POWERED BY HP...
HPe3000

PROGRAMMING AND POSIX

Steve Hoogheem

Hewlett-Packard Company

steve_hoogheem@hp.com

HEWLETT PACKARD

POWERED BY HP...
HPe3000

Contents

HEWLETT PACKARD

Getting Started

- Logon:

  :hello <user>.<account>

- Enter the POSIX shell:

  :sh **if HPPXUDC.PUB.SYS UDC set**

  or

  :xeq sh.hpbin.sys -L

- Exit the POSIX shell:

  > exit

A Simple Program and A CGI Program

- A Simple Program
  - Create the file
  - Compile and link
  - Run it

- A CGI Program
  - Create the file
  - Compile and link
  - Test it
  - Run it from a web browser

A Simple Program - 1

- Create the source file:

> cat >hw.c **Enter/Return to start new line**

```
#include <stdio.h>   /* printf() */

main()
{
     printf("hello world\n");
}
:eod
```

or CTRL-Y to end

or

> vi hw.c

POWERED BY HP...
HP e3000

A Simple Program - 2

- Compile and link the source file:

```
> c89 -o hw -D_POSIX_SOURCE hw.c
```

- Run the program:

```
> hw
  hello world
```

HEWLETT PACKARD

A CGI program - 1

- Edit the source file:

```
> cp hw.c hwcgi.c
> vi hwcgi.c
#define _POSIX_SOURCE
#include <stdio.h>

main()
{
        printf("Content-type: text/plain\n\n");
        printf("hello world\n");
}
```

- Compile and link the program:

```
> c89 -o hwcgi  hwcgi.c
```

POWERED BY HP...
HPe3000

A CGI program - 2

- Test the CGI program:

```
> echo foo | hwcgi | cat
Content-type: text/plain
hello world
```

- Copy CGI program to cgi-bin directory:

```
> cp hwcgi /APACHE/PUB/cgi-bin
```

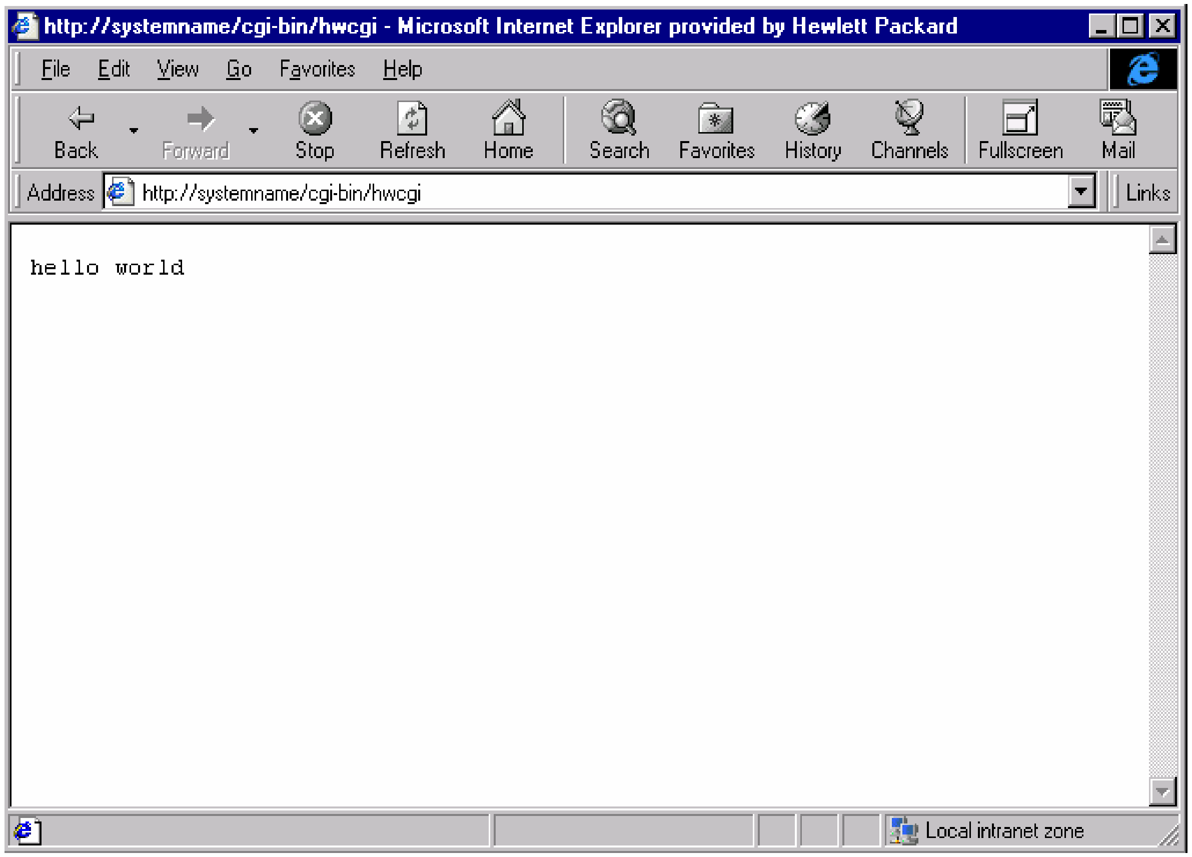
- Point browser at:

  http://systemname/cgi-bin/hwcgi

HEWLETT PACKARD

POWERED BY HP...
HPe3000

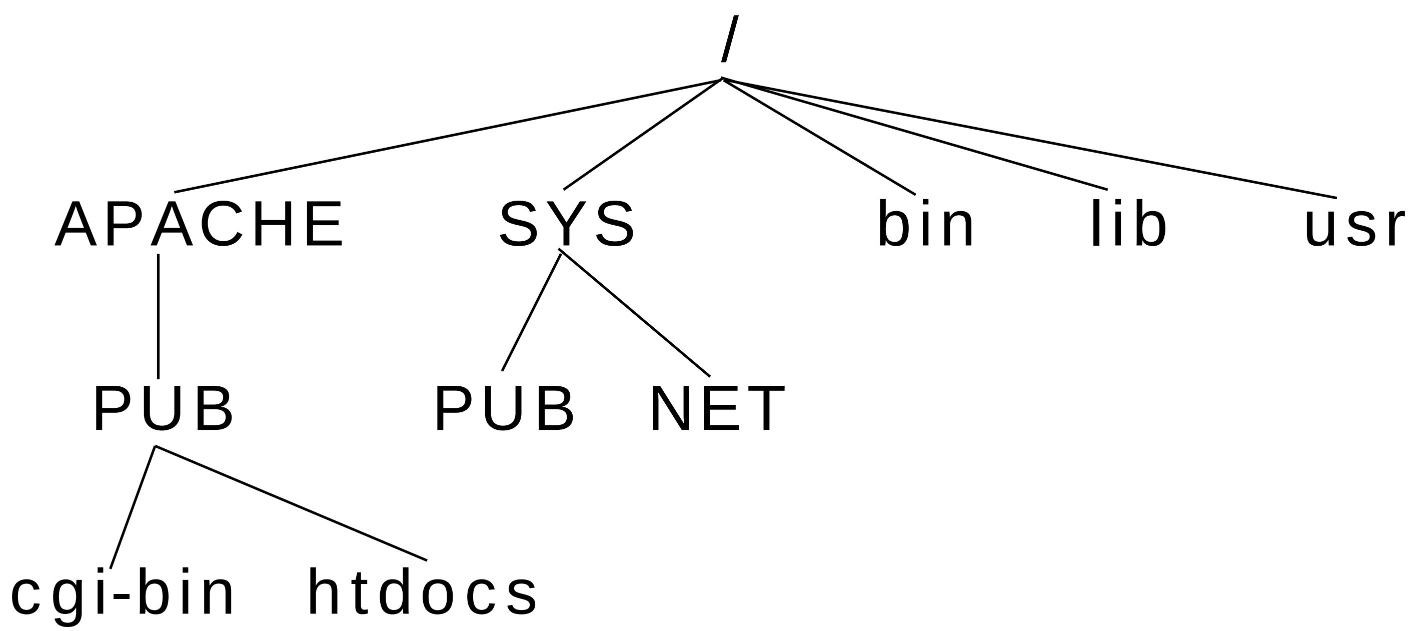
A CGI program - 3


http://systemname/cgi-bin/hwcgi - Microsoft Internet Explorer provided by Hewlett Packard
File Edit View Go Favorites Help
Back Forward Stop Refresh Home Search Favorites History Channels Fullscreen Mail
Address http://systemname/cgi-bin/hwcgi
Links
Local intranet zone

```
hello world
```

HEWLETT PACKARD

The Hierarchical File System (HFS)



Absolute path: /APACHE/PUB/cgi-bin/hwcgi

Relative path: ./hwcgi

POWERED BY HP...
HPe3000

Working with Files - A Review

- Naming a file
- File Types - bytestream vs. fixed record
- Creating and listing files - cat >, vi, ls
- Viewing and printing a file - more, cat, lp
- Copying, renaming, and removing files - cp, mv, rm
- Displaying and changing a file’s permissions and ownership - chmod, chown, chgrp

HEWLETT PACKARD

POWERED BY HP... HPe3000

Organizing Files with Directories - A Review

- Displaying your current directory - pwd
- Absolute and relative pathnames
- Changing to a different directory - cd
- Creating a new directory - mkdir
- Removing a directory - rmdir

HEWLETT PACKARD

Linking with System Libraries

- Libc is included in link by default

```
> c89 -o hwcgi hwcgi.c
```

- System libraries located in /lib and /usr/lib
  - **libc, libsvipc are in /lib**
  - **libsocket are in /usr/lib**
- System libraries exist in both archive and shared form (as of MPE 6.0). During link,
  - **archive library (.a suffix) merged into program**
  - **shared library (.sl suffix) is NOT merged**

Linking with Libraries - Syntax

- -lfoo means link with library libfoo.a
  - **-lc is included in link by default**
- -Lpath tells where library is located
  - **-L/lib -L/usr/lib is included in link by default**

- Link with libsvipc archive library

```
> c89 -o hwcgi hwcgi.c -lsvipc
```

- Link with libsvipc shared library

```
> c89 -o hwcgi hwcgi.c -WL,XL=/lib/libsvipc.sl
```

  - **-WL switch specifies shared library**
  - **must specify full pathname**

Creating an Archive Library - 1

- Write new helloworld() function:

```
> cat >helloworld.c
#define _POSIX_SOURCE
#include <stdio.h>

helloworld()
{
  printf("hello world\n");
}
```

```
> c89 -c helloworld.c
```

- Create the archive library:

```
> ar -rv libhw.a helloworld.o
```

Creating an Archive Library - 2

- Have our main program:

```
> cat >hwcgimain.c
#include <stdio.h>

extern void helloworld(void);

main()
{
   printf("Content-type: text/plain\n\n");
   helloworld();
}
```

```
> c89 -c -D_POSIX_SOURCE hwcgimain.c
```

- Link the program:

```
> c89 -o hwcgi hwcgimain.o -L. -lhw
```

  - **-L switch specifies library location (. is CWD)**

Creating a Shared Library

- Create the shared library:

```
> ld -b -o libhw.sl helloworld.o
```

- Link with the shared library:

```
> c89 -o hwcgi hwcgimain.o
                    -WL,cap=ph,XL=/APACHE/CGISRC/libhw.sl
```

  - **must specify full pathname**

POWERED BY HP...
HP e3000

Programming Review

- Create files - cat >, vi
- Compile C source code - c89
- Manage archive libraries - ar
- Create shared libraries - ld -b, c89 -b
- Link programs - ld, c89

HEWLETT PACKARD

POSIX Topics

- File Sharing
- Process Management
  - **fork**
  - **exec**
- InterProcess Communication
- Signals
- Sockets
- Error handling

POWERED BY HP...
HP e3000

File Sharing

- Duplicating file descriptors - dup & dup2
- File management - fcntl
  - Duplicate an existing file descriptor
  - Get & set file descriptor flags
  - Get & set file status flags
  - Record locking

HEWLETT PACKARD

Process Management - fork - 1

- pid_t fork(void);

```
 if ( (pid = fork()) < 0)
        perror("fork");
else if (pid == 0)              /* child */
{
        printf(“child: here\n”);
}
else  /* pid > 0 */             /* parent */
{
        printf(“parent: here\n”);
}
```

POWERED BY HP...
HPe3000

Process Management - fork - 2

- Compile & link sample program

```
> c89 -o forkt forkt.c
```

- Program & user must have PH capability
  - **c89 link adds PH capability by default to program**
  - **if -W option is used to add shared library,**
    must specify cap=ph

```
>c89 -o … -WL,cap=ph -W,XL=/lib/libsvipc.sl
```

- Run sample program

```
> forkt
child: here
parent: here
```

HEWLETT PACKARD

Process Management - exec

- 6 forms: execl, execve, execvp,
  execv, execve, execvp

```
if ( (pid = fork()) < 0)
    perrror("fork");
else if (pid == 0)                    /* child */
{
    if (execl("/bin/echo",
            "echo", "child:", "hello", "world", (char *) 0) < 0)
    perror("execl");
    printf("child: this never prints\n");
}
```

Process Management - execl

- Compile & link sample program

```
> c89 -o execlt execlt.c
```

- Run sample program

```
> execlt
child: hello world
parent: exiting
```

InterProcess Communication (IPC)

- Pipes
  - **pipe(fd[2])**
- FIFOs
  - **mkfifo(pathname)**
- Message queues
- Semaphores
- Shared memory

POWERED BY HP...
HPe3000

InterProcess Communication - pipes

- Pipes easy to demonstrate in shell:

```
> who am i
STEVE,CGI.APACHE@SYSTEMNAME  ldev5      TUE  1:04P
> who am I | cut -f1 -d' '
STEVE,CGI.APACHE@SYSTEMNAME
```

- int pipe(int filedes[2]);

POWERED BY HP...
HP e3000

Sockets

- InterProcess communciation across systems via socket address:
  - 32-bit IPv4 address
  - Internet or Unix (local)
  - Port number

- Functions

$$\begin{tikzcd}
\text{– Server: socket, bind, listen,} & \text{accept,} \arrow[d] & \text{read} \\
\text{– Client: socket,} & \text{connect,} & \text{write} \arrow[u]
\end{tikzcd}$$

HEWLETT PACKARD

Signals

- signal() & raise() are ANSI C, not POSIX.1
  - **Use sigaction() instead**
- Signal is generated, pending, delivered
  - **Signal not delivered if process is executing in system code; signal is delivered upon exit of system code**
- Process can:
  - **Ignore the signal**
  - **Execute a signal-handling function; process resumes where it was interrupted**
  - **Restore the default action of the signal**

Error Handling

- errno is a system global defined in <errno.h>
- Functions:
  - **char *strerror(int errnum);**
  - **void perror(const char *msg);**

```
if ( (fd = open(pathname, O_RDWR)) < 0)
{
        /* errno already set by open() */
        perror("functionX(): open()");
        return -1;
 }
```

POWERED BY HP...
HPe3000

Additional Programming Topics

- Debugging Your Application
- Shell Scripts
- make utility
- Development Tools
- GNU Tools
- Porting Wrappers

HEWLETT PACKARD

POWERED BY HP...
HPe3000

Debugging Your Application - 1

- Add printf() statements in your code
  - **use #ifdef DEBUG compile directive**

- Add perror() statements in your code
  - **use #ifdef PRINT_ERROR compile directive**

```
   if ( (fd = open(pathname, O_RDWR)) < 0)
   {
          /* errno already set by open() */
#if defined(DEBUG) || defined(PRINT_ERROR)
          sprintf(msg, "functionX(): open(%s, O_RDWR)”, pathname);
          perror(msg);
#endif
          return -1;
    }
```

HEWLETT PACKARD

Debugging Your Application - 2

- perror() continued:

```
    if ( functionX(argv[1]) < 0)
    {
            /* errno already set by functionX() */
#if defined(DEBUG) || defined(PRINT_ERROR)
            sprintf(msg, "functionY(): functionX(%s)”, argv[1]);
            perror(msg);
#endif
            return -1;
     }
```

POWERED BY HP...
HPe3000

Debugging Your Application - 3

- MPE System Debugger

  > callci "run ./program ;debug"

- Symbolic debugger - xdb
  - use -g switch during compile

    > c89 -g ...
  - link with /SYS/LIB/XDBEND
    - first, as MANAGER.SYS:

      > cd /SYS/LIB; ln -s XDBEND end.o

    > c89 -o … /SYS/LIB/end.o

    > xdb -h program

HEWLETT PACKARD

Shell Scripts

- Automate steps with a shell script

```
> cat >hwcgi.sh
#!/bin/sh
c89 -c helloworld.c
ar -rv libhw.a helloworld.o
c89 -c hwcgimain.c
c89 -o hwcgi hwcgimain.o -L. -lhw
```

- Execute permission required to execute

```
> chmod u+x hwcgi.sh
> hwcgi.sh
```

- Special scripts: /etc/profile and .profile

Make utility

- Rebuilds only components which need rebuilding

```
> cat >Makefile
all: hwcgi

hwcgi: hwcgimain.o libhw.a
        $(CC) -o $@ hwcgimain.o -L. -lhw

libhw.a: helloworld.o
        $(AR) $(ARFLAGS) $@ $?
> make
```

- make -n to display commands without execution

Development Tools

- Terminal Emulaters on Windows
  - **Reflection - http://www.wrq.com/products/refprod.htm**
  - **Qterm - http://aics-research.com/qcterm/**
- Edit files from another system
  - **Samba - http: ://jazz.external.hp.com/src/, select Samba/iX**
- Development Environments
  - **Whisper Technology - http://www.whispertech.com/pstudio.htm**

GNU Tools

- Downloadable software from:
  http: ://jazz.external.hp.com/src/, select GNU
- Tools include:
  - **gcc - C compiler**
  - **gxx or g++ - C++ compiler**
  - **gdb - debugger (port in progress)**
  - **gmake - for building software**
  - **gzip, gunzip - file compression and decompression**
  - **cvs - Concurrent Version System for software control**

Porting Wrappers

- Downloadable software from:

  http: ://jazz.external.hp.com/src/#PortingWrappers

- Additional Functions:
  - **Error reporting: pmpeerror, strmpeerror**
  - **Mapped regions: mmap, mprotect, msync, munmap**
  - **Sockets enabled: fcntl, fstat, stat**
- Additional Libraries & Header Files
- Additional Commands:
  - **ld, nm, nohup**
  - **Command wrappers: ftp, ipcs, ipcrm, ping, xdb**

POWERED BY HP...
HPe3000

Error Handling with MPE Intrinsics

- _mpe_errno, _mpe_intrinsic are system globals defined in <errno.h>
  - **Requires _MPEXL_SOURCE compile directive to use**
- Porting Wrappers has functions pmpeerror() & strmpeerror() plus header file <mpeerrno.h>

```
#include <mpeerrno.h>
#pragma intrinsic      FCONTROL
    FCONTROL(_MPE_FILENO(fildes), 2, &dummy);
    if ( ( ccode_return = ccode() ) != CCE )
    {
         errno = EINVAL;
         mpe_errno = ccode_return;
         mpe_intrinsic = FCONTROL_INTRINSIC;
#if defined(DEBUG) || defined(PRINT_ERROR)
         pmpeerror("functionX(): FCONTROL(2)");
#endif
         return -1;
    }
```

HEWLETT PACKARD

POWERED BY HP...
HPe3000

Summary

- Getting Started
- A Simple Program and a CGI Program
- The Hierarchical File System (HFS)
- Files and Directories - A Review
- Creating and Linking with Libraries
- POSIX Topics
- Additional Programming Topics

HEWLETT PACKARD

POWERED BY HP... HPe3000

Additional Resources

- MPE/iX manuals:

  http://www.docs.hp.com

  – HP C/iX Library Reference Manual - function man pages
  – MPE/iX Developer's Kit Reference Manual - function man pages
  – MPE/iX Shell and Utilities User's Guide - commands, shell, vi, make
  – New Features of MPE/iX: Using the Hierarchical File System - commands

- Programming with examples:

  – **"Advanced Programming in the UNIX Environment" by W. Richard Stevens**

  http://www.kohala.com/start/apue.html

  - directory util/apue in Porting Wrappers contains Stevens' main header file and library

HEWLETT PACKARD

Additional Resources

- POSIX
  - **“POSIX Programmer's Guide” by Donald Lewine** **http://www.oreilly.com/catalog/posix/**
  - **“The POSIX.1 Standard - A Programmer’s Guide” by Fred Zlotnick**
  - **POSIX Specifications from IEEE - very detailed** **http://standards.ieee.org/catalog/posix.html#gen22**
- make
  - **“Managing Projects with make” by Andrew Oram and Steve Talbott**

    http://www.oreilly.com/catalog/make2/
  - **MPE vs. POSIX Functions and Commands**