

Module 3

Relational Model

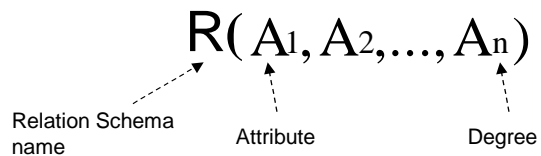
Objectives

- Learn Relational Database model
- Reference:
Elmasri & Navathe, 2nd ed., Chapter 6

Topics

- Relational Model Concepts
- Relational Model Constraints

Relation Schema



e.g.

STUDENT(name, ssn, phone, address)

R = STUDENT

A₁ = name

degree = 4

Attribute Domains

D = Domain
= Set of all possible values

dom(A_i) = domain of attribute A_i

e.g.

dom(phone) = {(ddd) ddd-dddd | d = digit 0...9}

dom(name) = { x | x is a string }

dom(age) = {x | 16 < x < 99}

Relations

R(A₁,A₂,A₃) = ACCOUNTS(Customer_Name,account_no,balance)

r(R)

ACCOUNTS

	customer_name	account_no	balance
t1	Lou	1001	1000
t2	Dan	1121	500
t3	Sue	1854	3000
t4	Lou	1234	750

tuple t2 = <Dan, 1121, 500>

t2[account_no] = 1121

t2[account_no,balance] = <1121,500>

Relations (Mathematical definition)

given schema $R(A_1, A_2, \dots, A_n)$

$r(R)$ is a relation over schema R

$r(R) \subseteq \text{dom}(A_1) \times \text{dom}(A_2) \times \dots \times \text{dom}(A_n)$

$r(R) = \{t_1, t_2, \dots, t_m\}$

$t = \langle v_1, v_2, \dots, v_n \rangle \quad v_i \in \text{dom}(A_i) \quad i=1 \dots n$

Relations are Unordered

ACCOUNTS			
	customer_name	account_no	balance
t1	Lou	1001	1000
t2	Dan	1121	500
t3	Sue	1854	3000
t4	Lou	1234	750

- $r(R)$ is a set therefore tuples (rows) are unordered
- Attributes (columns) are usually thought to be ordered
- There is a physical order when stored in actual data files but no logical order

Tuple Values

ACCOUNTS			
	customer_name	account_no	balance
t1	Lou Smith	1001	1000
t2	Dan Smith	1121	500
t3	Sue Jones	1854	3000
t4	Lou Smith	1234	750

- Tuple values are atomic
- “Lou Smith” cannot be further divided into first name and last name values
- Tuples cannot be multi-valued
- Tuples can have NULL value
- Tuples are facts about entities or relationships
- **NOTE:** both entities and relationships are modelled as relations

Relational Database

- Relational Database is a set of relations satisfying certain integrity constraints
- Relational Database Schema (S,IC)

$S = \{R_1, R_2, \dots, R_m\}$

IC = integrity constraints

- Relational Database DB

DB = $\{r_1, r_2, \dots, r_m\}$ such that r_i is instance of R_i
each r_i satisfies IC

Company Relational Database Schema

EMPLOYEE

fname	minit	lname	<u>ssn</u>	bdate	address	sex	salary	superssn	dno
-------	-------	-------	------------	-------	---------	-----	--------	----------	-----

DEPARTMENT

dname	<u>dnumber</u>	mgrssn	mgrstartdate
-------	----------------	--------	--------------

DEPT_LOCATIONS

<u>dnumber</u>	<u>dlocation</u>
----------------	------------------

PROJECT

pname	<u>pnumber</u>	plocation	dnum
-------	----------------	-----------	------

WORKS_ON

<u>essn</u>	<u>pno</u>	hours
-------------	------------	-------

DEPENDENT

<u>essn</u>	<u>dependent_name</u>	sex	bdate	relationship
-------------	-----------------------	-----	-------	--------------

Note:

Attributes referring to the same thing can have different name
(pnumber vs. pno)

Attributes referring to different things can have the same name
(name of employee or name of department)

Company Relations

EMPLOYEE

FNAME	INIT	LNAME	<u>SSN</u>	BDATE	ADDRESS	SEX	SALAR	<u>SUPERSSN</u>	DNO
John	B	Smith	123456789	9-Jan-55	731 Fondern	M	30000	333445555	5
Franklin	T	Wong	333445555	8-Dec-45	638 Voss	M	40000	888665555	5
Alicia	J	Zelaya	999887777	19-Jul-58	3321 Castle	F	25000	987987987	4
Jennifer	S	Wallace	987654321	20-Jun-31	291 Berry	F	43000	888665555	4
Ramesh	K	Narayan	666884444	15-Sep-52	975 Fire Oak	M	38000	333445555	5
Joyce	A	English	453453453	31-Jul-62	5631 Rice	F	25000	333445555	5
Ahmad	V	Jabber	987987987	29-Mar-59	980 Dallas	M	25000	987654321	4
James	E	Borg	888665555	10-Nov-27	450 Stone	M	55000	NULL	1

DEPARTMENT

DNAME	<u>DNUMBER</u>	MGRSSN	MGRSTARTDATE
Research	5	333445555	22-May-78
Administration	4	987654321	1-Jan-85
Headquarters	1	888665555	19-Jun-71

...Company Relations

DEPT_LOCATIONS

<u>DNUMBER</u>	<u>DLOCATION</u>
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WORKS_ON

<u>ESSN</u>	<u>PNO</u>	<u>HOURS</u>
123456789	1	32.50
123456789	2	7.50
666884444	3	40.00
453453453	1	20.00
453453453	2	20.00
333445555	2	10.00
333445555	3	10.00
333445555	10	10.00
333445555	20	10.00
999887777	30	30.00
999887777	10	10.00
987987987	10	35.00
987987987	30	5.00
987654321	30	20.00
987654321	20	15.00
888665555	20	NULL

...Company Relations

PROJECT

<u>PNAME</u>	<u>PNUMBER</u>	<u>PLOCATION</u>	<u>DNUM</u>
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

<u>ESSN</u>	<u>D_NAME</u>	<u>SEX</u>	<u>BDATE</u>	<u>RELATIONSHIP</u>
333445555	Alice	F	5-Apr-76	DAUGHTER
333445555	Theodore	M	25-Oct-73	SON
333445555	Joy	F	3-May-48	SPOUSE
987654321	Abner	M	29-Feb-32	SPOUSE
123456789	Michael	M	1-Jan-78	SON
123456789	Alice	F	31-Jan-78	DAUGHTER
123456789	Elizabeth	F	5-May-57	SPOUSE

Topics

- Relational Model Concepts
- Relational Model Constraints

Relational Model Constraints

- Domain Constraints
- Key Constraints
- Entity Integrity
- Referential Integrity
- Data dependencies
 - functional dependency
 - multi-valued dependency
 - discussed later in the course

Integrity Constraints

- **Integrity Constraints**
 - "Type checking for databases"
- **Intended to prevent accidental damage to the database**
- **Specified using database DDL**

Domain Constraints

- **Attribute A's value must be atomic value from $\text{dom}(A)$**
- **Typical Data Types**
 - integer
 - float
 - string
 - date
 - time
 - subrange
 - enumerated type
- **Conceptual types**
 - customer_name, branch_name, account_number
- **SQL types**
 - fixed length string, fixed point number, integer, small integer, float, date

Key Constraints

- Relation is a set of tuples, so tuples must be distinct
- $R(A_1, A_2, \dots, A_n) \quad S = \{A_1, A_2, \dots, A_n\}$

$u[S] \neq v[S]$ for any tuples u, v in $r(R)$... (1)

- Any subset of S for which (1) holds is a superkey
- A key is a minimal superkey
- Relation may have more than one key; each is called a candidate key
- A primary key is a designated key (usually underlined)

...Relation Key

CAR				
<u>licence_no</u>	serial_no	make	model	year
468 TEO	91134	Porsche	911	1975
LBU 068	76345	Nissan	Sentra	1980
2FST4U	56987	Toyota	Camry	1984
4 JOHN	66678	Toyota	Camry	1990

- Find all the
 - superkeys
 - candidate keys
 - primary key

Foreign Keys

R1= EMPLOYEE

fname	minit	lname	<u>ssn</u>	bdate	address	sex	salary	superssn	dno
-------	-------	-------	------------	-------	---------	-----	--------	----------	-----

R2 = DEPARTMENT

dname	<u>dnumber</u>	mgrssn	mgrstartdate
-------	----------------	--------	--------------

- attribute subset **FK** of **R1** is a **foreign key** of **R1** referring to **R2** if
- **FK** has the same domain as primary key **PK** of **R2**
- For tuple **t1** in **R1** either

t1[FK] = null or

t1[FK] = t2[PK] for some **t2** in **R2**

Entity Integrity

EMPLOYEE

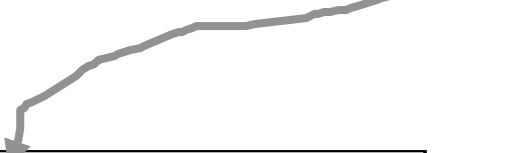
FNAME	INIT	LNAME	<u>SSN</u>	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B	Smith	123456789	9-Jan-55	731 Fondern	M	30000	333445555	5
Franklin	T	Wong	333445555	8-Dec-45	638 Voss	M	40000	888665555	5
Alicia	J	Zelaya	999887777	19-Jul-58	3321 Castle	F	25000	987987987	4
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Joyce	A	English	453453453	31-Jul-62	5631 Rice	F	25000	333445555	5
Ahmad	V	Jabber	NULL	29-Mar-59	980 Dallas	M	25000	987654321	4
James	E	Borg	NULL	10-Nov-27	450 Stone	M	55000	NULL	1

- **Entity Integrity**

-no primary key can be null

Dangling Tuples

EMPLOYEE								
FNAME	INIT	LNAME	<u>SSN</u>	BDATE	ADDRESS	SEX	SALAR	SUPERSSN DNO
John	B	Smith	123456789	9-Jan-55	731 Fondern	M	30000	333445555 5
Franklin	T	Wong	333445555	8-Dec-45	638 Voss	M	40000	888665555 5
Alicia	J	Zelaya	999887777	19-Jul-58	3321 Castle	F	25000	987987987 4
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Ahmad	V	Jabber	987987987	29-Mar-59	980 Dallas	M	25000	987654321 4
James	E	Borg	888665555	10-Nov-27	450 Stone	M	55000	NULL 1



DEPARTMENT			
DNAME	<u>DNUMBER</u>	MGRSSN	MGRSTARTDATE
Administration	4	987654321	1-Jan-85
Headquarters	1	888665555	19-Jun-71

Referential Integrity

- **Referential Integrity**

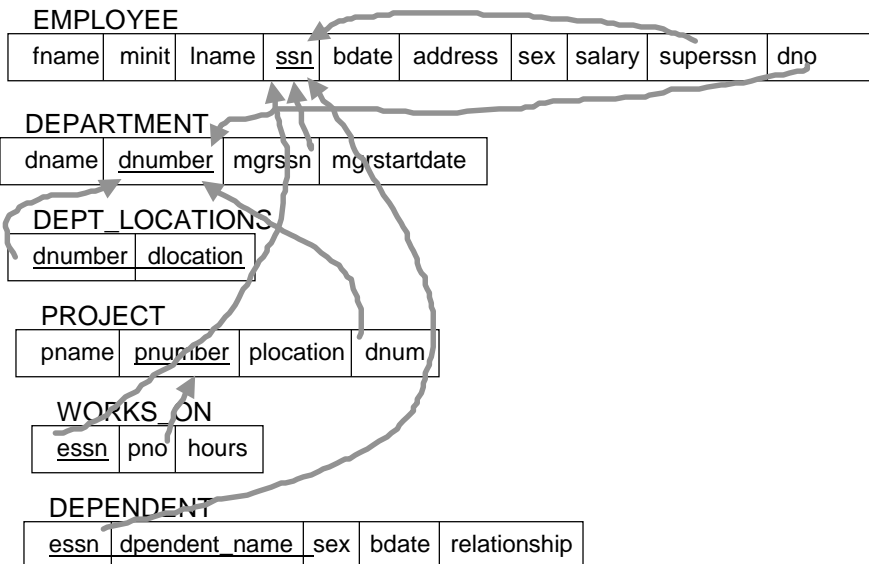
-If a tuple in one relation refers to another relation, it must refer to an existing tuple in that relation

-constrained by specifying a foreign key

-prevents “dangling tuples”

“You don’t have to have a bank account, but your bank account cannot exists without you”

Referential Constraints in Company Database



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Semantic Constraints

- “Highest paid employee cannot make more than seven times the lowest paid employee”
- “An employee cannot work more than 50 hours per week”
- These semantic constraints are not handled by relational model
- Handled by application programs accessing the data

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Defining the Relational Schema

defining the domains

```
DECLARE SCHEMA COMPANY
```

```
DECLARE DOMAIN PERSON_SSN TYPE FIXED_CHAR(9);
```

```
DECLARE DOMAIN PERSON_NAMES TYPE VARIABLE_CHAR(15);
```

```
DECLARE DOMAIN PERSON_INITIALS TYPE  
    ALPHABETIC_CHAR(1);
```

```
...
```

...Defining the Relational Schema

defining the relation schema and constraints

```
DECLARE RELATION EMPLOYEE
```

```
FOR SCHEMA COMPANY
```

```
ATTRIBUTES F_NAMES DOMAIN PERSON_NAMES;
```

```
          INIT DOMAIN PERSON_INITIALS;
```

```
          L_NAMES DOMAIN PERSON_NAMES;
```

```
...
```

```
CONSTRAINTS
```

```
    PRIMARY_KEY (SSN),
```

```
    FOREIGN_KEY (SUPERSSN) REFERENCES EMPLOYEE,
```

```
    FOREIGN_KEY (DNO) REFERENCES DEPARTMENT;
```