L15: Normalization

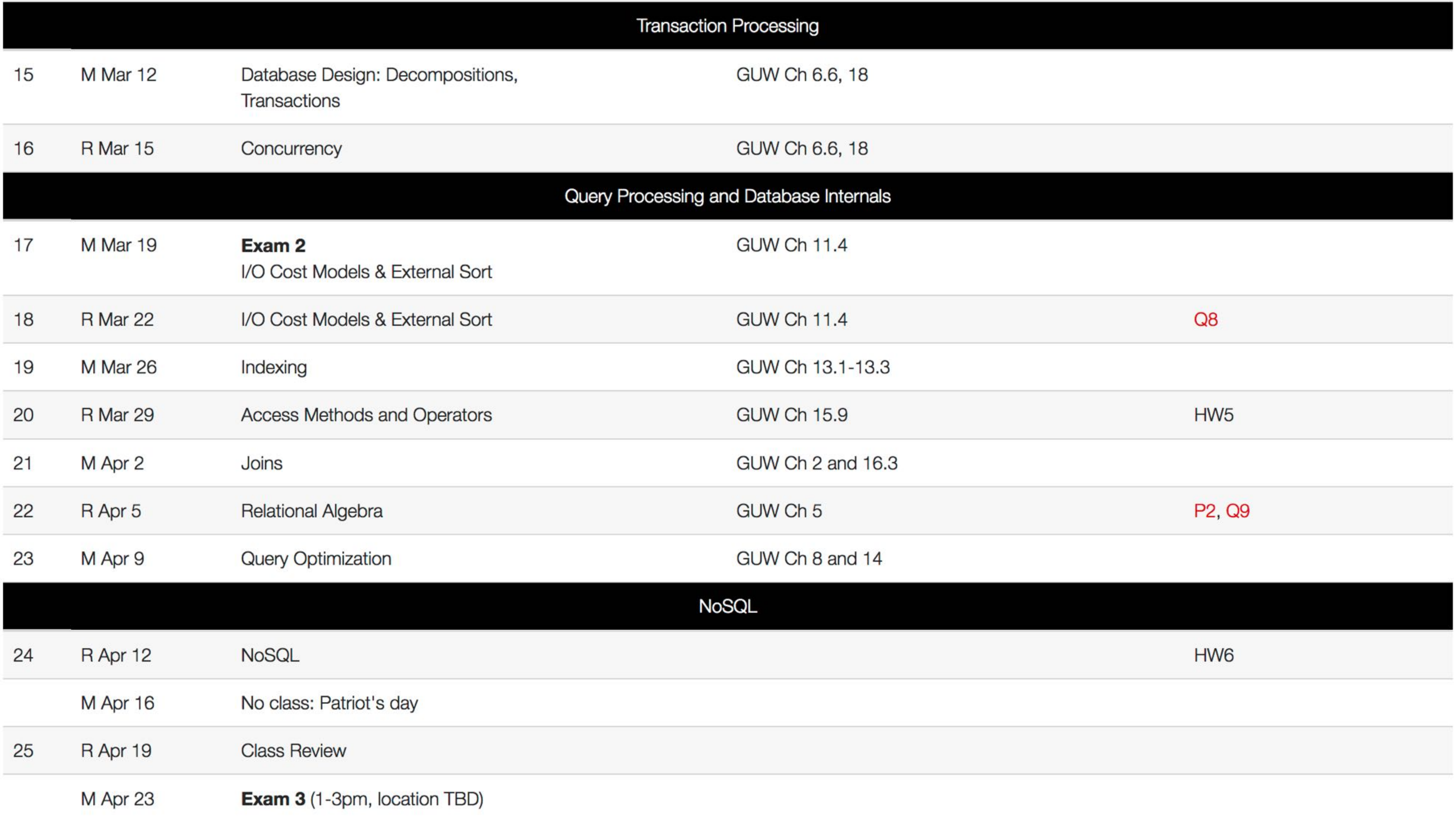
CS3200 Database design (sp18 s2)

https://course.ccs.neu.edu/cs3200sp18s2/

3/12/2018

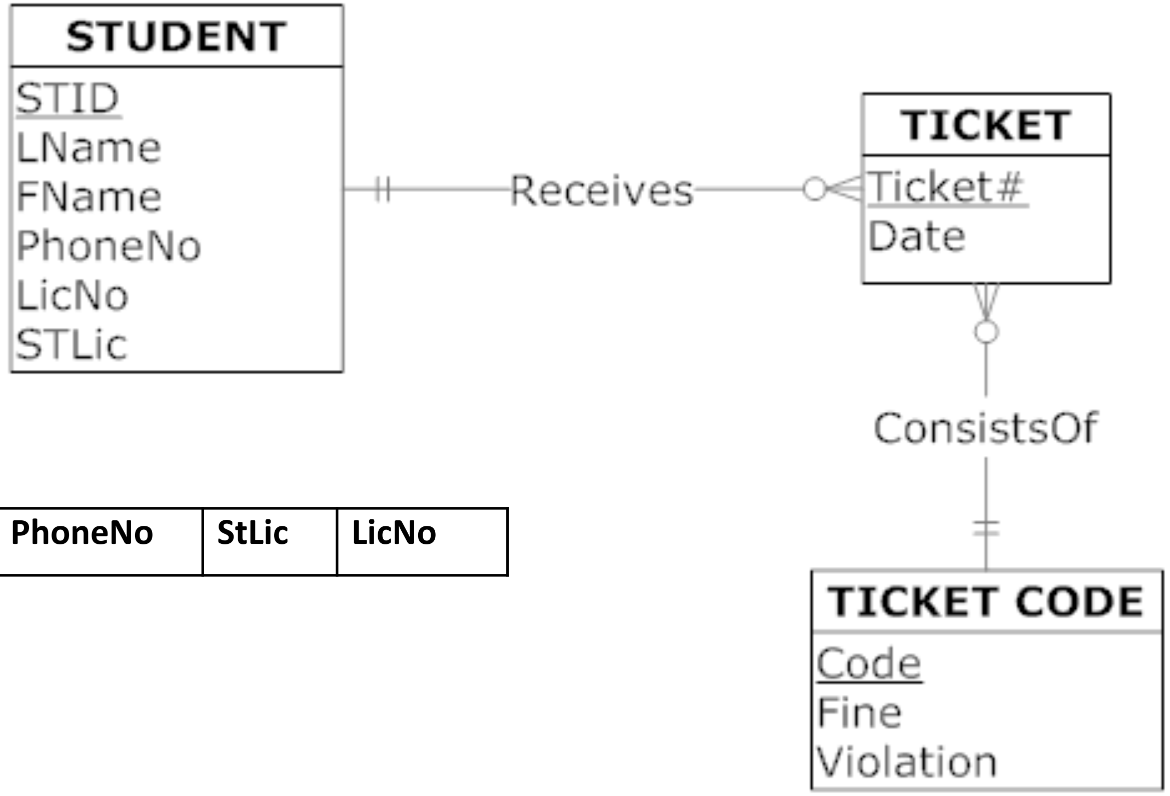
Announcements!

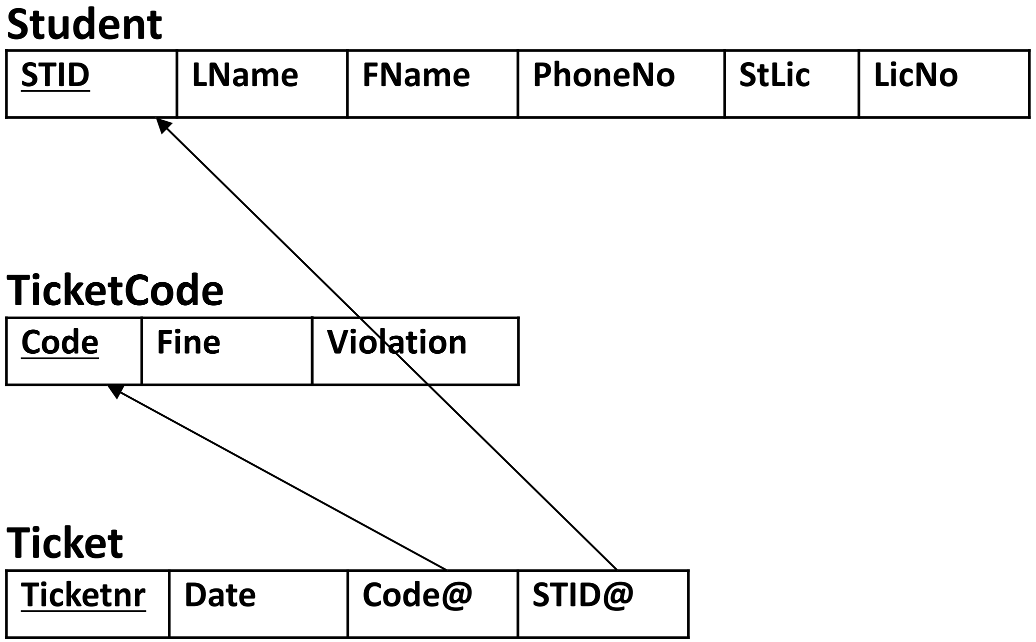
- Keep bringing your name plates ☺
- Verify your grades and feedback on BB. If something is unclear or confusing, or displays incorrectly, please let us know (e.g., via Piazza instructors only)
- P2 is posted and updated calendar
- Exam2 next week: content is everything seen until this Thursday: setup like for Exam1: laptop SQL + paper database design + paper transactions
- Outline today
  - HW4, Projects
  - Decompositions
  - Transactions!



Transaction Processing				
15	M Mar 12	Database Design: Decompositions, Transactions	GUW Ch 6.6, 18	
16	R Mar 15	Concurrency	GUW Ch 6.6, 18	
Query Processing and Database Internals				
17	M Mar 19	**Exam 2** I/O Cost Models & External Sort	GUW Ch 11.4	
18	R Mar 22	I/O Cost Models & External Sort	GUW Ch 11.4	Q8
19	M Mar 26	Indexing	GUW Ch 13.1-13.3	
20	R Mar 29	Access Methods and Operators	GUW Ch 15.9	HW5
21	M Apr 2	Joins	GUW Ch 2 and 16.3	
22	R Apr 5	Relational Algebra	GUW Ch 5	P2, Q9
23	M Apr 9	Query Optimization	GUW Ch 8 and 14	
NoSQL				
24	R Apr 12	NoSQL		HW6
	M Apr 16	No class: Patriot's day		
25	R Apr 19	Class Review		
	M Apr 23	**Exam 3** (1-3pm, location TBD)		

Ryan's question: Parking Tickets: ER Diagram





Student

STID	LName	FName	PhoneNo	StLic	LicNo

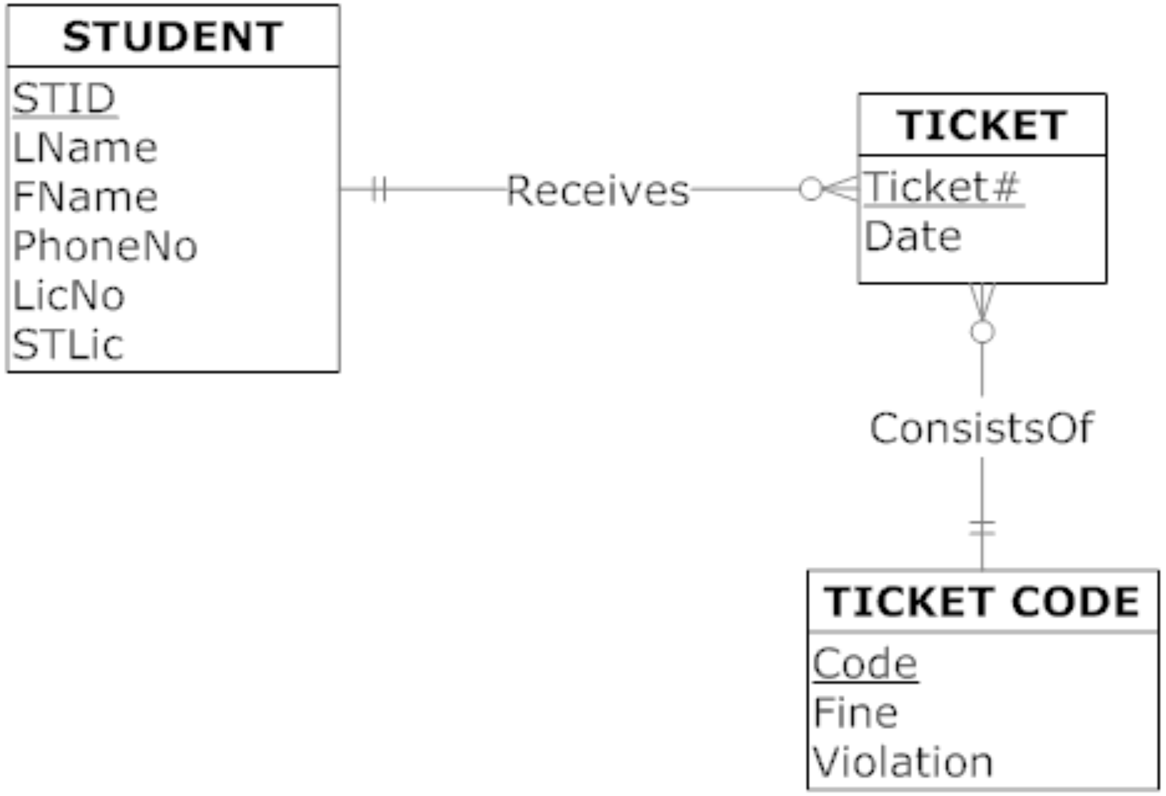
TicketCode

Code	Fine	Violation

Ticket

Ticketnr	Date	Code@	STID@

Ryan's question: Parking Tickets: ER Diagram



STUDENT

STID
LName
FName
PhoneNo
LicNo
STLic

Receives

TICKET

Ticket#
Date

ConsistsOf

TICKET CODE

Code
Fine
Violation

Decompositions

Recap: Decompose to remove redundancies

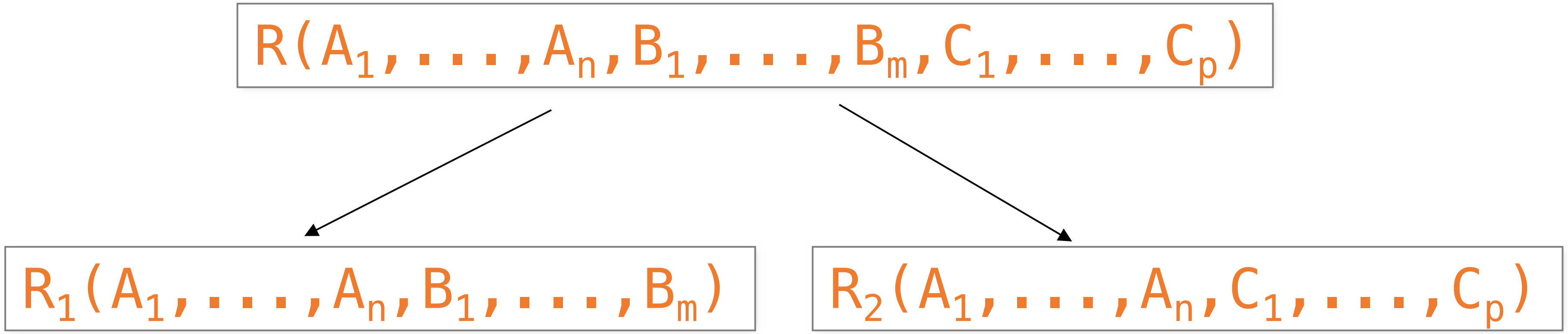
- We saw that redundancies in the data (“bad FDs”) can lead to data anomalies

- We developed mechanisms to detect and remove redundancies by decomposing tables into 3NF or BCNF
  - BCNF decomposition is standard practice- very powerful & widely used!

- However, sometimes decompositions can lead to more subtle unwanted effects…

When does this happen?

Decompositions in General



$R(A_1,\ldots,A_n,B_1,\ldots,B_m,C_1,\ldots,C_p)$

$R_1(A_1,\ldots,A_n,B_1,\ldots,B_m)$

$R_2(A_1,\ldots,A_n,C_1,\ldots,C_p)$

R_1 = the *projection* of R on $A_1, \ldots, A_n, B_1, \ldots, B_m$

R_2 = the *projection* of R on $A_1, \ldots, A_n, C_1, \ldots, C_p$

Theory of Decomposition

Name	Price	Category
Gizmo	19.99	Gadget
OneClick	24.99	Camera
Gizmo	19.99	Camera

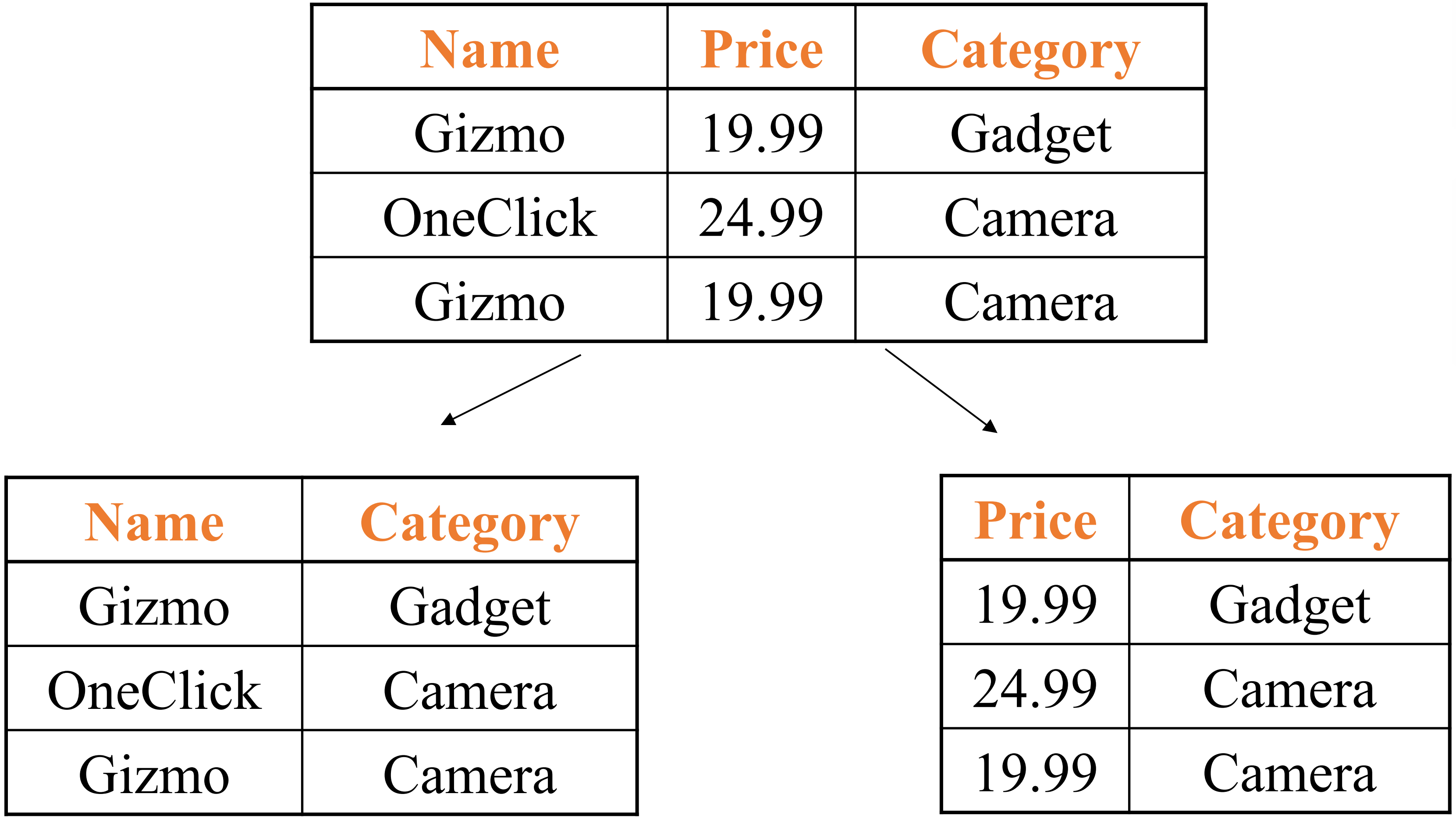
Name	Price
Gizmo	19.99
OneClick	24.99
~~Gizmo~~	~~19.99~~

Name	Category
Gizmo	Gadget
OneClick	Camera
Gizmo	Camera

Sometimes a decomposition is "correct"

I.e. it is a <u>**Lossless decomposition**</u>

Lossy Decomposition



Name	Price	Category
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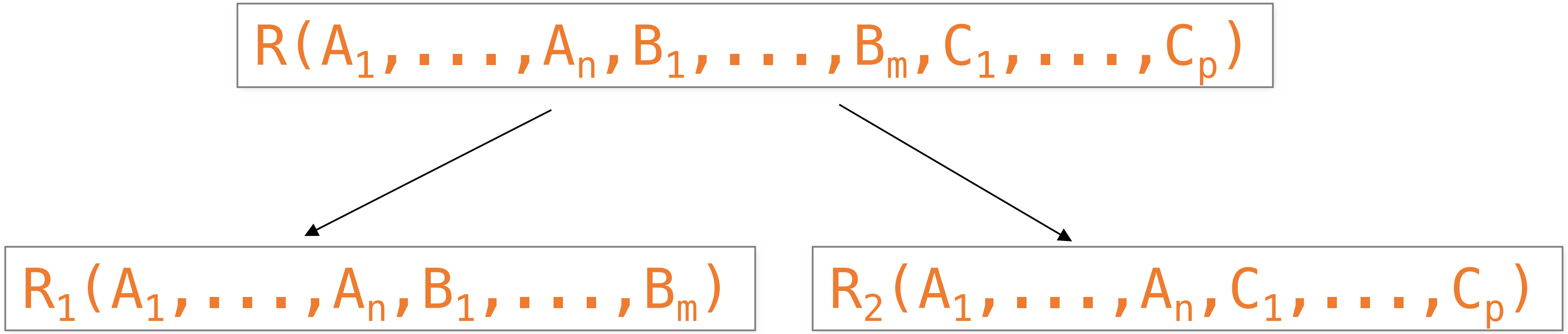
Name	Category
Gizmo	Gadget
OneClick	Camera
Gizmo	Camera

Price	Category
19.99	Gadget
24.99	Camera
19.99	Camera

However sometimes it isn’t

What’s wrong here?

Lossless Decompositions



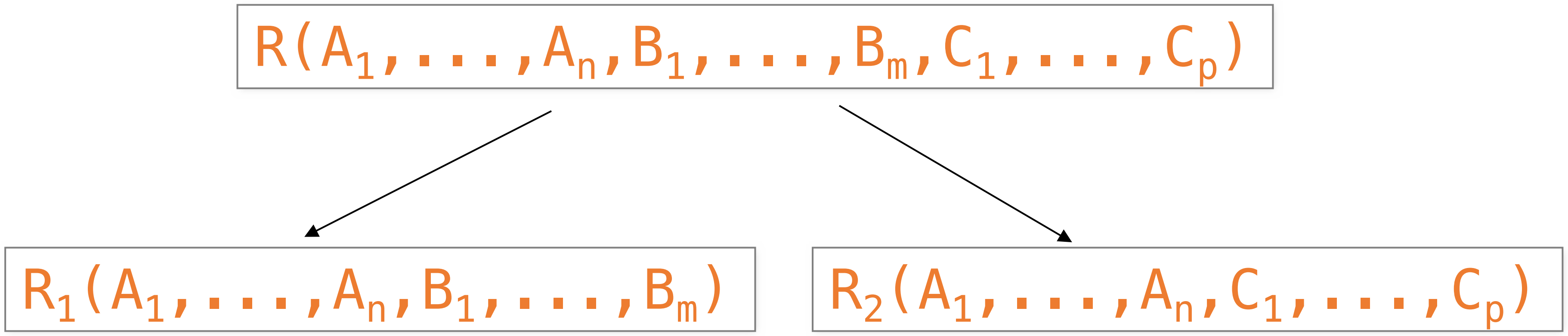
$R(A_1,\ldots,A_n,B_1,\ldots,B_m,C_1,\ldots,C_p)$

$R_1(A_1,\ldots,A_n,B_1,\ldots,B_m)$

$R_2(A_1,\ldots,A_n,C_1,\ldots,C_p)$

A decomposition R to (R1, R2) is **lossless** if R = R1 Join R2

Lossless Decompositions



$R(A_1,....,A_n,B_1,....,B_m,C_1,....,C_p)$

$R_1(A_1,....,A_n,B_1,....,B_m)$

$R_2(A_1,....,A_n,C_1,....,C_p)$

If $\{A_1, \ldots, A_n\} \rightarrow \{B_1, \ldots, B_m\}$
Then the decomposition is lossless

Note: don't need
$\{A_1, \ldots, A_n\} \rightarrow \{C_1, \ldots, C_p\}$

BCNF decomposition is always lossless. Why?

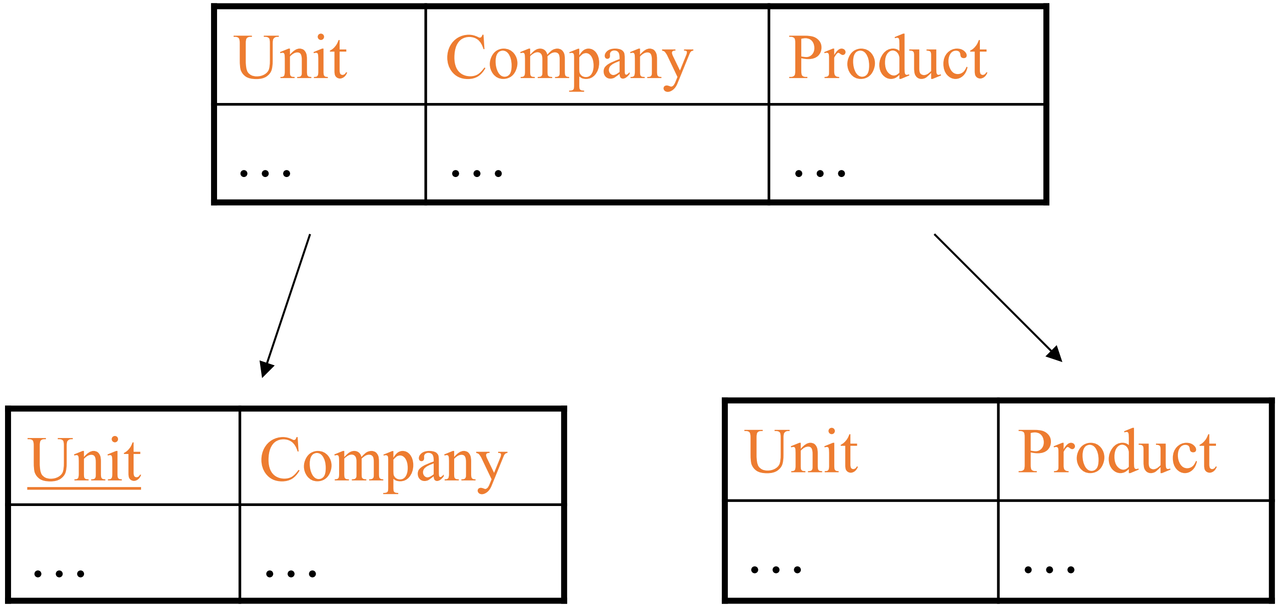
A problem with BCNF

Problem: To enforce a FD, must reconstruct original relation—*on each insert!*

Note: This is historically inaccurate, but it makes it easier to explain

A Problem with BCNF

{Unit} → {Company}
{Company,Product} → {Unit}



Unit	Company	Product
…	…	…

Unit	Company
…	…

Unit	Product
…	…

{Unit} → {Company}

We do a BCNF decomposition on a “bad” FD:
$\{\texttt{Unit}\}^{+} = \{\texttt{Unit, Company}\}$

We lose the FD {Company,Product} → {Unit}!!

So Why is that a Problem?

{Unit} → {Company}
{Company,Product} → {Unit}

Unit	Company
Galaga99	NEU
Bingo	NEU

Unit	Product
Galaga99	Databases
Bingo	Databases

No problem so far. All *local* FD's are satisfied.

{Unit} → {Company}

Unit	Company	Product
Galaga99	NEU	Databases
Bingo	NEU	Databases

Let's put all the data back into a single table again:

Violates the FD {Company,Product} → {Unit}!!

The Problem

- We started with a table R and FDs F
- We decomposed R into BCNF tables R1, R2, …
  with their own FDs F1, F2, …
- We insert some tuples into each of the relations—which satisfy their local FDs but when reconstruct it violates some FD across tables!

Practical Problem: To enforce FD, must reconstruct R—*on each insert!*

Possible Solutions

- Various ways to handle so that decompositions are all lossless / no FDs lost
  - For example 3NF: stop short of full BCNF decompositions.

- Usually a tradeoff between redundancy / data anomalies and FD preservation…

BCNF still most common- with additional steps to keep track of lost FDs…

4NF and higher

3NF Motivation

A relation R is in 3rd normal form if :
Whenever there is a nontrivial dep. $A_1, A_2, ..., A_n \rightarrow B$ for R,
then $\{A_1, A_2, ..., A_n\}$ is a super-key for R,
or B is part of a key.

Tradeoffs:

BCNF: no anomalies, but may lose some FDs

3NF: keeps all FDs, but may have some anomalies

Motivation of 4NF and higher

Assume for each course, we can independently choose a lecturer and a book. What is the problem?

Classes

Course	Lecturer	Book
cse444	Alexandra	Complete book
cse444	Wolfgang	Complete book
cse444	Alexandra	Cow book

cse444	Wolfgang	Cow book

Multi-valued dependency (MVD) Course →→ Lecturer:

In every legal instance, each Course value is associated with a set of Lecturer values and this set is independent of the values in the other attributes (here Book).