

Serverspec in cloud provision



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Successful operation automation usually needs, along with core tool technical skills some curiosity and knowledge about the system under test - not strictly but is recommended. For example, (no)SQL, Angular/MQ experience would be a great help in web testing, HTML / Javascript no longer sufficient .

Often more critical than provision engine (Puppet, Chef, Ansible, DSC learning curve.

In a similar case, an QA engineer fluent in Selenium Appium or Katalon often is or eager to grow Web developer skills but unlikely ever interested in the code base of those tools.



Terminology: what is *spec

RSpec - popular framework for Behavior Driven Development (BDD), from Rails time frame. BDD is a way of writing unit tests in a original DSL that reads like plain English phrases describing the expectations the software product is to satisfy taken from some stakeholders meeting minutes but at the same being a valid Ruby code can be automated and if/when fail, produce reasonably intelligent error messages. The application under test is not modified - it is RSpec job is to have it called the desired way.

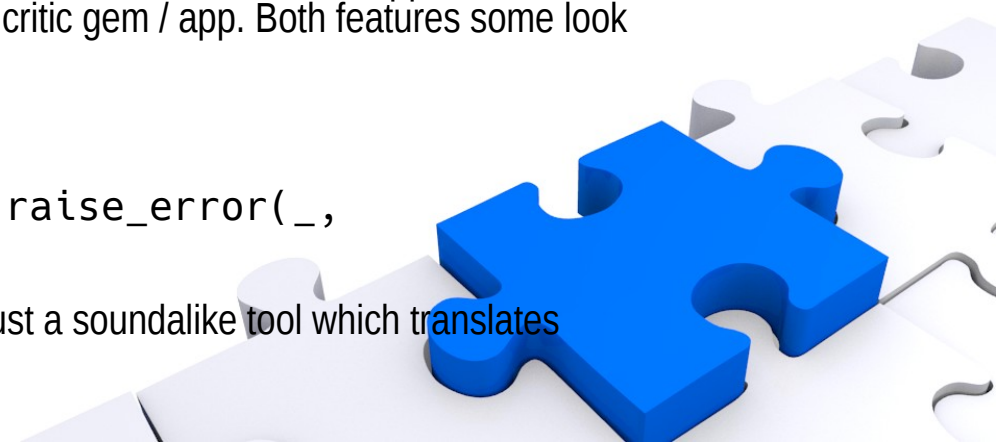
Puppet/Chef uses a similar frameworks to let module or profile developer compose assertions about their provision scenarios (a.k.a. catalogs) to e.g. have specific resources being declared in desired ways. Later, Puppet infrastructure guarantees the results of the real provision will match the spec.

When Puppet-RSpec gem and process step that constitutes certain lint checks to ensure the Puppet code follows the Puppet style guide. In Chef, comes under the name of foodcritic gem / app. Both features some look and feel of Rspec: matchers and chains

```
expect(some_subject) to do_verb.with_noun
```

```
expect { should_verb_noun('identifier') }.to raise_error(,  
  /no way/)
```

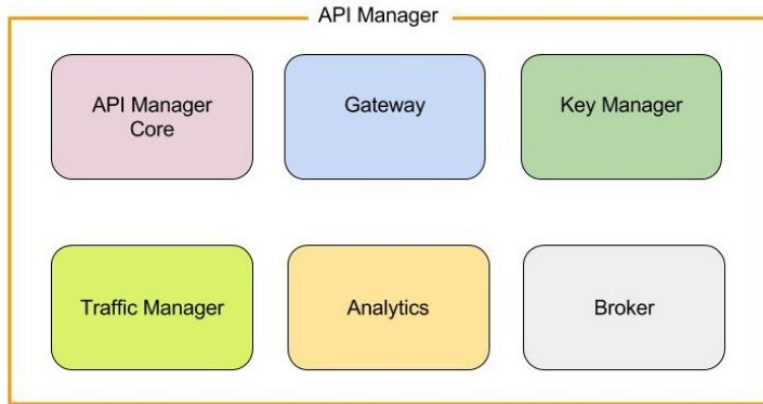
Other than using distinct trademark RSpec semantics Serverspec is just a soundalike tool which translates acceptance criteria simply into core OS and software feature probes.



IaaS to PaaS mutation challenge



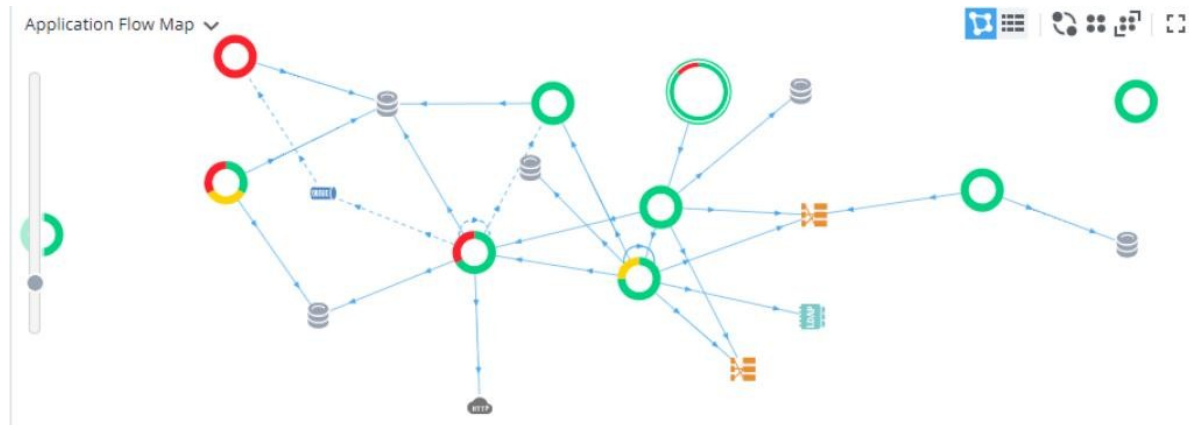
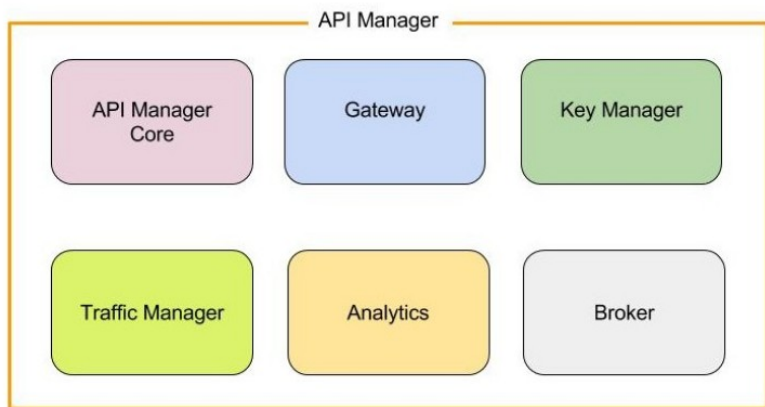
laaS to PaaS mutation challenge



Cloud architect envisions building a platform for some integrated enterprise modern application stack using WSO2 API Manager facilities to create, publish, manage, version, control access, throttle and monetize the APIs.



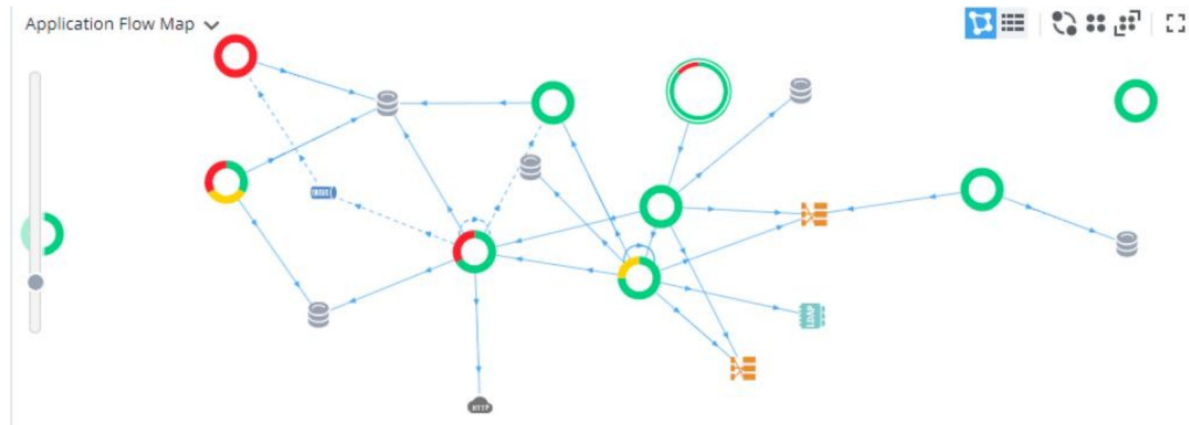
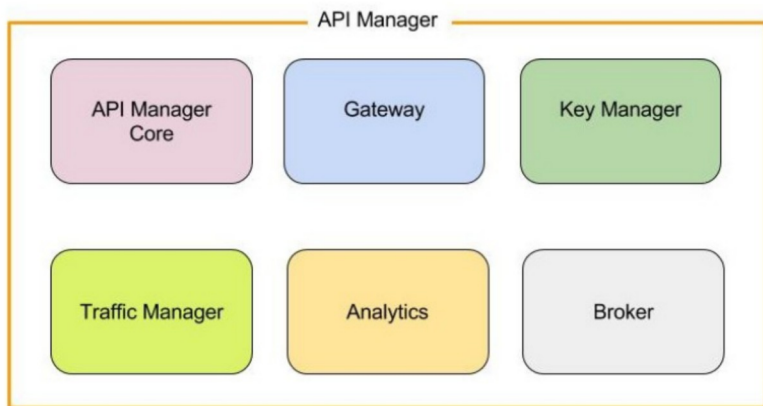
IaaS to PaaS mutation challenge



Cloud cluster will be provisioned by Puppet



IaaS to PaaS mutation challenge



WSO2 API Manager

WSO2 API Manager
Analytics

WSO2 App Manager

WSO2 Application Server

WSO2 Business Process Server

WSO2 Business Rules Server

WSO2 Carbon

WSO2 Complex Event Processor

WSO2 Dashboard Server

WSO2 Data Analytics Server

WSO2 Data Services Server

WSO2 Elastic Load Balancer

WSO2 Enterprise Integrator

WSO2 Enterprise Mobility Manager

WSO2 Enterprise Service Bus

WSO2 Enterprise Service Bus
Analytics

WSO2 Enterprise Store

WSO2 Governance Registry

WSO2 Identity Server

WSO2 Identity Server
Analytics

WSO2 Identity Server
Key Manager

WSO2 IoT Server

WSO2 Machine Learner

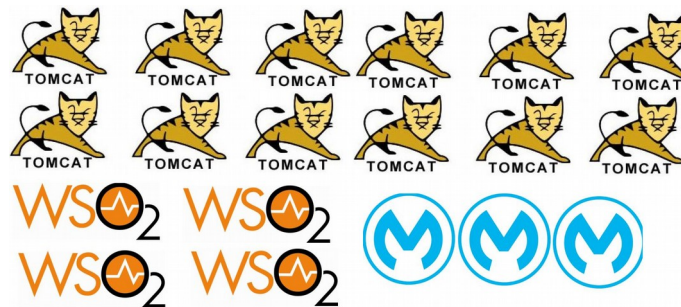
WSO2 Message Broker

WSO2 Private PaaS

WSO2 Storage Server



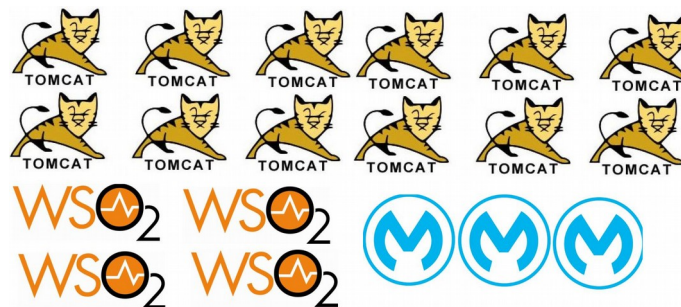
IaaS to PaaS mutation challenge



Platform will offer to mobile and web customers the existing and future API



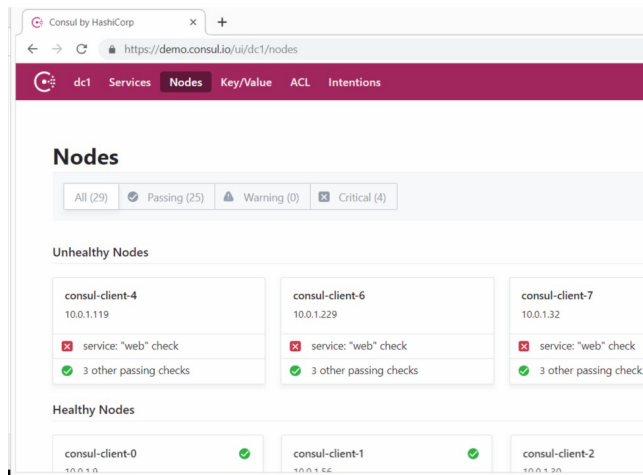
IaaS to PaaS mutation challenge



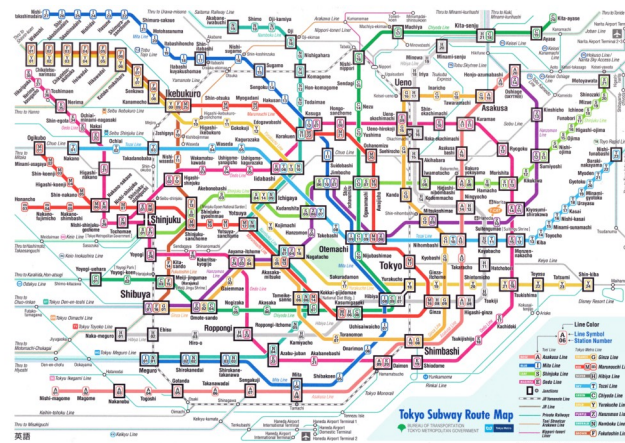
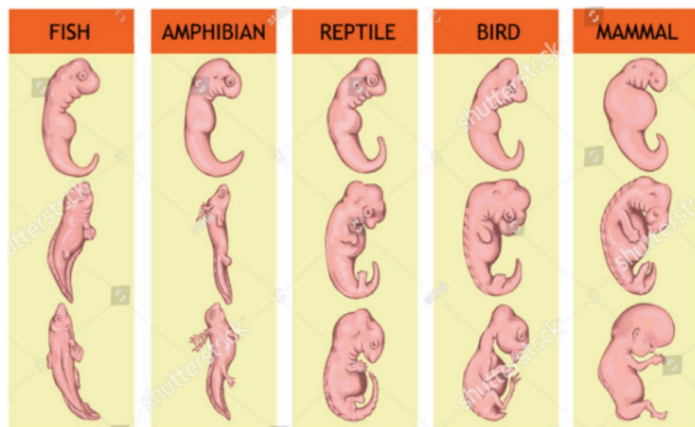
`org.springframework.cloud.client.discovery`

public interface `DiscoveryClient`

`DiscoveryClient` represents read operations
commonly available to
Discovery service such as
Netflix Eureka or consul.io



IaaS to PaaS mutation challenge



Puppet strengths

- Control repository and r10k effectively manage environments through git branches
- Hieras separate parameters from the manifests with easy parameter override
- Puppet operates system information and module specific facts to compile and apply the catalog



Coarse resource inventory

Fragment of the puppet log reporting creation of a file resource

```
==> targetnode: Notice:  
/Stage[main]/Main/Node[default]/File[/var/www/html/index.html]/ensure:  
defined content as '{md5}1ee4fb5c27dc46bb5cfa56065039bef5'  
==> targetnode: Notice: <!DOCTYPE html>
```

Fragment of the puppet command reporting status of the same file resource

```
puppet resource file  
Error: Could not run: Listing all file instances is not supported.  
Please specify a file or directory
```

```
puppet resource file '/var/www/html/index.html'  
file { '/var/www/html/index.html':  
  ensure => 'file',  
  content => '{md5}1ee4fb5c27dc46bb5cfa56065039bef5',
```



Granular Configuration Management Example

Fragment of the real systemd service unit file
/etc/systemd/system/gateway.service

[Unit]

Description=service

Requires=some prereq.service

After=another.service

[Service]

User=appuser

Environment=JAVA_HOME=/opt/jvm/java

*Environment='JAVA_OPTS=-Dcom.mycompany.package.App.app=/home/appuser/.app -
javaagent:/opt/appdynamics/appserveragent/javaagent.jar,EXTRA_JARS
=/opt/appdynamics/additional.jar'*

ExecStart=...

ExecStartPre=...

[Install]

WantedBy=multi-user.target



Granular Configuration Management Example

Fragment of the real apache configuration fragment hieradata/template configuration example of templates/vhost/_security.erb

```
<% if @_modsec_disable_ids.is_a?(Hash) -%>
<% @_modsec_disable_ids.each do |location, rules| -%>
  <LocationMatch <%= location %>>
<% Array(rules).each do |rule| -%>
  SecRuleRemoveById <%= rule %>
<% end -%>
</LocationMatch>
<% end -%>
```

https://github.com/puppetlabs/puppetlabs-apache/blob/master/templates/vhost/_security.erb



Granular Configuration Management Example (2)

Fragment of the real apache module manifest dealing with security configuration
manifests/vhost.pp

```
992 # Template uses:
993 # ...
994 # - $modsec_disable_ids
995   if $modsec_disable_ids {
996     concat::fragment { "${name}-security":
997       target => "${priority_real}${filename}.conf",
998       content => template('apache/vhost/_security.erb'),
999     }
1000 }
```

<https://github.com/puppetlabs/puppetlabs-apache/blob/master/manifests/vhost.pp>



Serverspec comes to rescue

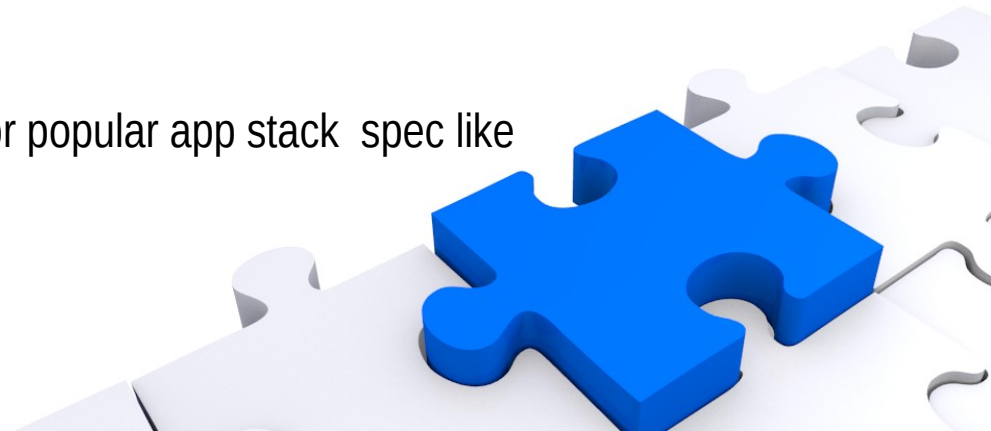
The home page <https://serverspec.org/> describes core resource types:

bond | bridge | cgroup | command | cron | default_gateway | docker_container | docker_image | file | group | host |
iis_app_pool | iis_website | interface | ip6tables | ipfilter | ipnat | iptables | kernel_module | linux_audit_system |
linux_kernel_parameter | lxc | mail_alias | mysql_config | package | php_config | port | ppa | process | routing_table |
selinux | selinux_module | service | user | x509_certificate | x509_private_key | windows_feature |
windows_registry_key | yumrepo | zfs

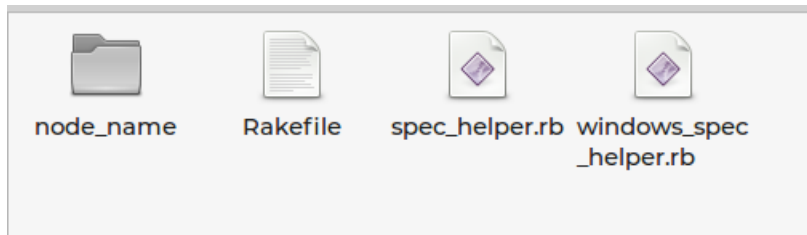
Code hosted on github in [mizzy/serverspec](#), [mizzy/specinfra](#), [vvchik/vagrant-serverspec](#),
covers 20+ operating systems

A very similar [inspec/inspec](#) framework exists for Chef.

A handful of active projects present extended types created for popular app stack spec like
npm, ELK etc.



Intro to Serverspec



- Directory with spec file(s) named as target node for multi node provisioning
- Helper file `spec_helper.rb` with OS-specific configuration `ssh`, `sudo`, `tempfile` and sets the `:backend` to either `:cmd`, `:exec`, `:ssh` or `:winrm`. Usually helper files for Windows and unix are stored separately
- `Rakefile` where path to every spec file passed to constructor of `RSpec::Core::RakeTask`
- An `rspec <filename>` command is also possible (with the same effect) and often used with Docker



Intro to Serverspec

The most basic spec are just a copy of the <http://serverspec.org> with only change in the subject name

```
context 'Basic' do
  name = 'jenkins'
  describe service(name) do
    it { should be_enabled }
    it { should be_running }
  end
end
```

```
service 'jenkins' do
  action [:enable, :start]
end
```

```
service {'jenkins':
  ensure => running,
  enable => true,
end
```



Where are practical expectations

The stock example would fit to validate the Jenkins module from Puppet Forge, but in practical scenario one's expectations are more specific

```
context 'Jenkins Security' do
  xmlfile = '/var/lib/jenkins/config.xml'
  describe file(xmlfile) do
    it { should exist }
    its(:content) { should match '<useSecurity>false</useSecurity>' }
  end
end
```



Exploring Serverspec

Having noticed that the 'file' method is backend run of a cat 'run_command', and intending to processes XML in Ruby one would compose the test which does just that. Gets complex quickly

```
require 'rexml/document'
describe file(xmlfile) do
  begin
    content = Specinfra.backend.run_command("cat '#{xmlfile}'").stdout
    begin
      doc = Document.new(content); // ready for some DOM processing
      result = true
    rescue ParseException => e
      result = false
    end
  rescue => e
    result = false
  end
  it { result.should be_truthy }
end
```

https://github.com/mizzy/serverspec/blob/master/lib/serverspec/type/hadoop_config.rb



Exploring Serverspec

Running vendor command is the ultimate way to query app configuration, especially when provision is broken and focus on verifying too close to what Puppet is modifying could yield a false positive

```
context 'Mysql Datadir' do
  custom_datadir = '/opt/mysql/var/lib/mysql/'
  describe command(<<-EOF
    mysql -sBEe 'select @@datadir;'
  EOF
  ) do
    its(:exit_status) {should eq 0 }
    # implicitly confirm the mysql is running
    its(:stdout) { should match custom_datadir }
  end
end
```



Raise of custom Serverspec

One is basically interested in

- application configuration files (JSON, XML)
- systemd service details, various response headers to web requests,
- open TCP ports, Unix socket and windows pipes
- download artifact hashes
- Jenkins fine level details of Jenkins job and pipeline configs
- GAC and assemblies
- Scheduled Tasks (Windows) and cron jobs (unix)
- Puppet last run reports

As a result one has quickly growing collection. E.g. repo

https://github.com/sergueik/serverspec_custom_types contains 100+100 snippets for each Linux and Windows.



Serverspec implementation

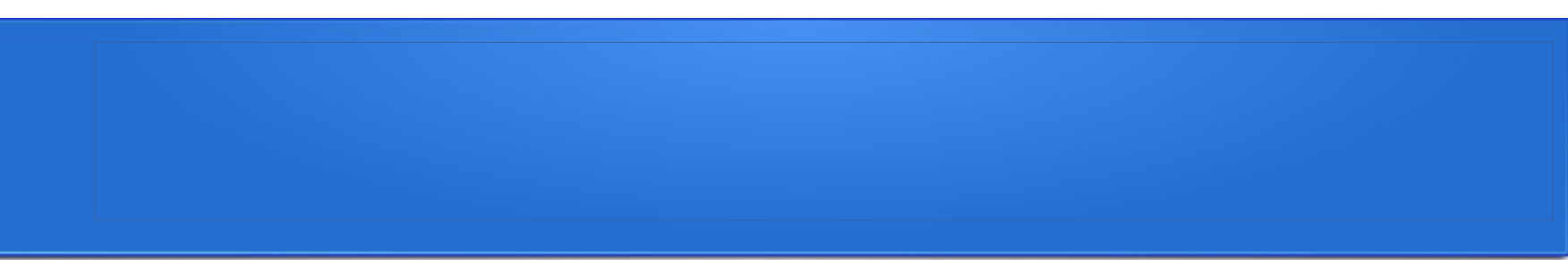


Extreme serverspec

The engine responsible for the serverspec execution resembles that of Puppet or Chef: source is sent from developer to the target node to be eventually converted into target OS specific low level commands to execute - result is sent back to the developer. Unlike provision the serverspec is executed for its direct, not side effects. Both serverspec and Puppet has significant amount of code wrapping the actual command in some custom DSL, however a plain Exec/Command class is still available.

In the extreme case in the body of a Ruby spec Command, one could find a full source code of a java class that would be compiled and run in the target node to load and examine some cryptic JDBC, or ELK configuration changes applied in the course of node provision:



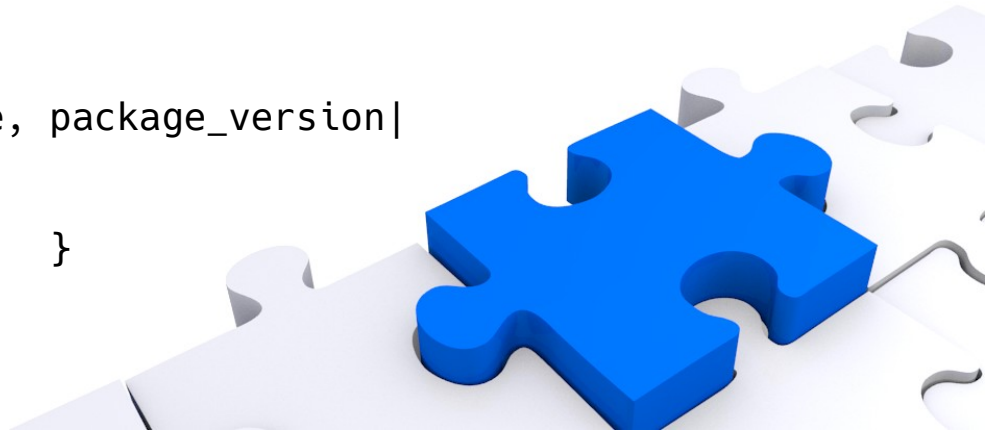


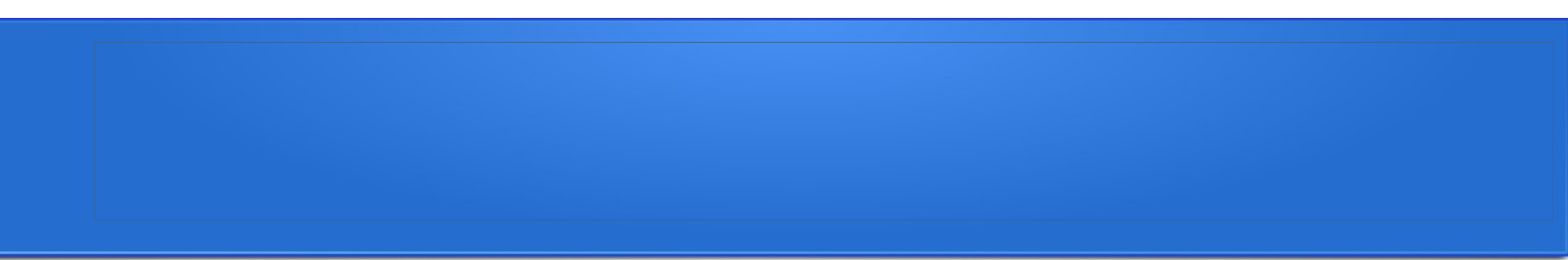
There isn't any 'spy' facilities for server spec or unit test developments, neither are any in pure Ruby, Java or .Net, nor there is any 'recording' environment. To help new developers learn and quickly adopt to server spec follow clear *Rspec/Cucumber* semantics:

```
describe service('tomcat') do
  it {should be_running }
end

describe port(8443) do
  it { should be_listening.with('tcp') }
end

{'linux-kstat' => '0.1.3' }.each do |package_name, package_version|
  describe package(package_name) do
    it { should be_installed.by('gem')
      .with_version(package_version) }
  end
end
```

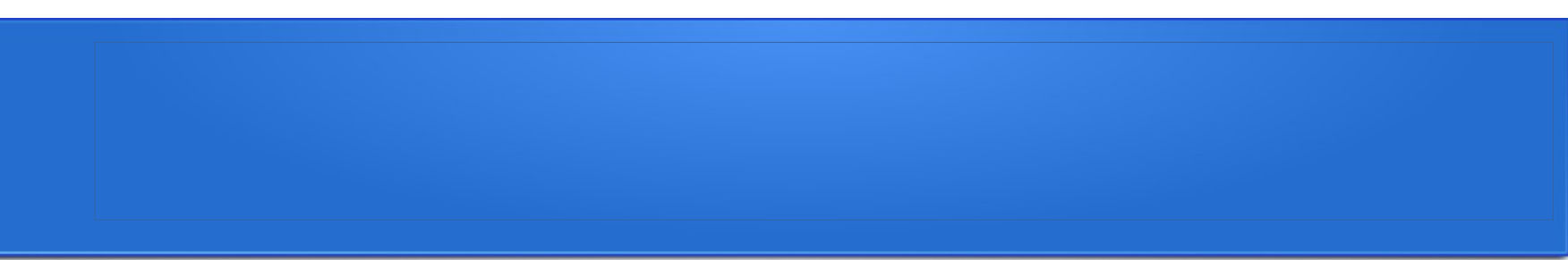




Soon with the growing number of detail the only two qualifying resources are the file and the command

```
context 'Virtual Host settings' do
  describe file('/etc/httpd/conf.d/vhost.conf') do
    [ 'ProxyRequests Off',
      # multiple settings
    ].each do |line|
      its(:content) { should match "^\\s*" + Regexp.escape(line) }
    end
  end
end
```





Eventually the *command* is where the tricky part is:

```
Context 'Security headers' do
  describe command('curl -k -I http://localhost') do
    its(:stdout) { should match /Server: Apache\/\d\/\d+\/\d+ (?:?Unix|CentOS)/i }
  end
end
```

```
context 'Tomcat shutdown port' do
  server_xml = "#{catalina_home}/conf/server.xml"
  describe command(<<-EOF
    xmllint --xpath "/Server[@shutdown='SHUTDOWN']/@port" #{server_xml}
  EOF
  ) do
    its(:exit_status) { should eq 0 }
    its(:stdout) { should match 'port="-1"' }
  end
end
```

<https://tomcat.apache.org/tomcat-8.5-doc/appdev/web.xml.txt>



Gradually the *command* itself could become tricky but reusable (Ruby or libxml2 used to focus on specific XML node):

```
describe 'redirect port 8080' do
  doc = Document.new(content)
  result = REXML::XPath.first(doc, "/Server/Service/Connector[@port = \"8080\"]
/@redirectPort").value
  it { result.should match '8443' }
end

context 'Tomcat servlet configuration' do
  class_name = 'com.mycompany.mypackage.ControllerServlet'
  describe command(<<-EOF
    xmllint --xpath \"//*[local-name()='servlet']/*[local-name()='servlet-class']/text()\"
#{web_xml}
    EOF
  ) do
    its(:stdout) { should match Regexp.new(class_name) }
  end
end
```

<https://tomcat.apache.org/tomcat-8.5-doc/appdev/web.xml.txt>






Eventually the *command* is where the tricky part is (jq used to focus into the specific node of the JSON configuration):

```
context 'Consul service health check configuration' do
{
  'myservice' => 'api/health'
}.each do |service, route|
  describe command("jq '.service.checks[].http' < '/etc/consul.d/#{service}.json'" ) do
    let(:path) { '/bin:/usr/bin:/usr/local/bin' }
    its(:stdout) { should match( Regexp.new(
      Regexp.escape("https://127.0.0.1:8443/#{route}") )) }
  end
end
end
end
```



On Windows, Powershell and C# is used to retrieve obscure information about .Net

```
context 'specific assembly in GAC' do
  assembly_name = 'WindowsFormsIntegration'
  token = '31bf3856ad364e35'
  describe command(<--EOF
    $result = @(
      [Object].Assembly.GetType('Microsoft.Win32.Fusion').GetMethod('ReadCache')
      .Invoke($null, @([Collections.ArrayList]$result, '#{assembly_name}', [UInt32]2 ))
    $result
  EOF
  )
  do
    its(:stdout) { should contain
      "#{assembly_name}, Version=3.0.0.0, Culture=neutral, PublicKeyToken=#{token}" }
  end
end
```



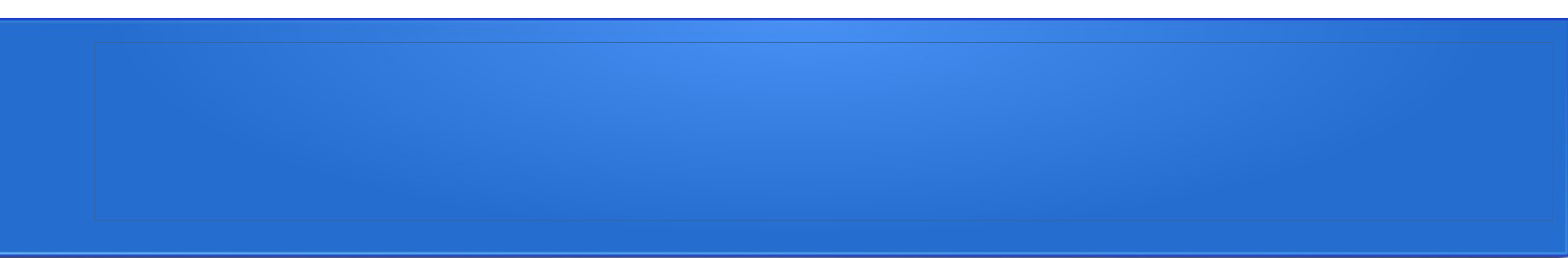
Serverspec usage for Puppet and Consul

A concise passing *serverspec expectation* may easily become a Puppet *fact* or an mco,knife/consul probe command

```
Facter.add('version') do
  confine :kernel => 'windows'
  script = "([xml](get-content -path 'version.xml')).Info.Product.version"
  command = "powershell.exe -executionpolicy remotesigned -command \" &
{ #{script} }\""
  result = Facter::Util::Resolution.exec(command)
end
```

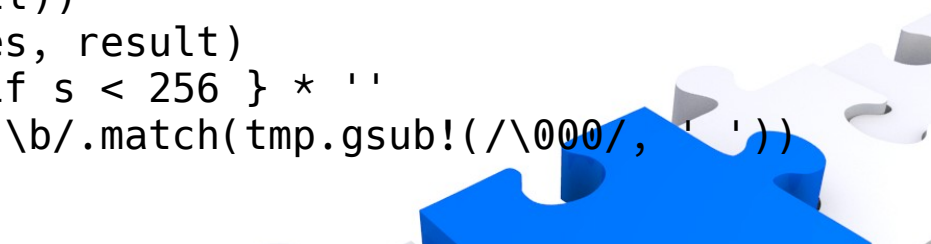
```
consul exec https://$LEADER:$PORT rpm -q $PACKAGE \&\&
hostname -f | grep -A 1 $VERSION | grep -v $PACKAGE
```





A proper *Serverspec expectation* could replace native Ruby Puppet module *fact* which can be quite cryptic:


```
Facter.add('version') do
  extend FFI::Library
  ffi_lib 'version.dll'
  attach_function :resource_size, :GetFileVersionInfoSizeA [:ptr, :ptr ], :int
  attach_function :version, :GetFileVersionInfoA, [ :ptr, :int, :int, :buf_out], :int
  version_information = '\VarFileInfo\Translation'.encode('UTF-16LE')
  result = ' ' * (resource_size(filepath, nil))
  status = version(filename, 0, size_in_bytes, result)
  tmp = result.unpack('v*').map{ |s| s.chr if s < 256 } * ''
  version_match = /FileVersion\s+\b([0-9.]+\)\b/.match(tmp.gsub!(/\\000/, ''))
  version_match[1].to_s
end
```





Serverspec expectation could be used for consul *“script-kind”* service check similar to `/etc/consul.d/mongodb.json`:

```
{
  "service": {
    "name": "mongo-db",
    "tags": ["mongo"],
    "address": "192.168.31.02",
    "port": 27017,
    "checks": [
      {
        "name": "Checking MongoDB"
        "script": "/usr/bin/check_mongo.py --host 192.168.31.02 --port 27017",
        "interval": "5s"
      }
    ]
  }
}
```



<https://www.consul.io/docs/agent/checks.html>

Making Java Application consul-ready

The *http-kind* service check heartbeat-response is provided by Spring after annotation is provided and dependency added to pom.xml:

```
@SpringBootApplication
```

```
@EnableDiscoveryClient
```

```
public class DiscoverableApplication {  
    public static void main(String[] args) {  
        SpringApplication.run(DiscoverableApplication.class, args);  
    }  
}
```

```
<dependency>
```

```
    <groupId>org.springframework.boot</groupId>
```

```
    <artifactId>spring-boot-starter-actuator</artifactId>
```

```
</dependency>
```



Serverspec Integration challenges



<https://tomcat.apache.org/tomcat-8.5-doc/appdev/web.xml.txt>



Vagrant Serverspec provisioner

serverspec vagrant provisioner is part of the Vagrant flow, a little bit of disadvantage so its rake spec is from a deep stack of Ruby calls

elementary tasks like `$DEBUG = ENV.fetch('DEBUG', false)` become a bit problematic

serverspec is scheduled afterprovision and rerun is time consuming - not really when module is idempotent

with default settings error stack is super extra verbose

spec file (`node_spec.rb`) is not visible to therefore can not be produced by Puppet module - solvable through relative reference placing under `files/serverspec/rhel/module_spec.rb` and making the legacy one simply require_relative `'../../files/serverspec/rhel/module_spec.rb'`, with the actual path determined by workspace directory layout

assumes the availability of ssh between developer machine and target instance

which may change during secure environment provision



Serverspec through own Puppet module

serverspec being just a handful of text files plus a Ruby runtime – calls to be provisioned (rvm-hosted) through Puppet from archive and templates and an exec for `rake spec` on the instance then updates Puppet and Vagrant logs with the result. This remediates limitations

`rake spec` is directly in console and can be run explicitly after provision and the spec file edited in the instance. Debugging is easy.

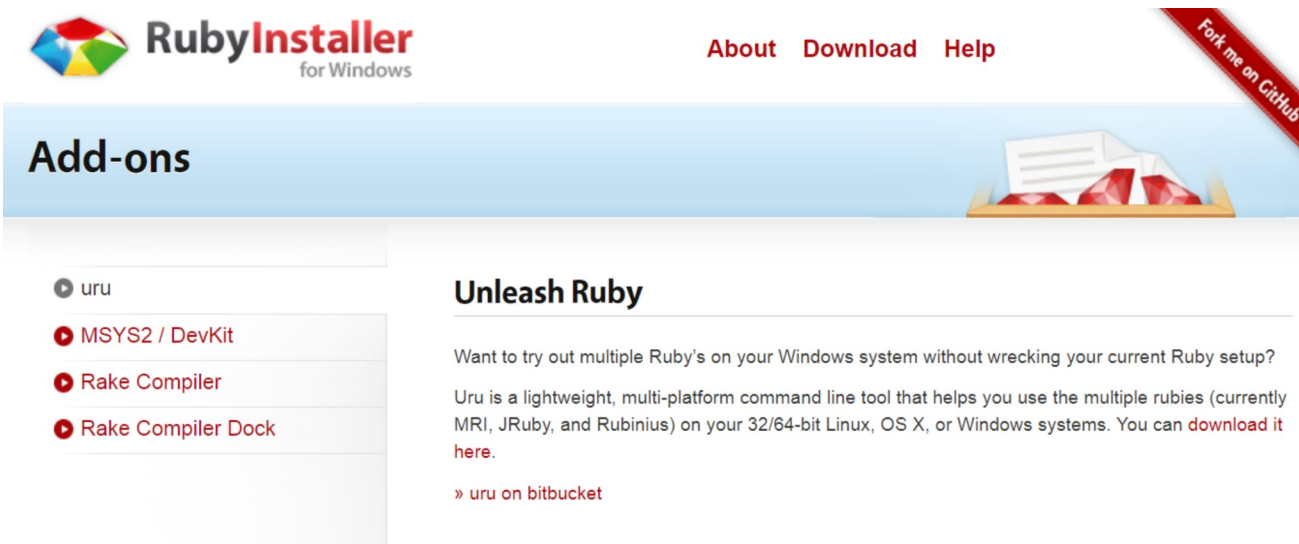
Spec file is generated by Puppet from template, hieradata etc. for version-sensitive portion (one can also keep serverspec require relative for Vagrant runs)

Runs on DMZ machine after lockdown, the results pushed to the developer, CI/CD etc.

A little cumbersome to modify file locally and push to the vm to validate



Serverspec through own Puppet module



The screenshot shows the RubyInstaller website for Windows. At the top left is the RubyInstaller logo, which consists of a colorful geometric shape next to the text 'RubyInstaller for Windows'. To the right of the logo are links for 'About', 'Download', and 'Help'. A red ribbon banner on the right side of the header says 'Fork me on GitHub'. Below the header is a light blue banner with the word 'Add-ons' on the left and an illustration of a box with papers and red gems on the right. On the left side of the main content area, there is a sidebar with a search bar and a list of add-ons: 'uru', 'MSYS2 / DevKit', 'Rake Compiler', and 'Rake Compiler Dock'. The 'uru' add-on is selected. The main content area features a section titled 'Unleash Ruby' with a sub-header. The text describes 'Uru' as a lightweight, multi-platform command line tool that helps use multiple rubies (MRI, JRuby, and Rubinius) on various systems. It includes a link to 'download it here' and a link to 'uru on bitbucket'.

RubyInstaller
for Windows

[About](#) [Download](#) [Help](#)

[Fork me on GitHub](#)

Add-ons

- uru
- MSYS2 / DevKit
- Rake Compiler
- Rake Compiler Dock

Unleash Ruby

Want to try out multiple Ruby's on your Windows system without wrecking your current Ruby setup?

Uru is a lightweight, multi-platform command line tool that helps you use the multiple rubies (currently MRI, JRuby, and Rubinius) on your 32/64-bit Linux, OS X, or Windows systems. You can [download it here](#).

» [uru on bitbucket](#)

<https://rubyinstaller.org/>



Serverspec through own Puppet module

```
hierarchy:  
  - name: 'Per-node data'  
    path: "node/%{::trusted.certname}.yaml"  
  - name: 'Per-role data'  
    path: "role/%{trusted.extensions.pp_role}.yaml"  
  - name: 'Shared data'  
    path: common.yaml
```

```
context 'Packages' do  
  {  
    consul => nil,  
    tomcat => '7.0.54-2',  
    jdk     => '1.8.0.192'  
  }. each do |name,version|  
    describe package(name) do  
      it { should be_installed.with_version(version)}  
    end  
  end  
end  
end
```



Puppet-RSpec

- Stubs target OS, environment facts, module parameters and hiera data
- Compiles and examines the 'Catalog'
- Asserts the specified actions are taken
- All that without requiring one to spawn the real instance
- Real provision will behave according to those specs

<http://rspec-puppet.com>

<https://github.com/chefspec/chefspec/tree/master/examples>

Puppet Rspec is useful with
module and profile development and refactoring
intelligent upgrade / downgrade logic is critical (present|latest|absent)
with complex module logic or generation of complex configurations



Chef Spec

- Performs the Puppet manifest / Chef cookbook compile check, all exceptions – will be also seen in real provision
- Dumps catalog through one of few available methods:

```
describe 'module' do
  it { should compile.with_all_deps }
  at_exit { RSpec::Puppet::Coverage.report! }
  it { p catalogue.resource }
end
```

no example for Chef



Chef Spec

- Stubs target platform, ohai, cookbook attributes
- Performs 'Converge' and examines the catalog, asserts specified actions are taken

```
require 'chefspec'  
require 'json'
```

```
describe 'selenium_hub::default' do  
  let(:chef_run) { ChefSpec::SoloRunner.converge(described_recipe) }  
  
  it 'creates selenium directory' do  
    expect(chef_run).to create_directory('/opt/selenium')  
  end  
  
  it 'starts selenium hub service' do  
    expect(chef_run).to start_service('selenium_hub')  
  end  
end
```

continued on the following slide

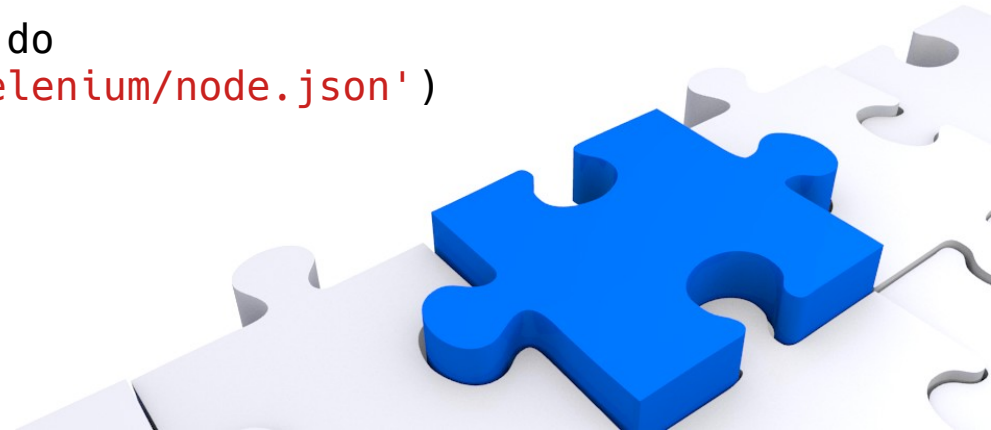


Chef Spec

Popular practice during module / cookbook development to run rspec to examine and fine tune resources produced from template, saving on a real Puppet / Chef run

```
describe 'selenium_hub::default' do
  let(:chef_run) { ChefSpec::SoloRunner.converge(described_recipe) }

  it 'generates init script configuration' do
    expect(chef_run).to render_file('/etc/init.d/selenium_hub')
  end
  it 'generates a valid json configuration' do
    expect(chef_run).to render_file('/opt/selenium/node.json')
      .with_content( satisfy do |content|
        JSON.parse(content) rescue nil
      end
    )
  end
end
```



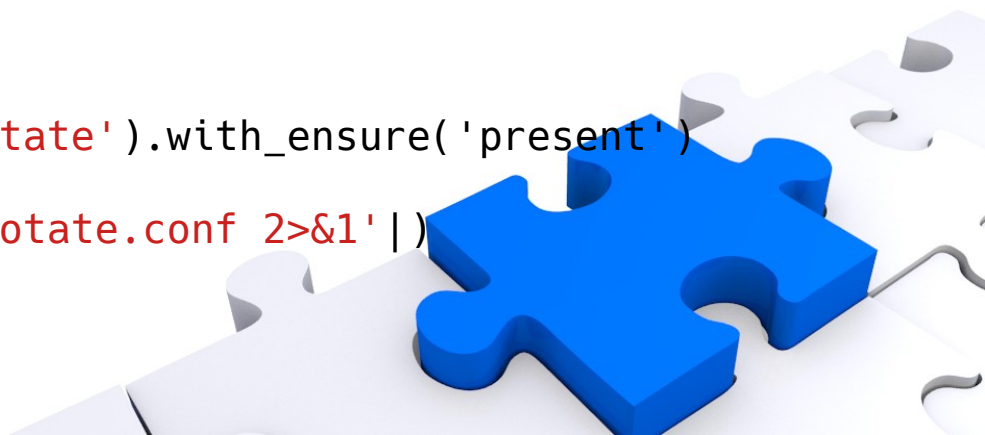
Puppet “defines” Spec

The Ruby DSL syntax is quite divergent

```
require 'spec_helper'
describe 'logrotate::cron' do
  # NOTE: verbatim Puppet code
  let(:pre_condition) { 'class { "::logrotate": }' }

  context 'with default params' do
    let(:title) { 'test' }
    let(:params) { { ensure: 'present' } }
    it {
      is_expected.to
        contain_file('/etc/cron.test/logrotate').with_ensure('present')
        .with_content(
          %r|'/usr/sbin/logrotate /etc/logrotate.conf 2>&1'|)
    }
  end
end
```

<https://github.com/voxpupuli/puppet-logrotate>



Chef Resource Relationship Spec

The Ruby DSL offers advanced 'relationship' expectation API, which unfortunately are not to be fully relied upon

```
it do
  should contain_file('c:/temp/log')
    .with(ensure => 'directory'
    .that_requires('c:/temp')
    .that_comes_before('Acl[c:/temp/log]')
end
```

```
it 'notifies service' do
  resource = chef_run.file(@setenv_file)
  expect(resource).to_not
    notify("service['#{@application_server}']").to(:restart).delayed
end
```



Chef Resource Relationship Spec

Overall with very few exceptions Rspec is valuable to module developer only. These specific scenarios include:

Module so flexible it is impractical to test all combination every supported configuration. E.g. logrotate that is a good example

https://github.com/rodjek/puppet-logrotate/blob/master/spec/defines/rule_spec.rb

-1100 + lines very granular.

Puppet module like puppetlabs-apache which managing something that is probably more complex, in many ways, than Puppet itself. Thus module also has 2000+ lines in some rspec

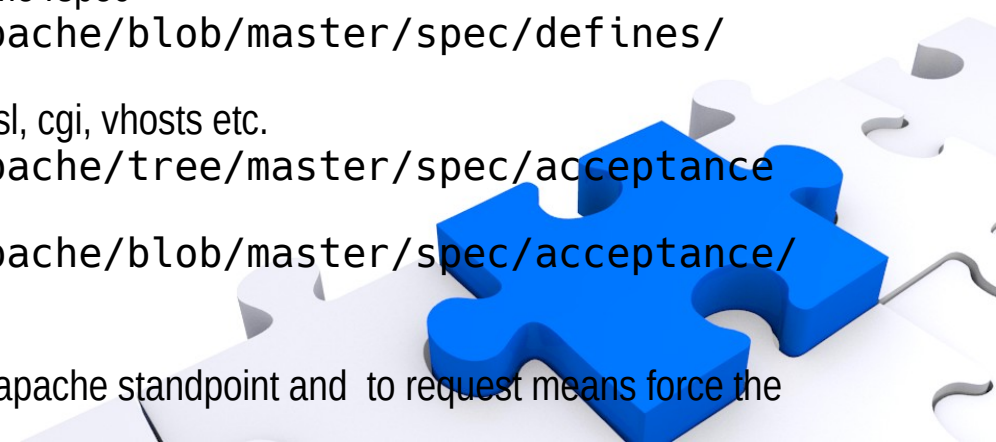
https://github.com/puppetlabs/puppetlabs-apache/blob/master/spec/defines/vhost_spec.rb

and also has equally big acceptance tests focusing on security, ssl, cgi, vhosts etc.

<https://github.com/puppetlabs/puppetlabs-apache/tree/master/spec/acceptance>
with 1700 lines of

https://github.com/puppetlabs/puppetlabs-apache/blob/master/spec/acceptance/vhost_spec.rb

In this case, some configurations are not meaningful or valid from apache standpoint and to request means force the provision fail.



Puppet Beaker Integration testing tool

Recently, used Beaker wraps Vagrant(Docker) and Serverspec to provision the instance(s), iterating over supported target platforms, often performing multiple consecutive puppet agent runs, and inspects the catalog compilation status and examines catalogs, focusing on reboots, idempotency (by ensuring no resources are modified in the second run).

Taking somewhat Rails-like metaprogramming style in defining boilerplate reusable but vague expectations require 'spec_helper_acceptance'

```
it 'should run with no errors applying all changes in the first run' do
  apply_manifest(<<-EOF
    include stdlib
  EOF
  ,
  :modulepath => '/etc/puppetlabs/code/modules',
  :debug      => true,
  :catch_failures => true).exit_code).to eq 2 # be_zero
end
```

<https://www.rubydoc.info/gems/beaker/2.4.1/Beaker/DSL/Helpers>



Questions?



Thank You



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