The Relational Data Model

Structures

In the relational model, everything is described using relations.

A relation can be thought of as a named table.

Each column of the table corresponds to a named attribute.

The set of allowed values for an attribute is called its domain.

Each row of the table is called a tuple of the relation.

N.B. There is no ordering of column or rows.

Example

PLAYER					
Name	Position	Goals	Age	Height	Weight
Heady	Half-forward	17	24	183	83
Sumich	Full-forward	59	26	191	92
Langdon	Utility	23	23	189	86

PLAYER					
Name	Age	Height	Weight	Goals	Position
Sumich	26	191	92	59	Full-forward
Langdon	23	189	86	23	Utility
Heady	24	183	83	17	Half-forward

Above two tables are the same relation ---- Player

Relational Data Model

Mathematically,

- a *domain D* is a set of atomic values (having some fixed data type) which represent some semantic meaning.
- an *attribute A* is the name of a role played by a *domain*, *dom*(*A*).
- a *relation schema R*, denoted by

  $R(A_1,A_2, ...,A_n)$, is a set of attributes

  $R = \{A_1,A_2, ...,A_n\}$.

Composite and multivalued attributes are disallowed!

Relational Data Model

A *tuple*, $t(A_1,A_2, ...,A_n)$, is a point in $dom(A_1) \times \ldots \times dom(A_n)$ where each $dom(A_j)$ is the domain of A_j.

A *relation (or a relation instance)* is a set of tuples: a subset of $dom(A_1) \times \ldots \times dom(A_n)$.

A relation schema is used to describe a relation.

The *degree* of a relation is the number of attributes of its relation schema.

Relational Data Model vs ER Model

Relation schema (intension) ⇄ entity or relationship type schema (intension).

attributes ⇄ attributes

tuple ⇄ instance of entity/relationship

relation (instance, extension) ⇄ entity/relationship extension

composite and multivalued attributes are allowed in ER model, but not allowed in relational data model.

Keys

Keys are used to identify tuples in a relation.

A *superkey* is a set of attributes that uniquely determines a tuple.

Note that this is a property of the relation that does not depend on the current relation instance.

A *candidate key* is a superkey, none of whose *proper* subsets is a superkey.

Keys are determined by the applications.

Keys

PLAYER					
Name	Position	Goals	Age	Height	Weight
Heady	Half-forward	17	24	183	83
Sumich	Full-forward	59	26	191	92
Langdon	Utility	23	23	189	86

E.g. if {Name} is unique then it is a candidate key for PLAYER; otherwise we need to use the whole tuple or create a candidate key, say PID.

{Goals} usually cannot not be a candidate key since different players *might* have the same number of goals.

{Name, Goals} is a superkey but not a candidate key if {Name} is a key.

Keys

PLAYER						
Person_ID	Name	Position	Goals	Age	Height	Weight
1	Heady	Half-forward	17	24	183	83
2	Sumich	Full-forward	59	26	191	92
3	Langdon	Utility	23	23	189	86

A *primary key* is a designated candidate key.

In many applications it is necessary to invent a primary key if there is no natural one - often this would be a non-negative integer

e.g. Person_ID.

When a relation schema has several candidate keys, usually better to choose a primary key with a single attribute or a small number of attributes.

Integrity constraints

There are several kinds of integrity constraints that are an integral part of the relational model:

Key constraint: candidate key values must be unique for every relation instance.

Entity integrity: an attribute that is part of a primary key cannot be NULL.

Referential integrity: The third kind has to do with “foreign keys”.

Keys

Foreign keys are used to refer to a tuple in another relation.

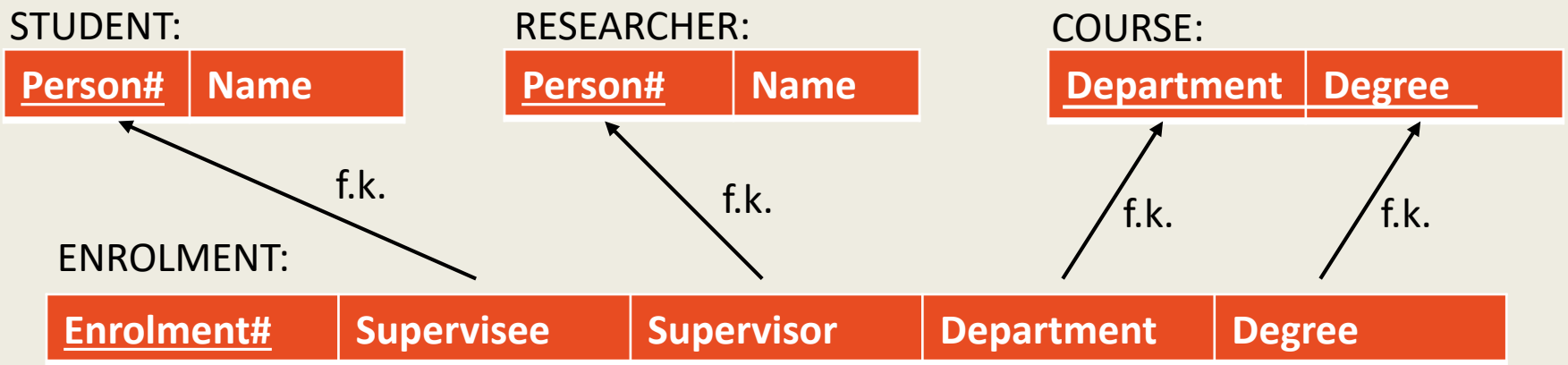
A set, *FK*, of attributes from a relation schema R1 may be a foreign *key* if

- the attributes have the same domains as the attributes in the primary key of another relation schema R_2, and
- a value of FK in a tuple t_1 of R_1 either occurs as a value of PK for some tuple t_2 in R_2 or is null.

Referential integrity: The value of *FK* must occur in the other relation or be entirely NULL.

Checking constraints on updates

- To maintain the integrity of the database, we need to check that integrity constraints will not be violated before proceeding with an update.
- Example: Suppose we have the following schema with foreign keys as shown:



STUDENT:

Person#	Name
1	Dr C.C.Chen
3	Ms K.Juliff
4	Ms J.Gledill
5	Ms B.K.Lee

RESEARCHER:

Person#	Name
1	Dr C.C.Chen
2	Dr R.G.Wilkinson

COURSE:

Department	Degree
Psychology	Ph.D.
Comp.Sci.	Ph.D.
Comp.Sci.	M.Sc.
Psychology	M.Sc.

ENROLMENT:

Enrolment#	Supervisee	Supervisor	Department	Degree
1	1	2	Psychology	Ph.D.
2	3	1	Comp.Sci.	Ph.D.
3	4	1	Comp.Sci.	M.Sc.
4	5	1	Comp.Sci.	M.Sc.

Insertions

Insertions: When inserting, we need to check

- that the candidate keys are not already present,
- that the value of each foreign key either

  –is all null, or

  – is all non-NULL and occurs in the referenced relation.

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1. Insert < 2, *Dr.V.Ciesielski* > into RESEARCHER
   Allowed? No. Violates a key constraint.
   Action? Reject or allow the user to correct.

STUDENT:

Person#	Name
1	Dr C.C.Chen
3	Ms K.Juliff
4	Ms J.Gledill
5	Ms B.K.Lee

RESEARCHER:

Person#	Name
1	Dr C.C.Chen
2	Dr R.G.Wilkinson

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3	4	1	Comp.Sci.	M.Sc.
4	5	1	Comp.Sci.	M.Sc.

2. Insert < *Comp.Sci.,NULL* > into COURSE
   Allowed? No. Violates the entity integrity constraint.
   Action: Reject or correct.

STUDENT:

Person#	Name
1	Dr C.C.Chen
3	Ms K.Juliff
4	Ms J.Gledill
5	Ms B.K.Lee

RESEARCHER:

Person#	Name
1	Dr C.C.Chen
2	Dr R.G.Wilkinson

COURSE:

Department	Degree
Psychology	Ph.D.
Comp.Sci.	Ph.D.
Comp.Sci.	M.Sc.
Psychology	M.Sc.

ENROLMENT:

Enrolment#	Supervisee	Supervisor	Department	Degree
1	1	2	Psychology	Ph.D.
2	3	1	Comp.Sci.	Ph.D.
3	4	1	Comp.Sci.	M.Sc.
4	5	1	Comp.Sci.	M.Sc.

3. Insert < 5, 6, 2, *Psychology*, *Ph.D.* > into ENROLMENT

Allowed? No. Violates a referential integrity constraint (There is no person number 6).

Action: Reject, correct or accept after insertion of person number 6.

Deletions

Deletions: When deleting, we need to check referential integrity – check whether the primary key occurs in another relation.

Examples:

RESEARCHER:

Person#	Name
1	Dr C.C.Chen
~~2~~	~~Dr R.G.Wilkinson~~

1. Delete tuple with Person# = 2 from RESEARCHER

   Allowed? No. Violates the referential integrity.

   Action: Reject, correct or modify the ENROLMENT tuple by the following actions:

Deletions

deleting it (note that the this requires another integrity check, possibly causing a cascade of deletions), or

setting the foreign key value to NULL (note this can’t be done if it is part of a primary key), or

setting the foreign key value to another

acceptable value.

Modifications

If the modified attribute is a

- primary key: this is similar to deleting and then reinserting.
- foreign key: check that the new value refers to an existing tuple.
- neither: no problems can arise.

Relational database definition

- A *relational database schema*, is a set of relation schema $\{R_1, \ldots, R_m\}$ and a set of integrity constraints.

- A relational database instance is a set of relation instances $\{r_1, \ldots, r_m\}$ such that each r_i is an instance of R_i , and the integrity constraints are satisfied.

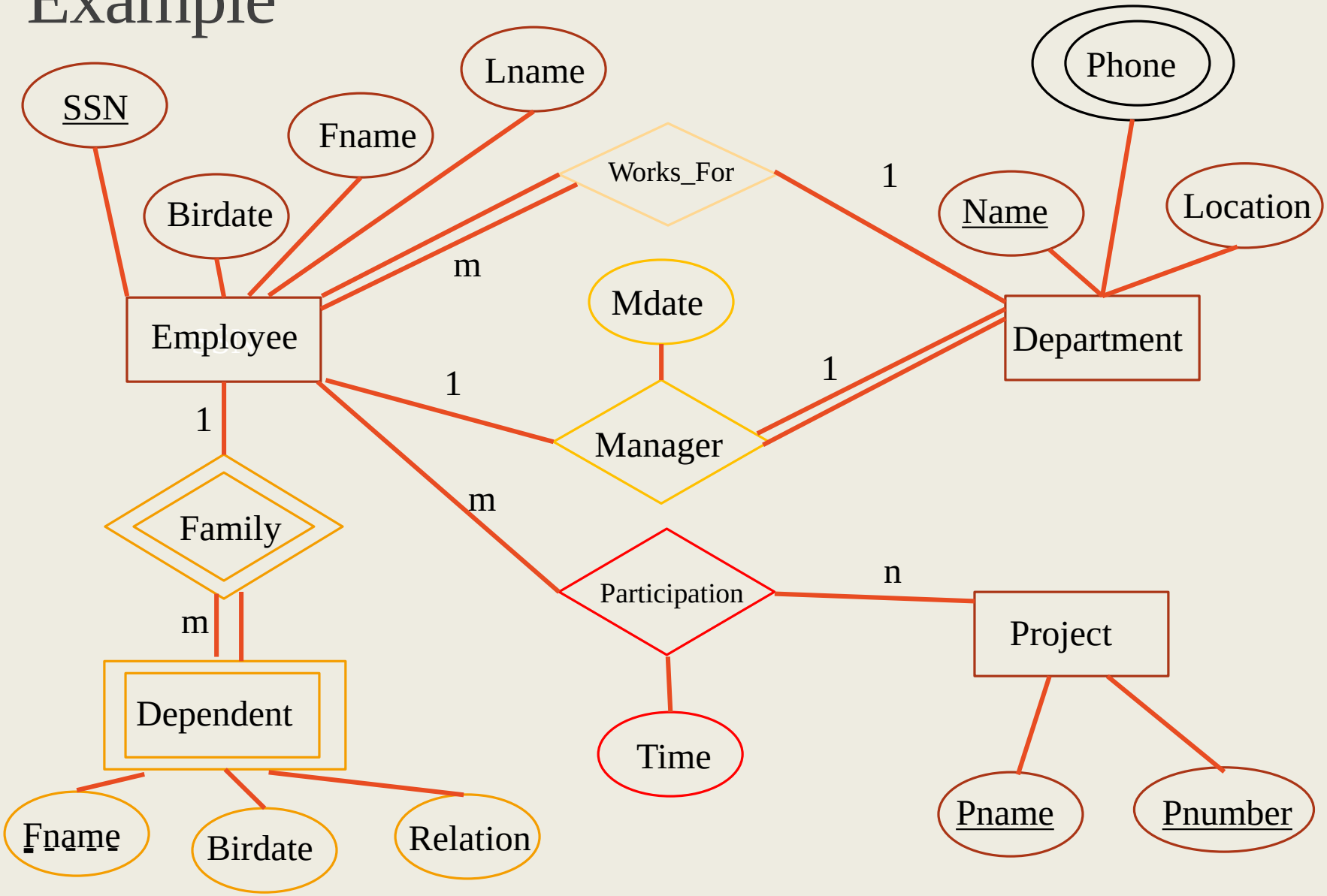
ER to Relational Data Model Mapping

One technique for database design is to first design a conceptual schema using a high-level data model, and then map it to a conceptual schema in the DBMS data model for the chosen DBMS.

Here we look at a way to do this mapping from the ER to the relational data model.

It involves the following 7 steps.

Example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ER to RDM

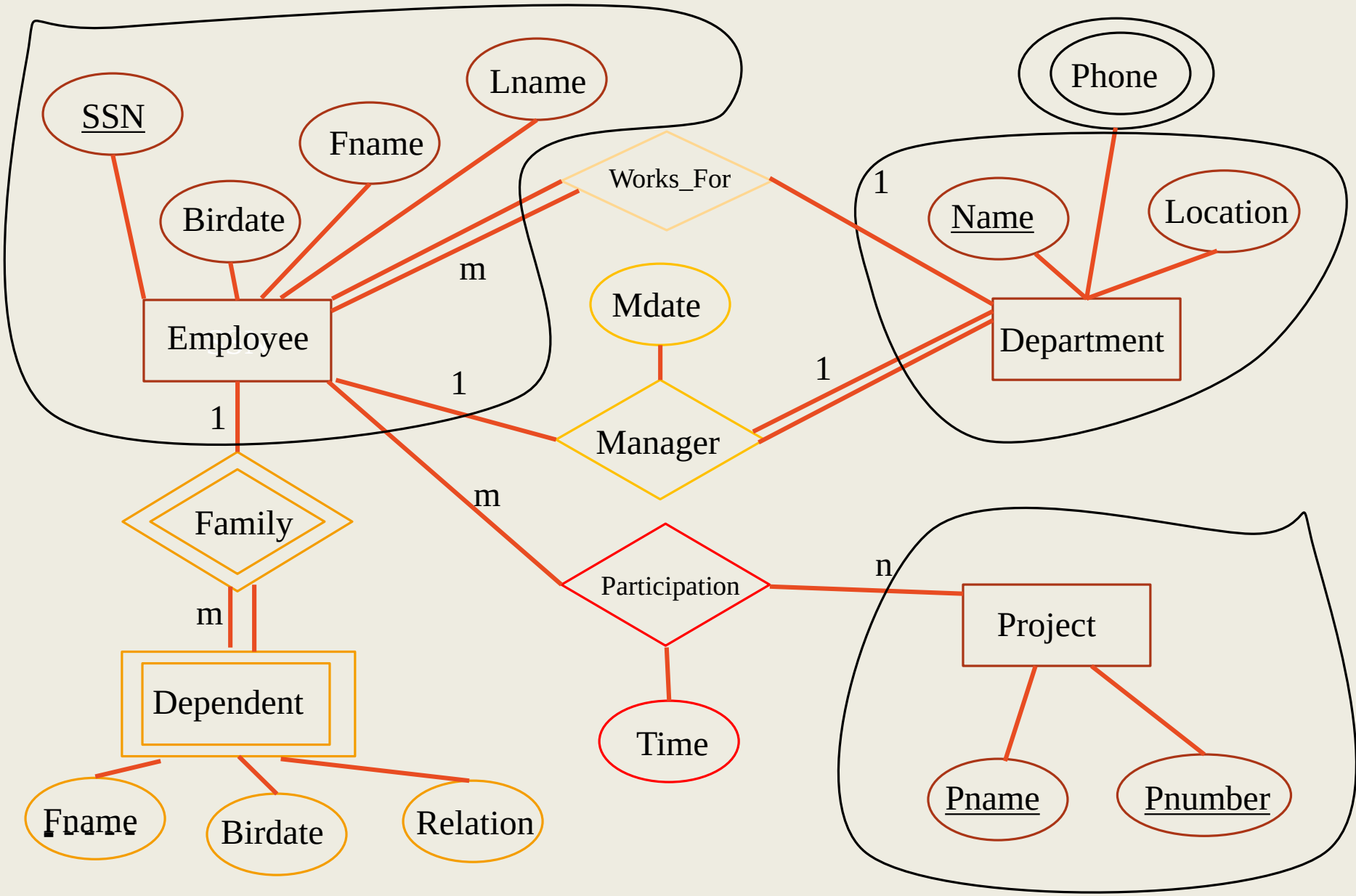
Step 1 : For each regular (not weak) entity type E, create a relation R with

- Attributes : All simple attributes (and simple components of composite attributes) of E.
- Key : Choose one of the keys of E as the primary key for the relation.

ER to RDM

Step 1a : For each specialised entity type E, with parent entity type P, create a relation R with

- Attributes : The attributes of the key of P, plus the simple attributes of E.
- Key : The key of P.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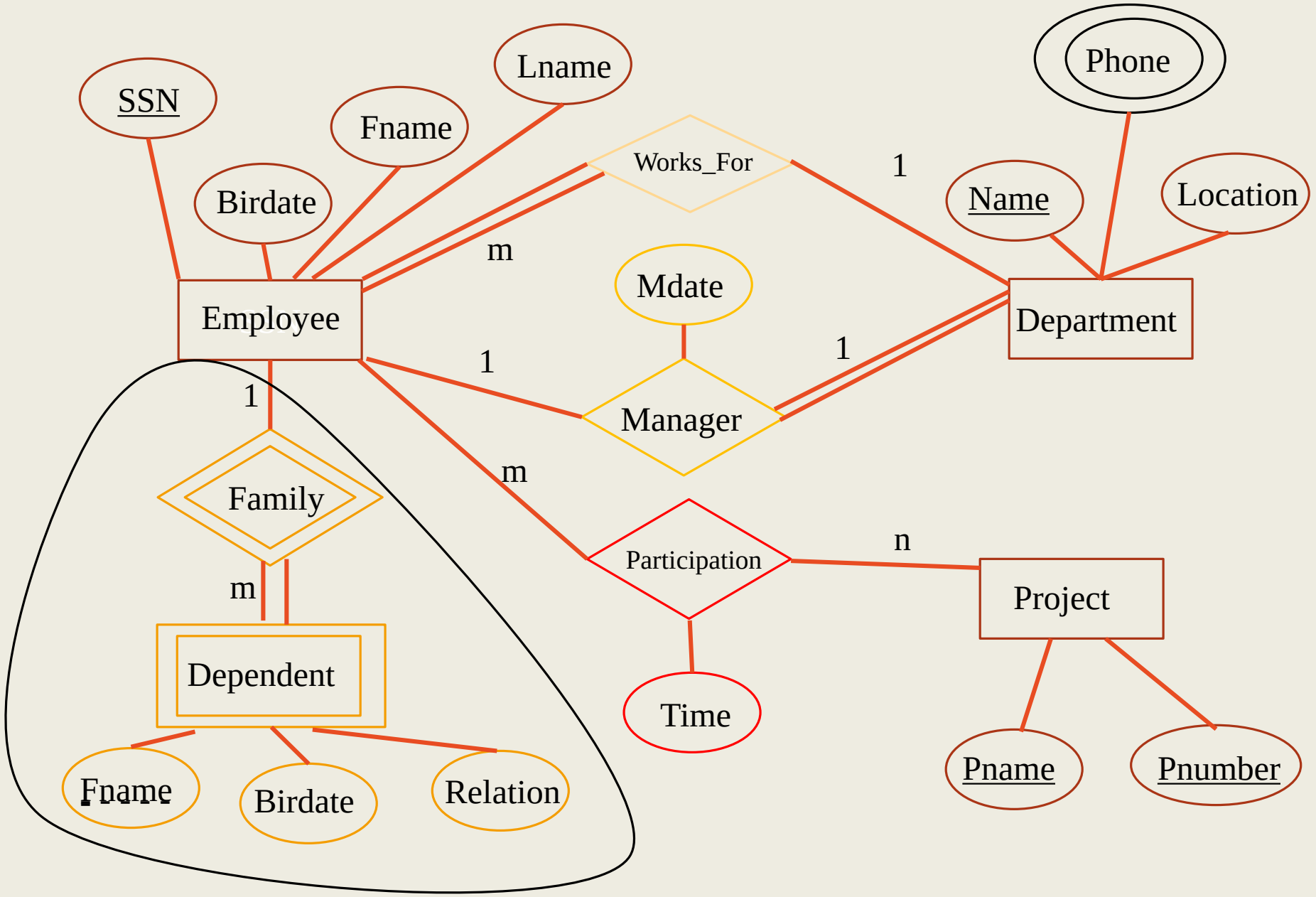
ER to RDM

Step 2 : For each weak entity type W, with owner entity type E, create a relation R with

- Attributes : All simple attributes (and simple components of composite attributes) of W, and include as a foreign key the prime attributes of the relation derived from E.
- Key : The foreign key plus the partial key of W.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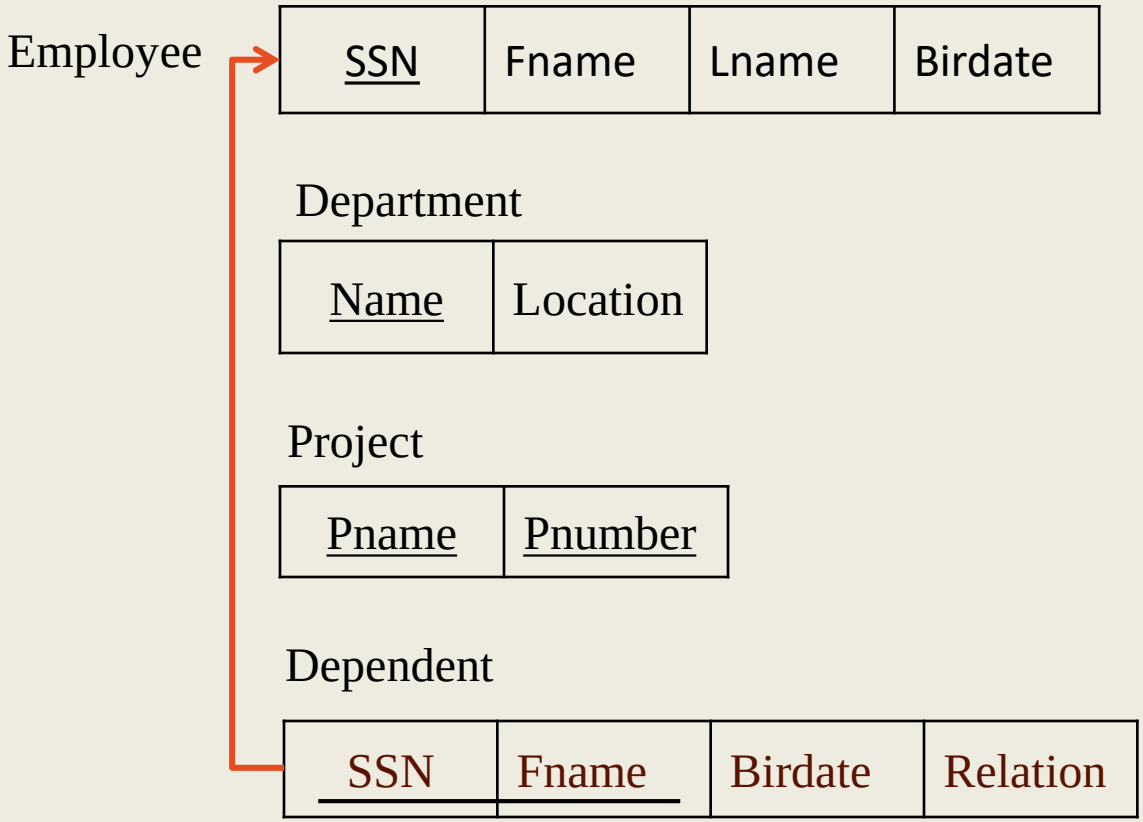
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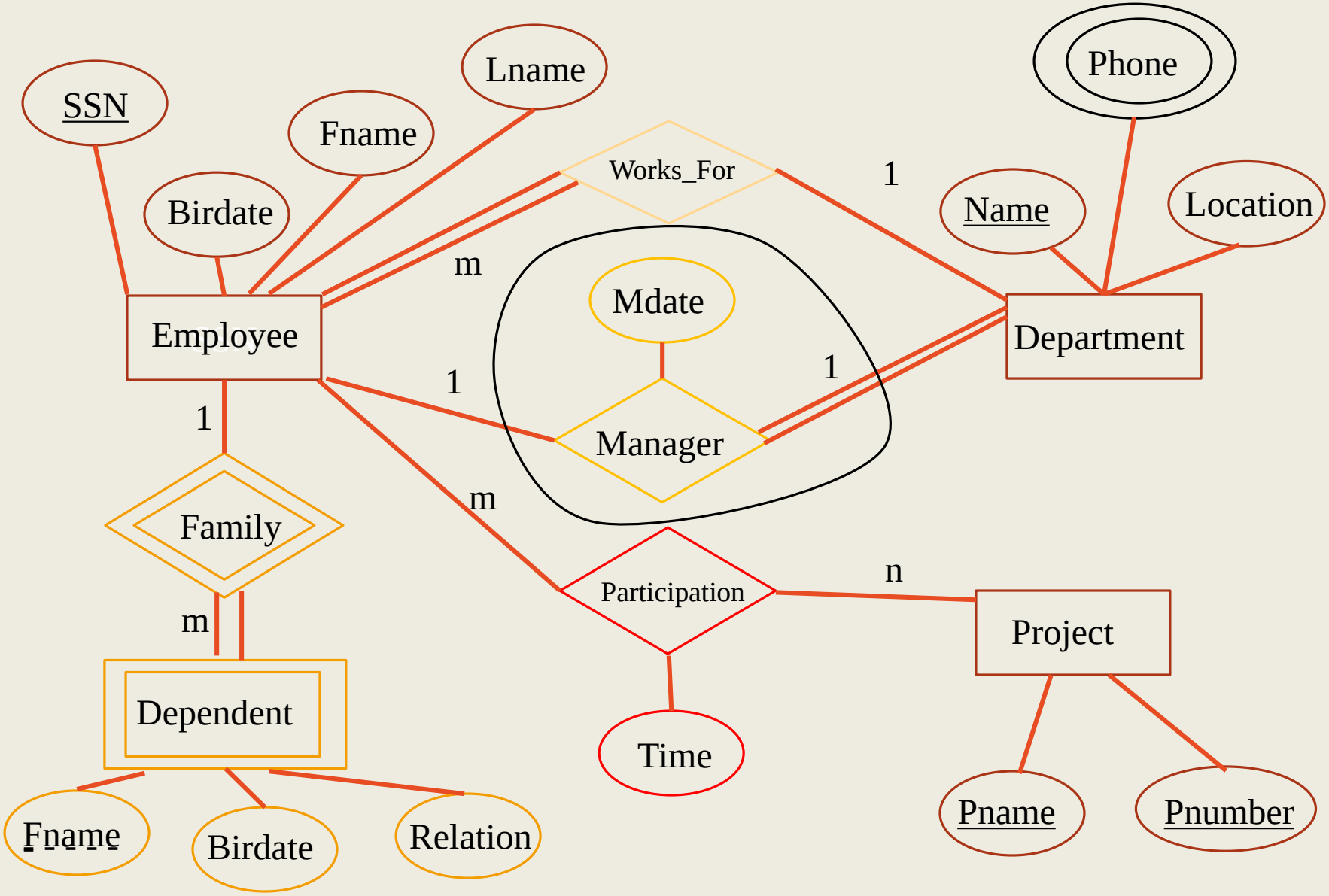
ER to RDM

Step 3 : For each 1:1 relationship type B. Let E and F be the participating entity types. Let S and T be the corresponding relations.

- Choose one of S and T (prefer one that participates totally), say S.
- Add the attributes of the primary key of T to S as a foreign key.
- Add the simple attributes (and simple components of composite attributes) of B as attributes of S.

(Alternative: merge the two entity types and the relationship into a single relation, especially if both participate totally and do not participate in other relationships).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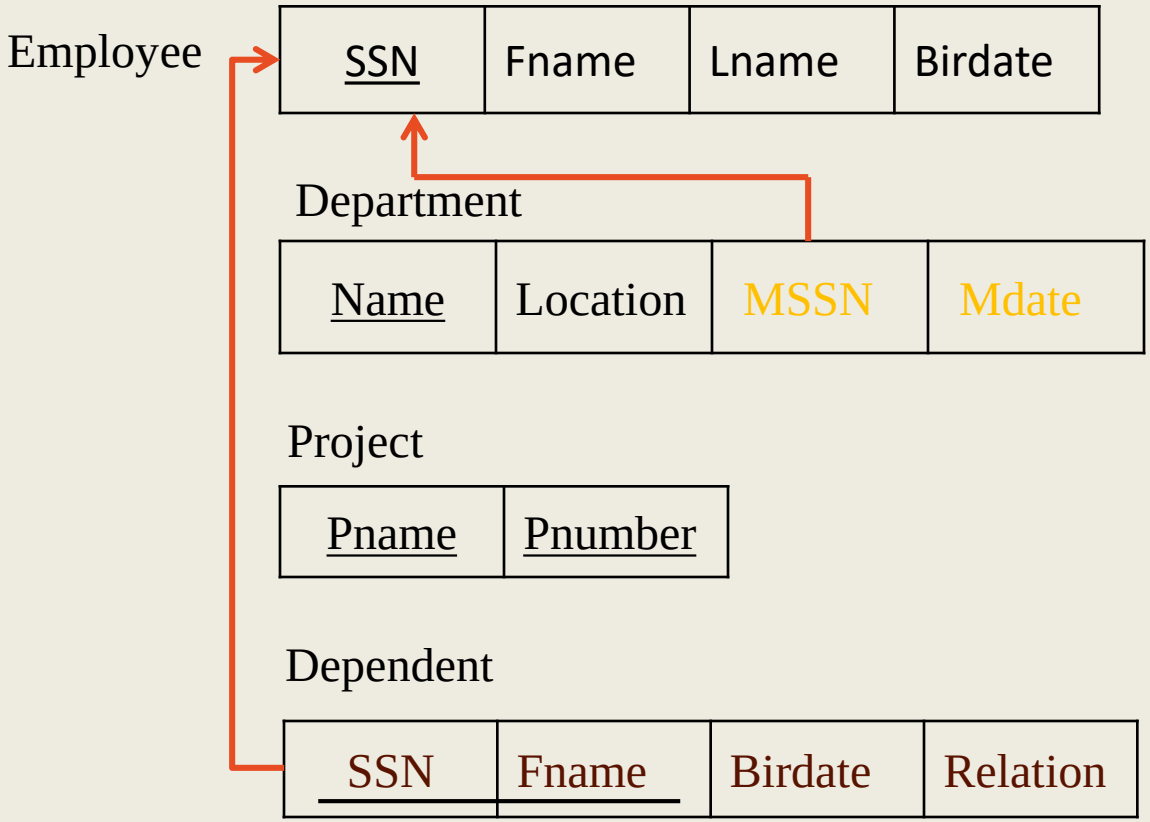
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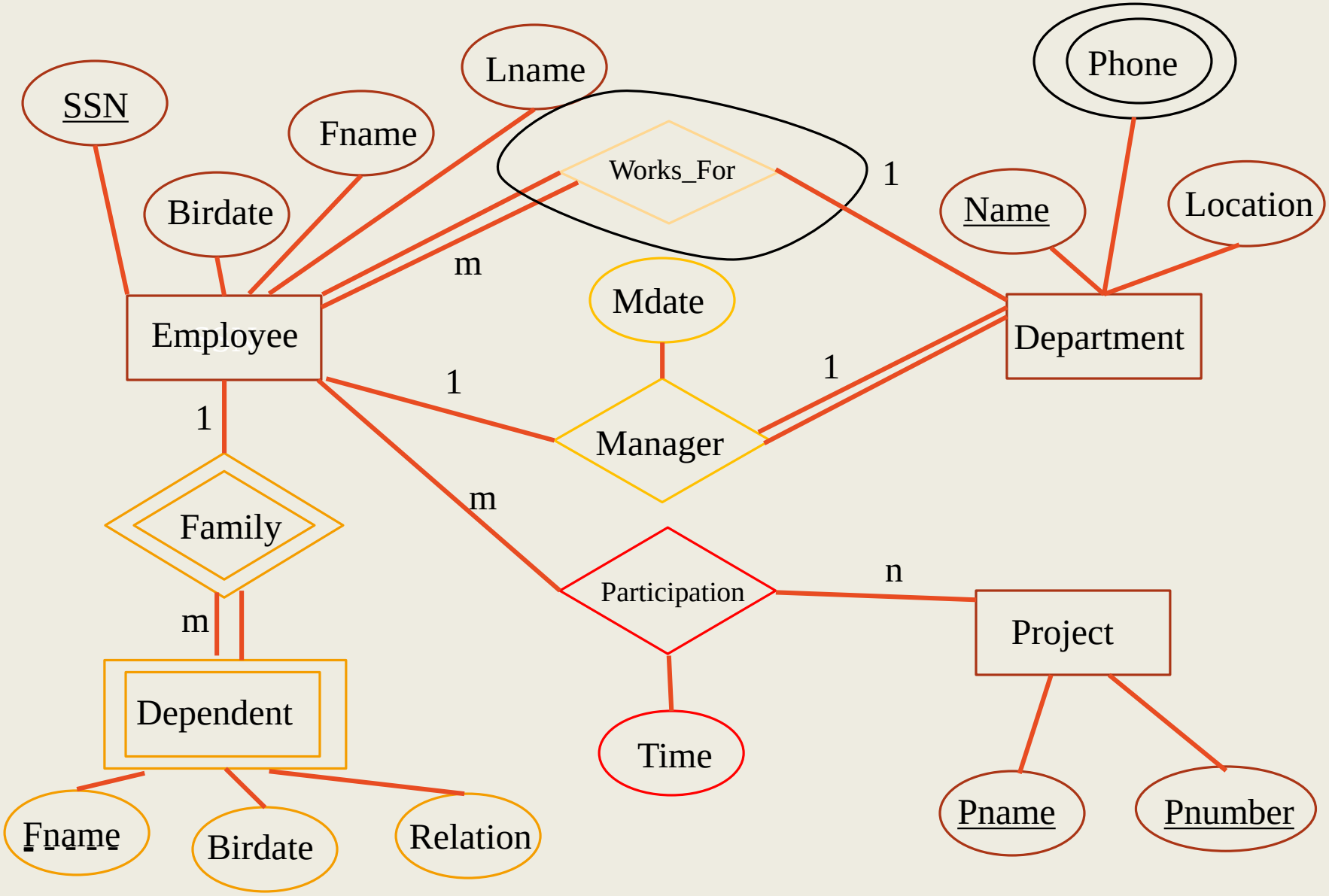
Relation

ER to RDM

Step 4 : For each regular 1:N relationship type B.

- Let E and F be the participating entity types.
- Let E by the entity type on the 1 side, F the one on the N side.
- Let S and T be the corresponding relations.
- Add the attributes of the primary key of S to T as a foreign key.
- Add to T any simple attributes (or simple components of composite attributes) of the relationship.

(Notice that this doesn’t add any new tuples, just attributes.)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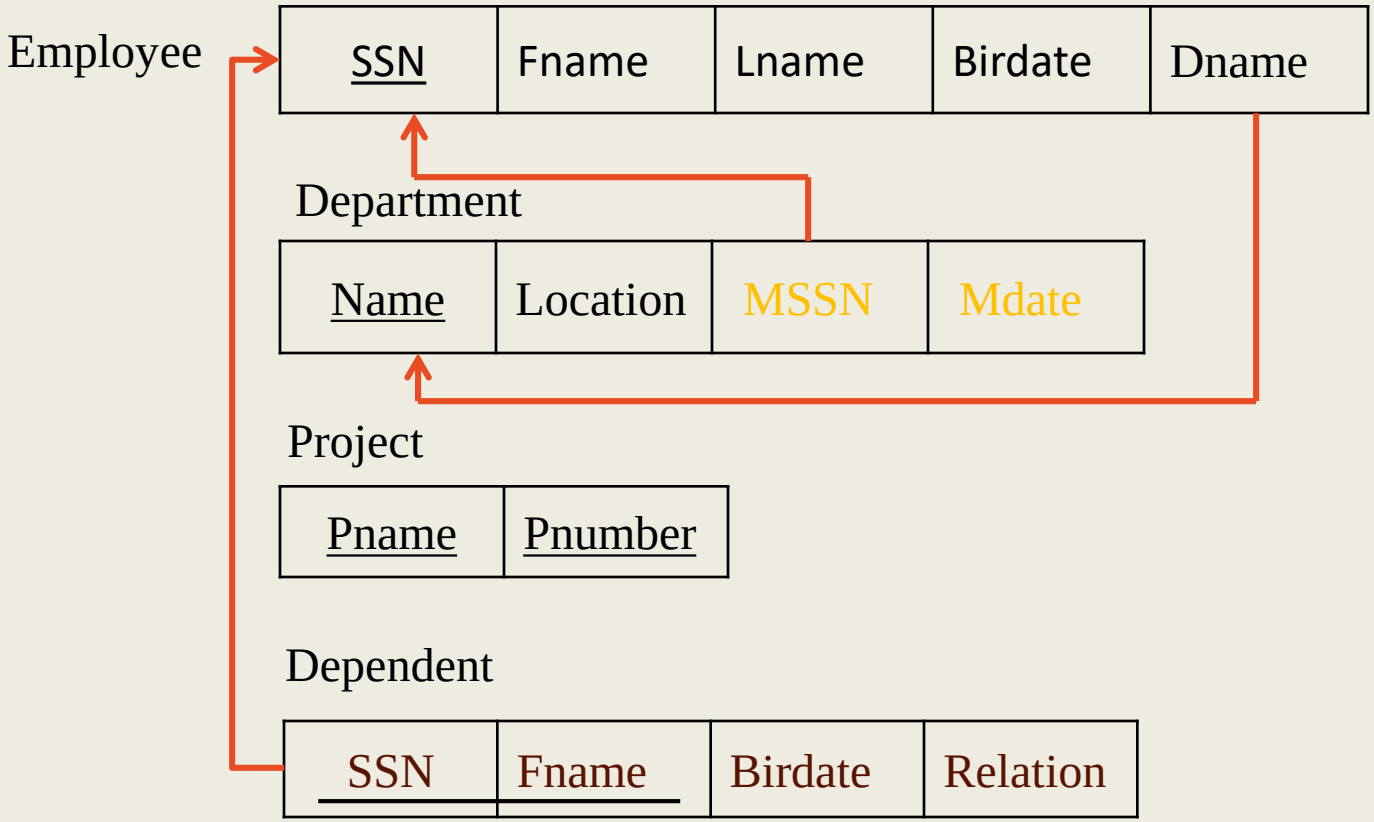
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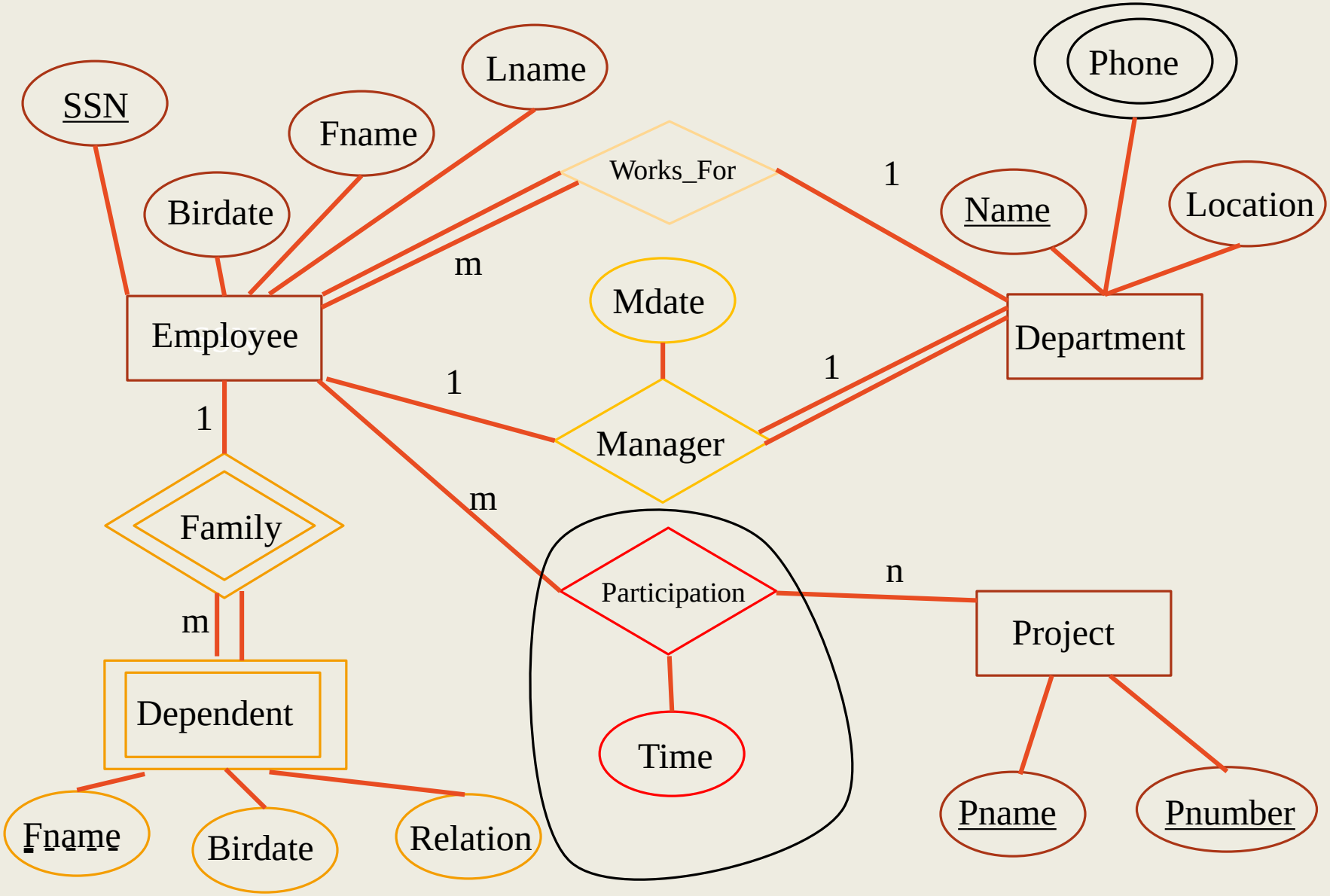
ER to RDM

Step 5 : For each N:M relationship type B. Create a new relation R. Let E and F be the participating entity types. Let S and T be the corresponding relations.

- Attributes : The key of S and the key of T as foreign keys, plus the simple attributes (and simple components of composite attributes) of B.
- Key : The key of S and the key of T.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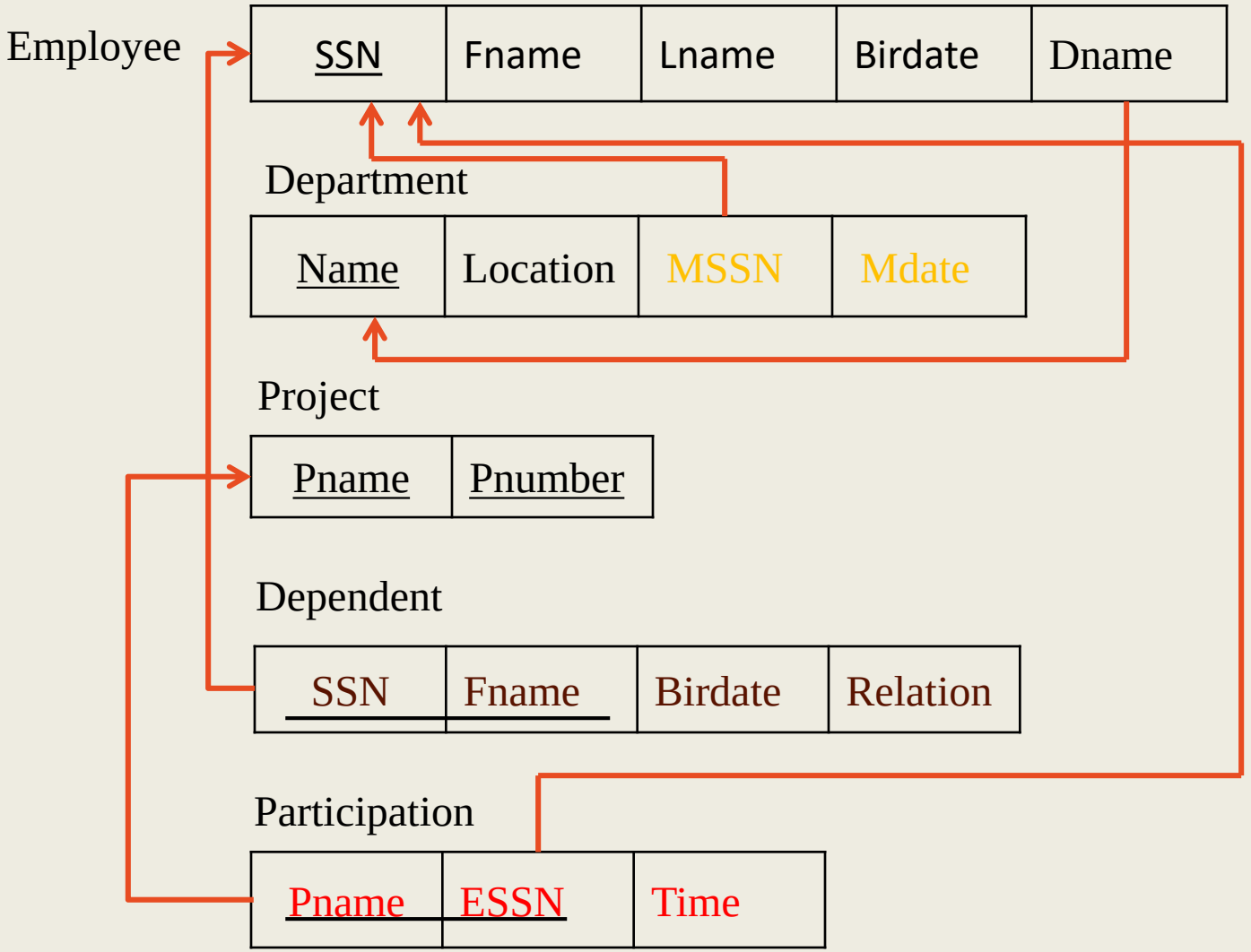
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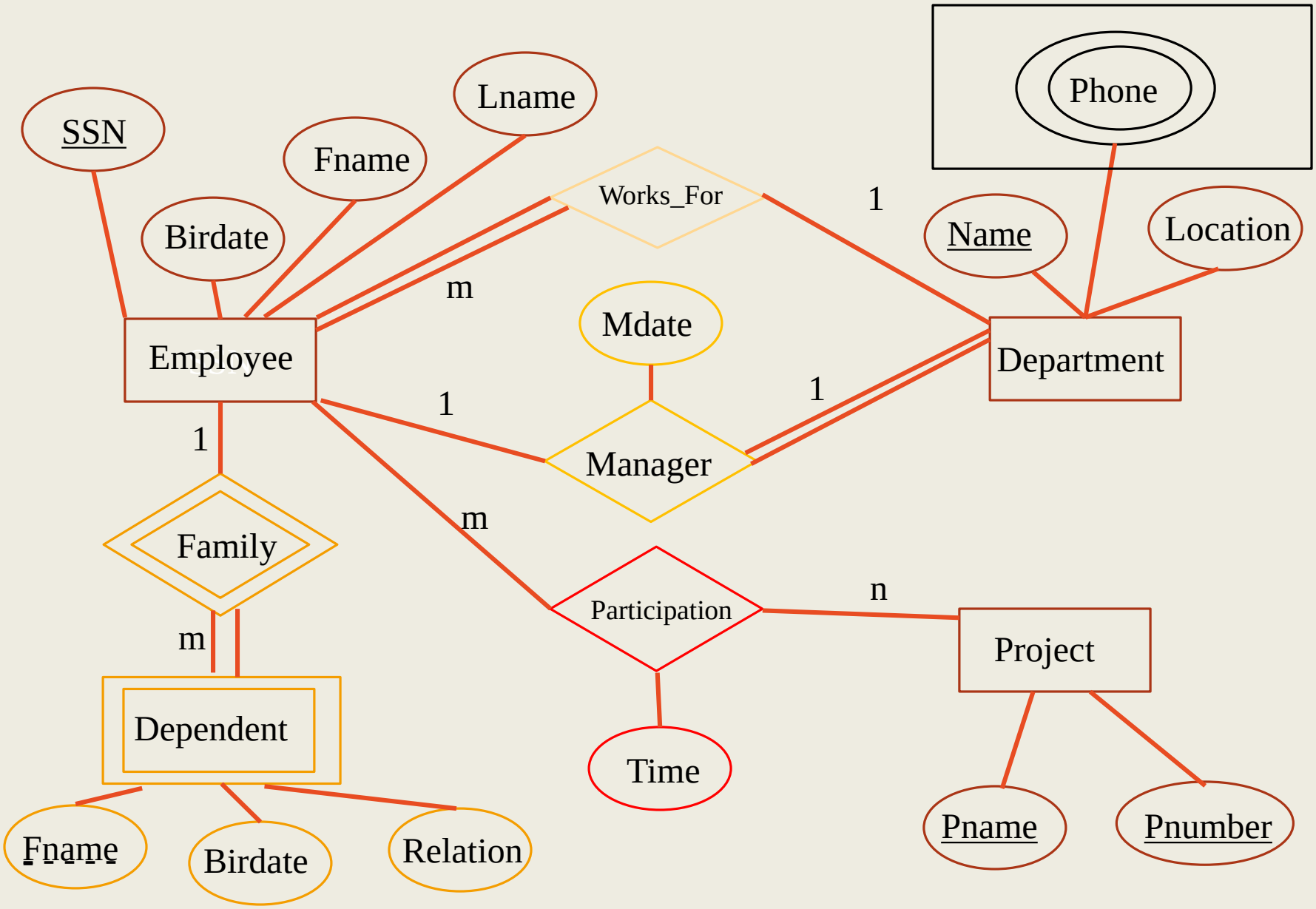
ER to RDM

Step 6 : For each multivalued attribute A. Create a new relation R. Let A be an attribute of E.

- Attributes :
  1. A (if A is a simple attribute) together with the key of E as a foreign key.
  2. The simple components of A (if A is a composite attribute), together with the key of E as a foreign key.
- Key : All attributes.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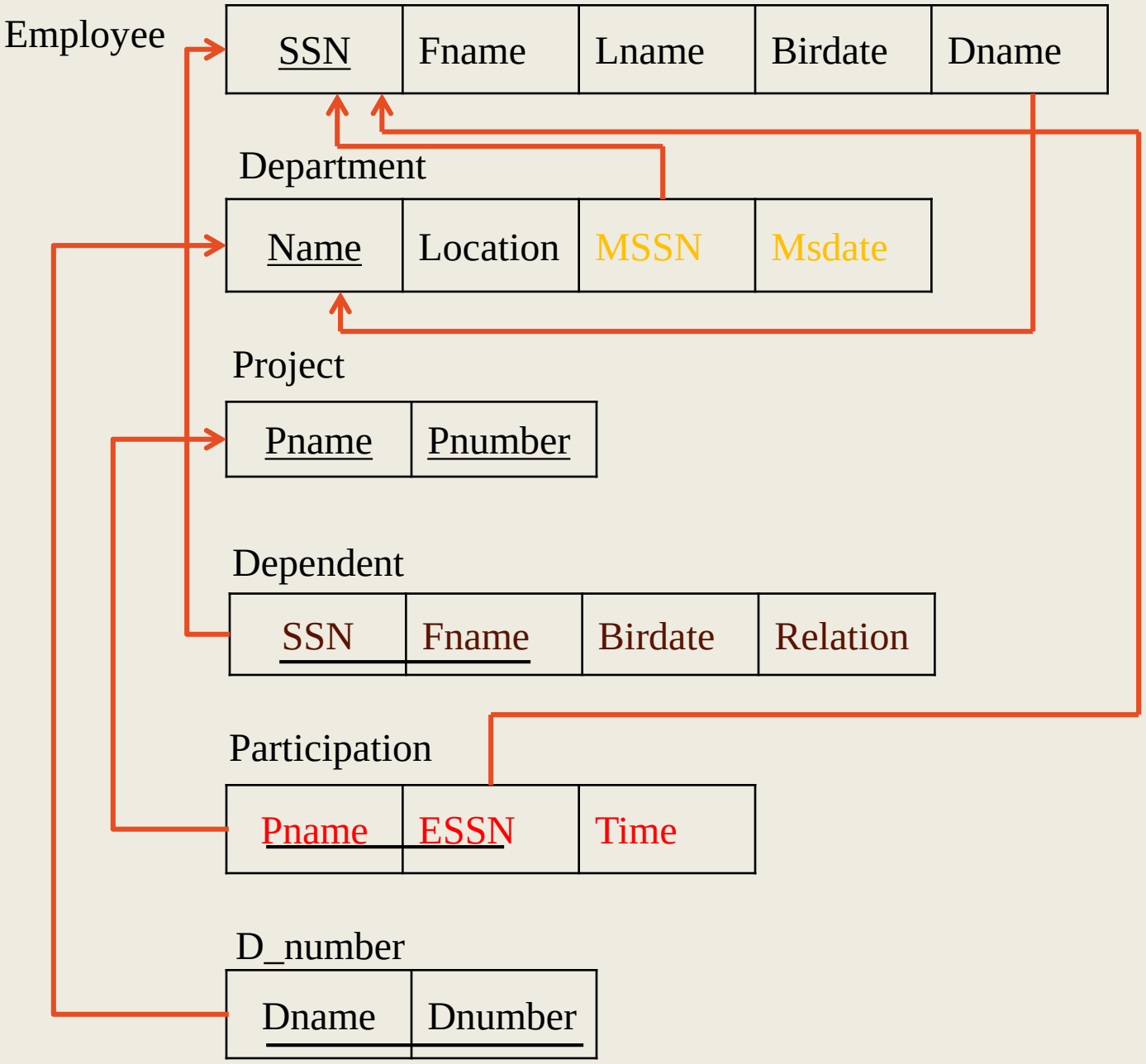
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ER to RDM

Step 7 : For each n-ary relationship type (n > 2). Create a new relation with

- Attributes : as for Step 5.
- Key : as for Step 5, except that if one of the participating entity types has participation ratio 1, its key can be used as a key for the new relation.