Process Management Example

ExecHandler (char* executable)

```
Process* p = new Process();
Process* parent = CurrentProcess();
create and initialize VAS for p;
p->Birth(parent);
start thread in child context;
allocate and return SpaceID;
```

JoinHandler(int spaceid)

```
Process* child = get from spaceID;
int status = child->Join();
return(status);
```

ExitHandler(int status)

```
Process* p = CurrentProcess();
tear down p's VAS, release memory;
p->Death(status);
delete p;
destroy this thread;
```

1. Parent waits in *Join* for child to exit (by calling *Death*).

2. Exited child waits in *Death* for parent to join or exit.

3. Exited parent waits in *Death* for children to exit.

Needed:
- 3 **wait**
- 3 **signal/broadcast**

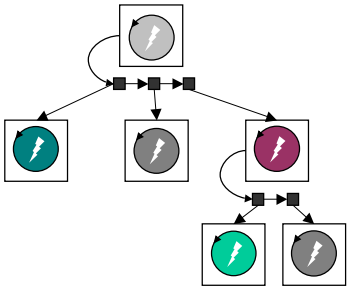
each in (*Join*, *Death*, *Death*)

Process Birth Example
(Midterm Problem #4)

pMx and *pCv* are global
(could use private CVs, but it's tricky)

```
Mutex* pMx;
Condition* pCv;

void
Process::Birth(Process *parent) {
        pMx->Acquire();
        this->parent = parent;
        parent->AddChild(this);
        status = 0;
        exited = 0;
        joinedOn = 0;
        pMx->Release();
}
```



Process Join Example
(Midterm Problem #4)

```
int
Process::Join() {
        int status;

        pMx->Acquire();
        while (!exited)
                pCv->Wait();        /* wait for child to exit */
        status = this->status;
        joinedOn = 1;
        pCv->Broadcast();           /* tell child that parent is done */
        pMx->Release();

        return(status);
}
```

1. Parent waits in *Join* for child to call *Death*.

2. Child waits in *Death* for parent to complete *Join*.

Common errors:

(1) What if I don't kick the condition variable? Child may block in Death() waiting for parent to Join.

(2) What if I set joinedOn too soon, before waiting? Child may return from Death thinking the join is complete.

(3) What if release the lock without saving status in a local variable? Child may return from Death and delete its process object as soon as I tell it the Join is complete.

Process Death Example

```
void Process::Death(int status) {
        pMx->Acquire();

        exited = 1;                         /* process has exited */
        this->status = status;
        pCv->Broadcast();                   /* wake parent from join */

        while (!joinedOn && !parent->exited)
                pCv->Wait();
        parent->RemoveChild(this);          /* parent may delete now */
        pCv->Broadcast();

        while (!children->Empty())
                pCv->Wait();

        pMx->Release();
}
```

1. Parent waits in *Join* for child to call *Death*.

2. Child waits in *Death* for parent to call *Death*.

3. Parent waits in *Death* for children to call *Death*.

Common errors:

(1) What if I wait for children before telling parent I exited? Parent must wait for all descendants to exit before it can reap child status and continue from Join.

(2) What if I RemoveChild too early, before verifying that parent has joined or exited? Parent may return from Death and delete itself, before I have finished looking at its exited flag.

(3) If I wait for parent to exit or complete join before telling it I exited, then I may deadlock if the parent is waiting for me in Join.