Topic
The Relational Model

Overview

- The Relational Model (RM)
  - Relations
  - Properties of relations
- Relational Constraints and Relational Database Schema
  - Domain Constraints, Key Constraints and Constraints on Null
  - Relational Database Schema
  - Entity Integrity, Referential Integrity, and Foreign Keys

Relational data model

- A database is a collection of relations (or tables)
- Each relation has a list of attributes (or columns)
  - ▫ Set-valued attributes not allowed
- Each attribute has a domain (or type)
- Each relation contains a set of tuples (or rows)
  - ▫ Duplicate tuples are not allowed

☞Simplicity is a virtue!

Sets

- A *set* is an *unordered* collection of distinction of *dictinct* objects.
  - Examples

    {3,4,a} is a set

    {a,3,4} is the same set as {a,4,3}

    {4,4} is not a set
- Set operations include
  - Intersection, e.g., {3,4,a} C{b,4} = {4}
  - Union, e.g., {3,4,a} D{b,4} = {3,4,a,b}
  - Difference, e.g., {3,4,a} – {b,4} = {3,a}

Domains and Attributes

- Definition: A *domain* is a set of values of some “type”
    - Positive integers = {1,2,3,4,…}
    - Alphanumberic characters = {„a“, „b“, …, „z“, „0“, …, „9“}

- A common database restriction: A domain is a atomic.
    - The following programming types are atomic domains.
      integer, char, float, varchar
    - Structs/records are a *composite* domain.
      struct {a: int, b: char}

- Definition: A *attribute* is the name of a domain.

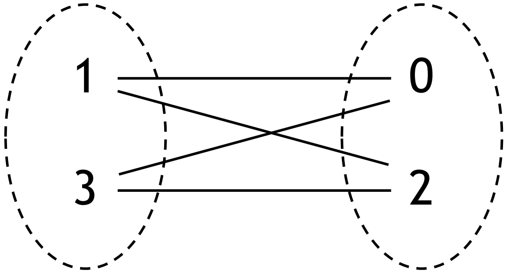
Relations

- Definition: Given sets A1, A2,…, An a relation r is a subset of their Cartesian product. ∈

  r A1 x A2 x … x An
- r is a set of n-tuples (a1, a2, …, an) where ai Ai
- Definition: R(A1, A2, …, An) is the schema of relation r.
  - A1, A2, …, An are domains; their names are attributes
  - R is the name of the relation
- Notation: r(R)is a relation on the relation schema R.

Relations as Tables

- Relations can be depicted as tables (approx.)
- ×(*O*,*E*) where *O* = {1,3} and *E* = {0,2}

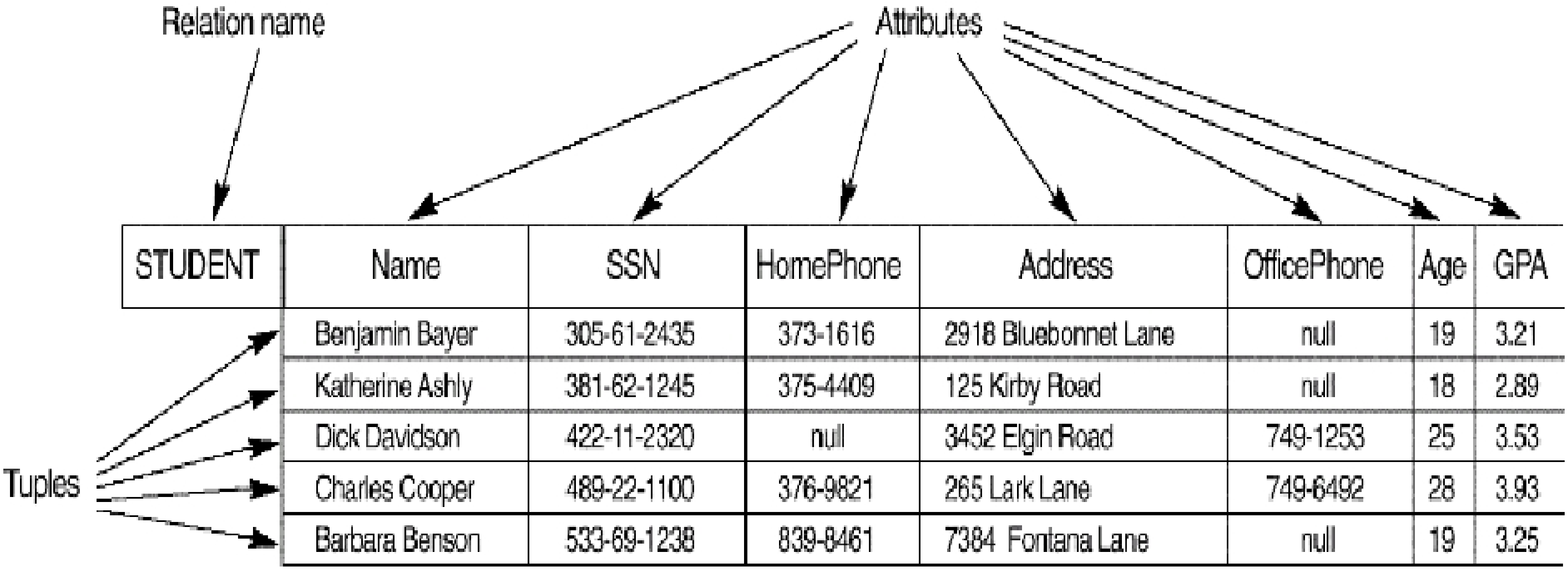


× **O** **E**

1	0
1	2
3	0
3	2

Tuples

- Definition:An element t of a relation r is called a *tuple*
- We refer to component values of a tuple t by t[Ai] = vi (the value of attribute Ai for tuple t)
    - Alternatively, use „dot‟ notation, e.g., t.Ai is the ith attribute of tuple t
- T[Ai, …, Ak] refers the subtuple of t containing the values of attributes Ai, …, Ak respectively.
- Table metaphor
    - Tuple is a row
    - Attribute is a column



STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21
	Katherine Ashly	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
	Charles Cooper	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

Characteristics of Relations

- Tuples in a relation are *unordered*.
- Example: The following two relations have the same information content.

Name	Age
Pat	1
Sue	2
Mo	3
Di	4

Name	Age
Di	4
Pat	1
Sue	2
Mo	3

Characteristics of Relations (cont.)

- Attribute in a tuple/relation are *ordered*.
- Example: The following two relations do not have the same information.

Name	Age
Pat	1
Sue	2
Mo	3
Di	4

Age	Name
1	Pat
2	Sue
3	Mo
4	Di

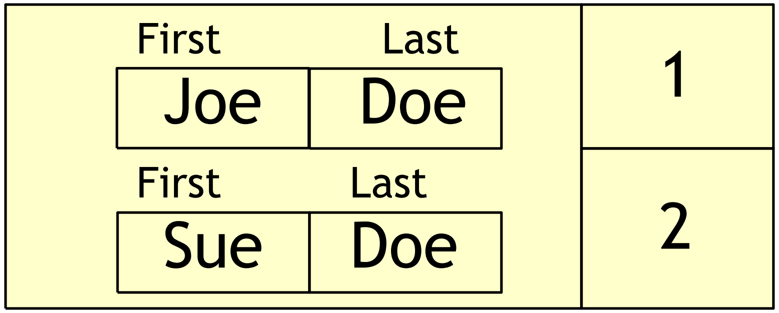
Characteristics of Relations (cont.)

- Values in a tuple are atomic (indivisible).
- A value cannot be a stucture, record, or relation

Example: All atomic values (string or integer).

Name	Age
Pat	1
Sue	2

Example: The following is not a relation. Name is not atomic.



First Last Joe Doe	1
First Last Sue Doe	2

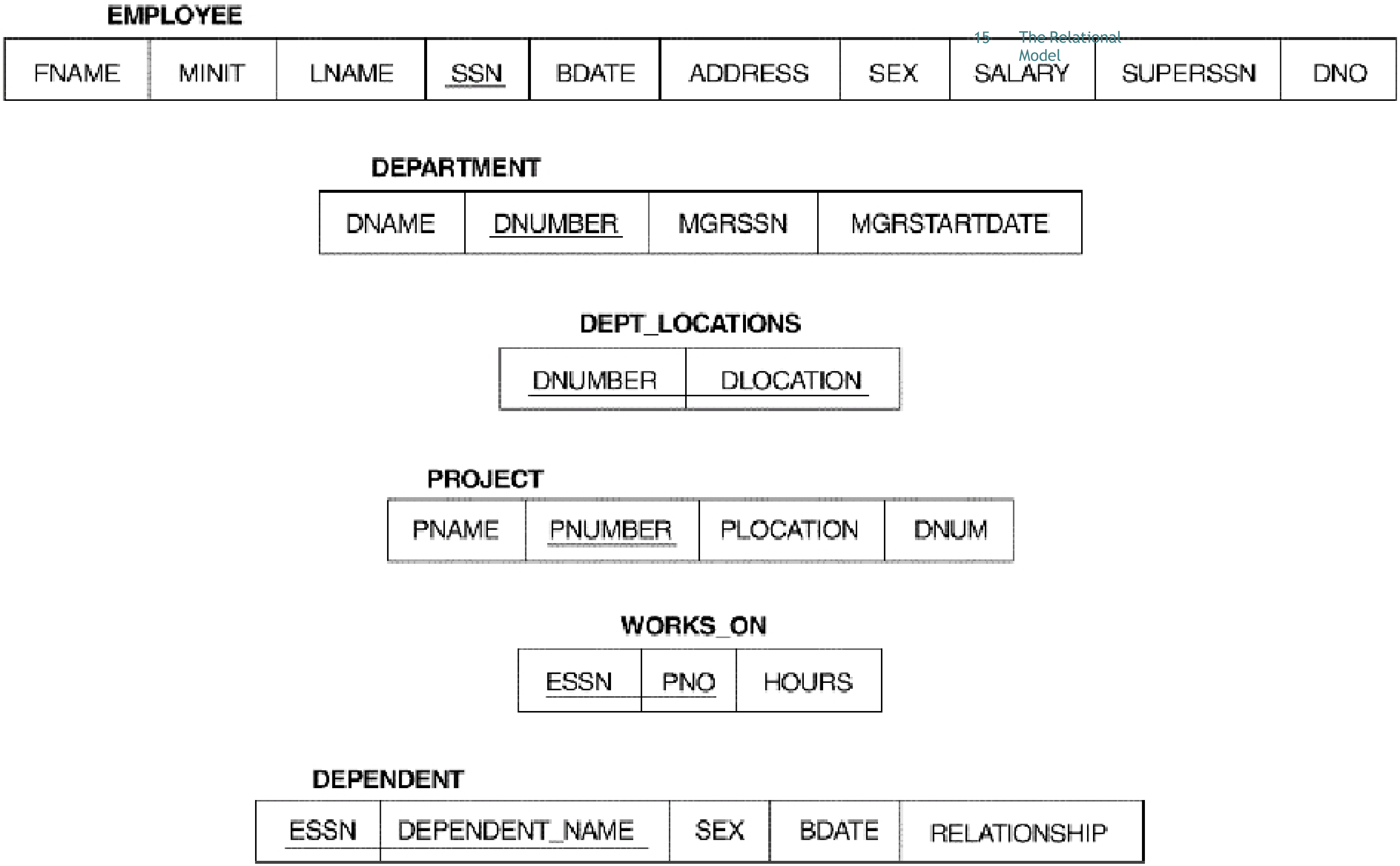
Relational Constraints

- Domain Constraints: The value of each attribute A must be an atomic value
- A superkey SK specifies a uniqueness constraint that no two distinct tuples in a state r of the relation schema R can have the same value for SK
- Another constraint on attributes specifies whether null values are or not permitted.

Relational Database Schemas

- A relational database schema S is a set of relation schema S={R1, R2, …, Rm} and a set of integrity constraints *IC*.
- A relational database state (instance) *DB of S* is a set of relation state DB={r1, r2, …, rm} such that each ri is a state of Ri and such that ri states satisfy the integrity constraints specified in *IC*.

Example: Schema diagram for a company database schema



EMPLOYEE

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

DEPARTMENT

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

DEPT_LOCATIONS

DNUMBER	DLOCATION

PROJECT

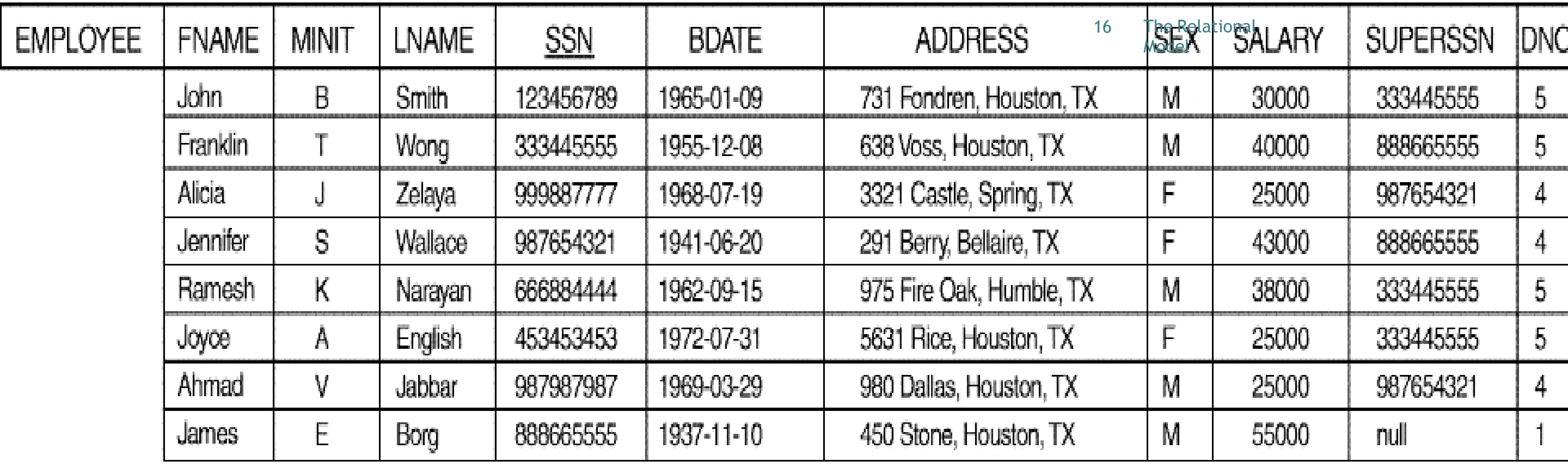
PNAME	PNUMBER	PLOCATION	DNUM

WORKS_ON

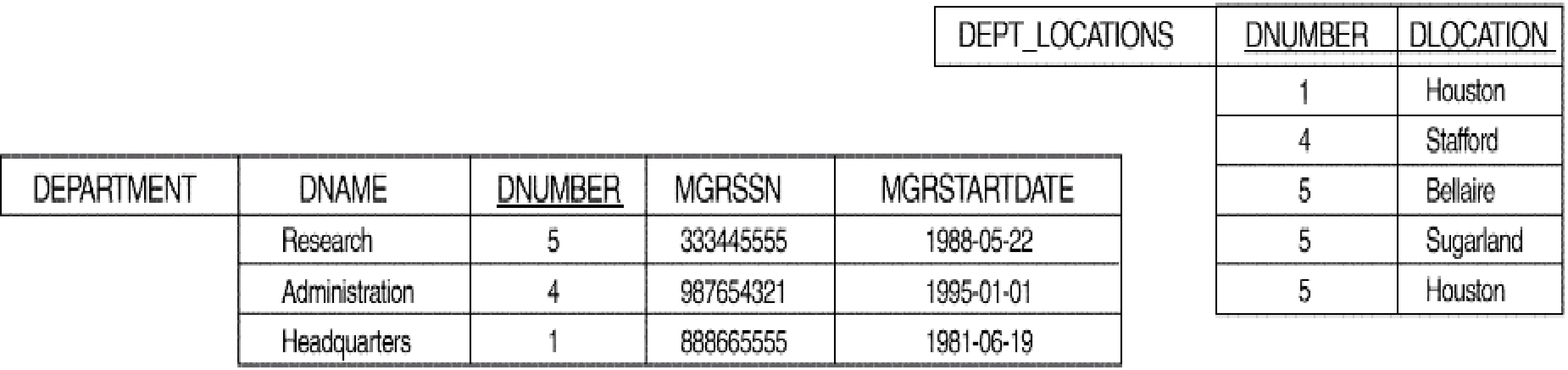
ESSN	PNO	HOURS

DEPENDENT

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP

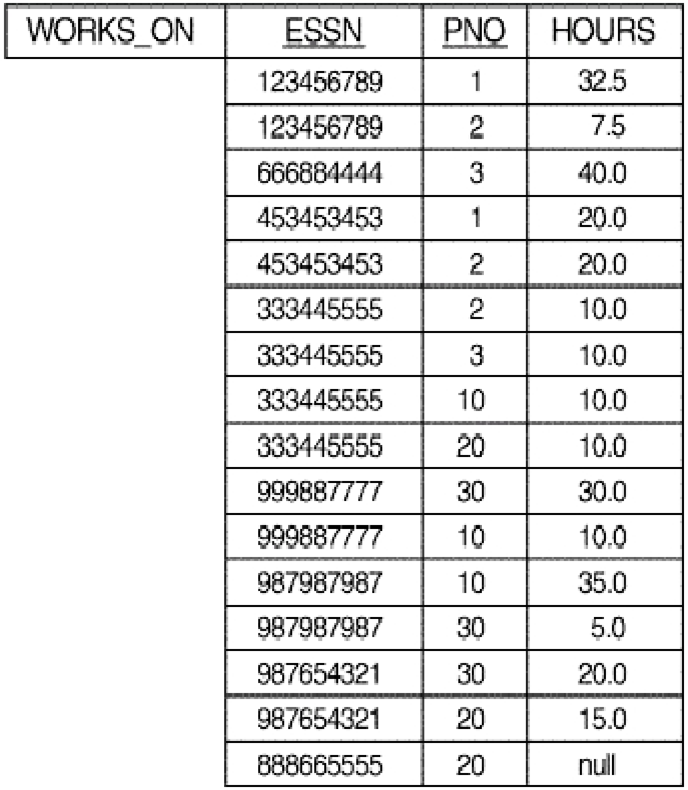


EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
	John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
	Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
	Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	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

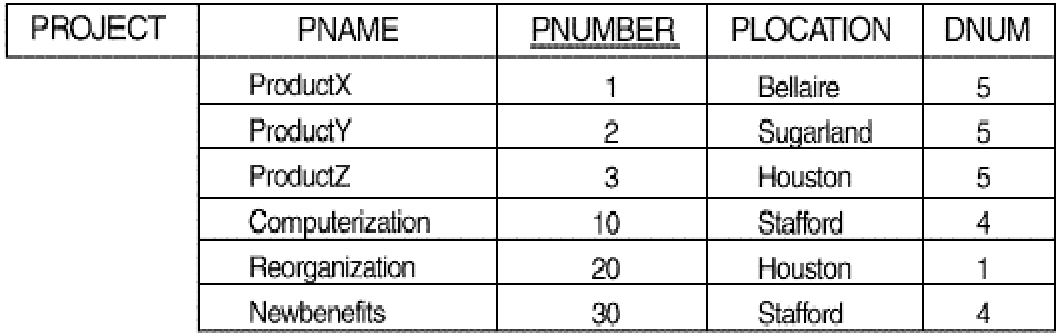


DEPT_LOCATIONS	DNUMBER	DLOCATION
	1	Houston
	4	Stafford
	5	Bellaire
	5	Sugarland
	5	Houston

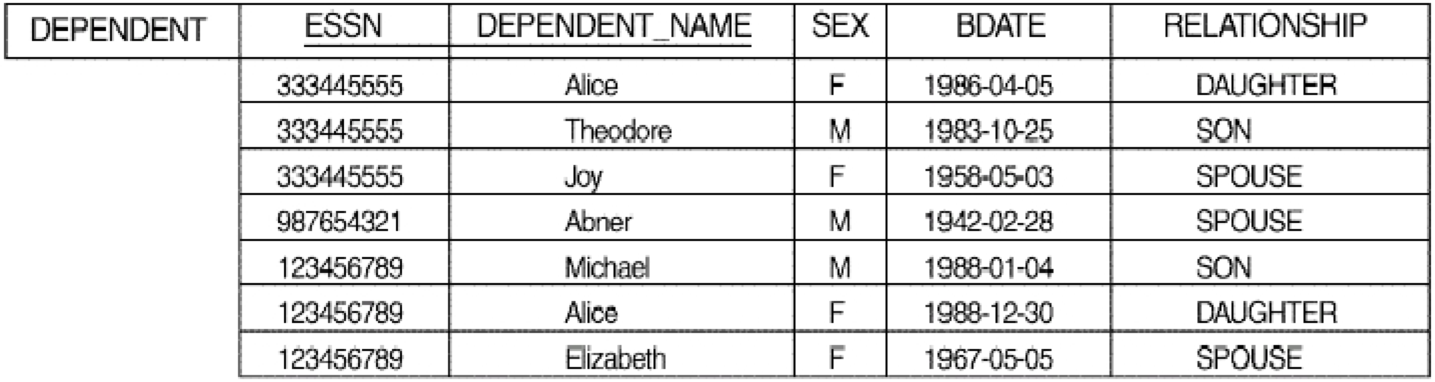
DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19



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



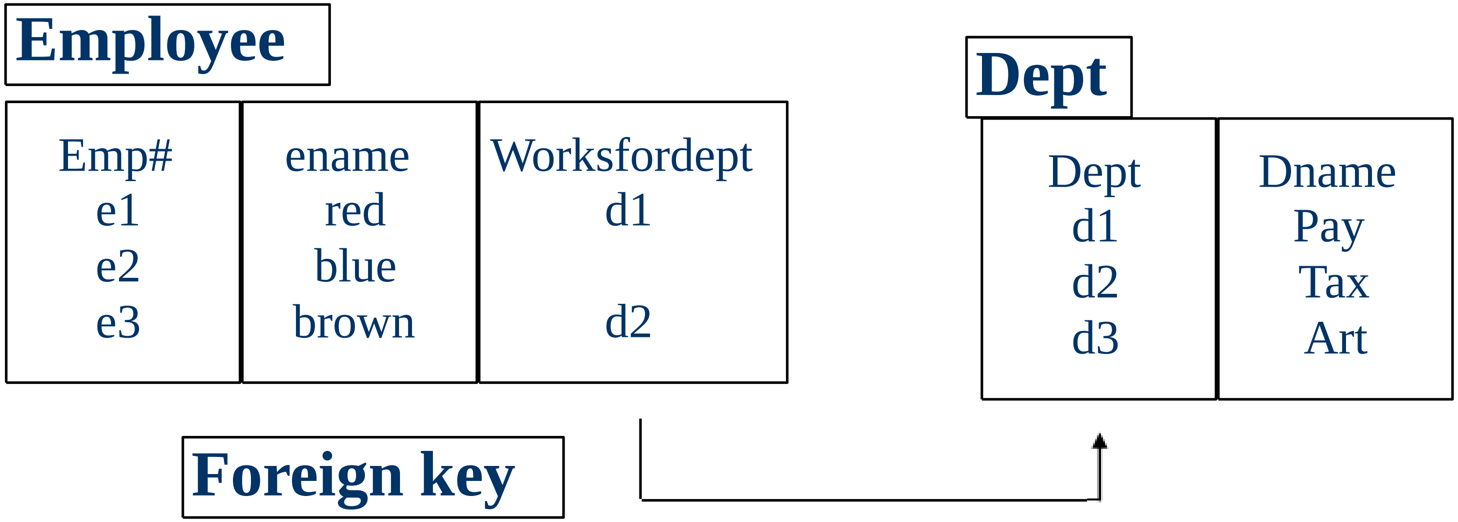
DEPENDENT	ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON
	333445555	Joy	F	1958-05-03	SPOUSE
	987654321	Abner	M	1942-02-28	SPOUSE
	123456789	Michael	M	1988-01-04	SON
	123456789	Alice	F	1988-12-30	DAUGHTER
	123456789	Elizabeth	F	1967-05-05	SPOUSE

Entity Integrity

- Primary Key: A candidate key of a relation is a set of attributes that satisfy two time independent properties:
  - Uniqueness - No two tuples of the relation have the same values for the set of attributes forming the candidate key.
  - Minimality - No attributes can be discarded from the candidate key without destroying the uniqueness property.
- No component of the Primary Key of a base relation is allowed to accept nulls.

Foreign key

- A foreign key is an attribute or attribute combination of one relation R2 whose values are required to match those of the primary key of relation R1 where R1 and R2 are not necessarily distinct. Note that a foreign key and the corresponding primary key should be defined on the same domain(s).



Employee

Emp#	ename	Worksfordept
e1	red	d1
e2	blue	
e3	brown	d2

Dept

Dept	Dname
d1	Pay
d2	Tax
d3	Art

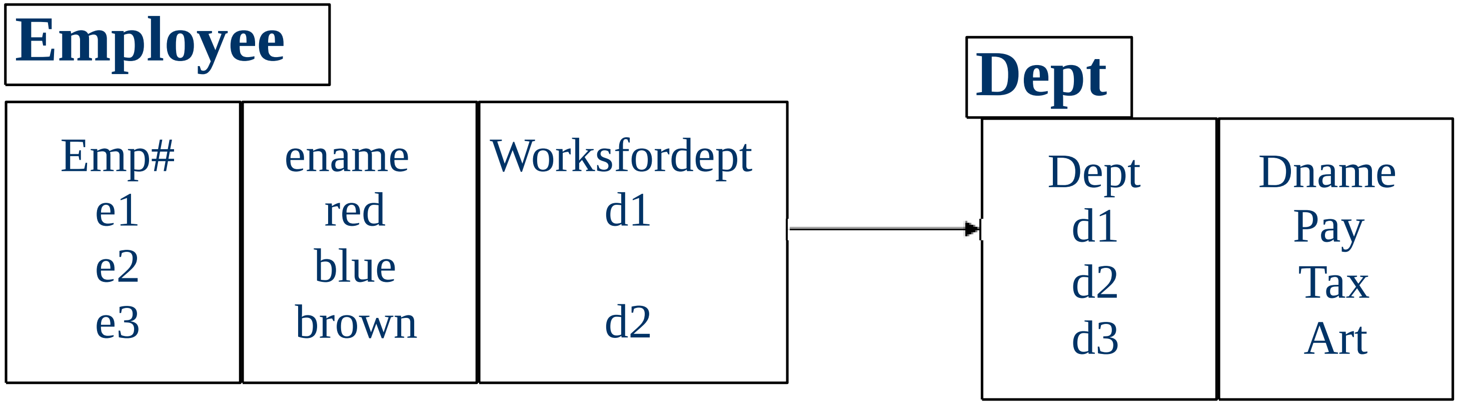
Foreign key

Referential Integrity

- If base relation R2 includes a foreign key FK matching the primary key PK of some base relation R1 then every value of FK in R2 must either
    - be equal to the value of PK in some tuple of R1, or
    - be wholly null.
- Note that PK and FK may comprise more than one attribute and that R1 and R2 are not necessarily distinct.
- *(Stated more simply a foreign key should be a valid primary key value or null.)*

Foreign Key Roles

- For each foreign key three rules need to be answered:
  - Can the foreign key accept nulls ?
  - What should happen on an attempt to delete the target of a foreign key reference?
  - What should happen on an attempt to update the target of a foreign key reference ?



Employee

Emp#	ename	Worksfordept
e1	red	d1
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e3	brown	d2

Dept

Dept	Dname
d1	Pay
d2	Tax
d3	Art