



Uses of the World Wide Web:

- static documents
(supported by HTML);
- dynamic documents
(supported by CGI, ASP, Ruby on Rails, various HTML extensions, ...); and
- interactive services
(supported by <bigwig> and MAWL).

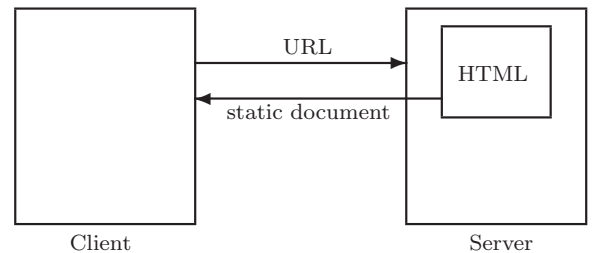
Static documents:

- there are too many documents;
- the documents are rarely updated; and
- the documents are not customized.

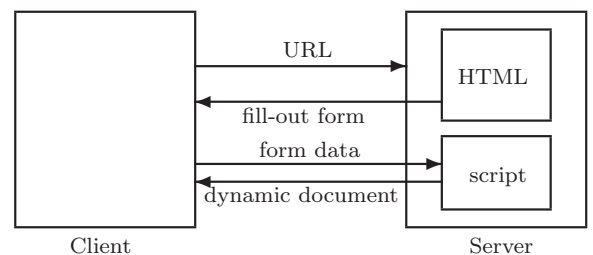
Dynamic documents:

- there are fewer documents;
- the documents are always updated;
- the documents are customized.

Standard interaction:



Common Gateway Interface:



Fill-out forms are HTML elements.

The `<form ...>` tag contains:

- the transmission method (POST or GET);
- the URL of the script; and
- a query string.

Extra tags for input fields:

- simple text fields;
- radio buttons;
- menus; and
- submit buttons.

A simple fill-out form:

HTML source for the fill-out form:

```
<form
  method="POST"
  action="http://www.brics.dk/cgi-mis/Python?Questions"
>
Your name:
<input name="name" type="text" size=20>.
<p>
Your quest:
<select name="quest">
<option value="grail">to find the Holy Grail
<option value="wig">to write a WIG compiler
</select>
<p>
Your favorite color:
<input name="color" type="radio" value="red">red
<input name="color" type="radio" value="green">green
<input name="color" type="radio" value="blue">blue
<input name="color" type="radio" value="argh">I don't know
<p>
<input name="submit" type="submit" value="Answer">
</form>
```

After filling out the form and clicking on the submit button, your browser sends the following text to the web server:

```
POST /cgi-mis/Python?Questions HTTP/1.0
Accept: www/source
Accept: text/html
.....
User-Agent: ... ..
From: ...
Content-type: application/x-www-form-urlencoded
Content-length: 47

name=Michael
&quest=wig
&color=blue
&submit=Answer
```

The web server parses the data from the client (e.g., a browser), sets environment variables and input, and invokes CGI scripts.

Additional information is available in several UNIX environment variables. Consider the following simple query

```
http://www.cs.mcgill.ca/~hendren/cgi-bin/myenv.cgi?foo :
```

```
QUERY_STRING = foo
SERVER_ADDR = 132.206.51.10
HTTP_ACCEPT_LANGUAGE = en-us,en;q=0.5
SERVER_PROTOCOL = HTTP/1.1
HTTP_CONNECTION = keep-alive
REMOTE_PORT = 35406
HTTP_USER_AGENT =
  Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.4)
  Gecko/20030624
HTTP_ACCEPT = text/xml,application/xml,application/xhtml+xml,
  text/html;q=0.9,text/plain;q=0.8,video/x-mng,
  image/png,image/jpeg,image/gif;q=0.2,*/*;q=0.1
GATEWAY_INTERFACE = CGI/1.1
HTTP_HOST = www.cs.mcgill.ca
SERVER_ADMIN = help@cs.mcgill.ca
SERVER_SOFTWARE = Apache/2.0.43 (Unix) PHP/4.3.0RC2
SCRIPT_URI =
  http://www.cs.mcgill.ca/~hendren/cgi-bin/myenv.cgi
REMOTE_ADDR = 132.206.3.136
SCRIPT_NAME = /~hendren/cgi-bin/myenv.cgi
```

```
SCRIPT_URL = /~hendren/cgi-bin/myenv.cgi
HTTP_ACCEPT_ENCODING = gzip,deflate
SERVER_NAME = www.cs.mcgill.ca
DOCUMENT_ROOT = /usr/local/www/data
REQUEST_URI = /~hendren/cgi-bin/myenv.cgi?Questions
HTTP_ACCEPT_CHARSET = ISO-8859-1,utf-8;q=0.7,*;q=0.7
REQUEST_METHOD = GET
SCRIPT_FILENAME =
  /u0/prof/hendren/public_html/cgi-bin/myenv.cgi
HTTP_KEEP_ALIVE = 300
PATH = /usr/local/bin:/usr/local/bin:/usr/bin:/bin
SERVER_PORT = 80
```

The script may be written in any programming or scripting language.

The form data appears on standard input as:

```
name=Michael&quest=wig&color=blue&submit=Answer
```

but must first be decoded:

- change '+' into a space character; and
- replace %xy by the ASCII character with hex value xy.

In this example, '=' and '&' must be encoded.

For more on URL encoding see:

```
http://www.w3schools.com/HTML/html_urlencode.asp
```

The dynamic document is supplied by the script on standard output:

```
Content-type: text/html
Hello Michael,
<p>
Good luck on writing a blue WIG compiler!
```

← important blank line

or may be redirected from a different document:

```
Location: http://some.abolute/url
Content-type: text/html
```

How do we know it is really HTML?

CGI is a state-less protocol:

- each exchange happens in isolation;
- no information remains on the server; and
- different users cannot communicate.

We would like to have:

- global state;
- sessions;
- concurrent threads; and
- local state.

Interacting with a service:

Please guess a number between 0 and 99: <input type="text" value="50"/>	That is not correct. Try a higher number: <input type="text" value="75"/>
<input type="button" value="continue"/>	<input type="button" value="continue"/>
That is not correct. Try a higher number: <input type="text" value="87"/>	That is not correct. Try a higher number: <input type="text" value="93"/>
<input type="button" value="continue"/>	<input type="button" value="continue"/>
That is not correct. Try a lower number: <input type="text" value="90"/>	You got it, using 5 guesses.
<input type="button" value="continue"/>	<input type="button" value="continue"/>
That makes you the new record holder, beating the old record of 10 guesses.	
Please enter your name for the hi-score list: <input type="text" value="Michael"/>	
<input type="button" value="continue"/>	
Thanks for playing this exciting game.	

The WIG language provides:

- global state;
- safe, dynamic documents;
- sequential sessions;
- multiple threads; and
- local state.

A WIG specification is compiled into a self-contained CGI-script.

The (once) ubiquitous counter:

```
service {
  const html Nikolaj = <html> <body>
    
    <p>
      <i>You are visitor number <[no]></i>
    </body> </html>;

  int counter;

  session Access() {
    counter = counter + 1;
    exit plug Nikolaj[no = counter];
  }
}
```



You are visitor number 87

A one-player guessing game:

```

service {
  const html GetSeed = <html> <body> ... </body> </html>;
  const html GameSeeded = <html> <body> ... </body> </html>;
  const html Init = <html> <body> ... </body> </html>;
  const html Retry = <html> <body> ... </body> </html>;
  const html Again = <html> <body> ... </body> </html>;
  const html Done = <html> <body> ... </body> </html>;
  const html Record = <html> <body> ... </body> </html>;
  const html Finish = <html> <body> ... </body> </html>;
  const html List = <html> <body> ... </body> </html>;

  int plays, record;
  int seed;
  string holder;

  int nextRandom() {
    int current;

    seed = (25173 * seed + 13849) % 65536;
    return(seed);
  }

  session Seed() {
    show GetSeed receive[seed = seed];
    exit GameSeeded;
  }

  ...
}

```

```

session Play() {
  int number, guesses, guess;
  string localholder;

  number = nextRandom() % 100;
  plays = plays + 1;
  guesses = 1;
  show Init receive[guess = guess];
  while (guess > 99) show Retry receive[guess = guess];
  while (guess != number) {
    guesses = guesses + 1;
    if (guess > number)
      show plug Again[correction = "lower"]
        receive[guess = guess];
    else
      show plug Again[correction = "higher"]
        receive[guess = guess];
    while (guess > 99) show Retry receive[guess = guess];
  }
  show plug Done[trys = guesses];
  if (record == 0 || record > guesses) {
    show plug Record[old = record]
      receive [localholder = name];
    holder = localholder;
    record = guesses;
  }
  exit Finish;
}

session HiScore() {
  exit plug List[plays = plays,
    holder = holder, record = record];
}

```

```

const html GetSeed = <html> <body>
  Please enter an integer seed for the random
  number generator:
  <input name="seed" type="text" size=5>
</body> </html>;

const html GameSeeded = <html> <body>
  Ok, now the game can proceed, the generator is seeded.
</body> </html>;

const html Init = <html> <body>
  Please guess a number between 0 and 99:
  <input name="guess" type="text" size=2>
</body> </html>;

const html Retry = <html> <body>
  That number is too large!
  <p>
  Please keep your guess between 0 and 99:
  <input name="guess" type="text" size=2>
</body> </html>;

const html Again = <html> <body>
  That is not correct. Try a <[correction]> number:
  <input name="guess" type="text" size=2>
</body> </html>;

```

```

const html Again = <html> <body>
  That is not correct. Try a <[correction]> number:
  <input name="guess" type="text" size=2>
</body> </html>;

const html Done = <html> <body>
  You got it, using <[trys]> guesses.
</body> </html>;

const html Record = <html> <body>
  That makes you the new record holder,
  beating the old record of <[old]> guesses.
  <p>
  Please enter your name for the hi-score list
  <input name="name" type="text" size=20>
</body> </html>;

const html Finish = <html> <body>
  Thanks for playing this exciting game.
</body> </html>;

const html List = <html> <body>
  In <[plays]> plays of this game, the record
  holder is <[holder]> with <[record]> guesses.
</body> </html>;

```

Syntax for WIG html:

```

htmls : html | htmls html ;
html : "const" "html" identifier "="
      "<html>" htmlbodies "</html>";

htmlbodies : /* empty */ | nehtmlbodies;
nehtmlbodies : htmlbody | nehtmlbodies htmlbody;
htmlbody : "<" identifier attributes ">"
          | "</" identifier ">"
          | "<[" identifier "]">"
          | whatever
          | meta
          | "<" "input" inputattrs ">"
          | "<" "select" inputattrs ">" htmlbodies
            "</" "select" ">";

inputattrs : inputattr | inputattrs inputattr;
inputattr : "name" "=" attr
           | "type" "=" inputtype
           | attribute;
inputtype : "text" | "radio";

attributes : /* empty */ | neattributes;
neattributes : attribute | neattributes attribute;
attribute : attr | attr "=" attr;
attr : identifier | stringconst;

```

Comments on WIG html:

- documents are implicitly forms;
- the <[foo]> tag defines gaps to be filled in dynamically;
- <input...> and <select...> tags are explicitly recognized; and
- all other tags and plain text are permitted but ignored.

Syntax for WIG statements:

```

stms : /* empty */ | nestms;
;
nestms : stm | nestms stm
;
stm : ";"
     | "show" document receive ";"
     | "exit" document ";"
     | "return" ";"
     | "return" exp ";"
     | "if" "(" exp ")" stm
     | "if" "(" exp ")" stm "else" stm
     | "while" "(" exp ")" stm
     | compoundstm
     | exp ";"
;
document : identifier
          | "plug" identifier "[" plugs "]";

receive : /* empty */
         | "receive" "[" inputs "]";

compoundstm : "{" variables stms "}";

plugs : plug | plugs "," plug;

plug : identifier = exp;

inputs : /* empty */ | neinputs;
neinputs : input | neinputs "," input;
input : lvalue = identifier;

```

Syntax for WIG expressions:

```

exp : lvalue
     | lvalue "=" exp
     | exp "==" exp
     | exp "!=" exp
     | exp "<" exp
     | exp ">" exp
     | exp "<=" exp
     | exp ">=" exp
     | "!" exp
     | "-" exp
     | exp "+" exp
     | exp "-" exp
     | exp "*" exp
     | exp "/" exp
     | exp "%" exp
     | exp "&&" exp
     | exp "||" exp
     | exp "<<" exp
     | exp "\" identifiers
     | exp "\" identifiers
     | identifier "(" exps ")"
     | intconst
     | "true"
     | "false"
     | stringconst
     | "tuple" "{" fieldvalues "}"
     | "(" exp ")"
;

```

Syntax for WIG expressions (cont.):

```

exps : /* empty */ | neexps;
neexps : exp | neexps "," exp;

lvalue : identifier | identifier "." identifier;

fieldvalues : /* empty */ | nefieldvalues ;
nefieldvalues : fieldvalue | nefieldvalues "," fieldvalue ;
fieldvalue : identifier "=" exp;

```

Syntax for WIG schemas, types and functions:

```

schemas: /* empty */ | neschemas;
neschemas: schema | neschemas schema;
schema : "schema" identifier "{" fields "}";

fields : /* empty */ | nefields;
nefields : field | nefields field;
field : simpletype identifier ";";

simpletype : "int" | "bool" | "string" | "void";
type : simpletype | "tuple" identifier;

functions : /* empty */ | nefunctions;
nefunctions : function | nefunctions function;
function : type identifier "(" arguments ")" compoundstm;

arguments : /* empty */ | nearguments;
nearguments : argument | nearguments "," argument;
argument : type identifier;

```

Syntax for WIG sessions, variables, and services:

```

sessions : session | sessions session;
session : "session" identifier "(" ")" compoundstm;

variables : /* empty */ | nevariables ;
nevariables : variable | nevariables variable ;
variable : type identifiers ";";
identifiers : identifier | identifiers "," identifier ;

service : "service" "{" htmls schemas
          variables functions sessions "}";

```

Compare our initial attempt at a grammar with a proper yacc/bison grammar with all conflicts resolved:

```
$ diff -u wiggrammar.txt wiggrammar_bison.txt
```

Some open questions on WIG semantics:

- what happens if not all gaps are plugged?
- what happens if a gap is plugged twice?
- must all form inputs be received?
- what are the allowed operations on tuples?
- what are the type rules?
- are global variables safe for concurrent threads?

There are many such questions to ponder.

A simple chat room:

```

service {
  const html Logon = <html> <body>
    <h1>Welcome to The Chat Room</h1>
    Please enter your on-line name:
    <input name="name" type="text" size=25>
  </body> </html>;

  const html Update = <html> <body>
    <h1>The Chat Room Service</h1> <hr>
    <b>Messages so far:</b> <p>
    <[msg0]><p><[msg1]><p><[msg2]><p><[msg3]><p>
    <[msg4]><p><[msg5]><p>
    <hr>
    <b>Your new message:</b>
    <p>
    <input name="msg" type="text" size=40>
    <p>
    <hr>
    <p>
    <input name="quit" type="radio" value="yes"> Quit now
  </body> </html>;

  const html ByeBye = <html> <body>
    <h1>Thanks for using The Chat Room</h1>
    You made <[conns]> connections
    and wrote <[msgs]> messages.
  </body> </html>;

  string msg0,msg1,msg2,msg3,msg4,msg5;

```

A simple chat room (cont.):

```

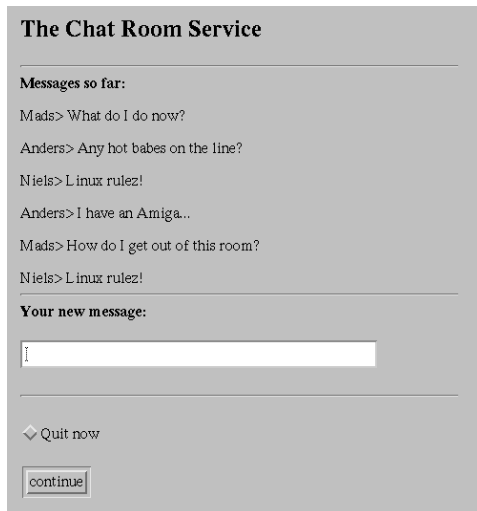
session Chat() {
  string name,msg,quit;
  int connections, written;

  show Logon receive [name = name];
  while (quit!="yes") {
    show plug Update[msg0 = msg0,
                      msg1 = msg1,
                      msg2 = msg2,
                      msg3 = msg3,
                      msg4 = msg4,
                      msg5 = msg5]

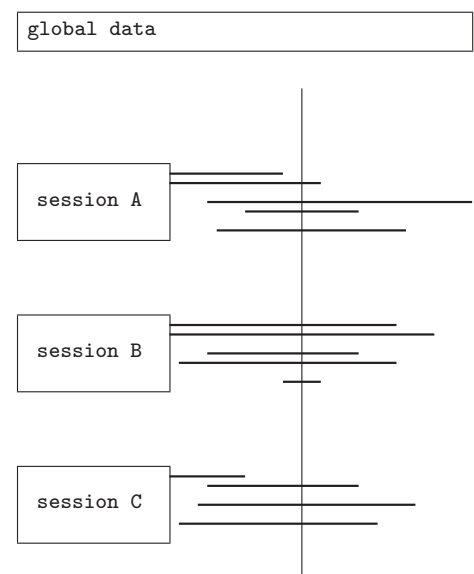
    receive[msg = msg, quit = quit];
    connections = connections+1;
    if (msg!="") {
      written = written+1;
      msg0 = msg1;
      msg1 = msg2;
      msg2 = msg3;
      msg3 = msg4;
      msg4 = msg5;
      msg5 = name + "> " + msg;
    }
  }
  exit plug ByeBye[conns = connections,
                  msgs = written];
}

```

A sample chat:



Concurrent threads in a service:



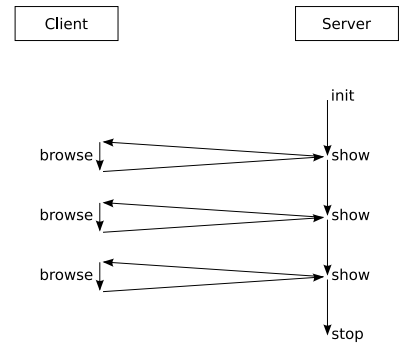
Maintaining global and local state:

- global variables reside in shared files;
- local variables reside in program variables inside each thread.

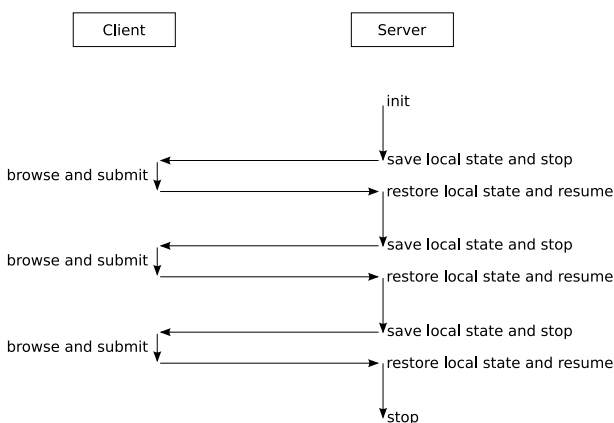
Emulating a sequential thread:

- each `show` causes the CGI-thread to save the local state and stop;
- each form submission causes the CGI-thread to resume and restore the local state.

A WIG session thread:



Corresponding CGI-threads:



Some synchronization issues and solutions:

- exclusive updates of global data:
global file locking;
- critical sections:
mutex semaphores.

Some security issues and solutions:

- tampering with the state:
keep all state on the server;
- hijacking a session:
use random keys in session id;
- rolling back a thread:
the server has the program counter.

A tiny WIG service:

```

service {
  const html Welcome = <html> <body>
    Welcome!
  </body> </html>;

  const html Pledge = <html> <body>
    How much do you want to contribute?
    <input name="contribution" type="text" size=4>
  </body> </html>;

  const html Total = <html> <body>
    The total is now <[total]>.
  </body> </html>;

  int amount;

  session Contribute() {
    int i;
    i = 87;
    show Welcome;
    show Pledge receive[i = contribution];
    amount = amount + i;
    exit plug Total[total = amount];
  }
}

```

Generated C-based CGI source code:

```

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <time.h>
#include "runwig.h"

char *url;
char *sessionid;
int pc;
FILE *f;

void output_Welcome()
{ printf("Welcome!\n");
}

void output_Pledge()
{ printf("How much do you want to contribute?\n");
  printf("<input name=\"contribution\"
        type=\"text\" size=4>\n");
}

void output_Total(char *total)
{ printf("The total is now %s.\n",total);
}

int local_Contribute_i;

```

```

int main() {

  /* initialize pseudorandom generator */
  srand48(time((time_t *)0));
  /* get form fields from CGI input */
  parseFields();
  /* assign the url of this service */
  url = "http://dovs-www.daimi.aau.dk/cgi-mis/tiny";
  /* find current sessionid from environment */
  sessionid = getenv("QUERY_STRING");

  /* do we start a new thread? */
  if (strcmp(sessionid,"Contribute")==0)
    goto start_Contribute;
  /* do we resume an old thread? */
  if (strncmp(sessionid,"Contribute$",11)==0)
    goto restart_Contribute;
  /* otherwise report an error */
  printf("Content-type: text/html\n\n");
  printf("<title>Illegal Request</title>\n\n");
  printf("<h1>Illegal request: %s</h1>\n\n",sessionid);
  exit(1);
}

```

```

/* start up a new thread */
start_Contribute:
/* initialize local variables */
local_Contribute_i = 87;
/* assign a random sessionid */
sessionid = randomString("Contribute",20);

/* show Welcome; */
printf("Content-type: text/html\n\n");
printf("<form method=\"POST\" action=\"%s%s\">\n",
       url,sessionid);
output_Welcome();
printf("<p><input type=\"submit\" value=\"continue\">\n");
printf("</form>\n");
/* save local state */
f = fopen(sessionid,"w");
fprintf(f,"1\n");
fprintf(f,"%i\n",local_Contribute_i);
fclose(f);
/* terminate thread */
exit(0);
/* and resume from here */
Contribute_1:

```

```

/* show Pledge... */
printf("Content-type: text/html\n\n");
printf("<form method=\"POST\" action=\"%s?%s\">\n",
      url,sessionid);
output_Pledge();
printf("<p><input type=\"submit\" value=\"continue\">");
printf("</form>\n");
/* save local state */
f = fopen(sessionid,"w");
fprintf(f,"2\n");
fprintf(f,"%i\n",local_Contribute_i);
fclose(f);
/* terminate thread */
exit(0);
/* and resume from here */
Contribute_2:

/* ...receive[i = contribution]; */
local_Contribute_i = atoi(getField("contribution"));
/* amount = amount + i; */
putGlobalInt("global_tiny_amount",
             getGlobalInt("global_tiny_amount")
             +local_Contribute_i);
/* exit plug Total[total = amount]; */
printf("Content-type: text/html\n\n");
output_Total(itoa(getGlobalInt("global_tiny_amount")));
exit(0);

```

```

/* restart a thread */
restart_Contribute:
/* restore local state */
f = fopen(sessionid,"r");
fscanf(f,"%i\n",&pc);
fscanf(f,"%i\n",&local_Contribute_i);
/* jump to current pc */
if (pc==1) goto Contribute_1;
if (pc==2) goto Contribute_2;

} /* end of main () */

```

The library `runwig.h` implements:

```

void parseFields();
char *getField(char *name);

char *randomString(char *name,int size);

int getGlobalInt(char *name);
void putGlobalInt(char *name,int value);

char *itoa(int i);

```

The service can be installed by a script:

```

#!/bin/sh
gcc tiny.c /path/to/wig4/runwig.c -o tiny4.cgi
cp tiny4.cgi ~/public_html/cgi-bin
chmod 755 ~/public_html/cgi-bin/tiny4.cgi

```

and invoked by:

```

http://www.cs.mcgill.ca/~'whoami'/cgi-bin/tiny.cgi?Contribute

```

Are we having fun yet?