AND, OR, and NOT

SET08104 Database Systems

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.

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- He entered the room AND sat down. $\Longrightarrow$ THEN

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- He entered the room AND sat down. $\Longrightarrow$ THEN
- She bought a computer AND a printer.

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

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- She bought a computer AND a printer. $\Longrightarrow$ AND
- Students in classes 101 AND 202. $\Longrightarrow$OR

OR

What does OR mean in these sentences:

- Would you like a beer OR a whisky.

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  $\Longrightarrow$ **exclusive OR**: EITHER OR (BOTH would be impolite)

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- I bet he is sitting in the bar and drinking a beer OR a whisky.

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  $\Longrightarrow$ **inclusive OR**: (BOTH is acceptable)

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What does OR mean in these sentences:

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  $\Longrightarrow$ **exclusive OR**: EITHER OR (BOTH would be impolite)
- I bet he is sitting in the bar and drinking a beer OR a whisky.
  $\Longrightarrow$ **inclusive OR**: (BOTH is acceptable)

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

NOT

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- Double negative: I doN'T DISlike computers. $\Longrightarrow$ positive
- Double negative: We doN'T need NO education.

NOT

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

Logical NOT NOT EXPRESSION always means EXPRESSION.

Inner and outer negation

- ALL cars are NOT blue.

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- ALL cars are NOT blue.
  $\Longrightarrow$ There is NOT ANY blue car.
  $\Longrightarrow$ NO car is blue.

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- NOT ALL cars are blue.
  $\Longrightarrow$ SOME car is NOT blue.

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  $\Longrightarrow$ SOME car is NOT blue.
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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.

Other inner and outer statements

- I don't like tea and coffee.
  $\Longrightarrow$ 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.)

Other inner and outer statements

- I don't like tea and coffee.
  $\Longrightarrow$ 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.

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)

NOT (NOT a) = a
a OR a = a; a AND a = a
a OR b = b OR a; a AND b = b AND a;
a OR (b AND c) = (a OR b) AND (a OR c);
a AND (b OR c) = (a AND b) OR (a AND c);

De Morgan's Law:

- NOT (a AND b) = (NOT a) OR (NOT b)
- NOT (a OR b) = (NOT a) AND (NOT b)

De Morgan's Law?

- He doesn't want tea or coffee.

De Morgan's Law?

- He doesn't want tea or coffee.
  He doesn't want tea and he doesn't want coffee.

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.

De Morgan's Law?

- He doesn't want tea or coffee.
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- 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?

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.

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.

References

An overview of 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.