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IYKRA
Data Fellowship Program

Database Schema and Normalizations

by (Bangun Sasongko)

Trainer Profile

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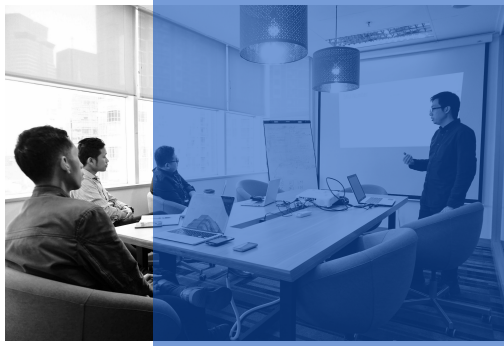


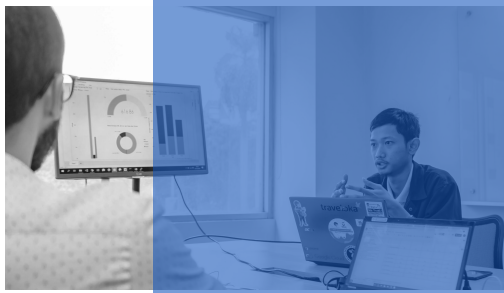
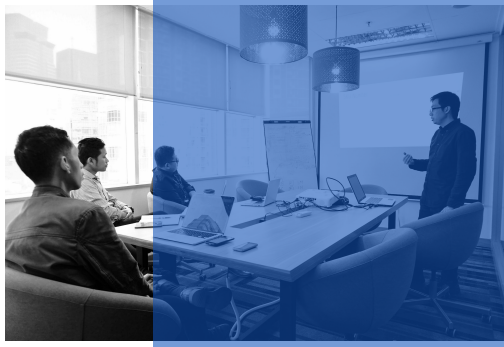
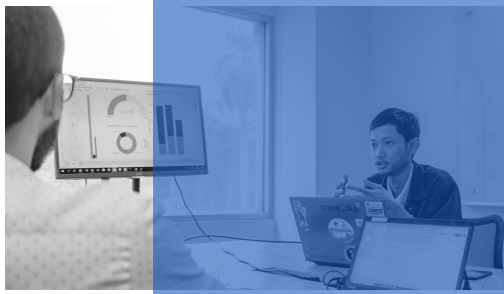


Table of Content

About this Course

This chapter will propel your data modeling expertise! We'll dive into crafting star and snowflake schemas, understand the significance of normalization, and explore techniques for normalizing databases to various levels.
Star and snowflake schema
Normalized and denormalized databases
Normal forms

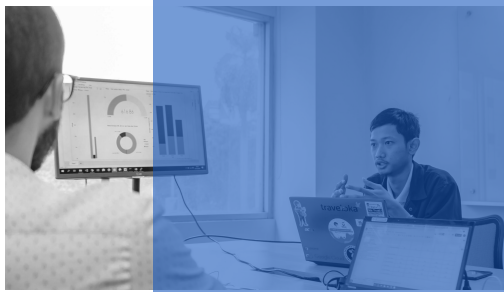




The Objectives

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

1. **Introduce star and snowflake schema design**: These are specific data structures used in data warehousing, and learning about them indicates a focus on practical application.
2. **Emphasize the importance of data normalization**: Normalization is a process of organizing data to reduce redundancy and improve efficiency. Highlighting its significance suggests the course will teach you this crucial concept.
3. **Equip you with database normalization techniques**: Learning how to normalize databases to various levels implies the course will provide hands-on skills for optimizing data structures.



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Star and snowflake schema

Star schema

Dimensional modeling: star schema Fact tables

- Holds records of a metric
- Changes regularly
- Connects to dimensions via foreign keys

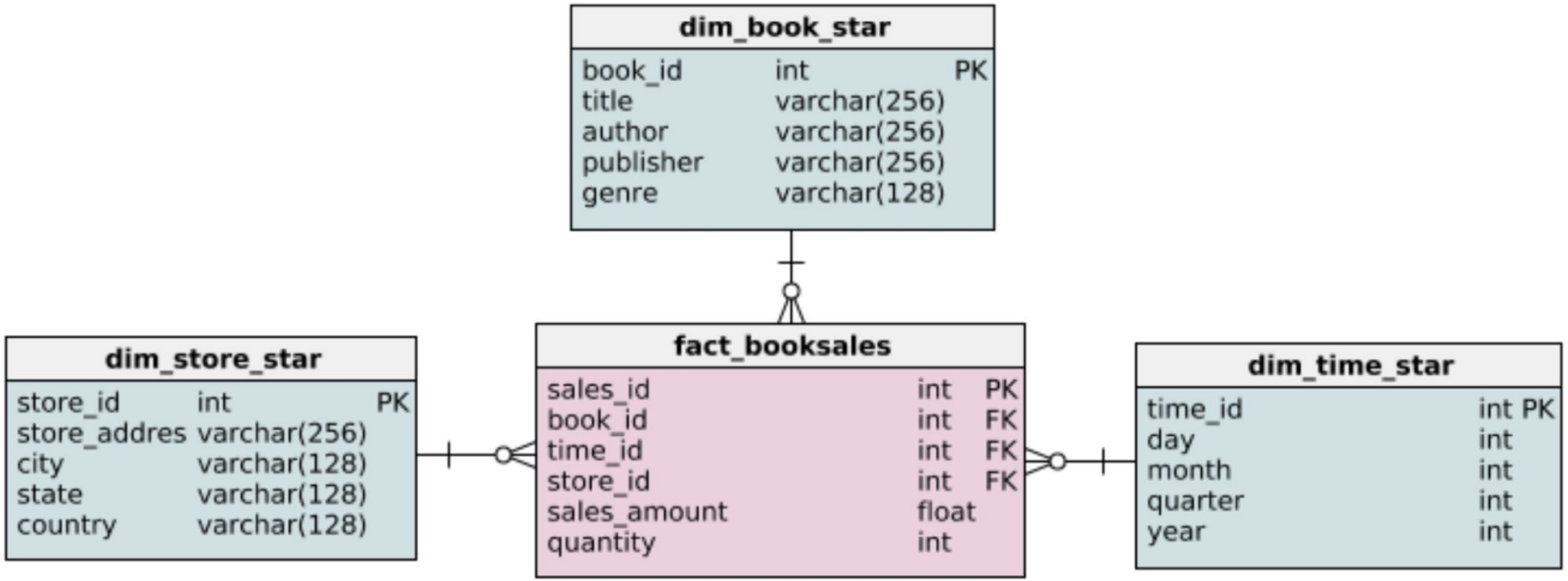
Dimension tables

- Holds descriptions of attributes
- Does not change as often

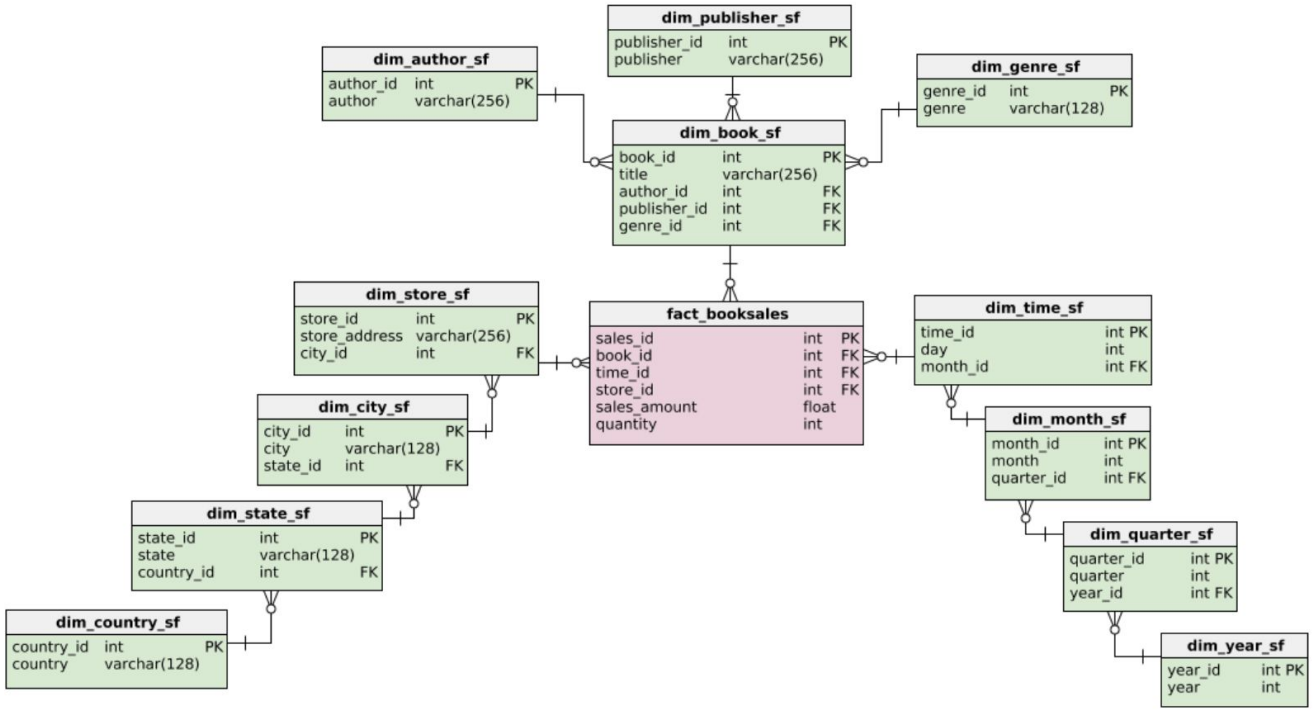
Example:

- Supply books to stores in USA and Canada
- Keep track of book sales

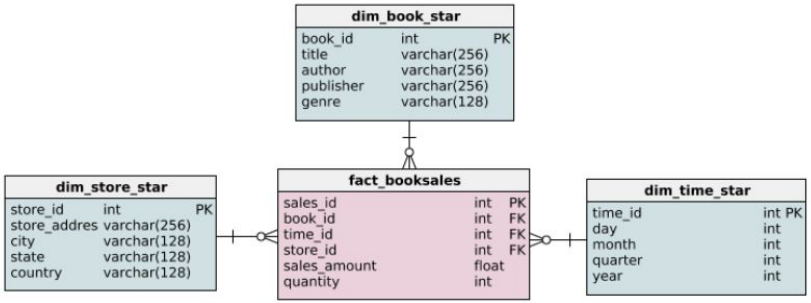
Star schema example

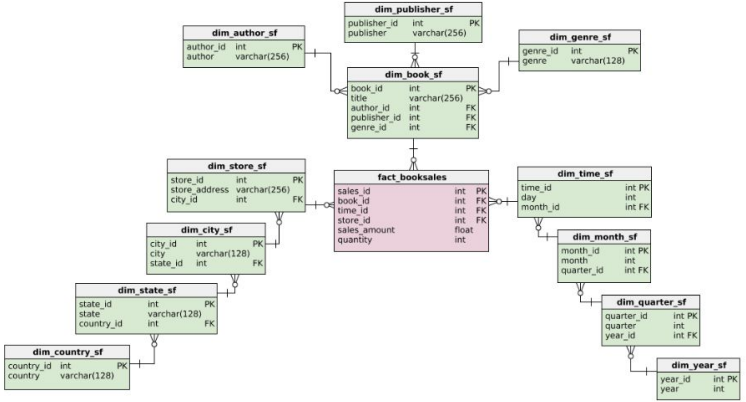


Snowflake schema (an extension)



Same fact table, different dimensions





Star schemas: one dimension

Snowflake schemas: more than one dimension

Because dimension tables are normalized

What is normalization?

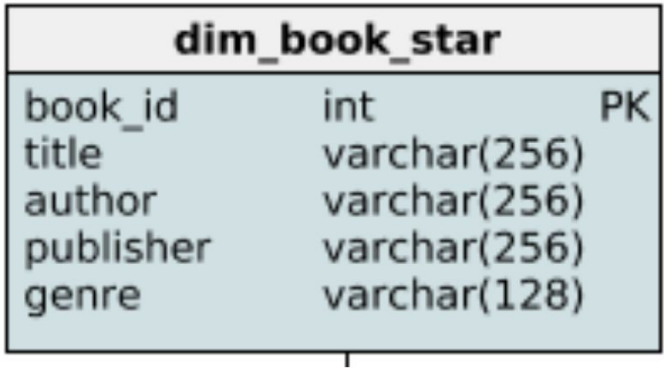
- Database design technique
- Divides tables into smaller tables and connects them via relationships
- Goal: reduce redundancy and increase data integrity

What is normalization?

- Database design technique
- Divides tables into smaller tables and connects them via relationships
- Goal: reduce redundancy and increase data integrity

Identify repeating groups of data and create new tables for them

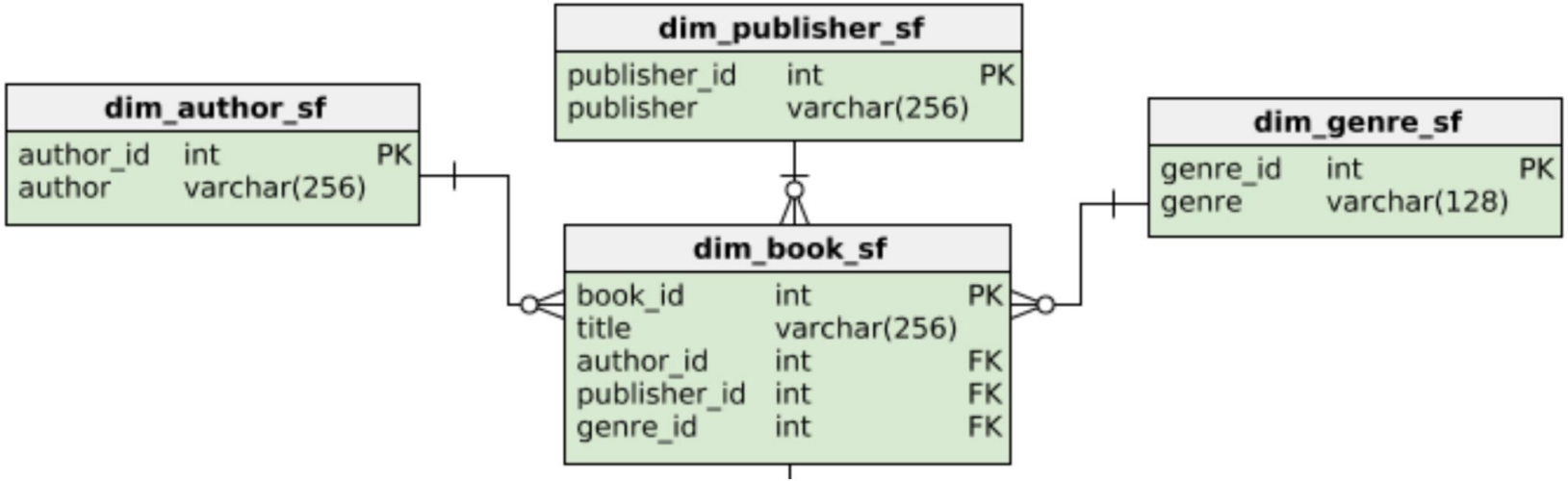
Book dimension of the star schema



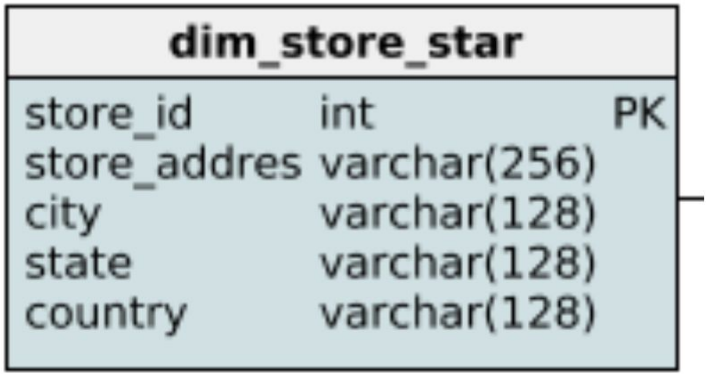
Most likely to have repeating values:

- Author
- Publisher
- Genre

Book dimension of the snowflake schema

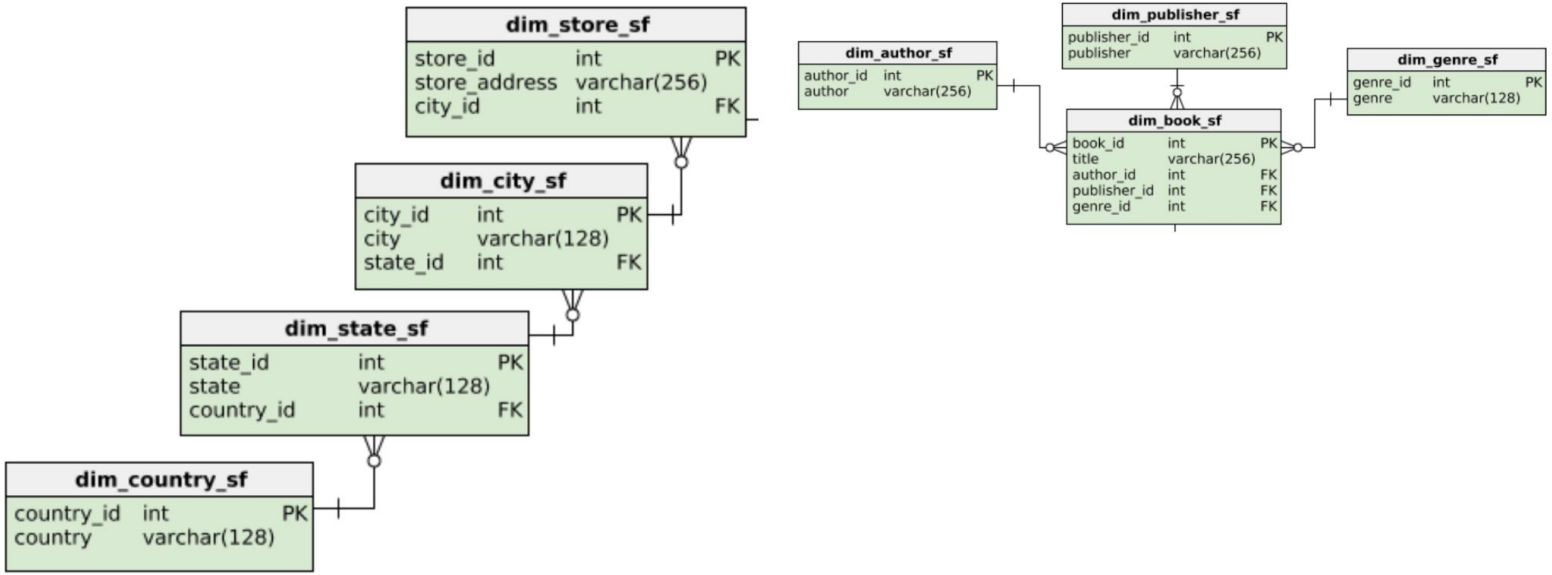


Store dimension of the star schema

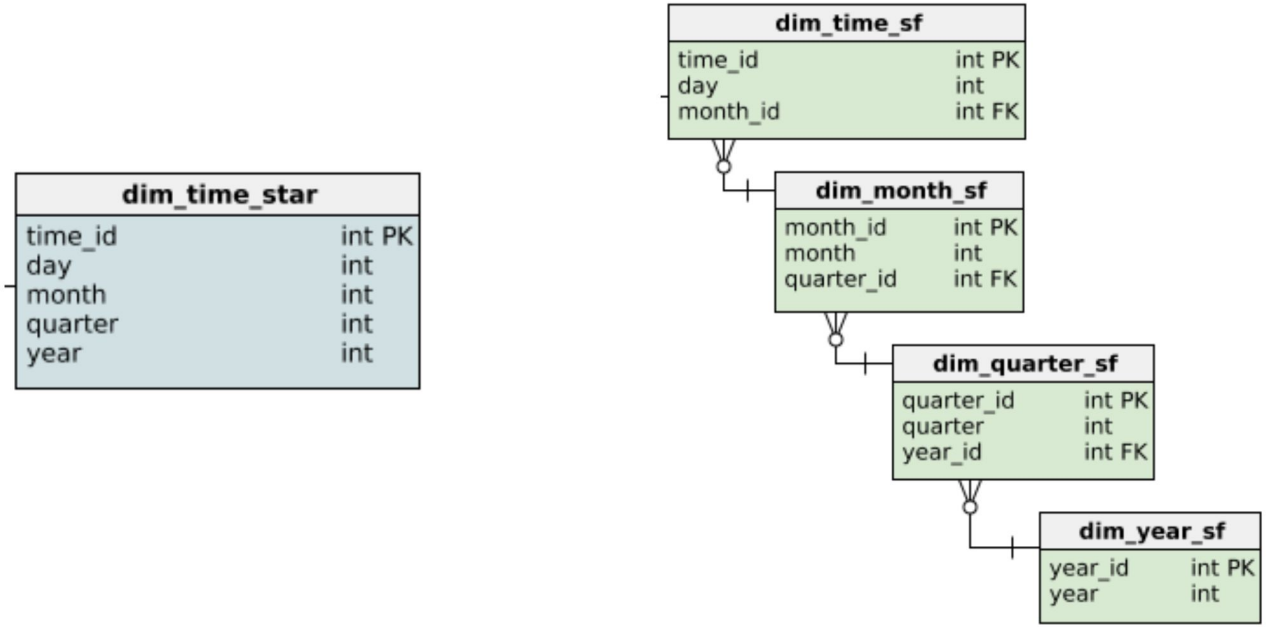


- City
- State
- Country

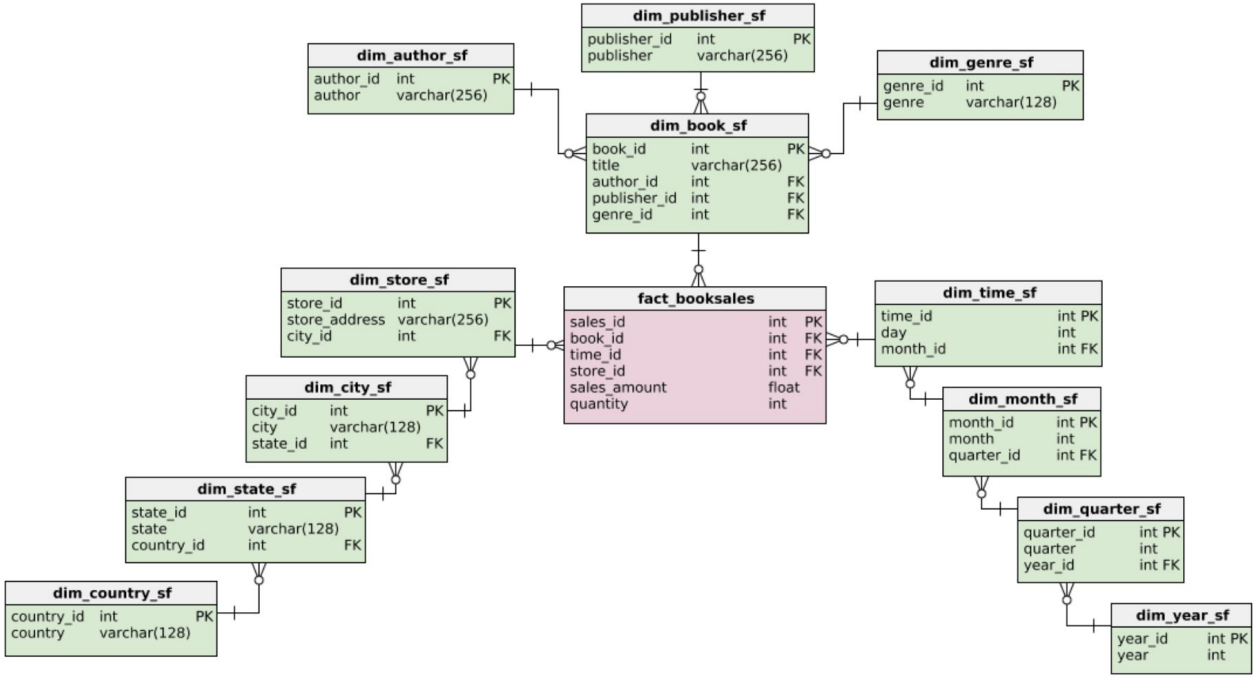
Store dimension of the snowflake schema



Store dimension of the snowflake schema



Store dimension of the snowflake schema



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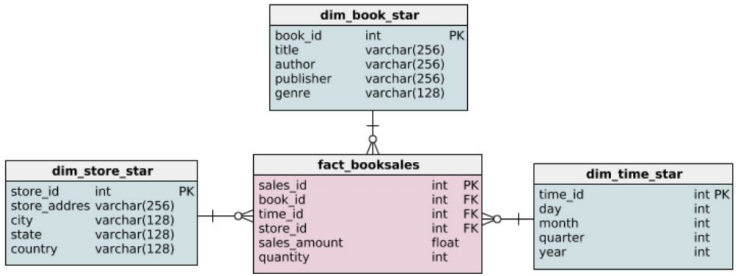
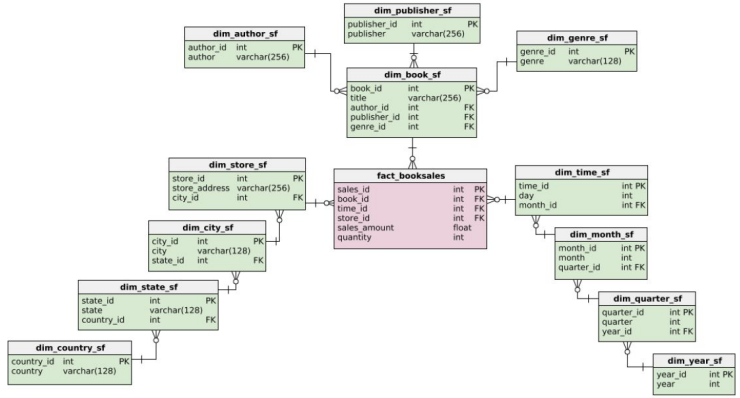
Normalized and denormalized databases

Back to our book store example

Denormalized: star schema



Normalized: snowflake schema



Denormalized Query

Goal: get quantity of all Octavia E. Butler books sold in Vancouver in Q4 of 2018

```
SELECT SUM(quantity) FROM fact_booksales
  -- Join to get city
  INNER JOIN dim_store_star on fact_booksales.store_id = dim_store_star.store_id
  -- Join to get author
  INNER JOIN dim_book_star on fact_booksales.book_id = dim_book_star.book_id
  -- Join to get year and quarter
  INNER JOIN dim_time_star on fact_booksales.time_id = dim_time_star.time_id
WHERE
  dim_store_star.city = 'Vancouver' AND dim_book_star.author = 'Octavia E. Butler' AND
  dim_time_star.year = 2018 AND dim_time_star.quarter = 4;
```

```
7600
```

Total of 3 joins

Normalized query

```sql
SELECT
  SUM(fact_booksales.quantity)
FROM
  fact_booksales
  -- Join to get city
  INNER JOIN dim_store_sf ON fact_booksales.store_id = dim_store_sf.store_id
  INNER JOIN dim_city ON dim_store_sf.city_id = dim_city_sf.city_id
  -- Join to get author
  INNER JOIN dim_book_sf ON fact_booksales.book_id = dim_book_sf.book_id
  INNER JOIN dim_author_sf ON dim_book_sf.author_id = dim_author_sf.author_id
  -- Join to get year and quarter
  INNER JOIN dim_time_sf ON fact_booksales.time_id = dim_time_sf.time_id
  INNER JOIN dim_month_sf ON dim_time_sf.month_id = dim_month_sf.month_id
  INNER JOIN dim_quarter_sf ON dim_month_sf.quarter_id =  dim_quarter_sf.quarter_id
  INNER JOIN dim_year_sf ON dim_quarter_sf.year_id = dim_year_sf.year_id
```

Normalized query (continued)

```
WHERE
  dim_city_sf.city = `Vancouver`
  AND
  dim_author_sf.author = `Octavia E. Butler`
  AND
  dim_year_sf.year = 2018 AND dim_quarter_sf.quarter = 4;
```

```
sum
7600
```

Total of 8 joins

So, why would we want to normalize a databases?

Normalization saves space

dim_store_star

id	store_address	city	state	country
1	67 First St	**Brooklyn**	**New York**	**USA**
2	12 Jefferson Rd	San Francisco	**California**	**USA**
3	90 Coolidge St	Los Angeles	**California**	**USA**
4	85 Main Ave	**Brooklyn**	**New York**	**USA**
5	123 Bedford St	**Brooklyn**	**New York**	**USA**

Denormalized databases enable **data redundancy**

Normalization saves space

dim_store_sf

id	store_address	city_id
1	67 First St	2
2	12 Jefferson Rd	3
3	90 Coolidge St	4
4	85 Main Ave	2
5	123 Bedford St	2

dim_city_sf

city_id	city_name	state_id
2	Brooklyn	43
3	San Francisco	36
4	Los Angeles	36

dim_state_sf

state_id	state	country_id
43	New York	121
36	California	121

Normalization eliminates **data redundancy**

Normalization ensures better data integrity

1. **Enforces data consistency**

Must respect naming conventions because of referential integrity, e.g., 'California', not 'CA' or 'california'

2. **Safer updating, removing, and inserting**

Less data redundancy = less records to alter

3. **Easier to redesign by extending**

Smaller tables are easier to extend than larger tables

Database normalization

Advantages

- Normalization eliminates data redundancy: save on storage
- Better data integrity: accurate and consistent data

Disadvantages

- Complex queries require more CPU

Remember OLTP and OLAP?

OLTP

e.g., Operational databases

Typically highly normalized

- Write-intensive
- Prioritize quicker and safer insertion of data

OLAP

e.g., Data warehouses

Typically less normalized

- Read-intensive
- Prioritize quicker queries for analytics

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Normal forms

Normalization

Identify repeating groups of data and create new tables for them

A more formal definition:

The goals of normalization are to:

- Be able to characterize the level of redundancy in a relational schema
- Provide mechanisms for transforming schemas in order to remove redundancy

Database Design, 2nd Edition by Adrienne Watt

Normal forms (NF)

Ordered from least to most normalized:

- First normal form (1NF)
- Second normal form (2NF)
- Third normal form (3NF)
- Elementary key normal form (EKNF)

  Boyce-Codd normal form (BCNF)
- Fourth normal form (4NF)
- Essential tuple normal form (ETNF)
- Fifth normal form (5NF)
- Domain-key Normal Form (DKNF)
- Sixth normal form (6NF)

https://en.wikipedia.org/wiki/Database_normalization

1NF rules

- Each record must be unique - no duplicate rows
- Each cell must hold one value

Initial data

Student_id	Student_Email	Courses_Completed
235	jim@gmail.com	Introduction to Python, Intermediate Python
455	kelly@yahoo.com	Cleaning Data in R
767	amy@hotmail.com	Machine Learning Toolbox, Deep Learning in Python

In 1NF form

Student_id	Student_Email
235	jim@gmail.com
455	kelly@yahoo.com
767	amy@hotmail.com

Student_id	Completed
235	Introduction to Python
235	Intermediate Python
455	Cleaning Data in R
767	Machine Learning Toolbox
767	Deep Learning in Python

2NF

- **Must satisfy 1NF AND**
  - If primary key is one column
    - then automatically satisfies 2NF
  - If there is a composite primary key
    - then each non-key column must be dependent on all the keys

Initial data

Student_id (PK)	Course_id (PK)	Instructor_id	Instructor	Progress
235	2001	560	Nick Carchedi	.55
455	2345	658	Ginger Grant	.10
767	6584	999	Chester Ismay	1.00

In 2NF form

Student_id (PK)	Course_id (PK)	Percent_Completed
235	2001	.55
455	2345	.10
767	6584	1.00

Course_id (PK)	Instructor_id	Instructor
2001	560	Nick Carchedi
2345	658	Ginger Grant
6584	999	Chester Ismay

3NF

- Satisfies 2NF
- No transitive dependencies: non-key columns can't depend on other non-key columns

Initial Data

Course_id (PK)	Instructor_id	Instructor	Tech
2001	560	Nick Carchedi	Python
2345	658	Ginger Grant	SQL
6584	999	Chester Ismay	R

In 3NF

Course_id (PK)	Instructor	Tech
2001	Nick Carchedi	Python
2345	Ginger Grant	SQL
6584	Chester Ismay	R

Instructor_id	Instructor
560	Nick Carchedi
658	Ginger Grant
999	Chester Ismay

Data anomalies

What is risked if we don't normalize enough?

1. **Update anomaly**
2. **Insertion anomaly**
3. **Deletion anomaly**

Update anomaly

Data inconsistency caused by data redundancy when updating

Student_ID	Student_Email	Enrolled_in	Taught_by
230	lisa@gmail.com	Cleaning Data in R	Maggie Matsui
367	bob@hotmail.com	Data Visualization in R	Ronald Pearson
520	ken@yahoo.com	Introduction to Python	Hugo Bowne-Anderson
520	ken@yahoo.com	Arima Models in R	David Stoffer

To update student 520 's email:

- Need to update more than one record, otherwise, there will be inconsistency
- User updating needs to know about redundancy

Insertion anomaly

Unable to add a record due to missing attributes

Student_ID	Student_Email	Enrolled_in	Taught_by
230	lisa@gmail.com	Cleaning Data in R	Maggie Matsui
367	bob@hotmail.com	Data Visualization in R	Ronald Pearson
520	ken@yahoo.com	Introduction to Python	Hugo Bowne-Anderson
520	ken@yahoo.com	Arima Models in R	David Stoffer

Unable to insert a student who has signed up but not enrolled in any courses

Deletion anomaly

Deletion of record(s) causes unintentional loss of data

Student_ID	Student_Email	Enrolled_in	Taught_by
230	lisa@gmail.com	Cleaning Data in R	Maggie Matsui
367	bob@hotmail.com	Data Visualization in R	Ronald Pearson
520	ken@yahoo.com	Introduction to Python	Hugo Bowne-Anderson
520	ken@yahoo.com	Arima Models in R	David Stoffer

If we delete Student **230** , what happens to the data on **Cleaning Data in R** ?

Data anomalies

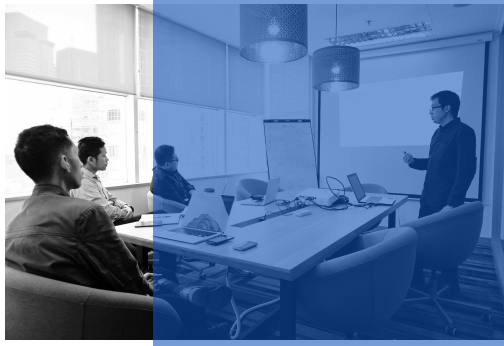
What is risked if we don't normalize enough?

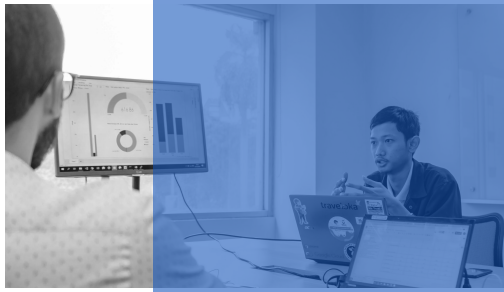
1. **Update anomaly**
2. **Insertion anomaly**
3. **Deletion anomaly**

The more normalized the database, the less prone it will be to data anomalies

References

Datacamp : database design
A cloud guru : database design





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Thank you!

nothin’ is impossible until its done