

# Multivalued Dependencies

Designing Schemas

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Kevin C.C. Chang, Professor  
Computer Science @ Illinois

# Learning Objectives

By the end of this video, you will be able to:

- Define multi-valued dependencies.
- Describe why MVD may cause redundancies.
- Explain why FD is a special case of MVD.

# More Than Functional Dependencies

- There are other kinds of dependencies than FDs.
  - Multivalued dependencies (MVD)
  - Inclusion dependencies (IND)
  - Join dependencies (JD)
- We will take a look at MVD.
  - So you can say you know about (multiple kinds of) dependencies!

# Consider Our Academic World

- We know that id determines birthday,  
 $\text{id} \rightarrow \text{birthday}$ .
- But, doesn't id also determine majors?
  - Donald Duck? Majors = {Bio}.
  - Bugs Bunny? Majors = {CS, Music}.

id	name	major	birthday
1	Bugs Bunny	CS	2004-11-06
1	Bugs Bunny	Music	2004-11-06
2	Donald Duck	Bio	1997-02-01
3	Peter Pan	Econ	1998-10-01
3	Peter Pan	Social	1998-10-01
3	Peter Pan	ME	1998-10-01
4	Mickey Mouse	CS	1995-04-01

Example Students relation

- So, id determines major – as **a set of** majors instead of a unique value.
- We call this determination a multivalued dependency:  
 $\text{id} \twoheadrightarrow \text{major}$ .

# MVD Is “Tuple Generating”

- Students(id, name, major, gpa, hobby, level)
- Suppose  $\text{id} \twoheadrightarrow \text{major, gpa}$ : Do you think this table is “complete”?

id	name	major	gpa	hobby	level
1	Bugs Bunny	CS	3.0	Tennis	Beginner
1	Bugs Bunny	Music	3.5	Tennis	Beginner
1	Bugs Bunny	CS	3.0	Chess	Advanced
2	Donald Duck	Bio	3.2	Basketball	Intermediate
3	Peter Pan	Econ	2.8	Piano	Beginner
3	Peter Pan	Social	3.0	Reading	Advanced
3	Peter Pan	ME	3.6	Swimming	Advanced
...	...	...	...	...	...

Example Students relation

# Multivalued Dependency (MVD)

- Notation:  $A_1, \dots, A_m \twoheadrightarrow B_1, \dots, B_n$
- We say:  $A_1, \dots, A_m$  **multidetermines**  $B_1, \dots, B_n$
- Meaning:
  - If two tuples agree on  $A_1, \dots, A_m$  values, then swapping their  $B_1, \dots, B_n$  values will result in two tuples that are also in the relation.
  - I.e.,  $B$  depends only on  $A$ , and is independent of the remaining attributes.

- Ex:  $\text{id} \twoheadrightarrow \text{major, gpa}$

id	name	major	gpa	hobby	level
1	Bugs Bunny	CS	3.0	Tennis	Beginner
1	Bugs Bunny	Music	3.5	Tennis	Beginner
1	Bugs Bunny	CS	3.0	Chess	Advanced
1	Bugs Bunny	Music	3.5	Chess	Advanced
2	Donald Duck	Bio	3.2	Basketball	Intermediate
3	Peter Pan	Econ	2.8	Piano	Beginner
3	Peter Pan	Social	3.0	Reading	Advanced
3	Peter Pan	ME	3.6	Swimming	Advanced
...	...	...	...	...	...

Example Students relation

# FD: Special Case of MVD

- FD is a special case of MVD.
- $\text{id} \rightarrow \text{birthday} \implies \text{id} \twoheadrightarrow \text{birthday}$

id	name	major	birthday
1	Bugs Bunny	CS	2004-11-06
1	Bugs Bunny	Music	2004-11-06
2	Donald Duck	Bio	1997-02-01
3	Peter Pan	Econ	1998-10-01
3	Peter Pan	Social	1998-10-01
3	Peter Pan	ME	1998-10-01
4	Mickey Mouse	CS	1995-04-01

Example Students relation

# FD/MVD Are Domain Knowledge

- What FDs/MVDs hold is your **knowledge** of the domain.
- $\text{id} \rightarrow \text{birthday?}$   $\text{id} \twoheadrightarrow \text{birthday?}$
- $\text{id} \rightarrow \text{major?}$   $\text{id} \twoheadrightarrow \text{major?}$
- $\text{age} \rightarrow \text{major?}$   $\text{age} \twoheadrightarrow \text{major?}$



*How do you suggest to normalize the problematic Students relation to eliminate MVDs?*

*Yes, you probably have (re-)invented 4NF!*

## Fourth normal form

Fourth normal form is a normal form used in database normalization. Introduced by Ronald Fagin in 1977, 4NF is the next level of normalization after Boyce–Codd normal form. [Wikipedia](#)

**Abbreviation:** 4NF

**Developed by:** [Ronald Fagin](#)

**Year introduced:** 1977

Google search result of 4NF

You need a magnifier to view it  
(Pixabay, 2017)



id	name	major	gpa	hobby	level
1	Blah Blah	CS	3.2	Chess	Beginner
1	Blah Blah	Math	3.2	Chess	Beginner
1	Blah Blah	CS	3.2	Chess	Advanced
2	Blah Blah	Math	3.2	Chess	Advanced
2	Blah Blah	Math	3.2	Basketball	Intermediate
3	Blah Blah	CS	3.2	Chess	Beginner
3	Blah Blah	Math	3.2	Chess	Advanced
3	Blah Blah	Math	3.2	Sports	Advanced

id	name	major	gpa
1	Blah Blah	CS	3.2
2	Blah Blah	Math	3.2
3	Blah Blah	Math	3.2

id	hobby	level
1	Chess	Beginner
2	Chess	Advanced
3	Chess	Advanced
4	Basketball	Intermediate
5	Chess	Beginner
6	Chess	Advanced
7	Sports	Advanced

id	major	gpa
1	CS	3.2
2	Math	3.2
3	Math	3.2

Sample answer for this FoT

# References

- Pixabay, 2017. *Image of a magnifier*[Online image]. Retrieved from <https://pixabay.com/en/inspector-man-detective-male-160143/>.