Main Topics

- ER model
- Relational Model - Algebra
- SQL
- Functional Dependences
Notation of ER Diagrams

- **E**  - Entity Set
- **A**  - Attribute
- **E**  - Weak Entity Set
- **A**  - Multivalued Attribute
- **R**  - Relationship Set
- **A**  - Derived Attribute
- **R**  - Identifying Relationship Set for Weak Entity Set
- **E**  - Total Participation of Entity Set in Relationship
- **A**  - Primary Key
- **_ _ _**  - Discriminating Attribute of Weak Entity Set
Notation of ER Diagrams (cont.)

- Many to Many Relationship
- Many to One Relationship
- One to One Relationship
- Cardinality Limits
- Role Name
- Role Indicator
- ISA (Specialization or Generalization)
- ISA (Disjoint Generalization)
- Total Generalization
Notation of ER Diagrams (cont.)
• **Relations**: schema and instances
• **Attributes**: single-valued, domain, keys
• **Set of records**: no duplicates, no order
• **Formal query languages**:
  - Relational algebra (RA)

• **Automatic conversion between relational and ER**
Relational Schema Example

branch (branch-name, branch-city, assets)  
customer (customer-name, customer-street, customer-city) 
account (account-number, branch-name, balance)  
loan (loan-number, branch-name, amount)  

depositor (customer-name, account-number)  
borrower (customer-name, loan-number)  

Keys are underlined and foreign keys are in italics.
Relational Algebra

- **Basic operations:**
  - Selection (\(\sigma\))
  - Projection (\(\pi\))
  - Cross-product (\(\times\))
  - Set-difference (\(-\))
  - Union (\(\cup\))
  - Renaming (\(\rho\))

- **Additional operations:**
  - Intersection, join, division
SQL Query Block

select select-clause
from from-clause
[where where-clause]
[order by order-by-expression]
[group by group-by-attributes
[having condition-for-each-group]]

• Query blocks may be
  – nested in from and where
  – connected using union, intersect, and except
• Duplicates: distinct for removal

• Aggregation queries
  – E.g., max, sum, etc.
  – They return a single value, unless there is a group by
  – All non-aggregation attributes in select with a group by must also appear in group by
  – If an attribute appears in group by, it may not necessarily appear in select
The functional dependency $X \rightarrow Y$ holds on $R$, if and only if for any legal relation instances, whenever any two tuples $t_1$ and $t_2$ agree on the attributes $X$, they also agree on the attributes $Y$.

The set of all functional dependencies logically implied by $F$ is the closure of $F$ (denoted by $F^+$).

For computing the closure we use Armstrong’s axioms:

- If $Y \subseteq X$, then $X \rightarrow Y$ (reflexivity)
- If $X \rightarrow Y$, then $ZX \rightarrow ZY$ (augmentation)
- If $X \rightarrow Y$, and $Y \rightarrow Z$, then $X \rightarrow Z$ (transitivity)

Given a set of attributes $X$, the closure of $X$ under $F$ (denoted by $X^+$) is the set of attributes that are functionally determined by $X$ under $F$.

If $X$ determines all attributes, then it is a superkey. If it is also minimal, then it is a candidate key.

A canonical cover of $F$ is a “minimal” set of functional dependencies equivalent to $F$, with no redundant dependencies or having redundant attributes.