Introduction to Programming and Computer Architecture Revision Lectures

Review of Pointers

There is no new material in this lecture, but it covers the use of pointers in the various contexts we have seen

Pointers and Variables

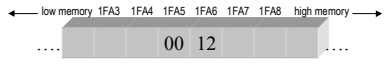
- C's variables have a data type, e.g. `int` or `double`
  - This tells the compiler how much memory to put aside for it, and the rules for manipulating it
  - Remember we don't know the size of types at compile time
  - Some systems may use 2 bytes (16 bits) for an `int` some 4 bytes
  - But the function of operations remains the same `%,*` etc
  - We can use the `sizeof([type])` to get this information at run time

Pointers and Variables

- E.g. the declaration

```
unsigned int x=18;
```

  - reserves 2 bytes (say) of memory, maybe 1FA5 and $1FA6_{hex}$
  - It is filled with a pattern of 0 and 1's meaning 18 (0012_{hex})



  - By convention, the address of `x` is the address of its first (lowest) byte. We can access this using the address of operator, `&`. So `&x` is $1FA5_{hex}$ in this case

Pointers and Variables

- We can also declare a variable of type pointer-to-int (`int*`)

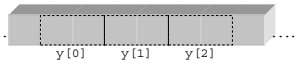
```
int* p;
```

- Suppose this takes up two bytes also, starting at address $2C91_{hex}$
- Then if we do p=&x;
- p will contain $1FA5_{hex}$

- We say that "p is pointing to x".
- We can refer to the same memory call (1FA5, 1FA6) as either x or *p

Arrays

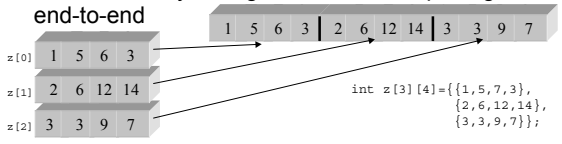
- An array is several similar data objects located next to each other in memory.
- E.g. `int y[3];`



- Note that `y[0]`, `y[1]` and `y[2]` are all `int`s
- However, y itself is a pointer-to-`int`
- In fact the subscript notation `y[n]` actually means `*(y+n)` its just a convenient shorthand for programmers

Arrays

- y+n means the base address of the array plus n times the object size.
  - The compiler keeps track of this, we don't need to bother
- Two dimensional arrays are more complicated, because a 2D structure must be represented in 1D memory
- This is done by slicing it into rows and putting them end-to-end



Arrays

- The first four `int`s as a group are called `z[0]`, the second four `z[1]` and the third four `z[2]`
- The first `int` is called `z[0][0]`, the last one `z[2][3]`
- Now, `z[2][3]` is an `int`, so `z[2]` must be a pointer-to-`int` (its an array), so `z` must be a pointer-to-pointer-to-`int` (its an array of arrays)
- So `z[2][3]` is a shorthand for `*(*z+2)+3)`

Strings

- A string is a null-terminated array of chars
  - Here null means the null character '\0' which has an ASCII code of zero
- `char s[]="word";`

- So s is a pointer-to-char.
  - *s is 'w'
  - *(s+1) is 'o'
  - Note that an extra "invisible" character is added as a "sentinel" to mark the end of the string

Pointers and functions

- A pointer is a variable that holds an address
- The important thing is that it is a variable, like any other so can be passed to a function
- We often see function prototypes like

```
char* head(char* str, int n);
```

- This means "head is a function that takes as arguments a pointer-to-`char` and an `int`"
- It returns a pointer-to-`char`

Pointers and functions

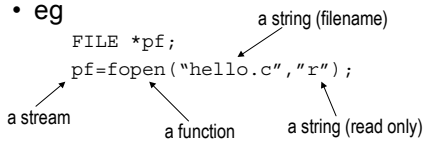
- An important use of pointers with functions is call-by-reference
- Here the address of a variable is passed to the function not the value of the variable
- This allows the function full access to the original variable
- Any changes made therefore change the original variable

Pointers and Structures

- A `struct` is simply a user defined data type
- Variables of can be created which are of type `struct`
- pointers-to-the-`struct`-type can be used e.g. for arrays or passing-by-reference

Pointers and Files

- There is a special `struct` type called `FILE` which must be used with pointers-to-`FILE` (streams) for file operations
- eg



In summary

- A pointer is a variable that holds an address
- It can be the address of an `int`, `float`, etc …. or `struct`
- The name of an array is a pointer and the subscript notation is a shorthand for a “pointee”
- The name of a 2D array is a pointer-to-a-pointer-to ……
- Strings are just arrays of `char`, so a string name is a pointer-to-`char`
- Pointer variables can be passed to and returned from functions just like other variables
- This is used in call-by-reference
- We can have pointers-to-`struct`-types
- These are used (as pointers-to-`FILE`, or streams) in file operations.