

Redis Database Analyses

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1 Data Model

Redis is a NoSQL database with an aggregate orientation and is likewise key-based. This means that keys identify the assigned value, this way a client can extract the value by knowing its key. Further you can put a value for a key or delete a key and likewise its value. Redis keys are binary safe which means any binary sequence can be used as a key. An empty string is also a valid key. But Redis is not a plain key-value store. Because a key is binary safe the value can hold more complex data structures. By complex is meant the possibility to nest values in values or even map objects.

1.1 Data Structures

Redis supports the following data structures:

- **Strings:** a String-value can have a total length of 512 Mb, assembling Strings
- **Lists:** simply an ordered list of Strings => a sequence with duplicates, adding new elements on the head (left) or on the tail (right), max length of a list is 232 (around 4 billion of elements per list)
- **Hashes:** maps between String-fields and String-values, mainly represent objects, have a max length of 232
- **Sets:** an ordered collection of Strings, not allowing duplicates (if u add the same element multiple times will result in having just a single copy of this element), max number of elements is the same as lists, you can apply commands or set operations
- **Sorted Sets:** similar to Set but associated with a score ordering the sorted set from the smallest to the greatest score, elements are unique but scores may be repeated
- **Bitmaps and HyperLogLogs:** basing on Strings with their own semantic Message Queues

You can run atomic operations on each of these data types. With SET you set a specific value for a key and with GET you retrieve this value. SET replaces any existing value already stored into a key in the case this key already exists. This way SET can be used to update a value of an existing key. Because the value of the key is overwritten with a new value, the old value is kind of deleted. To delete a key with its associated value you run the command DEL. Redis offers the possibility to set or retrieve the value of multiple keys in a single command using MSET and MGET. MGET returns an array of values.

There are two different functionings implemented in Redis. This is how Redis works internally:

1. **Snapshotting:** so called „in-memory“ meaning Redis holds the „Dictionary“ in the RAM and stores it onto the disk at predetermined intervals. The intervals to store data onto the disk can be configured by define the number of writing operations and a time limit. If the systems crashes the past operations can be reloaded to retrieve the primary state of the data.

2. Append Only File Mode: Every writing operation is stored onto the disk immediately.

Redis supports around 50 programming languages. 12 languages are particularly recommended. For Java there are 4 different libraries. A few examples for different programming languages in the following are JRedis for Java , Redis-rb for Ruby, Credis for C and Redis-py for Python.

2 Query Support

2.1 Supported query types, i.e. point, range, navigation, and/or arbitrary?

Redis supports different query types. Redis supports point and range queries for: strings, hashes, lists, sets, sorted sets. A string for example can be accessed via `GET <key>` and multiple Strings can be accessed, to name one possibility, for example with the command: `MGET <key> [<key>...]`. Geospatial indexes can even be searched by radius queries. That means Redis checks if the geospatial indexes are within a specific radius of a defined position. Arbitrary access of entries is also possible by getting a random key with the command `RANDOMKEY`. In comparison to plain key-value stores, Redis is able to store complex data structures and perform for the data structure specific commands. So for example in Redis it is possible in a list to prepend one or multiple values with the command: `LPUSH <key> <value> [<value>...]`. Another mentionable functionality of Redis is that keys can expire. Timeouts can be set on keys and after the timeout has expired, the key will automatically be deleted. The related command for expiring a key is the command: `EXPIRE <key> seconds`.

2.2 What is the query language of the system? Is it declarative, functional, algebraic and/or imperative?

In comparison to normal SQL Redis doesn't have a declarative query language. The query language of Redis is imperative. All queries in Redis are made with commands that can't be modified (apart from source code modifications in Ansi-C), except for the arguments, that can be passed into the command.

2.3 Are queries automatically optimized?

There is no automatic command optimization in Redis. One comparable approach in Redis is the Slowlog. Redis logs queries that exceed a specific, configurable execution time. The execution time is just the time actually needed to execute the command, not included in this case are for example the I/O operations or the communication with the client. With the Slowlog there is a chance to identify slowly executing commands. The commands themselves aren't automatically optimized.

3 Transactions and Concurrency Control

Redis support transactions. A basic transaction is a sequence of multiple commands. One client can execute multiple commands without other clients being able to interrupt them. In Redis the foundation of transactions are following commands: MULTI, EXEC, DISCARD and WATCH, which allow execution of a group of commands in a single step. The basic usage is to enter MULTI, enter multiple queries and enter EXEC for executing the multiple commands or DISCARD for flushing the transaction queue. Every command passed as a part of a basic MULTI/EXEC transaction is executed one after another until they have completed. After completion another client may execute their commands. The WATCH command is used to provide a check-and-set behaviour to transactions. This form of locking is called optimistic locking (which is an Optimistic Concurrency Control, short: OCC approach).

Transaction guarantees:

- all commands in a transaction are serialized no request by other client is served in the middle of the execution of a Redis Transaction guarantees isolation
- all commands are processed or none guarantees atomic transactions

A possible error before a transaction could be that the command maybe failed to queue due to wrong syntax of the command or e.g. memory errors. Another eventuality to produce an error after a transaction is executed could be to execute a command against a key with a wrong data structure (all data structures have specific commands and the actual values are unknown for the system). Even though a command might fail during execution, the execution of the following commands will be processed and not rolled back like in some relative database query languages.

Pessimistic Concurrency Controls (PCC) in distributed systems, with distributed locks are also possible with Redis, but not with the commands in the Redis query language itself. If necessary, the “Red-lock” algorithm can be integrated in diverse programming languages.