Making Systems More Robust with Flexible RPC Lookup

Russell Power

Abstract

Modern distributed systems use names everywhere. Lockservices such as Chubby [1] and ZooKeeper [3] provide an effective mechanism for mapping from application names to server instances, but proper usage of them requires a large amount of error-prone boiler-plate code.

Application programmers often try to write wrappers to abstract away this logic, but it turns out there is a more general and easier way of handling the issue. We show that by extending the existing name resolution capabilities of RPC libraries, we can remove the need for such annoying boiler-plate code while at the same time making our services more robust.

1 Introduction

Lockservers are gaining traction as an effective way to handle the thorny issue of ownership in distributed systems. Lock-services typically manage a directory of leases, each of which maps a name to a server that owns the lease. The advantage of using a lock-service is obvious - we only have to implement a distributed consensus algorithm in one place, and we can use it for all of our distributed systems.

Far too frequently, however, we see these services used in the following way (in this example, looking up the owner of a tablet in BigTable [2]):

Listing 1: Simple BigTable lookup.

```python
tablet_name = tablet_for_key("key")
server_name = lockserver.lookup(tablet_name)
server = rpc.connect(server_name)
server.put("key", "value")
```

This code is innocuous, but behaves poorly in the event of server failures. Assuming that the server side of this operation correctly rejects the operation, we're still going to have a missing put. Hopefully the programmer realizes this (or their RPC implementation throws exceptions). If not, we lose the put operation. If the programmer does realize the put can fail, we end up wrapping our logic in a cumbersome retry loop which does not make our code any easier to read:

Listing 2: Fixed BigTable lookup.

```python
timeout = 1
while 1:
    tablet_name = tablet_for_key("key")
    server_name = lockserver.lookup(tablet_name)
    server = rpc.connect(server_name)
    server.put("key", "value", timeout=timeout)
    timeout = min(timeout * 2, 60)
    if result.success(): break
```

A cursory examination of code that uses these lock services finds that these retry-loops occur very frequently. (Indeed, even the ZooKeeper codebase contains wrapper functions to try to simplify these issues when talking to the leasing service itself).

It turns out there is a very straightforward and robust way to encapsulate this retry pattern: extend our RPC system to use lease keys as names. Not only does this remove the need for retry logic, lookups are now handled implicitly, simplifying our code even further. What’s more, we even get a good guess at our what sort of timeout value to use for free (the remaining lease time). Most RPC libraries already have this sort of code for
dealing with more mundane re-connection issues already. Any RPC implementation worth its salt already has built-in support for one particular instance of this behavior, in the form of hostname (DNS) resolution. (Some even support looking up lease names, but sadly they are typically just used as an alternate form of domain name lookup).

To see what this looks like – our RPC library client gets extended to look up servers directly via the lease name:

Listing 3: Resolution integrated into RPC library.

class RPCClient:
def call(lease_name, request):
    while 1:
        target, lease_time = lockserver.lookup(lease_name)
        socket = connect(target)
        result = socket.send(request.str(), timeout=lease_time)
        if result.timed_out(): continue
        else:
            # success or application level error
            return result

Now in our application code we can use the leases directly, removing the lookup step and making our code more robust at the same time:

Listing 4: Simple BigTable lookup, take 2.

```
tablet_name = tablet_for_key("key")
tablet = rpc.connect(tablet_name)
tablet.put("key", "value")
```

Note that it’s now clearer that our operation is on a particular tablet. But of course, if you’re paying close attention (and aware of the details of how BigTable works), you’d notice that we might be talking to the wrong tablet. If the original tablet split between the time we got our name and when we did the put, then our client won’t have anyone to talk to – a very sad situation indeed. We might be tempted to wrap this into a retry loop like we did above, but then we’d have the same ugly, error-prone logic again:

Listing 5: Simple BigTable lookup, take 3.

```
while 1:
    tablet_name = tablet_for_key("key")
    tablet = rpc.connect(tablet_name)
    result = tablet.put("key", "value", timeout=XXX)
    if result:
        ...
```

We can do better though, and remove the yucky direct dependency on a lockservice we added to our RPC at the same time – we just to extend the concept of “lookup” for our RPC library. Traditionally, RPC libraries have hard-coded paths for handling things like domain-name resolution. But modern distributed applications have more flexible names – we should have more flexible naming. This is easily achieved by just specifying how to do lookup as a separate function. Note that our lookup function itself might now make RPC calls of its own.

Listing 6: Resolution integrated into RPC library.

class RPCClient:
def call(request, lookup_fn):
    while 1:
        target, timeout_guess = lookup_fn(request)
        socket = connect(target)
        result = socket.send(request.str(), timeout=timeout_guess)
        if result.timed_out(): continue
        else:
            # success or application level error
            return result

And our client code becomes:
Listing 7: Simple BigTable lookup, take 4.

```python
def lookup_tablet(req, next):
    tablet_name = tablet_for_key(req.key)
    return next(tablet_name)

# try applying each lookup function in order until we get
# a match
session = rpc.session(lookup=
    [lookup_tablet, lookup_lease, lookup_dns])

result = session.put("key", "value")
```

A simple local form of this request-based lookup is frequently seen in message-queue based systems (typically for sharding a request to a number of workers). Note that we’ve also reduced the coupling between operations and the server that handles them – this is a good thing. In any real distributed system, we can’t rely on having the same server handle multiple sequential calls, if our abstraction makes this obvious, all the better.

A naïve implementation of our lookup function would force us to re-perform a lookup for every request, which would likely have bad performance implications. This is easily solved by supplying a wrapper function that provides caching.

2 Conclusion

Name resolution isn’t just for domains anymore – our RPC libraries should be extended to support more dynamic, interesting forms of resolution. The benefit is simpler, more robust client code and better code reuse.

References

[1] M. Burrows. The chubby lock service for loosely-coupled distributed systems. In Proceedings of the 7th symposium on Operating systems design and implementation, pages 335–350. USENIX Association, 2006.

[2] F. Chang, J. Dean, S. Ghemawat, W. Hsieh, D. Wallach, M. Burrows, T. Chandra, A. Fikes, and R. Gruber. Bigtable: A distributed storage system for structured data. ACM Transactions on Computer Systems (TOCS), 26(2):4, 2008.

[3] P. Hunt, M. Konar, F. P. Junqueira, and B. Reed. Zookeeper: Wait-free coordination for internet-scale systems. In USENIX ATC, volume 10, 2010.