Boolean Expressions Lecture 9 Sections 2.11, 4.1, 4.7

Robb T. Koether

Hampden-Sydney College

Fri, Sep 13, 2019

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- 2 The bool Data Type
- 3 Precedence Rules





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Outline

Boolean Expressions

- 2 The bool Data Type
- 3 Precedence Rules
- 4 Examples

5 Assignment

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• A boolean variable may take on one of only two boolean values

- true
- false
- There are four standard boolean operators
 - and
 - or
 - not
 - exclusive or (xor)
- A boolean expression is an expression which takes on a boolean value (whether or not its components are boolean).
 - x > 2
 - *x* ≤ 0 or *x* ≥ 1

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• If *p* and *q* are boolean expressions, then the expression "*p* and *q*"

is true if and only if *p* is true and *q* is true.

p	q	p and q
Τ	Т	
Т	F	
F	Т	
F	F	

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• If *p* and *q* are boolean expressions, then the expression "*p* and *q*"

is true if and only if *p* is true and *q* is true.

р	q	p and q
Т	Т	Т
Т	F	F
F	Т	F
F	F	F

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 If p and q are boolean expressions, then the expression "p or q" is true if and only if p is true or q is true.

р	q	p or q
Τ	Т	
Т	F	
F	Т	
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 If p and q are boolean expressions, then the expression "p or q" is true if and only if p is true or q is true.

р	q	<i>p</i> or <i>q</i>
Т	Τ	Т
Т	F	Т
F	Т	Т
F	F	F

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 If *p* is a boolean expression, then the expression "not *p*" is true if and only if *p* is false, i.e., if *p* is not true.



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 If p is a boolean expression, then the expression "not p" is true if and only if p is false, i.e., if p is not true.



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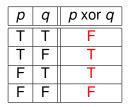
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If p and q are boolean expressions, then the expression "p xor q" (exclusive or) is true if p or q is true, but not both.

p	q	p xor q
Т	Т	
Т	F	
F	Т	
F	F	

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If p and q are boolean expressions, then the expression "p xor q" (exclusive or) is true if p or q is true, but not both.



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- A truth table for a Boolean expression is a table that shows every possible combination of boolean values of the variables, together with the boolean values of the expression.
- If there are *n* variables, then there are 2^{*n*} combinations of boolean values.

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р	q	r	q or r	not (<i>q</i> or <i>r</i>)	p and not (q or r)
Τ	Т	Τ			
Т	Т	F			
Т	F	Т			
Т	F	F			
F	Т	Т			
F	Т	F			
F	F	Т			
F	F	F			

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р	q	r	<i>q</i> or <i>r</i>	not (<i>q</i> or <i>r</i>)	p and not (q or r)
Τ	Т	Τ	Т		
Т	Т	F	Т		
Т	F	Т	Т		
Т	F	F	F		
F	Т	Т	Т		
F	Т	F	Т		
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р	q	r	q or r	not (<i>q</i> or <i>r</i>)	p and not (q or r)
Τ	Т	Τ	Т	F	
Т	Т	F	Т	F	
Т	F	Т	Т	F	
Т	F	F	F	Т	
F	Т	Т	Т	F	
F	Т	F	Т	F	
F	F	Т	Т	F	
F	F	F	F	Т	

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р	q	r	<i>q</i> or <i>r</i>	not (<i>q</i> or <i>r</i>)	p and not (q or r)
Т	Т	Τ	T	F	F
Т	Т	F	Т	F	F
Т	F	Т	Т	F	F
Т	F	F	F	Т	Т
F	Т	Т	Т	F	F
F	Т	F	Т	F	F
F	F	Т	Т	F	F
F	F	F	F	Т	F

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- In C++, there is the **bool** data type.
- A bool object can take on one of only two bool values.
 - true
 - false
- The bool type is in the integer family.
 - true is stored as 1.
 - false is stored as 0.
- **bool** objects occupy one byte of memory, even though they need only one bit.

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- There are three (not four) logical operators in C++.
 - The "and" operator is & &
 - The "or" operator is ||
 - The "not" operator is !

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Boolean	C++
(not p) or q	!p q
not (p or q)	!(p q)
(not p) and q	!p && q
not (p and q)	!(p && q)
p and q or r	p && q r

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- Relational operators are operators that compare objects.
- Equality Operators
 - The "equal to" operator is ==.
 - The "not equal to" operator is !=.
- Order Operators
 - The "greater than" operators is >.
 - The "less than" operator is <.
 - The "greater than or equal to" operator is >=.
 - The "less than or equal to" operator is <=.

- Typically, boolean expressions are created by using relational operators to compare numerical or other quantities.
- Examples
 - Integer: count != 0
 - Floating-point: x < 123.4
 - Character: c >= 'A' && c <= 'Z'
 - String: answer == "yes"
 - Mixed: count > 0 && sum <= 100.0
- The operands may be of various types, but the result is always bool.

- The equality operators == and != should be defined on all data types since they always make sense.
- The order operators <, >, <=, and >= should be defined only on data types for which they make sense.

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- For which types do the order operators make sense?
 - short, int, and long?
 - float and double?
 - char?
 - string?
 - bool?

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Precedence Rules

Precedence order from highest to lowest.

- Post-increment and post-decrement ++, --
- Logical "not" !
- Unary operators +, -
- Pre-increment and pre-decrement ++, --
- Multiplicative operators *, /, %
- Additive operators +, -
- Insertion and extraction <<, >>
- Relational ordering operators <, >, <=, >=
- Relational equality operators ==, !=
- Logical "and" operator & &
- Logical "or" operator | |
- Assignment operators =, +=, -=, *=, /=, %=

Examples

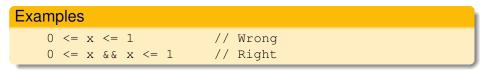
Improved Examples

$$(x = -y) || (z != 0)$$

 $(x < y) \&\& (y < z)$
 $x = ((b == 0) || ((a / b == c) \&\& !p))$

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• We cannot "chain together" inequalities

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- Note that << has a higher precedence than the relational operators ==, !=, <, >, <=, and >= and the logical operators && or | |.
- Therefore, the statement

cout << a == 0 << endl;

is illegal because it is interpreted as

(cout << a) == (0 << endl);

It must be written

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• Example

• BoolOperators.cpp

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Assignment

• Read Sections 2.11, 4.1, 4.7.

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