DATABASE TECHNOLOGY - 1DL116

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An introductury course on database systems

http://user.it.uu.se/~udbl/dbt-vt2007/
alt. http://www.it.uu.se/edu/course/homepage/dbastekn/vt07/

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Introduction to the Relational Model

Elmasri/Navathe ch 5, 7
Padron-McCarthy/Risch ch 5, 6

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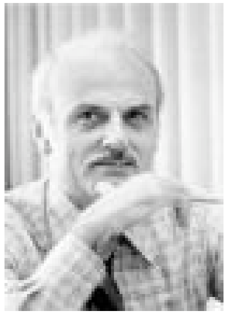
The Relational Model



- The relational model was introduced by Dr. Edgar (Ted) F. Codd (1924-2003) in 1970.
  - Dr. Codd. a mathematician from Oxford (UK), was at that time working as an IBM researcher in the IBM San Jose Research Laboratory (USA).
- Many DBMS's are based on the relational data model.
- It support simple declarative, but yet powerful, languages for describing operations on data.
- Operations in the relational model applies to relations (tables) and produce new relations.
  - This means that an operation can be applied to the result of another operation and that several different operations can be combined.
  - Operations are described in an algebraic notation that is based on relational algebra.

Relations as mathematical objects

- In set theory, a relation is defined as a subset of the product set (cartesian product) of a number of domains (value sets).
- The product set of the domains $D_1, D_2, \ldots, D_n$ is written as $D_1 \times D_2 \times .. \times D_n$.
- $\mathbf{D_1 \times D_2 \times \ldots \times D_n}$ constitute the set of all ordered sets $<v_1,v_2,\ldots,v_n>$ such that v_i belongs to D_i for all i.
  - If n=2, $D_1=\{T, F\}$ and $D_2=\{P, Q, R\}$ one gets the product sets:
    $D_1 \times D_2 = \{<T,P>,<T,Q>,<T,R>,<F,P>,<F,Q>,<F,R>\}$
    $D_2 \times D_1 = \{<P,T>,<P,F>,<Q,T>,<Q,F>,<R,T>,<R,F>\}$
  - For example, we have the relations:
    $R_1 \subseteq D_2 \times D_1$ $R_1= \{<P,T>,<Q,T>,<R,T>\}$
    $R_2 \subseteq D_2 \times D_1$ $R_2= \{<P,T>,<P,F>\}$
- Members of a relation is called **tuples**. If the relation is of **degree** n, the tuples are called *n-tuples*.

Relation schema and instance

- $A_1, A_2, \ldots, A_n$ are attributes
- $R = (A_1, A_2, \ldots, A_n)$ is a relation schema
  - *Customer-schema(customer-name, customer-street, customer-city)*
- r(R) is a relation on the relation schema R
  - *customer (Customer-schema)*
- The current values (*relation instance*) of a relation are specified by a table.
- An element *t* of *r* is a tuple - represented by a *row* in a table customer

an attribute

customer

a relation

customer-name	*customer-street*	*customer-city*
Jones	Main	Harrison
Smith	North	Rye
Curry	North	Rye
Lindsay	Park	Pittsfield

a tuple

First Normal Form

- Only simple or atomic values are allowed in the relational model.
- Attributes is not allowed to have composite or multiple values.
- The theory for the relational model is based on these assumptions which is called:

The first normal form assumption

Null values

- A special value, **null** or ⊥, can sometimes be used as an attribute value.
- Every occurence of null is unique. Thus, two occurences of null is not considered to be equal even if they are represented by the same symbol.
- null is used:
  - when one does not know the actual value of an attribute.
  - when a certain attribute does not have a value.
  - when an attribute is not applicable.
- Examples of the use of null are showed later.

Keys

- Because relations are sets, all tuples in the relation are different.
- There is usually a subset k of the attributes in a relation schema R, i.e. $k \subseteq R$, that has the characteristic that if the tuples $t1, t2 \in r(R)$ and $t1 \neq t2$, the following holds:
  $t1[k] \neq t2[k]$ (i.e. the value of k in $t1 \neq$ the value of k in t2)
- Every such subset k is called a **superkey** for R.

Keys - continued . . .

- A superkey k is *minimal* if there is no other superkey k' such that k' $\subset$ k.
- Every minimal superkey (NOTE! there can be more than one) is called a **candidate key** for R.
- The candidate key <u>chosen</u> by the database designer as the key for R is called R:s **primary key** or just **key**.
- In addition, term **foreign key** is used when a tuple is referenced, from another relation, with its key.

Determining keys from E-R types

- **Strong entity type**. The primary key of the entity type becomes the primary key of the relation.
- **Weak entity type**. The primary key of the relation consists of the union of the primary key of the strong entity type and the discriminator of the weak entity type.
- **Relationship type**. The union of the primary keys of the related entity types becomes a super key of the relation.
  - For binary many-to-many relationship types, above super key is also the primary key.
  - For binary many-to-one relationship types, the primary key of the "many" entity type becomes the relation's primary key.
  - For one-to-one relationship types, the relation's primary key can be that of either entity type.

Integrity constraints

for a relational database schema

- 1. Domain constraint
  - attribute values for attribute A shall be atomic values from dom(A)
- 2. Key constraint
  - candidate keys for a relation must be unique
- 3. Entity integrity constraint
  - no primary key is allowed to have a null value
- 4. Referential integrity constraint
  - a tuple that refers to another tuple in another relation must refer to an existing tuple
- 5. Semantic integrity constraint
  - e.g. “an employee’s total work time per week can not exceed 40 hours for all projects taken all together”

Steps in translation from E-R model to relational model

- Translation of entity types and their attributes
  - Step 1) Entity types
  - Step 2) Weak entity types
- Translation of relationships
  - Step 3) 1-1 Relationship
  - Step 4) 1-N Relationship
  - Step 5) M-N Relationship
- Translation of multivalued attributes and relationships
  - Step 6) Multivalued attributes
  - Step 7) Multivalued relationships

Translating entity types and their attributes

- Step 1: Entity types - a strong entity type reduces to a table with the same attributes.
  - Key attributes (primary key - pk) is made the primary key column(s) for the table. Each attribute gets their own column.
  - Composite attributes are normally represented by their simple components.
  - Example customer schema and table:

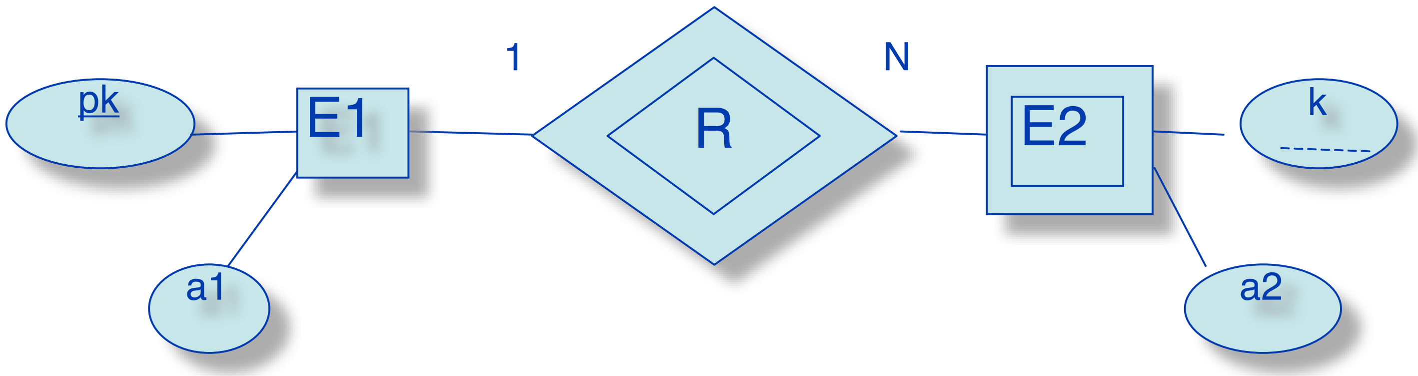
pk

Customer(<u>social-security</u>, customer-name, c-street, c-city)

<u>social-security</u>	*customer-name*	*c-street*	*c-city*
321-12-3123	Jones	Main	Harrison
019-28-3746	Smith	North	Rye
677-89-9011	Hayes	Main	Harrison

Translating entity types cont. . .

- Step 2: **Weak entity types** - a weak entity type becomes a table that includes a column for the primary key of the identifying strong entity type .



pk	a1

pk	k	a2

Translating entity types cont. . .

- The table corresponding to a relationship type linking a weak entity type to its identifying strong entity type is redundant.

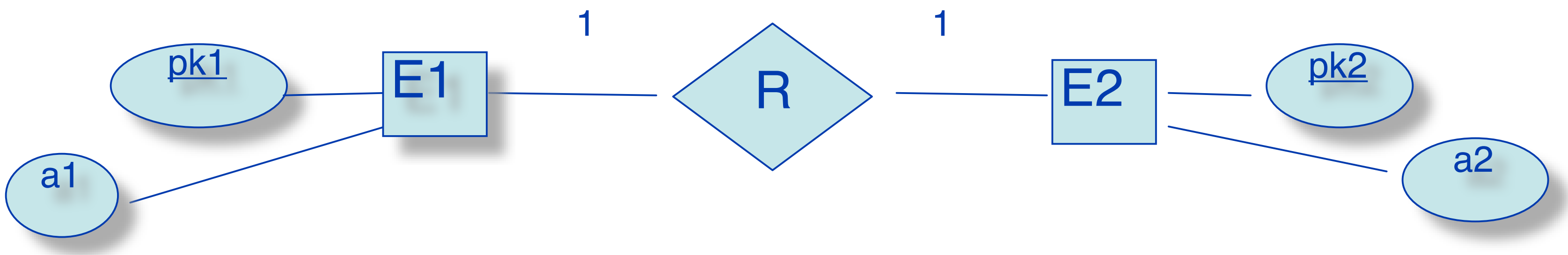
- Example of the payment schema and table:
  - The payment table already contains the information that would appear in the loan-payment table (i.e., the columns loan-number and payment-no).

Payment(<u>loan-number</u>, <u>payment-no</u>, pay-date, amount)

<u>loan-number</u>	*<u>payment-no</u>*	*pay-date*	*amount*
L-17	5	10 May 1996	50
L-23	11	17 May 1996	75
L-15	22	23 May 1996	300

Translating relationship types

- Step 3: 1-1 Relationship types
  - The foreign key column (fk) is a copy of the other entity’s primary key column (pk). The values in a fk-column point to unique row in the other table, and thus implement the relationship.



Alt 1:

pk1	a1

pk2	a2	f k1

Alt 2:

pk1	a1	f k2

pk2	a2

Translating 1-1 relationship types cont. . .

Alt 3:

E1

pk1	a1

R

f k1	f k2

E2

pk2	a2

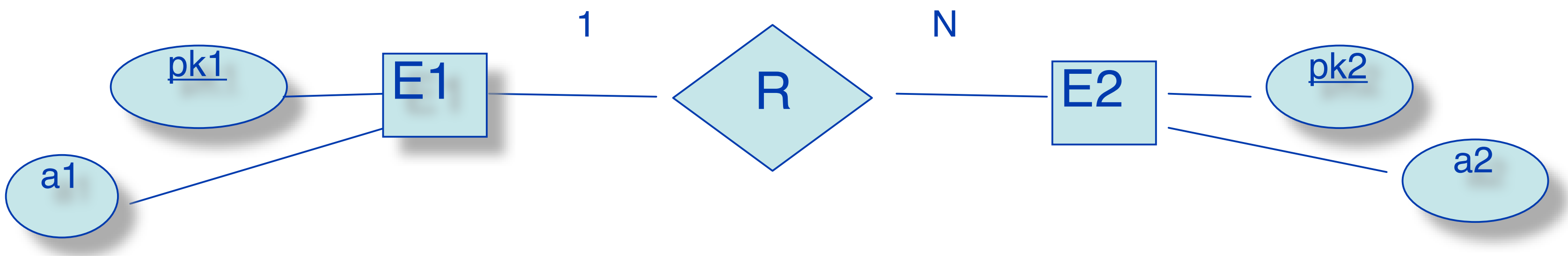
Alt 4:

E1 E2

pk1	a1	pk2	a2

Translating relationship . . . cont. . .

- Step 4: 1-N Relationship types
  - Include the primary key of the “1-side” as a foreign key on the “N-side”, (i.e. the foreign key column is placed on the entity on the N-side).
  - Alternatively, an extra table (R) is created whose primary key is a foreign key composed by the primary key from the N-side.



Alt 1:

pk1	a1

pk2	a2	f k1

Alt 2:

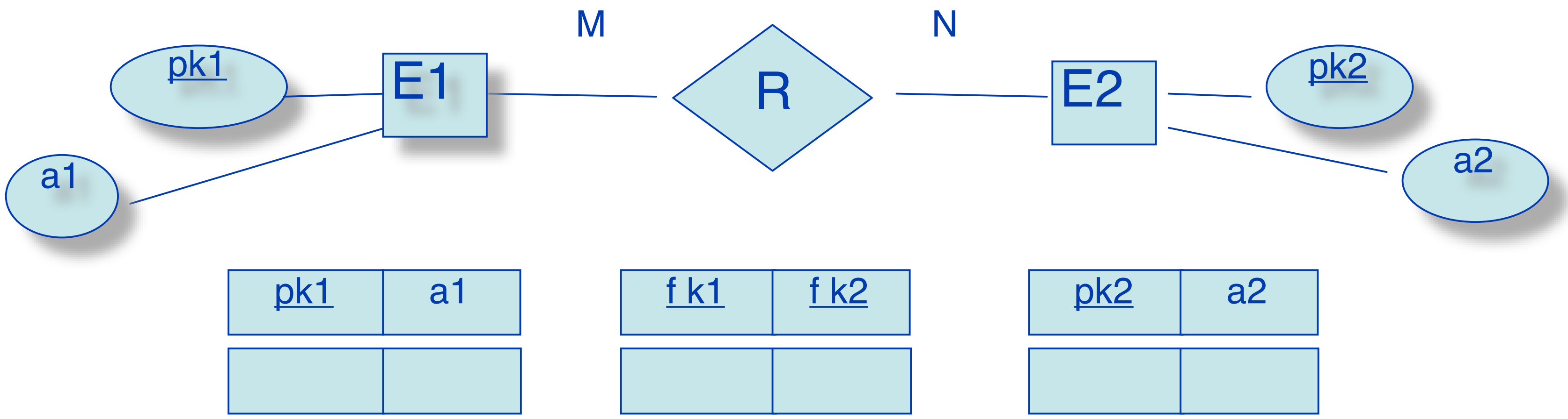
pk1	a1

f k1	f k2

pk2	a2

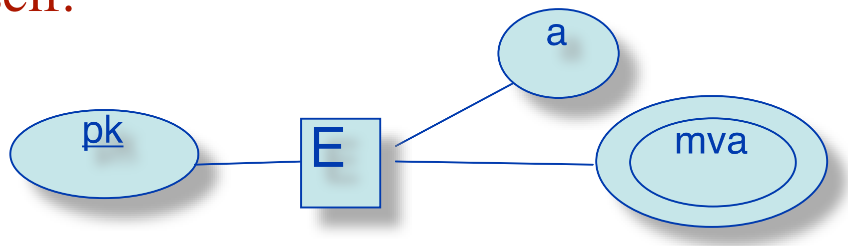
Translating relationship . . . cont. . .

- Step 5: M-N Relationship types
  - Always a separate table with columns for the primary keys of the two participating entity types, and any descriptive attributes of the relationship type.



Translating relationship . . . cont. . .

- Step 6: Multivalued attributes
  - A separate table is created for the multivalued attribute. Its primary key is composed of the owning entity's primary key, and the attribute value itself.



E

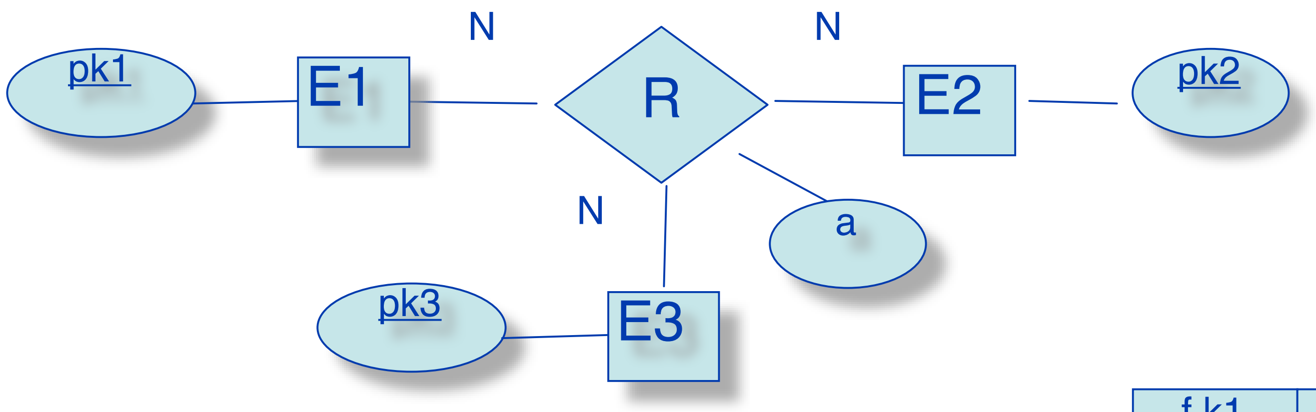
pk	a

E-MVA

pk	mva

Translating relationship . . . cont. . .

- Step 7: Multivalued relationship types
  - First try to remove multivalued relationships <u>on the E-R model level</u> by model transformation.
  - A separate table is created, with foreign keys to all tables that are included in the relationship. Its primary key is composed of all foreign keys.

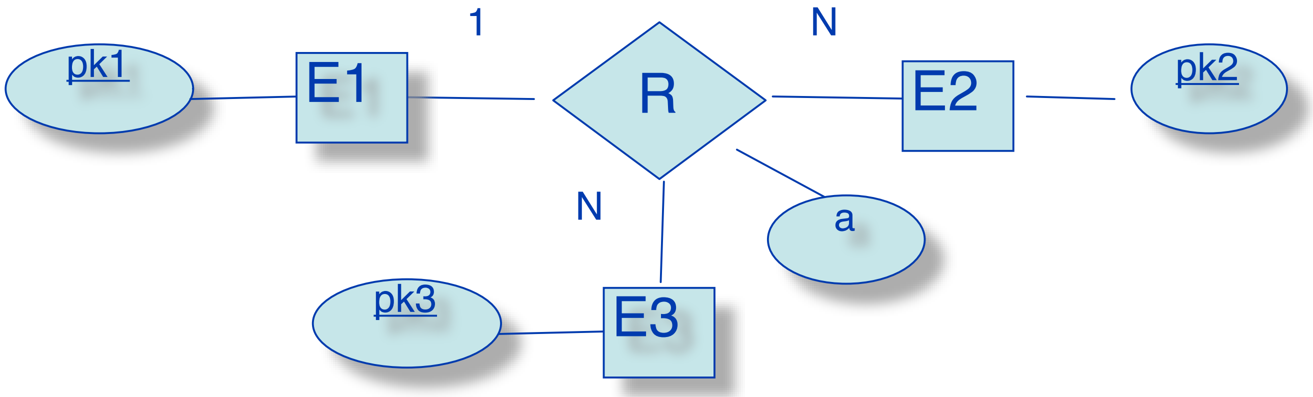


R

f k1	f k2	f k3	a

Translating relationship . . . cont. . .

- Step 7: Multivalued relationship types continued
  - In the case where R is 1-N-N, the primary key on R shall not include the fk for the table with cardinality 1.



R

f k1	f k2	f k3	a

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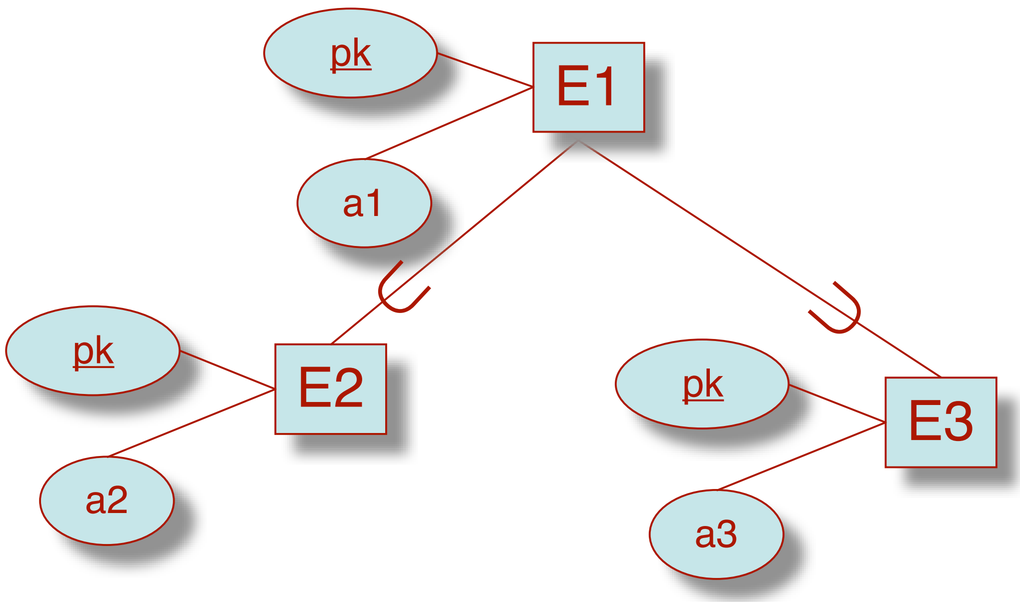
Translating Specialization/Generalization

- Alternative a) in Elmasri/Navathe



E1

pk	a1

E2

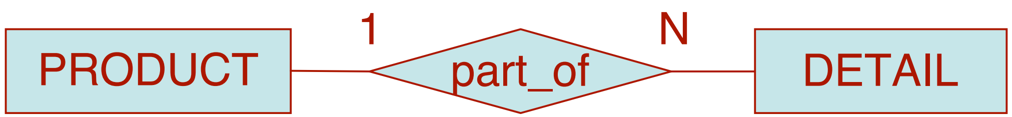
pk	a2

E3

pk	a3

Translating aggregation

- Translating an implicit aggregation relationship type.



PRODUCT

pid	

DETAIL

did		fk1

- Translating an objectified aggregation relationship type.

PRODUCT

pid	

ASSEMBLY

(aid)	pid	did

DETAIL

did	

Example E-R to relational model translation