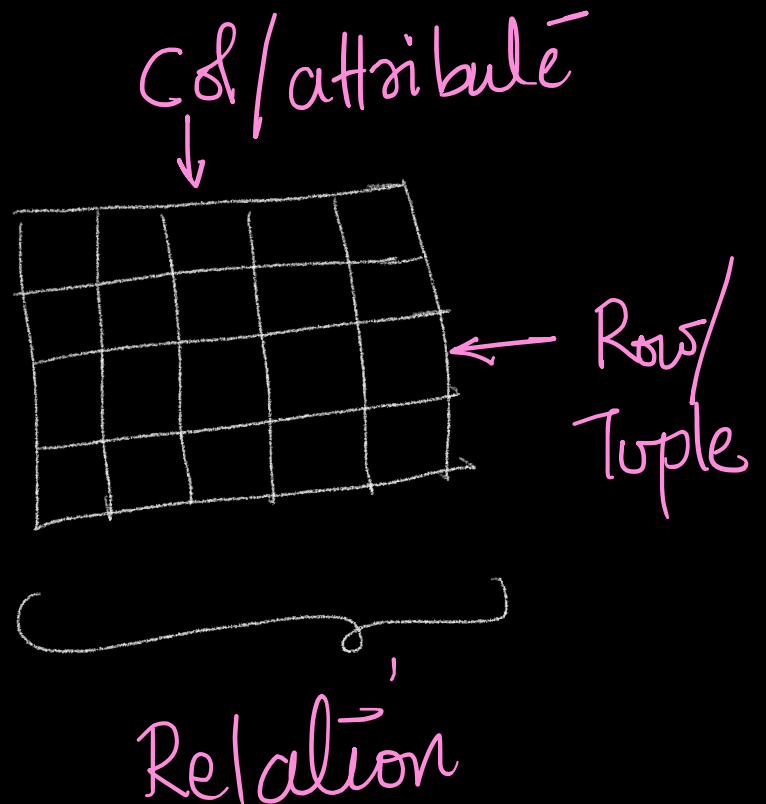
MongoDB

AppliedRoots.com

Relational Databases (1970's - Today)

- MySQL, Oracle, SQL-Server, ...
- Tables / Relations



Normalization → avoid redundant data storage

↓

atomic attributes

Atomic - attributes:

Non-atomic

T1:

ID	Color	Price
1	R, G	$10
2	G	$12
3	R, G, B	$16

T2:

ID	Color
1	R
1	G
2	G
3	R
3	B
3	G

T3:

ID	Price
1	$10
2	$12
3	$16

(JOIN)

Avoid redundant storage

T1:

CustID	PrID	Price	City
1	101	21	HYD
2	101	21	ND
1	102	10	HYD
2	103	12	ND

Normalization →

T2:

CustID	City
1	HYD
2	ND

T3:

PrID	Price
101	21
102	10
103	12

T4:

Cust ID	PID
1	101
2	101
1	102
2	103

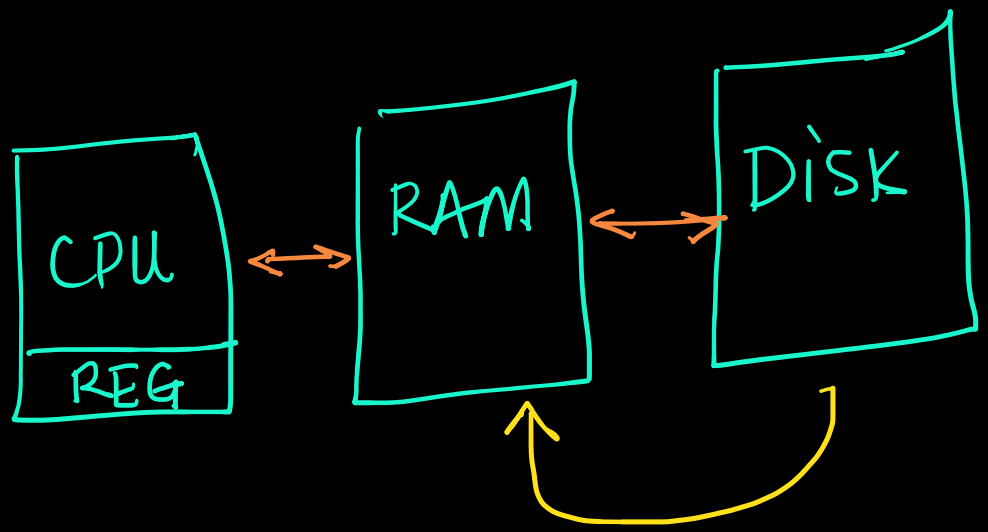
(JOINS)

Relational DB: fixed schema (Table structure)

Not flexible at all

Indexing (makes for faster searching)

→ B+ trees

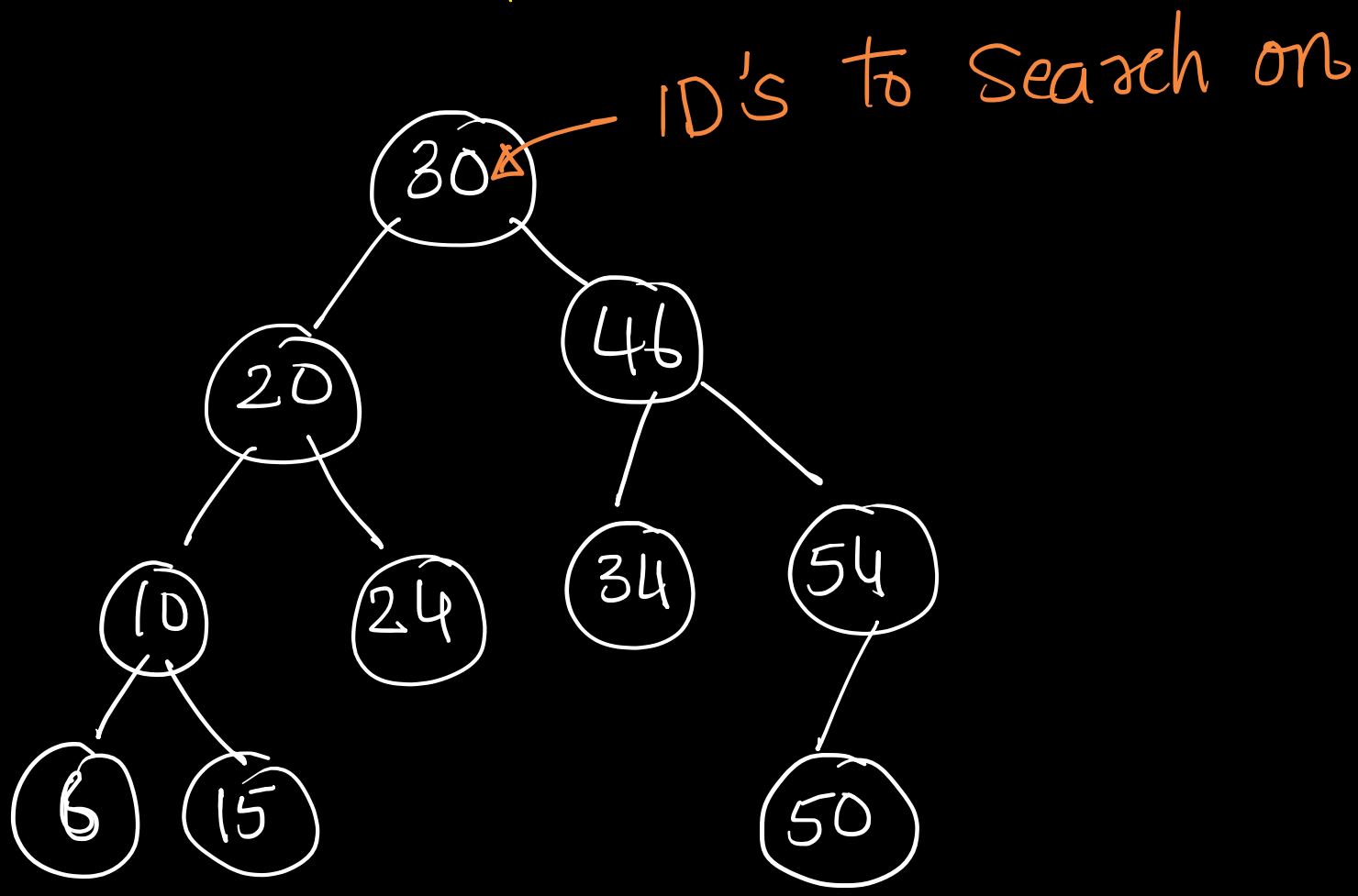


Computer Architecture (simplified)

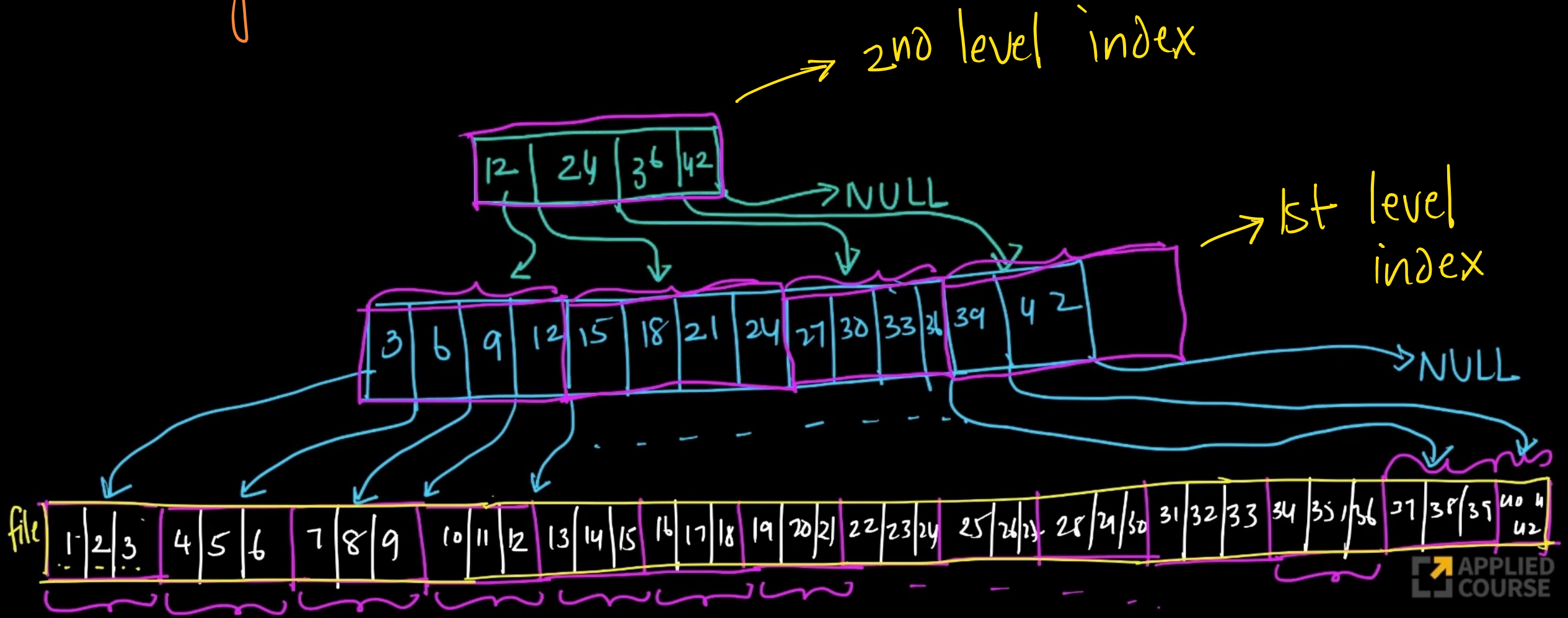
BLOCK ~ 512B (Linux)

* minimize block-reads

binary-Search trees:



m-ary search tree



B+ tree → block oriented

→ balanced trees

→ m-ary tree / multilevel index

B+ tree vs hash Index

↓

multi level index

↳ key = ID

Value = block number

Equality & Range Queries

↓

ID = 26

ID ≥ 10 and ID ≤ 50

B+ tree indexing

Hash indexing

} → Relational & NoSQL (e.g: MongoDB)

1970 - 2000 :

- disk space was precious ⇒ avoid redundancy
- Latency was not critical ⇒ ok to join tables
- scale of data was small

2000 - 2010:

- Explosion of internet & devices ⇒ more data
- Speed / Low - latency is key
- Compute ; RAM, diskspace became cheaper
- Hadoop (2006); MongoDB (2009); Redis (2009);

NO-SQL databases

=> Non-relational → Document store (MongoDB)

→ key-value DB (Redis)

→ Graph DB

→ Columnar RDBMS (Vertica 2005)

→ HIVE (Hadoop based) 2010

Columnar storage → PostgreSQL (2014)

in-memory (RAM) → MySQL - MEMORY engine

① MYSQL → @ Petabyte scale (FB)

(modified)

↓

HIVE & others

Late 1990's:

- OOP (objects, classes) has become popular

  object oriented storage

MongoDB:

- Most popular document-oriented DB

Rank Oct 2021	Rank Sep 2021	Rank Oct 2020	DBMS	Database Model	Score Oct 2021	Score Sep 2021	Score Oct 2020
1.	1.	1.	MongoDB	Document, Multi-model	493.55	-2.95	+45.53
2.	2.	2.	Amazon DynamoDB	Multi-model	76.55	-0.38	+8.14
3.	3.	3.	Microsoft Azure Cosmos DB	Multi-model	40.29	+1.76	+8.28
4.	4.	4.	Couchbase	Document, Multi-model	27.91	+0.23	-2.41
5.	5.	↑ 6.	Firebase Realtime Database	Document	19.02	+1.00	+2.76
6.	6.	↓ 5.	CouchDB	Document, Multi-model	15.79	+0.31	-1.62
7.	7.	7.	MarkLogic	Multi-model	9.43	-0.16	-2.30
8.	8.	8.	Realm	Document	9.29	-0.22	+0.55
9.	9.	9.	Google Cloud Firestore	Document	8.37	+0.27	-0.24
10.	↑ 11.	↑ 20.	Virtuoso	Multi-model	4.69	+0.27	+2.12
11.	↓ 10.	11.	ArangoDB	Multi-model	4.45	-0.34	-1.10
12.	12.	↓ 10.	Google Cloud Datastore	Document	4.43	+0.05	-1.50
13.	13.	↓ 12.	OrientDB	Multi-model	4.05	-0.20	-1.43
14.	14.	↑ 15.	Oracle NoSQL	Multi-model	4.03	-0.20	-0.21
15.	15.	↑ 16.	IBM Cloudant	Document	3.71	+0.22	-0.34
16.	16.	↓ 13.	RavenDB	Document, Multi-model	3.21	-0.25	-1.13
17.	17.	↓ 14.	RethinkDB	Document, Multi-model	3.09	-0.06	-1.19
18.	18.	↓ 17.	PouchDB	Document	2.86	+0.00	-0.61

https://db-engines.com/en/ranking/document+store

Data organization:

data record = document (~ row / Tuple)

many docs = collections (~ Table)

multiple collections = Data base (~ DB)

BSON: Binary JSON (Javascript Object Notation)

JSON:

```
{
   name: "sue",                    <-- field: value
   age: 26,                        <-- field: value
   status: "A",                    <-- field: value
   groups: [ "news", "sports" ]    <-- field: value
}
```

https://docs.mongodb.com/manual/core/document/

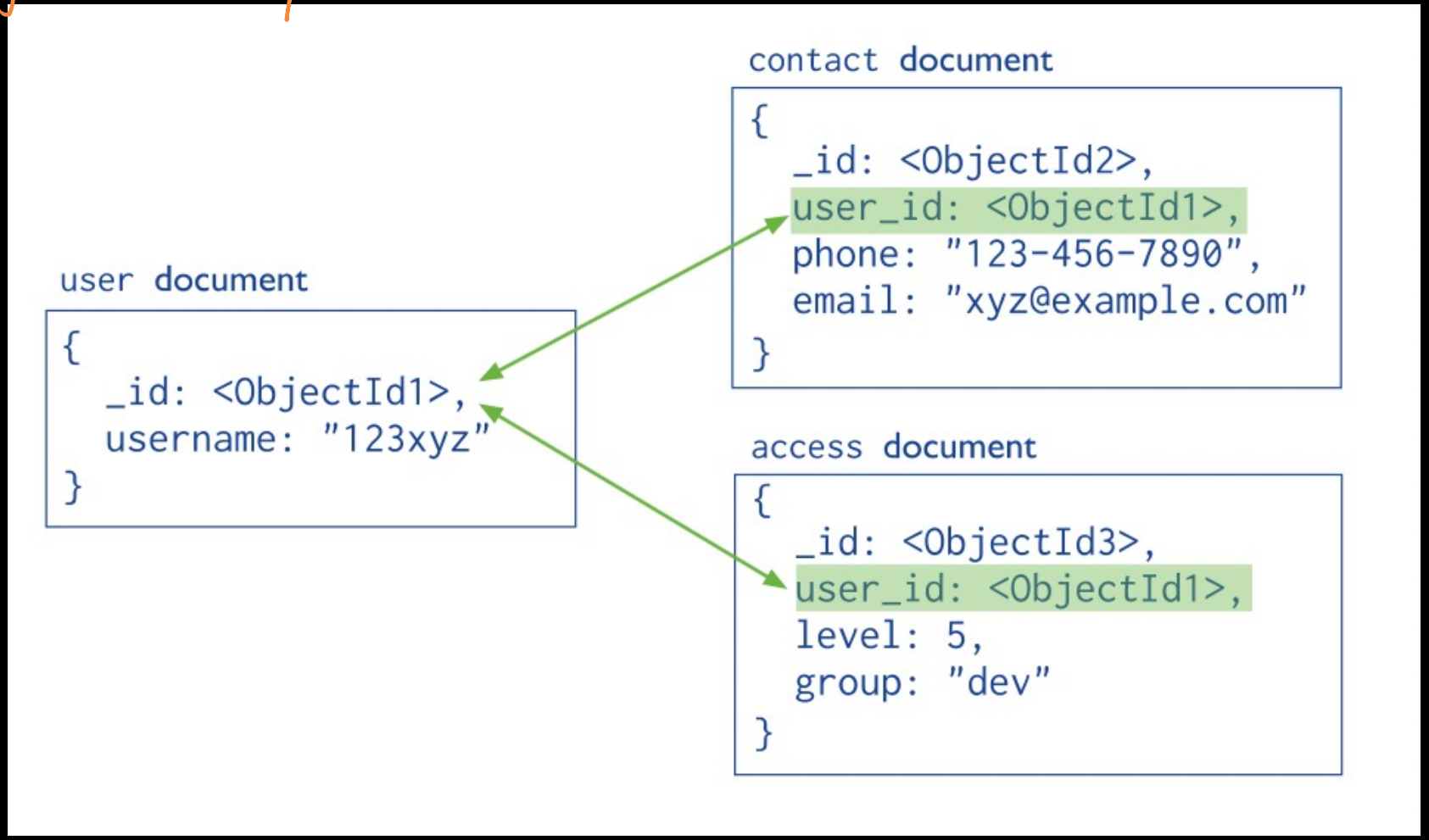
More about BSON: https://www.mongodb.com/basics/bson (144 examples)

APPLIED ROOTS

Embedded sub-doc

https://docs.mongodb.com/manual/core/data-modeling-introduction/

References / Links:



JOINS

- possible but not recommended
- Data Modeling based on application needs:

  e.g: prefer sub-doc embedding if we query for user's phone number using username a lot

Flexible schema: all docs dont need to have same fields.

```
{
   name: "sue",                    <-- field: value
   age: 26,                        <-- field: value
   status: "A",                    <-- field: value
   groups: [ "news", "sports" ]    <-- field: value
}
```

gender: "Male"

More advanced concepts (later)

- indexing
- scaling (horizontal & vertical)
- sharding
- Replication
- ⋮

Installation

- MongoDB Community

https://docs.mongodb.com/manual/administration/install-community/

- MongoDB Enterprise
- MongoDB Atlas (on cloud)

https://www.mongodb.com/cloud/atlas

Accessing:

- Mongo shell (Mongosh)
- Python / any programming language
- GUI: Compass (connect → URI: mongodb://localhost:27017)

CRUD : very simple

Create

Read

Update

Delete

https://www.mongodb.com/basics/create-database

(Shell)

① show dbs

```
test> show dbs
admin     41 kB
config   111 kB
local     41 kB
test    8.19 kB
```

② use mydb

```
test> use mydb
switched to db mydb
```

③ db.user.insert({name: "Ada Lovelace", age: 205})

```
mydb> db.user.insert({name: "Ada Lovelace", age: 205})
DeprecationWarning: Collection.insert() is deprecated. Use insertOne, insertMany, or bulkWrite.
{
  acknowledged: true,
  insertedIds: { '0': ObjectId("6162deb24674410b36f580b2") }
}
```

```
mydb> db.user.insertOne({name: "Alan Turing", age: 100})
{
  acknowledged: true,
  insertedId: ObjectId("6162e0be4674410b36f580b3")
}
```

APPLIED ROOTS

default primary key ; immutable ; default index ;

BSON-id ;

useful for references

Python 3:

$ pip install pymongo

Code:

```
import pymongo

myclient = pymongo.MongoClient("mongodb://localhost:27017/")
db = myclient["mydb"]
collec = db["user"]

d = {"name": "John Von Neuman", "age": 90} #dict

x = collec.insert_one(d)

print(x)
```

```
varma@Srikanths-MacBook-Air ~ % python3 mongo1.py
<pymongo.results.InsertOneResult object at 0x101526a00>
```

APPLIED ROOTS

Insert Documentation:

https://docs.mongodb.com/manual/tutorial/insert-documents/

SQL – MongoDB mapping:

https://docs.mongodb.com/manual/reference/sql-comparison/

SQL - Querying [partially Supported]

↳ MongoDB Atlas:

https://docs.mongodb.com/datalake/admin/query-with-sql/ (beta)

→ Studio 3T

https://studio3t.com/knowledge-base/articles/sql-query/ (some SQL operations)

Next Session:

- → CRUD
- – indexing
- – scaling (horizontal & vertical)
- – sharding
- – Replication .....

Create Empty collection :

```
test> use mydb
switched to db mydb
mydb> db.createCollection("coll")
{ ok: 1 }
mydb> show collections
coll
user
mydb>
```

Insert Command:

CRUD

https://www.mongodb.com/developer/quickstart/cheat-sheet/

Create

copy code

```
db.coll.insertOne({name: "Max"})
db.coll.insert([{name: "Max"}, {name:"Alex"}]) // ordered bulk insert
db.coll.insert([{name: "Max"}, {name:"Alex"}], {ordered: false}) // unordered bulk inse
db.coll.insert({date: ISODate()})
db.coll.insert({name: "Max"}, {"writeConcern": {"w": "majority", "wtimeout": 5000}})
```

https://docs.mongodb.com/manual/reference/write-concern/

APPLIED ROOTS

Read

copy code

```
1  db.coll.findOne() // returns a single document
2  db.coll.find()    // returns a cursor - show 20 results - "it" to display more
3  db.coll.find().pretty()
4  db.coll.find({name: "Max", age: 32}) // implicit logical "AND".
5  db.coll.find({date: ISODate("2020-09-25T13:57:17.180Z")})
6  db.coll.find({name: "Max", age: 32}).explain("executionStats") // or "queryPlanner" or "al
7  db.coll.distinct("name")
8
```

https://docs.mongodb.com/manual/reference/explain-results/

```
9  // Count
10 db.coll.count({age: 32})          // estimation based on collection metadata
11 db.coll.estimatedDocumentCount()  // estimation based on collection metadata
12 db.coll.countDocuments({age: 32}) // alias for an aggregation pipeline - accurate coun
   t
```

```
14  // Comparison
15  db.coll.find({"year": {$gt: 1970}})
16  db.coll.find({"year": {$gte: 1970}})
17  db.coll.find({"year": {$lt: 1970}})
18  db.coll.find({"year": {$lte: 1970}})
19  db.coll.find({"year": {$ne: 1970}})
20  db.coll.find({"year": {$in: [1958, 1959]}})
21  db.coll.find({"year": {$nin: [1958, 1959]}})
```

```
23  // Logical
24  db.coll.find({name:{$not: {$eq: "Max"}}})
25  db.coll.find({$or: [{"year" : 1958}, {"year" : 1959}]})
26  db.coll.find({$nor: [{price: 1.99}, {sale: true}]})
27  db.coll.find({
28    $and: [
29      {$or: [{qty: {$lt :10}}, {qty :{$gt: 50}}]},
30      {$or: [{sale: true}, {price: {$lt: 5 }}]}
31    ]
32  })
```

```
34  // Element
35  db.coll.find({name: {$exists: true}})
36  db.coll.find({"zipCode": {$type: 2 }})
37  db.coll.find({"zipCode": {$type: "string"}})
```

```
39  // Aggregation Pipeline
40  db.coll.aggregate([
41    {$match: {status: "A"}},
42    {$group: {_id: "$cust_id", total: {$sum: "$amount"}}},
43    {$sort: {total: -1}}
44  ])
```

https://docs.mongodb.com/manual/aggregation/

https://docs.mongodb.com/manual/reference/operator/aggregation/sort/

MongoDB uses Perl compatible regular expressions

```
49  // Regex
50  db.coll.find({name: /^Max/})   // regex: starts by letter "M"
51  db.coll.find({name: /^Max$/i}) // regex case insensitive
```

https://docs.mongodb.com/manual/reference/operator/query/regex/#examples

APPLIED ROOTS

Indexed Text Search

https://docs.mongodb.com/manual/reference/operator/query/text/#examples

```
58  // Projections
59  db.coll.find({"x": 1}, {"actors": 1})                // actors + _id
60  db.coll.find({"x": 1}, {"actors": 1, "_id": 0})      // actors
61  db.coll.find({"x": 1}, {"actors": 0, "summary": 0}) // all but "actors" and "summary"
```

https://docs.mongodb.com/manual/reference/method/db.collection.find/#projections

APPLIED ROOTS

```
63  // Sort, skip, limit
64  db.coll.find({}).sort({"year": 1, "rating": -1}).skip(10).limit(3)
65
66  // Read Concern
67  db.coll.find().readConcern("majority")
```

Array Querying :

https://docs.mongodb.com/manual/tutorial/query-arrays/

Update :

https://docs.mongodb.com/manual/tutorial/update-documents/

Delete

copy code

```
db.coll.remove({name: "Max"})
db.coll.remove({name: "Max"}, {justOne: true})
db.coll.remove({}) // WARNING! Deletes all the docs but not the collection itself and its index definitions
db.coll.remove({name: "Max"}, {"writeConcern": {"w": "majority", "wtimeout": 5000}})
db.coll.findOneAndDelete({"name": "Max"})
```

Drop

copy code

```
db.coll.drop()    // removes the collection and its index definitions
db.dropDatabase() // double check that you are *NOT* on the PROD cluster... :-)
```

JOIN:

https://docs.mongodb.com/manual/reference/operator/aggregation/lookup/#examples

Indexing

Create Indexes

copy code

```
// Index Types
db.coll.createIndex({"name": 1})                  // single field index
db.coll.createIndex({"name": 1, "date": 1})       // compound index
db.coll.createIndex({foo: "text", bar: "text"}) // text index
db.coll.createIndex({"$**": "text"})              // wildcard text index
db.coll.createIndex({"userMetadata.$**": 1})      // wildcard index
db.coll.createIndex({"loc": "2d"})                // 2d index
db.coll.createIndex({"loc": "2dsphere"})          // 2dsphere index
db.coll.createIndex({"_id": "hashed"})            // hashed index

```

equality and NOT for ranges

APPLIED ROOTS

Horizontal & Vertical Scaling

https://www.mongodb.com/databases/scaling

→ Sharding / Partioning

→ Replica Sets

→ Replication + sharding

How does sharding work internally:

https://docs.mongodb.com/manual/sharding/#sharding-strategy

Transactions:

- single vs multi-doc atomicity
- Replication: write & read concerns

https://docs.mongodb.com/manual/core/transactions/#transactions-and-atomicity

Q&A