CEKit

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CEKIT

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Container image creation tool.

CEKit helps to build container images from image definition files with strong focus on modularity and code reuse.

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Main features

- *Building container images* from *YAML image definitions* using many different *builder engines*
- *Integration/unit testing* of images

CHAPTER 3

I'm new, where to start?

We suggest looking at the *getting started guide*. It's probably the best place to start. Once get through this tutorial, look at *handbook* which describes how things work. Later you may be interested in the *guidelines sections*.

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Releases and changelog

See the releases page for latest releases and changelogs.

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Contact

- Please join the #cekit IRC channel on Freenode
- You can always mail us at: *cekit* `at` *cekit* `dot` *io*

CHAPTER 6

Documentation

6.1 Getting started guide

Welcome!

It looks like you're new to CEKit. This guide will walk you through the steps required to create your first container image from scratch.

If you need any help, just jump into the #cekit IRC channel on Freenode. We will assist you!

6.1.1 Before you start

Please ensure that you have followed the installation instructions that may be found *here*.

While several different build engines to construct container images are supported, this guide will use the *podman* engine.

6.1.2 Preparing image descriptor

This section will guide you through a very simple example.

1. Using a standard text editor create an empty `image.yml` file. It is recommended to use the `image.yaml` naming scheme.
2. As described in *Image Descriptor* several values are mandatory. Add the following to the file:

```
name: my-example
version: 1.0
from: centos:7
```

- Next, while optional, it is recommended to add a suitable `description` tag e.g.

```
description: My Example Tomcat Image
```

While this configuration will build in CEKit it isn't very interesting as it will simply create another image layered on top of CentOS 7. The descriptor should now look like:

Listing 1: image.yaml

```
name: my-example
version: 1.0
from: centos:7
description: My Example Tomcat Image
```

It is possible to directly add further content to the image at this point through a variety of methods. Labels, ports, packages etc can be used - see *here*. In general modules are used as the 'building blocks' to assemble the image - they can be used as individual libraries or shared blocks across multiple images. So, move onto to *modules* to discover more about these.

6.1.3 First modules

As described in the *module reference* modules are used as libraries or shared building blocks across images.

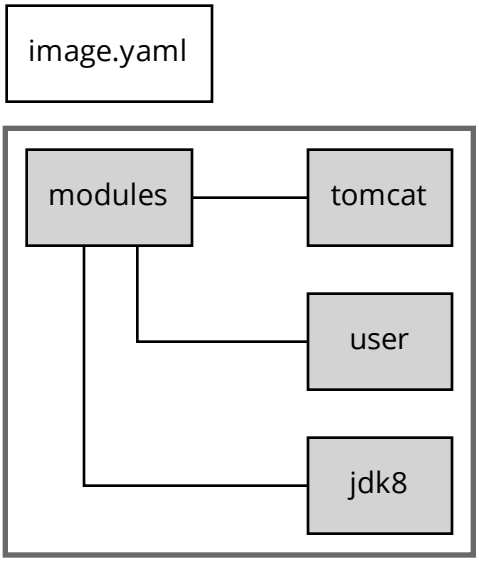
To add a module, the `image.yaml` file must be modified to add a modules section. This is responsible for defining module repositories and providing the list of modules to be installed in order. Modules may come from the local file system or from remote git based repositories e.g. on github.

Edit the file to add the highlighted section below.

```
name: my-example
version: 1.0
from: centos:7
description: My Example Image

modules:
  repositories:
      - path: modules
```

As per the below diagram a number of directories must be created next to `image.yaml`.



Once the modules subdirectory and the respective module directories below that have been created they can be added to the image. In order to select a module component from a repository it is necessary to add an `install` section as per the highlighted section below.

```
modules:
  repositories:
      - path: modules

  # Install selected modules (in order)
  install:
      - name: jdk8
      - name: user
      - name: tomcat
```

In order to add and populate the local file system modules follow the below instructions.

Note: All module yaml files should be named `module.yaml`

JDK8

- Create an empty `module.yaml` file within the `jdk8` directory.
- Enter the following code:

Listing 2: module.yaml

```
schema_version: 1
```

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```
name: jdk8
version: 1.0
description: Module installing OpenJDK 8

envs:
   - name: "JAVA_HOME"
     value: "/usr/lib/jvm/java-1.8.0-openjdk"

packages:
   install:
      - java-1.8.0-openjdk-devel
```

- An environment variable has been defined that will be present in the container after running the image.
- packages have been used to add the JDK RPM.

User

- Create the `module.yaml` and `create.sh` files within the `user` directory.
- Enter the following code:

Listing 3: module.yaml

```
schema_version: 1

name: user
version: 1.0
description: "Creates a regular user that could be used to run any service, gui/uid:␣
↪1000"

execute:
  - script: create.sh

run:
   user: 1000
   workdir: "/home/user"
```

Listing 4: create.sh

```
#!/bin/sh

set -e

groupadd -r user -g 1000 && useradd -u 1000 -r -g user -m -d /home/user -s /sbin/
↪nologin -c "Regular user" user
```

- An execute command is used to define what needs to be done to install this module in the image. It will be run at build time.
- A run command sets the working directory and user that is used to launch the main process.

Tomcat

- Finally, create the following two files inside the `tomcat` directory:

Listing 5: install.sh

```
#!/bin/sh
set -e
tar -C /home/user -xf /tmp/artifacts/tomcat.tar.gz
chown user:user -R /home/user
```

Listing 6: module.yml

```
name: tomcat
version: 1.0
description: "Module used to install Tomcat 8"
# Defined artifacts that are used to build the image
artifacts:
  - name: tomcat.tar.gz
    url: https://archive.apache.org/dist/tomcat/tomcat-8/v8.5.24/bin/apache-tomcat-8.
↪5.24.tar.gz
    md5: 080075877a66adf52b7f6d0013fa9730
execute:
  - script: install.sh

run:
   cmd:
     - "/home/user/apache-tomcat-8.5.24/bin/catalina.sh"
     - "run"
```

- The artifact command is used to retrieve external artifacts that need to be added to the image.

Move onto the *build section* to build this new image.

6.1.4 Building your image

Now that a fully assembled image definition file has been constructed it is time to try building it. As mentioned previously we will use `podman` to build this image; for other build engines see *here*

```
$ cekit build podman
```

This will output various logs (extra detail is possible via the verbose `-v` option).

```
cekit -v build podman
2019-04-05 13:23:37,408 cekit        INFO     You are running on known platform:␣
↪Fedora 29 (Twenty Nine)
2019-04-05 13:23:37,482 cekit        INFO     Generating files for podman engine
2019-04-05 13:23:37,482 cekit        INFO     Initializing image descriptor...
2019-04-05 13:23:37,498 cekit        INFO     Preparing resource 'modules'
2019-04-05 13:23:37,510 cekit        INFO     Preparing resource 'example-common-
↪module.git'
...
STEP 41: FROM 850380a44a2b458cdadb0306fca831201c32d5c38ad1b8fb82968ab0637c40d0
STEP 42: CMD ["/home/user/apache-tomcat-8.5.24/bin/catalina.sh", "run"]
--> c55d3613c6a8d510c23fc56e2b56cf7a0eff58b97c262bef4f75675f1d0f9636
STEP 43: COMMIT my-example:1.0
2019-04-05 13:27:48,975 cekit        INFO     Image built and available under␣
↪following tags: my-example:1.0, my-example:latest
2019-04-05 13:27:48,977 cekit        INFO     Finished!
```

It is possible to use `podman` to list the new image e.g.

```
$ podman images
REPOSITORY                  TAG      IMAGE ID       CREATED          SIZE
localhost/my-example        latest   c55d3613c6a8   48 seconds ago   709 MB
localhost/my-example        1.0      c55d3613c6a8   48 seconds ago   709 MB
```

6.1.5 Is it running?

Now lets try running the image. As was shown in the preceeding example it is possible to obtain the image id through the `podman images` command. To ensure the local host machine can see the image the following command will map port 8080 to 32597.

```
$ podman run -p 32597:8080 localhost/my-example:1.0
```

When the image is built it is automatically tagged using the `name` key in the image descriptor combined with the `version` key. As the tomcat module that was specified earlier included a *run* command it will automatically start the Tomcat webserver.

Using your browser go to http://localhost:32597 ; if successful then the image is running correctly.

Note: if you want to interactively explore the new image use the following command:

```
$ podman run -it --rm localhost/my-example:1.0 /bin/bash
```

Note: It is also possible to reference using the image id e.g. `podman run -it --rm $(podman images -q | head -1) /bin/bash`.

Once an interactive shell has been started on the image it is possible to verify the JDK has been installed e.g.

```
$ podman run -it --rm my-example:latest /bin/bash
[user@ff7b60ea4d7c ~]$ rpm -qa | grep openjdk-devel
java-1.8.0-openjdk-devel-1.8.0.201.b09-2.el7_6.x86_64
```

6.1.6 Let's write some tests!

Todo: Write this!

6.1.7 Summary

Congratulations! You have now completed the getting started guide.

The examples used are available at github:

- https://github.com/cekit/example-image-tomcat/
- https://github.com/cekit/example-common-module/

The only difference is that the `example-image-tomcat` utilises a remote module repository reference to load the `jdk8` and `user` modules which are within `example-common-module` e.g.

```
modules:
  repositories:
      - path: modules
      - git:
          url: https://github.com/cekit/example-common-module.git
          ref: master
```

6.2 Handbook

This chapter will guide you through the CEKit usage covering all important topics.

6.2.1 Installation

This chapter will guide you through all the steps needed to setup CEKit on your operating system.

Hint: We suggest to read carefully the *dependencies* section that covers the new dependencies mechanism in CEKit.

Installation instructions

Contents

We provide RPM packages for Fedora, CentOS/RHEL distribution. CEKit installation on other platforms is still possible via `pip`.

RPM packages are distributed via regular repositories in case of Fedora and the EPEL repository for CentOS/RHEL.

Warning: Currently packaged version is a snapshot release of the upcoming CEKit 3.0.

Tip: You can see latest submitted package updates submitted in Bodhi.

Warning: Make sure you read the *dependencies* chapter which contains important information about how CEKit dependencies are handled!

Fedora

Note: Supported versions: 29+.

CEKit is available from regular Fedora repositories.

```
dnf install cekit
```

CentOS / RHEL

Note: Supported versions: 7.x

CEKit is available from the EPEL repository.

```
yum install epel-release
yum install cekit
```

Other systems

We strongly advise to use Virtualenv to install CEKit. Please consult your package manager for the correct package name.

To create custom Python virtual environment please run following commands on your system:

```
# Prepare virtual environment
virtualenv ~/cekit
source ~/cekit/bin/activate

# Install CEKit
# Execute the same command to upgrade to latest version
pip install -U cekit

# Now you are able to run CEKit
cekit --help
```

Note: Every time you want to use CEKit you must activate CEKit Python virtual environment by executing `source ~/cekit/bin/activate`

If you don't want to (or cannot) use Virtualenv, the best idea is to install CEKit in the user's home with the `--user` prefix:

```
pip install -U cekit --user
```

Note: In this case you may need to add `~/.local/bin/` directory to your `$PATH` environment variable to be able to run the `cekit` command.

Upgrading

Note: If you run on Fedora / CentOS / RHEL you should be using RPMs from regular repositories. Please see *installation instructions*.

Upgrade from CEKit 2.x

Previous CEKit releases were provided via the COPR repository which is now **deprecated**. The COPR repository **won't be updated anymore** with new releases.

Fedora packages are not compatible with packages that come from the deprecated COPR repository, you need to uninstall any packages that came from it before upgrading.

Tip: You can use `dnf repolist` to get the repository id (should be `group_cekit-cekit` by default) which can be used for querying installed packages and removing them:

```
dnf list installed | grep @group_cekit-cekit | cut -f 1 -d ' ' | xargs sudo dnf␣
↪remove {}\;
```

Once all packages that came from the COPR repository you can follow the *installation instructions*.

Fedora

```
dnf update cekit
```

CentOS / RHEL

```
yum update cekit
```

Other systems

Use the `pip -U` switch to upgrade the installed module.

```
pip install -U cekit --user
```

Dependencies

By default when you install CEKit, **only required core dependencies are installed**. This means that in order to use some generators or builders you may need to install additional software.

Building container images for various platforms requires many dependencies to be present. We don't want to force installation of unnecessary utilities thus we decided to limit dependencies to the bare minimum (core dependencies).

If a required dependency (for particular run) is not satisfied, user will be let know about the fact. In case of known platforms (like Fedora or RHEL) we even provide the package names to install (if available).

Below you can see a summary of CEKit dependencies and when these are required.

Contents

Core dependencies

Following Python libraries are required to run CEKit:

- PyYAML
- Jinja2
- pykwalify
- colorlog
- click

Note: For more information about versions, please consult the `Pipfile` file available in the CEKit repository.

Additionally, we require **Git** to be present since we use it in many places.

Builder specific dependencies

This section describes builder-specific dependencies.

Docker builder dependencies

Docker Required to build the image.

Docker Python bindings We use Python library to communicate with the Docker daemon instead of using the `docker` command directly. Both, old (`docker-py`) and new (`docker`) library is supported.

Docker squash tool After an image is built, all layers added by the image build process are squashed together with this tool.

> **Note:** We are aware that Docker now supports the `--squash` parameter, but it's still an experimental feature which requires reconfiguring the Docker daemon to make it available. By default it's disabled. Instead relying on this, we use a proven tool that works in any case.

Important: If run within the *Red Hat environment* additional dependencies are required.

`odcs` command This is required when `generate` command and `--build-engine buildah` or `--build-engine docker` parameters are used. This package is available for Fedora and the CentOS family in the EPEL repository. For RHEL/Fedora OS'es this is satisfied by installing the `odcs-client` package.

`brew` command Used to identify and fetch artifacts from Brew.

Buildah builder dependencies

Buildah Required to build the image.

Important: If run within the *Red Hat environment* additional dependencies are required. See the *note in the Docker section above* for more details.

Podman builder dependencies

- **Podman** Required to build the image.

Important: If run within the *Red Hat environment* additional dependencies are required. See the *note in the Docker section above* for more details.

OSBS builder dependencies

`koji` command The `koji` command is used to interact with the Koji API to execute the build.

`fedpkg` command Used to clone and interact with dist-git repositories.

Important: If run within the *Red Hat environment* above dependencies are replaced with Red Hat specific tools:

- `koji` is replaced by `brew` command (or `brew-stage` if run with the `--stage` parameter)
- `fedpkg` is replaced by `rhpkg` command (or `rhpkg-stage` if run with the `--stage` parameter)

Test phase dependencies

For more information about testing, please take a *look here*.

Test dependencies can vary. CEKit uses a plugable way of defining Behave steps. The default test steps are located in https://github.com/cekit/behave-test-steps repository. You can find there more information about the current dependencies.

6.2.2 Building images

This chapter explains the build process as well as describes available options.

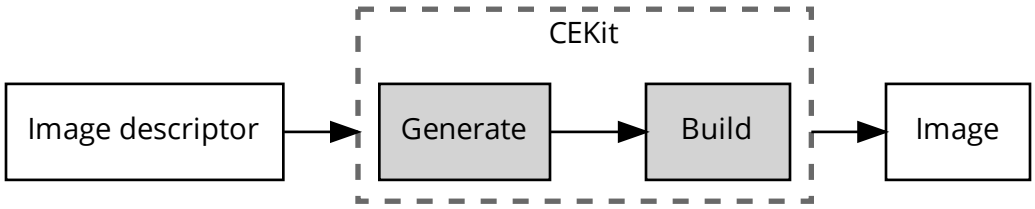
Build process explained

Contents

In this section we will go through the build process. You will learn what stages there are and what is done in every stage.

High-level overview

Let's start with a high-level diagram of CEKit.



Main input to CEKit is the *image descriptor*. It defines the image. This should be the definitive description of the image; what it is, what goes in and where and what should be run on boot.

Preparation of the image CEKit divides into two phases:

1. **Generation phase** Responsible for preparing everything required to build the image using selected builder.
2. **Build phase** Actual build execution with selected builder.

Result of these two phases is the image.

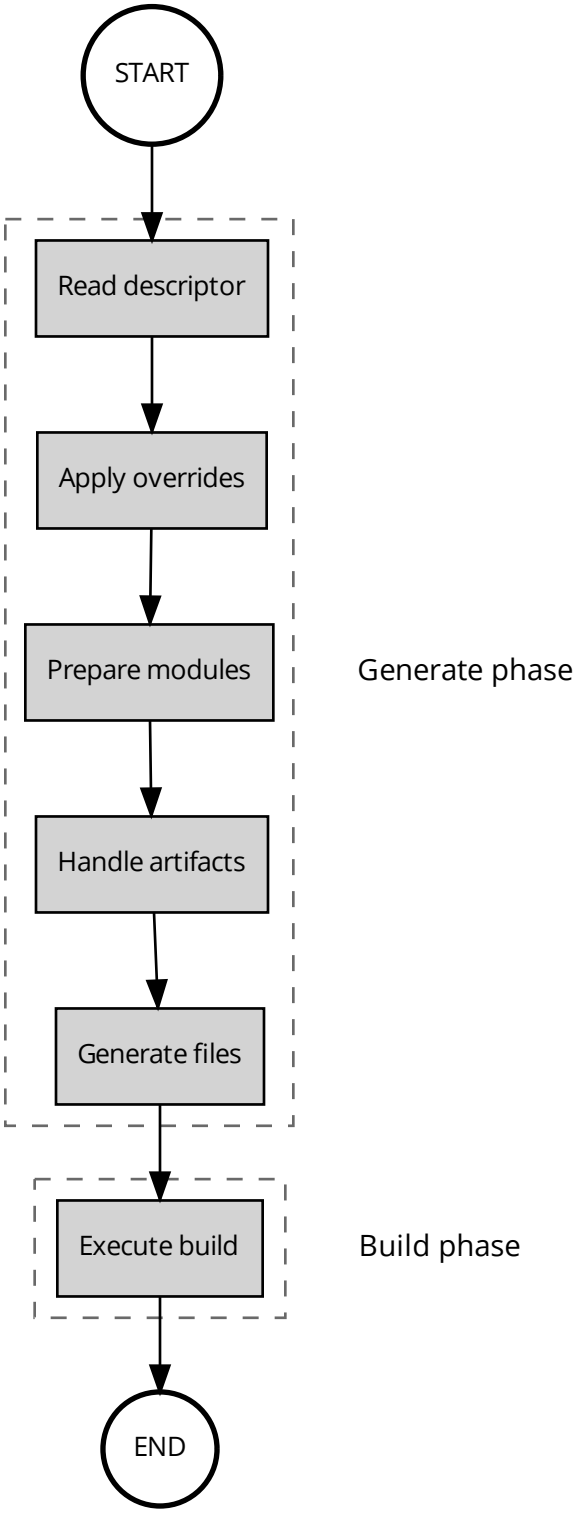
Let's discuss it in details.

Build process in details

As *mentioned above* the CEKit build process is divided into two phases:

1. Generation phase
2. Build phase

In this section we will go through these phases in detail to see what's happening in each. Below you can find diagram that shows what is done from beginning to the end when you execute CEKit.


START
Read descriptor
Apply overrides
Prepare modules
Handle artifacts
Generate files
Generate phase
Execute build
Build phase
END

The build process is all about preparation of required content so that the selected builder could create an image out of it. Depending on the builder, this could mean different things. Some builders may require generating Dockerfiles, some may require generating additional files that instruct the builder itself how to build the image or from where to fetch artifacts.

Reading image descriptor

In this phase the image descriptor is read and parsed. If the description is not in YAML format, it won't be read.

Next step is to prepare an **object representation** of the descriptor. In CEKit internally we do not work on the dictionary read from the descriptor, but we operate on objects. Each section is converted individually to object and **validated according to the schema** for the section.

This is an important step, because it ensures that the image descriptor uses correct schema.

Applying overrides

Applying *overrides* is the next step. There can be many overrides specified. Some of them will be declared on CLI directly, some of them will be YAML files. We need to create an array of overrides because the **order in which overrides are specified matters**.

Each override is converted into an object too, and yes, you guessed it – it's validated at the same time.

Last thing to do is to apply overrides on the image object we created before, in order.

Preparing modules

Next thing to do is to prepare *modules*. If there are any module repositories defined, we need to fetch them, and read. In most cases this will mean executing `git clone` command for each module repository, but sometimes it will be just about copying directories available locally.

All module repositories are fetched into a temporary directory.

For each module repository we read every module descriptor we can find. Each one is converted into an object and validated as well.

Once everything is done, we have a module registry prepared, but this is not enough.

Next step is to apply module overrides to the image object we have. Modules are actually overrides with the difference that modules encapsulate a defined functionality whereas overrides are just modifying things.

To do this we iterate over all modules that are defined to install and we try to find them in the module registry we built before. If there is no such module or the module version is different from what we request, the build will fail. If the requirement is satisfied the module is applied to the image object.

The last step is to copy only required modules (module repository can contain many modules) from the temporary directory to the final target directory.

Handling artifacts

Each module and image descriptor itself can define *artifacts*.

In this step CEKit is going to handle all defined artifacts for the image. For each defined artifact CEKit is going to fetch it. If there will be a problem while fetching the artifact, CEKit will fail with information why it happened.

Each successfully fetched artifact is automatically added to *cache* so that subsequent build will be executed faster without the need to download the artifact again.

Generating required files

When we have all external content handled and the image object is final we can generate required files. Generation is tightly coupled with the selected builder because different builders require different files to be generated.

For example Docker builder requires Dockerfile to be generated, but the OSBS builder requires additional files besides the Dockerfile.

For Dockerfiles we use a template which is populated which can access the image object properties.

Build execution

Final step is to execute the build using selected builder.

Resulting image sometimes will be available on your localhost, sometimes in some remote registry. It all depends on the builder.

Supported builder engines

Contents

CEKit supports following builder engines:

- *Docker builder* – builds the container image using Docker
- *OSBS builder* – builds the container image using OSBS service
- *Buildah builder* – builds the container image using Buildah
- *Podman builder* – builds the container image using Podman

Docker builder

This builder uses Docker daemon as the build engine. Interaction with Docker daemon is done via Python binding.

By default every image is squashed at the end of the build. This means that all layers above the base image will be squashed into a single layer. You can disable it by using the `--no-squash` switch.

Input format Dockerfile

Parameters

`--pull` Ask a builder engine to check and fetch latest base image

`--tag` An image tag used to build image (can be specified multiple times)

`--no-squash` Do not squash the image after build is done.

Example Building Docker image

```
$ cekit build docker
```

Remote Docker daemon

It is possible to use environment variables to let CEKit know where is the Docker daemon located it should connect to.

Note: Read more about Docker daemon settings related to exposing it to clients.

By default, if you do not specify anything, **CEKit will try to use a locally running Docker daemon**.

If you need to customize this behavior (for example when you want to use Docker daemon running in a VM) you can set following environment variables: `DOCKER_HOST`, `DOCKER_TLS_VERIFY` and `DOCKER_CERT_PATH`. See section about *Docker environment variables* below for more information.

Docker environment variables

`DOCKER_HOST` The `DOCKER_HOST` environment variable is where you specify where the Daemon is running. It supports multiple protocols, but the most widely used ones are: `unix://` (where you specify path to a local socket) and `tcp://` (where you can define host location and port).

Examples of `DOCKER_HOST`: `unix:///var/run/docker.sock`, `tcp://192.168.22.33:1234`.

Depending how your daemon is configured you may need to configure settings related to encryption.

```
# Connect to a remote Docker daemon
$ DOCKER_HOST="tcp://192.168.22.33:1234" cekit build docker
```

`DOCKER_TLS_VERIFY` You can set `DOCKER_TLS_VERIFY` to a non-empty value to indicate that the TLS verification should take place. By default certificate verification is **disabled**.

`DOCKER_CERT_PATH` You can point `DOCKER_CERT_PATH` environment variable to a directory containing certificates to use when connecting to the Docker daemon.

`DOCKER_TMPDIR` You can change the temporary directory used by Docker daemon by specifying the `DOCKER_TMPDIR` environment variable.

Note: Please note that this is environment variable **should be set on the daemon** and not on the client (CEKit command you execute). You need to modify your Docker daemon configuration and restart Docker to apply new value.

By default it points to `/var/lib/docker/tmp`. If you are short on space there, you may want to use a different directory. This temporary directory is used to generate the TAR file with the image that is later processed by the squash tool. If you have large images, make sure you have sufficient free space there.

TMPDIR This environment variable controls which directory should be used when a temporary directory is created by the CEKit tool. In case the default temporary directory location is low on space it may be required to point to a different location.

One example when such change could be required is when the squash post-processing of the image is taking place and the default temporary directory location is low on space. Squashing requires to unpack the original image TAR file and apply transformation on it. This can be very storage-consuming process.

You can read more on how this variable is used in the Python docs.

```
$ TMPDIR="/mnt/external/tmp" cekit build docker
```

DOCKER_TIMEOUT By default it is set to `600` seconds.

This environment variable is responsible for setting how long we will wait for the Docker daemon to return data. Sometimes, when the Docker daemon is busy and you have large images, it may be required to set this variable to some even higher number. Setting proper value is especially important when the squashing post-processing takes place because this is a very resource-consuming task and can take several minutes.

```
$ DOCKER_TIMEOUT="1000" cekit build docker
```

OSBS builder

This build engine is using `rhpkg` or `fedpkg` tool to build the image using OSBS service. By default it performs **scratch build**. If you need a proper build you need to specify `--release` parameter.

By default every image is squashed at the end of the build. This means that all layers above the base image will be squashed into a single layer.

Note: All URL based artifacts (See *here*) will **not** be cached and instead will be added to `fetch-artifacts.yaml` to use the OSBS integration

---

Note: Extra OSBS configuration may be passed in via the OSBS descriptor (See *here*). Automatic Cachito integration may also be included within the *OSBS configuration* and if this is detected CEKit will include the commands in the Dockerfile.

Input format Dockerfile

Parameters

--release Perform an OSBS release build

--user Alternative user passed to build task

--nowait Do not wait for the task to finish

--stage Use stage environment

--commit-message Custom commit message for dist-git

--sync-only New in version 3.4.

Generate files and sync with dist-git, but do not execute build

`--assume-yes` New in version 3.4.

Run build in non-interactive mode answering all questions with 'Yes', useful for automation purposes

Example Performing scratch build

```
$ cekit build osbs
```

Performing release build

```
$ cekit build osbs --release
```

Buildah builder

This build engine is using Buildah.

By default every image is squashed at the end of the build. This means that all layers (**including the base image**) will be squashed into a single layer. You can disable it by using the `--no-squash` switch.

Note: If you need to use any non default registry, please update `/etc/containers/registry.conf` file.

Input format Dockerfile

Parameters

`--pull` Ask a builder engine to check and fetch latest base image

`--tag` An image tag used to build image (can be specified multiple times)

`--no-squash` Do not squash the image after build is done.

Example Build image using Buildah

```
$ cekit build buildah
```

Build image using Buildah and tag it as `example/image:1.0`

```
$ cekit build buildah --tag example/image:1.0
```

Buildah environment variables

`BUILDAH_LAYERS` The `BUILDAH_LAYERS` environment variable allows you to control whether the builder engine will cache intermediate layers during build.

By default it is set to `false`.

You can enable it by setting the environment variable to `true`. The initial build process will take longer because result of every command will need to be stored on the disk (commited), but subsequent builds (without any code change) should be faster because the layer cache will be reused.

```
$ BUILDAH_LAYERS="true" cekit build buildah
```

Warning: Caching layers conflicts with *multi-stage builds*. A ticket was opened: https://bugzilla.redhat.com/show_bug.cgi?id=1746022. If you use multi-stage builds, make sure the `BUILDAH_LAYERS` environment variable is set to `false`.

Podman builder

This build engine is using Podman. Podman will perform non-privileged builds so no special configuration is required.

By default every image is squashed at the end of the build. This means that all layers (**including the base image**) will be squashed into a single layer. You can disable it by using the `--no-squash` switch.

Input format Dockerfile

Parameters

`--pull` Ask a builder engine to check and fetch latest base image

`--tag` An image tag used to build image (can be specified multiple times)

`--no-squash` Do not squash the image after build is done.

Example Build image using Podman

```
$ cekit build podman
```

Build image using Podman

```
$ cekit build podman --pull
```

Podman environment variables

`BUILDAH_LAYERS`

Note: Yes, the environment variable is called `BUILDAH_LAYERS`, there is no typo. Podman uses Buildah code underneath.

The `BUILDAH_LAYERS` environment variable allows you to control whether the builder engine will cache intermediate layers during build.

By default it is set to `true`.

You can disable it by setting the environment variable to `false`. This will make the build faster because there will be no need to commit result of every command. The downside of this setting is that you will not be able to leverage layer cache in subsequent builds.

```
$ BUILDAH_LAYERS="false" cekit build podman
```

Warning: Caching layers conflicts with *multi-stage builds*. A ticket was opened: https://bugzilla.redhat.com/show_bug.cgi?id=1746022. If you use multi-stage builds, make sure the `BUILDAH_LAYERS` environment variable is set to `false`.

Common build parameters

Below you can find description of the common parameters that can be added to every build command.

`--validate` Do not generate files nor execute the build but prepare image sources and check if these are valid. Useful when you just want to make sure that the content is buildable.

See `--dry-run`.

--dry-run Do not execute the build but let's CEKit prepare all required files to be able to build the image for selected builder engine. This is very handy when you want manually check generated content.

See `--validate`.

--overrides Allows to specify overrides content as a JSON formatted string, directly on the command line.

Example

```
$ cekit build --overrides '{"from": "fedora:29"}' docker
```

Read more about overrides in the *Overrides* chapter.

This parameter can be specified multiple times.

--overrides-file In case you need to override more things or you just want to save the overrides in a file, you can use the `--overrides-file` providing the path to a YAML-formatted file.

Example

```
$ cekit build --overrides-file development-overrides.yaml docker
```

Read more about overrides in the *Overrides* chapter.

This parameter can be specified multiple times.

6.2.3 Image testing

CEKit makes it possible to run tests against images. The goal is to make it possible to test images using different frameworks.

Using different frameworks allows to define specialized tests. For example you can write tests that focus only parts of the image (you can think about unit tests) or the image (or even a set of images even!) as a whole which is similar to integration testing.

Tip: We strongly recommend that a test is written for every feature that is added to the image.

Currently we support following test frameworks:

Behave

Behave test framework uses Gherkin language to describe tests.

Note: If you are not familiar with Behave, we suggest you read the Behave documentation and the Gherkin language reference before reading this chapter. This will make it much easier to understand how to write tests.

Introduction

To jump start you into Behave tests, consider the example below.

```
Feature: OpenShift SSO tests

  Scenario: Test if console is available
    When container is ready
    Then check that page is served
        | property | value |
        | port     | 8080  |
        | path     | /auth/admin/master/console/#/realms/master |
        | expected_status_code | 200 |
```

In this specific case, a container will be created from the image and after boot a http request will be made to the `8080` on the `/auth/admin/master/console/#/realms/master` context. A successful reply is expected (return code `200`).

We think that this way of describing what to test is concise and very powerful at the same time.

Behave tests overview

Behave tests are defined in two parts: **steps** and **features**.

Features

Feature files define what should be tested. A feature file can contain multiple scenarios grouped in features.

You can find a great introduction to feature files in the Behave documentation. We do not want to repeat it here. If you think something is missing or needs more explanation, please open a ticket.

Image vs. module features

In CEKit you write features to test images. But depending on the part of the image you write the test for, in many cases you will find that the test rather belongs to a **module** rather than the image itself. In our experience we see that this is the most common case.

Note: CEKit makes it possible to colocate tests with image source as well as module source. Please take a look at the *Test file locations* section for more information where these should be placed.

Placing feature files together with modules makes it easy to share the feature as well as tests. Such tests could be run by multiple different images which use this particular module.

Warning: There is a limitation in sharing module tests, please refer to the https://github.com/cekit/cekit/issues/421 issue fore more information.

Steps

Steps define what can be tested in scenarios. Steps are written in Python.

As with features, upstream documentation contains a section on steps. We suggest to read this, if it does not answer all your questions, let us know.

Note: For information how you can write your own steps, please take a look at the *Writing custom steps* paragraph.

Default steps

CEKit comes with a list of build-in steps that are available for use in features. These steps are available in the steps repository.

Hint: We encourage you to add or extend these steps instead of maintaining your own fork. We are happy to review your contributions!

We will be extending the default steps documentation to cover all available steps with examples. In the meantime we suggest to look at the source code itself.

Usage

Images can be tested by running:

```
$ cekit test behave
```

The most basic usage would be to run the test with just the `--image` parameter to specify which image should be tested.

```
$ cekit test --image example/test:1.0 behave
```

Options

Todo: Try to generate available options.

Tip: For all available options, please use the `--help` switch.

- `--wip` – Only run tests tagged with the `@wip` tag.
- `--steps-url` – A git repository url containing steps for tests.
- `--name` – *Scenario* name to be executed

Examples

In this section you can find some examples of frequently used tasks.

Running selected tests

CEKit makes it possible to run specific Scenario(s) only. To do it you need to run CEKit with `--name <name of the test>` command line argument.

Note: `--name` switch can be specified multiple times and only the Scenarios matching all of the names are executed.

If you have following Scenario in your feature files:

```
Scenario: Check custom debug port is available
    When container is started with env
        | variable   | value |
        | DEBUG      | true  |
        | DEBUG_PORT | 8798  |
    Then check that port 8798 is open
```

Then you can instruct CEKit to run this test in a following way:

```
$ cekit test behave --name 'Check custom debug port is available'
```

Skipping tests

Hint: See *Special tags* paragraph.

If there is a particular test which needs to be temporally disabled, you can use `@ignore` tag to disable it.

For example to disable following Scenario:

```
Scenario: Check custom debug port is available
    When container is started with env
        | variable   | value |
        | DEBUG      | true  |
        | DEBUG_PORT | 8798  |
    Then check that port 8798 is open
```

You need to tag it with `@ignore` tag in a following way:

```
@ignore
Scenario: Check custom debug port is available
    When container is started with env
        | variable   | value |
        | DEBUG      | true  |
        | DEBUG_PORT | 8798  |
    Then check that port 8798 is open
```

Test collection

It is important to understand how CEKit is collecting and preparing tests.

Todo: Explain how tests are collected

Feature tags

CEKit selects tests to run using the Behave built-in tags mechanism.

Tags are in format: `@TAG_NAME`, for example: `@jboss-eap-7`.

Below you can find several examples how tags could be used for managing tests across a set of images:

Image tags

CEKit derives two feature tag names from the name of the image being tested:

1. The image name itself (`name` key in image descriptor), and
2. Everything before the first `/` in the image name, also known as *image family*.

   Example If you test the `jboss-eap-7/eap7` image, tests will be invoked with tags `@jboss-eap-7` and `@jboss-eap-7/eap7`.

If `--tag` is specified, then the argument is used in place of the image name for the process above.

Example If you use `--tag foo/bar` parameter, then the tags used would be `@foo` and `@foo/bar`.

Special tags

`@wip` This is very special tag used while developing a test. Its purpose is to to limit the tests to be run to a subset you are working on. To achieve this you should mark your in-development test scenarios with the `@wip` tag and execute tests with `--wip` parameter. All scenarios not tagged with `@wip` will be ignored.

`@ci` If CEKit is **not** running as a user called `jenkins`, the tag `@ci` is added to the list of **ignored** tags, meaning any tests tagged `@ci` are ignored and not executed.

The purpose of this behavior is to ease specifying tests that are only executed when run within CI.

`@ignore` If a Scenario or Feature is tagged with `@ignore` these tests will be skipped.

Writing Behave tests

Todo: Write introduction

Test file locations

There are a few places where your tests can be stored:

1. `tests` directory next to the **image** descriptor
2. `tests` directory next to the **module** descriptor
3. `tests` directory in root of the module repository

The `tests` directory is structured as follows:

```
tests/features
tests/features/*.feature
tests/steps
tests/steps/*.py
```

The `tests/features` directory is the place where you can drop your behave features.

The `tests/steps` directory is optional and contains custom steps for the specific image/module.

Writing features

The most important

Todo: TBD

Writing custom steps

Todo: TBD

Running developed tests

To be able to run only the test you develop you can either use the `--name` parameter where you specify the scenario name you develop or use the `--wip` switch.

In our practice we found that tagging the scenario with `@wip` tag and using the `--wip` switch is a common practice, but it's up to you.

6.2.4 Modules

This chapter will guide you through modules. Understanding and making proper use of them is essential to succeed with CEKit.

Module processing

Contents

Note: This chapter applies to *builder engines* that use Dockerfile as the input.

Understanding how modules are merged together is important. This knowledge will let you introduce modules that work better together and make rebuilds faster which is an important aspect of the image and module development.

Order is important

Installation order of modules is extremely important. Consider this example:

```
1  modules:
2      repositories:
3          # Add local modules located next to the image descriptor
4          # These modules are specific to the image we build and are not meant
5          # to be shared
6          - path: modules
7
8          # Add a shared module repository located on GitHub. This repository
9          # can contain several modules.
10         - git:
11             url: https://github.com/cekit/example-common-module.git
12             ref: master
13
14     # Install selected modules (in order)
15     install:
16         - name: jdk8
17         - name: user
18         - name: tomcat
```

On lines 16-18 we have defined a list of modules to be installed. These are installed in the order as they are defined (from top to bottom). This means that the first module installed will be `jdk8` followed by `user` and the `tomcat` module will be installed last.

The same order is used later in the module merge process too.

Note: Defining module *repositories* in the `repositories` section does not require any particular order. Modules are investigated after all modules repositories are fetched.

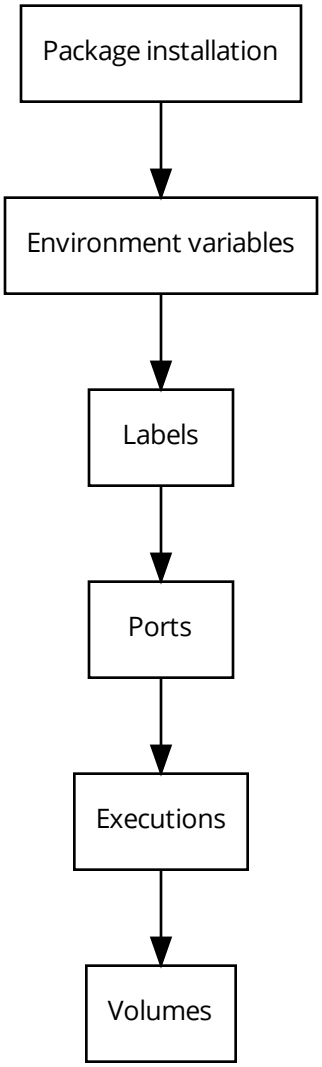
Module processing in template

Each module descriptor marked to be installed can *define many different things*. All this metadata needs to be merged correctly into a single image, so that the resulting image is what we really expected.

This is where templates come into play. We use a template to generate the Dockerfile that is later fed into the builder engine.

This section will go through it and explain how we combine everything together in the template.

Note: Sections not defined in the module descriptor are simply skipped.



Packages

The first thing done for each module is the package installation for all *packages defined in the module*. We do not clean the cache on each run, because this would slow subsequent package manager executions. You should also not worry about it taking too much space, because every image is squashed (depends on builder though).

Package installation is executed as `root` user.

Environment variables

Each defined *environment variable* is added to the Dockerfile.

Note: Please note that you can define an *environment variable without value*. In such case, the environment will not be added to Dockerfile as it serves only an information purpose.

Labels

Similarly to environment variables, *labels* are added too.

Ports

All *ports* defined in the descriptor are exposed as well.

Executions

This is probably the most important section of each module. This is where the actual module installation is done. Each script defined in the *execute section* is converted to a `RUN` instruction.

The user that executes the script can be modified with the `user` key.

Volumes

Last thing is to add the *volume* definitions.

Flattening nested modules

Above example assumed that modules defined in the image descriptor do not have any child modules. This is not always true. Each module can have *dependency on other modules*.

In this section we will answer the question: what is the order of modules in case where we have a hierarchy of modules requested to be installed?

Best idea to explain how module dependencies work is to look at some example. For simplicity, only the `install` section will be shown:

```
# Module A

name: "A"
modules:
    # This module requires two additional modules: B and C
    install:
        - name: B
        - name: C
```

```
# Module B

name: "B"
modules:
    # This module requires one additional module: D
    install:
        - name: D
```

```
# Module C

# No other modules required
name: "C"
```

```
# Module D

# No other modules required
name: "D"
```

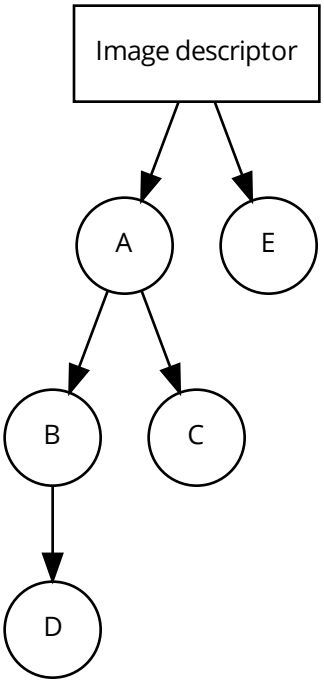
```
# Module E

# No other modules required
name: "E"
```

```
# Image descriptor

name: "example/modules"
version: "1.0"
modules:
    repositories:
        - path: "modules"
    install:
        - name: A
        - name: E
```

To make it easier to understand, below is the module dependency diagram. Please note that this diagram does not tell you the order in which modules are installed, but only what modules are requested.



The order in which modules will be installed is:

1. D
2. B
3. C
4. A
5. E

How it was determined?

```
modules = []
```

We start with the first module defined: *A*. We find that it has some dependencies: modules *B* and *C*. This means that we need to investigate these modules first, because these need to be installed before module *A* can be installed.

We investigate module *B*. This module has one dependency: *D*, so we investigate it and we find that this module has no dependency. This means that we can install it first.

```
modules = ["D"]
```

Then we go one level back and we find that module *B* has no other requirements besides module *D*, so we can install it too.

```
modules = ["D", "B"]
```

We go one level back and we're now investigating module *C* (a requirement of module *A*). Module *C* has no requirements, so we can install it.

```
modules = ["D", "B", "C"]
```

We go one level back. We find that module *A* dependencies are satisfied, so we can add module *A* too.

```
modules = ["D", "B", "C", "A"]
```

Last module is the module *E*, with no dependencies, we add it too.

```
modules = ["D", "B", "C", "A", "E"]
```

This is the final order in which modules will be installed.

Understanding the merge process

Now you know that we iterate over all modules defined to install and apply it one by one, but how it influences the build process? It all depends on the Dockerfile instructions that was used in the template. Some of them will overwrite previous values (`CMD`), some of them will just add values (`EXPOSE`). Understanding how Dockerfiles work is important to make best usage of CEKit with builder engines that require Dockerfile as the input.

Environment variables and labels can be redefined. If you define a value in some module, another module later in the sequence can change its effective value. This is a feature that can be used to redefine the value in subsequent modules.

Volumes and ports are just adding next values to the list.

Note: Please note that there is no way to actually **remove** a volume or port in subsequent modules. This is why it's important to create modules that define only what is needed.

We suggest to not add any ports or volumes in the module descriptors leaving it to the image descriptor.

Package installation is not merged at all. Every module which has defined packages to install will be processed one-by-one and for each module a *package manager* will be executed to install requested packages.

Same approach applies to the `execute` section of each module. All defined will be executed in the requested order.

Module versioning

Contents

Module versioning is an important aspect of image development process. Proper handling of versions makes it easy to control what exactly content should be part of the image.

This section describes how module versions are handled in CEKit.

See also:

If you want to learn best practices around module versioning, take a look at *module guidelines*.

Requirements

Every module **must have a version defined**. Version of the module is an important piece of information because based on the version we control what content goes into image.

You can look at module versioning similar to any library version. There are no libraries without version and there must not be modules without versions.

In module descriptor the version could be defined as string, float or integer. CEKit is converting this value internally to string which is *parsed later* to become a version object finally.

Note: Although CEKit does not enforce any versioning scheme, se suggest to use Python versioning scheme. Read more about *suggested approach*.

If your module version does not follow this scheme, CEKit will **log a warning**. In case you use your *own versioning scheme* you can ignore this warning.

Parsing

Every version of module is parsed internally. Before we can do this **any version is converted to string**. This means that

```
version: 1.0
```

and

```
version: "1.0"
```

are **exactly the same versions** for CEKit.

Handling modules with multiple versions

See also:

See *module descriptor documentation* and *image descriptor modules section documentation* for more information how to reference modules.

In case you do not specify version requirement in the module installation list in the image descriptor, CEKit will use **newest version to install**.

Internally we use the packaging module to convert the module version string into a Version object. If you use a *custom versioning scheme* your version may be represented by a LegacyVersion object.

Parsed versions are compared according to PEP 440 versioning scheme.

Custom versioning scheme in comparison with a PEP 440 version will be **always older**.

6.2.5 Multi-stage builds

Contents

This chapter discusses support for multi-stage builds in CEKit.

Introduction

Tip: Please read the Docker documentation on multi-stage builds.

Multi-stage builds define a process to build final image that uses intermediate images in the workflow. Such workflow is useful when we want to build some artifacts (applications, binaries, etc) as part of the build, but we are not interested in all dependencies that are required to build them.

Multi-stage builds can help with it, because intermediate images used as part of the build are thrown away after the build is finished. The effective image can contain binaries built in previous stages without the need to install all the build time dependencies there. This makes it possible to decrease the size of the image significantly. Other positive aspect is that having less packages installed in the image means that we are less exposed to CVE's making the image more secure.

CEKit implementation

In CEKit we use *image descriptor* to define the image. Descriptor format was extended and allows now a list of image descriptors.

Listing 7: image.yaml

```
- name: builder
  version: 1.0.0
  from: centos:7
  description: Some base image

  modules:
    repositories:
      - path: modules

    install:
      # Module providing environment required to build the application
      - name: python
      # Module required to build the application
      - name: build

- name: some/app
  version: 12
  from: centos:7
  description: Our application

  modules:
    repositories:
```

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```
    - path: modules

  # Install selected modules (in order)
  install:
    - name: setuptools
    # This module is responsible for fetching application built in previous stage
    - name: app
```

If a list of more than one image is found – multi-stage builds are assumed.

For multi-stage builds you have have multiple intermediate images and always just one final image. In CEKit this means that the **last image defined in the descriptor is the final one**, every other image is an intermediate image.

Let's go back to our example above.

We have two images defined: `builder` and `some/app`. As the name suggest, the first one is the builder (intermediate) image which will contain the build-time dependencies and where the actual artifact will be built.

Note: Although it is possible to use all keys available to use in an *image descriptor* when defining builder images, some of them does not have any effect. A few examples of such keys can be found below:

- `ports`
- `volumes`
- `run`
- `help`
- `osbs`

The second image is the final image where we will place the built artifact. But how to do it? Let's take a look at the `app` module which defines a special artifact.

Listing 8: module.yaml

```
name: app
version: 1.0

packages:
   install:
      - python-requests

artifacts:
    - name: application
      image: builder
      path: /path/to/application/inside/the/builder/image.jar

    - image: builder
      path: /path/to/lib.jar

execute:
    - script: install.sh
```

This artifact is called *image content resource* and it does define artifact that is located in an image built in previous stage of the multi-stage build workflow. You do not need to define anything in the builder image. It's responsibility is only to build the artifacts which can be referenced in the final image.

In our case we define two artifacts, both from the `builder` image.

The first one will become available as `/tmp/artifacts/application` and the second one as `/tmp/artifacts/lib.jar` in the final image.

Tip: You can change the destination as well as the target file name of artifacts. See how it can be done using *appropriate keys in the artifact*.

Image source artifacts can be handled and installed to the correct place, as you would normally do with other types of artifacts.

6.2.6 Base images

Contents

This chapter discusses support for creating images that extend the `scratch` image to build base images.

Introduction

Tip: Please read the Docker documentation on scratch base image.

The `scratch` image is a special type of image. It is an empty image and the `FROM scratch` instruction in Dockerfile results in no-op when building the container image. There are a few use-cases for such an image:

Storing native binaries It is very popular in the cloud-native era to use languages that produce native binaries which are packaged in a container image format and distributed this way. One of the most popular languages is Golang.

> **Tip:** You may be interested in *multi-stage builds* as well.

Storing shared content (for example metadata) Sometimes there is a requirement to store metadata (for example YAML files) in a container image so that it can be versioned and used elsewhere.

CEKit implementation

Support for `scratch` base image is a special case in CEKit. This means that some of the features you are used to may not work properly.

You need to ensure that modules you are including are written in a way so these can be installed and executed in an environment **without operating system libraries**.

In case of such container images it is important to understand how artifacts are put inside of them. By default CEKit copies artifacts into a temporary directory which are later handled by modules (copied to correct places, permissions are managed, etc). For `scratch` container images it won't work, because we don't have the operating system that would make it possible.

In this case, the `dest` keyword should be used to define the destination directory of the particular artifact.

Listing 9: image.yaml

```yaml
name: "cekit-scratch"
version: "1.0.0"
from: "scratch"
description: "Minimal scratch example"

labels:
    - name: "io.cekit.test"
      value: "This is a CEKit test label"

envs:
    - name: "CEKIT_TEST"
      value: "test"

artifacts:
    # Both files will be added to a /files directory in the container image
    # The /files directory itself will be created
    - name: "file1"
      path: metadata/test-file.txt
      dest: /files/
    - name: "file2"
      path: metadata/other.txt
      dest: /files/

    # Whole 'metadata' directory (path relative to image descriptor) will be copied to
    # the container and placed in /target directory
    - name: "dir"
      path: metadata
      dest: /target
```

In case of `scratch` container images it is safe to assume that following features are supported:

- Artifacts with `dest` property defined
- Environment variables
- Labels
- Entrypoint and command

Below you can find a multi-stage build which builds a Go binary in first stage and then it is copied to the resulting image which is an empty container image. Additionally the binary is set as an entrypoint.

Listing 10: image.yaml

```yaml
- name: builder
  version: 1.0.0
  from: golang:1.7.3

  modules:
    repositories:
      - path: modules

    install:
      # Module required to build the application
      - name: build

- name: some/app
```

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```
version: 12
from: scratch
description: Our application

artifacts:
  - name: application
    # Name of the image from where the binary will be copied
    image: builder
    # Path where the binary can be found in the 'builder' image
    path: /tmp/scripts/build/hello-world
    # Target file name of the artifact
    target: entrypoint
    # Destination directory in the image
    dest: /bin

run:
  entrypoint: ["/bin/entrypoint"]
```

Note: You can find above example in the CEKit source repository. It's run as part of integration tests.

6.2.7 Artifact caching

Contents

In this chapter we will go through the caching feature of CEKit.

CEKit has a built-in cache for artifacts. It's purpose is to speed up the build process for subsequent builds.

Technical design

By default cached artifacts are located in the `~/.cekit/cache/` directory.

Note: Cache location can be changed when you specify the `--work-dir` parameter. In such case cache will be located in a `cache` directory located inside the directory specified by the `--work-dir` parameter.

Every cached artifact is identified with a UUID (version 4). This identifier is also used as the file name (in the cache directory) for the artifact itself.

Each cached artifact contains metadata too. This includes information about computed checksums for this artifact as well as names which were used to refer to the artifact. Metadata is stored in the cache directory too, the file name is the UUID of the artifact with a `.yaml` extension.

Example If your artifact will have `1258069e-7194-426d-a6ab-ade0a27b8290` UUID assigned with it, then it will be found under the `~/.cekit/cache/1258069e-7194-426d-a6ab-ade0a27b8290` path and the metadata can be found in the `~/.cekit/cache/1258069e-7194-426d-a6ab-ade0a27b8290.yaml` file.

Artifacts in cache are **discovered by the hash value**.

While adding an artifact to the cache, CEKit is computing it's checksums for all currently supported algorithms (`md5`, `sha1`, `sha256`, `sha512`). This makes it possible to refer the same artifact in descriptors using different algorithms.

This also means that CEKit is using cache only for artifacts which define **at least one hash**.

Automatic caching

CEKit is automatically caching all artifacts used to build the image. Consider following image descriptor snippet:

```
artifacts:
    - name: jolokia-1.3.6-bin.tar.gz
      url: https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
```

This artifact will be automatically added into the cache during image build. This is useful as the artifact will be automatically copied from cache instead of downloading it again on any rebuild.

Managing cache

CEKit provides command line tool called `cekit-cache` which is used to manage cache.

It has a `--work-dir` (by default set to `~/.cekit`) parameter which sets CEKit's working directory. This is where the `cache` directory will be located.

> **Warning:** If you customize `--work-dir` – make sure you use the same path for `cekit` and `cekit-cache` commands. You can also set the path in the *configuration file*.

Caching artifacts manually

CEKit supports caching artifacts manually. This is very usefull if you need to introduce non-public artifact to a CEKit. To cache an artifact you need to specify path to the artifact on filesystem or its URL and **at least one** of the supported hashes (`md5`, `sha1`, `sha256`, `sha512`).

Examples Caching local artifact

```
$ cekit-cache add path/to/file --md5 checksum
```

Caching remote artifact

```
$ cekit-cache add https://foo.bar/baz --sha256 checksum
```

Listing cached artifacts

To list all artifact known to CEKit cache you need to run following command:

```
$ cekit-cache ls
```

After running the command you can see following output:

```
eba0b8ce-9562-439f-8a56-b9703063a9a3:
  sha512:␣
↪5f4184e0fe7e5c8ae67f5e6bc5deee881051cc712e9ff8aeddf3529724c00e402c94bb75561dd9517a372f06c1fcb78dc7a
  sha256: c93c096c8d64062345b26b34c85127a6848cff95a4bb829333a06b83222a5cfa
  sha1: 3c3231e51248cb76ec97214f6224563d074111c1
  md5: c1a230474c21335c983f45e84dcf8fb9
  names:
    - spark-2.4.0-bin-hadoop2.7.tgz

dba5a813-3972-4dcf-92a4-87049357f7e0:
  sha512:␣
↪cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63
  sha256: e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855
  sha1: da39a3ee5e6b4b0d3255bfef95601890afd80709
  md5: d41d8cd98f00b204e9800998ecf8427e
  names:
    - artifact
```

Removing cached artifact

If you are not interested in particular artifact from cache, you can delete it by executing following command:

```
$ cekit-cache rm uuid
```

Note: You can get uuid of any artifact by invoking `cekit-cache ls` command. Please consult *Listing cached artifacts*.

Wiping cache

To wipe whole artifact cache you need to run the `cekit-cache clear` command. This will ask you for confirmation of the removal step.

```
$ cekit-cache clear
```

6.2.8 Overrides

Contents

During an image life cycle there can be a need to do a slightly tweaked builds – using different base images, injecting newer libraries etc. We want to support such scenarios without a need of duplicating whole image sources.

To achieve this CEKit **supports overrides mechanism** for its descriptors. You can override anything from the descriptor. The overrides are based on overrides descriptor – a YAML object containing overrides for the image descriptor.

To use an override descriptor you need to pass `--overrides-file` argument to CEKit. You can also pass JSON/YAML object representing changes directly via `--overrides` command line argument.

Example Use `overrides.yaml` file located in current working directory

```
$ cekit build --overrides-file overrides.yaml podman
```

Example Override a label via command line

```
$ cekit build --overrides '{"labels": [{"name": "foo", "value": "overridden"}]}'␣
↪podman
```

Overrides chaining

You can even specify multiple overrides. Overrides are resolved that last specified is the most important one. This means that values from **last override specified overrides all values from former ones**.

Example If you run following command, label `foo` will be set to `baz`.

```
$ cekit build --overrides "{'labels': [{'name': 'foo', 'value': 'bar'}]} --
↪overrides "{'labels': [{'name': 'foo', 'value': 'baz'}]}" podman
```

How overrides works

CEKit is using YAML format for its descriptors. Overrides in CEKit works on YAML node level.

Scalar nodes

Scalar nodes are easy to override, if CEKit finds any scalar node in an overrides descriptor it updates its value in image descriptor with the overridden one.

Example Overriding scalar node

```yaml
# Image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "busybox:latest"
```

```yaml
# Override descriptor

schema_version: 1
from: "fedora:latest"
```

```yaml
# Resulting image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "fedora:latest"
```

Sequence nodes

Sequence nodes are a little bit tricky, if they're representing plain arrays, we cannot easily override any value so CEKit is just replacing the whole sequence.

Example Overriding plain array node.

```yaml
# Image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "busybox:latest"
run:
    cmd:
        - "echo"
        - "foo"
```

```yaml
# Override descriptor

schema_version: 1
run:
    cmd:
        - "bar"
```

```yaml
# Resulting image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "busybox:latest"
run:
    cmd:
        - "bar"
```

Mapping nodes

Mappings are merged via `name` key. If CEKit is overriding a mapping or array of mappings it tries to find a `name` key in mapping and use and identification of mapping. If two `name` keys matches, all keys of the mapping are updated.

Example Updating mapping node.

```
# Image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "busybox:latest"
envs:
    - name: "FOO"
      value: "BAR"
```

```
# Override descriptor

schema_version: 1
envs:
    - name: "FOO"
      value: "new value"
```

```
# Resulting image descriptor

schema_version: 1
name: "dummy/example"
version: "0.1"
from: "busybox:latest"
envs:
    - name: "FOO"
      value: "new value"
```

Removing keys

Overriding can result into need of removing a key from a descriptor. You can achieve this by overriding a key with a YAML null value.

You can use either the `null` word or the tilde character: `~` to remove particular key.

Example Remove value from a defined variable.

If you have a variable defined in a following way:

```
envs:
    - name: foo
      value: bar
```

you can remove `value` key via following override:

```
envs:
    - name: foo
      value: ~
```

It will result into following variable definition:

```
envs:
    - name: foo
```

Warning: In some cases it will not be possible to remove the element and an error saying that schema cannot be validated will be shown. If you run it again with verbose output enabled (`--verbose`) you will see `required.novalue` messages.

Improvement to this behavior is tracked here: https://github.com/cekit/cekit/issues/460

6.2.9 Configuration file

CEKit can be configured using a configuration file. We use the ini file format.

CEKit will look for this file at the path `~/.cekit/config`. Its location can be changed via command line `--config` option.

Example Running CEKit with different config file:

```
$ cekit --config ~/alternative_path build
```

Contents

Below you can find description of available sections together with options described in detail.

Common section

The `[common]` section contains settings used across CEKit.

Example

```
[common]
work_dir = /tmp
ssl_verify = False
cache_url = http://cache.host.com/fetch?#algorithm#=#hash#
redhat = True
```

Working directory

Key `work_dir`

Description Location of CEKit working directory, which is used to store some persistent data like dist-git repositories and artifact cache.

Default `~/.cekit`

Example

```
[common]
work_dir=/tmp
```

SSL verification

Key `ssl_verify`

Description Controls verification of SSL certificates, for example when downloading artifacts.

Default `True`

Example

```
[common]
ssl_verify = False
```

Cache URL

Key `cache_url`

Description Specifies a different location that could be used to fetch artifacts. Usually this is a URL to some cache service.

You can use following substitutions:

- `#filename#`–the file name from the url of the artifact
- `#algorithm#`–has algorithm specified for the selected artifact
- `#hash#`–value of the digest.

Default Not set

Example Consider you have an image definition with artifacts section like this:

```
artifacts:
    - url: "http://some.host.com/7.0.0/jboss-eap-7.0.0.zip"
      md5: cd02482daa0398bf5500e1628d28179a
```

If we set the `cache_url` parameter in following way:

```
[common]
cache_url = http://cache.host.com/fetch?#algorithm#=#hash#
```

The JBoss EAP artifact will be fetched from: `http://cache.host.com/fetch?md5=cd02482daa0398bf5500e1628d28179a`.

And if we do it like this:

```
[common]
cache_url = http://cache.host.com/cache/#filename#
```

The JBoss EAP artifact will be fetched from: `http://cache.host.com/cache/jboss-eap-7.0.0.zip`.

Red Hat environment

Key `redhat`

Description This option changes CEKit default options to comply with Red Hat internal infrastructure and policies.

> **Tip:** Read more about *Red Hat environment*.

Default `False`

Example

```
[common]
redhat = True
```

6.2.10 Red Hat environment

If you are running CEKit in Red Hat internal infrastructure it behaves differently. This behavior is triggered by changing *redhat configuration option* in CEKit configuration file.

Tools

CEKit integration with following tools is changed in following ways:

- runs `rhpkg` instead of `fedpkg`
- runs `odcs` command with `--redhat` option set

Environment Variables

Following variables are added into the image:

- `JBOSS_IMAGE_NAME` – contains name of the image
- `JBOSS_IMAGE_VERSION` – contains version of the image

Labels

Following labels are added into the image:

- `name` – contains name of the image
- `version` - -contains version of the image

Repositories

In Red Hat we are using ODCS/OSBS integration to access repositories for building our container images. To make our life easier for local development CEKit is able to ask ODCS to create `content_sets.yml` based repositories even for local Docker builds. This means that if you set *redhat configuration option* to True, your content_sets repositories will be injected into the image you are building and you can successfully build an image on non-subscribed hosts.

Artifacts

In Red Hat environment we are using Brew to build our packages and artifacts. CEKit provides an integration layer with Brew and enables to use artifact directly from Brew. To enable this set *redhat configuration option* to `True` (or use `--redhat` switch) and define plain artifacts which have `md5` checksum.

> **Warning:** Using different checksum thn `md5` will not work!

CEKit will fetch artifacts automatically from Brew, adding them to local cache.

Depending on the selected builders, different preparations will be performed to make it ready for the build process:

- for Docker/Buildah/Podman builder it will be available directly,
- for OSBS builder it uses the Brew/OSBS integration.

Example

```
artifacts:
    - name: jolokia-jvm-1.5.0.redhat-1-agent.jar
      md5: d31c6b1525e6d2d24062ef26a9f639a8
```

This is everything required to fetch the artifact.

6.3 Guidelines

This chapter focuses on best practices and guides related to developing images.

6.3.1 Local development

Contents

Developing image locally is an important part of the workflow. It needs to provide a simple way to reference parts of the image we changed. Executing a local build with our changes should be easily done too.

Module development

Referencing customized modules

CEKit enables you to use a work in progress modules to build the image by using its overrides system. As an example, imagine we have very simple image which is using one module from a remote Git repository, like this:

```
schema_version: 1

name: cekit/example-jdk8
version: 1.0
from: centos:7
description: "JDK 8 image"

modules:
  repositories:
    # Add a shared module repository located on GitHub. This repository
    # can contain several modules.
    - git:
        name: common
        url: https://github.com/cekit/example-common-module.git
        ref: master

# Install selected modules (in order)
install:
  - name: jdk8
  - name: user
```

Now imagine, we have found a bug in its `jdk8` module. We will clone the module repository locally by executing:

```
$ git clone https://github.com/cekit/example-common-module.git ~/repos/example-common-
↪module
```

Then we will create `overrides.yaml` file next to the `image.yaml` with following content:

```
modules:
  repositories:
    - name: common
      path: /home/user/repo/cct_module
```

Now we can build the image with Docker using overridden module by executing:

```
$ cekit build --overrides-file overrides.yaml docker
```

Note: Instead using an overrides you can use inline overrides too!

```
$ cekit build --overrides '{"modules": {"repositories": [{"name": "common", "path": "/
↪home/user/repo/cct_module"}]}}' docker
```

When your work on the module is finished, commit and push your changes to a module repository so that other can benefit from it. Afterwards you can remove your overrides file and use the upstream version of the module again.

Notes

Below you can see suggestions that should make developing modules easier.

Always define name for module repositories

We use the `name` key as the resource identifier in all places. If you do not define the `name` key yourself, we will generate one for you. This may be handy, but in cases where you plan to use overrides it may be much better idea to define them.

Lack of the `name` key in repositories definition may be problematic because CEKit would not know which repository should be overrides and instead overriding, a **new module repository will be added**. This will result in conflicting modules (upstream and custom modules have same name and version) and thus the build will fail.

Install order of modules matters

It is very important to install modules in the proper order. *Read more about it here*.

Besides this, module install order matters at image development time too. If you are going to modify code of some module installed very early in the process, you should expect that the image build time will be much slower. Reason for this is that every step below this particular module installation is **automatically invalidated**, cache cannot be used and needs a full rebuild.

This varies on the selected builder engine, but is especially true for *Docker*.

Injecting local artifacts

During module/image development there can be a need to use locally built artifact instead of a released one. The easiest way to inject such artifact is to use override mechanism.

Imagine that you have an artifact defined in following way:

```
artifacts:
    - name: jolokia
      md5: d31c6b1525e6d2d24062ef26a9f639a8
      url: https://maven.repository.redhat.com/ga/org/jolokia/jolokia-jvm/1.5.0.
↪redhat-1/jolokia-jvm-1.5.0.redhat-1-agent.jar
```

You want to inject a local build of new version of our artifact. To archive it you need to create following override:

```
artifacts:
    - name: jolokia
      path: /tmp/build/jolokia.jar
```

Please note that the `name` key is used to identify which artifact we are going to override.

Whenever you override artifact, all previous checksums are removed too. If you want your new artifact to pass integrity checks you need to define checksum also in overrides in a following way:

```
artifacts:
    - name: jolokia
      md5: d31c6b1525e6d2d24062ef26a9f639a8
      path: /tmp/build/joloika.jar
```

Using Docker cache

New in version 3.3.0.

Docker has support for caching layers. This is very convenient when you are developing images. It saves time by not rebuilding the whole image on any change, but instead it rebuilds layers that were changed only.

You can read more about it in Docker's documentation.

In version `3.3.0` CEKit we optimized the way we generate Dockerfile making it much easier to fully leverage the caching mechanism.

In order to make most of this feature we strongly suggest to execute Docker build with the the `--no-squash` parameter. This will make sure that the intermediate layers won't be removed. In other case, the squashing post-processing will take place and any intermediate layers will be cleaned afterwards effectively losing cached layers.

```
$ cekit build docker --no-squash
```

Warning: You need to be aware that rebuilding a Docker image numerous times with the `--no-squash` option will leave many dangling layers that could fill your Docker storage. To prevent this you need to remove unused images from time to time. The `docker system prune -a` command may be useful.

Note: Please note that `--no-squash` switch may be only useful when developing the image. We strongly suggest to not use it to build the final image.

6.3.2 Module guidelines

Modules are the heart of CEKit. In modules we define what is going into the image and how it is configured. Modules can be easily shared across images.

This chapter discusses guidelines around modules.

Module naming

Contents

In this section we will be talking about about best practices related to module naming.

Suggested naming scheme

We suggest to use reverse domain convention:

```
name: "org.jboss.container.openjdk"
version: "11"
description: "OpenJDK 11 module"

# [SNIP]
```

We suggest to use **lower-case letters**.

Background

This approach is used in many languages (like Java, or C#) to define modules/packages. Besides this it is suggested to be used in defining container image label names.

There are a few reasons why it is so popular and a great choice for module names too:

1. Simplicity.
2. Module maintainer is known immediately by looking just at the name.
3. Module name clashes are unlikely.

Module versioning

Contents

This section focuses on best practices around module versioning. For information about how module versions are handled in CEKit take a look at *descriptor documentation for modules*.

Suggested versioning scheme

You are free to define your versioning scheme, but we strongly suggest to follow Python versioning scheme.

Although it was developed for Python - it's easy to reuse it anywhere, including modules versioning.

Note: Its design is very similar to semantic versioning scheme. You can read about differences between these two here.

Versioning summary

1. Use `MAJOR.MINOR.MICRO` versioning scheme.
2. Try to **avoid release suffixes**, but if you really need to add one of them, use PEP 440 style:

- Pre-releases like Alpha, Beta, Release Candidate

Note: There is no dot before the modifier.

- Post-releases

Note: Please note the dot before the `post` modifier.

- Development releases

Note: Please note the dot before the `dev` modifier.

Custom versioning scheme

Although it is possible to to use a custom versioning scheme for modules, we suggest to not use it. Custom versioning scheme can lead to issues that will be hard to debug, especially when your image uses multiple module repositories and many modules.

You should be fine when you will be strictly defining modules and versions in the image descriptor, but it's very problematic to do so. It's even close to impossible when you do not control the modules you are consuming.

As an example, an issue can arrive when you mix versioning schemes in modules. Version that follows the *suggested versioning scheme* will always take precedence before a custom versioning scheme.

See also:

See information about *parsing module versions*.

Git references vs. module versions

It is very common use case to place modules inside a Git repository. This is a very efficient way to share modules with others.

Git repositories are always using version of some sort, in Git we talk about ref's. This can be a branch or a tag name. References can point to a stable release (tags) or to a work in progress (branches).

Defining module version is required in CEKit. This means that the module definition must have the `version` key.

If you reference modules stored in a Git repository we can talk about two layers of versioning:

1. Git references
2. Module versions itself

We will use a simple example to explain how we can reference modules. Here is the module descriptor.

Listing 11: module.yaml

```
name: "org.company.project.feature"
version: "1.0"

execute:
    - script: "install.sh"
```

Below you can see the image descriptor snippet with only relevant content for this example.

Listing 12: image.yaml

```
modules:
    repositories:
        - name: "org.company.project"
          git:
            url: "https://github.com/company/project-modules"
            ref: "release-3.1.0"

    install:
        - name: "org.company.project.feature"
```

Note: As you can see above, the module repository does have a different reference than `1.0`. This is not a mistake - module repositories can contain multiple modules with different versions. Module repositories **group modules** together under a **single version**.

Referencing stable versions of modules

Referencing stable versions of modules is very easy. The most important thing to remember is that in order to pin a version of module, we need to be able to **pin to a specific version of the module registry itself too**.

Referencing tags is a great way to ensure that we use the same code always. This means that the git repository references need to be managed carefully and proper tag management need to be preserved (no force push on tags).

Once we have tags – we can reference them in the module registry `ref` just like in the example above.

We don't need to specify versions in the install section of modules as long as we have a single version of particular module available in repositories. If this is not the case and in your workflow you maintain multiple versions of same module – specifying version to install may be required.

Note: An example could be a module that installs OpenJDK 8 and OpenJDK 11 – name of the module is the same, these live in the same module repository, but versions differ.

If multiple versions of a particular module are available and the version will not be specified in the module installation section *newest version will be installed*.

Referencing development versions of modules

Module being currently in development should have set the version in module descriptor being the next (target) version. This will make sure the version is already set in the module and no code changes are required to actually *release* a module.

Assuming that the current released version of the module is `1.0`, we can develop the `2.0` version of this module, so we just define it in the module descriptor:

Listing 13: module.yaml

```
name: "org.company.project.feature"
version: "2.0"
```

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```
execute:
    - script: "install.sh"
```

If we develop module locally and reference the module repository using `path` attribute, no Git repository references are used at all. Modules are copied from the repository to the target directory and used there at build time.

We can use *overrides feature* to point to our development work. Using overrides makes it easy to not touch the image descriptor at development time.

Listing 14: overrides.yaml

```
modules:
    repositories:

        # Override our module repository location to point to a local directory
        - name: "org.company.project"
          path: "project-modules"
```

Please note that we did not specify which version of the `org.company.project.feature` module should be installed. This is perfectly fine! Since we are overriding the module repository, the only module version of the `org.company.project.feature` available will be our locally developed – `2.0`, so there is no need to define it, but of course we can do it.

If we want to share with someone our development work, we should push the module repository to a Git repository **using specific branch**. This branch could be a feature branch, or a regular development branch (for example `master`), it depends on your workflow.

In our example, let's use a feature branch: `feature-dev`. Once code is pushed to this branch, we can update our `overrides.yaml` file to use it:

Listing 15: overrides.yaml

```
modules:
    repositories:
        - name: "org.company.project"
          git:
            url: "https://github.com/company/project-modules"
            ref: "feature-dev"
```

Changelog

Just as any other library, a module should carry a changelog. Every release should have published list of changes made in the code. This will make it much easier to consume particular module.

6.3.3 Artifact guidelines

Contents

* *Define checksums*
* *Add descriptions*

Building container images without content doesn't make sense. You can add *packages* shipped with the operating system, you can add scripts with *modules*, but sooner or later you will need to add some bigger (potentially binary) files to your image. Using *artifacts* is how we handle it in CEKit.

This section helps you define artifacts in your descriptors.

Artifact descriptor

There are many *artifact types available*. Please refer to that page on what is the usage of these.

Below you can find best practices related to defining artifacts.

Proper `name` key usage

```
artifacts:
    - name: jolokia
      url: https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      description: "Jolokia is remote JMX with JSON over HTTP"
```

It is very important to use the `name` key properly. In CEKit we use `name` keys as identifiers and this is what the artifact's `name` key should be – it should **define a unique key** for the artifact across the whole image. This is especially important when you define artifacts in modules that are reused in many images.

The `name` key should be generic enough and be descriptive at the same time.

Basing on the example above **bad examples** could be:

`jolokia-1.3.6-bin.tar.gz`: We should not use the artifact file name as the identifier.

`1.3.6`: There is no information about the artifact, just version is presented.

Better but not ideal is this:

`jolokia-1.3.6`: Defines what it is and adds full version. Adding exact version may be an overkill. Imagine that later we would like to override it with some different version, then the artifact `jolokia-1.3.6` could point to a `jolokia-1.6.0-bin.tar.gz` which would be very misleading. We should **avoid** specifying versions.

But the **best option** would be to use something like this:

`jolokia_tar`: In this case we define what artifact we plan to add and the type of it. We do not specify version at all here.

`jolokia`: This is another possibility, where we use just the common *name* of the artifact. This makes it very easy to override and is easy to memoize too.

Hint: When you define the `name` for the artifact, make sure you define the `target` key too. If you don't do this, the **target file name is defaulted to the value of the name key** which may be misleading in some cases. See *this section* for more information on this topic.

Define checksums

Note: *Learn more about checksums*.

```
artifacts:
    - name: jolokia
      url: https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      description: "Jolokia is remote JMX with JSON over HTTP"
```

Every artifact should have defined checksums. This will ensure that the fetched artifact's integrity is preserved. If you do not define them artifacts will be always fetched again. This is good when the artifact changes very often at the development time, but once you settle on a version, specify the checksum too.

Add descriptions

```
artifacts:
    - name: jolokia
      url: https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      description: "Jolokia is remote JMX with JSON over HTTP"
```

It's a very good idea to add descriptions to the artifacts. This makes it much easier to understand what the artifact is about. Besides this, descriptions are used when automatic fetching of artifact is not possible and is a hint to the developer where to fetch the artifact from manually.

Descriptions can be used also by tools that process image descriptors to produce documentation.

6.3.4 Repository guidelines

Contents

One of the biggest challenges we faced with CEKit is how to manage and define package repositories correctly. This section focuses on best practices around using package repositories.

CEKit support different ways of defining and injecting repositories. Besides this, repositories can be manually managed by scripts in the modules itself.

Background

To give an overview on the available options, we need to understand the challenges too. Among other things, two are the three visible ones:

1. Different requirements for repository access because of image types (community vs. product)
2. Image hierarchy
3. Source code requirement

Repositories availability

All public/community images have public repositories freely available. This applies to Fedora, CentOS images, but as well to Ubuntu or Alpine. All images come with a set of repositories already configured in the image itself and there is no need to do anything special to enable them.

On the other hand we have product images where repositories are guarded in some way, for example by requiring subscriptions. Sometimes subscriptions are transparent (need to be enabled on the host, but nothing needs to be done in the container), sometimes we need to point to a specific location internally.

This makes it hard to have a single way to add or enable repositories.

Image hierarchy challenges

Besides issues in repository management described above we can have issues with how we structure images. For example the main image descriptor could be a community image, using publicly available repositories. We could have an overrides file saved next to it that would convert the image to be a product image, which obviously uses different sources of packages.

Source code

This is a bit related to the image hierarchy challenges above. If we build community images, then we expect to have the source code in public. With product images this may or may not be the same case.

In case where product images source is hosted internally only, we don't need to hide internal package repositoties. But it we develop in the true open source spirit, everything should be public. In such case, the product image descriptor cannot really refer to internal repositories and we need to use available, public information and correctly point the builder to an internal repository. This is very hard to do correctly.

Guidelines

This section describes best practices for managing repositories. We divided them into two sub-sections: for community and product images.

Repositories in community images

In case of community images, in most cases you will be fine with whatever is already available in the image itself.

If you need to add some repository, we suggest to use one of three options:

1. Add a *package with repository definition*,
2. Add a *repository file definition*,
3. Manage it manually (advanced).

RPM defined repositories

First option is probably the cleanest one of all but it requires that a package with the repository definition exists in the already enabled repositories. This is true for example for EPEL repository or Software Collections repository.

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
```

Repository file defined repositories

Second option is to add prepared repository file.

```
packages:
    repositories:
        - name: foo
          url:
            repository: https://web.example/foo.repo
```

Here is an example repo file:

```
[google-chrome]
name=google-chrome
baseurl=http://dl.google.com/linux/chrome/rpm/stable/x86_64
enabled=1
gpgcheck=1
gpgkey=https://dl.google.com/linux/linux_signing_key.pub
```

It's easy to create one if need. Please note that it should be self-contained meaning that other things must not be required to configure to make it work. A good practice is to save this file on a host secured with SSL. The GPG key

should be always provided, but in case of development repositories it's OK to turn off GPG checking (set `gpgcheck` to `0`).

Manual repository management

Last option is all about manual repository management. This means that enabling and removing repositories can be done as part of a module which directly creates repo files in the image while building it.

Enabling repositories this way needs to be well thought. Repositories will be available for package installation in the **subsequent module execution**:

```
modules:
    install:
        - name: repository.enable
        - name: repository.packages.install
```

The reason for this is that package installation is done **before** any commands are executed and since we enable the repository as part of some command we cannot also request packages to be installed from that repository at that time.

There is one way to overcome this limitation.

Additionally to enabling the repository, you can use the package manager to install packages you want. This gives you great flexibility.

Consider following module descriptor:

```
# SNIP
execute:
    - script: packages.sh
```

and the `packages.sh` file content:

```
#!/bin/bash

curl -o /etc/yum.repos.d/foo.repo https://web.example/foo.repo
dnf -y install foo-package
```

This combination allows you to fully control what is done to packages as part of the build process.

Repositories in product images

Note: If your product image source code is not exposed to public as mentioned in the *previous section*, you may use the same *repository management methods as in community images*.

Everything below covers the case where product image source code is public.

Managing repositories in product images is completely different from what we saw in community images. The reason is that these require subscriptions to access them.

To enable repositories inside RHEL containers you need to subscribe the host. Read more about it here: https://access.redhat.com/solutions/1443553.

Besides this, we can have following situations:

1. Building RHEL based images on subscribed hosts
2. Building RHEL based images on unsubscribed hosts

Plain repositories

Plain repositories are an abstract way of defining package repositories. These are just markers that such and such repository is required to successfully build the image, but because these do not reveal the *implementation* of the repository, CEKit is unable to directly satisfy this requirement.

Why that would be a good thing? Because of two things:

1. If you specify plain repository with a defined `name` – it will be easy to override it! Additionally, the `id` key can suggest what should be the implementation of this repository definition, and
2. For subscribed hosts, no repository preparation is required.

Let's take a look at an example.

```
packages:
    repositories:
        - name: scl
          id: rhel-server-rhscl-7-rpms
```

This could be later overridden with something like this:

```
$ cekit build --overrides '{"packages": {"repositories": [{"name": "scl", "url": {
↪"repository": "http://internal/scl.repo"}}]}}' podman
```

On a subscribed host, there would be no need to do above overrides, because automatically every repository attached to a subscription is enabled in the container image running on that host.

Warning: It is not possible to limit repositories available to a container running on a subscribed host outside of the container. You need to manage it in the container. See https://access.redhat.com/solutions/1443553 for detailed information about this.

Content sets

Using content sets is the **preferred way when building Red Hat container images**. Content sets define all the sources for packages for particular container image.

A sample content sets file may look like this:

```
x86_64:
- server-rpms
- server-extras-rpms

ppx64le:
- server-for-power-le-rpms
- server-extras-for-power-le-rpms
```

This defines architectures and appropriate repository ID's. Defining content sets can be done in the `content_sets` section. For details please take a look at the *image descriptor documentation*.

Please note that the behavior of repositories when content sets are defined is different too; **when content sets are used – any repositories defined are ignored**. You will see a warning in the logs if that will be the case. This means that if a repository is defined in any module (see *note about this below*) or in image descriptor or in overrides – it will be ignored.

Note: If you want to enable content sets in OSBS, you need also set the `pulp_repos` key to `true` in the `compose` section of the *OSBS configuration*.

Notes

Here are a few notes from our experience. Hopefully this will make repository management easier for you too!

Always define name of the repository

When you define the repository, you should always specify the `name` key. It should be generic but self-explaining at the same time. This will make it much easier to understand what repository it is and in case where it's not available, finding a replacement source will be much easier task to do.

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
```

In this example, the `scl` is short and it clearly suggests Software Collections. Here is how it could be redefined to use some internal repository.

```
$ cekit build --overrides '{"packages": {"repositories": [{"name": "scl", "url": {
↪"repository": "http://internal/scl.repo"}}]}}' podman
```

Do not define repositories in modules

Although it is technically possible to define repositories in modules, it shouldn't be done. This makes is much harder to manage and override it. In case you do not own the module that defines the repository, you have little control over how it is defined and if it can be easily overridden.

Repositories should be a property of the image descriptor.

Use content sets for Red Hat images

If you are developing Red Hat container images, you should use content sets to define which repositories should be used.

6.4 Descriptor documentation

This chapter provides overview of available descriptors.

Note: Although descriptors look similar, these can differ in the availability of selected keys.

6.4.1 Image descriptor

Image descriptor contains all information CEKit needs to build and test a container image.

Contents

Name

Key `name`

Required Yes

Image name without the registry part.

Example

```
name: "jboss-eap-7/eap70-openshift"
```

Version

Key `version`

Required Yes

Version of the image.

```
version: "1.4"
```

Description

Key `description`

Required No

Short summary of the image.

Value of the `description` key is added to the image as two labels:

1. `description`, and
2. `summary`.

Note: These labels are not added is these are already defined in the *labels* section.

```
description: "Red Hat JBoss Enterprise Application 7.0 - An application platform for␣
↪hosting your apps that provides an innovative modular, cloud-ready architecture,␣
↪powerful management and automation, and world class developer productivity."
```

From

Key `from`

Required Yes

Base image of your image.

```
from: "jboss-eap-7/eap70:1.2"
```

Environment variables

Key `envs`

Required No

Similar to *labels* – we can specify environment variables that should be present in the container after running the image. We provide `envs` section for this.

Environment variables can be divided into two types:

1. **Information environment variables**

   These are set and available in the image. This type of environment variables provide information to the image consumer. In most cases such environment variables *should not* be modified.

2. **Configuration environment variables**

   This type of variables are used to define environment variables used to configure services inside running container.

These environment variables are **not** set during image build time but *can* be set at run time.

Every configuration enviromnent variable should provide an example usage (`example`) and short description (`description`).

Please note that you could have an environment variable with both: a `value` and `example` set. This suggest that this environment variable could be redefined.

Note: Configuration environment variables (without `value`) are not generated to the build source. These can be used instead as a source for generating documentation.

```
envs:
    # Configuration env variables below
    # These will be added to container
    - name: "STI_BUILDER"
      value: "jee"
    - name: "JBOSS_MODULES_SYSTEM_PKGS"
      value: "org.jboss.logmanager,jdk.nashorn.api"

    # Information env variables below
    # These will NOT be defined (there is no value)
```

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```
    - name: "OPENSHIFT_KUBE_PING_NAMESPACE"
      example: "myproject"
      description: "Clustering project namespace."
    - name: "OPENSHIFT_KUBE_PING_LABELS"
      example: "application=eap-app"
      description: "Clustering labels selector."
```

Labels

Key `labels`

Required No

Note: Learn more about standard labels in container images.

Every image can include labels. CEKit makes it easy to do so with the `labels` section.

```
labels:
    - name: "io.k8s.description"
      value: "Platform for building and running JavaEE applications on JBoss EAP 7.0"
    - name: "io.k8s.display-name"
      value: "JBoss EAP 7.0"
```

Artifacts

It's common for images to require external artifacts like jar files, installers, etc. In most cases you will want to add some files into the image and use them during image build process.

Artifacts section is meant exactly for this. CEKit will try to *automatically* fetch any artifacts specified in this section.

If for some reason automatic fetching of artifacts is not an option for you, you should define artifacts as plain artifacts and use the `cekit-cache` command to add the artifact to local cache, making it available for the build process automatically. See *Artifact caching* chapter.

Artifact features

Checksums Almost all artifacts will be checked for consistency by computing checksum of the fetched file and comparing it with the desired value. Currently supported algorithms are: `md5`, `sha1`, `sha256` and `sha512`.

You can define multiple checksums for a single artifact. All specified checksums will be validated.

If no algorithm is provided, artifacts will be fetched **every time**.

This can be useful when building images with snapshot content. In this case you are not concerned about the consistency but rather focusing on rapid development. We advice that you define checksum when your content becomes stable.

Caching All artifacts are automatically cached during an image build. To learn more about caching please take a look at *Artifact caching* chapter.

Common artifact keys

name Used to define unique identifier of the artifact.

The `name` key is very important. It's role is to provide a unique identifier for the artifact. If it's not provided, it will be computed from the resource definition, but we **strongly suggest** to provide the `name` keys always.

Value of this key does not need to be a filename, because it's just an identifier used to refer the artifact. Using meaningful and unique identifiers is important in case when you want to use *Overrides*. It will make it much easier to refer the artifact and thus override it.

target The output name for fetched resources will match the `target` attribute. If it is not defined then base name of the `name` attribute will be used. If it's not provided either then base name of the path/URL will be used.

Below you can find a few examples.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
      target: jboss-eap.zip
```

Target file name: `jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-distribution`.

```
artifacts:
    - path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-6.4.0.zip`.

dest The `dest` key defines the destination directory where the particular artifact will be placed within the container image. By default it is set to `/tmp/artifacts/`.

The `dest` key specifies the **directory** path, to control **file name**, use `target` key as explained above. In order to get maximum control over the target artifact naming, you should use both `dest` and `target` together.

Examples:

```
artifacts:
    - name: jboss-eap-distribution
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
```

Target file path is: `/tmp/artifacts/jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
        dest: /opt
```

Target file path is: `/opt/jboss-eap.zip`.

Note: The default temporary directory (`/tmp/artifacts/`) will be cleaned up automatically after the build process is done meaning that artifacts are available only at the build time.

Artifacts using custom `dest` values are not affected.

`description` Describes the artifact. This is an optional key that can be used to add more information about the artifact.

Adding description to artifacts makes it much easier to understand what artifact it is just by looking at the image/module descriptor.

```
artifacts:
  - path: jboss-eap-6.4.0.zip
    md5: 9a5d37631919a111ddf42ceda1a9f0b5
    description: "Red Hat JBoss EAP 6.4.0 distribution available on Customer␣
↪Portal: https://access.redhat.com/jbossnetwork/restricted/softwareDetail.html?
↪softwareId=37393&product=appplatform&version=6.4&downloadType=distributions"
```

If CEKit is not able to download an artifact and this artifact has a `description` defined – the build will fail but a message with the description will be printed together with information on where to place the manually downloaded artifact so that the build could be resumed.

Artifact types

CEKit supports following artifact types:

- Plain artifacts
- URL artifacts
- Path artifacts
- Image source artifacts

Plain artifacts

This is an abstract way of defining artifacts. The only required keys are `name` and the `md5` checksum. This type of artifacts is used to define artifacts that are not available publicly and instead provided by some (internal) systems.

Listing 16: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "required": true,
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
```

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```
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Listing 17: Examples

```
artifacts:
    - name: jolokia
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      target: jolokia.tar.gz
```

As you can see, the definition does not define from where the artifact should be fetched. This approach relies on *Artifact caching* to provide the artifact.

Note: See *Red Hat environment* for description how plain artifacts are used in the Red Hat environment.

URL artifacts

This is the simplest way of defining artifacts. You need to provide the `url` key which is the URL from where the artifact should be fetched from.

Listing 18: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
```

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```
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        },
        "url": {
            "desc": "URL where the resource can be found",
            "required": true,
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the downloaded artifact is correct.

Listing 19: Examples

```
artifacts:
    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # The md5 checksum of the artifact
      md5: "75e5b5ba0b804cd9def9f20a70af649f"

    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # Free text description of the artifact
      description: "Library required to access server data via JMX"
      md5: "75e5b5ba0b804cd9def9f20a70af649f"
      # Final name of the downloaded artifact
      target: "jolokia.tar.gz"
```

Path artifacts

This way of defining artifacts is mostly used in development *overrides* and enables you to inject artifacts from a local filesystem.

Listing 20: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Relative (suggested) or absolute path to the resource",
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
```

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```
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the artifact is correct.

Listing 21: Examples

```
artifacts:
    - name: jolokia-1.3.6-bin.tar.gz
      path: local-artifacts/jolokia-1.3.6-bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
```

Note: If you are using relative `path` to define an artifact, path is considered relative to an image descriptor which introduced that artifact.

Example If an artifact is defined inside `/foo/bar/image.yaml` with a path: `baz/1.zip` the artifact will be resolved as `/foo/bar/baz/1.zip`

Image source artifacts

Image source artifacts are used in *multi-stage builds*. With image source artifacts you can define files built in previous stages of the multi-stage builds.

Listing 22: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "image": {
            "desc": "Name of the image which holds the resource",
            "required": true,
            "type": "str"
        },
```

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```
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Path in the image under which the resource can be found",
            "required": true,
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Note: Please note that image source artifacts do not allow for defining checksums due to the nature of this type of artifact.

Listing 23: Examples

```
artifacts:
    - name: application
      # Name of the image (stage) from where we will fetch the artifact
      image: builder
      # Path to the artifact within the image
      path: /path/to/application/inside/the/builder/image.jar
```

Packages

Key `packages`

Required No

To install additional packages you can use the `packages` section where you specify package names and repositories to be used, as well as the package manager that is used to manage packages in this image.

Listing 24: Example package section for RPM-based distro

```
packages:
    repositories:
        - name: extras
          id: rhel7-extras-rpm
    manager: dnf
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
        - mysql-connector-java
        - maven
        - hostname
```

Listing 25: Example package section for Alpine Linux

```
packages:
    manager: apk
    install:
        - python3
```

Packages to install

Key `install`

Required No

Packages listed in the `install` section are marked to be installed in the container image.

```
packages:
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
```

Package manager

Key `manager`

Required No

It is possible to define package manager used in the image used to install packages as part of the build process.

Currently available options are `yum`, `dnf`, `microdnf` and `apk`.

Note: If you do not specify this key the default value is `yum`. If your image requires different package manager you need to specify it.

The default `yum` value will work fine on Fedora and RHEL images because OS maintains a symlink to the proper package manager.

```
packages:
    manager: dnf
    install:
        - git
```

Package repositories

Key `repositories`

Required No

Warning: Some package repositories are supported only on specific distributions and package manager combinations. Please refer to documentation below!

CEKit uses all repositories configured inside the image. You can also specify additional repositories using repositories subsection. CEKit currently supports following ways of defining additional repositories:

- *Plain repository*
- *RPM repository*
- *URL repository*
- *Content sets*

Tip: See *repository guidelines guide* to learn about best practices for repository definitions.

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
        - name: extras
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

Plain repository

Note: Available only on RPM-based distributions.

With this approach you specify repository `id` and CEKit will not perform any action and expect the repository definition exists inside the image. This is useful as a hint which repository must be present for particular image to be buildable. The definition can be overridden by your preferred way of injecting repositories inside the image.

```
packages:
    repositories:
        - name: extras
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

RPM repository

Note: Available only on RPM-based distributions.

This ways is using repository configuration files and related keys packaged as an RPM.

Example: To enable CentOS SCL inside the image you should define repository in a following way:

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
```

Tip: The `rpm` key can also specify a URL to a RPM file:

```
packages:
    repositories:
        - name: epel
          rpm: https://dl.fedoraproject.org/pub/epel/epel-release-latest-7.noarch.rpm
```

URL repository

Note: Available only on RPM-based distributions.

This approach enables you to download a yum repository file and corresponding GPG key. To do it, define repositories section in a way of:

```
packages:
    repositories:
        - name: foo
          url:
            repository: https://web.example/foo.repo
```

Content sets

Note: Available only on RPM-based distributions.

Content sets are tightly integrated to OSBS style of defining repositories in `content_sets.yml` file. If this kind of repository is present in the image descriptor it overrides all other repositories types. For local Docker based build these repositories are ignored similarly to Plain repository types and we expect repository definitions to be available inside image. See upstream docs for more details about content sets.

Note: Behavior of Content sets repositories is changed when running in *Red Hat Environment*.

There are two possibilities how to define Content sets type of repository:

Embedded content sets

In this approach content sets are embedded inside image descriptor under the `content_sets` key.

```
packages:
    content_sets:
        x86_64:
        - server-rpms
        - server-extras-rpms
```

Linked content sets

In this approach Contet sets file is linked from a separate yaml file next to image descriptor via `content_sets_file` key.

Image descriptor:

```
packages:
    content_sets_file: content_sets.yml
```

`content_sets.yml` located next to image descriptor:

```
x86_64:
  - server-rpms
  - server-extras-rpms
```

Ports

Key `ports`

Required No

This section is used to mark which ports should be exposed in the container. If we want to highlight a port used in the container, but not necessary expose it – we should set the `expose` flag to `false` (`true` by default).

You can provide additional documentation as to the usage of the port with the keys `protocol`, to specify which IP protocol is used over the port number (e.g TCP, UDP...) and `service` to describe what network service is running on top of the port (e.g. "http", "https"). You can provide a human-readable long form description of the port with the `description` key.

```
ports:
    - value: 8443
      service: https
    - value: 8778
      expose: false
      protocol: tcp
      description: internal port for communication.
```

Volumes

Key `volumes`

Required No

In case you want to define volumes for your image, just use the `volumes` section!

```
volumes:
    - name: "volume.eap"
      path: "/opt/eap/standalone"
```

Note: The `name` key is optional. If not specified the value of `path` key will be used.

Modules

Key `modules`

Required No

The modules section is responsible for defining module repositories and providing the list of modules to be installed in order.

```
modules:
    repositories:
        # Add local modules located next to the image descriptor
        # These modules are specific to the image we build and are not meant
        # to be shared
        - path: modules

        # Add a shared module repository located on GitHub. This repository
        # can contain several modules.
        - git:
            url: https://github.com/cekit/example-common-module.git
            ref: master

    # Install selected modules (in order)
    install:
        - name: jdk8
        - name: user
        - name: tomcat
```

Module repositories

Key `repositories`

Required No

Module repositories specify location of modules that are to be incorporated into the image. These repositories may be `git` repositories or directories on the local file system (`path`). CEKit will scan the repositories for `module.xml` files, which are used to encapsulate image details that may be incorporated into multiple images.

```
modules:
  repositories:
      # Modules pulled from Java image project on GitHub
    - git:
          url: https://github.com/jboss-container-images/redhat-openjdk-18-openshift-
↪image
          ref: 1.0

      # Modules pulled locally from "custom-modules" directory, collocated with image␣
↪descriptor
    - path: custom-modules
```

Module installation

Key `install`

Required No

The `install` section is used to define what modules should be installed in the image in what order. Name used to specify the module is the `name` field from the module descriptor.

```
modules:
  install:
      - name: xpaas.java
      - name: xpaas.amq.install
```

You can even request specific module version via *version* key as follows:

```
modules:
  install:
      - name: xpaas.java
        version: 1.2-dev
      - name: xpaas.amq.install
```

Run

Key `run`

Required No

The `run` section encapsulates instructions related to launching main process in the container including: `cmd`, `entrypoint`, `user` and `workdir`. All subsections are described later in this paragraph.

Below you can find full example that uses every possible option.

```
run:
    cmd:
        - "argument1"
        - "argument2"
    entrypoint:
        - "/opt/eap/bin/wrapper.sh"
    user: "alice"
    workdir: "/home/jboss"
```

Cmd

Key `cmd`

Required No

Command that should be executed by the container at run time.

```
run:
    cmd:
        - "some cmd"
        - "argument"
```

Entrypoint

Key `entrypoint`

Required No

Entrypoint that should be executed by the container at run time.

```
run:
    entrypoint:
        - "/opt/eap/bin/wrapper.sh"
```

User

Key `user`

Required No

Specifies the user (can be username or uid) that should be used to launch the main process.

```
run:
    user: "alice"
```

Working directory

Key `workdir`

Required No

Sets the current working directory of the entrypoint process in the container.

```
run:
    workdir: "/home/jboss"
```

Help

Key `help`

Required No

At image build-time CEKit can generate a documentation page about the image. This file is a human-readable conversion of the resulting image descriptor. That is, a descriptor with all overrides and modules combined together, which was used to build the image.

If an image help page is requested to be added to the image (by setting the `add` key), a `help.md` is generated and added to the **root of the image**.

By default image help pages are not generated.

The default help template is supplied within CEKit. You can override it for every image via image definition. The optional help sub-section can define defines a single key `template`, which can be used to define a filename to use for generating image documentation at build time.

The template is interpreted by the Jinja2 template engine. For a concrete example, see the default help.jinja supplied in the CEKit source code.

```
help:
  add: true
  template: my_help.md
```

OSBS

Key `osbs`

Required No

This section represents object we use to hint OSBS builder with a configuration which needs to be tweaked for successful and reproducible builds.

It contains two main keys:

- *repository*
- *configuration*

```
osbs:
    repository:
        name: containers/redhat-openjdk-18
        branch: jb-openjdk-1.8-openshift-rhel-7
    configuration:
        container:
            compose:
                pulp_repos: true
```

OSBS extra directory

Key `extra_dir`

Required No

If a directory name specified by `extra_dir` key will be found next to the image descriptor, the contents of this directory will be copied into the target directory and later to the dist-git directory.

Symbolic links are preserved (not followed).

Copying files is done before generation, which means that files from the extra directory can be overridden in the *generation phase* .

Note: If you do not specify this key in image descriptor, the default value of `osbs_extra` will be used.

```
osbs:
    extra_dir: custom-files
```

OSBS repository

Key `repository`

Required No

This key serves as a hint which DistGit repository and its branch we use to push generated sources into.

```
osbs:
    repository:
        name: containers/redhat-openjdk-18
        branch: jb-openjdk-1.8-openshift-rhel-7
```

OSBS Koji target

Key `koji_target`

Required No

To execute a build in OSBS the Koji target parameter needs to be provided. By default it is constructed based on the branch name (see above), like this:

In most cases this is what is expected, but sometimes you want to change this. An example of such situation is when you use a custom, private branch to execute a scratch build. Target can be overridden by specifying the `koji_target` key.

```
osbs:
    koji_target: rhaos-middleware-rhel-7-containers-candidate
```

OSBS configuration

Key `configuration`

Required No

This key is holding OSBS `container.yaml` file. See OSBS docs for more information about this file.

CEKit supports two ways of defining content of the `container.yaml` file:

1. It can be embedded in `container` key, or
2. It can be injected from a file specified in `container_file` key.

Selecting preferred way of defining this configuration is up to the user. Maintaining external file may be handy in case where it is shared across multiple images in the same repository.

Embedding In this case whole `container.yaml` file is embedded in an image descriptor under the `container` key.

```
# Embedding
osbs:
    configuration:
        # Configuration is embedded directly in the container key below
        container:
            compose:
                pulp_repos: true
```

Linking In this case `container.yaml` file is read from a file located next to the image descriptor using the `container_file` key to point to the file.

```
osbs:
    configuration:
        # Configuration is available in the container.yaml file
        container_file: container.yaml
```

and `container.yaml` file content:

```
compose:
    pulp_repos: true
```

6.4.2 Module descriptor

Module descriptor contains all information CEKit needs to introduce a feature to an image. Modules are used as libraries or shared building blocks across images.

It is very important to make a module self-contained which means that executing scripts defined in the module's definition file should always end up in a state where you could define the module as being *installed*.

Modules can be stacked – some modules will be run before, some after your module. Please keep that in mind at the time you are developing your module – you don't know how and when it'll be executed.

Contents

        * *User*
        * *Working directory*
    - *Help*

Name

Key `name`

Required Yes

Module identifier used to refer to the module, for example in list of modules to install or in overrides.

Warning: Please note that this key has a different purpose than the `name` key in *image descriptor*. When defined in a module it defines the module name and **does not** override the image name.

```
name: "python_flask_module"
```

Execute

Key `execute`

Required No

Execute section defines what needs to be done to install this module in the image. Every execution listed in this section will be run at image build time in the order as defined.

Note: When no `user` is defined, `root` user will be used to execute the script.

```
execute:
    # The install.sh file will be executed first as root user
    - script: install.sh
    # Then the redefine.sh file will be executed as jboss user
    - script: redefine.sh
      user: jboss
```

Version

Key `version`

Required Yes

Version of the image.

```
version: "1.4"
```

Description

Key `description`

Required No

Short summary of the image.

Value of the `description` key is added to the image as two labels:

1. `description`, and
2. `summary`.

Note: These labels are not added is these are already defined in the *labels* section.

```
description: "Red Hat JBoss Enterprise Application 7.0 - An application platform for␣
↪hosting your apps that provides an innovative modular, cloud-ready architecture,␣
↪powerful management and automation, and world class developer productivity."
```

From

Key `from`

Required Yes

Base image of your image.

```
from: "jboss-eap-7/eap70:1.2"
```

Environment variables

Key `envs`

Required No

Similar to *labels* – we can specify environment variables that should be present in the container after running the image. We provide `envs` section for this.

Environment variables can be divided into two types:

1. **Information environment variables**

   These are set and available in the image. This type of environment variables provide information to the image consumer. In most cases such environment variables *should not* be modified.

2. **Configuration environment variables**

   This type of variables are used to define environment variables used to configure services inside running container.

These environment variables are **not** set during image build time but *can* be set at run time.

Every configuration enviromnent variable should provide an example usage (`example`) and short description (`description`).

Please note that you could have an environment variable with both: a `value` and `example` set. This suggest that this environment variable could be redefined.

Note: Configuration environment variables (without `value`) are not generated to the build source. These can be used instead as a source for generating documentation.

```
envs:
    # Configuration env variables below
    # These will be added to container
    - name: "STI_BUILDER"
      value: "jee"
    - name: "JBOSS_MODULES_SYSTEM_PKGS"
      value: "org.jboss.logmanager,jdk.nashorn.api"

    # Information env variables below
    # These will NOT be defined (there is no value)
    - name: "OPENSHIFT_KUBE_PING_NAMESPACE"
      example: "myproject"
      description: "Clustering project namespace."
    - name: "OPENSHIFT_KUBE_PING_LABELS"
      example: "application=eap-app"
      description: "Clustering labels selector."
```

Labels

Key `labels`

Required No

Note: Learn more about standard labels in container images.

Every image can include labels. CEKit makes it easy to do so with the `labels` section.

```
labels:
    - name: "io.k8s.description"
      value: "Platform for building and running JavaEE applications on JBoss EAP 7.0"
    - name: "io.k8s.display-name"
      value: "JBoss EAP 7.0"
```

Artifacts

It's common for images to require external artifacts like jar files, installers, etc. In most cases you will want to add some files into the image and use them during image build process.

Artifacts section is meant exactly for this. CEKit will try to *automatically* fetch any artifacts specified in this section.

If for some reason automatic fetching of artifacts is not an option for you, you should define artifacts as plain artifacts and use the `cekit-cache` command to add the artifact to local cache, making it available for the build process automatically. See *Artifact caching* chapter.

Artifact features

Checksums Almost all artifacts will be checked for consistency by computing checksum of the fetched file and comparing it with the desired value. Currently supported algorithms are: `md5`, `sha1`, `sha256` and `sha512`.

You can define multiple checksums for a single artifact. All specified checksums will be validated.

If no algorithm is provided, artifacts will be fetched **every time**.

This can be useful when building images with snapshot content. In this case you are not concerned about the consistency but rather focusing on rapid development. We advice that you define checksum when your content becomes stable.

Caching All artifacts are automatically cached during an image build. To learn more about caching please take a look at *Artifact caching* chapter.

Common artifact keys

`name` Used to define unique identifier of the artifact.

The `name` key is very important. It's role is to provide a unique identifier for the artifact. If it's not provided, it will be computed from the resource definition, but we **strongly suggest** to provide the `name` keys always.

Value of this key does not need to be a filename, because it's just an identifier used to refer the artifact. Using meaningful and unique identifiers is important in case when you want to use *Overrides*. It will make it much easier to refer the artifact and thus override it.

`target` The output name for fetched resources will match the `target` attribute. If it is not defined then base name of the `name` attribute will be used. If it's not provided either then base name of the path/URL will be used.

Below you can find a few examples.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
      target: jboss-eap.zip
```

Target file name: `jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-distribution`.

```
artifacts:
    - path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-6.4.0.zip`.

`dest` The `dest` key defines the destination directory where the particular artifact will be placed within the container image. By default it is set to `/tmp/artifacts/`.

The `dest` key specifies the **directory** path, to control **file name**, use `target` key as explained above. In order to get maximum control over the target artifact naming, you should use both `dest` and `target` together.

Examples:

```
artifacts:
    - name: jboss-eap-distribution
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
```

Target file path is: `/tmp/artifacts/jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
```

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```
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
        dest: /opt
```

Target file path is: `/opt/jboss-eap.zip`.

Note: The default temporary directory (`/tmp/artifacts/`) will be cleaned up automatically after the build process is done meaning that artifacts are available only at the build time.

Artifacts using custom `dest` values are not affected.

`description` Describes the artifact. This is an optional key that can be used to add more information about the artifact.

Adding description to artifacts makes it much easier to understand what artifact it is just by looking at the image/module descriptor.

```
artifacts:
  - path: jboss-eap-6.4.0.zip
    md5: 9a5d37631919a111ddf42ceda1a9f0b5
    description: "Red Hat JBoss EAP 6.4.0 distribution available on Customer␣
↪Portal: https://access.redhat.com/jbossnetwork/restricted/softwareDetail.html?
↪softwareId=37393&product=appplatform&version=6.4&downloadType=distributions"
```

If CEKit is not able to download an artifact and this artifact has a `description` defined – the build will fail but a message with the description will be printed together with information on where to place the manually downloaded artifact so that the build could be resumed.

Artifact types

CEKit supports following artifact types:

- Plain artifacts
- URL artifacts
- Path artifacts
- Image source artifacts

Plain artifacts

This is an abstract way of defining artifacts. The only required keys are `name` and the `md5` checksum. This type of artifacts is used to define artifacts that are not available publicly and instead provided by some (internal) systems.

Listing 26: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
```

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```
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "required": true,
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Listing 27: Examples

```
artifacts:
    - name: jolokia
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      target: jolokia.tar.gz
```

As you can see, the definition does not define from where the artifact should be fetched. This approach relies on *Artifact caching* to provide the artifact.

Note: See *Red Hat environment* for description how plain artifacts are used in the Red Hat environment.

URL artifacts

This is the simplest way of defining artifacts. You need to provide the `url` key which is the URL from where the artifact should be fetched from.

Listing 28: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        },
        "url": {
            "desc": "URL where the resource can be found",
            "required": true,
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the downloaded artifact is correct.

Listing 29: Examples

```
artifacts:
    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # The md5 checksum of the artifact
      md5: "75e5b5ba0b804cd9def9f20a70af649f"
```

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```
    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # Free text description of the artifact
      description: "Library required to access server data via JMX"
      md5: "75e5b5ba0b804cd9def9f20a70af649f"
      # Final name of the downloaded artifact
      target: "jolokia.tar.gz"
```

Path artifacts

This way of defining artifacts is mostly used in development *overrides* and enables you to inject artifacts from a local filesystem.

Listing 30: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Relative (suggested) or absolute path to the resource",
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
```

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```
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the artifact is correct.

Listing 31: Examples

```
artifacts:
    - name: jolokia-1.3.6-bin.tar.gz
      path: local-artifacts/jolokia-1.3.6-bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
```

Note: If you are using relative `path` to define an artifact, path is considered relative to an image descriptor which introduced that artifact.

Example If an artifact is defined inside `/foo/bar/image.yaml` with a path: `baz/1.zip` the artifact will be resolved as `/foo/bar/baz/1.zip`

Image source artifacts

Image source artifacts are used in *multi-stage builds*. With image source artifacts you can define files built in previous stages of the multi-stage builds.

Listing 32: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "image": {
            "desc": "Name of the image which holds the resource",
            "required": true,
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Path in the image under which the resource can be found",
            "required": true,
            "type": "str"
```

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```
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Note: Please note that image source artifacts do not allow for defining checksums due to the nature of this type of artifact.

Listing 33: Examples

```
artifacts:
    - name: application
      # Name of the image (stage) from where we will fetch the artifact
      image: builder
      # Path to the artifact within the image
      path: /path/to/application/inside/the/builder/image.jar
```

Packages

Key `packages`

Required No

To install additional packages you can use the `packages` section where you specify package names and repositories to be used, as well as the package manager that is used to manage packages in this image.

Listing 34: Example package section for RPM-based distro

```
packages:
    repositories:
        - name: extras
          id: rhel7-extras-rpm
    manager: dnf
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
        - mysql-connector-java
        - maven
        - hostname
```

Listing 35: Example package section for Alpine Linux

```
packages:
    manager: apk
    install:
        - python3
```

Packages to install

Key `install`

Required No

Packages listed in the `install` section are marked to be installed in the container image.

```
packages:
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
```

Package manager

Key `manager`

Required No

It is possible to define package manager used in the image used to install packages as part of the build process.

Currently available options are `yum`, `dnf`, `microdnf` and `apk`.

Note: If you do not specify this key the default value is `yum`. If your image requires different package manager you need to specify it.

The default `yum` value will work fine on Fedora and RHEL images because OS maintains a symlink to the proper package manager.

```
packages:
    manager: dnf
    install:
        - git
```

Package repositories

Key `repositories`

Required No

Warning: Some package repositories are supported only on specific distributions and package manager combinations. Please refer to documentation below!

CEKit uses all repositories configured inside the image. You can also specify additional repositories using repositories subsection. CEKit currently supports following ways of defining additional repositories:

- *Plain repository*
- *RPM repository*
- *URL repository*
- *Content sets*

Tip: See *repository guidelines guide* to learn about best practices for repository definitions.

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
        - name: extras
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

Plain repository

Note: Available only on RPM-based distributions.

With this approach you specify repository `id` and CEKit will not perform any action and expect the repository definition exists inside the image. This is useful as a hint which repository must be present for particular image to be buildable. The definition can be overridden by your preferred way of injecting repositories inside the image.

```
packages:
    repositories:
        - name: extras
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

RPM repository

Note: Available only on RPM-based distributions.

This ways is using repository configuration files and related keys packaged as an RPM.

Example: To enable CentOS SCL inside the image you should define repository in a following way:

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
```

Tip: The `rpm` key can also specify a URL to a RPM file:

```
packages:
    repositories:
        - name: epel
          rpm: https://dl.fedoraproject.org/pub/epel/epel-release-latest-7.noarch.rpm
```

URL repository

Note: Available only on RPM-based distributions.

This approach enables you to download a yum repository file and corresponding GPG key. To do it, define repositories section in a way of:

```
packages:
    repositories:
        - name: foo
          url:
            repository: https://web.example/foo.repo
```

Content sets

Note: Available only on RPM-based distributions.

Content sets are tightly integrated to OSBS style of defining repositories in `content_sets.yml` file. If this kind of repository is present in the image descriptor it overrides all other repositories types. For local Docker based build these repositories are ignored similarly to Plain repository types and we expect repository definitions to be available inside image. See upstream docs for more details about content sets.

Note: Behavior of Content sets repositories is changed when running in *Red Hat Environment*.

There are two possibilities how to define Content sets type of repository:

Embedded content sets

In this approach content sets are embedded inside image descriptor under the `content_sets` key.

```
packages:
    content_sets:
        x86_64:
        - server-rpms
        - server-extras-rpms
```

Linked content sets

In this approach Contet sets file is linked from a separate yaml file next to image descriptor via `content_sets_file` key.

Image descriptor:

```
packages:
    content_sets_file: content_sets.yml
```

`content_sets.yml` located next to image descriptor:

```
x86_64:
  - server-rpms
  - server-extras-rpms
```

Ports

Key `ports`

Required No

This section is used to mark which ports should be exposed in the container. If we want to highlight a port used in the container, but not necessary expose it – we should set the `expose` flag to `false` (`true` by default).

You can provide additional documentation as to the usage of the port with the keys `protocol`, to specify which IP protocol is used over the port number (e.g TCP, UDP...) and `service` to describe what network service is running on top of the port (e.g. "http", "https"). You can provide a human-readable long form description of the port with the `description` key.

```
ports:
    - value: 8443
      service: https
    - value: 8778
      expose: false
      protocol: tcp
      description: internal port for communication.
```

Volumes

Key `volumes`

Required No

In case you want to define volumes for your image, just use the `volumes` section!

```
volumes:
    - name: "volume.eap"
      path: "/opt/eap/standalone"
```

Note: The `name` key is optional. If not specified the value of `path` key will be used.

Modules

Key `modules`

Required No

The modules section is responsible for defining module repositories and providing the list of modules to be installed in order.

```
modules:
    repositories:
        # Add local modules located next to the image descriptor
        # These modules are specific to the image we build and are not meant
        # to be shared
        - path: modules

        # Add a shared module repository located on GitHub. This repository
        # can contain several modules.
        - git:
            url: https://github.com/cekit/example-common-module.git
            ref: master

    # Install selected modules (in order)
    install:
        - name: jdk8
        - name: user
        - name: tomcat
```

Module repositories

Key `repositories`

Required No

Module repositories specify location of modules that are to be incorporated into the image. These repositories may be `git` repositories or directories on the local file system (`path`). CEKit will scan the repositories for `module.xml` files, which are used to encapsulate image details that may be incorporated into multiple images.

```
modules:
  repositories:
      # Modules pulled from Java image project on GitHub
    - git:
          url: https://github.com/jboss-container-images/redhat-openjdk-18-openshift-
↪image
          ref: 1.0

      # Modules pulled locally from "custom-modules" directory, collocated with image␣
↪descriptor
    - path: custom-modules
```

Module installation

Key `install`

Required No

The `install` section is used to define what modules should be installed in the image in what order. Name used to specify the module is the `name` field from the module descriptor.

```
modules:
  install:
      - name: xpaas.java
      - name: xpaas.amq.install
```

You can even request specific module version via *version* key as follows:

```
modules:
  install:
      - name: xpaas.java
        version: 1.2-dev
      - name: xpaas.amq.install
```

Run

Key `run`

Required No

The `run` section encapsulates instructions related to launching main process in the container including: `cmd`, `entrypoint`, `user` and `workdir`. All subsections are described later in this paragraph.

Below you can find full example that uses every possible option.

```
run:
    cmd:
        - "argument1"
        - "argument2"
    entrypoint:
        - "/opt/eap/bin/wrapper.sh"
    user: "alice"
    workdir: "/home/jboss"
```

Cmd

Key `cmd`

Required No

Command that should be executed by the container at run time.

```
run:
    cmd:
        - "some cmd"
        - "argument"
```

Entrypoint

Key `entrypoint`

Required No

Entrypoint that should be executed by the container at run time.

```
run:
    entrypoint:
        - "/opt/eap/bin/wrapper.sh"
```

User

Key `user`

Required No

Specifies the user (can be username or uid) that should be used to launch the main process.

```
run:
    user: "alice"
```

Working directory

Key `workdir`

Required No

Sets the current working directory of the entrypoint process in the container.

```
run:
    workdir: "/home/jboss"
```

Help

Key `help`

Required No

At image build-time CEKit can generate a documentation page about the image. This file is a human-readable conversion of the resulting image descriptor. That is, a descriptor with all overrides and modules combined together, which was used to build the image.

If an image help page is requested to be added to the image (by setting the `add` key), a `help.md` is generated and added to the **root of the image**.

By default image help pages are not generated.

The default help template is supplied within CEKit. You can override it for every image via image definition. The optional help sub-section can define defines a single key `template`, which can be used to define a filename to use for generating image documentation at build time.

The template is interpreted by the Jinja2 template engine. For a concrete example, see the default help.jinja supplied in the CEKit source code.

```
help:
  add: true
  template: my_help.md
```

6.4.3 Overrides descriptor

Overrides descriptors are used to modify on the fly *image descriptors*.

Contents

Name

Key `name`

Required Yes

Image name without the registry part.

Example

```
name: "jboss-eap-7/eap70-openshift"
```

Version

Key `version`

Required Yes

Version of the image.

```
version: "1.4"
```

Description

Key `description`

Required No

Short summary of the image.

Value of the `description` key is added to the image as two labels:

1. `description`, and
2. `summary`.

Note: These labels are not added is these are already defined in the *labels* section.

```
description: "Red Hat JBoss Enterprise Application 7.0 - An application platform for␣
↪hosting your apps that provides an innovative modular, cloud-ready architecture,␣
↪powerful management and automation, and world class developer productivity."
```

From

Key `from`

Required Yes

Base image of your image.

```
from: "jboss-eap-7/eap70:1.2"
```

Environment variables

Key `envs`

Required No

Similar to *labels* – we can specify environment variables that should be present in the container after running the image. We provide `envs` section for this.

Environment variables can be divided into two types:

1. **Information environment variables**

   These are set and available in the image. This type of environment variables provide information to the image consumer. In most cases such environment variables *should not* be modified.

2. **Configuration environment variables**

   This type of variables are used to define environment variables used to configure services inside running container.

These environment variables are **not** set during image build time but *can* be set at run time.

Every configuration enviromnent variable should provide an example usage (`example`) and short description (`description`).

Please note that you could have an environment variable with both: a `value` and `example` set. This suggest that this environment variable could be redefined.

Note: Configuration environment variables (without `value`) are not generated to the build source. These can be used instead as a source for generating documentation.

```
envs:
    # Configuration env variables below
    # These will be added to container
    - name: "STI_BUILDER"
      value: "jee"
    - name: "JBOSS_MODULES_SYSTEM_PKGS"
      value: "org.jboss.logmanager,jdk.nashorn.api"

    # Information env variables below
    # These will NOT be defined (there is no value)
    - name: "OPENSHIFT_KUBE_PING_NAMESPACE"
      example: "myproject"
      description: "Clustering project namespace."
    - name: "OPENSHIFT_KUBE_PING_LABELS"
      example: "application=eap-app"
      description: "Clustering labels selector."
```

Labels

Key `labels`

Required No

Note: Learn more about standard labels in container images.

Every image can include labels. CEKit makes it easy to do so with the `labels` section.

```
labels:
    - name: "io.k8s.description"
      value: "Platform for building and running JavaEE applications on JBoss EAP 7.0"
    - name: "io.k8s.display-name"
      value: "JBoss EAP 7.0"
```

Artifacts

It's common for images to require external artifacts like jar files, installers, etc. In most cases you will want to add some files into the image and use them during image build process.

Artifacts section is meant exactly for this. CEKit will try to *automatically* fetch any artifacts specified in this section.

If for some reason automatic fetching of artifacts is not an option for you, you should define artifacts as plain artifacts and use the `cekit-cache` command to add the artifact to local cache, making it available for the build process automatically. See *Artifact caching* chapter.

Artifact features

Checksums Almost all artifacts will be checked for consistency by computing checksum of the fetched file and comparing it with the desired value. Currently supported algorithms are: `md5`, `sha1`, `sha256` and `sha512`.

You can define multiple checksums for a single artifact. All specified checksums will be validated.

If no algorithm is provided, artifacts will be fetched **every time**.

This can be useful when building images with snapshot content. In this case you are not concerned about the consistency but rather focusing on rapid development. We advice that you define checksum when your content becomes stable.

Caching All artifacts are automatically cached during an image build. To learn more about caching please take a look at *Artifact caching* chapter.

Common artifact keys

`name` Used to define unique identifier of the artifact.

The `name` key is very important. It's role is to provide a unique identifier for the artifact. If it's not provided, it will be computed from the resource definition, but we **strongly suggest** to provide the `name` keys always.

Value of this key does not need to be a filename, because it's just an identifier used to refer the artifact. Using meaningful and unique identifiers is important in case when you want to use *Overrides*. It will make it much easier to refer the artifact and thus override it.

target The output name for fetched resources will match the `target` attribute. If it is not defined then base name of the `name` attribute will be used. If it's not provided either then base name of the path/URL will be used.

Below you can find a few examples.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
      target: jboss-eap.zip
```

Target file name: `jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
      path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-distribution`.

```
artifacts:
    - path: jboss-eap-6.4.0.zip
```

Target file name: `jboss-eap-6.4.0.zip`.

dest The `dest` key defines the destination directory where the particular artifact will be placed within the container image. By default it is set to `/tmp/artifacts/`.

The `dest` key specifies the **directory** path, to control **file name**, use `target` key as explained above. In order to get maximum control over the target artifact naming, you should use both `dest` and `target` together.

Examples:

```
artifacts:
    - name: jboss-eap-distribution
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
```

Target file path is: `/tmp/artifacts/jboss-eap.zip`.

```
artifacts:
    - name: jboss-eap-distribution
        path: jboss-eap-6.4.0.zip
        target: jboss-eap.zip
        dest: /opt
```

Target file path is: `/opt/jboss-eap.zip`.

Note: The default temporary directory (`/tmp/artifacts/`) will be cleaned up automatically after the build process is done meaning that artifacts are available only at the build time.

Artifacts using custom `dest` values are not affected.

---

description Describes the artifact. This is an optional key that can be used to add more information about the artifact.

Adding description to artifacts makes it much easier to understand what artifact it is just by looking at the image/module descriptor.

```
artifacts:
  - path: jboss-eap-6.4.0.zip
    md5: 9a5d37631919a111ddf42ceda1a9f0b5
    description: "Red Hat JBoss EAP 6.4.0 distribution available on Customer␣
↪Portal: https://access.redhat.com/jbossnetwork/restricted/softwareDetail.html?
↪softwareId=37393&product=appplatform&version=6.4&downloadType=distributions"
```

If CEKit is not able to download an artifact and this artifact has a `description` defined – the build will fail but a message with the description will be printed together with information on where to place the manually downloaded artifact so that the build could be resumed.

Artifact types

CEKit supports following artifact types:

- Plain artifacts
- URL artifacts
- Path artifacts
- Image source artifacts

Plain artifacts

This is an abstract way of defining artifacts. The only required keys are `name` and the `md5` checksum. This type of artifacts is used to define artifacts that are not available publicly and instead provided by some (internal) systems.

Listing 36: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "required": true,
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
```

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```
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Listing 37: Examples

```
artifacts:
    - name: jolokia
      md5: 75e5b5ba0b804cd9def9f20a70af649f
      target: jolokia.tar.gz
```

As you can see, the definition does not define from where the artifact should be fetched. This approach relies on *Artifact caching* to provide the artifact.

Note: See *Red Hat environment* for description how plain artifacts are used in the Red Hat environment.

URL artifacts

This is the simplest way of defining artifacts. You need to provide the `url` key which is the URL from where the artifact should be fetched from.

Listing 38: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "sha1": {
```

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```
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        },
        "url": {
            "desc": "URL where the resource can be found",
            "required": true,
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the downloaded artifact is correct.

Listing 39: Examples

```
artifacts:
    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # The md5 checksum of the artifact
      md5: "75e5b5ba0b804cd9def9f20a70af649f"

    - name: "jolokia"
      url: "https://github.com/rhuss/jolokia/releases/download/v1.3.6/jolokia-1.3.6-
↪bin.tar.gz"
      # Free text description of the artifact
      description: "Library required to access server data via JMX"
      md5: "75e5b5ba0b804cd9def9f20a70af649f"
      # Final name of the downloaded artifact
      target: "jolokia.tar.gz"
```

Path artifacts

This way of defining artifacts is mostly used in development *overrides* and enables you to inject artifacts from a local filesystem.

Listing 40: Schema

```
{
    "map": {
```

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```
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "md5": {
            "desc": "The md5 checksum of the resource",
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Relative (suggested) or absolute path to the resource",
            "required": true,
            "type": "str"
        },
        "sha1": {
            "desc": "The sha1 checksum of the resource",
            "type": "str"
        },
        "sha256": {
            "desc": "The sha256 checksum of the resource",
            "type": "str"
        },
        "sha512": {
            "desc": "The sha512 checksum of the resource",
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Tip: You should always specify at least one checksum to make sure the artifact is correct.

Listing 41: Examples

```
artifacts:
    - name: jolokia-1.3.6-bin.tar.gz
      path: local-artifacts/jolokia-1.3.6-bin.tar.gz
      md5: 75e5b5ba0b804cd9def9f20a70af649f
```

Note: If you are using relative `path` to define an artifact, path is considered relative to an image descriptor which introduced that artifact.

Example If an artifact is defined inside `/foo/bar/image.yaml` with a path: `baz/1.zip` the artifact will be

resolved as `/foo/bar/baz/1.zip`

Image source artifacts

Image source artifacts are used in *multi-stage builds*. With image source artifacts you can define files built in previous stages of the multi-stage builds.

Listing 42: Schema

```
{
    "map": {
        "description": {
            "desc": "Description of the resource",
            "type": "str"
        },
        "dest": {
            "default": "/tmp/artifacts/",
            "desc": "Destination directory inside of the container",
            "type": "str"
        },
        "image": {
            "desc": "Name of the image which holds the resource",
            "required": true,
            "type": "str"
        },
        "name": {
            "desc": "Key used to identify the resource",
            "type": "str"
        },
        "path": {
            "desc": "Path in the image under which the resource can be found",
            "required": true,
            "type": "str"
        },
        "target": {
            "desc": "Target file name for the resource",
            "type": "str"
        }
    }
}
```

Note: Please note that image source artifacts do not allow for defining checksums due to the nature of this type of artifact.

Listing 43: Examples

```
artifacts:
    - name: application
      # Name of the image (stage) from where we will fetch the artifact
      image: builder
      # Path to the artifact within the image
      path: /path/to/application/inside/the/builder/image.jar
```

Packages

Key `packages`

Required No

To install additional packages you can use the `packages` section where you specify package names and repositories to be used, as well as the package manager that is used to manage packages in this image.

Listing 44: Example package section for RPM-based distro

```
packages:
    repositories:
        - name: extras
          id: rhel7-extras-rpm
    manager: dnf
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
        - mysql-connector-java
        - maven
        - hostname
```

Listing 45: Example package section for Alpine Linux

```
packages:
    manager: apk
    install:
        - python3
```

Packages to install

Key `install`

Required No

Packages listed in the `install` section are marked to be installed in the container image.

```
packages:
    install:
        - mongodb24-mongo-java-driver
        - postgresql-jdbc
```

Package manager

Key `manager`

Required No

It is possible to define package manager used in the image used to install packages as part of the build process.

Currently available options are `yum`, `dnf`, `microdnf` and `apk`.

Note: If you do not specify this key the default value is `yum`. If your image requires different package manager you need to specify it.

The default `yum` value will work fine on Fedora and RHEL images because OS maintains a symlink to the proper package manager.

```
packages:
    manager: dnf
    install:
        - git
```

Package repositories

Key `repositories`

Required No

Warning: Some package repositories are supported only on specific distributions and package manager combinations. Please refer to documentation below!

CEKit uses all repositories configured inside the image. You can also specify additional repositories using repositories subsection. CEKit currently supports following ways of defining additional repositories:

- *Plain repository*
- *RPM repository*
- *URL repository*
- *Content sets*

Tip: See *repository guidelines guide* to learn about best practices for repository definitions.

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
        - name: extras
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

Plain repository

Note: Available only on RPM-based distributions.

With this approach you specify repository `id` and CEKit will not perform any action and expect the repository definition exists inside the image. This is useful as a hint which repository must be present for particular image to be buildable. The definition can be overridden by your preferred way of injecting repositories inside the image.

```
packages:
    repositories:
        - name: extras
```

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```
          id: rhel7-extras-rpm
          description: "Repository containing extras RHEL7 extras packages"
```

RPM repository

Note: Available only on RPM-based distributions.

This ways is using repository configuration files and related keys packaged as an RPM.

Example: To enable CentOS SCL inside the image you should define repository in a following way:

```
packages:
    repositories:
        - name: scl
          rpm: centos-release-scl
```

Tip: The `rpm` key can also specify a URL to a RPM file:

```
packages:
    repositories:
        - name: epel
          rpm: https://dl.fedoraproject.org/pub/epel/epel-release-latest-7.noarch.rpm
```

URL repository

Note: Available only on RPM-based distributions.

This approach enables you to download a yum repository file and corresponding GPG key. To do it, define repositories section in a way of:

```
packages:
    repositories:
        - name: foo
          url:
            repository: https://web.example/foo.repo
```

Content sets

Note: Available only on RPM-based distributions.

Content sets are tightly integrated to OSBS style of defining repositories in `content_sets.yml` file. If this kind of repository is present in the image descriptor it overrides all other repositories types. For local Docker based build these repositories are ignored similarly to Plain repository types and we expect repository definitions to be available inside image. See upstream docs for more details about content sets.

Note: Behavior of Content sets repositories is changed when running in *Red Hat Environment*.

There are two possibilities how to define Content sets type of repository:

Embedded content sets

In this approach content sets are embedded inside image descriptor under the `content_sets` key.

```
packages:
    content_sets:
        x86_64:
        - server-rpms
        - server-extras-rpms
```

Linked content sets

In this approach Contet sets file is linked from a separate yaml file next to image descriptor via `content_sets_file` key.

Image descriptor:

```
packages:
    content_sets_file: content_sets.yml
```

`content_sets.yml` located next to image descriptor:

```
x86_64:
  - server-rpms
  - server-extras-rpms
```

Ports

Key `ports`

Required No

This section is used to mark which ports should be exposed in the container. If we want to highlight a port used in the container, but not necessary expose it – we should set the `expose` flag to `false` (`true` by default).

You can provide additional documentation as to the usage of the port with the keys `protocol`, to specify which IP protocol is used over the port number (e.g TCP, UDP...) and `service` to describe what network service is running on top of the port (e.g. "http", "https"). You can provide a human-readable long form description of the port with the `description` key.

```
ports:
    - value: 8443
      service: https
    - value: 8778
      expose: false
      protocol: tcp
      description: internal port for communication.
```

Volumes

Key `volumes`

Required No

In case you want to define volumes for your image, just use the `volumes` section!

```
volumes:
    - name: "volume.eap"
      path: "/opt/eap/standalone"
```

Note: The `name` key is optional. If not specified the value of `path` key will be used.

Modules

Key `modules`

Required No

The modules section is responsible for defining module repositories and providing the list of modules to be installed in order.

```
modules:
    repositories:
        # Add local modules located next to the image descriptor
        # These modules are specific to the image we build and are not meant
        # to be shared
        - path: modules

        # Add a shared module repository located on GitHub. This repository
        # can contain several modules.
        - git:
            url: https://github.com/cekit/example-common-module.git
            ref: master

    # Install selected modules (in order)
    install:
        - name: jdk8
        - name: user
        - name: tomcat
```

Module repositories

Key `repositories`

Required No

Module repositories specify location of modules that are to be incorporated into the image. These repositories may be `git` repositories or directories on the local file system (`path`). CEKit will scan the repositories for `module.xml` files, which are used to encapsulate image details that may be incorporated into multiple images.

```
modules:
  repositories:
```

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```
    # Modules pulled from Java image project on GitHub
  - git:
      url: https://github.com/jboss-container-images/redhat-openjdk-18-openshift-
↪image
      ref: 1.0

    # Modules pulled locally from "custom-modules" directory, collocated with image␣
↪descriptor
  - path: custom-modules
```

Module installation

Key `install`

Required No

The `install` section is used to define what modules should be installed in the image in what order. Name used to specify the module is the `name` field from the module descriptor.

```
modules:
  install:
    - name: xpaas.java
    - name: xpaas.amq.install
```

You can even request specific module version via *version* key as follows:

```
modules:
  install:
    - name: xpaas.java
      version: 1.2-dev
    - name: xpaas.amq.install
```

Run

Key `run`

Required No

The `run` section encapsulates instructions related to launching main process in the container including: `cmd`, `entrypoint`, `user` and `workdir`. All subsections are described later in this paragraph.

Below you can find full example that uses every possible option.

```
run:
  cmd:
    - "argument1"
    - "argument2"
  entrypoint:
    - "/opt/eap/bin/wrapper.sh"
  user: "alice"
  workdir: "/home/jboss"
```

Cmd

Key `cmd`

Required No

Command that should be executed by the container at run time.

```
run:
    cmd:
        - "some cmd"
        - "argument"
```

Entrypoint

Key `entrypoint`

Required No

Entrypoint that should be executed by the container at run time.

```
run:
    entrypoint:
        - "/opt/eap/bin/wrapper.sh"
```

User

Key `user`

Required No

Specifies the user (can be username or uid) that should be used to launch the main process.

```
run:
    user: "alice"
```

Working directory

Key `workdir`

Required No

Sets the current working directory of the entrypoint process in the container.

```
run:
    workdir: "/home/jboss"
```

Help

Key `help`

Required No

At image build-time CEKit can generate a documentation page about the image. This file is a human-readable conversion of the resulting image descriptor. That is, a descriptor with all overrides and modules combined together, which was used to build the image.

If an image help page is requested to be added to the image (by setting the `add` key), a `help.md` is generated and added to the **root of the image**.

By default image help pages are not generated.

The default help template is supplied within CEKit. You can override it for every image via image definition. The optional help sub-section can define defines a single key `template`, which can be used to define a filename to use for generating image documentation at build time.

The template is interpreted by the Jinja2 template engine. For a concrete example, see the default help.jinja supplied in the CEKit source code.

```
help:
  add: true
  template: my_help.md
```

OSBS

Key `osbs`

Required No

This section represents object we use to hint OSBS builder with a configuration which needs to be tweaked for successful and reproducible builds.

It contains two main keys:

- *repository*
- *configuration*

```
osbs:
    repository:
        name: containers/redhat-openjdk-18
        branch: jb-openjdk-1.8-openshift-rhel-7
    configuration:
        container:
            compose:
                pulp_repos: true
```

OSBS extra directory

Key `extra_dir`

Required No

If a directory name specified by `extra_dir` key will be found next to the image descriptor, the contents of this directory will be copied into the target directory and later to the dist-git directory.

Symbolic links are preserved (not followed).

Copying files is done before generation, which means that files from the extra directory can be overridden in the *generation phase* .

Note: If you do not specify this key in image descriptor, the default value of `osbs_extra` will be used.

```
osbs:
    extra_dir: custom-files
```

OSBS repository

Key `repository`

Required No

This key serves as a hint which DistGit repository and its branch we use to push generated sources into.

```
osbs:
    repository:
        name: containers/redhat-openjdk-18
        branch: jb-openjdk-1.8-openshift-rhel-7
```

OSBS Koji target

Key `koji_target`

Required No

To execute a build in OSBS the Koji target parameter needs to be provided. By default it is constructed based on the branch name (see above), like this:

In most cases this is what is expected, but sometimes you want to change this. An example of such situation is when you use a custom, private branch to execute a scratch build. Target can be overridden by specifying the `koji_target` key.

```
osbs:
    koji_target: rhaos-middleware-rhel-7-containers-candidate
```

OSBS configuration

Key `configuration`

Required No

This key is holding OSBS `container.yaml` file. See OSBS docs for more information about this file.

CEKit supports two ways of defining content of the `container.yaml` file:

1. It can be embedded in `container` key, or
2. It can be injected from a file specified in `container_file` key.

Selecting preferred way of defining this configuration is up to the user. Maintaining external file may be handy in case where it is shared across multiple images in the same repository.

Embedding In this case whole `container.yaml` file is embedded in an image descriptor under the `container` key.

```
# Embedding
osbs:
    configuration:
        # Configuration is embedded directly in the container key below
        container:
            compose:
                pulp_repos: true
```

Linking In this case `container.yaml` file is read from a file located next to the image descriptor using the `container_file` key to point to the file.

```
osbs:
    configuration:
        # Configuration is available in the container.yaml file
        container_file: container.yaml
```

and `container.yaml` file content:

```
compose:
    pulp_repos: true
```

6.5 Contribution guide

We're excited to see your contributions!

We welcome any kind of contributions to the project; documentation, code or simply issue reports. **Everything matters**!

This guide will help you understand basics of how we work on CEKit which will help you create high quality contributions.

Thank you for being part of the project!

6.5.1 Submitting issues

Our main issue tracker can be found here: https://github.com/cekit/cekit/issues. This is the best place to report any issues with CEKit. Usually we divide tickets into two categories:

1. Bug reports
2. Enhancements

To make it much easier for you to submit a ticket we created templates for you: https://github.com/cekit/cekit/issues/new/choose. Of course if you have non-standard request, feel free to open a regular issue here: https://github.com/cekit/cekit/issues/new.

Note: We strongly suggest using our templates, because it tries to formalize a bit the reporting process which helps us review new tickets.

Labels

We use labels to categorize issues.

Each ticket has assigned three label categories:

- `type/`
- `priority/`
- `complexity/`

There can be other labels assigned of course too!

Labels are set by the template or by CEKit team members. Initial labels (after a ticket is created) are assigned after triage which is done ad-hoc by CEKit team members.

Milestones

We use milestones to group images that should go to a particular release. Assigning a milestone to a ticket does not mean that it will be fixed in that particular milestone. This is mostly a hint for developer (and the reported) what is the proposed milestone.

Tickets can be moved to different milestones at any time.

Boards

To have a better overview on the release we use boards (aka GitHub projects). Some of them are long-living, but some of them are targeting specific milestone. Usually we use Kanban-style boards.

6.5.2 Setting up environment

We strongly advise to use Virtualenv to develop CEKit. Please consult your package manager for the correct package name. Currently within Fedora 29 all the required packages are available as RPMs. A sample set of Ansible scripts that provide all pre-requistites for development are available here.

- If you are running inside the Red Hat infrastructure then `rhpkg` must be installed as well.

To create custom Python virtual environment please run following commands on your system:

```
# Prepare virtual environment
virtualenv ~/cekit
source ~/cekit/bin/activate

# Install as development version
pip install -e <cekit directory>

# Now you are able to run CEKit
cekit --help
```

It is possible to ask virtualenv to inherit pre-installed system packages thereby reducing the virtualenv to a delta between what is installed and what is required. This is achived by using the flag `--system-site-packages` (See here for further information).

Note: Every time you want to use CEKit you must activate CEKit Python virtual environment by executing `source ~/cekit/bin/activate`

For those using ZSH a useful addition is Zsh-Autoswitch-VirtualEnv the use of which avoids the labour of manually creating the virtualenv and activating it each time ; simply run `mkvenv --system-site-packages` initially and then it is handled automatically then on.

6.5.3 Code style

In case you contribute code, we generally ask for following the code style we are using already. This is a general Python style, with 4 spaces as the delimiter, nothing groundbreaking here :)

Formatting

For code formatting we use Flake8. You can find a `.flake8` configuration file in the root directory.

Linting

Additionally we check for code errors with Pylint. We provide a `.pylintrc` file in the root directory which defines differences from the default Pylint configuration. Your IDE may help with linting your code too!

Logging

Python supports a number of different logging patterns - for more information see Pyformat and Formatting python log messages. We request that the new format style is followed e.g.

```
logger.info("Fetching common steps from '{}'.".format(url))
```

6.5.4 Submitting changes

First of all; **thank you** for taking the effort to modify the code yourself and submitting your work so others can benefit from it!

Target branch

All development is done in the `develop` branch. This branch is what will the next major or minor CEKit release look like and this is the place you should submit your changes.

Note: Submitting a pull request against the `master` branch may result in a request to rebase it against `develop`.

In case a fix needs to target the currently released version (a bugfix), the commit will be manually cherry-picked by the CEKit team.

Review process

Each submitted pull request is reviewed by at least one CEKit team member. We may ask you for some changes in the code or

Tests

We expect that each pull request contains a test for the change. It's unlikely that a PR will be merged without a test, sorry!

Of course, if the PR is not about code change, but for example a documentation update, you don't need to write a test for it :)

GitHub automation

Please reference the issue in the PR to utilise GitHubs ability to automatically close issues. You can add e.g. `Fixes #nnn` somewhere in the initial comment.

6.5.5 Running tests

To run the tests it is recommended to use `tox`. To run a single function from a single test on a single version of python the following command may be used:

```
$ tox -e py37 -- tests/test_validate.py::test_simple_image_build
```

Or, using pytest directly:

```
$ pytest tests/test_validate.py::test_image_test_with_multiple_overrides
```

6.5.6 Contributing to documentation

We use the reStructuredText format to write our documentation because this is the de-facto standard for Python documentation. We use Sphinx tool to generate documentation from reStructuredText files.

Published documentation lives on Read the Docs: https://cekit.readthedocs.io/

reStructuredText

A good guide to this format is available in the Sphinx documentation.

Local development

Note: The documentation has its own `requirements.txt`. As above we would recommend using Virtualenv to use a clean development environment. The Ansible scripts above will install all documentation pre-requisites as well.

Support for auto generating documentation is avialable for local development. Run the command below.

```
make preview
```

Afterwards you can see generated documentation at http://127.0.0.1:8000. When you edit any file, documentation will be regenerated and immediately available in your browser.

Guidelines

Below you can find a list of conventions used to write CEKit documentation. Reference information on reStructuredText may be found here.

Headers

Because reStructredText does not enforce what characters are used to mark header to be a certain level, we use following guidelines:

```
h1 header
=========

h2 header
---------

h3 header
^^^^^^^^^

h4 header
*********
```

CHAPTER 7

Sponsor

Fig. 1: This is a Red Hat sponsored project.

CHAPTER 8

License

Distributed under the terms of the MIT license.