There have been some serious improvements since said post and I thought a (hopefully not-too-frequent) blog-journal of the development of this particular package might be interesting/useful to some folks, especially since I’m delving into some not-oft-blogged (anywhere) topics as I use some new tricks in this particular package.

**Thank The Great Maker for C++**

I’m comfortable and not-too-shabby at wrapping C/C++ things with an R bow and I felt quite daft seeing this after I had started banging on the mosquitto C interface. Yep, that’s right: it has a C++ interface. It’s waaaaay easier (in my experience) bridging C++ libraries since Dirk/Romain’sRcpp has *so many tools* available to do that very thing.

Code

|  |
| --- |
| #ifndef MOSQUITTOPP\_H |
|  | #define MOSQUITTOPP\_H |
|  |  |
|  | #if defined(\_WIN32) && !defined(LIBMOSQUITTO\_STATIC) |
|  | # ifdef mosquittopp\_EXPORTS |
|  | # define mosqpp\_EXPORT \_\_declspec(dllexport) |
|  | # else |
|  | # define mosqpp\_EXPORT \_\_declspec(dllimport) |
|  | # endif |
|  | #else |
|  | # define mosqpp\_EXPORT |
|  | #endif |
|  |  |
|  | #include <cstdlib> |
|  | #include <mosquitto.h> |
|  | #include <time.h> |
|  |  |
|  | namespace mosqpp { |
|  |  |
|  |  |
|  | mosqpp\_EXPORT const char \* strerror(int mosq\_errno); |
|  | mosqpp\_EXPORT const char \* connack\_string(int connack\_code); |
|  | mosqpp\_EXPORT int sub\_topic\_tokenise(const char \*subtopic, char \*\*\*topics, int \*count); |
|  | mosqpp\_EXPORT int sub\_topic\_tokens\_free(char \*\*\*topics, int count); |
|  | mosqpp\_EXPORT int lib\_version(int \*major, int \*minor, int \*revision); |
|  | mosqpp\_EXPORT int lib\_init(); |
|  | mosqpp\_EXPORT int lib\_cleanup(); |
|  | mosqpp\_EXPORT int topic\_matches\_sub(const char \*sub, const char \*topic, bool \*result); |
|  | mosqpp\_EXPORT int validate\_utf8(const char \*str, int len); |
|  | mosqpp\_EXPORT int subscribe\_simple( |
|  | struct mosquitto\_message \*\*messages, |
|  | int msg\_count, |
|  | bool retained, |
|  | const char \*topic, |
|  | int qos=0, |
|  | const char \*host="localhost", |
|  | int port=1883, |
|  | const char \*client\_id=NULL, |
|  | int keepalive=60, |
|  | bool clean\_session=true, |
|  | const char \*username=NULL, |
|  | const char \*password=NULL, |
|  | const struct libmosquitto\_will \*will=NULL, |
|  | const struct libmosquitto\_tls \*tls=NULL); |
|  |  |
|  | mosqpp\_EXPORT int subscribe\_callback( |
|  | int (\*callback)(struct mosquitto \*, void \*, const struct mosquitto\_message \*), |
|  | void \*userdata, |
|  | const char \*topic, |
|  | int qos=0, |
|  | const char \*host="localhost", |
|  | int port=1883, |
|  | const char \*client\_id=NULL, |
|  | int keepalive=60, |
|  | bool clean\_session=true, |
|  | const char \*username=NULL, |
|  | const char \*password=NULL, |
|  | const struct libmosquitto\_will \*will=NULL, |
|  | const struct libmosquitto\_tls \*tls=NULL); |
|  |  |
|  | /\* |
|  | \* Class: mosquittopp |
|  | \* |
|  | \* A mosquitto client class. This is a C++ wrapper class for the mosquitto C |
|  | \* library. Please see mosquitto.h for details of the functions. |
|  | \*/ |
|  | class mosqpp\_EXPORT mosquittopp { |
|  | private: |
|  | struct mosquitto \*m\_mosq; |
|  | public: |
|  | mosquittopp(const char \*id=NULL, bool clean\_session=true); |
|  | virtual ~mosquittopp(); |
|  |  |
|  | int reinitialise(const char \*id, bool clean\_session); |
|  | int socket(); |
|  | int will\_set(const char \*topic, int payloadlen=0, const void \*payload=NULL, int qos=0, bool retain=false); |
|  | int will\_clear(); |
|  | int username\_pw\_set(const char \*username, const char \*password=NULL); |
|  | int connect(const char \*host, int port=1883, int keepalive=60); |
|  | int connect\_async(const char \*host, int port=1883, int keepalive=60); |
|  | int connect(const char \*host, int port, int keepalive, const char \*bind\_address); |
|  | int connect\_async(const char \*host, int port, int keepalive, const char \*bind\_address); |
|  | int reconnect(); |
|  | int reconnect\_async(); |
|  | int disconnect(); |
|  | int publish(int \*mid, const char \*topic, int payloadlen=0, const void \*payload=NULL, int qos=0, bool retain=false); |
|  | int subscribe(int \*mid, const char \*sub, int qos=0); |
|  | int unsubscribe(int \*mid, const char \*sub); |
|  | void reconnect\_delay\_set(unsigned int reconnect\_delay, unsigned int reconnect\_delay\_max, bool reconnect\_exponential\_backoff); |
|  | int max\_inflight\_messages\_set(unsigned int max\_inflight\_messages); |
|  | void message\_retry\_set(unsigned int message\_retry); |
|  | void user\_data\_set(void \*userdata); |
|  | int tls\_set(const char \*cafile, const char \*capath=NULL, const char \*certfile=NULL, const char \*keyfile=NULL, int (\*pw\_callback)(char \*buf, int size, int rwflag, void \*userdata)=NULL); |
|  | int tls\_opts\_set(int cert\_reqs, const char \*tls\_version=NULL, const char \*ciphers=NULL); |
|  | int tls\_insecure\_set(bool value); |
|  | int tls\_psk\_set(const char \*psk, const char \*identity, const char \*ciphers=NULL); |
|  | int opts\_set(enum mosq\_opt\_t option, void \*value); |
|  |  |
|  | int loop(int timeout=-1, int max\_packets=1); |
|  | int loop\_misc(); |
|  | int loop\_read(int max\_packets=1); |
|  | int loop\_write(int max\_packets=1); |
|  | int loop\_forever(int timeout=-1, int max\_packets=1); |
|  | int loop\_start(); |
|  | int loop\_stop(bool force=false); |
|  | bool want\_write(); |
|  | int threaded\_set(bool threaded=true); |
|  | int socks5\_set(const char \*host, int port=1080, const char \*username=NULL, const char \*password=NULL); |
|  |  |
|  | // names in the functions commented to prevent unused parameter warning |
|  | virtual void on\_connect(int /\*rc\*/) {return;} |
|  | virtual void on\_connect\_with\_flags(int /\*rc\*/, int /\*flags\*/) {return;} |
|  | virtual void on\_disconnect(int /\*rc\*/) {return;} |
|  | virtual void on\_publish(int /\*mid\*/) {return;} |
|  | virtual void on\_message(const struct mosquitto\_message \* /\*message\*/) {return;} |
|  | virtual void on\_subscribe(int /\*mid\*/, int /\*qos\_count\*/, const int \* /\*granted\_qos\*/) {return;} |
|  | virtual void on\_unsubscribe(int /\*mid\*/) {return;} |
|  | virtual void on\_log(int /\*level\*/, const char \* /\*str\*/) {return;} |
|  | virtual void on\_error() {return;} |
|  | }; |
|  |  |
|  | } |
|  | #endif |

Rcpp Modules before (that link goes to a succinct but very helpful post by James Curran) but they make exposing C++ library functionality even easier than I had experienced before. So easy, in fact, that it made it possible to whip out an alpha version of a “domain specific language” (or a pipe-able, customized API — however you want to frame these things in your head) for the package. But, I’m getting ahead of myself.

Rcpp Modules

RCPP\_MODULE(MyModule) {

  using namespace Rcpp;

  class\_<MyClass>( "MyClass")

    .default\_constructor("Default constructor") // This exposes the default constructor

    .constructor<NumericVector>("Constructor with an argument") // This exposes the other constructor

    .method("print", &MyClass::print) // This exposes the print method

    .property("Bender", &MyClass::getBender, &MyClass::setBender) // and this shows how we set up a property

  ;

  class\_<AnotherClass>("AnotherClass")

    .default\_constructor("Default constructor")

    .constructor<int>("Constructor with an argument")

    .method("print", &AnotherClass::print)

  ;

}

The mosquittopp class in the mosqpp namespace is much like the third bowl of porridge: just right. It’s neither too low-level nor too high-level and it was well thought out enough that it only required a bit of tweaking to use as an Rcpp Module.

First there are more than a few char \* parameters that needed to be std::strings. So, something like:

int username\_pw\_set(const char \*username, const char \*password);

becomes:

int username\_pw\_set(std::string username, std::string password);

in our custom wrapper class.

Since the whole point of the mqtt package is to work in R vs C[++] or any other language, the callbacks — the functions that do the work when message, publish, subscribe, etc. events are triggered — need to be in R. I wanted to have some default callbacks during the testing phase and they’re really straightforward to setup in Rcpp:

Rcpp::Environment pkg\_env = Rcpp::Environment::namespace\_env("mqtt");

Rcpp::Function ccb = pkg\_env[".mqtt\_connect\_cb"];

Rcpp::Function dcb = pkg\_env[".mqtt\_disconnect\_cb"];

Rcpp::Function pcb = pkg\_env[".mqtt\_publish\_cb"];

Rcpp::Function mcb = pkg\_env[".mqtt\_message\_cb"];

Rcpp::Function scb = pkg\_env[".mqtt\_subscribe\_cb"];

Rcpp::Function ucb = pkg\_env[".mqtt\_unsubscribe\_cb"];

Rcpp::Function lcb = pkg\_env[".mqtt\_log\_cb"];

Rcpp::Function ecb = pkg\_env[".mqtt\_error\_cb"];

The handy thing about that approach is you don’t need to export the functions (it works like the ::: does).

But the kicker is the Rcpp Module syntactic sugar:

RCPP\_MODULE(MQTT) {

using namespace Rcpp;

class\_("mqtt\_r")

.constructor("id/host/port constructor")

.constructor("id/host/port/user/pass constructor")

.constructor("id/host/post/con/mess/discon constructor")

.method("connect", &mqtt\_r::connect)

.method("disconnect", &mqtt\_r::disconnect)

.method("reconnect", &mqtt\_r::reconnect)

.method("username\_pw\_set", &mqtt\_r::username\_pw\_set)

.method("loop\_start", &mqtt\_r::loop\_start)

.method("loop\_stop", &mqtt\_r::loop\_stop)

.method("loop", &mqtt\_r::loop)

.method("publish\_raw", &mqtt\_r::publish\_raw)

.method("publish\_chr", &mqtt\_r::publish\_chr)

.method("subscribe", &mqtt\_r::subscribe)

.method("unsubscribe", &mqtt\_r::unsubscribe)

.method("set\_connection\_cb", &mqtt\_r::set\_connection\_cb)

.method("set\_discconn\_cb", &mqtt\_r::set\_discconn\_cb)

.method("set\_publish\_cb", &mqtt\_r::set\_publish\_cb)

.method("set\_message\_cb", &mqtt\_r::set\_message\_cb)

.method("set\_subscribe\_cb", &mqtt\_r::set\_subscribe\_cb)

.method("set\_unsubscribe\_cb", &mqtt\_r::set\_unsubscribe\_cb)

.method("set\_log\_cb", &mqtt\_r::set\_log\_cb)

.method("set\_error\_cb", &mqtt\_r::set\_error\_cb)

;

}

That, combined with RcppModules: MQTT in the DESCRIPTION file and a MQTT <- Rcpp::Module("MQTT") just above where you’d put an .onLoad handler means you can do something like (internally, since it’s not exported):

mqtt\_obj <- MQTT$mqtt\_r

mqtt\_conn\_obj <- new(mqtt\_obj, "unique\_client\_id", "test.mosquitto.org", 1883L)

and have access to each of those methods right from R (e.g. mqtt\_conn\_obj$subscribe(0, "topic", 0)).

If you’re careful with your C++ class code, you’ll be able to breeze through exposing functionality.

Because of the existence of Rcpp Modules, I was able to do what follows in the next section in near record time.

**“The stump of a %>% he held tight in his teeth”**

I felt compelled to get a Christmas reference in the post and it’s relevant to this section. I like %>%, recommend the use of %>% and use %>% in my own day-to-day R coding (it’s even creeping into internal package code, though I still try not to do that). I knew I wanted to expose a certain way of approaching MQTT workflows in this mqtt package and that meant coming up with an initial — but far from complete — mini-language or pipe-able API for it. Here’s the current thinking/implementation:

* **Setup connection parameters with mqtt\_broker()**. For now, it takes some parameters, but there is a URI scheme for MQTT so I want to be able to support that as well at some point.
* **Support authentication with mqtt\_username\_pw()**. There will also be a function for dealing with certificates and other security-ish features which look similar to this.
* **Make it dead-easy to subscribe to topics and associate callbacks with mqtt\_subscribe()** (more on this below)
* **Support an “until you kill it” workflow with mqtt\_run()** that loops either forever or for a certain number of iterations
* **Support user-controlled iterations with mqtt\_begin(), mqtt\_loop() and mqtt\_end()**. An example (in a bit) should help explain this further, but this one is likely to be especially useful in a Shiny context.
* mqtt[s]://[username][:password]@host.domain[:port]

You write a function with a contractually defined set of parameters and operate on the values passed in. While we should all likely get into a better habit of using named function objects vs anonymous functions, anonymous functions are *super handy*, and short ones don’t cause code to get too gnarly. **However**, in this new DSL/API I’ve cooked up, each topic message callback has **six** parameters, so that means if you want to use an anonymous function (vs a named one) you have to do something like this in message\_subscribe():

mqtt\_subscribe("sometopic", function(id, topic, payload, qos, retain, con) {})

That’s not very succinct, elegant or handy. Since those are three attributes I absolutely about most things related to R, I had to do something about it.

Since I’m highly attached to the ~{} syntax introduced with purrr and now expanding across the Tidyverse, I decided to make a custom version of it for message\_subscribe(). As a result, the code above can be written as:

mqtt\_subscribe("sometopic", ~{})

and, you can reference id, topic, payload, etc inside those brackets without the verbose function declaration.

How is this accomplished? Via:

as\_message\_callback <- function(x, env = rlang::caller\_env()) {

rlang::coerce\_type(

x, rlang::friendly\_type("function"),

closure = { x },

formula = {

if (length(x) > 2) rlang::abort("Can't convert a two-sided formula to an mqtt message callback function")

f <- function() { x }

formals(f) <- alist(id=, topic=, payload=, qos=, retain=, con=)

body(f) <- rlang::f\_rhs(x)

f

}

)

}

It’s a shortened version of some Tidyverse code that’s more generic in nature. That as\_message\_callback() function looks to see if you’ve passed in a ~{} or a named/anonymous function. If ~{} was used, that function builds a function with the contractually obligated/expected signature, otherwise it shoves in what you gave it.

A code example is worth a thousand words (which is, in fact, the precise number of “words” up until this snippet, at least insofar as the WordPress editor counts them):

library(mqtt)

# We're going to subscribe to \*three\* BBC subtitle feeds at the same time!

#

# We'll distinguish between them by coloring the topic and text differently.

# this is a named function object that displays BBC 2's subtitle feed when it get messages

moar\_bbc <- function(id, topic, payload, qos, retain, con) {

if (topic == "bbc/subtitles/bbc\_two\_england/raw") {

cat(crayon::cyan(topic), crayon::blue(readBin(payload, "character")), "\n", sep=" ")

}

}

mqtt\_broker("makmeunique", "test.mosquitto.org", 1883L) %>% # connection info

mqtt\_silence(c("all")) %>% # silence all the development screen messages

# subscribe to BBC 1's topic using a fully specified anonyous function

mqtt\_subscribe(

"bbc/subtitles/bbc\_one\_london/raw",

function(id, topic, payload, qos, retain, con) { # regular anonymous function

if (topic == "bbc/subtitles/bbc\_one\_london/raw")

cat(crayon::yellow(topic), crayon::green(readBin(payload, "character")), "\n", sep=" ")

}) %>%

# as you can see we can pipe-chain as many subscriptions as we like. the package

# handles the details of calling each of them. This makes it possible to have

# very focused handlers vs lots of "if/then/case\_when" impossible-to-read functions.

# Ahh. A tidy, elegant, succinct ~{} function instead

mqtt\_subscribe("bbc/subtitles/bbc\_news24/raw", ~{ # tilde shortcut function (passing in named, pre-known params)

if (topic == "bbc/subtitles/bbc\_news24/raw")

cat(crayon::yellow(topic), crayon::red(readBin(payload, "character")), "\n", sep=" ")

}) %>%

# And, a boring, but -- in the long run, better (IMO) -- named function object

mqtt\_subscribe("bbc/subtitles/bbc\_two\_england/raw", moar\_bbc) %>% # named function

mqtt\_run() -> res # this runs until you Ctrl-C



There’s in-code commentary, so I’ll refrain from blathering about it more here except for noting there are a *staggering amount* of depressing stories on BBC News and an equally staggering amount of un-hrbrmstr-like language use in BBC One and BBC Two shows. Apologies if any of the GH README.md snippets or animated screenshots ever cause offense, as it’s quite unintentional.

**But you said something about begin/end/loop before?**

Quite right! For that we’ll use a different example.

I came across a topic — “sfxrider/+/locations” — on broker.mqttdashboard.com. It *looks* like live data from folks who do transportation work for (which is a crowd-sourced transportation/logistics provider in India). It publishes the following in the payload:

| device:6170774037 | latitude:28.518363 | longitude:77.095753 | timestamp:1513539899000 |

| device:6170774037 | latitude:28.518075 | longitude:77.09555 | timestamp:1513539909000 |

| device:6170774037 | latitude:28.518015 | longitude:77.095488 | timestamp:1513539918000 |

| device:8690150597 | latitude:28.550963 | longitude:77.13432 | timestamp:1513539921000 |

| device:6170774037 | latitude:28.518018 | longitude:77.095492 | timestamp:1513539928000 |

| device:6170774037 | latitude:28.518022 | longitude:77.095495 | timestamp:1513539938000 |

| device:6170774037 | latitude:28.518025 | longitude:77.095505 | timestamp:1513539947000 |

| device:6170774037 | latitude:28.518048 | longitude:77.095527 | timestamp:1513539957000 |

| device:6170774037 | latitude:28.518075 | longitude:77.095573 | timestamp:1513539967000 |

| device:8690150597 | latitude:28.550963 | longitude:77.13432 | timestamp:1513539975000 |

| device:6170774037 | latitude:28.518205 | longitude:77.095603 | timestamp:1513539977000 |

| device:6170774037 | latitude:28.5182 | longitude:77.095587 | timestamp:1513539986000 |

| device:6170774037 | latitude:28.518202 | longitude:77.095578 | timestamp:1513539996000 |

| device:6170774037 | latitude:28.5182 | longitude:77.095578 | timestamp:1513540006000 |

| device:6170774037 | latitude:28.518203 | longitude:77.095577 | timestamp:1513540015000 |

| device:6170774037 | latitude:28.518208 | longitude:77.095577 | timestamp:1513540025000 |

Let’s turn that into proper, usable, JSON (we’ll just cat() it out for this post):

library(mqtt)

library(purrr)

library(stringi)

# turn the pipe-separated, colon-delimeted lines into a proper list

.decode\_payload <- function(.x) {

.x <- readBin(.x, "character")

.x <- stri\_match\_all\_regex(.x, "([[:alpha:]]+):([[:digit:]\\.]+)")[[1]][,2:3]

.x <- as.list(setNames(as.numeric(.x[,2]), .x[,1]))

.x$timestamp <- as.POSIXct(.x$timestamp/1000, origin="1970-01-01 00:00:00")

.x

}

# do it safely as the payload in MQTT can be anything

decode\_payload <- purrr::safely(.decode\_payload)

# change the client id

mqtt\_broker("makemeuique", "broker.mqttdashboard.com", 1883L) %>%

mqtt\_silence(c("all")) %>%

mqtt\_subscribe("sfxrider/+/locations", ~{

x <- decode\_payload(payload)$result

if (!is.null(x)) {

cat(crayon::yellow(jsonlite::toJSON(x, auto\_unbox=TRUE), "\n", sep=""))

}

}) %>%

mqtt\_run(times = 10000) -> out

[](https://i1.wp.com/rud.is/b/wp-content/uploads/2017/12/tojson.gif?ssl=1)

What if you wanted do that one-by-one so you could plot the data live in a Shiny map? Well, we won’t do *that* in this post, but the user-controlled loop version would look like this:

mqtt\_broker("makemeuique", "broker.mqttdashboard.com", 1883L) %>%

mqtt\_silence(c("all")) %>%

mqtt\_subscribe("sfxrider/+/locations", ~{

x <- decode\_payload(payload)$result

if (!is.null(x)) {

cat(crayon::yellow(jsonlite::toJSON(x, auto\_unbox=TRUE), "\n", sep=""))

}

}) %>%

mqtt\_begin() -> tracker # \_begin!! not \_run!!

# call this individually and have the callback update a

# larger scoped variable or Redis or a database. You

# can also just loop like this `for` setup.

for (i in 1:25) mqtt\_loop(tracker, timeout = 1000)

mqtt\_end(tracker) # this cleans up stuff!

**FIN**

Whew. 1,164 words later and I hope I’ve kept your interest through it all. I’ve updated the GH repo for the package and also updated the requirements for the package in the README. I’m also working on a configure script and found Win32 library binaries that should make this easier to get up and running on Windows, so stay tuned for the next installment and don’t hesitate to jump on board with issues, questions, comments or PRs.