

Couchbase Server: A Usable Overview

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Couchbase, Inc. develops Couchbase Server (CBS), an open-source, document-oriented, NoSQL database. Couchbase targets situations requiring high availability and high throughput of large amounts of data, i.e., big data. CBS integrates Couchstore, Memcache and ForestDB, as well as a host of maintenance, administration

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and querying tools, in order to attempt to meet its promises to its users. Corporate Couchbase users include General Electric (GE), LinkedIn Corp. and American Airlines, among others.

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Keywords: Couchbbase, Memcache, CouchDB, Cloud, I524

<https://github.com/eunosm3/classes/blob/master/docs/source/format/report/report.pdf>

This review document is provided for you to achieve your best. We have listed a number of obvious opportunities for improvement. When improving it, please keep this copy untouched and instead focus on improving report.tex. The review does not include all possible improvement suggestions and if you see comment you may want to check if this comment applies elsewhere in the document.

As a technology review, the abstract should be the abstract of your whole paper. Treat your abstract as mini-version of your paper. The first part looks fine, but the last two sentences of the abstract are totally inappropriate with the abstract.

Corrected01

INTRODUCTION

Couchbase, Inc. offers Couchbase Server (CBS) to the market-place as its entry in the NoSQL, *big data* database field

Citation

When you mention a technology for the first time in a paper, that's where you should cite.

Salient features include a) an integrated cache tier which is essentail

Spelling

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to the product's operation; b) persistent storage in JSON document format, i.e. document-based storage, or simple key-value pairs; c) relatively uncomplicated scalability across clusters of commodity servers; d) sub-millisecond response times; e) a SQL-like query language; and, f) built-in cluster replication, failover and disaster recovery features. In addition, Couchbase markets a mobile product, Couchbase Mobile, which uses a Couchbase-designed syncing system to extend CBS to mobile devices and offline use cases.

I don't see the point putting company history in a technology review.

Corrected01

A Couchbase Server (CBS) system consists of at least one cluster of interconnected servers

Term

Corrected01

weird, server computers?

Corrected01

running a copy of CBS. By default, the CBS system's individual computers

Term

same here, CBS system computers?

Corrected01

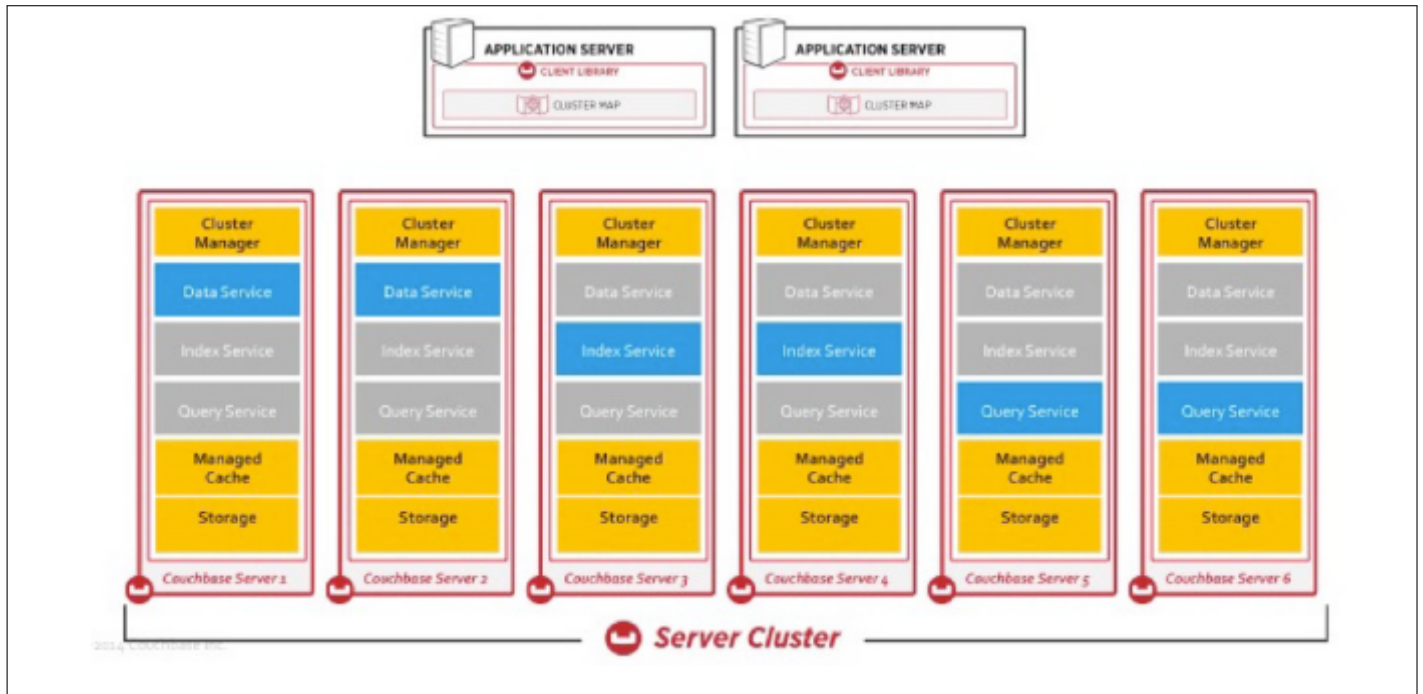


Fig. 1. Multidimensional Scaling with Couchbase [1]

, referred to as nodes, work together in a master-master setup, which Couchbase calls a peer-to-peer topology.

Citation

In a master-master distributed cluster, the nodes co-exist in flat hierarchy

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, i.e., no node acts as the central authority. This paradigm contrasts with the master-slave paradigm utilized by distributed NoSQL database competitor MongoDB

Citation

. Despite the egalitarian nature of the cluster, the nodes still need to coordinate activities. Therefore, the nodes *elect* a node to coordinate cluster functions. If the node fails or is removed from the cluster, the remaining nodes elect a new *orchestrator*.

In addition, the database administrator

Spelling

Corrected01

can override the default peer-to-peer topology by taking advantage of CBS' *multi-dimensional scaling*. This functionality allows the administrator

Spelling

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to customize nodes to perform tasks for which the node is best suited, e.g., memory-intensive processes or I/O-intensive processes, etc.

Font size within the figure is too small to read.

Corrected01

A complete CBS system physically consists of a) one or more server clusters running the couchbase daemon; b) high-speed

connections between the servers and between the clusters; and, c) client computer applications utilizing memcached-compatible software development kits, also known as *devkits* or *SDKs*.

Citation

I am not sure how to comply because this paragraph represents a portion of the mosaic of knowledge I now possess regarding CBS. That is, it is an original thought.

The main components of a Couchbase Server node consist of the following: a) the cluster manager; b) the data service; c) the query service; and, d) the index service, as well as the underlying managed cache and storage components.[1]

Cluster Manager The Cluster Manager, which runs on every node, manages each respective node's interaction and involvement with the other nodes in the cluster. The Cluster Manager configures and monitors the node, determines the layout for CBS' primary services, e.g., Data, Query and Index Services, controls data rebalancing amongst the cluster's nodes, gathers operational statistics, determines the nodes's membership in a cluster, authenticates connections to the cluster, responds to heartbeat requests and repairs itself if possible. [1, 2]

Data Service The Data Service provides the core functionality of any type of database management service - data access. CBS organizes documents, or items, into *buckets* and *vBuckets*. A bucket conceptually maps to a RDBMS database object

Citation

. Unlike a database object, CBS distributes a bucket evenly across the cluster's nodes. CBS refers to the portions of a bucket on a single node as a *vBucket*, which conceptually resembles a RDBMS shard. Buckets typically have 1,024 *vBuckets*, so a three-node cluster with one bucket would have 341 *vBuckets* on two nodes and 342 *vBuckets* on the last node.

The Data Service provides an API for creating, retrieving, updating and deleting (CRUD) items in CBS. It operates on

items with keys in buckets.[3]

Indexes and Index Services The index services create, maintain and destroy primary and secondary indexes of a bucket's keys for three index services. Couchbase refers to its index services as *Map-Reduce Views*, *Spatial Views* and *Global Secondary Indexes* or GSIs [4].

Citation

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Views, which represent CBS's first generation index service, exist within CBS' Data Service. Map-Reduce Views return, or emit, document attributes as View keys after applying user-defined map-reduce functions to JSON documents. Spatial Views act in a similar fashion, except they process geographic information and emit geographic coordinates as View keys. [4] Spatial Views for geospatial data equate to Map-Reduce Views non-geospatial data.

In contrast, CBS' Index Service represents the software's next-generation index, the GSIs. Couchbase developed GSIs in conjunction with, and in service of, its SQL-like query service.

As a result of their respective historical development paths, choosing to use a View or a GSI depends on the use case. For instance, Map-Reduce View indexes allow users to create arbitrarily complex indexes for later use. "[Map-Reduce] [v]iews are typically useful for interactive reporting type queries where complex data processing and custom data reshaping is necessary [5]."

Citation

Corrected01

Spatial View indexes allow users to create "multidimensional bounding box queries for location aware applications." [5]

Since Views, Map-Reduce or Spatial, exist as part of the Data Service, they are partition-aligned with the core data distribution. That is, CBS spreads Views across the cluster roughly proportionate to the underlying data. Therefore, performance slows as the number of nodes contacted increases due to network processing needs.

In contrast, Couchbase constrains a GSI to residence on a single node, i.e., *not* partition-aligned. This design allows GSIs to return results faster than Views. However, GSIs can handle only relatively simpler queries. In addition, users must manually create identical GSIs in order to use the index on multiple nodes for concurrent searches, or as a backup option.

Finally, a CBS system's *primary index* holds information for all of the data in a bucket, while its *secondary index* holds data for a pre-specified subset of the data. Couchbase encourages the use of secondary indexes since they avoid scanning the contents of an entire bucket index.

Query Service Couchbase Server provides four methods of querying the data. First, users can take advantage of the Data Service's key-value API. This method returns results faster the other methods, but it requires the user to know the item's key. The second and third methods complete query execution by accessing the Views API. Such queries operate on the map-reduce or spatial Views keys. These two methods provide the greatest query flexibility, including data reshaping, at the cost of increased elapsed query time. The fourth method provides query flexibility and speed between the key-value

Spelling

Corrected01

API and the Views API. Couchbase calls its newest method N1QL (pronounced *nickel*)

mentioned in previous paragraph

Corrected01

in homage to its SQL inspiration. Although the company designed GSIs for use by N1QL, it can complete ad-hoc queries, i.e., queries without a pre-defined index. It can also exploit View indexes in a limited fashion.

Managed Cache "Since Couchbase built Couchbase Server on a memory-first architecture, achieving high performance and scalability requires effective memory management." [6] CBS stores frequently accessed data items, such as documents and indexes, in its integrated cache tier. Couchbase opted for this setup as a method to provide high- performance, i.e., as fast as volatile memory allows, reads, writes and queries. CBS monitors the frequency with which users access items in order to determine which items to retain in cache and which items to write to disk. The various CBS services, e.g., Data Service, manage their respective cache usage to optimize their respective tasks. In addition, CBS administrators can allocate certain amounts of cache space by changing the system's Ram Quotas. [6]

Storage Components CBS utilizes two distinct storage engines, namely, Couchstore and ForestDB. Couchstore supports the Data Service, and, by extension, the View index service. It uses a B+tree structure for key-based access. It also captures changes to items via an append-only write model. In contrast, ForestDB uses a B+trie structure for key-based access. "B+trie provides a more efficient tree structure compared to B+trees and ensures a shallower tree hierarchy to better scale large item counts and very large index keys." [7].

B-tree, B+tree and B+trie Databases and filesystems commonly utilize a B-tree structure because data access and manipulation occurs in logarithmic time. A B+tree structure increases data access performance for filesystems over a B-tree because a) each node only holds keys instead of a key-value pair like a B-tree and b) each node has an additional level of linked leaves associated with it; these leaves function as a kind of metadata for the nodes. Finally, a B+trie node does not store key-value pairs or keys. Instead, its position in a B+trie determines the key with which it is associated. As a result, a B+trie's data access speed exceeds that of a B+tree.

This is very confusing since the difference of B+trie and B+tree is not explain at all.

Corrected01

ForestDB defaults to using an append-only write model, but can also utilize a "circular-reuse" model. The latter takes advantage of orphaned space the former ignores, thus reducing the frequency of compaction.

After this paragraph, I still don't understand the difference between two engines rather than two different tree-structure and models they use. It would be much better if you can elaborate on the models and perhaps B+trie since B+trie is something very new and unique. Don't just stuff a collection of jargons without explaining.

Corrected01

Cross Data Center Replication Service [XDCR] Couchbase created a service for CBS, *Cross Data Center Replication* or XDCR [8],

Citation

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to enhance data availability and disaster recovery. XDCR syncs data between separate CBS clusters, which can co-exist within a single data center or can reside in entirely separate geographies. Besides data replication for disaster recovery, XDCR can be configured to immediately take over for a failed primary cluster. In addition, XDCR can reduce latency by moving the data closer to the end user. Companies using CBS can target "external applications (e.g. Elastic, Spark, Storm, etc.)."[8]

USER INTERFACES

API Client applications interact with CBS through memcached-compatible SDKs,

What is a SDK?

Corrected01

which support numerous programming languages. As of version 4.6, developers could choose from an SDK for the following languages: a) Node.js; b) Java; c) PHP; d) .NET; e) Python; f) Go and g) C. [9].

I know these are languages, but do others also know about them? What if the reader is not from Computer Science at all?

Corrected01

Couchbase also provides a client library for JDBC/ODBC [10].

Citation

RESPONSE: I do not grasp how I should modify the current citation.

Shell Access Couchbase offers a variety of command line tools. The *cbc* tool operates on a node, a bucket or a vBucket (shard).

what is cbc? If you don't want to explain it, you shouldn't mention it.

RESPONSE: I do not understand the critique. The name of the tool is cbc. I also provide a brief explanation.

It includes commands to create, retrieve or remove documents in a CBS system, list the buckets in a cluster, manage users, etc. In addition, each CBS installation includes the *cbq* tool to issue N1QL queries. [11].

what is cbq?

RESPONSE: I do not understand the critique. The name of the tool is cbq. I mention its primary purpose.

CBS includes a number of other command line tools to accomplish various tasks [12].

Term

Corrected01

CLI, command line interface. No one says command line interface interfaces.

I don't see the point of making a long list of interfaces. What are you trying to do here? Are you trying to show the richness of command line tools/interfaces? You don't have to make a list of it if that's the case.

Corrected01

Graphical Interface Couchbase implements CBS' GUI

Term

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GUI, graphical user interface, needs to be in capitals.

Corrected01

via a web browser. Users access the web GUI by navigating to a cluster's url appended with the admin port number. The browser interface acts as the primary management tool for CBS.

Why are you put the actual port number in your paper? Are you trying to create a security breach?

RESPONSE: Couchbase openly publishes the admin port number, so mentioning it did not pose a security threat.

It offers access to node management, queries, indexes, etc. [13]

The figure is confusing here. ...

Corrected01

Figure removed

LICENSING

Couchbase, Inc. offers a community edition of Couchbase Server as well as an enterprise edition. Couchbase Server Enterprise Edition includes more features and better quality assurances, e.g., testing and bug fixes, versus Couchbase Server Community Edition. Couchbase targets "enterprise customers with large production deployments running in data centers and/or public clouds" [10]

Citation

Corrected01

with the Server Edition. The remaining, primary differentiating factor of the Enterprise Edition over the Community Edition consists of Couchbase's 24x7 technical support. Community Edition users must rely on published material and the online CBS community forum instead of dedicated technical support. [10]

ECOSYSTEM

CBS does not have a large ecosystem built around it, but Couchbase has developed a number of interfaces to software often used in conjunction with large data sets. The company offers the aforementioned client librarians, e.g., .NET, node.js, et al, as well as connectors and plugins for a) Spring Framework (connector); b) Spark (connector); c) Kafka (connector); d) Hadoop Sqoop (plugin); e) Elasticsearch (plugin); and, f) Solr LucidWorks Fusion (unspecified). Couchbase also maintains Moxi Server, a proxy for memcached traffic.[10]

USE CASES

General Use cases include a) supporting / enabling real-time analytics; b) building mobile apps with offline support via Couchbase Lite; c) digital communication by enabling low-latency read / write access to messages; and, d) purportedly holistic views of client data via aggregation from multiple sources even when the sources have different data models.

Use Cases for Big Data Couchbase markets CBS to customers who desire high throughput / low latency response times from a so-called schema-less database managing data at scale, i.e., *big data*. In the context of NoSQL, big data databases, low latency translates to sub-millisecond response times. Other aspects of competitive products in this space include scalability, a flexible data model (as implied by the NoSQL tag), a SQL-like query language and simple administration.[14]

The company highlights a number of real-world business wins to support its assertions that CBS meets these criteria.

Equifax, Inc. For instance, Equifax chose Couchbase Server Enterprise Edition when it needed to meet a new customer need in a short amount of time. In October 2015, the Federal National Mortgage Association, a government-sponsored entity (GSE) more commonly referred to as Fannie Mae, announced it would begin providing 24 months of trended credit history on its industry-standard *Desktop Underwriter* software instead of a point-in-time snapshot. Fannie Mae promised this change by the end of the second quarter of 2016. Therefore, Equifax had less than three calendar quarters to scale up its trended data product for a customer that underwrote nearly 46% of all US residential mortgages at the time, when combined with its GSE-twin, Freddie Mac. [15, 16]

Equifax needed a solution to handle the five petabytes (5Pb) of data plus the necessary throughput associated with trended data. In addition, it needed a) its new software to work with systems the company already used, like Hadoop and Spark; b) it needed the solution to facilitate application development; and, c) it needed five millisecond (5ms) response times. CBS met those requirements for Fannie Mae. The mortgage underwriting GSE also found the ease of data replication offered by CBS' XDCR attractive, as well as the minimal Java coding needed to make CBS' Views useful to its operations teams. [17]

LinkedIn Corp. LinkedIn also opted for Couchbase as its data management needs grew. More specifically, the challenges of moving data across its hosts / clusters with its prior Memcache-only design prompted it to consider other solutions. The company currently utilizes CBS as a) a simple read-through cache; b) an ephemeral counter store, i.e., storage for temporary IDs; c) a temporary de-duplication store; and, d) a *source of truth* for internal tooling. LinkedIn's data expands across 148 buckets and 2,821 hosts. The largest cluster by nodes consists of 72 hosts, while the largest cluster by documents holds 1.4 billion items. Overall, its CBS system handles 10 million-plus queries per second (QPS). [18]

EDUCATIONAL MATERIAL

If you would like to learn more about Couchbase Server, visiting developer.couchbase.com or the Couchbase Connect section of Couchbase's [youtube.com](https://www.youtube.com) channel should prove beneficial. In addition, perusing the works cited in the reference section may also prove beneficial.

CONCLUSION

Couchbase Server appears to offer the necessary features to succeed commercially as a *big data* database. That is, it scales well, it handles extremely large datasets well, it handles high-throughput transactions well and it has a SQL-like query interface. Whether or not CBS will succeed due to technical superiority, administrative ease or because

Spelling

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Couchbase simply marketed better than the competition exceeds the scope of this write-up, though. Based on the feature set and the business wins, it appears to be a legitimate option for organizations

Spelling

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interested in this type of general product.

ACKNOWLEDGEMENT

I would like to thank Dr. Gregor von Laszewski, the teaching assistants (TAs) for I524, Big Data Software and Projects in the Cloud and the other students in the class for their insights and assistance related to this paper.

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Matthew Lawson received his BSBA, Finance in 1999 from the University of Tennessee, Knoxville. His research interests include data analysis, visualization and behavioral finance.

WORK BREAKDOWN

The work on this project was distributed as follows between the authors:

Matthew Lawson. Researched Couchbase Server and related topics, wrote the paper and edited the paper.