

# Modeling UNIX in PintOS

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# What is the unix philosophy?

- Write programs that do one thing and do it well.
- Write programs that work together.
- Write programs to handle text streams, because that is a universal interface.



# File

- We have followed the Unix's “everything is a file” feature.
- STDIN, STDOUT, regular file, directory, and pipe are all file that can be read, write, and closed (directory is an exception: cannot read or write).



# File descriptor table

- File descriptors point into global open file table so threads can share files.
- Each thread's list of file descriptors offset an array of file pointers shared between the parent and child threads
- File's keep reference count, as multiple descriptors can point to the same file now.

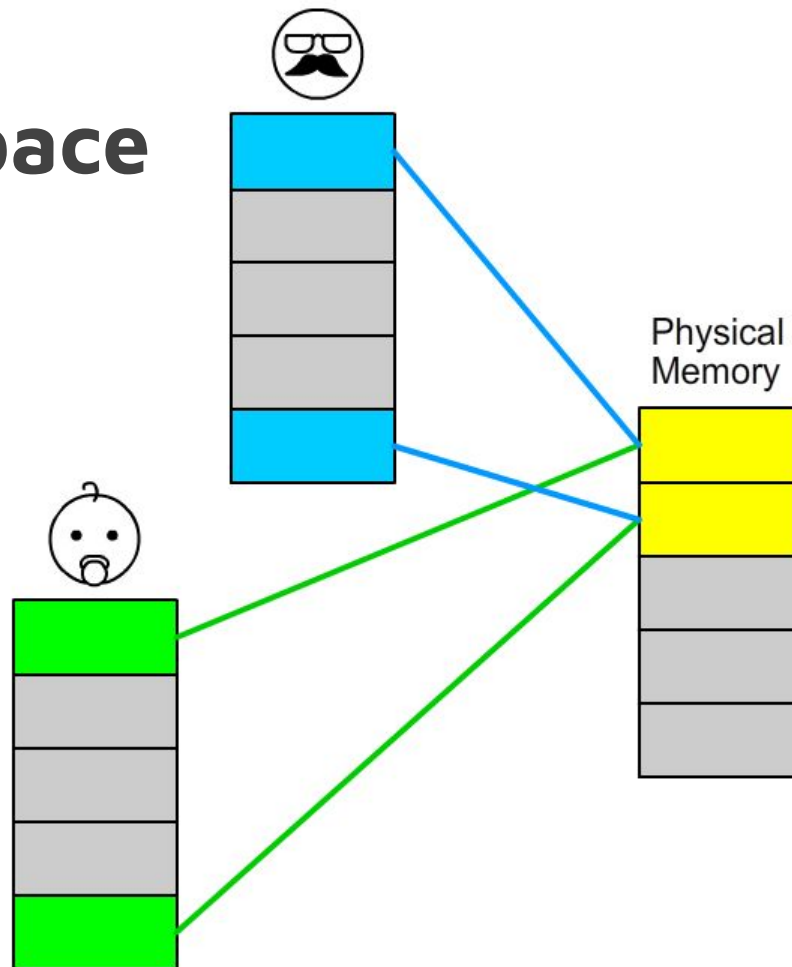


# fork () & exec2 ()

- Forking a thread spawns a new child thread that is a clone of the parent.
- The child thread clones the following from the parent:
  - Memory segments including stack, heap, and registers. They are separated once cloned.
  - File descriptor table which allows the child to inherit the parents open files.
- The exec2() system call simply loads the program and runs in the current process instead spawning and running it on the new child process like exec().

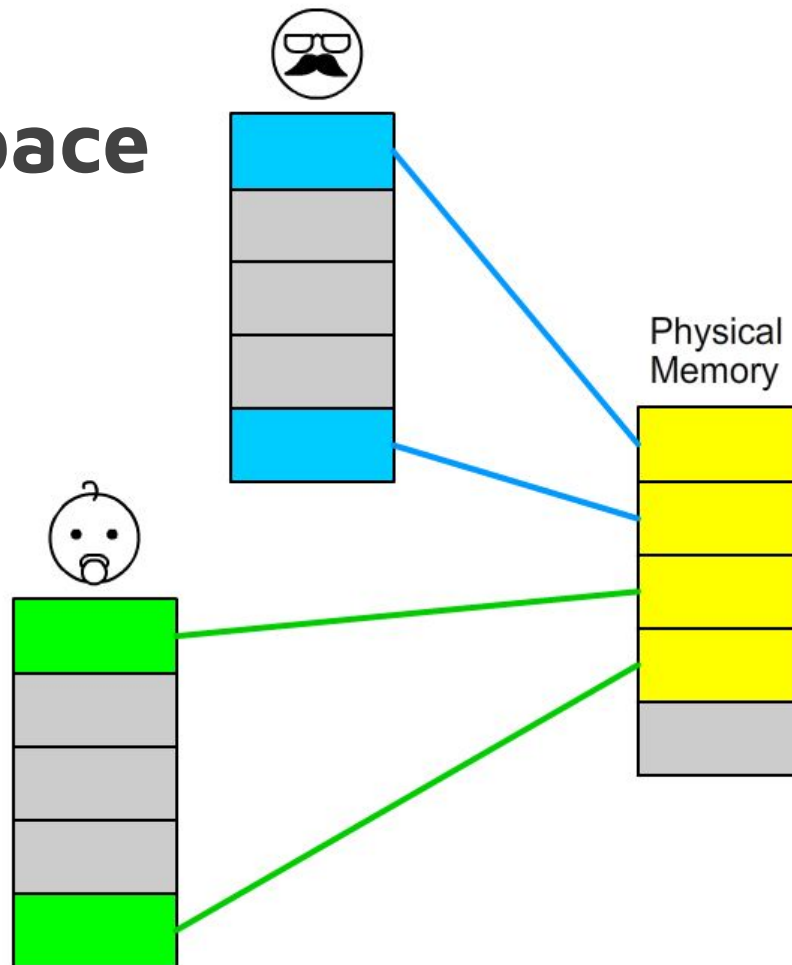
# Cloning address space

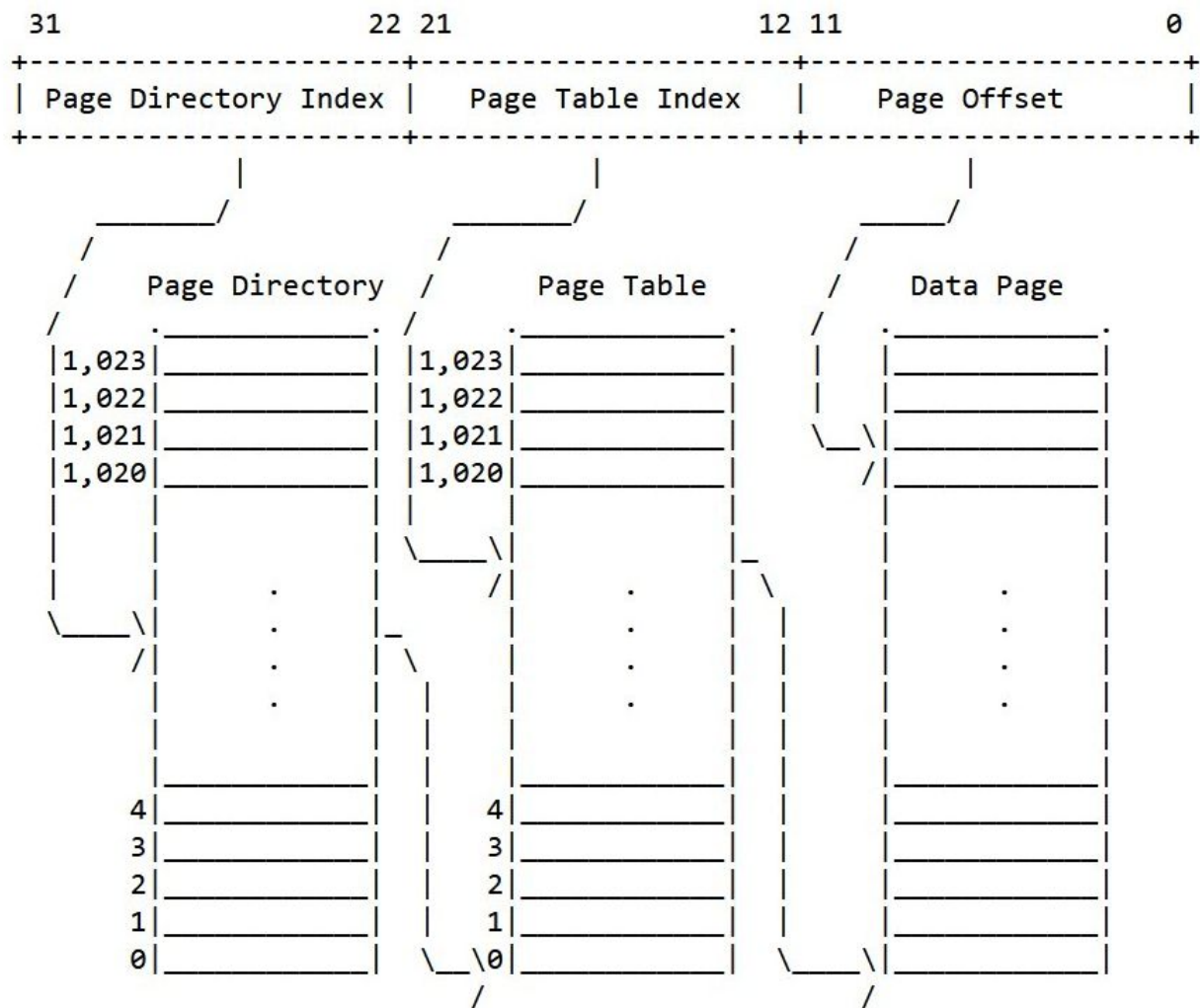
- Cloning is done by assigning new mapping to existing valid virtual address.
- We identify the valid virtual address by iterating over the multi-level page table. For each valid entries, we assigned new mapping in the physical memory.



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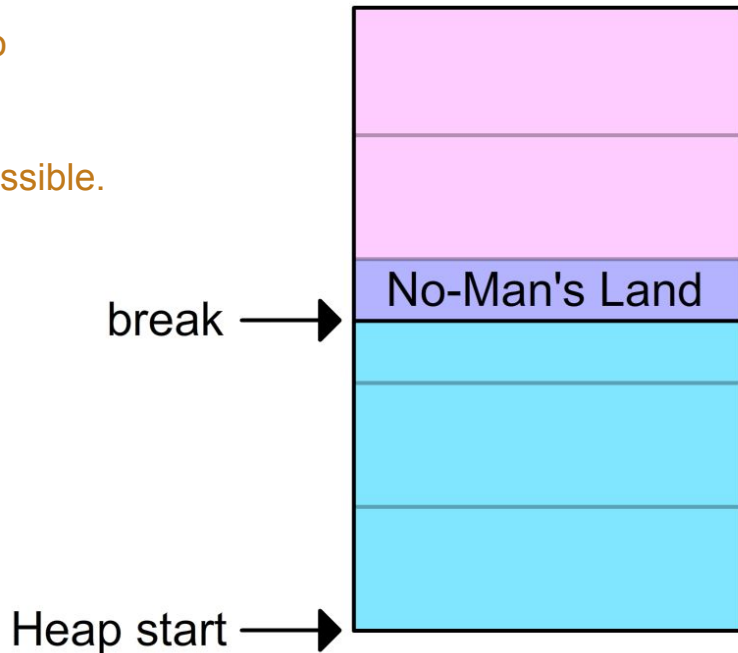
# dup2 ()

- Assign a new file descriptor that point to the same file as the old file descriptor.
- Changes are only visible within the current process.
- Useful because it allows for things like I/O redirection.



# sbrk () & malloc ()

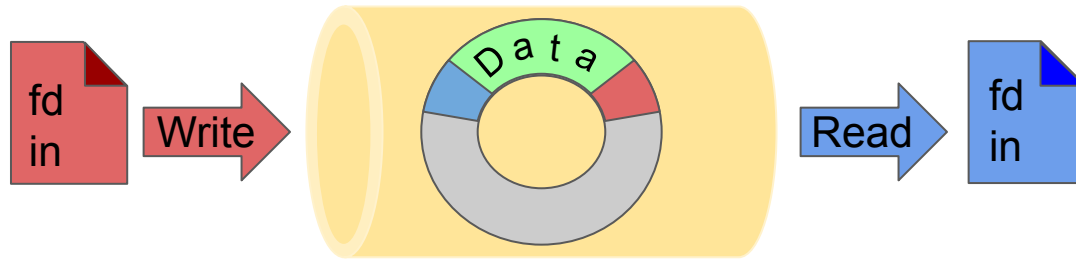
- Increments the threads break pointer
- User heap is defined from end of the BSS segment to thread break pointer
- As memory is mapped by page, No-Man's Land is possible.
- The user level memory allocator is ported from project 3 in CS3214



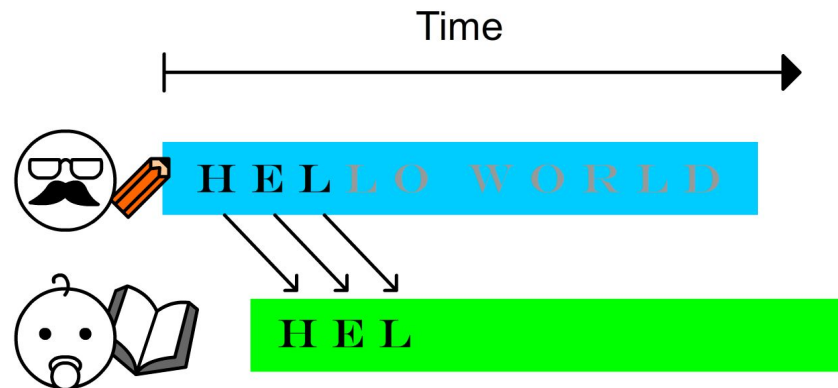
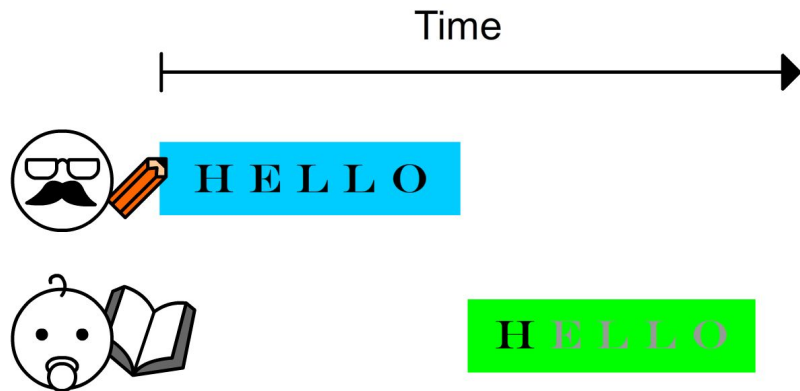


# pipe ()

- Spawns a unidirectional data channel for interprocess communication
- Pipe is allocated in kernel memory -> Substantial performance increase.
- Uses file descriptors to point to each end of the pipe.
- Implemented as a ring buffer using consumer/producer pattern.



# Pipe parallelism test(1)





# Pipe parallelism test(2)

mobydick.txt

When Stubb had departed, Ahab stood for a while leaning over the bulwarks; and then, as had been usual with him of late, calling a sailor of the watch, he sent him below for his ivory stool, and also his pipe. Lighting the pipe at the binnacle lamp and planting the stool on the weather side of the deck, he sat and smoked.

In old Norse times, the thrones of the sea-loving Danish kings were fabricated, saith tradition, of the tusks of the narwhale. How could one look at Ahab then, seated on that tripod of bones, without bethinking him of the royalty it symbolized? For a Khan of the plank, and a king of the sea, and a great lord of Leviathans was Ahab.

Some moments passed, during which the thick vapor came from his mouth in quick and constant puffs, which blew back again into his face. "How now," he soliloquized at last, withdrawing the tube, "this smoking no longer soothes. Oh, my pipe! hard must it go with me if thy charm be gone! Here have I been unconsciously toiling, not pleasuring--aye, and ignorantly smoking to windward all the while; to windward, and with such nervous whiffs, as if, like the dying whale, my final jets were the strongest and fullest of trouble. What business have I with this pipe? This thing that is meant for sereneness, to send up mild white vapors among mild white hairs, not among torn iron-grey locks like cat: exit(0)

> |

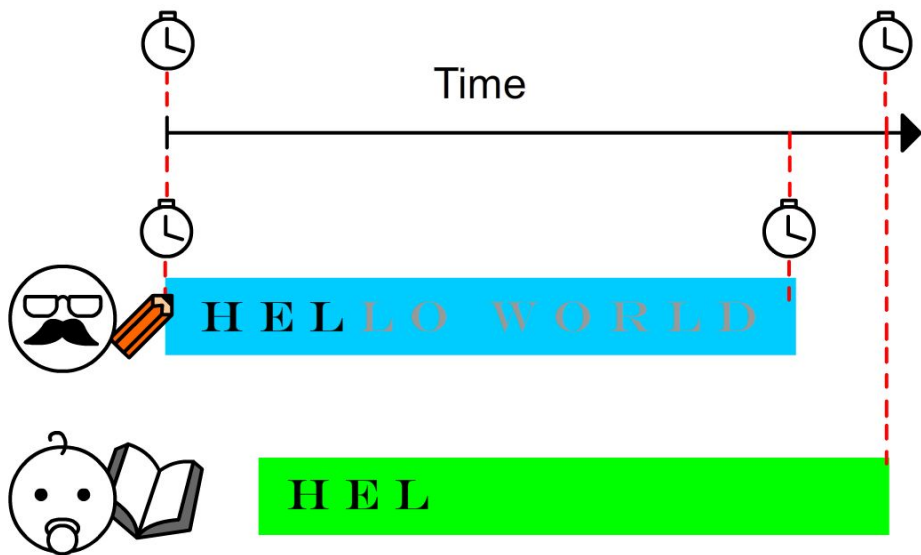
xor\_cipher encryption

```
*8?' .gk2.k8#*' 'k.9.k'$%,k8..k#&gk).*?'%,k#*8k?*&)$>9"%pA;9.'>8"=.k$-k?# .k,9.*?k)$ /2k$-k?#.k(9.<gA<.9.k*k-*9k&$9.k)*9)*9*(gk#. *?%.#"8#gk*% /k&$?' .2
9gk**;.k&*%ek$<gk"?k)."% ,#9'8?&*8k<#. %k?#.k8# ;k8#?k-9$&k$>?k#.9k#*9)$9gk
#.9.k8..&./k%$k8",%k$-k($&&$%k)$ /" '2k" ' '%.88k*)$>?k#"&gk%$9k$-k?#.A9.($=.9

#.%k"?k(*&.k>;$%k#"&gk%$?k"%k?#.A->92k$-k*%2k&$9?* 'k-9*2gk)>?k"%k*%k. ' .&.%
"?"$%8gk?#.k" &&. &$9"* 'k(9./>" " " .8gk;$;>' *9'2k"%=.8? /A?#"8k$' /k**3&*%k<"?
f<#("k&# ,#?k#*9/'2k($&.k? $A;*8gk8$ k#.k&>??9./ff?#. %gk<#$.=.9k8#>' /k/$k
k<#("k8?9.* . /k"?gk?#*?k-$9k?#.k-"98?k-.<k&$&.%?8k#k*9/'2A%$? /k?#*?k%$?k
"/A?#.k$' /k

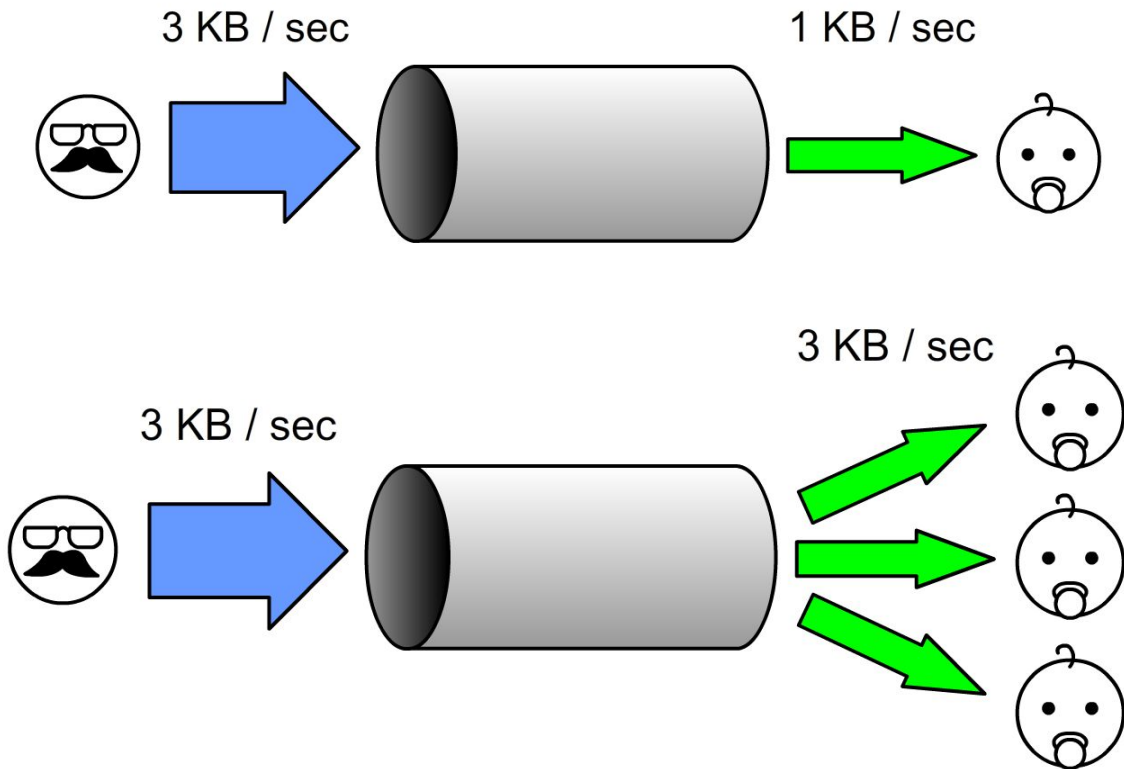
*2f.* /k%/"*%k$%(pki)>?k' " .k#"8k/"8&*8? /k(9-*?gk#.k8#" ; /A*%
$>?A).2$%/k?#.k8#" ;l8k=.9f;"? (" % ,k;9$<ek#.9.k<*8k*%k"%-" %"?2k$-k-"9&.8?A
.kk
-"3"$%A"%k#"8k-*(.pk"%k*' 'k?#.k%*&. ' .88k9. , *'k$=.9).*9"% ,k/" , %"?2k$-k8&$.A
gk) . , %k? $A,9$<k*%' "??' .k, , %"*'gk#.k).(*&.k8?' ' 'k'.88k*% /k'.88k*%k.(' >8.pk
*?k#.k<*8k*' &$8?k($%?">* ' '2k"%k?#.k*"9pk)>?gk*8k2.7gA-$9k*' 'k?#*?k#.k8#"/
% ,k, "9'8gk"%? .9=*'gk?#.k('$$/8k?#*?A' *2.9k>;$%k' *2.9k<.9.k; ' ' /k>;$%k#"8k)
92gk&8*%?#9$; ("k<$$/8pk=. %k?#.k)*9.8?gA9> , , / .8?gk&$8?k?#>%/ .9f('$=. %k$'
$%/k? $k?#.k; ' *2->'k*' '>9"% ,8k$-k?#*?k, "9" "8A* "9ek$9.k?#*%k$$(.k/" /k#.k;>?
%/k"(.).9.8k*' 'k*8?.9%gk?#.k>$ /k%$<k<.%?A9$' ' "% ,k?#9$> ,#k?#.k)9" ,#?k>?"?k8
$8.k).?< . %k8>(#k<"%8&$&.k/*28A*% /k8>(#k8.> / (" % ,k% , #?8ekk<.9.k>?k*' 'k?#.k<
A*% /k&$9.k?#.2k<9$> ,#?k$%k
* .->'pk*8k"-gk?#.k'$%, '9k' "% . /k<"?#k' "-.gk?#.k'.88A&*k#*8k?$k/$k<?"#k*>
.*9/8k<" ' ?k$-? . % .8?k' .*=.k?#.9k).9?#8k? $k="8"?k?#.A% , #?f('$* . /k/ (. ek?k
&./k8$ k&>(#k? $k' ".k"%k?#.k$; , %k*"9gk?#*?k?9>'2k8; .* "% ,gk#"8k="8"?8A<.9.
gk?#. %gk%$k$%.k($>' /k*2A%*2pk)>?k?#.9.k& , #?k).k8&$.k<*2k$-k&>--" "% ,k?#.k
```

## Pipe parallelism test(3)



```
-----  
| Read/Write overlap test result: |  
-----  
| Write duration: | 5768 ticks |  
| Total duration: | 6123 ticks |  
-----
```

## Pipe parallelism test(4)





## Pipe parallelism test(5)

Jobserver test result:			
-----			
1 worker:		6029 ticks	
2 workers:		3747 ticks	
4 workers:		3499 ticks	
-----			

Manager : preload mobydick.txt into memory, then write to write-end of the pipe.

Workers: read from pipe read-end and encrypt using XOR cipher.





# errno

- Thread local errno is set when syscall fail (return -1, NULL, or false)
- Tiny subset of errno are supported to help identify system error. (Some are custom)
- User can view syscall error description through perror()

errno name	Number	Description
EINVF	13	Invalid file descriptor
EBADF	113	Bad file descriptor
ENAME	126	Invalid file name length
ENOENT	129	No such file or directory



# Shell demo