$Id: lab9c-voidstar-generic.mm,v 1.21 2012-11-16 17:22:56-08 - - $
PWD: /afs/cats.ucsc.edu/courses/cmps012b-wm/Labs-cmps012m/lab9c-voidstar-generic
URL: http://www2.ucsc.edu/courses/cmps012b-wm/:/Labs-cmps012m/lab9c-voidstar-generic

## 1. Overview

In this lab, you will impement a generic sorting routing using the **`void*`** parameter declaration. This is similar to the C library function **`qsort`**(3). You will also review your knowledge of **`Makefile`**s and header files. Begin by studying the example programs **`cqsort-int.c`** and **`cqsort-string.c`** (**`Examples/wk08-lec22-cqsort/`**). Also study **`misc/voidstar.c`**.

## 2. Programs to write

Write the following programs and files, each as described here :

**`Makefile`**

Write a **`Makefile`** with the following targets, and in each case, provide the appropriate actions.

| | |
|---|---|
| **`all`**: | should build the two binaries **`numsort`** and **`linesort`**. |
| **`numsort`**: | depends on **`numsort.o`** and **`inssort.o`**. |
| **`linesort`**: | depends on **`linesort.o`** and **`inssort.o`**. |
| **`%.o`**: | depends on **`%.c`**. All C compilations should be done with the command **`gcc -g -O0 -Wall -Wextra -std=gnu99`** Note specifically the use of the **`-c`** and **`-o`** options from previous **`Makefile`**s. |
| **`ci`**: | depends on all source files and runs both **`ci`** and **`checksource`**. |
| **`submit`**: | depends on source files and submits them. |

**`numsort.c`**

This utility reads in **`double`** numbers from **`stdin`**, sorts them, then prints them.

(α) Write a program which will create an array **`double array[1000]`** and use **`scanf`** to read numbers into this array.

(β) It stops reading when the first of the following happens : end of file, any invalid input not recognized by **`scanf`**, or the array is full.

(γ) The numbers are then passed to the function **`inssort`**, along with a suitable comparison function. The numbers are sorted in increasing order.

(δ) The numbers are then printed one per line using the format **`"%20.15g\n"`**.

**`linesort.c`**

This utility reads in lines from **`stdin`** into an array, sorts them, then prints them.

(α) Allocate an array of 1000 pointers to character strings, read in each character string from **`stdin`** and **`strdup`** each line into the array. Plug the newline at the end of each line with a **`'\0'`**, but don't error out if there is no newline. Use **`char buffer[1000]`** as an input buffer. The program stops at end of file, or when the array is full.

(β) It then calls **`inssort`** to sort the strings using a suitable comparison function. The lines are sorted into increasing lexicographic order.

(γ) The lines are then printed, one per line of output.

**`inssort.h`**

This file is the header file to be included by both **`numsort.c`** and **`linesort.c`** and it is important that both of these programs call the same function. Do not write a separate **`double`** sorter and a separate **`char*`** sorter. Using proper style, provide file guards and necessary **`#include`**s to prototype the following function :

```
void inssort (void *base, size_t nelem, size_t size,
              int (*compar) (const void *, const void *));
```

The parameters are as follows:

(α) **`base`** is the base address of the array,

(β) **`nelem`** is the number of elements (length) of the array,

(γ) **`size`** is the number of bytes used by a single array element, and

(δ) **`compar`** is a comparison function which produces the usual results, i.e., a negative number if the first argument is less than the second, zero if equal, and a positive number of greater.

**`inssort.c`**

Before beginning your program, you may wish to use the library function **`qsort`**(3) to debug your main programs, but be sure to delete all references to **`qsort`** before submitting your program.

(α) Your program should be a direct line-for-line translation of the Java function **`insertion_sort`**, as shown in Figure 1.

(β) Inside the function, you must use byte offsets from the base of the array in order to compute data movements.

(γ) Cast addresses from **`void*`** to **`char*`** in order to do address arithmetic. An array element **`i`** is at location **`base + i * size`**.

(δ) Pass the address of each pair of elements to the comparison function. The comparison function accepts addresses of elements, not elements themselves.

(ε) Use the function **`memcpy`**(3) to copy parts of the array from one location in memory to another.

(ζ) To allocate space for the temporary **`element`** variable, use **`malloc`**(3). Don't forget to **`free`**(3) this temporary before returning from the function.

```
// Insertion sort.
static <elem_t extends Comparable <? super elem_t>>
void insertion_sort (elem_t[] array, int nelem) {
   for (int sorted = 1; sorted < nelem; ++sorted) {
      int slot = sorted;
      elem_t copy = array[slot];
      for (; slot > 0; --slot) {
         int cmp = copy.compareTo (array[slot - 1]);
         if (cmp > 0) break;
         array[slot] = array[slot - 1];
      }
      array[slot] = copy;
   }
}
```

**Figure 1.** Java function **`insertion_sort`**

### 3. Eliminate all warnings and submit

Eliminate all warnings that **`gcc`** with the above options may produce, ensure **`checksource`** does not complain, and eliminate all messages from **`valgrind --leak-check=full`**.

Submit **`README`**, **`Makefile`**, **`numsort.c`**, **`linesort.c`**, **`inssort.h`**, **`inssort.c`**. Also, if you are doing pair programming, submit the required pair programming files.