Selection Structures: Supplement

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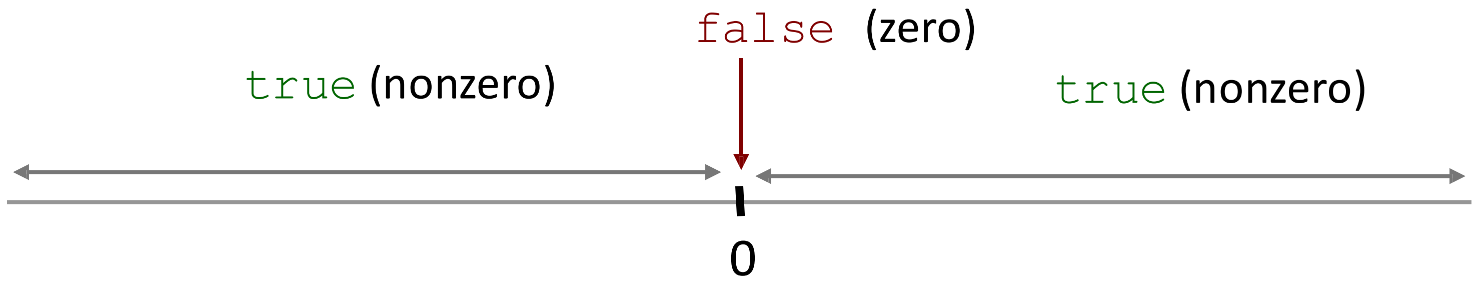
What is `true` and what is `false` in C

- C uses integer values to represent boolean `true` and `false`



```c
#include <stdbool.h>
………
int flag, p=100, q=50;
bool isBigger = false;

flag = (p <= q);
isBigger = (p >= q);
```

```
flag = 0;          false
isBigger = 1;      true
```

- You need to include `<stdbool.h>` to use `bool` data type in your program

Relational Operators

Purpose:

Compare two operands

Syntax:

`Operand1` **Relational Operator** `Operand2`

Operands:

constants

variables

arithmetic expressions

function calls

Operators

==	equal
!=	not equal
>	greater than
>=	greater than or equal to
<	less than
<=	less than or equal to

Examples:

```
y >= 20
offset == (640 + x)
z < log(y)
```

Logical operators

Syntax:

```
Operand1 LogicOperator Operand2
```

or `!Operand`

Examples:

```
(current >= 2.0e-3) && (current <= 5.0e-3)
ans = (p > 95) || (q < 95);
ans = !(p > 95);
```

Operands:
- `bool` constants
- `bool` variables
- relational expressions
- function calls

Operators:

`&&`	logical AND
`||`	logical OR
`!`	logical NOT

Expression result:
- `true`
- `false`

Apart from difference in syntax, all properties of C logical operators are similar to those used for digital hardware design (covered by ECTE233) and in MATLAB (covered by ENGG100)

Logical operators

Evaluation of logical expressions

x	y	x && y	x || y	!x
false	false	false	false	true
false	true	false	true	true
true	false	false	true	false
true	true	true	true	false

Truth table

As follows from the table:

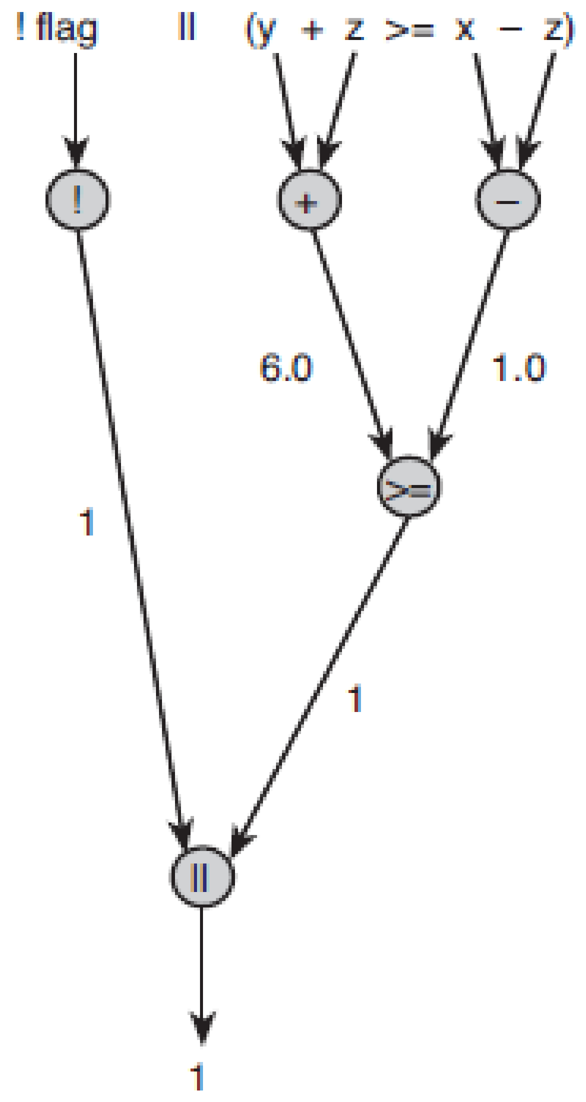
- If at least one operand is `false`, then `&&` is also `false`
- If at leas one operand is `true`, then `||` is also `true`

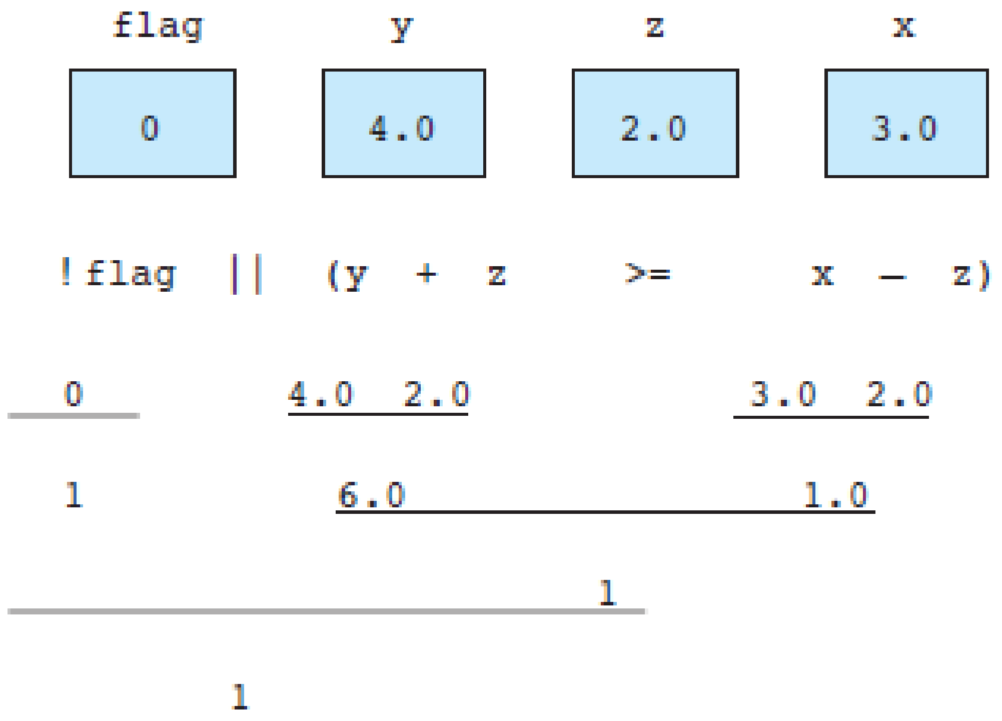
```
int x=2, y=4, z=9, flag;
bool isMaxVal;

            true       true
isMaxVal = (z > x) && (z > y);   /* true */
        false        true
flag = (x == y) && ( x < y );    /* false */
```

Operator Precedence

Operator	Precedence
function calls	highest (evaluated first)
! + - & (unary operator)	↓
* / %	↓
+ -	↓
< <= >= >	↓
== !=	↓
&&	↓
||	↓
=	lowest (evaluated last)

Evaluation Tree and Step-by-Step Evaluation for !flag || (y + z >= x - z)





Comparing Characters

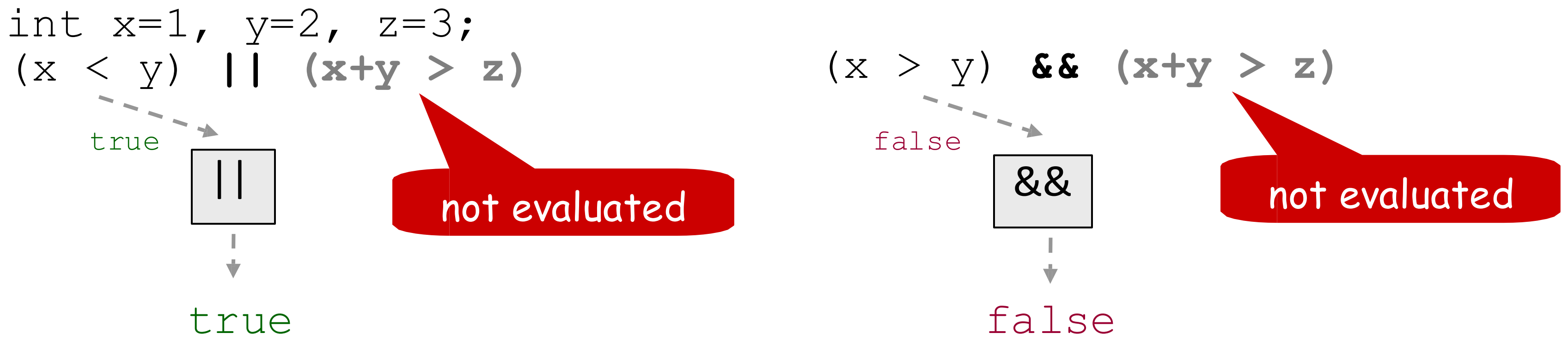
Expression	Value
‘9’ >= ‘0’	1 (true)
‘a’ < ‘e’	1 (true)
‘B’ <= ‘A’	0 (false)
‘Z’ == ‘z’	0 (false)
‘a’ <= ch && ch <= ‘z’	1 (true) if ch is a lowercase letter

Short circuit evaluation

Short-Circuit evaluation

- C stops further evaluation of an expression when the result becomes obvious (MATLAB uses short-circuit evaluation too)
  - –An expression of the form **`A||B`** **is always `true` if `A` is `true`**
  - –An expression of the form **`A&&B`** **is always `false` if `A` is `false`**

In these cases B is not evaluated



```
int x=1, y=2, z=3;
(x < y) || (x+y > z)
```

```
(x > y) && (x+y > z)
```

Short circuit evaluation

Short circuit evaluation reduces computational complexity of complex logical expressions

Does it have any side effects?

```
int x=1, y=2, z=3;
bool flag;

flag = x<0 || ++y > 7;        /* flag= false   y= 3 */
flag = x>0 || ++y > 7;        /* flag= true    y= 2 */
```

Not run in sequence

- When you use complex logical expression in your program, make sure that short circuit evaluation does not introduce intermittent mistakes in calculations

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Writing English Conditions in C

Table below shows some English conditions and the corresponding C expressions. Each expression is evaluated assuming `x` is `3.0`, `y` is `4.0`, and `z` is `2.0`.

English Condition	Logical Expression	Evaluation
`x` and `y` are greater than `z`	`x > z && y > z`	`1 && 1` is `1` (true)
`x` is equal to `1.0` or `3.0`	`x == 1.0 || x == 3.0`	`0 || 1` is `1` (true)
`x` is in the range `z` to `y`, inclusive	`z <= x && x <= y`	`1 && 1` is `1` (true)

`x` is outside the range `z` to `y`	`!(z <= x && x <= y)`
	`z > x || x > y`
		`!(1 && 1)` is `0` (false)
		`0 || 0` is `0` (false)

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Quiz

What are the values of the variables after execution of this code?

```
int a=0, b=0;

if (a > b || a==0 && b>0)
{
   a++;
   b += 2;
}
else
{
   a--;
   b -= 2;
}
```

```
int a=0, b=0;

if (a == 0)
   if (b > 0)
   {
      a++;
      b += 2;
   }
   else if (a > b)
   {
      a++;
      b += 2;
   }
   else
   {
       a--;
       b -= 2;
   }
```

a = -1 b = -2

a = -1 b = -2

Typical bugs

- Unnecessary semicolon after the `if(condition)`

```
if(number > THRESHOLD);   Null statement, do nothing
   number = 0;  <-  will be executed unconditionally
```

- Missing braces `{…}` to enclose compound statements

```
 if(number > THRESHOLD)
       number = 0;
else
       number = getNewNumber;
       counter++;  <-will be executed unconditionally
```

- Dangling `else`

```
if(a > 0)
     if(b < 10)
         c = 5;
else                          <-  else is always associated with the previous if
   c = 0;
```