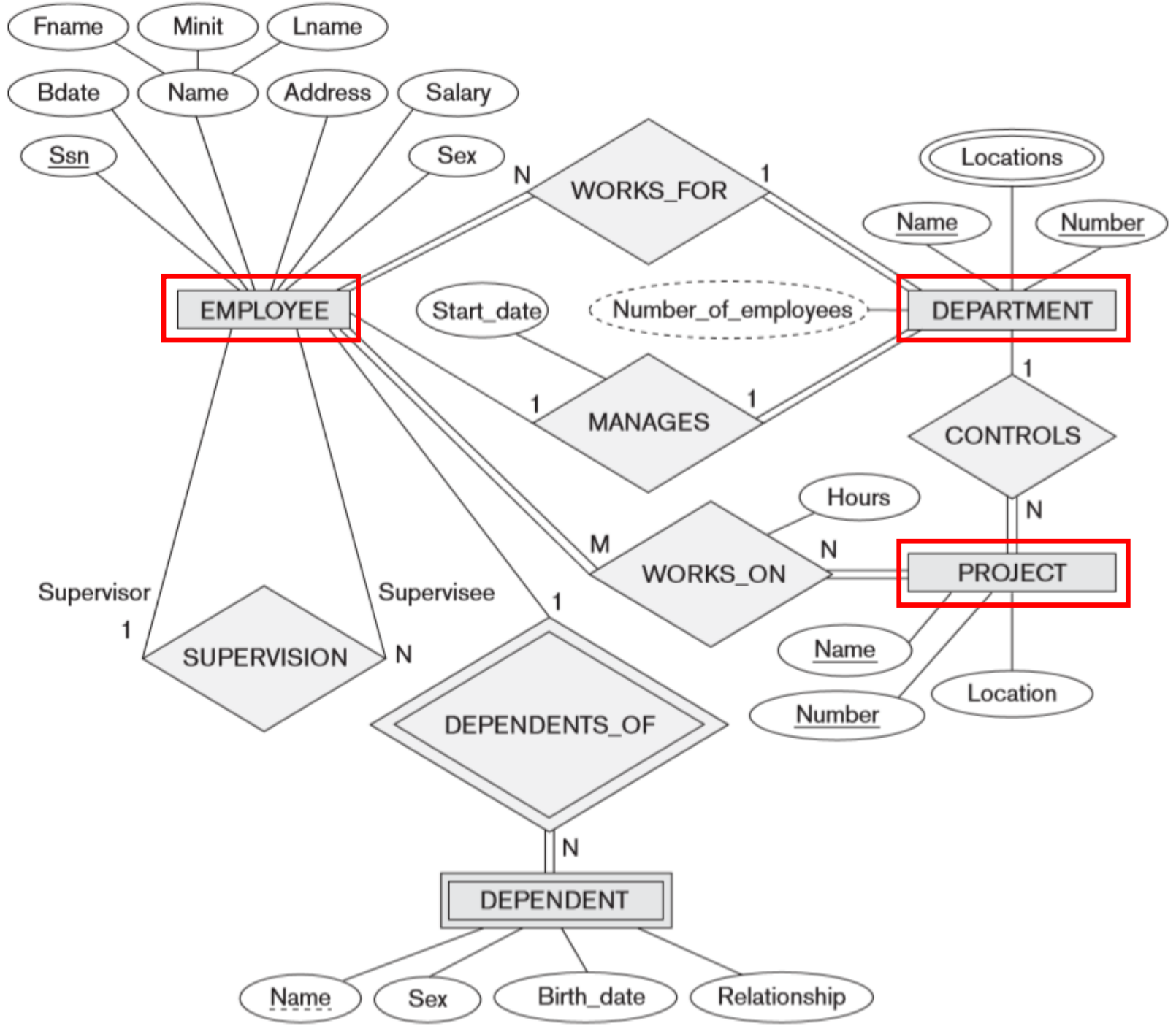
Relational Database Design by ER- and EER-to-Relational Mapping

Part 1

Relational Database Design by ER-to-Relational Mapping

ER-to-Relational Mapping Algorithm

- **Step 1: Mapping of Regular Entity Types.**
  - For each regular (strong) entity type E in the ER schema, create a relation R that includes all the simple attributes of E. Include only the simple component attributes of a composite attribute. Choose one of the key attributes of E as the primary key for R. If the chosen key of E is a composite, then the set of simple attributes that form it will together form the primary key of R.
  - If multiple keys were identified for E during the conceptual design the information describing the attributes that form each additional key is kept in order to specify secondary (unique) keys of relation R. Knowledge about keys is also kept for indexing purposes and other types of analyses.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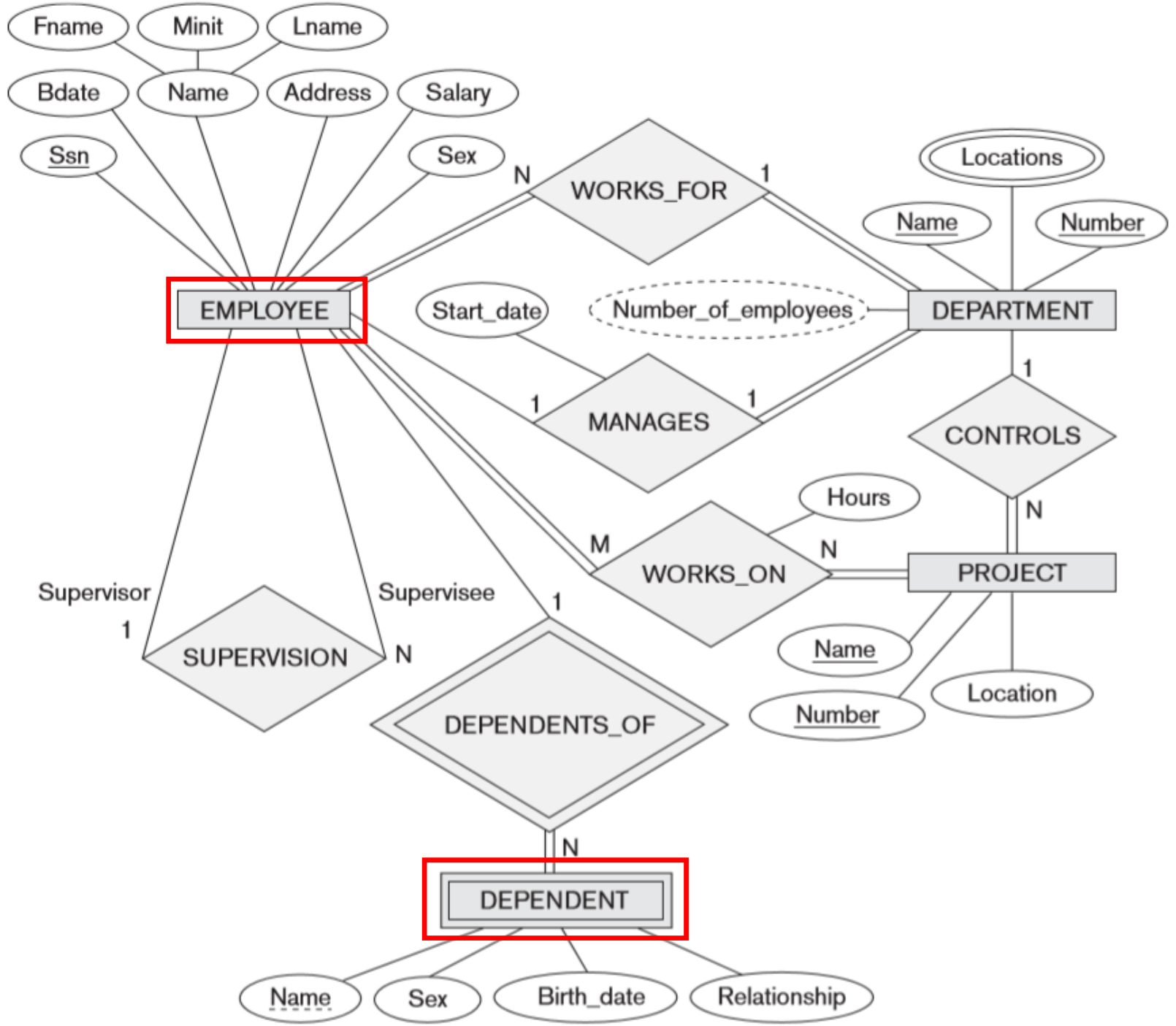
- **Step 2: Mapping of Weak Entity Types.**
  - For each weak entity type W in the ER schema with owner entity type E, create a relation R and include all simple attributes (or simple components of composite attributes) of W as attributes of R. In addition, include as foreign key attributes of R, the primary key attribute(s) of the relation(s) that correspond to the owner entity type(s); this takes care of mapping the identifying relationship type of W. The primary key of R is the combination of the primary key(s) of the owner(s) and the partial key of the weak entity type W, if any.
  - If there is a weak entity type E_2 whose owner is also a weak entity type E_1, then E_1 should be mapped before E_2 to determine its primary key first.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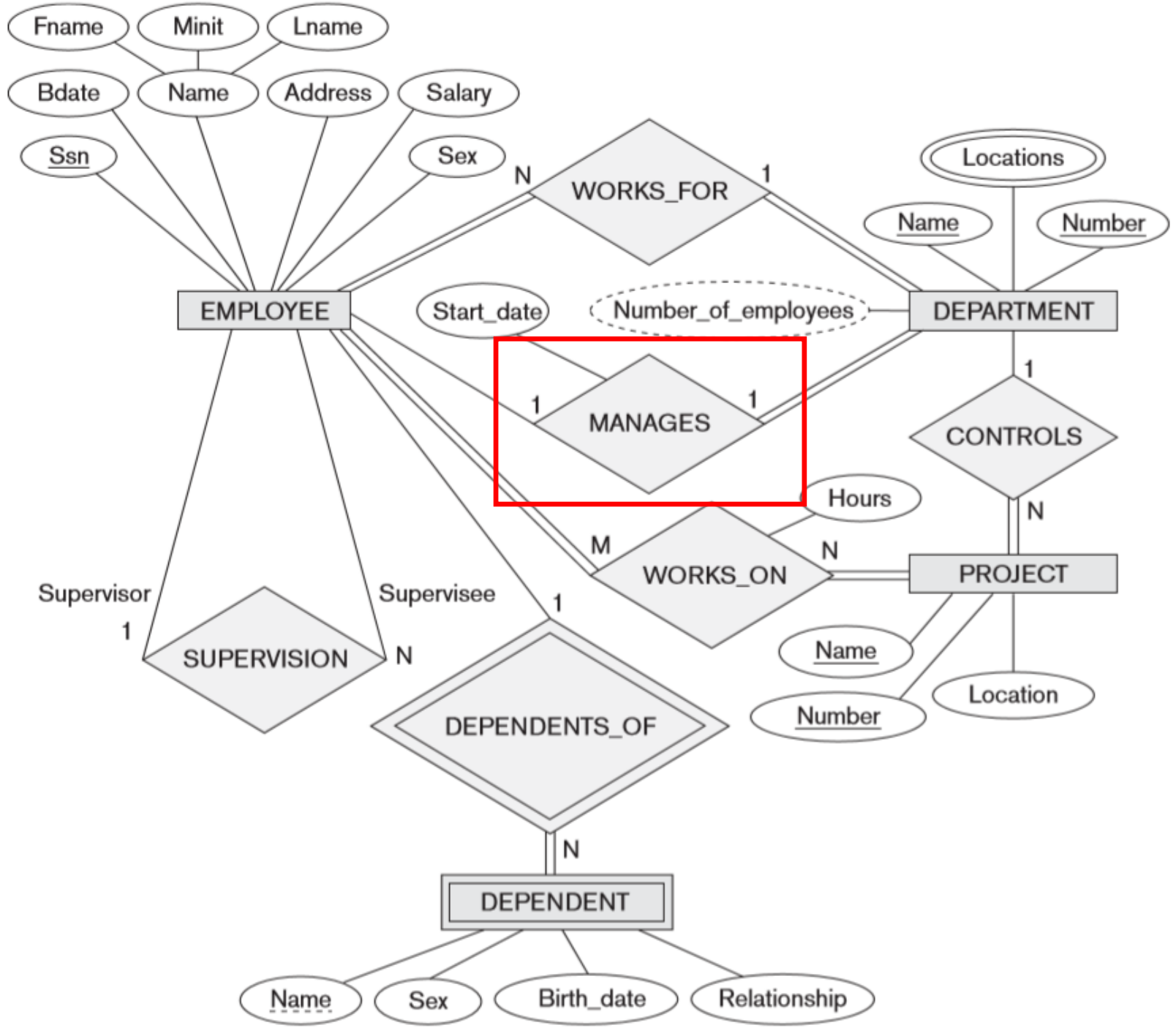
- **Step 3: Mapping of Binary 1:1 Relationship Types.**
  - For each binary $1:1$ relationship type R in the ER schema, identify the relations S and T that correspond to the entity types participating in R. There are three possible approaches: (1) the foreign key approach, (2) the merged relationship approach, and (3) the cross-reference or relationship relation approach. The first approach is the most useful and should be followed unless special conditions exist.

1. **Foreign key approach:** Choose one of the relations—S, say—and include as a foreign key in S the primary key of T. It is better to choose an entity type with *total participation* in R in the role of S. Include all the simple attributes (or simple components of composite attributes) of the $1:1$ relationship type R as attributes of S.

2. **Merged relation approach:** An alternative mapping of a `1:1` relationship type is to merge the two entity types and the relationship into a single relation. This is possible when *both participations are total*, as this would indicate that the two tables will have the exact same number of tuples at all times.

3. **Cross-reference or relationship relation approach:** The third option is to set up a third relation R for the purpose of cross-referencing the primary keys of the two relations S and T representing the entity types. The relation R is called a **relationship relation** (or sometimes a **lookup table**), because each tuple in R represents a relationship instance that relates one tuple from S with one tuple from T. The relation R will include the primary key attributes of S and T as foreign keys to S and T. The primary key of R will be one of the two foreign keys, and the other foreign key will be a unique key of R. The drawback is having an extra relation, and requiring an extra join operation when combining related tuples from the tables.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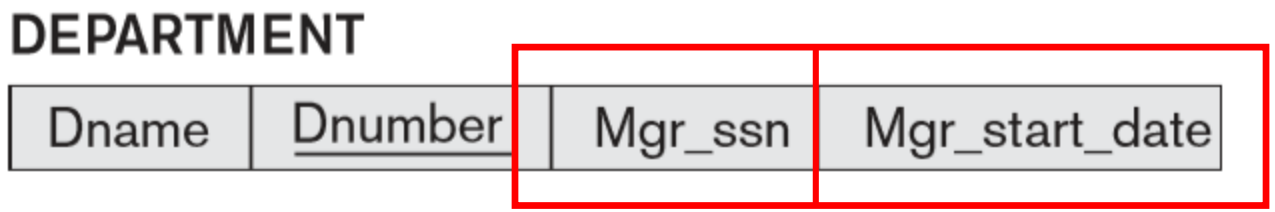
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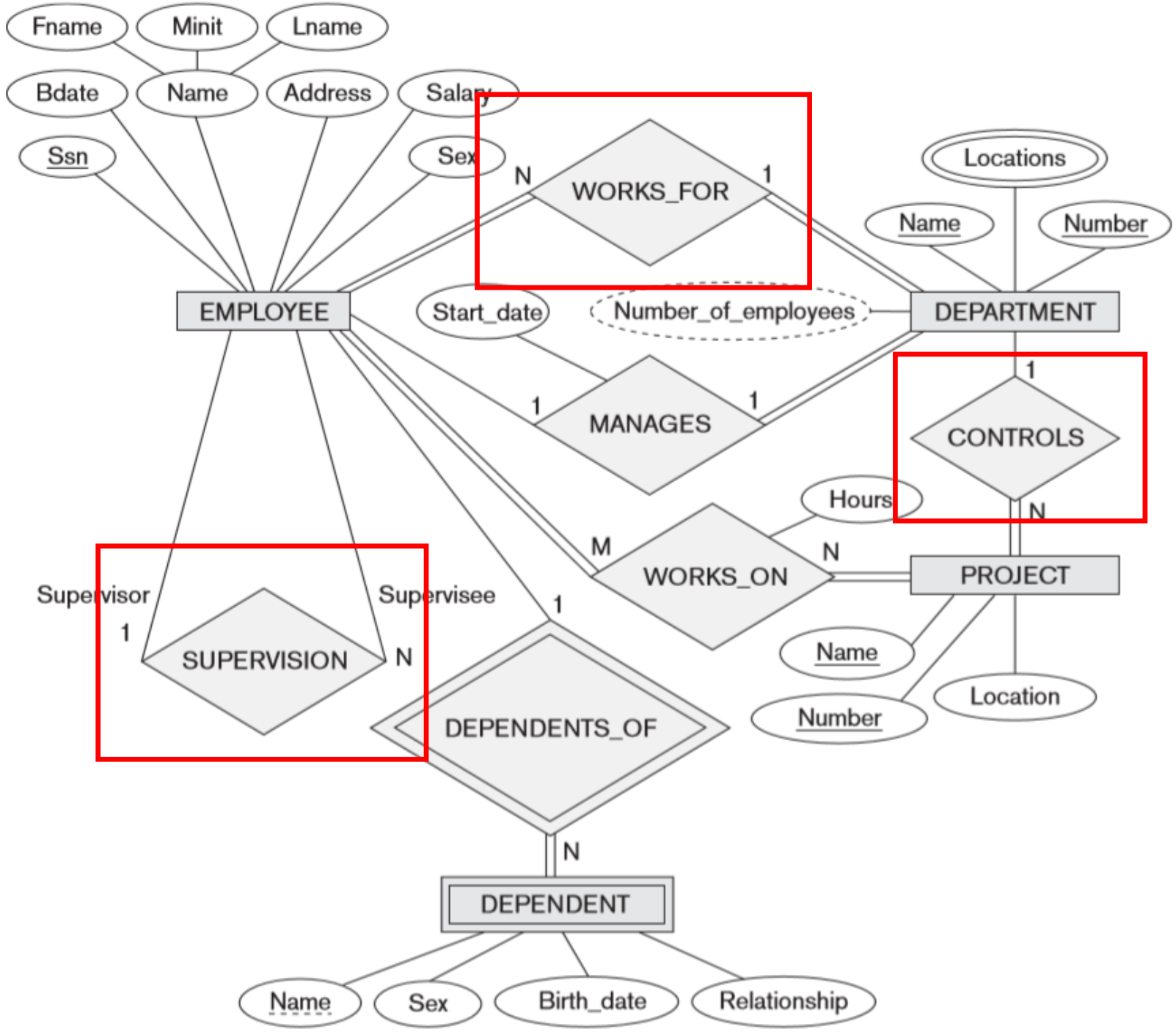
- **Step 4: Mapping of Binary 1:N Relationship Types.** For each regular binary 1 : N relationship type R, identify the relation S that represents the participating entity type at the *N-side* of the relationship type. Include as foreign key in S the primary key of the relation T that represents the other entity type participating in R; we do this because each entity instance on the N-side is related to at most one entity instance on the 1-side of the relationship type. Include any simple attributes (or simple components of composite attributes) of the 1 : N relationship type as attributes of S.

- An alternative approach is to use the **relationship relation** (cross-reference) option as in the third option for binary $1:1$ relationships. We create a separate relation R whose attributes are the primary keys of S and T, which will also be foreign keys to S and T. The primary key of R is the same as the primary key of S. This option can be used if few tuples in S participate in the relationship to avoid excessive NULL values in the foreign key.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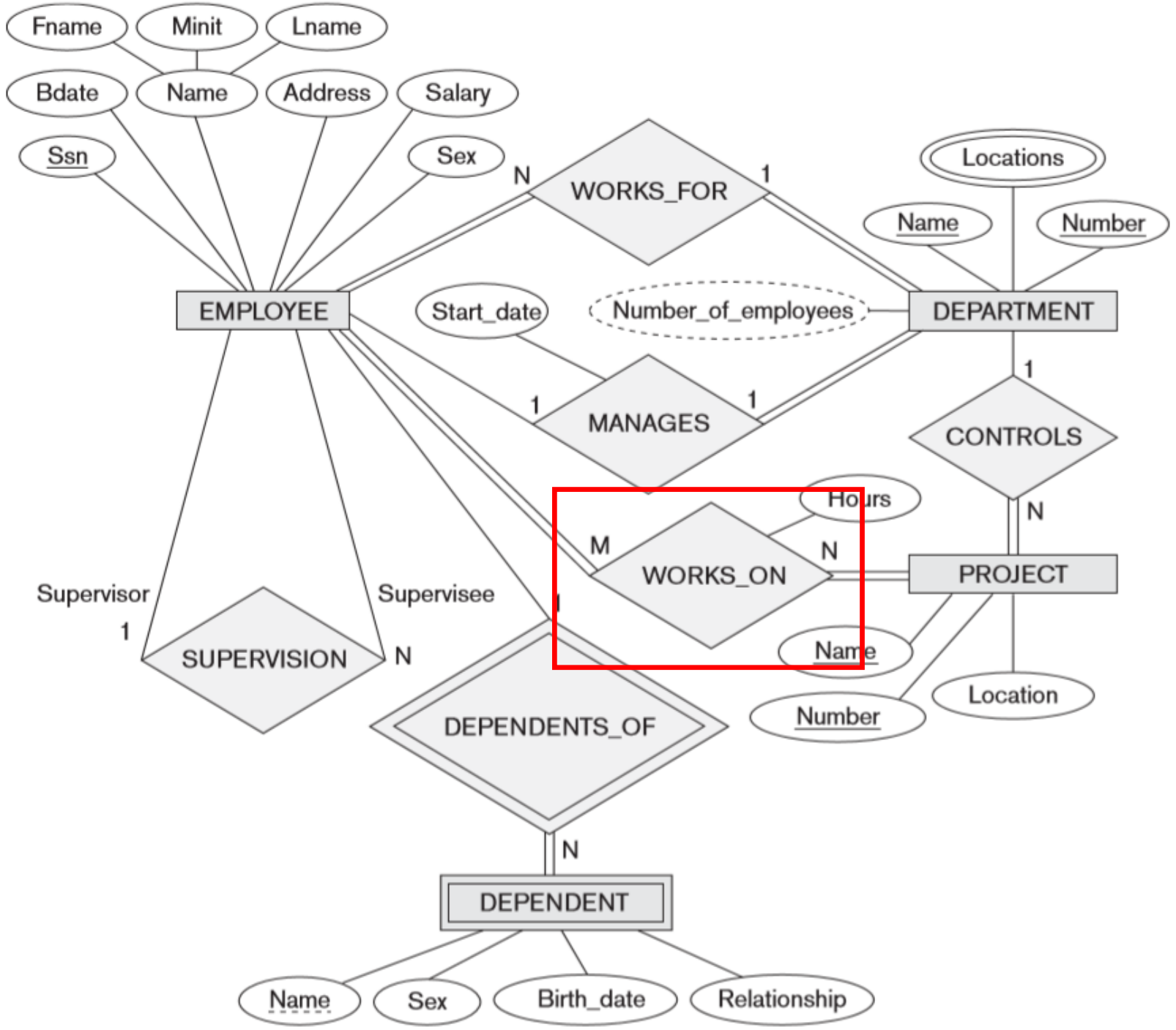
- **Step 5: Mapping of Binary M:N Relationship Types.** For each binary M:N relationship type R, create a new relation S to represent R. Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types; their *combination* will form the primary key of S. Also include any simple attributes of the M:N relationship type (or simple components of composite attributes) as attributes of S.

- The propagate (`CASCADE`) option for the referential triggered action should be specified on the foreign keys in the relation corresponding to the relationship *R*, since each relationship instance has an existence dependency on each of the entities it relates. This can be used for both `ON UPDATE` and `ON DELETE`.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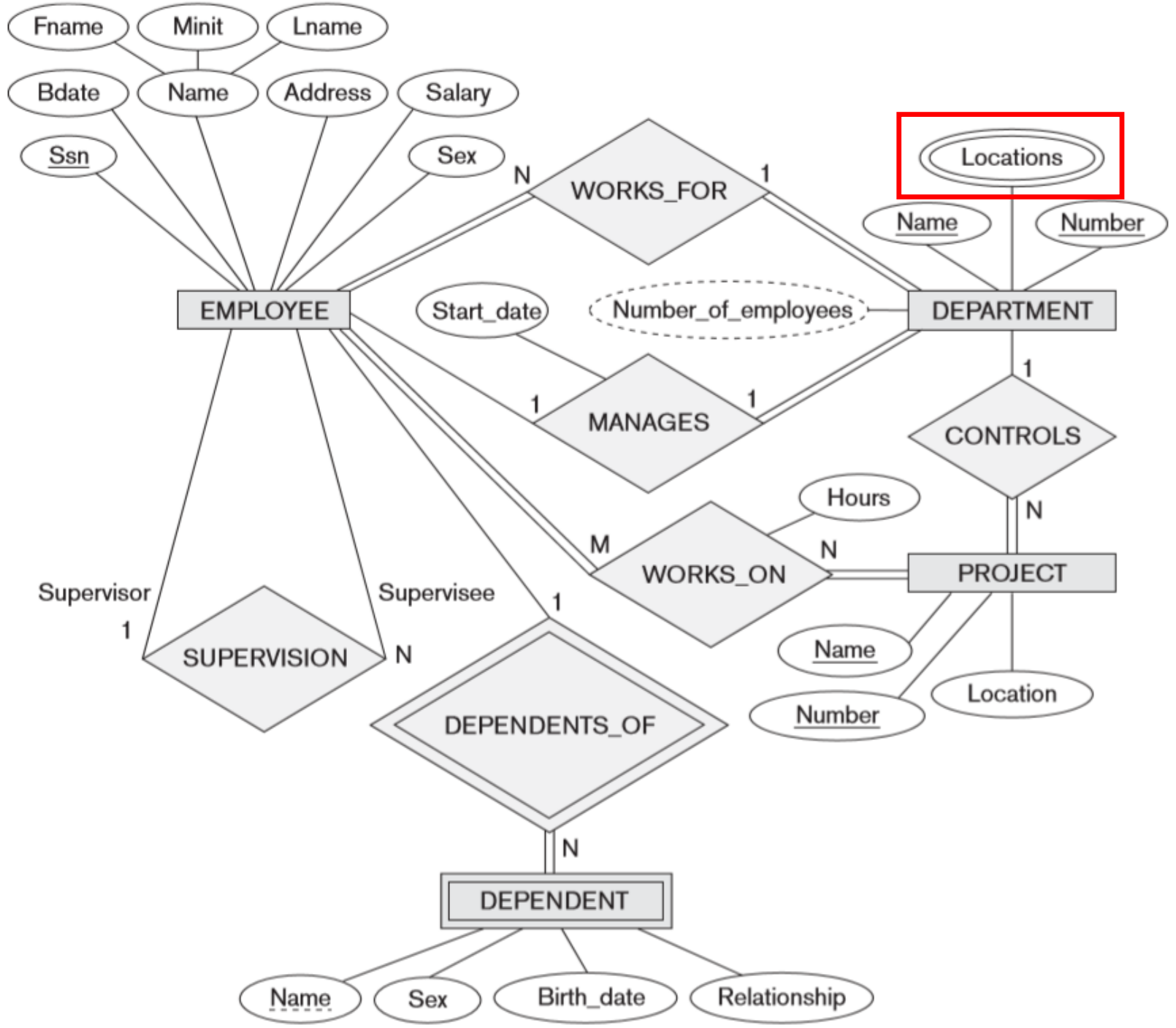
- **Step 6: Mapping of Multivalued Attributes.** For each multivalued attribute A, create a new relation R. This relation R will include an attribute corresponding to A, plus the primary key attribute K—as a foreign key in R—of the relation that represents the entity type or relationship type that has A as a multivalued attribute. The primary key of R is the combination of A and K. If the multivalued attribute is composite, we include its simple components.

- The propagate (CASCADE) option for the referential triggered action should be specified on the foreign key in the relation *R* corresponding to the multivalued attribute for both ON UPDATE and ON DELETE. We should also note that the key of *R* when mapping a composite, multivalued attribute requires some analysis of the meaning of the component attributes. In some cases, when a multivalued attribute is composite, only some of the component attributes are required to be part of the key of *R*; these attributes are similar to a partial key of a weak entity type that corresponds to the multivalued attribute.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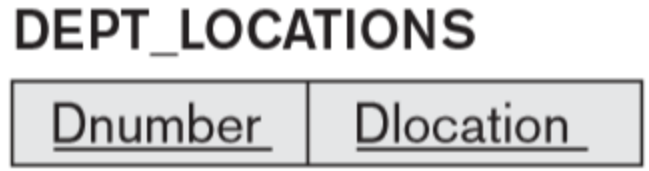
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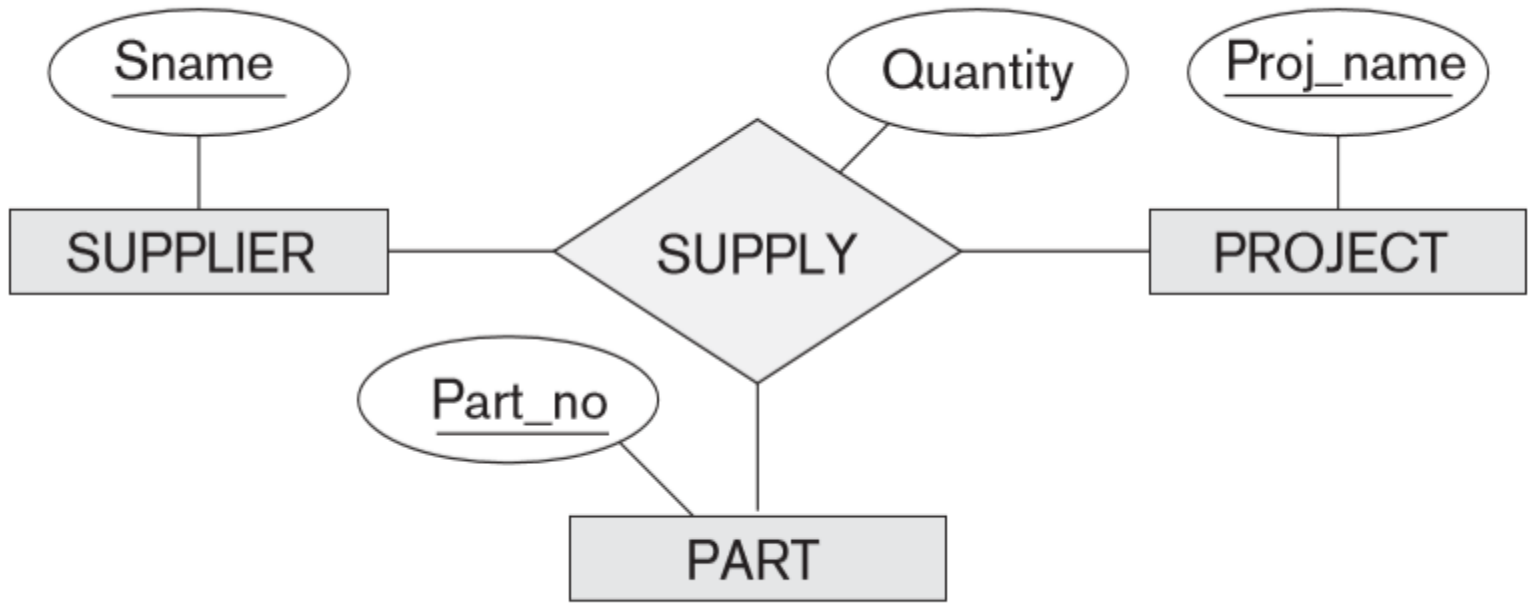
- **Step 7: Mapping of N-ary Relationship Types.** For each n-ary relationship type R, where $n > 2$, create a new relation S to represent R. Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types. Also include any simple attributes of the n-ary relationship type (or simple components of composite attributes) as attributes of S. The primary key of S is usually a combination of all the foreign keys that reference the relations representing the participating entity types. However, if the cardinality constraints on any of the entity types E participating in R is 1, then the primary key of S should not include the foreign key attribute that references the relation E' corresponding to E.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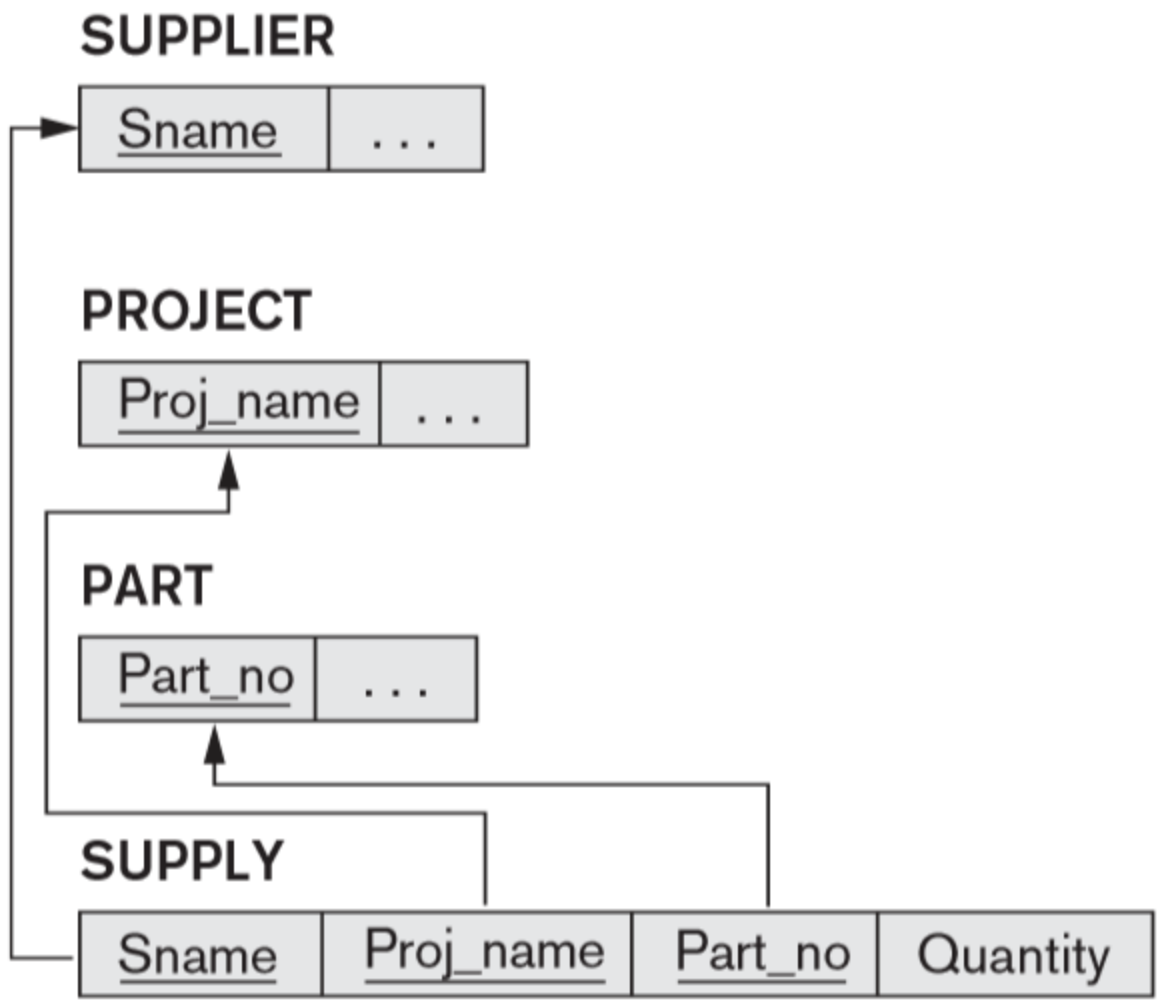
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