

Bioinformatics Lessons Schedule

Date	Subject
10-22	Terminus
10-29	Server Basics
11-5	Server Basics, continued
11-12	Server Basics, continued
11-19	Server Basics, continued
11-26	No lesson, week of Thanksgiving
12-03	Server Basics, repeat of Week 5, continued
12-10	Basic Git
12-17	How to run software on the server
12-24	Christmas break
12-31	Christmas break
01-07	Resume lessons

How to Use the Server

Input and Output (I/O), cont.

Input and Output Definitions

- Standard input (stdin) – information inputted into the terminal through the keyboard or input device



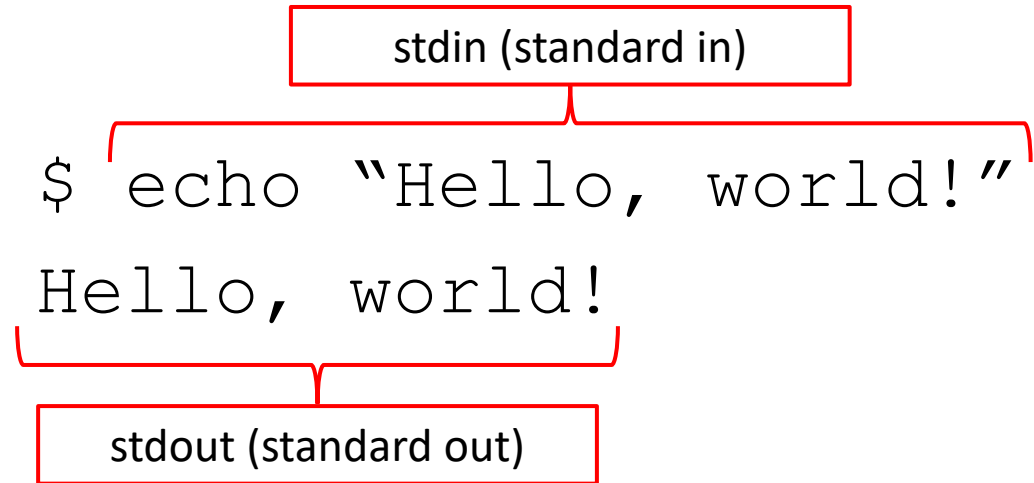
stdin (standard in)

```
$ echo "Hello, world!"
```

The diagram illustrates the concept of standard input (stdin). A red box labeled "stdin (standard in)" is positioned above the command "echo" in the terminal command "\$ echo 'Hello, world!'". A red bracket connects the box to the command, indicating that the command is receiving input from stdin.

Input and Output Definitions

- Standard input (stdin) – information inputted into the terminal through the keyboard or input device
- Standard output (stdout) – information outputted after the process is run



Input and Output Definitions

- Standard input (stdin) – information inputted into the terminal through the keyboard or input device
- Standard output (stdout) – information outputted after the process is run
- Standard error (stderr) – an error message outputted by a failed process

stdin (standard in)

```
$ echo "Hello, world!"  
Hello, world!
```

stdout (standard out)

```
$ ech "Hello, world!"  
bash: ech: command not  
found...
```

stderr (standard error)

I/O Operators

```
$ echo "Hello, world!" > hello.txt
```

I/O Operators

- `>` = Redirect stdout to a file

I/O Operators

```
$ echo "Hello, world!" > hello.txt  
$ cat hello.txt  
Hello, world!
```

- `>` = Redirect stdout to a file

I/O Operators

- > = Redirect stdout to a file
- >> = append

```
$ echo "Hello, world!" > hello.txt
$ cat hello.txt
Hello, world!
$ echo "This is how to use a Linux
server." >> hello.txt
```

I/O Operators

- `>` = Redirect stdout to a file
- `>>` = append
- `<` = redirect file to a command;
this exists, but people don't
really use it

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$ echo "Hello, world!" > hello.txt
$ cat hello.txt
Hello, world!
$ echo "This is how to use a Linux
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$ cat < hello.txt
Hello, world!
This is how to use a Linux server.
```

I/O Operators

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- `>>` = append
- `<` = redirect file to a command;
this exists, but people don't
really use it
- `1>` = redirect stdout

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- `2>` = redirect stderr

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I/O Operators

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- `>>` = append
- `<` - redirect file to a command; this exists, but people don't really use it
- `1>` = redirect stdout
- `2>` = redirect stderr
- `&>` = redirect stdout and stderr
- `|` = pipe (inspired `%>%` in R)

```
$ echo "Hello, world!" > hello.txt
$ cat hello.txt
Hello, world!
$ echo "This is how to use a Linux
server." >> hello.txt
$ cat < hello.txt
Hello, world!
This is how to use a Linux server.
$ cat wrong_alphabet.txt | sort |
uniq | head
A is for aardvark
B is for bumblebee
C is for chihuahua
D is for donkey
E is for elephant shrew
F is for flamingo
G is for Galapagos tortoise
H is for hippopotamus
I is for iguana
J is for jackal
```

Homework: Do the
I/O Operators Practice
on your own

Processes

What is a process?

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 - **foreground process** = processes initialized and controlled by an active terminal session; in other words, commands a user actively gives the server
 - **background process** = processes NOT connect to a terminal; either automatic processes the server is running, or processes the user has put in the background

Viewing Processes with top

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
KiB Swap: 59768828 total, 59525884 free, 242944 used. 40976441+avail Mem
```

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uptime = time since boot / time since the server was last restarted

Viewing Processes with top

uptime

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Viewing Processes with top

uptime

users

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users = number of users currently logged into the server

Viewing Processes with top

uptime

users

average load

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load average = average number of processes are waiting in the last 1, 5, and 15 minutes; max load is number of cores

Viewing Processes with top

tasks

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tasks = processes

Viewing Processes with top

tasks

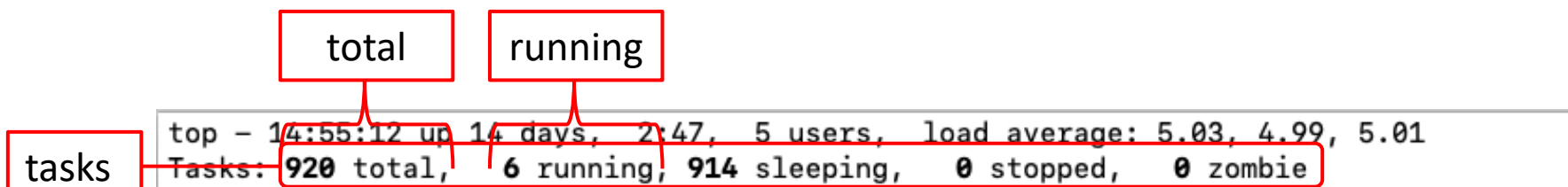
total

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tasks = processes

Viewing Processes with top



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running tasks = processes the server is currently working on

Viewing Processes with top

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sleeping tasks = processes that are waiting to be run

Viewing Processes with top

total

running

sleeping

stopped

tasks

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stopped tasks = processes that have been paused by a user

Viewing Processes with top

total running sleeping stopped zombie

tasks top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
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zombie tasks = processes that were finished but still have an ID associated with them for some reason

Viewing Processes with top

CPUs

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CPU = percentage of CPU time occupied; basically how much of the server capacity is occupied

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4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

CPU = percentage of CPU time occupied ; basically how much of the server capacity is occupied

Viewing Processes with top

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
KiB Swap: 59768828 total, 59525884 free, 242944 used. 40976441+avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
6433	kkeith	20	0	16.5g	16.2g	12548	R	100.0	3.2	8646:13	R
94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
96529	spanjar+	20	0	9318268	8.7g	6784	R	100.0	1.7	168:31.67	R
96176	spanjar+	20	0	7856944	7.3g	6784	R	100.0	1.4	189:42.14	R
4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

CPU = percentage of CPU time occupied ; basically how much of the server capacity is occupied

Viewing Processes with top

Diagram illustrating the output of the `top` command, highlighting key fields:

- users**: 5 users
- system**: 0.9 sy
- idle**: 94.2 id
- CPUs**: 4.9 us

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
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96529	spanjar+	20	0	9318268	8.7g	6784	R	100.0	1.7	168:31.67	R
96176	spanjar+	20	0	7856944	7.3g	6784	R	100.0	1.4	189:42.14	R
4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

CPU = percentage of CPU time occupied ; basically how much of the server capacity is occupied

Viewing Processes with top

memory

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
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```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
6433	kkeith	20	0	16.5g	16.2g	12548	R	100.0	3.2	8646:13	R
94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
96529	spanjar+	20	0	9318268	8.7g	6784	R	100.0	1.7	168:31.67	R
96176	spanjar+	20	0	7856944	7.3g	6784	R	100.0	1.4	189:42.14	R
4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

memory = how much memory is occupied in detail

Viewing Processes with top

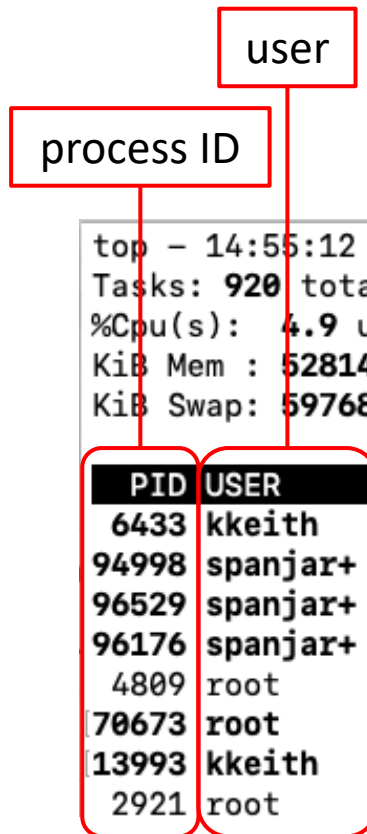
process ID

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
KiB Swap: 59768828 total, 59525884 free, 242944 used. 40976441+avail Mem
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6433	kkeith	20	0	16.5g	16.2g	12548	R	100.0	3.2	8646:13	R
94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
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4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

process ID = unique ID assigned by the server to each process

Viewing Processes with top



```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
KiB Swap: 59768828 total, 59525884 free, 242944 used. 40976441+avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
6433	kkeith	20	0	16.5g	16.2g	12548	R	100.0	3.2	8646:13	R
94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
96529	spanjar+	20	0	9318268	8.7g	6784	R	100.0	1.7	168:31.67	R
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2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

user = username of the process owner

Viewing Processes with top

top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
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PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
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4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
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13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

% CPU = amount of the available processing power the process is using

%MEM = amount of memory the process is using

Viewing Processes with top

top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
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PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
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13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

time = CPU time in minutes:seconds; NOT clock time

Viewing Processes with top

process ID

user

capacity in use

time

program

```

top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
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```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
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94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
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4809	root	20	0	0	0	0	S	45.7	0.0	3492:02	md0_raid6
70673	root	20	0	0	0	0	R	8.9	0.0	216:19.51	md0_resync
13993	kkeith	20	0	156860	3200	1612	R	1.3	0.0	0:00.27	top
2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

program = what program spawned the process

Viewing Processes with top

These are the four things you need to remember

CPUs

```
top - 14:55:12 up 14 days, 2:47, 5 users, load average: 5.03, 4.99, 5.01
Tasks: 920 total, 6 running, 914 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.9 us, 0.9 sy, 0.0 ni, 94.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 52814089+total, 1963956 free, 11728556+used, 40889136+buff/cache
KiB Swap: 59768828 total, 59525884 free, 242944 used. 40976441+avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
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94998	spanjar+	20	0	8081372	7.5g	6796	R	100.0	1.5	252:49.45	R
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2921	root	20	0	0	0	0	S	0.7	0.0	33:55.76	kdmwork-253:7

process ID

user

program

Managing Processes

Managing Processes

- Ctrl + C = cancel

Managing Processes

- Ctrl + C = cancel

[illegible]

Managing Processes

- Ctrl + C = cancel

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
@SN930:920:HJVVWBCX2:1:1113:4606:25218_1:N:0:GAGTGG
GATTGTATTTGTAGAAAAGTTAGTGTAATAGAGTTGGGAATGAGAAAGGGAAAGTTTAATGAATTAAAT
AATTGGTTTT
+
GGGGGIIIIIIIIIGIIIIIIIGGGGIIIIIIIGIGGIIIIIIIIIIIGGIIIIIIIIIGIIIIIIIG
IIIIIIIGIII
@SN930:920:HJVVWBCX2:1:1111:2820:31962_1:N:0:GAGTGG
AATATATAAAGAAAAAAAAAATTTTATTAATTTTGTAAAAATAAATATTATTAAATTATAAATTAAATT
TTGAAGA
+
GGGGGIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
IIIIIII
[kkeith]$
```

Hit Ctrl + C
here



Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop

Hit Ctrl + Z
here



```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
@SN930:920:HJVVWBCX2:1:1113:4606:25218_1:N:0:GAGTGG
GATTGTATTTGTAGAAAAGTTAGTGTAATAGAGTTGGGAATGAGAAAGGGAAAGTTTAATGAATTAAAT
AATTGGTTTT
+
GGGGGIIIIIIIIIGIIIIIIIGGGGIIIIIIIGIGGIIIIIIIIIIIGGIIIIIIIIIGIIIIIIIG
IIIIIGIIII
--More--
[1]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$
```


Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
@SN930:920:HJVVWBCX2:1:1113:4606:25218_1:N:0:GAGTGG
GATTGTATTTGTAGAAAAGTTAGTGTAAATAGAGTTGGGAATGAGAAAGGGAAAGTTTAATGAATTAAAT
AATTGGTTTT
+
GGGGGIIIIIIIIIGIIIIIIIGGGGIIIIIIIGIGGIIIIIIIIIIIGGIIIIIIIIIGIIIIIIIG
IIIIIIIGIII
--More--
[1]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
@SN930:920:HJVVWBCX2:1:1113:4606:25218_1:N:0:GAGTGG
GATTGTATTTGTAGAAAAGTTAGTGTAATAGAGTTGGGAATGAGAAAGGGAAAGTTTAATGAATTAAAT
AATTGGTTTT
+
GGGGGIIIIIIIIIGIIIIIIIGGGGIIIIIIIGIGGIIIIIIIIIIIGGIIIIIIIIIGIIIIIIIG
IIIIIIIGIII
```

```
--More--
```

```
[1]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ ps
```

PID	TTY	TIME	CMD
16123	pts/23	00:00:00	gzip
16146	pts/23	00:00:00	ps
98235	pts/23	00:00:00	bash

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process

```
[kkeith]$ ps
  PID TTY          TIME CMD
 16123 pts/23    00:00:00 gzip
 16146 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process

```
[kkeith]$ ps
  PID TTY          TIME CMD
 16123 pts/23    00:00:00 gzip
 16146 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
[kkeith]$ kill -SIGKILL 16123

[1]+  Killed                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process

```
[kkeith]$ ps
  PID TTY          TIME CMD
 16123 pts/23    00:00:00 gzip
 16146 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
[kkeith]$ kill -SIGKILL 16123

[1]+  Killed                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ ps
  PID TTY          TIME CMD
 16281 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process

```
[kkeith]$ ps
  PID TTY          TIME CMD
 16123 pts/23    00:00:00 gzip
 16146 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
[kkeith]$ kill -SIGKILL 16123

[1]+  Killed                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ ps
  PID TTY          TIME CMD
 16281 pts/23    00:00:00 ps
 98235 pts/23    00:00:00 bash
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process
- **jobs** = view your stopped commands

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ zcat data/rrbs_chr21_f14_L002_R1_001.fastq.gz
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process
- **jobs** = view your stopped commands

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ zcat data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ ps
```

PID	TTY	TIME	CMD
9055	pts/34	00:00:00	bash
9155	pts/34	00:00:00	gzip
11320	pts/34	00:00:00	gzip
11345	pts/34	00:00:00	gzip
11357	pts/34	00:00:00	ps

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process
- **jobs** = view your stopped commands

```
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ zcat data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ zcat data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ ps
```

PID	TTY	TIME	CMD
9055	pts/34	00:00:00	bash
9155	pts/34	00:00:00	gzip
11320	pts/34	00:00:00	gzip
11345	pts/34	00:00:00	gzip
11357	pts/34	00:00:00	ps

```
[kkeith]$ jobs
```

[1]	Stopped	zcat
		data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]-	Stopped	zcat
		data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[3]+	Stopped	zcat
		data/rrbs_chr21_f14_L002_R1_001.fastq.gz

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process
- **jobs** = view your stopped commands
- **fg** = resume (most recent) job in the foreground

```
[kkeith]$ jobs
[1]  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]-  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[3]+  Stopped                  zcat
data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ fg
```

Managing Processes

- **Ctrl + C** = cancel
- **Ctrl + Z** = stop
- **ps** = view your processes
- **kill** = terminate a process
- **jobs** = view your stopped commands
- **fg** = resume (most recent) job in the foreground

```
[kkeith]$ jobs
[1]  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]-  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[3]+  Stopped                  zcat
data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ fg
[kkeith]$ jobs
[1]-  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
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data/rrbs_chr21_f14_L001_R1_001.fastq.gz
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data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[3]+  Stopped                  zcat
data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ fg
[kkeith]$ jobs
[1]-  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ fg 1
```

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[3]+  Stopped                  zcat
data/rrbs_chr21_f14_L002_R1_001.fastq.gz
[kkeith]$ fg
[kkeith]$ jobs
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data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[2]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ fg 1
[kkeith]$ jobs
[2]+  Stopped                  zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

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- **bg** = resume (most recent job) in the background

```
[kkeith]$ jobs
```

```
[2]+  Stopped                  zcat  
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ bg
```

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[kkeith]$ jobs
```

```
[2]+  Stopped                  zcat  
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ bg
```

```
[2]+  Done                    zcat  
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

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```

```
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```
[kkeith]$ bg
```

```
[2]+  Done                    zcat  
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
```

```
[kkeith]$ jobs
```

```
[kkeith]$
```


PRACTICE

BREAK

Running Processes in the Background

- When you log out of the server, anything that's running is killed

Running Processes in the Background

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- **nohup** = ignore the log out signal and keep running

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```
[kkeith]$ nohup zcat  
data/rrbs_chr21_f14_L001_R1_001.fastq.gz &  
[1] 16432  
nohup: ignoring input and appending output to  
'nohup.out'
```

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data/rrbs_chr21_f14_L001_R1_001.fastq.gz &
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data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ ls

analysis  data  hello.txt  new_file2.txt  new_files.
txt  new_file.txt  nohup.out  practice_file.txt  REA
DME.md  scripts
```

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[1]+  Done                  nohup zcat
data/rrbs_chr21_f14_L001_R1_001.fastq.gz
[kkeith]$ ls
analysis  data  hello.txt  new_file2.txt  new_files.
txt  new_file.txt  nohup.out  practice_file.txt  REA
DME.md  scripts

[kkeith]$ head -n4 nohup.out

@SN930:920:HJVVWBCX2:1:1113:4606:25218_1:N:0:GAGTGG

GATTGTATTTGTAGAAAAGTTAGTGTAATAGAGTTGGGAATGAGAAAGGGAAAGTTTAA
TGAATTAAATAATTGGTTTT

+

GGGGGIIIIIIIIIGIIIIIIIGGGGIIIIIIIGIGGIIIIIIIIIIIGGIIIIIIII
IGIIIIIIIGIIIIIIIGIII
```

Running Processes in the Background

- When you log out of the server, anything that's running is killed
- **nohup** = ignore the log out signal and keep running
- **tmux** (terminal multiplexer) = program that allows you to create extra, persistent windows
 - `tmux new-session -s session1`

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[kkeith]\$

barbarbarbarbarbarbarbarbarbarbarbar

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```
[kkeith]$ pwd  
/home/kkeith/data/practice_directory
```

```
barbarbarbarbarbarbarbarbarbarbar
```

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 - Ctrl + B, then d to detach

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[kkeith]$ pwd  
/home/kkeith/data/practice_directory
```

1. Hit Ctrl + B
2. Hit d

barbarbarbarbarbarbarbarbarbarbar

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[detached (from session session1)]
```

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[detached (from session session1)]
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session1: 1 windows (created Mon Nov 18 16:42:27
2019)
```

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2019)
[kkeith]$ tmux kill-session -t session1

[kkeith]$ tmux ls

no server running on /private/tmp/tmux-
669394417/default
```

PRACTICE

BREAK

DONE!

