```
Handout for CS 372H
Class 10
21 February 2012

Therac−25

1. Software problem #1 (our best guess)

    A. Three threads:

        −−Hand: sets the collimator/turntable position

        −−Treat: sets a bunch of other parameters. Part of its job takes
        eight seconds, during which time it's ignoring everything else.

        −−Vtkbp (keyboard handler): invoked when user types. It parses
        the input, and writes to a two−byte shared variable, "MEOS" (mode/energy
        offset)
            −−"Treat" reads top byte, sets current and energy
            −−"Hand" reads bottom byte, sets the collimator/turntable position

    B. Pseudocode:

        Vtkbp (gets and parses keyboard input):

            data_completion_flag = 0

            while (1) {
                wait_for_keyboard_activity();
                /* there was some keyboard activity; let's check it */
                if (cursor_in_bottom_right) {
                    parse_the_input();
                    set the MEOS variable
                    set data_completion_flag = 1;
                    signal hand thread
                    signal treat thread
                } else {
                    /* operator still typing */
                    data_completion_flag = 0;
                }
                yield();
            }


        Hand (sets the turntable position):

            while (1) {
                wait until signalled
                read bottom byte of MEOS variable
                /* next line executes quickly */
                set turntable position
                yield();
            }

        Treat (sets a bunch of parameters and delivers treatment):

            dataent() { /* this is a subroutine that was called */

                while (1) {
                    wait until signalled
                    read top byte of MEOS variable
                    set_energy_and_current();
                    set_bending_magnets(); /* this takes eight seconds */
                    if (data_completion_flag == 1)
                        break;
                }
                /*
                 * now we leave the subroutine and progress to a state in
                 * which the machine will accept a "beam on" command
                 */
                return;
            }
```



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2. Software problem #2 (simplified)

    [Simplifying here and condensing to one thread of control; in
    reality, the functions below are spread over two different threads,
    but that is not actually the problem, despite what the paper
    sometimes says. The problem appears to be given by the following
    simplified description.]

     class3 = 0;

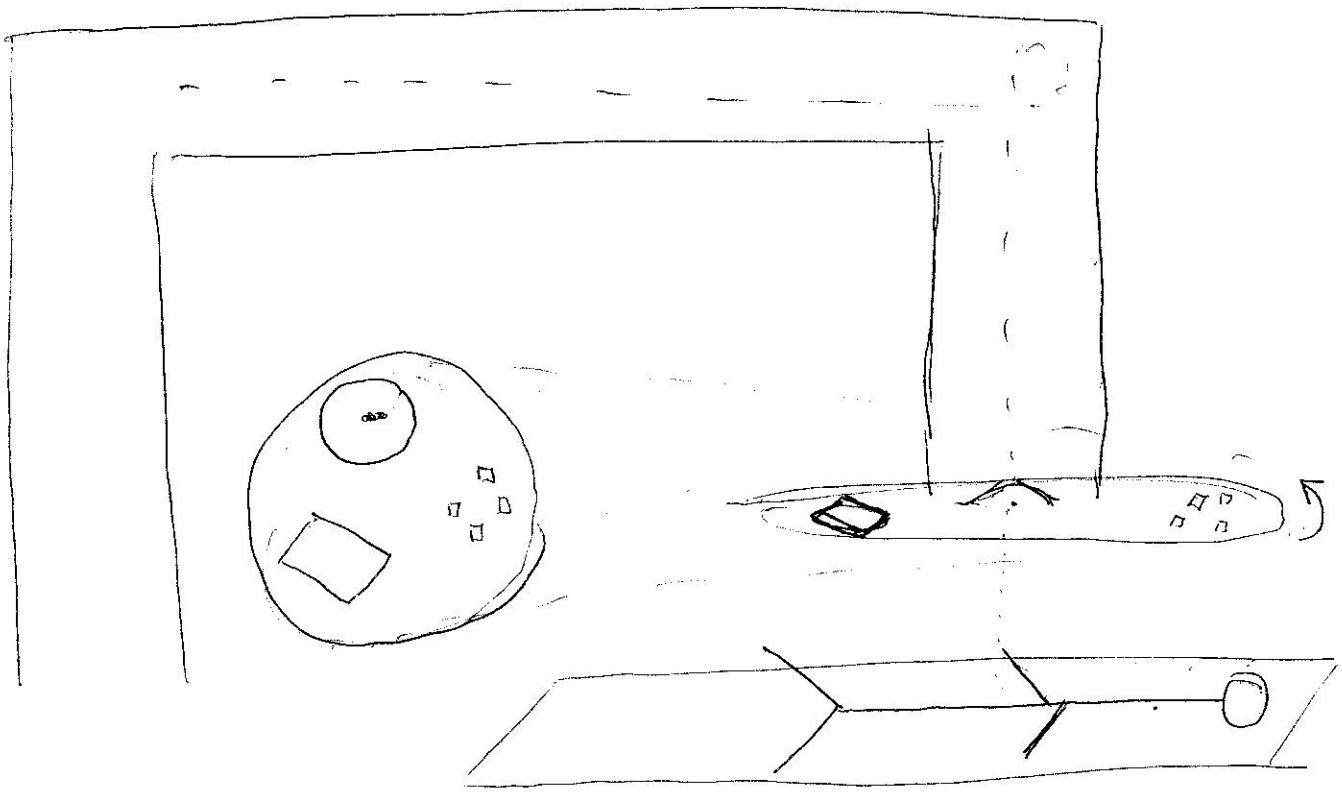
     while (1) {

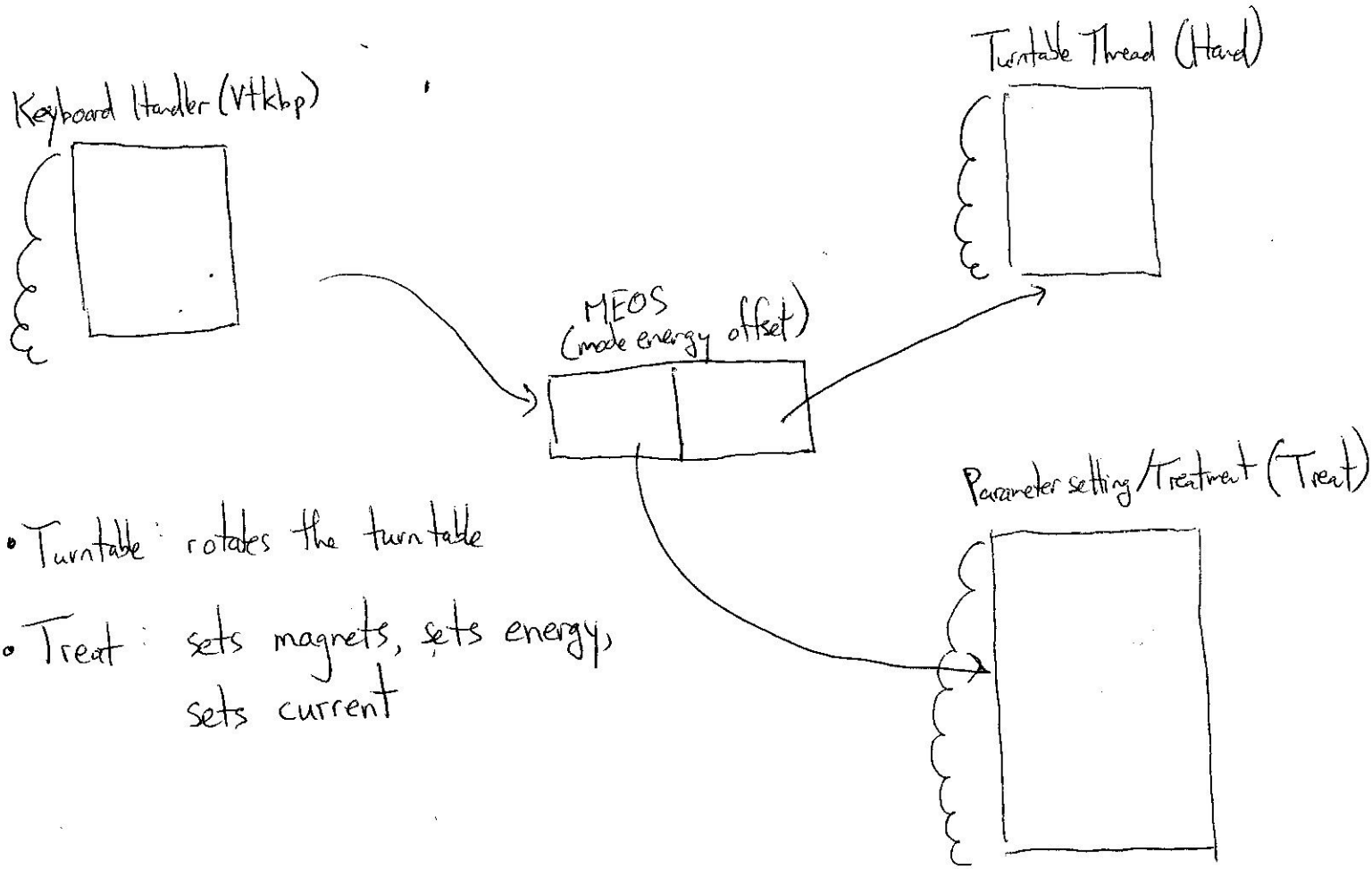
         if (in field light position) {
             increment class3;
         }

         check whether operator pressed "set"

         if (operator pressed set) {
             if (class3 != 0) {
                 move turntable out of field light mode;
             }
             break;
         }
     }

     What's the issue here? (Hint: class3 is only one byte.)
```





- Turntable: rotates the turntable
- Treat: sets magnets, sets energy, sets current

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3. Implementing threads

    Per−thread state in thread control block:

        typedef struct tcb {
            unsigned long esp;      /* Stack pointer of thread */
            char *t_stack;          /* Bottom of thread's stack */
            /* ... */
            };

    Machine−dependent thread−switch function:

        void swtch(tcb *current, tcb *next);

    Machine−dependent thread initialization function:

        void thread_init (tcb *t, void (*fn) (void *), void *arg);

    Implementation of swtch(current, next):

        pushl %ebp; movl %esp, %ebp             # Save frame pointer
        pushl %ebx; pushl %esi; pushl %edi      # Save callee−saved regs

        movl 8(%ebp),%edx                       # %edx = current
        movl 12(%ebp),%eax                      # %eax = next
        movl %esp,(%edx)                        # %edx−>esp = %esp
        movl (%eax),%esp                        # %esp = %eax−>esp

        popl %edi; popl %esi; popl %ebx         # Restore callee saved regs
        popl %ebp                               # Restore frame pointer
        ret                                     # Resume execution


    [thanks to David Mazieres]
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