Lecture 6

Making Decisions

Fundamentals of Computer and Programming

Instructor: Morteza Zakeri, Ph.D. (m-zakeri@live.com)

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Modified Slides from Dr. *Hossein Zeinali* and *Dr. Bahador Bakhshi*

Computer Engineering Department, Amirkabir University of Technology

What We Will Learn

- Introduction
- Conditions and Boolean operations
- **`if-else`** statement
- **`switch-case`** statement
- Conditional expressions

Decision

- Decisions are based on *conditions*
  - *If* it is snowing → We will cancel the game
  - If the class is not canceled → I will attend

    else → I will go to gym

- In programming
  - Do statements based on conditions
    - True → The statements will be done
    - False → The statement won't be done

Conditions

- Conditions by comparisons; *e.g.*,
  - Weather *vs.* snowing
  - Variable x *vs.* a value
- Comparing numbers: Relational Operators

Relational Operator	Meaning
<	is less than
<=	is less than or equal to
>	is greater than
>=	is greater than or equal to
==	is equal to
!=	is not equal to

Relations

- Relations are not a complete statement

```
int a, b;
a == b;          // ERROR
a <= b;          // ERROR
```

- Relations produce a boolean value

```
int a, b;
bool bl;              // #include <stdbool.h>
bl = a == b;
bl = a <= b;
```

Boolean operations

- Multiple conditions in decision making
- Logical relation between conditions
  - *if* you are student and you have the programming course

    → You should read the book
- C Boolean operators
  - and `&&`
  - or `||`
  - not `!`

p	q	p && q	p || q	!p
False	False	False	False	True
False	True	False	True	True
True	False	False	True	False
True	True	True	True	False

Boolean operations (cont'd)

- Examples

```
bool a = true, b = false, c;
c = !a;          // c = false
c = a && b;      // c = false
c = a || b;      // c = true
c = !a || b;     // c = false
```

Precedence

Operator	Operation
++ --	increment, decrement
+ -	unary plus, minus
!	boolean not
(<type>)	cast to <type>
* / %	multiplication, division, remainder
+ -	addition/concatenation, subtraction
< <= > >=	relational ordering
== !=	relational equality, inequality
&&	boolean and
||	boolean or
= += -= *= /= %=	assignments

Relations, No type effect

```
int a = 10, b = 20;
float f = 54.677f;
double d = 547.775;
char c1 = 'A', c2 = 'a';
bool b1;
b1 = a == f;                    // false
b1 = a <= d + 5;                // true
b1 = d < c1 * 10;               // true
b1 = c1 == c2;                  // false
b1 = '1' < '2';                 // true
b1 = c1 + f < d + a;            // true
```

Casting

- In logical operations
  - 0 → False, non-zero → True
- In mathematical & comparison operations
  - False → 0 , True → 1

```
bool b1, b2;
int i = 0, j = 20;
b1 = i && j;                    // b1 = false
b2 = j || j;                    // b2 = true
i = b1 + b2;                    // i = 1
j = (i < j) + (b1 && b2);       // j = 1
```

Examples

- x ∈ [10 , 20]
- Wrong Version
  - 10 <= x <= 20
  - Let x = 30
    - 10 <= 30 <=20 → (10 <= 30) <= 20
      → true <= 20 → 1 <= 20 → **true!!!**
- Correct Version
  - (10 <= x) && (x <= 20)
  - Let x = 30
    - (10 <= 30) && (30 <= 20) → true && false → **false**

Examples

- a,b > 0
- Wrong version
  - a && b > 0
  - Let a = -10, b = 20
    - -10 && 20 > 0 → -10 && (20 > 0)

    → -10 && true → true && true → true !!!
- Correct version
  - (a > 0) && (b > 0)
  - Let a = -10, b = 20
    - (-10 > 0) && (20 > 0) → false && true → false

Lazy (short-circuit) evaluation

- When final result is found, does not evaluate remaining

```
int i = -1;

bool a = true, b = false, c = true;

bool d = a || b || c

bool d = b && (a || c)

bool d = (i > 0) && (sqrt(i) > 5.6)
```

What We Will Learn

- Introduction
- Conditions and Boolean operations
- **`if-else`** statement
- **`switch-case`** statement
- Conditional expressions

Type of statements

- Expression statement (دستور عبارتی)
  - Single statements

```
x = y + 10; scanf("%d", &i);
```

- Control statement (دستور کنترلی)
  - Control the flow of program
    - Decisions (**`if`**, **`switch`**) and loops (**`for`**, **`while`**)
- Compound statement (دستور مرکب)
  - Starts with { and ends with }
  - All statements can be between { and }

if (if-else) statement

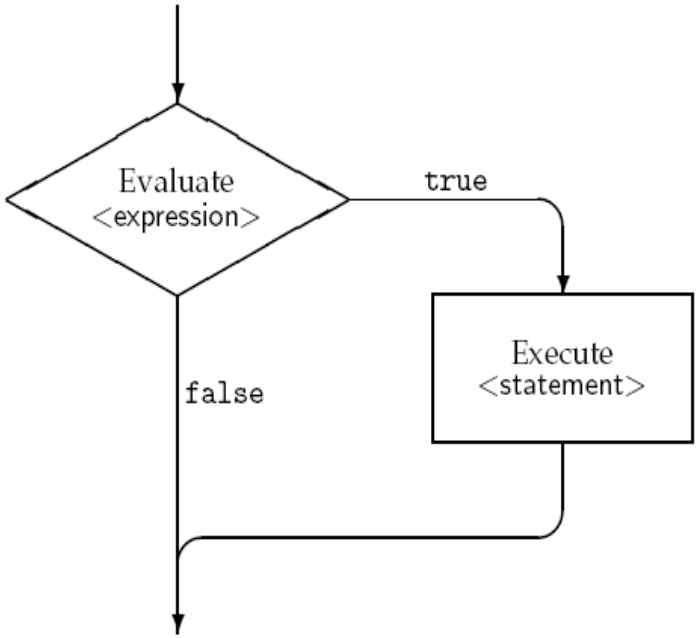
- Decision making in C

```
if( <expression> )
    <statements1>
else
    <statements2>
```

- Expression
  - A boolean statement: `a <= b`
  - A mathematical statement: `a + b` or a variable: `a`
    - zero → false
    - Non-zero → true

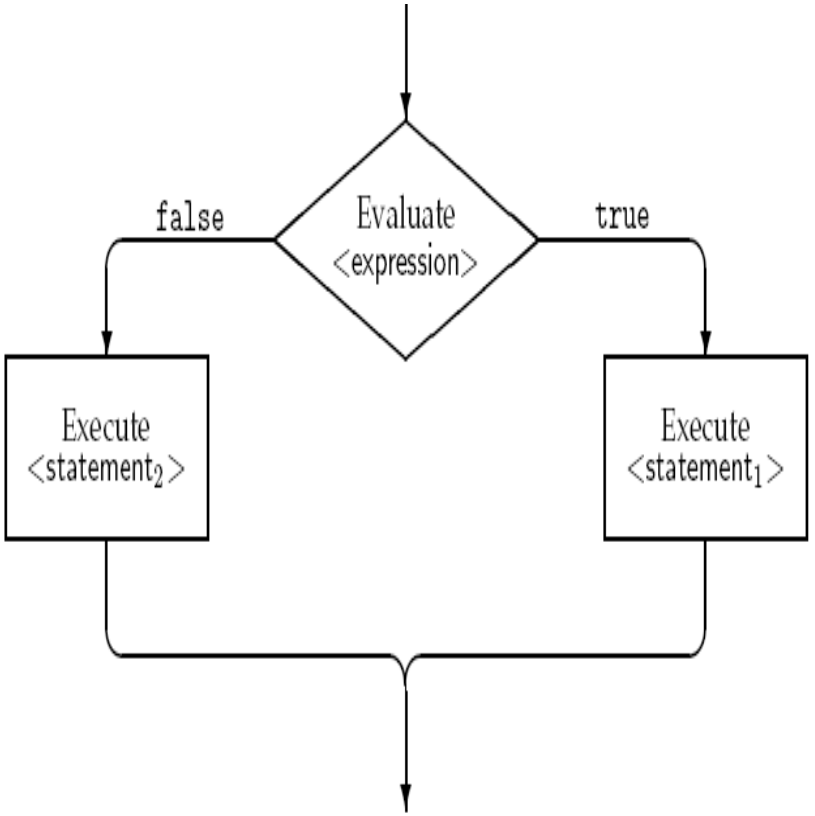
Flowcharts of if-else statement

if(<expression>)
    <statement>



if(<expression>)
    <statement1>

else
    <statement2>



Example 1

برنامه‌ای که یک عدد را از کاربر می‌گیرد و مشخص می‌کند که این عدد فرد است یا زوج.

```
#include <stdio.h>
int main(void){
   int number_to_test, remainder;

   printf("Enter your number to be tested: ");
   scanf("%d", &number_to_test);

   remainder = number_to_test % 2;
   if(remainder == 0)
       printf ("The number is even.\n");
   else
       printf ("The number is odd.\n");

   return 0;
}
```

Statements in if-else

- Empty statement

```
if(a > b)
  Printf("A is larger \n");
else
  ;
```

- Block statements

```
if(a <= b){
  printf("A is less than b or ");
  printf("A is equal b\n");
}
else
  printf("A is greater than b\n");
```

Example 2

برنامه‌ای که یک حرف و یک عدد را می‌گیرد. در مورد عدد مشخص می‌کند که آیا بزرگتر از صفر است یا نه. در مورد حرف اگر حرف عددی باشد، پیغام چاپ می‌کند.

```
#include <stdio.h>
int main(void){
   int i;
   char c;
   printf("Enter a char: ");
   scanf(" %c", &c);
   printf("Enter an int: ");
   scanf("%d", &i);
   if(i > 0)
       printf("Your number is larger than 0\n");
   else
       printf("Your number is less than or equal 0\n");
   if((c >= '0') && (c <= '9'))
       printf("Your char is Numeric \n");
   return 0;
}
```

More than two choices

- If statement: 2 choices
  - If conditions are true → if statements
  - If conditions are false → else statements

- How to make decisions when there are multiple choices?

Map numeric grade to alphabetic

```
int numg;
char alphag;
if(numg < 25)
  alphag = 'D';
if((numg >= 25) && (numg < 50))
  alphag = 'C';
if((numg >= 50) && (numg < 75))
  alphag = 'B';
if(numg >= 75)
  alphag = 'A';
```

More than two choices

- To avoid repeating conditions in if statements
- To avoid running unnecessary statements
- Nested if: check multiple conditions
  - <Statements 1> becomes an if-else statement
  - <Statements 2> becomes an if-else statement
  - Repeat it as many as needed

Nested if-else

```
if(c1 && c2)
  s1
if (c1 && !(c2))
  s2
if (!(c1) && c3)
  s3
if (!(c1) && !(c3))
  s4
```

```
if(c1)
  if(c2)
     s1
  else
     s2
else
  if(c3)
     s3
  else
     s4
```

Map numeric grade to alphabetic

```
int numg;
char alphag;
if(numg < 25)
   alphag = 'D';
else{
   if(numg < 50)
        alphag = 'C';
   else{
        if(numg < 75)
               alphag = 'B';
        else
               alphag = 'A'
   }
}
```

Nested if-else with else-if

```
if(<condition 1>)
  <statement 1>
else{
  if(<condition 2>)
     <statement 2>
  else
     <statement 3>
}
```

```
if(<condition 1>)
  <statement 1>
else if(<condition 2>)
     <statement 2>
else
     <statement 3>
```

Map numeric grade to alphabetic

```
int numg;
char alphag;
if(numg < 25)
  alphag = 'D';
else if(numg < 50)
  alphag = 'C';
else if(numg < 75)
  alphag = 'B';
else
  alphag = 'A';
```

Map numeric grade to alphabetic

```
int numg;
char alphag;
if(numg < 50){
   if(numg < 25)
        alphag = 'D';
   else
        alphag = 'C';
}
else{
   if(numg < 75)
        alphag = 'B';
   else
        alphag = 'A';
}
```

Nested if: Example 2

- Determine a char is alphabetic, Uppercase or not, numeric, less or greater than 5 or none of them

```
/* '0': 48, '9': 57, 'A': 65, 'Z': 90, 'a': 97, 'z': 122 */
char c;
if(((c >= 'a') && (c <= 'z')) || ((c >= 'A') && (c <= 'Z'))){
    if(c >= 'a')
        printf("The char is Lowercase \n");
    else
        printf("The char is Uppercase \n");
}
else if((c >= '0') && (c <= '9')){
    if(c > '5')
        printf("The char is greater than 5\n");
    else
        printf("The char is less than or equal 5\n");
}
else
    printf("The char is not either alphabetic or numeric");
```

Note: This program can be written in other ways.

Nested if: Incomplete branch

- 1) **`else`** part is optional
- 2) **`else`** always associates with the nearest **`if`**
  - 1 + 2 can be dangerous specially in incomplete branches
- Example: Tell user to move or game over

```
if(gameIsOver == 0)
    if(playerToMove == YOU)
        printf("Your Move\n");
else
    printf("The game is over\n");
```

- To avoid error you should
  - Close off your code or Use Empty statements

Nested if: close off & empty statement

```
if(gameIsOver == 0){
   if(playerToMove == YOU)
        printf ("Your Move\n");
}
else
   printf ("The game is over\n");
//---------------------------------
if(gameIsOver == 0)
   if(playerToMove == YOU)
        printf ("Your Move\n");
   else
        ;
else
   printf ("The game is over\n");
```

This one is better.

Duplicate zero, input is 3 digit

```
#include <stdio.h>
int main(void){
        int n, x1, x2, x3, q1, q2, result;
        printf("Enter a 3-digit number: ");
        scanf("%d", &n);
        if((n < 100) || (n > 999)){
                printf("Wrong input\n");
                return -1;
        }
        x1 = n / 100;
        x2 = (n % 100) / 10;
        x3 = n % 10;

        q1 = 100;
        q2 = 10;

        if(x3 == 0){
            q1 *= 10;
            q2 *= 10;
        }
        if(x2 == 0)
            q1 *= 10;

        result = (x1 * q1) + (x2 * q2) + x3;
        printf("result = %d\n", result);
        return 0;
}
```

What We Will Learn

- Introduction
- Conditions and Boolean operations
- `if-else` statement
- **`switch-case`** statement
- Conditional expressions

switch-case: Multiple choices

- Multiple conditions
  - If-else, if-else if- ….
- Select from alternative values of a variable
  - switch-case
  - Values should be constant not expression: `i, i+j,`
  - Values & Variables should be `int` or `char`

```
switch(variable){
    case value1:
        <statements 1>
    case value2:
        <statements 2>
}
```

How does switch-case work?

- Each **switch-case** can be rewritten by If-else
  - if-else version of switch-case in the previous slide

```
if(variable == value1)}
  <statements 1>
  <statements 2>
}
else if(variable == value2){
  <statements 2>
}
```

switch-case: complete version

```
switch(variable){
   case value1:
       <statements 1>
       break;
   case value2:
       <statements 2>
       break;
   default:
       <statements 3>
}
```

```
if(variable == value1){
   <statements 1>
}

else if(variable == value2){
   <statements 2>
}
else{
   <statements 3>
}
```

switch-case: Example

```
#include <stdio.h>

int main(void){
   int res, opd1, opd2;
   char opr;
   printf("Operand1 : ");
   scanf("%d", &opd1);
   printf("Operand2 : ");
   scanf("%d", &opd2);
   printf("Operator : ");
   scanf(" %c", &opr);
   switch(opr){
   case '+':
       res = opd1 + opd2;
       break;
```

برنامه‌ای که دو عدد و یک عملگر را می‌گیرد، عملگر را بر روی اعداد اعمال و نتیجه را چاپ می‌کند.

switch-case: Example (Cont'd)

```
    case '-':
        res = opd1 - opd2;
        break;
    case '/':
        res = opd1 / opd2;
        break;
    case '*':
        res = opd1 * opd2;
        break;
    default:
        printf("Invalid operator \n");
        return -1;
    }
    printf("%d %c %d = %d\n", opd1, opr, opd2, res);
    return 0;
}
```

switch-case (cont'd)

- All values used in case should be different

```
switch(i){
case 1:
…
case 2:
…
case 1: // Error
…
```

switch-case (cont'd)

- All values must be value, not expression of variables

```
switch(i){          //Error
case j:
…
case 2:
…
case k+10:
```

switch-case: multiple matches

```
switch(variable){
  case value1:
  case value2:
     <statements 1>
     break;
  case value3:
     <statements 2>
}
```

```
if(
(variable == value1) ||
(variable == value2)
){
   <statements 1>
}
else if
(variable == value3)
{
   <statements 2>
}
```


switch-case *vs.* if-else

- **`if-else`** is more powerful than **`switch-case`**
- **`switch-case`** is only for checking the values of a variable and the values must be constant
  - if-else is more suitable in some cases , *e.g.*,

```
double var1, var2;
if(var1 <= 1.1)
  <statements 1>

if(var1 == var2)
  <statements 2>
```

Nested switch-case

```
bool b;  // b = x && y
switch (x){
   case 0:
       b = 0;
       break;
   case 1:
       switch(y){
             case 0:
                   b = 0;
                   break;
             case 1:
                   b = 1;
                   break;
       }
       break;
}
```

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Conditional Expression

- Assign value according to conditions
- A ternary (سه تایی) operator

```
int i, j, k;
bool b;
...
i = b ? j : k;          /* if(b)
                         *       i = j;
                         * else
                         *       i = k;
                         */
```

Conditional Expression: Examples

y = abs(x)

```
y = (x > 0) ? x : -x;
```

$$\text{signum}(x) = \begin{cases} -1 & \text{if } x < 0 \\ 0 & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases}$$

```
signum = (x < 0) ? -1 : (x > 0 ? 1 : 0)
```

Map Alphabetic Grade to Numeric

```
int d = numg / 25

charg = (d == 0) ? ‘D’ : ((d == 1) ? ‘C’ : (d ==
   2) ? ‘B’ : ‘A’);
```

Common Bugs

- Equality of floating point numbers
  - Two **float** numbers may or may NOT be equal

```
double d1, d2;
d1 = 1e20 + 1;
d2 = 1e20 - 1;
if(d1 == d2)
    printf("They are equal :-o \n");
else
    printf("They are not equal :D \n");
```

They are equal :-o

Common Bugs

- Danger of empty statement
- Danger of assignment (=) and equality (==)

```
int a = 10;

int b = 20;

if(a=b) // logical but not compile error!!!
```

- Danger of similarity between C and mathematic
  - `if(a < b < c)    // Logical Error`
  - `if(a && b > 0)   // Logical Error`

Avoiding Bugs

- Precedence of operators

```
if(!a && b)
```
or
```
if(!(a && b))
```

- Use **parenthesis** in conditions

- Close-off code as much as you can
  - Put an end to a state or activity.

Debugging by assert

- The assert macro is defined in **`assert.h`**
- **`assert(`**an expression**`)`**
  - If the expression is true → nothing
  - If the expression is false → error message + halt

```
int x, y, z
…
assert(y != 0);
z = x / y;
```

Debugging by assert

- If the expression is false:
  - Output error: Assertion failed: y != 0, file test.c, line ??
- Assertion ***vs.*** Normal Error Handling
  - Assertions are mainly used to check logically impossible situations.
  - Assertions are generally disabled at run-time.
- Assertions can be **completely removed** at compile time using the preprocessor NDEBUG.

```
#define NDEBUG
```

Reference

- Reading Assignment: Chapter 3 of “C How to Program”