CFENGINE IN A DAY

NICK ANDERSON

BEFORE WE START

SCHEDULE

Table 1: A rough schedule (this varies greatly).

Time	Activity
09:00 AM - 10:30 AM	Class
10:30 AM - 11:00 AM	Morning break
11:00 AM - 12:30 PM	Class
12:30 PM - 01:30 PM	Lunch break
01:30 PM - 03:00 PM	Class
03:00 PM - 03:30 PM	Afternoon break
03:30 PM - 05:00 PM	Class

USE THE SOURCE

github.com/nickanderson/cfengine-training

HI, I'M NICK

- Wife, 2 kids and a dog
- Sysadmin/Infrastructure Engineer/Doer of things
- CFEngineering for >10 years
- Find me online
  - nick@cmdln.org | nick.anderson@northern.tech
  - @cmdln_
  - cmdln.org
  - linkedin.com/in/hithisisnick
  - `9274 E588 E866 A10B 713C 9CCD 9EB3 AD42 5D1C CC11`

WHO ARE YOU?

- Name
- Role
- Goals for this training

WHAT THIS TRAINING COVERS

- What is CFEngine
- High level architecture overview
- Language fundamentals (through CFEngine 3.15.0)
- Examples and Exercises
- Useful tooling and tips

WHY AUTOMATION?

Every time someone logs onto a system by hand, they jeopardize everyone's understanding of the system. – Mark Burgess

WHAT IS CFENGINE?

- Modern
- Secure
- Scale-able
- Agile **infrastructure automation tool**

HISTORY

- Written by Mark Burgess
- Originally released in 1993.
- Computer Immunology (Self Healing) 1998
- CFEngine 2 (1998)
- Promise Theory (2005)
- CFEngine 3 (2008)
- Company Founded (2008)
- CFEngine 3.15 (2019)

SMALL

As of Feb 2020:

- Lines of code ~ 115k
- ~ 6M Package size
- Memory Utilization: ~ 80MB
  - cf-agent ~ 30MB
  - cf-serverd ~ 30MB
  - cf-execd ~10MB
  - cf-monitord ~ 10MB

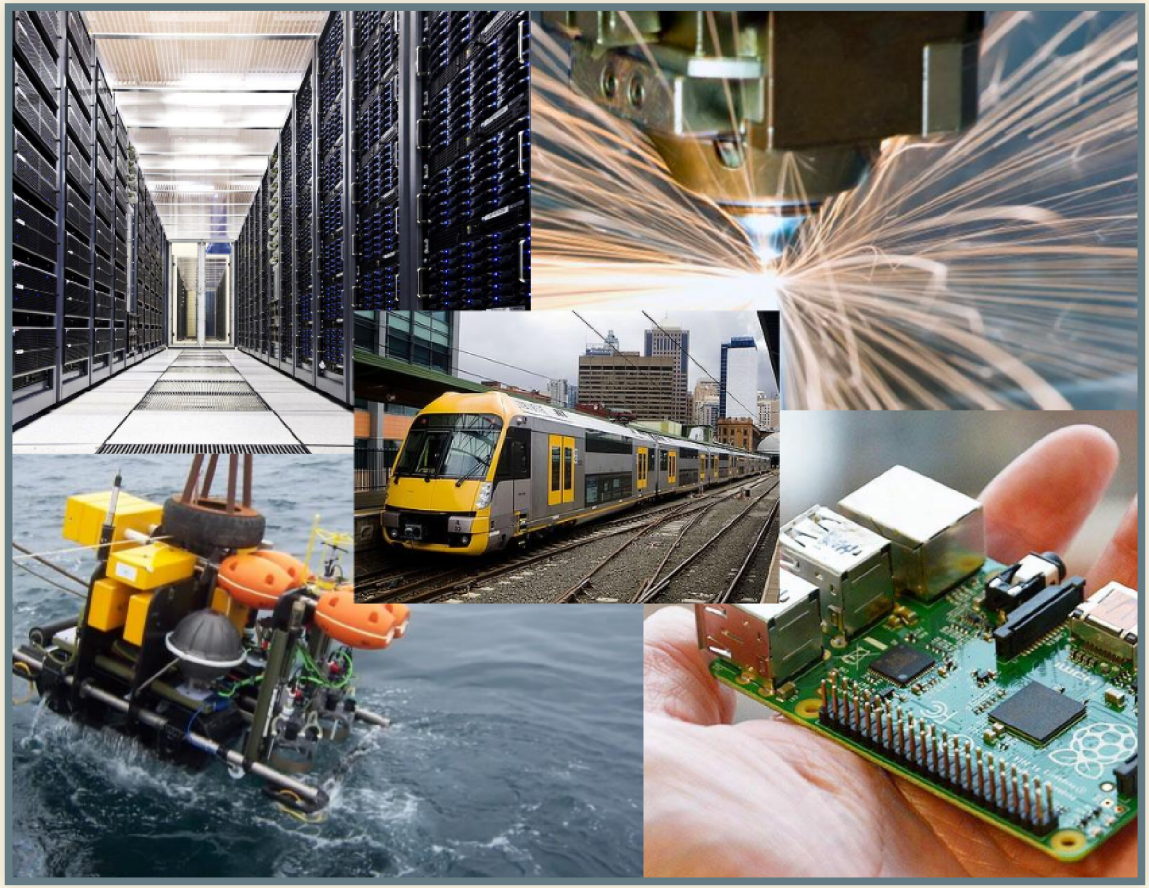
SECURE

A good track record.

- http://web.nvd.nist.gov/view/vuln/search

PORTABLE

Known to run on many platforms, and interesting places.

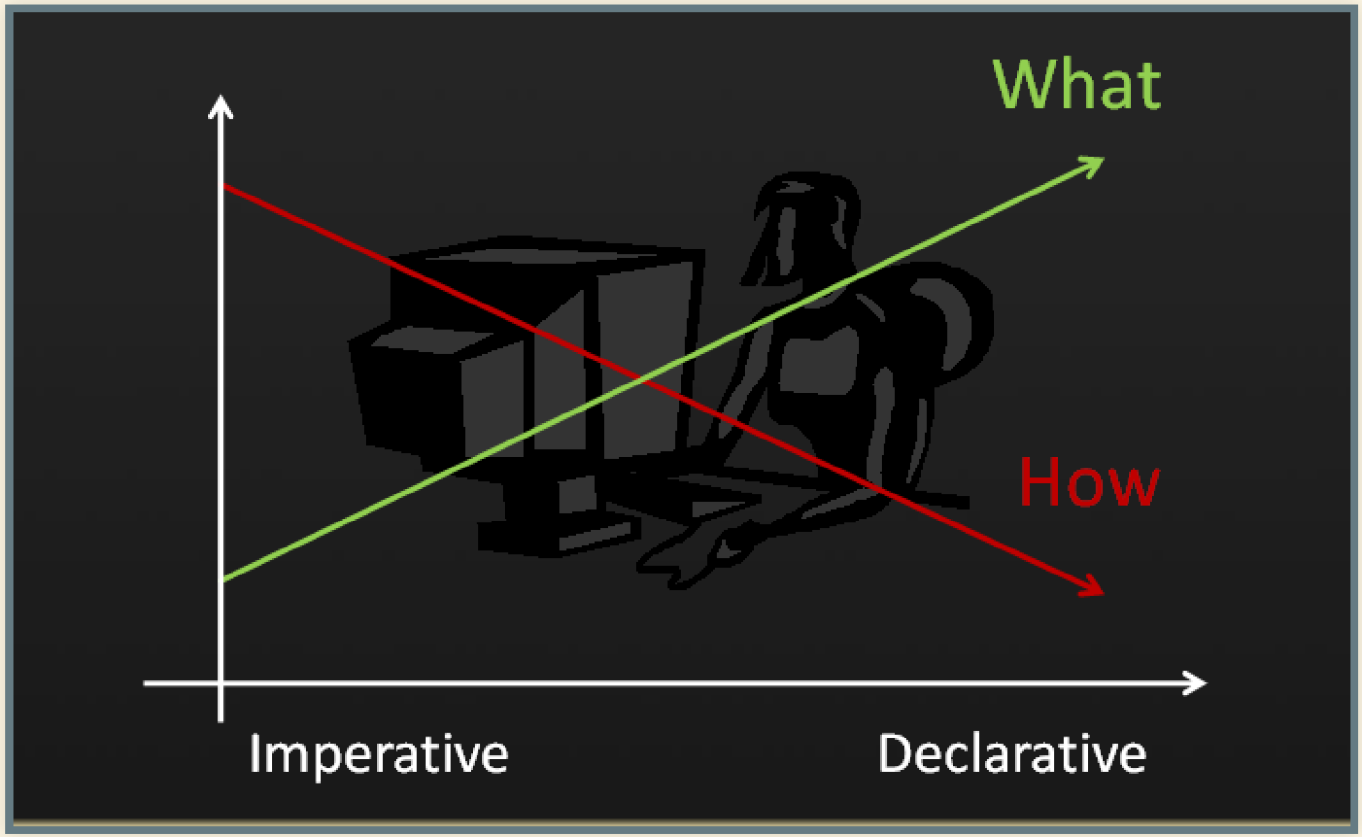


RESILIENT & AUTONOMOUS

- Policy cached locally
- Decisions made locally
- Actions taken locally
- Convergence, repair what you can and re-vist soon

DECLARATIVE

Focus on the **desired end state**


What
How
Imperative
Declarative

DECLARATIVE VS IMPERATIVE

```
bundle agent main                 | #!/bin/env/bash
{                                 | PKG="openssh-server"
  packages:                       | rpm -q ${PKG} || yum install ${PKG}
       "openssh-server"           | yum check-update openssh-server
         policy => "present",     | if [ $? -eq 100 ]; then
         version => "latest";     |   yum upgrade openssh-server
}                                 | fi
```

TYPICAL USE CASES

- Any **local** resource/state
  - Manage files, processes, commands
- Security Hardening
- Compliance
- Application Deployment/Management
- Inventory (with Enterprise)

EDITIONS

COMMUNITY (CORE)

- Github
- Tarballs
- Binary Packages
- Linux Package Repositories

Quick Install Community

```
wget -O- http://cfengine.package-repos.s3.amazonaws.com/\
  quickinstall/quick-install-cfengine-community.sh | sudo bash
```

ENTERPRISE FEATURES

- Dashboard
- Alerts and Triggered Actions
- Inventory Reporting
- Change Reporting
- File Integrity Monitoring
- Measurements
- REST APIs
- SQL Reporting
- Single Pane of Glass Reporting

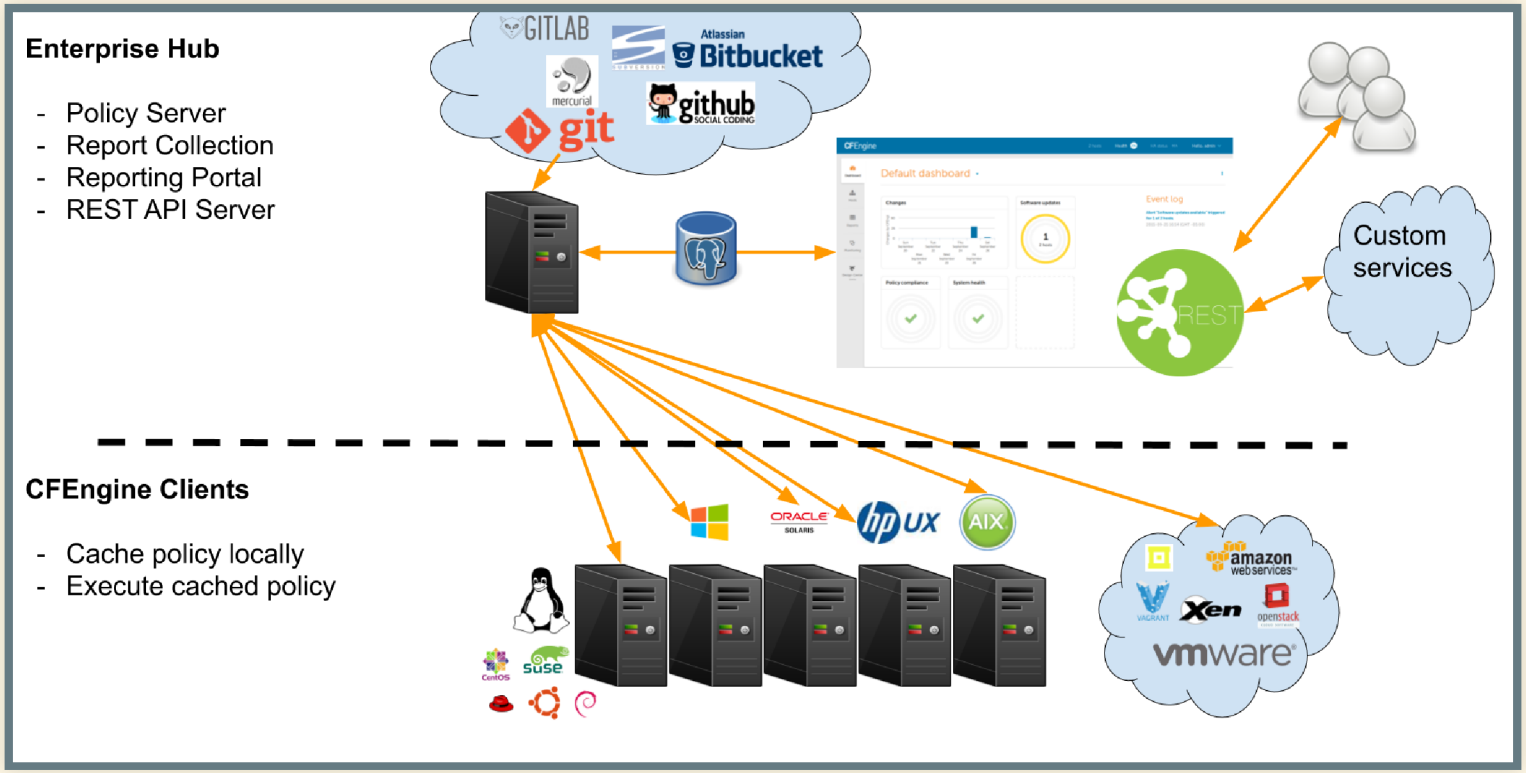
ENTERPRISE

- Vagrant Environment
- Binary Packages

Quick Install Enterprise

```
wget http://cfengine.package-repos.s3.amazonaws.com/quickinstall/\
quick-install-cfengine-enterprise.sh
sudo bash ./quick-install-cfengine-enterprise.sh <hub|agent>
```

CLIENT/SERVER ARCHITECTURE

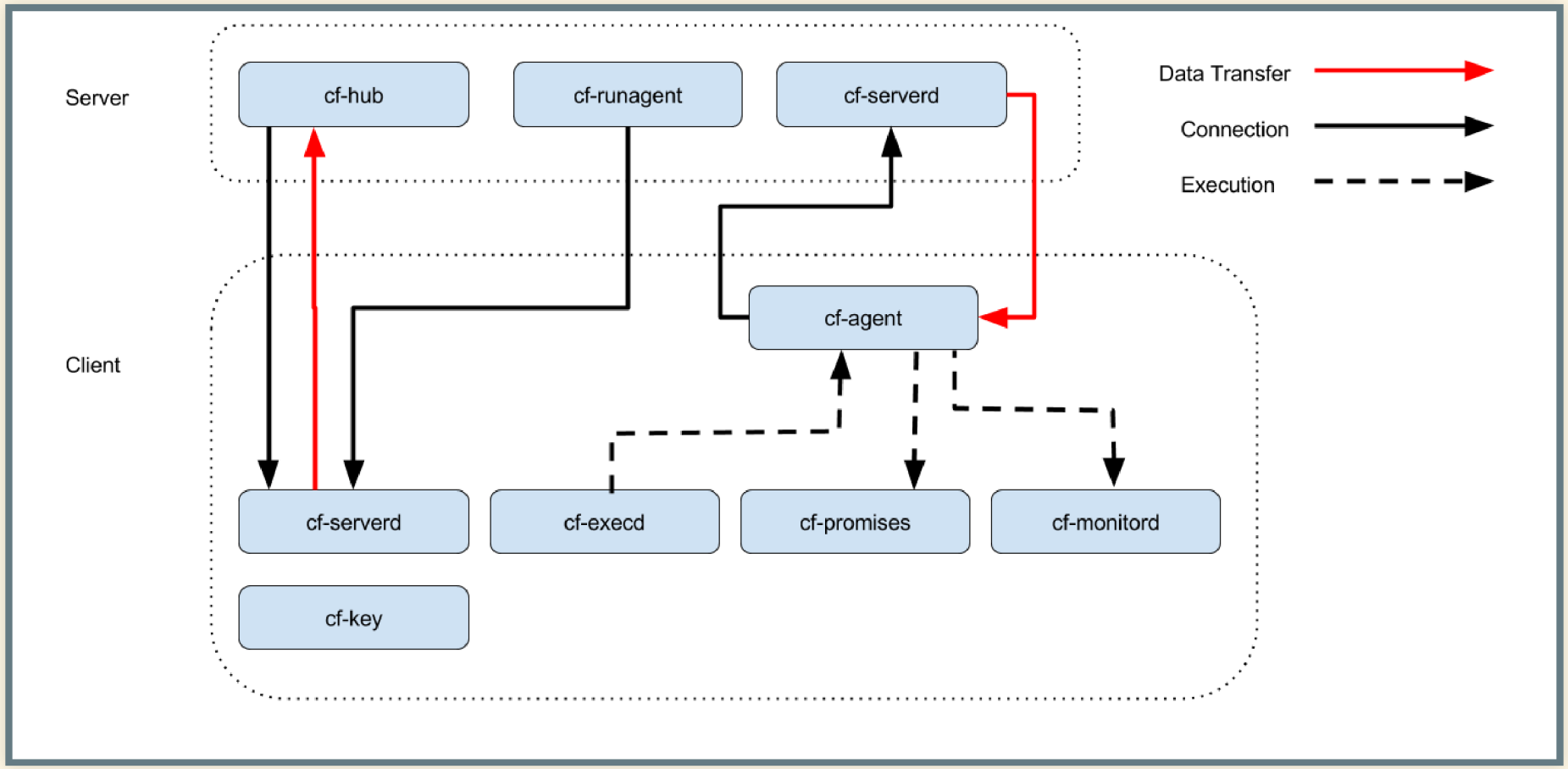


CLIENT SERVER COMMUNICATIONS

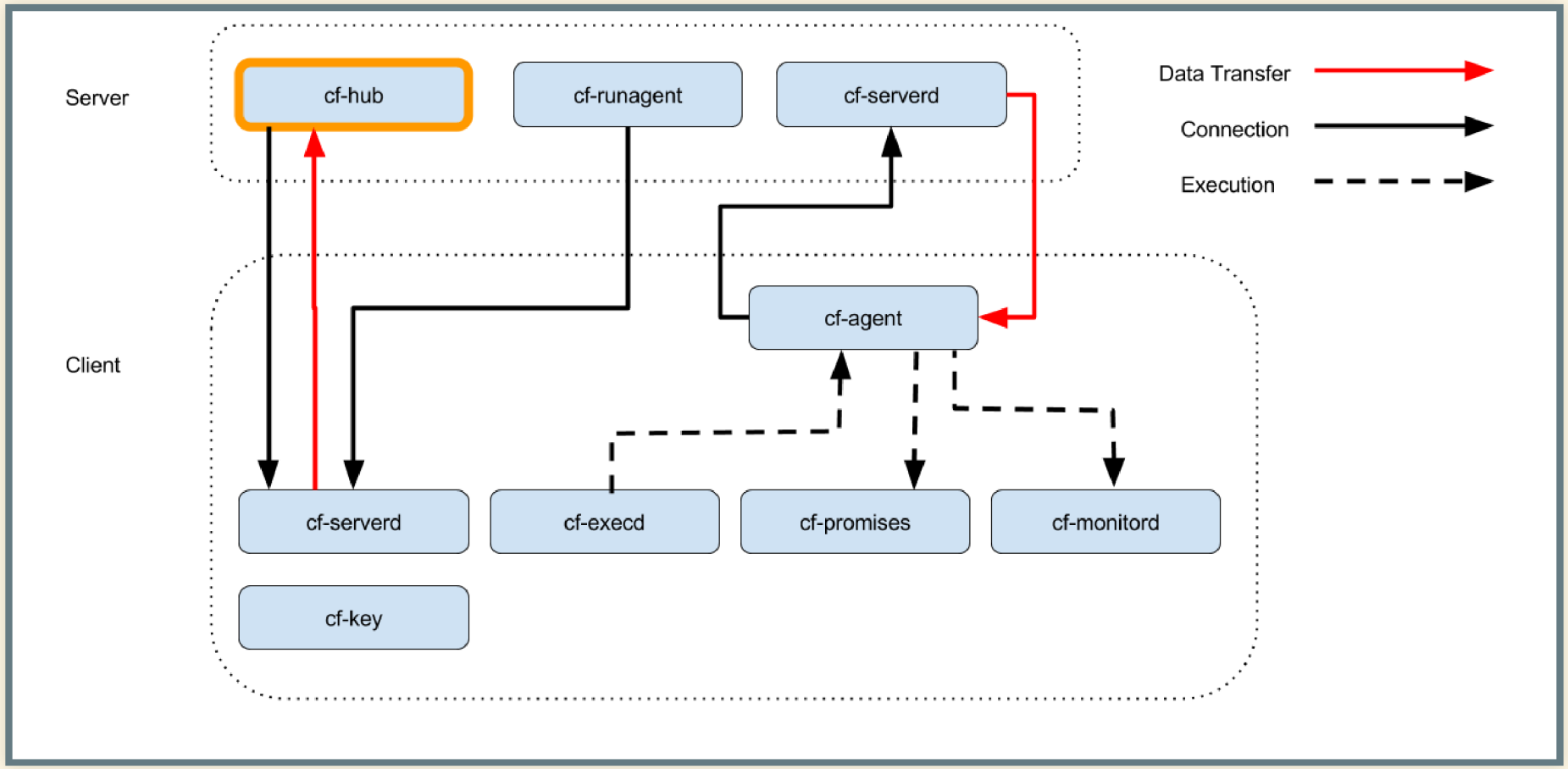
- Utilizes port 5308
- Encrypted (TLS)
- Public key authentication
- Agents download policy from hub
- Hub downloads reports from remote agents

AGENT COMPONENTS

AGENT COMPONENTS

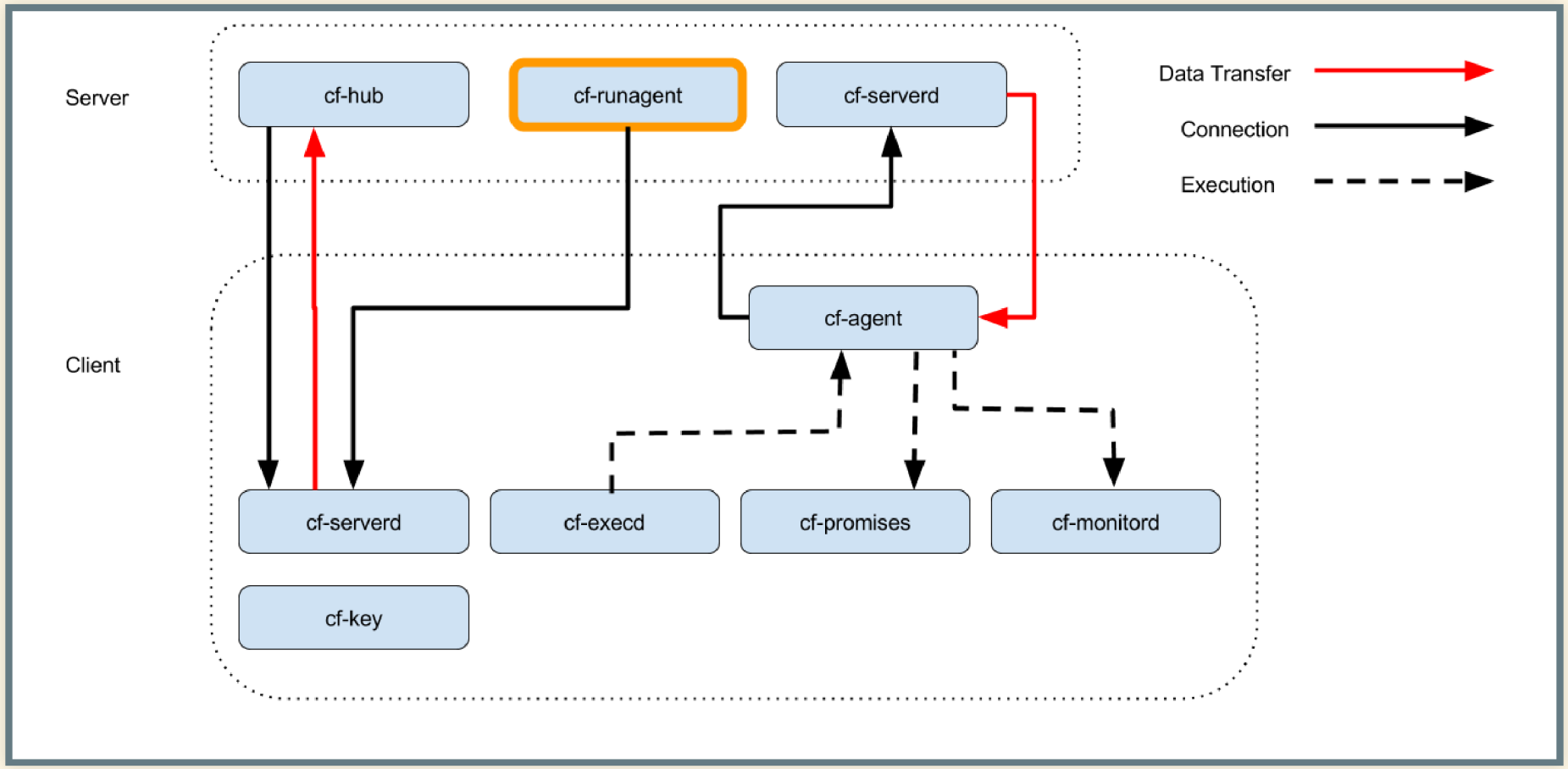


cf-hub


Server
cf-hub
cf-runagent
cf-serverd
Data Transfer
Connection
Execution
Client
cf-agent
cf-serverd
cf-execd
cf-promises
cf-monitord
cf-key

- Collects reports from remote agents
- Obeys `"common control"` and `"hub control"` bodies

cf-runagent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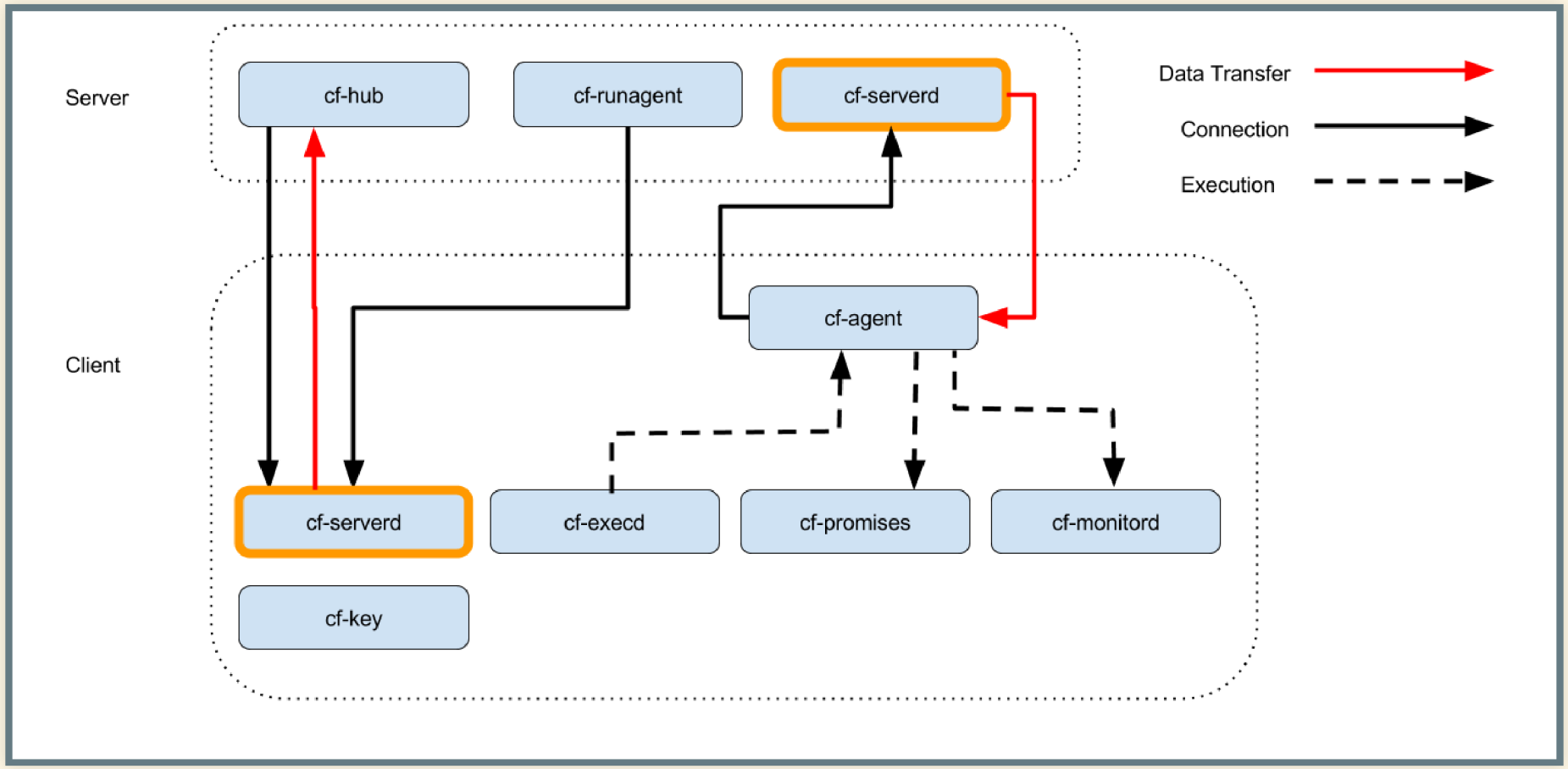
- Requests invocation of cf-agent on remote hosts
- Cannot invoke arbitrary commands
- Define classes to modify behavior (`--define`)
- Specify bundlesequence (`--remote-bundles`)

cf-serverd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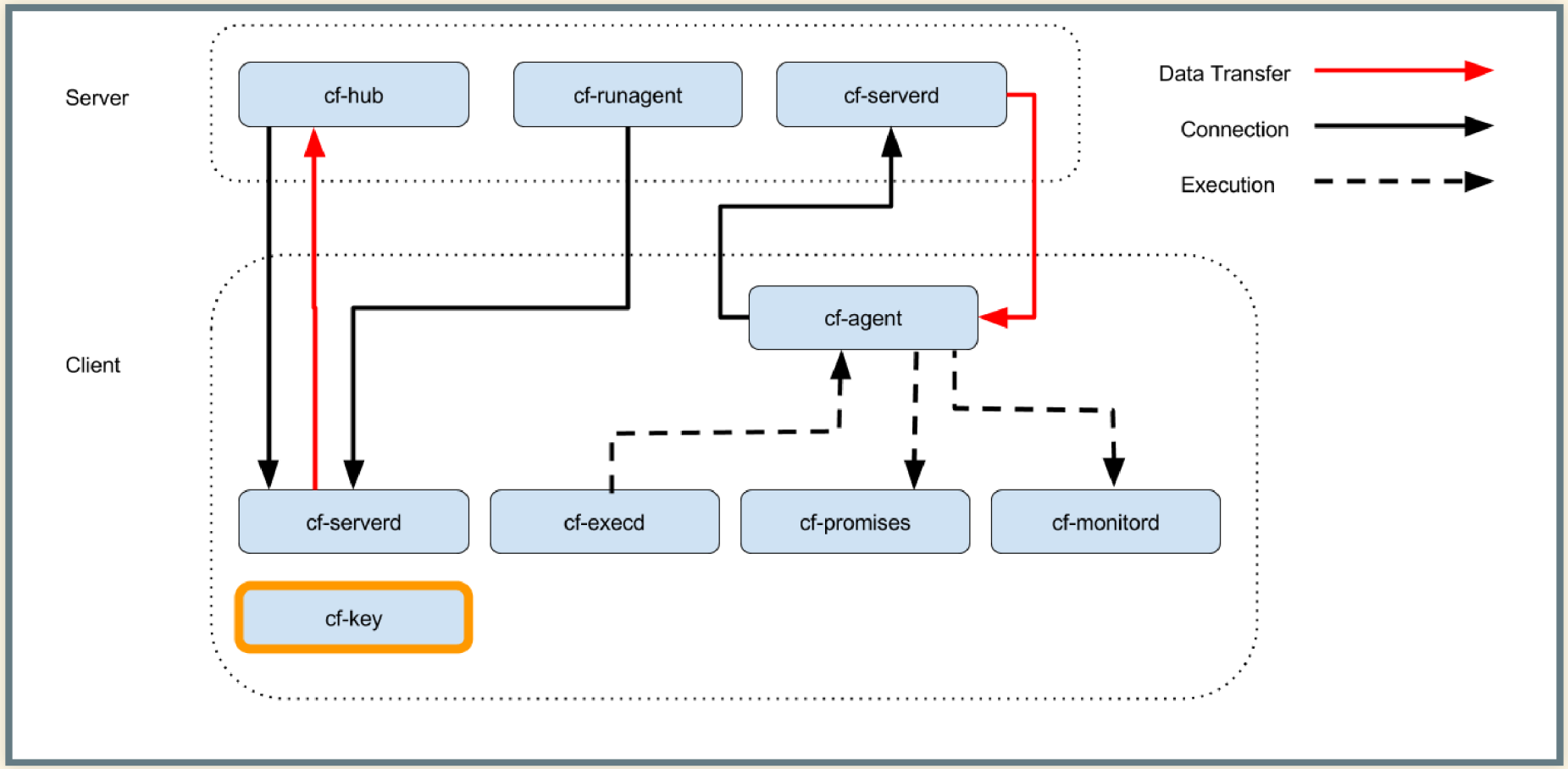
- Listens for connections on **TCP/5308**
- Enforces access control and authentication
- Serves files
- Serves `cf-runagent` requests
- Serves reports to `cf-hub`
- Runs on both server and clients
- Evaluates "`common`" and "`server`" bundles
- Obeys body "`server control`"

cf-key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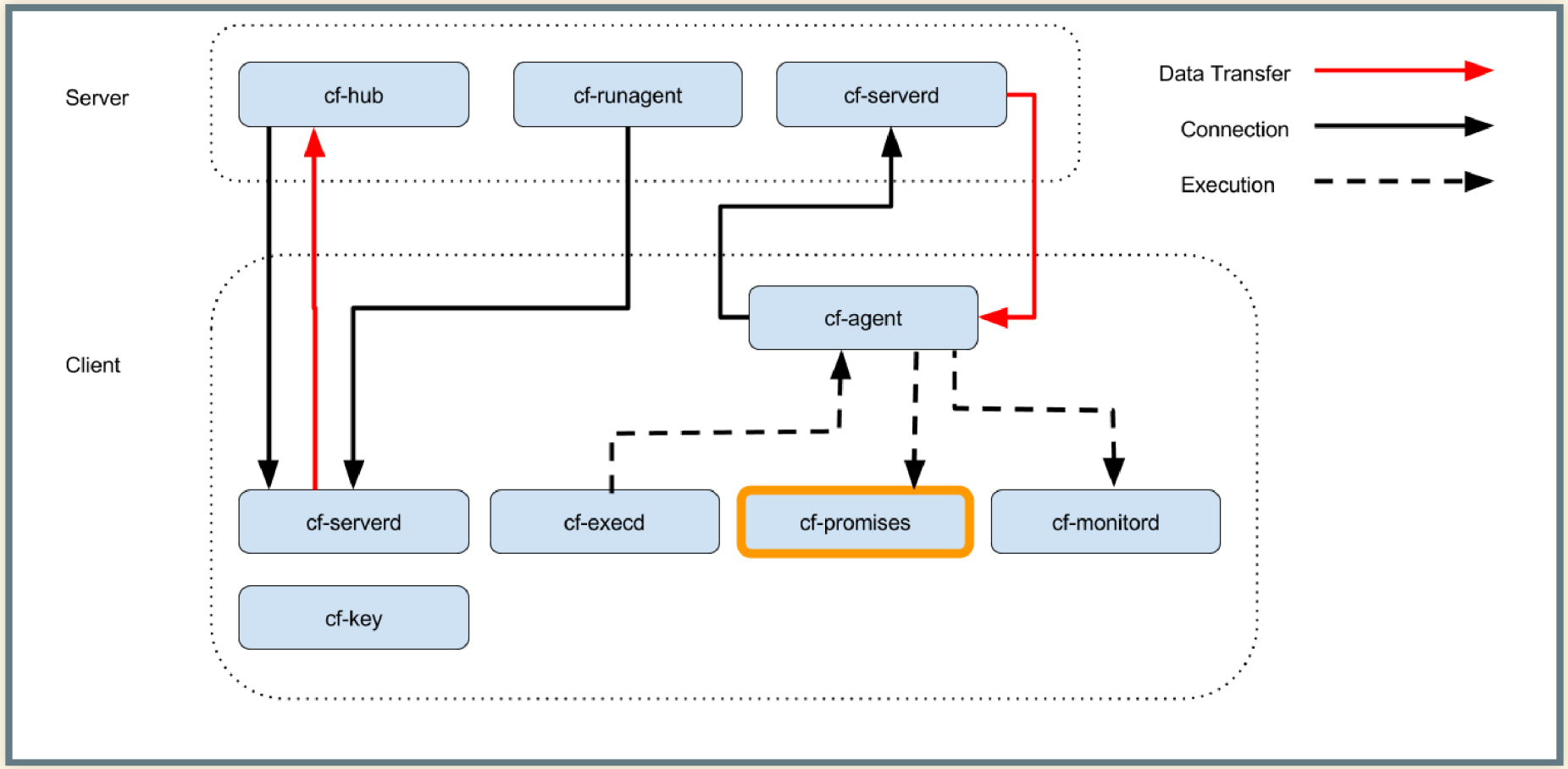
- Show recent connections
- Manage trust of public keys
- Generates key pairs
- Installs Enterprise License

cf-promises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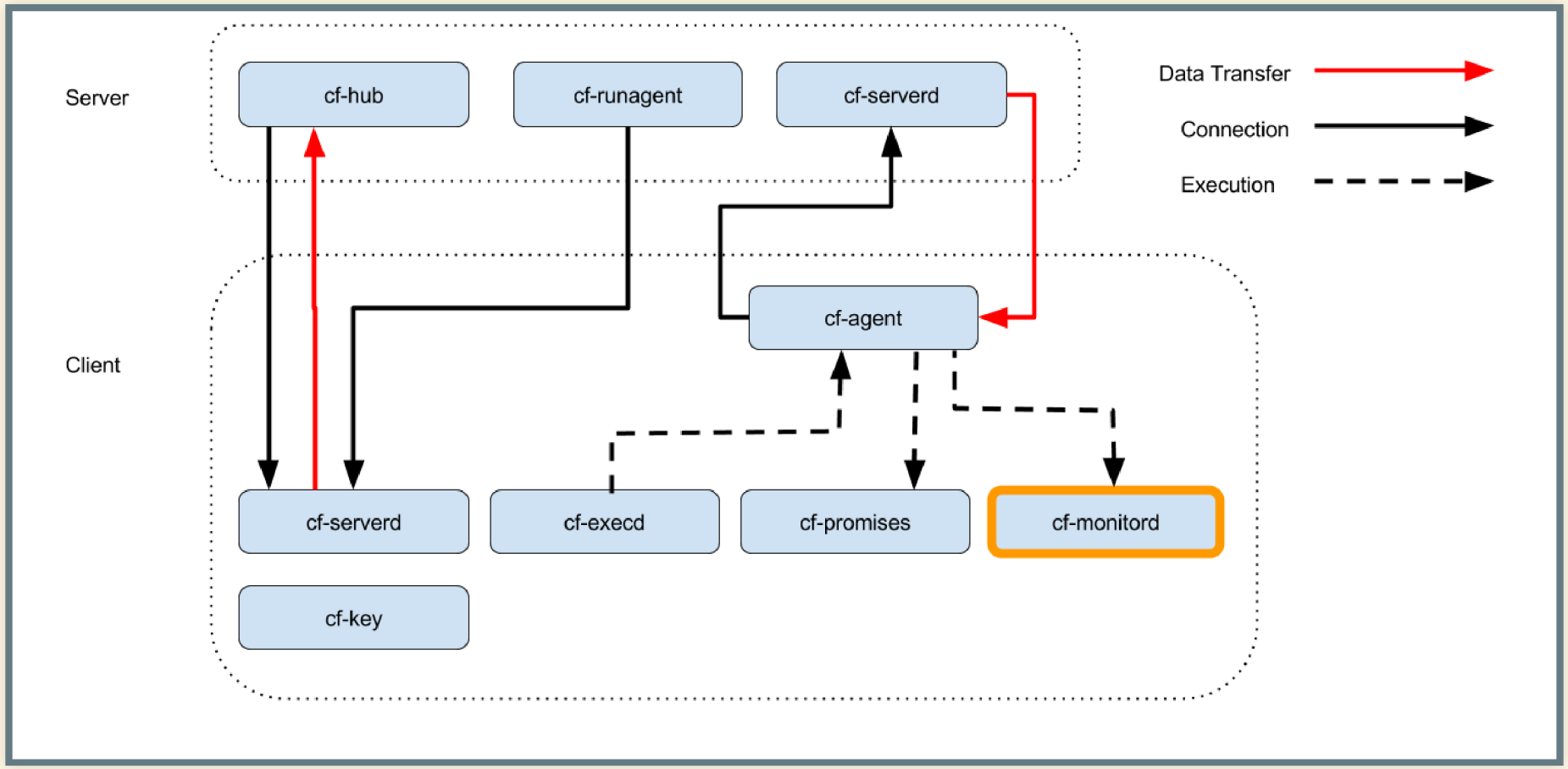
- Checks Syntax
- Dump Syntax (`cf-promises --syntax-description`
- Tag Policy Releases (`cf-promises --tag-release`)
- Show first order Variables and Classes (`cf-promises --show-vars --show-classes`

cf-monitord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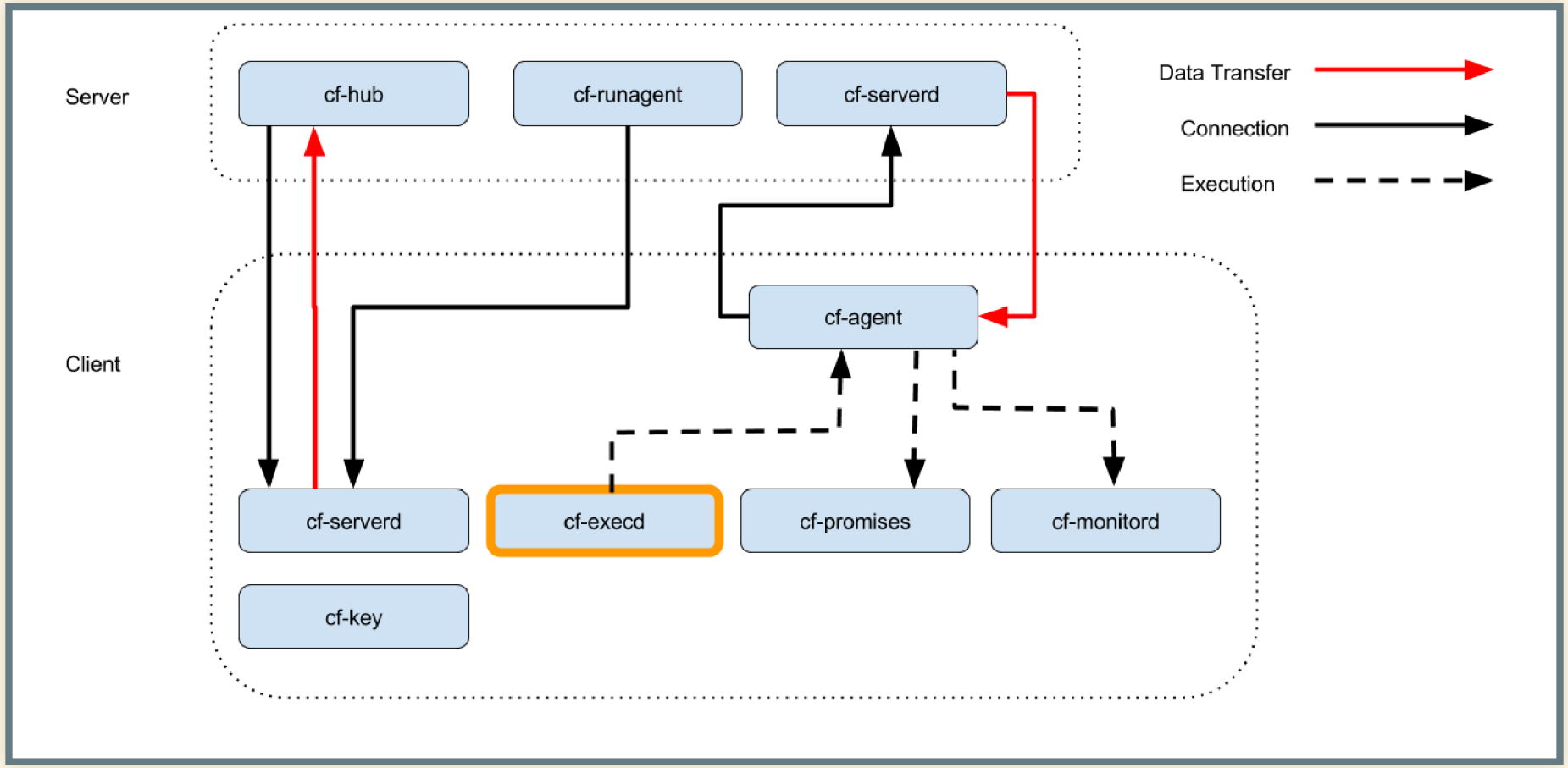
- Measures things
- Defines `mon.*` variables
- Defines classes based on anomaly detection
- Evaluates "`common`" and "`monitor`" bundles
- Obeys "`common control`" and "`monitor control`" bodies

cf-execd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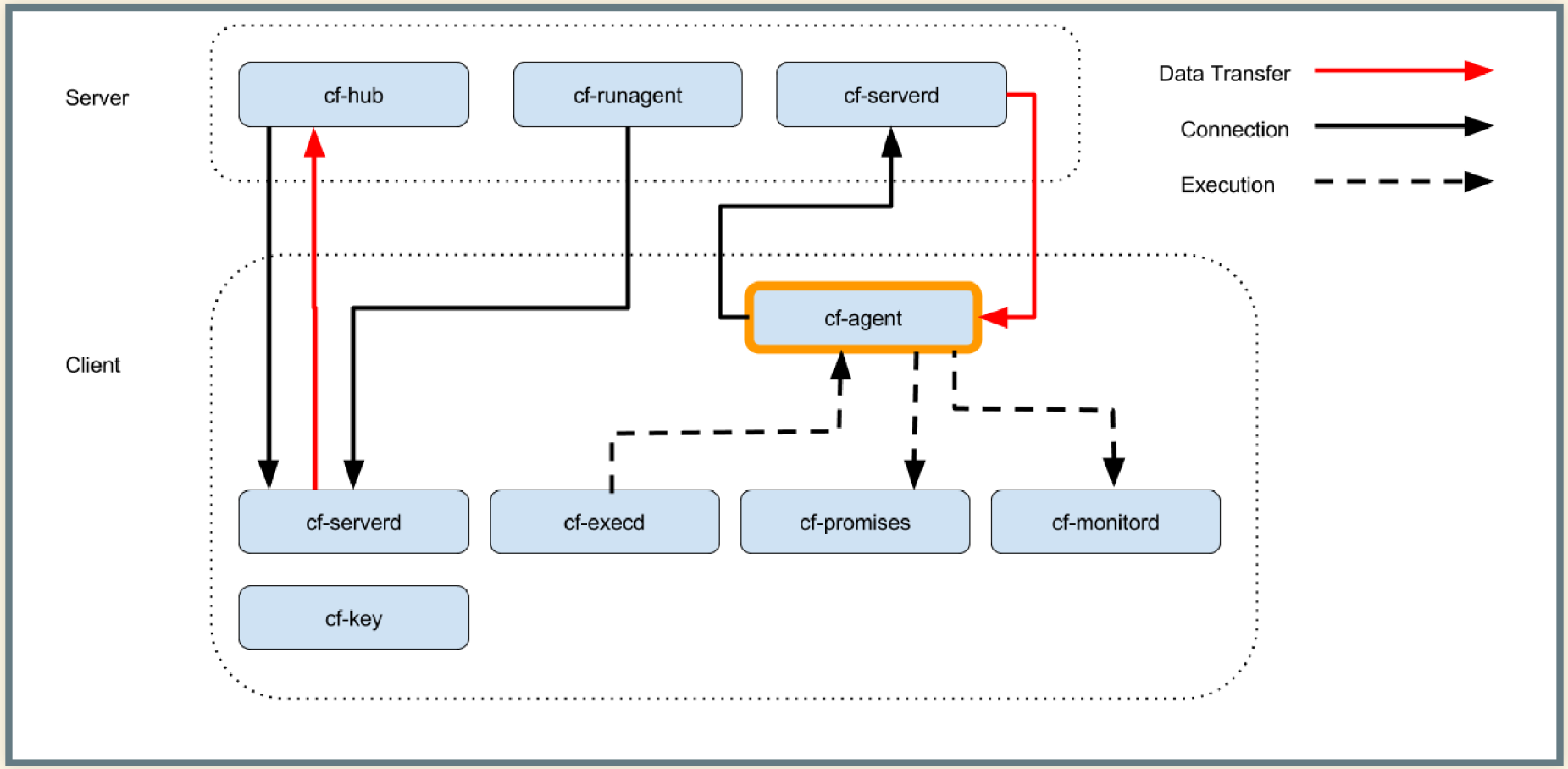
- Executes `cf-agent` periodically
- Controls period and splay time
- Collects, stores, and sends output
- Evaluates "`common`" bundles
- Obeys "`executor control`" body

cf-agent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- The catalyst or instigator of change
- Evaluates "`agent`" and "`common`" bundles
- Obeys "`common control`" and "`agent control`" bodies.
- By default runs `$(sys.default_policy_path)`
  - Privileged : `/var/cfengine/inputs/promises.cf`
  - Unprivileged: `~/.cfagent/inputs/promises.cf`

POP QUIZ

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- What needs to happen before remote agents can get policy from the hub?

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- What needs to happen before remote agents can get policy from the hub?
  - Where is the policy that the agent runs by default?
    - What port needs to be open bidirectionally?
- How does information from client hosts get into the Enterprise Hub Database?
- What is the meaning of life, the universe and everything?

MPF & STDLIB

The default "Masterfiles"

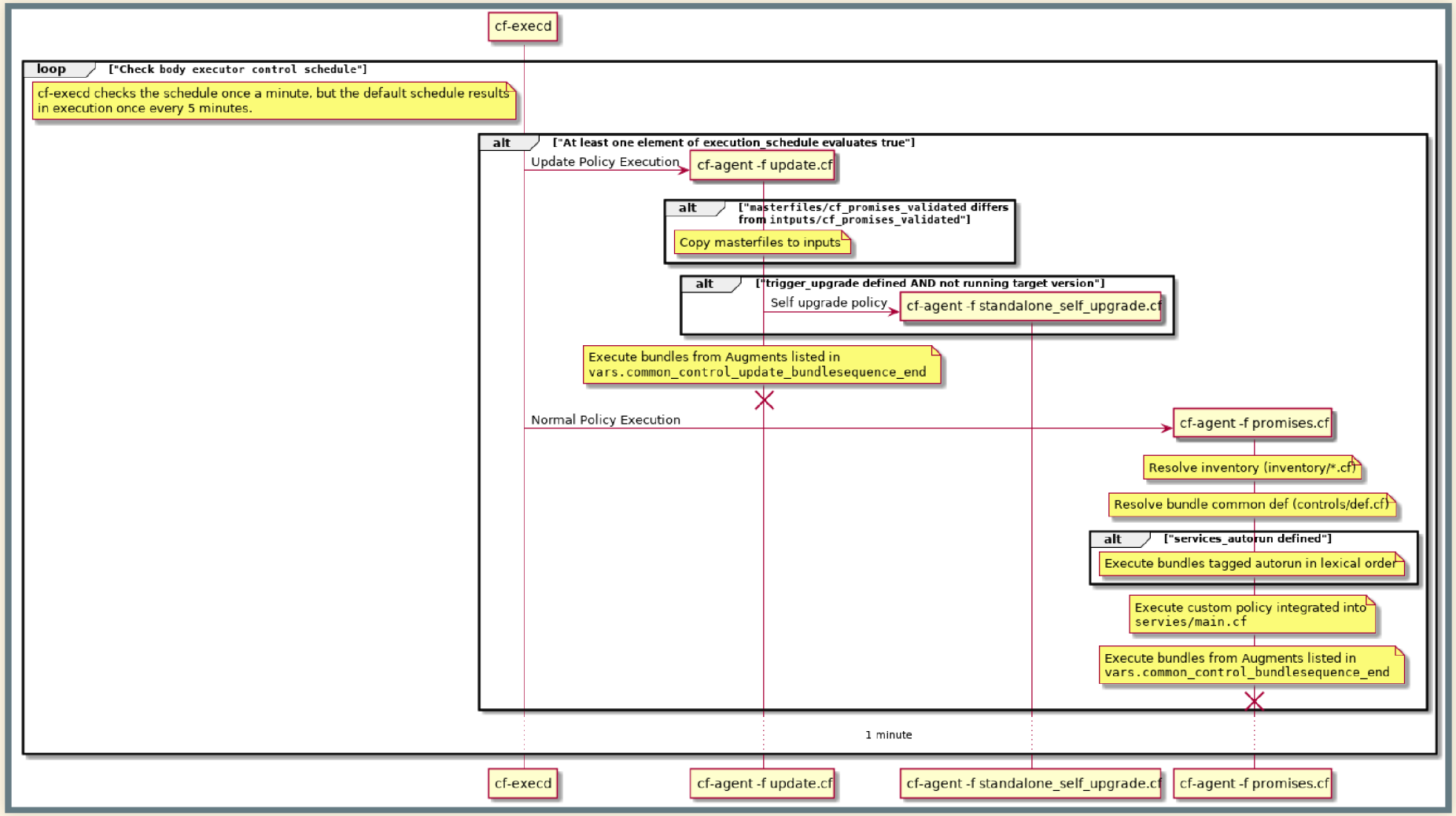
OVERVIEW

- promises.cf
- update.cf
- standalone_self_upgrade.cf
- lib/*
- cfe_internal/*
- controls/*
- inventory/*
- templates/*

USER ENTRIES

- `def.json` (*Augments*)
- `services/*.cf`
- `services/main.cf`
- `services/autorun/*.cf`
- `CUSTOM_DIRECTORY/*.cf`

UNATTENDED POLICY EXECUTION OVERVIEW



POP QUIZ

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- What is the *MPF*?

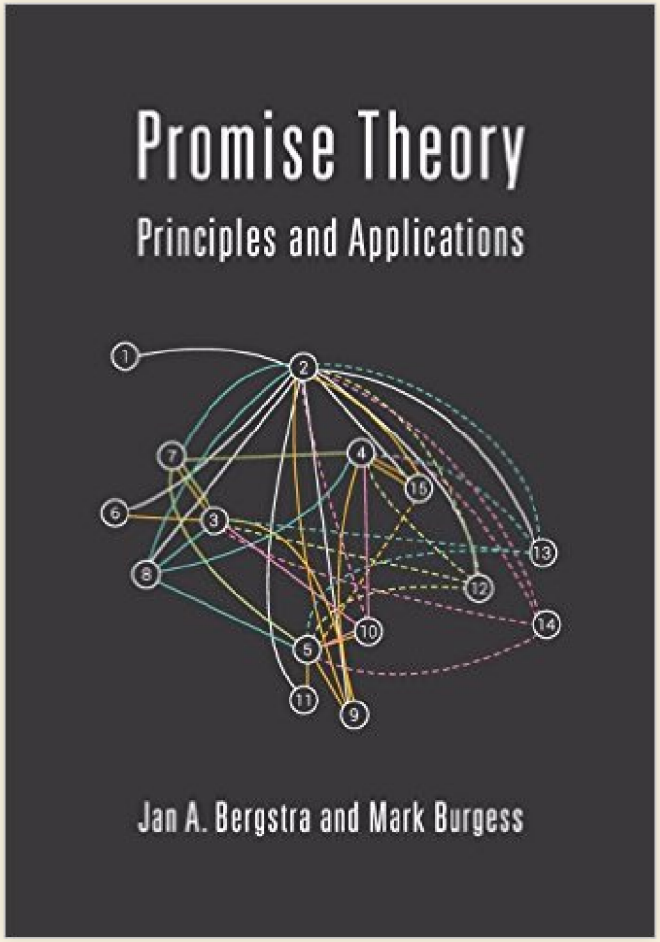
POP QUIZ

- What is the ***MPF***?
- Where do you configure *most* MPF tunables?

POP QUIZ

- What is the ***MPF***?
- Where do you configure *most* MPF tunables?
- When is the MPF typically upgraded?

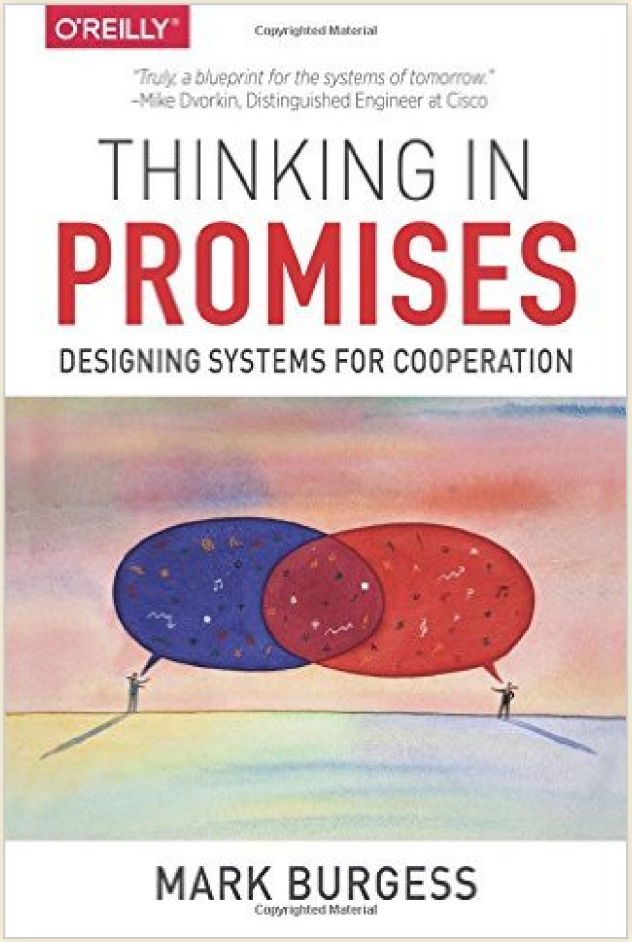
PROMISE THEORY



A model of **voluntary cooperation** between individual autonomous actors.

PROMISES

- A promise is a **statement of intent**
- Agents can only make promises about themselves



BASIC CONCEPTS

LANGUAGE

PROMISE OUTCOMES/RESULTS

- kept
- repaired
- not_kept
  - failed
  - denied
  - timeout

Note: Compound promises **can** have **multiple outcomes** at the same time (*not_kept* & *kept* & *repaired*).

```
files:
  "/mnt/volume/file.txt"
    create => "true",
    perms => m( 777 ),
    edit_line => lines_present( "Hello World $(sys.date)" ),
    edit_defaults => empty;
```

PROMISE TYPES

access, build_xpath, classes, **commands**, databases, defaults, delete_attribute, delete_lines, delete_text, delete_tree, field_edits, **files**, guest_environments, insert_lines, insert_text, insert_tree, measurements, meta, methods, **packages**, processes, replace_patterns, reports, roles, **services**, set_attribute, set_text, storage, users, vars

SYNTAX STRUCTURE

```
bundle type name
{
  promise_type:

    context::

      "promiser" -> { "optional", "stakeholder" }
        attribute_1 => value_1,
        attribute_2 => value_2,
        meta => { "tag1", "tag2", "tag3=something" },
        comment => "Why important";
}

body attribute_N name(optional)
{
    context::
      attribute_N_1 => "value";
      attribute_N_2 => { "value" };
}
```

BUNDLES

- Collection of logically related promises
- Can take parameters
- Maintain *some* variable state
- Can return values
- Are **not functions**

EXAMPLE BUNDLES HOLD *SOME* STATE

examples/example-bundles-maintain-some-variable-state.cf

```
bundle agent main
{
  methods:
      "" usebundle => set_item_in_bag( "hammer", "slightly damaged");
      "" usebundle => set_item_in_bag( "pickaxe", "perfect");
      "" usebundle => set_item_in_bag( "flask", "half full");
      "" usebundle => report_bag_contents;
  reports:
    "$(with)" with => join( ", ", getindices( "set_item_in_bag.array" ) );
}
bundle agent set_item_in_bag(item, value)
{
  vars:
    "$(item)" string => "$(value)";
    "array[$(item)]" string => "$(value)";
}
bundle agent report_bag_contents
{
  vars:
    "l" slist => variablesmatching("default:set_item_in_bag\..*");
    "a[$(l)]" string => nth( string_split( "$(l)", "\.", 2 ), 1);
  reports:"You look in the bag and see ...."; "A $($(l)) $(a[$(l)])";
}
```

```
R: You look in the bag and see ....
R: A slightly damaged hammer
R: A perfect pickaxe
R: A half full array[flask]
R: A half full flask
R: flask
```

BUNDLES FOR LOGICAL ABSTRACTION

For example, a bundle to configure Apache might:

- install the `apache2` package
- edit the configuration file
- copy the web server content
- configure file-system permissions
- ensure the httpd process is running
- restart the httpd process when necessary

BUNDLE TYPES

```
cf-promises --syntax-description json | jq '.bundleTypes | keys[]'
```

agent

evaluated by `cf-agent`

common

evaluated by **all** components

edit_line

evaluated by `cf-agent` for files type promises

edit_xml

evaluated by `cf-agent` for files type promises

monitor

evaluated by `cf-monitord`

server

evaluated by `cf-serverd`

BUNDLESEQUENCE

- `main` is the default
- `__main__` is treated as *main* if in `$(sys.policy_entry_filename)`

```
bundle agent inventory_things
{
  vars:
    "thing"
      string => readfile( "/tmp/thing", inf ),
      meta => { "inventory", "attribute_name=Inventoried Thing" };
}
bundle agent __main__
{
  methods: "inventory_things";
}
```

BODIES

- Collection of attributes
- Have a type (e.g. `classes`, `perms`, `copy_from`)
- Can take parameters
- Can be inherited (3.8+)
- Cab be *defaulted* for a given promise *type* (3.9+)

There are **41** body types as of 3.15.0

```
cf-promises --syntax-description json | jq '.bodyTypes | keys |join(", ") '
```

acl, action, agent, changes, classes, common, contain, copy_from, database_server, delete, delete_select, depth_search, edit_defaults, edit_field, environment_interface, environment_resources, executor, file, file_select, hub, insert_select, link_from, location, match_value, monitor, mount, package_method, package_module, password, perms, printfile, process_count, process_select, rename, replace_with, report_data_select, runagent, select_region, server, service_method, volume

SPECIAL BODIES THAT CONTROL AGENT BEHAVIOR

- body common control
- body file control
- body agent control
- body server control
- body executor control
- body hub control

DEFAULT BODIES

examples/default-bodies.cf

```
bundle agent main
{
  files:
    "/tmp/show_default_action"
      create => "true";

    "/tmp/show_explicit_action"
      create => "true",
      action => fix;
}

body action fix
{
  action_policy => "fix";
}

body file control
{
  namespace => "bodydefault";
}
body action files_action
{
  action_policy => "warn";
}
```

```
warning: Warning promised, need to create file '/tmp/show_default_action'
   info: Created file '/tmp/show_explicit_action', mode 0600
```

NORMAL ORDER

- The order in which CFEngine executes **promise types**
  - Classes then Vars are evaluated during policy parsing and pre-eval
  - Promises are evaluated from top to bottom respecting class restrictions
  - Bundles listed in the bundlesequence or activated via methods are given 3 pass evaluation

EXAMPLE:

```
bundle agent illustrating_normal_order
{
   vars:
     "color1" string => "red";

   reports:
     "$(color1)+$(color2) = Purple";

   vars:
     "color2" string => "blue";
}
```

```
# cf-agent --bundlesequence illustrating_normal_order --no-lock --log-level in
    info: Using command line specified bundlesequence
R: red+blue = Purple
```

```
bundle agent illustrating_normal_order
{
   vars:
     "color1" string => "red";
     "color2" string => "blue";

   reports:
     "$(color1)+$(color2) = Purple";
}
```

```
# cf-agent --bundlesequence illustrating_normal_order --no-lock --log-level in
    info: Using command line specified bundlesequence
R: red+blue = Purple
```

AUGMENTS (`def.json`)

- Very early definition
- Loaded if `def.json` is found next to `$(sys.policy_entry_filename)`
- Classes based on system discovery (platform/networks/arch)
- Variables defined in `def` bundle scope

EXAMPLE AUGMENTS

examples/augments/def.json

```
{
  "classes": {
      "by_regular_expression": [ "ubuntu_\\d+" ],
      "by_class_expression": [ "(Afternoon|Evening).(Monday|Wednesday|Friday)
  },
  "vars": {
      "myvar1": "defined from augments",
      "myvar2": "defined from augments"
    }
}
```

EXAMPLE POLICY USING AUGMENTS

examples/augments/augments.cf

```
bundle agent main
{
  reports:
    "I defined '$(const.dollar)(def.myvar1)' as '$(def.myvar1)'";

    by_regular_expression::
      "Define classes from augments based on a regular expression";

    by_class_expression::
      "Define classes from augments based on CFEngine class expressions";

}
```

EXAMPLE OUTPUT

```
cf-agent --no-lock --file ./examples/augments/augments.cf
```

```
R: I defined '$(def.myvar1)' as 'defined from augments'
R: Define classes from augments based on a regular expression
R: Define classes from augments based on CFEngine class expressions
```

POLICY ALWAYS WINS!

examples/augments/augments-policy-wins.cf

```
bundle common def
{
  vars:
    "myvar1" string => "Defined in policy";
    "myvar2"
      string => "Defined in policy",
      if => not( isvariable( myvar2 ) );
}
bundle agent main
{
  reports:
    "I defined '$(const.dollar)(def.myvar1)' as '$(def.myvar1)'";
    "I defined '$(const.dollar)(def.myvar2)' as '$(def.myvar2)'";

    by_regular_expression::
      "Define classes from augments based on a regular expression";

    by_class_expression::
      "Define classes from augments based on CFEngine class expressions";
}
```

EXAMPLE OUTPUT

```
cf-agent --no-lock --file ./examples/augments/augments-policy-wins.cf
```

```
R: I defined '$(def.myvar1)' as 'Defined in policy'
R: I defined '$(def.myvar2)' as 'defined from augments'
R: Define classes from augments based on a regular expression
R: Define classes from augments based on CFEngine class expressions
```

MULTIPLE AUGMENTS

Merge more augments on top.

examples/augments-multiple/def.json

```
{
  "vars": {
      "myvar1": "defined from augments for all",
      "myvar2": "defined from augments for all"
    },
  "augments": [ "$(sys.policy_entry_dirname)/$(sys.os).json" ]
}
```

examples/augments-multiple/linux.json

```
{
  "vars": {
      "myvar2": "override for linux hosts"
    }
}
```

MULTIPLE AUGMENTS: EXAMPLE POLICY

examples/augments-multiple/promises.cf

```
bundle agent main
{
  reports:
    "'$(const.dollar)(def.myvar1)' is '$(def.myvar1)'";
    "'$(const.dollar)(def.myvar2)' is '$(def.myvar2)'";
}
```

```
cf-agent --no-lock --file ./examples/augments-multiple/promises.cf
```

```
R: '$(def.myvar1)' is 'defined from augments for all'
R: '$(def.myvar2)' is 'override for linux hosts'
```

MACROS

- Prevent parsing
- Use for supporting future syntax, speed optimizations

MINIMUM_VERSION

examples/macros-if-minimum_version.cf

```
bundle agent example_macro_minimum_version
{
@if minimum_version(4.0.0)
  This contains completely invalid syntax, but it's OK.
  Only versions 4 and greater will evaluate this section.
@endif
@if minimum_version(3.14.0)
      # the function `classfiltercsv()` was introduced in 3.14.0
  vars:
      "container"  data => classfiltercsv( $(file), # File
                                           true, # Has header
                                           0, # Class column
                                           2); # Optional sort column
@endif
}
```

FEATURE

- Feature Macro documentation

You can conditionally parse policy based on compiled in features using this macro.

examples/macros-if-feature-yaml.cf

```
bundle agent main
{
@if feature(yaml)
# the yaml library may not be compiled in
  vars: "container" data => parseyaml('
- array1
- array2
- key: 1
- key: 2');
@endif

  reports:
    "$(with)" with => string_mustache('{{%-top-}}', container );
}
```

FUNCTIONS

There are 171 functions as of 3.15.0

accessedbefore, accumulated, ago, and, basename, bundlesmatching, bundlestate, callstack_callers, callstack_promisers, canonify, canonifyuniquely, changedbefore, classesmatching, classfiltercsv, classify, classmatch, concat, countclassesmatching, countlinesmatching, data_expand, data_readstringarray, data_readstringarrayidx, data_regextract, data_sysctlvalues, datastate, difference, dirname, diskfree, escape, eval, every, execresult, expandrange,

file_hash, fileexists, filesexist, filesize, filestat, filter, findfiles, findprocesses, format, getclassmetatags, getenv, getfields, getgid, getindices, getuid, getuserinfo, getusers, getvalues, getvariablemetatags, grep, groupexists, hash, hash_to_int, hashmatch, host2ip, hostinnetgroup, hostrange, hostsseen, hostswithclass, hubknowledge, ifelse, intersection, ip2host, iprange, irange, isdir, isexecutable, isgreaterthan, isipinsubnet, islessthan, islink, isnewerthan, isplain, isvariable,

join, lastnode, laterthan, ldaparray, ldaplist, ldapvalue, length, lsdir, makerule, maparray, mapdata, maplist, max, mean, mergedata, min, network_connections, none, not, now, nth, on, or, packagesmatching, packageupdatesmatching, parseintarray, parsejson, parserealarray, parsestringarray, parsestringarrayidx, parseyaml, peerleader, peerleaders, peers, processexists, product, randomint, read_module_protocol, readcsv, readdata, readenvfile,

readfile, readintarray, readintlist, readjson, readrealarray, readreallist, readstringarray, readstringarrayidx, readstringlist, readtcp, readyaml, regarray, regcmp, regex_replace, regextract, registryvalue, regldap, regline, reglist, remoteclassesmatching, remotescalar, returnszero, reverse, rrange, selectservers, shuffle, some, sort, splayclass, splitstring, storejson, strcmp, strftime, string_downcase, string_head, string_length, string_mustache, string_replace, string_reverse, string_split, string_tail, string_upcase, sublist, sum, sysctlvalue, translatepath, unique, url_get, usemodule, userexists, variablesmatching, variablesmatching_as_data, variance

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- What is the fundamental underlying philosophy that CFEngine is based on?

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- What is the fundamental underlying philosophy that CFEngine is based on?
- When is the next break?
- Which component collects reports from remote agents?
- What types of bundles are there?
- In what order are promises within a bundle processed?
- How can you use a new language features when you still have some old agents?

MAKING DECISIONS: CONTEXT CLASSES AND EXPRESSIONS

CLASSES

- Restrict promises based on context.
- Usable in bundles and bodies
- Used for making decisions
- Can be combined with expressions

WHAT CLASSES ARE DEFINED?

Before 3 pass evaluation

```
cf-promises --show-classes
```

At the end of a policy run

```
cf-agent --show-evaluated-classes
```

Currently within a policy

```
vars:
  "defined" slist => classesmatching( ".*" );
```

EXAMPLE

```
cf-promises --show-classes | tail -n+2 | awk -vORS=", " '{print $1}'
```

127_0_0_1, 172_17_0_1, 192_168_122_1, 192_168_42_189, 4_cpus, 64_bit, Afternoon, Day23, February, GMT_Day23, GMT_Evening, GMT_February, GMT_Hr18, GMT_Hr18_Q3, GMT_Lcycle_1, GMT_Min30_35, GMT_Min34, GMT_Q3, GMT_Sunday, GMT_Yr2020, Hr12, Hr12_Q3, Lcycle_1, Min30_35, Min34, PK_SHA_43c979e264924d0b4a2d3b568d71ab8c768ef6348 Q3, Sunday, Yr2020, any, cfengine, cfengine_3, cfengine_3_15, cfengine_3_15_0, common, compiled_on_linux_gnu, debian, debian_buster, enterprise, enterprise_3, enterprise_3_15, enterprise_3_15_0, enterprise_edition,

fe80__5ee0_c5ff_fe9f_f38f, feature, feature_curl, feature_def, feature_def_json, feature_def_json_preparse, feature_tls, feature_tls_1, feature_tls_1_0, feature_tls_1_1, feature_tls_1_2, feature_tls_1_3, feature_xml, feature_yaml, ipv4_127, ipv4_127_0, ipv4_127_0_0, ipv4_127_0_0_1, ipv4_172, ipv4_172_17, ipv4_172_17_0, ipv4_172_17_0_1, ipv4_192, ipv4_192_168, ipv4_192_168_122, ipv4_192_168_122_1, ipv4_192_168_42, ipv4_192_168_42_189, ipv4_gw_192_168_42_1, ipv6_fe80__5ee0_c5ff_fe9f_f38f, linux, linux_5_0_0_38_lowlatency, linux_x86_64, linux_x86_64_5_0_0_38_lowlatency, linux_x86_64_5_0_0_38_lowlatency__41_Ubuntu_SMP_PREE

mac_02_42_fb_b7_c0_59, mac_52_54_00_6b_62_06, mac_5c_e0_c5_9f_f3_8f, my_other_example, net_iface_docker0, net_iface_lo, net_iface_virbr0, net_iface_wlan0, nickanderson_thinkpad_w550s, nova, nova_3, nova_3_15, nova_3_15_0, nova_edition, systemd, test_class_29665402e2b4331f10b8d767b512cd916eeb5db9
test_class_29665402e2b4331f10b8d767b512cd916eeb5db9
ubuntu, ubuntu_19, ubuntu_19_04, x86_64,

CLASS EXPRESSIONS

Table 2: Class Expressions

. (dot)	**AND**
& (ampersand)	**AND**
| (pipe)	**OR**
! (exclamation)	**NOT**
() (parenthesis)	**grouping**

- It's more common to use **.** than **&** to express AND

EXAMPLE ILLUSTRATING CLASS EXPRESSIONS

examples/00-01-using_class_expressions.cf

```
bundle agent main
{
  files:
    linux.(Sunday|Saturday)::
      "/etc/nologin" -> { "Human Resources" }
        create => "true",
        comment => "Disallow non-root logins on the weekend.
                    We believe in work-life balance, and
                    encourage it.";

    linux.!(Sunday|Saturday)::
      "/etc/nologin" -> { "Business Operations" }
        delete => tidy,
        comment => "People need to be able to log in for them
                  to do their work during the week";
}
```

CLASS TYPES

- Hard Classes
- Soft Classes

HARD CLASSES

- Defined by agent
- Not configurable
- Always available
- Discovered each run
- Cannot be undefined

`redhat`, `Thursday`, `linux`

SOFT CLASSES

- Defined by policy
- Based on anything
- Available after definition
- Can persist for period of time
- Can be namespace or bundle scoped
- Can be undefined only as the result of a promise

VALID CLASS NAMES

- Allowed characters include `[a-zA-Z0-9_]`
- **Canonify** a string to produce a valid class name
  - Converts invalid characters to _.
- Automatically canonified **when defined**

Note: Classes are **NOT** automatically canonified when **checked**.

EXAMPLE OF AUTOMATIC CANONIFICATION

examples/00-01-classes_canonification.cf

```
bundle agent main
{
  vars:
    "my_class_name" string => "Invalid-Class/Name!";
    "c_my_class_name" string => canonify( "$(my_class_name)" );

  classes:
    "$(my_class_name)" expression => "any";

  reports:

    "'$(my_class_name)' is **NOT** a class that is defined"
      unless => "$(my_class_name)";

    "'$(c_my_class_name)' **IS** a defined class"
      if => canonify( $(my_class_name) );
}
```

```
R: 'Invalid-Class/Name!' is **NOT** a class that is defined
R: 'Invalid_Class_Name_' **IS** a defined class
```

CLASS SCOPE

- Namespace scoped classes are accessible from any bundle.
- Persist until end of agent run or explicitly undefined.
- Bundle scoped classes are only accessible from within the bundle the class was defined.
- All hard classes are namespace scoped

CLASS SCOPE RULES

Table 3: Default scope for `classes` **type** promises

Bundle Type	Scope
`common`	`namespace`
`agent`	`bundle`

- `classes` bodies default to **namespace scope**

Pro Tip: Use **`bundle`** scoped classes whenever possible.

DEFINE CUSTOM CLASSES BY EXPRESSION

examples/00-10-classes_by_expression.cf

```
bundle agent main
{
  classes:
    "weekend" or => { "Saturday", "Sunday" };
    "weekday" not => "weekend";

    "business_hours"
      expression => "weekday.(Hr9|Hr10|Hr11|Hr13|Hr14|Hr15|Hr16|Hr17)",
      comment => "Weekdays from 9-5 excluding the lunch hour.";

    "webserver"
      expression => regcmp( "www.*", $(sys.fqhost) ),
      comment => "Identify webservers based on their name";

    "north_america"
      expression => iprange( "10.1.0.0/16" );
}
```

DEFINE CUSTOM CLASSES BY PROMISE OUTCOME

examples/00-10-classes_define_based_on_promise_outcome.cf

```
bundle agent main
{
  vars:
    "config[PermitRootLogin]" string => "no";

  files:
    "/etc/ssh/sshd_config"
      edit_line => set_line_based("$(this.bundle).config", # Config MAP
                                  " ",         # Separator
                                  "\s+",       # Separator regex
                                  ".*",        # Keys to consider
                                  "\s*#\s*"), # Lines to ignore
      classes => scoped_classes_generic("bundle", "sshd_config");

  services:
    sshd_config_repaired::
      "sshd"
        service_policy => "restart",
        comment => "For sshd to pick up changed config it must be restarted."
}
```

EXAMPLE - TRADITIONAL CLASS EXPRESSIONS

examples/00-10-classes_traditional_expression.cf

```
bundle agent main
{
  reports:
      "Hello World!";
    linux.!(Saturday|Sunday)::
      "This is a linux host.";
      "Today is not Saturday or Sunday.";
}
```

```
R: Hello World!
R: This is a linux host.
R: Today is not Saturday or Sunday.
```

EXAMPLE - RESTRICT INDIVIDUAL PROMISES WITH IF AND UNLESS

examples/00-10-classes_example_if_and_unless.cf

```
bundle agent main
{
  vars:
    "platforms" slist => { "linux", "windows" };

  reports:
    "I am a $(platforms) host"
      if => "$(platforms)";
      # ifvarclass => "$(platforms)";

    "I was made by Microsoft"
      unless => "!windows";
}
```

```
R: I am a linux host
```

EXAMPLE - VARIABLE CLASS EXPRESSIONS

examples/00-10-classes_example_variable_class_expressions.cf

```
bundle agent main
{
  vars:
    "platforms" slist => { "linux", "windows" };

  reports:
    !(Saturday|Sunday)::
      "It's a weekday and I am a $(platforms) host!"
        if => "$(platforms)";

    "$(platforms)"::
      "I am a $(platforms) host and it's a weekday!"
        if => "!(Saturday|Sunday)";
}
```

```
R: It's a weekday and I am a linux host!
R: I am a linux host and it's a weekday!
```

FUNCTIONS THAT RETURN "CONTEXT"

```
cf-promises --syntax-description json | jq '.functions | \
   with_entries( select(.value.returnType == "context") ) | \
   keys | join( ", ")'
```

accessedbefore, changedbefore, classify, classmatch, every, fileexists, filesexist, groupexists, hashmatch, hostinnetgroup, hostrange, iprange, isdir, isexecutable, isgreaterthan, isipinsubnet, islessthan, islink, isnewerthan, isplain, isvariable, laterthan, ldaparray, none, processexists, read_module_protocol, regarray, regcmp, regextract, regldap, regline, reglist, remoteclassesmatching, returnszero, some, splayclass, strcmp, usemodule, userexists

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  - What is the difference?
  - What are valid class characters?
- What is the default scope for classes defined as the result of a promise outcome using a classes body?
- What component serves policy files, which hosts can be a policy server?

VARIABLES & DATA TYPES

VARIABLE SCOPING

- All variables are globally accessible
- `$(variable)`, `@(list or data container)`
- Use fully qualified variable names when accessing variables in other bundles.
  - `$(bundle.variable)`, `@(bundle.list)`
  - `$(namespace:bundle.variable)`, `@(namespace:bundle.list)`

DATATYPES

- string
- slist, ilist, rlist
- classic "array"
- data

EXAMPLE - STRINGS

examples/00-01-strings.cf

```
bundle agent main
{
  vars:
   "string1" string => "one";
    "string2" string => "strings
can be multi-line";
    "string3" string => "with \"quotes\"";
    "string4" string => 'or "quotes"';
    "string5" string => `with 'single' and "double" quotes`;

  reports:
    "string1 = '$(string1)'";
    "string2 = '$(string2)'";
    "string3 = '$(string3)'";
    "string4 = '$(string4)'";
    "string5 = '$(string5)'";
}
```

```
R: string1 = 'one'
R: string2 = 'strings
can be multi-line'
R: string3 = 'with "quotes"'
R: string4 = 'or "quotes"'
R: string5 = 'with 'single' and "double" quotes'
```

EXAMPLE - NUMBERS

examples/00-02-numbers.cf

```
bundle agent main
{
  vars:
    "var1" int => "1";
    "var2" int => "10K";
    "var3" real => "1.2";
    "var4" real => "10e-5";
    "var5" int => "inf";

  reports:
    "var1 = '$(var1)'";
    "var2 = '$(var2)'";
    "var3 = '$(var3)'";
    "var4 = '$(var4)'";
    "inf = '$(var5)'";
}
```

```
R: var1 = '1'
R: var2 = '10240'
R: var3 = '1.200000'
R: var4 = '0.000100'
R: inf = '999999999'
```

EXAMPLE - LISTS

examples/00-04-lists.cf

```
bundle agent main
{
  vars:
    "var1" ilist => { 1, 2, "3", "4" };
    "var2" rlist => { "1.2", "2.0", "3.3" };
    "var3" slist => { "one", "two", three,
                      @(var1), @(var2),
                    };
    "var4" real => sum( var2 );

  reports:
    "var1 = '$(var1)'";
    "var2 = '$(var2)'";
    "var3 = '$(var3)'";
    "var4 = '$(var4)'";
}
```

```
R: var1 = '1'
R: var1 = '2'
R: var1 = '3'
R: var1 = '4'
R: var2 = '1.2'
R: var2 = '2.0'
R: var2 = '3.3'
R: var3 = 'one'
R: var3 = 'two'
R: var3 = 'three'
R: var3 = '1'
R: var3 = '2'
R: var3 = '3'
R: var3 = '4'
R: var3 = '1.2'
R: var3 = '2.0'
R: var3 = '3.3'
R: var4 = '6.500000'
```

EXAMPLE - LIST ITERATION (LOOPS)

examples/00-03-list_iteration.cf

```
bundle agent main
{
  vars:
    "numbers" slist => { "1", "2", "3" };
    "colors" slist => { "red", "green", "blue" };

  reports:
    "$(numbers)";
    "$(colors)";
    "$(numbers) with $(colors)";
    "$(colors) with $(numbers)";
}
```

```
R: 1
R: 2
R: 3
R: red
R: green
R: blue
R: 1 with red
R: 1 with green
R: 1 with blue
R: 2 with red
R: 2 with green
R: 2 with blue
R: 3 with red
R: 3 with green
R: 3 with blue
R: red with 1
R: red with 2
R: red with 3
R: green with 1
R: green with 2
R: green with 3
R: blue with 1
R: blue with 2
R: blue with 3
```

EXAMPLE - "CLASSIC" ARRAYS

examples/00-05-classic_arrays.cf

```
bundle agent main
{
  vars:
    "file[motd]"  string => "/etc/motd";
    "file[fstab]" string => "/etc/fstab";

    "file_idx" slist => getindices( file );
    "files" slist => getvalues( file );

  reports:
   "The key '$(file_idx)' has the value '$(file[$(file_idx)])'";
   "file: '$(files)'";
}
```

```
R: The key 'motd' has the value '/etc/motd'
R: The key 'fstab' has the value '/etc/fstab'
R: file: '/etc/motd'
R: file: '/etc/fstab'
```

EXAMPLE - DATA CONTAINERS

examples/00-06-data_containers.cf

```
bundle agent main
{
  vars:
    "server" string => "mirror.int.cfengine.com";
    "repos"
      data => parsejson('{
                "rhel6_updates": {
                  "id": { "value":"RHEL6_UPDATES" },
                  "name": { "value": "RHEL 6.x Updates" },
                  "baseurl": { "value": "https://$(server)/RHEL6/updates" }
                }
              }');

    "idx" slist => getindices( repos );

  reports:
    "URL = '$(repos[$(idx)][baseurl][value])'";
}
```

```
R: URL = 'https://mirror.int.cfengine.com/RHEL6/updates'
```

DIFFERENCES BETWEEN "CLASSIC ARRAYS" AND "DATA CONTAINERS"

examples/00-04-classicarray-vs-datacontainer.cf

```
bundle agent main
{
  vars:
      "ClassicArray[key]" string => "value";
      "ClassicArray[deep]" slist => { "list" };
      "DataContainer"
        data => '{ "key": "value", "deep": [ "list" ] }';

  reports:
      "ClassicArray:$(with)"
        with => string_mustache( "{{%-top-}}", ClassicArray);
      "DataContainer:$(with)"
        with => string_mustache( "{{%-top-}}", DataContainer);
}
```

```
R: ClassicArray:{
  "deep": [
    "list"
  ],
  "key": "value"
}
R: DataContainer:{
  "deep": [
    "list"
  ],
  "key": "value"
}
```

POP QUIZ

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- Which component makes changes to your system?

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- Which component makes changes to your system?
  - Which component schedules agent runs?

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- What symbol terminates a promise?

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- Which component makes changes to your system?
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- What is your quest?
- What are promise comments used for?
- What types of variables are available?
- How are decisions made?

POLICY EXAMPLES

ENABLE SERVICES_AUTORUN

```
[root@hub masterfiles]# cat > def.json <<EOF
{
    "classes": {
        "cfengine_internal_masterfiles_update": [
            "policy_server"
        ],
        "services_autorun": [ "any" ]
    }
}
EOF
```

CREATE A FILE

Copy this example to

services/autorun/nologin.cf

examples/00-20-example-create_file.cf

```
bundle agent nologin
{
  files:
     "/tmp/nologin"
        create => "true",
        classes => results("bundle", "my_file");

   reports:
    my_file_repaired::
     "File repaired";

     any::
      "File Exists"
        if => fileexists("/tmp/nologin");
}
```

```
R: File repaired
R: File Exists
```

UPDATE FILE

examples/00-20-example-update_file.cf

```
bundle agent main
{
  meta:
    "tags" slist => { "autorun" };

  files:
    "$(sys.statedir)/$(this.bundle)" -> { "Monitoring" }
      create  => "true",
      touch   => "true",
      classes => scoped_classes_generic("bundle", "heartbeat"),
      handle  => "cf_agent_heartbeat_thump",
      comment => "This policy simply updates the timestamp
                  of the file so an external monitoring
                  system can validate the system is working.";

  reports:
    DEBUG|DEBUG_cf_agent_heartbeat::

      "DEBUG $(this.bundle): Heartbeat"
        if => "heartbeat_repaired";

      "DEBUG $(this.bundle): Flatline"
        unless => "heartbeat_repaired";
}
```

```
R: DEBUG main: Heartbeat
```

INSTALL A PACKAGE AND START A SERVICE

examples/00-20-example-package_and_service.cf

```
bundle agent main
{
  vars:
      "config[driftfile]" string => "/var/lib/ntp/drift";

  packages:
      "ntp" policy => "present";

  services:
      "ntpd" service_policy => "start";

       "ntpd"
        service_policy => "restart",
        if => "ntpd_conf_repaired";

  files:
      "/etc/ntp.conf"
        edit_line => set_line_based("$(this.bundle).config", # Key Values
                                    " ",          # Separator
                                    "\s+",        # Separator regex
                                    ".*",         # Keys to use
                                    "\s*#\s*"), # Ignore lines
        classes => results("bundle", "httpd_conf");
}
```

CLASSIFY ROLE BASED ON HOSTNAME

examples/00-20-example-classes-role_by_hostname.cf

```
bundle common classes_role_by_hostname
{
  classes:
    "env_prod"
      meta => { "inventory", "attribute_name=Role Classes" };
      or => {
              regcmp( "hub", $(sys.fqhost) ),
              regcmp( "^prd.*", $(sys.fqhost) ),
            };

    "webserver"
      expression => "host001",
      meta => { "inventory", "attribute_name=Role Classes" };

    "webserver"
      expression => regcmp( "^www.*", $(sys.fqhost) ),
      meta => { "inventory", "attribute_name=Role Classes" };
}
```

CLASSIFY GEOGRAPHIC LOCATION BY NETWORK

examples/00-20-example-classes-geographic_location_by_network.cf

```
bundle common classify_geo_location_by_network
{
  meta:
    "tags" slist => { "autorun" };

  vars:
    "nadc01_subnets"
      slist => { "172.16.25.0/25", "172.17.0.0/16",
                 "192.168.33.2/32",
               };

    "nadc02_subnets"
      slist => { "172.17.5.0/25", "172.42.0.0/16",
                 "192.168.33.3/32",
               };

    "sadc01_subnets"
      slist => { "172.19.4.0/23", "192.168.33.4-5" };

    "continent"
      string => ifelse("north_america", "North America",
                       "south_america", "South America",
                       "Unknown"),
```

```
meta => { "inventory", "attribute_name=Continent" };
```

Continued examples/00-20-example-classes-geographic_location_by_network.cf

```
  classes:
    "north_america"
      or => { "nadc01", "nadc02" };

    "south_america"
      expression => classmatch("^sadc\d+");

    "nadc01"
      expression => iprange( $(nadc01_subnets) );

    "nadc02"
      expression => iprange( $(nadc02_subnets) );

    "sadc01"
      expression => iprange( $(sadc01_subnets) );

  reports:
    "DEBUG|DEBUG_$(this.bundle)"::
      "DEBUG $(this.bundle): Continent = '$(continent)'";
}
```

MANAGE KEY VALUE ENTRIES IN A CONFIG FILE

manage_ssh in examples/00-20-example-key_value_config.cf

```
bundle agent manage_ssh
{
  meta:
    "tags" slist => { "autorun" };

  methods:
    "SSH Config Data"
      usebundle => ssh_config;

    "Manage SSH Config"
      usebundle => ssh_config_manage_kv("ssh_config.data");
}
```

ssh_config in examples/00-20-example-key_value_config.cf

```
bundle agent ssh_config
{
  vars:
      "data[PermitRootLogin]" string => "no";
      "data[Protocol]" string => "2";
      "data[Port]" string => "22";

    DEBUG|DEBUG_ssh_config::
      "keys" slist => getindices(data);

  reports:
    DEBUG|DEBUG_ssh_config::
      "DEBUG $(this.bundle): $(keys) = '$(data[$(keys)])'";
}
```

ssh_config_manage_kv in examples/00-20-example-key_value_config.cf

```
bundle agent ssh_config_manage_kv(data)
{
  vars:
    "config" string => "/etc/ssh/sshd_config";

  files:
    "$(config)"
      handle => "ssh_config_manage_kv_entries",
      edit_line => set_line_based("$(data)", " ", "\s+", ".*", "\s*#\s*"),
      classes => scoped_classes_generic("bundle", "sshd_config");

  classes:
    sshd_config_repaired::
      "config_valid"
        expression => returnszero("/usr/sbin/sshd -t -f $(config)", noshell),
        comment => "It's important that we don't restart the service with a
                    broken config, or the service will be down.";

  commands:
    sshd_config_repaired.config_valid::
      "$(paths.service)"
        handle => "ssh_config_manage_kv_restart_after_config_change",
        args => "sshd restart",
        comment => "The service must be restarted in order to pick up new
                    configuration settings.";

  reports:
```

```
      "DEBUG $(this.bundle): Reparied configuration"
        if => "sshd_config_repaired";

      "DEBUG $(this.bundle): Configuration Valid"
        if => "config_valid";

      "DEBUG $(this.bundle): Restarted sshd after config change"
        depends_on => { "ssh_config_manage_kv_restart_after_config_change" };
}
```

```
[root@hub masterfiles]# cf-agent -KID DEBUG_ssh_config,DEBUG_ssh_config_manage
    info: Installing cfe_internal_non_existing_package...
R: DEBUG ssh_config: PermitRootLogin = 'no'
R: DEBUG ssh_config: Protocol = '2'
R: DEBUG ssh_config: Port = '22'
    info: Edit file '/etc/ssh/sshd_config'
R: DEBUG ssh_config_manage_kv: Reparied configuration
    info: Executing 'no timeout' ... '/sbin/service sshd restart'
  notice: Q: "...in/service sshd": Stopping sshd:          [  OK  ]
Q: "...in/service sshd": Starting sshd:                    [  OK  ]
    info: Last 2 quoted lines were generated by promiser '/sbin/service sshd r
    info: Completed execution of '/sbin/service sshd restart'
R: DEBUG ssh_config_manage_kv: Configuration Valid
R: DEBUG ssh_config_manage_kv: Restarted sshd after config change
```

TEMPLATING A FILE WITH MUSTACHE

examples/00-20-example-mustache_template_vars.cf

```
bundle agent motd
{
  meta:
    "tags" slist => { "autorun" };

  vars:
    "owner" string => "Bruce Wayne";

  files:
    "/etc/motd"
      template_method => "inline_mustache",
      edit_template_string => 'Welcome to {{{vars.sys.fqhost}}}!

For support issues please contact {{{vars.motd.owner}}}.';
}
```

MUSTACHE EXTENSIONS

- `-top-` data handed to the templating engine
- @ Currently iterated *key*
- % Multi-line JSON representation of data
- $ Serialized JSON representation of data

`examples/02-01-mustache-extensions.cf`

```
bundle agent main
{
  vars: "d" data => '{ "key": "value", "list": ["one", "two"]}';
  reports:
    "Multiline: $(with)" with => string_mustache( "{{%-top-}}", d);
    "Serial: $(with)" with => string_mustache( "{{$-top-}}", d);
    "Keys: $(with)" with => string_mustache( "{{#-top-}}{{{@}}}, {{/top}}", d
}
```

```
R: Multiline: {
  "key": "value",
  "list": [
    "one",
    "two"
  ]
}
```

```
R: Serial: {"key":"value","list":["one","two"]}
R: Keys: key, list,
```

INVENTORY SSH HOST KEYS

```
bundle agent main
{
  vars:
      "keys" slist => lsdir("/etc/ssh", "ssh_host_\w+_key", "false");
      "$(keys)"
        data => data_regextract("ssh_host_(?<type>\w+)_key", $(keys) );

      "type[$(keys)]"
        string => "$($(keys)[type])",
        meta => { "inventory", "attribute_name=SSH HostKey Type" };

      # Warning ssh-keygen output may vary across versions
      "fingerprint[$(keys)]"
        string => nth(
                      string_split(
                                   execresult("/usr/bin/ssh-keygen -l -f /et
                                              noshell),
                                   "\s+", 5), 1),
        meta => { "inventory", "attribute_name=SSH HostKey Fingerprint" };

  reports:
      "/etc/ssh/$(keys).pub
        type: $($(keys)[type])
        fingerprint: $(fingerprint[$(keys)])";
}
```

```
R: /etc/ssh/ssh_host_ed25519_key.pub
        type: ed25519
        fingerprint: SHA256:NA04HcvSPZ/wAp/vJUIcOV799ImTWnbFEX0R9R2SXUI
R: /etc/ssh/ssh_host_ecdsa_key.pub
        type: ecdsa
        fingerprint: SHA256:gN37F6qt7vkYvVzxgOii5hNzu7EPJw/yTvEnRtr+rLk
R: /etc/ssh/ssh_host_dsa_key.pub
        type: dsa
        fingerprint: SHA256:/5b5NncWQL43gi9AQarZvVoQW5M+LJxk8KqFYGvZpqI
R: /etc/ssh/ssh_host_rsa_key.pub
        type: rsa
        fingerprint: SHA256:tSRcjuKPF6W/jcyhqYG7tHlVkcrUZGh0RmwFEEpMPzc
```

POLICY EXERCISES

EDIT A FILE

Write a policy that populates `/etc/issue` with legaleze.

CREATE LOCAL USERS

Write a policy that creates at least 2 users.

INVENTORY THE LOCAL USERS

Tag the variable(s) that contain the usernames you promised for *inventory*.

```
meta => { "inventory", "attribute_name=My users" }
```

CREATE A FILE

:PR :ID97441-1e2f-42ed-afbf-1658e1376199 :EN

Wri that ensures `/etc/cron.allow` is populated with one of the previously created users allowed to have cron jobs.

Swier and try to `crontab -e`.

INVENTORY USERS IN /ETC/CRON.ALLOW

Inventory the users listed in `/etc/cron.allow`

ENABLE SSHD BANNER

Write a policy that enables the ssh banner and directs it to `/etc/issue`. sshd should be restarted after changing its configuration.

MULTIPLE OUTCOMES

:PR :ID4c834-6662-40bf-b16e-d5ad864fdcd9 :EN

#+Cup for the example #+Bell sudp/immutable sudi /tmp/immutable #+E

```
bundle agent main
{
  files:
    "/tmp/immutable"
      create => "true",
      edit_line =>  example_edit_line,
      classes => results("bundle", "my_id");

  vars:
    "classes" slist => classesmatching(".*my_id.*");

  reports:
    "Found Class = '$(classes)'";
}

bundle edit_line example_edit_line
{
  insert_lines:
    "I want to edit an immutable file";
}
```

```
   error: Can't copy file permissions from '/tmp/immutable' to '/tmp/immutable
   error: Unable to save file '/tmp/immutable' after editing
R: Found Class = 'my_id_failed'
R: Found Class = 'my_id_not_kept'
R: Found Class = 'my_id_error'
R: Found Class = 'my_id_kept'
R: Found Class = 'my_id_reached'
```

Refer to implementation of the `results` classes body in the stdlib.

#+Canup immutable file

```
sudo chattr -i /tmp/immutable
sudo rm /tmp/immutable
```

REPORT

Write a policy that defines a name in separate parts (at least 3). Then have CFEngine report the name in a random order.

EXAMPLE SOLUTION

Example Solution

```
bundle agent main
{
  vars:
    "name_parts" slist => { "Ronald", "Mck", "Donald" };
    "shuffled" slist => shuffle( name_parts, randomint(0, inf) );
    "name" string => join(" ", shuffled );

  reports:
    "$(name)";
}
```

```
R: Donald Mck Ronald
R: Donald Ronald Mck
R: Ronald Donald Mck
```

TRIGGER AN ACTION WHEN A FILE CHANGES

Write policy to monitor a file for change. When a change is seen report `Winner Winner Chicken Dinner`. Manually edit the file, show how cfengine detects and reports on the change.

AUTOMATICALLY ABORT BASED ON FILE PRESENCE

Write a policy that will abort cfengine execution if the file `$(sys.statedir)/abort_agent_execution` exists.

- See abortclasses in the cfengine documentation

DELETE FILE BASED ON AGE

Write a policy that will delete `$(sys.statedir)/abort_agent_execution` if it is older than 1 hour.

KILL A PROCESS

Write a policy to kill irssi running on webservers. No need for our webservers to be connected to IRC.

```
cp /bin/sleep /tmp/irssi
/tmp/irssi 5000
```

ENTERPRISE REPORTING

APIS

- Host
- Inventory
- File Changes
- Health
- Query
- Settings
  - Federated Reporting
  - Import & Export
  - LDAP
  - Users
  - Version Control
  - RBAC

HOST API

```
curl -s -k --user $AUTHUSER:$PASSWORD \
  https://$HUB/api/host\?count\=2\&context-include\=cfengine_3_15_0
```


```
{
  "data": [
    {
      "firstseen": "1578745699",
      "hostname": "host001.example.com",
      "id": "SHA=e01f65d069b9035c280ea0bdba6cf6e47863ac074a170addbad26e98cc89
      "ip": "192.0.2.1",
      "lastreport": "1582643957"
    },
    {
      "firstseen": "1578745692",
      "hostname": "hub.example.com",
      "id": "SHA=70138d580b9fd292ff856746df2fe7f9ded29db9ffca0c4d83acbbb97cde
      "ip": "104.236.18.209",
      "lastreport": "1582643974"
    }
  ],
  "meta": {
    "count": 2,
    "page": 1,
    "timestamp": 1582644064,
    "total": 7
  }
}
```

INVENTORY API

INVENTORY API ATTRIBUTES

```
curl -q -k --user $AUTHUSER:$PASSWORD \
  -X GET \
  https://$HUB/api/inventory/attributes-dictionary | jq 'map(.attribute_name)
```

INVENTORY API QUERY

```
curl -q -k --user $AUTHUSER:$PASSWORD \
  -X POST \
  https://$HUB/api/inventory \
  -H 'content-type: application/json' \
  -d '{
        "sort":"Host name",
        "select":[
           "Host name",
           "OS",
           "Policy Release Id",
           "IPv4 addresses",
           "CFEngine version",
           "Ports listening"
        ],
        "hostContextInclude":[
           "coreos"
        ]
      }
'
```

HEALTH API

Get an overview of the health status

```
curl -s -k --user $AUTHUSER:$PASSWORD \
  -X GET \
  https://$HUB/api/inventory/attributes-dictionary | jq'
```

```
{
  "hostsNeverCollected": 0,
  "notRecentlyCollected": 3,
  "hostsUsingSameIdentity": 0,
  "agentNotRunRecently": 0,
  "lastAgentRunUnsuccessful": 0,
  "totalFailed": 3,
  "total": "8"
}
```

QUERY API

```
curl -q -k --user $AUTHUSER:$PASSWORD \
  -X POST \
  https://$HUB/api/query \
  -H 'content-type: application/json' \
  -d '{
        "query": "select hostname, ipaddress from hosts",
        "limit": 2,
        "hostContextExclude": ["policy_server"]
     }'
```

BASE64 ENCODED QUERY LINKS

```
HUB_URL="https://hub"
API="/index.php/advancedreports/#/report/run?sql="
SQL_QUERY="SELECT Hosts.HostName AS 'Host Name' FROM Hosts"
REPORT_TITLE="Example Report"
LINK="${HUB_URL}${API}$(echo ${SQL_QUERY} | base64)&title=$(/usr/bin/urlencode
echo "${LINK}"
```

SPECIAL TOPICS

INTERNAL AGENT UPGRADE MECHANISM

- Place agent packages in `/var/cfengine/master_software_updates/$(sy`
- Define `trigger_upgrade` for set of hosts. Ref `update`

```
classes:
  "trigger_upgrade" or => { "host1", "host2", "redhat_5" };
```

DATA TRANSFORMATIONS

RE-PARENT A DATA STRUCTURE

With `mergedata()` it is possible to wrap data containers inside of a new JSON data structure in the current namespace.

For example, here we take an array of objects describing content for pghba.conf file and re-parent it under the pghba key in a new data-structure.

```
bundle agent main
{
    vars:
      "pghba_directives" data => '[
  {
    "type": "host",
    "database": "replication",
    "user": "all",
    "address": "secondary-replication",
    "method": "trust"
  }
]';

      "data" data => mergedata( '{ "pghba": pghba_directives }');
```

```
  reports:
      "$(with)" with => string_mustache( "{{%-top-}}", data);

}
```

```
R: {
  "pghba": [
    {
      "address": "secondary-replication",
      "database": "replication",
      "method": "trust",
      "type": "host",
      "user": "all"
    }
  ]
}
```

USEFUL TOOLS AND TIPS

SYNTAX CHECKING

Full Syntax Check

```
cf-promises --eval-functions=yes --full-check \
  -f ./examples/00-01-hello_world.cf
```

- Full check requires `body common control` (or `bundle agent main`). Typically this is only used when you run cf-promsies against `promises.cf`, `update.cf`, or `standalone_self_upgrade.cf`

Partial Syntax Check

```
cf-promises -f ./examples/00-01-hello_world.cf
```

Build into your workflow!

- Editors
- vcs hooks
- build systems

noshell VS useshell FOR commands TYPE PROMISES, execresult(), AND returnszero()

- useshell allows you to use pipelines

```
bundle agent main
{

  vars:
      "result_with_shell"
        string => execresult( "/bin/echo 'Hello$(const.n) World' | grep Hello

    reports:
      "$(result_with_shell)";
}
```

```
R: Hello
```

- `useshell` allows you to redirect output

```
bundle agent main
{

  classes:

      "successfully_executed"
        expression => returnszero( "/bin/echo 'Hello$(const.n) World' | grep

    reports:
      successfully_executed::
      "Successfully Executed";
      "Grep found: "
        printfile => cat( "$(this.promise_filename).out" );
}
```

```
R: Successfully Executed
R: Grep found:
R:  World
```

- `useshell` allows you to use unqualified commands

```
bundle agent main
{

    vars:

      # Note that echo is not fully qualified. That's because it picked it up
      # from the shells PATH

      "result"
        string => execresult( "echo 'Hello World'", useshell);

    reports:
      "Result: $(result)";
}
```

```
R: Result: Hello World
```

cf-remote

- https://github.com/cfengine/core/tree/master/contrib/cf-remote

Install and bootstrap remote hosts

```
cf-remote install --hub 34.252.28.73 --bootstrap 172.31.30.237
```

cf-locate

`cf-locate`

Command line tool to help locate and optionally display a body or bundle within a policy

DEBUG REPORTS

Use standardized DEBUG reports for policy development and troubleshooting.

```
bundle agent main
{
  reports:
    DEBUG|DEBUG_this_bundle_name::
      "DEBUG $(this.bundle): ....";
    "DEBUG|DEBUG_$(this.bundle)"::
      "DEBUG $(this.bundle): ....";
 }
```

PROMISE COMMENTS

Use promise comments to document **WHY** the promise is important.

```
bundle agent main
{
  services:
    "firewalld"
      policy => "start",
      comment => "If this service isnt running, then we have unnecessary
                  exposure and increase our risk of a security breach.";
}
```

GETTING THE MOST FROM THE DOCUMENTATION

jq

```
echo '{
  "data": [
    {
      "firstseen": "1578745699",
      "hostname": "host001.example.com",
      "id": "SHA=e01f65d069b9035c280ea0bdba6cf6e47863ac074a170addbad26e98cc89
      "ip": "192.0.2.2",
      "lastreport": "1582643957"
    },
    {
      "firstseen": "1578745692",
      "hostname": "hub.example.com",
      "id": "SHA=70138d580b9fd292ff856746df2fe7f9ded29db9ffca0c4d83acbbb97cde
      "ip": "192.0.2.1",
      "lastreport": "1582643974"
    }
  ],
  "meta": {
    "count": 2,
    "page": 1,
    "timestamp": 1582644064,
    "total": 7
  }
}'
```

```
{
  "data": [
    {
```

```
      "firstseen": "1578745699",
      "hostname": "host001.example.com",
      "id": "SHA=e01f65d069b9035c280ea0bdba6cf6e47863ac074a170addbad26e98cc89
      "ip": "192.0.2.1",
      "lastreport": "1582643957"
    },
    {
      "firstseen": "1578745692",
      "hostname": "hub.example.com",
      "id": "SHA=70138d580b9fd292ff856746df2fe7f9ded29db9ffca0c4d83acbbb97cde
      "ip": "104.236.18.209",
      "lastreport": "1582643974"
    }
  ],
  "meta": {
    "count": 2,
    "page": 1,
    "timestamp": 1582644064,
    "total": 7
  }
}
```

Extract a list of IPs from HOST API response

```
echo $INPUT  | jq '.data | map(.ip) | join(",")'
```

```
192.0.2.2,192.0.2.1
```

cf-runagent

Run policy on all hosts reporting

not_rh_satellite_registered

```
cf-runagent --background=3 --remote-bundles satellite_registration \
  -H $(curl -s -k --user $USER:$PASSWORD \
  https://$HUB/api/host\?count\=2\&context-include\=not_rh_satellite_registere
  jq '.data | map(.ip) | join(",")'|tr -d '"')
```

ADDITIONAL RESOURCES

Learning CFEngine

Widely considered best book to get a good grounding in CFEngine.

CFEngine Tutorial

Training material published by Aleksey Tsalolikhin from Vertical Sysadmin, one of our partners.

VSA Training Material

Self paced in depth tutorial based on Vertical Sysadmin training coursework

Example Policy Layout

An example policy layout

CFEngine Spacemacs Layer

The best editor is neither Emacs nor Vim, it's Emacs and Vim!

and vim.

`cf-locate`

Find and optionally display body and bundle definitions within a policy set

Policy Style Guide

Write policy in a common style. Make it easier for others to quickly digest your policy.

`cf-keycrypt`

Tool to encrypt data with CFEngine public keys (in core as of 3.16.0)

- Allows to encrypt data for individual hosts using the public key
- Can be used with non host keys for "group" encryption

`cf-profile`

Displays execution time summary for cf-agent run to find time consuming polices

`vim_cf3`

CFEngine 3 vim plugin with Syntax highlighting

`reindent.pl`

Re-indent CFEngine policy using this script that leverages the excellent cfengine3 mode in Emacs

Sublime Text 3 CFEngine Beautifier

Automatically reformat CFEngine policy in Sublime Text

Sublime Text 3 Syntax Highlighter & Snippets

CFEngine Syntax highlighting and snippets for Sublime Text

`cfe-rsplaytime`

Compute splaytime for a given host

`cfe-profiler`

Measures bundle execution time helping to uncover the most time consuming bundles

Editor support for CFEngine

A list of editors with references for making working with cfengine syntax easier

CFEngine in a Day

Old, but still good 4 part video series ~ 5 hours of Mark Burgess (original author and founder) giving a one day training at SurfSara

CFEngine Tutorial

Training material published by Aleksey Tsalolikhin from Vertical Sysadmin, one of our partners.

General FAQs

Frequently asked questions

Hub Admin FAQ

Frequently asked questions about CFEngine Enterprise Hub administration

GIT PRIMER

GIT

Git is the most popular modern version control management tool. Github, Bitbucket, and GitLab all provide great hosted and on prem repository management solutions.

Using a git management system is reccomended for implementing access controls and improved collaboration with regard to policy and systems management.

GETTING STARTED

Log into the policy server

```
[user@workstation] $ vagrant ssh hub
[vagrant@hub] $ sudo -i
```

Configure git author

```
[root@hub masterfiles] # git config -—global user.name “Mr. Slate”
[root@hub masterfiles] # git config -—global user.email “bossman@slateco.com”
[root@hub masterfiles] # git config --global push.default simple
```

CLONE BUILTIN REPOSITORY

```
[root@hub masterfiles] # git clone /opt/cfengine/masterfiles.git /vagrant/mas
Cloning into '/vagrant/masterfiles'...
```

ADD A FILE TO THE REPOSITORY

```
[root@hub masterfiles] # cd /vagrant/masterfiles
[root@hub masterfiles] # ls
cfe_internal  Changelog  controls  def.cf  lessons  lib  libraries  promises.c
[root@hub masterfiles] # echo hi > file
[root@hub masterfiles] # git status
# On branch master
# Untracked files:
#   (use "git add <file>..." to include in what will be committed)
#
#       file
nothing added to commit but untracked files present (use "git add" to track)
```

STAGE AND COMMIT THE CHANGES

```
[root@hub masterfiles] # git add file
[root@hub masterfiles] # git status
# On branch master
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#
#       new file:   file
#
# git commit -m “Testing git workflow”
[master c886caf] Testing git workflow
 0 files changed, 0 insertions(+), 0 deletions(-)
 create mode 100644 file
```

PUBLISH THE CHANGE

```
[root@hub masterfiles] # git status
# On branch master
# Your branch is ahead of 'origin/master' by 1 commit.
#
nothing to commit (working directory clean)
[root@hub masterfiles] # git push
Counting objects: 4, done.
Delta compression using up to 2 threads.
Compressing objects: 100% (2/2), done.
Writing objects: 100% (3/3), 280 bytes, done.
Total 3 (delta 1), reused 0 (delta 0)
Unpacking objects: 100% (3/3), done.
To /opt/cfengine/masterfiles.git
   ee31801..94b8151  master -> master
# git status
# On branch master
nothing to commit (working directory clean)
```

MODIFY A FILE

```
[root@hub masterfiles] # echo HI >> file
[root@hub masterfiles] # git status
# On branch master
# Your branch is ahead of 'origin/master' by 1 commit.
#
# Changed but not updated:
#   (use "git add <file>..." to update what will be committed)
#   (use "git checkout -- <file>..." to discard changes in working directory)
#
#       modified:   file
#
no changes added to commit (use "git add" and/or "git commit -a")
```

DIFF TO VALIDATE DETAIL OF CONTENT CHANGE

```
[root@hub masterfiles] # git diff
diff --git a/file b/file
index 45b983b..313352b 100644
--- a/file
+++ b/file
@@ -1 +1,2 @@
 hi
+HI
```

STAGE AND COMMIT THE CHANGES

```
[root@hub masterfiles] # git add file
[root@hub masterfiles] # git status
# On branch master
# Your branch is ahead of 'origin/master' by 1 commit.
#
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#
#       modified:   file
#
# git commit -m "Modified file"
[master fd94885] Modified file
 1 files changed, 1 insertions(+), 0 deletions(-)
# git status
# On branch master
# Your branch is ahead of 'origin/master' by 1 commits.
#
nothing to commit (working directory clean)
```

PUBLISH THE CHANGE

```
[root@hub masterfiles] # git push
Counting objects: 7, done.
Delta compression using up to 2 threads.
Compressing objects: 100% (4/4), done.
Writing objects: 100% (5/5), 493 bytes, done.
Total 5 (delta 2), reused 0 (delta 0)
Unpacking objects: 100% (5/5), done.
To /opt/cfengine/masterfiles.git
   c886caf..fd94885  master -> master
```

REMOVE A FILE

```
[root@hub masterfiles] # git rm file
# rm 'file'
[root@hub masterfiles] # git status
# On branch master
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#
#       deleted:    file
#
# git commit -m "Remove file"
[master 4c9d46d] Remove file
 1 files changed, 0 insertions(+), 3 deletions(-)
 delete mode 100644 file
```

PUBLISH THE CHANGE

```
[root@hub masterfiles] # git push
Counting objects: 3, done.
Delta compression using up to 2 threads.
Compressing objects: 100% (2/2), done.
Writing objects: 100% (2/2), 230 bytes, done.
Total 2 (delta 1), reused 0 (delta 0)
Unpacking objects: 100% (2/2), done.
To /opt/cfengine/masterfiles.git
   92660a9..4c9d46d  master -> master
```

PLACE MASTERFILES INTO THE REPOSITORY

```
[root@hub masterfiles] # rsync -avz /var/cfengine/masterfiles/ .
[root@hub masterfiles] # git add -A
[root@hub masterfiles] # git commit -m "Seed repository with masterfiles"
[root@hub masterfiles] # git push
```

CONFIGURE MASTERFILES FOR GIT INTEGRATION

```
[root@hub masterfiles]# echo '{ "classes": { "cfengine_internal_masterfiles_up
[root@hub masterfiles]# git add def.json
[root@hub masterfiles]# git commit -m "Enable automatic masterfiles update fro
[master c206654] Enable automatic masterfiles update from repository
 1 file changed, 1 insertion(+)
 create mode 100644 def.json
[root@hub masterfiles]# git push
warning: push.default is unset; its implicit value is changing in
Git 2.0 from 'matching' to 'simple'. To squelch this message
and maintain the current behavior after the default changes, use:

  git config --global push.default matching

To squelch this message and adopt the new behavior now, use:

  git config --global push.default simple

See 'git help config' and search for 'push.default' for further information.
(the 'simple' mode was introduced in Git 1.7.11. Use the similar mode
'current' instead of 'simple' if you sometimes use older versions of Git)

Counting objects: 4, done.
Delta compression using up to 2 threads.
Compressing objects: 100% (3/3), done.
Writing objects: 100% (3/3), 370 bytes | 0 bytes/s, done.
Total 3 (delta 1), reused 0 (delta 0)
To /opt/cfengine/masterfiles.git
   a181449..c206654  master -> master
```

ACTIVATE CURRENT UPDATE POLICY WITH ENABLEMENT CLASS

```
[root@hub masterfiles]# cf-agent --no-lock \
--verbose \
--define cfengine_internal_masterfiles_update \
--file update.cf
```

VERIFY PRESENCE OF DEF.JSON

```
[root@hub masterfiles]# cat /var/cfengine/masterfiles/def.json
```

REVIEW

Now when the agent runs on hosts that define `policy_server` policy will be activated that keeps `/var/cfengine/masterfiles` up to date with whats in the repository as configured in mission portal (which by default is `/opt/cfengine/masterfiles.git`).

This means new policy will be distributed as you push it into the repository. Continuous delivery FTW!

GIT COMMAND REFERENCE

`git status`	`git pull --rebase`
`git diff`	`git grep`
`git add`	`git log`
`git diff --cached`	`git checkout -b new_feature`
`git commit`	`git push origin <branch>`

POP QUIZ

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- Who was Mr. Slate?
- How do you get an overview of the changes to your clone?
    - How can you easily search a git repository?

CFEngine