Schema Design

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

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?

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

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.

Designing a Schema

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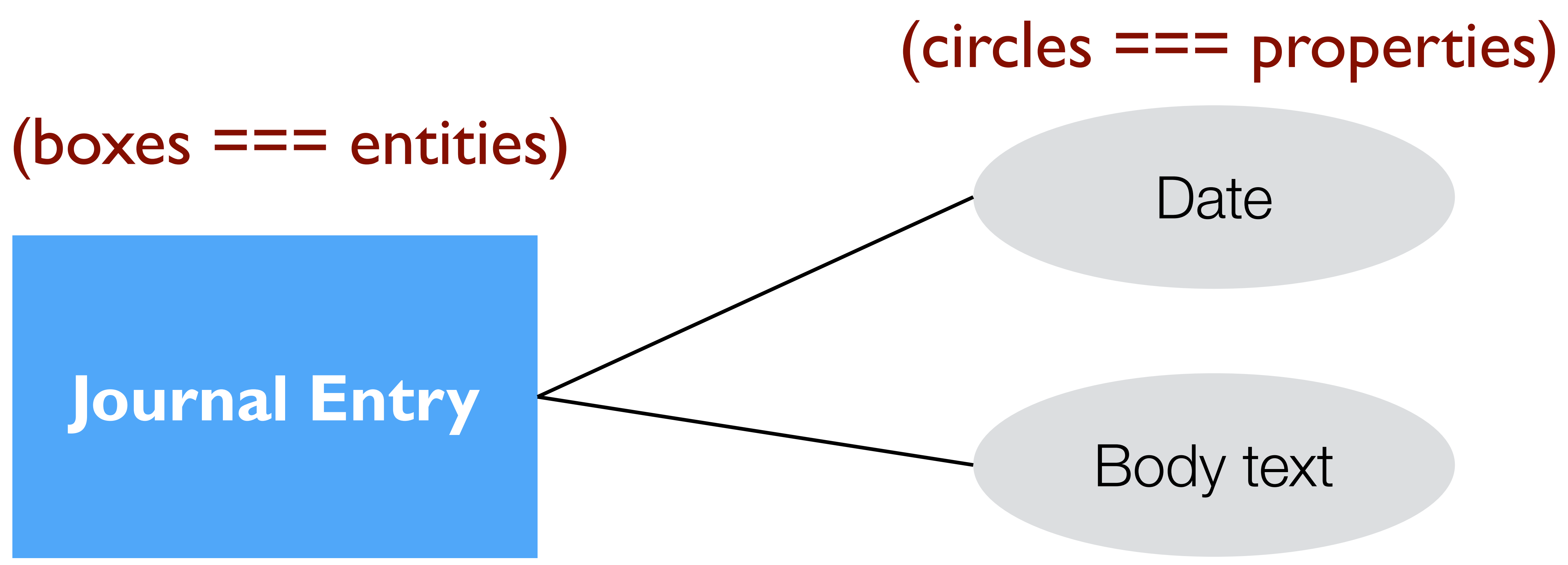
Entity Relationship Diagram (ERD)
Conceptual Design



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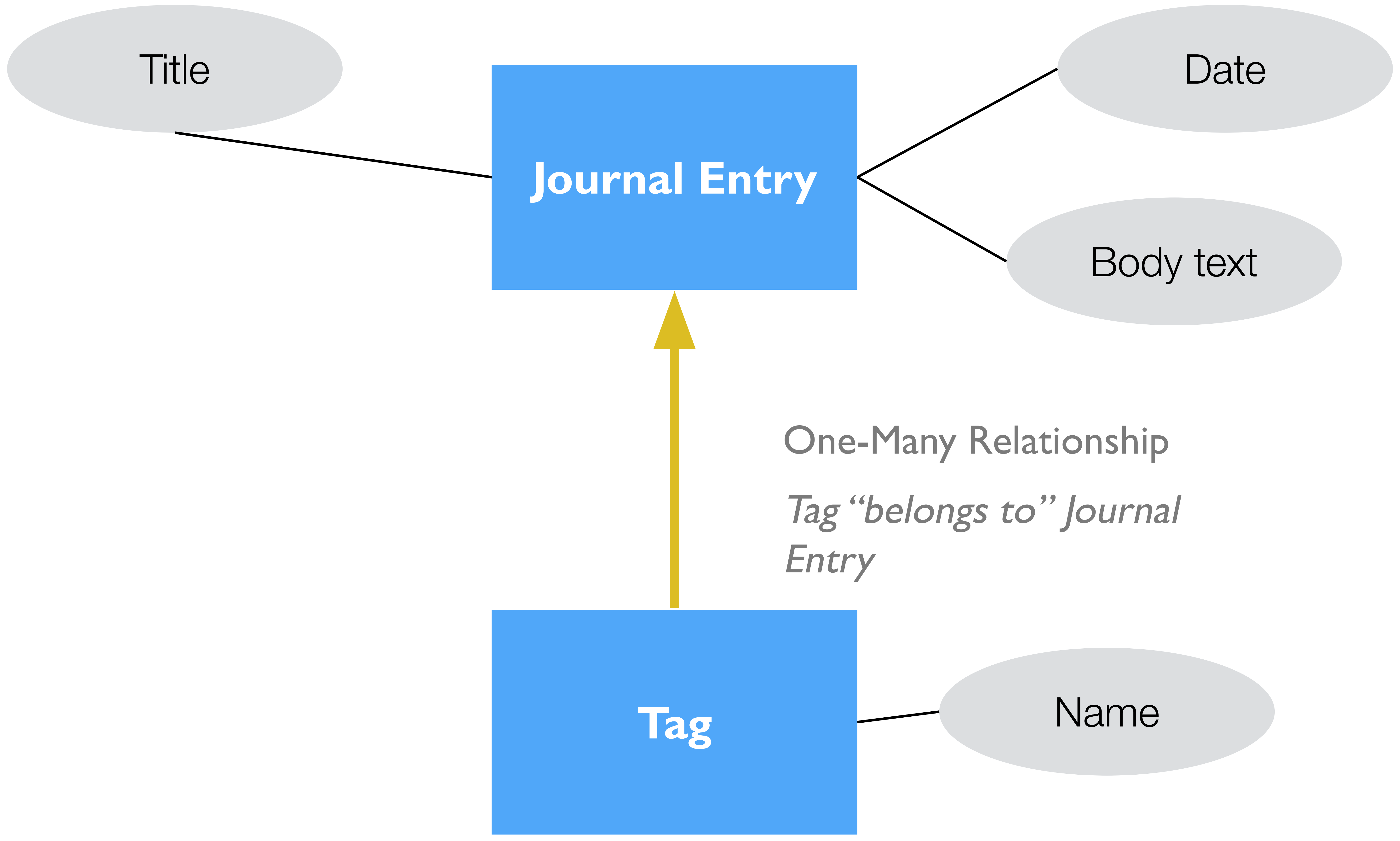
Entity Relationship Diagram (ERD)
Logical Design

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…

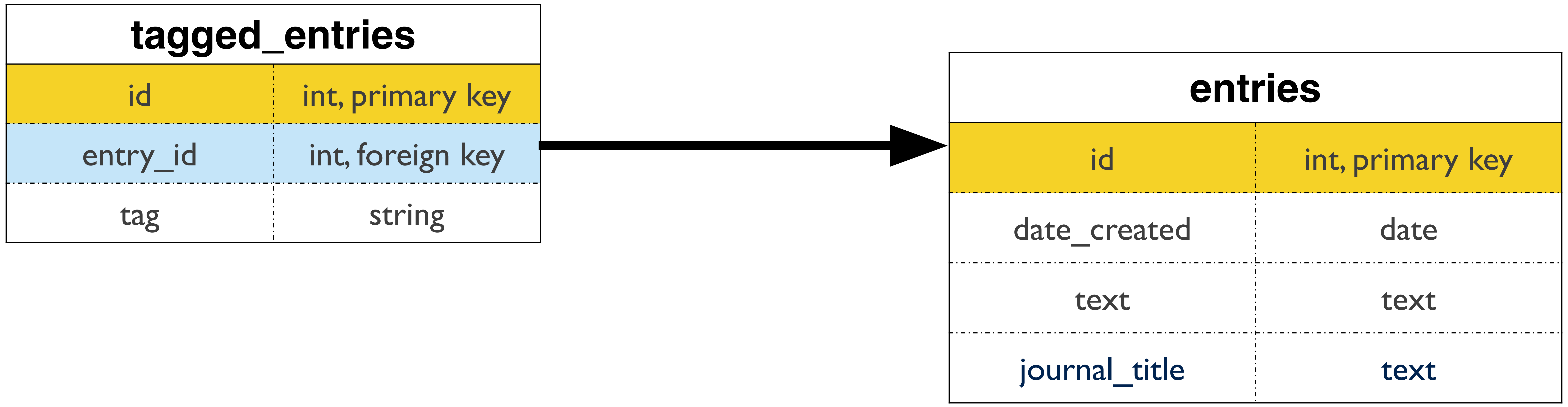
Example: A Journal Conceptual Design, Take 2



One-Many Relationship

Tag "belongs to" Journal Entry

Example: A Journal
Logical Design: Take 2



tagged_entries

id	int, primary key
entry_id	int, foreign key
tag	string

entries

id	int, primary key
date_created	date
text	text
journal_title	text

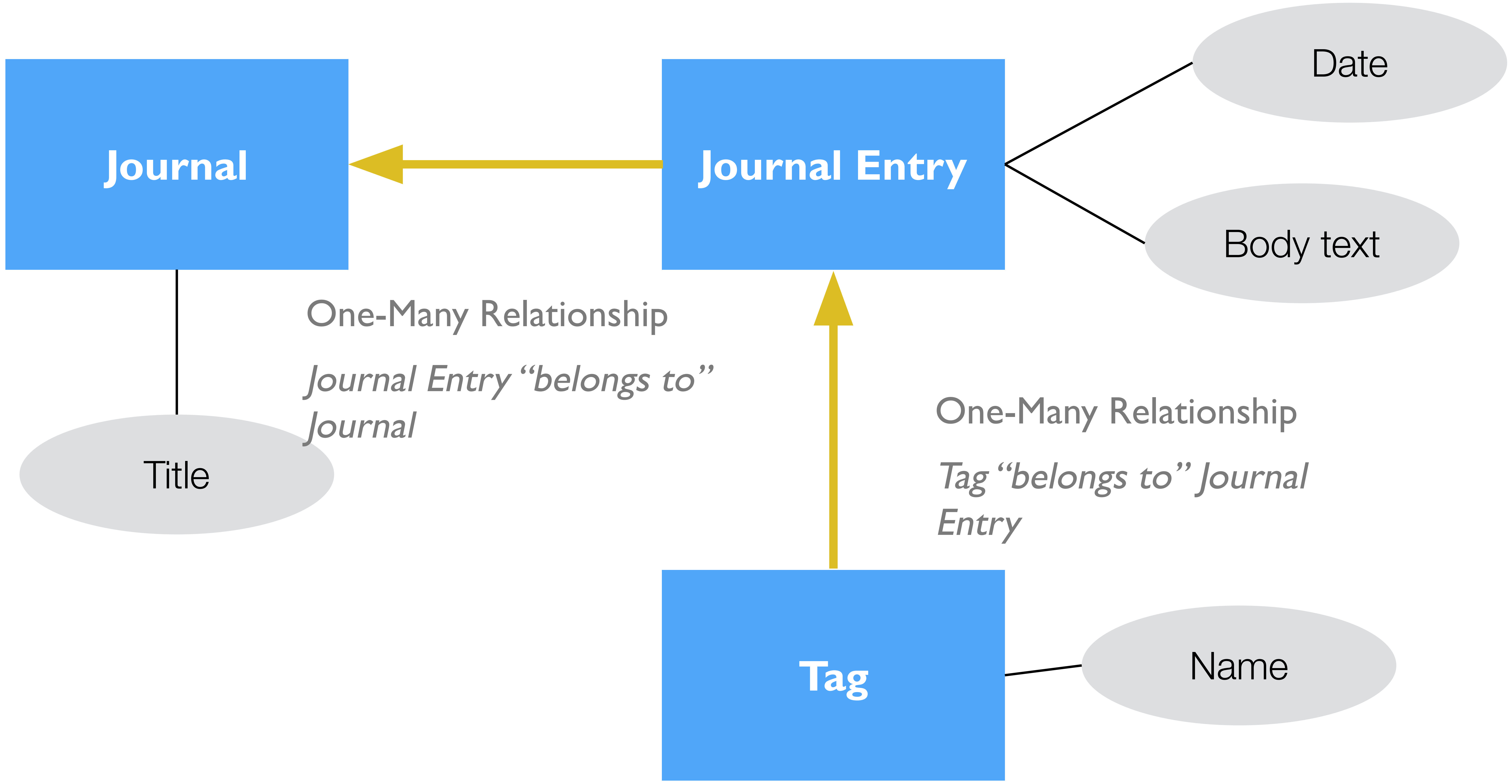
But Wait!!!
Normalization

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

select * from entries;

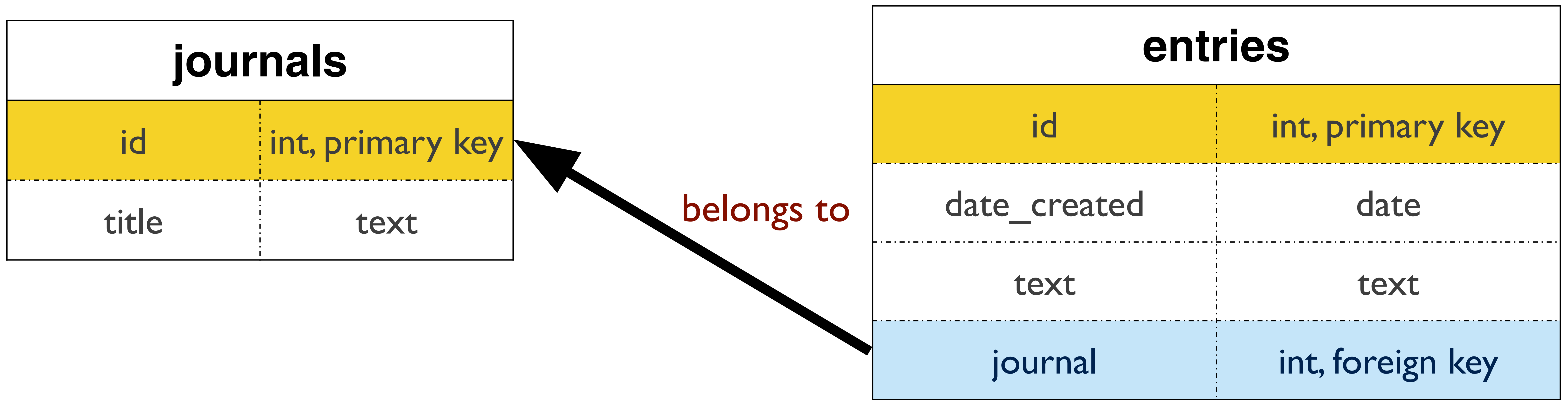
id	date_created	text	journal_title
0	2016-04-01	I am happy	happy times
1	2016-04-02	I am very happy	happy times
2	2016-04-03	Despair fills me	happy times
3	2016-04-03	Sadness is my life	an anatomy of pain

Conceptual Design, Take 3



Logical Design, Take 3

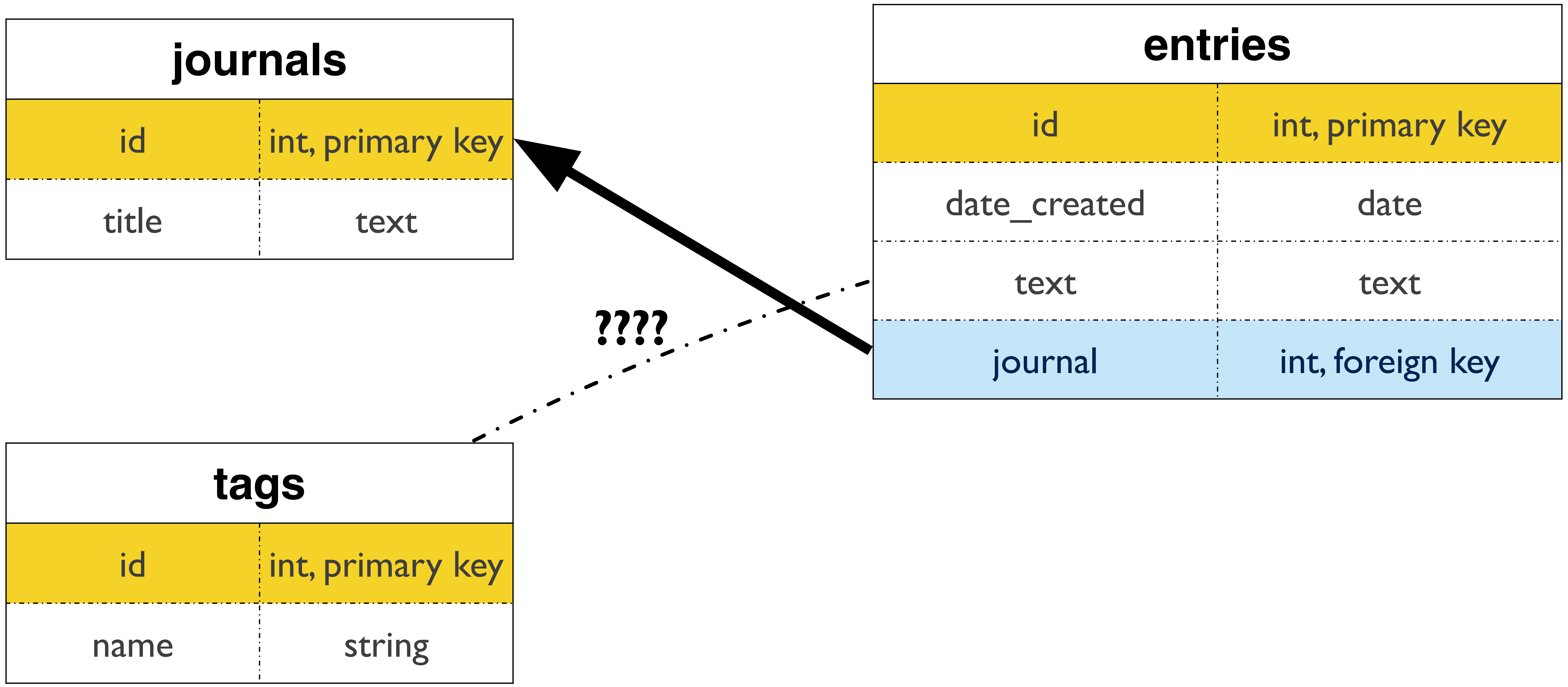
- Eliminate repeating groups in individual tables
- Create a separate table for each set of related data
- Identify each set of related data with a primary key



journals	
id	int, primary key
title	text

entries	
id	int, primary key
date_created	date
text	text
journal	int, foreign key

But what about tags?!?



journals

id	int, primary key
title	text

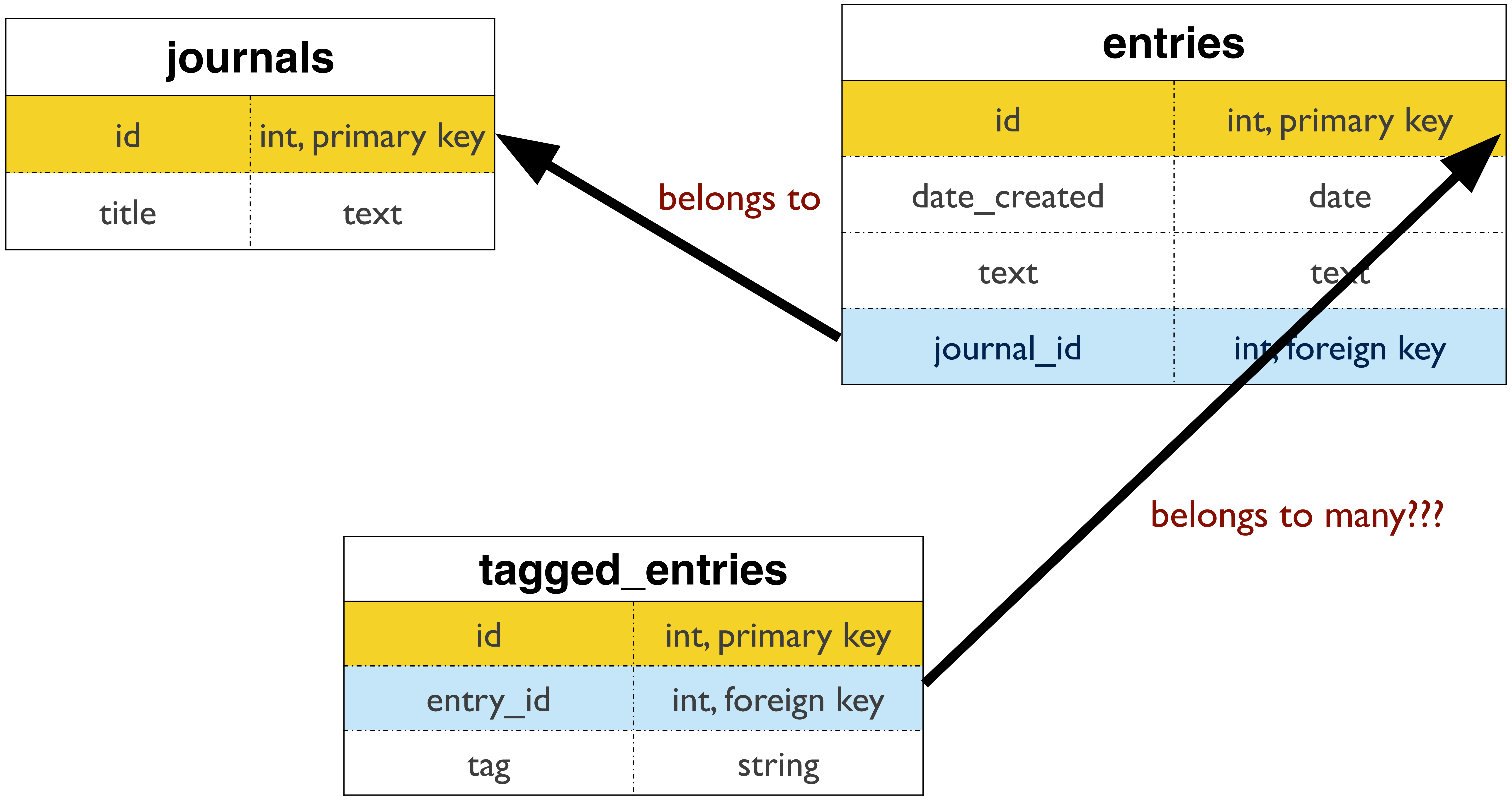
entries

id	int, primary key
date_created	date
text	text
journal	int, foreign key

tags

id	int, primary key
name	string

But what about tags?!?



journals

id	int, primary key
title	text

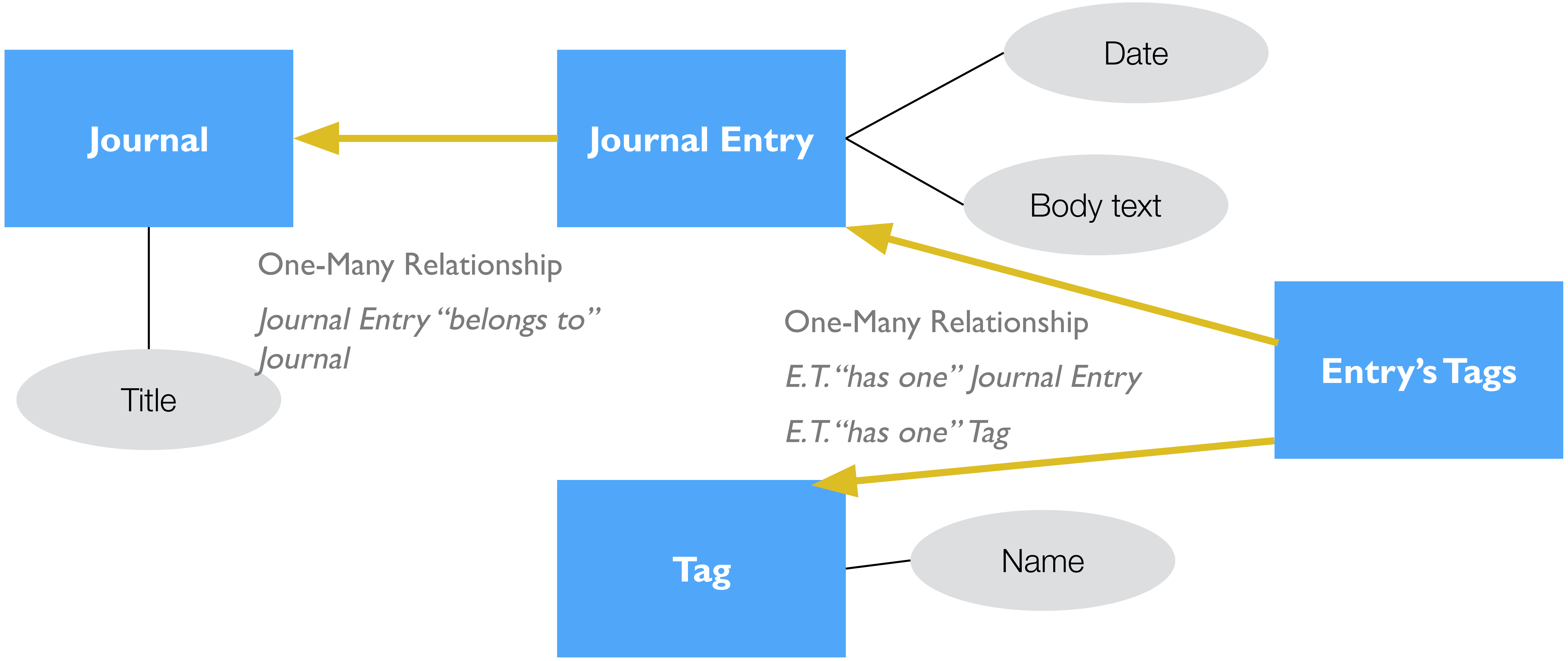
entries

id	int, primary key
date_created	date
text	text
journal_id	int, foreign key

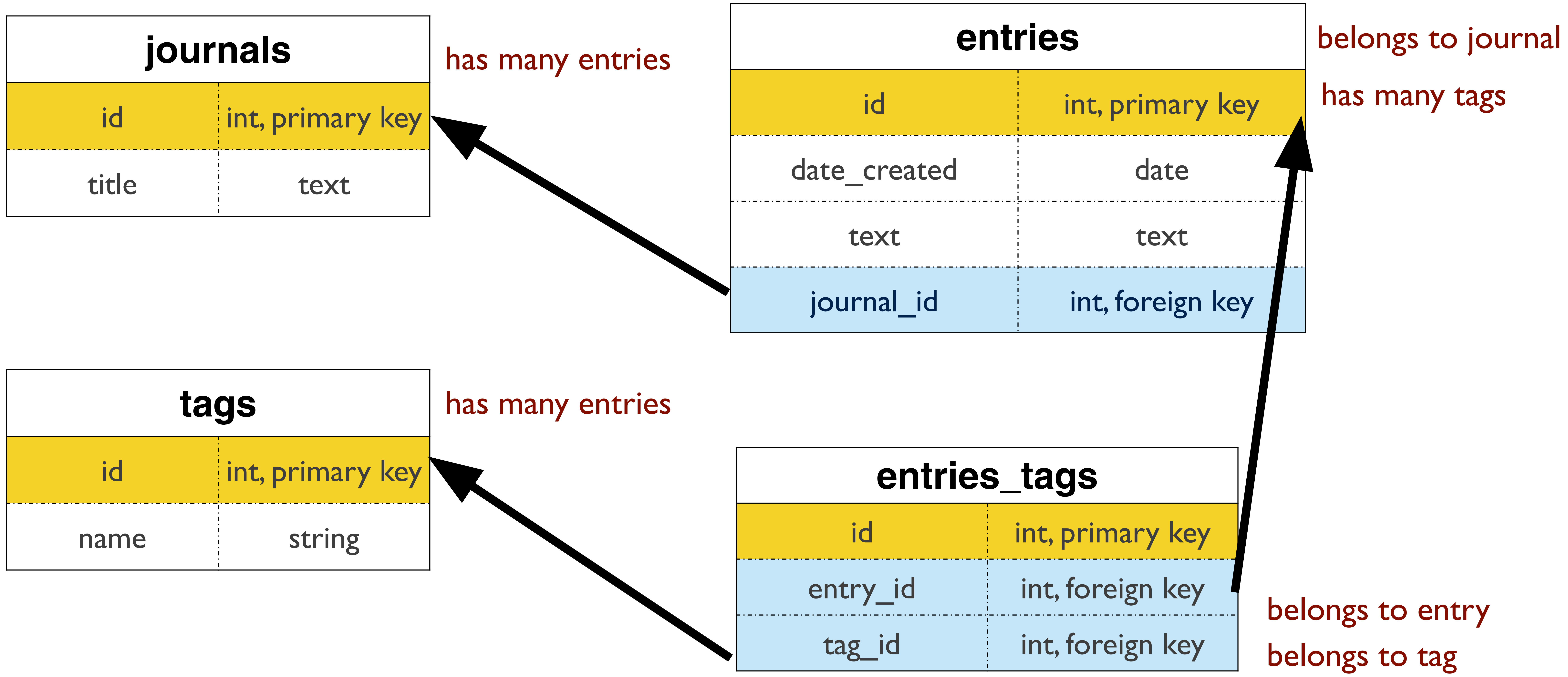
tagged_entries

id	int, primary key
entry_id	int, foreign key
tag	string

Conceptual Design, Take 4



Logical Design, Take 4



journals

id	int, primary key
title	text

has many entries

entries

id	int, primary key
date_created	date
text	text
journal_id	int, foreign key

belongs to journal

has many tags

tags

id	int, primary key
name	string

has many entries

entries_tags

id	int, primary key
entry_id	int, foreign key
tag_id	int, foreign key

belongs to entry

belongs to tag

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 entries_tags

tag_id	entry_id
0	0
0	1
1	0

SELECT * FROM tags

id	date_created	name
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

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

Example: A Journal Normalized!

select * from entries;			
id	date_created	text	journal_id
0	2016-04-01	I am happy	0
1	2016-04-02	Very happy	0
2	2016-04-03	Despair…	0
3	2016-04-03	Sadness…	1

select * from entries_tags;		
id	entry_id	tag_id
0	0	0
1	0	1
2	1	0
3	1	2

select * from entries;	
id	name
0	0
1	0
2	1
3	1

select * from journals;	
id	title
0	happy times
1	an anatomy of pain

Do we even need this?

Composite Primary Keys

select * from entries;			
id	date_created	text	journal_id
0	2016-04-01	I am happy	0
1	2016-04-02	Very happy	0
2	2016-04-03	Despair…	0
3	2016-04-03	Sadness…	1

select * from entries_tags;	
entry_id	tag_id
0	0
0	1
1	0
1	2

composite primary key

select * from entries;	
id	name
0	0
1	0
2	1
3	1

select * from journals;	
id	title
0	happy times
1	an anatomy of pain

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)

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

Design Twitter!