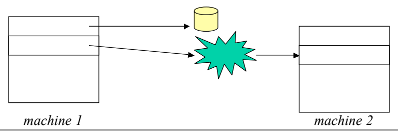
- With TCP/IP, each machine has a number of *ports* that can be contacted from a client.
- A machine has to serve a port by listening for connections to it.
- Ports for popular services are fixed:
  - ssh: 22, telnet: 23, www: 80
  - 1-1023 are reserved (well-known)
  - 1024-49151 are user level
  - 49152-65535 are private to the machine
- Clients use *ephemeral* ports

Naming

- In addition to addresses, nodes on the network can have associated names
- Names are translated into addresses by a server called a *nameserver*
- Local name address mappings stored in **`/etc/hosts`**

Sockets

- Sockets provide access to TCP/IP on UNIX systems
- Invented in Berkeley UNIX
- Allows a network connection to be opened as a file (**returns a file descriptor**)



Major Network Services

- Telnet
  - Provides a virtual terminal for a remote user
  - Port 23
  - **telnet** program can be used to connect to other ports
- FTP: File Transfer Protocol
  - A service that allows files to be transferred from one machine to another.
  - Uses port 20 for data, 21 for control
- SSH
  - Like telnet but encrypts data. Port 22

Major Network Services (cont.)

- SMTP
  - Host-to-host mail transport
  - Port 25
- IMAP
  - Email access
  - Port 143 (993 for SSL)
- HTTP
  - "… protocol for distributed, collaborative, hypermedia information systems"
  - Port 80

Ksh93: /dev/tcp

- Files in the form **`/dev/tcp/hostname/port`** result in a socket connection to the given service:

```
exec 3<>/dev/tcp/smtp.cs.nyu.edu/25 #SMTP
print -u3 "EHLO cs.nyu.edu"
print -u3 "QUIT"
while IFS= read -u3
do
        print -r "$REPLY"
done
```

HTTP

- The Hyper Text Transfer Protocol: Port 80
- Language used to communicate between browsers (IE, Mozilla) and web servers (Apache, IIS)
- Browsers make **requests**:
  - Request a URL
  - Also includes info such as the browser type, formats accepted, etc.
- Web servers reply with two parts
  - Header information describing the data
  - The actual data (e.g. HTML document)

```
GET /index.html HTTP/1.0
Connection: Keep-Alive
User-Agent: Mozilla/5.0 (Linux i686)
Host: www.cs.nyu.edu
Accept: image/gif, image/x-bitmap,
image/jpeg, */*
```

request

```
HTTP/1.0 200 Document follows
Date: Tue, 05 Nov 2002 12:03:23 EST
Server: Apache 1.1
Last-modified: Mon, 04 Nov 2002 03:34:43
EST
Content-type: text/html
Content-length: 2493

<H1> This is a test </H1>
```

response

Sample HTTP session

```
% telnet www.cs.nyu.edu 80
Trying 128.122.81.68...
Connected to cs.nyu.edu.
Escape character is '^]'.
GET / HTTP/1.1
Host: www.cs.nyu.edu

HTTP/1.1 200 OK
Date: Tue, 19 Oct 2004 05:12:27 GMT
Server: Apache/2.0.49 (Unix) mod_perl/1.99_14 …
Last-Modified: Thu, 12 Sep 2002 17:09:03 GMT
…
Content-Type: text/html; charset=ISO-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML//EN">
<html>
<head>
<title></title>
<meta HTTP-EQUIV="Refresh" CONTENT="0; URL=csweb/index.html">
<body>
</body>
</html>
```

URLs

- Uniform Resource Locator

```
http://www.cs.nyu.edu:80/courses/fall04/G22.2245-001/index.html
```

protocol *host* *port* *resource*

Connect to port 80 on machine ***`www.cs.nyu.edu`***

GET *`/courses/fall02/G22.2245-001/index.htm`*

HTML

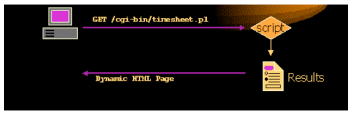
- **H**yper-**T**ext **M**arkup **L**anguage
- A text document with formatting information
  - Tags are embedded in the text
  - Common tags: `<P>`, `<B>`...`</B>`, `<UL>`, `<PRE>`, `<H1>`
- Browsers turn HTML into visual presentation

HTML

- HTML is a file format that describes a web page.
- These files can be made by hand, or generated by a program
- A good way to generate an HTML file is by writing a shell script

CGI Overview

- Web servers allow HTML documents to be generated on the fly through the **CGI** standard.
- A request is made for a web page, your program is called by the web server to generate the HTML, the HTML is rendered in the browser
  - Your program outputs HTML to standard output
- There are ways to get input to your script
  - Through standard input and/or environment variables

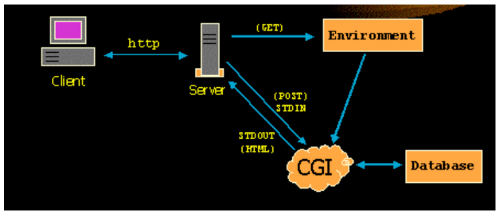


HTML Forms

- An HTML form provides a way to collect user input
  - Text Areas
  - Buttons
  - Menus
  - Checkboxes
- Browser send data via HTTP request
- Invokes a URL of a CGI script to process data when submitted

Forms and CGI

- HTTP defines how form variables are sent to the web server
- Two methods:
  - GET
    - Form variables encoded into an environment variable
  - POST
    - Form variables encoded into standard input as the content of the HTTP request



Sending form variables

- Browser sends form variables as name-value pairs:
  `name1=value1&name2=value2&name3=value3`
- Names are defined in form elements
  `<INPUT TYPE="checkbox" NAME="send_payment" Value="yes">`
- Values are specified by user
  - Encoded into special format: special characters replaced with %## (2-digit hex number), spaces replaced with +
    - Avoids parsing problems
    - e.g. "`10/20 Wed`" encoded as "`10%2F20+Wed`"

Submitting forms

- POST

```
POST /cgi-bin/sample.cgi HTTP/1.1
Host: www.cs.nyu.edu
Content-Length: 50
Content-Type: application/x-www-form-urlencoded

name1=value1&name2=value2
```

- GET

```
GET /cgi-bin/sample.cgi?name1=value1&name2=value2 HTTP/1.1
Host: www.cs.nyu.edu
```

Reading form inputs

- Forms specify whether to use GET or POST style HTTP request

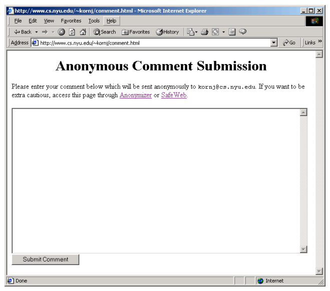
```
<FORM ACTION="/cgi-bin/sample.cgi METHOD=POST>
…
</FORM>
```

- GET: input encoded into **QUERY_STRING**
- POST: standard input (body of the request)
- Most scripts parse the input into an associative array
  - You can parse these yourself
  - But most people use libraries for this

CGI Environment Variables

- DOCUMENT_ROOT
- HTTP_HOST
- HTTP_REFERER
- HTTP_USER_AGENT
- HTTP_COOKIE
- REMOTE_ADDR
- REMOTE_HOST
- REMOTE_USER
- REQUEST_METHOD
- SERVER_NAME
- SERVER_PORT

CGI Script: Example


http://www.cs.nyu.edu/~kornj/comment.html - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://www.cs.nyu.edu/~kornj/comment.html
Go Links
Submit Comment
Done
Internet

Anonymous Comment Submission

Please enter your comment below which will be sent anonymously to `kornj@cs.nyu.edu`. If you want to be extra cautious, access this page through Anonymizer or SafeWeb.

Part 1: HTML Form

```
<html>
<center>
<H1>Anonymous Comment Submission</H1>
</center>
Please enter your comment below which will
be sent anonymously to <tt>kornj@cs.nyu.edu</tt>.
If you want to be extra cautious, access this
page through <a
href="http://www.anonymizer.com">Anonymizer</a>.
<p>
<form action=cgi-bin/comment.cgi method=post>
<textarea name=comment rows=20 cols=80>
</textarea>
<input type=submit value="Submit Comment">
</form>
</html>
```

Part 2: CGI Script (ksh)

```
#!/home/unixtool/bin/ksh

. cgi-lib.ksh  # Read special functions to help parse
ReadParse
PrintHeader

print -r -- "${Cgi.comment}" | /bin/mailx -s "COMMENT" kornj

print "<H2>You submitted the comment</H2>"
print "<pre>"
print -r -- "${Cgi.comment}"
print "</pre>"
```

Debugging

- Debugging can be tricky, since error messages don't always print well as HTML
- One method: run interactively

```
$ QUERY_STRING='birthday=10/15/03'
$ ./birthday.cgi
Content-type: text/html

<html>
Your birthday is <tt>10/15/02</tt>.
</html>
```

How to get your script run

- This can vary by web server type
  http://www.cims.nyu.edu/systems/resources/webhosting/index.html
- Typically, you give your script a name that ends with **.cgi**
- Give the script execute permission
- Specify the location of that script in the URL

CGI Security Risks

- Often CGI scripts are run as the author
  - setuid
- Be careful of security holes
- Never trust the input
- Clean up (don't leave sensitive data around)

CGI Benefits

- Simple
- Language independent
- UNIX tools are good for this because
  - Work well with text
  - Integrate programs well
  - Easy to prototype
  - No compilation (CGI scripts)

Example: Dump Some Info

```
#!/home/unixtool/bin/ksh

. ./cgi-lib.ksh
PrintHeader
ReadParse

print "<h1> Date </h1>"
print "<pre>"
date
print "</pre>"

print "<h1> Form Variables </h1>"
print "<pre>"
set -s -- ${!Cgi.*}
for var
do
        nameref r=$var
        print "${var#Cgi.} = $r"
        unset r
done
print "</pre>"

print "<h1> Environment </h1>"
print "<pre>"
env | sort
print "</pre>"
```

Example: Find words in Dictionary

```
<form action=dict.cgi>
Regular expression: <input type=entry
name=re value=".*">
<input type=submit>
</form>
```

Example: Find words in Dictionary

```
#!/home/unixtool/bin/ksh

PATH=$PATH:.
. cgi-lib.ksh
ReadParse
PrintHeader

print "<H1> Words matching <tt>${Cgi.re}</tt> in the dictionary
</H1>\n";
print "<OL>"
grep "${Cgi.re}" /usr/dict/words | while read word
do
        print "<LI> $word"
done
print "</OL>"
```