AT82.02

DATA MODELING AND MANAGEMENT

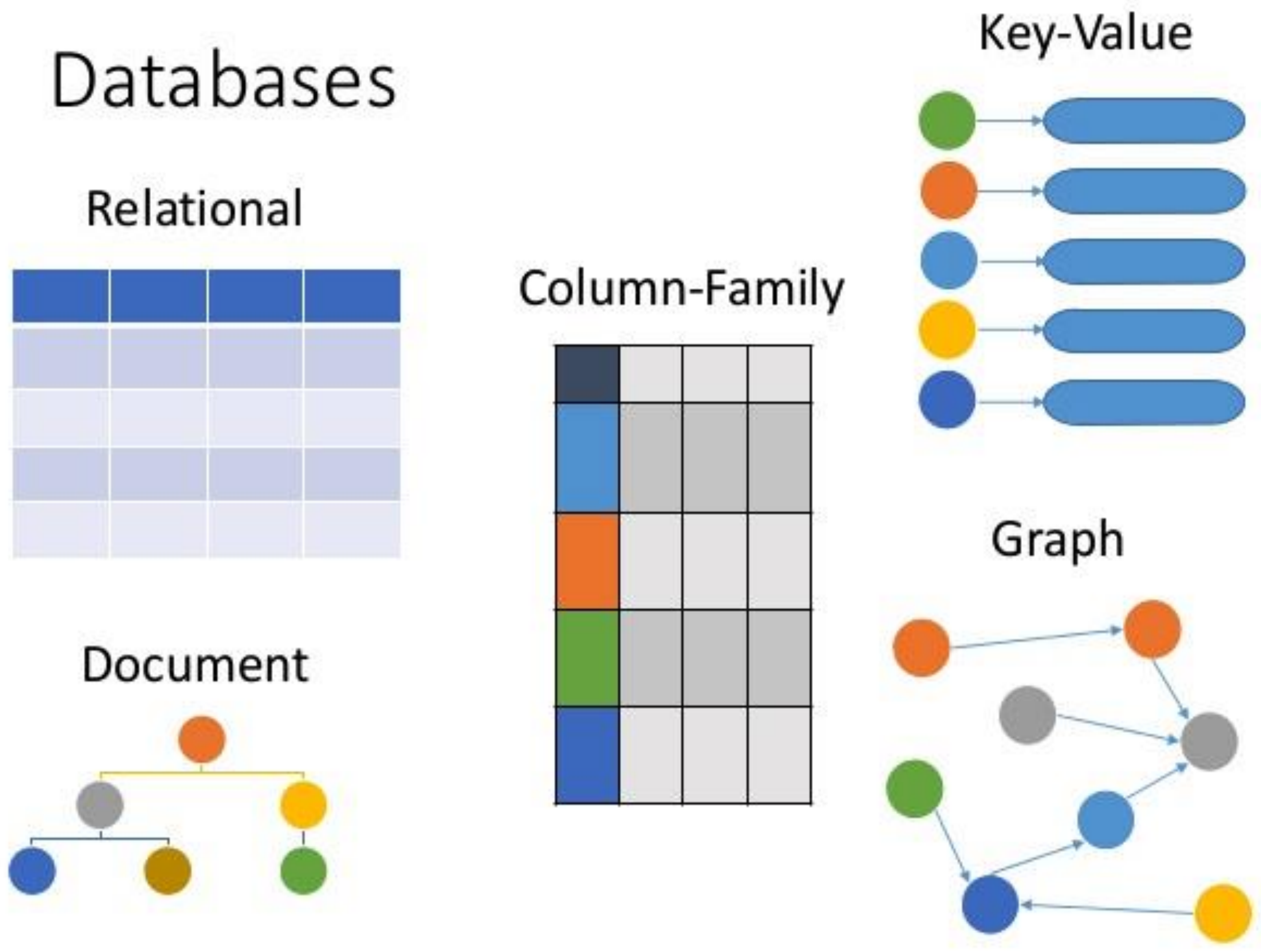
UNIT 2-3: COLUMN FAMILY MODEL

CHUTIPORN ANUTARIYA (CHUTI AT AIT DOT AC DOT TH)

Co-funded by the Erasmus+ Programme of the European Union

Database Family

RECAP



Column-Family Model

(AKA. COLUMNAR AND WIDE-COLUMN MODEL)

NOTE: MOST TERMINOLOGY USED HERE ARE BASED ON APACHE CASSANDRA SINCE IT IS ONE OF THE MOST POPULAR COLUMN-FAMILY STORES.

Column-Family Model

Column-family stores **enhance the key-value concept** by providing additional structure.

One of the most influential NoSQL database was Google’s BigTable.

Other stores: Cassandra, HBase, Hypertable, Amazon DynamoDB.

Column-Family Model

Most RDB databases has rows as unit of storage, which helps in writing performances.

In practical use, it has shown to be more efficient for optimizing read operations to store the data in relational tables not per row, but per column.

This is because all columns in one row are rarely needed at once, but there are groups of columns that are often read together.

Therefore, in order to optimize access, it is useful to structure the data in such groups of columns—column families—as storage units.

Column-Family Model

Columns can be grouped to column families to support organization and partitioning.

When you place related columns in the same family, instances of those columns will be stored as physically close to each other as possible.

Popular Column-Family Stores

Cassandra

HBase

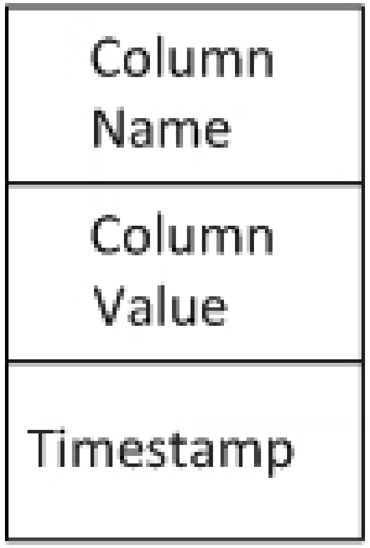
BigTable

- It uses a concept called keyspace, which works in a similar way to a relational model scheme.
- Each column is treated separately;
- They have high performance in aggregation queries (SUM, COUNT, AVG, MIN) since the data is available in one column;
- Widely used to manage data warehouses, business intelligence, CRM, card catalogs from the Library

Column

A column can be considered like a Key-Value pair:

- Key is the Column Name with an associated value.
- A column in a certain implementation may have an **additional field called timestamp.**



Column Name

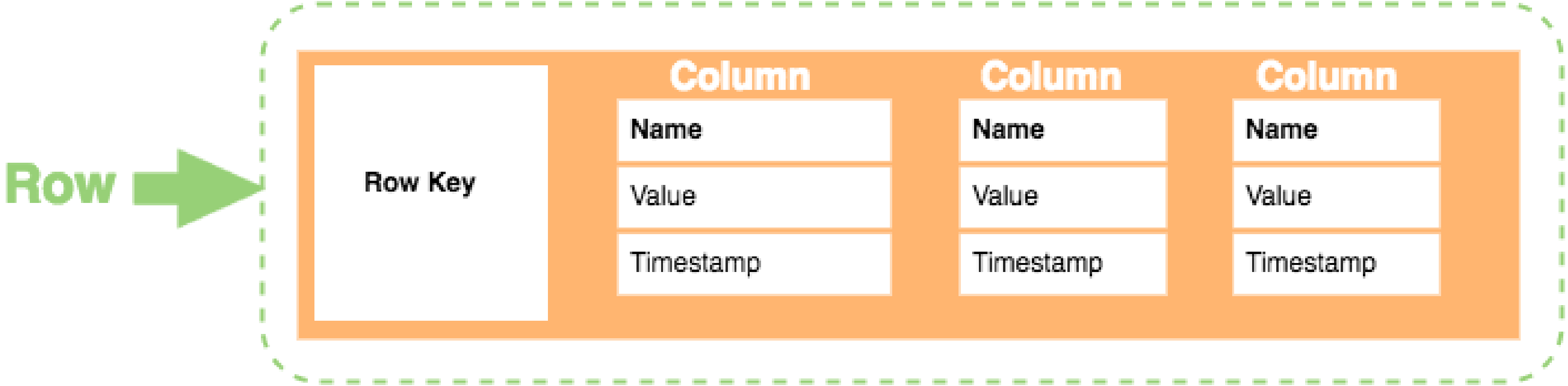
Column Value

Timestamp

Source: https://www.codeproject.com/Articles/518134/CassandraplusChapterplusThreeplus-e2-80-93plusData

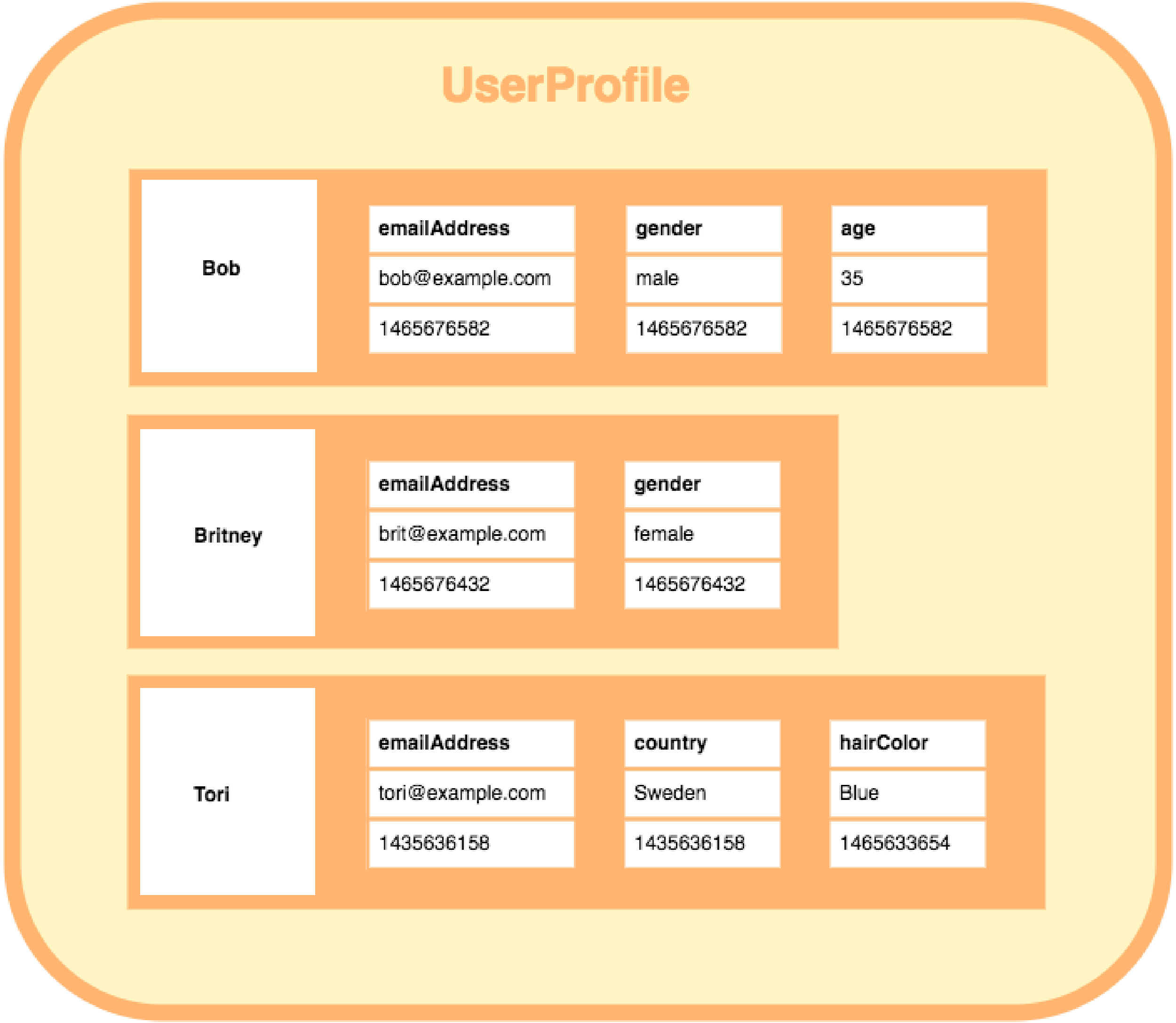
Column Family Data Model

- Row Key: Each row has a unique key, which is a unique identifier for that row.
- Column: Each column contains a name, a value, and timestamp.
  - Name: the name of the name/value pair.
  - Value: the value of the name/value pair.
  - Timestamp: provides the date and time that the data was inserted, which can be used to determine the most recent version of data.



src: https://database.guide/what-is-a-column-store-database/

Example: A Column Family with 3 rows



UserProfile

Bob

emailAddress	gender	age
bob@example.com	male	35
1465676582	1465676582	1465676582

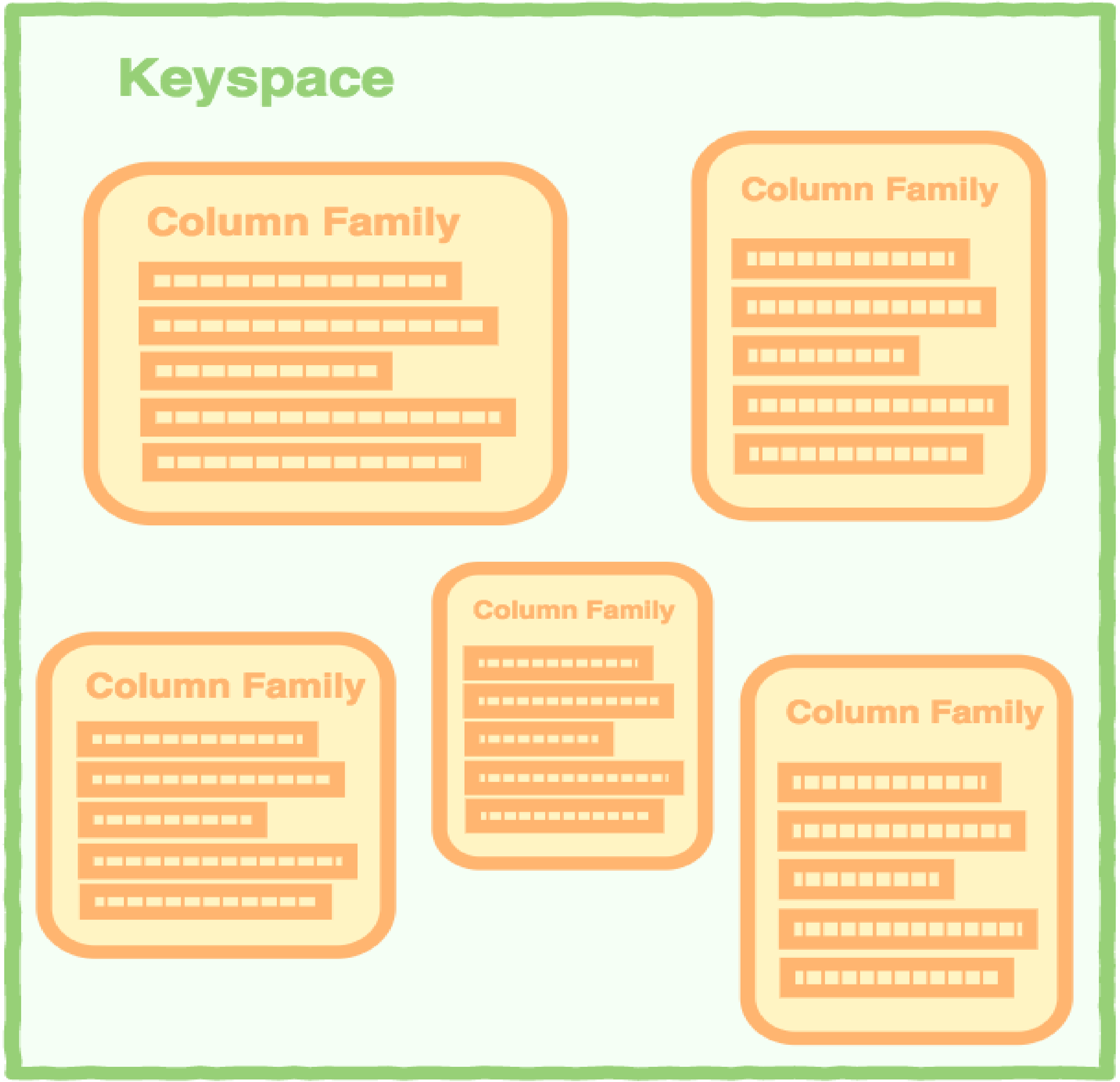
Britney

emailAddress	gender
brit@example.com	female
1465676432	1465676432

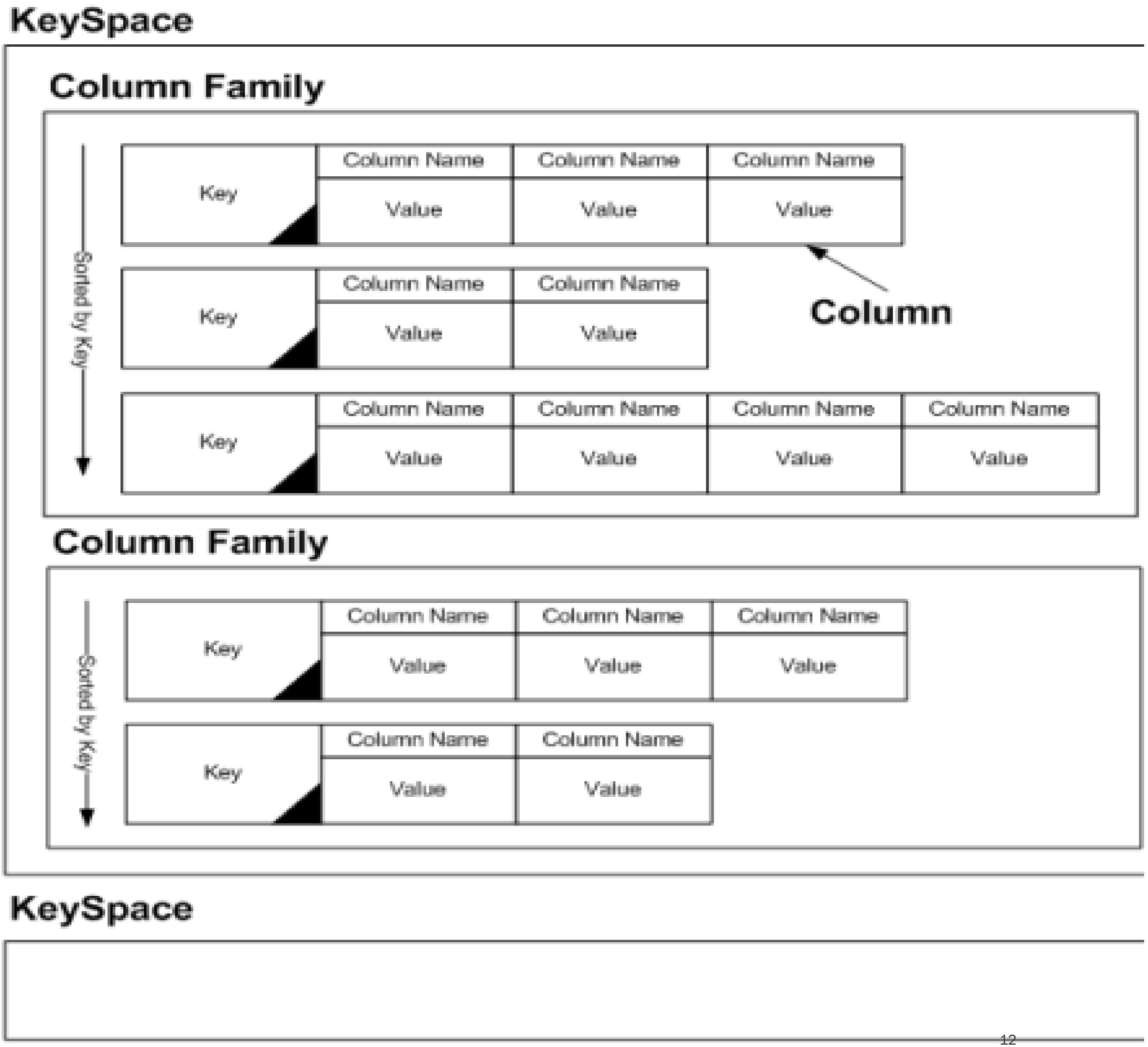
Tori

emailAddress	country	hairColor
tori@example.com	Sweden	Blue
1435636158	1435636158	1465633654

Keyspace

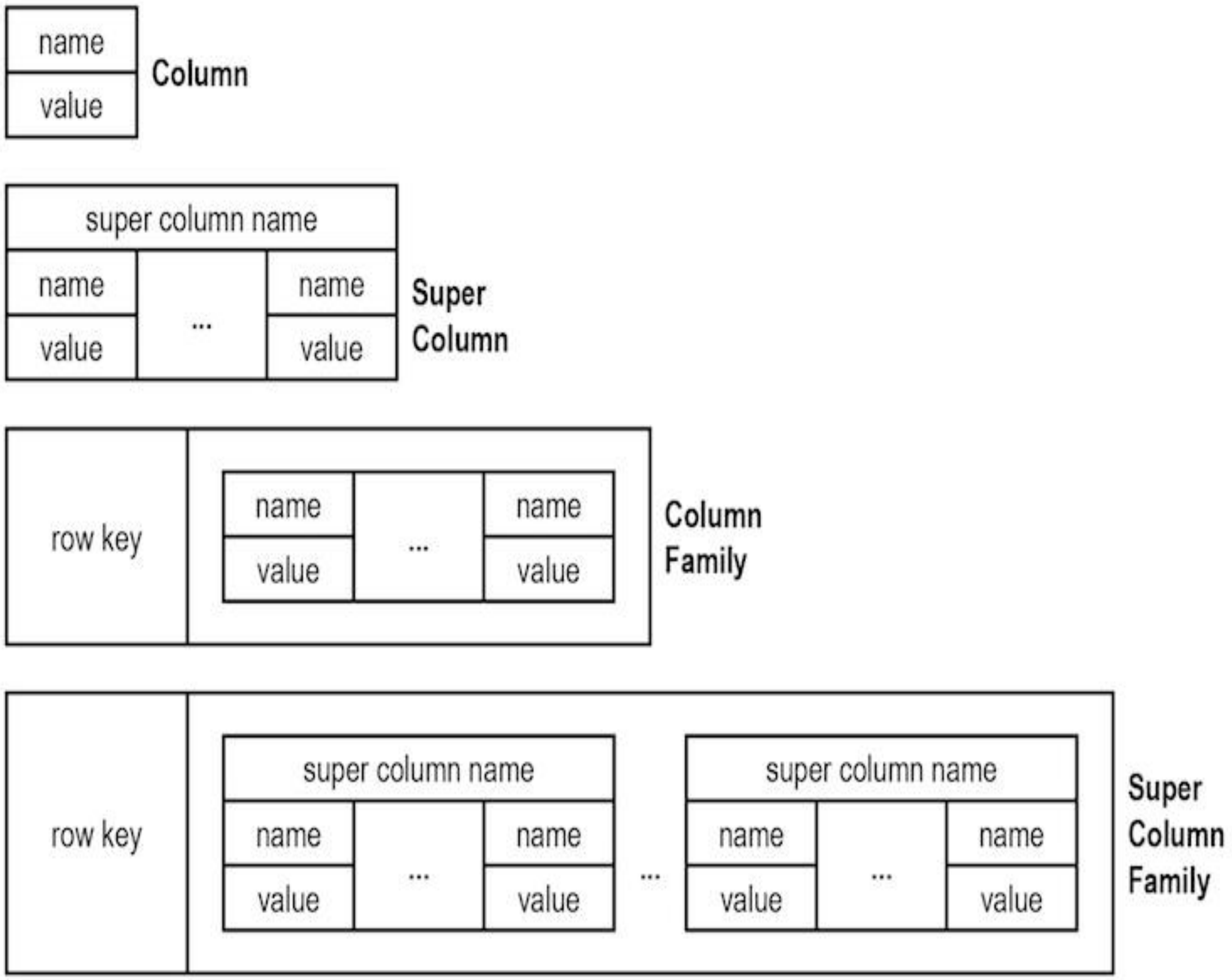

Keyspace
Column Family
Column Family
Column Family
Column Family
Column Family

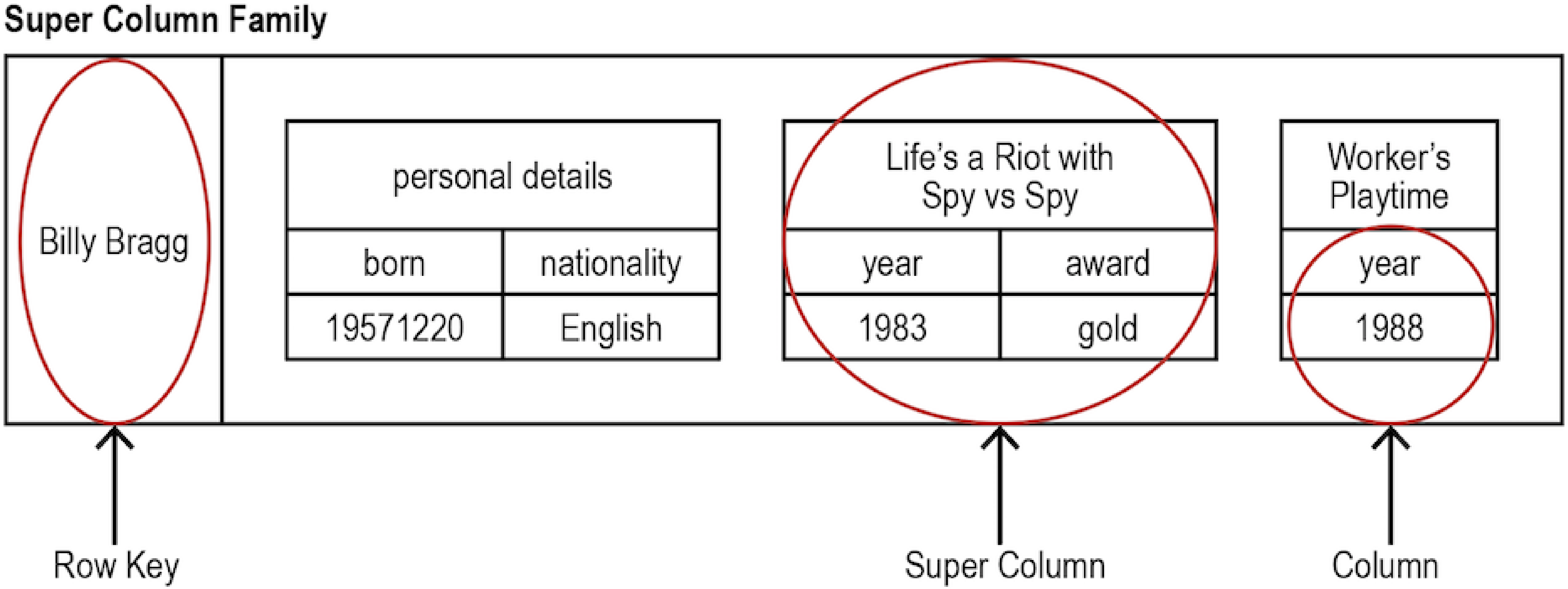
KeySpace


KeySpace
Column Family
Sorted by Key
Key
Column Name
Value
Column Name
Value
Column Name
Value
Column
Key
Column Name
Value
Column Name
Value
Key
Column Name
Value
Column Name
Value
Column Name
Value
Column Name
Value
Column Family
Sorted by Key
Key
Column Name
Value
Column Name
Value
Column Name
Value
Key
Column Name
Value
Column Name
Value
KeySpace

Four Building Blocks of Column Family Model

Figure source: https://neo4j.com/blog/aggregate-stores-tour/





Super Column Family

Billy Bragg

personal details

born	nationality
19571220	English

Life's a Riot with Spy vs Spy

year	award
1983	gold

Worker's Playtime

year
1988

Row Key

Super Column

Column

Storing Data in a Super Column Family

Figure source: https://neo4j.com/blog/aggregate-stores-tour/

Static vs. Dynamic Column Family

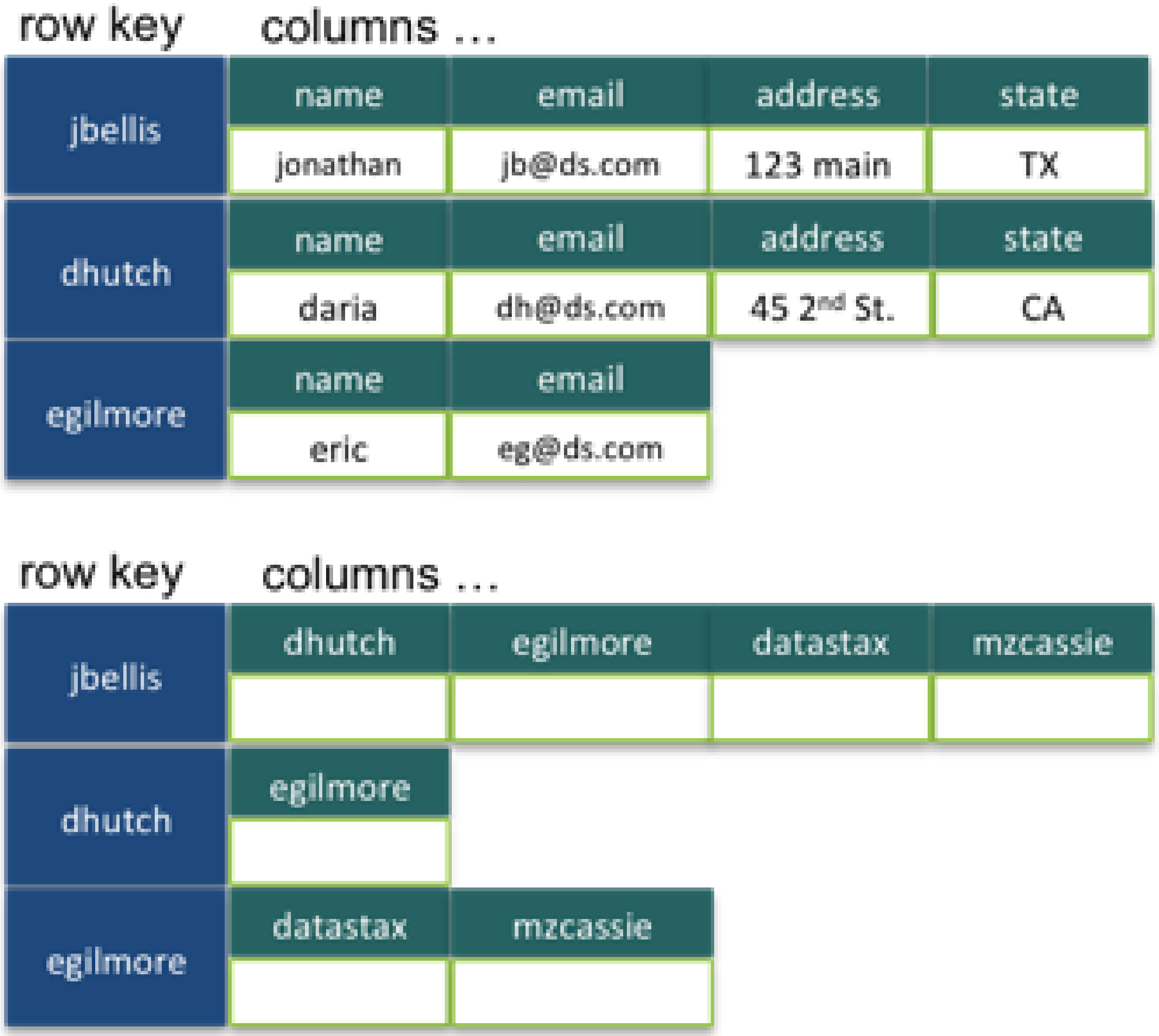
Static Column Family

- We can specify schema such as Column Names, their Data Types and indexes
- Rows are not required to reserve storage for every column defined in the schema and can be sparse.
- Space is only used for the columns that are present in the row.

Dynamic Column Family

- There is no schema. The application is free to store whatever columns it wants and their data types at run-time.

Static vs. Dynamic Column Family



row key	columns …			
jbellis	name	email	address	state
	jonathan	jb@ds.com	123 main	TX
dhutch	name	email	address	state
	daria	dh@ds.com	45 2nd St.	CA
egilmore	name	email		
	eric	eg@ds.com		

row key	columns …			
jbellis	dhutch	egilmore	datastax	mzcassie
dhutch	egilmore			
egilmore	datastax	mzcassie		

Summary

Keyspace: Top level container for Column Families

Column Family: A container for Row Keys and Column Families

Row Key: The unique identifier for data stored within a Column Family

Super Column: A Dictionary of Columns identified by Row Key

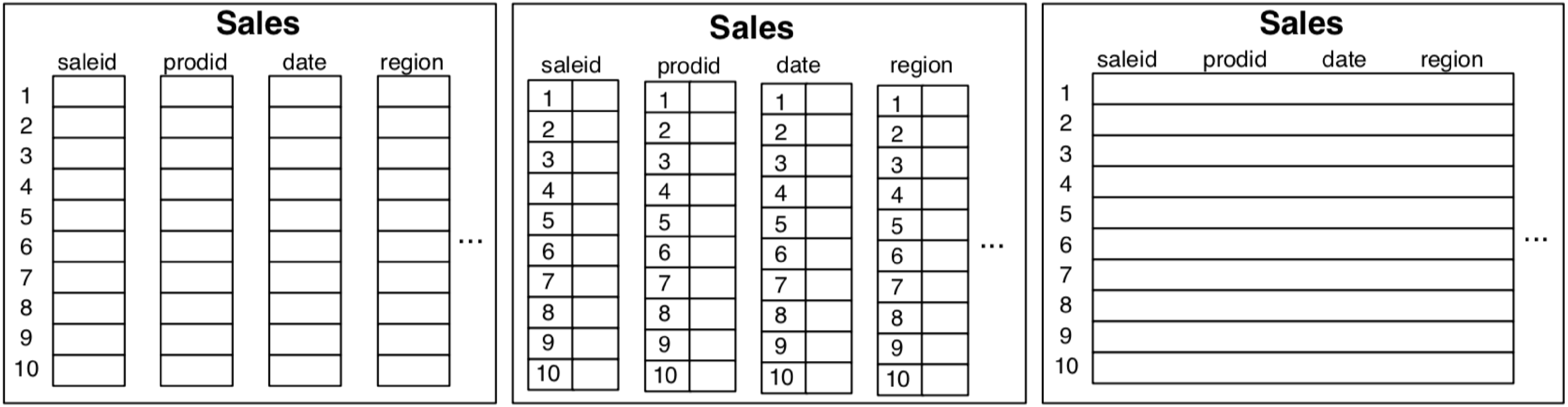
Column: Name-Value pair with an additional field: timestamp

Row-oriented vs. Column-oriented

Most RDB databases has rows as unit of storage, which helps in writing performances.

However, there are many scenarios where:

- Write are rares, but
- You need to read a few columns of many rows at once



(a) Column Store with Virtual Ids

(b) Column Store with Explicit Ids

(c) Row Store

Row-oriented vs. Column-oriented

Benefits & Limitations

The biggest benefit of a column-oriented database is fast data aggregation:

- Extracting data from a single column and providing summaries of that data.
- Google uses one, for example, to aggregate Web page visitation data. When the software has compiled the Web sites visited and the number of times each was visited, the data are archived.

Benefits & Limitations

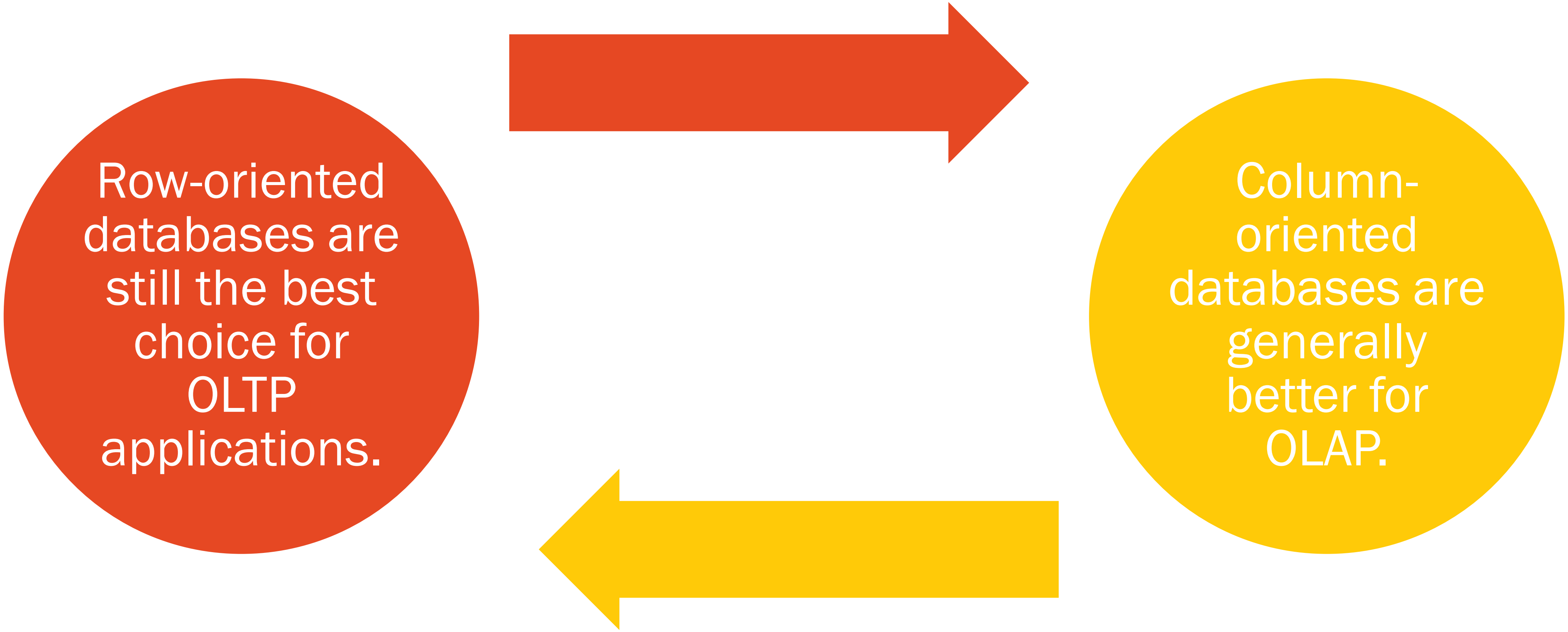
Unlike transactional data, which is written frequently, analytical data doesn't change often. It's usually created by infrequent bulk writes – data dumps.

Columnar store lets you ignore all data that do not apply to a particular query, because you can retrieve the information from just the columns you want.

To insert a new record in a row-oriented database, it takes a single operation.

However, it takes more computing resources to write a record to a columnar database, because you have to write all the fields to the proper columns one at a time.

Applications



Row-oriented databases are still the best choice for OLTP applications.

Column-oriented databases are generally better for OLAP.

Query-driven Modeling: an Example

Understanding a query-driven approach to data modeling

Using Cassandra to model a hotel reservation database and its queries

Comparing RDB Modeling with Cassandra query-driven modeling

http://cassandra.apache.org/doc/latest/cassandra/data_modeling/index.html

the REFERENCE

- P. Sadalage and M. Fowler: NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison-Wesley Professional, 2013
- Jan L. Harrington: Relational Database Design and Implementation, 4th edition, Morgan Kaufmann, 2016
- A. Makris, K. Tserpesa, V. Andronikou Dimosthenis Anagnostopoulos: A Classification of NoSQL Data Stores Based on Key Design Characteristics, Procedia Computer Science, Vol. 97, 2016, pp. 94-103.