Introduction to Programming Systems

CS 217

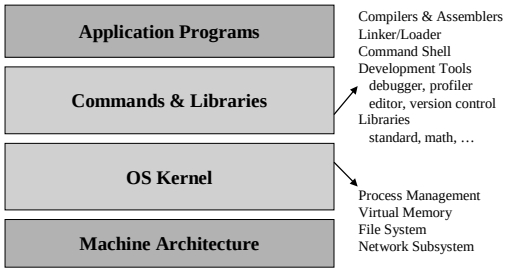
Goals

- Master the art of programming
  - exploit abstraction, modularity, interfaces
  - write efficient programs
  - write robust programs
- Learn C and the Unix development tools
  - C is the systems language of choice
  - Unix has a rich development environment
- Introduction to computer systems
  - operating systems and networks
  - compilers
  - machine architecture

The C Programming Language

- Systems programming language
  - originally used to write Unix and Unix tools
  - data types and control structures close to most machines
  - now also a popular application programming language
- Notable features
  - pointer (address) arithmetic
  - all functions are call-by-value
  - simple 2-level scope structure
  - no I/O or memory mgmt facilities (provided by libraries)
- History
  - BCPL → B → C → K&R C → ANSI C
    1960 1970 1972 1978 1988

Systems Software



Difficult Lessons

- Program specifications are ambiguous (buggy)
  - code you write (your assignments)
  - code you use
- Programming is mostly about writing robust code; the algorithms are often simple
- Systems programming cannot be rushed

Course Details

- Lectures
  - `www.cs.princeton.edu/courses/cs217/`
- Precepts
  - work through programming examples
  - demonstrate tools (gdb, makefiles, emacs, …)
- Assignments
  - six total (yes, you implement a shell)
  - 2/3rds of your grade

Course Details (cont)

- Textbooks
  - C: A Reference Manual. Harbison & Steele.
  - SPARC Architecture, Assembly Language Programming, and C. Paul.
  - C Interfaces and Implementations. Hanson.
  - Programming with GNU Software. Loukides & Oram.

Course Details (cont)

- Facilities
  - CIT's **`arizona`** cluster
  - SPARC lab in Friend 016
  - Your own laptop
    `ssh` access to **`arizona`**
    run **`GNU`** tools on Windows
    run **`GNU`** tools on Linux

Programming Style

- Variable names, indentation, structure,…
- Example style guide
  `www.cs.princeton.edu/courses/cs217/style.ps`
- Who reads your code?
  - compiler
  - other programmers
- Which one cares about style?
- Macho programmer **`!=`** good programmer
  - avoid trying to be too clever

Programming Style (cont)

- Names
  - use descriptive names for globals and functions
    e.g., **`elementCount`**
  - use concise names for local variables
    e.g., **`i`** (not **`arrayindex`**) for loop variable
  - use case judiciously
    e.g., **`PI`**, **`MAXLINE`** (reserve for constants)
  - use consistent style for compound names
    e.g., **`printword`**, **`PrintWord`**, **`print_word`**
  - use module prefixes to distinguish names
    e.g., **`Strset_T`**, **`Strset_add`**

Programming Style (cont)

- Layout and indentation
  - use white space judiciously
    e.g., to separate code into paragraphs
  - use indentation to emphasize structure
    use editor's autoindent facility
  - break long lines at logical places
    e.g., by operator precedence
  - line up parallel structures

```
alpha = angle(p1, p2, p3);
beta  = angle(p1, p2, p3);
gamma = angle(p1, p2, p3);
```


Programming Style (cont)

- Control structures

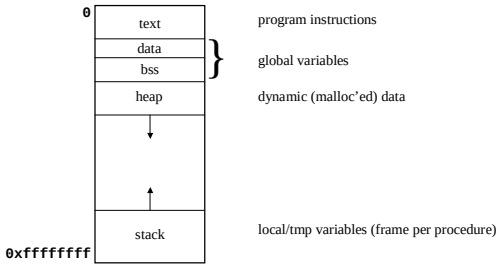
```
if (x < v[mid])          if (x < v[mid])
   high = mid – 1;           high = mid – 1;
else if (x < v[mid])       else if (x > v[mid])
   low = mid + 1;             low = mid + 1;
else                          else
   return mid;                   return mid;
```

implement multiway branches with **`if`** … **`else if`** … **`else`**
emphasize that only one action is performed
avoid empty **`then`** and **`else`** actions
handle default action, even if can't happen (use **`assert(0)`**)
avoid **`continue`**; minimize use of **`break`** and **`return`**
avoid complicated nested structures

Programming Style (cont)

- Documentation
  - comments should add new information
    ```
    i = i + 1;   /* add one to i */
    ```
  - comments must agree with the code
  - comment procedural interfaces liberally
  - comment algorithms, not coding idiosyncracies
  - master the language and its idioms; let the code speak for itself

Process Memory



Process Memory (cont)

```
int i;                  bss
int j = 74;             data
main()
{
    char *p;            stack
    p = malloc(8);      heap
    …
}
```

Software is Hard

"What were the lessons I learned from so many years of intensive work on the practical problem of setting type by computer? One of the most important lessons, perhaps, is the fact that SOFTWARE IS HARD. From now on I shall have significantly greater respect for every successful software tool that I encounter. During the past decade I was surprised to learn that the writing of programs for TeX and Metafont proved to be much more difficult than all the other things I had done (like proving theorems or writing books). The creation of good software demands a significantly higher standard of accuracy than those other things do, and it requires a longer attention span than other intellectual tasks."

Donald Knuth, 1989