

Lab #1: System Call Implementation

Group Members

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Link to Videos

1. Google Drive
 - a. https://drive.google.com/file/d/1dsCuwNWqNFMh9WYTxAoC5fOZWobuIrl/view?usp=share_link
2. Youtube
 - a. <https://youtu.be/ljfBkONmJco>

List of Files Modified

Makefile

| - kernel/

| - defs.h
| - kalloc.c
| - proc.c
| - proc.h
| - syscall.c
| - syscall.h
| - sysproc.c

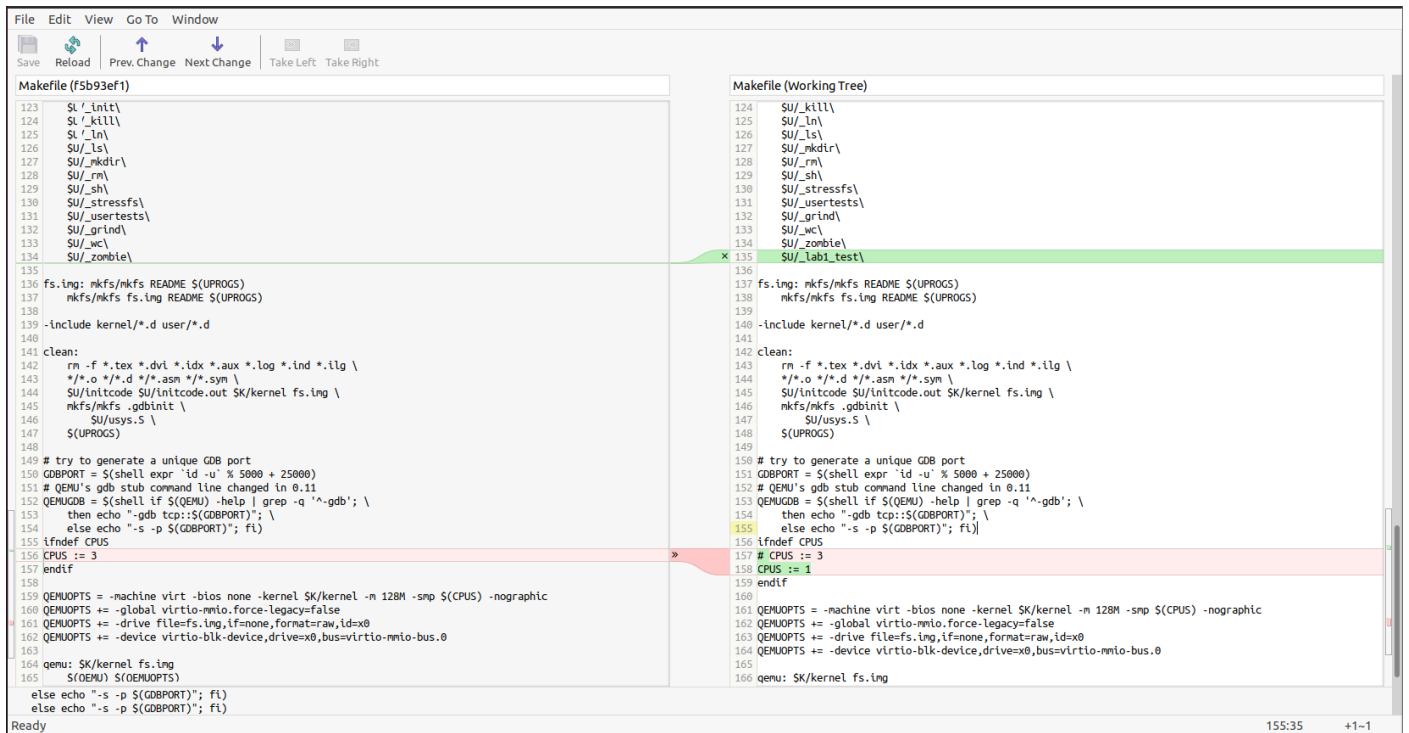
| - user/

| - lab1_test.c
| - user.h
| - usys.pl

Screenshot of changes and Explanation

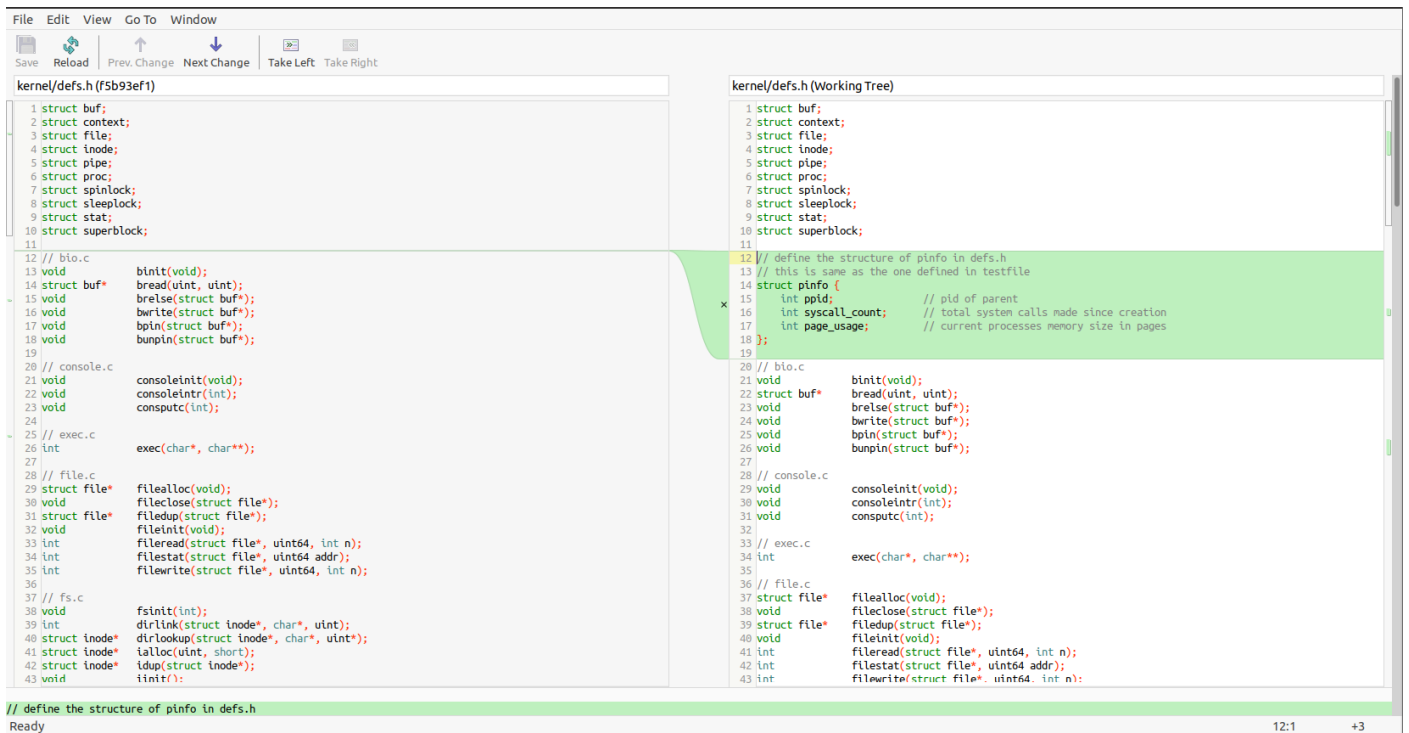
Makefile

- Added our lab1_test.c file to UPROGS
- Changed the number of CPUs to 1



kernel/defs.h

- Create a structure with the required fields
- Create a function *get_free_memory* that returns the number of free pages
- Define the function prototype for sysinfo system call
- Define the function prototype for procinfo system call



```

kernel/defs.h (F5b93ef1)
44 void iunlock(struct inode*);
45 void iunlockput(struct inode*);
46 void iunlockput(struct inode*);
47 void iupdate(struct inode*);
48 void iupdate(struct inode*);
49 int namecmp(const char*, const char*);
50 struct inode* namei(char*);
51 struct inode* nameiparent(char*, char*);
52 int read(struct inode*, int, uint64, uint, uint);
53 void stat(struct inode*, struct stat*);
54 int write(struct inode*, int, uint64, uint, uint);
55 void itrunc(struct inode*);
56
57 // randisk.c
58 void randiskinit(void);
59 void randiskintr(void);
60 void randiskrw(struct buf*);
61
62 // kalloc.c
63 void* kalloc(void);
64 void kfree(void *);
65 void kinit(void);
66
67 // log.c
68 void initlog(int, struct superblock*);
69 void log_write(struct buf*);
70 void begin_op(void);
71 void end_op(void);
72
73 // pipe.c
74 int pipealloc(struct file**, struct file**);
75 void pipeclose(struct pipe*, int);
76 int piperead(struct pipe*, uint64, int);
77 int pipewrite(struct pipe*, uint64, int);
78
79 // printf.c
80 void printf(char*, ...);
81 void panic(char*) __attribute__((noreturn));
82 void printfinit(void);
83
84 // proc.c
85 int cpuid(void);
86 void exit(int);
87
// function to traverse the freelist linked list and count the number of free pages
Ready
66:1 +3

```

```

kernel/defs.h (Working Tree)
54 void iunlock(struct inode*);
55 void iunlockput(struct inode*);
56 void iupdate(struct inode*);
57 int namecmp(const char*, const char*);
58 struct inode* namei(char*);
59 struct inode* nameiparent(char*, char*);
60 int read(struct inode*, int, uint64, uint, uint);
61 void stat(struct inode*, struct stat*);
62 int write(struct inode*, int, uint64, uint, uint);
63 void itrunc(struct inode*);
64
65 // randisk.c
66 void randiskinit(void);
67 void randiskintr(void);
68 void randiskrw(struct buf*);
69
70 // kalloc.c
71 void* kalloc(void);
72 void kfree(void *);
73 void kinit(void);
74 // function to traverse the freelist linked list and count the number of free pages
75 int get_free_memory(void);
76
77 // log.c
78 void initlog(int, struct superblock*);
79 void log_write(struct buf*);
80 void begin_op(void);
81 void end_op(void);
82
83 // pipe.c
84 int pipealloc(struct file**, struct file**);
85 void pipeclose(struct pipe*, int);
86 int piperead(struct pipe*, uint64, int);
87 int pipewrite(struct pipe*, uint64, int);
88
89 // printf.c
90 void printf(char*, ...);
91 void panic(char*) __attribute__((noreturn));
92 void printfinit(void);
93
94 // proc.c
95 int cpuid(void);
96 void exit(int);

```

```

kernel/defs.h (F5b93ef1)
78
79 // printf.c
80 void printf(char*, ...);
81 void panic(char*) __attribute__((noreturn));
82 void printfinit(void);
83
84 // proc.c
85 int cpuid(void);
86 void exit(int);
87 void fork(void);
88 void growproc(int);
89 void proc_mapstacks(pagetable_t);
90 pagetable_t proc_pagetable(struct proc *);
91 void proc_freepagetable(pagetable_t, uint64);
92 int kill(int);
93 int killed(struct proc*);
94 void setkilled(struct proc*);
95 struct cpu* mycpu(void);
96 struct cpu* getmycpu(void);
97 struct proc* myproc();
98 void procinit(void);
99 void scheduler(void) __attribute__((noreturn));
100 void sched(void);
101 void sleep(void*, struct spinlock*);
102 void userinit(void);
103 int wait(uint64);
104 void wakeup(void*);
105 void yield(void);
106 int either_copypout(int user_dst, uint64 dst, void *src, uint64 len);
107 int either_copypin(void *dst, int user_src, uint64 src, uint64 len);
108 void procdump(void);
109
110 // switch.S
111 void switch(struct context*, struct context*);
112
113 // spinlock.c
114 void acquire(struct spinlock*);
115 int holding(struct spinlock*);
116 void initlock(struct spinlock*, char*);
117 void release(struct spinlock*);
118 void push_off(void);
119 void pop_off(void);
120
// define the structure of pinfo in defs.h
Ready
12:1 +3

```

```

kernel/defs.h (Working Tree)
88
89 // printf.c
90 void printf(char*, ...);
91 void panic(char*) __attribute__((noreturn));
92 void printfinit(void);
93
94 // proc.c
95 int cpuid(void);
96 void exit(int);
97 void fork(void);
98 int growproc(int);
99 void proc_mapstacks(pagetable_t);
100 pagetable_t proc_pagetable(struct proc *);
101 void proc_freepagetable(pagetable_t, uint64);
102 int kill(int);
103 int killed(struct proc*);
104 void setkilled(struct proc*);
105 struct cpu* mycpu(void);
106 struct cpu* getmycpu(void);
107 struct proc* myproc();
108 void procinit(void);
109 void scheduler(void) __attribute__((noreturn));
110 void sched(void);
111 void sleep(void*, struct spinlock*);
112 void userinit(void);
113 int wait(uint64);
114 void wakeup(void*);
115 void yield(void);
116 int either_copypout(int user_dst, uint64 dst, void *src, uint64 len);
117 int either_copypin(void *dst, int user_src, uint64 src, uint64 len);
118 void procdump(void);
119
120 // define the process level implementation of sysinfo syscall
121 int get_sys_sysinfo(uint64, uint64);
122 // define the process level implementation of procinfo syscall
123 int get_sys_procinfo(uint64 addr);
124
125 // switch.S
126 void switch(struct context*, struct context*);
127
128 // spinlock.c
129 void acquire(struct spinlock*);
130 int holding(struct spinlock*);

```

kernel/kalloc.c

- Write the function body for `get_free_memory` that iterates the freelist linked list and return the number of free pages available.

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kernel/kalloc.c (f5b93ef1)

```

41 //
42 // Free the page of physical memory pointed at by pa,
43 // which normally should have been returned by a
44 // call to kalloc(). (The exception is when
45 // initializing the allocator; see kinit above.)
46 void
47 kfree(void *pa)
48 {
49     struct run *r;
50
51     if(((uint64)pa % PGSIZE) != 0 || (char*)pa < end || (uint64)pa >= PHYSTOP)
52         panic("kfree");
53
54     // Fill with junk to catch dangling refs.
55     memset(pa, 1, PGSIZE);
56
57     r = (struct run*)pa;
58
59     acquire(&kmem.lock);
60     r->next = kmem.freelist;
61     kmem.freelist = r;
62     release(&kmem.lock);
63 }
64
65 // Allocate one 4096-byte page of physical memory.
66 // Returns a pointer that the kernel can use.
67 // Returns 0 if the memory cannot be allocated.
68 void *
69 kalloc(void)
70 {
71     struct run *r;
72
73     acquire(&kmem.lock);
74     r = kmem.freelist;
75     if(r)
76         kmem.freelist = r->next;
77     release(&kmem.lock);
78
79     if(r)
80         memset((char*)r, 5, PGSIZE); // fill with junk
81     return (void*)r;
82 }
83

```

kernel/kalloc.c (Working Tree)

```

60 r->next = kmem.freelist;
61 kmem.freelist = r;
62 release(&kmem.lock);
63 }
64
65 // Allocate one 4096-byte page of physical memory.
66 // Returns a pointer that the kernel can use.
67 // Returns 0 if the memory cannot be allocated.
68 void *
69 kalloc(void)
70 {
71     struct run *r;
72
73     acquire(&kmem.lock);
74     r = kmem.freelist;
75     if(r)
76         kmem.freelist = r->next;
77     release(&kmem.lock);
78
79     if(r)
80         memset((char*)r, 5, PGSIZE); // fill with junk
81     return (void*)r;
82 }
83
84 // function to traverse the free memory pages and return count
85 int
86 get_free_memory() {
87     int
88     ctr = 0;
89
90     struct run *r;
91     r = kmem.freelist;
92
93     if (r)
94     {
95         while (r->next){
96             r = r->next;
97             ctr += 1;
98         }
99     }
100
101     return ctr;
102 }

```

Ready 82:2 ~1

kernel/proc.c

- Set the process level `sys_count` variable to 0 at the time of process initialization and termination
- Implemented the `sys_info` system call as per requirements. The function takes parameter as the input (0,1,2) and returns the entities accordingly as per the problem statement. If the parameter passed in the function is anything else than the 3 mentioned parameters, the function will return -1 which implies error.
- Implemented the `proc_info` system call as per requirements. This function provides information specific to the current process. A pointer of structure `pinfo` is passed to the function. Upon success the function returns 0 while in case of a failure it returns -1.

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kernel/proc.c (f5b93ef1)

```

150 //
151 // free a proc structure and the data hanging from it,
152 // including user pages.
153 // p->lock must be held.
154 static void
155 freeproc(struct proc *p)
156 {
157     if(p->trapframe)
158         kfree((void*)p->trapframe);
159     p->trapframe = 0;
160     if(p->pagetable)
161         proc_freepagetable(p->pagetable, p->sz);
162     p->pagetable = 0;
163     p->sz = 0;
164     p->pid = 0;
165     p->parent = 0;
166     p->name[0] = 0;
167     p->chan = 0;
168     p->killed = 0;
169     p->xstate = 0;
170     p->state = UNUSED;
171 }
172
173 // Create a user page table for a given process, with no user memory,
174 // but with trampoline and trapframe pages.
175 pagetable_t
176 proc_pagetable(struct proc *p)
177 {
178     pagetable_t pagetable;
179
180     // An empty page table.
181     pagetable = uvmcreate();
182     if(pagetable == 0)
183         return 0;
184
185     // map the trampoline code (for system call return)
186     // at the highest user virtual address.
187     // only the supervisor uses it, on the way
188     // to/from user space, so not PTE_U.
189     if(mappages(pagetable, TRAMPOLINE, PGSIZE,
190                (uint64)trampoline, PTE_R | PTE_X) < 0){
191         uvmfree(pagetable, 0);
192         return 0;
193     }
194
195     // reset sys_calls count to 0
196     p->sys_calls_count = 0;
197 }

```

kernel/proc.c (Working Tree)

```

152 // free a proc structure and the data hanging from it,
153 // including user pages.
154 // p->lock must be held.
155 static void
156 freeproc(struct proc *p)
157 {
158     if(p->trapframe)
159         kfree((void*)p->trapframe);
160     p->trapframe = 0;
161     if(p->pagetable)
162         proc_freepagetable(p->pagetable, p->sz);
163     p->pagetable = 0;
164     p->sz = 0;
165     p->pid = 0;
166     p->parent = 0;
167     p->name[0] = 0;
168     p->chan = 0;
169     p->killed = 0;
170     p->xstate = 0;
171     p->state = UNUSED;
172
173     // reset sys_calls count to 0
174     p->sys_calls_count = 0;
175 }
176
177 // Create a user page table for a given process, with no user memory,
178 // but with trampoline and trapframe pages.
179 pagetable_t
180 proc_pagetable(struct proc *p)
181 {
182     pagetable_t pagetable;
183
184     // An empty page table.
185     pagetable = uvmcreate();
186     if(pagetable == 0)
187         return 0;
188
189     // map the trampoline code (for system call return)
190     // at the highest user virtual address.
191     // only the supervisor uses it, on the way
192     // to/from user space, so not PTE_U.
193     if(mappages(pagetable, TRAMPOLINE, PGSIZE,
194                (uint64)trampoline, PTE_R | PTE_X) < 0){
195         uvmfree(pagetable, 0);
196         return 0;
197     }
198
199     // reset sys_calls count to 0
200     p->sys_calls_count = 0;
201 }

```

Ready 172:1 +2-1

```
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kernel/proc.c (f5b93ef1)
232 void
233 userir.it(void)
234 {
235     struct proc *p;
236
237     p = allocproc();
238     initproc = p;
239
240     // allocate one user page and copy initcode's instructions
241     // and data into it.
242     uvmfirst(p->pagetable, initcode, sizeof(initcode));
243     p->sz = PGSIZE;
244
245     // prepare for the very first "return" from kernel to user.
246     p->trapframe->epc = 0; // user program counter
247     p->trapframe->sp = PGSIZE; // user stack pointer
248
249     safestrcpy(p->name, "initcode", sizeof(p->name));
250     p->cwd = namei("/");
251
252     p->state = RUNNABLE;
253
254     release(&p->lock);
255 }
256
257 // Grow or shrink user memory by n bytes.
258 // Return 0 on success, -1 on failure.
259 int
260 growproc(int n)
261 {
262     uint64 sz;
263     struct proc *p = myproc();
264
265     sz = p->sz;
266     if(n > 0){
267         if((sz = uvmalloc(p->pagetable, sz, sz + n, PTE_W)) == 0) {
268             return -1;
269         }
270     } else if(n < 0){
271         sz = uvndealloc(p->pagetable, sz, sz + n);
272     }
273     p->sz = sz;
274     return 0;
275 }
276
277 // set sys_calls count to 0
Ready 254:1 +2~1
```

```
kernel/proc.c (Working Tree)
230 {
231     struct proc *p;
232
233     p = allocproc();
234     initproc = p;
235
236     // allocate one user page and copy initcode's instructions
237     // and data into it.
238     uvmfirst(p->pagetable, initcode, sizeof(initcode));
239     p->sz = PGSIZE;
240
241     // prepare for the very first "return" from kernel to user.
242     p->trapframe->epc = 0; // user program counter
243     p->trapframe->sp = PGSIZE; // user stack pointer
244
245     safestrcpy(p->name, "initcode", sizeof(p->name));
246     p->cwd = namei("/");
247
248     p->state = RUNNABLE;
249
250     // set sys_calls count to 0
251     p->sys_call_count = 0;
252
253     release(&p->lock);
254 }
255
256 // Grow or shrink user memory by n bytes.
257 // Return 0 on success, -1 on failure.
258 int
259 growproc(int n)
260 {
261     uint64 sz;
262     struct proc *p = myproc();
263
264     sz = p->sz;
265     if(n > 0){
266         if((sz = uvmalloc(p->pagetable, sz, sz + n, PTE_W)) == 0) {
267             return -1;
268         }
269     } else if(n < 0){
270         sz = uvndealloc(p->pagetable, sz, sz + n);
271     }
272     p->sz = sz;
273     return 0;
274 }
```

```
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kernel/proc.c (f5b93ef1)
642 // Returns 0 on success, -1 on error.
643 int
644 either_copyin(void *dst, int user_src, uint64 src, uint64 len)
645 {
646     struct proc *p = myproc();
647     if(user_src){
648         return copyin(p->pagetable, dst, src, len);
649     } else {
650         memmove(dst, (char*)src, len);
651         return 0;
652     }
653 }
654
655 // Print a process listing to console. For debugging.
656 // Runs when user types ^P on console.
657 // No lock to avoid wedging a stuck machine further.
658 void
659 procdump(void)
660 {
661     static char *states[] = {
662         [UNUSED] "unused",
663         [USED] "used",
664         [SLEEPING] "sleep ",
665         [RUNNABLE] "runble",
666         [RUNNING] "run ",
667         [ZOMBIE] "zombie"
668     };
669     struct proc *p;
670     char *state;
671
672     printf("\n");
673     for(p = proc; p < &proc[NPROC]; p++){
674         if(p->state == UNUSED)
675             continue;
676         if(p->state == 0 && p->state < NELEM(states) && states[p->state])
677             state = states[p->state];
678         else
679             state = "???";
680         printf("%d %s %s", p->pid, state, p->name);
681         printf("\n");
682     }
683 }
684
685 Show Applications
Ready 718:1 +2~1
```

```
kernel/proc.c (Working Tree)
692 // return free memory pages; for param = 2
693 // return -1 for param = rest
694 int get_sys_sysinfo(uint64 param, uint64 sys_calls_count)
695 {
696     if (param == 0)
697     {
698         struct proc *p;
699         static char *states[] = {
700             [UNUSED] "unused",
701             [USED] "used",
702             [SLEEPING] "sleep ",
703             [RUNNABLE] "runble",
704             [RUNNING] "run ",
705             [ZOMBIE] "zombie";
706
707         int proc_ctr = 0;
708
709         for (p = proc; p < &proc[NPROC]; p++)
710         {
711             if (states[p->state] == states[RUNNABLE] || states[p->state] == states[RUNNING] || states[p->state] == states[ZOMBIE])
712             {
713                 proc_ctr += 1;
714             }
715         }
716         return proc_ctr;
717     }
718     else if (param == 1)
719     {
720         return sys_calls_count;
721     }
722     else if (param == 2)
723     {
724         int count = get_free_memory();
725         return count;
726     }
727     else
728     {
729         return -1;
730     }
731 }
```

```
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kernel/proc.c (fsb93ef1)
642 // Returns 0 on success, -1 on error.
643 int
644 either_copyin(void *dst, int user_src, uint64 src, uint64 len)
645 {
646     struct proc *p = myproc();
647     if(user_src){
648         return copyin(p->pagetable, dst, src, len);
649     } else {
650         memmove(dst, (char*)src, len);
651         return 0;
652     }
653 }
654
655 // Print a process listing to console. For debugging.
656 // Runs when user types ^P on console.
657 // No lock to avoid wedging a stuck machine further.
658 void
659 procdump(void)
660 {
661     static char *states[] = {
662         [UNUSED] "unused",
663         [USED] "used",
664         [SLEEPING] "sleep ",
665         [RUNNABLE] "runble",
666         [RUNNING] "run ",
667         [ZOMBIE] "zombie"
668     };
669     struct proc *p;
670     char *state;
671
672     printf("\n");
673     for(p = proc; p < &proc[NPROC]; p++){
674         if(p->state == UNUSED)
675             continue;
676         if(p->state >= 0 && p->state < NELEM(states) && states[p->state])
677             state = states[p->state];
678         else
679             state = "???";
680         printf("%d %s %s", p->pid, state, p->name);
681         printf("\n");
682     }
683 }
684
Ready 718:1 +2-1
```

```
kernel/proc.c (Working Tree)
718     return proc_ctr;
719 }
720 }
721 else if (param == 1)
722 {
723     return sys_calls_count;
724 }
725 else if (param == 2)
726 {
727     int count = get_free_memory();
728     return count;
729 }
730 else
731 {
732     return -1;
733 }
734 }
735
736 // function to update the structure passed with required values
737 // ppid = process id of parent, requires wait_lock to be held
738 // syscall_count = count of system calls made by the process
739 // page_usage = pages used. xv6 has a 4096 page size and process stores size in bytes.
740 // so page count is ceil(sz/4kb)
741 // the data is in kernel and needs to be written in user space
742 // for this data is copied from using copyout
743 int get_sys_procInfo(uint64 addr)
744 {
745     struct proc *p = myproc();
746     struct pinf pinf;
747
748     acquire(&wait_lock);
749     pinf.ppid = p->parent->pid;
750     release(&wait_lock);
751
752     pinf.syscall_count = p->syscall_count;
753     pinf.page_usage = ((p->sz) / 4096) + (((p->sz) % 4096) != 0);
754
755     // copy the data from temp struct to the memory address of struct passed to system call
756     if (copyout(p->pagetable, addr, (char *)&pinf, sizeof(pinf)) < 0)
757         return -1;
758     return 0;
759 }
760
```

kernel/proc.h

- Added a process level variable to store the number of system calls made

```
File Edit View Go To Window
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kernel/proc.h (fsb93ef1)
66 /* 116 */ uint64 s2;
67 /* 114 */ uint64 s3;
68 /* 112 */ uint64 s4;
69 /* 200 */ uint64 s5;
70 /* 208 */ uint64 s6;
71 /* 216 */ uint64 s7;
72 /* 224 */ uint64 s8;
73 /* 232 */ uint64 s9;
74 /* 240 */ uint64 s10;
75 /* 248 */ uint64 s11;
76 /* 256 */ uint64 t3;
77 /* 264 */ uint64 t4;
78 /* 272 */ uint64 t5;
79 /* 280 */ uint64 t6;
80 };
81
82 enum procstate { UNUSED, USED, SLEEPING, RUNNABLE, RUNNING, ZOMBIE };
83
84 // Per-process state
85 struct proc {
86     struct spinlock lock;
87
88     // p->lock must be held when using these:
89     enum procstate state; // Process state
90     void *chan; // If non-zero, sleeping on chan
91     int killed; // If non-zero, have been killed
92     int xstate; // Exit status to be returned to parent's wait
93     int pid; // Process ID
94
95     // wait_lock must be held when using this:
96     struct proc *parent; // Parent process
97
98     // these are private to the process, so p->lock need not be held.
99     uint64 kstack; // Virtual address of kernel stack
100     uint64 sz; // Size of process memory (bytes)
101     pagetable_t pagetable; // User page table
102     struct trapframe *trapframe; // data page for trampoline.S
103     struct context context; // switch() here to run process
104     struct file *ofile[NOFILE]; // Open files
105     struct inode *cwd; // Current directory
106     char name[16]; // Process name (debugging)
107 };
108
int sys_call_count; // Total System calls made by the process
Ready 107:1 +1
```

```
kernel/proc.h (Working Tree)
67 /* 184 */ uint64 s3;
68 /* 192 */ uint64 s4;
69 /* 200 */ uint64 s5;
70 /* 208 */ uint64 s6;
71 /* 216 */ uint64 s7;
72 /* 224 */ uint64 s8;
73 /* 232 */ uint64 s9;
74 /* 240 */ uint64 s10;
75 /* 248 */ uint64 s11;
76 /* 256 */ uint64 t3;
77 /* 264 */ uint64 t4;
78 /* 272 */ uint64 t5;
79 /* 280 */ uint64 t6;
80 };
81
82 enum procstate { UNUSED, USED, SLEEPING, RUNNABLE, RUNNING, ZOMBIE };
83
84 // Per-process state
85 struct proc {
86     struct spinlock lock;
87
88     // p->lock must be held when using these:
89     enum procstate state; // Process state
90     void *chan; // If non-zero, sleeping on chan
91     int killed; // If non-zero, have been killed
92     int xstate; // Exit status to be returned to parent's wait
93     int pid; // Process ID
94
95     // wait_lock must be held when using this:
96     struct proc *parent; // Parent process
97
98     // these are private to the process, so p->lock need not be held.
99     uint64 kstack; // Virtual address of kernel stack
100     uint64 sz; // Size of process memory (bytes)
101     pagetable_t pagetable; // User page table
102     struct trapframe *trapframe; // data page for trampoline.S
103     struct context context; // switch() here to run process
104     struct file *ofile[NOFILE]; // Open files
105     struct inode *cwd; // Current directory
106     char name[16]; // Process name (debugging)
107     int sys_call_count; // Total system calls made by the process
108 };
109
```

kernel/syscall.c

- Created function definitions to be mapped with function calls
- Created system level variable to store all system calls
- Add an entry in syscalls array that maps syscall to its function definitions
- Increment system level syscall counter by 1 after a syscall is made
- Increment the process level syscall counter by 1 after a syscall is made

```
kernel/syscall.c (f5b93ef1)
84 // prototypes for the functions that handle system calls.
85 extern uint64 sys_fork(void);
86 extern uint64 sys_exit(void);
87 extern uint64 sys_wait(void);
88 extern uint64 sys_pipe(void);
89 extern uint64 sys_read(void);
90 extern uint64 sys_kill(void);
91 extern uint64 sys_exec(void);
92 extern uint64 sys_fstat(void);
93 extern uint64 sys_chdir(void);
94 extern uint64 sys_dup(void);
95 extern uint64 sys_getpid(void);
96 extern uint64 sys_sbrk(void);
97 extern uint64 sys_sleep(void);
98 extern uint64 sys_uptime(void);
99 extern uint64 sys_open(void);
100 extern uint64 sys_write(void);
101 extern uint64 sys_mknod(void);
102 extern uint64 sys_unlink(void);
103 extern uint64 sys_link(void);
104 extern uint64 sys_mkdir(void);
105 extern uint64 sys_close(void);
106
107 // An array mapping syscall numbers from syscall.h
108 // to the function that handles the system call.
109 static uint64 (*syscalls[])(void) = {
110     [SYS_fork] sys_fork,
111     [SYS_exit] sys_exit,
112     [SYS_wait] sys_wait,
113     [SYS_pipe] sys_pipe,
114     [SYS_read] sys_read,
115     [SYS_kill] sys_kill,
116     [SYS_exec] sys_exec,
117     [SYS_fstat] sys_fstat,
118     [SYS_chdir] sys_chdir,
119     [SYS_dup] sys_dup,
120     [SYS_getpid] sys_getpid,
121     [SYS_sbrk] sys_sbrk,
122     [SYS_sleep] sys_sleep,
123     [SYS_uptime] sys_uptime,
124     [SYS_open] sys_open,
125     [SYS_write] sys_write,
126     [SYS_mknod] sys_mknod,
127     [SYS_unlink] sys_unlink,
128     [SYS_link] sys_link,
129     [SYS_mkdir] sys_mkdir,
130     [SYS_close] sys_close,
131 };
132
133 // add mapped syscall function here.
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```
kernel/syscall.c (f5b93ef1)
106 // to the function that handles the system call.
107 static uint64 (*syscalls[])(void) = {
108     [SYS_fork] sys_fork,
109     [SYS_exit] sys_exit,
110     [SYS_wait] sys_wait,
111     [SYS_pipe] sys_pipe,
112     [SYS_read] sys_read,
113     [SYS_kill] sys_kill,
114     [SYS_exec] sys_exec,
115     [SYS_fstat] sys_fstat,
116     [SYS_chdir] sys_chdir,
117     [SYS_dup] sys_dup,
118     [SYS_getpid] sys_getpid,
119     [SYS_sbrk] sys_sbrk,
120     [SYS_sleep] sys_sleep,
121     [SYS_uptime] sys_uptime,
122     [SYS_open] sys_open,
123     [SYS_write] sys_write,
124     [SYS_mknod] sys_mknod,
125     [SYS_unlink] sys_unlink,
126     [SYS_link] sys_link,
127     [SYS_mkdir] sys_mkdir,
128     [SYS_close] sys_close,
129 };
130
131 void
132 syscall(void)
133 {
134     int num;
135     struct proc *p = myproc();
136
137     num = p->trapframe->a7;
138     if(num > 0 && num < NELEM(syscalls) && syscalls[num]) {
139         // Use num to lookup the system call function for num, call it,
140         // and store its return value in p->trapframe->a0
141         p->trapframe->a0 = syscalls[num]();
142     } else {
143         printf("%d %s: unknown sys call %d\n",
144             p->pid, p->name, num);
145         p->trapframe->a0 = -1;
146     }
147 }
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kernel/syscall.h

- Add proc_info system call and its number
- Add sys_info system call and its number

```
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kernel/syscall.h (f5b93ef1)
1 // System call numbers
2 #define SYS_fork 1
3 #define SYS_exit 2
4 #define SYS_wait 3
5 #define SYS_pipe 4
6 #define SYS_read 5
7 #define SYS_kill 6
8 #define SYS_exec 7
9 #define SYS_fstat 8
10 #define SYS_chdir 9
11 #define SYS_dup 10
12 #define SYS_getpid 11
13 #define SYS_sbrk 12
14 #define SYS_sleep 13
15 #define SYS_uptime 14
16 #define SYS_open 15
17 #define SYS_write 16
18 #define SYS_mknod 17
19 #define SYS_unlink 18
20 #define SYS_link 19
21 #define SYS_mkdir 20
22 #define SYS_close 21
23

kernel/syscall.h (Working Tree)
1 // System call numbers
2 #define SYS_fork 1
3 #define SYS_exit 2
4 #define SYS_wait 3
5 #define SYS_pipe 4
6 #define SYS_read 5
7 #define SYS_kill 6
8 #define SYS_exec 7
9 #define SYS_fstat 8
10 #define SYS_chdir 9
11 #define SYS_dup 10
12 #define SYS_getpid 11
13 #define SYS_sbrk 12
14 #define SYS_sleep 13
15 #define SYS_uptime 14
16 #define SYS_open 15
17 #define SYS_write 16
18 #define SYS_mknod 17
19 #define SYS_unlink 18
20 #define SYS_link 19
21 #define SYS_mkdir 20
22 #define SYS_close 21
23 // define the syscall here, assign it a number and define the corresponding function in syscall.c
24 #define SYS_sysinfo 22
25 // define the syscall here, assign it a number and define the corresponding function in syscall.c
26 #define SYS_procinfo 23

// define the syscall here, assign it a number and define the corresponding function in syscall.c
Ready 23:1 ~1
```

kernel/sysproc.c

- Initialize the system level syscall counter from 0
- Implement and call sysinfo system call with passed arguments
- Implement and call procinfo system call with passed arguments

```
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kernel/sysproc.c (f5b93ef1)
1 #include "types.h"
2 #include "riscv.h"
3 #include "defs.h"
4 #include "param.h"
5 #include "memlayout.h"
6 #include "spinlock.h"
7 #include "proc.h"
8
9 uint64
10 sys_exit(void)
11 {
12     int n;
13     argInt(0, &n);
14     exit(n);
15     return 0; // not reached
16 }
17
18 uint64
19 sys_getpid(void)
20 {
21     return myproc()->pid;
22 }
23
24 uint64
25 sys_fork(void)
26 {
27     return fork();
28 }
29
30 uint64
31 sys_wait(void)
32 {
33     uint64 p;
34     argaddr(0, &p);
35     return wait(p);
36 }
37
38 uint64
39 sys_sbrk(void)
40 {
41     uint64 addr;
42     int n;
43
44 // global system level variables
45 Ready 9:1 +1-1
```



```
kernel/sysproc.c (f5b93ef1)
50
51 uint64
52 sys_sleep(void)
53 {
54     int n;
55     uint ticks0;
56
57     argint(0, &n);
58     acquire(&tickslock);
59     ticks0 = ticks;
60     while(ticks - ticks0 < n){
61         if(killed(myproc)){
62             release(&tickslock);
63             return -1;
64         }
65         sleep(&ticks, &tickslock);
66     }
67     release(&tickslock);
68     return 0;
69 }
70
71 uint64
72 sys_kill(void)
73 {
74     int pid;
75
76     argint(0, &pid);
77     return kill(pid);
78 }
79
80 // return how many clock tick interrupts have occurred
81 // since start.
82 uint64
83 sys_uptime(void)
84 {
85     uint xticks;
86
87     acquire(&tickslock);
88     xticks = ticks;
89     release(&tickslock);
90     return xticks;
91 }
92

kernel/sysproc.c (Working Tree)
77 {
78     int pid;
79
80     argint(0, &pid);
81     return kill(pid);
82 }
83
84 // return how many clock tick interrupts have occurred
85 // since start.
86 uint64
87 sys_uptime(void)
88 {
89     uint xticks;
90
91     acquire(&tickslock);
92     xticks = ticks;
93     release(&tickslock);
94     return xticks;
95 }
96
97 // body of defined syscall function.
98 // call a function in process to execute0.
99 // get first argument passed to the system call
100 // pass the argument to process level function
101 uint64
102 sys_sysinfo(void)
103 {
104     int n;
105     argint(0, &n);
106     return get_sys_sysinfo(n, global_sys_calls_counter);
107 }
108
109 // body of defined syscall function.
110 // call a function in process to execute0.
111 // get first argument passed to the system call
112 // pass the argument to process level function
113 uint64
114 sys_procinfo(void)
115 {
116     uint64 pinfo_pointer; // user pointer to struct pinfo
117     argaddr(0, &pinfo_pointer);
118     return get_sys_procinfo(pinfo_pointer);
119 }
```

user/lab1_test.c

- Changes made to test file as given in lab 1

```
user/lab1_test.c (f5b93ef1)
1

user/lab1_test.c (Working Tree)
1 #include "kernel/types.h"
2 #include "kernel/stat.h"
3 #include "user/user.h"
4
5 #define MAX_PROC 10
6
7 // struct to be updated by proc_info syscall
8 struct pinfo
9 {
10     int ppid;
11     int syscall_count;
12     int page_usage;
13 };
14
15 // function to display the system information using sysinfo syscall
16 void print_sysinfo(void)
17 {
18     // updated to include a third param
19     // demonstrate what happens when param other than 0,1,2 is passed
20     int n_active_proc, n_syscalls, n_free_pages, error;
21     n_active_proc = sysinfo(0);
22     n_syscalls = sysinfo(1);
23     n_free_pages = sysinfo(2);
24     error = sysinfo(3);
25     printf("[sysinfo] active proc: %d, syscalls: %d, free pages: %d, error_val: %d\n",
26           n_active_proc, n_syscalls, n_free_pages, error);
27 }
28
29 int main(int argc, char *argv[])
30 {
31
32     int mem, n_proc, ret, proc_pid[MAX_PROC];
33
34     if (argc < 3)
35     {
36         printf("Usage: %s [MEM] [N_PROC]\n", argv[0]);
37         exit(-1);
38     }
39
40     mem = atoi(argv[1]);
41     n_proc = atoi(argv[2]);
42
43     if (n_proc > MAX_PROC)
```

```

user/lab1_test.c (f5b93ef1)
1

user/lab1_test.c (Working Tree)
40 men = atoi(argv[1]);
41 n_proc = atoi(argv[2]);
42
43 if (n_proc > MAX_PROC)
44 {
45     printf("Cannot test with more than %d processes\n", MAX_PROC);
46     exit(-1);
47 }
48
49 // get sysinfo before creating sub processes
50 print_sysinfo();
51
52 // create sub processes and display process info
53 for (int i = 0; i < n_proc; i++)
54 {
55     sleep(1);
56     ret = fork();
57     if (ret == 0)
58     { // child process
59
60         struct pinfo paran;
61         nalloc(men); // this triggers a syscall
62
63         for (int j = 0; j < 10; j++)
64             procinfo(&paran); // calls 10 times
65         printf("[procinfo %d] ppid: %d, syscalls: %d, page usage: %d\n",
66               getpid(), paran.ppid, paran.syscall_count, paran.page_usage);
67         while (1)
68             ;
69     }
70     else
71     { // parent
72         proc_pid[i] = ret;
73         continue;
74     }
75 }
76 sleep(1);
77 print_sysinfo();
78 for (int i = 0; i < n_proc; i++)
79     kill(proc_pid[i]);
80 exit(0);
81
82
#include "kernel/types.h"
Ready
1:1 -1
er inside or press Ctrl+G.

```

user/user.h

- Declare pinfo struct
- Declare function definitions for sysinfo and procinfo

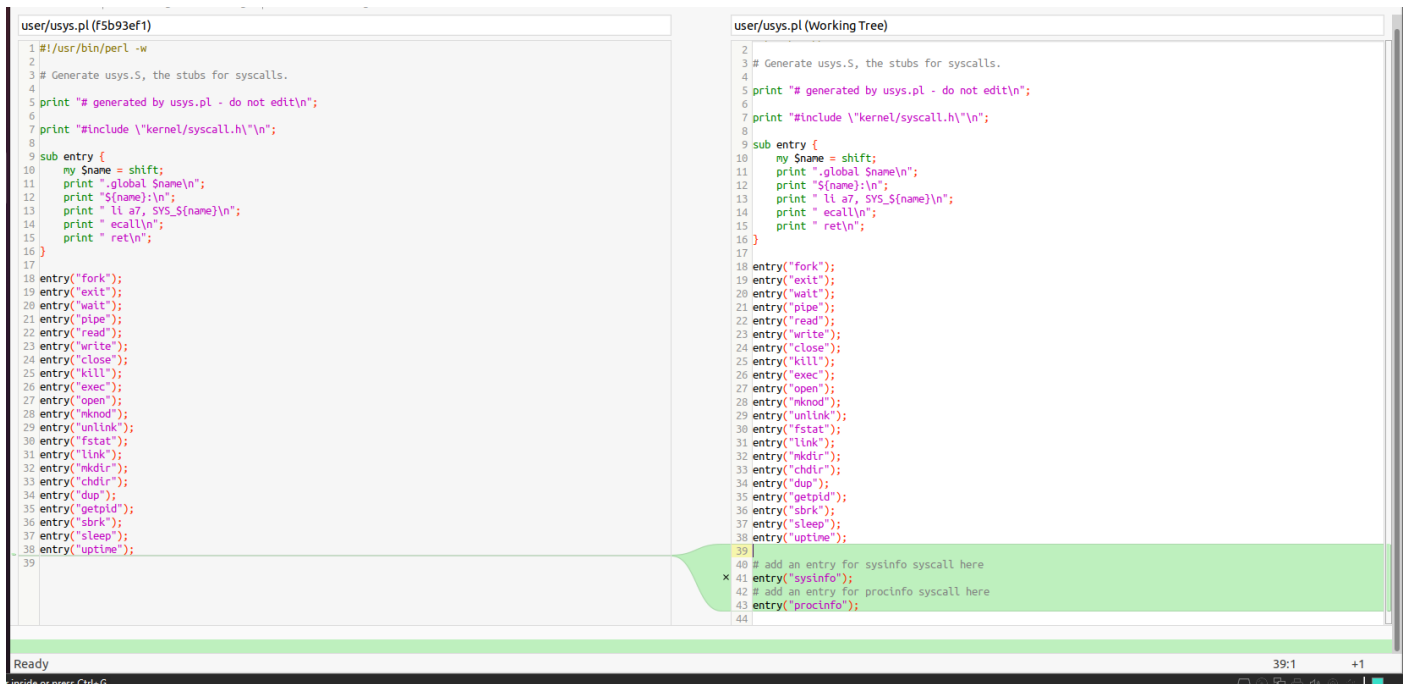
```

user/user.h (f5b93ef1)
1 struct stat;
2
3 // system calls
4 int fork(void);
5 int exit(int) __attribute__((noreturn));
6 int wait(int*);
7 int pipe(int*);
8 int write(int, const void*, int);
9 int read(int, void*, int);
10 int close(int);
11 int kill(int);
12 int exec(const char*, char**);
13 int open(const char*, int);
14 int mknod(const char*, short, short);
15 int unlink(const char*);
16 int fstat(int fd, struct stat*);
17 int link(const char*, const char*);
18 int mkdir(const char*);
19 int chdir(const char*);
20 int dup(int);
21 int getpid(void);
22 char* sbrk(int);
23 int sleep(int);
24 int uptime(void);
25
26 // ulib.c
27 int stat(const char*, struct stat*);
28 char* strcpy(char*, const char*);
29 void *memmove(void*, const void*, int);
30 char* strchr(const char*, char c);
31 int strcmp(const char*, const char*);
32 void fprintf(int, const char*, ...);
33 void printf(const char*, ...);
34 char* gets(char*, int max);
35 uint strlen(const char*);
36 void* memset(void*, int, uint);
37 void* malloc(uint);
38 void free(void*);
39 int atoi(const char*);
40 int memcmp(const void *, const void *, uint);
41 void *memcpy(void *, const void *, uint);
42
// include pinfo struct to be used
Ready
2:1 +2
er inside or press Ctrl+G.

```

user/usys.pl

- Add an entry for sysinfo system call
- Add an entry for procinfo system call



```
user/usys.pl (f5b93ef1)
1 #!/usr/bin/perl -w
2
3 # Generate usys.S, the stubs for syscalls.
4
5 print "# generated by usys.pl - do not edit!\n";
6
7 print "#include \"kernel/syscall.h\"\n";
8
9 sub entry {
10     my $name = shift;
11     print ".global $name\n";
12     print "$name:\n";
13     print "    li a7, SYS_$name\n";
14     print "    ecall\n";
15     print "    ret\n";
16 }
17
18 entry("fork");
19 entry("exit");
20 entry("wait");
21 entry("pipe");
22 entry("read");
23 entry("write");
24 entry("close");
25 entry("kill");
26 entry("exec");
27 entry("open");
28 entry("mknod");
29 entry("unlink");
30 entry("fstat");
31 entry("link");
32 entry("mkdir");
33 entry("chdir");
34 entry("dup");
35 entry("getpid");
36 entry("sbrk");
37 entry("sleep");
38 entry("uptime");
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- Implement param == 2 for sysinfo - free memory pages
- Member 3: Parth Bhatt (pbhat029@ucr.edu)
 - Implemented param == 1 for sysinfo - total system calls
 - Implemented param == 0 for sysinfo - total active processes
 - Implemented other param handling for sysinfo