Programming Proverbs

- 4. ‘‘Be aware of other approaches.’’
- Henry F. Ledgard, ‘‘Programming Proverbs: Principles of Good Programming with Numerous Examples to Improve Programming Style and Proficiency’’, (Hayden Computer Programming Series), Hayden Book Company, 1st edition, ISBN-13: 978-0810455221, December 1975.

Know your tools

- "a bad workman blames his tools",

  Cambridge Idioms Dictionary

- we will examine:
  - `emacs`, `etags`, `grep`, `diff`, `patch`, `gcc`, `gm2`, `cvs`, `gdb`, `svn`

- although in this lecture we will only cover `emacs` and `gdb`
  - and revise our knowledge of C pointers

For the GNU/Linux game developer GDB is the BFG

- get to know this tool!

emacs

- GNU Emacs is an extensible, customisable text editor-and more
- at its core is an interpreter for Emacs Lisp, a dialect of the Lisp programming language with extensions to support text editing
- features of GNU Emacs include:
  - content-sensitive editing modes
  - highly customisable, using Emacs Lisp code or a graphical interface
  - can run a shell, ssh session, read news, read mail, run `gdb`
  - all the above are editing sessions
  - learn how to navigate it once, use it in a multitude of ways

Minimal number of key commands for emacs

- deliberately kept short!
- `^c` means control key is pressed and kept down while the `c` key is also pressed. After which both are released.
- `M-x` means press the meta key (the `<alt>` key) and then press the `x` key and then release both.
- `M-x` can also be achieved by pressing the `<esc>` key, releasing it and then pressing `x` and releasing it.
- choose which ever seems most natural

emacs keys

```
Keys         meaning
=================
^x^c         exit emacs
^x2          split screens horizontally into two
^xo          move cursor into other window
^x^f         load in a new file
^x^s         save current buffer
^xs          save all buffers
^s           search forward
^r           search reverse
^k           cut rest of line into kill buffer
^y           yank the last kill buffer (paste it into the current location)
^<space>     mark the current position
^w           kill all text between current position and last marked position
M-x          move to the execute-extended-command line
^g           stop emacs from doing something
^xb          change buffer (press tab to see all available buffers)
```

emacs function keys

-
  ```
  f5    debug doom3
  f8    goto next compile error
  f11   full screen (toggle)
  f12   recompile doom3
  ```

- can be customised by changing `$HOME/.emacs`

Further emacs information

- emacs homepage ⟨`http://www.gnu.org/software/emacs`⟩
- the best way to learn how to use emacs is by reading the built-in documentation
- to do this, start emacs and then use the commands:
  - Interactive beginners’ tutorial - to start this from within emacs, type `^ht`
    - this is an extremely well written tutorial - well worth the reading effort
  - List of Frequently Asked Questions, type `^h^f`

C Pointers and arrays revisited

- a pointer is a variable that contains an address of a (normally different) variable
- arrays and pointers are closely related in C
- we can declare an array of integers by:

-
  ```
  int a[10];
  ```
- and we can declare a pointer to an integer, by:

-
  ```
  int *b;
  ```

Initialising a pointer

- we can make `b` point to the start of the array, by:

-
  ```
  int *b = (int *)&a;
  ```
- to set the first element of the array to `999` we can either use the pointer or the array variable

Initialising a pointer

```
#include <stdio.h>

int main ()
{
    int a[10];
    int *b = (int *)&a;

    a[0] = 111;
    printf("the first element of the array has been set to %d\n",
           a[0]);
    *b = 999;
    printf("the value of the first element is now %d\n", a[0]);
    return 0;
}
```

Initialising a pointer

- we can assign `777` to the second element of the array by the following code:

-
```
#include <stdio.h>

int main ()
{
    int a[10];
    int *b = (int *)&a;

    b++;
    *b = 777;
    printf("the second element of the array has been set to %d\n",
           a[1]);
    return 0;
}
```

- notice that we moved to the second element on the array by: `b++`

Initialising a pointer

- we could have also written the code like this:

-
  ```
  #include <stdio.h>

  int main ()
  {
      int a[10];
      int *b = (int *)&a[1];

      *b = 777;
      printf("the second element of the array has been set to %d\n",
             a[1]);
      return 0;
  }
  ```

Initialising a pointer

- or like this:

-
```
#include <stdio.h>

int main ()
{
    int a[10];
    int *b = ((int *)&a)+1;

    *b = 777;
    printf("the second element of the array has been set to %d\n",
           a[1]);
    return 0;
}
```

Initialising a pointer

- the addition of `1` to a pointer means increment the address value in the pointer variable by: `sizeof(*b)` bytes
- avoid arithmetic on pointers if at all possible

Interchanging pointers and arrays

- we can also set the third element of the array to 444 by:

-
  ```
#include <stdio.h>

int main ()
{
    int a[10];
    int *b = (int *)&a;

    b[3] = 444;
    printf("the second element of the array has been set to %d\n",
           b[3]);
    return 0;
}
```

- notice how we are treating `b` as an array, although we declared it as a pointer

Interchanging pointers and arrays

- clearer than adding, `3`, to a pointer, and the same code is generated by the compiler
- use the debugger to print out values, or set values
- compile the previous example using

-
  ```
  $ gcc -g pointer2.c
  ```
- then we can run the debugger as follows

Interchanging pointers and arrays

```
$ gdb ./a.out
GNU gdb 6.4.90-debian
Copyright etc...
(gdb) break main
Breakpoint 1 at 0x400480: file pointer2.c, line 6.
(gdb) run
Starting program: /home/gaius/text/Southwales/gaius/c/a.out
Breakpoint 1, main () at pointer2.c:6
6        int *b = (int *)&a;
(gdb) step
8        b[3] = 444;
(gdb) ptype b
type = int *
(gdb) step
9        printf("the second element of the array has been set to %d\n",
step
the second element of the array has been set to 444
11   }
```

Interchanging pointers and arrays

```
(gdb) set *b=999
(gdb) print b[0]
$2 = 999
(gdb) print b[3]
$3 = 444
(gdb) set *(b+3)=777
(gdb) print b[3]
$4 = 777
(gdb) quit
```

structs and pointers

- recall a `struct` can be define a linked list like this:

-
  ```
  struct list {
     struct list *right;
     struct list *left;
     char          ch;
  }
  ```

- here we declare a `list` structure which has 3 fields
  - `right`, `left`, and `ch`
  - `right` and `left` are also pointers to a `list` structure and `ch` is a character

Initialising a pointer to a struct

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

struct list {
   struct list *right;
   struct list *left;
   char         ch;
};

int main ()
{
    struct list *h = (struct list *)malloc (sizeof (struct list));

    h->right = NULL;
    h->left = NULL;
    h->ch = '\0';

    return 0;
}
```

prototype for malloc

-
  ```
  extern void *malloc (unsigned int nBytes);
  ```

- which means the function `malloc` takes one parameter, the number of bytes requested
  - and returns an address to the start of a memory block which can be used to contain `nBytes` of information

- remember a generic pointer can be defined by the construct `void *`

Implementing a program to create a linked list of characters

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

const char *myString = "hello world";

struct list {
  struct list *left;
  struct list *right;
  char         ch;
};

int main ()
{
  /* unfinished */

  return 0;
}
```

Implementing a program to create a linked list of characters

- fragment of implementation
-

```
struct list *head = NULL;

/* need to complete function add */

int main ()
{
  int n = strlen (myString);
  int i;

  for (i=0; i<n; i++) {
    add(a[i]);
  }
  return 0;
}
```

Implementing function add (which contains one deliberate mistake)

```
void add (char ch)
{
  struct list *e = (struct list *)malloc (sizeof (struct list));
  if (e == NULL) {
     perror("trying to add an element to the list");
     exit(1);
  }
  if (head == NULL) {
     head = e;
     e->right = e;
     e->left = e;
     e->ch = ch;
  }
  else {
    /* add e to the end of the list */
    e->right = head;
    e->left  = head->left;
    head->left->right = e;
    head->left = e;
  }
}
```

Function main

```
int main ()
{
  int n = strlen (myString);
  struct list *f;
  int i;

  for (i=0; i<n; i++) {
    add(myString[i]);
  }
  if (head != NULL) {
    f = head;
    do {
      printf("char %c\n", f->ch);
      f = f->right;
    } while (f != head);
  }
  return 0;
}
```

Tutorial

- firstly use the debugger and find the bug in `add`
- secondly can you rewrite functions `add` and `main` so that you always keep a dummy head element and therefore you can reduce the `head==NULL` tests
  - the lines of code will reduce and there will be no need for an `else` statement