Introduction to Data Structure (Data Management) Lecture 10

Felipe P. Vista IV

Reminder

- Everybody, make sure that your name in ZOOM is in the following format:
  - University ID Num Name (no “(   )“)
  - Ex: 202054321 Juan Dela Cruz
  -
  - Not changing your name to this format
    - you might be marked Absent

    * → absent?

- NoSQL

- JSon and Semi-tructured Data

INTRO TO DATA STRUCTURE

NOSQL
(CH 11.1)

Motivation for NoSQL

Hello
hello 2!

- Motivated by Web 2.0 Applications
  - Web 2.0 allow anyone to create and share online information or material
  - Key element is allow people to create, share, collaborate & communicate
  - Hosted services (Google Maps), Web Apps (Google Docs, Flickr), vid sharing sites(YouTube), wikis, blogs, SNS(FB,IG), microblogging(Twitter)

Motivation for NoSQL

- Goal is to scale simple OLTP-style applications to millions or even billions of users
- OLTP (OnLine Transaction Processing)
  - capture, store, process data from transactions in real-time
  - typical size range from 100MB to 10GB
  - Ex: online banking, purchasing book online, booking ticket, send text message, call center staff view/update customer info

Motivation for NoSQL

- Facebook has 1.79B active users daily (Q2 2020)
  - use often correlated in time in each region
    - *correlated : one thing affects or depends on another*
  - more than 10M requests/sec if 25% users arrive w/in hour
  - SQL Server would crash under this workload
- Users doing both reads and updates

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- Single server DBMS too small for Web data

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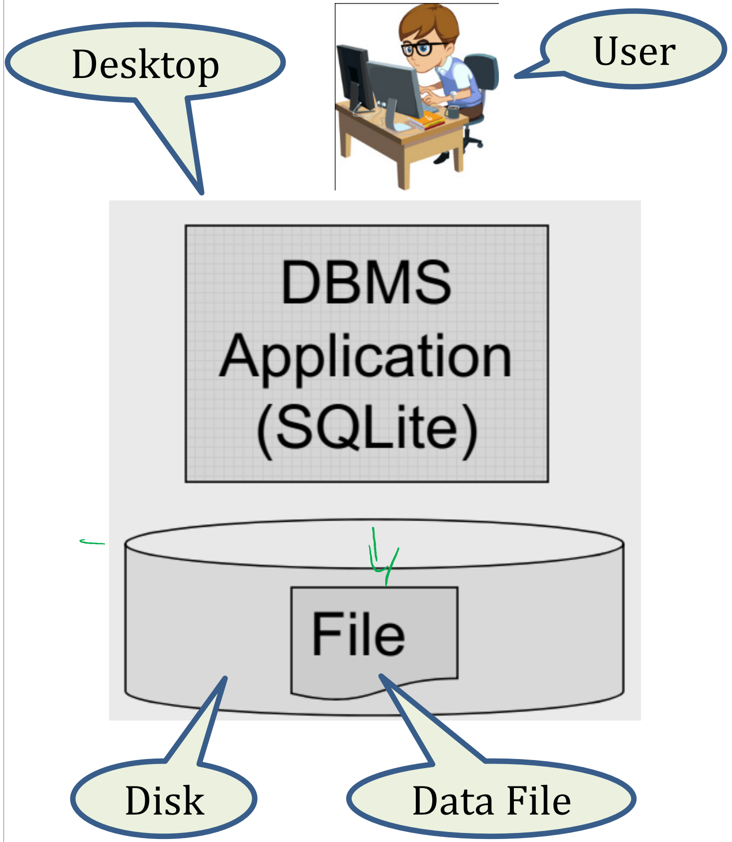
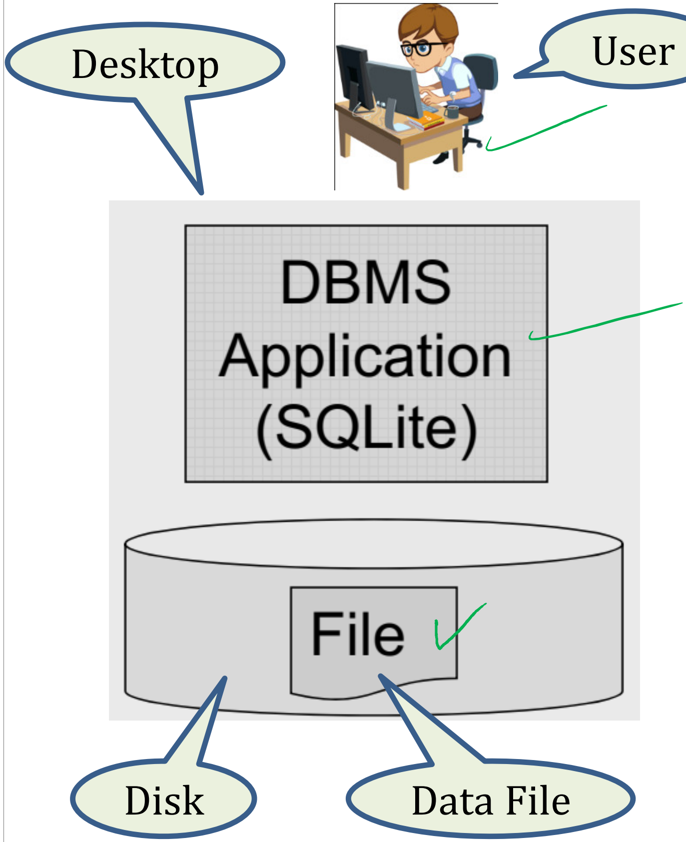
- NoSQL: reduce functionality for easier scaling
  - simpler data model
  - fewer guarantees

Serverless Architecture



Serverless Architecture



SQLite

- One data file
- One user
- One DBMS application

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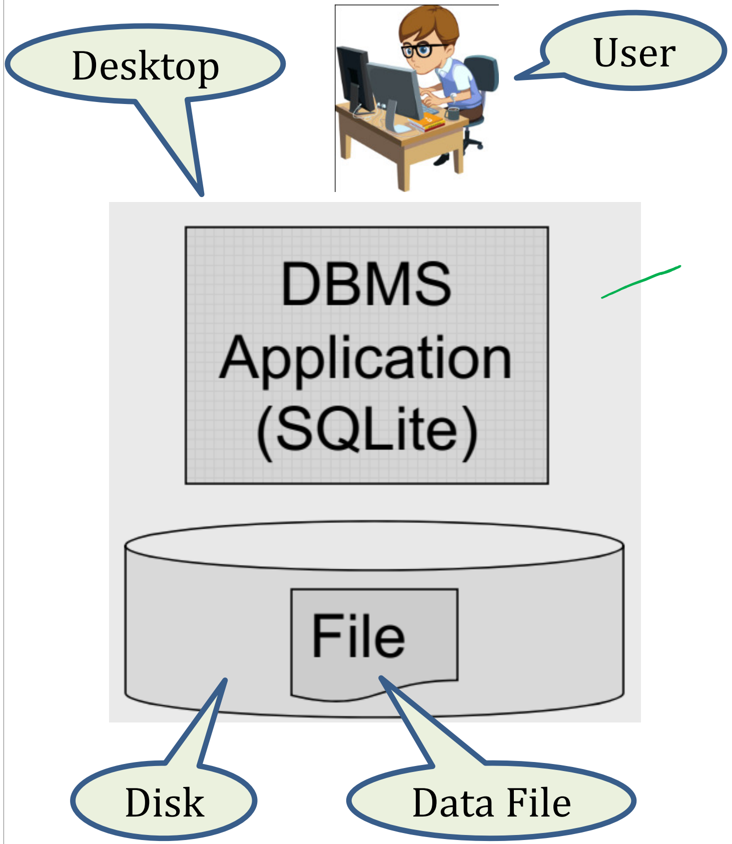

SQLite

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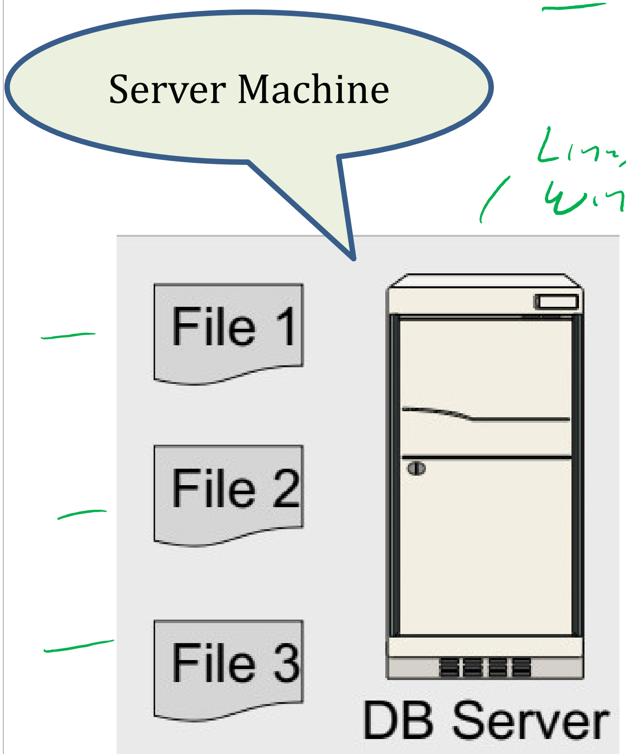
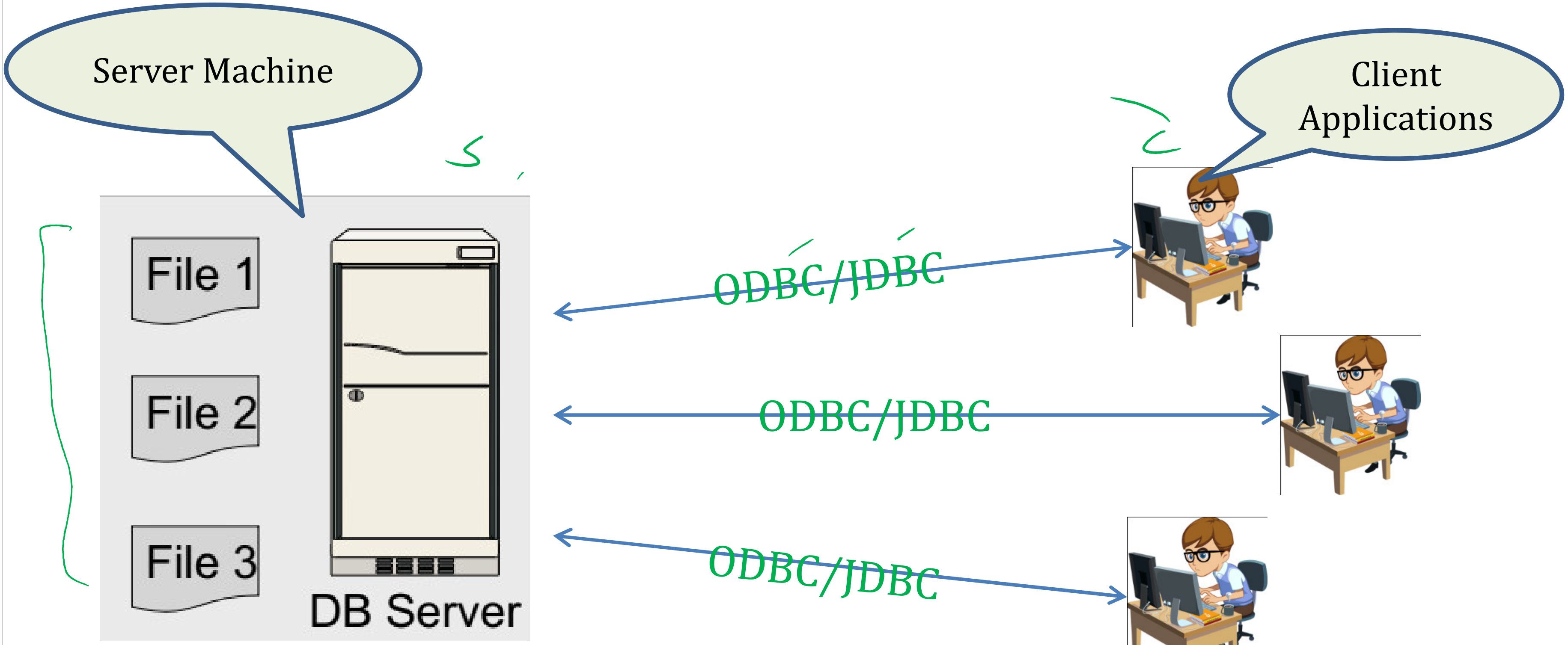
- Scales well
- But only a limited number of scenarios work with such model
- Can be in browser/ phone

Client-Server Architecture



Linux
Win
Unix

Client-Server Architecture



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- Many clients, connecting via ODBC (Open DB Connectivity / JDBC (Java DB Connectivity

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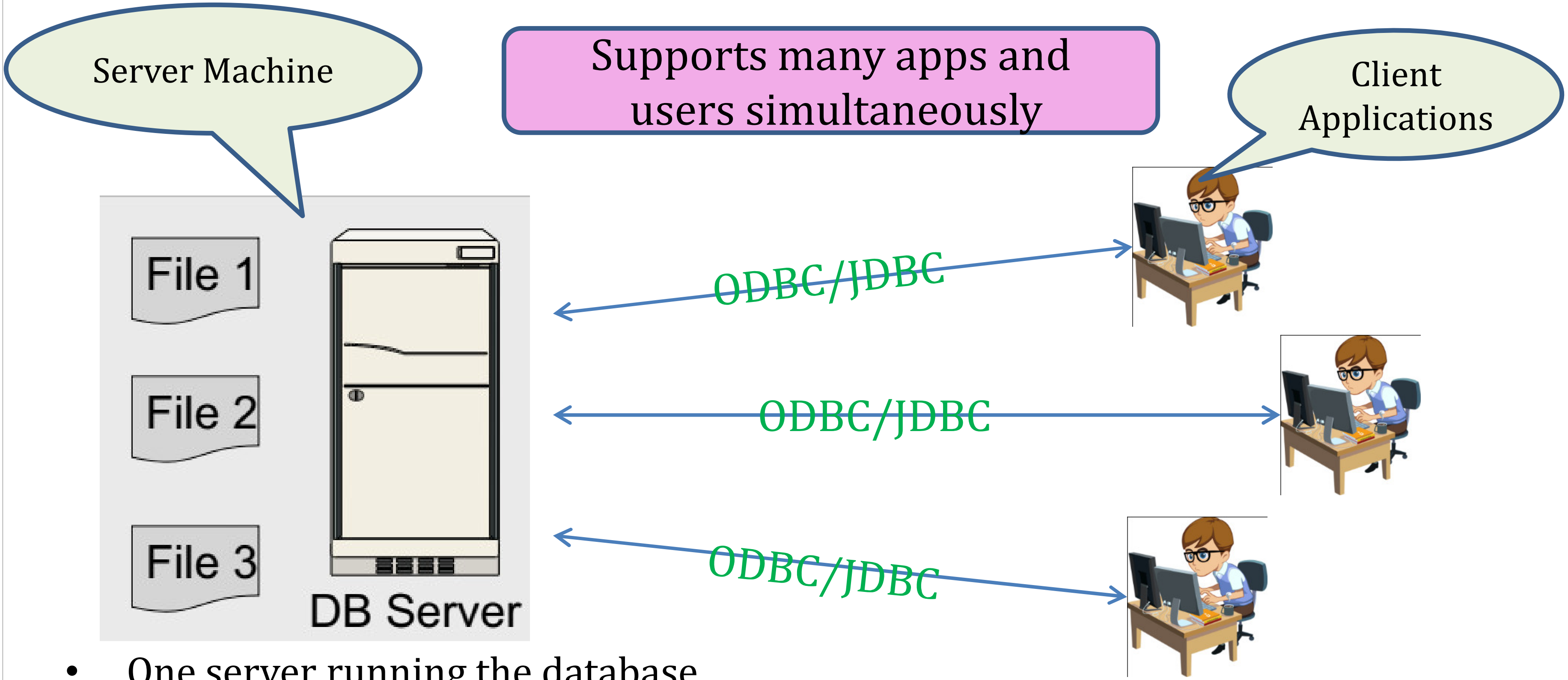

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  - pSQL (for postgres)
  - some Java program or C++ program

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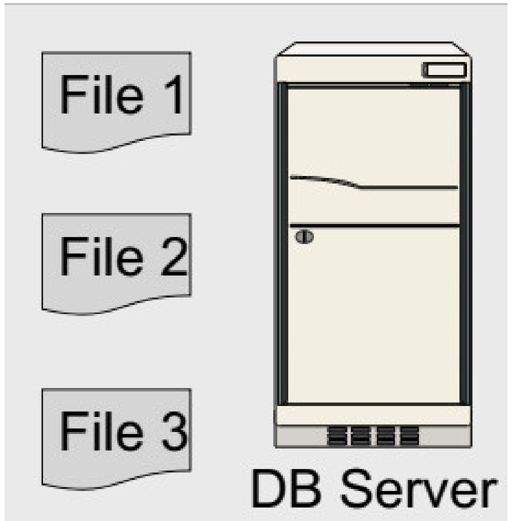
- Clients "talk" to server using ODBC/JDBC protocol

3-Tiered Architecture



Web-based Applications

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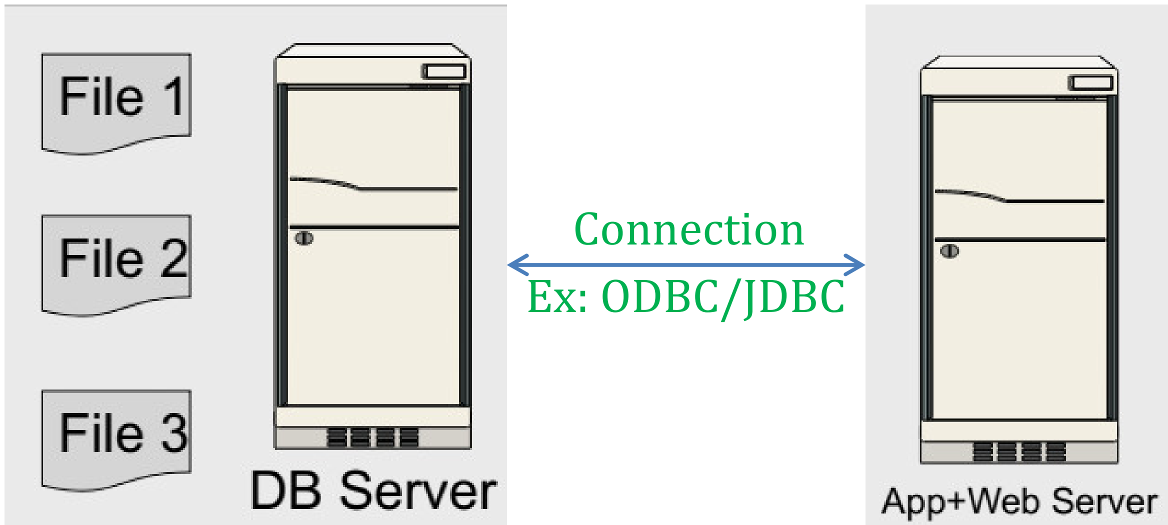

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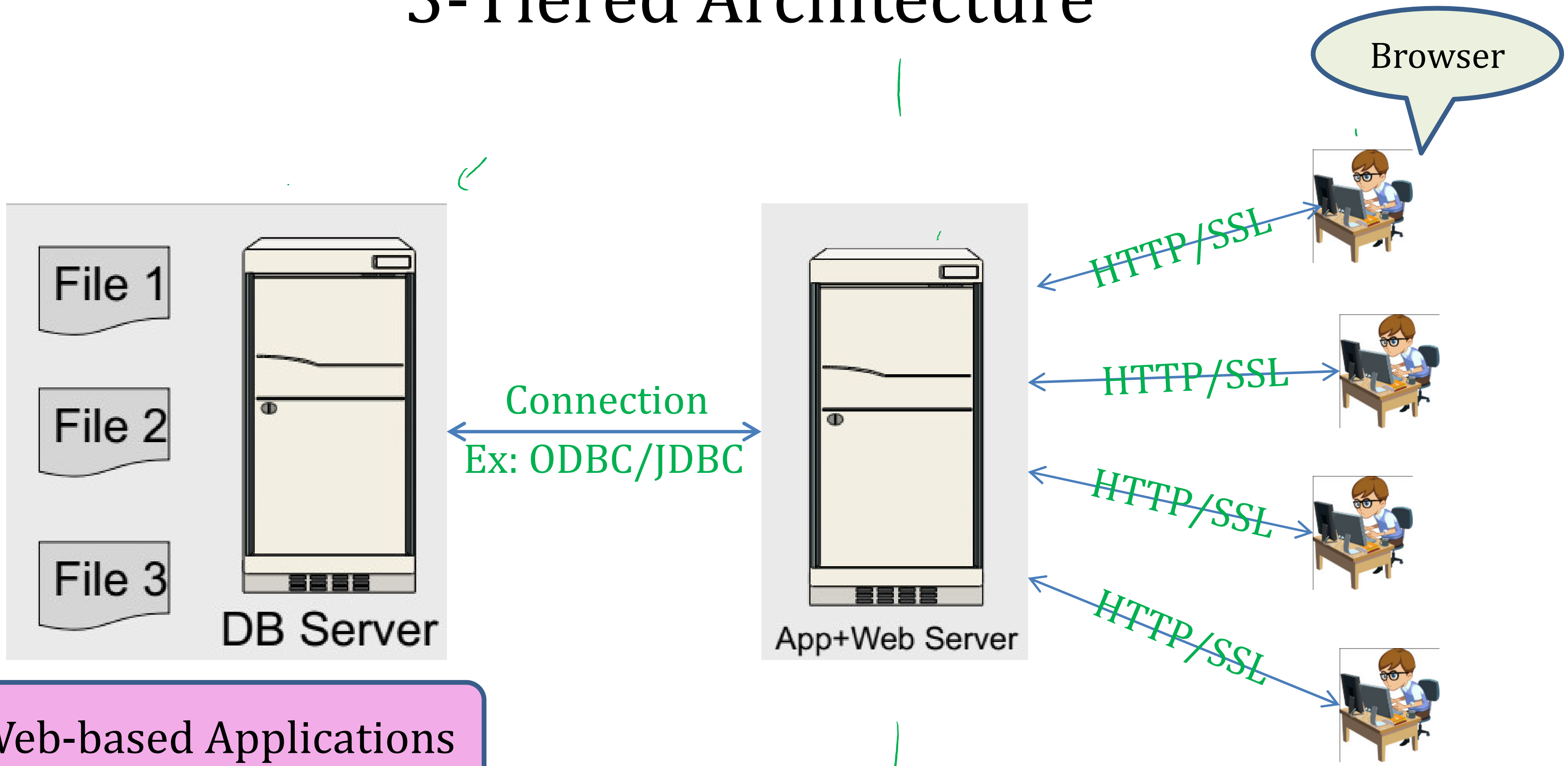

Web-based Applications

* HTTP s = Hyper Text Transfer Protocol Secure
* SSL = Secure Socket Layer

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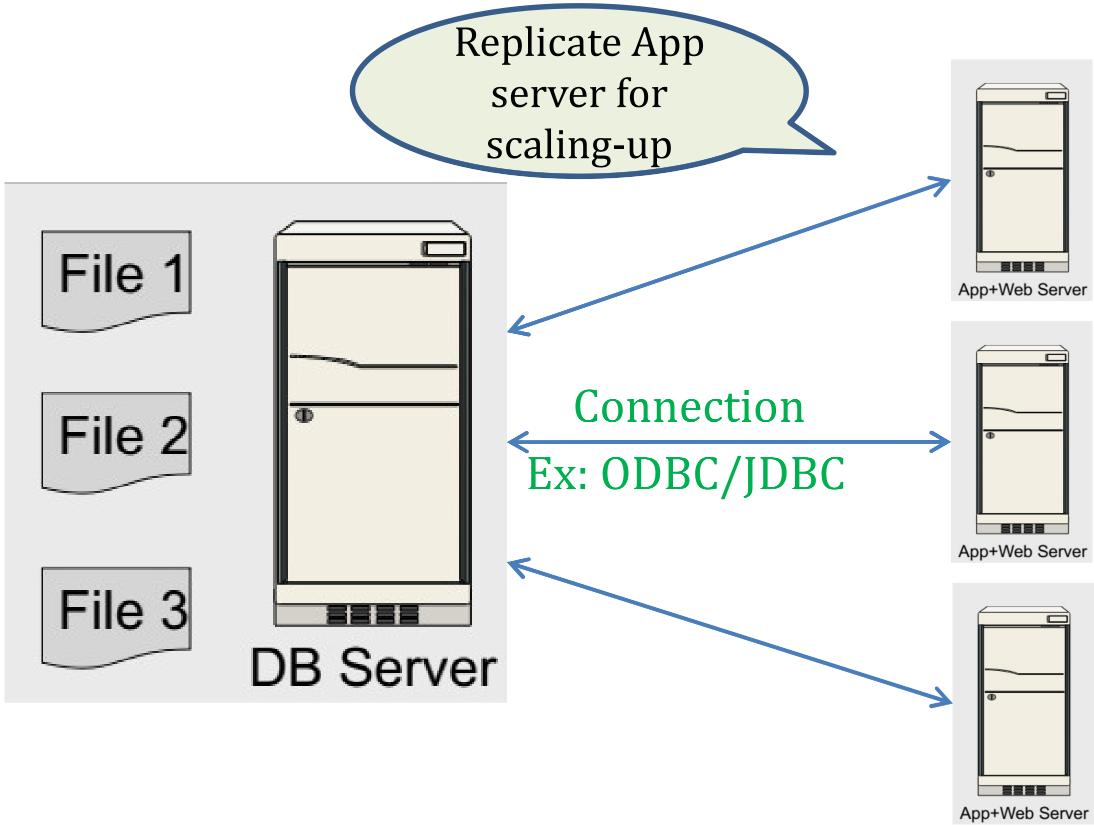

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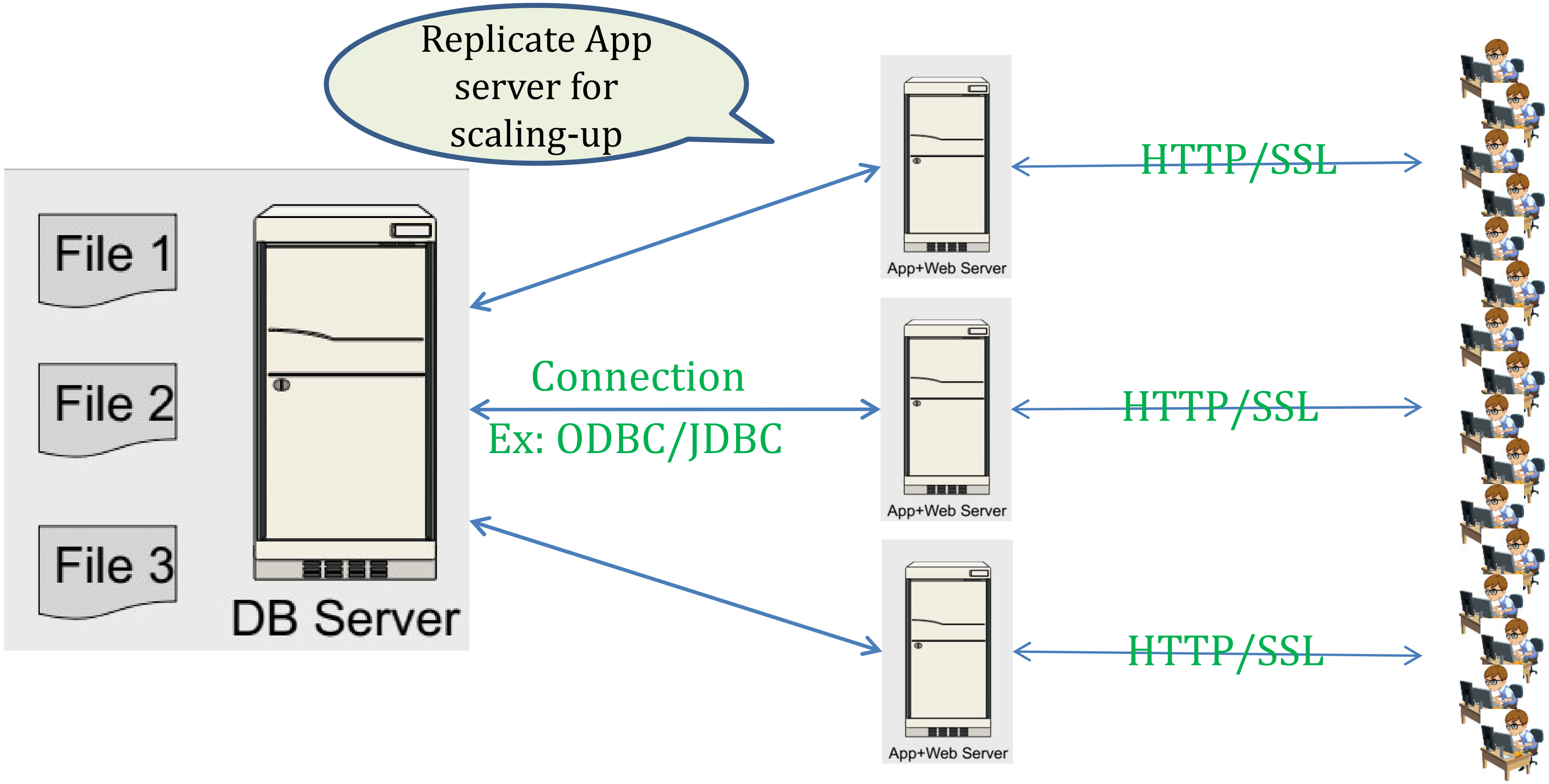

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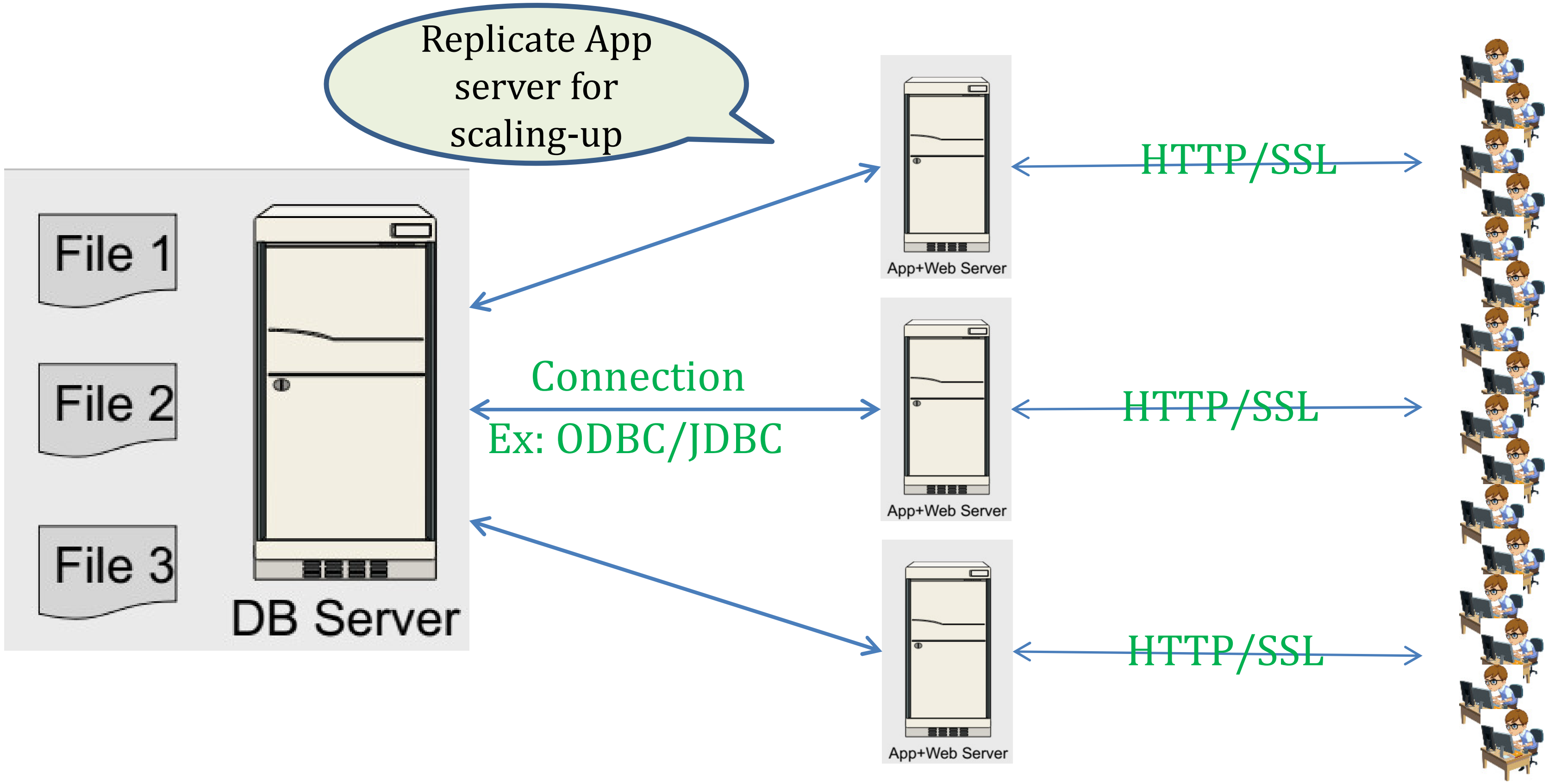

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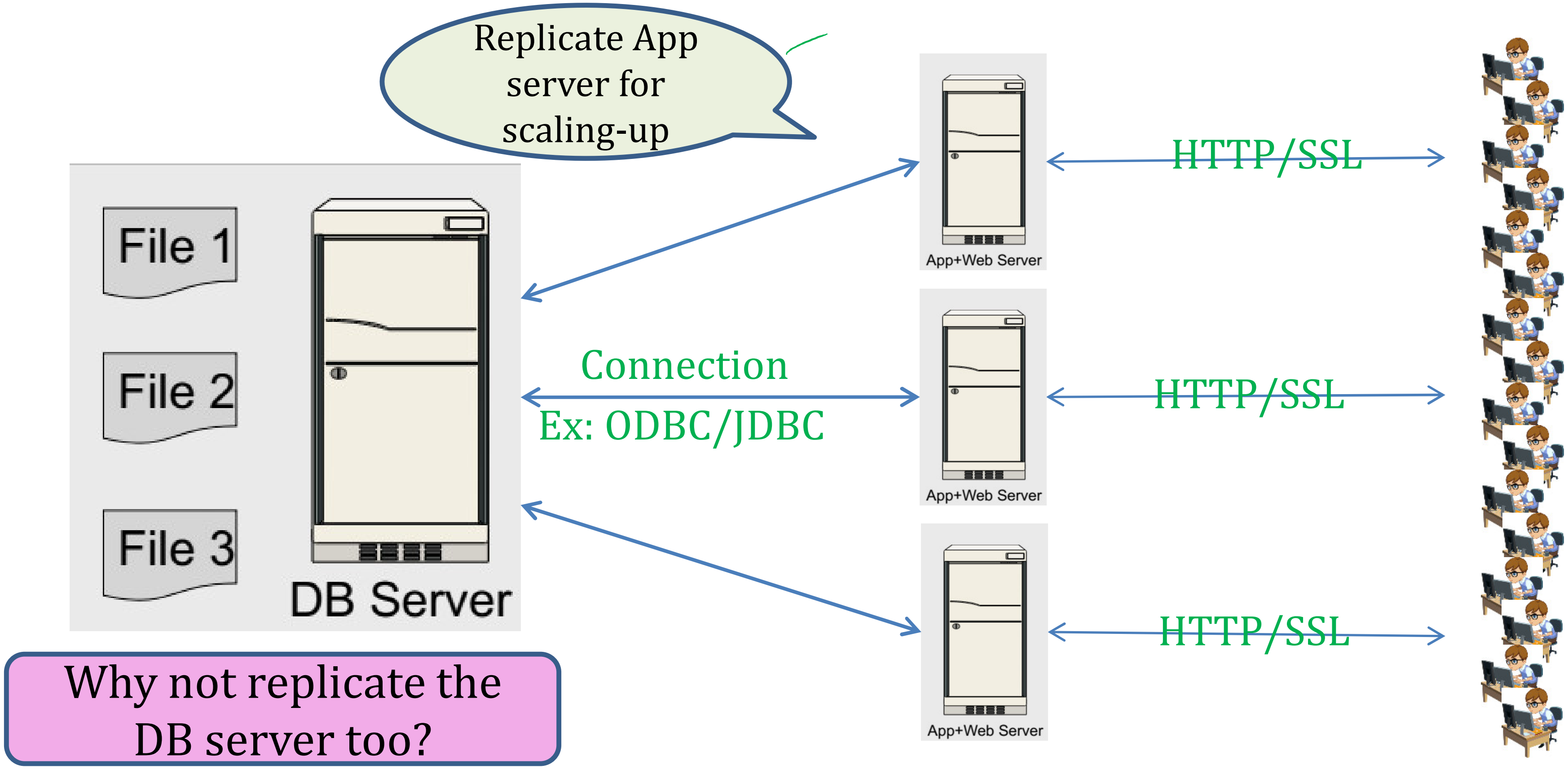

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Replicating the Database

- Much harder because the state must be unique. In other words, database must act as a whole
  - Current DB instance must always be ***consistent***
    - Ex: Foreign keys must exist
    - as a result, some **updates** must occur simultaneously

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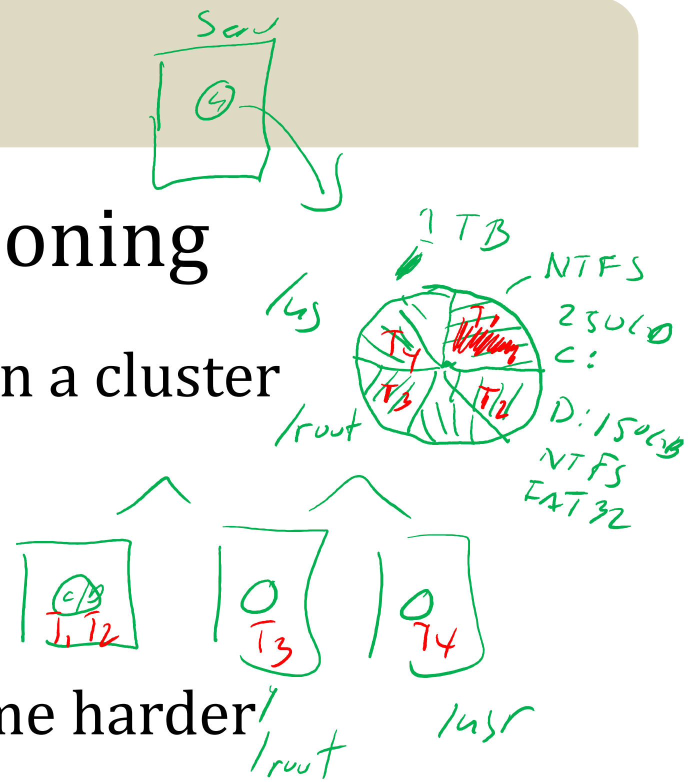
- Two basic approach:
  - Scale up by partitioning
  - Scale up by replication

Scale Through Partitioning



- Partition the DB across many machines in a cluster
  - Database could fit in main memory
  - Queries spread across these machines
- Can increase throughput
- Easy for (simple) writes but reads become harder

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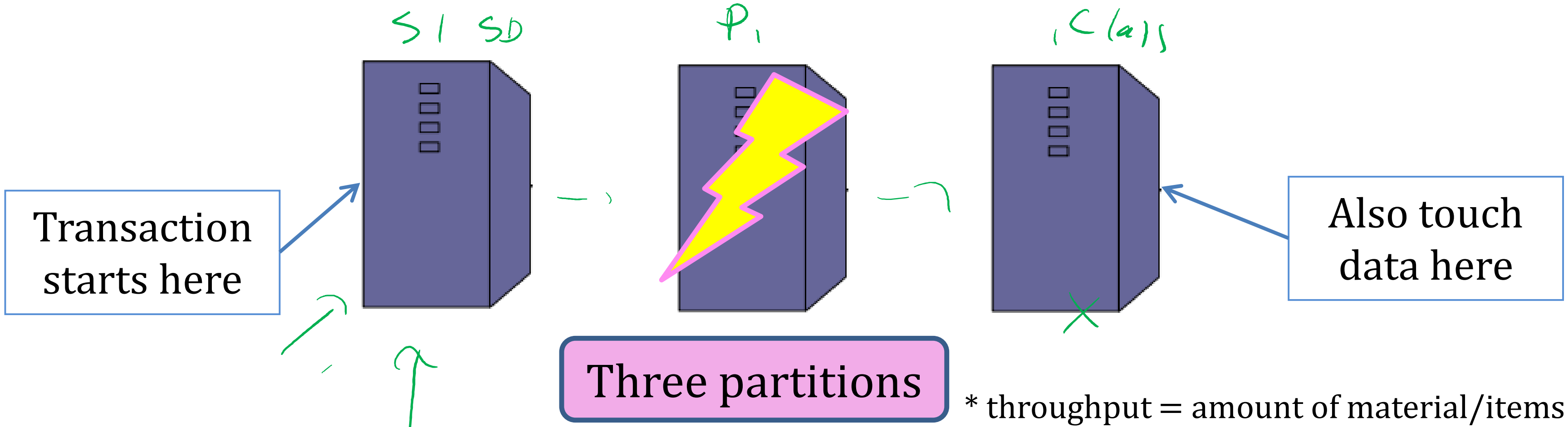

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Scale Through Replication

- Create multiple copies of each database partition
- Spread queries across these replicas
- Can increase throughput and lower latency
- Can also improve fault-tolerance
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* latency = delay before transfer of data starts after instruction for its transfer
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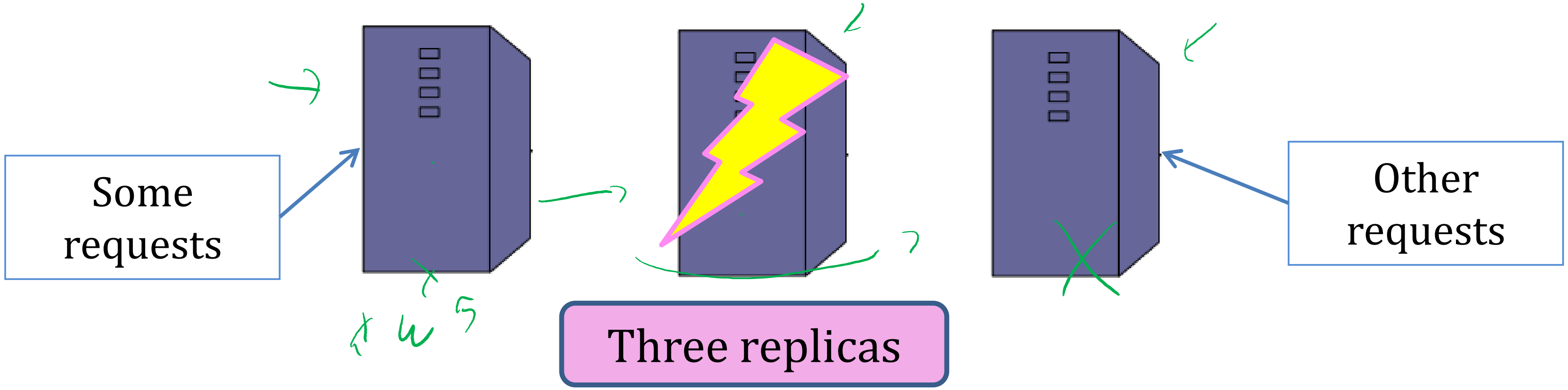

NoSQL Data Models

Taxonomy based on data models

- Key-value stores
  - Ex.: Project Voldemort(LinkedIn), Memcached

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- Operations
  - Get(key), Put(key, value)
  - Operations on value not supported
- Distribution/ Partitioning
  - No replication: key k is stored at server h(k)
  - 3-way replication: key is stored at h1(k), h2(k), h3(k)

How does get(k) work? How does put(k,v) work?

- `Flights(fid, date, carrier,`
  `flight_num, origin, dest, …)`
- `Carriers(cid, name)`

Example

How would you represent the Flights data as (key, value) pairs

```
Flights(fid, date, carrier,
        flight_num, origin, dest, …)
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date#c ..a # f num#...

- Option 1: key=fid, value=entire flight record

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datetime [ddmmyyhhmmss]

- Option 2: key=date, value=all flights that day

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How would you represent the Flights data as (key, value) pairs

- Option 1: key=fid, value=entire flight record
- Option 2: key=date, value=all flights that day
- Option 3: key=(origin, dest), value=all flights between

inc hwi

How does query processing work?

Key-Value Stores Internals

- Data remains in main memory
  - One implementation: distributed hash table

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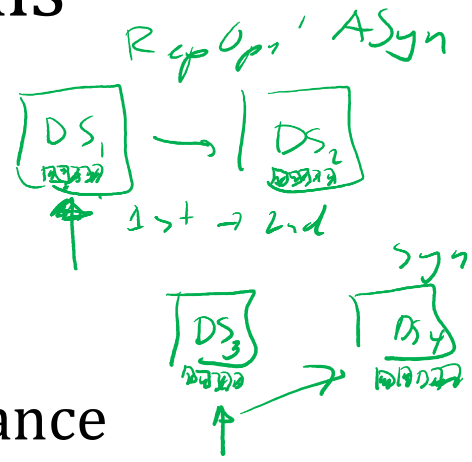


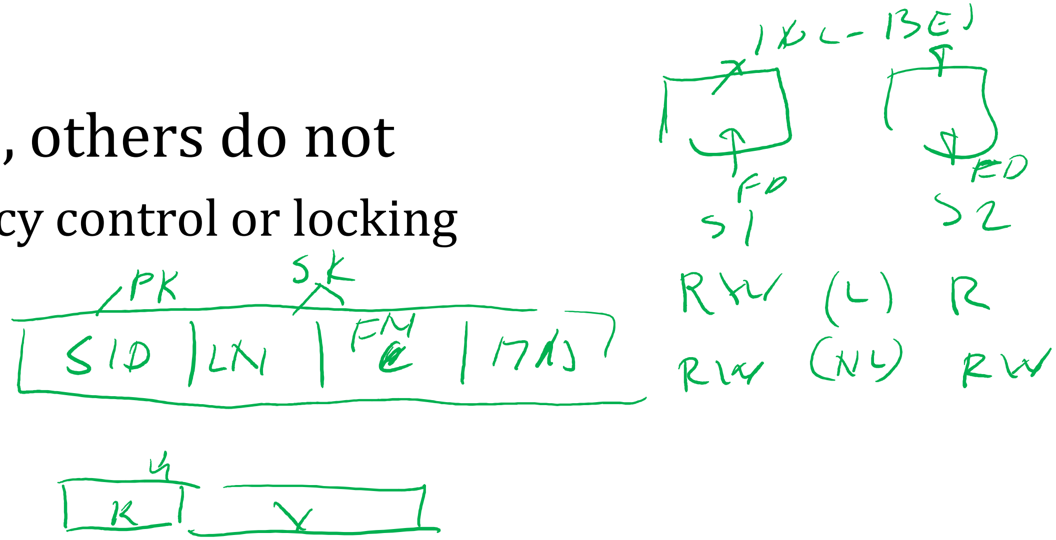
- Data remains in main memory
  - One implementation: distributed hash table
- Most systems also offer a persistence option
- Others use replication to provide fault-tolerance
  - Asynchronous replication: copy data to the replica after the data is already written to the primary storage
  - Synchronous replication: write data to primary storage and the replica simultaneously
  - Tunable consistency: read/write one replica or majority

Tune

* persistence = data survives after process it was created has ended
* replica = exact copy of a database or other data store

Key-Value Stores Internals

- Some offer transactions, others do not
  - Multi-version concurrency control or locking
- No secondary indices



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  - Get/Put document by key
  - Limited, non-standard query language on JSON
- Distribution/ Partitioning
  - Entire documents, as for key/value pairs

Will discuss JSon next time

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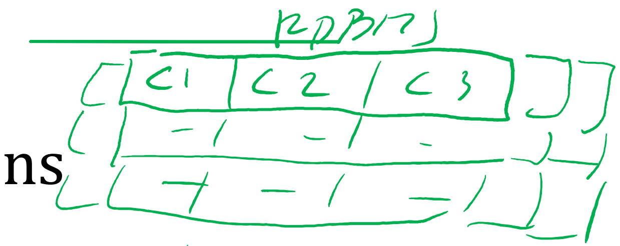

Long Schema

C1 : INT PK
C2 : vchar(2)

Extensible Record Stores

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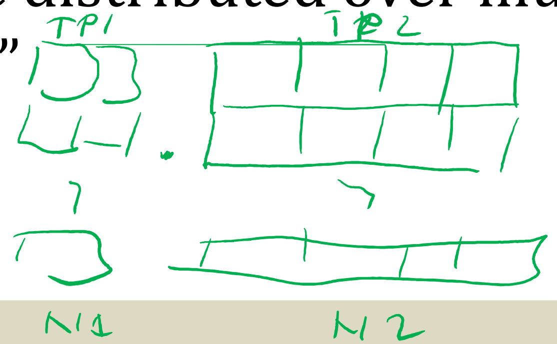
  - HBase is an open source implementation of BigTable
- Data model is rows and columns
  - Can add both new rows and new columns
- Scalability by splitting rows & columns over nodes
  - Rows partitioned through hashing on primary key
  - Columns of a table are distributed over multiple nodes using "column groups"



NoSQL Summary

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- Meanwhile…

  SQL systems continue to improve

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- Systems must weaken guarantees
- Google Spanner (support SQL)
  - Write data over whole globe (a bit slowly)
  - Reads occur slightly in the past

Prediction

- Best guess is SQL will win

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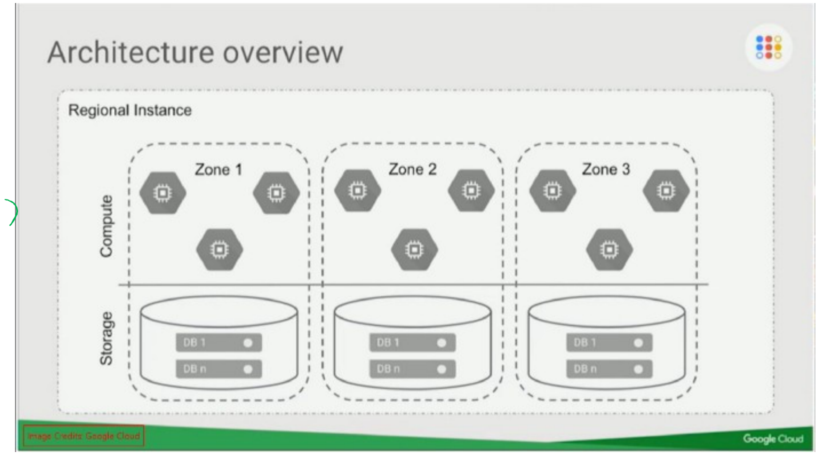
- Pieces are out there already
  - Spanner: multi-node transactions



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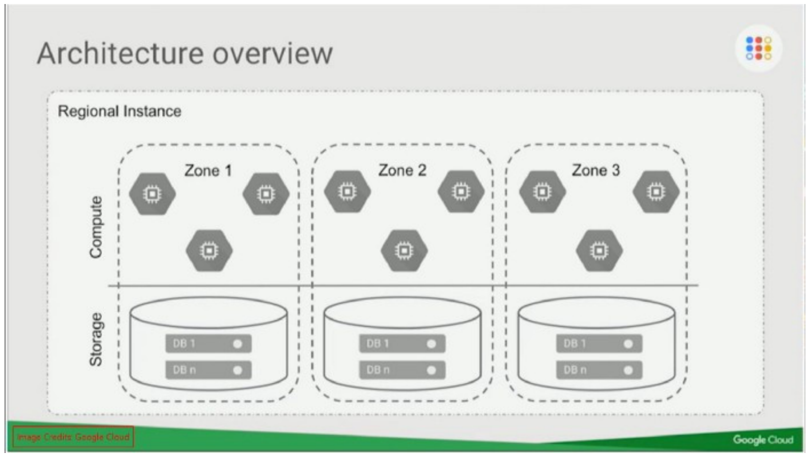

  - AsterixDB: multi-node query optimization
- For now, NoSQL still offers key benefits

INTRO TO DATA STRUCTURE

JSON

Where Are We

- So far, we have studied relational data model
  - Data are stored in tables (relations)
  - Queries are expressions in the SQL/ Datalog/ Relational Algebra

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- Today: Semi-structured data model
  - Popular formats: XML, JSon, protobuf

Semi-structured Data

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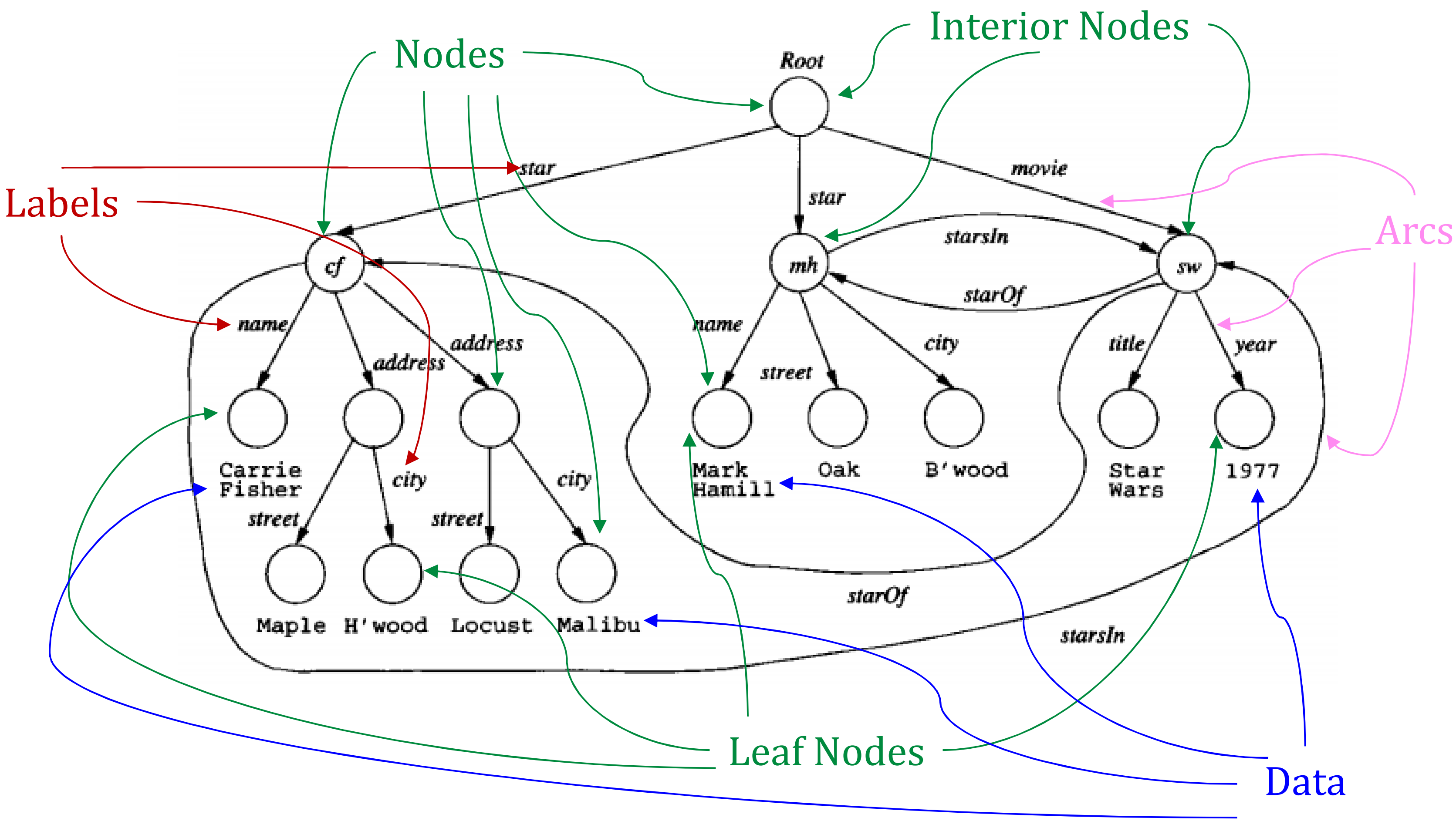
  - Associated data; any atomic type: integer, string, etc
- Interior node
  - One or more arcs going out, each arc has label
- Root node (an interior node)
  - No arc entering, represent entire DB
  - Every node must be reachable from root node

Semi-structured Data



JSON

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  - Native browser function parsed JSON 100x faster

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- JSON used in Gmail etc. for this reason
- Spread organically to server-side systems

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Overview of JSON

- JavaScript Object Notation
  - Lightweight text-based open standard designed for human-readable data interchange.
  - Interfaces in C, C++, Java, Python, Perl, etc.

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- The filename extension is .json

We will emphasize JSon as semi-structured data

JSon vs Relational

- Relational data model
  - Rigid flat structure (tables)
  - Schema must be fixed in advanced
  - Binary representation
    - *good for performance, bad for exchange*

JSon vs Relational

- Relational data model
  - Rigid flat structure (tables)
  - Schema must be fixed in advanced
  - Binary representation
    - *good for performance, bad for exchange*
- Semi-structured data model/JSon
  - Flexible, nested structure (trees)
  - Does not require predefined schema ("self-describing")
  - Text representation
    - *bad for performance, good for exchange*
  - Most common use
    - *language API; query languages emerging*

JSon Syntax

```
{ "book": [
    {"id": "01",
     "language": "Java",
     "author": "H. Javeson",
     "year": 2015
    },
    {"id": "07",
     "language": "C++",
     "edition": "second",
     "author": "E. Sepp",
     "price": 22.25
    }
  ]
}
```

JSon Terminology

- Curly braces “{ }”hold objects
  - Each object is a list of name/value pairs separated by a comma “,”
  - Each pair is a name followed by a colon “:”, and followed by the value

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- Curly braces "{ }"hold objects
  - Each object is a list of name/value pairs separated by a comma ","
  - Each pair is a name followed by a colon ":", and followed by the value
- Square brackets "[ ]" holds array and values are separated by comma ","
- Data made up of objects, lists, and atomic values (integers, floats, strings, booleans)

JSon Data Structures

- Collections of name-value pairs:
  - {“name1”:value1, “name2”:value2, …}
  - The “name” is also called a “key”

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- Collections of name-value pairs:
  - {"name1":value1, "name2":value2, ...}
  - The "name" is also called a "key"
- Ordered lists of values:
  - [obj1, obj2, obj3, ...]

Avoid Using Duplicate Keys

The standard allows them, but many implementations doesn't

```
{"id": "07",
 "title": "Databases",
 "author": "Garcia-Molina",
 "author": "Ullman",
 "author": "Widom",
}
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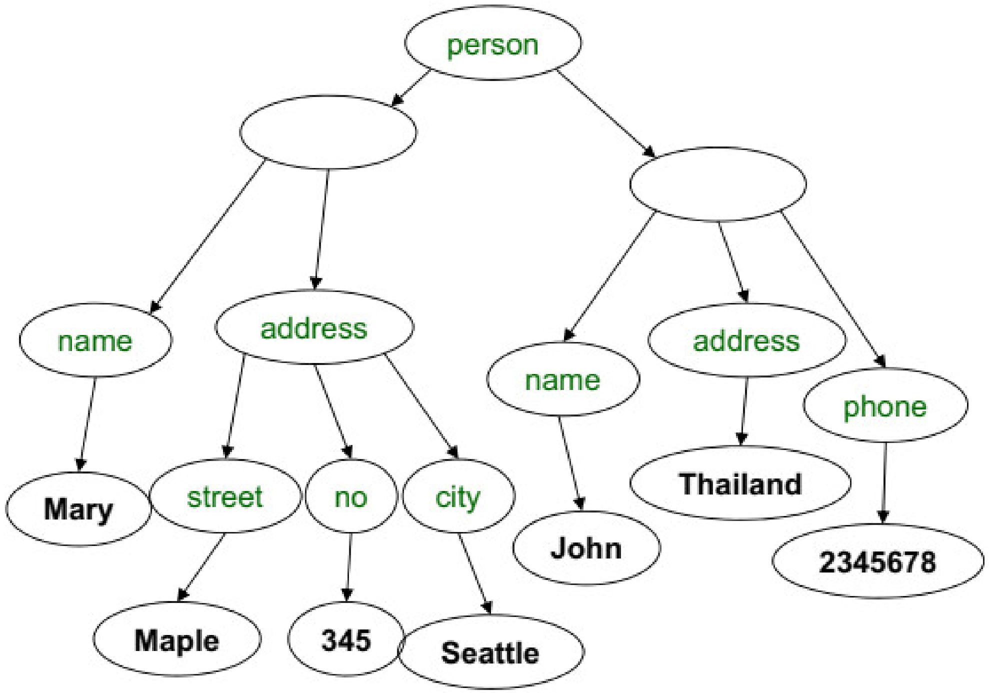
```
{"id": "07",
 "title": "Databases",
 "author": ["Garcia-Molina",
            "Ullman",
            "Widom"]
}
```

JSon Data Types

- Number
- String = double-quoted
- Boolean = True or False
- Null/empty

JSon Semantics

```
{“person”:
  [{“name”:”Mary”,
    “address”:
    {“street”:”Maple”,
     “no”:345,
     “city”:”Seattle”}},
   {“name”:”John”,
    “address”:”Thailand”,
    “phone”: 2345678}
  ]
}
```



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- JSon is an example of semi-structured data

Thank you.