Database Design Using the E-R Model

Question

6.1 Construct an E-R diagram for a car insurance company whose customers own one or more cars each. Each car has associated with it zero to any number of recorded accidents. Each insurance policy covers one or more cars and has one or more premium payments associated with it. Each payment is for a particular period of time and has an associated due date and the date when the payment was received.

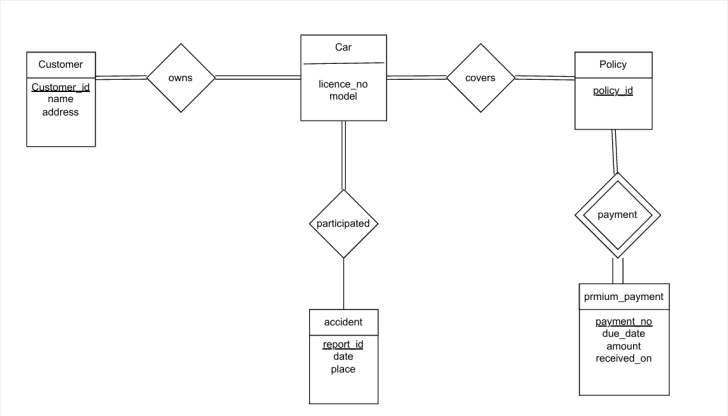

Figure 1: E-R diagram for a car insurance company

Question

6.2 Consider a database that includes the entity sets student, course, and section from the university schema and that additionally records the marks that students receive in different exams of different sections.

a) Construct an E-R diagram that models exams as entities and uses a ternary relationship as part of the design.

b) Construct an alternative E-R diagram that uses only a binary relationship between student and section. Make sure that only one relationship exists between a particular student and section pair, yet you can represent the marks that a student gets in different exams.

Solution

Answer 6.2(a)

The E-R diagram is shown in Figure 6.102. Note that an alternative is to model examinations as weak entities related to a section, rather than as strong entities. The exam_marks relationship would then be a binary relationship between student and exam, without directly involving section.

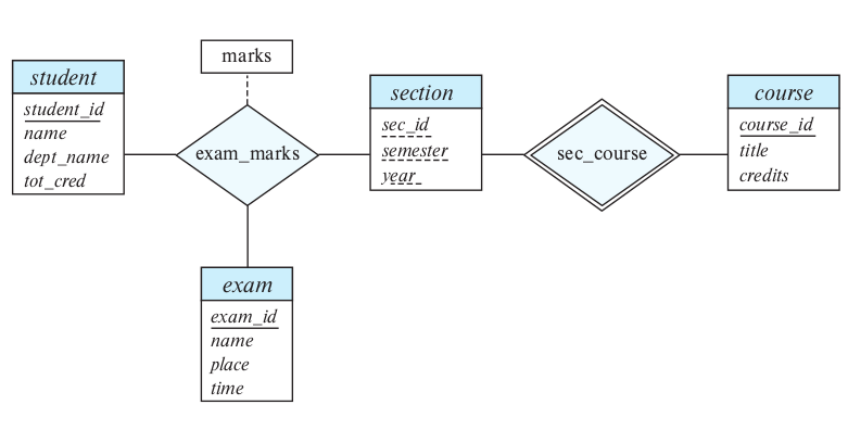

Figure 2: E-R diagram showing both ternary and binary relationship solutions

Solution

Answer 6.2(b)

The E-R diagram is shown in Figure 6.103. Note that here we have not modeled the name, place, and time of the exam as part of the relationship attributes. Doing so would result in duplication of the information, once per student, and we would not be able to record this information without an associated student. If we wish to represent this information, we need to retain a separate entity corresponding to each exam.

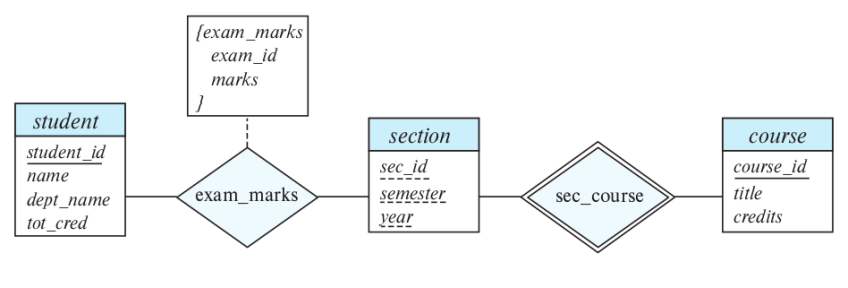

Figure 3: Another E-R diagram for marks database

Question

6.3 Design an E-R diagram for keeping track of the scoring statistics of your favorite sports team. You should store the matches played, the scores in each match, the players in each match, and individual player scoring statistics for each match. Summary statistics should be modeled as derived attributes with an explanation as to how they are computed.

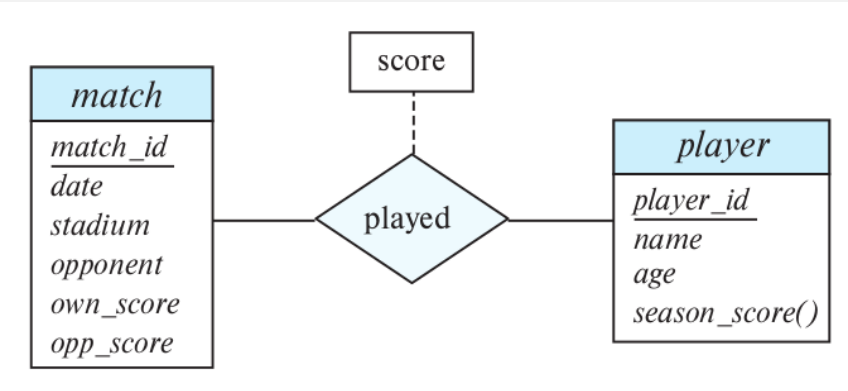

Figure 4: ER diagram for favourite team statistics

Question

6.5 An E-R diagram can be viewed as a graph. What do the following mean in terms of the structure of an enterprise schema?

a) The graph is disconnected.

b) The graph has a cycle.

Solution

Answer 6.5(a): The graph is disconnected

If the graph is disconnected, it means there exist one or more entities in the E-R diagram that are not connected to any other entity through a relationship. In terms of the enterprise schema, this implies that:

- Some parts of the schema are isolated and do not interact with other parts.
- These disconnected components may represent independent sections of data that do not share any relationships.
- This is usually undesirable in a well-designed enterprise database, as it may indicate incomplete modeling or a logical flaw in the schema.

Solution

Answer 6.5(b): The graph has a cycle

If the graph has a cycle, it means that there is a closed loop of relationships among entities — i.e., one can start at a particular entity and return to it by following a sequence of relationships.

In the context of the enterprise schema:

- This reflects cyclic relationships among entities.
- Cycles can be normal and often represent hierarchical or mutual dependencies, such as an employee managing a department and that department being linked back to another employee.

Question

6.7 A weak entity set can always be made into a strong entity set by adding to its attributes the primary-key attributes of its identifying entity set. Outline what sort of redundancy will result if we do so.

Solution

A weak entity set does not have a primary key of its own and depends on a strong entity set for identification. If we convert a weak entity set into a strong one by adding the primary key of the identifying entity, then the weak entity can be uniquely identified without the identifying relationship.

However, this will cause redundancy:

- The foreign key will be stored repeatedly in the weak entity set.
- Since weak entities are often associated with a single strong entity, repeating the identifying key in every weak entity record creates data duplication.
- This leads to more storage, and if the identifying entity's key changes, many rows need to be updated — causing update anomalies.

Question

6.9 Suppose the advisor relationship set were one-to-one. What extra constraints are required on the relation advisor to ensure that the one-to-one cardinality constraint is enforced?

Solution

If the advisor relationship set is one-to-one, it means:

- Each student has at most one advisor, and
- Each instructor advises at most one student

To enforce this one-to-one constraint in the advisor relation, we need to add the following constraints:

1. The student_id attribute must be a candidate key (unique constraint)
2. The instructor_id attribute must be a candidate key (unique constraint)
3. Neither attribute should allow NULL values (if we want to require every student to have an advisor and vice versa)

These constraints ensure that each student is advised by exactly one instructor, and each instructor advises exactly one student.

Question

6.14 Explain the distinctions among the terms primary key, candidate key, and superkey.

Solution

Superkey:
A superkey is any set of attributes that uniquely identifies a tuple in a relation. It may contain extra attributes that are not necessary for uniqueness.

Candidate key:
A candidate key is a minimal superkey. It has no unnecessary attributes and uniquely identifies each tuple. There can be multiple candidate keys in a relation.

Primary key:
A primary key is a chosen candidate key that is used as the main identifier for tuples in the table. It must be unique and cannot contain NULL values.

Example: In a Student relation with attributes (student_id, passport_num, name, email):

- {student_id, passport_num, name} is a superkey (but not minimal)
- {student_id} and {passport_num} are candidate keys (minimal)
- We might choose {student_id} as the primary key

Question

6.15 Construct an E-R diagram for a hospital with a set of patients and a set of medical doctors. Associate with each patient a log of the various tests and examinations conducted.

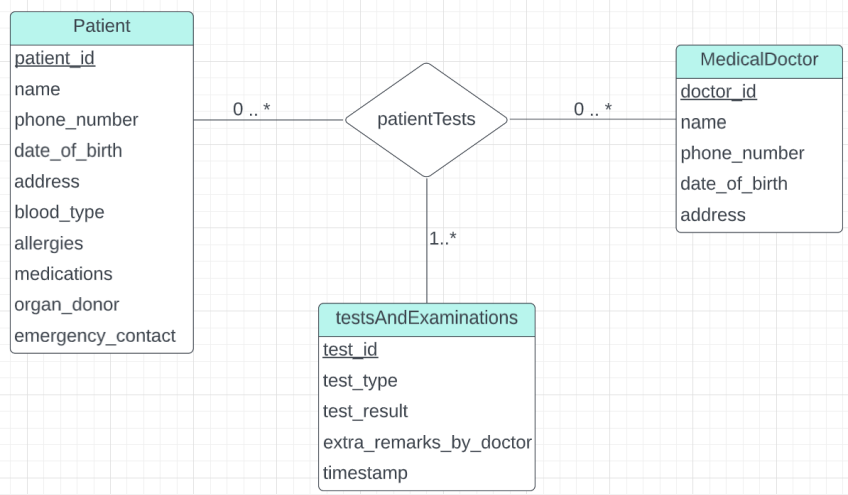

Figure 5: ER diagram for Hospitals

Question

6.19 We can convert any weak entity set to a strong entity set by simply adding appropriate attributes. Why, then, do we have weak entity sets?

Solution

Although it is possible to convert any weak entity set into a strong entity set by adding the primary key attributes of the identifying entity as its own attributes, weak entity sets still exist because:

1. **Conceptual clarity:** Weak entities model real-world concepts that cannot be uniquely identified on their own. Their existence depends on a strong entity.

2. **Data integrity:** Using weak entities helps represent this dependency clearly and maintain data integrity through referential integrity constraints.

3. **Avoiding redundancy:** It avoids unnecessary duplication of identifying attributes in the weak entity set.

4. **Semantic meaning:** It clearly expresses the "existence dependency" relationship which has semantic meaning beyond just foreign key constraints.

5. **Design simplification:** It simplifies the schema by separating entities that require identification from those that only make sense when linked to another entity.

Question

6.22 Design a database for an automobile company to provide to its dealers to assist them in maintaining customer records and dealer inventory and to assist sales staff in ordering cars.

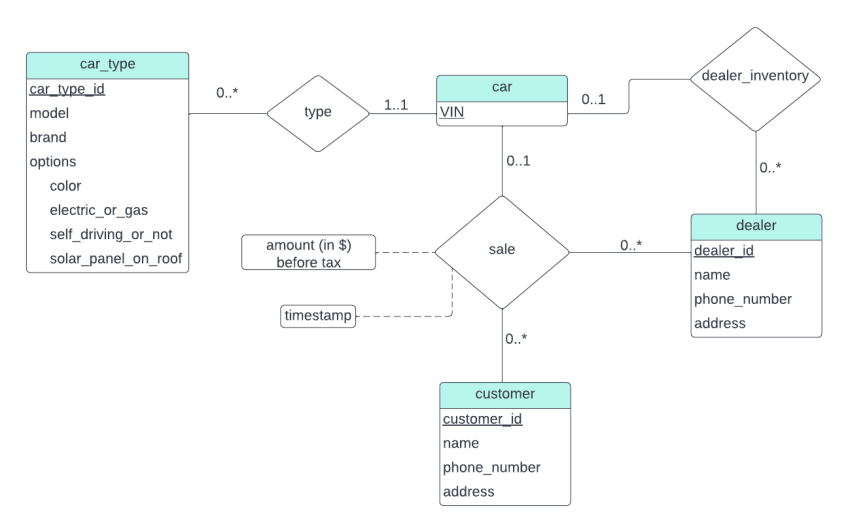

Figure 6: ER diagram Automobile production company

Question

6.24 Design a database for an airline. The database must keep track of customers and their reservations, flights and their status, seat assignments on individual flights, and the schedule and routing of future flights. Your design should include an E-R diagram, a set of relational schemas, and a list of constraints, including primary-key and foreign-key constraints.

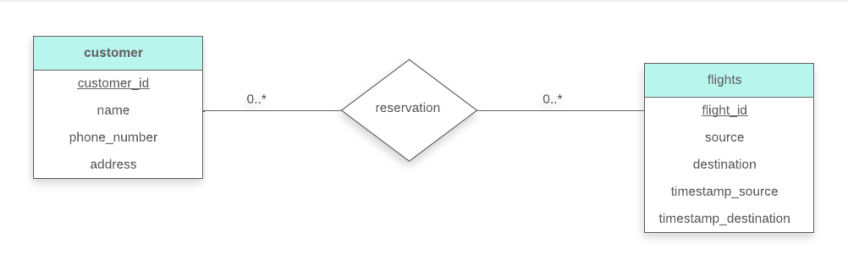

Figure 7: ER diagram airline company

Question

6.26 Design a generalization–specialization hierarchy for a motor vehicle sales company. The company sells motorcycles, passenger cars, vans, and buses. Justify your placement of attributes at each level of the hierarchy.

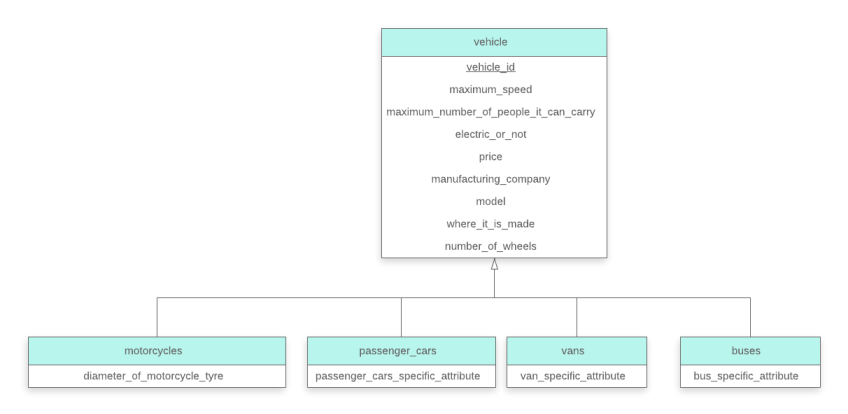

Figure 8: ER diagram motor vehicle company