LBSC 690: Information Technology Lecture 08 Structured data and databases

> William Webber CIS, University of Maryland

Spring semester, 2013

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Section 1

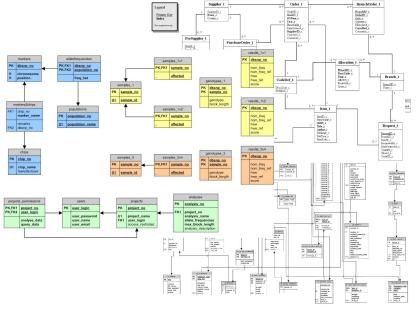
Databases



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9Pkev217.141002			9	59	Male	7	180/116	145/99		1.4.4	2.4	102	35	139	4.3	104	30
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9Space217.141			14	64	Female		160/98	142/60		144	3.4	106	29	142	4.7	108	25
9Thml217.1410			15	52	Female		150/104	104/76		142	3.3	105	24	137	4.4	106	25
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Schema



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Tables *		- Product Name -			Account Manager +		
Contacts	Datum	MacroPod, Softy	Alberts, Amy E.	Amy@datum.com	Polly, Laura Steele	Laura@Fabr	
Customers	Adventure Works	Gilow	Hanson, Mark	Mark@AdventureW.com	Sankovic, Barbara	Barbara@Fa	
	Alpine Ski House	MacroPod	Barber, David	David@alpine.com	Kharatishvili, Tengiz	Tengiz@Fab	
Issues	Baldwin Museum of Science		Holt, Holly	Holly@baldwinmofs.com	Wycoff, Pieter	Pieter@Fab	
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	Graphic Design Institute	Jetso	Oliveira, Manuel	Manuel@gdi.com	Rovik, Dag	dag@Fabrik	
Open Issues	Humongous Insurance	MacroPod	Aaling, Lene	Lene@humongousins.com	Paiha, Dominik		abrikam.com
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Systems



Section 2

Structured data

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Information without structure

Jane Doe (student id 1234-5678) is a student of LBSC 690, "Information Technology". taught by Doug Oard. Her student id is 1234-5678. Her final mark for the subject is 87.

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Information about an LBSC 690 student, presented in an "unstructured" way

Imposing structure upon information

Property	Value
Name	Jane Doe
Student id	1234-5678
Subject code	LBSC 690
Subject name	Information Technology
Mark	87
Instructor	Doug Oard

- Organize information into "property : value" pairs
- Often many choices about how to partition data into properties
- Not all data can be structured in this way
- Structure is something we impose on information

Data tables

Name	Student	Subject	Subject		
	id	code	name	Mark	Instructor
Jane Doe	1234-5678	LBSC 690	Information Technology	87	Doug Oard
John Dee	2233-4455	LBSC 690	Information Technology	75	Doug Oard
Jane Doe	1234-5678	LBSC 771	Records Management	76	Adam Adamson
John Dee	2233-4455	LBSC 601	Information Retrieval	52	Doug Oard

- Where structure is common to many entities, can be organized as a table.
 - Each row of table corresponds to an entity or record.

- Each column corresponds to a property or field.
- Each cell gives the entity's value for that field.
- These (spreadsheet-like) tables are at the heart of databases.

Typing of fields

Property	Туре	Constraint
Name Date of birth	String Date-Time	Required; Maximum 128 Characters
Student id	String	Required; Exactly 9 Characters
Subject code	String	Required; Exactly 8 Characters
Subject name	String	Maximum 64 Characters
Mark	Integer	
Instructor	String	Maximum 128 Characters

- The fields can be assigned types and constraints
- This ensures that (for instance) words are not entered into a field that should hold numbers
- It also allows us to perform type-specific operations (for instance, find the amount of time between two dates)
- Properties, types, and constraints constitute the schema of the table

Record keys and indexes

Name	* Student	* Subject	Subject		
	id	code	name	Mark	Instructor
Jane Doe	1234-5678	LBSC 690	Information Technology	87	Doug Oard
John Dee	2233-4455	LBSC 690	Information Technology	75	Doug Oard
Jane Doe	1234-5678	LBSC 771	Records Management	76	Adam Adamson
John Dee	2233-4455	LBSC 601	Information Retrieval	52	Doug Oard

- Key is a field or set of fields that uniquely identify a record
- Keys (and other fields) may be indexed to quickly look up records (matters when we have millions of records)

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Design choices and levels of granularity

				Property	Example
Property	Example	Property	Example	Given Name	Jane
Name	Jane Doe	Given Name Family Name	Jane Doe	Initials Family Name Title	J. Doe Ms.
				Nick Name	Jay

- Different levels of granularity are possible
- Generally, more granular is better, but you can go overboard
- Also, choices about representation (states as codes? names?)

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Designing a single-table database

The library director asks you to create a database to record a list of "Friends of the Library". The director wants to record:

- Name and contact information
- Age, gender, and ethnicity (optional)
- Total amount of donations

Your tasks:

- Come up with a schema (a list of typed properties) for the database
- What will be the key?
- Has the director missed any fields you think should be there?

Section 3

Relational data

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Repeated information

Name	* Student	* Subject	Subject		
	id	code	name	Mark	Instructor
Jane Doe	1234-5678	LBSC 690	Information Technology	87	Doug Oard
John Dee	2233-4455	LBSC 690	Information Technology	75	Doug Oard
Jane Doe	1234-5678	LBSC 771	Records Management	76	Adam Adamson
John Dee	2233-4455	LBSC 601	Information Retrieval	52	Doug Oard

Note that in the above database, we have repeated information about courses. This leads to several problems:

- Wastes space in the database
- Requires more data entry
- Leads to inconsistencies if information is modified

Compound entities

Field	Example value
Name	Jane Doe
Student id	1234-5678
Subject code	LBSC 690
Subject name	Information Technology
Mark	87
Instructor	Doug Oard

- The problem is that our table is really a compound of (actually more than) two distinct entities
 - Student
 - Subject
- Also, we don't separately store information about a class.
- What happens if there are no students enrolled in a class?

Decomposition

Field	Туре	Properties	
Student id Name Mark Subject	Character Character Integer ???	Primary Key	

Field	Туре	Properties
Code Name Instructor	Character Character Character	Primary Key

Table: Subject

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Table: Student

- Separate into two tables or entities
 - One for student
 - The other for subject
- But now how to mark which class a student is enrolled in?

Foreign key

Field	Туре	Properties
Student id Name Mark	Character Character Integer	Primary Key
Subject code	Character	Foreign Key \rightarrow Subject(Code)

Field	Туре	Properties
Code Name Instructor	Character Character Character	Primary Key

Table: Subject

Table: Student

- Subjects are identified by their codes (their primary key)
- We place the subject code into the Student table to say which subject the student is taking
- This is known as a foreign key

Splitting into two tables

Student					
Student	Name	Subject	Subject		
id		code	name	Mark	Instructor
1234-5678	Jane Doe	LBSC 690	Info. Tech.	87	Doug Oard
2233-4455	John Dee	LBSC 690	Info. Tech.	75	Doug Oard
1234-5678	Jane Doe	LBSC 771	Record Mgmnt	76	Adam Adamson
2233-4455	John Dee	LBSC 601	Info. Ret.	52	Doug Oard

Figure: Before

Student						I
Student	Name		Subject	Subject		
id		Mark	code	Code	Name	Instructor
1234-5678	Jane Doe	87	LBSC 690	LBSC 690	Info. Tech.	Doug Oard
2233-4455	John Dee	75	LBSC 690	LBSC 771	Record Mgmnt	Adam Adamson
1234-5678	Jane Doe	76	LBSC 771	LBSC 601	Info. Ret.	William Webber
2233-4455	John Dee	52	LBSC 601			

Figure: After

- Redundancy of subject information removed.
- Subject code acts as foreign key primay key link

Further decomposition

Field	Туре	Properties
Student id Name Mark	Character Character Integer	Primary Key
Subject code	Character	Foreign Key \rightarrow Subject(Code)

Table: Student

Field	Туре	Properties
Code	Character	Primary Key
Name	Character	
Instructor	Character	

Table: Subject

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We still have redundancy in our schema design:

- Where is it?
- Improve the design so as to remove the redundancy

Joins

Student		
Student		Subject
id	Mark	code
1234-5678	87	LBSC 690
2233-4455	75	LBSC 690
1234-5678	76	LBSC 771
2233-4455	52	LBSC 601

Table: Student

Subject		
Code	Name	Instructor
LBSC 690	Info. Tech.	Doug Oard
LBSC 771	Record Mgmnt	Adam Adamson
LBSC 601	Info. Ret.	William Webber

Table: Subject

Student JOIN Subject ON subjectcode=code

Join				
Student		Subject	Subject Name	Instructor
id	Mark	code	-	
1234-5678	87	LBSC 690	Info. Tech.	Doug Oard
2233-4455	75	LBSC 690	Info. Tech.	Doug Oard
1234-5678	76	LBSC 771	Record Mgmnt	Adam Adamson
2233-4455	52	LBSC 601	Info. Ret.	William Webber

Table: Joined student-subject table

 The JOIN operation allows us to reconstruct composite data as required on demand

Project

Student		
Student		Subject
id	Mark	code
1234-5678	87	LBSC 690
2233-4455	75	LBSC 690
1234-5678	76	LBSC 771
2233-4455	52	LBSC 601

Table: Student

SELECT studentID, subjectcode FROM Student

Projected	
Student	Subject
id	code
1234-5678	LBSC 690
2233-4455	LBSC 690
1234-5678	LBSC 771
2233-4455	LBSC 601

Table: Projected table

 The SELECT operation allows us to extract only desired columns

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Can be applied to joined tables

Restrict

Student		
Student		Subject
id	Mark	code
1234-5678	87	LBSC 690
2233-4455	75	LBSC 690
1234-5678	76	LBSC 771
2233-4455	52	LBSC 601

Table: Student

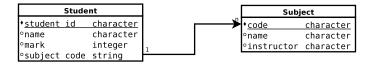
WHERE subjectcode="LBSC 690"

Student		
Student	Marili	Subject
id	Mark	code
1234-5678	87	LBSC 690
2233-4455	75	LBSC 690

Table: Student

The WHERE clause allows us to select only rows we are interested in

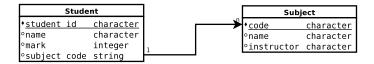
Entity-relation diagrams



- Diagram relationship between entities during design phase.
- Several standards; we're looking at a simple one.
- Each entity represented by box, with (optionally) attributes of entity listed in box.

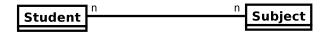
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Relationships in ERDs



- Relationships in ERDs shown by arrow
- Arrow points from entity that has reference (here, from the foreign key attribute), to entity that is referenced
- Cardinality of membership shown at connection to entity, generally either 1 or n (for "many").
 - Here, we are asserting that a student can have (be enrolled in) only one subject, but a subject can be had by (enrol) many students (a one-to-many relationship).

Further decomposition



- Previous slide we said "a student can be enrolled in only one subject"; however, this is clearly wrong.
- The correct statement is:

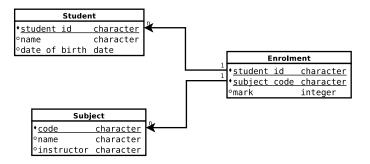
Definition (Student-subject relationship)

A student can be enrolled in many subjects; a subject can have many students enrolled in it.

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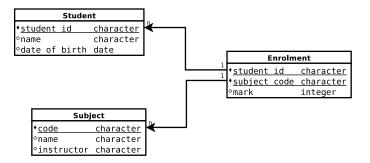
This is a many-to-many-relationship.

Many-to-many relationships



- For many-many relationships, we need a separate entity (table) recording relation.
- This separate entity also holds ancillary data that is common in such relations (here, "mark").

Further decomposition



Extend our entity-relationship diagram to encode the statement:

 Each subject has only one instructor, but an instructor can teach many subjects

Section 4

RDBMS and interfaces

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Database and RDBMS



	Set As		Filter			denge	
SampleID	Common_Name	Description	KeyHand	Digitifiand	Hand	Individual	
M9Akes217.1410.	keyboard	Akey	Left	NA.	Left	N9	
M988ey217.14103		Skey	Ambiguous	NA	Amb iqueus	M9	
M9Ckey217.1410.		Ckey	Left	NA	Left	149	
M30key217.1410	, keyboard	Dice	Left	NA.	Left	143	
M9Ekey217.1410+		Ekey	Left	NA	Left	149	
M9Enter217.1410	keyboard	Ente	Right.	NA	Right	142	
M3Fkey217.14108	5 keyboard	FARY	Left	NA	Left	M9	
M9Gkey217.1410		Ckey	Left	NA	Left	149	
M9Hkey217.1409	keyboard	Hkey	Eight.	NA	Right.	142	
M9900217.14105	6 human skin	finger.tip	NA.	Left	Left	M9	
M9indr217.14099	8 human skin	finant tip	NA	Right	Richt	149	
M943ces217.1410.	keyboard	Kkey	Elight.	NA	Right.	142	
M3M6dQ17.14104		finger.tip	NA.	Lett	Left	M9	
M9Midr217.14100		finger_tip	NA.	Right	Right	149	
M999kev217.1410	keyboard	Mkey	Right.	NA	Right.	N2	
M3Nkey217.1410		Nkey	Right	NA	Right	M9	
M90kev217.1410	keyboard	Okry	Right	NA	Right	149	
M3PH4217.14103		finate tip	NA	Left	Left	N2	
M9Pin/217.14100		finger_tip	NA.	Right	Right	M9	
M9Fkey217.14101	6 keyboard	Pixen	Right	NA	Right	142	
M9Qkev217.1410	keyboard	Chev	Left	NA	Left	M3	
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M1Rim217.14105	0 human skin	finant tip	NA	Right	Right.	142	
M35kev217.14100	4 keyboard	Shev	Left	NA	Left	M9	
M95pace217.141	keyboard	Space bar	Ambioupus	NA	Ambioupus	M9	
M9Thml217.1410	buman akin	finant tip	NA	Left	Left	142	
M9Threr212.1410	human skin	finger.tip	N.S.	Right	Richt	149	
Milvkes217.1410	keyboard	YARY	Left	NA	Left	M9	
MTW/xx217.1410	keyboard	Weev	Left	NA	Left	142	
M923/rs217.1410		Xhey	Left	NA	Left	M9	
Mittery217.14102	19 keyboard	Ykey	Right	NA	Right	M9	

- The database is the stored data and the schema that describes it
- Management of and access to the data (along with other services) is provided by the (relational) database management system (RDBMS).

Interfaces to the database

The RDBMS provides several interfaces to the database:

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Graphical user interface

Spreadsheet-like views, wizards

CLI, with specialist query language (SQL)

- Powerful search, manipulation
- Requires specialist knowledge

Programming language API

- Wraps SQL in programming constructs
- General interface for application development

RDBMS services

A fully-fledged RDBMS provides a number of other services:

- Allow database connections over network (database, application can run on different computers)
- Allow, manage multiple simultaneous database connections,
- Transaction support (allow applications to "lock" tables or rows) to block or undo conflicting updates

Desktop DBMS frequently do not offer such functionality, and may only offer a GUI interface. Easy to use, but not extensible to full application development.

Section 5

Review

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Structured data

Name	Student	Subject	Subject		
	id	code	name	Mark	Instructor
Jane Doe	1234-5678	LBSC 690	Information Technology	87	Doug Oard
John Dee	2233-4455	LBSC 690	Information Technology	75	Doug Oard
Jane Doe	1234-5678	LBSC 771	Records Management	76	Adam Adamson
John Dee	2233-4455	LBSC 601	Information Retrieval	52	Doug Oard

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- Organize information to property : value pairs
- Enforce types, constraints, indexes
- Single-table database: rows are entities, columns attributes
- Level of granularity

Relational data

Field	Туре	Properties
Student id Name Mark	Character Character Integer	Primary Key
Subject code	Character	Foreign Key \rightarrow Sub- ject(Code)

Table: Student

Field	Туре	Properties
Code Name Instructor	Character Character Character	Primary Key

Table: Subject

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- Decompose compound entities to avoid redundancy
- Use of foreign keys primary key link to connect records
- Join, project, restrict operations

ER diagrams, database systems



- ER diagrams: graphical representation of schema
- DB systems provide:
 - various interfaces to database (graphical, command-line, programmatic)

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 additional services (concurrent access, integrity maintenance)

Feedback

On a piece of paper, write (without names): What was the muddlest point in today's class?

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