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# AND, OR, and NOT

SET08104 Database Systems

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SQL is formal logic ...

but formal logic can be quite different from natural language.

Formal logic can be counter-intuitive.

# AND

What does AND mean in these sentences:

- ▶ He entered the room AND sat down.  $\implies$  THEN
- ▶ She bought a computer AND a printer.  $\implies$  AND
- ▶ Students in classes 101 AND 202.  $\implies$  OR

# OR

What does OR mean in these sentences:

- ▶ Would you like a beer OR a whisky.  
⇒ **exclusive OR**: EITHER OR (BOTH would be impolite)
- ▶ I bet he is sitting in the bar and drinking a beer OR a whisky.  
⇒ **inclusive OR**: (BOTH is acceptable)

Logical OR is always **inclusive**: ONE OR THE OTHER OR BOTH.

# NOT

- ▶ Rhetoric uses: The drink was NOT bad.
- ▶ Double negative: I doN'T DISlike computers.  $\implies$  positive
- ▶ Double negative: We doN'T need NO education.  $\implies$  negative

Logical NOT NOT EXPRESSION always means EXPRESSION.

## Inner and outer negation

- ▶ ALL cars are NOT blue.
  - ⇒ There is NOT ANY blue car.
  - ⇒ NO car is blue.
- ▶ ALL cars are blue.
  - ⇒ There is NOT ANY NON-blue car.
  - ⇒ NO car is NOT blue.
- ▶ NOT ALL cars are blue.
  - ⇒ SOME car is NOT blue.
- ▶ NOT ALL cars are NOT blue.
  - ⇒ SOME car is blue.

An outer negation refers to the statement as a whole.

An inner negation refers to some part of the statement.

## Quantifiers (SOME/ANY, ALL, NONE)

- ▶ ALL ... NOT = NOT ANY ... = NONE ...
- ▶ ALL ... = NOT ANY ... NOT = NONE ... NOT
- ▶ NOT ALL ... = SOME ... NOT
- ▶ NOT ALL ... NOT = SOME ...

## Other inner and outer statements

- ▶ I don't like tea and coffee.  
⇒ I don't like tea or I don't like coffee.  
NOT ALL ... = SOME ... NOT  
(This is de Morgan's law. We'll get back to this in a minute.)
- ▶ Larger than ANY = Larger than the minimum.  
Larger than ALL = Larger than the maximum.



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## How to cope with this confusion?

If you are writing an SQL statement that contains negation or other complex combinations of AND, OR, NOT.

- ▶ Forget your intuition!  
logical AND, OR, NOT can be counter-intuitive.
- ▶ Use one of the following three strategies:

## Strategy 1: Testing

- ▶ Write your logical statement.
- ▶ Use a database table which you are familiar with or which is quite small.
- ▶ Manually check which data need to be selected.
- ▶ Execute your query and test whether the result is as expected.
- ▶ If it doesn't work: exchange AND and OR, move the negation around.
- ▶ Test it again until it does what it is supposed to do.

## Strategy 2: Truth Tables

SELECT ... WHERE NOT (name = 'Smith' or age = '40').

name	age	name OR age	NOT(name OR age)
true	true	true	false
true	false	true	false
false	true	true	false
false	false	false	true

## Strategy 3: Understand the logical laws (Boolean Logic)

$$\text{NOT (NOT } a) = a$$

$$a \text{ OR } a = a; \quad a \text{ AND } a = a$$

$$a \text{ OR } b = b \text{ OR } a; \quad a \text{ AND } b = b \text{ AND } a;$$

$$a \text{ OR } (b \text{ AND } c) = (a \text{ OR } b) \text{ AND } (a \text{ OR } c);$$

$$a \text{ AND } (b \text{ OR } c) = (a \text{ AND } b) \text{ OR } (a \text{ AND } c);$$

De Morgan's Law:

- ▶  $\text{NOT } (a \text{ AND } b) = (\text{NOT } a) \text{ OR } (\text{NOT } b)$

- ▶  $\text{NOT } (a \text{ OR } b) = (\text{NOT } a) \text{ AND } (\text{NOT } b)$

## De Morgan's Law?

- ▶ He doesn't want tea or coffee.  
He doesn't want tea and he doesn't want coffee.
- ▶ She doesn't want strawberries and cream.  
She doesn't want strawberries and she doesn't want cream?  
She doesn't want strawberries or she doesn't want cream?
- ▶ He isn't taller than Susan and Mary.  
He isn't taller than Susan and he isn't taller than Mary.

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## References

An overview of Boolean Logic:

[http://en.wikipedia.org/wiki/Boolean\\_logic](http://en.wikipedia.org/wiki/Boolean_logic)

Stephen Crain's research on how context influences the interpretation of Boolean operators in natural language and how children acquire these operators.