elasticsearch

The Road to a Distributed, (Near) Real Time, Search Engine

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Lucene Basics - Directory

- A File System Abstraction
- Mainly used to read and write “files”
- Used to read and write different index files

Lucene Basics - IndexWriter

- Used to add documents / delete documents from the index
- Changes are stored in memory (possibly flushing to maintain memory limits)
- Requires a commit to make changes "persistent", which is expensive
- A single IndexWriter can write to an index, expensive to create (reuse at all cost!)

Lucene Basics - Index Segments

- An index is composed of internal segments
- Each segment is almost a self sufficient index by itself, immutable up to deletes
- Commits “officially” adds segments to the index, though internal flushing might create new segments as well
- Segments are merged continuously
- A lot of caching per segment (terms, field)

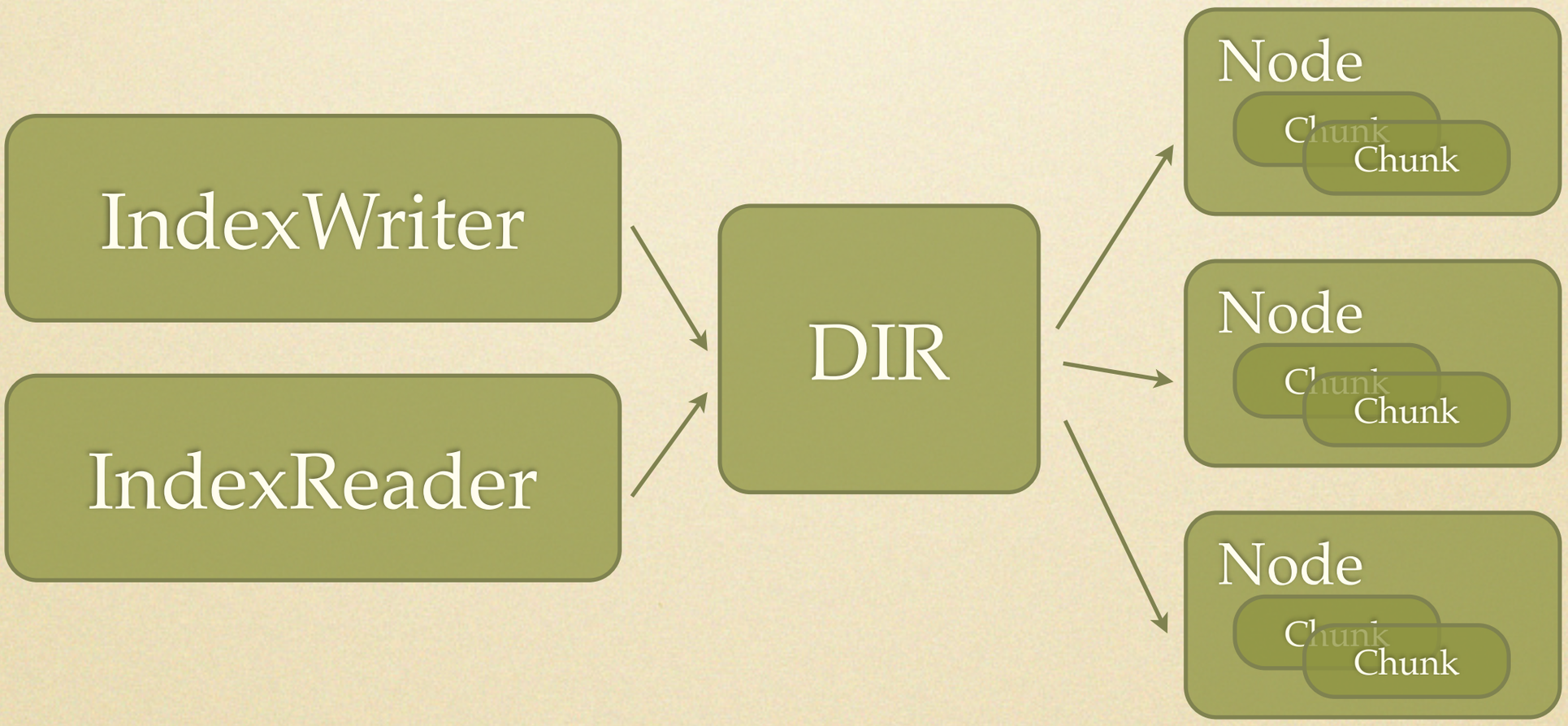
Lucene Basics - (Near) Real Time

- IndexReader is the basis for searching
- IndexWriter#getReader allows to get a refreshed reader that sees changes done to IW
  - Requires flushing (but not committing)
  - Can't call it on each operation, too expensive
- Segment based readers and search

Distributed Directory

- Implement a Directory that works on top of a distributed "system"
- Store file chunks, read them on demand
- Implemented for most (Java) data grids
  - Compass - GigaSpaces, Coherence, Terracotta
  - Infinispan

Distributed Directory



Distributed Directory

- "Chatty"- many network roundtrips to fetch data
- Big indices still suffer from a non distributed IndexReader
  - Lucene IndexReader can be quite "heavy"
- Single IndexWriter problem, can't really scale writes

Partitioning

- Document Partitioning
  - Each shard has a subset of the documents
  - A shard is a fully functional “index”
- Term Partitioning
  - Shards has subset of terms for all docs

Partitioning - Term Based

- pro: K term query -> handled at most by K shards
- pro: O(K) disk seeks for K term query
- con: high network traffic
  - data about each matching term needs to be collected in one place
- con: harder to have per doc information (facets / sorting / custom scoring)

Partitioning - Term Based

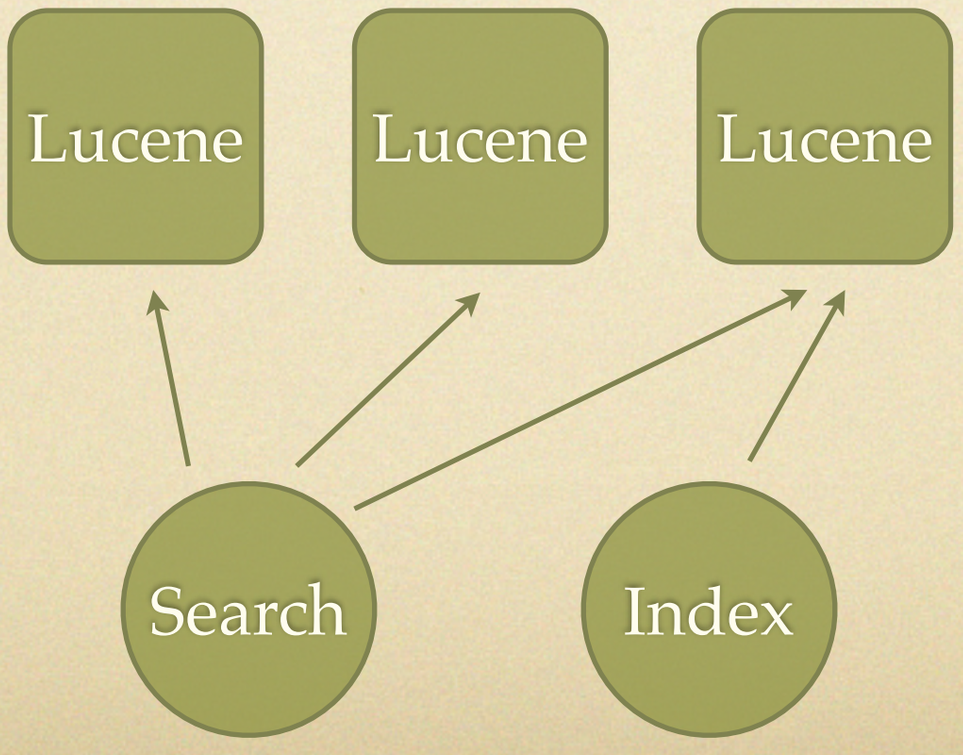
- Riak Search - Utilizing its distributed key-value storage
- Lucandra (abandoned, replaced by Solandra)
  - Custom IndexReader and IndexWriter to work on top of Cassandra
  - Very very “chatty” when doing a search
  - Does not work well with other Lucene constructs, like FieldCache (by doc info)

Partitioning - Document Based

- pro: each shard can process queries independently
- pro: easy to keep additional per-doc information (facets, sorting, custom scoring)
- pro: network traffic small
- con: query has to be processed by each shard
- con: O(K*N) disk seeks for K term on N shard

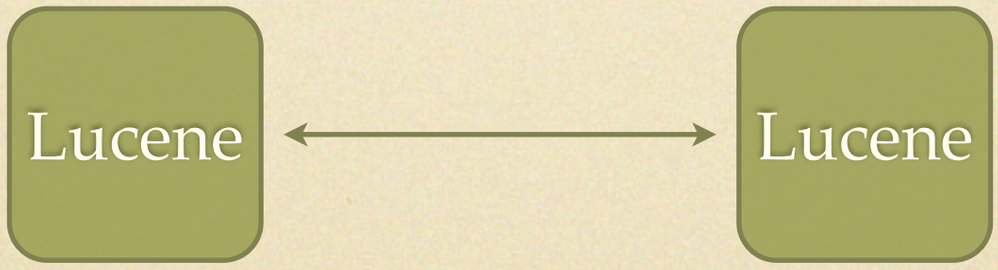
Distributed Lucene Doc Partitioning

- Shard Lucene into several instances
- Index a document to one Lucene shard
- Distribute search across Lucene shards



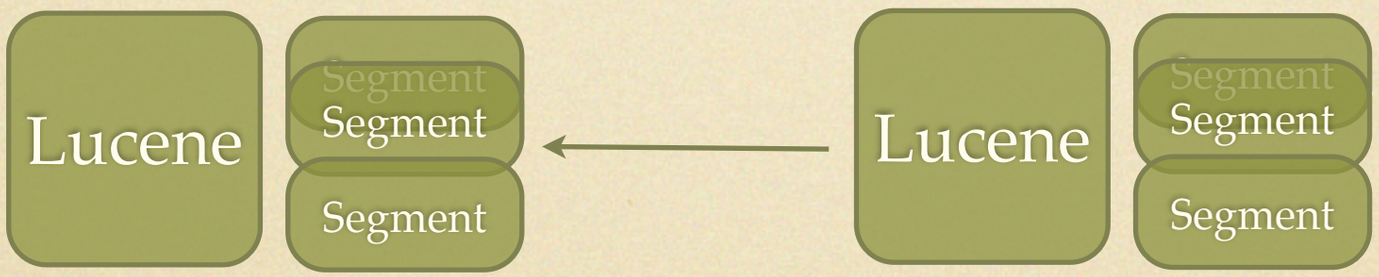
Distributed Lucene Replication

- Replicated Lucene Shards
  - High Availability
  - Scale search by searching replicas



Pull Replication

- Master - Slave configuration
- Slave pulls index files from the master (delta, only new segments)

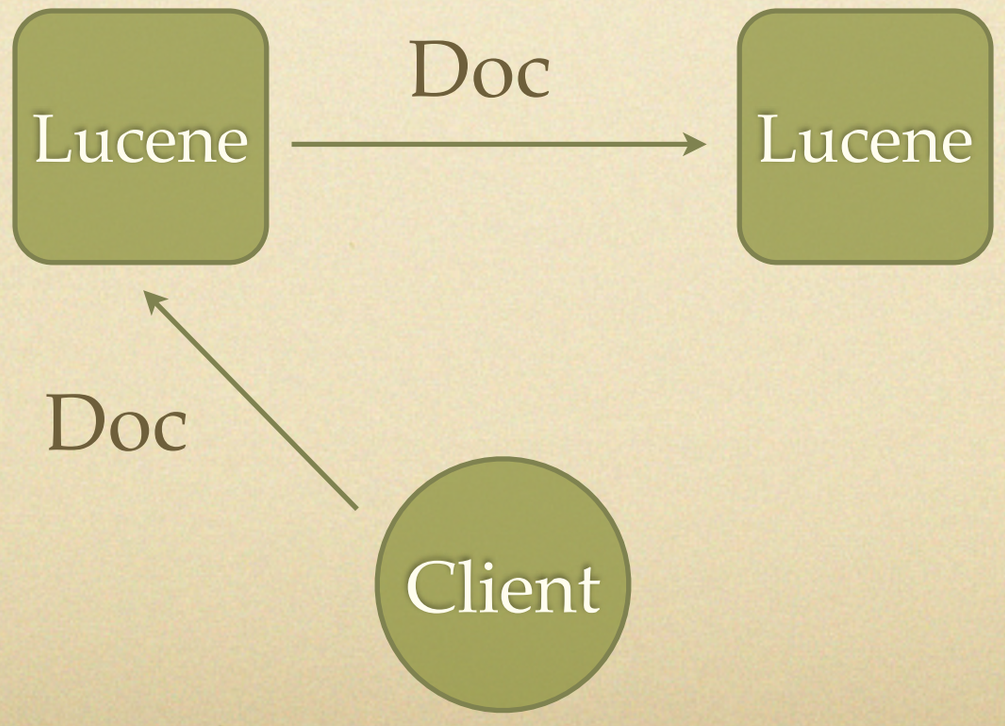


Pull Replication - Downsides

- Requires a "commit" on master to make changes available for replication to slave
- Redundant data transfer as segments are merged (especially for stored fields)
- Friction between commit (heavy) and replication, slaves can get "way" behind master (big new segments), looses HA
- Does not work for real time search, slaves are "too" behind

Push Replication

- "Master/Primary" push to all the replicas
- Indexing is done on all replicas



Push Replication - Downsides

- Indexing the document on all nodes
  - (though less data transfer over the wire)
- Delicate control over concurrent indexing operations
  - Usually solved using versioning

Push Replication - Benefits

- Documents indexed are immediately available on all replicas
  - Improves High Availability
  - Allows for (near) real time search architecture
- Architecture allows to switch “roles” ->
  - Primary dies, slave can become primary, and still allow indexing

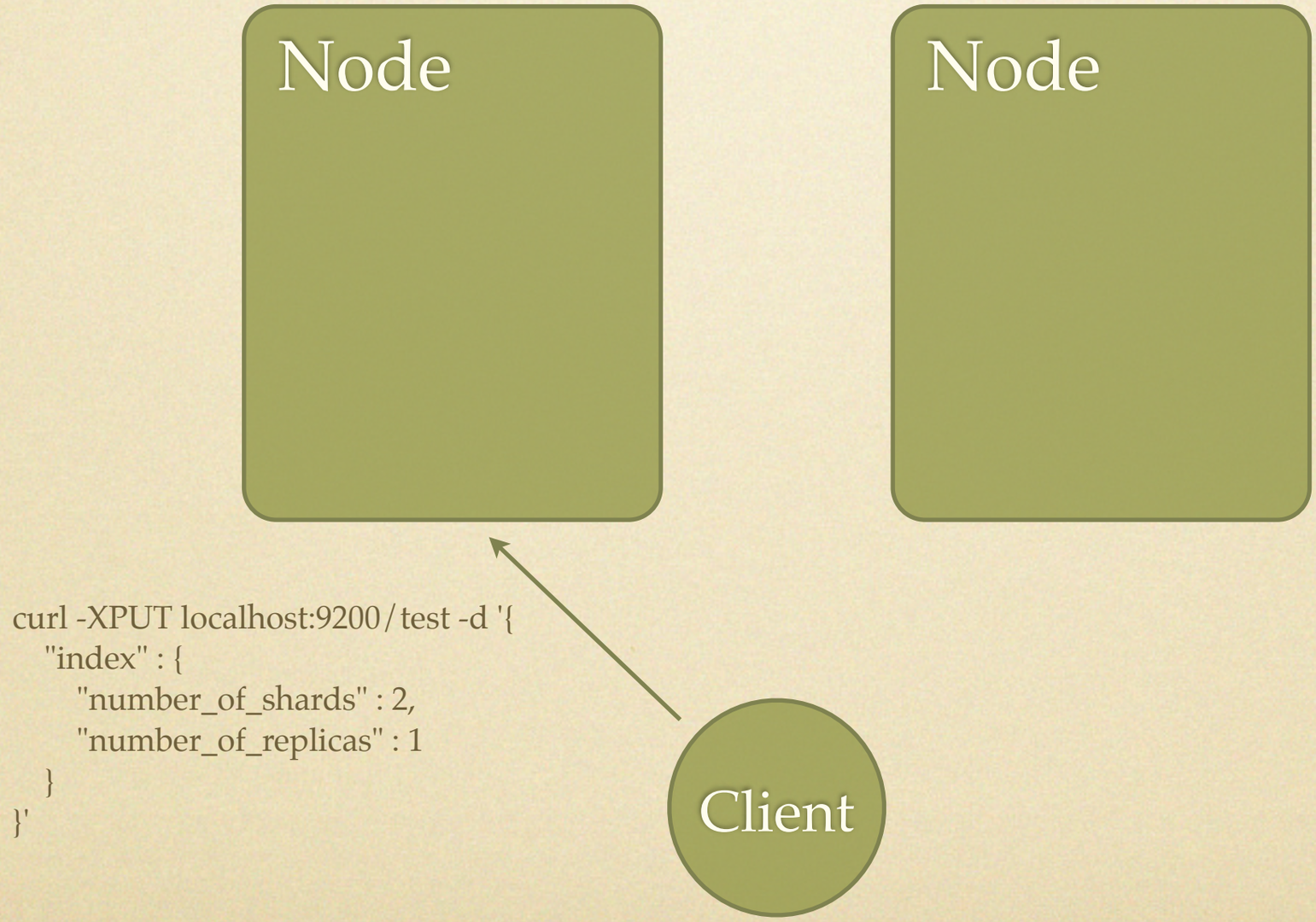
Push Replication - IndexWriter#commit

- IndexWriter#commit is heavy, but required in order to make sure data is actually persisted
- Can be solved by having a write ahead log that can be replayed on the event of a crash
- Can be more naturally supported in push replication

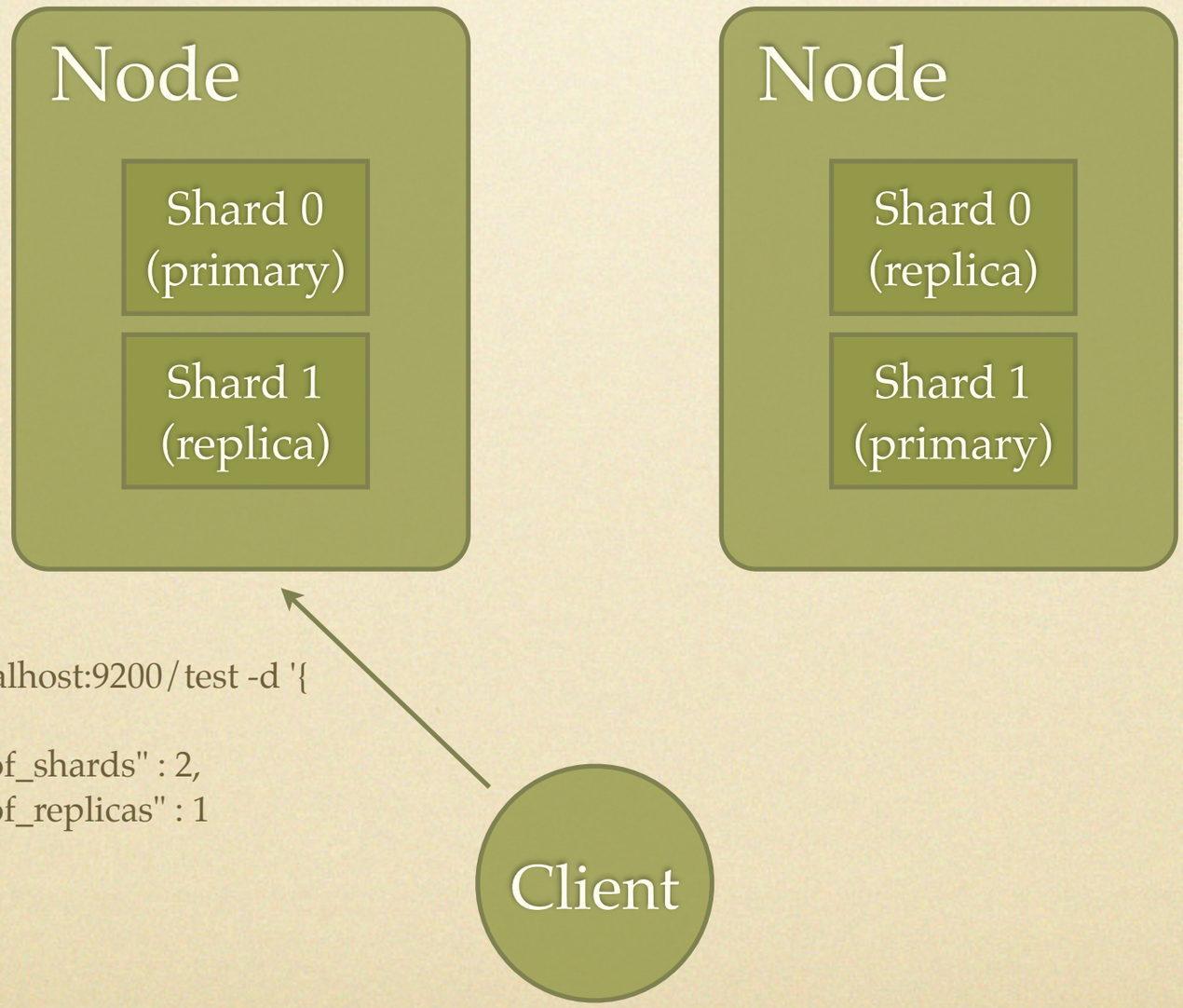
elasticsearch

http://www.elasticsearch.org

index - shards and replicas

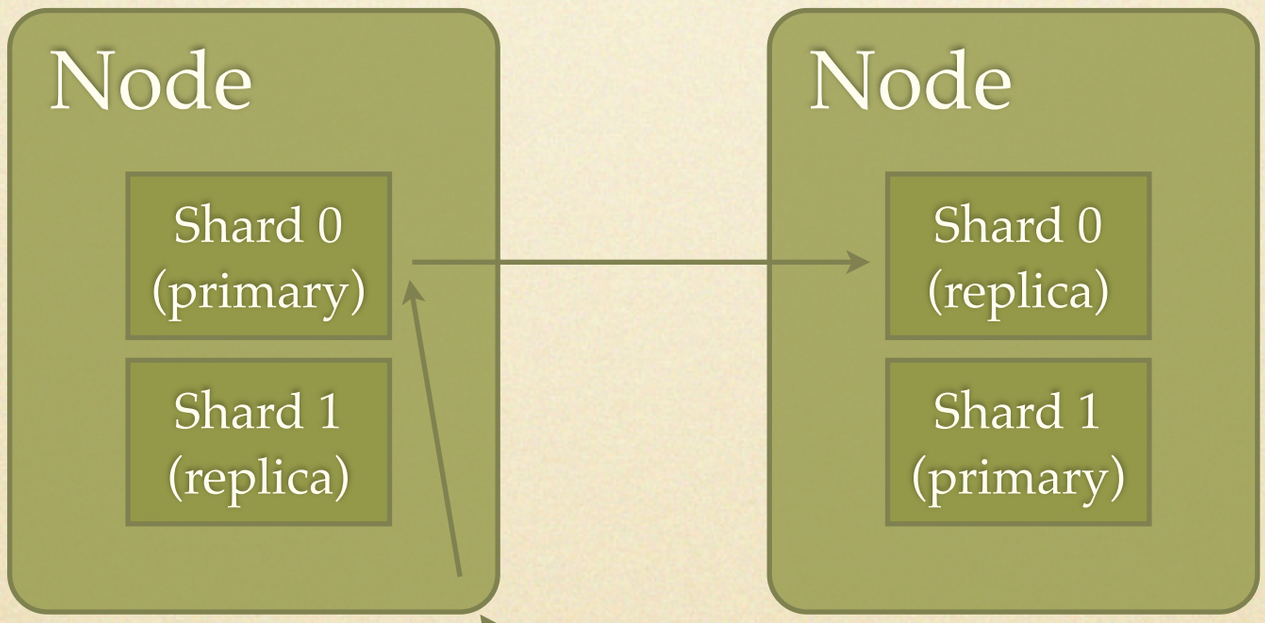


index - shards and replicas



indexing - 1

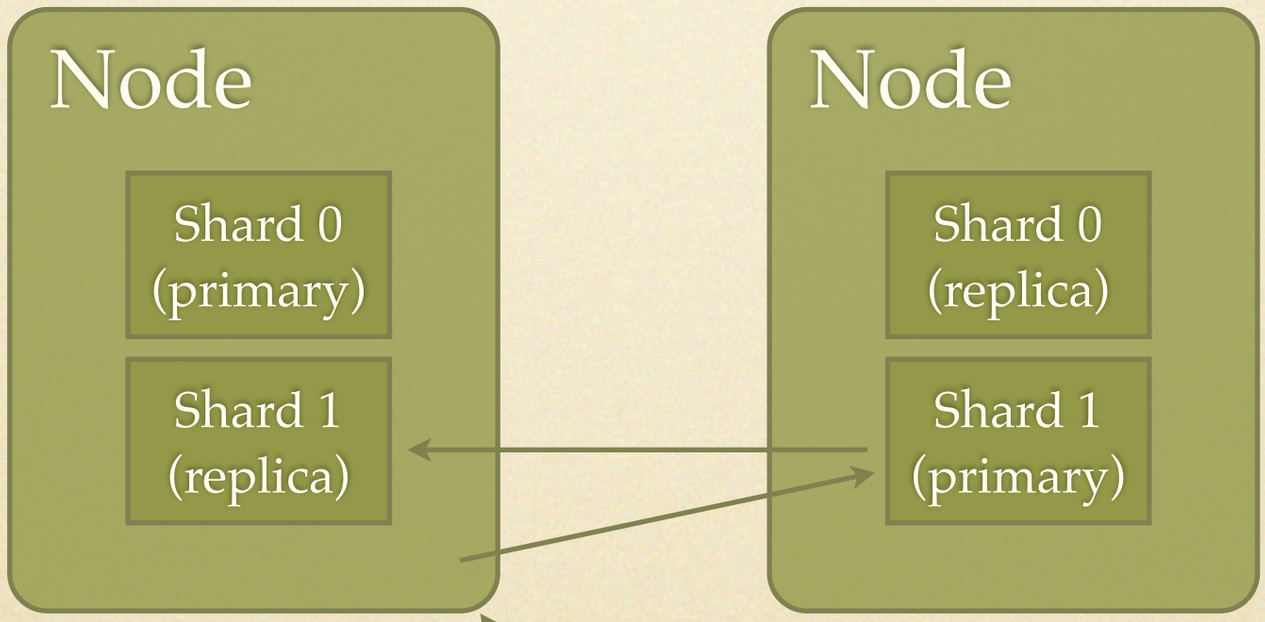
- Automatic sharding, push replication




```
curl -XPUT localhost:9200/test/type1/1 -d '{
    "name" : {
        "first" : "Shay",
        "last" : "Banon"
    },
    "title" : "ElasticSearch - A distributed search engine"
}'
```

indexing - 2

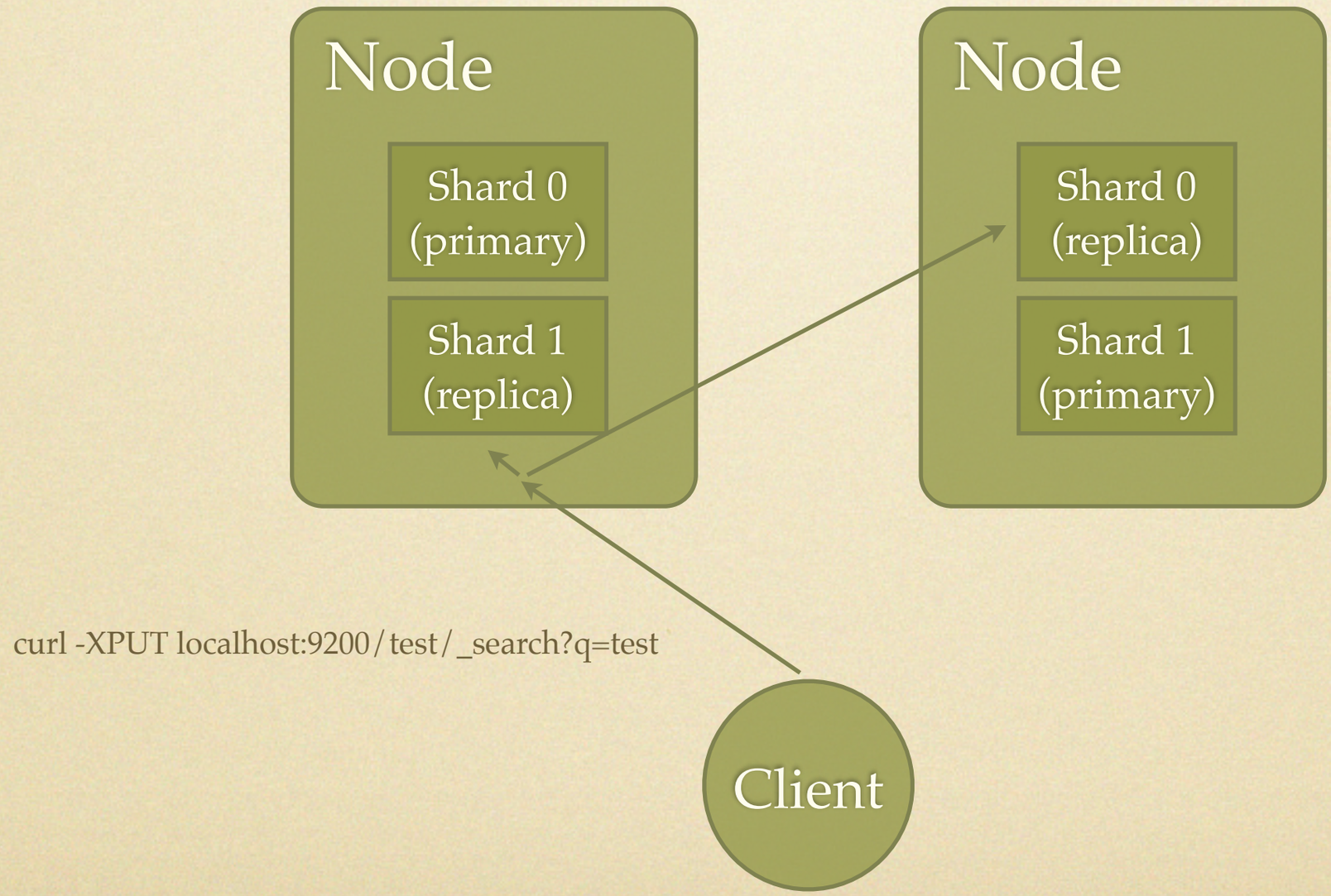
- Automatic request “redirection”




```
curl -XPUT localhost:9200/test/type1/2 -d '{
    "name" : {
        "first" : "Shay",
        "last" : "Banon"
    },
    "title" : "ElasticSearch - A distributed search engine"
}'
```

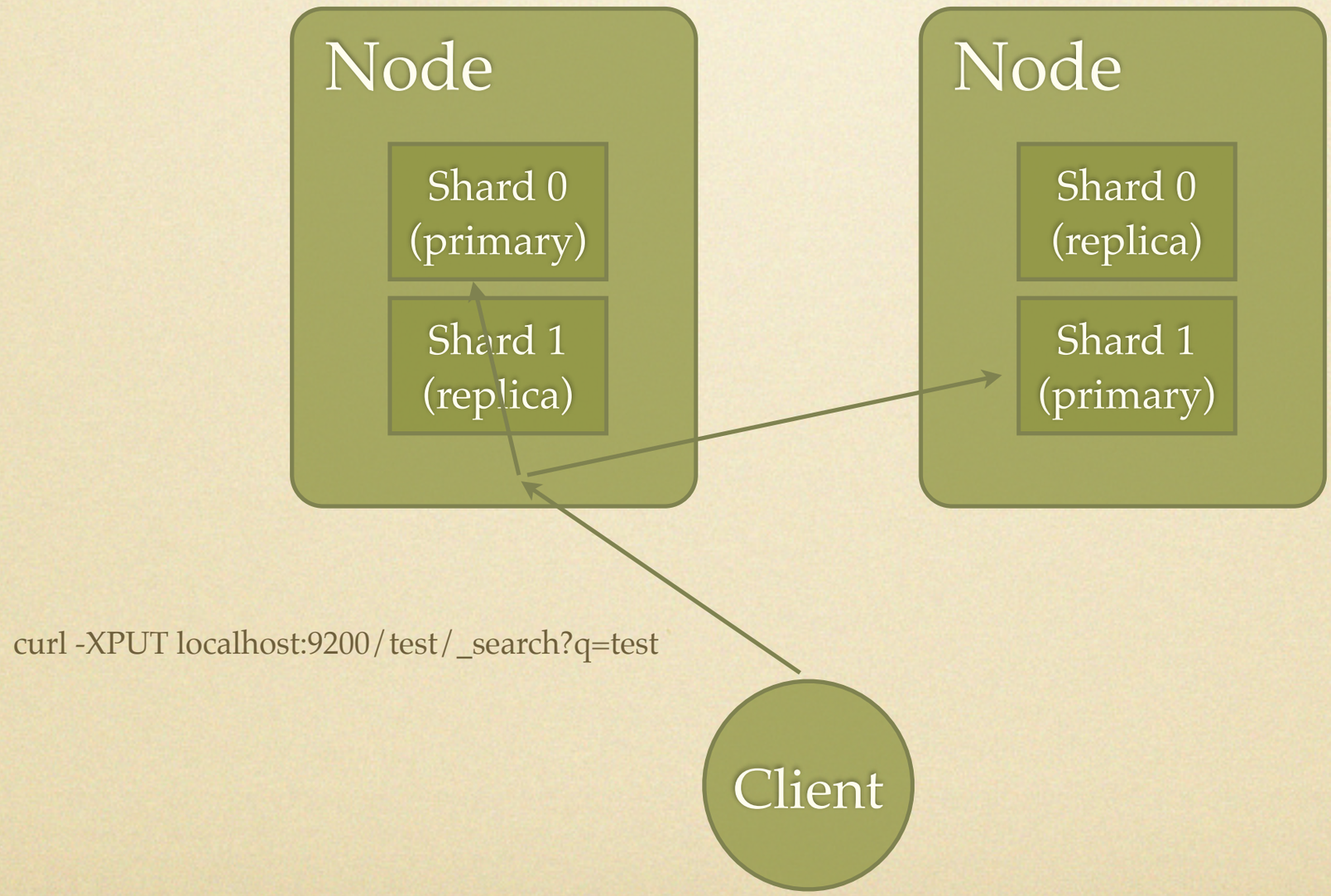
search - 1

- Scatter / Gather search



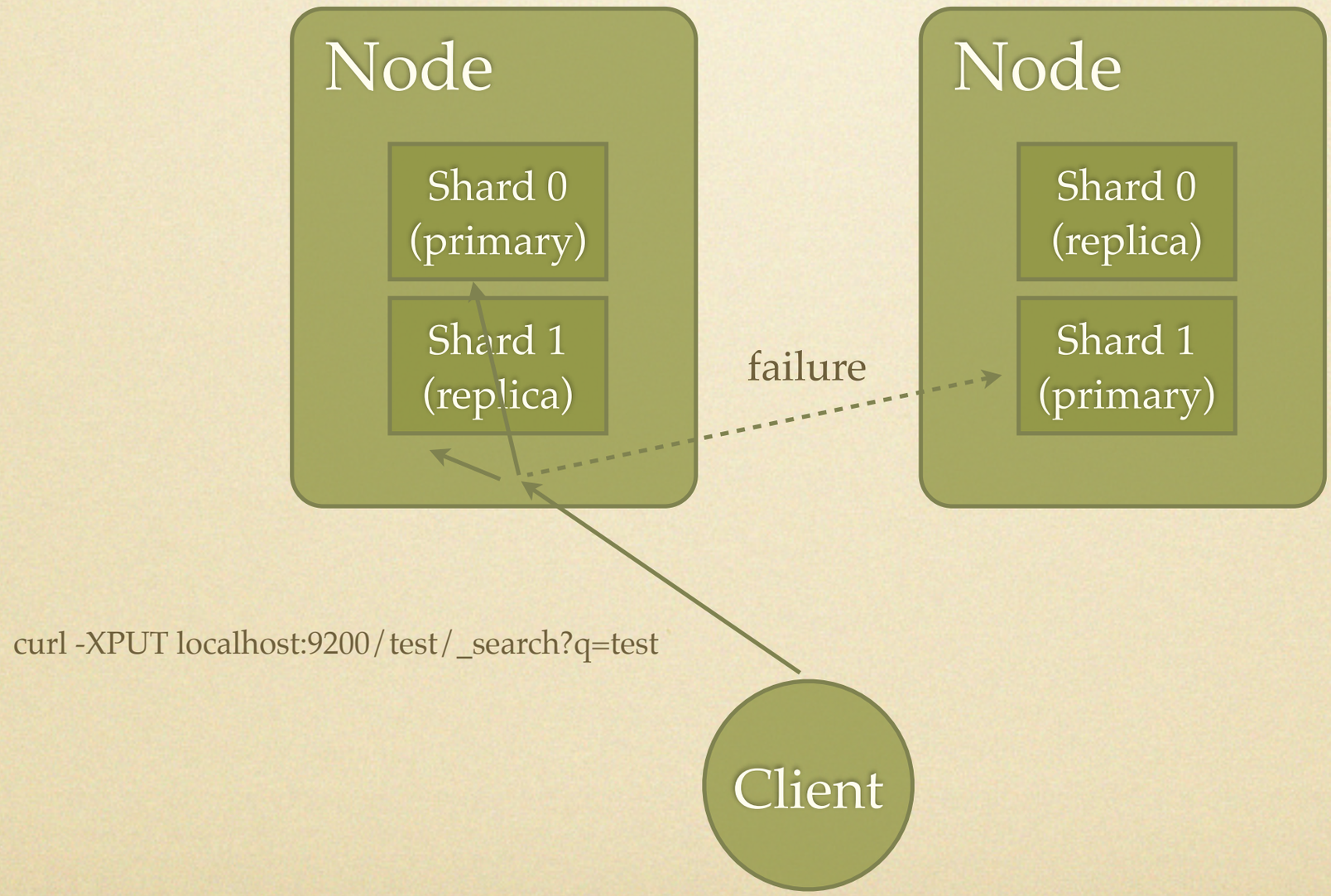
search - 2

- Automatic balancing between replicas



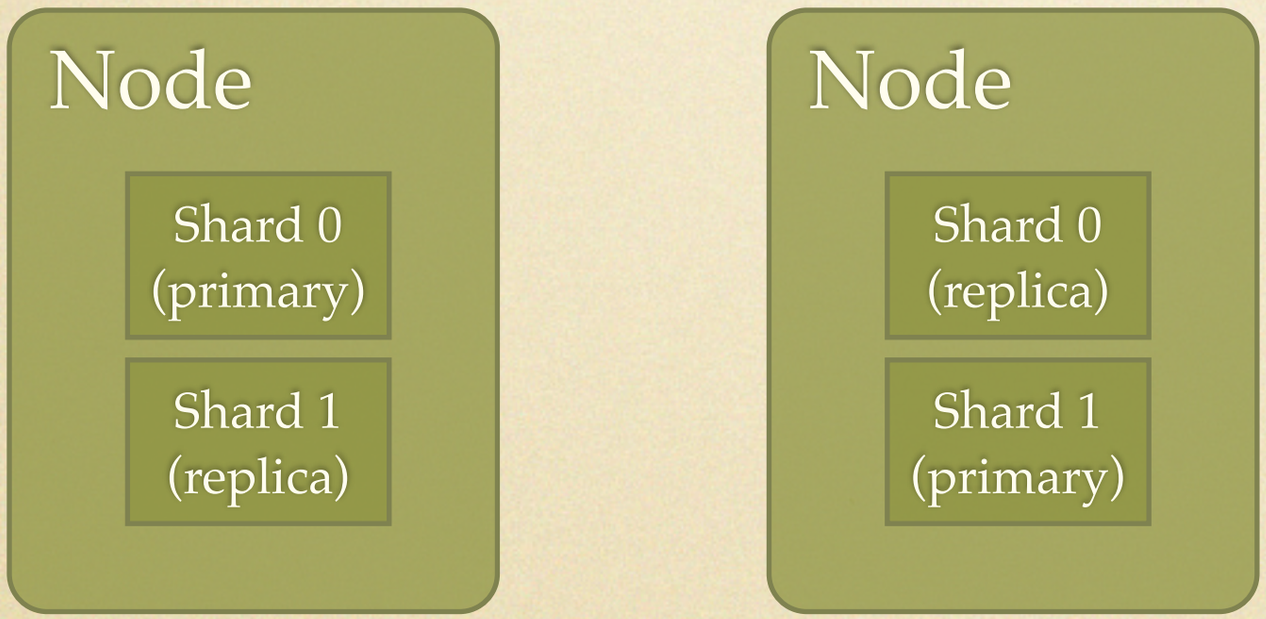
search - 3

- Automatic failover



adding a node

- "Hot" relocation of shards to the new node



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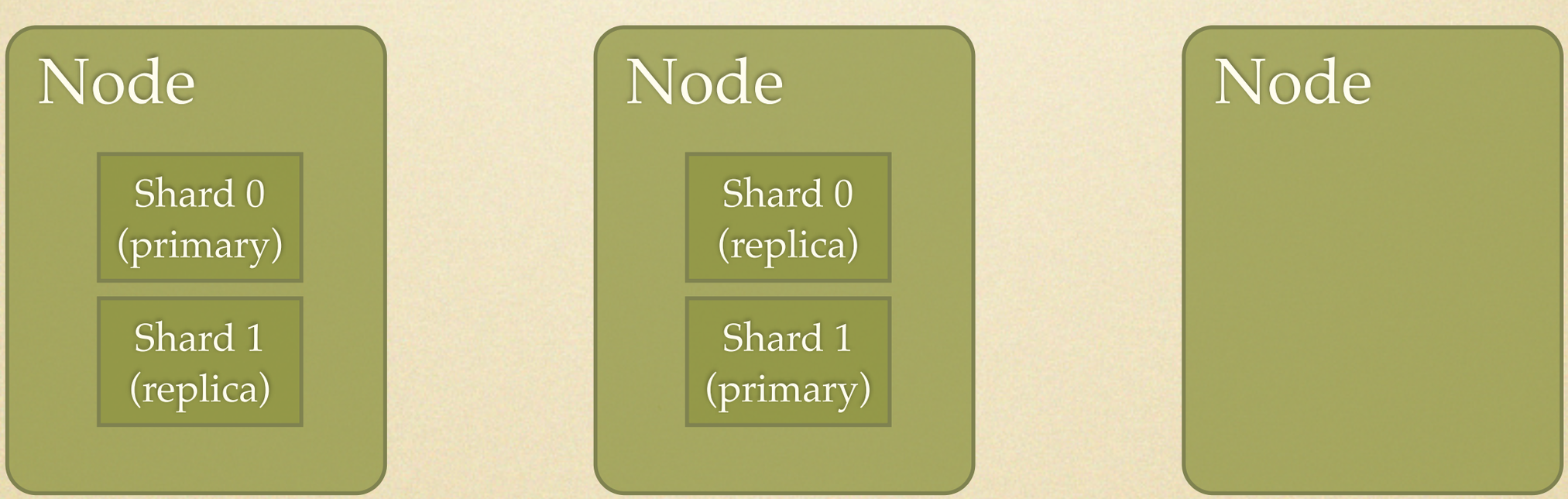

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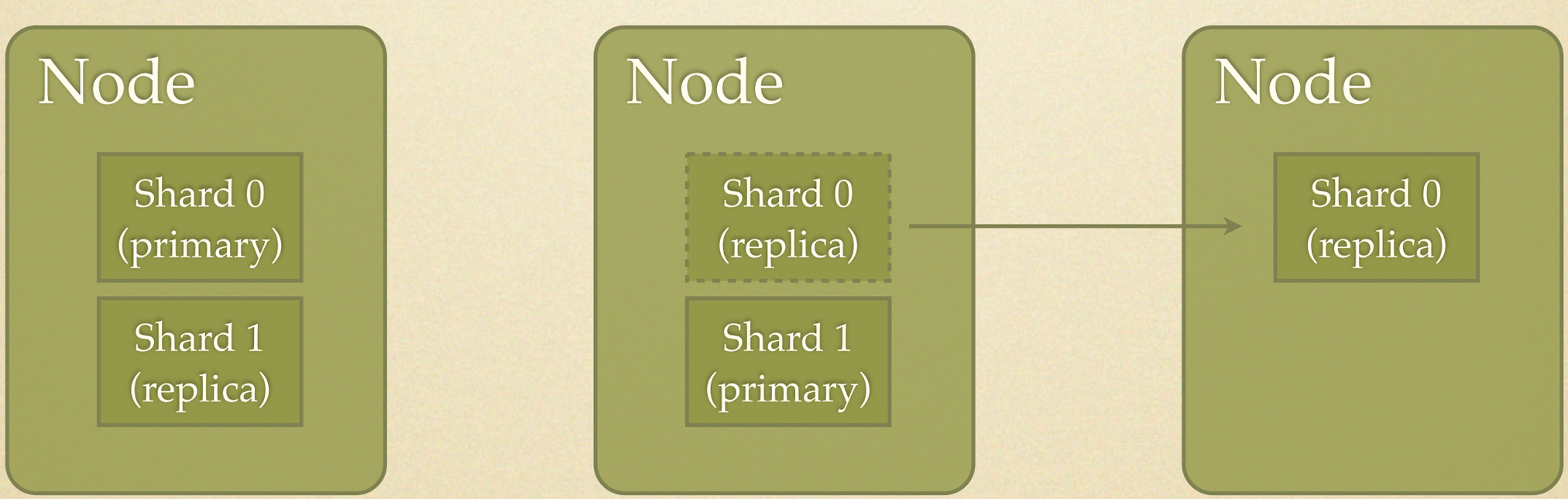
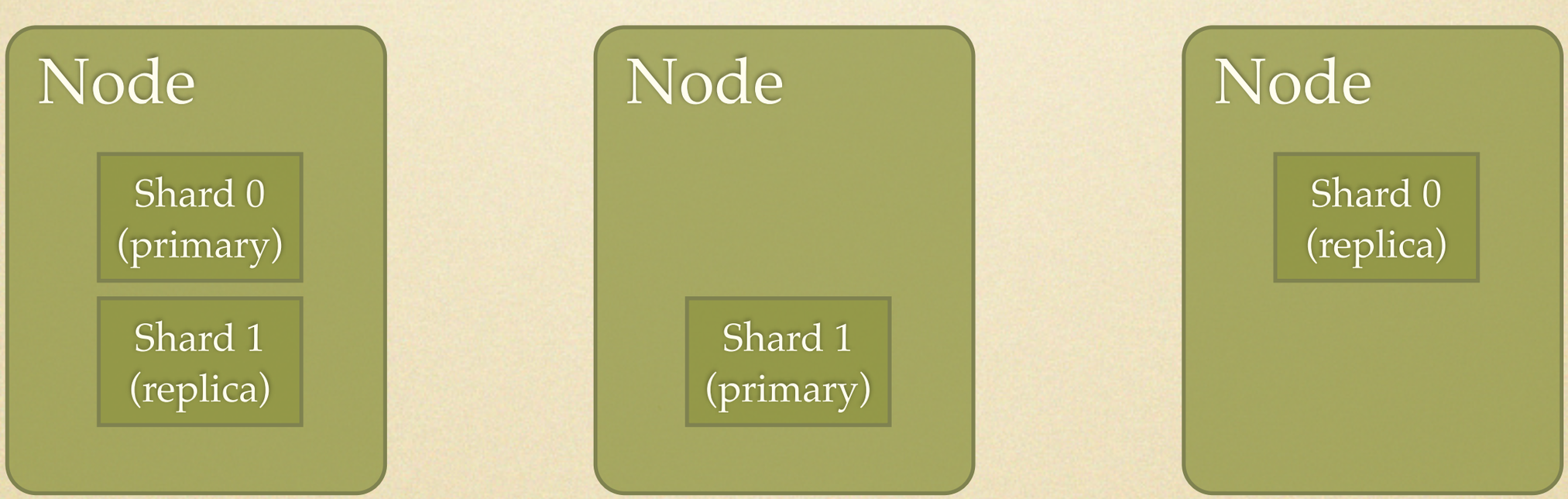
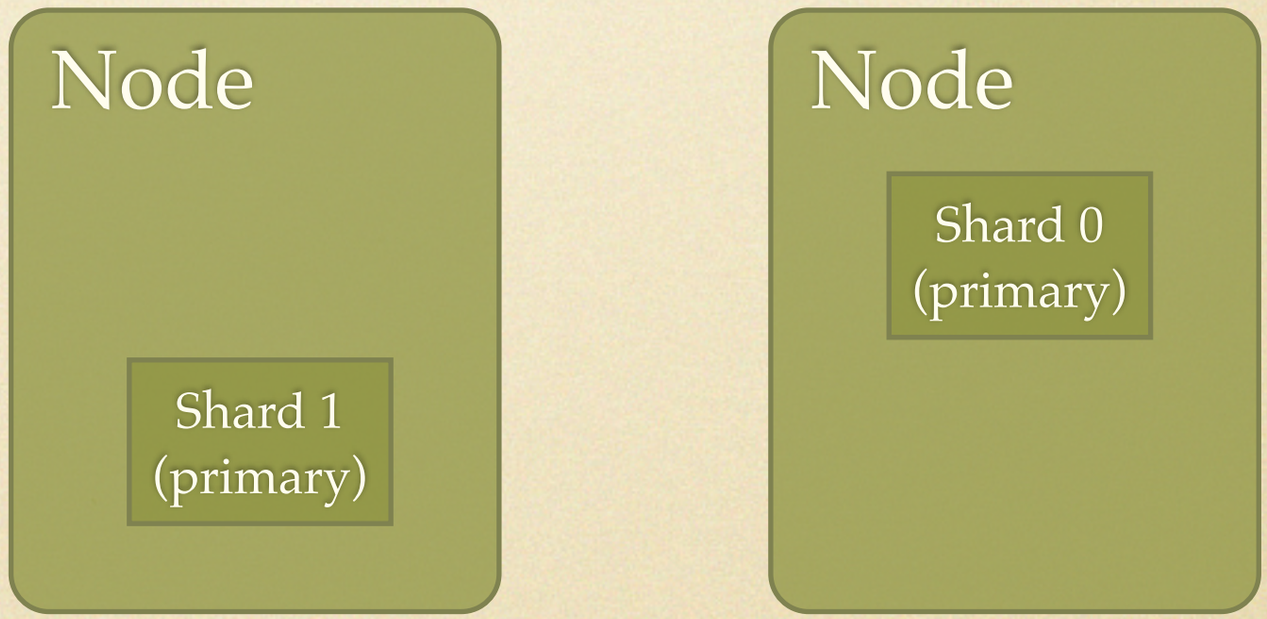


node failure



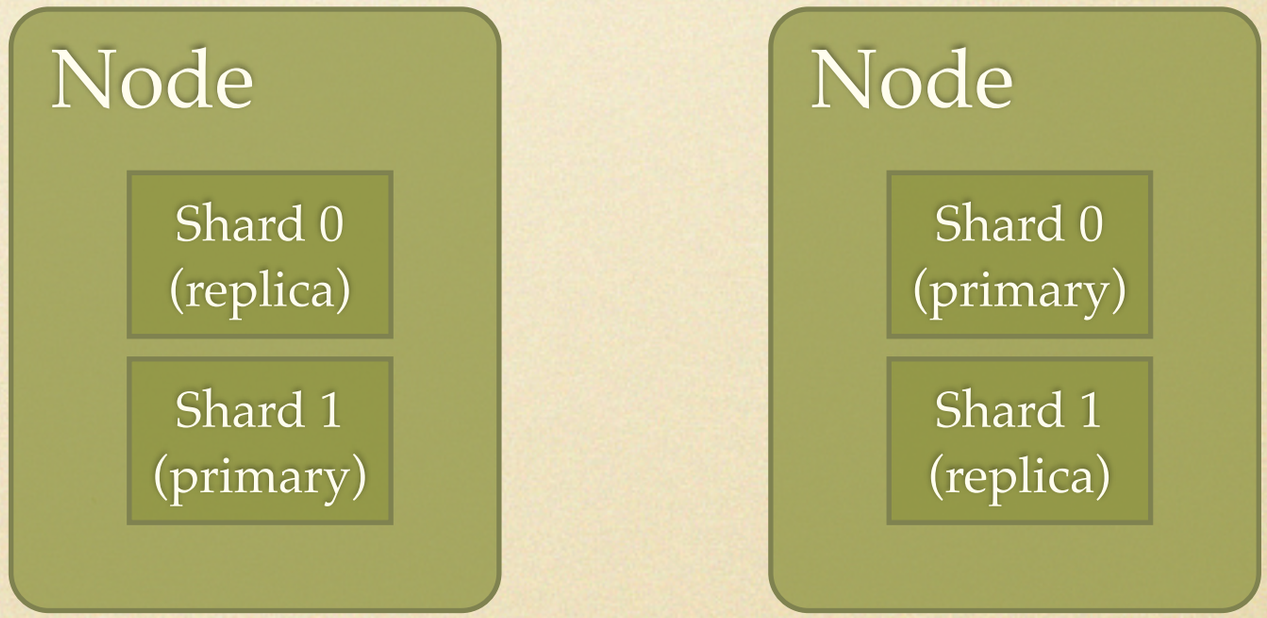
node failure - 1

- Replicas can automatically become primaries

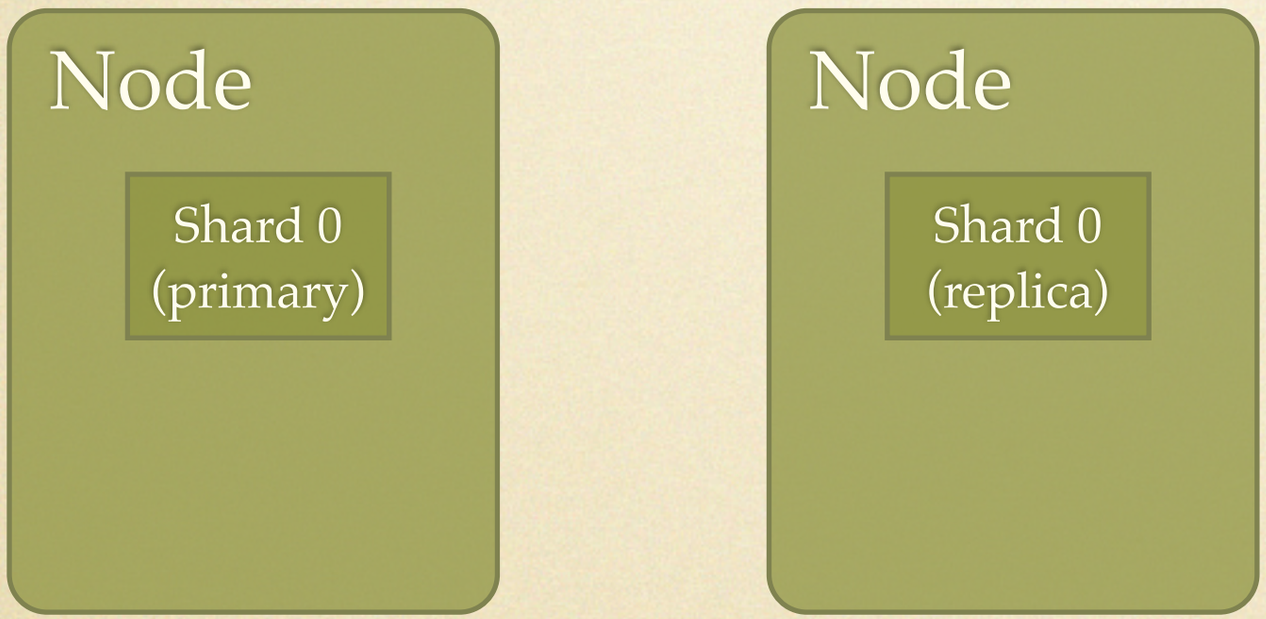


node failure - 2

- Shards are automatically assigned, and do "hot" recovery

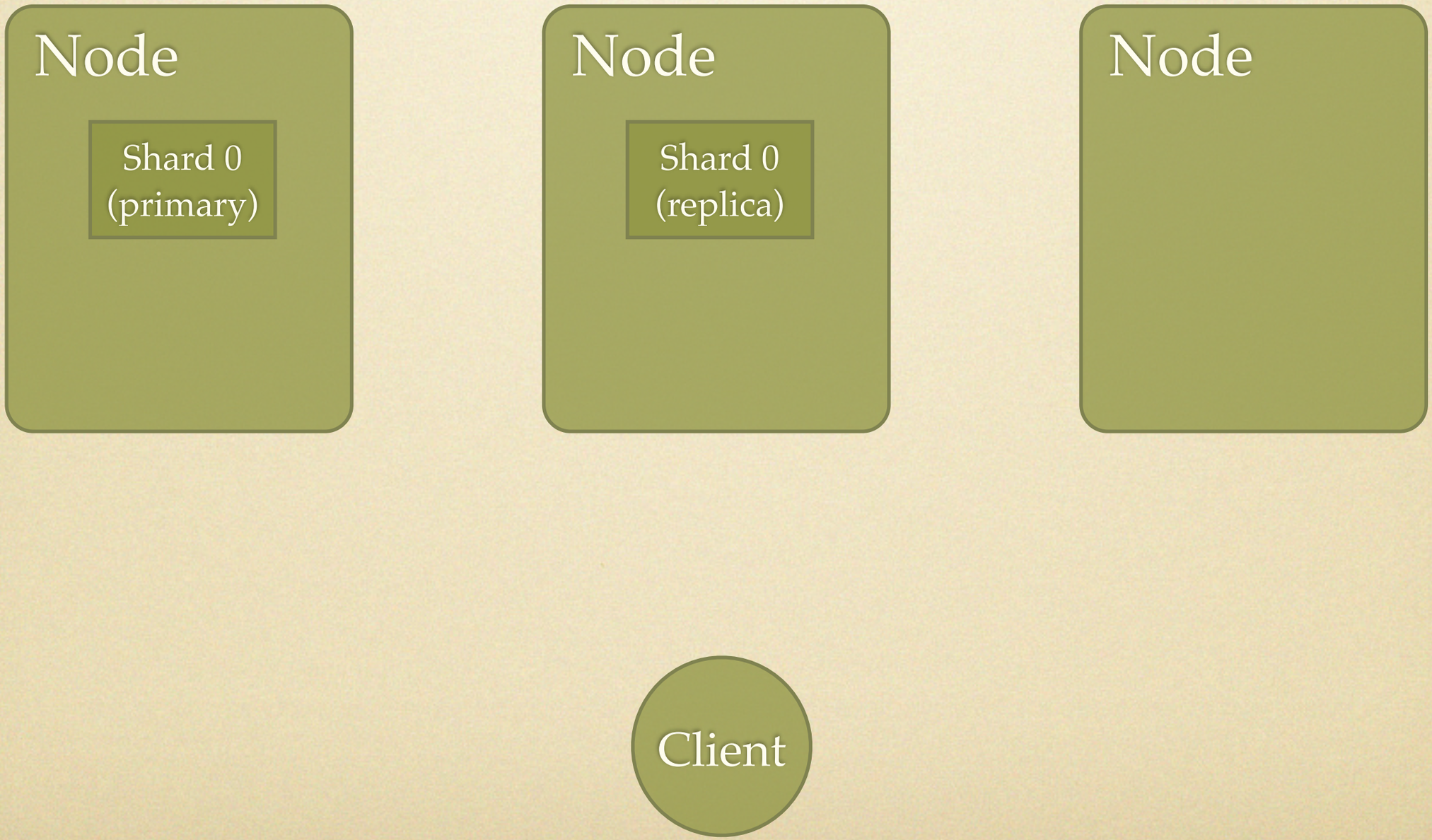


dynamic replicas

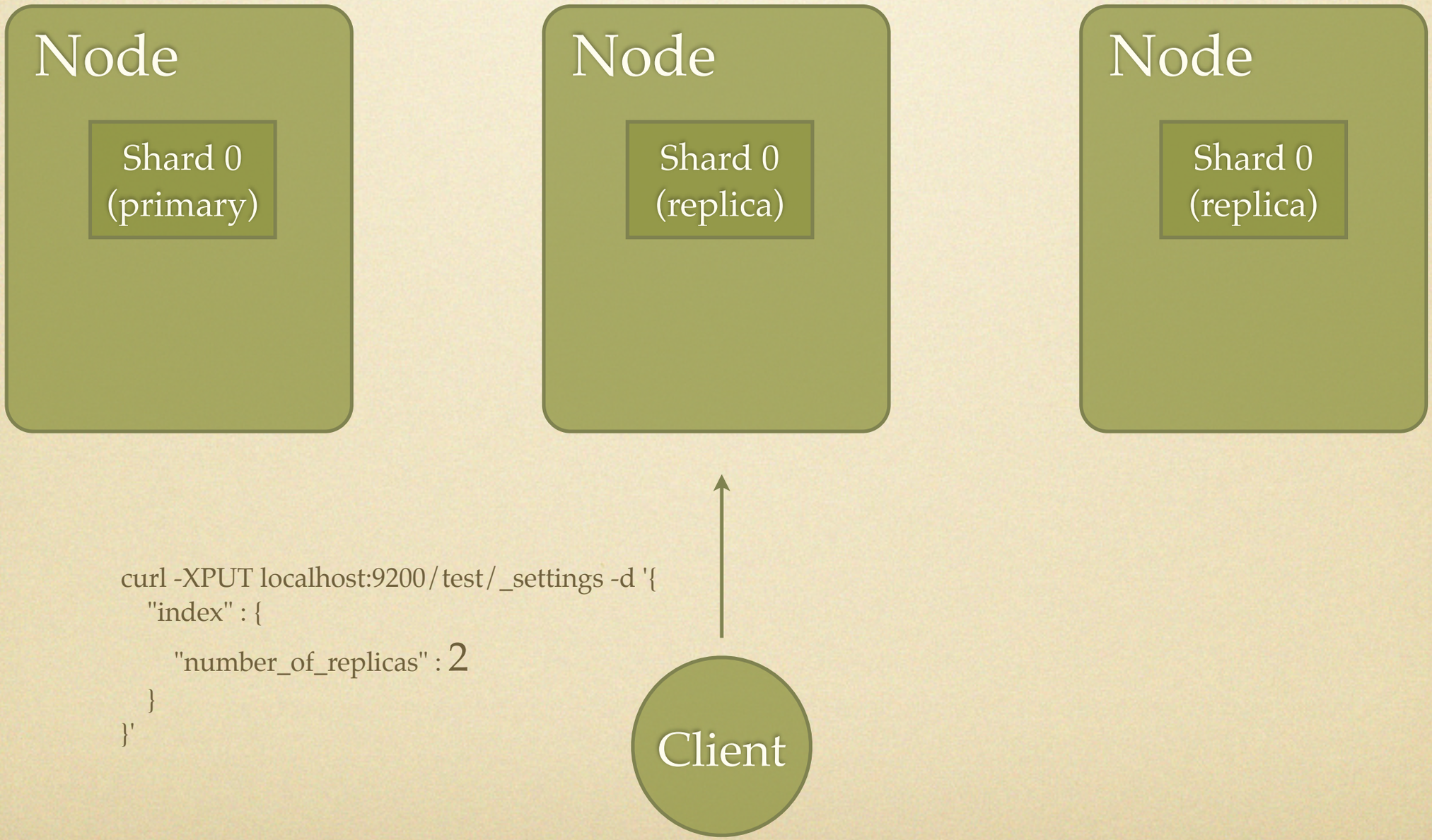



```
curl -XPUT localhost:9200/test -d '{
   "index" : {
      "number_of_shards" : 1,
      "number_of_replicas" : 1
   }
}'
```

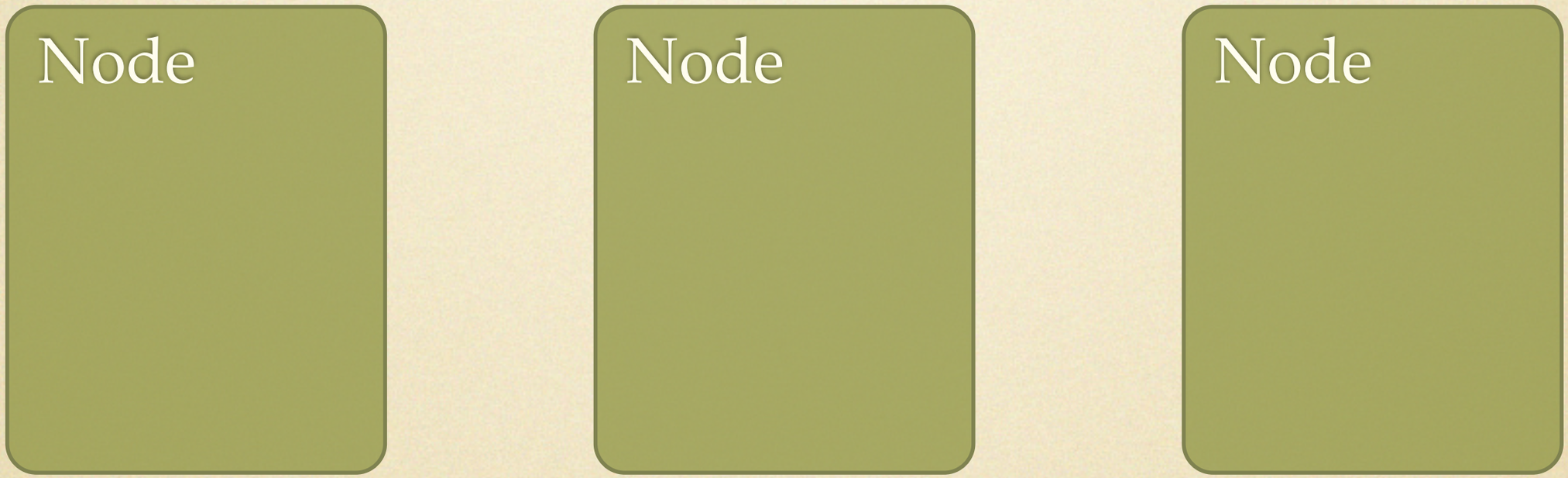
dynamic replicas



dynamic replicas

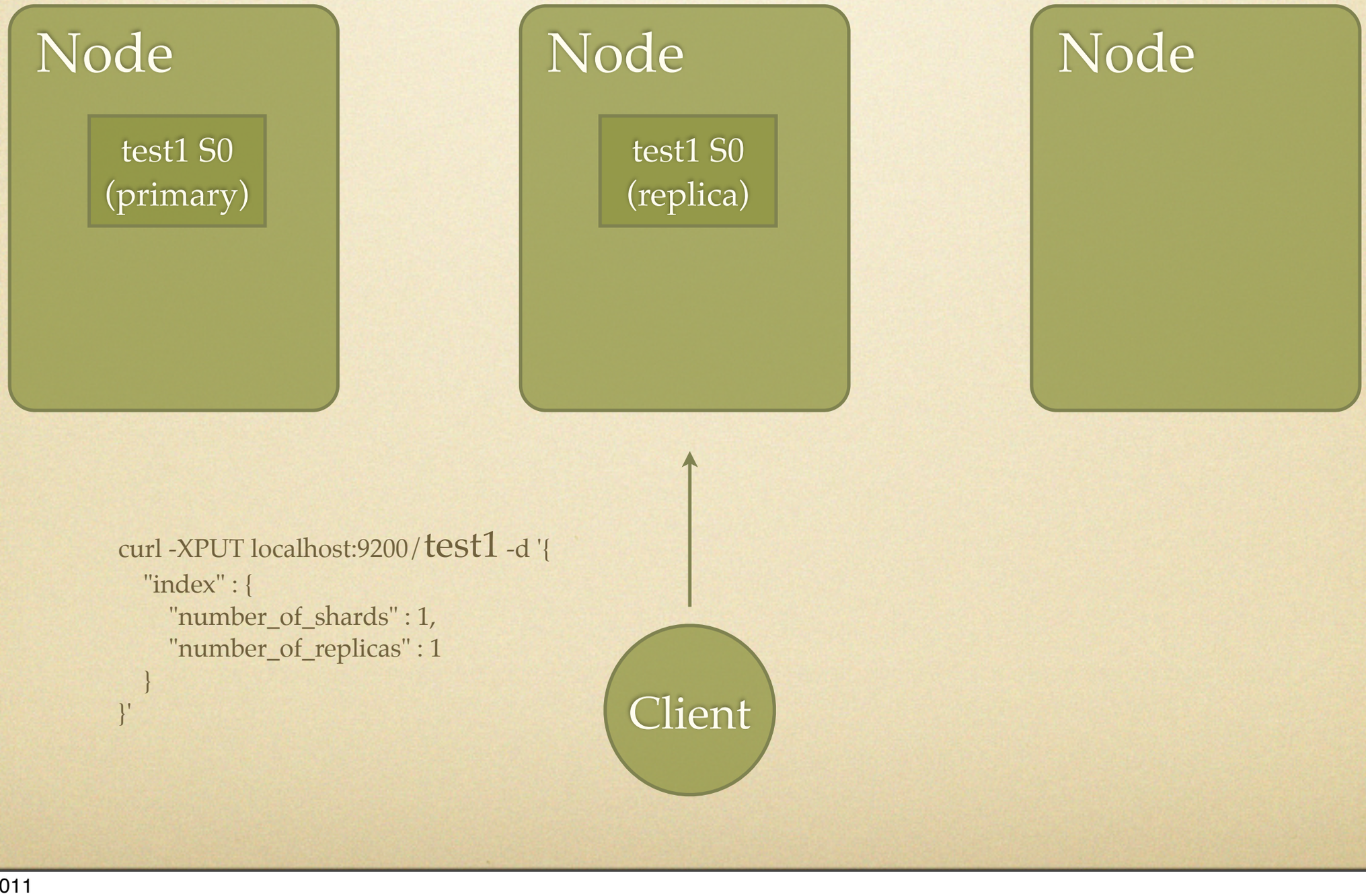


multi tenancy - indices

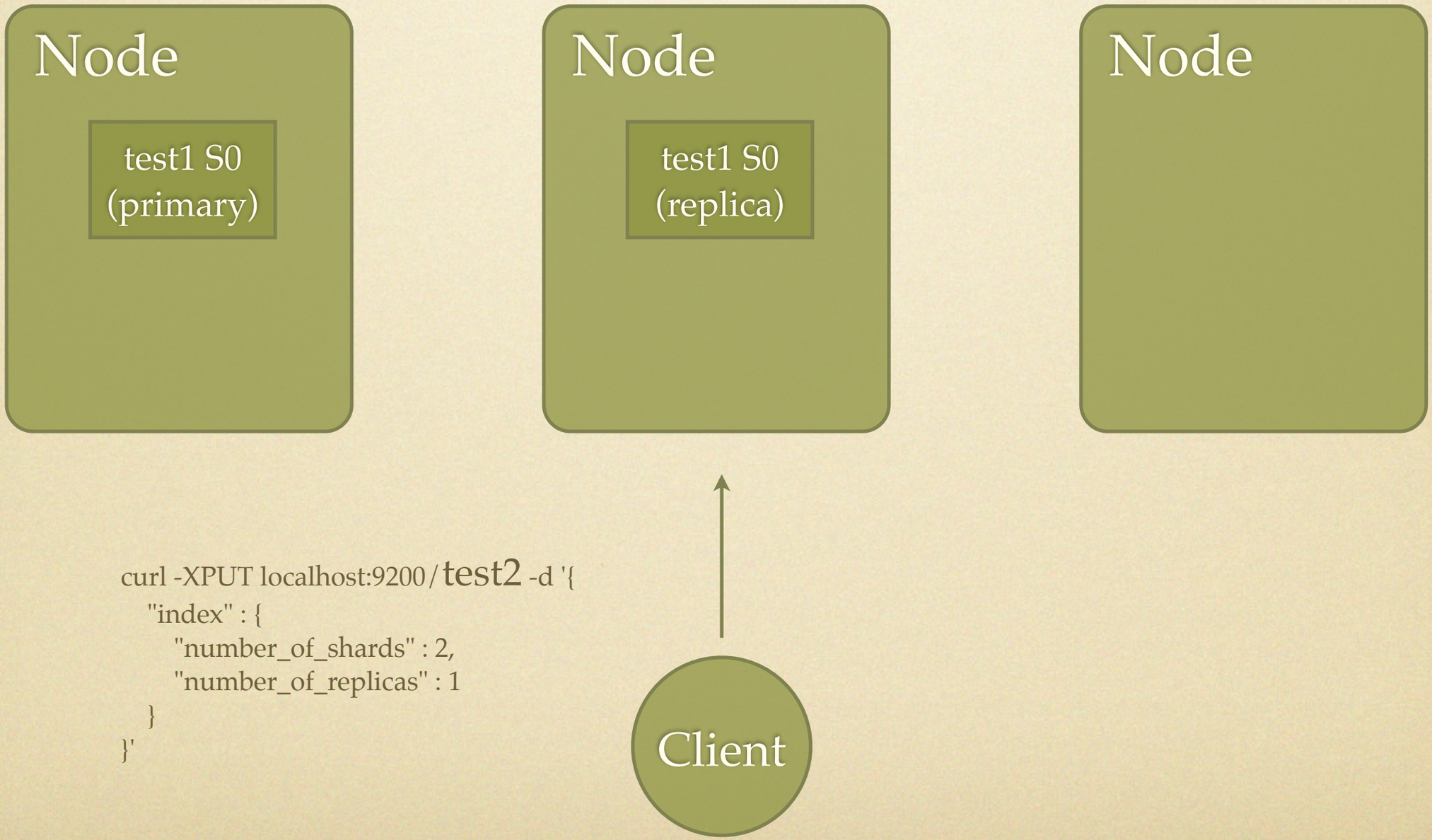



```
curl -XPUT localhost:9200/test1 -d '{
    "index" : {
        "number_of_shards" : 1,
        "number_of_replicas" : 1
    }
}'
```

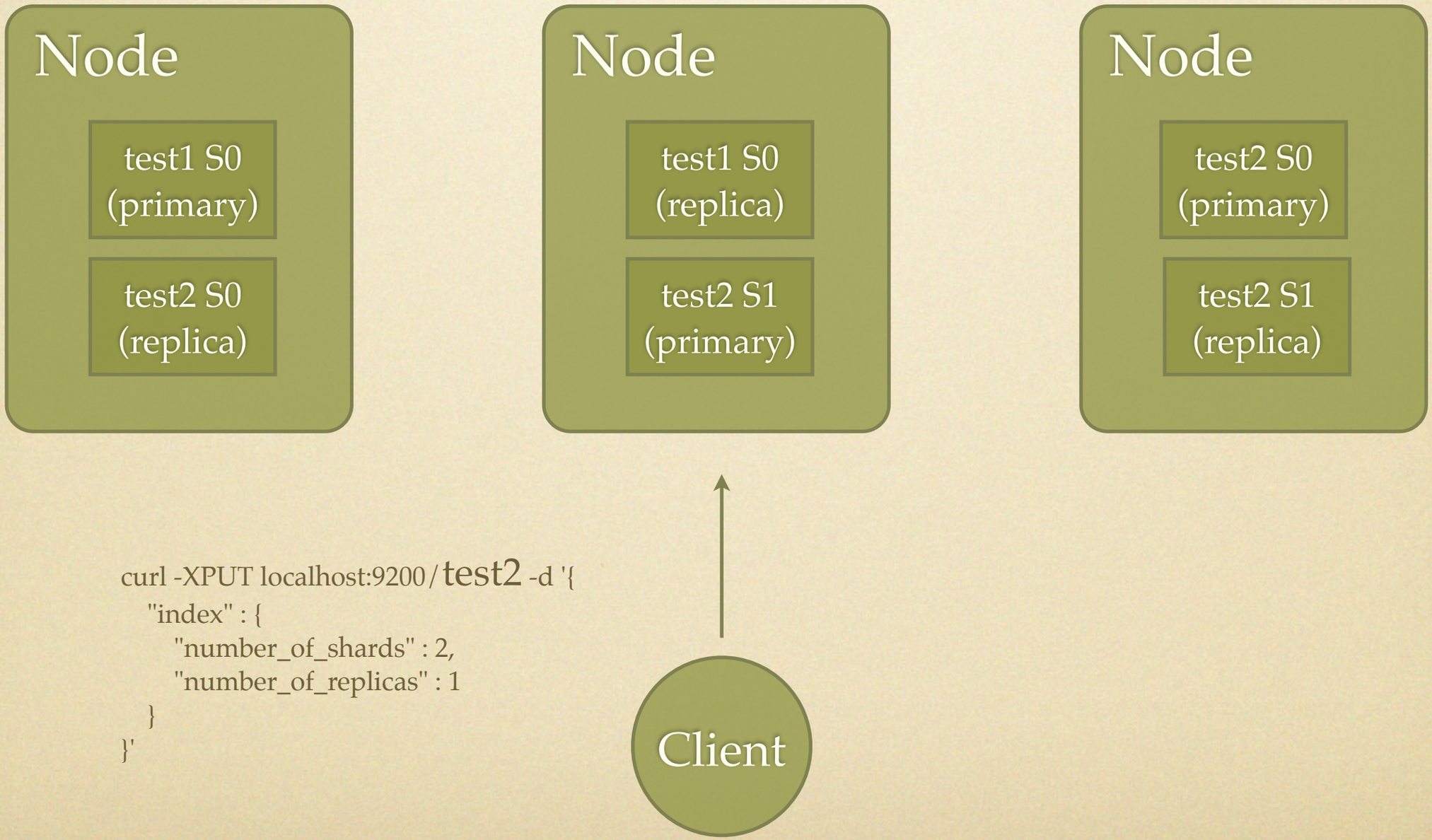
multi tenancy - indices



multi tenancy - indices



multi tenancy - indices



multi tenancy - indices

- Search against specific index
  - curl localhost:9200/test1/_search
- Search against several indices
  - curl localhost:9200/test1,test2/_search
- Search across all indices
  - curl localhost:9200/_search
- Can be simplified using aliases

transaction log

- Indexed / deleted doc is fully persistent
  - No need for a Lucene IndexWriter#commit
- Managed using a transaction log / WAL
- Full single node durability (kill dash 9)
- Utilized when doing hot relocation of shards
- Periodically “flushed” (calling IW#commit)

many more... (dist. related)

- Custom routing when indexing and searching
- Different "search execution types"
  - dfs, query_then_fetch, query_and_fetch
- Complete non blocking, event IO based communication (no blocking threads on sockets, no deadlocks, scalable with large number of shards/replicas)

Thanks

- Shay Banon, twitter: @kimchy
- elasticsearch
  - http://www.elasticsearch.org/
  - twitter: @elasticsearch
  - github: https://github.com/elasticsearch/elasticsearch