CSC 369: Distributed Computing

Alex Dekhtyar

April 15

Day 5: The Algebra Of Data Transformations

Housekeeping

- **LAST DAY TO DROP THE CLASS**

- 28 students enrolled, no more waitlist

➔ **Slack**: Can I ask every person to send me a private message? Tell me:

- ***How the quarter has been so far.***
- ***What is harder than than typically?***
- ***What is easier than typcially?***
- ***What do you miss the most?***
- *0.5% of the final grade in the class (comes out of "homework" allottment).*

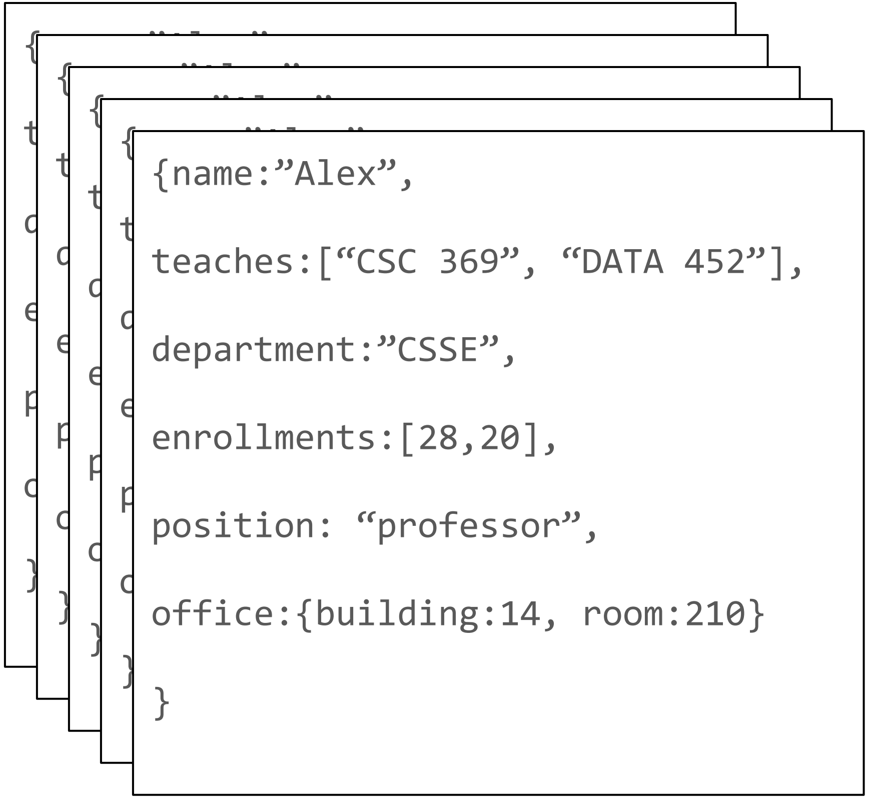
Housekeeping

Data Science Fellowship

I will send the flyer around

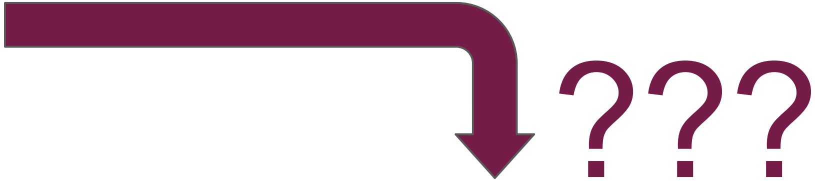
The most important conversation in the course

Motivating Example



```
{name:"Alex",

teaches:["CSC 369", "DATA 452"],

department:"CSSE",

enrollments:[28,20],

position: "professor",

office:{building:14, room:210}

}
```

Q1: Find all CSSE faculty with highest total enrollments, report name, number of sections taught, total enrollment



```
{name: "Julie",
 sections: 3,
 totalEnrollment: 112
}
{name: "Kurt V.",
 sections: 4,
 totalEnrollment: 112
}
```

What shall we do now?

Motivating Example

Q1: Find all CSSE faculty with highest
total enrollments, report name,
number of sections taught, total enrollment

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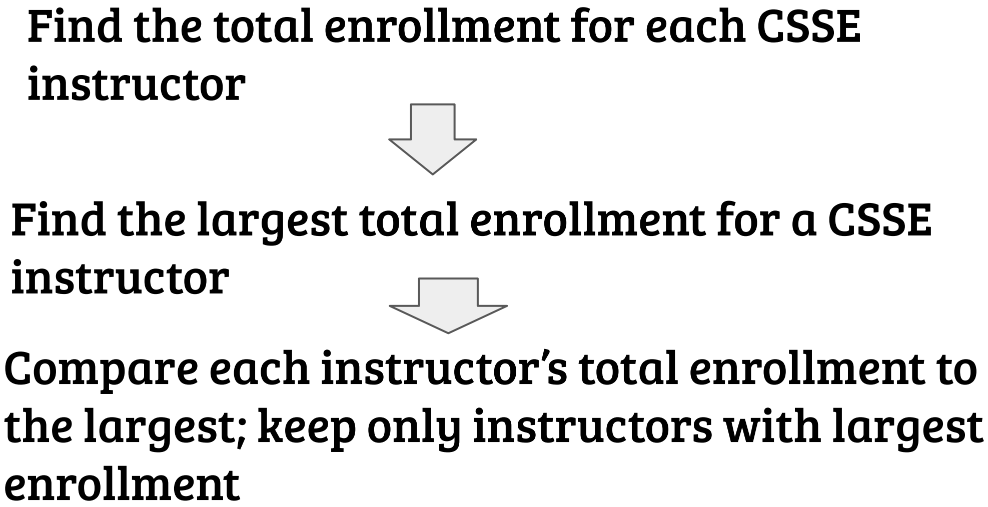

Find the total enrollment for each CSSE instructor

Find the largest total enrollment for a CSSE instructor

Compare each instructor’s total enrollment to the largest; keep only instructors with largest enrollment

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{name: “Julie”,
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Motivating Example

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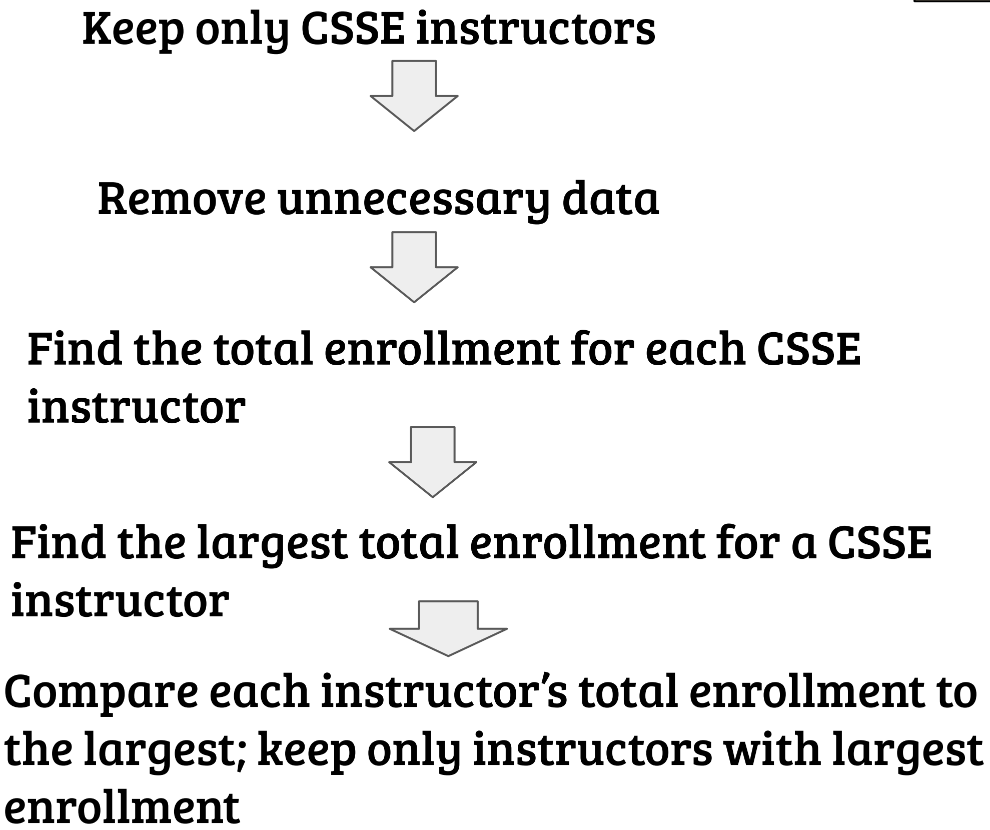

Keep only CSSE instructors

Remove unnecessary data

Find the total enrollment for each CSSE instructor

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Motivating Example

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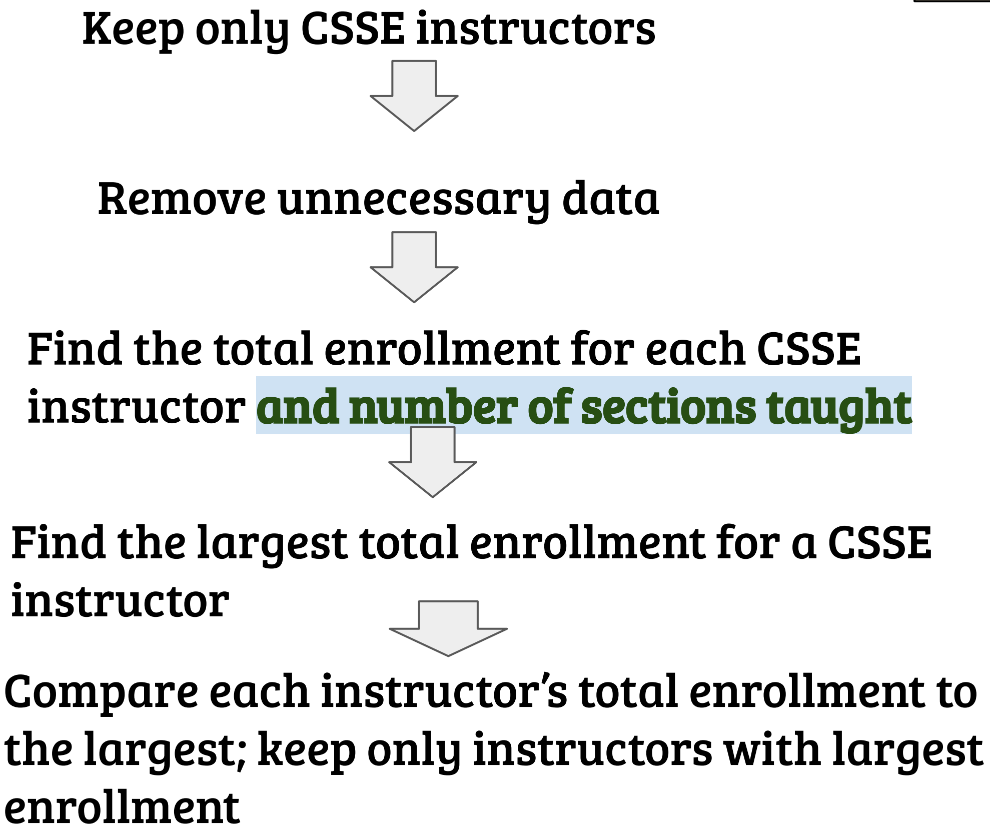

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Find the total enrollment for each CSSE instructor and number of sections taught

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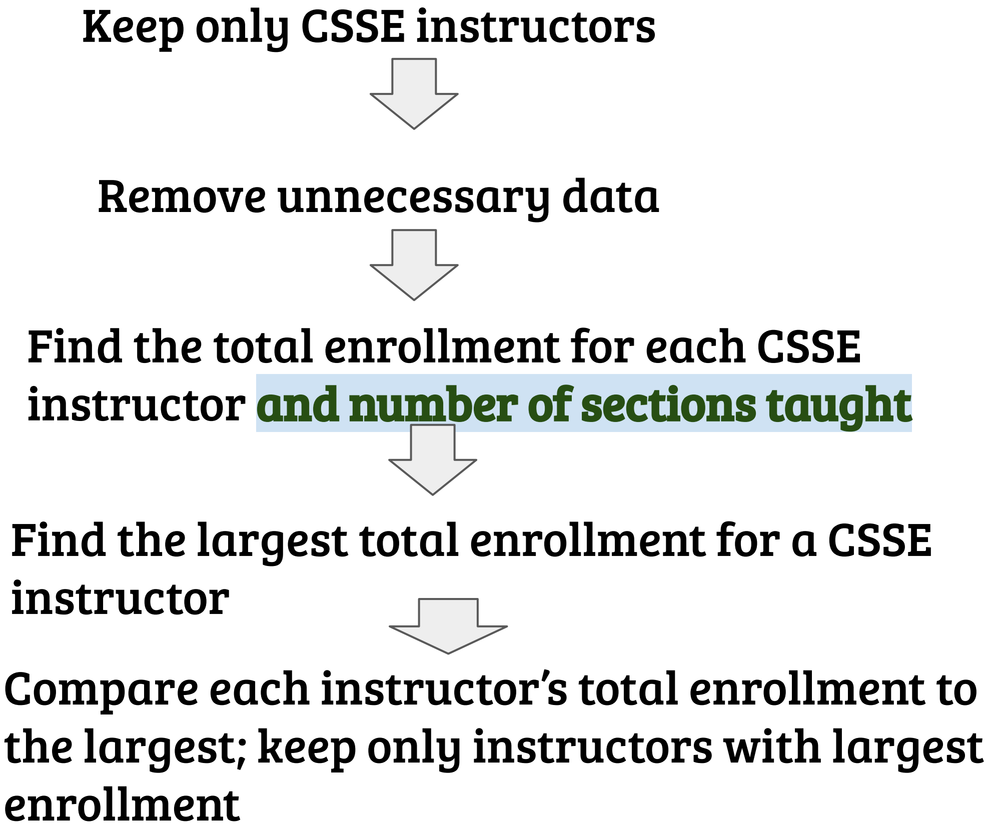

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Problem Decomposition!!!!

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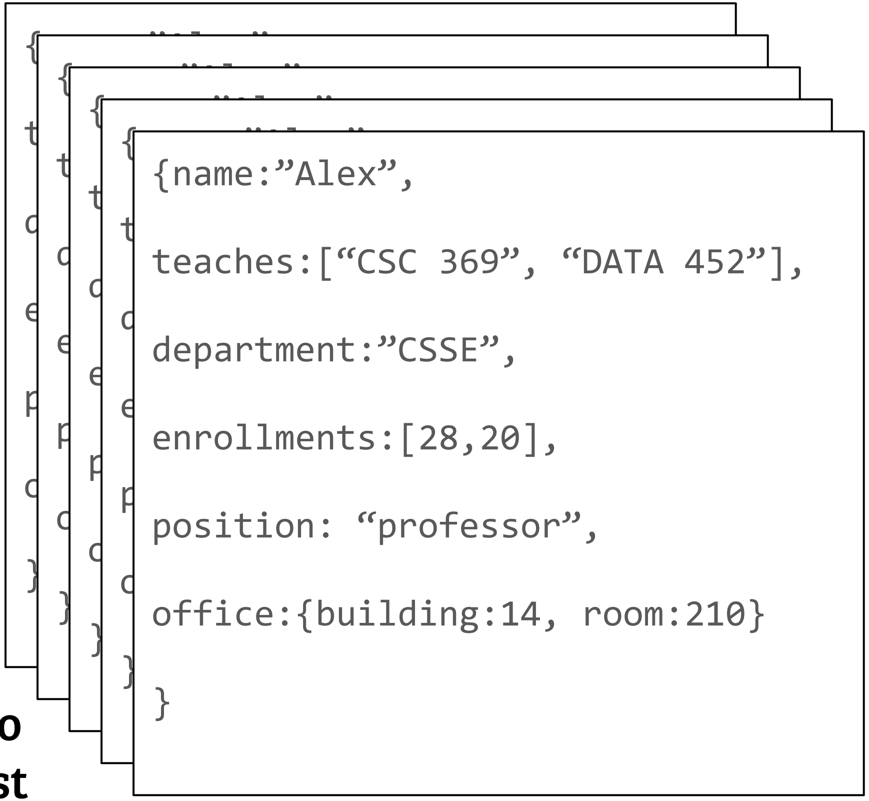

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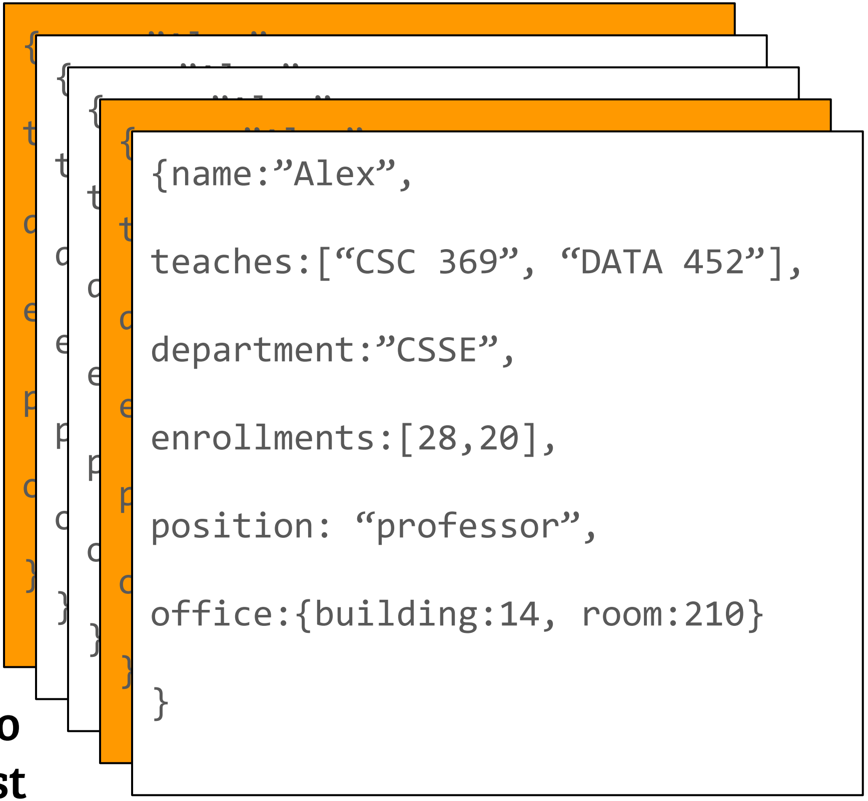

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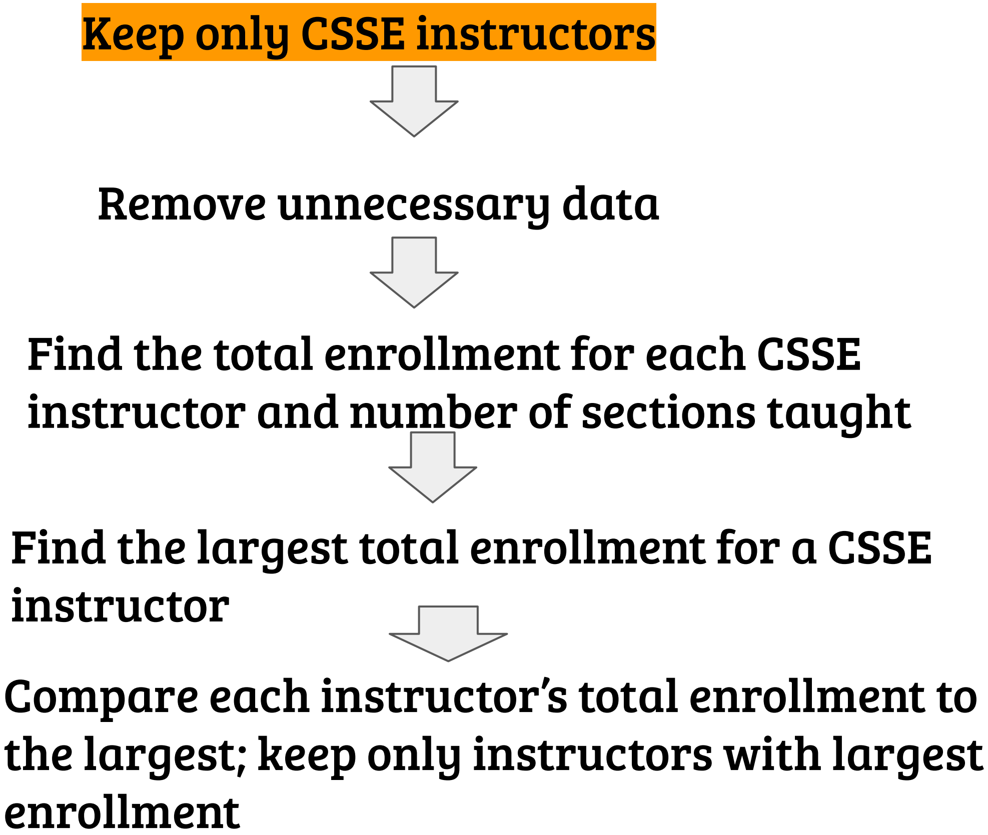

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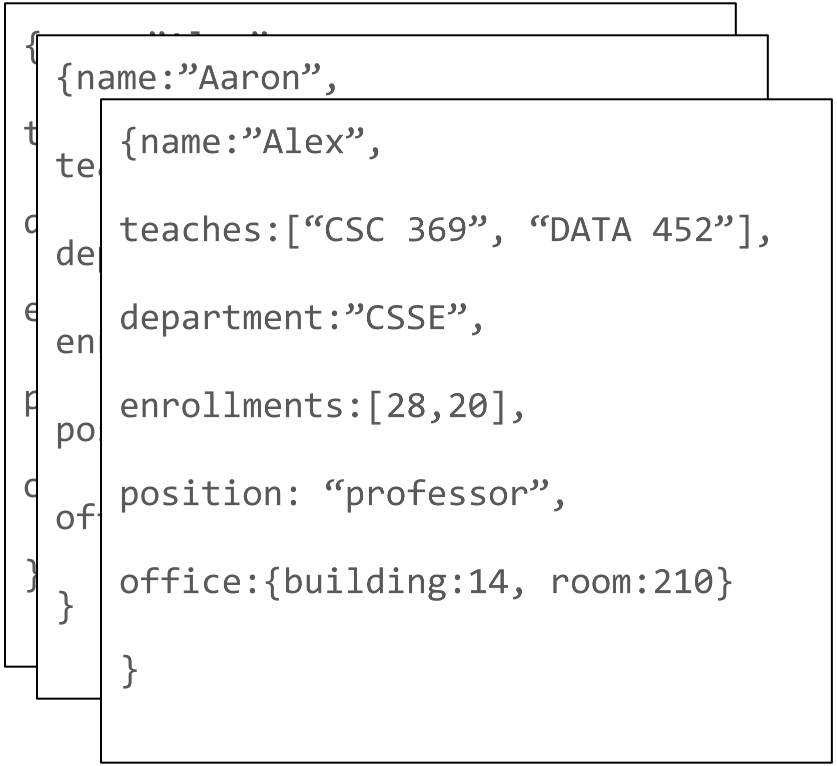

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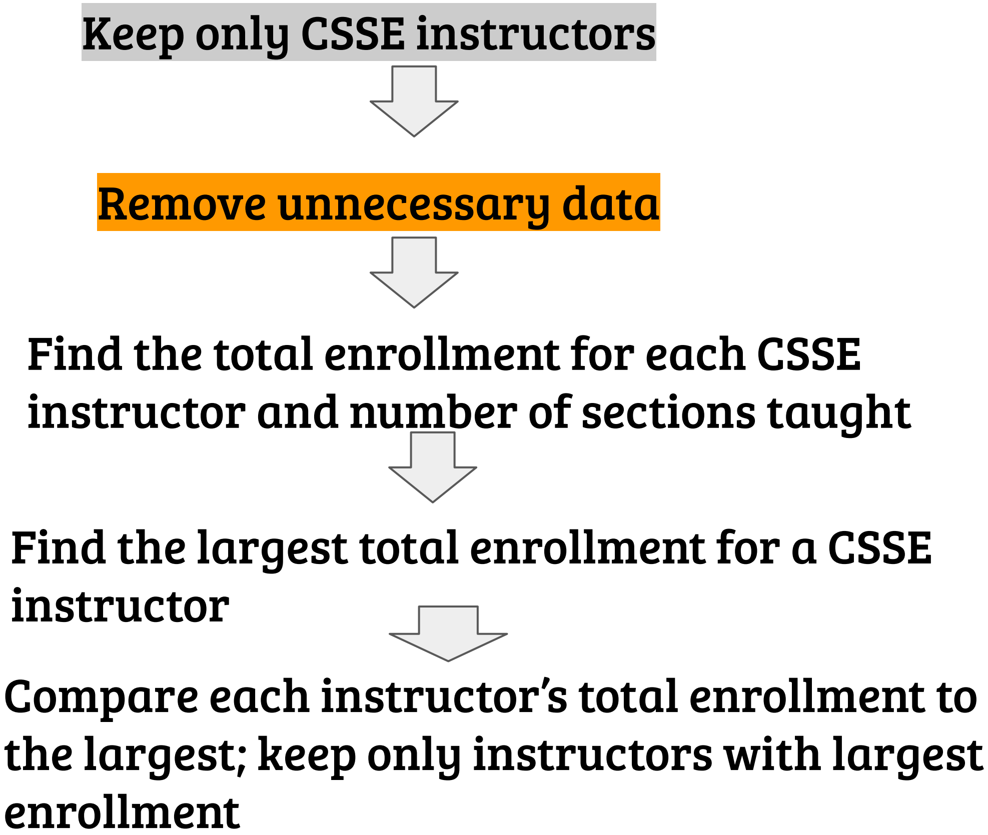

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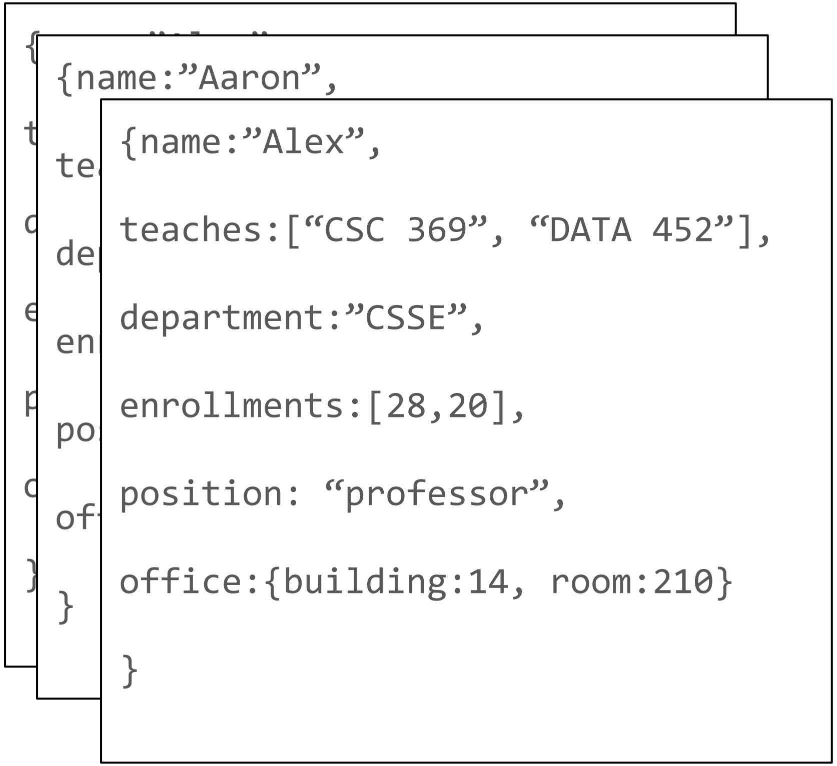

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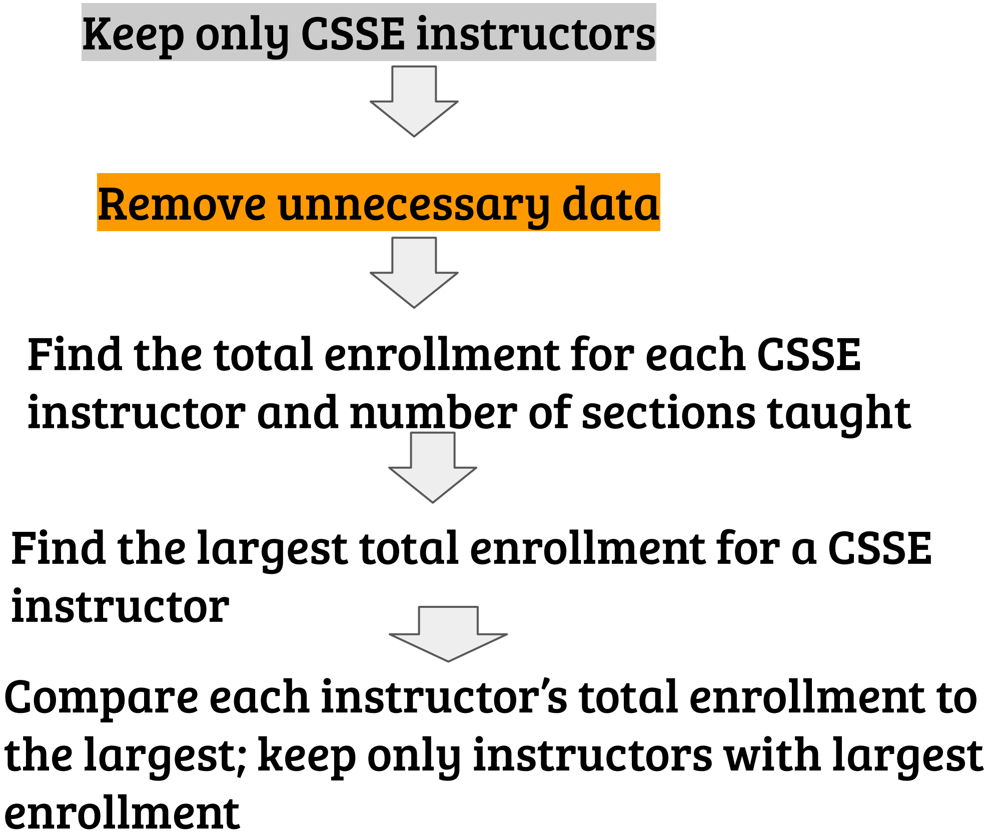

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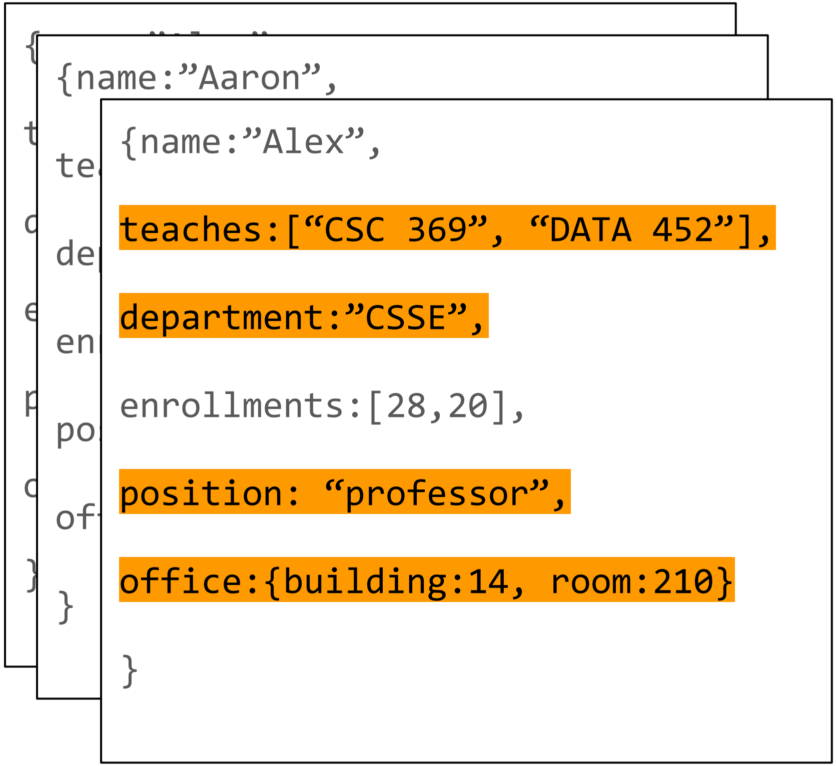

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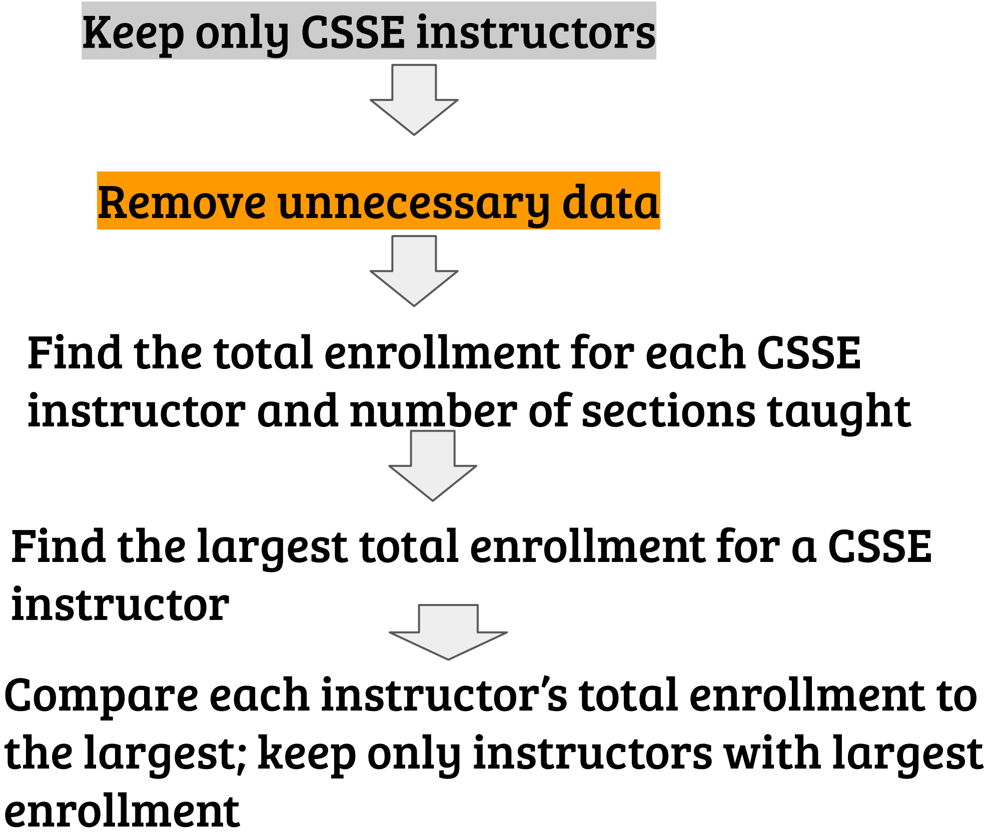

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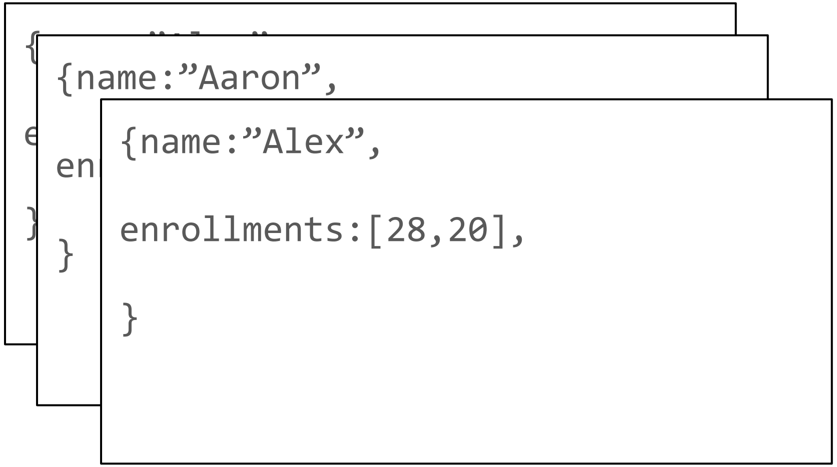

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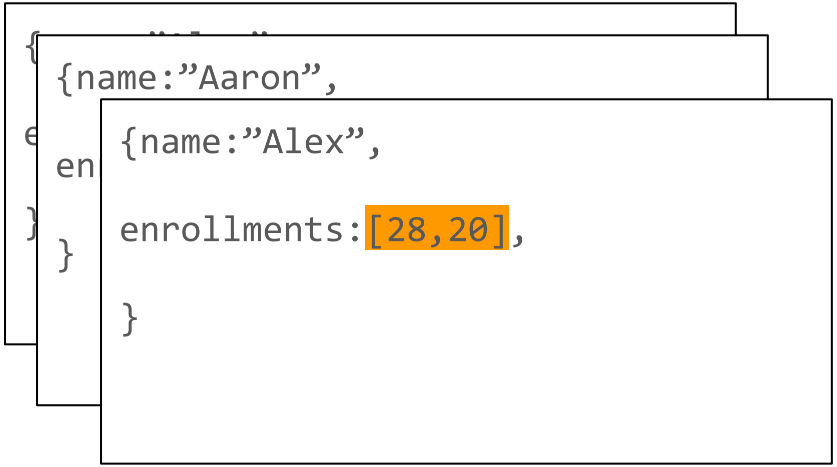

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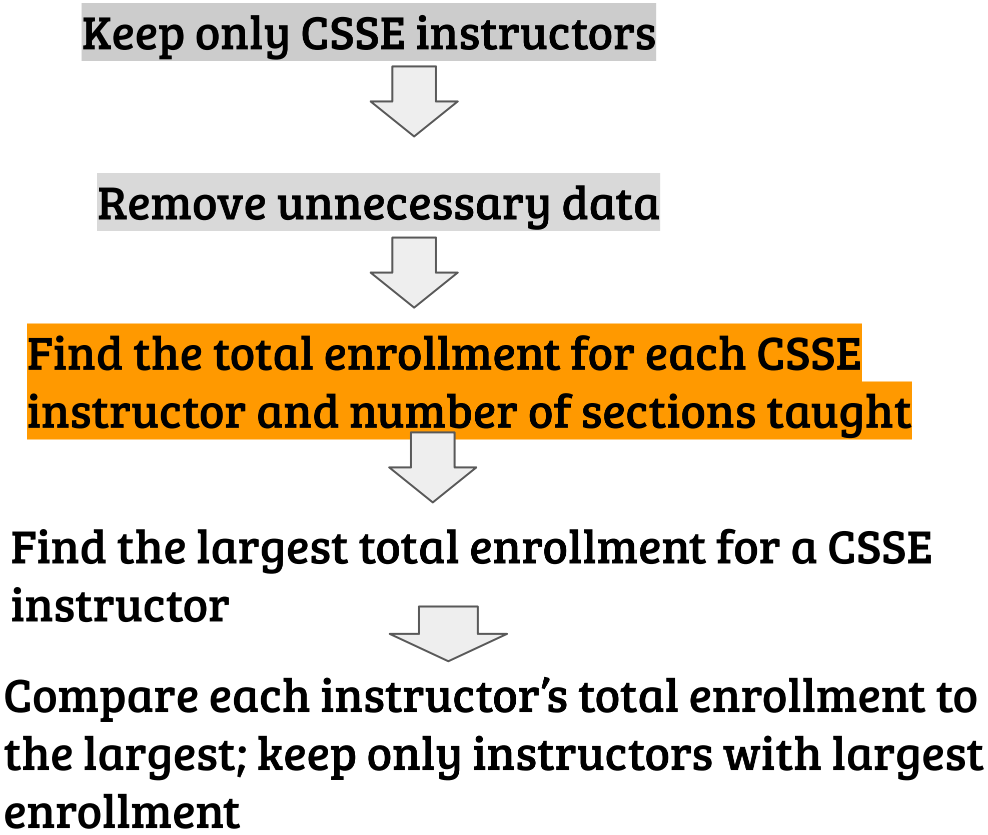

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{name:”Julie”,

enrollments:[35,35,  42]

}
```

```
{name:”Aaron”,

enrollments:[32,31]

}
```

```
{name:”Alex”,

enrollments:[28,20]

}
```

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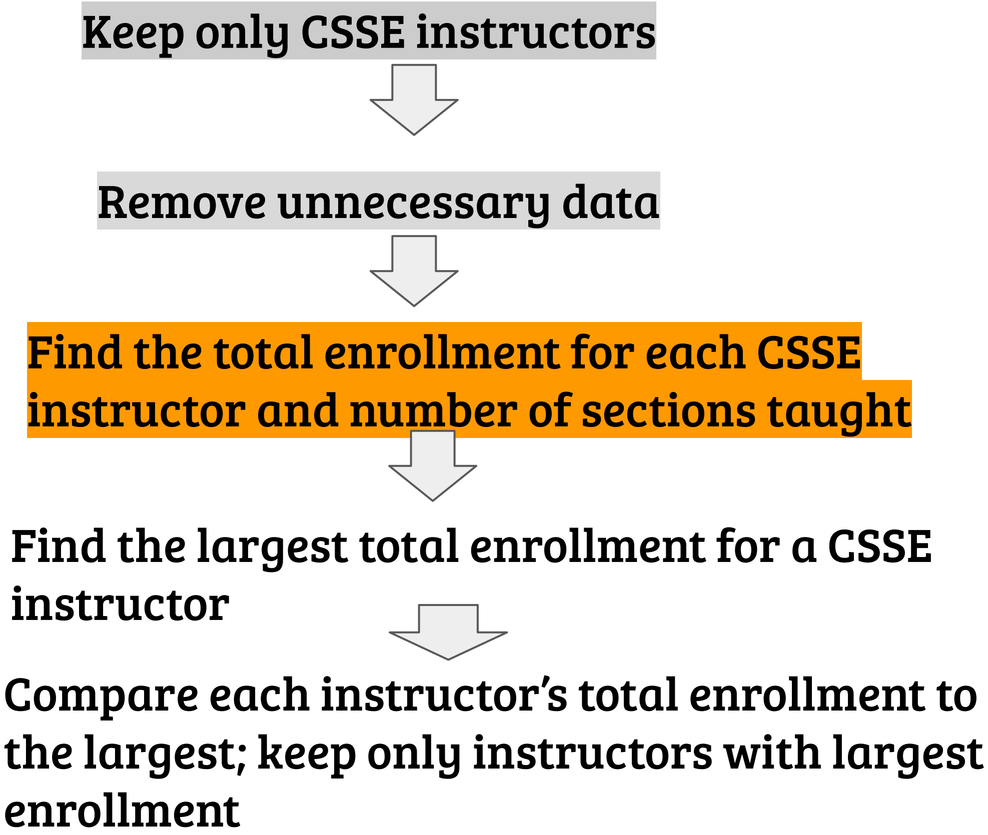

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Enrollment:112,
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}
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{name:”Aaron”,
enrollment: 63,
sections: 2
}
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{name:”Alex”,
enrollment:48,
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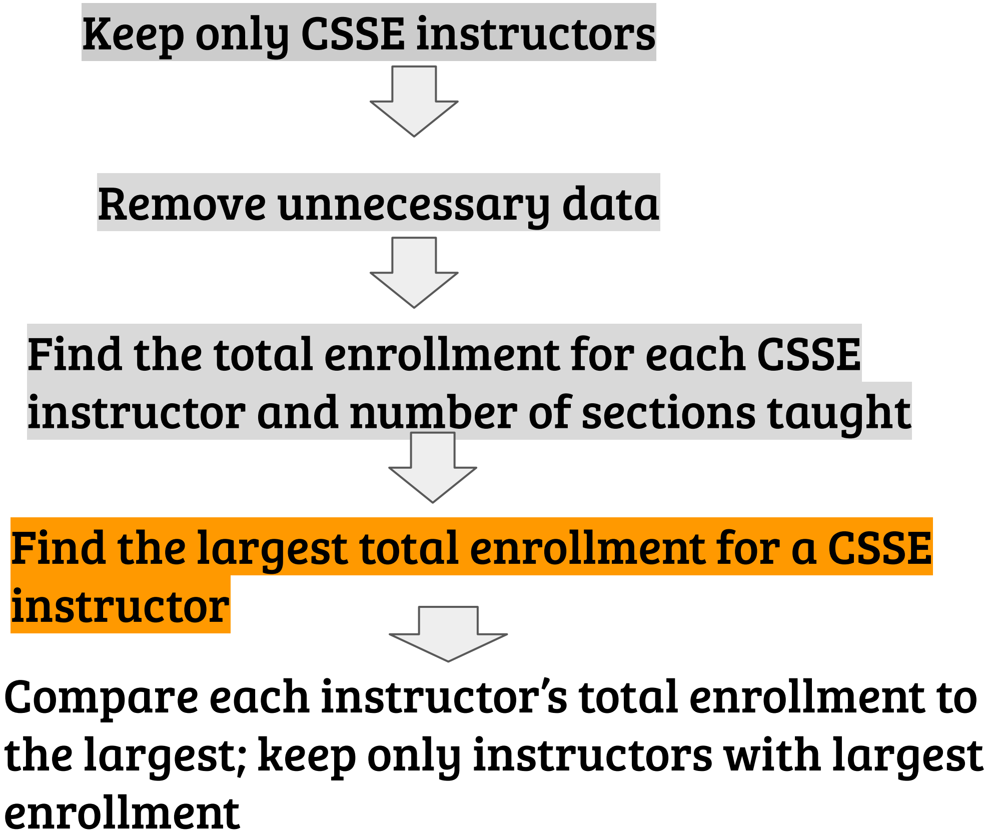

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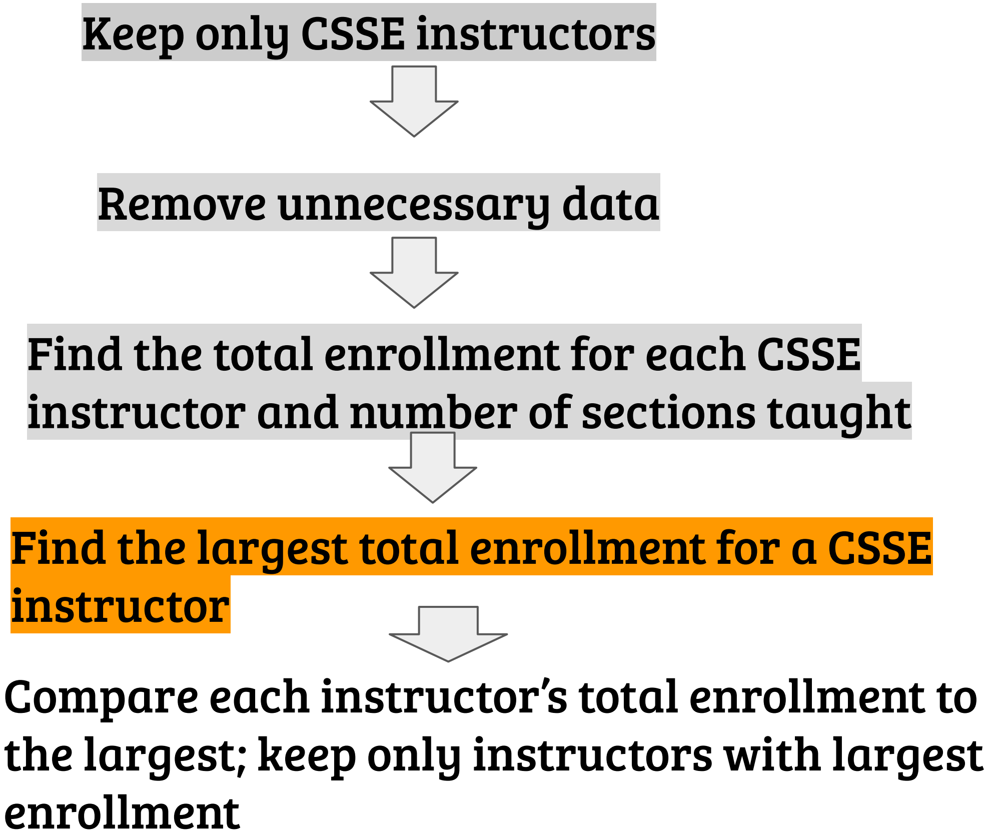

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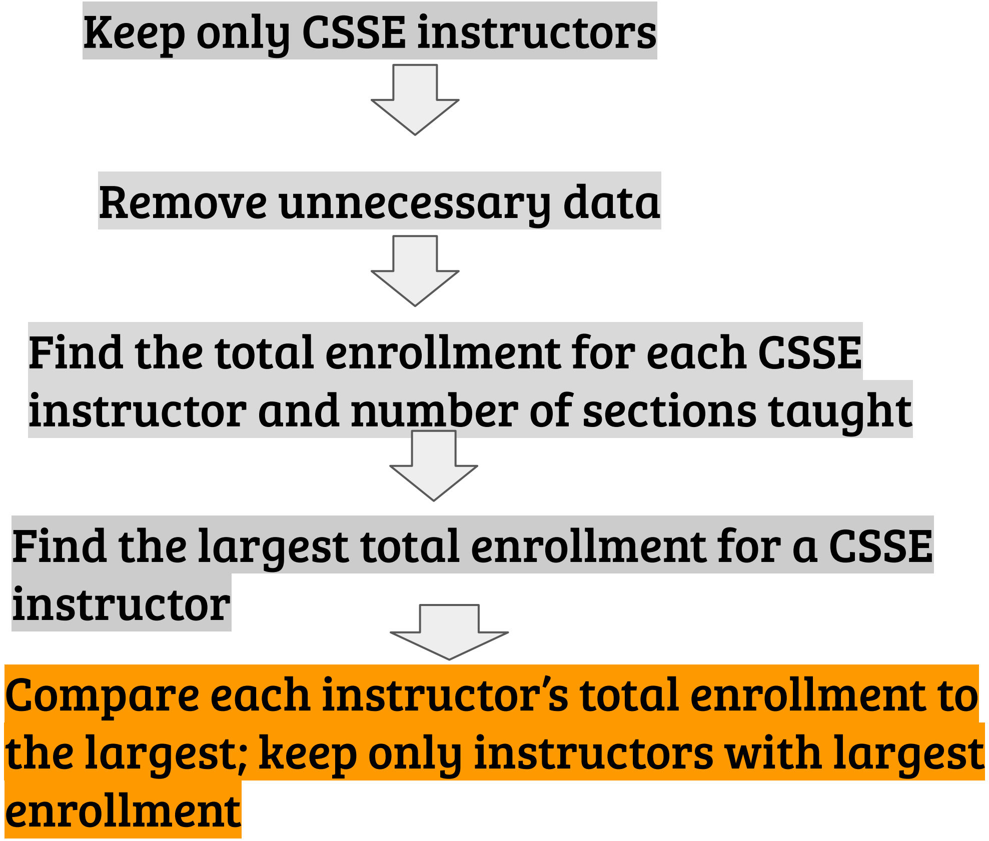

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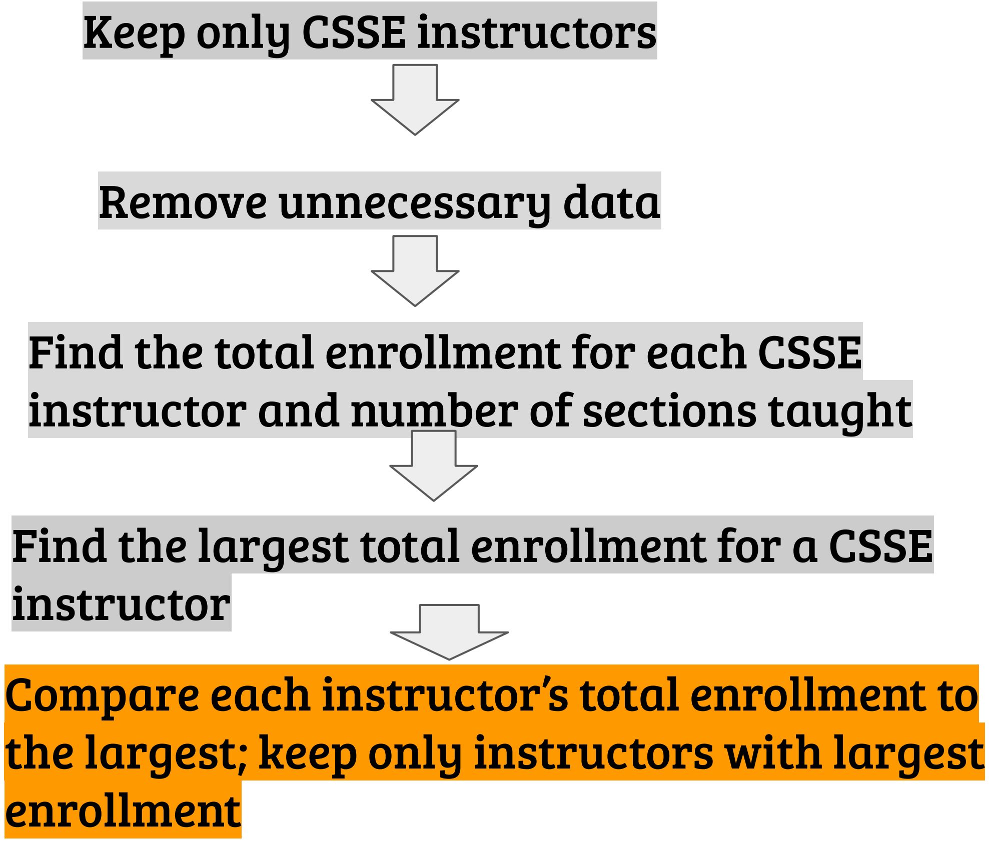

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✗

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✗

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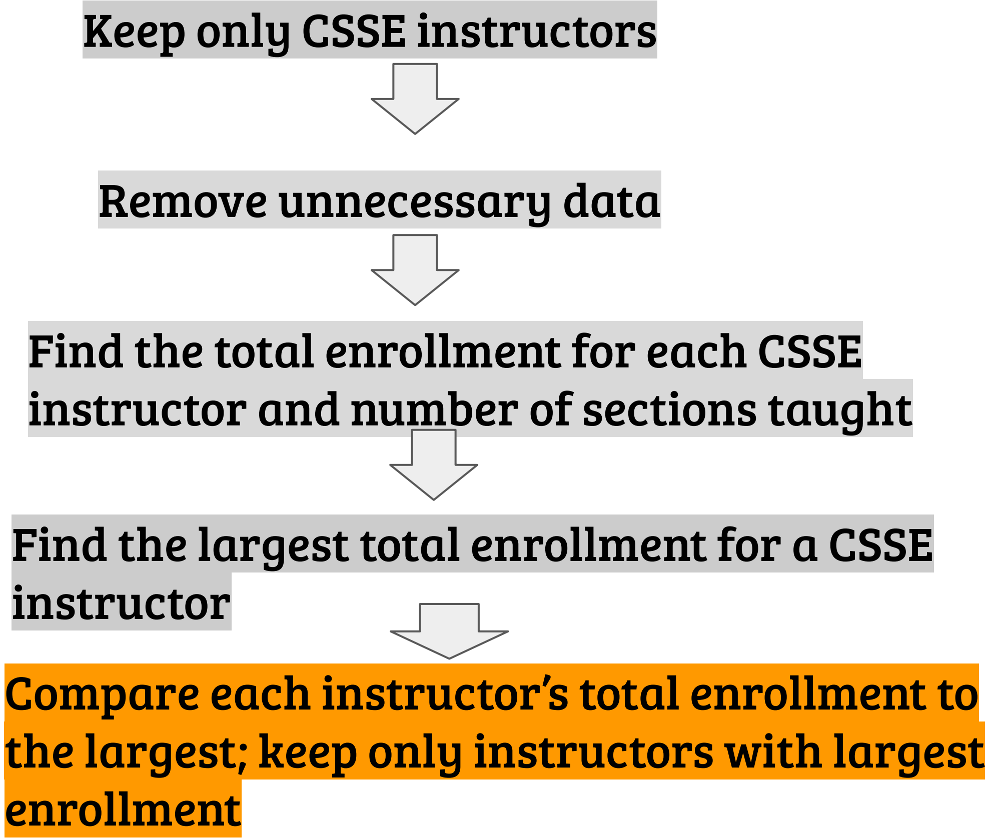

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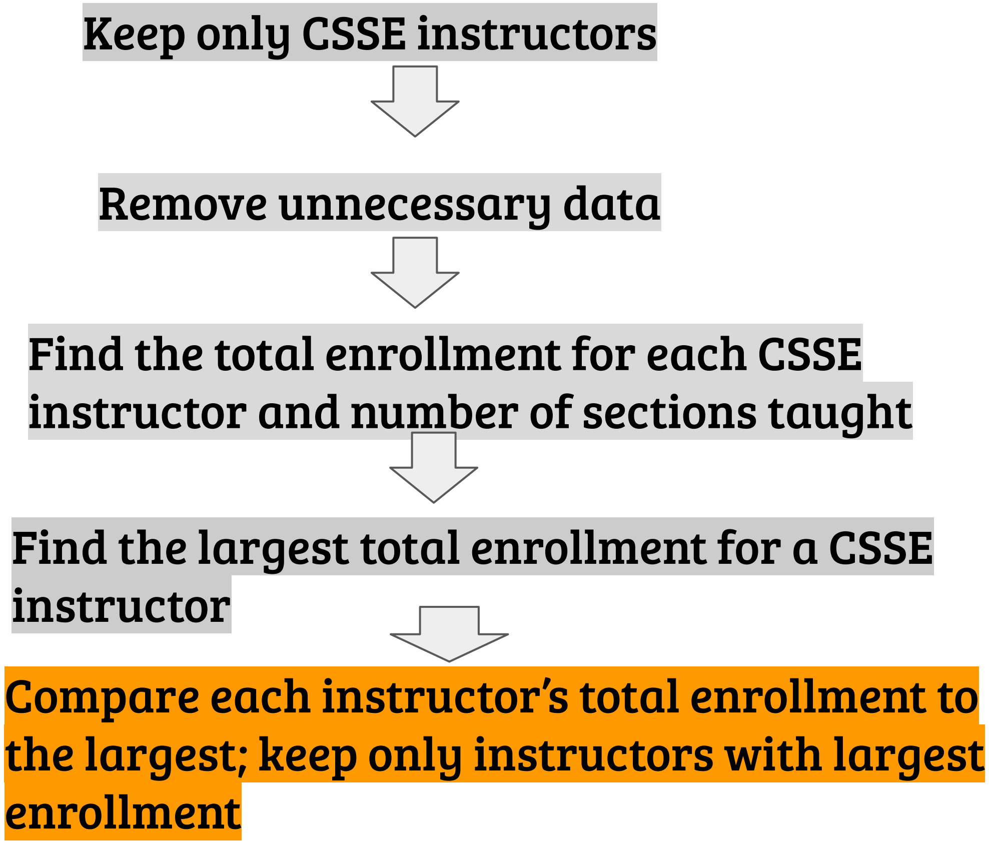

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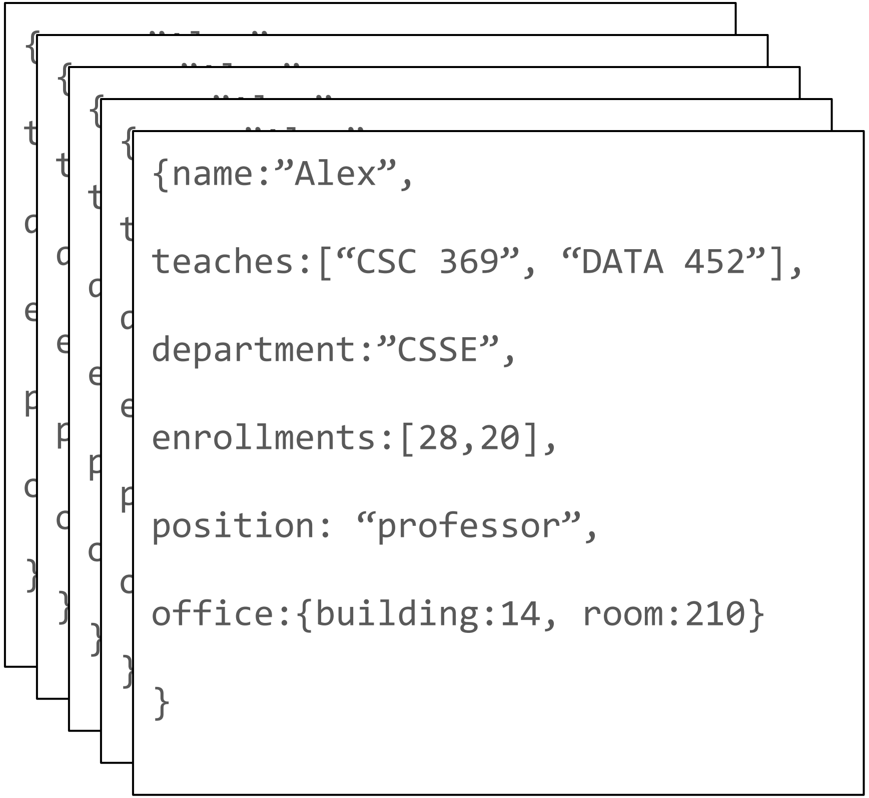
Motivating Example #2



```
{name:”Alex”,

teaches:[“CSC 369”, “DATA 452”],

department:”CSSE”,

enrollments:[28,20],

position: “professor”,

office:{building:14, room:210}

}
```

Q2: Report a list of instructors for each “CSC”, “CPE” and “DATA” course. For each instructor, list name and department.

```
{ course: “DATA 452”,
  instructors:[{name:”alex”, dept:”CSSE”}
               {name:”hunter”, dept:”STAT”}]
}
{course: “CSC 369”,
 instructors:[{name:”alex”, dept:”CSSE”}],
}
{course:”CSC 430”,
 Instructors: [{name:”john c”, dept:”CSSE”},
               {name:”aaron”, dept:”CSSE”}]
}
```

Motivating Example #2

Deconstruct “teaches” arrays, create one object per instructor-course pairing

Q2: Report a list of instructors for each “CSC”, “CPE” and “DATA” course. For each instructor, list name and department.

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}
```

```
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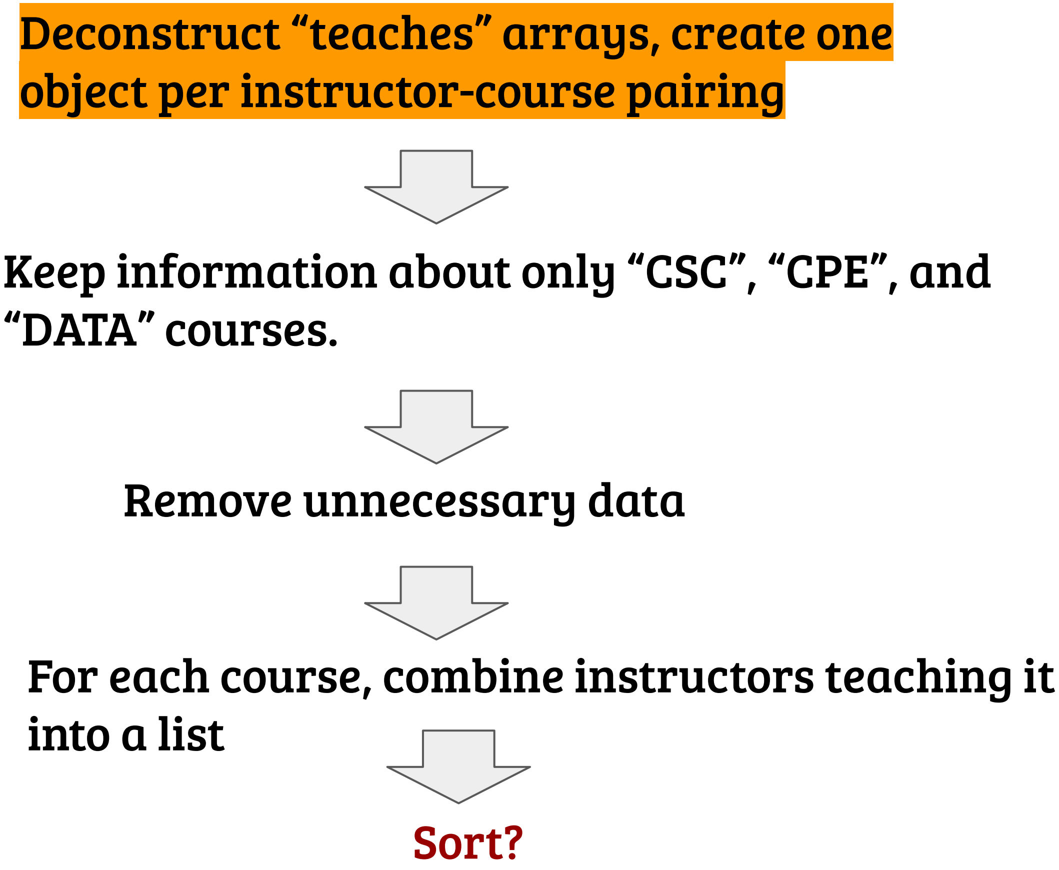
What did we just do?



Deconstruct “teaches” arrays, create one object per instructor-course pairing

Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

For each course, combine instructors teaching it into a list

Sort?

```
{name:”Alex”,
teaches:[“CSC 369”, “DATA 452”],
department:”CSSE”,
enrollments:[28,20],
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}
```

```
{name:”Hunter”,
teaches:[“DATA 452”, “STAT 431”],
department:”Statistics”,
enrollments:[20,30],
position: “assistant professor”,
office:{building:25, room:111}
}
```

What did we just do?

Deconstruct "teaches" arrays, create one object per instructor-course pairing

Keep information about only "CSC", "CPE", and "DATA" courses.

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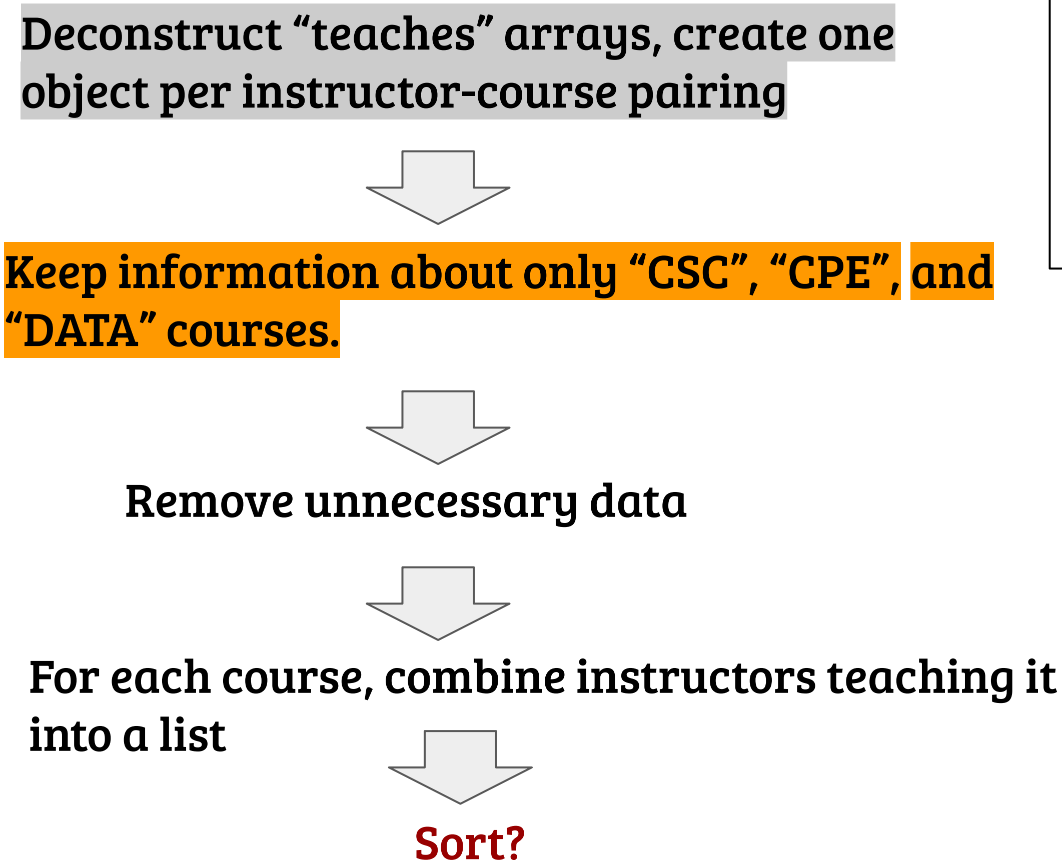

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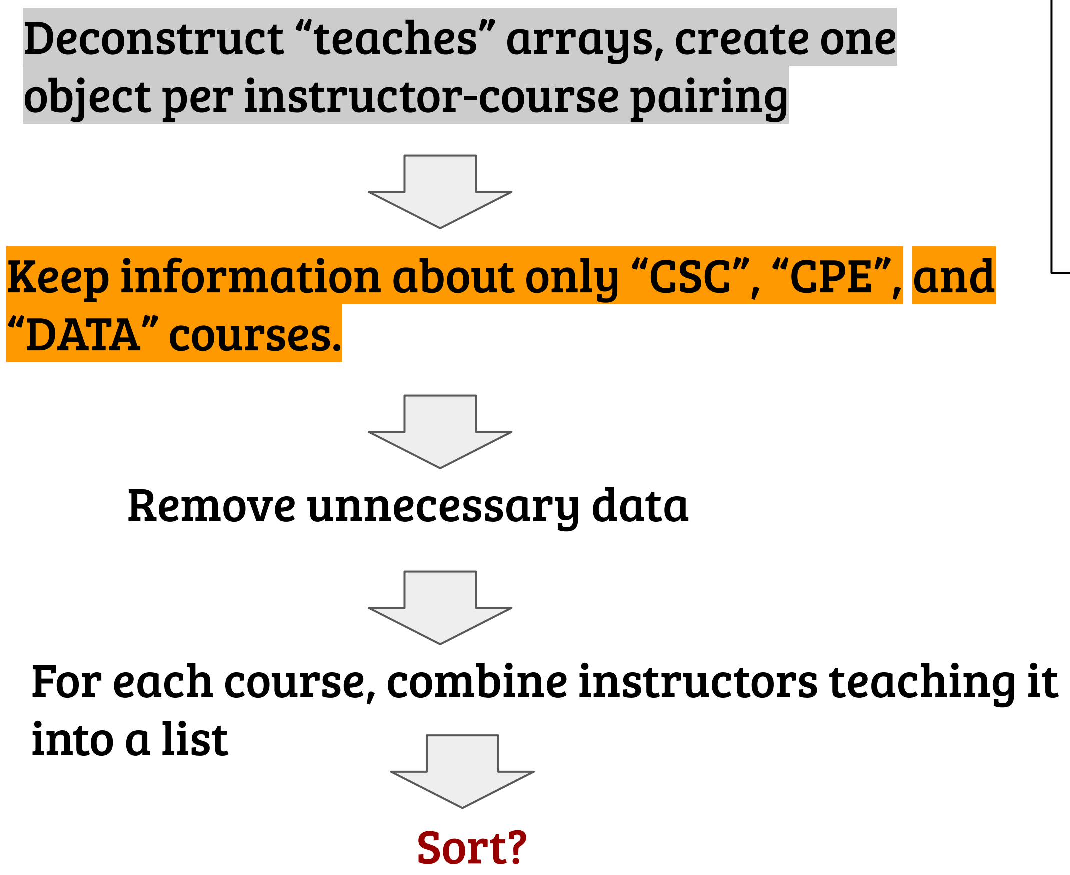

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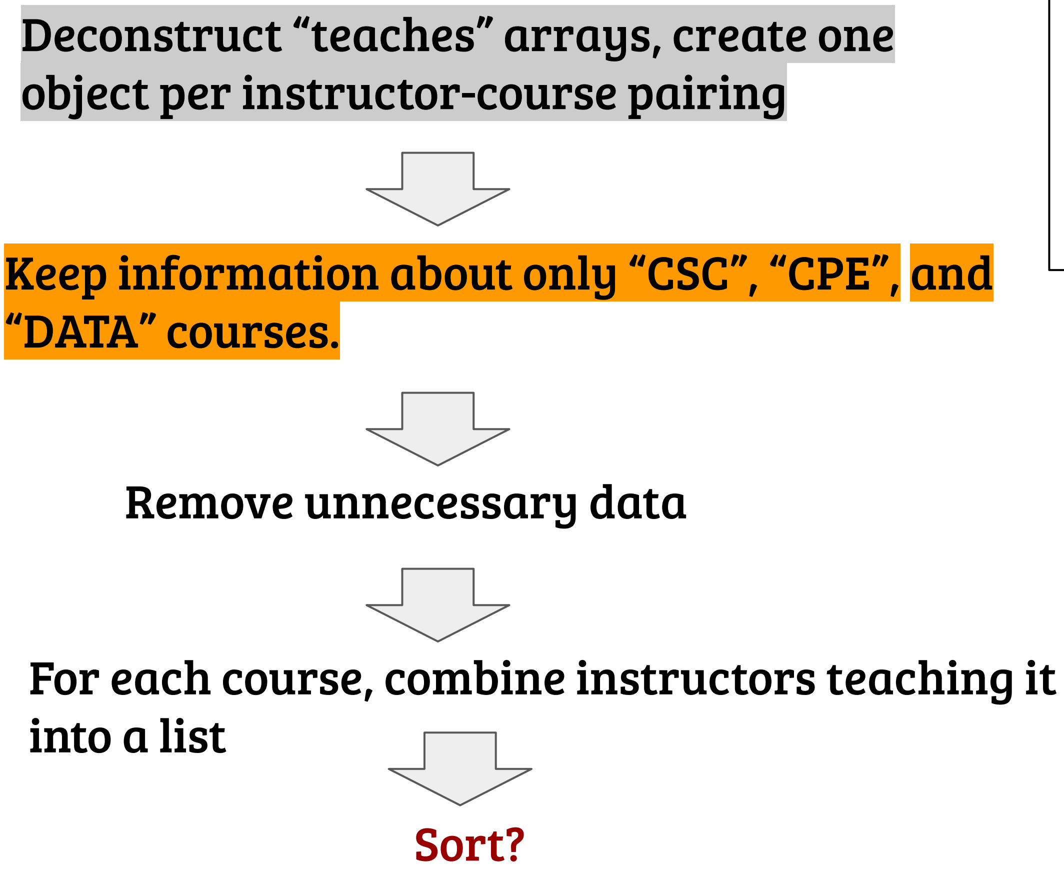

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teaches:“DATA 452”,
department:”Statistics”,
enrollments:[20,30],
position: “assistant professor”,
office:{building:25, room:111}
}
```
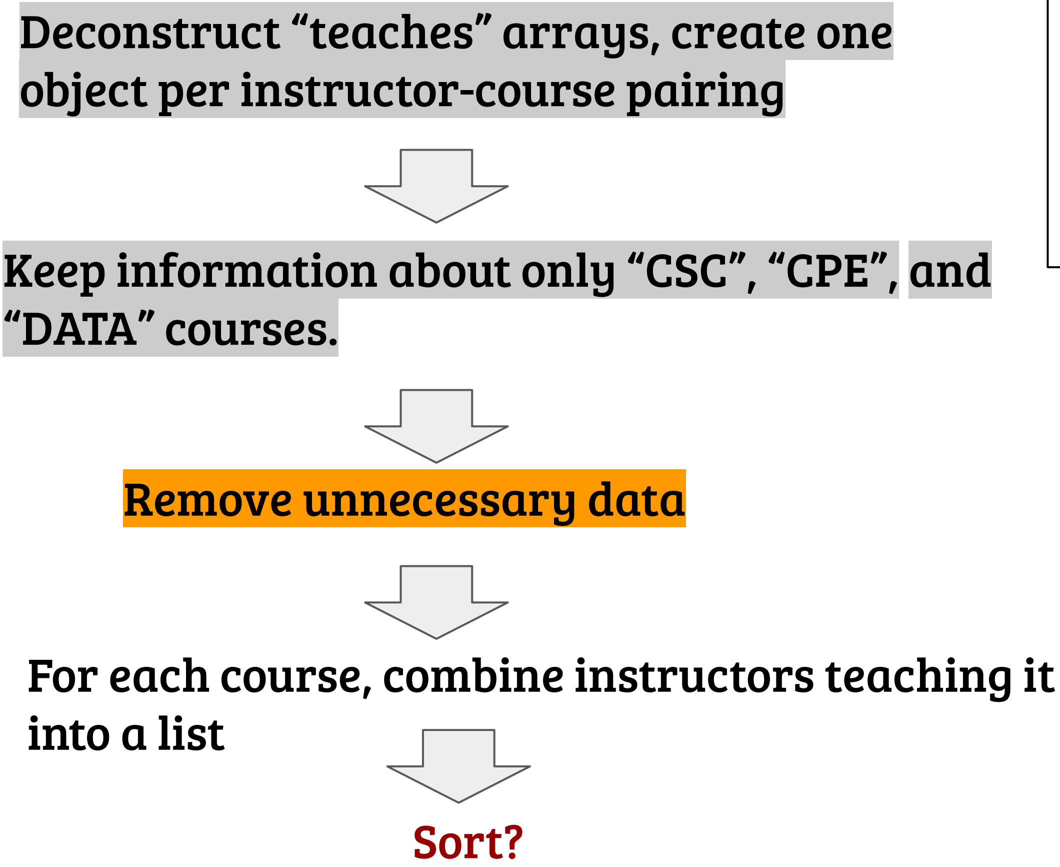

What did we just do?



Deconstruct “teaches” arrays, create one object per instructor-course pairing

Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

For each course, combine instructors teaching it into a list

Sort?

```
{name:”Alex”,
teaches:“CSC 369”
department:”CSSE”,
enrollments:[28,20]
position: “professo
office:{building:14,
}
```

```
{name:”Alex”,
teaches:“DATA 452”
department:”CSSE”,
enrollments:[28,20],
position: “professor”,
office:{building:14, room:210}
}
```

```
{name:”Hunter”,
teaches:“DATA 452”,
department:”Statistics”,
enrollments:[20,30],
position: “assistant professor”,
office:{building:25, room:111}
}
```

What did we just do?

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Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

For each course, combine instructors teaching it into a list

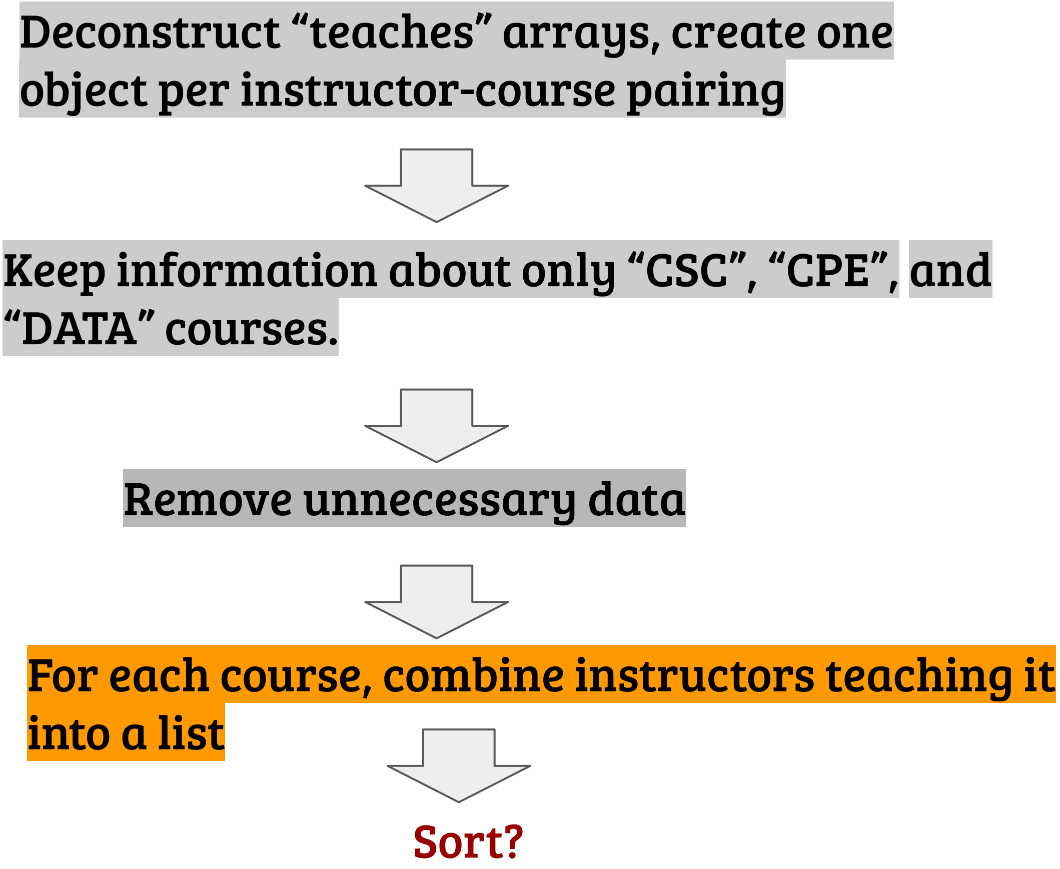
Sort?

```
{name:”Alex”,
teaches:“CSC 369” ,
department:”CSSE”
}
```

```
{name:”Alex”,
teaches:“DATA 452”
department:”CSSE”
}
```

```
{name:”Hunter”,
teaches:“DATA 452”,
department:”Statistics”
}
```

What did we just do?



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Remove unnecessary data

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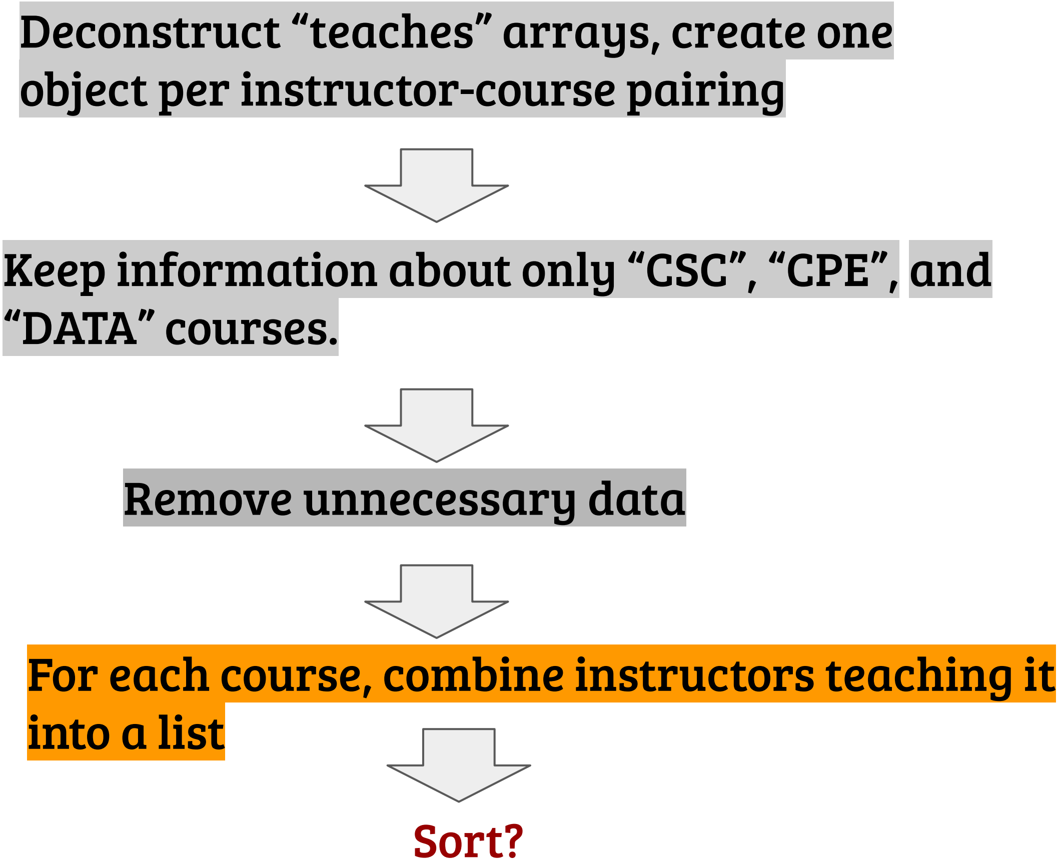
```
{name:”Alex”,
teaches:“CSC 369” ,
department:”CSSE”
}
```

```
{name:”Alex”,
teaches:“DATA 452”
department:”CSSE”
}
```

```
{name:”Hunter”,
teaches:“DATA 452”,
department:”Statistics”
}
```

What did we just do?



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Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

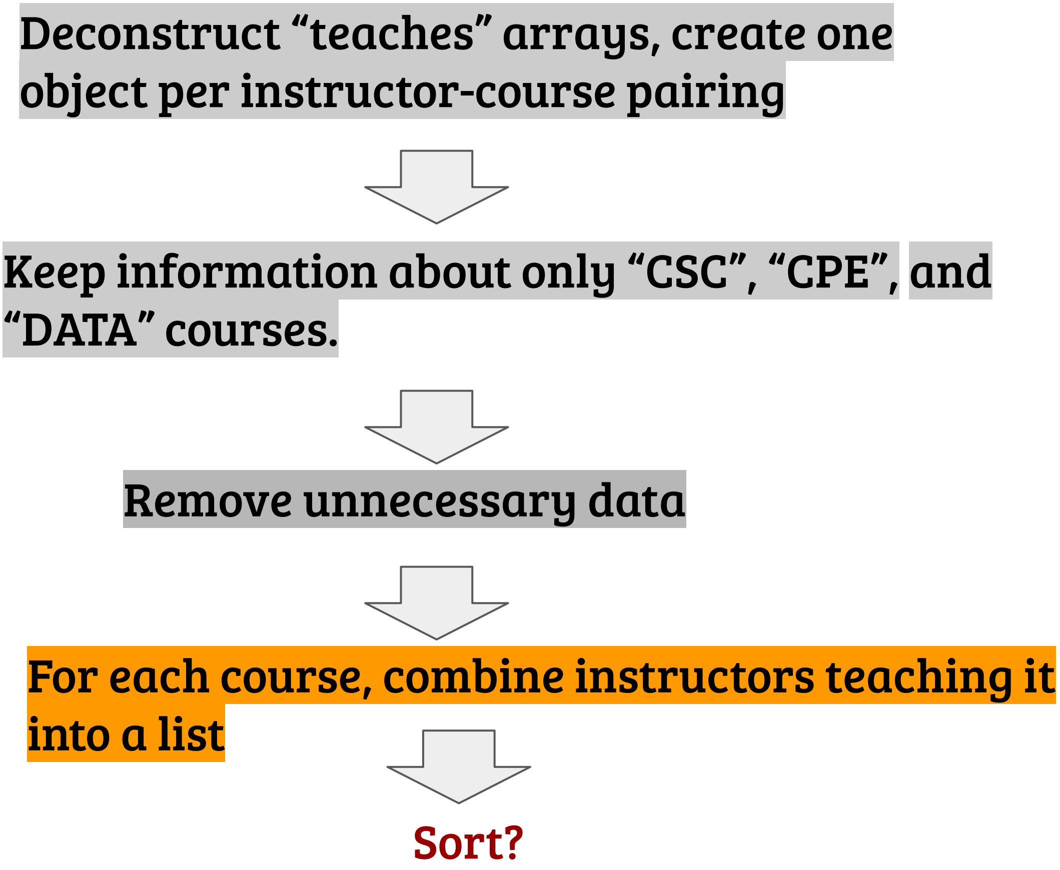
For each course, combine instructors teaching it into a list

Sort?

```
{teaches:“CSC 369” ,

instructors:[{name:”Alex”,

             department:”CSSE”}]

}
```

```
{teaches:“DATA 452” ,

Instructors:[{name: “Alex”,

             department:”CSSE”},

            {name:”Hunter”,

     department: “Statistics”   }]

}
```

What did we just do?



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Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

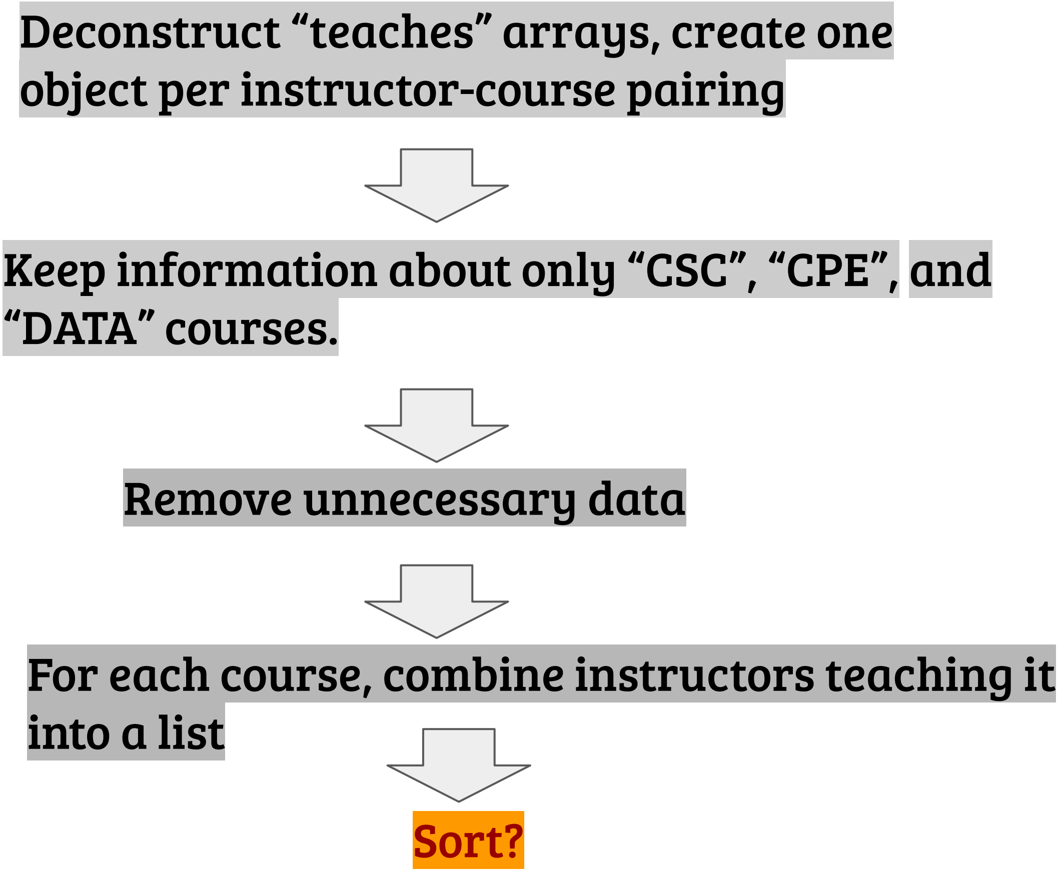
For each course, combine instructors teaching it into a list

Sort?

```
{course:“CSC 369” ,

instructors:[{name:”Alex”,

                department:”CSSE”}

}
```

```
{course: “DATA 452”,

instructors:[{name: “Alex”,

                department:”CSSE”},

                {name:”Hunter”,

     department: “Statistics”   }]

}
```

What did we just do?



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Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

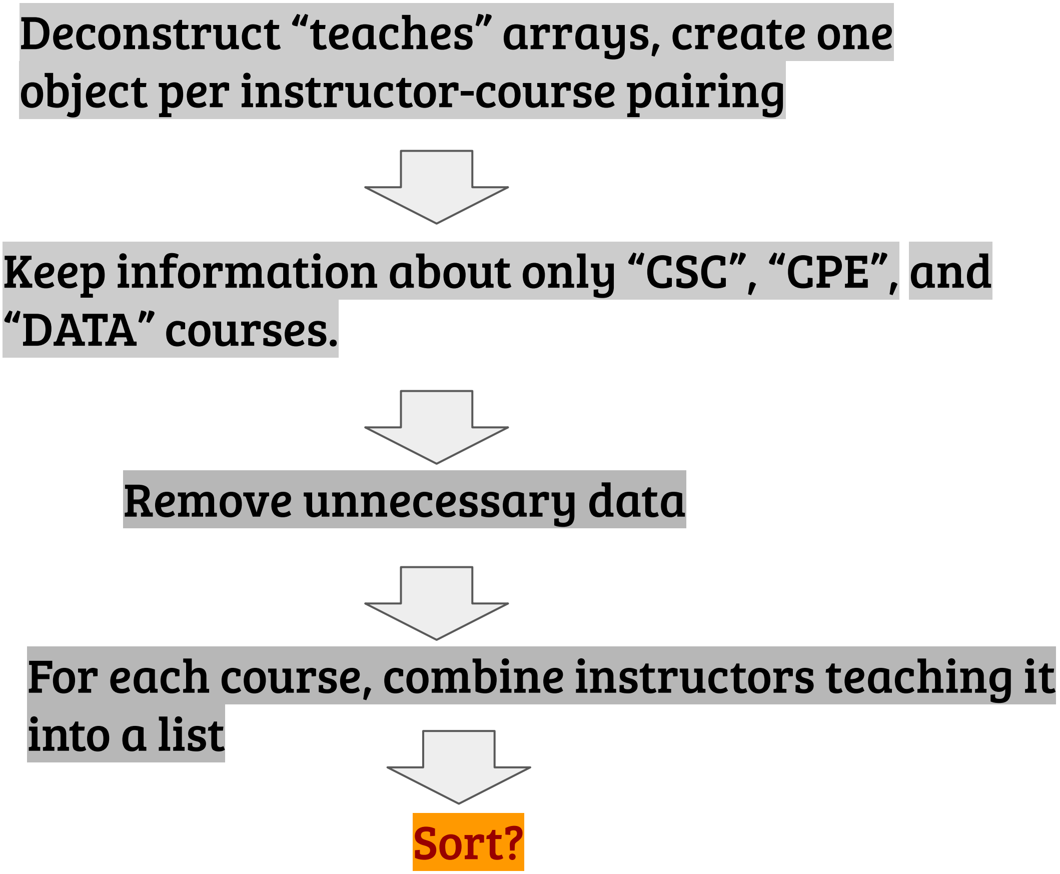
For each course, combine instructors teaching it into a list

Sort?

```
{course:“CSC 369” ,

instructors:[{name:”Alex”,

                department:”CSSE”}

}
```

```
{course: “DATA 452”,

instructors:[{name: “Alex”,

                department:”CSSE”},

             {name:”Hunter”,

     department: “Statistics”   }]

}
```

What did we just do?



Deconstruct “teaches” arrays, create one object per instructor-course pairing

Keep information about only “CSC”, “CPE”, and “DATA” courses.

Remove unnecessary data

For each course, combine instructors teaching it into a list

Sort?

```
{course:“CSC 369” ,

instructors:[{name:”Alex”,

                department:”CSSE”}

}
```

```
{course: “DATA 452”,

instructors:[{name: “Alex”,

                department:”CSSE”},

             {name:”Hunter”,

     department: “Statistics”   }]

}
```

What did we just do?

Problem Decomposition!!!!

into atomic operations

What "Atomic Operations"

Problem Decomposition!!!!

into atomic operations

Relational Algebra (hello, CSC 365)

What “Atomic Operations”

Problem Decomposition!!!!

into atomic operations

Relational Algebra (hello, CSC 365)

What “Atomic Operations”

Problem Decomposition!!!!

into atomic operations

Algebra of atomic Data operations

What “Atomic Operations”

Relational Algebra

Selection

Projection

Set Operations

Join

Grouping/Aggregation

Sort

What “Atomic Operations”

Relational Algebra	Generalized Algebra
Selection	Filtering
Projection	Projection/Transformation
Set Operations	
Join	Join
Grouping/Aggregation	Grouping/Aggregation
Sort	Sort

Why Do We Discuss these Operations?

```
db.collection.find(....).<finishingtouch>()
```

Selection, Projection, Sort, Skip, Limit

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

What “Atomic Operations”

Generalized Algebra

Filtering

Projection/Transformation

Join

Unwind ↔ Grouping/Aggregation

Limit

Sort

Skip

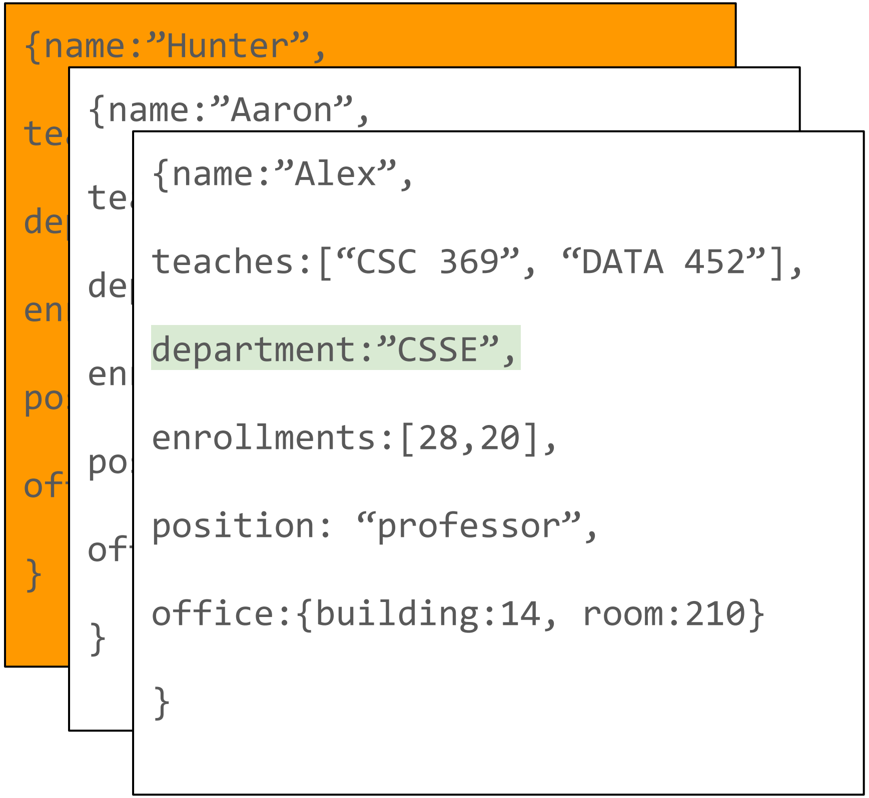
Overview: Selection/Filtering

Given a selection criterion keep objects that match it, Remove objects that don't.

Overview: Selection/Filtering

Given a selection criterion keep objects that match it, Remove objects that don’t.

Keep only CSSE instructors



```
{name:”Hunter”,
```

```
{name:”Aaron”,
```

```
{name:”Alex”,
teaches:[“CSC 369”, “DATA 452”],
department:”CSSE”,
enrollments:[28,20],
position: “professor”,
office:{building:14, room:210}
}
```

Overview: Projection/Transformation

Given an object, transform it into a different object

Overview: Projection/Transformation

Given an object, transform it into a different object

Remove unnecessary data

```
{name:”Alex”,

teaches:[“CSC 369”, “DATA 452”],

department:”CSSE”,

enrollments:[28,20],

position: “professor”,

office:{building:14, room:210}

}
```

Overview: Projection/Transformation

Given an object, transform it into a different object

```
{name:”Alex”,

enrollments:[28,20],

}
```

Remove unnecessary data

Overview: Aggregation

Given an object with arrays, aggregate their content.

Add up enrollments

```
{name:”Alex”,

enrollments:[28,20],

}
```

Overview: Aggregation

Given an object with arrays, aggregate their content.

Add up enrollments

```
{name:”Alex”,

enrollments:[28,20],

}
```

```
{name:”Alex”,

enrollments:48,

}
```

Overview: Grouping

Combine information from multiple objects into one, based on common attributes