Carnegie Mellon Univ.
Dept. of Computer Science
15-415/615 - DB Applications

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Lecture#2: E-R diagrams

Problem

- Develop an application for U.G. admin:
  - Student info
  - Who-takes-what class
  - Class rosters
  - Transcripts
- How do you proceed?
  - (Which role(s) are you playing?)

Database Design

- Requirements Analysis
- Conceptual Design
- Logical Design
- Schema Refinement
- Physical Design
- Security Design

✔ Requirements Analysis
  • Conceptual Design
  • Logical Design
  • Schema Refinement
  • Physical Design
  • Security Design

user’s needs
high level (ER)
Tables
Normalization
Indices etc
Access controls
Problem’

Maintain

- Develop an application for U.G. admin:
  - Student info
  - Who-takes-what class
  - Class rosters
  - Transcripts
- If you are the *new* DBA, what would you rather inherit:

This or this?

drop table if exists student;
cREATE TABLE student
  (ssn fixed,
  name char(20));
drop table if exists takes;
cREATE TABLE takes
  (ssn fixed,
  cid char(10),
  grade fixed);

True story

- Health insurance company
- Wants to catch (some of the abundant) fraud
- Schema:
  - patients, visit doctors, get medicine,
  - Doctors perform operations, …
  - Nurses monitor patients, …
  - etc etc
- Q: How many tables do you think it spans?

True story

- Schema:
  - patients, visit doctors, get medicine,
  - Doctors perform operations, …
  - Nurses monitor patients, …
  - etc etc
- Q: How many tables do you think it spans? 10? 20? 30?
True story

• Schema:
  – patients, visit doctors, get medicine,
  – Doctors perform operations, …
  – Nurses monitor patients, …
  – etc etc
• Q: How many tables do you think it spans? 10? × 30?
• A: 120 PAGES of schema

Motivation & upcoming conclusion:

• E-R diagrams are excellent documentation tools

Overview

• concepts
  – Entities
  – Relationships
  – Attributes
  – Specialization/Generalization
  – Aggregation
  – ER modeling questions

Tools

Entities (‘entity sets’)  

Relationships (‘rel. sets’)  

and mapping constraints

attributes
Example

Students, taking courses, offered by instructors; a course may have multiple sections; one instructor per section

nouns -> entity sets
verbs -> relationship sets

Example

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Example

Students, taking courses, offered by instructors; a course may have multiple sections; one instructor per section

nouns -> entity sets
verbs -> relationship sets
but: sections of course (with different instructors)?

Q: how to record that students take courses?

but: s-id is not unique... (see later)
**Cardinalities**

- 1 to 1 (example?)
- 1 to N
- N to M

**Cardinalities**

- COUNTRY → has → CAPITAL
- PERSON → owns → CAR
- STUDENT → takes → SECTION
Cardinalities

Book’s notation:
- COUNTRY → has → CAPITAL
- PERSON → owns → CAR
- STUDENT → takes → SECTION

Book’s notation vs 1 to N notation

‘Total/partial’ participation
- total, total
- ??
- ??
‘Total/partial’ participation

- total, total
  - COUNTRY 1:1 has 1:1 CAPITAL

- partial, total
  - PERSON 1:1 owns 0:N CAR
  - STUDENT ?:N takes 2:M SECTION

Is it ‘legal’?

- partial, total
  - PERSON 1:1 owns 0:N CAR

- partial, total
  - STUDENT 1:N takes 0:M SECTION

NO! why not?
Subtle concept: Weak entities

- ‘section’ has no unique-id of its own!(?)

Weak entities

- ‘weak’ entities: if they need to borrow a unique id from a ‘strong entity - thick box.
- ‘c-id’ + ‘s-id’: unique id for SECTION
- partial key (eg., ‘s-id’) - dashed-underline
- identifying relationship (eg., ‘has’)

Weak entities

- Other example(s) of weak entities?

Other example(s) of weak entities?
More details

• self-relationships - example?

More details

• self-relationships - example?

More details

• self-relationships - example?

More details

• 3-way and k-way relationships?
More details

- 3-way and k-way relationships? Rare, but possible:

```
EMPLOYEE   N  M   TOOL
\   \   \    \  
uses   \    \  
\     \  
PROJECT P
```

Other cases?

```
??   N  M   ??
??   \    \  
??   \     \  
P
```

App-store/amazon reviews

```
user   N  M   keyword
\   \   \    \  
reviews   \    \  
\     \  
app P
```

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More details - attributes

- **key** (or **primary key**): unique identifier
- **underlined**, in the ER diagram
- Not in textbook - FYI:
  - **multivalued** or set-valued attributes (eg., ’dependents’ for EMPLOYEE)
  - **derived** attributes (eg., 15% tip)

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Basic

Advanced/ rare

Specialization

- eg., students: part time (#credit-hours) and full time (major)

Observations

- Generalization: exact reverse of ‚specialization’
- attribute inheritance
- could have **many** levels of an IS-A hierarchy
More details

• Overlap constraints

• Covering constraints

More details

• Overlap constraints
  – can an entity belong to both ‘B’ and ‘C’?

• Covering constraints
  – can an ‘A’ entity belong to neither ‘B’ nor ‘C’?

More details

• Overlap constraints - examples?

No overlap

with overlap

More details

• Covering constraints - examples?

Total coverage

Partial coverage
Overview

- concepts
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Aggregation

- computer model (w/ CPU and HD)
- and Maker (eg., Dell, HP)

- treat a relationship as an entity
- used to express a relationship among relationships

Overview

- concepts
  - Entities
  - Relationships
  - Attributes
  - Specialization/Generalization
  - Aggregation
  - ER modeling questions
Conceptual design

• Entity vs attribute
• Entity vs relationship
• Binary or ternary relationships?
• Aggregation?

Entity vs. attribute

• Entity EMPLOYEE (w/ emp#, name, job_code, ...)
• Q: How about ‘spouse’ - entity or attribute?
• Q: How about ‘dependents’?

Entity vs. attribute

• Entity EMPLOYEE (w/ emp#, name, job_code, ...)
• Q: How about ‘spouse’ - entity or attribute?
• A: probably, ‘attribute’ is enough
• Q: How about ‘dependents’?
• A: Entity - we may have many dependents

Entity vs. Relationship

\[
\text{STUDENT} \hspace{1cm} \text{TAKES} \hspace{1cm} \text{SECTION}
\]

\[
\begin{align*}
\text{STUDENT} & \rightarrow \text{N} \\
\text{TAKES} & \rightarrow \text{M} \\
\text{SECTION} & \rightarrow \text{N}
\end{align*}
\]

OR

\[
\begin{align*}
\text{STUDENT} & \rightarrow \text{1} \\
\text{TAKES} & \rightarrow \text{N} \\
\text{SECTION} & \rightarrow \text{1}
\end{align*}
\]
Binary vs Ternary Relationships

• usually, binary relationships are ‘cleaner’:

If each policy is owned by just 1 employee:

Bad design

Key constraint on Policies would mean policy can only cover 1 dependent!
Binary vs. Ternary Relationships

If each policy is owned by just 1 employee:

- Key constraint on Policies would mean policy can only cover 1 dependent!
- What are the additional constraints in the 2nd diagram?

Better design

- But sometimes ternary rel. can not be replaced by a set of binary rel’s:

- What are the additional constraints in the 2nd diagram?

Better design

Suppliers

Parts

Contract

Departments

• S “can-supply” P, D “needs” P, and D “deals-with” S does not imply that D has agreed to buy P from S.

• How do we record qty?

why is it bad?
Binary vs. Ternary Relationships (Contd.)

Not in textbook: in practice, often:

```
Supplier — qty — Parts — Contract — Departments
```

Binary vs. Ternary Relationships (Contd.)

Not in textbook: in practice, often:

```
Supplier — qty — Parts — Contract — Departments
```

Ternary vs. aggregation

- use aggregation, if we want to attach a relationship to a relationship
- (see book for example)
- (in practice, again we create a unique-id and resort to binary relationships)
Ternary vs. aggregation

• How would you handle this case?

Ternary vs. aggregation

• How would you handle this case?
Summary

• E-R Diagrams: a powerful, user-friendly tool for data modeling:
  – Entities (strong, weak)
  – Attributes (primary keys, discriminators, derived, multivalued)
  – Relationships (1:1, 1:N, N:M; multi-way)
  – Generalization/Specialization; Aggregation

Summary - cont’d

<table>
<thead>
<tr>
<th>(strong) entity set</th>
<th>attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>weak entity set</td>
<td></td>
</tr>
<tr>
<td>relationship set</td>
<td>primary key</td>
</tr>
<tr>
<td>identifying rel. set for weak entity</td>
<td>partial key</td>
</tr>
</tbody>
</table>

cardinalities

N \rightarrow M

1:h \rightarrow 1':h'

(cardinalities with limits)

(not in textbook - FYI)
Summary - cont’d

IS-A

aggregation