[544] SQL Databases (MySQL)

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Learning Objectives

- create database schemas with types and keys
- use database transactions to group multiple updates together
- write SQL queries with common clauses (SELECT, FROM, JOIN, WHERE, GROUP BY, HAVING, ORDER BY, and LIMIT) to answer questions about data

Creating/designing tables

- data modeling
- primary/foreign keys

Transactions

Queries

Data Modeling

Data modeling: deciding how to represent something in an underlying system.

Low-level example (protobufs): how will we represent numbers as bytes being sent over a network?

Traditional Databases: how will we represent things/people/events/etc as rows in tables?

tbl_orders

option I:

	book	amount	county	state
Tyler Harter	Designing Data-	72	Dane	۱۸/۱
	Intensive Applications	23	Dane	VVI
Tyler Harter	Learning Spark		Dane	WI
Tyler Harter	Cassandra: The	39	Dane	WI
	Definitive Guide	39	Dane	VVI

Keys and Normalization

SQL keys:

- primary key: uniquely identify a row ("id" in tbl_counties)
- foreign key: reference a primary key ("county_id" in tbl_orders)

In database theory we would say option 2 is "more normalized" (note: there are well-defined normalization levels with formal rules -- we won't get into that in 544)

tbl_orders

	name	book	amount	county	state
	Tyler Harter	Designing Data-	7 2	Dane	WI
ontion		Intensive Applications	23		
option I:	Tyler Harter	Learning Spark	38	Dane	WI
	Tyler Harter	Cassandra: The	39	Dane	WI
		Definitive Guide	39		

tbl_orders

tbl_counties

	name	book	amount	county_id	id	county	state
tion 2:	Tyler Harter	Designing Data- Intensive Applications	23	1	1	Dane	WI
	Tyler Harter	Learning Spark	38	1	2	Milwaukee	WI
	Tyler Harter	Cassandra: The Definitive Guide	39	1	3	La Crosse	WI

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Normalization Tradeoffs

Benefits of more normalization:

- avoid inconsistencies
- changes in the real world correspond to fewer changes in the DB
- often save space

Downsides of more normalization:

- queries are sometimes slower
- historical record keeping (for example, if you need to reproduce an invoice prior to somebody's name change, you might want the name at time of purchase)

tbl_orders				tbl_counties			tb	_states	
name	book	amount	coun	ty_id	id	county	state_id	:al	stata
Tyler Harter	Designing Data- Intensive Applications	23	1		1	Dane	55 —		state WI
Tyler Harter	Learning Spark	38	1		2	Milwaukee	55		•••
Tyler Caraza- Harter	Cassandra: The Definitive Guide	39	1		3	La Crosse	55	•	

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Definitions of Transactions

Definition I, regarding access patterns

- analytics: calculate over many/all rows, few colums (corresponding DB: OLAP)
- transactions: work with whole row or few rows at a time (corresponding DB: OLTP)

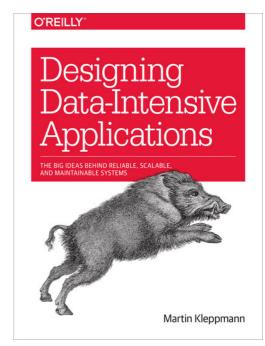
Definition 2, regarding guarantees for a collection of DB operations (often changes). Common guarantees:

- atomiticy: it all happens or nothing happens (partial progress is rolled back upon failure)
- consistency: application invariants (like no negative bank accounts) are supported
- isolation: others cannot see a transaction in progress (aka atomicity when talking about locks)
- durability: once finished, it persists (even if machine crashes+restarts)

Transactions in a DB are similar to critical sections in a multi-threaded process:

```
if bank_accounts[src] >= dollars:
bank_accounts[src] -= dollars
bank_accounts[dst] += dollars
critical section
(example from "locks" lecture)
```

"NoSQL" databases often have weaker transactions (not ACID) in order to achive other goals (e.g., performance, scalability, availability, etc).



"The Meaning of ACID"

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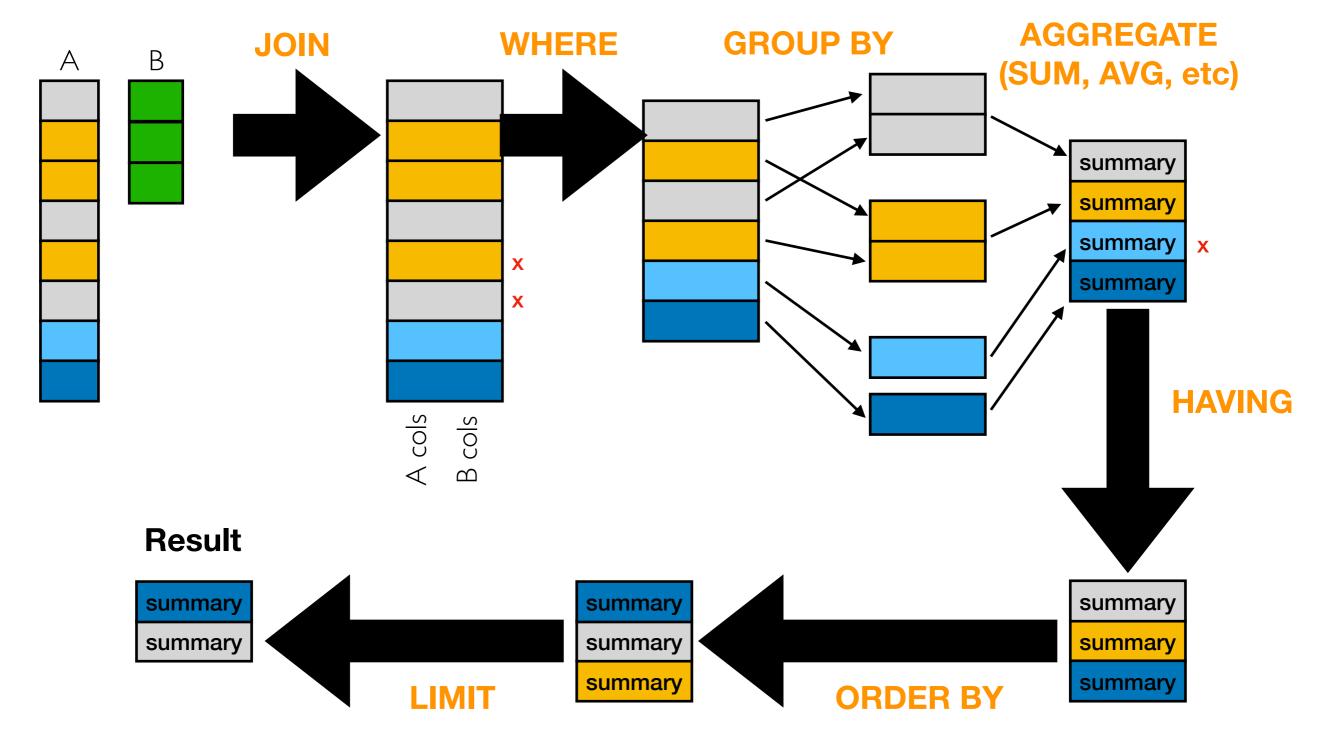
Queries

SQL Query: General Structure

SELECT FROM JOIN (optional) WHERE (optional) **GROUP BY (optional) HAVING** (optional) ORDER BY (optional) LIMIT (optional)

Query: a series of transformations

Tables



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Banking Demos



