2 Introduction to C

C Modules

- file translated into obj. file, which gets linked by linker to other object files and std libraries
- can refer to global variables/functions of other modules via. externs

Char input/output

- `getchar(void)`
- `putchar(c)`

`printf()` string formats

- `%.2f` floating pt to 2dp
- `%p` pointer

`scanf()`

- reads from std input
- returns number of read items
- parameters must be pointers

2 Introduction to Unix

`file`

- determines type of file
- e.g. ordinary, directory, device, 'special'

Shell environment

- at login, reads from `/etc/profile`
- gets `.bash_profile`, `.profile`

Permissions

- user, group, other
- read, write, execute
- use magical numbers (r: 4, w: 2, x: 1)

Redirections

- `a.out < data >res 2>errors`
- appending: `>>`

Shell scripts

- `#!/bin/bash`
- default search path `$PATH`
- to execute a script, `./scriptname`, otherwise if the current dir is in `$PATH` it can be executed using `scriptname`

Shell

- UNIX cmd interpreter
- reads in cmds, runs appropriate programs

I/O redirection

- when prog runs, 3 std files opened
  `0` std input
  `1` std output
  `2` std error

Shell variables

- stored in environment of the program
- setting: `VARNAME = value`
- using: `$VARNAME`
- script arguments: `$1, $2` etc.

`if` statement

- ```
  if <cmd>
  then
      <cmd>
  fi
  ```

`while` loop

- ```
  while <condition>
  do
      <cmd>
  done
  ```

`for` loop

- ```
  for <condition>
  do
      <cmd>
  done
  ```

`case`

- ```
  case $selector in
  1) <cmd> ;;
  2) <cmd> ;;
  esac
  ```

UNIX cmds

- `test`: tests a condition, exists with true/face
  `if test $1 == "blah"`
- `sort`: sorts lines of text in a file
- `cut`: cuts selected parts of lines of text in a file, and sends result to output
- `tr`: changes or removes chars from a file
- `comm`: compares files and prints lines that exist in only one or both files
- `grep`: searches text file/output, matching each line against specified regex, and prints all lines that match
- `diff` and `sdiff`: comparing files

Cmd substitution

- arg enclosed in backquotes indicates that a command is to run, and the output used as the actual argument(s)
- `prog ‘cat argfile‘`

Subshells

- run cmds in another copy of the shell
- environment copied from parent - subshell can change environ., but it will be reverted when the subshell exits
- `tar cf  mydir | (cd *loc*; tar xf -)`

Collecting output

- `(echo data; cat filename) > output`

Arithmetic

- `expr` evaluates its args as an expression
- `let` for assignment of variables
- `let count = count +1`

Read text from shell

- `read x`: reads in line from std input, and stores as x
- ”here document”

Finding files

- `find`: starts at curr dir and searches recursively
- `locate`: prints the full path names of all files that match
- `du`: prints disk usage starting at curr dir

Strange file names

- to open file named `-x`, use `nano ./-x`

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3 Pointers

- a memory address
- obtain address of variable with `&`
- create pointer to the address of `initial`
  `char initial = ’A’;`
  `char *initial_ptr = &initial;`
- `*` pointer to variable of specific type
- `**` unravels indirection
- `char msg[] = "message";`
  `char *string = &msg[0];` (or `msg`)
  $\therefore$ `msg[1] == *(string+1)`
- Iterating through a string with a pointer
  `while (*str != ’\0’) { str++ }`

Dynamic data structures

- dynamically allocate memory
- `malloc`, `realloc` etc.

Indirection operator

- declaration: pointer to specified type
  `int * ptr`
- dereferencing: dereferences the pointer to mean the content/value of the variable being pointed to

Array processing

- `int array[10]`
  `array == &array[0]`
- variables can change their values, but not their addresses
- pointer’s value is the address of another variable, $\therefore$ arithmetic ops permitted on pointer

Pointer scalars

- mathematical operations on pointers work regardless of the data type being pointer to
- ptr accesses to arrays will always move the correct number of bytes

Pass by reference

- swaps addresses of initial variables
- ```
  void swap (int *a, int *b) {
      int tmp = *a;
      *a = *b;
      *b = tmp;
  }
  ```
  ```

Pointers to pointers

- multiple indirection
- `argv[][] == *argv[] == **argv`

`void` pointers

- no associated scalar value
- can recieve/return ptrs of any type
- `void *malloc(size_t size);`

Function pointers

- refer to 12. string handling
- allows for selection of program behavior

`NULL` pointers

- pointer with value '0'
- denotes invalid pointer, not a ptr to something at address '0'

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3 Aggregate Data Structures

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enums

- associates name to a value
- maps to an int
- ```
  enum day_name {
      sun, mon, tue, wed, thur, fri,
  sat, sun
  }
  ```
  maps to ints 0..7
- can then use `sun++;`

Structures

- for a collection of data items of different types
- ```
  struct <tag> {
      <member-declarations>
  }
  ```
- declare: `struct <tag> <identifier-list>;`
- access: `<tag>.<element-required>;`
- if a pointer to a struct is used, `->` operator is used to get an element in a struct

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4 Source Code Control

Issues

- version control
- managing several versions of a program
- allows you to maintain current version whilst working on the next

Control

- checkin/checkout system
- e.g. svn, git, hg

Mercurial: hg

- distributed
  1. make copy of existing repo
  2. push changes to others
  3. pull changes from others
- `hg init`: creates repo
- `hg diff -r2 -r3`: diff b/w revision 2 and 3
- `hg revert -r2 code.c`: revert file to r2
- `hg push/pull/clone <repo>`
- repo: another dir/URL to a remote repo

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4 `make`

- program can use many `.c`, `.h` files that require compiling
- time consuming to compile lots of files separately
- object file: machine language, but not yet linked with other parts of the program
- several `.c`, `.o` files can be combined to give an executable program via. linkage
- after changing one `.c` file, you need to recompile affected file and relink ∴ `make` is sexy

Rules

- ```
  prog.o: prog.c prog.h      dependencies
      gcc -c prog.c          action
  ```
- `<target>`: name of file to be made
- `<1+ dependencies>`: files the target file depends on
- `<action>`: shell cmd that creates target
- default rules are the bomb
- can combine rules when targets have common dependencies and actions
- can create rules without dependences
  ```
  clean:
      rm *o
  ```
  ```

`make` variables

- assignments: `variable_name = value`
- use: `$(variable_name)`

Predefined variables

- `CC`: default C compiler
- `CFLAGS`: flags passed to the C compiler

Libraries

- gives you the ability to store the object code versions of the functions in one place and have them linked into your program
- stdlib automatically searched when prog is linked
- use functions from other libraries using `-l` flag when linking
- the C compiler will search for the library in standard directories: `/lib, /usr/lib`
- create own library using `ar`, which makes library mylib.a and will contain specified .o files
  `ar c mylib.a readit.o util.o`
- can then use created library when compiling
  `gcc myprog.o mylib.a -o myprog`

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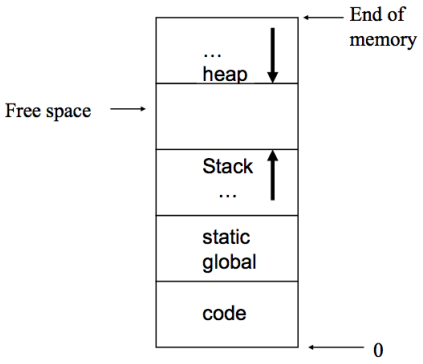
5 Memory Management



Memory areas

- code: program instructions
- global/static: global/static variables
- stack: local variables, function arguments, return addresses, temporary storage
- heap: dynamically allocated memory

Stack

- all variables local to a function and function args stored on the stack
- to call func:
  1. push args to stack
  2. push return address to stack
  3. jump to function code
- inside function:
  1. increment the stack pointer to allow space for the local variables
  2. execute the code
  3. pop local variables and arguments off the stack
  4. push the return result onto the stack
  5. jump to return address

Heap

- accessed under direct control
- request allocation, if there is sufficient contiguous memory available, a pointer is returned to the address of the stage of that memory block

Memory allocation functions

- returns a pointer to void
- pointer must be cast to a specific type

`malloc`

- `void *malloc(size_t size)`
- requests number of bytes of memory

`calloc`

- `void *calloc(size_t num, size_t size)`
- requests number of blocks of memory, and the size of each block
- allocated memory is cleared i.e. set to '0'

`realloc`

- `void *realloc(void *ptr, size_t size)`
- takes previously allocated memory, and attempts to resize it
- contents are preserved
- may require new block of memory (for contiguous-ness) ∴ new void pointer is returned

`free`

- `void free(void *ptr)`
- deallocates memory previously allocated
- `valgrind`: check for leaks

to make program happy

- check memory allocation for success (NULL pointer is returned if unsuccessful)
- don't free memory that has already been freed or was never allocated

5 Preprocessor

- `#include "decs.h"` ¿ copying declarations into every file
- useful for externs, tyedefs, struct definitions

Defined symbols

- replace identifier with string, everywhere it appears in the program
- can be any string of characters, ∴ should bracket arithmetic expressions

Macros

- `define min(a,b) ((a) < (b) ? (a) : (b))`

Conditional inclusion

- `#ifdef`, `#ifndef`, `#undef`
- `#if`, `#elif`, `#else`, `#end`

Predefined symbols

- `__LINE__`: current line number at any point
- `__FILE__`: name of current program file

Preprocessor ninjaness

- `gcc -E` runs only preprocessor
- exploit `#define` call by name, and `#ifdef` etc. for conditional generation of hacky templates

6 Unions and Bitfields

Unions

- variables that occupy the same space
- ```
  union {
      struct {
         /* struct guts */
      } type_one;
      struct {
         /* struct guts */
      } type_two;
  } info;
  ```
- access elements: `union_name.part_name`
- don't know which variant of the union is being used, ∴ need to use a separate variable to indicate this
- ```
  struct catalog x;
  switch (x.holding_type) {
      case book:
         <do stuff>
         break;
      case film:
         <do stuff>
         break;
  }
  ```