Shells

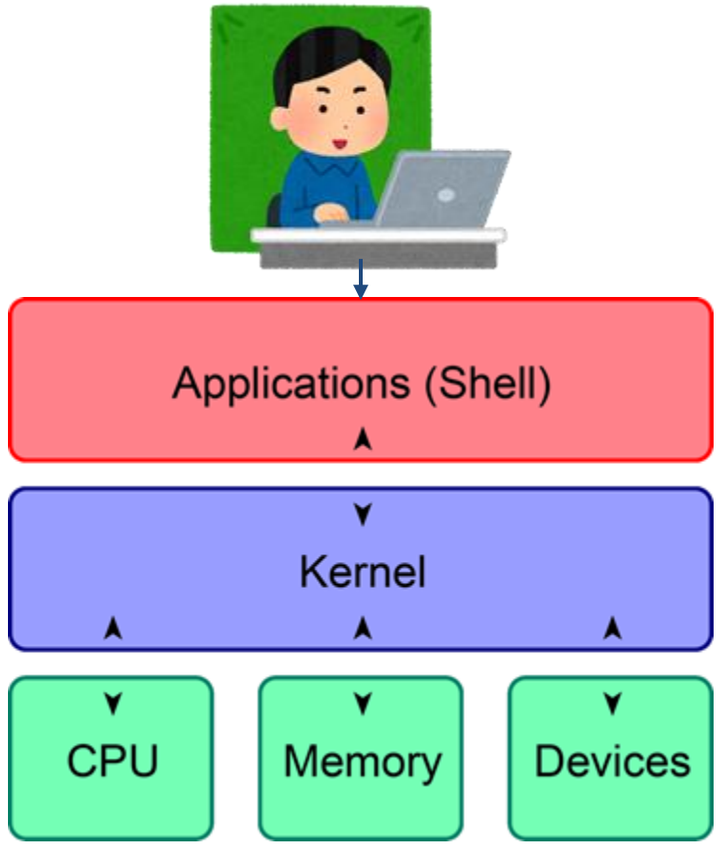
tsaimh (2022-2025, CC BY-SA)
lctseng (2019-2021, CC BY-SA)
? (1996-2018)

國立陽明交通大學資工系資訊中心
Information Technology Center, Department of Computer Science, NYCU

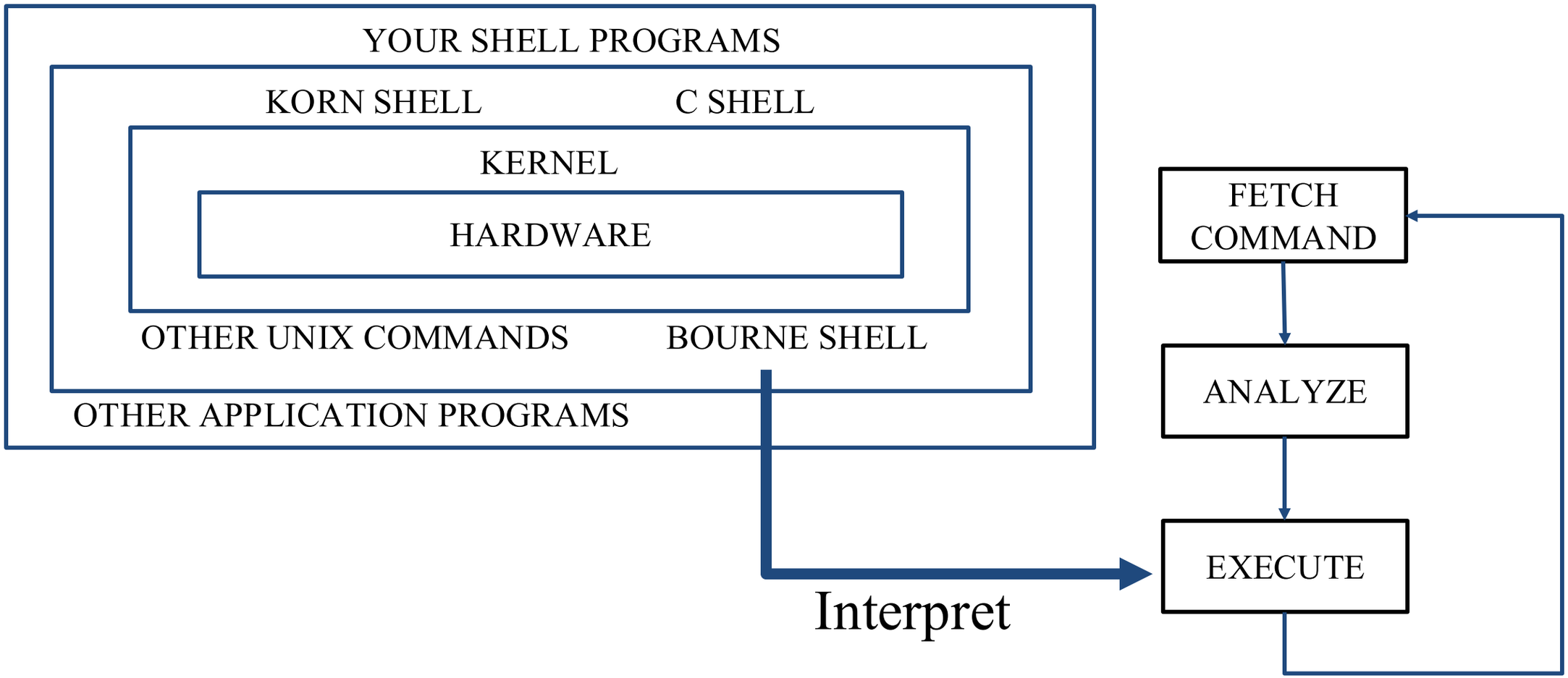
UNIX Kernel and Shell

- Interface to communicate with kernel
- Where you type commands

```
[Meng-Hsun Tsai@pts/37(alumni)][~] > date
Tue Aug 16 08:55:19 CST 2022
[Meng-Hsun Tsai@pts/37(alumni)][~] > pwd
/net/dcs/93/9317807
[Meng-Hsun Tsai@pts/37(alumni)][~] > whoami
tsaimh
[Meng-Hsun Tsai@pts/37(alumni)][~] >
```



UNIX Kernel and Shell (2)



The UNIX Shells

Shell	Originator	System Name in FreeBSD	Prompt
Bourne Shell **(In FreeBSD base)**	S. R. Bourne	/bin/sh	$
C Shell **(In FreeBSD base, Default for root)**	Bill Joy	/bin/csh	%
TENEX C Shell **(In FreeBSD base)**	Ken Greer	/bin/tcsh	>
Korn Shell	David Korn	(shells/ksh93)	$
Bourne-Again Shell **(Widely used)**	Brian J. Fox	(shells/bash)	$
Z Shell **(macOS default)**	Paul Falstad	(shells/zsh)	%

Windows Shell

- cmd.exe
  - First released in 1987
  - For Windows NT/Windows CE
  - Still used in modern Windows
- PowerShell
  - First released in 2006
  - To provide the same functionality as UNIX shells
  - Also has Linux/MacOS releases

Shell Startup Files

sh	/etc/profile	login shell, system wide
	~/.profile	login shell
	ENV	
csh	/etc/csh.cshrc	always, system wide
	/etc/csh.login	login shell, system wide
	~/.cshrc	always
	~/.login	login shell
	~/.logout	logout shell
	/etc/csh.logout	logout shell, system wide

Shell Startup Files (2)

tcsh	~/.tcshrc	login shell
	(csh startup files)	backward compatibility for csh
bash	/etc/profile ➔ ~/.bash_profile ➔ ~/.bash_login ➔ ~/.profile	login shell
	~/.bashrc	login shell
	BASH_ENV	

Bash Startup Files : https://www.gnu.org/software/bash/manual/html_node/Bash-Startup-Files.html

Shell Startup Files (3)

- A sample tcshrc for you to change your prompt
- Simplest install steps
  - Take a look at the content before running it

```
   $ fetch https://nasa.cs.nycu.edu.tw/sa/sample/.tcshrc.color -o
~/.tcshrc
   $ source ~/.tcshrc
```

```
tsaimh@bsd4:~ % fetch https://nasa.cs.nycu.edu.tw/sa/sample/.tcshrc.color -o ~/.tcshrc
/home/tsaimh/.tcshrc                                  861  B 7584 kBps    00s
tsaimh@bsd4:~ % source .tcshrc
[tsaimh@bsd4 ~ ]
```

Shell Environment Variables (1)

- Controlling shell behaviors
  - There are many environment variables that control the shell behavior
- To dump them:

```
$ env
```

- To get value:

```
$ echo $VARIABLE_NAME
$ echo ${VARIABLE_NAME}
$ echo "$PATH"
```

Shell Environment Variables (2)

- Useful Environment Variables

Variables	Description
`HOME`	User's home directory
`MAIL`	User's mailbox
`PATH`	Command search path

Variables and Strings Quotes

Char.		Purpose
sh	`var=value`	Assign value to variable
csh	`set var=value`	
`$var, ${var}`		Get shell variable
`` `cmd` ``		Substitution stdout
`'string'`		Quote character without substitution
`"string"`		Quote character with substitution

Variables and Strings Quotes (2)

Shell	sh	Csh
Commands	`$ varname=`/bin/date` $ echo $varname $ echo 'Now is $varname' $ echo "Now is $varname"`	`$ set varname=`/bin/date` $ echo $varname $ echo 'Now is $varname' $ echo "Now is $varname"`

Result	`Mon Aug 15 14:22:19 CST 2024`
	`Now is $varname`
	`Now is Mon Aug 15 14:22:19 CST 2024`	

Global Variables

- Use "env" command to display global variables
- Assignment

	Bourne Shell	C Shell
Local variable	`my=test` `current_month=`date +%m``	`set my=test` `set current_month=`date +%m``
Global variable	`export my=test` `export EDITOR=/usr/bin/ee`	`setenv my test` `setenv EDITOR /usr/bin/ee`

Shell Special Characters

- Reduce typing as much as possible

	Characters	Description
sh	*	Match any string of characters
	?	Match any single alphanumeric character
	[…]	Match any single character within []
	[!...]	Match any single character not in []
	~	Home directory

Shell Special Characters (2)

- Example: There are some files in current directory
  - test1, test2, test3, test4, test-5, testmess

	Command	Result
sh	`$ ls test*`	test1 test2 test3 test4 test-5 testmess
	`$ ls test?`	test1 test2 test3 test4
	`$ ls test[123]`	test1 test2 test3
	`$ ls test[!345]*`	test1 test2 test-5 testmess
	`$ ls ~`	List files under your home

Shell Special Characters (3)

Char.	Purpose	Example
#	Start a shell comment	`# this is a comment`
;	Command separator	`$ ls test*; ls test?`
&&	Executes the first command, and then executes the second if first command success (exit code=0)	`$ cd foo/bar && make install`
||	Executes the first command, and then executes the second if first command fail (exit code≠0)	`$ cp x y || touch y`

Shell Special Characters (4)

Char.	Purpose	Example

\	(1)Escape character
	(2)Command continuation indicator
		`$ touch test\*; ls test\*`
		`test*`
		`$ ls \`
		`> test*`

&	Background execution	`$ make buildworld &` `$ sleep 5 &`

Common Built-in Commands

SH	CSH	Description
`set/unset`		Set/Unset shell options and positional parameters
(empty)/`unset`	`set/unset`	Set/Unset a local variable
`export`	`setenv/unsetenv`	Set/Unset a global variable
`set`		Display shell variables (sh: local + global, csh: local)
`env`		Display global (environment) variables
(N/A)	`login, logout`	Login / Logout
`exit`		exit shell

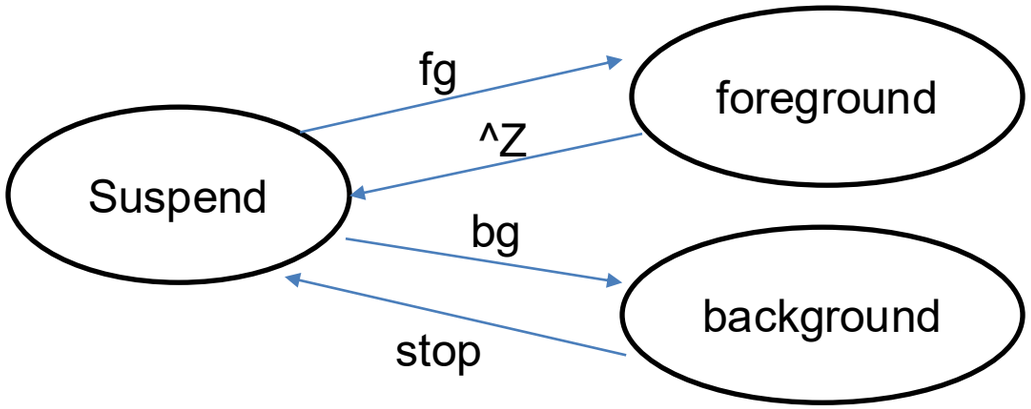
Common Built-in Commands (2)

SH	CSH	Description
(N/A)	`dirs`	print directory stack
(N/A)	`popd, pushd`	Pop/push directory stack
`echo`		write arguments on stdout
`alias/unalias`		command aliases
`fg, bg`		Bring a process to foreground/background (e.g. sleep 5 &)
`jobs`		List active jobs (with job numbers)
`%[job no.]`		Bring a process to foreground (e.g. %1)

```
tsaimh@linux1:~$ pushd /home
/home ~
tsaimh@linux1:/home$ cd /var
tsaimh@linux1:/var$ pushd /dev
/dev /var ~
tsaimh@linux1:/dev$ cd /
tsaimh@linux1:/$ dirs
/ /var ~
tsaimh@linux1:/$ popd
/var ~
tsaimh@linux1:/var$ cd /home
tsaimh@linux1:/home$ popd
~
tsaimh@linux1:~$
```

Built-in Shell Commands (3)

SH	CSH	Description
`kill`		Send a signal to a job (kill %job or kill pid)
(N/A)	`stop`	Suspend a background process (%job | pid)
`exec`		execute arguments
`nice`		Change nice value



Built-in Shell Commands (4)

SH	CSH	Description
(N/A)	`history`	Display history list
(N/A)	`rehash`	Evaluate the internal hash table of the contents of directories
(N/A)	`source`	Read and execute a file

References:

- *https://it.cs.nycu.edu.tw/unix-basic-commands*
- *http://www.unix.org.ua/orelly/unix/unixnut/ch04_06.htm*
- *http://publib.boulder.ibm.com/infocenter/pseries/index.jsp?topic=/com.ibm.aix.doc/aixuser/usrosdev/list_c_builtin_cmds.htm*
- *https://www.freebsd.org/cgi/man.cgi?query=tcsh*
- *https://www.freebsd.org/cgi/man.cgi?query=sh*

Input/Output Redirection

- There are 3 default file descriptors

Integer value	Name
0	stdin (Standard Input)
1	stdout (Standard Output)
2	stderr (Standard Error)

- Using man command to read more information
  - sh(1): Redirection
  - tcsh(1): Input/Output

Input/Output Redirection (2)

Method	Name
`cmd < file`	Open the file as stdin of cmd
`cmd > file`	Write stdout of cmd in the following file. Truncates existing files. (tcsh: use "set noclobber" to avoid overwriting)
`cmd >> file`	Append stdout of cmd to the following file
`2>&1`	Merge stdout with stderr
`cmd1 | cmd2`	Pipe stdout of cmd1 into stdin of cmd2

File and Directory Related Commands

Command	Purpose
`ls`	List a directory's content
`pwd`	Print working directory
`cd`	Change to other directory
`mkdir`	Make(create) a new directory
`rmdir`	Remove existing empty directory
`cat`	Concatenate file
`cp`	Copy file

File and Directory Related Commands (2)

Command	Purpose
`ln`	Link files
`mv`	Move file
`rm`	Remove file
`stat`	Display file status

Select and File Processing Related Commands

Command	Purpose
`head`	Display first lines of a file
`tail`	Select trailing lines
`grep`	Select lines
`diff`	Compare and select difference in two files
`wc`	Count characters, words or lines of a file
`uniq`	Select uniq lines
`cut`	Select columns

Select and File Processing Related Commands (2)

Command	Purpose
`sort`	Sort and merge multiple files together
`sed`	Edit streams of data
`awk`	Pattern scanning and processing language

Select and File Processing Related Commands (3) - Example Usage

- Look first few lines or last few lines
  - `$ head /var/log/message`
  - `$ tail /var/log/message`
    - -n : specific how many lines
- Find the occurrence of certain pattern in file
  - `$ grep -l tsaimh *`
    - Print the filename that has “tsaimh" as content
  - `$ grep -n tsaimh /etc/passwd`
    - Print the line number when using grep

Select and File Processing Related Commands (4) - Example Usage

- List tsaimh's id, uid, home, shell in /etc/passwd
  - `$ grep tsaimh /etc/passwd | cut -f1,3,6,7 -d:`
    - -f1,3,6,7 : fetch 1st ,3rd ,6th ,7th column
    - -d : separation symbol

```
tsaimh:*:1001:20:Meng-Hsun Tsai:/home/tsaimh:/bin/tcsh

$ grep tsaimh /etc/passwd | cut -f1,3,6,7 -d:
tsaimh:1001:/home/tsaimh:/bin/tcsh
```

Select and File Processing Related Commands (5) - Example Usage

- Cut out file permission and file name from ls output
  - `$ ls -l | grep -v ^total | cut -c 1-11,47-`
    - -c1-11 : 1st~11th characters (start from 1, instead of 0)
    - -c47- : characters after 47th character (include 47th)

```
$ ls -l
total 2312
-rw-r--r--  1 tsaimh  ta  875394 Aug 14 13:37 00_Syllabus.pdf
-rw-r--r--  1 tsaimh  ta  841270 Aug 12 15:59 01_Install_FreeBSD.pdf
-rw-r--r--  1 tsaimh  ta  457582 Aug 12 15:59 02_Installing_Applications.pdf
$ ls -l | grep -v ^total | cut -c 1-11,47-
-rw-r--r-- 00_Syllabus.pdf
-rw-r--r-- 01_Install_FreeBSD.pdf
-rw-r--r-- 02_Installing_Applications.pdf
```

Select and File Processing Related Commands (6) - Example Usage

- Use awk to generate the same behavior of cut
  - `$ ls -l | grep -v ^total | awk '{print $1 " " $9}'`
    - Result is same as P.30

```
$ ls -l
total 2312
-rw-r--r--  1 tsaimh  ta  875394 Aug 14 13:37 00_Syllabus.pdf
-rw-r--r--  1 tsaimh  ta  841270 Aug 12 15:59 01_Install_FreeBSD.pdf
-rw-r--r--  1 tsaimh  ta  457582 Aug 12 15:59 02_Installing_Applications.pdf
$ ls -l | grep -v ^total | awk '{print $1 " " $9}'
-rw-r--r-- 00_Syllabus.pdf
-rw-r--r-- 01_Install_FreeBSD.pdf
-rw-r--r-- 02_Installing_Applications.pdf
```

Select and File Processing Related Commands (7) - Example Usage

- Use awk to generate the same behavior of cut
  - `$ awk -F: '{print $1 " " $6}' /etc/passwd`
    - -F ：separation symbol

```
tsaimh:*:1001:20:Meng-Hsun Tsai:/home/tsaimh:/bin/tcsh

$ awk -F: '{print $1 " " $6}' /etc/passwd
tsaimh /home/tsaimh
```

Select and File Processing Related Commands (8) - Example Usage

- Options of "sort" command
  - -r : reverse
  - -u : unique keys
  - -n : numeric keys sorting
    - Default: string sorting, 14 > 123
  - -k : specific columns to sort with
  - -t : field separator

Select and File Processing Related Commands (9) - Example Usage

- List directory contents and sort by file size decreasingly
  - `$ ls -al | sort -n -k 5,5 -r`
    - -k : specific columns to sort with
    - -r : reverse

```
% ls -l | sort -n -k 5,5 -r
-rw-r--r--  1 tsaimh  ta  875394 Aug 14 13:37 00_Syllabus.pdf
-rw-r--r--  1 tsaimh  ta  841270 Aug 12 15:59 01_Install_FreeBSD.pdf
-rw-r--r--  1 tsaimh  ta  457582 Aug 12 15:59 02_Installing_Applications.pdf
```

Select and File Processing Related Commands (10) - Example Usage

- Sort contents of /etc/passwd by username and remove annotations
  - `$ sort -t: -k 1,1 /etc/passwd | grep -v ^#`
    - -t : field separator
    - -k : specific columns to sort with

```
games:*:7:13:Games pseudo-user:/usr/games:/usr/sbin/nologin
git_daemon:*:964:964:git daemon:/nonexistent:/usr/sbin/nologin
hast:*:845:845:HAST unprivileged user:/var/empty:/usr/sbin/nologin
kmem:*:5:65533:KMem Sandbox:/:/usr/sbin/nologin
tsaimh:*:1001:20:Meng-Hsun Tsai:/home/tsaimh:/bin/tcsh
```

Select and File Processing Related Commands (11) - Example Usage

- List records in /etc/hosts sorted by IPv4 address

```
$ sort -t. -n -k 1,1 -k 2,2 -k 3,3 -k 4,4 '/etc/hosts' | grep -v ^#
```

  - -n : numeric keys sorting

- Before sorting

```
# In the presence of the domain name service or NIS, this file may
# not be consulted at all; see /etc/nsswitch.conf for the
# resolution order.
#
::1                     localhost localhost.my.domain
127.0.0.1               localhost localhost.my.domain
140.113.17.26           nctucs.tw
64.233.187.95           www.googleapis.com googleapis.l.google.com
```

Select and File Processing Related Commands (12) - Example Usage

- List records in /etc/hosts sorted by IPv4 address

```
$ sort -t. -n -k 1,1 -k 2,2 -k 3,3 -k 4,4 '/etc/hosts' | grep -v ^#
```

  - -n : numeric keys sorting

- After sorting

```
::1                     localhost localhost.my.domain
64.233.187.95           www.googleapis.com googleapis.l.google.com
127.0.0.1               localhost localhost.my.domain
140.113.17.26           nycucs.tw
```

Select and File Processing Related Commands (13) - Example Usage

- Translate characters
  - `$ echo "Hello World" | tr "a-z" "A-Z"`
    - Change all alphabet to uppercase

```
$ echo "Hello World" | tr "a-z" "A-Z"
HELLO WORLD
```

  - `$ tr -d "\t" < file1`
    - Delete TAB in file1
  - `$ tr -s " " < file1`
    - Delete multiple space in file1

Select and File Processing Related Commands (14) - Example Usage

- Translate characters
  - `$ grep tsaimh /etc/passwd | tr ":" "\n"`
    - Change all ":" to "\n"

```
$ grep tsaimh /etc/passwd | tr ":" "\n"
tsaimh
*
1001
20
Meng-Hsun Tsai
/home/tsaimh
/bin/tcsh
```

xargs Command

- xargs – construct argument list(s) and execute utility
  - -n number
  - -I replstr (every)
  - -J replstr (first only)
  - -s size
  - ...

xargs Command (2)

```
% ls
2.sh        3.csh       4.csh       4.sh        bsd1.ping
testin
% ls | xargs echo
2.sh 3.csh 4.csh 4.sh bsd1.ping testin
% ls | xargs -n1 echo
2.sh
3.csh
4.csh
4.sh
bsd1.ping
testin
```

xargs Command (3)

```
% ls | xargs -I % -n1 echo % here %
2.sh here 2.sh
3.csh here 3.csh
4.csh here 4.csh
4.sh here 4.sh
bsd1.ping here bsd1.ping
testin here testin
```

xargs Command (4)

```
% ls | xargs -J % -n1 echo % here %
2.sh here %
3.csh here %
4.csh here %
4.sh here %
bsd1.ping here %
testin here %
```

xargs Command (5)

- Example : ping all hosts in file

```
$ cat host
www.google.com
bsd1.cs.nycu.edu.tw
linux3.cs.nycu.edu.tw
cs.nycu.edu.tw

$ cat host | xargs -n1 ping -c 1 | grep "bytes from"
64 bytes from 64.233.188.103: icmp_seq=0 ttl=47 time=6.944 ms
64 bytes from 140.113.235.135: icmp_seq=0 ttl=57 time=1.451 ms
64 bytes from 140.113.235.153: icmp_seq=0 ttl=57 time=1.612 ms
64 bytes from 140.113.235.47: icmp_seq=0 ttl=57 time=1.856 ms
```

The Unix Philosophy

- https://en.wikipedia.org/wiki/Unix_philosophy
- Lots of little tools, each good at one thing
  - Use them together to achieve your goal
- Try other shells (install from package/ports)
  - zsh
    - Oh-my-zsh: https://github.com/robbyrussell/oh-my-zsh
  - fish

ShellCheck

- Finds bugs in your shell scripts
- https://www.shellcheck.net/
- devel/hs-ShellCheck
- pkg install hs-ShellCheck

Appendix

Command History in (t)csh

國立陽明交通大學資工系資訊中心

Information Technology Center, Department of Computer Science, NYCU

Command History in (t)csh

Commands	Description
!n	exec previous command line n (see history)
!-n	exec current command line minus n
!!	exec last command (the same as !-1)
!str	exec previous command line beginning with str
!?str	exec previous command line containing str

```
% history
10  8:31    cp ypwhich.1 ypwhich.1.old
11  8:31    vi ypwhich.1
12  8:32    diff ypwhich.1.old ypwhich.1
13  8:32    history
% !?old
```

Command History in (t)csh (2)

Commands	Description
!!:n	use the nth word of previous comm
!!:m-n	select words m ~ n of previous command
!!:*	use all arguments of previous command
!!:s/str1/str2/	substitute str1 with str2 in previous command

```
% history
15  8:35    cd /etc
16  8:35    ls HOSTS FSTAB
17  8:35    history
% cat !-2:*:s/HOSTS/hosts/:s/FSTAB/fstab → cat hosts fstab
```

- tcsh(1): History Substitution