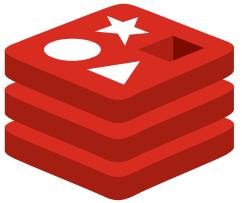
Embedding Lua scripts for Redis in C & other lessons learned



https://nchan.slact.net

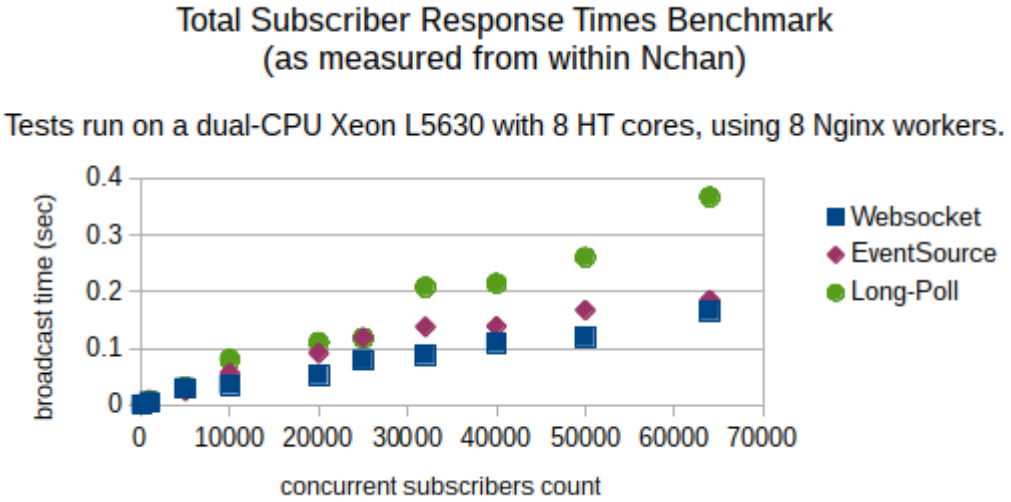
: What is it?

- Third Party Nginx Module
- Buffering Pub/Sub server for web clients
- Subscribe via Long-Polling, Websocket, EventSource / SSE, Chunked-Transfer, multipart/mixed
- Publish via HTTP and Websocket
- Storage in-memory & on-disk, or in Redis.
- Uses channels to coordinate publishers and subscribers.

Some Features

- Channel ID derived from publisher / subscriber request.
- Per-channel configurable message expiration.
- Multiplexed subscriptions.
- Access controls based on channel metadata or upstream application response.
- Resumable subscriber connections with no-loss, no-repetition delivery guarantees.

Scalability



- It's pretty fast…
  - 30K websocket responses per 100ms
  - Handles connections as well as Nginx, because it *is* Nginx.
- Scales vertically with more CPU and RAM bandwidth
- Scales horizontally by sharding subscribers…
  …or by using Redis…

An aside on Nginx configs

```
#very basic nchan config
worker_processes 5;
http {
  server {
    listen        80;

    location ~ /sub/(.+)$ {
      nchan_subscriber;
      nchan_channel_id $1;
    }

    location ~ /pub/(.+)$ {
      nchan_publisher;
      nchan_channel_id $1;
    }
  }
}
```

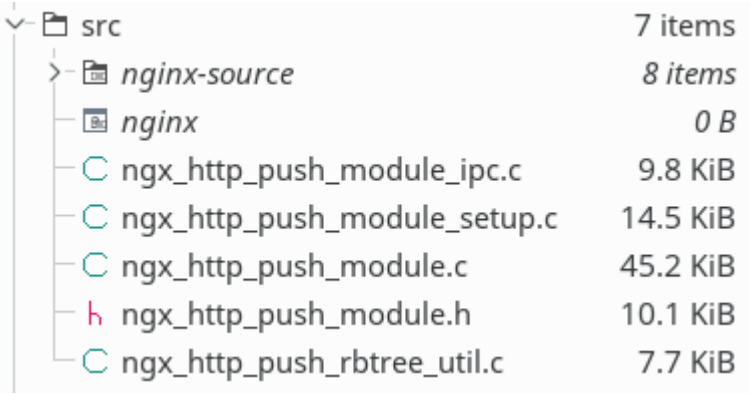
```
curl -v http://localhost/sub/foo
*   Trying 127.0.0.1...
* Connected to localhost (127.0.0.1) port 80 (#0)
> GET /sub/broadcast/foo HTTP/1.1
> Host: localhost:80
> User-Agent: curl/7.48.0
> Accept: */*
>
< HTTP/1.1 200 OK
< Server: nginx/1.9.15
< Date: Mon, 25 Apr 2016 22:21:07 GMT
< Content-Type: application/x-www-form-urlencoded
< Content-Length: 5
< Last-Modified: Mon, 25 Apr 2016 22:21:07 GMT
< Connection: keep-alive
< Etag: 0
< Vary: If-None-Match, If-Modified-Since
<
* Connection #0 to host localhost left intact
hi%
```

```
curl -X POST http://localhost:8082/pub/foo -d hi

queued messages: 1
last requested: 0 sec. ago
active subscribers: 1
last message id: 1461622867:0
```

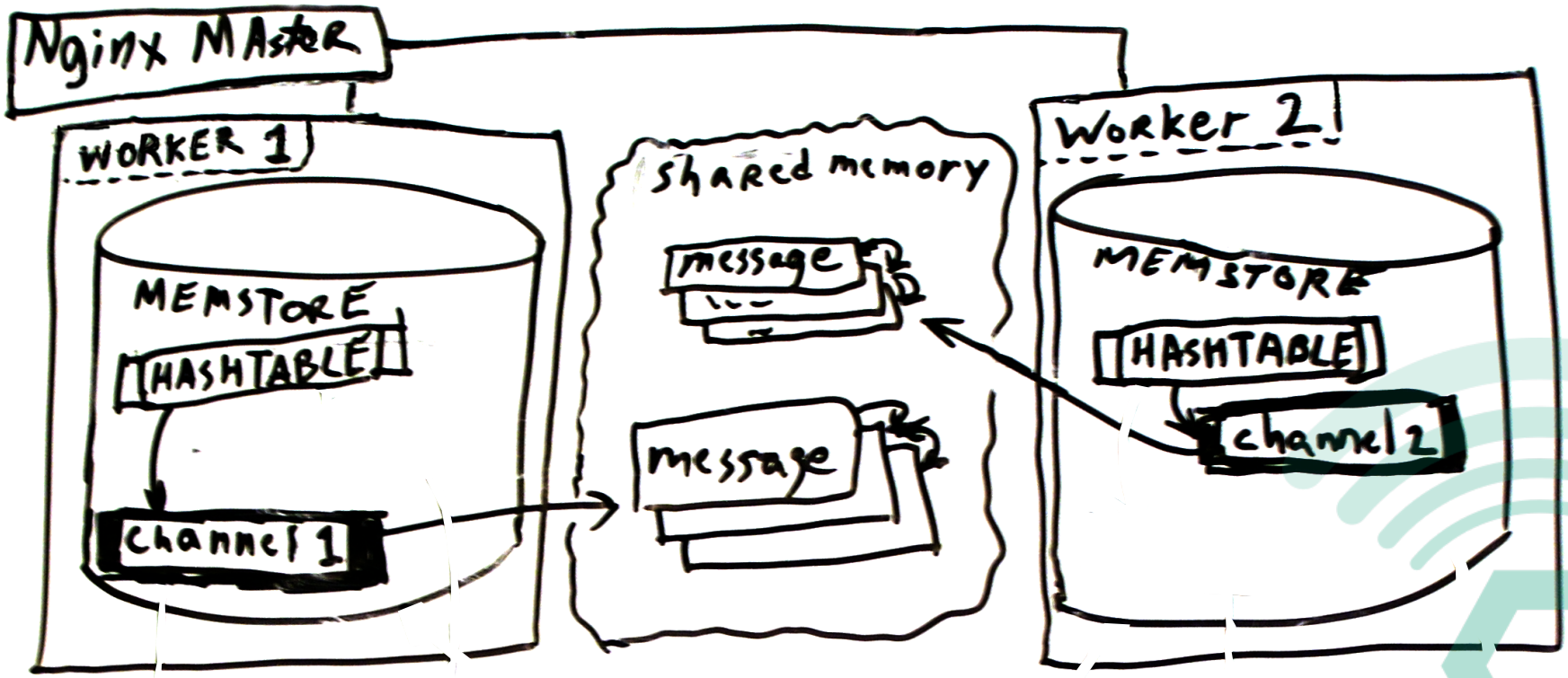
Some history…

nginx_http_push_module (2009-2011)

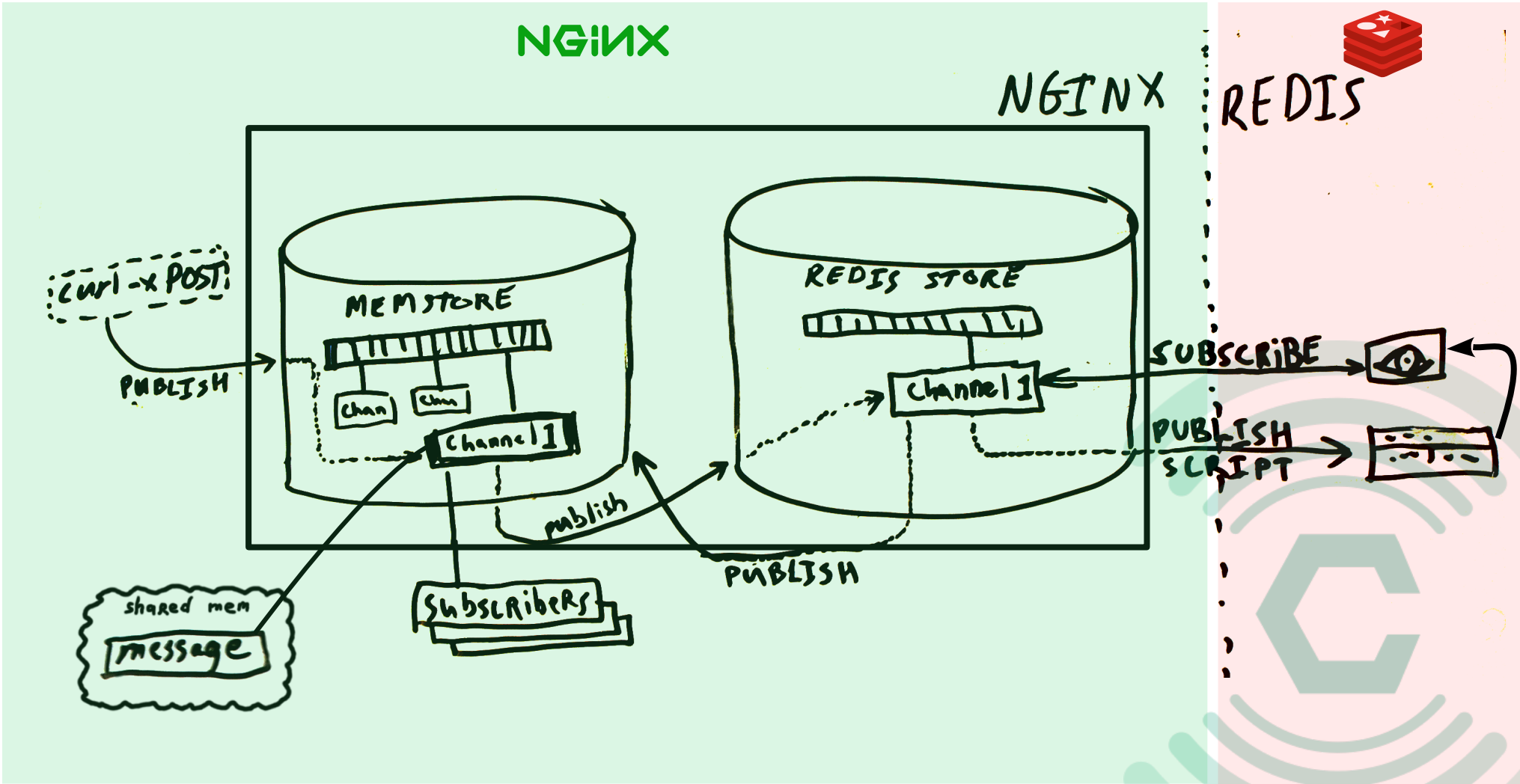
- Longpoll-only
- Storage was in shared memory, using an (ugly) global mutex
- Gradually refactored in the course of the last 2 years.
- Rebuilt into Nchan in 2015



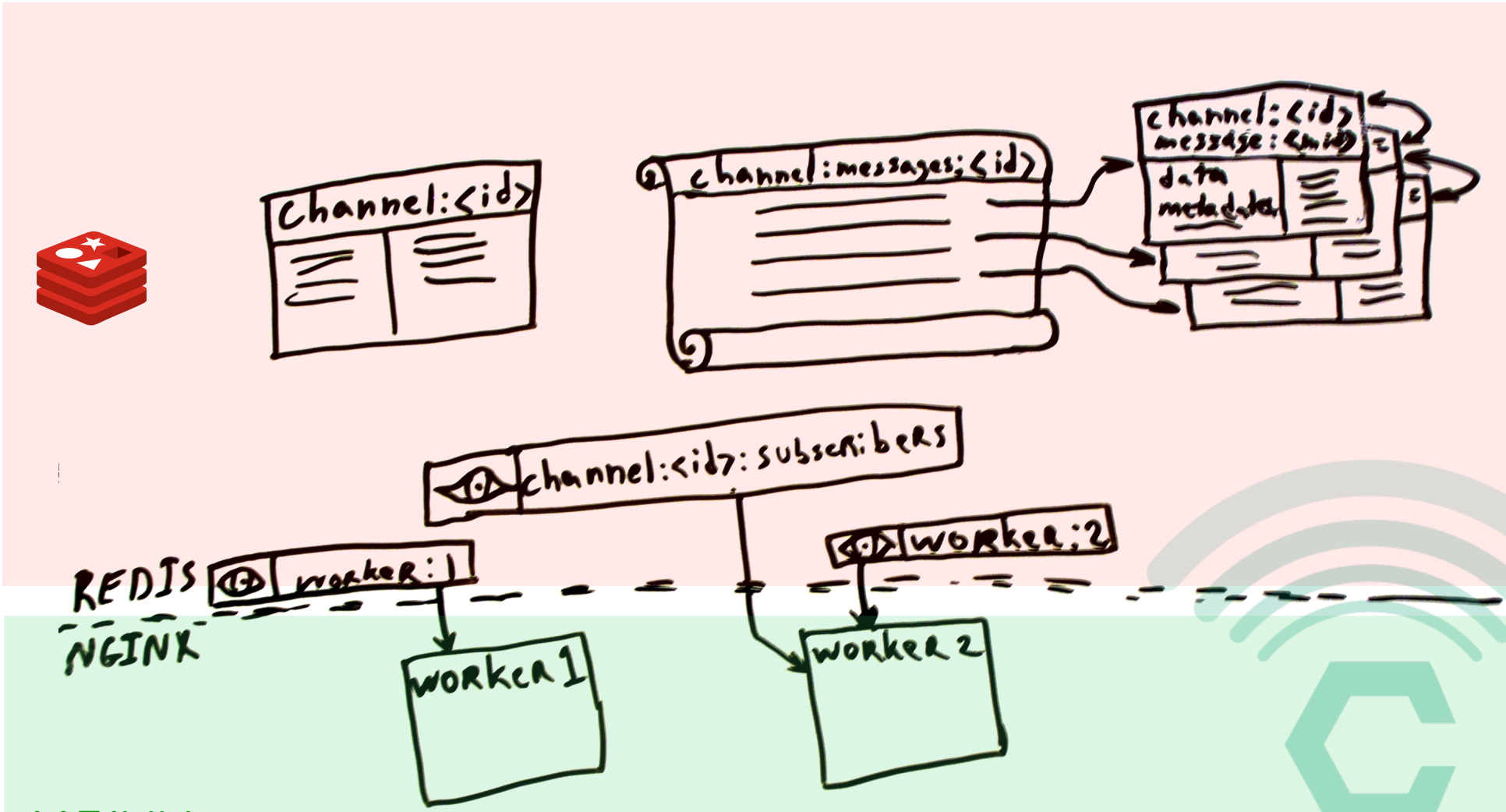
Architecture Overview: Memory Store



Architecture Overview: Memory & Redis Store



Redis Data Architecture



hi redis

- Nginx uses a custom event loop
- hiredis has adapters for all the standard event libraries, but not for Nginx
- Fortunately, there are nginx-hiredis adapters out there already:
  - https://github.com/wandenberg/redis_nginx_adapter
  - https://github.com/alexly/redis_nginx_module
- Each Nginx worker uses 3 connections to redis:
  - 1 asyncronous, for running sripts
  - 1 asyncronous, for PUBSUB
  - 1 syncronous, for use when shutting down

Lua Scripts

- Great for cutting down roundtrips, but…
- No easy way to call scripts from within scripts.
- No way to share functions.
- No way to reuse code.

The Two Forms of Redis Scripts: 1. The All-in-One Script

geo.lua: `EVALSHA <hash> <keys> <COMMAND> <args...>`
(https://github.com/RedisLabs/geo.lua)

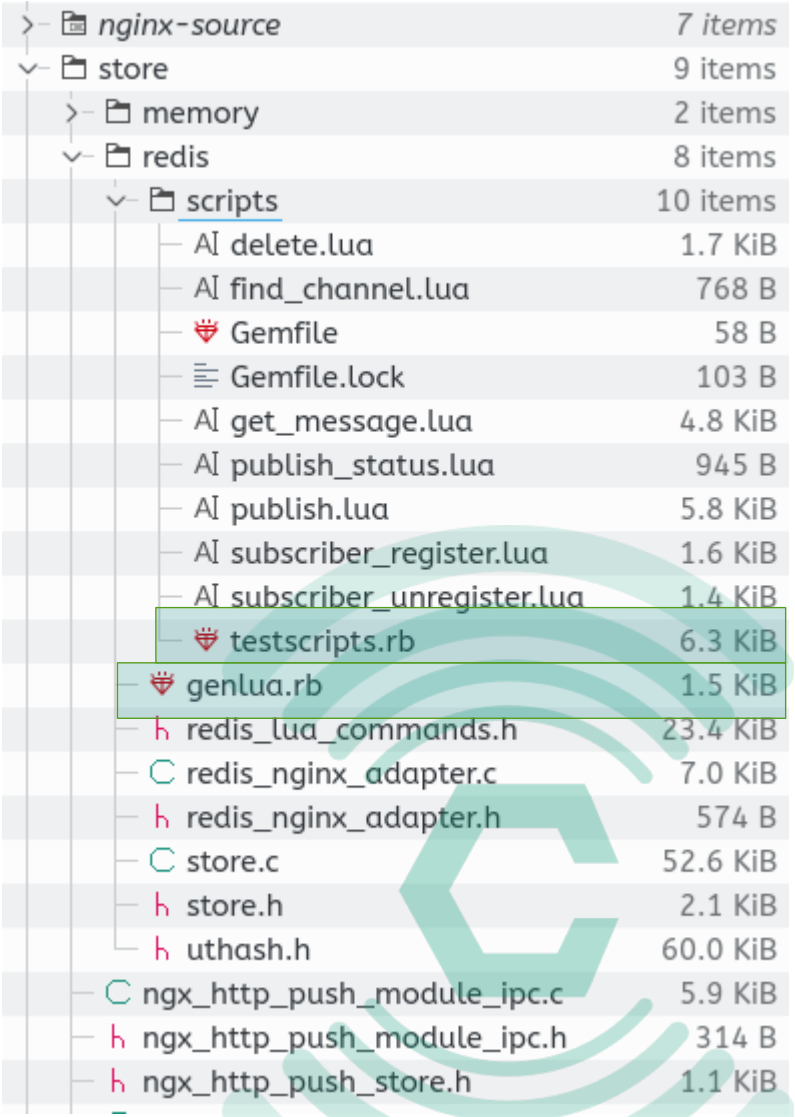
- Necessary for function reuse.
- A bit difficult to write and debug.

The Two Forms of Redis Scrips: 2. Split Scripts

- One script per ‘command’
- Useful when little functional overlap between ‘commands’
- (Arguably) easier to write and debug.
- DRYDRY: Prepare to repeat yourself.

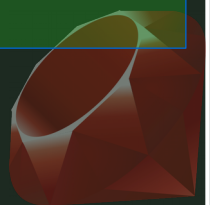
Gluing it Together with Scripts

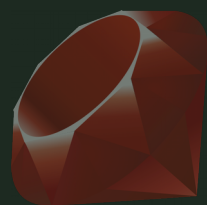
- Scripts can be tested with a high-level language before embedding
- How to embed Lua scripts in C?
- How to load scripts?
- How to do error checking?



testscripts.rb : testing lua with ruby

```ruby
#!/usr/bin/ruby
require 'digest/sha1'
require "redis"
require 'open3'
require 'minitest'
require 'minitest/reporters'
require "minitest/autorun"
require 'securerandom'

REDIS_HOST="127.0.0.1"
REDIS_PORT=8537
REDIS_DB=1

class PubSubTest < Minitest::Test
  @@redis=nil
  @@scripts= {}
  @@files=   {}
  @@scripts= {}
  @@hashes=  {}

  def self.test_order; :alpha; end

  def self.luac
    if @@scripts
      @@scripts.each do |name, script|
        Open3.popen2e('luac', "-p", @@files[name]) do |stdin, stdouterr, process|
          raise stdouterr.read unless process.value.success?
        end
      end
    else
      raise "scripts not loaded yet"
    end
  end

  def self.loadscripts
    @@scripts.each do |name, script|
      begin
        h=@@redis.script :load, script
        @@hashes[name]=h
      rescue Redis::CommandError => e
        e.message.gsub!(/:\s+(user_script):(\d+):/, ":\n#{name}.lua:\\2:")
        def e.backtrace; []; end
        raise e
      end
    end
  end

  def setup
    unless @@redis
      @@redis=Redis.new(:host => REDIS_HOST, :port => REDIS_PORT, :db => REDIS_DB)

      Dir[ "#{File.dirname(__FILE__)}/*.lua" ].each do |f|
        scriptname=File.basename(f, ".lua").to_sym
        @@scripts[scriptname]=IO.read f
        @@files[scriptname]=f
      end
      self.class.luac
      self.class.loadscripts
    end
  end

  def redis; @@redis; end
  def hashes; @@hashes; end
  #here be tests
end
```





testscripts.rb : minitest is pretty nice

Embedding

- Import scripts as C strings:

```lua
--input: keys: [],  values: [ channel_id ]
--output: channel_hash {ttl, time_last_seen, subscribers, messages} or nil
-- finds and return the info hash of a channel, or nil of channel not found
local id = ARGV[1]
local key_channel='channel:'..id

redis.call('echo', ' #######  FIND_CHANNEL ######## ')

if redis.call('EXISTS', key_channel) ~= 0 then
  local ch = redis.call('hmget', key_channel, 'ttl', 'time_last_seen', 'subscribers', 'fake_subscribers')
  if(ch[4]) then
    --replace subscribers count with fake_subscribers
    ch[3]=ch[4]
    table.remove(ch, 4)
  end
  for i = 1, #ch do
    ch[i]=tonumber(ch[i]) or 0
  end
  table.insert(ch, redis.call('llen', "channel:messages:"..id))
  return ch
else
  return nil
end
```


```c
"--input: keys: [],  values: [ channel_id ]\n"
"--output: channel_hash {ttl, time_last_seen, subscribers, messages} or nil\n"
"-- finds and return the info hash of a channel, or nil of channel not found\n"
"local id = ARGV[1]\n"
"local key_channel='channel:'..id\n"
"\n"
"redis.call('echo', ' #######  FIND_CHANNEL ######## ')\n"
"\n"
"if redis.call('EXISTS', key_channel) ~= 0 then\n"
"  local ch = redis.call('hmget', key_channel, 'ttl', 'time_last_seen', 'subscribers', 'fake_subscribers')\n"
"  if(ch[4]) then\n"
"    --replace subscribers count with fake_subscribers\n"
"    ch[3]=ch[4]\n"
"    table.remove(ch, 4)\n"
"  end\n"
"  for i = 1, #ch do\n"
"    ch[i]=tonumber(ch[i]) or 0\n"
"  end\n"
"  table.insert(ch, redis.call('llen', \"channel:messages:\"..id))\n"
"  return ch\n"
"else\n"
"  return nil\n"
"end\n"
```

(must have the same hash)

Error Handling?

```
127.0.0.1:6379> evalsha "f738535cb8488ef039e747d144a5634b8408c7c5" 0

(error) ERR Error running script (call to f_f738535cb8488ef039e747d144a5634b8408c7c5):
@enable_strict_lua:15: user_script:1: Script attempted to access unexisting global variable
'foobar'
```

Script hash is known, but no script name…

- Let's use it to lookup the script name by hash!
- So we need to embed the script *name* and *hash* along with the source…

(The price of having a simple server is offloading complexity to the client)

genlua.rb

input: script files

output: C structs with script src, hashes, and names

example/

- delete.lua

```lua
--deletes first key
redis.call('del', KEYS[1])
```

- echo.lua

```lua
--echoes the first argument
redis.call('echo', ARGS[1])
```


```c
typedef struct {
  //deletes first key
  char *delete;

  //echoes the first argument
  char *echo;

} redis_lua_scripts_t;

static redis_lua_scripts_t redis_lua_hashes = {
  "c6929c34f10b0fe8eaba42cde275652f32904e03",
  "8f8f934c6049ab4d6337cfa53976893417b268bc"
};

static redis_lua_scripts_t redis_lua_script_names = {
  "delete",
  "echo",
};

static redis_lua_scripts_t redis_lua_scripts = {
  //delete
  "--deletes first key\n"
  "redis.call('del', KEYS[1])\n",

  //echo
  "--echoes the first argument\n"
  "redis.call('echo', ARGS[1])\n"
};
```

Introducing **hsss**: Hash-Safe Script Splinterer

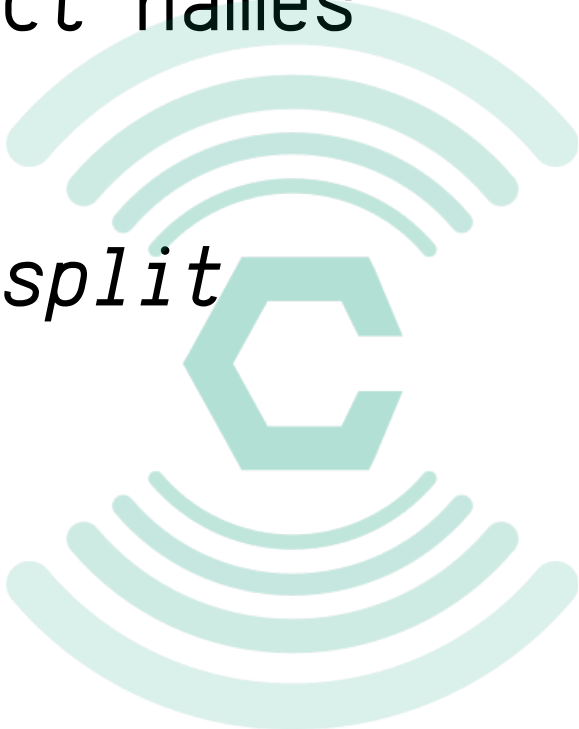
- Ruby gem for Lua Script and hash embedding into C source.

```
> gem install hsss
```

```
> hsss --help
Hash-Safe Script Splinterer, a Lua Script and hash embedder into C source.
Good for putting Redis Lua scripts in your C headers.
Usage: hsss [options] files
        --format [split|whole]             Output as separate or a single struct
        --struct [redis_lua_scripts_t]     C struct name
        --row-struct [redis_lua_script_t]  Hash+name+script struct for 'whole' format.
        --scripts [redis_lua_scripts]      Scripts variable (split or whole format)
        --hashes [redis_lua_hashes]        Hashes variable (split format)
        --names [redis_lua_script_names]   Script names variable (split format)
        --count [redis_lua_scripts_count]  integer script count variable
        --no-count                         Omit script count variable
        --each-macro [REDIS_LUA_SCRIPTS_EACH]  Iterator macro
        --no-each                          Omit the iterator macro
        --no-parse                         Skip using luac to check script syntax
        --prefix PREFIX                    Prefix default names with this
```

hsss features

- runs luac -p on each script to validate syntax
  - (almost) doesn't matter if using lua 5.1, 5.2 or 5.3
- Customizable variable and struct names
- Iterator macro
- Two output formats: *whole* and *split*



hsss output

```
> hsss --format whole example/*.lua
```

```c
// don't edit this please, it was auto-generated by hsss
// https://github.com/slact/hsss

typedef struct {
  char *name;
  char *hash;
  char *script;
} redis_lua_script_t;

typedef struct {
  //deletes first key
  redis_lua_script_t delete;

  //echoes the first argument
  redis_lua_script_t echo;

} redis_lua_scripts_t;

static redis_lua_scripts_t redis_lua_scripts = {
  {"delete", "c6929c34f10b0fe8eaba42cde275652f32904e03",
   "--deletes first key\n"
   "redis.call('del', KEYS[1])\n"},

  {"echo", "8f8f934c6049ab4d6337cfa53976893417b268bc",
   "--echoes the first argument\n"
   "redis.call('echo', ARGS[1])\n"}
};

const int redis_lua_scripts_count=2;
#define REDIS_LUA_SCRIPTS_EACH(script) \
for((script)=(redis_lua_script_t *)&redis_lua_scripts; (script) <
(redis_lua_script_t *)(&redis_lua_scripts + 1); (script)++)
```

```
> hsss --format split example/*.lua
```

```c
// don't edit this please, it was auto-generated by hsss
// https://github.com/slact/hsss

typedef struct {
  //deletes first key
  char *delete;

  //echoes the first argument
  char *echo;

} redis_lua_scripts_t;

static redis_lua_scripts_t redis_lua_hashes = {
  "c6929c34f10b0fe8eaba42cde275652f32904e03",
  "8f8f934c6049ab4d6337cfa53976893417b268bc"
};

static redis_lua_scripts_t redis_lua_script_names = {
  "delete",
  "echo",
};

static redis_lua_scripts_t redis_lua_scripts = {
  //delete
  "--deletes first key\n"
  "redis.call('del', KEYS[1])\n",

  //echo
  "--echoes the first argument\n"
  "redis.call('echo', ARGS[1])\n"
};

const int redis_lua_scripts_count=2;
#define REDIS_LUA_SCRIPTS_EACH(script_src, script_name, script_hash) \
for((script_src)=(char **)&redis_lua_scripts, (script_hash)=(char
**)&redis_lua_hashes, (script_name)=(char **)&redis_lua_script_names;
(script_src) < (char **)(&redis_lua_scripts + 1); (script_src)++,
(script_hash)++, (script_name)++)
```

The rest of the talk (mostly) assumes the 'whole' format.

LOADing scripts from **hsss** output

```c
static void redisLoadScriptCallback(redisAsyncContext *c, void *r, void *privdata) {
  redis_lua_script_t  *script = privdata;

  redisReply *reply = r;
  if (reply == NULL) return;
  switch(reply->type) {
    case REDIS_REPLY_ERROR:
      ngx_log_error(NGX_LOG_ERR, ngx_cycle->log, 0, "nchan: Failed loading redis lua script %s :
%s", script->name, reply->str);
      break;
    case REDIS_REPLY_STRING:
      if(ngx_strncmp(reply->str, script->hash, REDIS_LUA_HASH_LENGTH)!=0) {
        ngx_log_error(NGX_LOG_ERR, ngx_cycle->log, 0, "nchan Redis lua script %s has unexpected
hash %s (expected %s)", script->name, reply->str, script->hash);
      }
      break;
  }
}

static void redisInitScripts(redisAsyncContext *c){
  redis_lua_script_t  *script;

  REDIS_LUA_SCRIPTS_EACH(script) {
    redisAsyncCommand(c, &redisLoadScriptCallback, script, "SCRIPT LOAD %s", script->script);
  }
}
```

EVALSHAing scripts

--format whole

```c
redisAsyncCommand(asyncContext, asyncCommandCallback, privdata, "EVALSHA
%s 1 foo", redis_lua_scripts.get_message_from_key.hash);
```

--format split

```c
redisAsyncCommand(asyncContext, asyncCommandCallback, privdata, "EVALSHA
%s 1 foo", redis_lua_script_hashes.get_message_from_key);
```

```c
static void asyncCommandCallback(redisAsyncContext *c, void *r,
void *privdata) {
  redisReply *reply = (redisReply *)r;
  if(reply != NULL && reply->type == REDIS_REPLY_ERROR) {
    redisCheckErrorCallback(c, r, privdata);
  else {
    //script response handling logic
  }
}
```

Async error handler

```
(error) ERR Error running script (call to f_f738535cb8488ef039e747d144a5634b8408c7c5):
@enable_strict_lua:15: user_script:1: Script attempted to access unexisting global variable
'foobar'
```

```c
static void redisCheckErrorCallback(redisAsyncContext *c, void *r, void *privdata) {
  static const ngx_str_t script_error_start= ngx_string("ERR Error running script (call to f_");
  redisReply *reply = (redisReply *)r;
  if(reply != NULL && reply->type == REDIS_REPLY_ERROR) {
    if(ngx_strncmp(reply->str, script_error_start.data, script_error_start.len) == 0 && (unsigned ) reply->len > script_error_start.len + REDIS_LUA_HASH_LENGTH) {
      char *hash = &reply->str[script_error_start.len];
      redis_lua_script_t  *script;
      REDIS_LUA_SCRIPTS_EACH(script) {
        if (ngx_strncmp(script->hash, hash, REDIS_LUA_HASH_LENGTH)==0) {
          ngx_log_error(NGX_LOG_ERR, ngx_cycle->log, 0, "REDIS SCRIPT ERROR: %s :%s", script->name, &reply->str[script_error_start.len + REDIS_LUA_HASH_LENGTH + 2]);
          return;
        }
      }
      ngx_log_error(NGX_LOG_ERR, ngx_cycle->log, 0, "REDIS SCRIPT ERROR: (unknown): %s", reply->str);
    }
    else {
      ngx_log_error(NGX_LOG_ERR, ngx_cycle->log, 0, "REDIS_REPLY_ERROR: %s", reply->str);
    }
  }
}
```

hsss in your build script

Shell script
(actual snippet from nchan)

```
#!/bin/zsh

#...
rdstore_dir=${MY_PATH}/../src/store/redis
bundle exec hsss \
    --format whole \
    --no-count \
    ${rdstore_dir}/scripts/*.lua > $
{rdstore_dir}/redis_lua_commands.h
if ! [ $? -eq 0 ]; then;
  echo "failed generating redis lua scripts";
  exit 1
fi
#...
```

Makefile

```
IDIR =./
CC=gcc
CFLAGS=-I$(IDIR)
ODIR=./
LIBS=-lhiredis
_DEPS = scripts.h
DEPS = $(patsubst %,$(IDIR)/%,$(_DEPS))
_OBJ = embeddy.o
OBJ = $(patsubst %,$(ODIR)/%,$(_OBJ))

$(ODIR)/%.o: %.c $(DEPS)
        $(CC) -c -o $@ $< $(CFLAGS)

embeddy: scripts.h $(OBJ)
        $(CC) -o $@ $^ $(CFLAGS) $(LIBS)

scripts.h: *.lua
        bundle exec hsss --format whole \
        ./*.lua > scripts.h

.PHONY: clean

clean:
        rm -f $(ODIR)/*.o *~ core $(INCDIR)/*~
```

hsss in Redis, why not?

src/scripting.c

```c
void scriptingEnableGlobalsProtection(lua_State *lua) {
    char *s[32];
    sds code = sdsempty();
    int j = 0;

    /* strict.lua from:
http://metalua.luaforge.net/src/lib/strict.lua.html.
     * Modified to be adapted to Redis. */
    s[j++]="local dbg=debug\n";
    s[j++]="local mt = {}\n";
    s[j++]="setmetatable(_G, mt)\n";
    s[j++]="mt.__newindex = function (t, n, v)\n";
    s[j++]="  if dbg.getinfo(2) then\n";
    s[j++]="    local w = dbg.getinfo(2, \"S\").what\n";
    s[j++]="    if w ~= \"main\" and w ~= \"C\" then\n";
    s[j++]="      error(\"Script attempted to create global
variable '\"..tostring(n)..\"'\", 2)\n";
    s[j++]="    end\n";
    s[j++]="  end\n";
    s[j++]="  rawset(t, n, v)\n";
    s[j++]="end\n";
    s[j++]="mt.__index = function (t, n)\n";
    s[j++]="  if dbg.getinfo(2) and
dbg.getinfo(2, \"S\").what ~= \"C\" then\n";
    s[j++]="    error(\"Script attempted to access unexisting
global variable '\"..tostring(n)..\"'\", 2)\n";
    s[j++]="  end\n";
    s[j++]="  return rawget(t, n)\n";
    s[j++]="end\n";
    s[j++]="debug = nil\n";
    s[j++]=NULL;

    for (j = 0; s[j] != NULL; j++) code =
sdscatlen(code,s[j],strlen(s[j]));

luaL_loadbuffer(lua,code,sdslen(code),"@enable_strict_lua");
    lua_pcall(lua,0,0,0);
    sdsfree(code);
}
```

```c
void scriptingInit(int setup) {
    /* [...] */
    /* Add a helper function that we use to sort the multi bulk output of non
     * deterministic commands, when containing 'false' elements. */
    {
        char *compare_func =    "function __redis__compare_helper(a,b)\n"
                                "  if a == false then a = '' end\n"
                                "  if b == false then b = '' end\n"
                                "  return a<b\n"
                                "end\n";
        luaL_loadbuffer(lua,compare_func,strlen(compare_func),"@cmp_func_def");
        lua_pcall(lua,0,0,0);
    }
    /* Add a helper function we use for pcall error reporting.
     * Note that when the error is in the C function we want to report the
     * information about the caller, that's what makes sense from the point
     * of view of the user debugging a script. */
    {
        char *errh_func =       "local dbg = debug\n"
                                "function __redis__err__handler(err)\n"
                                "  local i = dbg.getinfo(2,'nSl')\n"
                                "  if i and i.what == 'C' then\n"
                                "    i = dbg.getinfo(3,'nSl')\n"
                                "  end\n"
                                "  if i then\n"
                                "    return i.source .. ':' .. i.currentline ..
': ' .. err\n"
                                "  else\n"
                                "    return err\n"
                                "  end\n"
                                "end\n";
        luaL_loadbuffer(lua,errh_func,strlen(errh_func),"@err_handler_def");
        lua_pcall(lua,0,0,0);
    }
    /* [...] */
}
```

src/scripts/

compare_func.lua

```lua
-- helper function that we use to sort the multi bulk output of non-deterministic commands, when containing 'false' elements
function __redis__compare_helper(a,b)
  if a == false then a = '' end
  if b == false then b = '' end
  return a<b
end
```

enable_strict.lua

```lua
--strict.lua from: http://metalua.luaforge.net/src/lib/strict.lua.html.
-- Modified to be adapted to Redis.
local dbg=debug
local mt = {}
setmetatable(_G, mt)
mt.__newindex = function (t, n, v)
  if dbg.getinfo(2) then
    local w = dbg.getinfo(2, "S").what
    if w ~= "main" and w ~= "C" then
      error("Script attempted to create global variable '"..tostring(n).."'", 2)
    end
  end
  rawset(t, n, v)
end
mt.__index = function (t, n)
  if dbg.getinfo(2) and dbg.getinfo(2, "S").what ~= "C" then
    error("Script attempted to access unexisting global variable '"..tostring(n).."'", 2)
  end
  return rawget(t, n)
end
debug = nil
```

error_handler_func.lua

```lua
-- a helper function we use for pcall error reporting. Note that when the error is in the C function we want to report the
-- information about the caller, that's what makes sense from the point of view of the user debugging a script.
local dbg = debug
function __redis__err__handler(err)
  local i = dbg.getinfo(2,'nSl')
  if i and i.what == 'C' then
    i = dbg.getinfo(3,'nSl')
  end
  if i then
    return i.source .. ':' .. i.currentline .. ': ' .. err
  else
    return err
  end
end
```

hsss in Redis? Why not.

src/scripting.c

```c
#include "luascripts.h"
/* ... */

void scriptingEnableGlobalsProtection(lua_State *lua) {
    luaL_loadbuffer(lua, luaScript.enable_strict, strlen(luaScript.enable_strict),"@enable_strict_lua");
    lua_pcall(lua,0,0,0);
}

void scriptingInit(int setup) {
    /* [...] */

    /* Add a helper function that we use to sort the multi bulk output of non
     * deterministic commands, when containing 'false' elements. */
    luaL_loadbuffer(lua,luaScript.compare_func,strlen(luaScript.compare_func),"@cmp_func_def");
    lua_pcall(lua,0,0,0);


    /* Add a helper function we use for pcall error reporting.
     * Note that when the error is in the C function we want to report the
     * information about the caller, that's what makes sense from the point
     * of view of the user debugging a script. */
    luaL_loadbuffer(lua,luaScript.error_handler_func,strlen(luaScript.error_handler_func),"@err_handler_def");
    lua_pcall(lua,0,0,0);

    /* [...] */
}
```

hsss in Redis? Why not.

src/Makefile

```
#[...]

luascripts.h: scripts/*.lua
        hsss --format split \
                --no-names  \
                --no-hashes \
                --no-count \
                --no-each \
                --struct redisLuaScripts \
                --scripts luaScript \
                scripts/*.lua > luascripts.h

dep: luascripts.h
        $(REDIS_CC) -MM *.c > Makefile.dep
```

run *make dep* once, then…

hsss in Redis? Why not.

https://asciinema.org/a/b35ki1280vk04pxj2opol3zvg

https://github.net/slact/redis

hsss: embedding Lua scripts made painless

```
> gem install hsss
```

https://github.com/slact/hsss

- Highly customizable output
- Iterator macro
- Seamlessly integrates into build tooling
  - Needed only during development, not source distribution
- Onomatopoeic

Debugging

https://redislabs.com/blog/5-methods-for-tracing-and-debugging-redis-lua-scripts

- Use 3.2's *redis-cli --ldb* for debugging with breakpoints
- Otherwise, debug output is your (only) option.
- Many ways to log output, but the most powerful is redis-cli monitor + redis.call('echo', message)
- Why MONITOR?…

```
redis-cli monitor
OK
1461473912.214865 [0 127.0.0.1:60118] "SUBSCRIBE" "channel:pubsub:test/foo"
1461473912.214908 [0 127.0.0.1:60116] "EVALSHA" "a717de6d8fc25c375e97d095bb21b7cfdec466b6" "0" "test/foo" "-" "300"
1461473912.214933 [0 lua] "echo" "######## SUBSCRIBER REGISTER SCRIPT ######## "
1461473912.214947 [0 lua] "HINCRBY" "channel:test/foo" "last_subscriber_id" "1"
1461473912.214957 [0 lua] "hincrby" "channel:test/foo" "subscribers" "1"
1461473912.214963 [0 lua] "ttl" "channel:test/foo"
1461473912.214969 [0 lua] "expire" "channel:subscribers:test/foo" "300"
1461473912.214974 [0 lua] "expire" "channel:messages:test/foo" "300"
1461473912.214978 [0 lua] "expire" "channel:test/foo" "300"
1461473912.215015 [0 127.0.0.1:60116] "EVALSHA" "71c1046fd6c7500ba588857fe6fe93480f0b21d6" "0" "test/foo" "0" "0" "FILO"
1461473912.215027 [0 lua] "echo" "######## GET_MESSAGE ######## "
1461473912.215032 [0 lua] "HGETALL" "channel:test/foo"
1461473912.215043 [0 lua] "lindex" "channel:messages:test/foo" "-1"
1461473912.315520 [0 127.0.0.1:60122] "EVALSHA" "f33207af23f0efab740207e8faf45a29acbb4c0a" "0" "test/foo" "1"
1461473912.315554 [0 lua] "echo" "####### FAKESUBS ####### "
1461473912.315567 [0 lua] "EXISTS" "channel:test/foo"
1461473912.315578 [0 lua] "HINCRBY" "channel:test/foo" "fake_subscribers" "1"
1461473919.670390 [0 127.0.0.1:60116] "EVALSHA" "eebcaa531438f8ef81c3b8347468d16bcbe5fef9" "0" "test/foo" "1461473919"
"foobar" "" "" "240" "200"
1461473919.670473 [0 lua] "echo" "####### PUBLISH ######## "
1461473919.670490 [0 lua] "EXISTS" "channel:test/foo"
1461473919.670499 [0 lua] "HGETALL" "channel:test/foo"
1461473919.670525 [0 lua] "echo" "channel present"
1461473919.670542 [0 lua] "echo" "channel current_message absent"
1461473919.670559 [0 lua] "EXISTS" "channel:msg:1461473919:0:test/foo"
[...]
1461473919.670634 [0 lua] "echo" "channel.max_stored_messages was not set, but is now 200"
1461473919.670666 [0 lua] "HMSET" "channel:msg:1461473919:0:test/foo" "content_type" "" "id" "1461473919:0" "data" "foobar"
"prev_tag" "0" "time" "1461473919" "eventsource_event" "" "prev_time" "0" "ttl" "240" "tag" "0"
[...]
1461473919.670829 [0 lua] "echo" "Stored message with id 1461473919:0 => foobar"
1461473919.670840 [0 lua] "PUBSUB" "NUMSUB" "channel:pubsub:test/foo"
1461473919.670858 [0 lua] "PUBLISH" "channel:pubsub:test/foo"
"\x99\xa3msg\xcc\xf0\xceW\x1cR\x7f\x00\x00\x00\xa6foobar\xa0\xa0"
1461473919.670874 [0 lua] "llen" "channel:messages:test/foo"
1461473919.670891 [0 lua] "echo" "channel test/foo ttl: 240, subscribers: 1(fake: 1), messages: 1"
1461473919.671141 [0 127.0.0.1:60116] "EVALSHA" "71c1046fd6c7500ba588857fe6fe93480f0b21d6" "0" "test/foo" "1461473919" "0"
"FILO"
1461473919.671190 [0 lua] "echo" "####### GET_MESSAGE ######## "
1461473919.671202 [0 lua] "HGETALL" "channel:test/foo"
```

That's why we MONITOR.

- Script parameters, commands executed available "for free".
- Script names need to be marked **####### CLEARLY AND EMPHATICALLY #######**.
- *redis-cli monitor* output can be piped to grep for more careful real-time analysis.

Echo echo echo echo

- All-purpose debug output

```lua
local dbg = function(...)
  local arg = {...}
  for i = 1, #arg do
    arg[i]=tostring(arg[i])
  end
  redis.call('echo', table.concat(arg, " "))
end

dbg(' ########## ', "SCRIPT NAME", " ############# ")
dbg(nil, 0, false, {foo=1}, "banana")
```

```
1461476791.535382 [0 lua] "echo" " ##########  SCRIPT NAME  ############# "
1461476791.535399 [0 lua] "echo" "nil 0 false table: 0x256bd00 banana"
```

Putting It All Together

subscribe

- Update subscriber count
- Assign subscriber ids (unused for now)
- Manage key expiration

subscriber_register.lua

```lua
--input: keys: [], values: [channel_id, subscriber_id, active_ttl]
--  'subscriber_id' can be '~' for new id, or an existing id
--  'active_ttl' is channel ttl with non-zero subscribers. -1 to persist, >0 ttl in sec
--output: subscriber_id, num_current_subscribers, next_keepalive_time

local id, sub_id, active_ttl, concurrency = ARGV[1], ARGV[2], tonumber(ARGV[3]) or 20, ARGV[4]

--local dbg = function(...) redis.call('echo', table.concat({...})); end

redis.call('echo', ' ######## SUBSCRIBER REGISTER SCRIPT ######## ')

local keys = {
  channel =     'channel:'..id,
  messages =    'channel:messages:'..id,
  subscribers = 'channel:subscribers:'..id
}

local setkeyttl=function(ttl)
  for i,v in pairs(keys) do
    if ttl > 0 then
      redis.call('expire', v, ttl)
    else
      redis.call('persist', v)
    end
  end
end

local random_safe_next_ttl = function(ttl)
  return math.floor(ttl/2 + ttl/2.1 * math.random())
end

local sub_count

if sub_id == '~' then
  sub_id = tonumber(redis.call('HINCRBY', keys.channel, 'last_subscriber_id', 1))
  sub_count=tonumber(redis.call('hincrby', keys.channel, 'subscribers', 1))
else
  sub_count=tonumber(redis.call('hget', keys.channel, 'subscribers'))
end

local next_keepalive
local actual_ttl = tonumber(redis.call('ttl', keys.channel))
if actual_ttl < active_ttl then
  setkeyttl(active_ttl)
  next_keepalive = random_safe_next_ttl(active_ttl)
else
  next_keepalive = random_safe_next_ttl(actual_ttl)
end

return {sub_id, sub_count, next_keepalive}
```

subscriber_unregister.lua

```lua
--input: keys: [], values: [channel_id, subscriber_id, empty_ttl]
--  'subscriber_id' is an existing id
--  'empty_ttl' is channel ttl when without subscribers. 0 to delete immediately, -1 to persist, >0 ttl in sec
--output: subscriber_id, num_current_subscribers

local id, sub_id, empty_ttl = ARGV[1], ARGV[2], tonumber(ARGV[3]) or 20

--local dbg = function(...) redis.call('echo', table.concat({...})); end

redis.call('echo', ' ######## SUBSCRIBER UNREGISTER SCRIPT ######## ')

local keys = {
  channel =     'channel:'..id,
  messages =    'channel:messages:'..id,
  subscribers = 'channel:subscribers:'..id,
}

local setkeyttl=function(ttl)
  for i,v in pairs(keys) do
    if ttl > 0 then
      redis.call('expire', v, ttl)
    elseif ttl < 0 then
      redis.call('persist', v)
    else
      redis.call('del', v)
    end
  end
end

local sub_count = 0
if redis.call('EXISTS', keys.channel) ~= 0 then
   sub_count = redis.call('hincrby', keys.channel, 'subscribers', -1)

  if sub_count == 0 and tonumber(redis.call('LLEN', keys.messages)) == 0 then
    setkeyttl(empty_ttl)
  elseif sub_count < 0 then
    return {err="Subscriber count for channel " .. id .. " less than zero: " .. sub_count}
  end
else
  --dbg("channel ", id, " already gone")
end

return {sub_id, sub_count}
```

publish.lua

- Store message
- Delete old messages
- Garbage-collect message list
- Update key expiration
- PUBLISH to PUBSUB clients (as msgpack)

```
--input:  keys: [], values: [channel_id, time, message, content_type, eventsource_event, msg_ttl, max_msg_buf_size]
--output: message_tag, channel_hash {ttl, time_last_seen, subscribers, messages}

local id=ARGV[1]
local time=tonumber(ARGV[2])
local msg={
  id=nil,
  data= ARGV[3],
  content_type=ARGV[4],
  eventsource_event=ARGV[5],
  ttl= tonumber(ARGV[6]),
  time= time,
  tag= 0
}
if msg.ttl == 0 then
  msg.ttl = 126144000 --4 years
end
local store_at_most_n_messages = tonumber(ARGV[7])
if store_at_most_n_messages == nil or store_at_most_n_messages == "" then
  return {err="Argument 7: max_msg_buf_size, can't be empty"}
end
if store_at_most_n_messages == 0 then
  msg.unbuffered = 1
end

local dbg = function(...)
  local arg = {...}
  for i = 1, #arg do
    arg[i]=tostring(arg[i])
  end
  redis.call('echo', table.concat(arg))
end

if type(msg.content_type)== 'string' and msg.content_type:find('"') then
  return {err="Message content-type cannot contain '\"' character"}
end

redis.call('echo', '-------  PUBLISH  -------')

-- sets all fields for a hash from a dictionary
local hmset = function (key, dict)
  if next(dict) == nil then return nil end
  local bulk = {}
  for k, v in pairs(dict) do
    table.insert(bulk, k)
    table.insert(bulk, v)
  end
  return redis.call('HMSET', key, unpack(bulk))
end

local tohash=function(arr)
  if type(arr)~='table' then
    return nil
  end
  local h = {}
  local k=nil
  for i, v in ipairs(arr) do
    if k == nil then
      k=v
    else
      h[k]=v; k=nil
    end
  end
  return h
end

local key={
  time_offset=   'nchan:message_time_offset',
  last_message= nil,
  message=      'channel:msg:%s'..id, --not finished yet
  channel=      'channel:'..id,
  messages=     'channel:messages:'..id,
  subscribers=  'channel:subscribers:'..id
}

local channel_pubsub = 'channel:pubsub:'..id

local new_channel
local channel
if redis.call('EXISTS', key.channel) ~= 0 then
  channel=tohash(redis.call('HGETALL', key.channel))
end

if channel~=nil then
  --dbg("channel present")
  if channel.current_message ~= nil then
    --dbg("channel current_message present")
    key.last_message=('channel:msg:%s:%s'):format(channel.current_message, id)
  else
    --dbg("channel current_message absent")
    key.last_message=nil
  end
  new_channel=false
else
  --dbg("channel missing")
  channel={}
  new_channel=true
  key.last_message=nil
end

--set new message id
if key.last_message then
  local lastmsg = redis.call('HMGET', key.last_message, 'time', 'tag')
  local lasttime, lasttag = tonumber(lastmsg[1]), tonumber(lastmsg[2])
  --dbg("New message id: last_time ", lasttime, " last_tag ", lasttag, " msg_time ", msg.time)
  if lasttime==msg.time then
    msg.tag=lasttag+1
  end
  msg.prev_time = lasttime
  msg.prev_tag = lasttag
else
  msg.prev_time = 0
  msg.prev_tag = 0
end
msg.id=('%i:%i'):format(msg.time, msg.tag)

key.message=key.message:format(msg.id)
if redis.call('EXISTS', key.message) ~= 0 then
  return {err=('Message for channel %s id %s already exists'):format(id, msg.id)}
end
```

```
msg.prev=channel.current_message
if key.last_message and redis.call('exists', key.last_message) == 1 then
  redis.call('HSET', key.last_message, 'next', msg.id)
end

--update channel
redis.call('HSET', key.channel, 'current_message', msg.id)
if msg.prev then
  redis.call('HSET', key.channel, 'prev_message', msg.prev)
end
if time then
  redis.call('HSET', key.channel, 'time', time)
end
if not channel.ttl then
  channel.ttl=msg.ttl
  redis.call('HSET', key.channel, 'ttl', channel.ttl)
end

if not channel.max_stored_messages then
  channel.max_stored_messages = store_at_most_n_messages
  redis.call('HSET', key.channel, 'max_stored_messages', store_at_most_n_messages)
  --dbg("channel.max_stored_messages was not set, but is now ", store_at_most_n_messages)
else
  channel.max_stored_messages =tonumber(channel.max_stored_messages)
  --dbg("channel.mas_stored_messages == " , channel.max_stored_messages)
end

--write message
hmset(key.message, msg)


--check old entries
local oldestmsg=function(list_key, old_fmt)
  local old, oldkey
  local n, del=0,0
  while true do
    n=n+1
    old=redis.call('lindex', list_key, -1)
    if old then
      oldkey=old_fmt:format(old)
      local ex=redis.call('exists', oldkey)
      if ex==1 then
        return oldkey
      else
        redis.call('rpop', list_key)
        del=del+1
      end
    else
      break
    end
  end
end

local max_stored_msgs = tonumber(redis.call('HGET', key.channel, 'max_stored_messages')) or -1

if max_stored_msgs < 0 then --no limit
  oldestmsg(key.messages, 'channel:msg:%s'..id)
  redis.call('LPUSH', key.messages, msg.id)
elseif max_stored_msgs > 0 then
  local stored_messages = tonumber(redis.call('LLEN', key.messages))
  redis.call('LPUSH', key.messages, msg.id)
  if stored_messages > max_stored_msgs then
    local oldmsgid = redis.call('RPOP', key.messages)
    redis.call('DEL', 'channel:msg:'..id..':'..oldmsgid)
  end
  oldestmsg(key.messages, 'channel:msg:%s'..id)
end


--set expiration times for all the things
redis.call('EXPIRE', key.message, msg.ttl)
redis.call('EXPIRE', key.time_offset, channel.ttl)
redis.call('EXPIRE', key.channel, channel.ttl)
redis.call('EXPIRE', key.messages, channel.ttl)
redis.call('EXPIRE', key.subscribers, channel.ttl)

--publish message
local unpacked

if #msg.data < 5*1024 then
  unpacked= {
    msg,
    msg.ttl or 0,
    msg.time,
    tonumber(msg.tag) or 0,
    msg.prev_time or 0,
    msg.prev_tag or 0,
    msg.data or "",
    msg.content_type or "",
    msg.eventsource_event or ""
  }
else
  unpacked= {
    "msgkey",
    msg.time,
    tonumber(msg.tag) or 0,
    key.message
  }
end

local msgpacked

--dbg(("Stored message with id %i:%i => %s"):format(msg.time, msg.tag, msg.data))

--now publish to the efficient channel
local numsub = redis.call('PUBSUB', 'NUMSUB', channel_pubsub)[2]
if tonumber(numsub) > 0 then
  msgpacked = cmsgpack.pack(unpacked)
  redis.call('PUBLISH', channel_pubsub, msgpacked)
end
local num_messages = redis.call('llen', key.messages)

--dbg("channel ", id, " ttl: ",channel.ttl, ", subscribers: ", channel.subscribers, "(fake: ", channel.fake_subscribers or "nil", "), messages: ", num_messages)
return { msg.tag, {tonumber(channel.ttl or msg.ttl), tonumber(channel.time or msg.time),
tonumber(channel.fake_subscribers or channel.subscribers or 0), tonumber(num_messages)},
new_channel}
```

delete.lua

- Does the obvious thing
- PUBLISHes deletion notice to all PUBSUB clients

```
--input: keys: [],  values: [ channel_id ]
--output: channel_hash {ttl, time_last_seen, subscribers, messages} or nil
-- delete this channel and all its messages
local id = ARGV[1]
local key_msg=     'channel:msg:%s:'..id --not finished yet
local key_channel='channel:'..id
local messages=    'channel:messages:'..id
local subscribers='channel:subscribers:'..id
local pubsub=      'channel:pubsub:'..id

redis.call('echo', ' ####### DELETE #######')
local num_messages = 0
--delete all the messages right now mister!
local msg
while true do
  msg = redis.call('LPOP', messages)
  if msg then
    num_messages = num_messages + 1
    redis.call('DEL', key_msg:format(msg))
  else
    break
  end
end

local del_msgpack =cmsgpack.pack({"alert", "delete channel", id})
for k,channel_key in pairs(redis.call('SMEMBERS', subscribers)) do
  redis.call('PUBLISH', channel_key, del_msgpack)
end

local nearly_departed = nil
if redis.call('EXISTS', key_channel) ~= 0 then
  nearly_departed = redis.call('hmget', key_channel, 'ttl', 'time_last_seen',
'subscribers')
  for i = 1, #nearly_departed do
    nearly_departed[i]=tonumber(nearly_departed[i]) or 0
  end

  --leave some crumbs behind showing this channel was just deleted
  redis.call('setex', "channel:deleted:"..id, 5, 1)

  table.insert(nearly_departed, num_messages)
end

redis.call('DEL', key_channel, messages, subscribers)

if redis.call('PUBSUB','NUMSUB', pubsub)[2] > 0 then
  redis.call('PUBLISH', pubsub, del_msgpack)
end

return nearly_departed
```

odds and ends

- add_fakesub
  - updated once per subscriber request
  - too much traffic, so binned to 100-ms intervals
- find_channel
  - used for access controls
- channel_keepalive
  - key expiry management
- get_message_from_key
  - easier to deal with than an HMGET

add_fakesub.lua

```
--input:  keys: [], values: [channel_id, number]
--output: current_fake_subscribers

redis.call('echo', ' ####### FAKESUBS ####### ')
local id=ARGV[1]
local num=tonumber(ARGV[2])
if num==nil then
  return {err="fakesub number not given"}
end

local chan_key = 'channel:'..id
local exists = false
if redis.call('EXISTS', chan_key) == 1 then
  exists = true
end

local cur = 0

if exists or (not exists and num > 0) then
  cur = redis.call('HINCRBY', chan_key, 'fake_subscribers',
num)
  if not exists then
    redis.call('EXPIRE', chan_key, 5) --something small
  end
end

return cur
```

find_channel.lua

```
--input: keys: [],  values: [ channel_id ]
--output: channel_hash {ttl, time_last_seen, subscribers,
messages} or nil
-- finds and return the info hash of a channel, or nil of
channel not found
local id = ARGV[1]
local key_channel='channel:'..id

redis.call('echo', ' #######  FIND_CHANNEL ######## ')

if redis.call('EXISTS', key_channel) ~= 0 then
  local ch = redis.call('hmget', key_channel, 'ttl',
'time_last_seen', 'subscribers', 'fake_subscribers')
  if(ch[4]) then
    --replace subscribers count with fake_subscribers
    ch[3]=ch[4]
    table.remove(ch, 4)
  end
  for i = 1, #ch do
    ch[i]=tonumber(ch[i]) or 0
  end
  table.insert(ch, redis.call('llen',
"channel:messages:"..id))
  return ch
else
  return nil
end
```

channel_keepalive.lua

```
--input:  keys: [], values: [channel_id, ttl]
-- ttl is for when there are no messages but at least 1
subscriber.
--output: seconds until next keepalive is expected, or -1
for "let it disappear"
redis.call('ECHO', ' ####### CHANNEL KEEPALIVE ####### ')
local id=ARGV[1]
local ttl=tonumber(ARGV[2])
if not ttl then
  return {err="Invalid channel keepalive TTL (2nd arg)"}
end

local random_safe_next_ttl = function(ttl)
  return math.floor(ttl/2 + ttl/2.1 * math.random())
end

local key={
  channel=      'channel:'..id, --hash
  messages=     'channel:messages:'..id, --list
}

local subs_count = tonumber(redis.call('HGET', key.channel,
"subscribers")) or 0
local msgs_count = tonumber(redis.call('LLEN',
key.messages)) or 0
local actual_ttl = tonumber(redis.call('TTL',  key.channel))

if subs_count > 0 then
  if msgs_count > 0 and actual_ttl > ttl then
    return random_safe_next_ttl(actual_ttl)
  end
  --refresh ttl
  redis.call('expire', key.channel, ttl);
  redis.call('expire', key.messages, ttl);
  return random_safe_next_ttl(ttl)
else
  return -1
end
```

get_message_from_key.lua

```
--input:  keys: [message_key], values: []
--output: msg_ttl, msg_time, msg_tag, prev_msg_time,
prev_msg_tag, message, content_type, eventsource_event,
channel_subscriber_count

local key = KEYS[1]

local ttl = redis.call('TTL', key)
local time, tag, prev_time, prev_tag, data, content_type,
es_event = unpack(redis.call('HMGET', key, 'time', 'tag',
'prev_time', 'prev_tag', 'data', 'content_type',
'eventsource_event'))

return {ttl, time, tag, prev_time or 0, prev_tag or 0, data
or "", content_type or "", es_event or ""}
```

Wishes and TODOs

- hiredis:
  - no-copy redisCommand parameter
- Nchan (redis stuff):
  - Configurable key prefix
  - Multiple Redis servers
  - Redis cluster support

Try **hsss**

```
> gem install hsss
```

- Code and documentation at https://github.com/slact/hsss

- Try Redis + **hsss**:

  https://github.com/slact/redis
  (unstable branch)

Try NCHAN

- Thorough documentation and examples at https://nchan.slact.net

- Build and run:
  - macs:
    ```
    > brew tap homebrew/nginx
    > brew install nginx-full --with-nchan
    ```
  - From source: http://github.com/slact/nchan
  - Pre-packaged: https://nchan.slact.net/#download

Fin

Contact me: shell@slact.net

slides and notes at
https://nchan.slact.net/redisconf

- https://github.com/slact
- https://nchan.slact.net
- Please support Nchan Development (if you're interested):
  - *Paypal*: nchan@slact.net
  - *Bitcoin*:15dLBzRS4HLRwCCVjx4emYkxXcyAPmGxM3