Lecture 2: Relational Model

CS3402 Database Systems

Introduction (1/2)

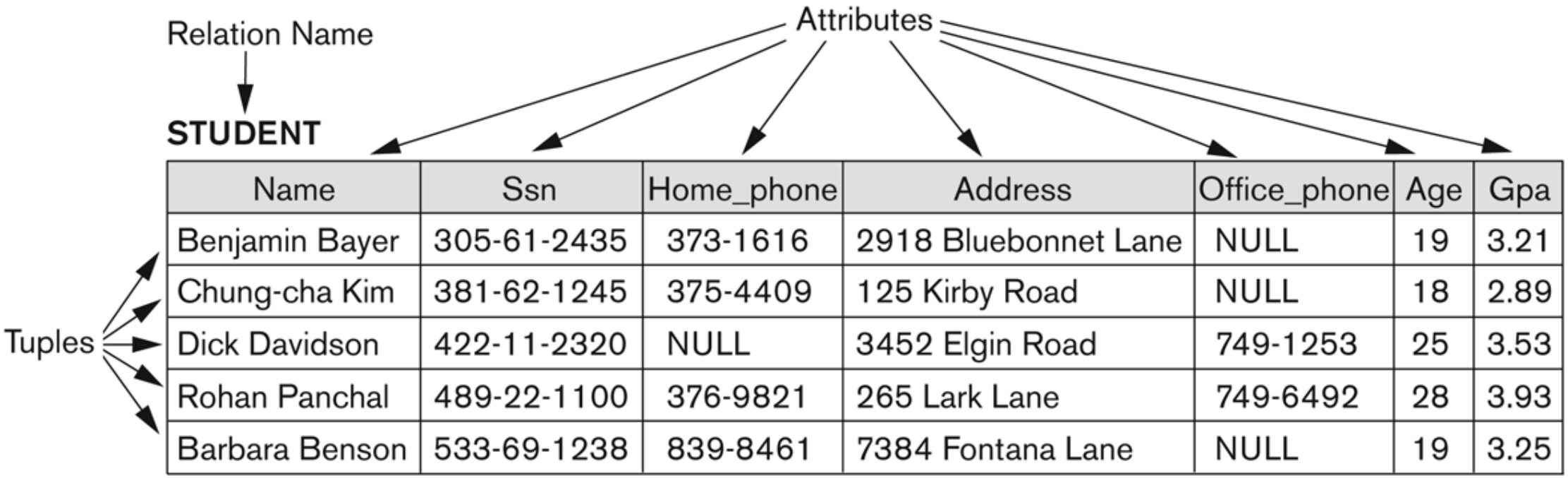
- Although the ER approach is a simple and an appropriate way to describe the structure of data, many database implementations are always based on another approach called the relational model
- Translate ER Diagram into Relational Model

Introduction (2/2)

- A relation looks like a table (rows x columns) of values
- A relation contains a set of rows (tuples) and each column (attribute) has a column header that gives an indication of the meaning of the data items in that column
  - Associated with each attribute of a relation is a set of values (domain)
  - Students(SSN:string, Name:string, GPA:double)
- The data elements in each row (tuple) represent certain facts that correspond to a real-world entity or relationship

Example

- The attributes (columns) and tuples (rows) of a relation (table) STUDENT



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	749-1253	25	3.53
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	NULL	19	3.25

Primary Key vs Foreign Key

- Primary Key
  - Primary key uniquely identify a tuple in the table.
  - We can have only one primary key in a table.
- Foreign Key
  - Foreign key is a field in the table that is primary key in another table.
  - We can have more than one foreign key in a table. For example, a relationship is associated with two entity types; one foreign key for each entity type.

Relational Data Model: Basic Structure (1/2)

- Records
  - Each tuple (row) in a relation (table) is a record (entity).
  - Each attribute (column) in a relation corresponds to a particular field of a record
- Sample relational database schema

Customer

customer_no	customer_name	address

(Primary Key)

Part

part_no	part_name	cost

(Primary Key)

Order

order_no	customer_no	part_no	quantity

(Primary Key) (Foreign Key) (Foreign Key)

Relational Data Model: Basic Structure (2/2)

- Corresponding database records

Customer

customer_no	customer_name	address
101	Alan	8 Blue St., LA
102	Bob	6 Red Ave., SF
103	Carrie	12 Pink Rd., NY

Part

part_no	part_name	cost
301	widget	25,000
302	Gadget	17,500
303	screw	5,900

Order

order_no	customer_no	part_no	quantity
1	101	301	2
2	101	302	5
3	103	303	5
4	102	301	6

Relation State

- Each populated relation has many records (tuples) in its current relation state
- Whenever the database is changed, a new state arises.
- Basic operations for changing the database:
  - Insert – add a new tuple in a relation
  - Delete – remove an existing tuple from a relation
  - Update – modify an attribute of an existing tuple

Database State

- One possible database state for the Company relational database schema

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

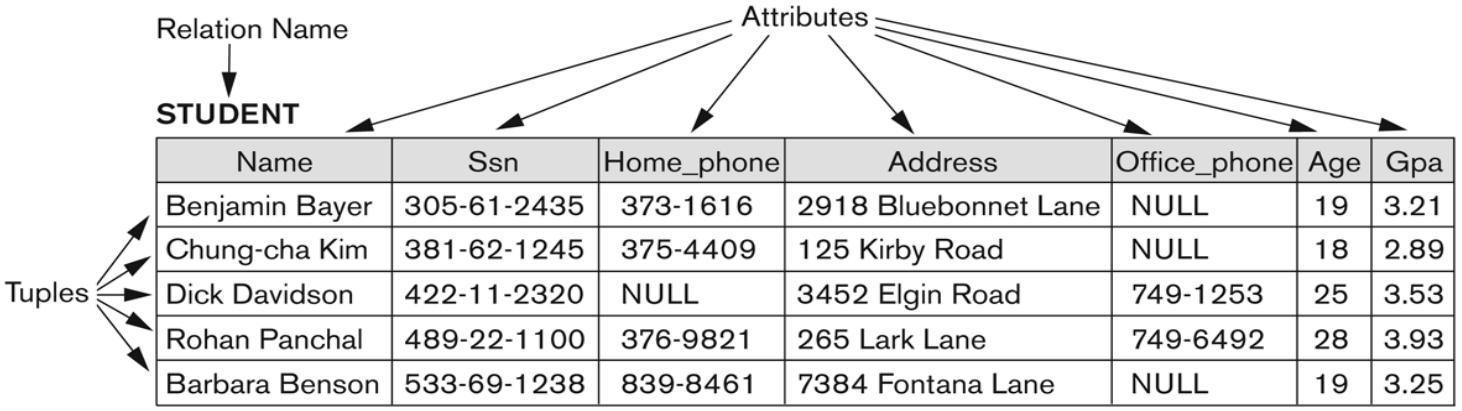
Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

Definition Summary

Informal Terms	Formal Terms
Table	Relation
Column header	Attribute
All possible values for a column	Domain
Row	Tuple
Table definition	Relation schema
Populated table	Relation state

Characteristics of Relations (1/2)

- The tuples are not considered to be ordered, even though they appear to be in a tabular form (may have different presentation orders)
- Same relation state with different order of tuples



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	749-1253	25	3.53
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	NULL	19	3.25

Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	749-1253	25	3.53
Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	NULL	19	3.25
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Chung-cha Kim	381-62-1245	375-4409	125 Kirby Road	NULL	18	2.89
Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	NULL	19	3.21

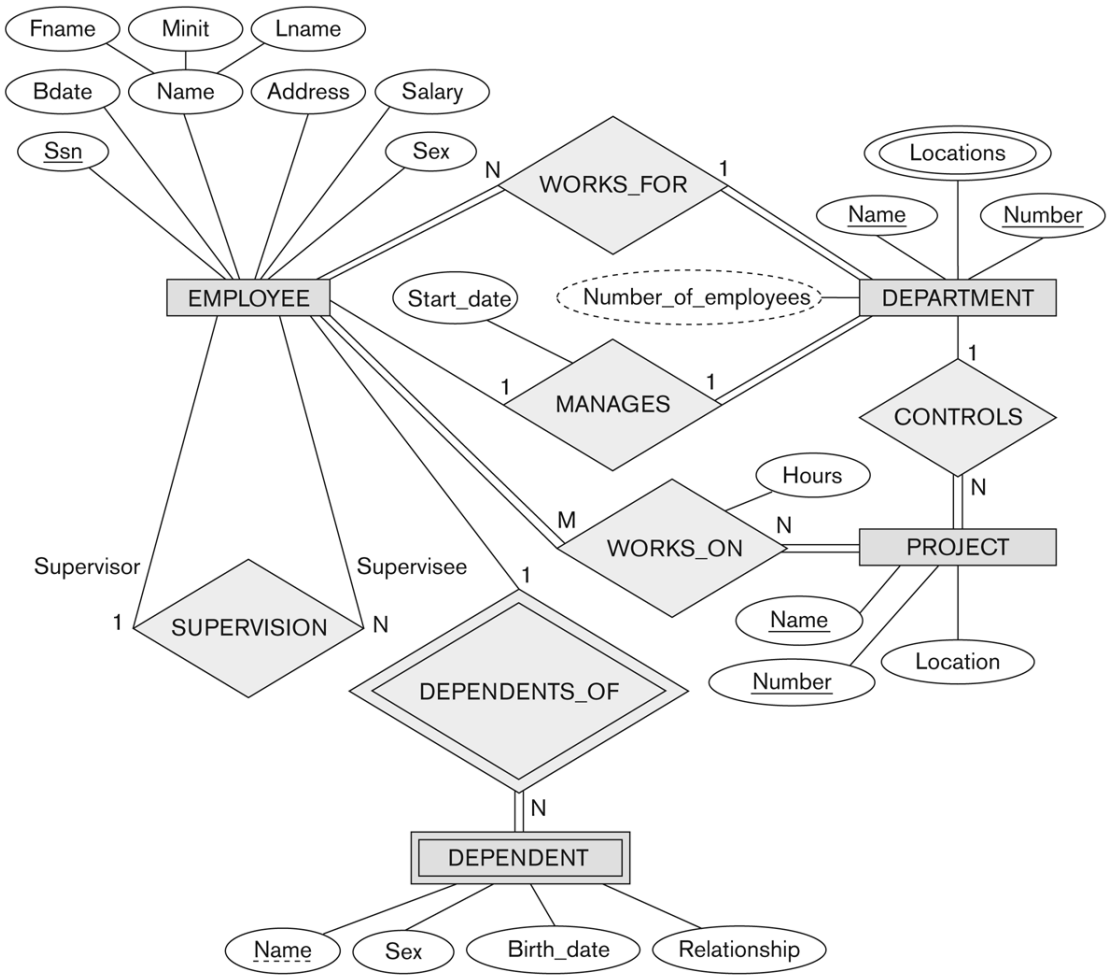
Characteristics of Relations (2/2)

- Values in a tuple
  - All values are considered atomic (indivisible)
  - Basic unit for manipulation (add or change)
- Each value in a tuple must be from the domain (set of values) of the attribute for that column
- A special null value is used to represent values that are unknown or not available or inapplicable in certain tuples

From ER Diagrams to Relations: Step 1 (1/2)

- Mapping of strong entity types
- For each strong entity type E,
  - Create a relation R that includes all the (i) simple attributes and (ii) simple components of composite attributes of E as its attributes
  - Choose one of the key attributes of E as the primary key for R
- R is called an entity relation
  - Each tuple in R represents an entity instance

From ER Diagrams to Relations: Step 1 (2/2)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname

DEPARTMENT

Dnumber	Dname

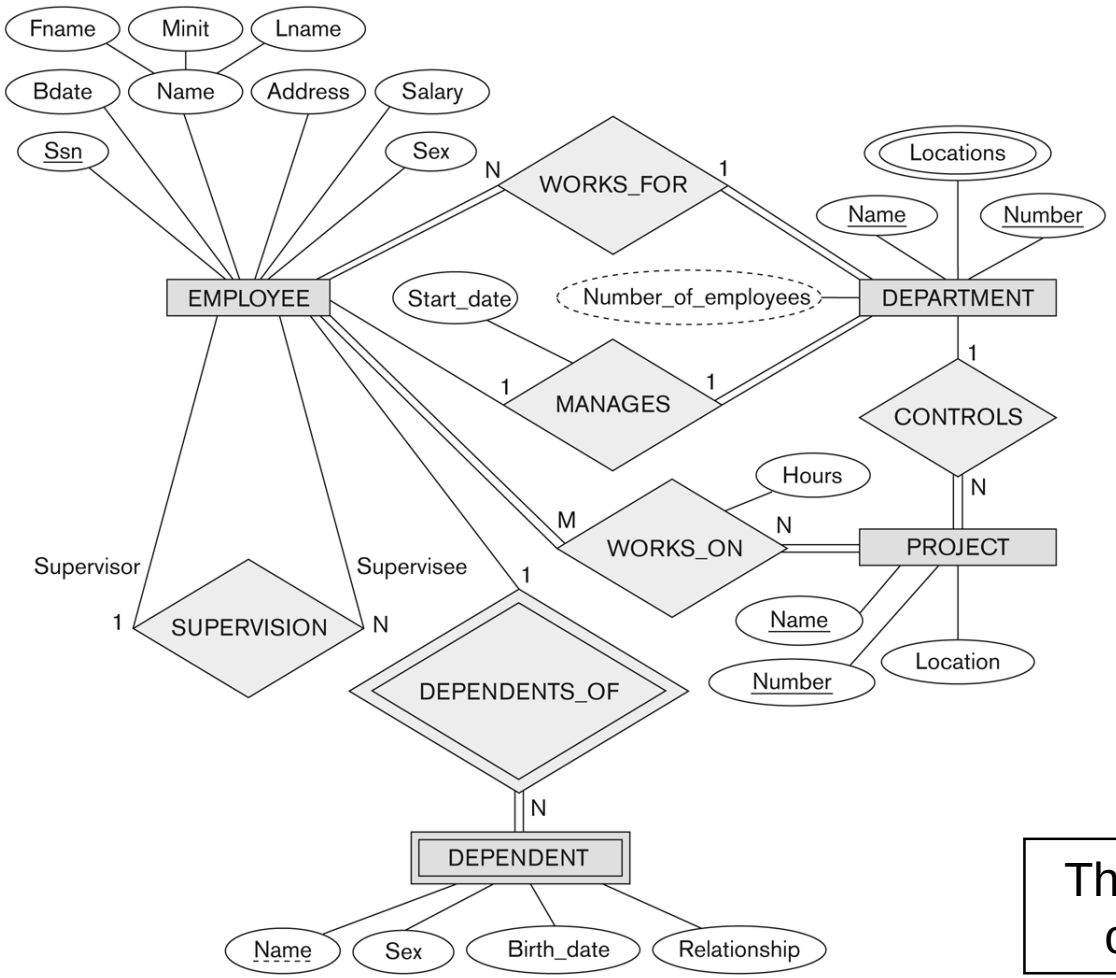
PROJECT

Pnumber	Pname	Plocation

From ER Diagrams to Relations: Step 2 (1/2)

- Mapping of weak entity types
- For each weak entity type E’,
  - Create a relation R that includes all the (i) simple attributes and (ii) simple components of composite attributes of E’ as its attributes, and (iii) the primary key of the relation representing the owner of E’ as the foreign key
  - The primary key of R is the combination of (a) the foreign key referring to the relation representing the owner or E’ and (b) the partial key of E’

From ER Diagrams to Relations: Step 2 (2/2)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname

DEPARTMENT

Dnumber	Dname

PROJECT

Pnumber	Pname	Plocation

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

The primary key of the owner

The partial key of the weak entity type

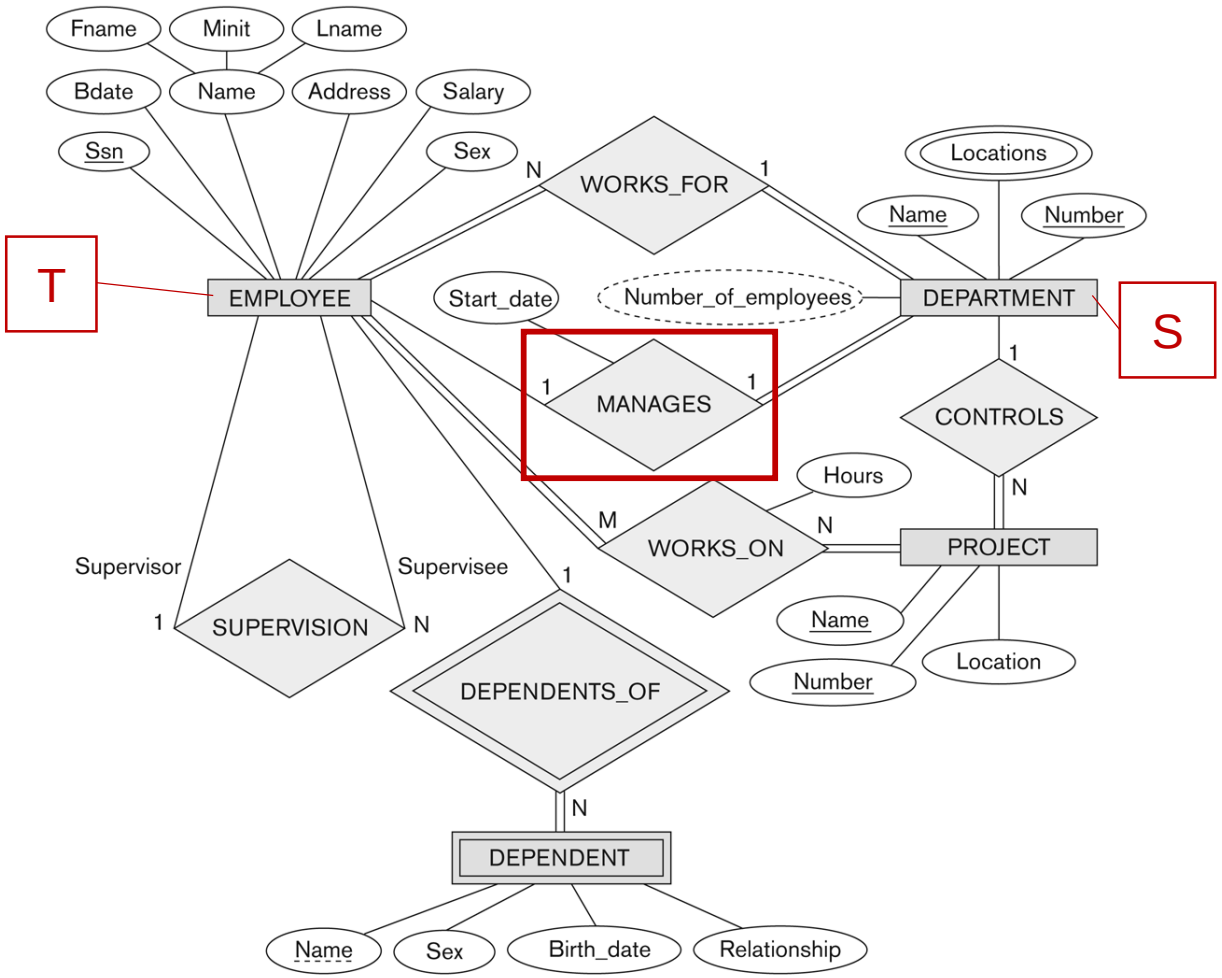
From ER Diagrams to Relations: Step 3 (1/4)

- Mapping of binary 1:1 relationship types
- For each binary 1:1 relationship type,
  - Identify relations that correspond to the entity types participating in R
- Possible approaches
  - Foreign key approach
  - Merged relationship approach
  - Relationship relation (or cross reference) approach

From ER Diagrams to Relations: Step 3 (2/4)

- Foreign key approach (with relations S and T)
  - Choose one of the relations (i.e., S) and include the primary key of T as the foreign key in S
  - Include all the simple attributes and simple components of composite attributes of the relationship as S' attributes

From ER Diagrams to Relations: Step 3 (3/4)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname

DEPARTMENT

Dnumber	Dname	Mgr_ssn	Mgr_start_date

PROJECT

Pnumber	Pname	Plocation

Include the primary key in EMPLOYEE as a foreign key

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

From ER Diagrams to Relations: Step 3 (4/4)

- Merged relationship approach (with relations S and T)
  - Merge S, T and the relationship into a single relation
- Relationship relation approach (with relations S and T)
  - Create a relation R that includes all the (i) simple attributes and (ii) simple components of composite attributes of the relationship as its attributes, and (iii) the primary keys of S and T as the foreign keys to S and T
  - The primary key of R is one of the two foreign keys

EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname

DEPARTMENT_MANAGER

Dnumber	Ssn	Start_date

DEPARTMENT

Dnumber	Dname

From ER Diagrams to Relations: Step 4 (1/2)

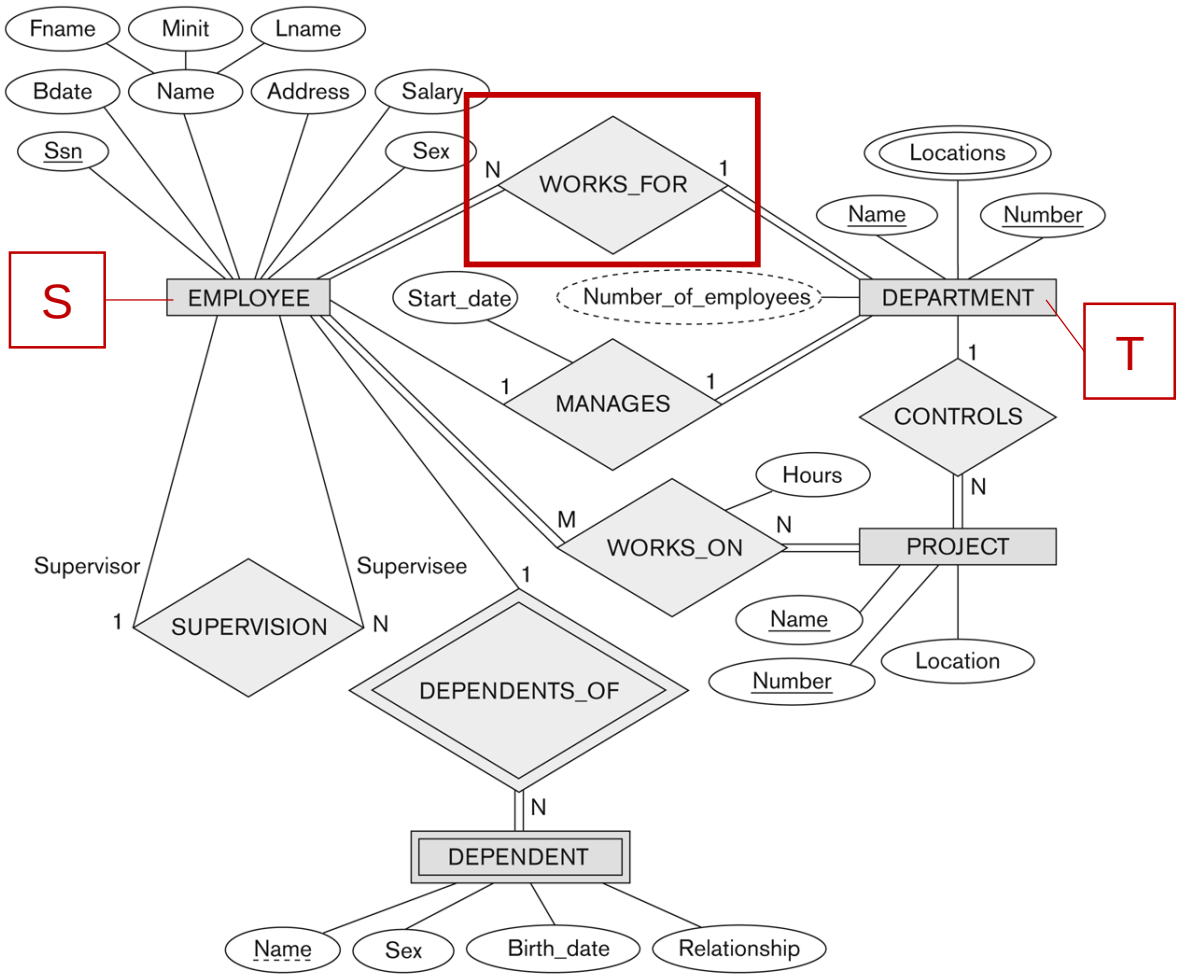
- Mapping of binary 1:N relationship types
  - Identify relation S that represents participating entity type at N-side of relationship type
  - S include all the (i) simple attributes and (ii) basic components of composite attributes of the relationship as its attributes, and (iii) the primary key of T as its foreign key
- Alternative approach
  - Use the relationship relation option as in the third approach for binary 1:1 relationships, but the primary key of R are the two foreign keys of both participating entities.

WORKS_FOR

Dnumber	Ssn

(For alternative approach)

From ER Diagrams to Relations: Step 4 (2/2)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname	Dno

DEPARTMENT

Dnumber	Dname	Mgr_ssn	Mgr_start_date

PROJECT

Pnumber	Pname	Plocation

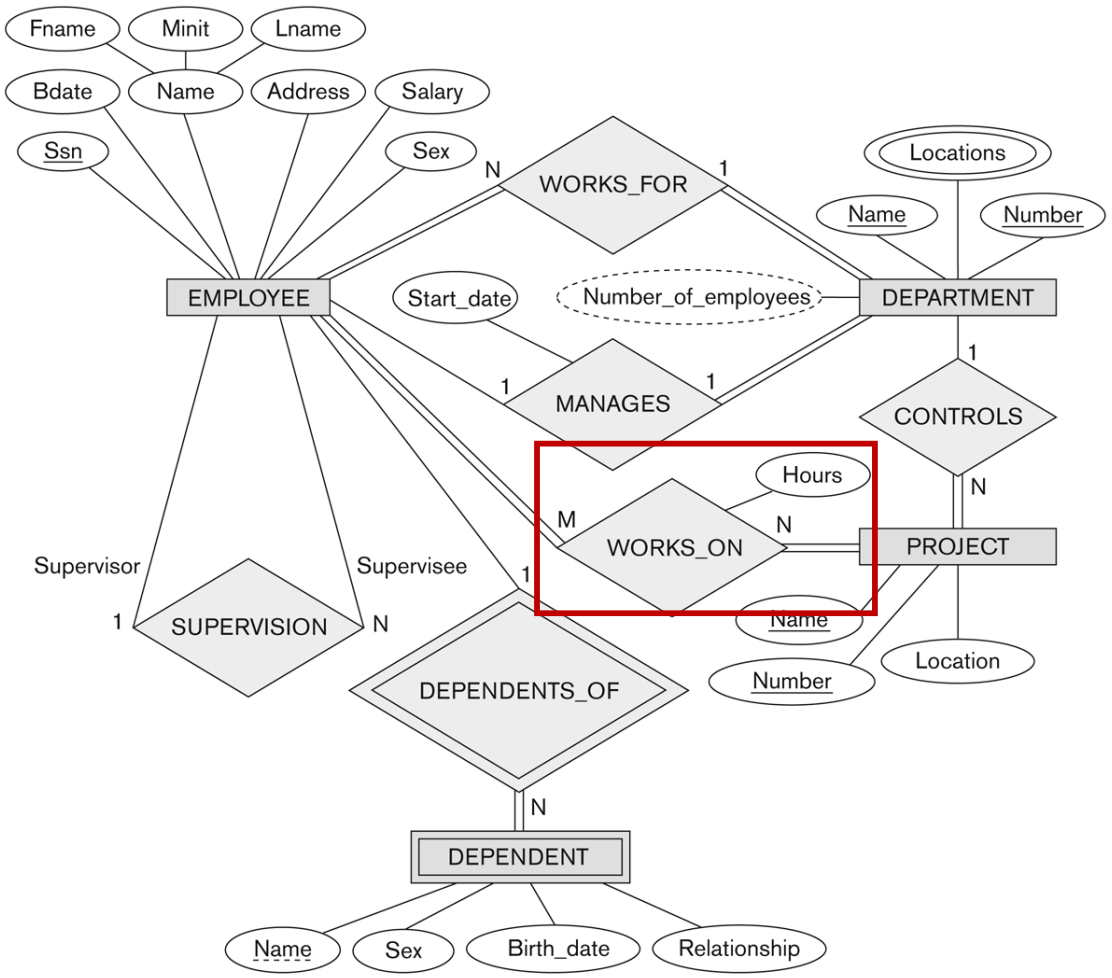
DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

From ER Diagrams to Relations: Step 5 (1/2)

- Mapping of binary M:N relationship types
  - Create a new relation R that includes all the (i) simple attributes and (ii) basic components of composite attributes of the relationship as its attributes, and (iii) the primary key of the relations representing the participating entity types as its foreign keys
  - The primary key of R is the combination of all the foreign keys referring to the relations representing the participating entity types.

From ER Diagrams to Relations: Step 5 (2/2)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname	Dno

DEPARTMENT

Dnumber	Dname	Mgr_ssn	Mgr_start_date

PROJECT

Pnumber	Pname	Plocation

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

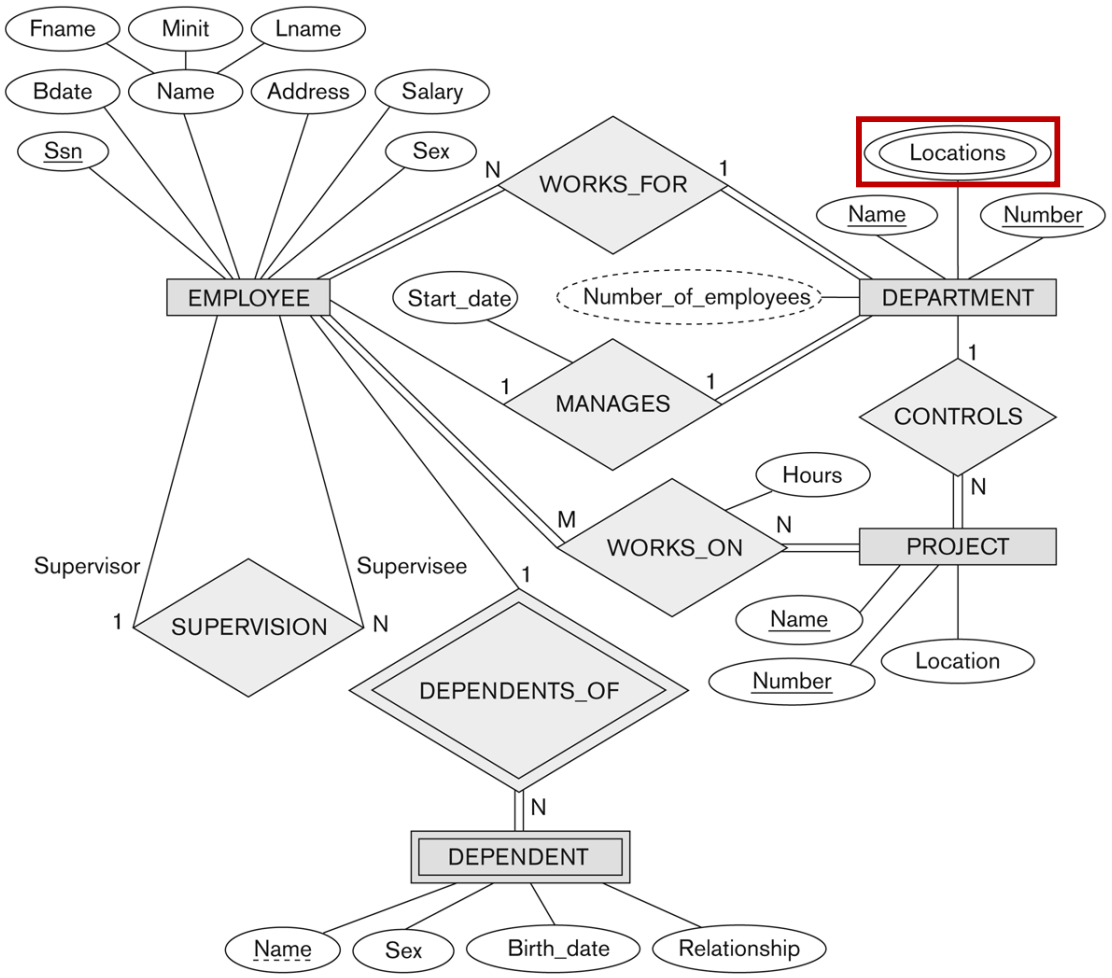
WORKS_ON

Essn	Pno	Hours

From ER Diagrams to Relations: Step 6 (1/2)

- Mapping of Multivalued Attributes
- For each multivalued attribute A,
  - Create a relation R that includes (i) A as its attribute and (ii) the primary key of the relation R’ representing the entity or relationship type that has A as its foreign key.
  - The primary of R is the combination of (a) A and (b) the foreign key referring to relation R’.
  - If the multivalued attribute is composite, include its simple components.

From ER Diagrams to Relations: Step 6 (2/2)



EMPLOYEE

Ssn	Bdate	Address	Salary	Sex	Fname	Minit	Lname	Dno

DEPARTMENT

Dnumber	Dname	Mgr_ssn	Mgr_start_date

PROJECT

Pnumber	Pname	Plocation

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

WORKS_ON

Essn	Pno	Hours

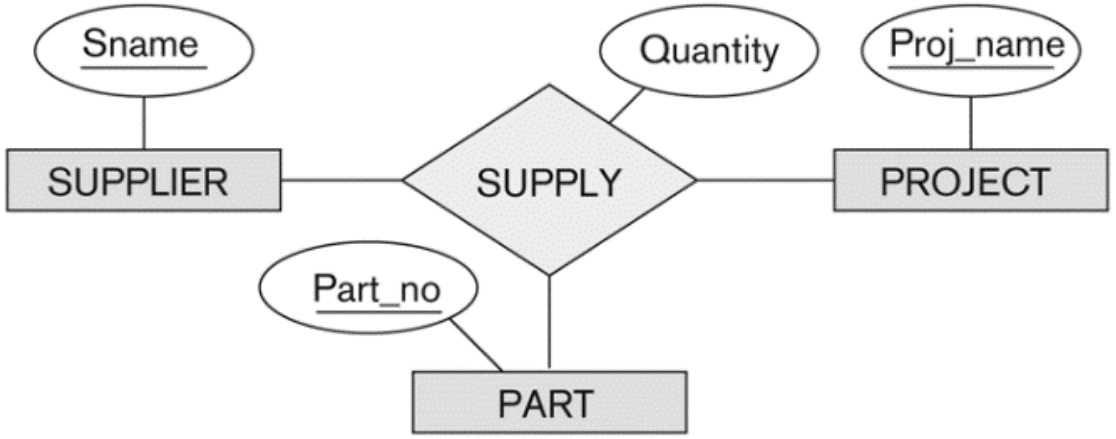
DEPT_LOCATION

Dnumber	Dlocation

From ER Diagrams to Relations: Step 7 (1/2)

- Mapping of n-ary relationship types
- For each n-ary relationship type,
  - Create a relation R that includes all the (i) simple attributes and (ii) simple components of composite attributes of the relationship as its attributes and (iii) the primary keys of the relations that represent the participating entity types as its foreign keys
  - The primary key of R is a combination of all the foreign keys referring to the relations that represent the participating entity types

From ER Diagrams to Relations: Step 7 (2/2)



SUPPLY

Sname	Proj_name	Part_no	Quantity

Summary of Mapping for ER Model to Relational Model

ER Model	Relational Model
Entity type	Entity relation
Binary 1:1 or 1:N relationship type	Foreign key (or relationship relation)
Binary M:N relationship type	Relationship relation and two foreign keys
n-ary relationship type	Relationship relation and n foreign keys
Simple attribute	Attribute
Composite attribute	Set of simple component attributes
Multivalued attribute	Relation and foreign key
Value set	Domain
Key attribute	Primary key