ECE437/CS481

M02E: PROCESSES & THREADS
CLOCK & TIMING

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Process Timing

❑ Different concepts of time

- ✓ User time of a process: the total amount of CPU time spent in user-mode (outside the kernel) for the process. Other time spends (e.g., the time of the process being blocked) do not count.
- ✓ System time of a process: the total amount of CPU time spent in kernel-mode for the process. Other time spends (e.g., the time of the process being blocked) do not count.
- ✓ Real time/Wall clock time of a process: overall time from start to terminate of the process.
- ✓ Real time ? User time+ System time

Process Timing

❑ Timing --- When? Get the wall-clock time

- ➢ Use system call: gettimeofday--retrieve the current Coordinated Universal Time (UTC)

```
#include < sys/time.h>
int gettimeofday(struct timeval *tp, struct timezone *tzp);
```

  - ✓ It sets the system's notion of the current time
  - ✓ A timeval structure includes the following members:

```
long tv_sec; /* seconds */
long tv_usec; /*microseconds */
```

  - ✓ A timezone structure includes the following members:

```
int tz_minuteswest; /* minutes west of Greenwich */
int tz_dsttime; /* type of day saving time correction */
```

Process Timing

❑ Timing --- How long? Measuring processing time

- ➢ We might be interested in the user/system CPU time of a process/thread.
- ➢ Use system call: getrusage

```
#include <sys/time.h>
#include <sys/resource.h>
int getrusage(int who, struct rusage *usage);
```

- ✓ who: RUSAGE_SELF, RUSAGE_CHILDREN, RUSAGE_THREAD
- ✓ The rusage structure contains:

```
struct rusage {
    struct timeval ru_utime; /* user CPU time used */
    struct timeval ru_stime; /* system CPU time used */
    long   ru_maxrss;        /* maximum resident set size */
    long   ru_ixrss;         /* integral shared memory size */
    long   ru_idrss;         /* integral unshared data size */
    long   ru_isrss;         /* integral unshared stack size */
    long   ru_minflt;        /* page reclaims (soft page faults) */
    long   ru_majflt;        /* page faults (hard page faults) */
    long   ru_nswap;         /* swaps */
    long   ru_inblock;       /* block input operations */
    long   ru_oublock;       /* block output operations */
    long   ru_msgsnd;        /* IPC messages sent */
    long   ru_msgrcv;        /* IPC messages received */
    long   ru_nsignals;      /* signals received */
    long   ru_nvcsw;         /* voluntary context switches */
    long   ru_nivcsw;        /* involuntary context switches */
};
```

The accuracy of getrusage is us ($1*10^{-6}$ s)

Process Timing

- getrusage() example: obtain the user time and system time of the "for" loop

```c
#include <stdio.h>
#include <stdlib.h>
#include <sys/time.h>
#include <sys/resource.h>
#include <math.h>

int main(int argc, char** argv){
        double dum, usertime, systime;
        struct rusage r;
        struct timeval u_start, s_start, u_end, s_end;
        getrusage(RUSAGE_SELF, &r);
        u_start=r.ru_utime;
        s_start=r.ru_stime;
        for(int i = 0; i < 100000000; i++){dum=i*exp(0.5)+i;}
        getrusage(RUSAGE_SELF, &r);
        u_end=r.ru_utime;
        s_end=r.ru_stime;
        usertime=(u_end.tv_sec*1000000+u_end.tv_usec)-(u_start.tv_sec*1000000+u_start.tv_usec);//us
        systime=(s_end.tv_sec*1000000+s_end.tv_usec)-(s_start.tv_sec*1000000+s_start.tv_usec); //us
        printf("User time: %fus\n", usertime);
        printf("System time: %fus\n", systime);
        printf("maxrss=%ld\n", r.ru_maxrss);
        return 0;
}
```

```
shaun@shaun-VirtualBox:~/OS_code/timing$ ./getrusage
User time: 295070.000000us
System time: 0.000000us
maxrss=2264
```

Process Timing

Timing --- How long? Measuring processing time

- We might be interested in the user/system CPU time of a process/thread.
- Use system call: times()

```
#include < sys/times.h>
clock_t times(struct tms *buffer);
```

  - ✓ times() stores the current process times in the struct tms that buffer points to.
  - ✓ It returns the number of clock ticks that have elapsed since an arbitrary point in the past.
  - ✓ clock_t is arithmetic types capable of representing times.
  - ✓ Convert clock_t to second: (clock_t) value/sysconf(_SC_CLK_TCK).
  - ✓ The tms structure, defined in < sys/times.h>, contains the following members:

```
clock_t tms_utime; /* user time */
clock_t tms_stime; /* system time */
clock_t tms_cutime; /* children's user time */
clock_t tms_cstime; /* children's system time */
```

Process Timing

- times() example

```c
#include <stdio.h>
#include <sys/times.h>
#include <unistd.h>
#include <limits.h>

main () {
    struct tms buf;
    clock_t sinceboot;
    // chew up some CPU time
    int i,j;
    for (i=0,j=0; i<100000000; i++) { j+=i*i; }
    // measure elapsed time
    sinceboot = times(&buf);
    printf("user: %ld ticks\n", buf.tms_utime);
    printf("system: %ld ticks\n", buf.tms_stime);
    int ticks_per_second = sysconf(_SC_CLK_TCK);
    printf("%d ticks per second\n",ticks_per_second);
    double usec = (double)buf.tms_utime / (double) ticks_per_second;
    double ssec = (double)buf.tms_stime / (double) ticks_per_second;
    printf("user time = %g seconds\n", usec);
    printf("system time = %g seconds\n", ssec);
}
```

```
shaun@shaun-VirtualBox:~/OS_code/timing$ ./times
user: 23 ticks
system: 0 ticks
100 ticks per second
user time = 0.23 seconds
system time = 0 seconds
```

Process Timing

Timing --- Put process to sleep

sleep()

```
#include <unistd.h>
unsigned int sleep(unsigned int seconds);
```

- ✓ The current process is suspended from execution for the number of seconds specified by the argument.
- ✓ The actual waiting time may be less than that requested--any caught signal will awake the process.
- ✓ The actual waiting time may be longer than requested because of the scheduling of other activity in the system.
- ✓ The value returned by sleep() will be the amount of ``un-slept'' time (the requested sleep time minus the time actually slept)

Process Timing

❑ Timing --- Put process to sleep

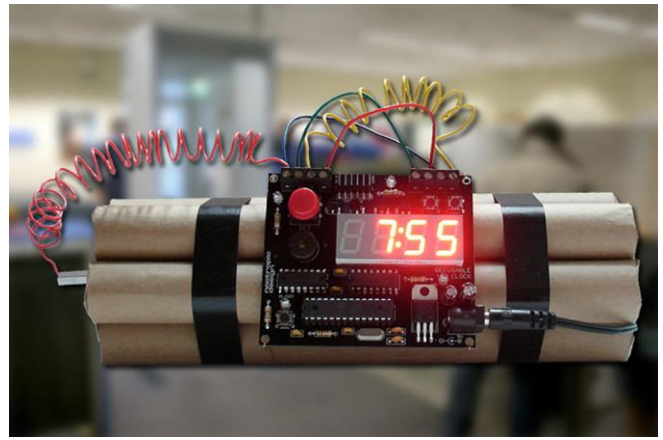
➢ usleep()

```
#include <unistd.h>
int usleep(useconds_t useconds);
```

- ✓ The usleep() function suspends the current process from execution for the number of microseconds specified by the useconds argument.

Process Timing

❑ Timing --- Set alarm timer



➢ alarm()

```
#include <unistd.h>
unsigned int alarm(unsigned int sec);
```

- ✓ The alarm() function arranges for a SIGALRM signal to be delivered to the calling process in *sec* seconds.
- ✓ alarm() returns
  - 0 if there was no previous scheduled alarm();
  - the number of seconds remaining of the previous scheduled alarm().
- ✓ If sec=0, any pending alarm is canceled.
- ✓ If the SIGALRM is not caught, blocked, or ignored by the calling process, the calling process will be terminated.