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DATABASE MODELS AND ESSENCE-COMMUNICATION MODEL

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ABSTRACT	KEYWORDS
This article provides a comprehensive analysis of the main database models — hierarchical, networked, relational, object — oriented, and NoSQL models. Also, the concept of the essence-communication (MA) model, its main components, practical methods of constructing a diagram and the rules for transferring to a relational scheme are covered in detail. The article is intended for students, programmers and database engineers.	Database, MB model, relational model, essence-communication model, ER-diagram, normalization, SQL, NoSQL.

Introduction

Annotatsiya:
Ushbu maqolada ma'lumotlar bazasining asosiy modellari — ierarxik, tarmoqli, relyatsion, ob'yektga yo'naltirilgan va NoSQL modellari — keng qamrovli tahlil qilingan. Shuningdek, mohiyat-aloqa (MA) modeli tushunchasi, uning asosiy komponentlari, diagramma qurishning amaliy usullari va relyatsion sxemaga o'tkazish qoidalari batafsil yoritilgan. Maqola talabalar, dasturchilar va ma'lumotlar bazasi muhandislari uchun mo'ljallangan.

Kalit so'zlar: ma'lumotlar bazasi, MB modeli, relyatsion model, mohiyat-aloqa modeli, ER-diagramma, normallash, SQL, NoSQL.

Аннотация:
В данной статье представлен всесторонний анализ основных моделей баз данных — иерархической, сетевой, реляционной, объектно-ориентированной и NoSQL-моделей. Также дано подробное объяснение концепции сущностно-реляционной (ER) модели, её основных компонентов, практических методов построения диаграмм и правил преобразования в реляционную схему. Статья предназначена для студентов, программистов и инженеров баз данных.

Ключевые слова: база данных, модель БД, реляционная модель, сущностно-реляционная модель, ER-диаграмма, нормализация, SQL, NoSQL.

Databases (DBs) are the foundation of modern information systems. Today, industries such as e-commerce, banking, medical records, educational platforms, and government cannot function without well-designed databases.

The model chosen when designing a database is a key decision that determines how data is stored, retrieved, and managed. An incorrectly chosen model can lead to significant rework costs later.

The main purpose of this article is to systematically review DB models and fully explain the practical importance of the entity-relationship model. The article solves the following tasks:

Presenting the main DB models in the historical development sequence, comparative analysis of the technical characteristics of each model, detailed study of the structural components of the DB model, showing the algorithm for converting from ER-diagram to relational schema, normalization process and providing practical examples

A database model is an abstract structure that defines the method of logically organizing data, storing it and performing operations on it. Historically, DB models have developed in the following order:

Hierarchical model is the first official DB model, developed by IBM in 1966 under the name IMS (Information Management System). In this model, data is organized in a tree structure: each "parent" record has one or more "child" records, but each child has only one parent.

Application areas: Airline reservation system, IBM CICS transaction systems, old banking applications.

The network model, standardized by the Conference on Data Systems Languages (CODASYL), overcomes the limitations of the hierarchical model. The data is organized in a graph structure, allowing for the direct representation of many-to-many (M:N) relationships.

Central to the network model is the concept of "sets" - a set of parent records and their associated child records.

Edgar F. Codd published a revolutionary paper in 1970 at IBM Research Labs, titled "A Relational Model of Data for Large Shared Data Banks." This paper laid the foundation for modern DB science and earned Codd the Turing Award in 1981. In the relational model, data is stored in the form of two-dimensional tables (relationships). Each table consists of rows (tuples) and columns (attributes). The relationship between tables is provided by the “key - foreign key” mechanism.

Data independence - the physical storage method is separated from the logical schema, SQL language - convenient access through the declarative query language, ACID guarantees - atomicity, consistency, isolation and durability of transactions, referential integrity - maintaining data relationships through foreign key constraints.

With the widespread use of object-oriented programming, an object-oriented approach has also developed in the database field. In this model, data is stored as objects, which combine both data (attributes) and operations performed on them (methods).

The main concepts of OO-DBMSs are: classes and objects, inheritance, encapsulation, polymorphism, object identifier (OID). Systems such as Db4o, ObjectDB, Versant support this model.

With the development of the Internet and cloud computing, traditional relational DBMSs have encountered difficulties in efficiently processing large amounts of distributed data. The NoSQL ("Not Only SQL") paradigm emerged in response to this problem.

Key-Value: Redis, DynamoDB — fast cache and session management, Document: MongoDB, CouchDB — variable data, Column-family: Cassandra, HBase — large-scale analytical workloads, Graph: Neo4j, ArangoDB — social networks, recommendation systems.

Table 1. Comparative table of database models

Model	Structure	Advantages	Disadvantages
Hierarchical	Tree structure	Fast search, simple structure	No many-to-many relationships
Network	Graph structure	Supports many-to-many relationships	Complex management
Relational	Tables (2D)	Flexible, supports SQL	Slow with large data volumes
Object-Oriented (OO)	Objects	Handles complex data well	Lack of standardization issues
NoSQL	Document / Graph / Key-Value	High scalability and speed	Not fully ACID compliant

The Entity-Relationship model (ER model) was proposed by Peter Chen in 1976 and is still the most common way to conceptually design a database. The ER model allows for a graphical representation of real-world concepts, regardless of the details of the software implementation.

Table 2. The main components of the entity-relationship model and their definition.

Component	Description	Example
Entity	A collection of data representing a real-world object	STUDENT, COURSE, TEACHER
Attribute	A characteristic or property of an entity	Name, Date of Birth, ID
Relationship	A connection between entities	ENROLLS IN, TEACHES
Cardinality	Expresses the ratio of a relationship	1:1, 1:N, M:N
Key Attribute	A unique identifier for an entity	Student_ID (underlined)

Entity — an object that is a real-world or abstract concept that needs to be stored in a database. Entities are divided into several types:

Strong entity: Not dependent on other entities — STUDENT, PRODUCT, EMPLOYEE

Weak entity: Identifiable only through another entity — ORDER_BAND (dependent on ORDER)

Associative entity: Created to represent a many-to-many relationship — RECORD (between STUDENT and COURSE)

Attributes represent the properties of the entity or relationship. In MA diagrams, attributes are depicted as ovals: Simple attribute: Indivisible — Name, Price, Date, composite attribute: Divisible into smaller parts — Full_Name (First_Name + Last_Name + Middle_Name), multi-valued attribute: Has more than one value — Phone_Number, Email_Mail, calculated attribute: Calculated from other attributes — Age (From_Date_of_Birth), key attribute: For unique identification of the entity — Student_ID, Passport_Number (underlined)

Cardinality shows how many entity instances participate in the relationship. There are three main types of cardinality:

One-to-one (1:1): Each entity A is related to only one entity B — EMPLOYEE and MACHINE (service machine)

One-to-many (1:N): One entity A is related to many entities B — DEPARTMENT and EMPLOYEE relationship

Many-to-many (M:N): Many A — many B — STUDENT and COURSE: one student has many courses, and one course has many students

The participation ratio indicates whether the entity's participation in the relationship is mandatory (total) or optional (partial). A double line indicates mandatory participation.

The MA diagram is a conceptual design that must be converted into a relational schema (a set of tables) for practical use. This process is carried out according to the following rules:

Strong entities: Each strong entity becomes a separate table. The key attribute is the Primary Key.

Example: STUDENT(Student_ID [PK], FirstName, LastName, Date_of_Birth, Group_ID [FK])

Weak entities: The weak entity is converted into a table and the primary key of the parent entity is added as a foreign key. The primary key consists of the parent key + a discriminator attribute.

One-to-one (1:1) relationship: The primary key of one entity is added as a foreign key to the second entity table. Usually, it is added to the optional participant side.

One-to-many (1:N) relationship: The primary key of the "one" side is inserted as a foreign key into the table on the "many" side.

Many-to-many (M:N) relationship: A new intermediate table is created. This table contains the primary keys of both entities, and together they form the primary key.

Example: ENROLL(Student_ID [PK, FK], Course_ID [PK, FK], Enrollment_Date, Grade)

Normalization is the process of successively transforming a relational schema to eliminate duplication of data and ensure integrity.

1NF (1st normal form): All attributes must be atomic (indivisible) and there must be no repeating groups

2NF (2nd normal form): 1NF + every attribute that is not a primary key must be fully functionally dependent on the entire primary key

3NF (3rd normal form): 2NF + no transitive dependencies (no A -> B -> C)

BCNF (Boyce-Codd normal form): A strengthened form of 3NF — every determinant must be a key

In practice, most projects are limited to achieving 3NF. In some cases, deliberate denormalization is also used to quickly access data.

The field of database models has developed rapidly since the 1960s. The journey from hierarchical and network models, through the dominance of the relational model to modern NoSQL and multi-model DBMSs, represents one of the most remarkable developmental journeys in the IT industry.
The entity-relationship model remains a constant key tool in this process. Peter Chen's 1976 discovery is still widely used by engineers and programmers in the early stages of DB design today - because it is close to human thinking, simple and can be expressed graphically.

References

1. Alimovna E. Y., Alimovna E. G., Burievna M. S. Historical Stages Of Innovative processes In Higher Education Of Uzbekistan //Solid State Technology. – 2020. – T. 63. – №. 6. – C. 9824-9834.
2. Alimovna E. G. THE ROLE OF CONTEXT IN THE INTERPRETATION OF PREPOSITIONAL PHRASES IN PREDICATIVE CONSTRUCTIONS //Central Asian Journal of Academic Research. – 2025. – T. 3. – №. 9. – C. 103-106.
3. Alimovna E. Y., Alimovna E. G. Policy of" Cultural Revolution" in Uzbekistan and Methods of Its Implementation //International Journal on Economics, Finance and Sustainable Development. – 2020. – T. 2. – №. 11. – C. 4-6.
4. Alimovna E. G. Study of the semantic and syntactical analyses of prepositional constructions //PARTICULAR PAGE NO. – 2022.
5. Jabborovich J. K., Keldiyorovna O. M. Systactical methods of the Uzbek and English language terminology //International Journal of Psychosocial Rehabilitation. – 2020. – T. 24. – №. 6. – C. 3117-3122.
6. Rizayeva B., Daminova B. STATISTIK TAHLILDA DASTURIY VOSITALARDAN FOYDALANISH //MUHANDISLIK VA IQTISODIYOT. – 2026. – T. 4.
7. Daminova B. E. et al. SUN’IY INTELLEKT SOHASIDA QO ‘LLANADIGAN ZAMONAVIY PYTHON KUTUBXONALARI //Экономика и социум. – 2025. – №. 4-2 (131). – C. 205-209.
8. Daminova B. E. et al. SUN’IY INTELLEKT VA KIBERXAVFSIZLIK //Экономика и социум. – 2025. – №. 5-1 (132). – C. 212-215.
9. Daminova B. E. et al. SUN’IY NEYRON TARMOQLARINING NAZARIY ASOSLARI VA AMALIY ILOVALARIDA ISHLASH USULLARI //Экономика и социум. – 2025. – №. 5-1 (132). – C. 226-230.
10. Daminova B. E. et al. ROBOTOTEXNIKA VA AVTOMATLASHTIRISHNING AHAMIYATI //Экономика и социум. – 2025. – №. 5-1 (132). – C. 208-211.
11. Daminova B. Organizational and economic mechanisms and conceptual directions of tourism development in the region //Green Economy and Development. – 2024. – T. 3. – №. 7. – C. 666343.
12. Esanovna D. B. ORGANIZATIONAL AND ECONOMIC MECHANISMS AND CONCEPTUAL DIRECTIONS OF TOURISM DEVELOPMENT IN THE REGION //INTERNATIONAL JOURNAL OF SOCIAL SCIENCE & INTERDISCIPLINARY RESEARCH ISSN: 2277-3630 Impact factor: 8.036. – 2025. – T. 14. – №. 11. – C. 91-94.

13. Esanovna D. B. ОРГАНИЗАЦИОННО-ЭКОНОМИЧЕСКИЕ МЕХАНИЗМЫ И КОНЦЕПТУАЛЬНЫЕ НАПРАВЛЕНИЯ РАЗВИТИЯ СФЕРЫ ТУРИЗМА В РЕГИОНЕ //Modern education and development. – 2025. – Т. 33. – №. 1. – С. 32-38.
14. Daminova B. E., Boboyorov B. E. QASHQADARYO YOSHLARINI VA ILM-FAN SOHASIDAGI MUTAXASSISLARNI AXBOROT TEXNOLOGIYALARIGA JALB QILISH //Экономика и социум. – 2025. – №. 5-1 (132). – С. 188-191.
15. Daminova B. E., Omonov J. M., Norqo’Chqorov Y. Y. NUTQNI TANISH TIZIMINI CHUQUR NEYRON TARMOQLARI YORDAMIDA YARATISH BOSQICHLARI //Экономика и социум. – 2025. – №. 4-2 (131). – С. 221-227.
16. Daminova B. E. et al. ARDUINO PLATFORMASIDAN FOYDALANIB SUV SARFINI HISOBLOVCHI DASTURIY VA TEXNIK TA'MINOT ISHLAB CHIQISH //Экономика и социум. – 2025. – №. 4-2 (131). – С. 210-215.
17. Daminova B. E. et al. ELEKTRON HUKUMAT VA ELEKTRON RAQAMLI IMZONING QO’LLANILISHI //Экономика и социум. – 2025. – №. 4-2 (131). – С. 216-220.
18. Omonova M. NOMINATIVE-DEFINITIVE FUNCTIONS OF COMPONENTS OF AMELIORATIVE TERMS IN ENGLISH AND UZBEK LANGUAGES //Theoretical & Applied Science. – 2021. – №. 4. – С. 84-86.
19. Omonova M. K. Comparative analysis of semantical features of meliorative terms in English and Uzbek //Experientia est optima magistra. – 2021. – С. 269-272.
20. Omonova M. Innovative ways of teaching vocabulary in ESL and EFL classrooms //Science and Education. – 2020. – Т. 1. – №. 7. – С. 229-233