CS100 Introduction to Programming

Recitation 8

llk89

NO PLAGIARISM!!!

- The most likely cause for failing this course.
- You WILL be caught!
- We WILL punish!
- They WILL know!
  - Parents
  - University
  - School
  - Fellows

Disclaimer

- I do not use Visual Studio, nor MacOS
- Directives for Windows and MacOS can therefore be wrong and damage your computer
- Use at your own peril, or somehow get a Ubuntu instance

Clone the skeleton code

- `git clone https://github.com/llk89/cs100recitation8`
- This will be used through out the entire recitation

Overview

- Shared pointers
- friend
- References, const & namespace
- Solving linear systems with C++

Shared Pointers

Location: shared_pointer/

Shared Pointers

- Imagine the following simple Test class
  - The class does not do much except notifying us about construction and destruction

```
class TestClass {
public:
  TestClass() {
    std::cout << "dummy object is created\n"; }
  virtual ~TestClass() {
    std::cout << "dummy object is destroyed\n"; }
  void printSomething() { std::cout << "hello\n"; }
private:
  double m_dummy;
};
```

Shared Pointers

- The main function

```
int main() {
  int indexA = 1;
  int indexB = 1;
  if( indexA == 1) {
    std::cout << "Entering scope A\n";
    SharedPointer<TestClass> ptrA;
    if( indexB == 1 ) {
      std::cout << "Entering scope B\n";
      SharedPointer<TestClass> ptrB( new TestClass() );
      ptrA = ptrB;
    }
    std::cout << "Returning to scope A\n";
  }
  std::cout << "Returning to global scope\n";
  return 0;
}
```

Custom shared-pointer class

Shared Pointers

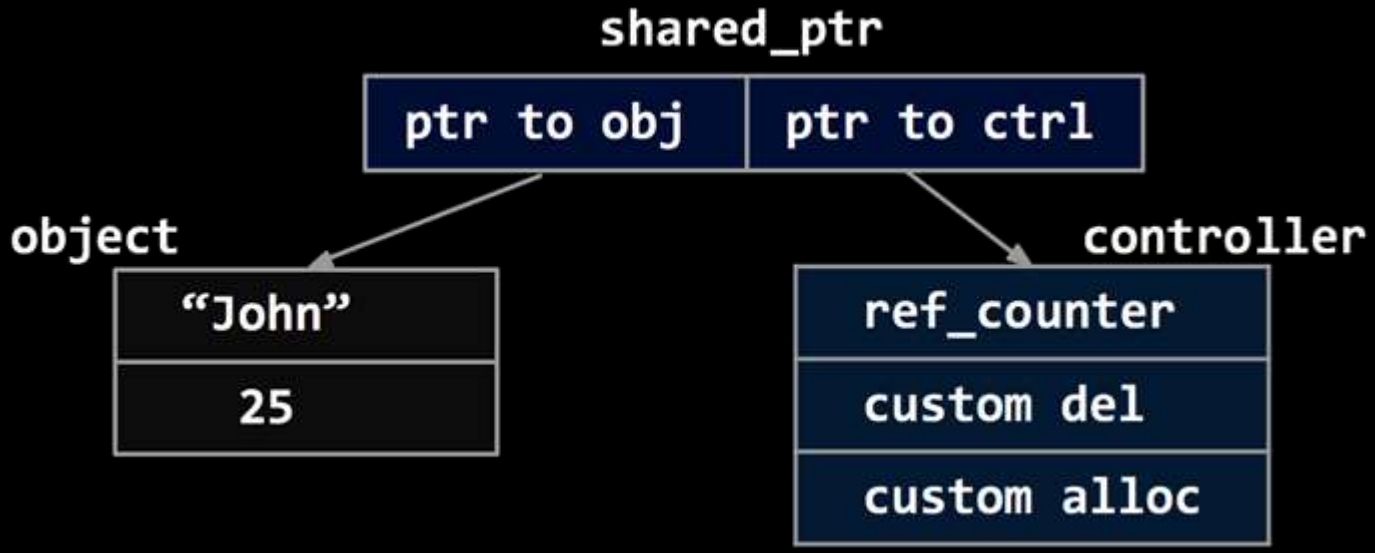
- Typical shared pointer declaration

```
template<class T>
class SharedPointer {
public:
  SharedPointer();
  SharedPointer( T * ptr );
  SharedPointer( const SharedPointer & ptr );
  virtual ~SharedPointer();

  SharedPointer & operator=( const SharedPointer & ptr );

  T * get();
  T & operator*();
  T * operator->();
private:
  T * m_ptr;
  SharedPointerController * m_controller;
};
```

Remember: A shared pointer takes two members, a pointer to the underlying variable, and a pointer to a control structure with reference counter

std::shared_ptr

- Shared pointers have a garbage collection mechanism based on a reference counter contained in a control block
- Each new shared owner copies the pointer to the control block and increases the count by 1



Shared pointers

- Tasks:
  - Implement SharedPointerController
  - Implement destructor of SharedPointer

friend

Location: friend/

Using friend

- Look at this vector

```
class MyVector {
public:
  MyVector();
  virtual ~MyVector();

  double & at( int index );
  const double & at( int index ) const;
  void clear();
  int size() const;
  MyVector & push_back( double val );
private:
  std::vector<double> m_data;
};
```

Using friend

- Task
  - Make it possible to stream a MyVector to an std::ostream (base class of std::ofstream, std::cout, std::stringstream, etc.)
  - Make it possible for this function to have direct access to MyVector’s data (by using friend)

References, const & namespace

Location: map/

Fix up old code

- Finish skeleton code in LinkedMap.hpp
  - This skeleton is wrong in almost every sense, and incomplete
  - The only thing correct is existing names and main function

- Compile with

```
D:\>cl /c /Wall main.cpp                    // May not work!
```

```
llk89@athena: ~$ g++ --std=c++11 -c main.cpp -o main.o
```

- This is not executable...
  - All you need to do is to make it pass the type checker

Special requirements

- You may add new functions
- You should not rename existing classes and functions
- Add as many const as you can
  - Do not add const that has no effect
- Use references wherever possible
- Adjust main.cpp as needed
  - Do not remove any const from main.cpp
  - Do not remove any line from main.cpp

Check

- You should have added
  - 2 new functions
  - 9+ consts
  - many “&”
  - 1 friend
  - 1 new nested class with its functions
- You should be able to compile main.cpp
- You should have somehow fixed the name collision

How big are these?

No skeleton

Instruments

- sizeof(): a compile time function-like syntax construct to figure out the size of passed in element
- “a” “b”: In C/C++, two adjacent string literal will be automatically concatenated together
  - e.g. printf(“This is “ “the same string!”)
- #: Convert the item to a string literal
  - e.g. #define msg(x) printf(“This is “ #x “!”)

Exersice

- Print the size of
  - char
  - short
  - short int
  - int
  - long int
  - unsigned int
- Remember to include cstdint and ctime
- Less than 3 sizeof.
  - It could be done with only one sizeof

Solving large* linear systems

Location: eigen/

*: dimension>1000

Project Specification

- Read dimension *n* from `stdin`
- Cap n at 4000 if a certain macro is defined at compile time
- Generate a random $n \times n$ matrix
- Generate a random vector from R^n
- Solve the linear system fast
- Print the time used to solve the linear system

Design considerations

- Matrix operations can be expensive
- A poor implementation could leads to sever performance degradation
  - e.g. from <0.1s to >100s
- Solution: Learn linear algebra, algorithms, data structures, computer architecture, parallel computing, CUDA and become an expert

- Matrix operations is very common
- There *must* be some very brilliant implementation out there already
- Solution: Use Eigen, a high level C++ library for linear algebra

Install Eigen3 - Ubuntu

- `sudo apt-get update`
- `sudo apt-get install -y libeigen3-dev`

Install Eigen3 - MacOS

- Install homebrew
- `brew install eigen`

Install Eigen3 - Windows

- Download the desired release from https://eigen.tuxfamily.org.
- Extract the inner folder and rename it to Eigen3 or Eigen
- Put that folder at C:\
  - You can put it elsewhere as long as you can make CMake to find it

CMakeLists.txt

- Open eigen/CMakeLists.txt in cloned repo
- Explain the file

- Check other CMakeLists.txt in the cloned repo
- Make sure you understand them as well

Build and Execute

- mkdir build
- cd build
- cmake ..
- make
- ./eigen

- Input 4000 and hit enter, so Eigen starts working
- The program seems to hang…
- A bug?

Debug vs Release

- By default, CMake compiles in debug mode
  - optimizer off
  - add debug symbols
  - prefer compile speed over anything else
- Use -DCMAKE_BUILD_TYPE=Release to compile with release mode
  - optimizer on
  - no debug symbols
  - prefer execution speed
- Try it now. It should take less than 10 seconds to finish now.
  - You might need to consider renting a VPS for study if it goes over 10 seconds

add_definition()

- add_definition() is the cmake way to provide preprocessors with macro info
  - e.g. add_definition(-DCAP_N) is equivalent to gcc -DCAP_N
- Try implement the cap on n functionality now
- It is taboo to use `set(CMAKE_CXX_FLAGS "-DCAP_N")`
  - This works, why it is not allowed?

option()

- You don’t always want to have the cap
- Changing CMakeLists.txt to get another executable is tedious
- How about let cmake accept an option to configure it?

option()

- Use cmake command

  `option(<option_name> "documentation" [initial_value])`
  - Default to `OFF` unless `initial_value` specified
  - Use cmake `-Doption_name=ON/OFF` to change at command line
  - Use `if(option_name) ... endif(option_name)` to check
- Try it now!

Shipping both version

- Some want binary with cap off, some want the other
- To distribute both version, both binaries need to be built.
- Tedious to build one with cap on and another with cap off
- Best to combine both in the same CMakeLists.txt
- Add another target called `eigen_test_capped`

target_compile_definition()

- Specify macro definition on a per target basis
  - target_compile_definitions(<target> <INTERFACE|PUBLIC|PRIVATE> [item1...])
- Use PRIVATE for now
- Use PUBLIC when you are writing a library

- Try it now!

Installer

- Tasks:
  - install()s
  - CPack

QA Time

- If you have any problems with…
  - last week's lecture
  - Git
  - CMake
  - Homework
  - Recitation 8
- Ask now