A TALK ABOUT CONSUL

HELLO!
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Hi! Thanks for coming! My name is Rob. There's some places you can find me. Do say hi!

These slides are available here, so if I fly past something you were interested in, you'll be able to find it there

The very tiny plug for my company, FastMail, who support me fiddling with cool bits of tech and talking to you about it. We care about email and we care about you, so if you'd like your email service with a smile, why not check us out? There's a few FastMailers here, come talk to us later!

CONSUL

So, lets talk about Consul.

CONSUL

» One instance on every node (host) on your network

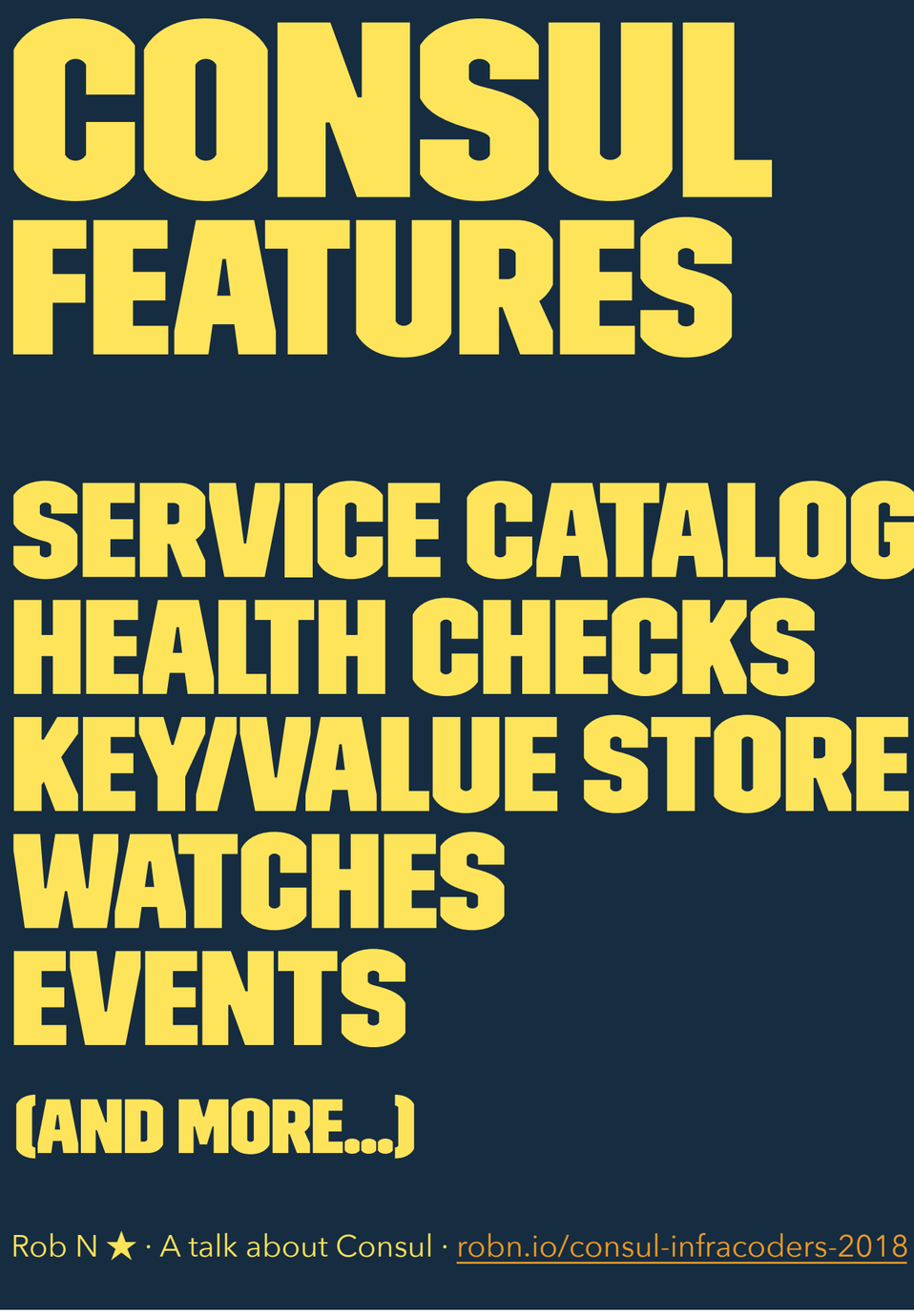
» Working together

» Tools for managing your services, hosts and networks

★ Consul is a little program that runs on every node on your network

★ All the nodes talk to each other. They use a consensus algorithm called Raft that arranges it so that when something changes, that change is reflected across all nodes at the same amd no matter which node you ask, you will always get the same result.

★ And then Consul builds a bunch of useful tools on top of that.



Consul has tons of interesting features. I get really excited about it because every time I look there's always something new in there and every time I have a problem, there's often a way to solve it with Consul.

I'm only going to talk about some of these features today.

SERVICE CATALOG

The most important tool Consul provides is the service catalog.

So you have your service, whatever it is. Mine is email. It's made of a number of internal components, usually several instances of each. These talk to each other to do stuff for your users. To talk to each other, they need to find each other!

The service catalog is the place to put all of your services and let them find out about each other.

SERVICE CATALOG

» Register instances of a service (by name)

» Ask the API where a service is, get an IP:port back

» Better: ask DNS!

★ So, you register each instance of a service with Consul's service catalog

★ And then you ask the Consul API where some named service is, and it'll tell you. I'll talk about the API a bit later.

★ Consul also has a built-in DNS server, so you can just ask that, making it easy to hook together services that aren't Consul-aware.

SERVICE CATALOG
SERVICES.JSON

```
{
  "address" : "10.202.2.10",
  "name" : "hopscotch",
  "port" : 8084,
  "tags" : [
    "beta"
  ]
}
```


So here's an example. At FastMail, we have an internal service called "hopscotch". It's a small image proxy so we can embed off-site images in user email without running into browser origin restrictions. Its cool, and entirely unimportant for this talk.

So in Consul's `services.json`, on every node that runs hopscotch, we have a service definition like the above. The name of the service, IP and port, and any tags that let us tell the difference between different flavours of this service. Pretty straightforward?

SERVICE CATALOG

```
$ consul catalog nodes -service=hopscotch
Node        ID          Address         DC
betaweb1    8a619b68    10.202.2.10     nyi
qaweb1      2b002a91    10.202.2.11     nyi
web1        66f57633    10.202.2.211    nyi
web2        7d7fcc9a    10.202.2.212    nyi
web3        e47dea91    10.202.2.213    nyi
web4        cf531ebe    10.202.2.214    nyi
web5        b55241eb    10.202.2.215    nyi
web6        7d2d2552    10.202.2.216    nyi
```


We can ask Consul to tell use about all the instances of that service.

SERVICE CATALOG
DNS LOOKUP

```
$ dig +noall +answer hopscotch.service.consul
hopscotch.service.consul. 0 IN  A   10.202.2.212
hopscotch.service.consul. 0 IN  A   10.202.2.214
hopscotch.service.consul. 0 IN  A   10.202.2.10
hopscotch.service.consul. 0 IN  A   10.202.2.216
hopscotch.service.consul. 0 IN  A   10.202.2.213
hopscotch.service.consul. 0 IN  A   10.202.2.11
hopscotch.service.consul. 0 IN  A   10.202.2.215
hopscotch.service.consul. 0 IN  A   10.202.2.211
```


And even better, we can ask Consul via DNS, which means we could put the name `hopscotch.service.consul` into some other service, and it would find its way there without even knowing Consul is involved.

SERVICE CATALOG
DNS LOOKUP

```
$ dig +noall +answer beta.hopscotch.service.consul
beta.hopscotch.service.consul. 0    IN  A   10.202.2.10
```


Remember how we added tags? We can include them in our lookup to find just flavour we're interested in.

SERVICE CATALOG
`consul-template`

» Watch the catalog for changes

» Rewrite a config file

» Restart a service

We don't always want to use the DNS though. There is a lookup cost, and we can't express everything through DNS, like consistent hashing or ordering. For this, `consul-template` is a useful tool.

★ It's another program that watches the catalog for changes. ★ When a change happens, it rewrites a config file from a template, filling in values it got from the catalog. ★ And it can then take other actions, like restarting the service.

consul-template

```
upstream hopscotch {
{{ range service "prod.hopscotch" }} server {{ .Address }}:{{ .Port }};
{{ end }}}
```


So here's a template for a fragment of nginx config. If you don't know nginx, something it can do is forward web requests on to a pool of backend servers, which it calls "upstreams". So this template builds an upstream block for our hopscotch service.

Consul is written in Go, so this uses Go's in-built template language.

consul-template

```
upstream hopscotch {
{{ range service "prod.hopscotch" }} server {{ .Address }}:{{ .Port }};
{{ end }}}
```

```
$ consul-template -template nginx.tpl:nginx.cfg -once
```


Here we run `consul-template` in its "generate config and exit" mode.

consul-template

```
upstream hopscotch {
{{ range service "prod.hopscotch" }} server {{ .Address }}:{{ .Port }};
{{ end }}}
```

```
$ consul-template -template nginx.tpl:nginx.cfg -once
```

```
upstream hopscotch {
 server 10.202.2.211:8084;
 server 10.202.2.212:8084;
 server 10.202.2.213:8084;
 server 10.202.2.214:8084;
 server 10.202.2.215:8084;
 server 10.202.2.216:8084;
}
```


And it produces an nginx config with all the hopscotch instances from the catalog.

consul-template

Rewrite config file when catalog changes:

```
$ consul-template -template nginx.tpl:nginx.cfg
```

Rewrite config and run command:

```
$ consul-template
    -template 'nginx.tpl:nginx.cfg:service nginx reload'
```

Process supervisor!

```
$ consul-template
    -template nginx.tpl:nginx.cfg -exec 'nginx -c nginx.cfg'
```


There's a bunch of different ways to run it. We can have `consul-template` run forever, watching the catalog for changes, and rewriting the config file when it does.

Here we're having it rewrite the config and then run a command, in this case calling the init system to reload the config.

Or we can use it as a complete process supervisor. In this case when `consul-template` starts, it spawns nginx as a child process and then when the catalog changes it rewrites the config file and sends a SIGHUP to nginx to have it reload.

There's lots of options.

HEALTH CHECKS

I keep talking about "when the catalog changes". What makes it change? Health checks are what!

HEALTH CHECKS

» Checks run on a node

» Associated with a single service, or the whole node

» Failing check will mark the service or node "unavailable"

  » Won't be returned by a catalog query

★ Each node has its own set of checks

★ A check is associated with a single service, or the node as a whole

★ A failing check will mark the service or node "unavailable"

★ "unavailable" services/nodes won't be returned by a catalog query

HEALTH CHECKS

- Check types:
  - HTTP (Consul asks service regularly)
  - TTL (Service tells Consul regularly)
  - Script (run program, check exit status)
  - Others: TCP, gRPC, Docker

★ There's a few different kinds of checks you can set up.

★ HTTP checks, where Consul makes a HTTP request and looks for a success/fail status

★ TTL checks, where a service calls into Consul regularly, and the check fails if we haven't heard from them in a while

★ Script checks, where Consul runs a program and the return code decides success/fail

★ And others

HEALTH CHECKS
CONSUL.JSON

```
{
  "id": "hopscotch",
  "name": "hopscotch running",
  "service_id": "hopscotch",
  "http": "http://localhost:8084/health",
  "interval": "10s",
  "timeout": "1s"
}
```


Here's a simple check for our hopscotch service. This fragment goes in the main Consul config file.

You see the `service_id` there, that's associating the check with the hopscotch service. If this check fails, only that service is made unavailable. Without that, a failing check would make all services on the node unavailable.

It's a HTTP check, that's the URL to hit. If it returns a 200 status, the check passes, otherwise it fails.

And how often to check it, and how long to wait. There's a bunch of other options of course.

HEALTH CHECKS
HTTP CHECK

```
127.0.0.1 - - [06/Aug/2018:12:50:39 +0000]
"GET /health HTTP/1.1" 200 0 "-" "Consul Health Check"
```


After we add this check, hopscotch starts getting requests to its `/health` endpoint.

HEALTH CHECKS
DNS LOOKUP

```
$ dig +noall +answer hopscotch.service.consul
hopscotch.service.consul. 0 IN  A   10.202.2.211
hopscotch.service.consul. 0 IN  A   10.202.2.212
hopscotch.service.consul. 0 IN  A   10.202.2.213
hopscotch.service.consul. 0 IN  A   10.202.2.214
hopscotch.service.consul. 0 IN  A   10.202.2.215
hopscotch.service.consul. 0 IN  A   10.202.2.216
```


As before, we can see all instances in a catalog query.

HEALTH CHECKS
CHECK FAILING

```
2018-08-06T12:54:40.693711+00:00 web4 consul[79519]:
agent: Check "hopscotch" HTTP request failed: Get http://localhost:8084/health:
dial tcp 127.0.0.1:8084: getsockopt: connection refused
```


Then one instance fails (in this case, I shut it down by hand). Consul starts reporting the check failure in its log.

HEALTH CHECK
DNS LOOKUP

```
$ dig +noall +answer hopscotch.service.consul
hopscotch.service.consul. 0 IN  A   10.202.2.211
hopscotch.service.consul. 0 IN  A   10.202.2.212
hopscotch.service.consul. 0 IN  A   10.202.2.213
hopscotch.service.consul. 0 IN  A   10.202.2.215
hopscotch.service.consul. 0 IN  A   10.202.2.216
```


Now when we query the catalog, the failed service is not returned.

That's pretty much all there is to it. Give your services associated health checks, and other services will only ever find ones that are working right now!

KEY/VALUE STORE

Another major Consul feature is its key/value store.

KEY/VALUE STORE

» Simple store for service config and other metadata

» Consistent and available everywhere

» Not for big data!

» Not for fast access!

★ It's a simple store for service config and other metadata

★ It's built on top of the Raft log, so its guaranteed to be consistent and available everywhere

★ Before you get too excited, remember that Consul is a service management system, so the KV store is not designed to store big data. It's for small configuration items and service state.

★ And it's not fast! It's designed for consistency, not speed.

KEY/VALUE STORE

```
# consul kv put foo/bar 23
Success! Data written to: foo/bar
```


It works about how you'd expect. Store some value.

KEY/VALUE STORE

```
# consul kv put foo/bar 23
Success! Data written to: foo/bar

# consul kv get foo/bar
23
```


And pull it back.

KEY/VALUE STORE

```
# consul kv put foo/baz 32
Success! Data written to: foo/baz
# consul kv put foo/quux 41
Success! Data written to: foo/quux
```


The keys are a tree.

KEY/VALUE STORE

```
# consul kv put foo/baz 32
Success! Data written to: foo/baz
# consul kv put foo/quux 41
Success! Data written to: foo/quux

# consul kv get -recurse foo/
foo/bar:23
foo/baz:32
foo/quux:41
```


So you can ask for everything under some part of the tree.

BORING

That's all great, but its about the minimum of what you'd expect from a KV store. But there's some really nice tools we get from the consistency guarantees Consul provides.

KEY/VALUE STORE
CHANGE INDEX

» Every change bumps the index number

» Every key records the index number when the key was created, modifed and locked

» Allows efficient synchronisation

» You know if the value has changed since you last checked!

The store keeps an index number, or change sequence number.

★ Every changes bumps the number

★ Every key records what the index was the last time it was touched

★ This allows easy synchronisation. ★ Your program can come back and say "did this key change since I was last here" or, better, "give me everything that changed since I was last here".

KEY/VALUE STORE
CHECK-AND-SET (CAS)

» Set this key to X, but only if its index is N

» Allows higher-level distributed synchronisation primitives (locks, semaphores, shared queues, etc)

The KV store offers an atomic "check and set" operation.

★ which means "set this key, but only if it hasn't changed since I last looked at it".

★ And lets you build higher-level synchronisation primitives like distributed locks, shared queues, that sort of thing.

For example, you can implement a lock by trying to get some key, and if it doesn't exist, create it against the current index. If the create works, you know you have the lock. If Consul rejects it because someone else already created the key since you were last there, then you don't have the lock and should try again later.

WATCHES

A couple more quick features, which I've mentioned along the way.

Watches are just a way of saying "block me until some object changes".

WATCHES

» Wait for something to change

  » key, keyprefix, services, nodes, service, checks, event

» Take some action in response

★★ We can wait on any of Consul's core objects

★ And then take some action. We looked at `consul-template` earlier; that's exactly what its doing.

WATCHES

consul watch

```
# consul watch -type=key -key=foo/bar cat
{
  "Key": "foo/bar",
  "CreateIndex": 65791, "ModifyIndex": 65791, "LockIndex": 0,
  "Flags": 0, "Value": "MjM=", "Session": ""
}
```


Consul ships with the `consul` `watch` tool. It lets you create watches from the command line. So here we are making a watch on a single KV key.

WATCHES

consul watch

```
# consul kv put foo/bar 99
Success! Data written to: foo/bar
```


Elsewhere, we store a new value on that key.

WATCHES

consul watch

```
# consul watch -type=key -key=foo/bar cat
{
  "Key": "foo/bar",
  "CreateIndex": 65791, "ModifyIndex": 65791, "LockIndex": 0,
  "Flags": 0, "Value": "MjM=", "Session": ""
}
{
  "Key": "foo/bar",
  "CreateIndex": 65791, "ModifyIndex": 69188, "LockIndex": 0,
  "Flags": 0, "Value": "OTk=", "Session": ""
}
```


Then we go back to `consul watch`, and see its received the updated key data.

EVENTS

Events are the last feature I want to talk about today.

EVENTS

» Broadcast a tiny bit of data to Consul nodes

» Watcher can wait for event, then take action

» Example: cache flush

★ Lets your send a message to multiple Consul nodes at once. ★ Then you can have a watcher running on those nodes, and take action when the event arrives.

★ An example we've experimented with a bit is to control cache flushes. Many services cache rarely-changing data in memory. Instead of flushing or rechecking periodically, they set up a Consul watch. When that data does change (some user or administrator action), we send a "flush your cache" event to those nodes. The watches wake up, and those services drop their caches and reload the data.

ACCESS CONTROLS
SERVICE MESH
NETWORK TOPOLOGY
PREPARED QUERIES
KV TRANSACTIONS
SESSIONS
SNAPSHOTS

Consul has a ton of other features, and they add something new and intresting in every release. So far, they're holding to the idea of providing a set of building blocks that can be combined in interesting ways.

TOOLS

It can be a bit rough to hand you a box of parts and say "make something", so here's a few tools that come with or work with Consul to get you started.

TOOLS
consul-template

» Watch for changes in catalog or KV store

» Rewrite files with new data

» Run programs, send signals, etc

We've already seen consul-template. ★ It watches for changes, ★ rewrites config files, ★ and takes actions, sends signals, other stuff.

TOOLS
`consul lock`

» Take a lock

  » Or block if lock already held

» Run a program

» Keep the lock held until the program finishes

» No more than one copy of the program running across all nodes

★ Takes a lock using a key in the KV store. ★ If it can't get the lock, it sets up a watch and waits until it can.

★ Once it has the lock, runs a program

★ Keeps the lock alive until the program exits (using Consul's "sessions" feature)

★ So you can use it to make sure the program never has more than one running at a time.

TOOLS
consul exec

» Run a program on multiple nodes

» Collect and show the output

★ It's a remote execution tool. Run a program on some set of nodes.

★ Each node stores the output in the KV store, and the calling node sets up a watch to grab it and display it as it comes in.

TOOLS
consul exec

```
# consul exec -node '^wbackup' uptime
    wbackup5:  08:44:18 up 59 days, 12:07,  0 users,  load average: 0.26, 0.16, 0.23
    wbackup5:
==> wbackup5: finished with exit code 0
    wbackup3:  08:44:18 up 164 days, 16:53,  0 users,  load average: 0.25, 0.84, 0.95
    wbackup3:
==> wbackup3: finished with exit code 0
    wbackup1:  08:44:18 up 38 days, 10:07,  1 user,  load average: 0.79, 0.63, 0.66
    wbackup1:
==> wbackup1: finished with exit code 0
    wbackup6:  08:44:18 up 25 days, 10:25,  0 users,  load average: 1.87, 1.86, 1.85
    wbackup6:
==> wbackup6: finished with exit code 0
    wbackup2:  08:44:18 up 5 days,  8:59,  0 users,  load average: 0.04, 0.04, 0.01
    wbackup2:
==> wbackup2: finished with exit code 0
    wbackup4:  08:44:18 up 19 days, 11:14,  0 users,  load average: 2.06, 1.70, 1.25
    wbackup4:
==> wbackup4: finished with exit code 0
6 / 6 node(s) completed / acknowledged
```


Here's a basic example. Run the `uptime` command on all of my servers named `wbackup`.

TOOLS
PROMETHEUS

» Metrics gathering, monitoring and alerting system

» Reaches out to services on the network and asks them for stats

» Native support for Consul service discovery

Prometheus! My other favourite tool at the moment!

★ It's a time-series database with features for collecting and alerting.

★ Works by reaching out to services on the network and asking them what they're up to.

★ And it has native support for Consul service discovery. So once again, it sets up a watch, and when new services appear, it starts to probe them.

TOOLS
WE GOT ALL KINDS

https://github.com/josegonzalez/awesome-consul

Of course, there's an awesome list of Consul-aware tools and services. Have a look, there's lots of interesting stuff there.

And of course, there's an API

API

» Access to all Consul features

  » Many not available from command line

» Simple HTTP+JSON protocol

» Client libraries for every language

★ Complete access to all Consul features, ★ for some things the only way.

★ It's a simple HTTP protocol, with return data in plain JSON

★ There's client libraries for pretty much every language

API
SERVICE CATALOG

```
# curl 'http://localhost:8500/v1/catalog/service/hopscotch?tag=prod'
[                                                    |
  {                                                  |
    "ID": "66f57633-955f-2136-a5e8-933b1693c4ea",    |    "ServiceID": "hopscotch",
    "Node": "web1",                                  |    "ServiceName": "hopscotch",
    "Address": "10.202.2.211",                       |    "ServiceTags": [
    "Datacenter": "nyi",                             |      "prod"
    "TaggedAddresses": {                             |    ],
      "lan": "10.202.2.211",                         |    "ServiceAddress": "10.202.2.211",
      "wan": "10.202.2.211"                          |    "ServicePort": 8084,
    },                                               |    "ServiceEnableTagOverride": false,
    "NodeMeta": {                                    |    "CreateIndex": 75454374,
      "consul-network-segment": ""                   |    "ModifyIndex": 75454374
    },                                               |  }
                                                     | ]
```


Here's one example we saw earlier, returning all the available instances of the named services. There's lots of other values we haven't seen yet, but all the interesting bits are there: address, port, tags, and so on.

API
KV STORE

```
# curl http://localhost:8500/v1/kv/foo/bar
[
  {
    "LockIndex": 0,
    "Key": "foo/bar",
    "Flags": 0,
    "Value": "OTk=",
    "CreateIndex": 65791,
    "ModifyIndex": 69188
  }
]
```


KV store fetch is the same idea.

API
CLIENT LIBRARY

```
  DB<1> x Consul->kv->get("foo/bar")
0  Consul::API::KV::Response=HASH(0x2f18990)
   'create_index' => 65791
   'flags'        => 0
   'key'          => 'foo/bar'
   'lock_index'   => 0
   'modify_index' => 69188
   'value'        => 99
1  Consul::Meta=HASH(0x3127470)
   'index'        => 69188
   'known_leader' => 1
   'last_contact' => 0
```


Or you can use a client library. This is the Perl client library in action from Perl's debugger. I'm using this as the example because I wrote the client library, and I want you to see that Perl is still relevant. But it'll be largely the same in your language of choice.

A TALK ABOUT CONSUL

And that's it. Consul is a whole suite of interesting tools for managing your services, hosts and datacentres. If you're not already using it you should take a look because there might be something in there you can use right now. And if you are using it, look again, because its getting more and more interesting stuff all the time.