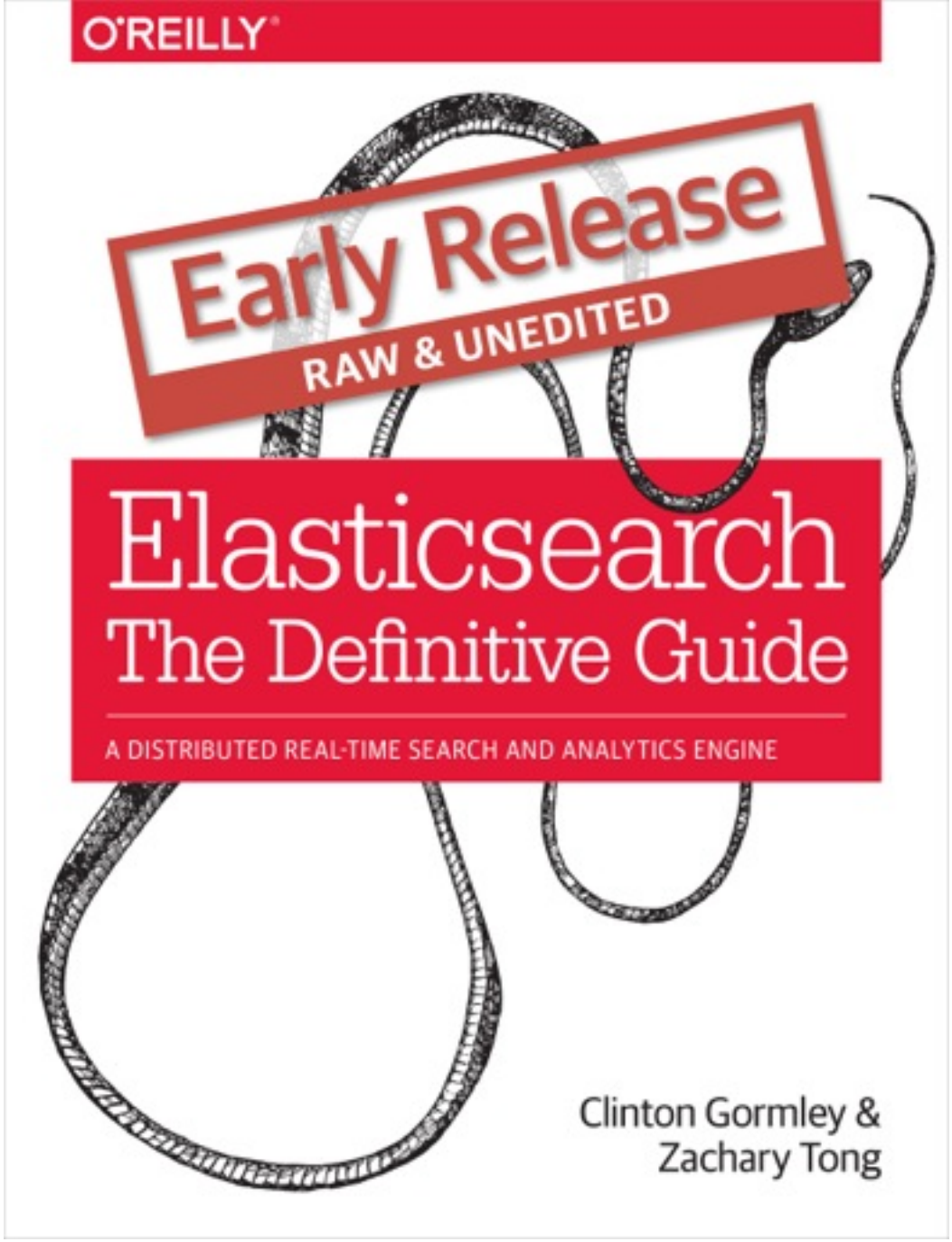
Scaling real time search and analytics with elasticsearch

Clinton Gormley
@clintongormley

elasticsearch.



elasticsearch.

elasticsearch.org/guide

elasticsearch.

elasticsearch

elasticsearch

- real-time

elasticsearch

- real-time
- distributed

elasticsearch

- real-time
- distributed
- search

elasticsearch

- real-time
- distributed
- search
- analytics

how to use it?

how to use it?

how does it work?

step 1:

making text searchable

Shall I compare thee to a summer's day?
Thou art more lovely and more temperate:
Rough winds do shake the darling buds of May,
And summer's lease hath all too short a date:
Sometime too hot the eye of heaven shines,
And often is his gold complexion dimmed,
And every fair from fair sometime declines,
By chance, or nature's changing course untrimmed:
But thy eternal summer shall not fade,
Nor lose possession of that fair thou ow'st,
Nor shall death brag thou wander'st in his shade,
When in eternal lines to time thou grow'st,
  So long as men can breathe, or eyes can see,
  So long lives this, and this gives life to thee.

Shall I compare thee to a summer's day?
Thou art more lovely and more temperate:
Rough winds do shake the darling buds of May,
And summer's lease hath all too short a date:

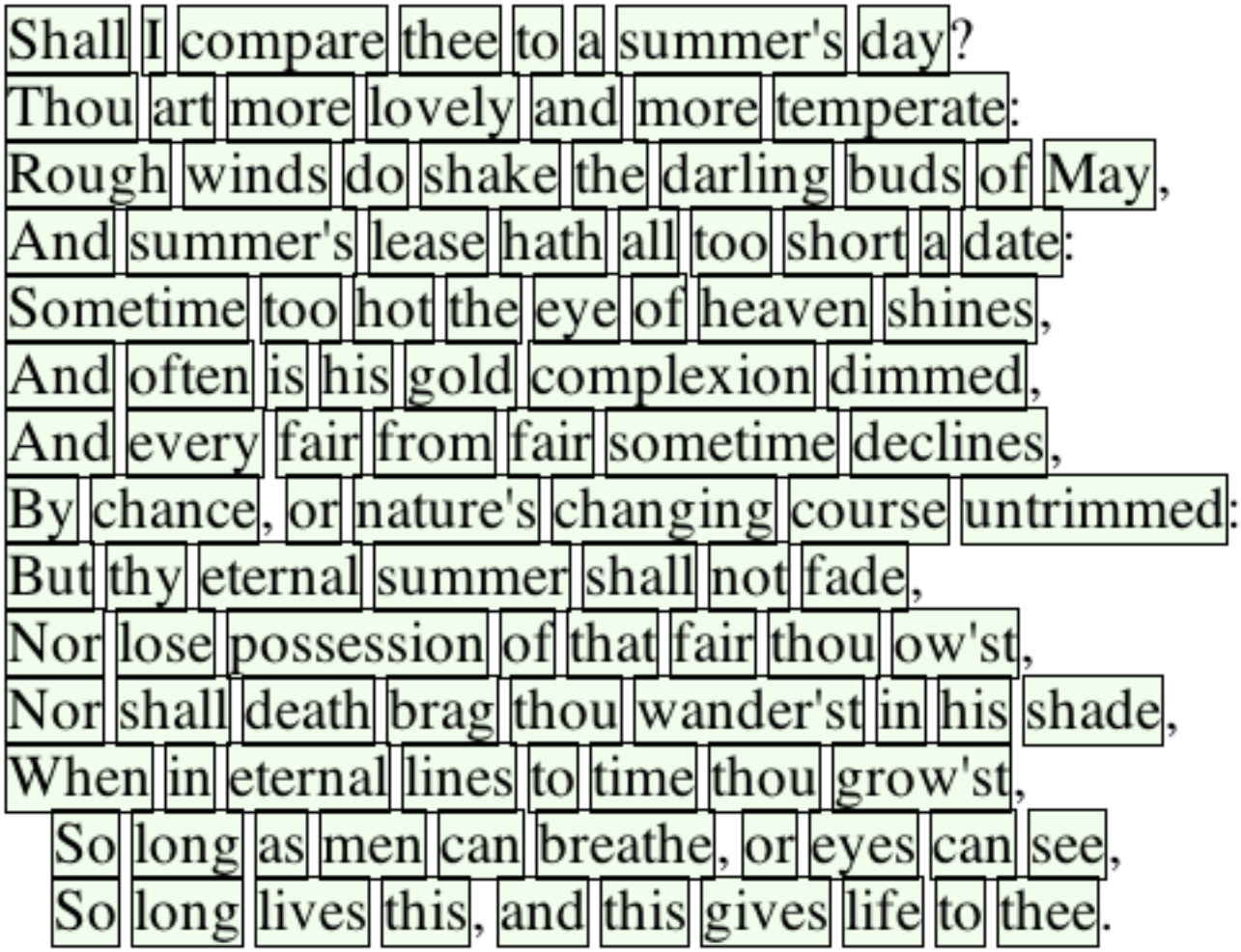
```
where content like
"%darling%buds%"
```

Nor lose possession of that fair thou ow'st,
Nor shall death brag thou wander'st in his shade,
When in eternal lines to time thou grow'st,
So long as men can breathe, or eyes can see,
So long lives this, and this gives life to thee.

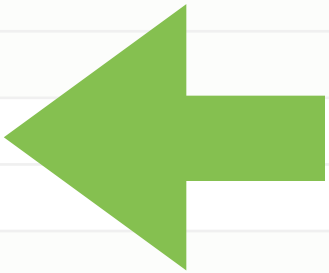
Shall I compare thee to a summer's day?
Thou art more lovely and more temperate:
Rough winds do shake the darling buds of May,
And summer's lease hath all too short a date:
Sometime too hot the eye of heaven shines.

slow & inflexible

But thy eternal summer shall not fade,
Nor lose possession of that fair thou ow'st,
Nor shall death brag thou wander'st in his shade,
When in eternal lines to time thou grow'st,
So long as men can breathe, or eyes can see,
So long lives this, and this gives life to thee.



Term	Doc 1	Doc 2	Doc 3
breathe			
brings			
buds			
but			
by			
can			
…			
damasked			
darling			
date			
day			
deaf			
death			
declines			
delight			



sorted list of unique terms

Term	Doc 1	Doc 2	Doc 3

where they occur

Term	Doc 1	Doc 2	Doc 3
breathe			
brings			
buds			
but			
by			
can			
…			
damasked			
darling			
date			
day			
deaf			
death			
declines			
delight			

Term	Doc 1	Doc 2	Doc 3
breathe			
brings			
buds			
but			
by			
can			
…			
damasked			
darling			
date			
day			
deaf			
death			
declines			
delight			

inverted index

inverted index

- term frequencies

inverted index

- term frequencies » relevance

inverted index

- term frequencies » relevance
- text length

inverted index

- term frequencies » relevance
- text length » doc weight

inverted index

- term frequencies » relevance
- text length » doc weight
- term positions

inverted index

- term frequencies » relevance
- text length » doc weight
- term positions » word proximity

inverted index

- term frequencies » relevance
- text length » doc weight
- term positions » word proximity
- char offsets

inverted index

- term frequencies » relevance
- text length » doc weight
- term positions » word proximity
- char offsets » highlighting

inverted index

not just for text

inverted index

numbers, dates, bools, enums

geopoints, geoshapes, etc

step 2:

analytics

for search

map values → doc_ids

for search

map values → doc_ids

for analytics

map doc_ids → values

uninvert the index

uninvert the index

cache values in memory
called “fielddata”

uninvert the index

data access from RAM

very fast

on-the-fly analytics

in the context of a user's query

on-the-fly analytics

relevant analytics
for each user

calculate metrics

count, min, max, sum, avg,
percentiles, cardinality,
stddev, variance, sum of squares

grouped by

popular terms, significant terms, ranges, dates, geolocation, etc

grouped by

groups can

… contain subgroups

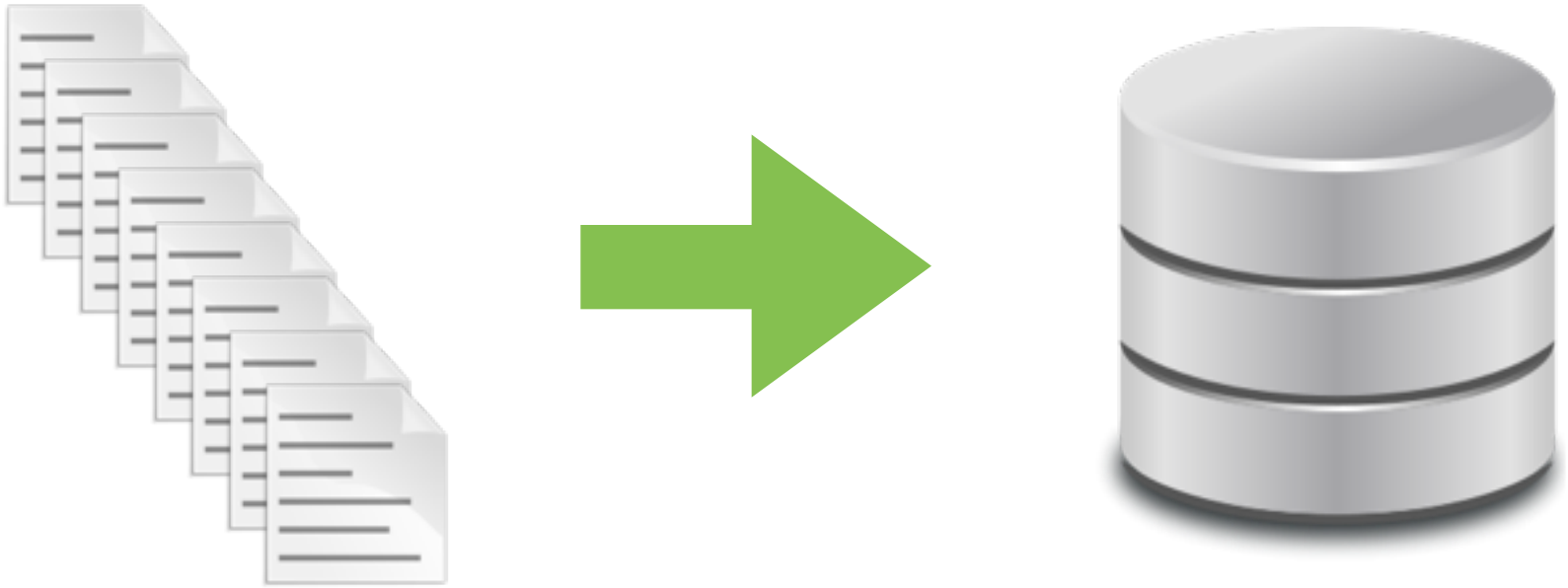
… which contain subgroups

etc

step 3:

building the inverted index

inverted index



immutable

immutable

- cache friendly

immutable

- cache friendly
- reads from RAM

immutable

- cache friendly
- reads from RAM
- fielddata never changes

immutable

- cache friendly
- reads from RAM
- fielddata never changes
- compressible

immutable

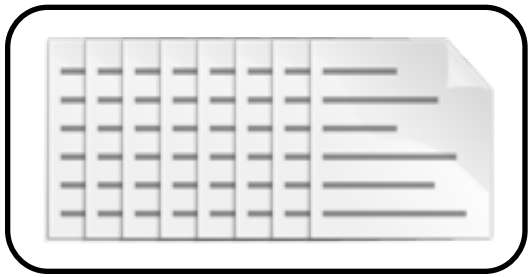
- cache friendly
- reads from RAM
- fielddata never changes
- compressible
- no locking

but, immutable...

step 4:

dynamic inverted index

in-memory buffer



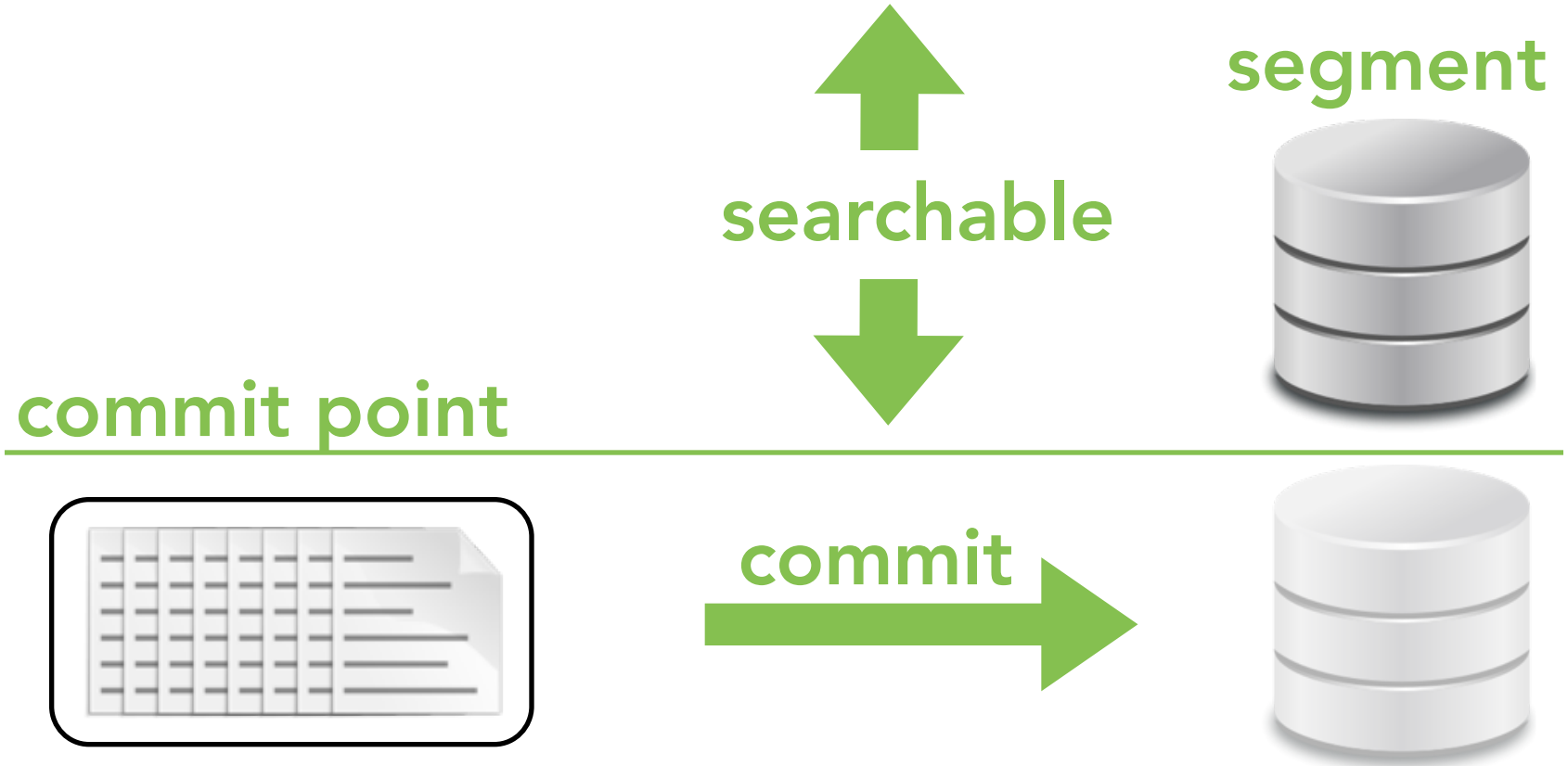
commit

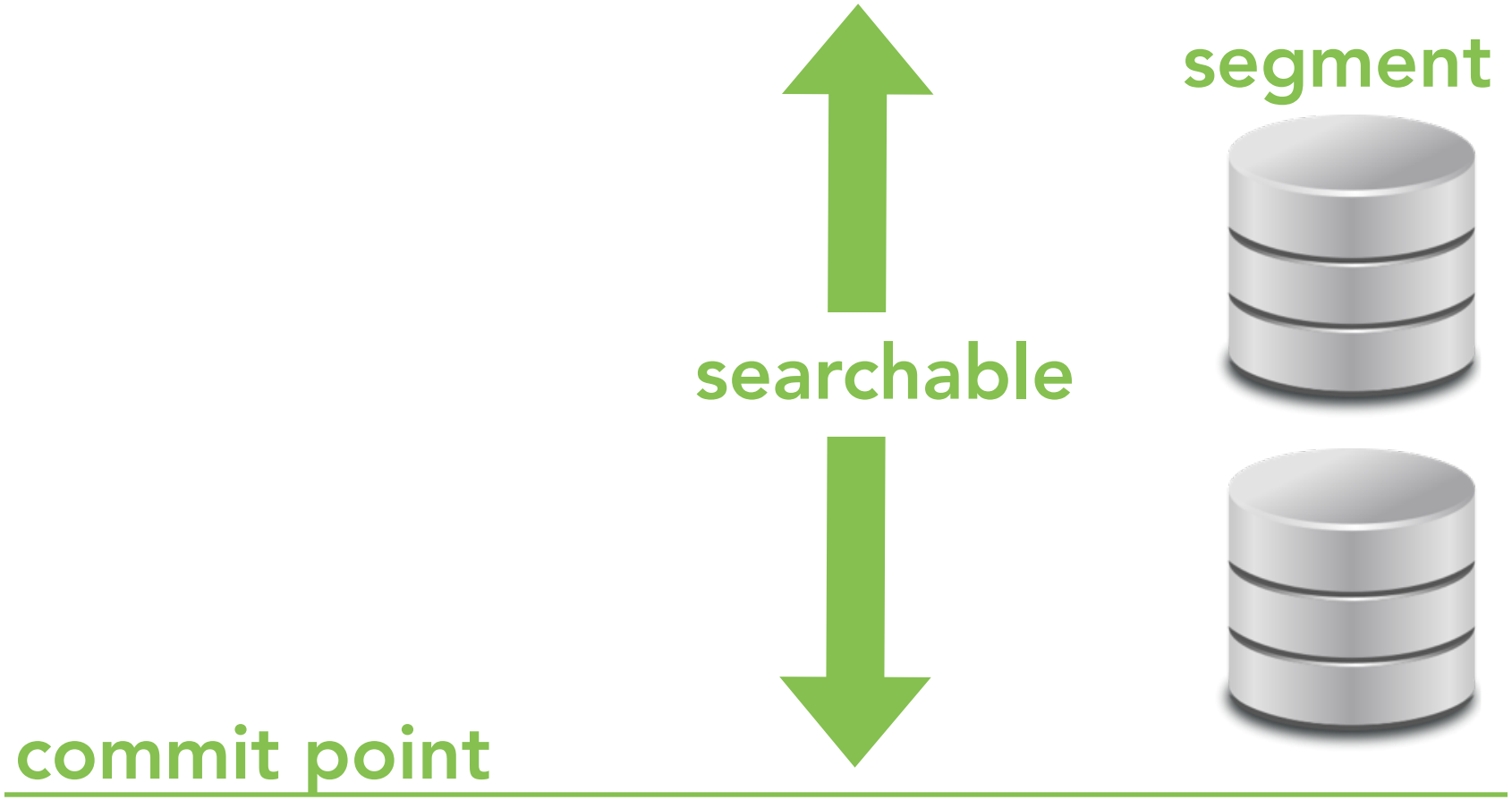
segment

segment

searchable

commit point

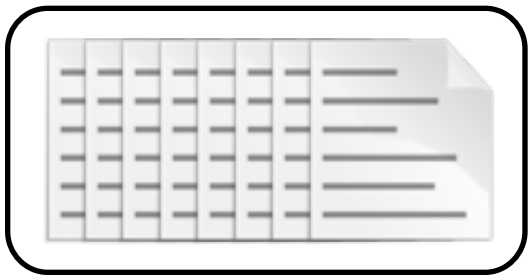




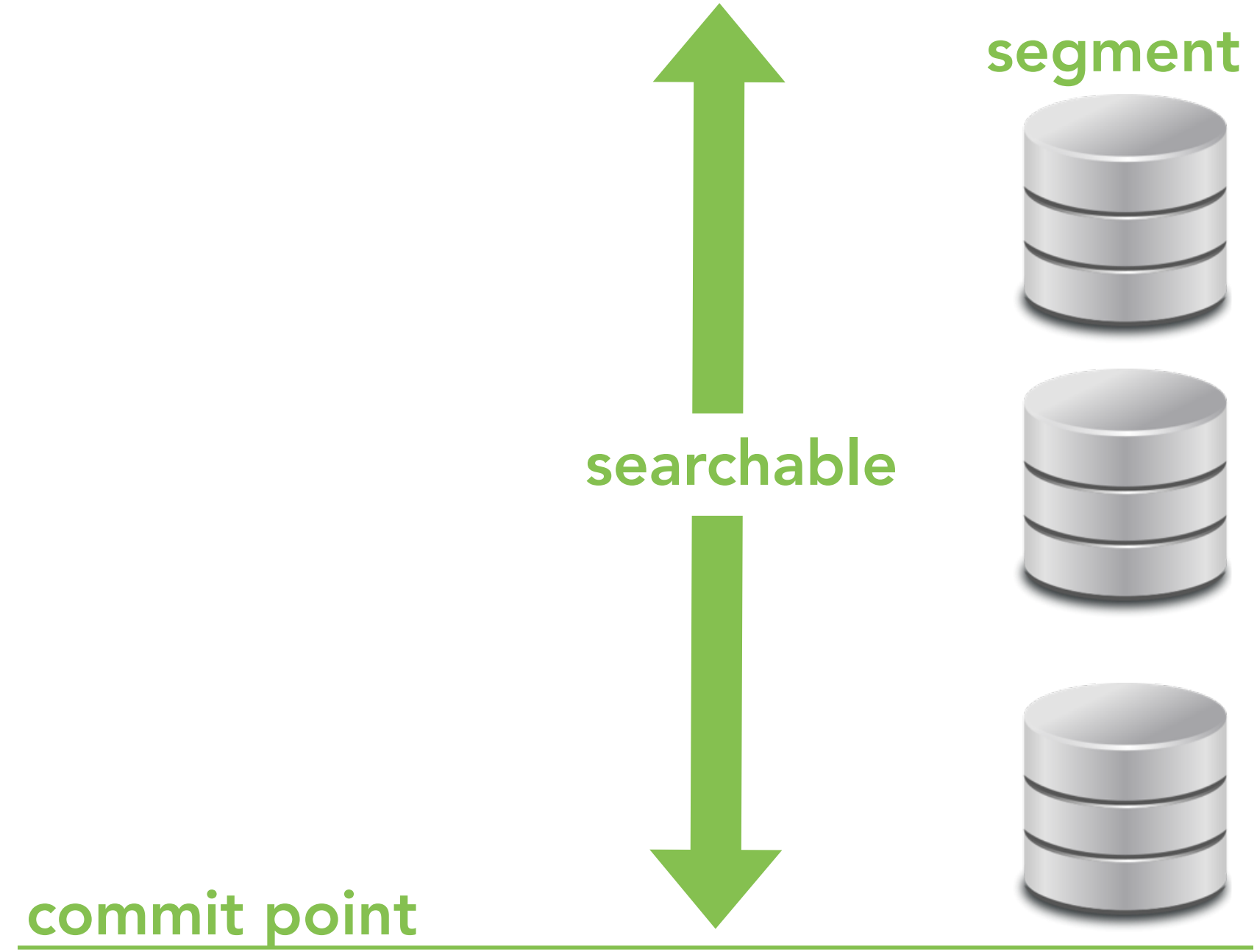
segment

searchable

commit point



commit



lucene commit

lucene commit

- write new segment

lucene commit

- write new segment
- write new commit point

lucene commit

- write new segment
- write new commit point
- fsync

lucene commit

- write new segment
- write new commit point
- fsync
- clear buffer

lucene commit

- write new segment
- write new commit point
- fsync
- clear buffer
- reopen index

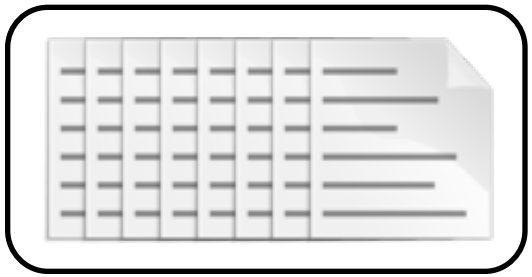
lucene commit

- write new segment
- write new commit point
- **fsync** ← **expensive!**
- clear buffer
- reopen index

step 5:

near real-time search

in-memory buffer

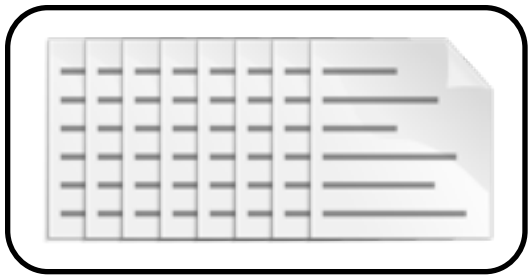


flush

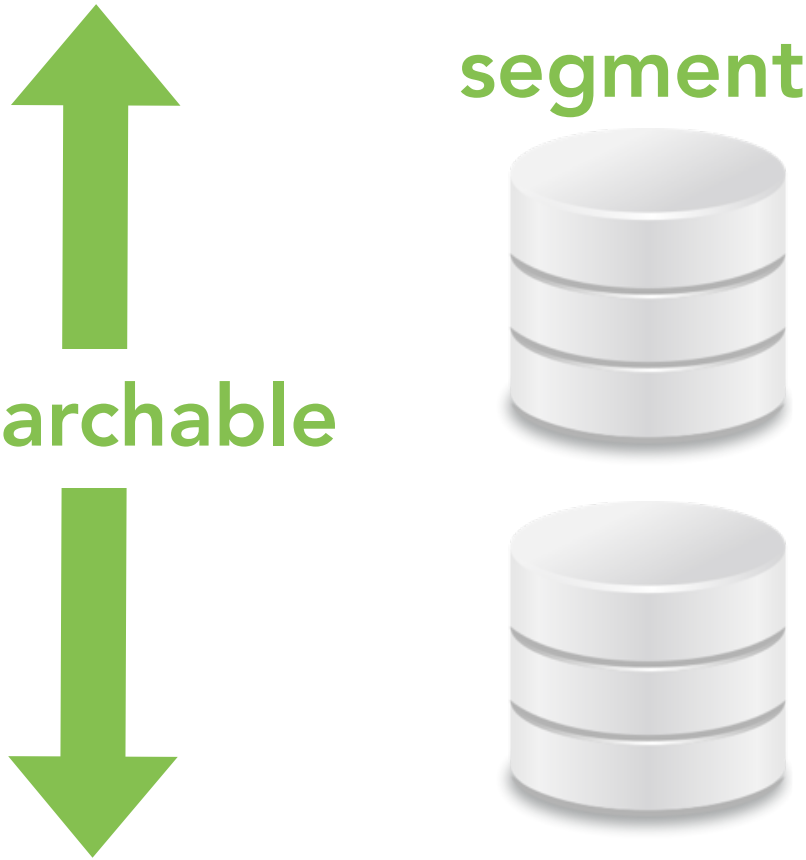
segment

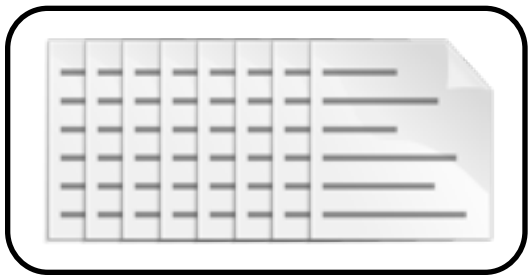
searchable

segment



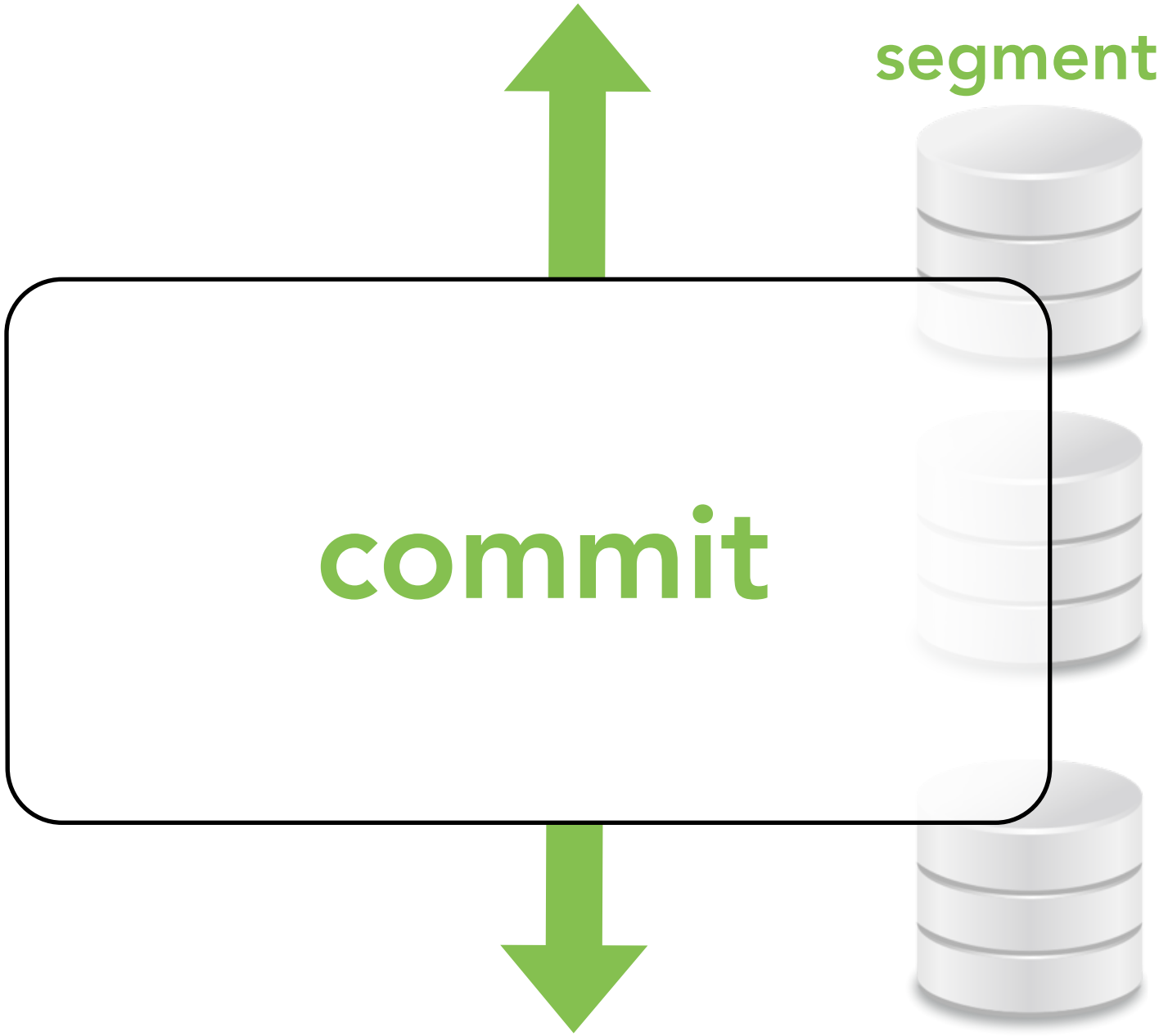
segment

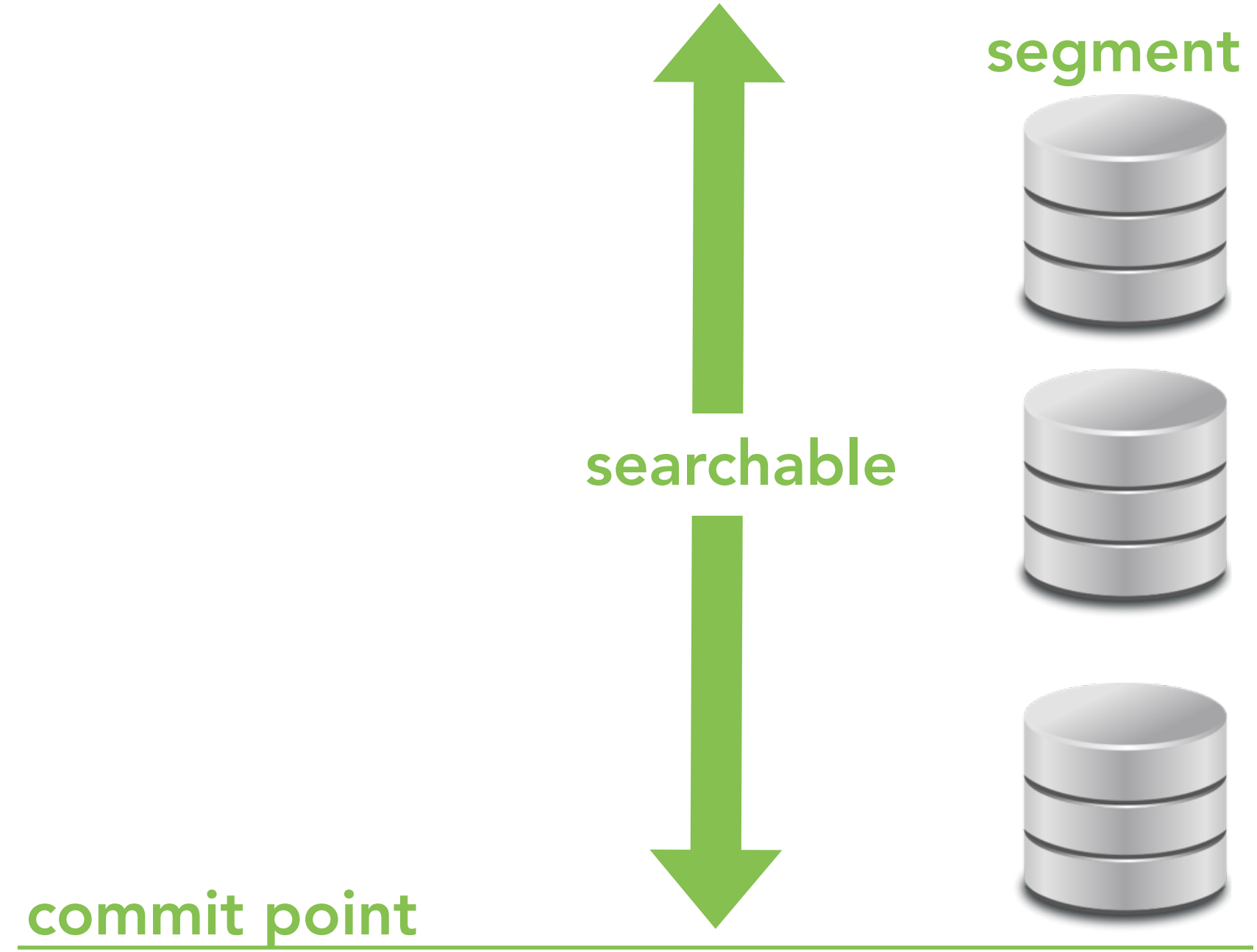




segment

elasticsearch.





lucene flush

lucene flush

- write new segment
- clear buffer
- reopen index

lucene flush

- write new segment
- clear buffer
- reopen index
- **no fsync**

lucene flush

- write new segment
- clear buffer
- reopen index
- **no fsync → lightweight**

but…

data not safe until fsync'ed!

step 6:

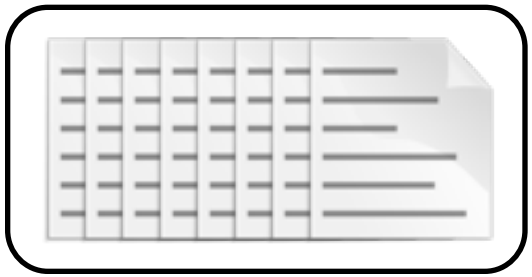
don't lose data

step 6:

don't lose data

→ transaction log

in-memory buffer



flush

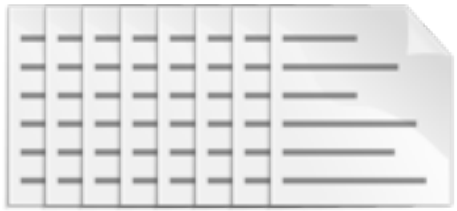
segment

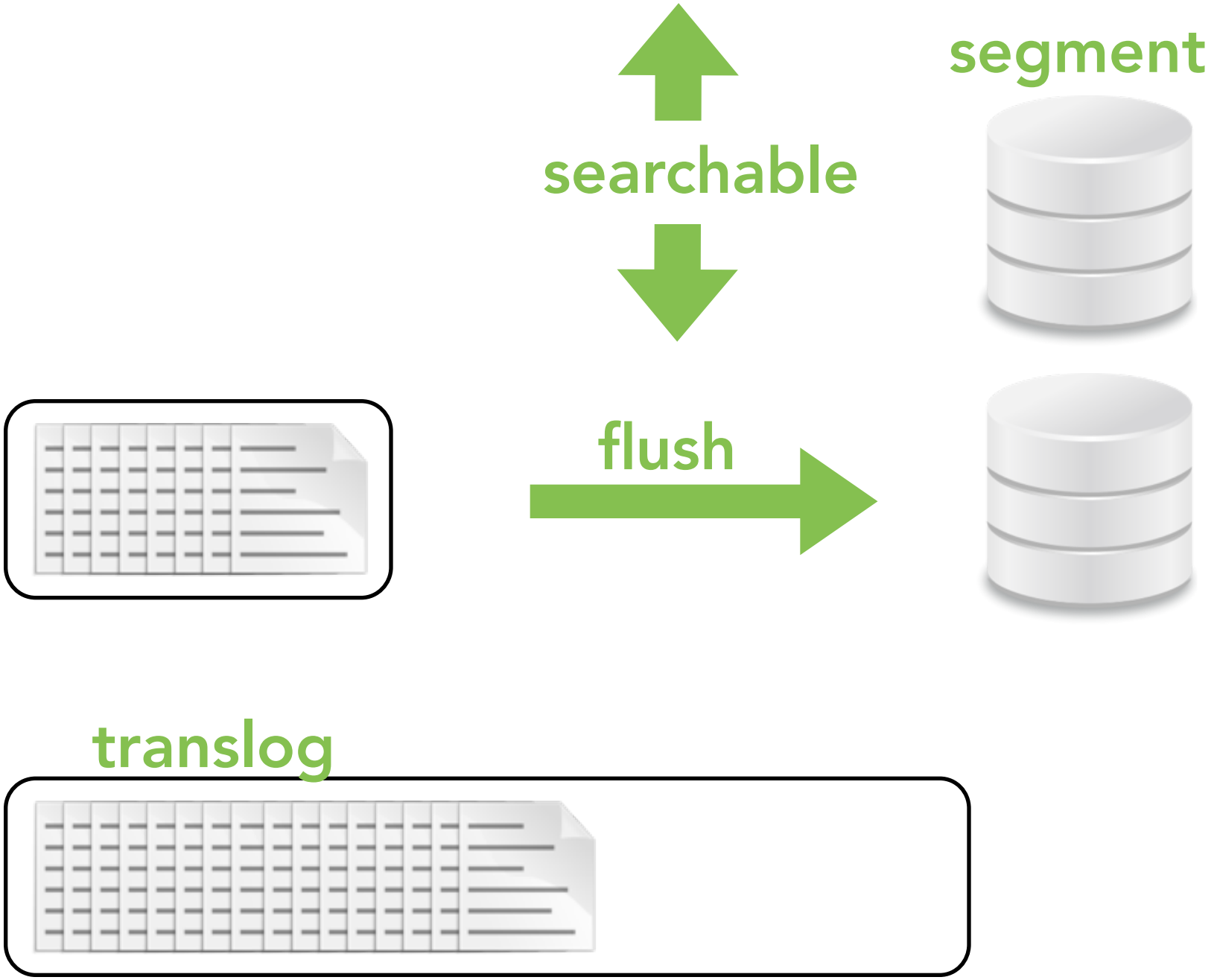
translog

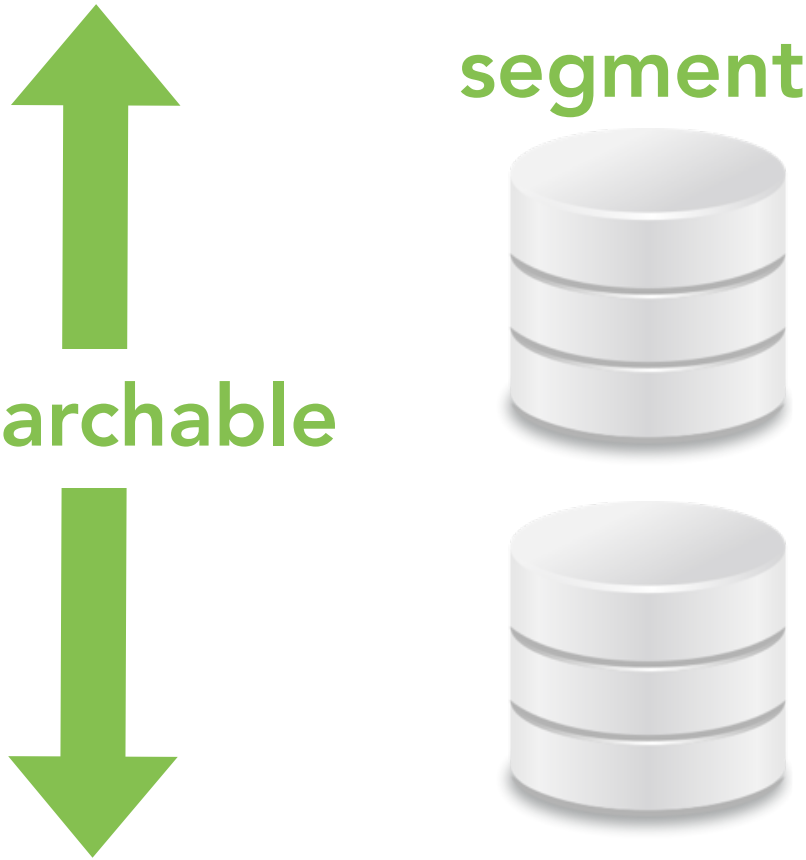
searchable

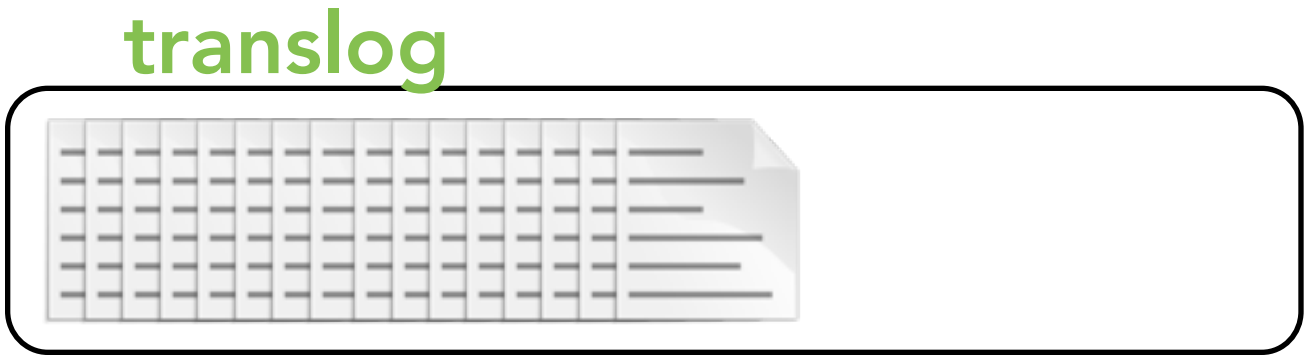
segment

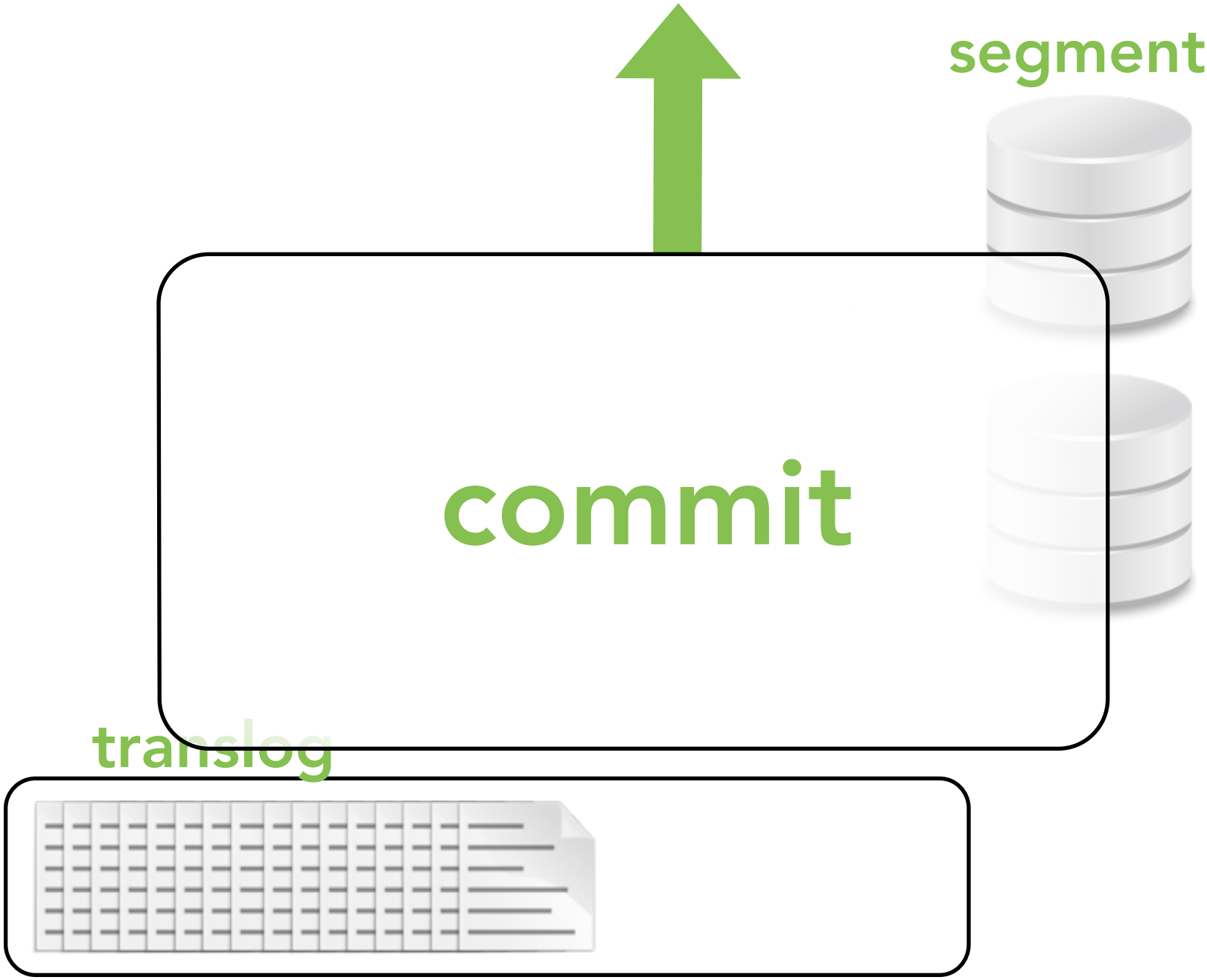
translog

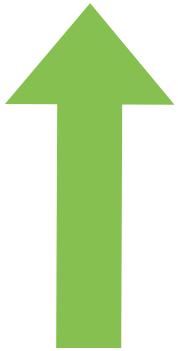












segment

searchable

commit point

translog

elasticsearch "refresh"

- lucene "flush"
- makes changes searchable
- lightweight

elasticsearch "flush"

- lucene "commit"
- clears transaction log
- persists changes
- heavy

refresh every second

near real-time search!

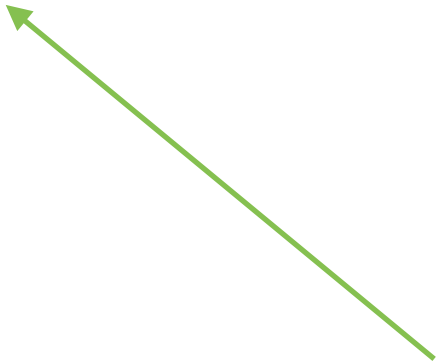
near real-time search!
near real-time analytics!

too many segments

- slow searches
- poor term frequencies
- poor compression

step 7:

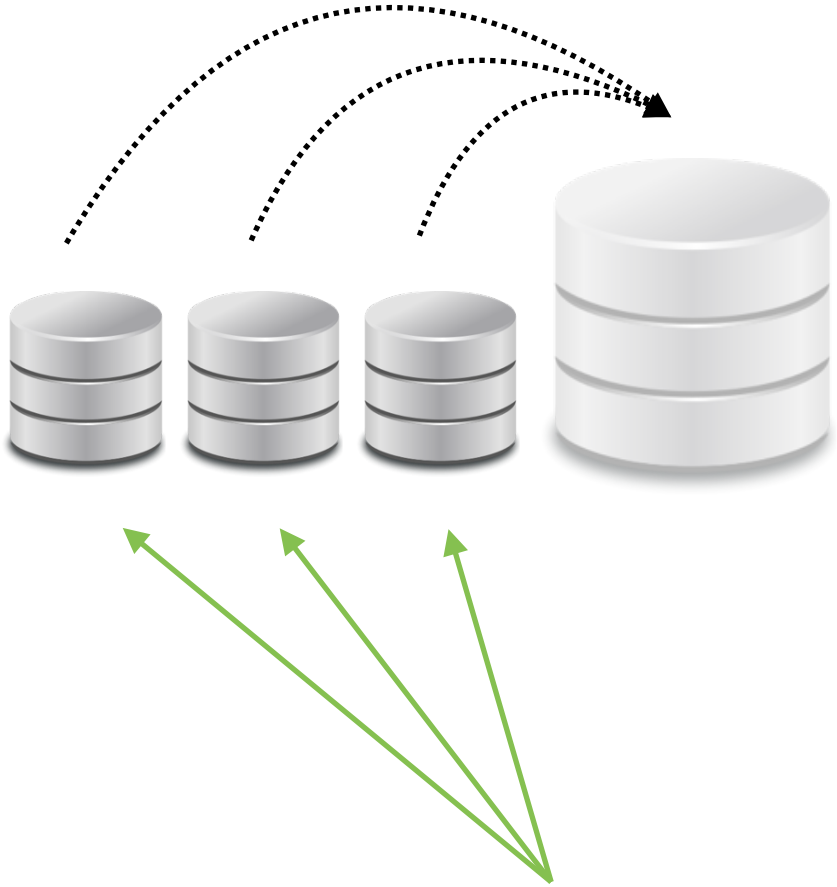
reduce segments



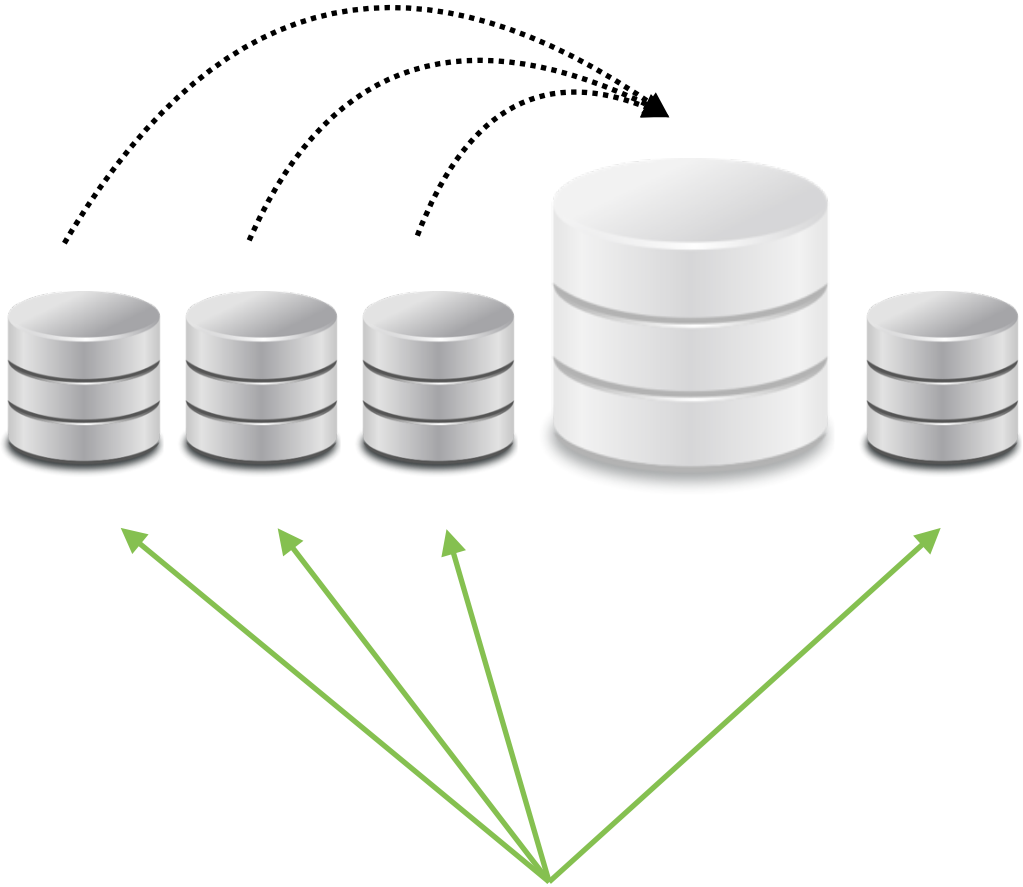
searchable

searchable

searchable



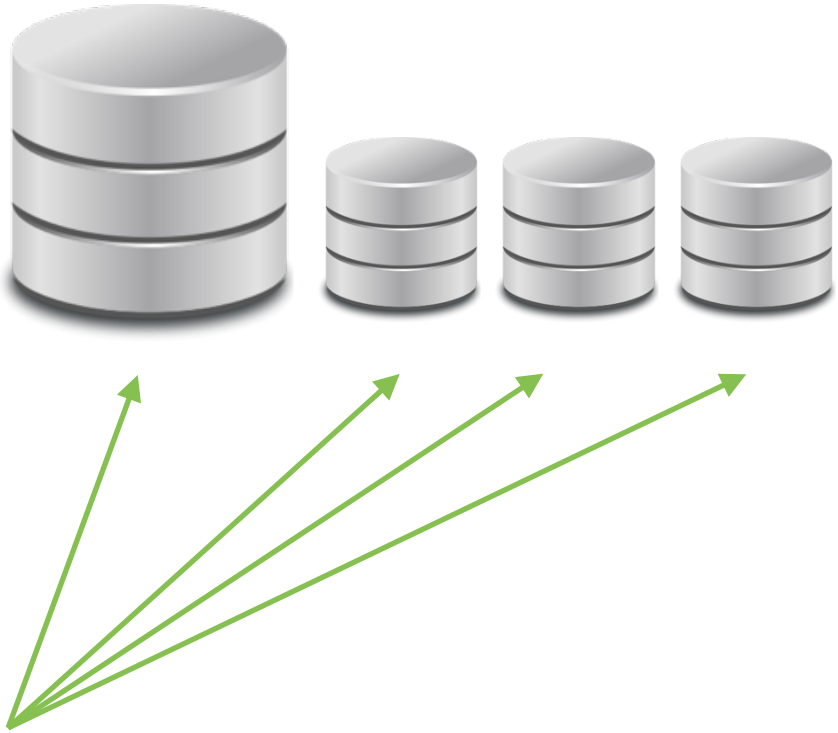
searchable



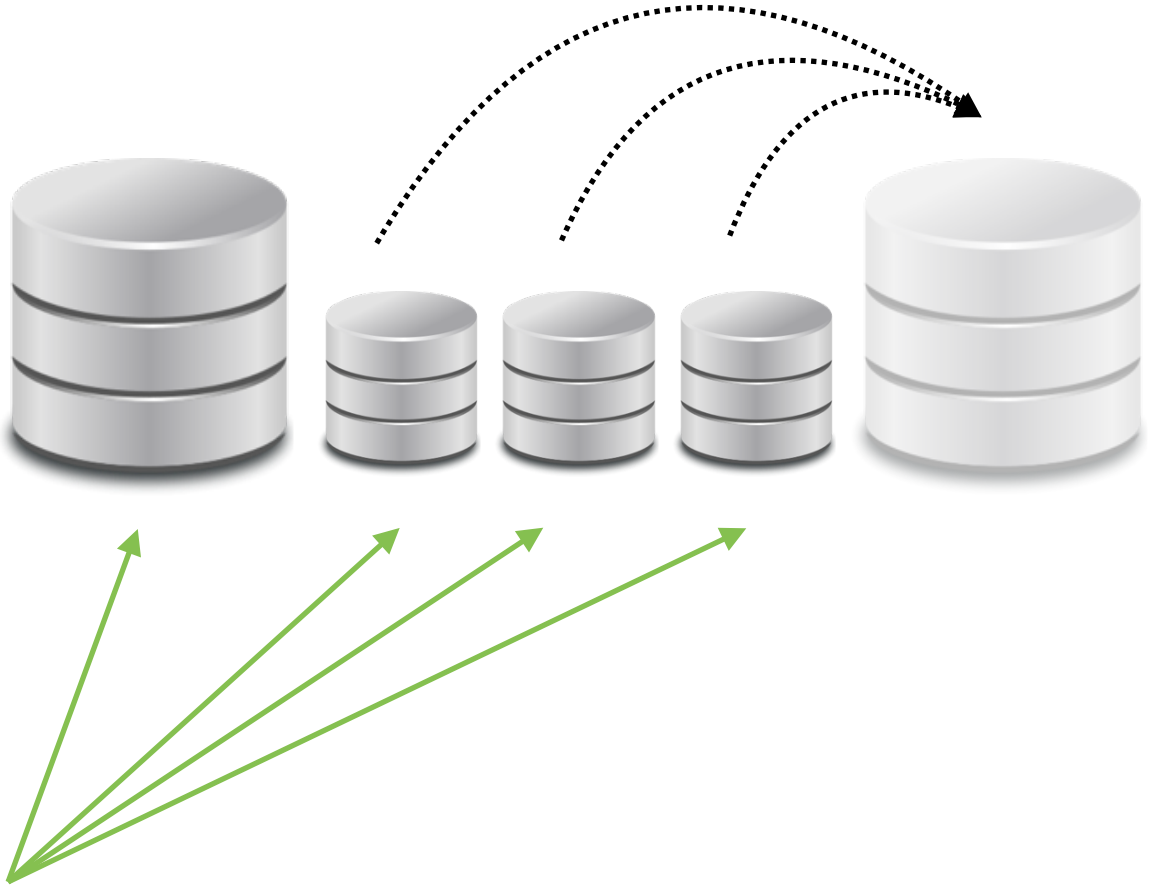
searchable

searchable

searchable

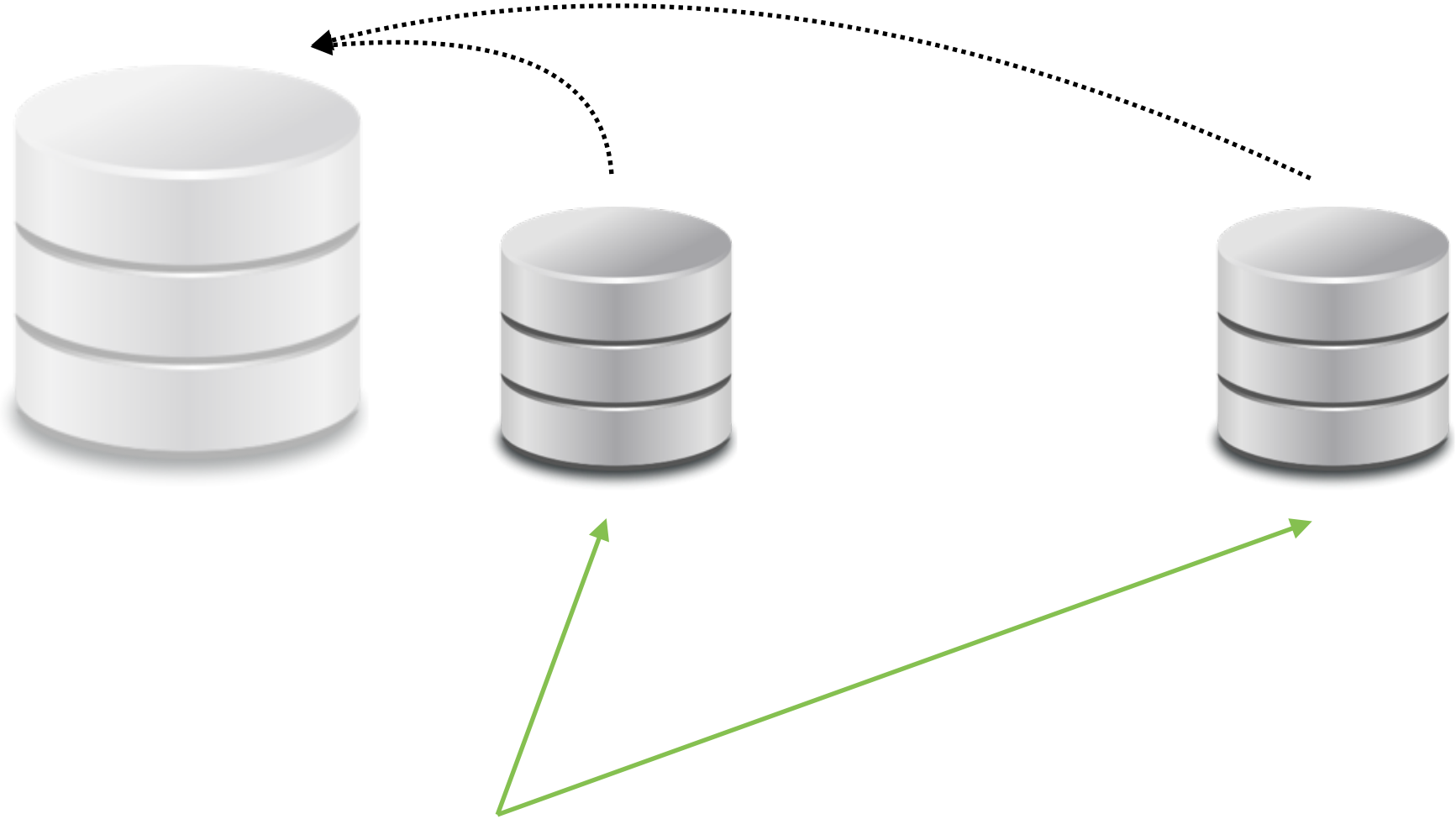


searchable



searchable

searchable



searchable

searchable

merge process

- many small → one big
- removes deleted docs
- runs in background
- throttled

but...

sometimes you need another truck

step 8:

scale out, not up

shard your data

shard your data

transparent in elasticsearch

many segments

many segments → one shard

many segments → one shard

many shards

many segments → one shard

many shards → one index

"node"

running instance of elasticsearch

≈ one server

"shard"

bucket of data

physical worker unit

lives on one node

"index"

logical namespace

points to one or more shards

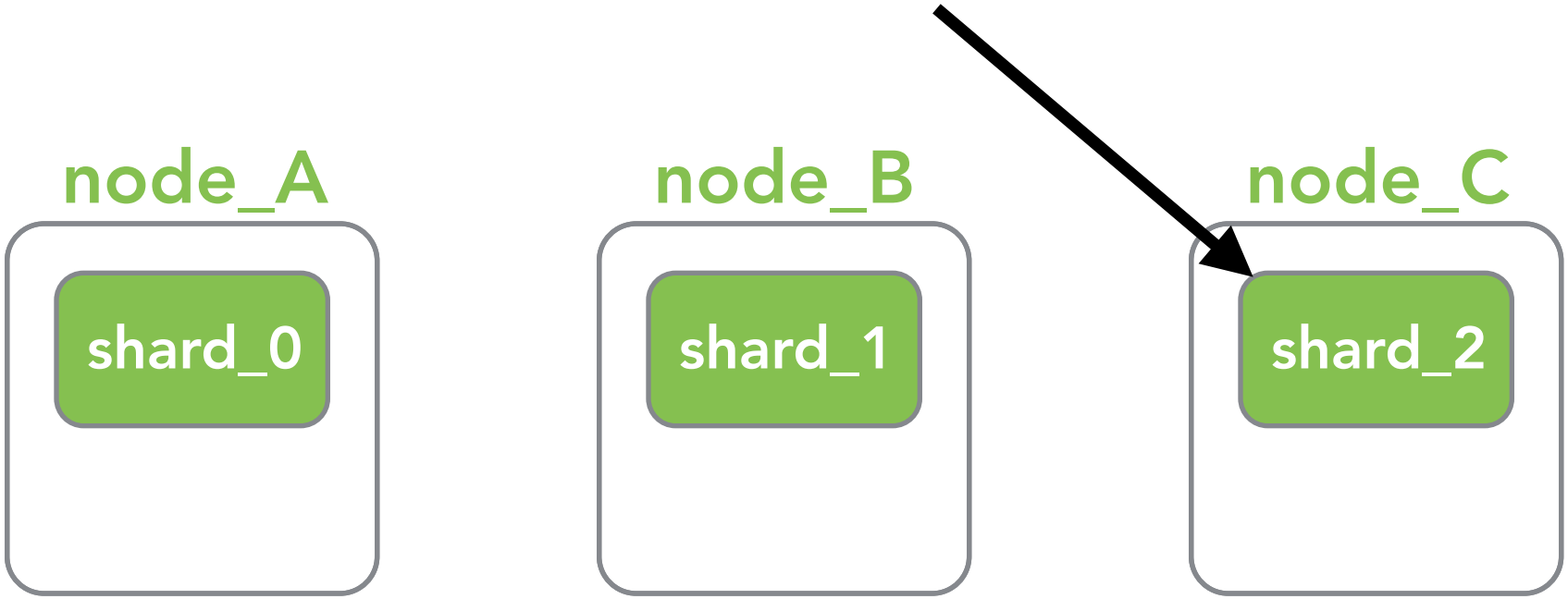
"index"

logical namespace

points to one or more shards

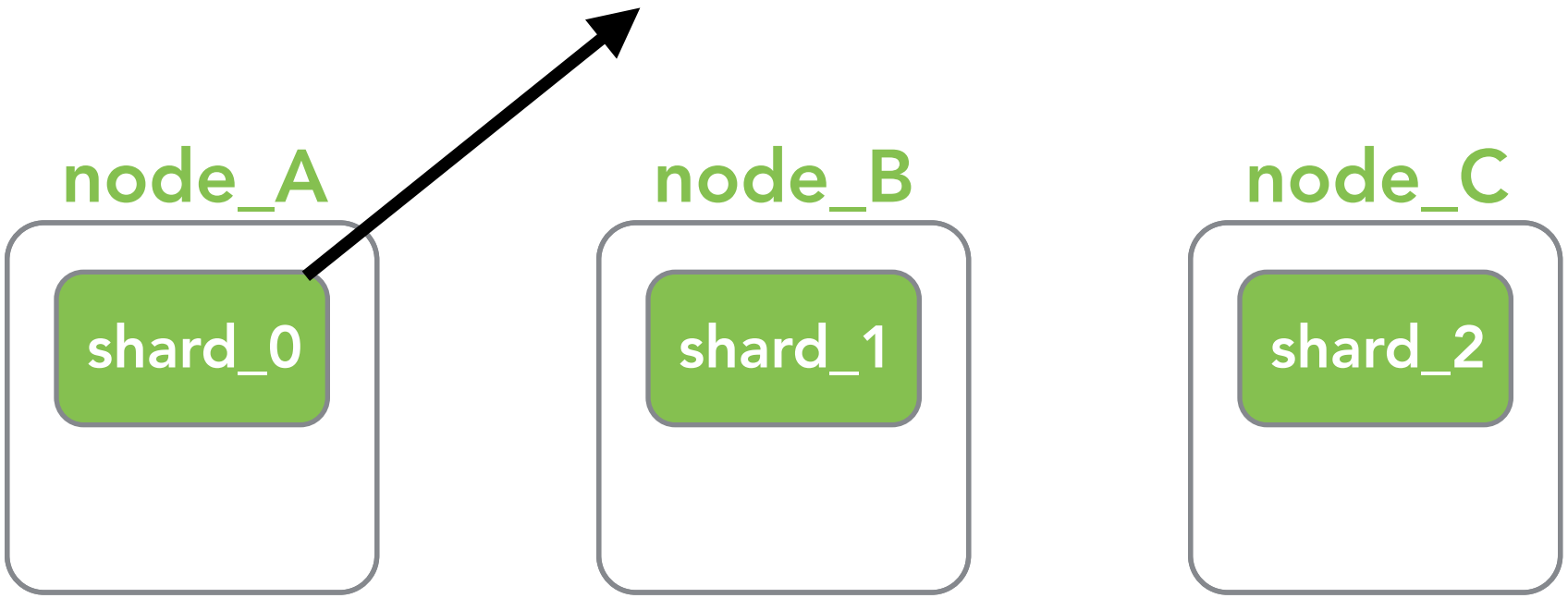
```
shard = hash(_id) % no_of_shards
```

PUT doc _id:1



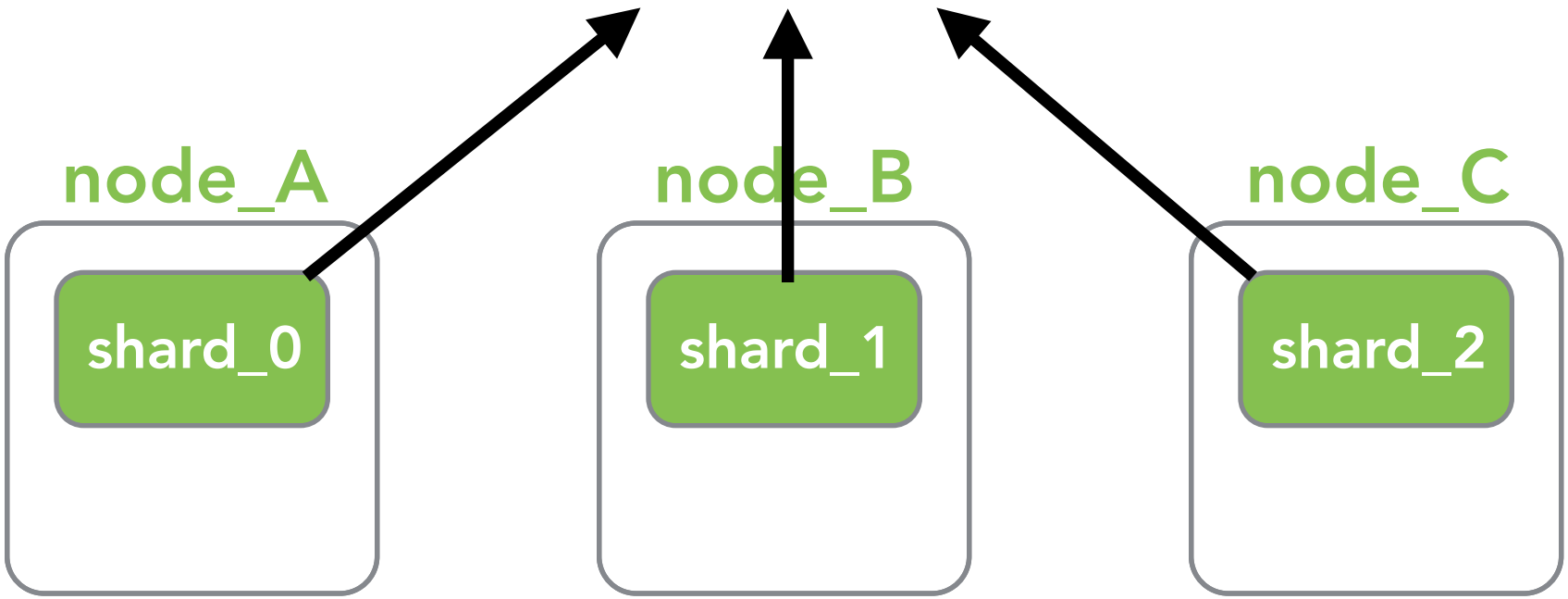

```
hash(1) % 3 ⇒ shard_2
```

GET doc _id:2




```
hash(2) % 3 ⇒ shard_0
```

Search all docs

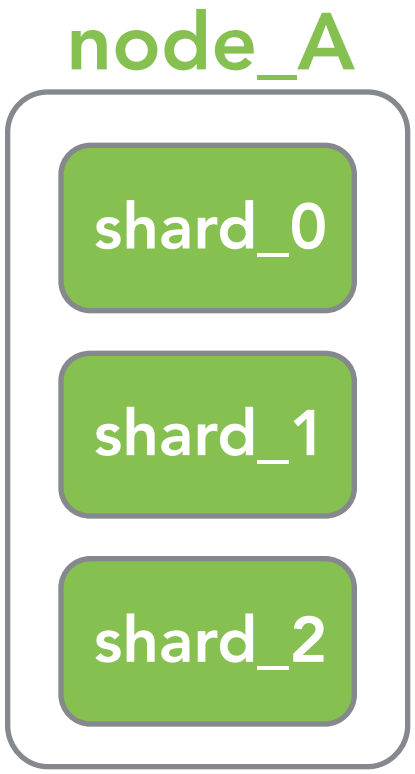


~~shard = hash(_id) % no_of_shards~~

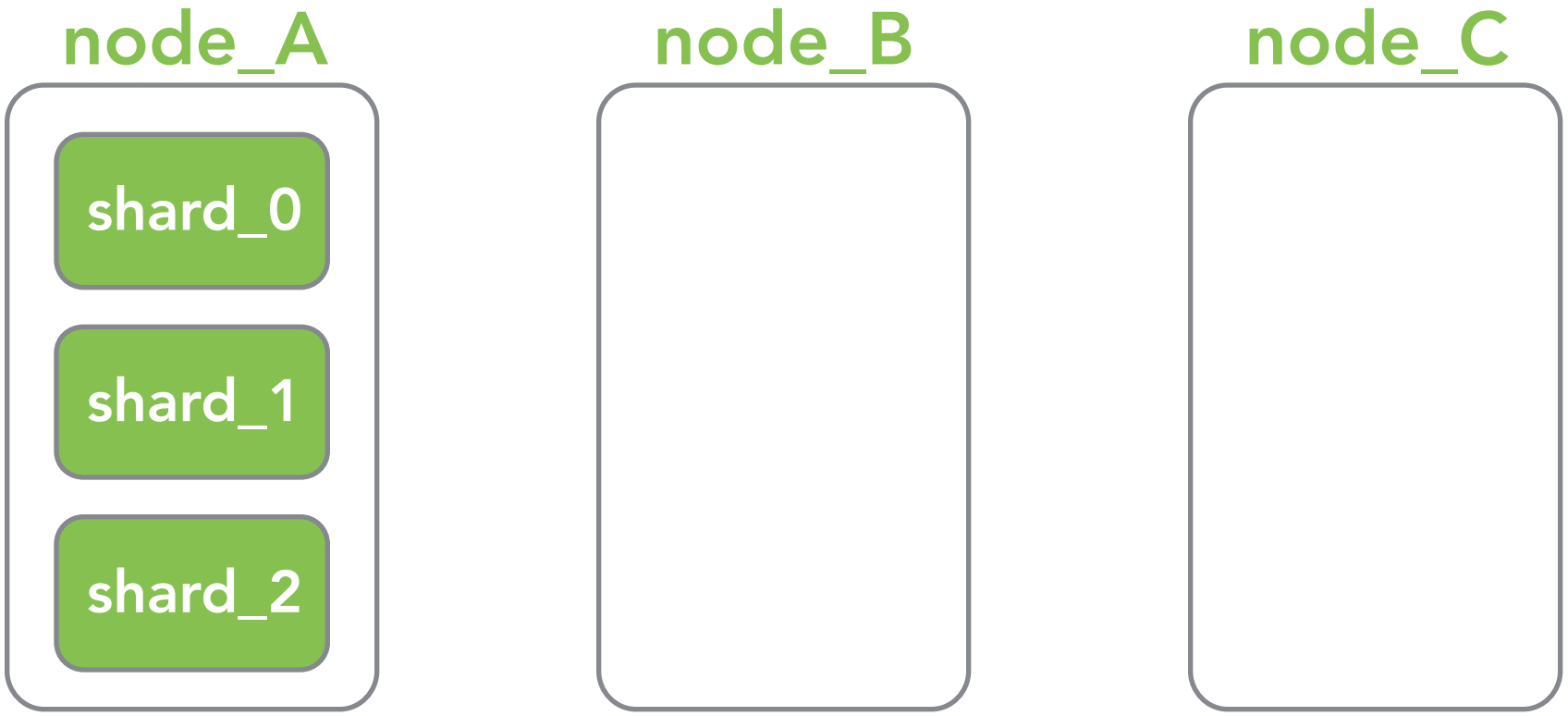
step 9:

scaling elastically

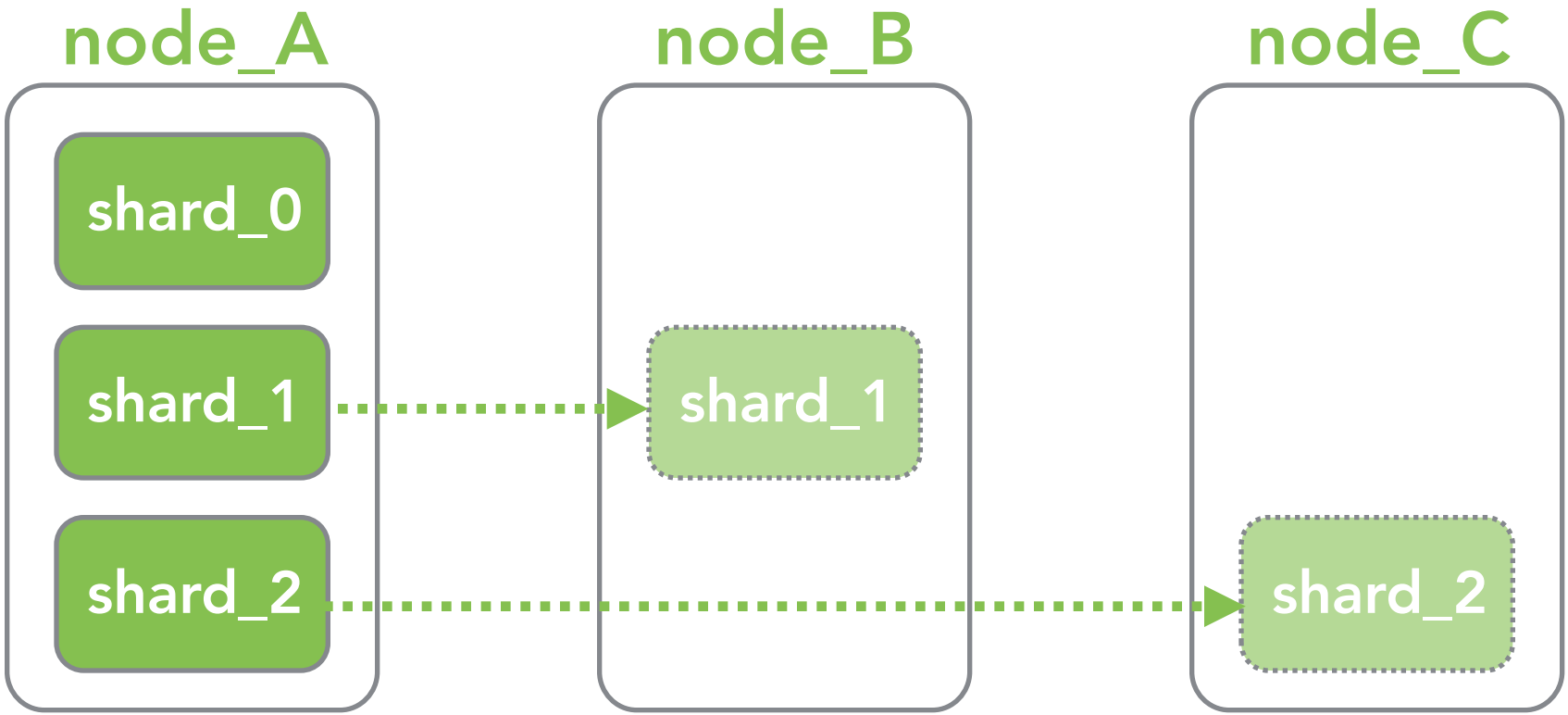
start small



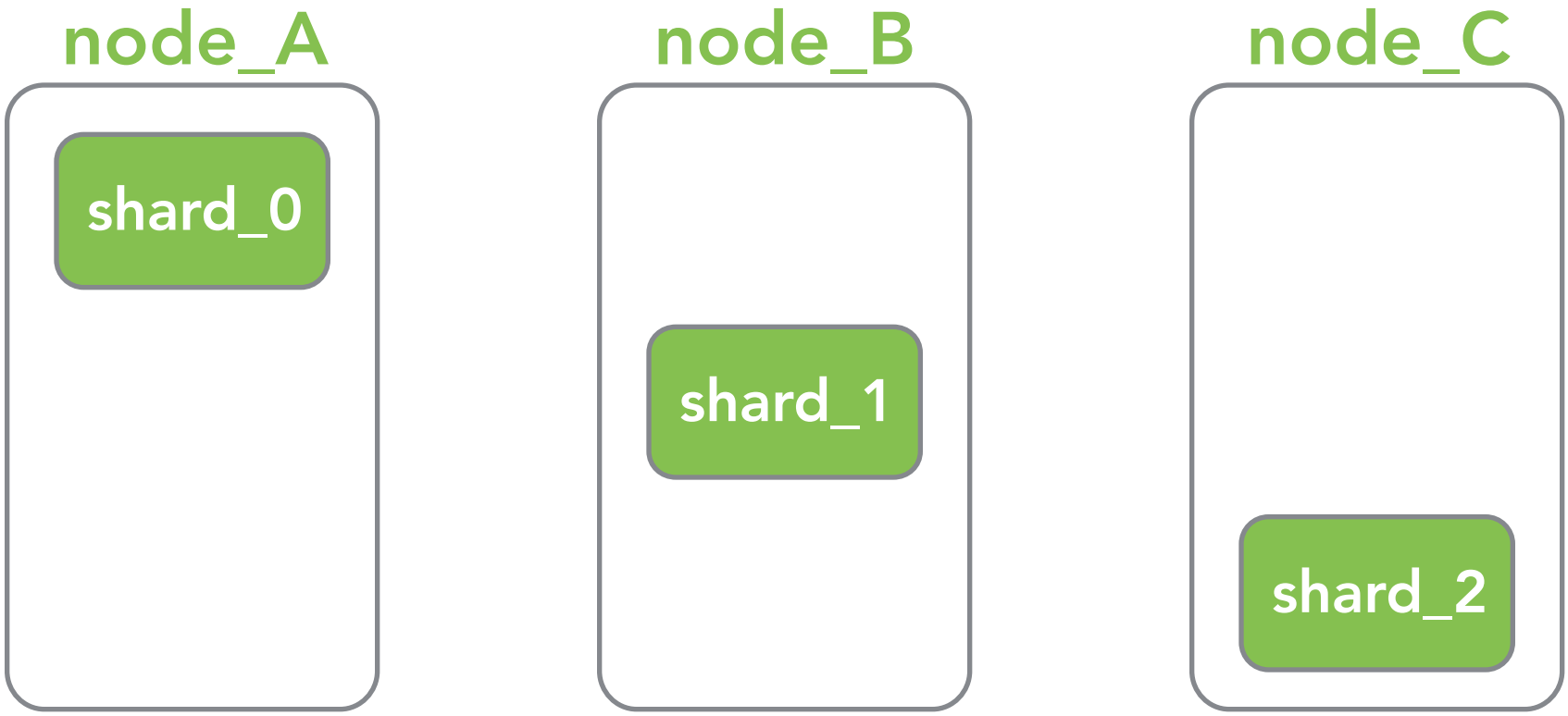
add more nodes



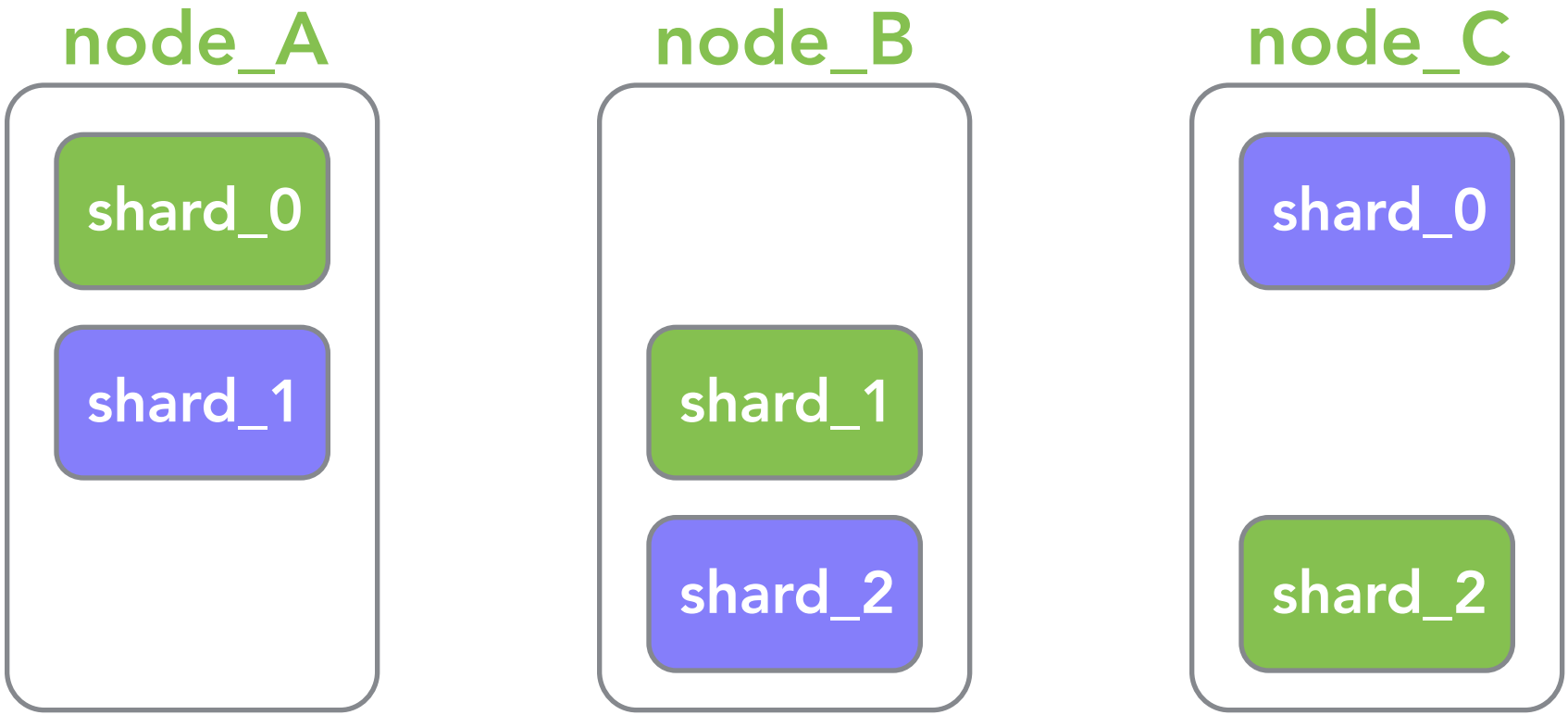
shards migrate



rebalanced



add new index



but...

but...

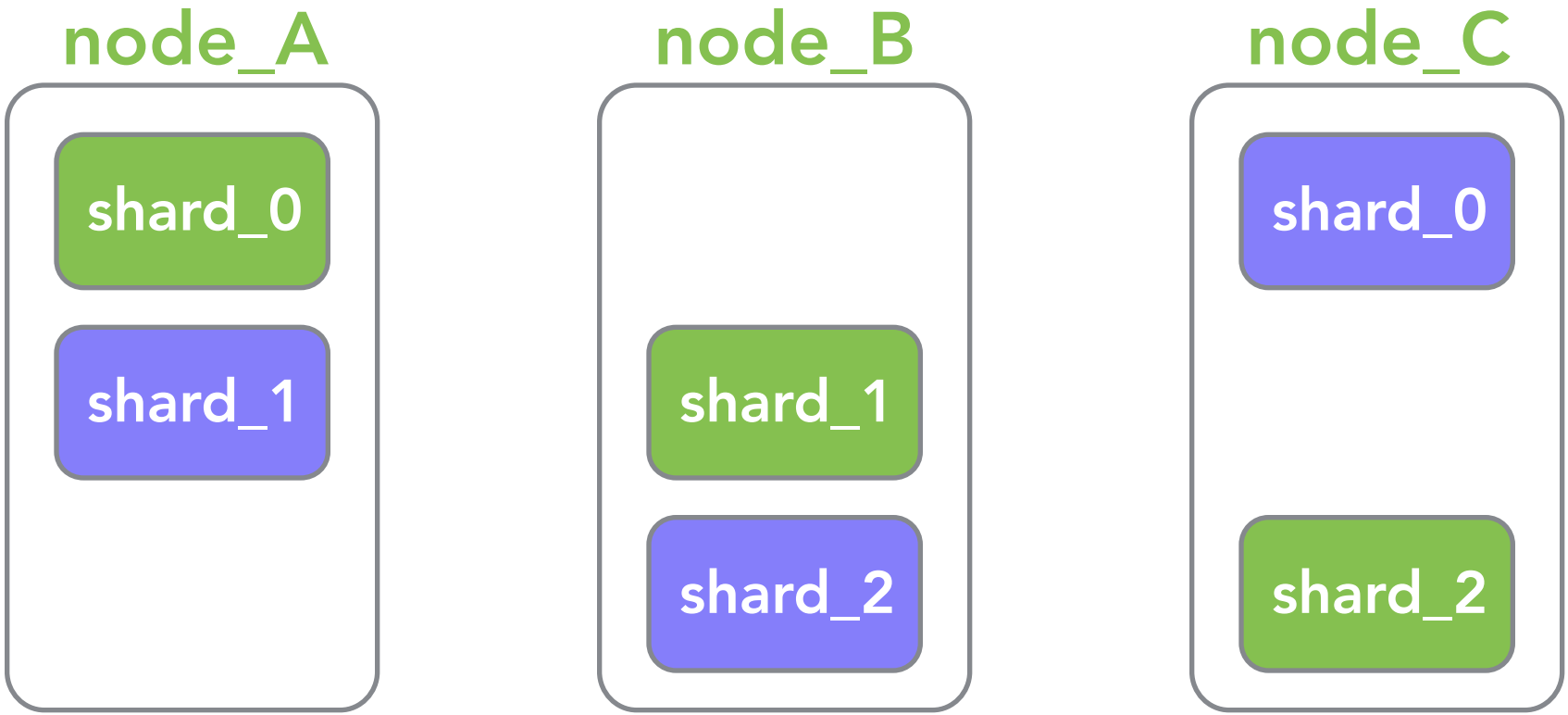
more hardware?

but...

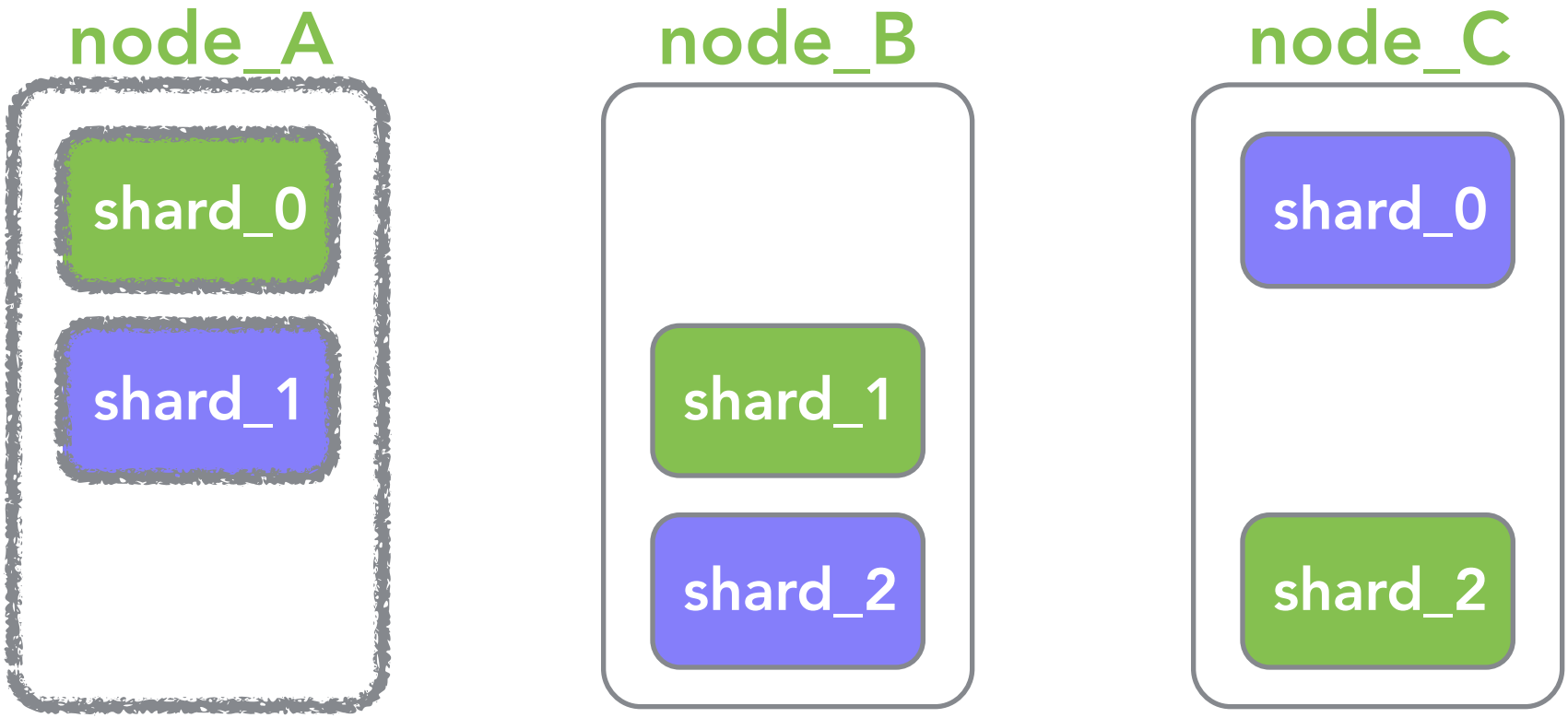
more hardware?

more hardware failure

at 3am on sunday...



boom!



step 10:

add redundancy

for every shard

...make a copy

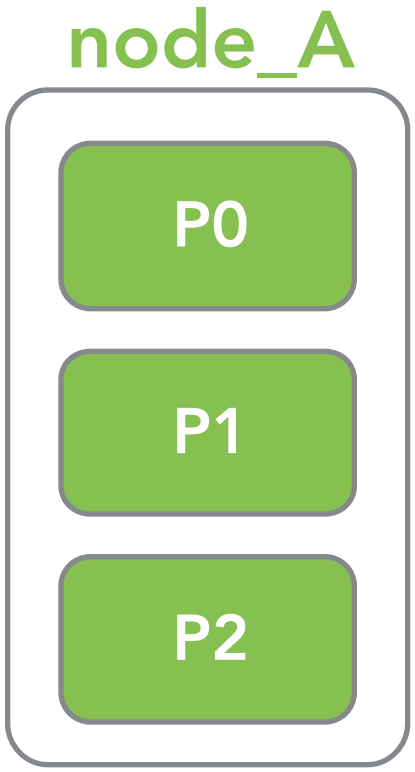
"primary shard"

main shard

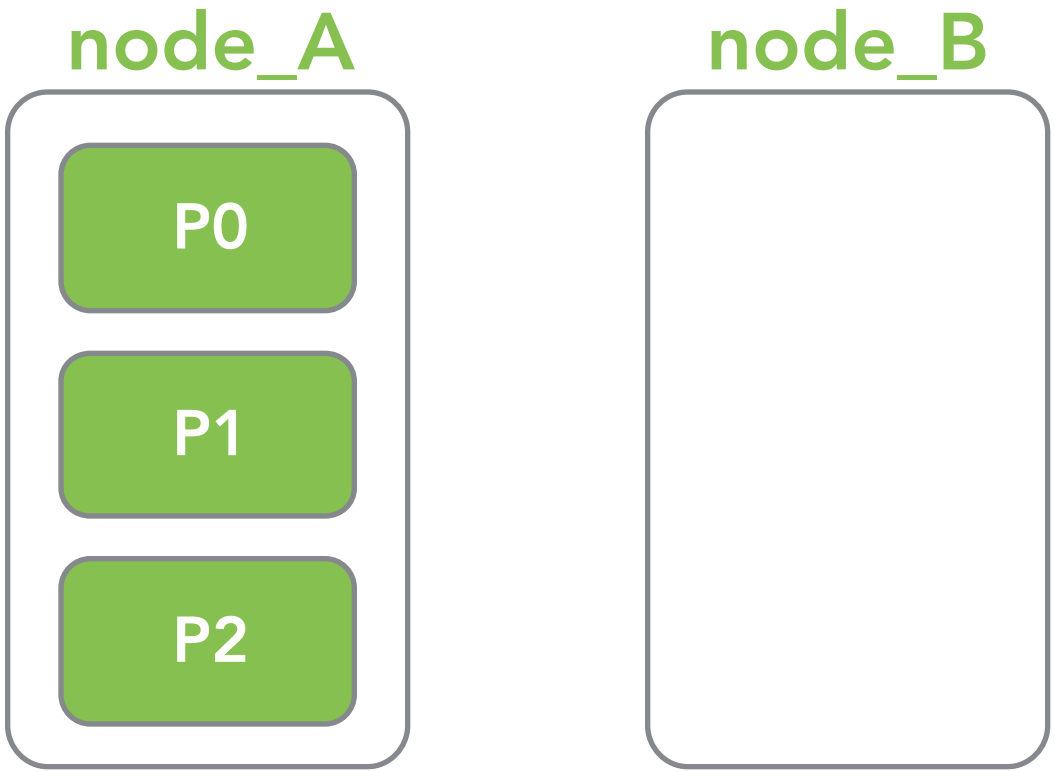
"replica shard(s)"

copy of primary shard

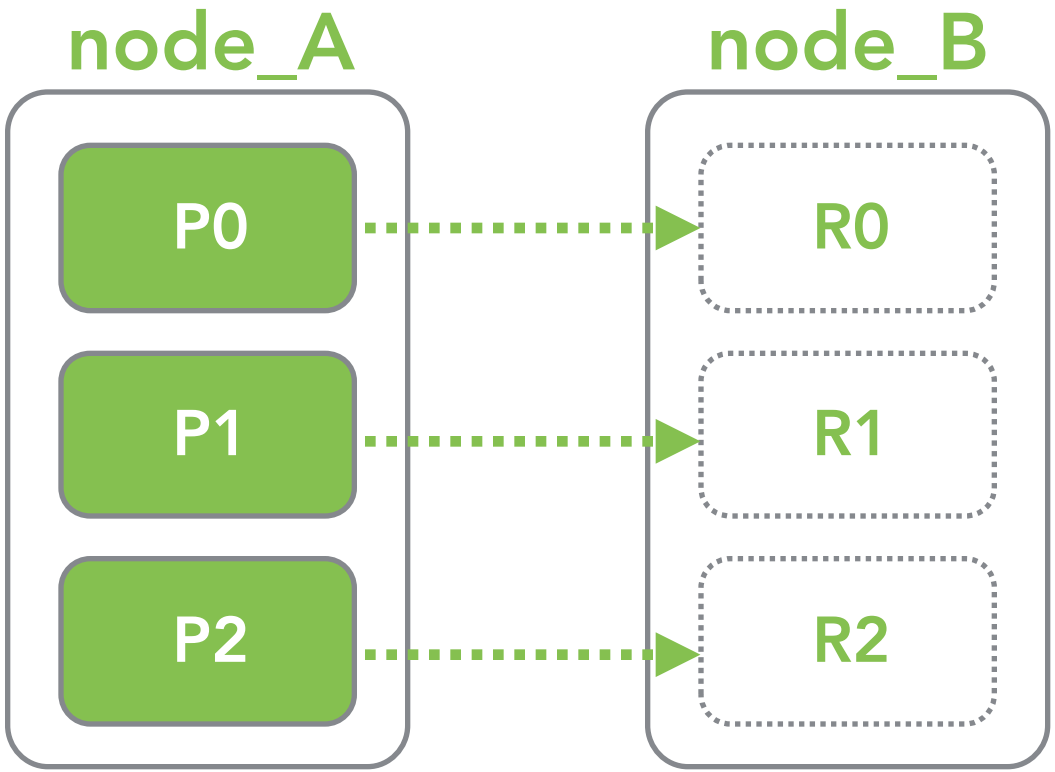
one node



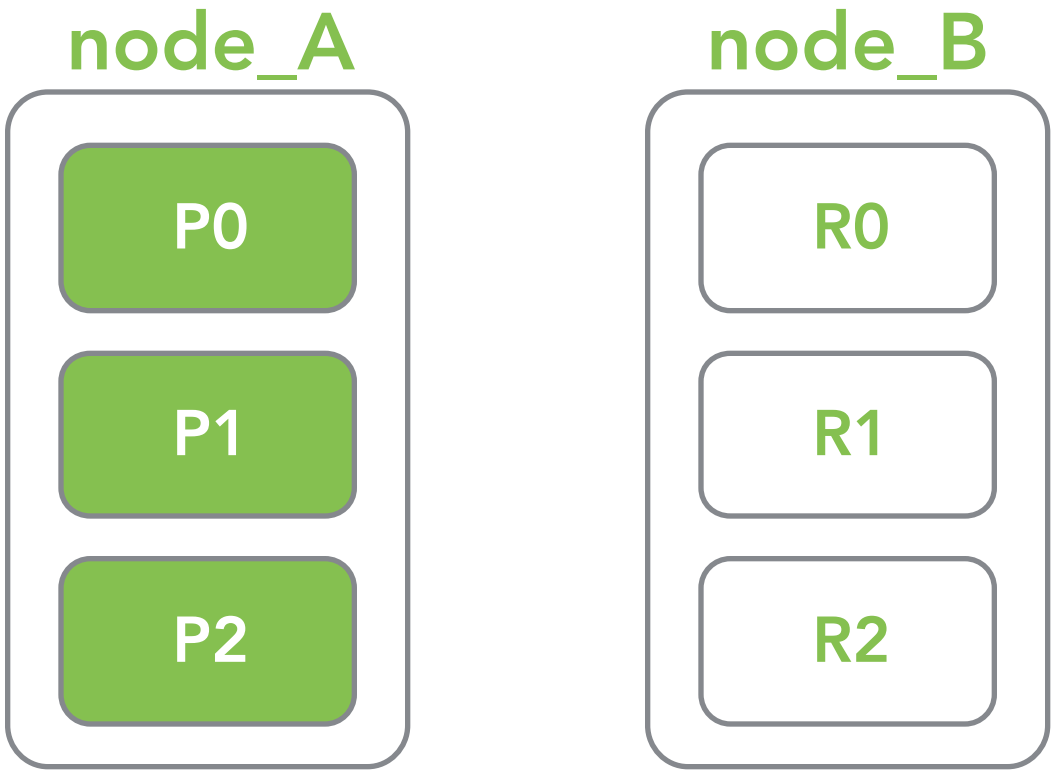
add a node



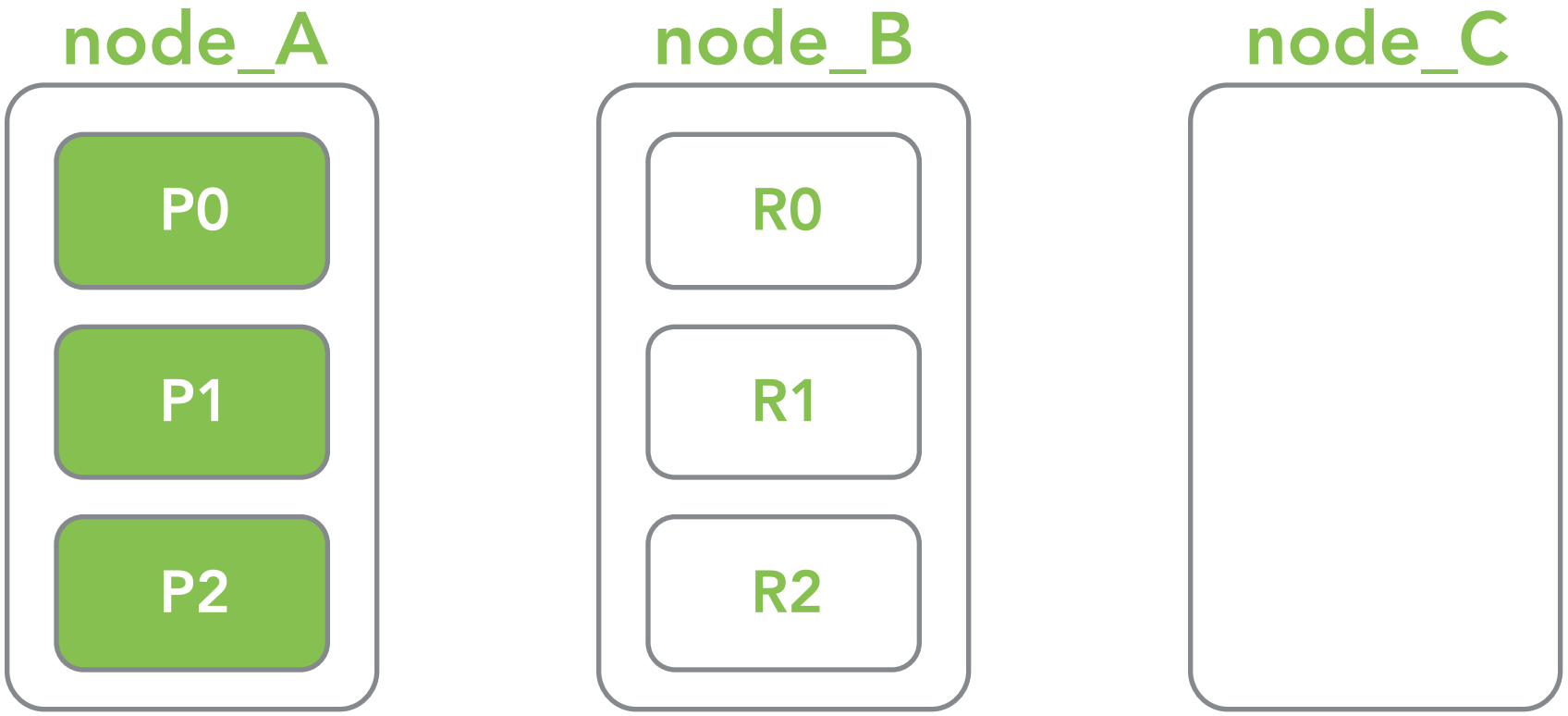
add a node



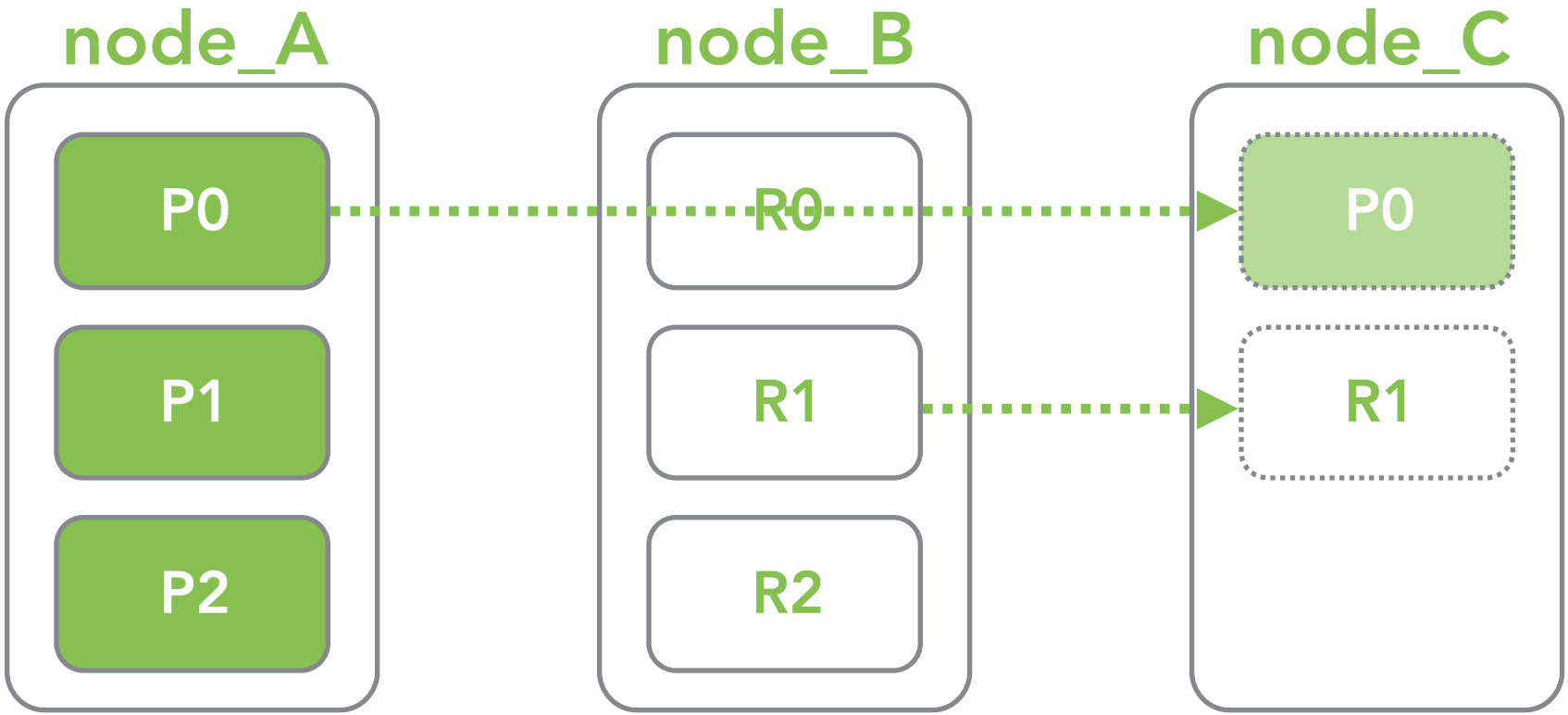
redundancy



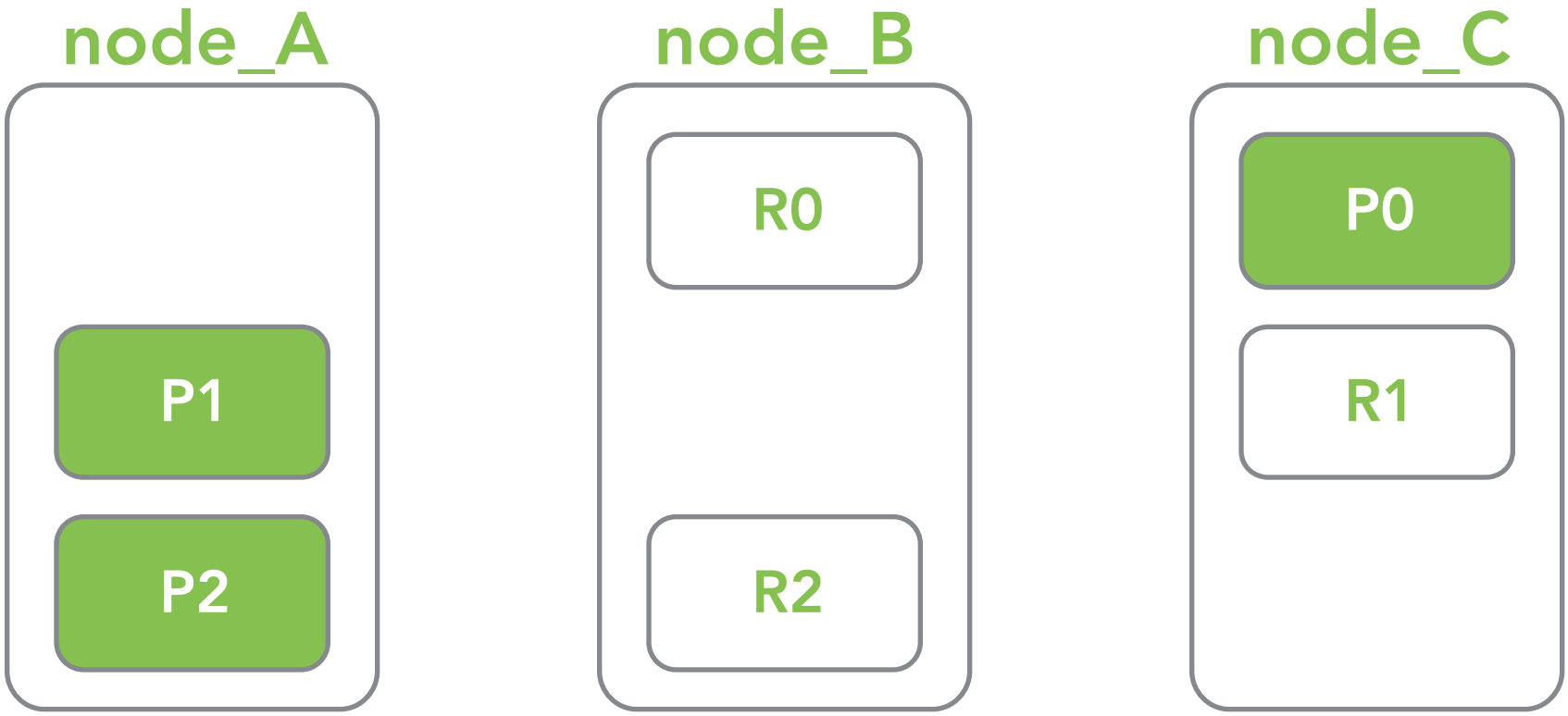
add a node



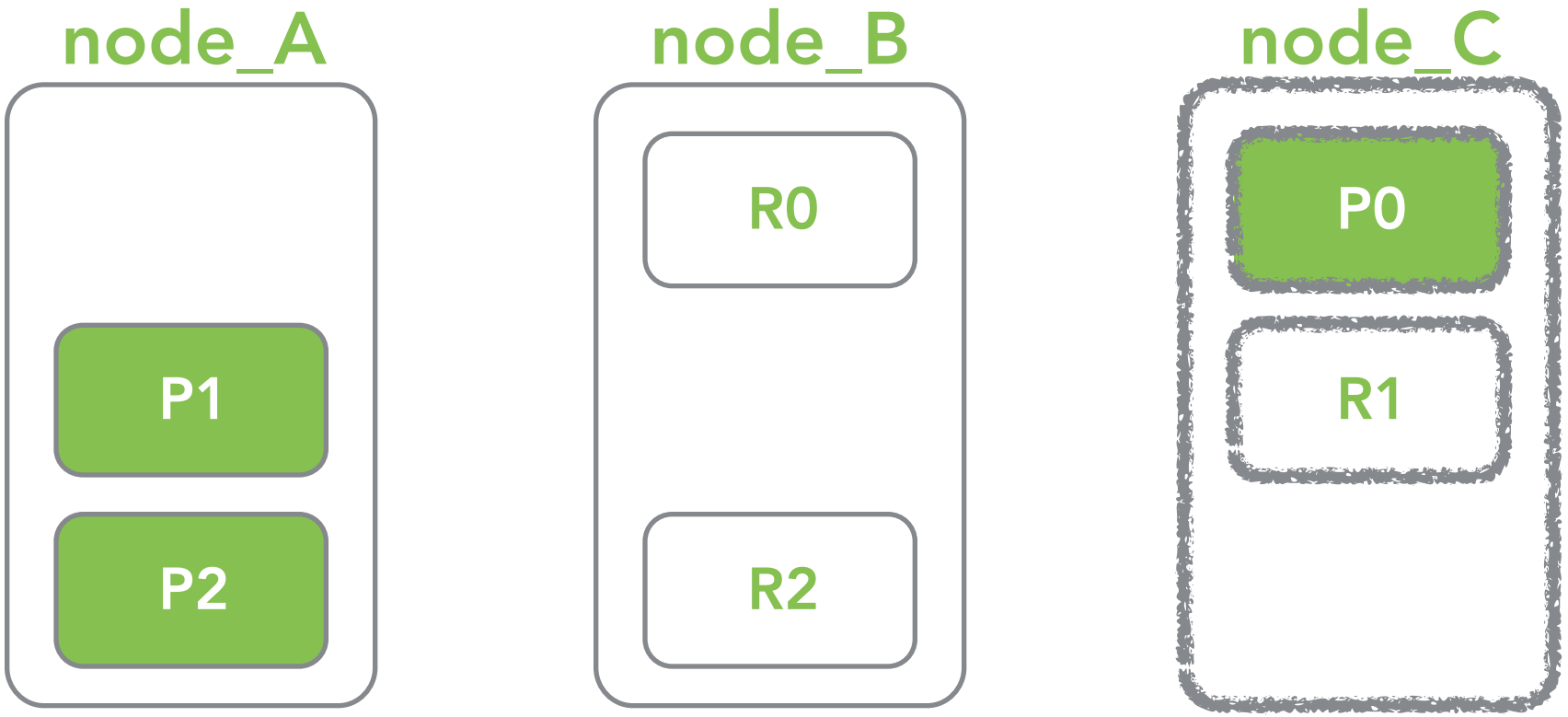
add a node



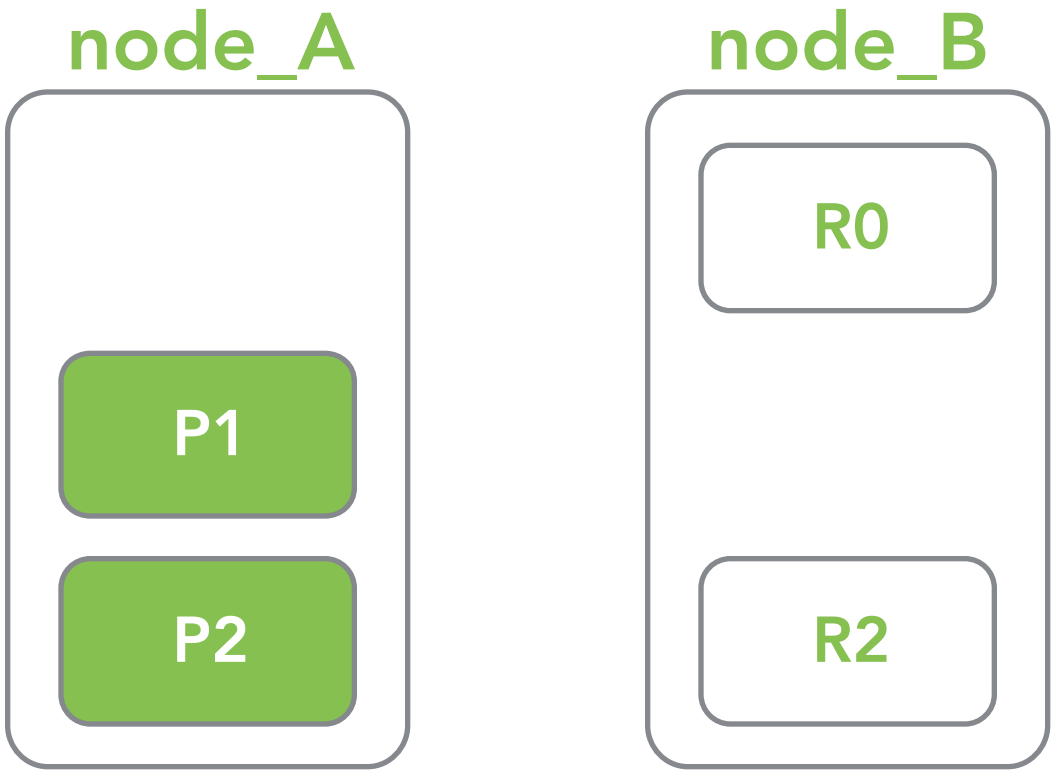
rebalanced



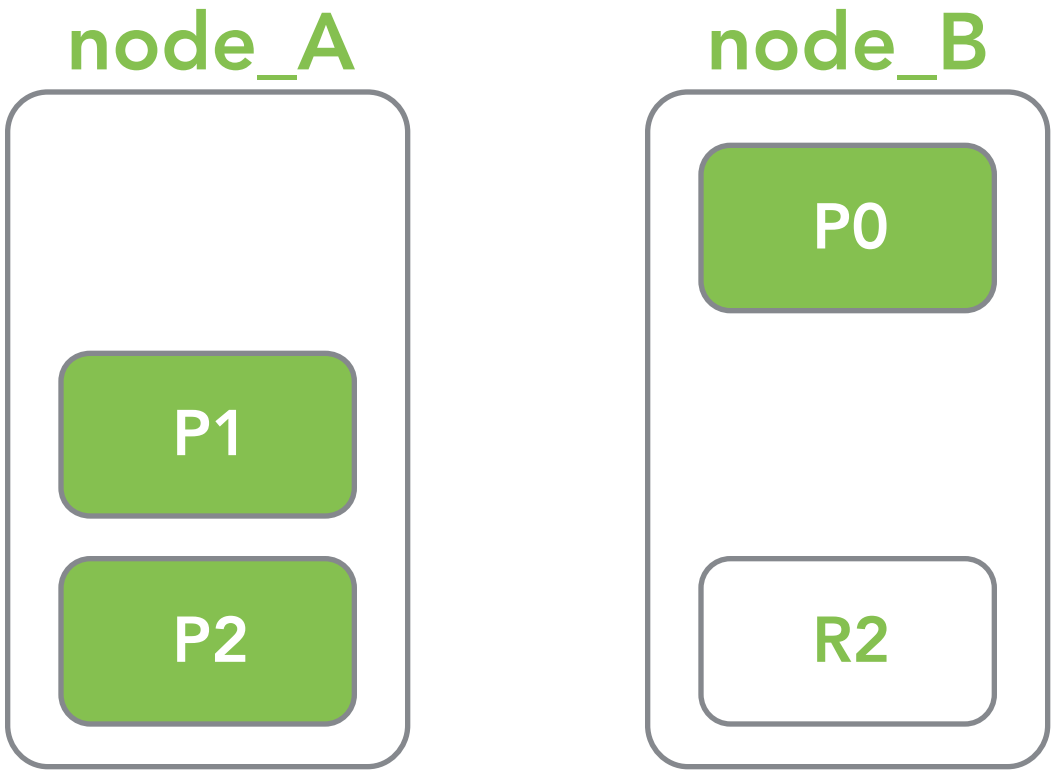
lose a node



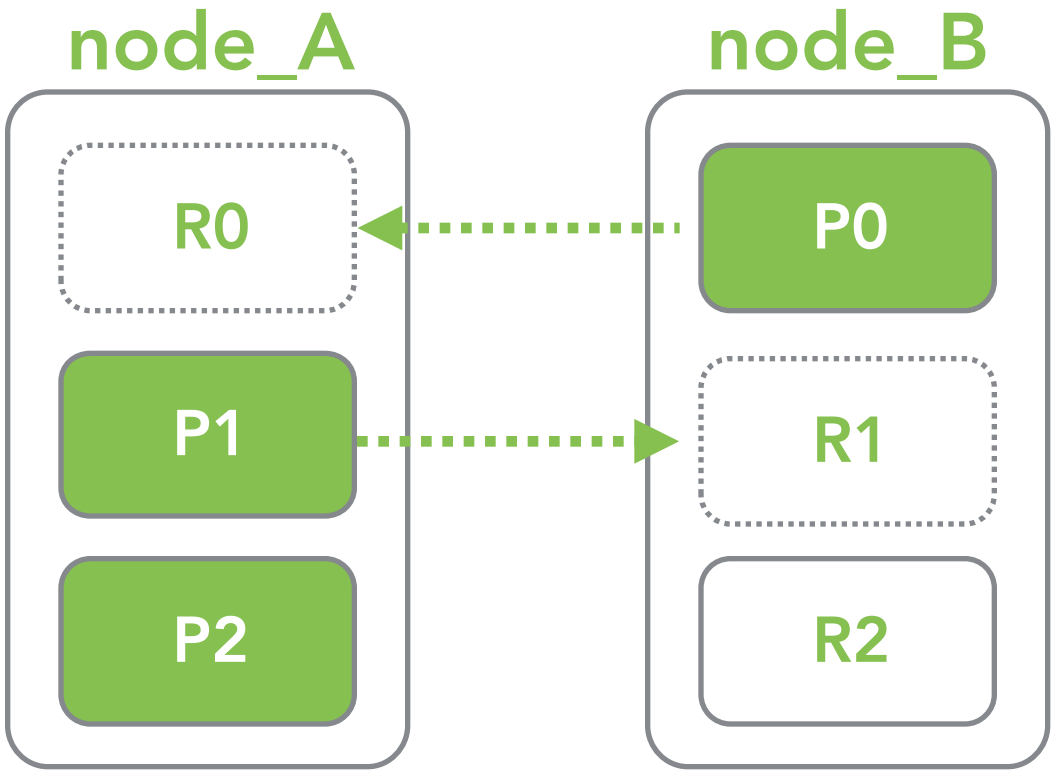
replica ⇒ primary



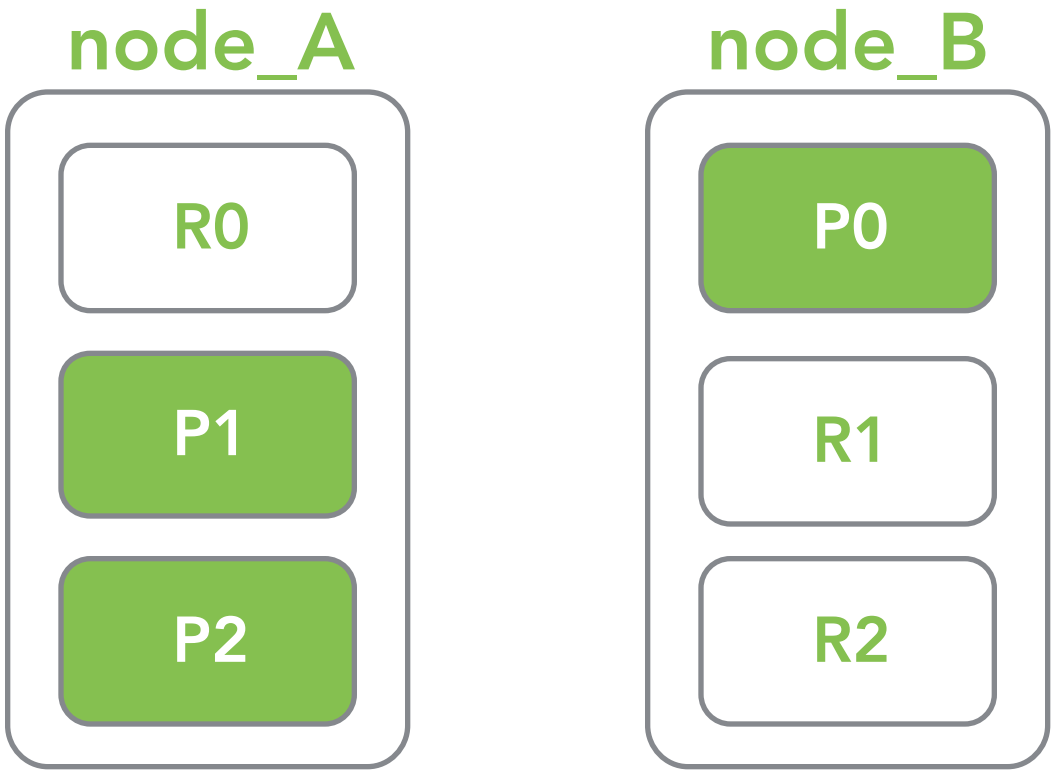
replica ⇒ primary



allocate replicas



rebalanced



primary shard

- just a role
- receives doc changes first
- forwards new doc to replicas in parallel
- number of primaries fixed

replica shard

- copy of primary shard
- serves read/search requests
- number of replicas can be changed
- more replicas → more read throughput
  if you have more hardware

but...

but...

who controls all this?

step 11:

the master node

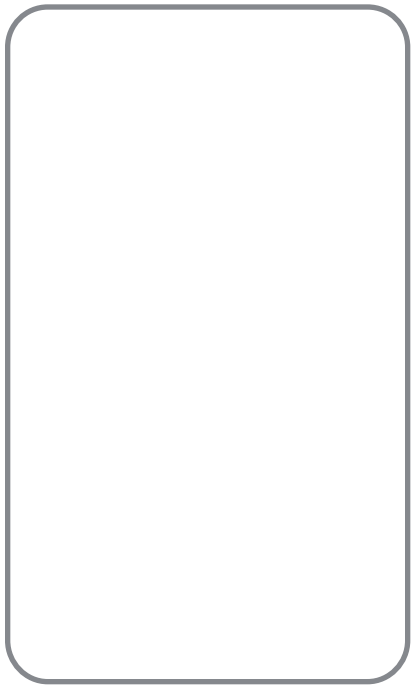
"node"

running instance of elastic search

"node"

running instance of elastic search

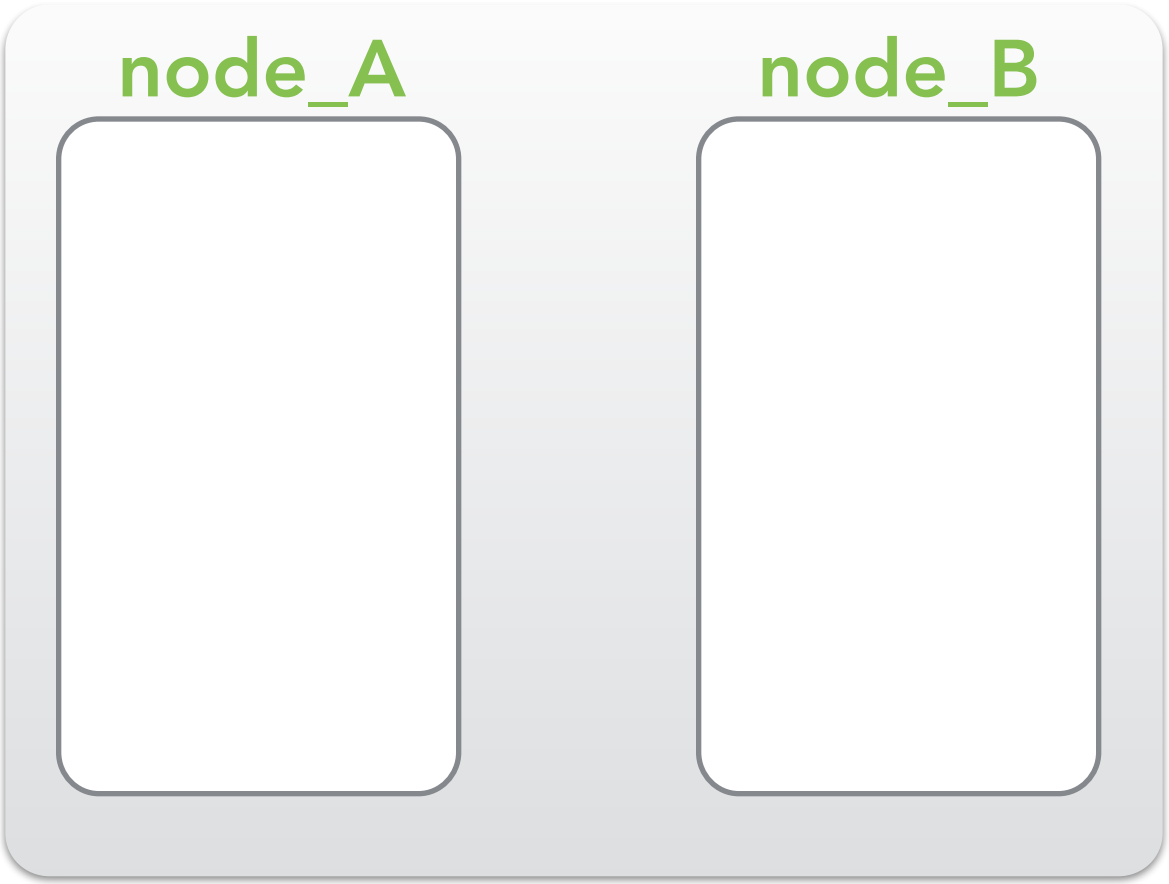
node_A



"cluster"

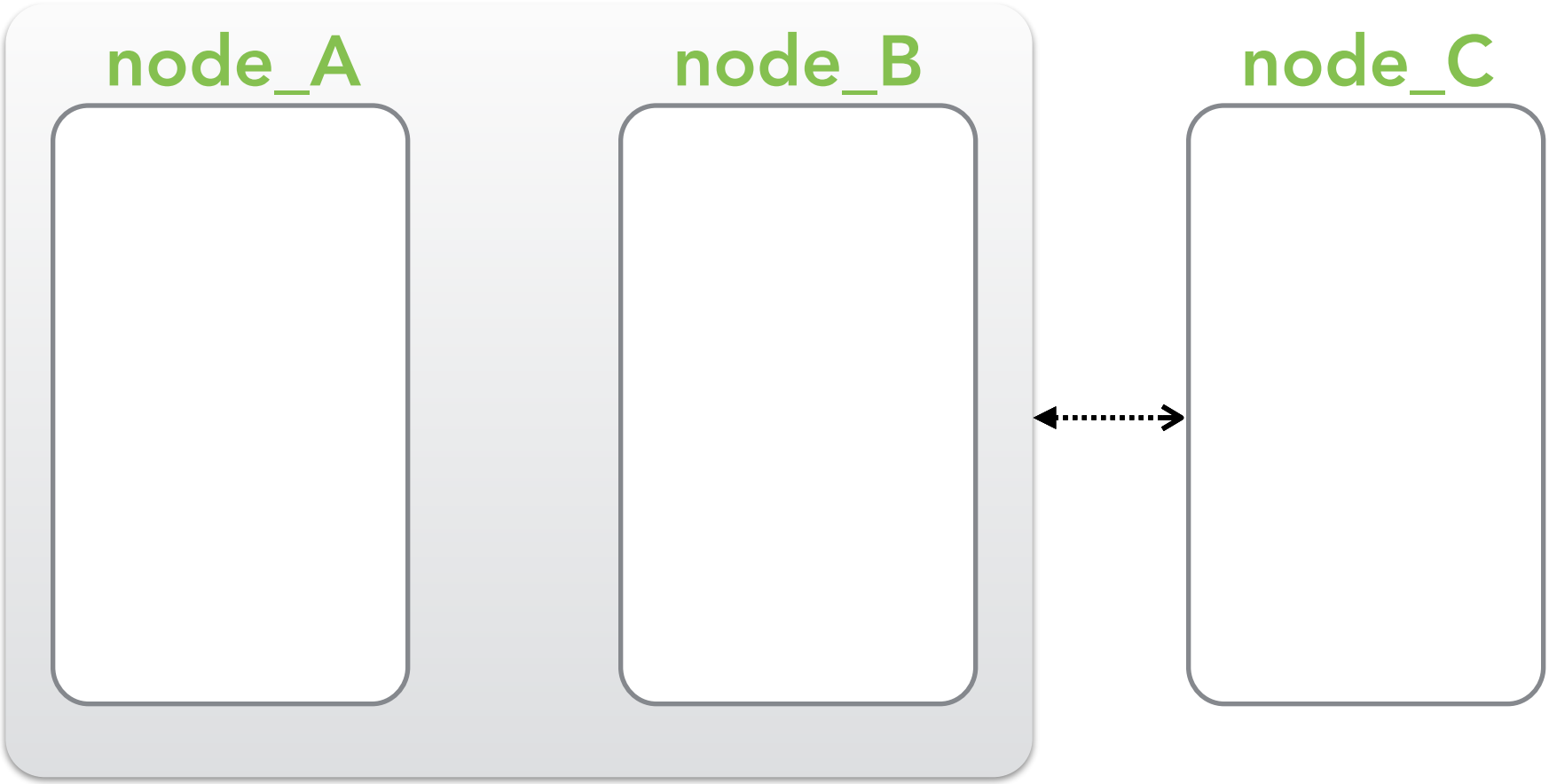
one or more nodes
with same cluster name
working together

"cluster"



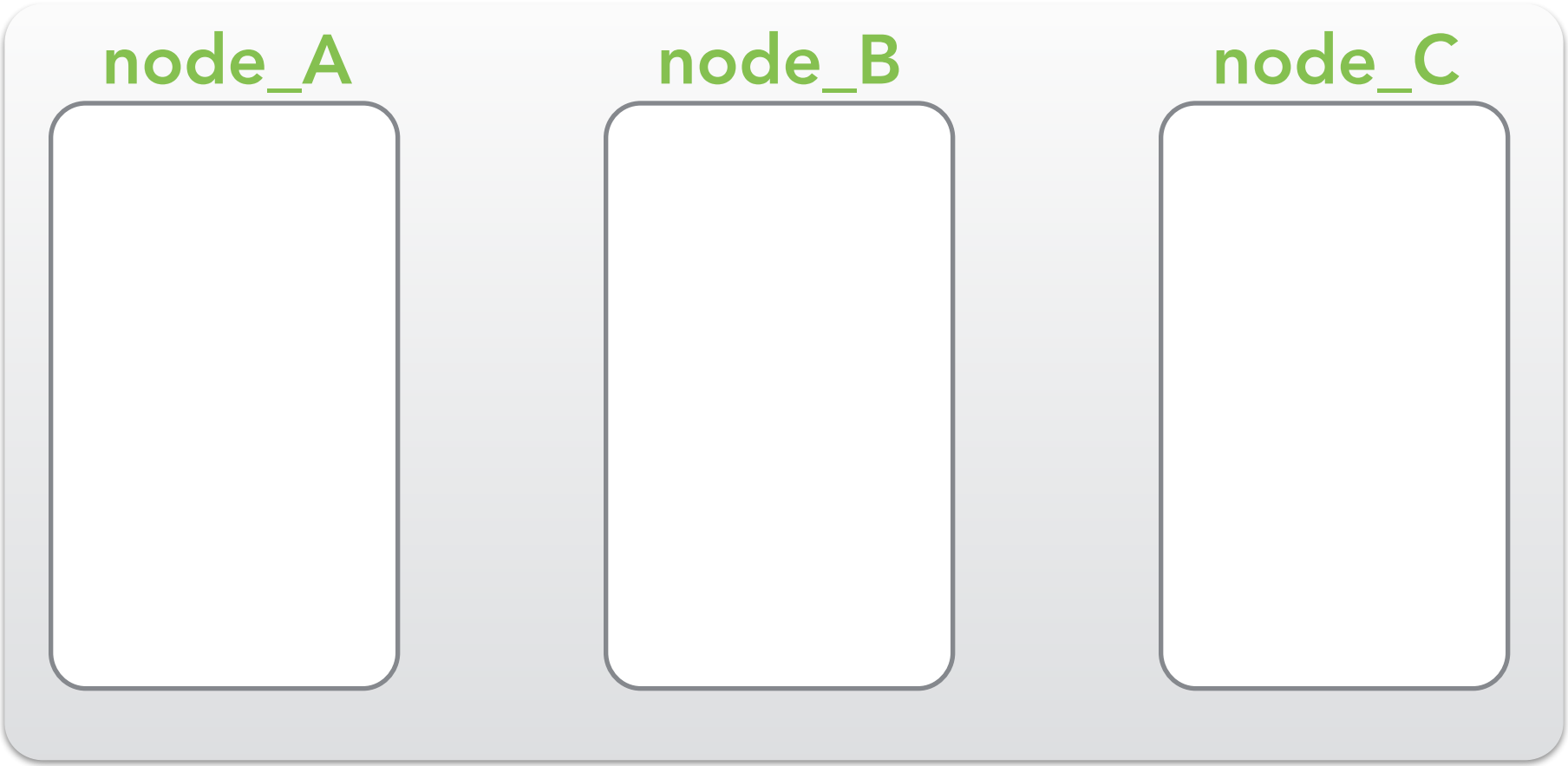
discover a cluster

with multicast/unicast



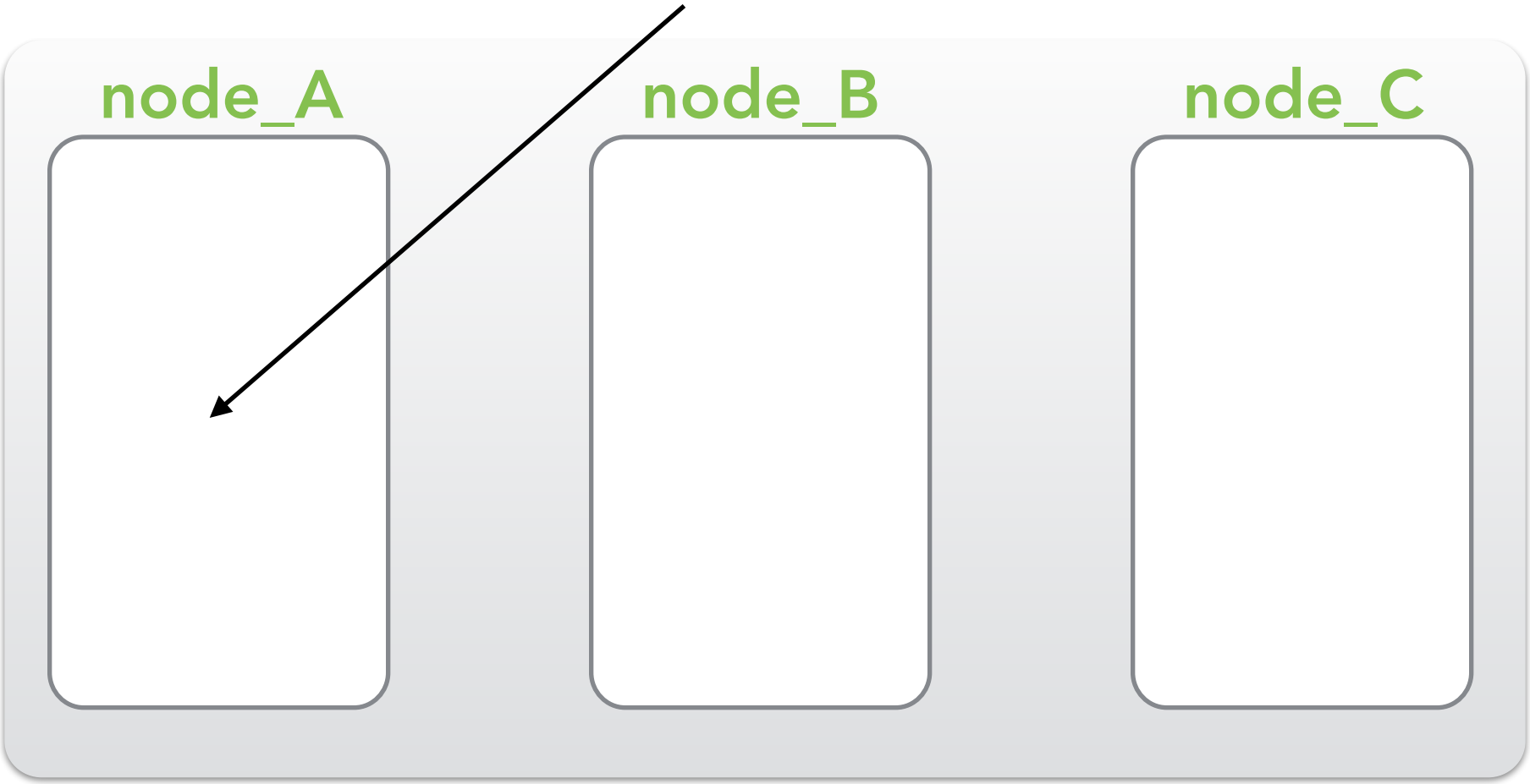
discover a cluster

with multicast/unicast



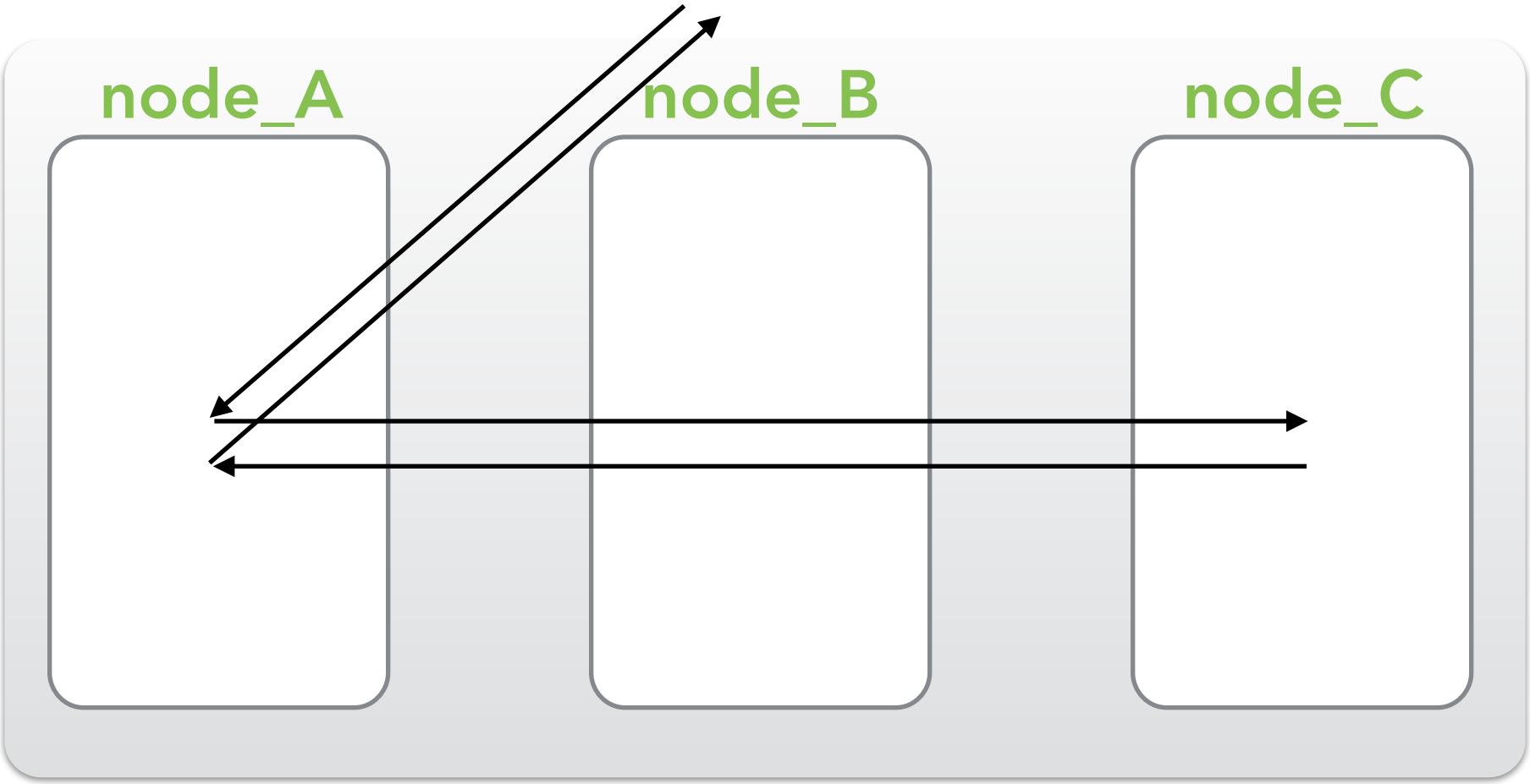
request routing

send request to any node



request routing

forwards to correct node



how?

how?

every node knows where every document is

cluster state

every node knows where every document is

cluster state

cluster level information

cluster state

cluster level information

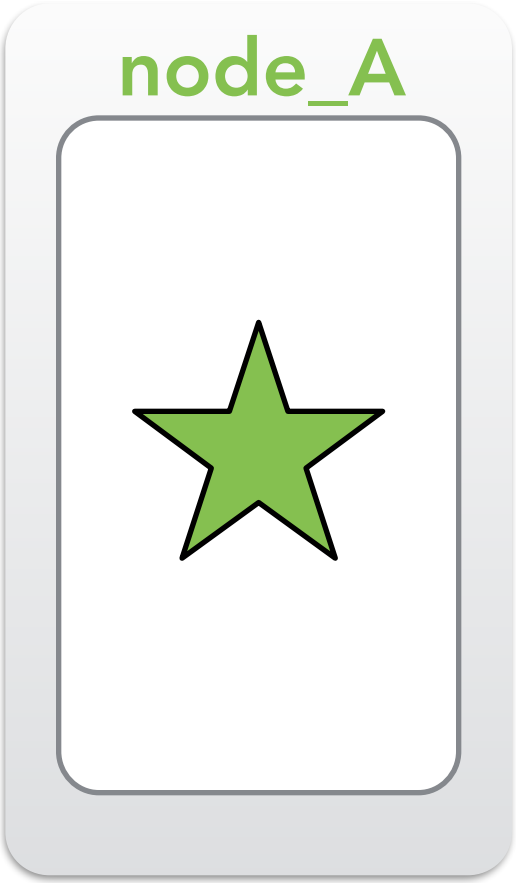
indices ⇔ shards ⇔ nodes

cluster state

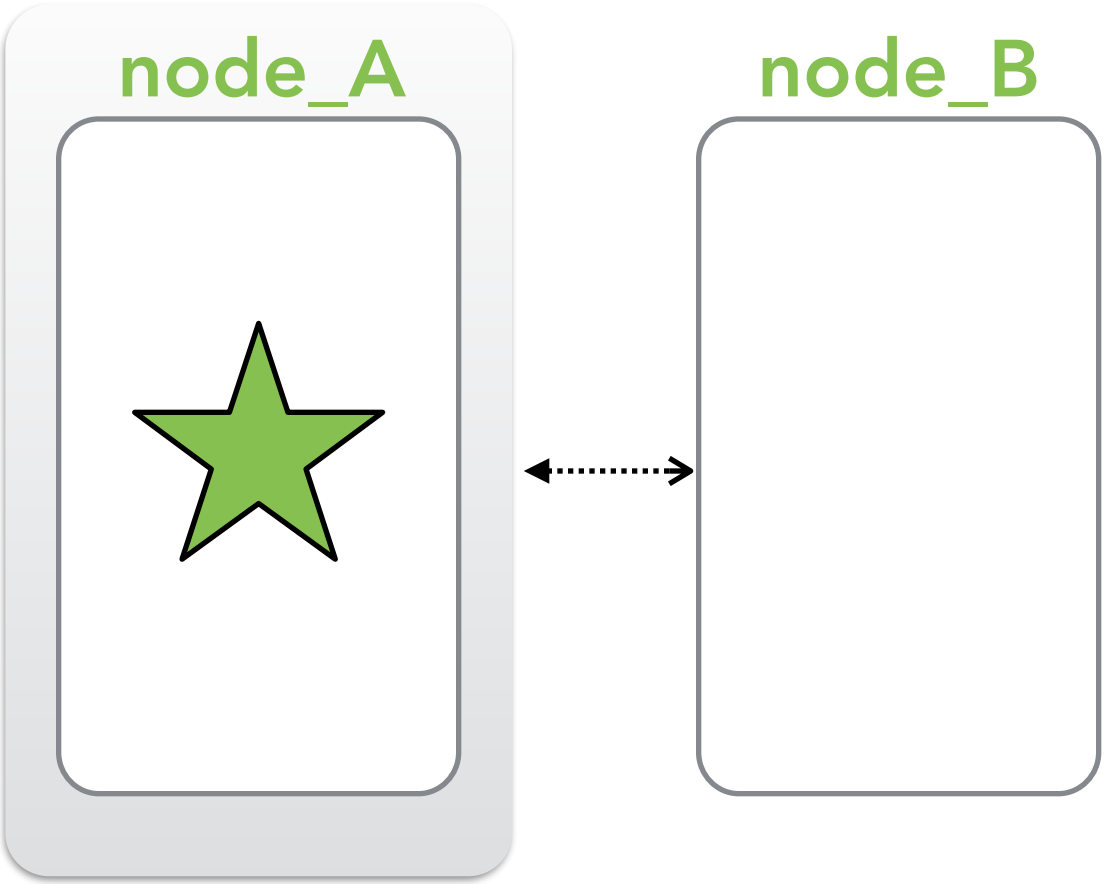
can only be updated by the master node

master node

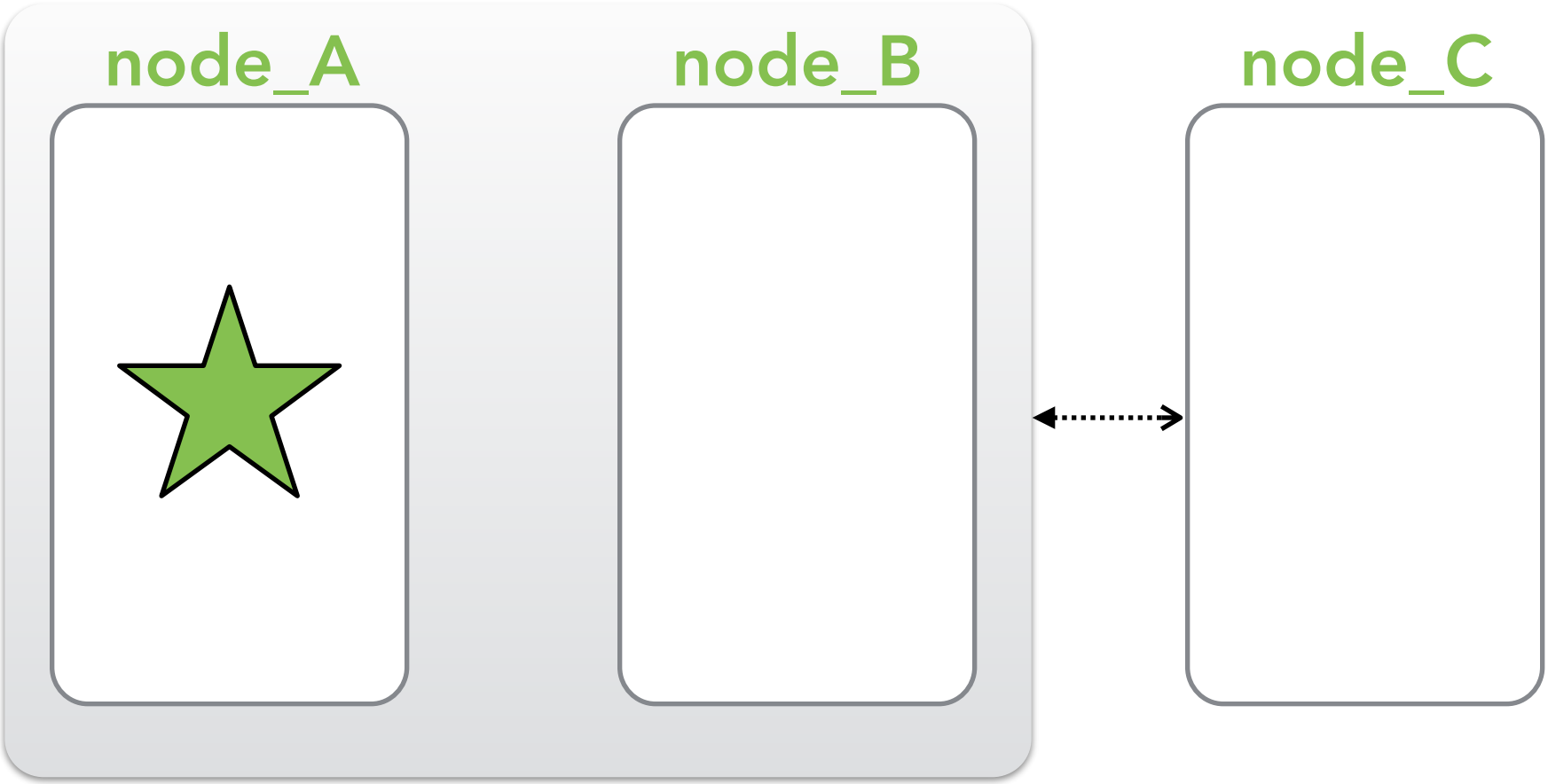
elected when cluster forms



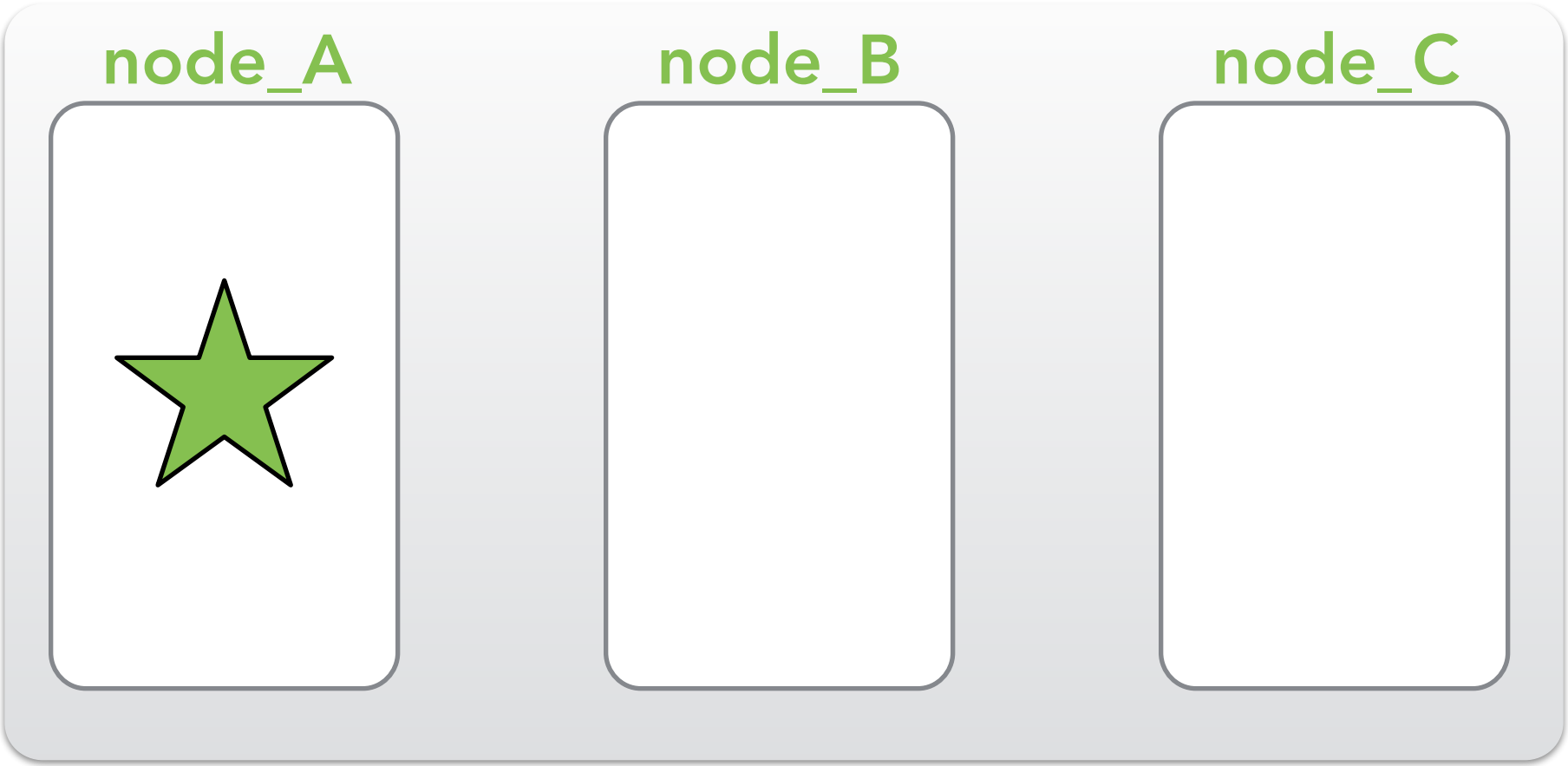
master node



master node

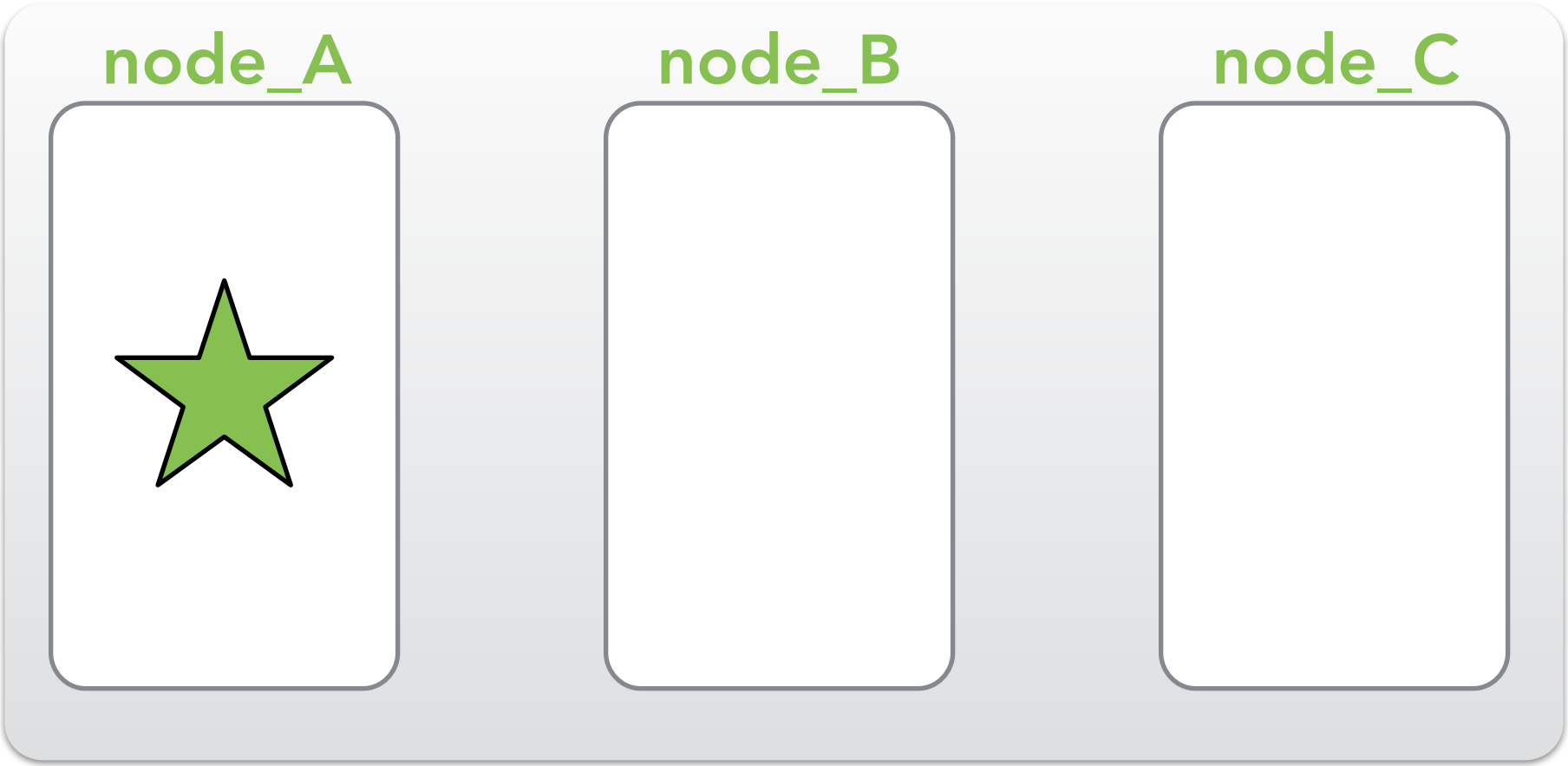


master node



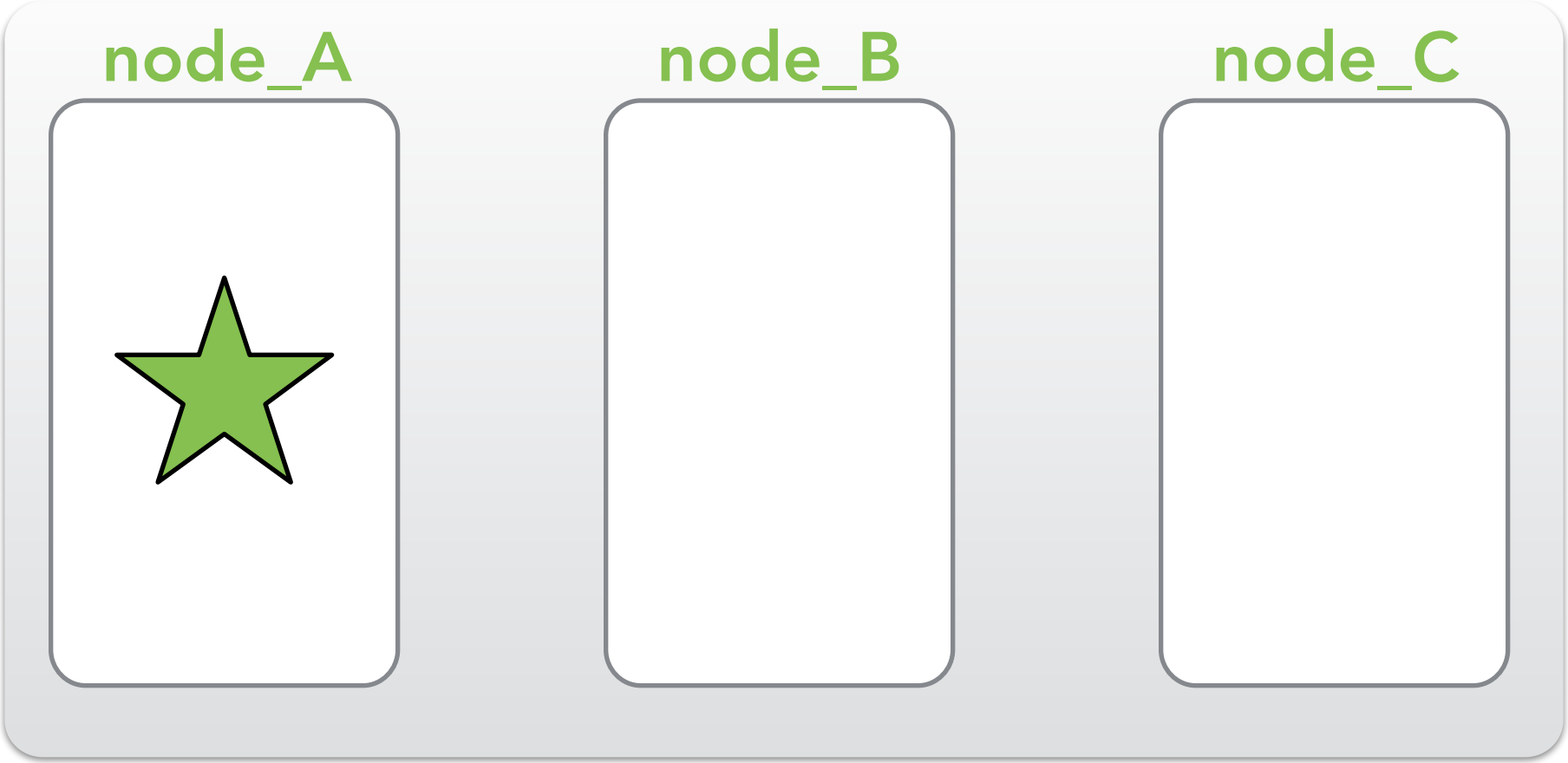
master node

just a role



master node

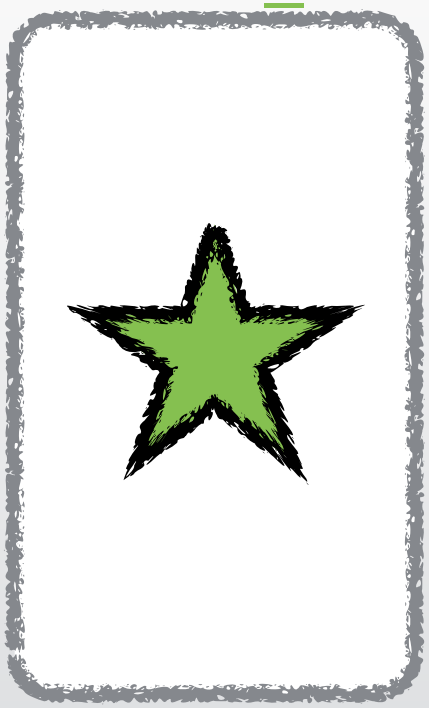
re-elected if master fails



master node

re-elected if master fails

node_A

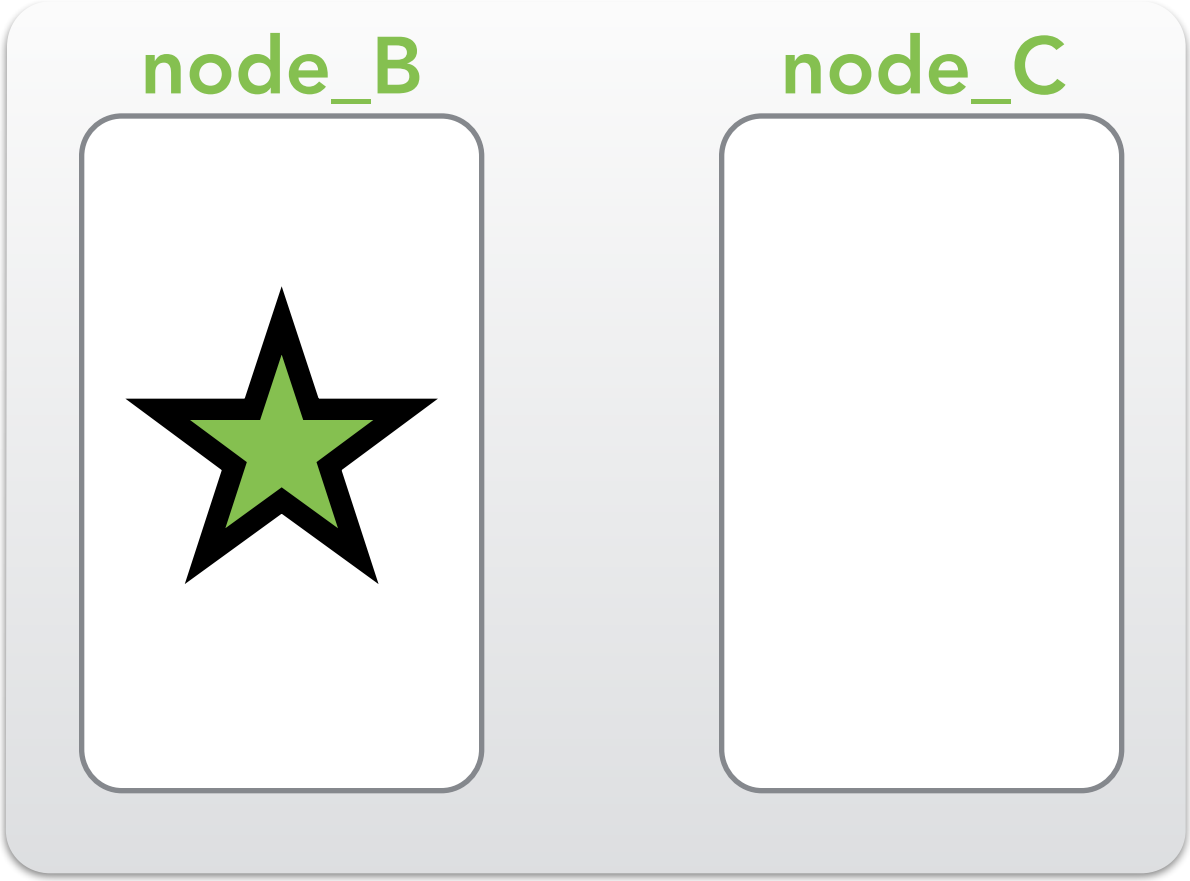


node_B

node_C

master node

re-elected if master fails



master node

only manages
cluster level changes

master node

not doc-level

get/put/search

the result?

distributed
real-time
search & analytics

which works in the same way on your laptop...


...as on your
1,000 node cluster

who is using it?

WIKIPEDIA
The Free Encyclopedia

- full text search
- highlighted search snippets
- ***search-as-you-type***
- ***did-you-mean*** suggestions

theguardian

- combine visitor logs with social network data
- real-time feedback to editors

- combines full text search with geolocation
- uses ***more-like-this*** to find related questions and answers

GitHub

- search repositories, users, issues, pull requests
- search 130 billion lines of code
- track all alerts, events, logs

- index and analyse
  5TB of log data every day

thank you

@clintongormley

elasticsearch.org/downloads

elasticsearch.com/support

elasticsearch.com/jobs