MongoDB Patterns, Pitfalls, & Best Practices

Michael Carducci

@MichaelCarducci

3 reasons to use MongoDB

Note: This is precursor post to my talk at Mongo Boston on September 20th. It's gonna be at Mi
COMPLETELY AWESOME). If you haven't signed up yet, stop being lame. It's gonna be awesom
http://www.10gen.com/conferences/mongoboston2010

People have asked me why to use MongoDB. I used to answer with "it's SO FREAKING
how "new" and "cool" and "hawt" it felt. I would wax on about how it felt like the first ti

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joepie91's Ramblings RSS

Why you should never, ever, ever use MongoDB

19 Jul 2015

MongoDB is evil. It...

- ... loses data (sources: 1, 2)
- ... in fact, for a long time, ignored errors by default and assumed every single write

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DZone / Database Zone

Over a m

CARDZ GUIDES ZONES JOBS | AGILE AI BIG DATA CLOUD DATABASE DEVOPS INTEGRATIO

F*** MongoDB, F*** Node.js, and F**

I hate MongoDB. I hate Node.JS. I hate everything about NoSQL. While I'm hate Apple OS and Windows and Linux.

by Allen Coin · Oct. 01, 12 · Database Zone · Not set

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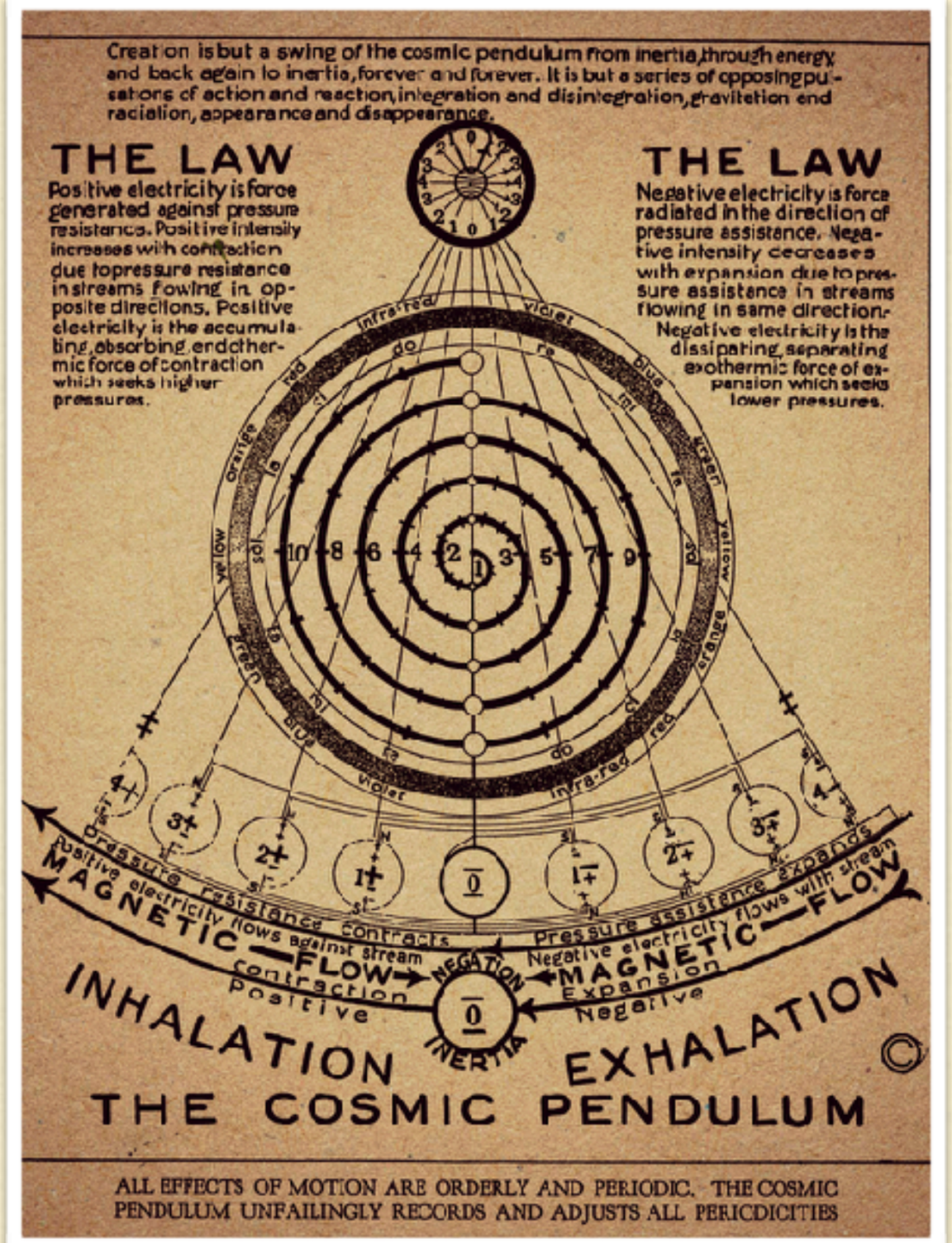
MongoDB Pitfalls

USING THE RIGHT TOOL FOR THE JOB



WHEN TO USE MONGODB

- If your data structures are fluid or dynamic
- Storing hierarchical data
- Caching/presenting data
- Storing Documents
- High write volume that can tolerate loss

WHEN **NOT** TO USE MONGODB

- If your data is relational
- If durability and consistency are important
- If you need transactions

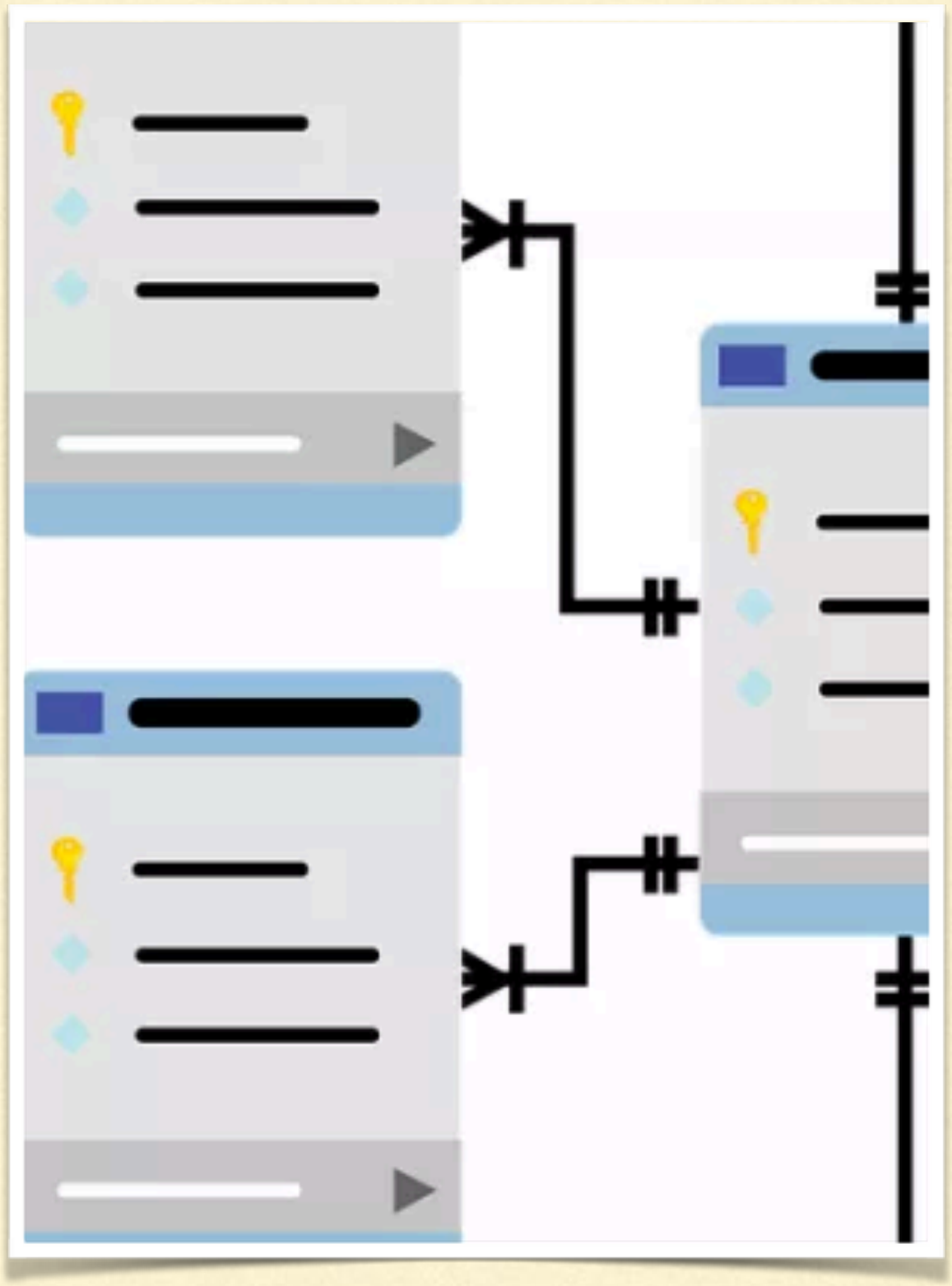
WHEN TO USE CAUTION

- Using either solution without a clear understanding of the problems you're trying to solve

MONGO CAN BE PART OF A LARGER ARCHITECTURE

Patterns and Best Practices

DOCUMENT DESIGN

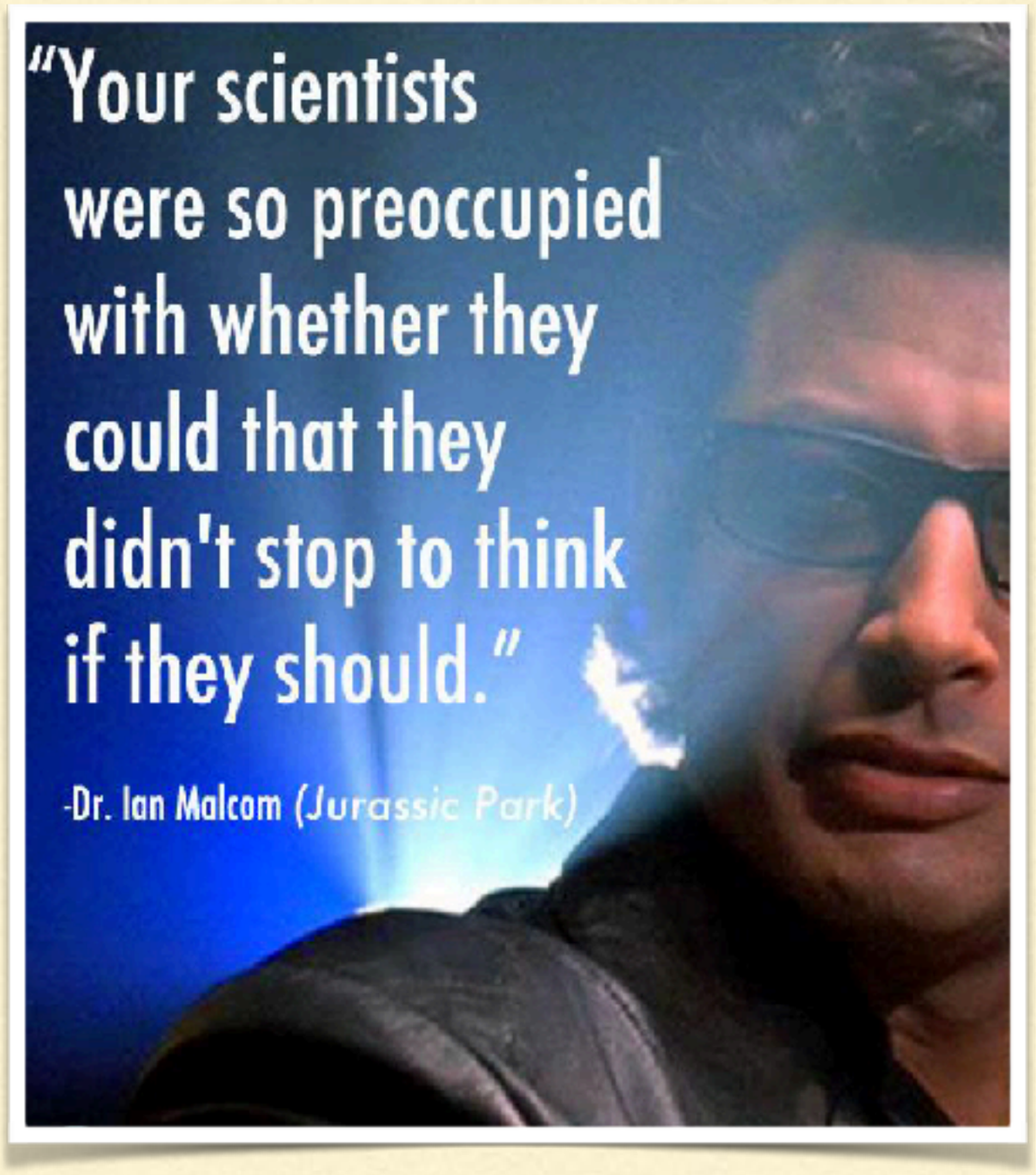


WHAT IS A DOCUMENT

```
{
    _id: “123”,
    title: "MongoDB: The Definitive Guide",
    authors: [
        { _id: "kchodorow", name: "Kristina Chodorow“ },
        { _id: "mdirold", name: “Mike Dirolf“ }
    ],
    published_date: ISODate(“2010-09-24”),
    pages: 216,
    language: "English",
    thumbnail: BinData(0,"AREhMQ=="),
    publisher: {
        name: "O’Reilly Media",
        founded: 1980,
        locations: ["CA”, ”NY“ ]
    }
}
```

Pitfall

MONGODB IS SCHEMALESS! WHO NEEDS DATA DESIGN?



GOOD DATA DESIGN GOES BEYOND THE DB

- Clear Structures
- Data structure harmonized with code
- Lessons Learned from RDBMS Databases

GOOD ARCHITECTURE IS FORWARD LOOKING

- Unknown future requirements
- Ability to scale economically
- Shorter Solution Lifecycles

MONGODB DOCUMENTS ARE FLEXIBLE

- TIMTOWTDI
- Document Design decisions involve trade-offs

DOCUMENT DESIGN BY EXAMPLE

Talent Agency Database

TALENT AGENCY

- Performers
- Clients
- Venues
- Bookings

PERFORMER COLLECTION

```
> db.performers.find({_id:'Shawn'}).pretty()
{
        "_id" : "Shawn",
        "FirstName" : "Shawn",
        "LastName" : "Popp",
        "Website" : "http://openthetrapdoor.com",
        "PerformanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Comedy Magic",
                "Mentalism"
        ]
}
> db.addresses.find({_id:'Shawn'}).pretty();
{
        "_id" : "Shawn",
        "Street" : "123 Magic Street",
        "City" : "Centennial",
        "State" : "CO",
        "Zip" : 80123
}
>
```

PERFORMER + ADDRESS - THE MONGODB WAY

```
> db.performers.find({_id:'Shawn'}).pretty()
{
        "_id" : "Shawn",
        "firstName" : "Shawn",
        "lastName" : "Popp",
        "website" : "http://openthetrapdoor.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Comedy Magic",
                "Mentalism"
        ],
        "address" : {
                "street" : "123 Magic Street",
                "city" : "Centennial",
                "state" : "CO",
                "zip" : 80123
        }
}
>
```

TAKE WHAT YOU NEED - PROJECTION

```
> db.performers.find({_id:'Shawn'}, {'_id':0, 'firstName':1, 'lastName':1, 'address.city':1}).pretty();
{
        "firstName" : "Shawn",
        "lastName" : "Popp",
        "address" : {
                "city" : "Centennial"
        }
}
>
```

SUBSTRUCTURES WORK WELL WITH CODE

```
let addr = db.performers.find({_id:'Shawn'}, {'_id':0,  'address':1}).pretty();

// Pass the whole Map to this function:
doSomethingWithOneAddress(addr);

//Somewhere in the code this function is defined
doSomethingWithOneAddress(Map addr){
. . //Look For State
. . }
```

WHY DOES THIS MATTER?

DOCUMENT SHAPES CAN VARY

```
[> db.performers.insertOne({_id:'Michael', firstName: 'Michael', lastName: 'Carducci'
 , website: 'http://trulymagic.com', performanceStyles: ['CloseUp magic','Stage Magic
 ',  'Mentalism'], address: {street:'3537 Stronghold Way', city:'Parker', state:'CO',
  country:'USA'}} );
> db.performers.find({}, {'_id':1, 'address':1}).pretty();;
{
        "_id" : "Shawn",
        "address" : {
                "street" : "123 Magic Street",
                "city" : "Centennial",
                "state" : "CO",
                "zip" : 80123
        }
}
{
        "_id" : "Michael",
        "address" : {
                "street" : "3537 Stronghold Way",
                "city" : "Parker",
                "state" : "CO",
                "country" : "USA"
        }
}
>
```

SUBSTRUCTURES WORK WELL WITH CODE

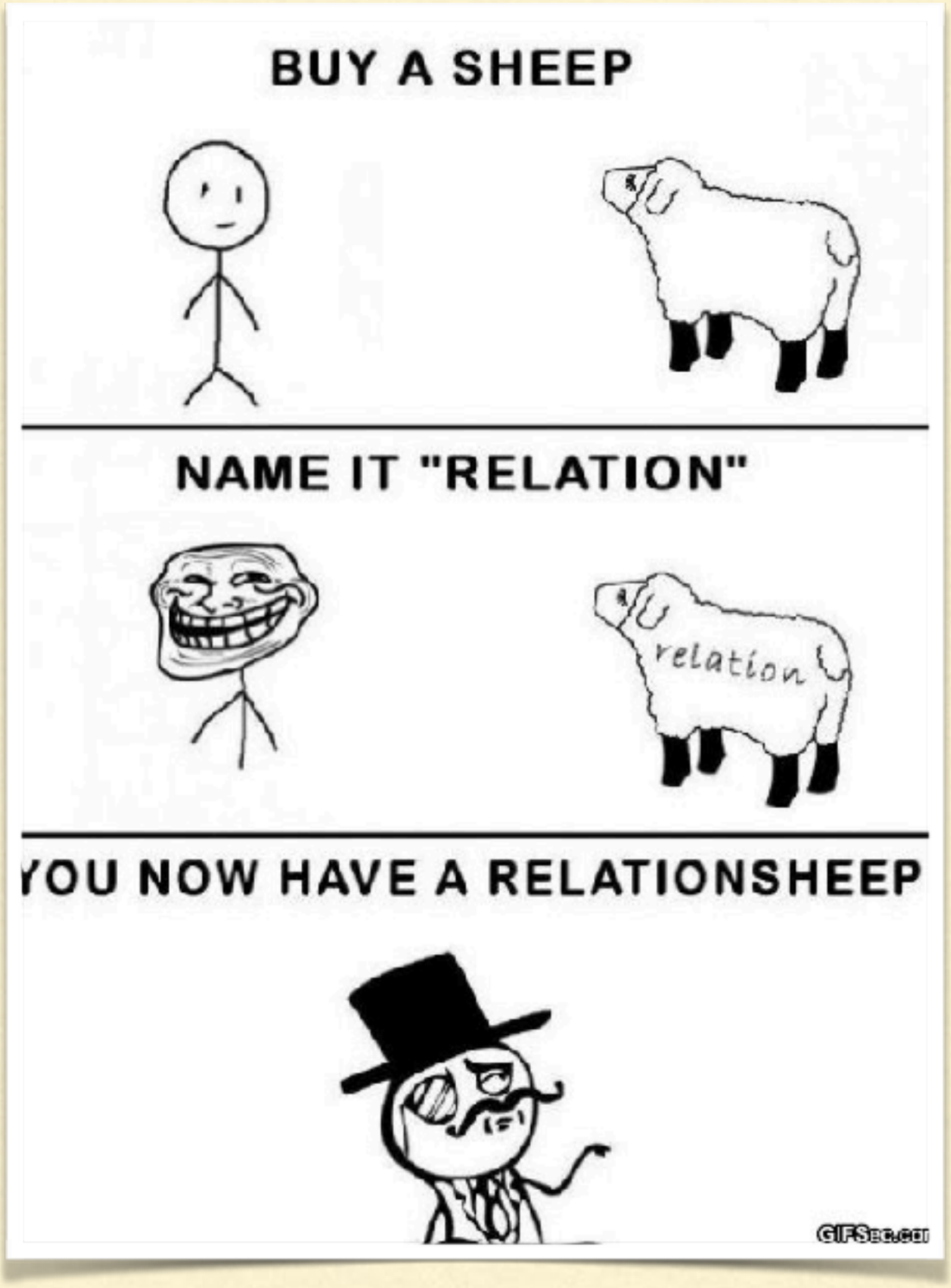
```
> addr = db.performers.find({_id:'Michael'}, {'_id':1, 'address':1}).pretty();
{
        "_id" : "Michael",
        "address" : {
                "street" : "3537 Stronghold Way",
                "city" : "Parker",
                "state" : "CO",
                "country" : "USA"
        }
}
```

```
// Pass the whole Map to this function:
doSomethingWithOneAddress(addr);

//Somewhere in the code this function is defined
doSomethingWithOneAddress(Map addr){
.. //Look For State Or Optional Country
.. }
```

Patterns & Best Practices

MODELING RELATIONSHIPS IN MONGODB



ONE-TO-ONE RELATIONSHIPS

- Belongs-to relationships are typically embedded
- Holistic view of the entity with embedded relationships and sub-structures
- Great Read Performance
- Keeps things simple
- Frees up time to tackle harder schema issues

ONE-TO-N BELONGS

MULTIPLE ADDRESSES

```
> db.performers.find({_id:'Michael'}).pretty();;
{
        "_id" : "Michael",
        "firstName" : "Michael",
        "lastName" : "Carducci",
        "website" : "http://trulymagic.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Mentalism"
        ],
        "addresses" : [
                {
                        "street" : "3537 Stronghold Way",
                        "city" : "Parker",
                        "state" : "CO",
                        "country" : "USA"
                },
                {
                        "street" : "123 S. Parker Rd STE 314",
                        "city" : "Parker",
                        "state" : "CO",
                        "country" : "USA"
                }
        ]
}
```

MULTIPLE ADDRESSES

```
> db.performers.find({_id:'Shawn'}).pretty()
{
        "_id" : "Shawn",
        "firstName" : "Shawn",
        "lastName" : "Popp",
        "website" : "http://openthetrapdoor.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Comedy Magic",
                "Mentalism"
        ],
        "address" : {
                "street" : "123 Magic Street",
                "city" : "Centennial",
                "state" : "CO",
                "zip" : 80123
        }
}
>
```

MIGRATION OPTIONS

- Leave it alone
  - Write code that knows how to handle both **address** and **addresses**
- Migrate all documents when Schema Changes
- Migrate On Demand
  - As a record is loaded, make the change
  - Inactive performers never get updated

ONE-TO-MANY USING EMBEDDING

ONE-TO-MANY USING EMBEDDING

```
> db.events.find().pretty();;
{
        "_id" : "Party",
        "name" : "Corporate Holiday Party",
        "performers" : [
                {
                        "firstName" : "Michael",
                        "lastName" : "Carducci"
                },
                {
                        "firstName" : "Shawn",
                        "lastName" : "Popp"
                }
        ],
        "eventDate" : ISODate("2017-12-15T00:00:00Z"),
        "showTime" : "19:30"
}
```

ONE-TO-MANY USING EMBEDDING

- Optimized for read performance of events
- We accept data duplication
- An index on “performer.name” provides
  - efficient lookup for all events for a given performer
  - efficient way to find all performer names (distinct)
- Does not automatically mean there is no master performer collection (where data would be copied from)

ONE-TO-MANY LINKING

```
> db.events.find().pretty();;
{
        "_id" : "Party",
        "name" : "Corporate Holiday Party",
        "performers" : [
                {
                        "performer_id" : "Michael"
                },
                {
                        "performer_id" : "Shawn"
                }
        ],
        "eventDate" : ISODate("2017-12-15T00:00:00Z"),
        "showTime" : "19:30"
}
>
```

ONE-TO-MANY LINKING

```
> db.performers.find({_id:{$in:['Michael','Shawn']}}).pretty();
{
        "_id" : "Michael",
        "firstName" : "Michael",
        "lastName" : "Carducci",
        "website" : "http://trulymagic.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Mentalism"
        ],
        "addresses" : [
                {
                        "street" : "3537 Stronghold Way",
                        "city" : "Parker",
                        "state" : "CO",
                        "country" : "USA"
                },
                {
                        "street" : "123 S. Parker Rd STE 314",
                        "city" : "Parker",
                        "state" : "CO",
                        "country" : "USA"
                }
```

ONE-TO-MANY LINKING

```
> db.events.find({eventDate: {$gt:ISODate(2018-05-01)}}).forEach(function(event) {
... //do whatever you need with the event document
... //in addition, caputure performer id
... //use it as a key in an object (Map)
... tmpm[event.performers.performer_id]= true;
... });
> uniqueIds = Object.keys(tmpm);
> db.performers.find({'_id': {'$in':uniqueIds} });
```

ONE-TO-MANY LINKING

- Optimized for efficient management of mutable data
- Familiar way to organize basic entities
- Code is not used to assemble fetched material into other objects, not disassemble a single ResultSet
  - More complicated queries may be easier to code and maintain with assembly vs disassembly

CAUTIONS

- Avoid Using Large or unbounded Arrays

CAUTIONS

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- Avoid Heavily Nested BSON documents

CAUTIONS

- Avoid Using Large Arrays
- Avoid Heavily Nested BSON documents
- Avoid collection over-normalization

UNBOUNDED ARRAYS

```
> client = db.clients.find({_id:'CarducciInc'}).pretty();
{
        "_id" : "CarducciInc",
        "name" : "Carducci Inc",
        "phone" : "555-1212",
        "events" : [
                "1",
                "2",
                "3"
        ]
}
> events = db.events.find({_id: {$in: client.events} });
```

ALTERNATIVE - PARENT-REFERENCING

```
> db.hosts.findOne()
{
    _id : ObjectID('AAAB'),
    name : 'goofy.example.com',
    ipaddr : '127.66.66.66'
}

>db.logmsg.findOne()
{
    time : ISODate("2014-03-28T09:42:41.382Z"),
    message : 'cpu is on fire!',
    host: ObjectID('AAAB')      // Reference to the Host document
}
```

UNBOUNDED ARRAYS

```
> client = db.clients.find({_id:'CarducciInc'}).pretty();
{
        "_id" : "CarducciInc",
        "name" : "Carducci Inc",
        "phone" : "555-1212",
        "events" : [
                "1",
                "2",
                "3"
        ]
}
> events = db.events.find({_id: {$in: client.events} });
```

STRATEGIC DATA DUPLICATION

```
> events = db.events.find().pretty();
{
        "_id" : "Party",
        "name" : "Corporate Holiday Party",
        "performers" : [
                {
                        "performer_id" : "Michael",
                        "firstName" : "Michael",
                        "lastName" : "Carducci"
                },
                {
                        "performer_id" : "Shawn",
                        "firstName" : "Shawn",
                        "lastName" : "Popp"
                }
        ],
        "eventDate" : ISODate("2017-12-15T00:00:00Z"),
        "showTime" : "19:30"
}
>
```

EMBEDDING VS LINKING

- **Embedding**
  - Great for Read Performance
    - Pre-aggregated material
    - Complex Structures
  - Great for Insert-only/immutable Designs
  - Inserts might be slower than linking
  - Data integrity for not-belongs-to needs to be managed
- **Linking**
  - flexible
  - Data-integrity is built-in
  - Work is done during Reads

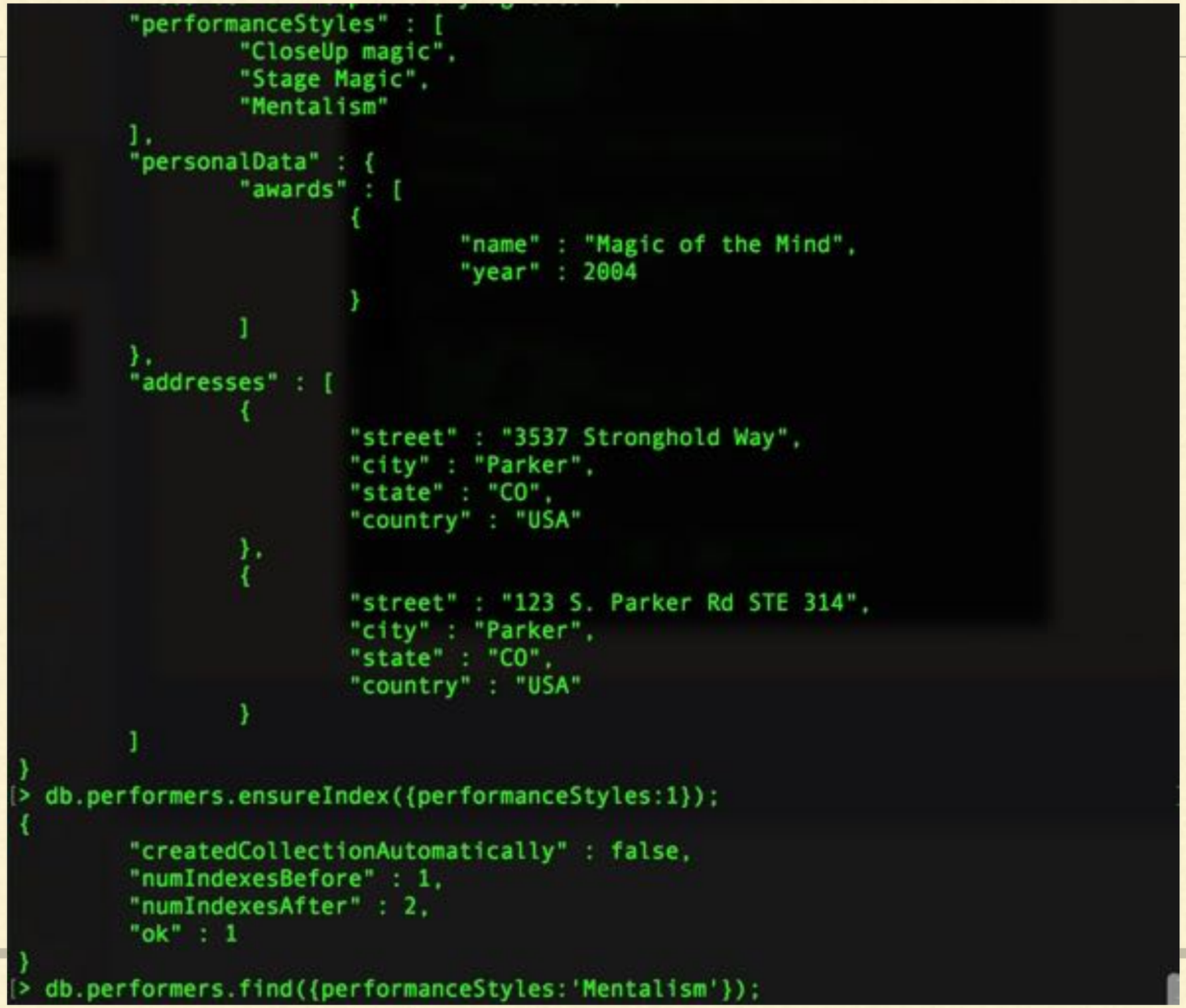
BEST PRACTICE: ASSIGN DYNAMIC STRUCTURE TO A KNOWN NAME

```
> db.performers.find().pretty();;
{
        "_id" : "Shawn",
        "firstName" : "Shawn",
        "lastName" : "Popp",
        "website" : "http://openthetrapdoor.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Comedy Magic",
                "Mentalism"
        ],
        "personalData" : {
                "birthday" : ISODate("1980-05-20T00:00:00Z")
        },
        "addresses" : [
                {
                        "street" : "123 Magic Street",
                        "city" : "Centennial",
                        "state" : "CO",
                        "zip" : 80123
                }
        ]
}
{
        "_id" : "Michael",
        "firstName" : "Michael",
        "lastName" : "Carducci",
        "website" : "http://trulymagic.com",
        "performanceStyles" : [
                "CloseUp magic",
                "Stage Magic",
                "Mentalism"
        ],
        "personalData" : {
                "awards" : [
                        {
                                "name" : "Magic of the Mind",
                                "year" : 2004
                        }
                ]
        },
```

POLYMORPHISM

```
> db.events.find()
{ type: “click", ts: ISODate(“2015-03-03T12:34:56.789Z“,
data: { x: 123, y: 625, adId: “AE23A“ } }

{ type: “click", ts: ISODate(“2015-03-03T12:35:01.003Z“,
data: { x: 456, y: 611, adId: “FA213“ } }

{ type: “view", ts: ISODate(“2015-03-03T12:35:04.102Z“,
data: { scn: 2, reset: false, … } }

{ type: “click", ts: ISODate(“2015-03-03T12:35:05.312Z“,
data: { x: 23, y: 32, adId: “BB512“ } }

{ type: “close", ts: ISODate(“2015-03-03T12:35:08.774Z“,
data: { snc: 2, logout: true, mostRecent: [ … ] } }

{ type: “click", ts: ISODate(“2015-03-03T12:35:10.114Z“,
data: { x: 881, y: 913, adId: “F430“ } }
```

SEARCHING BY ARRAY



DOCUMENT VALIDATION

```
> db.createCollection("books", { "validator":
{ $and: [
            { "title": {$type: “string”} },
            { "publishDate": {$type: “date”} },
            { $or: [
                    { "thumbnail": {$exists: False}},
                    { "thumbnail": {$type: “binary”}}
                    ]
                    }
             ]
}
});
```

SCHEMA SOFT VERSIONING

```
> db.createCollection("books", { "validator":
{ $or: [
  { $and: [ { "v": 1},
          { "title": {$type: “string”} }
           ]
           },
   { $and: [ { "v": 2},
          { "title": {$type: “string”} },
          { "publishDate": {$type: “date”} },
          { $or: [
                  { "thumbnail": {$exists: False}},
                  { "thumbnail": {$type: “binary”}}
                  ]
                  }
           ]
   }
]
});
```

SUMMARY

- Physical Design is different in MongoDB
  - Basic data design principles stay the same
  - Focus on how an application accesses/manipulates the data
  - Seek out and capture belongs-to/1:1 relationships
  - Use substructure to better align code objects
  - Be polymorphic
  - Evolve the schema to meet requirements as they change

DON’T LINK THE DOCUMENTS

SCHEMA DESIGN BEST PRACTICES

- favor embedding unless there is a compelling reason not to

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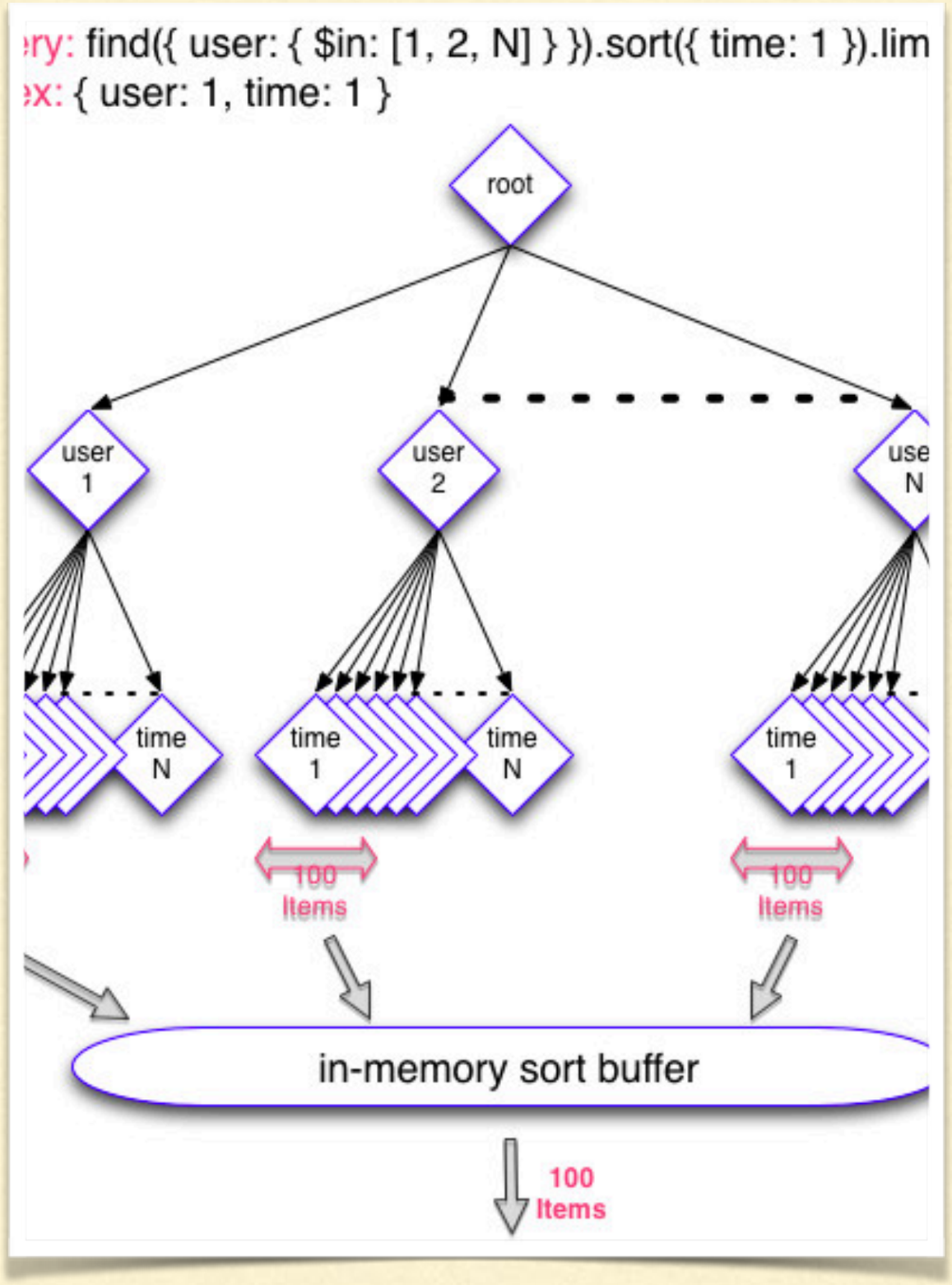
- Consider the write/read ratio when denormalizing.

SCHEMA DESIGN BEST PRACTICES

- favor embedding unless there is a compelling reason not to
- needing to access an object on its own is a compelling reason not to embed it
- Avoid unbounded arrays
- Don’t fear application-level joins
- Consider the write/read ratio when denormalizing.
- Structure data based on anticipated data-access patterns

Patterns & Best Practices

INDEXES IN MONGODB



SELECTING WHAT TO INDEX

Optimize for workload

Write Performance

Read Performance

MONGODB INDEX LIMITATIONS

- A collection cannot have more than 64 indexes.
- Index entries cannot exceed 1024 bytes.
- The name of an index must not exceed 125 characters (including its namespace).
- In-memory sorting of data without an index is limited to 32MB. This operation is very CPU intensive, and in-memory sorts indicate an index should be created to optimize these queries.

MONGODB INDEX BUILDING TECHNIQUES

- Foreground Index Build

MONGODB INDEX BUILDING TECHNIQUES

- Foreground Index Build
- Background Index Build

MONGODB INDEX BUILDING TECHNIQUES

- Foreground Index Build
- Background Index Build
- Rolling Index Build

INDEX BEST PRACTICES

USE A COMPOUND INDEX, NOT INDEX INTERSECTION

USE A COMPOUND INDEX, NOT INDEX INTERSECTION

AVOID LOW SELECTIVITY INDEXES

USING REGULAR EXPRESSIONS

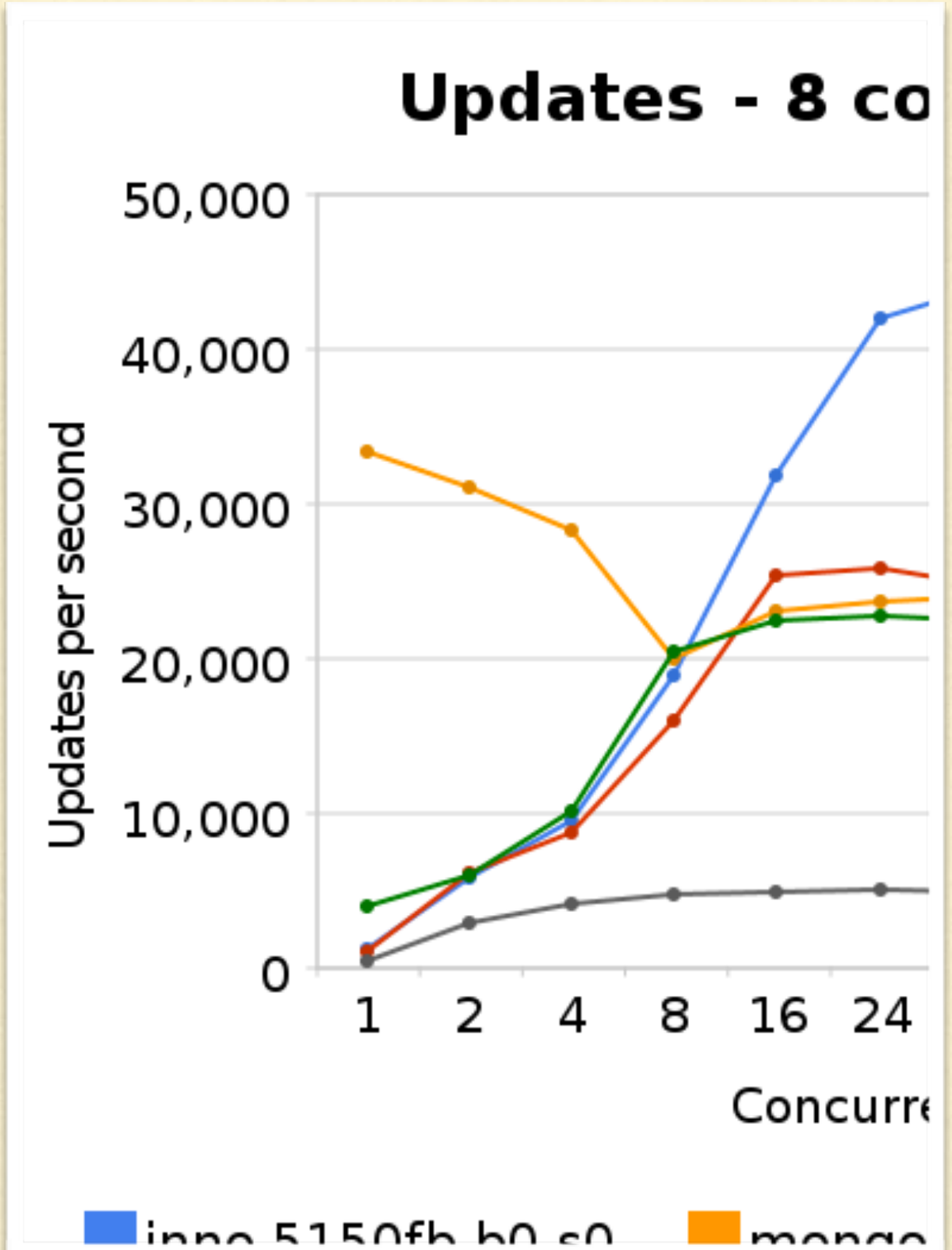
INEQUALITY QUERIES CAN BE INEFFICIENT

ELIMINATE UNNECESSARY INDEXES

USE PARTIAL INDEXES WHERE APPROPRIATE

Patterns, Pitfalls & best practices

PERFORMANCE



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AVOID GROWING DOCUMENTS

USE FIELD MODIFIERS

PAY ATTENTION TO BSON DATA TYPES

PREALLOCATE DOCUMENTS

PREALLOCATE DOCUMENTS

USE _ID FOR YOUR OWN PURPOSES

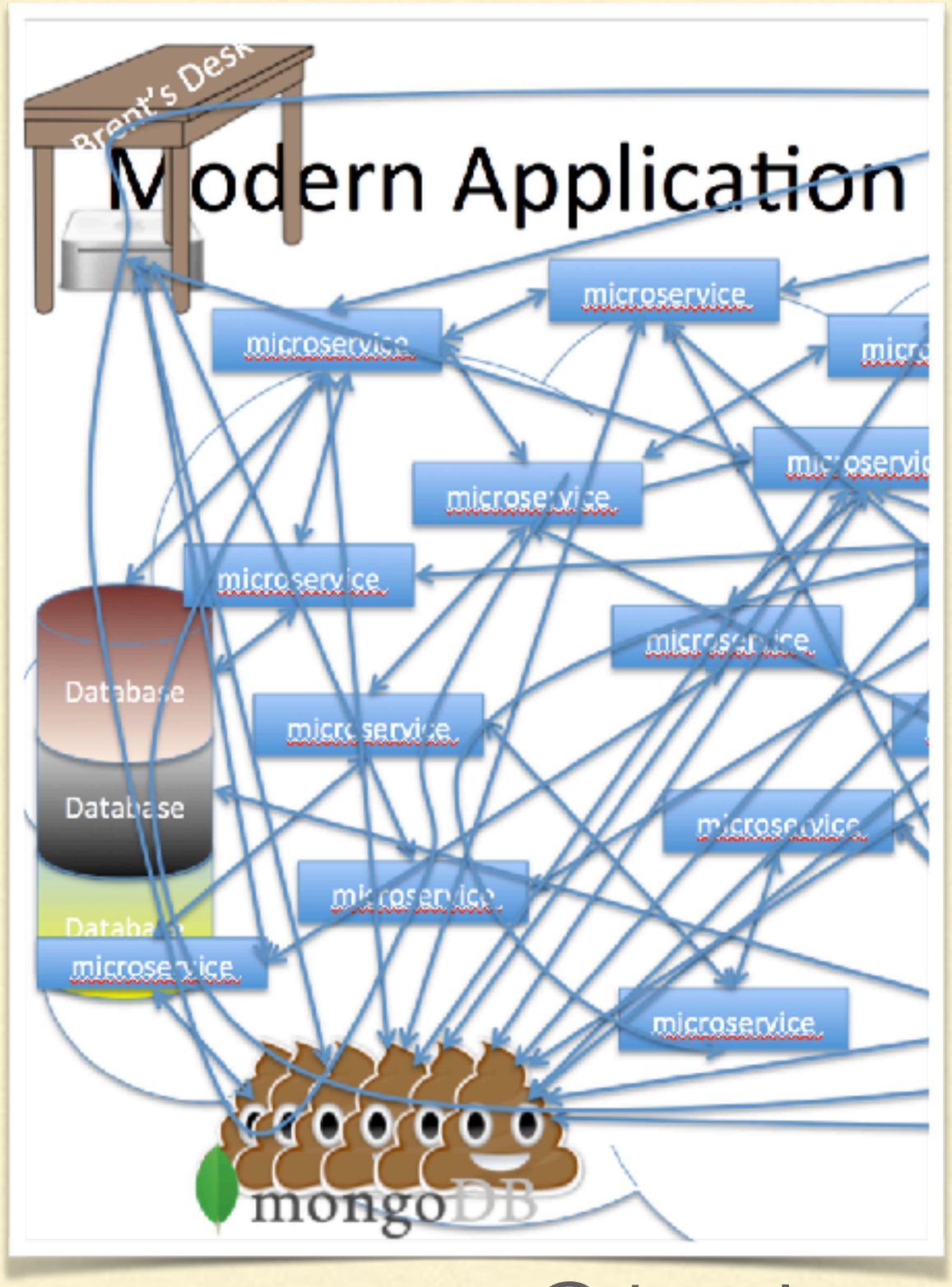
USE COVERED INDEXES

USE COLLECTIONS AND DATABASES TO YOUR ADVANTAGE

USE COLLECTIONS AND DATABASES TO YOUR ADVANTAGE

Pitfalls

OPERATIONS BEST PRACTICES



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DURABILITY

"..... If you were stupid enough to totally ignore durability just to get benchmarks, I suggest you pipe your data to /dev/null. It will be very fast."

–garlt

WRITE ACKNOWLEDGED

JOURNAL ACKNOWLEDGED

REPLICA ACKNOWLEDGED

MAJORITY ACKNOWLEDGED

CONSISTENCY

DESIGN YOUR SCHEMA FOR SCALE

OPTIMIZE YOUR INDEXES

OPTIMIZE YOUR HARDWARE

KNOW YOUR PERFORMANCE METRICS

SCALING MONGO (OUT)

"Shards are the secret ingredient in the web scale sauce. They just work."

–garlt

CHOOSE YOUR SHARD KEY WISELY

CHOOSING A SHARD KEY

- Cardinality

CHOOSING A SHARD KEY

- Cardinality
- Insert Scaling

CHOOSING A SHARD KEY

- Cardinality
- Insert Scaling
- Query Isolation

SHARDING PITFALLS

DON'T USE A MONOTONICALLY INCREASING SHARD KEY (LIKE OBJECTID)

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USE HASHED SHARDING

YOU CAN'T UPDATE YOUR SHARD KEY

YOU CAN'T UPDATE YOUR SHARD KEY

MISC SHARDING BEST PRACTICES

- Add capacity before it is needed.

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- Run 3+ configuration servers to provide redundancy

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MISC SHARDING BEST PRACTICES

- Add capacity before it is needed.
- Run 3+ configuration servers to provide redundancy
- Use Replica Sets
- Pre-split bulk inserts

PRACTICE PRINCIPLE OF LEAST PRIVILEGE

ENCRYPT DATA IN TRANSPORT

ENCRYPT DATA AT REST

ENCRYPT DATA AT REST

- The MongoDB Encrypted storage engine
- Certified database encryption solutions from MongoDB partners such as IBM and Vormetric
- Logic within the application itself

READ-ONLY, REDACTED VIEWS

MISC BEST PRACTICES

MISC BEST PRACTICES

- Always Use Replica Sets

MISC BEST PRACTICES

- Always Use Replica Sets
- Use the latest versions

MISC BEST PRACTICES

- Always Use Replica Sets
- Use the latest versions
- Turn on journaling by default

MISC BEST PRACTICES

- Always Use Replica Sets
- Use the latest versions
- Turn on journaling by default
- Your working set should fit in memory

Thank you

Michael Carducci

@MichaelCarducci


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