Thread Library Implementation in XV6

- Define System Call Clone. It calls the implementation of clone function defined in proc.c

```
93   int sys_clone(void) {
94     void *func;
95     void *stack;
96     int size;
97     void *arg;
98
99     if (argptr(0, (char**)(&func), sizeof(void*)) < 0) return -1;
100    if (argptr(1, (char**)(&stack), sizeof(void*)) < 0) return -1;
101    if (argint(2, &size) < 0) return -1;
102    if (argptr(3, (char**)(&arg), sizeof(void*)) < 0) return -1;
103
104    return clone((void*)(func), (void*)stack, size, (void*)arg);
105  }
```

- A new data type to store the lock in types.h

types.h > ...

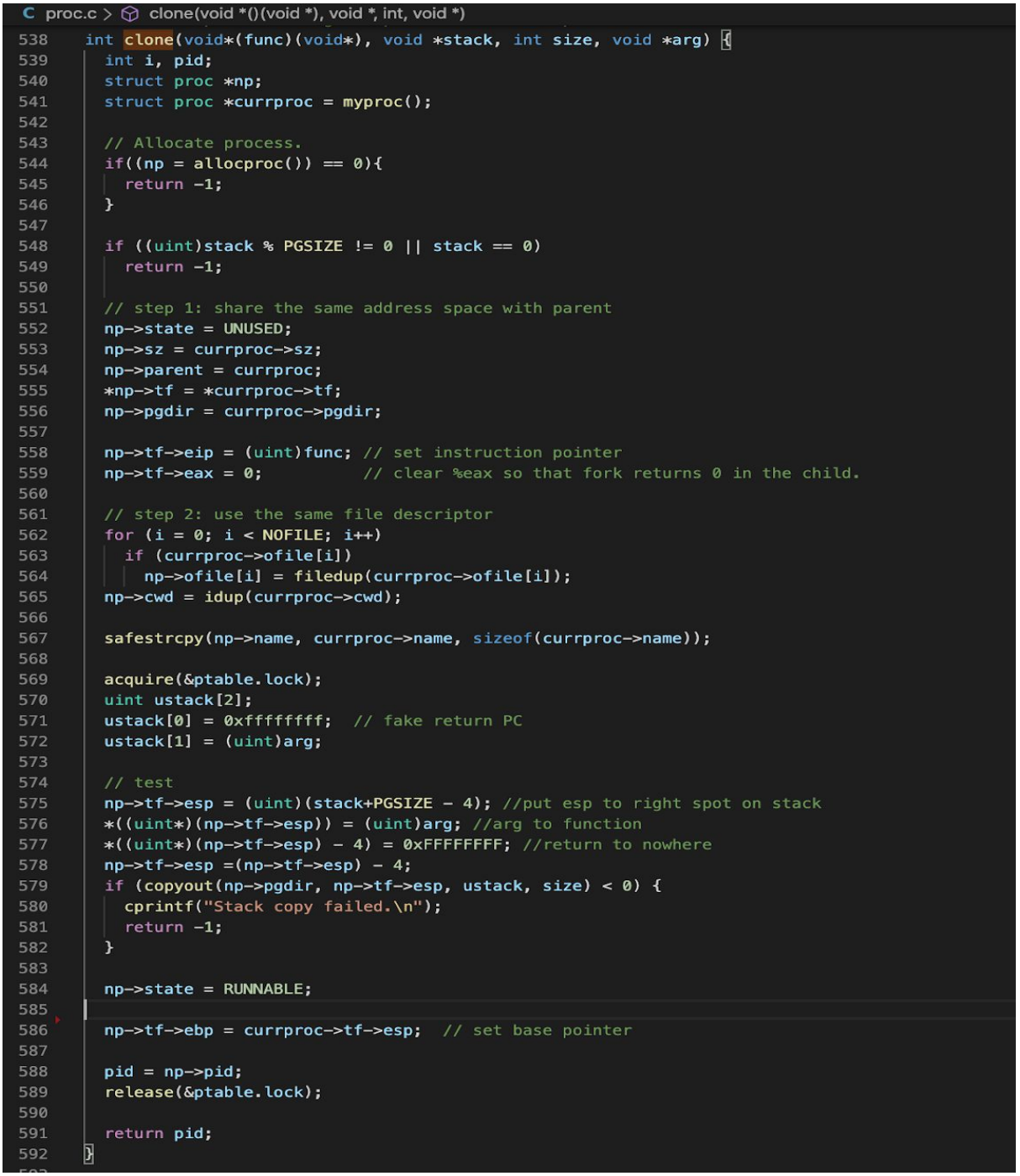
```
1   #ifndef __TYPE_H__
2   #define __TYPE_H__
3
4   typedef unsigned int   uint;
5   typedef unsigned short ushort;
6   typedef unsigned char  uchar;
7   typedef uint pde_t;
8
9   typedef struct {
10      uint locked;
11  }lock_t;
12
13  #endif
```

- A thread library is created in ulib.c.Two pages for stack are allocated at first. If the virtual address of the start of the stack is not page-aligned, it is rounded up. Then the clone() system call is made in which, only one argument of type "unsigned int" is passed to the function, so the size is assigned to be eight. The new thread starts executing at the address specified by start_routine().

  Spinlock initialization, acquire and release are defined.

```
100  void*
101  memmove(void *vdst, const void *vsrc, int n)
102  {
103    char *dst;
104    const char *src;
105
106    dst = vdst;
107    src = vsrc;
108    while(n-- > 0)
109      *dst++ = *src++;
110    return vdst;
111  }
112
113  // thread library
114  void lock_init(lock_t *lock) {
115    lock->locked = 0;
116  }
117
118  void lock_acquire(lock_t *lock) {
119    while(xchg(&(lock->locked), 1) != 0);
120  }
121
122  void lock_release(lock_t *lock) {
123    xchg(&(lock->locked), 0);
124  }
125
126  void *thread_create(void*(start_routine)(void*), void *arg) {
127    void *stack = malloc(2 * PGSIZE);
128
129    if((uint)stack % PGSIZE)
130      stack = stack + (PGSIZE - (uint)stack % PGSIZE);
131
132    int size = 8;
133    int tid = clone(start_routine, stack, size, arg);
134
135    if (tid < 0) {
136      printf(1, "# Clone failed\n");
137      return 0;
138    }
139
140    return 0;
141  }
```

- Implementation of Clone.
    - Unlike fork(), it uses parent's address space.
    - Thread should have the same file descriptor as parent.
    - A user stack has been created to store the passed arguments and a kernel function copyout() to copy ustack to the virtual address in page table pgdir. Register $esp stores the address of the top of the stack. After deciding the address of the top of the stack, register $eip is set to point to the next instruction the system is about to execute, and the base pointer register $ebp is set to be the same as $esp.



- Test program frisbee

C frisbee.c > ...

```c
#include "fcntl.h"
#include "syscall.h"
#include "traps.h"
#include "memlayout.h"
#include "semaphore.h"

#define NUMTHREADS 20

lock_t lock;
int thrower;

void player(void *arg_ptr);

int main(int argc, char *argv[]) {
  int i;

  lock_init(&lock);

  for (i = 0; i < NUMTHREADS; i++) {
    thread_create((void*)player, (void*)&i);
    sleep(10);
  }
  while(wait()>=0) ;
  exit();
}

void player(void *arg_ptr) {
  int i, self;
  int *num = (int*) arg_ptr;
  self = *num;

  for (i = 0; i < 10; i++) {
    if (thrower != self) {
      lock_acquire(&lock);
      printf(1, "%d caught frisbee from %d\n", self, thrower);
      thrower = self;
      printf(1, "  throwing frisbee\n", self);
      sleep(20);
      lock_release(&lock);
    }
    sleep(20);
  }
  exit();
}
```

- Output
    - With command frisbee 20 20

```
xv6...
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start 58
init: starting sh
$ frisbee 20 20
]# Pass number no: 1 | Thread 0 is passing the token to thread 1
# Pass number no: 2 | Thread 1 is passing the token to thread 2
# Pass number no: 3 | Thread 2 is passing the token to thread 3
# Pass number no: 4 | Thread 3 is passing the token to thread 4
# Pass number no: 5 | Thread 4 is passing the token to thread 5
# Pass number no: 6 | Thread 5 is passing the token to thread 6
# Pass number no: 7 | Thread 6 is passing the token to thread 7
# Pass number no: 8 | Thread 7 is passing the token to thread 8
# Pass number no: 9 | Thread 8 is passing the token to thread 9
# Pass number no: 10 | Thread 9 is passing the token to thread 10
# Pass number no: 11 | Thread 10 is passing the token to thread 11
# Pass number no: 12 | Thread 11 is passing the token to thread 12
# Pass number no: 13 | Thread 12 is passing the token to thread 13
# Pass number no: 14 | Thread 13 is passing the token to thread 14
# Pass number no: 15 | Thread 14 is passing the token to thread 15
# Pass number no: 16 | Thread 15 is passing the token to thread 16
# Pass number no: 17 | Thread 16 is passing the token to thread 17
# Pass number no: 18 | Thread 17 is passing the token to thread 18
# Pass number no: 19 | Thread 18 is passing the token to thread 19
# Pass number no: 20 | Thread 19 is passing the token to thread 20
# Simulation of Frisbee game has finished, 20 rounds were played in total!
```

    - Default (with command frisbee)

```
xv6...
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start 58
init: starting sh
$ frisbee
# Default thread number: 4, pass round: 6
# Pass number no: 1 | Thread 0 is passing the token to thread 1
# Pass number no: 2 | Thread 1 is passing the token to thread 2
# Pass number no: 3 | Thread 2 is passing the token to thread 3
# Pass number no: 4 | Thread 3 is passing the token to thread 4
# Pass number no: 5 | Thread 4 is passing the token to thread 1
# Pass number no: 6 | Thread 1 is passing the token to thread 2
# Simulation of Frisbee game has finished, 6 rounds were played in total!
zombie!
```