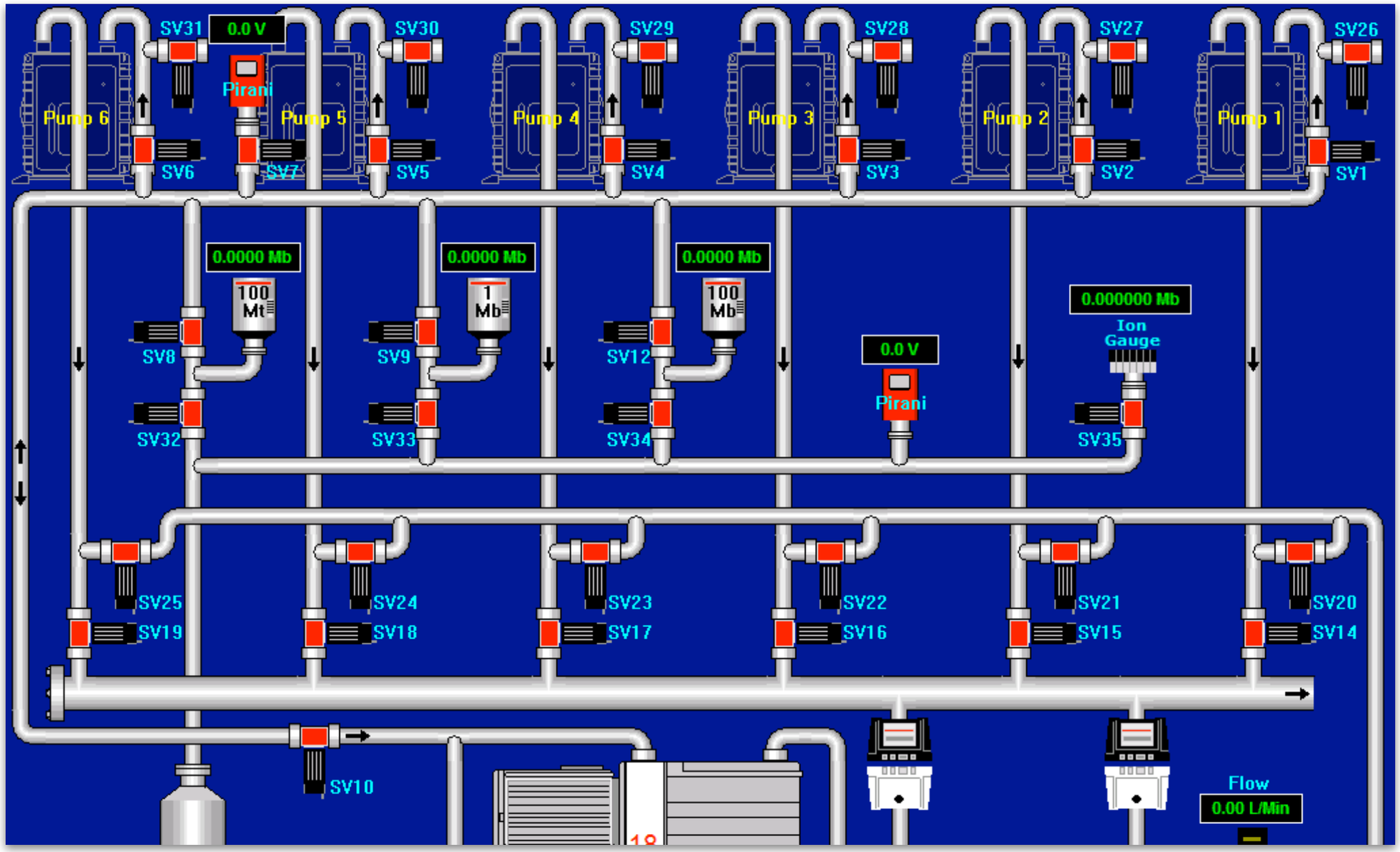

Processes

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- Variables and the Shell
- Processes
- Working with Processes
- IO Streams
- Pipes and Redirections

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Variables

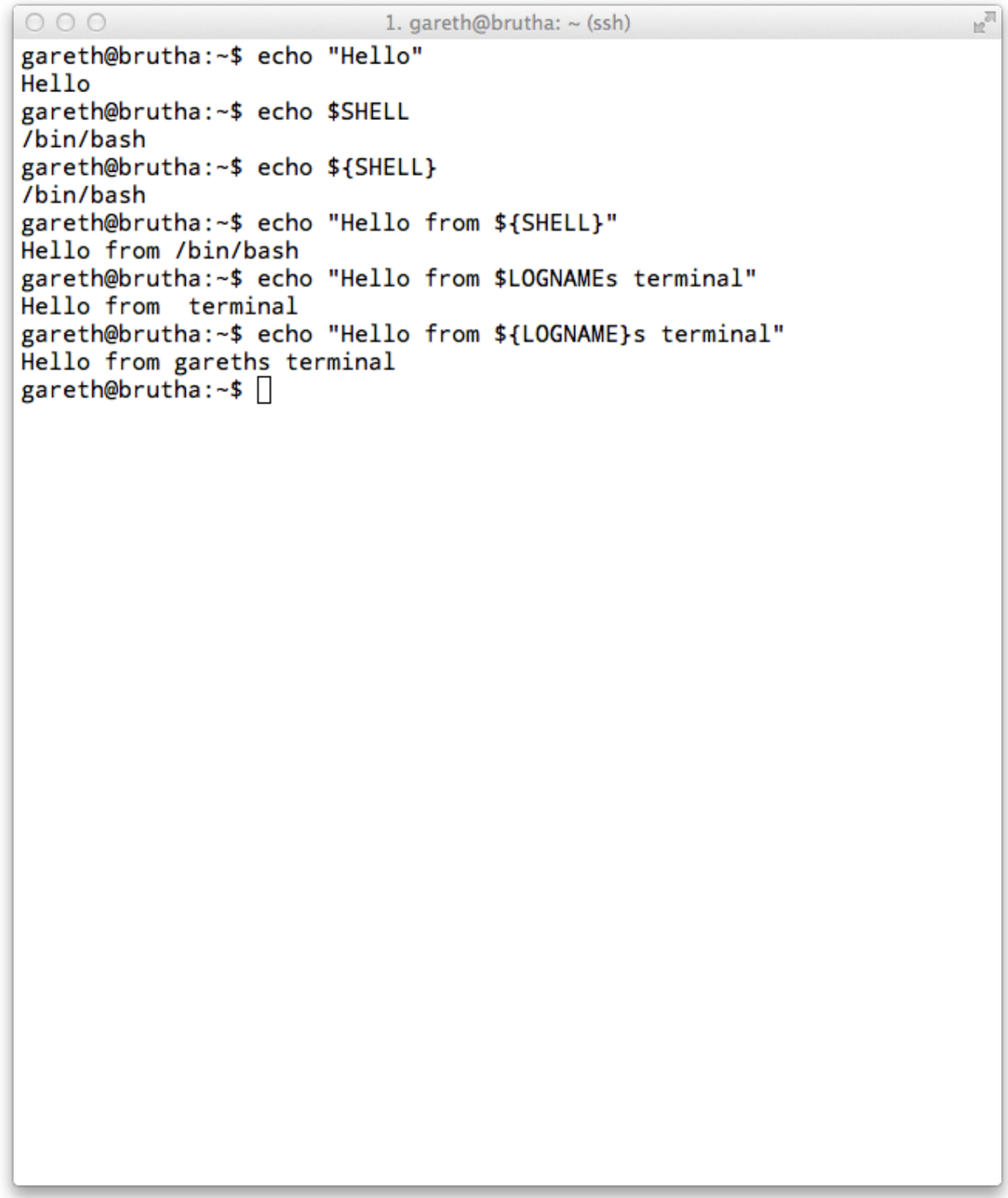
- The “shell” stores parameters in variables. These are referred to as environment variables.
- In these examples we assume our shell is **bash**.
- To assign a value to a bash variable on the command line we would do:
  - **export** SOME_VAR=“some value”
  - **Note:** their are no spaces between the “=“ and the left and right hand side of the assignment and variables are case sensitive.
- **bash** and most shells use these variables to store configuration information.
- By convention most environment variable names are all in uppercase.
- You can see all the variables set in a running shell by using the **env** or **export** commands.

1. gareth@brutha: ~ (ssh)

```
SSH_TTY=/dev/pts/0
USER=gareth
LS_COLORS=rs=0:di=01;34:ln=01;36:mh=00:pi=40;33:so=01;35:do=01;35:bd=4
0;33;01:cd=40;33;01:or=40;31;01:su=37;41:sg=30;43:ca=30;41:tw=30;42:ow
=34;42:st=37;44:ex=01;32:*.tar=01;31:*.tgz=01;31:*.arj=01;31:*.taz=01;
31:*.lzh=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:*.zip=01;31:*.z=01
;31:*.Z=01;31:*.dz=01;31:*.gz=01;31:*.lz=01;31:*.xz=01;31:*.bz2=01;31:
*.bz=01;31:*.tbz=01;31:*.tbz2=01;31:*.tz=01;31:*.deb=01;31:*.rpm=01;31
:*.jar=01;31:*.war=01;31:*.ear=01;31:*.sar=01;31:*.rar=01;31:*.ace=01;
31:*.zoo=01;31:*.cpio=01;31:*.7z=01;31:*.rz=01;31:*.jpg=01;35:*.jpeg=0
1;35:*.gif=01;35:*.bmp=01;35:*.pbm=01;35:*.pgm=01;35:*.ppm=01;35:*.tga
=01;35:*.xbm=01;35:*.xpm=01;35:*.tif=01;35:*.tiff=01;35:*.png=01;35:*.
svg=01;35:*.svgz=01;35:*.mng=01;35:*.pcx=01;35:*.mov=01;35:*.mpg=01;35
:*.mpeg=01;35:*.m2v=01;35:*.mkv=01;35:*.webm=01;35:*.ogm=01;35:*.mp4=0
1;35:*.m4v=01;35:*.mp4v=01;35:*.vob=01;35:*.qt=01;35:*.nuv=01;35:*.wmv
=01;35:*.asf=01;35:*.rm=01;35:*.rmvb=01;35:*.flc=01;35:*.avi=01;35:*.f
li=01;35:*.flv=01;35:*.gl=01;35:*.dl=01;35:*.xcf=01;35:*.xwd=01;35:*.y
uv=01;35:*.cgm=01;35:*.emf=01;35:*.axv=01;35:*.anx=01;35:*.ogv=01;35:*
.ogx=01;35:*.aac=00;36:*.au=00;36:*.flac=00;36:*.mid=00;36:*.midi=00;3
6:*.mka=00;36:*.mp3=00;36:*.mpc=00;36:*.ogg=00;36:*.ra=00;36:*.wav=00;
36:*.axa=00;36:*.oga=00;36:*.spx=00;36:*.xspf=00;36:
LD_LIBRARY_PATH=/opt/lib/root:/opt/lib:
SSH_AUTH_SOCK=/tmp/ssh-ZJvjQ41732/agent.41732
LIBGL_ALWAYS_INDIRECT=1
MAIL=/var/mail/gareth
PATH=/opt/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:
/bin:/usr/games
PWD=/home/gareth
LANG=en_GB.UTF-8
ROOTSYS=/opt
SHLVL=1
HOME=/home/gareth
LANGUAGE=en_GB:en
MATHEMATICA_HOME=/usr/local/Wolfram/Mathematica/10.0
PYTHONPATH=/opt/lib/root:/opt/lib:
LOGNAME=gareth
SSH_CONNECTION=194.36.1.2 59716 130.209.202.212 22
LESSOPEN=| /usr/bin/lesspipe %s
LESSCLOSE=/usr/bin/lesspipe %s %s
_=/usr/bin/env
gareth@brutha:~$
```

Variables

- To access a specific variable we can use the **echo** command.
- **echo** writes to the screen anything passed to it:
  - **echo** “hello”
- To access a specific shell variable we can echo it’s contents by adding **$** to its name:
  - **echo** $SHELL
- It’s better practice to reference our variables using ${} notation. The above would then be
  - **echo** ${SHELL}
- This allows us to embed the variable expansion inside another value without worrying about the variable name:
  - **echo** “Hello from ${SHELL}”



Important Variables

- Their are some shell variables that it is useful to know about
- **$PATH** - the places to look for a particular command.
- **$HOME** - the users home directory (can be accessed using the **~** symbol)
- **$PWD** - the current working directory (also available via **pwd** command)
- **$USER** - the username (also available via the **whoami** command)
- **$LD_LIBRARY_PATH** - the paths to search for library files when building C code.

3. gareth@brutha: ~ (ssh)

```
gareth@brutha:~$ echo $PATH
/opt/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:
/usr/games
gareth@brutha:~$ echo $HOME
/home/gareth
gareth@brutha:~$ echo ~
/home/gareth
gareth@brutha:~$ echo $PWD
/home/gareth
gareth@brutha:~$ pwd
/home/gareth
gareth@brutha:~$ echo $USER
gareth
gareth@brutha:~$ whoami
gareth
gareth@brutha:~$ echo $LD_LIBRARY_PATH
/opt/lib/root:/opt/lib:
gareth@brutha:~$
```

Aliases

- Often typed commands can be “aliased” to much simpler commands.
- For instance if we would like a long directory listing, showing all hidden files and a classifer:
  - **ls -laF**
- This could be aliased to
  - **alias ll=‘ls -laF’**
- At the command line we would then use:
  - **ll**
- You can see a list of all aliases set in your shell by running the alias command without any arguments
  - **alias**

3. gareth@brutha: ~/Examples (ssh)

```
gareth@brutha:~/Examples$ ls -laF
total 12
drwxrwxr-x  3 gareth gareth 4096 Jan 21 13:22 ./
drwxr-x--- 29 gareth gareth 4096 Jan 20 16:23 ../
-r--r--r--  1 gareth gareth    0 Jan 14 09:05 a
-rw-rw-r--  1 gareth gareth    0 Jan 14 09:05 b
-rw-rw-r--  1 gareth gareth    0 Jan 14 13:59 c
drwxrwxr-x  4 gareth gareth 4096 Jan 14 09:28 dir1/
gareth@brutha:~/Examples$ alias ll='ls -laF'
gareth@brutha:~/Examples$ ll
total 12
drwxrwxr-x  3 gareth gareth 4096 Jan 21 13:22 ./
drwxr-x--- 29 gareth gareth 4096 Jan 20 16:23 ../
-r--r--r--  1 gareth gareth    0 Jan 14 09:05 a
-rw-rw-r--  1 gareth gareth    0 Jan 14 09:05 b
-rw-rw-r--  1 gareth gareth    0 Jan 14 13:59 c
drwxrwxr-x  4 gareth gareth 4096 Jan 14 09:28 dir1/
gareth@brutha:~/Examples$ alias
alias alert='notify-send --urgency=low -i "$([ $? = 0 ] && echo termin
al || echo error)" "$(history|tail -n1|sed -e '\''s/^\s*[0-9]\+\s*//;s
/[;&|]\s*alert$//'\'')"'
alias egrep='egrep --color=auto'
alias fgrep='fgrep --color=auto'
alias grep='grep --color=auto'
alias l='ls -CF'
alias la='ls -A'
alias ll='ls -laF'
alias ls='ls --color=auto'
gareth@brutha:~/Examples$
```

Persistant Variables

- All variables in **bash** shells are transient.
- Variables you set in one shell will not persist when you open a new one.
- When you open a new shell bash reads a number of configuration files to set it's state.
- We can make variables persist by adding them to one of these configuration files.
- Bash has two configuration files found in you home directory
  - **.bashrc**
  - **.bash_profile**
- The difference is subtle and most times you'll want to but settings in **.bashrc** but be aware that **.bash_profile** exists.
- If you edit your .bashrc file you can load the new variables into the current shell by
  - **source .bashrc**

3. gareth@brutha: ~ (ssh)

```
gareth@brutha:~$ export HELLO_WORLD="Hello"
gareth@brutha:~$ echo ${HELLO_WORLD}
Hello
gareth@brutha:~$ exit
logout
Connection to 130.209.202.212 closed.
Folkvangr:Desktop gareth$ ssh brutha
Welcome to Ubuntu 12.04.5 LTS (GNU/Linux 3.13.0-43-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Wed Jan 21 13:29:37 2015 from ppegw.physics.gla.ac.uk
gareth@brutha:~$ echo ${HELLO_WORLD}

gareth@brutha:~$ grep alias .bashrc
# enable color support of ls and also add handy aliases
    alias ls='ls --color=auto'
    #alias dir='dir --color=auto'
    #alias vdir='vdir --color=auto'
    alias grep='grep --color=auto'
    alias fgrep='fgrep --color=auto'
    alias egrep='egrep --color=auto'
# some more ls aliases
alias ll='ls -alF'
alias la='ls -A'
alias l='ls -CF'
# Add an "alert" alias for long running commands.  Use like so:
alias alert='notify-send --urgency=low -i "$([ $? = 0 ] && echo termin
al || echo error)" "$(history|tail -n1|sed -e '\''s/^\s*[0-9]\+\s*//;s
/[;&|]\s*alert$//'\'')"'
# ~/.bash_aliases, instead of adding them here directly.
if [ -f ~/.bash_aliases ]; then
    . ~/.bash_aliases
gareth@brutha:~$
```

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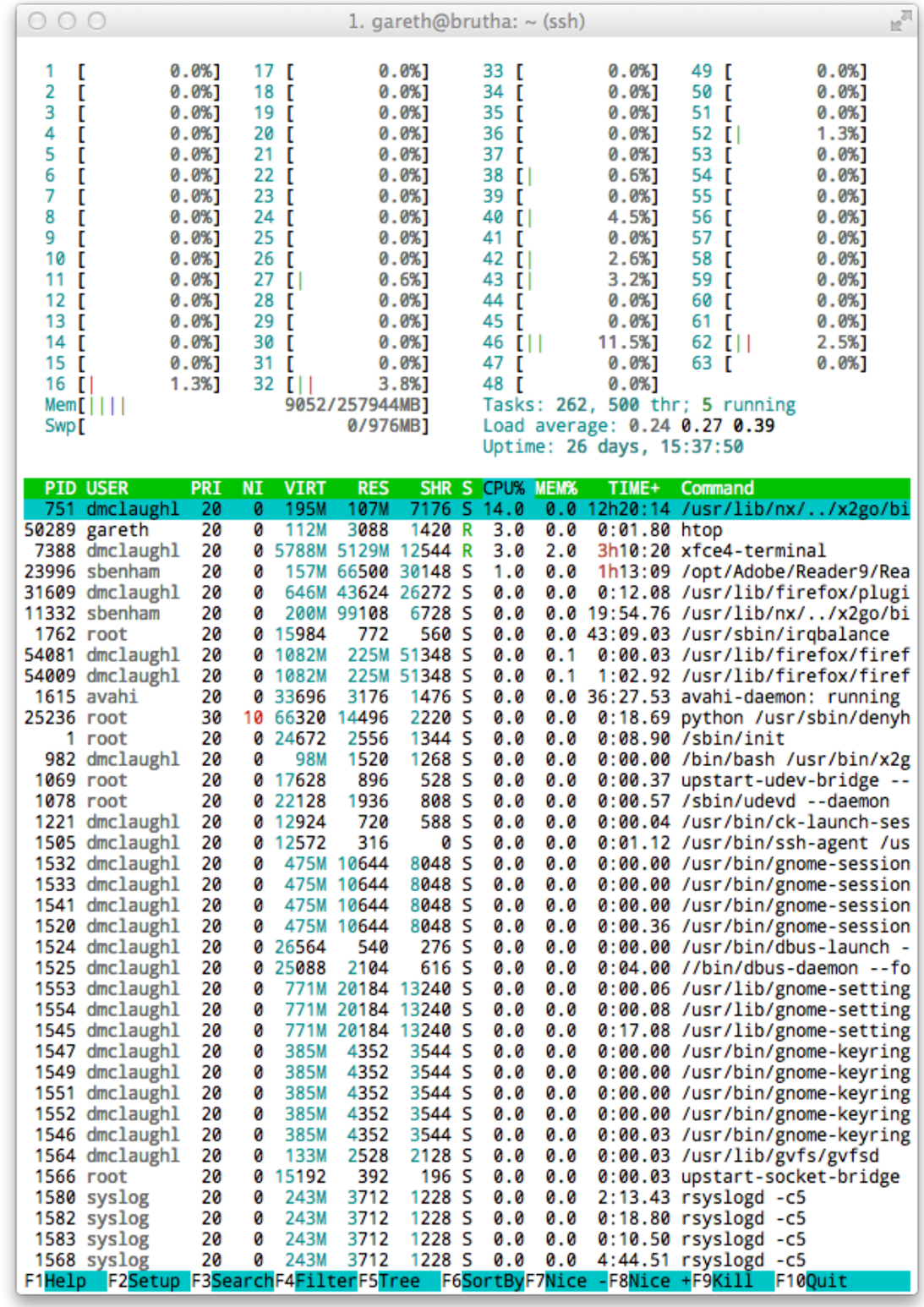
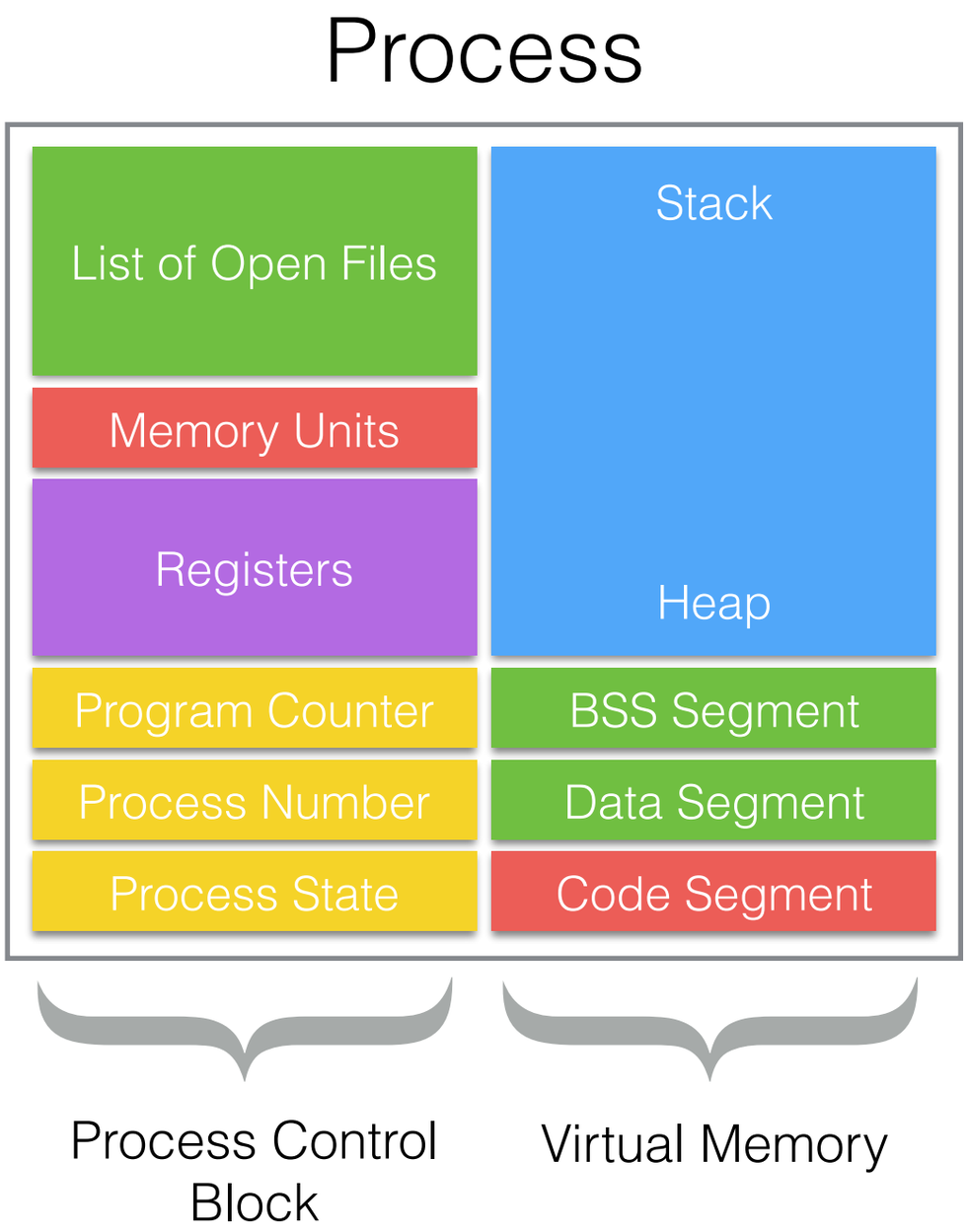
What is a Process?

- Each program that runs on a Linux system runs inside a process.
- Each process is self contained, even when it's for the same program.
- The Linux Kernel schedules CPU time for each process to run.
- Processes are created as children of other processes by a method called "**forking**".
- **pstree** will show all the processes running on a system, and the relationship they have with each other.



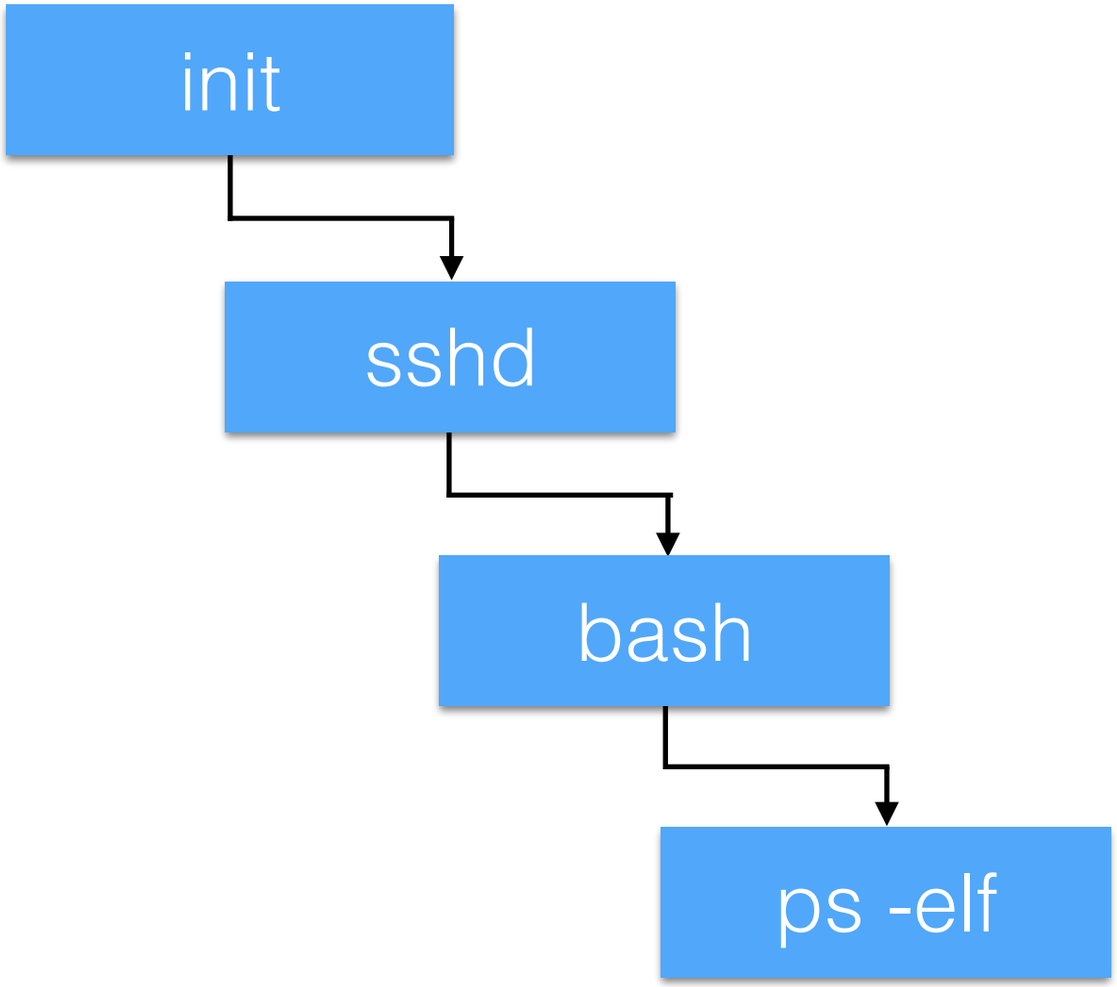
What's inside a Process?

- It contains:
  - a copy of the of the program.
  - a section of Virtual Memory assigned to the process (containing the Stack and Heap).
  - a link to any open files (file descriptors)
  - a snapshot of the processor state (including register contents)
  - attributes such as owner and permissions.
- Each process is isolated from every other process in the system.



Forking

- Processes are created by "**forking**".
- When a process **forks** it creates a copy of itself and then starts the program it desires to run.
- This gives a parent child relationship between processes.
- The initial process is usually "**init**"



1. gareth@brutha: ~ (ssh)

```
gareth@brutha:~$ ps -elf |grep gareth
4 S root     49740 38657  0  80   0 - 23088 poll_s 12:00 ?        00:00:00 sshd: gareth [priv]
5 S gareth   49755 49740  0  80   0 - 23088 poll_s 12:00 ?        00:00:00 sshd: gareth@pts/0
0 S gareth   49756 49755  3  80   0 - 29351 wait   12:00 pts/0    00:00:00 -bash
0 R gareth   49960 49756  0  80   0 - 26557 -      12:01 pts/0    00:00:00 ps -elf
0 S gareth   49961 49756  0  80   0 - 24365 pipe_w 12:01 pts/0    00:00:00 grep --color=auto gareth
gareth@brutha:~$ pstree 49755
sshd──bash──pstree
gareth@brutha:~$ ps auxwf |grep gareth
root     49740  0.0  0.0  92352  4068 ?        Ss   12:00   0:00  \_ sshd: gareth [priv]
gareth   49755  0.0  0.0  92352  1696 ?        S    12:00   0:00      \_ sshd: gareth@pts/0
gareth   49756  1.1  0.0 117404 10576 pts/0    Ss   12:00   0:00          \_ -bash
gareth   50071  0.0  0.0 107152  2140 pts/0    R+   12:01   0:00              \_ ps auxwf
gareth   50072  0.0  0.0  97460   920 pts/0    S+   12:01   0:00              \_ grep --color=auto gareth
gareth@brutha:~$
```

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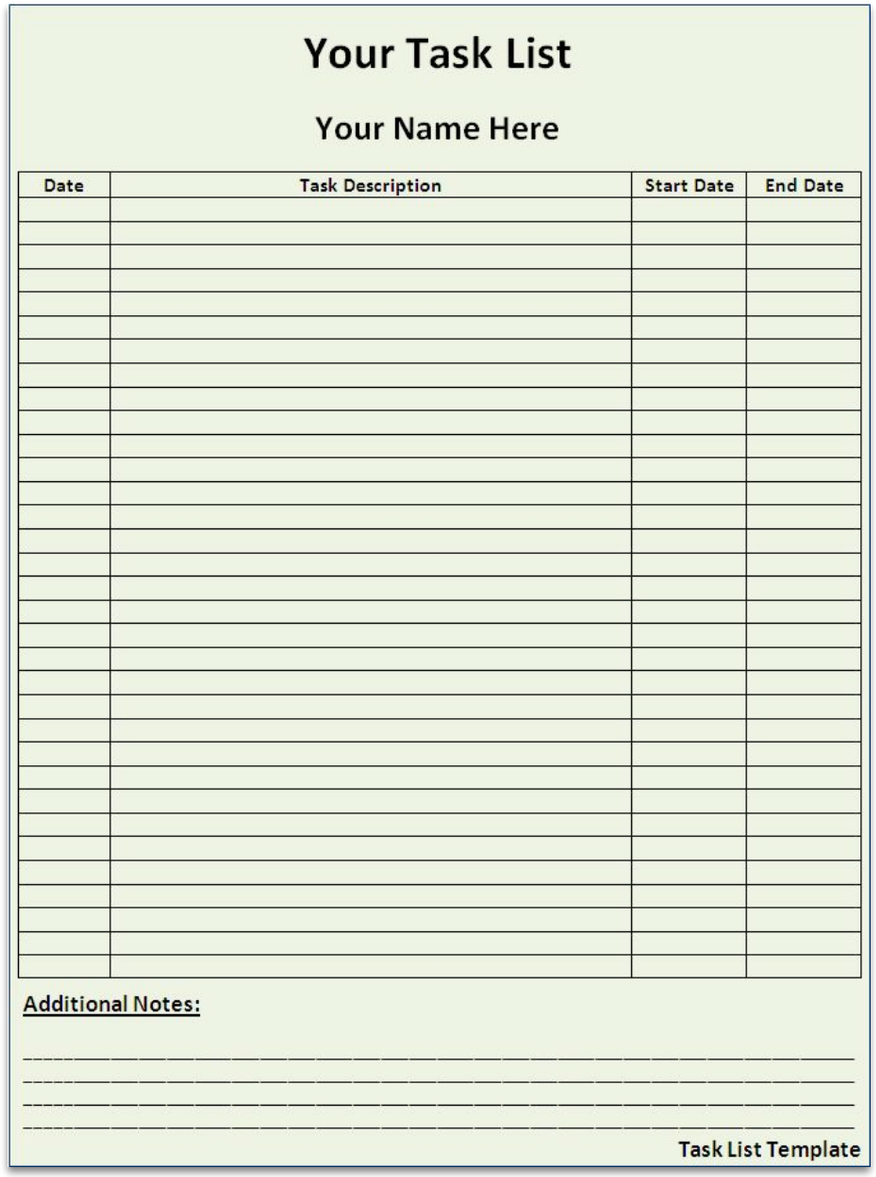
Common Tasks

- view the processes running on the system.
- start a new process in the background.
- move a process to the background.
- suspend a running process.
- kill a process.


Your Task List

Your Name Here

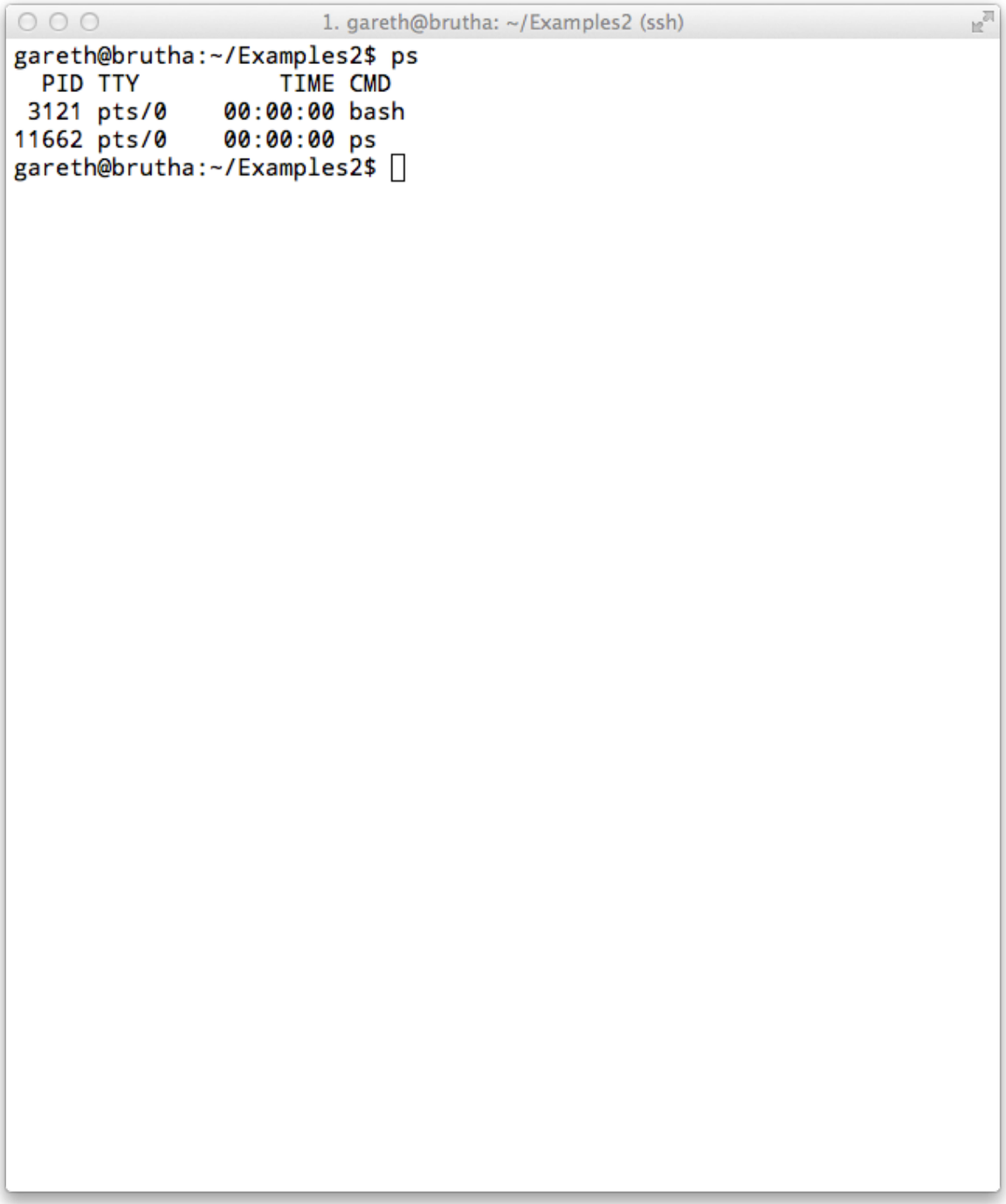
Date	Task Description	Start Date	End Date

Additional Notes:

Task List Template

Seeing processes

- You'll often need to monitor the status of processes running on your system.
- You can get a list of processes running on your system by using **ps**
- **ps** with no arguments will show you only the processes running in your shell
- **ps** shows the process id (**pid**), how long the command has been running and the command that is run.
- **ps -e** (or **ps -ax**) will show you all processes running on the system.
- other useful filters are:
  - **ps -elf**
  - **ps -auxwf**



Other useful process tools

- If you want to see what processes are using particular resources you can use **top**.
- By default top sorts by **%CPU**.
- This can be changed by typing **F** and selecting a new sort field.
- To exit **top** type the **q** character.
- To see a hierarchical list of all the process we can use **pstree**.
- **pstree** shows the parent and children of each process in a graph. This lets us easily see the relationship between processes

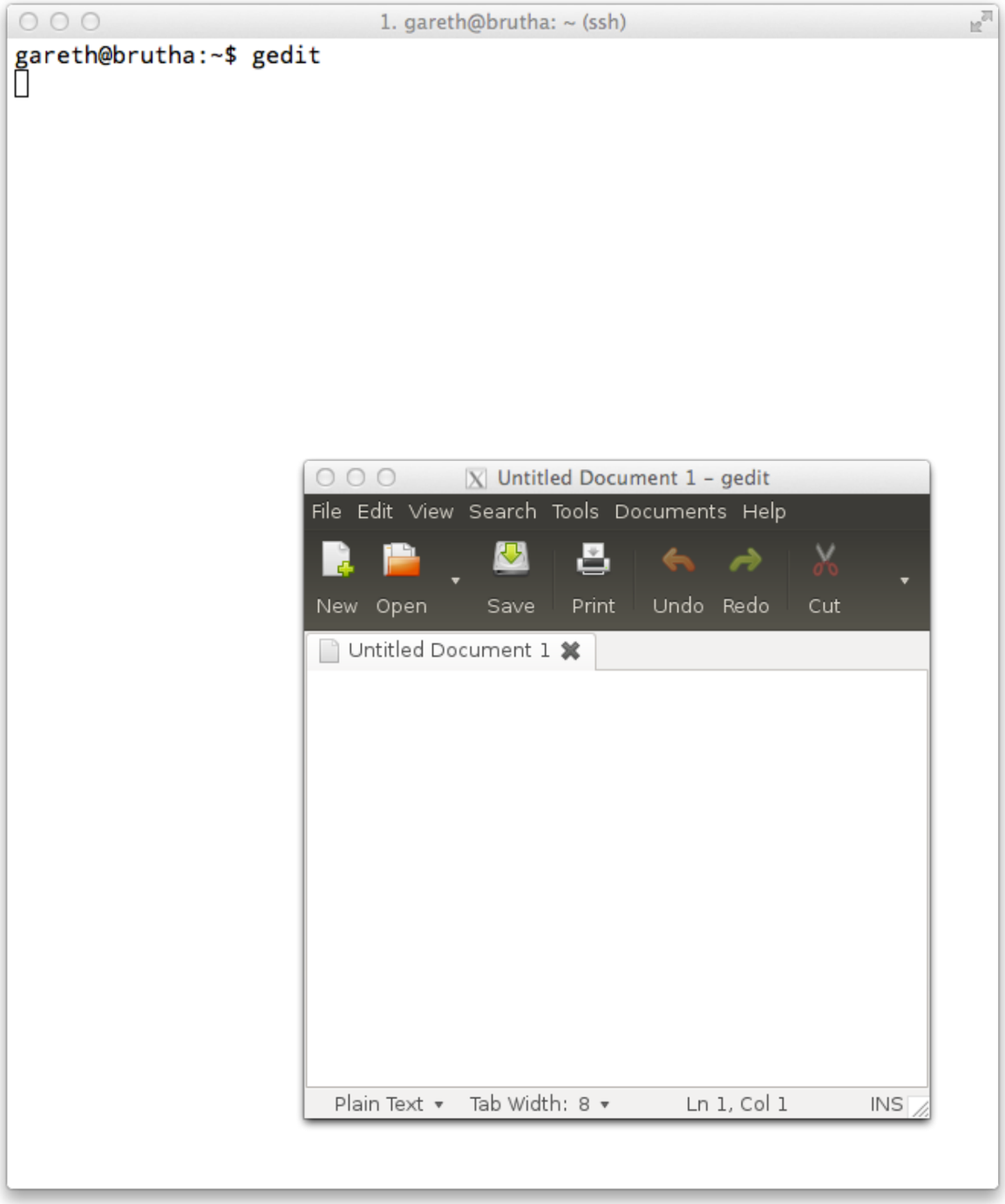
1. gareth@brutha: ~/Examples2 (ssh)

```
top - 10:02:51 up 33 days, 13:29,  5 users,  load average: 0.06, 0.07,
Tasks: 1249 total,   4 running, 1234 sleeping,  10 stopped,   1 zombie
Cpu(s):  0.1%us,  0.1%sy,  0.0%ni, 99.8%id,  0.0%wa,  0.0%hi,  0.0%si,
Mem:  264134840k total, 19521920k used, 244612920k free,  1240860k buf
Swap:  1000444k total,        0k used,  1000444k free, 10701224k cache

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
13758 gareth    20   0 18272 2256  972 R    1  0.0   0:00.13 top
55841 dmclaugh  20   0  673m  70m  28m S    1  0.0  49:17.05 plugin-co
15753 mdeans    20   0 3367m 199m 112m S    1  0.1  37:36.07 chromium-
27165 mwood     20   0  662m  49m  25m S    1  0.0  67:07.93 plugin-co
  942 root      20   0     0    0    0 S    0  0.0   0:22.73 kworker/2
 1576 mdeans    20   0  223m 122m 7164 S    0  0.0   9:17.35 x2goagent
 1615 avahi     20   0 34664 4260 1476 S    0  0.0  49:48.17 avahi-dae
 1762 root      20   0 15984  772  560 S    0  0.0  54:29.84 irqbalanc
 2286 lightdm   20   0  794m  23m  13m S    0  0.0 131:20.14 unity-gre
50591 dmclaugh  20   0 1172m 311m  53m S    0  0.1  30:16.79 firefox
61378 martynas  20   0  646m  42m  25m S    0  0.0  39:17.52 plugin-co
    1 root      20   0 24672 2556 1344 S    0  0.0   0:15.47 init
    2 root      20   0     0    0    0 S    0  0.0   0:00.84 kthreadd
    3 root      20   0     0    0    0 S    0  0.0   0:08.19 ksoftirqd
    4 root      20   0     0    0    0 S    0  0.0   0:00.00 kworker/0
    5 root       0 -20     0    0    0 S    0  0.0   0:00.00 kworker/0
    8 root      20   0     0    0    0 S    0  0.0  72:31.30 rcu_sched
    9 root      20   0     0    0    0 S    0  0.0   6:38.74 rcuos/0
   10 root      20   0     0    0    0 S    0  0.0   5:49.49 rcuos/1
   11 root      20   0     0    0    0 S    0  0.0   2:01.68 rcuos/2
   12 root      20   0     0    0    0 S    0  0.0   0:37.26 rcuos/3
   13 root      20   0     0    0    0 S    0  0.0   1:50.76 rcuos/4
   14 root      20   0     0    0    0 S    0  0.0   5:04.32 rcuos/5
   15 root      20   0     0    0    0 S    0  0.0   1:53.96 rcuos/6
   16 root      20   0     0    0    0 S    0  0.0   5:32.29 rcuos/7
   17 root      20   0     0    0    0 S    0  0.0   0:54.64 rcuos/8
   18 root      20   0     0    0    0 S    0  0.0   0:21.13 rcuos/9
   19 root      20   0     0    0    0 S    0  0.0   0:38.66 rcuos/10
   20 root      20   0     0    0    0 S    0  0.0   1:18.35 rcuos/11
   21 root      20   0     0    0    0 S    0  0.0   0:43.65 rcuos/12
   22 root      20   0     0    0    0 S    0  0.0   0:11.34 rcuos/13
   23 root      20   0     0    0    0 S    0  0.0   0:44.64 rcuos/14
   24 root      20   0     0    0    0 S    0  0.0   0:29.06 rcuos/15
   25 root      20   0     0    0    0 S    0  0.0   0:16.16 rcuos/16
```

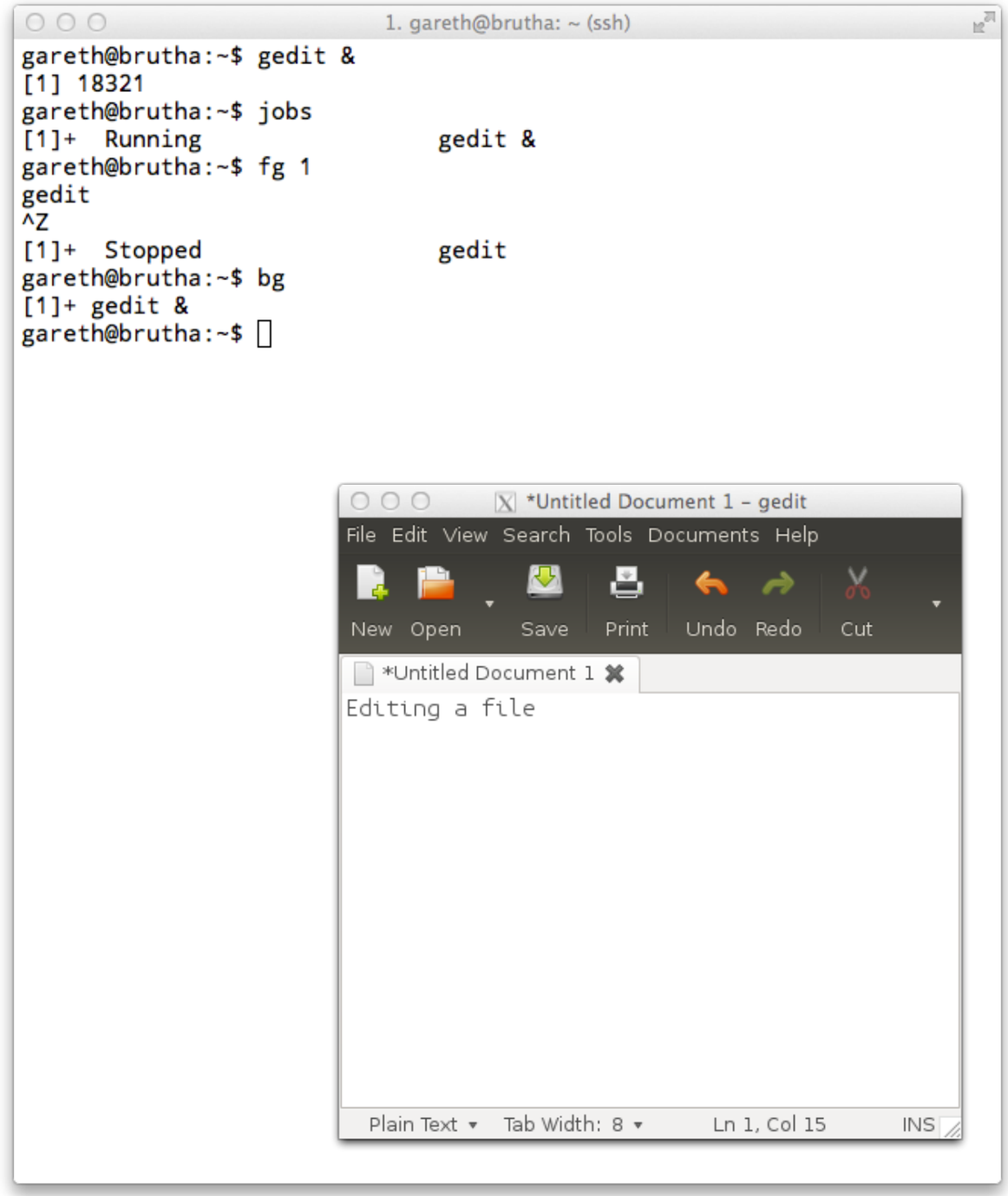
Foreground and Background

- Foreground jobs are processes that have interactive access to the command line.
- Background processes don't have access to the interactive command line but still run.
- Use '**&**' to start a process in the background and return to the command line for the next instruction.
- This can be used to start a text editor but allow you to continue to use the terminal.
- Use 'jobs' to check what processes are running in the current terminal.



Job Control

- **ctrl-c** - will kill a job that is currently running in the foreground.
- **ctrl-z** - will suspend a job that's currently running in the foreground.
- A suspended job retains it's state but doesn't run or use CPU time.
- **fg** <job id> - will bring the specific job into the foreground.
- **bg** <job id> - will put a suspended job into the background



Killing jobs

- Sometime we want to get rid of running processes.
- To remove a process from the system we use the **kill** command
  - **kill** <pid>
- You can find the pid either by running ps, or by using the pidof command
  - **pidof** <name>
- Sometimes we want to kill a process and all of it's children. to do this we use:
  - **kill** -9 <pid>

1. gareth@brutha: ~/Examples2 (ssh)

```
gareth@brutha:~/Examples2$ ./infinite > /dev/null &
[1] 23300
gareth@brutha:~/Examples2$ jobs
[1]+  Running                 ./infinite > /dev/null &
gareth@brutha:~/Examples2$ ps
  PID TTY          TIME CMD
17397 pts/0    00:00:00 bash
17690 pts/0    00:00:00 dbus-launch
23300 pts/0    00:00:08 infinite
23337 pts/0    00:00:00 ps
gareth@brutha:~/Examples2$ pidof infinite
23300
gareth@brutha:~/Examples2$ kill 23300
gareth@brutha:~/Examples2$ ps
  PID TTY          TIME CMD
17397 pts/0    00:00:00 bash
17690 pts/0    00:00:00 dbus-launch
23412 pts/0    00:00:00 ps
[1]+  Terminated              ./infinite > /dev/null
gareth@brutha:~/Examples2$
```

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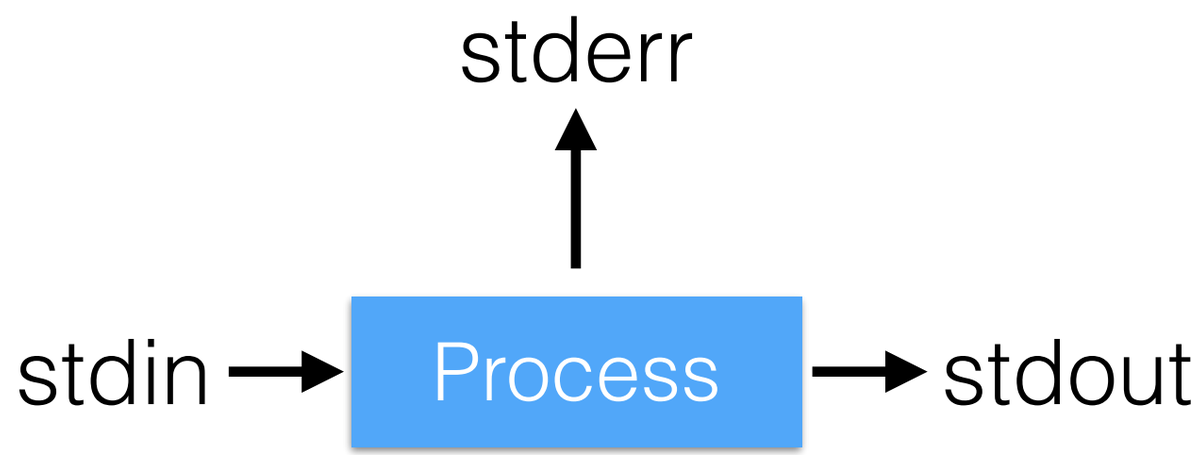
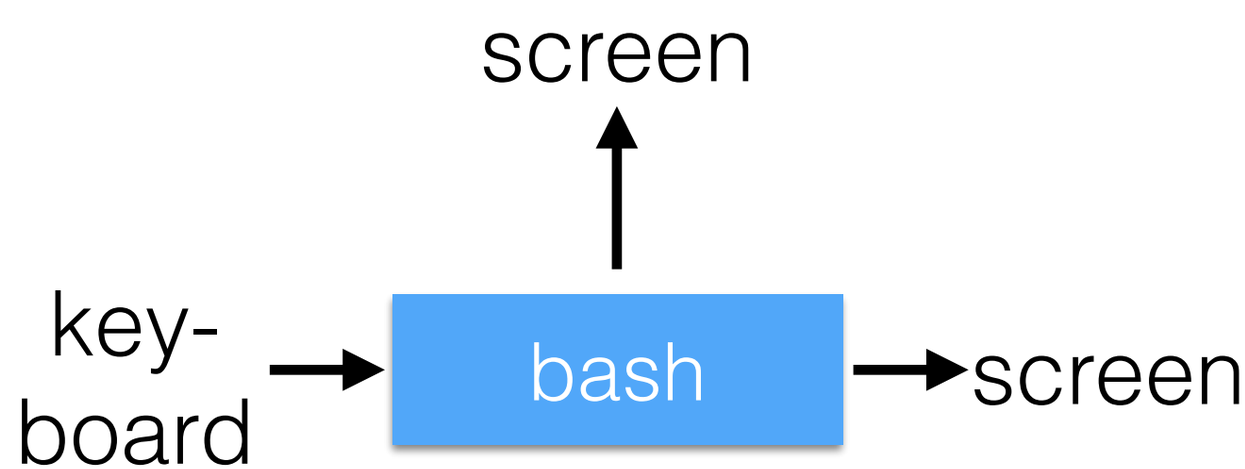
Standard Streams

- Each process has three standard input/output streams.
- These come from the C standard and are built-in to every executable that has a "**main**" function.
- **stdin** - is the standard source of input to the program.
- **stdout** - is the standard output of the program, in the cases we have see this is written to the screen/ shell.
- **stderr** - is the standard error of the program, this allows errors to be handled separately from output.





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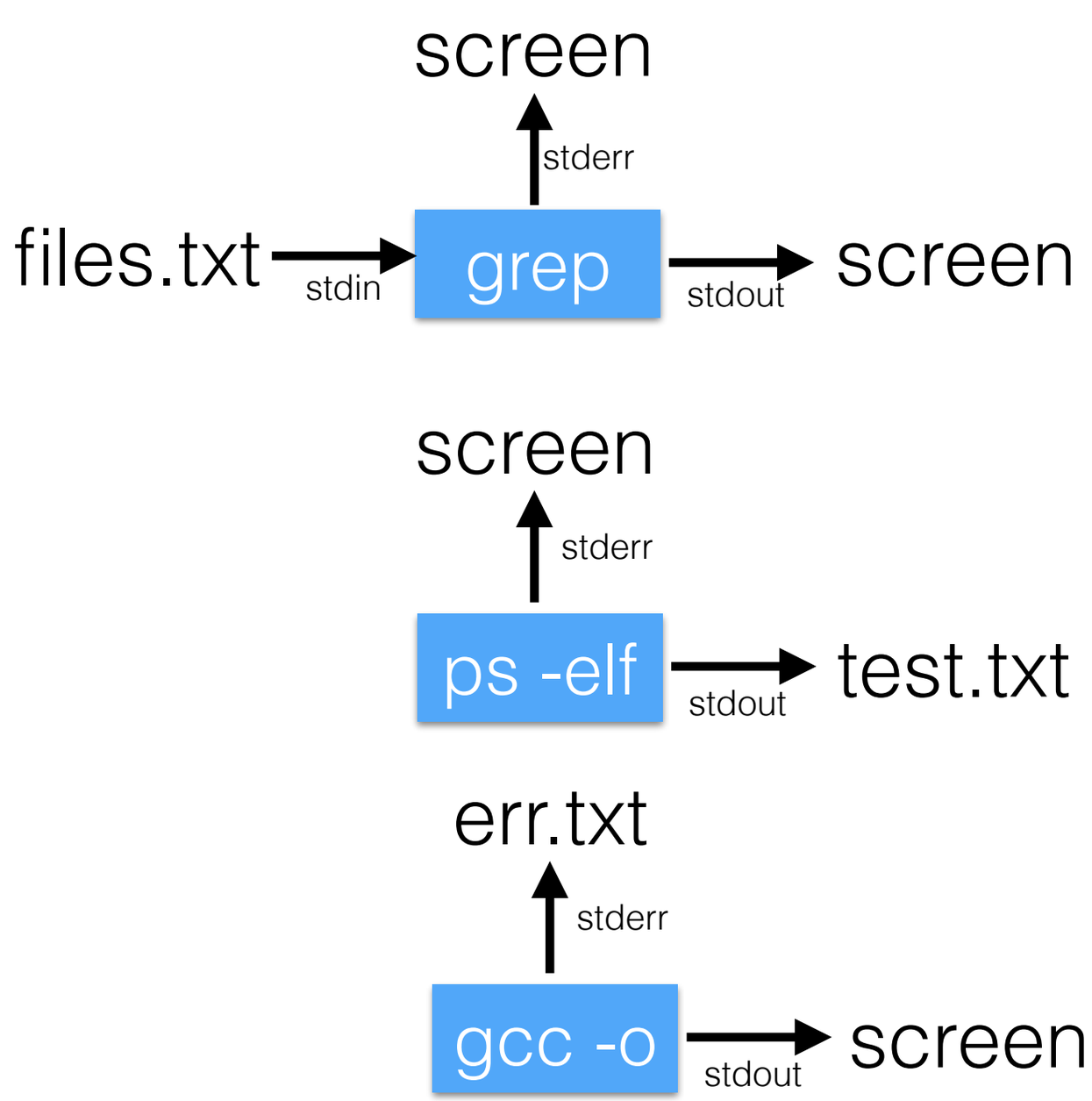
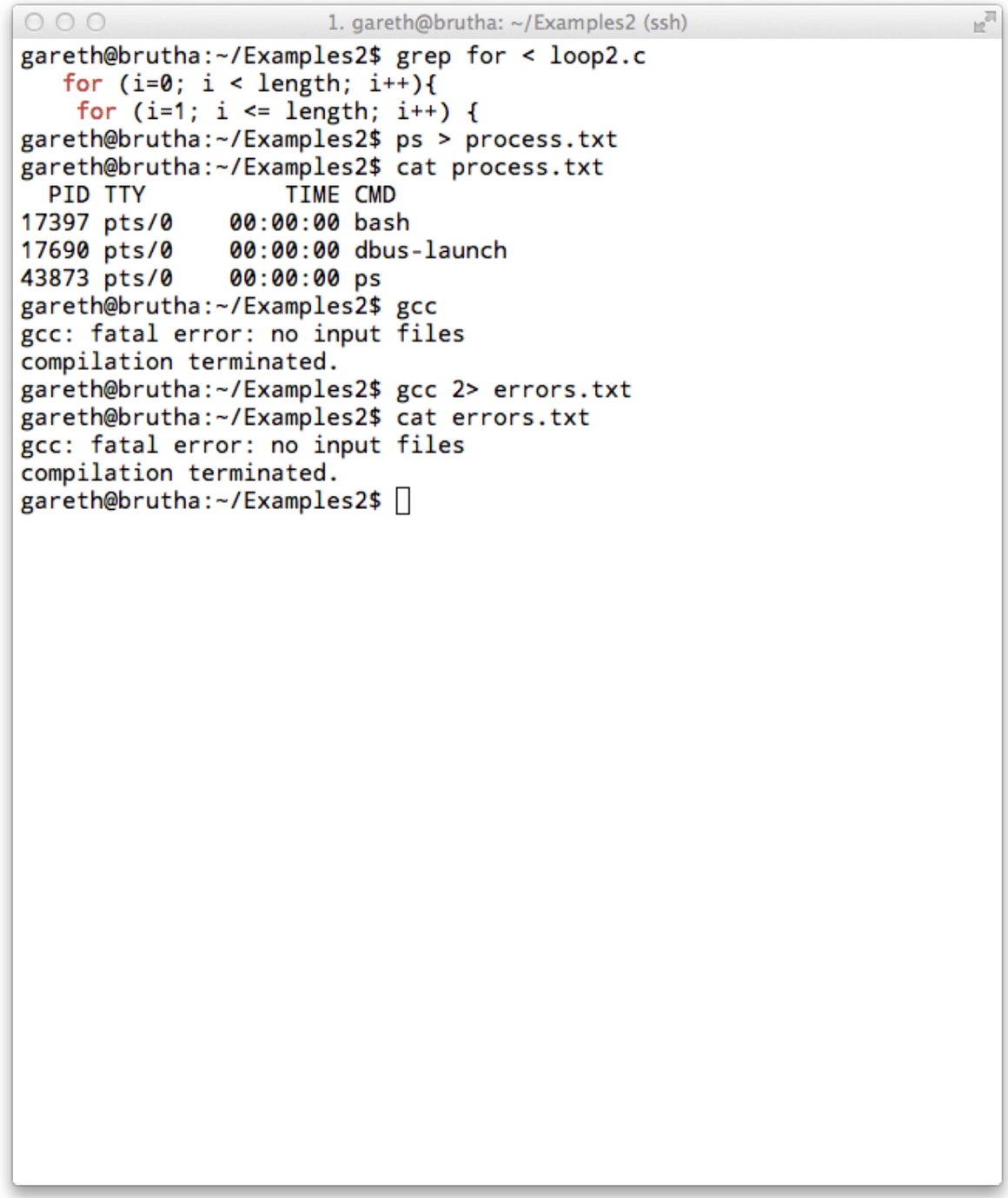
Redirection

- The standard streams (**stdin**, **stderr** and **stderr**) can be redirected to point to places.
- You can redirect stdin to put a list of typed commands into a program.
- You can redirect stdout to save the output of a program to a file for later processing.
- You can redirect stderr to save the error messages to look at later, or fix.



Redirection

- On the command line we redirect via the following commands:
- **<** - redirect stdin from a file or another stream.
- **1>** or **>** - redirect stdout to a file or another stream. If the file didn't exist it will be created, if it did exist it will be overwritten.
- **2>** - redirect stderr to a file or another stream
- **>&1** - redirect to stdout (i.e. **2>&1** to redirect stderr to stdout)
- **>&2** - redirect to stderr
- **>>** - append rather than overwrite.



Pipes

- We often want to take the output of one command and use it as the input of another command.
- Using redirection we could do something like:
  - **ps -elf** > temp.txt && **grep** n_tty < temp.txt
- This is such a common pattern on UNIX systems that the OS provides a system for doing this called pipes.
- The above command could be re-written as:
  - **ps -elf I grep n_tty**
- Where the | character means take the stout of the first command and attach it to the second.
- This allows us to chain together multiple commands.

1. gareth@brutha: ~/Examples2 (ssh)

```
gareth@brutha:~/Examples2$ ps -elf > temp.txt && grep n_tty < temp.txt
4 S root      1705     1  0  80   0 - 25964 n_tty_  2014 tty4     00:0
0:00 /sbin/getty -8 38400 tty4
4 S root      1713     1  0  80   0 - 25964 n_tty_  2014 tty5     00:0
0:00 /sbin/getty -8 38400 tty5
4 S root      1732     1  0  80   0 - 25964 n_tty_  2014 tty2     00:0
0:00 /sbin/getty -8 38400 tty2
4 S root      1733     1  0  80   0 - 25964 n_tty_  2014 tty3     00:0
0:00 /sbin/getty -8 38400 tty3
4 S root      1736     1  0  80   0 - 25964 n_tty_  2014 tty6     00:0
0:00 /sbin/getty -8 38400 tty6
4 S root      2530     1  0  80   0 - 25964 n_tty_  2014 tty1     00:0
0:00 /sbin/getty -8 38400 tty1
0 S 2080089M  7540  7533  0  80   0 - 28189 n_tty_ Jan21 pts/5    00:0
0:00 bash
0 S mdeans   14281 14243  0  80   0 - 28236 n_tty_ Jan20 pts/13   00:0
0:00 bash
0 S mdeans   27672 14243  0  80   0 - 28239 n_tty_ Jan22 pts/12   00:0
0:00 bash
0 S mwood    35105 35082  0  80   0 - 28278 n_tty_ Jan20 pts/11   00:0
0:01 /bin/bash
0 S sams     45877 45866  0  80   0 - 25454 n_tty_ 11:48 pts/15   00:0
0:00 pager -s
0 S 2083412S 47319 47312  0  80   0 - 28200 n_tty_ Jan23 pts/29   00:0
0:00 /bin/bash
0 S 20878010 58152 58145  0  80   0 - 29356 n_tty_ Jan23 pts/14   00:0
0:00 /bin/bash
gareth@brutha:~/Examples2$ ps -elf |grep n_tty |wc
     15     246    1366
gareth@brutha:~/Examples2$
```

- Variables and the Shell
- Processes
- Working with Processes
- IO Streams
- Pipes and Redirections