Aggregation Framework

Agenda

- State of Aggregation
- Pipeline
- Usage and Limitations
- Optimization
- Sharding
- Expressions (time permitting)
- Looking Ahead

State of Aggregation

State of Aggregation

- We're storing our data in MongoDB
- We need to do ad-hoc reporting, grouping, common aggregations, etc.
- What are we using for this?

Data Warehousing

Data Warehousing

- SQL for reporting and analytics
- Infrastructure complications
  - Additional maintenance
  - Data duplication
  - ETL processes
  - Real time?

Aggregation Framework

http://www.swissknifeshop.com/swiss-army-giant-by-wenger

mongoDB

MapReduce

- Extremely versatile, powerful
- Intended for complex data analysis
- Overkill for simple aggregation tasks
  - Averages
  - Summation
  - Grouping

MapReduce in MongoDB

- Implemented with JavaScript
  - Single-threaded
  - Difficult to debug
- Concurrency
  - Appearance of parallelism
  - Write locks

Aggregation Framework

http://www.victorinox.com/us/product/Swiss-Army-Knives/Category/Classics/Classic-SD/53001

Aggregation Framework

- Declared in JSON, executes in C++
- Flexible, functional, and *simple*
  - Operation pipeline
  - Computational expressions
- Plays nice with sharding

Pipeline

Pipeline

- Process a stream of documents
  - Original input is a collection
  - Final output is a result document
- Series of operators
  - Filter or transform data
  - Input/output chain

Pipeline Operators

- $match
- $project
- $group
- $unwind
- $sort
- $limit
- $skip

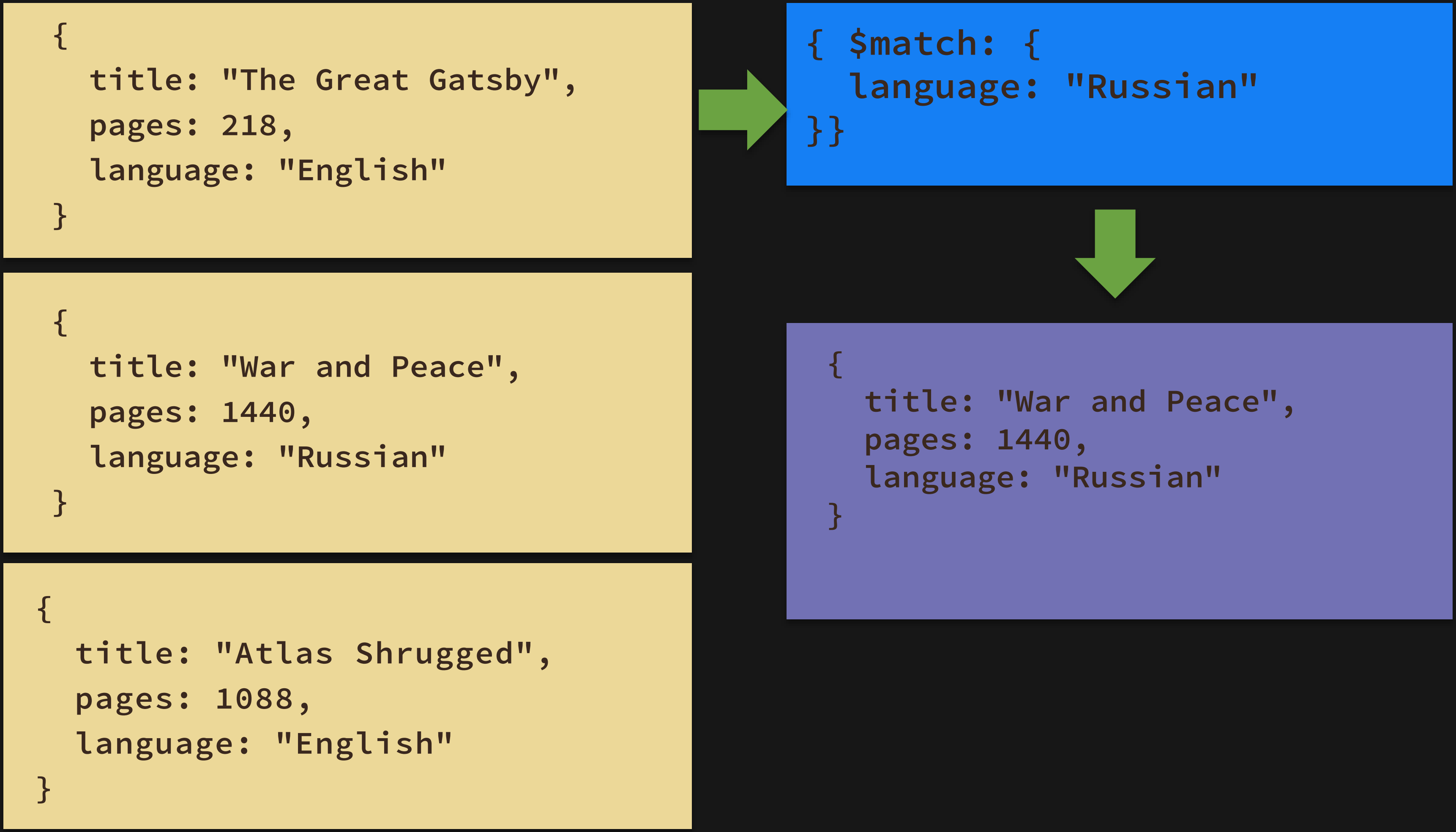
Our Example Data

```
{
  _id: 375,
  title: "The Great Gatsby",
  ISBN: "9781857150193",
  available: true,
  pages: 218,
  chapters: 9,
  subjects: [
    "Long Island",
    "New York",
    "1920s"
  ],
  language: "English"
}
```

$match

- Filter documents
- Uses existing query syntax
- No geospatial operations or $where

Matching Field Values



```
{
  title: "The Great Gatsby",
  pages: 218,
  language: "English"
}
```

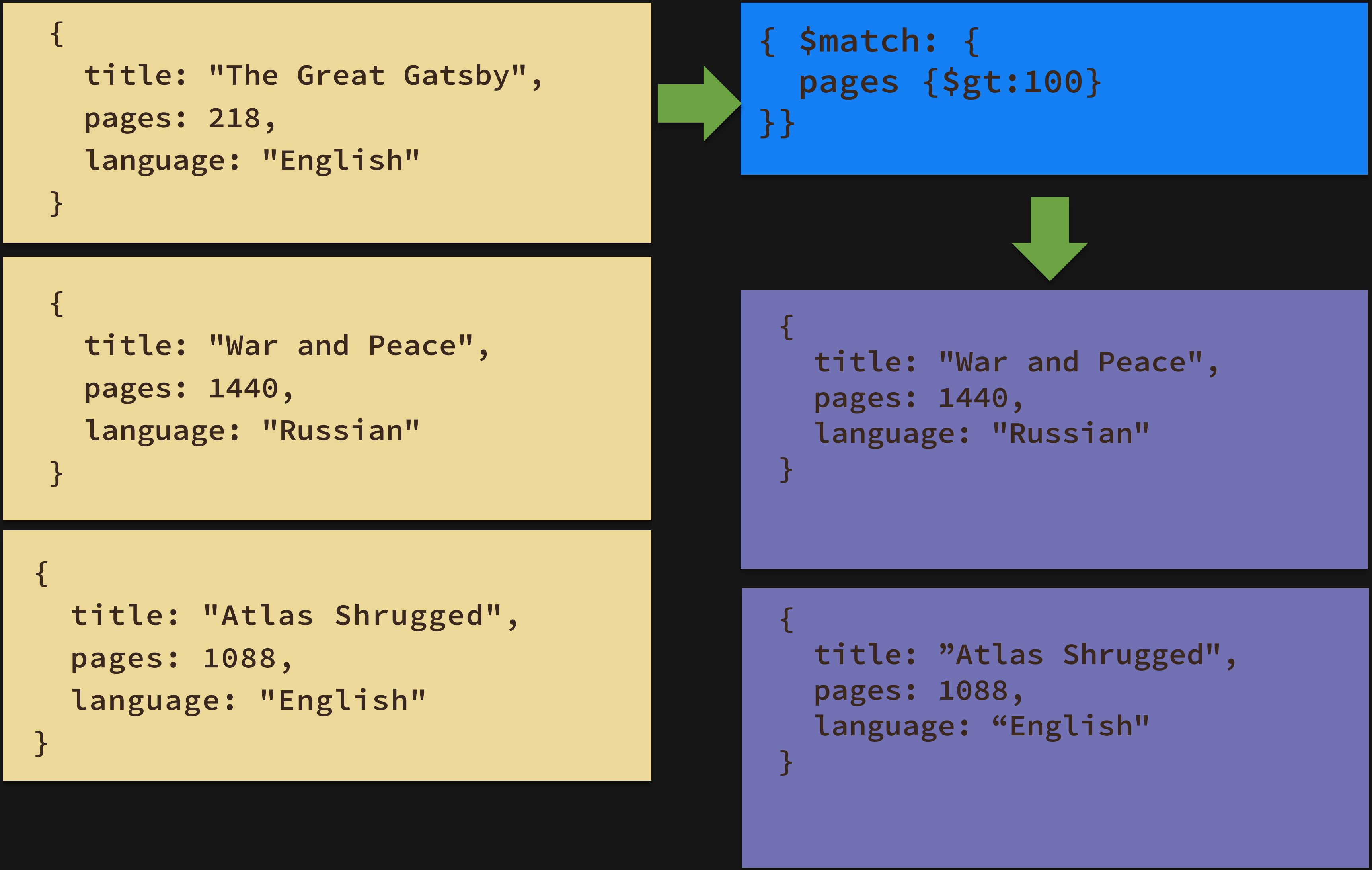
```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: "Atlas Shrugged",
  pages: 1088,
  language: "English"
}
```

```
{ $match: {
  language: "Russian"
}}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

Matching with Query Operators



```
{
  title: "The Great Gatsby",
  pages: 218,
  language: "English"
}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: "Atlas Shrugged",
  pages: 1088,
  language: "English"
}
```

```
{ $match: {
  pages {$gt:100}
}}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: ”Atlas Shrugged",
  pages: 1088,
  language: “English"
}
```

$project

- Reshape documents
- Include, exclude or rename fields
- Inject computed fields
- Create sub-document fields

Including and Excluding Fields

```
{
  _id: 375,
  title: "Great Gatsby",
  ISBN: "9781857150193",
  available: true,
  pages: 218,
  subjects: [
    "Long Island",
    "New York",
    "1920s"
  ],
  language: "English"
}
```

```
{ $project: {
  _id: 0,
  title: 1,
  language: 1
}}
```

```
{
  title: "Great Gatsby",
  language: "English"
}
```

Renaming and Computing Fields

```
{
  _id: 375,
  title: "Great Gatsby",
  ISBN: "9781857150193",
  available: true,
  pages: 218,
  chapters: 9,
  subjects: [
    "Long Island",
    "New York",
    "1920s"
  ],
  language: "English"
}
```

```
{ $project: {
    avgChapterLength: {
      $divide: ["$pages",
                "$chapters"]
    },
    lang: "$language"
}}
```

```
{
  _id: 375,
  avgChapterLength: 24.2222,
  lang: "English"
}
```

Creating Sub-Document Fields

```
{
  _id: 375,
  title: "Great Gatsby",
  ISBN: "9781857150193",
  available: true,
  pages: 218,
  chapters: 9,
  subjects: [
    "Long Island",
    "New York",
    "1920s"
  ],
  language: "English"
}
```

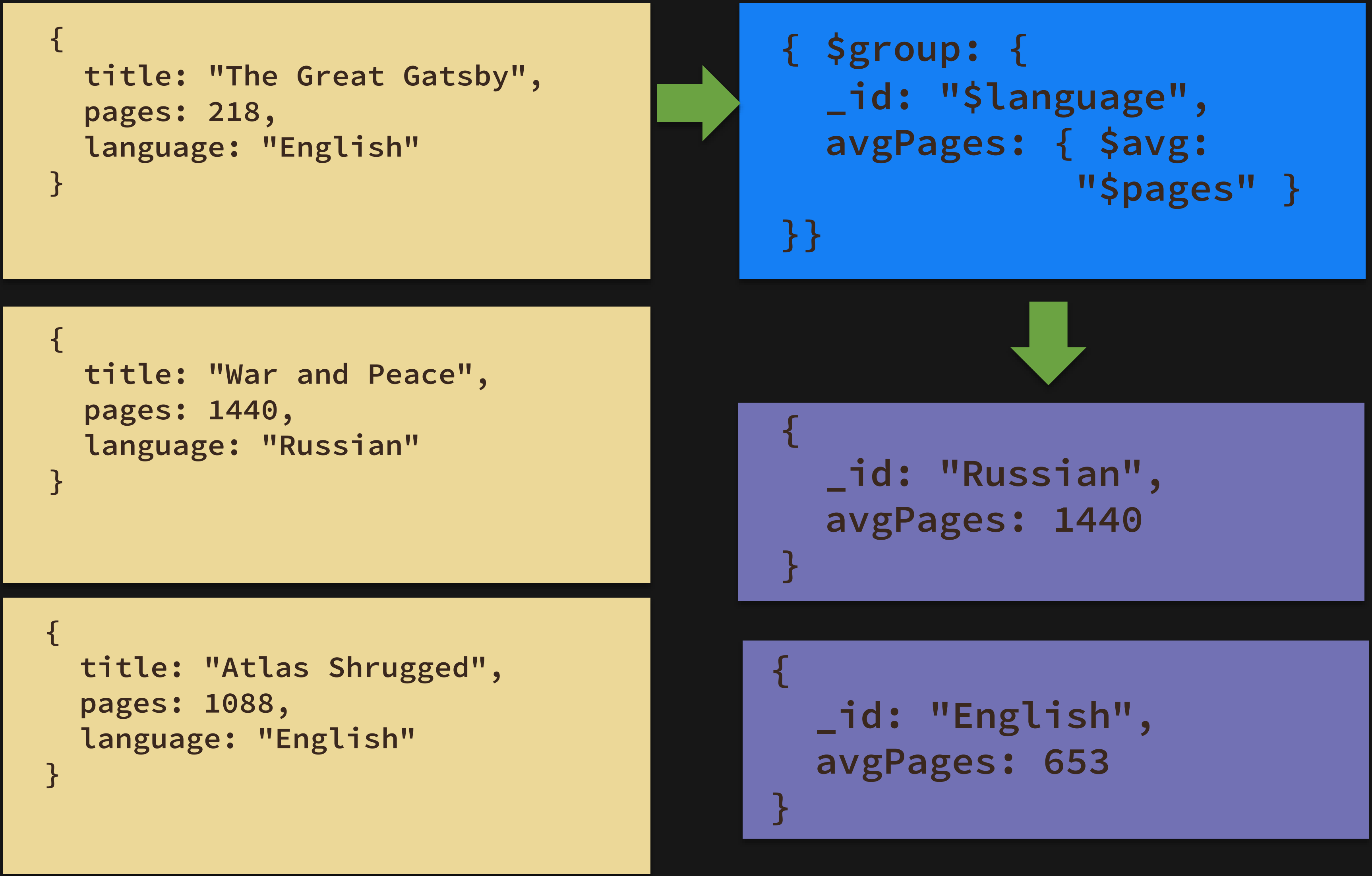
```
{ $project: {
  title: 1,
  stats: {
    pages: "$pages",
    language: "$language",
  }
}}
```

```
{
  _id: 375,
  title: "Great Gatsby",
  stats: {
    pages: 218,
    language: "English"
  }
}
```

$group

- Group documents by an ID
  - Field reference, object, constant
- Other output fields are computed
  - `$max, $min, $avg, $sum`
  - `$addToSet, $push`
  - `$first, $last`
- Processes all data in memory

Calculating An Average



```
{
  title: "The Great Gatsby",
  pages: 218,
  language: "English"
}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: "Atlas Shrugged",
  pages: 1088,
  language: "English"
}
```

```
{ $group: {
  _id: "$language",
  avgPages: { $avg:
             "$pages" }
}}
```

```
{
  _id: "Russian",
  avgPages: 1440
}
```

```
{
  _id: "English",
  avgPages: 653
}
```

Summating Fields and Counting

```
{
  title: "The Great Gatsby",
  pages: 218,
  language: "English"
}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: "Atlas Shrugged",
  pages: 1088,
  language: "English"
}
```

```
{ $group: {
  _id: "$language",
  avgPages: { $avg:
                "$pages" }
}}
```

```
{
  _id: "Russian",
  avgPages: 1440
}
```

```
{
  _id: "English",
  avgPages: 653
}
```

Collecting Distinct Values

```
{
  title: "The Great Gatsby",
  pages: 218,
  language: "English"
}
```

```
{
  title: "War and Peace",
  pages: 1440,
  language: "Russian"
}
```

```
{
  title: "Atlas Shrugged",
  pages: 1088,
  language: "English"
}
```

```
{ $group: {
    _id: "$language",
    titles: { $addToSet:
"$title" }
}}
```

```
{
  _id: "Russian",
  titles: [“War and Peace”]
}
```

```
{
  _id: "English",
  titles: [
    "Atlas Shrugged",
    "The Great Gatsby” ]
}
```

$unwind

- Operate on an array field
- Yield new documents for each array element
  - Array replaced by element value
  - Missing/empty fields → no output
  - Non-array fields → error
- Pipe to `$group` to aggregate array values

Collecting Distinct Values

```
{
  title: "The Great
Gatsby",
  ISBN: "9781857150193",
  subjects: [
    "Long Island",
    "New York",
    "1920s"
  ]
}
```

```
{ $unwind: "$subjects" }
```

```
{ title: "The Great Gatsby",
  ISBN: "9781857150193",
  subjects: "Long Island” }
```

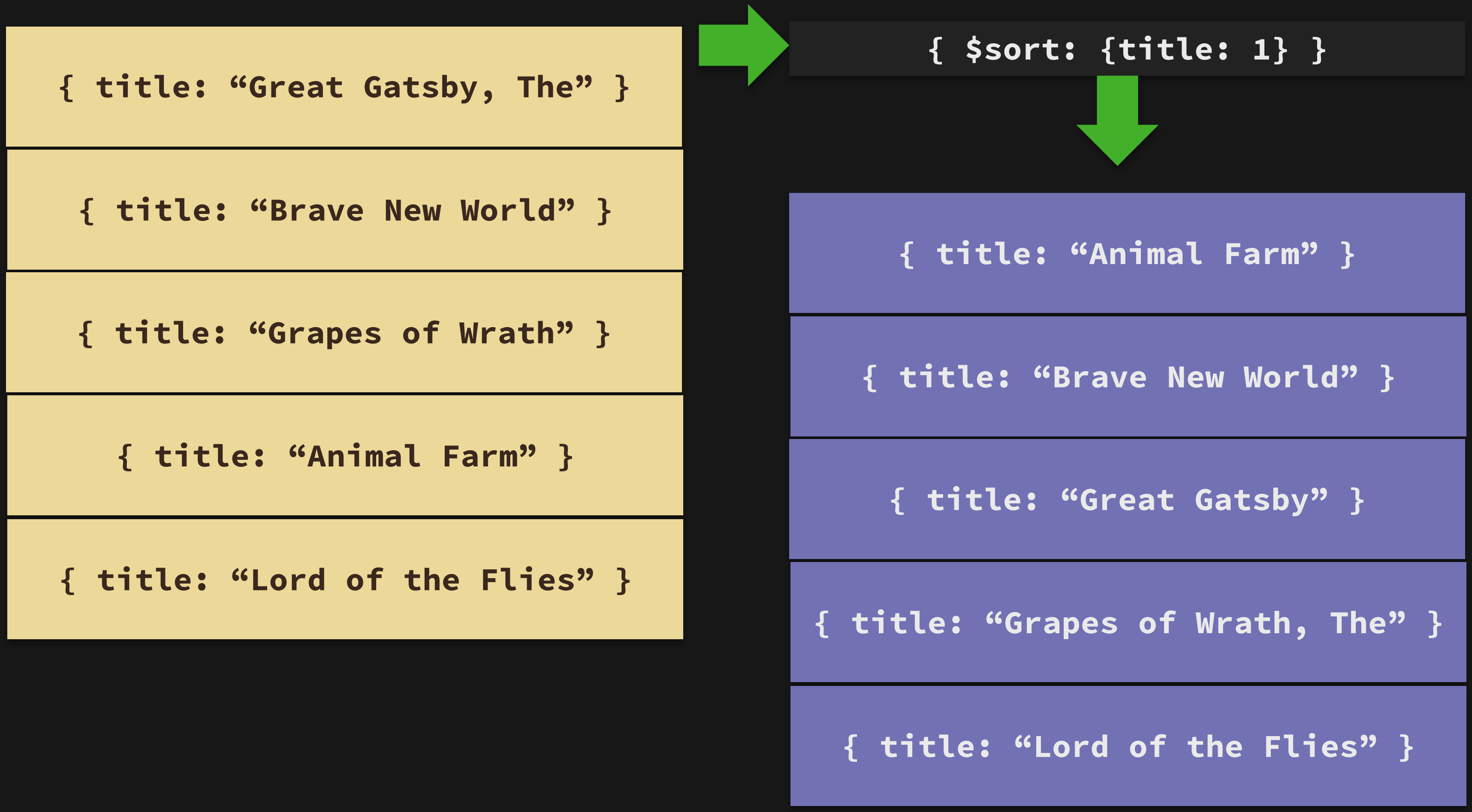
```
{ title: "The Great Gatsby",
  ISBN: "9781857150193",
  subjects: "New York” }
```

```
{ title: "The Great Gatsby",
  ISBN: "9781857150193",
  subjects: "1920s” }
```

$sort, $limit, $skip

- Sort documents by one or more fields
  - Same order syntax as cursors
  - Waits for earlier pipeline operator to return
  - In-memory unless early and indexed
- Limit and skip follow cursor behavior

Sort All the Documents in the Pipeline

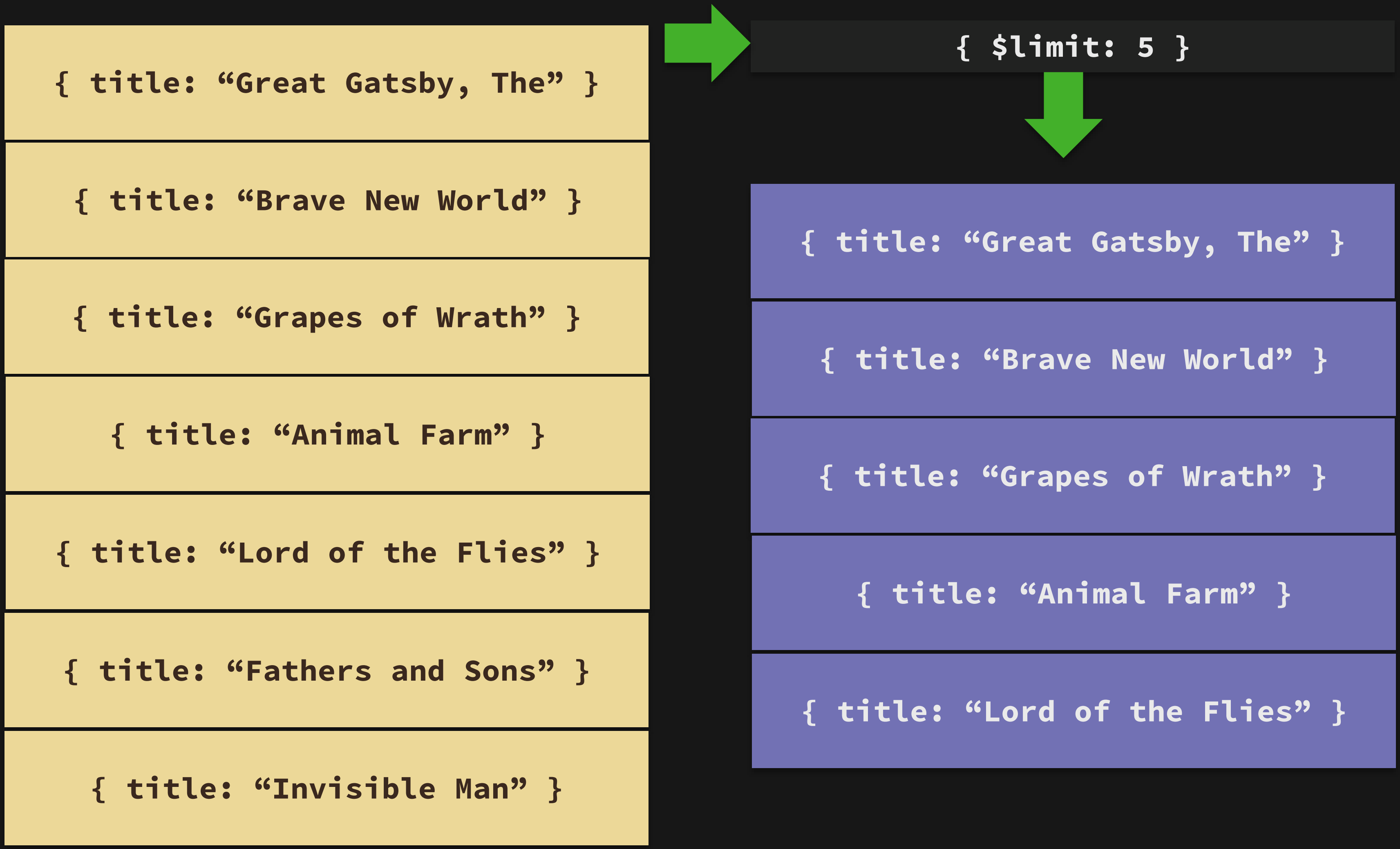


```
{ title: “Great Gatsby, The” }
{ title: “Brave New World” }
{ title: “Grapes of Wrath” }
{ title: “Animal Farm” }
{ title: “Lord of the Flies” }
```

```
{ $sort: {title: 1} }
```

```
{ title: “Animal Farm” }
{ title: “Brave New World” }
{ title: “Great Gatsby” }
{ title: “Grapes of Wrath, The” }
{ title: “Lord of the Flies” }
```

Limit Documents Through the Pipeline

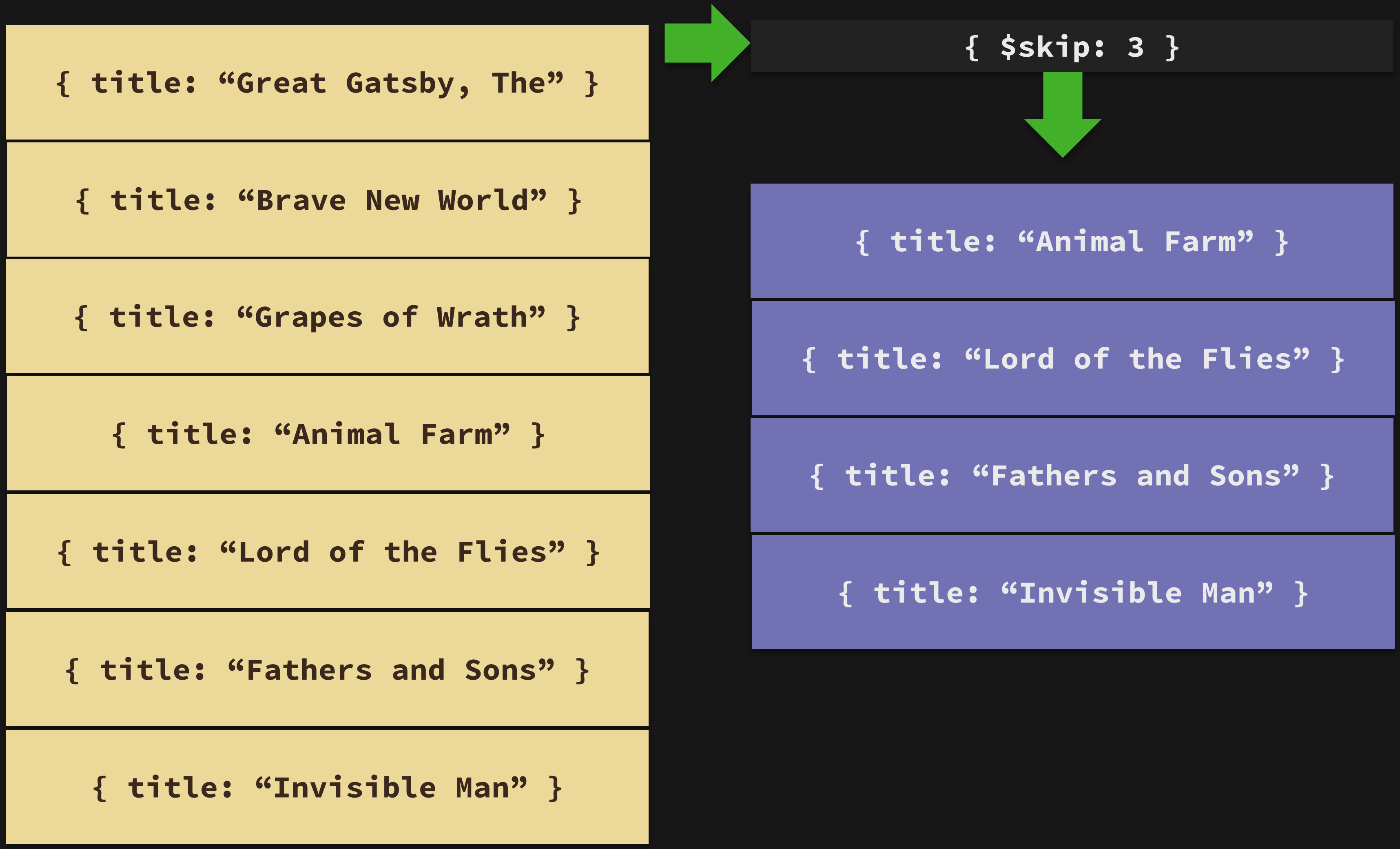


```
{ title: “Great Gatsby, The” }
{ title: “Brave New World” }
{ title: “Grapes of Wrath” }
{ title: “Animal Farm” }
{ title: “Lord of the Flies” }
{ title: “Fathers and Sons” }
{ title: “Invisible Man” }
```

```
{ $limit: 5 }
```

```
{ title: “Great Gatsby, The” }
{ title: “Brave New World” }
{ title: “Grapes of Wrath” }
{ title: “Animal Farm” }
{ title: “Lord of the Flies” }
```

Limit Documents Through the Pipeline



```
{ title: “Great Gatsby, The” }
{ title: “Brave New World” }
{ title: “Grapes of Wrath” }
{ title: “Animal Farm” }
{ title: “Lord of the Flies” }
{ title: “Fathers and Sons” }
{ title: “Invisible Man” }
```

```
{ $skip: 3 }
```

```
{ title: “Animal Farm” }
{ title: “Lord of the Flies” }
{ title: “Fathers and Sons” }
{ title: “Invisible Man” }
```

Usage and Limitations

Usage

- `collection.aggregate()` method
  - Mongo shell
  - Most drivers
- `aggregate database` command

Collection

```
db.books.aggregate([
  { $project: { language: 1 }},
  { $group: { _id: "$language", numTitles: { $sum: 1 }}}
])
```

```
{
  result: [
    { _id: "Russian", numTitles: 1 },
    { _id: "English", numTitles: 2 }
  ],
  ok: 1
}
```

Database Command

```
db.runCommand({
  aggregate: "books",
  pipeline: [
    { $project: { language: 1 }},
    { $group: { _id: "$language", numTitles: { $sum: 1 }}}
   ]
})
```

```
{
  result: [
    { _id: "Russian", numTitles: 1 },
    { _id: "English", numTitles: 2 }
  ],
  ok: 1
}
```

Limitations

- Result limited by BSON document size
  - Final command result
  - Intermediate shard results
  - **cursor and $out variants in MongoDB 2.5 beta!**
- Pipeline operator memory limits
- Some BSON types unsupported
  - Binary, Code, deprecated types

Sharding

mongoDB

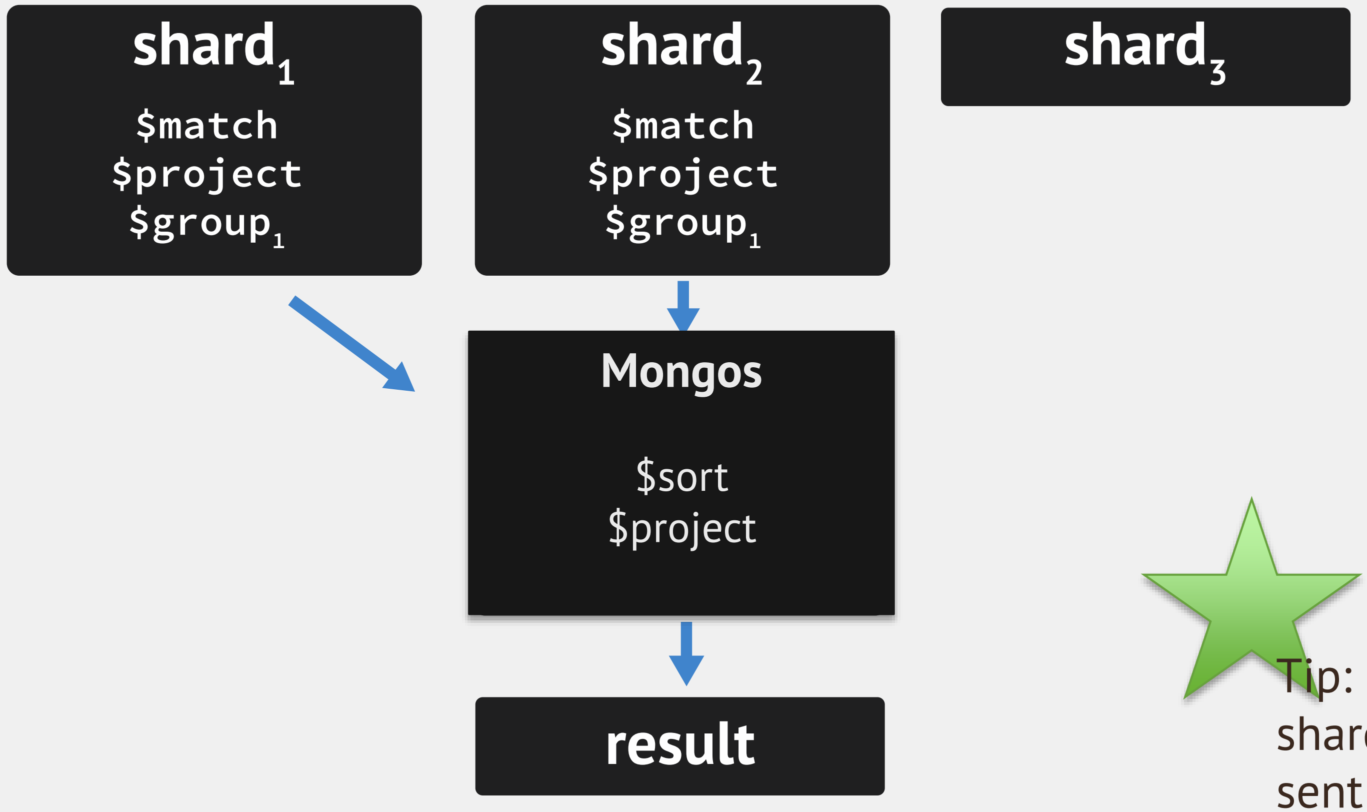
Sharding

- Split the pipeline at first `$group` or `$sort`
  - Shards execute pipeline up to that point
  - `mongos` merges results and continues
- Early `$match` may excuse shards
- CPU and memory implications for `mongos`

Sharding

```
[
  { $match:   { /* filter by shard key */ }},
  { $project: { /* select fields       */ }},
  { $group:   { /* group by some field */ }},
  { $sort:    { /* sort by some field  */ }},
  { $project: { /* reshape result      */ }}
]
```

Sharding



Tip: Use profiler on each shard to see what mongos sent to the shard.

Looking Ahead

Extending the Framework

- Adding new pipeline operators, expressions
- Removing 16MB limit for result set
- `$out` and “`tee`” for output control
  - https://jira.mongodb.org/browse/SERVER-3253
- explain()

Thank You

mongoDB