The Advanced Database Management System

The Relational Model

The Relational Data Model has the relation at its heart but it is a whole series of rules governing:

- Keys
- Relationship
- Joins
- Functional dependencies
- Transitive depndencies
- Multi-valued dependencies
- Modification anomalies

Relation

The *Relation* is the basic element in a relational data model and its subject to these rules:

- Relation (file, table) is a two-dimensional table.
- Attribute (i.e. field or data item) is a **column** in the table.
- Each column in the table has a unique name within that table.
- Each column is homogeneous.
- Each column has a **domain**,
- A Tuple (i.e. record) is a row in the table.
- The order of the rows and columns is not important.
- Values of a row all relate to some thing or portion of a thing.
- Repeating groups are not allowed.
- Duplicate rows are not allowed
- Cells must be single-valued

Special Notation of Relation

A relation may be expressed using the notation R(A,B,C, ...) where:

- R = the name of the relation.
- (A,B,C, ...) = the attributes within the relation.
- A = the attribute(s) which form the primary key.

Keys

A **simple** key contains a single attribute.

A **composite key** is a key that contains more than one attribute.

A [candidate key] is an attribute (or set of attributes) that uniquely identifies a row. A candidate key must possess the following properties:

- Unique identification - For every row the value of the key must uniquely identify that row.
- Non redundancy - No attribute in the key can be discarded without destroying the property of unique identification.

A **primary key** is the candidate key which is selected as the principal unique identifier. Every relation must contain a primary key. The primary key is usually the key selected to identify a row when the database is physically implemented. For example, a part number is selected instead of a part description.

A **superkey** is any set of attributes that uniquely identifies a row. A superkey differs from a candidate key in that it does not require the non redundancy property.

Key….

A **foreign key** is an attribute (or set of attributes) that appears (usually) as a non key attribute in one relation and as a primary key attribute in another relation.

- A many-to-many relationship can only be implemented by introducing an intersection or link table which then becomes the child in two one-to-many relationships. The intersection table therefore has a foreign key for each of its parents, and its primary key is a composite of both foreign keys.
- A one-to-one relationship requires that the child table has no more than one occurrence for each parent, which can only be enforced by letting the foreign key also serve as the primary key

Keys…

A **semantic** or **natural** key is a key for which the possible values have an obvious meaning to the user or the data. For example a COUNTRY entity might contain the value 'USA' for the occurrence describing the United States of America.

A **technical** or **surrogate** or **artificial** key is a key for which the possible values have no obvious meaning to the user or the data. These are used instead of semantic keys for any of the following reasons:

- When the value in a semantic key is likely to be changed by the user, or can have duplicates. For example, on a PERSON table it is unwise to use PERSON_NAME as the key as it is possible to have more than one person with the same name, or the name may change such as through marriage.
- When none of the existing attributes can be used to guarantee uniqueness. In this case adding an attribute whose value is generated by the system, e.g from a sequence of numbers, is the only way to provide a unique value. Typical examples would be ORDER_ID and INVOICE_ID. The value '12345' has no meaning to the user as it conveys nothing about the entity to which it relates.

Keys…

A key functionally determines the other attributes in the row, thus it is always a determinant.

Note that the term 'key' in most DBMS engines is implemented as an index which does not allow duplicate entries.

The Relationship

One table (relation) may be linked with another in what is known as a **relationship**.

- A relationship is between two tables in what is known as a **one-to-many** or **parent-child** or **master-detail** relationship.
- It is possible for a record on the **parent** table to exist without corresponding records on the **child** table, but it should not be possible for an entry on the **child** table to exist without a corresponding entry on the **parent** table.
- A **child** record without a corresponding **parent** record is known as an **orphan**.
- It is possible for a table to be related to itself. For this to be possible it needs a **foreign key** which points back to the **primary key**.
- A **table** may be the subject of any number of relationships, and it may be the **parent** in some and the **child** in others.
- Some database engines allow a **parent** table to be linked via a **candidate key**, but if this were changed it could result in the link to the **child** table being broken.
- Some database engines allow relationships to be managed by rules known as **referential integrity** or **foreign key restraints**.

Relational Joins

- The join operator is used to combine data from two or more relations (tables) in order to satisfy a particular query.
- Two relations may be joined when they share at least one common attribute.
- The join is implemented by considering each row in an instance of each relation.
- A row in relation R1 is joined to a row in relation R2 when the value of the common attribute(s) is equal in the two relations.
- The join of two relations is often called a **binary join.**
- The join of two relations creates a new relation.
- The notation **R1 x R2** indicates the join of relations R1 and R2. For example, consider the following:

Eg.

Note that the instances of relation R1 and R2 contain the same data values for attribute B.

Data normalisation is concerned with decomposing a relation (e.g. R(A,B,C,D,E) into smaller relations (e.g. R1 and R2).

The data values for attribute B in this context will be identical in R1 and R2.

The instances of R1 and R2 are projections of the instances of R(A,B,C,D,E) onto the attributes (A,B,C) and (B,D,E) respectively.

A projection will not eliminate data values - duplicate rows are removed, but this will not remove a data value from any attribute

Relation R1

A	B	C
1	5	3
2	4	5
8	3	5
9	3	3
1	6	5
5	4	3
2	7	5

Relation R2

B	D	E
4	7	4
6	2	3
5	7	8
7	2	3
3	2	2

The join of relations R1 and R2 is possible because B is a common attribute.

The result of the join is:

Relation R1 x R2

A	B	C	D	E
1	5	3	7	8
2	4	5	7	4
8	3	5	2	2
9	3	3	2	2
1	6	5	2	3
5	4	3	7	4
2	7	5	2	3

Relation

- The row (2 4 5 7 4) was formed by joining the row (2 4 5) from relation R1 to the row (4 7 4) from relation R2.
- The two rows were joined since each contained the same value for the common attribute B.
- The row (2 4 5) was not joined to the row (6 2 3) since the values of the common attribute (4 and 6) are not the same.
- The relations joined in the preceding example shared exactly one common attribute.
- However, relations may share multiple common attributes. All of these common attributes must be used in creating a join.
- For example, the instances of relations R1 and R2 in the following example are joined using the common attributes B and C

Before join R1 and R2

After join R1 and R2

Relation R1		
A	B	C
6	1	4
8	1	4
5	1	2
2	7	1

Relation R2		
B	C	D
1	4	9
1	4	2
1	2	1
7	1	2
7	1	3

The row (6 1 4 9) was formed by joining the row (6 1 4) from relation R1 to the row (1 4 9) from relation R2.
The join was created since the common set of attributes (B and C) contained identical values (1 and 4)
The row (6 1 4) from R1 was not joined to the row (1 2 1) from R2 since the common attributes did not share identical values - (1 4) in R1 and (1 2) in R2.

Relation R1 x R2			
A	B	C	D
6	1	4	9
6	1	4	2
8	1	4	9
8	1	4	2
5	1	2	1
2	7	1	2
2	7	1	3

The join operation provides a method for reconstructing a relation that was decomposed into two relations during the normalisation process.

The join of two rows, however, can create a new row that was not a member of the original relation.

Thus invalid information can be created during the join process.

Lossless Joins

- A set of relations satisfies the lossless join property if the instances can be joined without creating invalid data (i.e. new rows).
- A join that is not lossless will contain extra, invalid rows.
- Thus the term **gainless join** might be more appropriate.
- To give an example of incorrect information created by an invalid join let us take the following data structure:
- **R(student, course, instructor, hour, room, grade)**

Dependences

Assuming that only one section of a class is offered during a semester we can define the following functional dependencies:

- (HOUR, ROOM)   COURSE
- (COURSE, STUDENT)   GRADE
- (INSTRUCTOR, HOUR)   ROOM
- (COURSE)   INSTRUCTOR
- (HOUR, STUDENT)   ROOM

Dependencies and Relationship

STUDENT	COURSE	INSTRUCTOR	HOUR	ROOM	GRADE
Smith	Math 1	Jenkins	8:00	100	A
Jones	English	Goldman	8:00	200	B
Brown	English	Goldman	8:00	200	C
Green	Algebra	Jenkins	9:00	400	A

The following four relations, each in 4th normal form, can be generated from the given and implied dependencies:

R1(<u>STUDENT</u>, <u>HOUR</u>, COURSE)
R2(<u>STUDENT</u>, <u>COURSE</u>, GRADE)
R3(<u>COURSE</u>, INSTRUCTOR)
R4(<u>INSTRUCTOR</u>, <u>HOUR</u>, ROOM)

Note that the dependencies (HOUR, ROOM)   COURSE and (HOUR, STUDENT)   ROOM are not explicitly represented in the preceding decomposition.
The goal is to develop relations in 4th normal form that can be joined to answer any ad hoc inquiries correctly.
This goal can be achieved without representing every functional dependency as a relation.
Furthermore, several sets of relations may satisfy the goal.

Preceding set of relation

R1		
STUDENT	HOUR	COURSE
Smith	8:00	Math 1
Jones	8:00	English
Brown	8:00	English
Green	9:00	Algebra

R2		
STUDENT	COURSE	GRADE
Smith	Math 1	A
Jones	English	B
Brown	English	C
Green	Algebra	A

R3		
COURSE	INSTRUCTOR	
Math 1	Jenkins	
English	Goldman	
Algebra	Jenkins	

R4		
INSTRUCTOR	HOUR	ROOM
Jenkins	8:00	100
Goldman	8:00	200
Jenkins	9:00	400

Now suppose that a list of courses with their corresponding room numbers is required.

Relations R1 and R4 contain the necessary information and can be joined using the attribute HOUR.

The result of this join is:

R1 x R4

STUDENT	COURSE	INSTRUCTOR	HOUR	ROOM
Smith	Math 1	Jenkins	8:00	100
Smith	Math 1	Goldman	8:00	200
Jones	English	Jenkins	8:00	100
Jones	English	Goldman	8:00	200
Brown	English	Jenkins	8:00	100
Brown	English	Goldman	8:00	200
Green	Algebra	Jenkins	9:00	400

- This join creates the following invalid information (denoted by the coloured rows):
- Smith, Jones, and Brown take the same class at the same time from two different instructors in two different rooms.
- Jenkins (the Maths teacher) teaches English.
- Goldman (the English teacher) teaches Maths.
- Both instructors teach different courses at the same time.

- Another possibility for a join is R3 and R4 (joined on INSTRUCTOR).
- The result would be:

R3 x R4			
COURSE	INSTRUCTOR	HOUR	ROOM
Math 1	Jenkins	8:00	100
Math 1	Jenkins	9:00	400
English	Goldman	8:00	200
Algebra	Jenkins	8:00	100
Algebra	Jenkins	9:00	400

This join creates the following invalid information:

Jenkins teaches Math 1 and Algebra simultaneously at both 8:00 and 9:00.

A correct sequence is to join R1 and R3 (using COURSE) and then join the resulting relation with R4 (using both INSTRUCTOR and HOUR).

The result would be:

R1 x R3

STUDENT	COURSE	INSTRUCTOR	HOUR
Smith	Math 1	Jenkins	8:00
Jones	English	Goldman	8:00
Brown	English	Goldman	8:00
Green	Algebra	Jenkins	9:00

(R1 x R3) x R4

STUDENT	COURSE	INSTRUCTOR	HOUR	ROOM
Smith	Math 1	Jenkins	8:00	100
Jones	English	Goldman	8:00	200
Brown	English	Goldman	8:00	200
Green	Algebra	Jenkins	9:00	400

Extracting the COURSE and ROOM attributes (and eliminating the duplicate row produced for the English course) would yield the desired result:

COURSE	ROOM
Math 1	100
English	200
Algebra	400

The correct result is obtained since the sequence (R1 x r3) x R4 satisfies the lossless (gainless?) join property

- A relational database is in 4th normal form when the lossless join property can be used to answer unanticipated queries.
- However, the choice of joins must be evaluated carefully.
- Many different sequences of joins will recreate an instance of a relation.
- Some sequences are more desirable since they result in the creation of less invalid data during the join operation.
- Suppose that a relation is decomposed using functional dependencies and multi-valued dependencies.
- Then at least one sequence of joins on the resulting relations exists that recreates the original instance with no invalid data created during any of the join operations.

For example, suppose that a list of grades by room number is desired.

This question, which was probably not anticipated during database design, can be answered without creating invalid data by either of the following two join sequences:

R1 x R3	R1 x R3
(R1 x R3) x R2	(R1 x R3) x R4
((R1 x R3) x R2) x R4	((R1 x R3) x R4) x R2

The required information is contained with relations R2 and R4, but these relations cannot be joined directly.

In this case the solution requires joining all 4 relations.

Functional Dependency

- The database may require a 'lossless join' relation, which is constructed to assure that any ad hoc inquiry can be answered with relational operators.
- This relation may contain attributes that are not logically related to each other.
- This occurs because the relation must serve as a bridge between the other relations in the database.
- For example, the lossless join relation will contain all attributes that appear only on the left side of a functional dependency.
- Other attributes may also be required, however, in developing the lossless join relation.
- Consider relational schema R(A, B, C, D), A B and C D.
- Relations Rl(<u>A</u>, B) and R2(<u>C</u>, D) are in 4th normal form.
- A third relation R3(<u>A</u>, <u>C</u>), however, is required to satisfy the lossless join property.
- This relation can be used to join attributes B and D.
- This is accomplished by joining relations R1 and R3 and then joining the result to relation R2.
- No invalid data is created during these joins. The relation R3(<u>A</u>, <u>C</u>) is the lossless join relation for this database design.

Multi-valued Dependencies

- A relation is usually developed by combining attributes about a particular subject or entity.
- The lossless join relation, however, is developed to represent a relationship among various relations.
- The lossless join relation may be difficult to populate initially and difficult to maintain - a result of including attributes that are not logically associated with each other.
- The attributes within a lossless join relation often contain multi-valued dependencies.
- Consideration of 4th normal form is important in this situation.
- The lossless join relation can sometimes be decomposed into smaller relations by eliminating the multi-valued dependencies.
- These smaller relations are easier to populate and maintain.

Determinant and Dependent

- The expression $X \rightarrow Y$ means 'if I know the value of X, then I can obtain the value of Y' (in a table or somewhere).
- In the expression $X \rightarrow Y$, X is the **determinant** and Y is the **dependent** attribute.
- The value X **determines** the value of Y.
- The value Y **depends on** the value of X.

Functional Dependencies (FD)

- An attribute is functionally dependent if its value is determined by another attribute *which is a key*.
- If we know the value of one (or several) data items, then we can find the value of another (or several).
- Functional dependencies are expressed as X→Y, where X is the determinant and Y is the functionally dependent attribute.
- If A→ (B,C) then A→B and A→C.
- If (A,B) →C, then it is not necessarily true that A→C and B→C.
- If A→B and B→A, then A and B are in a 1-1 relationship.
- If A→B then for A there can only ever be one value for B.

Transitive Dependencies (TD)

- An attribute is transitively dependent if its value is determined by another attribute *which is not a key*.
- If X→Y and X is not a key then this is a transitive dependency.
- A transitive dependency exists when A→B→C but NOT A→C.

Multi-Valued Dependencies (MVD)

- A table involves a multi-valued dependency if it may contain multiple values for an entity.
- A multi-valued dependency may arise as a result of enforcing 1st normal form.
- X →→Y, ie X multi-determines Y, when for each value of X we can have more than one value of Y.
- If A→→B and A→→C then we have a single attribute A which multi-determines two other independent attributes, B and C.
- If A→→(B,C) then we have an attribute A which multi-determines a set of associated attributes, B and C.

Join Dependencies (JD)

- If a table can be decomposed into three or more smaller tables, it must be capable of being joined again on common keys to form the original table

Modification Anomalies

A major objective of data normalisation is to avoid modification anomalies. These come in two flavours:

- An **insertion anomaly** is a failure to place information about a new database entry into all the places in the database where information about that new entry needs to be stored.
- In a properly normalized database, information about a new entry needs to be inserted into only one place in the database.
- In an inadequately normalized database, information about a new entry may need to be inserted into more than one place, and, human fallibility being what it is, some of the needed additional insertions may be missed.
- A **deletion anomaly** is a failure to remove information about an existing database entry when it is time to remove that entry.
- In a properly normalized database, information about an old, to-be-gotten-rid-of entry needs to be deleted from only one place in the database.

Anomalies…

- In an inadequately normalized database, information about that old entry may need to be deleted from more than one place, and, human fallibility being what it is, some of the needed additional deletions may be missed.
- An update of a database involves modifications that may be additions, deletions, or both.
- Thus **'update anomalies'** can be either of the kinds of anomalies discussed above.
- All three kinds of anomalies are highly undesirable, since their occurrence constitutes corruption of the database.
- Properly normalised databases are much less susceptible to corruption than are unnormalised databases.

Types of Relational Join

A JOIN is a method of creating a result set that combines rows from two or more tables (relations).

When comparing the contents of two tables the following conditions may occur:

- Every row in one relation has a match in the other relation.
- Relation R1 contains rows that have no match in relation R2.
- Relation R2 contains rows that have no match in relation R1.

INNER joins contain only matches. OUTER joins may contain mismatches as well.

Inner Join

This is sometimes known as a **simple** join. It returns all rows from both tables where there is a match. If there are rows in R1 which do not have matches in R2, those rows will **not** be listed.

There are two possible ways of specifying this type of join:

SELECT * FROM R1, R2 WHERE R1.r1_field = R2.r2_field;

SELECT * FROM R1 INNER JOIN R2 ON R1.field = R2.r2_field

If the fields to be matched have the same names in both tables then the **ON** condition, as in:

ON R1.fieldname = R2.fieldname

ON (R1.field1 = R2.field1 AND R1.field2 = R2.field2)

can be replaced by the shorter **USING** condition, as in:

- **USING fieldname**
- **USING (field1, field2)**

Natural Join

A natural join is based on all columns in the two tables that have the same name.

It is semantically equivalent to an INNER JOIN or a LEFT JOIN with a **USING** clause that names all columns that exist in both tables.

SELECT * FROM R1 NATURAL JOIN R2

The alternative is a **keyed** join which includes an **ON** or **USING** condition.

Left Outer Join

Returns all the rows from R1 even if there are no matches in R2.

If there are no matches in R2 then the R2 values will be shown as null.

SELECT * FROM R1 LEFT [OUTER] JOIN R2 ON R1.field = R2.field

Right Outer Join

Returns all the rows from R2 even if there are no matches in R1.

If there are no matches in R1 then the R1 values will be shown as null.

- **SELECT * FROM R1 RIGHT [OUTER] JOIN R2 ON R1.field = R2.field**

Full Outer Join

Returns all the rows from both tables even if there are no matches in one of the tables.

If there are no matches in one of the tables then its values will be shown as null.

SELECT * FROM R1 FULL [OUTER] JOIN R2 ON R1.field = R2.field

Self Join

This joins a table to itself.

This table appears twice in the FROM clause and is followed by table aliases that qualify column names in the join condition.

SELECT a.field1, b.field2 FROM R1 a, R1 b WHERE a.field = b.field

Cross Join

This type of join is rarely used as it does not have a join condition, so every row of R1 is joined to every row of R2.

For example, if both tables contain 100 rows the result will be 10,000 rows.

This is sometimes known as a **cartesian product** and can be specified in either one of the following ways:

- **SELECT * FROM R1 CROSS JOIN R2**
- **SELECT * FROM R1, R2**

Logical Design

- Constructing ERD

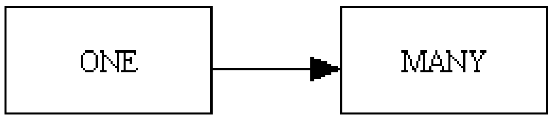
Entity Relationship Diagram (ERD)

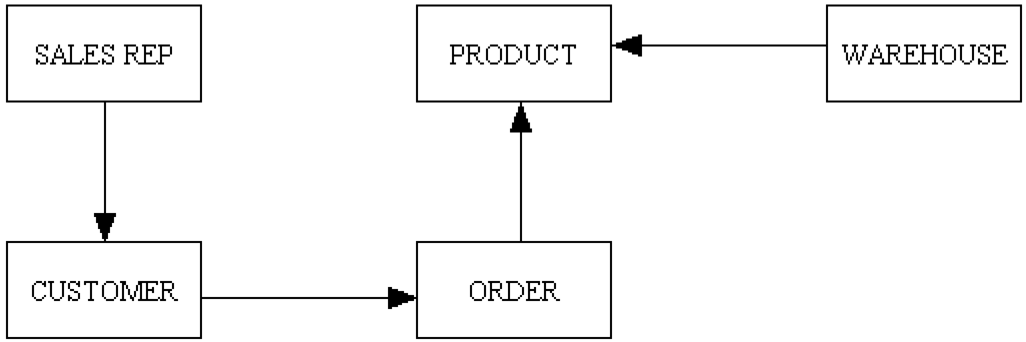
- An entity-relationship diagram (ERD) is a data modeling technique that creates a graphical representation of the entities, and the relationships between entities, within an information system.
- Any ER diagram has an equivalent relational table, and any relational table has an equivalent ER diagram.
- ER diagramming is an invaluable aid to engineers in the design, optimization, and debugging of database programs.
- The entity is a person, object, place or event for which data is collected.
- It is equivalent to a database table.
- An entity can be defined by means of its properties, called attributes.
- For example, the CUSTOMER entity may have attributes for such things as name, address and telephone number.

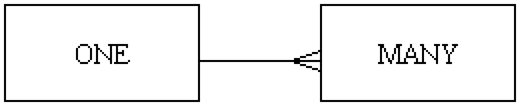
ERD…

- The relationship is the interaction between the entities. It can be described using a verb such as:
  - A customer *places* an order.
  - A sales rep *serves* a customer.
  - A order *contains* a product.
  - A warehouse *stores* a product.
- In an entity-relationship diagram entities are rendered as rectangles, and relationships are portrayed as lines connecting the rectangles.
- One way of indicating which is the 'one' or 'parent' and which is the 'many' or 'child' in the relationship is to use an arrowhead.

ERD Diagram Notation







ERD and Relationship

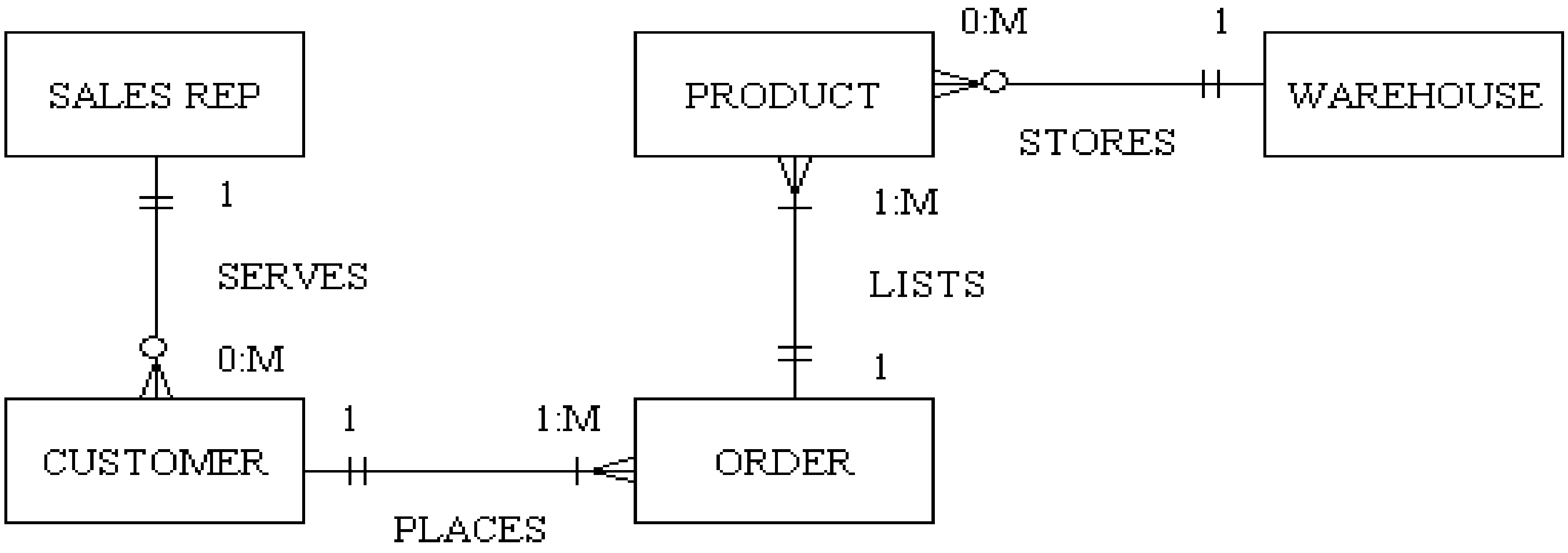
The relating line can be enhanced to indicate cardinality which defines the relationship between the entities in terms of numbers. An entity may be *optional* (zero or more) or it may be mandatory (one or more).

- A single bar indicates **one**.
- A double bar indicates **one and only one**.
- A circle indicates **zero**.
- A crowsfoot or arrowhead indicates **many**.

As well as using lines and circles the cardinality can be expressed using numbers, as in:

- One-to-One expressed as 1:1
- Zero-to-Many expressed as 0:M
- One-to-Many expressed as 1:M
- Many-to-Many expressed as N:M

Representation of ERD



In plain language the relationships can be expressed as follows:

- 1 instance of a SALES REP serves 1 to many CUSTOMERS
- 1 instance of a CUSTOMER places 1 to many ORDERS
- 1 instance of an ORDER lists 1 to many PRODUCTS
- 1 instance of a WAREHOUSE stores 0 to many PRODUCTS

ERD Rules

In order to determine if a particular design is correct simple test has been placed:

- Take the written rules and construct a diagram.
- Take the diagram and try to reconstruct the written rules.

- If the output from step (2) is not the same as the input to step (1) then something is wrong.
- If the model allows a situation to exist which is not allowed in the real world then this could lead to serious problems.
- The model must be an accurate representation of the real world in order to be effective.
- If any ambiguities are allowed to creep in they could have disastrous consequences.

ERD Rules…

Before construct the physical database there are several steps that must take place:

- Assign attributes (properties or values) to all the entities.
- After all, a table without any columns will be of little use to anyone.
- Refine the model using a process known as ‘normalization'.
- This ensures that each attribute is in the right place.
- During this process it may be necessary to create new tables and new relationships.

Physical Design

- General consideration

Database Names

- Database names should be short and meaningful, such as **products**, **purchasing** and **sales**.
  - Short, but not too short, as in **prod** or **purch**.
  - Meaningful but not verbose, as in 'the database used to store product details'.
- Do not waste time using a prefix such as **db** to identify database names.
- DBMS allows a mixture of upper and lowercase names, and it is case sensitive
- It is better to stick to a standard naming convention such as:
  - All uppercase.
  - All lowercase
  - Leading uppercase, remainder lowercase.
- Inconsistencies may lead to confusion, confusion may lead to mistakes, mistakes can lead to disasters.

Database Names…

- Database name contains more than one word, such as in **sales orders** and **purchase orders**, decide how to deal with it:
  - Separate the words with a single space, as in **sales orders**(not allowed)
  - Separate the words with an underscore, as in **sales_orders**
  - Separate the words with a hyphen, as in **sales-orders**.
  - Use camel caps, as in **SalesOrders**.
- Again, be consistent.
- Rather than putting all the tables into a single database it may be better to create separate databases for each logically related set of tables.
- This may help with security, archiving, replication, etc.

Table Names

- Table names should be short and meaningful, such as **part**, **customer** and **invoice**.
  - Short, but not too short.
  - Meaningful, but not verbose.
- Do not use a prefix or suffix such as **tbl** to identify table names.
- Table names should be in the singular (e.g. **customer** not **customers**).
- DBMS allows a mixture of upper and lowercase names, and it is case sensitive.
- It is better to stick to a standard naming convention such as:
  - All uppercase.
  - All lowercase.
  - Leading uppercase, remainder lowercase.
- Inconsistencies may lead to confusion, confusion may lead to mistakes, mistakes can lead to disasters.

Table Names..

- If a table name contains more than one word, such as in **sales order** and **purchase order**, decide how to deal with it:
  - Separate the words with a single space, as in **sales order**
  - Separate the words with an underscore, as in **sales_order**
  - Separate the words with a hyphen, as in **sales-order**
  - Use camel caps, as in **SalesOrder**.
- Again, be consistent.
- Be careful if the same table name is used in more than one database - it may lead to confusion.

Field Names

- Field names should be short and meaningful, such as **part_name** and **customer_name**.
  - Short, but not too short, such as in **ptnam**.
  - Meaningful, but not verbose, such as **the name of the part**.
- Do not use a prefix or suffix such as **col** or **fld** to identify column/field names.
- DBMS allows a mixture of upper and lowercase names, and it is case sensitive, it is better to stick to a standard naming convention such as:
  - All uppercase.
  - All lowercase.
  - Leading uppercase, remainder lowercase.
- Inconsistencies may lead to confusion, confusion may lead to mistakes, mistakes can lead to disasters.

Field Names..

- If a field name contains more than one word, such as in **part name** and **customer name**, decide how to deal with it:
  - Separate the words with a single space, as in **part name**.
  - Separate the words with an underscore, as in **part_name** .
  - Separate the words with a hyphen, as in **part-name**.
  - Use camel caps, as in **PartName**.
- Again, be consistent.
- Common words in field names may be abbreviated, but be consistent.
  - Do not allow a mixture of abbreviations, such as 'no', 'num' and 'nbr' for 'number'.
  - Publish a list of standard abbreviations and enforce it.
- Although field names must be unique within a table
- It is possible to use the same name on multiple tables even if they are unrelated, or they do not share the same set of possible values.
- It is recommended that this practice should be avoided, for reasons described in Field names should identify their content and The naming of Foreign Keys.

Primary Key

- It is recommended that the primary key of an entity should be constructed from the table name with a suffix of **_ID**.
- This makes it easy to identify the primary key in a long list of field names.
- Do not use prefix or suffix such as **pk** to identify primary key fields. This has absolutely no meaning to any database engine or any application.
- Avoid using generic names for all primary keys.
- It may seem a clever idea to use the name **ID** for every primary key field, but this causes problems:
  - It causes the same name to appear on multiple tables with totally different contexts.
  - The string ID='ABC123' is extremely vague as it gives no idea of the entity being referenced.
  - Is it an invoice id, customer id, or what?
- It also causes a problem with foreign keys.

Primary Key…

- There is no rule that says a primary key must consist of a single attribute - both simple and composite keys are allowed.
- Avoid the unnecessary use of technical keys.
- If a table already contains a satisfactory unique identifier, whether composite or simple, there is no need to create another one.
- The use of a technical key can be justified in certain circumstances, it takes intelligence to know when those circumstances are right.
- The indiscriminate use of technical keys shows a distinct lack of intelligence.

Foreign Keys

- It is recommended that where a foreign key is required that you use the same name as that of the associated primary key on the foreign table.
- It is a requirement of a relational join that two relations can only be joined when they share at least one common attribute, and this should be taken to mean the attribute name(s) as well as the value(s). Thus where the**customer** and **invoice** tables are joined in a parent-child relationship the following will result:
  - The primary key of **customer** will be **customer_id**.
  - The primary key of **invoice** will be **invoice_id**.
  - The foreign key which joins **invoice** to **customer** will be **customer_id**.
- For MySQL users this means that the shortened version of the join condition may be used:
  - Short: A LEFT JOIN B USING (a,b,c)
  - Long: A LEFT JOIN B ON (A.a=B.a AND A.b=B.b AND A.c=B.c)

Foreign Kesy…

- The only exception to this naming recommendation should be where a table contains more than one foreign key to the same parent table.
- Simply add a meaningful suffix to each name to identify the usage, such as:
  - To signify movement use **location_id_from** and **location_id_to**.
  - To signify positions in a hierarchy use **node_id_snr** and **node_id_jnr**.
  - To signify replacement use **part_id_old** and **part_id_new**.
- Prefer to use a suffix rather than a prefix as it makes the leading characters match (as in **PART_ID_old** and **PART_ID_new**) instead of having the trailing characters match (as in **old_PART_ID** and **new_PART_ID**)

Generating Unique ids

- Where a technical primary key is used a mechanism is required that will generate new and unique values.
- Such keys are usually numeric, so there are several methods available:
- Some database engines will maintain a set of sequence numbers for you which can be referenced using code such as :

  SELECT <seq_name>.NEXTVAL FROM DUAL
- Using such a sequence is a two-step procedure:
  - Access the sequence to obtain a value.
  - Use the supplied value on an INSERT statement.

Generating Unique ids..

- It is sometimes possible to access the sequence directly from an INSERT statement, as in the following:

  INSERT INTO tablename (col1,col2,...) VALUES (tablename_seq.nextval,'value2',...)
- If the number just used needs to be retrieved so that it can be passed back to the application it can be done so with the following:

  SELECT <seq_name>.CURRVAL FROM DUAL
- But a disadvantage that found is that the DBMS has no knowledge of what primary key is linked to which sequence
- So it is possible to insert a record with a key not obtained from the sequence and thus cause the two to become unsynchronised.
- The next time the sequence is used it could therefore generate a value which already exists as a key and therefore cause an INSERT error.

Generating Unique ids…

- Some database engines will allow to specify a numeric field as 'auto-increment‘
- An INSERT they will automatically generate the next available number.
- This is better than the previous method because:
  - The sequence is tied directly to a particular database table and is not a separate object, thus it is impossible to become unsynchronised.
  - It is not necessary to access the sequence then use the returned value on an INSERT statement - just leave the field empty and the DBMS will fill in the value automatically.

Generating Unique ids..

- While the previous methods have their merits, they both have a common failing in that they are not-standard extensions to the SQL standard, therefore they are not available in all SQL-compliant database engines.
- This becomes an important factor if it is ever decided to switch to another database engine.
- A truly portable method which uses a standard technique and can therefore be used in any SQL-compliant database is to use an SQL statement similar to the following to obtain a unique key for a table:

    SELECT max(table_id) FROM <tablename> table_id = table_id+1

Generating Unique ids…

- Some people seem to think that this method is inefficient as it requires a full table search, but they are missing the fact that **table_id** is a primary key, therefore the values are held within an index.
- The **SELECT max(…)** statement will automatically be optimized to go straight to the last value in the index, therefore the result is obtained with almost no overhead.
- This would not be the case if I used **SELECT count(…)** as this would have to physically count the number of entries.
- Another reason for not using **SELECT count(…)** is that if records were to be deleted then record count would be out of step with the highest current value.

Generating Unique ids...

- The Radicore development framework has separate data access objects for each DBMS to which it can connect.
- This means that the different code for dealing with auto_increment keys can be contained within each object, so is totally transparent to the application.
- All that is necessary is that the key be identified as 'auto_increment' in the Data Dictionary and the database object will take care of all the necessary processing.