Database Management System – 15 (Relational Model Constraints)

Ajay James
Asst. Prof in CSE
Government Engineering College Thrissur

Outline

- Relational Integrity Constraints
- Key constraints
- Entity Integrity constraints
- Referential Integrity constraints

Relational Integrity Constraints

- Constraints are *conditions* that must hold on *all* valid relation instances
  - ***Inherent model-based constraints or implicit constraints***
  - ***Schema-based constraints or explicit constraints***
  - ***Application-based or semantic constraints or business rules***
- **Inherent model-based constraints**
  - Key constraints
  - Entity Integrity constraints
  - Referential Integrity constraints

Key Constraints

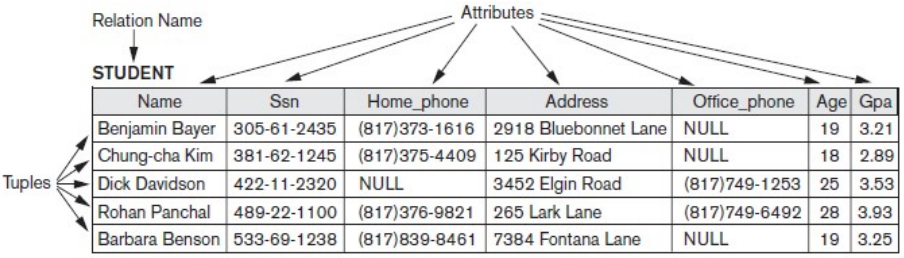
- **Superkey** of R:
  - A set of attributes SK of R such that no two tuples *in any valid relation instance r(R)* will have the same value for SK
  - For any distinct tuples t1 and t2 in r(R), t1[SK] ≠ t2[SK]
- **Key** of R:
  - A "minimal" superkey
  - A superkey K such that removal of any attribute from K results in a set of attributes that is not a superkey

  Example: CAR(State, Reg#, SerialNo, Make, Model, Year)

  has two keys Key1 = {State, Reg#}, Key2 = {SerialNo}, which are also superkeys

  {SerialNo, Make} is a superkey but *not* a key
- If a relation has *several* **candidate keys**, one is chosen arbitrarily to be the **primary key**
- Primary key attributes are *underlined*

Example



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Rohan Panchal	489-22-1100	(817)376-9821	265 Lark Lane	(817)749-6492	28	3.93
Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25

CAR

License_number	Engine_serial_number	Make	Model	Year
Texas ABC-739	A69352	Ford	Mustang	02
Florida TVP-347	B43696	Oldsmobile	Cutlass	05
New York MPO-22	X83554	Oldsmobile	Delta	01
California 432-TFY	C43742	Mercedes	190-D	99
California RSK-629	Y82935	Toyota	Camry	04
Texas RSK-629	U028365	Jaguar	XJS	04

Entity Integrity

- **Relational Database Schema**:
  - A set S of relation schemas that belong to the same database. S is the *name* of the **database**

$$S = \{R_1, R_2, ..., R_n\}$$

- **Entity Integrity**:
  - *Primary key attributes* PK of each relation schema R in S cannot have null values in any tuple of r
  - $t[PK] \neq null$ for any tuple t in r(R)
- Note: Other attributes of R may be similarly constrained to disallow null values, even though they are not members of the primary key

Example

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

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	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

Referential Integrity

- Constraint involving *two* relations
- Used to specify a *relationship* among tuples in two relations: the **referencing relation** and the **referenced relation**
- Tuples in the *referencing relation* R_1 have attributes FK (called **foreign key** attributes) that reference the primary key attributes PK of the *referenced relation* R_2
- A tuple t_1 in R_1 is said to **reference** a tuple t_2 in R_2 if $\boldsymbol{t_1[FK] = t_2[PK]}$
- Displayed in a relational database schema as a directed arc from R_1.FK to R_2. PK

Example

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
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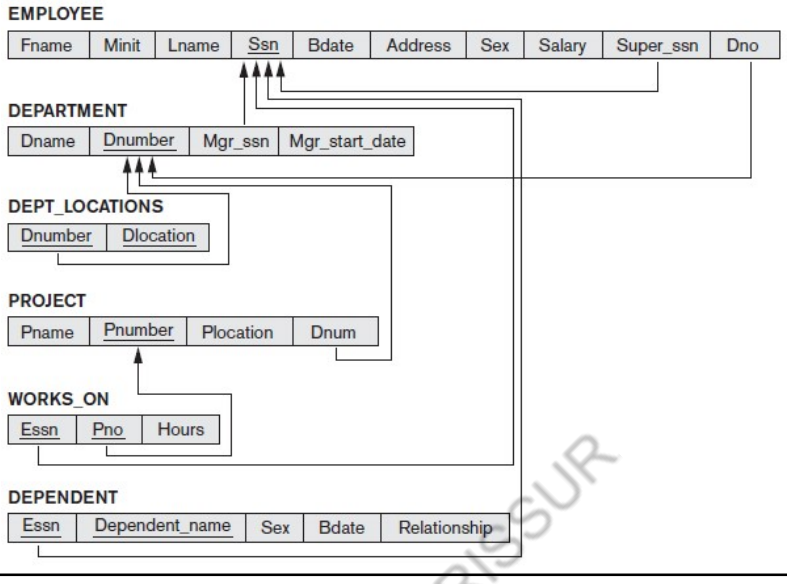
Referential Integrity Constraint

1. The attributes in FK have the same domain(s) as the primary key attributes PK of R_2; the attributes FK are said to reference or refer to the relation R_2
2. A value of FK in a tuple t_1 of the current state $r_1(R_1)$ either occurs as a value of PK for some tuple t_2 in the current state $r_2(R_2)$ or is NULL
   - In the former case, we have $t_1[FK] = t_2[PK]$
   - In case (2), the FK in R_1 should <u>not</u> be a part of its own primary key

Referential Integrity Constraint



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5	Houston

Other Types of Constraints

- Semantic Integrity Constraints:
- based on application semantics and cannot be expressed by the model
- E.g., "the max. no. of hours per employee for all projects he or she works on is 56 hrs per week"
- A *constraint specification language* may have to be used to express these

Exercise - 1

1. Consider the following relations for a database that keeps track of student enrollment in courses and the books adopted for each course:

STUDENT(Ssn, Name, Major, Bdate)
COURSE(Course#, Cname, Dept)
ENROLL(Ssn, Course#, Quarter, Grade)
BOOK_ADOPTION(Course#, Quarter, Book_isbn)
TEXT(Book_isbn, Book_title, Publisher, Author)

Specify the foreign keys for this schema, stating any assumptions you make.

Exercise - 1

2. Consider the following relations for a database that keeps track of business trips of salespersons in a sales office:

   SALESPERSON(Ssn, Name, Start_year, Dept_no)

   TRIP(Ssn, From_city, To_city, Departure_date, Return_date, Trip_id)

   EXPENSE(Trip_id, Account#, Amount)

   A trip can be charged to one or more accounts. Specify the foreign keys for this schema, stating any assumptions you make.

Reference

- Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education 6th edition and 7th edition

Thank you