EL2310 – Scientific Programming

Lecture 12: Memory, Files and Bitoperations

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Overview

Lecture 12: Memory, Files and Bit operations

- Wrap Up
- Main function; reading and writing
- Bitwise Operations

Project

Last time

- Complex data structures (`struct`)
- Memory

Today

- More on Memory
- Reading/writing files
- Bitwise operations

Pointers and structures

- You can use pointers to structures
- Ex:

```
struct complex_number x;
struct complex_number *xptr = &x;
```

- To access a member using a pointer we use the "$->$" operator
- Ex: `xptr->real = 2;`
- Same as `(*xptr).real = 2;`
- and `x.real = 2;`

Structures of structures

- You can have any number of levels of structures of structures
- Ex:

```
struct position {
  double x;
  double y;
};
struct line {
  struct position start;
  struct position end;
};
```

Pointers to structures in structures

- Normally you need to declare a type before you use it.
- You can have a pointer to the structure you define
- Ex:
```
struct person {
  char name[32];
  struct person *parent;
};
```

cast

- Some conversions between types are implicit
- Ex: `double x = 4;` (cast from int to double)
- In other cases you need to tell the compiler to do this
- Ex: `int a = (int)4.2;` (will truncate to 4)
- Often used together with pointers
- Ex:

```
int a;
unsigned char *byte = (unsigned char*)&a;
```

Dynamic allocation of memory

- Sometimes you do not know the size of arrays etc.
- Idea: Allocate memory dynamically
- This way you can allocate memory at runtime

malloc

- Allocate memory with `malloc`
- Need to `#include<stdlib.h>`
- This function returns a pointer of type `void*`
  Ex: `int *p = malloc(100*sizeof(int));`
- To avoid warnings, add explicit cast
  Ex: `int *p = (int *)malloc(100*sizeof(int));`
- Will allocate memory for 100 `int`s

free

- You should free the memory that you no longer need!!!
- Ex:

```
int *p = (int *)malloc(100*sizeof(int));

...

free(p);
```

- If you do not free allocated memory you will get memory leaks
- Your program will crash eventually
- A big problem if you program should run a very long time

Memory

- When you run your program the memory is divided between the *heap* and the *stack*
- The stack:
  - Memory allocated for all parameters and local variables of a function
  - Fast-allocated memory
  - Current function at the top of the stack
  - When a function returns its memory is removed from the stack
- The heap:
  - Used for *persistent* data
  - Dynamically allocated memory

From http://www.csl.mtu.edu/cs3090/www/lecture-notes/Memory Allocation.ppt

Common mistakes

- Forgetting to free memory (memory leak!!!)
- Using memory that you have not initialized
- Using memory that you do not own
- Using more memory than you allocated
- Returning pointer to local variable (thus no longer existing)

Tip when using dynamic memory allocation

- If you have a `malloc` think about where the corresponding `free` is

Command line arguments

- You add parameters to the `main` function
- `int main(int argc, char **argv)`
- See the lab in C for more details and examples
- First argument is in `argv[1]`, `argv[0]` contains program name
- `atoi` and `atof` are useful to get number from char arrays
- Ex:

```
int value;
...
if (argc > 1) value = atoi(argv[1]);
else value = 42;
```

Reading and writing files

- We have already seen how we can write to the screen with `printf`
- This writes to a special file called `stdout`
- Can also write to `stderr`
- Ex: `fprintf(stderr, ``Hello world\n'');`

Reading from the keyboard

- Can use `char getchar();` to get a single character
- For more more complex input try `scanf(...)` which is the "dual" of `printf(...)`
- The arguments for `scanf` the same as for printf except that it wants pointers to where to put the data
- Ex:

```
int i;
double num[3];
printf("Enter 3 number:  ");
fflush(stdout);
for (i = 0; i < 3; i++) {
  scanf("%lf", &num[i]);
}
```

Opening/closing a file

- `FILE *fopen(char *path, char *mode);`
- mode is “r”: read, “w”: write, “a”:append, . . .
- On success returns pointer to `file descriptor`, else NULL
- `fclose(FILE*);`

Writing to a file

- Write to the file with for example
- `fprintf(FILE*, ...);`
- Ex:

```
double x=1, y=2, theta=0.5;
FILE *fd = NULL;
fd = fopen("test.txt", ``w'');
fprintf(fd, "Robot pose is %f %f %f\n",
x,y,theta);
fclose(fd);
```

Reading from a file

- Read from the file with for example
- `fscanf(FILE*, ...);`
- Ex:
```
double x,y,theta;
FILE *fd = NULL;
fd = fopen("test.txt", "r");
fscanf(fd, "Robot pose is %lf %lf %lf\n",
&x,&y,&theta);
fclose(fd);
```
- Notice that you need `%lf` when you read a double, `%f` for a float
- Function `sscanf()` is similar but operates on a char array instead of a file

Bitwise operations

- When programming at low level, bitwise operations are common
- Also, if you want to store flags it is very wasteful to use 1 byte for every flag that can only be 0 or 1.
- Typical construction, use *bitmask*
- Let each bit in the variable be one flag

Bitwise operator

- `&` bitwise AND
- `|` bitwise inclusive OR
- `^` bitwise exclusive OR
- `<<` left shift
- `>>` right shift
- `~` bitwise NOT

Example of bit operations

- `mask = mask & 0xF` Set all but the lower 4 bits to zero
- `mask = mask | 0x3` Set lower 2 bits
- ```
  short value;
  ...
  unsigned char lower = (short & 0xFF);
  unsigned char upper = (short >> 8);
  ```
- What is printed?

```
int x = 1, y = 2;
if (x && y) printf("Case 1\n");
if (x & y) printf("Case 2\n");
```
```

Shift operators

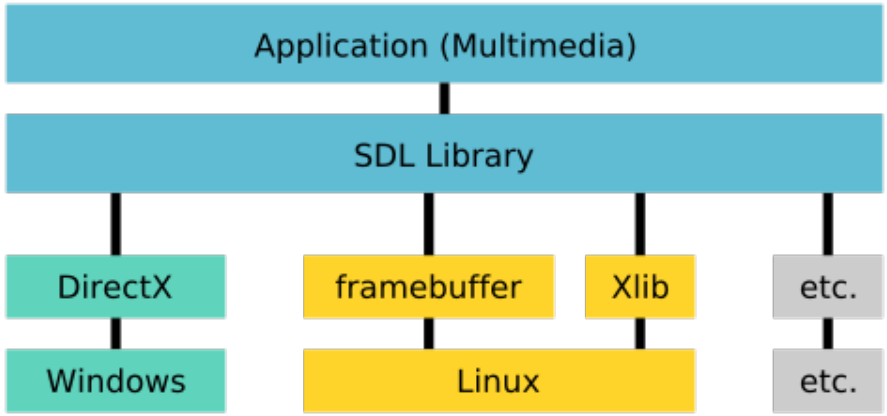
- Should primarily be used on `unsigned` data types
- Shifting results in division (right) and multiplication (left) of integers by 2 times the number of shifts

Project

Boids

- Simulate Flocking
- Invented by Craig Reynolds 1987
- Based on very simple interaction rules

SDL - Simple DirectMedia Layer



- Open Source C library for,
  - Graphics
  - Sound
  - Input

`main`

1. Define Variables
2. Initialise Screen to draw on
3. Event Loop
4. Cleans up

Event Loop

- Switch statement
  - `SDL_KEYDOWN`: if key is pressed, check if key is `ESC`
  - `SDL_QUIT`: Quit using system
  - `SDL_MOUSEMOTION`: If mose is moving
- `FPS` times per second call
  - `update_boids()`
  - `render_screen(screen)`

Skeleton

- `int render_screen(SDL_Surface* screen);`
- `void update_boids(void);`
- `void clean_up(SDL_Surface* screen);`
- `void read_mouse(SDL_Event* event);`
- `void put_pixel(SDL_Surface* screen,int x,int y,pixel* p);`
- `void clear_screen(SDL_Surface* screen);`
- `void render_boids(void);`

```
int render_screen(SDL_Surface* screen);
```

1. Creates a white pixel
2. `SDL_LockSurface(screen);`: Opens the screen for rendering
3. `SDL_UnlockSurface(screen);`: Closes the screen
4. You can only safely write to the screen between these commands

```
void read_mouse(SDL_Event* event);
```

- Called if mouse movement triggered
- Prints out mouse pointer coordinates

Project

- Think through how to structure data
  - `structs`
  - `structs of structs`
  - `...`
- How should the “flow” of the program be
- Divide into several functions
- Comment code for someone else to understand
- Base program is **NOT** the only solution