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Process Control and Execution

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Multiprocess Programming

★ is basically a single running program

★ can be a system initiated program or user space program

★ each process is identified by a unique process ID (PID)

★ process are treated as separate program and do not communicate with each other

★ special mechanisms for process communications:
  – signals
  – semaphores
  – shared memory
  – pipes
  – message passing
Section I

Current Process
Current Process Information

★ defined in the unistd.h and sys/types.h header files

★ pid_t getpid(void);
★ pid_t getppid(void);

– gets the process identification numbers
– getpid gets the current process id
– getppid gets the parent process id of the current process
Process Groups

★ is a collection of one or more processes
★ the process group leader’s PID is the same as the Process Group ID (PGID)
★ defined in the unistd.h and sys/types.h header files

★ int setpgid(pid_t pid, pid_t pgid);
★ int setpgrp(void);
   – sets the process group of the current process
   – returns -1 if an error occurs
   – setpgid() sets the process group of pid to pgid
   – If pid is zero, the process ID of the current process is used
   – If pgid is zero, the process ID of the process specified by pid is used
   – setpgrp() is similar to setpgid(0, 0)
* pid_t getpgid(pid_t pid);

* pid_t getpgrp(void);
  
  – returns the process group ID of the process specified by pid
  
  – If pid is zero, the process ID of the current process is used
  
  – returns -1 if an error occurs
  
  – getpgrp () is similar to getpgid (0)
Session

★ is a collection of one or more process groups

★ defined in the unistd.h and sys/types.h header files

★ `pid_t setsid(void);`
  - creates a new session and returns the session ID (SID)
  - sets the process group ID and session ID of the current process to SID
  - if the calling process is a session leader the current SID is returned
  - returns -1 if an error occurs

★ `pid_t getsid(pid_t pid);`
  - gets the session ID of the process `pid`
  - `getsid(0)` returns the session ID of the calling process
  - returns -1 if an error occurs
Exit Functions

★ defined in the stdlib.h header file

★ void exit(int status);
  – terminates the current process
  – performs process cleanup before returning control to the operating system

★ void _exit(int status);
  – terminates the current process
  – does not perform system cleanup

★ int atexit(void (*function)(void));
  – registers a function to be called upon normal program termination
  – functions are called exit handlers
  – exit handlers are executed in last in first out fashion
  – returns a -1 if registration is not successful
Environment Variables

★ defined in the stdlib.h header file

★ char *getenv(const char *name);
  
  – searches the environment list for the environment variable defined by name
  
  – returns a pointer to the value in the environment
  
  – returns NULL if an error occurred

★ int setenv(const char *name, const char *value, int overwrite);

★ void unsetenv(const char *name);

  – correspondingly sets the environment variable defined by the name and value pair
  
  – overwrites existing data if overwrite is non-zero
  
  – returns -1 if an error occurs
unsetenv() unsets the environment variable

`extern char **environ;`
- points to an array of strings that contains the environment
- each environment variable is defined as a `name=value` pair
- defined in the `unistd.h` header file and the `_GNU_SOURCE` must be defined
Section II

Process Management
Spawned a New Process

- defined in the unistd.h and sys/types.h header files

- pid_t fork(void);

- pid_t vfork(void);
  - creates a child process
  - returns the pid of the child for the parent and zero for the child
  - both parent and child continue executing the instructions after the fork functions is executed
  - returns -1 on error
  - vfork() is used when the only purpose of the forked processes is to call the exec() -like functions
  - vfork() typically uses the address space of the parent but not entirely and not always
Typically Calling Sequence

```c
if ( ( pid = fork () ) < 0 )
    printf ("error forking\n");
else if ( pid == 0 ) {
    /* execute child stuff here */
}
else {
    /* place parent stuff here */
}
```
Process Termination

* defined in the `sys/wait.h` and `sys/types.h` header files

* `pid_t wait(int *status);`

* `pid_t waitpid(pid_t pid, int *status, int options);`

  – functions used to block until a process terminates
  – `wait()` waits until a child has exited
  – in `wait()` if the child has already exited this function immediately returns
  – `waitpid()` waits until a child specified by `pid` returns
  – in `waitpid()` can have the values:
    * `< −1` to wait for any process in that process group `−pid`
    * `−1` makes `waitpid` behave like `wait`
    * `0` waits for any child in the same process group
* $ \geq 0$ wait for process defined by \texttt{pid}

- returns the PID of the child, returns -1 if an error occurred, returns 0 if no child was available

- if the value of \texttt{status} is not NULL then \texttt{status} points to the location of the status information
Potential Problems with Multiprocess Programming

- runaway forking
- data dependencies
- synchronization and race conditions
Section III

Remote Execution
Exec and Friends

* defined in the unistd.h header file

* int execl( const char *path, const char *arg, ...

* int execlp( const char *file, const char *arg, ...

* int execle( const char *path, const char *arg, ..., char* const envp[]);

* int execv( const char *path, char *const argv[]);

* int execvp( const char *file, char *const argv[]);

* int execve (const char *filename, char *const
argv [], char *const envp[]);

- executes a file
- this replaces the current process image with the new process

- `execle()`, `execlp()`, `execle()`, `execv()`, `execvp()` are frontends to the `execve()` function

- returns -1 if an error occurs
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