

Big Data Processing

— L24-25:
Big Data Storage —

Dr. Ignacio Castineiras
Department of Computer Science

Outline

1. Setting the Context.
2. MongoDB: Conceptual Approach.
3. MongoDB: Demonstrating Split and Migrate.
4. My Cluster Simulator: Split, Migrate and Auto-scale.

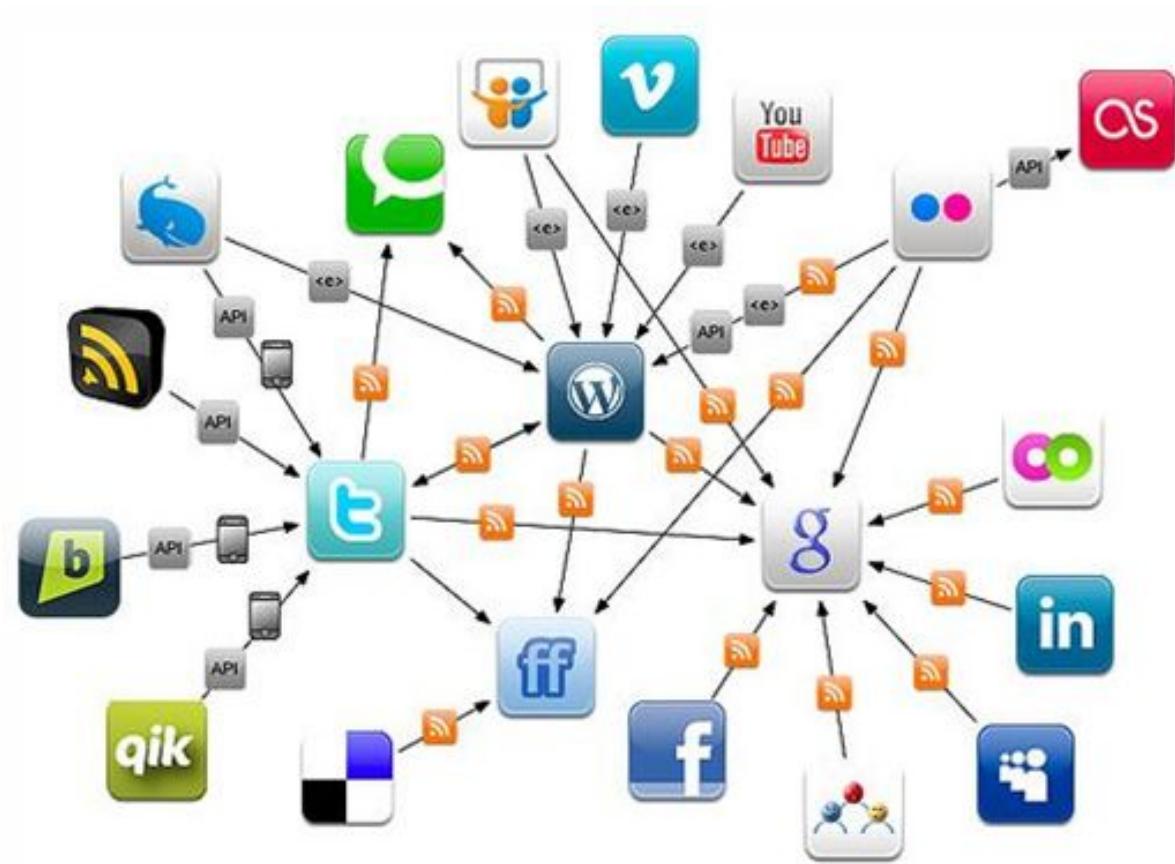
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Setting the Context

- Google indexes 30 trillion pages

Google



Setting the Context

- Facebook connects 1.69 billion of users



Setting the Context

- Amazon offers 12 million products



Computing



Electronics



Mobile Phones



Kitchen & Home



Video Games



Sports & Outdoors



Books



Toys



Health & Personal Care



Baby Products



Shoes & Apparel



Amazon Devices



Setting the Context

Google, Facebook and Amazon
have big Data Centres to store all this data...



Setting the Context

Google, Facebook and Amazon
have big Data Centres to store all this data...

...but this does not mean being able to deal with it



Setting the Context

Goal of this Lecture:

How is Big Data Organised
when it is stored
for its further processing?



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MongoDB Intro

MongoDB is the state-of-the-art
NoSQL document-oriented database.



mongo**D**B

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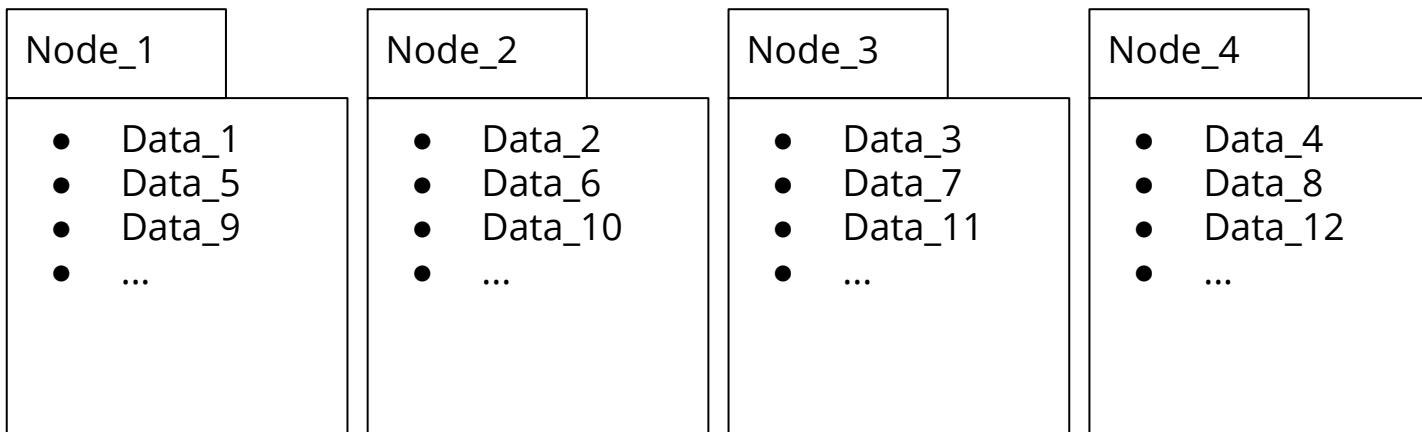


- In this semester we are not interested in MongoDB.
- But today we are looking at it to understand the basic concepts of data organisation in Big Data Storage.

MongoDB Intro

Data Distribution.

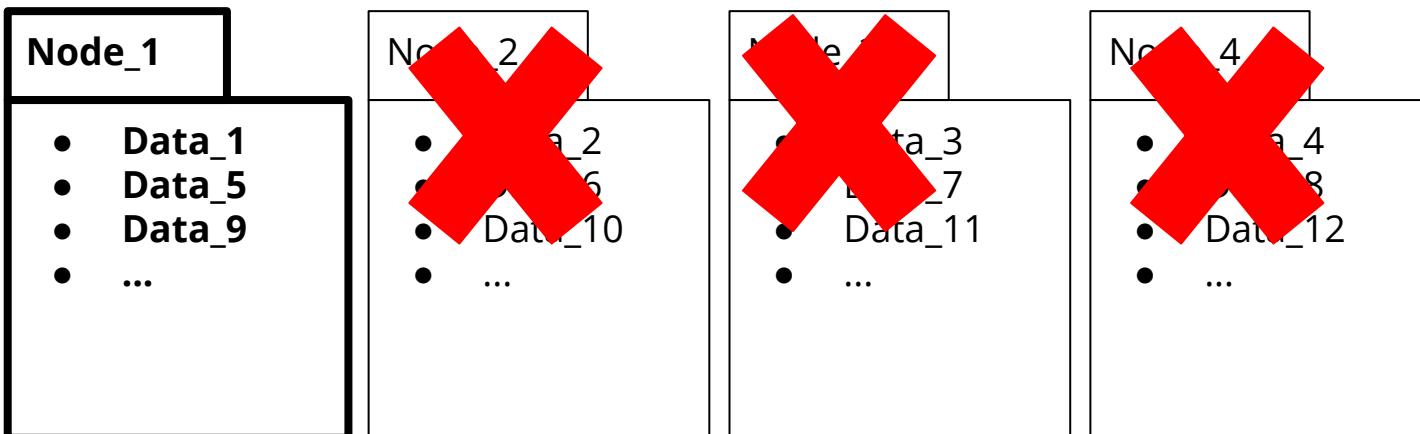
- Main concept: Data is distributed among the nodes of the cluster for both its storage and processing.



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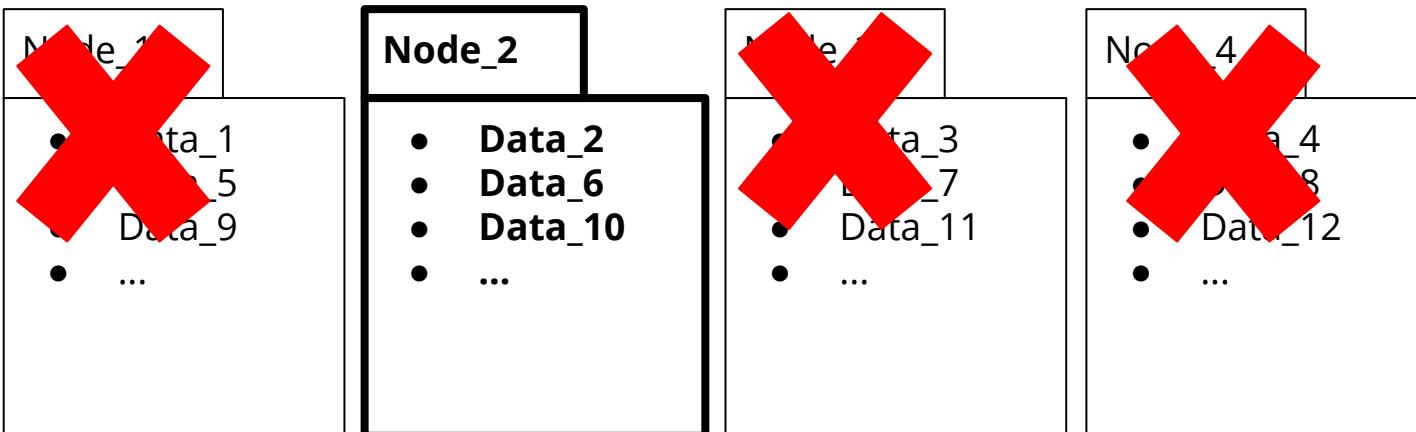
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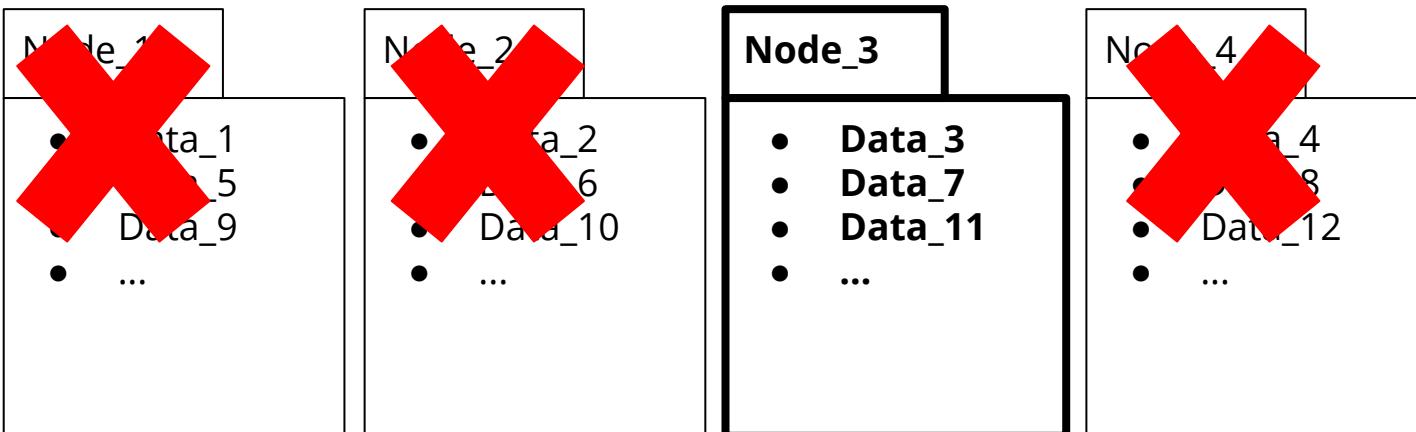
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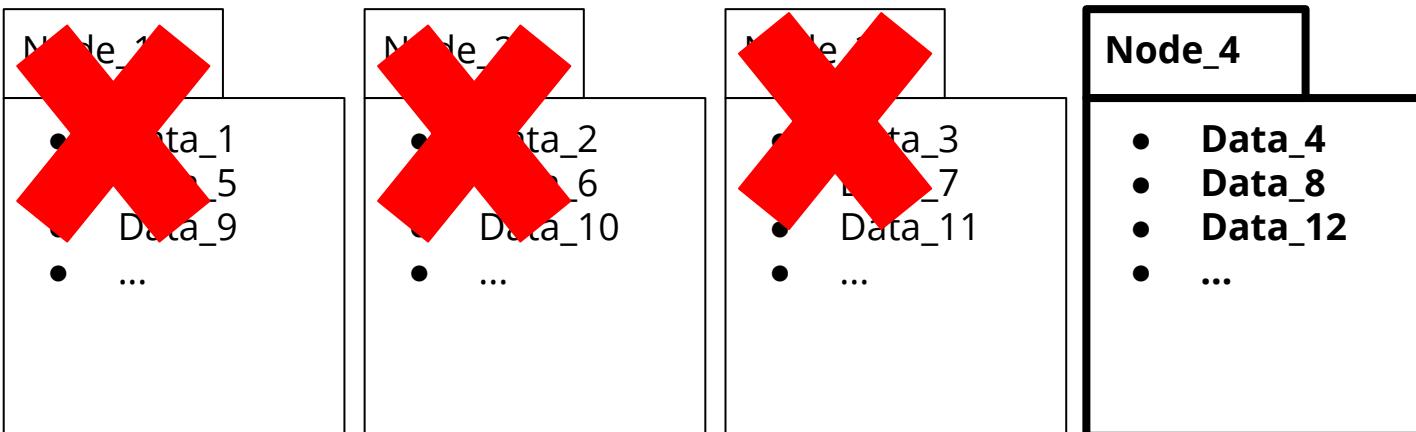
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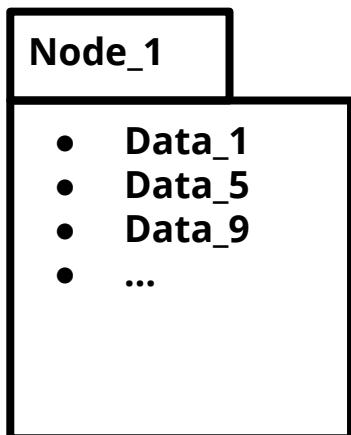
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MongoDB Intro

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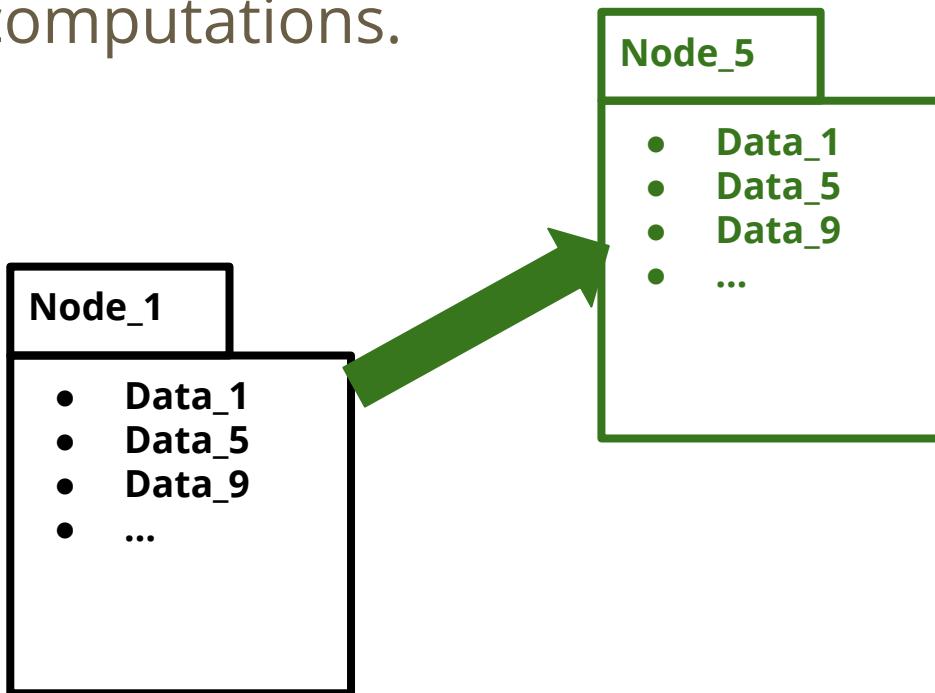
- Data is replicated among different nodes of the cluster for redundancy, availability and fault tolerant-free computations.



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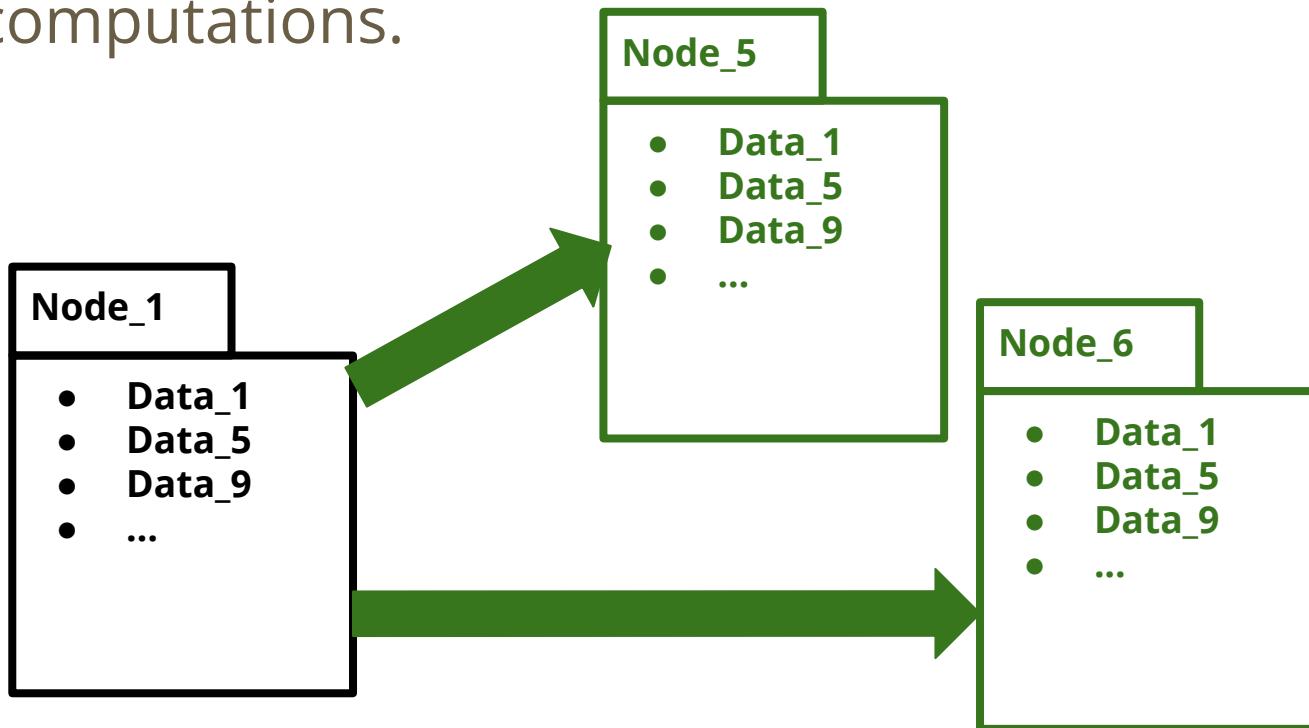
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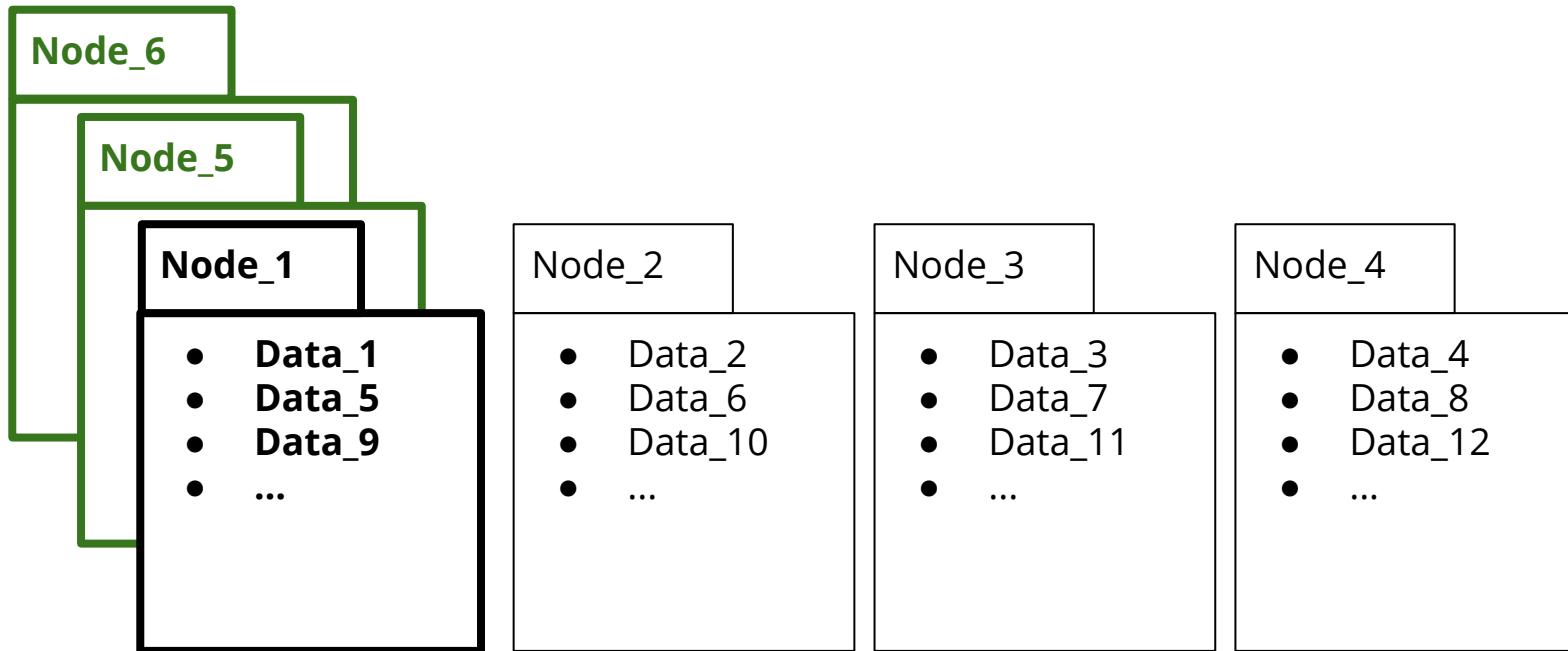
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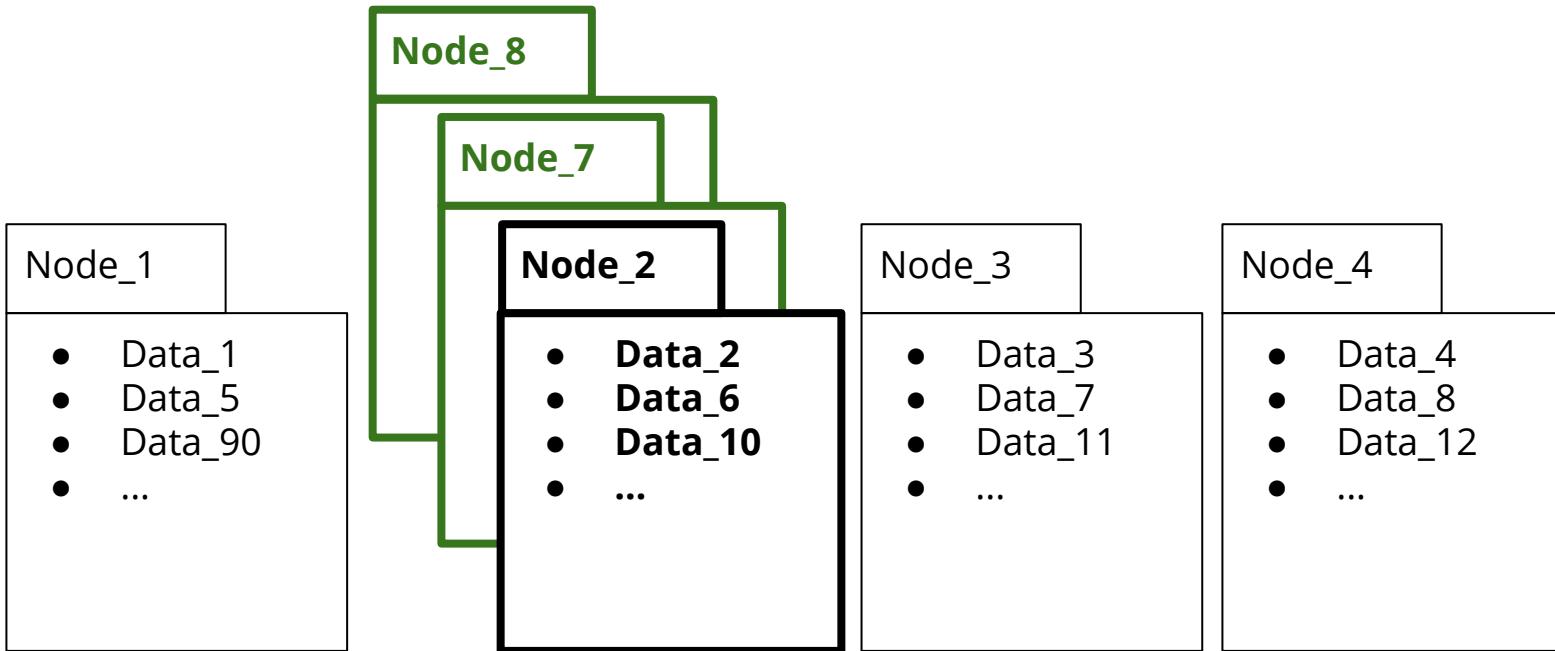
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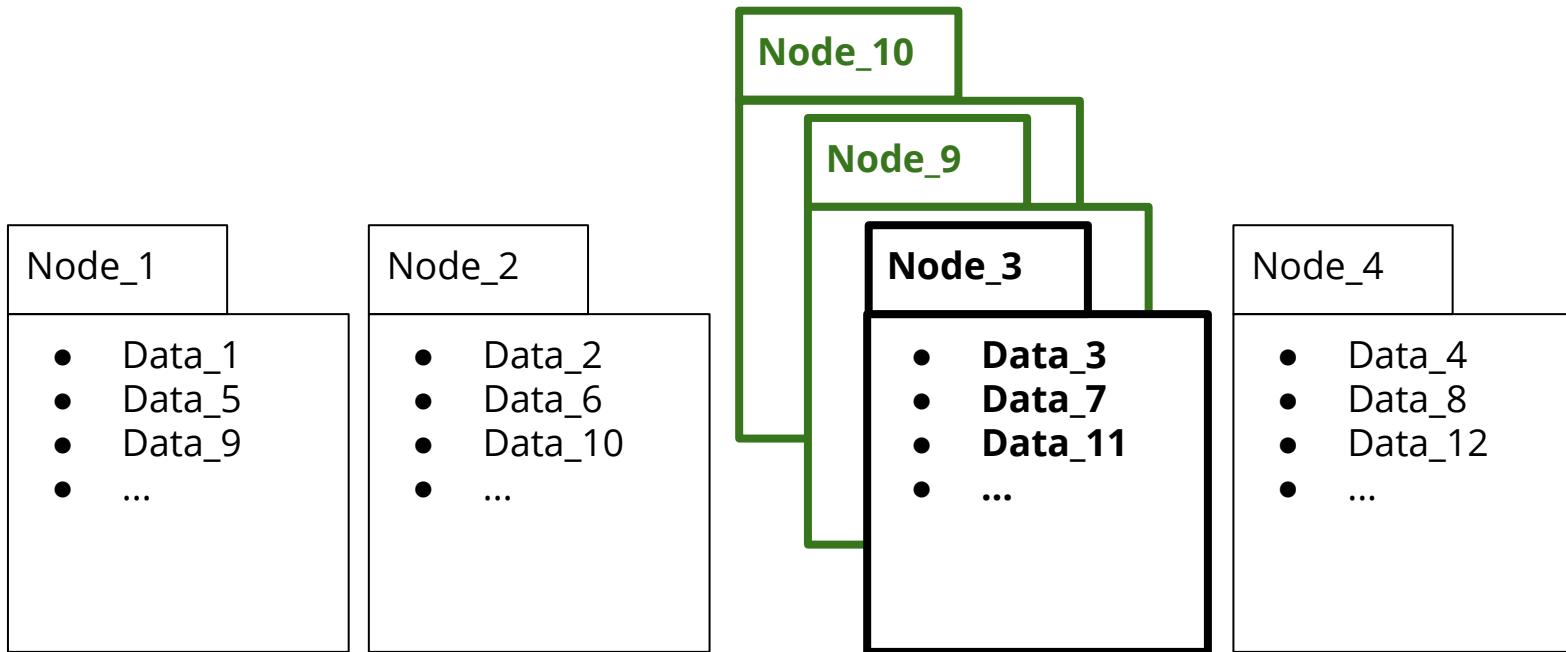
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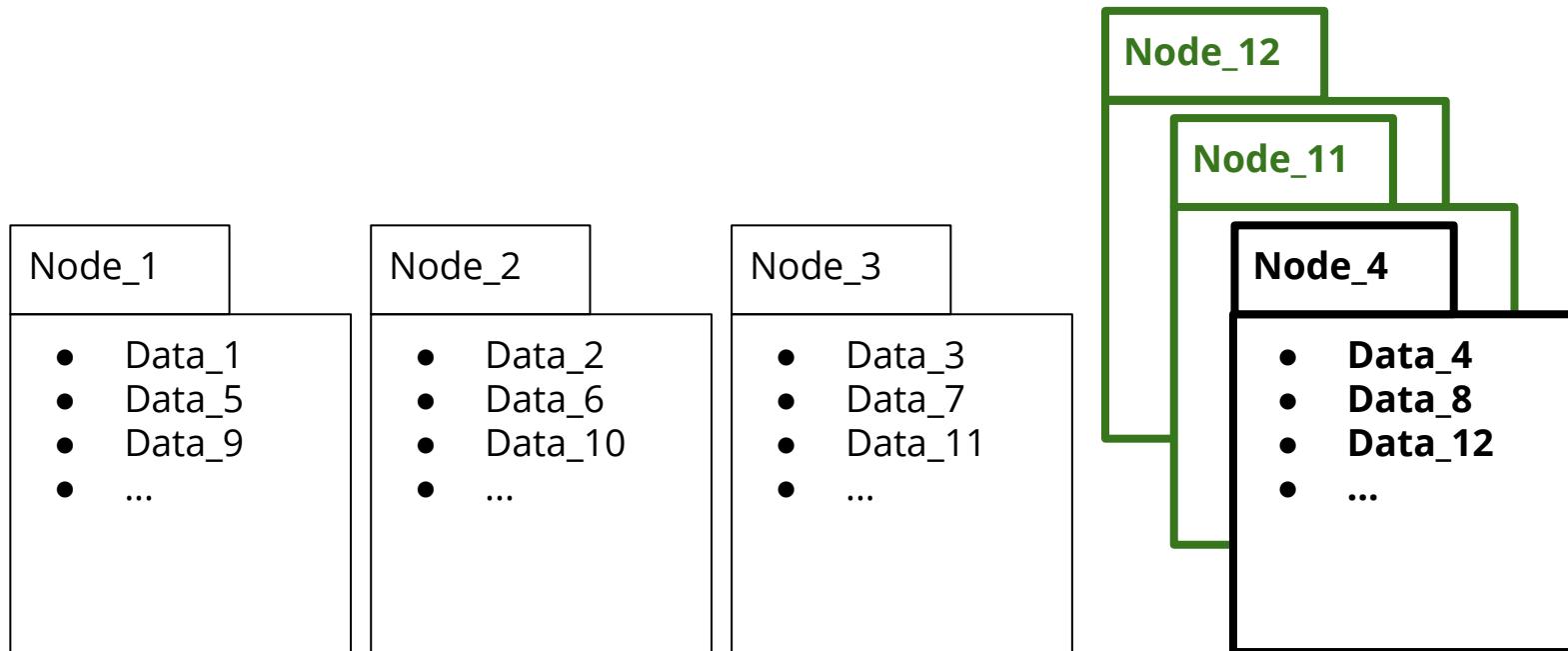
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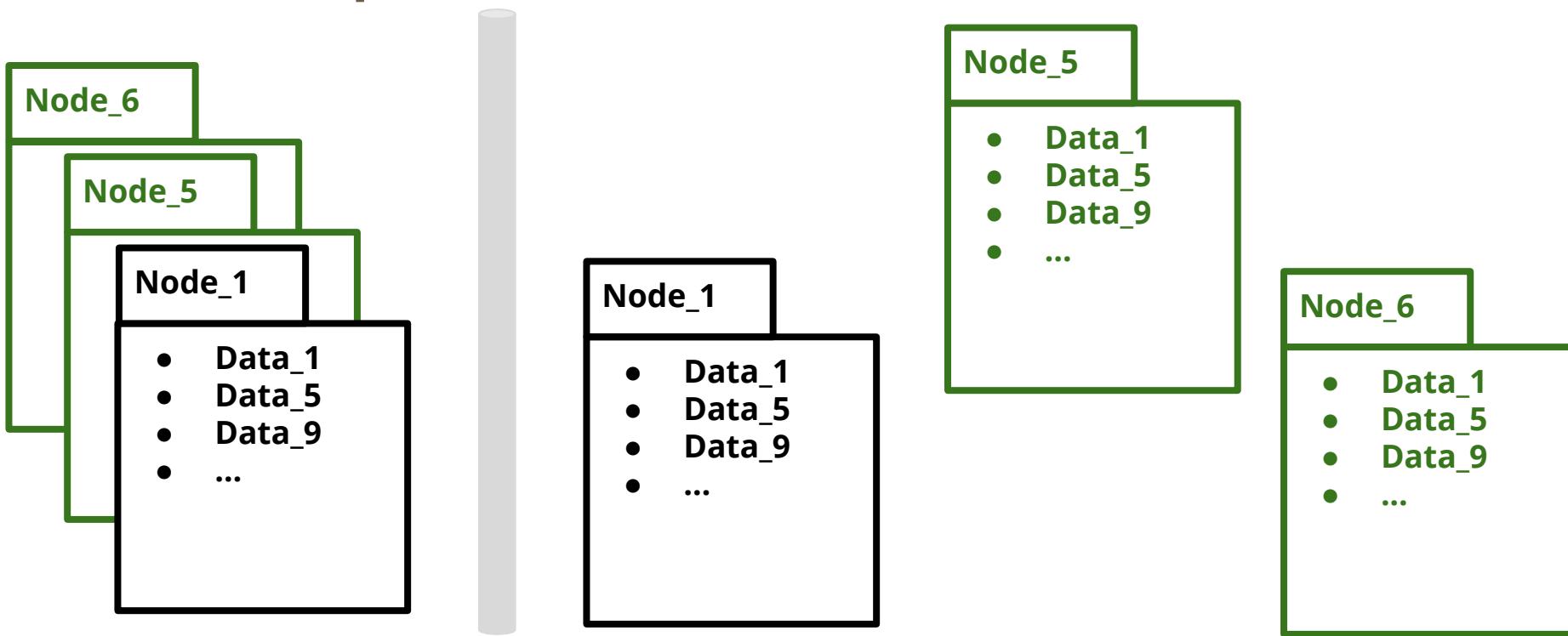
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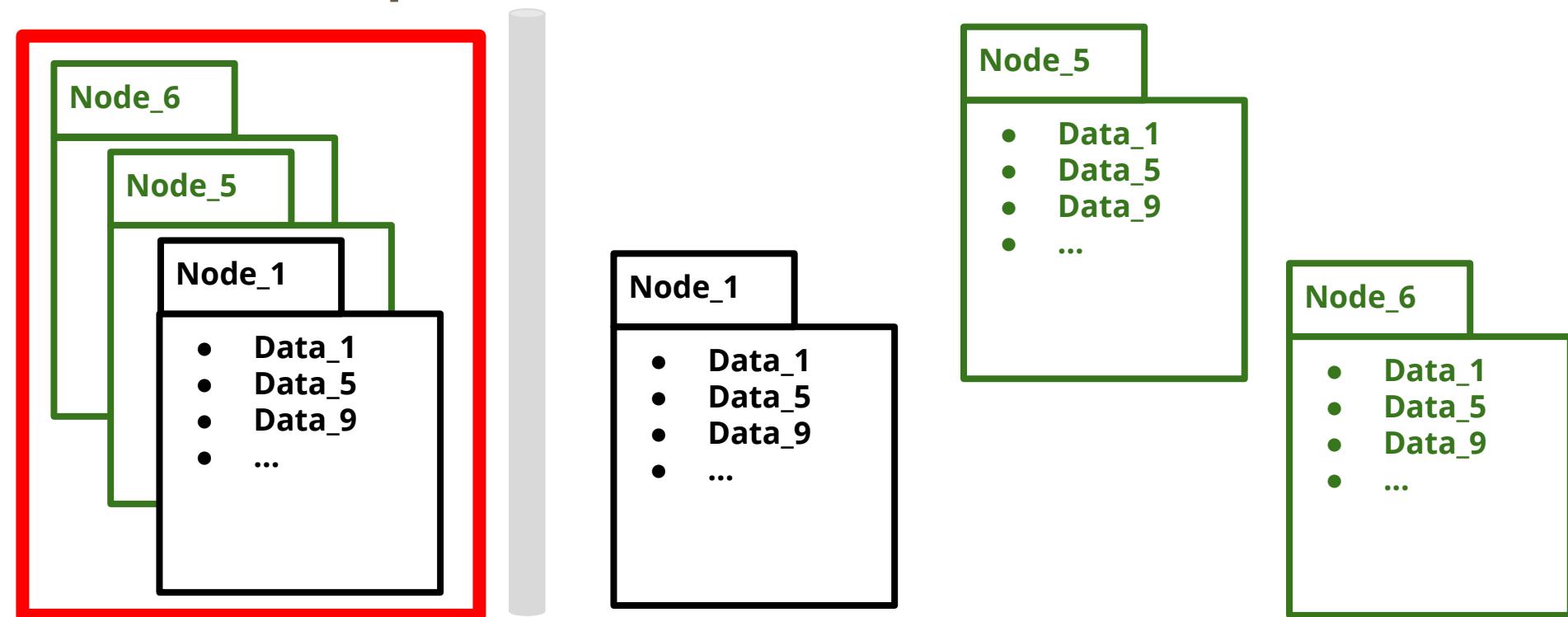
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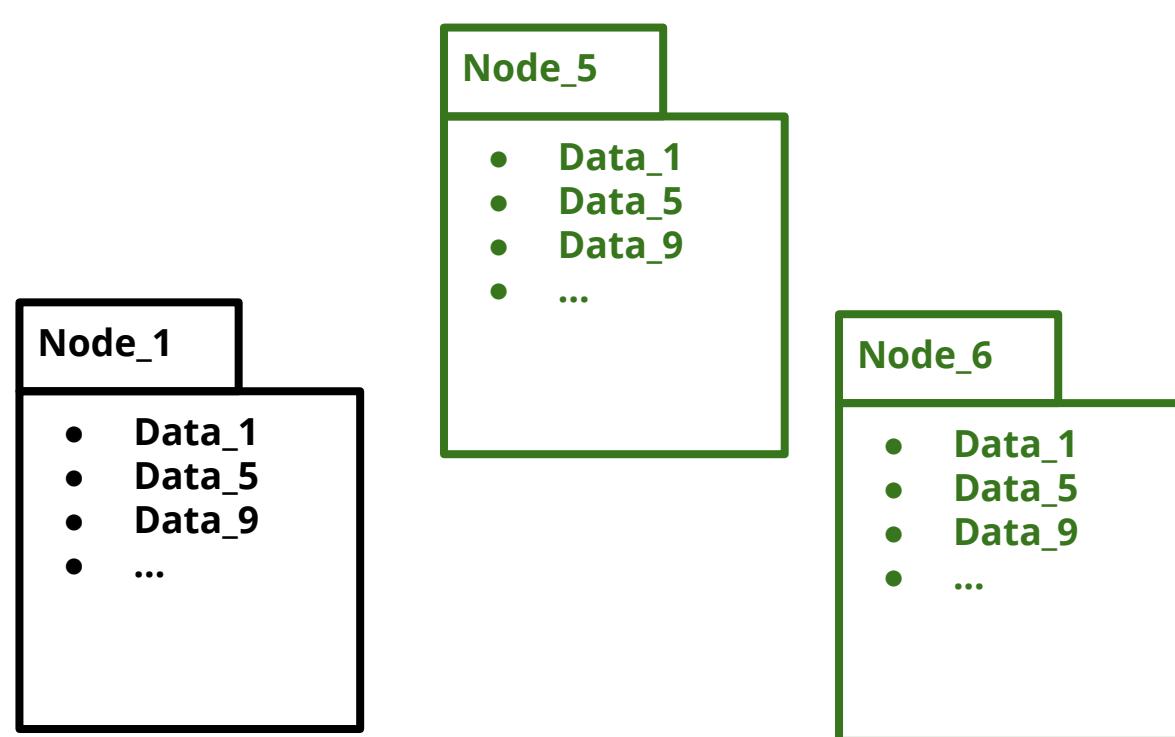


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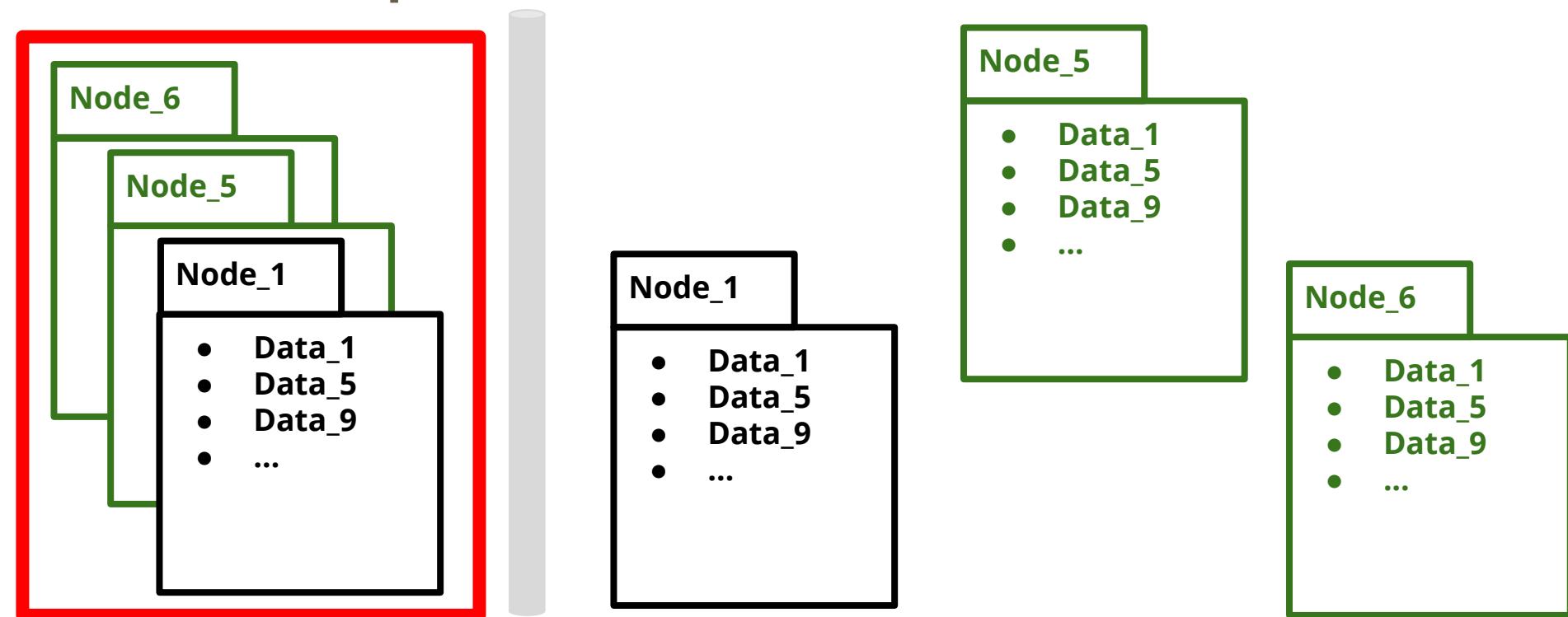
REPLICA SET



MongoDB Intro

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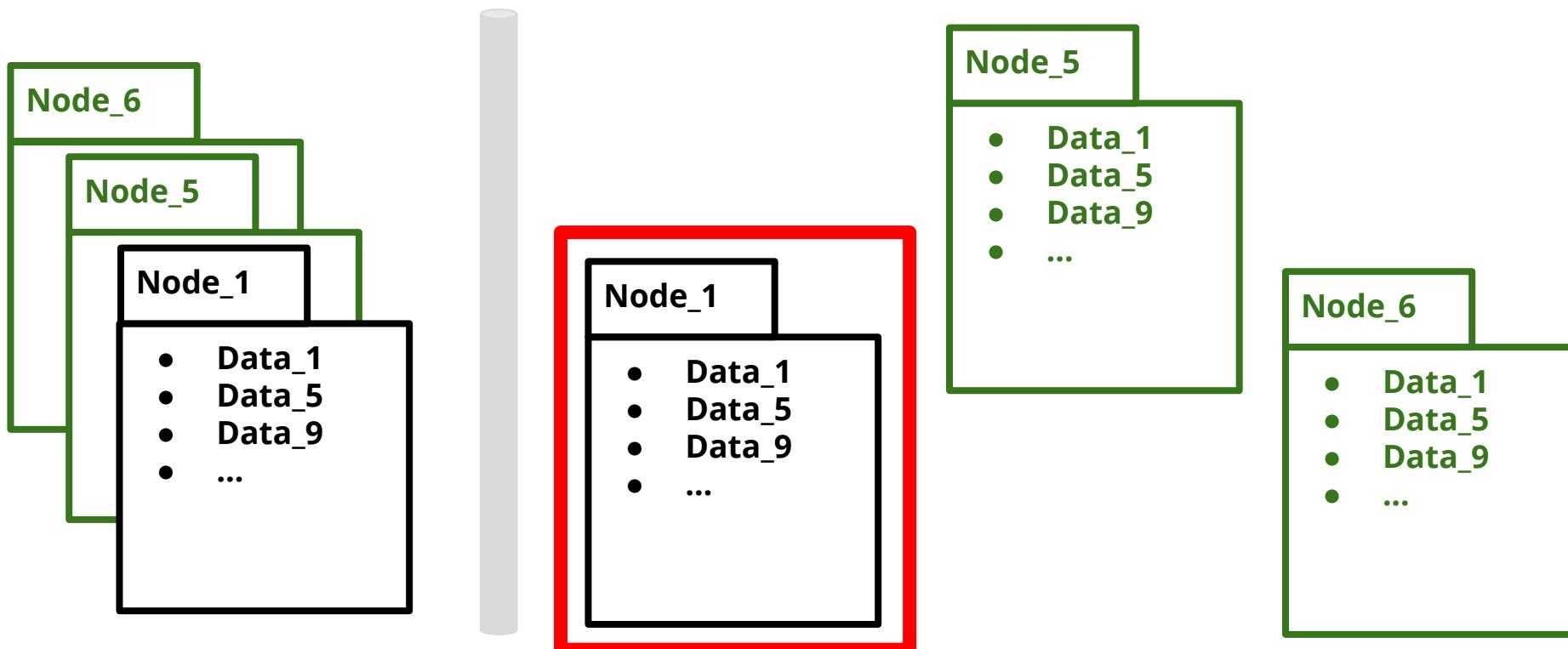
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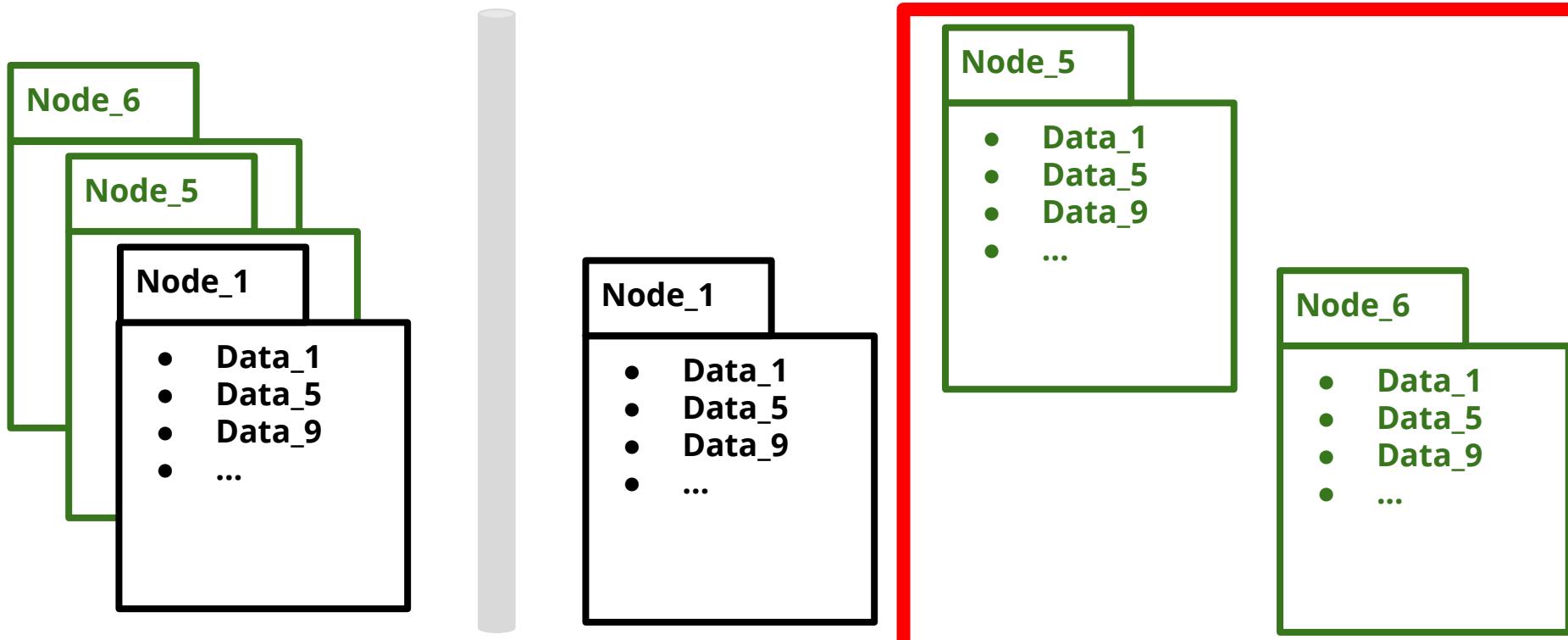
- 1 node of the replica set is the **primary node**.
Data is written to it / read from it.



MongoDB Intro

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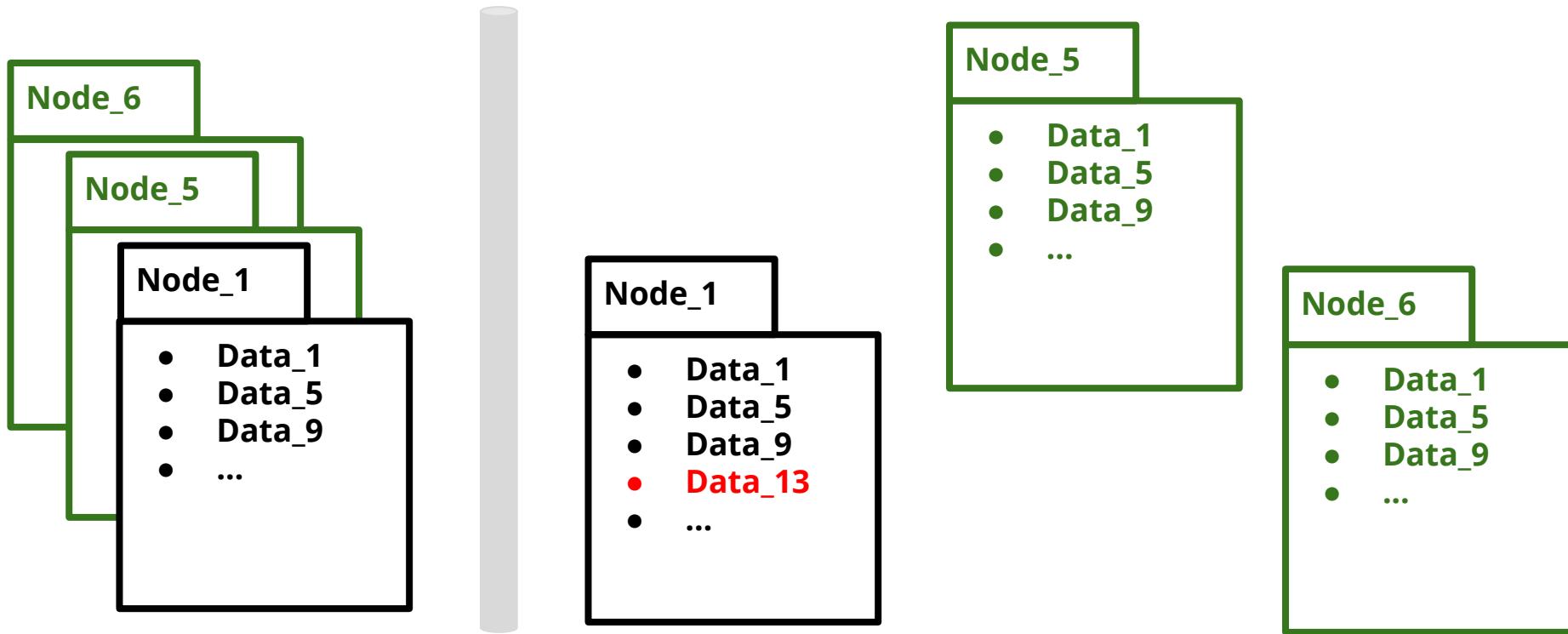
- All other nodes of the replica set are **secondary nodes**.



MongoDB Intro

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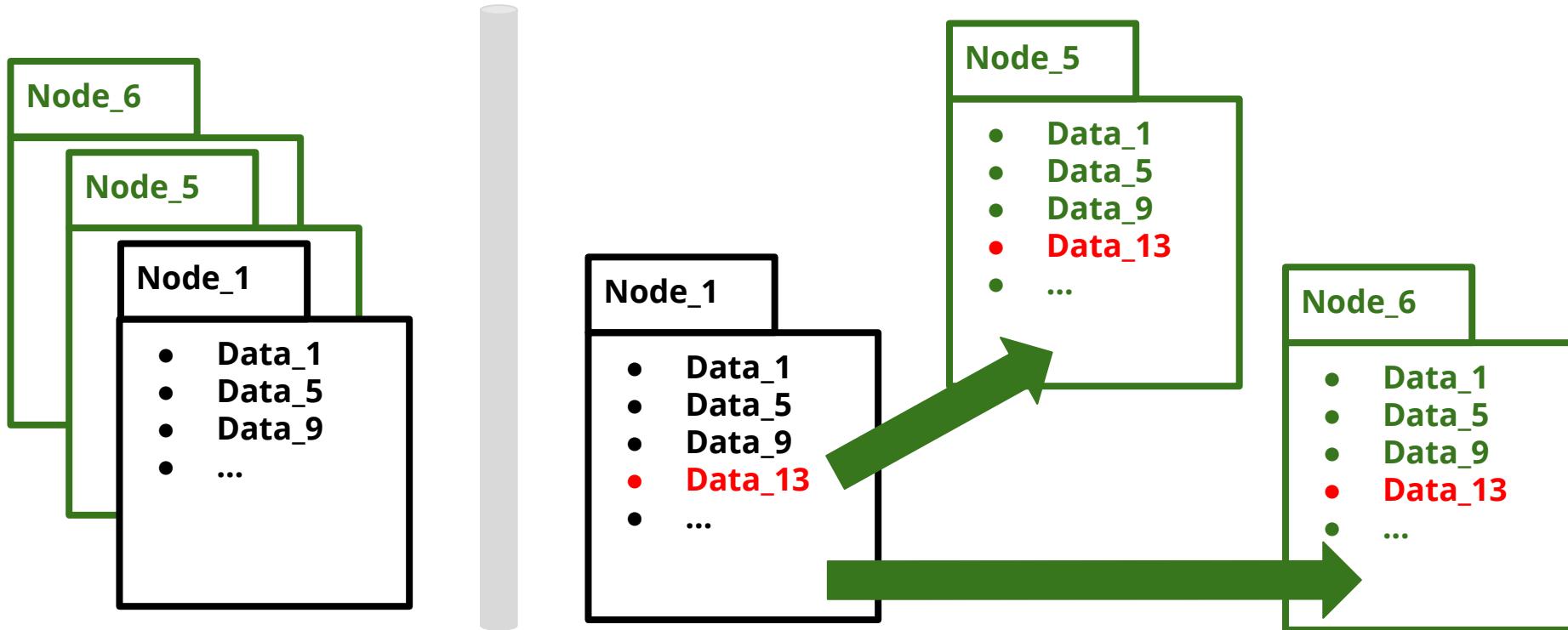
- When new data is written to the primary node...



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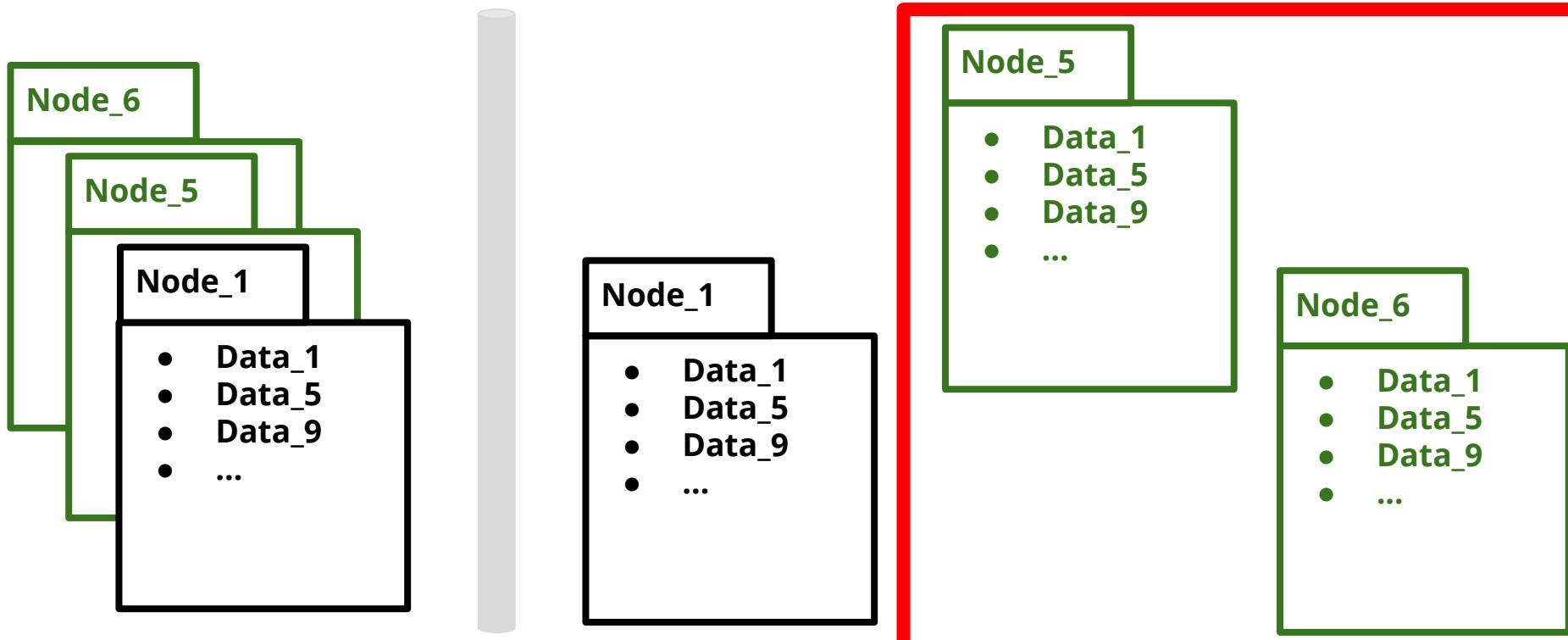
- When new data is written to the primary node...it is automatically synchronised to the secondary nodes.



MongoDB Intro

Fault Tolerant System.

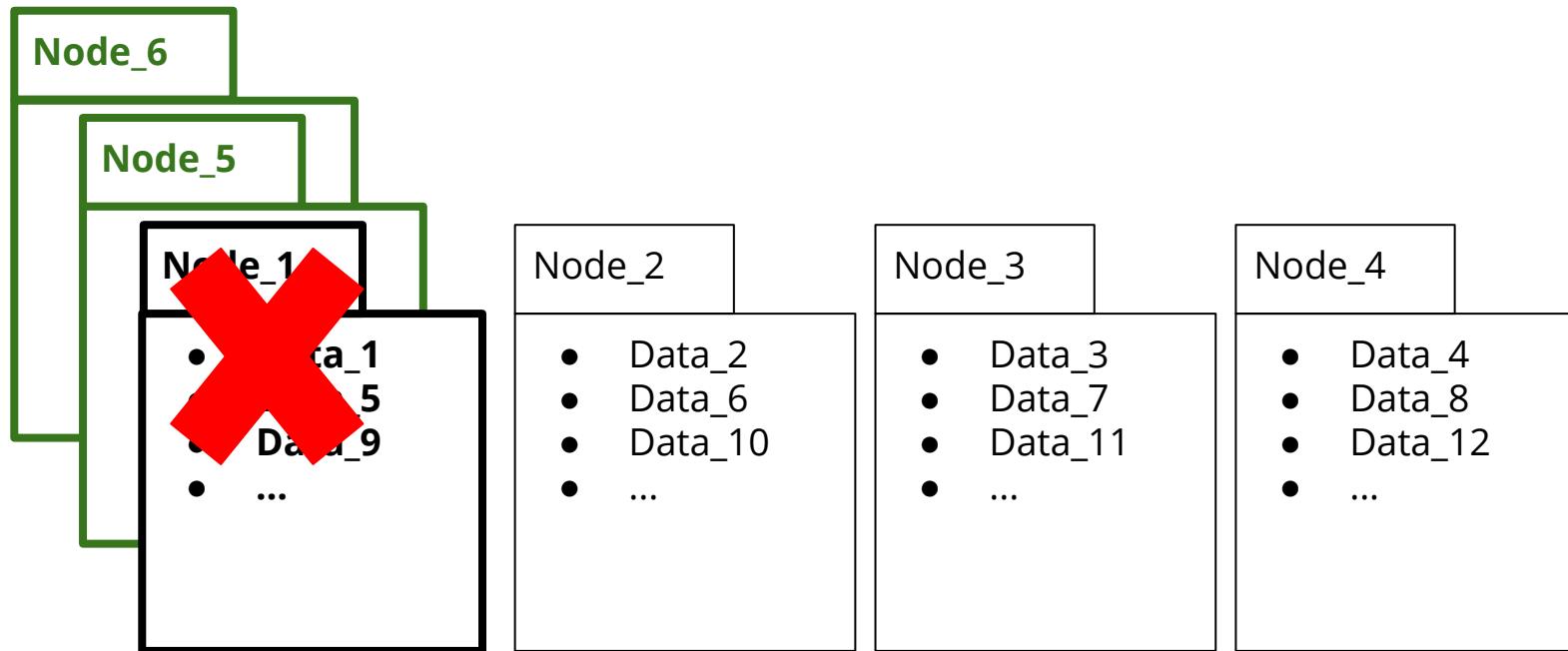
- **Secondary nodes** serve fault tolerant purposes.



MongoDB Intro

Fault Tolerant System.

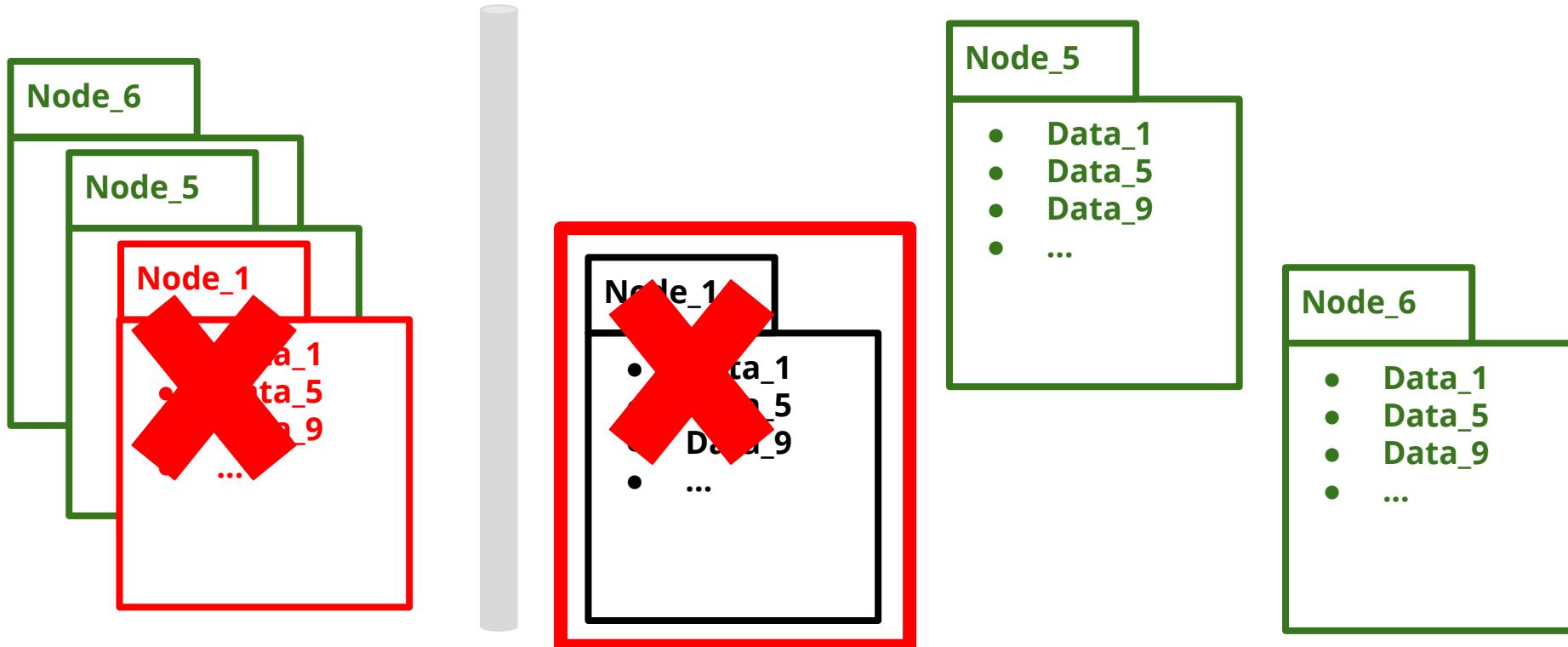
- If the primary node of a replica set unexpectedly shuts down...



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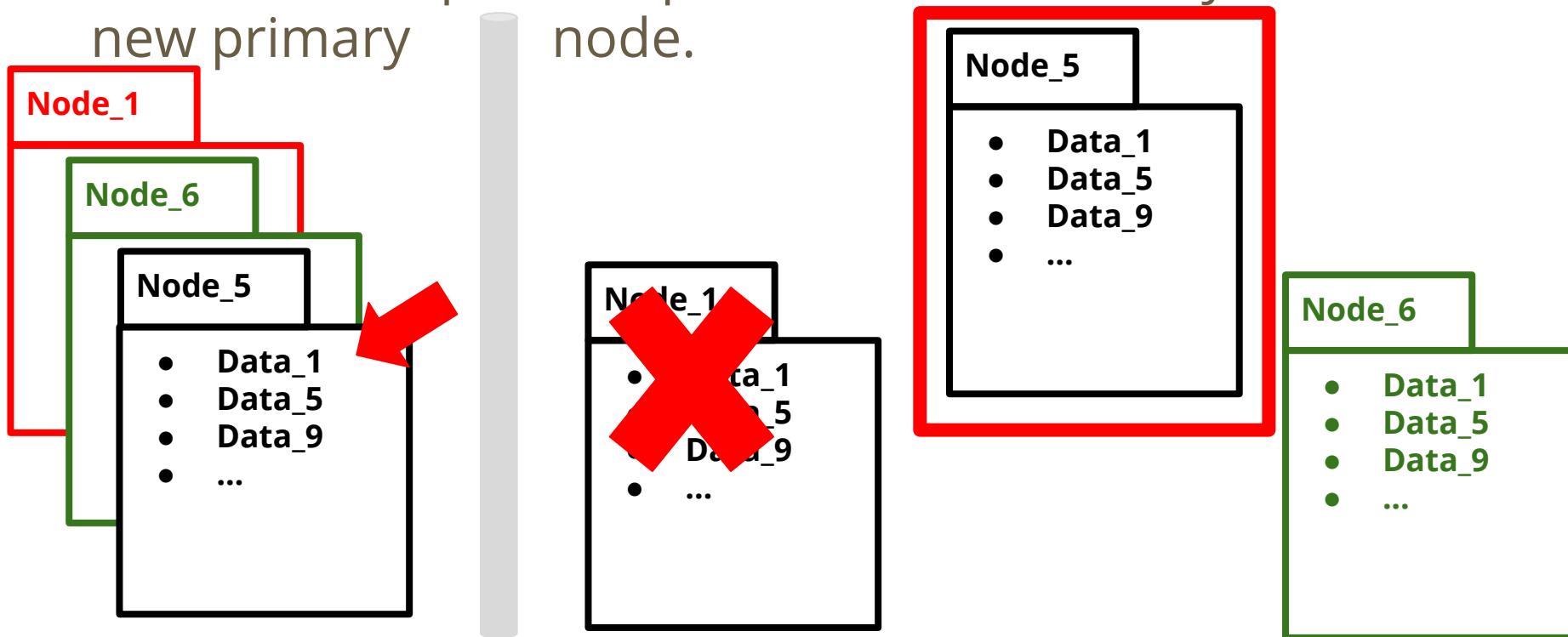
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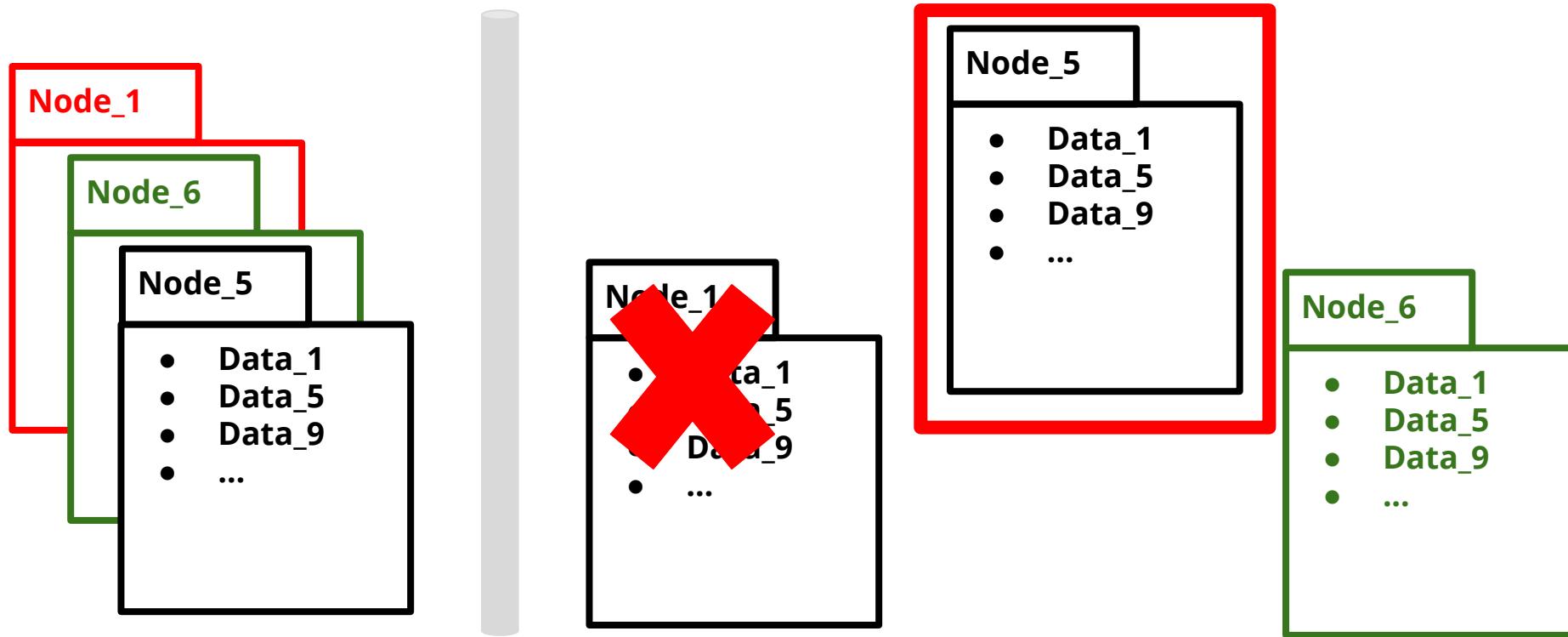
- If the primary node of a replica set unexpectedly shuts down... the replica set promotes a secondary node as new primary



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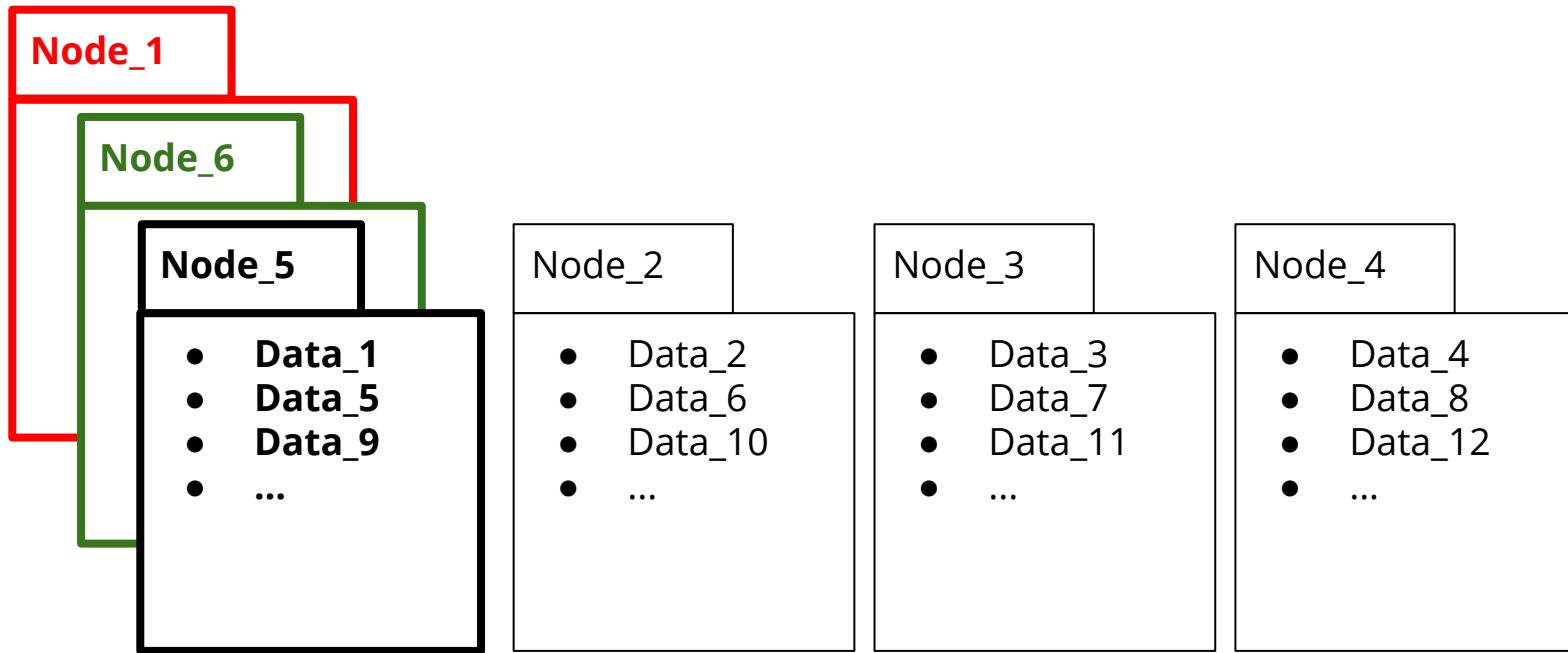
- This allows the system to continue working.



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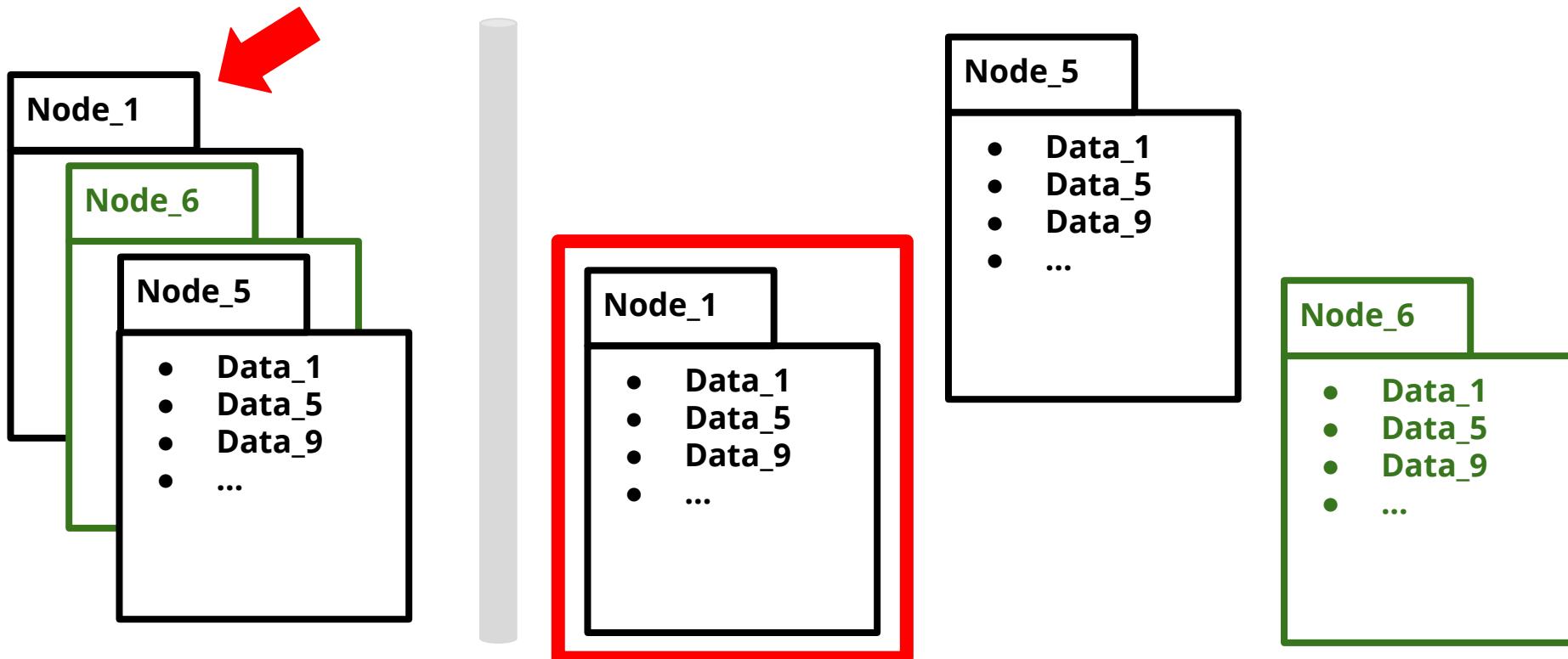
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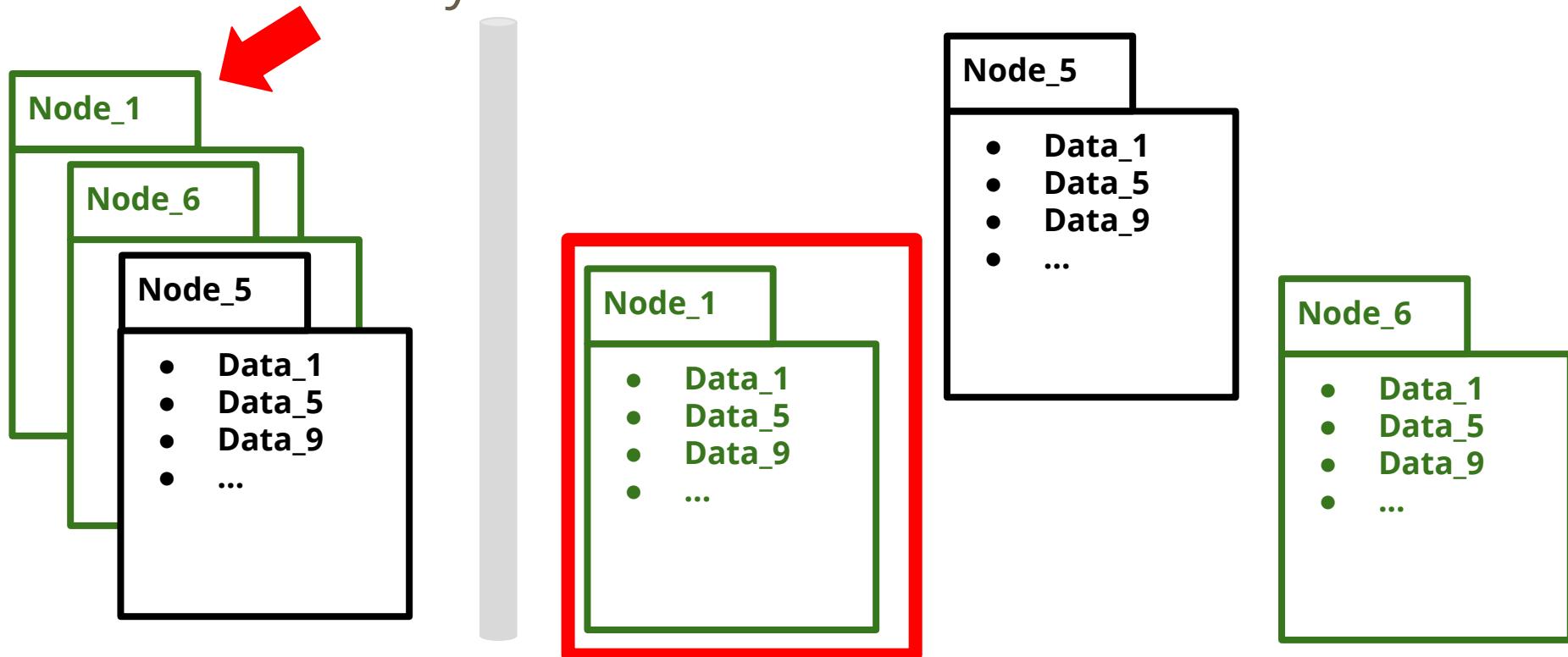
- Once the node recovers...



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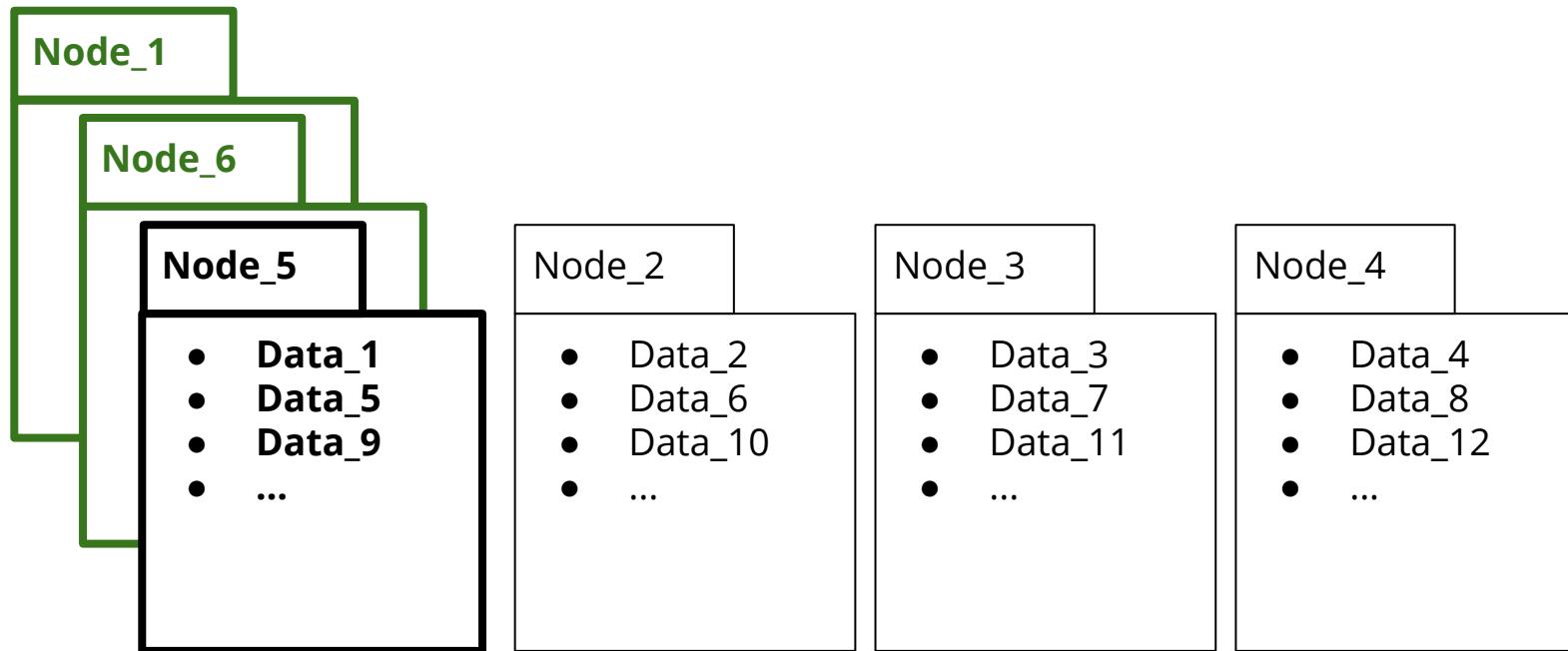
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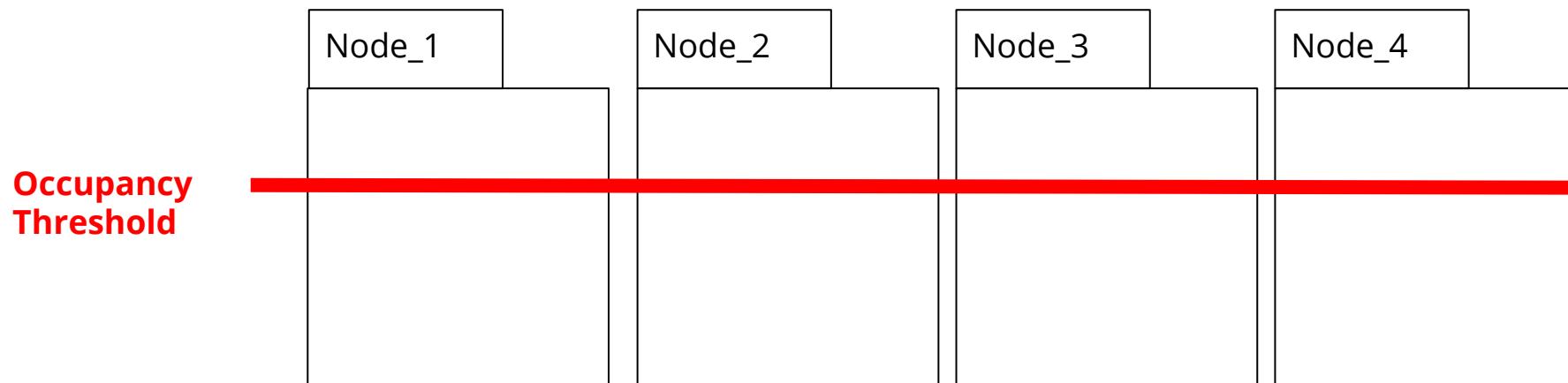
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 - Policy Example: When all nodes have an occupancy above a certain threshold.



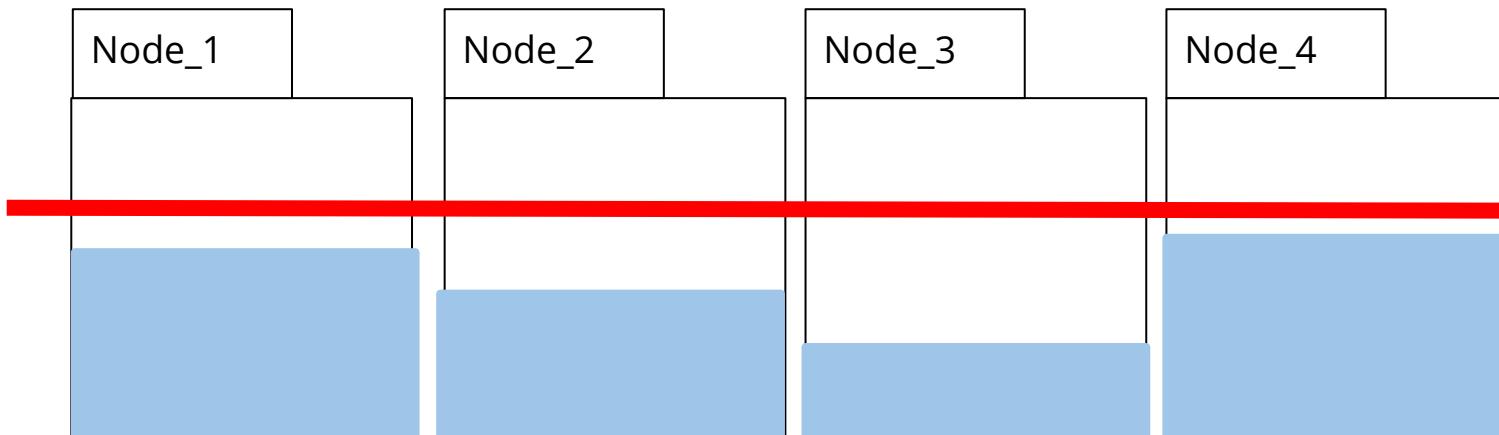
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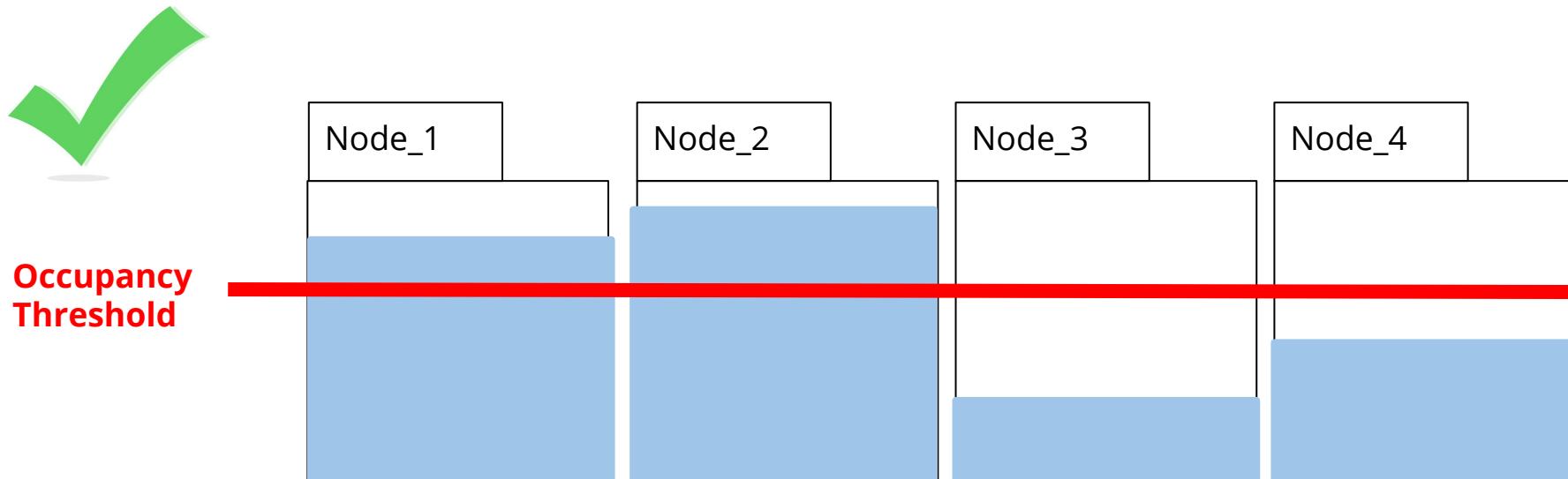
Occupancy Threshold



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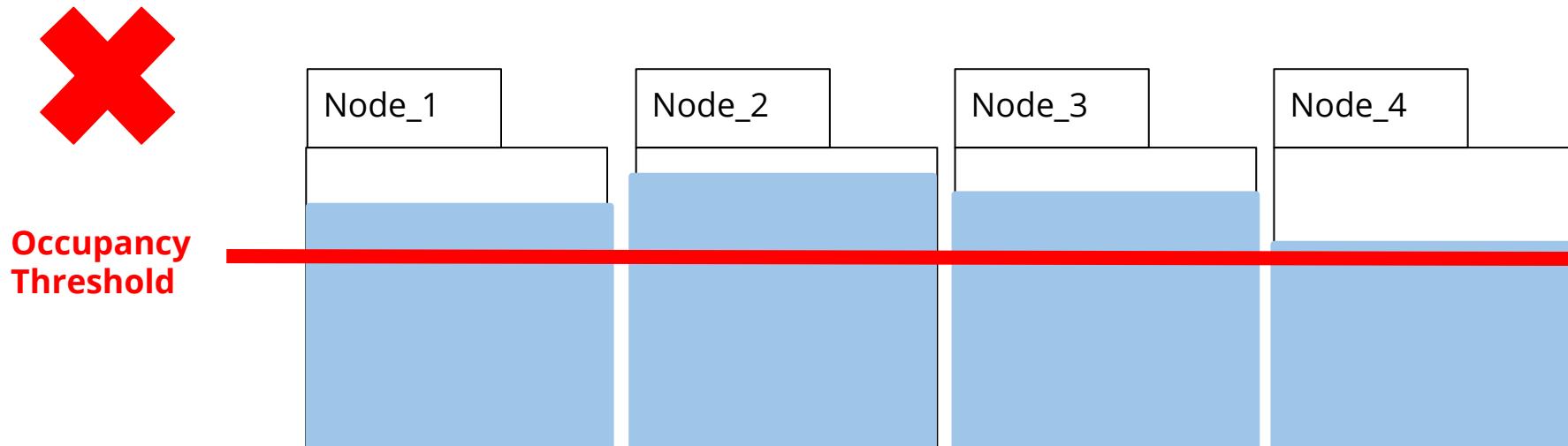
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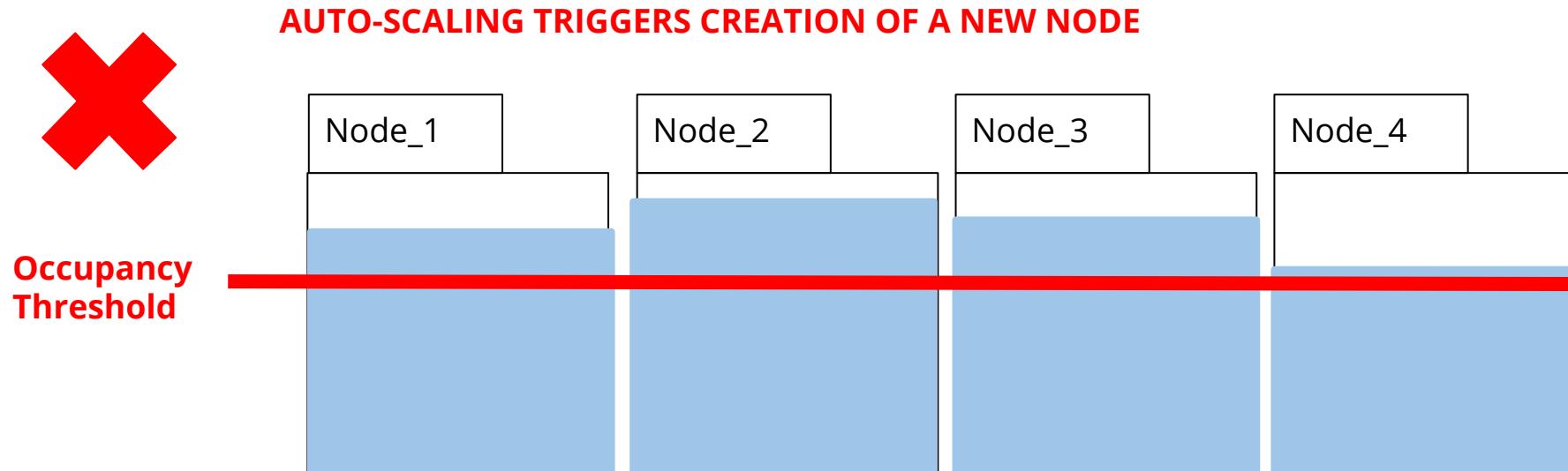
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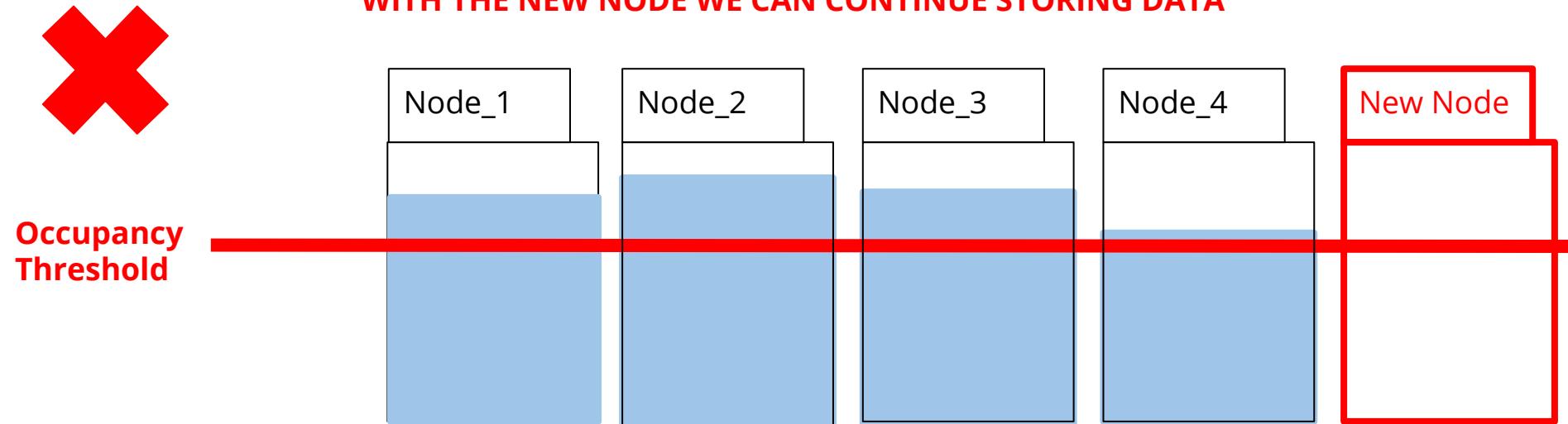


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WITH THE NEW NODE WE CAN CONTINUE STORING DATA



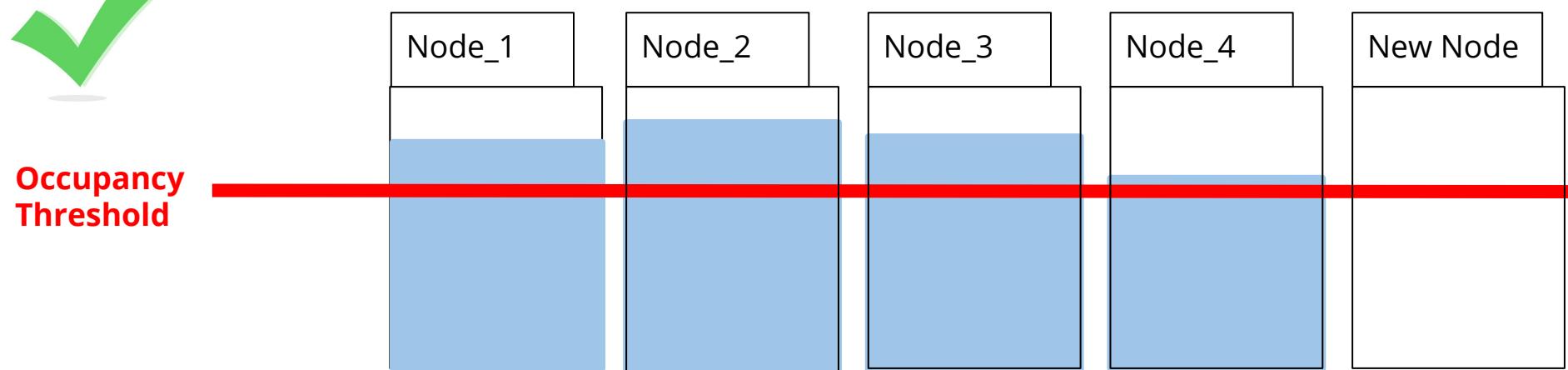
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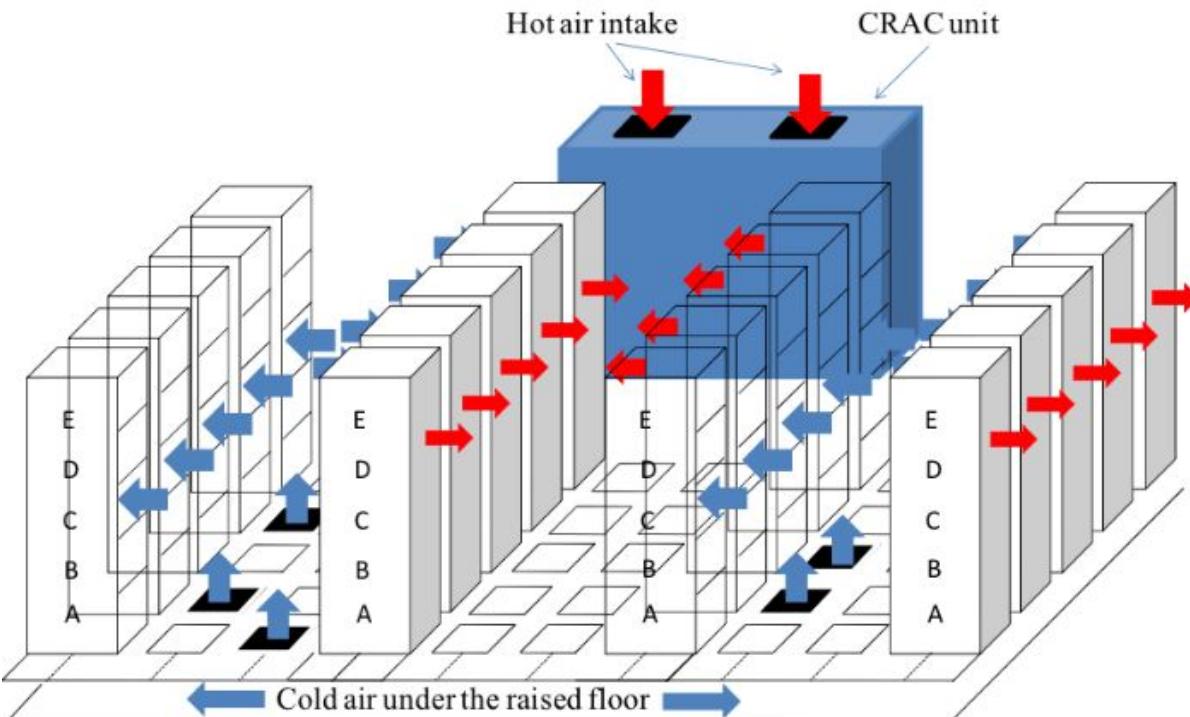


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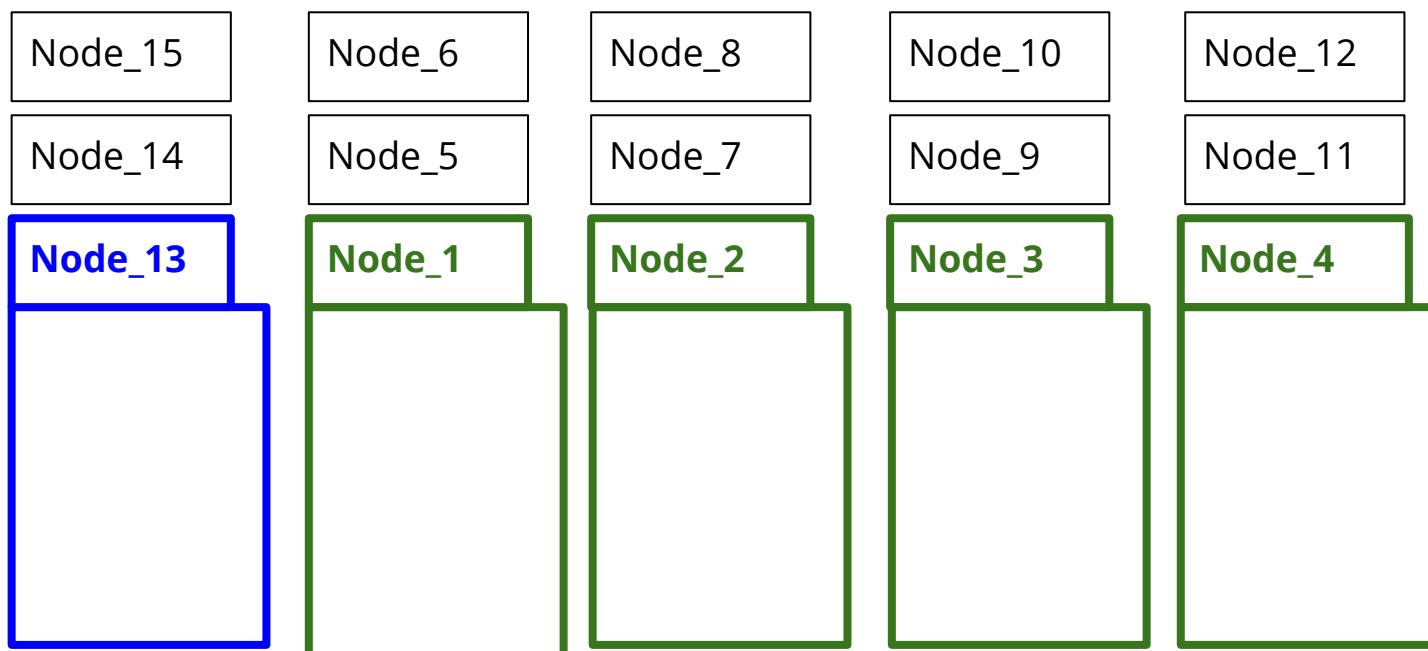
Cluster and Data Organisation

A MongoDB cluster consists on $n \geq 1$ nodes, that we can assume placed in a single data centre.



Cluster and Data Organisation

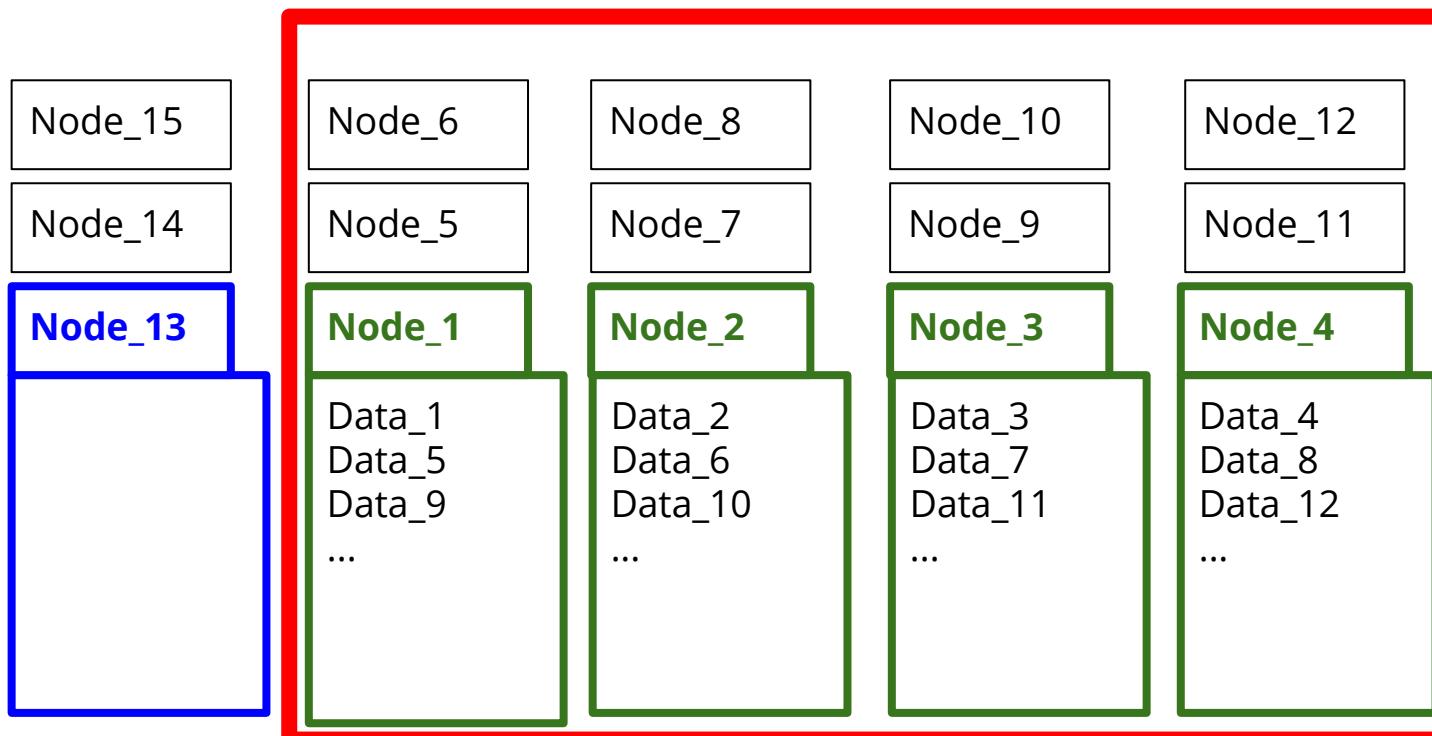
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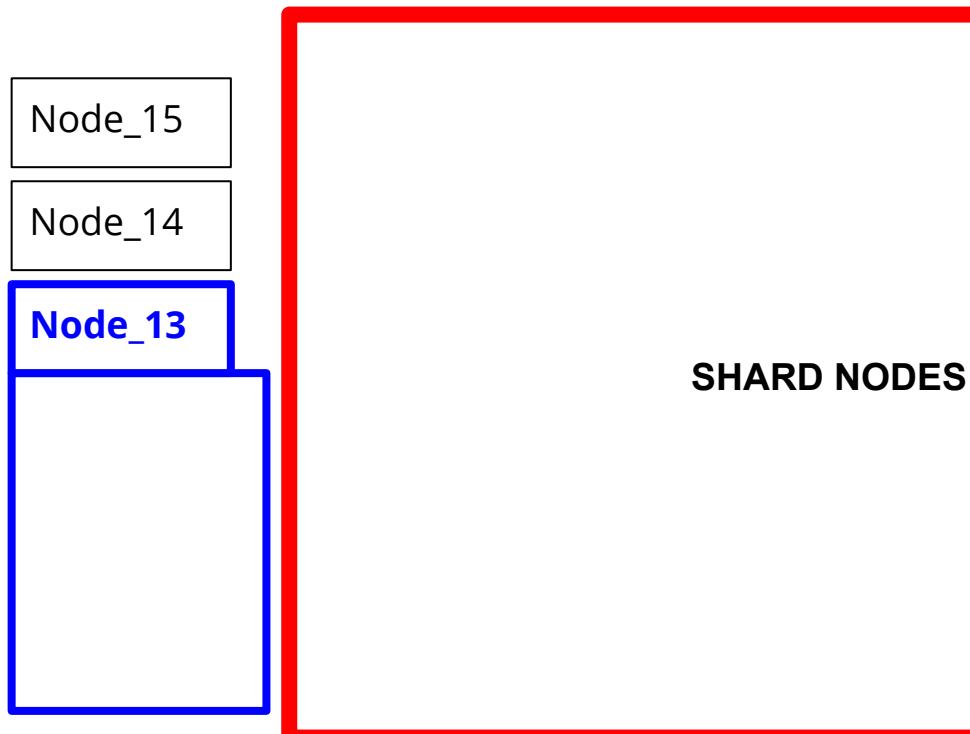
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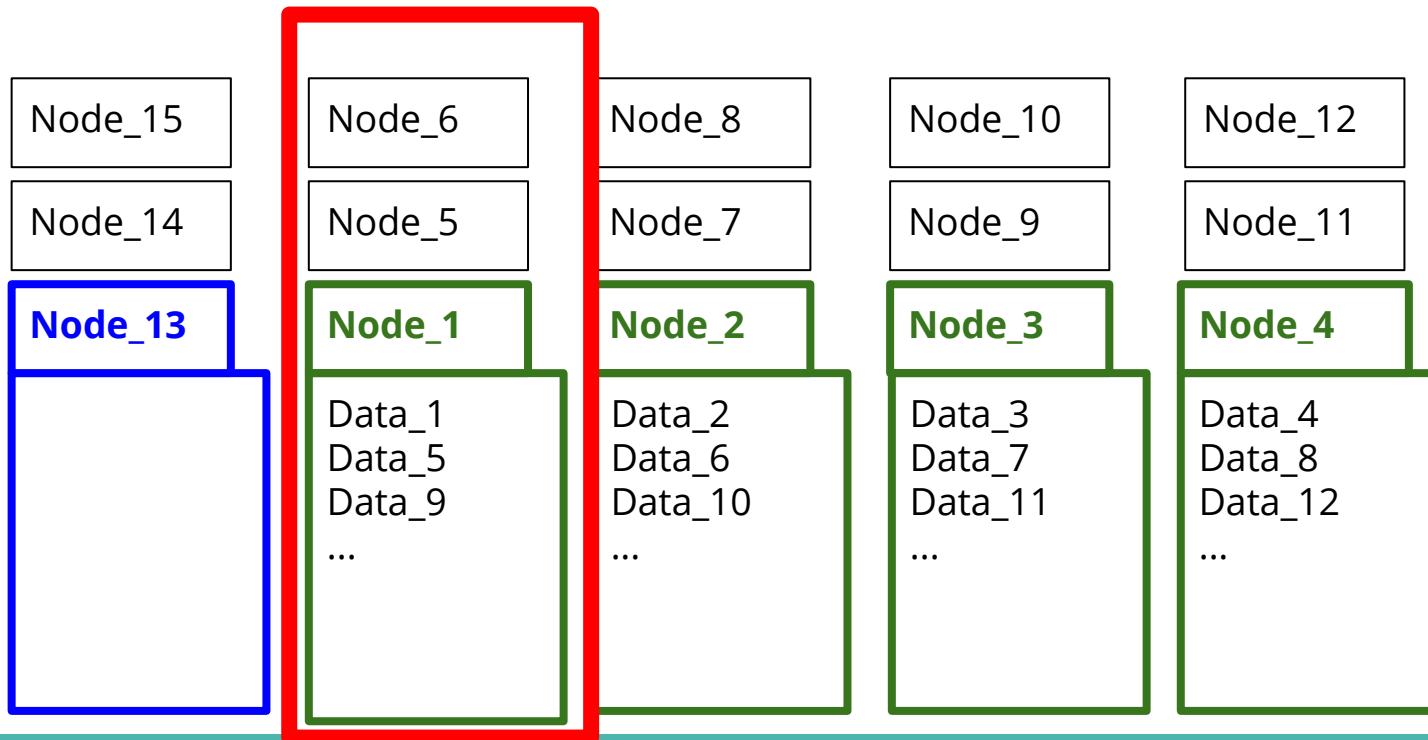
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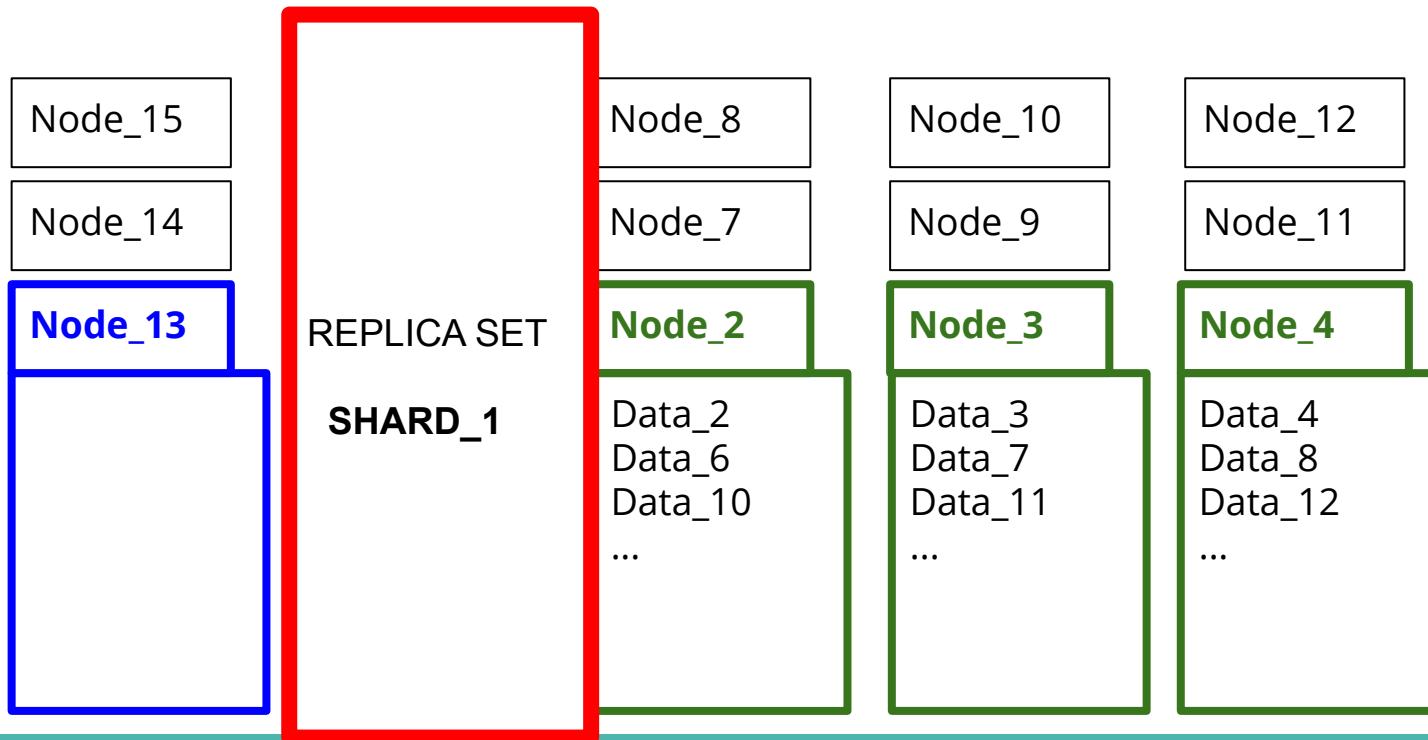
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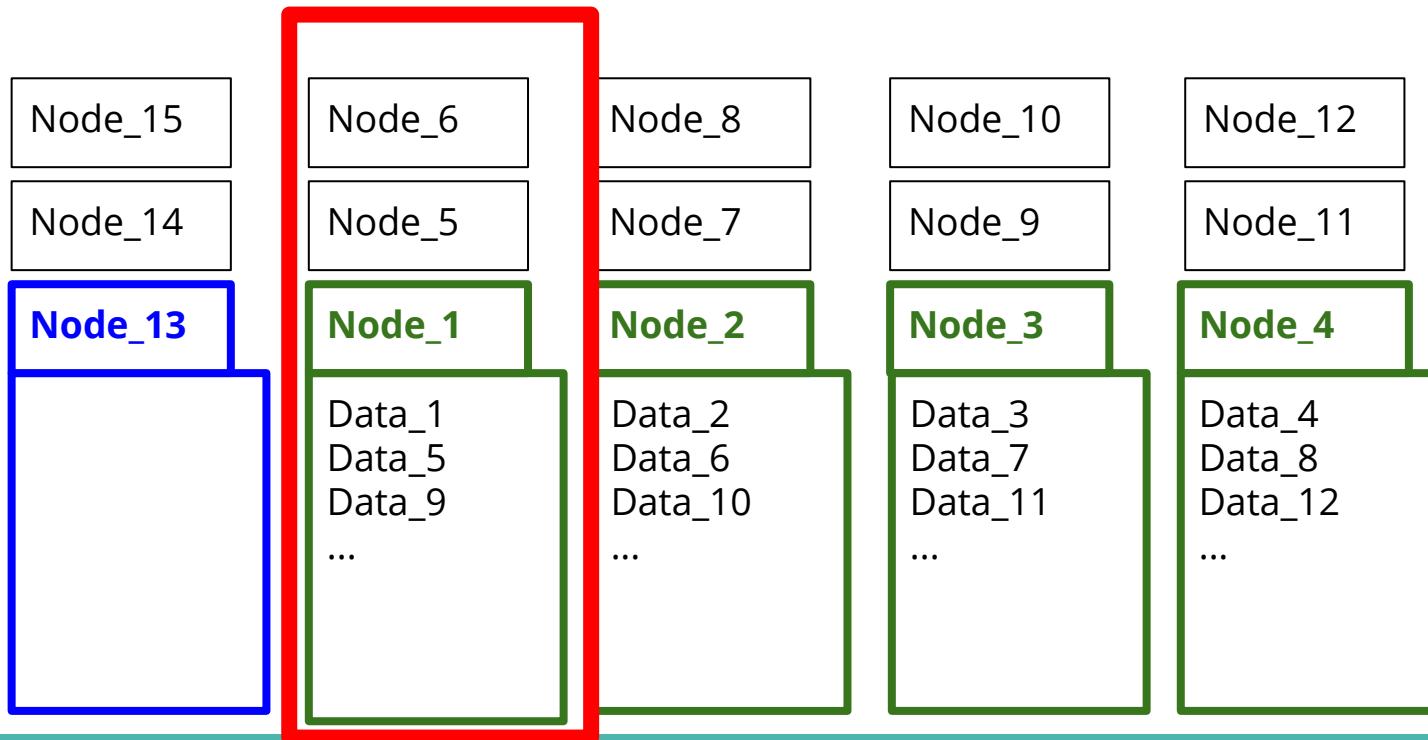
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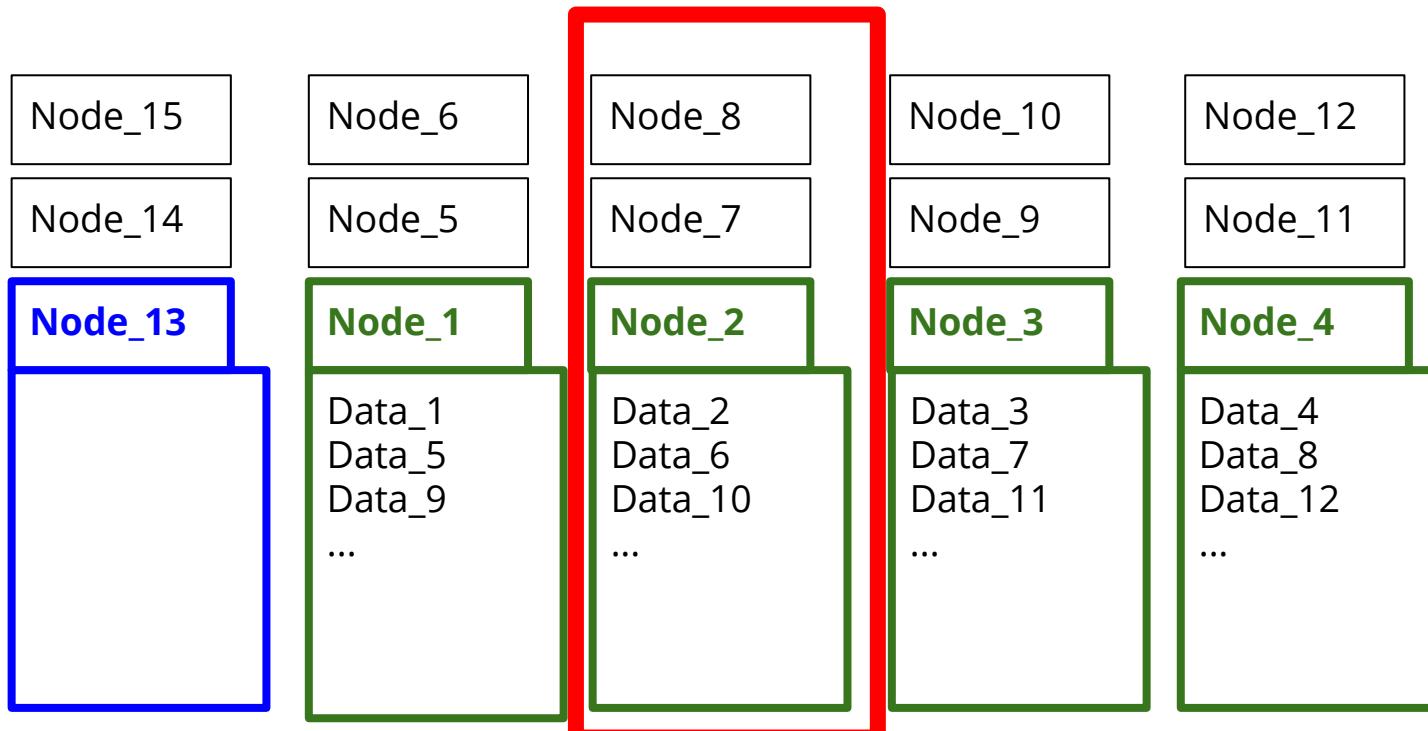
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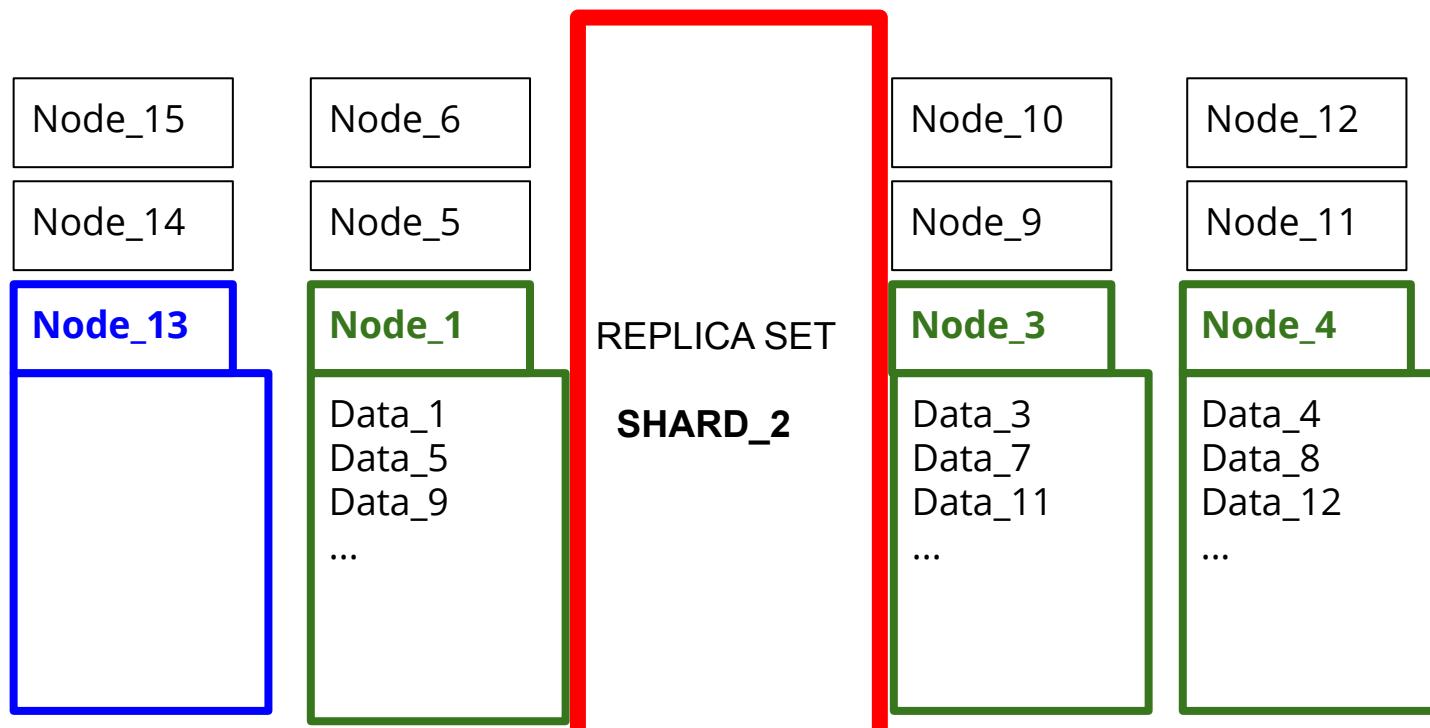
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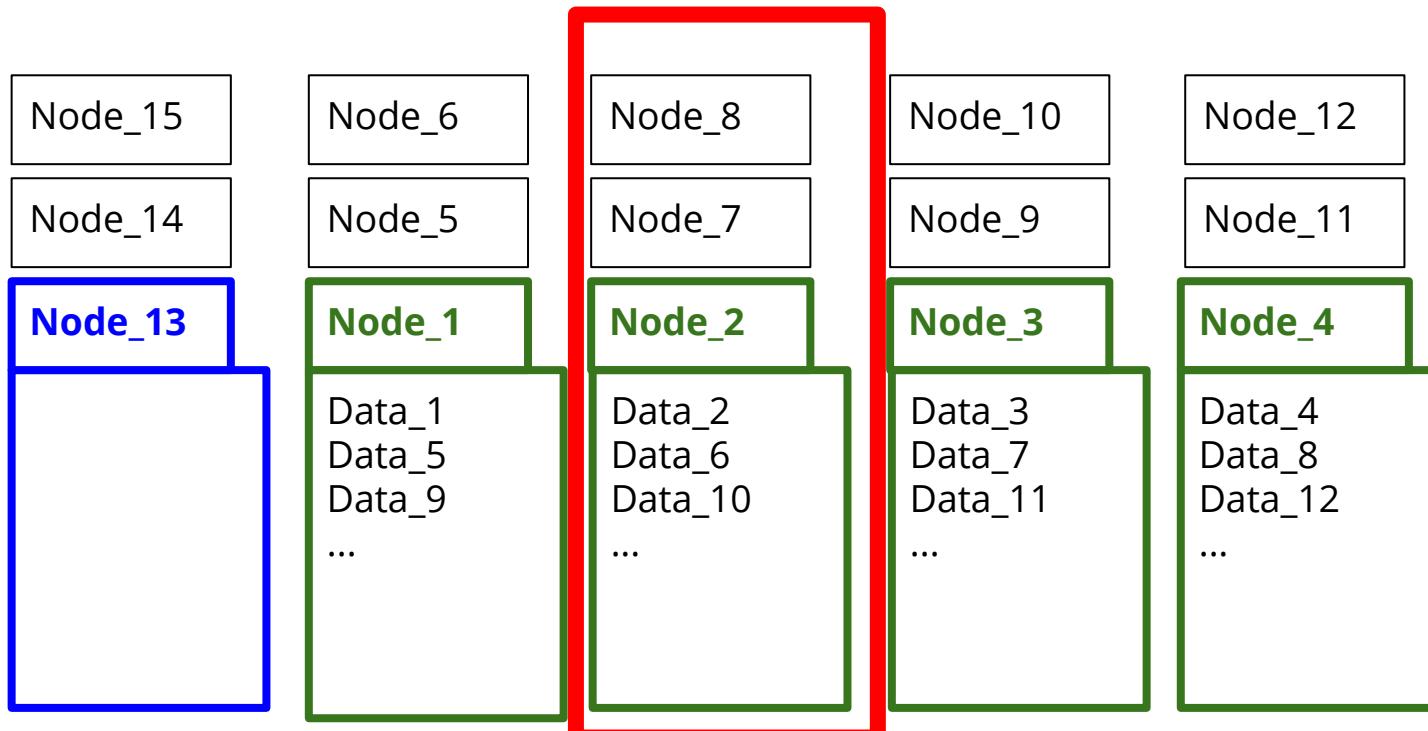
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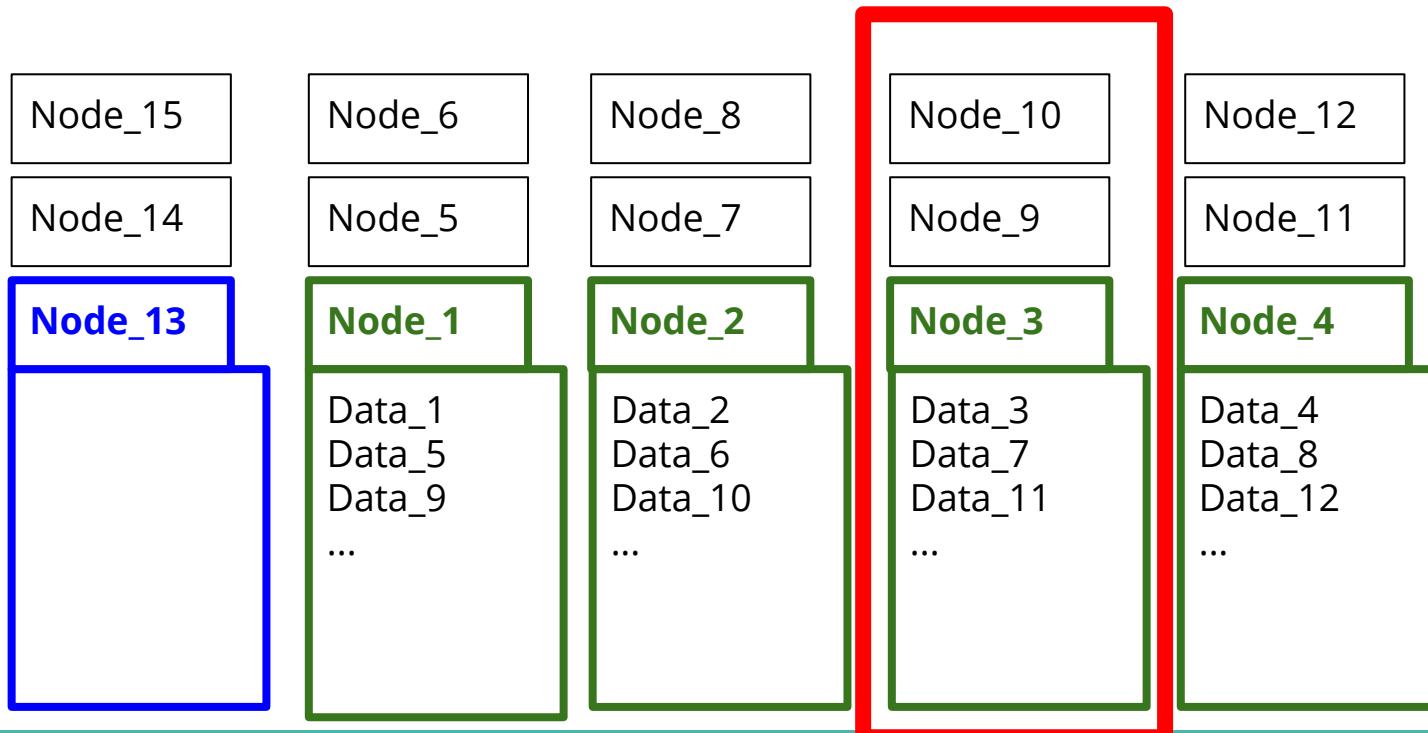
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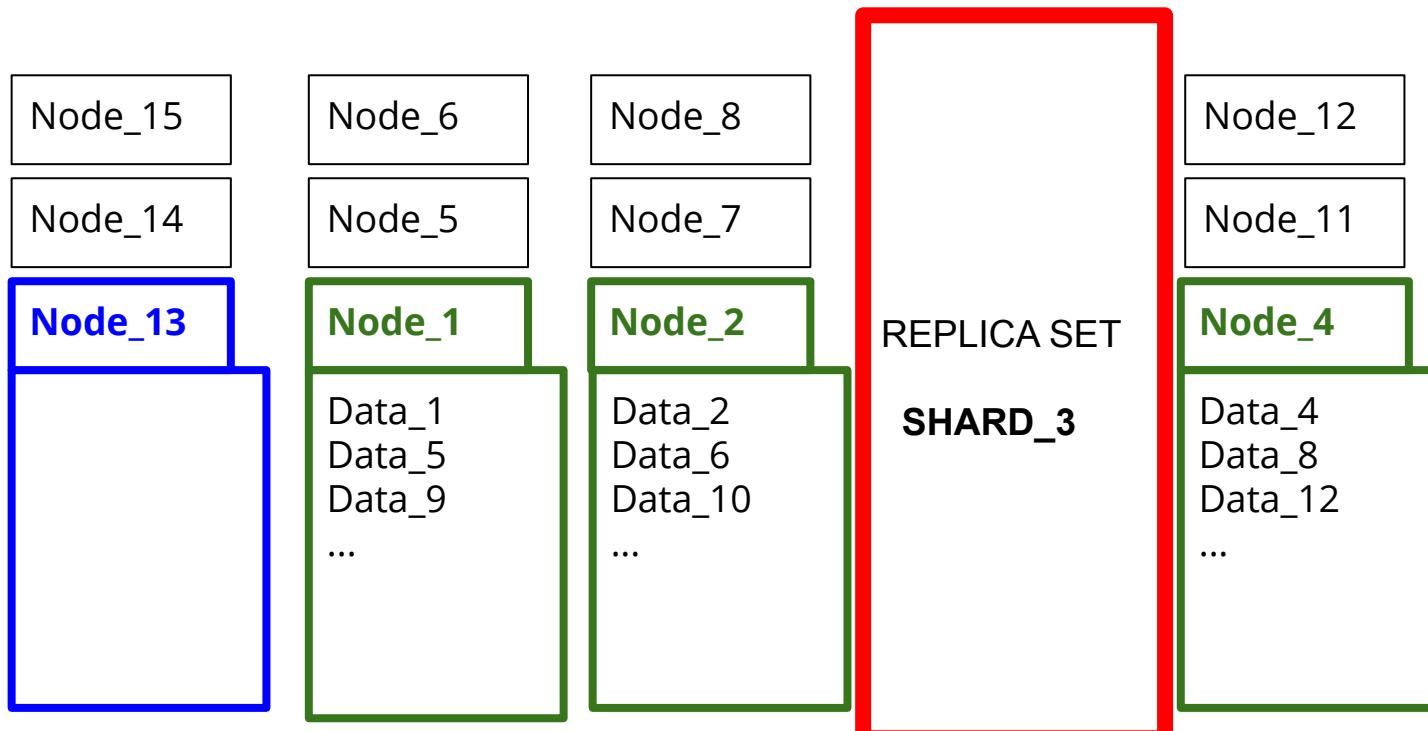
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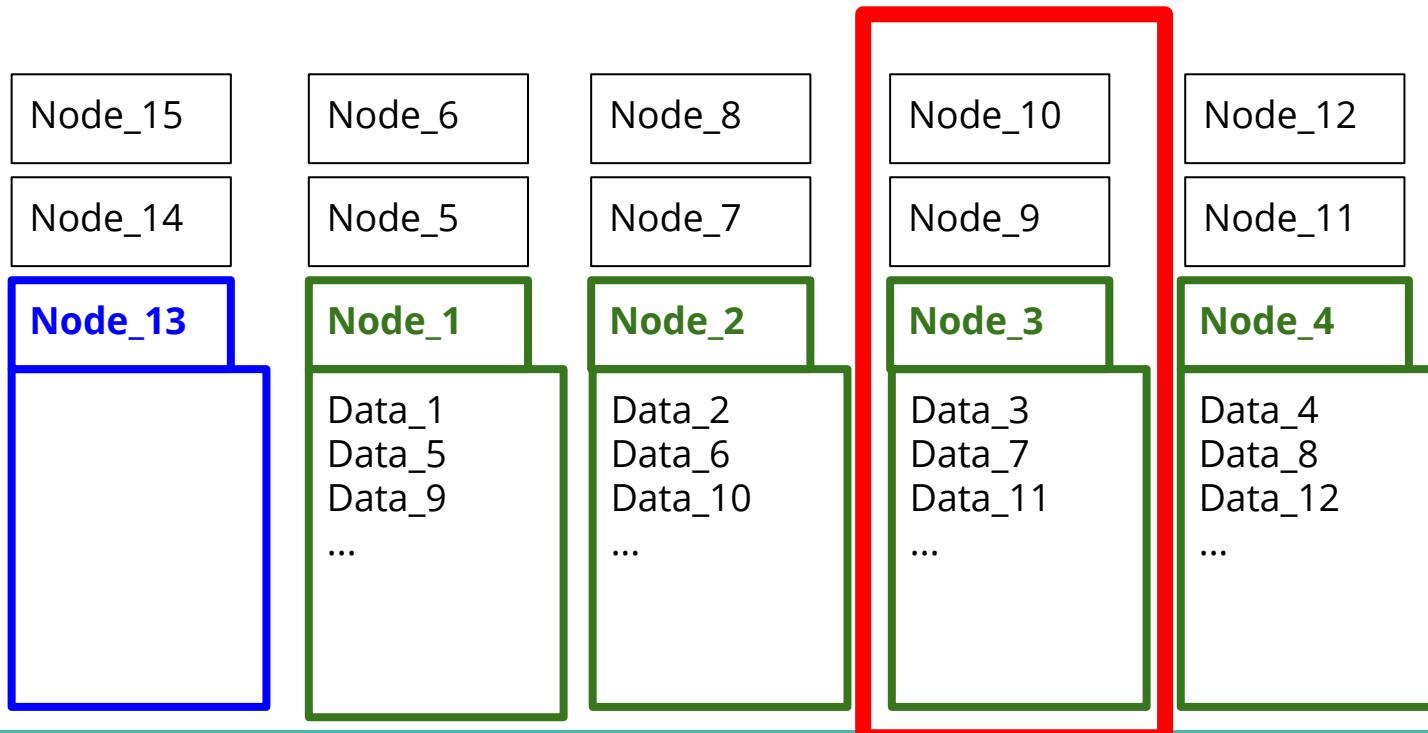
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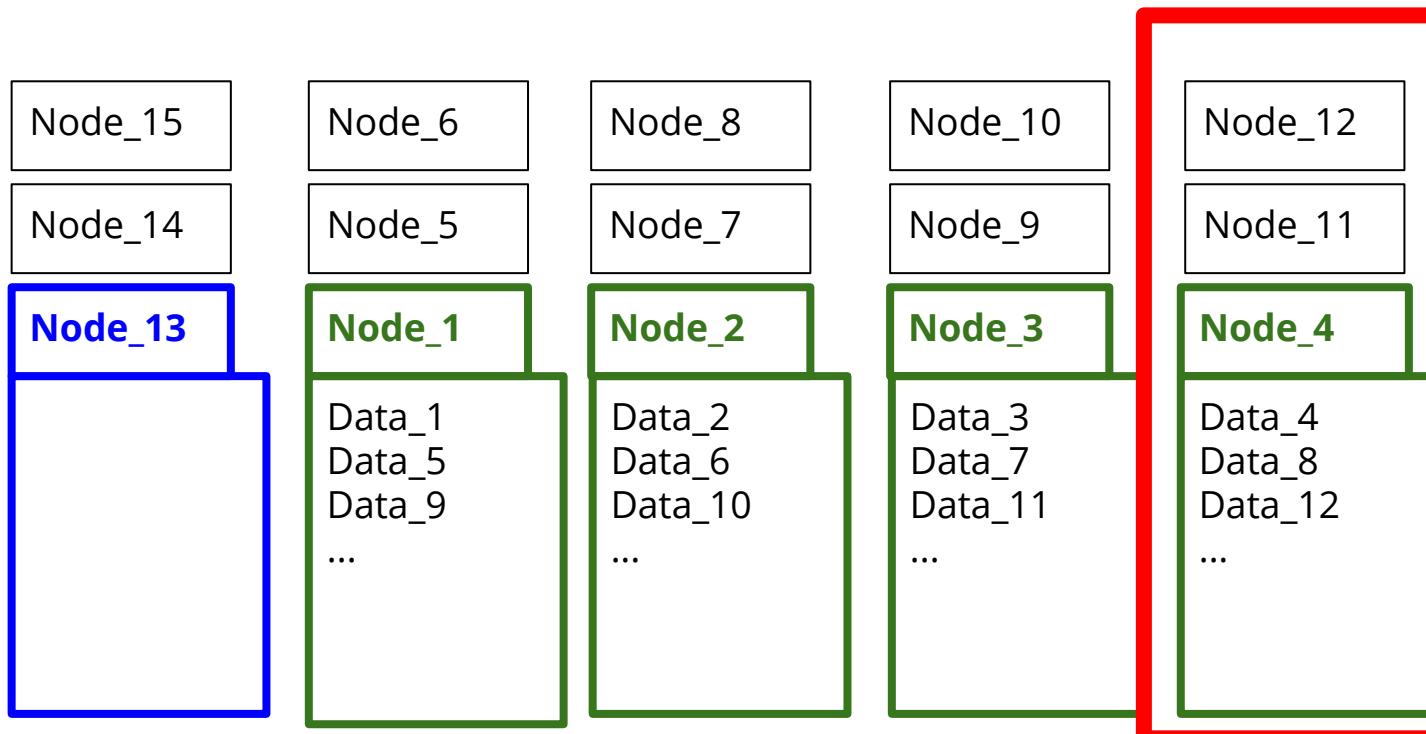
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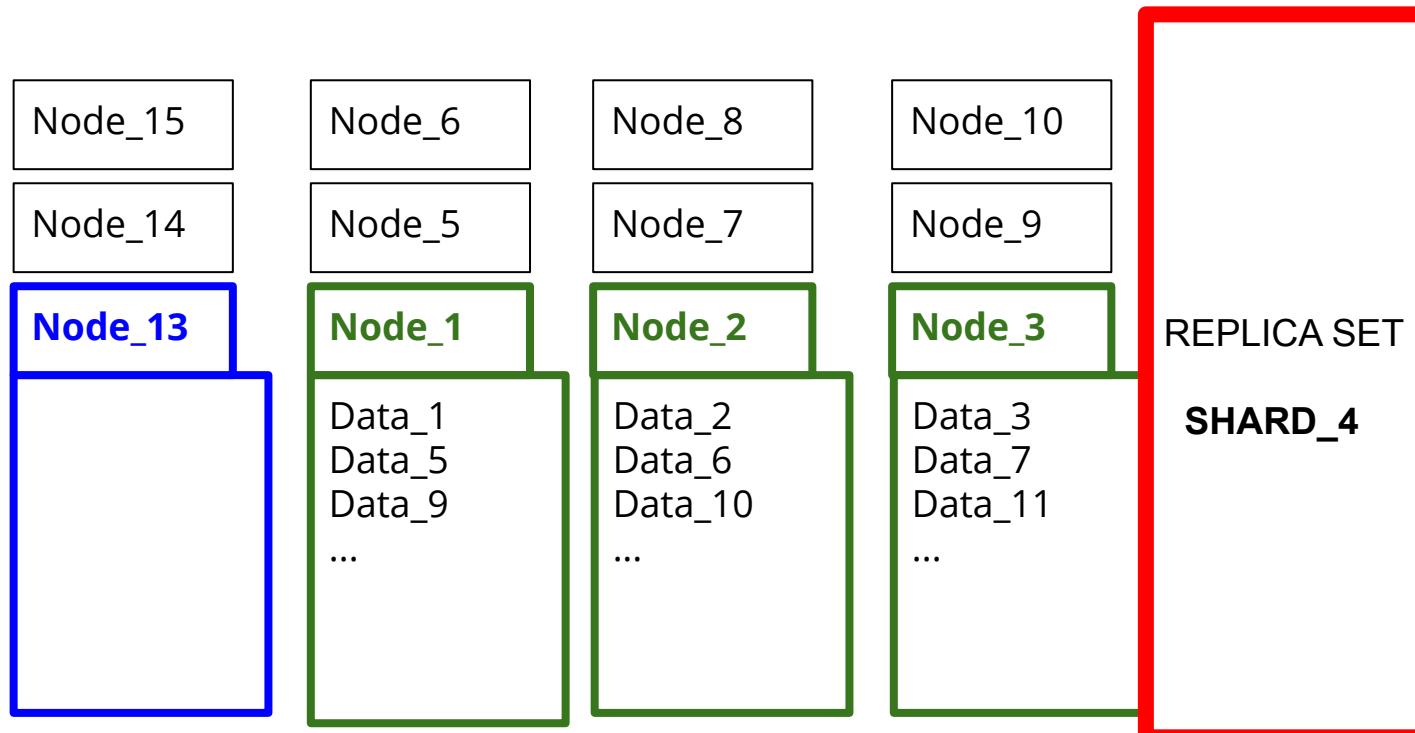
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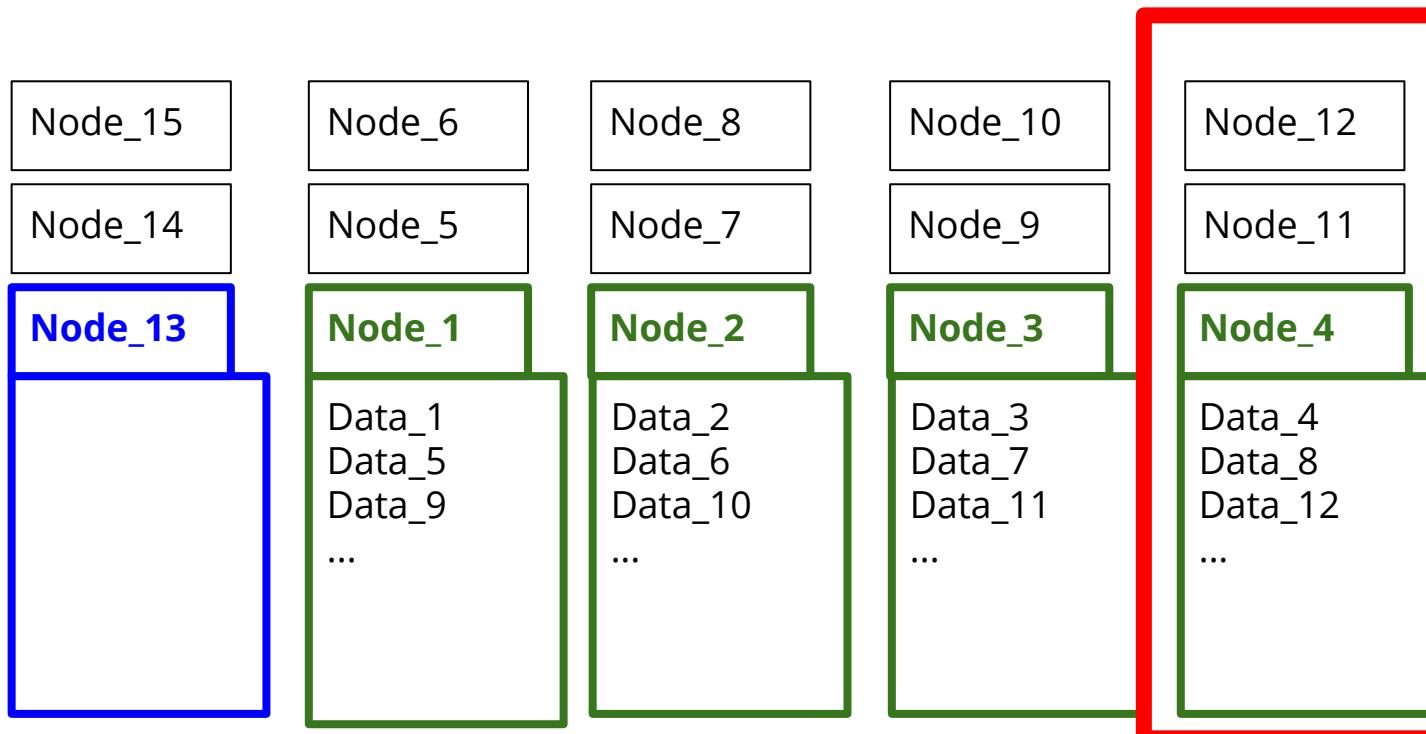
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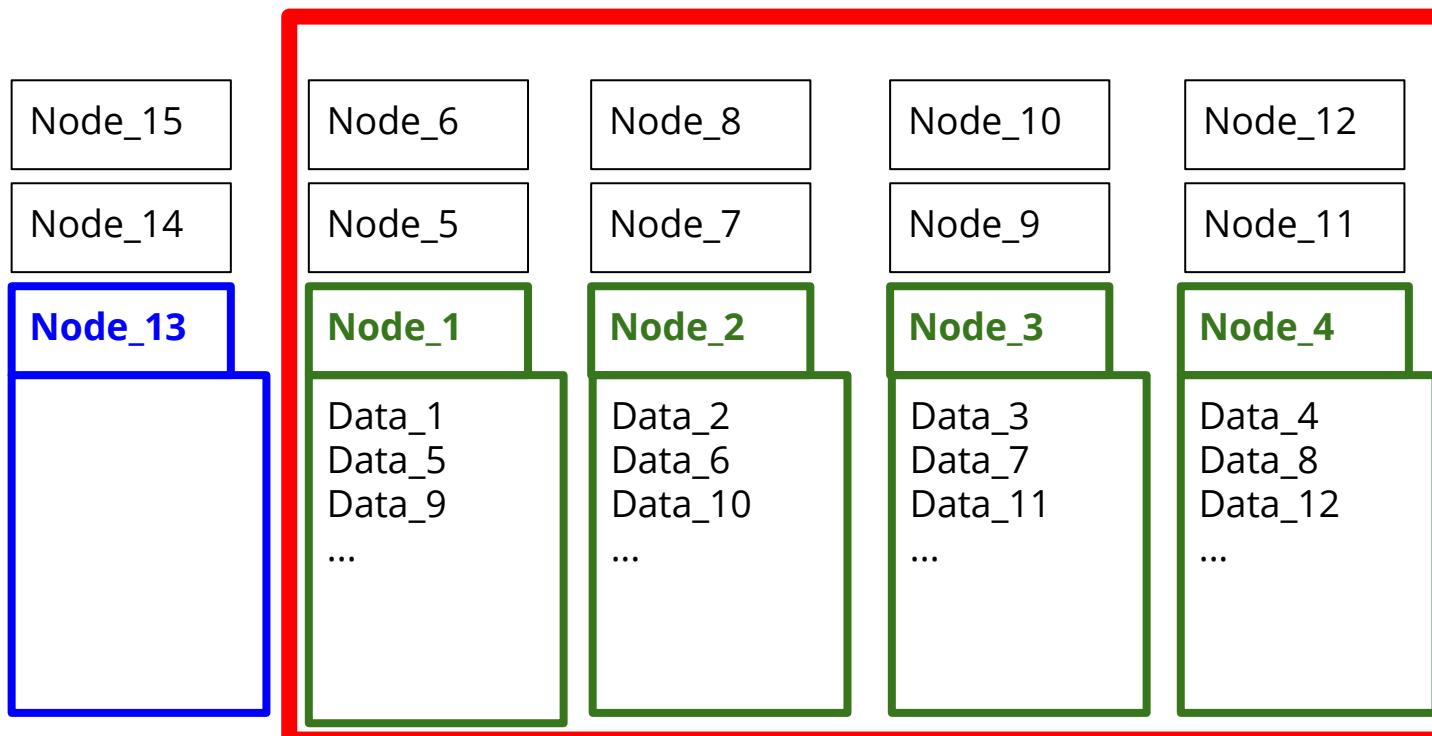
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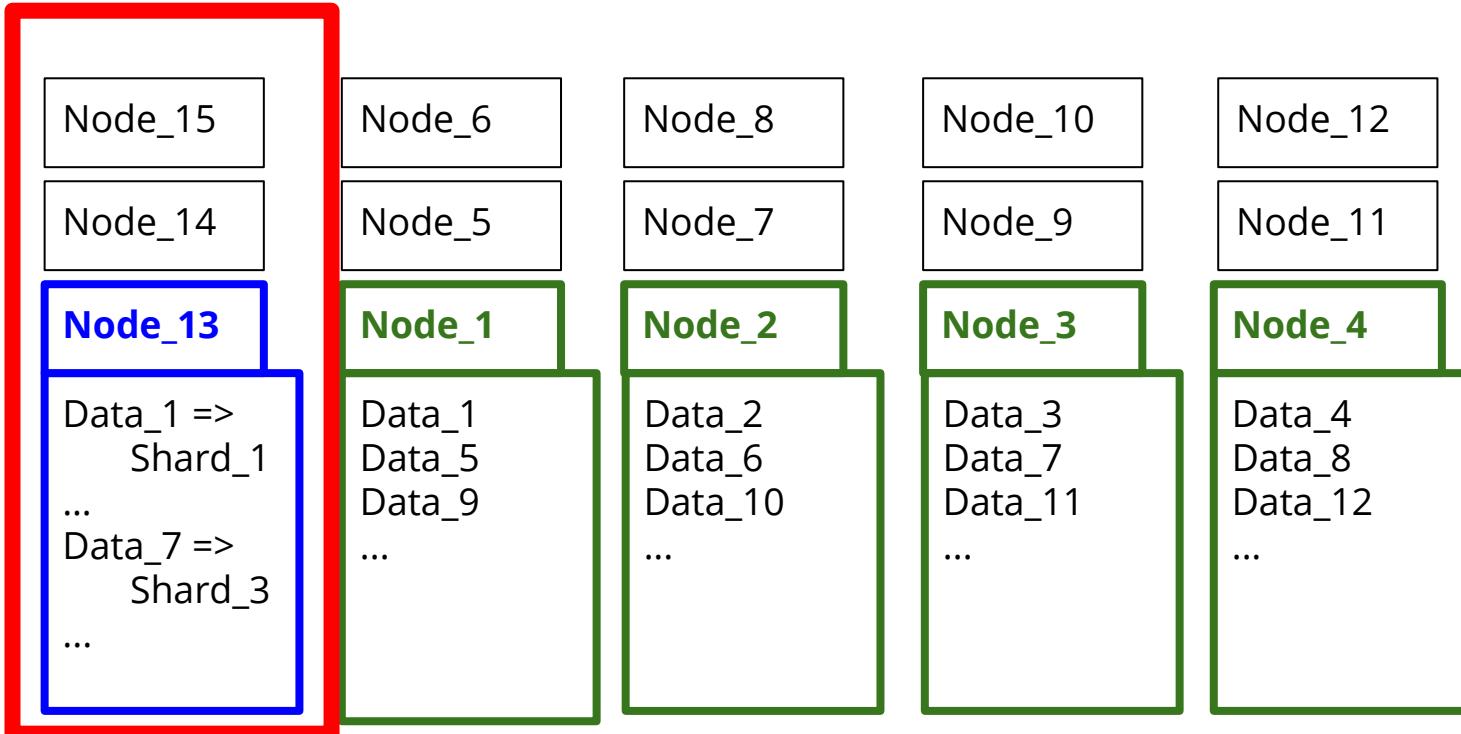
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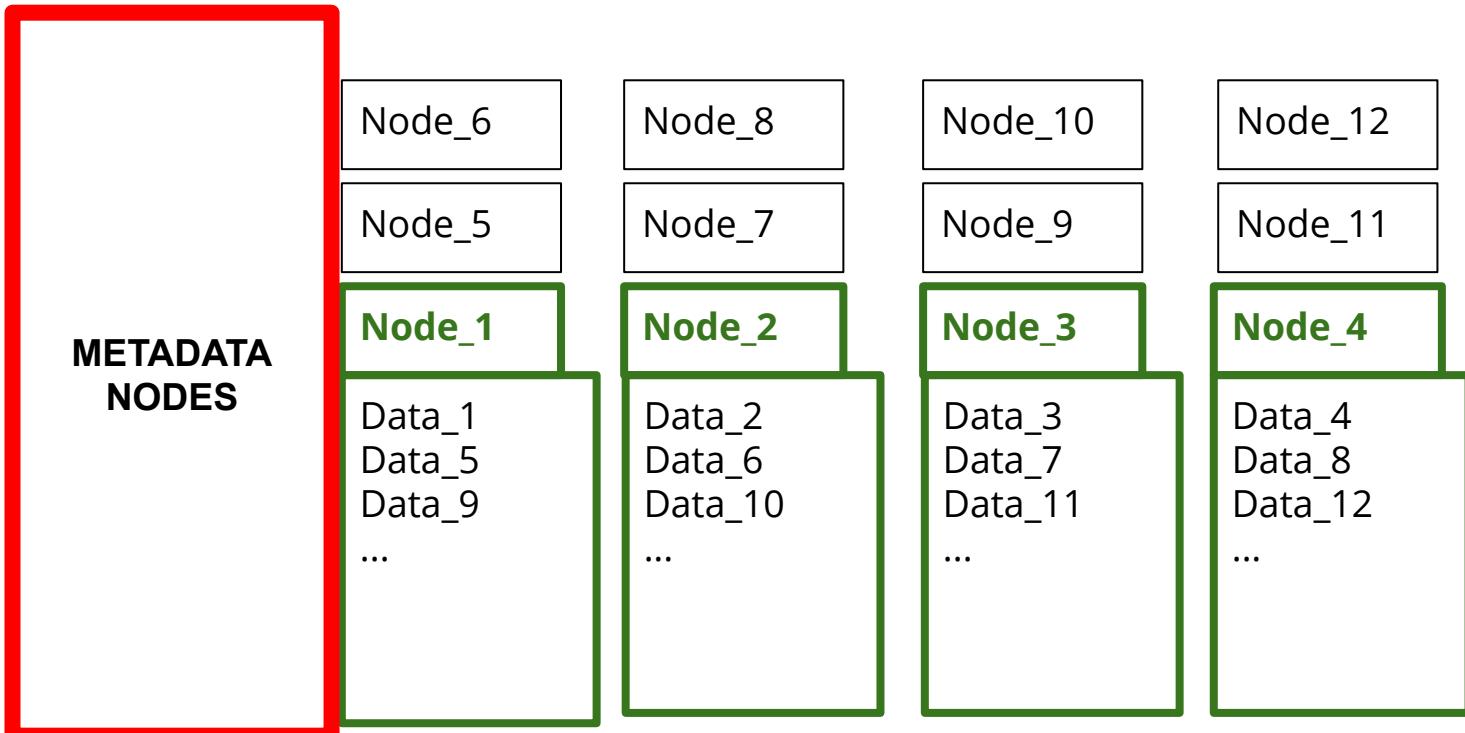
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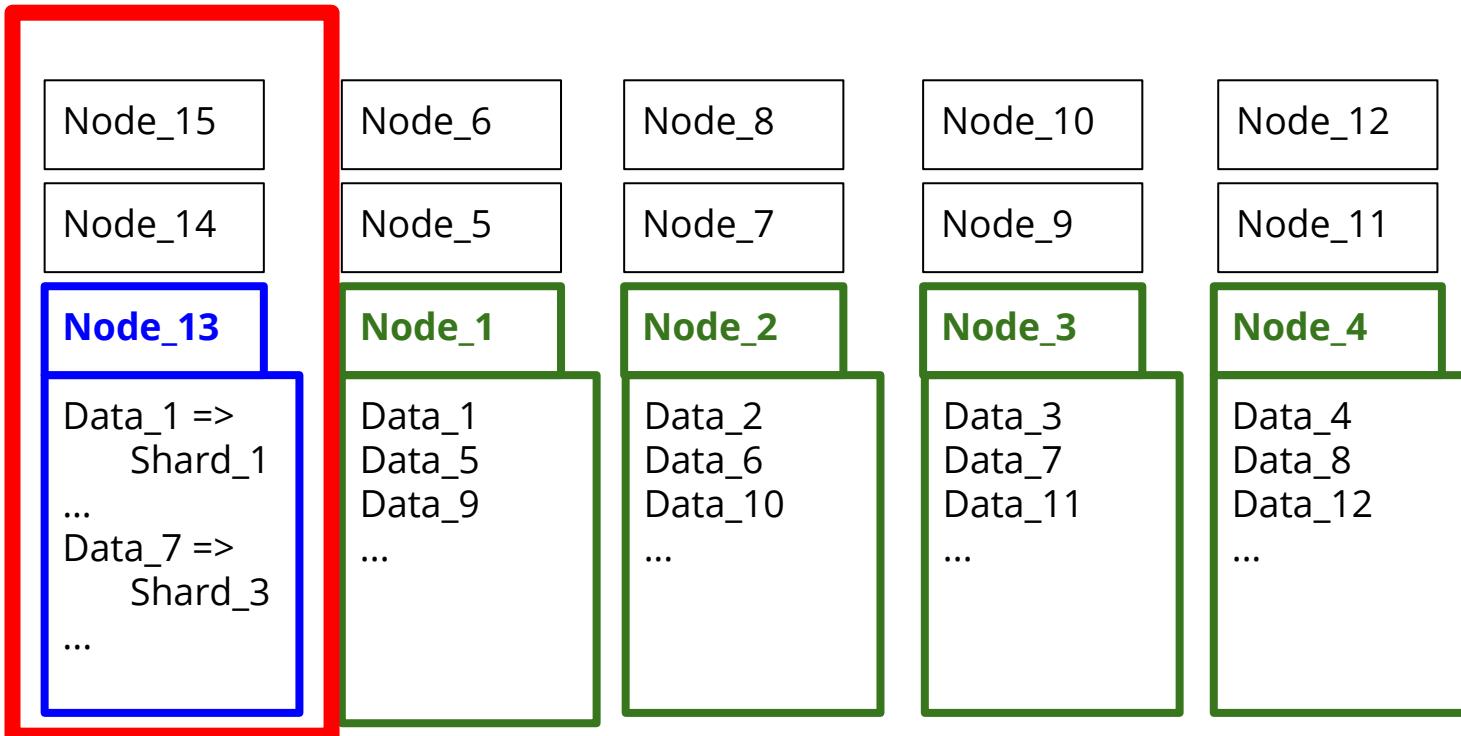
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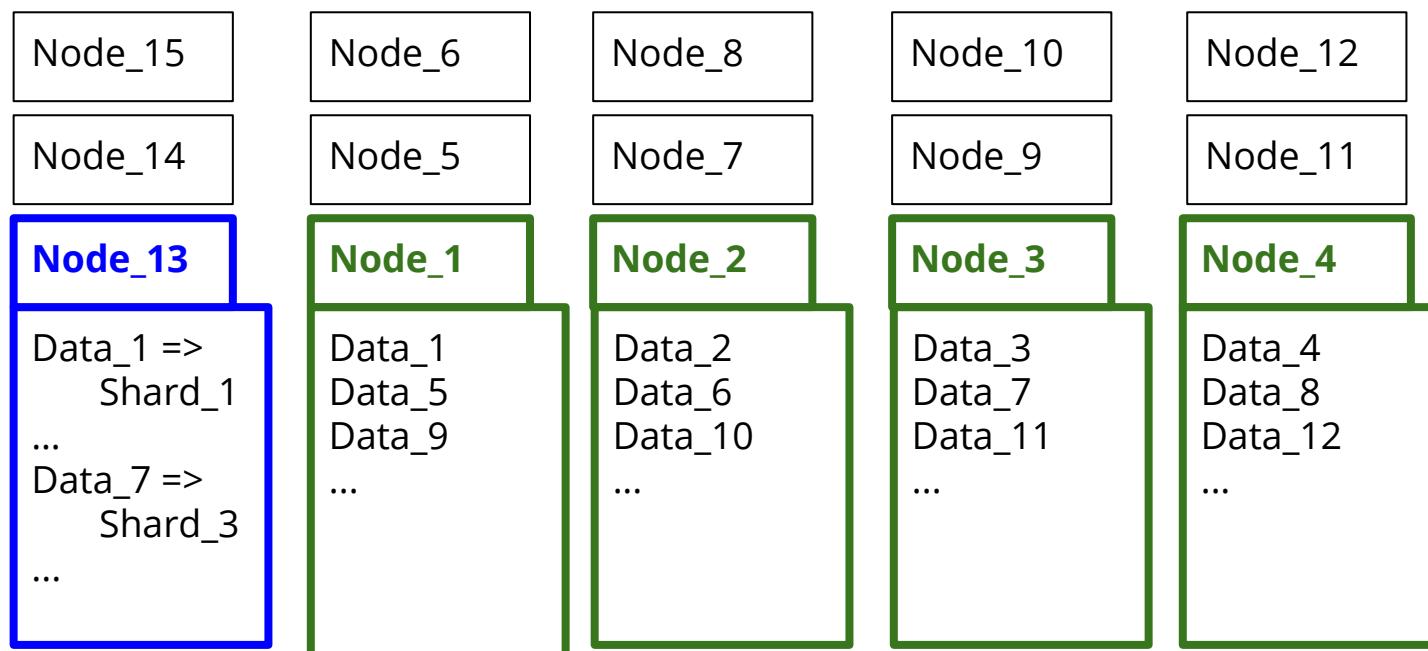
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Cluster and Data Organisation

A possible metaphor is for Metadata Nodes to be the table of contents of a book (they contain no text themselves, but they know where to find each piece of text from the book).



Cluster and Data Organisation

- From a Data Perspective, a MongoDB database consists on a number of collections (each of them logically independent from the others).

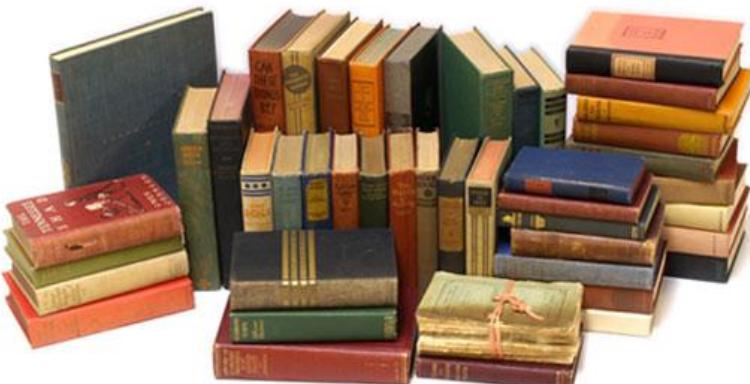
Cluster and Data Organisation

- From a Data Perspective, a MongoDB database consists on a number of **collections** (each of them logically independent from the others).
- For example, a restaurant collection with info from 25k restaurants of New York is provided by MongoDB:
<https://docs.atlas.mongodb.com/sample-data/sample-restaurants/#sample-restaurants-restaurants>



Cluster and Data Organisation

- A **collection** puts together a bunch of **documents**, each of them independent from the others.



Cluster and Data Organisation

- A **document** is represented by a JSON object, and contains a number of fields (keys), each of them with its associated value.

Cluster and Data Organisation

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- For example, the following JSON document represents the Morris Park Bake Shop, in the Bronx.

```
{  
  "name" : "Morris Park Bake Shop",  
  "cuisine" : "Bakery",  
  "borough" : "Bronx",  
  "address" : { "building": "1007", "street": "Morris Park Ave"},  
  "grades" : [ ... ]  
}
```

Cluster and Data Organisation

- A **document** is represented by a JSON object, and contains a number of fields (keys), each of them with its associated value.
- For example, the following JSON document represents the Morris Park Bake Shop, in the Bronx.

DOCUMENT: **doc_173**

COLLECTION: **restaurants**

DATABASE: **my_database**

Cluster and Data Organisation

- A **document** is represented by a JSON object, and contains a number of fields (keys), each of them with its associated value.
- For example, the following JSON document represents the Morris Park Bake Shop, in the Bronx.

```
{  
  "name" : "Morris Park Bake Shop",  
  "cuisine" : "Bakery",  
  "borough" : "Bronx",  
  "address" : { "building": "1007", "street": "Morris Park Ave"},  
  "grades" : [ ... ]  
}
```

Cluster and Data Organisation

- To scale on the size of the collections being managed MongoDB implements **Sharding**, an efficient way of organising data for its storage and further access.

Cluster and Data Organisation

The main idea of **Sharding** is to:

Cluster and Data Organisation

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1. Amalgamate documents into **partitions**.

Cluster and Data Organisation

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Cluster and Data Organisation

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Cluster and Data Organisation

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Cluster and Data Organisation

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3. **Split** the partitions to maintain them within a size range.
4. **Migrate** the partitions for a fair distribution among the Shard Nodes.
5. Metadata Node maps <partition, shard node>.

Cluster and Data Organisation

Partitions.

Given...

Cluster and Data Organisation

Partitions.

Given...

- A collection of documents (e.g., *restaurants*).



Cluster and Data Organisation

Partitions.

Given...

- A collection of documents (e.g., *restaurants*).
- A common comparable field to all of them, called the **shard key**: (e.g., *"cuisine"*, *"borough"*, *"name"* or a combination of them).



Cluster and Data Organisation

Partitions.

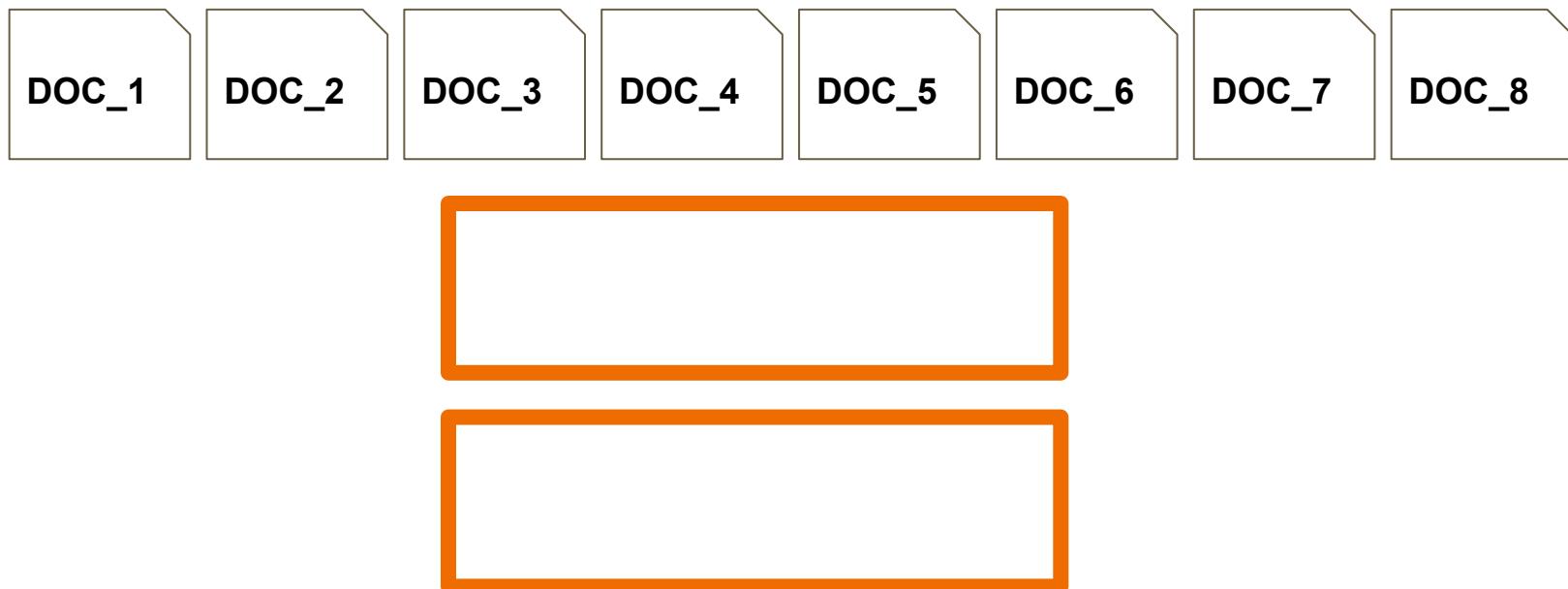
Given...

- A collection of documents (e.g., *restaurants*).
- A common comparable field to all of them, called the **shard key**: (e.g., "*cuisine*", "*borough*", "*name*" or a combination of them).
- A max size / number of documents for the partitions (e.g., 3MB or 3 documents).



Cluster and Data Organisation

Assuming the documents are inserted one by one,
let's see how do they organise into partitions.



Cluster and Data Organisation

Assuming the documents are inserted one by one,
let's see how do they organise into partitions.



Cluster and Data Organisation

Step 0: The collection is empty, so it has just an empty partition. Its shard key range is the entire amount of keys.



P1

P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 1: Doc_1 is to be stored, it goes to P1.

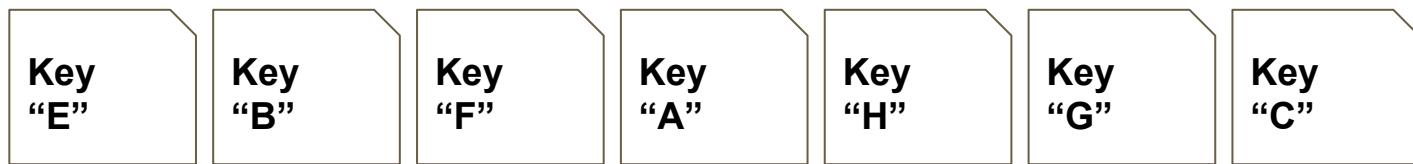


P1

P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 1: Doc_1 is to be stored, it goes to P1.



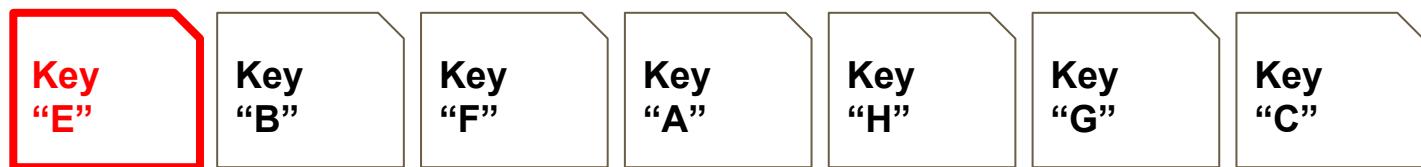
P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 2: Doc_2 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 2: Doc_2 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 3: Doc_3 is to be stored, it goes to P1.



P1

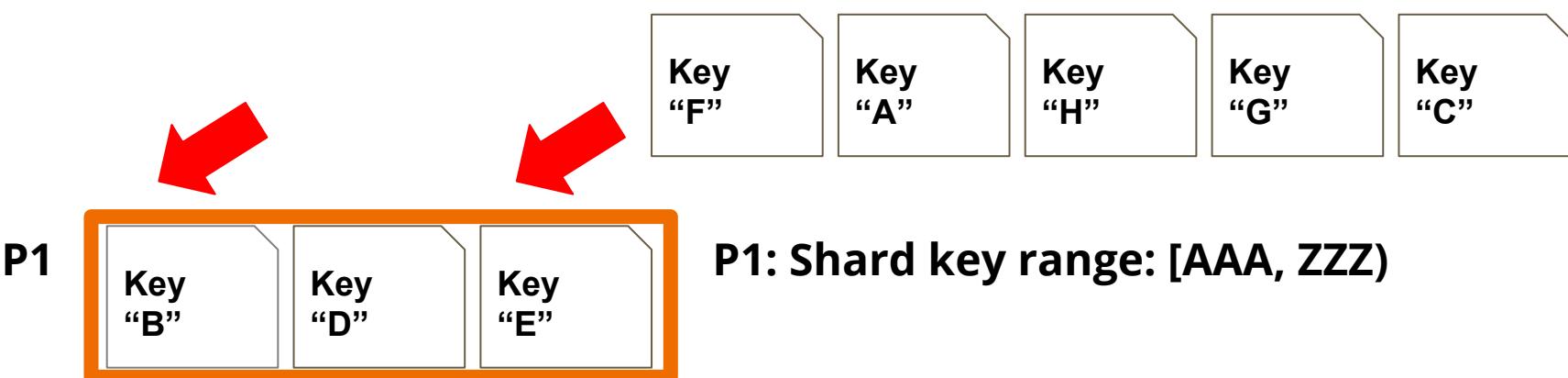


P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

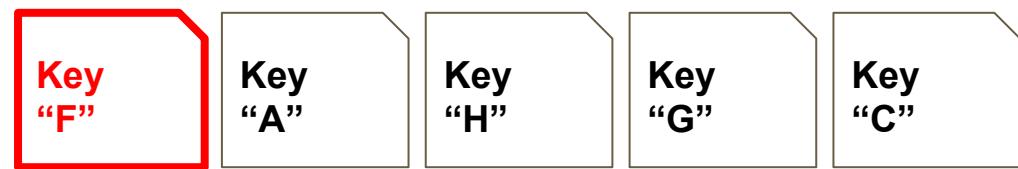
Step 3: Doc_3 is to be stored, it goes to P1.

Note that the documents in the partition are ordered by their key.



Cluster and Data Organisation

Step 4: Doc_4 is to be stored, it goes to P1.



P1

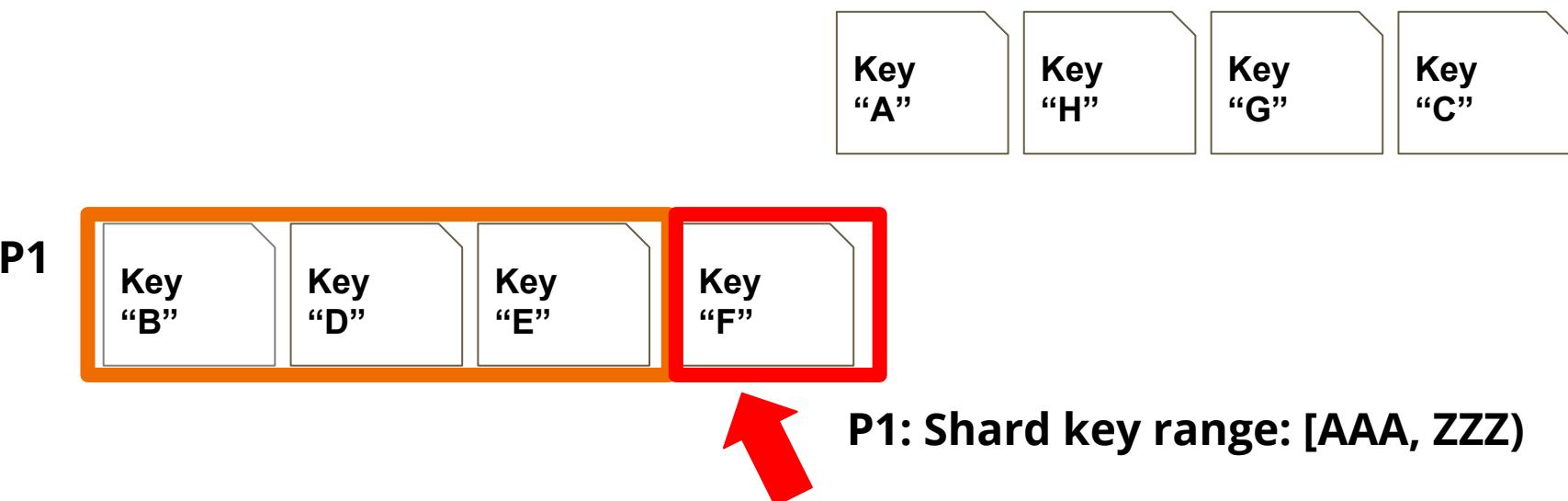


P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

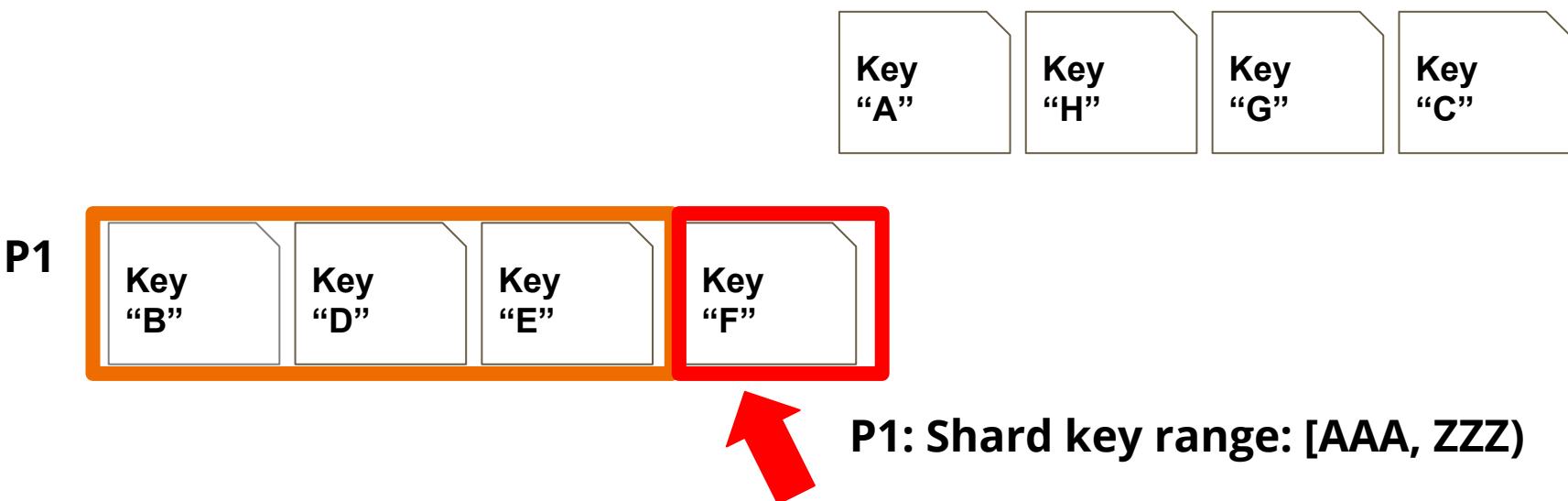
Step 4: Doc_4 is to be stored, it goes to P1.

Note that the maximum size of the partition has been exceeded.



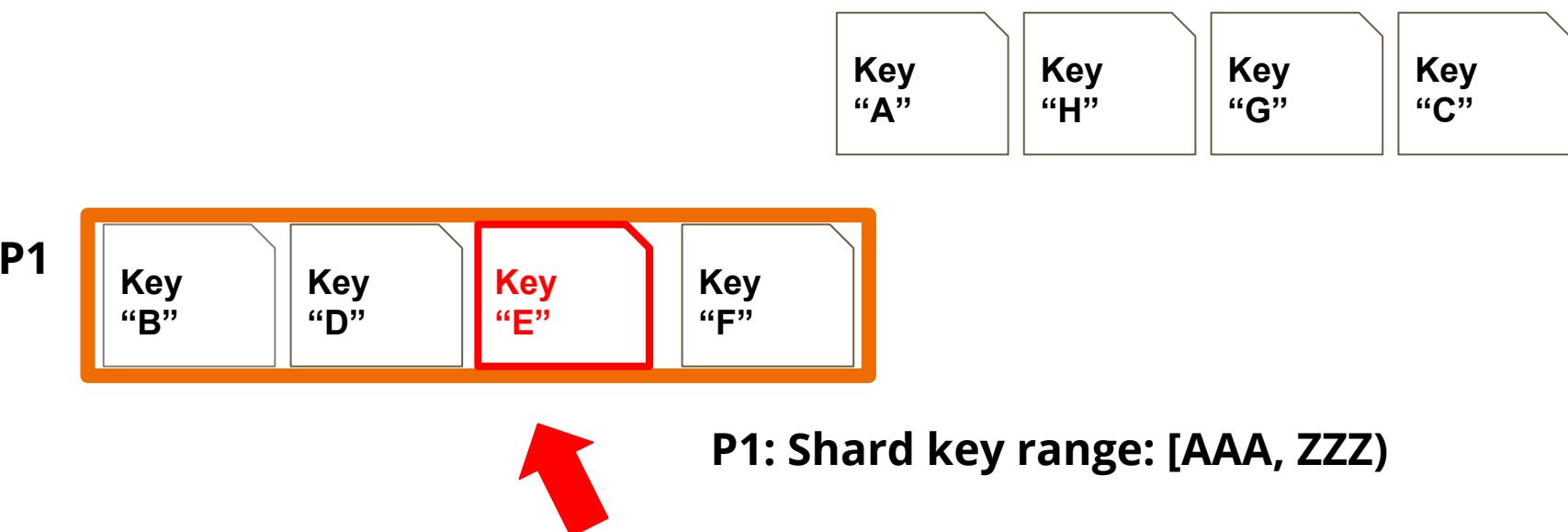
Cluster and Data Organisation

Step 4: At this stage the **split** daemon of MongoDB enters in action.



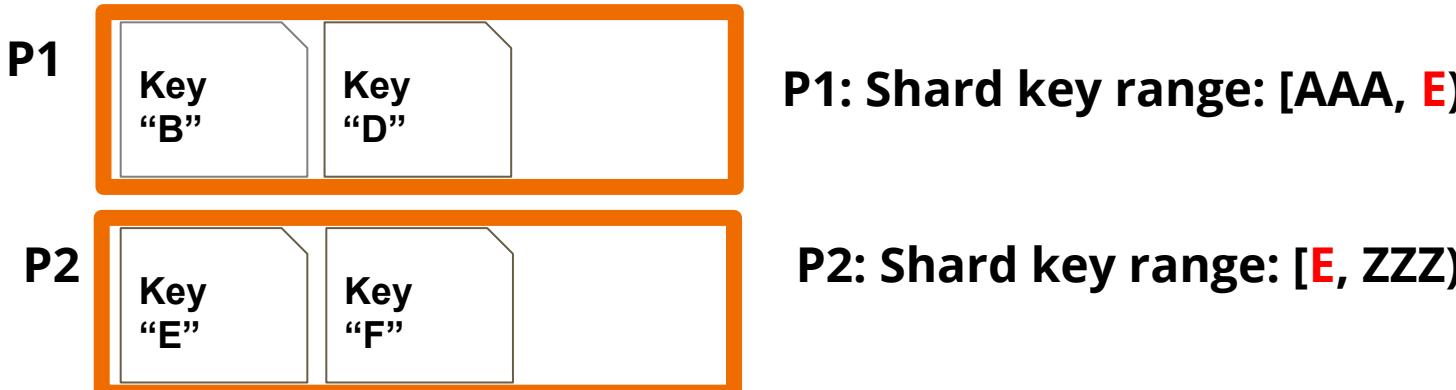
Cluster and Data Organisation

Step 4: At this stage the **split** daemon of MongoDB enters in action. It looks for the middle key ("E") and splits P1 into two partitions: P1 and P2.



Cluster and Data Organisation

Step 4: At this stage the **split** daemon of MongoDB enters in action. It looks for the middle key of the partition and splits it into two partitions. **Please note the updated shard key ranges of P1 and P2.**

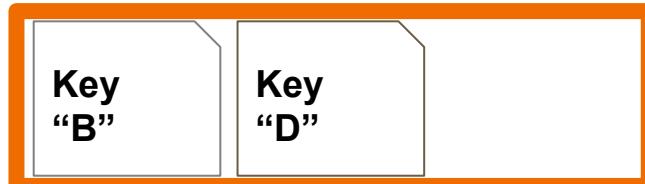


Cluster and Data Organisation

Step 5: Doc_5 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, E)

P2



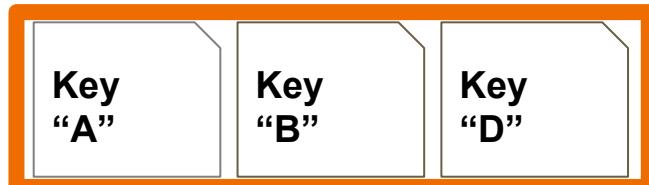
P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

Step 5: Doc_5 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, E)

P2



P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

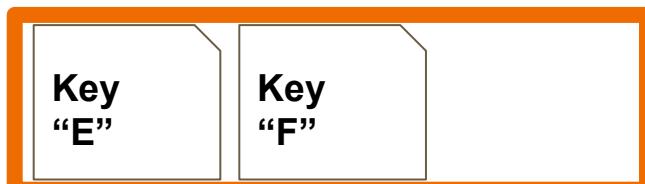
Step 6: Doc_6 is to be stored, it goes to P2.

P1



P1: Shard key range: [AAA, E)

P2



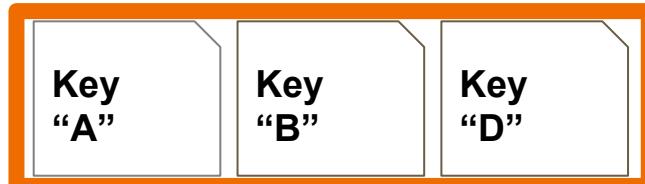
P2: Shard key range: [E, ZZZ)



Cluster and Data Organisation

Step 6: Doc_6 is to be stored, it goes to P2.

P1



P1: Shard key range: [AAA, E)

P2



P2: Shard key range: [E, ZZZ)



Cluster and Data Organisation

Step 7: Doc_7 is to be stored, it goes to P2.

The split daemon enters in action again and splits it into partitions P2 and P3, also updating their shard key ranges.



P1



P1: Shard key range: [AAA, E)

P2

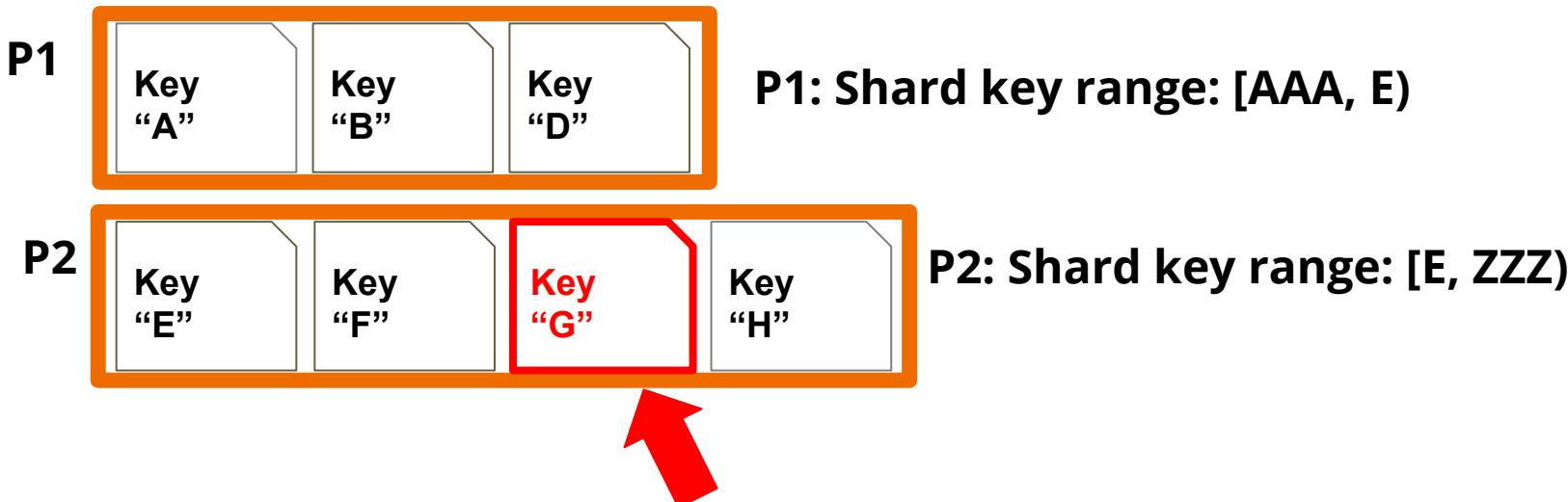


P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

Step 7: Doc_7 is to be stored, it goes to P2.

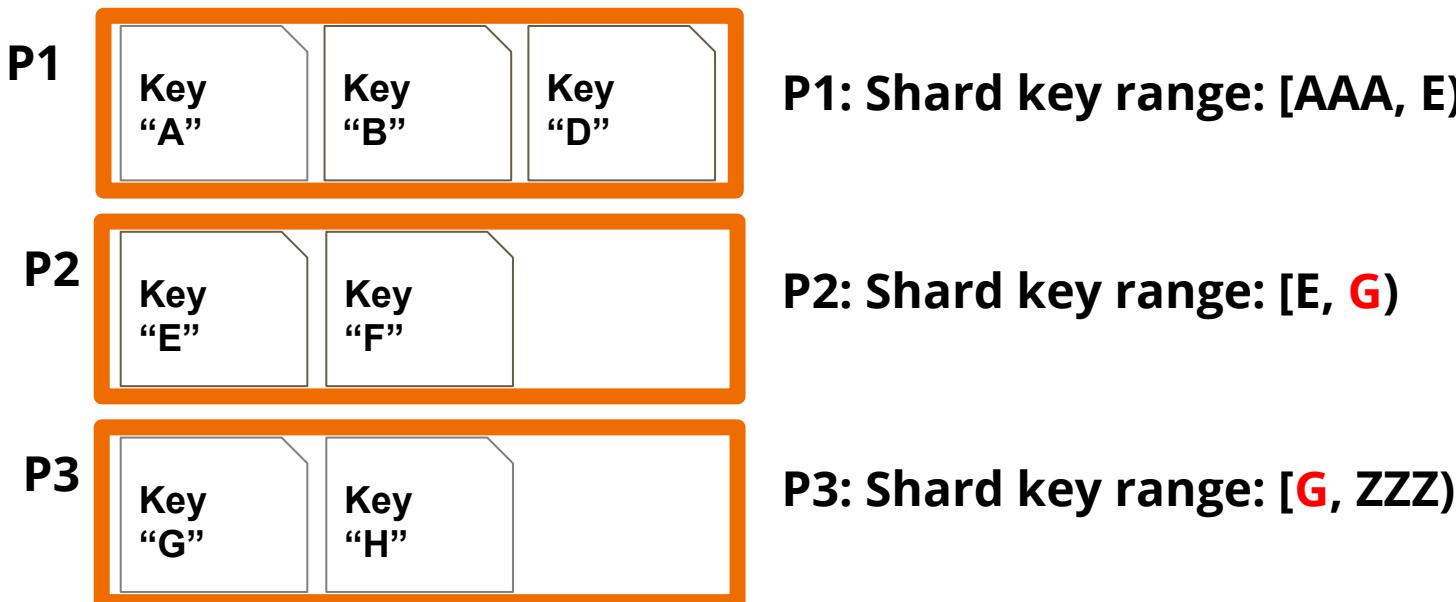
The split daemon enters in action again and splits it into partitions P2 and P3, also updating its shard key ranges.



Cluster and Data Organisation

Step 7: Doc_7 is to be stored, it goes to P2.

The split daemon enters in action again and splits it into partitions P2 and P3, also updating its shard key ranges.

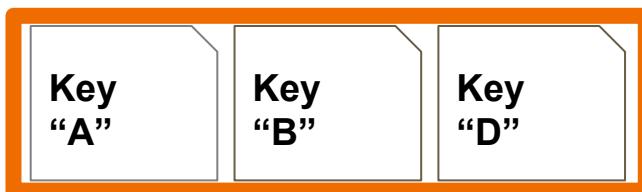


Cluster and Data Organisation

Step 8: Doc_8 is to be stored, it goes to P1.

The split daemon enters in action again and splits it into partitions P1 and P4, also updating their shard key ranges.

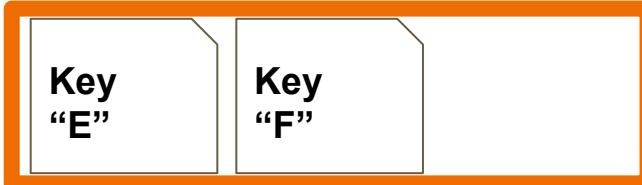
P1



P1: Shard key range: [AAA, E)

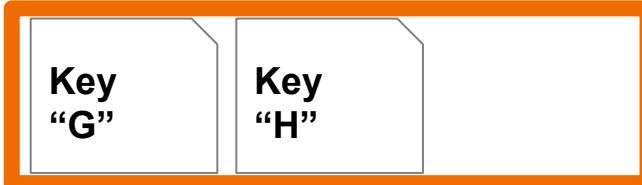


P2



P2: Shard key range: [E, G)

P3



P3: Shard key range: [G, ZZZ)

Cluster and Data Organisation

Step 8: Doc_8 is to be stored, it goes to P1.

The split daemon enters in action again and splits it into partitions P1 and P4, also updating their shard key ranges.

P1



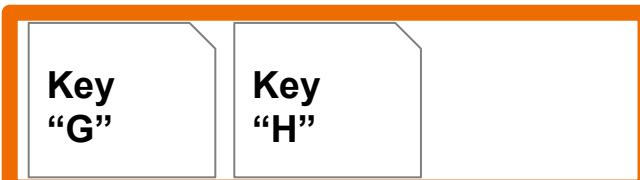
P1: Shard key range: [AAA, **C**)

P2



P2: Shard key range: [E, G)

P3



P3: Shard key range: [G, ZZZ)

P4



P4: Shard key range: [**C**, E)

Cluster and Data Organisation

Step 8: Doc_8 is to be stored, it goes to P1.

The split daemon enters in action again and splits it into partitions P1 and P4, also updating their shard key ranges.

P1



P1: Shard key range: [AAA, C)

P2



P2: Shard key range: [E, G)

P3



P3: Shard key range: [G, ZZZ)

P4



P4: Shard key range: [C, E)

Cluster and Data Organisation

Migration.

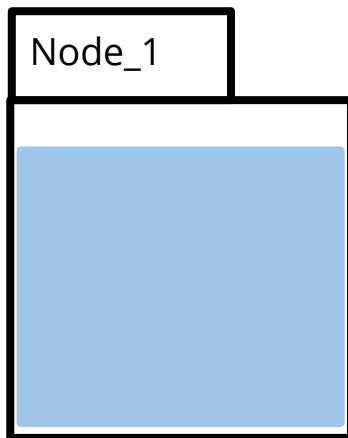
Given...

Cluster and Data Organisation

Migration.

Given...

- A shard node hosting some partitions (e.g., P1 and P2).

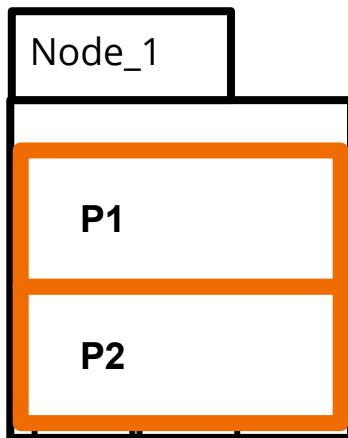


Cluster and Data Organisation

Migration.

Given...

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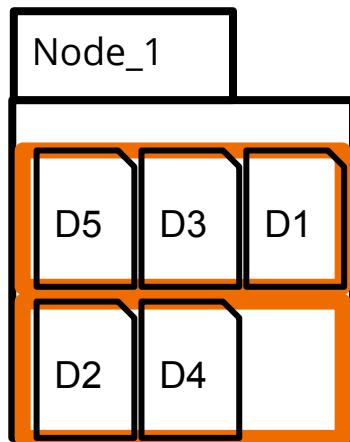


Cluster and Data Organisation

Migration.

Given...

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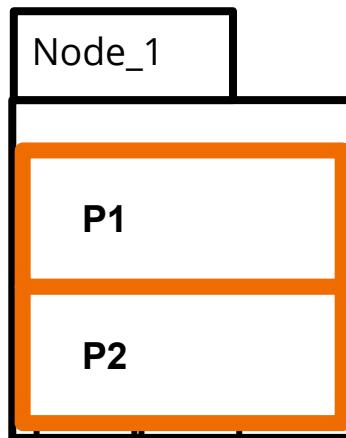


Cluster and Data Organisation

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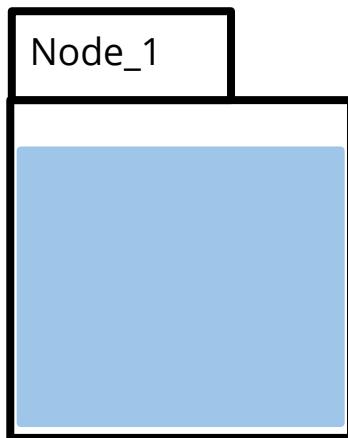


Cluster and Data Organisation

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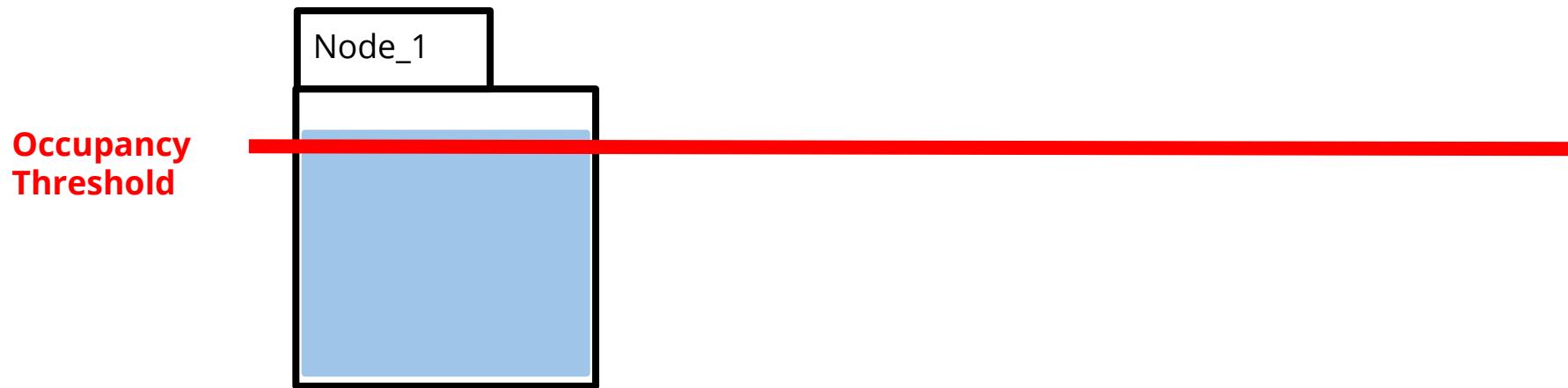


Cluster and Data Organisation

Migration.

Given...

- A shard node hosting some partitions (e.g., P1 and P2).
- An occupancy threshold (e.g., 5MB or documents).

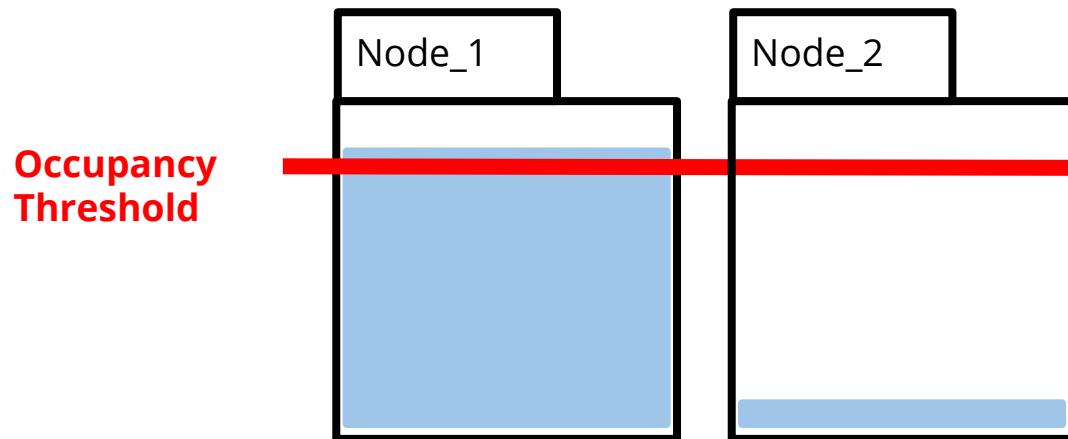


Cluster and Data Organisation

Migration.

Given...

- A shard node hosting some partitions (e.g., P1 and P2).
- An occupancy threshold (e.g., 5MB or 5 documents).
- Another shard node with occupancy below the threshold.

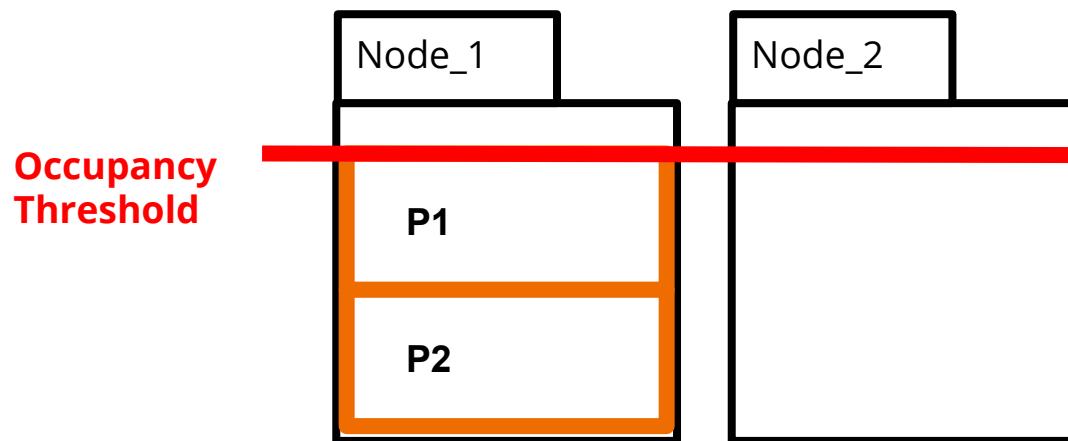


Cluster and Data Organisation

Migration.

Given...

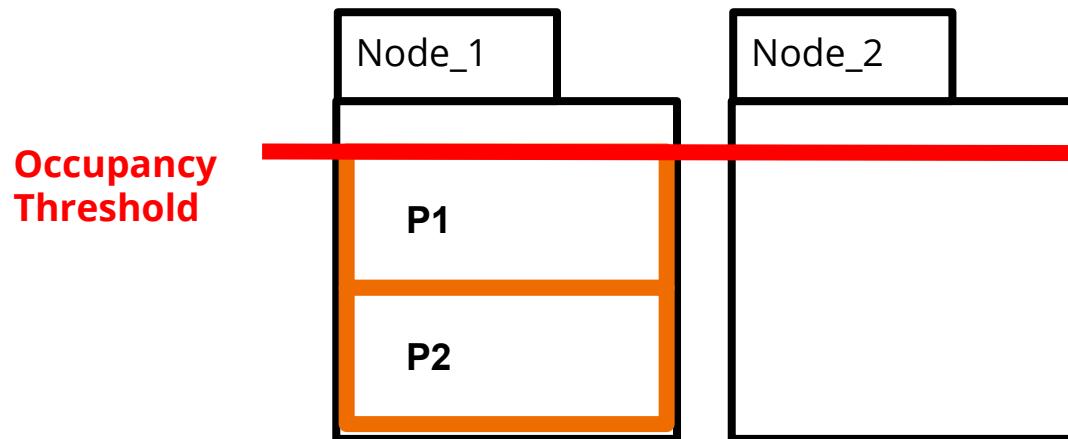
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- Another shard node with occupancy below the threshold.



Cluster and Data Organisation

Migration.

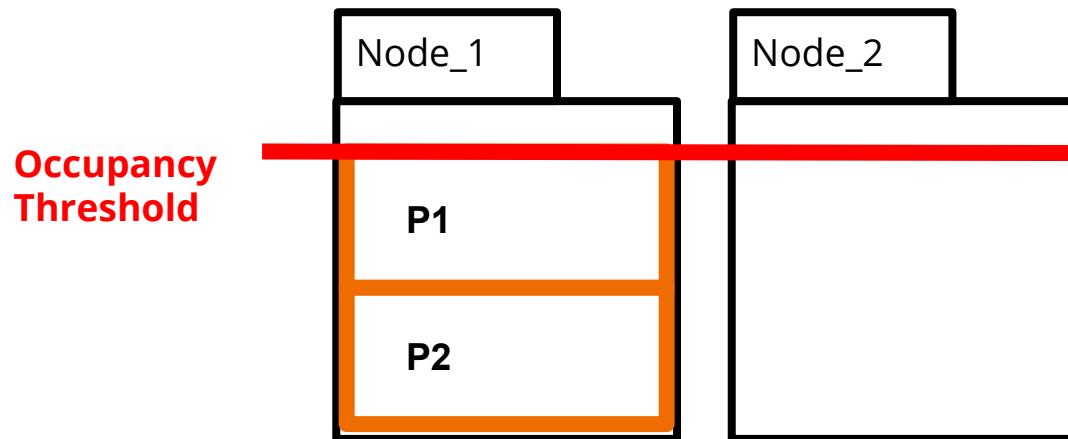
- The **migrate** daemon of MongoDB transfers one or more partitions from Node_1 to Node_2 so as to achieve a fair distribution of the partitions among the shard nodes.



Cluster and Data Organisation

Migration.

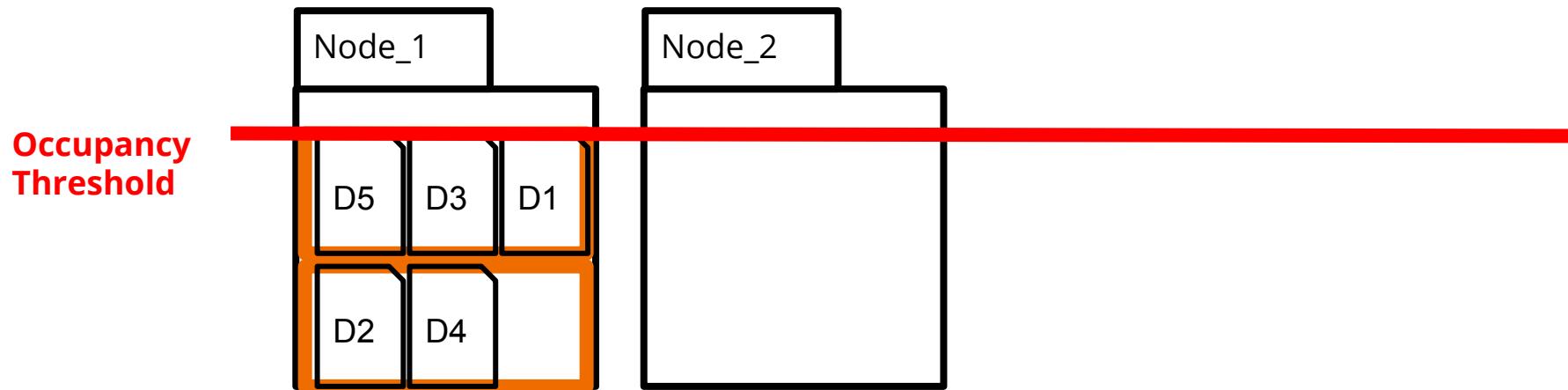
- The **migrate** daemon of MongoDB transfers one or more partitions from Node_1 to Node_2 so as to achieve a fair distribution of the partitions among the shard nodes.
 - Policy e.g.: migrate the **smallest partition to the shard node less occupied**.



Cluster and Data Organisation

Migration.

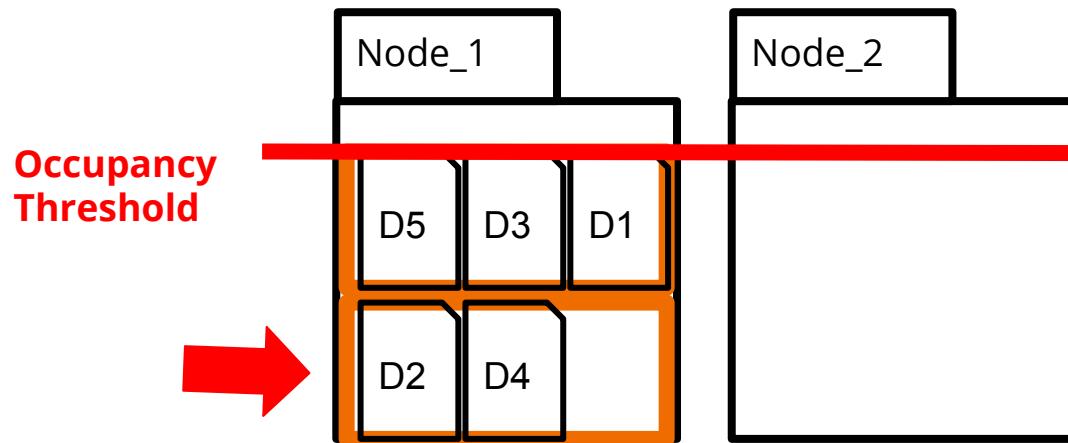
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Cluster and Data Organisation

Migration.

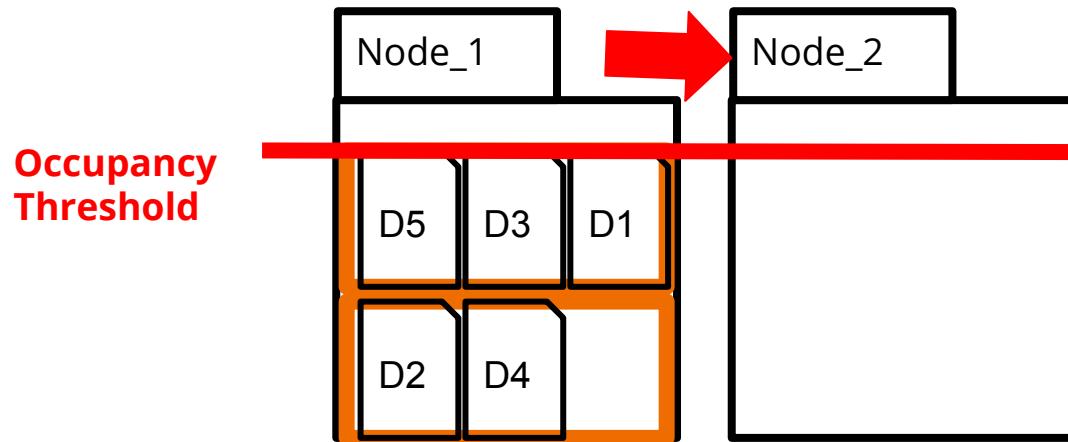
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Cluster and Data Organisation

Migration.

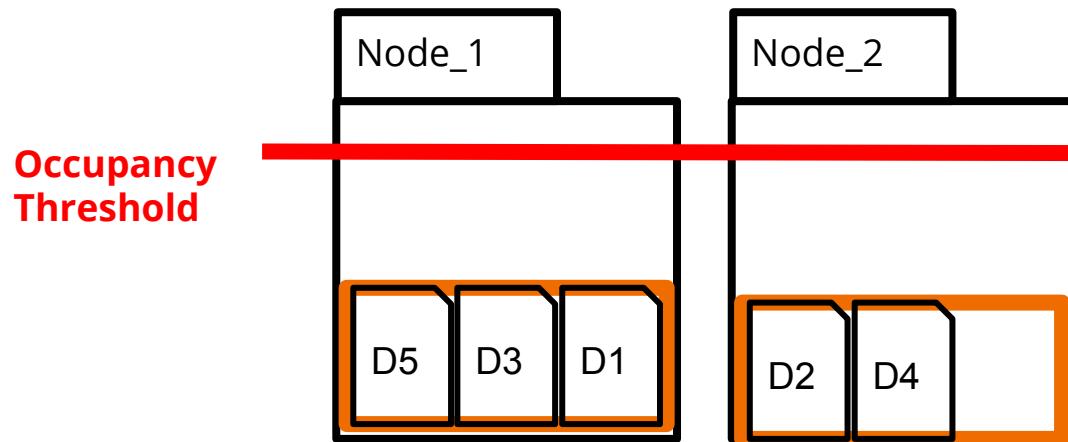
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Cluster and Data Organisation

Migration.

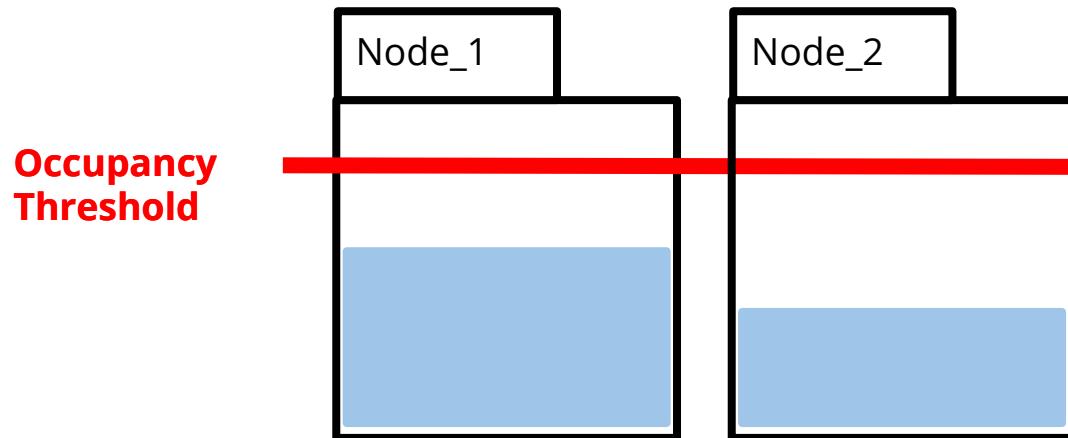
- The **migrate** daemon of MongoDB transfers one or more partitions from Node_1 to Node_2 so as to achieve a fair distribution of the partitions among the shard nodes.
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Cluster and Data Organisation

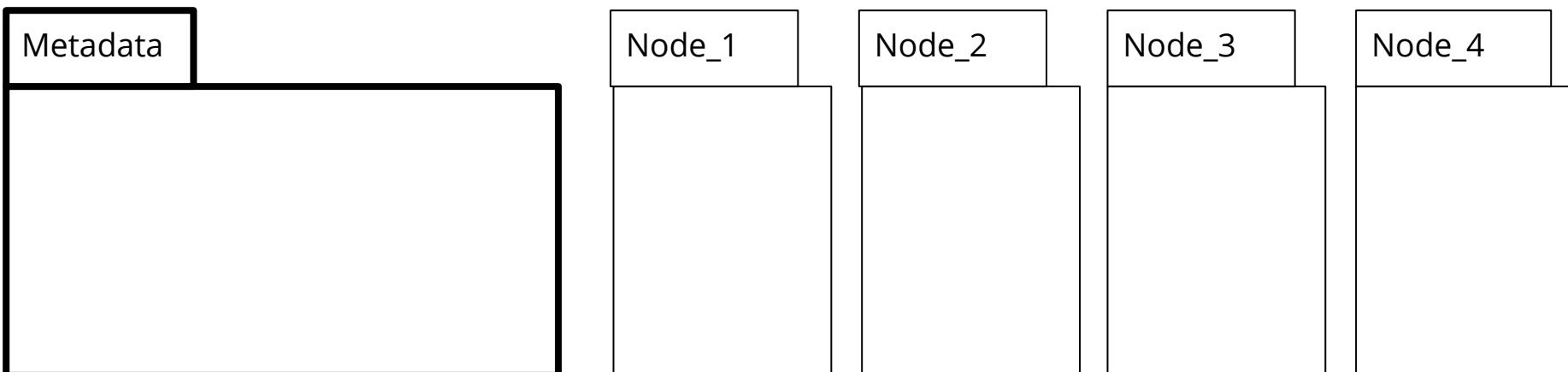
Migration.

- The **migrate** daemon of MongoDB transfers one or more partitions from Node_1 to Node_2 so as to achieve a fair distribution of the partitions among the shard nodes.
 - Policy e.g.: migrate the **smallest partition to the shard node less occupied**.



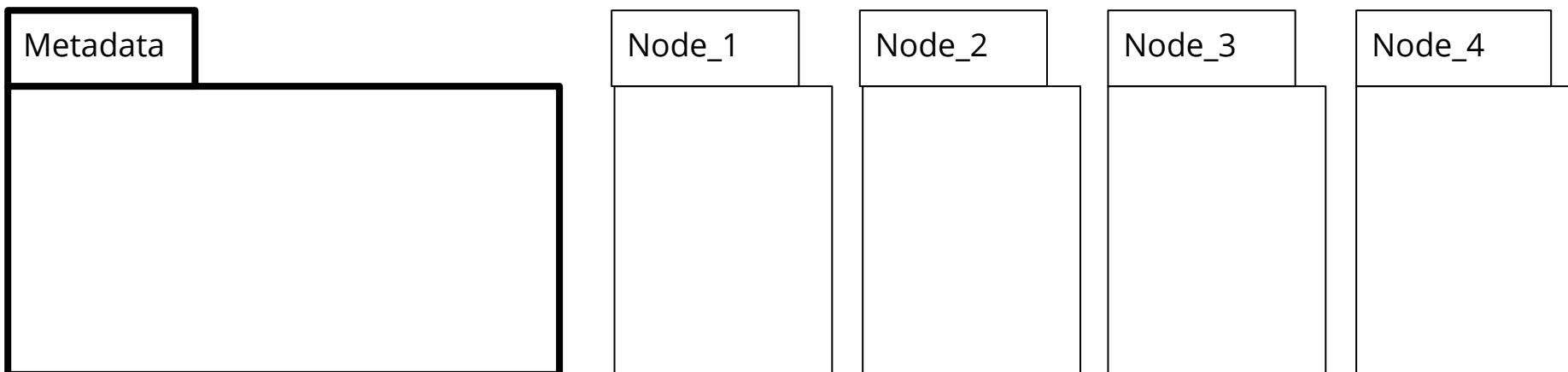
Cluster and Data Organisation

Let's now repeat the simulation we did before, but now with a view on the Metadata Nodes and the migration of partitions.



Cluster and Data Organisation

- Let's assume a migration policy based on minimising the difference between the node with most partitions and the one with less partitions.



Cluster and Data Organisation

Step 0: The collection is empty, so it has just an empty partition. Its shard key range is the entire amount of keys.

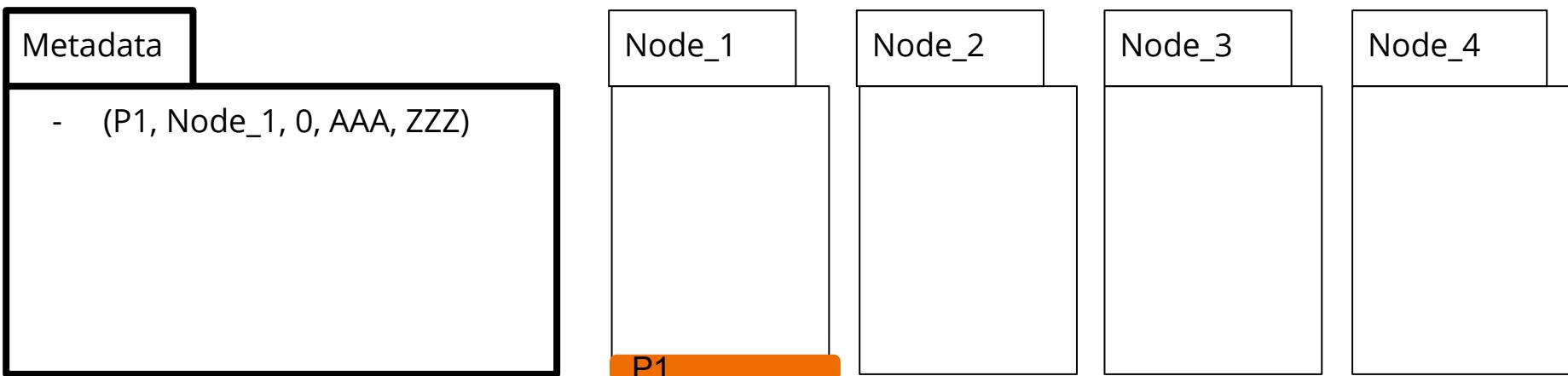


P1

P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Cluster Overview:



Cluster and Data Organisation

Step 1: Doc_1 is to be stored, it goes to P1.

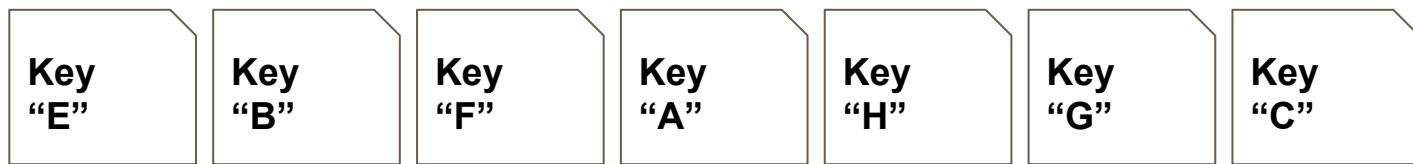


P1

P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 1: Doc_1 is to be stored, it goes to P1.



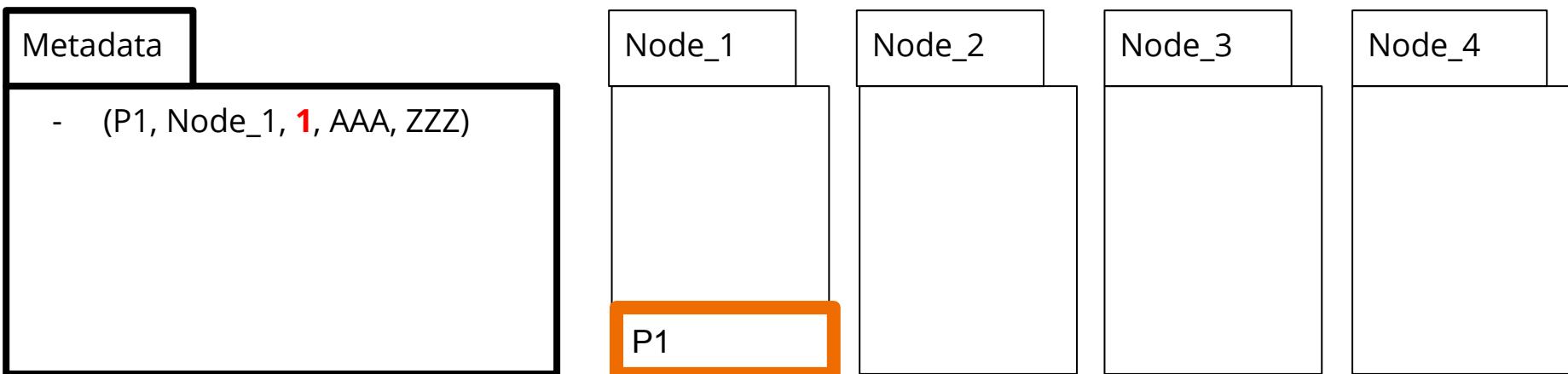
P1



P1: Shard key range: [AAA, ZZZ)

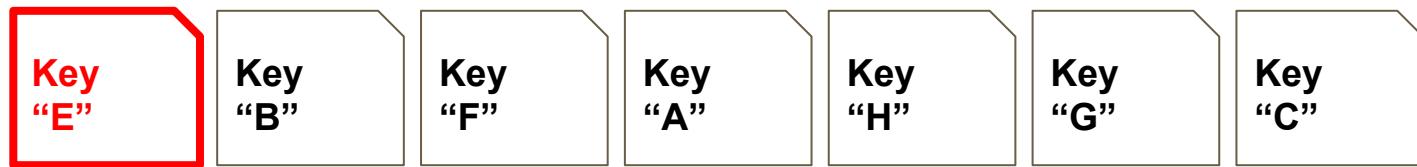
Cluster and Data Organisation

Cluster Overview:



Cluster and Data Organisation

Step 2: Doc_2 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 2: Doc_2 is to be stored, it goes to P1.



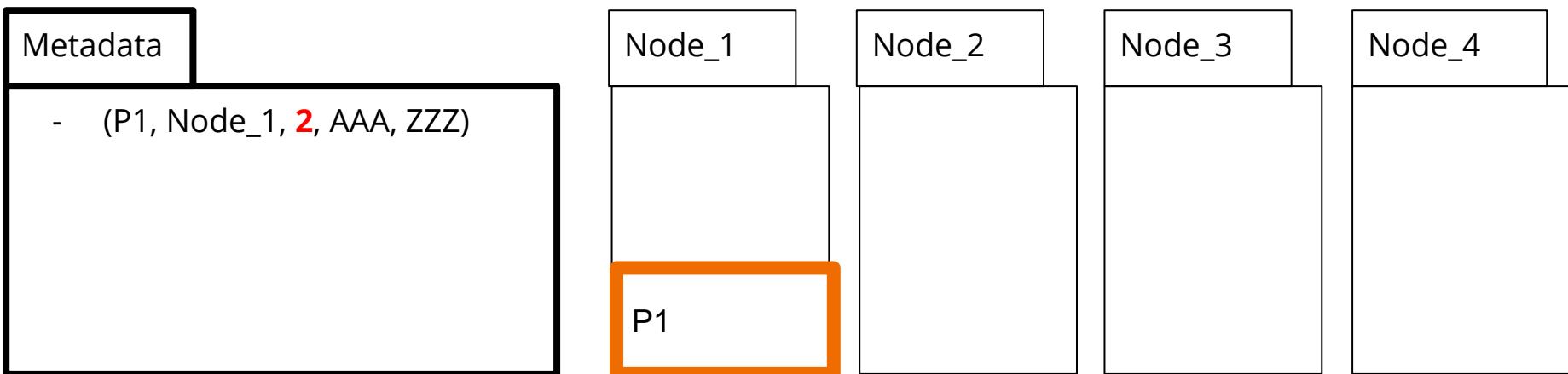
P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Cluster Overview:



Cluster and Data Organisation

Step 3: Doc_3 is to be stored, it goes to P1.



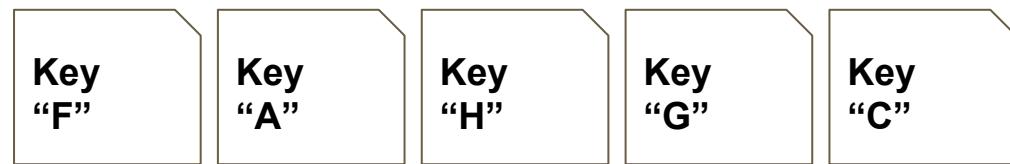
P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 3: Doc_3 is to be stored, it goes to P1.



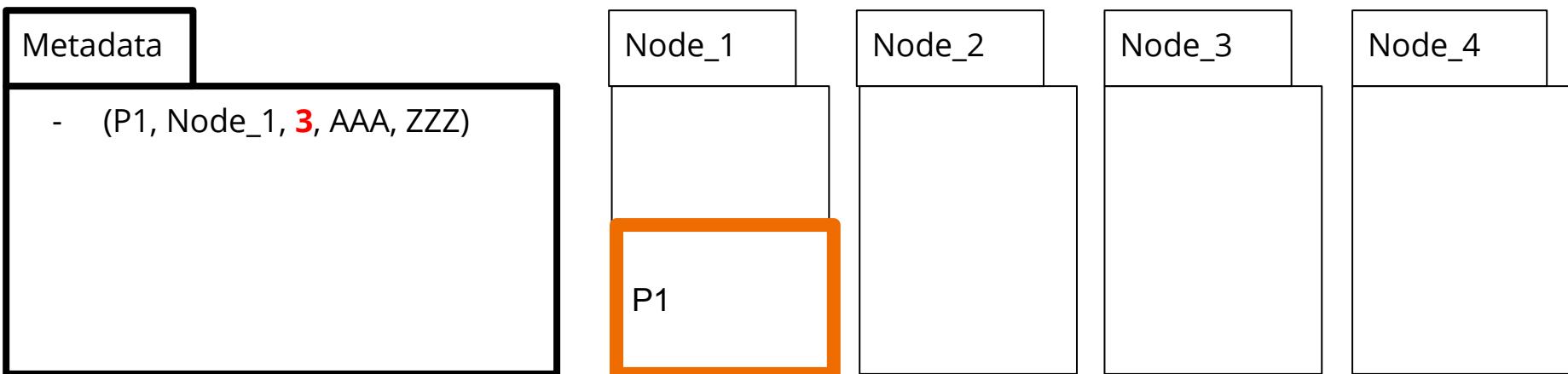
P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

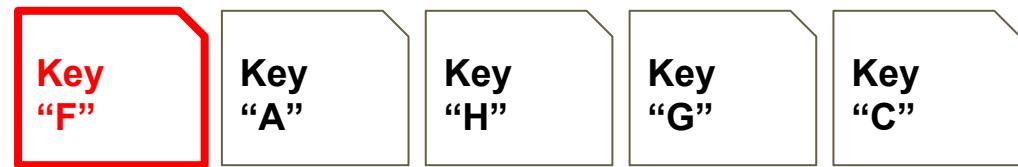
Cluster Overview:



Cluster and Data Organisation

Step 4: Doc_4 is to be stored, it goes to P1.

Split daemon splits P1 into P1 and P2.



P1



P1: Shard key range: [AAA, ZZZ)

Cluster and Data Organisation

Step 4: Doc_4 is to be stored, it goes to P1.

Split daemon splits P1 into P1 and P2.

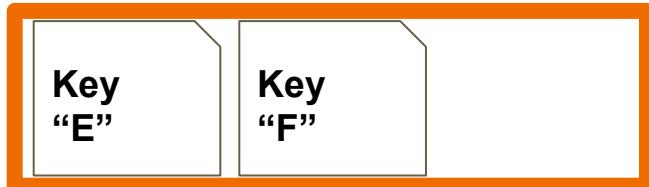


P1



P1: Shard key range: [AAA, E)

P2

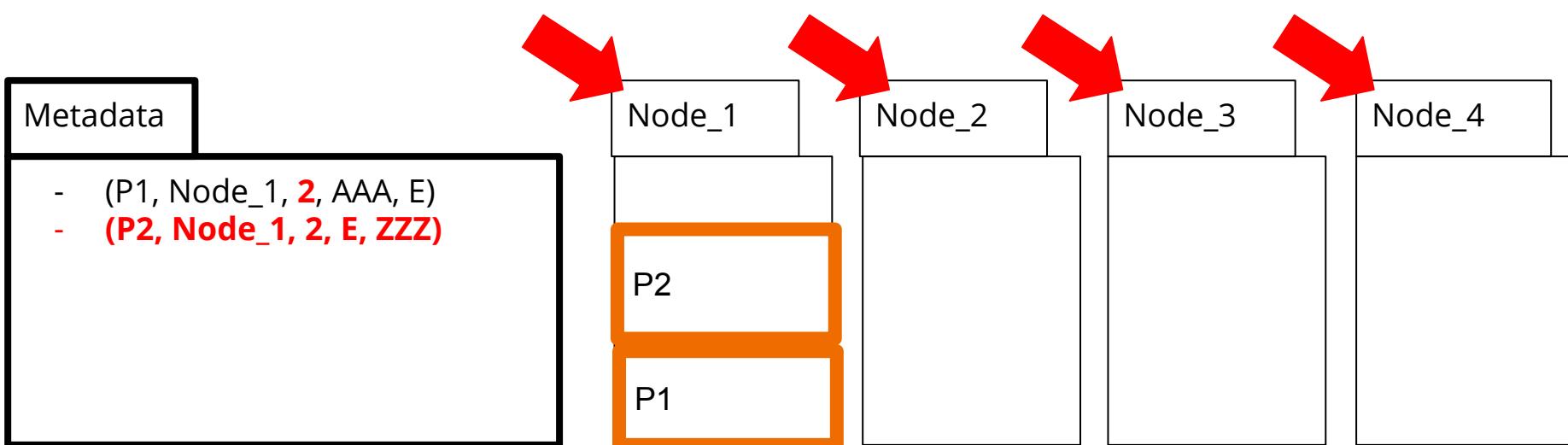


P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

Cluster Overview:

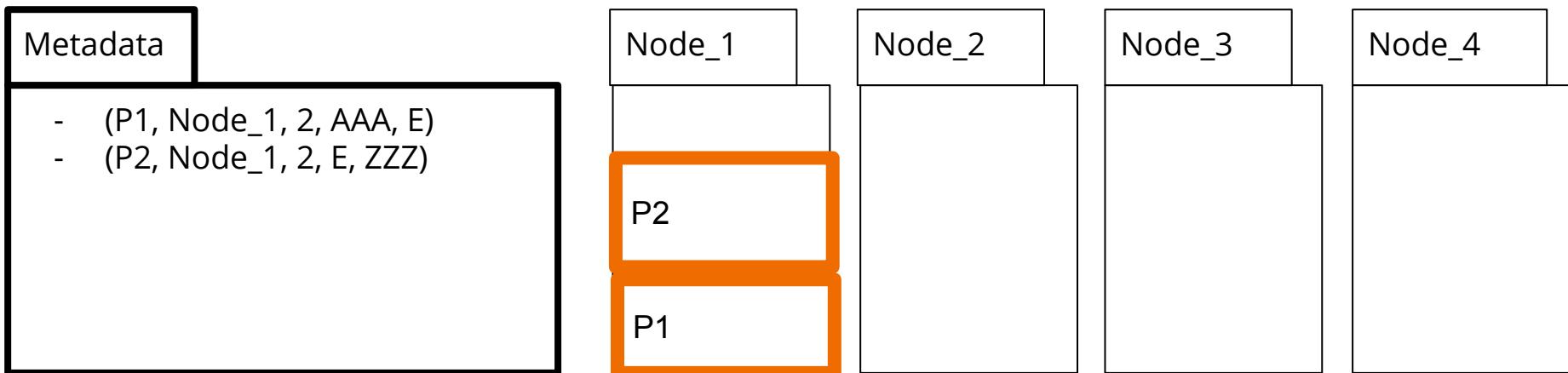
With the creation of the new partition P2, now the difference between the node with most partitions (Node_1) and the one with less (Node_2, Node_3, Node_4) becomes **2**.



Cluster and Data Organisation

Cluster Overview:

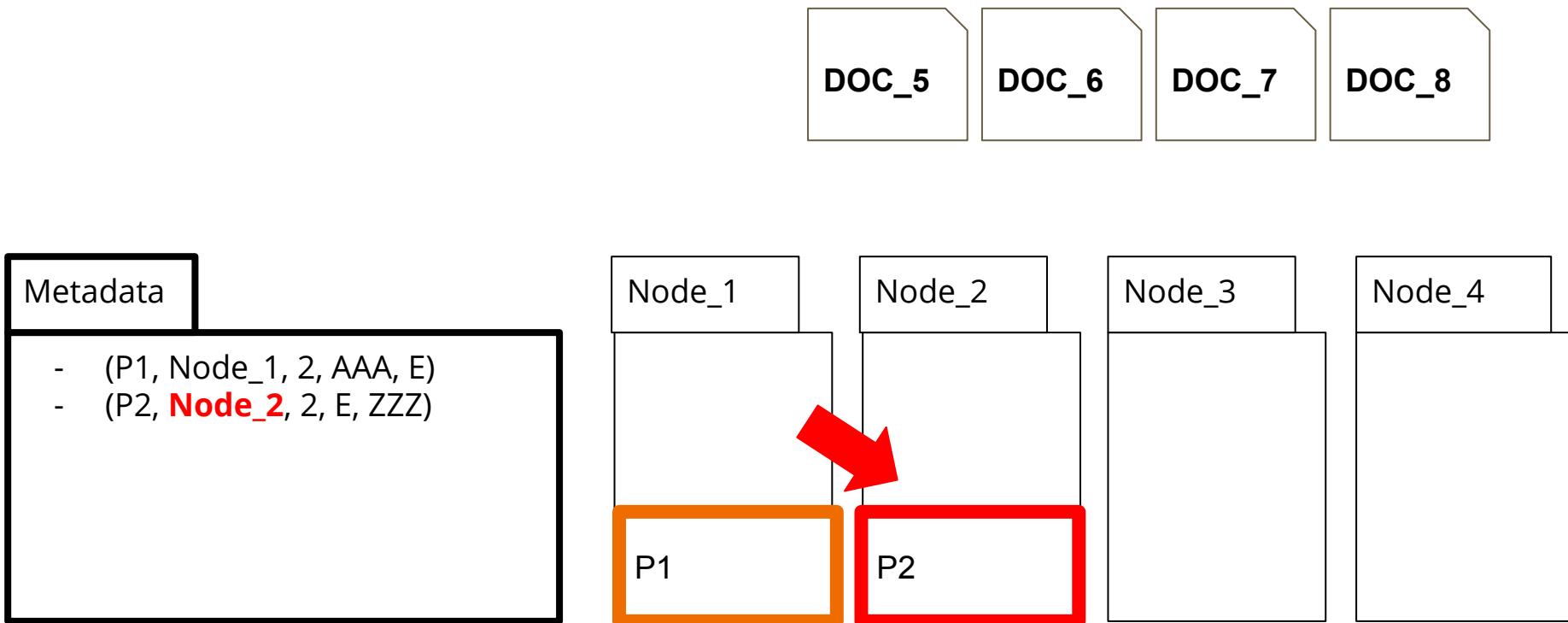
This triggers our **migrate** daemon, which enters in action to reduce this number.



Cluster and Data Organisation

Cluster Overview:

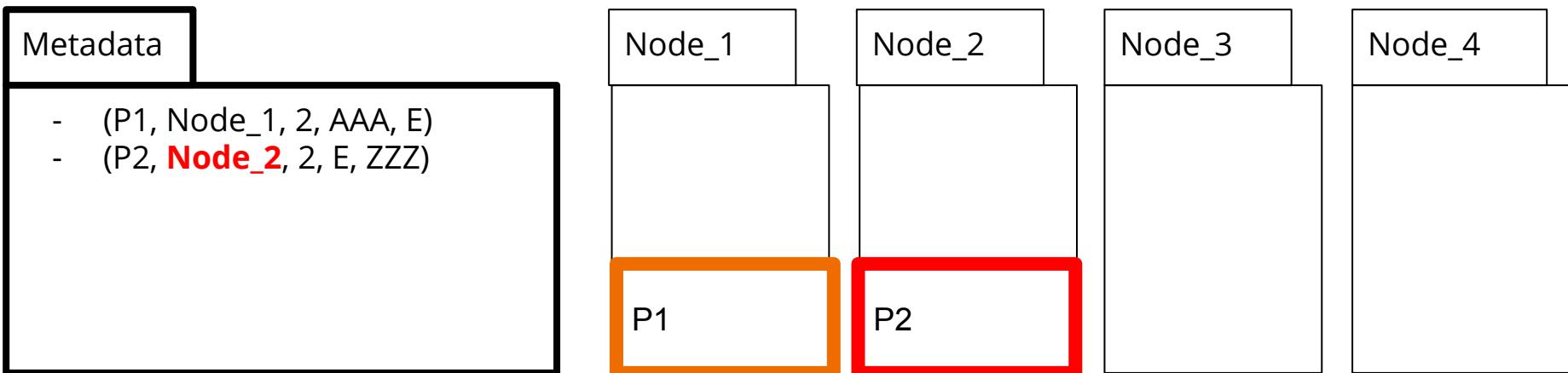
Migrate daemon migrates P2 from Node_1 to Node_2.



Cluster and Data Organisation

Cluster Overview:

Migrate daemon migrates P2 from Node_1 to Node_2. This reduces the difference between the nodes with most partitions (Node_1, Node_2) and the ones with less (Node_3, Node_4) to just **1**.

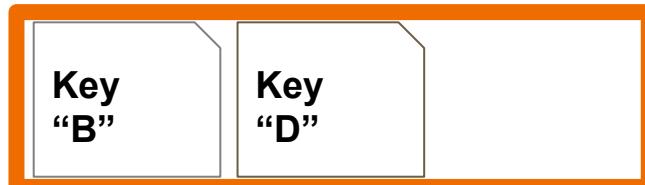


Cluster and Data Organisation

Step 5: Doc_5 is to be stored, it goes to P1.

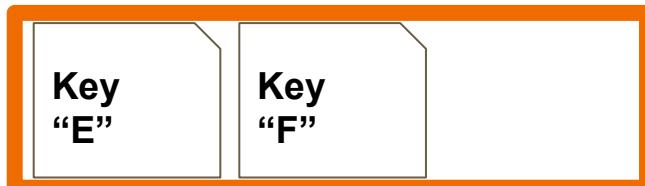


P1



P1: Shard key range: [AAA, E)

P2



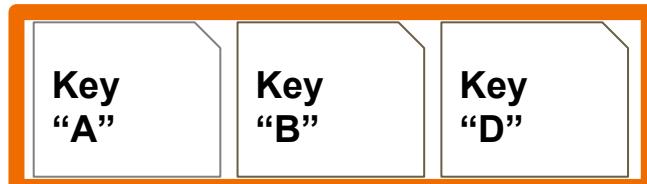
P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

Step 5: Doc_5 is to be stored, it goes to P1.



P1



P1: Shard key range: [AAA, E)

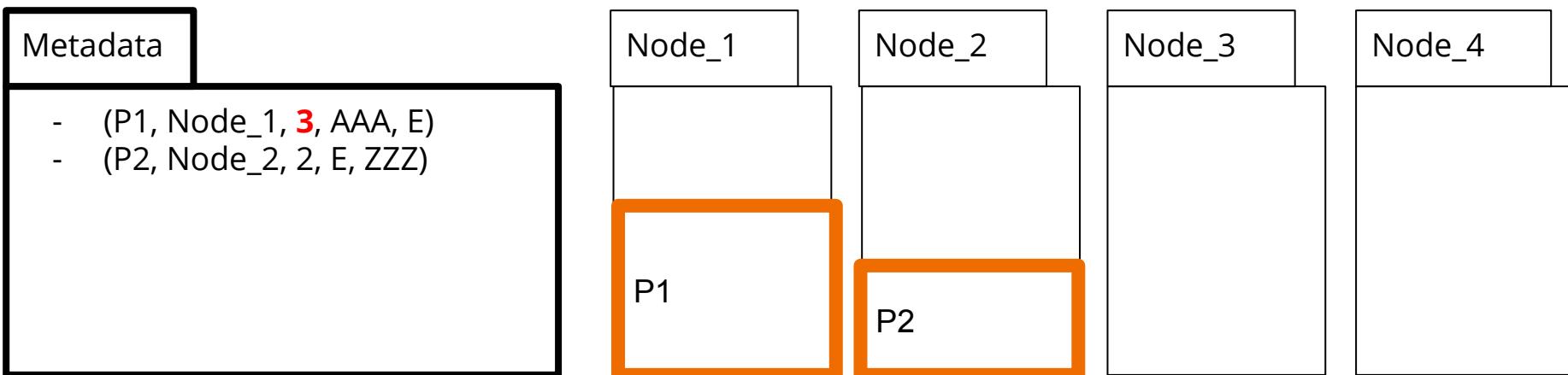
P2



P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

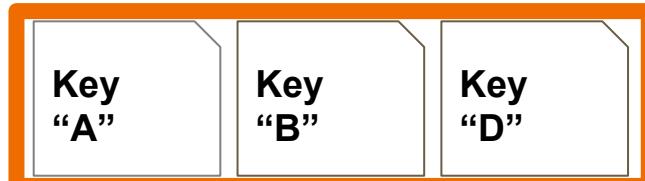
Cluster Overview:



Cluster and Data Organisation

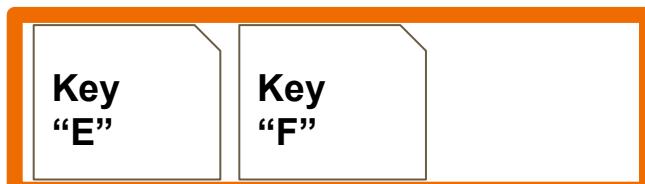
Step 6: Doc_6 is to be stored, it goes to P2.

P1



P1: Shard key range: [AAA, E)

P2



P2: Shard key range: [E, ZZZ)



Cluster and Data Organisation

Step 6: Doc_6 is to be stored, it goes to P2.

P1



P1: Shard key range: [AAA, E)

P2

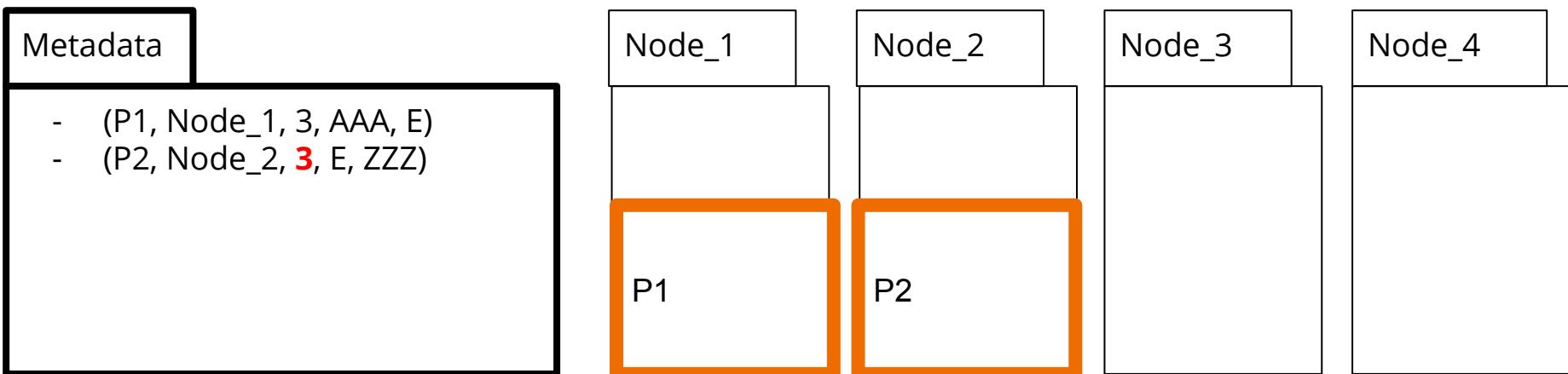


P2: Shard key range: [E, ZZZ)



Cluster and Data Organisation

Cluster Overview:



Cluster and Data Organisation

Step 7: Doc_7 is to be stored, it goes to P2.

The split daemon enters in action again and splits it into partitions P2 and P3, also updating their shard key ranges.



P1



P1: Shard key range: [AAA, E)

P2

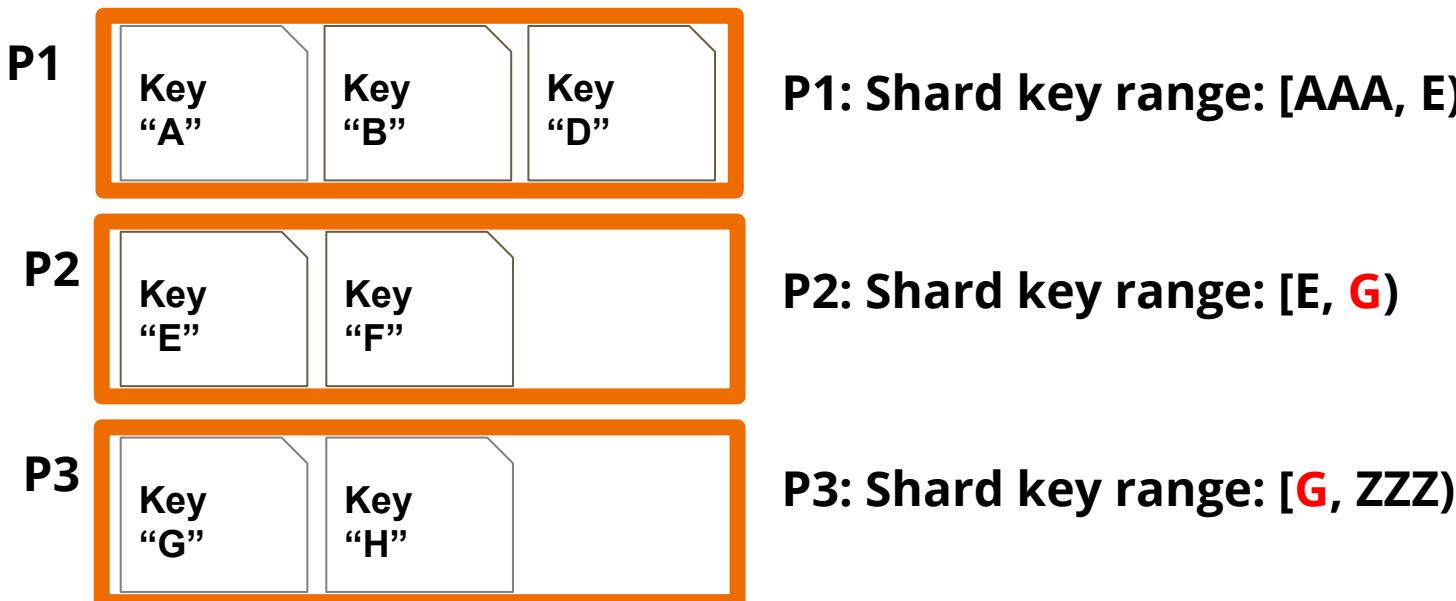


P2: Shard key range: [E, ZZZ)

Cluster and Data Organisation

Step 7: Doc_7 is to be stored, it goes to P2.

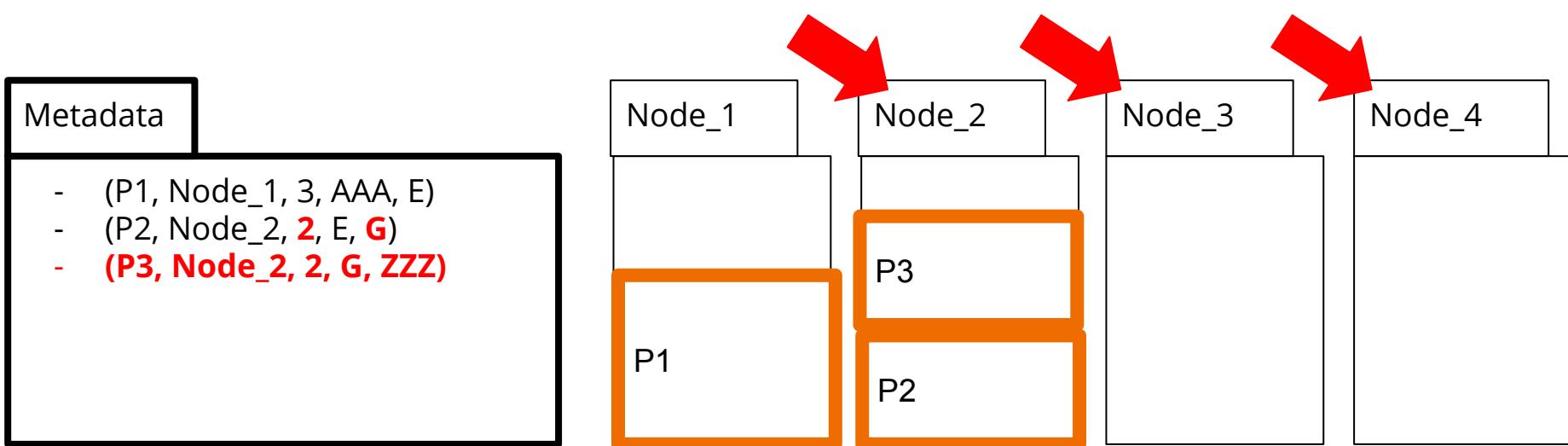
The split daemon enters in action again and splits it into partitions P2 and P3, also updating its shard key ranges.



Cluster and Data Organisation

Cluster Overview:

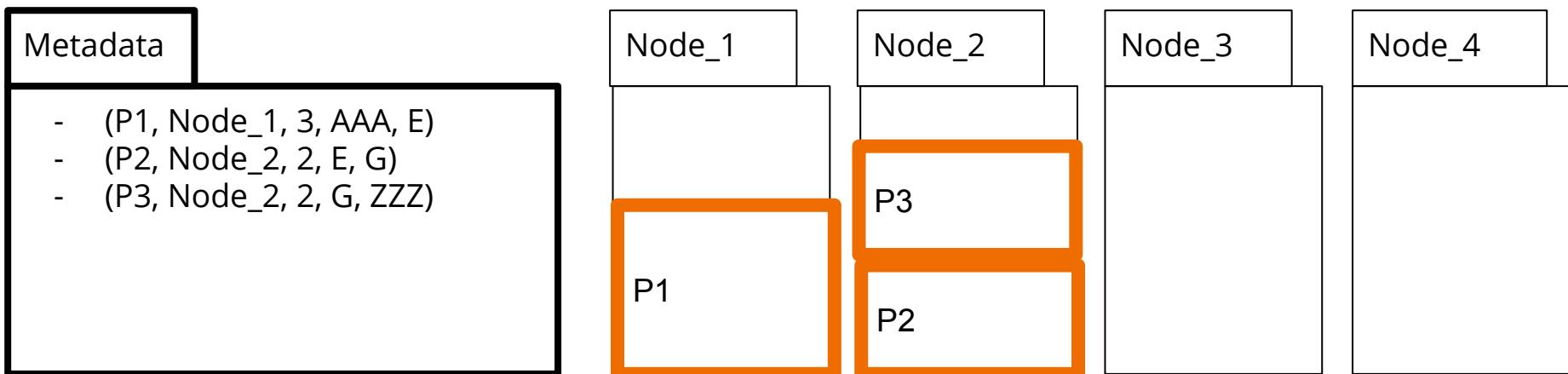
With the creation of the new partition P3, now the difference between the node with most partitions (Node_2) and the one with less (Node_3, Node_4) becomes again **2**.



Cluster and Data Organisation

Cluster Overview:

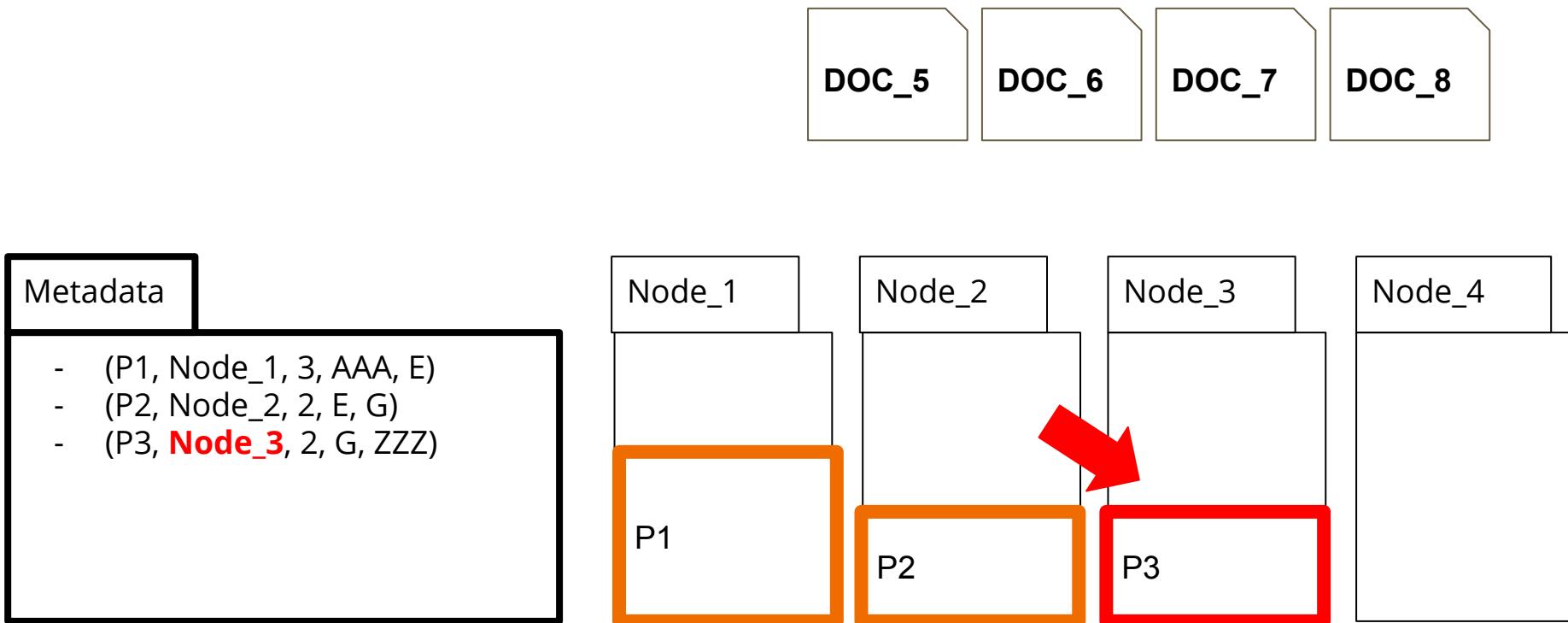
This triggers our **migrate** daemon, which enters in action to reduce this number.



Cluster and Data Organisation

Cluster Overview:

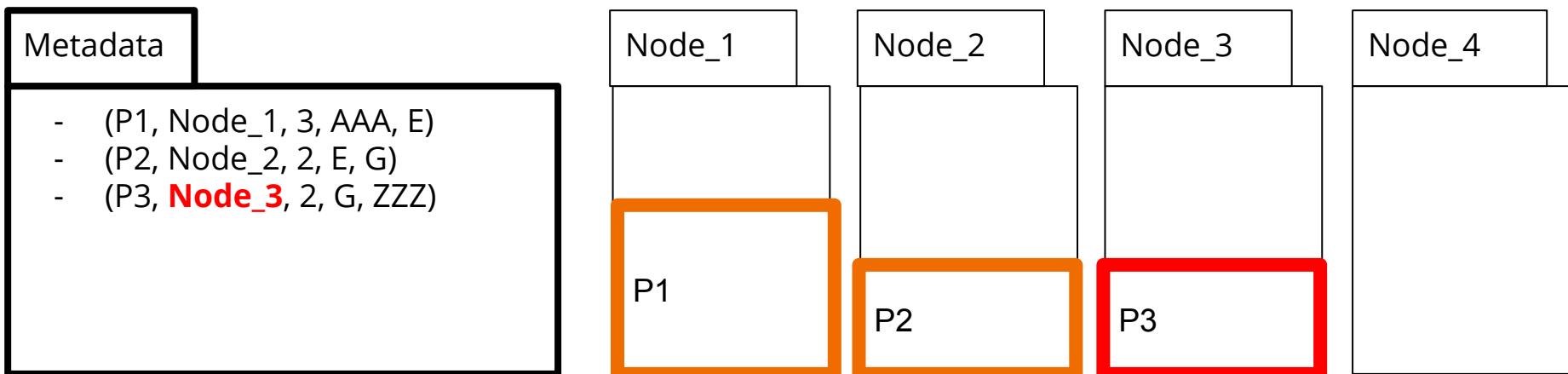
Migrate daemon migrates P3 from Node_2 to Node_3.



Cluster and Data Organisation

Cluster Overview:

Migrate daemon migrates P3 from Node_2 to Node_3. This reduces the difference between the nodes with most partitions (Node_1, Node_2, Node_3) and the one with less (Node_4) to just **1**.

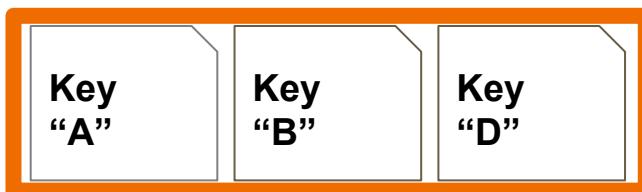


Cluster and Data Organisation

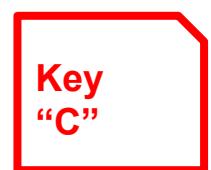
Step 8: Doc_8 is to be stored, it goes to P1.

The split daemon enters in action again and splits it into partitions P1 and P4, also updating their shard key ranges.

P1



P1: Shard key range: [AAA, E)



P2



P2: Shard key range: [E, G)

P3



P3: Shard key range: [G, ZZZ)

Cluster and Data Organisation

Step 8: Doc_8 is to be stored, it goes to P1.

The split daemon enters in action again and splits it into partitions P1 and P4, also updating their shard key ranges.

P1



P1: Shard key range: [AAA, C)

P2



P2: Shard key range: [E, G)

P3



P3: Shard key range: [G, ZZZ)

P4

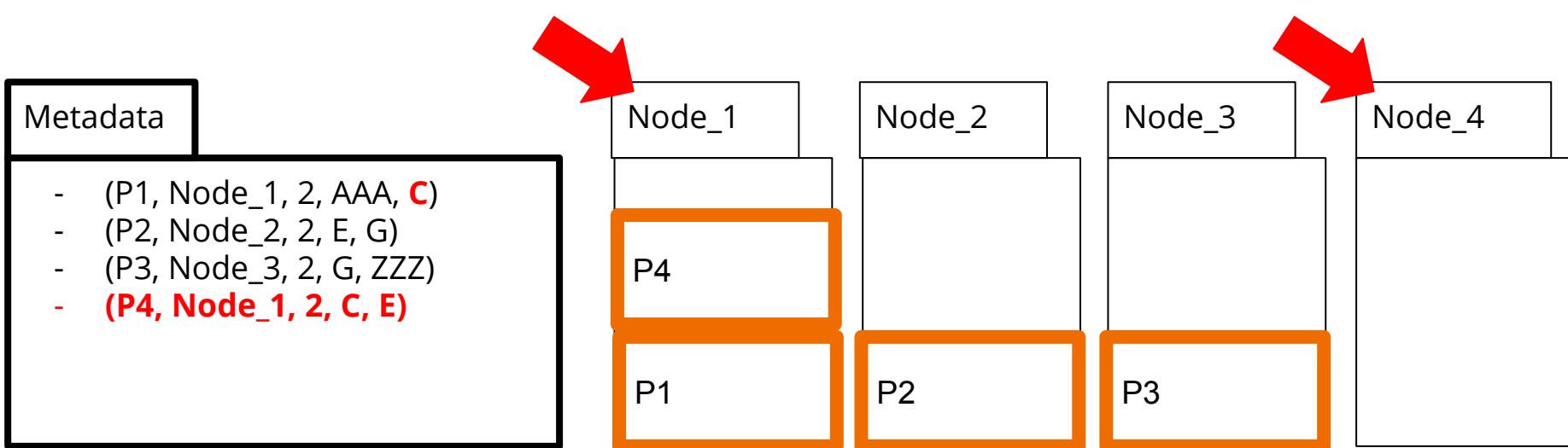


P4: Shard key range: [C, E)

Cluster and Data Organisation

Cluster Overview:

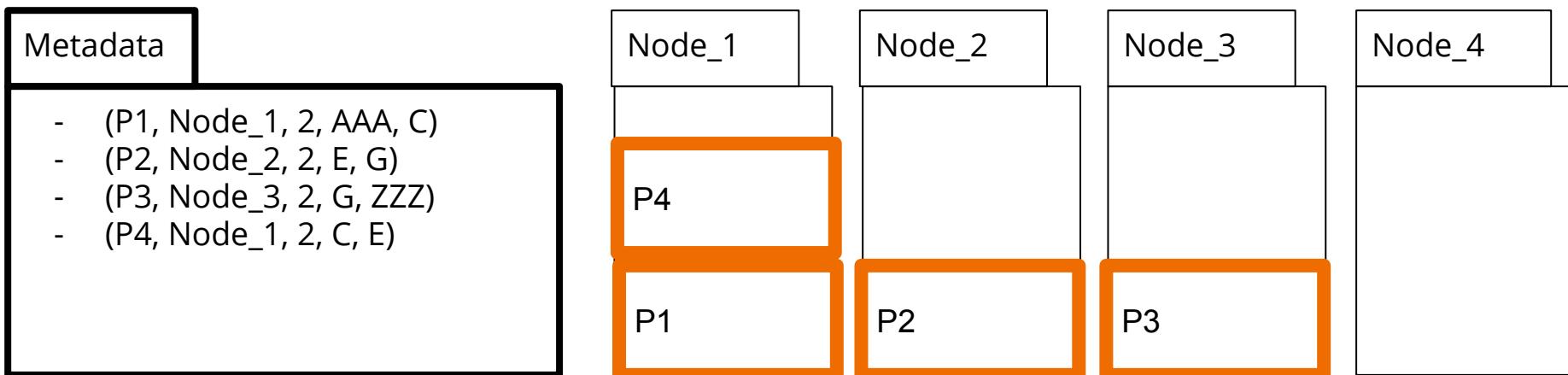
With the creation of the new partition P4, now the difference between the node with most partitions (Node_1) and the one with less (Node_4) becomes again **2**.



Cluster and Data Organisation

Cluster Overview:

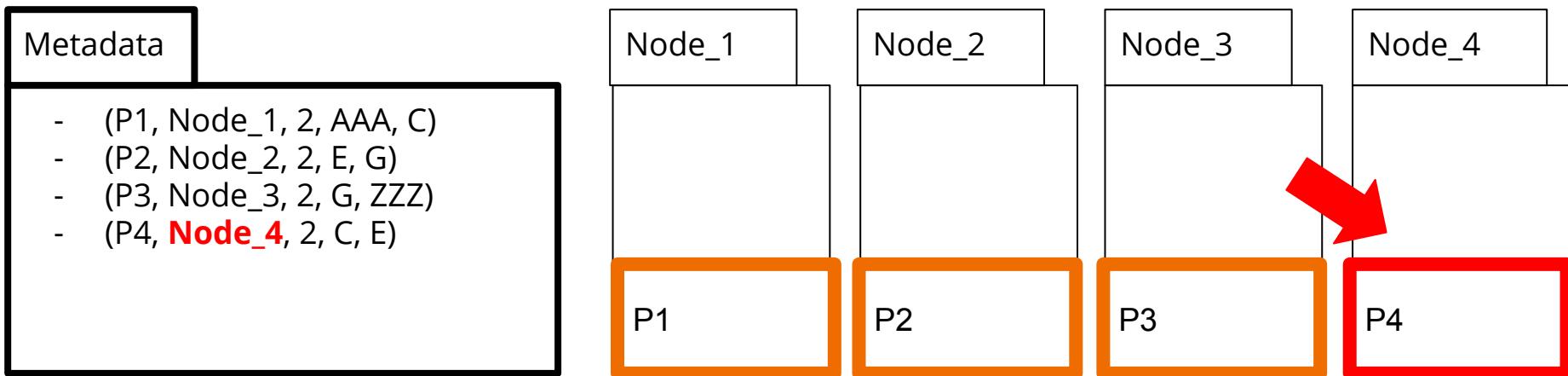
This triggers our **migrate** daemon, which enters in action to reduce this number.



Cluster and Data Organisation

Cluster Overview:

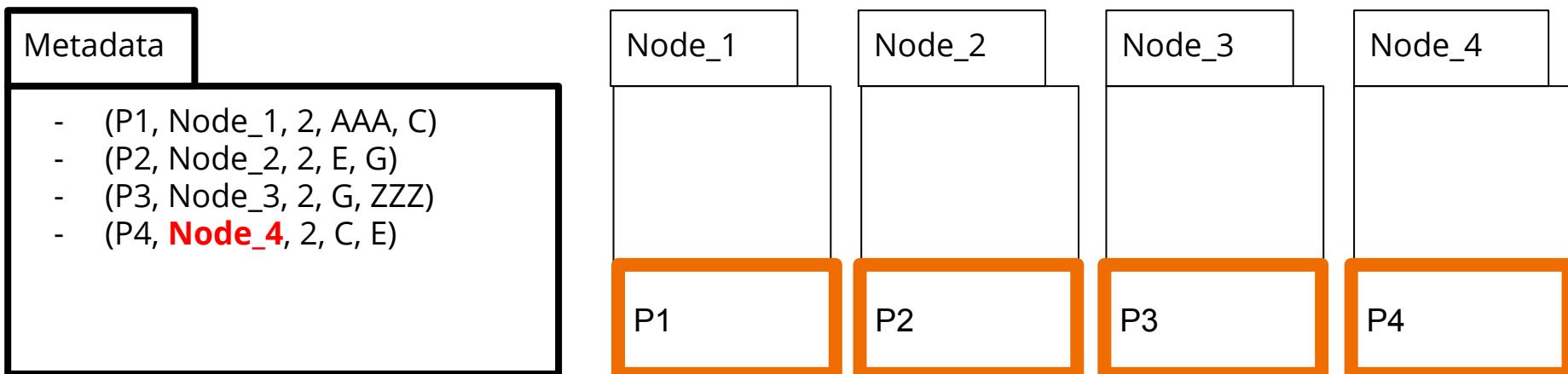
Migrate daemon migrates P4 from Node_1 to Node_4.



Cluster and Data Organisation

Cluster Overview:

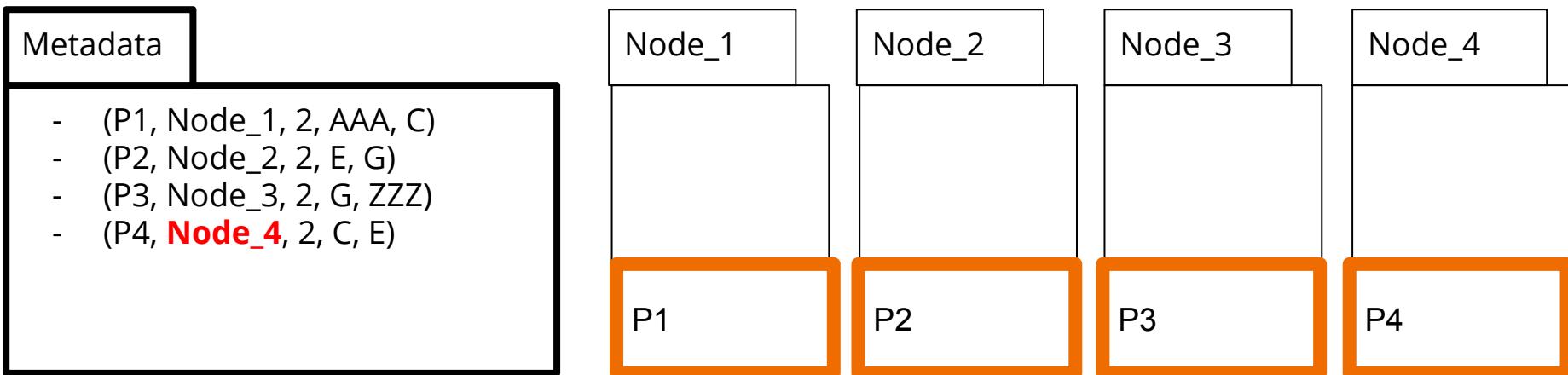
Migrate daemon migrates P4 from Node_1 to Node_4. This reduces the difference between the nodes with most partitions (Node_1, Node_2, Node_3, Node_4) and the one with less (Node_1, Node_2, Node_3, Node_4) becomes **0**.



Cluster and Data Organisation

Cluster Overview:

This concludes our simulation!

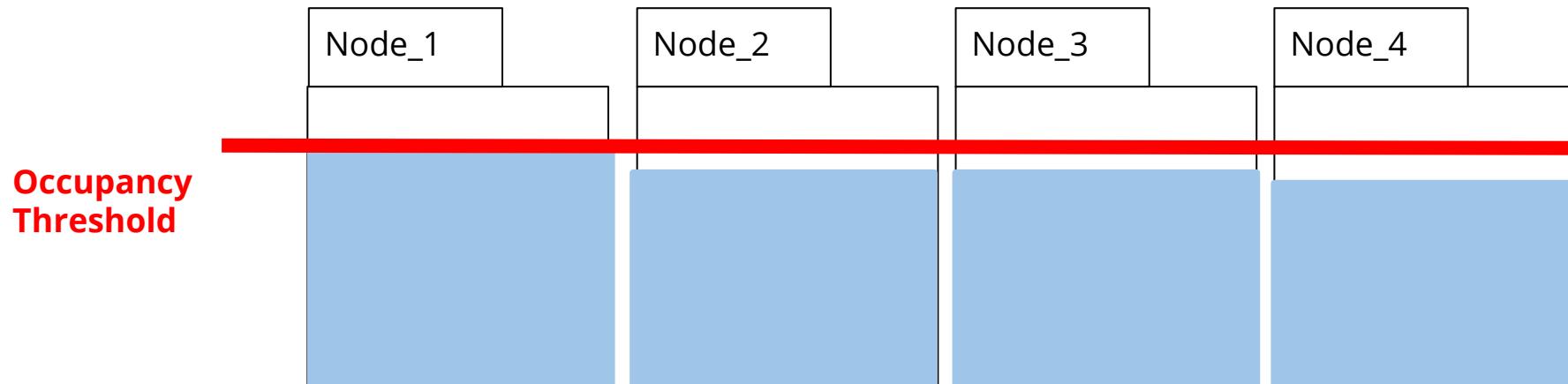


Cluster and Data Organisation

Auto-scale.

- As a last remark, as previously described, more shard nodes can be incorporated to deal with data scalability.
 - Policy Example: When no existing shard node can host the migration, create a new node.

AUTO-SCALING TRIGGERS CREATION OF A NEW NODE

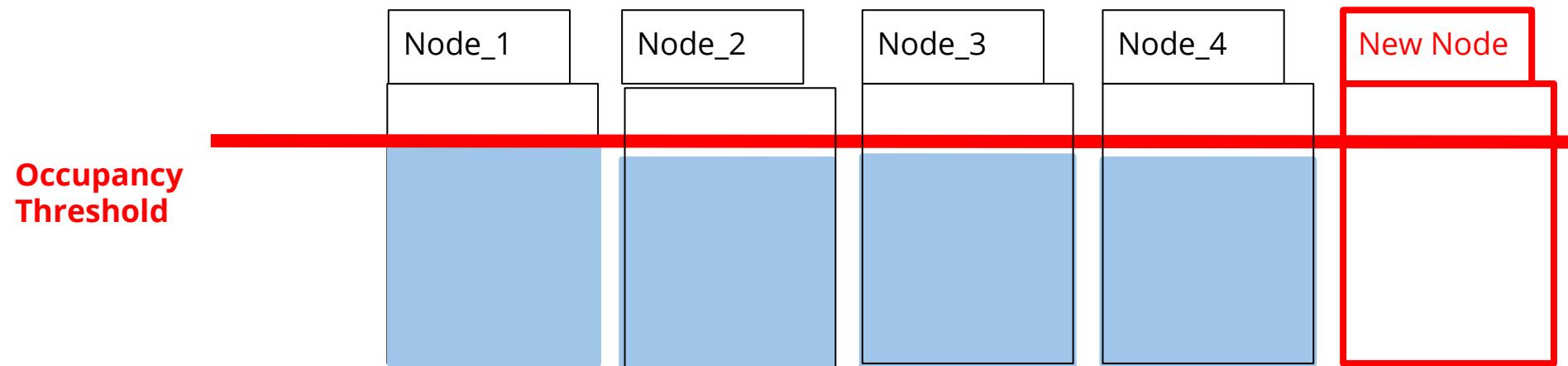


Cluster and Data Organisation

Auto-scale.

- To deal with data scalability, creation of new nodes can be automated following a concrete policy.
 - Policy Example: When no existing shard node can host the migration, create a new node.

WITH THE NEW NODE WE CAN CONTINUE STORING DATA



Outline

1. Setting the Context.
2. MongoDB: Conceptual Approach.
 - a. MongoDB Intro.
 - b. Cluster and Data Organisation.
3. MongoDB: Demonstrating Split and Migrate.
4. My Cluster Simulator: Split, Migrate and Auto-scale.

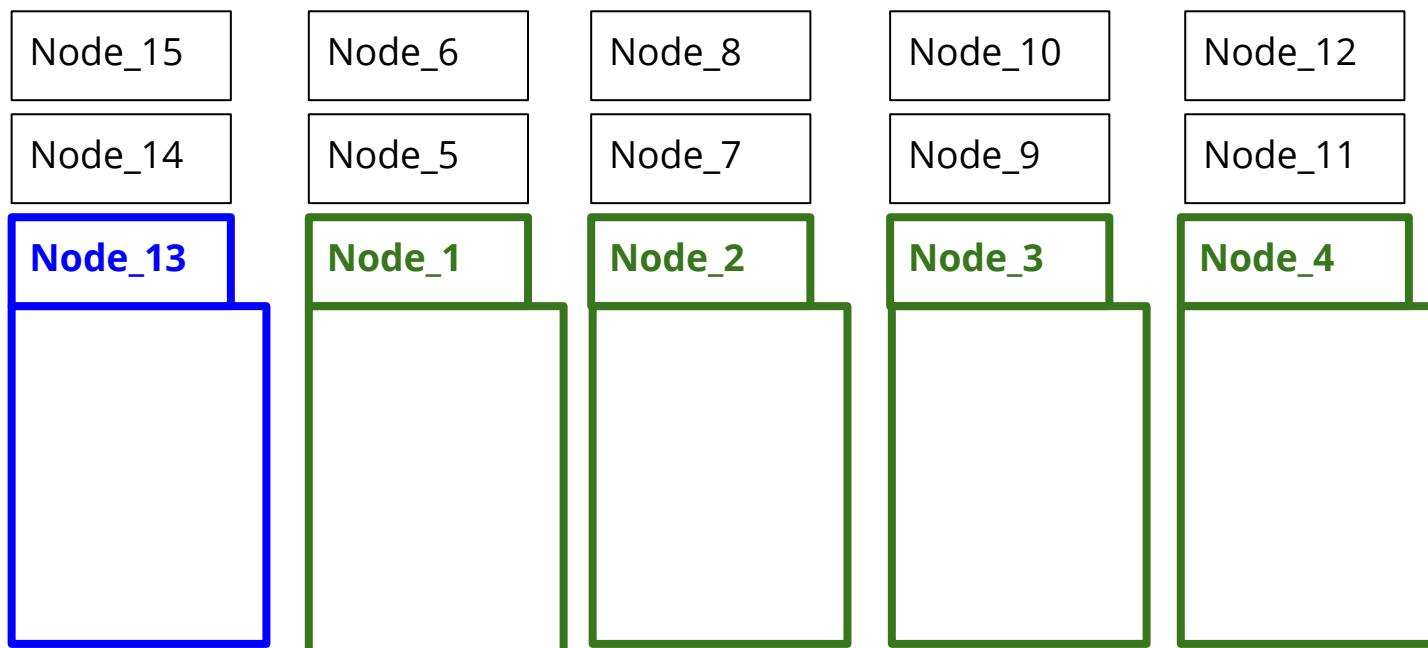
Outline

1. Setting the Context.
2. MongoDB: Conceptual Approach.
3. MongoDB: Demonstrating Split and Migrate.
4. My Cluster Simulator: Split, Migrate and Auto-scale.

MongoDB: Demonstrating Split and Migrate

Let's demonstrate the **split** and **migrate** daemons using:

- Our own laptop as a cluster (with Ubuntu 18.04)



MongoDB: Demonstrating Split and Migrate

- Although MongoDB is though for running in a cluster with $n > 1$ machines, we can do the simulation just with 1 machine by having it working in pseudo-distributed mode.

MongoDB: Demonstrating Split and Migrate

- Indeed, conceptually a MongoDB “Node” is nothing more than a database engine, characterised by:
 - The machine in which it is running.



MongoDB: Demonstrating Split and Migrate

- Indeed, conceptually a MongoDB “Node” is nothing more than a database engine, characterised by:
 - The machine in which it is running.
 - The folder of the machine in which it stores its data.



MongoDB: Demonstrating Split and Migrate

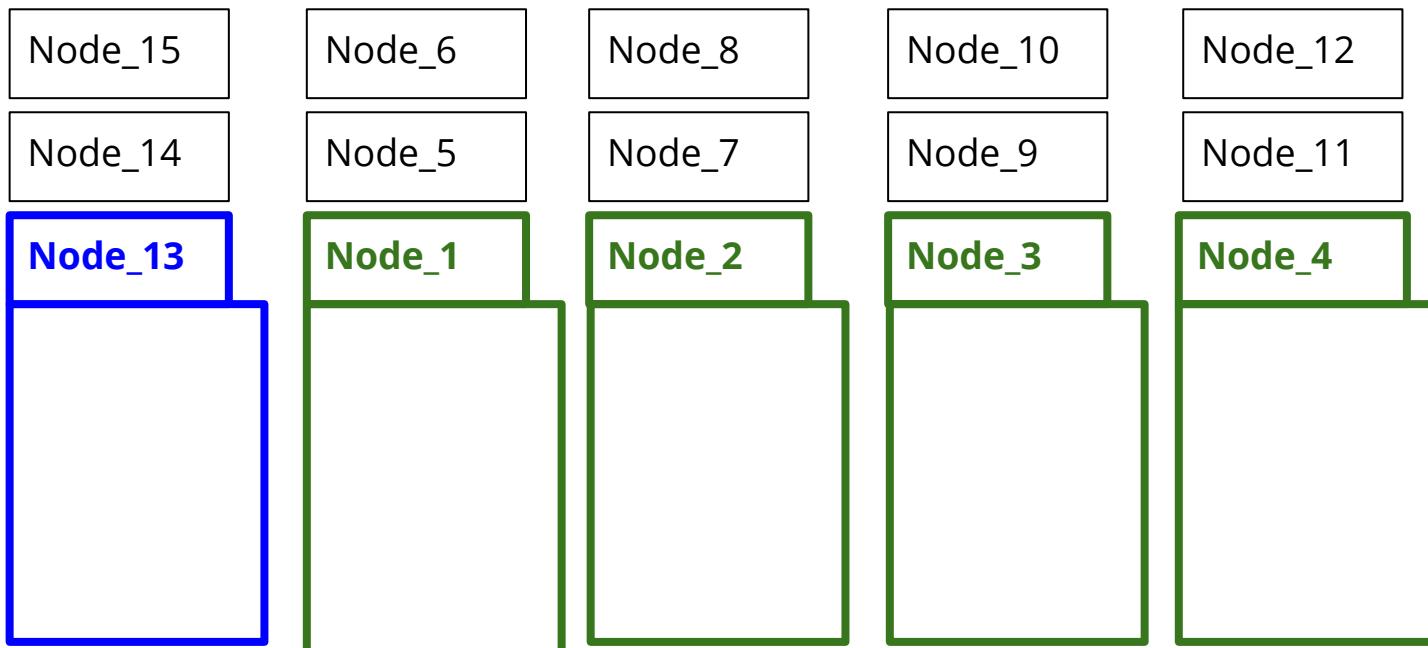
- Indeed, conceptually a MongoDB “Node” is nothing more than a database engine, characterised by:
 - The machine in which it is running.
 - The folder of the machine in which it stores its data.
 - The port of the machine it listens to, so that clients can connect to it.



MongoDB: Demonstrating Split and Migrate

Let's demonstrate the **split** and **migrate** daemons using:

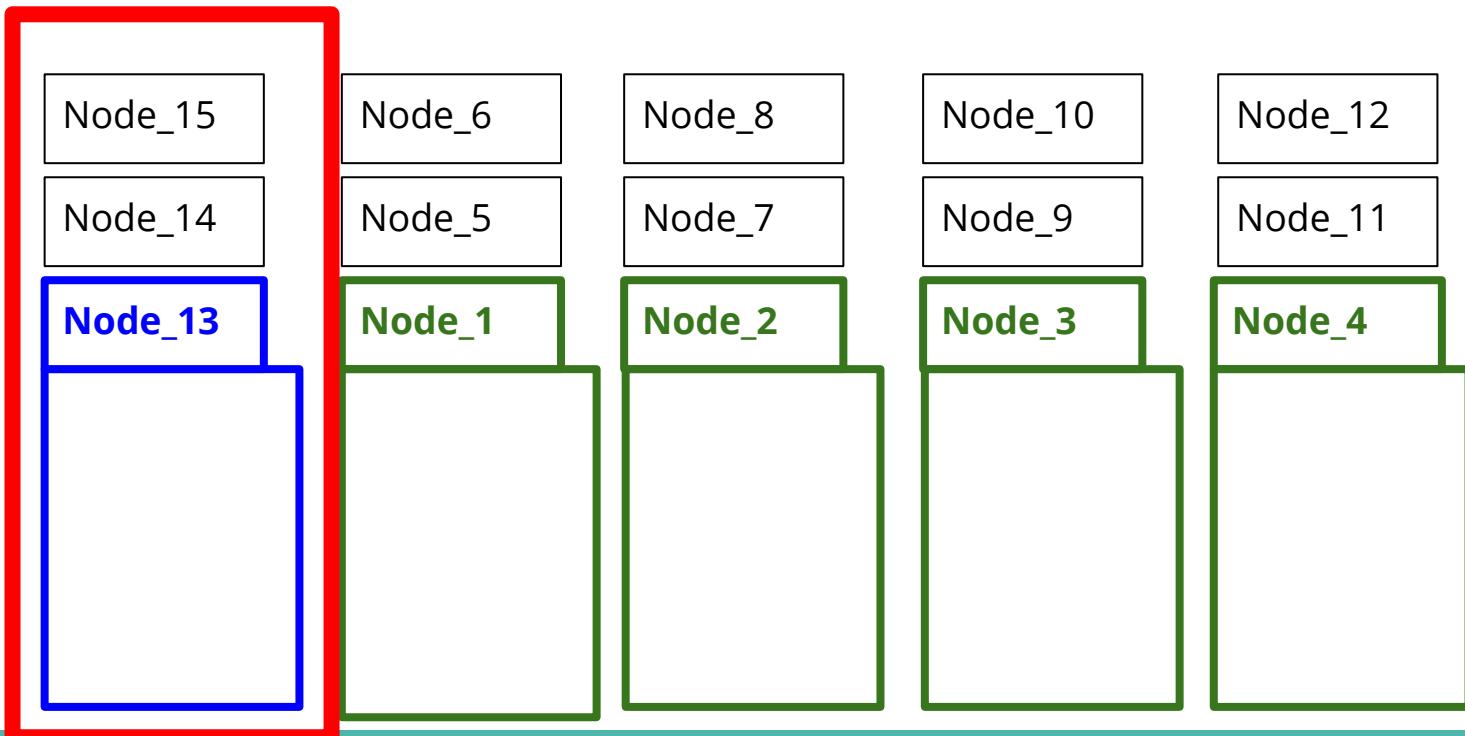
- Our own laptop as a cluster (with Ubuntu 18.04)
We simulate a cluster with the following Nodes:



MongoDB: Demonstrating Split and Migrate

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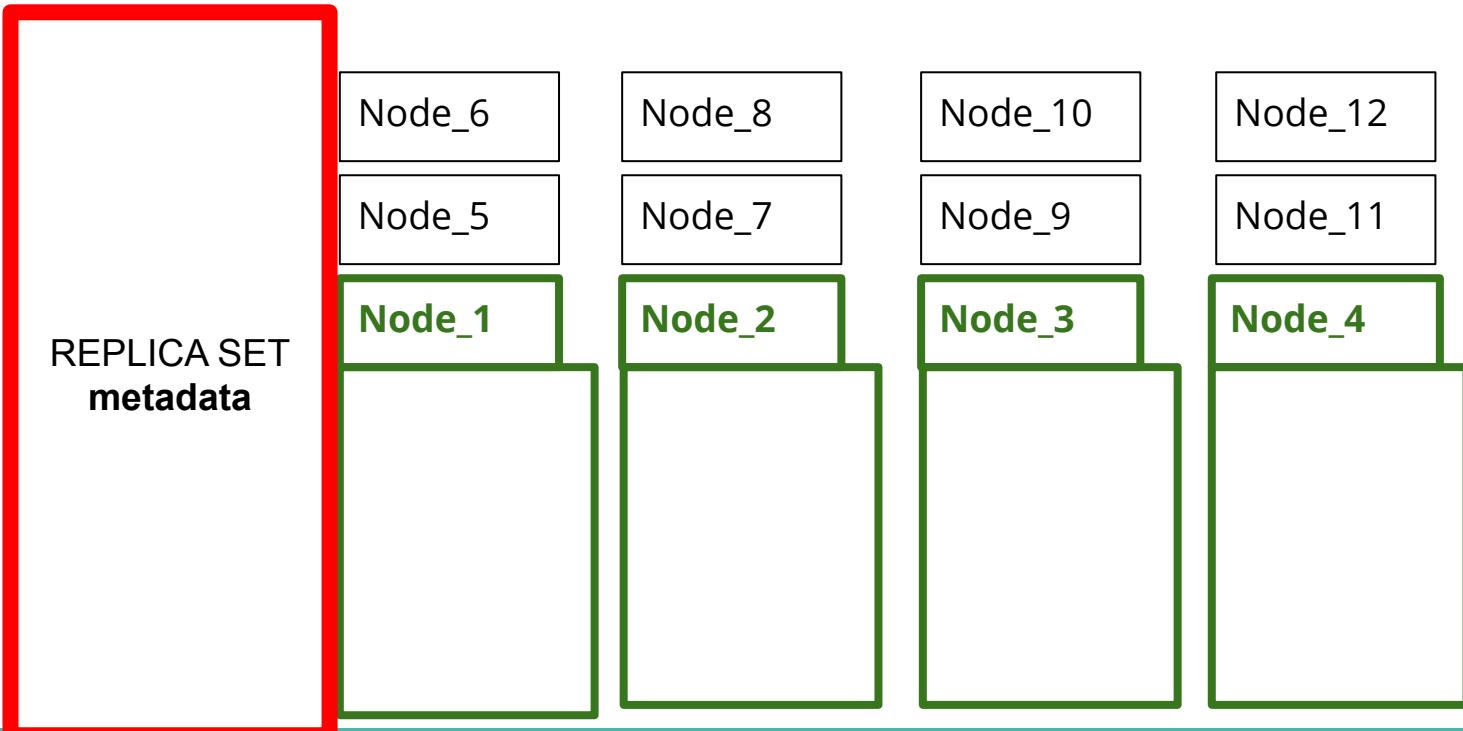
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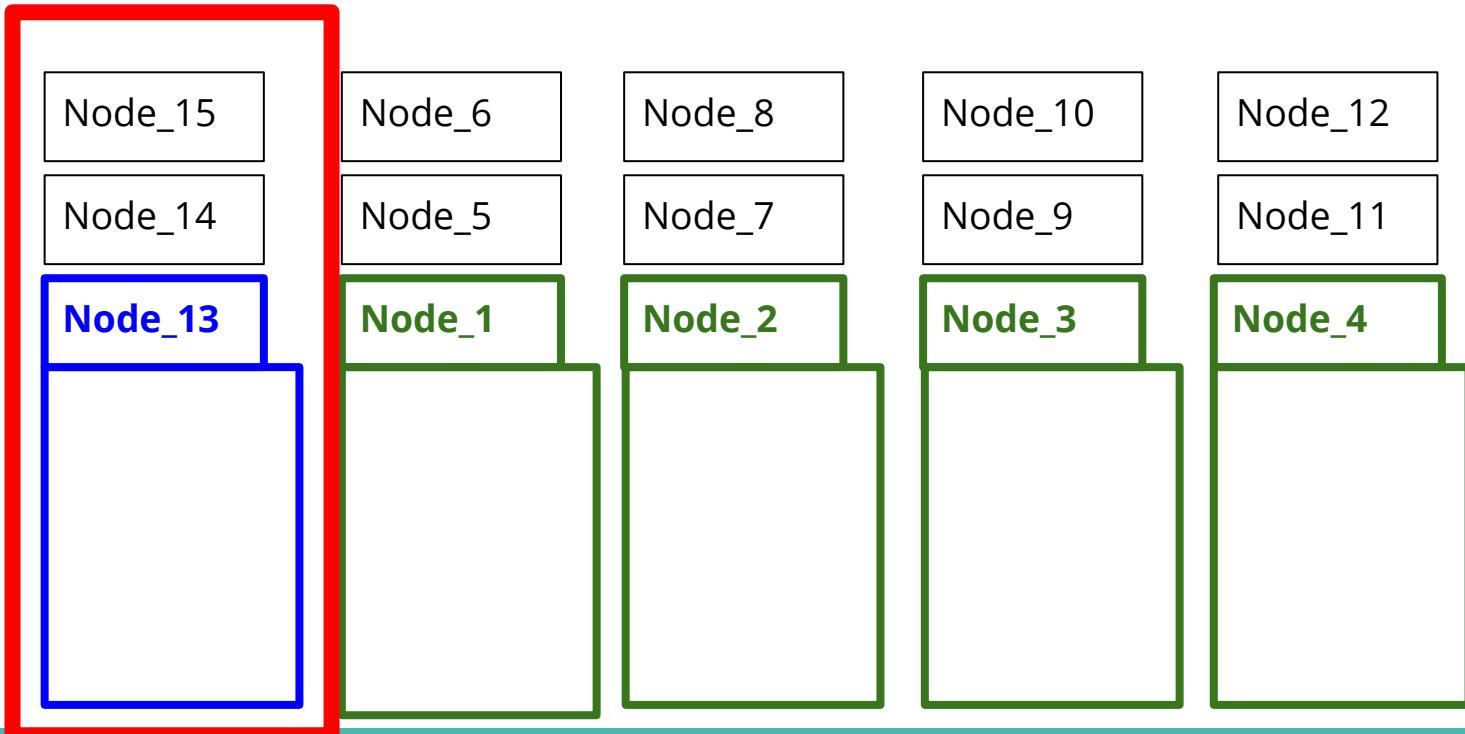
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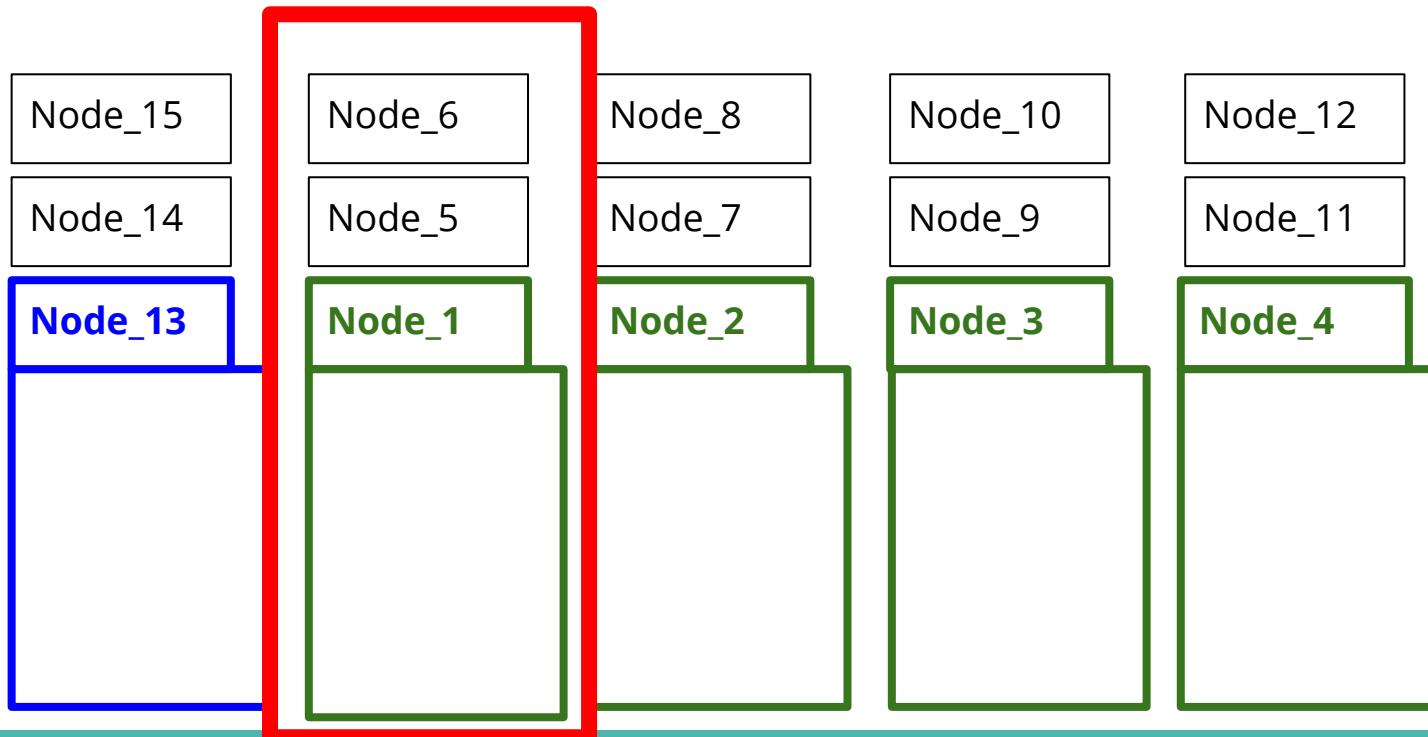
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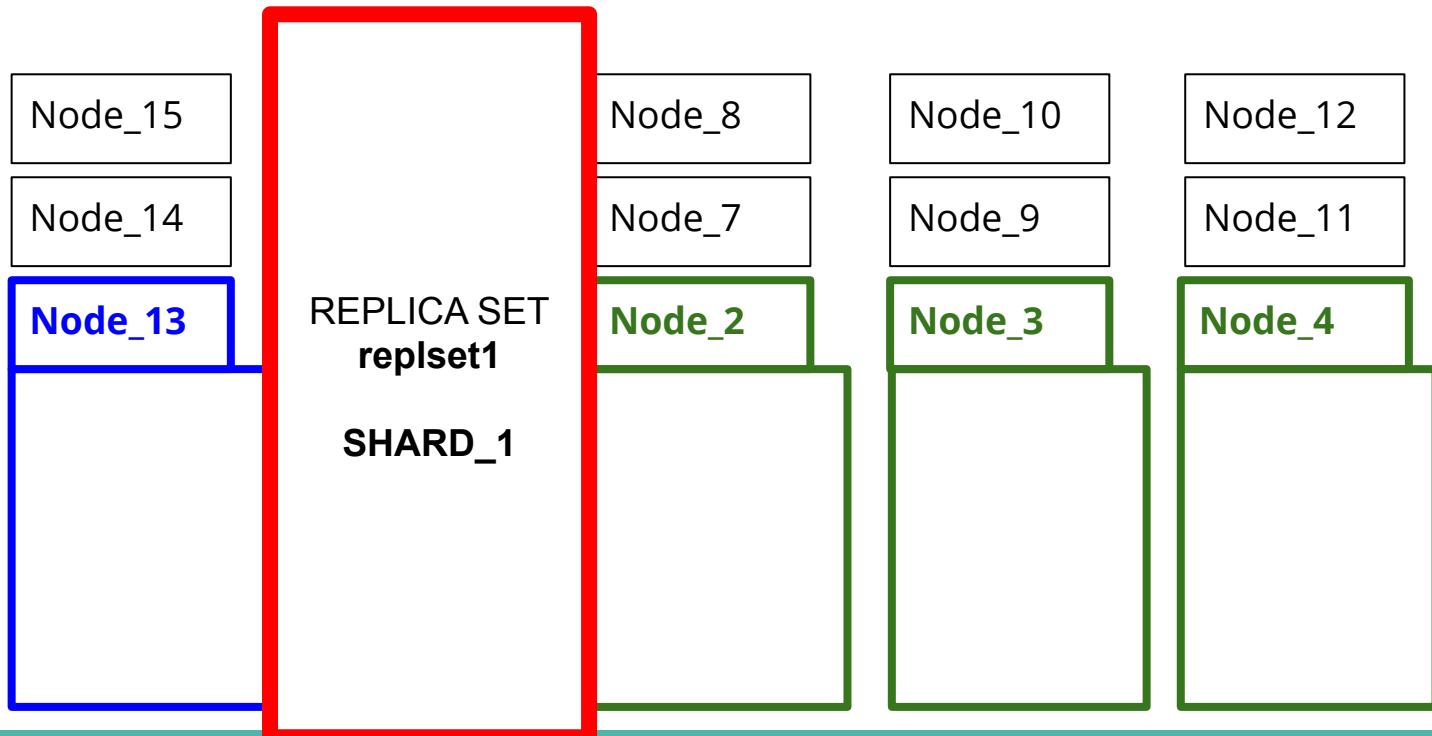
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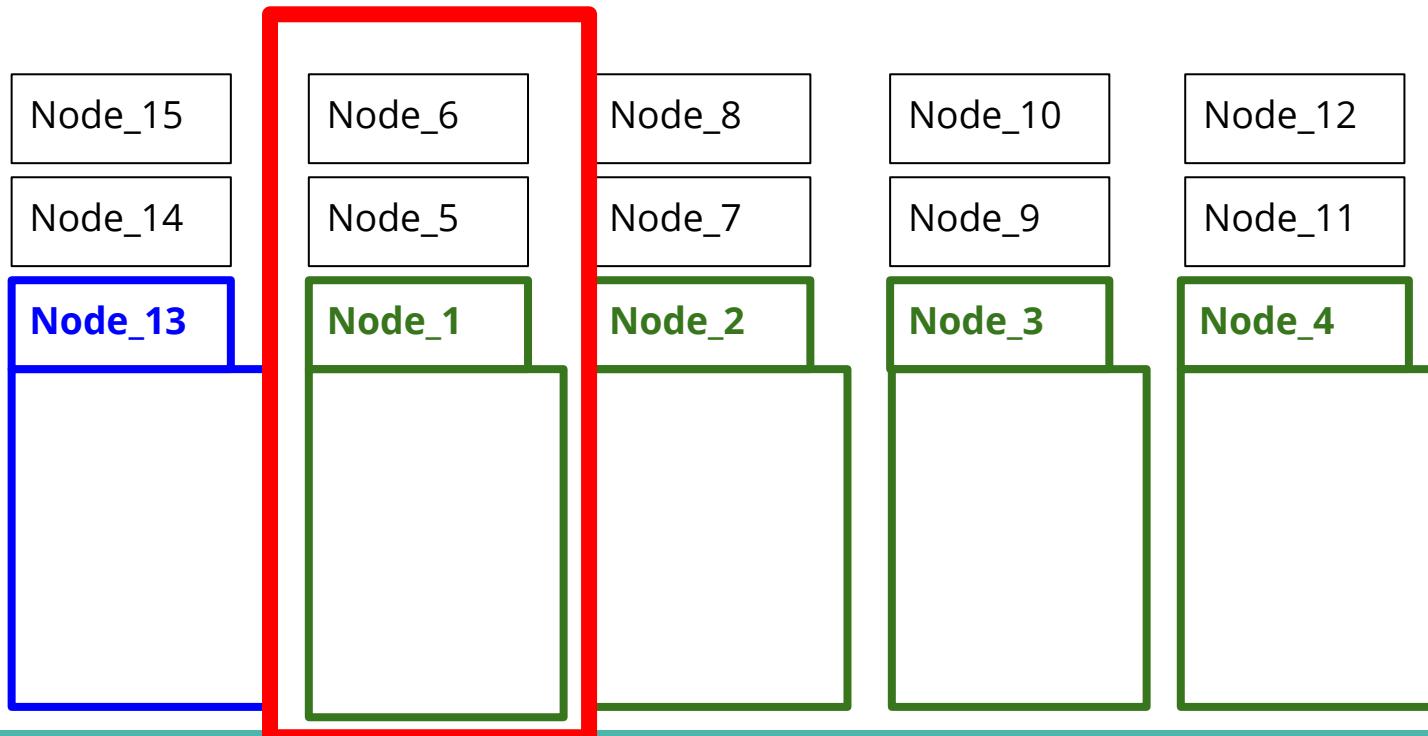
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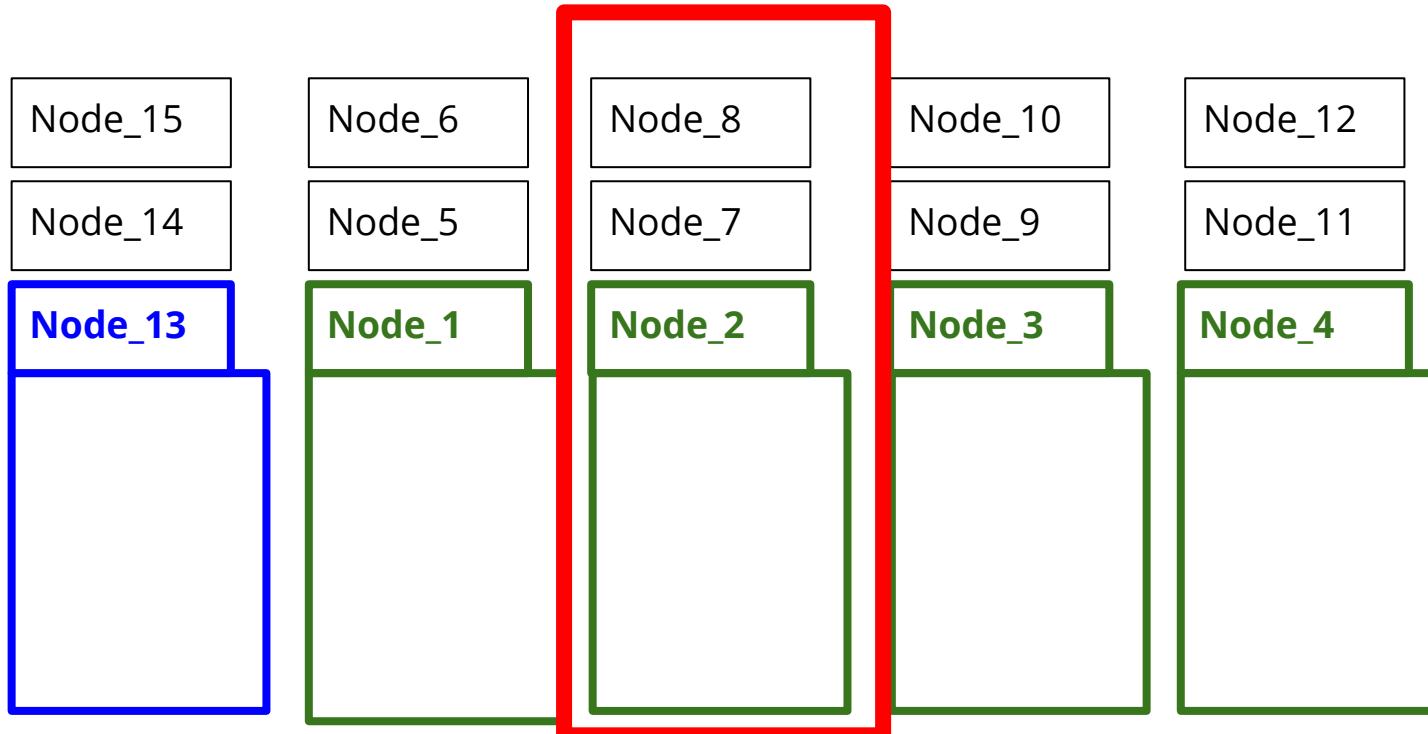
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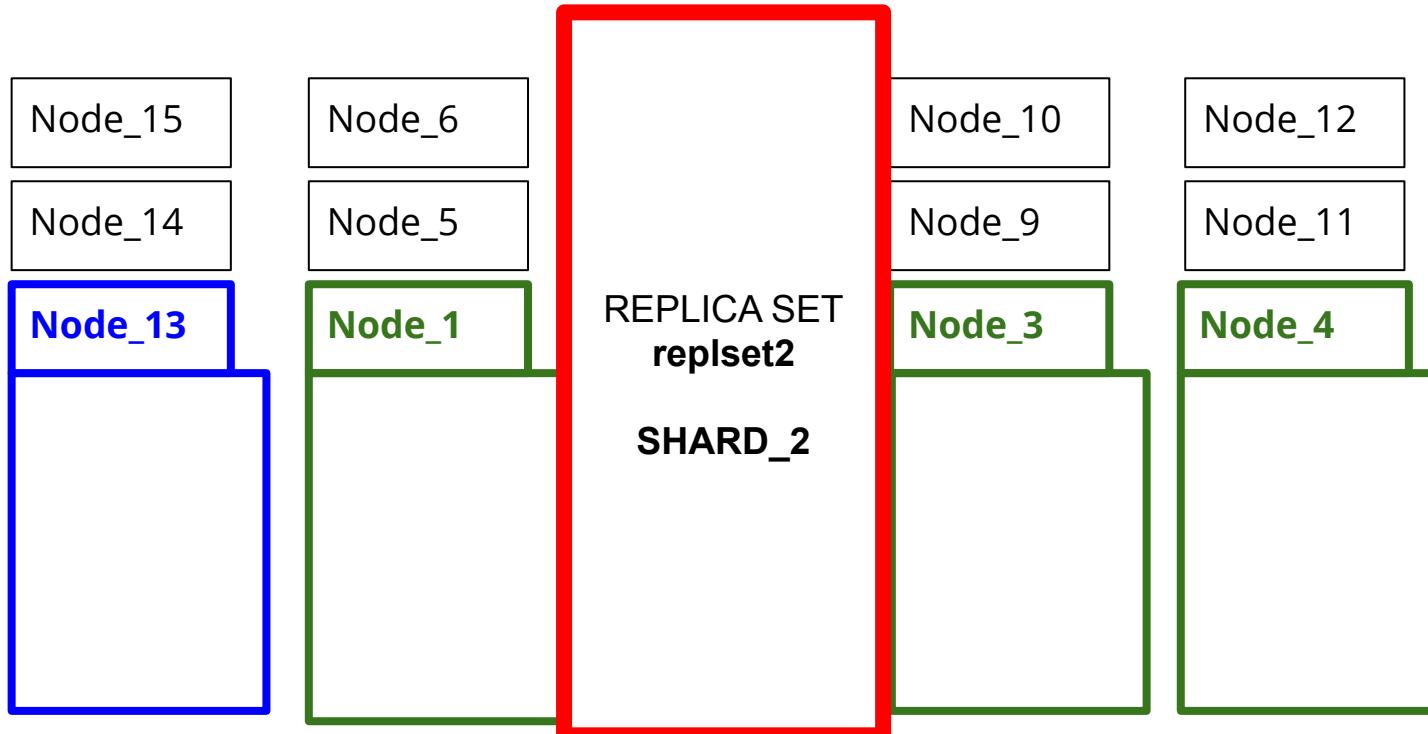
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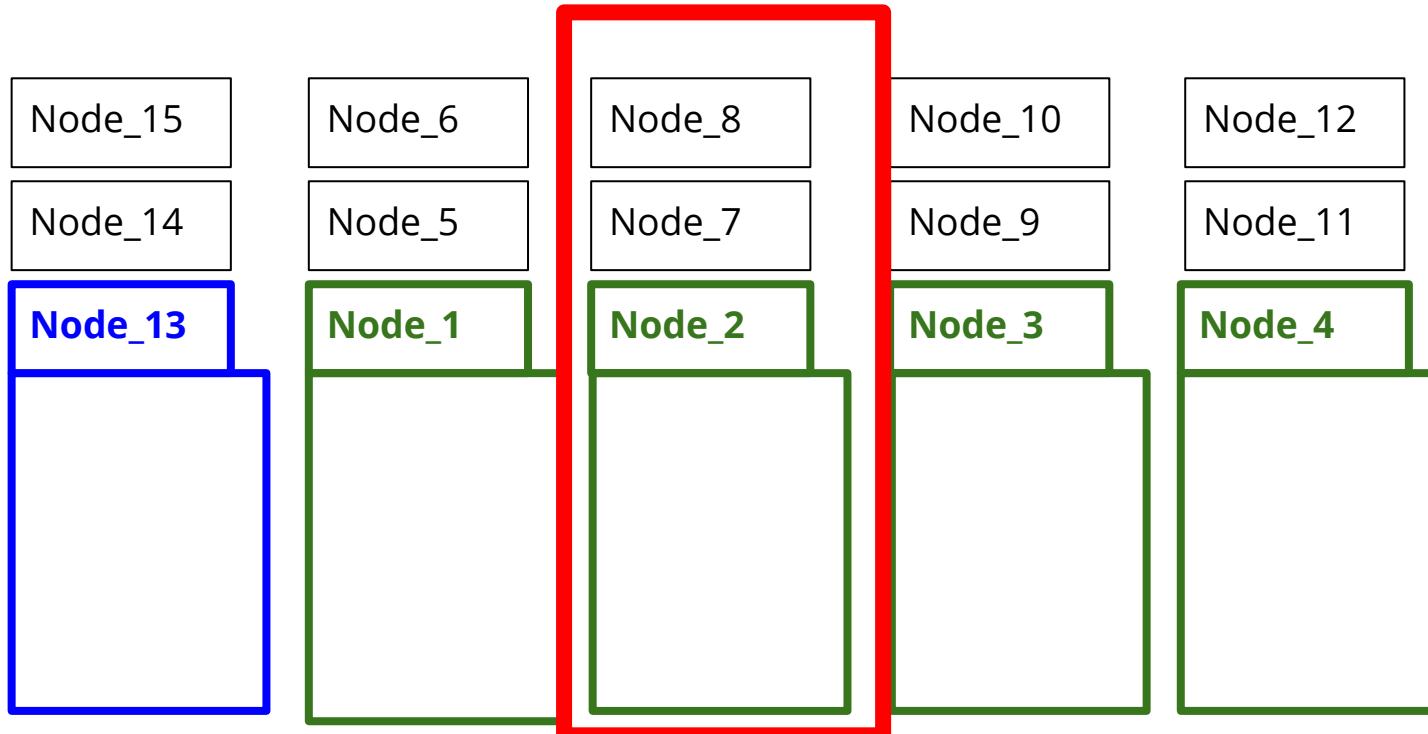
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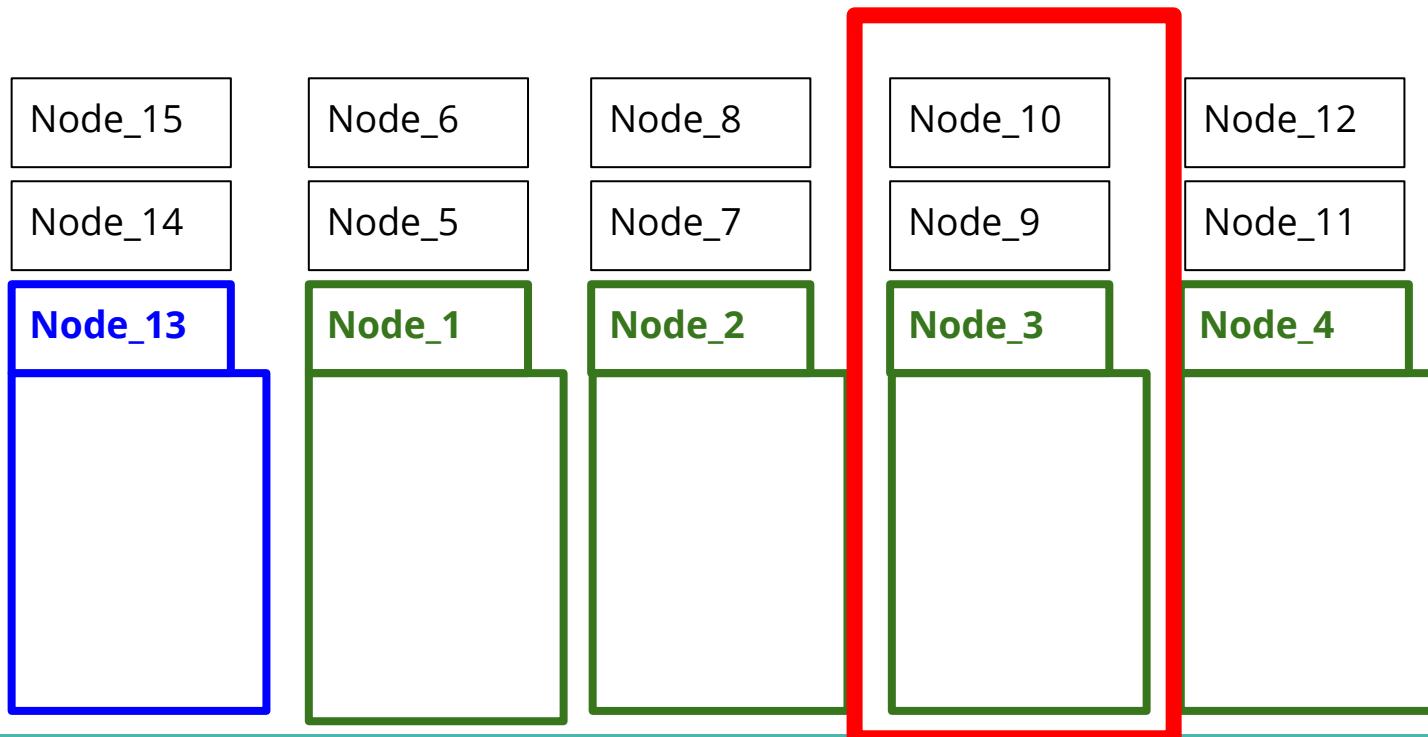
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MongoDB: Demonstrating Split and Migrate

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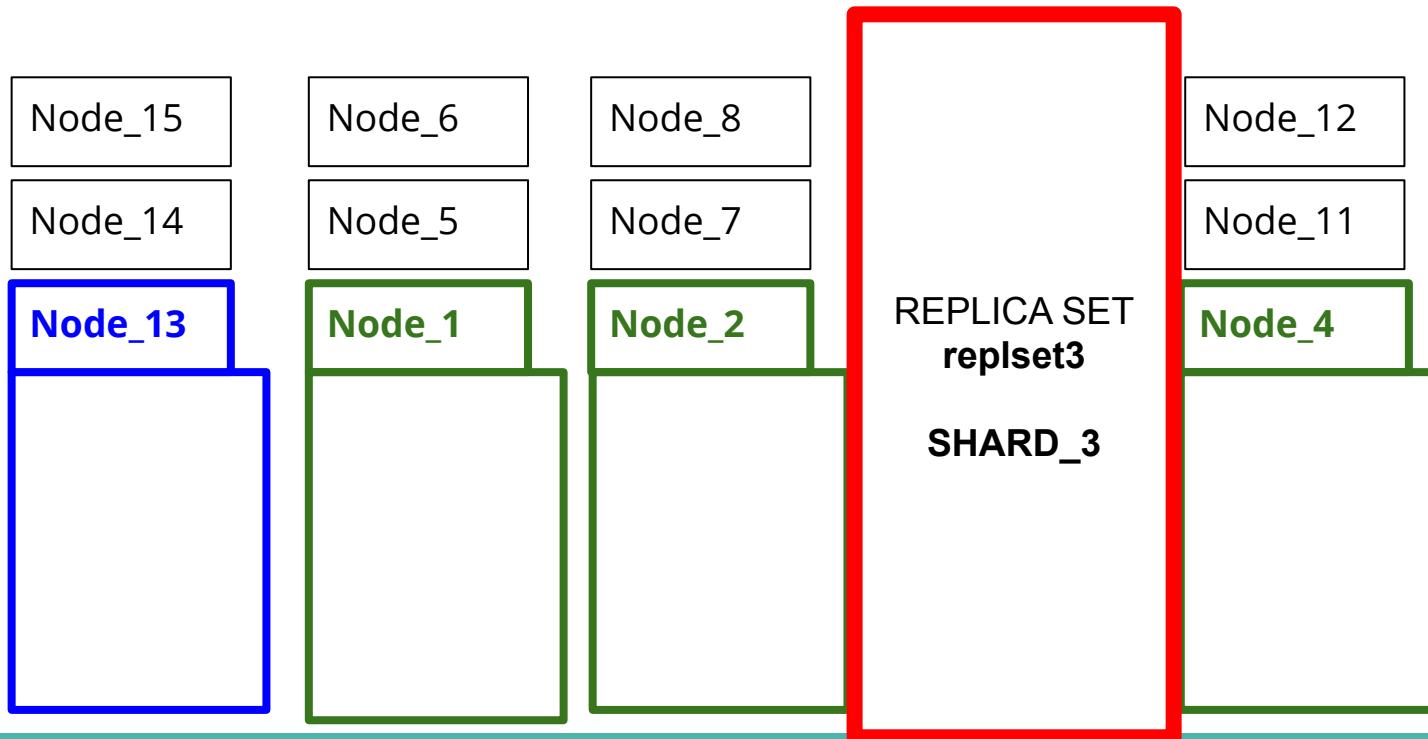
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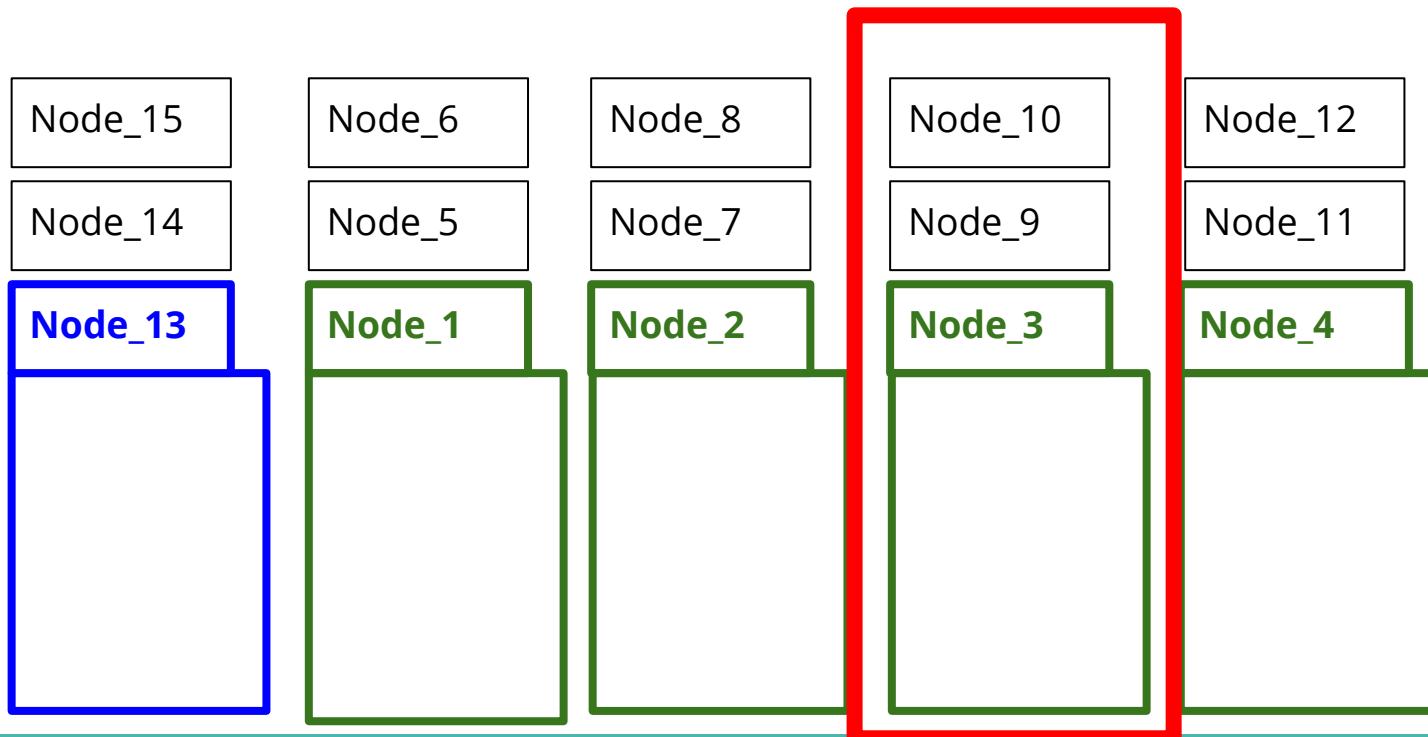
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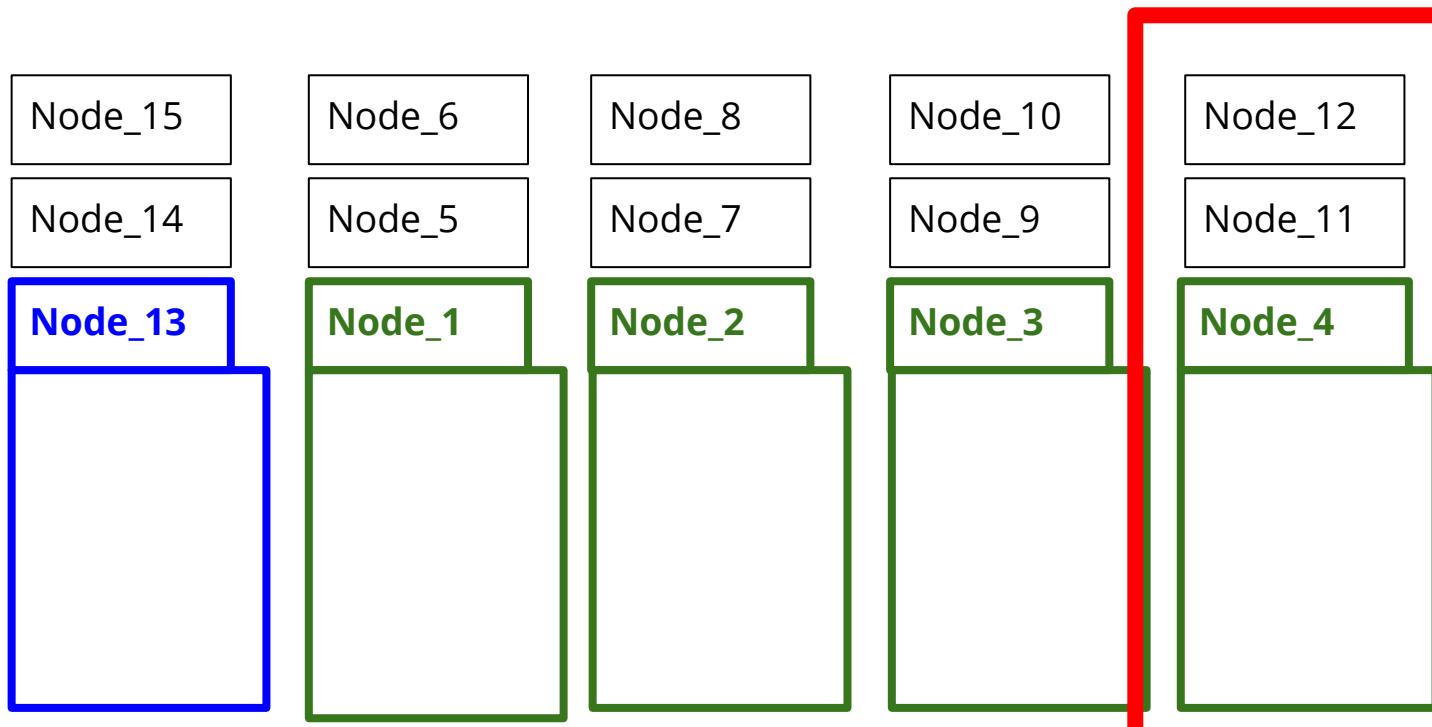
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MongoDB: Demonstrating Split and Migrate

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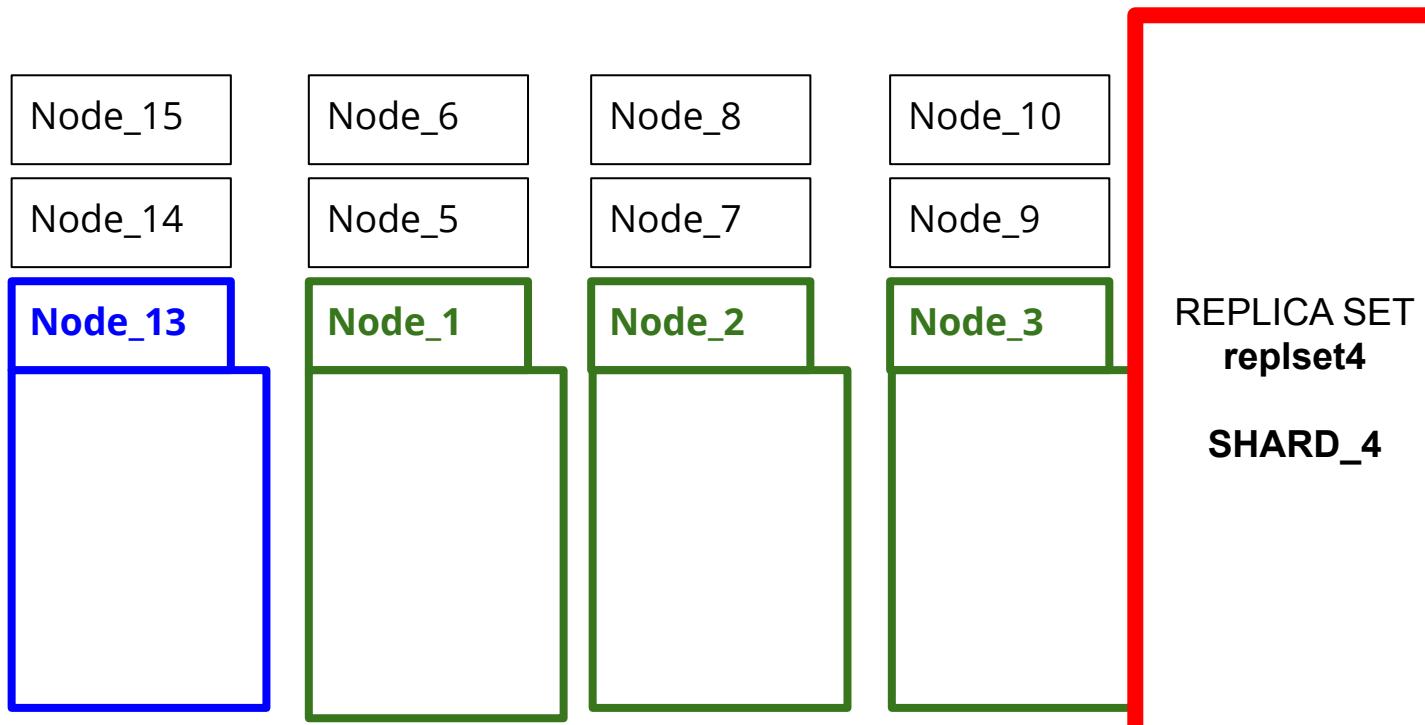
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MongoDB: Demonstrating Split and Migrate

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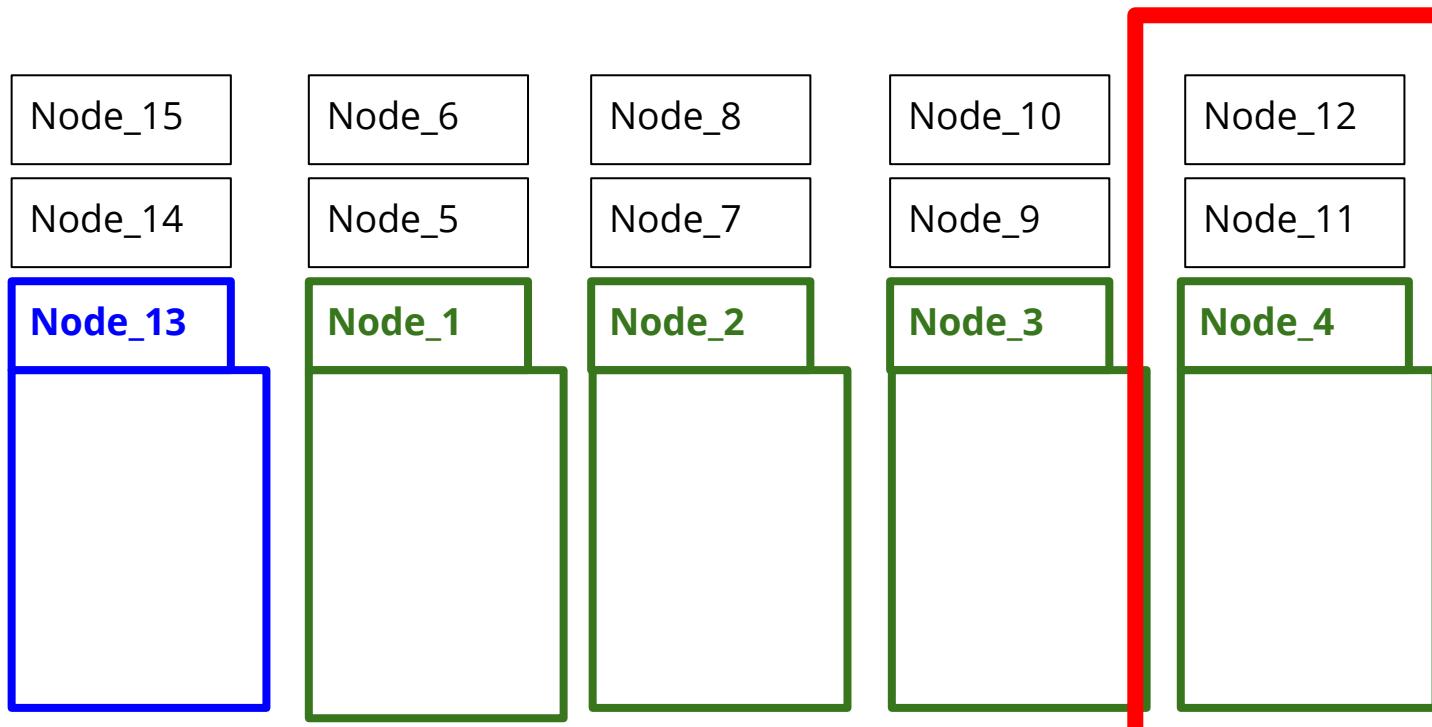
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MongoDB: Demonstrating Split and Migrate

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- Our own laptop as a cluster (with Ubuntu 18.04)



MongoDB: Demonstrating Split and Migrate

Let's demonstrate the **split** and **migrate** daemons using:

- Our own laptop as a cluster (with Ubuntu 18.04)
- MongoDB (version 3.6.3), server version



MongoDB: Demonstrating Split and Migrate

Let's demonstrate the **split** and **migrate** daemons using:

- Our own laptop as a cluster (with Ubuntu 18.04)
- MongoDB (version 3.6.3), server version
- The restaurants collection.



MongoDB: Demonstrating Split and Migrate

- Given the documents of the restaurant collection, we choose the pair (**cuisine**, **borough**) as **shard key**.

```
{  
  "name" : "Morris Park Bake Shop",  
  "cuisine" : "Bakery",  
  "borough" : "Bronx",  
  "address" : { "building": "1007", "street": "Morris Park Ave"},  
  "grades" : [ ... ]  
}
```

MongoDB: Demonstrating Split and Migrate

- Given the documents of the restaurant collection, we choose the pair **(cuisine, borough)** as **shard key**.

DOCUMENT: **doc_173**
COLLECTION: **restaurants**
DATABASE: **my_database**

MongoDB: Demonstrating Split and Migrate

- Given the documents of the restaurant collection, we choose the pair (**cuisine**, **borough**) as **shard key**.

```
{  
  "name" : "Morris Park Bake Shop",  
  "cuisine" : "Bakery",  
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  "address" : { "building": "1007", "street": "Morris Park Ave"},  
  "grades" : [ ... ]  
}
```

MongoDB: Demonstrating Split and Migrate

- We set the partition max size to **1MB**.

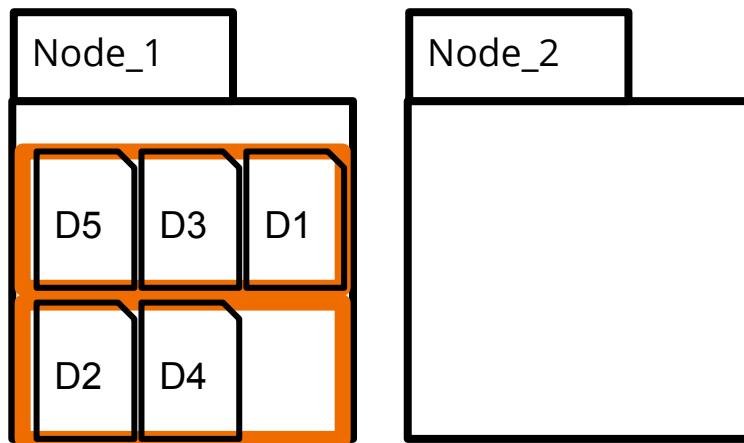


MongoDB: Demonstrating Split and Migrate

- We use the default migration balancing-based policy:
 - **Minimise the difference between the node with most partitions and the node with less partitions.**

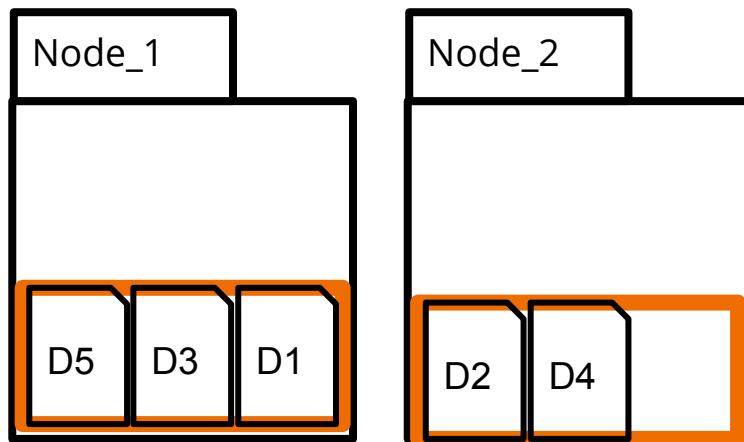
MongoDB: Demonstrating Split and Migrate

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MongoDB: Demonstrating Split and Migrate

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 - **Minimise the difference between the node with most partitions and the node with less partitions.**



MongoDB: Demonstrating Split and Migrate

Fundamental difference:

In the previous section we simulated the partitions creation, splitting and migration assuming the documents of the collection entered the database one at a time.



MongoDB: Demonstrating Split and Migrate

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DOC_8

MongoDB: Demonstrating Split and Migrate

Fundamental difference:

Now in this section we simulate the partitions creation, splitting and migration using the tool **mongoimport**, which enters all the documents of the collection **all in one time**.



MongoDB: Demonstrating Split and Migrate

Fundamental difference:

Now in this section we simulate the partitions creation, splitting and migration using the tool **mongoimport**, which enters all the documents of the collection **all in one time**.



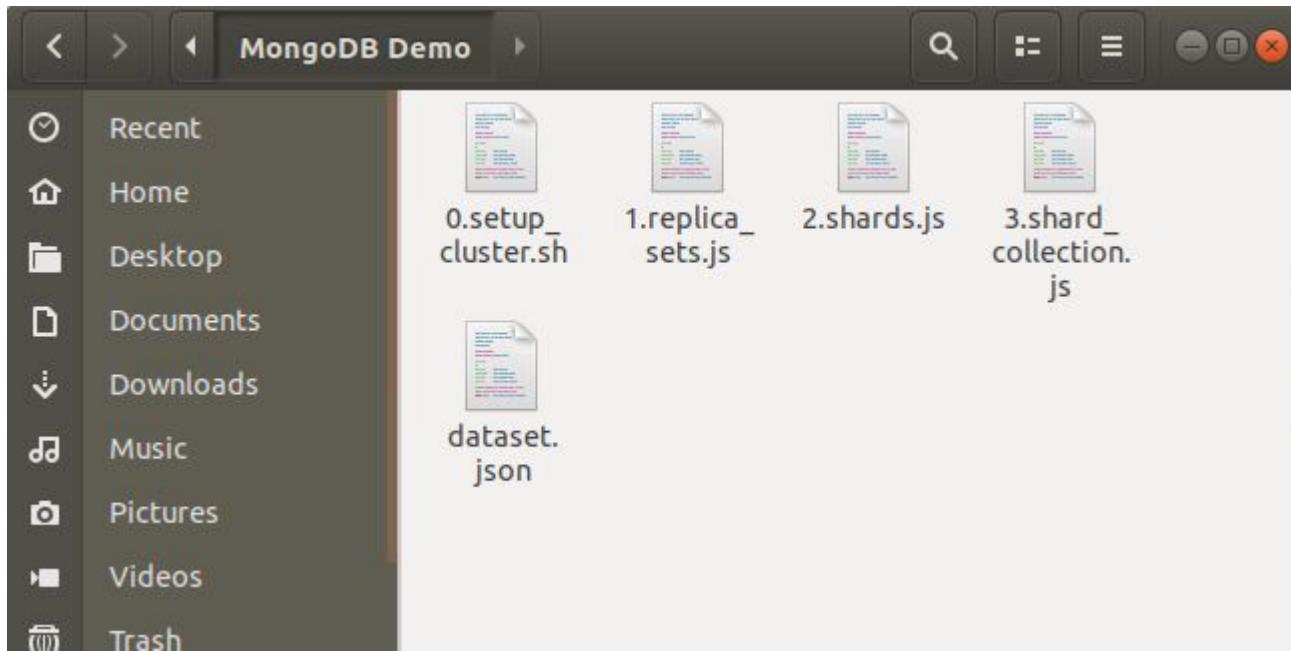
MongoDB: Demonstrating Split and Migrate

Fundamental difference:

Now in this section we simulate the partitions creation, splitting and migration using the tool **mongoimport**, which enters all the documents of the collection **all in one time**.

MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:



MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:

- **0.setup_cluster.sh**: main Bash script to be executed from a terminal. It creates the cluster and co-ordinates the rest of scripts.

MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:

- **1.replica_sets.js**: JavaScript MongoDB commands in charge of creating the replica sets.

MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:

- **2.shards.js**: JavaScript MongoDB commands in charge of turning each replica set into a shard.

MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:

- **3.shard_collection.js**: JavaScript MongoDB commands in charge of creating the **shard key**, set the **partition max size** and enabling the **sharding** of the collection to trigger the split and migrate daemons.

MongoDB: Demonstrating Split and Migrate

To create the cluster, entering the documents of the collection and demonstrate the split and migrate daemons we use the code of the folder **MongoDB Demo**, which includes the following scripts:

- **dataset.json**: Dataset with the 25k restaurants collection. Each document is provided in 1 line as a JSON object (with the format we have already described).

MongoDB: Demonstrating Split and Migrate

Demo Concept 1:

Cluster Creation and Collection Setup

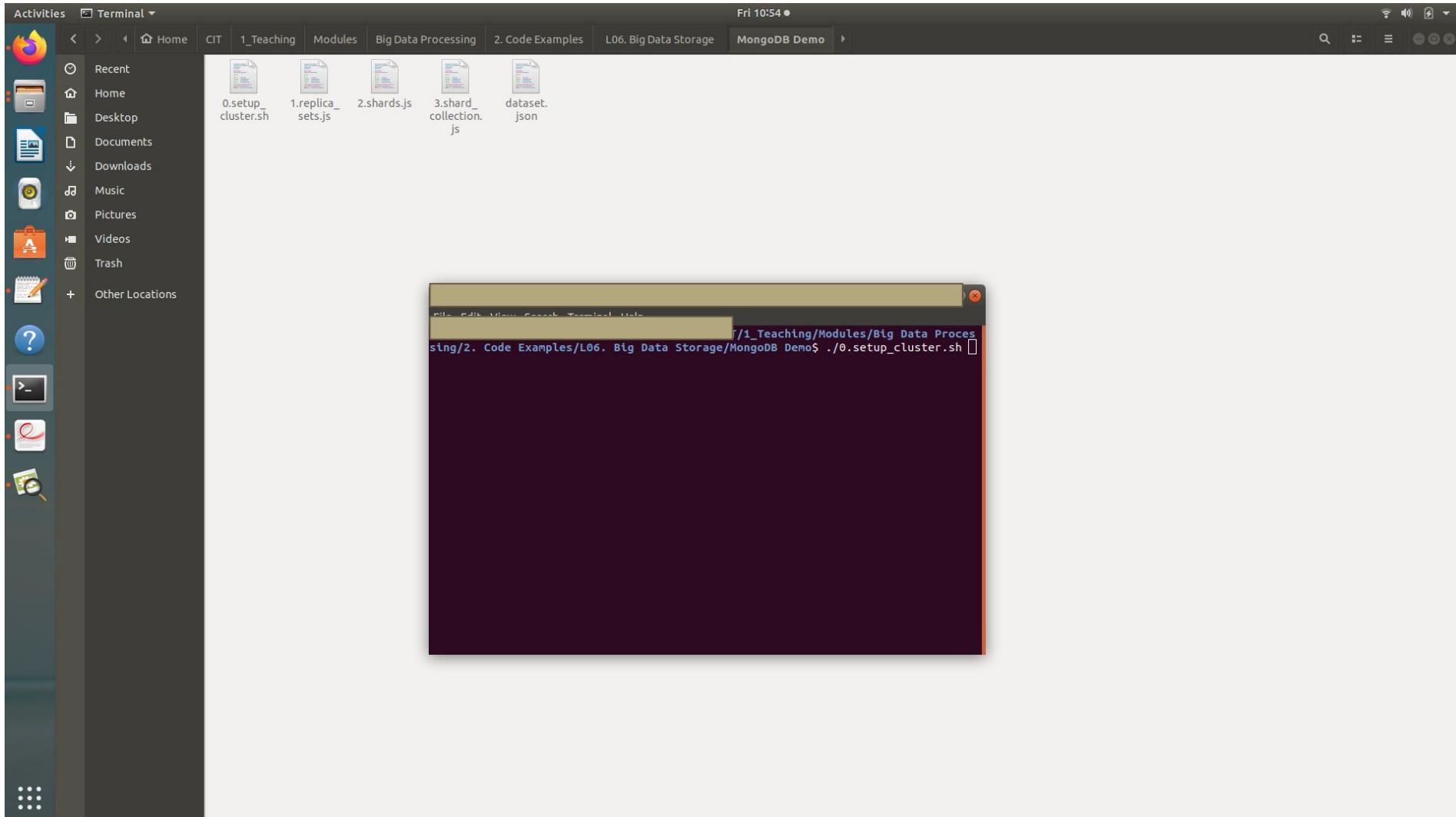
MongoDB: Demonstrating Split and Migrate

The following screenshots are taken
as the main script **0.setup_cluster.sh** executes.

MongoDB: Demonstrating Split and Migrate

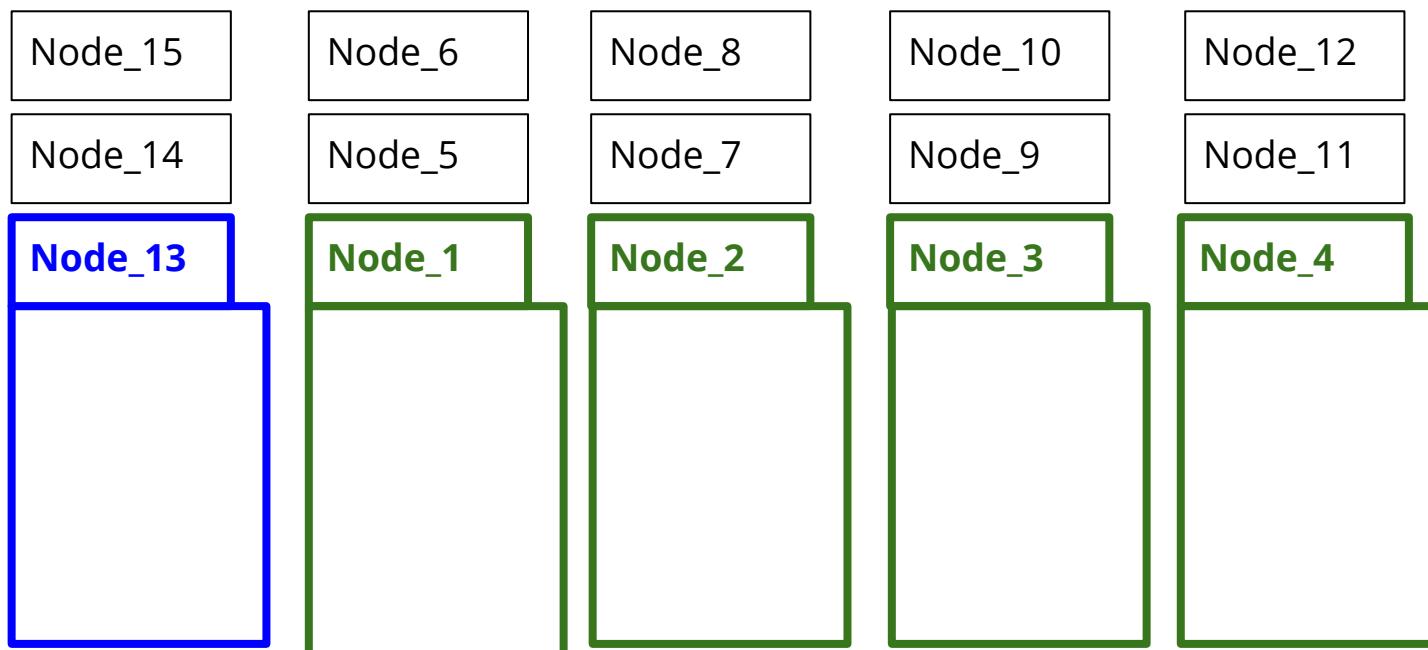
At the start of the execution, there are no nodes.

MongoDB: Demonstrating Split and Migrate

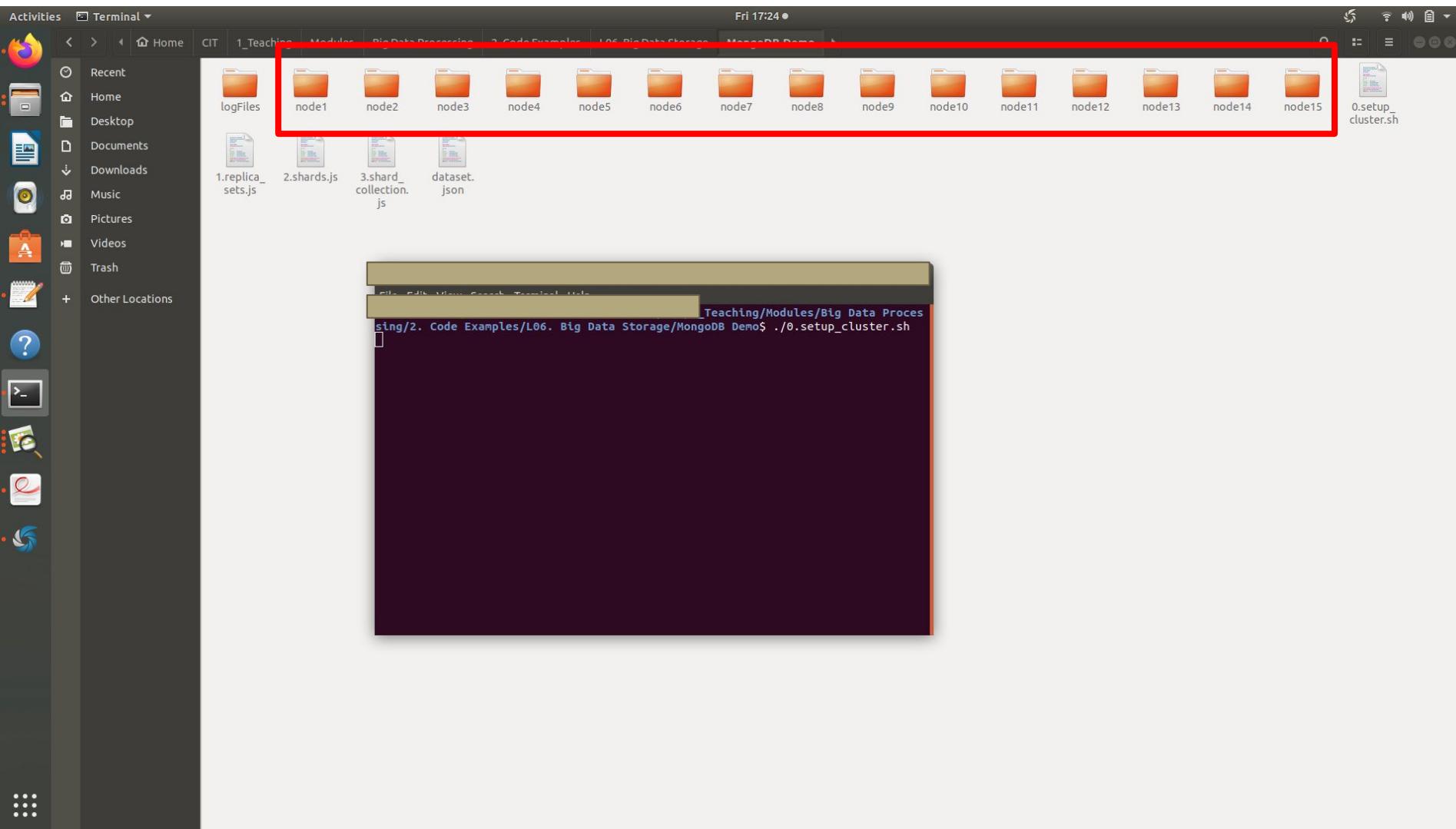


MongoDB: Demonstrating Split and Migrate

The first thing the script does is to create the 15 nodes.

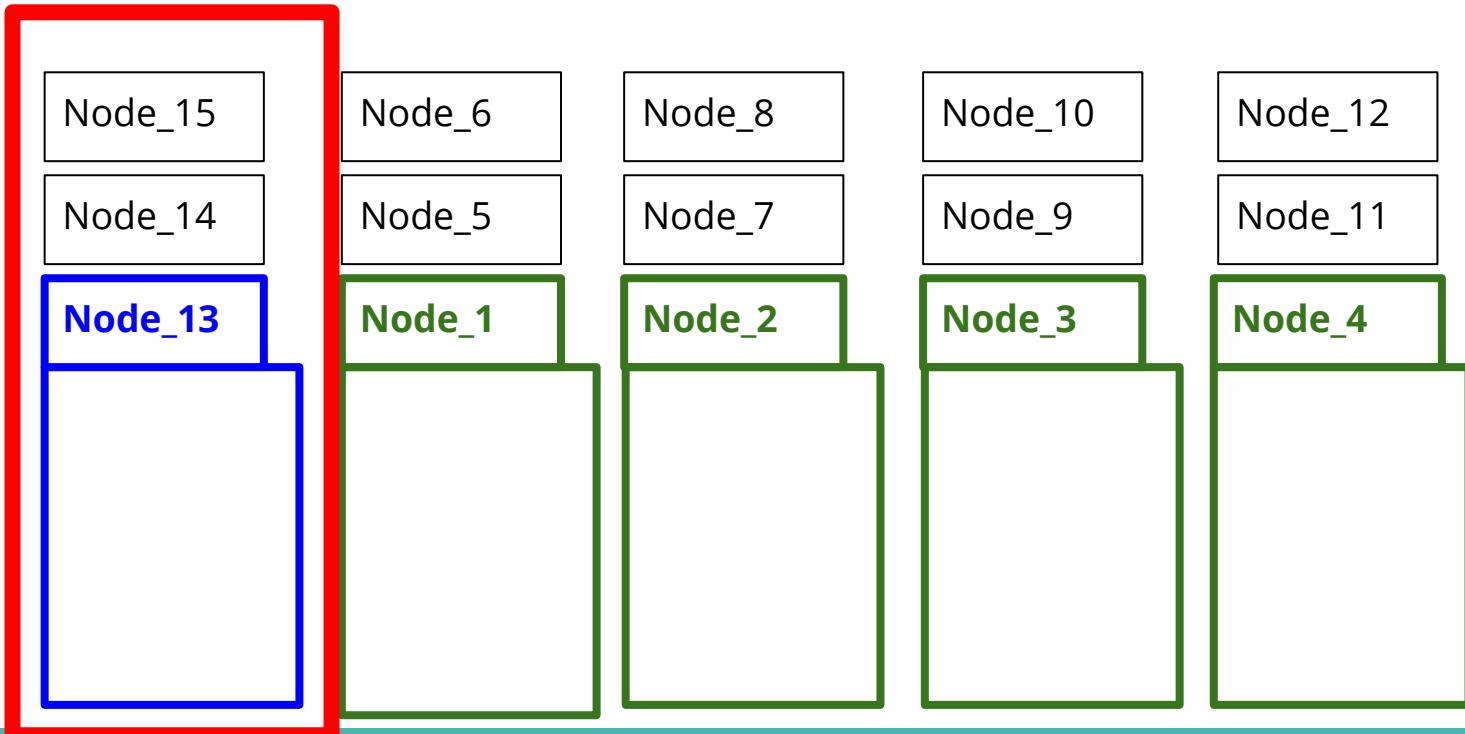


MongoDB: Demonstrating Split and Migrate

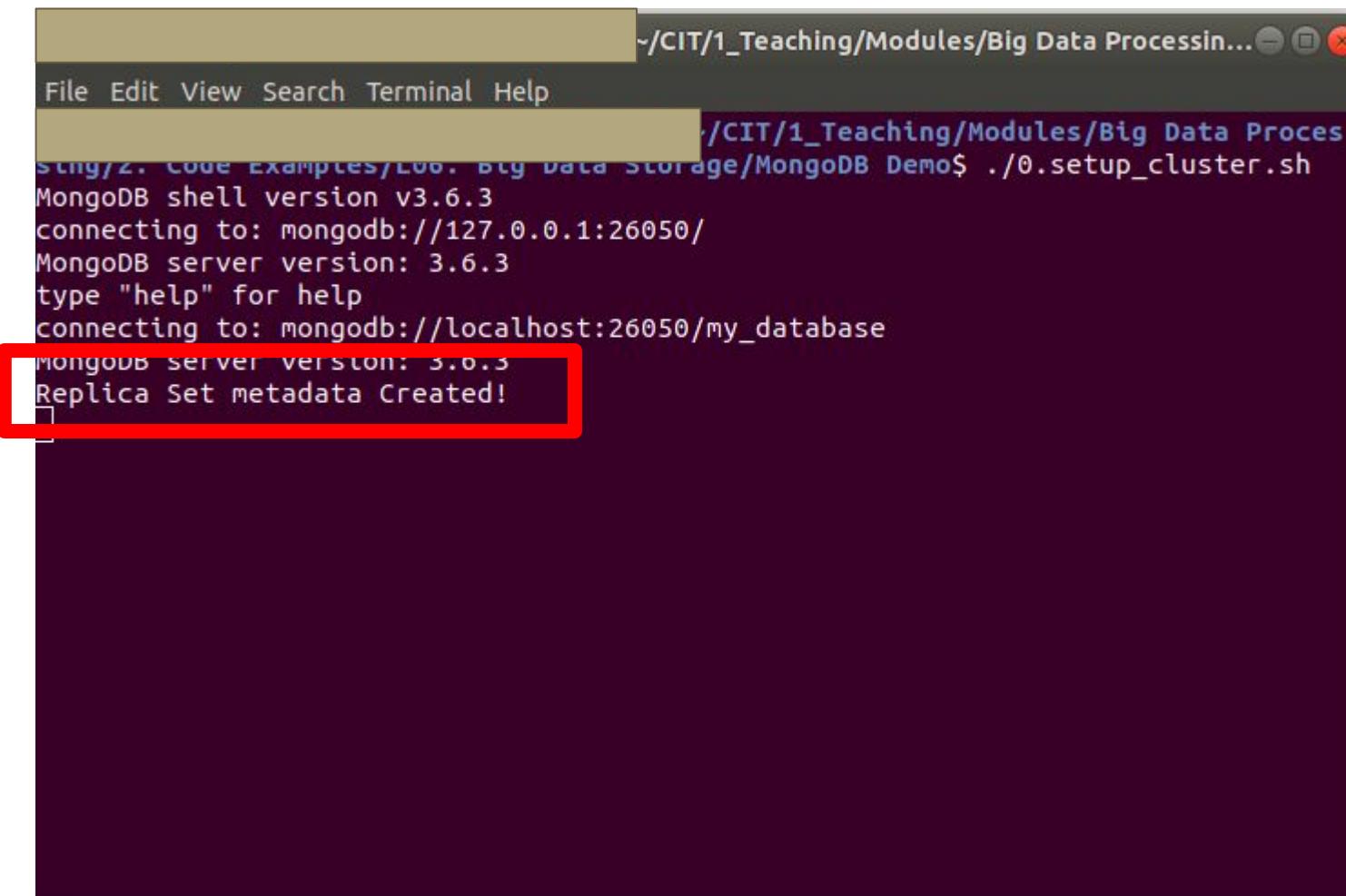


MongoDB: Demonstrating Split and Migrate

- Nodes 13-15 are set up as the metadata replica set.



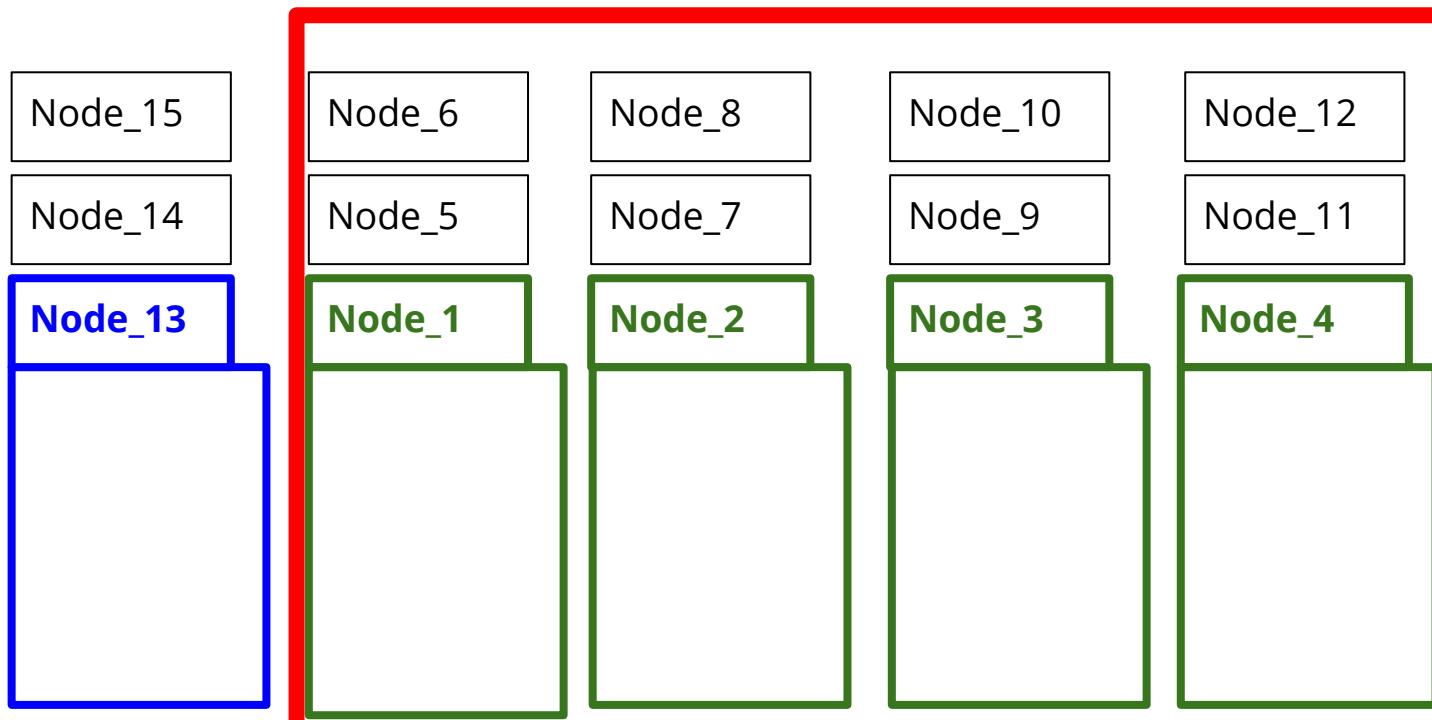
MongoDB: Demonstrating Split and Migrate



```
~/CIT/1_Teaching/Modules/Big Data Processin... ◯ ⊞ ✕
File Edit View Search Terminal Help
~/CIT/1_Teaching/Modules/Big Data Proces
sing/z. CODE EXAMPLES/L06. BIG DATA STORAGE/MongoDB Demo$ ./0.setup_cluster.sh
MongoDB shell version v3.6.3
connecting to: mongodb://127.0.0.1:26050/
MongoDB server version: 3.6.3
type "help" for help
connecting to: mongodb://localhost:26050/my_database
MongoDB server version: 3.6.3
Replica Set metadata Created!
```

MongoDB: Demonstrating Split and Migrate

- Nodes 1-12 are set up as replset1, replset2, replset3 and replset4, resp.



MongoDB: Demonstrating Split and Migrate

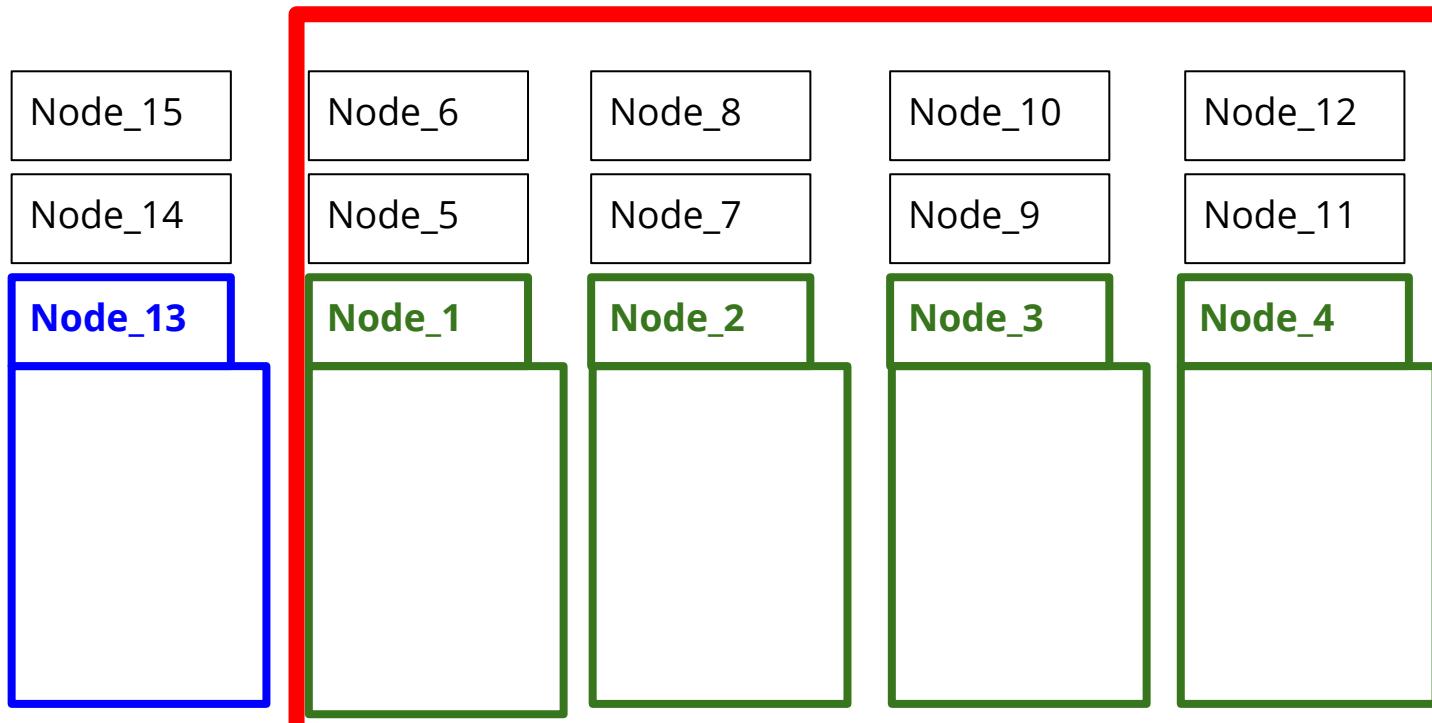
```
/CIT/1_Teaching/Modules/Big Data Processin... ◯ ✎ ✖
```

File Edit View Search Terminal Help

```
MongoDB shell version v3.6.3
connecting to: mongodb://127.0.0.1:26050/
MongoDB server version: 3.6.3
type "help" for help
connecting to: mongodb://localhost:26050/my_database
MongoDB server version: 3.6.3
Replica Set metadata Created!
Replica Set metadata Up!
connecting to: mongodb://localhost:27000/my_database
MongoDB server version: 3.6.3
Replica Set replset1 Created!
Replica Set replset1 Up!
connecting to: mongodb://localhost:27100/my_database
MongoDB server version: 3.6.3
Replica Set replset2 Created!
Replica Set replset2 Up!
connecting to: mongodb://localhost:27200/my_database
MongoDB server version: 3.6.3
Replica Set replset3 Created!
Replica Set replset3 Up!
connecting to: mongodb://localhost:27300/my_database
MongoDB server version: 3.6.3
Replica Set replset4 Created!
```

MongoDB: Demonstrating Split and Migrate

- replset1, replset2, replset3 and replset4 are set up as shard_1, shard_2, shard_3 and shard_4, resp.



MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ×
```

File Edit View Search Terminal Help

connecting to: mongodb://localhost:27300/my_database

MongoDB server version: 3.6.3

Replica Set replset4 Created!

Replica Set replset4 Up!

MongoDB shell version v3.6.3

connecting to: mongodb://127.0.0.1:27017

MongoDB server version: 3.6.3

type "help" for help

connecting to: mongodb://localhost:27000/my_database

MongoDB server version: 3.6.3

Shard_1 Added!

connecting to: mongodb://localhost:27100/my_database

MongoDB server version: 3.6.3

Shard_2 Added!

connecting to: mongodb://localhost:27200/my_database

MongoDB server version: 3.6.3

Shard_3 Added!

connecting to: mongodb://localhost:27300/my_database

MongoDB server version: 3.6.3

Shard_4 Added!

2020-08-28T10:55:52.039+0100 connected to: localhost

2020-08-28T10:55:52.040+0100 dropping: my_database.restaurants

2020-08-28T10:55:54.005+0100 imported 25359 documents

MongoDB: Demonstrating Split and Migrate

- The entire collection of 25k restaurant documents is added in one go using Mongolimport.

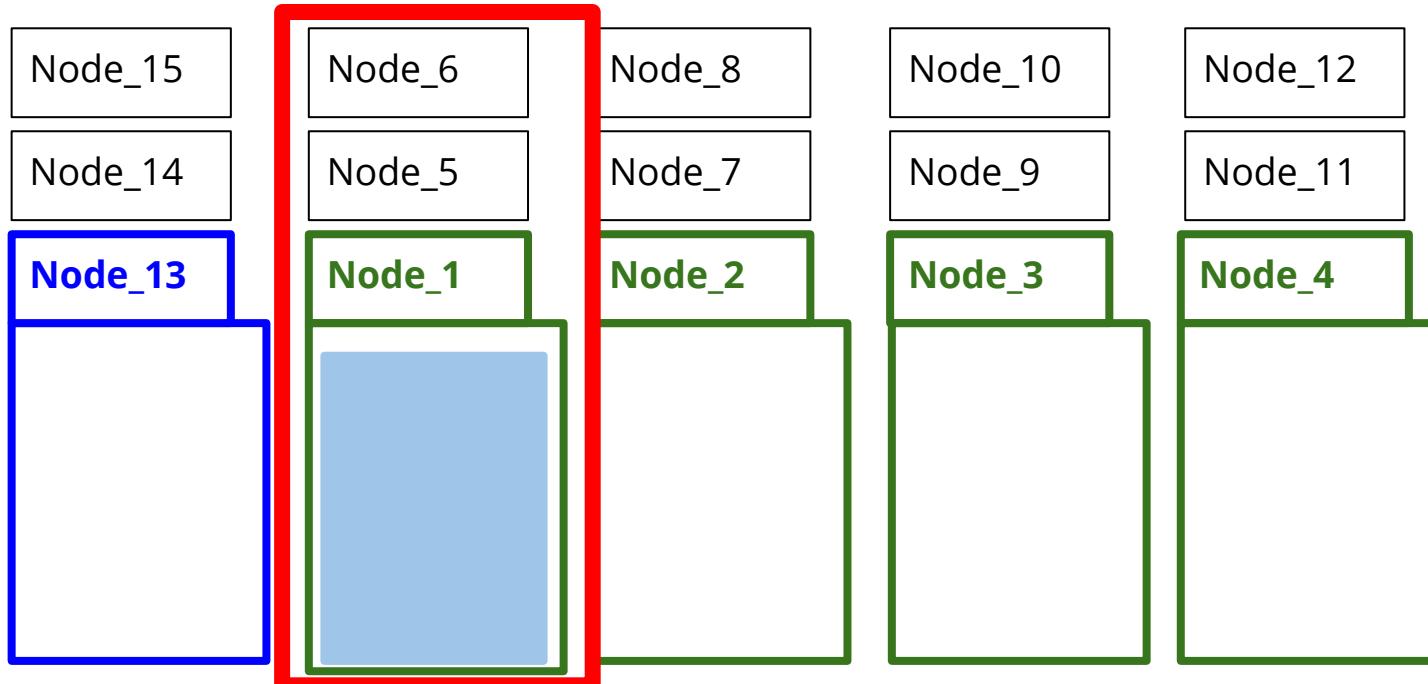


MongoDB: Demonstrating Split and Migrate

```
File Edit View Search Terminal Help
connecting to: mongodb://localhost:27300/my_database
MongoDB server version: 3.6.3
Replica Set replset4 Created!
Replica Set replset4 Up!
MongoDB shell version v3.6.3
connecting to: mongodb://127.0.0.1:27017
MongoDB server version: 3.6.3
type "help" for help
connecting to: mongodb://localhost:27000/my_database
MongoDB server version: 3.6.3
Shard_1 Added!
connecting to: mongodb://localhost:27100/my_database
MongoDB server version: 3.6.3
Shard_2 Added!
connecting to: mongodb://localhost:27200/my_database
MongoDB server version: 3.6.3
Shard_3 Added!
connecting to: mongodb://localhost:27300/my_database
MongoDB server version: 3.6.3
Shard_4 Added!
2020-08-28T10:55:52.039+0100      connected to: localhost
2020-08-28T10:55:52.040+0100      dropping: my_database.restaurants
2020-08-28T10:55:54.005+0100      imported 25359 documents
```

MongoDB: Demonstrating Split and Migrate

- The entire collection of 25k restaurant documents is added in one go using Mongolimport.
 - As we will see, the entire collection is initially stored in replset1 ⇔ shard_1.



MongoDB: Demonstrating Split and Migrate

Demo Concept 2:

Split and Migrate

MongoDB: Demonstrating Split and Migrate

The following screenshots are taken as the main script **0.setup_cluster.sh** continues its execution.

MongoDB: Demonstrating Split and Migrate

- We then enable **sharding** in the collection restaurants, setting the **shard key** for split and migrate to enter in action, partitioning and distributing the documents among the shards.

MongoDB: Demonstrating Split and Migrate

```
!: ~/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎ ×
File Edit View Search Terminal Help
connecting to: mongo://127.0.0.1:27017
MongoDB server version: 3.6.3
type "help" for help
my_database Enable for Sharding!
restaurant Collection Index Created!
restaurant Collection Sharded!
--- sharding status ---
sharding version: {
    "_id" : 1,
    "minCompatibleVersion" : 5,
    "currentVersion" : 6,
    "clusterId" : ObjectId("5f48d4899d791ff28e155e7e")
}
shards:
    { "_id" : "replicaSet1", "host" : "replicaSet1/localhost:27000,localhost:27001,localhost:27002", "state" : 1 }
    { "_id" : "replicaSet2", "host" : "replicaSet2/localhost:27100,localhost:27101,localhost:27102", "state" : 1 }
    { "_id" : "replicaSet3", "host" : "replicaSet3/localhost:27200,localhost:27201,localhost:27202", "state" : 1 }
    { "_id" : "replicaSet4", "host" : "replicaSet4/localhost:27300,localhost:27301,localhost:27302", "state" : 1 }
active mongoses:
    "3.6.3" : 4
```

MongoDB: Demonstrating Split and Migrate

```
1: ~/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎ ×  
File Edit View Search Terminal Help  
connecting to: mongodb://127.0.0.1:27017  
MongoDB server version: 3.6.3  
type "help" for help  
my_database Enable for Sharding!  
restaurant Collection Index Created!  
restaurant Collection Sharded!  
--- Sharding Status ---  
sharding version: {  
    "_id" : 1,  
    "minCompatibleVersion" : 5,  
    "currentVersion" : 6,  
    "clusterId" : ObjectId("5f48d4899d791ff28e155e7e")  
}  
shards:  
    { "_id" : "replicaSet1", "host" : "replicaSet1/localhost:27000,localhost:27001,localhost:27002", "state" : 1 }  
    { "_id" : "replicaSet2", "host" : "replicaSet2/localhost:27100,localhost:27101,localhost:27102", "state" : 1 }  
    { "_id" : "replicaSet3", "host" : "replicaSet3/localhost:27200,localhost:27201,localhost:27202", "state" : 1 }  
    { "_id" : "replicaSet4", "host" : "replicaSet4/localhost:27300,localhost:27301,localhost:27302", "state" : 1 }  
    native mongos  
        "3.6.3" : 4  
        2.0.0 : 1
```

MongoDB: Demonstrating Split and Migrate

```
-/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎
```

File Edit View Search Terminal Help

```
Currently enabled: yes
balancer:
  Currently enabled: yes
  Currently running: yes
  Collections with active migrations:
    my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
      NO RECENT MIGRATIONS
databases:
  { "_id" : "config", "primary" : "config", "partitioned" : true }
  { "_id" : "my_database", "primary" : "replica1", "partitioned" : true
}
my_database.restaurants
  shard key: { "cuisine" : 1, "borough" : 1 }
  unique: false
  balancing: true
  chunks:
    replica1          20
    too many chunks to print, use verbose if you want to for
ce print
```

MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎

File Edit View Search Terminal Help
    Currently enabled: yes
balancer:
    Currently enabled: yes
    Currently running: yes
    Collections with active migrations:
        my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        NO RECENT MIGRATIONS
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replica1", "partitioned" : true
}
my_database.restaurants
    shard key: { "cuisine" : 1, "borough" : 1 }
    unique: false
    balancing: true
    chunks:
        replica1          20
        too many chunks to print, use verbose if you want to for
ce print

```

MongoDB: Demonstrating Split and Migrate

```
-/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎
```

File Edit View Search Terminal Help

```
Currently enabled: yes
balancer:
    Currently enabled: yes
    Currently running: yes
    Collections with active migrations:
        my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        NO RECENT MIGRATIONS
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replica1"      "partitioned" : true
}
my_database.restaurants
    shard key: { "cuisine" : 1, "borough" : 1 }
    unique: false
    balancing: true
    chunks:
        replica1          20
        too many chunks to print, use verbose if you want to for
ce print
```

MongoDB: Demonstrating Split and Migrate

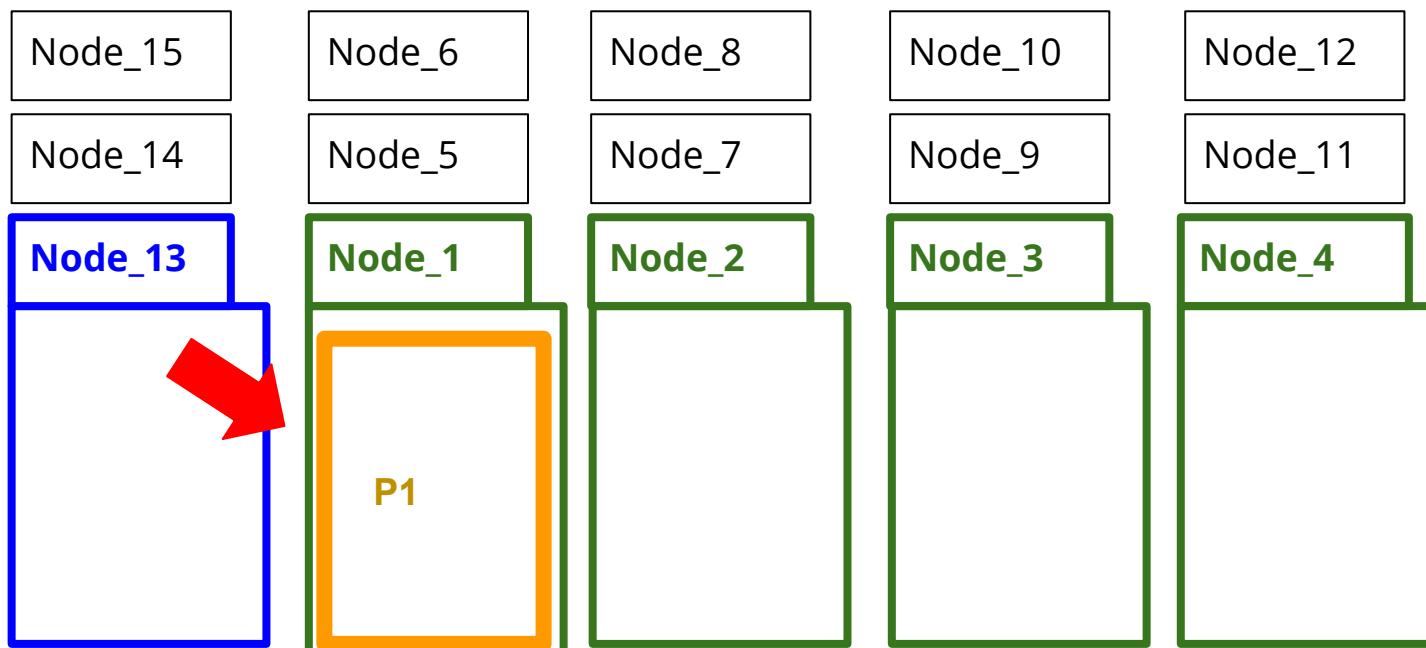
```
~/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎

File Edit View Search Terminal Help
    Currently enabled: yes
balancer:
    Currently enabled: yes
    Currently running: yes
    Collections with active migrations:
        my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        No recent migrations
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replica1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
            unique: false
            balancing: true
            chunks:
                replica1          20
                too many chunks to print, use verbose if you want to for
ce print

```

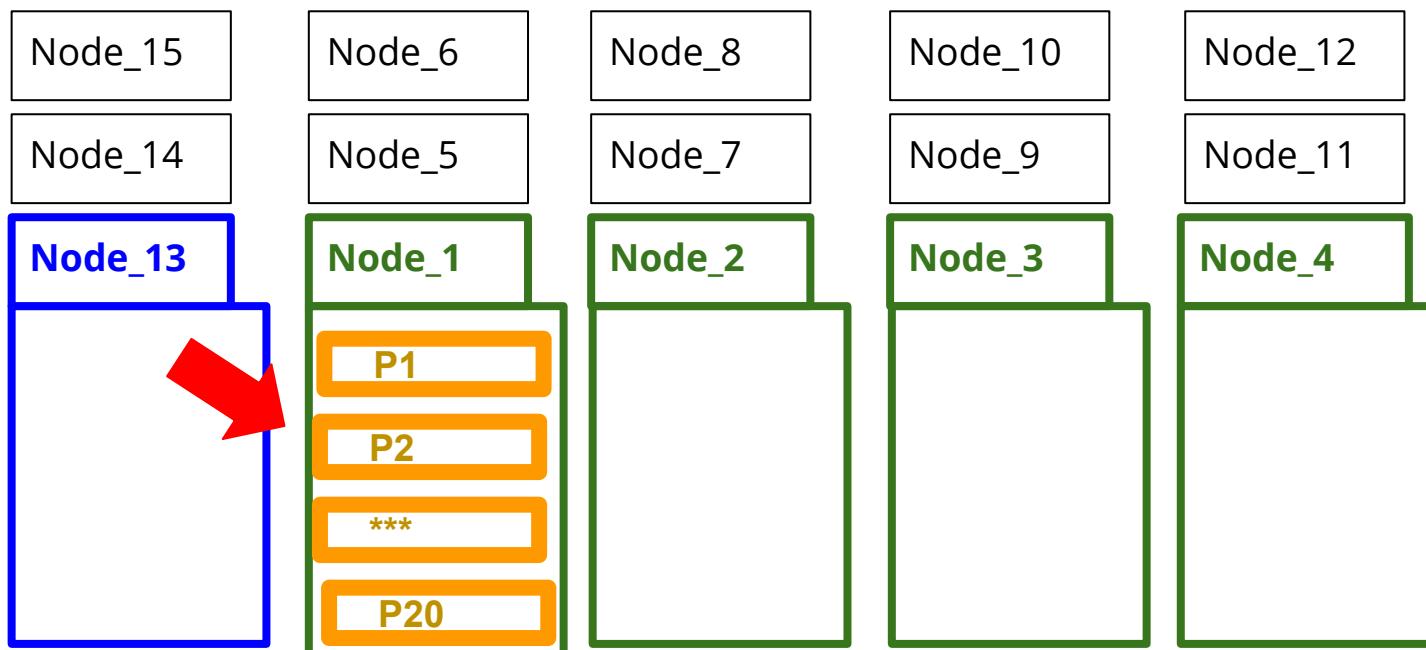
MongoDB: Demonstrating Split and Migrate

- The size of the collection is so big, that the **split** daemon enters in action to get it to the desired size (1MB).



MongoDB: Demonstrating Split and Migrate

- The size of the collection is so big, that the **split** daemon enters in action to get it to the desired size (1MB).
 - This leads to 20 partitions, all in replset_1 ⇔ shard_1.



MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎
```

File Edit View Search Terminal Help

Currently enabled: yes

balancer:

Currently enabled: yes

Currently running: yes

Collections with active migrations:

my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+0100 (IST)

Failed balancer rounds in last 5 attempts: 0

Migration Results for the last 24 hours:

No recent migrations

databases:

{ "_id" : "config", "primary" : "config", "partitioned" : true }

{ "_id" : "my_database", "primary" : "replica1", "partitioned" : true }

}

my_database.restaurants

shard key: { "cuisine" : 1, "borough" : 1 }

unique: false

balancing: true

chunks:

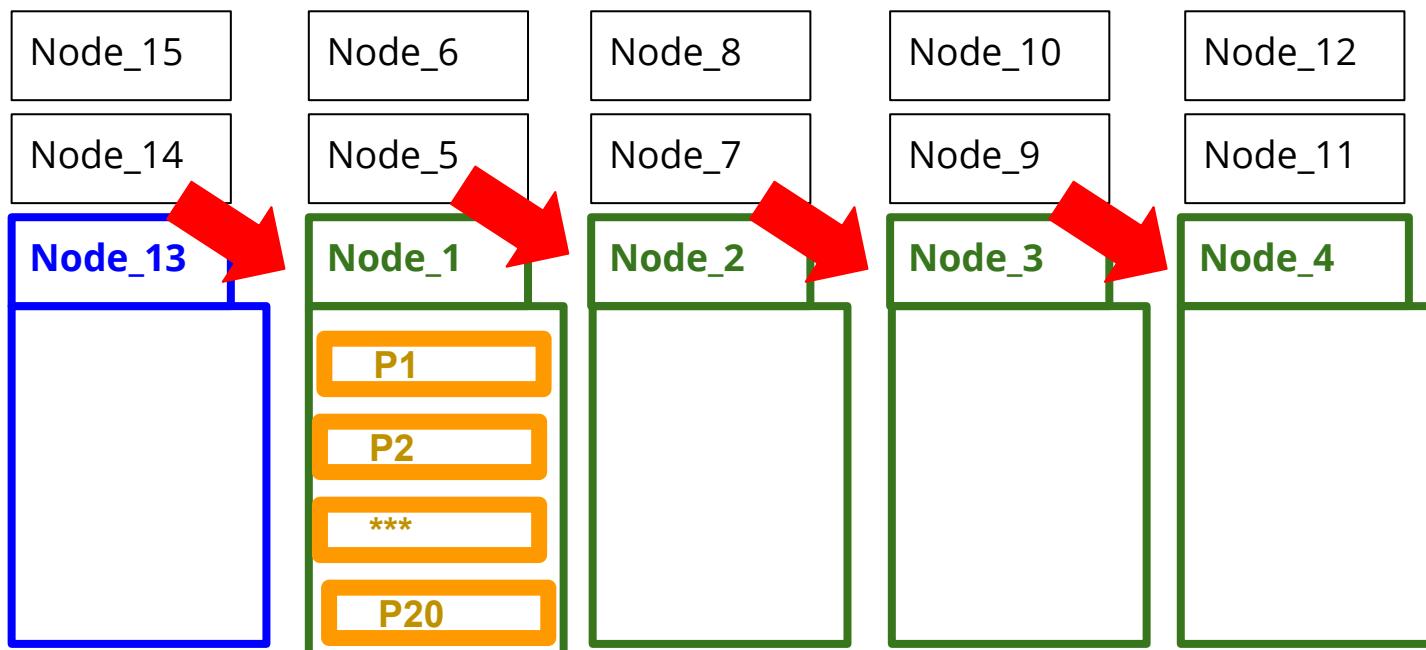
replica1 20

too many chunks to print, use verbose if you want to for

ce print

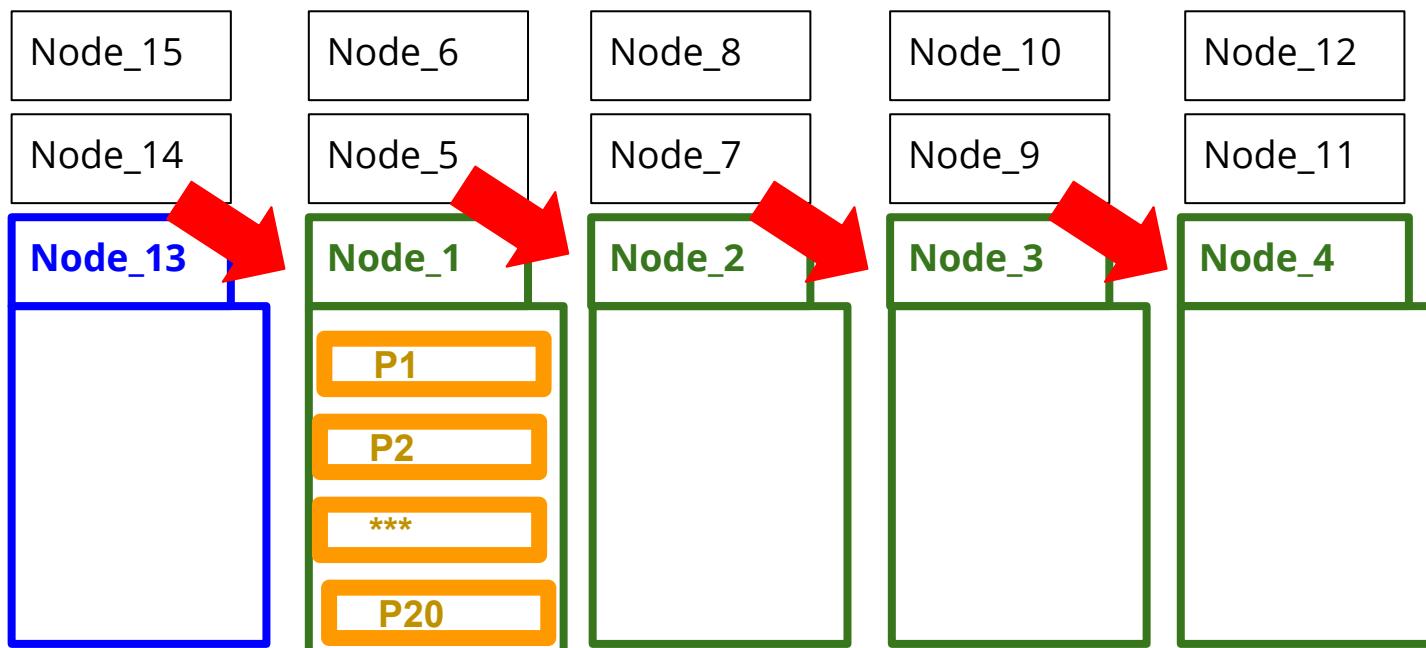
MongoDB: Demonstrating Split and Migrate

- The migration policy is to balance the partitions to minimise the difference between the shard with most partitions and the one with less partitions.



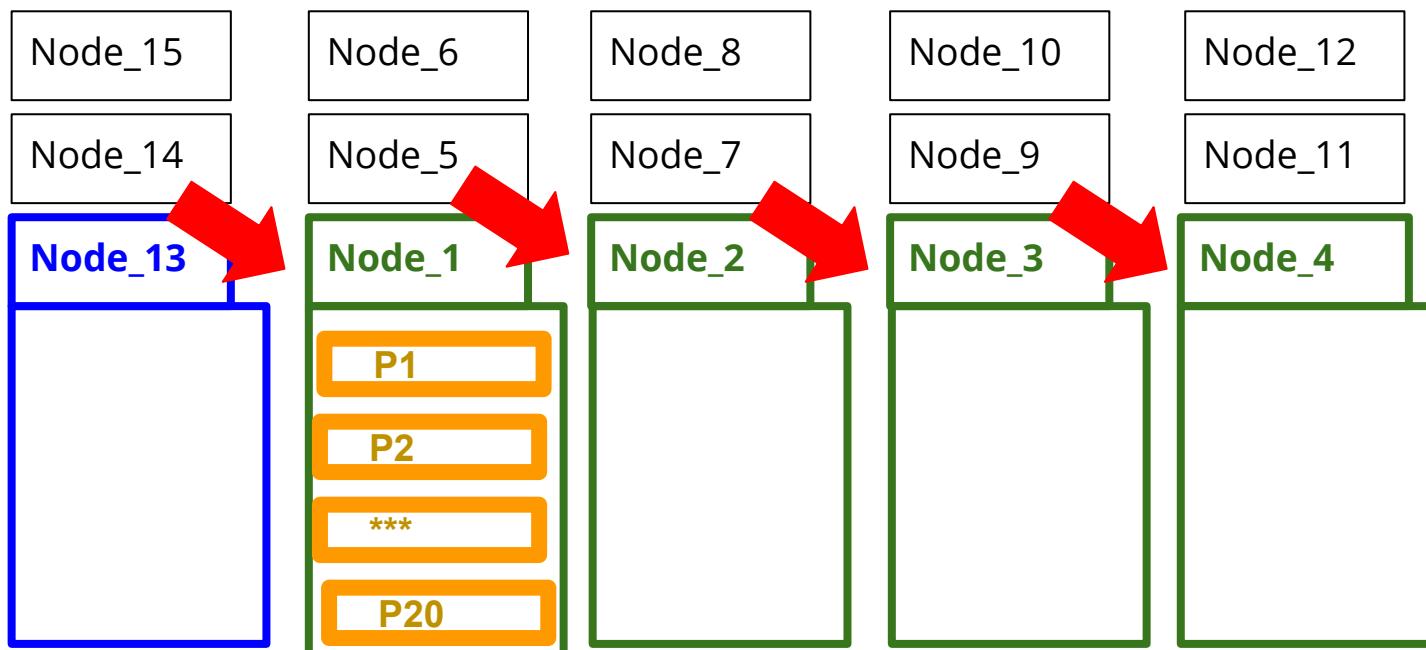
MongoDB: Demonstrating Split and Migrate

- Thus, the **migrate** daemon enters in action to reduce this number from its current value of **20**.



MongoDB: Demonstrating Split and Migrate

- Migrating partitions takes much longer than splitting them, so we refresh every 10 seconds to see the evolution of the migration process.



MongoDB: Demonstrating Split and Migrate

```
-/CIT/1_Teaching/Modules/Big Data Processin... - ◻ ✎
```

File Edit View Search Terminal Help

Currently enabled: yes

balancer:

- Currently enabled: yes
- Currently running: yes

Collections with active migrations:

- my_database.restaurants started at Fri Aug 28 2020 10:56:12 GMT+0100 (IST)

Failed balancer rounds in last 5 attempts: 0

Migration Results for the last 24 hours:

- No recent migrations

databases:

- { "_id" : "config", "primary" : "config", "partitioned" : true }
- { "_id" : "my_database", "primary" : "replica1", "partitioned" : true }

}

my_database.restaurants

- shard key: { "cuisine" : 1, "borough" : 1 }
- unique: false
- balancing: true

chunks:

replica1	20
----------	----

too many chunks to print, use verbose if you want to for
ce print

MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ◻ ✎ ×
File Edit View Search Terminal Help
Currently running: yes
Collections with active migrations:
    my_database.restaurants started at Fri Aug 28 2020 10:56:22 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        3 : Success
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replica1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
        unique: false
        balancing: true
        chunks:
            replica1          17
            replica2          1
            replica3          1
            replica4          1
        too many chunks to print, use verbose if you want to for
ce print

```

MongoDB: Demonstrating Split and Migrate

```
1_Teaching/Modules/Big Data Processin... ● ○ ✕
File Edit View Search Terminal Help
Currently running: yes
Collections with active migrations:
    my_database.restaurants started at Fri Aug 28 2020 10:56:33 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        6 : Success
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replset1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
        unique: false
        balancing: true
        chunks:
            replset1      14
            replset2      2
            replset3      2
            replset4      2
            too many chunks to print, use verbose if you want to for
ce print

```

MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ● ○ ✕
File Edit View Search Terminal Help
Currently enabled: yes
Currently running: yes
Collections with active migrations:
    my_database.restaurants started at Fri Aug 28 2020 10:56:42 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        9 : Success
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replset1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
        unique: false
        balancing: true
        chunks:
            replset1      10
            replset2      4
            replset3      3
            replset4      3
        too many chunks to print, use verbose if you want to for
ce print
```

MongoDB: Demonstrating Split and Migrate

```
File Edit View Search Terminal Help
Currently running: yes
Collections with active migrations:
    my_database.restaurants started at Fri Aug 28 2020 10:56:53 GMT+
0100 (IST)
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        12 : Success
databases:
{   "_id" : "config", "primary" : "config", "partitioned" : true }
{   "_id" : "my_database", "primary" : "replica1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
        unique: false
        balancing: true
        chunks:
            replica1          8
            replica2          4
            replica3          4
            replica4          4
    too many chunks to print, use verbose if you want to force print
```

MongoDB: Demonstrating Split and Migrate

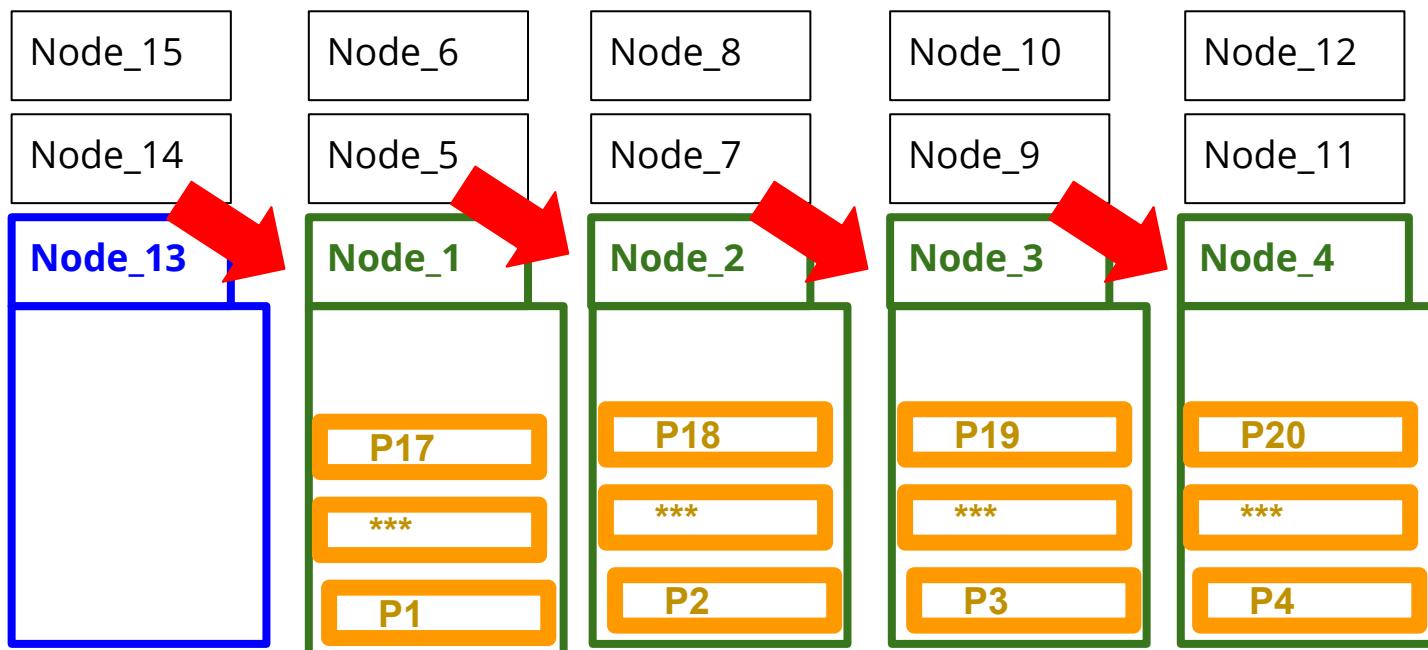
```
~/CIT/1_Teaching/Modules/Big Data Processin... ◯ ×
```

File Edit View Search Terminal Help

```
Currently enabled: yes
balancer:
    Currently enabled: yes
    Currently running: no
    Failed balancer rounds in last 5 attempts: 0
    Migration Results for the last 24 hours:
        15 : Success
databases:
    { "_id" : "config", "primary" : "config", "partitioned" : true }
    { "_id" : "my_database", "primary" : "replset1", "partitioned" : true
}
    my_database.restaurants
        shard key: { "cuisine" : 1, "borough" : 1 }
        unique: false
        balancing: true
        chunks:
            replset1      5
            replset2      5
            replset3      5
            replset4      5
            too many chunks to print, use verbose if you want to for
ce print
```

MongoDB: Demonstrating Split and Migrate

- The **migrate** daemon balances all partitions across the shards, getting an optimal value of **0**.



MongoDB: Demonstrating Split and Migrate

Demo Concept 3:

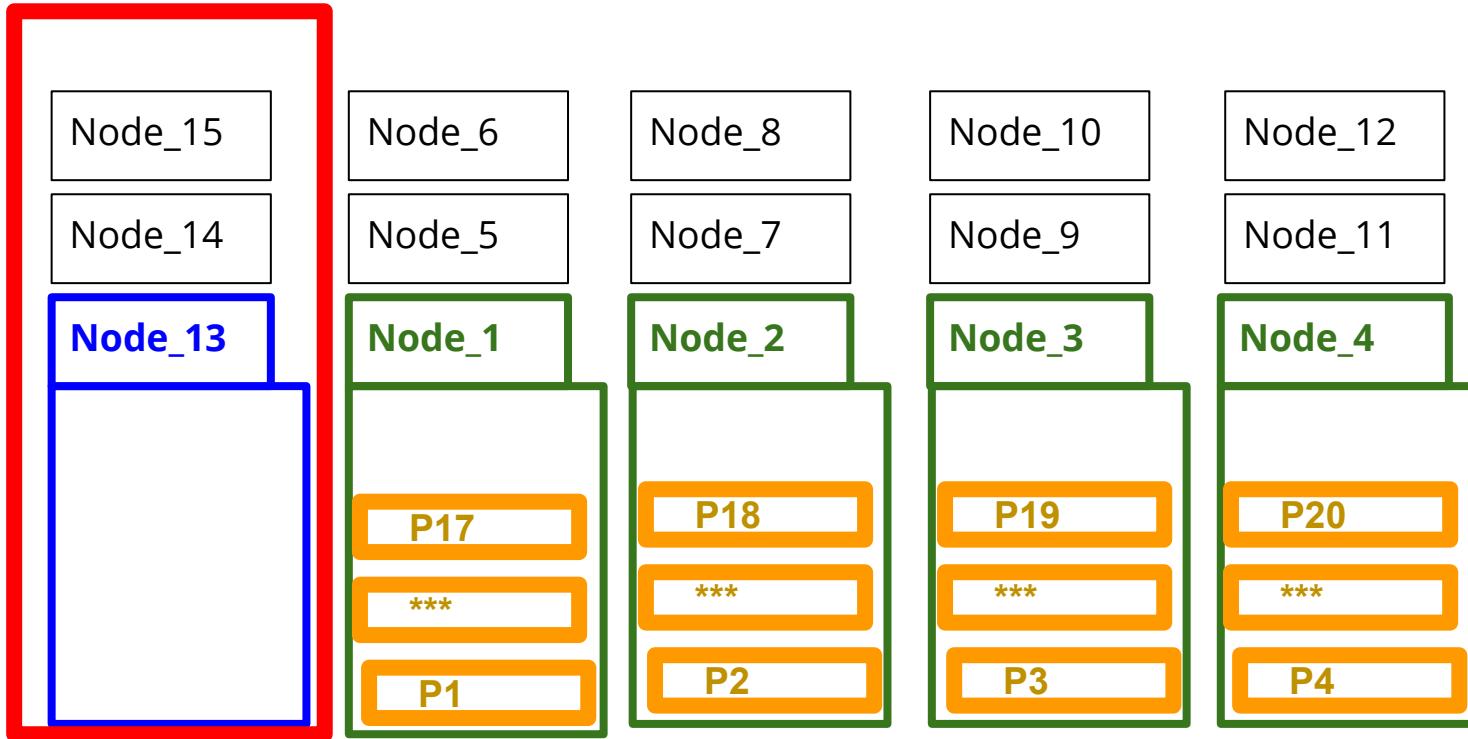
Metadata Info

MongoDB: Demonstrating Split and Migrate

The following screenshots are taken by opening a new terminal and connecting it to the cluster.

MongoDB: Demonstrating Split and Migrate

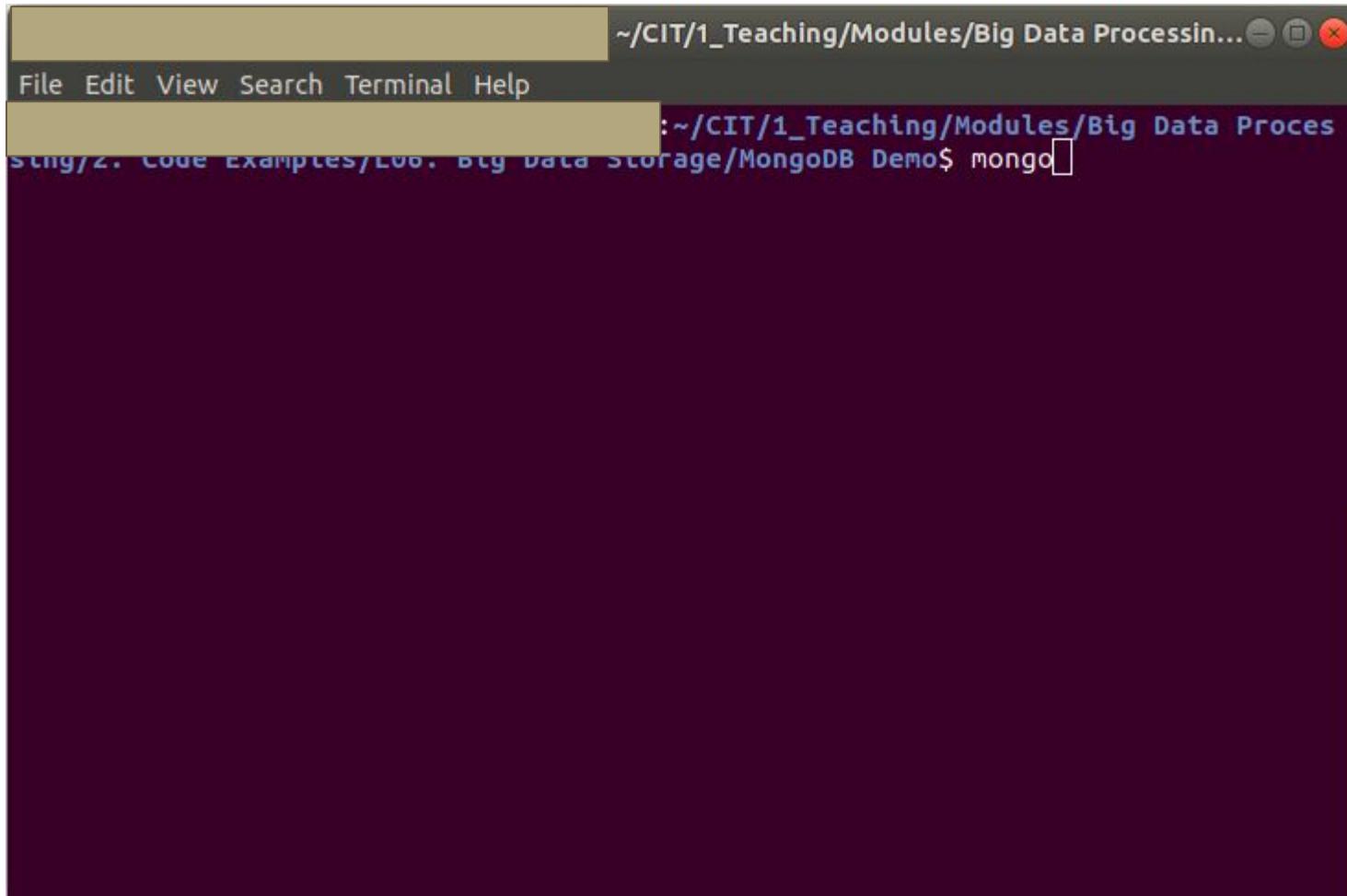
Let's now look at the **metadata** database **config** to demonstrate the map <partition, shard>



MongoDB: Demonstrating Split and Migrate

We open a new mongo client to connect to the cluster.

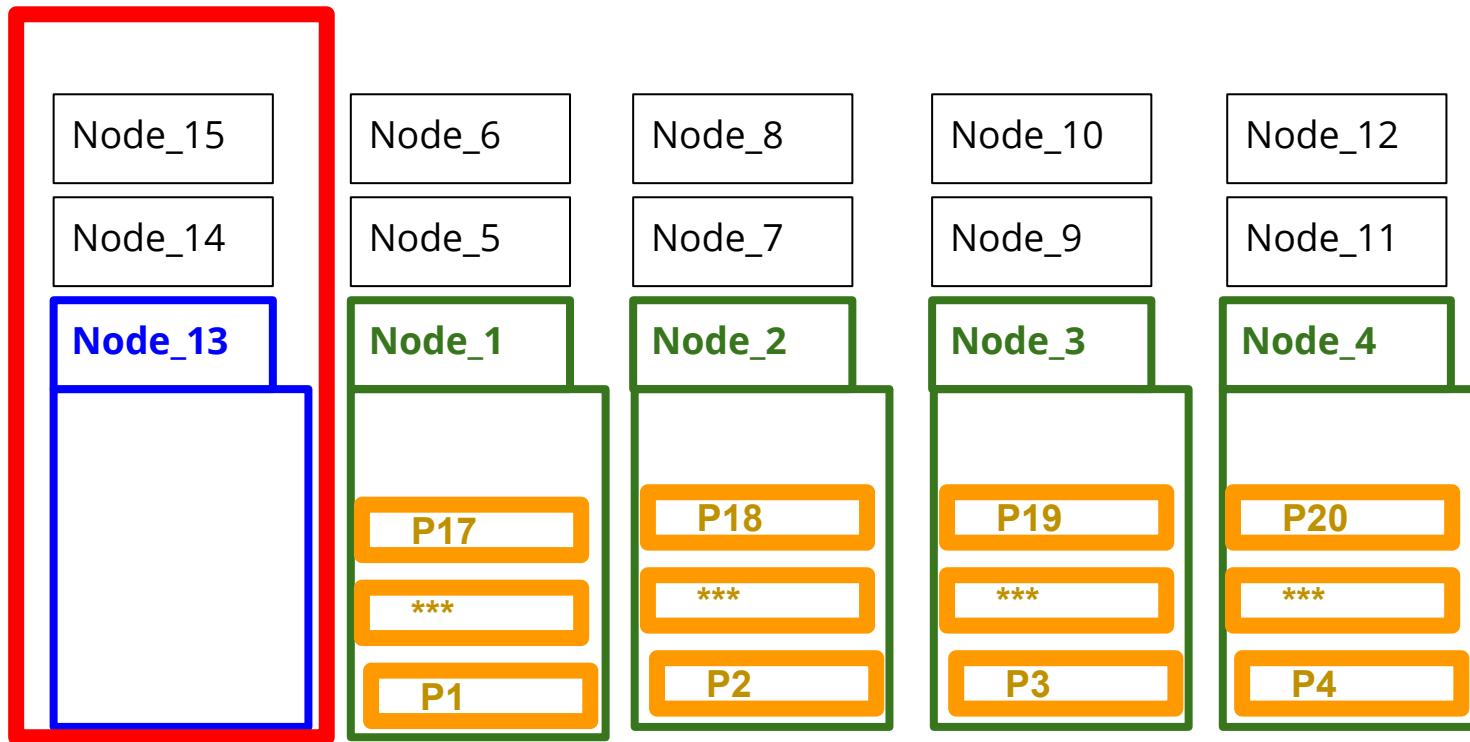
MongoDB: Demonstrating Split and Migrate



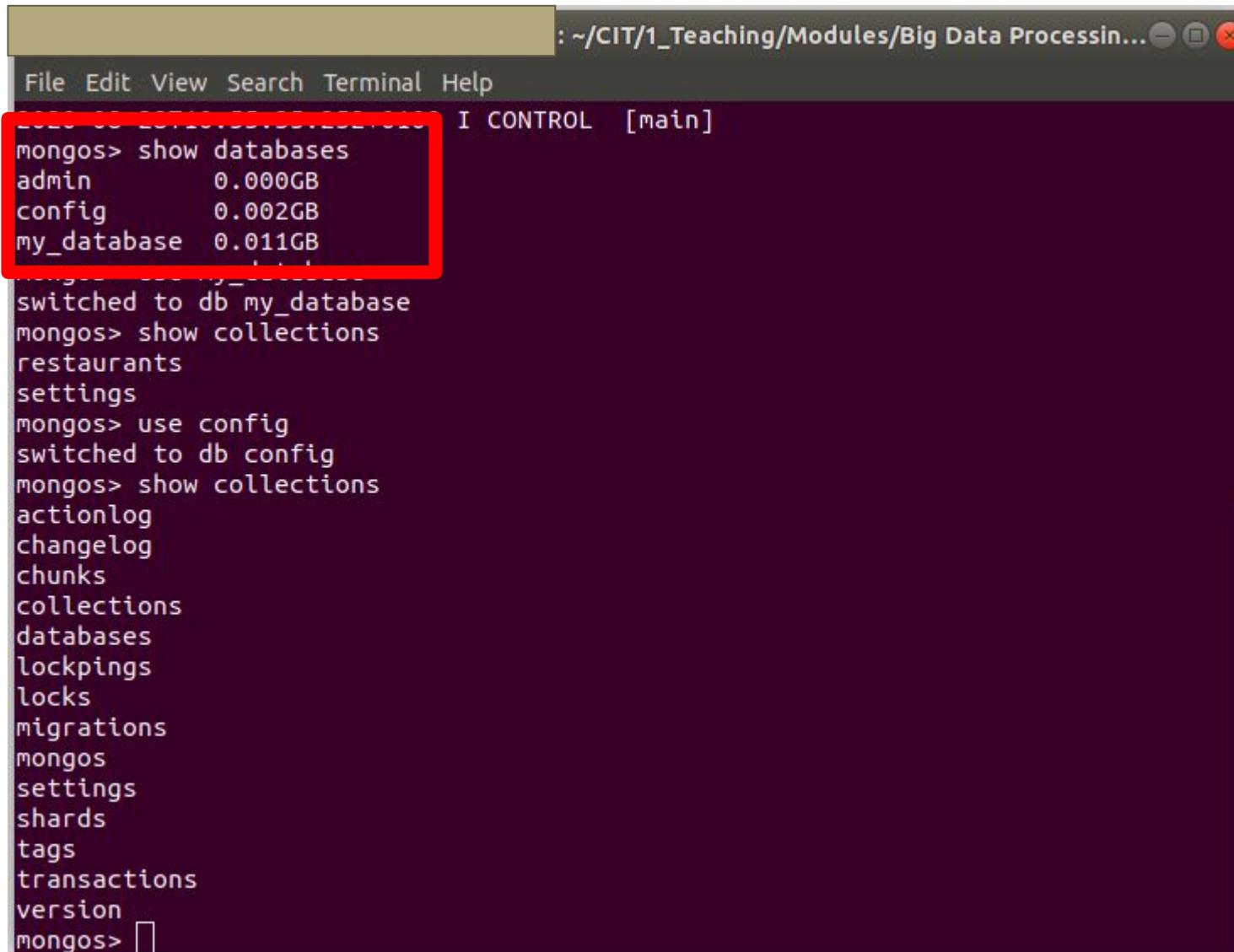
A screenshot of a terminal window titled "~/CIT/1_Teaching/Modules/Big Data Processin...". The window has a dark background and a light-colored title bar. The menu bar contains "File", "Edit", "View", "Search", "Terminal", and "Help". The command line shows the user's path: "cd ~/CIT/1_Teaching/Modules/Big Data Processing/2. Code Examples/Lab. Big Data Storage/MongoDB Demo\$ mongo". The terminal is currently empty, indicating no output from the command.

MongoDB: Demonstrating Split and Migrate

We connect to the **config** database, contained in the **metadata** replica set.



MongoDB: Demonstrating Split and Migrate



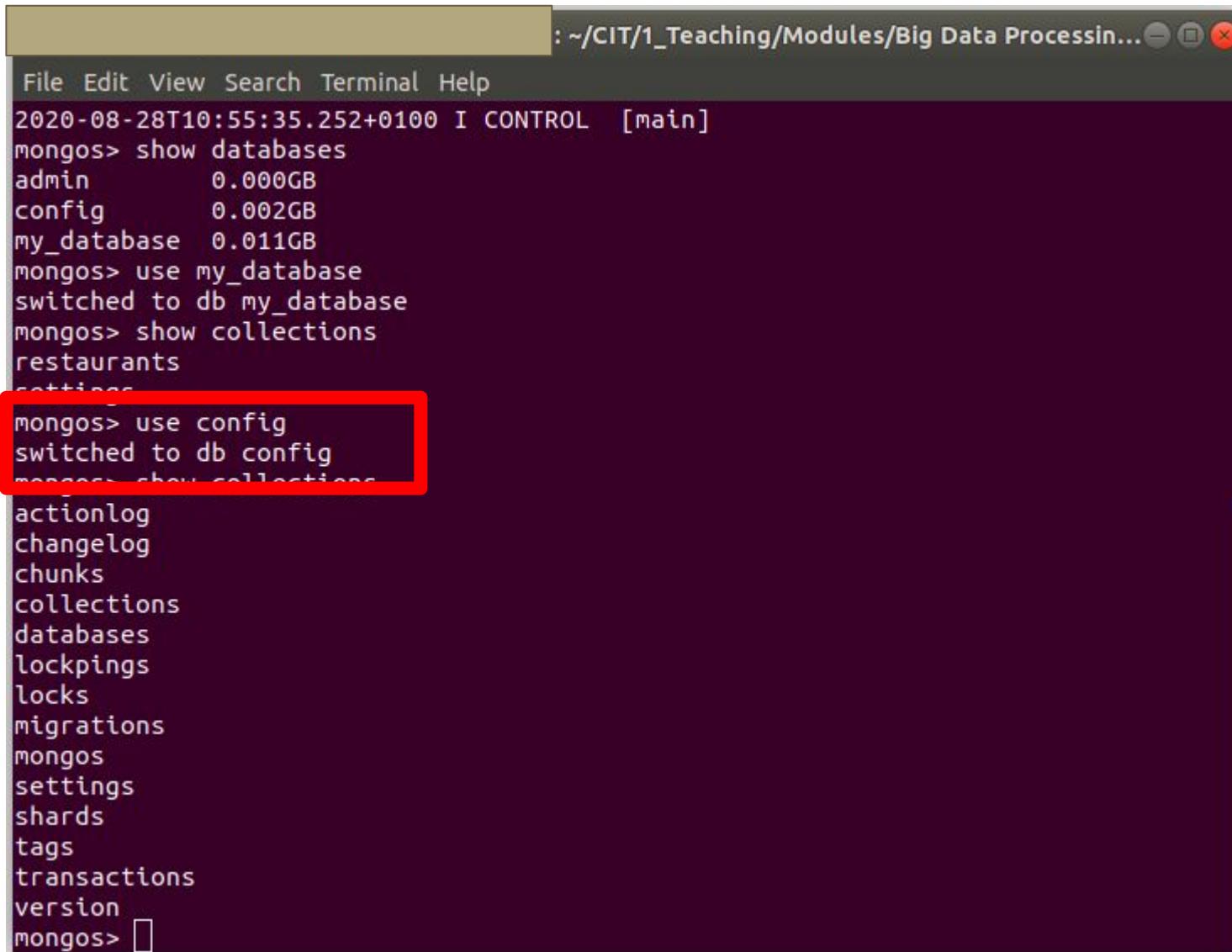
The screenshot shows a terminal window with a dark background and a light gray header bar. The header bar displays the path: `: ~/CIT/1_Teaching/Modules/Big Data Processin...` and the title `I CONTROL [main]`. The terminal menu bar includes File, Edit, View, Search, Terminal, and Help. The main area of the terminal shows the MongoDB shell (mongos) running. A red rectangular box highlights the first command and its output:

```
mongos> show databases
admin      0.000GB
config     0.002GB
my_database 0.011GB
```

Below this, several other commands are listed without their outputs:

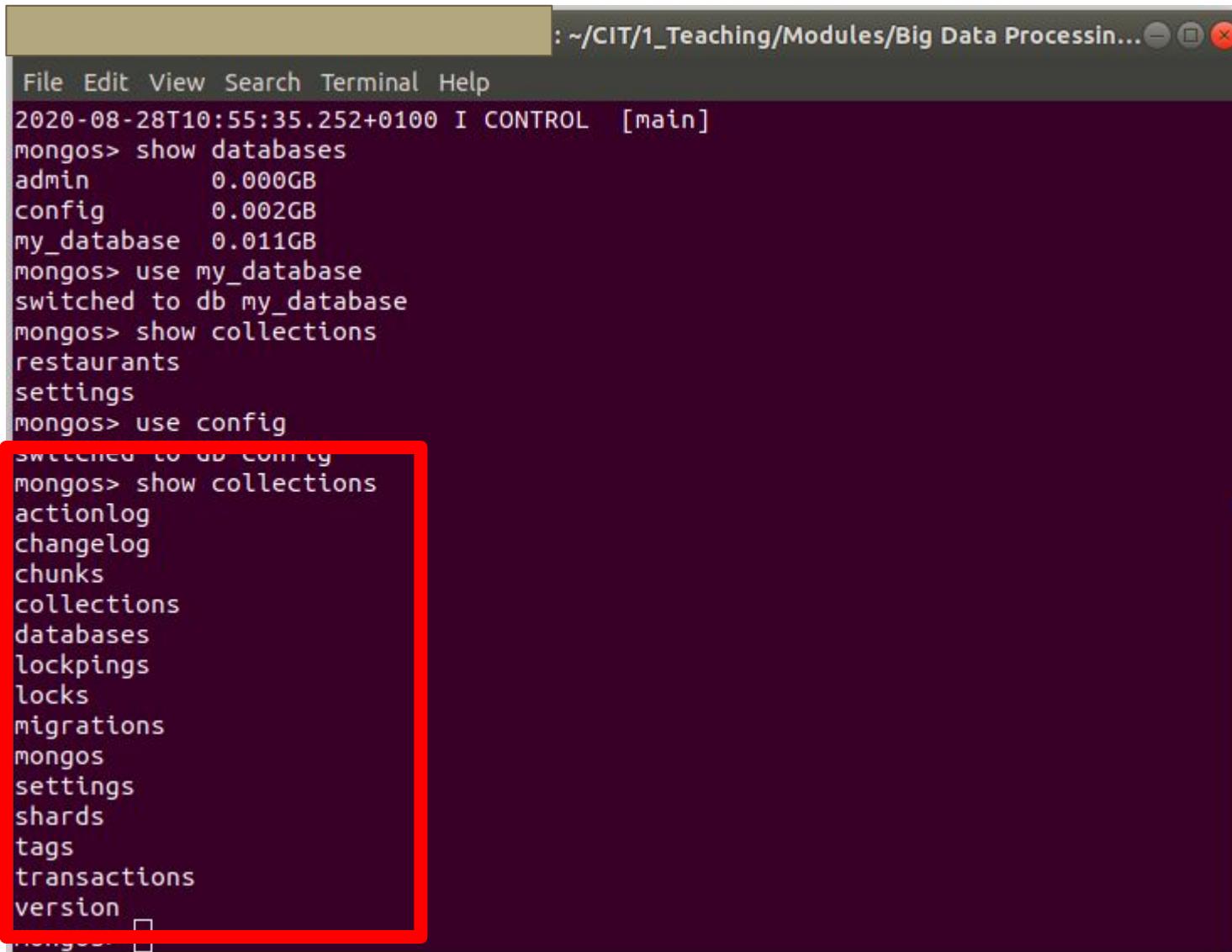
```
switched to db my_database
mongos> show collections
restaurants
settings
mongos> use config
switched to db config
mongos> show collections
actionlog
changelog
chunks
collections
databases
lockpings
locks
migrations
mongos
settings
shards
tags
transactions
version
mongos> 
```

MongoDB: Demonstrating Split and Migrate



```
File Edit View Search Terminal Help
2020-08-28T10:55:35.252+0100 I CONTROL  [main]
mongos> show databases
admin      0.000GB
config      0.002GB
my_database 0.011GB
mongos> use my_database
switched to db my_database
mongos> show collections
restaurants
settings
mongos> use config
switched to db config
mongos> show collections
actionlog
changelog
chunks
collections
databases
lockpings
locks
migrations
mongos
settings
shards
tags
transactions
version
mongos> 
```

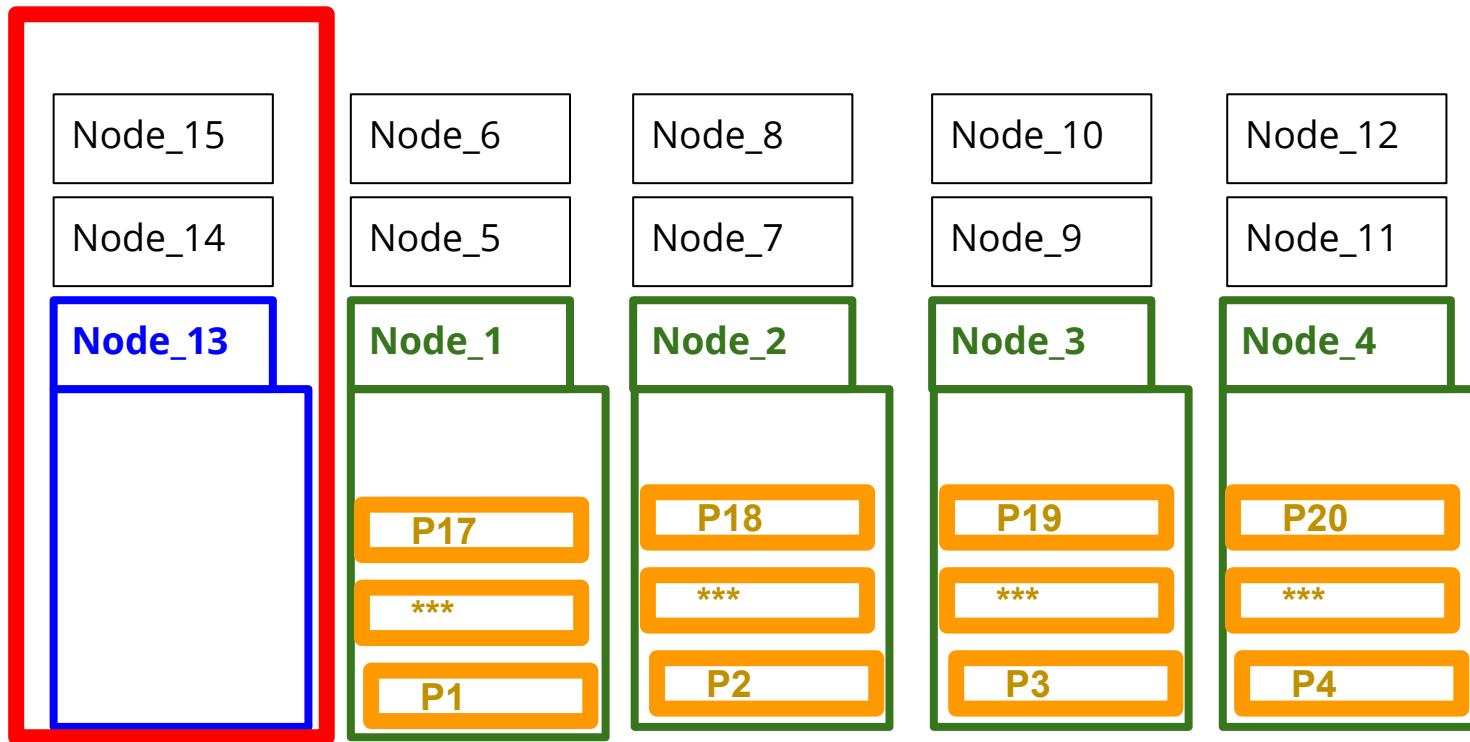
MongoDB: Demonstrating Split and Migrate



```
File Edit View Search Terminal Help
2020-08-28T10:55:35.252+0100 I CONTROL  [main]
mongos> show databases
admin      0.000GB
config     0.002GB
my_database 0.011GB
mongos> use my_database
switched to db my_database
mongos> show collections
restaurants
settings
mongos> use config
switched to db config
mongos> show collections
actionlog
changelog
chunks
collections
databases
lockpings
locks
migrations
mongos
settings
shards
tags
transactions
version
```

MongoDB: Demonstrating Split and Migrate

We use the collection **databases** to see how many databases the **metadata** is aware of.

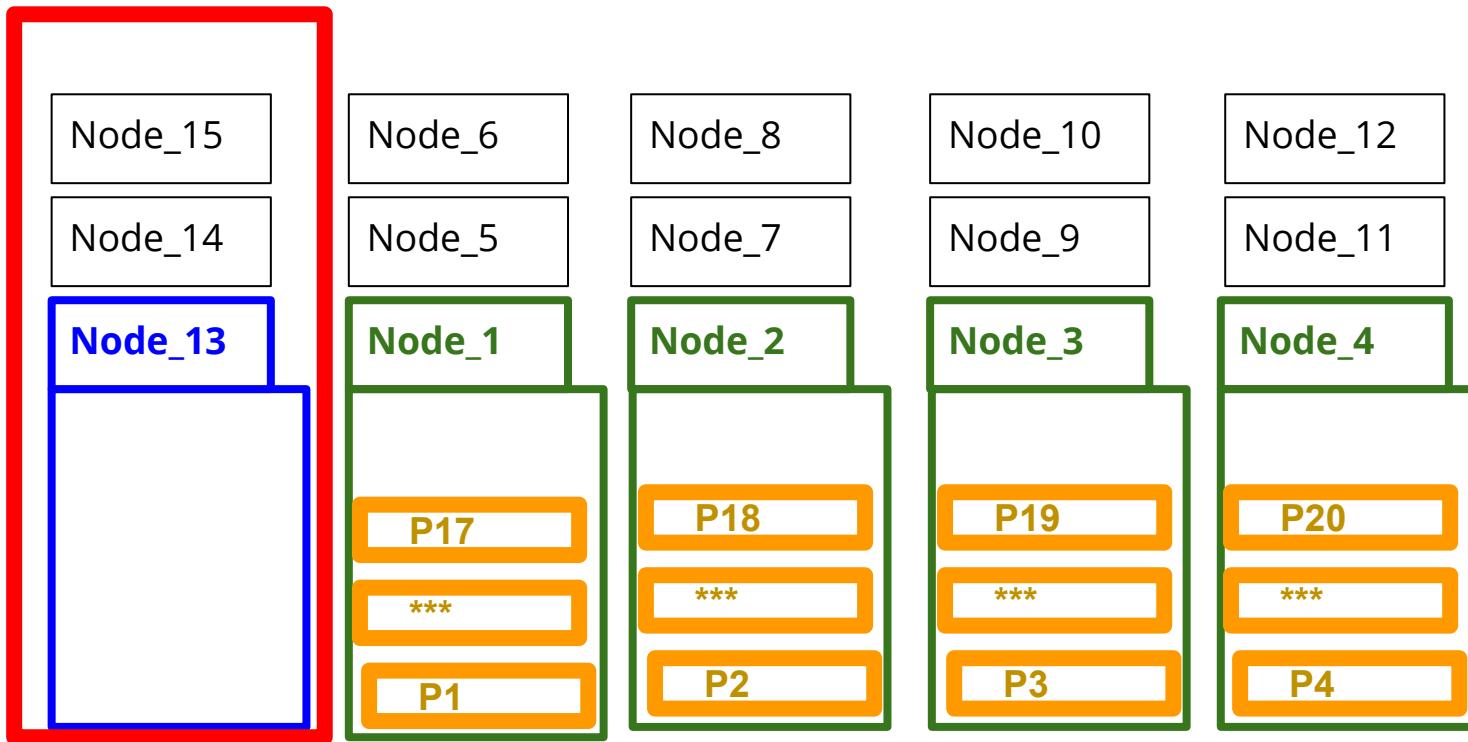


MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help
e unable to connect to this server.
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with
--bind_ip <address> to specify which IP
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should s
erve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
s. If this behavior is desired, start the
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
127.0.0.1 to disable this warning.
2020-08-28T10:55:35.252+0100 T CONTROL [main]
mongos> use config
switched to db config
mongos> db.databases.find({})
{ "_id" : "my_database", "primary" : "replica1", "partitioned" : true }
mongos> db.databases.find({})
{ "_id" : "replica1", "host" : "replica1/localhost:27000,localhost:27001,localhost:27002", "state" : 1 }
{ "_id" : "replica2", "host" : "replica2/localhost:27100,localhost:27101,localhost:27102", "state" : 1 }
{ "_id" : "replica3", "host" : "replica3/localhost:27200,localhost:27201,localhost:27202", "state" : 1 }
{ "_id" : "replica4", "host" : "replica4/localhost:27300,localhost:27301,localhost:27302", "state" : 1 }
mongos> 
```

MongoDB: Demonstrating Split and Migrate

We use the collection **shards** to see how many shards the **metadata** is aware of.

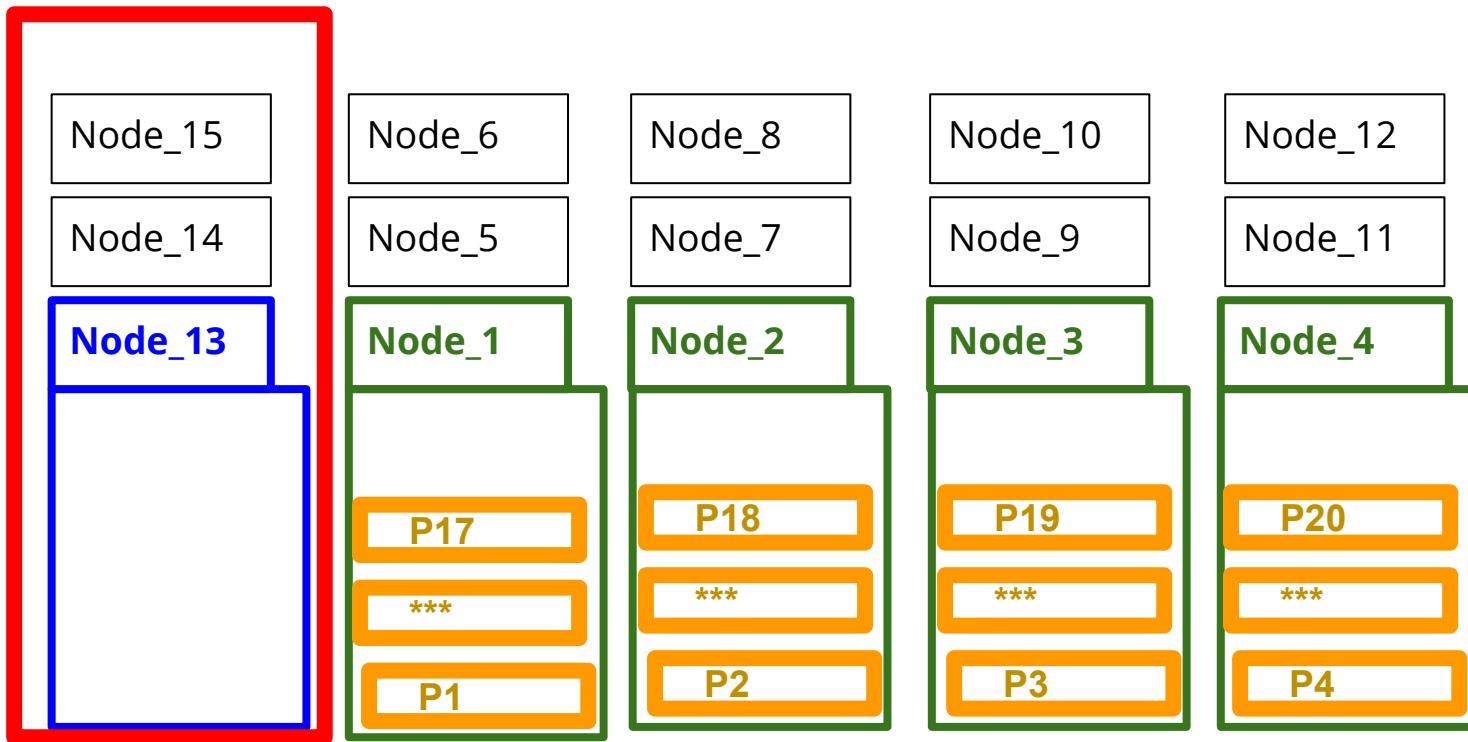


MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help
e unable to connect to this server.
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with
--bind_ip <address> to specify which IP
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should s
erve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
s. If this behavior is desired, start the
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
127.0.0.1 to disable this warning.
2020-08-28T10:55:35.252+0100 I CONTROL [main]
mongos> use config
switched to db config
mongos> db.databases.find({})
[{"_id": "config", "name": "config", "partition": "config", "shard": null}
mongos> db.shards.find({})
{ "_id" : "rep1set1", "host" : "rep1set1/localhost:27000,localhost:27001,localhost:27002", "state" : 1 }
{ "_id" : "rep1set2", "host" : "rep1set2/localhost:27100,localhost:27101,localhost:27102", "state" : 1 }
{ "_id" : "rep1set3", "host" : "rep1set3/localhost:27200,localhost:27201,localhost:27202", "state" : 1 }
{ "_id" : "rep1set4", "host" : "rep1set4/localhost:27300,localhost:27301,localhost:27302", "state" : 1 }
mongos>
```

MongoDB: Demonstrating Split and Migrate

We use the collection **chunks** to see how many partitions the **metadata** is aware of.



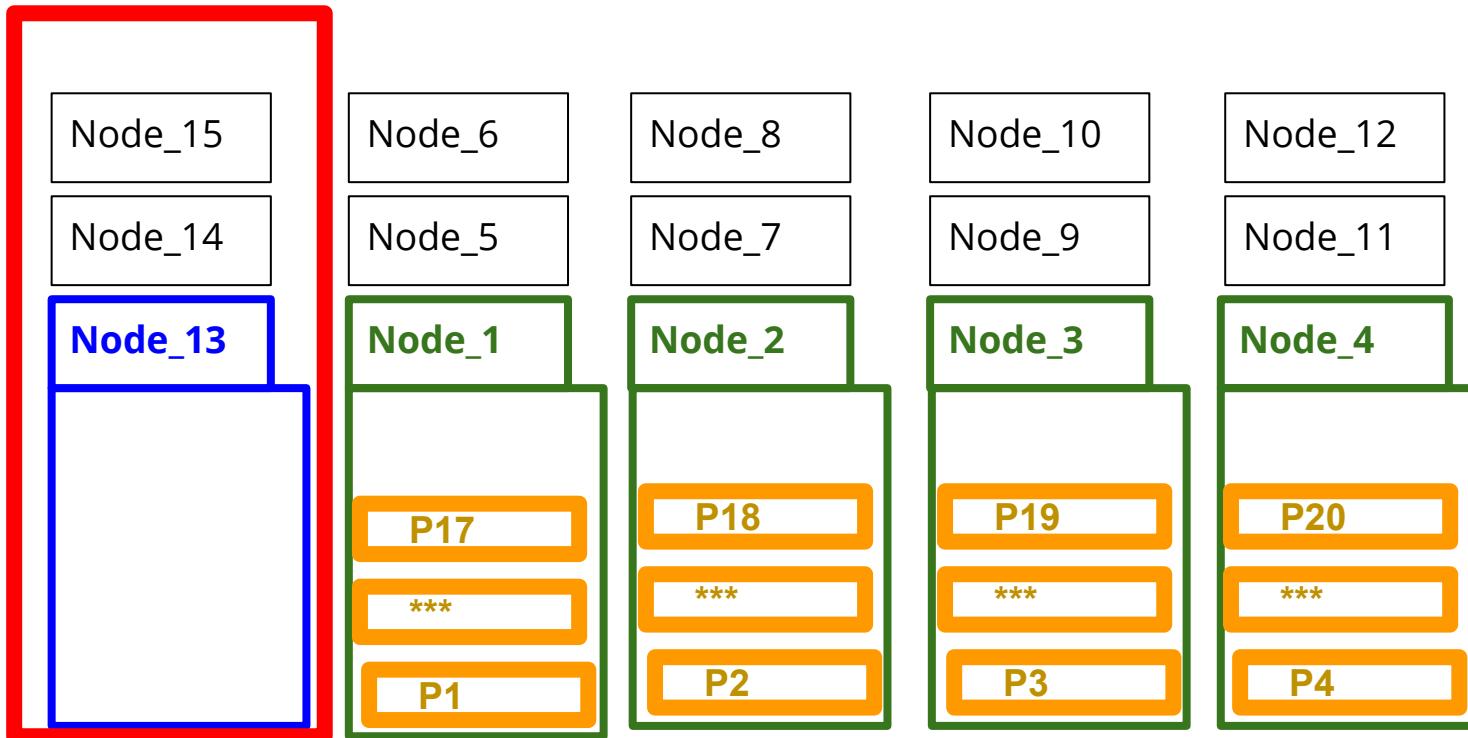
```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ● ◻ ✕
FILE EDIT VIEW SEARCH TERMINAL HELP
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Manhatta

```

MongoDB: Demonstrating Split and Migrate

For each partition we can see:

- The **partition id**



```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\"American \"borough_\"Brooklyn
\",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "id" : "mv database.restaurants-cuisine_\"American \"borough_\"Manhatta
}
```

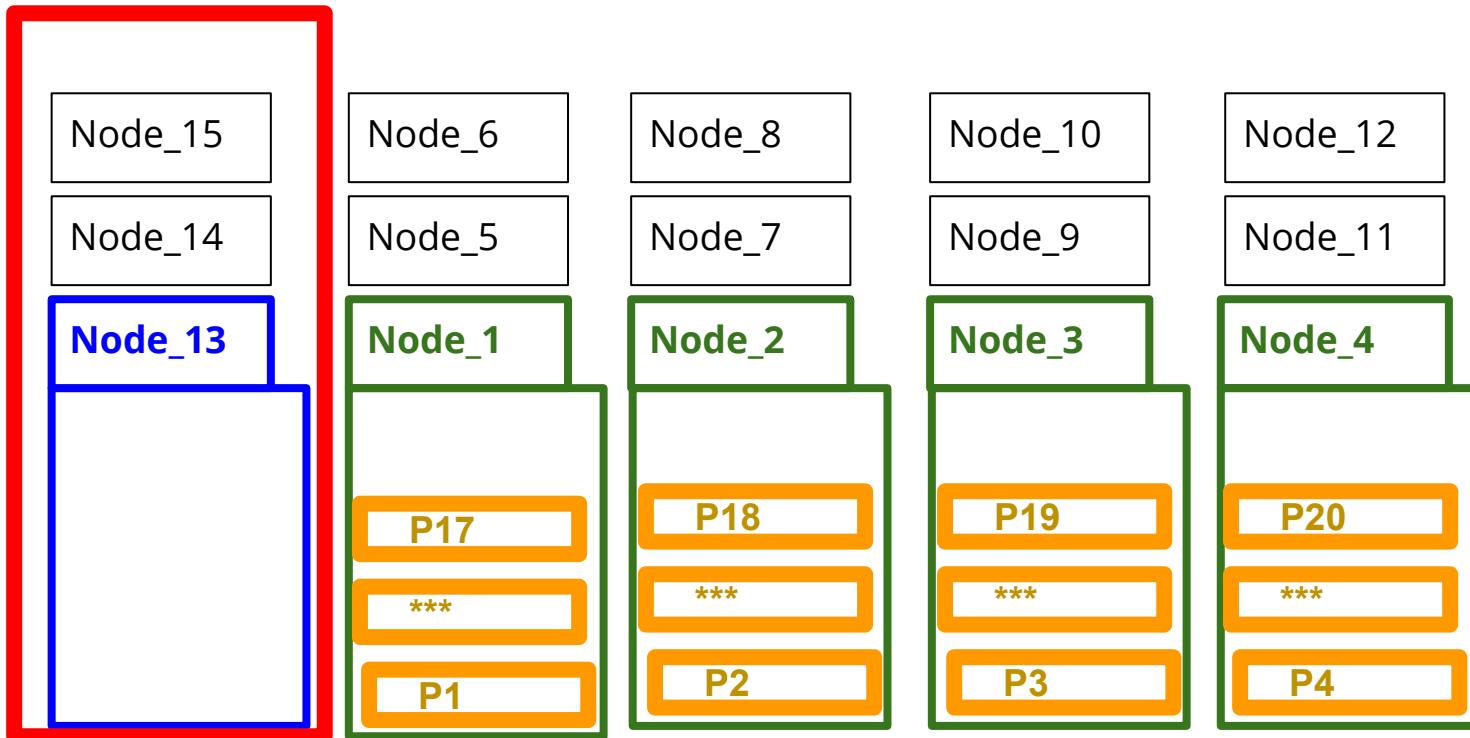
```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\"American \"\boroug...
\",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "id" : "my_database.restaurants-cuisine_\"American \"\boroug...

```

MongoDB: Demonstrating Split and Migrate

For each partition we can see:

- The range of **shard keys** for the documents contained in the partition.



```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ● ◻ ✕
FILE EDIT VIEW SEARCH TERMINAL HELP
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Manhatta

```

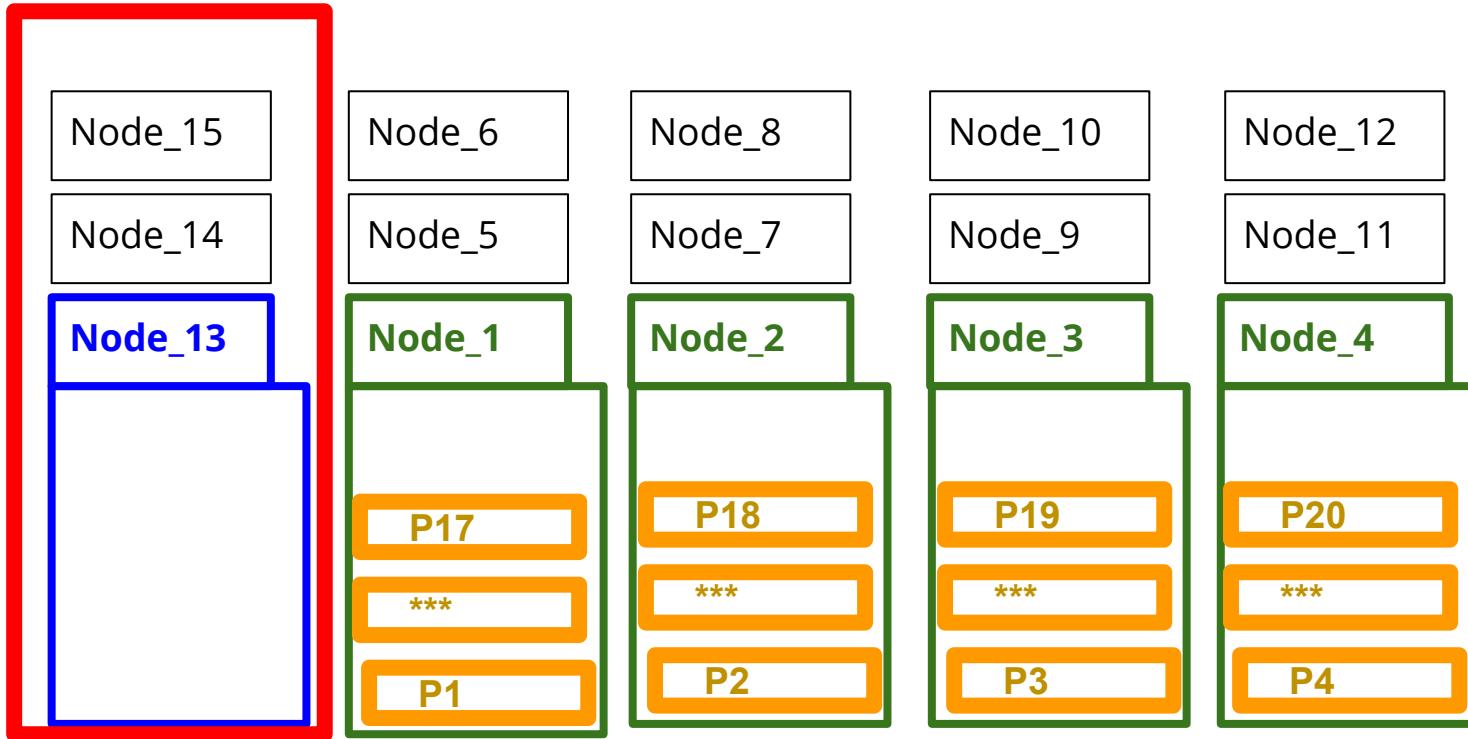
```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
FILE EDIT VIEW SEARCH TERMINAL HELP
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "rep1set2"
}
{
    "_id" : "my_database.restaurants-cuisine_\"American \"borough_\"Brooklyn
\",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "rep1set3"
}
{
    "_id" : "mv_database.restaurants-cuisine_\"American \"borough_\"Manhatta

```

MongoDB: Demonstrating Split and Migrate

For each partition we can see:

- The shard hosting the partition.

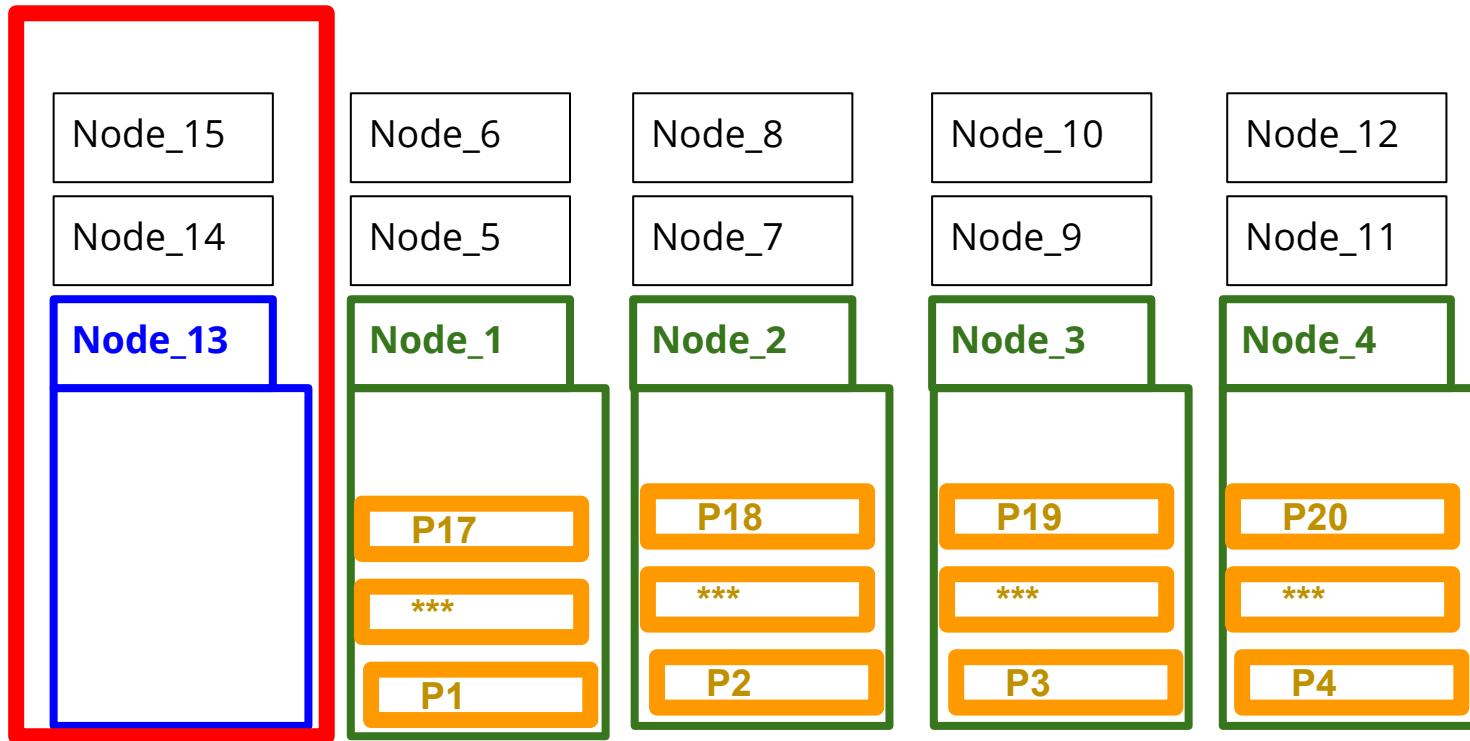


```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
FILE EDIT VIEW SEARCH TERMINAL HELP
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine \\"American \\"borough \\"Manhatta

```

MongoDB: Demonstrating Split and Migrate

Let's check all of this for one partition more



```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
},
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
}
ID : my_database.restaurants-cuisine \ American \ borough \ Manhattan
```

```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine \\"American \\"borough \\"Manhattan"
}
```

```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine \\"American \\"borough \\"Manhattan"
}
```

```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine \\"American \\"borough \\"Manhattan"
}
```

```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻
File Edit View Search Terminal Help
mongos> db.chunks.find({}).pretty()
{
    "_id" : "my_database.restaurants-cuisine_MinKeyborough_MinKey",
    "lastmod" : Timestamp(2, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : { "$minKey" : 1 },
        "borough" : { "$minKey" : 1 }
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "shard" : "replicaSet2"
}
{
    "_id" : "my_database.restaurants-cuisine_\\"American \\"borough_\\"Brooklyn
\\"",
    "lastmod" : Timestamp(3, 0),
    "lastmodEpoch" : ObjectId("5f48d4b49d791ff28e15620d"),
    "ns" : "my_database.restaurants",
    "min" : {
        "cuisine" : "American ",
        "borough" : "Brooklyn"
    },
    "max" : {
        "cuisine" : "American ",
        "borough" : "Manhattan"
    },
    "shard" : "replicaSet3"
}
{
    "_id" : "my_database.restaurants-cuisine \\"American \\"borough \\"Manhattan"
}
```

MongoDB: Demonstrating Split and Migrate

Demo Concept 4:

An important remark on
how this cluster data organisation
has an impact
on further data access

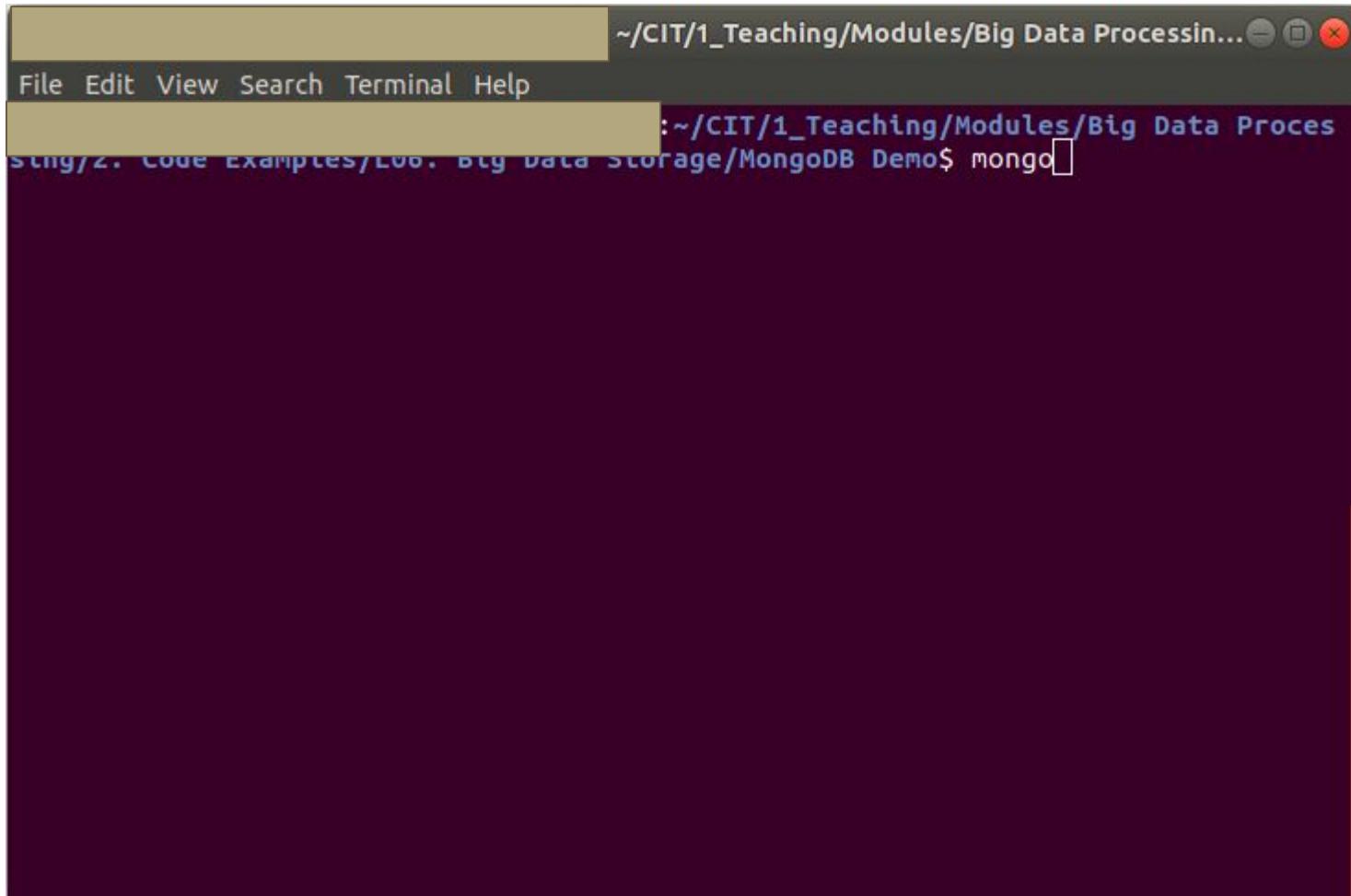
MongoDB: Demonstrating Split and Migrate

The following screenshots are taken by opening a new terminal and connecting it to the cluster.

MongoDB: Demonstrating Split and Migrate

We connect to the database **my_database** and the collection **restaurants** to trigger a couple of queries:

MongoDB: Demonstrating Split and Migrate

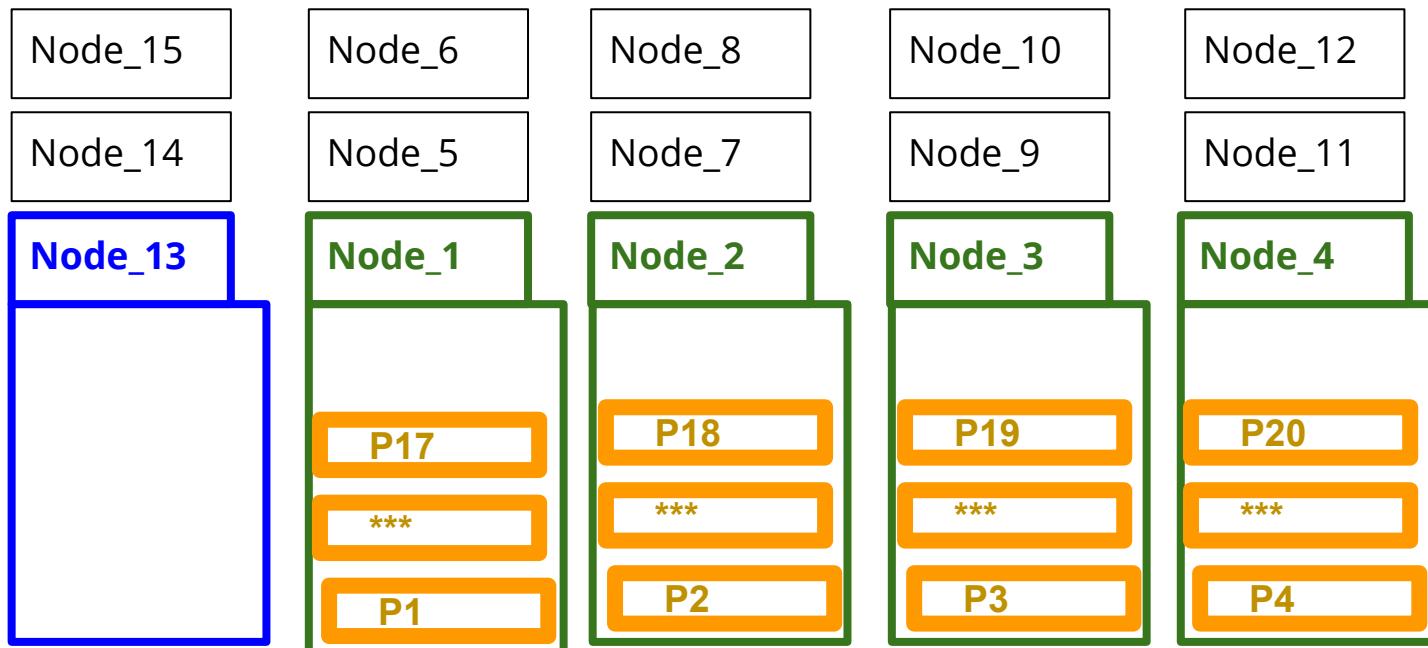


A screenshot of a terminal window titled "~/CIT/1_Teaching/Modules/Big Data Processin...". The window has a dark background and a light-colored title bar. The menu bar contains "File", "Edit", "View", "Search", "Terminal", and "Help". The command line shows the user's path: "cd ~/CIT/1_Teaching/Modules/Big Data Processing/2. Code Examples/Lab. Big Data Storage/MongoDB Demo\$ mongo". The terminal is currently empty, awaiting input.

MongoDB: Demonstrating Split and Migrate

Query 1:

Find our well known restaurant “Morris Park Bake Shop”.



MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ◯ ×
```

File Edit View Search Terminal Help

```
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Remote systems will b  
e unable to connect to this server.  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with  
--bind_ip <address> to specify which IP  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should s  
erve responses from, or with --bind_ip_all to  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface  
s. If this behavior is desired, start the  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip  
127.0.0.1 to disable this warning.  
2020-08-28T10:55:35.252+0100 I CONTROL [main]  
mongos> use my_database  
switched to db my_database  
mongos> db.restaurants.find({ "name" : "Morris Park Bake Shop" })  
{ "_id" : ObjectId("5f48d4a889a4e40940f2cd7f"), "address" : { "building" : "1007", "coord" : [ -73.856077, 40.848447 ], "street" : "Morris Park Ave", "zipcode" : "10462" }, "borough" : "Bronx", "cuisine" : "Bakery", "grades" : [ { "date" : ISODate("2014-03-03T00:00:00Z"), "grade" : "A", "score" : 2 }, { "date" : ISODate("2013-09-11T00:00:00Z"), "grade" : "A", "score" : 6 }, { "date" : ISODate("2013-01-24T00:00:00Z"), "grade" : "A", "score" : 10 }, { "date" : ISODate("2011-11-23T00:00:00Z"), "grade" : "A", "score" : 9 }, { "date" : ISODate("2011-03-10T00:00:00Z"), "grade" : "B", "score" : 14 } ], "name" : "Morris Park Bake Shop", "re  
staurant_id" : "30075445" }  
mongos> □
```

MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ◯ ×
```

File Edit View Search Terminal Help

```
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Remote systems will b  
e unable to connect to this server.  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with  
--bind_ip <address> to specify which IP  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should s  
erve responses from, or with --bind_ip_all to  
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface  
s. If this behavior is desired, start the  
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127.0.0.1 to disable this warning.  
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mongos> use my_database  
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{ "_id" : ObjectId("5f48d4a889a4e40940f2cd7f"), "address" : { "building" : "1007",  
"coord" : [ -73.856077, 40.848447 ], "street" : "Morris Park Ave", "zipcode" : "10462" },  
"borough" : "Bronx", "cuisine" : "Bakery", "grades" : [ { "date" : ISODate("2014-03-03T00:00:00Z"),  
"grade" : "A", "score" : 2 }, { "date" : ISODate("2013-09-11T00:00:00Z"), "grade" : "A", "score" : 6 },  
{ "date" : ISODate("2013-01-24T00:00:00Z"), "grade" : "A", "score" : 10 }, { "date" : ISODate("2011-11-23T00:00:00Z"),  
"grade" : "A", "score" : 9 }, { "date" : ISODate("2011-03-10T00:00:00Z"), "grade" : "B", "score" : 14 } ],  
"name" : "Morris Park Bake Shop", "re  
staurant_id" : "30075445" }
```

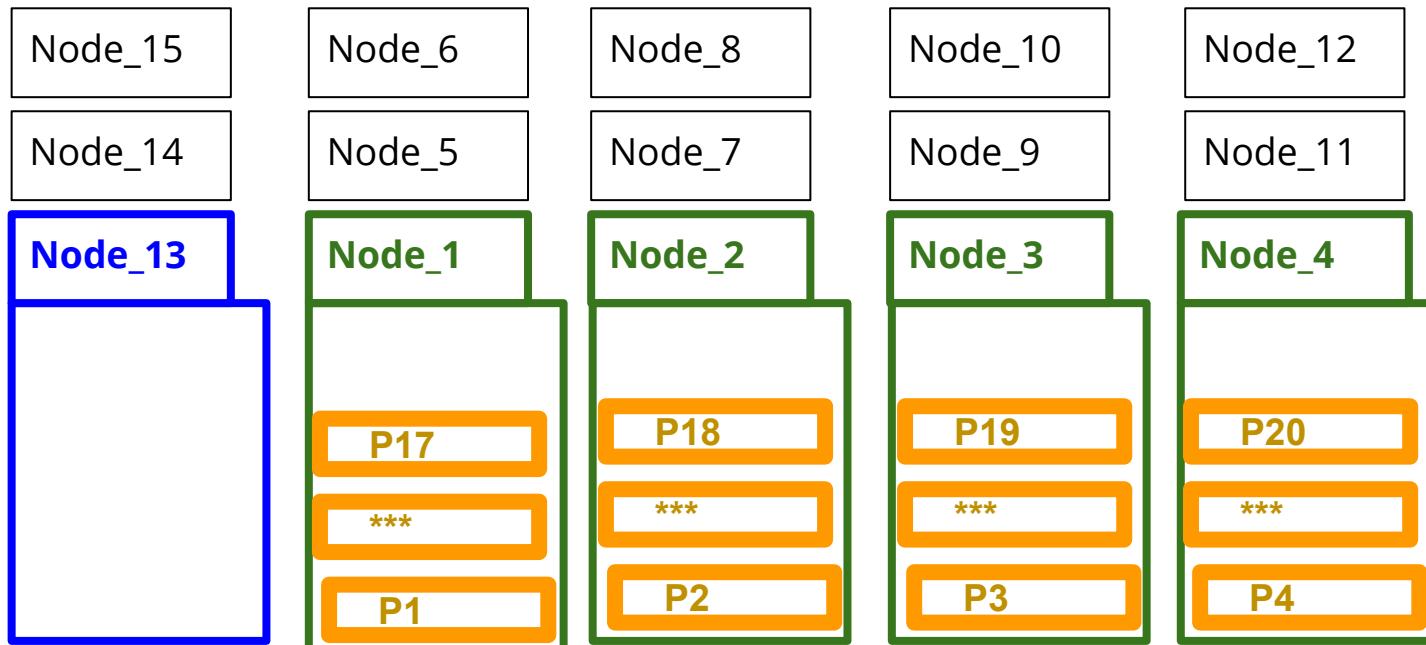
MongoDB: Demonstrating Split and Migrate

```
{  
  "name" : "Morris Park Bake Shop",  
  "cuisine" : "Bakery",  
  "borough" : "Bronx",  
  "address" : { "building": "1007", "street": "Morris Park Ave"},  
  "grades" : [ ... ]  
}
```

MongoDB: Demonstrating Split and Migrate

Now, let's look at how efficient this query was. In particular:

- How many shards were explored?
- How many documents were explored?

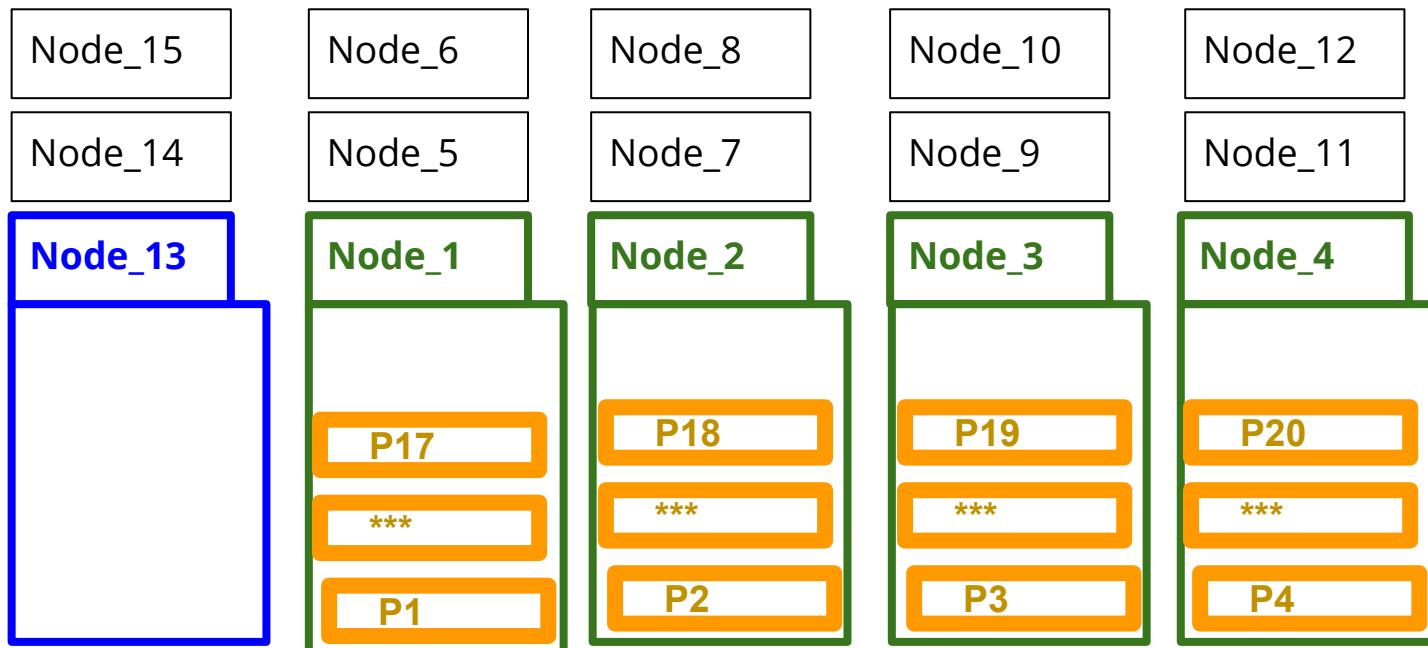


MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help
serve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
s. If this behavior is desired, start the
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
127.0.0.1 to disable this warning.
2020-08-28T10:55:35.252+0100 I CONTROL [main]
mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({"name" : "Morris Park Bake Shop"}).explain("executi
onStats")
{
    "queryPlanner" : {
        "mongosPlannerVersion" : 1,
        "winningPlan" : {
            "stage" : "SHARD_MERGE",
            "shards" : [
                {
                    "shardName" : "replicaSet3",
                    "connectionString" : "replicaSet3/localhost
:27200,localhost:27201,localhost:27202",
                    "serverInfo" : {
                        "host" : "smartebuses1-Latitude-
5401",
                        "port" : 27202,
                    }
                }
            ]
        }
    }
}
```

MongoDB: Demonstrating Split and Migrate

As we can see, the query planner indicates **“SHARD_MERGE”**, which means the query was redirected to multiple shards (map stage) and merged afterwards (reduce stage).



MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help
serve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
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2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
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2020-08-28T10:55:35.252+0100 I CONTROL [main]
mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({"name" : "Morris Park Bake Shop"}).explain("executi
onStats")
{
  "queryPlanner" : {
    "mongosPlannerVersion" : 1,
    "winningPlan" : {
      "stage" : "SHARD_MERGE",
      "shards" : [
        {
          "shardName" : "replicaSet3",
          "connectionString" : "replicaSet3/localhost
:27200,localhost:27201,localhost:27202",
          "serverInfo" : {
            "host" : "smartebuses1-Latitude-E
5401",
            "port" : 27202
          }
        }
      ]
    }
  }
}
```

MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
```

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```
serve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
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2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
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mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({"name" : "Morris Park Bake Shop"}).explain("executi
onStats")
{
  "queryPlanner" : {
    "mongosPlannerVersion" : 1,
    "winningPlan" : {
      "stage" : "SHARD_MERGE"
      "shards" : [
        {
          "shardName" : "replicaSet3",
          "connectionString" : "replicaSet3/localhost
:27200,localhost:27201,localhost:27202",
          "serverInfo" : {
            "host" : "smartebuses1-Latitude-E
5401",
            "port" : 27202
          }
        }
      ]
    }
  }
}
```

MongoDB: Demonstrating Split and Migrate

```
~/CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help
serve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
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2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
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mongos> db.restaurants.find({"name" : "Morris Park Bake Shop"}).explain("executi
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{
  "queryPlanner" : {
    "mongosPlannerVersion" : 1,
    "winningPlan" : {
      "stage" : "SHARD_MERGE",
      "shards" : [
        {
          "shardName" : "replicaSet3",
          "connectionString" : "replicaSet3/localhost
:27200,localhost:27201,localhost:27202",
          "serverInfo" : {
            "host" : "smartebuses1-Latitude-E
5401",
            "port" : 27202
          }
        }
      ]
    }
  }
}
```

MongoDB: Demonstrating Split and Migrate

```
File Edit View Search Terminal Help
serve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
s. If this behavior is desired, start the
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
 127.0.0.1 to disable this warning.
2020-08-28T10:55:35.252+0100 I CONTROL [main]
mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({"name" : "Morris Park Bake Shop"}).explain("executi
onStats")
{
  "queryPlanner" : {
    "mongosPlannerVersion" : 1,
    "winningPlan" : {
      "stage" : "SHARD_MERGE",
      "shards" : [
        {
          "shardName" : "replicaSet3", // Shaded in yellow
          "connectionString" : "replicaSet3/localhost
:27200,localhost:27201,localhost:27202",
          "serverInfo" : {
            "host" : "smartebuses1-Latitude-E
5401",
            "port" : 27200
          }
        }
      ]
    }
  }
}
```

MongoDB: Demonstrating Split and Migrate

```
CIT/1_Teaching/Modules/Big Data Processin... ● ○ ×
File Edit View Search Terminal Help "Seq" :
"Morris Park Bake Shop"
}
},
"direction" : "forward"
}
},
"rejectedPlans" : [ ]
},
{
"shardName" : "replset2",
"connectionString" : "replset2/localhost
:27100,localhost:27101,localhost:27102",
"serverInfo" : {
"host" : "smarteborgues1-Latitude-
5401",
"port" : 27101,
"version" : "3.6.3",
"gitVersion" : "9586e557d54ef70f
9ca4b43c26892cd55257e1a5"
},
"plannerVersion" : 1,
"namespace" : "my_database.restaurants",
"indexFilterSet" : false,
```

MongoDB: Demonstrating Split and Migrate

```
File Edit View Search Terminal Help
        "rejectedPlans" : [ ]
    },
{
    "shardName" : "replset4",
    "connectionString" : "replicaSet4/localhost
:27300,localhost:27301,localhost:27302",
    "serverInfo" : {
        "host" : "smartebuses1-Latitude-
5401",
        "port" : 27302,
        "version" : "3.6.3",
        "gitVersion" : "9586e557d54ef70f
9ca4b43c26892cd55257e1a5"
    },
    "plannerVersion" : 1,
    "namespace" : "my_database.restaurants",
    "indexFilterSet" : false,
    "parsedQuery" : {
        "name" : {
            "$eq" : "Morris Park Bak
e Shop"
        }
    },
    "winningPlan" : {
```

MongoDB: Demonstrating Split and Migrate

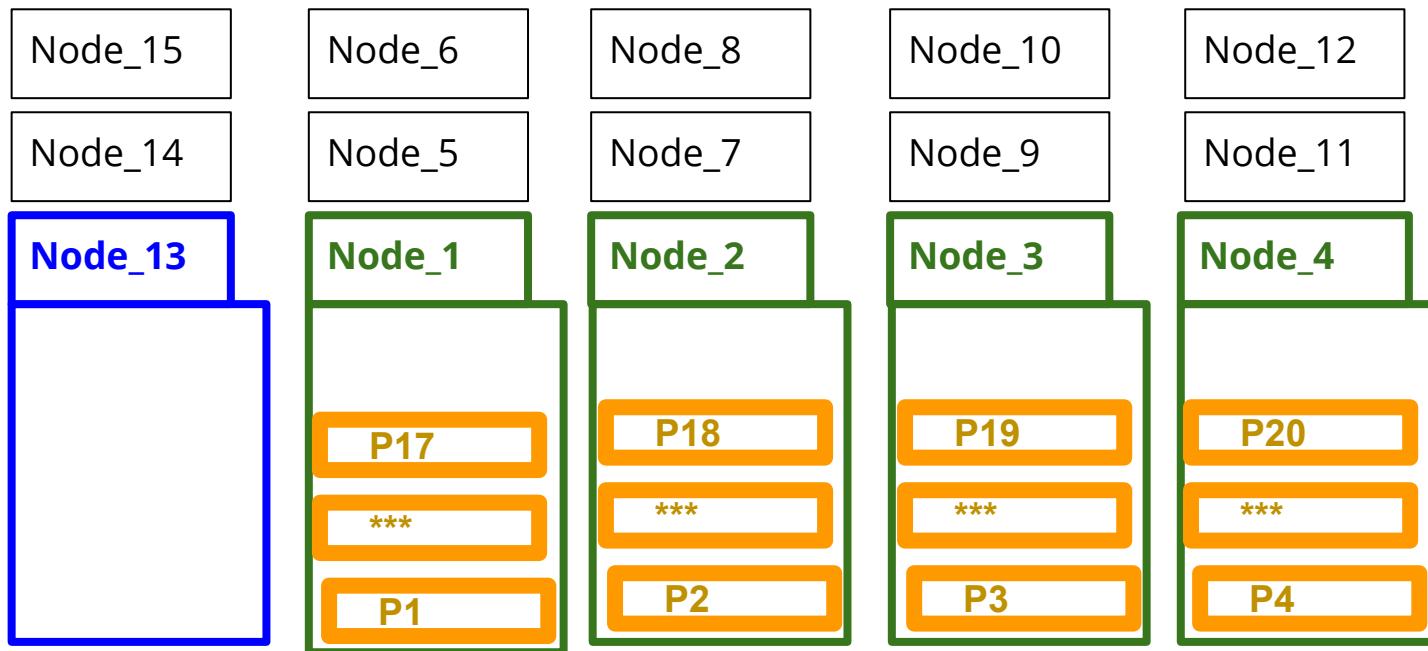
```
:IT/1_Teaching/Modules/Big Data Processin... ━ ◻ X
```

File Edit View Search Terminal Help

```
        "rejectedPlans" : [ ]  
    },  
    {  
        "shardName" : "replica1",  
        "connectionString" : "replica1/localhost:  
:27000,localhost:27001,localhost:27002",  
        "serverInfo" : {  
            "host" : "smartebuses1-Latitude-  
5401",  
            "port" : 27000,  
            "version" : "3.6.3",  
            "gitVersion" : "9586e557d54ef70f  
9ca4b43c26892cd55257e1a5"  
        },  
        "plannerVersion" : 1,  
        "namespace" : "my_database.restaurants",  
        "indexFilterSet" : false,  
        "parsedQuery" : {  
            "name" : {  
                "$eq" : "Morris Park Bak  
e Shop"  
            }  
        },  
        "winningPlan" : {
```

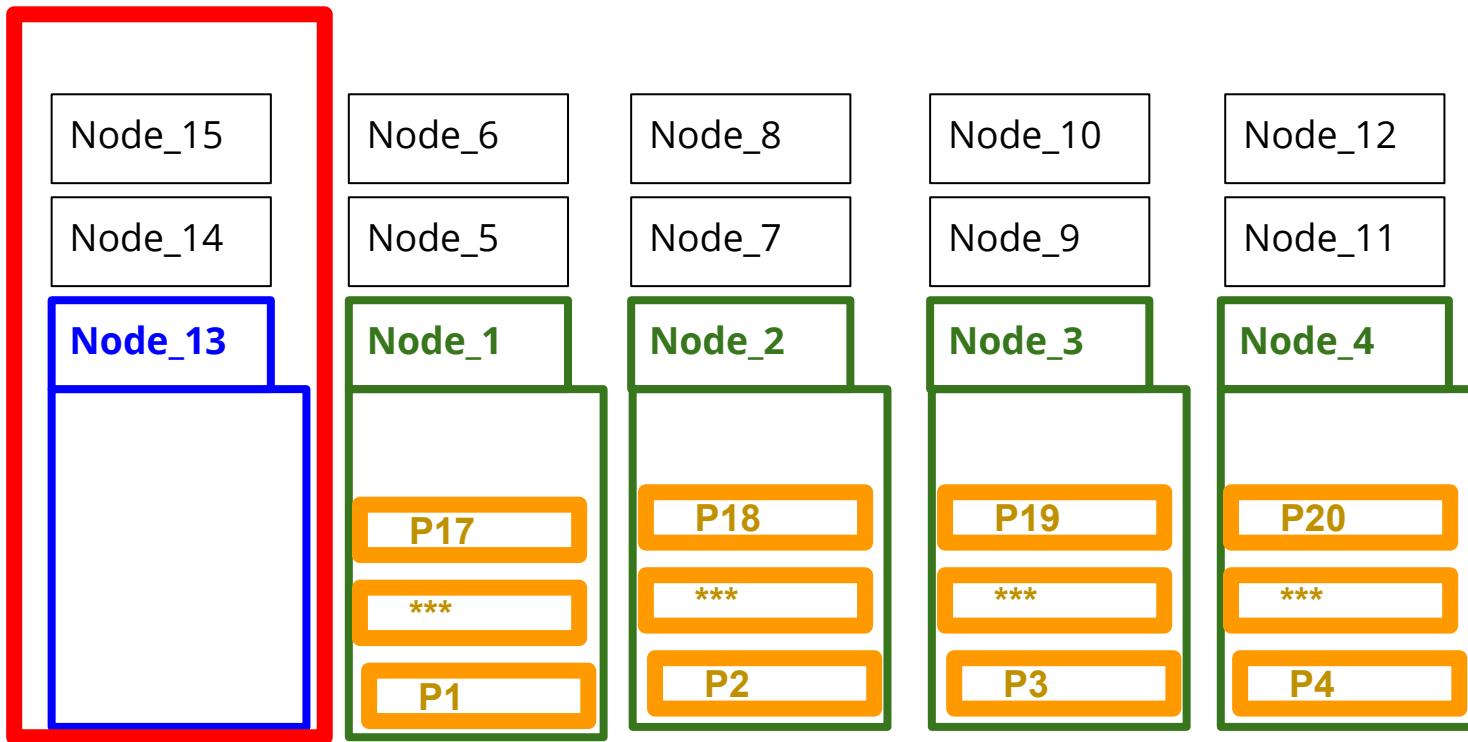
MongoDB: Demonstrating Split and Migrate

As we can see, the query was directed to the 4 shards!



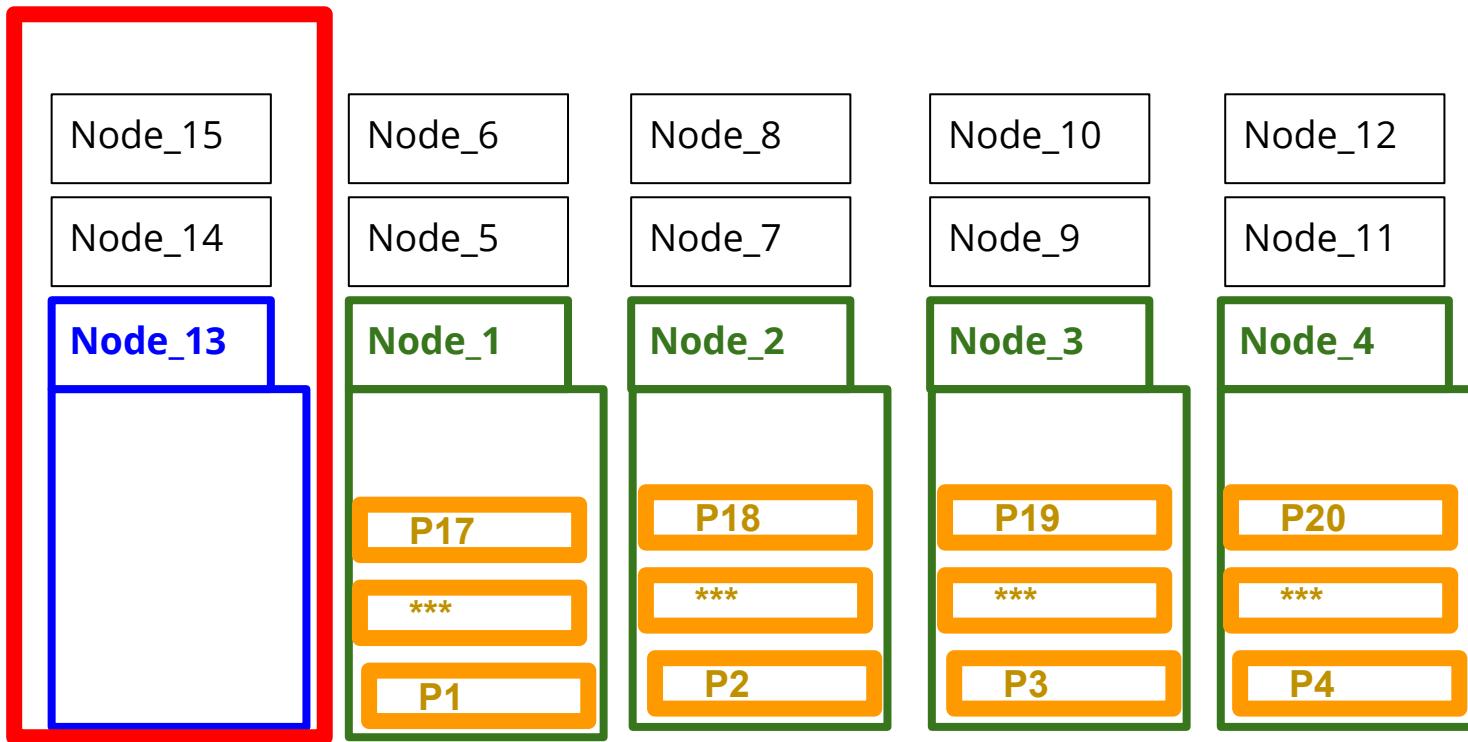
MongoDB: Demonstrating Split and Migrate

This makes sense: the query was initially directed to the metadata.



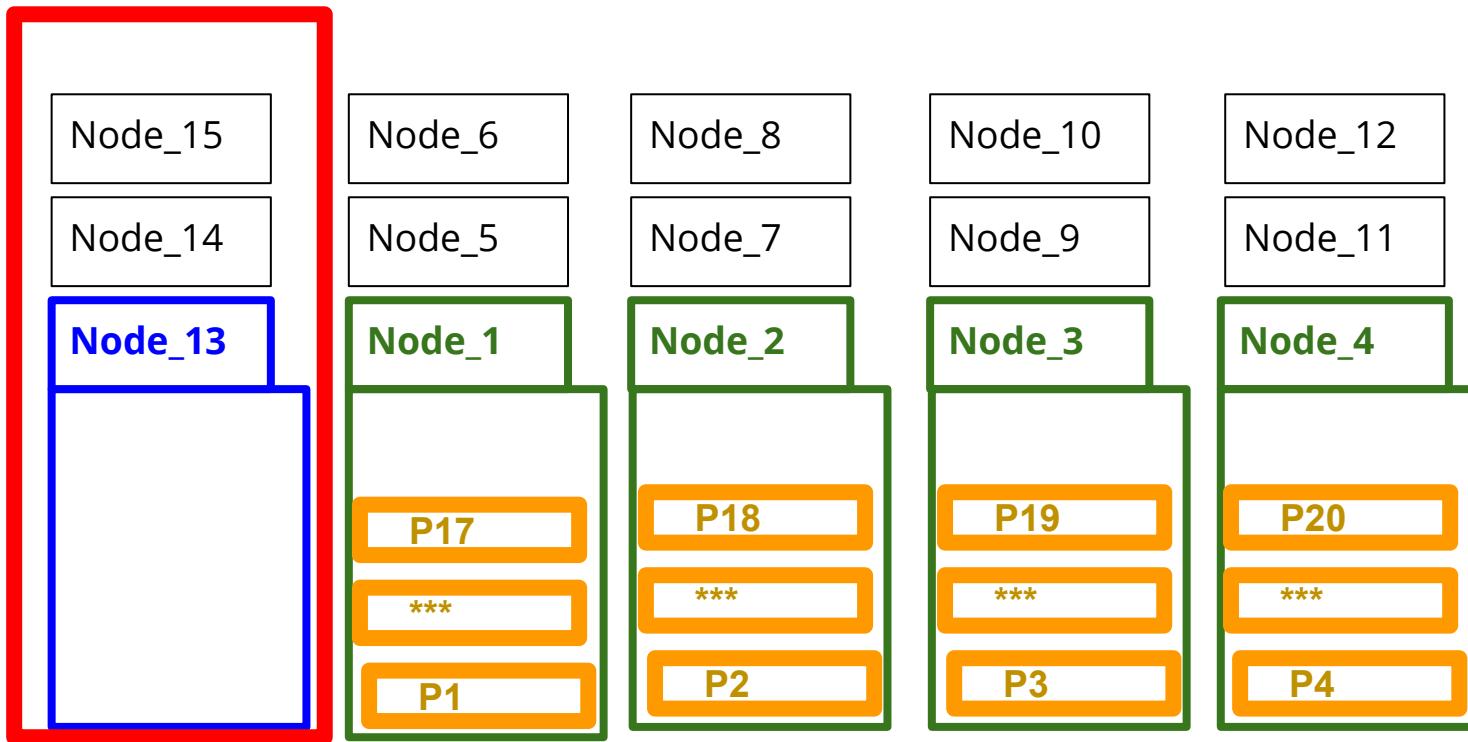
MongoDB: Demonstrating Split and Migrate

The metadata knows about the organisation of the partitions based on their shard key **cuisine** and **borough**, but not based on their key **name**.



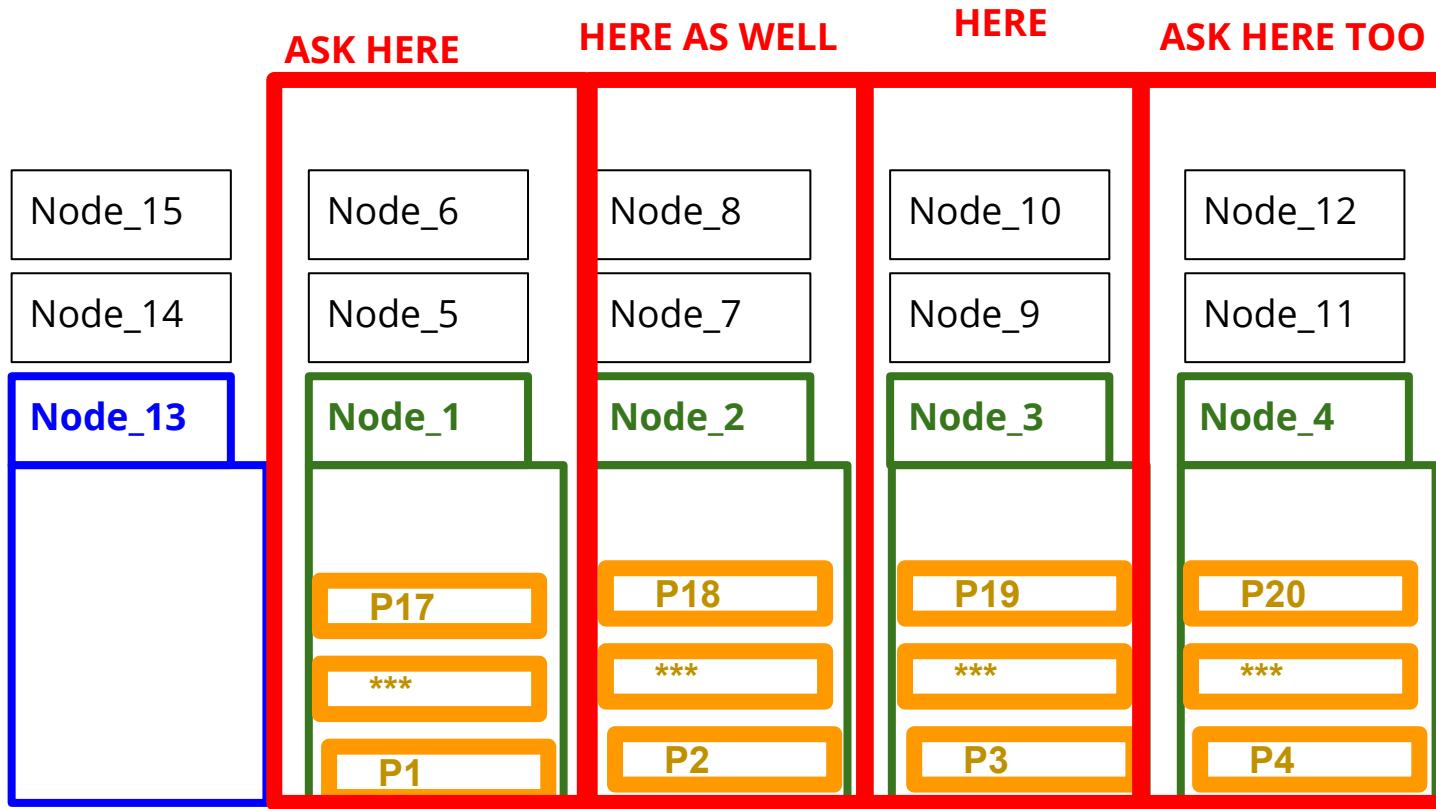
MongoDB: Demonstrating Split and Migrate

Thus, the metadata has no idea of which partition can contain the restaurant :(



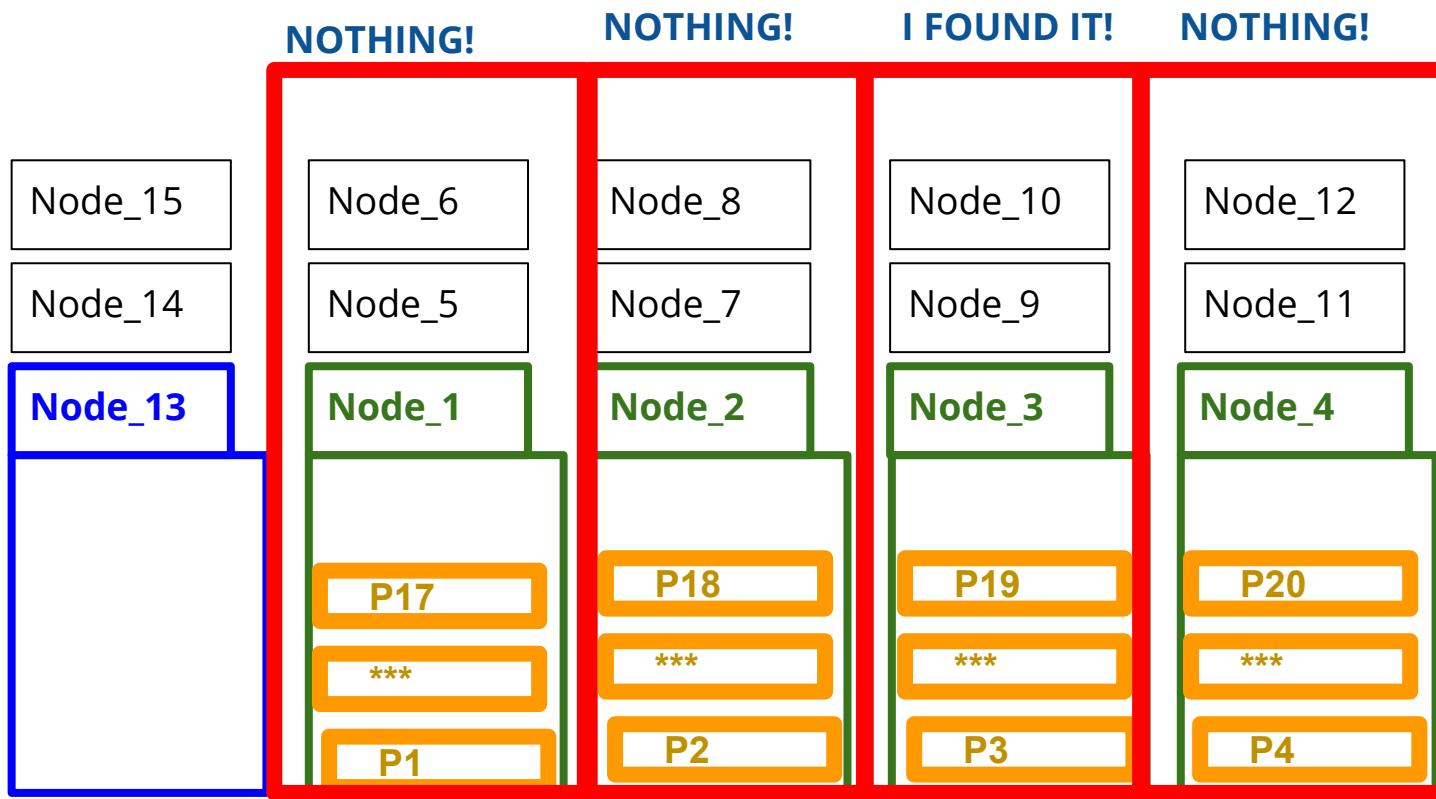
MongoDB: Demonstrating Split and Migrate

Thus, all shards must be queried (map stage).



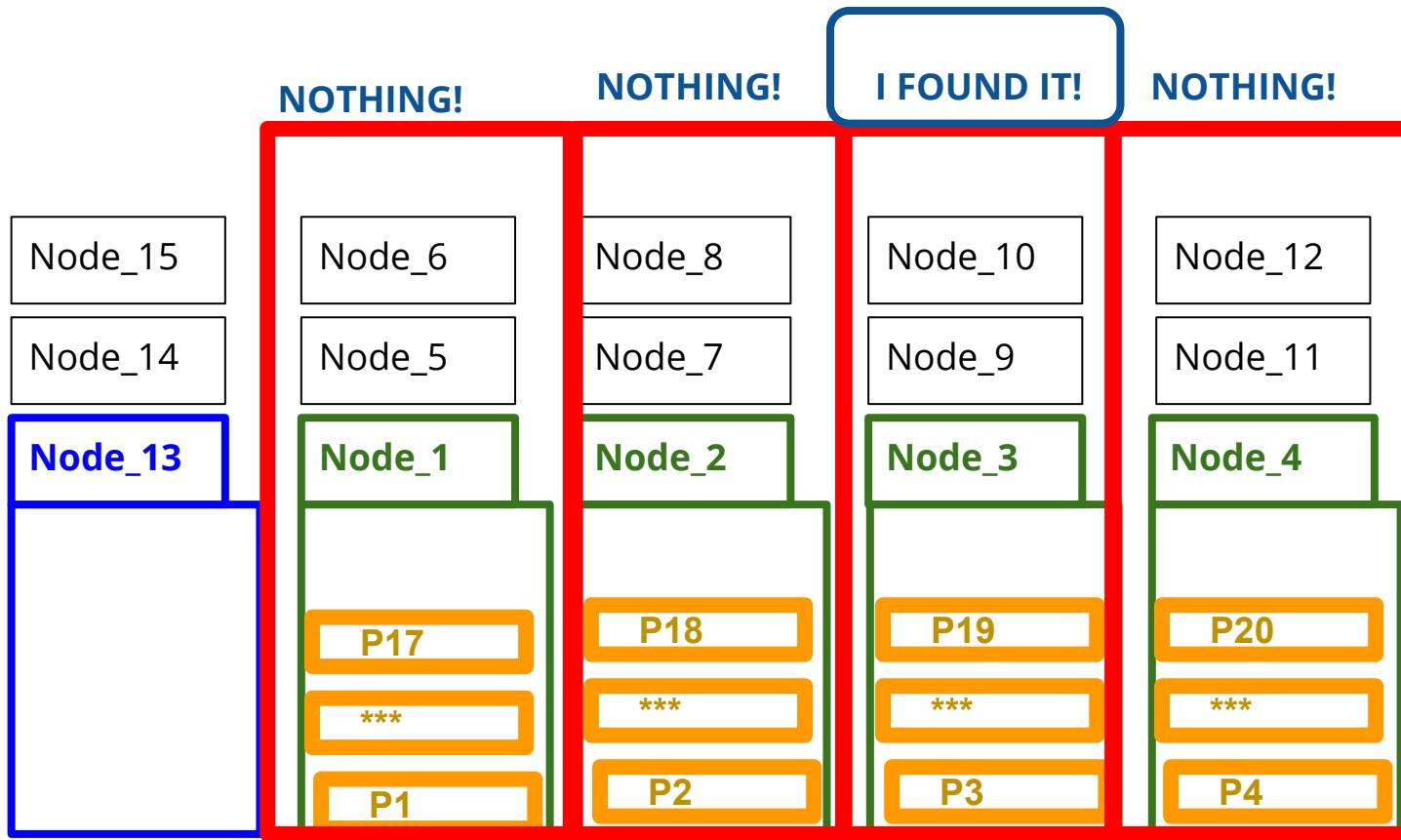
MongoDB: Demonstrating Split and Migrate

And the results of each shard are merged to get the final result to the query.



MongoDB: Demonstrating Split and Migrate

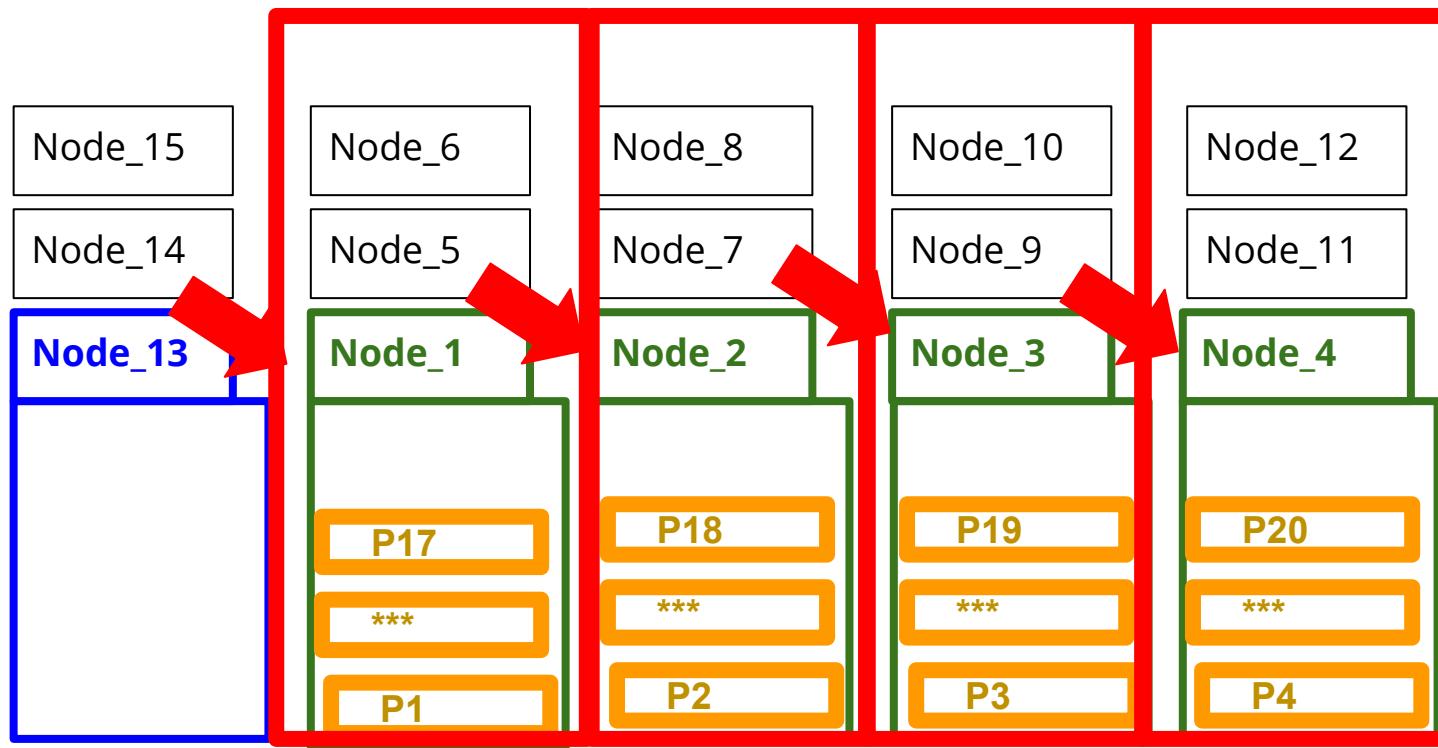
And the results of each shard are merged to get the final result to the query.



MongoDB: Demonstrating Split and Migrate

Conclusion:

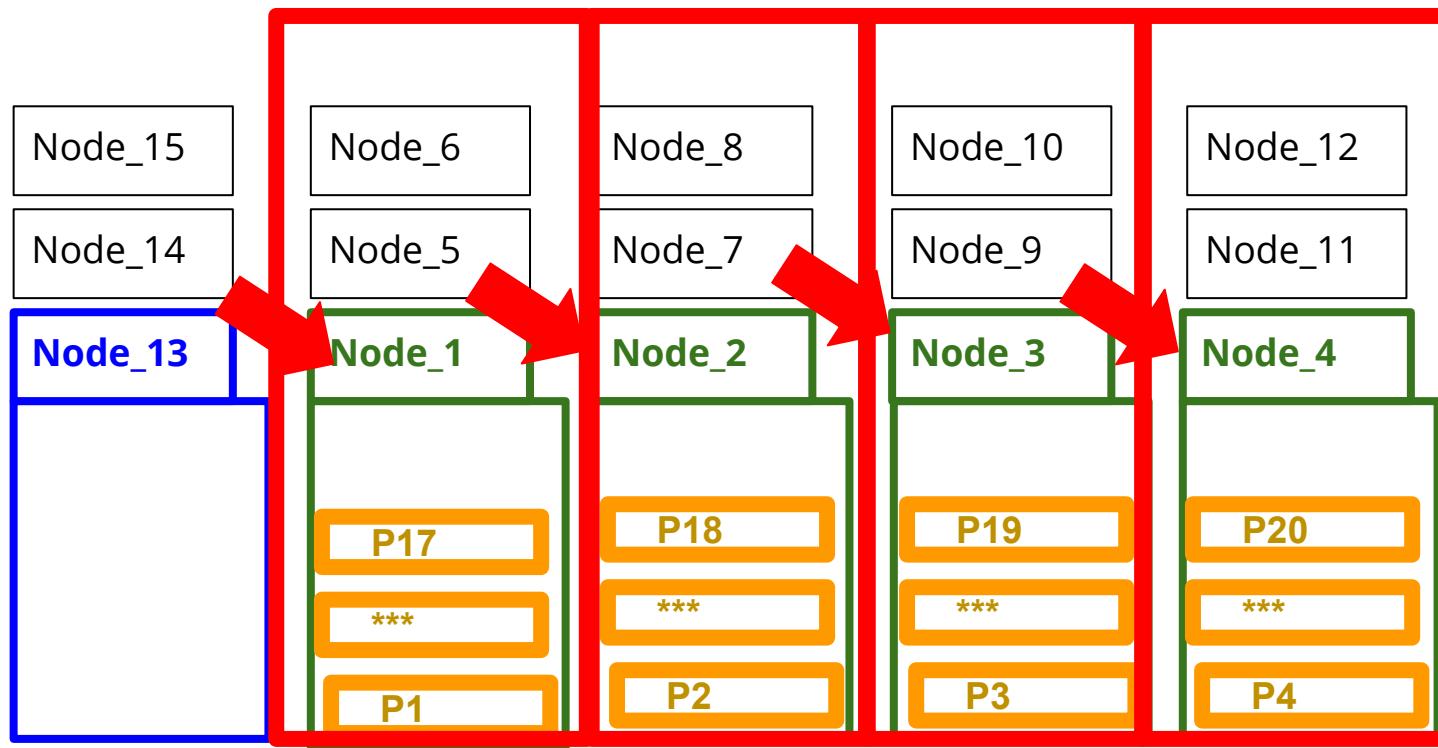
Even if the search was speed-up by having the shards working in parallel...



MongoDB: Demonstrating Split and Migrate

Conclusion:

...the query was inefficient, as it had to explore the entire collection using all shards...



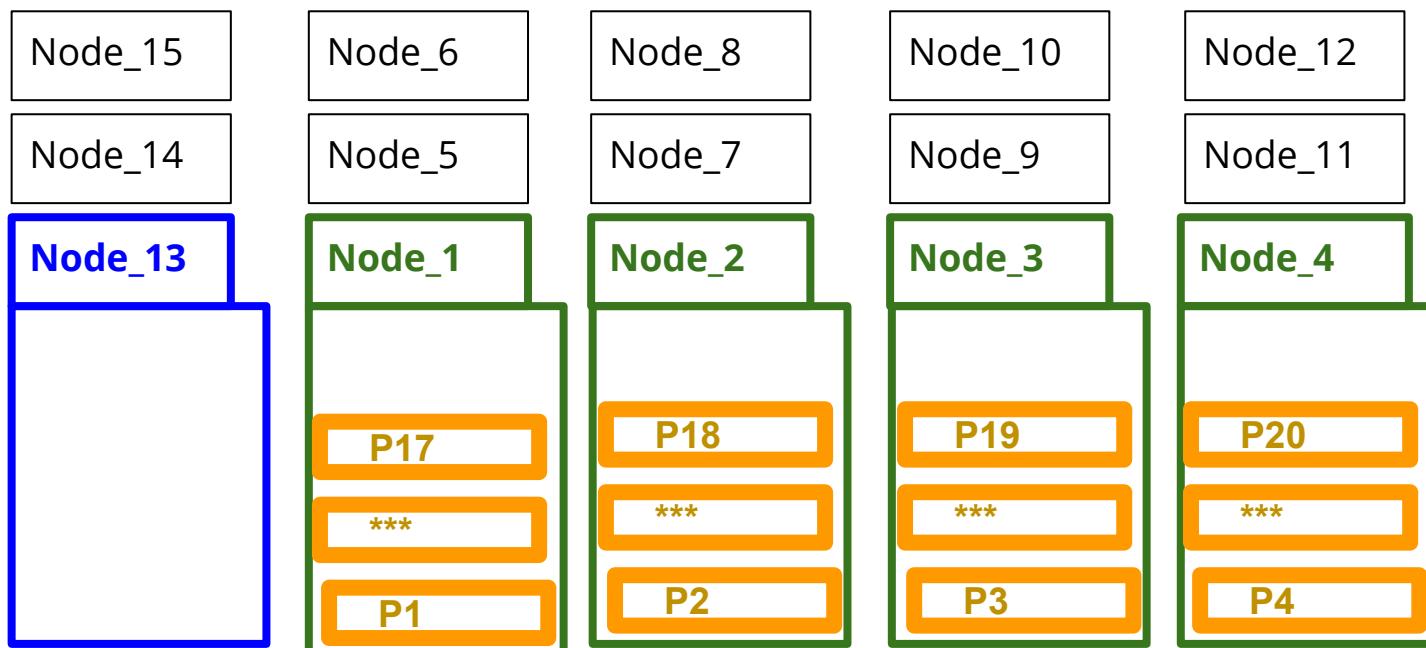
MongoDB: Demonstrating Split and Migrate

```
host": "192.168.1.11:27017",
port": 27000,
version": "3.6.3",
"db": "Morris_Park_BakeShop"
"version": 1,
"ns": "ny_database.restaurants",
"erset": false,
"ary": [
"ame": {
"Seq": "Morris Park Bak
"n": 1,
"o": 1,
"l": 1
}
],
"rejectedPlans": []
},
"executionStats": {
"nReturned": 1,
"executionTimeMillis": 19,
"totalKeysExamined": 0,
"totalDocsExamined": 25359,
"executionStages": [
{
"stage": "SHARD_MERGE",
"nReturned": 1,
"executionTimeMillis": 19,
"totalKeysExamined": 0,
"totalDocsExamined": 25359,
"totalChildMillis": NumberLong(47),
"totalParentMillis": NumberLong(47)
}
]
}
}
```

MongoDB: Demonstrating Split and Migrate

Query 2:

Count how many restaurants of Italian cuisine are there in the Staten Island borough.



MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ━ ━ ━
```

File Edit View Search Terminal Help

enabled for the database.

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Read and write access to data and configuration is unrestricted.

2020-08-28T10:55:35.252+0100 I CONTROL [main]

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** WARNING: This server is bound to localhost.

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Remote systems will be unable to connect to this server.

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with --bind_ip <address> to specify which IP

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should serve responses from, or with --bind_ip_all to

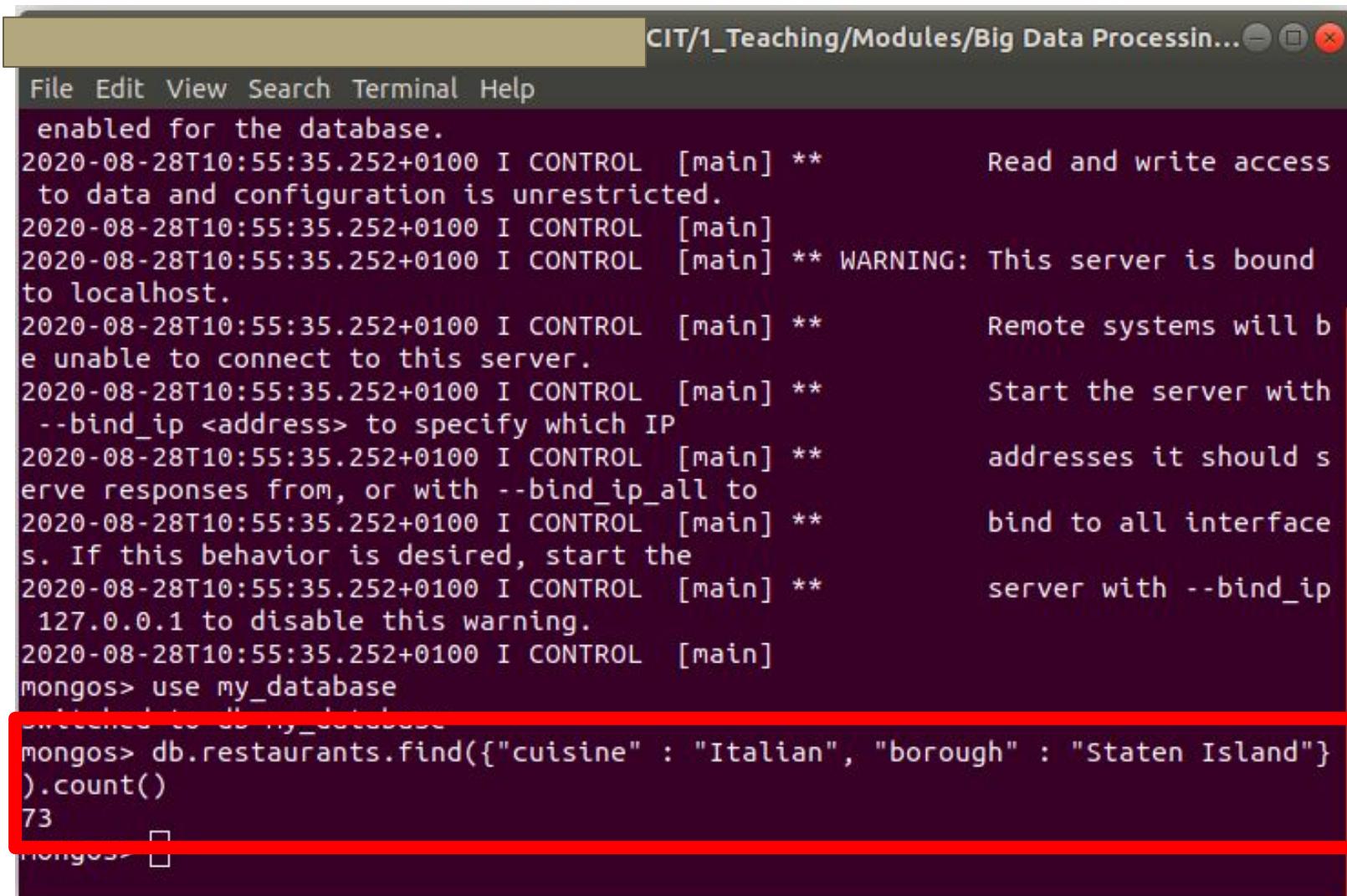
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface

2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip 127.0.0.1 to disable this warning.

2020-08-28T10:55:35.252+0100 I CONTROL [main]

```
mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({ "cuisine": "Italian", "borough": "Staten Island" })
.count()
73
mongos> ━
```

MongoDB: Demonstrating Split and Migrate



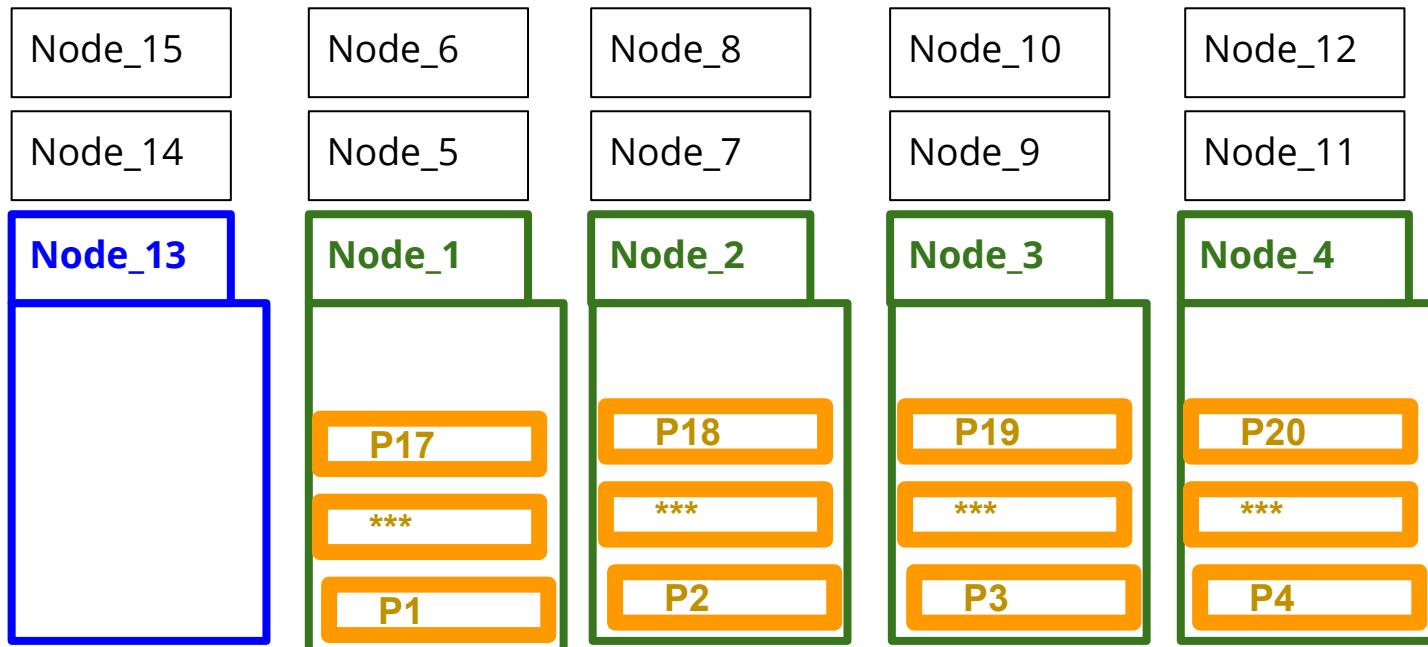
CIT/1_Teaching/Modules/Big Data Processin... ━ ━ ×

```
File Edit View Search Terminal Help
enabled for the database.
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Read and write access
to data and configuration is unrestricted.
2020-08-28T10:55:35.252+0100 I CONTROL [main]
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** WARNING: This server is bound
to localhost.
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Remote systems will b
e unable to connect to this server.
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** Start the server with
--bind_ip <address> to specify which IP
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** addresses it should s
erve responses from, or with --bind_ip_all to
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** bind to all interface
s. If this behavior is desired, start the
2020-08-28T10:55:35.252+0100 I CONTROL [main] ** server with --bind_ip
127.0.0.1 to disable this warning.
2020-08-28T10:55:35.252+0100 I CONTROL [main]
mongos> use my_database
switched to db my_database
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"})
).count()
73
mongos>
```

MongoDB: Demonstrating Split and Migrate

Now, let's look at how efficient this query was. In particular:

- How many shards were explored?
- How many documents were explored?



MongoDB: Demonstrating Split and Migrate

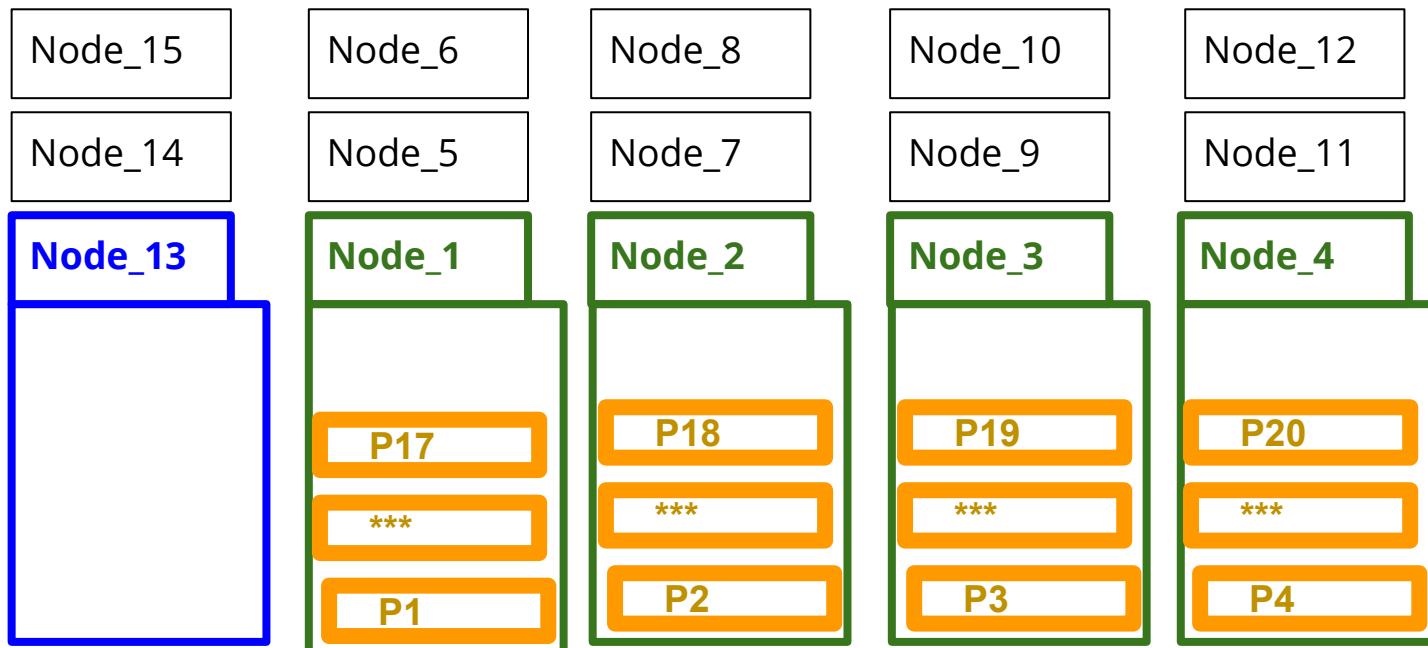
```
/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻

File Edit View Search Terminal Help
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"}).explain("executionStats")
{
  "queryPlanner" : {
    "mongosPlannerVersion" : 1,
    "winningPlan" : {
      "stage" : "SINGLE_SHARD",
      "shards" : [
        {
          "shardName" : "replicaSet2",
          "connectionString" : "replicaSet2/localhost:27100,localhost:27101,localhost:27102",
          "serverInfo" : {
            "host" : "smartebuses1-Latitude-5401",
            "port" : 27100,
            "version" : "3.6.3",
            "gitVersion" : "9586e557d54ef70f9ca4b43c26892cd55257e1a5"
          },
          "plannerVersion" : 1,
          "namespace" : "my_database.restaurants",
          "indexFilterSet" : false,
          "parsedQuery" : {

```

MongoDB: Demonstrating Split and Migrate

As we can see, the query planner indicates **“SINGLE_SHARD”**, which means the query was redirected to just one shard in order to compute the final result.



MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ─ ┡ ┢ ┤
```

File Edit View Search Terminal Help

```
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"}).explain("executionStats")
```

```
    "queryPlanner" : {  
        "mongosPlannerVersion" : 1,  
        "winningPlan" : {  
            "stage" : "SINGLE_SHARD",  
            "shards" : [  
                {  
                    "shardName" : "replicaSet2",  
                    "connectionString" : "replicaSet2/localhost:  
27100,localhost:27101,localhost:27102"  
                },  
                {  
                    "serverInfo" : {  
                        "host" : "smartebuses1-Latitude-  
5401",  
                        "port" : 27100,  
                        "version" : "3.6.3",  
                        "gitVersion" : "9586e557d54ef70f  
9ca4b43c26892cd55257e1a5"  
                    },  
                    "plannerVersion" : 1,  
                    "namespace" : "my_database.restaurants",  
                    "indexFilterSet" : false,  
                    "parsedQuery" : {  
                }  
            ]  
        }  
    }
```

MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ─ ┡ ┢ ┤
```

File Edit View Search Terminal Help

```
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"}).explain("executionStats")
```

```
    "queryPlanner" : {  
        "mongosPlannerVersion" : 1,  
        "winningPlan" : {  
            "stage" : "SINGLE_SHARD",  
            "shards" : [  
                {  
                    "shardName" : "replicaSet2",  
                    "connectionString" : "replicaSet2/localhost:  
27100,localhost:27101,localhost:27102"  
                }  
            ],  
            "serverInfo" : {  
                "host" : "smartebuses1-Latitude-  
5401",  
                "port" : 27100,  
                "version" : "3.6.3",  
                "gitVersion" : "9586e557d54ef70f  
9ca4b43c26892cd55257e1a5"  
            },  
            "plannerVersion" : 1,  
            "namespace" : "my_database.restaurants",  
            "indexFilterSet" : false,  
            "parsedQuery" : {
```

MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ◻ ◻ ◻

File Edit View Search Terminal Help
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"})
).explain("executionStats")
{
    "queryPlanner" : {
        "mongosPlannerVersion" : 1,
        "winningPlan" : {
            "stage" : "COLLSCAN",
            "shards" : [
                {
                    "shardName" : "replicaSet0-shard-00001",
                    "connectionString" : "replicaSet0/localhost:27100,localhost:27101,localhost:27102"
                }
            ],
            "serverInfo" : {
                "host" : "smartebuses1-Latitude-5401",
                "port" : 27100,
                "version" : "3.6.3",
                "gitVersion" : "9586e557d54ef70f9ca4b43c26892cd55257e1a5"
            },
            "plannerVersion" : 1,
            "namespace" : "my_database.restaurants",
            "indexFilterSet" : false,
            "parsedQuery" : {
```

MongoDB: Demonstrating Split and Migrate

```
/CIT/1_Teaching/Modules/Big Data Processin... ━ ━ ━
```

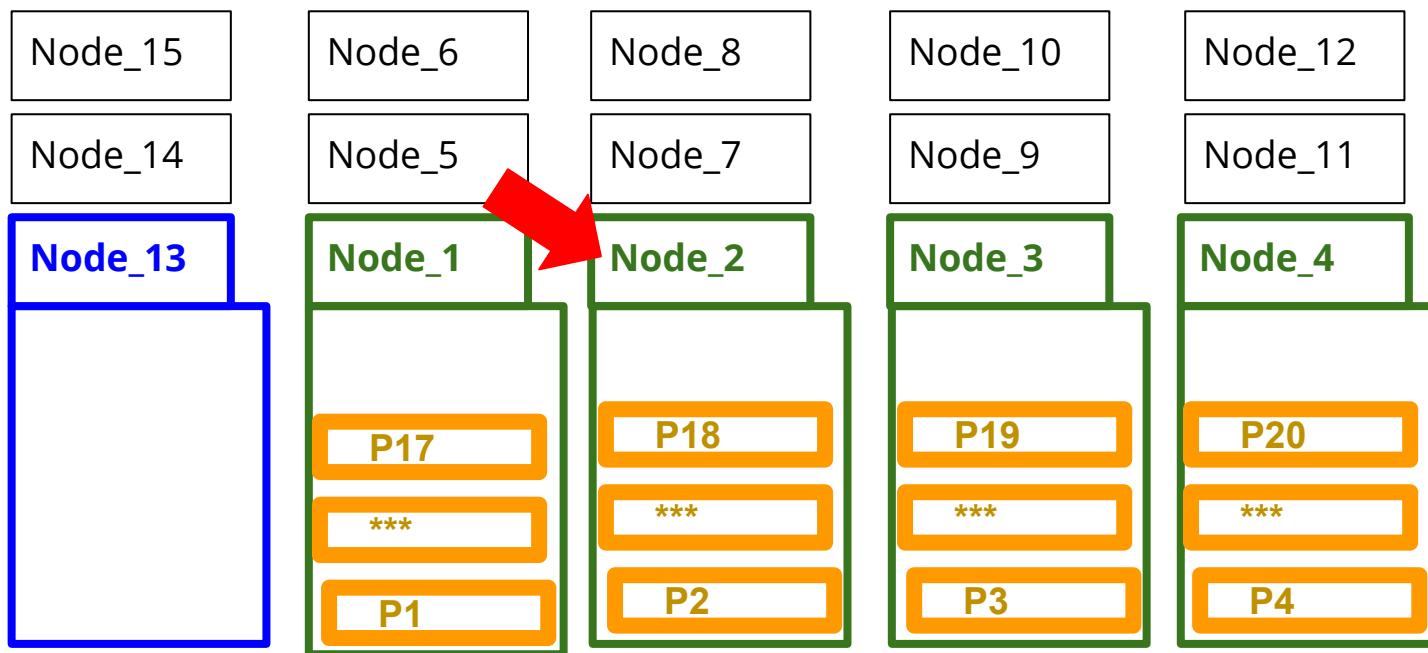
File Edit View Search Terminal Help

```
mongos> db.restaurants.find({"cuisine" : "Italian", "borough" : "Staten Island"}).explain("executionStats")
```

```
    "queryPlanner" : {  
        "mongosPlannerVersion" : 1,  
        "winningPlan" : {  
            "stage" : "SINGLE_SHARD",  
            "shards" : [  
                {  
                    "shardName" : "replicaSet2",  
                    "connectionString" : "replicaSet2/localhost:  
27100,localhost:27101,localhost:27102"  
                },  
                {  
                    "serverInfo" : {  
                        "host" : "smartebuses1-Latitude-  
5401",  
                        "port" : 27100,  
                        "version" : "3.6.3",  
                        "gitVersion" : "9586e557d54ef70f  
9ca4b43c26892cd55257e1a5"  
                    },  
                    "plannerVersion" : 1,  
                    "namespace" : "my_database.restaurants",  
                    "indexFilterSet" : false,  
                    "parsedQuery" : {  
                }  
            ]  
        }  
    }
```

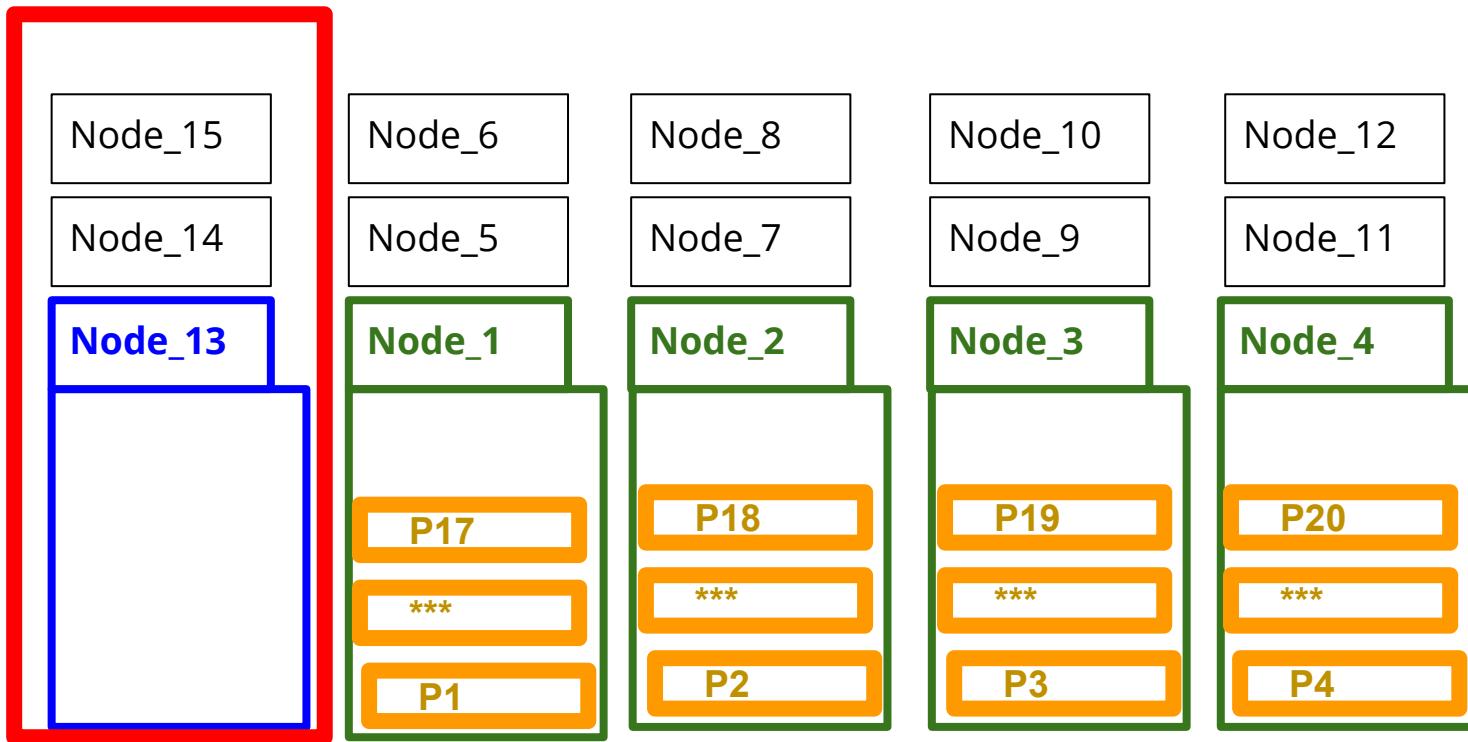
MongoDB: Demonstrating Split and Migrate

As we can see, the query was directed just to shard_2!



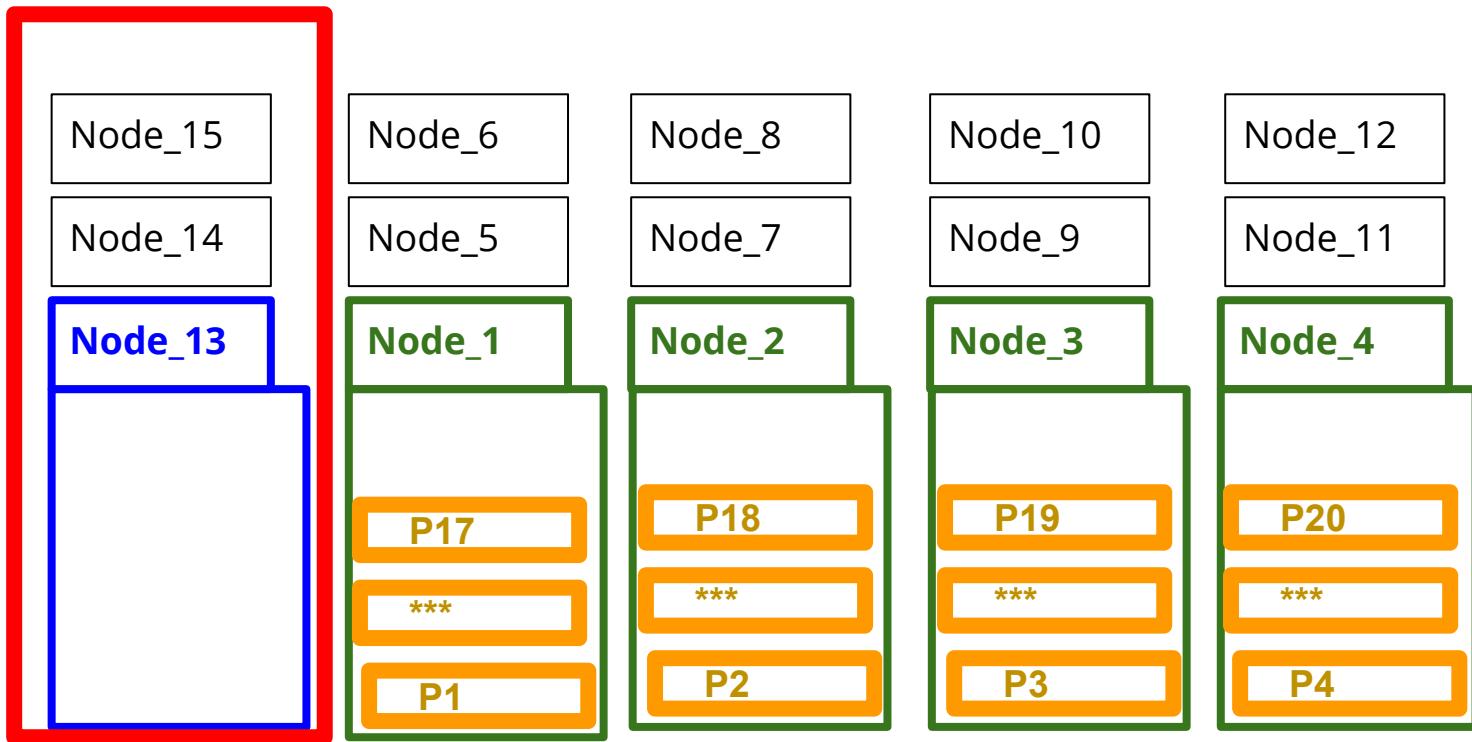
MongoDB: Demonstrating Split and Migrate

This makes sense: the query was initially directed to the metadata.



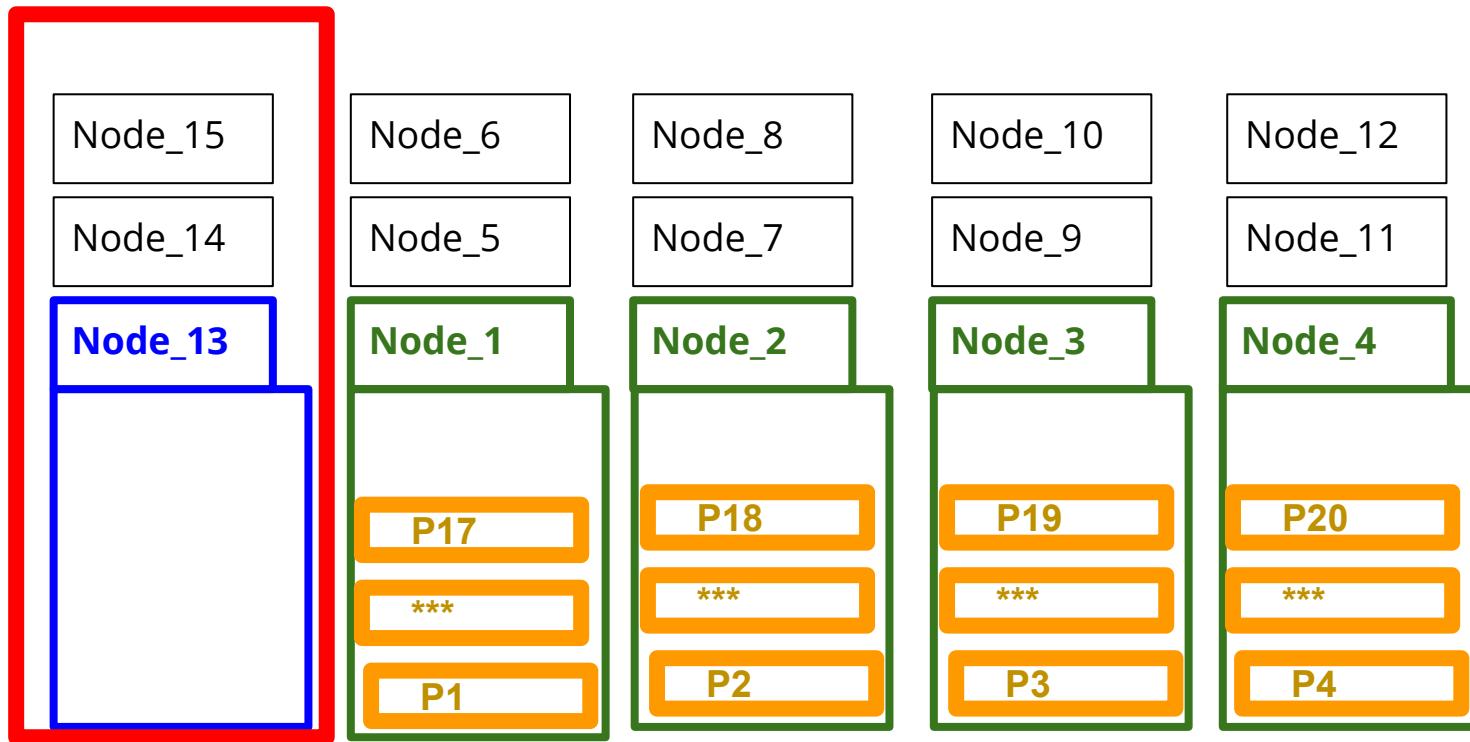
MongoDB: Demonstrating Split and Migrate

The metadata knows about the organisation of the partitions based on their shard key **cuisine** and **borough**, and Query2 is based on them.



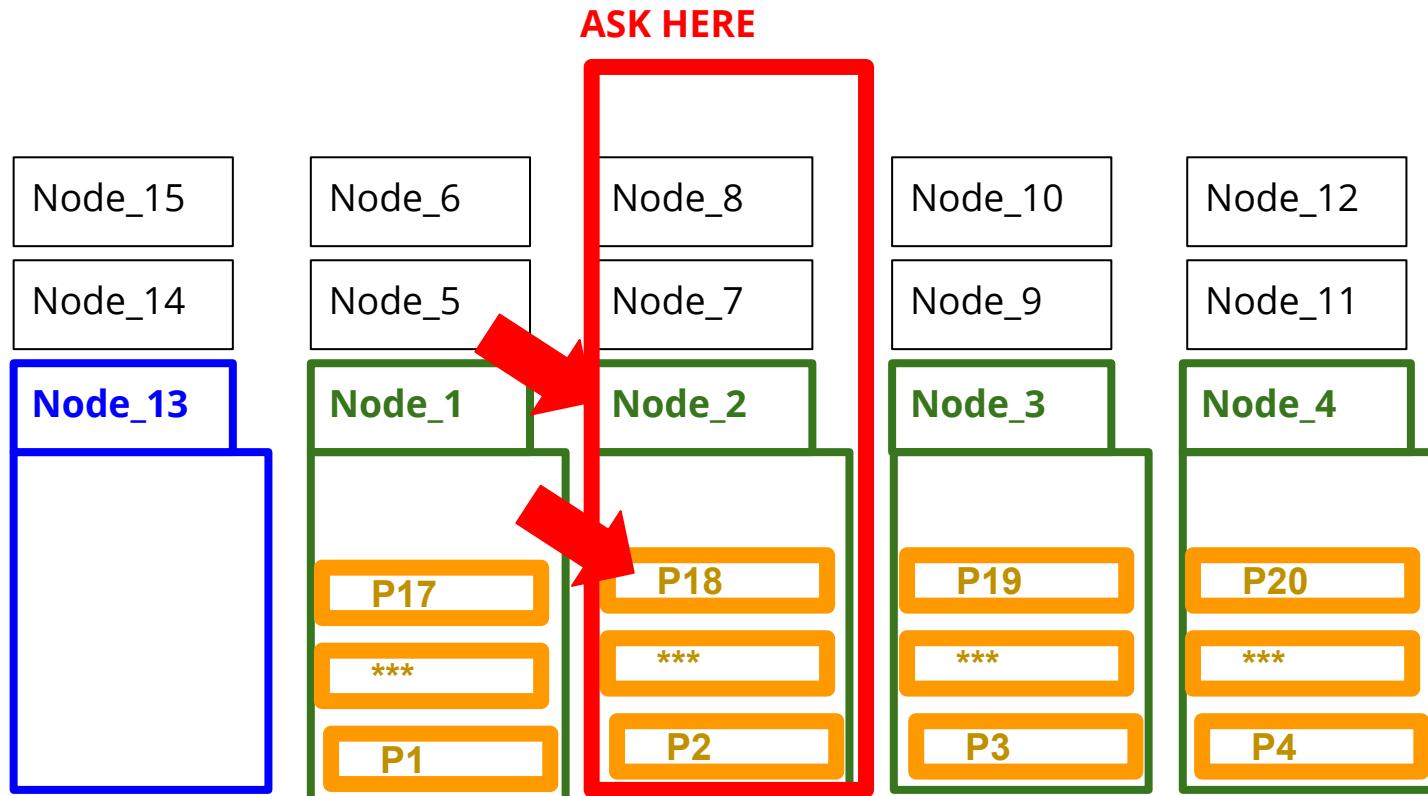
MongoDB: Demonstrating Split and Migrate

Thus, the metadata knows the partition(s) relevant to the query, as well as the shards hosting them :)



MongoDB: Demonstrating Split and Migrate

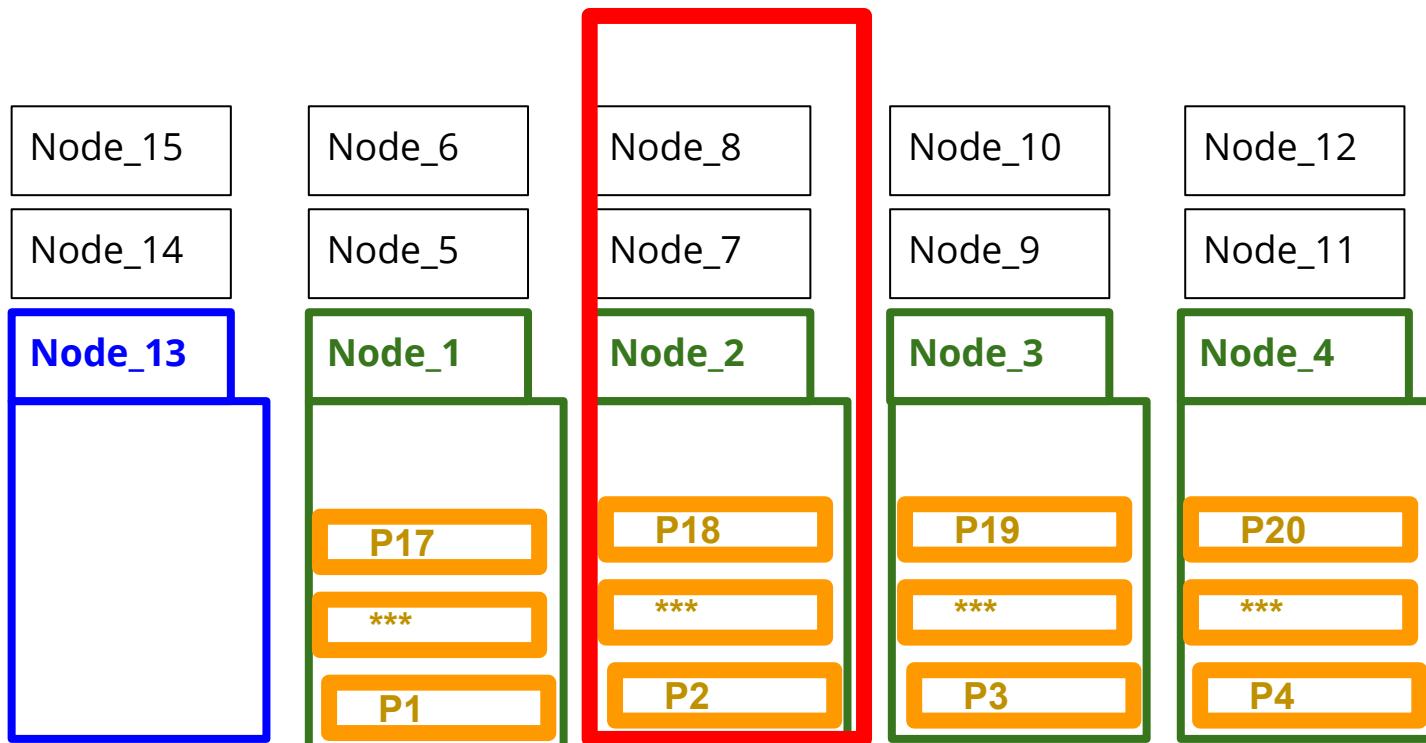
Thus, only this shard(s) must be queried (map stage).
In this case, just one shard.



MongoDB: Demonstrating Split and Migrate

And the results of each shard(s) are merged to get the final result to the query. In this case, as it was just one shard being queried there is nothing to merge.

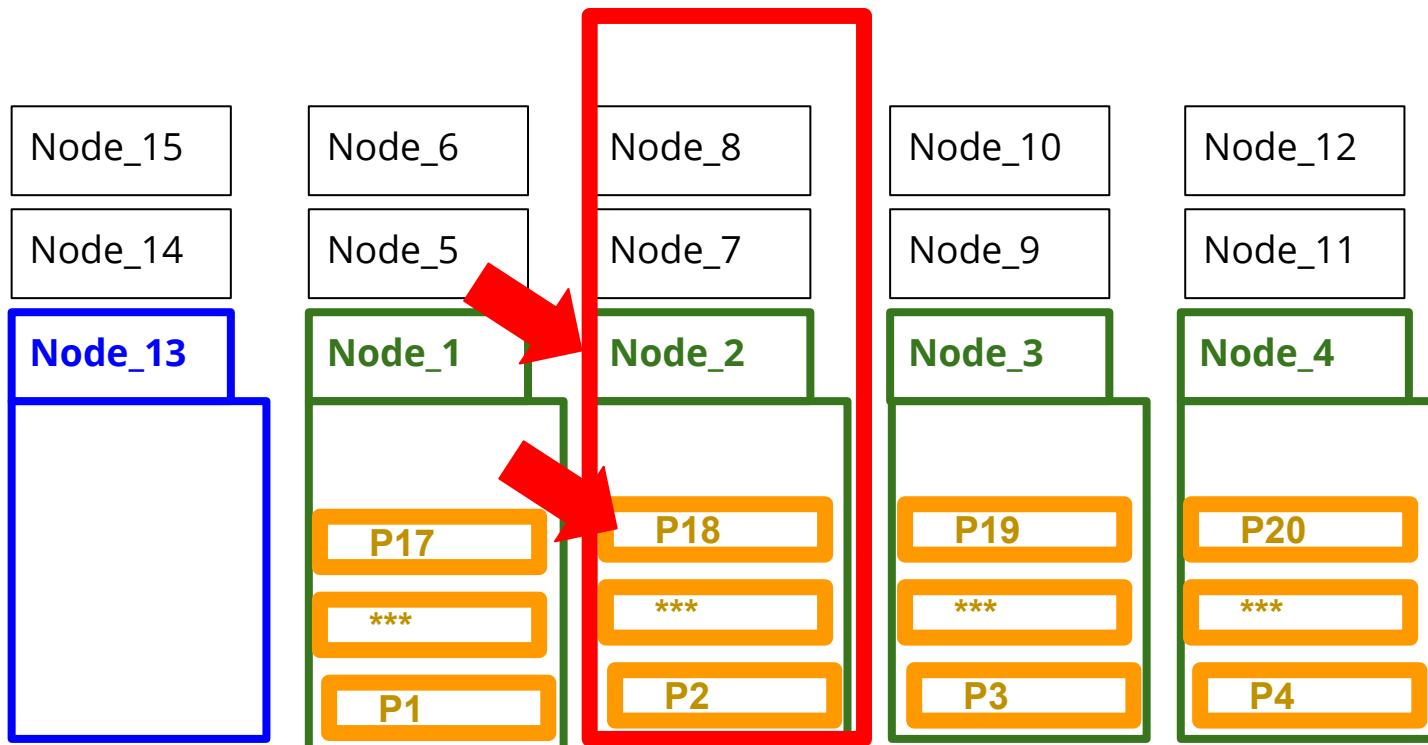
I FOUND IT!



MongoDB: Demonstrating Split and Migrate

Conclusion:

The data distribution has made this query extremely efficient!



MongoDB: Demonstrating Split and Migrate

```
smartebuses1@smartebuses1-Latitude-5401: ~/CIT/1_Teaching/Modules/Big Data Processin... ~
```

File Edit View Search Terminal Help

```
, "executionStats" : { "nReturned" : 73, "executionTimeMillis" : 3, "totalDocsExamined" : 73, "totalKeysExamined" : 73, "stage" : "SINGLE_SHARD", "nReturned" : 73, "executionTimeMillis" : 3, "totalKeysExamined" : 73, "totalDocsExamined" : 73, "totalChildMillis" : NumberLong(0), "shards" : [ { "shardName" : "repset2", "executionSuccess" : true, "executionStages" : { "stage" : "FETCH", "nReturned" : 73, "executionTimeMillisEstimate" : 0, "works" : 74, "advanced" : 73, "needTime" : 0, "needYield" : 0, "saveState" : 0, "restoreState" : 0, "isEOF" : 1, "invalidates" : 0, "docsExamined" : 73, "alreadyHasObj" : 0, "inputStage" : { "stage" : "SHARDING_FILTER", "nReturned" : 73, "executionTimeMillisEsti
```

MongoDB: Demonstrating Split and Migrate

Main Conclusion!

MongoDB: Demonstrating Split and Migrate

Main Conclusion:

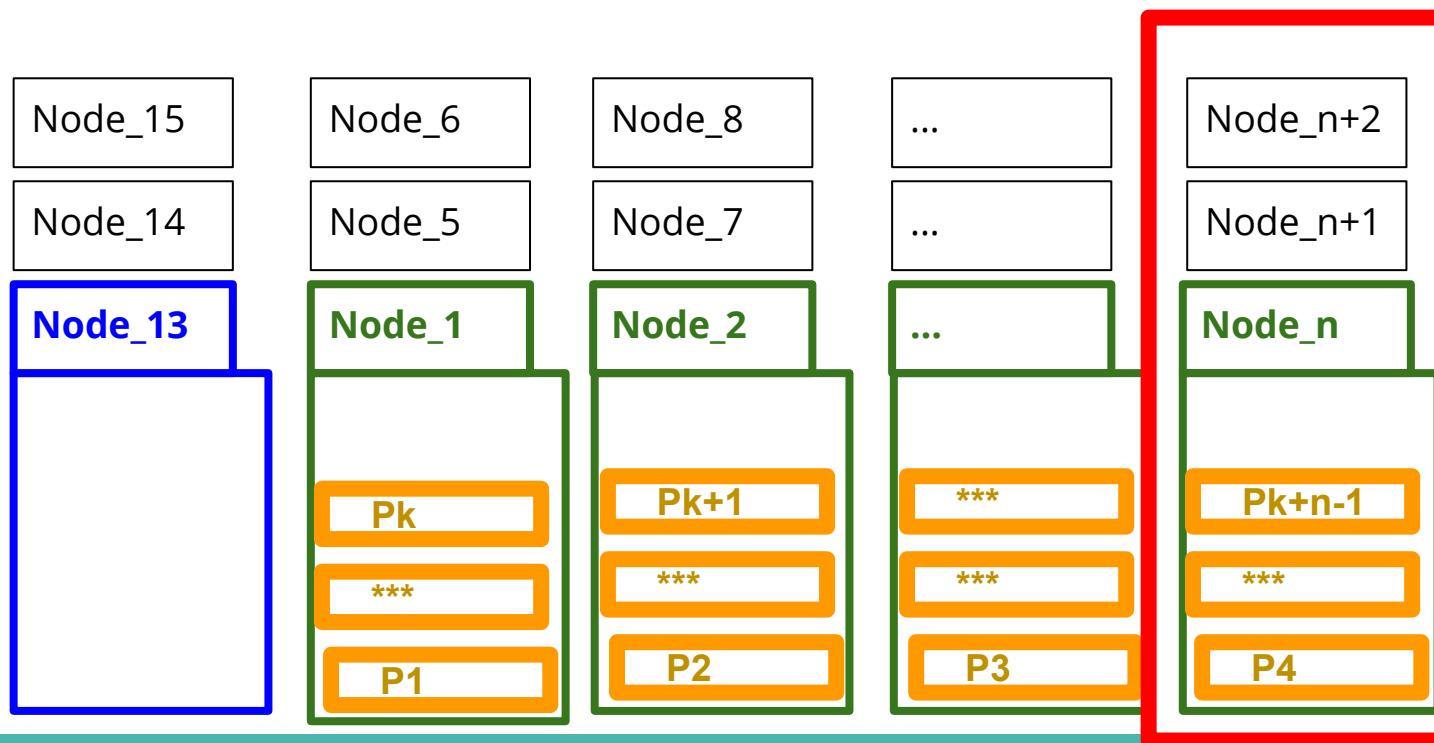
Big Data Storage: if the amount of data scales...



MongoDB: Demonstrating Split and Migrate

Main Conclusion:

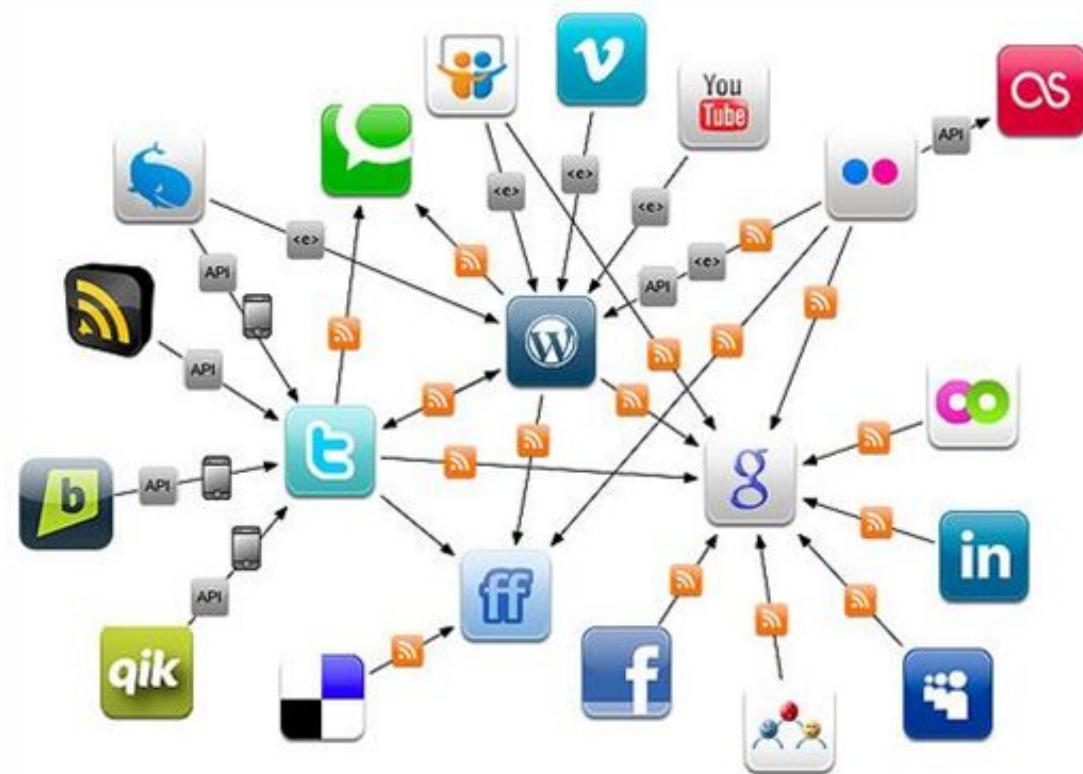
No problem! We just need a bigger cluster and a good data organisation to continue making our queries efficient!



MongoDB: Demonstrating Split and Migrate

- And that's how Google indexes millions of new pages every day and still produce quick search queries.

Google



Outline

1. Setting the Context.
2. MongoDB: Conceptual Approach.
3. MongoDB: Demonstrating Split and Migrate.
4. My Cluster Simulator: Split, Migrate and Auto-scale.

My Cluster Simulator: Split, Migrate and Auto-Scale

Besides demonstrating **split** and **migrate**
in the real-world system MongoDB...



My Cluster Simulator: Split, Migrate and Auto-Scale

...we want to demystify the programming of such **split**, **migrate** and **auto-scale** routines...

My Cluster Simulator: Split, Migrate and Auto-Scale

...we want to demystify the programming of such **split**, **migrate** and **auto-scale** routines...

...by doing our own implementation of them in the simple Python application **My_Own_Simulator** simulating a cluster in our own machine.

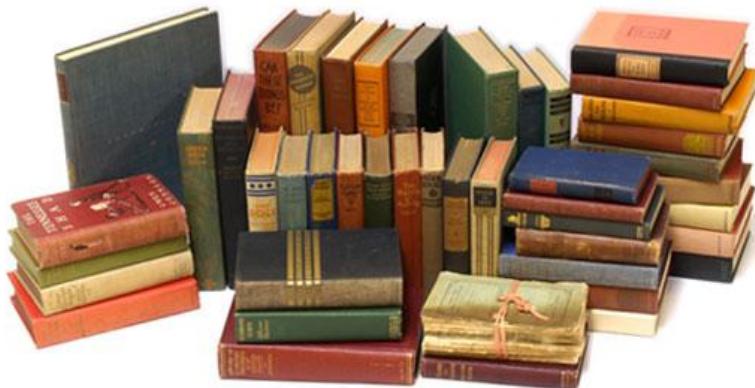


My Cluster Simulator: Split, Migrate and Auto-Scale

Dataset:

We use The Guardian's compiled list of 1000 must-read books (actually there are only 998 :)

<https://www.theguardian.com/books/2009/jan/23/bestbooks-fiction>



My Cluster Simulator: Split, Migrate and Auto-Scale

Dataset:

We clean the dataset into the single file **my_dataset.csv**.

Each line contains the info for 1 book, with format:
<Title ; Author ; Genre>.



My Cluster Simulator: Split, Migrate and Auto-Scale

Dataset:

We clean the dataset into the single file **my_dataset.csv**.

For example, **line 3** of the file contains:

<Title ; Author ; Genre>

Orlando;Virginia Woolf;Science fiction and fantasy



My Cluster Simulator: Split, Migrate and Auto-Scale

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We clean the dataset into the single file **my_dataset.csv**.

For example, line 3 of the file contains:

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Orlando;**Virginia Woolf**;Science fiction and fantasy



My Cluster Simulator: Split, Migrate and Auto-Scale

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Orlando;Virginia Woolf;**Science fiction and fantasy**



My Cluster Simulator: Split, Migrate and Auto-Scale

Dataset:

We are not dealing anymore with MongoDB, so let's avoid the **document** nomenclature and use instead **data item**.



My Cluster Simulator: Split, Migrate and Auto-Scale

Dataset:

We are not dealing anymore with MongoDB, so let's avoid the **document** nomenclature and use instead **data item**.

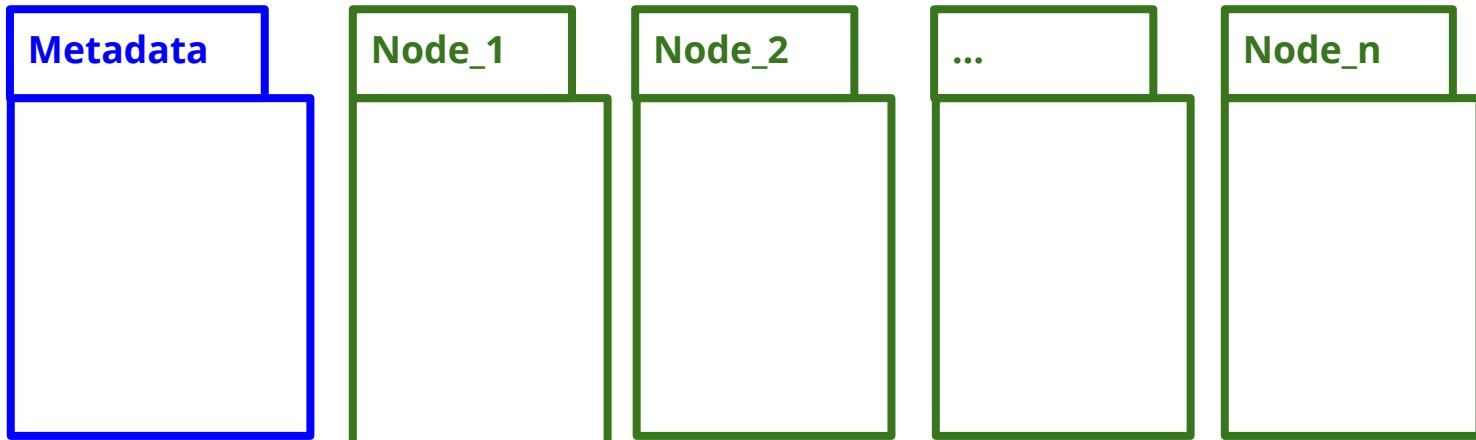
Moreover, let's avoid the **collection** nomenclature and use instead **dataset**.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

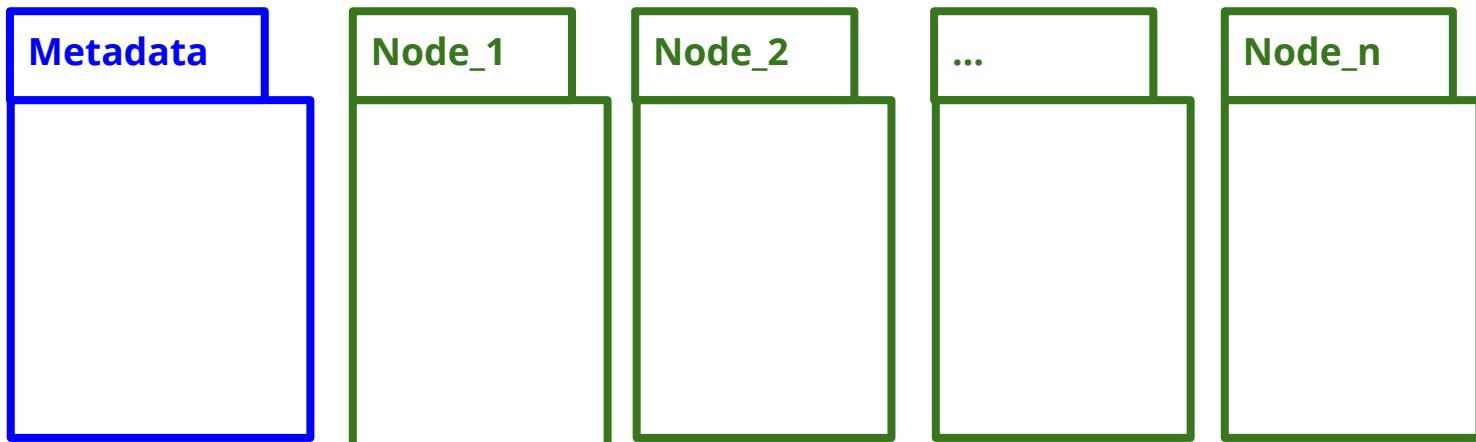
- 1 Metadata Node.
- A **dynamic number n** of Data Nodes.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

We do not consider data replication or fault tolerance!
This means we do not set up replica sets, and both
Metadata and Data Nodes consist in just 1 node.

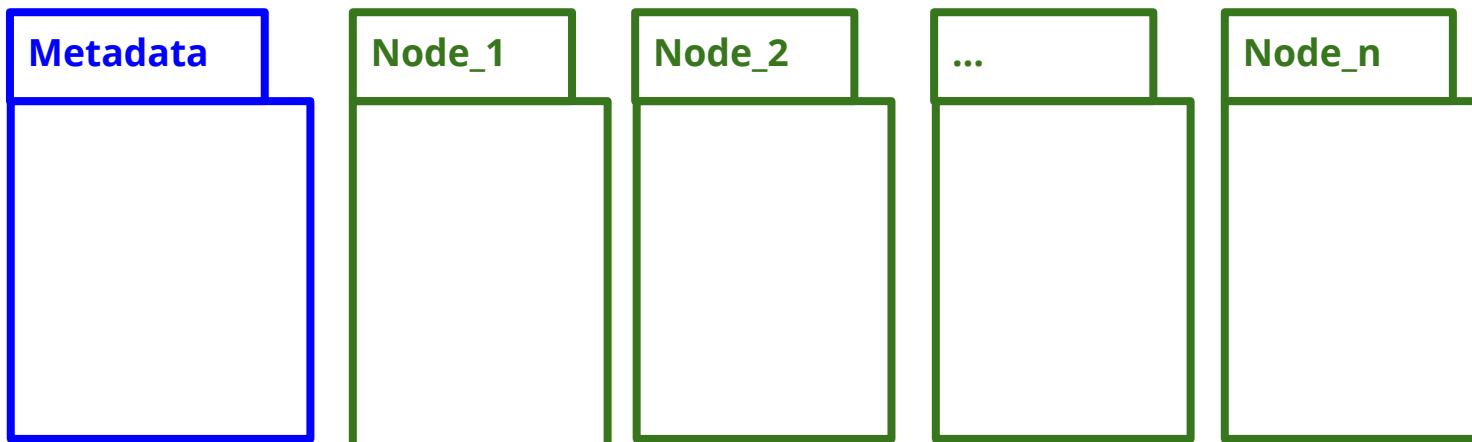


My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

We do not consider data replication or fault tolerance!
This means we do not set up replica sets, and both
Metadata and Data Nodes consist in just 1 node.

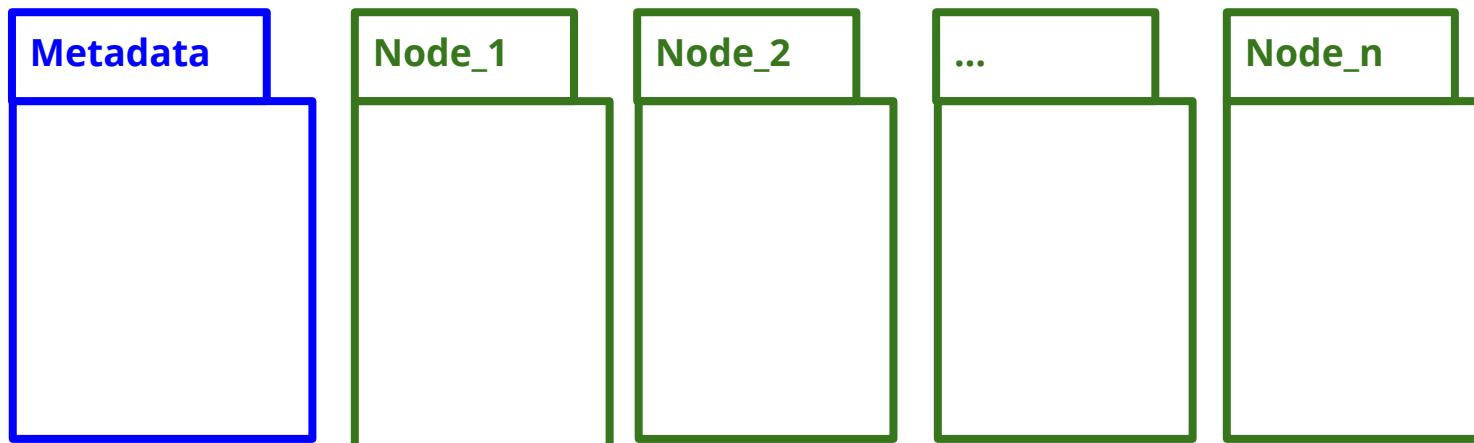
- Also, this means each data item is contained just once in 1 data node.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

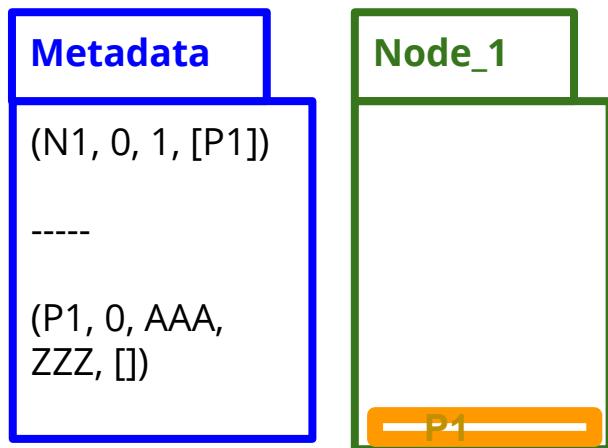
We make the data items of the dataset to enter the cluster one at a time.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

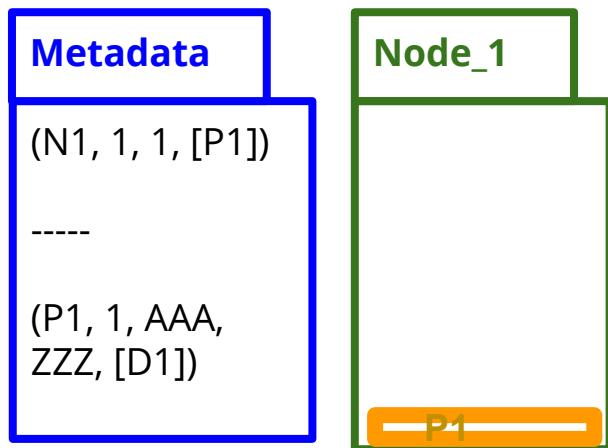
Before start processing any data item, our cluster contains just 1 node with 1 empty partition.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

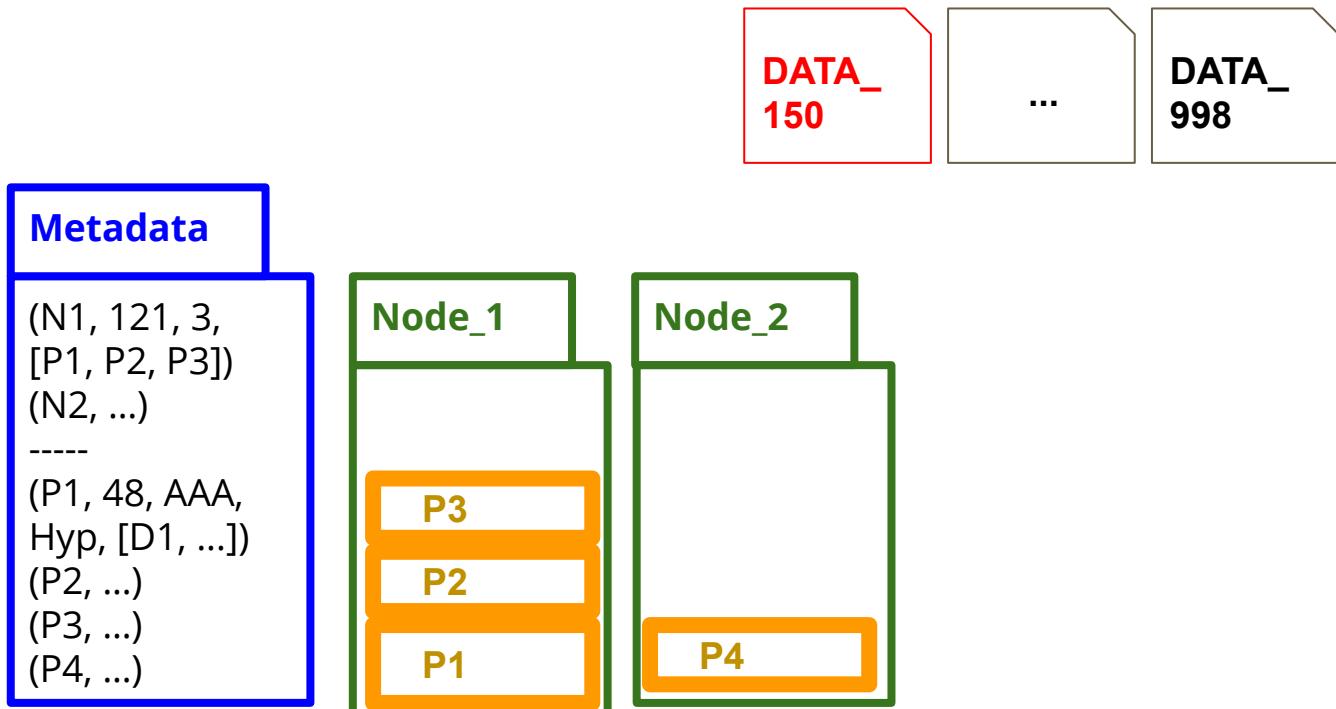
Then, as we process data items, the number of partitions and nodes evolve based on our split and migrate policies.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

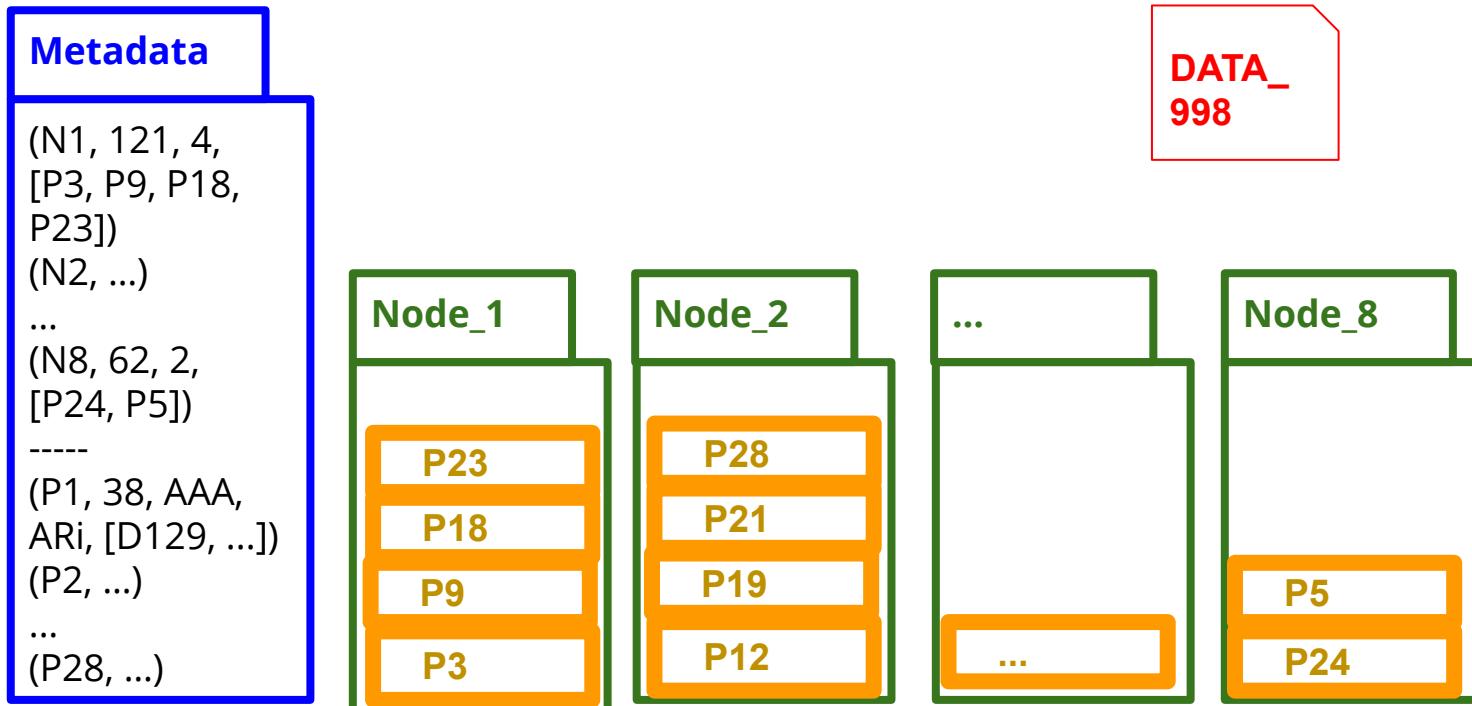
Then, as we process data items, the number of partitions and nodes evolve based on our split and migrate policies.



My Cluster Simulator: Split, Migrate and Auto-Scale

Cluster:

Then, as we process data items, the number of partitions and nodes evolve based on our split and migrate policies.



My Cluster Simulator: Split, Migrate and Auto-Scale

Distribution Key:

We use Title as the distribution key

<Title ; Author ; Genre>

Orlando;Virginia Woolf;Science fiction and fantasy



My Cluster Simulator: Split, Migrate and Auto-Scale

Distribution Key:

We use Title as the distribution key

<Title ; Author ; Genre>

Orlando;Virginia Woolf;Science fiction and fantasy

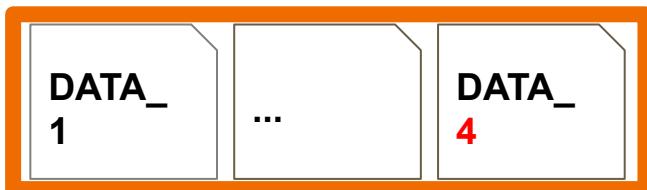
We are not dealing anymore with MongoDB, so let's avoid the shard key nomenclature and use instead key.



My Cluster Simulator: Split, Migrate and Auto-Scale

Partition Max Size:

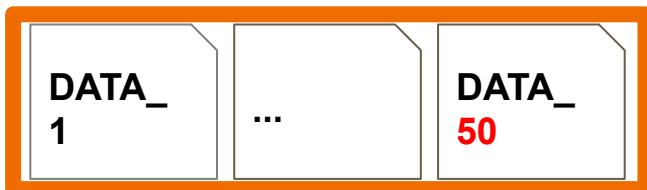
We base the partition max size in a number of data items (e.g., **4**).



My Cluster Simulator: Split, Migrate and Auto-Scale

Partition Max Size:

We base the partition max size in a number of data items (e.g., **50**).

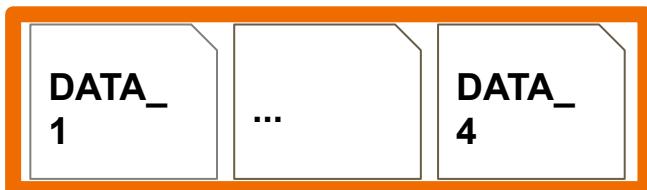


My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

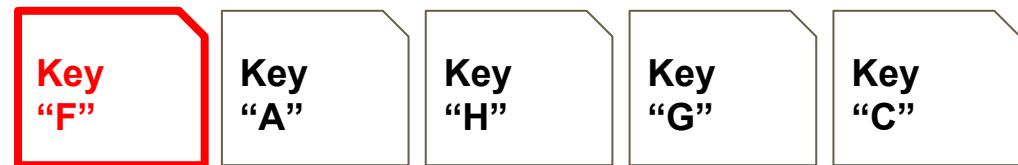
- Once a partition reaches its max size, we look for its middle key and split the partition into two.



My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

DATA_4 is to be stored, it goes to P1.



P1



P1: Key range: [AAA, ZZZ)

My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

DATA_4 is to be stored, it goes to P1.

Note that the maximum size of the partition has been reached.



P1

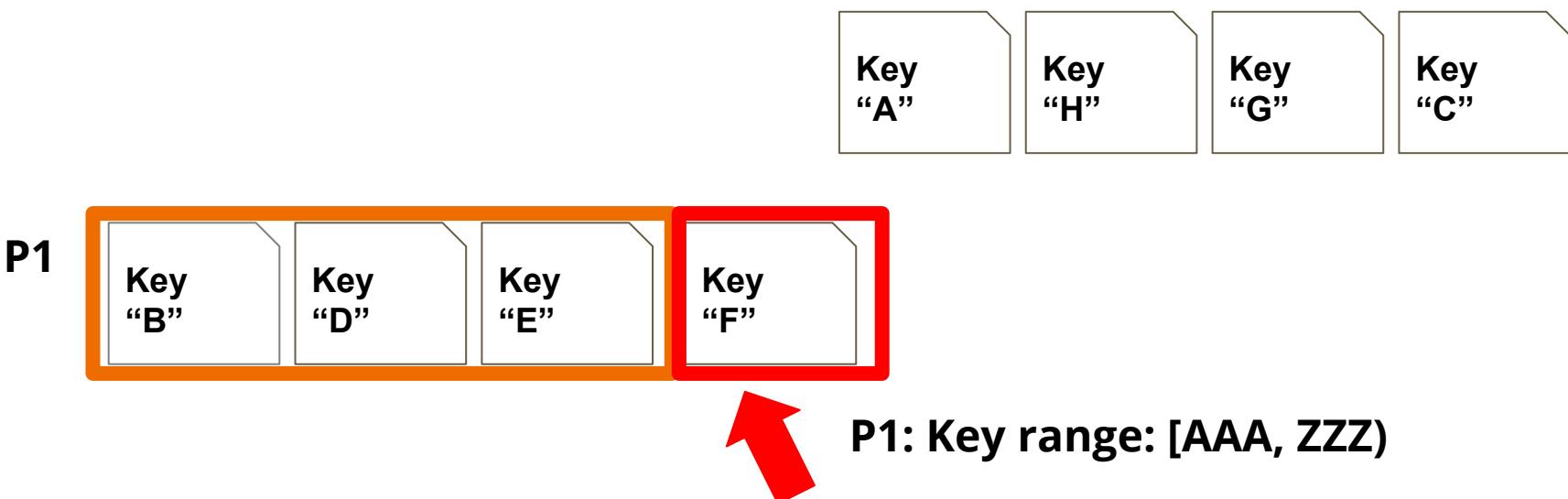


P1: Key range: [AAA, ZZZ)

My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

At this stage our **split** subroutine enters in action.



My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

At this stage our **split** subroutine enters in action.
It looks for the middle key ("E") and splits P1 into two partitions: P1 and P2.



P1



P1: Key range: [AAA, ZZZ)

My Cluster Simulator: Split, Migrate and Auto-Scale

Split:

Please note the updated key ranges of P1 and P2.



P1



P1: Key range: [AAA, E)

P2



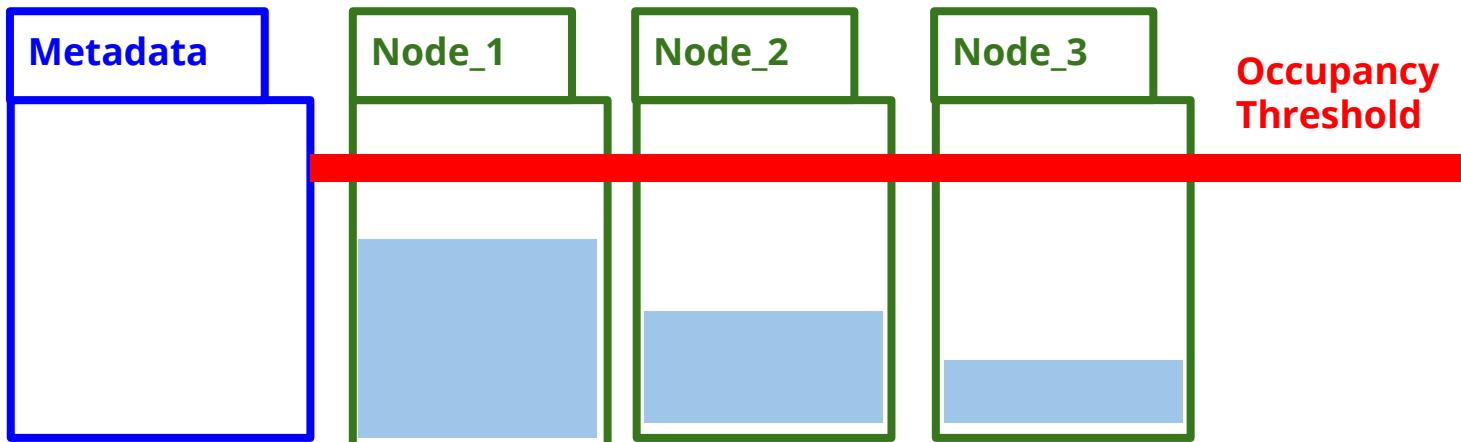
P2: Key range: [E, ZZZ)

My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

- We use an occupancy threshold.

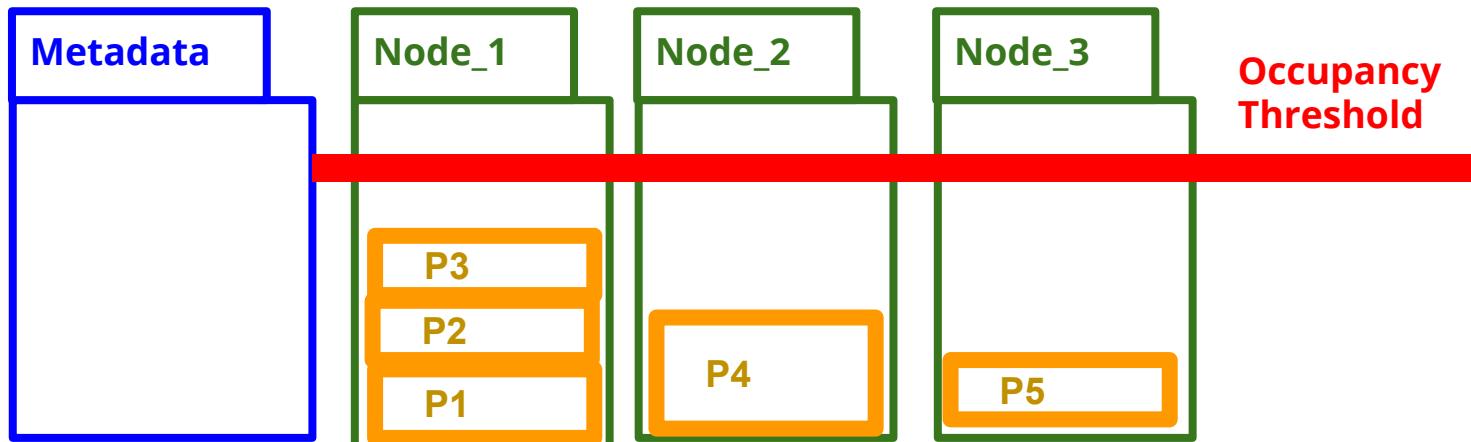


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

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- We use an occupancy threshold.

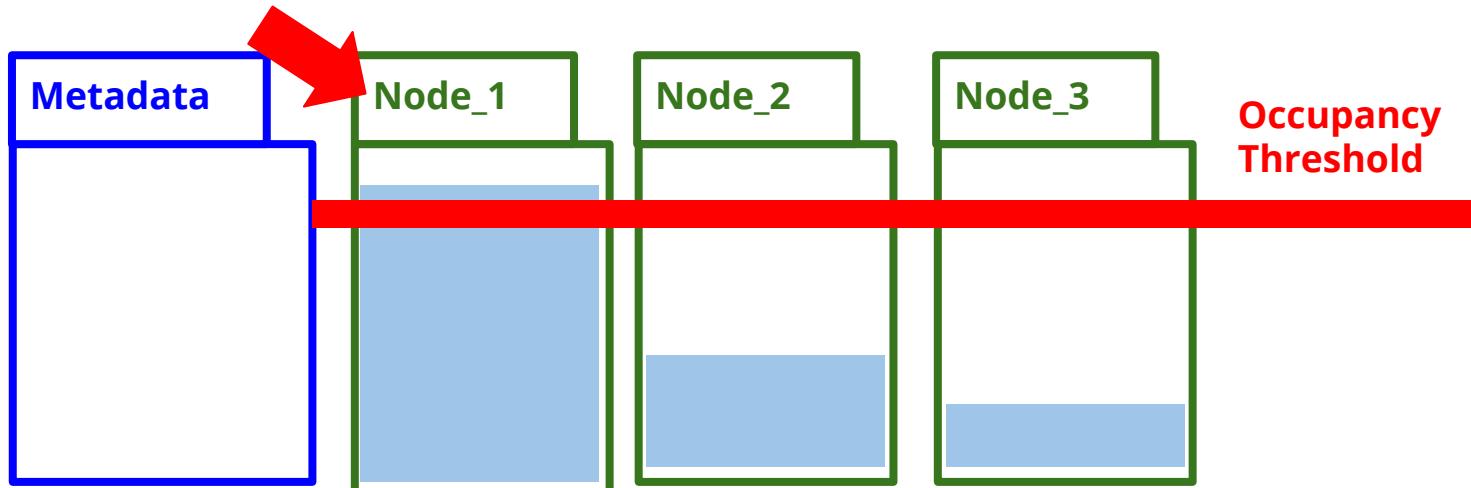


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

- When a node reaches this occupancy threshold...

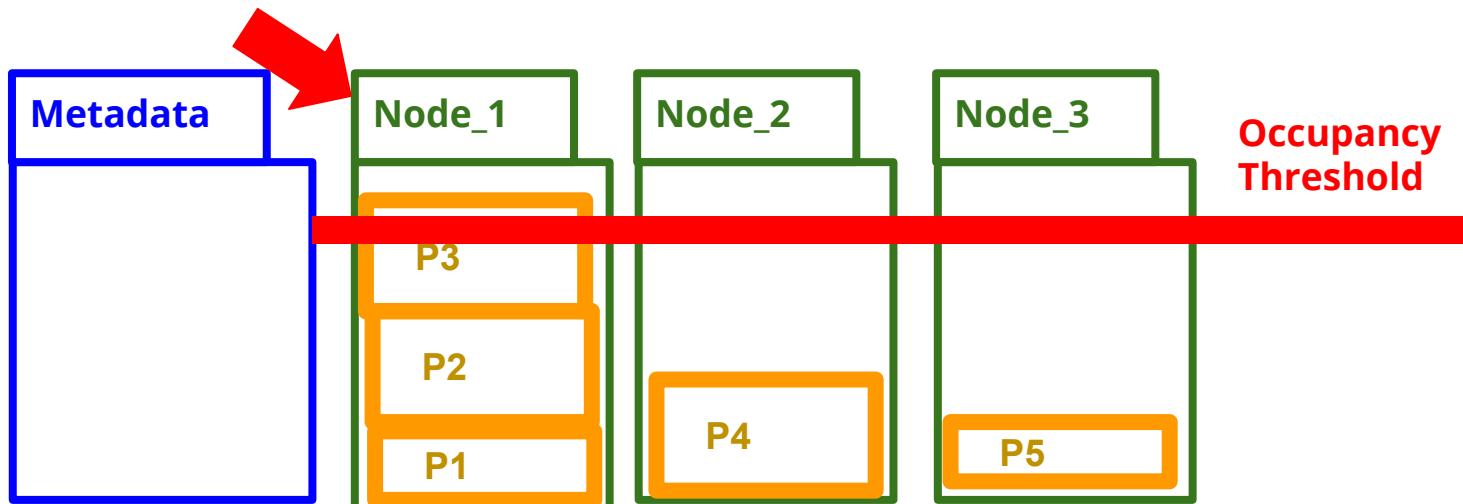


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

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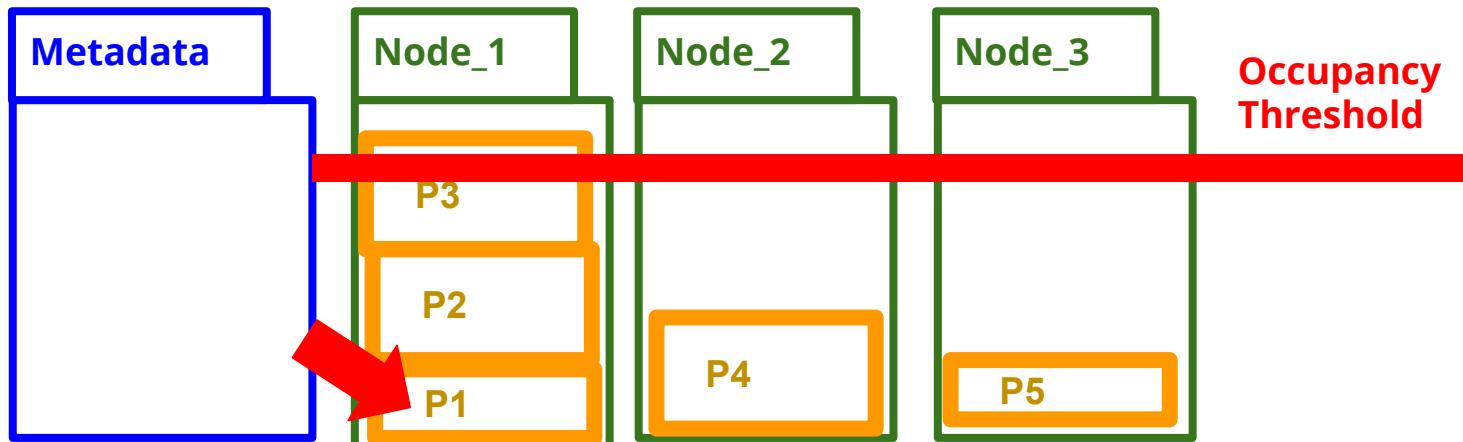


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

- When a node reaches this occupancy threshold...
...we migrate its smallest partition....

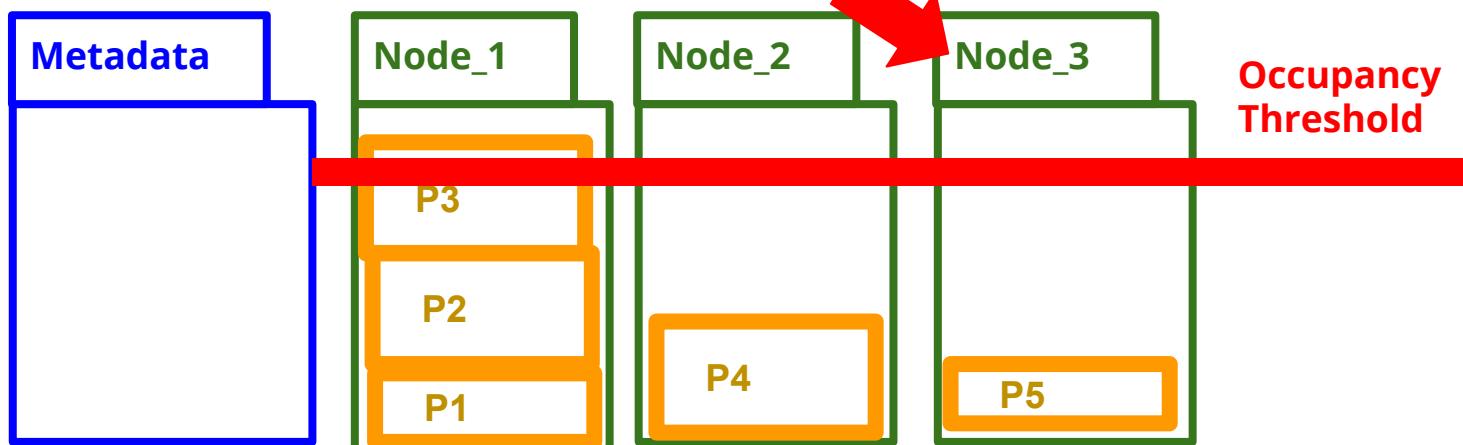


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

- When a node reaches this occupancy threshold...
...we migrate its smallest partition....
...to the node with smallest occupancy.

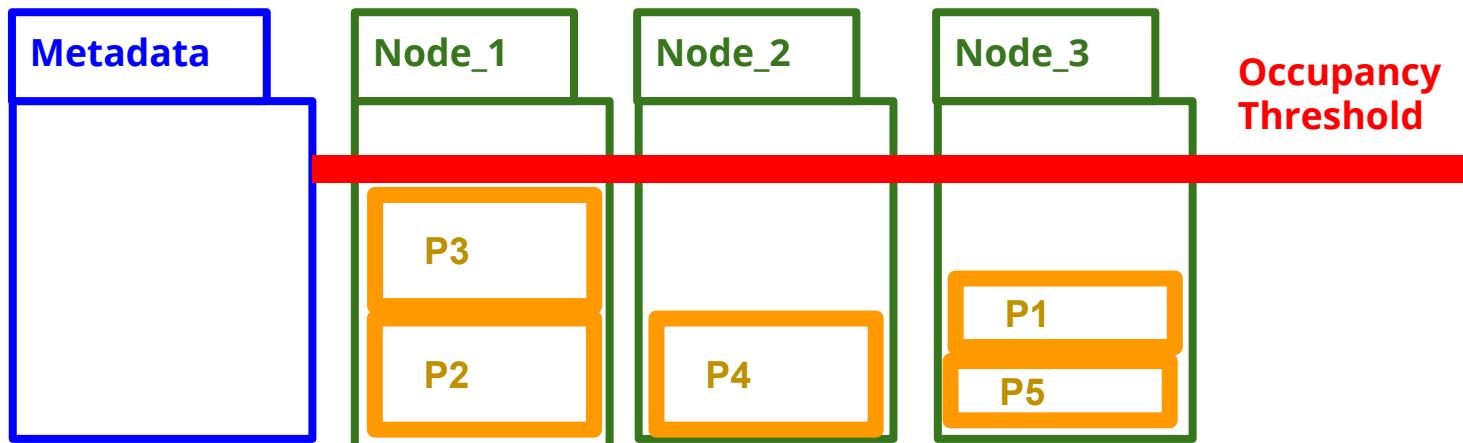


My Cluster Simulator: Split, Migrate and Auto-Scale

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We follow the same policy as of Section “*Cluster and Data Organisation*”:

- When a node reaches this occupancy threshold...
...we migrate its smallest partition....
...to the node with smallest occupancy.

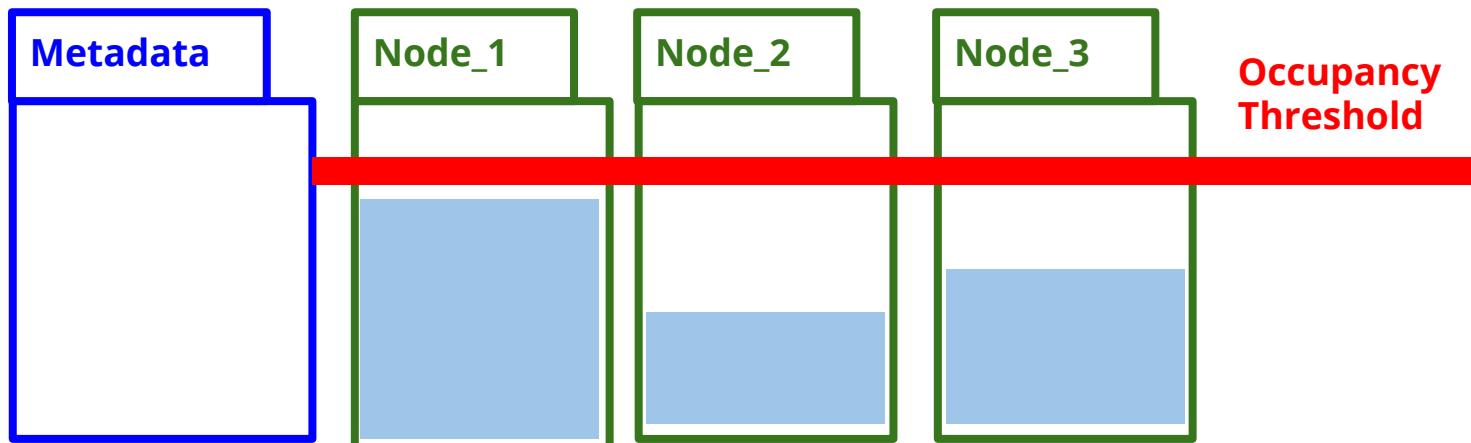


My Cluster Simulator: Split, Migrate and Auto-Scale

Migrate:

We follow the same policy as of Section “*Cluster and Data Organisation*”:

- When a node reaches this occupancy threshold...
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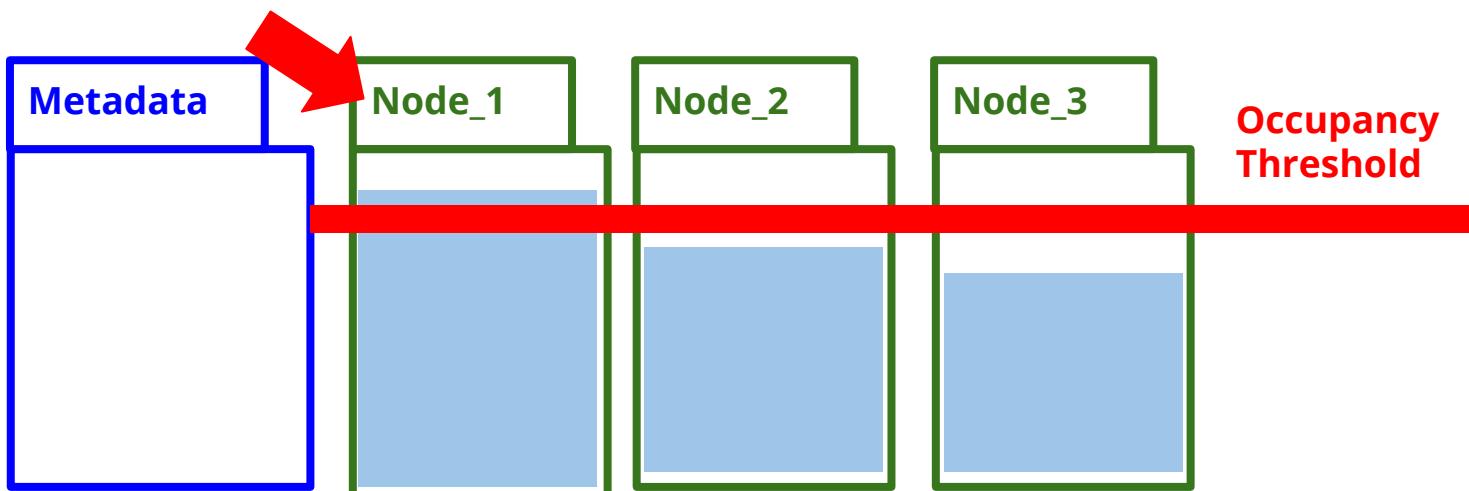


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

Our migration policy has one rule more:

- When a node reaches this occupancy threshold...
...we migrate its smallest partition....
...to the node with smallest occupancy...

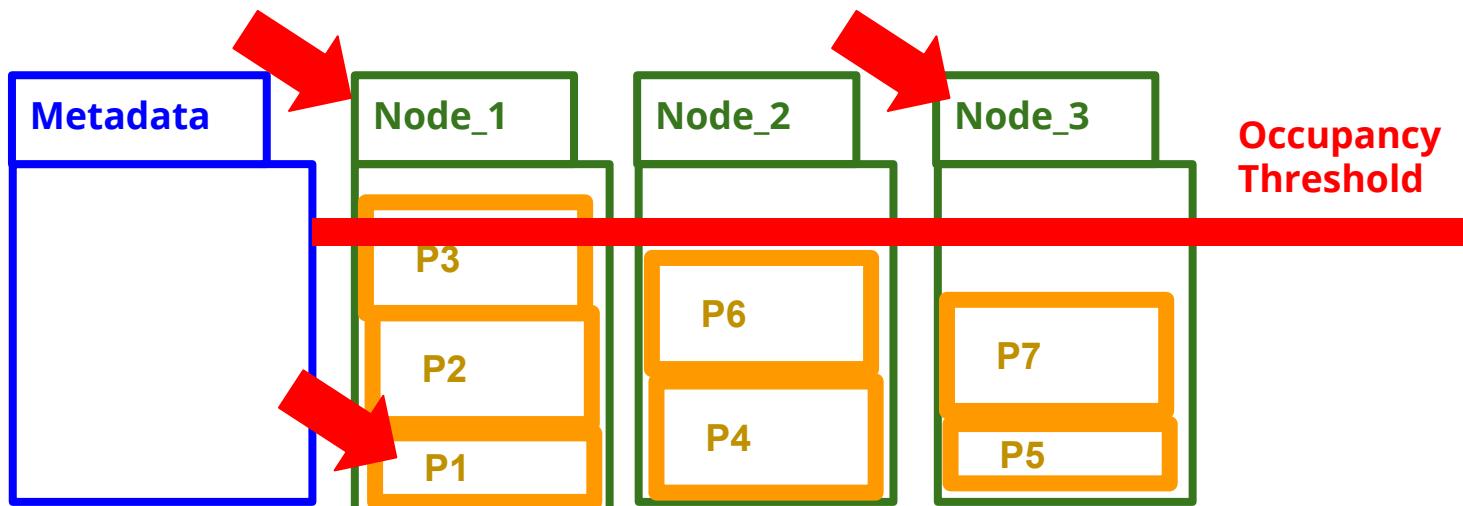


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

Our migration policy has one rule more:

- When a node reaches this occupancy threshold...
...we migrate its smallest partition....
...to the node with smallest occupancy...

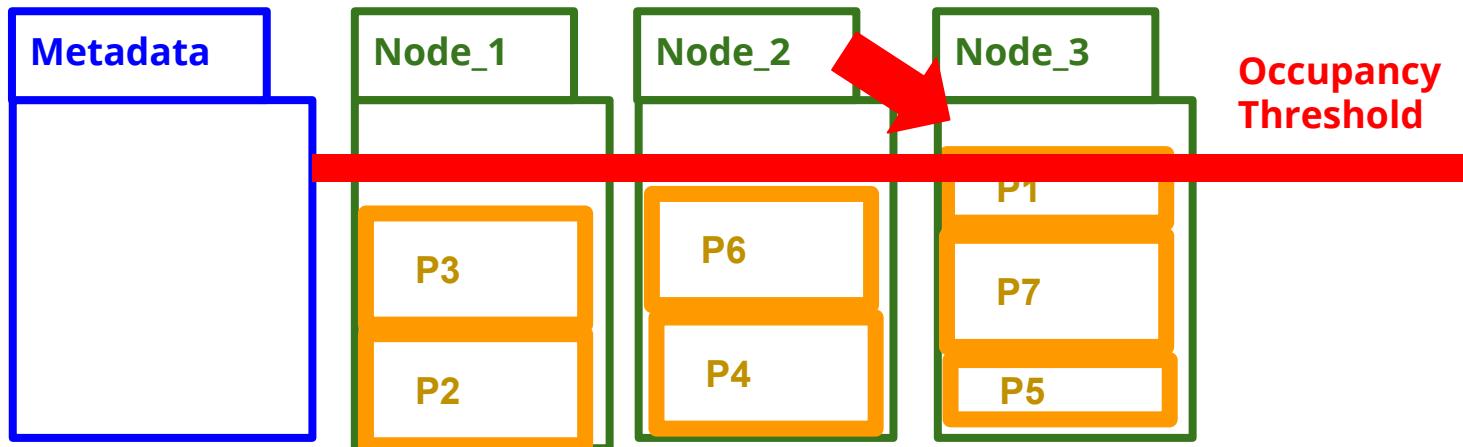


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

Our migration policy has one rule more:

- ...unless doing so makes the destination node to reach/exceed the occupancy threshold as well!

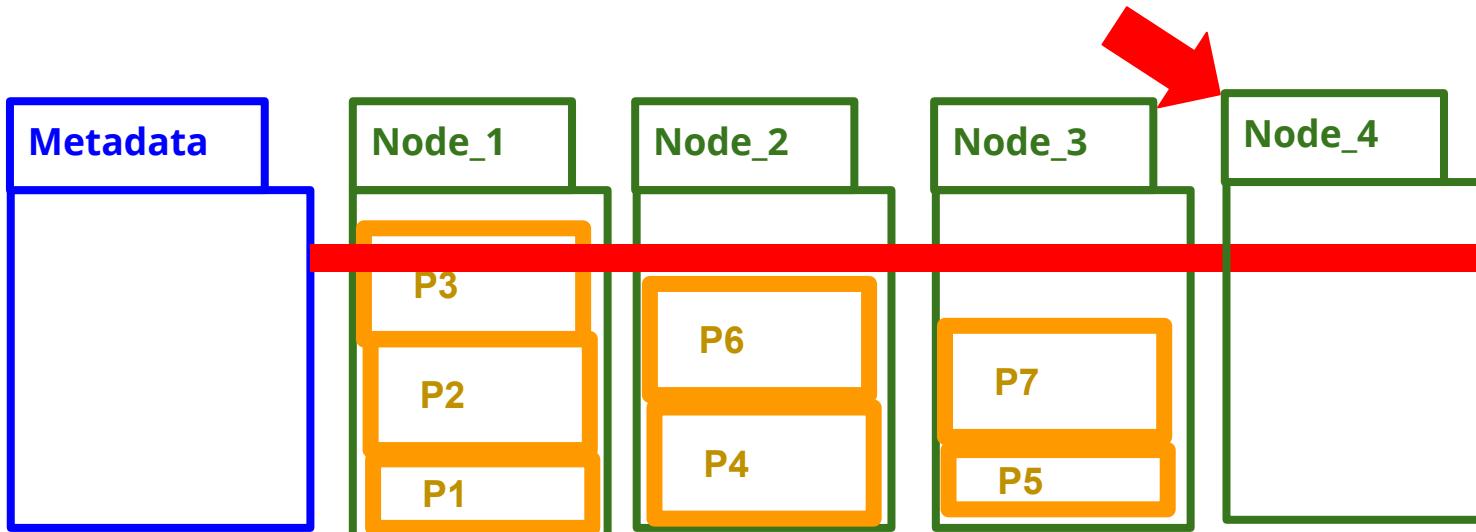


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

Our migration policy has one rule more:

- If this is the case, then we auto-scale the cluster by creating a new node...

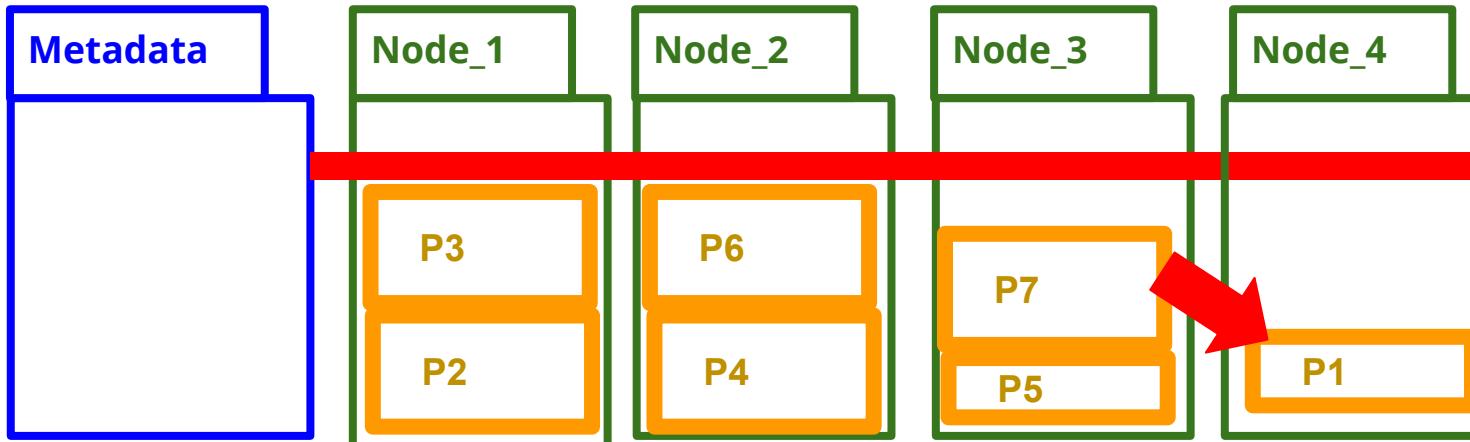


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

Our migration policy has one rule more:

- If this is the case, then we auto-scale the cluster by creating a new node...**and migrate the partition there.**

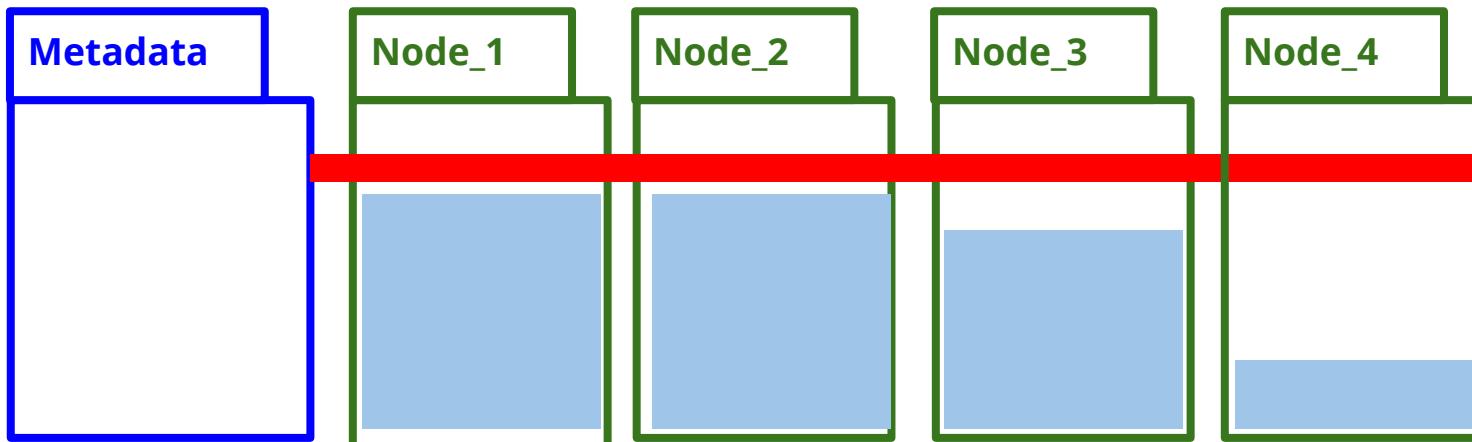


My Cluster Simulator: Split, Migrate and Auto-Scale

Auto-scale:

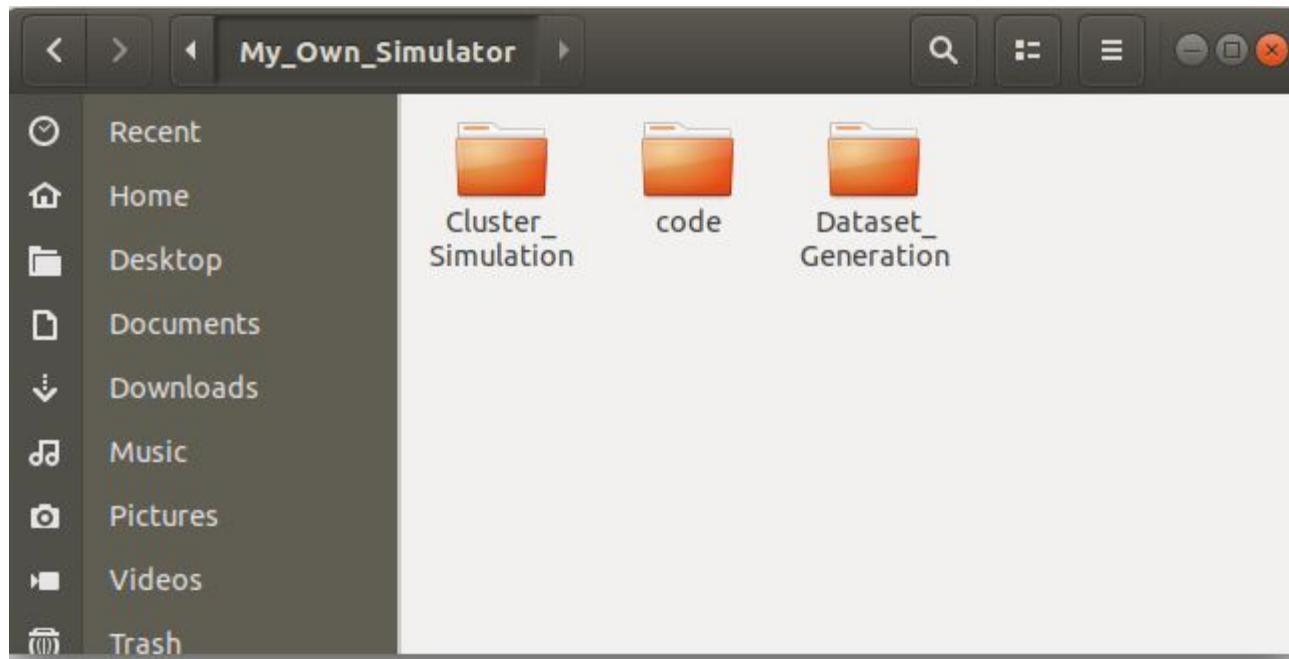
Our migration policy has one rule more:

- If this is the case, then we auto-scale the cluster by creating a new node...and migrate the partition there.



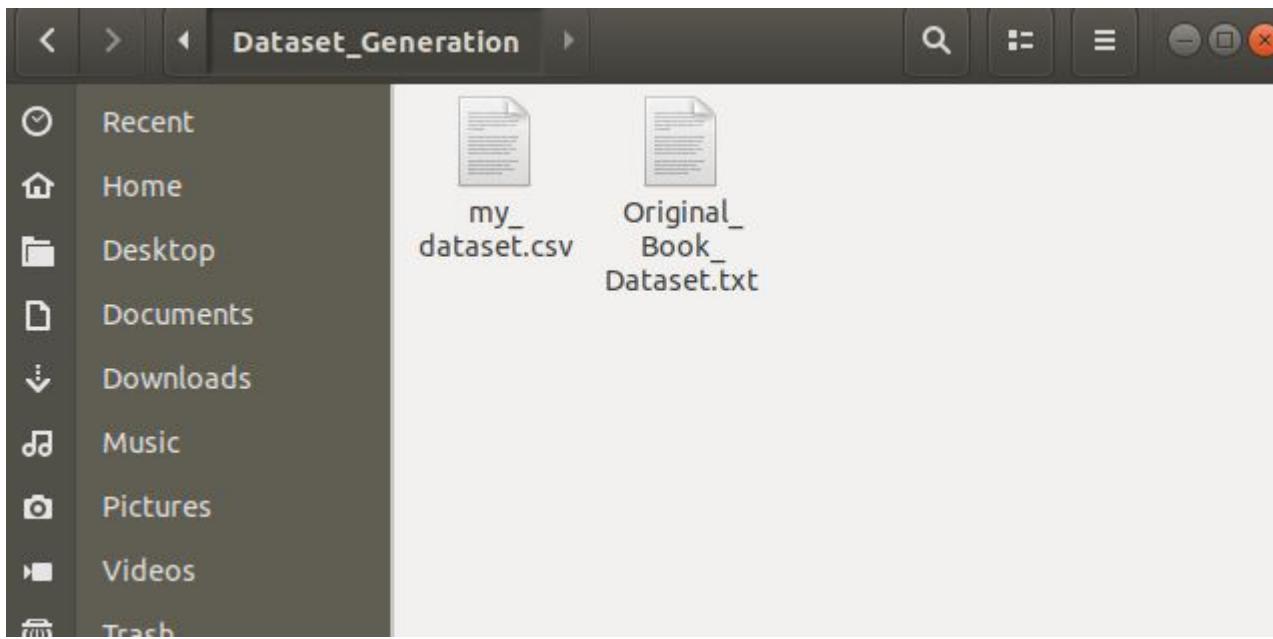
My Cluster Simulator: Split, Migrate and Auto-Scale

The folder **My_Own_Simulator** contains all the necessary infrastructure to carry on our demo:



My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Dataset_Generation** contains:



My Cluster Simulator: Split, Migrate and Auto-Scale

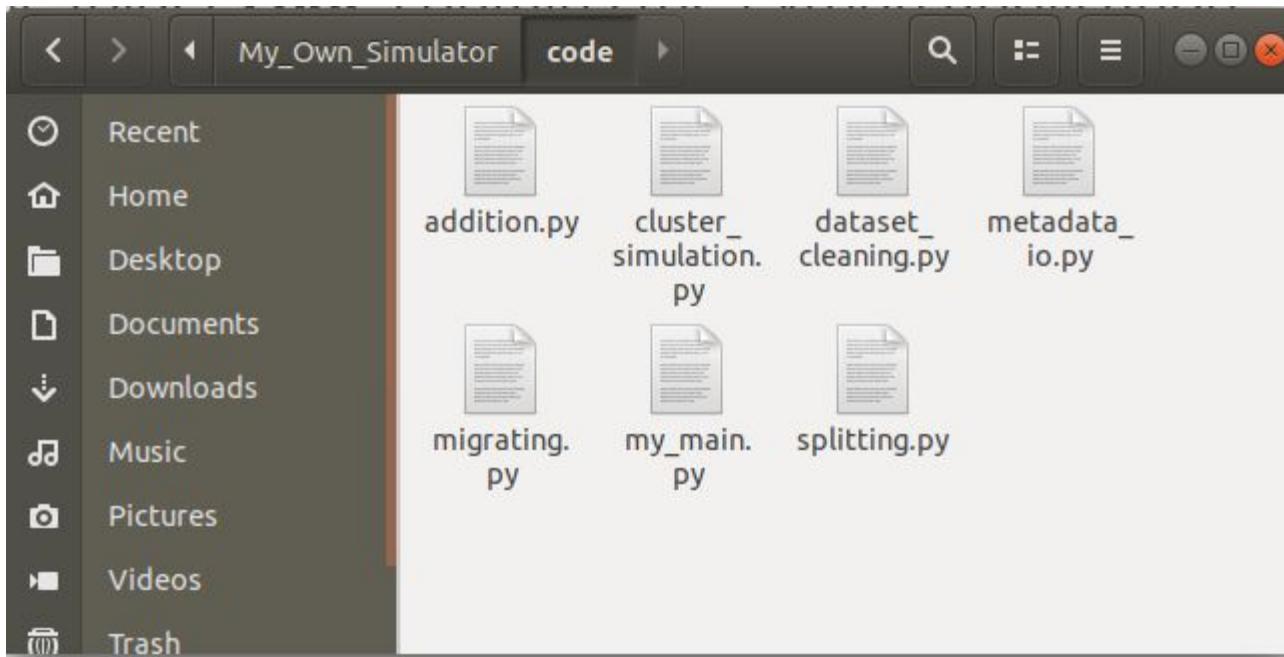
- The folder **Dataset_Generation** contains:
 - **Original_Book_dataset.txt**: The Guardian dataset.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Dataset_Generation** contains:
 - **my_dataset.csv**: The dataset, once cleaned and having the right format, ready to be used by the application.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:



My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **my_main.py**: Containing the application entry point.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **dataset_cleaning.py**: Responsible of the subroutines for cleaning and formatting the dataset.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **metadata_io.py**: Responsible of the subroutines for managing the content of the Metadata Node.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **cluster_simulation.py**: Responsible of the subroutines for processing a new data item of the dataset.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **addition.py**: Responsible of the subroutines for adding a new data item to a partition.

My Cluster Simulator: Split, Migrate and Auto-Scale

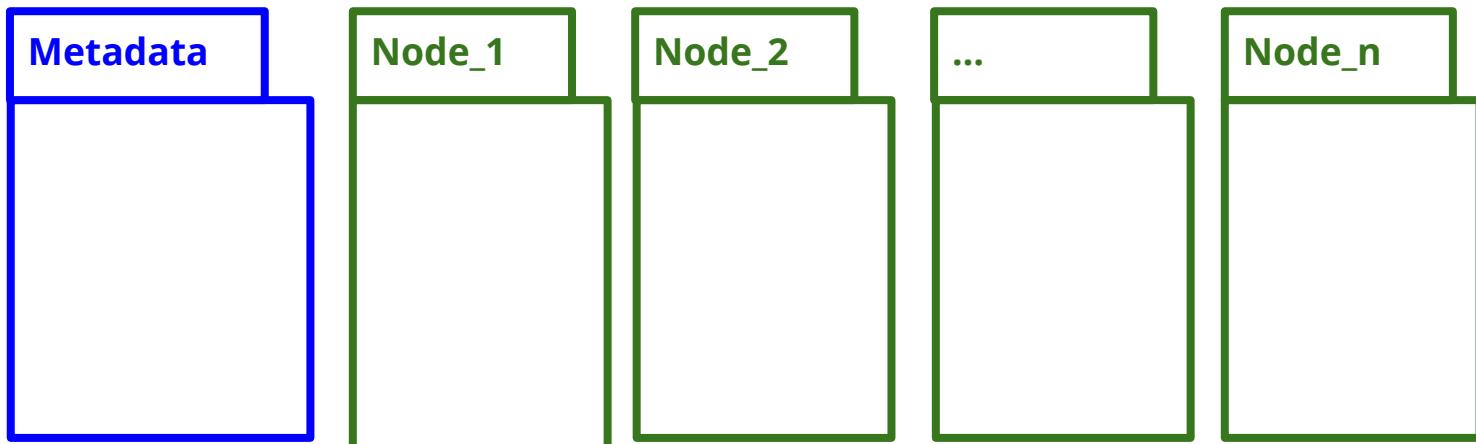
- The folder **code** contains the Python application:
 - **splitting.py**: Responsible of the subroutines for splitting a partition.

My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **code** contains the Python application:
 - **migrating.py**: Responsible of the subroutines for migrating a partition (possibly also auto-scaling the cluster).

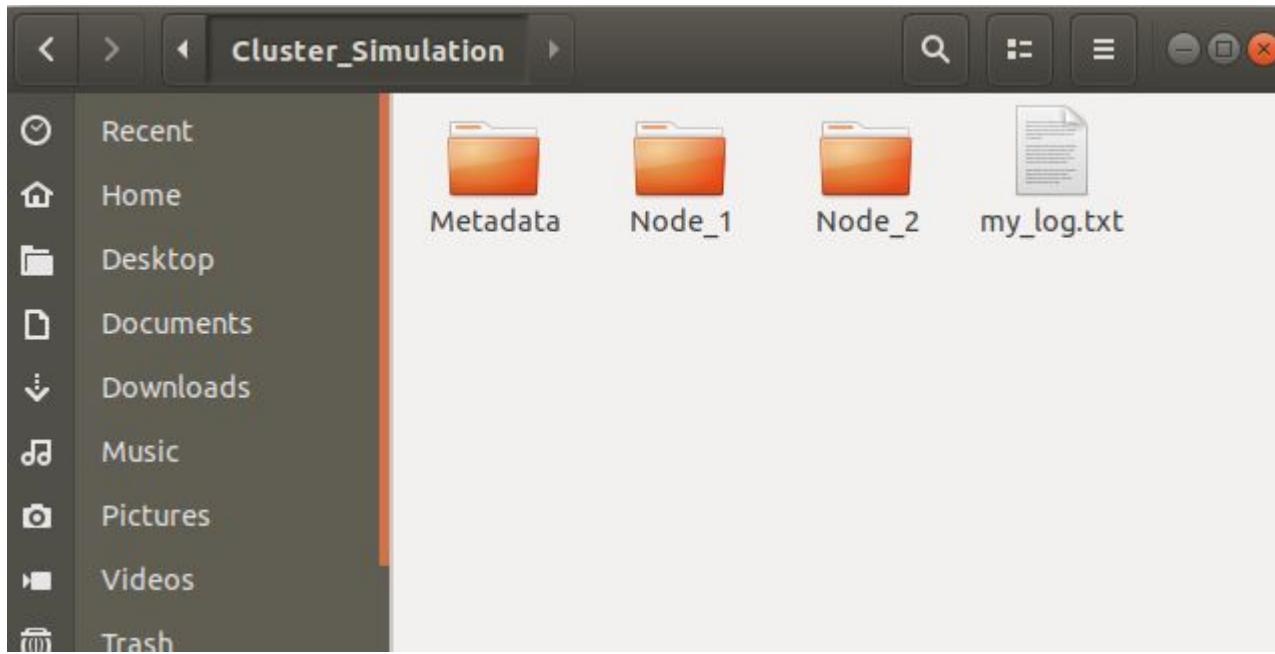
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:



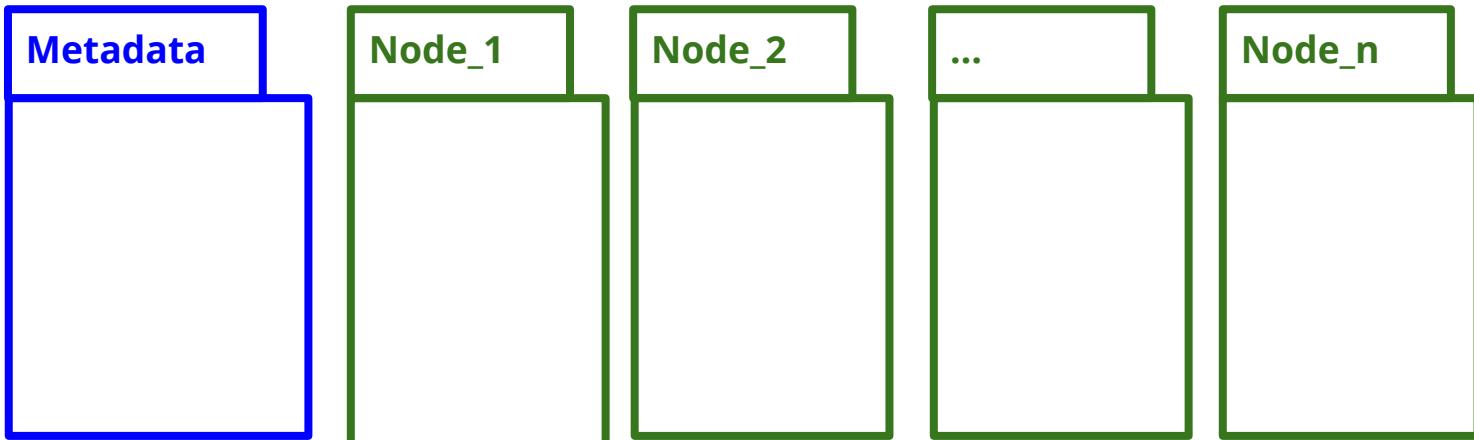
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:



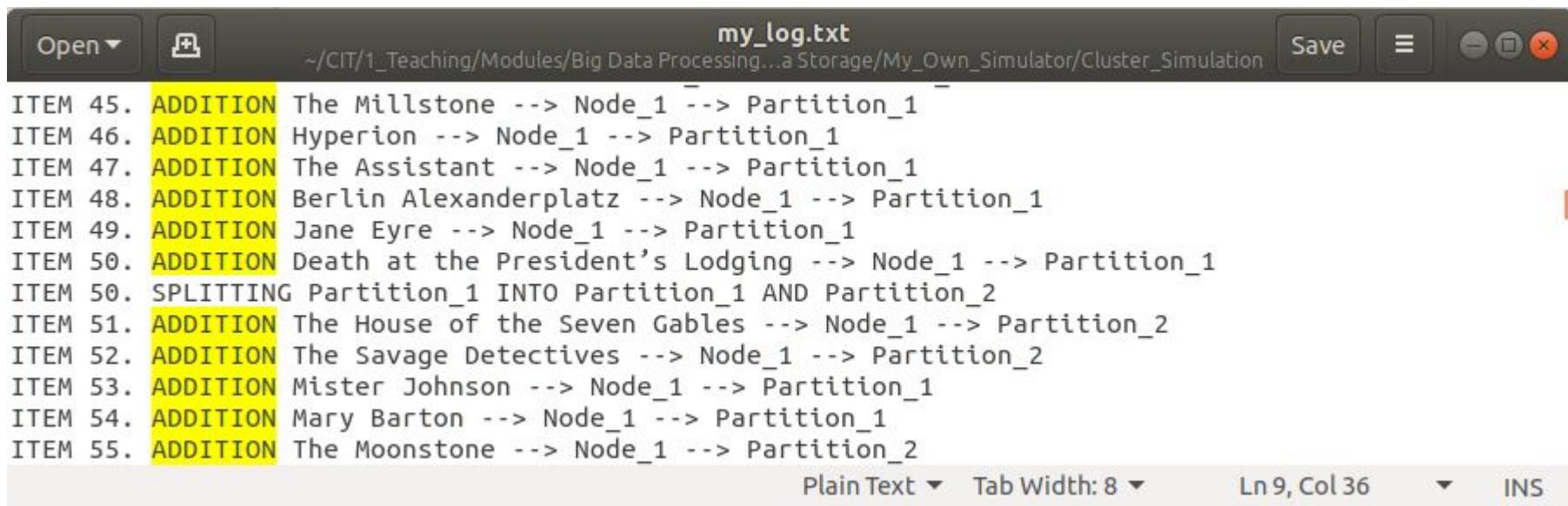
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **my_log.txt**: This file keeps track of any cluster event:
 - Data item addition.



My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:



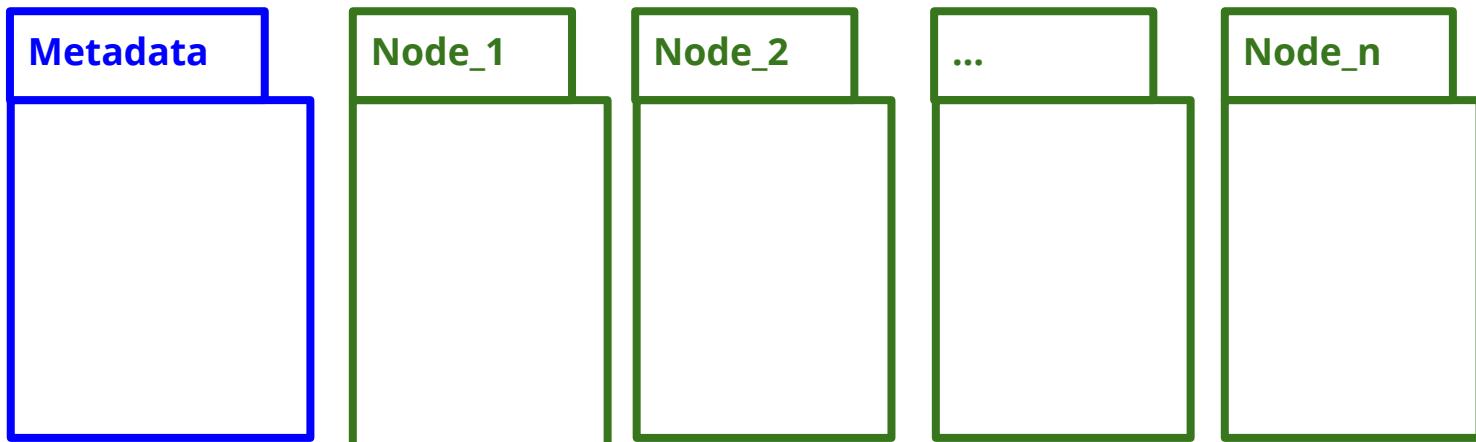
A screenshot of a terminal window titled "my_log.txt". The window has standard OS X-style controls at the top. The log file content is displayed in a monospaced font. Lines 45 through 55 are highlighted in yellow, while the rest of the log is in white text on a black background. The log entries show various additions and a splitting operation:

```
my_log.txt
~/CIT/1_Teaching/Modules/Big Data Processing...a Storage/My_Own_Simulator/Cluster_Simulation
Save □ ×
Open ▾
ITEM 45. ADDITION The Millstone --> Node_1 --> Partition_1
ITEM 46. ADDITION Hyperion --> Node_1 --> Partition_1
ITEM 47. ADDITION The Assistant --> Node_1 --> Partition_1
ITEM 48. ADDITION Berlin Alexanderplatz --> Node_1 --> Partition_1
ITEM 49. ADDITION Jane Eyre --> Node_1 --> Partition_1
ITEM 50. ADDITION Death at the President's Lodging --> Node_1 --> Partition_1
ITEM 50. SPLITTING Partition_1 INTO Partition_1 AND Partition_2
ITEM 51. ADDITION The House of the Seven Gables --> Node_1 --> Partition_2
ITEM 52. ADDITION The Savage Detectives --> Node_1 --> Partition_2
ITEM 53. ADDITION Mister Johnson --> Node_1 --> Partition_1
ITEM 54. ADDITION Mary Barton --> Node_1 --> Partition_1
ITEM 55. ADDITION The Moonstone --> Node_1 --> Partition_2
```

Plain Text ▾ Tab Width: 8 ▾ Ln 9, Col 36 ▾ INS

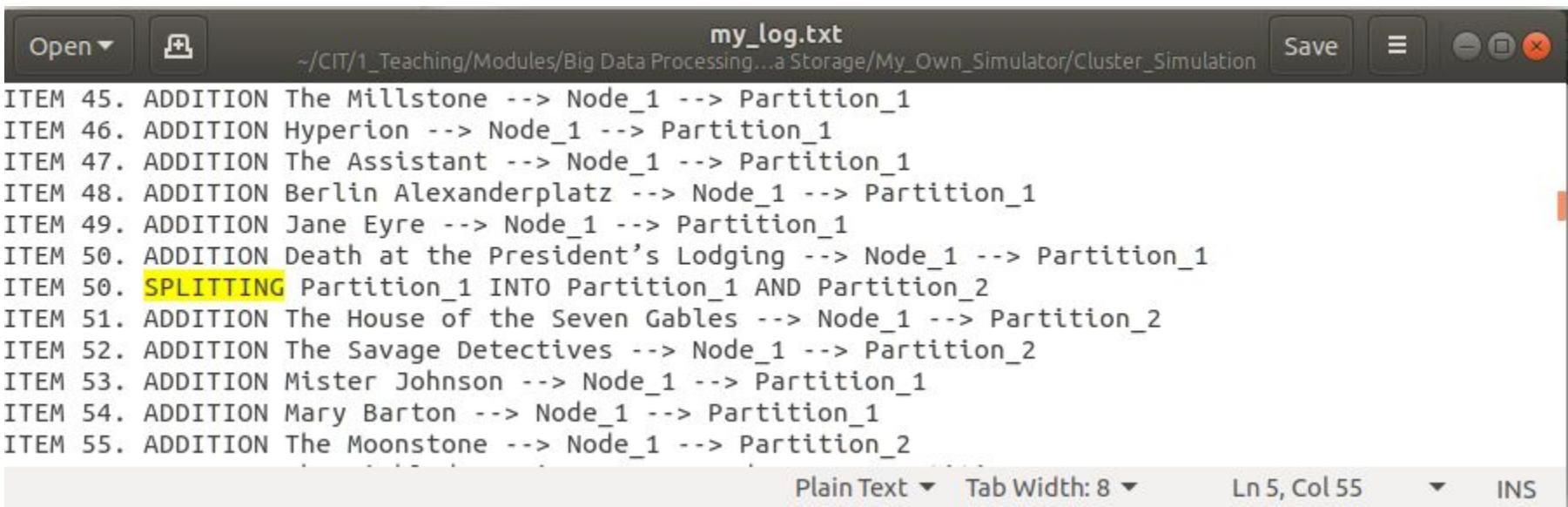
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **my_log.txt**: This file keeps track of any cluster event:
 - Data item addition.
 - Partition split.



My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:



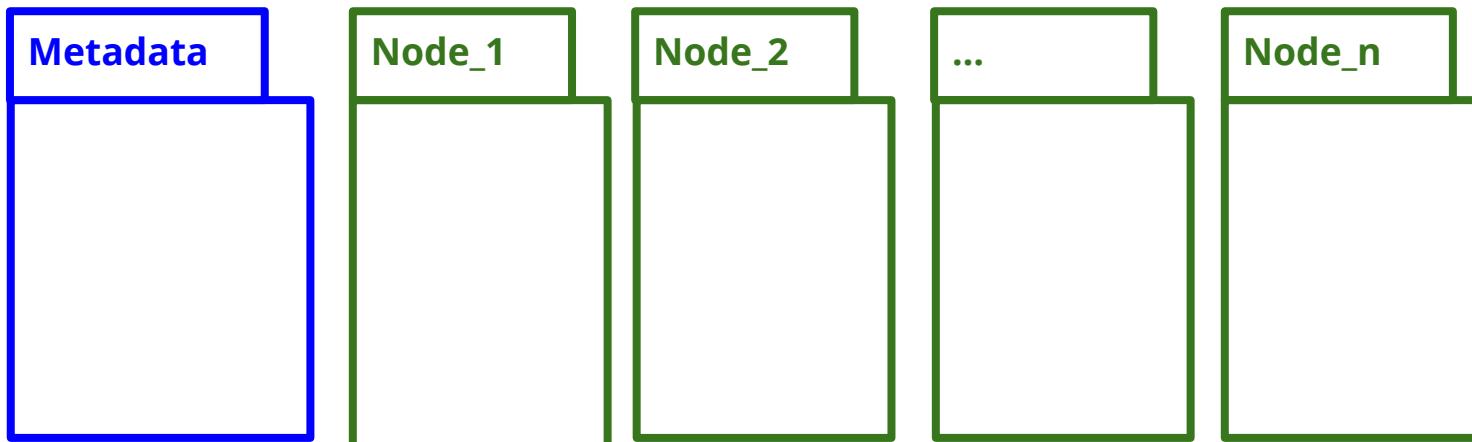
A screenshot of a terminal window titled "my_log.txt". The window has standard OS X-style controls at the top. The log file content is displayed in a text editor-like interface. The text shows a sequence of operations on a cluster, starting with additions of books to a node and ending with a partition splitting operation.

```
ITEM 45. ADDITION The Millstone --> Node_1 --> Partition_1
ITEM 46. ADDITION Hyperion --> Node_1 --> Partition_1
ITEM 47. ADDITION The Assistant --> Node_1 --> Partition_1
ITEM 48. ADDITION Berlin Alexanderplatz --> Node_1 --> Partition_1
ITEM 49. ADDITION Jane Eyre --> Node_1 --> Partition_1
ITEM 50. ADDITION Death at the President's Lodging --> Node_1 --> Partition_1
ITEM 50. SPLITTING Partition_1 INTO Partition_1 AND Partition_2
ITEM 51. ADDITION The House of the Seven Gables --> Node_1 --> Partition_2
ITEM 52. ADDITION The Savage Detectives --> Node_1 --> Partition_2
ITEM 53. ADDITION Mister Johnson --> Node_1 --> Partition_1
ITEM 54. ADDITION Mary Barton --> Node_1 --> Partition_1
ITEM 55. ADDITION The Moonstone --> Node_1 --> Partition_2
```

At the bottom of the window, there are standard OS X text editor controls: Plain Text ▾, Tab Width: 8 ▾, Ln 5, Col 55 ▾, and INS.

My Cluster Simulator: Split, Migrate and Auto-Scale

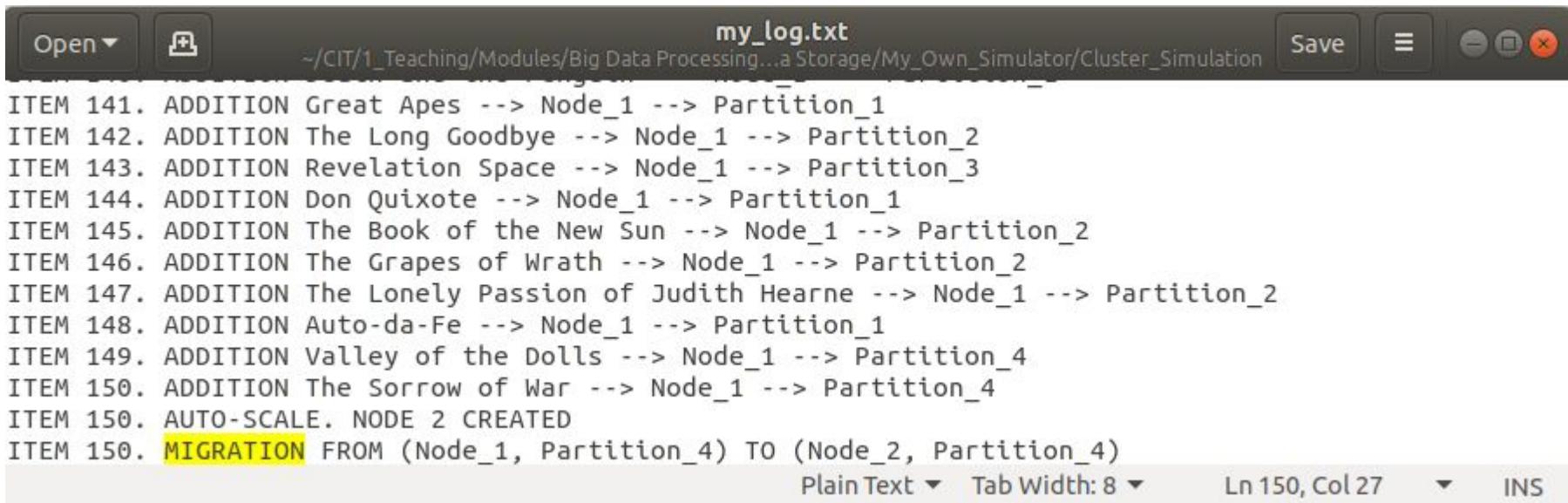
- The folder **Cluster_Simulation** contains our cluster:
 - **my_log.txt**: This file keeps track of any cluster event:
 - Data item addition.
 - Partition split.
 - Partition migration.



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder **My_Own_Simulator** contains all the necessary infrastructure to carry on our demo:

- The folder **Cluster_Simulation** contains our cluster:



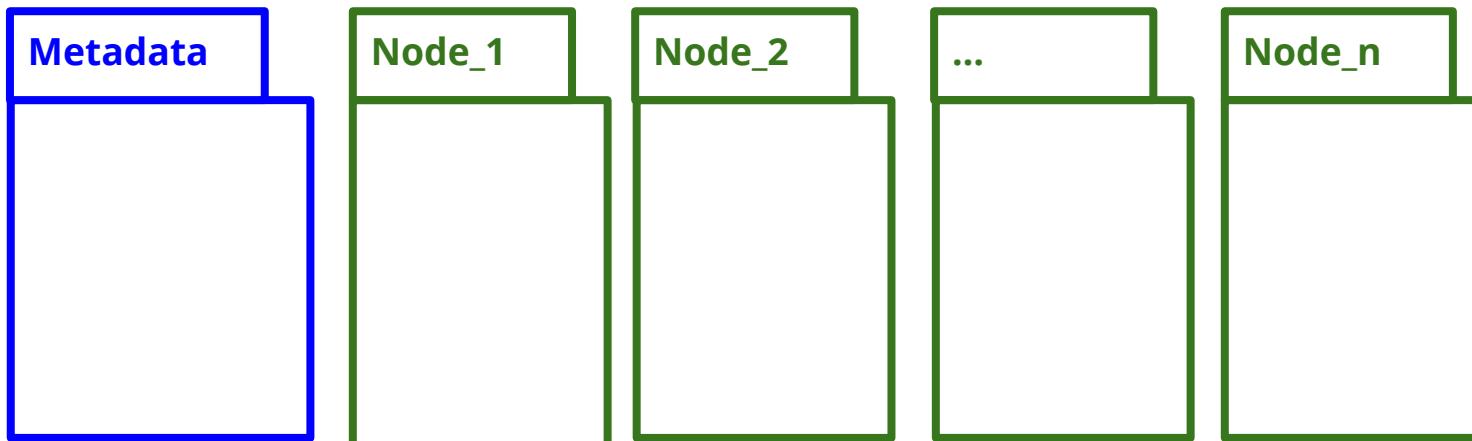
```
my_log.txt
~/CIT/1_Teaching/Modules/Big Data Processing...a Storage/My_Own_Simulator/Cluster_Simulation
Save

ITEM 141. ADDITION Great Apes --> Node_1 --> Partition_1
ITEM 142. ADDITION The Long Goodbye --> Node_1 --> Partition_2
ITEM 143. ADDITION Revelation Space --> Node_1 --> Partition_3
ITEM 144. ADDITION Don Quixote --> Node_1 --> Partition_1
ITEM 145. ADDITION The Book of the New Sun --> Node_1 --> Partition_2
ITEM 146. ADDITION The Grapes of Wrath --> Node_1 --> Partition_2
ITEM 147. ADDITION The Lonely Passion of Judith Hearne --> Node_1 --> Partition_2
ITEM 148. ADDITION Auto-da-Fe --> Node_1 --> Partition_1
ITEM 149. ADDITION Valley of the Dolls --> Node_1 --> Partition_4
ITEM 150. ADDITION The Sorrow of War --> Node_1 --> Partition_4
ITEM 150. AUTO-SCALE. NODE 2 CREATED
ITEM 150. MIGRATION FROM (Node_1, Partition_4) TO (Node_2, Partition_4)

Plain Text ▾ Tab Width: 8 ▾ Ln 150, Col 27 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

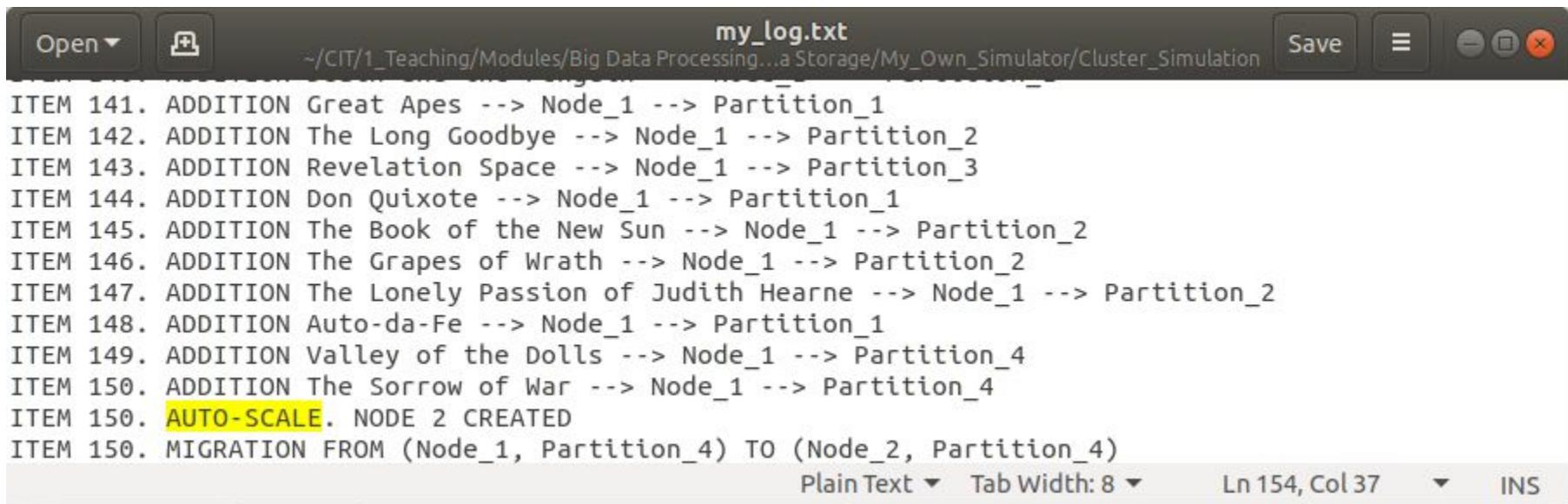
- The folder **Cluster_Simulation** contains our cluster:
 - **my_log.txt**: This file keeps track of any cluster event:
 - Data item addition.
 - Partition split.
 - Partition migration.
 - **Node auto-scale.**



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder **My_Own_Simulator** contains all the necessary infrastructure to carry on our demo:

- The folder **Cluster_Simulation** contains our cluster:

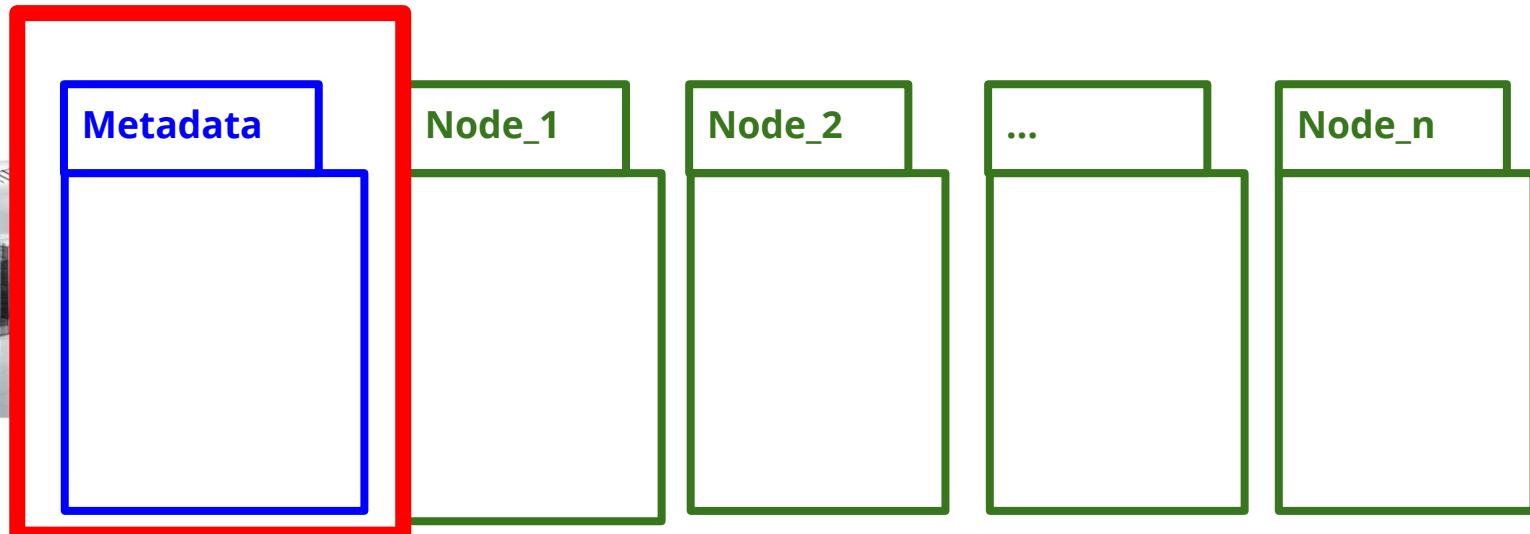


A screenshot of a terminal window titled "my_log.txt". The window has standard OS X-style controls at the top. The log file content shows a series of "ADDITION" events followed by an "AUTO-SCALE" event and a "MIGRATION" event.

```
my_log.txt
~/CIT/1_Teaching/Modules/Big Data Processing...a Storage/My_Own_Simulator/Cluster_Simulation
Save
Open ▾
ITEM 141. ADDITION Great Apes --> Node_1 --> Partition_1
ITEM 142. ADDITION The Long Goodbye --> Node_1 --> Partition_2
ITEM 143. ADDITION Revelation Space --> Node_1 --> Partition_3
ITEM 144. ADDITION Don Quixote --> Node_1 --> Partition_1
ITEM 145. ADDITION The Book of the New Sun --> Node_1 --> Partition_2
ITEM 146. ADDITION The Grapes of Wrath --> Node_1 --> Partition_2
ITEM 147. ADDITION The Lonely Passion of Judith Hearne --> Node_1 --> Partition_2
ITEM 148. ADDITION Auto-da-Fe --> Node_1 --> Partition_1
ITEM 149. ADDITION Valley of the Dolls --> Node_1 --> Partition_4
ITEM 150. ADDITION The Sorrow of War --> Node_1 --> Partition_4
ITEM 150. AUTO-SCALE. NODE 2 CREATED
ITEM 150. MIGRATION FROM (Node_1, Partition_4) TO (Node_2, Partition_4)
Plain Text ▾ Tab Width: 8 ▾ Ln 154, Col 37 ▾ INS
```

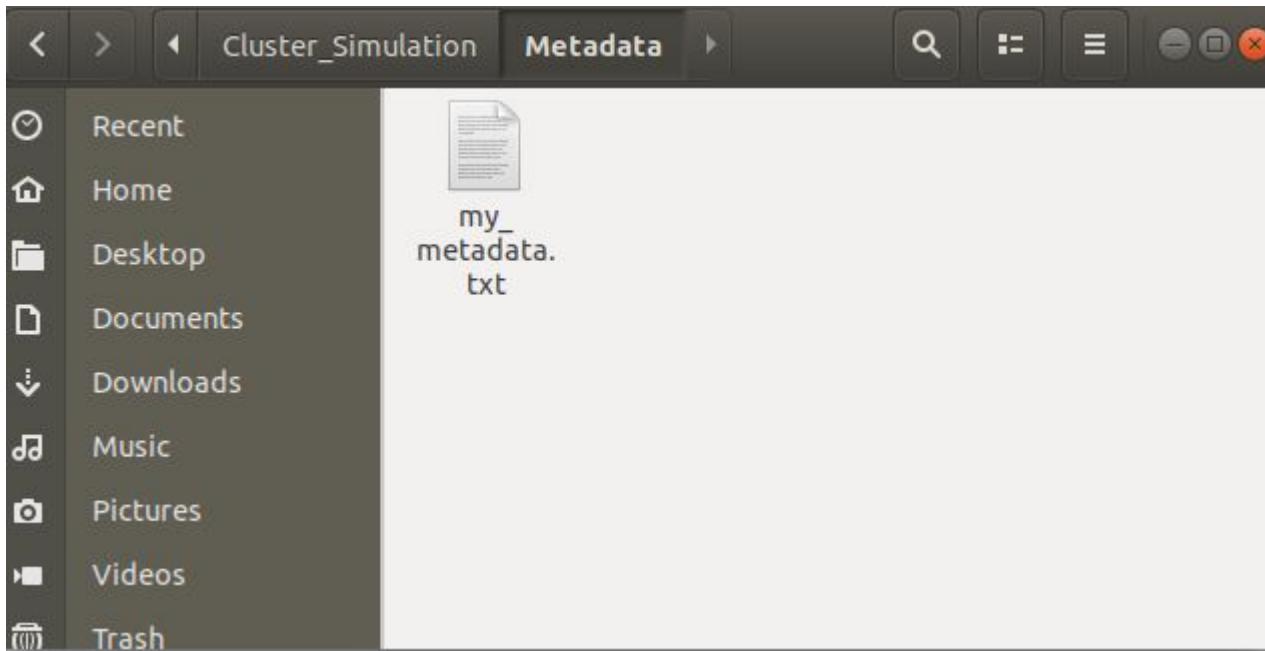
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **Metadata:** This folder represents the metadata node.



My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **Metadata:** This folder represents the metadata node.



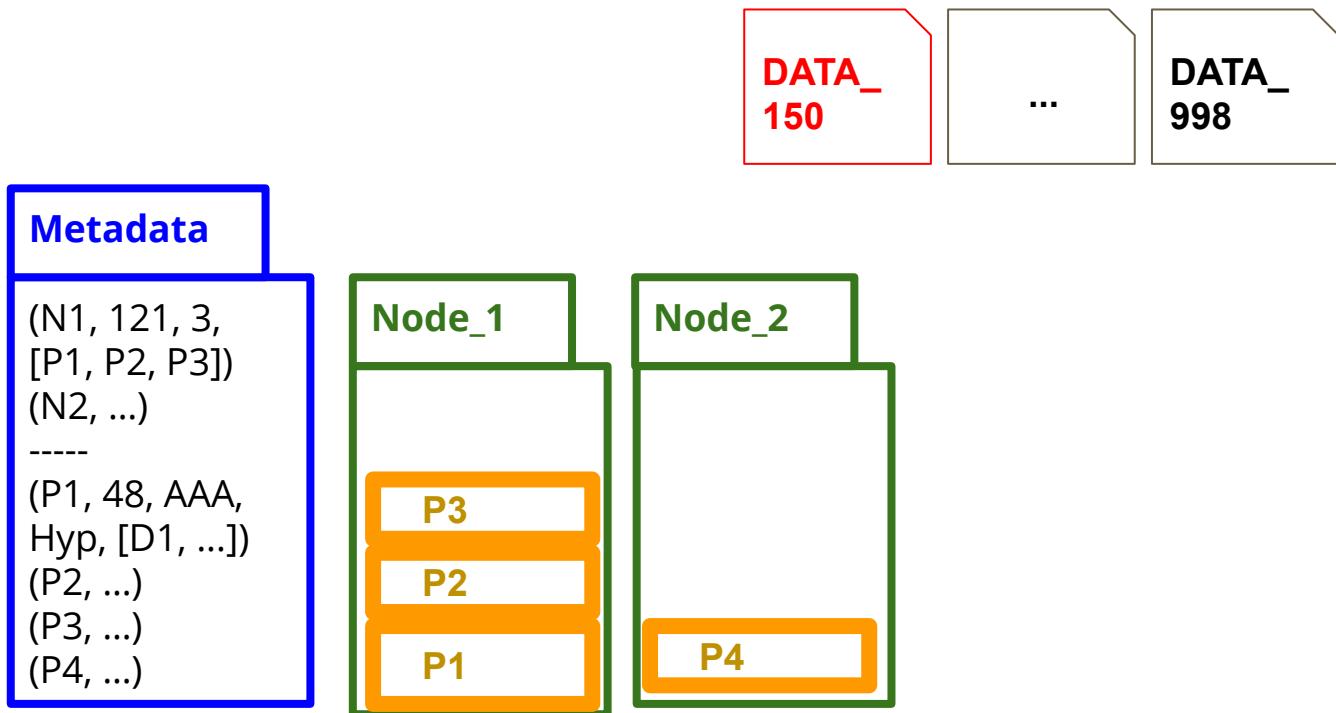
My Cluster Simulator: Split, Migrate and Auto-Scale

The file **my_metadata.txt** has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])

My Cluster Simulator: Split, Migrate and Auto-Scale

- For example, given the following state of the cluster:



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])

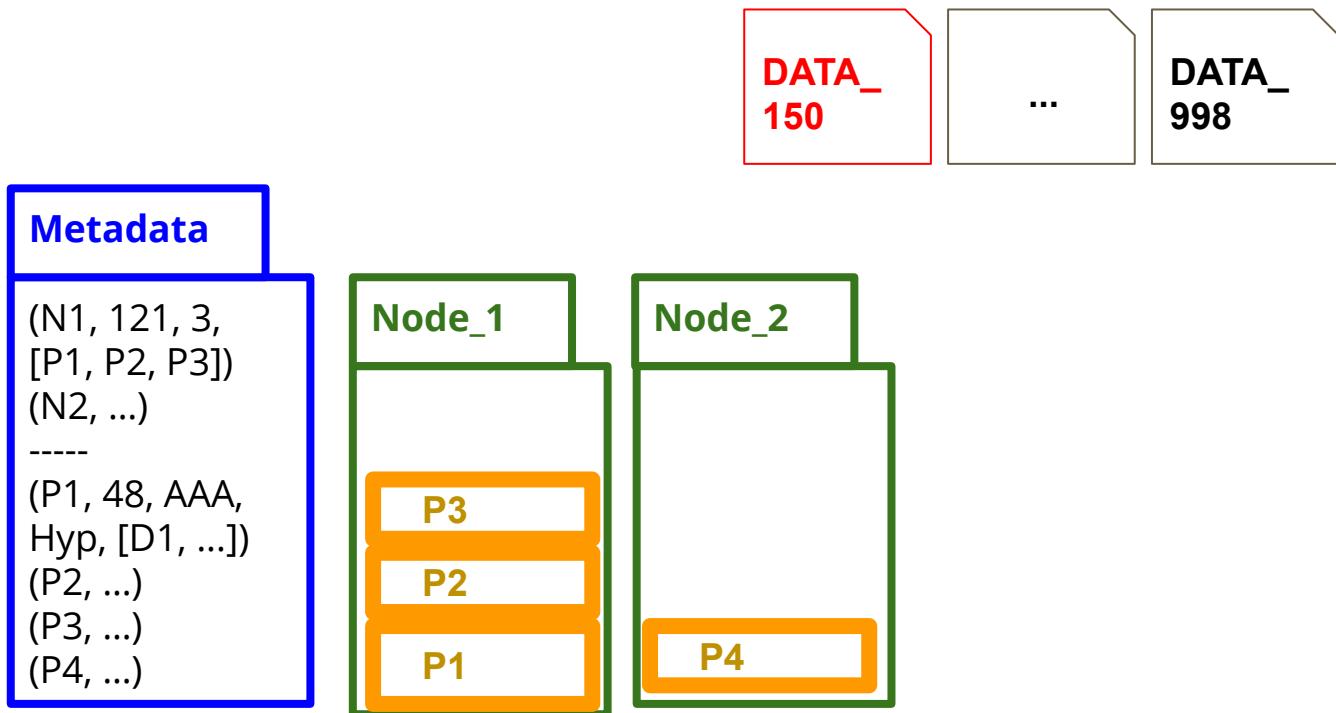
		Partition_1	Partition_2	Partition_3	Partition_4
Node_1	121	2			
Node_2	29	1			Partition_4
	4				
Partition_1	48	00	Hyperion A Bend in the River A Dry White Season A		
Flag for Sunrise			A Kestrel for a Knave A Room with a View Afternoon Men All the		
Pretty Horses			An American Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-		
Two-Birds			Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist Bleak House		
Blood Meridian			Bold as Love Bomber Breakfast at Tiffany's Breathing Lessons Bridget		
Jones's Diary			Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard		
Call it Sleep			Captain Blood Changing Places Charade Cider with Rosie Clayhanger		
Cloud Atlas			Confederates Couples Death and the Penguin Death at the President's		
Lodging Dom Casmurro			Dom Joaquim Don Quixote Dune Empire of the Sun Excellent Women		
Family Matters			Gorky Park Gravity's Rainbow Great Apes Herland High Fidelity		
How Green was My Valley			Humboldt's Gift		
Partition_2	34		The Andromeda Strain The Millstone The Andromeda Strain The Ascent		
of Rum Doodle			The Assistant The Beach The Big Blowdown The Black Prince		
The Blackwater Lightship			The Blue Flower The Book of the New Sun The Bottle Factory		
Outing			The Buddha of Suburbia The Catcher in the Rye The Crab with the Golden Claws The Crow		
Road			The Curious Incident of the Dog in the Night-time The Good Companions The Grapes		
of Wrath			The Grass is Singing The Great Impersonation The Guns of Navarone The		
History of Mr Polly			The History of Pompey the Little The House of the Seven Gables		
The Island of Dr Moreau			The King of Torts The Lecturer's Tale The Leopard The Life		
and Loves of a She-Devil			The Lonely Londoners The Lonely Passion of Judith Hearne		
The Long Goodbye			The Man of Property The Manchurian Candidate The Military		
Philosophers					
Partition_3	39		Hyperion The Andromeda Strain Hyperion Jane Eyre		
Lady Chatterley's Lover			Lord Jim Love in a Cold Climate Lucky Jim L'Histoire de Gil		
Blas de Santillane (Gil Blas)			Martin Chuzzlewit Mary Barton Maurice Guest Memoirs of		
a Gnostic Dwarf			Memoirs of a Survivor Mister Johnson Money Moon over Africa More Die		
of Heartbreak			Mrs Dalloway Music and Silence My Cousin Rachel New Grub Street		
North and South			Northanger Abbey Orlando Persuasion Pnin Pointed Roofs		
Possession			Pride and Prejudice Put Out More Flags Regeneration Revelation		
Space			Revolutionary Road Room Temperature Rubyfruit Jungle Sharpe's Eagle		
She: A History of Adventure			Tender is the Night The Adventures of Augie March The		
African Queen					
Partition_4	29		The Millstone } The Millstone The Moonstone The Old Men at the		
Zoo			The Parasites The Ragged Trousered Philanthropists The Recognitions The Savage		
Detectives			The Slaves of Solitude The Sorrow of War The Strange Case of Dr Jekyll and		
Mr Hyde The Third Man			The Three Musketeers The Three Sisters The Trial The Virgin		
Suicides			The Wasp Factory The Wimbledon Poisoner The Woman in White They Were		
Counted To The Ends of the Earth			trilogy Treasure Island Two Serious Ladies USA		
Valley of the Dolls			Venus on the Half-Shell Vile Bodies Waterland Who Do You Think		
You Are?			Williwaw		



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluste...
Save   =
2
Node_1 121      3      Partition_1      Partition_2      Partition_3
Node_2 29       1      Partition_4
Plain Text ▾  Tab Width: 8 ▾  Ln 1, Col 1 ▾  INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

- For example, given the following state of the cluster:

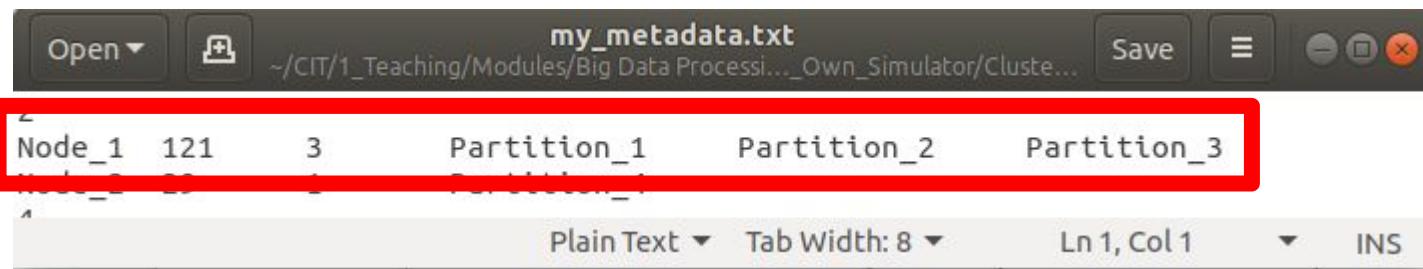


My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])

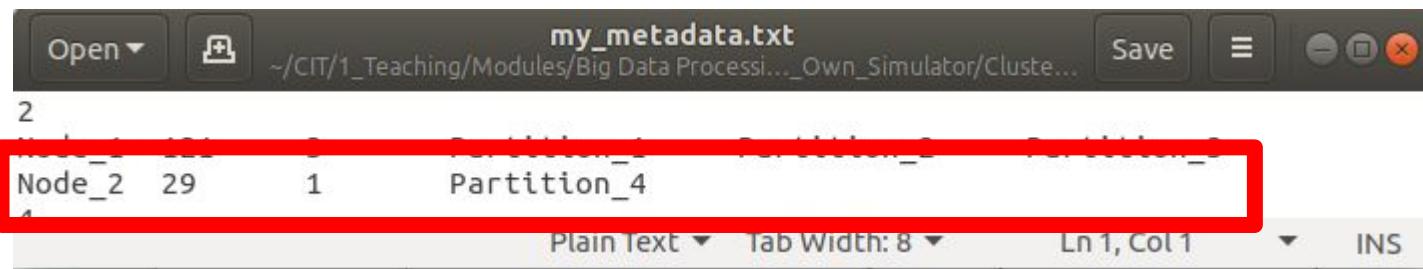
			Partition_1	Partition_2	Partition_3	
Node_1	121	3				
Node_2	29	1				
			Partition_4			
Partition_1	48	89	Hyperion	A Bend in the River	A Dry White Season	A
Flag for Sunrise			A Kestrel for a Knave	A Room with a View	Afternoon Men	All the
Pretty Horses			An American Tragedy	Anglo-Saxon Attitudes	Asterix the Gaul	At-Swim-
Two-Birds			Auto-da-Fe	Beloved Berlin Alexanderplatz	Blacklist	Bleak House
Blood Meridian			Bold as Love	Bomber Breakfast at Tiffany's	Breathing Lessons	Bridget
Jones's Diary			Bright Lights, Big City	Cakes and Ale - Or, the Skeleton in the Cupboard		
Call it Sleep			Captain Blood	Changing Places Charade Cider with Rosie		Clayhanger
Cloud Atlas			Confederates	Couples Death and the Penguin	Death at the President's	
Lodging Dom Casmurro			Joaquim	Don Quixote Dune	Empire of the Sun	Excellent Women
Family Matters			Gorky Park	Gravity's Rainbow	Great Apes	Herland High Fidelity
How Green was My Valley			Humboldt's Gift			
Partition_2	34		The Andromeda Strain	The Millstone	The Andromeda Strain	The Ascent
of Rum Doodle			The Assistant	The Beach	The Big Blowdown	The Black Prince
The Blackwater Lightship				The Blue Flower	The Book of the New Sun	The Bottle Factory
Outing			The Buddha of Suburbia	The Catcher in the Rye	The Crab with the Golden Claws	The Crow
Road			The Curious Incident of the Dog in the Night-time		The Good Companions	The Grapes
of Wrath			The Grass is Singing	The Great Impersonation	The Guns of Navarone	The
History of Mr Polly			The History of Pompey the Little		The House of the Seven Gables	
The Island of Dr Moreau			The King of Torts	The Lecturer's Tale	The Leopard	The Life
and Loves of a She-Devil			The Lonely Londoners	The Lonely Passion of Judith Hearne		
The Long Goodbye			The Man of Property	The Manchurian Candidate		The Military
Philosophers						
Partition_3	39		Hyperion	The Andromeda Strain	Hyperion	Jane Eyre
Lady Chatterley's Lover			Lord Jim	Love in a Cold Climate	Lucky Jim	L'Histoire de Gil
Blas de Santillane (Gil Blas)			Martin Chuzzlewit	Mary Barton	Maurice Guest	Memoirs of
a Gnostic Dwarf			Memoirs of a Survivor	Mister Johnson	Money Moon over Africa	More Die
of Heartbreak			Mrs Dalloway	Music and Silence	My Cousin Rachel	New Grub Street
North and South			Northanger Abbey	Orlando Persuasion	Pnin Pointed Roofs	
Possession			Pride and Prejudice	Put Out More Flags	Regeneration	Revelation
Space			Revolutionary Road	Room Temperature	Rubyfruit Jungle	Sharpe's Eagle
She: A History of Adventure			Tender is the Night	The Adventures of Augie March	The	
African Queen						
Partition_4	29		The Millstone	}	The Millstone	The Old Men at the
Zoo			The Parasites	The Ragged Trousered Philanthropists	The Recognitions	The Savage
Detectives			The Slaves of Solitude	The Sorrow of War	The Strange Case of Dr Jekyll and	
Mr Hyde The Third Man			The Three Musketeers	The Three Sisters	The Trial	The Virgin
Suicides			The Wasp Factory	The Wimbleton Poisoner	The Woman in White	They Were
Counted To The Ends of the Earth			trilogy	Treasure Island	Two Serious Ladies	USA
Valley of the Dolls			Venus on the Half-Shell	Vile Bodies	Waterland	Who Do You Think
You Are?			Williwaw			



my_metadata.txt

```
Node_1 121 3 Partition_1 Partition_2 Partition_3
```

Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluste...
Save
☰
Open ▾
Node_2 29 1 Partition_4
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (**node_id**, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])



The screenshot shows a terminal window with the following content:

```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluste...
Save   =  -  ×
2
Node_1 121      3      Partition_1      Partition_2      Partition_3
Node_2 29       1      Partition_4
1
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

The first row of data is highlighted with a red box around "Node_1".

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

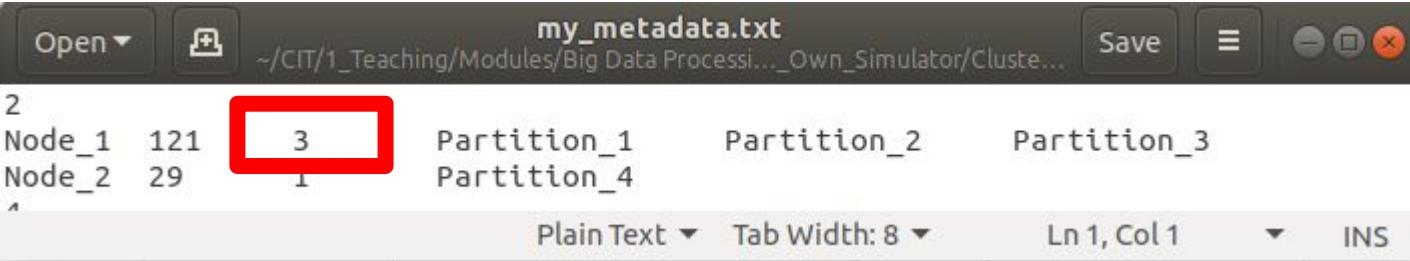
- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, **num_items**, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, **num_partitions**, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])

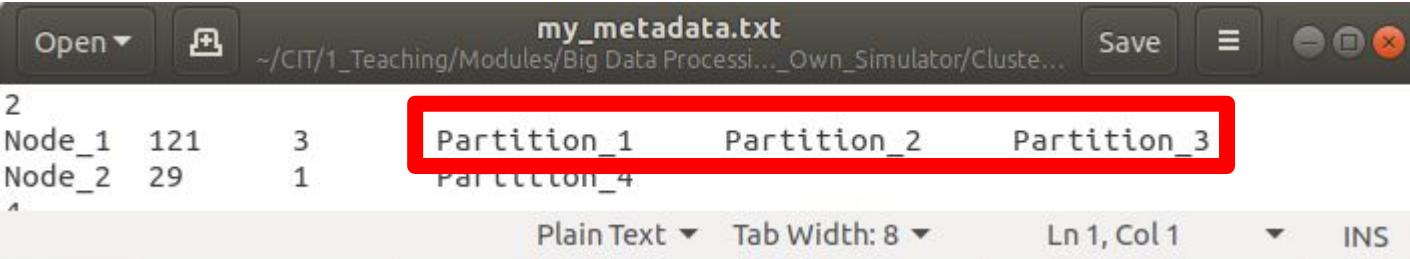


			Partition_1	Partition_2	Partition_3
2					
Node_1	121	3			
Node_2	29	1	Partition_4		

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, **[partition_id]**)
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])



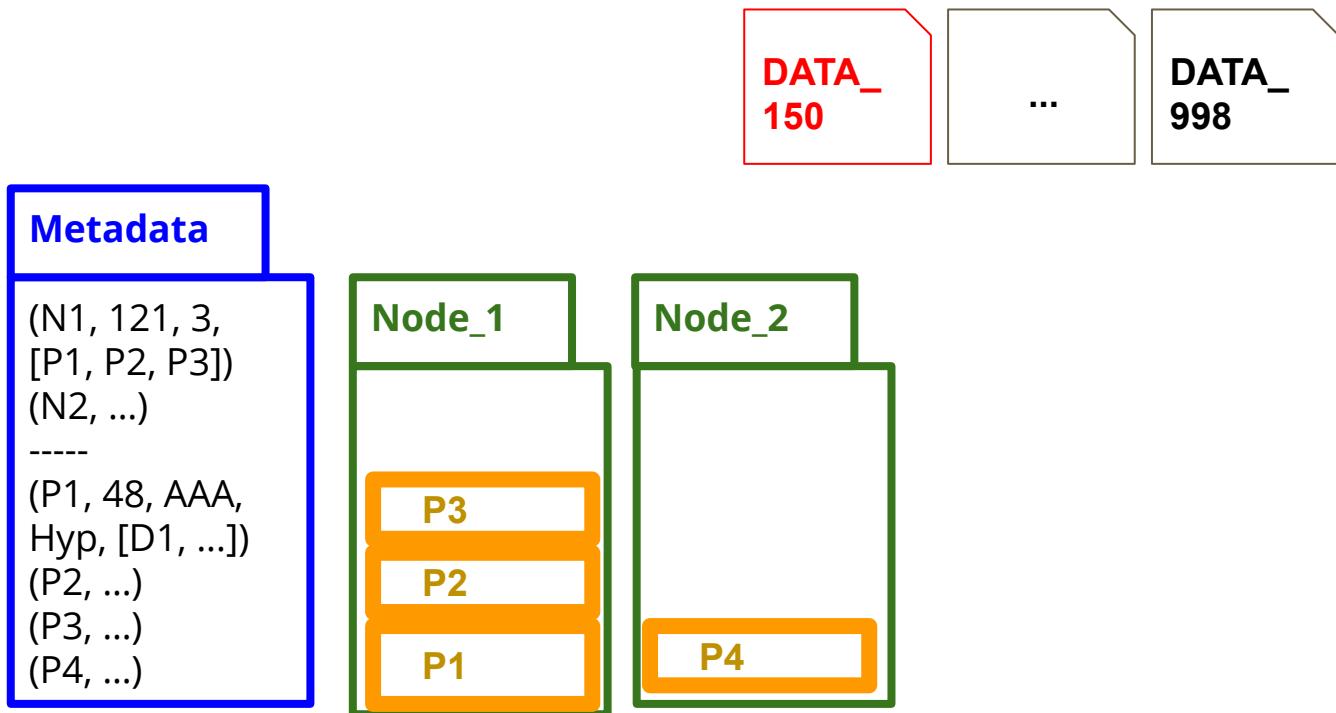
my_metadata.txt

			Partition_1	Partition_2	Partition_3
2					
Node_1	121	3			
Node_2	29	1	Partition_4		

Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS

My Cluster Simulator: Split, Migrate and Auto-Scale

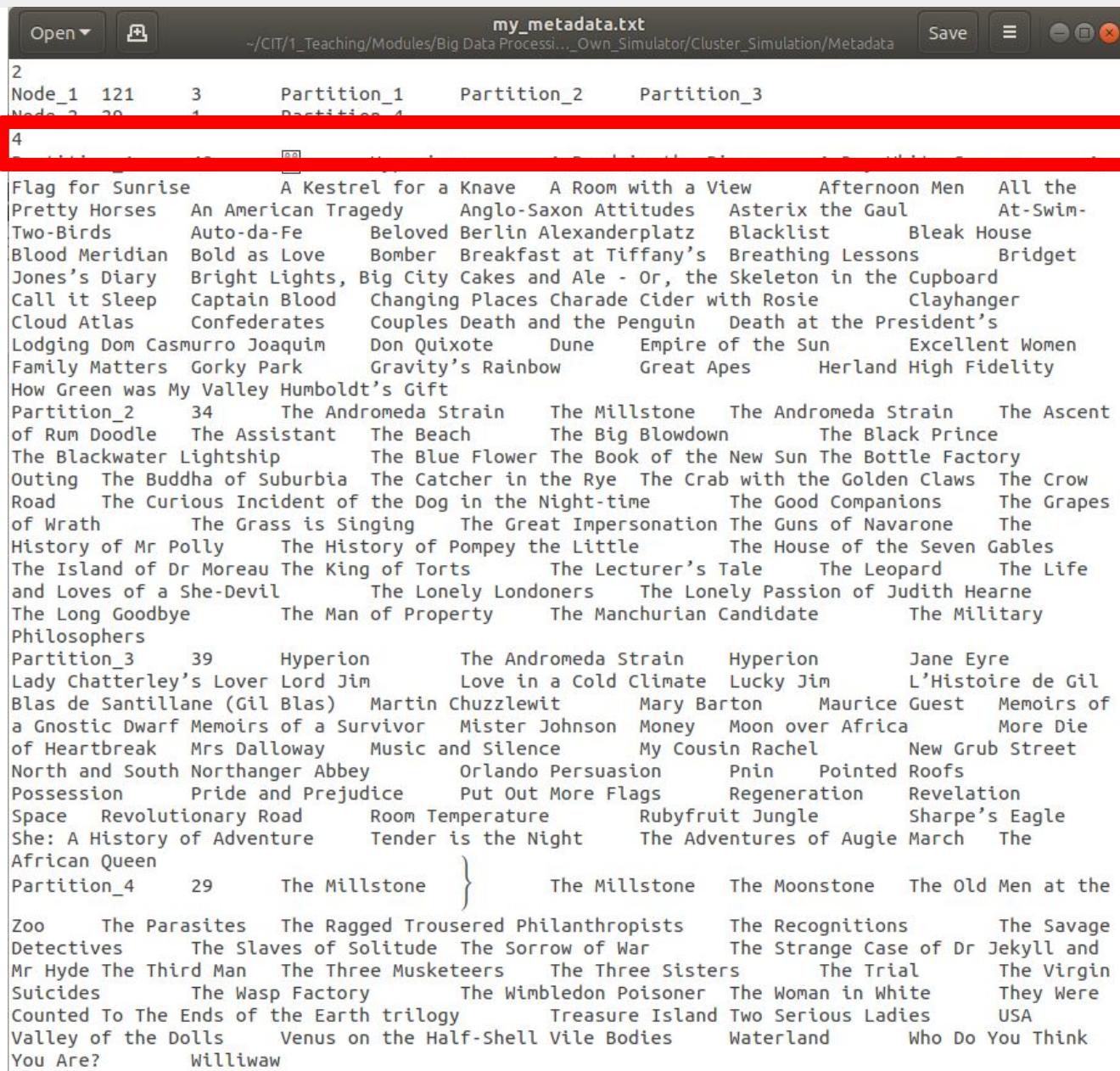
- For example, given the following state of the cluster:



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])



my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata

	Partition_1	Partition_2	Partition_3
2	Node_1 121 3	Partition_1	Partition_2
Node_2 29 1	Partition_1	Partition_2	Partition_3
4			
	Flag for Sunrise A Kestrel for a Knave A Room with a View Afternoon Men All the		
Pretty Horses	An American Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-		
Two-Birds	Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist Bleak House		
Blood Meridian	Bold as Love Bomber Breakfast at Tiffany's Breathing Lessons Bridget		
Jones's Diary	Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard		
Call it Sleep	Captain Blood Changing Places Charade Cider with Rosie Clayhanger		
Cloud Atlas	Confederates Couples Death and the Penguin Death at the President's		
Lodging Dom Casmurro Joaquim	Don Quixote Dune Empire of the Sun Excellent Women		
Family Matters Gorky Park	Gravity's Rainbow Great Apes Herland High Fidelity		
How Green was My Valley Humboldt's Gift			
Partition_2 34	The Andromeda Strain The Millstone The Andromeda Strain The Ascent		
of Rum Doodle	The Assistant The Beach The Big Blowdown The Black Prince		
The Blackwater Lightship	The Blue Flower The Book of the New Sun The Bottle Factory		
Outing	The Buddha of Suburbia The Catcher in the Rye The Crab with the Golden Claws The Crow		
Road	The Curious Incident of the Dog in the Night-time The Good Companions The Grapes		
of Wrath	The Grass is Singing The Great Impersonation The Guns of Navarone The		
History of Mr Polly	The History of Pompey the Little The House of the Seven Gables		
The Island of Dr Moreau	The King of Torts The Lecturer's Tale The Leopard The Life		
and Loves of a She-Devil	The Lonely Londoners The Lonely Passion of Judith Hearne		
The Long Goodbye	The Man of Property The Manchurian Candidate The Military		
Philosophers			
Partition_3 39	Hyperion The Andromeda Strain Hyperion Jane Eyre		
Lady Chatterley's Lover Lord Jim	Love in a Cold Climate Lucky Jim L'Histoire de Gil		
Blas de Santillane (Gil Blas)	Martin Chuzzlewit Mary Barton Maurice Guest Memoirs of		
a Gnostic Dwarf Memoirs of a Survivor	Mister Johnson Money Moon over Africa More Die		
of Heartbreak Mrs Dalloway	Music and Silence My Cousin Rachel New Grub Street		
North and South Northanger Abbey	Orlando Persuasion Pnin Pointed Roofs		
Possession	Pride and Prejudice Put Out More Flags Regeneration Revelation		
Space Revolutionary Road	Room Temperature Rubyfruit Jungle Sharpe's Eagle		
She: A History of Adventure	Tender is the Night The Adventures of Augie March The		
African Queen			
Partition_4 29	The Millstone } The Millstone The Moonstone The Old Men at the		
Zoo	The Parasites The Ragged Trousered Philanthropists The Recognitions The Savage		
Detectives	The Slaves of Solitude The Sorrow of War The Strange Case of Dr Jekyll and		
Mr Hyde The Third Man	The Three Musketeers The Three Sisters The Trial The Virgin		
Suicides	The Wasp Factory The Wimbledon Poisoner The Woman in White They Were		
Counted To The Ends of the Earth trilogy	Treasure Island Two Serious Ladies USA		
Valley of the Dolls	Venus on the Half-Shell Vile Bodies Waterland Who Do You Think		
You Are?	Williwaw		

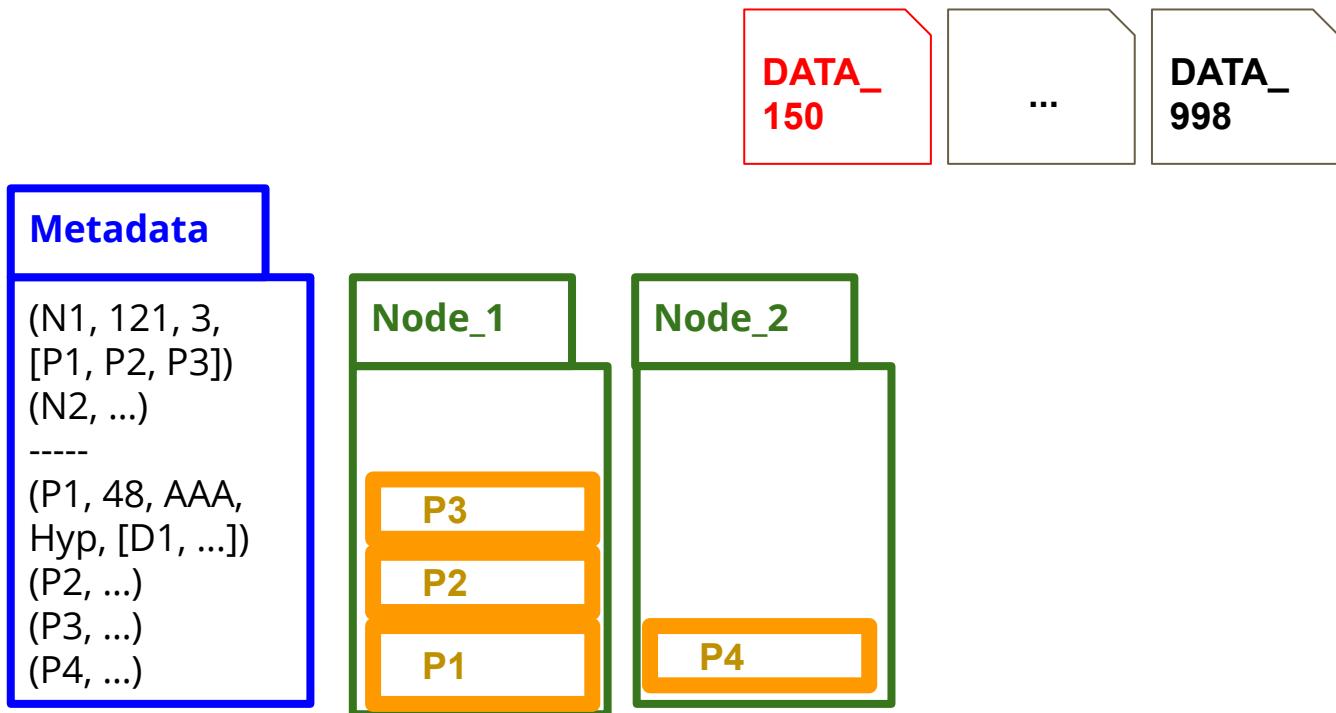


The screenshot shows a terminal window titled "my_metadata.txt" with the path "/CIT/1_Teaching/Modules/Big Data Processi....Own_Simulator/Clust...". The window has a red box highlighting the number "4" in the first column of the text output.

4	Partition_1	48	Hyperion	A Bend in the River	A
	Dry White Season		A Flag for Sunrise	A Kestrel for a Knave	A
	Room with a View		Afternoon Men	All the Pretty Horses	An American
	Tragedy Anglo-Saxon Attitudes		Asterix the Gaul		At-Swim-Two-
	Birds Auto-da-Fe		Beloved Berlin Alexanderplatz		Blacklist
	Bleak House		Blood Meridian	Bold as Love	Bomber Breakfast at
	Tiffany's		Breathing Lessons	Bridget Jones's Diary	Bright
	Lights, Big City		Cakes and Ale - Or, the Skeleton in the		
	Cupboard		Call it Sleep	Captain Blood	Changing Places Charade
	Cider with Rosie		Clayhanger	Cloud Atlas	Confederates
	Couples Death and the Penguin		Death at the President's Lodging		Dom
	Casmurro Joaquim		Don Quixote	Dune	Empire of the Sun
	Excellent Women		Family Matters	Gorky Park	Gravity's Rainbow
	Great Apes		Herland	High Fidelity	How Green was My Valley Humboldt's
	Gift				
	Partition 2	34	The Andromeda Strain	The Millstone	The
			Plain Text ▾	Tab Width: 8 ▾	Ln 1, Col 1 ▾
					INS

My Cluster Simulator: Split, Migrate and Auto-Scale

- For example, given the following state of the cluster:



My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, [item_id])

my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata

		Partition_1	Partition_2	Partition_3	
2	Node_1	121	3	Partition_1	Partition_2
	Node_2	29	1	Partition_4	Partition_3
	Partition_1	48	{	Hyperion	A Bend in the River
	Flag for Sunrise			A Kestrel for a Knave	A Room with a View
	Pretty Horses			Anglo-Saxon Attitudes	Asterix the Gaul
	Two-Birds			Beloved Berlin Alexanderplatz	Blacklist
	Blood Meridian			Bomber Breakfast at Tiffany's	Breathing Lessons
	Jones's Diary			Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard	Bridget
	Call it Sleep			Captain Blood Changing Places Charade Cider with Rosie	Clayhanger
	Cloud Atlas			Confederates Couples Death and the Penguin	Death at the President's
	Lodging Dom Casmurro			Don Quixote Dune Empire of the Sun	Excellent Women
	Family Matters			Gorky Park Gravity's Rainbow	Great Apes
	How Green was My Valley			Humboldt's Gift	Herland High Fidelity
	Partition_2	34		The Andromeda Strain	The Millstone
	of Rum Doodle			The Assistant	The Big Blowdown
	The Blackwater Lightship			The Beach	The Book of the New Sun
	Outing			The Buddha of Suburbia	The Crab with the Golden Claws
	Road of Wrath			The Curious Incident of the Dog in the Night-time	The Good Companions
	The History of Mr Polly			The Grass is Singing	The Great Impersonation
	The Island of Dr Moreau			The King of Torts	The Guns of Navarone
	and Loves of a She-Devil			The Lecturer's Tale	The House of the Seven Gables
	The Long Goodbye			The Man of Property	The Leopard
	Philosophers			The Manchurian Candidate	The Life
	Partition_3	39		Hyperion	The Andromeda Strain
	Lady Chatterley's Lover			Lord Jim	Hyperion
	Blas de Santillane (Gil Blas)			Martin Chuzzlewit	Jane Eyre
	a Gnostic Dwarf Memoirs of a Survivor			Mary Barton	L'histoire de Gil
	of Heartbreak			Mister Johnson	Maurice Guest
	Mrs Dalloway			Music and Silence	Memoirs of
	North and South			My Cousin Rachel	More Die
	Northanger Abbey			Orlando Persuasion	New Grub Street
	Possession			Pnin	Pointed Roofs
	Space			Put Out More Flags	Regeneration
	Revolutionary Road			Rubyfruit Jungle	Revelation
	She: A History of Adventure			Tender is the Night	Sharpe's Eagle
	African Queen			The Adventures of Augie March	The
	Partition_4	29		The Millstone	}
	Zoo Detectives			The Millstone	The Moonstone
	The Parasites			The Moonstone	The Old Men at the
	The Slaves of Solitude			The Recognition	The Savage
	Mr Hyde The Third Man			The Sorrows of War	The Strange Case of Dr Jekyll and
	Suicides			The Three Musketeers	The Three Sisters
	Counted To The Ends of the Earth			The Trial	The Virgin
	Valley of the Dolls			trilogy	The Woman in White
	You Are?			Treasure Island	They Were
	Venus on the Half-Shell			Two Serious Ladies	USA
	Williwaw			Waterland	Who Do You Think

my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata

		Partition_1	Partition_2	Partition_3	
2	Node_1	121	3	Partition_1	Partition_2
	Node_2	29	1	Partition_4	Partition_3
	Partition_1	48	88	Hyperion	A Bend in the River
	Flag for Sunrise			A Kestrel for a Knave	A Room with a View
	Pretty Horses			Anglo-Saxon Attitudes	Asterix the Gaul
	Two-Birds			Beloved Berlin Alexanderplatz	Blacklist
	Blood Meridian			Bomber Breakfast at Tiffany's	Breathing Lessons
	Jones's Diary			Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard	Bridget
	Call it Sleep			Captain Blood Changing Places Charade Cider with Rosie	Clayhanger
	Cloud Atlas			Confederates Couples Death and the Penguin	Death at the President's
	Lodging Dom Casmurro			Don Quixote Dune Empire of the Sun	Excellent Women
	Family Matters			Gorky Park Gravity's Rainbow	Great Apes
	How Green was My Valley			Humboldt's Gift	Herland High Fidelity
	Partition_2	34		The Andromeda Strain	The Millstone
	of Rum Doodle			The Andromeda Strain	The Ascension
	The Assistant			The Big Blowdown	The Black Prince
	The Blackwater Lightship			The Blue Flower	The Book of the New Sun
	Outing			The Crab with the Golden Claws	The Bottle Factory
	Road			The Curious Incident of the Dog in the Night-time	The Crow
	of Wrath			The Catcher in the Rye	The Good Companions
	The Grass is Singing			The Crab with the Golden Claws	The Grapes
	The History of Mr Polly			The Great Impersonation	The Guns of Navarone
	The Island of Dr Moreau			The House of the Seven Gables	The
	The King of Torts			The Lecturer's Tale	The Leopard
	and Loves of a She-Devil			The Lonely Londoners	The Lonely Passion of Judith Hearne
	The Long Goodbye			The Man of Property	The Manchurian Candidate
	Philosophers				The Military
	Partition_3	39		Hyperion	The Andromeda Strain
	Lady Chatterley's Lover			Hyperion	Hyperion
	Lord Jim			Love in a Cold Climate	Jane Eyre
	Blas de Santillane (Gil Blas)			Lucky Jim	L'Histoire de Gil
	Memoirs of a Survivor			Martin Chuzzlewit	Mary Barton
	of Heartbreak			Maurice Guest	Memoirs of
	Mrs Dalloway			Mister Johnson	Money Moon over Africa
	North and South			Music and Silence	More Die
	Northanger Abbey			My Cousin Rachel	New Grub Street
	Possession			Orlando Persuasion	Pnin Pointed Roofs
	Pride and Prejudice			Put Out More Flags	Regeneration
	Space			Rubyfruit Jungle	Revelation
	Revolutionary Road			Room Temperature	Sharpe's Eagle
	She: A History of Adventure			Tender is the Night	The Adventures of Augie March
	African Queen				The
	Partition_4	29		The Millstone	The Moonstone
	Zoo			}	The Old Men at the
	The Parasites			The Millstone	The Recognition
	Detectives			The Ragged Trousered Philanthropists	The Savage
	The Slaves of Solitude			The Sorrow of War	The Strange Case of Dr Jekyll and
	Mr Hyde The Third Man			The Three Musketeers	The Three Sisters
	Suicides			The Trial	The Virgin
	The Wasp Factory			The Wimbleton Poisoner	The Woman in White
	Counted To The Ends of the Earth			They Were	They Were
	trilogy			Treasure Island	Two Serious Ladies
	Valley of the Dolls			Waterland	USA
	Venus on the Half-Shell				Who Do You Think
	Vile Bodies				
	You Are?			Williwaw	

```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata
Open Save
2
Node_1 121      3      Partition_1      Partition_2      Partition_3
Node_2 29       1      Partition_4
4
Partition_1      48      [8]      Hyperion      A Bend in the River      A Dry White Season      A
Flag for Sunrise      A Kestrel for a Knave      A Room with a View      Afternoon Men      All the
Pretty Horses      An American Tragedy      Anglo-Saxon Attitudes      Asterix the Gaul      At-Swim-
Two-Birds      Auto-da-Fe      Beloved Berlin Alexanderplatz      Blacklist      Bleak House
Blood Meridian      Bold as Love      Bomber Breakfast at Tiffany's      Breathing Lessons      Bridget
Jones's Diary      Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard
Call it Sleep      Captain Blood      Changing Places Charade Cider with Rosie      Clayhanger
Cloud Atlas      Confederates      Couples Death and the Penguin      Death at the President's
Lodging Dom Casmurro Joaquim      Don Quixote      Dune Empire of the Sun      Excellent Women
Family Matters      Gorky Park      Gravity's Rainbow      Great Apes      Herland High Fidelity

Partition_2      34      The Andromeda Strain      The Millstone      The Andromeda Strain      The Ascent
of Rum Doodle      The Assistant      The Beach      The Big Blowdown      The Black Prince
The Blackwater Lightship      The Blue Flower      The Book of the New Sun      The Bottle Factory
Outing      The Buddha of Suburbia      The Catcher in the Rye      The Crab with the Golden Claws      The Crow
Road      The Curious Incident of the Dog in the Night-time      The Good Companions      The Grapes
of Wrath      The Grass is Singing      The Great Impersonation      The Guns of Navarone      The
History of Mr Polly      The History of Pompey the Little      The House of the Seven Gables
The Island of Dr Moreau The King of Torts      The Lecturer's Tale      The Leopard      The Life
and Loves of a She-Devil      The Lonely Londoners      The Lonely Passion of Judith Hearne
The Long Goodbye      The Man of Property      The Manchurian Candidate      The Military
Philosophers
Partition_3      29      The Moonstone      The Old Men at the
Lady Chatterley's Lover Lord Jim      Love in a Cold Climate      Lucky Jim      L'Histoire de Gil
Blas de Santillane (Gil Blas)      Martin Chuzzlewit      Mary Barton      Maurice Guest      Memoirs of
a Gnostic Dwarf Memoirs of a Survivor      Mister Johnson      Money Moon over Africa      More Die
of Heartbreak      Mrs Dalloway      Music and Silence      My Cousin Rachel      New Grub Street
North and South Northanger Abbey      Orlando Persuasion      Pnin Pointed Roofs
Possession      Pride and Prejudice      Put Out More Flags      Regeneration      Revelation
Space      Revolutionary Road      Room Temperature      Rubyfruit Jungle      Sharpe's Eagle
She: A History of Adventure      Tender is the Night      The Adventures of Augie March      The
African Queen
Partition_4      29      The Millstone      }      The Millstone      The Moonstone      The Old Men at the
Zoo      The Parasites      The Ragged Trousered Philanthropists      The Recognitions      The Savage
Detectives      The Slaves of Solitude      The Sorrow of War      The Strange Case of Dr Jekyll and
Mr Hyde The Third Man      The Three Musketeers      The Three Sisters      The Trial      The Virgin
Suicides      The Wasp Factory      The Wimbledon Poisoner      The Woman in White      They Were
Counted To The Ends of the Earth trilogy      Treasure Island Two Serious Ladies      USA
Valley of the Dolls      Venus on the Half-Shell Vile Bodies      Waterland      Who Do You Think
You Are?      Williwaw
```

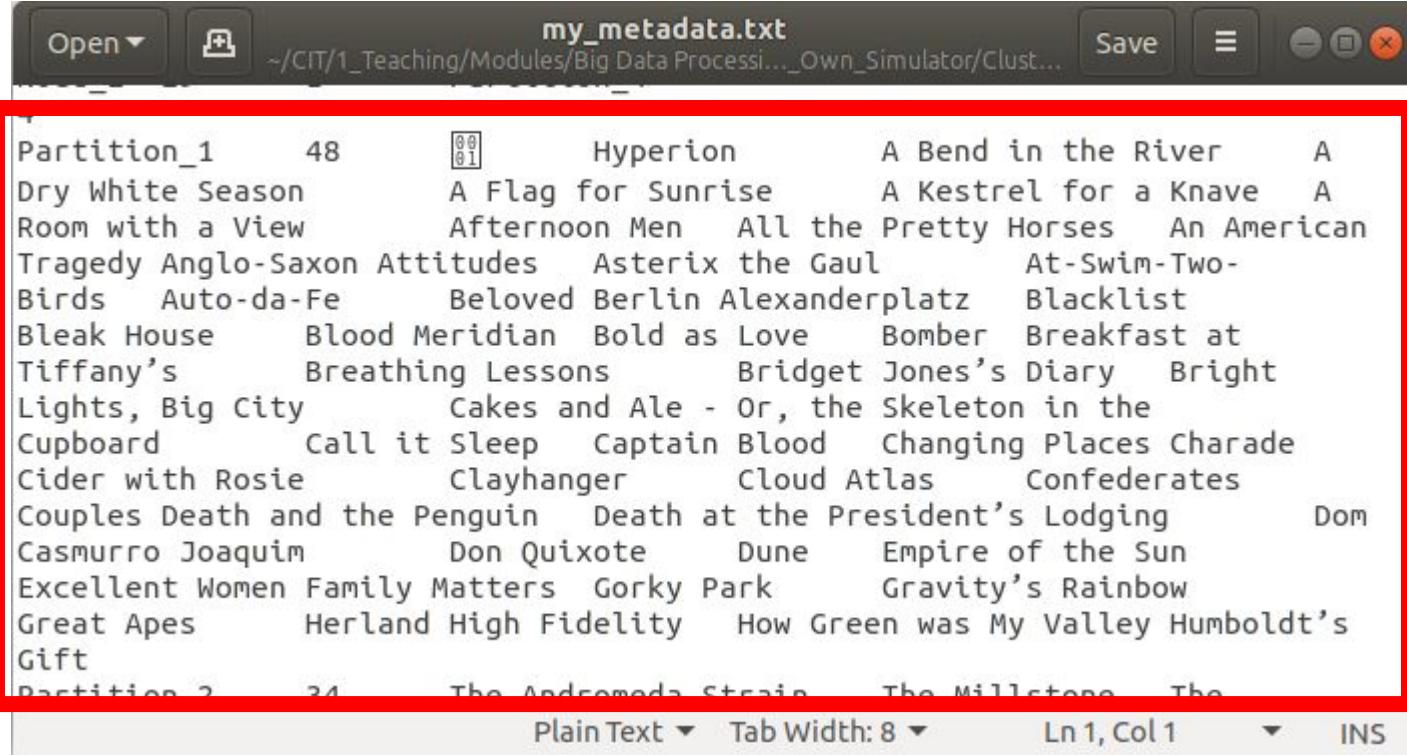
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata

	Node_1	121	3	Partition_1	Partition_2	Partition_3	
2	Node_2	29	1	Partition_4			
4							
Partition_1	48	88	Hyperion	A Bend in the River	A Dry White Season	A	
Flag for Sunrise			A Kestrel for a Knave	A Room with a View	Afternoon Men	All the	
Pretty Horses			An American Tragedy	Anglo-Saxon Attitudes	Asterix the Gaul	At-Swim-	
Two-Birds			Auto-da-Fe	Beloved Berlin Alexanderplatz	Blacklist	Bleak House	
Blood Meridian			Bold as Love	Bomber Breakfast at Tiffany's	Breathing Lessons	Bridget	
Jones's Diary			Bright Lights, Big City	Cakes and Ale - Or, the Skeleton in the Cupboard			
Call it Sleep			Captain Blood	Changing Places Charade Cider with Rosie		Clayhanger	
Cloud Atlas			Confederates	Couples Death and the Penguin	Death at the President's		
Lodging Dom Casmurro			Joaquim	Don Quixote	Dune Empire of the Sun	Excellent Women	
Family Matters			Gorky Park	Gravity's Rainbow	Great Apes	Herland High Fidelity	
How Green was My Valley			Humboldt's Gift				
Partition_2	34		The Andromeda Strain	The Millstone	The Andromeda Strain	The Ascent	
of Rum Doodle			The Assistant	The Beach	The Big Blowdown	The Black Prince	
The Blackwater Lightship				The Blue Flower	The Book of the New Sun	The Bottle Factory	
Outing			The Buddha of Suburbia	The Catcher in the Rye	The Crab with the Golden Claws	The Crow	
Road			The Curious Incident of the Dog in the Night-time		The Good Companions	The Grapes	
of Wrath			The Grass is Singing	The Great Impersonation	The Guns of Navarone	The	
History of Mr Polly			The History of Pompey the Little		The House of the Seven Gables		
The Island of Dr Moreau			The King of Torts	The Lecturer's Tale	The Leopard	The Life	
and Loves of a She-Devil			The Lonely Londoners	The Lonely Passion of Judith Hearne			
The Long Goodbye			The Man of Property	The Manchurian Candidate		The Military	
Partition_3	39		Hyperion	The Andromeda Strain	Hyperion	Jane Eyre	
Lady Chatterley's Lover			Lord Jim	Love in a Cold Climate	Lucky Jim	L'Histoire de Gil	
Blas de Santillane (Gil Blas)			Martin Chuzzlewit	Mary Barton	Maurice Guest	Memoirs of	
a Gnostic Dwarf Memoirs of a Survivor			Mister Johnson	Money	Moon over Africa	More Die	
of Heartbreak			Mrs Dalloway	Music and Silence	My Cousin Rachel	New Grub Street	
North and South			Northanger Abbey	Orlando Persuasion	Pnin	Pointed Roofs	
Possession			Pride and Prejudice	Put Out More Flags	Regeneration	Revelation	
Space			Revolutionary Road	Room Temperature	Rubyfruit Jungle	Sharpe's Eagle	
She: A History of Adventure			Tender is the Night	The Adventures of Augie March		The	
African Queen			Zoo	The Parasites	The Ragged Trousered Philanthropists	The Recognitions	The Savage
Partition_4	30		The Williwaw	The Williwaw	The Williwaw	The Williwaw	The Williwaw
Detectives							
Mr Hyde			The Slaves of Solitude	The Sorrow of War	The Strange Case of Dr Jekyll and		
The Third Man			The Three Musketeers	The Three Sisters	The Trial	The Virgin	
Suicides			The Wasp Factory	The Wimbleton Poisoner	The Woman in White	They Were	
Counted To The Ends of the Earth			trilogy	Treasure Island	Two Serious Ladies	USA	
Valley of the Dolls			Venus on the Half-Shell	Vile Bodies	Waterland	Who Do You Think	
You Are?			Williwaw				

my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Cluster_Simulation/Metadata

			Partition_1	Partition_2	Partition_3			
2	Node_1	121	3	Partition_1	Partition_2	Partition_3		
	Node_2	29	1	Partition_4				
4								
	Partition_1	48	{}	Hyperion	A Bend in the River	A Dry White Season	A	
	Flag for Sunrise			A Kestrel for a Knave	A Room with a View	Afternoon Men	All the	
	Pretty Horses			An American Tragedy	Anglo-Saxon Attitudes	Asterix the Gaul	At-Swim-	
	Two-Birds			Auto-da-Fe	Beloved Berlin Alexanderplatz	Blacklist	Bleak House	
	Blood Meridian			Bold as Love	Bomber Breakfast at Tiffany's	Breathing Lessons	Bridget	
	Jones's Diary			Bright Lights, Big City Cakes and Ale - Or, the Skeleton in the Cupboard				
	Call it Sleep			Captain Blood	Changing Places Charade Cider with Rosie		Clayhanger	
	Cloud Atlas			Confederates	Couples Death and the Penguin	Death at the President's		
	Lodging Dom Casmurro			Joaquim	Don Quixote	Dune Empire of the Sun	Excellent Women	
	Family Matters			Gorky Park	Gravity's Rainbow	Great Apes	Herland High Fidelity	
	How Green was My Valley			Humboldt's Gift				
	Partition_2	34		The Andromeda Strain	The Millstone	The Andromeda Strain	The Ascent	
	of Rum Doodle			The Assistant	The Beach	The Big Blowdown	The Black Prince	
	The Blackwater Lightship				The Blue Flower	The Book of the New Sun	The Bottle Factory	
	Outing			The Buddha of Suburbia	The Catcher in the Rye	The Crab with the Golden Claws	The Crow	
	Road			The Curious Incident of the Dog in the Night-time		The Good Companions	The Grapes	
	of Wrath			The Grass is Singing	The Great Impersonation	The Guns of Navarone	The	
	History of Mr Polly			The History of Pompey the Little		The House of the Seven Gables		
	The Island of Dr Moreau			The King of Torts	The Lecturer's Tale	The Leopard	The Life	
	and Loves of a She-Devil				The Lonely Londoners	The Lonely Passion of Judith Hearne		
	The Long Goodbye			The Man of Property	The Manchurian Candidate		The Military	
	Philosophers							
	Partition_3	39		Hyperion	The Andromeda Strain	Hyperion	Jane Eyre	
	Lady Chatterley's Lover			Lord Jim	Love in a Cold Climate	Lucky Jim	L'Histoire de Gil	
	Blas de Santillane (Gil Blas)			Martin Chuzzlewit	Mary Barton	Maurice Guest	Memoirs of	
	a Gnostic Dwarf Memoirs of a Survivor			Mister Johnson	Money	Moon over Africa	More Die	
	of Heartbreak			Mrs Dalloway	Music and Silence	My Cousin Rachel	New Grub Street	
	North and South			Northanger Abbey	Orlando Persuasion	Pnin	Pointed Roofs	
	Possession			Pride and Prejudice	Put Out More Flags	Regeneration	Revelation	
	Space			Revolutionary Road	Room Temperature	Rubyfruit Jungle	Sharpe's Eagle	
	She: A History of Adventure			Tender is the Night	The Adventures of Augie March	The		
	African Queen							
	Partition_4	29		The Millstone	}	The Millstone	The Moonstone	The Old Men at the
	Zoo			The Parasites	The Ragged Trousered Philanthropists	The Recognitions	The Savage	
	Detectives			The Slaves of Solitude	The Sorrow of War	The Strange Case of Dr Jekyll and		
	Mr Hyde			The Third Man	The Three Musketeers	The Three Sisters	The Virgin	
	Suicides			The Wasp Factory	The Wimbledon Poisoner	The Woman in White	They Were	
	Counted To The Ends of the Earth			trilogy	Treasure Island	Two Serious Ladies	USA	
	Valley of the Dolls			Venus on the Half-Shell	Vile Bodies	Waterland	Who Do You Think	
	You Are?			Williwaw				

My Cluster Simulator: Split, Migrate and Auto-Scale



```
my_metadata.txt
Open Save
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Partition_1 48      80 81   Hyperion      A Bend in the River    A
Dry White Season          A Flag for Sunrise    A Kestrel for a Knave    A
Room with a View          Afternoon Men     All the Pretty Horses  An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe        Beloved Berlin Alexanderplatz Blacklist
Bleak House    Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's      Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City          Cakes and Ale - Or, the Skeleton in the
Cupboard       Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie          Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim          Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes      Herland High Fidelity How Green was My Valley Humboldt's
Gift           Partition_2 34      The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (**partition_id**, num_items, key_lb, key_ub, [item_id])

My Cluster Simulator: Split, Migrate and Auto-Scale



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi....Own_Simulator/Clust...
Open Save Partition_1 48 Hyperion A Bend in the River A
Dry White Season A Flag for Sunrise A Kestrel for a Knave A
Room with a View Afternoon Men All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist
Bleak House Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City Cakes and Ale - Or, the Skeleton in the
Cupboard Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34 The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, **num_items**, key_lb, key_ub, [item_id])

My Cluster Simulator: Split, Migrate and Auto-Scale



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi....Own_Simulator/Clust...
Open Save
4
Partition_1 48 00 01 Hyperion A Bend in the River A
Dry White Season A Flag for Sunrise A Kestrel for a Knave A
Room with a View Afternoon Men All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist
Bleak House Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City Cakes and Ale - Or, the Skeleton in the
Cupboard Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34 The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

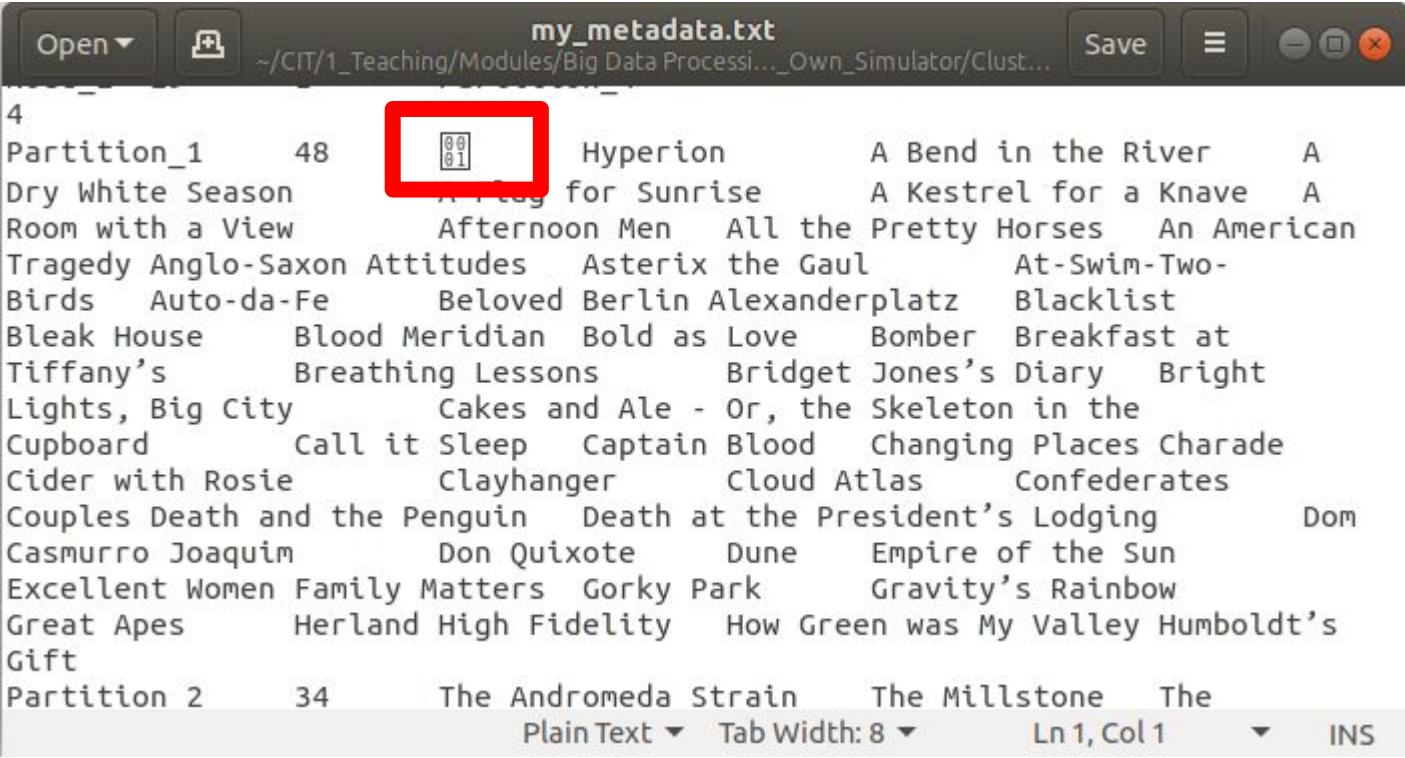
My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, **key_lb**, key_ub, [item_id])

My Cluster Simulator: Split, Migrate and Auto-Scale

This is the smallest character in UTF-8, our equivalent to AAA.



```
my_metadata.txt
Open Save
~/CIT/1_Teaching/Modules/Big Data Processi..._Own_Simulator/Clust...
4
Partition_1 48      Hyperion      A Bend in the River      A
Dry White Season      A Long Day's Journey into the Night for Sunrise      A Kestrel for a Knave      A
Room with a View      Afternoon Men      All the Pretty Horses      An American
Tragedy      Anglo-Saxon Attitudes      Asterix the Gaul      At-Swim-Two-
Birds      Auto-da-Fe      Beloved Berlin Alexanderplatz      Blacklist
Bleak House      Blood Meridian      Bold as Love      Bomber Breakfast at
Tiffany's      Breathing Lessons      Bridget Jones's Diary      Bright
Lights, Big City      Cakes and Ale - Or, the Skeleton in the
Cupboard      Call it Sleep      Captain Blood      Changing Places Charade
Cider with Rosie      Clayhanger      Cloud Atlas      Confederates
Couples Death and the Penguin      Death at the President's Lodging      Dom
Casmurro Joaquim      Don Quixote      Dune      Empire of the Sun
Excellent Women Family Matters      Gorky Park      Gravity's Rainbow
Great Apes      Herland High Fidelity      How Green was My Valley Humboldt's
Gift
Partition 2 34      The Andromeda Strain      The Millstone      The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

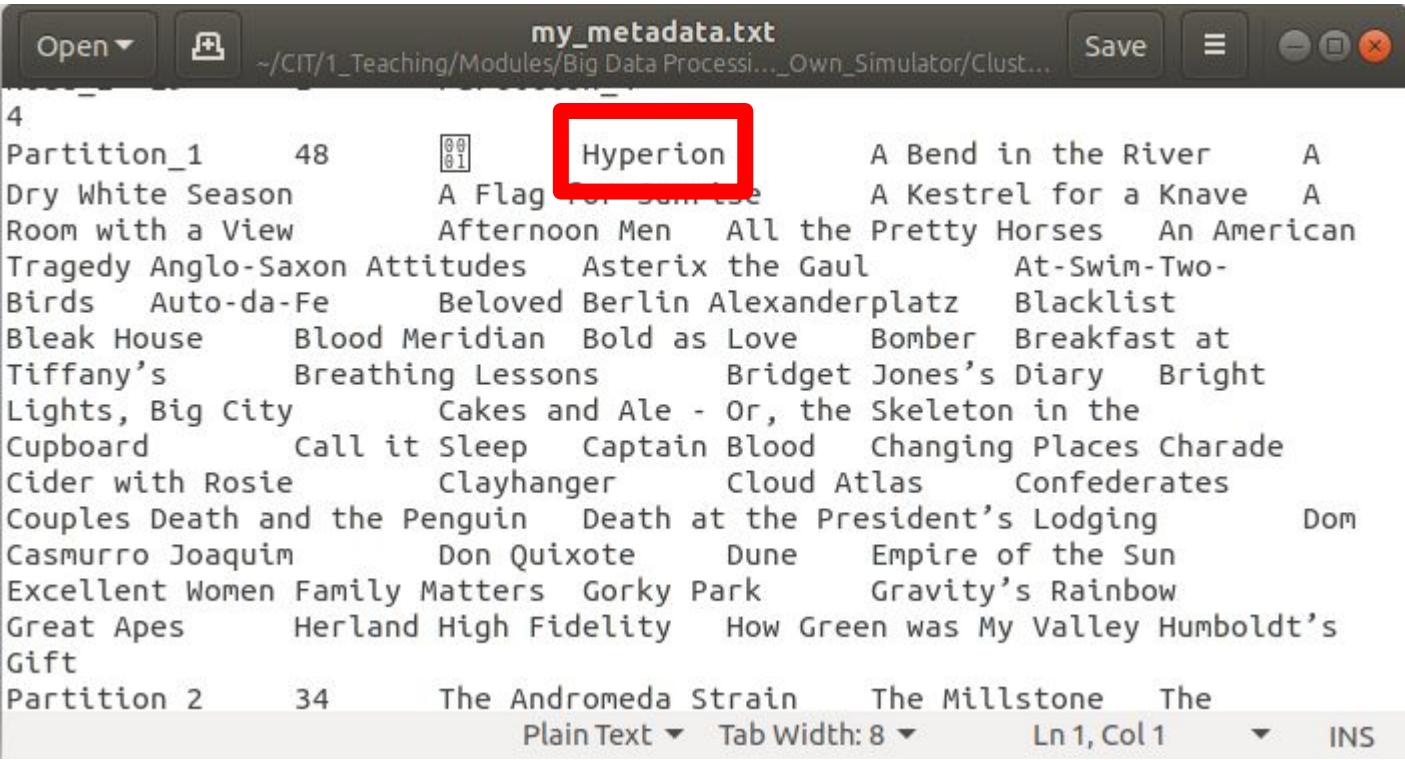
My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, **key_ub**, [item_id])

My Cluster Simulator: Split, Migrate and Auto-Scale

This is the smallest character in UTF-8, our equivalent to AAA.



```
my_metadata.txt
Open Save
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
4
Partition_1 48      00 01 Hyperion      A Bend in the River      A
Dry White Season          A Flag for Salmagundi      A Kestrel for a Knave      A
Room with a View          Afternoon Men      All the Pretty Horses      An American
Tragedy Anglo-Saxon Attitudes      Asterix the Gaul      At-Swim-Two-
Birds Auto-da-Fe      Beloved Berlin Alexanderplatz      Blacklist
Bleak House      Blood Meridian      Bold as Love      Bomber Breakfast at
Tiffany's Breathing Lessons      Bridget Jones's Diary      Bright
Lights, Big City          Cakes and Ale - Or, the Skeleton in the
Cupboard Call it Sleep      Captain Blood      Changing Places Charade
Cider with Rosie          Clayhanger      Cloud Atlas      Confederates
Couples Death and the Penguin      Death at the President's Lodging      Dom
Casmurro Joaquim          Don Quixote      Dune      Empire of the Sun
Excellent Women Family Matters      Gorky Park      Gravity's Rainbow
Great Apes Herland High Fidelity      How Green was My Valley Humboldt's
Gift
Partition 2 34      The Andromeda Strain      The Millstone      The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

The folder Metadata contains all its info represented in the file **my_metadata.txt**. The file has the following format:

- **First line:**
 - num_nodes
- **Next “num_nodes” lines:**
 - node_i info (1 line per node)
 - (node_id, num_items, num_partitions, [partition_id])
- **Next line:**
 - num_partitions
- **Next “num_partitions” lines:**
 - partition_j info (1 line per partition)
 - (partition_id, num_items, key_lb, key_ub, **[item_id]**)

My Cluster Simulator: Split, Migrate and Auto-Scale

As we can see, the keys are sorted in alphabetical order.

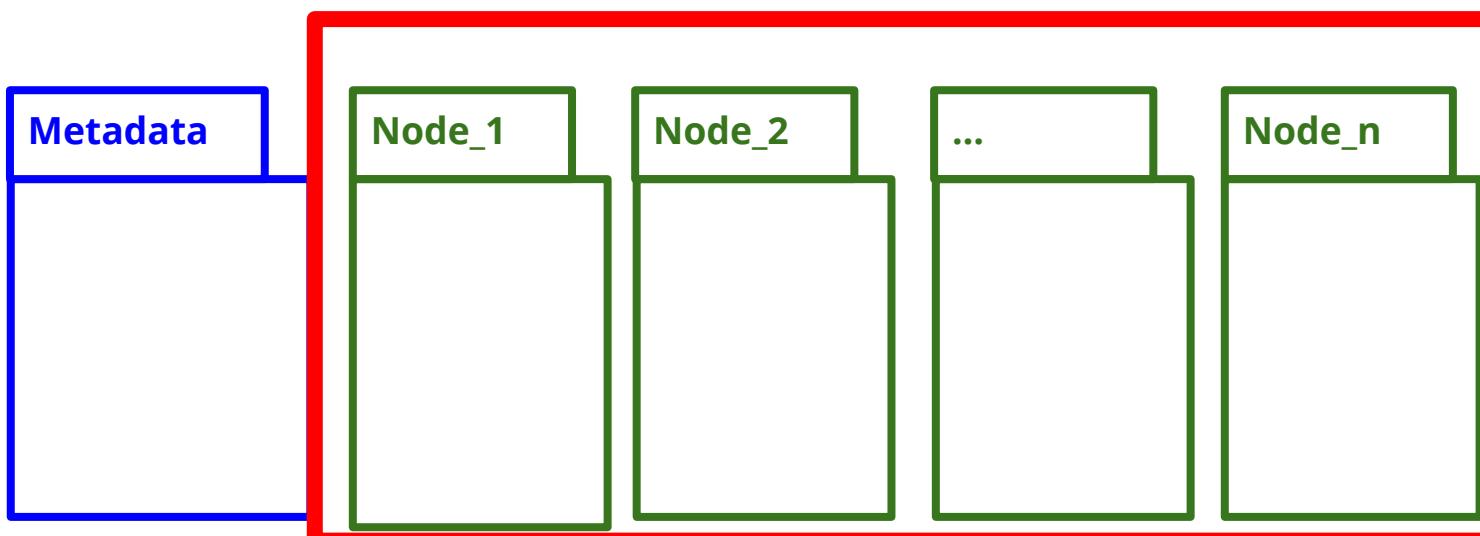


The screenshot shows a terminal window titled "my_metadata.txt" with a red box highlighting the sorted list of books. The list is organized into four columns: book titles, authors, and two additional columns at the end. The books are sorted by title.

Book Title	Author	Column 3	Column 4
Dry White Season	A Flag for Sunrise	A Kestrel for a Knave	A
Room with a View	Afternoon Men	All the Pretty Horses	An American
Tragedy Anglo-Saxon Attitudes	Asterix the Gaul	At-Swim-Two-	
Birds Auto-da-Fe	Beloved Berlin Alexanderplatz	Blacklist	
Bleak House	Blood Meridian	Bold as Love	Bomber Breakfast at
Tiffany's	Breathing Lessons	Bridget Jones's Diary	Bright
Lights, Big City	Cakes and Ale - Or, the Skeleton in the		
Cupboard	Call it Sleep	Captain Blood	Changing Places Charade
Cider with Rosie	Clayhanger	Cloud Atlas	Confederates
Couples	Death and the Penguin	Death at the President's Lodging	Dom
Casmurro	Joaquim	Don Quixote	Dune Empire of the Sun
Excellent Women	Family Matters	Gorky Park	Gravity's Rainbow
Great Apes	Herland	High Fidelity	How Green was My Valley Humboldt's
Gift			
Partition 2	24	The Andromeda Strain	The Millstone

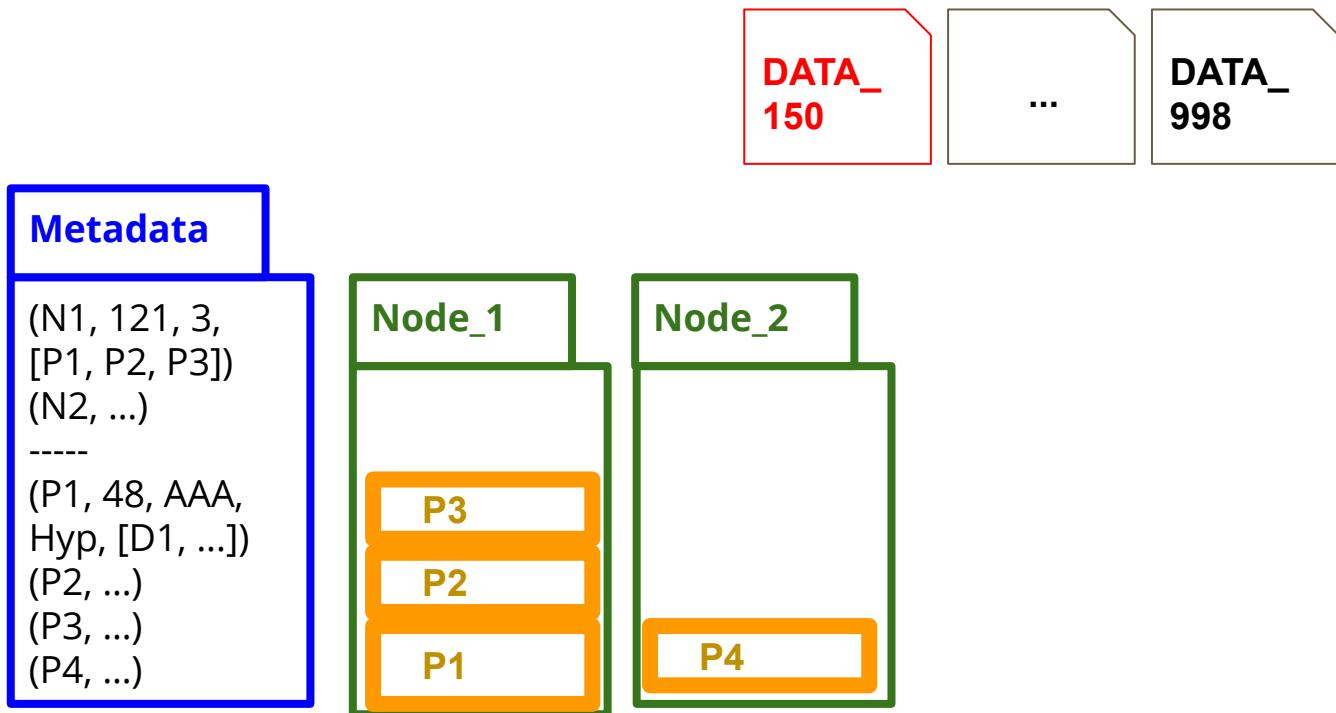
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **Node_i**: This folder represents the data node.



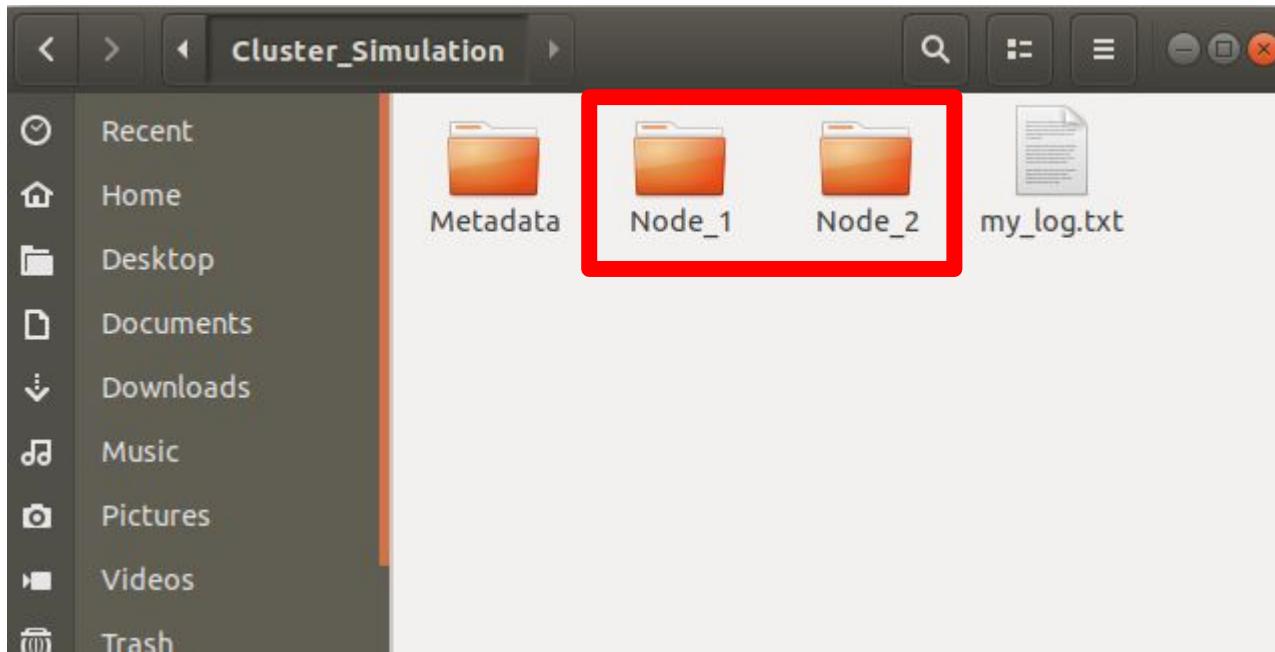
My Cluster Simulator: Split, Migrate and Auto-Scale

- For example, given the following state of the cluster:



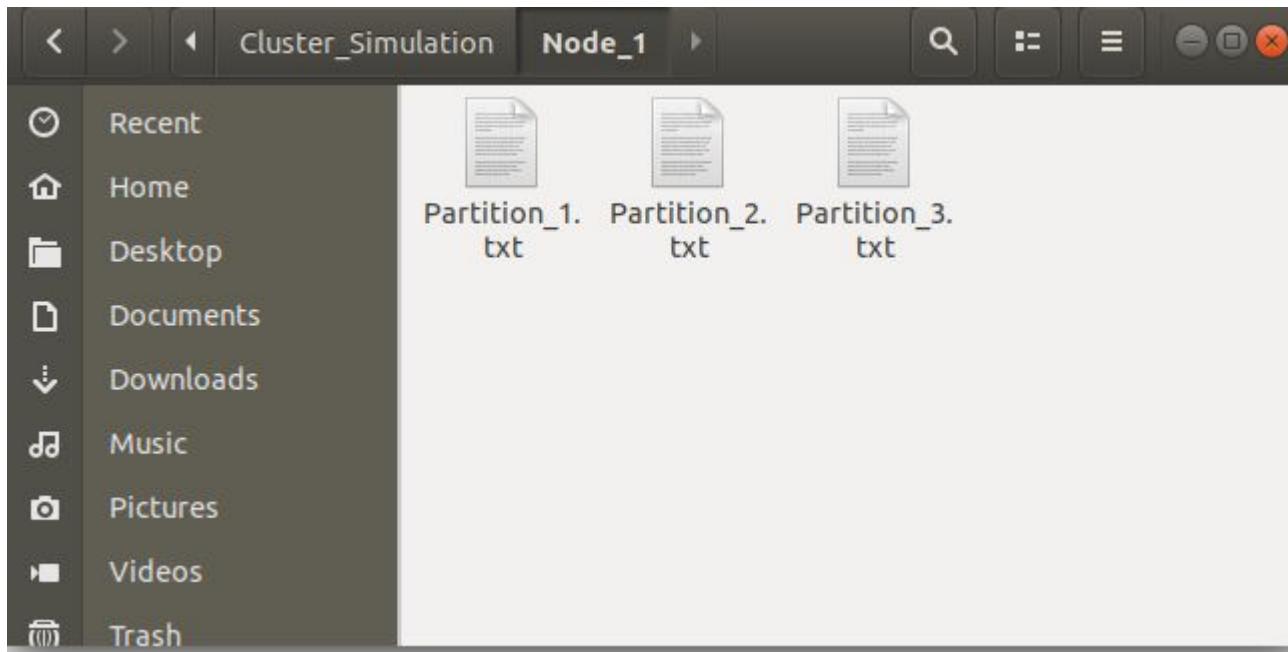
My Cluster Simulator: Split, Migrate and Auto-Scale

- The folder **Cluster_Simulation** contains our cluster:
 - **Node_i**: This folder represents the data node.



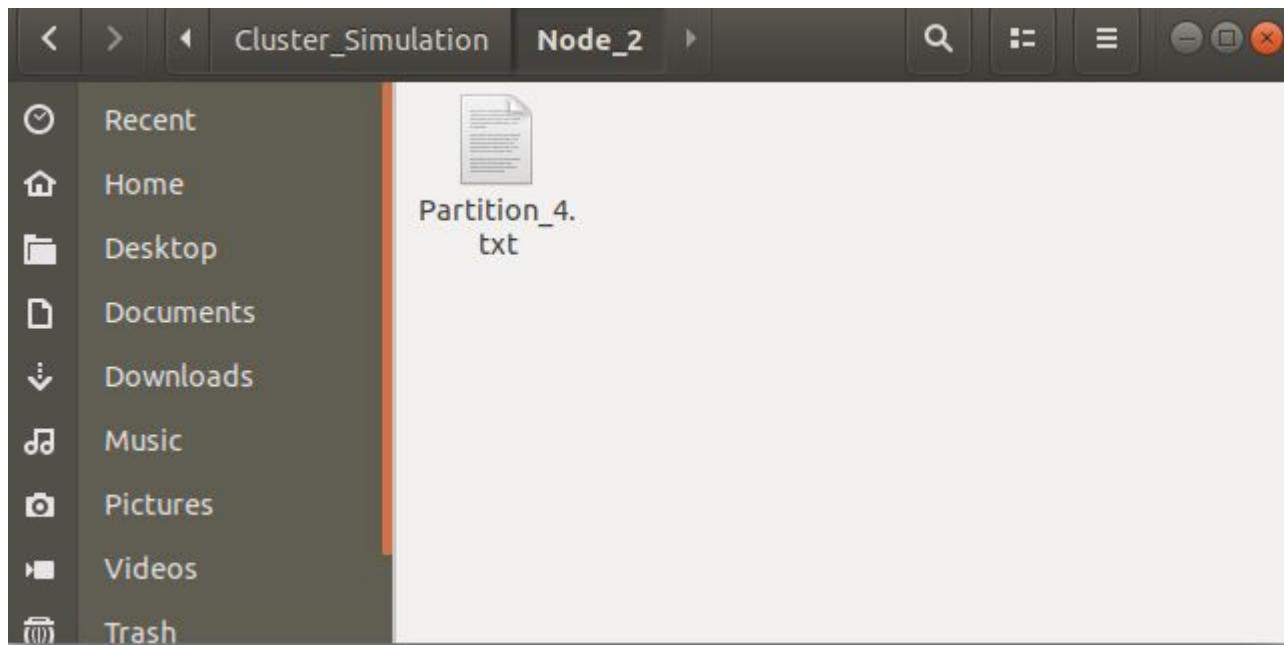
My Cluster Simulator: Split, Migrate and Auto-Scale

- Each node contains one file for each partition it hosts.



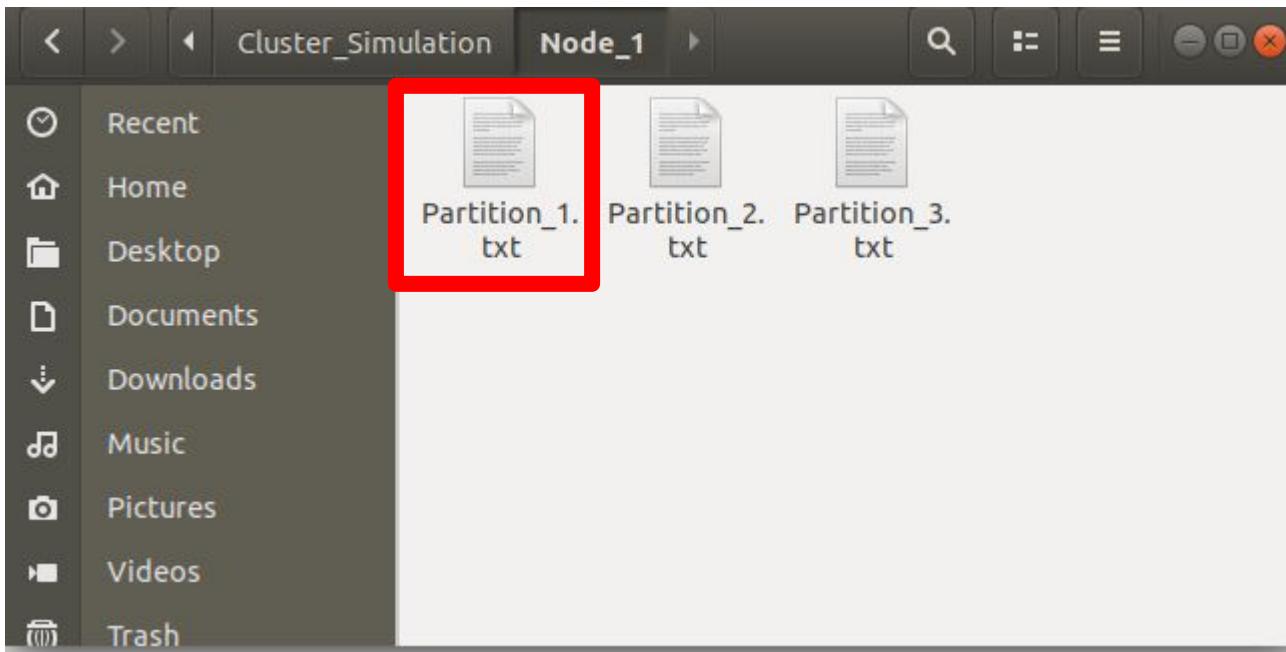
My Cluster Simulator: Split, Migrate and Auto-Scale

- Each node contains one file for each partition it hosts.



My Cluster Simulator: Split, Migrate and Auto-Scale

- The partition contains all the data items specified in the metadata info.



The screenshot shows a terminal window titled "Partition_1.txt" with the following content:

```
A Bend in the River;VS Naipaul;State of the nation
A Dry White Season;Andre Brink;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
At-Swim-Two-Birds;Flann O'Brien;Family and self
Auto-da-Fe;Elias Canetti;War and travel
Beloved;Toni Morrison;Science fiction and fantasy
Berlin Alexanderplatz;Alfred Döblin;State of the nation
Blacklist;Sara Paretsky;Crime
Bleak House;Charles Dickens;State of the nation
Blood Meridian;Cormac McCarthy;War and travel
Bold as Love;Gwyneth Jones;Science fiction and fantasy
Bomber;Len Deighton;War and travel
Breakfast at Tiffany's;Truman Capote;Love
Breathing Lessons;Anne Tyler;Love
Bridget Jones's Diary;Helen Fielding;Comedy
Bright Lights, Big City;Jay McInerney;Comedy
Cakes and Ale - Or, the Skeleton in the Cupboard;W Somerset Maugham;Comedy
Call it Sleep;Henry Roth;Family and self
Captain Blood;Rafael Sabatini;War and travel
Changing Places;David Lodge;Comedy
Charade;John Mortimer;Comedy
Cider with Rosie;Laurie Lee;Family and self
Clayhanger;Arnold Bennett;State of the nation
Cloud Atlas;David Mitchell;Science fiction and fantasy
Confederates;Thomas Keneally;War and travel
Couples;John Updike;State of the nation
Death and the Penguin;Andrey Kurkov;Comedy
Death at the President's Lodging;Michael Innes;Crime
Dom Casmurro Joaquim;Maria Machado de Assis;Love
Don Quixote;Miguel de Cervantes;Comedy
Dune;Frank L Herbert;Science fiction and fantasy
Empire of the Sun;JG Ballard;War and travel
Excellent Women;Barbara Pym;Comedy
Family Matters;Rohinton Mistry;Family and self
Gorky Park;Martin Cruz Smith;Crime
Gravity's Rainbow;Thomas Pynchon;War and travel
Great Apes;Will Self;Comedy
Herland;Charlotte Perkins Gilman;Science fiction and fantasy
High Fidelity;Nick Hornby;Comedy
How Green was My Valley;Richard Llewellyn;Family and self
Humboldt's Gift;Saul Bellow;Family and self
```

At the bottom of the terminal window, there are status indicators: "PlainText ▾ Tab Width: 8 ▾ Ln 48, Col 1 ▾ INS".

My Cluster Simulator: Split, Migrate and Auto-Scale

Looking in more detail we can see the data items, one by one...



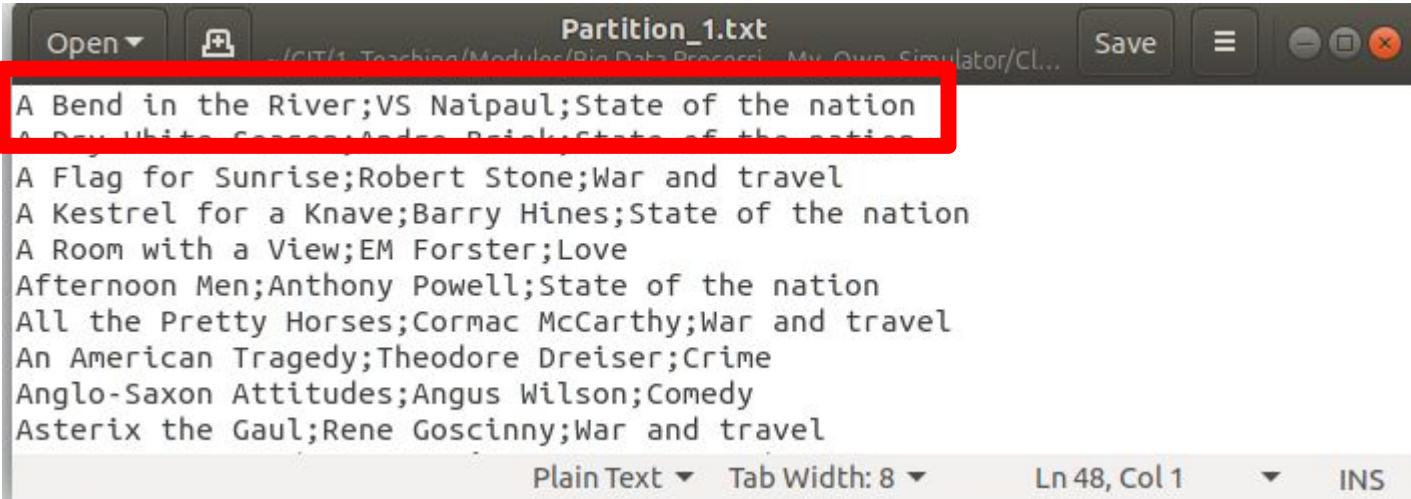
The screenshot shows a text editor window titled "Partition_1.txt". The file path is indicated as "-/CIT/1_Teaching/Modules/Big Data Processi...My_Own_Simulator/Cl...". The editor has standard controls for Open, Save, and Close. The text area contains a list of book titles with their authors and genres, separated by semicolons. The genres listed are State of the nation, War and travel, Love, Crime, Comedy, and War and travel again. The list includes:

```
A Bend in the River;VS Naipaul;State of the nation
A Dry White Season;Andre Brink;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
```

The bottom of the editor shows status information: "Plain Text" dropdown, "Tab Width: 8" dropdown, "Ln 48, Col 1" status bar, and "INS" indicator.

My Cluster Simulator: Split, Migrate and Auto-Scale

Looking in more detail we can see the data items, one by one...



```
Partition_1.txt
Open Save
/CIT/1_Teaching/Modules/Big Data Processing - My Own Simulator/Cl...
A Bend in the River;VS Naipaul;State of the nation
A Dry White Season;Adrienne Rich;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
```

The screenshot shows a text editor window titled "Partition_1.txt". The window has a dark header bar with "Open", "Save", and other icons. Below the header is a toolbar with "Plain Text" and "Tab Width: 8". The main area contains a list of book entries, each consisting of three fields separated by semicolons. The first two entries are highlighted with a red rectangular box around them. The entries are:
A Bend in the River;VS Naipaul;State of the nation
A Dry White Season;Adrienne Rich;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel

My Cluster Simulator: Split, Migrate and Auto-Scale

Looking in more detail we can see the data items, one by one...



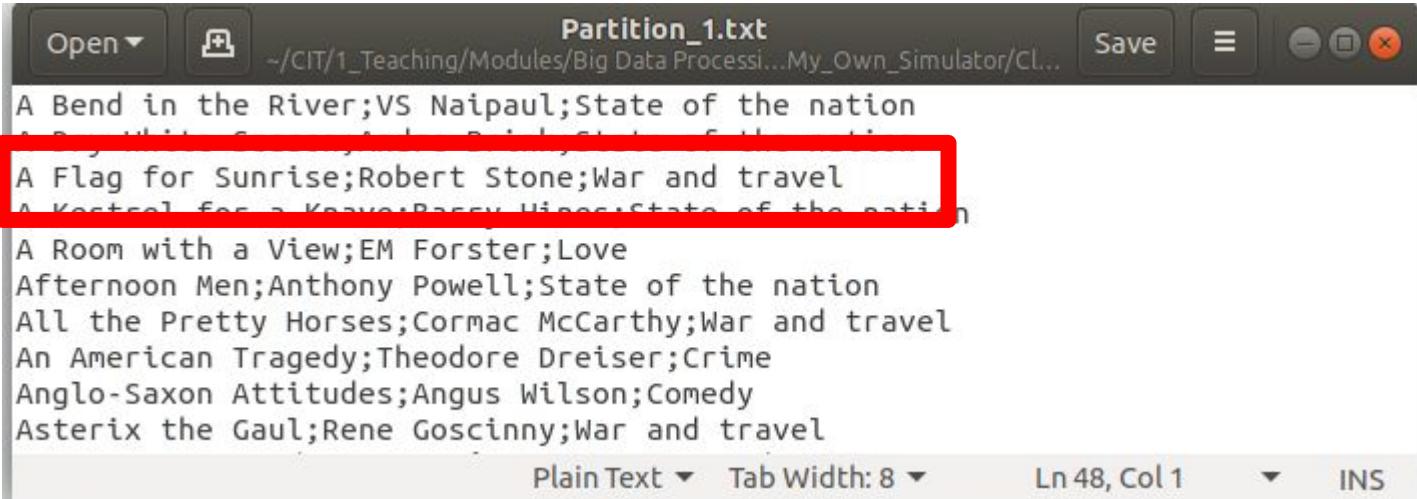
The screenshot shows a terminal window titled "Partition_1.txt". The window contains a list of books, each entry consisting of a title, author, and genre separated by semicolons. The first two entries are highlighted with a red rectangle. The text is as follows:

```
A Bend in the River;vs Naipaul;State of the nation
A Dry White Season;Andre Brink;State of the nation
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
```

The terminal interface includes standard controls like Open, Save, and Close, and status indicators like "Ln 48, Col 1" and "INS".

My Cluster Simulator: Split, Migrate and Auto-Scale

Looking in more detail we can see the data items, one by one...



```
Partition_1.txt
Open Save
~/CIT/1_Teaching/Modules/Big Data Processi...My_Own_Simulator/Cl...
A Bend in the River;VS Naipaul;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Percy Higgs;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
```

Plain Text ▾ Tab Width: 8 ▾ Ln 48, Col 1 ▾ INS

My Cluster Simulator: Split, Migrate and Auto-Scale

Looking in more detail we can see the data items, one by one...for a total of 48 data items.



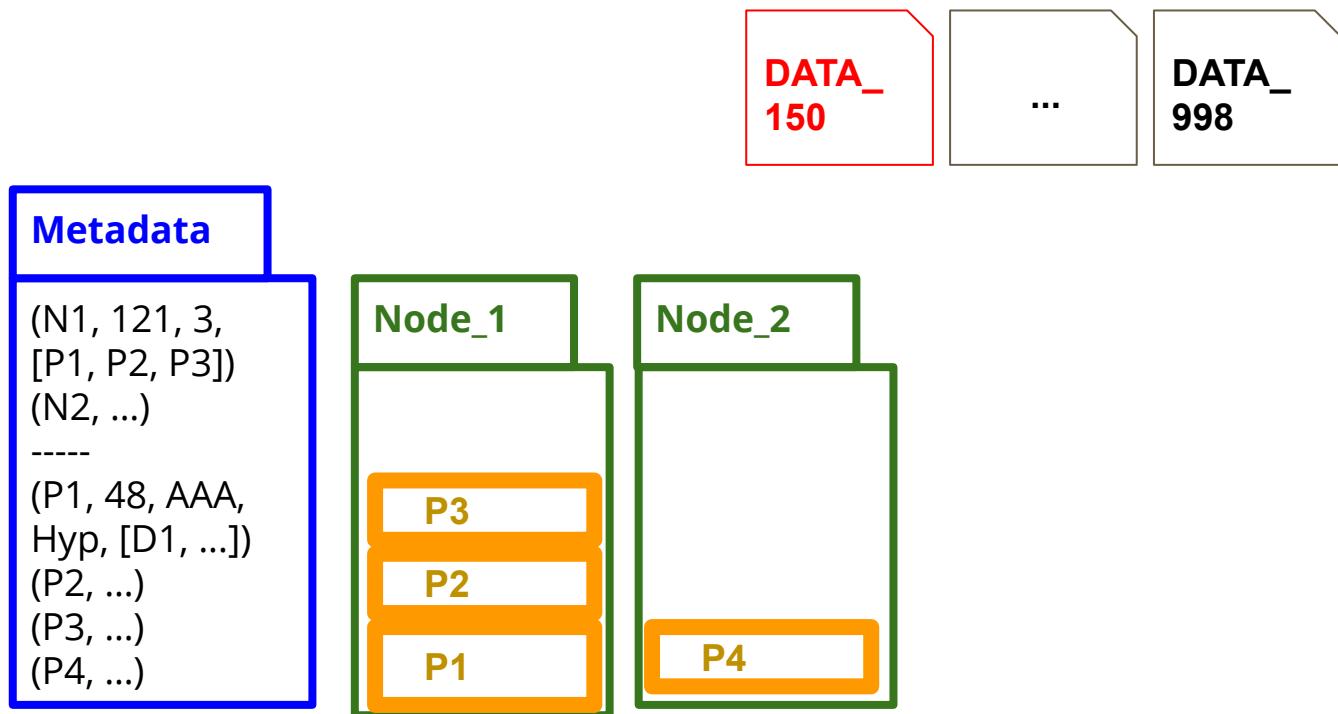
The screenshot shows a text editor window titled "Partition_1.txt". The file path is indicated as "/CIT/1_Teaching/Modules/Big Data Processi...My_Own_Simulator/Cl...". The editor has standard toolbar buttons for Open, Save, and window controls. The main text area contains 48 lines of text, each consisting of three fields separated by semicolons. The lines are:

```
A Bend in the River;VS Naipaul;State of the nation
A Dry White Season;Andre Brink;State of the nation
A Flag for Sunrise;Robert Stone;War and travel
A Kestrel for a Knave;Barry Hines;State of the nation
A Room with a View;EM Forster;Love
Afternoon Men;Anthony Powell;State of the nation
All the Pretty Horses;Cormac McCarthy;War and travel
An American Tragedy;Theodore Dreiser;Crime
Anglo-Saxon Attitudes;Angus Wilson;Comedy
Asterix the Gaul;Rene Goscinny;War and travel
```

The status bar at the bottom of the editor shows "Plain Text" and "Tab Width: 8". A red box highlights the status bar text "Ln 48, Col 1", indicating the current line and column position.

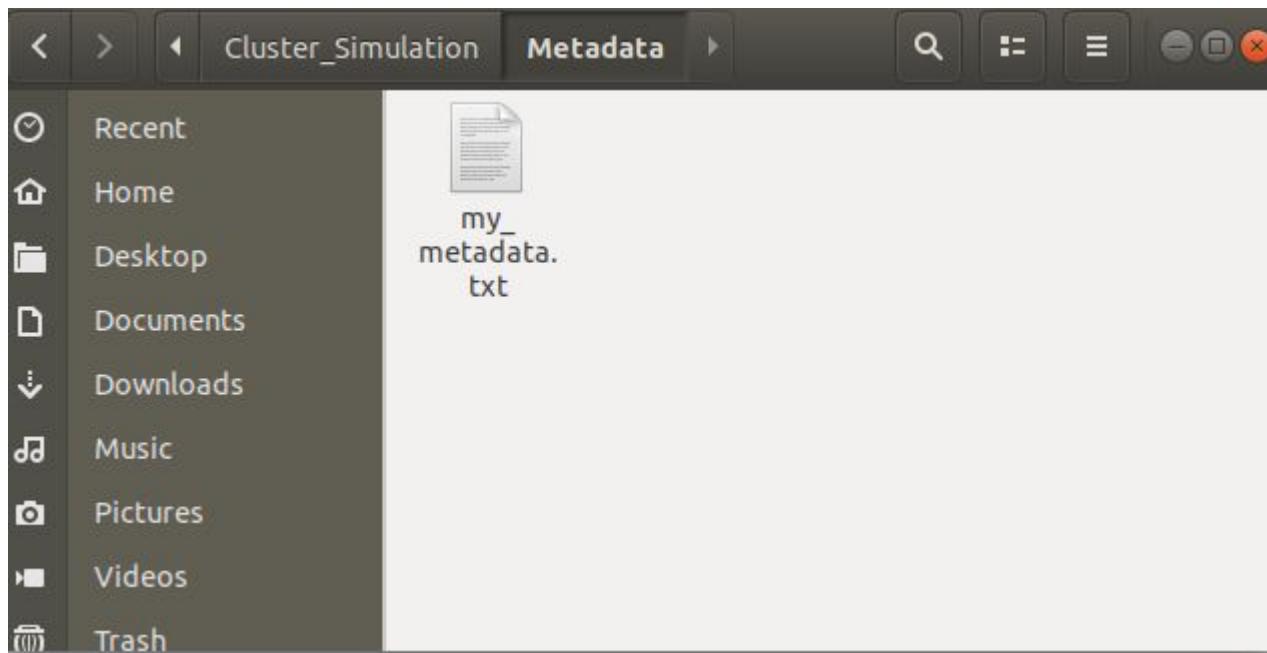
My Cluster Simulator: Split, Migrate and Auto-Scale

Once again, this corresponds with the metadata info we presented before...



My Cluster Simulator: Split, Migrate and Auto-Scale

Once again, this corresponds with the metadata info we presented before...



My Cluster Simulator: Split, Migrate and Auto-Scale

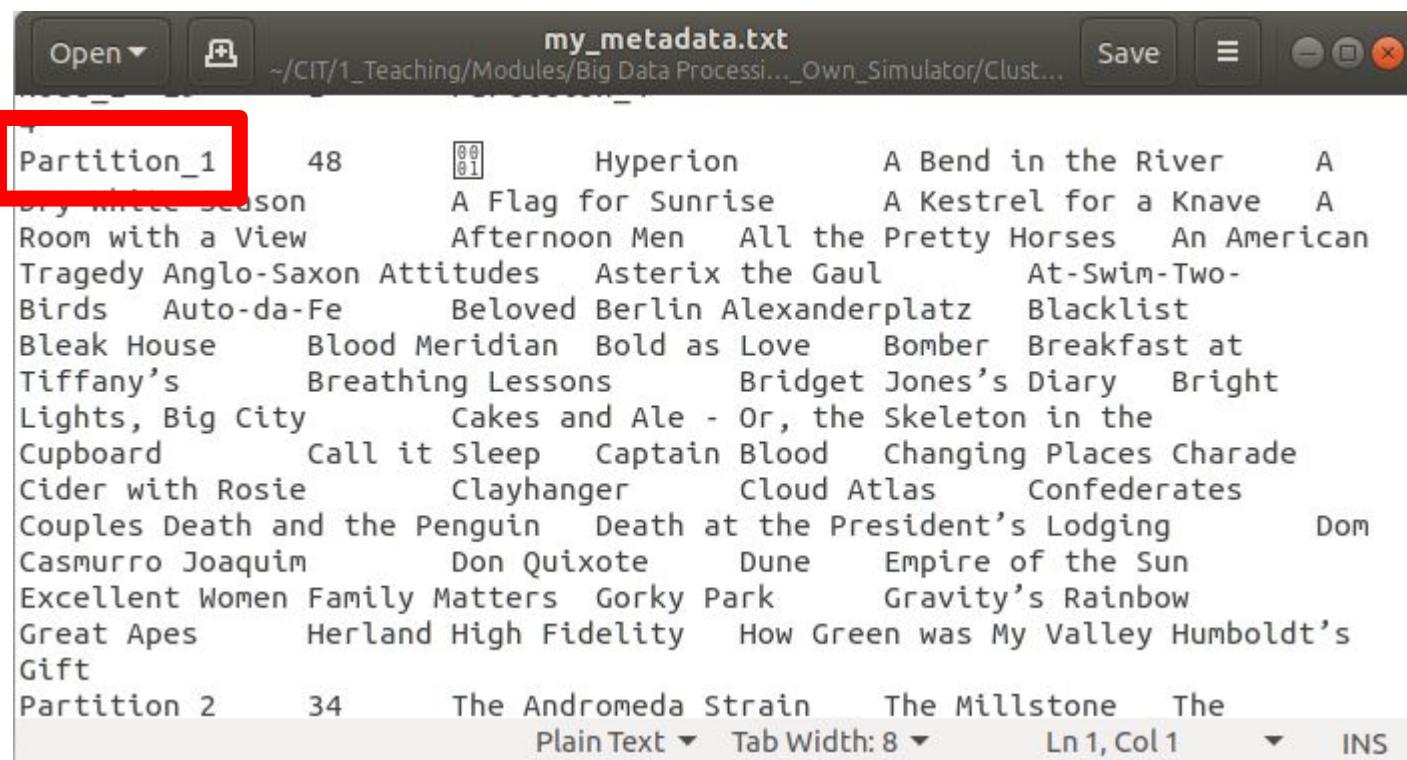
Once again, this corresponds with the metadata info we presented before...



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Open Save
Partition_1 48      80  Hyperion    A Bend in the River   A
Dry White Season          A Flag for Sunrise   A Kestrel for a Knave   A
Room with a View           Afternoon Men   All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe        Beloved Berlin Alexanderplatz Blacklist
Bleak House    Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's     Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City          Cakes and Ale - Or, the Skeleton in the
Cupboard      Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie          Clayhanger   Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim          Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes       Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition_2 34      81  The Andromeda Strain The Millstone The
```

Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS

My Cluster Simulator: Split, Migrate and Auto-Scale



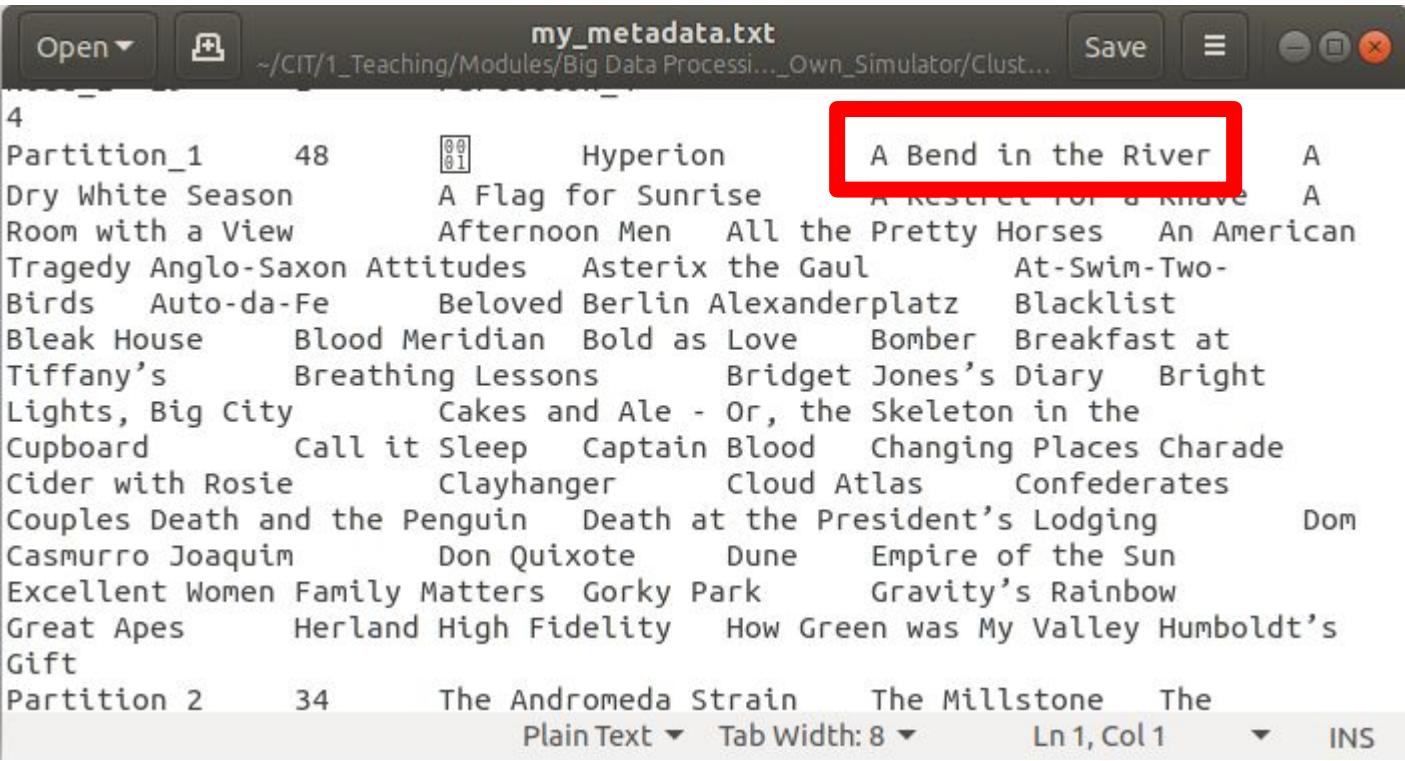
```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi....Own_Simulator/Clust...
Open Save Partition_1 48 Hyperion A Bend in the River A
Dry White Season A Flag for Sunrise A Kestrel for a Knave A
Room with a View Afternoon Men All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist
Bleak House Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City Cakes and Ale - Or, the Skeleton in the
Cupboard Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34 The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Open Save
4
Partition_1 48  Hyperion A Bend in the River A
Dry White Season A Flag for Sunrise A Kestrel for a Knave A
Room with a View Afternoon Men All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe Beloved Berlin Alexanderplatz Blacklist
Bleak House Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City Cakes and Ale - Or, the Skeleton in the
Cupboard Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34 The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

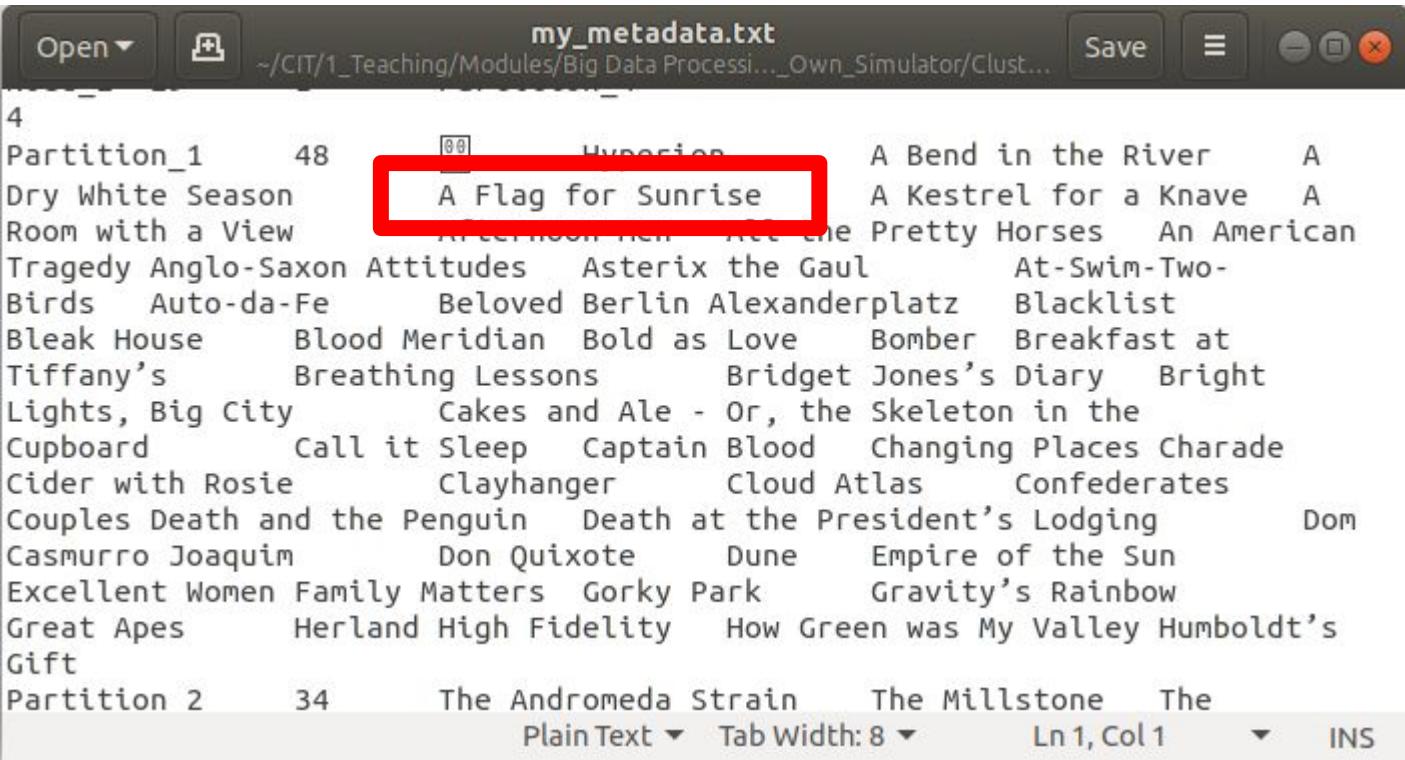


```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Open Save
4
Partition_1 48      00 01 Hyperion    A Bend in the River    A
Dry White Season          A Flag for Sunrise   A Racer for a Knave   A
Room with a View           Afternoon Men     All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe        Beloved Berlin Alexanderplatz Blacklist
Bleak House    Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's      Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City          Cakes and Ale - Or, the Skeleton in the
Cupboard       Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie          Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim          Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes      Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34      The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Open Save
4
Partition_1      48      00 01 Hyperion      A Bend in the River      A
Dry White Season          A Flag for Sunrise      A Kestrel for a Knave
Room with a View          Afternoon Men      All the Pretty Horses      An American
Tragedy Anglo-Saxon Attitudes      Asterix the Gaul      At-Swim-Two-
Birds      Auto-da-Fe      Beloved Berlin Alexanderplatz      Blacklist
Bleak House      Blood Meridian      Bold as Love      Bomber Breakfast at
Tiffany's      Breathing Lessons      Bridget Jones's Diary      Bright
Lights, Big City      Cakes and Ale - Or, the Skeleton in the
Cupboard      Call it Sleep      Captain Blood      Changing Places Charade
Cider with Rosie      Clayhanger      Cloud Atlas      Confederates
Couples Death and the Penguin      Death at the President's Lodging      Dom
Casmurro Joaquim      Don Quixote      Dune      Empire of the Sun
Excellent Women Family Matters      Gorky Park      Gravity's Rainbow
Great Apes      Herland High Fidelity      How Green was My Valley Humboldt's
Gift
Partition 2      34      The Andromeda Strain      The Millstone      The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale



```
my_metadata.txt
~/CIT/1_Teaching/Modules/Big Data Processi...._Own_Simulator/Clust...
Open Save
4
Partition_1 48 Hypocrite    A Bend in the River   A
Dry White Season          A Flag for Sunrise
Room with a View          Afternoon Tea - All the Pretty Horses An American
Tragedy Anglo-Saxon Attitudes Asterix the Gaul At-Swim-Two-
Birds Auto-da-Fe        Beloved Berlin Alexanderplatz Blacklist
Bleak House    Blood Meridian Bold as Love Bomber Breakfast at
Tiffany's      Breathing Lessons Bridget Jones's Diary Bright
Lights, Big City          Cakes and Ale - Or, the Skeleton in the
Cupboard       Call it Sleep Captain Blood Changing Places Charade
Cider with Rosie          Clayhanger Cloud Atlas Confederates
Couples Death and the Penguin Death at the President's Lodging Dom
Casmurro Joaquim          Don Quixote Dune Empire of the Sun
Excellent Women Family Matters Gorky Park Gravity's Rainbow
Great Apes     Herland High Fidelity How Green was My Valley Humboldt's
Gift
Partition 2 34 The Andromeda Strain The Millstone The
Plain Text ▾ Tab Width: 8 ▾ Ln 1, Col 1 ▾ INS
```

My Cluster Simulator: Split, Migrate and Auto-Scale

Try the application by yourself!

My Cluster Simulator: Split, Migrate and Auto-Scale

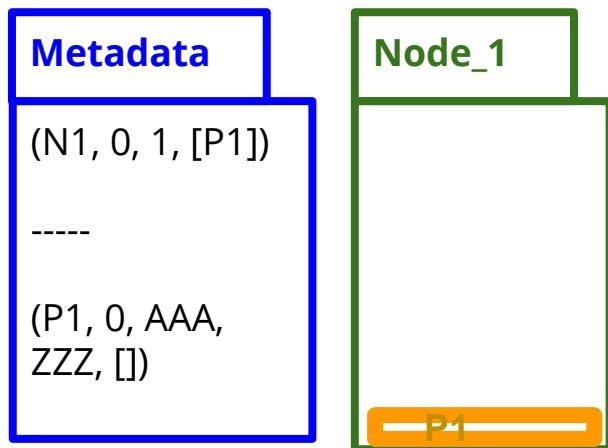
Concept 1:

Run the program **my_main.py**
by trying different values for
num_items_to_process.

My Cluster Simulator: Split, Migrate and Auto-Scale

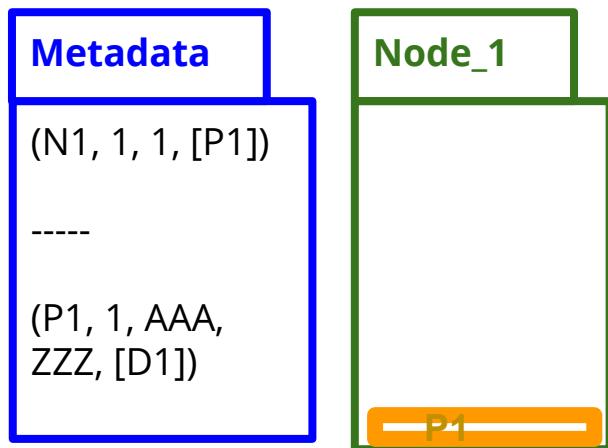
The application will first reset the cluster.

This will reset to just the Metadata Node with Node_1 and Partition_1 empty.



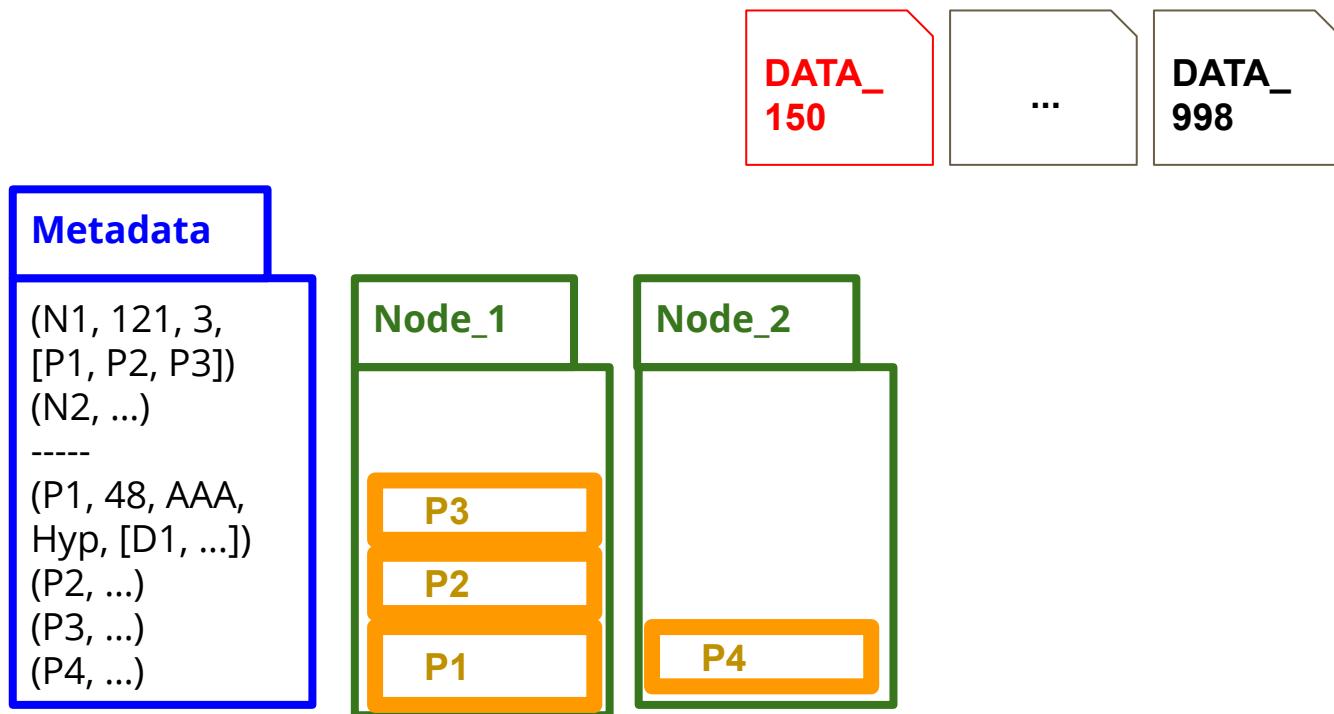
My Cluster Simulator: Split, Migrate and Auto-Scale

Then, based on **num_items_to_process**, the data items will be processed one by one, making the number of nodes, partitions and their distribution evolve.



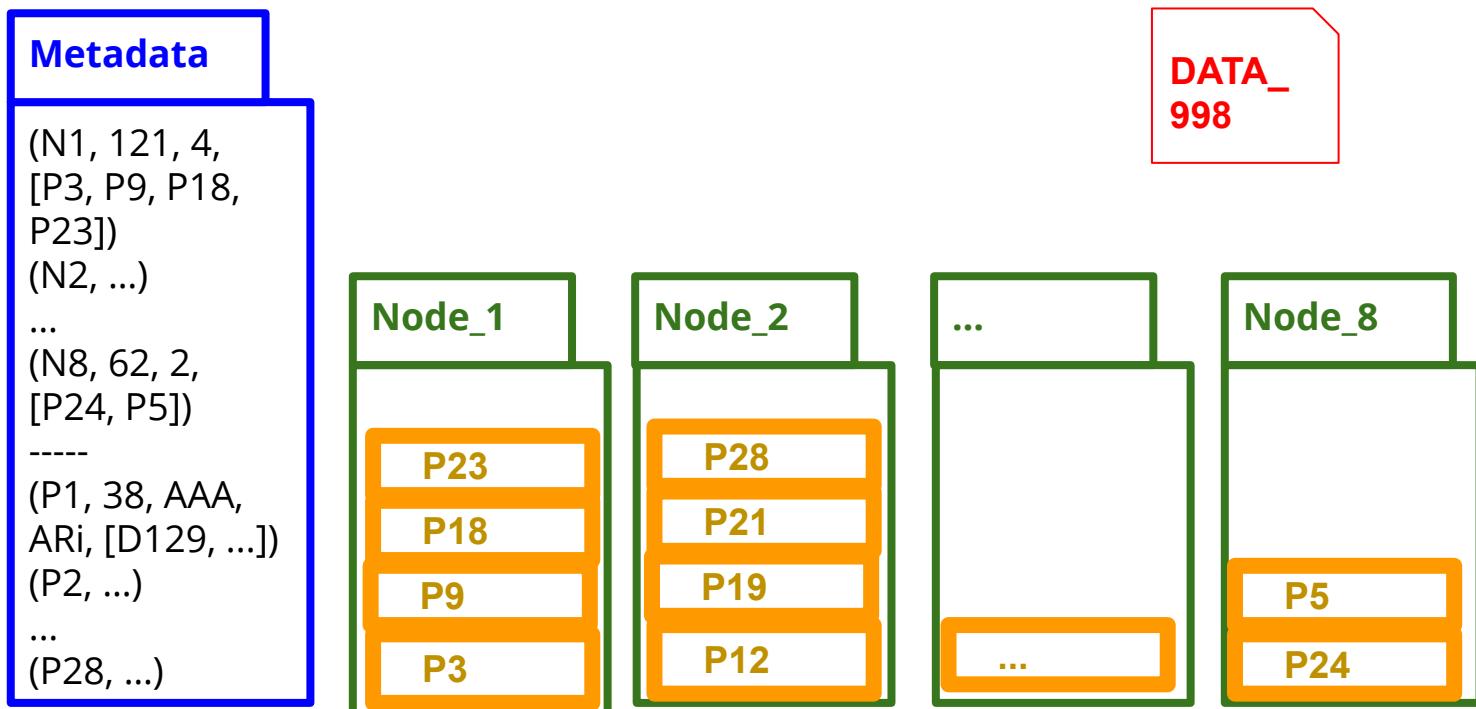
My Cluster Simulator: Split, Migrate and Auto-Scale

Then, based on **num_items_to_process**, the data items will be processed one by one, making the number of nodes, partitions and their distribution evolve.



My Cluster Simulator: Split, Migrate and Auto-Scale

Then, based on `num_items_to_process`, the data items will be processed one by one, making the number of nodes, partitions and their distribution evolve.



My Cluster Simulator: Split, Migrate and Auto-Scale

Explore **my_log.txt** when running the application
for consecutive values for **num_items_to_process**
to observe the effect of:

- Data item addition.
- Partition split.
- Partition migration.
- Node auto-scale.

My Cluster Simulator: Split, Migrate and Auto-Scale

Concept 2:

Run the program **my_main.py**
by trying different values for

- **partition_max_size**
 - **node_max_size**
 - **node_threshold.**

My Cluster Simulator: Split, Migrate and Auto-Scale

Explore **my_log.txt** when running the application
for consecutive values for **num_items_to_process**
to observe the effect of:

- Data item addition.
- Partition split.
- Partition migration.
- Node auto-scale.

with different values for:

- **partition_max_size**
- **node_max_size**
- **node_threshold**

My Cluster Simulator: Split, Migrate and Auto-Scale

Concept 3:

Modify the code of the application by yourself in order to implement alternative split, migrate and auto-scale subroutines with **different policies** to the ones presented in this demo.

Outline

1. Setting the Context.
2. MongoDB: Conceptual Approach.
3. MongoDB: Demonstrating Split and Migrate.
4. My Cluster Simulator: Split, Migrate and Auto-scale.

Thank you for your attention!