# Lecture 7

Part I
Shell Scripting (continued)

## Parsing and Quoting

## Shell Quoting

- Quoting causes characters to loose special meaning.
- `\`    Unless quoted, `\` causes next character to be quoted. In front of new-line causes lines to be joined.
- `'…'`        Literal quotes. Cannot contain `'`
- `"…"`        Removes special meaning of all characters except **`$`**, `"`, `\` and `` ` ``. The `\` is only special before one of these characters and new-line.

## Simple Commands

- A simple command consists of three types of tokens:
  - Assignments (must come first)
  - Command word tokens
  - Redirections: *redirection-op* + *word-op*
  - The first token must not be a reserved word
  - Command terminated by new-line or `;`
- Example:

  -
    ```
    foo=bar z=`date`
    echo $HOME
    x=foobar > q$$ $xyz z=3
    ```

## Word Splitting

- **After parameter expansion**, **command substitution**, and arithmetic expansion, the characters that are generated as a result of these expansions that are not inside double quotes are checked for split characters
- Default split character is *space* or *tab*
- Split characters are defined by the value of the **`IFS`** variable (**`IFS=""`** disables)

## Word Splitting Examples

```
FILES="file1 file2"
cat $FILES
a
b

IFS=
cat $FILES
cat: file1 file2: cannot open
```

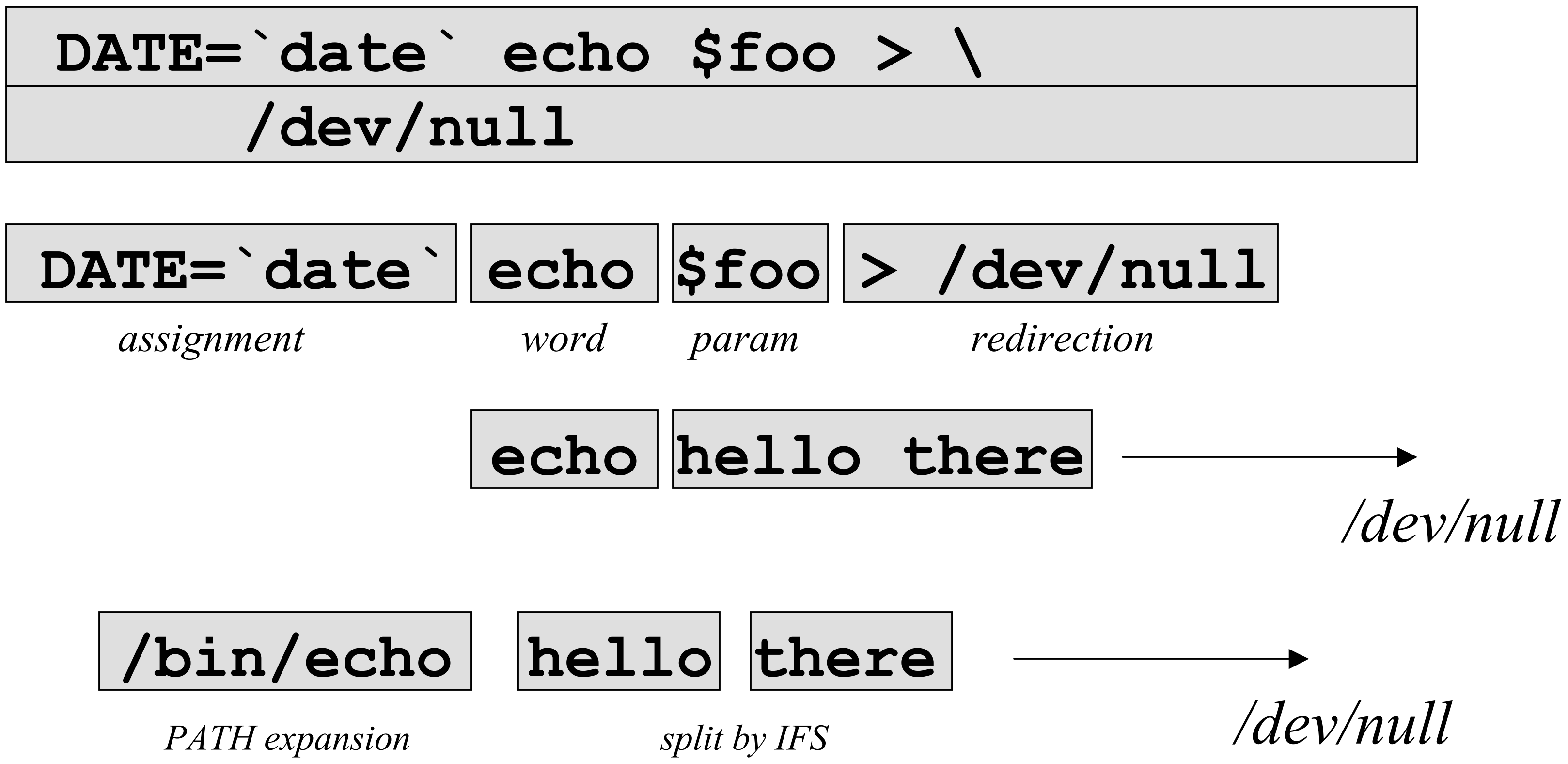
---

```
IFS=x v=exit
echo exit $v "$v"
exit e it exit
```

## Pathname Expansion

- **After** word splitting, each field that contains pattern characters is replaced by the pathnames that match
- Quoting prevents expansion
- **`set -o noglob`** disables
  - Not in original Bourne shell, but in POSIX

# Parsing Example



```
DATE=`date` echo $foo > \
      /dev/null
```

```
DATE=`date`   echo   $foo   > /dev/null
```

```
echo   hello there
```

```
/bin/echo   hello   there
```

## The eval built-in

- **`eval`** ***`arg`*** …
  - Causes all the tokenizing and expansions to be performed again

## trap command

- **trap** specifies command that should be **eval**ed when the shell receives a signal of a particular value.
- **`trap [ [`***`command`***`] {`***`signal`***`}+]`**
  - If ***command*** is omitted, signals are ignored
- Especially useful for cleaning up temporary files

```
trap 'echo "please, dont interrupt!"' SIGINT

trap 'rm /tmp/tmpfile' EXIT
```

## Reading Lines

- **read** is used to read a line from a file and to store the result into shell variables
  - **read –r** prevents special processing
  - Uses **IFS** to split into words
  - If no variable specified, uses **REPLY**

```
read
read –r NAME
read FIRSTNAME LASTNAME
```

## Script Examples

- Rename files to lower case
- Strip CR from files
- Emit HTML for directory contents

## Rename files

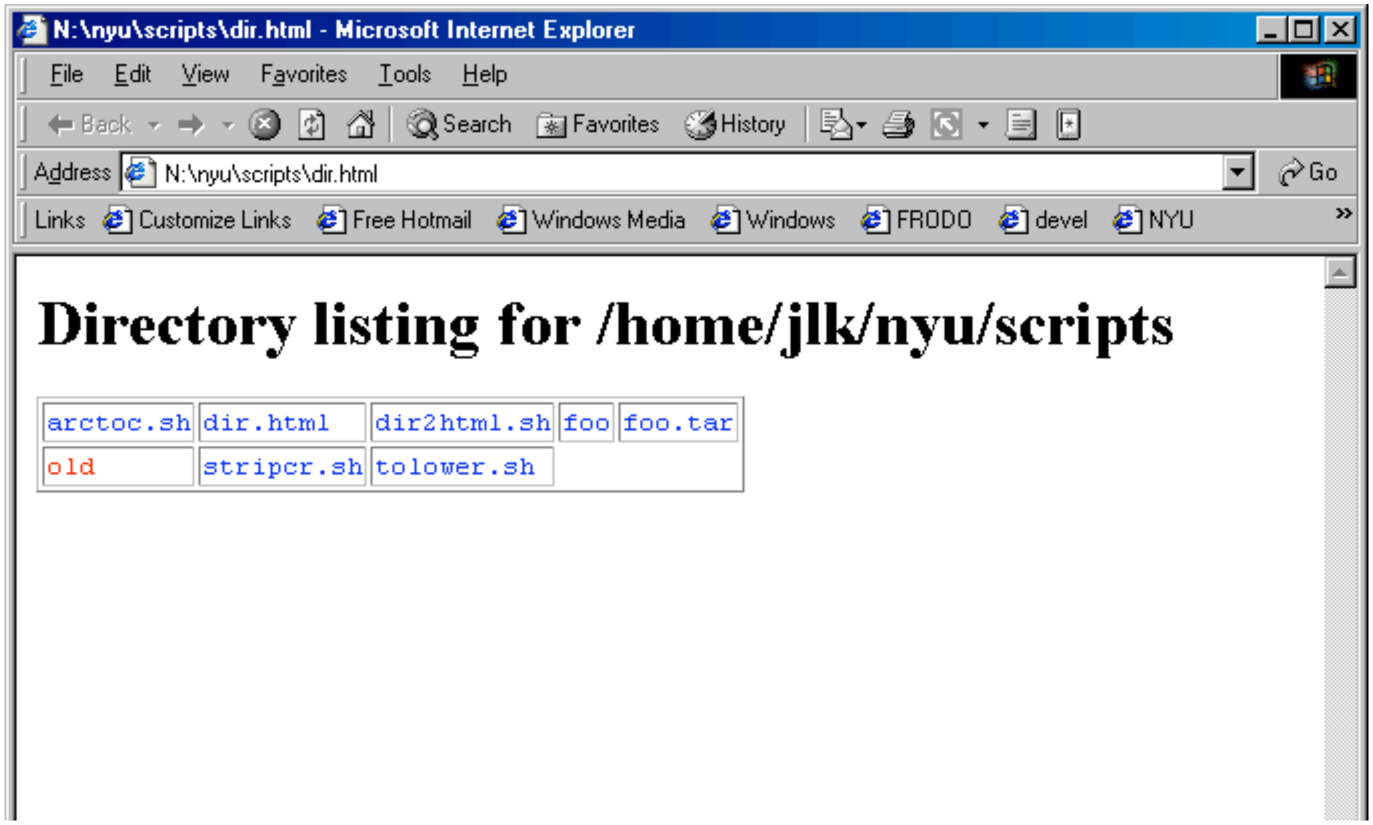
```
#!/bin/sh

for file in *
do
        lfile=`echo $file | tr A-Z a-z`
        if [ $file != $lfile ]
        then
                mv $file $lfile
        fi
done
```

## Remove DOS Carriage Returns

```
#!/bin/sh

TMPFILE=/tmp/file$$

if [ "$1" = "" ]
then
        tr -d '\r'
        exit 0
fi

trap 'rm -f $TMPFILE' 1 2 3 6 15

for file in "$@"
do
        if tr -d '\r' < $file > $TMPFILE
        then
                mv $TMPFILE $file
        fi
done
```

## Generate HTML

```
$ dir2html.sh > dir.html
```


N:\nyu\scripts\dir.html - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address N:\nyu\scripts\dir.html Go
Links Customize Links Free Hotmail Windows Media Windows FRODO devel NYU

### Directory listing for /home/jlk/nyu/scripts

| | | | | |
|---|---|---|---|---|
| arctoc.sh | dir.html | dir2html.sh | foo | foo.tar |
| old | stripcr.sh | tolower.sh | | |

## The Script

```
#!/bin/sh

[ "$1" != "" ] && cd "$1"

cat <<HUP
 <html>
 <h1> Directory listing for $PWD </h1>
 <table border=1>
 <tr>
HUP
num=0
for file in *
do
    genhtml $file    # this function is on next
page
done
cat <<HUP
 </tr>
 </table>
 </html>
HUP
```

## Function genhtml

```
genhtml()
{
    file=$1
    echo "<td><tt>"
    if [ -f $file ]
    then    echo "<font color=blue>$file</font>"
    elif [ -d $file ]
    then    echo "<font color=red>$file</font>"
    else    echo "$file"
    fi
    echo "</tt></td>"
    num=`expr $num + 1`
    if [ $num -gt 4 ]
    then
        echo "</tr><tr>"
        num=0
    fi
}
```

## Korn Shell / bash Features

## Command Substitution

- Better syntax with $(*command*)
  - Allows nesting
  - **`x=$(cat $(generate_file_list))`**
- Backward compatible with ` … ` notation

## Expressions

- Expressions are built-in with the `[[ ]]` operator
  `if [[ $var = "" ]]` …
- Gets around parsing quirks of **/bin/test,** allows checking strings against *patterns*
- Operations:
  - *string* `==` *pattern*
  - *string* `!=` *pattern*
  - *string1* `<` *string2*
  - *file1* `-nt` *file2*
  - *file1* `-ot` *file2*
  - *file1* `-ef` *file2*
  - `&&`, `||`

## Patterns

- Can be used to do string matching:

```
if [[ $foo = *a* ]]
if [[ $foo = [abc]* ]]
```

- Similar to regular expressions, but different syntax

## Additional Parameter Expansion

- `${#`*param*`}` – Length of *param*
- `${`*param*`#`*pattern*`}` – Left strip min *pattern*
- `${`*param*`##`*pattern*`}` – Left strip max *pattern*
- `${`*param*`%`*pattern*`}` – Right strip min *pattern*
- `${`*param*`%%`*pattern*`}` – Right strip max *pattern*
- `${`*param*`-`*value*`}` – Default *value* if *param* not set

## Variables

- Variables can be arrays
  - `foo[3]=test`
  - `echo ${foo[3]}`
- Indexed by number
- **`${#arr}`** is length of the array
- Multiple array elements can be set at once:
  - `set -A foo a b c d`
  - `echo ${foo[1]}`
  - Set command can also be used for positional params: `set a b c d;  print $2`

## Printing

- Built-in **print** command to replace echo
- Much faster
- Allows options:

    -u#    print to specific file descriptor

## Functions

- Alternative function syntax:

```
function name {
    commands
  }
```

- Allows for local variables
- $0 is set to the name of the function

## Additional Features

- Built-in arithmetic: Using $((*expression* ))
  - e.g., **`print $(( 1 + 1 * 8 / x ))`**
- Tilde file expansion

|  |  |
|---|---|
| ~ | $HOME |
| ~**user** | home directory of user |
| ~+ | $PWD |
| ~**-** | $OLDPWD |

# KornShell 93

## Variable Attributes

- By default attributes hold strings of unlimited length
- Attributes can be set with typeset:
  - readonly (-r) – cannot be changed
  - export (-x) – value will be exported to env
  - upper (-u) – letters will be converted to upper case
  - lower (-l) – letters will be converted to lower case
  - ljust (-L *width*) – left justify to given width
  - rjust (-R *width*) – right justify to given width
  - zfill (-Z *width*) – justify, fill with leading zeros
  - integer (-I [*base*]) – value stored as integer
  - float (-E [*prec*]) – value stored as C double
  - nameref (-n) – a name reference

## Name References

- A name reference is a type of variable that references another variable.
- **`nameref`** is an alias for **`typeset -n`**
  - Example:

```
user1=”mehryar"
user2="adam"
typeset -n name="user1"
print $name
mehryar
```

## New Parameter Expansion

- ${param/pattern/str} – Replace first pattern with str
- ${param//pattern/str} – Replace all patterns with str
- ${param:offset:len} – Substring with offset

# Patterns Extended

- Additional pattern types so that shell patterns are equally expressive as regular expressions
- Used for:
  - file expansion
  - **`[[ ]]`**
  - case statements
  - parameter expansion

| *Patterns* | *Regular Expressions* |
|---|---|
| `?` | `.` |
| `*` | `.*` |
| `[...]` | `[...]` |
| `[!...]` | `[^...]` |
| `?(...)` | `(...)?` |
| `*(...)` | `(...)*` |
| `+(...)` | `(...)+` |
| `@(...)` | `(...)` |
| `!(...)` | |
| `a\|b` | `a\|b` |
| `a&b` | |
| `{n}(...)` | `(...){n}` |
| `{m,n}(...)` | `(...){m,n}` |
| `\d` | `\d` |

## ANSI C Quoting

- **`$'`…`'`** Uses C escape sequences

  **`$'\t'   $'Hello\nthere'`**
- **printf** added that supports C like printing:

  `printf "You have %d apples" $x`
- Extensions
  - `%b` – ANSI escape sequences
  - `%q` – Quote argument for reinput
  - `\E` – Escape character (033)
  - `%P` – convert ERE to shell pattern
  - `%H` – convert using HTML conventions
  - `%T` – date conversions using date formats

## Associative Arrays

- Arrays can be indexed by string
- Declared with **`typeset -A`**
- Set: **`name["foo"]="bar"`**
- Reference **`${name["foo"]}`**
- Subscripts: **`${!name[@]}`**

## Corresponding Shell Features

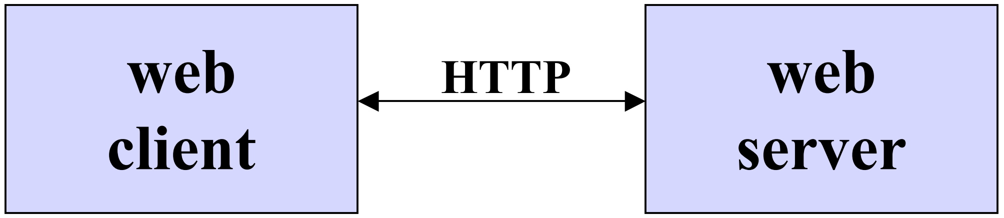
- Standard input, output, error
  - Redirection
  - Here documents
  - Pipelines
  - Command substitution
- Exit status
  - $?
  - &&, ||, if, while
- Environment
  - export, variables
- Arguments
  - Command substitution
  - Variables
  - Wildcards

# Lecture 7

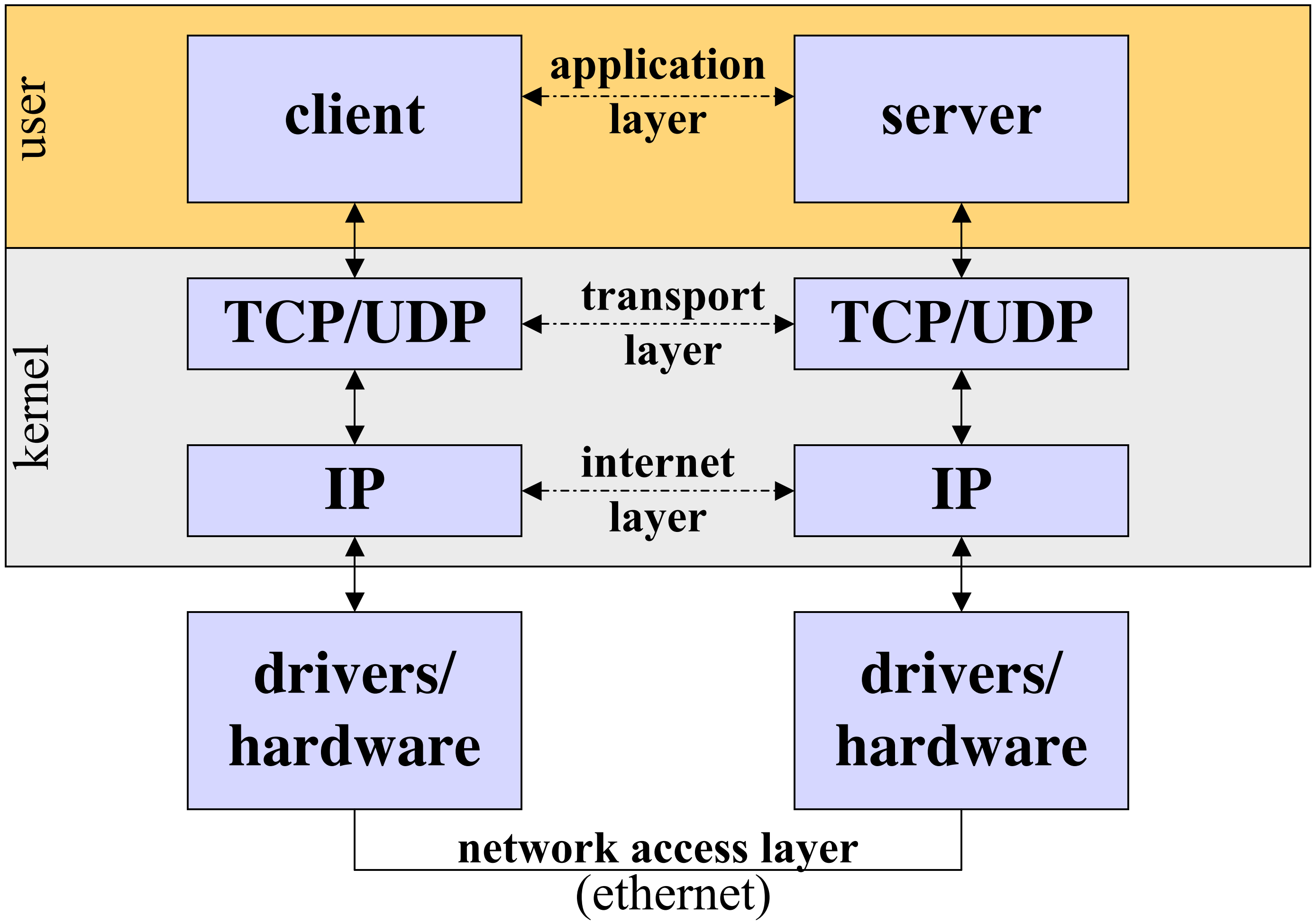
Part II
Networking, HTTP, CGI

## Network Application

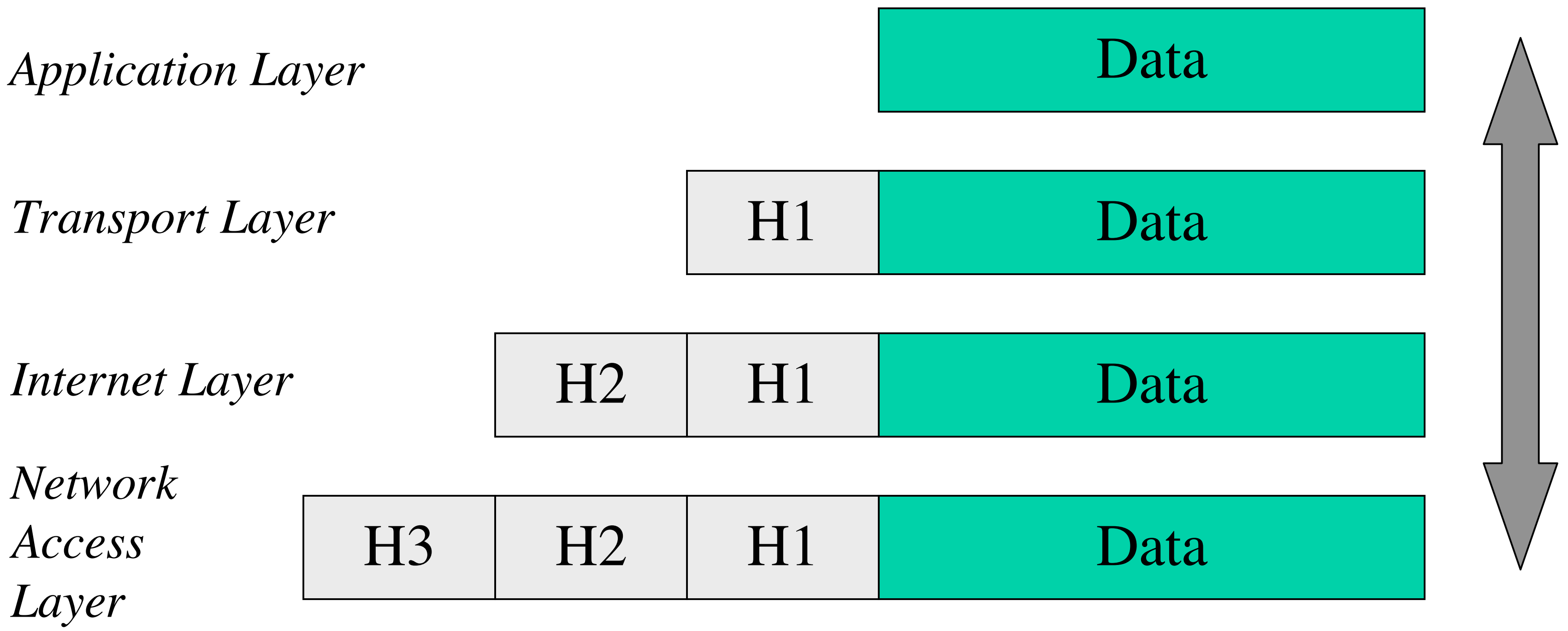
- Client application and server application communicate via a network protocol
- A **protocol** is a set of rules on how the client and server communicate



# TCP/IP Suite


user
kernel
client
application layer
server
TCP/UDP
transport layer
TCP/UDP
IP
internet layer
IP
drivers/ hardware
drivers/ hardware
network access layer
(ethernet)

# Data Encapsulation



## Network Access/Internet Layers

- Network Access Layer
  - Deliver data to devices on the same physical network
  - Ethernet
- Internet Layer
  - Internet Protocol (IP)
  - Determines routing of *datagram*
  - IPv4 uses 32-bit addresses (e.g. 128.122.20.15)
  - Datagram fragmentation and reassembly

## Transport Layer

- Transport Layer
  - Host-host layer
  - Provides error-free, point-to-point connection between hosts
- User Datagram Protocol (UDP)
  - Unreliable, connectionless
- Transmission Control Protocol (TCP)
  - Reliable, connection-oriented
  - Acknowledgements, sequencing, retransmission

## Ports

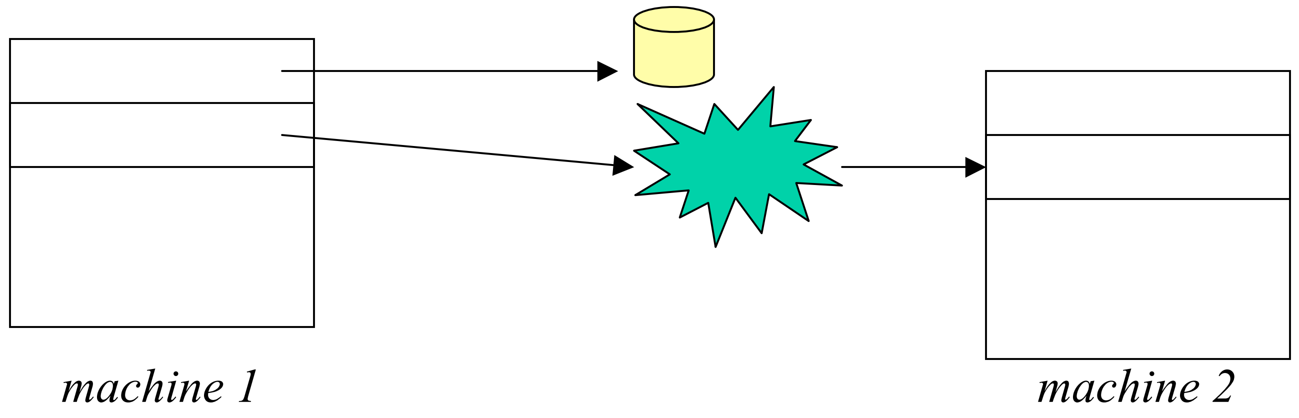
- Both TCP and UDP use 16-bit *port numbers*
- A server application listen to a specific *port* for connections
- Ports used by popular applications are well-defined
  - SSH (22), SMTP (25), HTTP (80)
  - 1-1023 are reserved (*well-known*)
  - 1024-49151 are user level
  - 49152-65535 are private to the machine
- Clients use *ephemeral* ports

## Name Service

- Every node on the network normally has a hostname in addition to an IP address
- Domain Name System (DNS) maps IP addresses to names
  - e.g. 128.122.20.15 is sparky.cs.nyu.edu
- DNS lookup utilities: **nslookup**, **dig**
- 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 (Port 23)
  - Provides virtual terminal for remote user
  - The telnet program can also be used to connect to other ports
- FTP (Port 20/21)
  - Used to transfer files from one machine to another
  - Uses port 20 for data, 21 for control
- SSH (Port 22)
  - For logging in and executing commands on remote machines
  - Data is encrypted

## Major Network Services cont.

- SMTP (Port 25)
  - Host-to-host mail transport
  - Used by mail transfer agents (MTAs)
- IMAP (Port 143)
  - Allow clients to access and manipulate emails on the server
- HTTP (Port 80)
  - Protocol for WWW

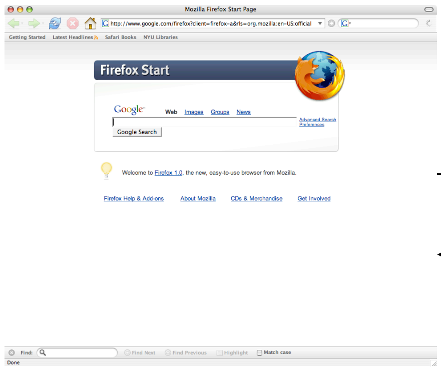
## Ksh93: /dev/tcp

- 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
```

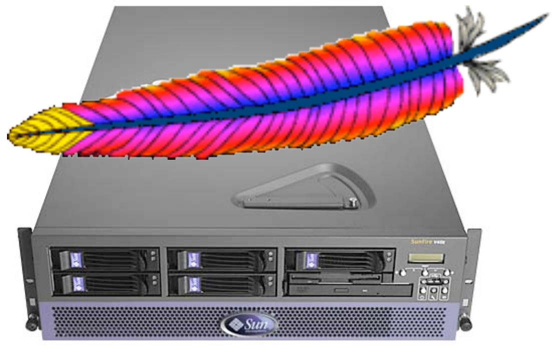
# HTTP

- Hypertext Transfer Protocol
  - Use port 80
- Language used by web browsers (IE, Netscape, Firefox) to communicate with web servers (Apache, IIS)



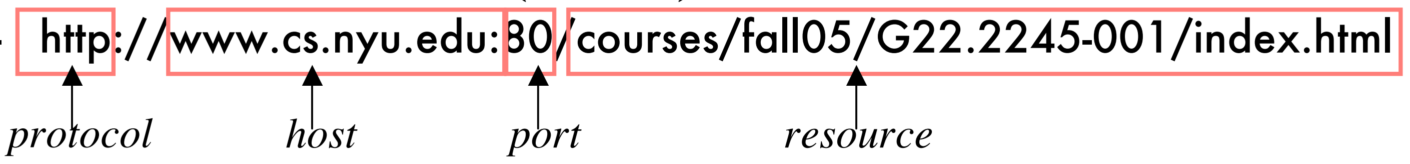
*HTTP request:*
Get me this document →

← *HTTP response:*
Here is your document



## Resources

- Web servers host web resources, including HTML files, PDF files, GIF files, MPEG movies, etc.
- Each web object has an associated MIME type
  - HTML document has type **text/html**
  - JPEG image has type **image/jpeg**
- Web resource is accessed using a Uniform Resource Locator (URL)
  - http://www.cs.nyu.edu:80/courses/fall05/G22.2245-001/index.html


http://www.cs.nyu.edu:80/courses/fall05/G22.2245-001/index.html
protocol
host
port
resource

## HTTP Transactions

- HTTP request to web server

```
GET /v40images/nyu.gif HTTP/1.1
Host: www.nyu.edu
```

- HTTP response to web client

```
HTTP/1.1 200 OK
Content-type: image/gif
Content-length: 3210
```

# Sample HTTP Session

*request*

```
GET / HTTP/1.1
HOST: www.cs.nyu.edu
```

*response*

```
HTTP/1.1 200 OK
Date: Wed, 19 Oct 2005 06:59:49 GMT
Server: Apache/2.0.49 (Unix) mod_perl/1.99_14 Perl/v5.8.4
   mod_ssl/2.0.49 OpenSSL/0.9.7e mod_auth_kerb/4.13 PHP/5.0.0RC3
Last-Modified: Thu, 12 Sep 2002 17:09:03 GMT
Content-Length: 163
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>
```

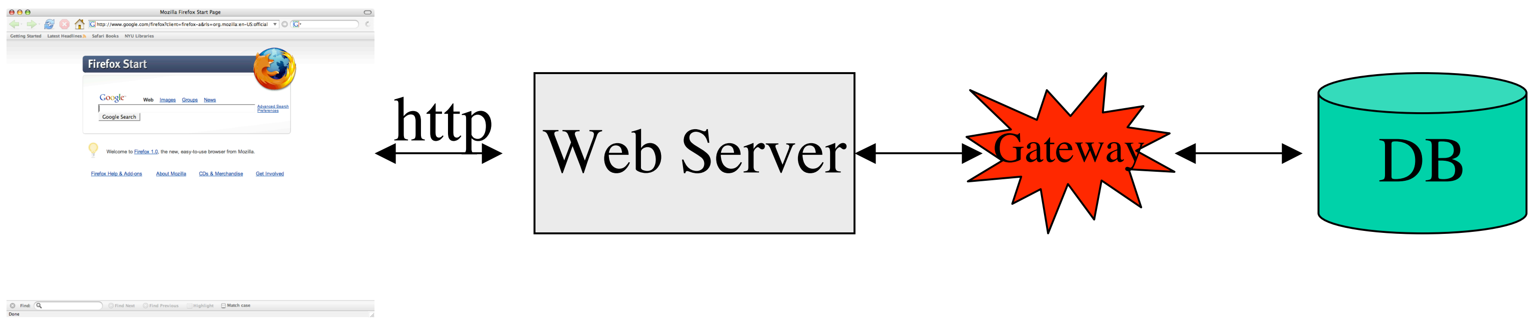
## Status Codes

- Status code in the HTTP response indicates if a request is successful
- Some typical status codes:

| | |
|---|---|
| 200 | OK |
| 302 | Found; Resource in different URI |
| 401 | Authorization required |
| 403 | Forbidden |
| 404 | Not Found |

## Gateways

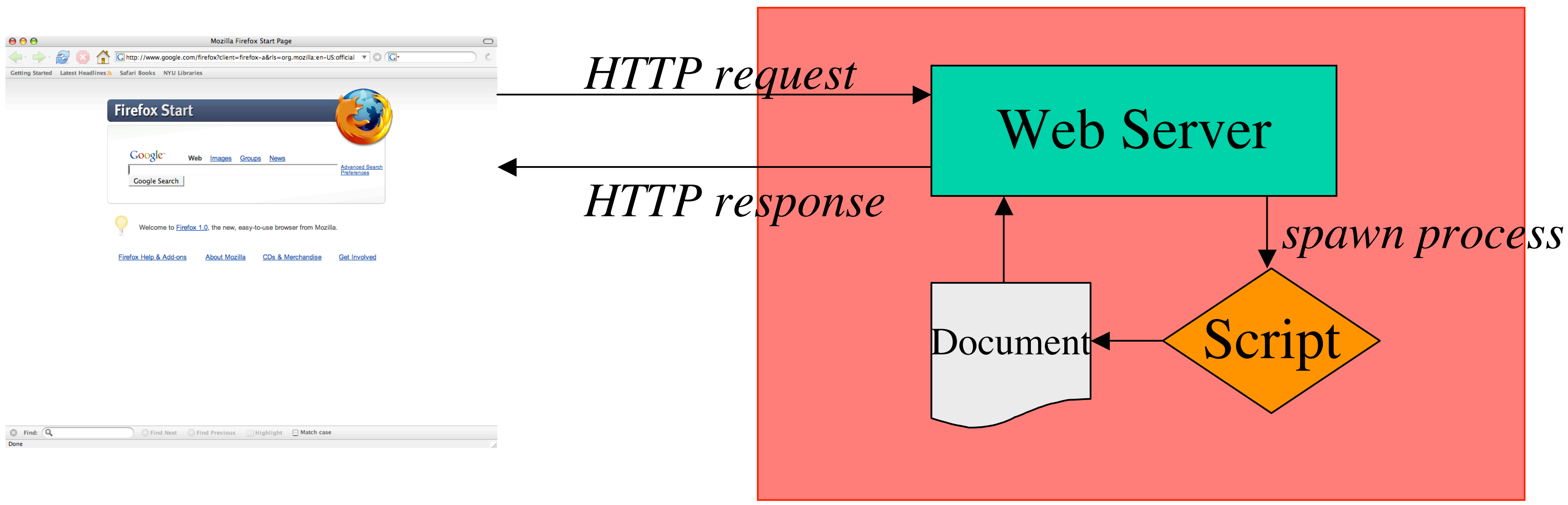
- Interface between resource and a web server



## CGI

- **Common Gateway Interface** is a standard interface for running helper applications to generate dynamic contents
  - Specify the encoding of data passed to programs
- Allow HTML documents to be created on the fly
- Transparent to clients
  - Client sends regular HTTP request
  - Web server receives HTTP request, runs CGI program, and sends contents back in HTTP responses
- CGI programs can be written in any language

# CGI Diagram


Mozilla Firefox Start Page
Firefox Start
Google Search
HTTP request
HTTP response
Web Server
spawn process
Document
Script

## HTML

- Document format used on the web

```
<html>
<head>
<title>Some Document</title>
</head>
<body>
<h2>Some Topics</h2>
This is an HTML document
<p>
This is another paragraph
</body>
</html>
```

## 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

## Forms

- HTML forms are used to collect user input
- Data sent via HTTP request
- Server launches CGI script to process data

```
<form method=POST
  action="http://www.cs.nyu.edu/~unixtool/cgi-
  bin/search.cgi">
Enter your query: <input type=text name=Search>
<input type=submit>
</form>
```

## Input Types

- Text Field

```
<input type=text name=zipcode>
```

- Radio Buttons

```
<input type=radio name=size value=“S”> Small
<input type=radio name=size value=“M”> Medium
<input type=radio name=size value=“L”> Large
```

- Checkboxes

```
<input type=checkbox name=extras value=“lettuce”> Lettuce
<input type=checkbox name=extras value=“tomato”> Tomato
```

- Text Area

```
<textarea name=address cols=50 rows=4>
…
</textarea>
```

## Submit Button

- Submits the form for processing by the CGI script specified in the `form` tag

```
<input type=submit value="Submit Order">
```

## HTTP Methods

- Determine how form data are sent to web server
- Two methods:
  - **GET**
    - Form variables stored in URL
  - **POST**
    - Form variables sent as content of HTTP request

## Encoding Form Values

- Browser sends form variable as name-value pairs
  - `name1=value1&name2=value2&name3=value3`
- Names are defined in form elements
  - `<input type=text name=ssn maxlength=9>`
- Special characters are replaced with **%##** (2-digit hex number), spaces replaced with **+**
  - e.g. "`10/20 Wed`" is encoded as "`10%2F20+Wed`"

# GET/POST examples

*GET:*

```
GET /cgi-bin/myscript.pl?name=Bill%20Gates&
  company=Microsoft HTTP/1.1

HOST: www.cs.nyu.edu
```

*POST:*

```
POST /cgi-bin/myscript.pl HTTP/1.1

HOST: www.cs.nyu.edu
```

…other headers…

```
name=Bill%20Gates&company=Microsoft
```

## GET or POST?

- GET method is useful for
  - Retrieving information, e.g. from a database
  - Embedding data in URL without form element
- POST method should be used for forms with
  - Many fields or long fields
  - Sensitive information
  - Data for updating database
- GET requests may be cached by clients browsers or proxies, but not POST requests

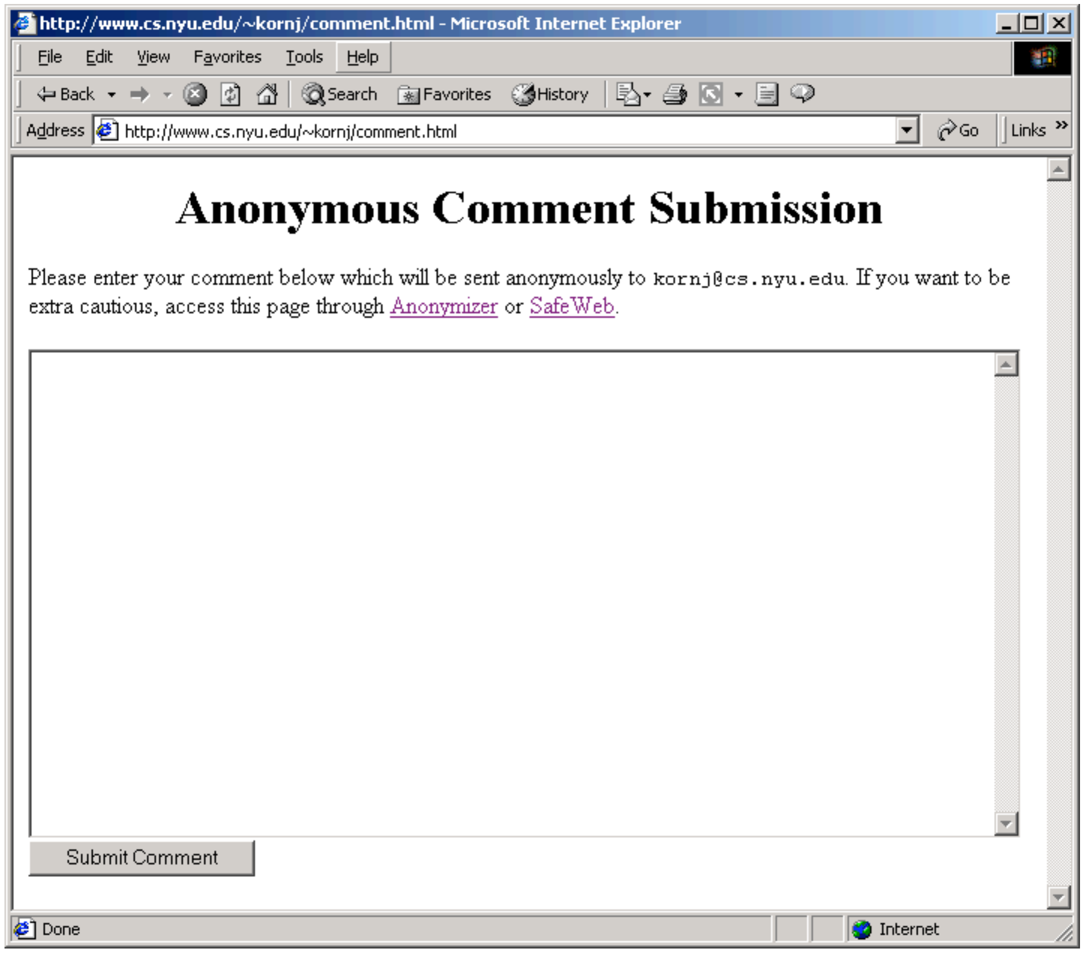
## Parsing Form Input

- Method stored in HTTP_METHOD
- **GET**: Data encoded into QUERY_STRING
- **POST**: Data in standard input (from body of request)
- Most scripts parse input into an associative array
  - You can parse it yourself
  - Or use available libraries (better)

## 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
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.

Submit Comment

## Part 1: HTML Form

```html
<html>
<center>
<H1>Anonymous Comment Submission</H1>
</center>
Please enter your comment below which will
be sent anonymously to <tt>mohri@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" mohri

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

- Sometimes CGI scripts run as owner of the scripts
- Never trust user input - sanity-check everything
- If a shell command contains user input, run without shell escapes
- Always encode sensitive information, e.g. passwords
  - Also use HTTPS
- 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>
```

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```
#!/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>"
```