Schema Design

schema, n. — a representation of a plan or theory in the form of an outline or model.

Schema - your database without the data
Definition from the Oxford American College Dictionary (used by Google Search)

Schemas

- **Table Schema (i.e. relation schema)**
  - What is the table called?
  - What columns does it have? What are their data types?
- **Database Schema**
  - What tables are in the database?
  - How are tables related?

A **relation schema** is the logical definition of a table - it defines what the name of the table is, and what the name and type of each **column** is. It's like a plan or a blueprint.
A **database schema** is the collection of relation schemas for a whole database.

A database is, formally, any collection of data. In this context, the database would be a collection of tables. A DBMS (Database Management System) is the software (like MySQL, SQL Server, Oracle, etc) that manages and runs a database.

Data Modeling

- **How do we represent real world relationships and properties in our program?**
  - …in a way that makes writing the program easy
  - …while remaining flexible for future changes
  - …oh, it also has to be fast (enough).

Designing a Schema

- **Analysis**
  - What does my program need to output?
  - What data will I need to produce that output?
- **Conceptual Design**
  - Conceptual entities and their relationships
- **Logical Design**
  - In a SQL database: What are my tables, attributes, and relationships?
  - In a program: What are my functions and data structures?
- **Physical Design**
  - JavaScript code, CREATE TABLE statements

Conceptual — we have this entity with some properties on it and now how does it relate to this other entity with other properties

Designing a Schema

What we'll focus on today

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Example: A Journal
Analysis

- I want a program to keep my journal in.
- I want to be able to enter the **text** of each journal entry.
- I want to be able to see journal entries **chronologically**.

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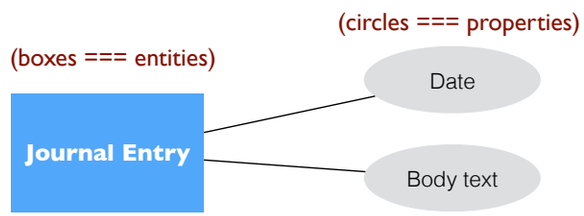
Entity Relationship Diagram (ERD)
Conceptual Design



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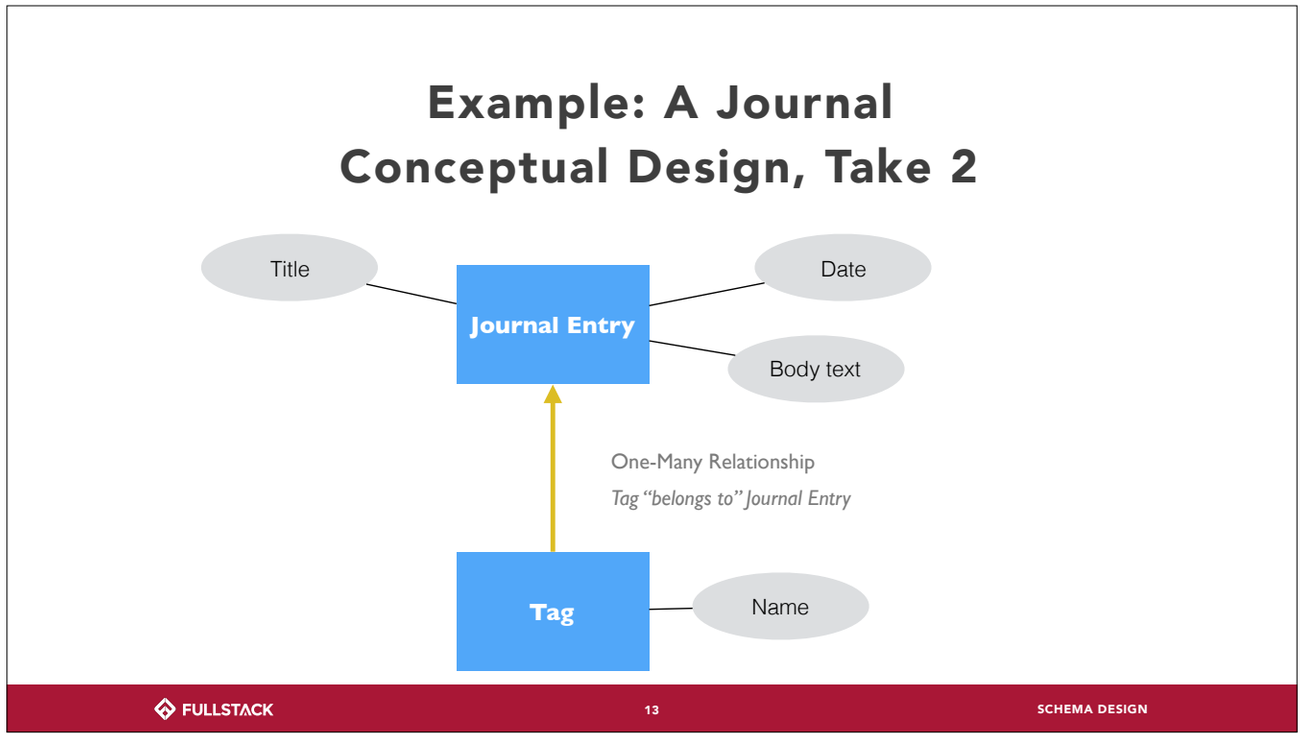
Entity Relationship Diagram (ERD)
Logical Design

entries	
id	int, primary key
date_created	date
text	text

All done!

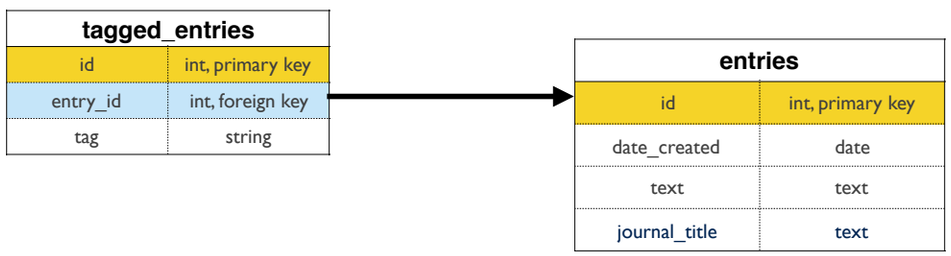
- **Oh wait, I forgot a couple of things**
  - I want to be able to have multiple journals
  - I want to be able to #tag entries and find all entries with a particular #tag
- **Take 2…**

Suggestions?



Here is one possibility.

Example: A Journal
Logical Design: Take 2



Any problems?

But Wait!!!
Normalization

- Organization that minimizes data redundancy and improves data integrity
- How do I change the name of “happy times” to “sadness”?

select * from entries;

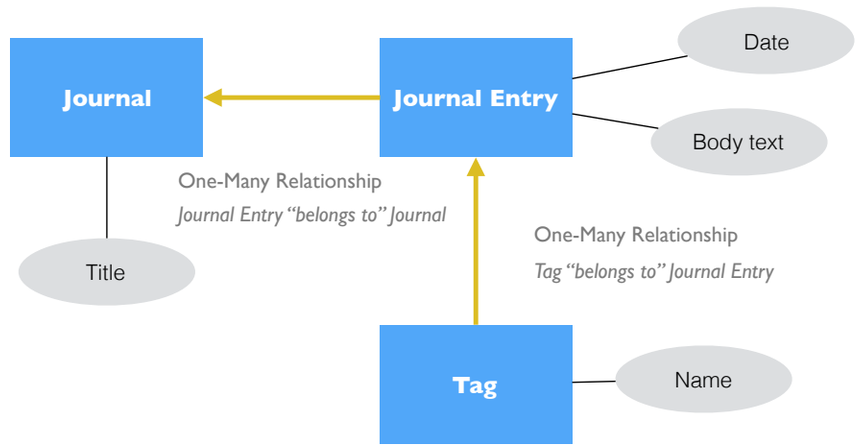
id	date_created	text	journal_title
0	2016-04-01	I am happy	happy times
1	2016-04-02	I am very happy	happy times
2	2016-04-03	Despair fills me	happy times
3	2016-04-03	Sadness is my life	an anatomy of pain

Database Normalization — is the process of organizing the columns (attributes) and tables (relations) of a relational database to minimize data redundancy and improve data integrity.

Having a piece of data live in multiple places makes it possible for your data to get out of sync
Strings are more expensive to compare than numbers.

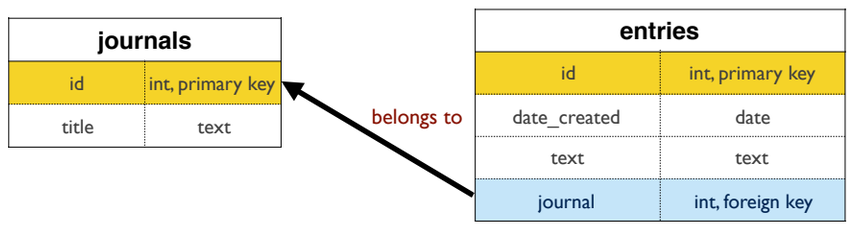
Minimize redesign when extending the database structure

Conceptual Design, Take 3

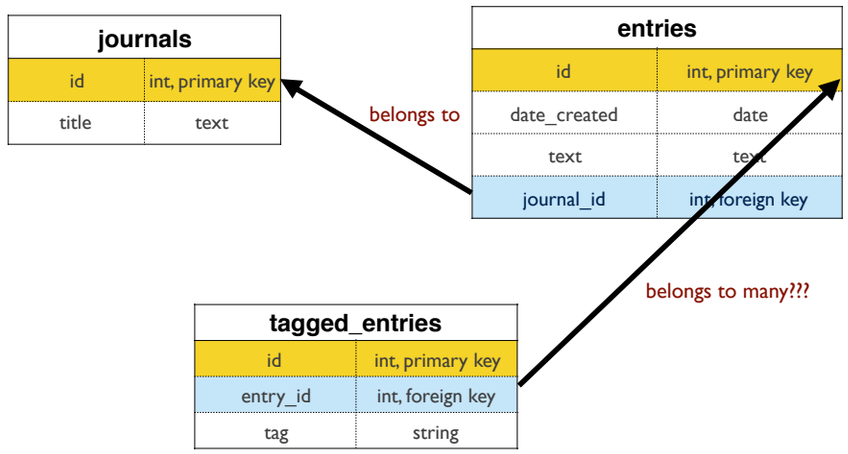


Logical Design, Take 3

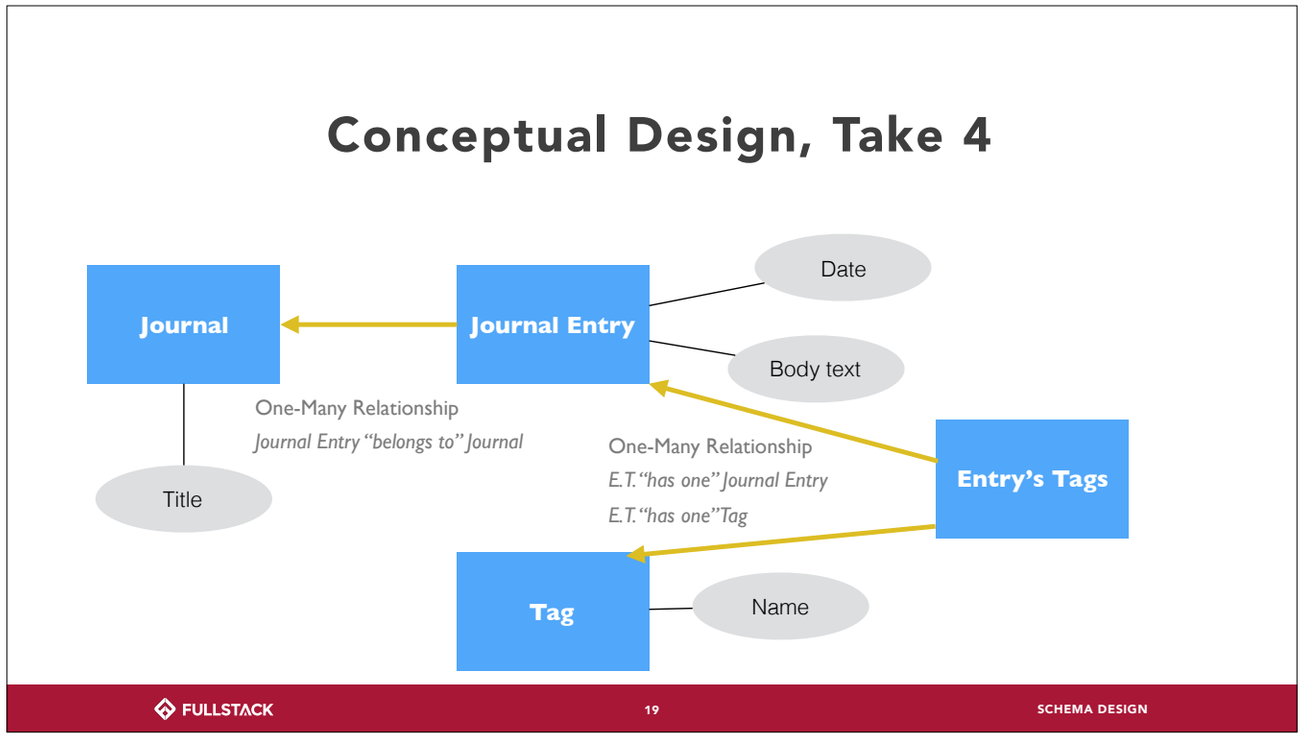
- Eliminate repeating groups in individual tables
- Create a separate table for each set of related data
- Identify each set of related data with a primary key



But what about tags?!?

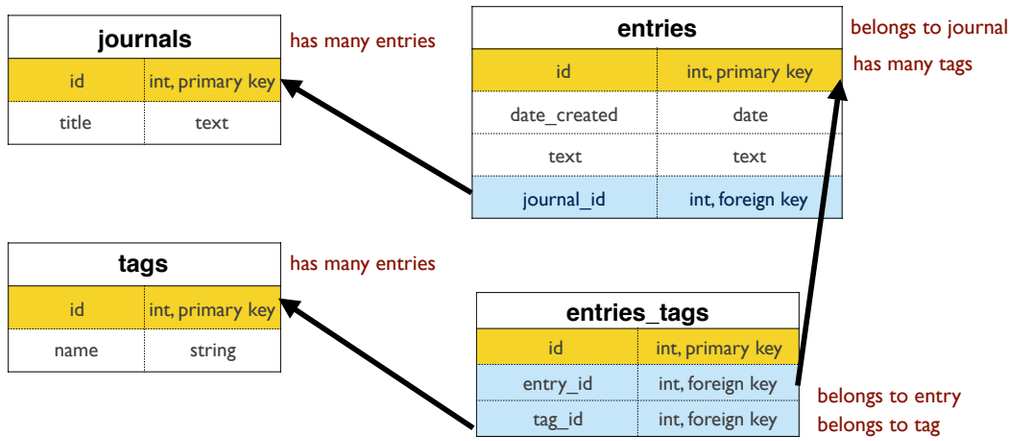


What’s the problem with tags? What if two different entries have the same tag? This leads to redundancy in the tagged_entries table.



Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity. Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity.

Logical Design, Take 4



Logical Design, Take 4

SELECT * FROM entries

id	date_created	Text	journal_id
0	2016-04-01	I am happy	0
1	2016-04-02	I am very happy	0
2	2016-04-03	Despair fills me	0
3	2016-04-03	Sadness is my life	1

SELECT * FROM journals

id	date_created	Title
0	2016-04-01	happy times
1	2016-04-02	an anatomy of pain

SELECT * FROM tags-entries

tag_id	entry_id
0	0
0	1
1	0

SELECT * FROM tags

id	date_created	Tag
0	2016-04-01	#YOLO
1	2016-04-02	#LOVELIFE

Has vs. Belongs To

- If rows in table A “belong to” rows in table B, that means A contains a foreign key for B
- If rows in table A “have” one or many rows in table B, that means table B is responsible for keeping track of the foreign key
- Think: the “owner” has less to worry about

- Entries “belongs to” journals, so entries has the FK to journals
- Journals have many entries, so entries is responsible for keeping track of FK

Relationships

- **Has One/Belongs To**
  - Author has one Journal
  - Journal belongs to an Author
- **Has Many/Belongs To**
  - Entries belong to a Journal
  - A Journal has many Entries
- **Belongs To Many**
  - Tags and Journal Entries

Tags belong to many journal entries

Normalized Databases

- **Focus on optimal storage - often at odds with retrieval speed due to complex queries using complicated joins**
- **Work best when the application is write-intensive and write-load is more than read-load**
  - Tables are usually smaller as data is divided vertically (fast reads on single tables)
  - Updates and Inserts are fast because there are no duplicates to update
  - Data is not duplicated so there is less of a need for process intensive group by or distinct queries
- **Normalized tables mean join tables, which mean read operations on multiple tables suffer (indexing strategies don't work as well with joins)**

*avoid redundancy

Denormalized

- **Works best when the application is read-intensive**
  - The data is present in the same table (no need for joins)
  - A single table with all required data allows for efficient index usage
- **Data is duplicated which means that updates and inserts become complex and costly**

What Do I Do?!

- Real world applications will most likely have both read-loads and write-loads
- Utilize both approaches depending on the situation!
- Befriend your local DBA

Steps for Developing your ERD

1. Identify Entities
2. Define Relationships
3. Draw Rough-Draft ERD
4. Fill in Cardinality/Modality (arrows with relationship type)
5. Define Primary Keys
6. Label Foreign Keys
7. Identify and Map Attributes

Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity. Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity.

Design one!

- Twitter
- Gmail
- Facebook
- Instagram
- Wordpress
- Wikipedia
- AirBnB
- GitHub
- Youtube
- Spotify
- Slack
- Google (search)

Google drawings: https://docs.google.com/drawings