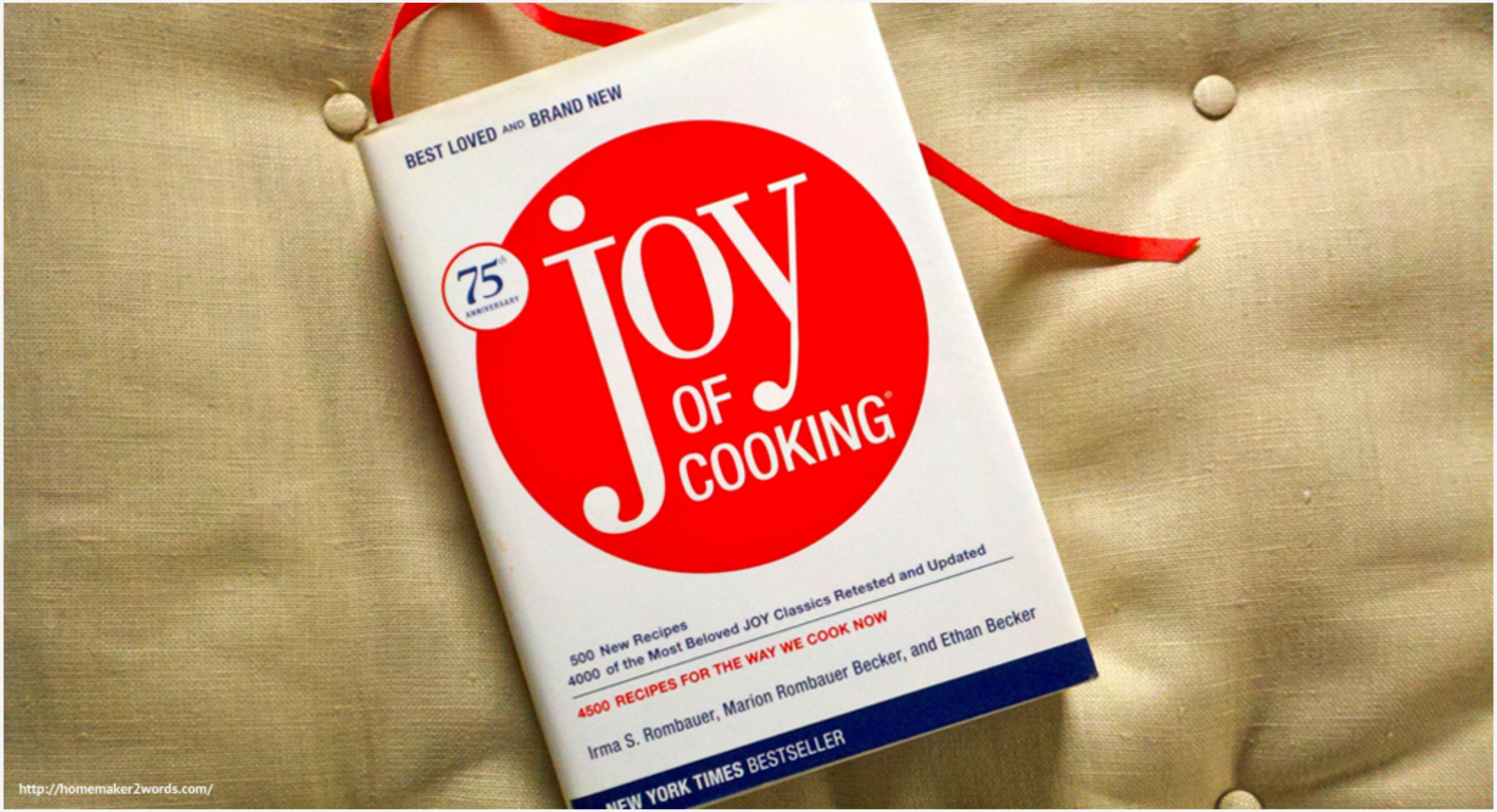
Indexing and Query Optimization

Agenda

- What are indexes?
- Why do I need them?
- Working with indexes in MongoDB
- Optimize your queries
- Avoiding common mistakes

What Are Indexes?

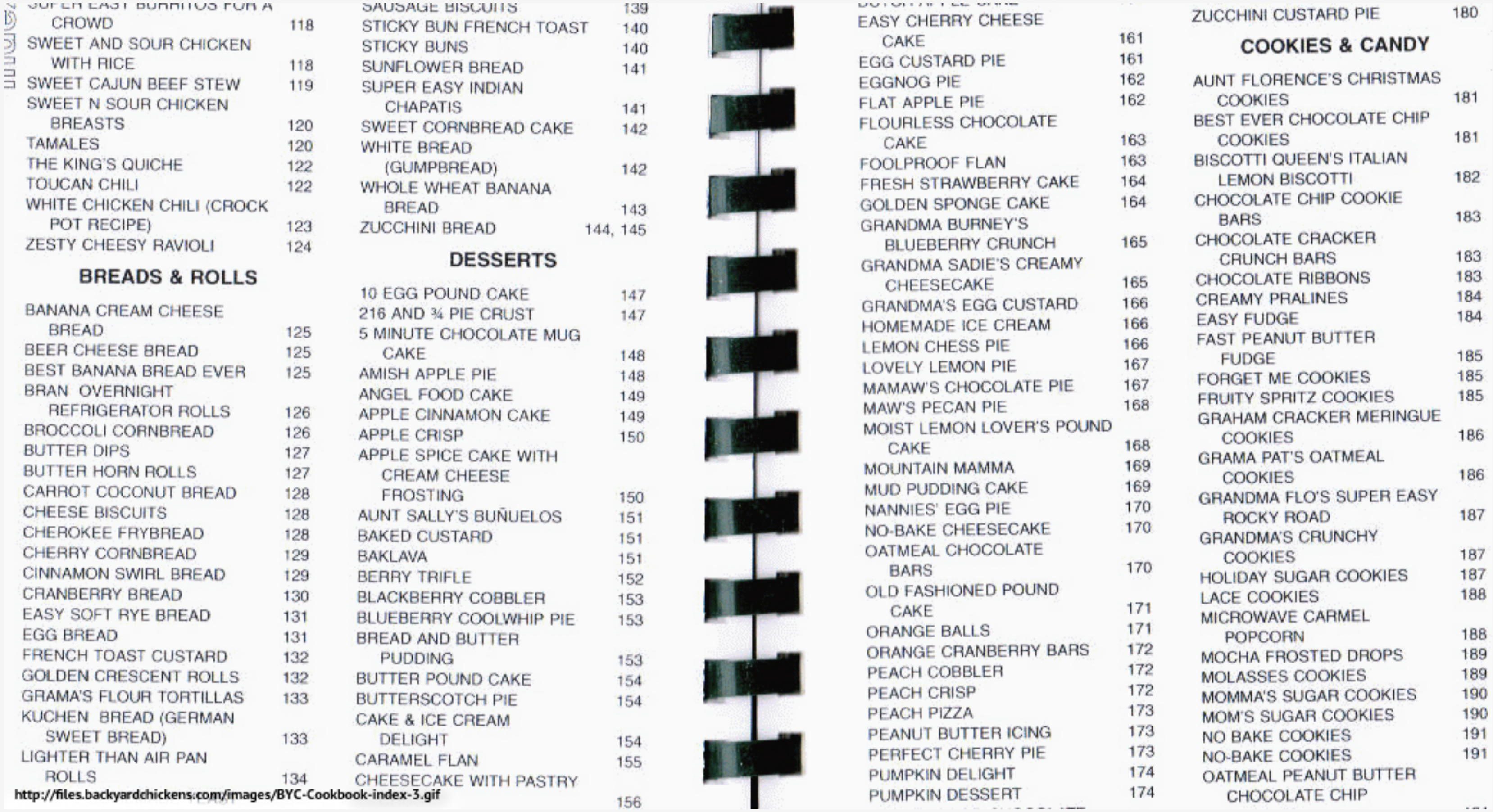

BEST LOVED AND BRAND NEW
75th ANNIVERSARY
joy OF COOKING
500 New Recipes
4000 of the Most Beloved JOY Classics Retested and Updated
4500 RECIPES FOR THE WAY WE COOK NOW
Irma S. Rombauer, Marion Rombauer Becker, and Ethan Becker
NEW YORK TIMES BESTSELLER

http://homemaker2words.com/

What Are Indexes?

Imagine you're looking for a recipe in a cookbook ordered by recipe name. Looking up a recipe by name is quick and easy.

Consult the Index



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http://files.backyardchickens.com/images/BYC-Cookbook-index-3.gif

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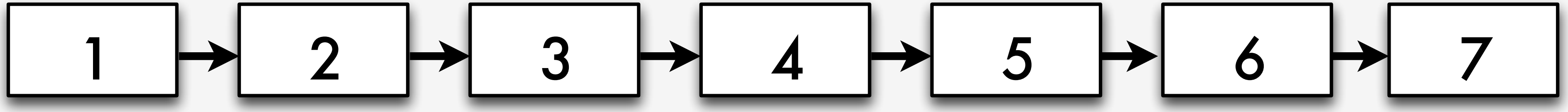
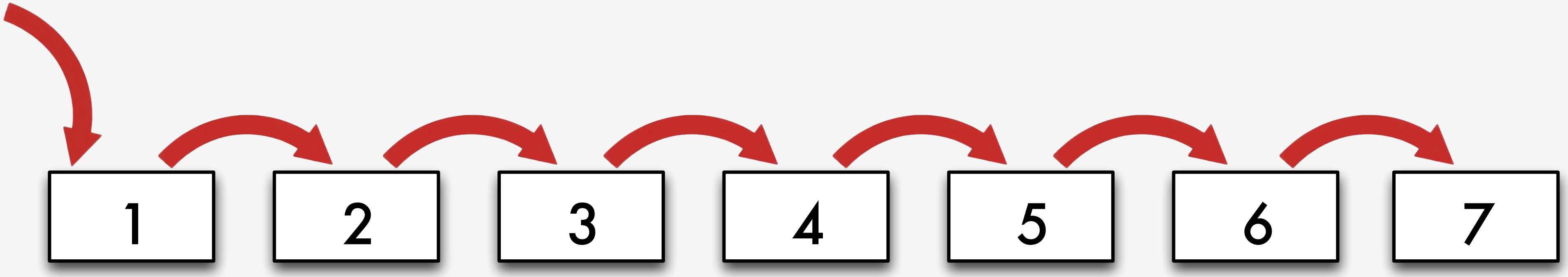
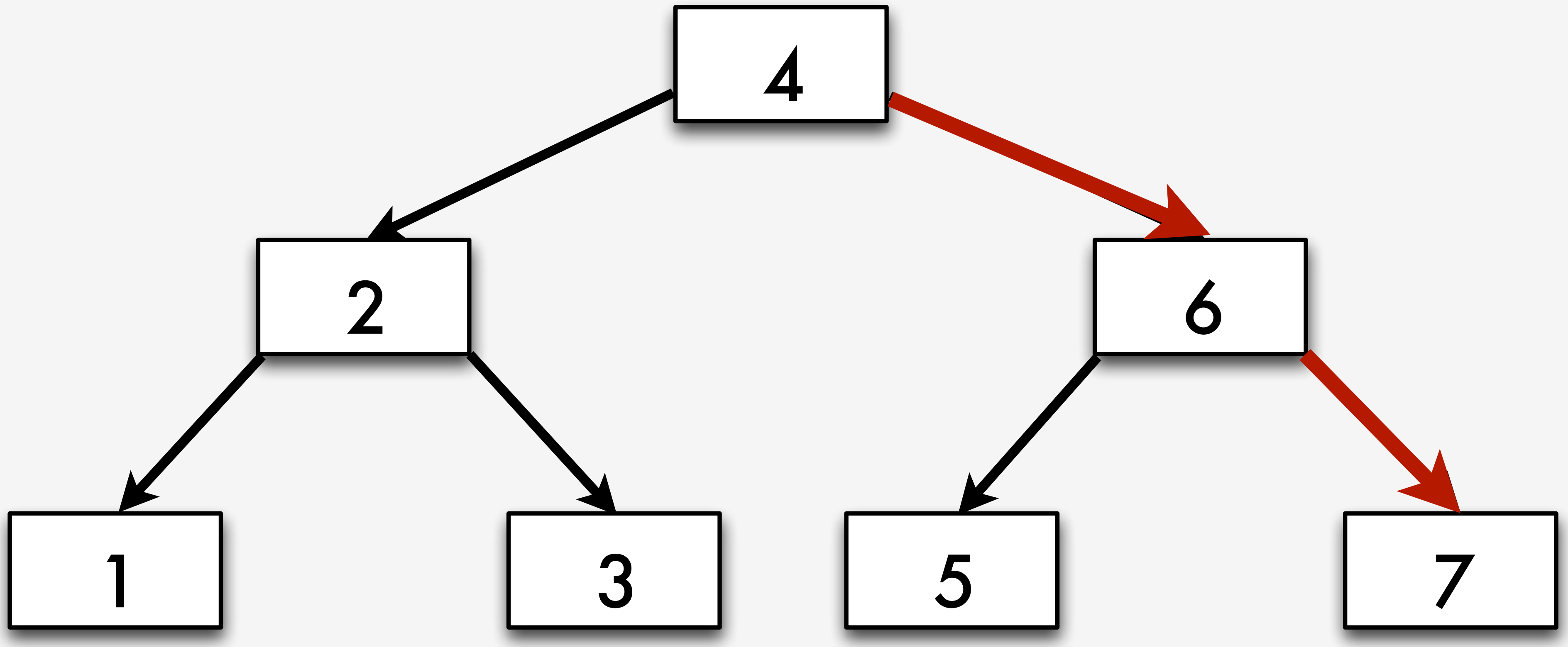


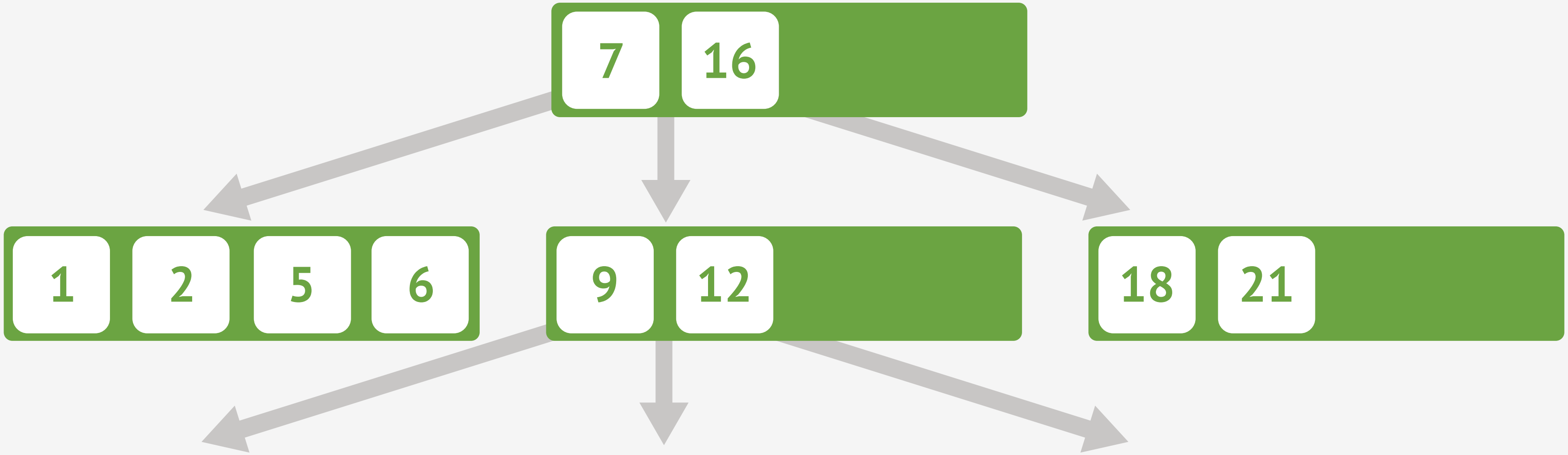
Finding 7 in a Linked List



Finding 7 In a Tree

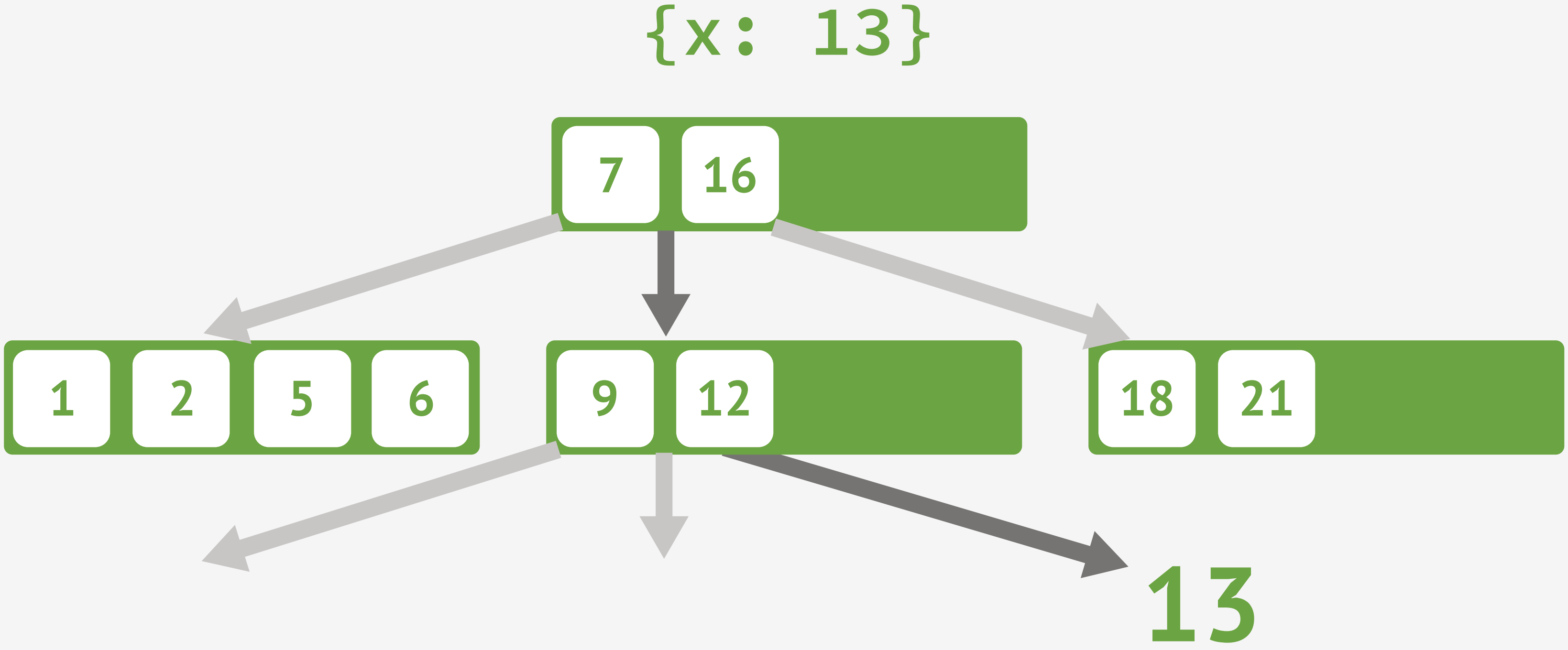


Indexes in MongoDB are B-Trees



Queries, inserts and deletes: O(log(n)) time

B-Trees



Indexes are the single biggest tunable performance factor in MongoDB

Absent or suboptimal indexes are the most common avoidable MongoDB performance problem.

Why do I need indexes?

A brief story

Working with Indexes in MongoDB

How Do I Create Indexes?

```
// Create an index if one does not exist
db.recipes.ensureIndex ( { main_ingredient : 1 } )



// The client remembers the index and raises no errors
db.recipes.ensureIndex( { main_ingredient : 1 } )
```

* 1 means ascending, -1 descending

What Can Be Indexed?

```
// Multiple fields (compound key indexes)
db.recipes.ensureIndex({
    main_ingredient: 1,
    calories: -1
})

// Arrays of values (multikey indexes)
{
    name: 'Chicken Noodle Soup’,
    ingredients : [ 'chicken', 'noodles’ ]
}

db.recipes.ensureIndex( { ingredients : 1 } )
```

What Can Be Indexed?

```
// Embedded documents
{
    name : 'Apple Pie',
    contributor : {
        name : 'Joe American',
        id : 'joea123'
    }
}

db.recipes.ensureIndex ( { 'contributor.id’ : 1 } )

db.recipes.ensureIndex ( { 'contributor’ : 1 } )
```

How Do I Manage Indexes?

```
// List a collection's indexes
db.recipes.getIndexes()
db.recipes.getIndexKeys()

// Drop a specific index
db.recipes.dropIndex ( { ingredients : 1 } )

// Drop all indexes and recreate them
db.recipes.reIndex( )

// Default (unique) index on _id
```

Background Index Builds

```
// Index creation is a blocking operation that can take a long time
// Background creation yields to other operations
db.recipes.ensureIndex (
    { ingredients: 1 },
    { background: true }
)
```

Options

- Uniqueness constraints (unique, dropDups)
- Sparse Indexes

Uniqueness Constraints

```
// Only one recipe can have a given value for name

db.recipes.ensureIndex( { name: 1 }, { unique: true } )


// Force index on collection with duplicate recipe names – drop the duplicates

db.recipes.ensureIndex(
    { name: 1 },
    { unique: true, dropDups: true }
)
```

* dropDups should be used with caution

Sparse Indexes

```
// Only documents with field calories will be indexed
db.recipes.ensureIndex(
    { calories : -1 },
    { sparse : true }
)
// Allow multiple documents to not have calories field
db.recipes.ensureIndex (
    { name: 1 , calories : -1 },
    { unique : true, sparse : true }
)
```

* Missing fields are stored as null(s) in the index

Other Index Types

- Geospatial Indexes (2d Sphere)
- Text Indexes
- TTL Collections (expireAfterSeconds)
- Hashed Indexes for sharding

Geospatial Indexes

```
// Add GeoJSON
{
   name: ’MongoDB Palo Alto’,
   loc: { type : “Point”,
          coordinates: [ 37.449157 , -122.158574 ] }
}
// Index the coordinates
db.locations.ensureIndex( { loc : '2dsphere' } )
```

Geospatial Indexes

```
// Query for locations 'near' a particular coordinate
db.locations.find ( {
   loc: { $near:
          { $geometry:
               { type : “Point”,
               coordinates: [ 37.4, -122.3 ] },
          $maxDistance: 40 }
          }
} )
```

Text Indexes

```
db.recipes.insert( { _id : 4 , y : “add flour and mix" } );
db.recipes.ensureIndex( { y : "text" } );
```

Limitations

- Collections can not have > 64 indexes.
- Index keys can not be > 1024 bytes (1K).
- The name of an index, including the namespace, must be < 125 characters.
- Queries can only use 1 index*
- Indexes have storage requirements, and impact the performance of writes.
- In memory sort (no-index) limited to 32mb of return data.

Optimize Your Queries

The “Explain” Plan (Pre-Index)

```
db.recipes.find( { calories:
   { $lt : 40 } }
).explain( )
{
  "cursor" : "BasicCursor" ,
  "n" : 42,
  "nscannedObjects” : 12345,
  "nscanned" : 12345,
   ...
  "millis" : 356,
   ...
}
```

* Doesn’t use cached plans, re-evals and resets cache

The “Explain” Plan (Post-Index)

```
db.recipes.find( { calories:
   { $lt : 40 } }
).explain( )
{
  "cursor" : ”BtreeCursor calories_1" ,
  "n" : 42,
  "nscannedObjects” : 42,
  "nscanned" : 42,
   ...
  "millis" : 3,
   ...
}
```

* Doesn’t use cached plans, re-evals and resets cache

Profiling Slow Operations

db.setProfilingLevel(*n* , *slowms=100ms*)

n=0 profiler off

n=1 record operations longer than *slowms*

n=2 record all queries

db.system.profile.find()

* The profile collection is a capped collection, and fixed in size

The Query Optimizer

- For each "type" of query, MongoDB periodically tries *all* useful indexes
- Aborts the rest as soon as one plan wins
- The winning plan is temporarily cached for each “type” of query

Manually Select Index to Use

```
// Tell the database what index to use
db.recipes.find( {
    calories: { $lt : 1000 } }
).hint ( { _id : 1 } )

// Tell the database to NOT use an index
db.recipes.find(
    { calories: { $lt : 1000 } }
).hint( { $natural : 1 } )
```

Use Indexes to Sort Query Results

```
// Given the following index
db.collection.ensureIndex( { a : 1, b : 1 , c : 1, d : 1 } )

// The following query and sort operations can use the index
db.collection.find( ).sort( { a : 1 } )
db.collection.find( ).sort( { a : 1, b : 1 } )

db.collection.find( { a : 4 } ).sort( { a : 1, b : 1 } )

//This query will not use the index, but will use the index to sort
db.collection.find( { b : 5 } ).sort( { a : 1, b : 1 } )
```

Indexes that won’t work for sorting query results

```
// Given the following index
db.collection.ensureIndex( { a : 1, b : 1, c : 1, d : 1 } )


// These can not sort using the index
db.collection.find( ).sort( { b : 1 } )
db.collection.find( { b : 5 } ).sort( { b : 1 } )
```

Indexes that won’t work for sorting query results

```
// MongoDB can return data from just the index
db.recipes.ensureIndex({ main_ingredient : 1, name : 1 })

// Return only the ingredients field
db.recipes.find(
   { main_ingredient : 'chicken’ },
   { _id: 0, name : 1 }
)

// indexOnly will be true in the explain plan
db.recipes.find(
   { main_ingredient : 'chicken' },
   { _id: 0, name: 1 }
).explain()
{
   "indexOnly” : true,
}
```

Absent or suboptimal indexes are the most common avoidable MongoDB performance problem.

Avoiding Common Mistakes

Trying to Use Multiple Indexes

```
// MongoDB can only use one index for a query
db.collection.ensureIndex( { a : 1 } )
db.collection.ensureIndex( { b : 1 } )

// Only one of the above indexes is used
db.collection.find( { a : 3, b : 4 } )
```

Compound Key Mistakes

```
// MongoDB can only use one index for a query
db.collection.ensureIndex({ a: 1 })
db.collection.ensureIndex({ b: 1 })

// Only one of the above indexes is used
db.collection.find({ a: 3, b: 4 })

// Use a compound index
db.collection.ensureIndex( { a : 1, b : 1 } )
```

Low Selectivity Indexes

```
db.collection.distinct('status’)
[ 'new', 'processed' ]

db.collection.ensureIndex( { status : 1 } )

// Low selectivity indexes provide little benefit
db.collection.find( { status : 'new' } )

// Better
db.collection.ensureIndex ({ status : 1, created_at : -1 } )
db.collection.find(
    { status : 'new' }
).sort( { created_at : -1 } )
```

Regular Expressions

```
db.users.ensureIndex( { username : 1 } )

// Left anchored regex queries can use the index
db.users.find( { username : /^joe smith/ } )

// But not generic regexes
db.users.find( {username : /smith/ } )

// Or case insensitive queries
db.users.find( { username : /Joe/i } )
```

Negation

```
// Indexes aren't helpful with negations
db.things.ensureIndex( { x : 1 } )

// e.g. "not equal" queries
db.things.find( { x : { $ne : 3 } } )

// ...or "not in" queries
db.things.find( { x : { $nin : [2, 3, 4 ] } } )

// ...or the $not operator
db.people.find( { name: { $not : 'John Doe' } } )
```

Choosing the right indexes is one of the most important things you can do as a MongoDB developer. **Take indexes into consideration when designing your application.**

Thank You