Relationship

- A relationship describes a connection between several entities, e.g., student Smith attends lecture COP 4720, teaching assistant Benson works for professor Meyer.

- A homogeneous set of relationships is collected in a relationship set, e.g., relationship sets attends_lecture or works_for.

- Formal: relationship set $R$ between the entity sets $E_1, E_2, \ldots, E_n$ as a relation, i.e.,
  $$R \subseteq E_1 \times E_2 \times \ldots \times E_n,$$
  $n$ degree of relationship set $R$.
  
  - attends_lecture $\subseteq$ students $\times$ lectures
  - works_for $\subseteq$ TAs $\times$ professors

- Attributes may characterize relationships, e.g., frequency as an attribute for attends_lecture.

- An entity set can occur more than once in a relationship set.

- If there is only one entity set $E$ participating in a binary relationship $R(E, E)$, each of these entity sets can be assigned roles.
  E.g., is_precondition_of $\subseteq$ lectures $\times$ lectures
  First lecture / second lecture has the role of a predecessor / successor.
Constraints of binary relationship sets

- **1:1-relationship** (one-to-one relationship)
  if for a binary relationship set $R(E_1, E_2)$ each entity in $E_1$ is associated with *at most* one entity in $E_2$, and vice versa

- **1:m-relationship** (one-to-many relationship)
  if for a binary relationship set $R(E_1, E_2)$ each entity in $E_1$ is associated with any number (zero or more) of entities in $E_2$, and each entity in $E_2$ is associated with *at most* one entity in $E_1$

- **m:1-relationship** (many-to-one relationship)
  analogous to the 1:m-relationship

- **m:n-relationship** (many-to-many relationship)
  if for a binary relationship set $R(E_1, E_2)$ each entity in $E_1$ is associated with any number (zero or more) of entities in $E_2$, and vice versa

- constraints considered as *partial functions*, e.g.
  for 1:1-relationship: has_husband: women $\rightarrow$ husbands, has_wife: men $\rightarrow$ wives
  for m:1-relationships: employed_by: persons $\rightarrow$ companies
E-R diagrams

- graphical representation of entity sets, relationship sets, and their attributes by means of a graph

Notations

- rectangles represent entity sets: \( E \)

- ellipses represent attributes: \( A \)
  - they are connected with their entity set by undirected edges
  - key attributes are underlined

- relationship sets are represented by diamonds: \( R \)
  - relationship sets are connected with their pertaining entity sets by edges
  - edges carry information about cardinality according to imposed constraints

- a role of a relationship set is attached to the corresponding edge
Example: conceptual university schema

- **students** (m) to **attends** (n) to **lectures** (m)
  - **reg-id**, **name**, **sem**
  - **is_precondition_of**: predecessor (m) to successor (n)
  - **tests**: grade
  - **gives**: id (1)

- **assistants** (m) to **works_for** (1) to **professors**
  - **pers-id**, **name**, **room**
  - **pers-id**, **name** (room)
  - **rank**, **room**
Extensions

- existence dependent (\textbf{weak}) entity sets
  - assumption so far: entities exist autonomously and can be uniquely identified within an entity set by their key attributes (\textbf{strong} entity set)
  - in reality there are also weak entities that do not have sufficient attributes to form a key. These entities are
    + dependent in their existence from another, superior entity and
    + can be uniquely identified only in combination with the key of a superior entity
  - superior entity set is called \textbf{identifying} or \textbf{owner entity set}
  - graphical notation: 

- identifying relationship set
  - a weak entity set $E_1$ must be associated with an identifying entity set $E_2$ by an \textbf{identifying relationship set}, if the key of $E_1$ comprises the key of $E_2$ and if it contains one or more additional attributes of $E_1$
  - relationship from the weak entity set to the superior entity set has usually an $m:1$-cardinality and more seldom a $1:1$-cardinality
  - graphical notation: 

example:

- total participation of an entity set in a relationship
  - all entities of an entity set $E_1$ are associated with another entity set $E_2$ by a relationship set $R$
  - this holds, in particular, for weak entity sets
  - example:

more precise characterization of cardinalities of relationship sets
- $(min, max)$-notation
- for each entity set participating in a relationship set
  + $min$ expresses that each entity of this set is in relationship at least $min$ times
  + $max$ expresses that each entity of this set is in relationship at most $max$ times