Data Models
Key/Value: Amazon Dynamo

Part 3

Thanks to David Maier, M. Grossniklaus & K. Tufte

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Techniques Used in Dynamo

Problem	Techniques	Advantage
Partitioning	Consistent hashing	Incremental scalability
High availability for writes	Vector clocks with reconciliation during reads Buffered writes	Availability over consistency
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Data Management in the Cloud

Part 1

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Document: MongoDB

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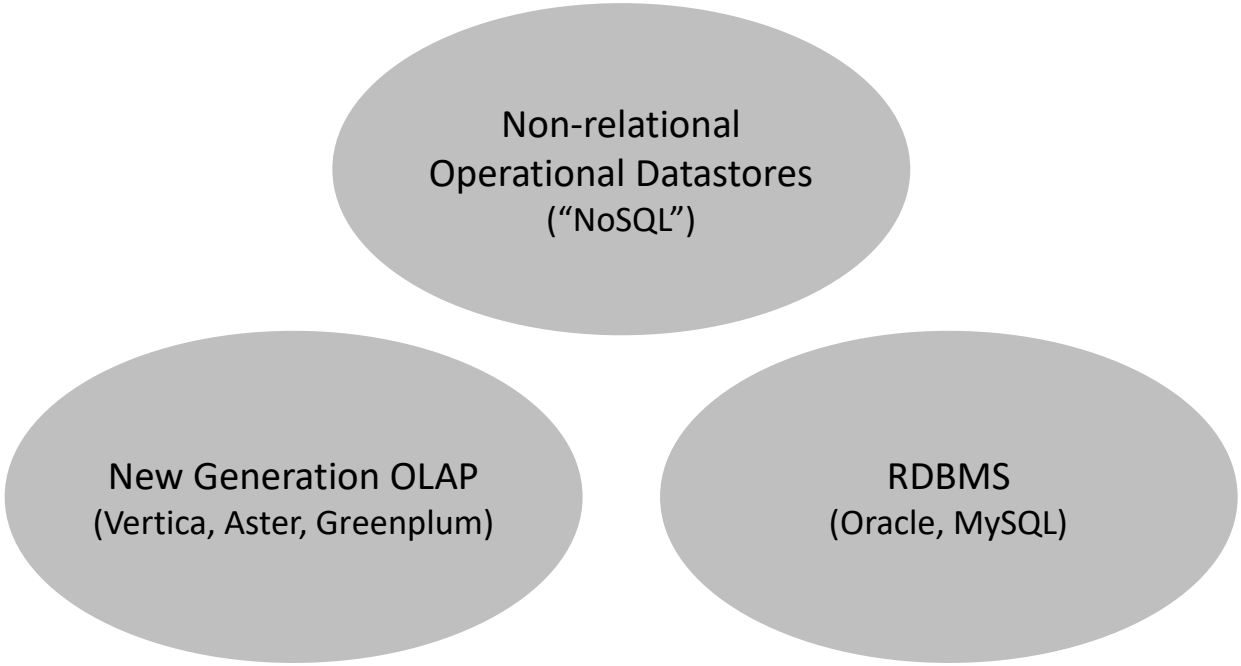
Trend Towards Specialization
* no longer one size fits all *



MongoDB's definition of "NoSQL":
non-relational, next-generation operational datastores and databases

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Unifying Theme of NoSQL Systems: Horizontally Scalable Architectures

- No joins + complex multi-row transactions
  - hard to implement both when scaling horizontally
  - abandon the relational data model
- New data models
  - **key/value**: memcached, Dynamo
  - **document-oriented**: MongoDB, CouchDB, JSON stores
  - **tabular**: BigTable
- Improved ways to develop applications?
  - "easier than a relational database management system"
  - **data modeling**: begin with normalized model and extend model by embedding documents

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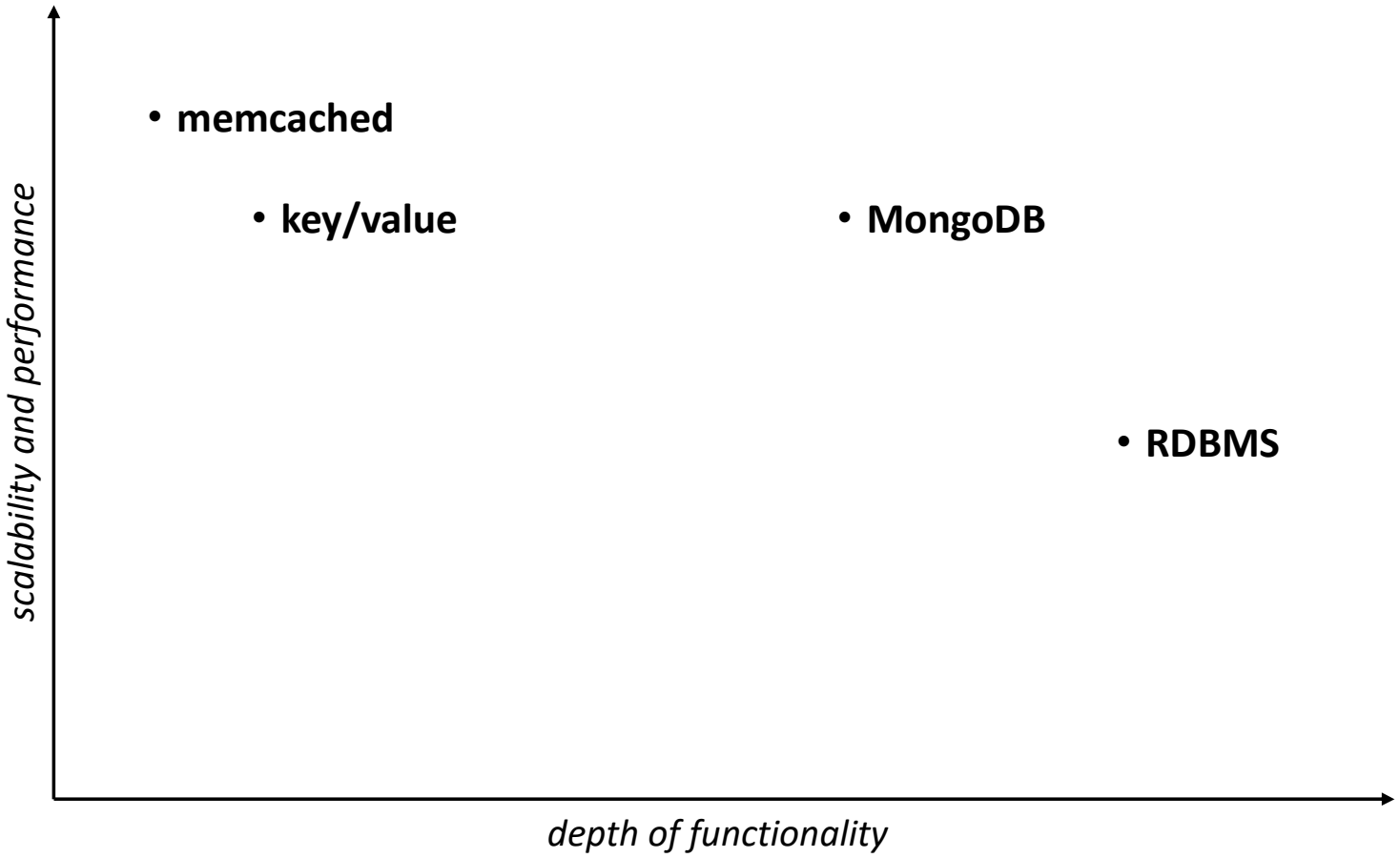
Spectrum of Systems



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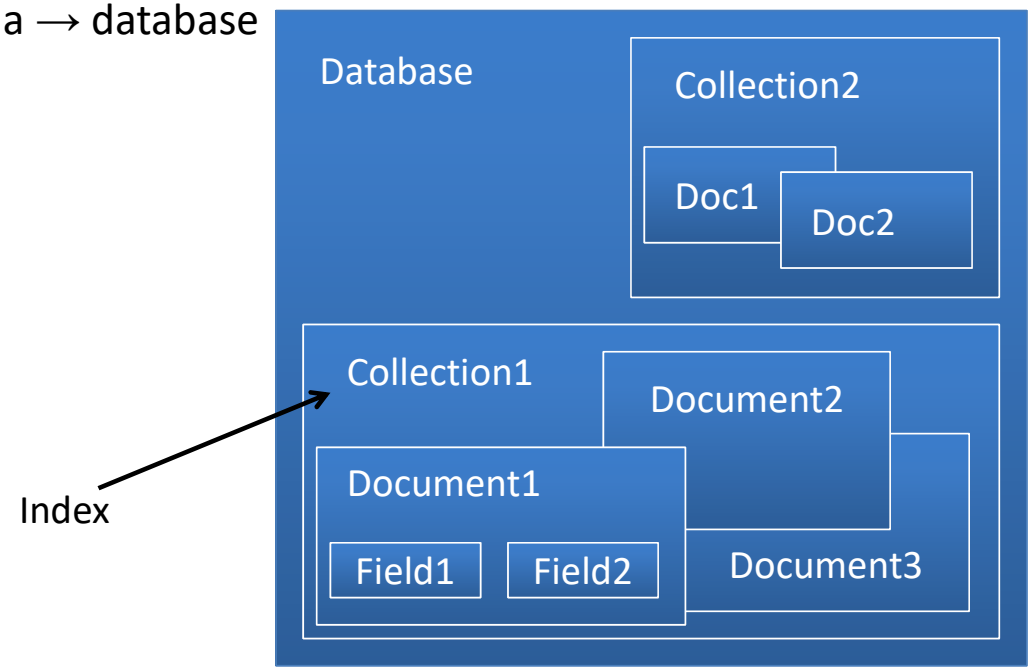
MongoDB vs. RDBMS

- What is missing?
  - joins
  - SQL (but MongoDB has document-based query API)
- Terminology
  - database or schema ⟶ database
  - table ⟶ collection
  - row ⟶ document
  - column ⟶ field



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- "relational databases define columns at the table level whereas a document-oriented database defines its fields at the document level" - http://openmymind.net/mongodb.pdf
  - Table -> Collection; Row -> Document

Shoes Table

Brand	Size	Color
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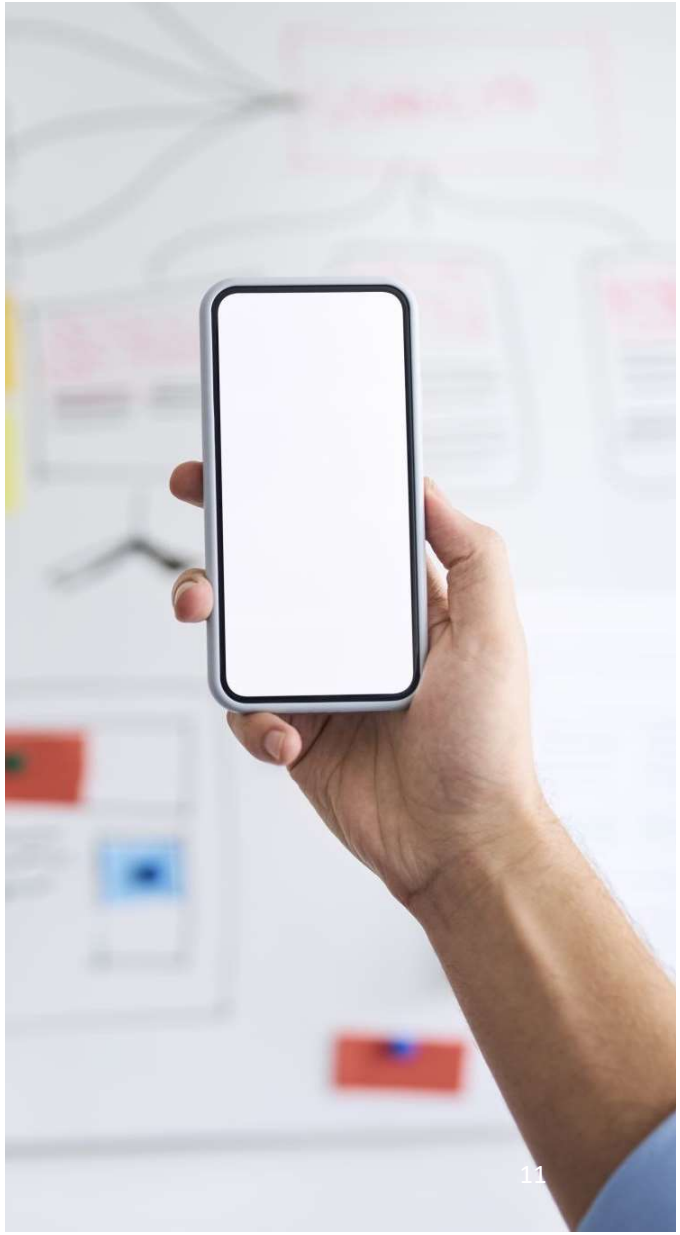

MongoDB Data Model & Features

- Advantages of document model
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  - Embedded documents and arrays reduce need for expensive joins
- High Performance
  - Support for embedded data models reduces I/O activity
  - Indexes; can include keys from embedded documents and arrays
- High Availability
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- Automatic Scaling
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  - Replica sets for eventually consistent reads

http://docs.mongodb.org/manual/introduction/

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Data Model

- MongoDB stores JSON-**style** documents
  - internally represented as BSON (binary JSON)
  - `{"hello": "world"}`

    ↓

    `\x16\x00\x00\x00\x02hello\x00`
    `\x06\x00\x00\x00world\x00\x00`
  - General-purpose serialization format
  - light-weight and traversable
  - driver converts programming language objects to BSON
  - document size limited to 16 MB
- Flexible "schemas"
  - the "big difference" between a collection and a table

document size

field type (string)

field name

field value

end of object

both documents can be stored in the same collection

```
{"author": "fred",
 "text": "LOL"}
```

```
{"author": "mary",
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```

this is a list

Source: http://bsonspec.org

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Storing Documents

```
post = {author: "mike",
        date: new Date(),
        text: "my blog post...",
        tags: ["mongodb", "intro"]}

db.posts.save(post)
```

JavaScript object

tags embedded in post vs. many-to-many join

database

collection

- Example uses JavaScript
  - MongoDB supports JavaScript on the client and server side
  - other language bindings exist
- BSON is the basis for a rich type system
  - e.g., (binary) date values are not possible in JSON
- Collections are created implicitly on demand
  - Created first time a document is saved to that collection

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CRUD Operations

- Create: `insert` (won't overwrite)

```
db.posts.insertOne({author: "Maria",
                    text: "My response ...})
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- Read: `find` (examples later)
- Update

```
db.posts.updateMany({author: "mike"},
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```

- Delete

```
db.posts.deleteMany({status: "reject"})
```


Source: https://docs.mongodb.com/manual/crud/

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Document Identifiers

- Special field **`_id`**
  - present in all documents: user or system-defined
  - unique across a collection
  - can be any type
- System-defined default **`_id`** is added if not specified by user
  - similar to GUID/UUID, lightweight (only 12 bytes) and fast to generate
  - generated at the client
  - **`ObjectId("4bface1a2231316e04f3c434")`**

timestamp

machine id

process id

incrementing counter

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Queries

- Query evaluation invoked by method **`find()`** on collection
  - posts by author

```
db.posts.find({author: "mike"})
```

- Query language
  - query-by-example plus "$ modifiers": **`$gt`**, **`$lt`**, **`$gte`**, **`$lte`**, **`$ne`**, **`$all`**, **`$in`**, and **`$nin`**
  - age between 20 and 40

```
{author: "mike", age: {$gte: 20, $lt: 40}}
```

- Advanced queries
  - keyword **`$where`**

```
db.posts.find({$where: "this.author == 'mike' ||
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```


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Complex Queries

- Queries involving dates
  - posts since April 1

JavaScript starts counting months at 0

```
april1 = new Date(2024, 4, 1)
db.posts.find({date: {$gt: april1}})
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- Sorting and limit
  - last ten posts

all posts

descending

```
db.posts.find()
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  - lazy evaluation (cursors)
  - sort is defined on the cursor instance

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c.next()
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omit first 20 results

only return 10 results

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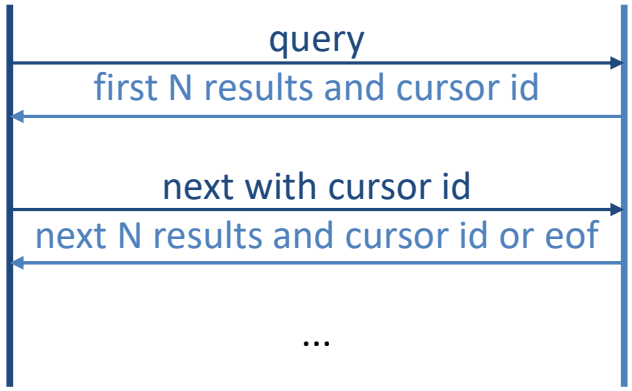

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Queries over Text and Collections

- Use regular expression in find() method
  - posts ending with "Tech"

```
db.posts.find({text: /Tech$/})
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Regular Expression

- Members of collection-valued attributes are queried in the same way as attributes with atomic values
  - posts with a specific tag

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- Use of a multi-key index speeds up collection-oriented queries
  - `db.posts.ensureIndex({tags: 1})`
  - The '1' means increasing order

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Aggregation Functions

- Counting the number of documents in a collection
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  - total posts authored by Mike

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- Method **`distinct()`** displays the distinct values found for a specified fieldin a collection
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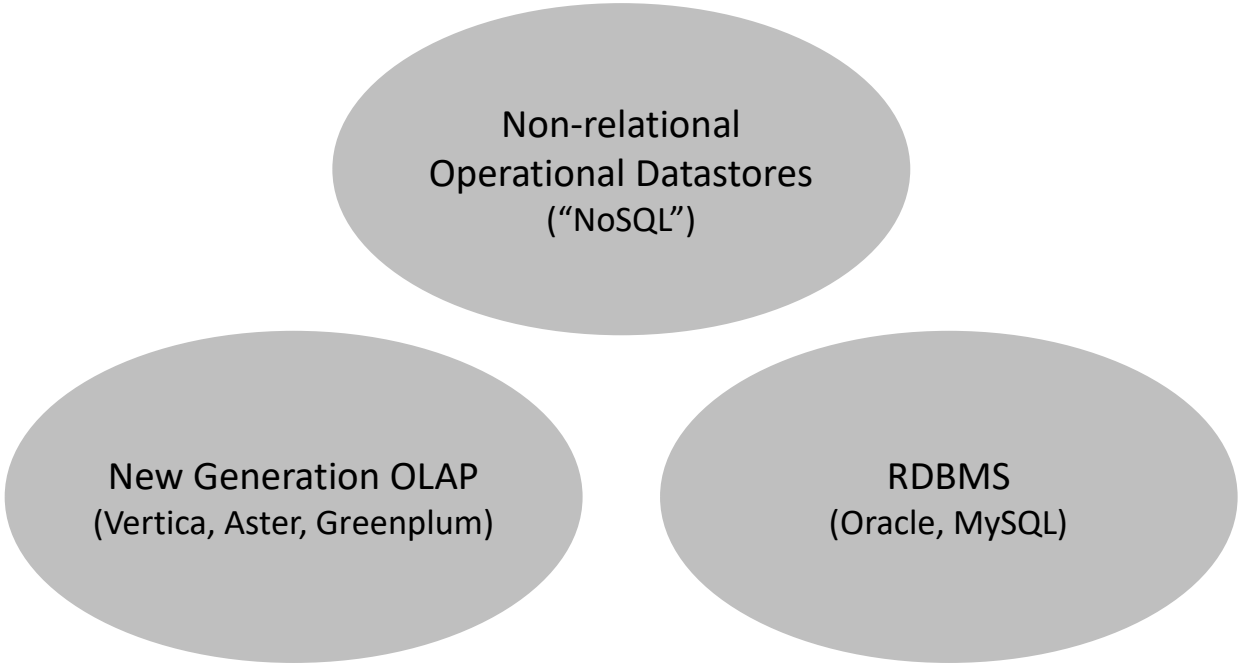

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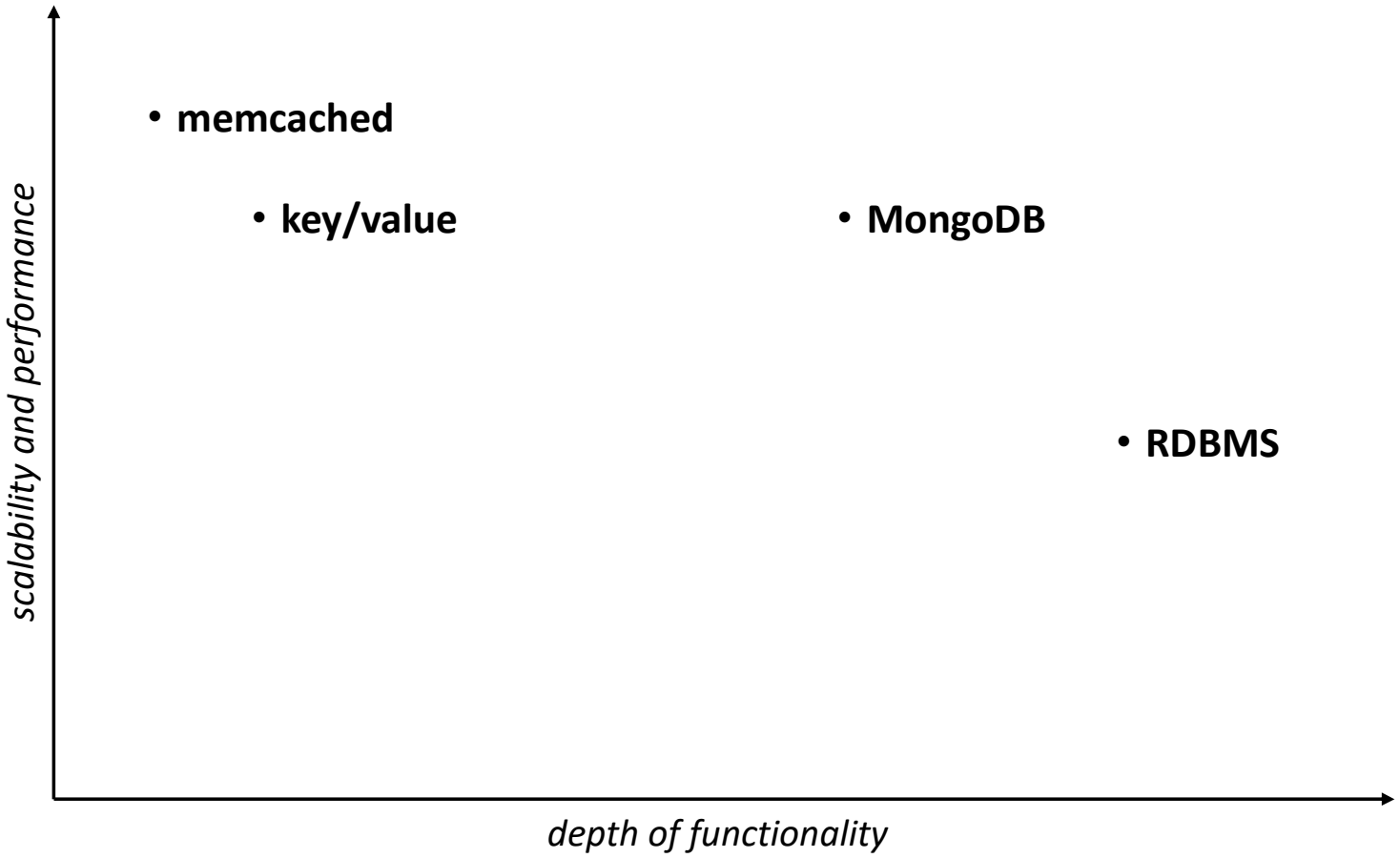

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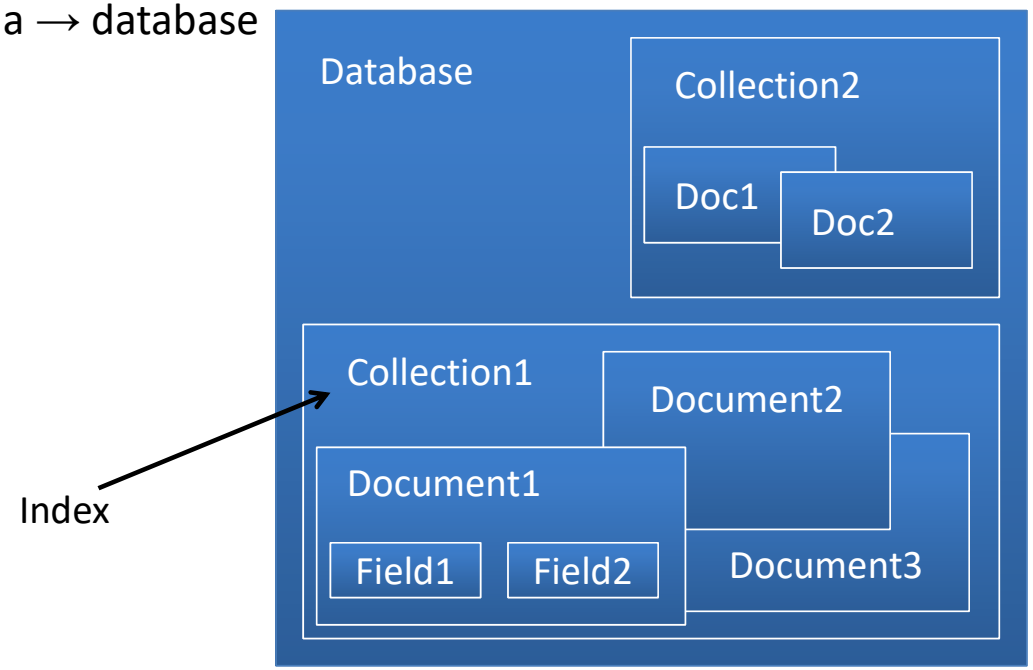

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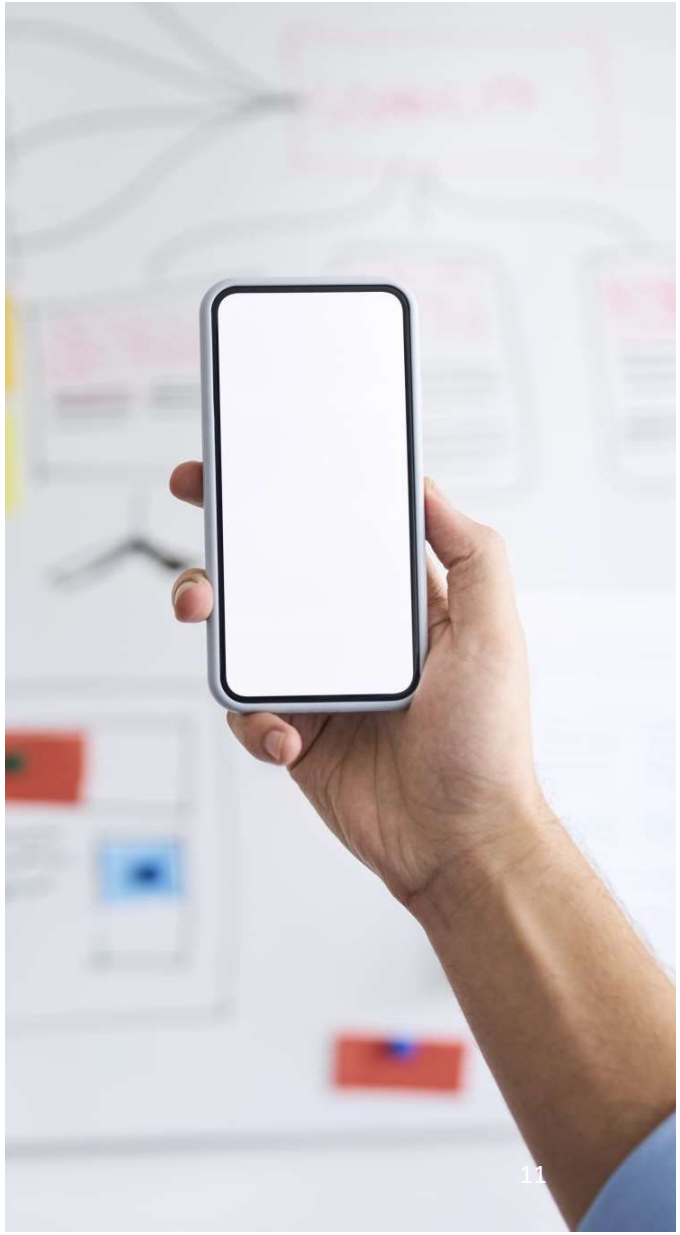

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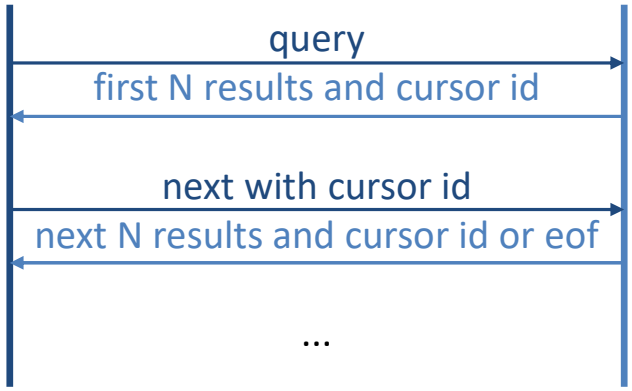

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