COMP 2355 Introduction to Systems Programming

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Today

- Terminal Programming
- Job Control

Why bother with text mode?

- Often only practical mode for accessing systems over the network
- Available on all development platforms
- Easier to implement than graphical interfaces

$\Rightarrow$ Text-mode often only/first interface for prototypes

$\Rightarrow$ Text-mode is great for testing: focus on problem, ignore GUI

- Learn more about good programming practice and operating systems

What is a Terminal?

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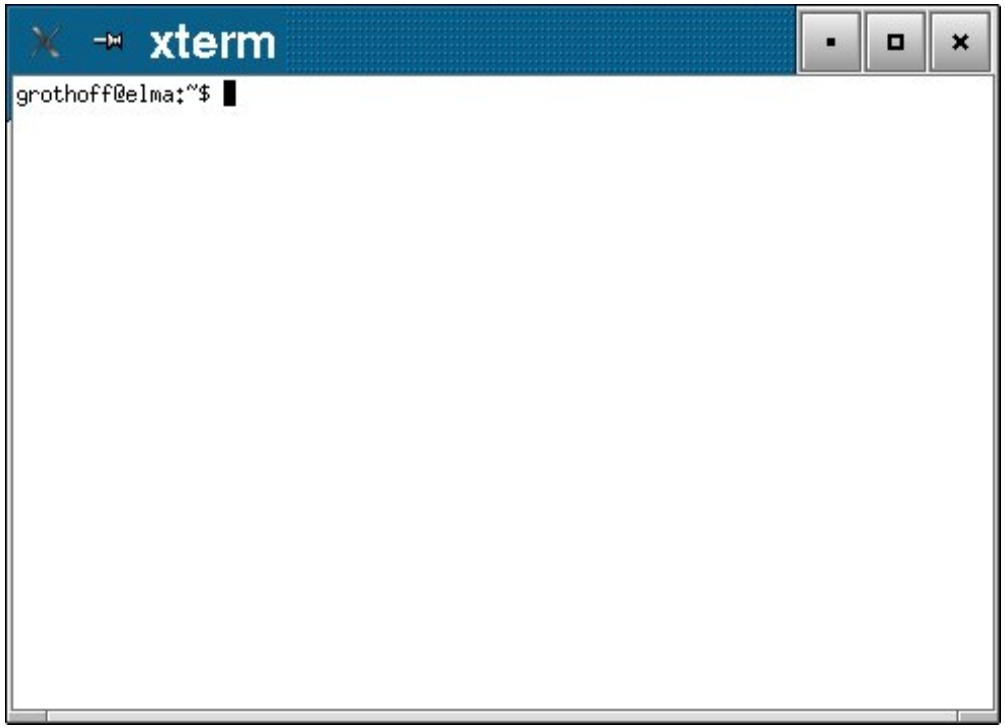
A VT-100!

What is a Terminal?



An xterm!

What is a Terminal?

- A device used for human-computer interaction
- Terminals provide text input and text output
- These days, a terminal can refer to hardware or software emulating hardware

Terminal = Keyboard + Monitor?

Not quite:

- Terminals can be programmed and support individual character IO or line-based IO
- Monitors display pixels, terminals display characters
- Keyboards report key strokes and key release, terminals report characters
- Keyboard hardware has no transmission problems; historical (networked) terminals did

Terminals vs. `stdin/stdout`

- `stdin` (when used with a terminal) is by default line-based
- `stdin` echos characters typed in to the terminal (by default)
- A terminal maybe shared by multiple processes!

$\Rightarrow$ Sharing of `stdin` and `stdout` must be controlled!

$\Rightarrow$ Job control

Controlling a Terminal

- Terminals are controlled using file descriptors (int)
- The same terminal maybe accessed via many different file desciptors
- Control operations affect all users of the (same) terminal

Identifying Terminals

- IO redirection may mean that `stdin` or `stdout` do not correspond to a terminal!
- `int isatty(int filedes)` can be used to check!

Input Processing Modes

- Canonical: input is processed in lines, the OS provides (minimal) editing facilities
- Noncanonical: granularity of input is not fixed, user can specify number of characters and timeout; no editing support by the OS

Getting and Setting Modes

- `int tcgetattr(int filedes, struct termios * termios-p)`
- `int tcsetattr(int filedes, int when,`
  `const struct termios * termios-p)`
- When: TCSANOW (immediately), TCSADRAIN (after queued output has been written), TCSAFLUSH (like DRAIN, but discard all input), TCSASOFT (read manual)

struct termios

```
struct termios {
  tcflag_t c_iflag;  // input
  tcflag_t c_oflag;  // output
  tcflag_t c_cflag;  // control (network)
  tcflag_t c_lflag;  // control (local)
  cc_t c_cc[NCCS];   // special characters
  // ...
}
```

Setting Modes

- `struct termios` may have additional members
- Additional bits maybe defined in the future

$\Rightarrow$ Never set the entire structure! Instead:

1. Get the current values
2. Modify the **bit** you intend to change
3. Set the resulting structure

Example: enter non-canonical mode

```
void go_noncanonical(int td) {
  struct termios settings;

  if (0 != tcgetattr (td, &settings))
    return 1;
  settings.c_lflag &= ~ICANON;
  if (0 != tcsetattr (td, TCSANOW, &settings))
    return 1;
  return 0;
}
```

Example: enter canonical mode

```
void go_canonical(int td) {
  struct termios settings;

  if (0 != tcgetattr (td, &settings))
    return 1;
  settings.c_lflag |= ICANON;
  if (0 != tcsetattr (td, TCSANOW, &settings))
    return 1;
  return 0;
}
```

Example: toggle echo

```
void toggle_canonical(int td) {
  struct termios settings;

  if (0 != tcgetattr (td, &settings))
    return 1;
  settings.c_lflag ^= ECHO;
  if (0 != tcsetattr (td, TCSANOW, &settings))
    return 1;
  return 0;
}
```

Controlling the input rate

In noncanonical mode, the application has to define how soon input should be transmitted:

- `terminos.c_cc[VMIN]` specifies the minimum number of bytes that must be available in order for `read` to return
- `terminos.c_cc[VTIME]` specifies how long to wait for another character before returning

Details are in the GNU C library manual, section 17.4.10.

Other modes

- There are many more options for terminals
- Some are only of historic value (modems, old hardware)
- Read the manual if you need something specific!

Curses!

- Terminals interpret certain control sequences for special actions, such as deleting a character, moving the cursor or clearing the screen
- Different (historic) terminals supported different control sequences; today, VT100's set is the most common standard
- The `curses` (and now `ncurses`) libraries provide a common API for virtually all terminals

GNU readline

- Software library for line-input processing with editing
- `char * readline(const char * prompt)`
- Supports history using `add_history(const char * line)`
- Supports TAB completion

Job Control

- Concepts
- Sharing a Terminal
- SIGHUP
- Shells

Sessions

The canonical setup under UNIX is that:

- A session contains all of the processes associated with a particular terminal
- The shell is the session leader and controls the terminal
- `pid_t setsid(void)` creates a new session, making the current process the session leader

Process Groups

The canonical setup under UNIX is that:

- A process group contains all of the processes belonging to the same shell command
- `setpgid(pid_t pid, pid_t pgid)` sets the process group
- Job control operations in the shell determine which process group (currently) controls the terminal

Sharing a Terminal: Reading

- Only one process can read from the terminal at any given time
- This is the foreground job
- `int tcsetpgrp(int filedes, pid_t pgid_id)` sets the foreground job for a terminal
- All other processes trying to read will receive a `SIGTTIN` signal, which by default stops all of the processes in that group

Sharing a Terminal: Writing

- By default, multiple processes can write
- If `TOSTOP` is set in `c_lflag`, writing will cause a `SIGTTOU` signal, which again by default stops all processes in the group

SIGHUP

What happens if the terminal is disconnected (or the session leader terminates)?

- A signal `SIGHUP` is sent to all processes in the group
- By default, this causes these processes to terminate
- `SIGHUP` can also be caught
- The `nohup` command installs a handler causing `SIGHUP` to be ignored

Shells

- The GNU C library manual (section 27.6) contains a skeleton
- You can use the code from the manual in your implementation
- You must acknowledge using code from the manual in comments
- You can use GNU's libreadline for input processing

Questions

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