Config5

Systems Administrator's Guide

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Preface

Config5 is a configuration management utility for UNIX systems. It is particularly well suited to manage large numbers of systems in an enterprise where the configuration varies in the various organizational units. Configuration data can be verified before deployment which makes deployment more resilient to human errors and facilitates teamwork. Config5 is highly customizable and extensible to support a broad variation of UNIX and UNIX-like operating systems.

1. Background

The IT Service Group (*isginf*) of the Department of Computer Science at ETH Zurich is managing UNIX systems since the early nineties. Since then we have always used custom configuration management utilities to provision servers and workstations. Config5 is the *fifth* utility that we developed, hence its name. We believe that Config5 may be useful for others too and therefore release Config5 as open source project and make it publicly available.

2. Motivation

Having a way to provision computer systems with configuration data over the whole life cycle is important to any systems administrator who manages two computers or more.

Some enterprise operating systems provide a way to provision a configuration during the initial installation but usually provide none to update the configuration later. Many programs exist to fill in this gap. Utilities like Bcfg2 [1], Cfengine [2], LCFG [3], Puppet [4] and many others were all developed to solve one problem: To consistently manage the configuration of many computers. Each of them has a different philosophy, different design requirements and different strengths and weaknesses. A systems administrator can already now pick the one that fits his or her needs, policies or work flow best.

At the end of 2010 *isginf* was preparing to roll out Red Hat Enterprise Linux 6. Because of some important missing functionality and other problems with our previous configuration management utilities we once more looked for alternatives. Unfortunately none of the existing utilities were suitable for our requirements and we developed Config5.

2.1. Requirements

The way IT is organized for us (in an educational institution with thirty-odd research groups) defines an interesting set of general conditions:

- Our people are free to use our service but are not required to. As a consequence we never know for sure what machines are around. A system that we install today may be reinstalled by its owner with his favorite distro the next day. Workstations are generally installed with both Windows and Linux and either of them may not be booted into for months. The difference between a reinstalled system and one that is always booted in the other operating system is difficult to track.

- We provide installations on laptops too. These may be outside the organization for weeks but must be able to update themselves without access to our infrastructure.

- Every research group has its own set of configuration data that is unique to it. Configured printers, authentication settings, firewall rules are typically all different.

  Total uniformity of the deployed systems even within a research group is difficult to enforce. There are always exceptions or special configurations requested for a project. Such exceptions must be tracked and documented.

- We are organized as a team with individual responsibilities. Parts of the configuration may be changed by several team members at the same time.

Based on the above and a few lessons learned we defined the following set of requirements for a suitable configuration management utility:

- The configuration must be pulled by client systems rather than pushed on by a server.

- The configuration must be selected using information that may be only known to the client system but is not maintained in a central database. This implies that the client system selects the configuration that it needs rather than having a server unilaterally decide what it has to have.

- Configuration files must be constructible from templates and fragments.

- The deployment should be fast and scalable. The configuration may be applied often and on many systems.

- Changes to the configuration must be traceable and revertible. This can usually be achieved with a version control management system.

- The system should be resilient to human error as much as possible. In combination with a version control management system it should prevent invalid, conflicting or incomplete configuration data.

3. Development

Development of Config5 is continuing on GitHub at `https://github.com/isginf/config5`. The latest release can be downloaded from `https://github.com/isginf/config5/tree/master/releases`.

4. Acknowledgments

Config5 bases on configng (our *fourth* configuration management utility) done by Klaus Ethgen (<klaus@ethgen.ch>) while he was a member of *isginf* . Some concepts and ideas used in configng were taken from Template Tree II [6].

Chapter 1. Introduction

In this chapter you will get a quick overview of how Config5 works and how it is used.

1.1. Overview

Configuration data that is managed and deployed with Config5 is maintained in a simple directory structure. A main directory (the *feature set*) contains a set of sub directories (*features*), each of which contains configuration files and a specification (the *spec* file) that contains instructions.

By default the main directory is named `features` and located in the directory `deploy` of the Config5 distribution:

```
$ ls
deploy  doc  example
$ ls deploy
bin  etc  features  lib
```

A feature must at least contain the specification file which is by default named `spec`. A fictive feature named `test` would look like this:

```
$ ls deploy/features
test
$ ls deploy/features/test
spec
```

1.1.1. The spec File

The spec file describes the changes to do by grouping them in *classes* and is processed from top to bottom. Classes start at the beginning of a line and are followed by a colon. *Changes* are identified by a unique keyword with leading whitespace. Each change belongs to the most recent class declaration:

```
# This is a comment

class1: …
  change1 …
  change2 …
  change3 …

class2: …
  change1 …
```

1.1.2. Changes

Config5 has nine core changes built in: `copy`, `truncate`, `append`, `directory`, `link`, `symlink`, `properties`, `remove` and `execute`. Additional changes can be added with extensions.

Each change supports a number of optional flags right after the keyword which modify the behavior of the change. The arguments after each keyword vary:

```
  copy       [-bintT] src path user group mode [context] [key=value...]
  truncate   [-intT]  path user group mode [context]
  append     [-b]     src path [key=value...]
  directory  [-ntT]   path user group mode [context]
  link       [-ntT]   src_path dest_path
  symlink    [-bntT]  value path user group [context]
  properties [-ntT]   path user group mode [context]
  remove     [-ntT]   path
  execute    [-bntT]  shell_line
```

Changes are only applied on the *target system* (the computer on which Config5 is executed) if necessary. The only exceptions is the `execute` change which is always applied.

For each change Config5 will check if applying the change would actually modify the state of the target system and skip it if does not.

1.1.3. Classes

A class may be a host name, an operating system identifier or some other property. A target system that configures itself with Config5 will use the available information about itself (the *system information*) to choose the best matching class and perform the changes of this class:

```
foobar:
```

```
  copy hosts.allow.foobar /etc/hosts.allow root root 644
  copy hosts.deny /etc/hosts.deny root root 644

RedHatEnterpriseServer:
  copy hosts.allow /etc/hosts.allow root root 644
  copy hosts.deny /etc/hosts.deny root root 644

RedHatEnterpriseWorkstation_6.1:
  copy hosts.allow.61 /etc/hosts.allow root root 644
  copy hosts.deny /etc/hosts.deny root root 644
```

Identifying the best matching class is customizable but generally the class that matches the target system in the most specific way is used. For example, if there is a class for the operating system identifier and one for the host name of the target system, the later is chosen.

Classes can also include other classes and override changes to files done in the included classes:

```
foobar: RedHatEnterpriseServer
  copy hosts.allow.foobar /etc/hosts.allow root root 644

RedHatEnterpriseServer:
  copy hosts.allow /etc/hosts.allow root root 644
  copy hosts.deny /etc/hosts.deny root root 644

RedHatEnterpriseWorkstation_6.1: RedHatEnterpriseServer
  copy hosts.allow.61 /etc/hosts.allow root root 644
```

1.1.4. File Generation

Files can be constructed from fragments using the `append` change which can be distributed over multiple features.

All files that are copied and all fragments that are appended are by default processed with Template Toolkit [5]. Using *substitution* (replacing parts of the template with generated content) it is then very easy to generate customized configuration files for a set of system from one template. The substitutions can be specified in the class declaration or per change. Substitutions in the class declaration are passed down to all included classes and all changes of the class. Substitutions that are passed down override substitutions with the same name in included classes and changes:

```
foobar: RedHatEnterpriseServer ACCESS=snafu

RedHatEnterpriseServer:
  copy hosts.allow /etc/hosts.allow root root 644 ACCESS=ALL
```

1.2. Examples

To illustrate how Config5 is used we will create a feature to configure `ntpd` and deploy it to the host `sample` which is running `Red Hat Enterprise Linux 6` (`RHEL6`). In subsequent steps we will enhance the configuration step by step.

First we start by downloading and unpacking the Config5 distribution:

```
$ cd /tmp
$ wget https://github.com/isginf/config5/blob/master/releases/config5-latest.tgz?raw=true
$ tar zxf config5-latest.tgz
$ cd config5-?.?
```

1.2.1. The Basic `ntp` feature

First we create a new feature called `ntp` and `spec` file:

```
$ cd deploy/features
$ mkdir ntp
$ cd ntp
$ vi spec
```

The content of the `spec` file should look like this:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
```

This change will copy the file `ntp.conf` to `/etc/ntp.conf` for all target systems that are running `Red Hat Enterprise Linux Workstation` and set the permissions as indicated.

The only missing part is the file `ntp.conf` which is created in the same place as the `spec` file:

```
$ vi ntp.conf
```

We will use a simplified version of the default `/etc/ntp.conf` that ships with `RHEL6`:

```
restrict default kod nomodify notrap nopeer noquery
restrict -6 default kod nomodify notrap nopeer noquery
restrict 127.0.0.1
restrict -6 ::1

server 0.rhel.pool.ntp.org
server 1.rhel.pool.ntp.org
server 2.rhel.pool.ntp.org
```

Now we can deploy the configuration to the host `sample`:

```
$ ( cd ../../.. ; tar cf /tmp/c5.tar deploy )
$ scp /tmp/c5.tar root@sample:/root/c5.tar
$ ssh root@sample "tar xf c5.tar ; deploy/bin/config5"
```

The output of the last command will look like this:

```
Date:               Fri Aug 24 09:54:47 2012
Host name:          sample
Architecture:       x86_64
OS:                 RedHatEnterpriseWorkstation
Release:            6.3
IP:                 127.0.0.1
FQHN:               sample.example.com
FQDN:               example.com
Root:               /
Stage:              production

Pass 1:
/etc/ntp.conf: file (ntp:RedHatEnterpriseWorkstation) - CHANGED

Done.
```

If the last command is run again it will not change the file a second time and display the following output:

```
$ ssh root@sample deploy/bin/config5
…
Root:               /
Stage:              production

Done.
```

1.2.2. Best Matching Class

When the configuration in a feature is applied, Config5 will select the class that it applies using a list of classes generated from the system information. The first class that exists in the feature will be used.

The list of all classes that are checked on a system can be obtained by running **config5 --report classorder**. For host sample the output will look like this:

```
$ ssh root@sample "deploy/bin/config5 --report classorder"
sample_RedHatEnterpriseWorkstation_6.3_x86_64
sample_RedHatEnterpriseWorkstation_6.3
sample_RedHatEnterpriseWorkstation_x86_64
sample_RedHatEnterpriseWorkstation
sample_x86_64
sample
RedHatEnterpriseWorkstation_6.3_x86_64
RedHatEnterpriseWorkstation_6.3
RedHatEnterpriseWorkstation_x86_64
RedHatEnterpriseWorkstation
```

The class `RedHatEnterpriseWorkstation` from our example is the last one in the list. We could modify the `spec` file to look like this:

```
sample:
  copy ntp.conf /etc/ntp.conf root root 644
```

When this configuration is on the host sample the result is the same. When the same configuration is applied on any other system the feature would not be applied because no class matches (assuming that the system is not named `sample`).

1.2.3. Adding Service Management to the `ntp` Feature

The `ntp` feature so far only copies the file. This is not enough because the `ntpd` service is not enabled by default and is not running. We will extend the feature to enable the service and start it:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
  execute chkconfig ntpd on
  execute service ntpd start
```

This will additionally execute the two shell commands **chkconfig ntpd on** and **service ntpd start**.

If we deploy this to `sample` like before the output will look like this:

```
$ ssh root@sample "tar xf c5.tar ; deploy/bin/config5"
…

Pass 1:
run (ntp:RedHatEnterpriseWorkstation): chkconfig ntpd on
run (ntp:RedHatEnterpriseWorkstation): service ntpd restart

Done.
```

The output remains the same if the **config5** command is run a second time. The service is enabled and started every time but we actually only want that to happen when `/etc/ntp.conf` changes. To change that we add a trigger flag to the lines that execute the shell commands:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
  execute -t root root chkconfig ntpd on
  execute -t root root service ntpd restart
```

Now the commands are only executed if the configuration file changes. When we deploy this to `sample` the output again shows no changes because the correct `/etc/ntp.conf` is already in place:

```
$ ssh root@sample "tar xf c5.tar ; deploy/bin/config5"
…
Root:               /
Stage:              production

Done.
```

1.2.4. Improving the `ntp` Feature with Extensions

Executing commands to enable and start the `ntpd` service works but there is a better way. Config5 ships with a set of extensions and one of them is the Services extension which will manage system services using the **chkconfig** and the **service** commands. It does follow the overall principle of Config5 that it only applies a change if necessary, i.e., only enable or start a service if it is not enabled or started yet.

The installation of the extension is simple:

```
$ ( cd ../.. ; tar zxf ../extensions/service.tgz )
```

We modify the spec file and use the new `service` change provided by the extension:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
  service enable ntpd
  service start ntpd
```

The trigger flags are gone which makes subtle difference for the systems administrator: Any time **config5** is run it will enable and start the service, even if an administrator has intentionally shut it down on a specific target system. For `ntpd` this is probably the right choice but for services that require maintenance such as `mysqld`, `httpd` or `samba` an administrator will probably not want these services to be suddenly started, especially if **config5** is run from `cron`. For these services it is better to at least trigger the service start on configuration file changes.

There is still one issue with the above spec file though. The `ntpd` service will not be restarted if the configuration file changes while the `ntpd` service is already running. The Services extension does intentionally not provide a `restart` action but the original **service ntpd restart** command will do the job:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
  execute -t root root service ntpd restart
  service enable ntpd
  service start ntpd
```

The `execute` change is inserted before the service changes to avoid a restart of the service because one of the `service` changes needs to be applied.

1.2.5. Installation vs. Production

We will typically install Red Hat Enterprise Linux Workstation on a target system over the network using kickstart and at that time also run **config5** from a post script section to apply the configuration. However, the environment during installation is not exactly the same as when the system is running with the installed operating system. The installer has already configured the local time so we actually do not want to start or restart `ntpd` at this point.

Config5 predefines two *stages* for a target system, `installation` and `production`, the later being the default. We will tag the service start and restart changes to only be applied in the production stage:

```
RedHatEnterpriseWorkstation:
  copy ntp.conf /etc/ntp.conf root root 644
  execute -tP root root service ntpd restart
  service enable ntpd
  service -P start ntpd
```

To make this work we will run **config5** with the option `--set stage=installation` in the kickstart post script.

1.2.6. Adding Time Servers to the `ntp` Feature

We are actually running two time servers `ts1.example.com` and `ts2.example.com` that we would prefer to the default servers. Workstations will only use `ts1` while servers will use `ts2`. We could create two files, one for servers and one for workstations but we can do better using a template. We modify the file `ntp.conf` as follows:

```
restrict default kod nomodify notrap nopeer noquery
restrict -6 default kod nomodify notrap nopeer noquery
restrict 127.0.0.1
restrict -6 ::1

[%- IF server %]
server [% server %]
[%- ELSE %]
server 0.rhel.pool.ntp.org
server 1.rhel.pool.ntp.org
server 2.rhel.pool.ntp.org
[%- END %]
```

To generate two distinct files for servers and workstations we change the `spec` file to this:

```
RedHatEnterpriseWorkstation: _ntp server=ts2.example.com
RedHatEnterpriseServer: _ntp server=ts1.example.com

_ntp:
  copy ntp.conf /etc/ntp.conf root root 644
  execute -tP root root service ntpd restart
  service enable ntpd
  service -P start ntpd
```

1.2.7. Dealing with Exceptions

As time passes we encounter a few exceptions that our configuration has to cover:

- The laptop `foobar` is configured as workstation but cannot contact the time servers because of the company firewall.
- The user of workstation `snafu` wants it to be configured to use `ts2`.
- A bug in `ntpd` on 64 bit systems causes it to crash all the time. Until the bug is fixed we need a workaround.

We change the `spec` file by adding the following two host-specific lines:

```
foobar: RedHatEnterpriseWorkstation
snafu: RedHatEnterpriseWorkstation server=ts2.example.com
```

The generated `/etc/ntp.conf` on `foobar` will contain the three time servers in the `ntp.org` pool. The same file on `snafu` will refer to `ts2.example.com`.

A suitable workaround for the crashes of `ntpd` could be to set the time with **ntpdate** and run it whenever **config5** runs: Adding the following snippet to the `spec` file does this:

```
RedHatEnterpriseWorkstation_x86_64: _ntpdate server=ts1.example.com
RedHatEnterpriseServer_x86_64: _ntpdate server=ts2.example.com
```

```
_ntpdate:
  service -P stop ntpd
  service disable ntpd
  execute ntpdate [% server %]
```

The workarounds for `foobar` and `snafu` need to be verified again at this point. Since `foobar` is an old laptop it will remain a 32 bit installation. The workstation `snafu` on the other hand could be reinstalled with either 32 or 64 bit so we make sure both work fine and add this line to the `spec` file:

```
snafu_x86_64: RedHatEnterpriseWorkstation_x86_64 server=ts2.example.com
```

Chapter 2. Configuration Data

The following sections provide in-depth explanation of the various concepts and the structure of configuration data that is deployed using Config5.

2.1. Feature Set

Configuration data that is applied using Config5 is organized in a *feature set*. A feature set is nothing more than a directory containing features (see Section 2.2, “Features”).

By default Config5 has one feature set that is located in a directory named `features` in the same directory as the `bin` directory containing the **config5** script:

```
$ ls
deploy  doc  example  util
$ ls deploy/
bin  etc  features  lib
$ ls deploy/bin
config5
```

There are two ways to customize the location of the default feature set:

- The directory `features` can be replaced by a symbolic link that points to the real location of the feature set directory. The directory the symbolic link links to must be available on all target systems that are going to be managed.
- The directory name can be changed by customizing the Config5 settings (see Section 7.3, “Settings Reference”).

2.2. Features

The actual configuration data is organized in one or more *features* in the feature set (see Section 2.1, “Feature Set”). Each feature is again a directory containing a *specification file*. The default name for the file is `spec` but that can be changed (see Section 7.3, “Settings Reference”):

```
$ ls deploy/features
autofs  firewall  ssh  sshd
$ ls deploy/features/sshd
sshd_config spec
```

The specification file contains a number of class definitions.

2.3. Classes

Classes group together individual the changes (see Section 2.4, “Changes”). The general syntax is the following:

```
class: [referenced_class…] [key=value…]
```

Any string of character excluding white space is suitable as a class name. Classes that are not intended to match (see Section 7.3.8, “Class Match Order”) can still be referenced by other classes. Typically these classes have a naming convention that distinguishes them from classes that can be selected as best match, for instance by prefixing them with an underscore.

2.3.1. Substitutions

One of the strengths of Config5 is its capability to create config files from templates using the Template Toolkit [5]. Command lines run by the `execute` change are also processed using Template Toolkit.

Substitutions are always specified as `key=value` pair. If `value` contains spaces the pair must be quoted. Substitutions can be specified in two places:

- In class definitions. Substitutions are passed to all changes of the class and all included classes.
- In `copy` or `append` changes.

Substitutions that are passed down override substitutions in changes or included classes. Each substitution is a variable in Template Toolkit with the name `key` and `value` as value.

Example 2.1. Substitution Specification

```
RedHatEnterpriseServer: _sshd permitroot=1
RedHatEnterpriseWorkstation: _sshd permitroot=0

_sshd:
  copy sshd_config /etc/sshd/sshd_config root root 600

sample:
  copy sshd_config.test /etc/sshd/sshd_config root root 600 permitroot=1
```

2.3.1.1. Predefined Substitutions

A set of substitutions are predefined and relate to information about the target system and the configuration:

Variable	Description
`auto_base`	The base directory of Config5 (parent directory of the directory containing the running **config5** script)
`auto_class`	The name of the matching class of the `copy` or `append` change
`auto_class_lc`	Same as `auto_class` but all lower case
`auto_feature`	The name of the feature of the `copy` or `append` change
`auto_dynamic_rnd`	32 bit random number (changes every time **config5** is run)
`auto_static_rnd`	32 bit random number (changed only when the `host` system item changes)
`auto_program_version`	The version of the Config5

Additionally the value of all system information items (see Section 6.2, “System Information Items”) is available as `info_`*`item`* variable. For list type system information items a variable info_*`item_entry`* is set to `1` for each entry of the list. Both *`item`* and *`entry`* are converted to lower case.

All predefined substitutions can be overloaded at class or change level.

2.3.2. Best Match

For each feature a class is selected and its changes are processed. The class is selected according to a prioritized list of class names that are generated from the available system information items. The first class that is found is used. The feature is ignored if no class matches.

See Section 7.3.8, “Class Match Order” for information about the default list.

2.4. Changes

The *changes* specify individual changes to the system. Each change is identified by a keyword, usually a verb or noun and followed by parameters.

Extensions can define additional changes with other keywords.

2.4.1. Flags

Some aspects of a change can be modified using a set of *flags*. Flags are indicated using a leading minus sign. The flags are optional but if present must be directly after the keyword.

The following common flags are handled the same way for all changes, both core changes and changes from extensions:

Flag	Description
`-0` to `-9`	Sets the pass in which the change is applied
`-b`	Data is binary and should not be processed with the Template Toolkit
`-i`	Files are changed in-place
`-n`	All errors are ignored
`-t`	Change is only performed if another change in the same class was applied
`-T`	Change is only performed if another change in the same feature was applied

Stages (see Section 3.2.2, “Stages”) are also specified as flags.

2.4.2. Parameters

Every change has its own set of mandatory and optional parameters. The core changes share some common parameters.

The following subsections describe common parameters that are handled the same way for all changes, both core changes and changes from extension.

2.4.2.1. Source File

The *source* file may be specified as path relative to the feature directory or an absolute path on the target system.

2.4.2.2. Destination Path

The *destination* path for changes related to the file system must always be absolute.

2.4.2.3. User

The *user* for a file (symbolic link, etc.) or directory can be specified as a uname or a numeric uid.

For an existing file or directory it is possible to use a minus sign as user in which case the current user of the file is unchanged. If the file does not exist the user of the file is set to root (uid 0).

2.4.2.4. Group

The *group* for a file (symbolic link, etc.) or directory can be specified as a group name or a numeric gid.

For an existing file or directory it is possible to use a minus sign as group in which case the current group of the file is unchanged. If the file does not exist the group of the file is set to root (gid 0).

2.4.2.5. Mode

The *mode* for a file or directory is specified as an octal number.

If a minus sign is used as mode then the current mode of the file is unchanged. If the file does not exist then the mode is set to 0644.

2.4.2.6. SELinux Context

For files (directories, symbolic links, etc.) the core changes accept an optional SELinux context if SELinux support is activated (see Section 7.3, “Settings Reference”). A context can be specified in three formats:

type	SELinux type, expands to system_u:object_r:*type*:s0.
user:role:type	SELinux user, role and type, expands to *user*:*role*:*type*:s0.
user:role:type:range	Complete SELinux context.

The core changes that accept an optional SELinux context will keep the current context of an existing file. If a file is created then the context is defined by the SELinux policy.

2.4.3. Core Changes

The following subsections explain the core changes that are natively supported by Config5, i.e., are not provided by an extension.

2.4.3.1. Copy File

The *copy* change is used to copy a regular file.

Synopsis	copy [-bintT] *source* *destination* *user* *group* *mode* [*context*] [*key*=*value*…]

The parameters *source*, *destination*, *user*, *group*, *mode* and *context* are common parameters (see Section 2.4.2, “Parameters”).

One or more substitutions can be appended as *key*=*value* pairs (see Section 2.3.1, “Substitutions”). If the -b flag is used the file is treated as binary and no substitutions are done.

The content of a file (after applying all append changes for the same file), *user*, *group*, *mode* and *context* are individually compared to the destination file and copied or set when different.

If *destination* exists and is not a file then it will be deleted before creating the file.

Example 2.2. Copy File

```
sample:
  copy sshd_config /etc/sshd/sshd_config root root 600 permitroot=1
  copy authorised_keys /root/.ssh/authorized_keys root root 644 ssh_home_t
```

2.4.3.2. Truncate File

The *truncate* change is used to create a empty file.

Synopsis	`truncate [-intT] destination user group mode [context]`

The parameters *source*, *destination*, *user*, *group*, *mode* and *context* are common parameters (see Section 2.4.2, “Parameters”).

The content of a file (after applying all `append` changes for the same file), *user*, *group*, *mode* and *context* are individually compared to the destination file and copied or set when different.

If *destination* exists and is not a file then it will be deleted before creating the file.

Example 2.3. Truncate File

```
sample:
  truncate /etc/rc.d/rc.local root root 755
```

2.4.3.3. Append to File

The *append* change is used to append data to a file.

Synopsis	`append [-b] source destination [key=value...]`

The parameters *source* and *destination* are common parameters (see Section 2.4.2, “Parameters”).

One or more substitutions can be appended as *key=value* pairs (see Section 2.3.1, “Substitutions”). If the `-b` flag is used the appended data is treated as binary and no substitutions are done.

Important

To append to a file it must be copied or truncated. A corresponding copy or truncate change must be present in exactly one of the features.

Example 2.4. Append to File

```
sample:
  append rc.local /etc/rc.d/rc.local
```

2.4.3.4. Create Directory

The *directory* change is used to create a directory.

Synopsis	`directory [-ntT] destination user group mode [context]`

The parameters *source*, *destination*, *user*, *group*, *mode* and *context* are common parameters (see Section 2.4.2, “Parameters”).

The *user*, *group*, *mode* and *context* are individually compared to the destination path and copied or set when different.

If *destination* exists and is not a directory then it will be deleted before creating the file.

Example 2.5. Create Directory

```
sample:
  directory /local root root 1777
```

2.4.3.5. Create Link

The *link* change is used to create a (hard) link.

Synopsis	`link [-ntT] source destination`

The parameter *destination* is a common parameter (see Section 2.4.2, “Parameters”). The *source* parameter is like the *destination* parameter an absolute path in the file system of the target system.

If *destination* exists and its inode or device id is different then it will be deleted before creating the link.

Example 2.6. Create Link

```
sample:
  link /tmp/a /tmp/b
```

2.4.3.6. Create Symbolic Link

The *symlink* change is used to create a symbolic link.

Synopsis	symlink [-bntT] *value destination user group* [*context*]

The parameters *destination*, *user*, *group* and *context* are common parameters (see Section 2.4.2, “Parameters”). The parameter value is usually a path but may be set to any string.

The substitutions defined for the class or inherited from including classes are applied to value unless the -b flag is used.

The content of the symbolic link, *user*, *group* and *context* are individually compared to the destination path and set when different.

If *destination* exists and is not a symbolic link then it will be deleted before creating the symbolic link.

Example 2.7. Create Symbolic Link

```
sample:
  copy ca.pem /etc/openldap/cacerts/ca.pem root root 644
  symlink ca.pem /etc/openldap/cacerts/12345678.0 root root
```

2.4.3.7. Change Properties

The *properties* change is used to change the properties of an existing file.

Synopsis	properties [-ntT] *destination user group mode* [*context*] [*key=value*...]

The parameters *destination*, *user*, *group*, *mode* and *context* are common parameters (see Section 2.4.2, “Parameters”).

The *user*, *group*, *mode* and *context* are individually compared to the destination file and set when different.

Example 2.8. Change Properties

```
sample:
  properties /var/log/messages - - 644
```

2.4.3.8. Remove

The *remove* change is used to delete a file, directory, symbolic link, link or special file.

Synopsis	remove [-ntT] *destination*

The parameters *destination* is a common parameter (see Section 2.4.2, “Parameters”).

Important

It is currently not possible to recursively remove a directory with the remove change. Run **rm -rf** using the execute change instead (see Section 2.4.3.9, “Execute Shell Command Line”).

Example 2.9. Remove

```
sample:
  remove /etc/openldap/cacerts/ca.pem
  remove /etc/openldap/cacerts/12345678.0
  remove /etc/openldap/cacerts
```

2.4.3.9. Execute Shell Command Line

The *execute* change is used to execute a shell command line.

Synopsis	`execute` [`-bntT`] ...

The entire rest of the line is executed as a shell command line. The line is executed as the user and group of the running **config5** process which is usually both `root`.

The substitutions defined for the class or inherited from including classes are applied to the command line before executing it unless the `-b` flag is used.

The execute change is always performed unless the `-t` or `-T` flag is used but no earlier change triggers it.

Example 2.10. Execute Shell Command Line

```
sample:
  execute service sssd stop ; rm -f rm -f /var/lib/sss/db/* ; service sssd start
```

Chapter 3. Configuration Application

Understanding how the configuration is applied to a system is essential and outlined in this chapter.

3.1. Configuration Processing

The information in the feature set is processed in a well defined order:

- All features are processed in alphabetical order.
- Starting with the class that matches best in each feature (if there is any, see Section 2.3.2, “Best Match”) the referenced classes are processed first from left to right. Classes are processed once every time they are referenced which may be more than once.
- In each class that is processed the changes are processed from top to bottom.

Some changes are applied in the order they are processed (see Section 3.3.3, “Changes”).

3.2. Environment

3.2.1. Root Directory

The root directory that is used when Config5 applies the configuration on a target system is typically /. The root directory can be changed by setting the root system information item, for instance using the `--set` command line option of **config5**.

All core changes support a different root directory. All changes except the execute change will automatically prepend the root directory to all absolute source or destination paths. The execute change is executed but requires the use of substitution by inserting *`[% info_root %]`* where needed.

3.2.2. Stages

A target system may require different configurations throughout its life cycle. Config5 supports this in a generic fashion by defining a set of *stages*. The default configuration defines the following two stages:

Stage	Flag	Description
`installation`	`-I`	System is being installed.
`production`	`-P`	System is up and running (default).

Individual changes can be selectively enabled for only some stages by specifying the stages as flags (see Section 2.4.1, “Flags”). If no stage is specified this means that the change is applied in any stage.

The stage can be set using the `--set` command line option of **config5**.

3.3. Configuration Application

The configuration is applied after processing in a structured manner.

3.3.1. Passes

The configuration is applied in ten *passes*. The pass in which a change is applied can be specified with the flags `-0` to `-9` for each change. The default pass is `1`.

Applying the configuration in multiple passes can be helpful in a couple of scenarios:

- Changes that must be done before or after everything else can be placed in an earlier or later pass.
- Configuration files that are generated by a command that writes a temporary file which is copied to the final destination.

3.3.2. Phases

In each pass the relevant changes are applied in different phases. Currently the following phases are defined and processed in this order:

1. Install or remove packages
2. Delete files and directories
3. Create files and directories
4. Modify files and directories

5. Configure system
6. Execute commands

Each type of change is applied in exactly one phase:

Install or remove packages	(not used by the core changes)
Delete files and directories	`remove`
Create files and directories	`append`, `copy`, `directory`, `link`, `symlink`, `truncate`
Modify files and directories	(not used by the core changes)
Configure system	(not used by the core changes)
Execute commands	`execute`, `service`

For each phase the order in which changes are applied is also defined:

Install or remove packages	All changes are applied in the order the changes were processed (see Section 3.1, “Configuration Processing”).
Delete files and directories	All changes are ordered according to the *reverse alphabetical order* of the destination path and applied in this order. Files are deleted before their parent directory.
Create files and directories	All changes are ordered according to the *alphabetical order* of the destination path and applied in this order. Directories are created before files they contain.
Modify files and directories	All changes are ordered according to the *alphabetical order* of the destination path and applied in this order. Directories are created before files they contain.
Configure system	All changes are applied in the order the changes were processed (see Section 3.1, “Configuration Processing”).
Execute commands	All changes are applied in the order the changes were processed (see Section 3.1, “Configuration Processing”).

3.3.2.1. Data Generation

Before the files are copied in phase `3` of each pass, the content of files are generated. This is done on two steps:

1. The source data of all append and copy changes that are not marked as binary using the `-b` flag is processed using Template Toolkit.
2. The processed data from all `append` changes is appended to the processed data of the respective `copy` or `truncate` changes.

The processed data is not written to the destination files yet but kept in memory for use during the actual configuration application.

Important

Copying large files may use up a lot of memory because of the intermediate copy in memory.

3.3.3. Changes

For each change that is applied **config5** will first check if there are modifications needed. Changes that require no modifications on the target system are not shown in the default verbosity level.

The following subsections describe how each change type is applied.

3.3.3.1. `copy` and `truncate`

When applying a `copy` or `truncate` change **config5** will do it with as few side effects as possible. A file is only replaced or created if it is missing or its content (or file type) changes in which case **config5** does the following:

1. If the file already exists but is not a plain file then it will be deleted first.
2. It will create a temporary file with the new content and set all permissions as specified. If SELinux is enabled and no SELinux context is specified and the file is replaced then the context from the current file is copied to the temporary file.
3. The temporary file is renamed to the real file name which also deletes the old file.

If *in-place* modification is explicitly enabled using the `-i` flag then the existing file is modified directly instead and **config5** does the following:

1. If the file already exists but is not a plain file then it will be deleted first.

2. It will write the new content to the file.

If the file is already present and the content is the same then only the properties such as user, group, mode or SELinux context (if enabled) are modified if necessary.

3.3.3.2. `directory`

If a file exists with the same path as the directory it is removed.

3.3.3.3. `execute`

The command line is executed by the default shell of the user who is running **config5**.

3.3.3.4. `link`

If the link is missing or does not have the same device and inode number as the file it links to **config5** does the following:

1. It will create a temporary link to the source file

2. The temporary link is renamed to the real file name which also deletes the old link.

3.3.3.5. `remove`

If the file or directory exists it will be removed.

Important

Recursively deleting directories is not supported at this time. Use an `execute` change to run **rm** instead.

3.3.3.6. `symlink`

If the symbolic link is missing or does not have the right content **config5** does the following:

1. If the file already exists but is not a symbolic link then it will be deleted first.

2. It will create a temporary symbolic link with the new content and set all permissions as specified. If SELinux is enabled and no SELinux context is specified and the symbolic link is replaced then the context from the current symbolic link is copied to the temporary symbolic link.

3. The temporary symbolic link is renamed to the real file name which also deletes the old symbolic link.

3.3.3.7. properties

The file or directory must exist. The properties such as user, group, mode or SELinux context (if enabled) are modified if necessary.

3.3.4. Triggered Changes

A simple mechanism exists to make the application of changes depend on the modifications of previous changes. The most common case where this is used is to restart a service after updating its configuration files.

Each class and each feature has a *triggered* flag which are cleared before configuration application. Every change that requires a relevant modification (see Section 3.3.4.1, “Relevant Modifications”) to the target system will set the triggered flags of its class and feature. Each change can be flagged to be triggered using either the `-t` or `-T` flag. In this case the change is only applied if the triggered flag of the class (`-t`) or the feature (`-T`) of the change is set.

The following facts are also relevant when working with triggered changes:

- The flags are kept across all phases and passes
- Triggered changes never set the triggered flags

3.3.4.1. Relevant Modifications

Not every modification that is done when a change is applied sets the triggered flags. The following table lists the modifications that set or do not set the triggered flags:

Change	Triggered Flag Set	No Change
`append`	Never	
`copy`	File missing or not a plain file,content changed	Change of user, group, mode or other properties

Change	Triggered Flag Set	No Change
`directory`	Directory missing or not a directory	Change of user, group, mode or other properties
`execute`	Never	
`link`	Link missing or to different inode	
`properties`	Change of user, group, mode or other properties	
`remove`	File or directory existing	
`symlink`	Symbolic link missing or not a symbolic link, content changed	Change of user, group or other properties
`truncate`	File missing or not a plain file,content changed	Change of user, group, mode or other properties

Chapter 4. The config5 Script

This chapter describes the **config5** script and how to use it for configuration verification, application and various management tasks.

4.1. Requirements

The **config5** script is written in Perl and therefore requires a Perl installation with the core modules as well as a number of additional modules.

4.1.1. Perl Modules

The following non-core Perl modules are required to run **config5**:

- `Module::Load`
- `Module::Load::Conditional`
- `Template`

The following modules are only required if a given feature is enabled:

`File::ExtAttr`	Required for SELinux support (see Section 7.3.2, “Operating System Settings”).
`Socket6`	Required for IPv6 support if the IP6 address is a mandatory system information item (see Section 7.3.3, “System Information Settings”).

4.1.2. Other Requirements

These external programs are required if a given feature or component of **config5** is used:

lsb_release	Required for the LSB system information module.

4.2. Running config5

The **config5** script will determine its location and automatically find settings, libraries and the feature set relative to its path.

The libraries and settings are expected to be found in the directories `../lib` and `../etc` respectively. The feature set is expected in `../features` unless the path of the feature set is explicitly set using the `--features` command line option.

4.2.1. Arguments

The arguments to **config5** are a list of features. Only the features listed on the command line are processed in alphabetical order.

If no features are specified then all features of the feature set are processed.

4.3. Applying the Configuration

The configuration is applied by running the config5 script with the `--apply` command line option.

```
# /usr/config5/bin/config5 --apply
```

This is also the default action (the other two are `--check` and `--report`) so the option can be omitted:

```
# /usr/config5/bin/config5
```

While the configuration is applied config5 will use a lock file to make sure that no other instance of config5 is running at the same time. The file is relative to the root directory system item (see Section 6.2.3, “Root”), the default path for the file is `/var/lock/config5` but can be changed (see Section 7.3.1, “General Settings”).

4.3.1. Changing System Information Items

The `--set` command line options can be used to override the system information items that are automatically determined. The argument to `--set` is of the form `key=value` where `key` is the identifier of the system information item and `value` is the value to set:

```
# /usr/config5/bin/config5 --set host=foobar
```

The list of identifiers of all configured system information items can be displayed using `--report systemitems`.

4.3.2. SELinux Support

SELinux support is a built-in feature and typically configured via the global configuration (see Section 7.3.2, “Operating System Settings”). In some situations, such as when running **config5** on diskless clients, it may be required to override this setting via command line. SELinux support is also automatically disabled when the root directory is not `/` but the command line options take precedence.

The `--selinux` command line option enables SELinux support, the `--no-selinux` command line option disables it:

```
# /usr/config5/bin/config5 --no-selinux
```

4.3.3. Dry Run

The `--dummy` command line options will force **config5** to simulate configuration application:

```
# /usr/config5/bin/config5 --apply --dummy
```

No changes to the system will be done. The changes that would be done are printed.

Important

The dry run uses the current system state for the simulation which may not be enough to reflect the changes that would really be done.

For instance a `service start` change that follows a `service stop` change for a service would usually be executed but in dry run mode the current state is not the same as after the `service stop` change was executed.

4.3.4. Disable Configuration Application

The configuration application for a single system can be disabled by creating an empty *disable file*. This is usually helpful when manual maintenance is done on a system and running **config5** would interfere. The file is relative to the root directory system item (see Section 6.2.3, “Root”).

The default path for the file is `/etc/config5-disabled` but can be changed (see Section 7.3.1, “General Settings”).

4.4. Verifying the Configuration

With the `--check` command line option the configuration will only be checked for correctness. Currently the following static checks are performed:

- Syntax errors in the `spec` files or missing spec files.
- Missing source files for copy or append.
- File or directory modified in more than one feature.
- Missing referenced class.
- Missing `copy` or `truncate` change for `append` changes.
- Duplicate classes in a feature.

Ensuring that every append change has a corresponding copy or truncate change cannot be verified statically. To enable this check do the following:

1. Collect the output of **config5 --report rawsystem** from all systems the configuration will be applied to and store each output in an individual file in some directory, typically a network share. The directory must be readable from where you will run config5 --check (if you integrate config5 with Subversion such as described in Chapter 5, *Deployment* then the directory must also be accessible on your Subversion server). The best is to do this periodically.
2. Set the setting `$self->{system}->{variations_directory}` (see Section 7.3.3, “System Information Settings”) to the directory containing the above files.

4.5. Reports

The `--report` command line option can be used to produce a variety of reports. The argument to `--report` is a report type:

`changes`	Report the keywords of all changes.
`classes`	Report all classes of all features.
`classorder`	Report all classes that can be matched in a `spec` file, in the order they are matched (see Section 2.3.2, “Best Match”).

`features`	Produce a normalized output of all changes, classes and features.
`files`	Report all files that are copied or truncated in all classes of all features. This information can be used to manage configuration file upgrades when a new release of an operating system is available.
`matches`	Report the matching class for each feature based on the available system information.
`rawsystem`	Report the current values for all system information items for the system in a form that can be parsed by a shell or used for configuration verification.
`stages`	Report all configured stages.
`system`	Report the current values for all system information items for the system. This is also printed first when applying the configuration.
`systemitems`	Report all configured system information items.

Chapter 5. Deployment

This chapter provides information and tips how to actually deploy Config5 in your organization.

Deploying Config5 to a system is done in two steps:

1. Distributing the Config5 deployment kit including the configuration data on the system

2. Running the **config5** script

Config5 is very flexible and allows for a wide range of approaches for both.

5.1. Distribution of the Configuration

The **config5** script along with its settings and libraries are typically distributed along with the feature set. This set comprises the deployment kit (the `deploy` folder in the distribution). Some options for distributing the deployment kit include:

Network File system	The files of the deployment kit are exported via CIFS or NFS and mounted read-only on the system to configure. If applicable the authentication scheme of the network file system can be used to restrict access.
Version Control System	A version control system such as Subversion or GIT can be used as a distribution point. A system will check out the latest version of the deployment kit.
Remote Copy	The deployment kit is pushed on a system via **rsync**, **scp** or any other tool that does the job.

The right choice of the deployment method largely depends on your work flow, policies and security requirements.

5.1.1. Integration with Subversion

Config5 integrates well with Subversion. The configuration check function of **config5** (see Section 4.4, “Verifying the Configuration”) can easily be used in a pre-commit hook to guard against common errors such as syntax errors and missing configuration files:

```
#!/bin/sh

REPOSITORY="$1"
TRANSACTION="$2"

TEMPDIR=`/bin/mktemp -d`
export-commit "$REPOSITORY" "$TRANSACTION" trunk "$TEMPDIR" 1>&2

"$TEMPDIR/trunk/bin/config5" --check 1>&2

RC=$?
rm -rf "$TEMPDIR"
exit $RC
```

This script relies on an additional script **export-commit** which performs an export of the repository *including the pending commit*:

```
#!/bin/sh

REPOSITORY="$1"
TRANSACTION="$2"
SUBDIR="$3"
DIRECTORY="$4"

svnlook tree --full-paths "$REPOSITORY" -t "$TRANSACTION" "$SUBDIR" | while read path
do
   if [[ $path =~ "\/$" ]]
   then
      mkdir -p "$DIRECTORY/$path"
   else
      svnlook cat "$REPOSITORY" -t "$TRANSACTION" "$path" > "$DIRECTORY/$path";
      chmod 755 "$DIRECTORY/$path"
   fi
done
```

Both scripts can be found in the directory `examples/svn` in the distribution.

5.2. Running config5

Running the **config5** script at the right time is an important decision for a successful deployment and depends on several factors such as the operating system, work flows, policies, etc. Below is a non-conclusive list of possible places from where to run **config5**:

cron	Running **config5** periodically via **cron** is the simplest way to make sure that all running systems receive a new configuration.
anacron	Configuring **anacron** on systems such as laptops and desktops that may be put in sleep mode or hibernation can be a meaningful complement to **cron**. If cron runs config5 often (like, every hour) this may not be necessary.
on boot	After the operating system has booted it is usually best to run **config5** once to get the latest configuration updates immediately, possibly before the services it configures start up.
after package updates	After packages are updated it may be required to overwrite configuration files by running **config5** immediately afterward.

When **config5** is running it uses a lock file to make sure that only one instance of **config5** is running at a time. It is therefore save to run **config5** from different places without additional synchronization means.

5.2.1. Random Delay

If many system are likely to update their configuration at the same time, it may be meaningful to add a random delay before running **config5**. This is usually the case if **config5** is run via **cron** on managed systems. If the deployment kit is on a network file system then all managed systems will otherwise access the file server at the same time. Depending on the file server and file system this may cause all kinds of errors.

The following **bash** code will perform a random five minute delay before running **config5**:

Example 5.1. Random Delay with bash

```
RND=$RANDOM ; let "RND\%=300" ; sleep $RND; /usr/config5/bin/config5
```

If the deployment kit is pulled from a central repository via download or checkout the delay should be placed before the download or checkout commands for similar reasons.

Chapter 6. System Information

Config5 uses an approach where the configuration is selected on the system that is being configured. This chapter explains the mechanism by which **config5** discovers information about the system it runs on.

6.1. The System Information Module

The module used for gathering the system information is exchangeable. Config5 ships with two modules for immediate productive use: `LSB` (the default) and `Hardwired`.

Custom modules can also be added. A sample module (the one that we at *isginf* use in our productive environment) can be found in `examples/modules/System/SystemInfo.pm` in the distribution.

6.2. System Information Items

The system information is organized in *items*. Each item is determined somehow by the system information module and can be used in the class matching process and is available as a variable for substitution.

Each item has a unique name and the following relevant information associated with it:

- Priority for displaying the system information summary (low priority means display first).
- Whether or not the item is optional (`0`) or mandatory (`1`).
- The type of the system information item (`0` for scalar, `1` for ordered list).
- A conversion method for the gathered value of the item (see below).
- The human readable description displayed in the system information summary.

The conversion is useful to modify the raw value gathered by the module. No conversions are used in the default configuration. The following conversions are supported:

none	No conversion.
toupper	Convert all characters to upper case.
tolower	Convert all characters to lower case.
nows	Strip all white space characters.
wstounderscore	Convert all white space characters to underscore.

The available system information items are configured via settings (see Section 7.3.3, “System Information Settings”). The following items are configured by default:

Item	Priority	Mandatory	Type	Conversion	Description
`date`	`10`	no	scalar	none	Architecture
`host`	`20`	yes	scalar	none	Host name
`arch`	`30`	yes	scalar	none	Architecture
`os`	`40`	yes	scalar	none	OS
`release`	`50`	yes	scalar	none	Release
`ip`	`60`	no	scalar	none	IP
`ip6`	`70`	no	scalar	none	IP6
`fqhn`	`80`	no	scalar	none	Fully qualified host name
`fqdn`	`90`	no	scalar	none	Fully qualified domain name
`properties`	`100`	no	list	none	Properties
`root`	`110`	yes	scalar	none	Root directory
`stage`	`120`	yes	scalar	none	Stage

6.2.1. Common System Information Items

The following system information items are determined independent of the chosen module and are always available and are determined from the running operating system:

- `arch`
- `host`
- `ip` (if configured)
- `ip6` (if configured)
- `properties`
- `root`
- `stage`

If the root directory is changed (see Section 3.2.1, “Root Directory”) then only the following items are determined.

- `properties`
- `root`
- `stage`

The remaining mandatory modules must be provided by command line argument or by an alternative system information module such as the `Hardwired` module (see Section 6.3.2, “Hardwired”).

6.2.2. Properties

The properties are read from a file that contains space- or comma-separated words. This file can be provisioned during installation.

6.2.3. Root

The root directory (see Section 3.2.1, “Root Directory”) can be modified with the `--set` command line option when running **config5**. Changing the root directory only makes sense when the configuration is applied to something other than the system where **config5** is run, for instance a diskless client image on the file server that serves it.

The default path of the root directory is taken from the `$self->{os}->{root}` setting (see Section 7.3.2, “Operating System Settings”) and is typically `/`.

6.2.4. Stage

The stage (see Section 3.2.1, “Root Directory”) can be modified with the `--set` command line option when running **config5**.

The default change can be changed with the following setting:

Setting	Default	Description
`$self->{system}->{defaults}->{stage}`	`production`	The default stage.

6.3. System Information Modules

The system information module to use can be changed in the settings (see Section 7.3.3, “System Information Settings”).

6.3.1. LSB

The `LSB` module can determine the OS name and release using **lsb_release**.

The following settings can be used to control the information gathering:

Setting	Default	Description
`$self->{system}->{lsb}->{append_code}`	`0`	Append the OS code name to the OS id with an underscore in between.

6.3.2. Hardwired

The `Hardwired` module can read constants for the active system information items from the Config5 settings. Supplied constants overload the automatically determined information (architecture, host name, etc.):

Setting	Default	Description
`$self->{system}->{hardwired}->{`*`item`*`}`	*`undefined`*	Set the constant value for system information item *`'item'`*.

Chapter 7. Customization

Config5 ships with a reasonable set of default settings for the **config5** script for a normal deployment using the core features.

Systems administrators with special needs or policies can tweak many settings that affect the file system structure or behavior of Config5.

7.1. Files

All files are located under the directory `etc` next to the `bin` directory containing the **config5** script. In the official distribution the files are in `deploy/etc`:

```
$ ls deploy/etc
custom.d  extensions.d  settings.pl
```

All configuration files are basically perl code that modifies the settings data structure which is passed in `$_` by reference.

7.1.1. Order of Processing

The various files are processed in the following order:

1. The main settings file `settings.pl`.
2. All files ending in `.pl` in `extensions.d` in alphabetical order.
3. All files ending in `.pl` in `custom.d` in alphabetical order.

Settings in one file can be removed, replaced or extended by files that are loaded afterward.

7.2. Custom Settings

Custom settings should be placed in a file ending in `.pl` in the directory `etc/custom.d`. A custom settings file should start with the following code:

```
my $self = $_;
```

This is not absolutely necessary but the other settings file all use `$self` and settings can be customized easier using copy-paste.

Each file should also end with the following line:

```
1;
```

The file `examples/settings/custom.pl.example` in the distribution of Config5 can be used as template for a custom configuration file.

7.3. Settings Reference

The following reference lists the various settings. All examples assume that `$self` is defined and holds the reference to the settings structure.

7.3.1. General Settings

The following settings are of general nature:

Setting	Default	Description
`$self->{disable}->{file}`	`/etc/config5-disabled`	The path of the disable file. If this file is present then **config5** will not run. Dry runs via dummy mode are still possible.
`$self->{lock}->{file}`	`/var/lock/config5`	The path of the lock file used to prevent concurrent execution of **config5**. *This file must be on the local file system and not on a network share.*
`$self->{lock}->{timeout}`	`5`	The timeout after which **config5** will abort if the lock file cannot be locked. A value of `0` will block indefinitely until the lock file can be locked.
`$self->{features}->{name}`	`features`	The directory name of the feature set.

Setting	Default	Description
`$self->{spec}->{name}`	`spec`	The name of the specification file in each feature directory.

7.3.2. Operating System Settings

The following settings control additional support for features of the operating system:

Setting	Default	Description
`$self->{os}->{env}->{`*`variable`*`}`	undefine `LANG`	Set environment variable to a given string. To undefine an environment variable set it to `undef`.
`$self->{os}->{root}`	`/`	The root directory.
`$self->{os}->{selinux}->{enable}`	`0`	Enables support for SELinux if set to `1` and disables it if set to `0`.
`$self->{os}->{syslog}->{enable}`	`1`	Enables logging via `syslog` if set to 1 and disables it if set to `0`.
`$self->{os}->{syslog}->{identifier}`	`config5`	The identifier for log entries if logging via `syslog` is enabled.
`$self->{os}->{syslog}->{facility}`	`local5`	The facility for log entries if logging via `syslog` is enabled.
`$self->{os}->{umask}`	`022`	The file and directory creating mask for shell commands.

7.3.3. System Information Settings

The following settings control the system information collection.

Setting	Default	Description
`$self->{system}->{class}`	`Config5::System::LSB`	The class that collects the system information.
`$self->{system}->{items}->{`*`item`*`}`	`see Section 6.2, “System Information Items”`	The known system information items.
`$self->{system}->{properties}->{file}`	`/etc/config5-properties`	The file name of the properties file.
`$self->{system}->{variations_directory}`	*`undefined`*	Directory containing files variations of system information (see Section 4.4, “Verifying the Configuration”).

7.3.4. Built-in Changes

The following settings control the behavior of the built-in changes.

Setting	Default	Description
`$self->{builtin}->{execute}->{allow_chroot}`	`0`	Apply execute changes if root is not `/`.

7.3.5. Verbosity

The amount of information that is printed at which verbosity level can be configured by changing the following settings.

Setting	Default	Description
`$self->{display}->{entities}->{system}`	`1`	Print the system information.
`$self->{display}->{entities}->{pass}`	`1`	Print the pass numbers.
`$self->{display}->{entities}->{status}`	`1`	print the status.

The default verbosity level is `1` which means that by default all three items are printed.

7.3.6. Stages

The stages and the associated flags can be altered by defining `$self->{stage}->{stages}` like this:

```
# Stages of the target system
$self->{stage}->{stages} =
{
   'installation' => 'I',
   'startup' => 'S'
   'production' => 'P'
};
```

The flags defined for the stages must not conflict with the regular flags (see Section 2.4.1, “Flags”).

7.3.7. Change Keywords

The keywords for changes can be altered by modifying `$self->{change}->{keywords}` like this:

```
# Replace the keyword 'directory' by 'mkdir'
delete $self->{change}->{keywords}->{directory};
$self->{change}->{keywords}->{mkdir} = 'directory';

# Add 'package' as keyword for 'yum'
$self->{change}->{keywords}->{package} = 'yum';
```

Similarly the identifier used for changes when displaying them can be changed by modifying `$self->{display}->{keywords}`:

```
# Replace the keyword 'directory' by 'mkdir'
$self->{display}->{keywords}->{directory} = 'mkdir';

# Add 'package' as keyword for 'yum'
$self->{display}->{keywords}->{yum} = 'package';
```

The names for the core changes are:

- `copy`
- `truncate`
- `append`
- `directory`
- `link`
- `symlink`
- `properties`
- `remove`
- `execute`

7.3.8. Class Match Order

The search order for the best class match in each feature can be customized by modifying `the list referenced by $self->{class}->{match}`. Each list entry is a string containing placeholders of the form *`{item}`* which are replaced by the value of the respective system information item.

The default search order is the following:

1. `{host}_{os}_{release}_{arch}`
2. `{host}_{os}_{release}`
3. `{host}_{os}_{arch}`
4. `{host}_{os}`
5. `{host}_{arch}`
6. `{host}`
7. `{properties}_{os}_{release}_{arch}`

8. `{properties}_{os}_{release}`
9. `{properties}_{os}_{arch}`
10. `{properties}_{os}`
11. `{properties}_{arch}`
12. `{properties}`
13. `{os}_{release}_{arch}`
14. `{os}_{release}`
15. `{os}_{arch}`
16. `{os}`

Appendix A. Man Pages

A.1. config5

```
NAME
    config5 - 5th Generation Unix Configuration Management Utility

SYNOPSIS
    config5 [-vqdnhmV] [--selinux|--no-selinux] [--set *key=value*]
    [--apply|--check|--report *type*] [--features dir] [feature...]

DESCRIPTION
    config5 is the main script of the *Config5* Unix Configuration
    Management Kit. It can apply a configuration (feature set), check
    configuration metadata for consistency and give various reports on the
    configuration and the system it is run on.

    When run without arguments it will perform all operations with the full
    set of features. Otherwise it will only process the features specified.
    The feature set location defaults to 'features' in the *Config5* base
    directory and can be altered with the --features otion.

    Information about the system a configuration is appled to is collected
    from data on the system where config5 is run. The collected values can
    be altered using the --set option.

    For detailed documentation consult the "Config5 Systems Administrator's
    Guide".

OPTIONS
    --apply
        Apply the configuration. Either the entire feature set or only the
        features specified on the command line are applied.

    --check
        Perform consistency checks of the entire configuration. Checks
        include syntax checks of the specification files in all features,
        checks for references to missing files and more.

    --report *type*
        Print various reports. The report *type* can be one of:

        *changes*
            Report the keywords for all changes.

        *classes*
            Report all classes in alphabetical order.

        *classorder*
            Report the classes used to match the best class in each feature.
            The classes are reported in the order they are checked and are
            generated using the gathered system information and the values
            set using --set.

        *features*
            Report all classes and changes for all features in a normalized
            form.

        *files*
            Report all files that are modified by any class of all features.

        *matches*
            Report the matching class for each feature using the gathered
            system information and the values set using --set.

        *stages*
            Report all defined target system stages.

        *system*
            Show the various values of the system information.
```

```
        *rawsystem*
            Show the various values of the system information as parsable
            output. The output can be sourced by a shell.

        *systemitems*
            Report all configured system information items with description,
            identifier and other meta information.

        For all reports relating to features the report comprises either all
        features or only the features specified on the command line.

    --set *key=value*
        Change the value of one of the system information items.

    --features dir
        Sets the directory containing the feature set.

    --set *key=value*
        Change the value of one of the system information items.

    --selinux or --no-selinux
        Activates or deactivates SELinux support, overrides the
        configuration in the settings.

    --help, -h
        Print a brief help message and exit.

    --man, -m
        Print this manual page and exit.

    --version, -V
        Print the version number of the script and exit.

    --verbose, -v
        Enable verbose messages on the process. Can be specified multiple
        times to increase verbosity.

    --quiet, -q
        Only print errors and warning. This option overrides --verbose.

    --debug, -d
        Enable debugging output. Can be specified multiple times to increase
        the debug level.

    --dummy, -n
        Activate dummy mode where no actual changes are made.

EXIT VALUES
    If there were no errors the program exists with return code 0. Otherwise
    the return code is 1.

EXAMPLES
    "config5"
        Apply the entire configuration.

    "config5 --set root=/var/diskless/host1 --set host=host1"
        Apply the configuration for a diskless client on the server.

    "config5 --report info"
        Report information about the system.

    "config5 --dummy"
        Simulate application of the configuration.

    "config5 --check"
        Check the feature set for consistency and syntax errors.

    "config5 --set host=sample --report matches cifs nfs"
        Report the matching class of features 'nfs' and 'cifs' for host
        'sample'.
```

Appendix B. Error Messages

B.1. Runtime Errors

Disabled via '*file*'	Configuration application is disabled because the named disable file is present (see Section 4.3.4, “Disable Configuration Application”). Remove the file to enable configuration application.
Unable to lock 'file'	A lock could not be obtained for the lock file. Verify that the lock file can be created, is writable and on a local file system. Increase the wait time for obtaining the lock (see Section 7.3.1, “General Settings”).

B.2. System Errors

System errors are fatal, no changes will be done to the system.

Cannot run 'lsb_release -…' to determine …	The **lsb_release** command could not be run. Install or deploy the package containing the **lsb_release** command on all systems where **config5** is run with the same settings.
Perl module '*module*' is not installed …	The named perl module is not installed but either generally required or required because of an optional functionality that is enabled. Install or deploy the named module on all systems where **config5** is run with the same settings.

B.3. Setting Errors

Setting errors are fatal, no changes will be done to the system.

Cannot load module '*module*' for keyword in …	The module of the handling class for the change failed to load.
Cannot read feature list in '*directory*'	The features directory could not be read.
Mandatory system information item '*item*' could not be determined	The settings list the system information item as mandatory but the system information module did not set a value for it.
No handling class for keyword '*keyword*' in …	The settings do not specify a class to handle changes with this keyword.
Undefined system information item '*item*'	An undefined system information item was used in the class match list (see Section 7.3.8, “Class Match Order”.)

B.4. Configuration Data Errors

Configuration data errors are fatal, no changes will be done to the system.

Change '*change*' in feature '*feature*' without class	A change was correctly parsed but no class was declared.
Conflict for '*file*' between …	The same file or directory is configured in different features.
Duplicate class '*class*' in feature '*feature*'	The feature contains two declarations of the same class.
Feature '*feature*' does not contain a '…' file	The feature does not contain a spec file.
'*file*' is of the wrong type for …	An `append` change was used for a path that is not a plain file.
'*file*' needs to be created for …	An `append` change for a file was found for which there is no matching `touch` or `copy` change in the same pass.
Garbage '…' in …	Unexpected arguments were found in a change.
Insufficient arguments in …	The change requires more arguments.
Invalid flag '*flag*' for …	The flag is invalid for the change.
Invalid mode '*mode*' in …	The mode is invalid. See Section 2.4.2, “Parameters” for a description of the mode parameter.

Invalid SELinux context '*context*' in …	The SELinux context is invalid. See Section 2.4.2.6, “SELinux Context” for a list of supported context formats.
Invalid substitution '*substitution*' in …	The substitution is invalid.
No file '*file*' in …	The file could not be found in the file system of the target system or in the feature.
Path '*path*' is not absolute in …	The path of the file or directory is not absolute.
Problem with template …	Template Toolkit failed to process the content of the source file.
Recursive reference to class '*class*' in class '*parent*'	A class declaration references an undefined class.
Reference to undefined class '*class*' in class '*class*' in feature '*feature*'	A class declaration references an undefined class.
Unable to append data in '*source*' to '*file*'	The data from the source file could not be read. Verify that the source file exists and is readable.
Unknown change keyword '*keyword*' in …	The change with this keyword is unknown.
Unknown group '*group*' in …	The group is unknown or invalid. See Section 2.4.2, “Parameters” for a description of the group parameter.
Unknown user '*user*' in …	The user is unknown or invalid. See Section 2.4.2, “Parameters” for a description of the user parameter.
Unparsable line *number* in '…' file for feature '*feature*': …	The line is not a valid class declaration or change.

B.5. Configuration Application Errors

The following errors are reported for changes as they are applied but do not interrupt the application of other changes.

Command '*command*' returned *error* in …	The command returned a non-zero return value. Increase the verbosity level to see the output and error messages of the command.
Failed to correctly apply change in …	The change could not be correctly applied.
Unable to chcon '*path*' to *context* in …	The SELinux context of the file or directory could not be set. Verify that the given path is on a file system that has SELinux support.
Unable to chmod '*file*' to mode *mode* in …	The mode bits of the file or directory could not be set.
Unable to chown '*path*' to *uid*:*gid* in …	The user and group of the file or directory could not be set.
Unable to create directory '*directory*' in …	The directory could not be created. Verify that the directory containing the file exists and that it is in a local, writable file system.
Unable to create link '*link*' to '*source*' in …	The link to the source path could not be created. Verify that the source file exists and is in the same file system as the link. Verify that the directory containing the link exists and that it is in a local, writable file system.
Unable to create symbolic link 'link' in …	The symbolic link could not be created. Verify that the directory containing the symbolic link exists and that it is in a local, writable file system.
Unable to get properties of '*file*' in …	The properties of an existing file could not be read.
Unable to open '*file*' for writing in …	The file could not be opened for writing. Verify that the directory containing the file exists and that it is in a local, writable file system.
Unable to remove 'path' in …	The file or directory could not be removed Verify that the file or directory is in a local, writable file system. When a directory is removed it must be empty.
Unable to rename temporary to '*file*' in …	The temporary file could not be renamed to the file.
Unable to write to '*file*' in …	An error occurred while writing data to the file. Verify that the file system containing the file has enough free space.

Appendix C. GNU General Public License version 3

Version 3, 29 June 2007

Preamble

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If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with… Texts.” line with this:

```
with the Invariant Sections being LIST THEIR TITLES, with the Front-Cover Texts
```

```
being LIST, and with the Back-Cover Texts being LIST.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Glossary

Config5 Concepts

Change	A change defines a single modification to the configuration. Changes always belong to a class. See Also Class.
Class	A class is part of a feature and defines a set of changes. When applying the configuration Config5 searches for the best matching class in each feature. A class can include other classes of the same feature. Substitutions for files defined at class level are available in all changes of the class or any included class. See Also Feature, Change.
Deployment Kit	The deployment kit is that part of the Config5 distribution that needs to be present on all managed systems. By default this is everyting in the `deploy` folder in the distribution and contains scripts, library files, settings and the feature set.
Feature	A feature groups together changes that belong together according to some criteria, including all files needed for these changes. Features are structured into classes. See Also Class, Change.
Feature Set	The feature set groups together all features of a deployable configuration. See Also Feature.
Pass	The configuration is applied in ten passes, in each pass all phases are performed once. Changes are flagged to run in a given pass. See Also Feature, Feature.
Phase	The application of the configuration of one pass is structured into phases. Each phase groups all changes that affect a given configurable aspect of a system such as files, packages, services, etc. See Also Pass.
Specification File	The specification file is part of a feature and contains the classed and changes. See Also Feature.
Stage	The stage defines the state a target system is currently in when the configuration is applied. Only the changes that are intended to be applied at this stage are applied. See Also Change.
Substitution	Substitutions are keywords that are substituted by a value using Template Toolkit. They are specified in class definitions and in changes that support it. See Also Class, Change.

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