Computer Programming

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Session: Iteration Idioms: Motivation

Quick Recap of Relevant Topics

- Structure of a simple C++ program
- Sequential execution of statements
- Conditional execution of statements
- Programming to solve simple problems

Overview of This Lecture

- Need for iteration in programming
  - Convenience
  - Necessity
  - Intuitive programming
- Generic iteration construct
- Iteration constructs in C++

A Simple Problem

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Read quiz 1 marks of ten CS101 students and print their sum, average, maximum and minimum

Can we solve using what we've learnt so far?

- assignment statements, input/output statements
- arithmetic expressions
- sequential and conditional execution of statements

Overall Strategy

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- Maintain “running” *sum*, *max* and *min* (aggregates)
- Initialize aggregates
- Read input 1 and update aggregates
- Read input 2 and update aggregates

  …
- Read input 10 and update aggregates
- Compute *average* as *sum*/10
- Output *sum, average, max, min*

A Simple Flowchart

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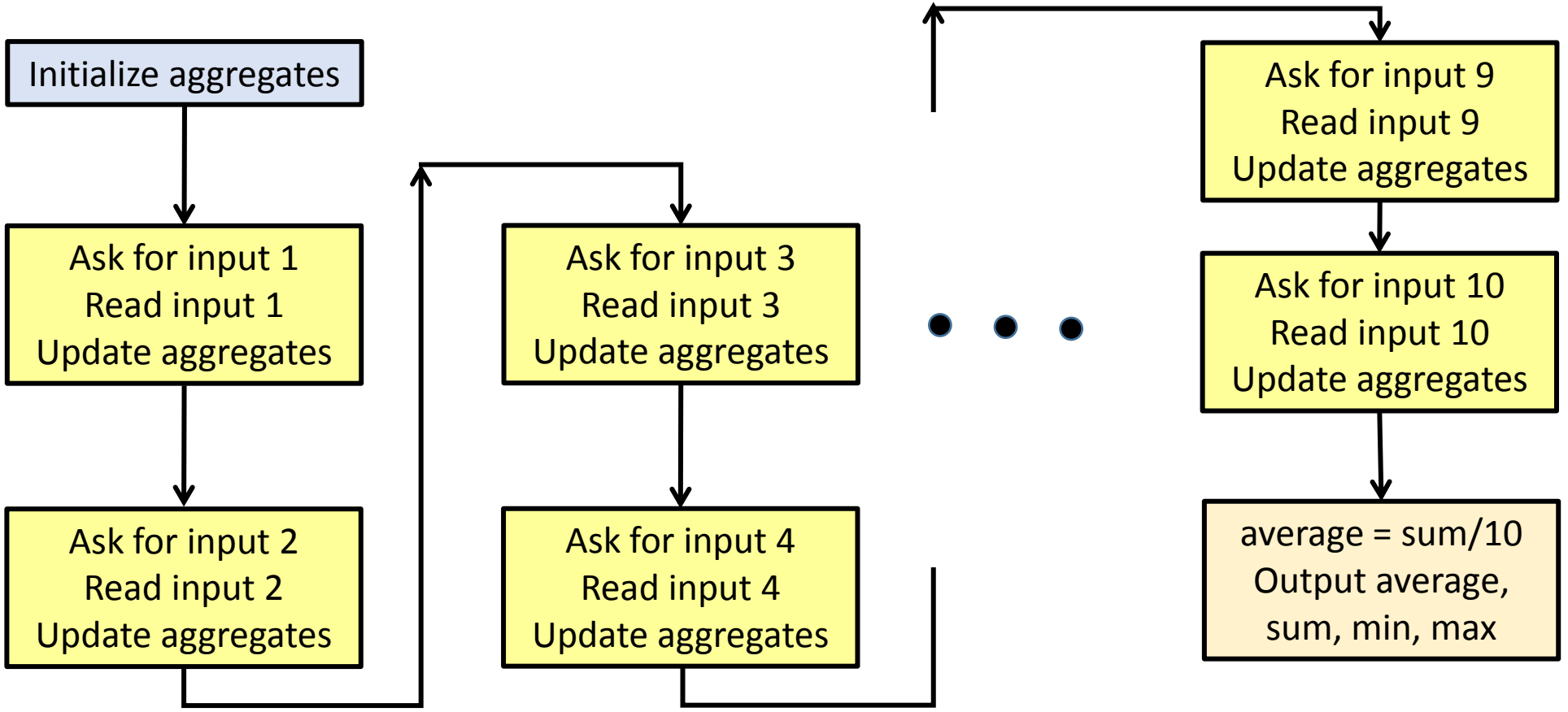

C++ Program

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```
int main() {
   // Variable declarations
   int marks, sum, min, max;
   float average;
  // Initialization of aggregates
   sum = 0; average = 0;

  // Further code comes here
  return 0;
}
```

C++ Program

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```
int main() {
  // Variable declarations and initialization of sum and average

  cout << “Give quiz marks of student 1:  “;
  cin >> marks;
  sum = sum + marks;
  // Initialize min and max with first input
  min = marks; max = marks;
  // Further code comes here
return 0;
}
```

C++ Program

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```
int main() {
  // Variable declarations and initialization of sum and average
  // Read marks of student 1, and update aggregates
  cout << “Give quiz marks of student 2:  “;
  cin >> marks;
  sum = sum + marks;
  min = (min > marks) ? marks: min;
  max = (max < marks) ? marks: max;
  // Further code comes here
  return 0;
}
```

C++ Program

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```
int main() {
  // Variable declarations and initialization of sum and average
  // Read marks of students 1 and 2, and update aggregates
  cout << “Give quiz marks of student 3:  “;
  cin >> marks;
  sum = sum + marks;
  min = (min > marks) ? marks: min;
  max = (max < marks) ? marks: max;
  // Further code comes here
  return 0;
}
```

C++ Program

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```
int main() {
  // Variable declarations and initialization of sum and average
  // Read marks of students1, 2 … 10, and update aggregates
 // Calculate and print aggregates
  average = sum/10.0;
  cout  << “Average: “ << average << “Sum: “ << sum;
  cout << “Min: “ << min << “Max: “ << max << endl;
 return 0;
}
```

Some Observations

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- (Almost) same instructions repeated multiple times

```
cout << "Give marks of student 3:  ";
cin >> marks;
sum = sum + marks;
min = (min > marks)  ? marks : min;
max = (max < marks) ? marks : max;
```

Slightly different for student 1:
min = marks; max = marks;

- Intuitively, we would like to execute (almost) the same instructions for all students

Some Observations

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- Suppose we had a construct in C++ that allowed us to effectively say

  Repeat the following block of instructions a specified number of times

- Could we write a less repetititve C++ program to aggregate quiz 1 marks ?

Another Attempt At Our C++ Program


```
int main() {
  // Variable declarations and initialization of aggregates
  int count = 1;
  // Repeat the following block of code 10 times
    {  cout << "Give  marks of student " << count << ": ";
       cin >> marks;
       sum = sum + marks;
       // Update min and max appropriately
       count = count + 1;
     }  // End of block of code to be repeated
  // Code for computing average and printing comes here
 return 0;
}
```

Another Attempt At Our C++ Program

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```
int main() {
  // Variable declarations and initialization of aggregates
  int count = 1;
  // Repeat the following block of code 10 times
    {  cout << "Give  marks of student " << count << ": ";
       cin >> marks;
       sum = sum + marks;
       if (count == 1) { min = marks; max = marks; }
       else { min = (min > marks) ?  marks:min;  max = (max < marks) ? marks: max; }
       count = count + 1;
    }  // End of block of code to be repeated
  // Code for computing average and printing comes here
 return 0;
}
```

Updating min and max appropriately

Another Attempt At Our C++ Program

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```
int main() {
  // Variable declarations and initialization of aggregates
  int count = 1;
  // Repeat the following block of code 10 times
    {  cout << "Give  marks of student " << count << ": ";
       cin >> marks;
       sum = sum + marks;
       if (count == 1) { min = marks; max = marks; }
       else { min = (min > marks) ?  marks:min;  max = (max < marks) ? marks: max; }
       count = count + 1;
    }  // End of block of code to be repeated
  // Code for computing average and printing comes here
  return 0;
}
```

Currently, only for this message

Need for this?

Another Attempt At Our C++ Program

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```
int main() {
  // Variable
  int count =
  // Repeat th
    {  cout << "Give  marks of student " << count << ": ";
       cin >>
       sum =
       if (cour
       else { n                                              ax; }
       count = count + 1;
    }  // End of block of code to be repeated
  // Code for computing average and printing comes here
 return 0;
}
```

Compared to our earlier program, this one is less repetititve, and closer to intuition

Yet, the original problem could have been solved without the repetition/iteration construct

Repetition in Programming

- Wasteful

  If you can achieve something by coding once, why code again?
- Potential source of bugs and inconsistencies
  - Afterthought: Want to say "Thank you" after each marks is read
  - **cout << "Thank you";** at 10 places
  - What if there was a typo **("Think yoo")** at one place?
  - Can be more dangerous than just a message being printed wrong
- Maintainability of large code with repetition difficult
  - Small change in replicated code requires replicating change at several places
- **Reuse as much code as possible, avoid repetitions consciously**

More General Iteration

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```
int main() {
  // Variable declarations and initialization of aggregates
  int count = 1;
  // Repeat the following block of code 10 times
    {  cout << "Give  marks of student " << count << ": ";
       cin >> marks;
       sum = sum + marks;
       if (count == 1) { min = marks; max = marks; }
       else { min = (min > marks) ?  marks:min;  max = (max < marks) ? marks: max; }
       count = count + 1;
     }  // End of block of code to be repeated
  // Code for computing average and printing comes here
  return 0;
}
```

What if we want to aggregate marks of "n" students, where "n" is user specified?

Number of repetitions cannot be determined when writing program

More General Iteration

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```
int main() {
  // Variable declarations and initialization of aggregates
  int count = 1;
  // Repeat the following block of code 10 times
    {  cout << "Give  marks of student " << count << ": ";
       cin >> marks;
                                                    marks: max; }
  // Code for computing average and printing comes here
  return 0;
}
```

What if we want to aggregate marks of "n" students, where "n" is user specified?

Necessity of repetition/iteration construct: Problem cannot be solved without this

Number of repetitions cannot be determined when writing program

More General Iteration

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```
int  numStudents, count;
cout << "Give number of students in CS101: ";  cin >> numStudents
count = 1;
// Repeat the following block of code while (count <= numStudents)
   {  cout << "Give  marks of student " << count << ": ";
      cin >> marks;
      sum = sum + marks;
      if (count == 1) { min = marks; max = marks; }
      else { min = (min > marks) ?  marks:min;  max = (max < marks) ? marks: max; }
      count = count + 1;
   }  // End of block of code to be repeated

//  Code to compute aggregates and print them
```

Iterate while a logical condition is satisfied

Crucial: Affects logical condition for loop termination

A Generic Iteration Construct

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- General structure of program with iteration

Part of program before iteration

```
Iteration initialization (setting up initial values, etc)
Iterate/Repeat as long as a logical condition stays  true
  {
   Block of statements
   Optional instructions to execute at end of every iteration
  }
```

Part of program after iteration

A Generic Iteration Construct

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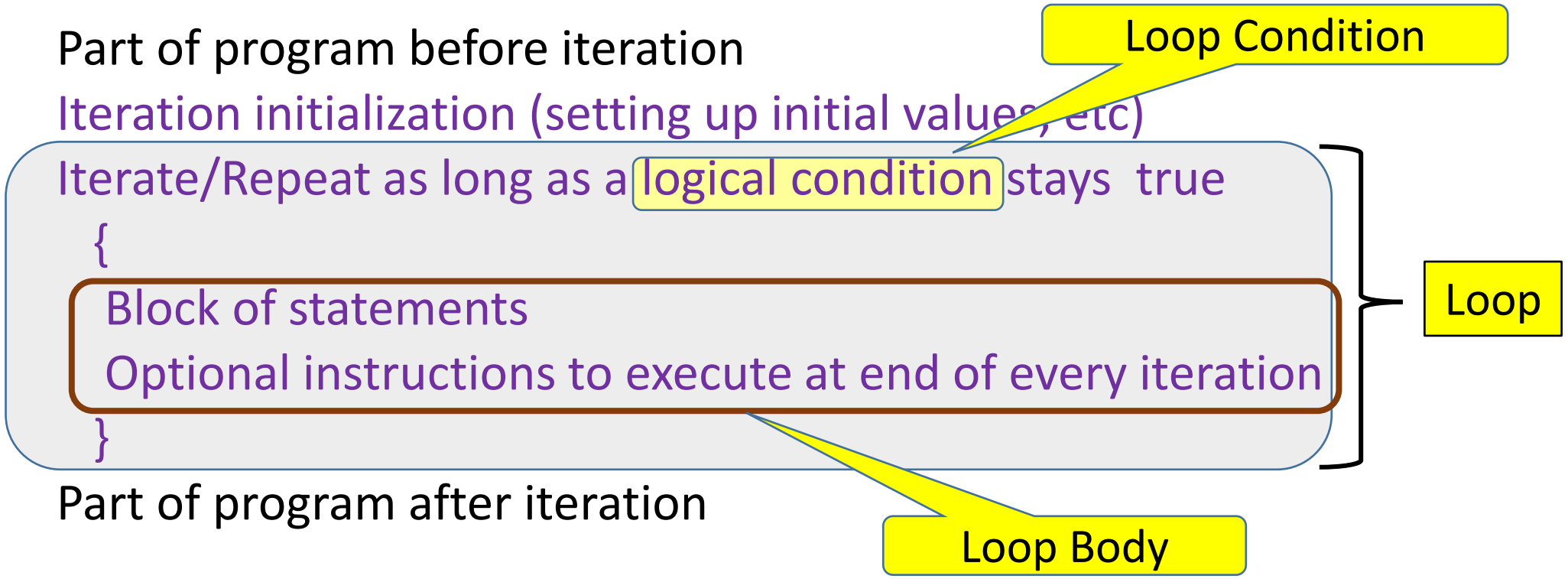
- General structure of program with iteration



C++ Iteration Constructs

- Several iteration constructs in C++
  - while (loopCondition) { Block of Statements to Iterate Over };
  - do { Block of Statements to Iterate Over} while (loopCondition);
  - for (initializationCode; loopCondition;
    CodeToExecuteAfterEachIteration)
    { Block of Statements to Iterate Over };

- Details in next lecture …

Summary

- Iteration idioms in programming
  - Necessary in general
  - Convenient to write intuitive code
  - Enables code reuse, avoids pitfalls of repetition
- Glimpse of iteration constructs in C++