

READY, SET, CLOJURE!

Building Beautiful Abstractions with Lisp

Aaron Bedra



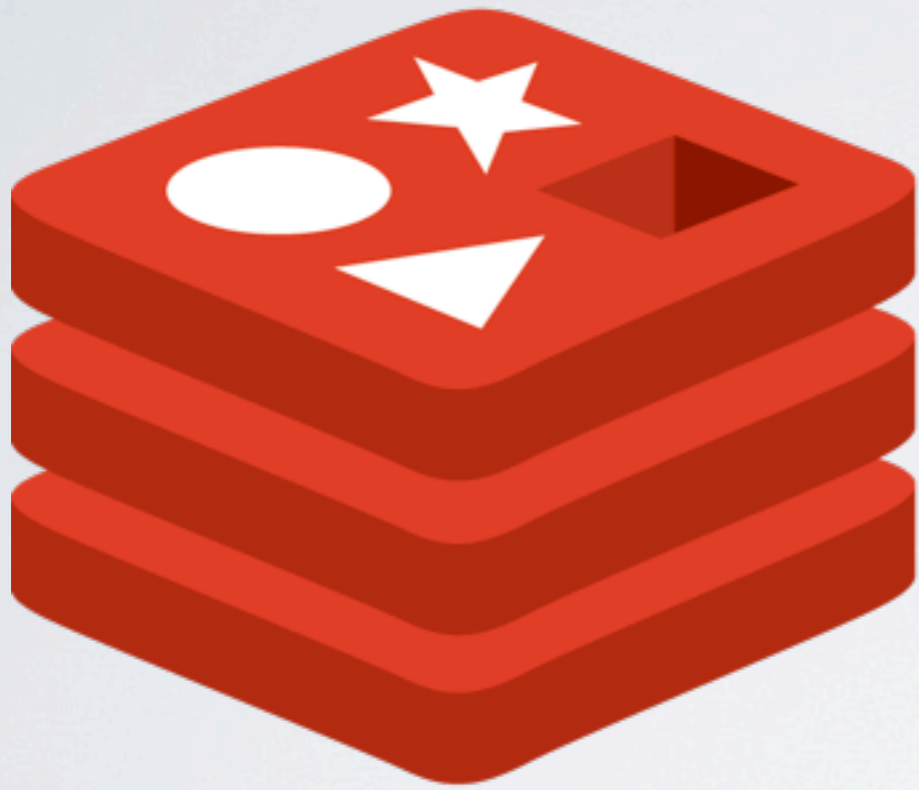
WHY CLOJURE?

- Built on top of a solid foundation (JVM)
- Full interoperability with the host platform(s)*
- Immutable by default
- Well controlled mutation when necessary
- Mostly functional
- Brings all the expressiveness and power of LISP

WHAT WE WILL COVER

- Clojure basics
- Clojure's built in test framework (clojure.test)
- Java Interoperability
- Polymorphism
- Macros
- Leiningen

WHAT PROBLEM ARE WE
TRYING TO SOLVE?



redis

SURELY SOMEBODY ALREADY
SOLVED THIS PROBLEM?

CURRENT LIBRARIES

- Accession
- clj-redis
- Carmine
- redis-clojure
- labs-redis-clojure

GETTING STARTED

```
$ lein new yow  
$ cd yow  
$ mkdir script  
$ touch script/bootstrap  
$ chmod +x script/bootstrap
```

```
REDIS_VERSION=2.6.4
```

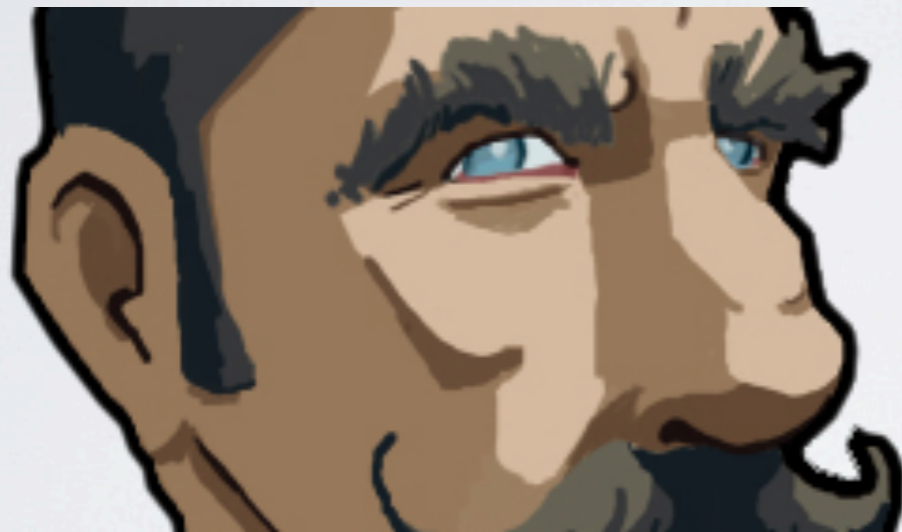
```
URL=http://redis.googlecode.com/files/  
\$REDIS\_VERSION.tar.gz
```

```
if [ ! -d "vendor" ]; then  
    mkdir vendor  
    pushd vendor  
    if which wget > /dev/null; then  
        wget $URL  
    else  
        curl -O $URL  
    fi  
    tar xvf $REDIS_VERSION.tar.gz  
    pushd $REDIS_VERSION  
    make  
    popd  
    popd  
fi
```

```
if [ ! -d "config" ]; then
    mkdir config
    cp vendor/$REDIS_VERSION/redis.conf config/
fi

if [ ! -d "bin" ]; then
    mkdir bin
    cp vendor/$REDIS_VERSION/src/redis-server bin/
    cp vendor/$REDIS_VERSION/src/redis-cli bin/
fi
```

```
$ tree
|-- README.md
|-- bin
|   |-- redis-cli
|   `-- redis-server
|-- config
|   `-- redis.conf
|-- project.clj
|-- script
|   |-- bootstrap
|-- src
|   |-- yaw
|   |   |-- core.clj
|-- test
|   |-- yaw
|   |   |-- core_test.clj
`-- vendor
    |-- redis-2.6.4
```



Leiningen

THE GOODNESS* OF MAVEN
WRAPPED IN CLOJURE

*YMMV

```
(defproject yaw "0.1.0-SNAPSHOT"
  :description "A Redis Adapter"
  :url "http://github.com/abedra/yow-2012"
  :license {:name "Eclipse Public License"
            :url "http://www.eclipse.org/legal/epl-v10.html" }
  :dependencies [[org.clojure/clojure "1.4.0"]
                 [org.clojure/data.json "0.2.0"]])
```

THE REDIS UNIFIED PROTOCOL

*<number of arguments> CR LF
\$<number of bytes of argument 1> CR LF
<argument data> CR LF
...
\$<number of bytes of argument N> CR LF
<argument data> CR LF

*3
\$3
SET
\$5
mykey
\$7
myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

***<number of arguments> CR LF**

\$<number of bytes of argument 1> CR LF

<argument data> CR LF

...

\$<number of bytes of argument N> CR LF

<argument data> CR LF

*3

\$3

SET

\$5

mykey

\$7

myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

*<number of arguments> CR LF

\$<number of bytes of argument 1> CR LF

<argument data> CR LF

...

\$<number of bytes of argument N> CR LF

<argument data> CR LF

*3

\$3

SET

\$5

mykey

\$7

myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

*<number of arguments> CR LF
\$<number of bytes of argument 1> CR LF
<argument data> CR LF

...

\$<number of bytes of argument N> CR LF
<argument data> CR LF

*3
\$3
SET
\$5
mykey
\$7
myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

*<number of arguments> CR LF
\$<number of bytes of argument 1> CR LF
<argument data> CR LF
...
\$<number of bytes of argument N> CR LF
<argument data> CR LF

***3**
\$3
SET
\$5
mykey
\$7
myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

*<number of arguments> CR LF
\$<number of bytes of argument 1> CR LF
<argument data> CR LF
...
\$<number of bytes of argument N> CR LF
<argument data> CR LF

*3
\$3
SET
\$5
mykey
\$7
myvalue

"*3\r\n\$3\r\nSET\r\n\$5\r\nmykey\r\n\$7\r\nmyvalue\r\n"

CLOJURE'S BUILT IN TEST FRAMEWORK

```
(defn hello  
  [name]  
  (str "Hello " name "!"))
```

```
(defn hello  
  [name]  
  (str "Hello " name "!"))
```

```
(deftest test-hello  
  (is (= "Hello Yow!" (hello "Yow"))))
```

LET'S TURN THE PROTOCOL
EXAMPLE INTO A TEST!

```
(deftest test-command
  (testing "Produces proper SET command"
    (is (= "*3\r\n$3\r\nSET\r\n$5\r\nmykey\r\n$7\r\nmyvalue\r\n"
           (command "set"
                    "mykey"
                    "myvalue")))))
```

IMPLEMENTATION TIME

```
(defn command
  [name & args]
  (let [crlf "\r\n"]
    (str "*" (inc (count args)) crlf
      "$" (count name) crlf
      (str/upper-case name) crlf
      (str/join crlf
        (map
          (fn [arg]
            (str "$" (count arg) crlf arg))
          args))
      crlf)))
```

Testing yow.core-test

Ran 1 tests containing 1 assertions.
0 failures, 0 errors.

JAVA INTEROP IN CLOJURE

```
user> (import '(java.net Socket))
;-> java.net.Socket
user> (Socket.)
;-> #<Socket Socket[unconnected]>
user> (Socket. "localhost" 6379)
;-> #<Socket Socket[addr=localhost/
127.0.0.1,port=6379,localport=45284]>
user> (def s (Socket. "localhost" 6379))
;-> #'user/s
user> (.setKeepAlive s true)
;-> nil
user> (.getKeepAlive s)
;-> true
```

HELLO REDIS!

```
(defn- socket
  []
  (doto (Socket. "localhost" 6379)
    (.setTcpNoDelay true)
    (.setKeepAlive true)))

(defn request
  [command]
  (with-open [socket (socket)
              in (DataInputStream.
                  (BufferedInputStream.
                   (.getInputStream socket)))
              out (.getOutputStream socket)]
    (.write out (.getBytes command))
    (println in)))
```

```
user> (request (command "set" "foo" "bar"))  
;-> #<DataInputStream java.io.DataInputStream@580a00fd>
```

```
$ bin/redis-cli get foo  
"bar"
```

POLYMORPHISM IN CLOJURE

EXAMPLES

- Most core datastructures implemented using Java Interfaces
- Interface generation via **proxy** & **reify**
- Protocols
- Multimethods

```
(defmulti encounter
  (fn [x y]
    [(:Species x) (:Species y)]))
```

```
(defmethod encounter [ :Bunny :Lion] [b l] :run-away)
(defmethod encounter [ :Lion :Bunny] [b l] :eat)
(defmethod encounter [ :Lion :Lion] [b l] :fight)
(defmethod encounter [ :Bunny :Bunny] [b l] :mate)
```

```
(def b1 {:Species :Bunny :other :stuff})  
(def b2 {:Species :Bunny :other :stuff})  
(def l1 {:Species :Lion :other :stuff})  
(def l2 {:Species :Lion :other :stuff})
```

```
(encounter b1 b2)  
;-> :mate  
(encounter b1 l1)  
;-> :run-away  
(encounter l1 b1)  
;-> :eat  
(encounter l1 l2)  
;-> :fight
```

THE REDIS RESPONSE STRUCTURE

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

| | |
|----------------------------------------|------|
| A single line reply first byte will be | "+" |
| An error message first byte will be | "_" |
| An integer first byte will be | ":" |
| A bulk reply first byte will be | "\$" |
| A multi-bulk first byte will be | "*" |

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

A single line reply first byte will be "+"

An error message first byte will be "-"

An integer first byte will be ":"

A bulk reply first byte will be "\$"

A multi-bulk first byte will be "*"

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

A single line reply first byte will be "+"

An error message first byte will be "-"

An integer first byte will be ":"

A bulk reply first byte will be "\$"

A multi-bulk first byte will be "*"

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

A single line reply first byte will be "+"

An error message first byte will be "-"

An integer first byte will be ":"

A bulk reply first byte will be "\$"

A multi-bulk first byte will be "*"

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

A single line reply first byte will be "+"

An error message first byte will be "-"

An integer first byte will be ":"

A bulk reply first byte will be "\$"

A multi-bulk first byte will be "*"

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the first byte sent by the server:

A single line reply first byte will be "+"

An error message first byte will be "-"

An integer first byte will be ":"

A bulk reply first byte will be "\$"

A multi-bulk first byte will be "*"

Redis will reply to commands with different kinds of replies. It is possible to check the kind of reply from the **first byte** sent by the server:

| | | | |
|---------------------|-------------------|---------|------|
| A single line reply | first byte | will be | "+" |
| An error message | first byte | will be | "-" |
| An integer | first byte | will be | ":" |
| A bulk reply | first byte | will be | "\$" |
| A multi-bulk | first byte | will be | "*" |

```
(defmulti response
  (fn [in] (char (.readByte in))))

(defmethod response \- [in]
  (.readLine in))

(defmethod response \+ [in]
  (.readLine in))

(defmethod response \: [in]
  (Long/parseLong (.readLine in)))

(defmethod response \$ [in]
  (.readLine in)
  (.readLine in))

(defmethod response \* [in]
  (throw (UnsupportedOperationException.
    "Not Yet Implemented")))
```

```
user> (request (command "set" "foo" "bar" ) )  
;-> "OK"
```

```
user> (request (command "get" "foo" ) )  
;-> "bar"
```

```
;; Examples taken from http://try.redis-db.com/
(deftest test-basic-interaction
  (testing "SET then GET"
    (is (= "OK" (request (command "set" "server:name" "fido"))))
    (is (= "fido" (request (command "get" "server:name")))))
  (testing "INCR"
    (request (command "set" "connections" "10"))
    (is (= 11 (request (command "incr" "connections")))))
  (testing "DEL"
    (is (= 1 (request (command "del" "connections"))))))
```

Testing yow.core-test

Ran 2 tests containing 5 assertions.
0 failures, 0 errors.

REDIS.IO/COMMANDS

```
(ns yow.commands
  (:use [clojure.data.json :only (read-str)]))

(defn fetch-redis-commands
  []
  (map first
    (read-str
      (slurp "https://raw.githubusercontent.com/antirez/redis-doc/master/commands.json") )))

user> (count (fetch-redis-commands))
;-> 144
```

ZREM ZREMRANGEBYRANK PUNSUBSCRIBE BRPOP BITCOUNT SET PEXPIREAT
FLUSHDB BGSAVE ZRANGE SLOWLOG SCARD HDEL HSETNX STRLEN CONFIG SET
HEXISTS SMOVE SUNIONSTORE ZINCRBY CONFIG RESETSTAT LINSERT
BRPOPLPUSH ECHO PSETEX LPOP SMEMBERS LPUSH ZRANK LINDEX RPOPLPUSH
DECRBY ZREVRANGEBYSORE BLPOP ZADD SREM GETRANGE RENAMENX AUTH
HINCRBYFLOAT SINTER SDIFFSTORE LLEN MGET SUBSCRIBE ZCARD SETBIT
MIGRATE INCRBY DEL GETSET SETNX DEBUG OBJECT TTL RPUSH ZUNIONSTORE
RPUSHX HLEN TIME LREM INFO SLAVEOF HGET RESTORE LTRIM SADD BITOP
WATCH PUBLISH PEXPIRE QUIT SCRIPT FLUSH DECR EVALSHA HMGET LRANGE
EXEC SCRIPT EXISTS INCRBYFLOAT UNSUBSCRIBE BGREWRITEAOF MOVE PING
EXPIREAT SRANDMEMBER LPUSHX HGETALL LASTSAVE SCRIPT KILL HINCRBY
CLIENT KILL CLIENT LIST INCR ZREVRANGE PERSIST KEYS DUMP SETEX
ZCOUNT MSET ZREVRANK LSET UNWATCH SHUTDOWN GET SISMEMBER GETBIT
CONFIG GET SINTERSTORE ZRANGEBYSORE ZSCORE SDIFF MULTI MONITOR
HVALS DEBUG SEGFAULT PSUBSCRIBE HSET APPEND TYPE SETRANGE SYNC
SCRIPT LOAD EXISTS EVAL SELECT UNION HKEYS RANDOMKEY PTTL
FLUSHALL HMSET SAVE DISCARD SPOP SORT ZREMRANGEBYSORE RENAME
RPOP EXPIRE ZINTERSTORE MSETNX DBSIZE OBJECT

```
"BITOP": {
  "summary": "Perform bitwise operations between strings",
  "complexity": "O(N)",
  "arguments": [
    {
      "name": "operation",
      "type": "string"
    },
    {
      "name": "destkey",
      "type": "key"
    },
    {
      "name": "key",
      "type": "key",
      "multiple": true
    }
  ],
  "since": "2.6.0",
  "group": "string"
}
```

HOW SHOULD WE
IMPLEMENT ALL 144
COMMANDS?

DO WE WRITE 144
FUNCTIONS?

HELL NO! WE ABSTRACT!

CONSIDER THE FOLLOWING
DSL...

```
( defcommands
  ( set    [key value] )
  ( get    [key] )
  ( incr   [key] )
  ( del    [key & keys] ) )
```

CLOJURE HAS A VERY
POWERFUL MACRO SYSTEM

YOU CAN ESSENTIALLY
EXTEND THE COMPILER

BUT REMEMBER THE FIRST
RULE OF MACRO CLUB!

“Macros are harder to write than ordinary Lisp functions, and it's considered to be bad style to use them when they're not necessary.”

-Paul Graham, “Beating the Averages”

```
;; clojuredocs.org/clojure\_core/clojure.core/defmacro  
(defmacro unless [pred a b]  
  `(if (not ~pred) ~a ~b))
```

```
;; usage:  
(unless false  
  (println "Will print")  
  (println "Will not print"))
```

```
user> (macroexpand-1  
      '(unless false  
        (println "Will print")  
        (println "Will not print")))
```

```
;; (if (clojure.core/not false)  
;;   (println "Will print")  
;;   (println "Will not print"))
```

LETS BRING OUR DSL TO LIFE

```
(defmacro defcommand
  [name params]
  (let [p (parameters params)]
    `(defn ~name ~params
      (apply
        command ~(str com) ~@p))))
```

```
user> (macroexpand-1 '(defcommand set [key value]))
;; (clojure.core/defn set
;;   [key value]
;;   (clojure.core/apply
;;     yaw.core/command "set" key value nil))

user> (macroexpand-1 '(defcommand del [key & keys]))
;; (clojure.core/defn del
;;   [key & keys]
;;   (clojure.core/apply
;;     yaw.core/command "del" key keys))
```

```
(defmacro defcommands  
  [& commands]  
  `(do ~@(map (fn [c] `(defcommand ~@c)) commands)))
```

```
(defmacro defcommands
  [& commands]
  `(do ~@(map (fn [c] `(defcommand ~@c)) commands)))
```

```
user> (macroexpand-1
      '(defcommands (set [set value]) (del [key & keys])))
;; (do
;;   (yow.core/defcommand set [set value])
;;   (yow.core/defcommand del [key & keys]))
```

```

(defmacro defcommands
  [& commands]
  `(do ~@(map (fn [c] `(defcommand ~@c)) commands)))

user> (macroexpand-1
      '(defcommands (set [set value]) (del [key & keys])))
;; (do
;;   (yow.core/defcommand set [set value])
;;   (yow.core/defcommand del [key & keys]))

user> (clojure.walk/macroexpand-all
      '(defcommands (set [set value]) (del [key & keys])))
;; (do
;;   (def set
;;     (fn* ([set value]
;;           (clojure.core/apply
;;            yow.core/command "set" set value nil))))
;;   (def del
;;     (fn* ([key & keys]
;;           (clojure.core/apply
;;            yow.core/command "del" key keys))))

```

CLEANING UP

```
(ns yaw.core
  (:refer-clojure :exclude [set get])
  (:require [clojure.string :as str])
  (:import (java.net Socket)
            (java.io BufferedInputStream DataInputStream)))
```

;; Prefer require over use so that you don't have to propagate the
;; :refer-clojure into every namespace that pulls the library in

```
user> (require '[yaw.core :as redis])
;-> nil
user> (redis/request (redis/set "foo" "bar"))
;-> "OK"
user> (redis/request (redis/get "foo"))
;-> "bar"
```

WITH THIS WE'RE OFF TO A
GREAT START!

WE'VE CREATED A REDIS
INTERACTION LIBRARY IN
UNDER 80 LINES OF CODE

BUT IT'S FAR FROM FINISHED

PERHAPS WE COULD EVEN
AUTOMATE TRACKING THE
COMMANDS!

```
(defn fetch-redis-commands
  []
  (read-str
    (slurp "https://raw.githubusercontent.com/antirez/redis-doc/master/commands.json") ))
```

```
user> (def com-list (fetch-redis-commands))
```

```
#'user/com-list
```

```
user> (pprint (first com-list))
```

```
;; ["ZREM"
;;  {"summary" "Remove one or more members from a sorted set",
;;   "complexity"
;;   "O(M*log(N)) with N being the number of elements in the
sorted set and M the number of elements to be removed.",
;;   "arguments"
;;   [{"name" "key", "type" "key"}
;;    {"name" "member", "type" "string", "multiple" true}],
;;   "since" "1.2.0",
;;   "group" "sorted_set"}]
```

```

(defmacro define-command [command]
  (let [command (eval command)
        name (.toLowerCase (first command))
        data (second command)
        docstring (str (data "summary")
                        "\n" "Complexity: "
                        (data "complexity"))
        arguments (vec (apply symbol
                               (map #(% "name") (data "arguments"))))
        varargs? (some #(= % "multiple")
                        (flatten (map keys (data "arguments"))))
        since (data "since")
        group (data "group")]
    `(defn ~(symbol name) ~docstring ~arguments
      (apply command ~name ~arguments))))

```

```
user> #'zrem
```

```
;; CompilerException java.lang.RuntimeException: Unable to resolve  
;; var: zrem in this context, compiling:(NO_SOURCE_PATH:1)
```

```
user> #'zrem
```

```
;; CompilerException java.lang.RuntimeException: Unable to resolve  
;; var: zrem in this context, compiling:(NO_SOURCE_PATH:1)
```

```
user> (define-command (first com-list))
```

```
;-> #'user/zrem
```

```
user> #'zrem
```

```
;; CompilerException java.lang.RuntimeException: Unable to resolve  
;; var: zrem in this context, compiling:(NO_SOURCE_PATH:1)
```

```
user> (define-command (first com-list))
```

```
;-> #'user/zrem
```

```
user> #'zrem
```

```
;-> #'user/zrem
```

```
user> #'zrem
```

```
;; CompilerException java.lang.RuntimeException: Unable to resolve  
;; var: zrem in this context, compiling:(NO_SOURCE_PATH:1)
```

```
user> (define-command (first com-list))
```

```
;-> #'user/zrem
```

```
user> #'zrem
```

```
;-> #'user/zrem
```

```
user> (doc zrem)
```

```
;; -----
```

```
;; user/zrem
```

```
;; ([key member])
```

```
;; Remove one or more members from a sorted set
```

```
;; Complexity:  $O(M \cdot \log(N))$  with N being the number of elements in
```

```
;; the sorted set and M the number of elements to be removed.
```

```
user> #'zrem
```

```
;; CompilerException java.lang.RuntimeException: Unable to resolve  
;; var: zrem in this context, compiling:(NO_SOURCE_PATH:1)
```

```
user> (define-command (first com-list))
```

```
;-> #'user/zrem
```

```
user> #'zrem
```

```
;-> #'user/zrem
```

```
user> (doc zrem)
```

```
;; -----
```

```
;; user/zrem
```

```
;; ([key member])
```

```
;; Remove one or more members from a sorted set
```

```
;; Complexity:  $O(M \log(N))$  with  $N$  being the number of elements in
```

```
;; the sorted set and  $M$  the number of elements to be removed.
```

```
user> (zrem "foo" "bar")
```

```
;-> "*3\r\n$4\r\nZREM\r\n$3\r\nfoo\r\n$3\r\nbar\r\n"
```

BUT IT'S FAR FROM FINISHED

YOU WILL HAVE TO USE YOUR
NEW CLOJURE POWERS TO
COMPLETE THIS EXERCISE

MAY THE () BE WITH YOU

REFERENCES

- clojure.org
- redis.io
- github.com/abedra/accession
- github.com/abedra/yow-2012
- pragprog.com/book/shcloj2/programming-clojure

