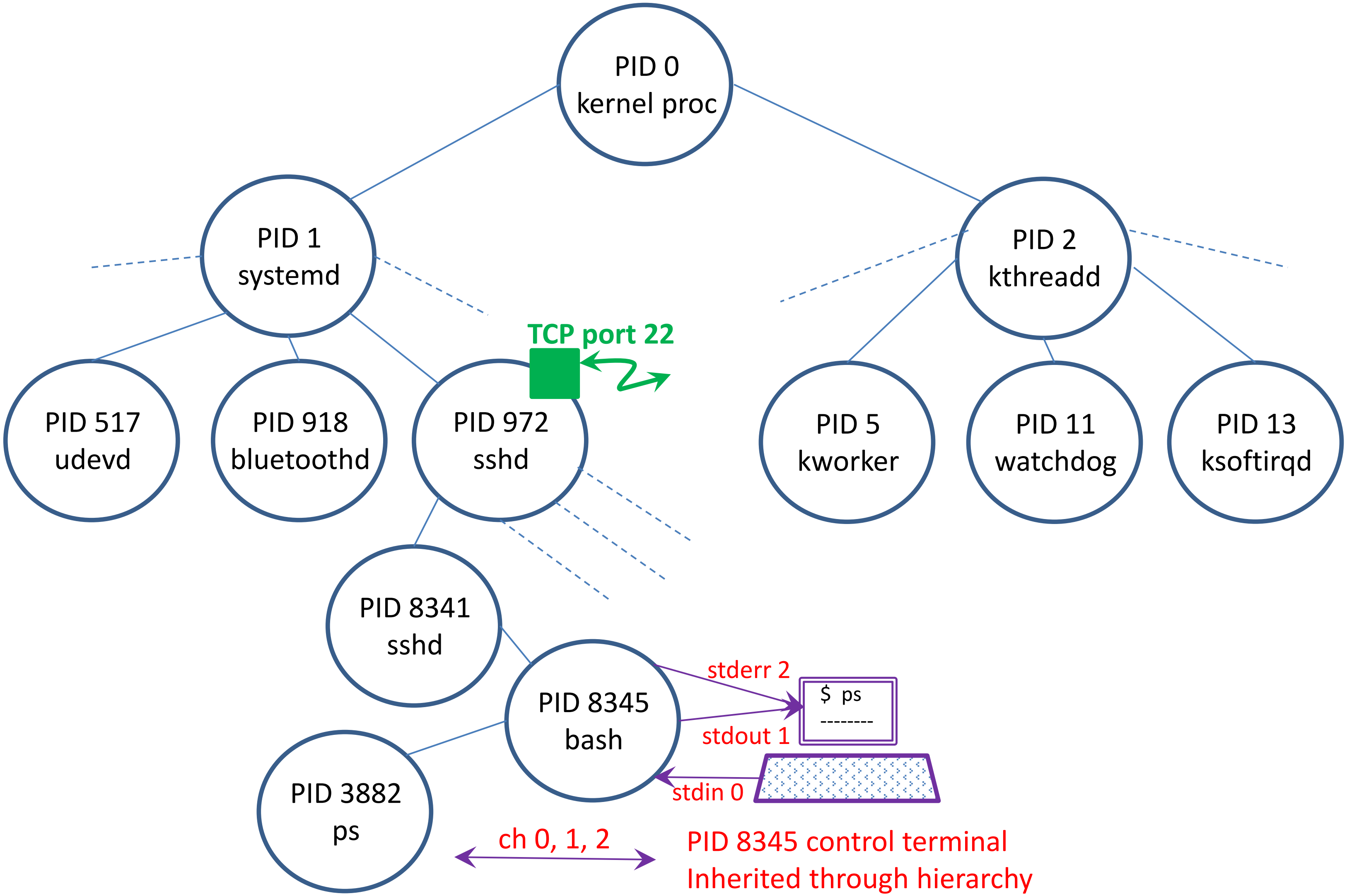
Processes

- In most contemporary Operating Systems such as Windows and Linux/UNIX, the unit of management is called a **process**
- A process is a resource container
  - Depending on the specific operating system, a process will have a set of defining attributes
  - At any given moment, the collection of processes in a system completely defines the system
    - All computations must be done in the context of a process

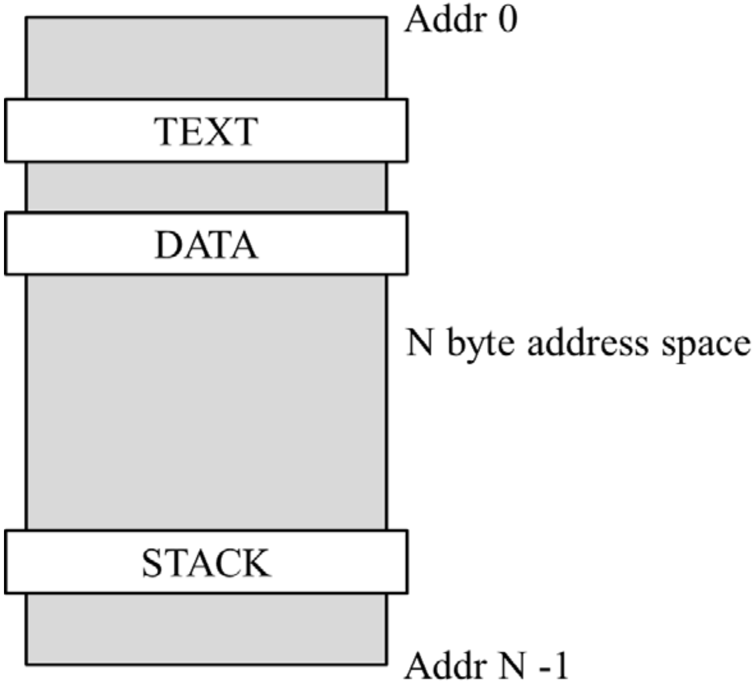
Processes (cont’d)

- While processes on various systems share much more in common than in difference, we will focus on the process model used in **Linux**
- A Linux process is characterized by many attributes, but foremost among these are:
  - An executable program
  - One or more threads that can run the program
  - An address space to contain all process memory objects (i.e. text, data, stack, etc.)

A Linux Process Tree



Process Address Space

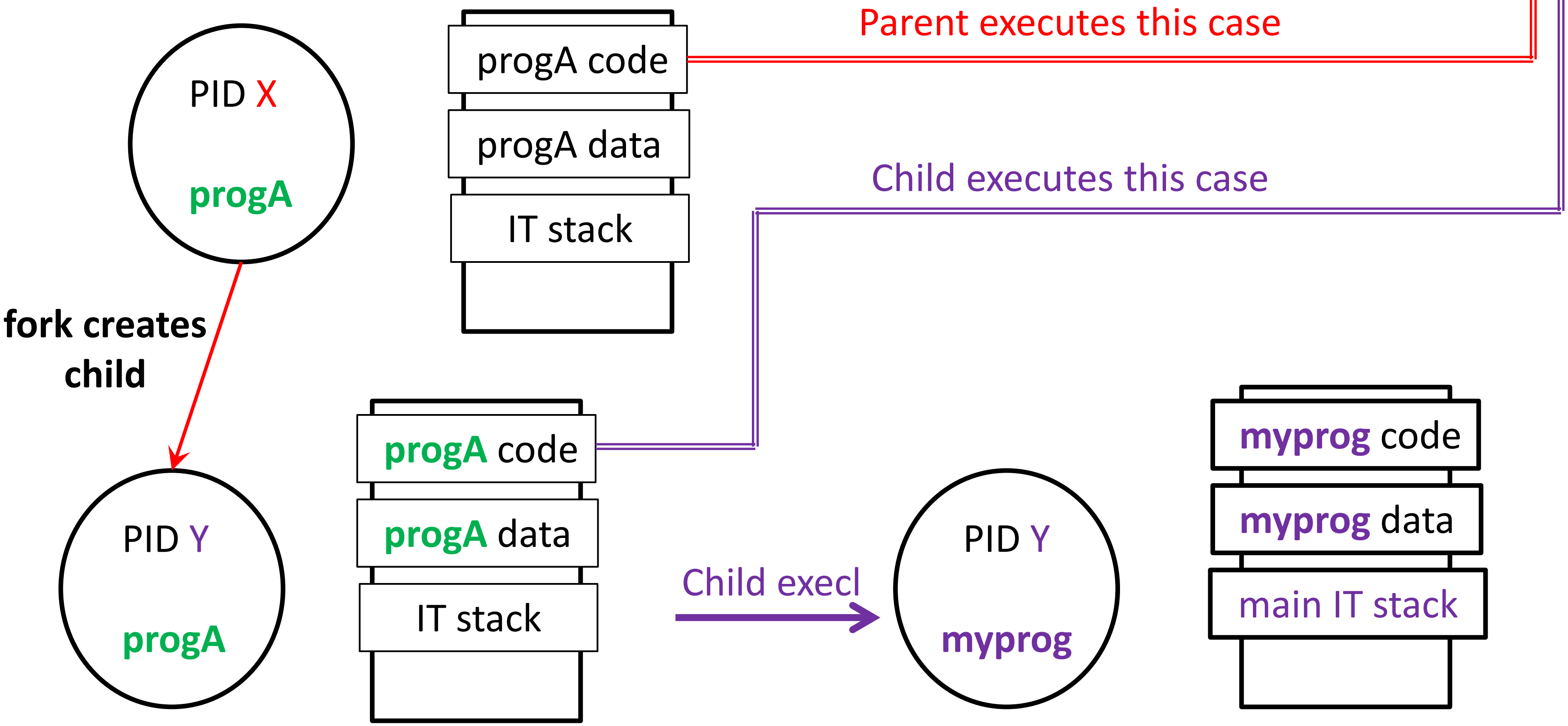


- Each memory object is a contiguous range of bytes within the address space
- The size of the address space is limited by the CPU architecture and the operating system version
- In a 32 bit Linux system on an x86 processor, the user default space is 3 GB (it's 128 TB in a 64 bit x86 system)

Threads

- The executable (schedulable) elements in a Linux system
- Each thread in the system is uniquely contained by some process
  - Each user thread is contained by some user PID
  - Each kernel thread is contained in PID 0
- When a new process is created, it is populated by exactly one executable thread, known as the ***Initial Thread*** (IT) of the new process
- The IT of a process can create new threads only within its own process
- While the IT must create the ***second thread*** in a process, any subsequent threads can then create new threads, but only within their own process

```
switch (int pid = fork()){
   case -1: perror(“fork failed “);
            exit(1);
   case 0:  printf(“child alive\n”);
            execl(“./myprog”, “myprog”, NULL);
   default: printf(“created PID %d \n”, pid);
} // end switch
```

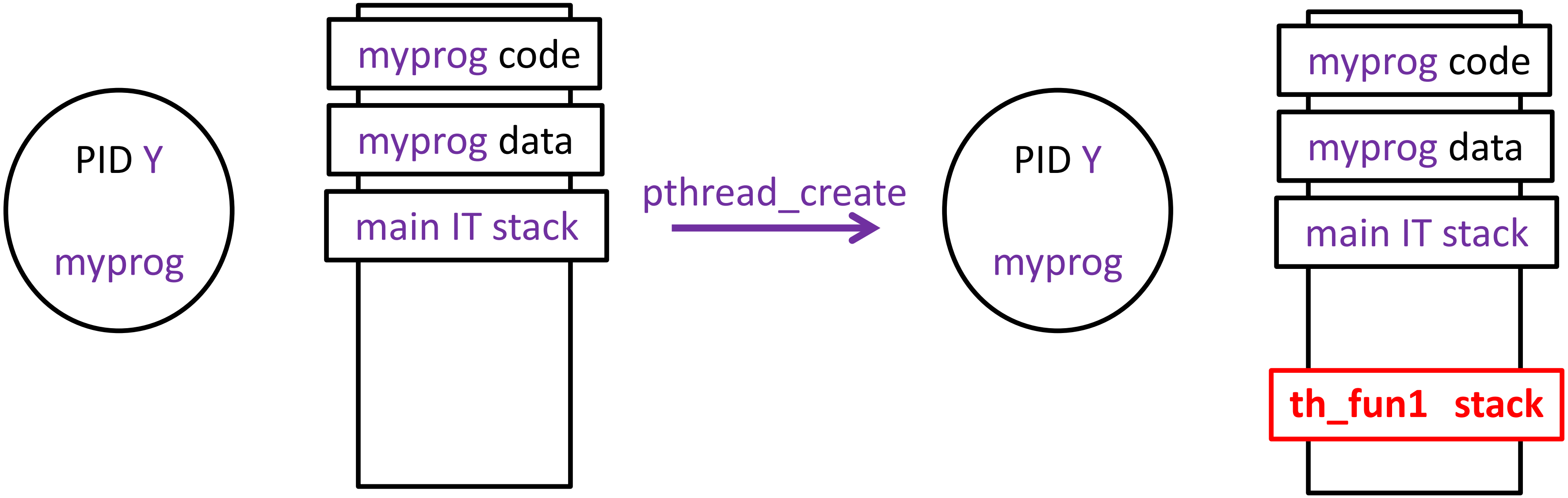


The new child program **myprog** executes from the first statement in its **main()** function.

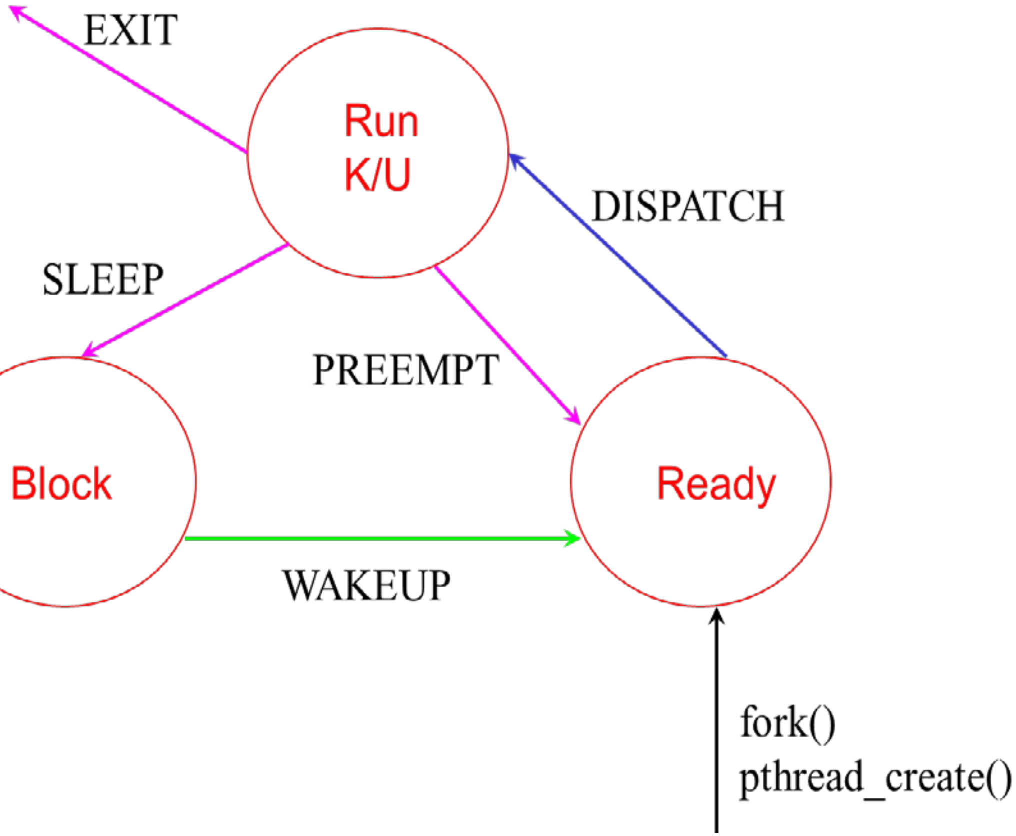
If the new program executes the following statement:

```
    pthread_create(&tid_id, NULL, th_fun1, NULL);
```

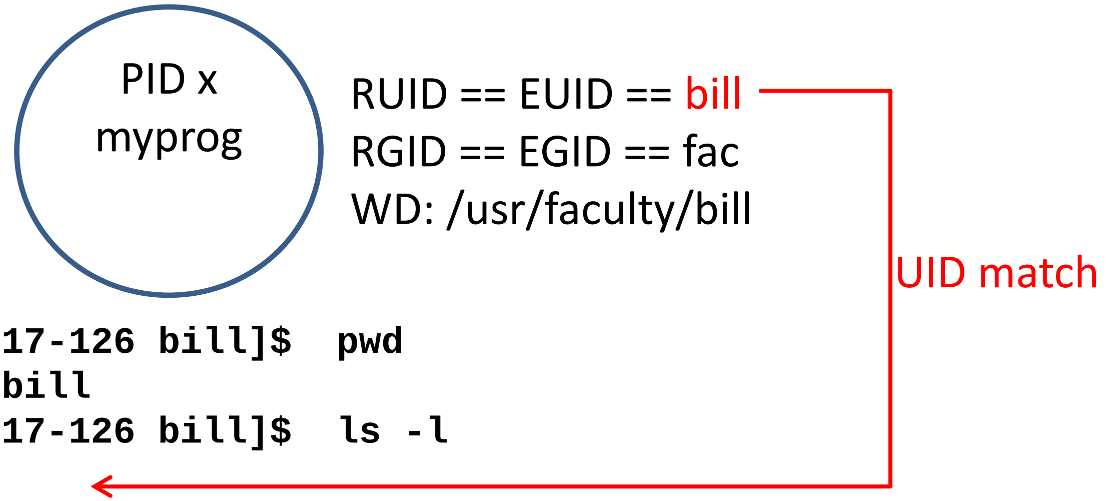
a **new stack** will be mapped into the address space



Thread States and Transitions



Thread Access Example



PID x
myprog

RUID == EUID == bill
RGID == EGID == fac
WD: /usr/faculty/bill

UID match

```
[bill@mich-fc17-126 bill]$  pwd
/usr/faculty/bill
[bill@mich-fc17-126 bill]$  ls -l
total 48
-rw-r--r--. 1 bill fac   20483 Aug  6 11:33 mmap_rw_var.c
-r--rw-rw-. 1 bill fac   22097 Aug  6 11:34 malloc_th.c
```

- A ***system call*** made by a thread in PID x is:

  `int channel = open("/usr/faculty/bill/mmap_rw_var.c", O_RDWR, 0);`
- The system call ***succeeds*** and returns a valid channel to read and write
- A second call made by a thread in PID x is:

  `int channel = open("/usr/faculty/bill/malloc_th.c", O_RDWR, 0);`
- This call ***fails***, since the calling process is the owner, and owner permissions don't allow WRITE, even though group and other do