C++ Programming

- Looping

With Thanks to Dr. Xin Feng

Outline

- Looping statements
  - `while`
  - `do-while`
  - `for`
  - `break`
  - `continue`
  - `goto`

Looping

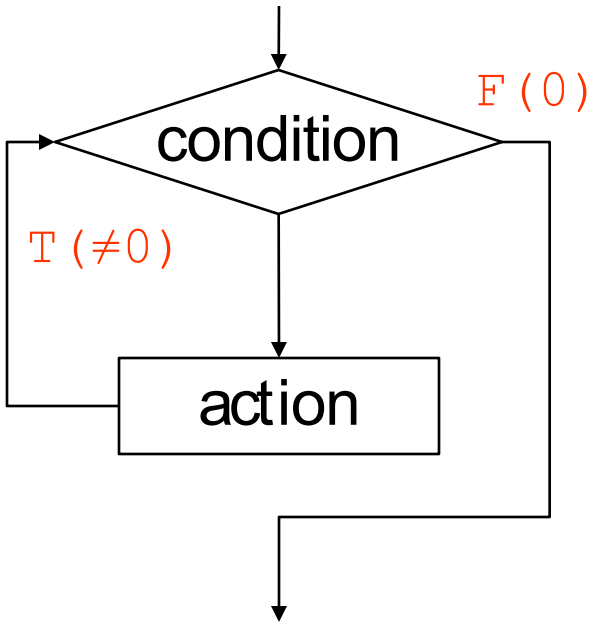
- In our daily life, some actions have been repeated.
  - e.g.,
    - Eat 10 bites of an apple
    - Eat an apple until it is finished

- In a C/C++ program, we can also describe repeated actions

The `while` Loop

Syntax:

```
while (condition)
      action;

or

while (condition) {
      action;
}
```



- If `condition` is true then execute `action`
- Repeat this process until `condition` evaluates to `false`
- `action` is either a single statement or a group of statements within a pair of curly brackets

An Example

```
int n = 10;
while (n > 1){
  cout << n << endl;
  n--;
 }
```

- What is the final value of n
- How many times "`n--`" is executed?
- What is the output of this program?
- What is this program's flowchart?

An Example

- Computer factorial of `n` (`n!`)
- First step, we need to work out the algorithm for this computation.
  - `1! = 1`
  - `2! = 2 * 1 = 2 * 1!`
  - `3! = 3 * 2 * 1 = 3 * 2!`
  - `4! = 4 * 3 * 2 * 1 = 4 * 3!`
  - …
  - `n! = n * (n - 1) * … * 1 = n * (n - 1)!`

An Example

Compute factorial of `n` (`n!`)

```
int number, factorial, counter;
cout << "Enter a positive integer:";
cin >> number;

factorial = 1;  // initialization
counter = 1;

while(counter <= number){
   factorial = factorial * counter;
   counter++; //counter = counter + 1;
}
cout << "The factorial of " << number << " is " <<
   factorial;
```

Class Exercises

- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n-1}$

Can you write a program to compute 2^n using `while`?

Another Example

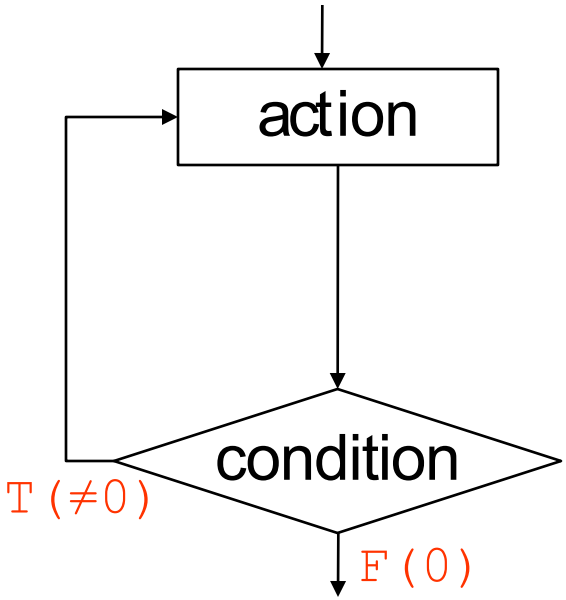
```
int value;  // input value
int max = 0;       // maximum value
cout << "Enter a positive integer (-1 to stop):";
cin >> value;
while(value != -1){
   if(value > max)
     max = value;
  cin >> value;
}
cout << "The maximum value is "<< max << endl;
```

What does this program do?

The `do-while` Loop

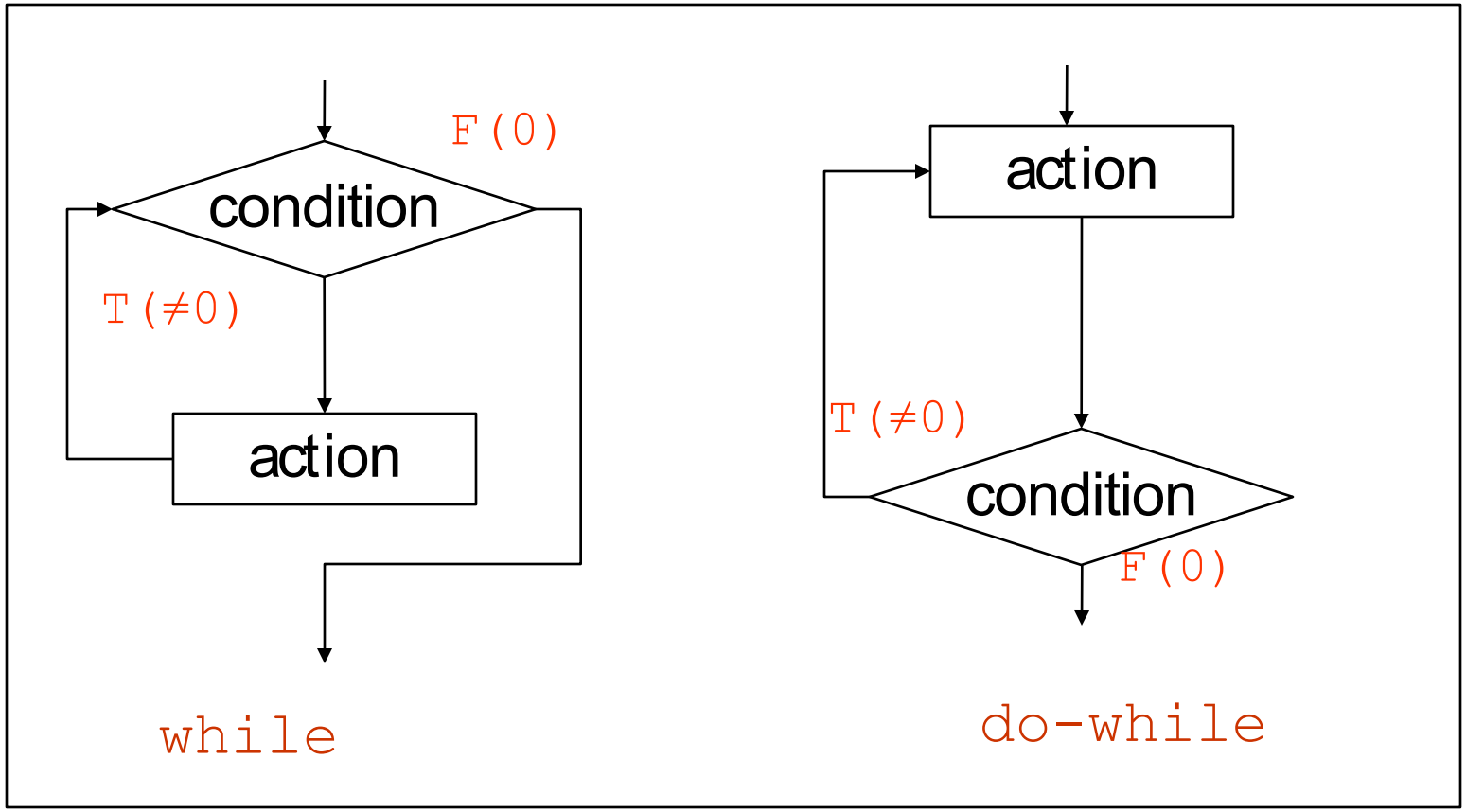
Syntax:

```
do
        action;
while(condition);

or

do{
        action;
} while(condition);
```



- First execute the `action`, then check the `condition` of the loop
- `action` is either a single statement or a group of statements within a pair of curly brackets

Compare `while` and `do-while`



Differences?

Compare `while` and `do-while`

- `while`
  - First check the condition of the loop
  - then execute the body of the loop
- `do-while`
  - First execute the body of the loop
  - then check the condition of the loop
  - the body of the loop is executed at least once

The n! Example

```
int number, factorial, counter;

cout << "Enter a positive integer:";
cin >> number;
factorial = 1;  // initialization
counter = 1;

do{
  factorial *= counter;
  counter++;
}while(counter <= number);

cout << "The factorial of " << number << " is " <<
factorial;
```

```
while(counter <= number){
  factorial = factorial*counter ;
  counter++;
}
```

Any difference between this program and the one using `while`?

Class Exercises

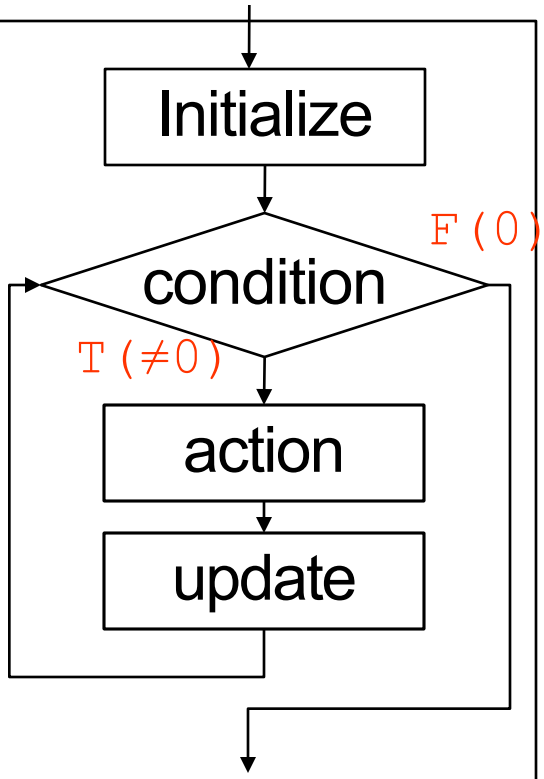
- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n-1}$

Can you write a program to compute 2^n using `do-while`??

The `for` Loop

Syntax:

```
for (initialize; condition; update)
      action

or

for (initialize; condition; update) {
      action
}
```



- Initialize first
- while `condition` is true, execute `action` and execute `update`
- `Initialization, condition and update` can be empty

The n! Example

```
int number, factorial, i;

cout << "Enter a positive integer:";
cin >> number;
factorial = 1;  // initialization

for(i = 1; i <= number; i++)
   factorial *= i; // factorial = factorial * i;

cout << "The factorial of " << number << " is " <<
   factorial;
```

Class Exercise

- Compute 2^n
- First step, we need to work out the algorithm for this computation.
  - $2^0 = 1$
  - $2^1 = 2 * 2^0$
  - $2^2 = 2 * 2^1$
  - $2^3 = 2 * 2^2$
  - …
  - $2^n = 2 * 2^{n-1}$

Can you write a program to compute 2^n using `for`?

Attentions in Loops

- Make sure there is a statement that will eventually stop the loop.
  - Infinite Loop == loop that never stops

```
int i = 1;
int number = 100;
int sum = 0;
while (i <= number){
 sum = sum + i;
 i--;
}
cout << "the sum of integers from 1 to
      100 is " << sum << endl;
```

What is the problem?

Attentions in Loops

- Make sure to initialize loop counters correctly.
  - Off-By-One == the number of times that a loop is executed is 1 more or less.

```
int i = 1;
int number = 100;
int sum = 0;
while (i < number){
 sum = sum + i;
 i++;
}
cout << "the sum of integers from 1 to
      100 is " << sum << endl;
```

Which Loop to Use?

- `for`
  - for calculations that are repeated a fixed number of times
  - controlled by a variable that is changed by an equal amount (usually 1) during each iteration
- `while`
  - The number of iterations depends on a condition which could be changed during execution.
- `do-while`
  - The code segment is always executed at least once.

Examples

```
for (i = 1; i <= 10; i++)
   cout << "***********\n";
```

```
i = 1;
while (i <= 10){
   cout << "***********\n";
   i++;

}
```

```
i = 1;
do{
   cout << "***********\n";
   i++;

}while(i <= 10));
```

Compare these three segments, which one is better?

Examples

```
max = 0;
cin >> value;
while(value != -1){
  if(value > max)
    max = value;
  cin >> value;
}
```

```
max = 0;
value = 0;
do{
  if(value > max)
    max = value;
  cin >> value;
} while(value != -1);
```

```
max = 0;
cin >> value;
for (; value != -1; cin >> value){
  if(value > max)
    max = value;
}
```

Compare these three segments, which one is better?

Examples

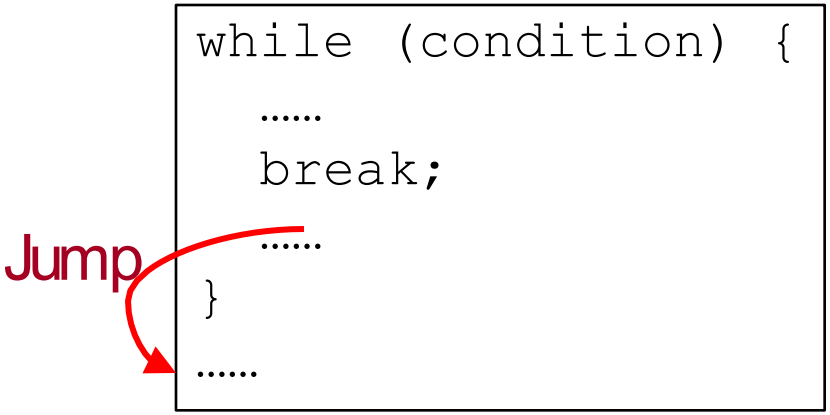
```
char reply;
cout << "************\n";
cout << "continue? (y/n)";
cin >> reply;
while(reply == 'y'){
  cout << "************\n";
  cout << "continue? (y/n)";
  cin >> reply;
}
```

```
char reply;
do{
  cout << "************\n";
  cout << "continue? (y/n)";
  cin >> reply;
} while(reply == 'y');
```

Compare these two segments, which one is better?

Stop the Loop

- There are two ways to stop the loop.
  - Normal way: check the conditions in the `for`, `while` and `do-while`, if the condition is false, stop the loop.
  - Forced way: Use `break` statement
    - When the `break` statement is executed, the loop statement terminates immediately.
    - The execution continues with the statement following the loop statement.



Examples

```
sum = 0;
for (i = 1; i <= 100; i++){
  sum = sum + i;
  if (sum >= 1000)
    break;
}
cout << "i = " << i << ',' << "sum = " << sum;
```

Difference??

```
sum = 0;
for (i = 1; i <= 100; i++)
  sum = sum + i;
cout << "i = " << i << ',' << "sum = " << sum;
```

The `continue` Statement

- The `continue` command terminates the current iteration (i.e., ignore the rest statements in this loop) and starts the next iteration.

```
while (condition)) {
   ......
   continue;
   ......
}
......
```

Jump

Examples

```
sum = 0;
for (i = 1; i <= 100; i++){
  if (i % 2 == 0)
    break;
  sum = sum + i;
}
cout << "i = " << i << ',' << "sum = " << sum;
```

Difference??

```
sum = 0;
for (i = 1; i <= 100; i++){
  if (i % 2 == 0)
    continue;
  sum = sum + i;
}
cout << "i = " << i << ',' << "sum = " << sum;
```

Infinite Loops

- The following formats can cause the infinite loops if no special statement is used to terminate the loop
  - `while (1)`
  - `for ( ; ;)`

An Example

```
int mycard = 3;
int guess;
for(;;) // infinite loop, we can also use while(1)
{
   cout << "Guess my card:";
   cin >> guess;
   if(guess == mycard){
       cout << "Good guess!\n";
       break;   // get out of the infinite loop
   }
   else
       cout << "Try again.\n";
}
```

Infinite Loops

- A trap
  - We can never check if a float variable equals `0` in a condition.

May never be `false` in a machine due to the float data expression

```
while(balance != 0.0){
  balance = balance - amount;
}
```

Nested Loops

- Nested loops are loops within loops.
- Nested loops are similar in principle to nested `if` and `if-else` statements.
- Many applications require nested loops.

Nested Loops

```
int row;     // Outer loop counter
int col;     // Inner loop counter

for(row = 1; row <= 10; row++){
   for(col = 1; col <= 10; col++)
       cout << row * col << " ";
   cout << "\n";
}
```

Questions:

1. How many times `cout << row*col << " ";` is executed?
2. How many times `cout << "\n";` is executed?
3. What is the output of this program?

Nested Loops

Output:

```
1 2 3 4 5 6 7 8 9 10
2 4 6 8 10 12 14 16 18 20
3 6 9 12 15 18 21 24 27 30
4 8 12 16 20 24 28 32 36 40
5 10 15 20 25 30 35 40 45 50
6 12 18 24 30 36 42 48 54 60
7 14 21 28 35 42 49 56 63 70
8 16 24 32 40 48 56 64 73 80
9 18 27 36 45 54 63 72 81 90
10 20 30 40 50 60 70 80 90 100
```