Northwestern
INFORMATION TECHNOLOGY

NoSQL Databases: MongoDB

Scott Coughlin, Computational Specialist

Some slides adapted from Professor Michael Coughlin and Matthew Graham

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Databases, SQL, and Django

Topics Covered

1. What drove the development of NoSQL? - Pros and cons of traditional SQL systems
2. NoSQL: motivation and promise
3. What are the different flavors of NoSQL?
4. Some SQL to MongoDB Command Mapping

What drove the development of NoSQL?

Pros of traditional SQL systems

- Have been around for quite a while
- SQL: mature and powerful
- Transactions + ACID-compliance built-in
- Data normalization + joins
- Schema: good when data can be represented in appropriate way
- Many open-source solutions

Reminder of ACID

By definition, a database transaction must be:

- **A**tomic: all or nothing
- **C**onsistent: no integrity constraints violated
- **I**solated: does not interfere with any other transaction
- **D**urable: committed transaction effects persist

Cons of traditional SQL systems

- Horizontal scale-out | scaling issues
- Joins + transactions across multiple databases quickly become costly for complicated objects and big data -> performance and availability are affected
- Object-relational impedance mismatch
- Schema: bad for unstructured/evolving data

NoSQL: motivation and promise

NoSQL: motivation and promise

The design and development of NoSQL databases has been largely driven by the RDBMS cons from the previous slide.

- Deliver performance for big, potentially unstructured or evolving data that may come in in real time
- Simple design
- Horizontal scaling
- NoSQL ~= not only SQL, i.e. some systems support SQL-like query languages

NoSQL: motivation and promise

Always comes with a cost!

- Most such systems lack ACID transactions and offer BASE (Basic Availability, Soft state and Eventual consistency) instead
- Some systems exhibit potential lost writes and other forms of data loss but not MongoDB
- No schema means data integrity might become an issue
- Some systems do allow defining schemas and perform validation/enforcement (e.g. MongoDB)
- Many query languages vs single SQL (albeit with different flavors)

NoSQL: relational data

In practice, you almost always still need to deal with relational data! There are three main techniques to do that:

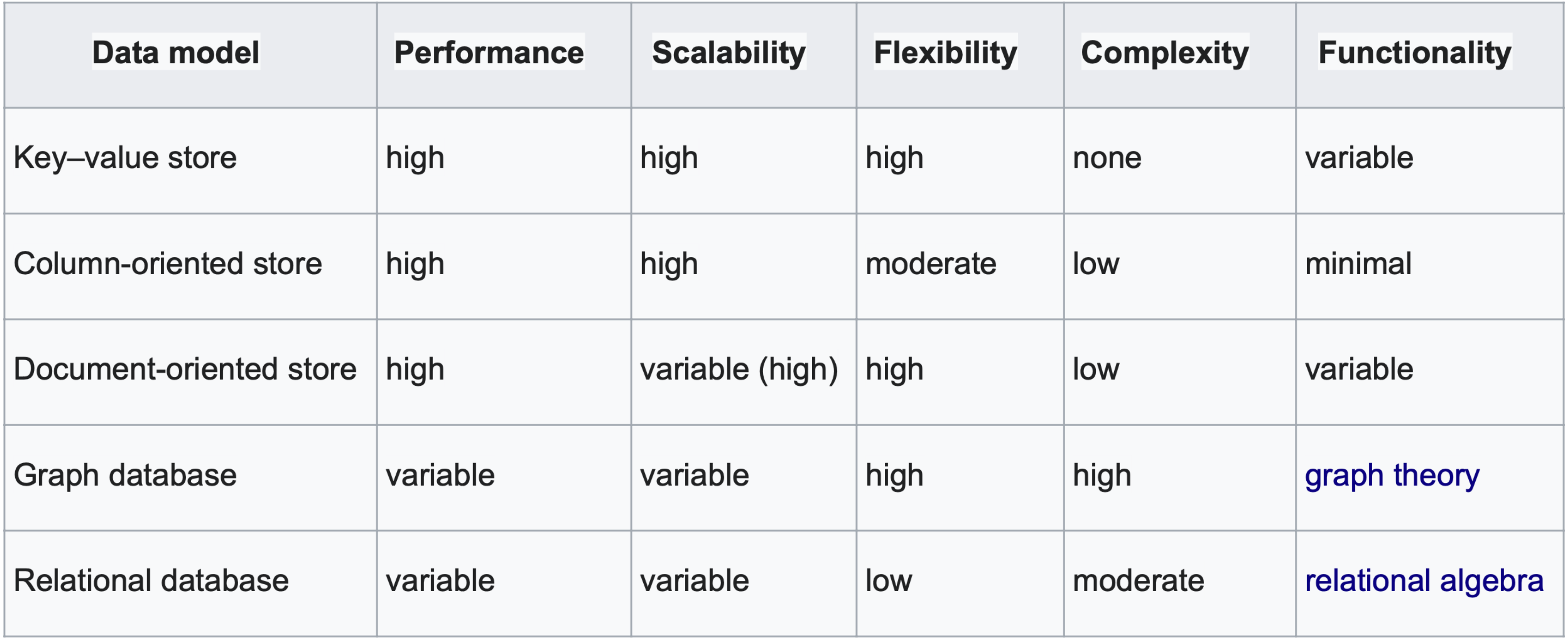
- Nesting/embedding data
- Store all data needed for a specific task in one place (e.g. in a single document)
- Linking + Multiple queries
- Store a foreign key and fetch data in multiple queries.
- Caching and replication
- Instead of storing a foreign key, store the actual values

Main types of NoSQL databases

NoSQL: What are the different flavors of NoSQL?

- Key-value store
  - Uses maps/dictionaries/associated lists/hash tables with corresponding operation complexities
  - Examples: Redis, ArangoDB, ZooKeeper, Couchbase, Cassandra, Amazon DynamoDB
- Wide column store
  - Essentially, a two-dimensional semi-structured key-value store
  - Examples: Cassandra, HBase
- Document store
  - Semi-structured; data are encapsulated in some standard form (XML, JSON, BSON) in "documents" with unique keys/identifiers
  - Often uses B-trees with corresponding operation complexities
  - Examples: Couchbase, MongoDB, Amazon DynamoDB
- Graph store
  - Uses graphs to represent data + relationship between them (the latter can be queried, too)
  - Examples: Neo4J, ArangoDB

NoSQL: What are the performance differences for these flavors of NoSQL?



Data model	Performance	Scalability	Flexibility	Complexity	Functionality
Key–value store	high	high	high	none	variable
Column-oriented store	high	high	moderate	low	minimal
Document-oriented store	high	variable (high)	high	low	variable
Graph database	variable	variable	high	high	graph theory
Relational database	variable	variable	low	moderate	relational algebra

MongoDB: Document-Based NoSQL

MongoDB

- Uses BSON (serialized binary **python-dictionary-like** structures) **documents** to store the data in **collections** (a rough analog of a **table** in the relational DBMS world).
- Giant B-tree (Binary Tree): O(log(N)) guaranteed for search, insert, and delete operations, where N is the number of documents in a collection.
- MongoDB Query Language (MQL): cone and general searches, aggregation pipelines
- Horizontal scale-out
- ACID-compliant transactions

MongoDB Commands Compared to SQL

In the following slides we compare Mongo commands to SQL

CREATE

CREATE TABLE *tableName* (name1 type1, name2 type2, …);

```
CREATE TABLE star (name varchar(20), ra float, dec float,
vmag float);
```

MongoDB: Create a Collection

```
db.people.insertOne( {
user_id: "abc123",
age: 55,
status: "A"
} )
```

ALTER

ALTER TABLE *table …;*

```
ALTER TABLE star ADD COLUMN bmag double AFTER vmag;

ALTER TABLE star DROP COLUMN bmag;
```

MongoDB

```
db.people.updateMany(
{ },
{ $set: { join_date: new Date() } }
)
```

```
db.people.updateMany(
{ },
{ $unset: { "join_date": "" } }
)
```

DROP

DROP TABLE *table;*

```
DROP TABLE star;
```

MongoDB: Drop a Collection

```
db.people.drop()
```

INSERT

INSERT INTO *table* VALUES(val1, val2, ..);

```
INSERT INTO star VALUES('Sirius', 101.287, -16.716, -1.47);
```

Mongo: insertOne

```
db.people.insertOne(

{ user_id: "bcd001", age: 45, status: "A" }

)
```

SELECT

SELECT *column1, column2* FROM *table* WHERE *condition* (LIMIT *#ofrows)*
ORDER BY *sort_expression [ASC | DESC];*

```
SELECT name, constellation FROM star WHERE dec > 0 ORDER

BY vmag;
```

Mongo: find

```
db.people.find(
{ },
{ user_id: 1, status: 1, _id: 0 }
)
```

```
db.people.distinct( "status" )
```

```
db.people.find()
```

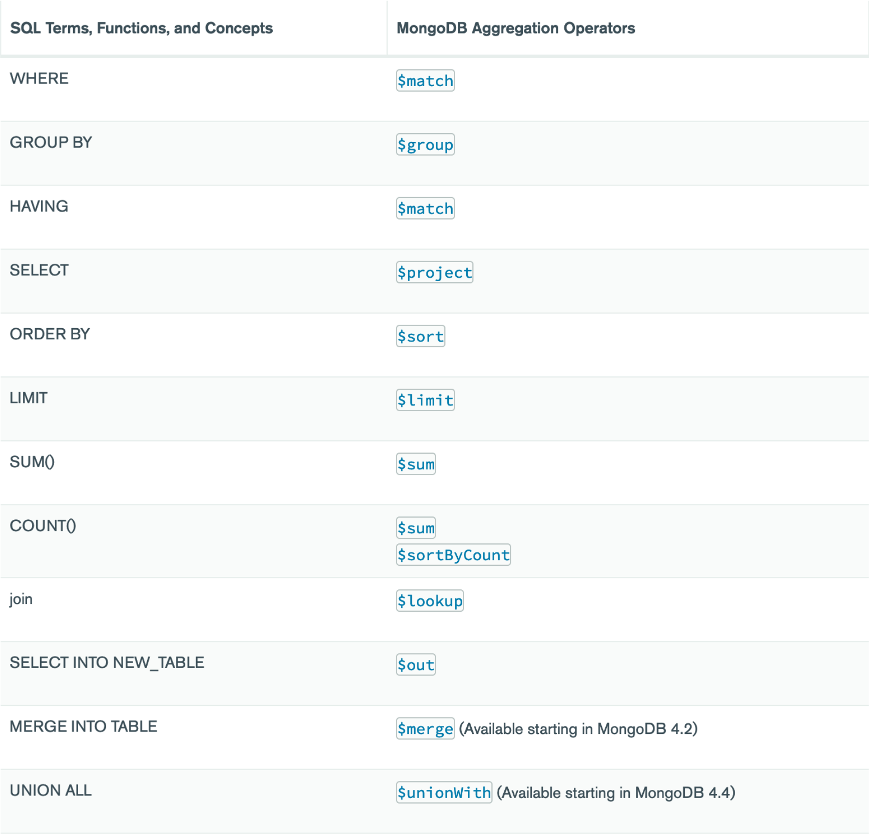
```
db.people.find(
{ status: "A" },
{ user_id: 1, status: 1, _id: 0 }
)
```

Aggregate Functions

```
SELECT cust_id,
ord_date,
SUM(price) AS total
FROM orders
GROUP BY cust_id,
ord_date
HAVING total > 250
```

```
db.orders.aggregate( [
{
$group: {
_id: {
cust_id: "$cust_id",
ord_date: { $dateToString: {
format: "%Y-%m-%d",
date: "$ord_date"
}}
},
total: { $sum: "$price" }
}
},
{ $match: { total: { $gt: 250 } } }
] )
```

Aggregate Functions



SQL Terms, Functions, and Concepts	MongoDB Aggregation Operators
WHERE	`$match`
GROUP BY	`$group`
HAVING	`$match`
SELECT	`$project`
ORDER BY	`$sort`
LIMIT	`$limit`
SUM()	`$sum`
COUNT()	`$sum` `$sortByCount`
join	`$lookup`
SELECT INTO NEW_TABLE	`$out`
MERGE INTO TABLE	`$merge` (Available starting in MongoDB 4.2)
UNION ALL	`$unionWith` (Available starting in MongoDB 4.4)

UPDATE

UPDATE *table* SET *column* = val1 WHERE condition;

```
UPDATE star SET vmag = vmag + 0.5;

UPDATE star SET vmag = -1.47 WHERE name LIKE 'Sirius';

UPDATE star INNER JOIN temp on star.id = temp.id SET star.vmag = temp.mag;
```

Mongo: updateMany

```
db.people.updateMany(
{ status: "A" } ,
{ $inc: { age: 3 } }
)
```

```
db.people.updateMany(
{ age: { $gt: 25 } },
{ $set: { status: "C" } }
)
```

Thank You