Advantages of Using Secure Web Server on OpenVMS

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Agenda

- Overview & history of Apache
- HP Secure Web Server
- Optional Modules
- Futures
- Installation
- Configuring the Server
- Security
- Crash Course (“How to” or “What is”)
- Information

The Apache Web Server

- HTTP server based on National Center for Supercomputing Applications developed web server httpd
- U.S. Government funded NCSA httpd so the software is in the public domain
- User community worked together to share modifications.
  - The result was “a patchy server”, hence the name Apache

The Apache Web Server

- Those making the modifications became known as The Apache Group
  - Now known as the Apache Software Foundation
  - **http://www.apache.org/**
  - Supported by companies such as HP, IBM and Sun
- The Apache Software Foundation sponsors numerous other projects
  - SOAP, Xerces (XML), Jakarta, TOMCAT (JSP), …
- Many enhancements for the server are available
  - Perl, JServ, JSSI, …

Apache HTTP Server

- HTTP/1.1 (RFC2616) compliant web server
- Highly configurable and extensible
- Customized using the Apache module API
- Complete source code, non-restrictive license
- Runs on OpenVMS, Windows, UNIX, and other OS platforms
- Active, global development community
- Most popular web server on the Internet (67.37% vs 21.32% for IIS – July 2004)
  - http://news.netcraft.com/archives/web_server_survey.html

HP Secure Web Server for OpenVMS (SWS)

- Based on recent Apache HTTP baselevels
- Tailored for OpenVMS cluster and security architecture
- Includes SSL (certificate-based authentication and encryption services for sockets)
- VeriSign supported platform
  http://www.verisign.com/support/install/
- Multiple scripting capabilities (CGI, Java, Perl, PHP)

SWS (Continued)

- Netcraft recognizes OpenVMS platform
  http://www.netcraft.com/
- OpenVMS external web site is running SWS
  http://h71000.www7.hp.com/
- SWS source code is available on the web
- User contributions (ht://Dig, SWISH-E, Python…)

SWS (Continued)

- Supported modules (as of SWS 1.3)
  - Standard Apache modules
    - mod_access, mod_actions, mod_alias, mod_asis, mod_auth, mod_autoindex, mod_cgi, mod_define, mod_dir, mod_env, mod_imap, mod_include, mod_info, mod_log_config, mod_mime, mod_negotiation, mod_proxy, mod_rewrite, mod_setenvif, mod_so, mod_ssl (DSO), mod_status, mod_unique_id, mod_userdir
  - OpenVMS-unique modules
    - mod_auth_openvms (DSO), mod_osuscript
  - Optional modules
    - mod_jk, mod_jserv, mod_perl, mod_php, mod_DAV
    - Above modules are DSO
  - User written modules (not supported by HP)
    - mod_put, mod_python etc

SWS Shipping Today

- SWS V1.3 ECO 5 shipped (based on Apache 1.3.26)
  - suEXEC for running CGI scripts under a different username
  - WebDAV
    - Distributed Authoring & Versioning aka “poor man’s Pathworks”
  - OpenSSL 0.9.6g
  - Enhancements to MOD_AUTH_OPENVMS
    - Require group using rights identifier
  - New server configuration features
    - Startup, shutdown & tag

SWS Shipping Today

- SWS 2.0
  - Based on Apache 2.0.47
  - Implements the pre-fork, not the multi-threaded model
    - Similar to SWS V1.3
  - Includes IPv6 support (runs on either stack)
  - Requirements:
    - ODS-5
    - VMS 7.3-1 or later
    - TCP/IP 5.3 (runs on Multinet and TCPWare)
    - Stream-LF record formats only
  - Perl/PHP/Tomcat

SWS Optional Products

- SWS_JAVA V2.1
  - Based on Tomcat 4.1.24
  - Supports JSP 1.2, Servlet 2.3, Ant
  - Will work with SWS 1.3 or 2.0
- SWS_PHP V1.2 (mod_php 4.3.2)
  - PHP scripting language embedded within HTML
  - **Updated OpenSSL extension**
  - **OpenVMS extension**, which performs several functions such as converting filenames and showing uptime
  - **MySQL extension**, which allows you to access MySQL database servers

SWS Futures

- SWS 1.3-1
  - Based on Apache 1.3.26 (Common source)
  - Includes OpenSSL 0.9.7D
  - Alpha and Itanium kits are available with OpenVMS 8.2 field test media
- Initial release on OpenVMS IA64
  - SWS (based upon Apache 1.3)
  - SWS_JAVA
  - SWS_PHP
  - SWS_PERL
  - Perl
  - PHP

SWS Futures (Continued)

- SWS 2.1?
  - We heard you!!!!!
    - Lift STM-LF only restriction
  - STM-LF is mmap() restriction
  - Selectable (Speed vs function)

SWS Installation

- Download kit
- Decompress (Itanium HP-I64VMS…)

```
$ RUN CPQ-AXPVMS-CSWS-V0103--1.PCSI-DCX-
  AXPEXE
```

- Install kit onto ODS-5 disk

```
$ PROD INST CSWS /DEST=device:[directory-
  name]
```

- Configure Apache
- `$ @SYS$STARTUP:APACHE$CONFIG`

SWS Installation (Continued)

- APACHE$CONFIG.COM
  - Creates APACHE$WWW account
  - Creates systemwide logical names
  - Optionally adds support for MOD_SSL & MOD_suEXEC
  - Sets correct ownership on SWS files
- APACHE$STARTUP.COM
- APACHE$SHUTDOWN.COM

SWS Installation (Continued)

- Test installation by telnet

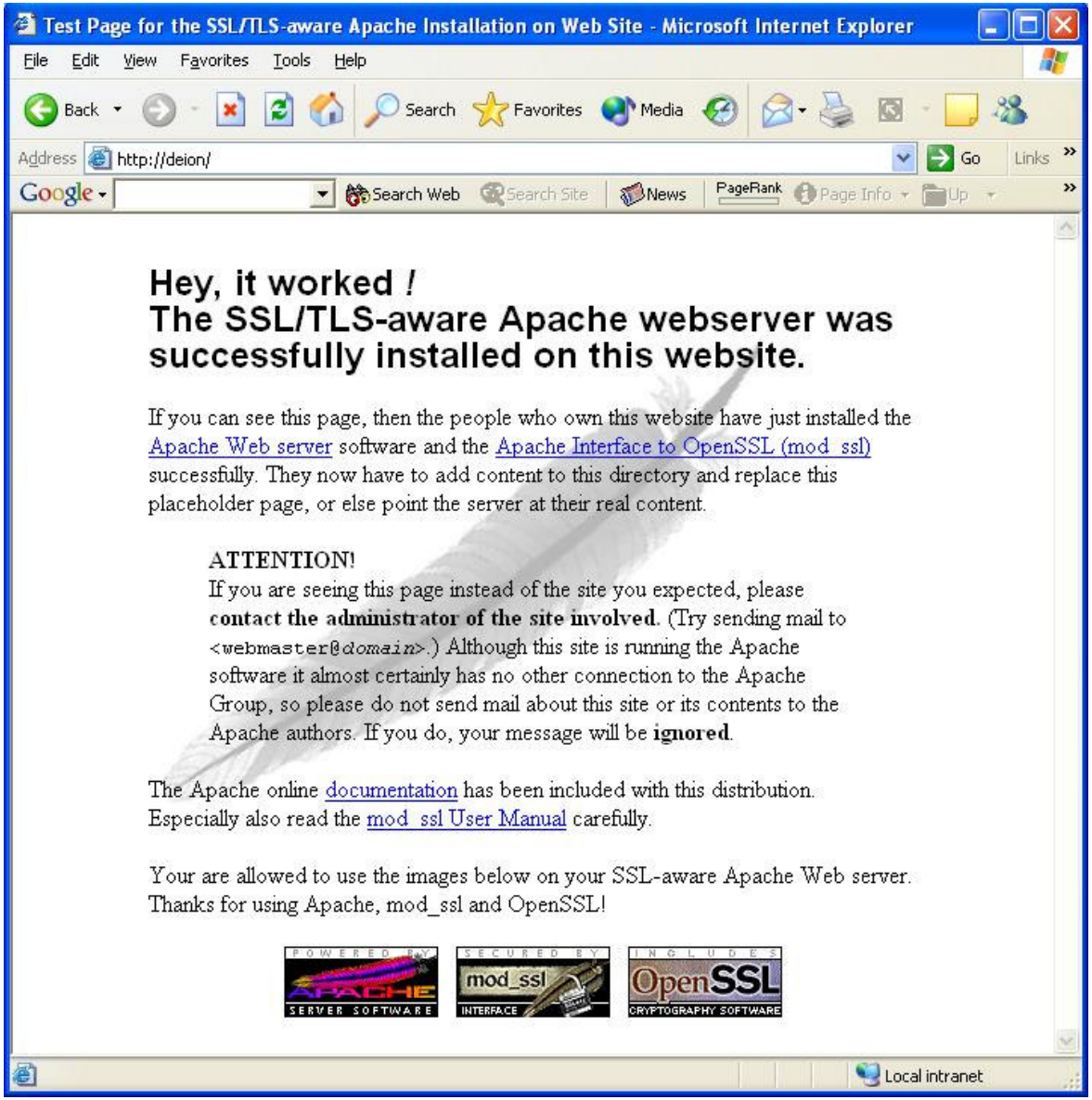
telnet host 80

HEAD / HTTP/1.0

Press ENTER twice

SWS Installation (Continued)

```
HTTP/1.1 200 OK
Date: Wed, 21 May 2003 09:44:06 GMT
Server: Apache/1.3.26 (OpenVMS) mod_jk/
.10 OpenSSL/0.9.6b
Content-Location: index.html_en
Vary: negotiate,accept-language
TCN: choice
Last-Modified: Tue, 20 May 2003 10:59:2
ETag: "1c0574-a71-3eca0a8a;3eca43d7"
Accept-Ranges: bytes
Content-Length: 2673
Connection: close
Content-Type: text/html
Content-Language: en
Expires: Wed, 21 May 2003 09:44:06 GMT
```


Test Page for the SSL/TLS-aware Apache Installation on Web Site - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://deion/
Go Links
Google Search Web Search Site News PageRank Page Info Up
Hey, it worked !
The SSL/TLS-aware Apache webserver was successfully installed on this website.
If you can see this page, then the people who own this website have just installed the Apache Web server software and the Apache Interface to OpenSSL (mod_ssl) successfully. They now have to add content to this directory and replace this placeholder page, or else point the server at their real content.
ATTENTION!
If you are seeing this page instead of the site you expected, please contact the administrator of the site involved. (Try sending mail to <webmaster@domain>.) Although this site is running the Apache software it almost certainly has no other connection to the Apache Group, so please do not send mail about this site or its contents to the Apache authors. If you do, your message will be ignored.
The Apache online documentation has been included with this distribution.
Especially also read the mod_ssl User Manual carefully.
Your are allowed to use the images below on your SSL-aware Apache Web server.
Thanks for using Apache, mod_ssl and OpenSSL!
POWERED BY APACHE SERVER SOFTWARE
SECURED BY mod_ssl INTERFACE
INCLUDES OpenSSL CRYPTOGRAPHY SOFTWARE
Local intranet

Configuring the Server

- apache$root:[conf]httpd.conf (text file)
  - Define server and virtual host configuration
  - Define loadable module configuration
  - Define document types and handlers
  - Define document directories and access control
  - Define access and error log files and formats
- Changes to httpd.conf require a restart
- See **http://<servername>/manual/** for on-line documentation or see comments in httpd.conf

Security

- On OpenVMS, servers and CGI scripts run under the APACHE$WWW user profile (unprivileged)
  - Server never runs as “root” like on UNIX (although the server eventually forks as “nobody”, certain functions execute as “root”, see TransferLog)
- Operations that require privileges are implemented as user-written system services
  - Bind to “privileged” socket (80), auth_openvms, ...
  - These services can be disabled
- SSL provides strong authentication and encryption capabilities

Security (Continued)

- Running a web server opens a window to your network - that's a web server's purpose in life
- Damage from web server security violations can simply be embarrassing or lead to large financial losses or potentially involve legal liability
- Security violations result from buggy software (more complex software, more bugs) and/or configuration mismanagement
- Server extensions (CGI, Perl, Java, etc.) add complexity and potential security holes

Crash Course
“How to” or “What is”

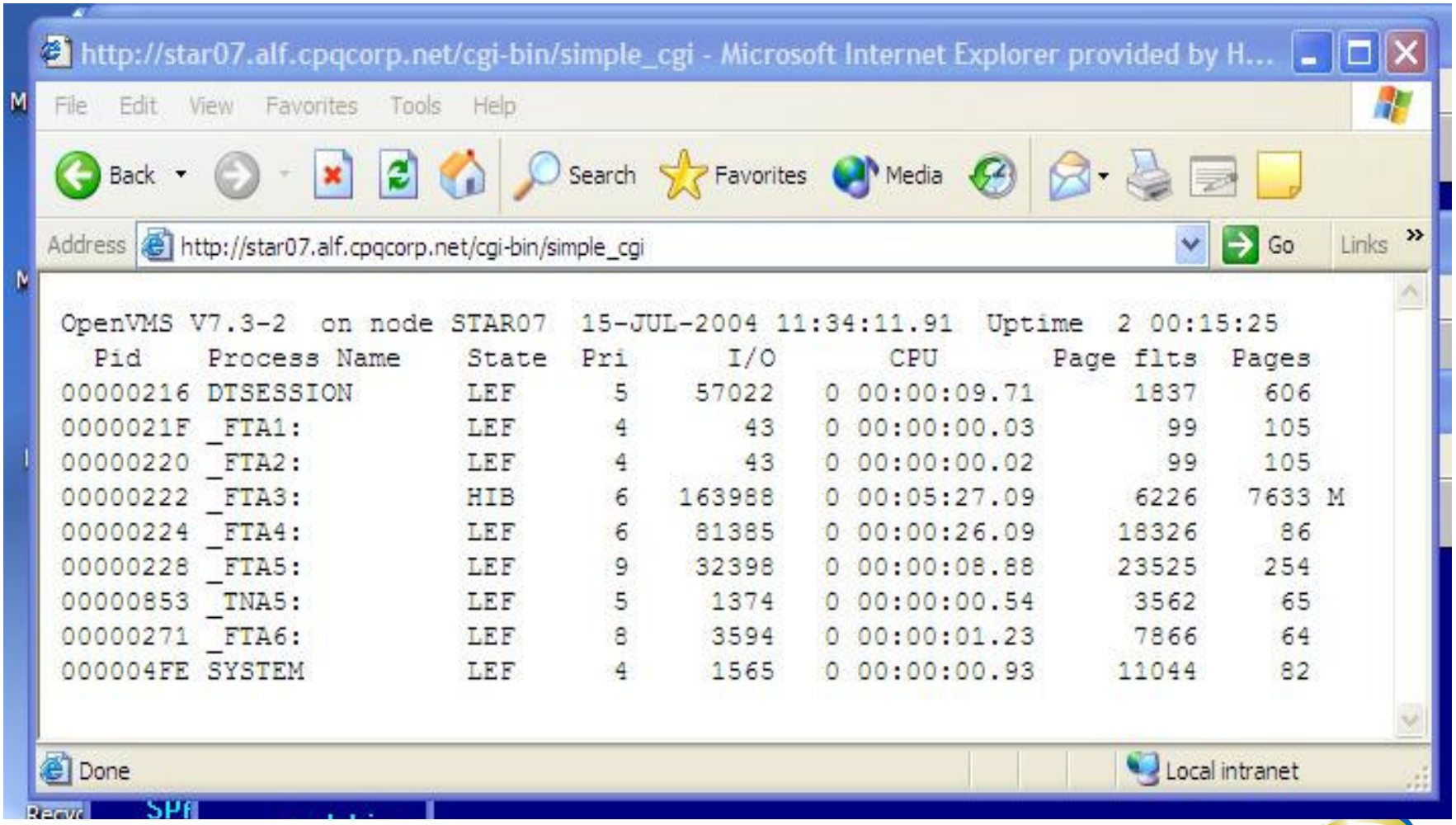
- DCL CGI
- OpenVMS Authorization
- Monitoring (mod_status, mod_info)
- Mod_dav
- Performance testing
- SWS_Java
- JSP/Servlets
- Mod_jk2

DCL CGI Example

- *The CGI (Common Gateway Interface) defines a way for a web server to interact with external content-generating programs, which are often referred to as CGI programs or CGI scripts. It is the simplest, and most common, way to put dynamic content on your web site. This document will be an introduction to setting up CGI on your Apache web server, and getting started writing CGI programs.*
- *Default scriptalias is in apache$root:[cgi-bin]*
- *Simple example:*

```
$ set noon
$!
$ write sys$output f$fao("!AS!/!/", "Content-type: text/plain")
$ show sys/int
$ exit
```

Simple_cgi output



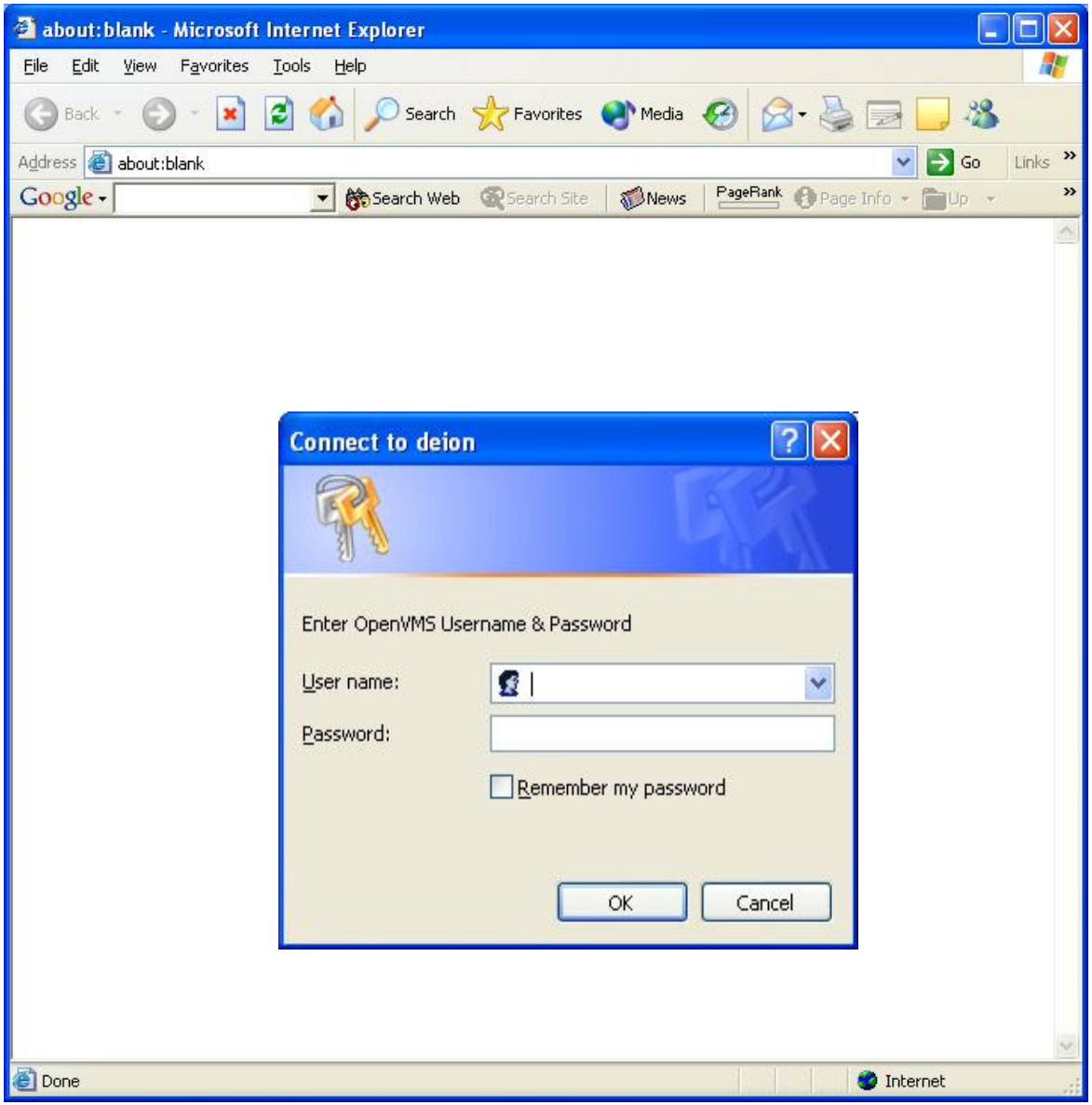
Mod_Auth_Openvms

- Authentication Using OpenVMS Usernames and Passwords
- This module supports authentication using the usernames and passwords contained in the system authorization file (SYS$SYSTEM:SYSUAF.DAT). You can optionally load the new module at startup
- Clear text because mod_auth_openVMS uses HTTP's basic authentication protocol
- Recommendation: Use mod_auth_openvms with a SSL connection to protect usernames and password

Edit apache$root:[conf]httpd.conf

- Add (SWS 2.0)

```
LoadModule auth_openvms_module   /apache$common/modules/mod_auth_openvms.exe
<Directory "/apache$common/htdocs">
    AuthType Basic
    AuthName "OpenVMS authentication"
    AuthOpenVMSUser On
    require valid-user
    Options Indexes FollowSymLinks Multiviews
 AllowOverride None
#
# Or you Auth* commands can be in an .htaccess file on a directory
# by directory, if you set “AllowOverride AuthConfig”
Order allow,deny
    Allow from all
</Directory>
```


about:blank - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address about:blank
Go Links
Google Search Web Search Site News PageRank Page Info Up
Connect to deion
Enter OpenVMS Username & Password
User name:
Password:
Remember my password
OK
Cancel
Done
Internet

Mod_status

- *The Status module allows a server administrator to find out how well their server is performing. A HTML page is presented that gives the current server statistics in an easily readable form. If required this page can be made to automatically refresh (given a compatible browser). Another page gives a simple machine-readable list of the current server state.*
- *The details given are:*
- The number of children serving requests
- The number of idle children
- The status of each child, the number of requests that child has performed and the total number of bytes served by the child (*)
- A total number of accesses and byte count served (*)
- The time the server was started/restarted and the time it has been running for
- Averages giving the number of requests per second, the number of bytes served per second and the average number of bytes per request (*)
- The current percentage CPU used by each child and in total by Apache (*)
- The current hosts and requests being processed (*)

Edit apache$root:[conf]httpd.conf

```
<Location /server-status>
    SetHandler server-status
    Order deny,allow
    Deny from all
#     Allow from .your_domain.com
    Allow from all
</Location>
#
ExtendedStatus On
```

http://star07/server-status Part 1

Apache Server Status for star07.alf.cpqcorp.net

Server Version: Apache/1.3.26 (OpenVMS) mod_perl/1.25
Server Built: Sep 25 2002 11:51:51
Current Time: Thursday, 15-Jul-2004 14:21:09 EDT
Restart Time: Thursday, 15-Jul-2004 14:13:06 EDT
Parent Server Generation: 1
Server uptime: 8 minutes 3 seconds
Total accesses: 104 - Total Traffic: 260 kB
CPU Usage: u18.57 s0 cu0 cs0 - 3.84% CPU load
.215 requests/sec - 551 B/second - 2560 B/request
19 requests currently being processed, 1 idle servers

KKKKKWKKRKKKRKKW_SSS.....
.....

Scoreboard Key:
"_" Waiting for Connection, "**S**" Starting up, "**R**" Reading Request, "**W**" Sending Reply, "**K**" Keepalive (read), "**D**" DNS Lookup, "**L**" Logging, "**G**" Gracefully finishing, "**.**" Open slot with no current process

http://star07/server-status Part 2

Extend status for star07.alf.cpqcorp.net

```
Srv PID Acc     M CPU SS Req Conn ChildSlot   Host              VHost             Request
0-1 89a 1/11/11 K 1.46 1 2169 0.9 0.02 0.02 16.113.41.17 star07.alf.cpqcorp.net GET /cgi-bin/simple_cgi HTTP/1.1
1-1 89b 1/17/17 K 1.69 1 2411 0.9 0.05 0.05 16.113.41.17 star07.alf.cpqcorp.net GET /index.html HTTP/1.1
2-1 89c 1/7/7   K 1.19 1 3669 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /testing/image.jpg HTTP/1.1
3-1 89d 1/10/10 K 1.22 1 3467 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /testing/image.jpg HTTP/1.1
4-1 89e 1/11/11 K 1.57 1 1830 0.9 0.02 0.02 16.113.41.17 star07.alf.cpqcorp.net GET /cgi-bin/simple_cgi HTTP/1.1
5-1 8a4 9/11/11 W 1.05 1 0 84.4 0.09 0.09 16.113.41.17 star07.alf.cpqcorp.net GET /server-status HTTP/1.1
6-1 8a7 1/7/7   K 1.39 1 2679 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /index.html HTTP/1.1
7-1 8ac 1/7/7   K 1.26 1 3910 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /index.html HTTP/1.1
8-1 8ad 0/6/6   R 1.06 1 242 0.0 0.01 0.01 ? ? ..reading..
9-1 8b1 1/5/5   K 1.42 1 2156 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /image.jpg HTTP/1.1
10-1 8b2 1/5/5  K 1.11 1 1301 0.9 0.01 0.01 16.113.41.17 star07.alf.cpqcorp.net GET /cgi-bin/simple_cgi HTTP/1.1
Srv Child Server number - generation
PID OS process ID
Acc Number of accesses this connection / this child / this slot
M Mode of operation
CPU CPU usage, number of seconds
SS Seconds since beginning of most recent request
Req Milliseconds required to process most recent request
Conn Kilobytes transferred this connection Child Megabytes transferred this child
Slot Total megabytes transferred this slot
```

Mod_info

- Provides a comprehensive overview of the server configuration

```
<Location /server-info>
    SetHandler server-info
    Order deny,allow
    Deny from all
#    Allow from .your_domain.com
    Allow from all
</Location>
```

http://star07/server-info

Apache Server Information

Server Settings, MOD_PERL.C, MOD_SETENVIF.C, MOD_SO.C, MOD_UNIQUE_ID.C, MOD_AUTH.C, MOD_ACCESS.C, MOD_PROXY.C, MOD_REWRITE.C, MOD_ALIAS.C, MOD_USERDIR.C, MOD_ACTIONS.C, MOD_IMAP.C, MOD_ASIS.C, MOD_OSUSCRIPT.C, MOD_CGI.C, MOD_DIR.C, MOD_AUTOINDEX.C, MOD_INCLUDE.C, MOD_INFO.C, MOD_STATUS.C, MOD_NEGOTIATION.C, MOD_MIME.C, MOD_LOG_CONFIG.C, MOD_DEFINE.C, MOD_ENV.C, HTTP_CORE.C

Server Version: Apache/1.3.26 (OpenVMS) mod_perl/1.25
Server Built: Sep 25 2002 11:51:51
API Version: 19990320:13
Run Mode: standalone
User/Group: APACHE$WWW(12582913)/192
Hostname/port: star07.alf.cpqcorp.net:80
Daemons: start: 5 min idle: 5 max idle: 10 max: 20
Max Requests: per child: 0 keep alive: on max per connection: 100
Threads: per child: 0
Excess requests: per child: 0
Timeouts: connection: 300 keep-alive: 15
Server Root: /apache$root
Config File: conf/httpd.conf
PID File: logs/httpd.pid
Scoreboard File: logs/apache_runtime_status

Module Name: MOD_PERL.C

.....

MOD_DAV (Distributed Authoring and Versioning)

- DAV is a set of extensions to the HTTP protocol that allows users to collaboratively edit and manage files on remote web servers using DAV-enabled client applications. MOD_DAV is an Apache module that provides DAV capabilities (RFC 2518) for the Apache web server
- Poor man's Pathworks
- Web Folders are folders that you can use like a local or network drive via Microsoft windows.

Mod_dav Example Setup

- Create directory

  $ create/dir/owner=apache$www –

  Apache$common:[myproject]

- Add load modules httpd.conf

  LoadModule dav_module modules/mod_dav.exe

  LoadModule dav_fs_module modules/mod_dav_fs.exe

- Add locking database file to httpd.conf

  DocumentRoot "/apache$common/htdocs"

  DAVLockDB /apache$common/myproject/lock.db

- Add an alias and directory

  Alias /myproject "/apache$common/myproject"

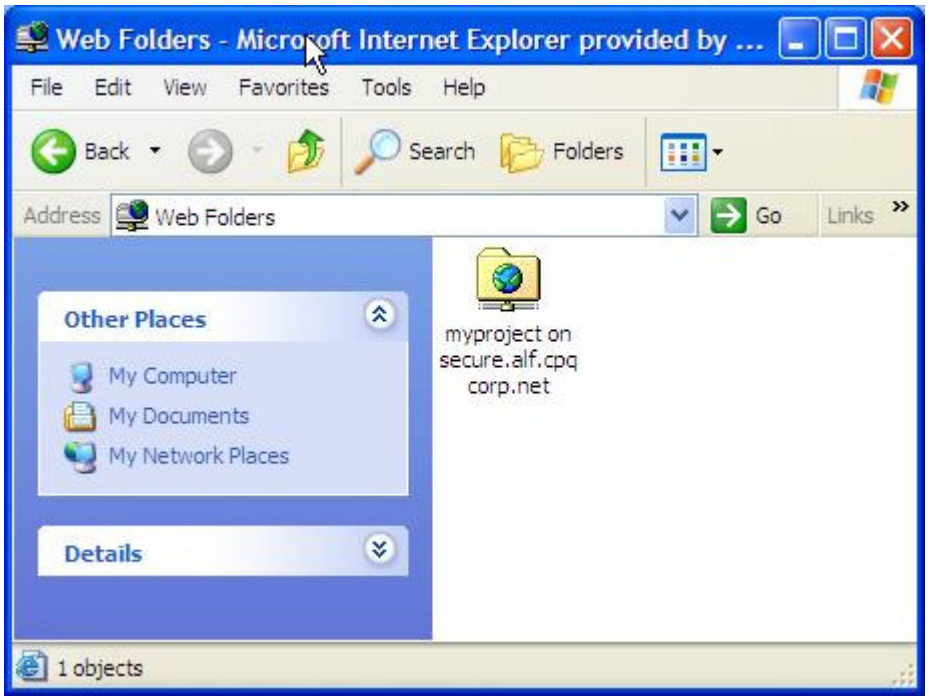
Mod_dav Setup (Continue)

```
<Directory /apache$common/myproject>
    AuthType Basic
    AuthName "OpenVMS authentication"
    AuthOpenVMSUser On
    require valid-user
  AllowOverride None
  DAV On
  Options Indexes
  Order allow,deny
#Example of a default read only access for general user community.
    Allow from all
    <Limit HEAD GET POST OPTIONS PROPFIND>
       Allow from all
     </Limit>
    <Limit MKCOL PUT DELETE LOCK UNLOCK COPY MOVE PROPPATCH>
        Deny from all
    </Limit>
  require valid-user
</Directory>
```

Use Internet Explorer…

- Run Internet Explorer and select File/Open. Select "Open as web folder" and enter the URL of the DAV folder (for example: http://your-server/webdav/). Internet Explorer will open your DAV folder and display its contents. In addition, Windows Explorer may now show a Web Folders folder that you can use like a local or network drive.
- In our example:
  - http://hostname/myproject

Just another folder



Performance Testing Hints

- For a quick test - Apache$common:[bin]ab.exe
  - **ab** is a tool for benchmarking the performance of your Apache HyperText Transfer Protocol (HTTP) server. It does this by giving you an indication of how many requests per second your Apache installation can serve.
  - Sample command for testing 5 con-current users, each requesting “index.html” 50 times.

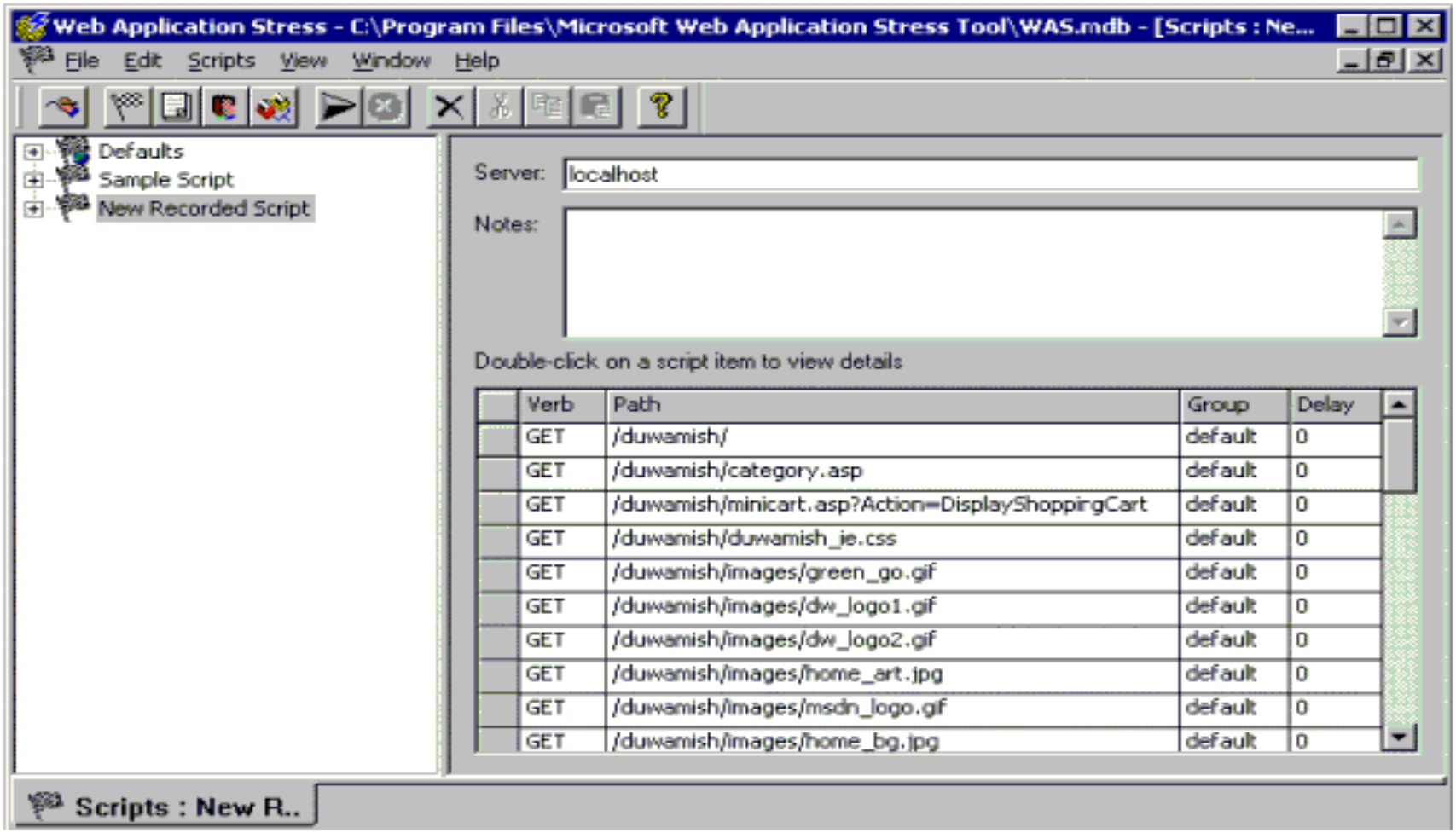
$ ab:==$apache$common:[bin]ab

$ ab -c 5 -n 500 http://10.0.11.222/index.html

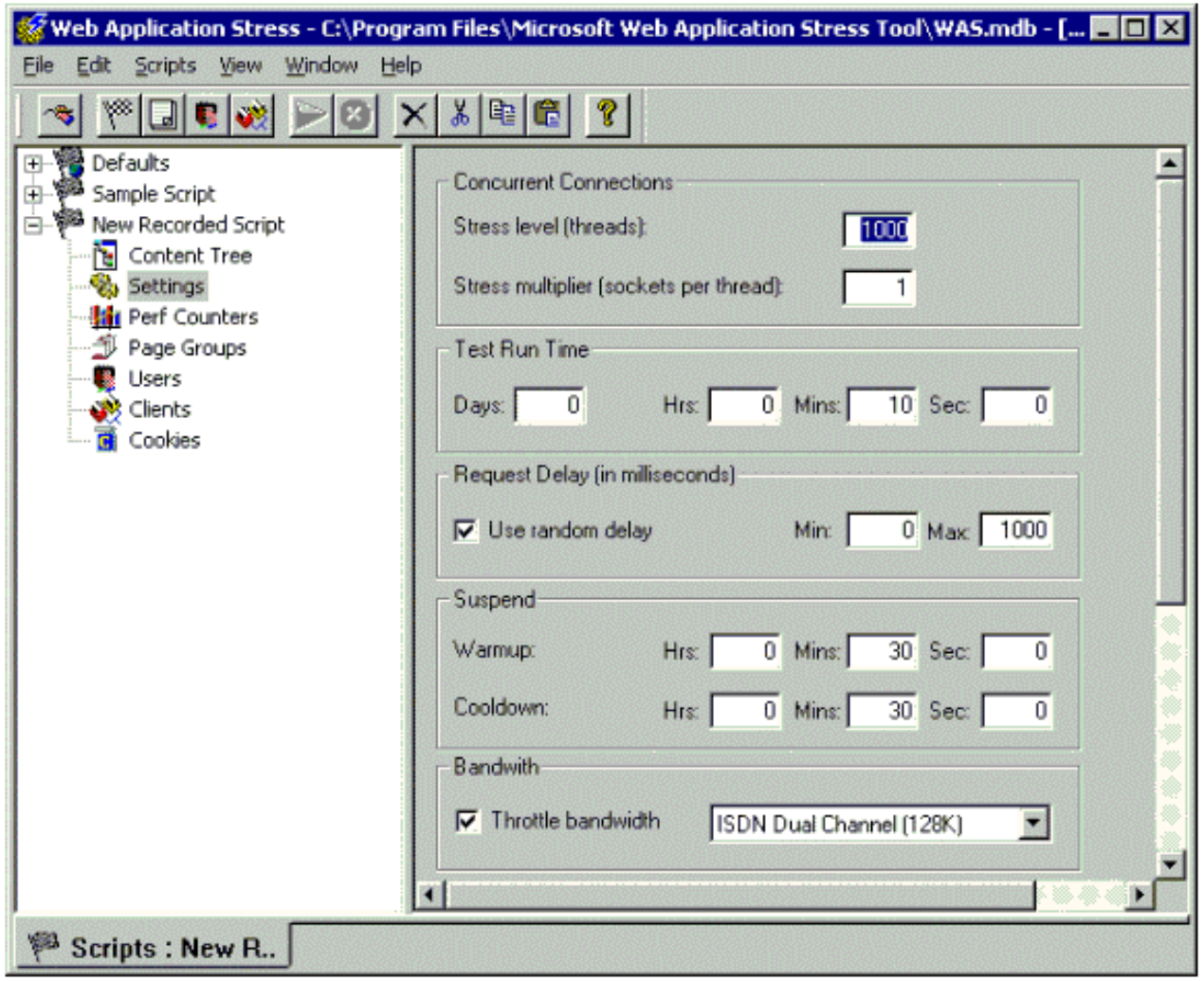
Performance Testing Hints

- I use a free Microsoft tool called WAS
  - Web Application Stress Tool
    - The Microsoft WAS web stress tool is designed to realistically simulate multiple browsers requesting pages from a web site. You can use this tool to gather performance and stability information about your web application. This tool simulates a large number of requests with a relatively small number of client machines. The goal is to create an environment that is as close to production as possible so that you can find and eliminate problems in the web application prior to deployment.
  - Supports
    - Keepalive, cookies, user thinking time (delay's between requests), recording of a session…
    - Most browser requests come from the Windows…

Sample Test Script



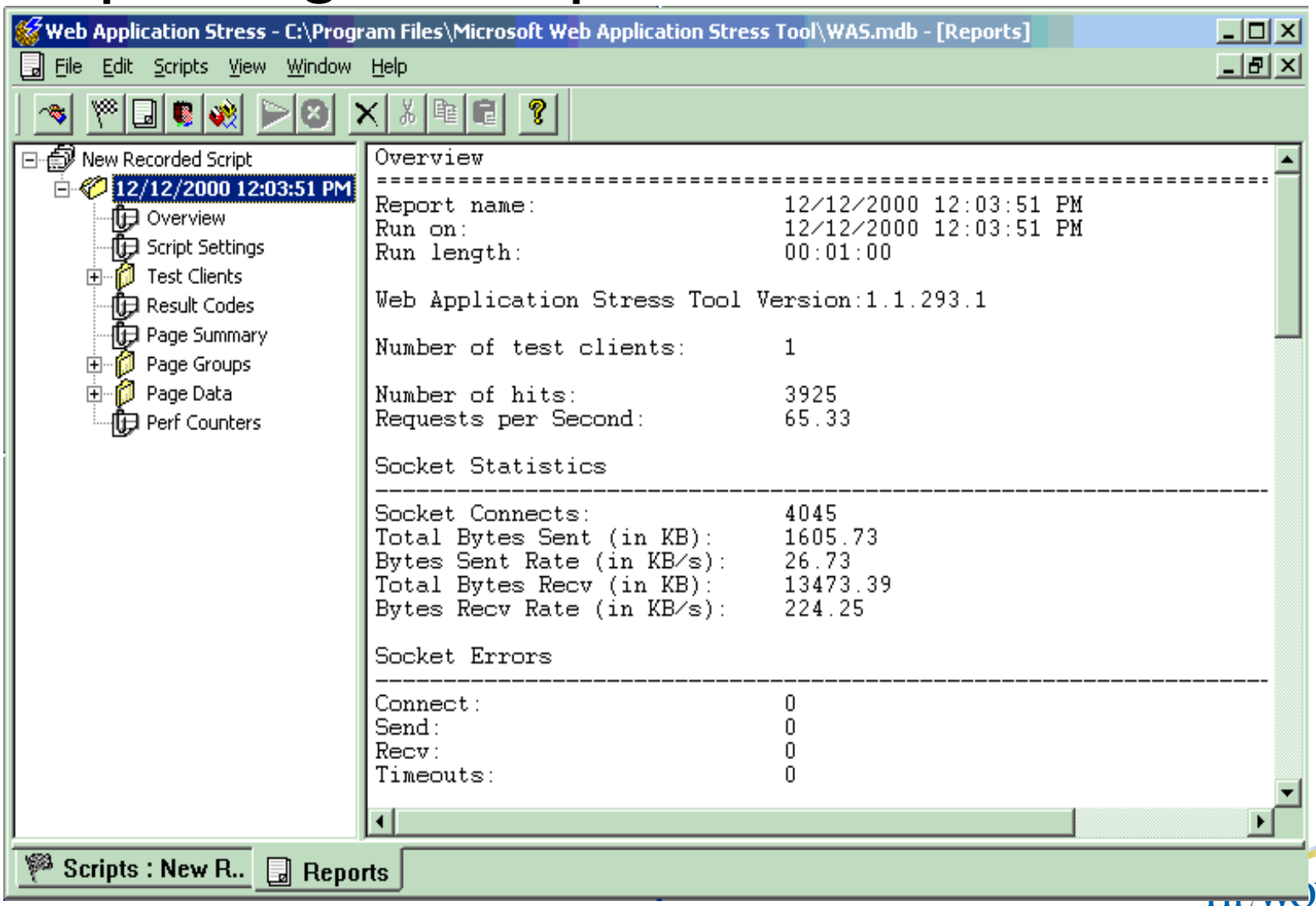
Adjust Script Settings



For the best results

- Don't expect a high number of con-current users with zero think time (use the random delay field)
- Don't expect a high number of con-current users if you are using keepalive connections
  - Think about it there needs to be a worker for each connection ;-)
- Total Concurrent Requests = Stress level (threads) x Stress multiplier (sockets per thread) = Total Number Sockets
- http://www.microsoft.com/technet/itsolutions/ecommerce/maintain/optimize/d5wast_2.mspx

Reporting Example



SWS_Java (Tomcat/Jakarta)

- Jakarta is the "overall" project for many subprojects.
- Tomcat Java engine that is the official reference implementation for the Java servlet and JavaServer pages technologies. The Java Servlet and JavaServer pages specifications are developed by Sun under the Java community process.
- Tomcat is developed in an open and participatory environment and released under the Apache software license.

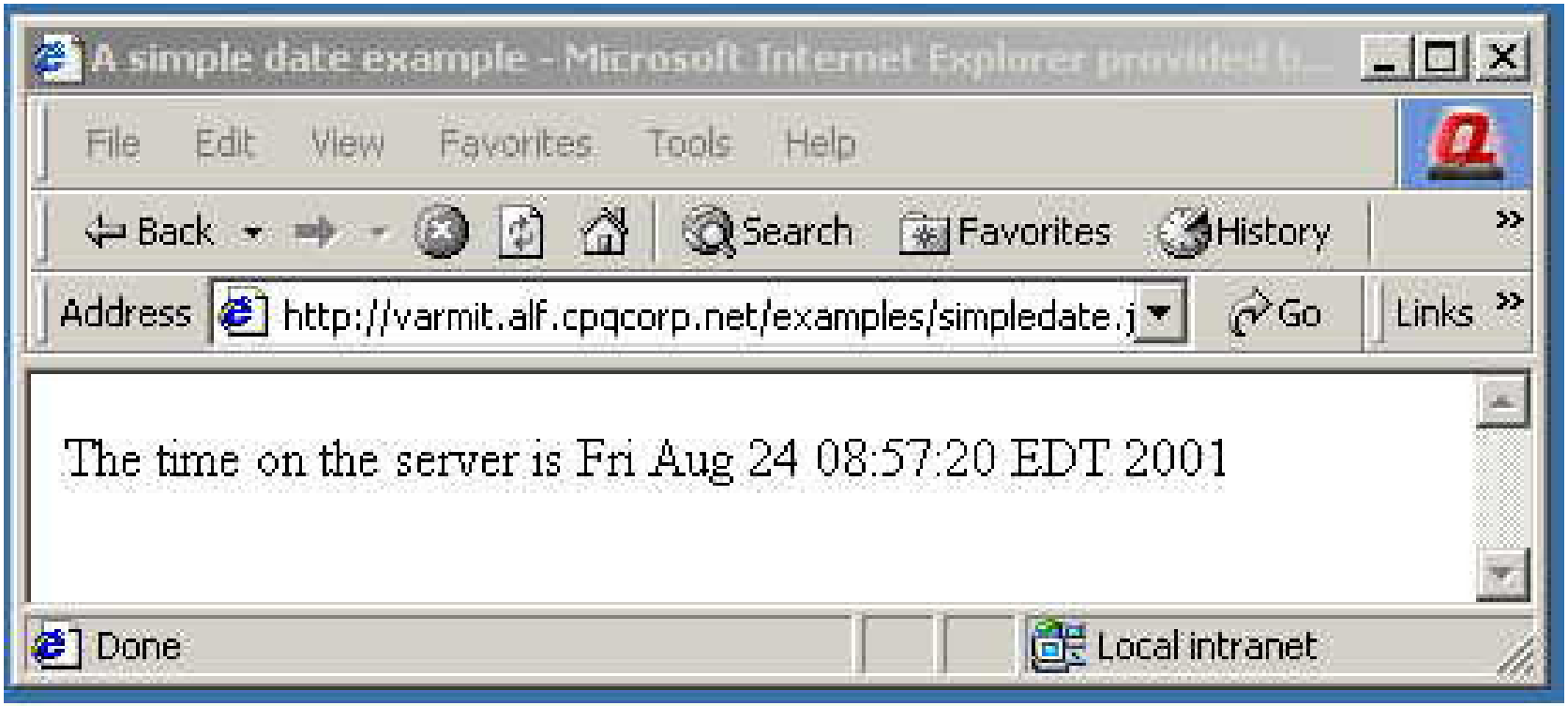
What is a Java Servlet Page (JSP)

- JavaServer Pages technology uses XML-like tags and scriptlets written in the Java programming language to encapsulate the logic that generates the content for the page.
- Separation of form and function.
  - Function (Servlets, Java Beans, EJB).
    - Java programmer can code develop a library of dynamic functions and features.
  - Form.
    - Web designer concentrated on the design layout of the static HTML page, and add dynamic features with the library.

Simple JSP Example

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML
4.0 Final//EN">
<HTML>
<HEAD>
<TITLE>A simple date example</TITLE>
</HEAD>
<BODY COLOR=#ffffff>
The time on the server is
<%= new java.util.Date() %>
</BODY>
</HTML>
```

Simple Date – Browser Output



What are Servlets?

- Servlets are programs written in Java to extend the functionality of HTTP servers
- Replacement for CGI scripts and programs
  - Servlets are faster and scale with multiprocessors
  - User Session Tracking built in!
  - Cross platform (hardware and web server)
- Applet is to client as Servlet is to server
- Supported by all major web servers
- Its Java!

Hello.java - Servlet Example

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class Hello extends HttpServlet
{
   public void doGet (HttpServletRequest request,
                      HttpServletResponse response)
      throws ServletException, IOException
      {
         PrintWriter out;
         String title = "Example Java Servlet";
```

Hello.java (Continued)

```
// set content type and other response header fields first
        response.setContentType("text/html");

        // then write the data of the response
        out = response.getWriter();

        out.println("<HTML><HEAD><TITLE>");
        out.println(title);
        out.println ("</TITLE></HEAD><BODYbgcolor=\"#FFFFFF\">");
        out.println("<H1>" + title + "</H1>");
        out.println ("<H2> Congratulations, HelloWorld Servlet is working<br>");
        out.println("</BODY></HTML>");
        out.close();
        }
}
```


Example Java Servlet - Microsoft Internet Explorer provided by Compaq Computer Corporation
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://varmit.alf.cpqcorp.net/examples/servlet/Hello
Go Links
Example Java Servlet
Congratulations, HelloWorld Servlet is working!
Done
Local intranet

Web Server Adapters
Mod_jk2

- Web server adapter to sit in Apache and redirect requests to Tomcat.
  - *.jsp or servlet/ requests are redirected to Tomcat
  - *.html (non-Java requests) are served by Apache
  - Each layer can add additional information.
  - Jk2 library makes it easier to support both Apache 1.3.X and Apache 2.x.x
  - Supports other web servers
  - Load Balance support
  - Workers2.properties
  - AJP v1.2 and V1.3 protocol

  Browser -> Apache -> Mod_jk2 -> Tomcat jsp/servlet/html

  Browser <- Apache <- Mod_Jk2 <- Output from Tomcat
- **http://jakarta.apache.org/tomcat/tomcat-4.1-doc/jk2/index.html**

Worker2.properties

```
[lb:lb]
info=Default load balancer.
# Example socket channel, override port and host.
[channel.socket:localhost:8009]
port=8009
host=127.0.0.1
group=lb
# define the worker
[ajp13:localhost:8009]
channel=channel.socket:localhost:8009
# Uri mapping
[uri:/examples/*]
group=lb
#worker=ajp13:localhost:8009
[status:]
info=Status worker, displays runtime informations
[uri:/jkstatus/*]
info=Display status information and checks the config file for changes.
group=status:
```

More Information

- CSWS web site
  - http://h71000.www7.hp.com/openvms/products/ips/apache/csws.html
- OpenVMS eBusiness technologies
  - http://h71000.www7.hp.com/ebusiness/technology.html
- Apache Software Foundation
  - http://www.apache.org/
- PHP: Hypertext Processor http://www.php.net/

  MySQL http://www.mysql.com/
- phpMyAdmin to manage MySQL
  - http://www.phpmyadmin.net/

More Information (Support)

- Open Source Community (Of course ;-)
- CSC support is included with the standard OpenVMS support agreement
- Supported & Maintained by OpenVMS Engineers
- We have an e-Business lab where you can test your applications and evaluate the OpenVMS e-Business and Internet infrastructure in a secure hardware and software environment
- We offer customized two-day Architectural Workshops to help you explore the possibilities for re-engineering your enterprise to match the challenges posed by the advent of business on and over the Internet.
- Or Email me at powell.hazzard@hp.com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