IE301

Analysis and Design of Data Systems

Lecture 16

General Definitions of 2NF & 3NF
Boyce-Codd Normal Form

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General Definitions of 2NF & 3NF

So far definitions of 2NF and 3NF were based on Primary Keys, hence the normalization procedure was useful in situations for a given database when the primary keys were already been defined.

Now, let's give definitions of 2NF and 3NF that take all candidate keys into account.

General definition of **prime attribute:**

An attribute that is part of *any candidate key* will be considered as prime

Definition:
If a functional dependency $X -> Y$ holds true where Y is not a subset of X then this dependency is called **non-trivial** Functional dependency.

General Definition of 2NF

Definition based on primary key:

A relation schema R is in 2NF if every nonprime attribute A in R is *fully functionally dependent* on the primary key of R.

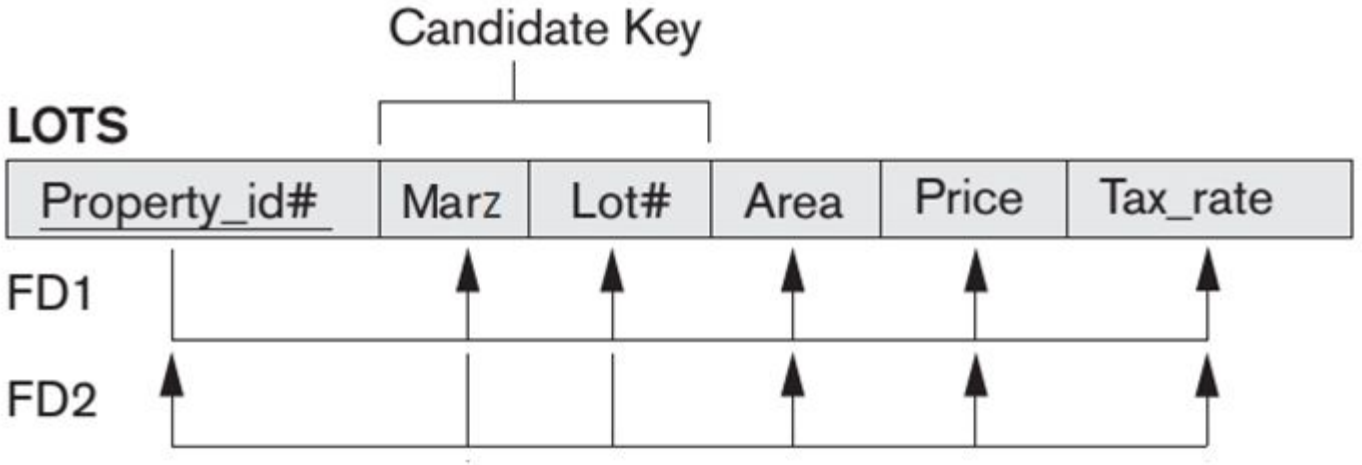
General Definition:

A relation schema R is in **second normal form (2NF)** if every nonprime attribute A in R is *fully functionally dependent* on every key of R.

Example

Relation LOTS describes pieces of land for sale in various Marzes of Armenia

- Lot numbers are unique only within each county
- Property_id# numbers are unique across the country

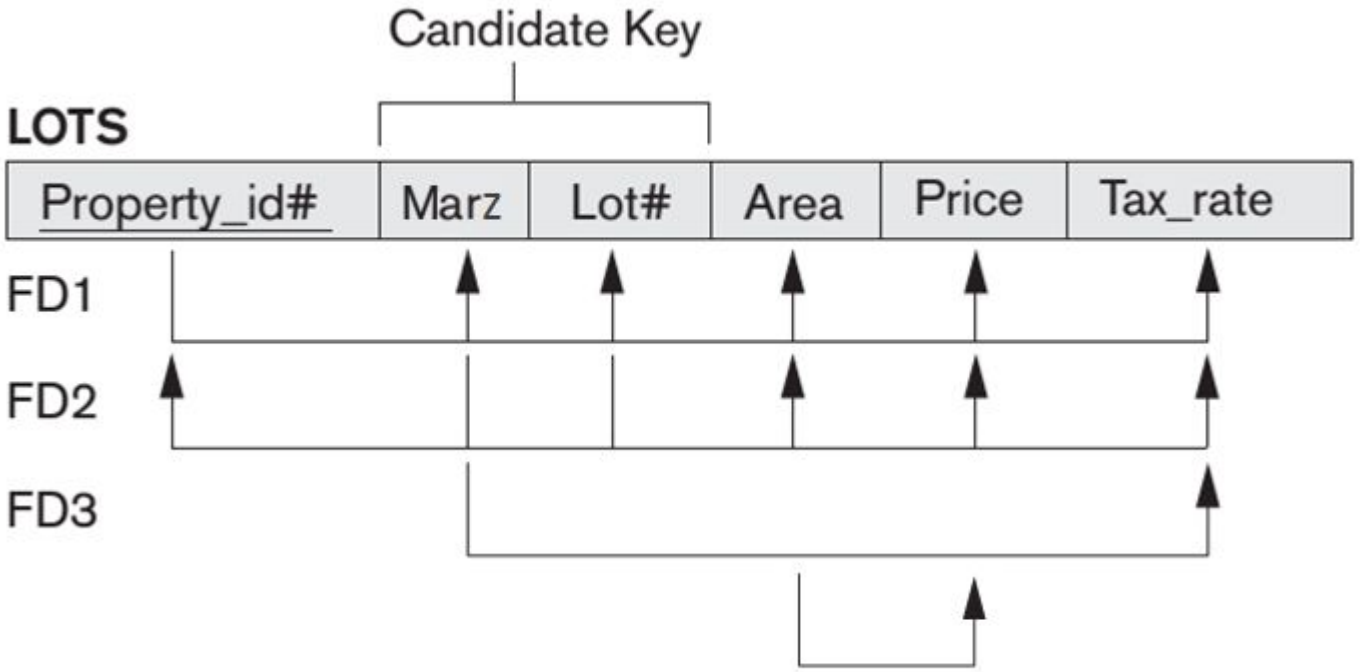


Since the primary key consists of only one attribute, it means that all the nonprime attributes are fully functionally dependent on the primary key

Example (cont.)

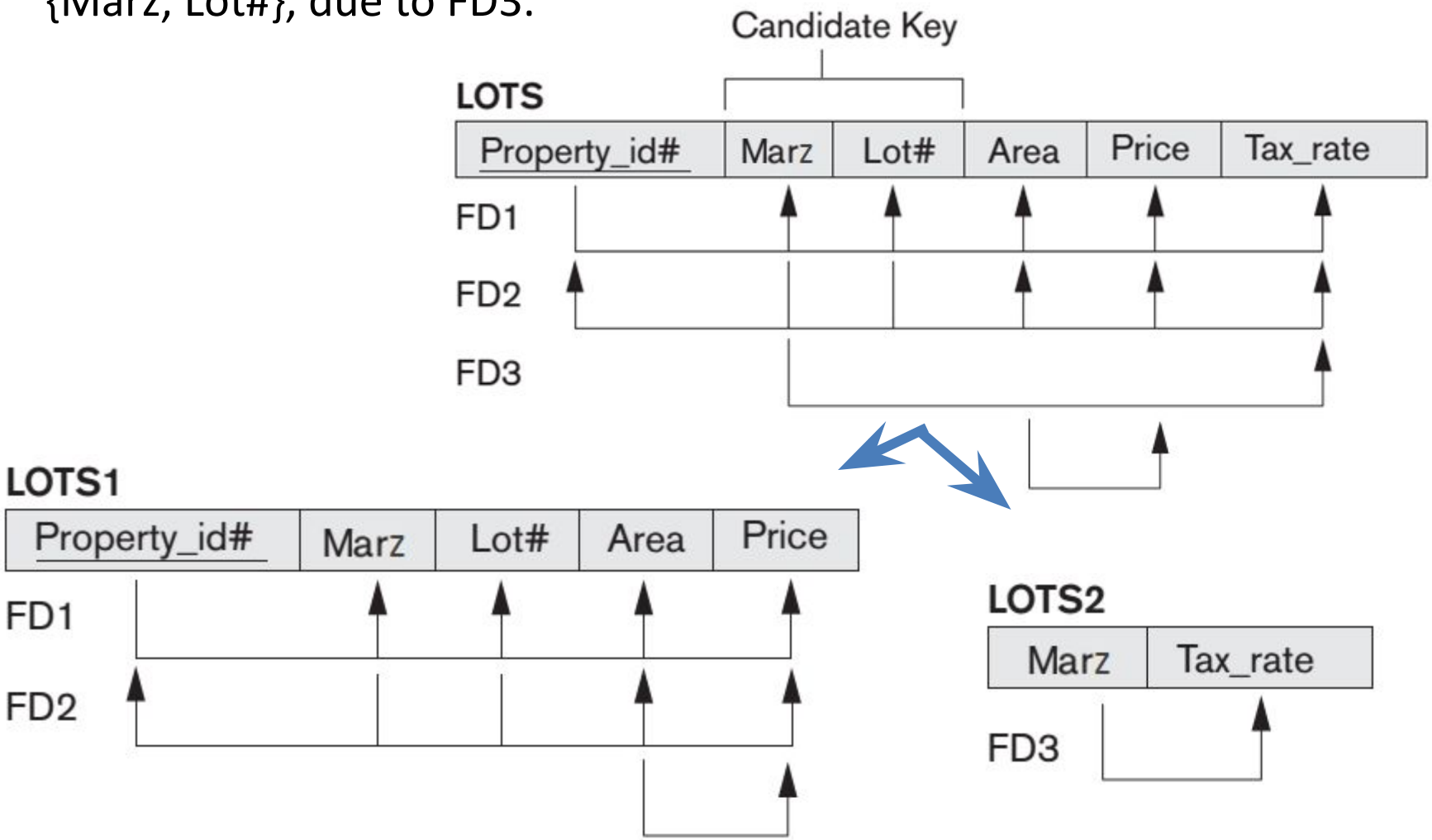
Suppose that the following two additional functional dependencies hold in LOTS: FD3: Marz → Tax_rate, Area → Price

- ✔ FD3 says that the tax rate is fixed for a given Marz (does not vary lot by lot within the same Marz)
- ✔ FD4 says that the price of a lot is determined by its area regardless of which Marz it is in. (Assume that this is the price of the lot for tax purposes.)



Example (cont.)

- The LOTS relation schema violates the general definition of 2NF because Tax_rate is partially dependent on the candidate key {Marz, Lot#}, due to FD3.



General Definition of 3NF

Definition based on primary key:

A relation schema *R* is in **3NF** if it satisfies 2NF *and* no nonprime attribute of *R* is transitively dependent on the primary key.

General Definition:

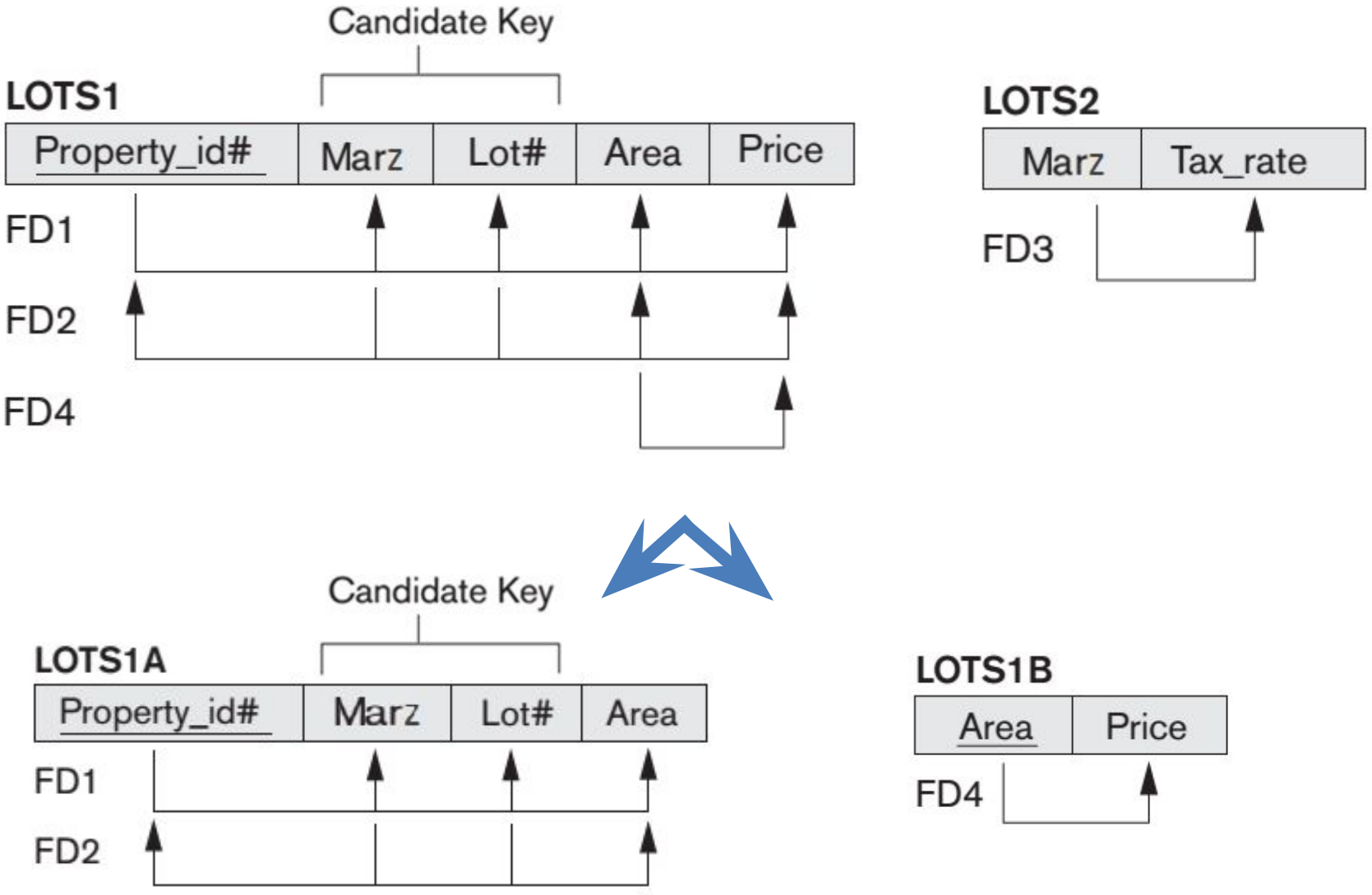
A relation schema *R* is in **3NF** if every nonprime attribute of *R* meets both of the following conditions:

- It is fully functionally dependent on every key of *R*.
- It is nontransitively dependent on every key of *R*.

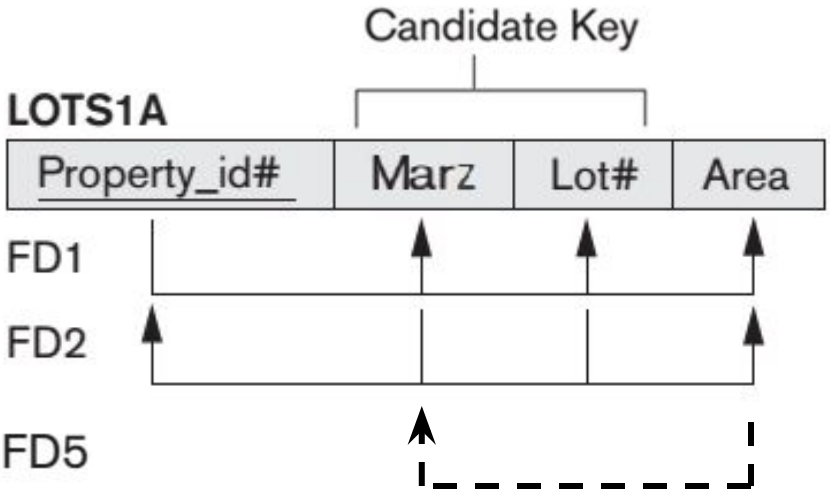
Alternative Definition:

A relation schema *R* is in **3NF** if, whenever a *nontrivial* functional dependency $X \rightarrow A$ holds in R, either (a) X is a superkey of R, or (b) A is a prime attribute of R.

Example


Candidate Key
LOTS1
Property_id#
Marz
Lot#
Area
Price
FD1
FD2
FD4
LOTS2
Marz
Tax_rate
FD3
Candidate Key
LOTS1A
Property_id#
Marz
Lot#
Area
FD1
FD2
LOTS1B
Area
Price
FD4

Boyce-Codd Normal Form (BCNF)



Is in 3NF

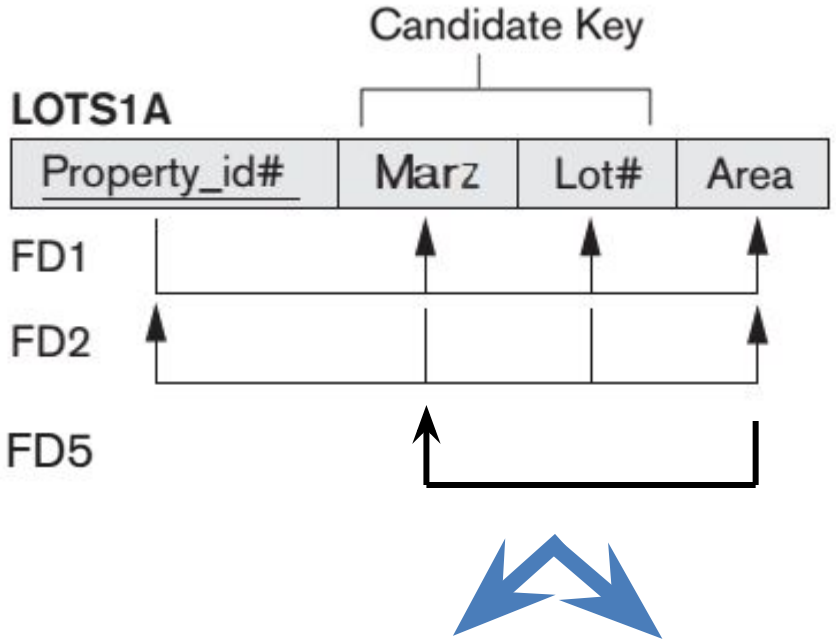
Let's imagine that:

- We have only two Marzes: Kotayk and Shirak
- Lot sizes in Kotayk marz are only 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0 hectares
- Lot sizes in Shirak marz are restricted to 1.1, 1.2, ..., 1.9, and 2.0 hectares

✓ In such a situation we would have new FD5: Area → County_name

 FD5 is a source of redundancy

Boyce-Codd Normal Form (BCNF)



Definition. A relation schema R is in **BCNF** if whenever a *nontrivial* functional dependency $X \rightarrow A$ holds in R, then X is a superkey of R.