ENGG1003 - Tuesday Week 5

Static Variables
Commenting
Arrays
Maybe Strings

Brenton Schulz

University of Newcastle

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Static Variable Example

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- Function prototype: `int counter(void);`
- Function definition:

```
1 int counter() {
2   static int count = 0;
3   return count++;
4 }
```

Static Variable Example

- The variable `count` is declared `static`
- The initialisation, `count = 0`, happens *once*
- The value of `count` is retained between function calls

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    - Good discussion here

Static Variable Example

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- The function can be called from *anywhere* in your code
- A "counter" variable that did the same job would have to be "global" to be visible anywhere
  - For multiple reasons we try to avoid variables with global scope
    - Good discussion here
  - There are *very good* reasons to use them in embedded systems, but not on a desktop PC or server

Static Variable Example

Wrapping the function in some test code:

```
1  #include <stdio.h>
2
3  int counter(void);
4
5  int main() {
6    for(int k = 0; k < 10; k++)
7      printf("counter(): %d\n", counter() );
8    return 0;
9  }
10
11 int counter(void) {
12   static int count = 0;
13   return count++;
14 }
```

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- It means the minimum amount of code required to verify a function's behaviour
- Always test your functions *in isolation*!
- If you write "too much" code before testing it will make debugging **much** harder

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- After 20 years of experience?
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- Never underestimate:
  - How hard programming is
  - How easy it is to make mistakes
  - How *brutally catastrophic* bugs can be

Bug Case Study

Paraphrased from Wikipedia:

"The Therac-25 was a computer-controlled radiation therapy machine ... It was involved in at least six accidents ... in which patients were given massive overdoses of radiation. Because of concurrent programming errors, it sometimes gave its patients radiation doses that were hundreds of times greater than normal, resulting in death or serious injury."

Back to Functions...

- When should functions be used?

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- When should functions be used?
- Well, what do they achieve?
  - *Much* easier to solve problems when they're broken down into sub-tasks
  - Reduce code line count and complexity (if they are called multiple times)
  - Allows code re-use between projects
  - *Much* easier to perform project management between multiple programmers
  - Bugs in a function are easier to fix than a bug in code which has been copy+pasted multiple times
  - ...the list goes on

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  - Break a big problem into multiple sub-problems
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    - Do what you feel is most "readable"
    - Your opinion here will change with experience, I will try to provide guidance

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- But what is "good" commenting?
- Lets look at some examples:
  - From the Linux kernel source
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- Just a little different from each other, eh?
- Commenting is very application specific
- Commenting is very audience specific

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- On one hand: only comment what *you* need
- On the other: we need to assess your comments eventually...
- And the assessment needs to minimise demonstrator judgement...
- Maybe I create different strict rules for different assignments? Similar to ENGG1500 report rules.

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- What do you do if you need a million of them?
- Declare a million variables?
- Cry?
- Use an *array*!
  - Maybe still cry...at first.
- An *array* is a collection of variables of the same data type

Arrays

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$$x_0, x_1, x_2, x_3, \ldots$$

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- We used it for a single variable, x, changing with time
  - The "old" values of x were discarded
- An array allows us to store *all* the values of x_n in memory
- The variable name, x, and the "index", n, are both needed to access a particular value

Arrays

- In C, an array declaration **needs** three things:
  - The data type
  - A name
  - The number of *elements*
- (Optional) Arrays can be initialised
- The syntax for an array of length N is:

```
data_type name[N];
```

- Examples:
  - `int list[20];`
  - `char name[200], c; //array and var`
  - `double data[100000];`

Arrays

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- The variable's value must be known at the time of declaration
- This is fine:

```
1 int x;
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  - If `x` is large enough your program will access memory the operating system has not allowed it to
  - This will cause segmentation faults (Linux/macOS) or illegal operations (Windows)

Using Arrays

- A C array of size N is *indexed* from 0 to $N-1$
  - Programmers get *illogically angry* when arguing about 0-indexing Vs 1-indexing
- To access an element use the syntax:

```
1 arrayName[index]
```

  where `index` **must be an integer**
- Each array index has a *different* physical memory address
- Each array index accesses a unique variable

Array Initialisation

- General rule: all variables need to be initialised before use
- For arrays there are two solutions:
  - Initialise at declaration with the syntax:

```
1     int x[10] = {1,2,3,4,5,6,7,8,9,0};
2
```

  When doing this the size is optional:

```
1     int x[] = {1,2,3}; // int x[3]
2
```

  - Explicitly initialise in a loop

Array Initialisation

- When the array is "large" do this instead:

```
1 int x[N];
2 int counter;
3 for(counter = 0; counter < N; counter++) {
4   x[counter] = 0;
5 }
```

Array Usage

- Examples:
  - `x = y[12] + 28.0;`
  - `x[0] = 1.0;`
  - `printf("%f\n", x[2]);`
  - `y = sin(x[i]);`
- It is common to loop over a whole array, as-per the initialisation example

Array Problems

- The size of an array is not intrinsically known
- You must manually make sure that the array index never exceeds the array's boundary!
- The following program is **guaranteed** to crash:

```
1 #include <stdio.h>
2
3 int main() {
4   int x[10];
5   int idx;
6   for(idx = 0; idx < 100000000000L; idx++)
7     printf("%d\n", x[idx]);
8 }
```