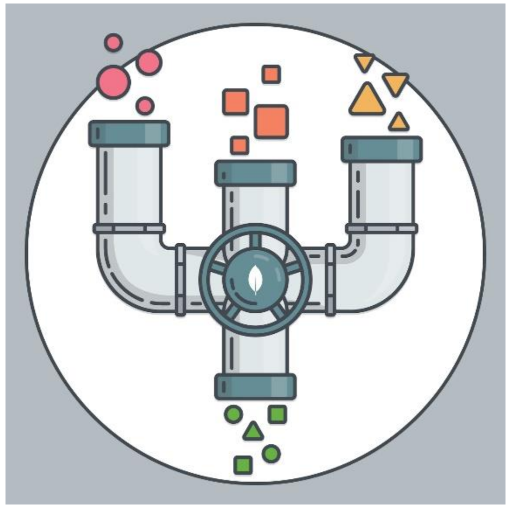
# Day 28

# Aggregation

- More powerful way of reshaping data easily
  - Without resorting to writing application
- Aggregation pipeline is a series of document transformers
  - Each transformer will received a stream of documents
    - Either directly from the collection, or
    - From an earlier transformer
  - Transformer process the document and outputs the transformed document



# MongoDB Aggregation

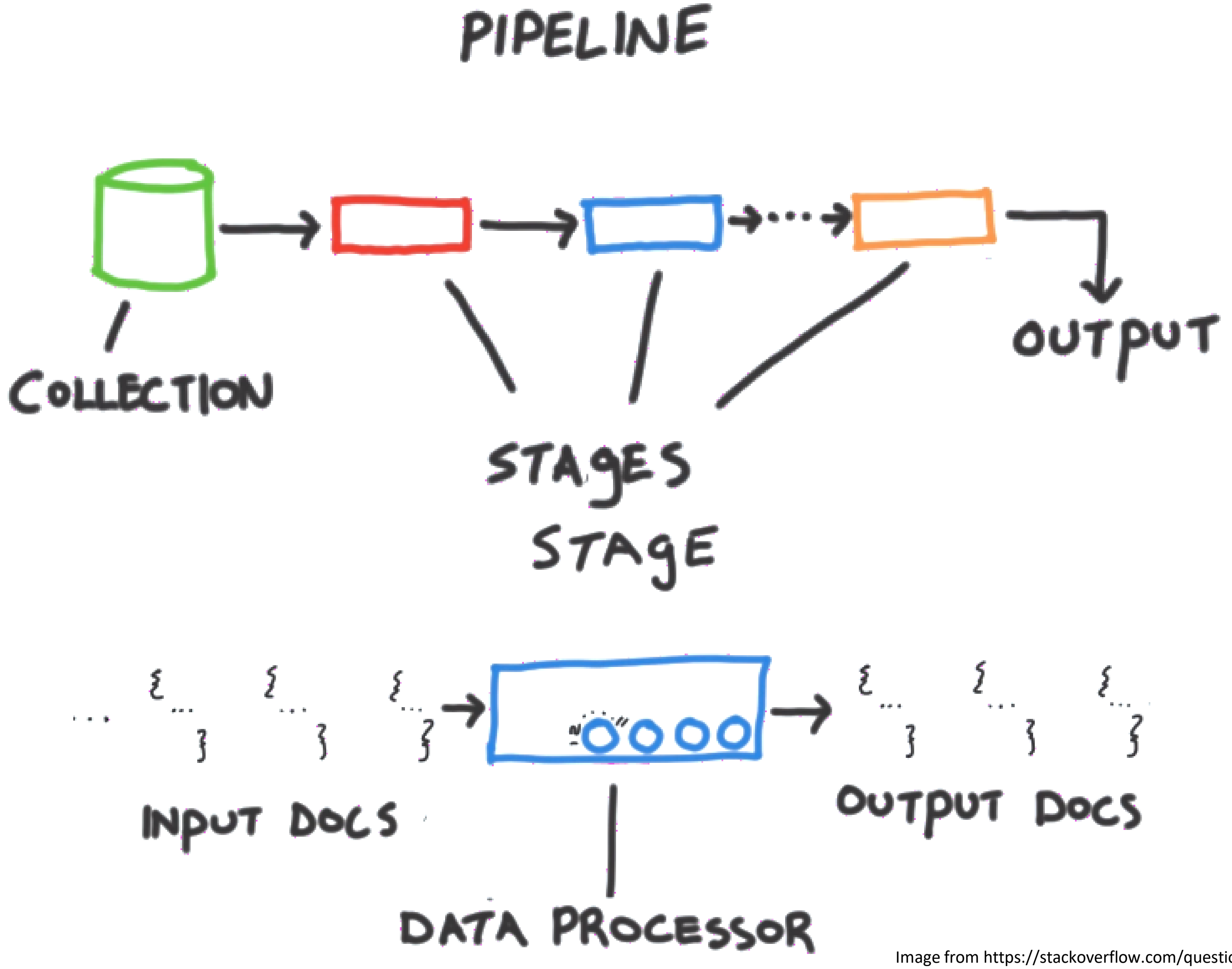


Image from https://stackoverflow.com/questions/12702080/mongodb-explain-for-aggregation-framework

# Aggregation Example

Use the aggregate function to perform aggregation

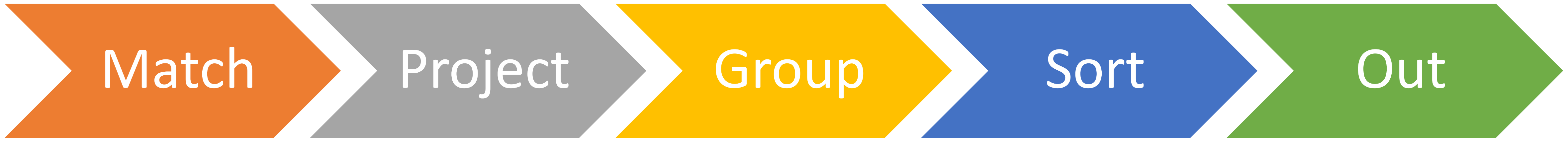
Array contains one or more stages

An aggregation operation

Single stage

```
db.comments.aggregate([
  {
    $match: {
      user: /^lifehacker$/i
    }
  }
]);
```

# Typical Pipeline



- Find or filter documents

- Select fields
- Delete fields
- Add fields

- Group documents
- Perform consolidation - sum, average, count

- Sort the documents according to one or more attributes

- Write out the transformed document to a new collection

Image from https://www.slideshare.net/mongodb/beyond-the-basics-2-aggregation-framework

## Pipeline Operators

- `$match`
  - Filter documents
- `$project`
  - Reshape documents
- `$group`
  - Summarizes documents
- `$sort`
  - Orders the documents
- `$limit`, `$skip`, `$first`, `$last`
  - Paginate documents
- `$unwind`
  - Unroll an array into multiple documents
- `$lookup`
  - Join 2 collections
- `$out`
  - Create a new collection

Image from https://www.slideshare.net/mongodb/beyond-the-basics-2-aggregation-framework

## Filtering Documents

Return only documents that at `TV-G` rated

A single aggregate/stage in the pipeline

```
db.movies.aggregate([
  {
    $match: { rated: "TV-G" }
  },
]);
```

Aggregates are defined in an array
They are executed sequentially starting from index 0

# Aggregation with `MongoTemplate`

- Uses the **`aggregate`** method
- Creates one or more aggregating stages with static methods in **`Aggregation`**
  - `Aggregation.match()`, `Aggregation.group()`, `Aggregation.project()`, `Aggregation.sort()`, `Aggregation.bucket()`, `Aggregation.lookup()`, `Aggregation.limit()`
  - See document for other aggregate operations
- Aggregates are assembled into a pipeline with the `Aggregation.newAggregate()` method

## Filtering Documents

Create a match aggregate

Assemble the aggregates into a pipeline

```
MatchOperation matchRated = Aggregation.match(
    Criteria.where("rated").is("TV-G")
);

Aggregation pipeline = Aggregation.newAggregation(matchRated);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

Perform the aggregation on the collection with the defined pipeline.
Results are returned as Document

## Filtering and Projecting Documents

```
db.movies.aggregate([
  {
    $match: { rated: "TV-G" }
  },
  {
    $project: { _id: -1, title: 1, fullplot: 1 }
  }
]);
```

# Filtering and Projecting Documents

```
MatchOperation matchRated = Aggregation.match(
    Criteria.where("rated").is("TV-G")
);
ProjectOperation projectFields = Aggregation.project(
    "title", "fullplot")
  .andExclude("_id");

Aggregation pipeline = Aggregation.newAggregation(
    matchRated, projectFields);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

Assemble the aggregates into a pipeline

# Grouping

```
_id: 1
title: Spider Man -
No Way Home
year: 2021
```

```
_id: 2
title: Top Gun
year: 1986
```

```
_id: 3
title: From Dusk
Till Dawn
year: 1996
```

```
_id: 4
title: Highlander
year: 1986
```

```
_id: 5
title: Wargames
year: 1983
```

Group movies by release year

The field used for grouping (`year`) becomes the id of the grouped documents

```
_id: 2021
titles: [ "Spider Man -
No Way Home" ]
```

```
_id: 1986
titles: [ "Top Gun",
"Highlander" ]
```

```
_id: 1996
titles: [ "From Dusk
Till Dawn" ]
```

```
_id: 1983
titles: [ "Wargames" ]
```

## Grouping

```
db.movies.aggregate([
   {
     $group: {
       _id: "$rated",
       count: { $sum: 1 },
       titles: { $push: "$title" }
     }
   },
   {
     $sort: { count: -1 }
   }
]);
```

Group the documents by `rated`.
Count the number of documents in each group
Add the `title` field to a new field which is an array called `titles`

Sort the document is ascending order by `count` field, the number of titles in each group

The `$` sign indicates the value of the attribute from the incoming document. Only appears in RHS

New fields in the output document

## Grouping - Output

```
{
   _id: “R”,
   count: 5538,
   titles: [ ... ]
},
{
   _id: “PG-13”,
   count: 2232
   titles: [ ... ]
},
{
   _id: ”PG”,
   count: 1853,
   titles: [ ... ]
}
...
```

# Grouping

Creates a new field in the output document from the aggregated fields from the input

```
GroupOperation groupByRated = Aggregation.group("rated")
    .push("title").as("titles")
    .count().as("count");
SortOperation sortByCount = Aggregation.sort(
    Sort.by(Direction.ASC, "count"));

Aggregation pipeline = Aggregation.newAggregation(
     groupByRated, sortByCount);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

## Projection

- Projection in aggregation can do the following
  - Suppress fields
  - Add new fields
- Uses cases for projection
  - Reduce the result size
  - Transform the structure of a document

# Projection

```
db.movies.aggregate([
   {
     $project: {
       _id: 1, title : 1,
       summary: "$plot"
   },
   {
     $sort: { title: 1 }
   }
]);
```

Keep these 2 fields

New attribute

## Projection

`and()` is used to create a new property

`as()` is used to create a new property

```
ProjectionOperation projectMovieSummary =
    Aggregation.project("_id", "title")
     .and("plot").as("summary")
SortOperation sortByTitle = Aggregation.sort(
    Sort.by(Direction.ASC, "title"));

Aggregation pipeline = Aggregation.newAggregation(
     projectMovieSummary, sortByTitle);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

## `AggregationExpression`

- Most of the `project()`, `match()`, `sort()` etc provides simple operations to working with fields
  - Usually a single field
- More complex use cases, require using `AggregationExpression`
- Provides string, maths, conversions, array, bucket, date, etc operations

# Projection

```
db.movies.aggregate([
  {
    $project: {
      _id: 1,
      title: {
        $concat: [ "$title", " (", "$rated", ")" ]
      }
      summary: "$plot"
    },
  {
    $sort: { title: 1 }
  }
]);
```

Change an existing field

New attribute

## Projection

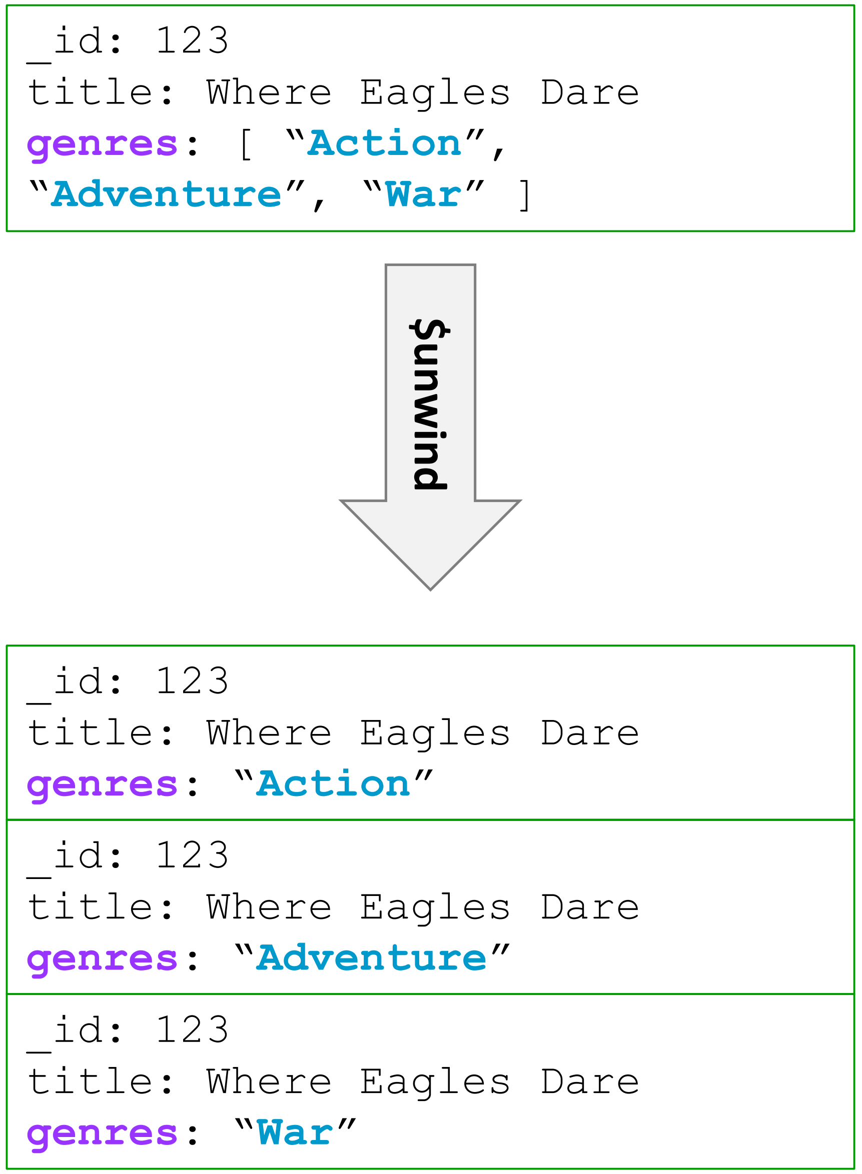
```
ProjectionOperation projectMovieSummary =
    Aggregation.project("_id", "title")
      .and("plot").as("summary")
      .and(
          StringOperators.Concat.valueOf("name").concat(" (")
              .concatValueOf("rated").concat(")")
      ).as("title");
SortOperation sortByTitle = Aggregation.sort(
    Sort.by(Direction.ASC, "title"));

Aggregation pipeline = Aggregation.newAggregation(
     projectMovieSummary, sortByTitle);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

## Projection - Output

```
{
   _id: ObjectId(...),
   title: “101 Dalmations (G)”,
   summary: “...“,
},
{
   _id: ObjectId(...),
   title: “101 Reykjavek (NOT RATED)”,
   plot: “...”,
},
{
   _id: ObjectId(...),
   title: “12 (PG-13)”,
   plot: “...”,
},
```

# Unwinding Arrays

- Cannot process elements in an array
  - No loops within an aggregation pipeline
- Need to simplify the document by expanding the array
  - Duplicate a document for every element in the array
- Final document will no longer have any arrays in any of its fields



```
_id: 123
title: Where Eagles Dare
genres: [ "Action",
"Adventure", "War" ]
```

```
_id: 123
title: Where Eagles Dare
genres: "Action"
```

```
_id: 123
title: Where Eagles Dare
genres: "Adventure"
```

```
_id: 123
title: Where Eagles Dare
genres: "War"
```

# Unwinding an Array

```
{
    _id: ObjectId("abc123"),
    title: "Dark Crystal",
    ...
    genres: [ "Adventure", "Family", "Fantasy" ],
    rating: "PG"
}
```

Unwind this array

```
db.tv_shows.aggregate([
   {
     $unwind: "$genres"
   }
]);
```

```
{
    _id: ObjectId("abc123"),
    title: "Dark Crystal",
    ...
    genres: "Adventure",
    rating: "PG"
},
{
    _id: ObjectId("abc123"),
    title: "Dark Crystal",
    ...
    genres: "Family",
    rating: "PG"
},
{
    _id: ObjectId("abc123"),
    title: "Dark Crystal",
    ...
    genres: "Fantasy",
    rating: "PG"
}
```

## Unwinding an Array

```
db.tv_shows.aggregate([
   {
      $unwind: "$genres"
   },
   {
      $group: {
         _id: "$genres",
         titles: {
            $push: "$title"
         },
         titles_count: {
            $sum: 1
         }
      }
   }
]);
```

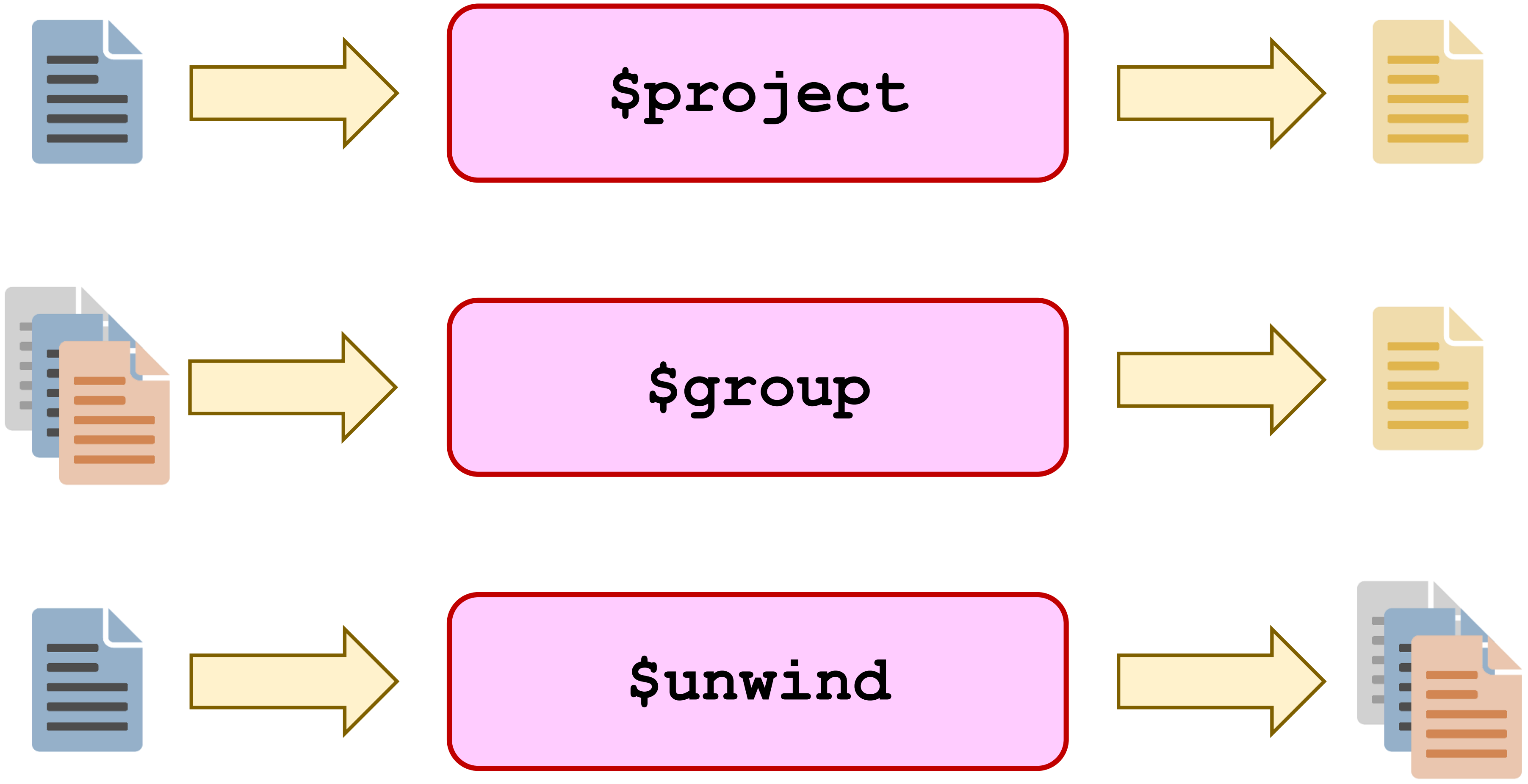
The incoming document's `genres` attribute is an array. 'Flattens' the genres array producing one document per array element

The unwound document's `genres` is now a single value

# Unwinding an Array

```
AggregationOperation unwindGenres = Aggregation.unwind("genres");
GroupOperation groupByGenres = Aggregation.group("genres")
    .push("title").as("titles")
    .count().as("titles_count");
ProjectionOperation projectGenresSummary =
    Aggregation.project("_id", "titles", "titles_count");
SortOperation sortByTitlesCount = Aggregation.sort(
    Sort.by(Direction.DESC, "titles_count"));

Aggregation pipeline = Aggregation.newAggregation(unwindGenres,
     groupByGenres, projectGenresSummary, sortByTitlesCount);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, "movies", Document.class);
```

# $project, $group, $unwind



# Classifying Documents into Buckets

```
db.movies.aggregate([
  {
    $bucket: {
      groupBy: "$imdb.rating",
      boundaries: [ 3, 5, 8 ],
      default: 'Others',
    }
  }
]);
```

rating < 3
3 <= rating < 5
5 <= rating < 8
rating >= 8

Create 4 buckets to group the documents based on their IMDB ratings

## Bucket - Output

```
{
   _id: 3.0,
   count: <a number>
},
{
   _id: 5.0,
   count: <a number>
},
{
   _id: 8.0,
   count: <a number>
},
{
   _id: “>8”,
   count: <a number>
}
```

# Classifying Documents into Buckets

```
BucketOperation bucketRating = Aggregation.bucket("imdb.rating")
  .withBoundaries(3, 5, 8)
  .withDefaultBucket(">8");

Aggregation pipeline = Aggregation.newAggregation(bucketRating);

AggregationResults<Document> results = mongoTemplate.aggregate(
   pipeline, "movies", Document.class);
```

## Classifying Documents into Buckets

```
db.tv_shows.aggregate([
  {
    $bucket: {
      groupBy: "$imdb.rating",
      boundaries: [ 3, 5, 8 ],
      default: 'Others',
      output: {
        count: { $sum: 1 },
        titles: { $push: "$title" }
      }
    }
  }
]);
```

3 <= rating < 5
5 <= rating < 8
rating >= 8

Documents are classified according to the following boundaries

Any document that cannot be sorted into a bucket goes to the default bucket

Shape of the output document/ bucket

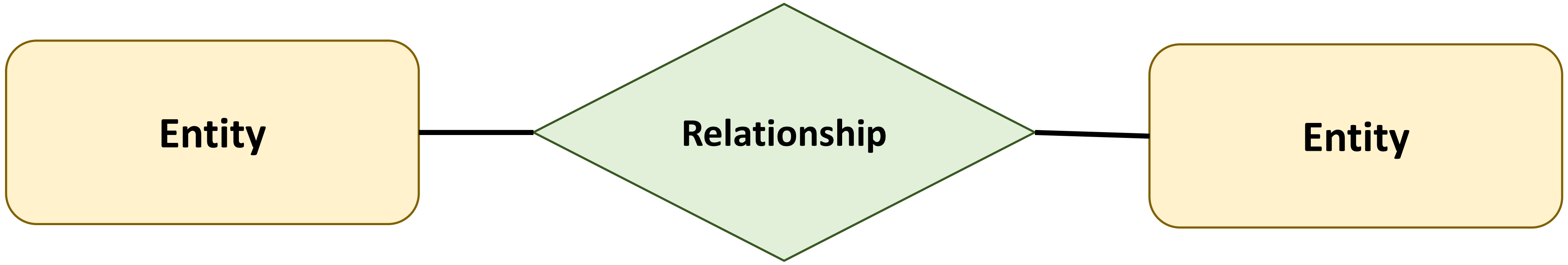
# Bucket - Output

```
{
    _id: 3.0,
    count: <a number>,
    titles: [ ... ]
},
{
    _id: 5.0,
    count: <a number>,
    titles: [ ... ]
},
{
    _id: 8.0,
    count: <a number>,
    titles: [ ... ]
},
{
    _id: “>8”,
    count: <a number>,
    titles: [ ... ]
}
```

# Classifying Documents into Buckets

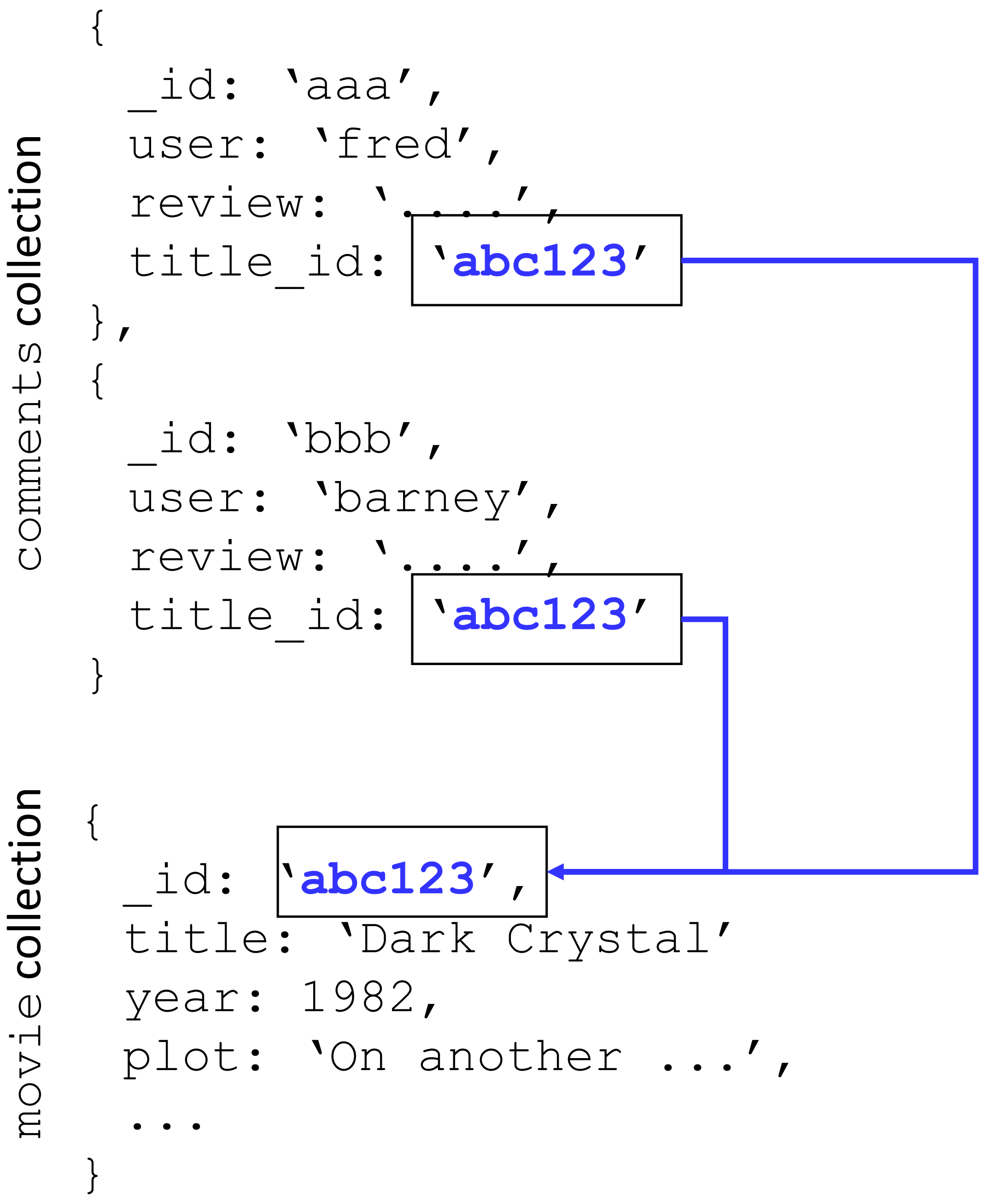
```
BucketOperation bucketRating = Aggregation.bucket(“imdb.rating”)
  .withBoundaries(3, 5, 8)
  .withDefaultBucket(“>8”)
  .andOutputCount().as(“count”)
  .andOutput(“title”).push().as(“titles”);

Aggregation pipeline = Aggregation.newAggregation(bucketRating);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, “movies”, Document.class);
```

# Modelling Relationships



# Referenced Document

- Referenced one document from another
  - Using an attribute to hold the value of the other document's _id
  - Like relational database
- Require 2 access to retrieve the document and its corresponding 'child'
  - Eg. a movie and all its related reviews



```
{
  _id: 'aaa',
  user: 'fred',
  review: '....',
  title_id: 'abc123'
},
{
  _id: 'bbb',
  user: 'barney',
  review: '....',
  title_id: 'abc123'
}
```

```
{
  _id: 'abc123',
  title: 'Dark Crystal'
  year: 1982,
  plot: 'On another ...',
  ...
}
```

## Embedded Document

- Embed related documents into the parent
  - De-normalization
- Embedding defines the relationship
  - Eg. embedding all reviews into the related move
- MongoDB has a cap of 16MB per document
  - Embedded documents may cause the container to grow beyond this size
  - Have to use GridFS

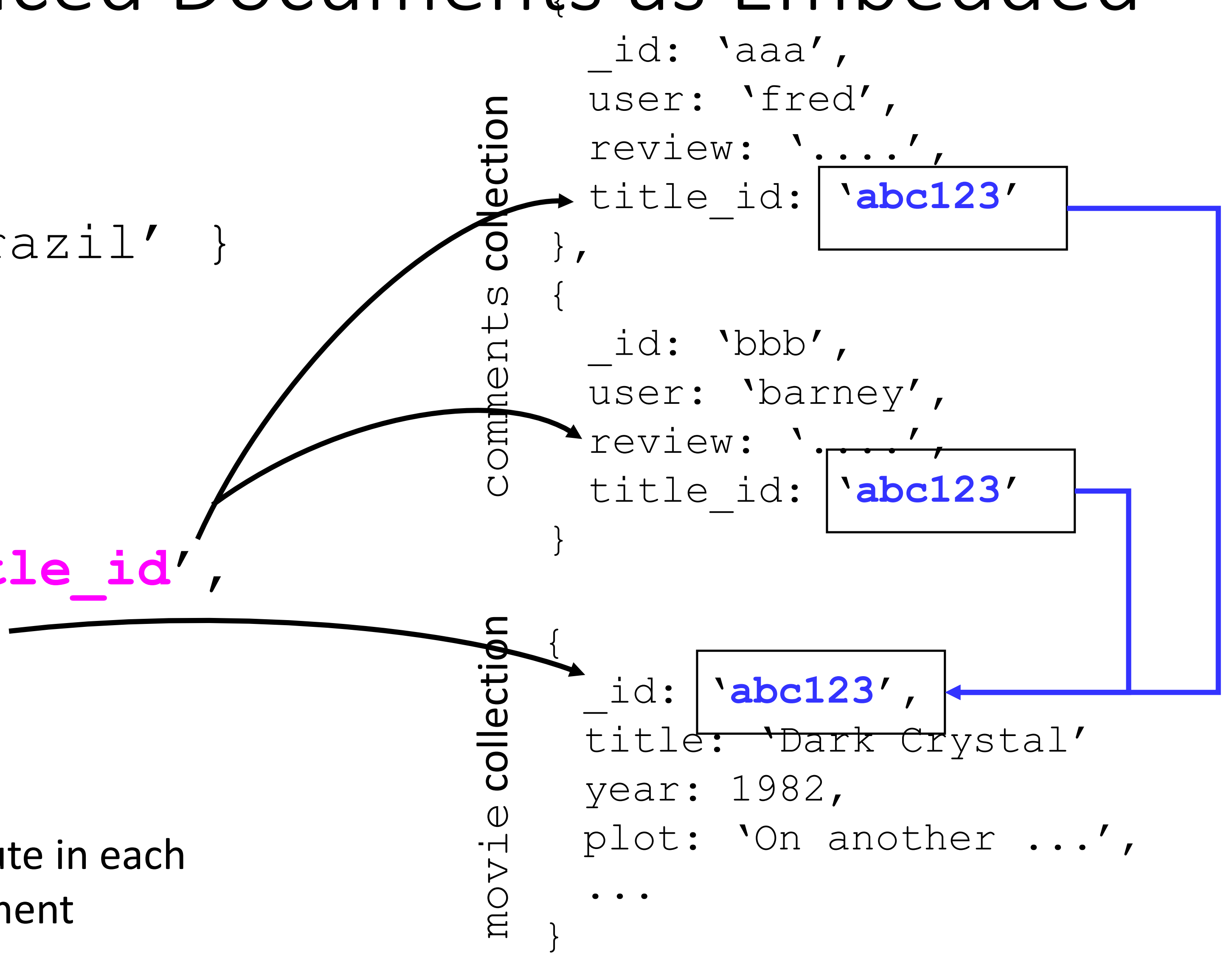
```
{
 _id: 'abc123',
 title: 'Dark Crystal'
 year: 1982,
 plot: 'On another ...',
 ...
 reviews: [
   {
     _id: 'aaa',
     user: 'fred',
     review: '....',
   },
   {
     _id: 'bbb',
     user: 'barney',
     review: '....',
   }
 ]
}
```

Embedded documents

# Returning Referenced Documents as Embedded

```
db.tv_shows.aggregate([
   {
     $match: { title: 'Brazil' }
   },
   {
      $lookup: {
       from: 'comments',
       foreignField: 'title_id',
       localField: '_id',
       as: 'reviews'
     }
   }
]);
```

Create a new attribute in each of the output document



```
{
  _id: 'aaa',
  user: 'fred',
  review: '....',
  title_id: 'abc123'
},
{
  _id: 'bbb',
  user: 'barney',
  review: '....',
  title_id: 'abc123'
}

{
  _id: 'abc123',
  title: 'Dark Crystal'
  year: 1982,
  plot: 'On another ...',
  ...
}
```

## Returning Referenced Documents as Embedded

```
MatchOperation matchTitle = Aggregation.match(
    Criteria.where(“name”).is(“Brazil”)
);
LookupOperation lookupComments = Aggregation.lookup(
    “comments”, “title_id”, “_id”, “reviews”);

Aggregation pipeline = Aggregation.newAggregation(
    matchTitle, lookupComments);

AggregationResults<Document> results = mongoTemplate.aggregate(
    pipeline, “movies”, Document.class);
```

## Property of Database - ACID

- **A**tomicity
- **C**onsistency
- **I**solation
- **D**urability

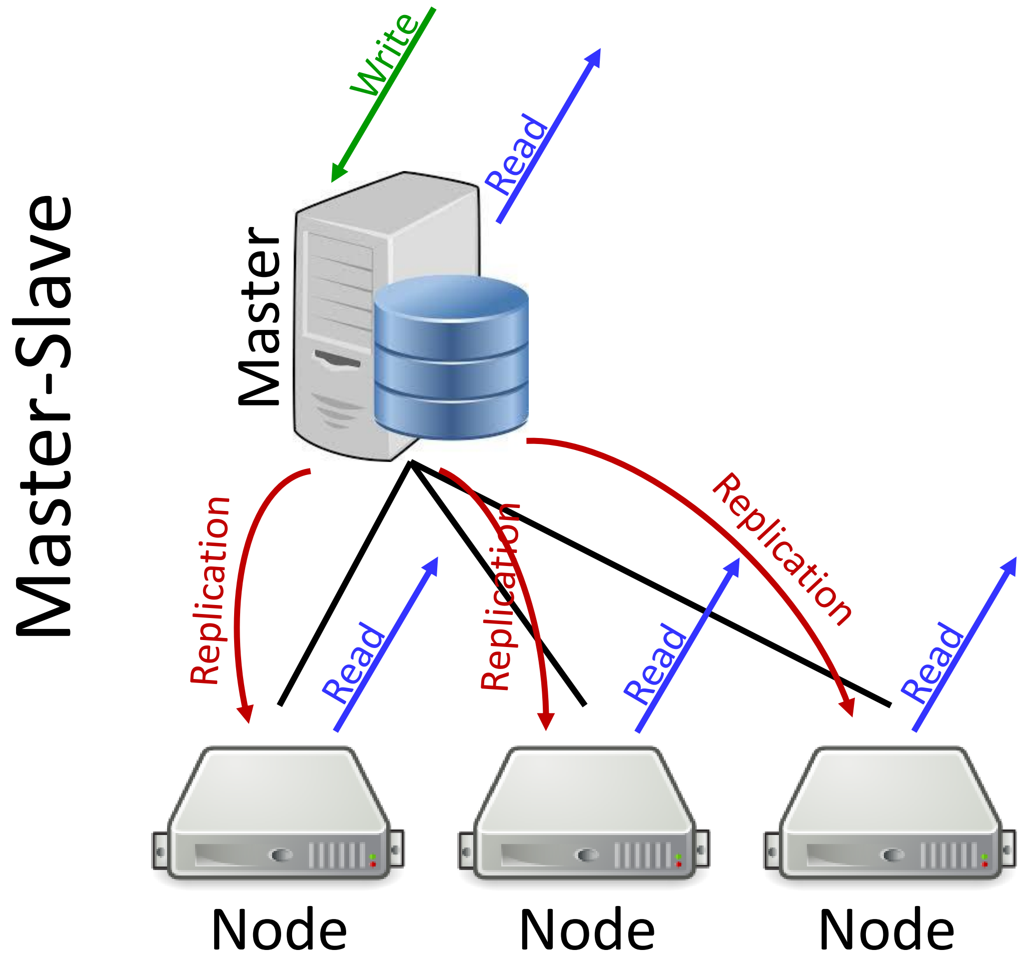
- Strong consistency
- Isolation
- Transactions
- Vertical scaling/scale up
- Precise result
- Consistency first

## Property of Database - BASE

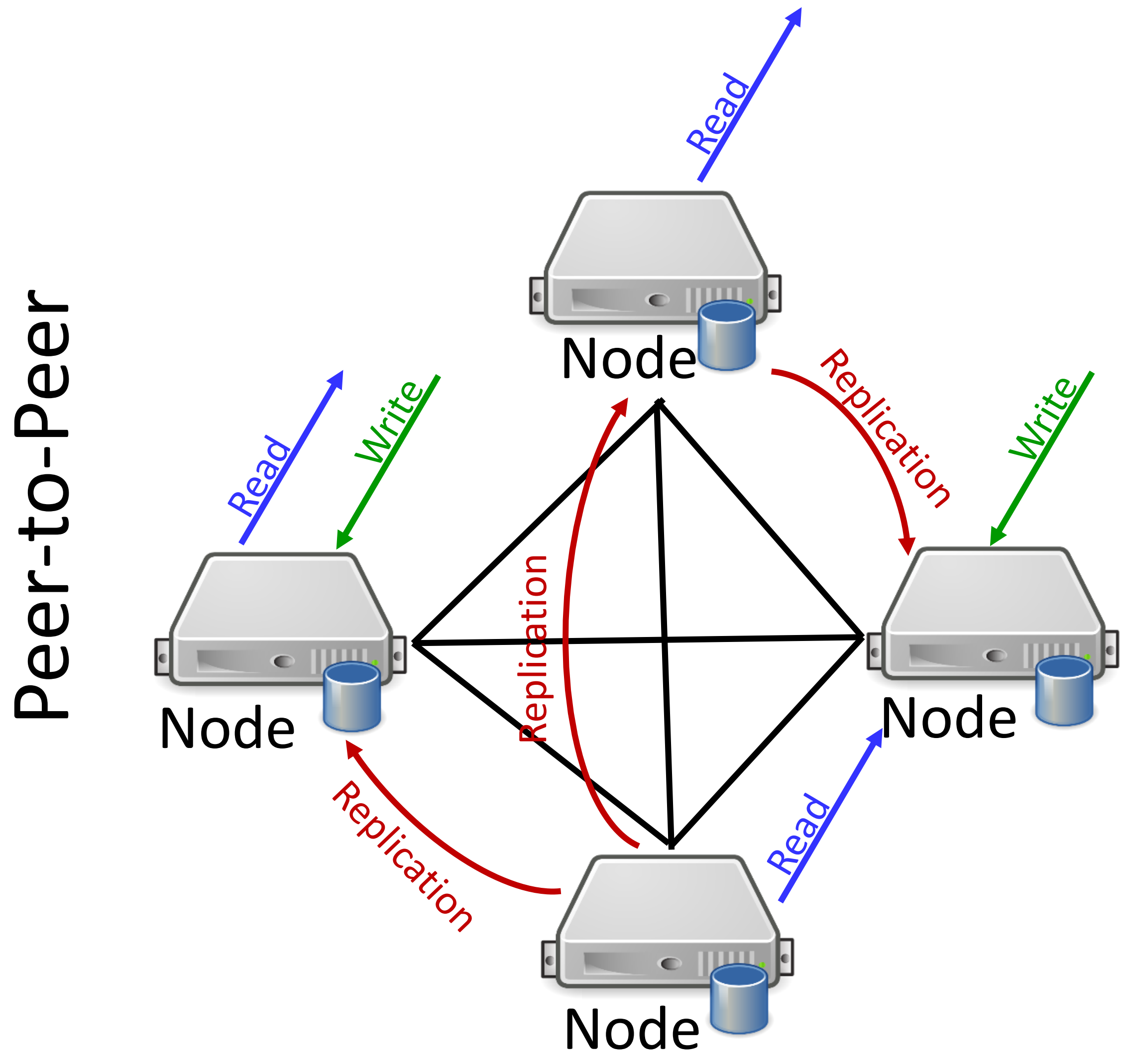
- **B**asically **A**vailable
- **S**oft state
- **E**ventual consistency

- Weak consistency
- Last write wins
- No transaction support
  - No longer true
- Horizontal scaling/scale out
- Approximate results
- Availability first

# Architecture



ACID

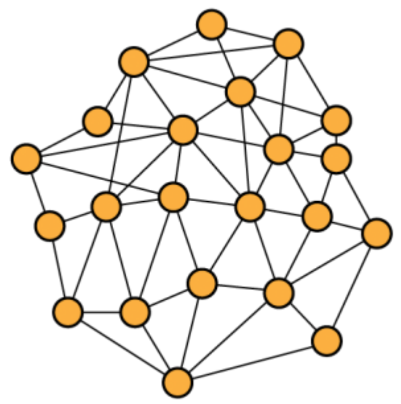


BASE

## Property of the Architecture - CAP

### C : Consistency

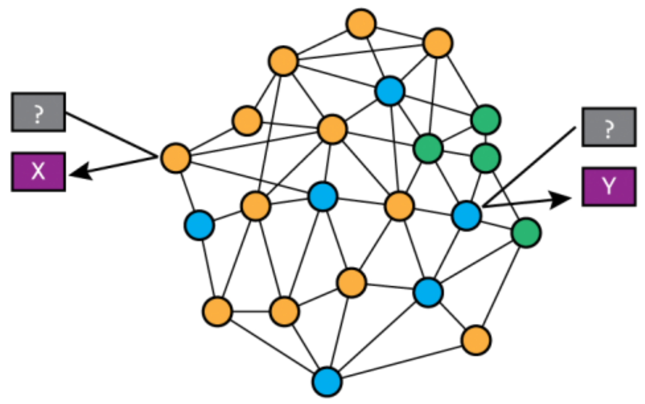
At any given time, all nodes in the network have exactly the same (most recent) **value.**



🟠 = Value: X @ 2018-05-03T08:52:40

### A : Availability

Every **request** to the network receives a **response**, though without any guarantee that returned data is the most recent.



🟠 = Value: X @ 2018-05-03T08:52:40

🟢 = Value: Z @ 2018-05-03T08:32:58

🔵 = Value: Y @ 2018-05-03T07:12:12

### P : Partition tolerance

The network continues to operate, even if an arbitrary number of nodes are **failing**.

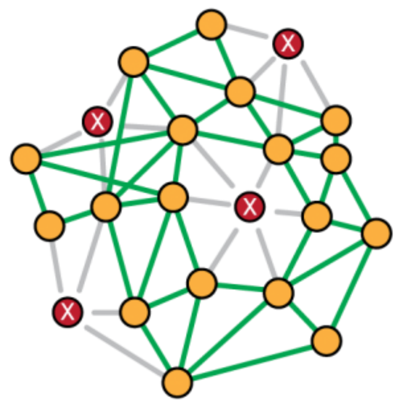
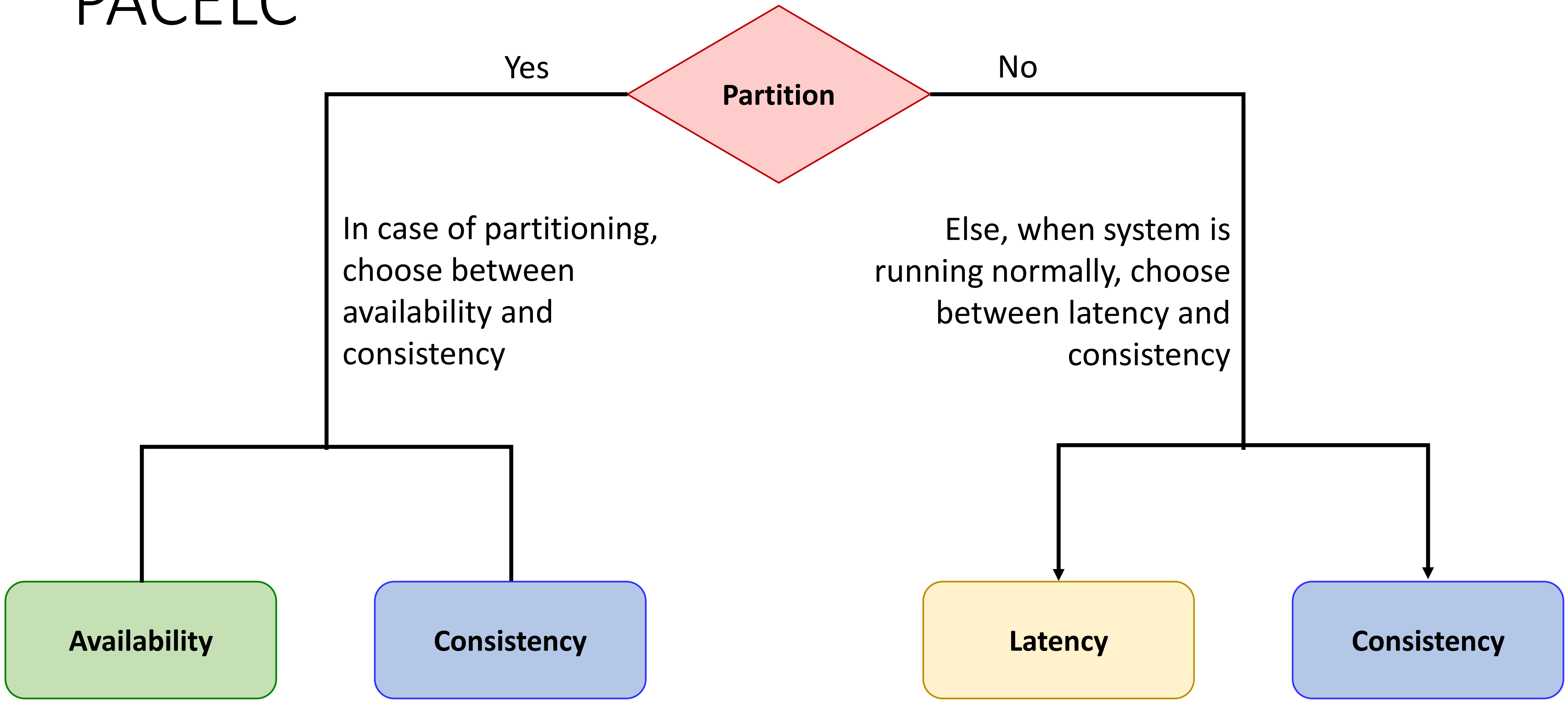


Image from https://cryptographics.info/cryptographics/blockchain/cap-theorem/

# PACELC


Partition
Yes
No
In case of partitioning, choose between availability and consistency
Else, when system is running normally, choose between latency and consistency
Availability
Consistency
Latency
Consistency

## Unused

# Projection - Converting Data

```
{
 "_id": "abc123",
 "coord": {
  "lon": "-0.13",
  "lat": "51.51"
 },
 "weather": [
  {
   "id": 300,
   "main": "Drizzle",
   "description": "light intensity drizzle",
   "icon": "09d"
  }
 ]
}
```

Note: string type

Convert to GeoJSON format

```
{
 "coord": {
  "type": "Point",
  "coordinates": [ -0.13, 51,51 ]
 },
 "weather": [ ... ]
}
```

## Projection

```
db.tv_shows.aggregate([
    {
        $project: {
            _id: 1,
            weather: 1
            coord: {
                type: "Point",
                coordinates: [
                    { $convert: {
                            input: "$coord.lon", to: "double",
                            onError: 0.0, onNull: 0.0 }
                    },
                    { $convert: {
                            input: "$coord.lat", to: "double",
                            onError: 0.0, onNull: 0.0 }
                    }
                ]
            }
        }
]);
```

Convert from string to double. If the input fields are erroneous or null, then set the value to 0.0

# Data Conversion - `$convert`

```
{ dob: {
   $convert {
     input: "$dob.date",
     to: "date"
     onError: {
       $dateFromString: {
           dateString: "1970-01-01"
       }
     }
}
```

```
$convert {
  input: "<input value>",
  to: "<data type>",
  onError: "<data type>",
  onNull: "<data type>"
}
```

- Shorthand
  - `$toBool`, `$toDate`, `$toInt`, `$toObjectId`, …

## Projection - Array Elements

```
db.tv_shows.aggregate([
  {
    $project: {
      _id: 1,
      genres: {
        $filter: {
          input: "$genres"
          as: "genre",
          cond: { $eq: [ "$$genre": "Family" ] }
        }
      },
      plot: 1
    }
]);
```

$filter loops through the array `genres`, assign each value to control variable `genre` Access control variable genre with `$$`

Will only project those array elements that passes the predicate