copenhagen goto; conference

Writing Datomic in Clojure

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Datomic, Clojure

Overview

- What is Datomic?
- Architecture
- Implementation - Clojure Applied
- Summary

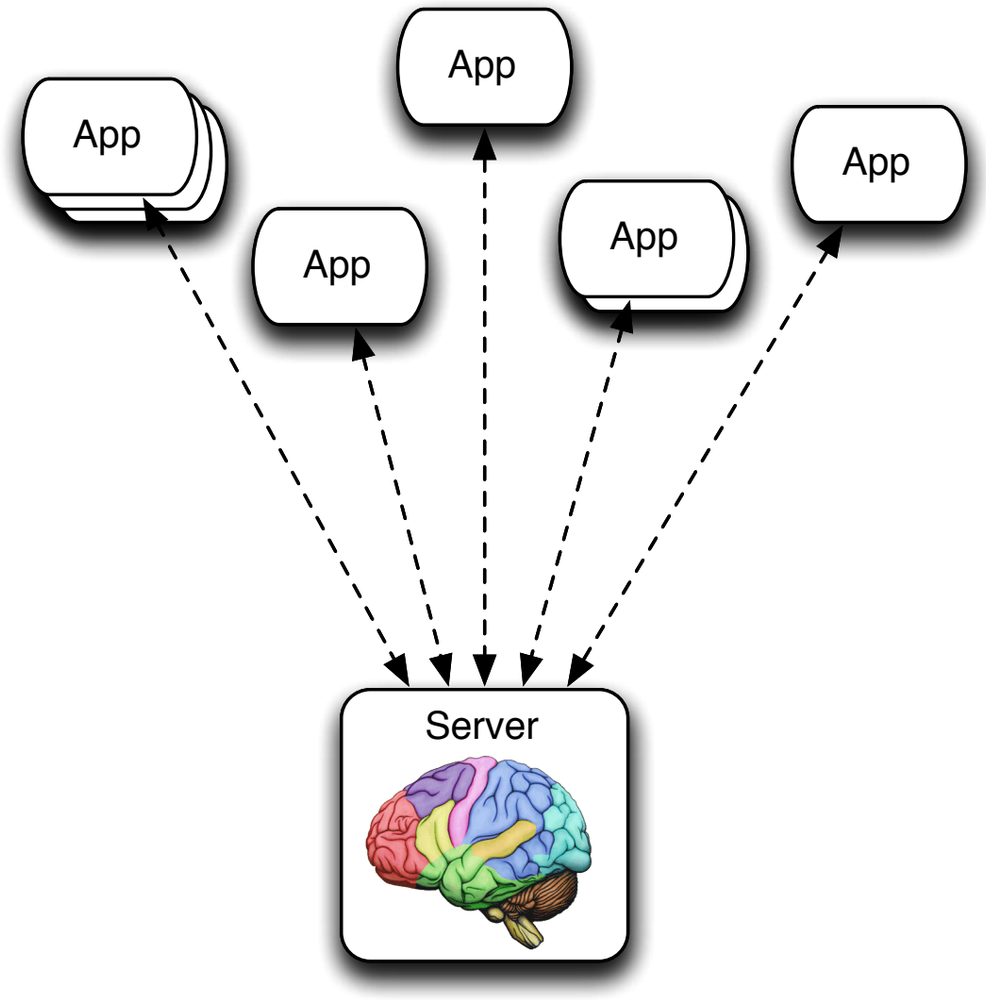
What is Datomic?

- A new kind of database
- Bringing data power *into* the application
- A sound model of information, with time
- Enabled by architectural advances

Why Datomic?

- Architecture
- Data Model

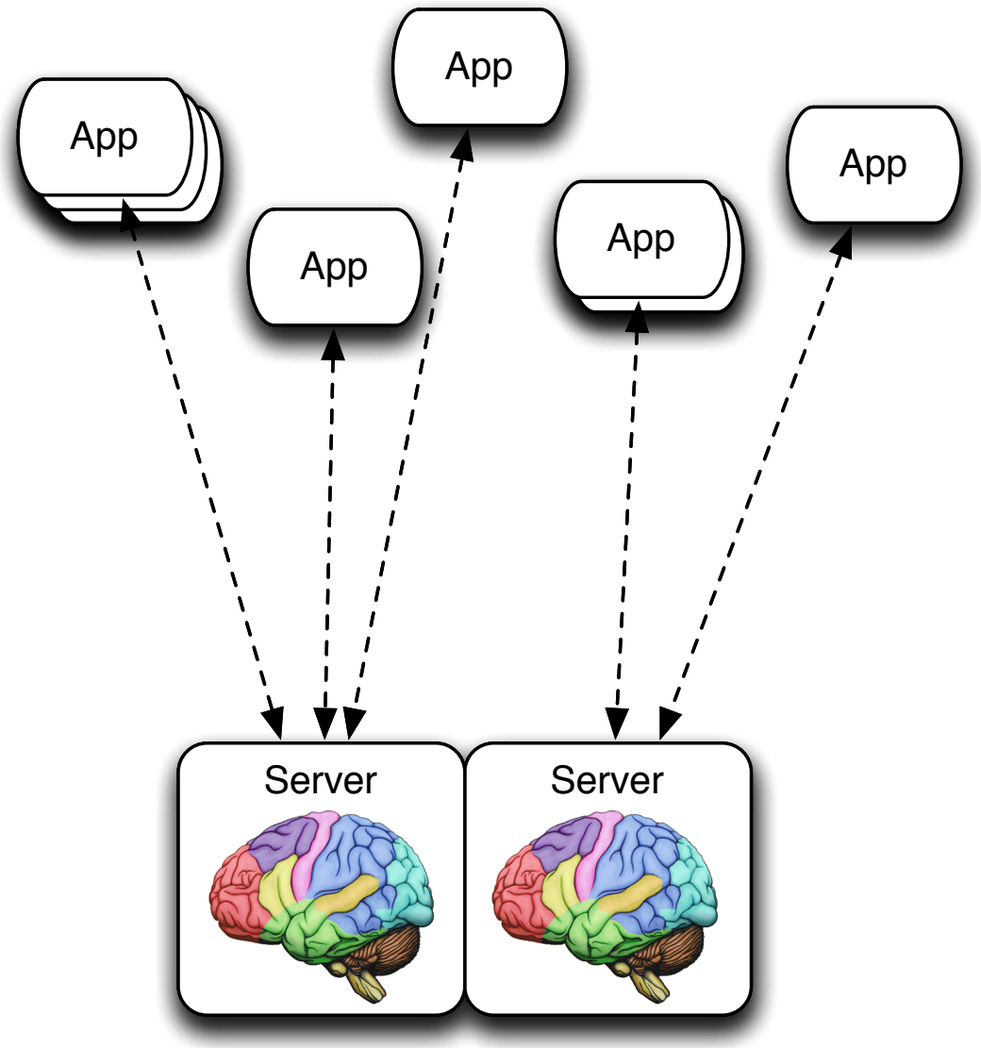
Architectures



Client-Server

Queries
Transactions
Consistency
Storage

Architectures



Clustered Client-Server

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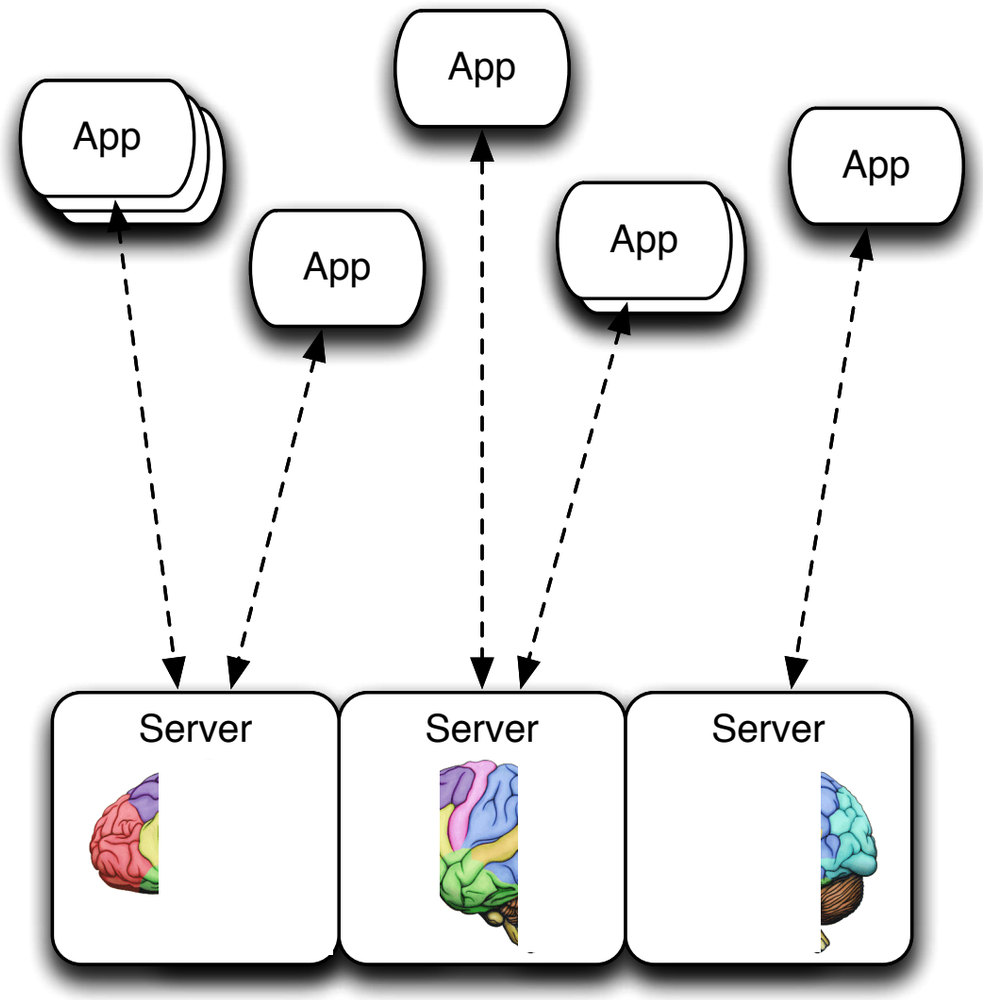
Architectures



Sharded Client-Server

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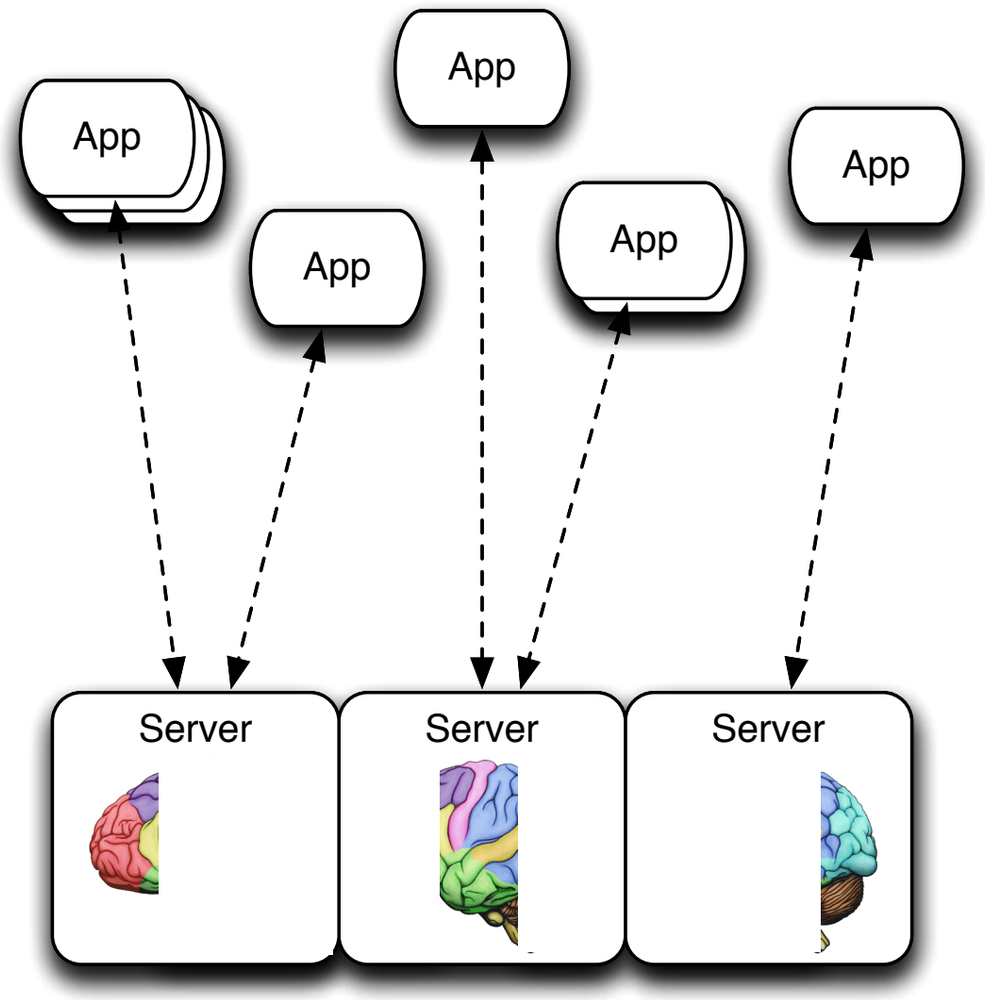
Architectures



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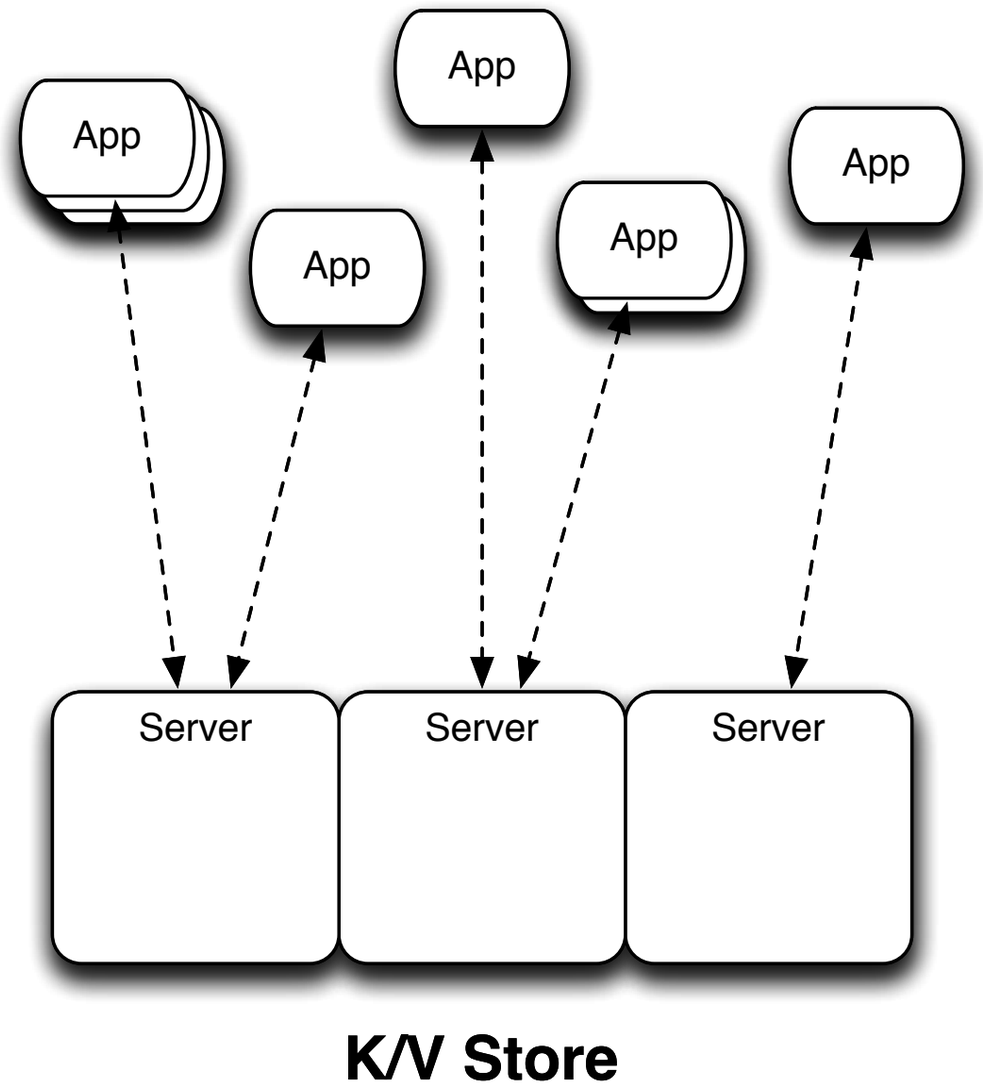

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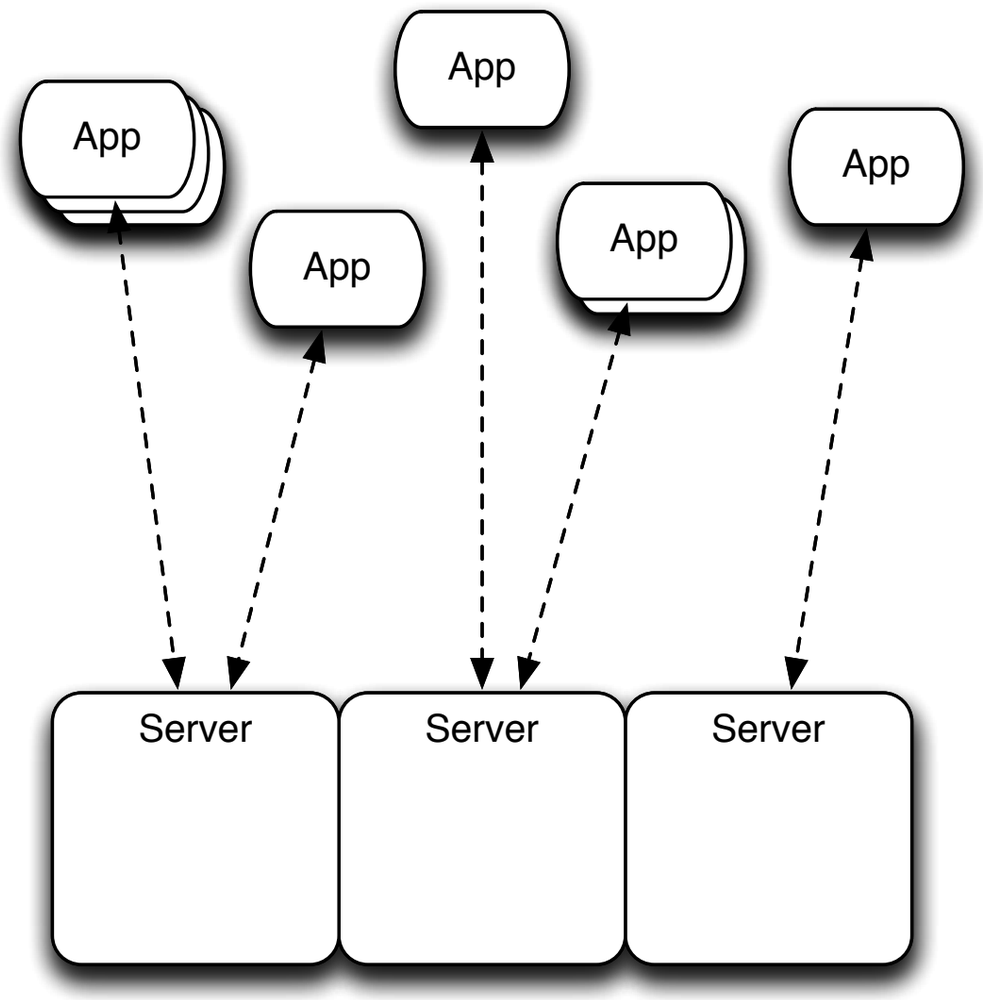

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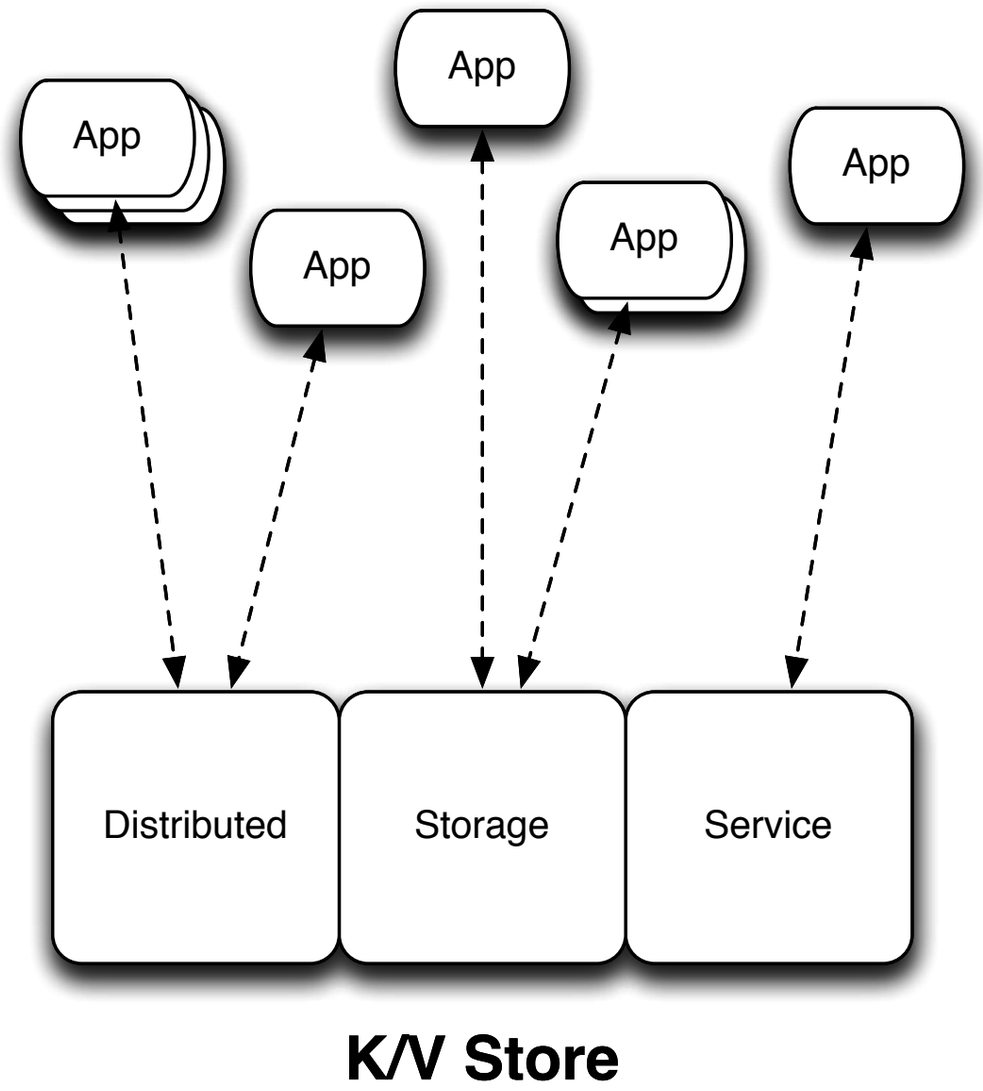

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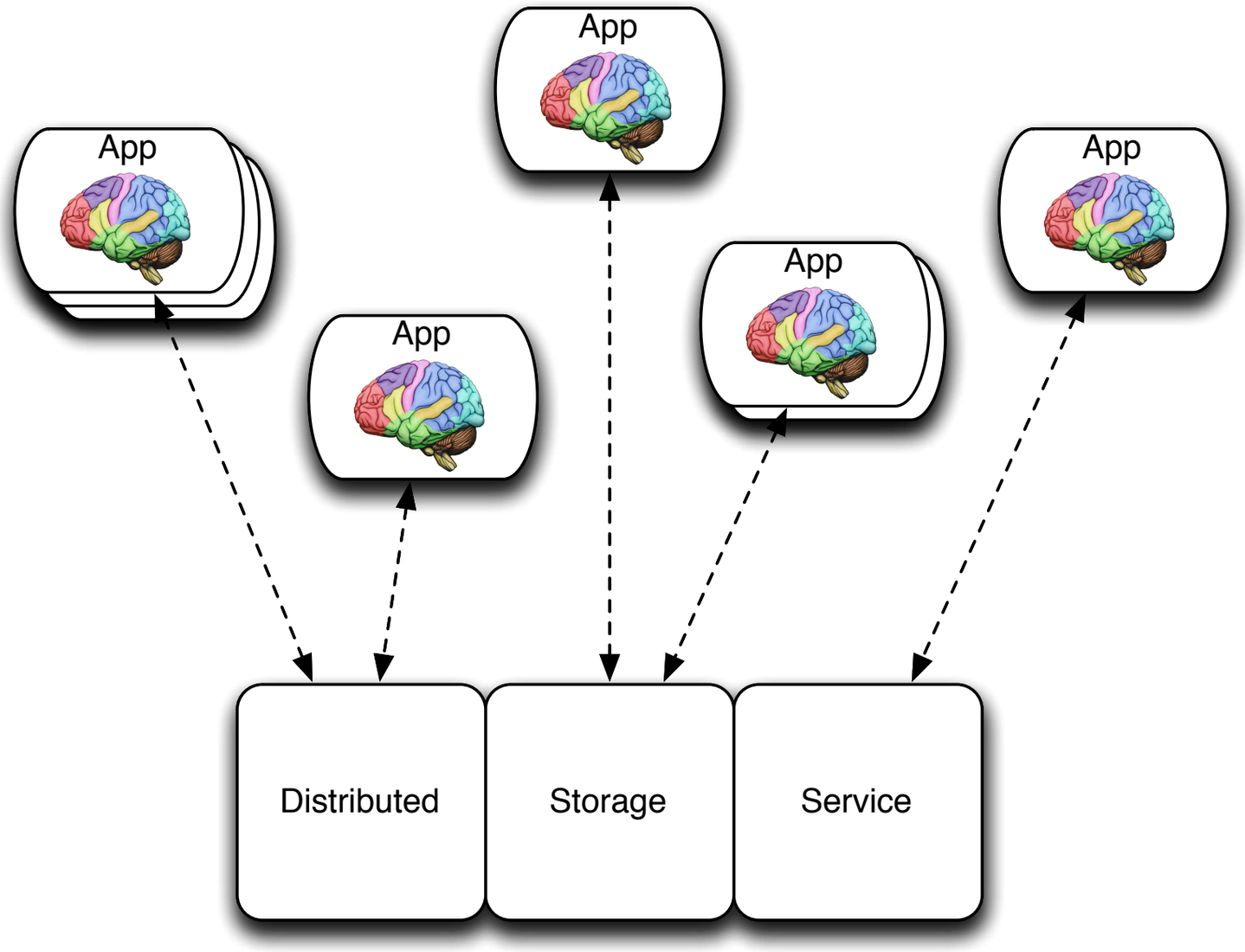
Datomic Architecture



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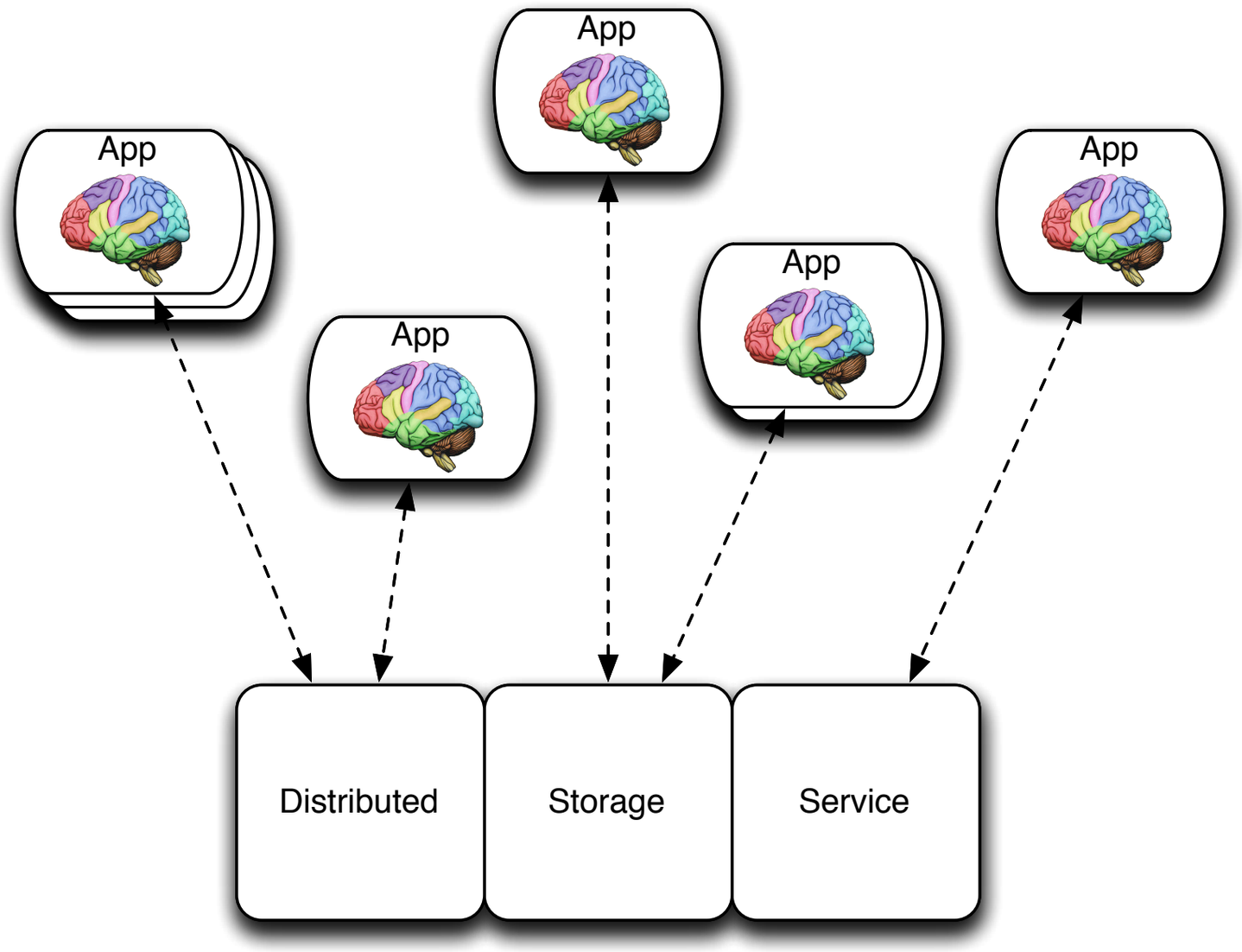

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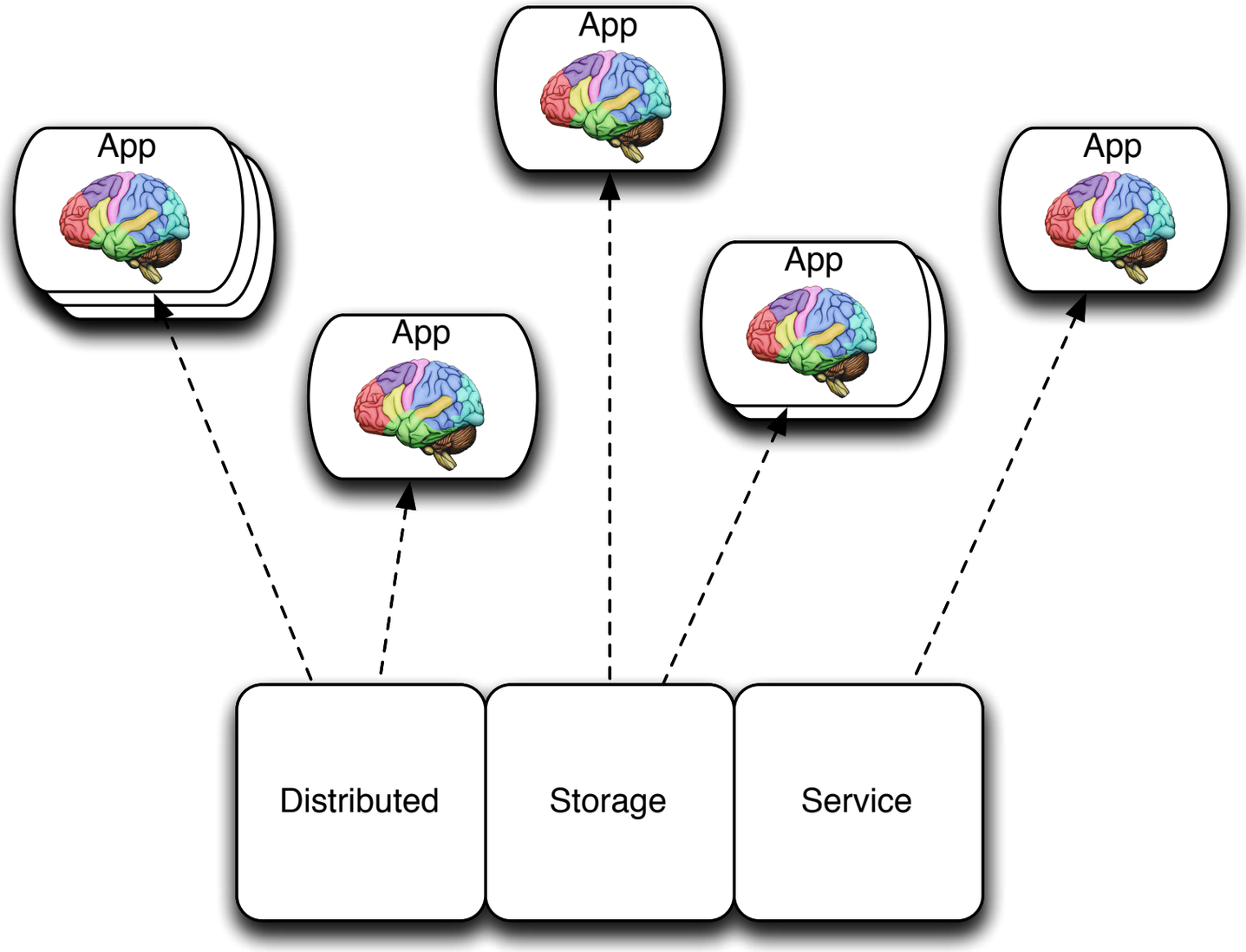

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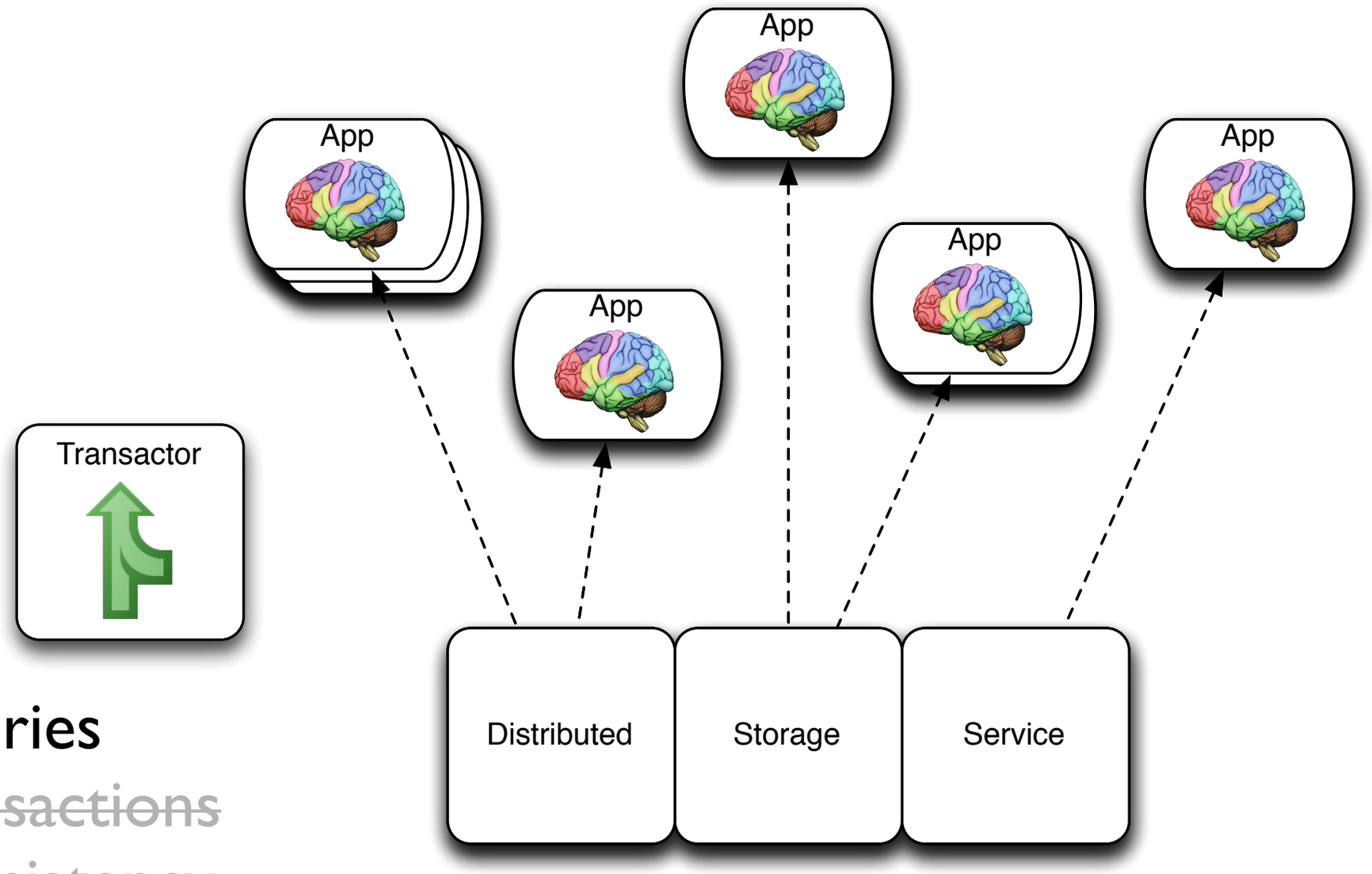

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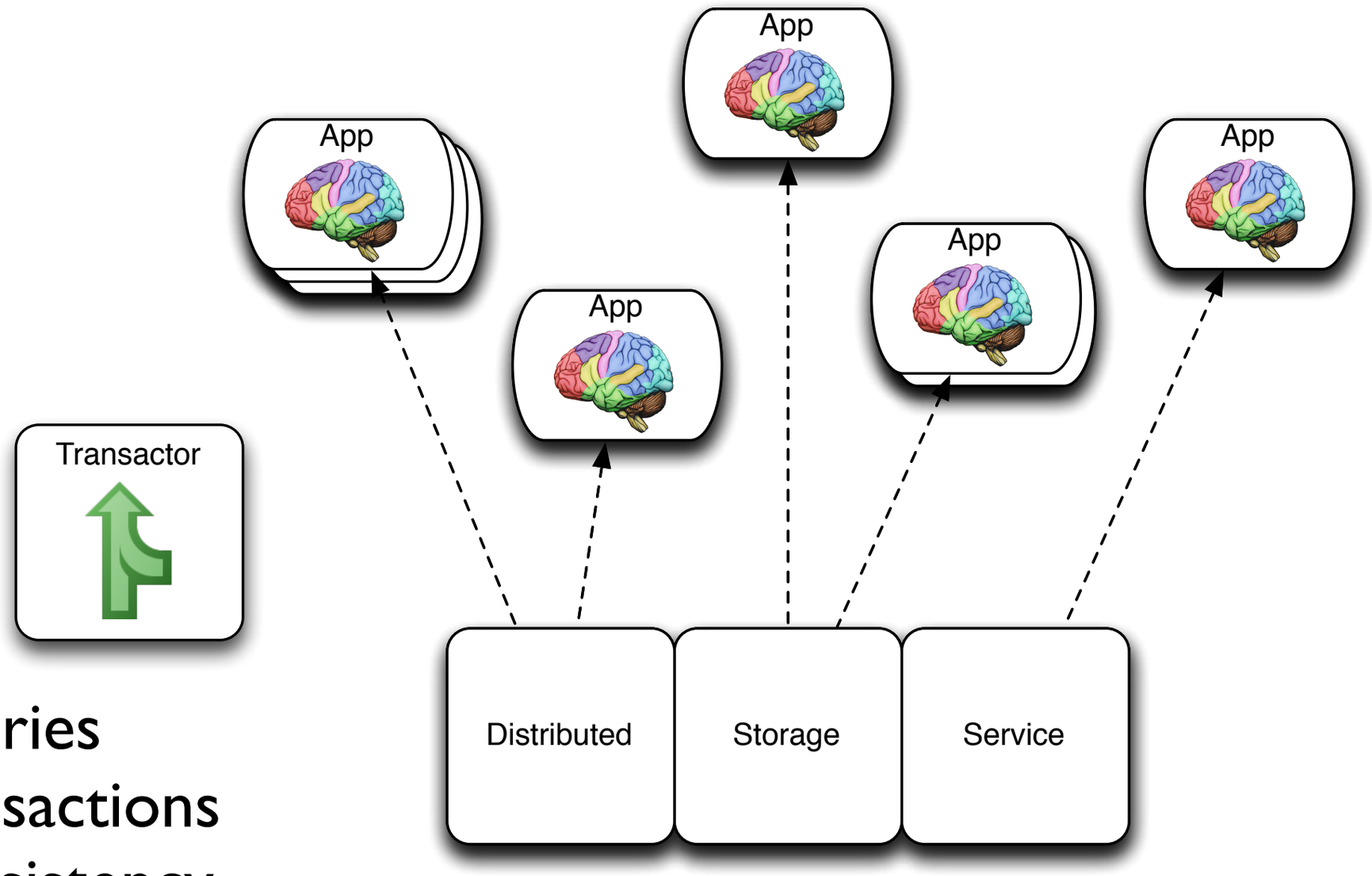

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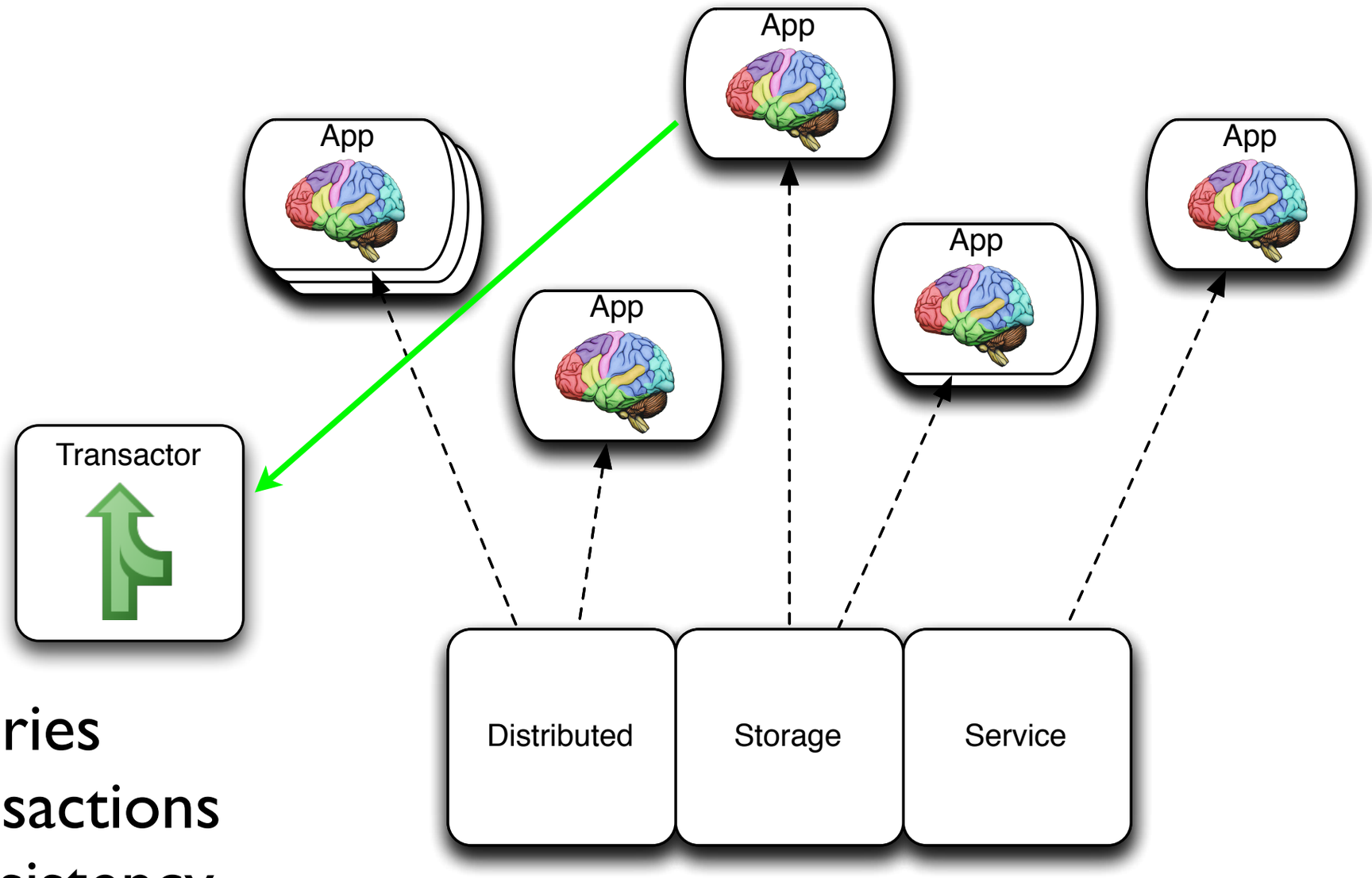

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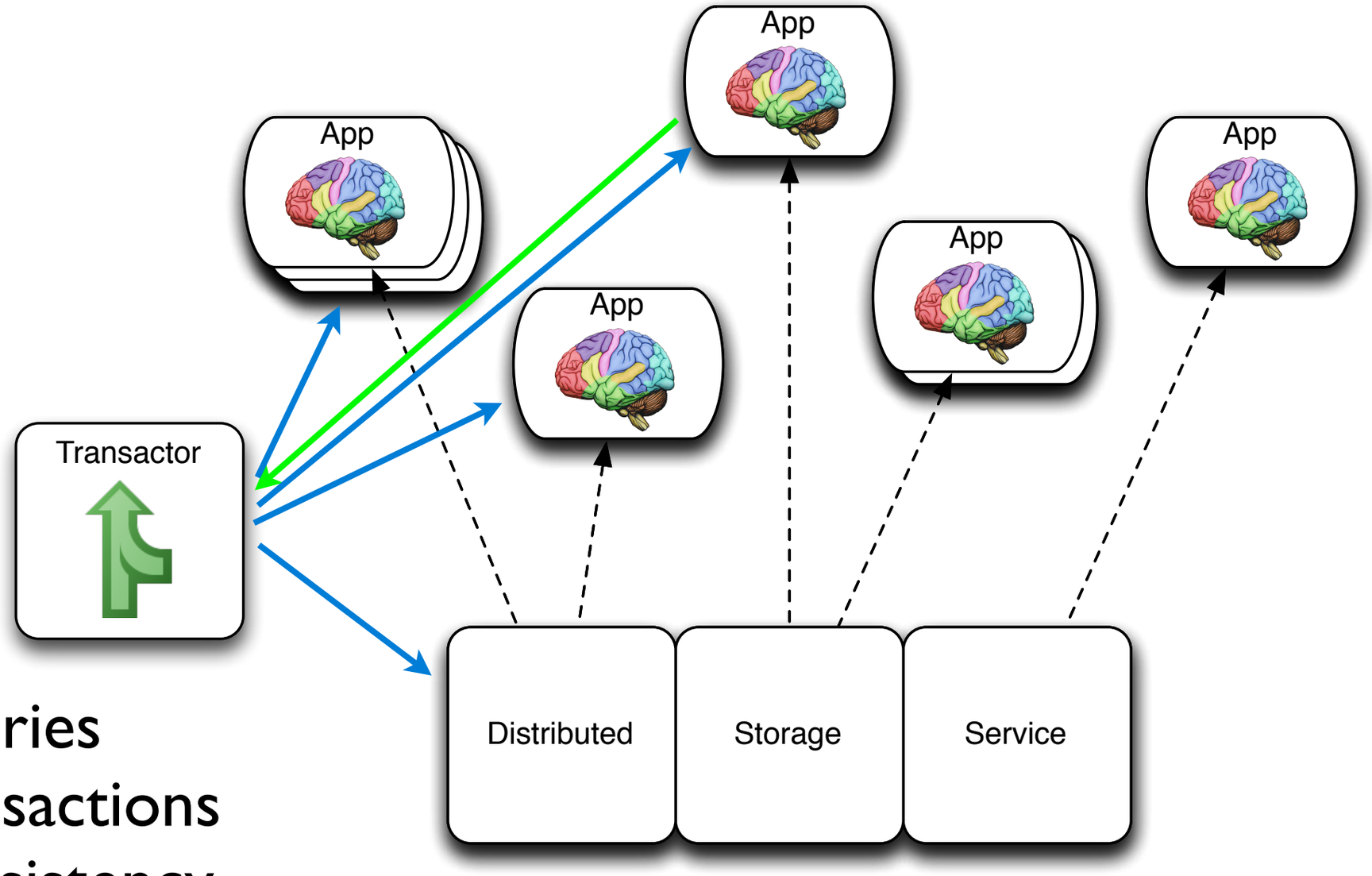

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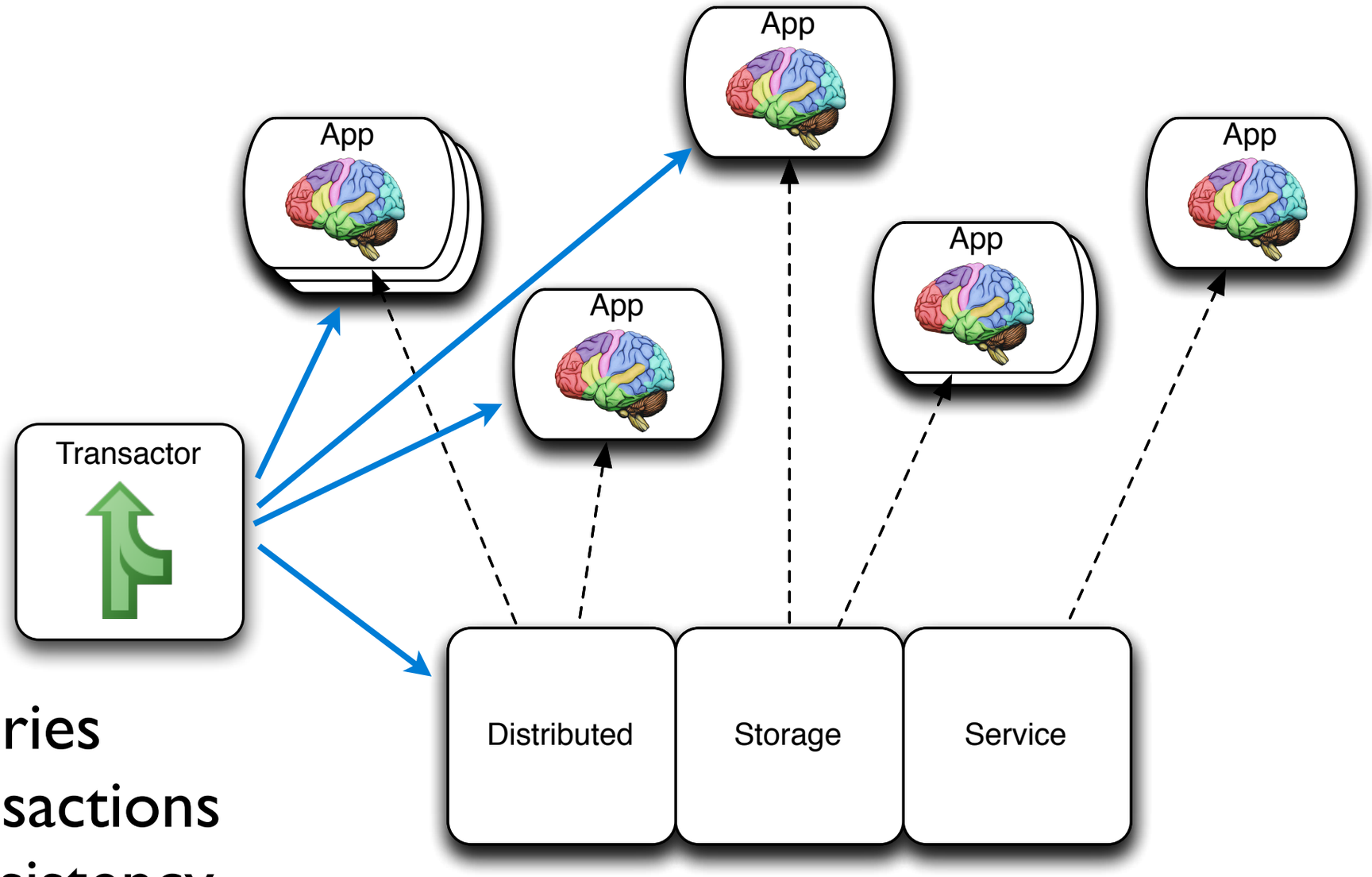

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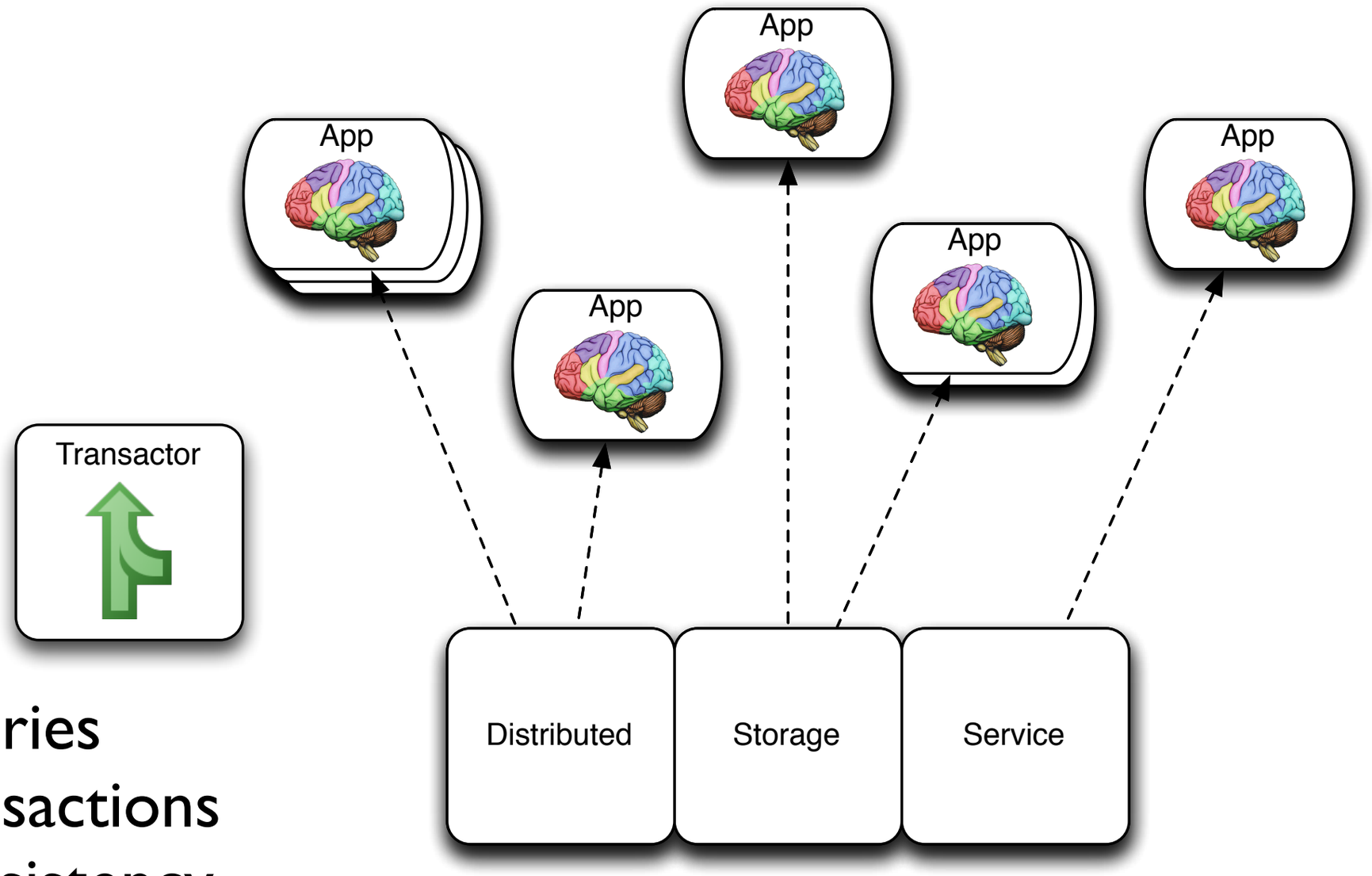

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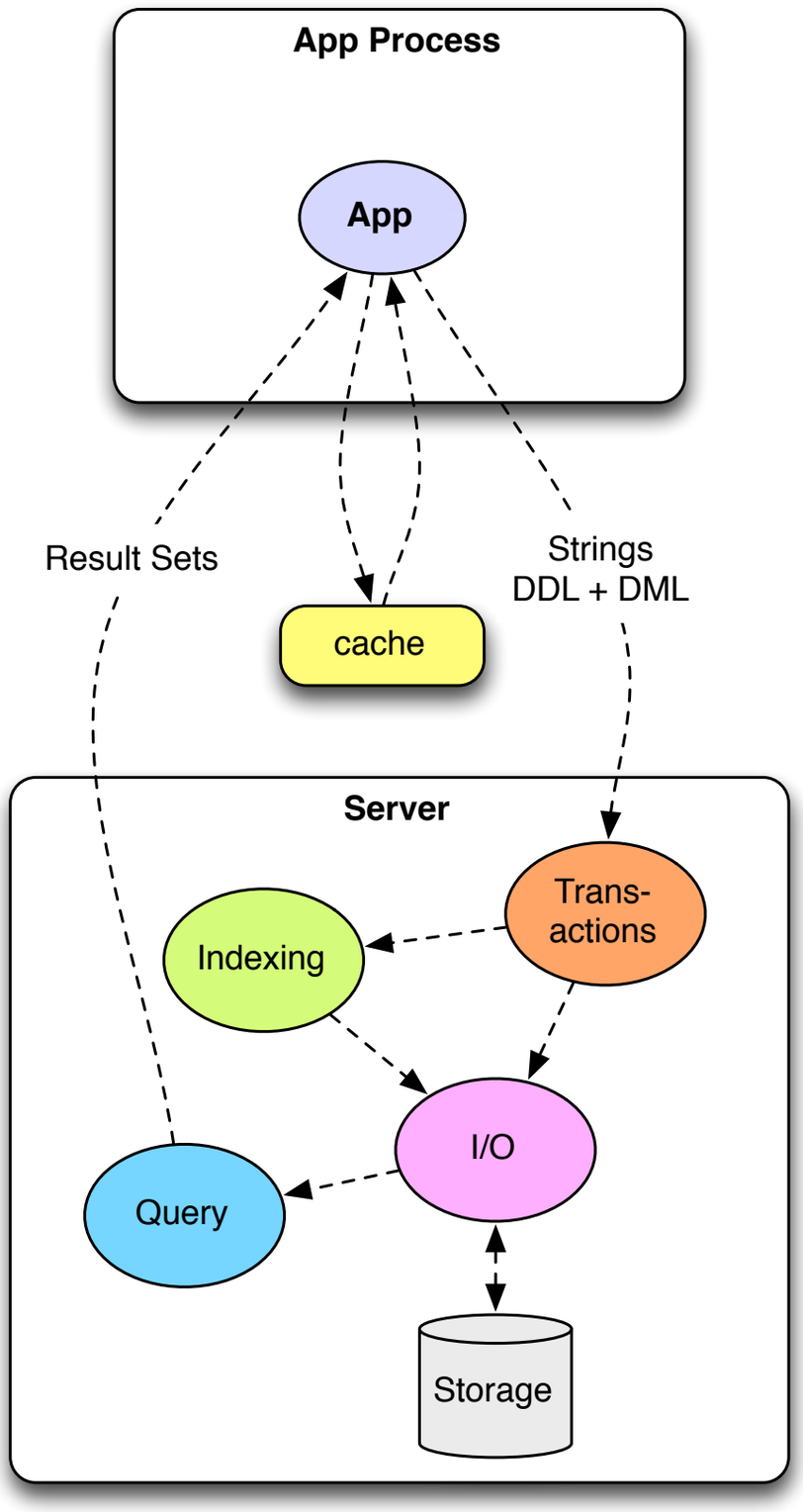
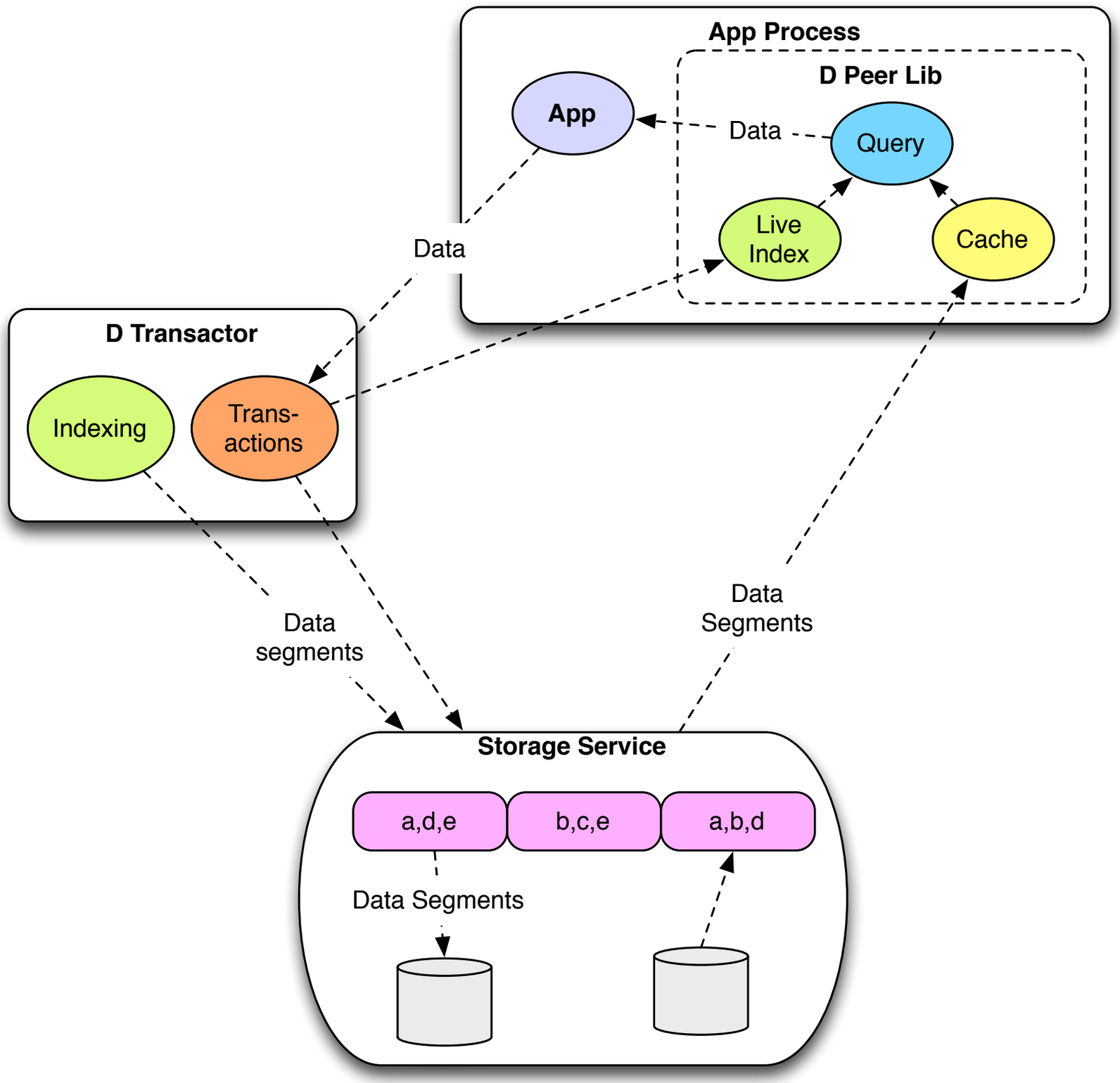
The Database, Deconstructed



Traditional DB



Datomic

Designed for the Cloud

- Ephemeral instances, unreliable disks
- Redundancy in storage service
- Leverages reliable storage services
  - e.g. DynamoDB

Elastic Scaling

- More peers, more power
- Fewer peers, less power, lower cost
- Demand-driven
  - No configuration

Get Your Own Brain

- Query, communication and memory engine
- Goes into your app, making it a peer
- The db is effectively local
- Ad hoc, long running queries - ok

Logic

- Declarative search and business logic
- The query language is Datalog
  - Simple rules and data patterns
- Joins are implicit, meaning is evident
- db and non-db sources

Perception

- Obtain a queue of transactions
  - not just your own
- Query transactions for filtering/triggering

Consistency

- ACID transactions add new facts
- Database presented to app as a value
- Data in storage service is immutable

Programmability

- Transactions/Rules/Queries/Results are data
- Extensible types, predicates, etc
- Queries can invoke your code

A Database of Facts

- A single storage construct, the datom
  - Entity/Attribute/Value/Transaction
- Attribute definition is the only 'schema'

Adaptability

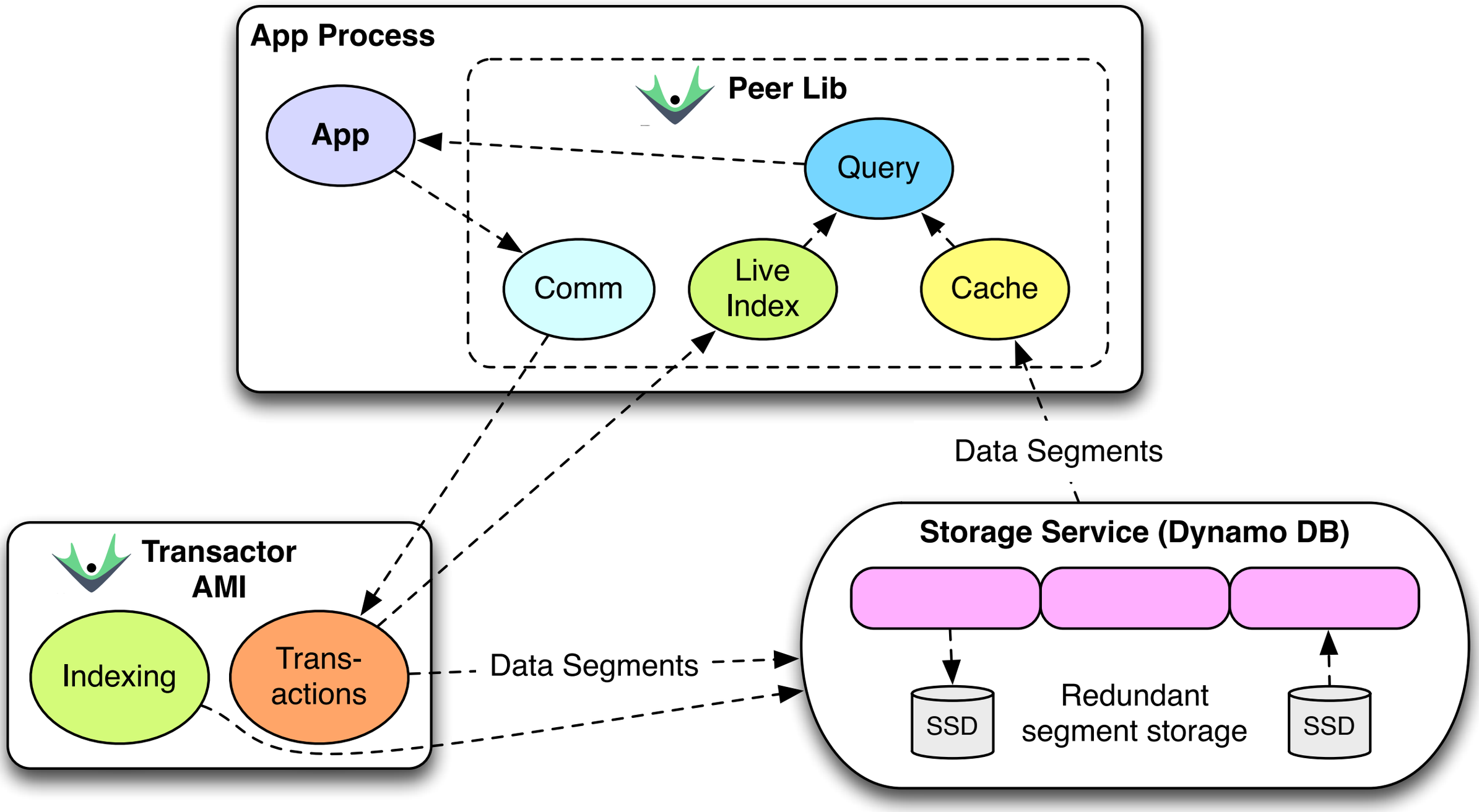
- Sparse, irregular, hierarchical data
- Single and multi-valued attributes
- No structural rigidity

Time Built-in

- Every datom retains its transaction
- Transactions are totally ordered
- Transactions are first-class entities
- Get the db as-of, or since, a point in time

Implementation

Architecture



State

- Immutable, expanding value
- Must be organized to support query
- Sorted set of facts
- Maintaining sort live in storage - bad
  - BigTable - mem + storage merge
  - occasional merge into storage
  - persistent trees

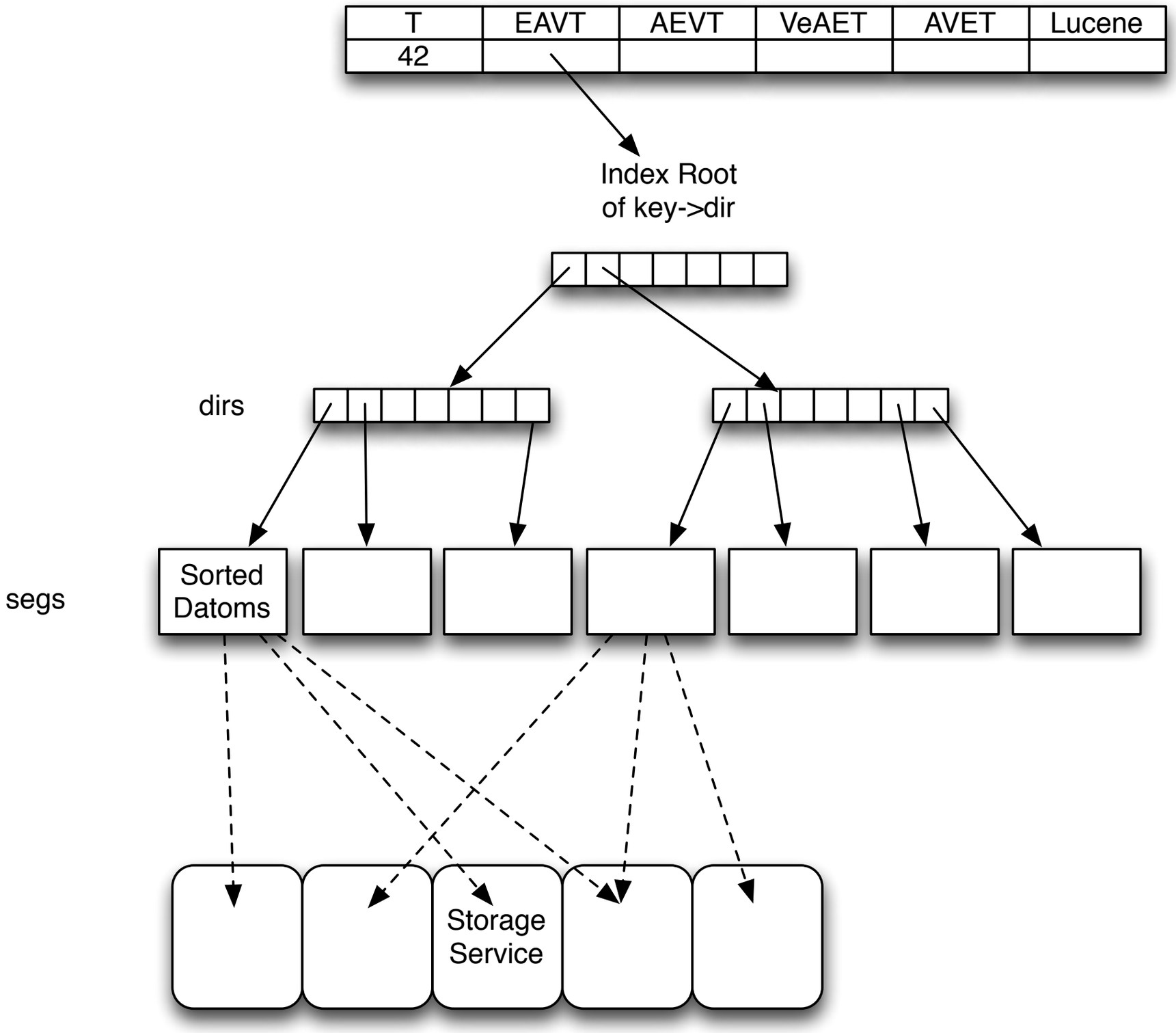
Memory Index

- New persistent sorted set
- Large internal nodes
- Pluggable comparators
- 2 sorts always maintained
  - EAVT, AEVT
- plus AVET, VAET

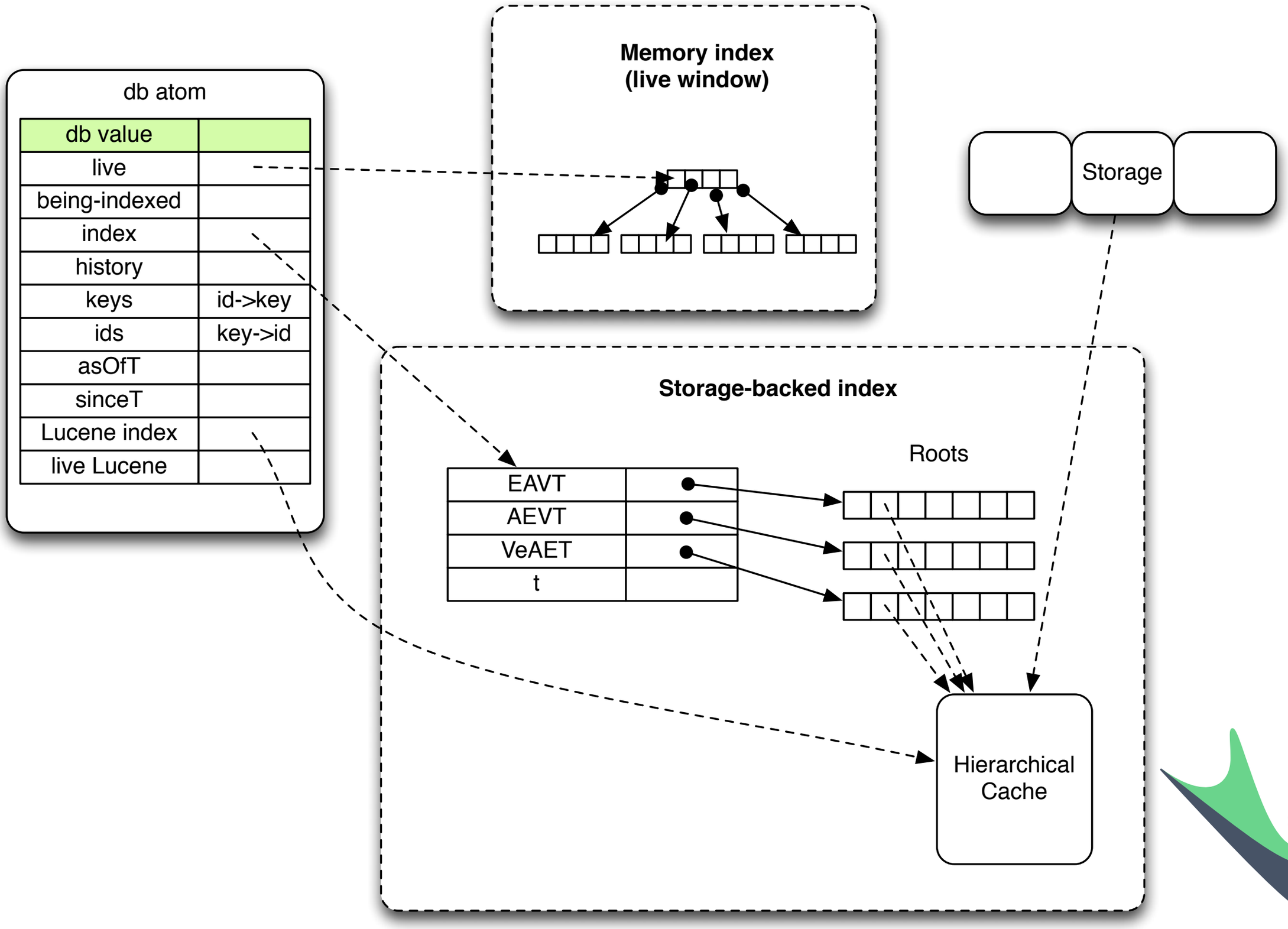
Storage

- Log of tx asserts/retracts (in tree)
- Various covering indexes (trees)
- Storage requirements
  - Data segment values (K->V)
  - atoms (consistent read)
  - pods (conditional put)

Index Storage



What's in a DB Value?

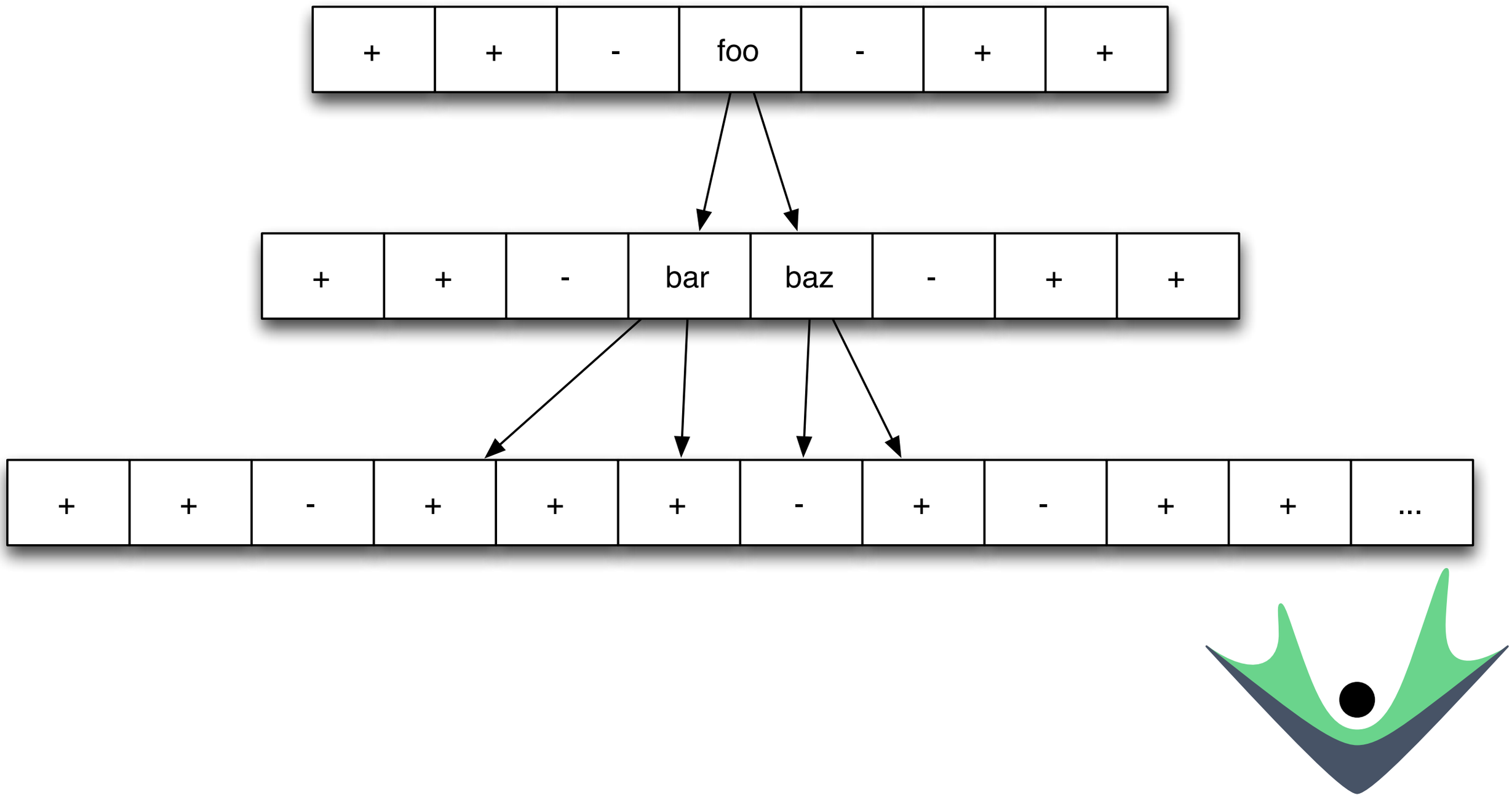


Process

- Assert/retract can't express transformation
- Transaction function:

  (f db & args) -> tx-data
- tx-data: assert|retract|(tx-fn args...)
- Expand/splice until all assert/retracts

Process Expansion



Transactor

- Accepts transactions
  - Expands, applies, logs, broadcasts
- Periodic indexing, in background
- Indexing creates garbage
  - Storage GC

Transactor Implementation

- HornetQ for transaction communication
- Extensive internal pipelining - j.u.c. queues
- Async message decompression
  - transaction expansion/application
  - encoding for, communication with storage
- Java interop to storage APIs

Indexing

- Extensive use of laziness
- Parallel processing
- Parallel I/O
- Async, rejoins via queue

Declarative Programming

- Embedded Datalog
- Takes data sources and rule sets as args
- Extended to work with scalars/collections
- Expression clauses call your code

Datalog Implementation

- Data driven, in and out
- Query/Subquery Recursive (QSQR)
  - Dynamic, set oriented
- DB joins leverage indexes
- Expressions use Clojure compiler
  - caching of transforms at all stages

Over Here

- Peers directly access storage service
- Have own query engine
- Have live mem index and merging
- Two-tier cache
  - Segments (on/off heap)
  - Datoms w/object values (on heap)

Peer Implementation

- HornetQ for transaction communication
- Google Guava caches
- Java APIs for storage
- Entities are like multimaps
  - key -> value(s)
  - reverse attrs

Consistency and Scale

- Process/writes go through transactor
  - traditional server scaling/availability
- Immutability supports consistent reads
  - without transactions
  - scale reads turning knobs on storage
- Query scales with peers
  - dynamic e.g. auto-scaling

Testing

- test.generative was born here
- Functional tests
- Simulation-based testing

Simplicity is Agility

- Key protocols extremely small (< 7 fns)
- Memory, embedded SQL, remote SQL, Infinispan, DynamoDB
- Move from our own dynamo cluster to DynamoDB:
  - 2 weeks
- Support PostgreSQL, Infinispan
  - 1 day each

Leverage

✓ Read/print data

✓ Embedded language

✓ Runtime compilation

✓ Extend standard interfaces/protocols

✓ Interop

✓ State model - extended

Summary

- Clojure was made for this kind of app
- Fast enough at all levels
- Most key subsystems < 1000 lines
- A ton of concurrency, no sweat
- Leverage interop - Hornetq, Guava etc
- Startup time could be better
- Datomic is Simple