

A decorative graphic on the left side of the slide, consisting of a network of white lines and small circles on a blue gradient background, resembling a circuit board or a neural network.

WEEK 9

FUNCTIONAL DEPENDENCIES

STUDENT OBJECTIVES

- Upon completion of this video, you should be able to:
 - Given two attributes, determine if they functionally determine each other
 - Draw the functional dependencies for a table
 - Differential between a full functional dependency and a partial dependency
 - List the 3 rules you can use to help derive functional dependencies

FUNCTIONAL DEPENDENCY

- Functional Dependencies is the main tool for measuring the appropriateness of your attribute grouping into relations.
- Used to normalize into second and third normal forms.
- $X \rightarrow Y$ (**Y is functionally dependent (FD) on X**) where X and Y are sets of attributes from relation instance r of R states that for any 2 tuples t1 and t2 in r such that if $t1[X] = t2[X]$ then $t1[Y] = t2[Y]$. I.E. the values of the Y component of a tuple in r depend on, or are uniquely determined by the X component (**X functionally determines Y**).

Assume we have a row (t1) with the attribute LastName (X) with a value of "Jones"

We have another row (t2) with the attribute LastName(X) also with a value of "Jones"

Can we say FOR SURE what the value of Y (StudentNumber) would be?

NO, so LastName does NOT functionally determine StudentNumber

Now assume we have row (t1) with the attribute StudentNumber (X) with a value of 250012345

Can we say FOR SURE what the value of Y (LastName) would be?

YES, if we know the StudentNumber, then we know the LastName FOR SURE! So StudentNumber does functionally determine LastName

EXAMPLES

- Assume you have:
 - The student table full of data
 - The course table full of data
 - The grades table full of data
- If I give you the student number: **250512345**, can you tell me **FOR SURE** the last name of the student? ✓
- If I give you the last name: **Wonnacott**, can you tell me the student number of the student? ✗
- If I give you **87%** can you tell me **for sure** which student & course it is for? ✗
- If I give you the student number **250512345** can you tell me the final grade? ✗
- If I give you the course number **cs3319a** can you tell me the final grade? ✗
- If I give you **250512345** AND **cs3319a**, can you tell me the final grade? ✓

ID & course number functionally determine final grade.

EXAMPLES:

- EmpID → {Lastname, Firstname}
- ProjectNumber → {ProjectName, ProjLocation}
- {EmpSSNum, ProjectNumber} → Hours
- Sex → Bad! NO!

The image shows three screenshots of database tables. The top screenshot is the 'Project' table, the middle is the 'Department' table, and the bottom is the 'Employee' table.

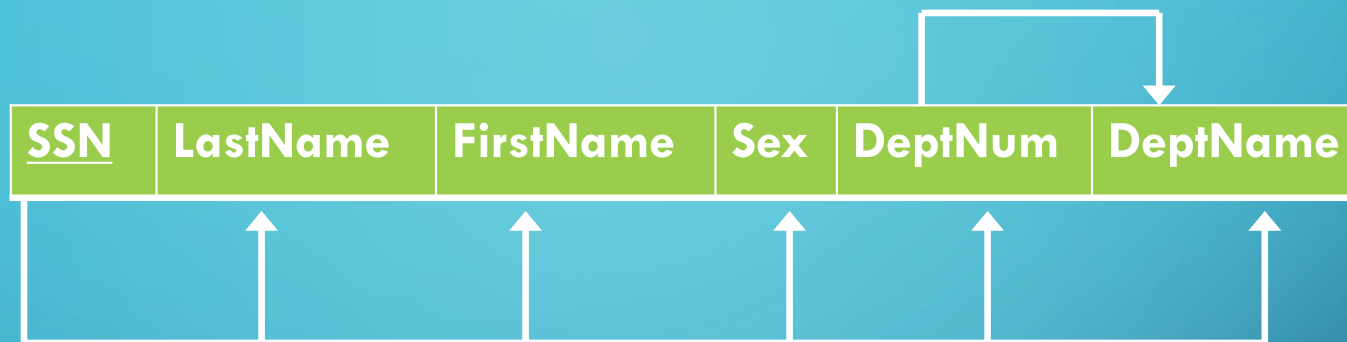
ProjectNu	ProjectName	ProjLocati	Managing
A1	Accounting Update	Toronto	S7G
A3	Acc3	Springfield	G8H
A6	Acct6	Toronto	S7G
I1	Inventory	Toronto	G8H
I2	Inventory2	London	S7G
P1	Payroll	Springfield	G8H
P2	Payroll2	London	G8H
P3	Payroll3	London	G8H

DeptNun	DeptName	ManagerEmpID	ManagerStartdate
G8H	Head Office	4	12/12/1999
S7G	Safety Department	3	11/11/1998
YSJ	Research Department	6	12/24/1998

EmpID	Last Name	First Name	DeptNumber	Sex	BDate	SuperSSN	Salary
1	Simpson	Bart	G8H	M	2/2/1995	2	\$1,000.00
2	Smithers	Waylan	S7G	M	1/1/1960	4	\$2,000.00
3	Beauvieu	Patty	YSJ	F	3/3/1959	6	\$4,000.00
4	Burns	Monty	S7G	M	7/7/2020		\$5,000.00
6	Simpson	Lisa	S7G	F	6/6/1990	2	\$1,000.00
12	Simpson	Homer	G8H	M	8/8/1961	2	\$2,000.00

We can say that if we are given the value of EmpID, we KNOW the LastName and FirstName of the employee, or we must find a unique LastName and FirstName. (EmpID functionally determines first and last name)

Draw functional dependencies like this:



- FD cannot be inferred automatically from the particular instance of the database, but must be defined by someone who knows the semantics of the database.

Example:

Pilot	Airline	Flight
Jones	Air Emirates	345
Nelson	Delta	543
Smith	United Airlines	365
White	Air Canada	322

QUESTION: Is the pilot functionally dependent on the airline or the flight? ✗

*It is in this case,
but it may be not for the rest of the data.*

- A functional dependency $X \rightarrow Y$ is a **full functional dependency** if removal of any attribute A from X means that the dependency does not hold anymore.
- A functional dependency $X \rightarrow Y$ is a **partial dependency** if some attribute A contained in X can be removed from X and the dependency still holds.

EXAMPLE:

SSN	Ename	Pnumber	Hours
2222	Smith	X	45
4444	Jones	Y	23
1111	Simpson	Y	10
4444	Jones	W	22

- $\{SSN, PNumber\} \rightarrow Hours$ is a **full** dependency because neither $\{SSN\} \rightarrow Hours$ nor $\{Pnumber\} \rightarrow Hours$ holds
- However $\{SSN, PNumber\} \rightarrow Ename$ is **partial** because $\{SSN\} \rightarrow Ename$ holds.

QUESTION: Circle the one that is valid:

Postal Code \rightarrow City OR *City \rightarrow Postal Code*

DEDUCING NEW FUNCTIONAL DEPENDENCIES FROM GIVEN ONES

- Sometimes you want to know what the consequences are of some given FDs
- There are rules called inference rules that allow you to make these deductions
- The following set of 3 rules is what is called a complete set (they allow you to derive anything which can be derived).

- **Reflexive rule** (not really useful): if X is a set of attributes and $X \supseteq Y$, then $X \rightarrow Y$ (or: If A is a set of attributes, and B is a set of attributes that are completely contained in A , then A implies B .)

- $X = \{\text{lastname}, \text{firstname}, \text{ssn}\}$, $Y = \{\text{firstname}\}$ then $X \rightarrow Y$
- THEN lastname, firstname, ssn \rightarrow firstname

- **Transitive rule:** if $X \rightarrow Y$ and $Y \rightarrow Z$ then $X \rightarrow Z$

- $X = \{\text{ssn}\}$, $Y = \{\text{deptno}\}$, $Z = \{\text{deptname}\}$ and $\text{ssn} \rightarrow \text{deptno}$ and $\text{deptno} \rightarrow \text{deptname}$
- THEN $\text{ssn} \rightarrow \text{deptname}$

- **Union or additive rule:** if $X \rightarrow Y$ and $X \rightarrow Z$ then $X \rightarrow YZ$

- $X = \{\text{ssn}\}$, $Y = \{\text{deptno}\}$, $Z = \{\text{lastname}\}$, $\text{ssn} \rightarrow \text{deptno}$ & $\text{ssn} \rightarrow \text{lastname}$
- THEN $\text{ssn} \rightarrow \text{deptno}, \text{lastname}$

QUESTION: Suppose you are given $\{SSN\} \rightarrow \{Address\}$ and $\{Address\} \rightarrow \{PostalCode\}$. Can you derive $\{SSN\} \rightarrow \{PostalCode\}$? ✓

Can you derive $\{SSN, Address\} \rightarrow \{PostalCode\}$?

Add \rightarrow PC.

Can you derive $\{PostalCode\} \rightarrow \{SSN\}$? What about $\{SSN, PostalCode\} \rightarrow \{Address\}$?
✗

Another definition of **Candidate Key** is that it is any set of attributes K such that you can derive $K \rightarrow \{\text{all the attributes in the relation}\}$.

REVIEW

- Check all that apply

ProjectNu	ProjectName	ProjLocati	Managing
A1	Accounting Update	Toronto	S7G
A3	Acc3	Springfield	G8H
A6	Acct6	Toronto	S7G
I1	Inventory	Toronto	G8H
I2	Inventory2	London	S7G
P1	Payroll	Springfield	G8H
P2	Payroll2	London	G8H
P3	Payroll3	London	G8H

DeptNun	DeptName	ManagerEmpID	ManagerStartdate
G8H	Head Office	4	12/12/1999
S7G	Safety Department	3	11/11/1998
Y5J	Research Department	6	12/24/1998

EmpID	LastName	FirstName	DeptNumber	Sex	BDate	SuperSSN	Salary
1	Simpson	Bart	G8H	M	2/2/1995	2	\$1,000.00
2	Smithers	Waylan	S7G	M	1/1/1960	4	\$2,000.00
3	Beauvieu	Patty	Y5J	F	3/3/1959	6	\$4,000.00
4	Burns	Monty	S7G	M	7/7/2020		\$5,000.00
6	Simpson	Lisa	S7G	F	6/6/1990	2	\$1,000.00
12	Simpson	Homer	G8H	M	8/8/1961	2	\$2,000.00

EmpSSNu	ProjectNu	Hours
1 A3		45
2 A1		56
3 A3		3
3 A6		45
3 I1		43
3 P1		9
4 A1		6
4 A3		5
4 A6		6
4 I1		43
4 I2		8
4 P1		67
4 P2		77
4 P3		67
6 I2		6
12 A3		56

Functional Dependency

True

False

EmpID → Bdate



DeptNum → Manager's LastName



DeptNum → Emp LastName



EmpID → DeptName



Salary → EmpID

