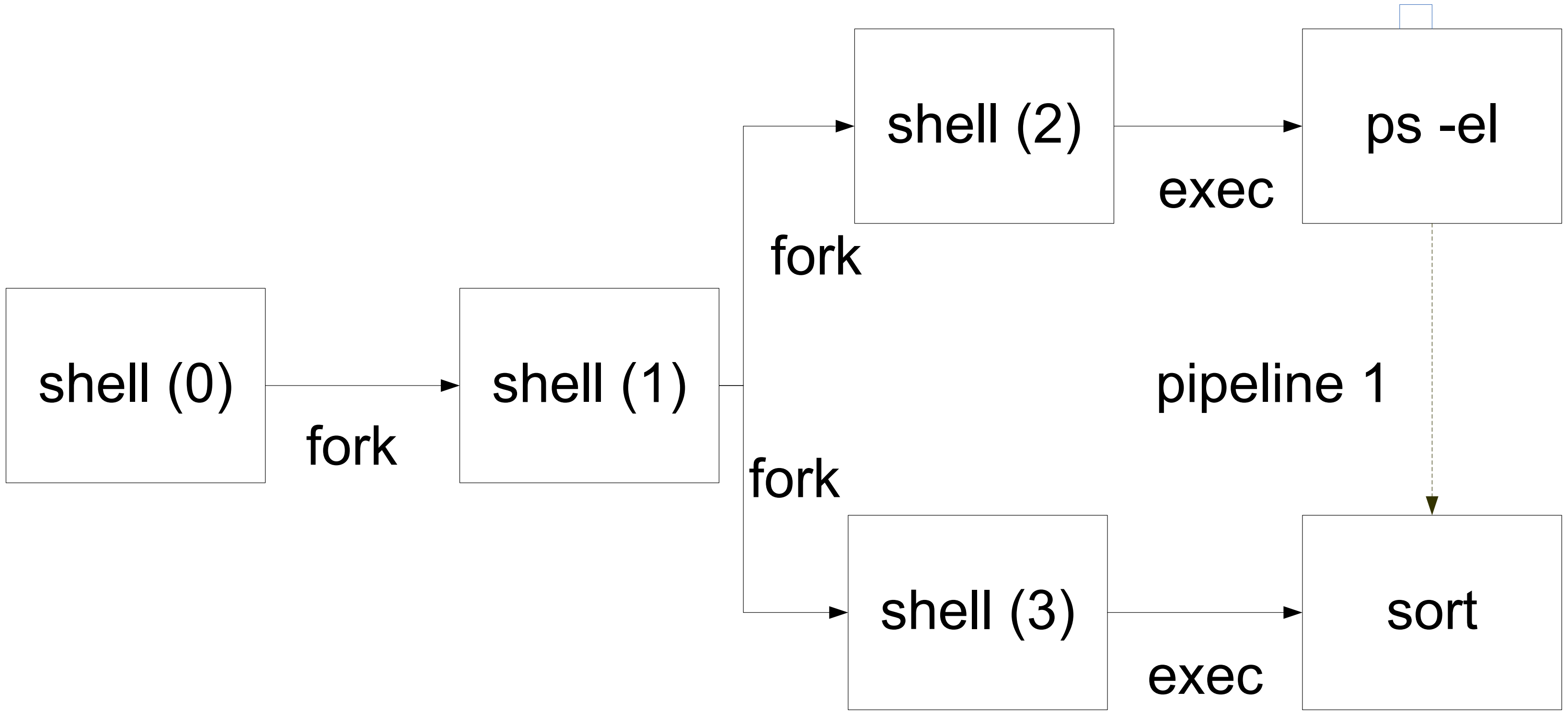
Assignment 1

Suggested Approach for a Single Pipe

- The first process (parent shell) should fork one child process.
- The parent shell should wait for this child process to complete
- The child process is the parent of all other processes where each of these processes executes a command.
- Let's look at an example for

```
ps -l | sort
```

Example


shell (0)
fork
shell (1)
fork
fork
shell (2)
exec
ps -el
pipeline 1
shell (3)
exec
sort

Example

- The parent shell (0) forks one child process (1). It waits for that child to terminate.
- The child process (shell 1) of the first step forks off two other processes: shell 2 and shell 3.
  - Each process redirects STDIN and STDOUT to the appropriate pipe and then calls exec() to execute the proper command

Another Approach

- The parent shell (0) forks one child process (1). It waits for that child to terminate.
- The child process (shell 1) of the first step forks off one other process: shell 2
  - Both processes redirect STDIN and STDOUT to the appropriate pipe and then calls exec() to execute the proper command
  - The shell 1 process executes the second command

I/O Redirection

- We have discussed this already;
- Basically you will redirect standard input and output based using dup2

File Descriptor Considerations

- The process that is the child of the shell (shell 1) is responsible for creating all the needed pipes before it forks off any of its children
  - This means that each of the children of shell 1 has a set of file descriptors for all pipes in the total pipeline

File Descriptor Considerations

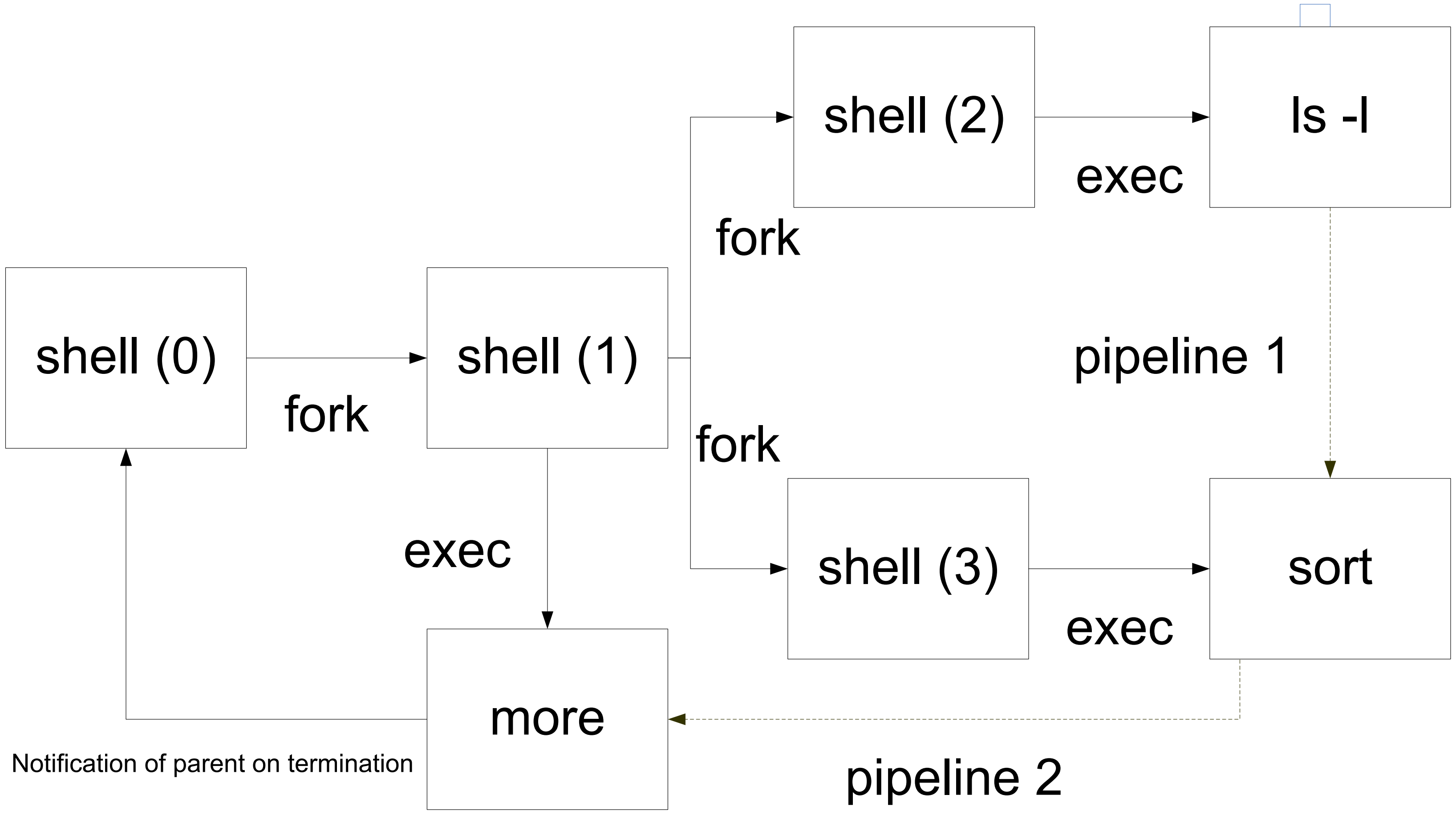
- Each forked process must specify exactly which pipe ends become its *stdin* and *stdout*
  - For example for ls the output should be associated with the pipeline 1
  - Use dup2(pipefd, stdin) or dup2(pipefd,stdout)
- Each forked process must close all file descriptors that comprise its pipes so that the pipes do not hang

Multiple pipes

- The first process (parent shell) should fork one child process.
- The parent shell should wait for this child process to complete
- The child process is the parent of all other processes where each of these processes executes a command.
- Let’s look at an example for

```
ls -l | sort | more
```

Example


shell (0)
fork
shell (1)
fork
shell (2)
exec
ls -l
fork
pipeline 1
shell (3)
exec
sort
exec
more
Notification of parent on termination
pipeline 2

Example

- The parent shell (0) forks one child process (1). It waits for that child to terminate.
  - This child process (shell 1) executes the last command i.e., the more command.
- The child process (shell 1) of the first step forks off two other processes: shell 2 and shell 3.
  - Each new child process redirects STDIN and STDOUT to the appropriate pipe and then calls exec() to execute the proper command

Example

- shell 2's exec call loads the ls binary
- shell 3's exec call loads the sort binary
- shell 1's exec call loads the more binary
  - When it terminates it sends a notification to the parent shell
- The parent shell must wait on the last command to finish before continuing