CSCI-1200 Data Structures — Spring 2021
Lab 13 Garbage Collection & Smart Pointers

Checkpoint 0 (Extra Credit)

If you haven't done so already, please complete your AEFIS course evaluation for Data Structures (your honest & anonymous feedback is very important!). Have the webpage receipt saying "completed" open in your browser to receive credit for Checkpoint 0.

Checkpoint 1   *estimate: 20-40 minutes*

OPTIONAL: You may work through this checkpoint with the other students in your lab study group!

For the first checkpoint, download, compile, and run these files:

http://www.cs.rpi.edu/academics/courses/spring21/csci1200/labs/13_smart_memory/stop_and_copy.h

http://www.cs.rpi.edu/academics/courses/spring21/csci1200/labs/13_smart_memory/stop_and_copy.cpp

http://www.cs.rpi.edu/academics/courses/spring21/csci1200/labs/13_smart_memory/main_stop_and_copy.cpp

In Lecture 25, we stepped through the Stop and Copy garbage collection algorithm on a small example. Examine the output of the program to see a computer simulation of this same example. Verify that the program behaves as we predicted in lecture.

Continuing with the same example, 3 more nodes have been added and the garbage collector must be run again. Draw a "box and pointer" diagram (the more usual human-friendly version of the interconnected node structure with few or no crossing pointer arrows) of the memory accessible from the root pointer after these 3 nodes are added and work through the Stop and Copy algorithm for this example on paper. When you are finished, uncomment the simulation and check your work.

To complete this checkpoint: Show one of the TAs your box and pointer diagram and the scratch paper where you worked through the example.

Checkpoint 2   *estimate: 20-40 minutes*

The theme for this checkpoint are the helium filled balloons for the Macy's Thanksgiving Day parade. These balloons are held in place by one or more ropes held by people on the ground. Alternately, balloons may be connected to other balloons that are held by people! People can swap which balloon they are holding on to, but if everyone holding on to the ropes for a particular balloon lets go, we will have a *big* problem! Download, compile, and run these files. Use Dr. Memory or Valgrind to inspect the initial code for memory errors and/or memory leaks.

http://www.cs.rpi.edu/academics/courses/spring21/csci1200/labs/13_smart_memory/ds_smart_pointers.h

http://www.cs.rpi.edu/academics/courses/spring21/csci1200/labs/13_smart_memory/main_smart_pointers.cpp

Carefully examine the example allocations in the main function of the provided code. Draw simple pictures to help keep track of which objects have been allocated with new, and which variables currently point to each dynamically allocated object.

To fix the memory leaks in this program, you will need to add explicit deallocation for the non-smart pointer examples (marked CHECKPOINT 2A and 2B). For comparison, the code includes simple examples of smart pointers for these objects as well! When we know that just one person will hold on to a Balloon at a time (one owner) we can use a `dsAutoPtr` (see also the STL `auto_ptr` or STL `unique_ptr`, depending on your version of `g++/clang/STL`). When multiple people might hold ropes to the same Balloon, we should use a `dsSharedPtr` (see also STL `shared_ptr` or Boost `shared_ptr`). A shared pointer uses reference counting! When the last person disconnects from a Balloon using a shared pointer, the Balloon is automatically deleted.

Re-compile & re-run with the memory debugger to confirm you have fixed the simple leaks. For the final

piece of this checkpoint (marked CHECKPOINT 2C), you must also re-rewrite the interconnected balloon example to use shared pointers. You will need to modify the `Balloon` class to use `dsSharedPointer` as well.

To complete this checkpoint: Explain to your TA the code you needed to add and/or modify to correct the memory leaks in the provided code. Show your TA the result of the memory debugger on your finished implementation.

> Checkpoint 3 will be available at the start of Wednesday's lab.