NoSQL Databases
To SQL or not to SQL

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Committer, PMC
http://n10k.com

2015-12-02

Apache HBase (@hbase)
http://hbase.apache.org

Apache Phoenix (@ApachePhoenix)
http://phoenix.apache.org

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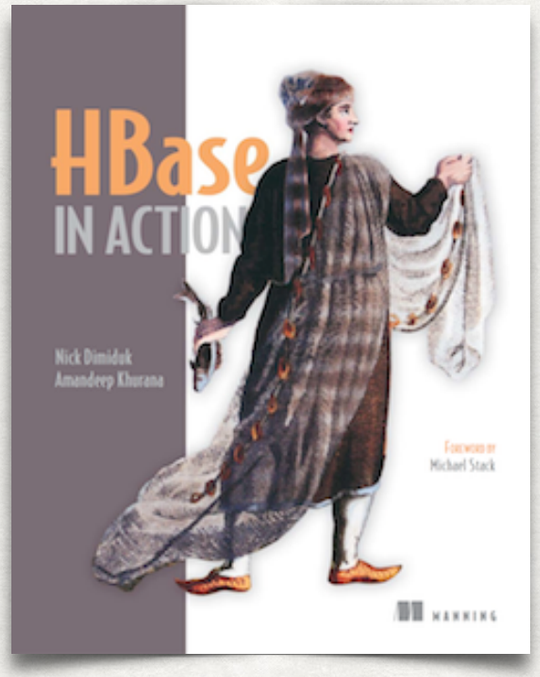
About Me

- Working with NoSQL and Hadoop since 2008
- Committer and PMC Member
  - Apache HBase
  - Apache Phoenix
- Release manager for HBase 1.1 releases



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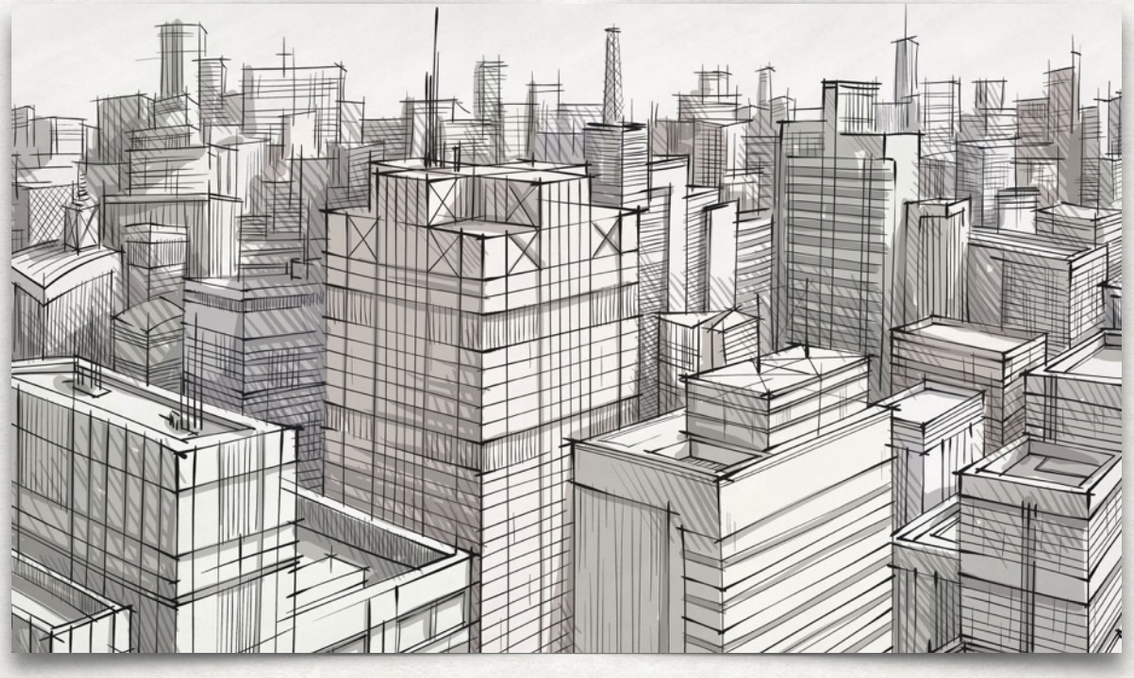
Agenda

- Part 1: What is NoSQL?
- Part 2: Data at Scale
- Part 3: NoSQL in Depth with Apache HBase
- Part 4: Bring SQL Back with Apache Phoenix



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Part 1

What is NoSQL?

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What is NoSQL?

"... a mechanism for storage and retrieval of data that is modeled in means **other than the tabular relations used in relational databases**."

https://en.wikipedia.org/wiki/NoSQL

WIKIPEDIA
The Free Encyclopedia

N★SQL

"... often more characteristics apply such as: **schema-free, easy replication support, simple API, eventual consistency / BASE (not ACID), a huge amount of data**."

http://nosql-database.org

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What is NoSQL?

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What is NoSQL?

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The Right Tool For The Job

http://www.flickr.com/photos/zakh/337938459/

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What Kinds Of Other Tools?

- Difficult to model with relational algebra
  - graphs, timeseries
- Performance gaps in RDBMS implementation
  - full-text search
- "Inside-out" requirements
  - multi-master, distributed, offline applications
- Ease of development
  - JavaScript/JSON/HTTP vs SQL/ODBC
- In-memory latency requirements
- Some **other** requirement more important than relationships/constraints

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What NoSQL is Not

- NoSQL is not **a standard**
  - there is no ANSI NoSQL-2014 definition
  - API, not SQL; different for each tool
- NoSQL is not **THE new database**
  - specialized tools for specific purposes
  - results in "polyglot storage"
- NoSQL is not **a silver bullet ***
  - how to integrate into existing data workflows?
  - are the tradeoffs acceptable?

* http://www.cs.nott.ac.uk/~pszcah/G51ISS/Documents/NoSilverBullet.html *

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Key-Value Stores

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Document Stores

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Bigtable Databases

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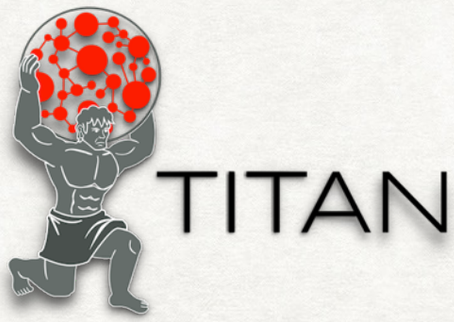
Graph Databases



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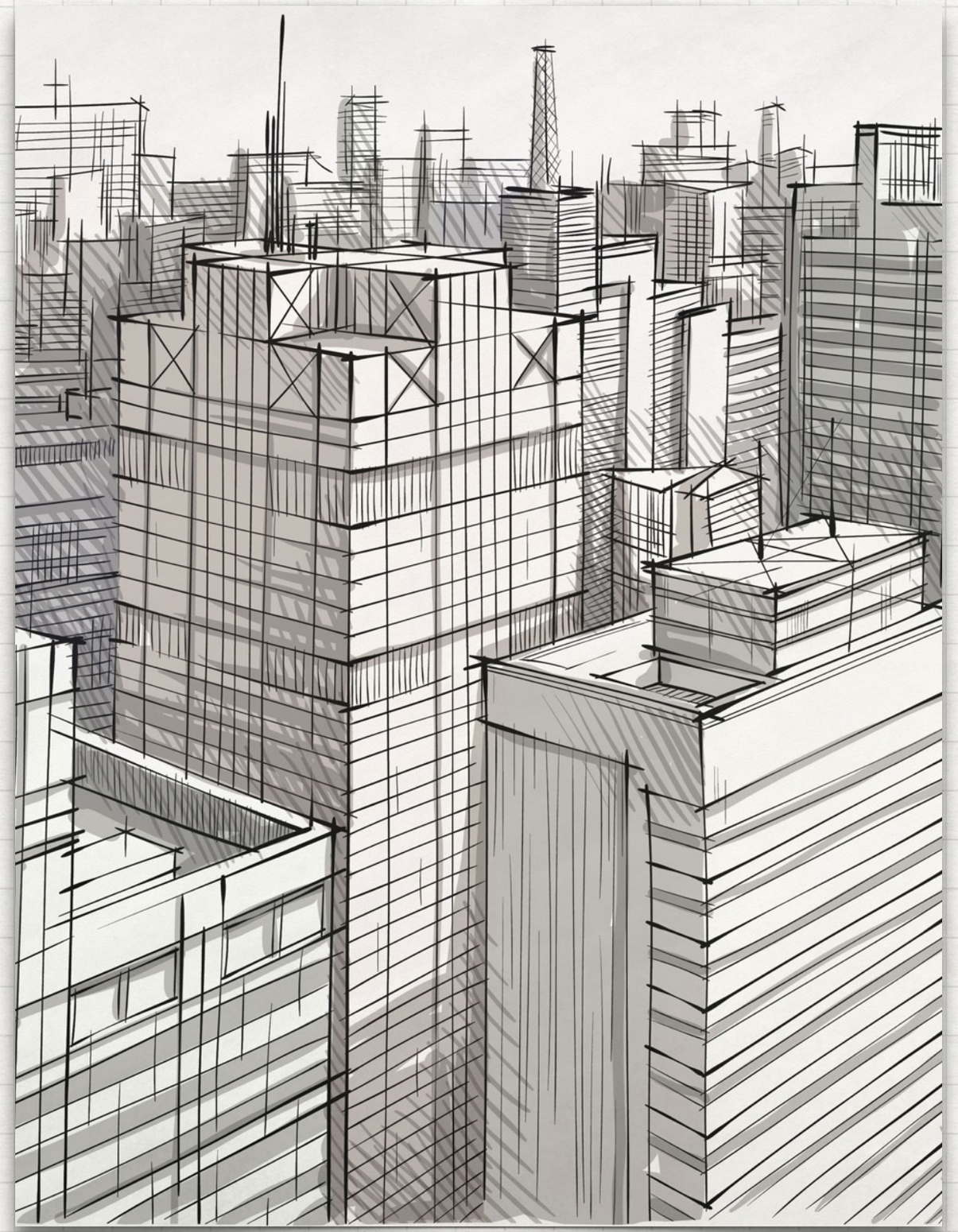
Part 2

Data at Scale



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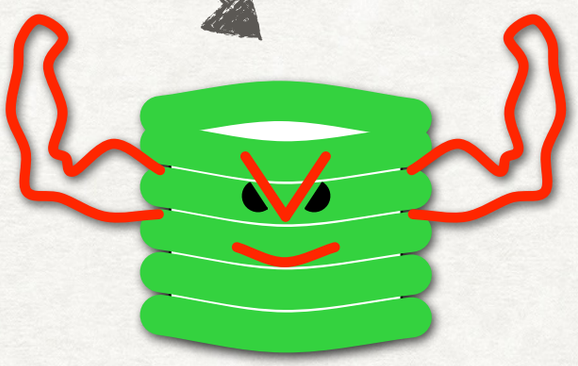
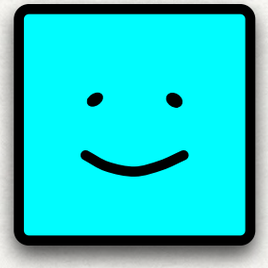
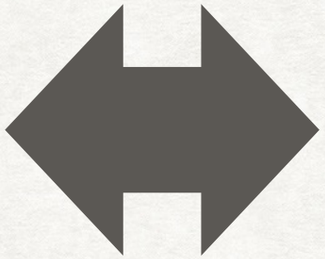
Typical Application

Database Server





App Server



Village People

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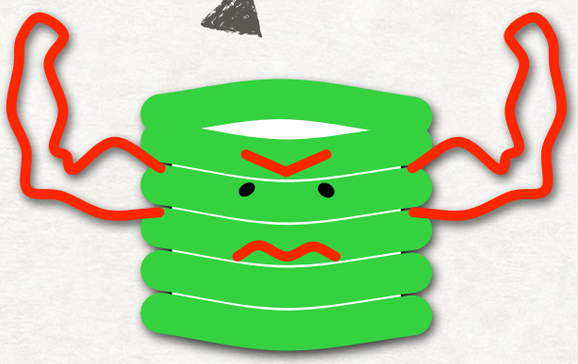
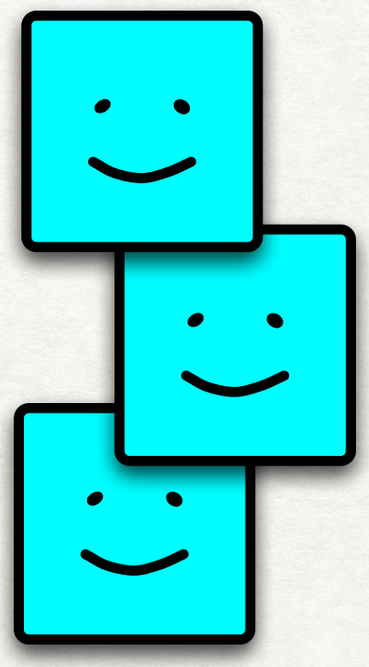
Growing Pains

Database Server





App Servers

API

Villages of People

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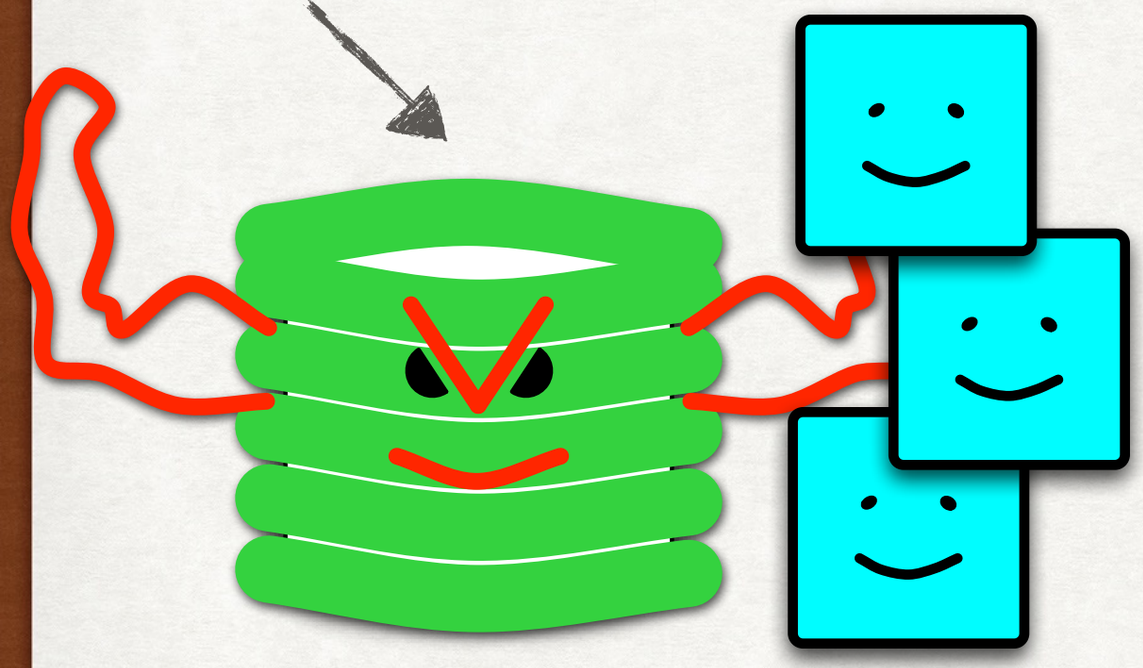
Vertical Scaling

BIGGER
Database Server



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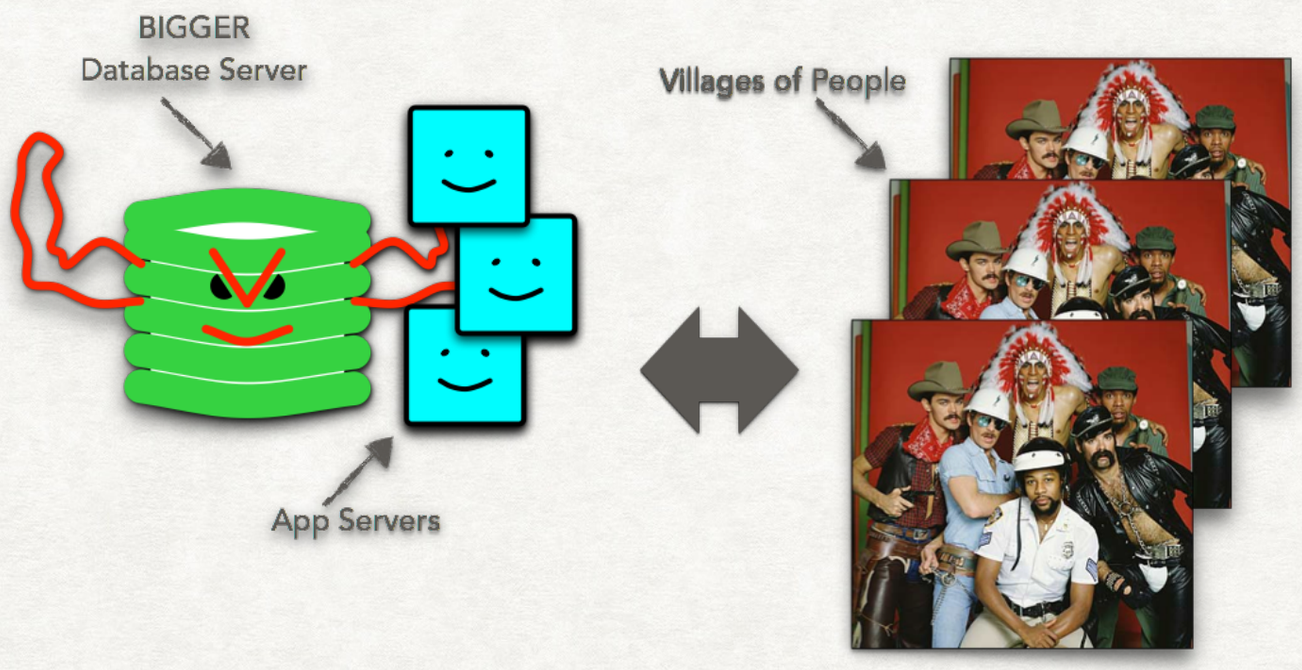
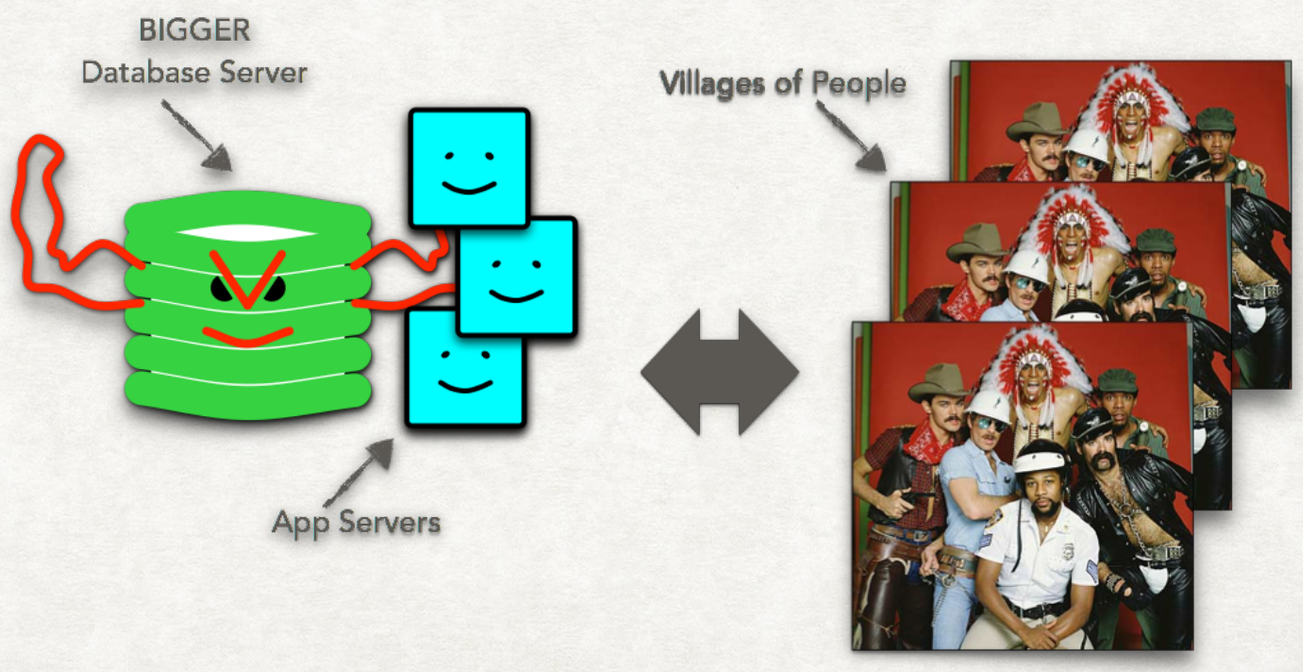
Application Partitioning





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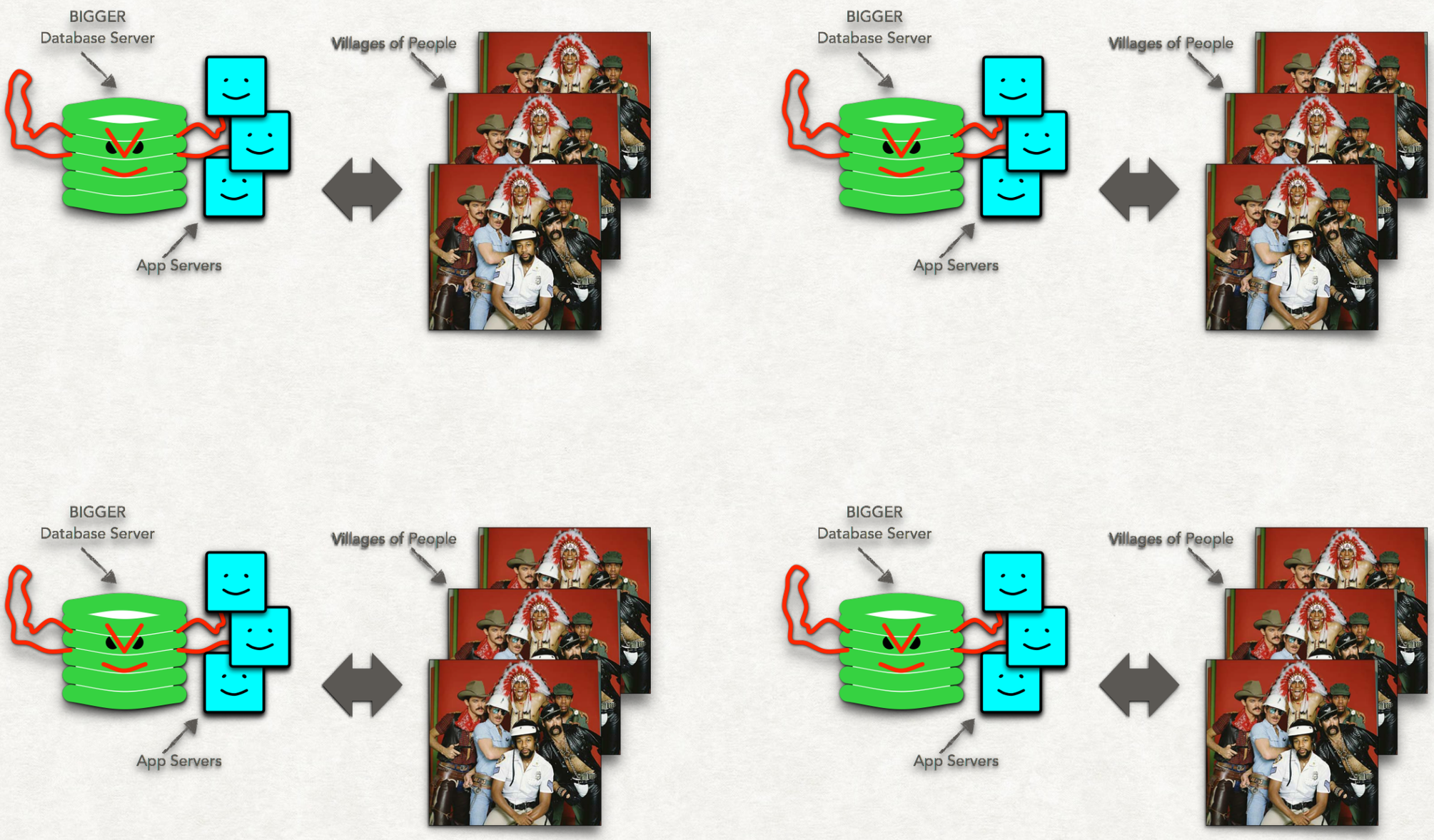

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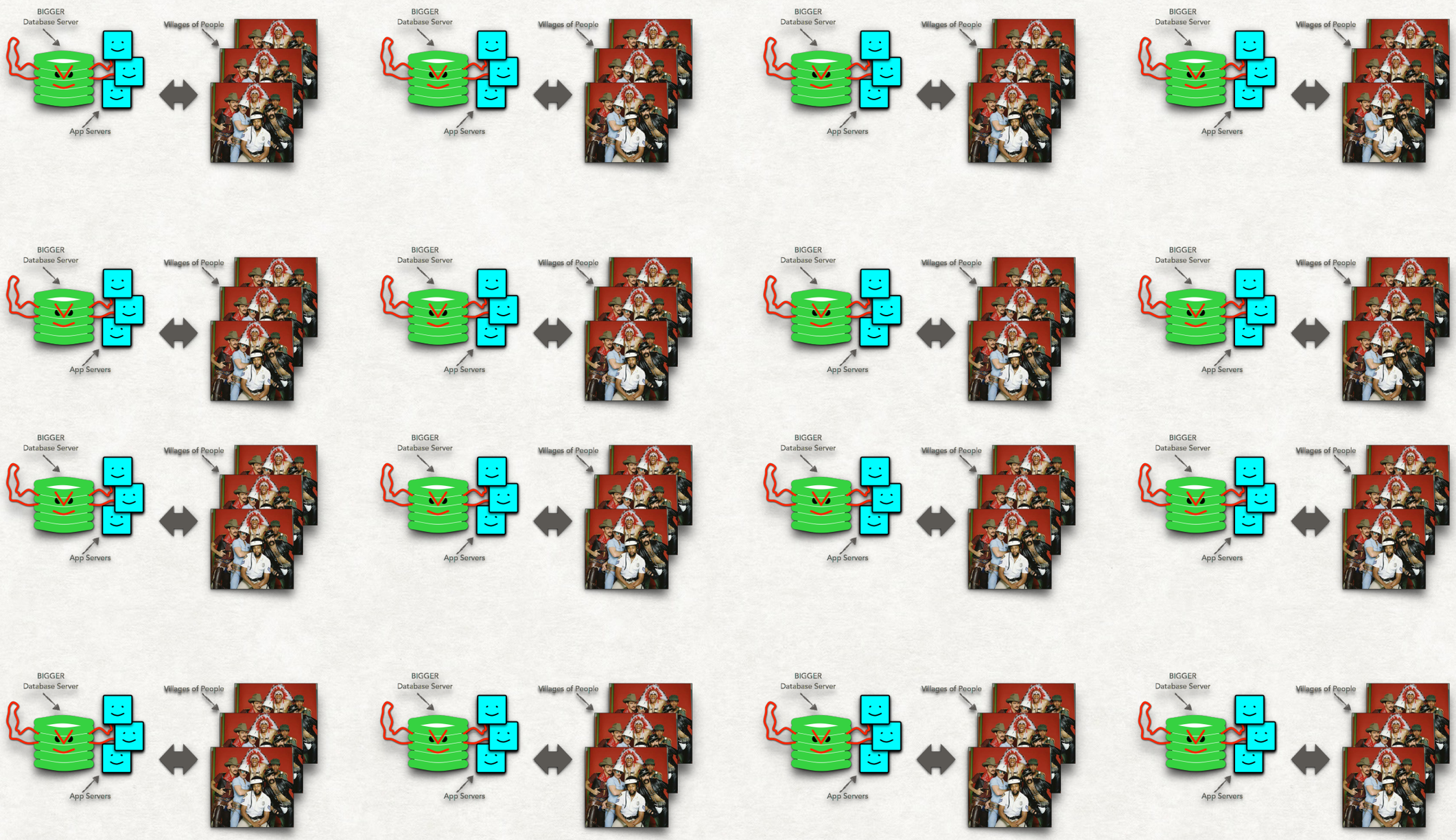

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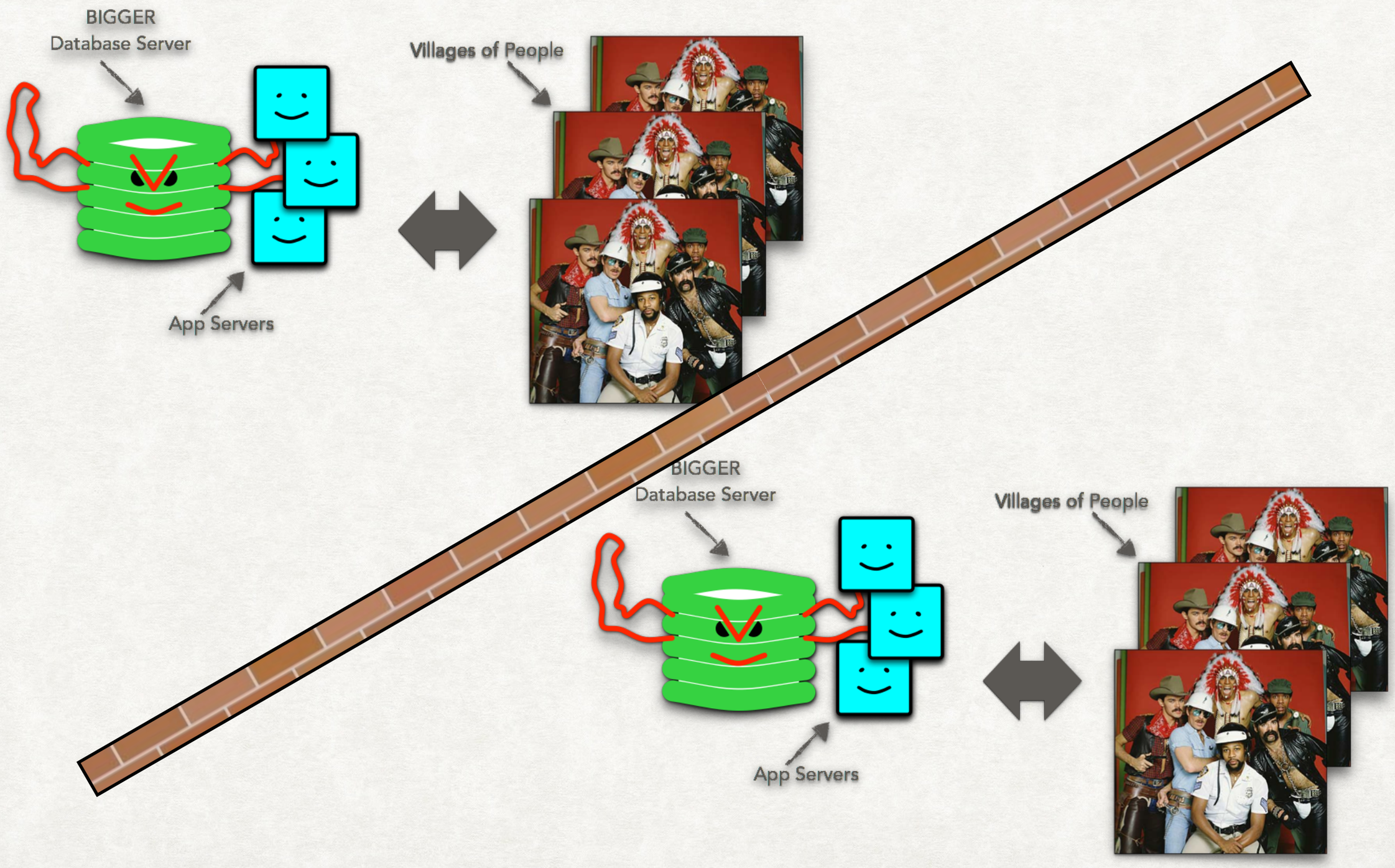
Physical Partitioning



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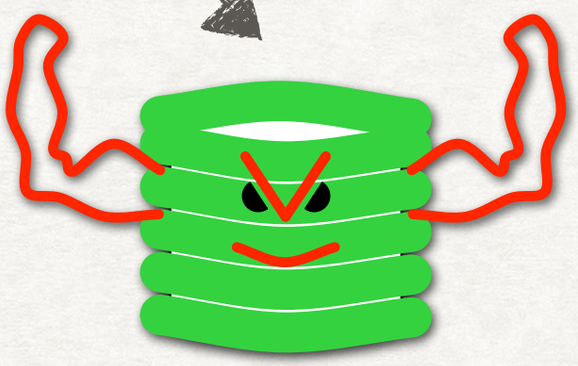
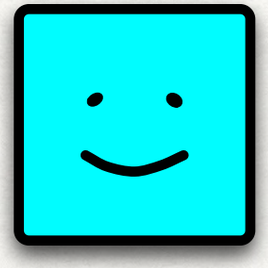
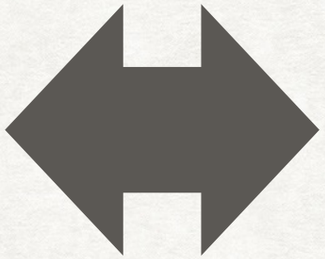
Database Server





App Server



Village People

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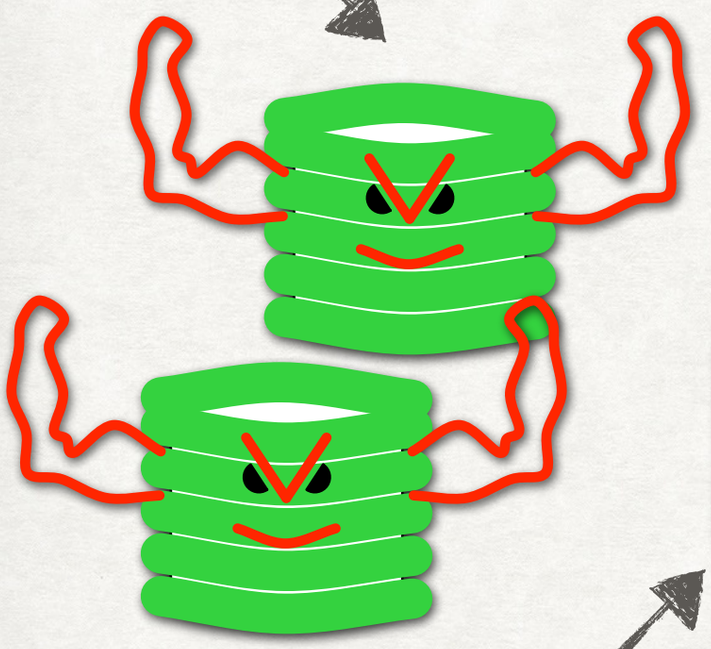
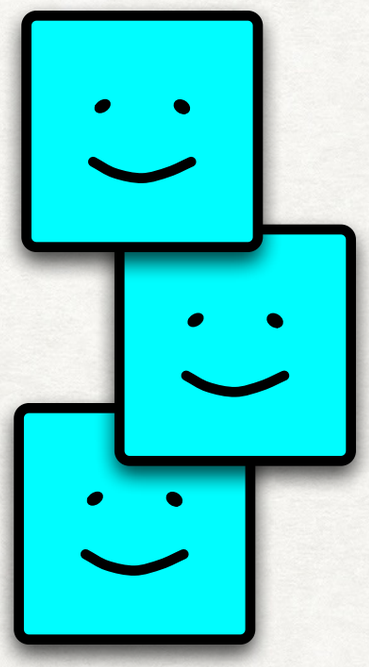
Horizontal Scaling

Database Servers





App Servers

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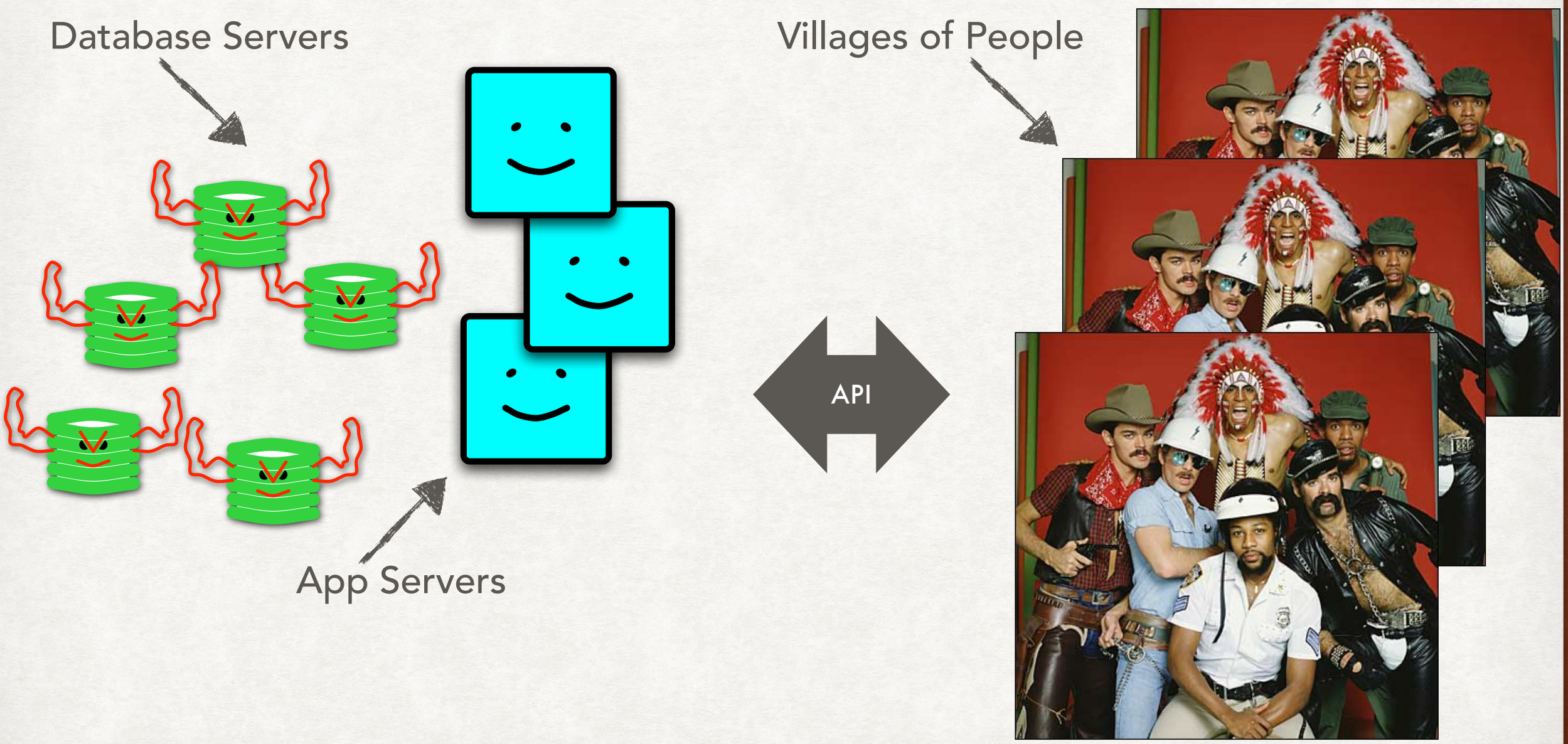
Horizontal Scaling



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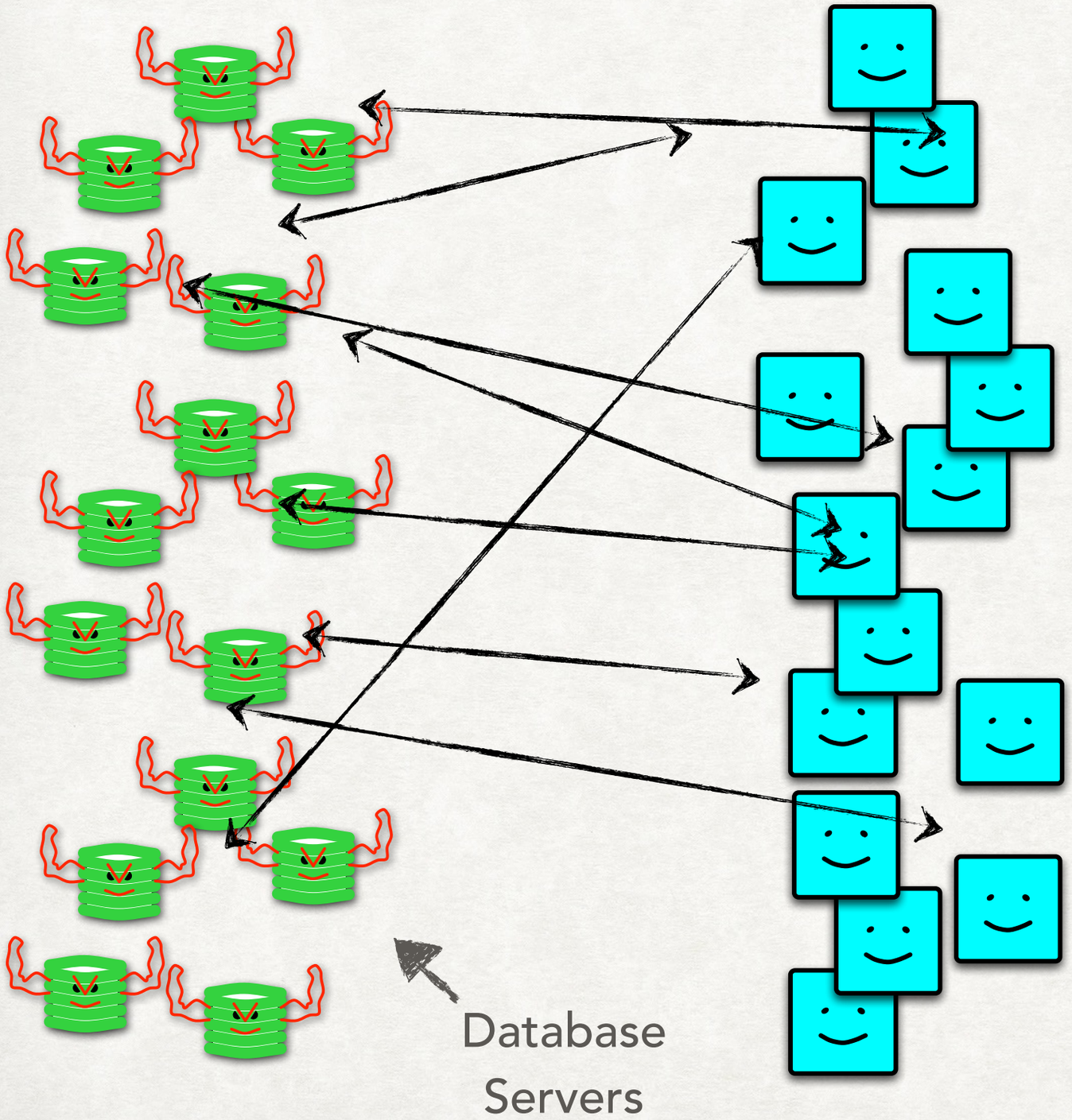
Horizontal Scaling



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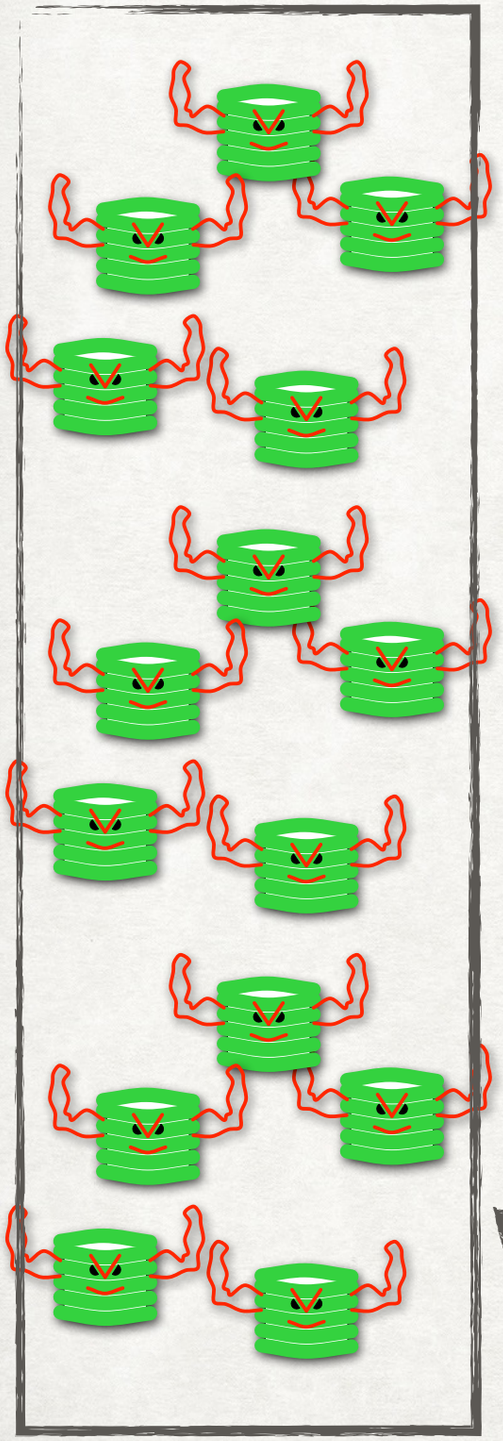
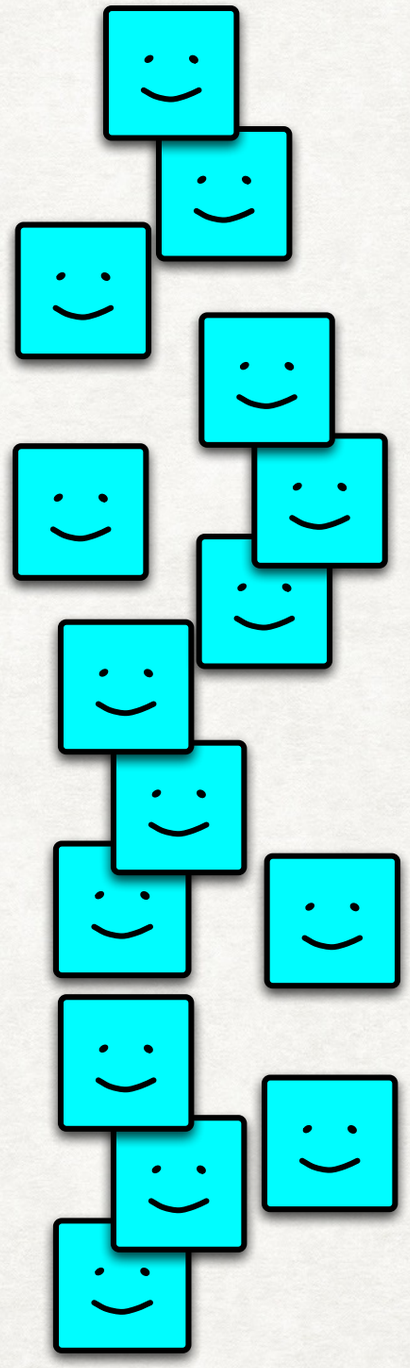
Distributed Database



Database Cluster

API



API

App Servers

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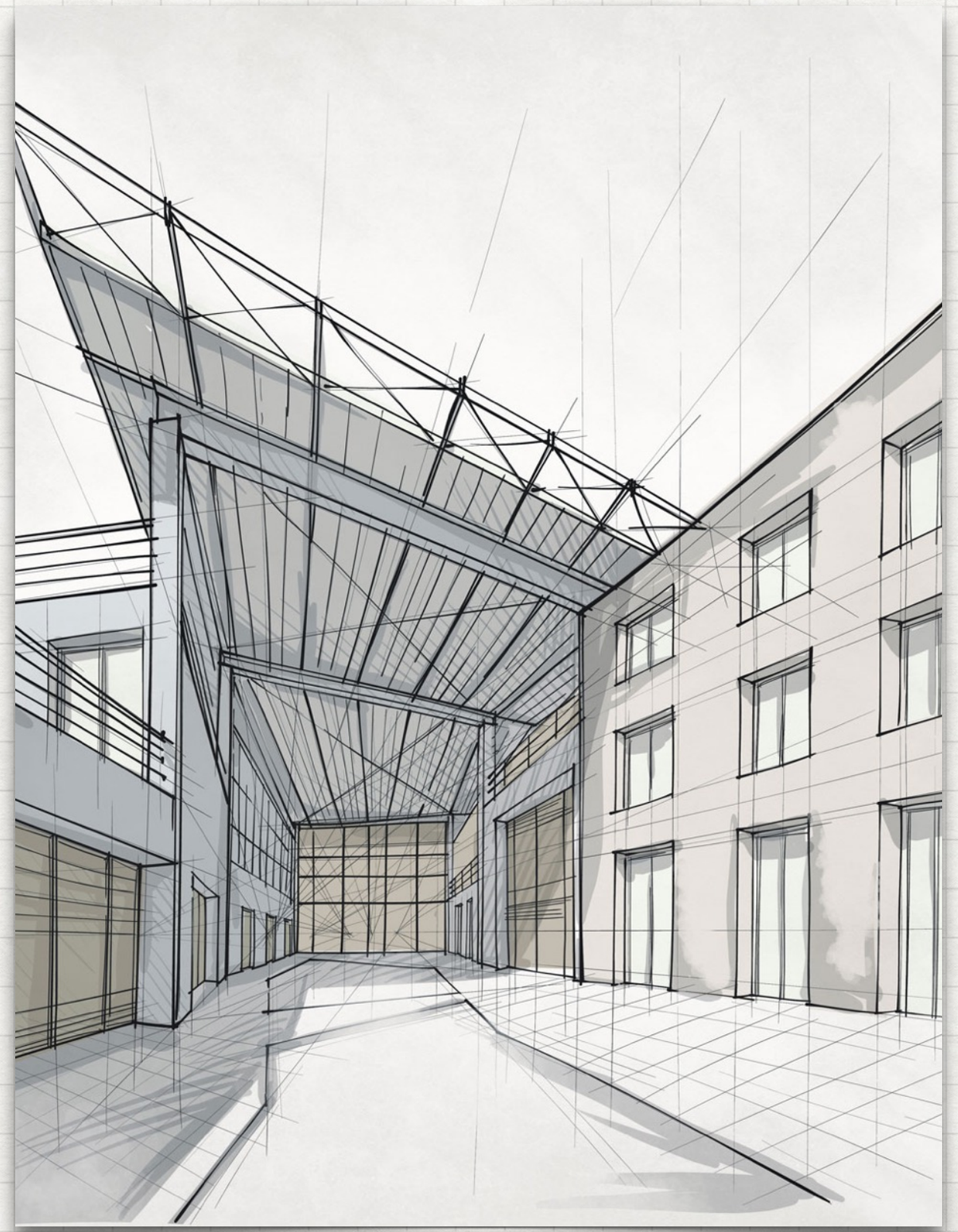
A Short Detour:

Computer Science!



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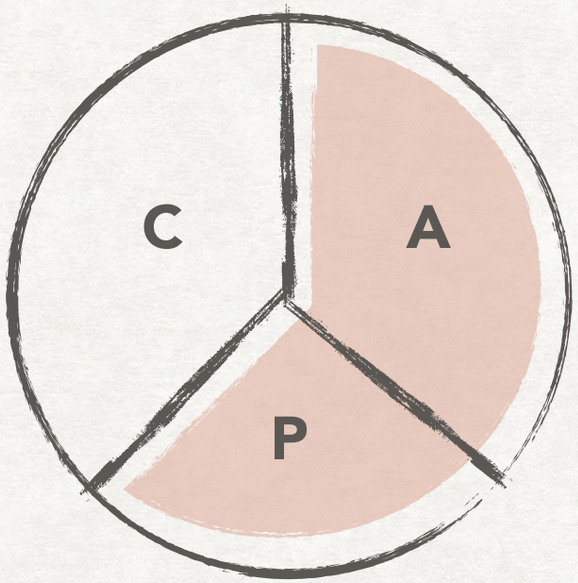
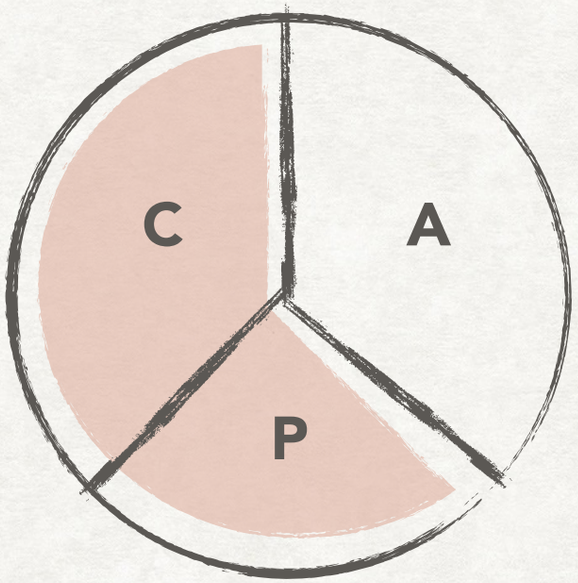
Brewer's CAP Conjecture/Theorem

For strict definitions of **C**onsistency, **A**vailability, Tolerance to Network **P**artitions:

- Define expectations when Bad Things[tm] happen
- Distributed storage focus on either CP or AP





http://www.cs.berkeley.edu/~brewer/cs262b-2004/PODC-keynote.pdf
http://www.infoq.com/articles/cap-twelve-years-later-how-the-rules-have-changed

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How we Distribute

Quorum Operations

- Group of members agree on every change
- Odd number of members, majority wins
- Member failure transparent to clients
- Agreement latency increases with quorum size

Federated Responsibility

- Regions operate independently
- Some "oracle" defines region boundaries
- Single member is authority within region
- Authority failure requires recovery

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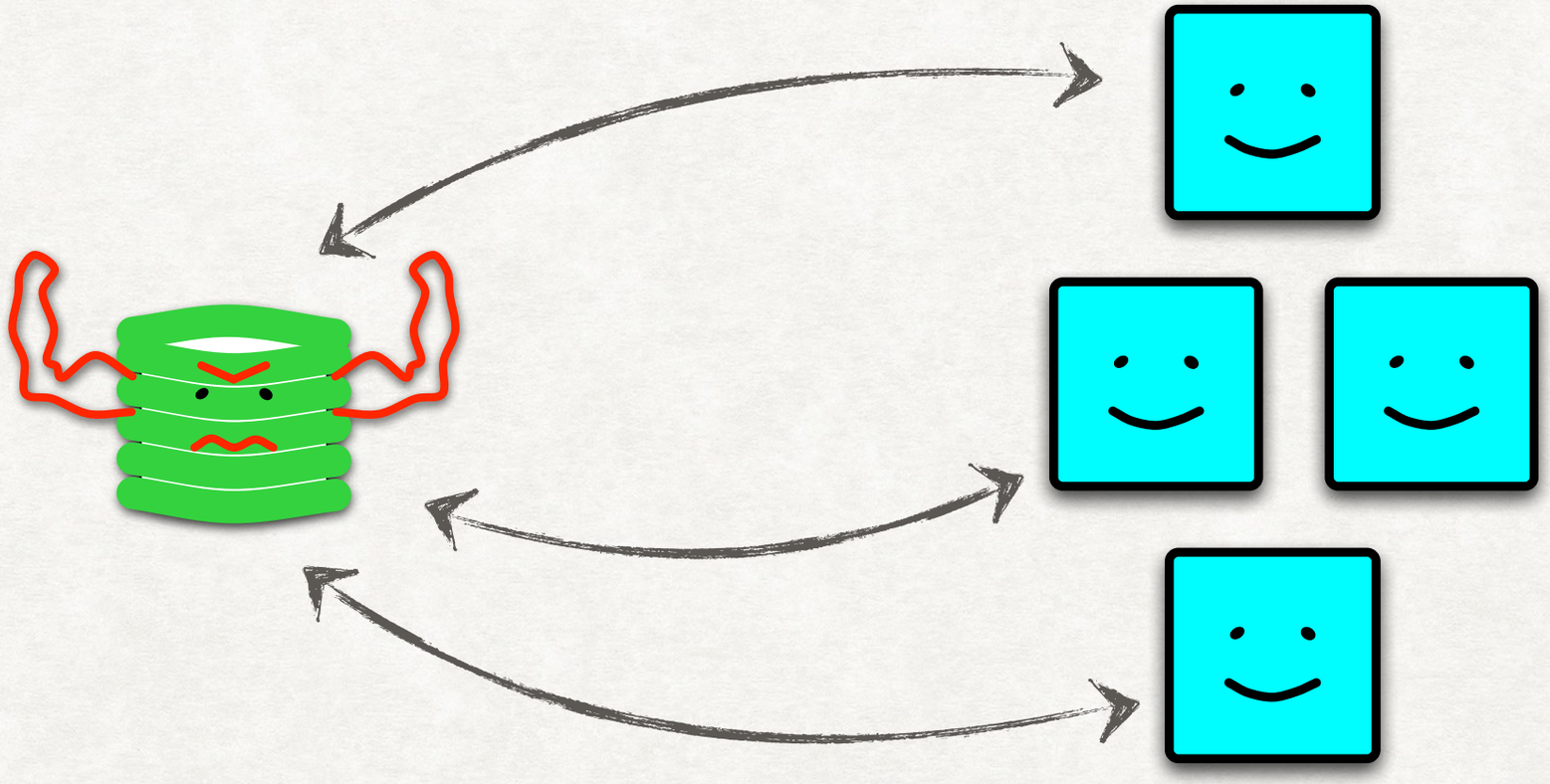
Growing Pains



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Dimensions of Growing Pains

Scaling user load

- problem: increasing service load to 1000's or millions of clients
- solution: replication

Scaling data volume

- problem: increasing amount of data under management
- solution: partitioning

Data durability

- problem: retaining data in the presence of member failure
- solution: replication

Service availability

- problem: serving requests in the presence of member failure
- solution: replication, partitioning

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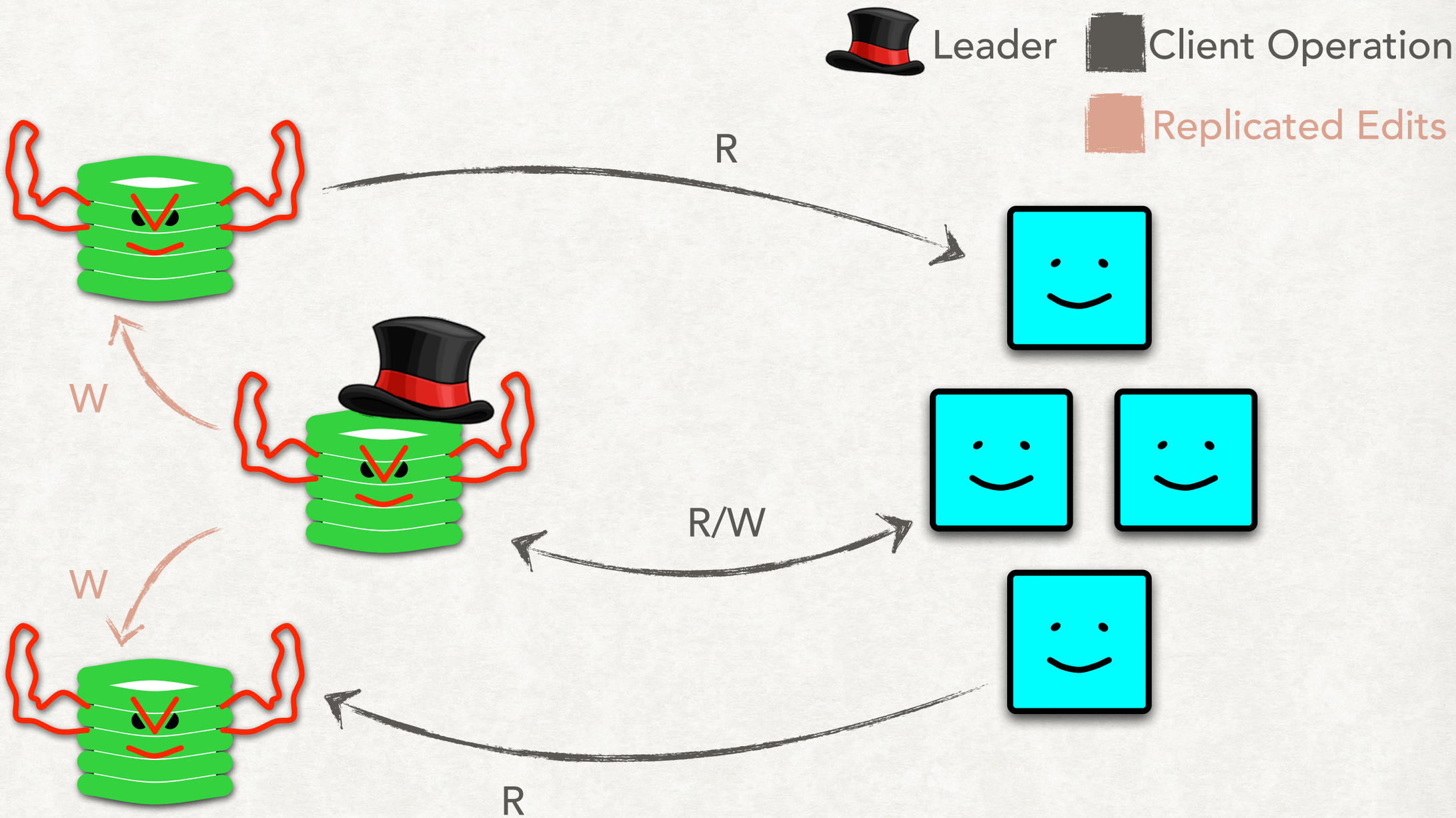
Scaling User Load with Replication



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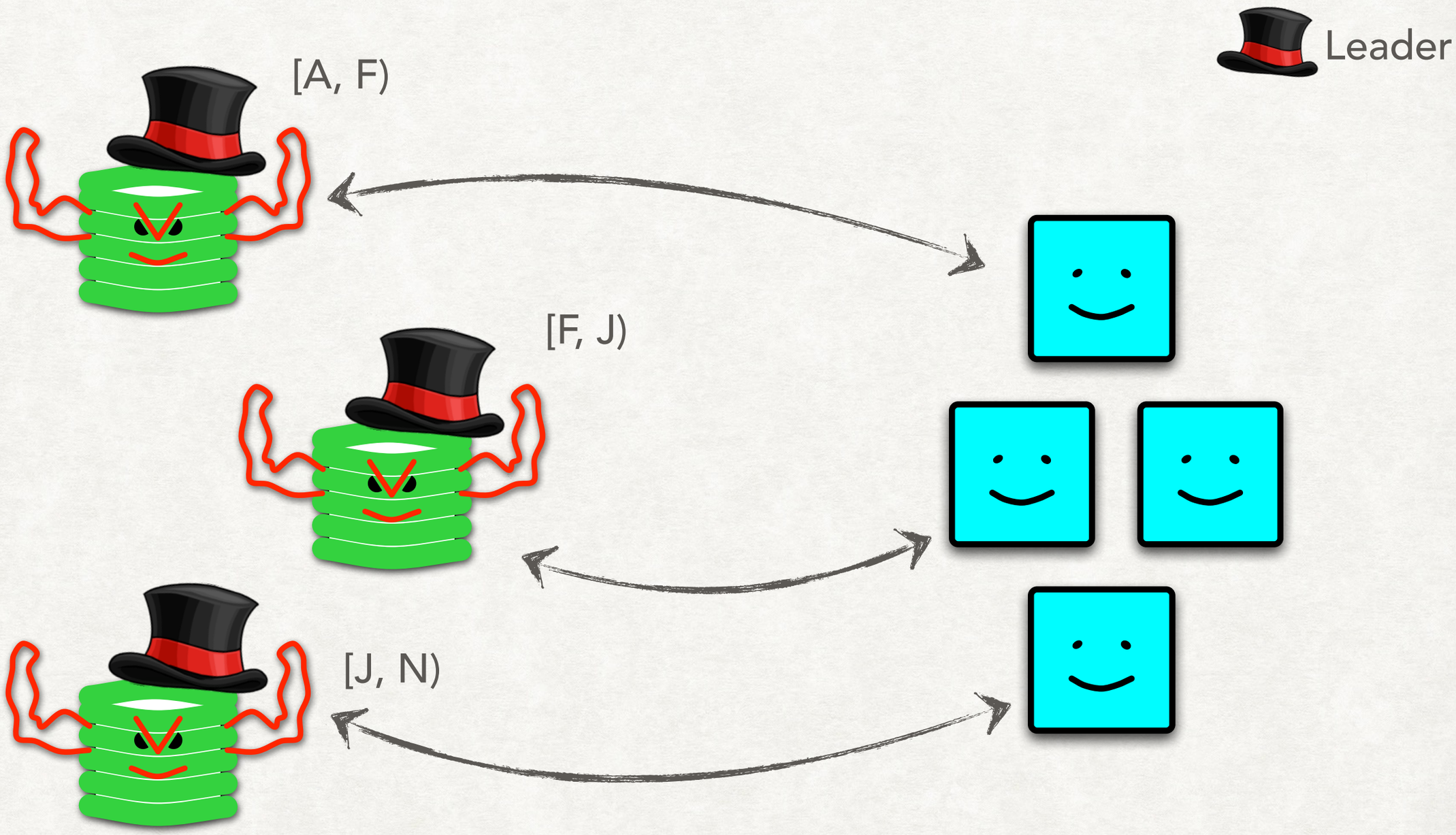
Scaling Data Volume with Partitioning



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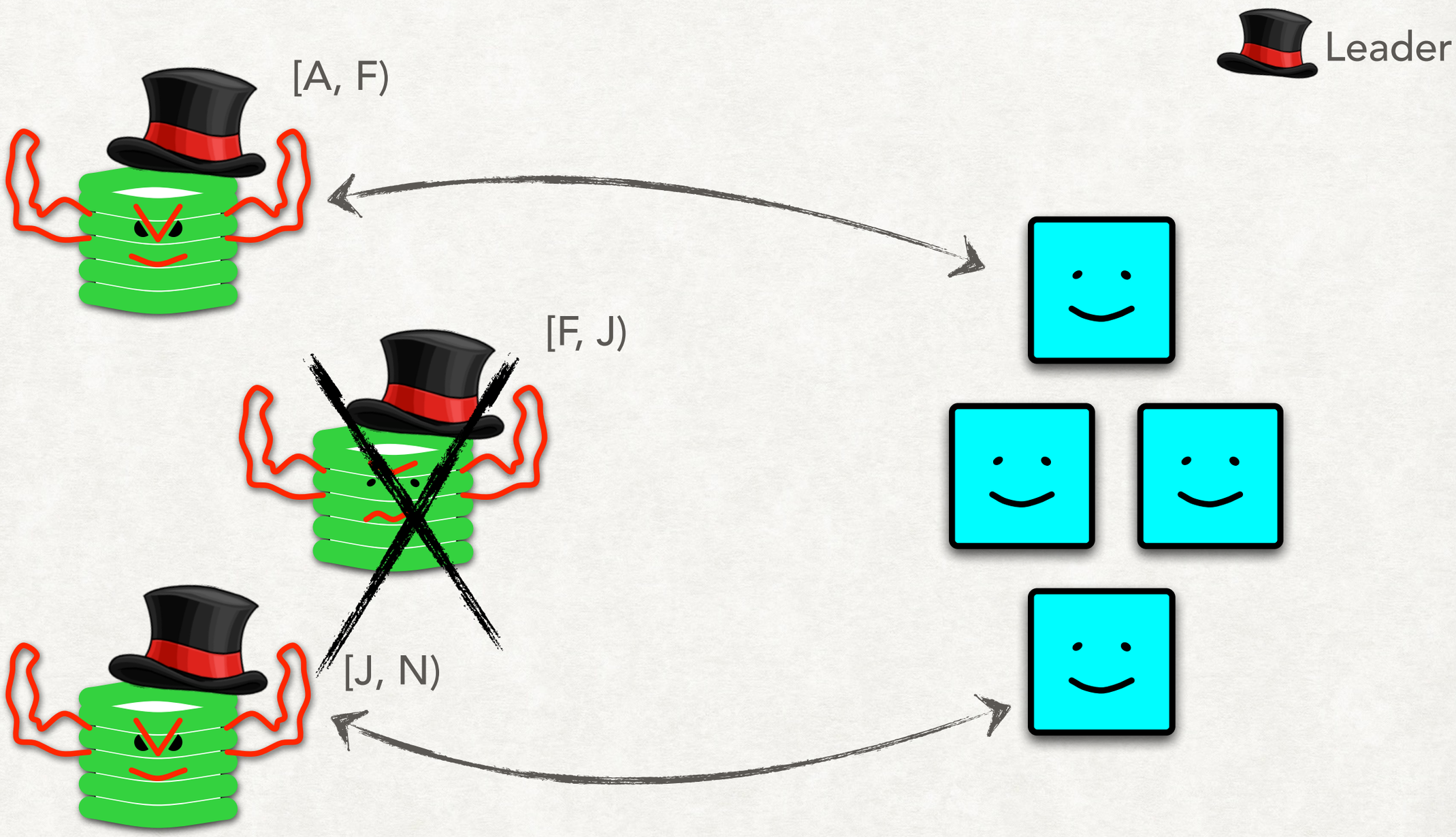
Availability with Partitioning



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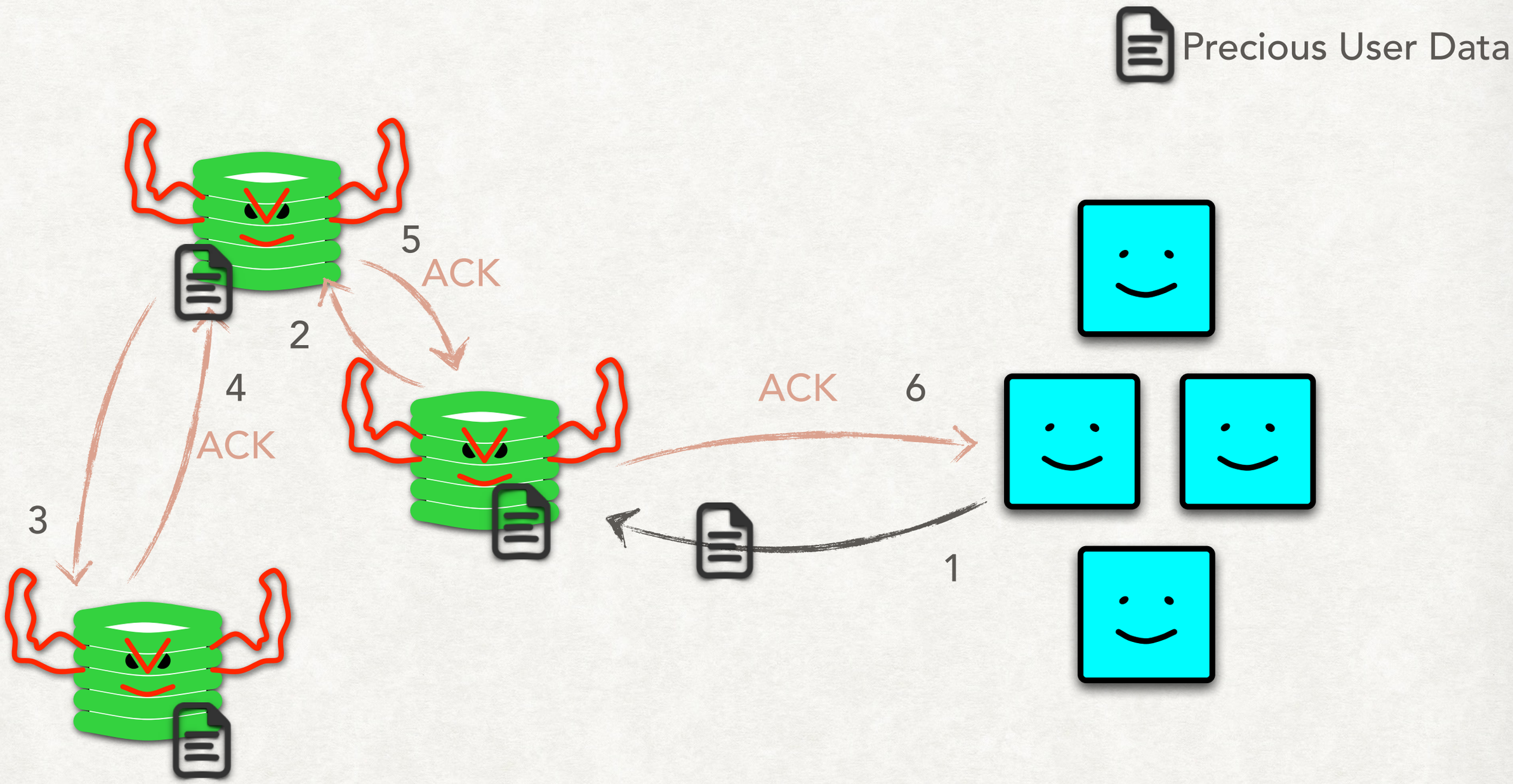
Durability with Replication



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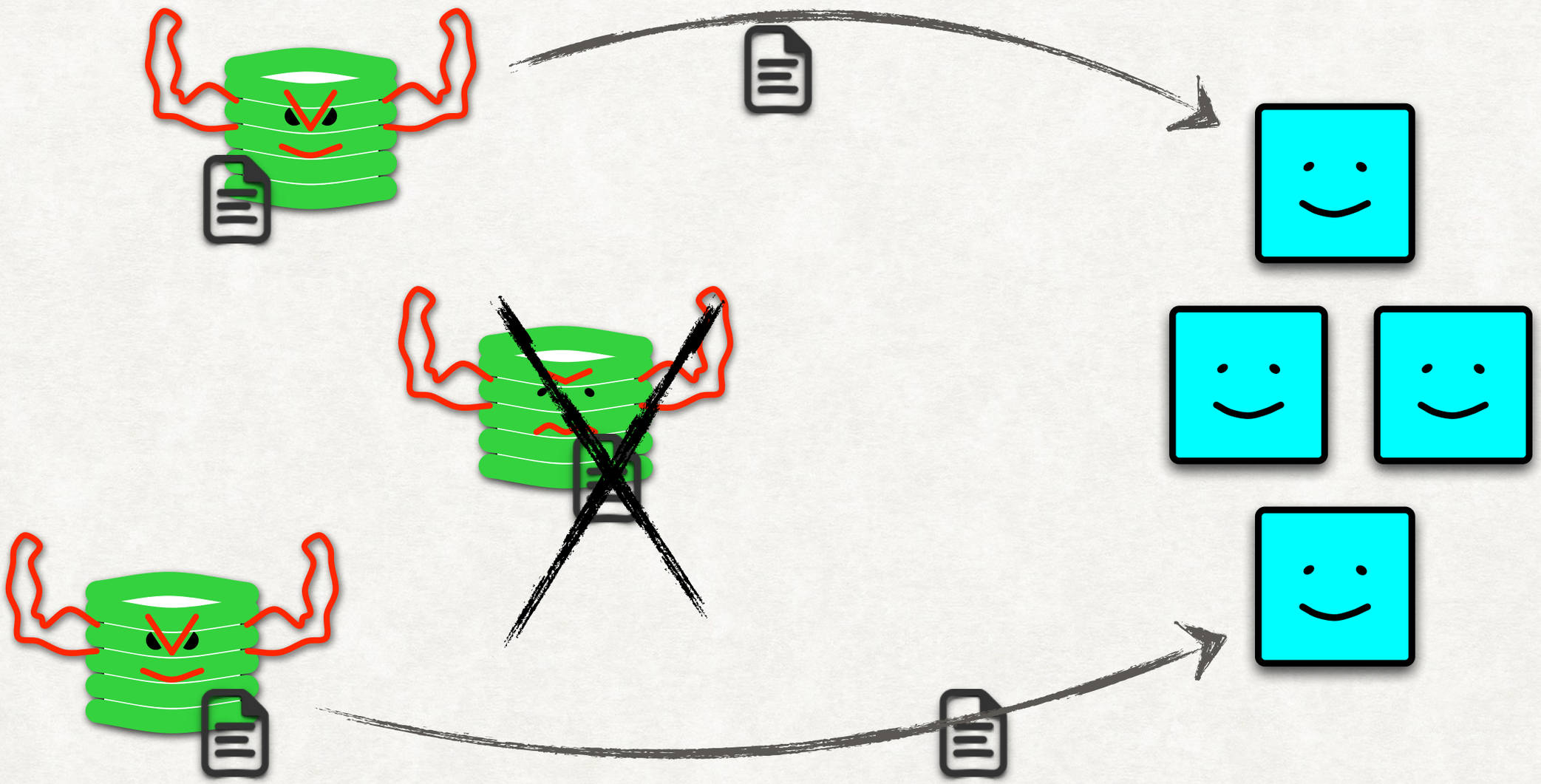
Durability with Replication



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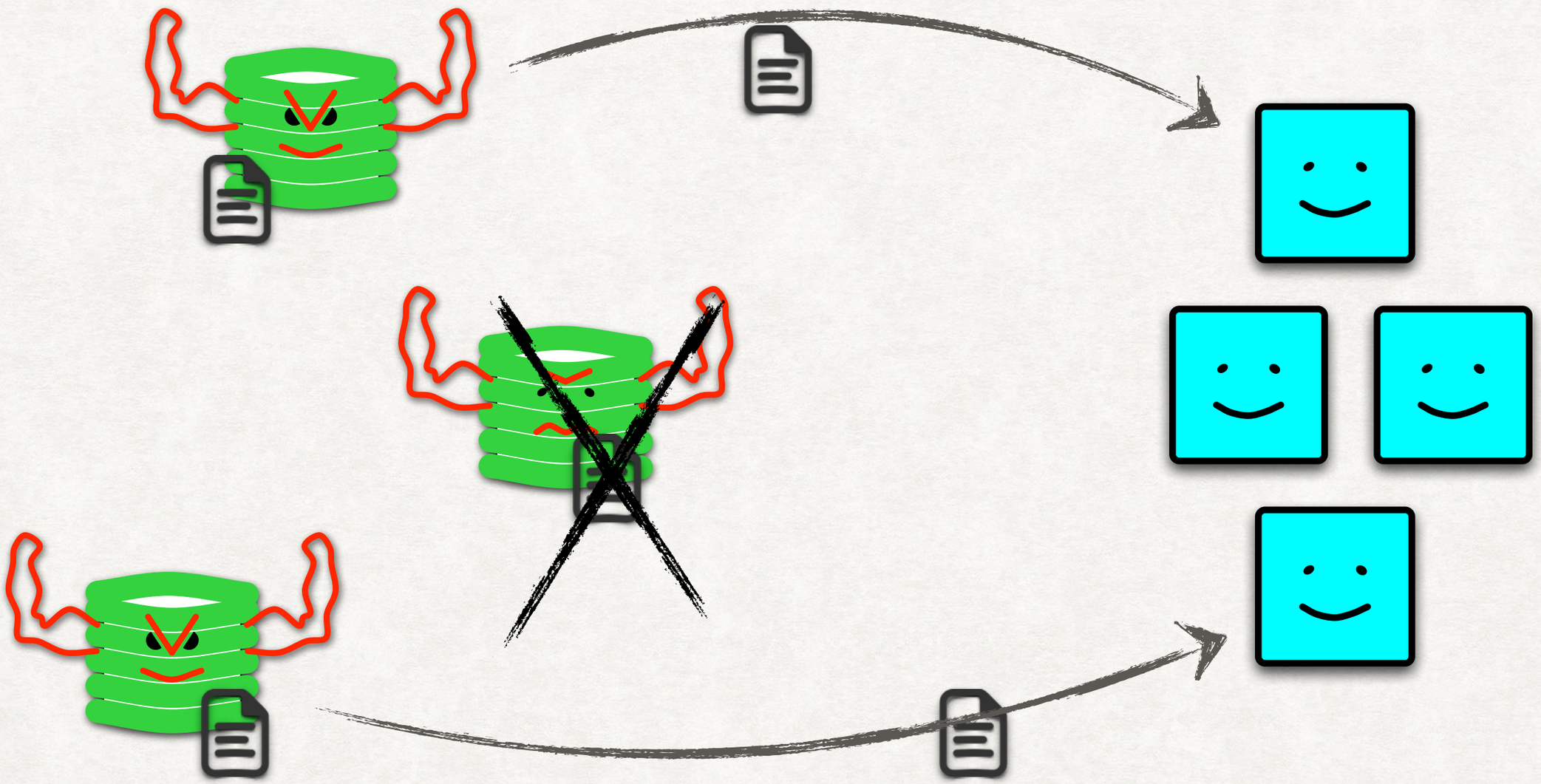
~~Durability~~Availability with Replication



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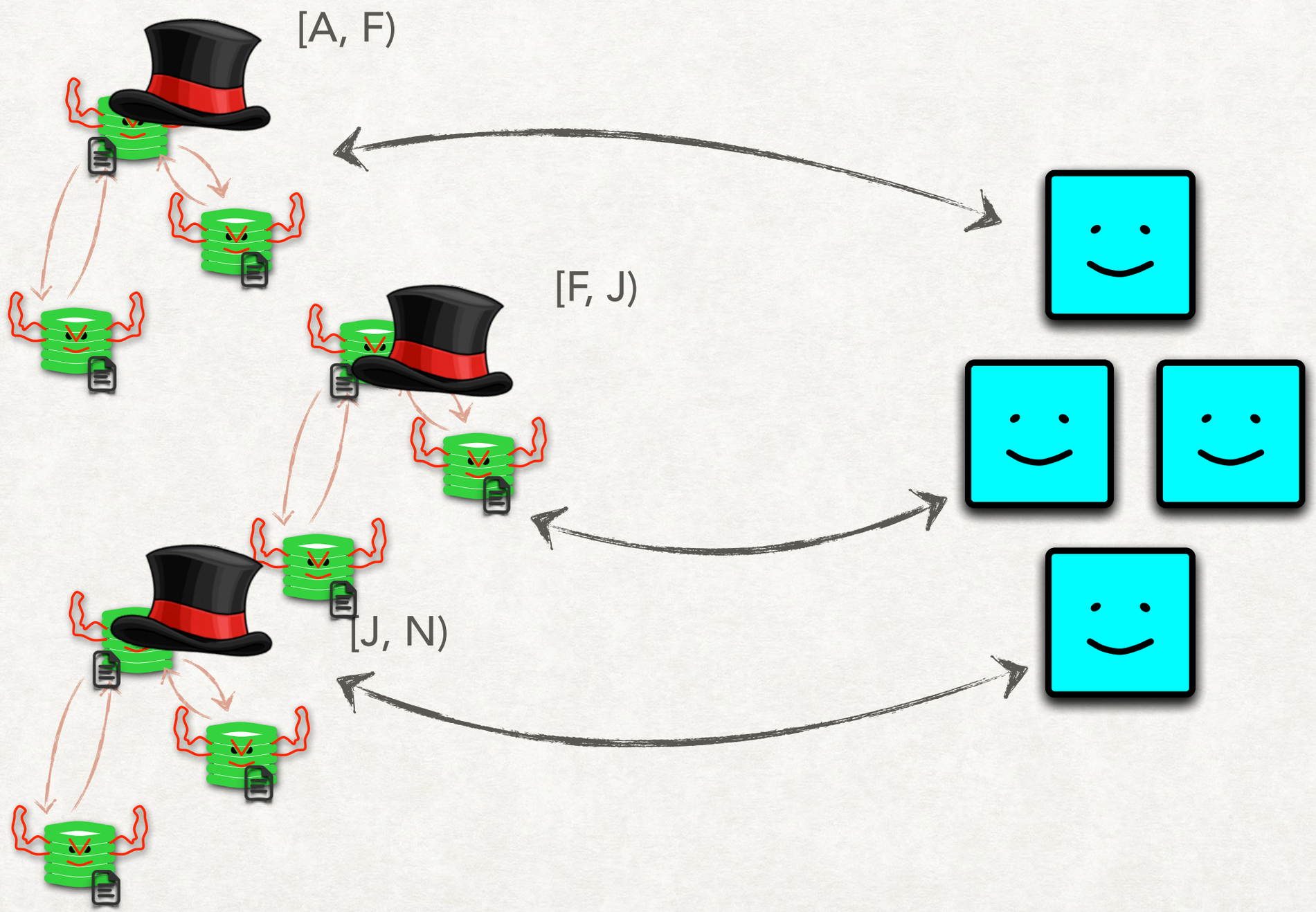
Durable, Available Partitions



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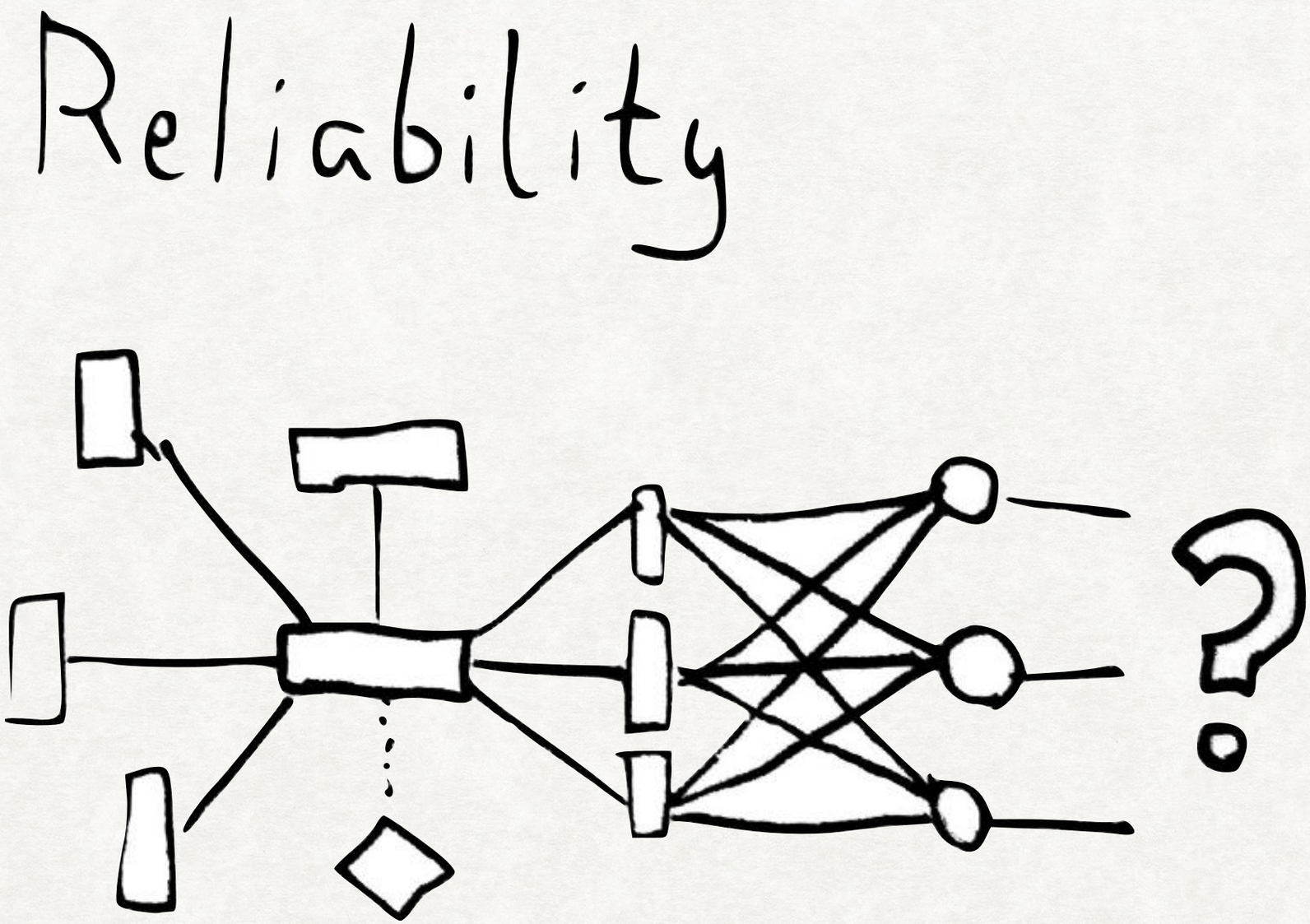
Empirical Evidence



https://aphyr.com/posts/
281-call-me-maybe-carly-rae-jepsen-and-the-perils-of-network-partitions

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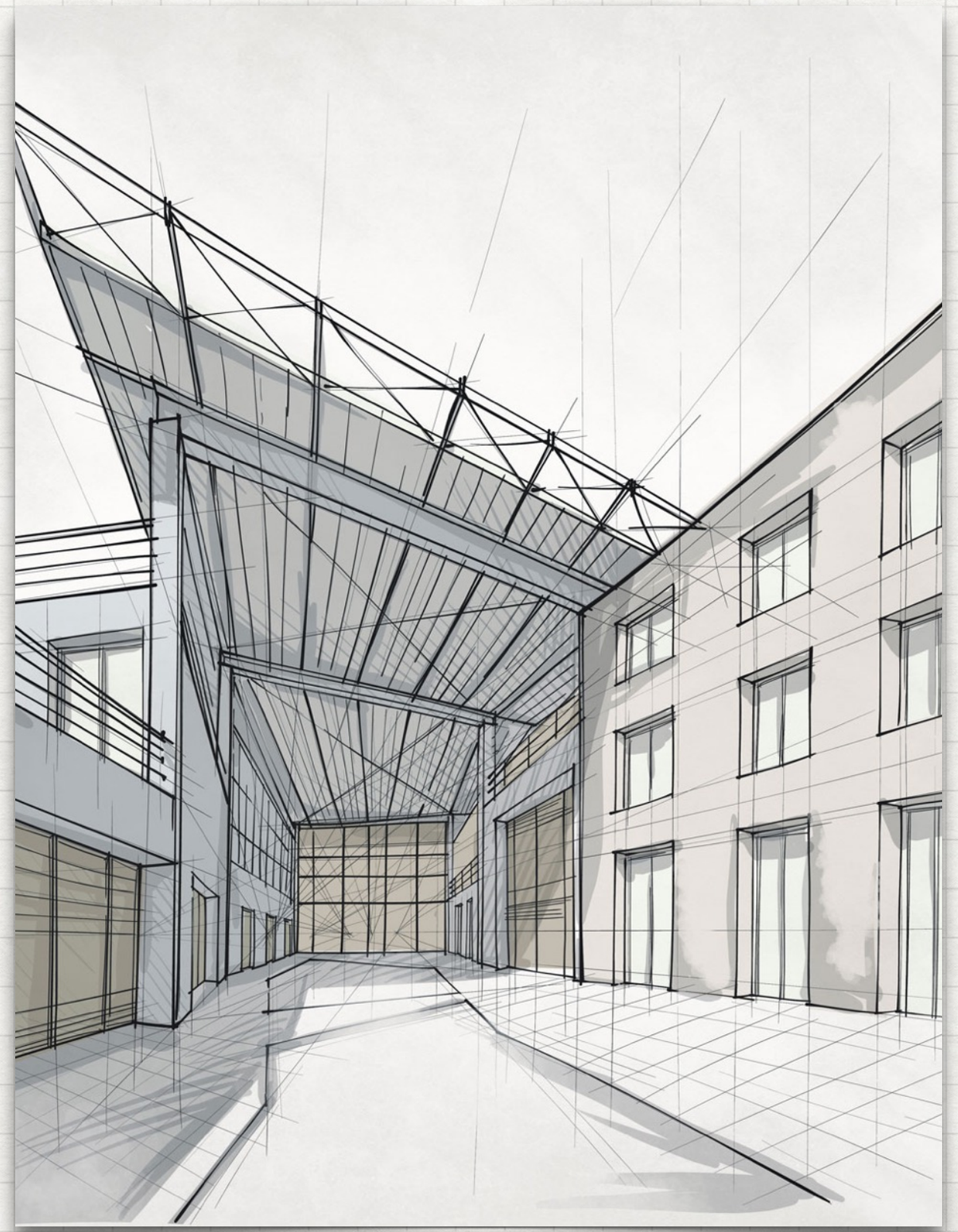
Part 3

NoSQL In Depth With Apache HBase



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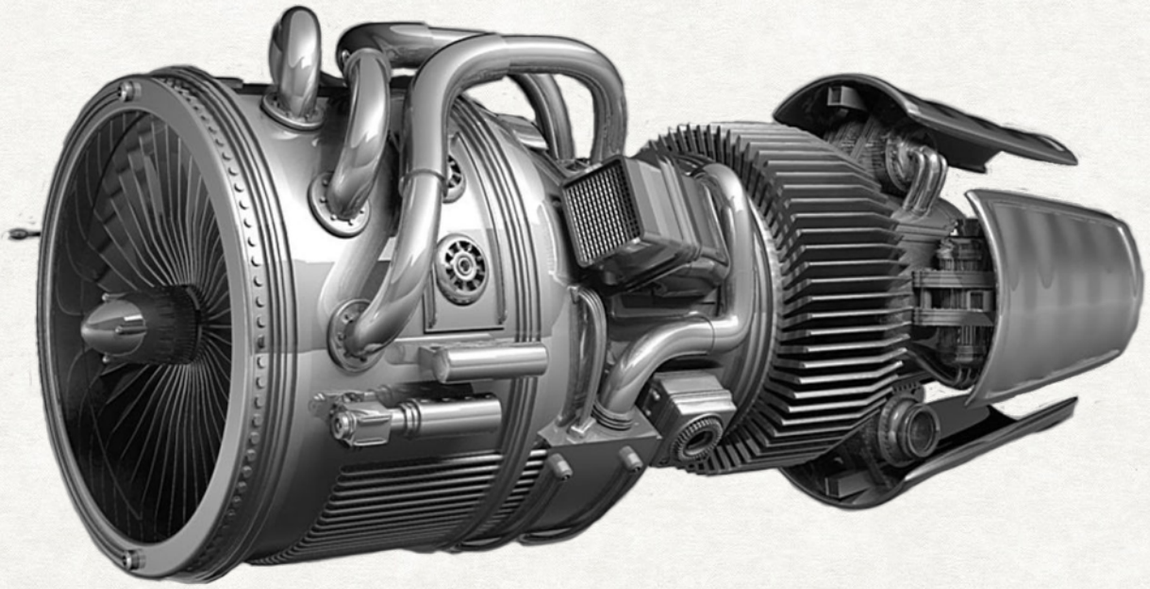
What is Apache HBase?

A high performance horizontally scalable bytestore for Big Data, suitable as the store of record for *mission critical data*.



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What is Apache HBase?

"Bigtable: A Distributed Storage System for Structured Data"

- Chang, Fay, et al. OSDI'06
- "Bigtable is a sparse, distributed, persistent multi-dimensional sorted map."
- http://research.google.com/archive/bigtable.html

Key Features include:

- Distributed storage over a cluster of machines
- Random, online, read and write access
- Schema-less data model
- Self-managed partitions

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Apache HBase Dependencies

Apache Hadoop Distributed Filesystem (HDFS)

- Distributed, fault-tolerant, throughput-optimized data storage
- The Google File System, 2003, Ghemawat et al.
- http://research.google.com/archive/gfs.html

Apache Zookeeper (ZK)

- Distributed, available, reliable coordination system
- The Chubby Lock Service …, 2006, Burrows
- http://research.google.com/archive/chubby.html

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Data Model

Table A

Column Families

Rows

rowkey	column family	column qualifier	timestamp	value
a	cf1	"bar"	1368394583	7
			1368394261	"hello"
		"foo"	1368394583	22
			1368394925	13.6
			1368393847	"world"
	cf2	"2011-07-04"	1368396302	"fourth of July"
		1.0001	1368387684	"almost the loneliest number"
b	cf2	"thumb"	1368387247	[3.6 kb png data]

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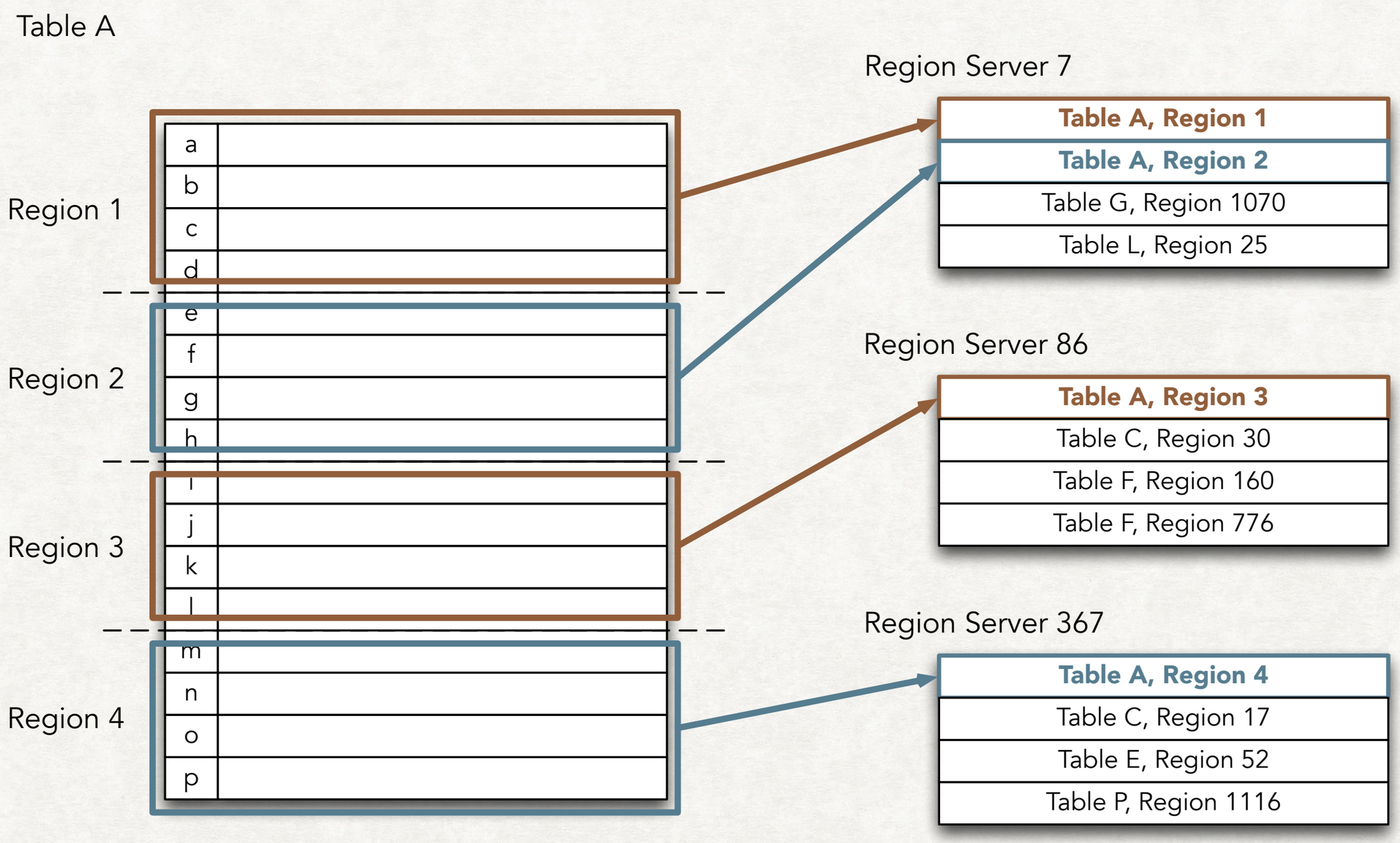
Logical Architecture



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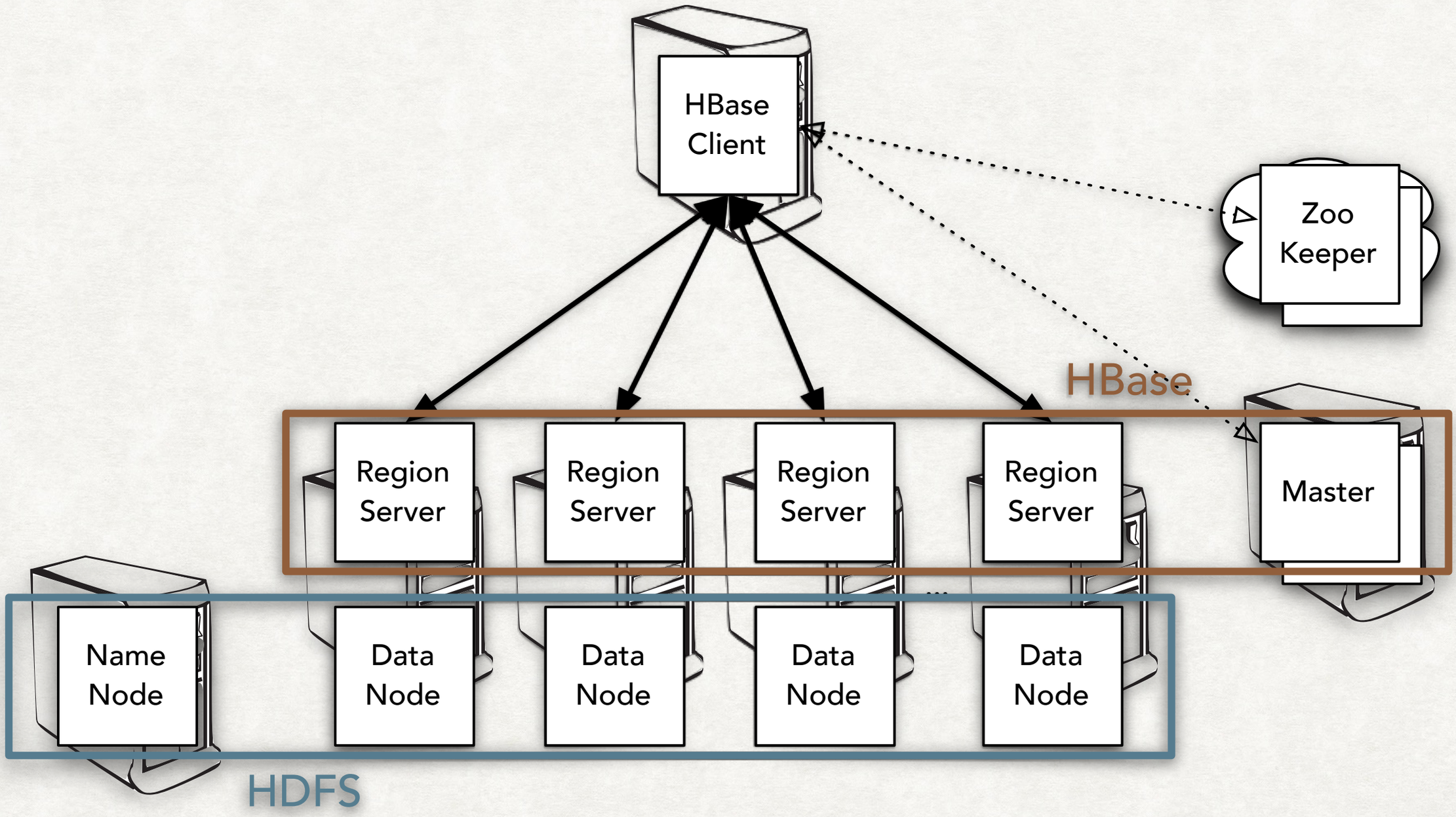
Physical Architecture



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User API

{rowkey => {family => {qualifier => {version => value}}}}

- Think: nested TreeMap (Java), OrderedDictionary (C#), OrderedDict (Python)

Basic data operations: GET, PUT, DELETE

SCAN over range of key-values

- benefit of the sorted rowkey business
- this is how you implement any kind of "complex query" *

GET, SCAN support Filters

- Push application logic to RegionServers

INCREMENT, APPEND, CheckAnd{Put,Delete}

- Server-side, atomic data operations, can be contentious!

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Part 4

Bringing SQL Back With Apache Phoenix

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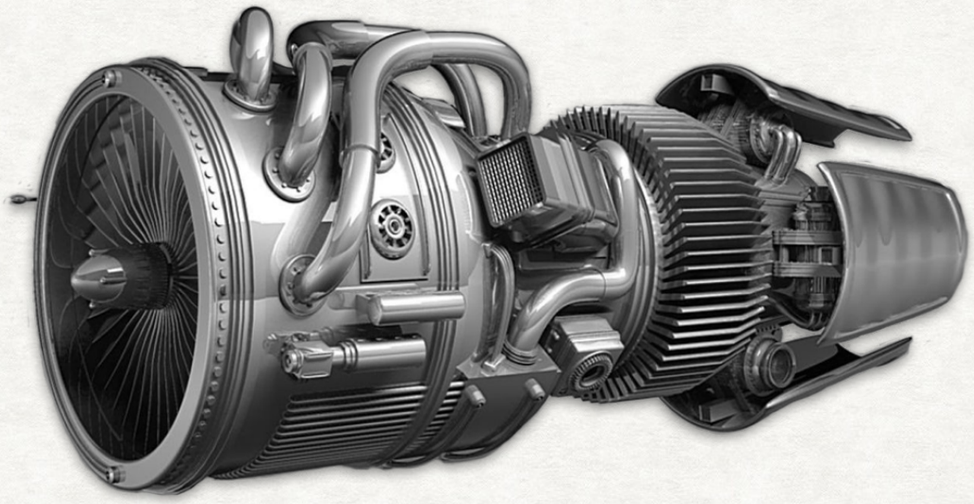
What is Apache Phoenix?

==



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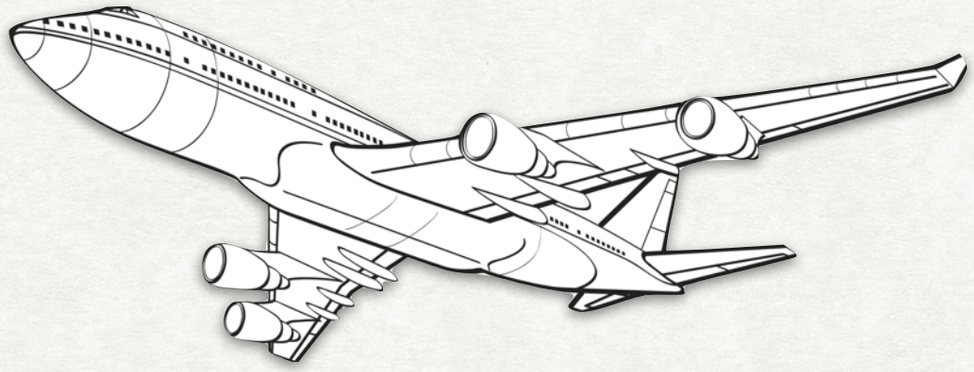

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What is Apache Phoenix?

A relational database layer for Apache HBase

- Query Engine
  - Transforms SQL queries into native HBase API calls
  - Push as much work as possible into HBase region servers
- Metadata repository
  - Typed access to data stored in HBase tabled
- Thick and thin JDBC Driver

Originally Developed at Salesforce

A growing community

APACHE HBASE

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APACHE PHOENIX

Phoenix puts SQL back in NoSQL

Familiar SQL interface (DDL, DML, &c.)

- Read only materialized views on existing tables
- Dynamic columns extend schema at runtime
- Flashback queries using versioned schema

Data Types

Secondary Indices

Joins

Query planning and optimization

Multi-tenancy

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APACHE PHOENIX

Phoenix puts SQL back in NoSQL

Accessing HBase data with Phoenix can be substantially easier than directly through the HBase API:

```
SELECT * FROM foo WHERE bar > 30
```

Versus

```
HTable t = new HTable("foo");
RegionScanner s = t.getScanner(new Scan(…,
    new ValueFilter(CompareOp.GT,
        new CustomTypedComparator(30)), …));
while ((Result r = s.next()) != null) {
     // blah blah blah Java Java Java
}
s.close();
t.close();
```

Your BI tool probably can't do this

(And we didn't include error handling…)

APACHE HBASE

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APACHE PHOENIX

Phoenix puts SQL back in NoSQL

Accessing HBase data with Phoenix can be substantially faster than direct HBase API use:

- Phoenix parallelizes queries based on stats; HBase does not know how to chunk queries beyond scanning an entire region
- Phoenix pushes processing to the server - most "by hand" API accesses do not use coprocessors
  - A huge difference for aggregation queries
- Phoenix supports and uses secondary indexes
- Phoenix uses "every trick in the book" based on various factors: the HBase version, metadata and query, reverse scans, small scans, skip scans, etc.

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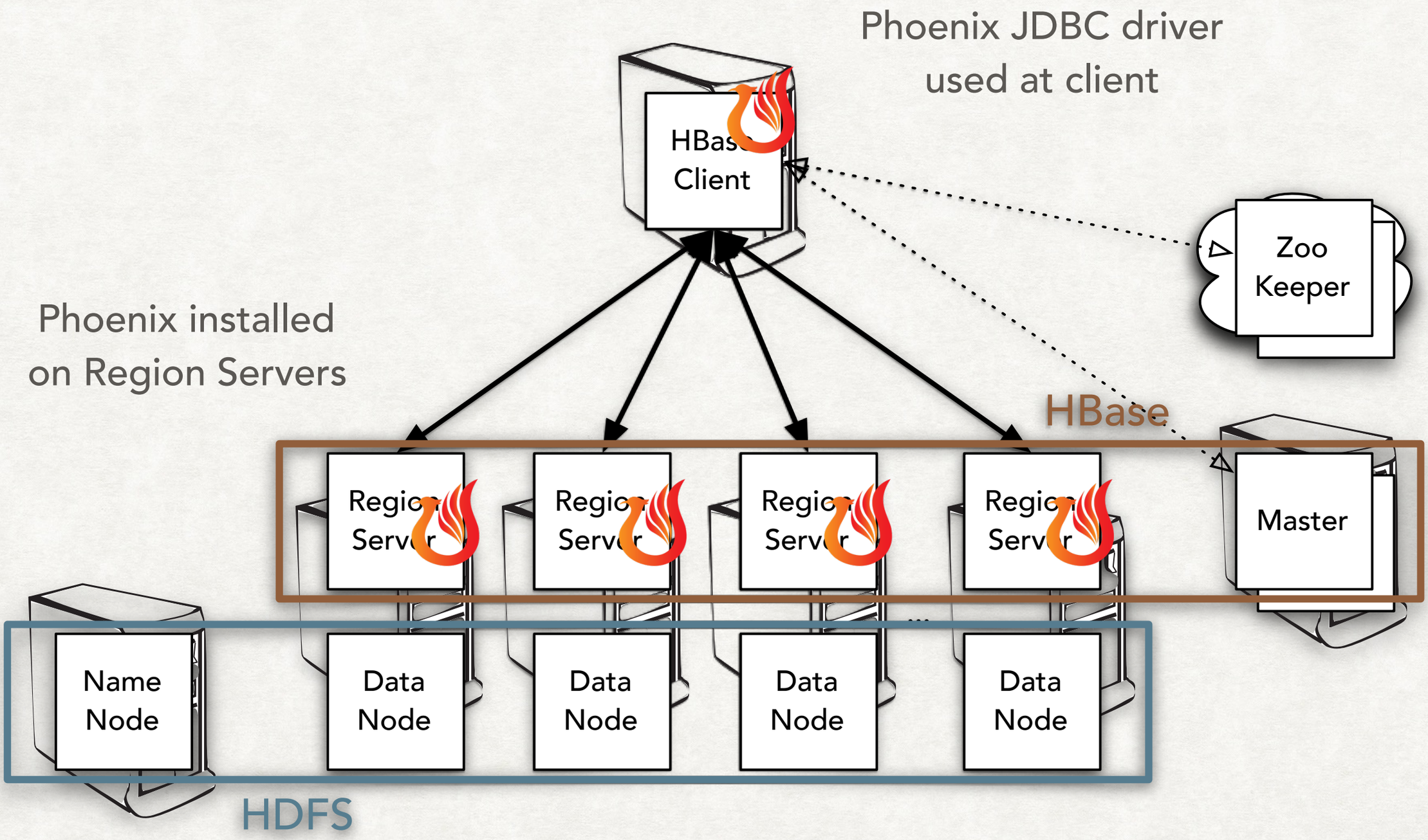
Phoenix + HBase Architecture



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Thanks!

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2015-12-02

Apache HBase (@hbase)
http://hbase.apache.org

Apache Phoenix (@ApachePhoenix)
http://phoenix.apache.org

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