

Database Systems

Lecture



Normalization





Database schema design guidelines: G1

- **Guideline 1:** Design a schema so that it's easy to explain its meaning
 - Remember: the data that you're going to save in a database represents some real world objects and concepts
 - It's very important to store it in a meaningful way, so that we can extract meaningful information out of it!
 - Keep the entities separate
 - Link the attributes to entities that they logically belong to!



Database schema design guidelines: G1

EMP_DEPT

Ename	<u>Ssn</u>	Bdate	Address	Dnumber	Dname	Dmgr_ssn
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX	5	Research	333445555
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5	Research	333445555
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4	Administration	987654321
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 FireOak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555



Database schema design guidelines: G1

Problem: Redundancy!

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Database schema design guidelines: G1

Problem: Redundancy!

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123456789	2	7.5	Smith, John B.	ProductY	Sugarland
666884444	3	40.0	Narayan, Ramesh K.	ProductZ	Houston
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333445555	2	10.0	Wong, Franklin T.	ProductY	Sugarland
333445555	3	10.0	Wong, Franklin T.	ProductZ	Houston
333445555	10	10.0	Wong, Franklin T.	Computerization	Stafford
333445555	20	10.0	Wong, Franklin T.	Reorganization	Houston
999887777	30	30.0	Zelaya, Alicia J.	Newbenefits	Stafford
999887777	10	10.0	Zelaya, Alicia J.	Computerization	Stafford
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Database schema design guidelines

■ Anomalies arising due to bad schema design:

○ Insertion anomaly # 1:

- To insert a new employee in EMP_DEPT, we will have to add all information related to his/her department (or NULL if no department has been assigned to the new employee...)
- The full information related to the department must be consistent with previous information
- This will not be a problem if the DEPT relation was kept separate from EMP!

○ Insertion anomaly # 2:

- If we need to insert a new department, we will need to insert NULL for employee, and employee SSN is a PK...
- When an employee is assigned to this new department, we won't need this tuple with NULL employee values...



Database schema design guidelines: G1

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English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555
Wallace, Jones K.	334466778	1942-10-03	567 Cave Hill, San Jose	4	Adminstratin	987654331

When we're inserting a new tuple we must make sure it is consistent with previous information!



Database schema design guidelines: G1

EMP_DEPT

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Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 FireOak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555
NULL	NULL	NULL	NULL	2	Production	NULL

Inserting a new department without an employee will be a problem...



Database schema design guidelines

- **Anomalies arising due to bad schema design:**
 - **Deletion anomaly:**
 - If we delete an employee from EMP_DEPT who is the last employee for a department, then all information for that department will also be lost...
 - This will not be a problem if the EMP and DEPT relations were separate
 - **Modification anomaly:**
 - If we need to change the value of a particular attribute for DEPT, we'll need to change this in the whole relation! There may be a consistency issue...
 - This will not be a problem if the EMP and DEPT relations were separate



Database schema design guidelines

EMP_DEPT

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Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 FireOak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555

If we change manager of Administration we must make sure it is changed across whole relation!



Database schema design guidelines

EMP_DEPT

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Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5	Research	333445555
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4	Administration	987654321
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
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Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
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If we delete this employee we also lose all information about Headquarters!



Database schema design guidelines: G2

- **Guideline 2:** Design the relations such that no insert, delete or modification anomalies are present
- Sometimes it is not possible to avoid modification anomalies
 - In such cases, using triggers or stored procedures or some other programmatic way, the automatic updates must be ensured that cause no anomalies



Database schema design guidelines: G3

- **Guideline 3:** Avoid placing attributes in relations whose values are frequently NULL
 - NULL values are waste of space and must be minimized
 - NULL values negatively affect aggregate functions, selections and joins
- One way to reduce NULL values is to move the attribute with excessive NULL values to a new relation
 - For example, if only a few employees have Office_Phone, then there is no need to put Office_Phone in main relation
 - Instead, making a new relation with two attributes Emp_SSN and Office_Phone will be a much better solution



Database schema design guidelines

EMP_LOCS

Ename	Plocation
Smith, John B.	Bellaire
Smith, John B.	Sugarland
Narayan, Ramesh K.	Houston
English, Joyce A.	Bellaire
English, Joyce A.	Sugarland
Wong, Franklin T.	Sugarland
Wong, Franklin T.	Houston
Wong, Franklin T.	Stafford
Zelaya, Alicia J.	Stafford
Jabbar, Ahmad V.	Stafford
Wallace, Jennifer S.	Stafford
Wallace, Jennifer S.	Houston
Borg, James E.	Houston

EMP_PROJ

Ssn	Pnumber	Hours	Pname	Plocation
123456789	1	32.5	ProductX	Bellaire
123456789	2	7.5	ProductY	Sugarland
666884444	3	40.0	ProductZ	Houston
453453453	1	20.0	ProductX	Bellaire
453453453	2	20.0	ProductY	Sugarland
333445555	2	10.0	ProductY	Sugarland
333445555	3	10.0	ProductZ	Houston
333445555	10	10.0	Computerization	Stafford
333445555	20	10.0	Reorganization	Houston
999887777	30	30.0	Newbenefits	Stafford
999887777	10	10.0	Computerization	Stafford
987987987	10	35.0	Computerization	Stafford
987987987	30	5.0	Newbenefits	Stafford
987654321	30	20.0	Newbenefits	Stafford
987654321	20	15.0	Reorganization	Houston
888665555	20	NULL	Reorganization	Houston

Two 'badly' designed relations



Database schema design guidelines

Joining the two relations has produced wrong tuples!

Ssn	Pnumber	Hours	Pname	Plocation	Ename
123456789	1	32.5	ProductX	Bellaire	Smith, John B.
* 123456789	1	32.5	ProductX	Bellaire	English, Joyce A.
123456789	2	7.5	ProductY	Sugarland	Smith, John B.
* 123456789	2	7.5	ProductY	Sugarland	English, Joyce A.
* 123456789	2	7.5	ProductY	Sugarland	Wong, Franklin T.
666884444	3	40.0	ProductZ	Houston	Narayan, Ramesh K.
* 666884444	3	40.0	ProductZ	Houston	Wong, Franklin T.
* 453453453	1	20.0	ProductX	Bellaire	Smith, John B.
453453453	1	20.0	ProductX	Bellaire	English, Joyce A.
* 453453453	2	20.0	ProductY	Sugarland	Smith, John B.
453453453	2	20.0	ProductY	Sugarland	English, Joyce A.
* 453453453	2	20.0	ProductY	Sugarland	Wong, Franklin T.
* 333445555	2	10.0	ProductY	Sugarland	Smith, John B.
* 333445555	2	10.0	ProductY	Sugarland	English, Joyce A.
333445555	2	10.0	ProductY	Sugarland	Wong, Franklin T.
* 333445555	3	10.0	ProductZ	Houston	Narayan, Ramesh K.



Database schema design guidelines: G4

- **Guideline 4:** Design relation schemas so that they can be joined in such a way that no spurious tuples are created
- Only possible by connecting two relations using a suitable PK, FK pair



Functional dependency

- A functional dependency (FD) is a constraint between two sets of attributes from the database
- Assume that the database has only one universal relation schema denoted by $R = \{A_1, A_2, \dots, A_n\}$
- A set of attributes $X \subset R$ functionally determines another set of attributes $Y \subset R$, or $X \rightarrow Y$, if for any two tuples t_1 and t_2 in R ,
 $t_1[X] = t_2[X]$ then we must have $t_1[Y] = t_2[Y]$
- In other words, given a value in X we can obtain a unique value for Y



Functional dependency

Determinant
attribute

Ssn → Ename

EMP_PROJ

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123456789	1	32.5	Smith, John B.	ProductX	Bellaire
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888665555	20	Null	Borg, James E.	Reorganization	Houston



Functional dependency

Determinant
attribute



Ssn → Ename



Determined
attribute

EMP_PROJ

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Functional dependency

Ssn → Ename

Does not mean
Ename → Ssn!

EMP_PROJ

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Ssn → Ename

Pnumber → Pname

Pnumber → Plocation

(Ssn, Pnumber) →
Hours

Functional dependency and keys

- A set of attributes that functionally determines all attributes is Superkey
 - {S_RegID, S_Name}
 - {S_RegID, S_Email}
 - {S_RegID, S_Email, S_Name}
 - {S_RegID, S_Email, S_Name, S_Program, S_CGPA, S_Address}
- A key is the minimal superkey
 - If we take out any attribute from a key, then that key will no longer be a superkey...
 - S_RegID and S_Email are keys, so is {S_Name, S_Address}
- If a relation has more than one key, then these are called candidate keys

Functional dependency and keys

- A prime attribute is an attribute that is part of some candidate key
 - If $\{S_Name, S_Address\}$ is a composite candidate key, then both S_Name and $S_Address$ are prime attributes
- An attribute that is not part of any candidate key is a non-prime attribute

Full functional dependency

- A functional dependency $X \rightarrow Y$ is a full functional dependency if removal of any attribute A from X means that the dependency does not hold anymore

Full functional dependency

(Ssn, Pnumber) →
Hours is a full FD

If we remove Ssn then
Pnumber alone can't
functionally determine
Hours...

And if we remove
Pnumber then Ssn
alone can't functionally
determine Hours

EMP_PROJ

<u>Ssn</u>	<u>Pnumber</u>	Hours	Ename	Pname	Plocation
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Full functional dependency

(Pnumber, Pname) →
Plocation is a partial FD

If we remove Pnumber
then Pname alone can
functionally determine
Plocation

And if we remove
Pname then Pnumber
alone can functionally
determine Plocation

EMP_PROJ

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333445555	10	10.0	Wong, Franklin T.	Computerization	Stafford
333445555	20	10.0	Wong, Franklin T.	Reorganization	Houston
999887777	30	30.0	Zelaya, Alicia J.	Newbenefits	Stafford
999887777	10	10.0	Zelaya, Alicia J.	Computerization	Stafford
987987987	10	35.0	Jabbar, Ahmad V.	Computerization	Stafford
987987987	30	5.0	Jabbar, Ahmad V.	Newbenefits	Stafford
987654321	30	20.0	Wallace, Jennifer S.	Newbenefits	Stafford
987654321	20	15.0	Wallace, Jennifer S.	Reorganization	Houston
888665555	20	Null	Borg, James E.	Reorganization	Houston



Thanks a lot

