1. Création des répertoires de données

Dans le terminal CLIENT :

Trois répertoires de stockage ont été créés afin d'isoler les données du serveur de configuration et celles des deux shards.
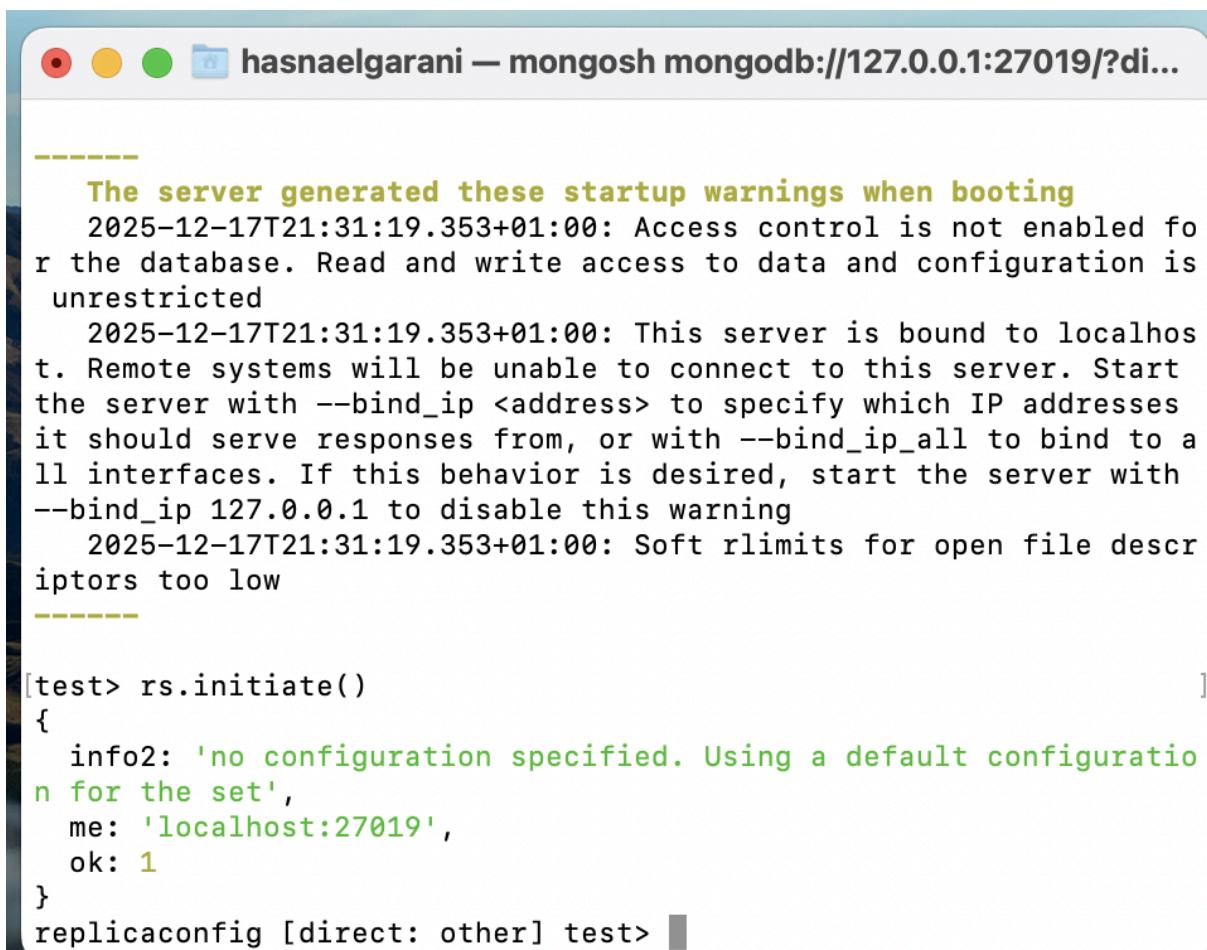
2. Mise en place du Config Server

Terminal : CONFIG_SVR

```
[hasnaelgarani@Air-de-hasna ~ % mongod --configsvr --replSet replic
aconfig --dbpath configsvrdb --port 27019
{"t":{"$date":"2025-12-17T21:31:18.347+01:00"},"s":"I",  "c":"NETW
ORK",  "id":4915701, "ctx":"thread1","msg":"Initialized wire speci
fication","attr":{"spec":{"incomingExternalClient":{"minWireVersio
n":0,"maxWireVersion":21},"incomingInternalClient":{"minWireVersio
n":0,"maxWireVersion":21},"outgoing":{"minWireVersion":6,"maxWireV
ersion":21},"isInternalClient":true}}}
{"t":{"$date":"2025-12-17T21:31:18.370+01:00"},"s":"I",  "c":"CONT
ROL",  "id":23285,   "ctx":"thread1","msg":"Automatically disablin
g TLS 1.0, to force-enable TLS 1.0 specify --sslDisabledProtocols
'none'"}
{"t":{"$date":"2025-12-17T21:31:18.371+01:00"},"s":"I",  "c":"NETW
ORK",  "id":4648602, "ctx":"thread1","msg":"Implicit TCP FastOpen
in use."}
{"t":{"$date":"2025-12-17T21:31:18.376+01:00"},"s":"I",  "c":"REPL
",    "id":5123008, "ctx":"thread1","msg":"Successfully registere
d PrimaryOnlyService","attr":{"service":"ReshardingCoordinatorServ
ice","namespace":"config.reshardingOperations"}}
{"t":{"$date":"2025-12-17T21:31:18.376+01:00"},"s":"I",  "c":"REPL
",    "id":5123008, "ctx":"thread1","msg":"Successfully registere
d PrimaryOnlyService","attr":{"service":"ConfigsvrCoordinatorServi
ce","namespace":"config.sharding_configsvr_coordinators"}}
```

Dans le terminal CLIENT :

Un serveur de configuration a été démarré sur le port 27019. Celui-ci est intégré dans un replica set nommé replicaconfig, indispensable au bon fonctionnement du sharding, car il stocke les métadonnées de partitionnement du cluster.

```
●  ●  ●       hasnaelgarani — mongosh mongodb://127.0.0.1:27019/?di...


------
    The server generated these startup warnings when booting
    2025-12-17T21:31:19.353+01:00: Access control is not enabled fo
r the database. Read and write access to data and configuration is
 unrestricted
    2025-12-17T21:31:19.353+01:00: This server is bound to localhos
t. Remote systems will be unable to connect to this server. Start
the server with --bind_ip <address> to specify which IP addresses
it should serve responses from, or with --bind_ip_all to bind to a
ll interfaces. If this behavior is desired, start the server with
--bind_ip 127.0.0.1 to disable this warning
    2025-12-17T21:31:19.353+01:00: Soft rlimits for open file descr
iptors too low
------

[test> rs.initiate()                                              ]
{
   info2: 'no configuration specified. Using a default configuratio
n for the set',
   me: 'localhost:27019',
   ok: 1
}
replicaconfig [direct: other] test> ▮
```

3. Démarrage du routeur mongos

Terminal : MONGOS

Le routeur mongos a été lancé. Il joue le rôle d'intermédiaire entre les clients et les shards, en redirigeant les requêtes vers les serveurs appropriés en fonction de la clé de sharding.

[hasnaelgarani@Air-de-hasna ~ % mongos --configdb replicaconfig/lo]
calhost:27019
{"t":{"$date":"2025-12-17T20:36:03.363Z"},"s":"W", "c":"SHARDING
", "id":24132, "ctx":"thread1","msg":"Running a sharded cluster
 with fewer than 3 config servers should only be done for testing
 purposes and is not recommended for production."}
{"t":{"$date":"2025-12-17T21:36:03.365+01:00"},"s":"I", "c":"CON
TROL", "id":23285, "ctx":"thread1","msg":"Automatically disabl
ing TLS 1.0, to force-enable TLS 1.0 specify --sslDisabledProtoco
ls 'none'"}
{"t":{"$date":"2025-12-17T21:36:03.365+01:00"},"s":"I", "c":"NET
WORK", "id":4915701, "ctx":"thread1","msg":"Initialized wire spe
cification","attr":{"spec":{"incomingExternalClient":{"minWireVer
sion":0,"maxWireVersion":21},"incomingInternalClient":{"minWireVe
rsion":0,"maxWireVersion":21},"outgoing":{"minWireVersion":21,"ma
xWireVersion":21},"isInternalClient":true}}}
{"t":{"$date":"2025-12-17T21:36:03.370+01:00"},"s":"I", "c":"NET
WORK", "id":4648602, "ctx":"thread1","msg":"Implicit TCP FastOpe
n in use."}
{"t":{"$date":"2025-12-17T21:36:03.370+01:00"},"s":"I", "c":"HEA
LTH", "id":5936503, "ctx":"thread1","msg":"Fault manager change
d state ","attr":{"state":"StartupCheck"}}
{"t":{"$date":"2025-12-17T21:36:03.370+01:00"},"s":"W", "c":"CON
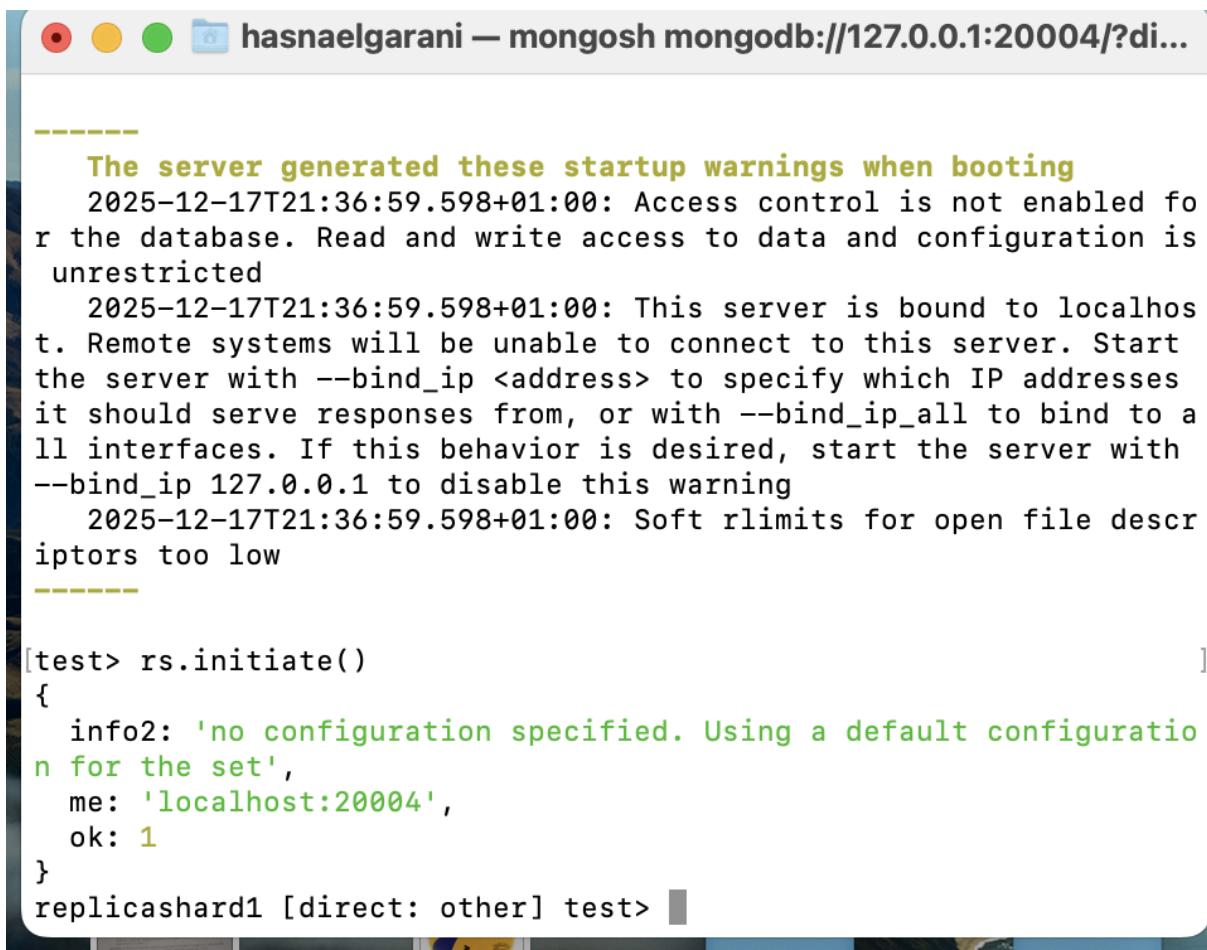
4. Mise en place des shards

◆ **Shard 1**

Terminal : SHARD1

[hasnaelgarani@Air-de-hasna ~ % mongod --replSet replicashard1 --dbpath serv1 --shardsvr --port 20004
{"t":{"$date":"2025-12-17T21:36:58.636+01:00"},"s":"I", "c":"CONTROL", "id":23285, "ctx":"thread1","msg":"Automatically disabling TLS 1.0, to force-enable TLS 1.0 specify --sslDisabledProtocols 'none'"}
{"t":{"$date":"2025-12-17T21:36:58.658+01:00"},"s":"I", "c":"NETWORK", "id":4915701, "ctx":"thread1","msg":"Initialized wire specification","attr":{"spec":{"incomingExternalClient":{"minWireVersion":0,"maxWireVersion":21},"incomingInternalClient":{"minWireVersion":0,"maxWireVersion":21},"outgoing":{"minWireVersion":6,"maxWireVersion":21},"isInternalClient":true}}}
{"t":{"$date":"2025-12-17T21:36:58.659+01:00"},"s":"I", "c":"NETWORK", "id":4648602, "ctx":"thread1","msg":"Implicit TCP FastOpen in use."}
{"t":{"$date":"2025-12-17T21:36:58.662+01:00"},"s":"I", "c":"REPL", "id":5123008, "ctx":"thread1","msg":"Successfully registered PrimaryOnlyService","attr":{"service":"RenameCollectionParticipantService","namespace":"config.localRenameParticipants"}}
{"t":{"$date":"2025-12-17T21:36:58.662+01:00"},"s":"I", "c":

```
------
    The server generated these startup warnings when booting
    2025-12-17T21:36:59.598+01:00: Access control is not enabled fo
r the database. Read and write access to data and configuration is
 unrestricted
    2025-12-17T21:36:59.598+01:00: This server is bound to localhos
t. Remote systems will be unable to connect to this server. Start
the server with --bind_ip <address> to specify which IP addresses
it should serve responses from, or with --bind_ip_all to bind to a
ll interfaces. If this behavior is desired, start the server with
--bind_ip 127.0.0.1 to disable this warning
    2025-12-17T21:36:59.598+01:00: Soft rlimits for open file descr
iptors too low
------

[test> rs.initiate()                                               ]
{
   info2: 'no configuration specified. Using a default configuratio
n for the set',
   me: 'localhost:20004',
   ok: 1
}
replicashard1 [direct: other] test>
```

◆ **Shard 2**

Terminal : SHARD2

[hasnaelgarani@Air-de-hasna ~ % mongod --replSet replicashard2 --d]
bpath serv2 --shardsvr --port 20005
{"t":{"$date":"2025-12-17T21:38:33.421+01:00"},"s":"I", "c":"NET
WORK", "id":4915701, "ctx":"thread1","msg":"Initialized wire spe
cification","attr":{"spec":{"incomingExternalClient":{"minWireVer
sion":0,"maxWireVersion":21},"incomingInternalClient":{"minWireVe
rsion":0,"maxWireVersion":21},"outgoing":{"minWireVersion":6,"max
WireVersion":21},"isInternalClient":true}}}
{"t":{"$date":"2025-12-17T21:38:33.423+01:00"},"s":"I", "c":"CON
TROL", "id":23285,   "ctx":"thread1","msg":"Automatically disabl
ing TLS 1.0, to force-enable TLS 1.0 specify --sslDisabledProtoco
ls 'none'"}
{"t":{"$date":"2025-12-17T21:38:33.423+01:00"},"s":"I", "c":"NET
WORK", "id":4648602, "ctx":"thread1","msg":"Implicit TCP FastOpe
n in use."}
{"t":{"$date":"2025-12-17T21:38:33.424+01:00"},"s":"I", "c":"REP
L",   "id":5123008, "ctx":"thread1","msg":"Successfully registe
red PrimaryOnlyService","attr":{"service":"RenameCollectionPartic
ipantService","namespace":"config.localRenameParticipants"}}
{"t":{"$date":"2025-12-17T21:38:33.424+01:00"},"s":"I", "c":"REP
L",   "id":5123008, "ctx":"thread1","msg":"Successfully registe
red PrimaryOnlyService","attr":{"service":"ShardingDDLCoordinator
","namespace":"config.system.sharding_ddl_coordinators"}}
{"t":{"$date":"2025-12-17T21:38:33.424+01:00"},"s":"I", "c":"REP

Dans CLIENT :

```
●  ●  ●  📁 hasnaelgarani — mongosh mongodb://127.0.0.1:20005/?di...


    ------
    The server generated these startup warnings when booting
    2025-12-17T21:38:34.389+01:00: Access control is not enabled fo
r the database. Read and write access to data and configuration is
 unrestricted
    2025-12-17T21:38:34.390+01:00: This server is bound to localhos
t. Remote systems will be unable to connect to this server. Start
the server with --bind_ip <address> to specify which IP addresses
it should serve responses from, or with --bind_ip_all to bind to a
ll interfaces. If this behavior is desired, start the server with
--bind_ip 127.0.0.1 to disable this warning
    2025-12-17T21:38:34.390+01:00: Soft rlimits for open file descr
iptors too low
    ------

[test> rs.initiate()
{
  info2: 'no configuration specified. Using a default configuratio
n for the set',
  me: 'localhost:20005',
  ok: 1
}
replicashard2 [direct: other] test> ▊
```

Deux shards ont été déployés, chacun configuré comme un replica set. Cette approche permet d'assurer la tolérance aux pannes et la montée en charge du cluster.

5. Ajout des shards au cluster
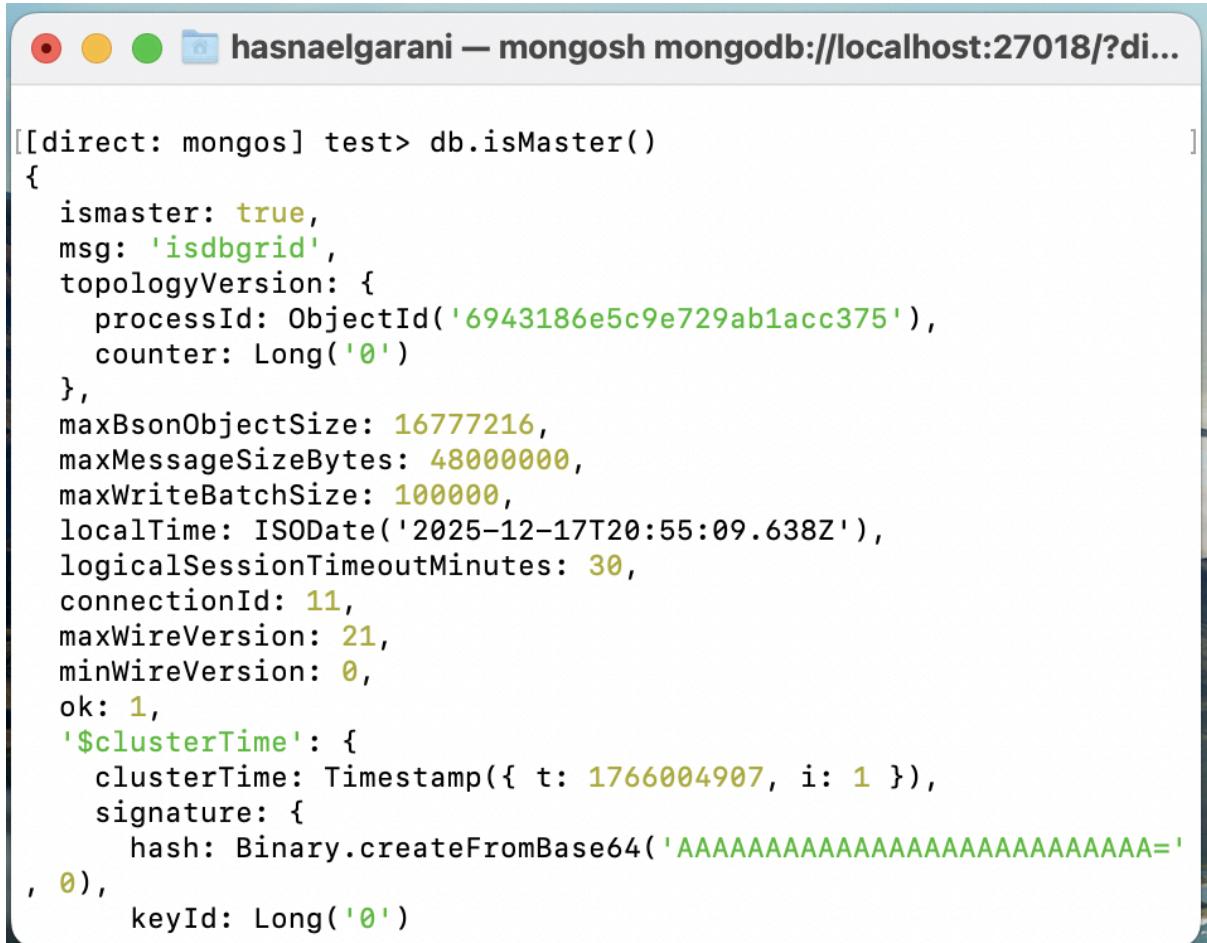
Terminal : CLIENT (connecté à mongos)

```
hasnaelgarani@Air-de-hasna ~ % mongosh --host localhost --port 270
18

Current Mongosh Log ID: 6943189f83c2b56eeec4c5f0
Connecting to:          mongodb://localhost:27018/?directConnectio
n=true&serverSelectionTimeoutMS=2000&appName=mongosh+2.5.9
Using MongoDB:          7.0.26
Using Mongosh:          2.5.9
mongosh 2.5.10 is available for download: https://www.mongodb.com/
try/download/shell

For mongosh info see: https://www.mongodb.com/docs/mongodb-shell/

------
   The server generated these startup warnings when booting
   2025-12-17T21:54:06.236+01:00: Access control is not enabled fo
r the database. Read and write access to data and configuration is
 unrestricted
   2025-12-17T21:54:06.236+01:00: This server is bound to localhos
t. Remote systems will be unable to connect to this server. Start
the server with --bind_ip <address> to specify which IP addresses
it should serve responses from, or with --bind_ip_all to bind to a
ll interfaces. If this behavior is desired, start the server with
--bind_ip 127.0.0.1 to disable this warning
```

```
● ● ●    📁 hasnaelgarani — mongosh mongodb://localhost:27018/?di...

[[direct: mongos] test> db.isMaster()
{
  ismaster: true,
  msg: 'isdbgrid',
  topologyVersion: {
    processId: ObjectId('6943186e5c9e729ab1acc375'),
    counter: Long('0')
  },
  maxBsonObjectSize: 16777216,
  maxMessageSizeBytes: 48000000,
  maxWriteBatchSize: 100000,
  localTime: ISODate('2025-12-17T20:55:09.638Z'),
  logicalSessionTimeoutMinutes: 30,
  connectionId: 11,
  maxWireVersion: 21,
  minWireVersion: 0,
  ok: 1,
  '$clusterTime': {
    clusterTime: Timestamp({ t: 1766004907, i: 1 }),
    signature: {
      hash: Binary.createFromBase64('AAAAAAAAAAAAAAAAAAAAAAAAAAA='
, 0),
      keyId: Long('0')
```

Les deux shards ont été ajoutés dynamiquement au cluster MongoDB à l'aide du routeur mongos.

```
}
[direct: mongos] test> sh.addShard("replicashard1/localhost:20004"
)
{
  shardAdded: 'replicashard1',
  ok: 1,
  '$clusterTime': {
    clusterTime: Timestamp({ t: 1766005073, i: 5 }),
    signature: {
      hash: Binary.createFromBase64('AAAAAAAAAAAAAAAAAAAAAAAAAAA='
, 0),
      keyId: Long('0')
    }
  },
  operationTime: Timestamp({ t: 1766005073, i: 5 })
}
[direct: mongos] test>
```

```
}
[direct: mongos] test> sh.addShard("replicashard2/localhost:20005"
)
{
  shardAdded: 'replicashard2',
  ok: 1,
  '$clusterTime': {
    clusterTime: Timestamp({ t: 1766005107, i: 13 }),
    signature: {
      hash: Binary.createFromBase64('AAAAAAAAAAAAAAAAAAAAAAAAAAA='
, 0),
      keyId: Long('0')
    }
  },
  operationTime: Timestamp({ t: 1766005107, i: 3 })
}
[direct: mongos] test>
```

6. Activation du sharding sur la base

Le sharding n'étant pas activé par défaut, il a été explicitement activé sur la base de données mabasefilms.

```
        }
]
[direct: mongos] test> sh.enableSharding("mabasefilms")
[...                                                                    ]
{
  ok: 1,
  '$clusterTime': {
    clusterTime: Timestamp({ t: 1766005196, i: 9 }),
    signature: {
      hash: Binary.createFromBase64('AAAAAAAAAAAAAAAAAAAAAAAAAAA='
, 0),
      keyId: Long('0')
    }
  },
  operationTime: Timestamp({ t: 1766005196, i: 3 })
}
[direct: mongos] test>
```

7. Sharding de la collection

La collection films a été shardée en utilisant le champ titre comme clé de partitionnement. Cette clé permet de répartir les documents entre les shards selon des plages de valeurs.

```
        }
[direct: mongos] test> sh.shardCollection("mabasefilms.films", { "
titre": 1 })
[...                                                                    ]
{
  collectionsharded: 'mabasefilms.films',
  ok: 1,
  '$clusterTime': {
    clusterTime: Timestamp({ t: 1766005256, i: 8 }),
    signature: {
      hash: Binary.createFromBase64('AAAAAAAAAAAAAAAAAAAAAAAAAAA='
, 0),
      keyId: Long('0')
    }
  },
  operationTime: Timestamp({ t: 1766005256, i: 8 })
}
[direct: mongos] test>
```

8. Insertion des données et observation

Lors de l'insertion massive des films, MongoDB a automatiquement découpé les données en chunks et les a redistribués entre les shards afin d'équilibrer la charge, grâce au balancer.

```
directory
(monenv) hasnaelgarani@Air-de-hasna Downloads % python monappunparun.py

Insertion film par film en cours...
Insertion terminée. Temps total : 83.43 secondes.
(monenv) hasnaelgarani@Air-de-hasna Downloads %

                                          L 1, col 1   Espaces : 4   UTF-8   L
```

→ La commande sh.status() :

Cette commande permet de vérifier l'état général du cluster sharded, en affichant les shards, les chunks et l'activité du balancer.

```
      }
    },
    operationTime: Timestamp({ t: 1766008547, i: 1 })
  }
[[direct: mongos] mabasefilms> sh.status()
shardingVersion
{ _id: 1, clusterId: ObjectId('6943140386e0ee5a54b7358c') }
---
shards
[
  {
    _id: 'replicashard1',
    host: 'replicashard1/localhost:20004',
    state: 1,
    topologyTime: Timestamp({ t: 1766005073, i: 2 })
  },
  {
    _id: 'replicashard2',
    host: 'replicashard2/localhost:20005',
    state: 1,
    topologyTime: Timestamp({ t: 1766005107, i: 1 })
  }
]
---
active mongoses
[ { '7.0.26': 1 } ]
---
autosplit
{ 'Currently enabled': 'yes' }
---
balancer
{
  'Currently enabled': 'yes',
  'Failed balancer rounds in last 5 attempts': 0,
  'Currently running': 'no',
  'Migration Results for the last 24 hours': 'No recent migrations'
}
---
shardedDataDistribution
[
  {
    ns: 'config.system.sessions',
    shards: [
      {
        shardName: 'replicashard1',
        numOrphanedDocs: 0,
```

→ La commande db.printShardingStatus():

Cette commande fournit des informations détaillées sur le sharding de chaque collection, la clé de sharding utilisée, et la répartition des chunks entre les shards.

```
●  ●  ●    🗂 hasnaelgarani — mongosh mongodb://localhost:27018/?directC
]
[[direct: mongos] mabasefilms> db.printShardingStatus()
shardingVersion
{ _id: 1, clusterId: ObjectId('6943140386e0ee5a54b7358c') }
---
shards
[
  {
    _id: 'replicashard1',
    host: 'replicashard1/localhost:20004',
    state: 1,
    topologyTime: Timestamp({ t: 1766005073, i: 2 })
  },
  {
    _id: 'replicashard2',
    host: 'replicashard2/localhost:20005',
    state: 1,
    topologyTime: Timestamp({ t: 1766005107, i: 1 })
  }
]
---
active mongoses
[ { '7.0.26': 1 } ]
---
autosplit
{ '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': 'No recent migrations'
}
---
shardedDataDistribution
[
  {
    ns: 'config.system.sessions',
    shards: [
      {
        shardName: 'replicashard1',
        numOrphanedDocs: 0,
        numOwnedDocuments: 11,
        ownedSizeBytes: 1089,
        orphanedSizeBytes: 0
```

→ La commande db.stats():

Cette commande affiche les statistiques globales de la base de données sélectionnée,
notamment le nombre de documents, la taille des données et l'espace utilisé par les indexes.

```
[[direct: mongos] mabasefilms> db.stats()
{
  raw: {
    'replicashard1/localhost:20004': {
      db: 'mabasefilms',
      collections: Long('0'),
      views: Long('0'),
      objects: Long('0'),
      avgObjSize: 0,
      dataSize: 0,
      storageSize: 0,
      indexes: Long('0'),
      indexSize: 0,
      totalSize: 0,
      scaleFactor: Long('1'),
      fsUsedSize: 0,
      fsTotalSize: 0,
      ok: 1
    },
    'replicashard2/localhost:20005': {
      db: 'mabasefilms',
      collections: Long('1'),
      views: Long('0'),
      objects: Long('112482'),
      avgObjSize: 129.99284329937234,
      dataSize: 14621855,
      storageSize: 4550656,
      indexes: Long('2'),
      indexSize: 5324800,
      totalSize: 9875456,
      scaleFactor: Long('1'),
      fsUsedSize: 220412985344,
      fsTotalSize: 245107195904,
      ok: 1
    }
  },
  db: 'mabasefilms',
  collections: 1,
  views: 0,
  objects: 112482,
  avgObjSize: 129.99284329937234,
  dataSize: 14621855,
  storageSize: 4550656,
  totalSize: 9875456,
  indexes: 2,
  indexSize: 5324800,
```