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INFORMATION MODEL FOR MANAGEMENT OF NANOTECHNOLOGIES

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1. Introduction

The realization aspect of an information model for management of nanotechnologies in electronics is studied in a University. A relational data base is designed, containing information for management of nanotechnologies. The main goal of the relational database design is optimization by elimination of the data dependency. This dependency will be overcome by transformation of relational schemas, representing classes of managed objects, in normal form. The transformation is performed by methods, depending on the number of the managed objects and the number of the actors.

2. Functional dependencies

The data dependency is a restriction over the possible relations, which could represent the current set of copies of a relational schema. For example, if one attribute of the schema defines entirely another attribute, then "the second attribute is functionally dependent on the first attribute", or "the first attribute defines functionally the second".

The data dependency can generate several problems.

- Excess of data-one attribute is written always as functionally determining attribute
- Potential contradiction (anomalies in the updates) Due to the excess of data, one attribute may be updated in one record, while it could remain the same in another one. In this case there will be not a single unique value for the functionally determining attribute.
- Insertion anomaly: It will be impossible an attribute to be recorded, if it is not functionally defined by another one. The value zero can be put on the place of the determining attribute, but with the input of such attribute, the row with zero value should always be deleted. Furthermore since, the defining attribute represents the relation key, if the field for the key contains zero, the reviewing of the rows, according to the primary index may become impossible.
- Deletion anomaly: The opposite problem to this in the above item is that: if all attributes, determining one other attribute should be deleted, the determining attribute would be lost.

To avoid all these problems, the relations should meet the following restrictions conditions:

- Depending on the equality or inequality of values
- Independent of values: Functional dependency and other

The second type of restrictions exerts greater influence on the database schema, as compared to the first type.

To show, that the projected relational schemas for the management of nanotechnologies do not contain functional dependencies, which leads to the mentioned above problems, there are used consequences of the functional dependencies.

For the set of consequences F+, or to say that at defined candidate keys, the functional dependency is in F+, deduction rules are needed, which have to state how one or more dependencies entail other dependencies. These are rules, which give the opportunity to extract all correct dependencies, i.e. these in F+ from a given set of dependencies F. This body of inference rules is named Armstrong' axiom (4)

A1: Reflexivity: If $Y \subseteq X \subseteq U$, then F logically implies $X \rightarrow Y$

A2: Augmentation: If $X \rightarrow Y$ and Z is subset of U, then $XZ \rightarrow YZ$

A3: Transitivity: If $X \rightarrow Y$ and $Y \rightarrow Z$, then $X \rightarrow YZ$

A4: Union: $\{X \rightarrow Y, X \rightarrow Z\}$ I= $X \rightarrow YZ$

A5: Pseudo transitivity: $\{X \rightarrow Y, WY \rightarrow Z\}$, I=W $X \rightarrow Z$

A6: Decomposition: $X \rightarrow Y$ and $Z \subseteq Y$, then $X \rightarrow Z$

3. Normal forms

Aiming to avoid the problems with duplicates and anomalies, considered above, the relational schemas for management of nanotechnologies in electronics should be transformed in normal form. The normal form is a property of the relational schemas with dependencies. The most important of them are the “third normal form” and “the normal form of Boyce-Codd”.

- Boyce-Codd normal form: The normal form of Boyce-Codd is a stronger version than the normal forms. A relation schema R is a Boyce-Codd normal form, if and only if the following conditions are hold: $X \rightarrow A$, and A is not in X, then X is superkey for R, i.e. X is superkey, or contains a superkey.
- Third normal form: A relation schema R is a third normal form, if and only if the following conditions in R hold: $X \rightarrow A$, and A is not in X, then or X is a superkey for R, or A is a prime-attribute. The definitions of both Boyce-Codd normal form and third normal form are identical, except the clause “or A is a prime-attribute”, which make the third normal form slightly weaker than the Boyce-Codd normal form. An attribute A in a relational schema R is a prime-attribute, if all keys in R contain A. If A is not contained in any key in R, then A is no-key attribute.

4. Transformation of relational schemas in Boyce-Codd normal form

The Boyce-Codd normal form is chosen, as it is stronger than the third normal form. The checking whether X is a key is made according to the following algorithm:

Algorithm for checking whether a given attribute is a key:

- Determines the set of consequences of F:F+

F is a set of functional dependencies, valid for the relation R.

- X is chosen and it is checked whether X is a superkey

X is chosen as a set of attributes, which clearly define the entity. X is a key in R, if:

- o $X \rightarrow \{A_1, A_2 \ldots A_n\} \in F+$ or

$\{A_1, A_2\} \rightarrow \{A_1, A_2 \ldots A_n\} \in F+$

- o $Y \subset X$, for example A_1

Then $A_1 \rightarrow \{A_1, A_2 \ldots A_n\} \notin F+$ minimal condition

Depending on the number of objects in the relational schema and the number of actors, two methods are used: direct method, and decomposition method

- Direct method: It is applied to transform relational forms in normal form with:
    - Smaller number of managed objects and 1 or more actors
    - Greater number of managed objects and 1 actor

The method only contains an algorithm for checking whether a given attribute is a key.

- Decomposition method: It is applied to transform relational forms, with greater number of managed objects and one actor, in normal form. The method contains:
    - Decomposition in constituent schemas
    - Applying an algorithm for checking whether the given attribute is a key for each schema
    - Determining the superkey for the whole schema.

At the transformation, the role of attributes is played by predefined managed objects (2),(3). The direct method is illustrated by an example of the developed information models.

5. Results

The information model of the configuration of nanotechnologies (2),(3), is transformed in Boyce-Codd normal form by the direct method. The schema contains two actors: professor and assistant. The attributes taking part in this information model are: NanotConfiguration, NanotComponent, Material, Design, Device, Memory, Optoelectronics, NanotData, AssConfiguration, PIN, Interest. Affixed to:

NanotConfiguration = A

NanotComponen = B

Material = C

Design = D

Device = E

Memory = F

Optoelectronics = G

NanotData = H

AssConfiguration = I

PIN = J

Interest = K

The relational schema R = ABCDEFGHIJK is obtained.

It has to be proven, that at the given dependencies, the relation has a key. For this purpose, the algorithm for checking whether a given attribute is a key is used.

On fig.1 are shown the functional dependencies of the set F.

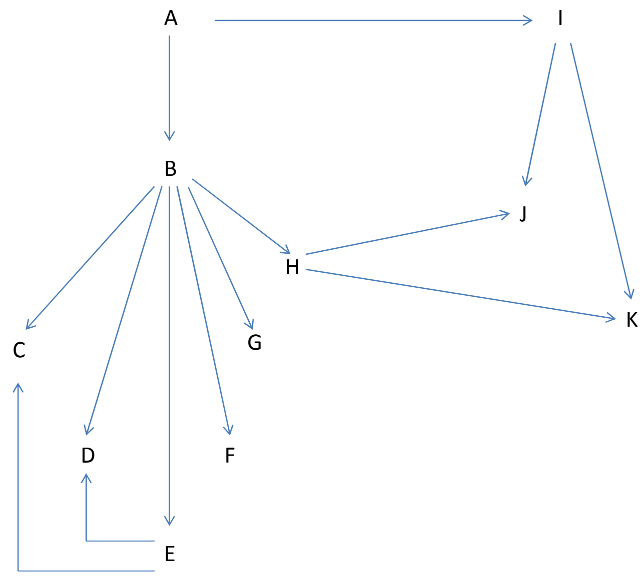

Fig. 1. Functional dependencies in a Configuration of nanotechnologies
Information model for management of nanotechnologies, Mila Ilieva-Obretenova

Figure 1. Functional dependencies in a Configuration of nanotechnologies

The functional dependencies in the set F are:
A→B, B→C, B→D, B→E, B→F, B→G, B→H, E→C, E→D, A→I, I→J, I→K, H→J, H→K
The functional dependencies in the set F+ are:

1. From I→J, I→K,

   =>I→JK∈ F+ (union lemma)

2. From A→I and I→JK

   =>A→JK∈ F+ (transitivity lemma)

3. From B→C, B→D, B→E, B→F, B→G, B→H

   => B→CDEFGH∈ F+ (union lemma)

4. From E→C, E→D

=>E→CD∈ F+ (union lemma)

5. From A→B, and B→CDEFGH

=>A→ CDEFGH ∈ F+ (transitivity lemma)

6. From A→JK, and A→CDEFGH

=>A→ CDEFGHJK ∈ F+ (decomposition lemma)

An assumption is made, that A is a key, i.e. A→ABCDEFGHIJK

Z= CDEFGHJK ⊂ ABCDEFGHIJK is applied

=>A→ CDEFGHJK (decomposition lemma)

It is already proven that A→ CDEFGHJK ∈ F+

=>A is a key of the relational schema

=> the attribute NanotConfiguration is a key of the relational schema Configuration of nanotechnologies

=> The relational schema Configuration of nanotechnologies is in Boyce-Codd normal form.

6. Conclusions

A relational database is projected on the base of developed models for management of nanotechnologies. The relational schemas with classes of managed subjects are transformed in Boyce-Codd normal form. In result the database is optimized, and the data dependencies, which can lead to an excess of data and anomalies at the updating of the database content, is avoided. The direct approach is applied at the transformation in Boyce-Codd normal form. The approach is illustrated with the relational schema of the Configuration of nanotechnologies.

It is also suitable for the following schemas: Nanotechnologies' installing, Nanotechnologies' maintaining, and Nanotechnologies' defense, Nanotechnologies' taxing, as well as, Technical characteristics of the information system and Users' control. The approach based on the decomposition to the transformation in Boyce-Codd normal form shall apply to the schema-Technology providing. A creation of a prototype of the database is forthcoming(1).

References:

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