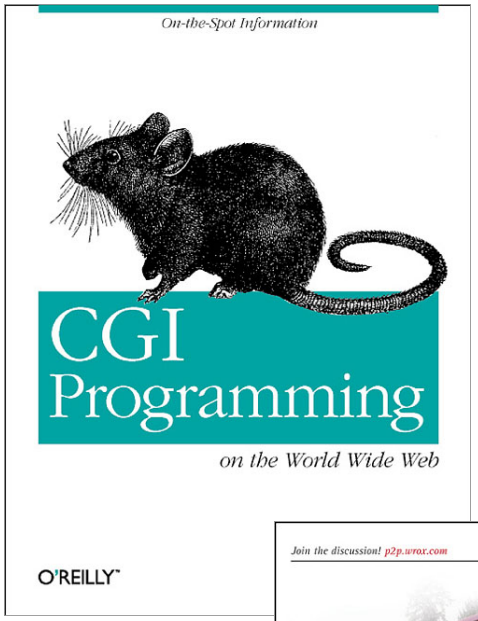
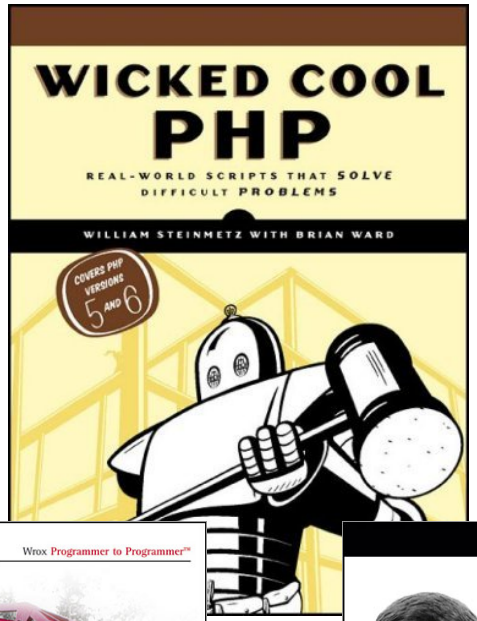
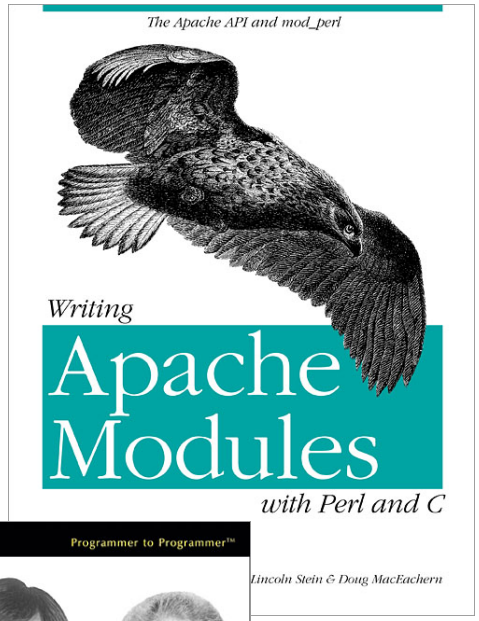
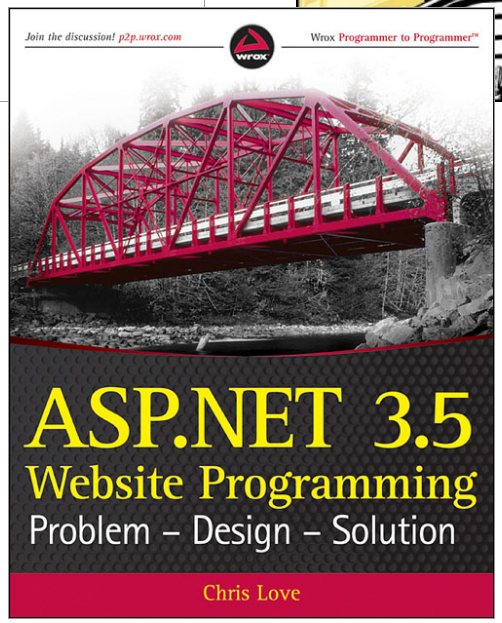
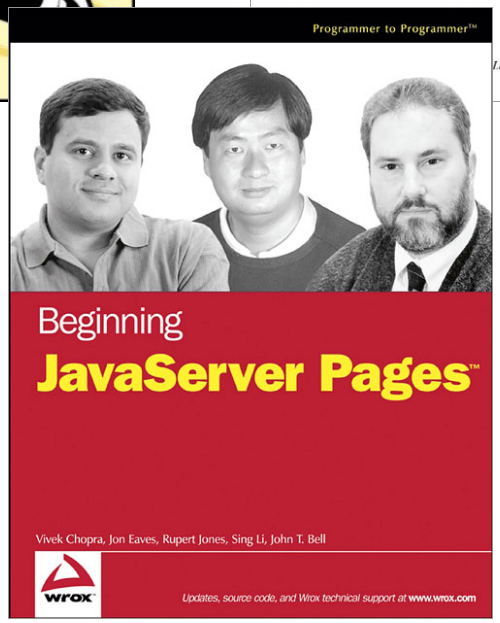
Dynamic web content technologies











Overview

- Dynamic content
  - What it is
  - Sources of input
- CGI (Common Gateway Interface)
  - Benchmarks from assignment #1 (last year's class)
- FastCGI
- Server-side scripting
- Web server modules
  - For specific language: mod_perl, mod_python
  - Custom

Static vs. dynamic

- Static content
  - Images and pages don't change
    - Always the same, like a file server
  - Fast to deliver, easy to cache, etc.
- Dynamic content
  - Same URL may result in different delivered HTML
    - e.g. different preference on # of products to display
  - May change as user interaction progresses
    - e.g. adding items to a shopping cart
  - Need something besides just HTTP and HTML
    - HTTP is stateless
    - HTML is not programmable (e.g. conditional, loops)

Input to dynamic pages

- Form fields
  - <INPUT> tags inside the <FORM> tag
  - Data is URL encoded (percent-encoded)
    - In the URL if GET, in the HTTP payload if POST
    - Unreserved characters:
      - ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz0123456789-_.~
    - Reserved characters:
      - !*'();:@&=$,/?#[]
      - Converted to %XX, where XX is ASCII in hexadecimal
      - %20 = space (also +), %21 = !, %23 = #, %25 = %, …
    - Most languages have URL encode/decode functions

Input to dynamic pages

- Cookies
  - Differentiate different clients hitting same page
- Other sources
  - User agent (browser)
  - HTTP referer
    - Misspelled since original RFC 1945
    - The page you came from to get to this one
  - Client's IP address
  - Time of day
  - …

CGI

- CGI (Common Gateway Interface)
  - In use since 1993
  - Requests a URL in a special location/file extension
    - e.g. http://www.blah.com/cgi-bin/lookup
  - Web server passes request to script/program
    - Sets a laundry list of environment variables
    - Creates new process and runs program
    - Program's output sent to web client
  - Notes:
    - Program must have read+execute permission by web server user
    - Probably shouldn't be writeable by anybody

CGI pros

- Advantages
  - Simple to code CGI program
    - HTTP GET: input from environment variables
    - HTTP POST: input from standard input
    - Output via standard output
  - Highly portable
    - Supported by virtually all web servers
    - Write in portable scripting language, e.g. Perl, Python
  - Safer?
    - Runs outside web server process space
      - Can run as different user
    - But subject to exploits if care not taken

CGI cons

- Disadvantages
  - Expensive
    - Takes time
      - Most fork process for each HTTP request
      - Process has to fire up resources, e.g. interpreter, DB connection
    - Takes memory
      - Process consumes resources (particularly for interpreted languages)

How expensive is CGI?

- Creating/destroying a process?
- Starting/ending Perl?
- Starting/ending Python?
- Experiment:
  - Test options on a page that doesn't do anything
  - Isolates process startup expense
  - Isolate interpreter startup expense

```
#!/usr/bin/perl

print "Content-Type: text/plain;charset=us-ascii\n\n";
```

CGI noop results

- Test setup:
  - Pentium 4 @ 3.0 Ghz, 1GB memory, 512K L2 cache
  - Apache 2.2.21
  - Apache benchmark (ab) to localhost "noop" pages
    - 1000 requests each at concurrency {1, 5, 10, 20}
    - Variants: No CGI, CGI C, CGI Perl, CGI Python

Test case	Requests / second
No CGI	1272.2
CGI C program	389.7
CGI Perl script	236.1
CGI Python script	24.7

CGI results

- CGI benchmark on a "real" application:
  - Return value given key
  - Text file containing 100, 1000, or 10000 identify pairs

Name	Language	System	Requests / second
Keith	C	lab	327.3
Ryan	C	?	2172.8
Miles	Python	lab	19.8
Chris	Python	lab	22.5
Jake	Python	lab	15.0

C CGI results in detail

file	c	requests/sec	
100	1	1408.87	
100	5	4035.85	
100	10	4107.28	
100	20	4125.28	3419.32
1000	1	885.79	
1000	5	2994.63	
1000	10	3030.05	
1000	20	3043.18	2480.91
10000	1	199.67	
10000	5	743.88	
10000	10	772.82	
10000	20	756.58	618.23
mean	-	2172.82333	

Ryan, home computer, 4 cores

file	c	requests/sec	
100	1	350.66	
100	5	429.90	
100	10	427.01	
100	20	426.31	408.47
1000	1	309.90	
1000	5	400.93	
1000	10	397.84	
1000	20	383.55	373.06
10000	1	171.59	
10000	5	213.30	
10000	10	208.12	
10000	20	207.81	200.21
mean	-	327.24	

Keith, lab machine, 1 core

C CGI results in detail

file	c	requests/sec	
100	1	1408.87	
100	5	4035.85	
100	10	4107.28	
100	20	4125.28	3419.32
1000	1	885.79	
1000	5	2994.63	
1000	10	3030.05	
1000	20	3043.18	2480.91
10000	1	199.67	
10000	5	743.88	
10000	10	772.82	
10000	20	756.58	618.23
mean	-	2172.82	

Ryan, home computer, 4 cores

file	c	requests/sec	
100	1	336.71	
100	5	3530.49	
100	10	4295.64	
100	20	4291.02	3113.47
1000	1	298.63	
1000	5	3549.84	
1000	10	4059.63	
1000	20	4017.70	2981.45
10000	1	141.43	
10000	5	2203.17	
10000	10	2520.40	
10000	20	2547.34	1853.09
mean	-	2649.33	

Keith, home machine, 6 cores

Improving CGI

- FastCGI
  - Developed by third party: Open Market
  - Language independent (like CGI)
    - Supported by many languages: C, C++, Java, Python, Perl, Ruby, …
  - Isolated from web server process space (like CGI)
  - Supported by many servers
    - e.g. Apache, IIS, Lighttpd, Nginx, …
- Benefits:
  - Faster! Persistent process serves many requests
    - Amortizes process/interpreter startup
  - Can proxy work to another server

FastCGI sample code

```
#!/usr/bin/perl

use FCGI;
use strict;

my $i = 0;

while (FCGI::accept() >= 0)
{
    print "Content-Type: text/plain;charset=us-ascii\n\n";
    print "Hello world! i = " . $i;
    $i++;
}
```

```
# Adding FastCGI support in its own directory
LoadModule fastcgi_module modules/mod_fastcgi.so
<Directory "/usr/local/apache2/fcgi-bin">
    AllowOverride None
    Options None
    Order allow,deny
    Allow from all
    SetHandler fastcgi-script
</Directory>
```

```
#include "fcgi_stdio.h
#include <stdlib.h>

int main(void)
{
    int count = 0;
    while (FCGI_Accept() >= 0)
    {
        printf("Content-Type: text/plain;charset=us-ascii\n\n");
        printf("Hello world! count = %d\n", count);
        count++;
    }
}
```

FastCGI C results

- Name/value lookup from file application

file	c	requests/sec	
100	1	350.66	
100	5	429.90	
100	10	427.01	
100	20	426.31	408.47
1000	1	309.90	
1000	5	400.93	
1000	10	397.84	
1000	20	383.55	373.06
10000	1	171.59	
10000	5	213.30	
10000	10	208.12	
10000	20	207.81	200.21
mean	-	327.24	

Results using normal CGI

file	c	requests/sec	
100	1	1064.58	
100	5	1268.05	
100	10	1259.81	
100	20	1282.40	1218.71
1000	1	843.90	
1000	5	985.43	
1000	10	982.07	
1000	20	940.33	937.93
10000	1	258.12	
10000	5	272.00	
10000	10	278.23	
10000	20	281.88	272.56
mean	-	809.73	

Results using FastCGI

Server-side scripting

- Server-side scripting
  - Do your smart stuff inside the web server process
    - No process/interpreter startup expense
    - But still interpreted
  - Embed code into your HTML page
    - <? echo "hello world!"; ?>
    - Embedded code run by web server
    - Results are sent to client, not the code itself
  - Wide-variety of choices:
    - PHP: Hypertext Preprocessor
    - ASP (Active Server Pages), now ASP.NET
    - JSP (Java Server Pages)
    - ColdFusion

Server-side scripting

```
<html>
  <head>
    <script language="JavaScript">
       var secret = Math.floor(Math.random() * 10) + 1;
    </script>
  </head>
  <body onload="document.getElementById('num').innerHTML = secret;">
    Pssst, the secret number is <span class="num" id="num"></span>
    <br /><br />
    Your IP address is :
    <?php echo $_SERVER["REMOTE_ADDR"]; ?>
    <br /><br />
    <?php
    for ($i = 0; $i < 10; $i++)
       echo $i . " ";
    echo "<br />";
    ?>
  </body>
</html>
```

File as seen on the web server.

Scripting example

```
<html>
  <head>
    <script language="JavaScript">
       var secret = Math.floor(Math.random() * 10) + 1;
    </script>
  </head>
  <body onload="document.getElementById('num').innerHTML = secret;">
    Pssst, the secret number is <span class="num" id="num"></span>
    <br /><br />
    Your IP address is : ::1<br />
    <br />
    0 1 2 3 4 5 6 7 8 9 <br />  </body>
</html>
```

File as seen by the client's browser.

PHP scripting

- PHP: Hypertext Preprocessor
  - For documentation see http://php.net
  - Syntax very C/Java/Perl like
  - Variables
    - Prefixed with $
    - Loosely typed
    - Don't need to be declare beforehand
  - Hundreds of base functions:
    - e.g. File I/O functions:
      - fopen(), fgets(), fputs(), fclose(), feof()
  - Normally interpreted
    - Some compiled versions, e.g. HipHop by Facebook

Web server module

- Install web server module
  - e.g. mod_perl, mod_python
  - Interpreter now in web server process space
  - No startup expense

```
Alias /perl/ /var/www/perl/
  PerlModule Apache::Registry
  <Location /perl>
    SetHandler perl-script
    PerlHandler Apache::Registry
    Options ExecCGI
    allow from all
    PerlSendHeader On
  </Location>
```

Going even faster…

- Server-side scripting or mod_perl/python
  - Normally interpreted
  - Not as fast as native code
- Put native code in web server process
  - e.g. Apache module, IIS ISAPI, Netscape NSAPI
  - Fast!
    - No startup expense
    - Runs as native compiled code
  - But:
    - Not as portable, tied to specific web server
    - Web server process exposed to bugs in module

Apache hello world module

```c
#include "httpd.h"
#include "http_config.h"
#include "http_protocol.h"
#include "ap_config.h"

/* The sample content handler */
static int poc_rest_handler(request_rec *r)
{
    if (strcmp(r->handler, "poc_rest"))
        return DECLINED;
    r->content_type = "text/html";
    if (!r->header_only)
        ap_rputs("Hello world!\n", r);
    return OK;
}

static void poc_rest_register_hooks(apr_pool_t *p)
{
    ap_hook_handler(poc_rest_handler, NULL, NULL, APR_HOOK_MIDDLE);
}

/* Dispatch list for API hooks */
module AP_MODULE_DECLARE_DATA poc_rest
    STANDARD20_MODULE_STUFF,
    NULL,                  /* create p
    NULL,                  /* merge  p
    NULL,                  /* create per-server config structures */
    NULL,                  /* merge  per-server config structures */
    NULL,                  /* table of config file commands       */
    poc_rest_register_hooks  /* register hooks                      */
};
```

```
# My custom hello world Apache module
LoadModule hello_module modules/mod_hello.so
<Location /hello>
  SetHandler hello
</Location>
```

Apache module results 1

- Name/value lookup from file application

file	c	requests/sec	
100	1	350.66	
100	5	429.90	
100	10	427.01	
100	20	426.31	408.47
1000	1	309.90	
1000	5	400.93	
1000	10	397.84	
1000	20	383.55	373.06
10000	1	171.59	
10000	5	213.30	
10000	10	208.12	
10000	20	207.81	200.21
mean	-	327.24	

Results using normal CGI

file	c	requests/sec	
100	1	1552.30	
100	5	1851.48	
100	10	1853.66	
100	20	1900.98	1789.61
1000	1	1179.88	
1000	5	1296.82	
1000	10	1320.85	
1000	20	1285.90	1270.86
10000	1	311.48	
10000	5	330.26	
10000	10	329.59	
10000	20	333.12	326.11
mean	-	1128.86	

Results using custom Apache module

Apache module results 3

- Name/value lookup from file application

file	c	requests/sec	
100	1	1552.30	
100	5	1851.48	
100	10	1853.66	
100	20	1900.98	1789.61
1000	1	1179.88	
1000	5	1296.82	
1000	10	1320.85	
1000	20	1285.90	1270.86
10000	1	311.48	
10000	5	330.26	
10000	10	329.59	
10000	20	333.12	326.11
mean	-	1128.86	

Apache module, lab machine, 1 core

file	c	requests/sec
100	1	1794.89
100	5	8401.91
100	10	20268.64
100	20	15072.73
1000	1	1189.34
1000	5	5346.56
1000	10	19515.01
1000	20	18133.85
10000	1	314.18
10000	5	2350.68
10000	10	2911.20
10000	20	3416.14
mean	-	8226.26

Apache module, home machine, 6 cores

Even faster?

- What could possibly be better than running native code inside the Apache server process?
  - Create custom web server
  - HTTP is simple protocol
    - Why reinvent your own socket protocol?
  - Only handles HTTP requests for specific app
  - Could be deployed on separate servers
  - Perhaps faster
    - No overhead associated with lots and lots of features
  - Smaller memory footprint
    - Important for scalability

Summary

- Dynamic content
  - Many ways to skin a cat?
  - Each has pros and cons
- CGI (Common Gateway Interface)
- FastCGI
- Server-side scripting
- Web server modules
- Building a custom web server