CSC 369: Distributed Computing

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April 22

Day 8: Problem-solving with db.collection.aggregate()

April 22: Vladimir Lenin’s Birthday

Housekeeping

Lab 3: now with a deadline (Friday midnight + grace period)

Lab 4: Friday -- Monday, May 4 (gives you time)

Lab 5: Hadoop

Friday: quiz. Be ON TIME

Monday: 12:10pm - Lab Test. Read email/slack for details

Grading: Lab 2 -> Quiz -> Lab 2 -> Lab Test -> Lab 1

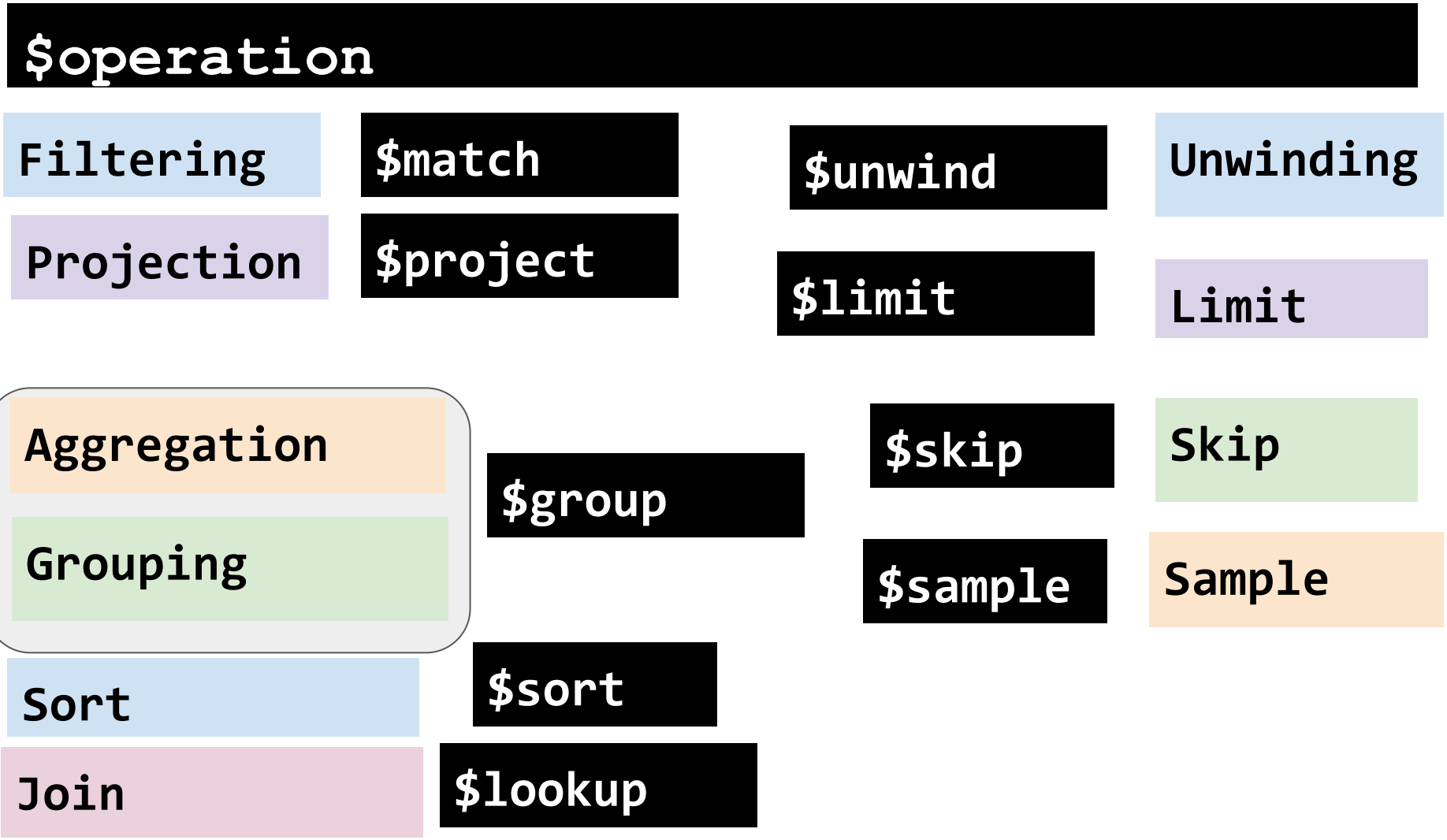
Back into the fray

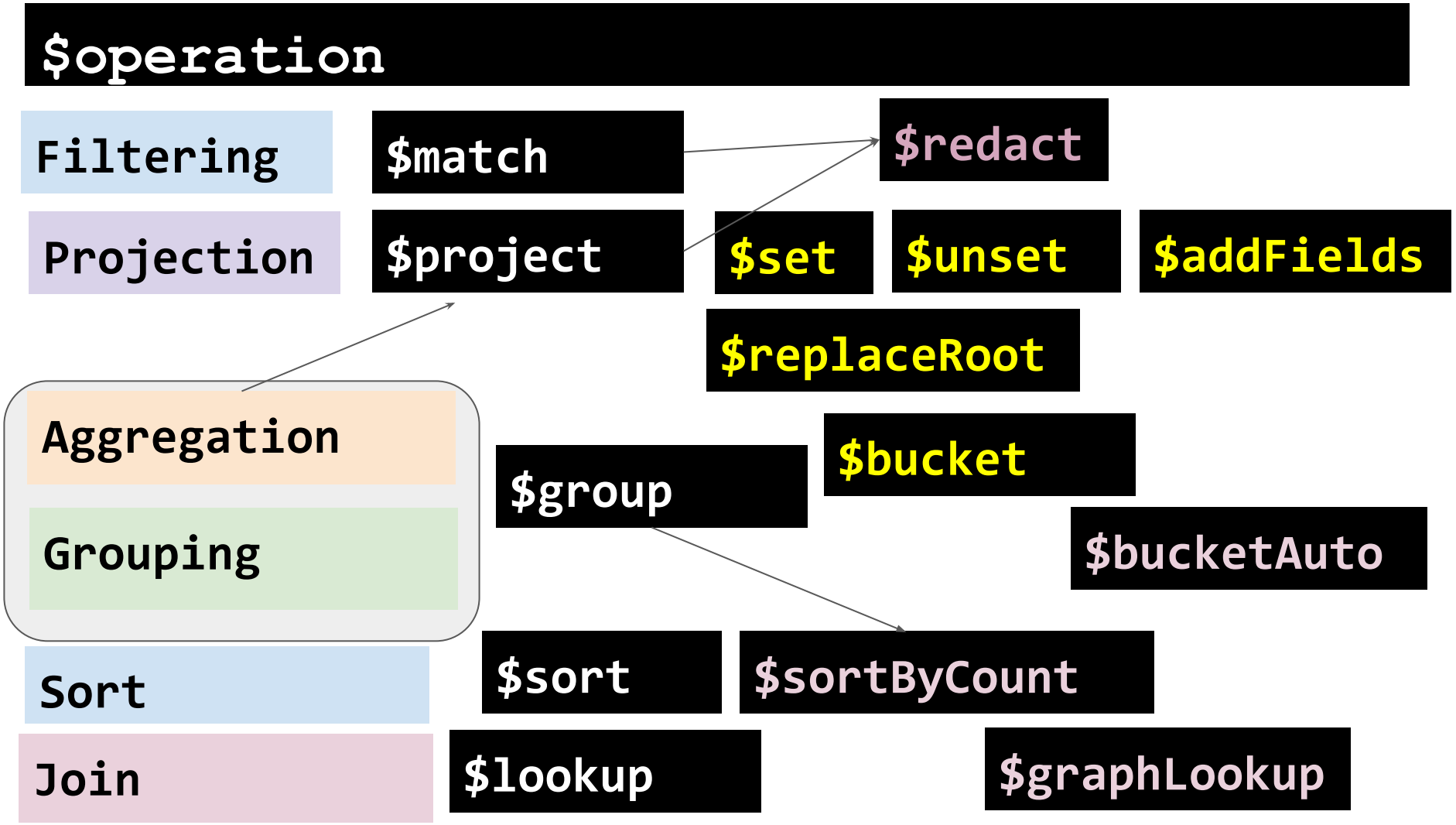
Very Tersely

`Filtering`	Given a condition - keep only objects that satisfy it
`Projection` `Transformation`	Modify the contents of its object based solely on what's in the object itself
`Grouping`	Break collection into groups, each representing objects with same values of some keys
`Aggregation`	Compute an aggregate value over a set of objects
`Join`	Combine objects from two different collections based on matches in values of some keys
`Sort`	Return objects in a specific order

… and a few more

`Ungrouping` `Unwinding`	Opposite of grouping - build an object for each element of an array
`Limit`	Return a specific number of documents
`Skip`	Return documents after skipping a specified number
`Sample`	Return a random sample of documents
`Facets`	Run multiple operations concurrently, combine results in a single document


$operation
Filtering
$match
$unwind
Unwinding
Projection
$project
$limit
Limit
Aggregation
$group
$skip
Skip
Grouping
$sample
Sample
Sort
$sort
Join
$lookup


$operation
Filtering
$match
$redact
Projection
$project
$set
$unset
$addFields
$replaceRoot
Aggregation
Grouping
$group
$bucket
$bucketAuto
Sort
$sort
$sortByCount
Join
$lookup
$graphLookup

This is a lot to take in

How do we actually solve problems with

```
db.collection.aggregate()
```

???

Key things to remember

Filtering
Selection

Grouping
Aggregation

Faceting

Projection
Transformation

Join

Unwind

Other operations - as needed to assist the main flow

Key things to remember

Selections/Filters are EASY to recognize

For all days in March, find the number of hospitalized people in the state of California.

Report each day when the number of new cases exceeded 10% of the number of cumulative cases.

Key things to remember

Selections/Filters are EASY to recognize

What are the tell-tales?

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constants

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*For all days in **March**, find the number of hospitalized people in the state of **California**.*

*Report each day when the number of new cases exceeded **10%** of the number of cumulative cases.*

Key things to remember

Selections/Filters are EASY to recognize

What are the tell-tales?

constants

*For all days in **March**, find the number of hospitalized people in the state of **California**.*

*Report each day when the number of new cases **exceeded** **10%** of the number of cumulative cases.*

comparisons

Key things to remember

Projections are everywhere

Use Case #1: Show only the things we are interested in

Shows up in support of other operations (selection, join, grouping)

Use Case #2: Transform the output

Central activity in an information request

Key things to remember

Projections are everywhere

Use Case #1: Support

For all days in March, find the number of hospitalized people in the state of California.

Report each day when the number of new cases exceeded 10% of the number of cumulative cases.

Key things to remember

Projections are everywhere

Use Case #1: Support

Explicit restrictions

*For all days in March, find **the number of hospitalized people** in the state of California.*

*Report **each day** when the number of new cases exceeded 10% of the number of cumulative cases.*

Key things to remember

Projections are everywhere

Use Case #2: Main Target

Compute the ratio of people on ICU to all hospitalized people

Create a "status" attribute. Set "status" to "in trouble" if the number of new deaths exceeds 10% of the number of new cases. Otherwise, set status to "coping".

Key things to remember

Projections are everywhere

Use Case #2: Main Target

Computation (using single object data)

Compute the ratio *of people on ICU to all hospitalized people*

Create a "status" attribute. Set "status" to "in trouble" if the number of new deaths exceeds 10% of the number of new cases. Otherwise, set status to "coping".

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Computation (using single object data)

Compute the ratio *of people on ICU to all hospitalized people*

Create a "status" attribute*. Set "status" to "in trouble" if the number of new deaths exceeds 10% of the number of new cases. Otherwise, set status to "coping".*

Explicit Transformation

Key things to remember

Projections are everywhere

Use Case #3: **Implicit Cleanup after Joins/Unwinds/Grouping**

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Use Case #3: Implicit Cleanup after Joins/Unwinds/Grouping

For each state report the total number of days with more than 10 ICU patients. Report results in the form:

```
{state: <state>,
   badICUDays: <nDays>}
```

Key things to remember

Projections are everywhere

Use Case #3: Implicit

For each state report the total number of days with more than 10 ICU patients. Report results in the form:

```
{state: <state>,
   badICUDays: <nDays>}
```

```
{$match: {...}},
{$group: {_id:"$state",
                badICUDays: {$sum:1}}}
```

Key things to remember

Projections are everywhere

Use Case #3: Implicit

For each state report the total number of days with more than 10 ICU patients. Report results in the form:

```
{state: <state>,
   badICUDays: <nDays>}
```

```
{$match: {...}},
{$group: {_id:"$state",
                badICUDays: {$sum:1}}}
```

```
{_id: "CA",
 badICUDays: 21 }
```

Key things to remember

Projections are everywhere

Use Case #3: Implicit

For each state report the total number of days with more than 10 ICU patients. Report results in the form:

```
{state: <state>,
   badICUDays: <nDays>}
```

```
{$match: {...}},
{$group: {_id:"$state",
                badICUDays: {$sum:1}}}
```

```
{_id: "CA",
 badICUDays: 21 }
```

Key things to remember

Projections are everywhere

Use Case #3: Implicit

For each state report the total number of days with more than 10 ICU patients. Report results in the form:

```
{state: <state>,
   badICUDays: <nDays>}
```

```
{$match: {...}},
{$group: {_id:"$state",
          badICUDays: {$sum:1}}},
{$project: {_id:0, state:"$_id"}}
```

```
{state: "CA",
 badICUDays: 21 }
```

Key things to remember

Grouping combines data from multiple documents into one

For each state *report the* ***total number of days*** *with more than 10 ICU patients. Report results in the form:*

```
{state: <state>,
   badICUDays: <nDays>}
```

Is this a grouping and aggregation query?

Key things to remember

Grouping combines data from multiple documents into one

For each state *report the* ***total number of days*** *with more than 10 ICU patients. Report results in the form:*

```
{state: <state>,
   badICUDays: <nDays>}
```

Is this a grouping and aggregation query?

Yes, with daily.json data

Key things to rem

Grouping combines

For each state *report the tot*
Report results in the form:

```
{state: <state>,
   badICUDays: <
```

Is this a gro

Yes,


```
{ "_id" : ObjectId("5e941e9cf9e720b73b7d96ff"),
    "date" : 20200405,
    "state" : "AK",
    "positive" : 185,
    "negative" : 6099,
    "pending" : null,
    "hospitalizedCurrently" : null,
    "hospitalizedCumulative" : 20,
    "inIcuCurrently" : 12,
    "inIcuCumulative" : null,
    "onVentilatorCurrently" : null,
    "onVentilatorCumulative" : null,
    "recovered" : null,
    "hash" : "661d7b0f627847a2dceb5d70d4e9260965031cc2",
    "dateChecked" : "2020-04-05T20:00:00Z",
    "death" : 6,
    "hospitalized" : 20,
    "total" : 6284,
    "totalTestResults" : 6284,
    "posNeg" : 6284,
    "fips" : "02",
    "deathIncrease" : 1,
    "hospitalizedIncrease" : 4,
    "negativeIncrease" : 230,
    "positiveIncrease" : 14,
    "totalTestResultsIncrease" : 244}
```

Key things to remember

Grouping combines data from multiple documents into one

For each state *report the* ***total number of days*** *with more than 10 ICU patients. Report results in the form:*

```
{state: <state>,
   badICUDays: <nDays>}
```

Is this a grouping and aggregation query?

No, with other input data

Key things to remember

Grouping combines d

For each state report the tot
Report results in the form:

```
{state: <state>,
   badICUDays: <
```

Is this a gro

```
{ "_id" : 8888,
  state: "CA",
  month: "March",
  badICUDays: 9,
  goodICUDays: 4,
  noInfo: 17,
  cumulativeICUPatients: 88
}
```

No, with other input data

Key things to remember

Grouping combines data from multiple documents into one

For each state *report the* ***total number of days*** *with more than 10 ICU patients. Report results in the form:*

```
{state: <state>,
   badICUDays: <nDays>}
```

KNOW YOUR DATA!!!

Key things to remember

Grouping does NOT always mean aggregation

For each state create a list of dates when there were more than 10 ICU patients

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```
$push
$addToSet
```

Are your biggest friends!

Key things to remember

We can "hide" information while grouping

```
$push
$addToSet
```

Are your biggest friends!

```
{$group:
  {_id:"$state",
   avgPatients:{$avg:"$hospitalized"},
   $push: {$hospitalized}
   }
}
```

Key things to remember

We can “hide” information while grouping

```
$push
$addToSet
```

Create array attributes

We can “unhide” information AFTER grouping

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We can "hide" information while grouping

```
$push
$addToSet
```

Create array attributes

We can "unhide" information AFTER grouping

```
{$group:
  {_id:"$state",
   avgPatients:{$avg:"$hospitalized"},
   data: $push: {$hospitalized}
   }
},
{$unwind: "$data"}
```

$unwind after $group

Key things to remember

Grouping combines data from multiple documents into one

Grouping does NOT always mean aggregation

We can “hide” information while grouping

We can “unhide” information AFTER grouping

Compound Keys

$first, $last

constant key values

Key Things To Remember

Joins involve comparisons of documents to documents

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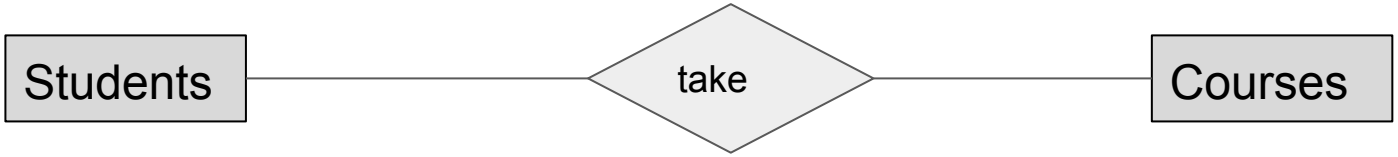
Use Case #1: Join to different collections

Use Case #2: Self Join

Often can be avoided by embedding documents

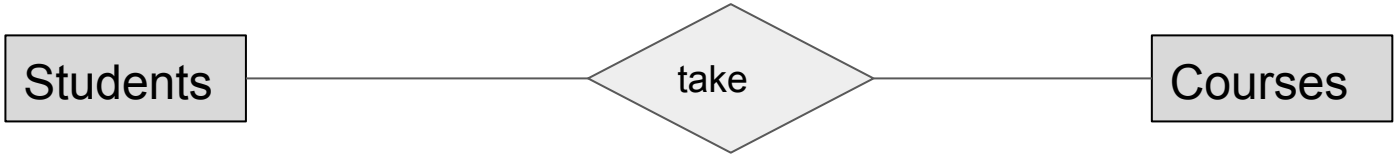


(StudentID, Name)

(StudentID, Course, Section)

(CourseID, Name,Section, Instructor)

```
SELECT * FROM Students s, take t, Courses c
WHERE s.StudentID = t.StudentId and t.Course = C.CourseID
      and t.Section  = C.Section
```



(StudentID, Name)

(StudentID, Course, Section)

(CourseID, Name,Section, Instructor)

```
{course: "CSC 369",
 roster: [{student:"Bob Smith"},
          {student:"Alice Lee"},
             ...
         ]
}
```

Key Things To Remember

Joins involve comparisons of documents to documents

Use Case #1: Join to different collections

Use Case #2: Self Join

$lookup is expensive. Self Joins can be “tricked”

Key Things To Remember

Joins involve comparisons of documents to documents

Use Case #1: Join to different collections

Use Case #2: Self Join

$lookup is expensive. Self Joins can be "tricked" with $group

Tricks
and
dealing with MongoDB idiosyncrasies

Trick 1: $project as a filter

Problem: $match cannot compare two attributes to each other

*Report each day when the **number of new cases exceeded 10% of the number of cumulative cases**.*

```
{ …
  positive: 566,
  positiveIncrease: 65
  …
}
```

Trick 1: $project as a filter

Problem: $match cannot compare two attributes to each other

*Report each day when the **number of new cases exceeded 10% of the number of cumulative cases**.*

```
{ …
  positive: 566,
  positiveIncrease: 65
  …
}
```

```
{$project:
  {flag: {$cond: [{$gt: [{"$positiveIncrease",
                          {$multiply: ["$positive",
                                       0.1]}]},
                  True,
                  False
                  }]}}
```

Trick 1: $project as a filter

Problem: $match cannot compare two attributes to each other

*Report each day when the **number of new cases exceeded 10% of the number of cumulative cases**.*

```
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  positive: 566,
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                  True,
                  False
                  }]}},
{$match: {flag: True}}
```

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                          {$multiply: ["$positive",
                                       0.1]}]},
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                  False
                  }]}},
{$match: {flag: True}}
```

Trick 1: $project as a filter

Problem: $match cannot compare two attributes to each other

All computations can and should be done in $project

Trick 2: Who has the optimal value?

Problem: {$sort: {foo:-1}},{limit:1} fails when there are ties

Report the state and the date of the largest single increase in the number of positive cases.

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Step 1: Use $group $push to "hide" data
Use constant for grouping value

Step 1.5: Unwind

Trick 2: Who has the optimal value?

Report the state and the date of the largest single increase in the number of positive cases.

```
{ _id: "1",
  largestIncrease: 10841
  data: [{...},{...},...,{...}]
}
```

```
{$unwind:"$data"}
```

```
{ _id: "1",
  largestIncrease: 10841
  data: {...}
}
```

Trick 2: Who has the optimal value?

Report the state and the date of the largest single increase in the number of positive cases.

```
{ _id: "1",
  largestIncrease: 10841
  data: [{...},{...},...,{...}]
}
```

Bulky, but straightforward and repeatable

```
{$unwind:"$data"}
```

```
{ _id: "1",
  largestIncrease: 10841
  data: {...}
}
```

```
{$project ...}
```

Get rid of embedding if needed

Trick 2: Who has the optimal value?

Problem: {$sort: {foo:-1}},{limit:1} fails when there are ties

Report the state and the date of the largest single increase in the number of positive cases.

Step 1: Use $group $push to "hide" data
Use constant for grouping value

Step 1.5: Unwind
And $project if desired

Step 2. See **Trick 1** to finish

Trick 3: Join Avoidance

Self-joins can be done outside of $lookup

But with some painful manipulations

Leverage $group $push / $addToSet
$unwind
$project

Trick 4: Generalizing Joins

Problem: $lookup is a left outer **equijoin**

Joins can be more complex:

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Joins can be more complex:

Report governors of all states with less than 400 positive cases per million on April 4, 2020

daily.json

```
{state: "CA"
 governor:"Gavin Newsom"
 population: 39510000}
```

Trick 4: Generalizing Joins

Problem: $lookup is a left outer **equijoin**

Joins can be more complex:

> *Report governors of all states with less than 400 positive cases per million on April 4, 2020*

```
{...
state:"CA"
 positive: 12026
...
}
```

```
{state: "CA"
 governor:"Gavin Newsom"
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Trick 4: Generalizing Joins

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Join = Cartesian Product followed by Selection

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> *Report governors of all states with less than 400 positive cases per million on April 4, 2020*

Join = Cartesian Product followed by Selection

Use for comparisons (Trick 1)