COMP1511 - Programming Fundamentals

Week 10 - Lecture 18

What did we cover last lecture?

Exam

- Exam format
- Difficulty of Questions
- How to approach it

Course Recap

- The first part of COMP1511

What are we covering today?

Course Recap

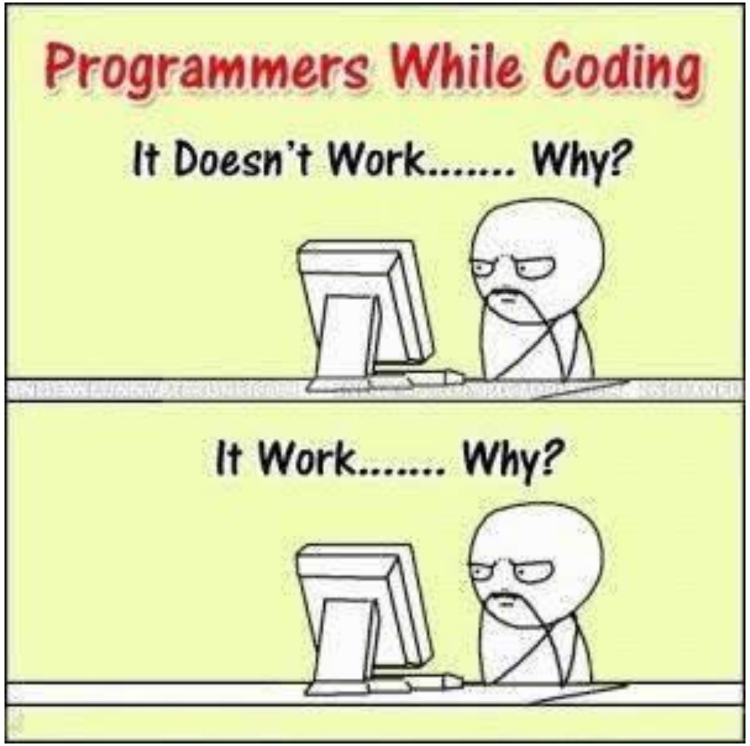
- Going through the rest of the course
- Non-technical programming skills
- The second half of the technical parts

Programming is much more than just code

COMP1511 Programming Skills Topics

- History of Computing
- Problem Solving
- Code Style
- Code Reviews
- Debugging
- Theory of a Computer
- Professionalism

Problem Solving



Problem Solving

Approach Problems with a plan!

- Big problems are usually collections of small problems
- Find ways to break things down into parts
- Complete the ones you can do easily
- Test things in parts before moving on to other parts

Code Style

Half the code is for machines, the other half for humans

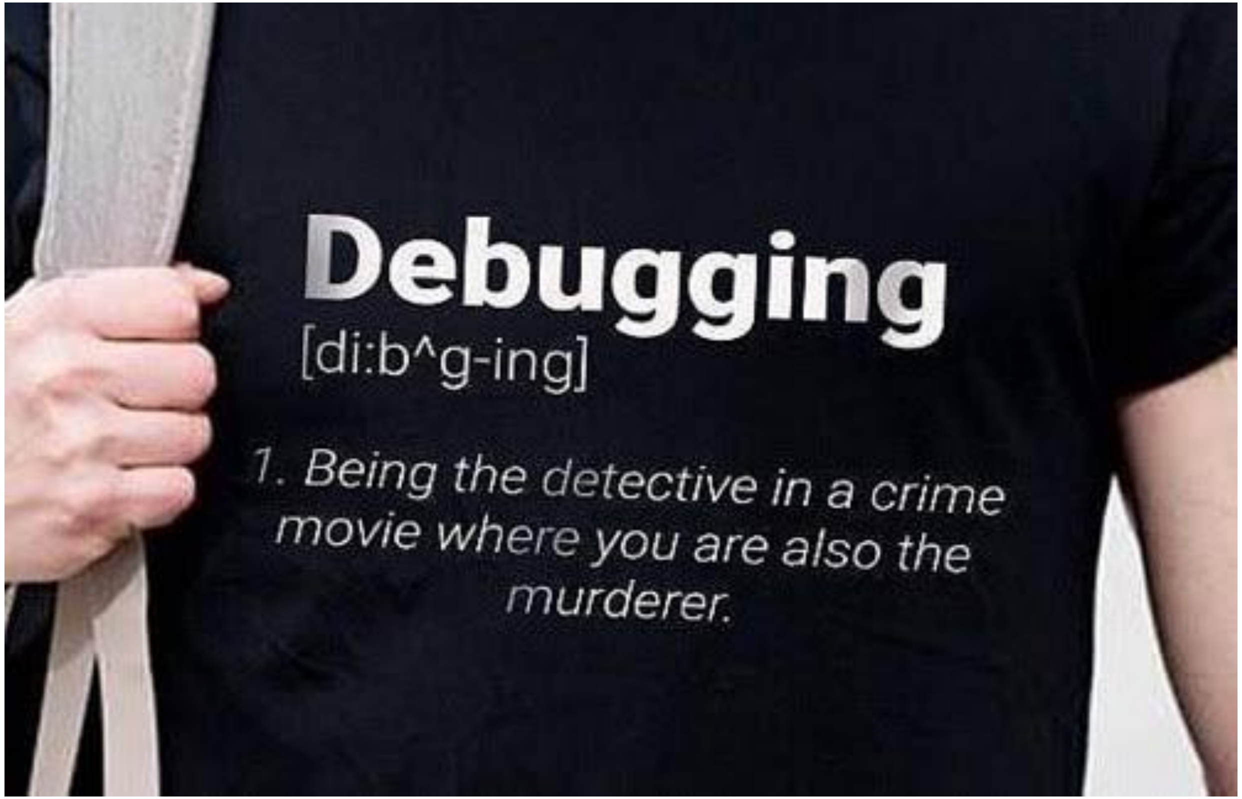
- Remember . . . readability == efficiency
- Also super important for working in teams
- It's much easier to isolate problems in code that you fully understand
- It's much easier to get help if someone can skim read your code and understand it
- It's much easier to modify code if it's written to a good style

Code Reviews

No one has to work without help

- If we read each other's code . . .
- We learn more
- We help each other
- We see new ways of approaching things
- We are able to teach (which is a great way to cement knowledge)

Debugging


Debugging
[di:b^g-ing]
1. Being the detective in a crime movie where you are also the murderer.

Debugging

The removal of bugs (programming errors)

- Syntax errors are code language errors
- Logical errors are the code not doing what we intend

- The first step is always: Get more information!
- Once you know exactly what your program is doing around a bug, it's easier to fix it
- Separate things into their parts to isolate where an error is
- Always try to remember what your intentions are for your code rather than getting bogged down

Professionalism

There's so much more to computing than code

- What's the most important thing for a Software Professional?
- It's not always coding!
- It's caring about what you do and the people around you!
- Even in terms of pure productivity, it's going to get more work done long term than being good at programming
- If you care about your work, you will be fulfilled by it
- If you care about your coworkers you'll teach and learn from them and you'll all grow into a great team

Break Time

A thought exercise . . . the future

- Why are you doing computer science (or related field)?
- Is there something you'd like to do with these skills?
  - Jobs?
  - Research?
  - Change the World?
- How do you want to use your time at UNSW to push yourself towards your goals?
- Note: You don't need all the answers yet, but it's useful to start thinking about these things!

Course Survey - MyExperience

Please fill out the survey!

- Accessible via Moodle
- Or directly via http://myexperience.unsw.edu.au/
- This helps us a lot to figure out what is and isn't working in the course
- A lot of the course structure and even things like marks distribution is based on feedback from previous myExperience feedback
- Chicken will love you if you leave us feedback!

Characters and Strings

Used to represent letters and words

- **char** is an 8 bit integer that allows us to encode characters
- Uses ASCII encoding (but we don't need to know ASCII to use them)

- Strings are arrays of characters
- The array is usually declared larger than it needs to be
- The word inside is ended by a Null Terminator `'\0'`
- Using C library functions can make working with strings easier

Characters and Strings in code

```c
// read user input
char input[MAX_LENGTH];
fgets(input, MAX_LENGTH, stdin);
printf("%s\n", input);

// print string vertically
int i = 0;
while (input[i] != '\0') {
    printf("%c\n", input[i]);
    i++;
}
```

Structures

Custom built types made up of other types

- **`structs`** are declared before use
- They can contain any other types (including other structs and arrays)
- We use a `.` operator to access fields they contain
- If we have a pointer to a struct, we use `->` to access fields

Structs in code

```c
struct spaceship {
    char name[MAX_NAME_LENGTH];
    int engines;
    int wings;
};

int main (void) {
    struct spaceship xwing;
    strcpy(xwing.name, "Red 5");
    xwing.engines = 4;
    xwing.wings = 4;

    struct spaceship *myShip = &xwing;

    // my ship takes a hit
    myShip->engines--;
    myShip->wings--;
}
```

Memory

Our programs are stored in the computer's memory while they run

- All our code will be in memory
- All our variables also
- Variables declared inside a set of curly braces will only last until those braces close (*what goes on inside curly braces stays inside curly braces*)
- If we want some memory to last longer than the function, we allocate it
- **`malloc()`** and **`free()`** allow us to allocate and free memory
- **`sizeof`** provides an exact size in bytes so malloc knows how much we need

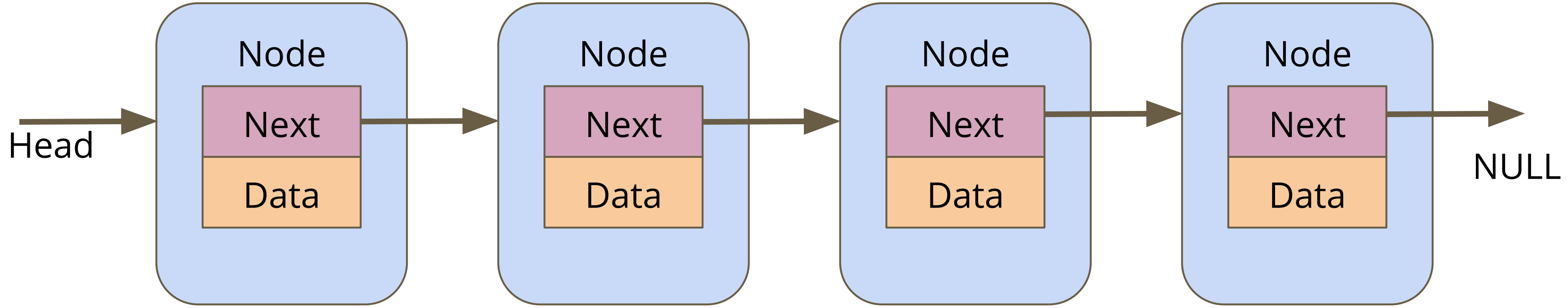
Memory code

```
struct spaceship {
    char name[MAX_NAME_LENGTH];
    int engines;
    int wings;
};

int main (void) {
    struct spaceship *myShip = malloc(sizeof (struct spaceship));
    strcpy(myShip->name, "Millennium Falcon");
    myShip->engines = 1;
    myShip->wings = 0;

    // Lost my ship in a Sabacc game, free its memory
    free(myShip);
}
```

Linked Lists

Structs for nodes that contain pointers to the same struct

- Nodes can point to each other in a chain to form a linked list
- Convenient because:
  - They're not a fixed size (can grow or shrink)
  - Elements can be inserted or removed easily anywhere in the list
- The nodes may be in separate parts of memory



Linked Lists

Function: Removes first item from a linked list.

Second Item:

Linked Lists in code

```c
struct location {
    char name[MAX_NAME_LENGTH];
    struct location *next;
};

int main (void) {
    struct location *head = NULL;
    head = addNode("Tatooine", head);
    head = addNode("Yavin IV", head);
}

// Add a node to the start of a list and return the new head
struct location *addNode(char *name, struct location *list) {
    struct location *newNode = malloc(sizeof(struct location));
    strcpy(newNode->name, name);
    newNode->next = list;
    return newNode;
}
```

Complications in Pointers, Structs and Memory

What's a pointer?

- It is a number variable that stores a memory address
- Any changes made to pointers will only change where they're aiming

What does * do?

- It allows us to access the memory that the pointer aims at (like following the address to the actual location)
- This is called "dereferencing" (because the pointer is a reference to something)

Complications in Pointers, Structs and Memory

What about -> ?

- Specifically access a struct at the end of a pointer
- `->` must point at one of the fields in the struct that the pointer aims at
- It will dereference the pointer AND access the field

Pointers to structs that contain pointers to other structs!

- We can follow chains of pointers like `library->playList->track`

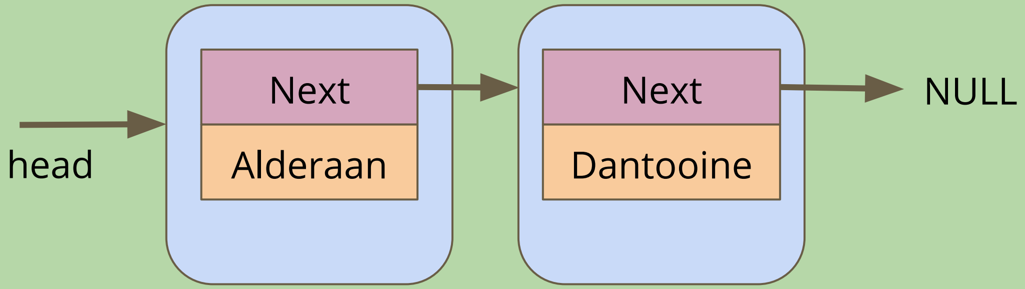
Complicated Pointer Code

```
int main (void) {
    // create a list with two locations
    struct location *head = addNode("Dantooine", NULL);
    head = addNode("Alderaan", head);

    // create a pointer to the first location
    struct location *alderaan = head;

    // set head to a newly created location
    head = malloc(sizeof(struct location));

    // What has happened to the alderaan pointer now?
    // What has happened to the variable that the head and alderaan
    // both pointed at?
}
```

Pointer Arithmetic

A program's memory (not to scale)

Create a linked list of two locations with a head pointer aimed at the first location

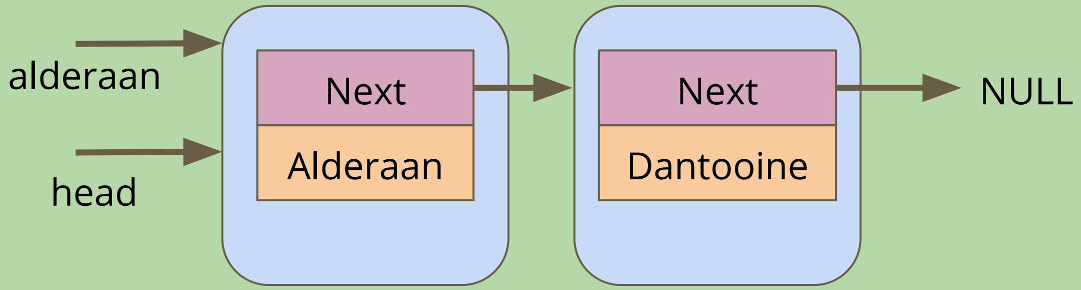


Pointer Arithmetic

A program's memory (not to scale)

```
struct location *alderaan = head
```

This line creates a new pointer that's a copy of the head pointer. It is given the same value as head, which means it's aimed at the same memory address

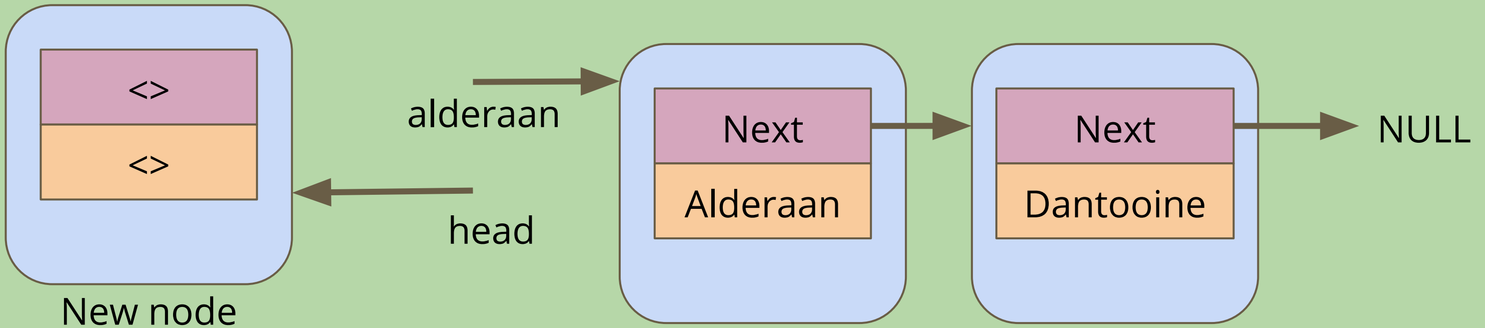


Pointer Arithmetic

A program's memory (not to scale)

```
head = malloc(sizeof(struct location));
```

This line allocates new memory and assigns the address of this new allocation to the head pointer.
Changing head doesn't change the node it was pointing at!



New node allocated

Keeping track of pointers

```
library->head->next->tracks->next = ????
```

- This is code that might work in most CSpotify implementations

- **Remember:**
- Changing a pointer changes its value, a memory address
- Changing a pointer will change where it's aiming, nothing more!
- Once you use `->` on a pointer, you're now looking at a struct field
- This means you are not changing that pointer, you have dereferenced it and accessed a field inside the struct

Abstract Data Types

Me: calls stack.pop()
Item at the top of the stack:

Abstract Data Types

Separating Declared Functionality from the Implementation

- Functionality declared in a Header File
- Implementation in a C file
- This allows us to hide the Implementation
- It protects the raw data from incorrect access
- It also simplifies the interface when we just use provided functions

Abstract Data Types Header code

```c
// ship type hides the struct that it is
// implemented as
typedef struct shipInternals *Ship;

// functions to create and destroy ships
Ship shipCreate(char* name);
void shipFree(Ship ship);

// set off on a voyage of discovery
Ship voyage(Ship ship, int years);
```

Abstract Data Types Implementation

```
struct shipInternals {
    char name[MAX_NAME_LENGTH];
};

Ship shipCreate(char* name) {
    Ship newShip = malloc(sizeof (struct shipInternals));
    strcpy(newShip->name, name);
    return newShip
}
void shipFree(Ship ship) {
    free(ship);
}
// set off on a voyage of discovery
Ship voyage(Ship ship, int years) {
    int discoveries = 0, yearsPast = 0;
    while(yearsPast < years) {
        discoveries++;
    }
}
```

Abstract Data Types Main

- Including the Header allows us access to the functions
- The main doesn't know how they're implemented
- We can just trust that the functions do what they say

```
#include "ship.h"

int main (void) {
    Ship myShip = shipCreate("Enterprise");
    myShip = voyage(myShip, 5);
}
```

Recursion

Functions calling themselves

- A slightly inverted way of thinking about program flow
- The order of execution is determined by the Program Call Stack
- Chooses between a stopping case or a recursive case in the function

A Recursive Function in code

```c
// Print out the names stored in the list in reverse order
// This is a recursive programming implementation
void revPrintRec(struct player *playerList) {
    if (playerList == NULL) {
        // stopping case (there are no elements)
        return;
    } else {
        // there are element(s)
        revPrintRec(playerList->next);
        fputs(playerList->name, stdout);
        putchar('\n');
    }
}
```

Order of execution

More recursive function calls

1. Check if we're stopping, if so return
2. Otherwise, call the function again with the tail (all remaining elements)
    a. Check if we're stopping, if so return
    b. Otherwise, call the function again with the tail (all remaining elements)
        i. Check if we're stopping, if so return
        ii. Otherwise, call the function again with the tail (all remaining elements)
        iii. Then print the name of the current head of the list
    c. Then print the name of the current head of the list
3. Then print the name of the current head of the list

So, you're programming now…

So, you're programming now…

Where do we go from here?

- There's so much you can do with code now
- But there's also so much to learn
- Programming has more to offer than anyone can learn in a lifetime
- There's always something new you can discover
- It's up to you to decide what you want from it and how much of your life you want to commit to it
- Remember to care for yourselves and your work
- Enjoy yourselves, keep working as hard as you can and I hope to bask in your future glory

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Good luck, have fun :)