

CSCE 240: Advanced Programming Techniques

Lecture 17: (C++) Testing Strategies, HW 5 (given), PA 4(start)

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

15TH MARCH 2022

Carolinian Creed: “I will practice personal and academic integrity.”

Credits: Some material reused with permission of Dr. Jeremy Lewis.
Others used as cited with thanks.

Organization of Lecture 17

- Introduction Section
 - Recap of Lecture 16
 - TA and SI Updates
- Main Section
 - Concept: Testing strategies
 - Concept: C++ considerations
 - Task: HW 5 – details (due March 17, 2022)
 - Task: Project – PA #4 starts - details
- Concluding Section
 - About next lecture – Lecture 18
 - Ask me anything

Introduction Section

Recap of Lecture 16

- Reviewed HW#4
- We looked at the concept of operators
 - Many types: right sidebar
 - Precedence order when evaluating

C++ Standard Library

- [Input/output](#)
- [Strings](#)
- [algorithm](#)
- [functional](#)

[Containers](#)

- [Sequence containers](#)
- [Associative containers](#)
- [Unordered associative containers](#)

[C standard library](#)

- [Data types](#)
- [Character classification](#)
- [Strings](#)
- [Mathematics](#)
- [File input/output](#)
- [Date/time](#)
- [Localization](#)
- [Memory allocation](#)
- [Process control](#)
- [Signals](#)
- [Alternative tokens](#)
- Miscellaneous headers:
 - [<assert.h>](#)
 - [<errno.h>](#)
 - [<setjmp.h>](#)
 - [<stdarg.h>](#)

Assignments: Late Submission Policy and Extra Marks

- There is **no provision for late submission** for programming assignments
 - Except when prior approval has been taken from instructor due to health reasons
- One can possibly make more marks when doing final project assembly
 - **Remember:** PA1, PA2, PA3, PA4, PA5 will be the 5 programs from assignments. [100 points for each assignment]
 - **Remember:** Assembling code from one's on assignments gets the standard [100 points].
 - Extra points will be given if you make your code (for PA1 – PA5) available to others (make repository public) AND someone uses your code (any of PA1-PA5). Both will have to be reported in project report.
 - 40 points will be given per assignment to student whose assignment is reused, and
 - 20 points will be given to person who reuses code
 - Extra points will not exceed 100 points for any student. That is, one cannot make more than 700 points.

Updates from TA, SU

- TA update: Yuxiang Sun (Cherry)
 - HW4 marks now on Blackboard
 - Assignments and homeworks: confirm submission in spreadsheet with time completed.
- SI update: Blake Seekings

Main Section

Concept: Testing Strategies

Testing – What is It ?

- Ensure software works
 - As asked
 - Customer wanted – requirement
 - Developer says it works – specification
 - On diverse data
 - Test data
 - Unseen data
 - Under various conditions
 - Ideal condition (as and if customer stipulates)
 - Typical operating condition
 - Without harm

Important Types of Testing

- Unit testing
 - Purpose: Check a basic functionality is working. Example, a function or programming assignment in course project
 - Developer does on their own
- Integration testing
 - Purpose: Ensure different components of project work together. Example, complete course project
 - Developer or dedicated tester performs
- Functional testing
 - Purpose: business requirement is met. Checks output, not intermediate results
 - Tester performs
- Acceptance testing
 - Purpose: business requirement is met both functionally and non-functionally like performance, throughput. Checks output, not intermediate results
 - Tester performs; customer performs
- Regression testing
 - Purpose: ensure existing functionality is preserved; especially after a code change
 - Tester performs

We are mostly doing unit and integration testing in the course

How to Perform Testing

- Manual Testing
 - Common testing practice; usually the default if not specified otherwise
 - Common for unit and system testing
- Automated Testing
 - Needs specification of expected outcome
 - Common for performance and regression testing

We are mostly doing **unit and integration** manual testing in the course

When to Stop Testing

- Code coverage is over a limit: when desired percentage of code has been exercised by test cases
 - Code Coverage = (Number of lines of code executed) / (Total Number of lines of code in the system component) * 100
- Number of bugs discovered exceeds a count
- All high priority bugs are identified and fixed

Example – Calculating Fibonacci Number

- Concept in mathematics:
 - Fibonacci number of a number is the sum of F numbers of its two predecessors
 - Credit: https://en.wikipedia.org/wiki/Fibonacci_number
- Popularized by Fibonacci around 1200 AD, known before in India as early as 450 BC

F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}	F_{16}	F_{17}	F_{18}	F_{19}	F_{20}
0	1	1	2	3	5	8	13	21	34	55	89	144	233	377	610	987	1597	2584	4181	6765

Implementing and Testing in C++ (V1)

```
int fibonacci(int n)
{
    return fibonacci(n-1) + fibonacci(n-2);
}
```

What can be wrong ?

F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}	F_{16}	F_{17}	F_{18}	F_{19}	F_{20}
0	1	1	2	3	5	8	13	21	34	55	89	144	233	377	610	987	1597	2584	4181	6765

Implementing and Testing in C++ (V2)

```
long fibonacci(unsigned int n)
{
    if (n < 2) return n;
    return fibonacci(n-1) + fibonacci(n-2);
}
```

Fixed for handling

- Negative numbers
- Larger return type

But may take too long

Implementing and Testing in C++ (V3) With Measuring Time

```
long fibonacci(unsigned int n)
{
    if (n < 2) return n;
    return fibonacci(n-1) + fibonacci(n-2);
}

int main ()
{
    auto start = std::chrono::steady_clock::now(); // measures start time
    long result = fibonacci(n); // calls function
    cout << "f(" << n << ") = " << result << '\n'; // prints result
    auto end = std::chrono::steady_clock::now(); // measures end time

    // prints time elapsed
}
```

Fixed for handling

- Negative numbers
- Larger return type

Reports time

* But time includes printing time

Implementing and Testing in C++ (V4) With Measuring Time

```
long fibonacci(unsigned int n)
{
    if (n < 2) return n;
    return fibonacci(n-1) + fibonacci(n-2);
}

int main ()
{
    auto start = std::chrono::steady_clock::now(); // measures start time
    long result = fibonacci(n); // calls function
    auto end = std::chrono::steady_clock::now(); // measures end time

    cout << "f(" << n << ") = " << result << '\n'; // prints result

    // prints time elapsed
}
```

Fixed for handling

- Negative numbers
- Larger return type

Reports time

Home Work 5

Due Tuesday, March 17, 2022

Home Work (#5) – C++ - Background

- A *factorial* is a function that multiplies a number by every number below it. For a number N , it is denoted $N!$
 - Example: $4! = 4 \times 3 \times 2 \times 1 = 24$
- Factorial notation is used in many problems dealing with permutations and combinations
- Note:
 - $0! = 1$
 - $1! = 1$
- *Combination*: Number of ways r items can be selected from a set of size n where the order of picking does not matter
 - Example: Handshakes between 6 people = C_2^6
 - $= (6!) / (2! * 4!) = (6 * 5 * 4!) / (2! * 4!) = 15$
- Note:
 - r is smaller than n

$${}_nC_r = \frac{n!}{r!(n-r)!}$$

Credit: <https://en.wikipedia.org/wiki/Combination>

Home Work (#5) – C++ - Requirement

- So, write a program named:
FactorialFun
- It will support inputs/ arguments in two formats:
 - N: number // to find factorial of N
 - N: number, r: number // to find C_r^N
- Output:
 - Value // computed value
 - Time taken // time for processing

Example invocation

```
> FactorialFun 4
24
Time for processing: 0.023 seconds

> FactorialFun 6 2
15
Time for processing: 0.0034 seconds
```

Home Work (#5) – C++ - Code Design

- Create test cases, i.e., input/ output pairs, to test for boundary conditions
- Use exception to handle likely errors – user may given any input

Discussion: Course Project

Course Project – Assembling of Prog. Assignments

- **Project:** Develop collaborative assistants (chatbots) that offer innovative and ethical solutions to real-world problems ! *(Based on competition - <https://sites.google.com/view/casy-2-0-track1/contest>)*
- Specifically, **the project will be building a chatbot that can answer questions about a South Carolina member of state legislature from:**
<https://www.scstatehouse.gov/member.php?chamber=H>
 - Each student will choose a district (from 122 available).
 - Programming assignment programs will: (1) extract data from the district, (2) process it, (3) make content available in a command-line interface, (4) handle any user query and (5) report on interaction statistics.

Review of Assignments PA1,PA2, PA2 - Feedback

- Do not put a.out or .exe in git; it is a binary
- Put a Readme.md or Readme.txt in your assignment's main directory so that the reviewer knows what is the main file, where is the data, how is your program invoked, etc
- Avoid hardcoding in code
 - Paths an absolute no-no
 - Data based string extraction
 - Students have hardcoded line number, character offset, or simply written values in code (manual extraction).
 - Will make code hard to generalize; no one else will be able to reuse
 - Regex makes extraction easy to understand and simpler
 - Loading extraction logic (regex, string indexes) from a config file makes code easy to generalize

Externalizing Extraction Logic From Code

Loading extraction logic (regex, string indexes) from a config file makes code easy to generalize

Configuration file (Data)

```
# Format: entity name, regex pattern
# Format: entity name, line, start index, end index
Name, (N|n)ame:, $
Phone-number, 13, 23, 47
```

Code

1. Read configuration file
2. Read data stream
3. For each pattern
 extract entity value from data stream
4. Close files
5. # Rest of the processing

Now, to extract a new pattern or change extraction rule, we just have to modify the configuration file!

Core Programs Needed for Project

- Prog 1: extract data from the district [\[prog1-extractor\]](#)
- Prog 2: process it (extracted data) based on questions [\[prog2processor\]](#)
- Prog 3: make content available in a command-line interface [\[prog3-ui\]](#)
- **Prog 4: handle any user query** [\[prog4-userintent2querymapper\]](#)
- Prog 5: report statistics on interaction of a session, across session

Objective in Programming Assignment # 4:

Remove Requirement on User to Know Supported Queries!

- Until now, use needed to know what the program supports.
- **Can the system adapt rather than ask the user to adapt ?**
- **Approach Suggested**
 - Take user's utterance
 - Match to the closest supported query (six) and a confidence estimate
 - If confidence greater than a threshold
 - Run the query,
 - Otherwise
 - Ask user to re-phrase and ask again

- Program should do the following:
 - Run in an infinite loop until the user wants to quit
 - Handle any user response
 - **[#1]** User can quit by typing "Quit" or "quit" or just "q"
 - User can enter any other text and the program has to handle it. The program should write back what the user entered and say – "I do not know this information".
 - Handle known user query
 - **[#2]** "Tell me about the representative", "Tell me about the rep" => Personal Information (Type-I2)
 - **[#3]** "Where does the rep live" => Contact Information (Type-I1): Home Address
 - **[#4]** "How do I contact my rep" => Contact Information (Type-I1)
 - **[#5]** "What committees is my repo on" => Committee Assignments (Type-I3)
 - **[#6]** "Tell me everything" => *Give all information extracted*

Programming Assignment # 4

- Goal: **make an utterance to query** [Name: **prog4-userintent2querymapper**]
- Program may do the following – pseudo-code
 - Run in an infinite loop until the user wants to quit
 - Get a user utterance. We will call it u
 - See if u matches to supported queries in Q **// 6 until now**
 - Split u into words
 - For each query q in Q
 - Split q into words
 - Check how many words of u and w match **// one can also consider partial match**
 - Compute a percentage of match
 - q_i: let this be the query with the highest match percentage
 - If q_i > 0.7 **// 0.7: parameter**
 - Consider it to be the query. Inform user and execute; give information (result)
 - Else
 - Tell user cannot understand u. Example: rephrase and try again.

Programming Assignment # 4

- Code organization
 - Create a folder in your GitHub called “**prog4-userintent2querymapper**”
 - Have sub-folders: src (or code), data, doc, test
 - Write a 1-page report in ./doc sub-folder
 - Put a log of system interacting in ./test
 - Send a confirmation that code is done by updating Google sheet; optionally, send email to instructor and TA
- Use concepts learned in class
 - Exceptions

Announcements

- Chatbots – Event on March 18, 2022
 - Collaborative Assistants for Society (CASy) – in person and virtual event on campus
 - 9:30 am – 1:00 pm; talks and student use-cases
- Details and registration info: <https://casys.aiisc.ai>
- Looking for a panelist from class

Concluding Section

Lecture 17: Concluding Comments

- We looked at common testing types
- Considered an example and different pitfalls
- Gave HW5, due on Thursday (March 17, 2022)
- Gave PA 4, due on Thursday (March 24, 2022)

About Next Lecture – Lecture 18

Lecture 18: Advanced - Pointers

- Pointers
 - Pointer management
 - Function pointers
 - Shared pointers
- HW #5 review

17	Mar 15 (Tu)	Testing strategies	Prog 4 - start
18	Mar 17 (Th)	Advanced: Pointers	HW 5 due
19	Mar 22 (Tu)	Advanced: I/O	
20	Mar 24 (Th)	Advanced: Operator overloading	Prog 4 - end
21	Mar 29 (Tu)	Advanced: Memory Management	Prog 5 - start
22	Mar 31 (Th)	Advanced: Code efficiency	