



MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

Ukrainian State University of Science and Technology

Department «Electronic Computers»

DATABASE

Methodical recommendations for individual task

ЕЛЕКТРОННИЙ АНАЛОГ ДРУКОВАНОГО ВИДАННЯ

Dnipro 2022

UDK 681.3:519.68

Authors:

V. M. Pakhomova

Reviewer:

head of the department of Telecommunication Systems and Networks, Dniprovsky
National University named after Olesya Gonchara
doctor of technical sciences, professor *V. M. Korchinsky*;
Department «Foreign Languages» (protocol № 6 from 17.01.2022)

Recommended to friend MCF CTS (protocol № 5 from 11.02.2022).
Registered EMD UDUST (registry № 550 from 25.05.2022).

Databases [Text]: methodical recommendations for individual task / Authors: V. N. Pakhomova; Ukrainian State University of Science and Technology. Dnipro : Edition Department of Ukrainian State University of Science and Technology, 2022. – 20 p.

Methodological recommendations are aimed at preparing and doing individual tasks in the discipline «Databases» for foreign applicants of Bachelor's Degree of specialties 123 «Computer Engineering» and 125 «Cybersecurity».

Fig. 18. Bibliogr. titles. 4.

Pakhomova V. M.; packing, 2022
Edition Department of Ukrainian State University
of Science and Technology,
editing, original layout, 2022

CONTENTS

| | |
|--|----|
| Preface | 4 |
| 1. STATEMENT OF THE COURSE ASSIGNMENT..... | 5 |
| 1.1 Formulation of the course assignment..... | 5 |
| 1.2 List of topics for the course assignment..... | 5 |
| 2. AN EXAMPLE OF A COURSE ASSIGNMENT..... | 7 |
| Exercise № 1: Elements of the relational model..... | 7 |
| Exercise № 2: Types of binary links..... | 8 |
| Exercise № 3: Example of designing a database by the «Normal forms» method..... | 10 |
| Exercise № 4: Example of designing a database by the «Essence-Relation» method..... | 15 |
| Test questions and tasks..... | 18 |
| Conclusions..... | 19 |
| References | 19 |

Preface

Methodical recommendations for the individual task in the «Databases» discipline are intended for bachelors of specialties 123 «Computer Engineering» and 125 «Cybersecurity» of foreign origin in order to design a relational database using mathematical and graphical methods. Methodical recommendations contribute to the achievement of the following learning outcomes:

- implementation of binary binding of tables based on the use of a foreign key;
- definition of functional dependencies between attributes;
- assessment of the degree of normalization and denormalization of the relations;
- comparison of the process and results of relational database design by different methods;
- development of a general structure of a relational database with the definition of relation keys and link keys.

The methodical recommendations formulate the formulation of the course task, which consists of the following parts: study of the elements of the relational data model; creating binary relationships of entity tables; designing a database by the method of normal forms; design of the database by the «Essence-Relation» method, topics for the course task, as well as examples of all parts of the course task.

At the end of the educational and methodical publication, control questions on the defense of the course task are presented, as well as a list of recommended sources. Preparation for the course task involves the processing of lecture material (in the form of presentations) in the «Databases» discipline in distance learning «Lider» system [1], as additional sources are recommended [2-3]. The teacher developed a methodology for the formation of competencies in applicants of the bachelor's degree of foreign origin in distance learning in the «Databases» discipline in [4].

1. STATEMENT OF THE COURSE ASSIGNMENT

1.1. Formulation of the course assignment

Exercise № 1. Show the elements of the relational database based on the table. Specify possible keys for the relation.

Exercise № 2. Demonstrate the binary link of essence tables. In each table specify the link key (+) and the primary of relations (*).

Exercise № 3. Using the normal forms method, normalize an original relation that has redundant data duplication. The table should have 9-11 attributes.

Exercise № 4. Take the original relation from exercise № 3 and use the «Essence-relation» method to design the database.

1.2. List of topics for the course assignment

1. Shops sell cars.
2. Real estate companies sell houses.
3. Firms produce furniture.
4. Marriage agencies offer services.
5. Cinemas show movies.
6. Dating sites accept applications.
7. Actors act in films.
8. Public transport runs routes.
9. Pharmacy sells drugs.
10. Universities are engaged in research work.
11. Students live in dormitories.
12. Medical institutions buy medicines.
13. Universities have faculties.
14. Firms sell mobile phones.
15. Sports clubs offer services.
16. Artists release music albums.
17. Libraries subscribe to the press.
18. Tourists go on vacation.
19. Restaurants offer “crown“ dishes.
20. Athletes choose simulators.
21. Dry cleaners offer services.
22. Coaches conduct classes.
23. Fast food offers a menu.
24. Computer network works on technology.

25. Banks serve customers.
26. People check into a hotel.
27. Programmers fulfill orders.
28. Antiviruses protect objects.
29. Students take exams.
30. Meteorological center provides weather.
31. Animals are listed in the Red Book.
32. Universities train specialists.
33. Film studios produce films.
34. Writers write books.
35. TV channels offer entertainment programs.
36. Clothing designers hold a show.
37. Countries are preparing for the Olympics.
38. Football clubs buy football players.
39. Nurseries grow trees.
40. The traffic police patrols the roads.
41. Children have hobbies.
42. People move into apartments.
43. People are doing apartment renovations.
44. New stores are opening in the cities.
45. Football clubs play in the Champions League.
46. Mines extract coal.
47. Fashion studios accept orders.
48. Beauty salons offer services.
49. Applicants enter universities.
50. Farmers grow vegetables.
51. Airports accept aircraft.
52. Museums hold exhibitions.
53. Children play with toys.
54. Nominees receive the Nobel Prize.
55. Climbers conquer the peaks.
56. Artists paint pictures.
57. Stations serve passengers.
58. Airplanes fly.
59. Banks issue loans.
60. A football player scores a goal.

2. AN EXAMPLE OF A COURSE ASSIGNMENT

Exercise № 1: Elements of the relational model

Essence is the object of any nature, which data is stored in the database.

Attributes is the characteristic of essence (they correspond to the column headers of the table).

Cortege (tuple) – a just string of two-dimensional table.

Scheme relation is the set of all attributes of relation.

Body relation is the set of all corteges.

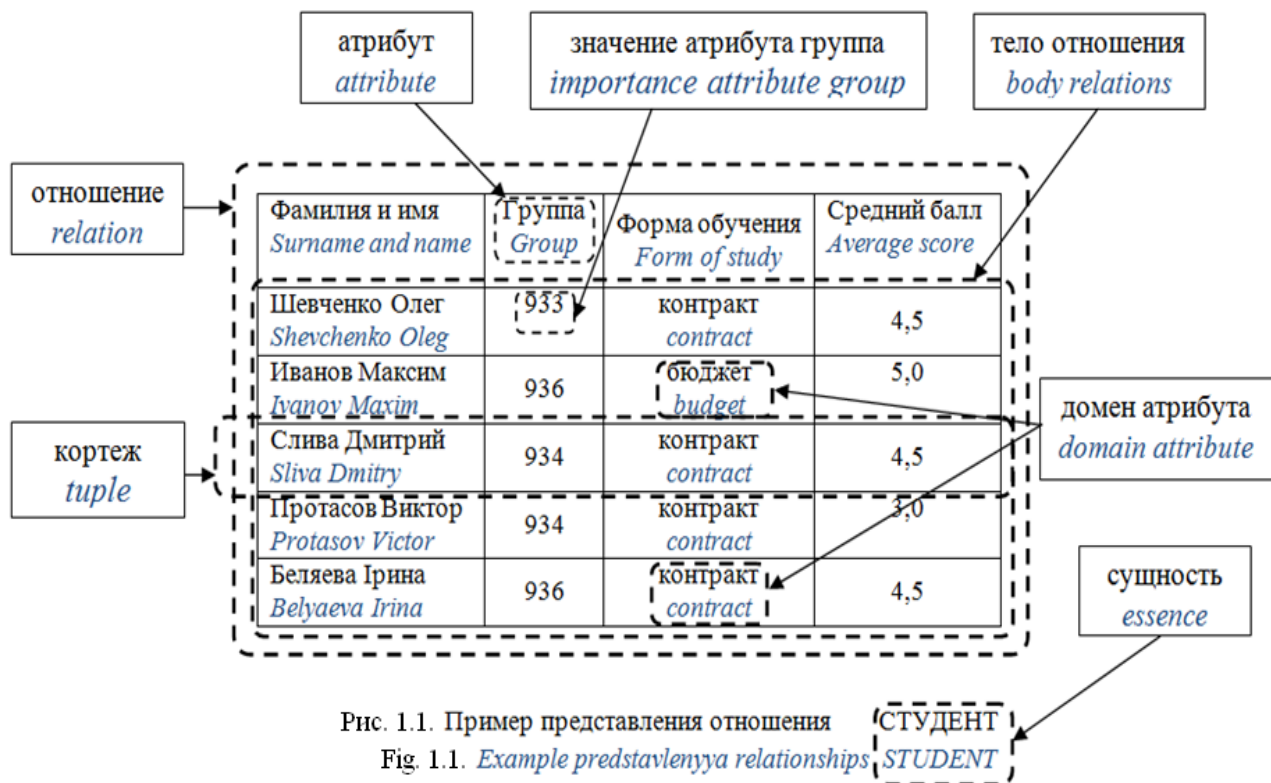
Attribute value – the value of the field in the record of table.

Data type – this type of element values in the table: numeric, text, date/time, money and others.

Domain – the set of all possible values of the attribute relation. The number of domains corresponds to the number of attributes.

Primary key – an attribute (simple key) or a group of attributes (a composite key) uniquely identifies each of its corteges. Each relation has a combination of attributes that can serve as a key.

Any relation has two characteristics: degree and power. **Degree of relation** is the number of attributes (static characteristic; 4 in Figure 1.1). **Power of relation** is the number of corteges (dynamic characteristic; 5 in Figure 1.1).



Exercise № 2: Types of binary links

The binary link 1:1 is established in the case where one cortege of main (left) table correspond to only one cortege of additional (right) table.

Since the values in the key fields of both tables are not repeated, then provided one-to-one correspondence of corteges of the tables. Tables are equal.

Example 1. Suppose we have the main table PRODUCTS and additional table WAREHOUSE (Figure 2.1). The binary link between cortege (0011; 2,50) of table PRODUCTS and cortege (0011; Str. Lazaryana 10) of table WAREHOUSE; the reason for this is the matching values of link key Product_Identifier in these tables.

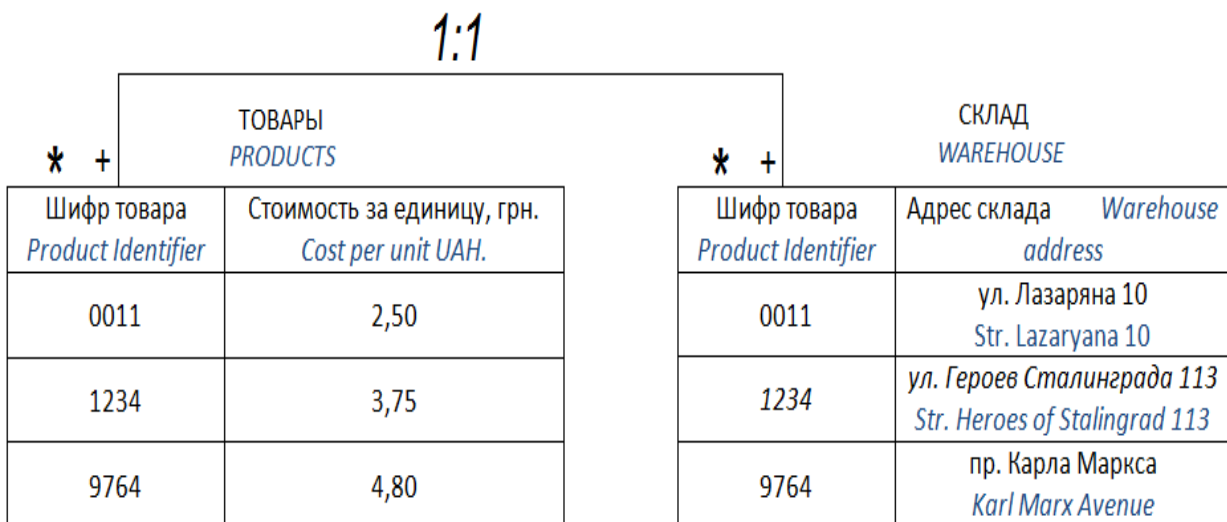


Fig. 2.1. The example of binary link 1:1:

* primary key; + link key

The binary link M:M is established in the case when multiple corteges of left table corresponds to multiple corteges of right table.

Note: The binary link M:M is characterized as a weak form of binary link.

The binary link 1:M is established in the case when one cortege of left table corresponds to multiple corteges of right table.

Note: The binary link 1:M has received the most widespread in practice.

Example 2. Suppose we have the tables STUDENTS and HOBBY (Figure 2.2). In the main table primary key is simple (Full_Name). In the additional table primary key is composite (Full_Name and Hobby). Link Key: Full_Name. In the table HOBBY attribute Full_Name is foreign key.

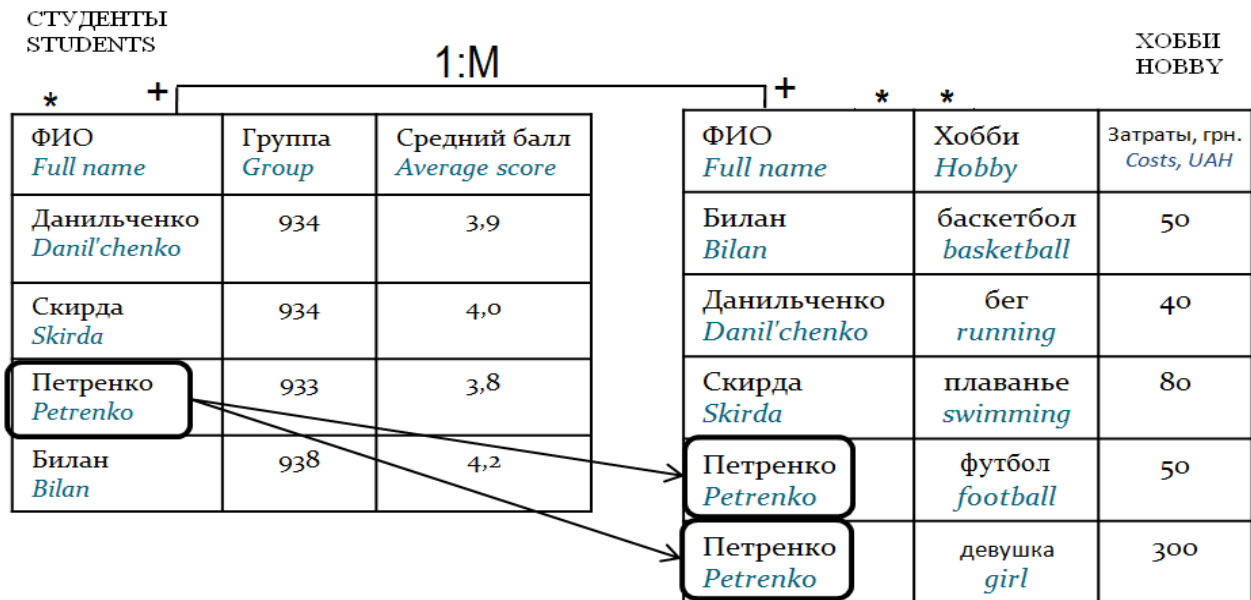


Fig. 2.2. The example of binary link 1:M:

STUDENTS – parent table; HOBBY – child table

The binary link M:1 is established in the case when multiple corteges of left table corresponds to one cortege of the right table.

Note: The binary link M:1 is the mirror image binary link 1:M.

Example 3. Suppose we are given two tables PATIENT and DOCTOR (Figure 2.3). In the table DOCTOR primary key is simple (Full_Name_doctor). In the additional table primary key is composite (Full_Name_doctor and Full_Name_patient). Link Key: Full_Name_doctor. In the table PATIENT attribute Full_Name_doctor is foreign key.

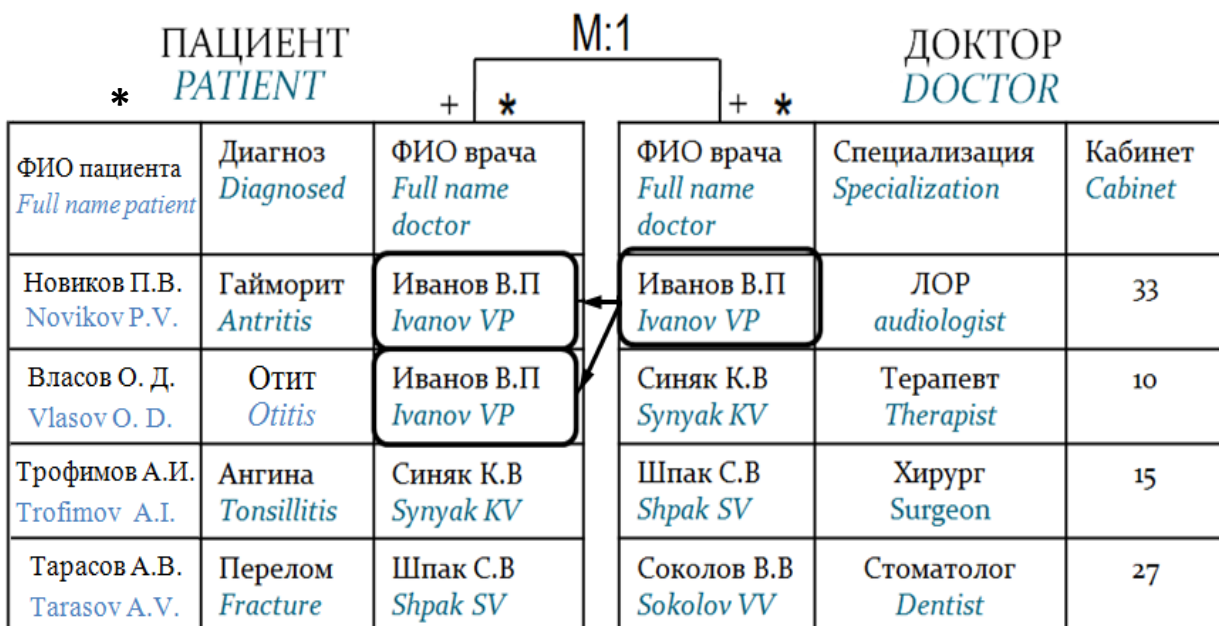


Fig. 2.3. The example of binary link M:1:

DOCTOR – parent table; PATIENT – child table

Exercise № 3: Example of designing a database by the «Normal forms» method

For the university creates database of teachers.

Composition of the original relation **TEACHER** (Figure 3.1).

| ФИО Full name | Должность Position | Оклад, грн. Salary, UAH | Стаж Seniority | Надб_ст, % Ex_sen, % | Кафедра Pulpit | Предмет Subject | Группа Group | Вид занятия Kind activities |
|--------------------------------------|----------------------------------|----------------------------|-------------------|-------------------------|-------------------|--|-----------------|--------------------------------|
| Жуковицкий И. В. Zhukovitsky I.V. | професор professor | 3000 | 40 | 30 | ЕОМ ЕС | криптография cryptography | 936 | лекция lecture |
| Жуковицкий И. В. Zhukovitsky I.V. | професор professor | 3000 | 40 | 30 | ЕОМ ЕС | защита информации protection informations | 946 | лекция lecture |
| Жуковицкий И. В. Zhukovitsky I.V. | професор professor | 3000 | 40 | 30 | ЕОМ ЕС | периферийные устройства peripheral devices | 943 | лекция lecture |
| Жуковицкий И. В. Zhukovitsky I.V. | професор professor | 3000 | 40 | 30 | ЕОМ ЕС | периферийные устройства peripheral devices | 944 | лекция lecture |
| Пахомова В. Н. Pahomova V.N. | доцент docent | 2500 | 25 | 20 | ЕОМ ЕС | организация БД organization database | 933 | лекция lecture |
| Пахомова В. Н. Pahomova V.N. | доцент docent | 2500 | 25 | 20 | ЕОМ ЕС | организация БД organization database | 933_2 | лаб. раб. lab work |
| Пахомова В. Н. Pahomova V.N. | доцент docent | 2500 | 25 | 20 | ЕОМ ЕС | защита информации protection informations | 926 | лекция lecture |
| Пахомова В. Н. Pahomova V.N. | доцент docent | 2500 | 25 | 20 | ЕОМ ЕС | локальные сети LANs | 943 | лекция lecture |
| Тихонов А.П. Tihonov A.P. | ст. преподав. senior lecturer | 2200 | 30 | 30 | ЕОМ ЕС | схемотехника circuitry | 933 | лекция lecture |
| Тихонов А.П. Tihonov A.P. | ст. преподав. senior lecturer | 2200 | 30 | 30 | ЕОМ ЕС | схемотехника circuitry | 933_1 | лаб. раб. lab work |
| Дзюба В. В. Dziuba V.V. | ст. преподав. senior lecturer | 2200 | 10 | 0 | ЕОМ ЕС | основы программирования basics of programming | 924 | лаб. раб. lab work |
| Дзюба В. В. Dziuba V.V. | ст. преподав. senior lecturer | 2200 | 10 | 0 | ЕОМ ЕС | основы программирования basics of programming | 926 | лаб. раб. lab work |

Fig. 3.1. The original relation **TEACHER** (1NF)

In the relation **TEACHER** let's highlight the dependencies between the attributes (Figure 3.2). In the original relation primary key is composite (Full_name, Subject, Group).

In the original relation there is **redundant duplication of data**, which are the cause of the anomalies editing. **Evident redundancy** in the relation: the corteges to the data about teachers are repeated. **Non-evident redundancy** in the relation: the same salary of one position and the same additions to the salary for the same seniority.

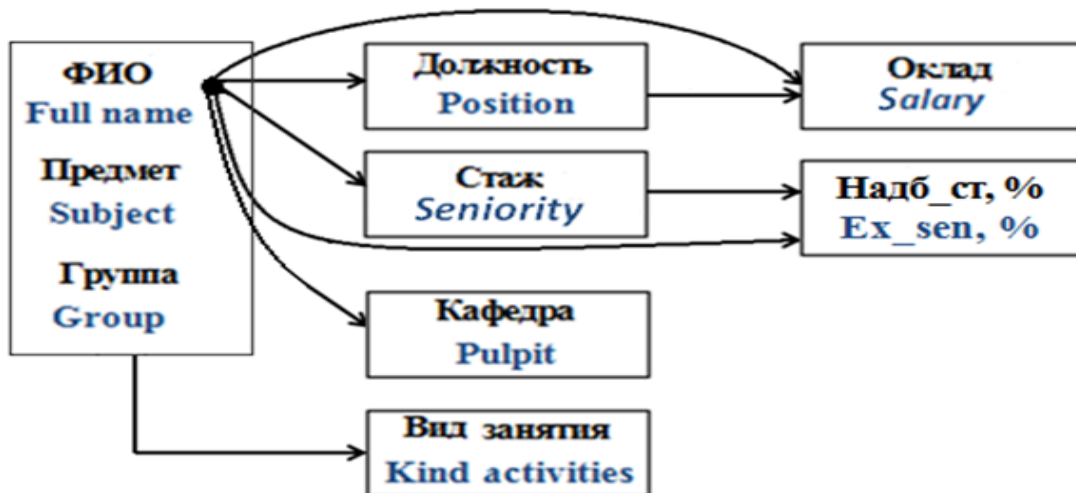


Fig. 3.2. Dependencies between attributes

The first stage of normalization: the original relation from 1NF transfer in 2NF. To do this, you must get rid of the partial functional dependency. The original relation is decomposed into two relations R1 (Figure 3.3) and R2 (Figure 3.4), are in 2NF, on the basis of which we will build the corresponding relations (Figure 3.5, Figure 3.6).

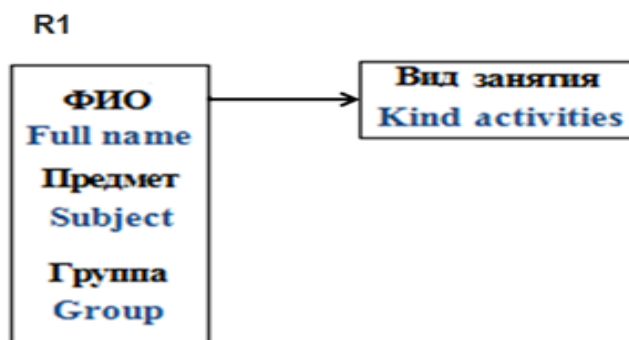


Fig. 3.3. The projection R1

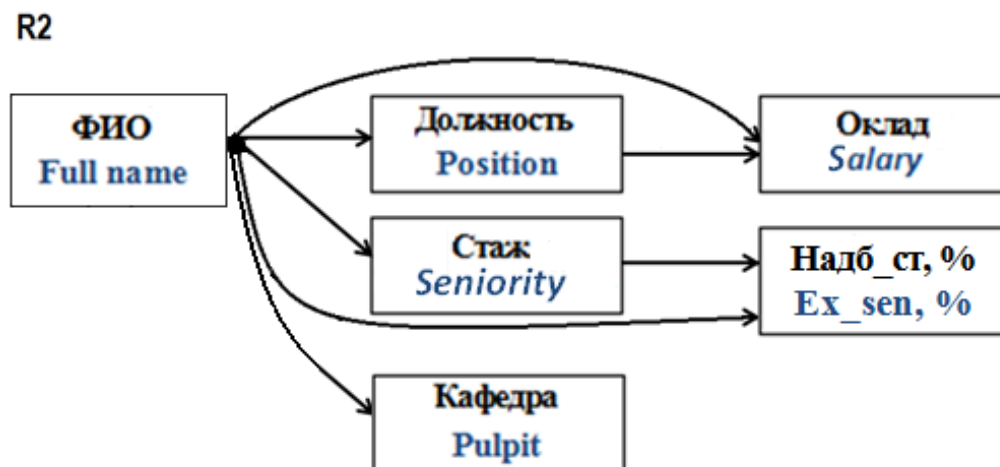


Fig. 3.4. The projection R2

| ФИО Full name | Предмет Subject | Группа Group | Вид занятия Kind activities |
|---|---|-----------------|--------------------------------|
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | криптография <i>cryptography</i> | 936 | лекция <i>lecture</i> |
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | защита информации <i>protection informations</i> | 946 | лекция <i>lecture</i> |
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | периферийные устройства <i>peripheral devices</i> | 943 | лекция <i>lecture</i> |
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | периферийные устройства <i>peripheral devices</i> | 944 | лекция <i>lecture</i> |
| Пахомова В. Н. <i>Rahomova V.N.</i> | организация БД <i>organization database</i> | 933 | лекция <i>lecture</i> |
| Пахомова В. Н. <i>Rahomova V.N.</i> | организация БД <i>organization database</i> | 933_2 | лаб. раб. <i>lab work</i> |
| Пахомова В. Н. <i>Rahomova V.N.</i> | защита информации <i>protection informations</i> | 926 | лекция <i>lecture</i> |
| Пахомова В. Н. <i>Rahomova V.N.</i> | локальные сети <i>LANs</i> | 943 | лекция <i>lecture</i> |
| Тихонов А.П. <i>Tihonov A.P.</i> | схемотехника <i>circuitry</i> | 933 | лекция <i>lecture</i> |
| Тихонов А.П. <i>Tihonov A.P.</i> | схемотехника <i>circuitry</i> | 933_1 | лаб. раб. <i>lab work</i> |
| Дзюба В. В. <i>Dziuba V.V.</i> | основы программирования <i>basics of programming</i> | 924 | лаб. раб. <i>lab work</i> |
| Дзюба В. В. <i>Dziuba V.V.</i> | основы программирования <i>basics of programming</i> | 926 | лаб. раб. <i>lab work</i> |

Fig. 3.5. The relation R1 (2NF)

| ФИО Full name | Должность Position | Оклад, грн. <i>Salary, UAH</i> | Стаж <i>Seniority</i> | Надб_ст, % <i>Ex_sen, %</i> | Кафедра <i>Pulpit</i> |
|---|---|-----------------------------------|--------------------------|--------------------------------|--------------------------|
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | профессор <i>professor</i> | 3000 | 40 | 30 | ЕОМ ЕС |
| Пахомова В. Н. <i>Rahomova V.N.</i> | доцент <i>docent</i> | 2500 | 25 | 20 | ЕОМ ЕС |
| Тихонов А.П. <i>Tihonov A.P.</i> | ст. преподав. <i>senior lecturer</i> | 2200 | 30 | 30 | ЕОМ ЕС |
| Дзюба В. В. <i>Dziuba V.V.</i> | ст. преподав. <i>senior lecturer</i> | 2200 | 10 | 0 | ЕОМ ЕС |

Fig. 3.6. The relation R2 (2NF)

In relation R1 is absent evident redundancy of data. In relation R2 is present non-evident redundancy of data.

The second stage of normalization: translation relation R2 from 2NF to 3NF. To do this, you must get rid of the transitive dependencies. Let us construct the corresponding projections R3 (Figure 3.7), R4 and R5 (Figure 3.8), on the basis of which we represent the relations (Figure 3.9-3.11).

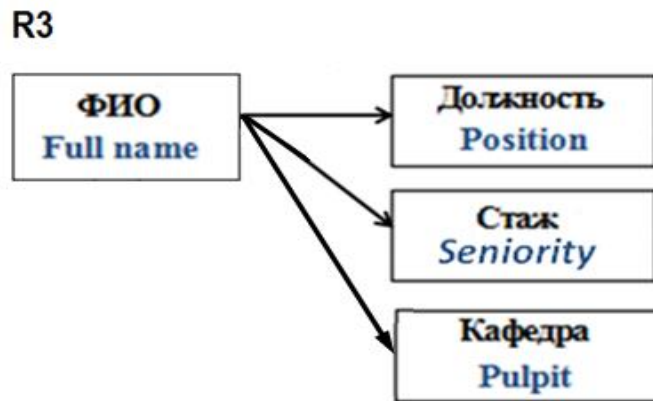


Fig. 3.7. The projection R3

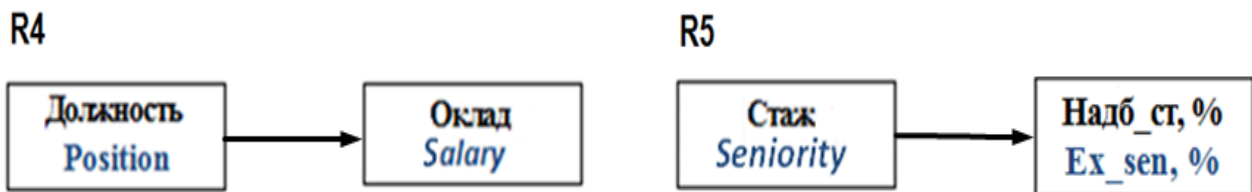


Fig. 3.7. The projections R4 and R5

| ФИО Full name | Должность Position | Стаж Seniority | Кафедра Pulpit |
|---|----------------------------------|-------------------|-------------------|
| Жуковицкий И. В. <i>Zhukovitsky I.V.</i> | професор professor | 40 | ЕОМ ЕС |
| Пахомова В. Н. <i>Рахомова V.N.</i> | доцент docent | 25 | ЕОМ ЕС |
| Тихонов А.П. <i>Tihonov A.P.</i> | ст. преподав. senior lecturer | 30 | ЕОМ ЕС |
| Дзюба В. В. <i>Dziuba V.V.</i> | ст. преподав. senior lecturer | 10 | ЕОМ ЕС |

Fig. 3.9. The relation R3 (3NF)

| | |
|----------------------------------|----------------------------|
| Должность Position | Оклад, грн. Salary, UAH |
| професор professor | 3000 |
| доцент docent | 2500 |
| ст. преподав. senior lecturer | 2200 |

Fig. 3.10. The relation R4 (3NF)

| | |
|-------------------|-------------------------|
| Стаж Seniority | Надб_ст, % Ex_sen, % |
| 40 | 30 |
| 25 | 20 |
| 30 | 30 |
| 10 | 0 |

Fig. 3.11. The relation R5 (3NF)

Relations R3, R4, R5 are in 3NF. **All resulting relations are in the normal form Boyce-Codd (BCNF).** The result of the design is a database consisting of relations R1, R3, R4, R5, each of which satisfy demands BCNF. The structure is designed database by using the «Normal forms» method (Figure 3.12).

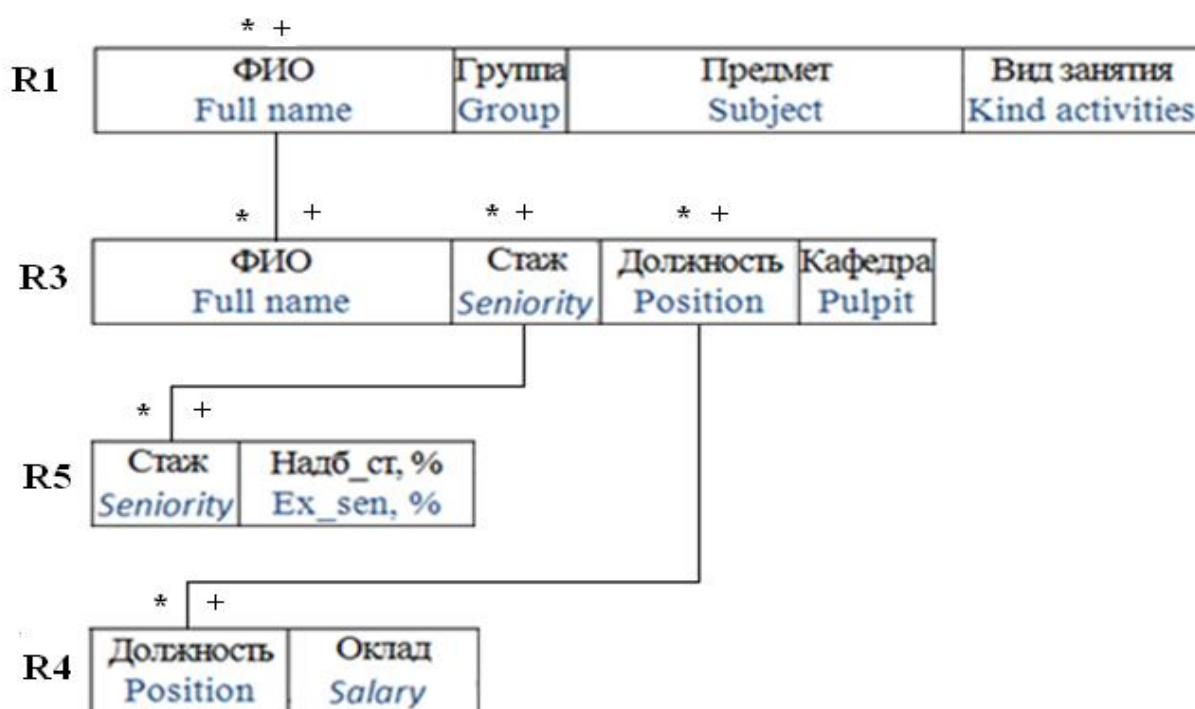


Fig. 3.12. The structure is designed database by using the normal forms

Exercise № 4: Example of designing a database by the «Essence-relation» method

The first stage is the selection of essences and connections between them.

Essences:

- TEACHER (Full name);
- SENIORITY (Seniority);
- LESSON (Group, Subject);
- POSITION (Position).

Connections:

- TEACHER HAS SENIORITY;
- TEACHER LEADS LESSON;
- TEACHER TAKES POSITION.

The second stage of the design - build diagram ER-type with all the essences and connections between them.

TEACHER HAS SENIORITY. The degree of connection HAS is M:1, as the same seniority can have multiple teachers (Figure 4.1).

The essence of the TEACHER has obligatory class, because each teacher has their own seniority. The essence of the SENIORITY has non-obligatory class, as possible the values of seniority, which has none of the teachers.

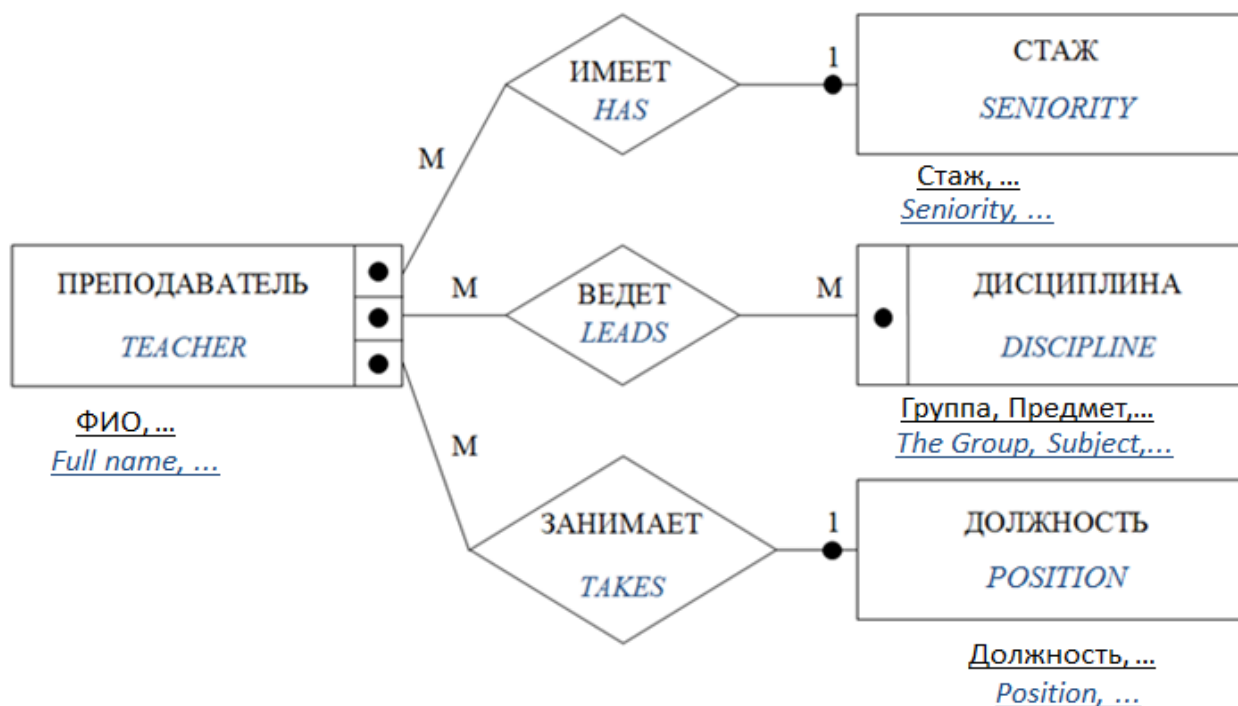


Рис. 4.1. Диаграмма ER-типа для рассматриваемого примера

Fig. 4.1. ER-Diagram type for this example

TEACHER LEADS LESSON. The degree of connection LEADS is M:M, because the teacher can lead a many lessons, and each lesson can be conducted in many different teachers (Figure 4.1).

Both essences have obligatory class, because there are teachers who do not lead lessons, and there are no lessons that are not provided by the teachers.

TEACHER TAKES POSITION. The degree of connection TAKES is M:1, as each teacher takes a certain position and the same position can take many teachers (Figure 4.1).

The essence of the TEACHER has obligatory class, because every teacher holds the position.

The essence of the POSITION is non-obligatory class, so as not to exclude, for example, the lack of posts of professors in the pulpit, and therefore a teacher who fills it.

The third stage is the formation of the pre-set relations indicating a primary key for each relation, using the diagrams ER-type.

The connection **HAS** satisfies the conditions of rule 4, according to which we get two relations:

- TEACHER (Full name, Seniority, ...)
- SENIORITY (Seniority, ...)

Note: the underlined attribute means that the attribute key.

The connection **LEADS** satisfies the conditions of rule 6, according to which received three relations:

- TEACHER (Full name, Seniority, ...
- LEADS (Full name, Group, Subject, ...
- LESSON (Group, Subject, ...

The connection **TAKES** satisfies the conditions of rule 4, therefore have the following two relations:

- TEACHER (Full name, Seniority, Position, ...
- POSITION (Position, ...

The fourth stage is the addition of non-key attributes, which were not previously involved:

- TEACHER (Full name, Seniority, Position, Pulpit);
- LEADS (Full name, Group, Subject, Kind activity);
- SENIORITY (Seniority, Ex_sen_%);
- LESSON (Group, Subject);
- POSITION (Position, Salary).

The resulting relations should be checked for satisfaction of Boyce-Codd.

As the relation LESSON does not contain any other attributes other than the key attributes of the Group, Subject contained in relation LEADS, it is desirable that the relation LESSON be excluded from the projected database.

The structure is designed database by using the «Essence-relation» (Figure 4.2) exactly matches the structure of the designed database by the method of normal forms (Figure 3.12): *LEADS* coincides with R1; *TEACHER* coincides with R3; *SENIORITY* coincides with R5 and *POSITION* coincides with R4.

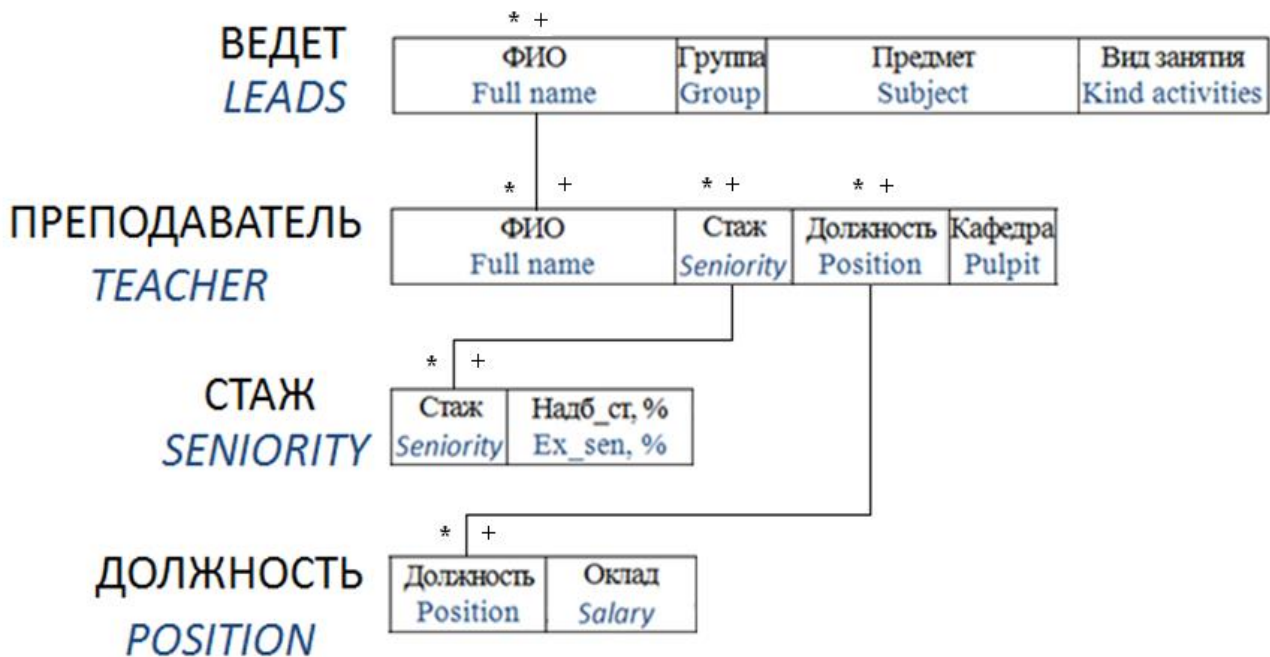


Fig. 4.2. The structure is designed database by using the «Essence-relation»

Test questions and tasks

1. Define the essence.
2. Define the relation.
3. Give a mathematical definition of the relation.
4. Conditions under which the table can be considered a relation.
5. Define the scheme of relation.
6. Define the body of relation.
7. Define the primary key of relation.
8. When should I use a folded key?
9. Define the train.
10. Define the attribute.
11. Define the domain.
12. Define the power of relation.
13. Define the degree of relation.
14. Types of binary table relations.
15. Define the foreign key.
16. Types of duplication.
17. Simple data duplication.
18. Redundant data duplication.
19. What duplication should be eliminated in databases and why?
20. Types of anomalies.
21. Types of dependencies of the attributes of the relation.
22. Define functional dependence.
23. Define functional interdependence.
24. Define partial functional dependence.
25. Define full functional dependence.
26. Define transitive dependence.
27. Define multivalued dependence.
28. Varieties of multivalued dependence.
29. Define functional interdependence.
30. What is the method of normal forms (NF)?
31. Define 1NF.
32. Define 2NF.
33. Define 3NF.
34. Define the BCNF.

35. What is the method of «Essence-Relation»?
36. What does «ambiguous» essence mean?
37. Rule № 1 for the formation of relations.
38. Rule № 2 for the formation of relations.
39. Rule № 3 for the formation of relations.
40. Rule № 4 for the formation of relations.
41. Rule № 5 for the formation of relations.
42. Rule № 6 for the formation of relations.
43. What rules form the three relations?
44. What rules form the two relations?
45. What rules form the one relation?
46. In what rules the link 1:1 is considered?
47. In what rules the link 1:M is considered?
48. In which rules does the class of affiliation not matter?
49. What does the mandatory affiliation class mean?
50. What does an optional affiliation class mean?

Conclusions

When designing small databases, it is advisable to use the mathematical method (normal form method). When designing databases consisting of a significantly large number of attributes, it is advisable to use the graphical method (the «Essence-Relation» method).

References

1. Дистанційний курс в системі «Лідер» з дисципліни «Бази даних» для здобувачів ступеня «бакалавр» спеціальностей «Комп'ютерна інженерія» і «Кібербезпека»; укл.: Пахомова В. М. Сертифікат № ДК0288 від 20.08.2018.
2. Сидоренко В. В., Константинова Л. В., Смірнов С. А. Організація баз даних: Навчальний посібник. Кропивницький: ЦНТУ, 2018. 274 с.
3. Ярцев В. П. Організація баз даних та знань: навчальний посібник. Київ: нац. техн. ун-т України, «Київський політехнічний інститут ім. Ігоря Сікорського», 2018. 214 с.
4. Pakhomova V. N. Formation of competencies in applicants of the bachelor's degree of foreign origin in distance learning in the «Database» discipline // Modern engineering and innovative technologies. Germany, Karlsruhe: Sergeieva&Co, «ISE&E». 2022. №21-01. pp. 109-113. DOI: 10.30890/2567-5273.2022-21-01-038.

Pakhomova V. M.

DATABASE

Methodical recommendations for individual task

Підписано до друку 10.10.2022. Формат 60x84 1/16. Папір друк. Друк плоский. Облік.-вид. арк. 1,17. Умов. друк. арк. 1,16. Замовлення №84

Український державний університет науки і технологій
49010, м. Дніпро, вул. Лазаряна, 2
Редакційно-видавничий відділ УДУНТ