
netjsonconfig documentation

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1	Setup	3
1.1	Install stable version from pypi	3
1.2	Install development version	3
1.3	Install git fork for contributing	3
2	Basic concepts	5
2.1	NetJSON configuration dictionary	5
2.2	Backend	6
2.3	Schema	7
2.4	Validation	7
2.5	Template	8
2.6	Multiple template inheritance	10
2.7	Context (configuration variables)	12
2.8	Project goals	13
2.9	Support	14
2.10	License	14
3	OpenWRT Backend	15
3.1	Initialization	15
3.2	Render method	16
3.3	Generate method	17
3.4	Write method	18
3.5	Parse method	19
3.6	JSON method	19
3.7	General settings	19
3.8	Network interfaces	20
3.9	Bridge settings	24
3.10	Wireless settings	25
3.11	Radio settings	36
3.12	Static Routes	38
3.13	Policy routing	40
3.14	Programmable switch settings	41
3.15	NTP settings	43
3.16	LED settings	44
3.17	Including custom options	45
3.18	Including custom lists	46
3.19	Including additional files	49

3.20	OpenVPN	50
3.21	All the other settings	51
4	OpenWISP 1.x Backend	53
4.1	Generate method	53
4.2	General settings	53
4.3	Traffic Control	54
5	OpenVPN 2.3 Backend	59
5.1	OpenVPN backend schema	60
5.2	Working around schema limitations	62
5.3	Automatic generation of clients	62
6	Create your backend	65
7	Command line utility	69
7.1	Environment variables	70
8	Running tests	73
8.1	Using runtests.py	73
8.2	Using nose2	73
9	Contributing	75
9.1	Reach out before you start	75
9.2	Create a virtual environment	76
9.3	Fork repo and install your fork	76
9.4	Ensure test coverage does not decrease	76
9.5	Follow style conventions (PEP8, isort)	76
9.6	Update the documentation	77
9.7	Send pull request	77
10	Motivations and Goals	79
10.1	Motivations	79
10.2	Goals	79
11	Change log	81
11.1	Version 0.7.0 [2020-01-14]	81
11.2	Version 0.6.4 [2019-12-09]	81
11.3	Version 0.6.3 [2018-07-09]	81
11.4	Version 0.6.2 [2017-08-29]	82
11.5	Version 0.6.1 [2017-07-05]	82
11.6	Version 0.6.0 [2017-06-01]	82
11.7	Version 0.5.6 [2017-05-24]	82
11.8	Version 0.5.5.post1 [2017-04-18]	82
11.9	Version 0.5.5 [2017-03-15]	83
11.10	Version 0.5.4.post1 [2017-03-07]	83
11.11	Version 0.5.4 [2017-02-14]	83
11.12	Version 0.5.3 [2017-01-17]	83
11.13	Version 0.5.2 [2016-12-29]	83
11.14	Version 0.5.1 [2016-09-22]	83
11.15	Version 0.5.0 [2016-09-19]	83
11.16	Version 0.4.5 [2016-09-05]	84
11.17	Version 0.4.4 [2016-06-27]	84
11.18	Version 0.4.3 [2016-04-23]	84
11.19	Version 0.4.2 [2016-04-11]	84

11.20 Version 0.4.1 [2016-04-04]	84
11.21 Version 0.4.0 [2016-03-22]	85
11.22 Version 0.3.7 [2016-02-19]	86
11.23 Version 0.3.6 [2016-02-17]	86
11.24 Version 0.3.5 [2016-02-10]	86
11.25 Version 0.3.4 [2016-01-14]	86
11.26 Version 0.3.3 [2015-12-18]	87
11.27 Version 0.3.2 [2015-12-11]	87
11.28 Version 0.3.1 [2015-12-02]	87
11.29 Version 0.3 [2015-11-30]	87
11.30 Version 0.2 [2015-11-23]	87
11.31 Version 0.1 [2015-10-20]	88
12 Indices and tables	89
Index	91

Netjsonconfig is part of the [OpenWISP project](#) and it's the official configuration engine of [OpenWISP 2](#).

netjsonconfig is a python library that converts [NetJSON DeviceConfiguration](#) objects into real router configurations that can be installed on systems like [OpenWRT](#), [LEDE](#) or [OpenWisp Firmware](#).

Its main features are:

- [OpenWRT / LEDE](#) support
- [OpenWisp Firmware](#) support
- [OpenVPN](#) support
- Plugin interface for external backends, support more firmwares with an external package
 - *Create your backend* as a plugin
 - Experimental [AirOS support](#) as a plugin
- Based on the [NetJSON RFC](#)
- **Validation** based on [JSON-Schema](#)
- **Templates**: store common configurations in templates
- **Multiple template inheritance**: reduce repetition to the minimum
- **File inclusion**: easy inclusion of arbitrary files in configuration packages
- **Variables**: reference variables in the configuration
- **Command line utility**: easy to use from shell scripts or from other programming languages

Contents:

1.1 Install stable version from pypi

The easiest way to install *netjsonconfig* is via the [python package index](#):

```
pip install netjsonconfig
```

1.2 Install development version

If you need to test the latest development version you can do it in two ways;

The first option is to install a tarball:

```
pip install https://github.com/openwisp/netjsonconfig/tarball/master
```

The second option is to install via pip using git (this will automatically clone the repo and store it on your hard drive):

```
pip install -e git+git://github.com/openwisp/netjsonconfig#egg=netjsonconfig
```

1.3 Install git fork for contributing

If you want to contribute see [Fork repo and install your fork](#).

CHAPTER 2

Basic concepts

Before starting, let's quickly introduce the main concepts used in `netjsonconfig`:

- *NetJSON configuration dictionary*: python dictionary representing the configuration of a router
- *Backend*: python class used to convert the *configuration dictionary* to the format used natively by a router firmware and vice versa
- *Schema*: each backend has a *JSON-Schema* which defines the useful configuration options that the backend is able to process
- *Validation*: the configuration is validated against its JSON-Schema before being processed by the backend
- *Template*: common configuration options shared among routers (eg: VPNs, SSID) which can be passed to backends
- *Multiple template inheritance*: possibility to inherit common configuration options from more than one template
- *Context (configuration variables)*: variables that can be referenced from the *configuration dictionary*

2.1 NetJSON configuration dictionary

`netjsonconfig` is an implementation of the *NetJSON* format, more specifically the *DeviceConfiguration* object, therefore to understand the configuration format that the library uses to generate the final router configurations it is essential to read at least the relevant *DeviceConfiguration* section in the *NetJSON RFC*.

Here it is a simple *NetJSON DeviceConfiguration* object represented with a python dictionary:

```
{
  "type": "DeviceConfiguration",
  "general": {
    "hostname": "RouterA"
  },
  "interfaces": [
    {
      "name": "eth0",
```

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```
        "type": "ethernet",
        "addresses": [
            {
                "address": "192.168.1.1",
                "mask": 24,
                "proto": "static",
                "family": "ipv4"
            }
        ]
    }
]
```

The previous example describes a device named `RouterA` which has a single network interface named `eth0` with a statically assigned ip address `192.168.1.1/24` (CIDR notation).

Because `netjsonconfig` deals only with `DeviceConfiguration` objects, the `type` attribute can be omitted.

The previous configuration object therefore can be shortened to:

```
{
    "general": {
        "hostname": "RouterA"
    },
    "interfaces": [
        {
            "name": "eth0",
            "type": "ethernet",
            "addresses": [
                {
                    "address": "192.168.1.1",
                    "mask": 24,
                    "proto": "static",
                    "family": "ipv4"
                }
            ]
        }
    ]
}
```

From now on we will use the term *configuration dictionary* to refer to *NetJSON DeviceConfiguration* objects.

2.2 Backend

A backend is a python class used to convert the *configuration dictionary* to the format used natively by the router (forward conversion, from NetJSON to native) and vice versa (backward conversion, from native to NetJSON), each supported firmware or operating system will have its own backend and third parties can write their own custom backends.

The current implemented backends are:

- *OpenWrt*
- *OpenWisp* (based on the *OpenWrt* backend)
- *OpenVpn* (custom backend implementing only OpenVPN configuration)

Example initialization of OpenWrt backend:

```
from netjsonconfig import OpenWrt

ipv6_router = OpenWrt({
    "interfaces": [
        {
            "name": "eth0.1",
            "type": "ethernet",
            "addresses": [
                {
                    "address": "fd87::1",
                    "mask": 128,
                    "proto": "static",
                    "family": "ipv6"
                }
            ]
        }
    ]
})
```

Each backend will implement **parsers**, **renderers** and **converters** to accomplish its configuration generation or parsing goals.

The process is best explained with the following diagram:

Converters take care of converting between *NetJSON* and the intermediate data structure (and vice versa).

Renderers take care of rendering the intermediate data structure to the native format.

Parsers perform the opposite operation of **Renderers**: they take care of parsing native format and build the intermediate data structure.

2.3 Schema

Each backend has a JSON-Schema, all the backends have a schema which is derived from the same parent schema, defined in `netjsonconfig.backends.schema` ([view source](#)).

Since different backends may support different features each backend may extend its schema by adding custom definitions.

2.4 Validation

All the backends have a `validate` method which is called automatically before trying to process the configuration.

If the passed configuration violates the schema the `validate` method will raise a `ValidationError`.

An instance of validation error has two public attributes:

- `message`: a human readable message explaining the error
- `details`: a reference to the instance of `jsonschema.exceptions.ValidationError` which contains more details about what has gone wrong; for a complete reference see the [python-jsonschema documentation](#)

You may call the `validate` method in your application arbitrarily, eg: before trying to save the *configuration dictionary* into a database.

2.5 Template

If you have devices with very similar *configuration dictionaries* you can store the shared blocks in one or more reusable templates which will be used as a base to build the final configuration.

2.5.1 Combining different templates

Let's illustrate this with a practical example, we have two devices:

- Router1
- Router2

Both devices have an `eth0` interface in DHCP mode; *Router2* additionally has an `eth1` interface with a statically assigned ipv4 address.

The two routers can be represented with the following code:

```
from netjsonconfig import OpenWrt

router1 = OpenWrt({
    "general": {"hostname": "Router1"}
    "interfaces": [
        {
            "name": "eth0",
            "type": "ethernet",
            "addresses": [
                {
                    "proto": "dhcp",
                    "family": "ipv4"
                }
            ]
        }
    ]
})

router2 = OpenWrt({
    "general": {"hostname": "Router2"},
    "interfaces": [
        {
            "name": "eth0",
            "type": "ethernet",
            "addresses": [
                {
                    "proto": "dhcp",
                    "family": "ipv4"
                }
            ]
        },
        {
            "name": "eth1",
            "type": "ethernet",
            "addresses": [
```

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```

        {
            "address": "192.168.1.1",
            "mask": 24,
            "proto": "static",
            "family": "ipv4"
        }
    ]
}
]
})

```

The two *configuration dictionaries* share the same settings for the `eth0` interface, therefore we can make the `eth0` settings our template and refactor the previous code as follows:

```

from netjsonconfig import OpenWrt

dhcp_template = {
    "interfaces": [
        {
            "name": "eth0",
            "type": "ethernet",
            "addresses": [
                {
                    "proto": "dhcp",
                    "family": "ipv4"
                }
            ]
        }
    ]
}

router1 = OpenWrt(config={"general": {"hostname": "Router1"}},
                  templates=[dhcp_template])

router2_config = {
    "general": {"hostname": "Router2"},
    "interfaces": [
        {
            "name": "eth1",
            "type": "ethernet",
            "addresses": [
                {
                    "address": "192.168.1.1",
                    "mask": 24,
                    "proto": "static",
                    "family": "ipv4"
                }
            ]
        }
    ]
}

router2 = OpenWrt(router2_config, templates=[dhcp_template])

```

2.5.2 Overriding a template

In many occasions you may want to define a general template which can be overridden in some specific occasions.

A common use case is to define a general radio template and override its channel on certain access points:

```
from netjsonconfig import OpenWrt

general_radio_template = {
    "radios": [
        {
            "name": "radio0",
            "phy": "phy0",
            "protocol": "802.11n",
            "driver": "mac80211",
            "channel": 0, # zero means "auto"
            "channel_width": 20,
            "country": "US",
            "disabled": False
        }
    ]
}

specific_radio_config = {
    "radios": [
        {
            "name": "radio0",
            "channel": 10,
        }
    ]
}

router1 = OpenWrt(config=specific_radio_config,
                  templates=[general_radio_template])

print(router1.render())
```

Will generate the following output:

```
package wireless

config wifi-device 'radio0'
    option channel '10'
    option country 'US'
    option disabled '0'
    option htmode 'HT20'
    option hwmode '11g'
    option phy 'phy0'
    option type 'mac80211'
```

2.6 Multiple template inheritance

You might have noticed that the `templates` argument is a list; that's because it's possible to pass multiple templates that will be added one on top of the other to build the resulting *configuration dictionary*, allowing to reduce or even eliminate repetitions.

Note: When using multiple templates, their order is important. Templates that are specified afterwards override the ones that come first.

To understand this, read the section *Multiple overrides*.

2.6.1 Multiple overrides

Here's a more complex example involving multiple overrides:

```
from netjsonconfig import OpenWrt

general_radio_template = {
    "radios": [
        {
            "name": "radio0",
            "phy": "phy0",
            "protocol": "802.11n",
            "driver": "mac80211",
            "channel": 0, # zero means "auto"
            "channel_width": 20,
            "country": "00", # world
            "disabled": False
        }
    ]
}

united_states_radio_template = {
    "radios": [
        {
            "name": "radio0",
            "country": "US"
        }
    ]
}

specific_radio_config = {
    "radios": [
        {
            "name": "radio0",
            "channel": 10,
        }
    ]
}

router1 = OpenWrt(config=specific_radio_config,
                  templates=[general_radio_template,
                             united_states_radio_template])

print(router1.render())
```

Will generate the following output:

```
package wireless

config wifi-device 'radio0'
    option channel '10'
    option country 'US'
    option disabled '0'
    option htmode 'HT20'
```

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```
option hwmode '11g'
option phy 'phy0'
option type 'mac80211'
```

2.6.2 Implementation details

The functions used under the hood to merge configurations and templates are `netjsonconfig.utils.merge_config` and `netjsonconfig.utils.merge_list`:

`netjsonconfig.utils.merge_config(template, config, list_identifiers=None)`

Merges config on top of template.

Conflicting keys are handled in the following way:

- simple values (eg: str, int, float, ecc) in config will overwrite the ones in template
- values of type list in both config and template will be merged using to the `merge_list` function
- values of type dict will be merged recursively

Parameters

- **template** – template dict
- **config** – config dict
- **list_identifiers** – list or None

Returns merged dict

`netjsonconfig.utils.merge_list(list1, list2, identifiers=None)`

Merges list2 on top of list1.

If both lists contain dictionaries which have keys specified in `identifiers` which have equal values, those dicts will be merged (dicts in `list2` will override dicts in `list1`). The remaining elements will be summed in order to create a list which contains elements of both lists.

Parameters

- **list1** – list from template
- **list2** – list from config
- **identifiers** – list or None

Returns merged list

2.7 Context (configuration variables)

Without variables, many bits of configuration cannot be stored in templates, because some parameters are unique to the device, think about things like a *UUID* or a public ip address.

With this feature it is possible to reference variables in the *configuration dictionary*, these variables will be evaluated when the configuration is rendered/generated.

Here's an example from the real world, pay attention to the two variables, `{{ UUID }}` and `{{ KEY }}`:

```

from netjsonconfig import OpenWrt

openwisp_config_template = {
    "openwisp": [
        {
            "config_name": "controller",
            "config_value": "http",
            "url": "http://controller.examplewifiservice.com",
            "interval": "60",
            "verify_ssl": "1",
            "uuid": "{{ UUID }}",
            "key": "{{ KEY }}"
        }
    ]
}

context = {
    'UUID': '9d9032b2-da18-4d47-a414-1f7f605479e6',
    'KEY': 'xk7OzAlqN6h1Ggxy8UH5NI8kQnbuLxsE'
}

router1 = OpenWrt(config={"general": {"hostname": "Router1"}},
                  templates=[openwisp_config_template],
                  context=context)

```

Let's see the result with:

```

>>> print(router1.render())
package system

config system
    option hostname 'Router1'
    option timezone 'UTC'
    option zonename 'UTC'

package openwisp

config controller 'http'
    option interval '60'
    option key 'xk7OzAlqN6h1Ggxy8UH5NI8kQnbuLxsE'
    option url 'http://controller.examplewifiservice.com'
    option uuid '9d9032b2-da18-4d47-a414-1f7f605479e6'
    option verify_ssl '1'

```

Warning: When using variables, keep in mind the following rules:

- variables must be written in the form of `{{ var_name }}` or `{{var_name}}`;
- variable names can contain only alphanumeric characters and underscores;
- unrecognized variables will be ignored;

2.8 Project goals

If you are interested in this topic you can read more about the *Goals and Motivations* of this project.

2.9 Support

See [OpenWISP Support Channels](#).

2.10 License

This software is licensed under the terms of the GPLv3 license, for more information, please see full [LICENSE](#) file.

The `OpenWrt` backend allows to generate OpenWRT compatible configurations.

Note: This backend purposely generates only named UCI blocks.

UCI stands for [Unified Configuration Interface](#) and it is the default configuration system installed on [OpenWRT](#) and its fork [LEDE](#).

3.1 Initialization

`OpenWrt.__init__(config=None, native=None, templates=None, context=None)`

Parameters

- **config** – dict containing a valid **NetJSON** configuration dictionary
- **native** – str or file object representing a native configuration that will be parsed and converted to a **NetJSON** configuration dictionary
- **templates** – list containing **NetJSON** configuration dictionaries that will be used as a base for the main config
- **context** – dict containing configuration variables

Raises `TypeError` – raised if `config` is not of type `dict` or if `templates` is not of type `list`

If you are unsure about the meaning of the initialization parameters, read about the following basic concepts:

- *NetJSON configuration dictionary*
- *Backend*
- *Template*
- *Context (configuration variables)*

Initialization example (forward conversion):

```
from netjsonconfig import OpenWrt

router = OpenWrt({
    "general": {
        "hostname": "HomeRouter"
    }
})
```

Initialization example (backward conversion):

```
from netjsonconfig import OpenWrt

router = OpenWrt(native=open('./openwrt-config.tar.gz'))
```

3.2 Render method

`OpenWrt.render(files=True)`

Converts the configuration dictionary into the corresponding configuration format

Parameters `files` – whether to include “additional files” in the output or not; defaults to `True`

Returns string with output

Code example:

```
from netjsonconfig import OpenWrt

o = OpenWrt({
    "interfaces": [
        {
            "name": "eth0.1",
            "type": "ethernet",
            "addresses": [
                {
                    "address": "192.168.1.2",
                    "gateway": "192.168.1.1",
                    "mask": 24,
                    "proto": "static",
                    "family": "ipv4"
                },
                {
                    "address": "192.168.2.1",
                    "mask": 24,
                    "proto": "static",
                    "family": "ipv4"
                },
                {
                    "address": "fd87::2",
                    "gateway": "fd87::1",
                    "mask": 64,
                    "proto": "static",
                    "family": "ipv6"
                }
            ]
        }
    ]
})
```

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```

    }
  ]
})
print(o.render())

```

Will return the following output:

```

package network

config interface 'eth0_1'
    option gateway '192.168.1.1'
    option ifname 'eth0.1'
    option ip6addr 'fd87::2/64'
    option ip6gw 'fd87::1'
    list ipaddr '192.168.1.2/24'
    list ipaddr '192.168.2.1/24'
    option proto 'static'

```

3.3 Generate method

`OpenWrt.generate()`

Returns a `BytesIO` instance representing an in-memory tar.gz archive containing the native router configuration.

Returns in-memory tar.gz archive, instance of `BytesIO`

Example:

```

>>> import tarfile
>>> from netjsonconfig import OpenWrt
>>>
>>> o = OpenWrt({
...     "interfaces": [
...         {
...             "name": "eth0",
...             "type": "ethernet",
...             "addresses": [
...                 {
...                     "proto": "dhcp",
...                     "family": "ipv4"
...                 }
...             ]
...         }
...     ]
... })
>>> stream = o.generate()
>>> print(stream)
<_io.BytesIO object at 0x7fd2287fb410>
>>> tar = tarfile.open(fileobj=stream, mode='r:gz')
>>> print(tar.getmembers())
[<TarInfo 'etc/config/network' at 0x7fd228790250>]

```

As you can see from this example, the `generate` method does not write to disk, but returns an instance of `io.BytesIO` which contains a tar.gz file object with the following file structure:

```
/etc/config/network
```

The configuration archive can then be written to disk, served via HTTP or uploaded directly on the OpenWRT router where it can be finally “restored” with `sysupgrade`:

```
sysupgrade -r <archive>
```

Note that `sysupgrade -r` does not apply the configuration, to do this you have to reload the services manually or reboot the router.

Note: the `generate` method intentionally sets the timestamp of the `tar.gz` archive and its members to 0 in order to facilitate comparing two different archives: setting the timestamp would infact cause the checksum to be different each time even when contents of the archive are identical.

3.4 Write method

`OpenWrt.write(name, path='./')`
Like `generate` but writes to disk.

Parameters

- **name** – file name, the `tar.gz` extension will be added automatically
- **path** – directory where the file will be written to, defaults to `./`

Returns None

Example:

```
>>> import tarfile
>>> from netjsonconfig import OpenWrt
>>>
>>> o = OpenWrt({
...     "interfaces": [
...         {
...             "name": "eth0",
...             "type": "ethernet",
...             "addresses": [
...                 {
...                     "proto": "dhcp",
...                     "family": "ipv4"
...                 }
...             ]
...         }
...     ]
... })
>>> o.write('dhcp-router', path='/tmp/')
```

Will write the configuration archive in `/tmp/dhcp-router.tar.gz`.

3.5 Parse method

`OpenWrt.parse(native)`

Parses a native configuration and converts it to a NetJSON configuration dictionary

This method is automatically called when initializing the backend with the `native` argument:

```
from netjsonconfig import OpenWrt

router = OpenWrt(native=open('./openwrt-config.tar.gz'))
```

The argument passed to `native` can be a string containing a dump obtained via `uci export`, or a file object (real file or `BytesIO` instance) representing a configuration archive in `tar.gz` format typically used in OpenWRT/LEDE.

3.6 JSON method

`OpenWrt.json(validate=True, *args, **kwargs)`

returns a string formatted as **NetJSON DeviceConfiguration**; performs validation before returning output;

`*args` and `*kwargs` will be passed to `json.dumps`;

Returns string

Code example:

```
>>> from netjsonconfig import OpenWrt
>>>
>>> router = OpenWrt({
...     "general": {
...         "hostname": "HomeRouter"
...     }
... })
>>> print(router.json(indent=4))
{
  "type": "DeviceConfiguration",
  "general": {
    "hostname": "HomeRouter"
  }
}
```

3.7 General settings

The general settings reside in the `general` key of the *configuration dictionary*, which follows the [NetJSON General object](#) definition (see the link for the detailed specification).

Currently only the `hostname` option is processed by this backend.

3.7.1 General object extensions

In addition to the default *NetJSON General object options*, the `OpenWrt` backend also supports the following custom options:

key name	type	function
timezone	string	one of the allowed timezone values (first element of each tuple)

3.7.2 General settings example

The following *configuration dictionary*:

```
{
  "general": {
    "hostname": "routerA",
    "timezone": "UTC",
    "ula_prefix": "fd8e:f40a:6701::/48"
  }
}
```

Will be rendered as follows:

```
package system

config system 'system'
    option hostname 'routerA'
    option timezone 'UTC'
    option zonename 'UTC'

package network

config globals 'globals'
    option ula_prefix 'fd8e:f40a:6701::/48'
```

3.8 Network interfaces

The network interface settings reside in the `interfaces` key of the *configuration dictionary*, which must contain a list of [NetJSON interface objects](#) (see the link for the detailed specification).

There are 3 main type of interfaces:

- **network interfaces**: may be of type `ethernet`, `virtual`, `loopback` or `other`
- **wireless interfaces**: must be of type `wireless`
- **bridge interfaces**: must be of type `bridge`

3.8.1 Interface object extensions

In addition to the default *NetJSON Interface object options*, the OpenWrt backend also supports the following custom options for every type of interface:

key name	type	allowed values
network	string	logical interface name (UCI specific)

In the following sections some examples of the most common use cases are shown.

3.8.2 Loopback interface example

The following *configuration dictionary*:

```
{
  "interfaces": [
    {
      "name": "lo",
      "type": "loopback",
      "addresses": [
        {
          "address": "127.0.0.1",
          "mask": 8,
          "proto": "static",
          "family": "ipv4"
        }
      ]
    }
  ]
}
```

Will be rendered as follows:

```
package network

config interface 'lo'
  option ifname 'lo'
  option ipaddr '127.0.0.1'
  option netmask '255.0.0.0'
  option proto 'static'
```

3.8.3 Dualstack (IPv4 & IPv6)

The following *configuration dictionary*:

```
{
  "interfaces": [
    {
      "name": "eth0",
      "type": "ethernet",
      "addresses": [
        {
          "family": "ipv4",
          "proto": "static",
          "address": "10.27.251.1",
          "mask": 24
        },
        {
          "family": "ipv6",
          "proto": "static",
          "address": "fdb4:5f35:e8fd::1",
          "mask": 48
        }
      ]
    }
  ]
}
```

Will be rendered as follows:

```
package network

config interface 'eth0'
    option ifname 'eth0'
    option ip6addr 'fdb4:5f35:e8fd::1/48'
    option ipaddr '10.27.251.1'
    option netmask '255.255.255.0'
    option proto 'static'
```

3.8.4 DNS servers and search domains

DNS servers can be set using `dns_servers`, while search domains can be set using `dns_search`.

If specified, these values will be automatically added in every interface which has at least one static ip address; interfaces which have no ip address configured or are using dynamic ip address configuration won't get the `dns` option in the UCI output, eg:

```
{
  "dns_servers": ["10.11.12.13", "8.8.8.8"],
  "dns_search": ["openwisp.org", "netjson.org"],
  "interfaces": [
    {
      "name": "eth0",
      "type": "ethernet",
      "addresses": [
        {
          "address": "192.168.1.1",
          "mask": 24,
          "proto": "static",
          "family": "ipv4"
        }
      ]
    },
    {
      # the following interface has DHCP enabled
      # and it won't contain the dns setting
      {
        "name": "eth1",
        "type": "ethernet",
        "addresses": [
          {
            "proto": "dhcp",
            "family": "ipv4"
          }
        ]
      }
    },
    {
      # the following VLAN interface won't get
      # the dns nor the dns_search settings
      {
        "name": "eth1.31",
        "type": "ethernet"
      }
    }
  ]
}
```

Will return the following UCI output:

```

package network

config interface 'eth0'
    option dns '10.11.12.13 8.8.8.8'
    option dns_search 'openwisp.org netjson.org'
    option ifname 'eth0'
    option ipaddr '192.168.1.1'
    option netmask '255.255.255.0'
    option proto 'static'

config interface 'eth1'
    option dns_search 'openwisp.org netjson.org'
    option ifname 'eth1'
    option proto 'dhcp'

config interface 'eth1_31'
    option ifname 'eth1.31'
    option proto 'none'

```

3.8.5 DHCP ipv6 ethernet interface

The following *configuration dictionary*:

```

{
  "interfaces": [
    {
      "name": "eth0",
      "network": "lan",
      "type": "ethernet",
      "addresses": [
        {
          "proto": "dhcp",
          "family": "ipv6"
        }
      ]
    }
  ]
}

```

Will be rendered as follows:

```

package network

config interface 'lan'
    option ifname 'eth0'
    option proto 'dchp6'

```

3.8.6 Using different protocols

OpenWRT and LEDE support many protocols (pppoe, pppoa, pptp, l2tp, ecc) and the list of supported protocols evolves over time.

OpenWISP and netjsonconfig try to stay out of your way by leaving you maximum flexibility to use any protocol and any configuration option you may need, just set `type` to `other`, then proceed by setting `proto` and any other configuration option according to your needs, see the example below.

PPPoE proto example

The following configuration dictionary:

```
{
  "interfaces": [
    {
      "type": "other",
      "name": "eth0",
      "network": "wan",
      "proto": "pppoe",
      "username": "<username>",
      "password": "<password>"
    }
  ]
}
```

Will be rendered as follows:

```
package network

config interface 'wan'
    option ifname 'eth0'
    option password '<password>'
    option proto 'ppoe'
    option username '<username>'
```

3.9 Bridge settings

Interfaces of type `bridge` can contain a few options that are specific for network bridges:

- `bridge_members`: interfaces that are members of the bridge
- `stp`: spanning tree protocol

The OpenWrt backend NetJSON extensions for bridge interfaces:

key name	type	default	allowed values
<code>igmp_snooping</code>	boolean	True	sets the <code>multicast_snooping</code> kernel setting for a bridge

3.9.1 Bridge interface example

The following *configuration dictionary*:

```
{
  "interfaces": [
    {
      "name": "eth0.1",
      "network": "lan",
      "type": "ethernet"
    },
    {
      "name": "eth0.2",
      "network": "wan",
```

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```

        "type": "ethernet"
    },
    {
        "name": "lan_bridge", # will be named "br-lan_bridge" by OpenWRT
        "type": "bridge",
        "stp": True, # enable spanning tree protocol
        "igmp_snooping": True, # enable igmp snooping
        "bridge_members": [
            "eth0.1",
            "eth0.2"
        ],
        "addresses": [
            {
                "address": "172.17.0.2",
                "mask": 24,
                "proto": "static",
                "family": "ipv4"
            }
        ]
    }
]
}

```

Will be rendered as follows:

```

package network

config interface 'lan'
    option ifname 'eth0.1'
    option proto 'none'

config interface 'wan'
    option ifname 'eth0.2'
    option proto 'none'

config interface 'lan_bridge'
    option ifname 'eth0.1 eth0.2'
    option igmp_snooping '1'
    option ipaddr '172.17.0.2'
    option netmask '255.255.255.0'
    option proto 'static'
    option stp '1'
    option type 'bridge'

```

3.10 Wireless settings

Interfaces of type wireless may contain a lot of different combination of settings to configure wireless connectivity: from simple access points, to 802.1x authentication, 802.11s mesh networks, adhoc mesh networks, WDS repeaters and much more.

The OpenWrt backend NetJSON extensions for wireless interfaces:

key name	type	default	allowed values
network	array	[]	attached networks; if left blank will be automatically determined

Some extensions are applicable only when mode is `access_point`:

key name	type	default	allowed values
wmm	boolean	True	enables WMM (802.11e) support
isolate	boolean	False	isolate wireless clients from one another
macfilter	string	disable	ACL policy, accepts: “disable”, “allow” and “deny”
maclist	array	[]	mac addresses filtered according to macfilter policy

These extensions must be used the `wireless` object of a wireless interface eg:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "myWiFi",
        # OpenWrt backend NetJSON extensions
        "wmm": True,
        "isolate": True
      }
    }
  ]
}
```

The same applies for custom configuration options not included in the OpenWrt backend schema:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "myWiFi",
        # custom configuration options not defined
        # in the OpenWrt backend schema
        "beacon_int": 200,
        "noscan": True,
        "custom1": "made-up-for-example-purposes",
      }
    }
  ]
}
```

In the following sections some examples of the most common use cases are shown.

3.10.1 Wireless access point

The following *configuration dictionary* represent one of the most common wireless access point configuration:


```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "myWiFi",
        "wmm": True, # 802.11e
        "isolate": True # client isolation
      }
    }
  ]
}
```

UCI output:

```
package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
    option device 'radio0'
    option ifname 'wlan0'
    option isolate '1'
    option mode 'ap'
    option network 'wlan0'
    option ssid 'myWiFi'
    option wmm '1'
```

Note: the network option of the wifi-iface directive is filled in automatically but can be overridden if needed by setting the network option in the wireless section of the *configuration dictionary*. The next example shows how to do this.

3.10.2 Wireless attached to a different network

In some cases you might want to attach a wireless interface to a different network, for example, you might want to attach a wireless interface to a bridge:

```
{
  "interfaces": [
    {
      "name": "eth0",
      "type": "ethernet"
    },
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
```

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```

        "radio": "radio0",
        "mode": "access_point",
        "ssid": "wifi service",
        # the wireless interface will be attached to the "lan" network
        "network": ["lan"]
    },
    {
        "name": "lan", # the bridge will be named br-lan by OpenWRT
        "type": "bridge",
        "bridge_members": [
            "eth0",
            "wlan0"
        ],
        "addresses": [
            {
                "address": "192.168.0.2",
                "mask": 24,
                "proto": "static",
                "family": "ipv4"
            }
        ]
    }
]
}

```

Will be rendered as follows:

```

package network

config interface 'eth0'
    option ifname 'eth0'
    option proto 'none'

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

config interface 'lan'
    option ifname 'eth0 wlan0'
    option ipaddr '192.168.0.2'
    option netmask '255.255.255.0'
    option proto 'static'
    option type 'bridge'

package wireless

config wifi-iface 'wifi_wlan0'
    option device 'radio0'
    option ifname 'wlan0'
    option mode 'ap'
    option network 'lan'
    option ssid 'wifi service'

```

3.10.3 Wireless access point with macfilter ACL

The OpenWrt backend supports a custom NetJSON extension for wireless access point interfaces: `macfilter` (read more about `macfilter` and `maclist` on the [OpenWRT documentation for Wireless configuration](#)).

In the following example we ban two mac addresses from connecting to a wireless access point:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "MyWifiAP",
        "macfilter": "deny",
        "maclist": [
          "E8:94:F6:33:8C:1D",
          "42:6c:8f:95:0f:00"
        ]
      }
    }
  ]
}
```

UCI output:

```
package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
    option device 'radio0'
    option ifname 'wlan0'
    option macfilter 'deny'
    list maclist 'E8:94:F6:33:8C:1D'
    list maclist '42:6c:8f:95:0f:00'
    option mode 'ap'
    option network 'wlan0'
    option ssid 'MyWifiAP'
```

3.10.4 Wireless mesh (802.11s) example

Setting up **802.11s** interfaces is fairly simple, in the following example we bridge `eth0` with `mesh0`, the latter being a layer2 802.11s wireless interface.

Note: in 802.11s mesh mode the `ssid` property is not required, while `mesh_id` is mandatory.

```
{
  "interfaces": [
    {
      "name": "eth0",
      "type": "ethernet"
    },
    {
      "name": "mesh0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "802.11s",
        "mesh_id": "ninux",
        "network": ["lan"]
      }
    },
    {
      "name": "lan",
      "type": "bridge",
      "bridge_members": ["eth0", "mesh0"],
      "addresses": [
        {
          "address": "192.168.0.1",
          "mask": 24,
          "proto": "static",
          "family": "ipv4"
        }
      ]
    }
  ]
}
```

UCI output:

```
package network

config interface 'eth0'
    option ifname 'eth0'
    option proto 'none'

config interface 'mesh0'
    option ifname 'mesh0'
    option proto 'none'

config interface 'lan'
    option ifname 'eth0 mesh0'
    option ipaddr '192.168.0.1'
    option netmask '255.255.255.0'
    option proto 'static'
    option type 'bridge'

package wireless

config wifi-iface 'wifi_mesh0'
    option device 'radio0'
    option ifname 'mesh0'
    option mesh_id 'ninux'
```

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```
option mode 'mesh'
option network 'lan'
```

3.10.5 Wireless mesh (adhoc) example

In wireless adhoc mode, the `bssid` property is required.

The following example:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "ssid": "freifunk",
        "mode": "adhoc",
        "bssid": "02:b8:c0:00:00:00"
      }
    }
  ]
}
```

Will result in:

```
package network

config interface 'wlan0'
  option ifname 'wlan0'
  option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
  option bssid '02:b8:c0:00:00:00'
  option device 'radio0'
  option ifname 'wlan0'
  option mode 'adhoc'
  option network 'wlan0'
  option ssid 'freifunk'
```

3.10.6 WDS repeater example

In the following example we show how to configure a WDS station and repeat the signal:

```
{
  "interfaces": [
    # client
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
```

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```

        "mode": "station",
        "radio": "radio0",
        "network": ["wds_bridge"],
        "ssid": "FreeRomaWifi",
        "bssid": "C0:4A:00:2D:05:FD",
        "wds": True
    },
    # repeater access point
    {
        "name": "wlan1",
        "type": "wireless",
        "wireless": {
            "mode": "access_point",
            "radio": "radio1",
            "network": ["wds_bridge"],
            "ssid": "FreeRomaWifi"
        }
    },
    # WDS bridge
    {
        "name": "br-wds",
        "network": "wds_bridge",
        "type": "bridge",
        "addresses": [
            {
                "proto": "dhcp",
                "family": "ipv4"
            }
        ],
        "bridge_members": [
            "wlan0",
            "wlan1",
        ]
    }
]
}

```

Will result in:

```

package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

config interface 'wlan1'
    option ifname 'wlan1'
    option proto 'none'

config interface 'br_wds'
    option ifname 'wlan0 wlan1'
    option network 'wds_bridge'
    option proto 'dhcp'
    option type 'bridge'

package wireless

```

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```

config wifi-iface 'wifi_wlan0'
    option bssid 'C0:4A:00:2D:05:FD'
    option device 'radio0'
    option ifname 'wlan0'
    option mode 'sta'
    option network 'wds_bridge'
    option ssid 'FreeRomaWifi'
    option wds '1'

config wifi-iface 'wifi_wlan1'
    option device 'radio1'
    option ifname 'wlan1'
    option mode 'ap'
    option network 'wds_bridge'
    option ssid 'FreeRomaWifi'

```

3.10.7 WPA2 Personal (Pre-Shared Key)

The following example shows a typical wireless access point using *WPA2 Personal (Pre-Shared Key)* encryption:

```

{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "wpa2-personal",
        "encryption": {
          "protocol": "wpa2_personal",
          # possible cipher values are:
          # "auto", "tkip", "ccmp", and "tkip+ccmp"
          "cipher": "tkip+ccmp",
          "key": "passphrase012345"
        }
      }
    }
  ]
}

```

UCI output:

```

package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
    option device 'radio0'
    option encryption 'psk2+tkip+ccmp'

```

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```
option ifname 'wlan0'
option key 'passphrase012345'
option mode 'ap'
option network 'wlan0'
option ssid 'wpa2-personal'
```

3.10.8 WPA2 Enterprise (802.1x) ap

The following example shows a typical wireless access point using *WPA2 Enterprise (802.1x)* security on **OpenWRT**, you can use this type of configuration for networks like eduroam:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "eduroam",
        "encryption": {
          "protocol": "wpa2_enterprise",
          "cipher": "auto",
          "key": "radius_secret",
          "server": "192.168.0.1",
          "port": 1812,
          "acct_server": "192.168.0.2",
          "acct_port": 1813,
          "nasid": "hostname"
        }
      }
    }
  ]
}
```

UCI Output:

```
package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
    option acct_port '1813'
    option acct_server '192.168.0.2'
    option device 'radio0'
    option encryption 'wpa2'
    option ifname 'wlan0'
    option key 'radius_secret'
    option mode 'ap'
    option nasid 'hostname'
    option network 'wlan0'
```

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```
option port '1812'
option server '192.168.0.1'
option ssid 'eduroam'
```

3.10.9 WPA2 Enterprise (802.1x) client

WPA2 Enterprise (802.1x) client example:

```
{
  "interfaces": [
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "station",
        "ssid": "enterprise-client",
        "bssid": "00:26:b9:20:5f:09",
        "encryption": {
          "protocol": "wpa2_enterprise",
          "cipher": "auto",
          "eap_type": "tls",
          "identity": "test-identity",
          "password": "test-password",
        }
      }
    }
  ]
}
```

UCI Output:

```
package network

config interface 'wlan0'
  option ifname 'wlan0'
  option proto 'none'

package wireless

config wifi-iface 'wifi_wlan0'
  option bssid '00:26:b9:20:5f:09'
  option device 'radio0'
  option eap_type 'tls'
  option encryption 'wpa2'
  option identity 'test-identity'
  option ifname 'wlan0'
  option mode 'sta'
  option network 'wlan0'
  option password 'test-password'
  option ssid 'enterprise-client'
```

3.11 Radio settings

The radio settings reside in the `radio` key of the *configuration dictionary*, which must contain a list of [NetJSON radio objects](#) (see the link for the detailed specification).

3.11.1 Radio object extensions

In addition to the default *NetJSON Radio object options*, the `OpenWrt` backend also requires setting the following additional options for each radio in the list:

key name	type	allowed values
<code>driver</code>	string	mac80211, madwifi, ath5k, ath9k, broadcom
<code>protocol</code>	string	802.11a, 802.11b, 802.11g, 802.11n, 802.11ac

3.11.2 Radio example

The following *configuration dictionary*:

```
{
  "radios": [
    {
      "name": "radio0",
      "phy": "phy0",
      "driver": "mac80211",
      "protocol": "802.11n",
      "channel": 11,
      "channel_width": 20,
      "tx_power": 5,
      "country": "IT"
    },
    {
      "name": "radio1",
      "phy": "phy1",
      "driver": "mac80211",
      "protocol": "802.11n",
      "channel": 36,
      "channel_width": 20,
      "tx_power": 4,
      "country": "IT"
    }
  ]
}
```

Will be rendered as follows:

```
package wireless

config wifi-device 'radio0'
    option channel '11'
    option country 'IT'
    option htmode 'HT20'
    option hwmode '11g'
    option phy 'phy0'
```

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```

    option txpower '5'
    option type 'mac80211'

config wifi-device 'radio1'
    option channel '36'
    option country 'IT'
    option disabled '0'
    option htmode 'HT20'
    option hwmode '11a'
    option phy 'phy1'
    option txpower '4'
    option type 'mac80211'

```

3.11.3 Automatic channel selection example

If you need to use the “automatic channel selection” feature of OpenWRT, you must set the channel to 0 and, unless you are using neither **802.11n** nor **802.11ac**, you must set the `hwmode` property to tell OpenWRT which band to use (11g for 2.4 GHz, 11a for 5 GHz).

The following example sets “automatic channel selection” for two radios, the first radio uses **802.11n** in the 2.4 GHz band, while the second uses **802.11ac** in the 5 GHz band.

```

{
  "radios": [
    {
      "name": "radio0",
      "phy": "phy0",
      "driver": "mac80211",
      "protocol": "802.11n",
      "channel": 0, # 0 stands for auto
      "hwmode": "11g", # must set this explicitly, 11g means 2.4 GHz band
      "channel_width": 20
    },
    {
      "name": "radio1",
      "phy": "phy1",
      "driver": "mac80211",
      "protocol": "802.11ac",
      "channel": 0, # 0 stands for auto
      "hwmode": "11a", # must set this explicitly, 11a means 5 GHz band
      "channel_width": 80
    }
  ]
}

```

UCI output:

```

package wireless

config wifi-device 'radio0'
    option channel 'auto'
    option htmode 'HT20'
    option hwmode '11g'
    option phy 'phy0'
    option type 'mac80211'

```

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```
config wifi-device 'radio1'
    option channel 'auto'
    option htmode 'VHT80'
    option hwmode '11a'
    option phy 'phy1'
    option type 'mac80211'
```

3.11.4 802.11ac example

In the following example we show how to configure an *802.11ac* capable radio:

```
{
  "radios": [
    {
      "name": "radio0",
      "phy": "phy0",
      "driver": "mac80211",
      "protocol": "802.11ac",
      "channel": 36,
      "channel_width": 80,
    }
  ]
}
```

UCI output:

```
package wireless

config wifi-device 'radio0'
    option channel '36'
    option htmode 'VHT80'
    option hwmode '11a'
    option phy 'phy0'
    option type 'mac80211'
```

3.12 Static Routes

The static routes settings reside in the `routes` key of the *configuration dictionary*, which must contain a list of [NetJSON Static Route objects](#) (see the link for the detailed specification).

3.12.1 Static route object extensions

In addition to the default *NetJSON Route object options*, the `OpenWrt` backend also allows to define the following optional settings:

key name	type	default	description
type	string	unicast	unicast, local, broadcast, multicast, unreachable prohibit, blackhole, anycast
mtu	string	None	MTU for route, only numbers are allowed
table	string	None	Routing table id, only numbers are allowed
onlink	boolean	False	When enabled, gateway is on link even if the gateway does not match any interface prefix

3.12.2 Static route example

The following *configuration dictionary*:

```
{
  "routes": [
    {
      "device": "eth1",
      "destination": "192.168.4.1/24",
      "next": "192.168.2.2",
      "cost": 2,
      "source": "192.168.1.10",
      "table": "2",
      "onlink": True,
      "mtu": "1450"
    },
    {
      "device": "eth1",
      "destination": "fd89::1/128",
      "next": "fd88::1",
      "cost": 0,
    }
  ]
}
```

Will be rendered as follows:

```
package network

config route 'route1'
  option gateway '192.168.2.2'
  option interface 'eth1'
  option metric '2'
  option mtu '1450'
  option netmask '255.255.255.0'
  option onlink '1'
  option source '192.168.1.10'
  option table '2'
  option target '192.168.4.1'

config route6 'route2'
  option gateway 'fd88::1'
  option interface 'eth1'
  option metric '0'
  option target 'fd89::1/128'
```

3.13 Policy routing

The policy routing settings reside in the `ip_rule` key of the *configuration dictionary*, which is a custom NetJSON extension not present in the original NetJSON RFC.

The `ip_rule` key must contain a list of rules, each rule allows the following options:

key name	type
<code>in</code>	string
<code>out</code>	string
<code>src</code>	string
<code>tos</code>	string
<code>mark</code>	string
<code>invert</code>	boolean
<code>lookup</code>	string
<code>goto</code>	integer
<code>action</code>	string

For the function and meaning of each key consult the relevant [OpenWrt documentation about rule directives](#).

3.13.1 Policy routing example

The following *configuration dictionary*:

```
{
  "ip_rules": [
    {
      "in": "eth0",
      "out": "eth1",
      "src": "192.168.1.0/24",
      "dest": "192.168.2.0/24",
      "tos": 2,
      "mark": "0x0/0x1",
      "invert": True,
      "lookup": "0",
      "action": "blackhole"
    },
    {
      "src": "192.168.1.0/24",
      "dest": "192.168.3.0/24",
      "goto": 0
    },
    {
      "in": "vpn",
      "dest": "fdca:1234::/64",
      "action": "prohibit"
    },
    {
      "in": "vpn",
      "src": "fdca:1235::/64",
      "action": "prohibit"
    }
  ]
}
```

Will be rendered as follows:

```
package network

config rule 'rule1'
    option action 'blackhole'
    option dest '192.168.2.0/24'
    option in 'eth0'
    option invert '1'
    option lookup '0'
    option mark '0x0/0x1'
    option out 'eth1'
    option src '192.168.1.0/24'
    option tos '2'

config rule 'rule2'
    option dest '192.168.3.0/24'
    option goto '0'
    option src '192.168.1.0/24'

config rule6 'rule3'
    option action 'prohibit'
    option dest 'fdca:1234::/64'
    option in 'vpn'

config rule6 'rule4'
    option action 'prohibit'
    option in 'vpn'
    option src 'fdca:1235::/64'
```

3.14 Programmable switch settings

The programmable switch settings reside in the `switch` key of the *configuration dictionary*, which is a custom NetJSON extension not present in the original NetJSON RFC.

The `switch` key must contain a list of dictionaries, all the following keys are required:

key name	type
name	string
reset	boolean
enable_vlan	boolean
vlan	list

The elements of the `vlan` list must be dictionaries, all the following keys are required:

key name	type
device	string
reset	boolean
vlan	integer
ports	string

For the function and meaning of each key consult the relevant [OpenWrt documentation](#) about switch directives.

3.14.1 Switch example

The following *configuration dictionary*:

```
{
  "switch": [
    {
      "name": "switch0",
      "reset": True,
      "enable_vlan": True,
      "vlan": [
        {
          "device": "switch0",
          "vlan": 1,
          "ports": "0t 2 3 4 5"
        },
        {
          "device": "switch0",
          "vlan": 2,
          "ports": "0t 1"
        }
      ]
    }
  ]
}
```

Will be rendered as follows:

```
package network

config switch 'switch0'
    option enable_vlan '1'
    option name 'switch0'
    option reset '1'

config switch_vlan 'switch0_vlan1'
    option device 'switch0'
    option ports '0t 2 3 4 5'
    option vid '1'
    option vlan '1'

config switch_vlan 'switch0_vlan2'
    option device 'switch0'
    option ports '0t 1'
    option vid '2'
    option vlan '2'
```

3.14.2 Overriding or disabling vid UCI option

The OpenWRT/LEDE UCI `vid` option of `switch_vlan` sections is automatically inferred from the `vlan` number, although it's possible to override it or disable it if needed:

```
{
  "switch": [
    {
      "name": "switch0",
```

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```

    "reset": True,
    "enable_vlan": True,
    "vlan": [
        {
            "device": "switch0",
            "vlan": 1,
            "vid": 110, # manual override
            "ports": "0t 2 3 4 5"
        },
        {
            "device": "switch0",
            "vlan": 2,
            # ``None`` or empty string will remove
            # ``vid`` output from the UCI result
            "vid": None,
            "ports": "0t 1"
        }
    ]
}

```

Will be rendered as follows:

```

package network

config switch 'switch0'
    option enable_vlan '1'
    option name 'switch0'
    option reset '1'

config switch_vlan 'switch0_vlan1'
    option device 'switch0'
    option ports '0t 2 3 4 5'
    option vid '110'
    option vlan '1'

config switch_vlan 'switch0_vlan2'
    option device 'switch0'
    option ports '0t 1'
    option vlan '2'

```

3.15 NTP settings

The Network Time Protocol settings reside in the `ntp` key of the *configuration dictionary*, which is a custom NetJSON extension not present in the original NetJSON RFC.

The `ntp` key must contain a dictionary, the allowed options are:

key name	type	function
enabled	boolean	ntp client enabled
enable_server	boolean	ntp server enabled
server	list	list of ntp servers

3.15.1 NTP settings example

The following *configuration dictionary*:

```
{
  "ntp": {
    "enabled": True,
    "enable_server": False,
    "server": [
      "0.openwrt.pool.ntp.org",
      "1.openwrt.pool.ntp.org",
      "2.openwrt.pool.ntp.org",
      "3.openwrt.pool.ntp.org"
    ]
  }
}
```

Will be rendered as follows:

```
package system

config timeserver 'ntp'
    list server '0.openwrt.pool.ntp.org'
    list server '1.openwrt.pool.ntp.org'
    list server '2.openwrt.pool.ntp.org'
    list server '3.openwrt.pool.ntp.org'
    option enable_server '0'
    option enabled '1'
```

3.16 LED settings

The led settings reside in the `led` key of the *configuration dictionary*, which is a custom NetJSON extension not present in the original NetJSON RFC.

The `led` key must contain a list of dictionaries, the allowed options are:

key name	type
name	string
default	boolean
dev	string
sysfs	string
trigger	string
delayoff	integer
delayon	integer
interval	integer
message	string
mode	string

The required keys are:

- name
- sysfs
- trigger

For the function and meaning of each key consult the relevant [OpenWrt documentation about led directives](#).

3.16.1 LED settings example

The following *configuration dictionary*:

```
{
  "led": [
    {
      "name": "USB1",
      "sysfs": "tp-link:green:usb1",
      "trigger": "usbdev",
      "dev": "1-1.1",
      "interval": 50
    },
    {
      "name": "USB2",
      "sysfs": "tp-link:green:usb2",
      "trigger": "usbdev",
      "dev": "1-1.2",
      "interval": 50
    },
    {
      "name": "WLAN2G",
      "sysfs": "tp-link:blue:wlan2g",
      "trigger": "phy0tpt"
    }
  ]
}
```

Will be rendered as follows:

```
package system

config led 'led_usb1'
  option dev '1-1.1'
  option interval '50'
  option name 'USB1'
  option sysfs 'tp-link:green:usb1'
  option trigger 'usbdev'

config led 'led_usb2'
  option dev '1-1.2'
  option interval '50'
  option name 'USB2'
  option sysfs 'tp-link:green:usb2'
  option trigger 'usbdev'

config led 'led_wlan2g'
  option name 'WLAN2G'
  option sysfs 'tp-link:blue:wlan2g'
  option trigger 'phy0tpt'
```

3.17 Including custom options

It is very easy to add configuration options that are not explicitly defined in the schema of the OpenWrt backend.

For example, in some cases you may need to define a “ppp” interface, which can use quite a few properties that are

not defined in the schema:

```
from netjsonconfig import OpenWrt

o = OpenWrt({
    "interfaces": [
        {
            "name": "ppp0",
            "type": "other",
            "proto": "ppp",
            "device": "/dev/usb/modem1",
            "username": "user1",
            "password": "pwd0123",
            "keepalive": 3,
            "ipv6": True
        }
    ]
})

print(o.render())
```

UCI output:

```
package network

config interface 'ppp0'
    option device '/dev/usb/modem1'
    option ifname 'ppp0'
    option ipv6 '1'
    option keepalive '3'
    option password 'pwd0123'
    option proto 'ppp'
    option username 'user1'
```

3.18 Including custom lists

Under specific circumstances, OpenWRT allows adding configuration options in the form of lists. Many of these UCI options are not defined in the *JSON-Schema* of the OpenWrt backend, but the schema allows adding custom properties.

The OpenWrt backend recognizes list options for the following sections:

- interface settings
- ip address settings
- wireless settings
- radio settings

3.18.1 Interface list setting example

The following example shows how to set a list of `ip6class` options:

```
o = OpenWrt({
    "interfaces": [
        {
```

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```

        "name": "eth0",
        "type": "ethernet",
        "ip6class": ["wan6", "backbone"]
    }
]
})
print(o.render())

```

UCI Output:

```

package network

config interface 'eth0'
    option ifname 'eth0'
    list ip6class 'wan6'
    list ip6class 'backbone'
    option proto 'none'

```

3.18.2 Address list setting example

The following example shows how to set a list of dhcp reqopts settings:

```

o = OpenWrt({
    "interfaces": [
        {
            "name": "eth0",
            "type": "ethernet",
            "addresses": [
                {
                    "proto": "dhcp",
                    "family": "ipv4",
                    "reqopts": ["43", "54"]
                }
            ]
        }
    ]
})
print(o.render())

```

UCI Output:

```

package network

config interface 'eth0'
    option ifname 'eth0'
    option proto 'dhcp'
    list reqopts '43'
    list reqopts '54'

```

3.18.3 Radio list setting example

The following example shows how to set a list of advanced capabilities supported by the radio using ht_capab:

```
o = OpenWrt({
    "radios": [
        {
            "name": "radio0",
            "phy": "phy0",
            "driver": "mac80211",
            "protocol": "802.11n",
            "channel": 1,
            "channel_width": 20,
            "ht_capab": ["SMPS-STATIC", "SHORT-GI-20"]
        }
    ]
})
print(o.render())
```

UCI output:

```
package wireless

config wifi-device 'radio0'
    option channel '1'
    list ht_capab 'SMPS-STATIC'
    list ht_capab 'SHORT-GI-20'
    option htmode 'HT20'
    option hwmode '11g'
    option phy 'phy0'
    option type 'mac80211'
```

3.18.4 Wireless list setting example

The following example shows how to set the supported basic rates of a wireless interface using `basic_rate`:

```
o = OpenWrt({
    "interfaces": [
        {
            "name": "wlan0",
            "type": "wireless",
            "wireless": {
                "radio": "radio0",
                "mode": "access_point",
                "ssid": "open",
                "basic_rate": ["6000", "9000"]
            }
        }
    ]
})
print(o.render())
```

UCI output:

```
package network

config interface 'wlan0'
    option ifname 'wlan0'
    option proto 'none'
```

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```
package wireless

config wifi-iface 'wifi_wlan0'
    list basic_rate '6000'
    list basic_rate '9000'
    option device 'radio0'
    option ifname 'wlan0'
    option mode 'ap'
    option network 'wlan0'
    option ssid 'open'
```

3.19 Including additional files

The OpenWrt backend supports inclusion of arbitrary plain text files through the `files` key of the *configuration dictionary*. The value of the `files` key must be a list in which each item is a dictionary representing a file, each dictionary is structured as follows:

key name	type	required	function
path	string	yes	filesystem path, will be encoded in the tar.gz archive
contents	string	yes	plain text contents of the file, new lines must be encoded as <code>\n</code>
mode	string	yes	filesystem permissions, defaults to <code>0644</code>

The `files` key of the *configuration dictionary* is a custom NetJSON extension not present in the original NetJSON RFC.

Warning: The files are included in the output of the `render` method unless you pass `files=False`, eg: `openwrt.render(files=False)`

3.19.1 Plain file example

The following example code will generate an archive with one file in `/etc/crontabs/root`:

```
from netjsonconfig import OpenWrt

o = OpenWrt({
    "files": [
        {
            "path": "/etc/crontabs/root",
            "mode": "0644",
            # new lines must be escaped with ``\n``
            "contents": '* * * * * echo "test" > /etc/testfile\n'
                       '* * * * * echo "test2" > /etc/testfile2'
        }
    ]
})

o.generate()
```

3.19.2 Executable script file example

The following example will create an executable shell script:

```
o = OpenWrt({
  "files": [
    {
      "path": "/bin/hello_world",
      "mode": "0755",
      "contents": "#!/bin/sh\n"
                  "echo 'Hello world'"
    }
  ]
})
o.generate()
```

3.20 OpenVPN

This backend includes the schema of the OpenVpn backend, inheriting its features.

For details regarding the OpenVPN schema please see [OpenVPN backend schema](#).

3.20.1 Schema additions

The OpenWrt backend adds a few properties to the OpenVPN schema, see below.

key name	type	default	allowed values
disabled	boolean	False	

3.20.2 OpenVPN example

The following *configuration dictionary*:

```
{
  "openvpn": [
    {
      "ca": "ca.pem",
      "cert": "cert.pem",
      "dev": "tap0",
      "dev_type": "tap",
      "dh": "dh.pem",
      "disabled": False,
      "key": "key.pem",
      "mode": "server",
      "name": "test-vpn-server",
      "proto": "udp",
      "tls_server": True
    }
  ]
}
```

Will be rendered as follows:


```

package openvpn

config openvpn 'test_vpn_server'
    option ca 'ca.pem'
    option cert 'cert.pem'
    option dev 'tap0'
    option dev_type 'tap'
    option dh 'dh.pem'
    option enabled '1'
    option key 'key.pem'
    option mode 'server'
    option proto 'udp'
    option tls_server '1'

```

3.21 All the other settings

Do you need to include some configuration directives that are not defined in the NetJSON spec nor in the schema of the OpenWrt backend? **Don't panic!**

Because netjsonconfig aims to be very flexible, it ships code that will try to render extra parts of the *configuration dictionary* into meaningful UCI output.

In order to accomplish this, you must add extra keys to the *configuration dictionary* which have to meet the following requirements:

- the name of the key must be the name of the package that needs to be configured
- the value of the key must be a list
- each element in the list must be a dict
- each dict **MUST** contain a key named `config_name`
- each dict **MAY** contain a key named `config_value`

This feature is best explained with a few examples.

3.21.1 Dropbear example

The following *configuration dictionary*:

```

{
  "dropbear": [
    {
      "config_name": "dropbear",
      "config_value": "dropbear_1",
      "PasswordAuth": "on",
      "RootPasswordAuth": "on",
      "Port": 22
    }
  ]
}

```

Will be rendered as follows:

```
package dropbear

config dropbear 'dropbear_1'
    option PasswordAuth 'on'
    option Port '22'
    option RootPasswordAuth 'on'
```

3.21.2 OLSRd2 example

The following *configuration dictionary*:

```
{
  "olsrd2": [
    {
      "config_name": "global",
      "config_value": "global",
      "pidfile": "/var/run/olsrd2.pid",
      "lockfile": "/var/lock/olsrd2"
    },
    {
      "config_name": "log",
      "config_value": "log",
      "syslog": "true",
      "stderr": "true",
      "file": "/var/log/olsrd2.log"
    },
    {
      "config_name": "interface",
      "config_value": "olsr2_common",
      "ifname": [
        "loopback",
        "wlan0",
        "wlan1"
      ]
    }
  ]
}
```

Will be rendered as follows:

```
package olsrd2

config global 'global'
    option lockfile '/var/lock/olsrd2'
    option pidfile '/var/run/olsrd2.pid'

config log 'log'
    option file '/var/log/olsrd2.log'
    option stderr 'true'
    option syslog 'true'

config interface 'olsr2_common'
    list ifname 'loopback'
    list ifname 'wlan0'
    list ifname 'wlan1'
```

OpenWISP 1.x Backend

The OpenWISP 1.x Backend is based on the OpenWRT backend, therefore it inherits all its features with some differences that are explained in this page.

4.1 Generate method

The `generate` method of the OpenWisp backend differs from the OpenWrt backend in a few ways.

1. the generated `tar.gz` archive is not designed to be installed with `sysupgrade -r`
2. the `generate` method will automatically add a few additional executable scripts:
 - `install.sh` to install the configuration
 - `uninstall.sh` to uninstall the configuration
 - `tc_script.sh` to start/stop traffic control settings
 - one “up” script for each tap VPN configured
 - one “down” script for each tap VPN configured
3. the `openvpn` certificates are expected to be located the following path: `/openvpn/x509/`
4. the `crontabs` are expected in to be located at the following path: `/crontabs/`

4.2 General settings

The `hostname` attribute in the `general` key is **required**.

4.3 Traffic Control

For backward compatibility with [OpenWISP Manager](#) the schema of the OpenWisp backend allows to define a `tc_options` section that will be used to generate `tc_script.sh`.

The `tc_options` key must be a list, each element of the list must be a dictionary which allows the following keys:

key name	type	function
<code>name</code>	string	required , name of the network interface that needs to be limited
<code>input_bandwidth</code>	integer	maximum input bandwidth in kbps
<code>output_bandwidth</code>	integer	maximum output bandwidth in kbps

4.3.1 Traffic control example

The following *configuration dictionary*:

```
{
  "tc_options": [
    {
      "name": "tap0",
      "input_bandwidth": 2048,
      "output_bandwidth": 1024
    }
  ]
}
```

Will generate the following `tc_script.sh`:

```
#!/bin/sh /etc/rc.common

KERNEL_VERSION=`uname -r`
KERNEL_MODULES="sch_htb sch_prio sch_sfq cls_fw sch_dsmark sch_ingress sch_tbf sch_
↪red sch_hfsc act_police cls_tcindex cls_flow cls_route cls_u32"
KERNEL_MPATH=/lib/modules/$KERNEL_VERSION/

TC_COMMAND=/usr/sbin/tc

check_prereq() {
    echo "Checking prerequisites..."

    echo "Checking kernel modules..."
    for kmod in $KERNEL_MODULES; do
        if [ ! -f $KERNEL_MPATH/$kmod.ko ]; then
            echo "Prerequisite error: can't find kernel module '$kmod' in '$KERNEL_MPATH'"
            exit 1
        fi
    done

    echo "Checking tc tool..."
    if [ ! -x $TC_COMMAND ]; then
        echo "Prerequisite error: can't find traffic control tool ($TC_COMMAND)"
        exit 1
    fi

    echo "Prerequisites satisfied."
```

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```

}

load_modules() {
    for kmod in $KERNEL_MODULES; do
        insmod $KERNEL_MPATH/$kmod.ko >/dev/null 2>&1
    done
}

unload_modules() {
    for kmod in $KERNEL_MODULES; do
        rmmod $kmod >/dev/null 2>&1
    done
}

stop() {

    tc qdisc del dev tap0 root

    tc qdisc del dev tap0 ingress

    unload_modules
}

start() {
    check_prereq
    load_modules

    # shaping output traffic for tap0
    # creating parent qdisc for root
    tc qdisc add dev tap0 root handle 1: htb default 2

    # aggregated traffic shaping parent class

    tc class add dev tap0 parent 1 classid 1:1 htb rate 1024kbit burst 191k

    # default traffic shaping class
    tc class add dev tap0 parent 1:1 classid 1:2 htb rate 512kbit ceil 1024kbit

    # policing input traffic for tap0
    # creating parent qdisc for ingress
    tc qdisc add dev tap0 ingress

    # default policer with lowest preference (last checked)
    tc filter add dev tap0 parent ffff: preference 0 u32 match u32 0x0 0x0 police_
↪rate 2048kbit burst 383k drop flowid :1

}

boot() {
    start

```

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```
}

restart() {
    stop
    start
}
```

4.3.2 Full OpenWISP configuration example

The following example shows a full working *configuration dictionary* for the OpenWisp backend.

```
{
  "general": {
    "hostname": "OpenWISP"
  },
  "interfaces": [
    {
      "name": "tap0",
      "type": "virtual"
    },
    {
      "network": "service",
      "name": "br-service",
      "type": "bridge",
      "bridge_members": [
        "tap0"
      ]
    },
    {
      "name": "wlan0",
      "type": "wireless",
      "wireless": {
        "radio": "radio0",
        "mode": "access_point",
        "ssid": "provinciawifi",
        "isolate": True,
        "network": ["service"]
      }
    }
  ],
  "radios": [
    {
      "name": "radio0",
      "phy": "phy0",
      "driver": "mac80211",
      "protocol": "802.11g",
      "channel": 11,
      "channel_width": 20,
      "tx_power": 10,
      "country": "IT"
    }
  ],
  "openvpn": [
    {
      "name": "2693",
```

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```

    "cipher": "AES-128-CBC",
    "ca": "/tmp/owispmanager/openvpn/x509/ca_1_service.pem",
    "mute_replay_warnings": True,
    "script_security": 1,
    "proto": "tcp-client",
    "mute": 10,
    "up_delay": 1,
    "cert": "/tmp/owispmanager/openvpn/x509/l2vpn_client_2693.pem",
    "up": "/tmp/owispmanager/openvpn/vpn_2693_script_up.sh",
    "log": "/tmp/openvpn_2693.log",
    "verb": 1,
    "dev_type": "tap",
    "persist_tun": True,
    "keepalive": "5 40",
    "key": "/tmp/owispmanager/openvpn/x509/l2vpn_client_2693.pem",
    "ns_cert_type": "server",
    "mode": "p2p",
    "pull": True,
    "enabled": True,
    "comp_lzo": "yes",
    "down": "/tmp/owispmanager/openvpn/vpn_2693_script_down.sh",
    "dev": "tap0",
    "nobind": True,
    "remote": [
        {
            "host": "vpn.openwisp.org",
            "port": 12128
        }
    ],
    "tls_client": True,
    "resolve_retry": True,
    "up_restart": True
},
"tc_options": [
    {
        "name": "tap0",
        "input_bandwidth": 2048,
        "output_bandwidth": 1024
    }
],
"files": [
    {
        "path": "/openvpn/x509/ca.pem",
        "mode": "0644",
        "contents": "-----BEGIN CERTIFICATE-----\nstripped_down\n-----END_\nCERTIFICATE-----\n"
    },
    {
        "path": "/openvpn/x509/l2vpn_client_1_2325_2693.pem",
        "mode": "0644",
        "contents": "-----BEGIN CERTIFICATE-----\nstripped_down\n-----END_\nCERTIFICATE-----\n-----BEGIN RSA PRIVATE KEY-----\nstripped_down\n-----END RSA_\nPRIVATE KEY-----\n"
    },
    {
        "path": "/crontabs/root",

```

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```
        "mode": "0644",
        "contents": "* * * * * echo 'test' > /tmp/test-cron"
    }
]
}
```

OpenVPN 2.3 Backend

The OpenVpn backend allows to generate OpenVPN 2.3.x compatible configurations.

Its schema is limited to a subset of the features available in OpenVPN and it doesn't recognize interfaces, radios, wireless settings and so on.

The main methods work just like the *OpenWRT backend*:

- `__init__`
- `render`
- `generate`
- `write`
- `json`

The main differences are in the resulting configuration and in its schema.

See an example of initialization and rendering below:

```
from netjsonconfig import OpenVpn

config = OpenVpn({
    "openvpn": [
        {
            "ca": "ca.pem",
            "cert": "cert.pem",
            "dev": "tap0",
            "dev_type": "tap",
            "dh": "dh.pem",
            "key": "key.pem",
            "mode": "server",
            "name": "example-vpn",
            "proto": "udp",
            "tls_server": True
        }
    ]
})
```

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```

    ]
  })
  print(config.render())

```

Will return the following output:

```

# openvpn config: test-no-status

ca ca.pem
cert cert.pem
dev tap0
dev-type tap
dh dh.pem
key key.pem
mode server
proto udp
tls-server

```

5.1 OpenVPN backend schema

The OpenVpn backend schema is limited, it only recognizes an `openvpn` key with a list of dictionaries representing vpn instances. The structure of these dictionaries is described below.

Alternatively you may also want to take a look at the [OpenVPN JSON-Schema source code](#).

According to the [NetJSON](#) spec, any unrecognized property will be ignored.

5.1.1 General settings (valid both for client and server)

Required properties:

- name
- mode
- proto
- dev

key name	type	default	allowed values
name	string		2 to 24 alphanumeric characters, dashes and underscores
mode	string		p2p or server
proto	string		udp, tcp-client, tcp-server
port	integer	1194	integers
dev_type	string		tun, tap
dev	string		any non-whitespace character (max length: 15)
local	string		any string
comp_lzo	string	adaptive	yes, no or adaptive
auth	string	SHA1	see auth property source code
cipher	string	BF-CBC	see cipher property source code
engine	string		bsd, rsax, dynamic or empty string
ca	string		any non whitespace character

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Table 1 – continued from previous page

key name	type	default	allowed values
cert	string		any non whitespace character
key	string		any non whitespace character
pkcs12	string		any non whitespace character
ns_cert_type	string		client, server or empty string
mtu_disc	string	no	no, maybe or yes
mtu_test	boolean	False	
fragment	integer	0	any positive integer
mssfix	integer	1450	any positive integer
keepalive	string		two numbers separated by one space
persist_tun	boolean	False	
persist_key	boolean	False	
up	string		any non whitespace character
up_delay	integer	0	any positive integer
down	string		any non whitespace character
script_security	integer	1	0, 1, 2, 3
user	string		any string
group	string		any string
mute	integer	0	any positive integer
status	string		string and number separated by space, eg: /var/log/openvpn.statu
status_version	integer	1	1, 2, 3
mute_replay_warnings	boolean	False	
secret	string		any non whitespace character
reneg_sec	integer	3600	any positive integer
tls_timeout	integer	2	any positive integer
tls_cipher	string		any string
remote_cert_tls	string		client, server or empty string
float	boolean	False	
fast_io	boolean	False	
log	string		filesystem path
verb	integer	1	from 0 (disabled) to 11 (very verbose)

5.1.2 Client specific settings

Required properties:

- remote

key name	type	de- fault	allowed values
remote	list	[]	list of dictionaries containing host (str) and port (str). Must contain at least one element
nobind	boolean	True	
resolv_retry	boolean	True	
tls_client	boolean	True	
pull	boolean	True	
remote_random	boolean	False	
auth_user_pass	string		any non whitespace character
auth_retry	string	none	none, nointeract or interact

5.1.3 Server specific settings

key name	type	default	allowed values
tls_server	boolean	True	
dh	string		any non whitespace character
crl_verify	string		any non whitespace character
duplicate_cn	boolean	False	
client_to_client	boolean	False	
client_cert_not_required	boolean	False	
username_as_common_name	boolean	False	
auth_user_pass_verify	string		any non whitespace character

5.2 Working around schema limitations

The schema does not include all the possible OpenVPN settings, but it can render appropriately any property not included in the schema as long as its type is one the following:

- boolean
- integer
- strings
- lists

For a list of all the OpenVPN configuration settings, refer to the [OpenVPN 2.3 manual](#).

5.3 Automatic generation of clients

classmethod `OpenVpn.auto_client` (*host*, *server*, *ca_path=None*, *ca_contents=None*,
cert_path=None, *cert_contents=None*, *key_path=None*,
key_contents=None)

Returns a configuration dictionary representing an OpenVPN client configuration that is compatible with the passed server configuration.

Parameters

- **host** – remote VPN server
- **server** – dictionary representing a single OpenVPN server configuration
- **ca_path** – optional string representing path to CA, will consequently add a file in the resulting configuration dictionary
- **ca_contents** – optional string representing contents of CA file
- **cert_path** – optional string representing path to certificate, will consequently add a file in the resulting configuration dictionary
- **cert_contents** – optional string representing contents of cert file
- **key_path** – optional string representing path to key, will consequently add a file in the resulting configuration dictionary
- **key_contents** – optional string representing contents of key file

Returns dictionary representing a single OpenVPN client configuration

Example:

```
from netjsonconfig import OpenVpn

server_config = {
    "ca": "ca.pem",
    "cert": "cert.pem",
    "dev": "tap0",
    "dev_type": "tap",
    "dh": "dh.pem",
    "key": "key.pem",
    "mode": "server",
    "name": "example-vpn",
    "proto": "udp",
    "tls_server": True
}
dummy_contents = '----- EXAMPLE -----'
client_config = OpenVpn.auto_client('vpn1.test.com',
                                    server=server_config,
                                    ca_path='ca.pem',
                                    ca_contents=dummy_contents,
                                    cert_path='cert.pem',
                                    cert_contents=dummy_contents,
                                    key_path='key.pem',
                                    key_contents=dummy_contents)

client = OpenVpn(client_config)
print(client.render())
```

Will be rendered as:

```
# openvpn config: example-vpn

ca ca.pem
cert cert.pem
dev tap0
dev-type tap
key key.pem
mode p2p
nobind
proto udp
remote vpn1.test.com 1195
resolv-retry
tls-client

# ----- files ----- #

# path: ca.pem
# mode: 0644

----- EXAMPLE -----

# path: cert.pem
# mode: 0644

----- EXAMPLE -----

# path: key.pem
# mode: 0644
```

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```
----- EXAMPLE -----
```

CHAPTER 6

Create your backend

Every backend is based on the common ground of some elements provided by the `netjsonconfig` library. The `BaseBackend`, `BaseConverter`, `BaseParser` and `BaseRenderer` are a battle proven set of tools that can be extended when creating you backend.

But the `netjsonconfig` package is not a playground to experiment, your contributions to a new backend should start elsewhere, a different package, where you are in control and can make errors and experiment more.

Netjsonconfig can now discover packages that provides a custom backend using a feature available in the Python packaging ecosystem which is called *entry_points*.

To create a new backend start from scratch with a new folder and add this file to your project root directory.

```
# example_backend/setup.py
from setuptools import setup, find_packages

setup(
    name='example_backend',
    version='0.0.0',
    description='an example to illustrate a netjsonconfig backend as an external_
↪module',
    install_requires=['netjsonconfig>=0.6.3'],
    packages=find_packages(),
    entry_points={
        'netjsonconfig.backends': [
            'example=example_backend.__init__:ExampleBackend',
        ]
    }
)
```

this file can be used to create a package that can be installed using pip or other tools in the python ecosystem. You can find more information about Python packaging at packaging.python.org and at [the hitchhikers guide to packaging](#).

The most important part is to give your package a good name, a well thought description and to add the `entry_points` keyword argument with the following code

```
{  
    # this is used by netjsonconfig  
    # to find your backend  
    'netjsonconfig.backends': [  
        ...  
    ]  
}
```

Now your package will be in the list of backends that netjsonconfig can use!

But we still have to give us a name to be unique! Netjsonconfig already defined the names `openwisp`, `openwrt` and `openvpn` but you can choose whatever you like most.

The name `netjsonconfig.backends` will be associated with a list of classes from your package that will be presented to netjconfig at runtime. To specify which classes you want to expose write the triple `name, path` and `class_name` using the format `name=path:class_name` as in the example below.

The `path` part is simply the path to the file that contains the class you want to expose and the `class_name` is the name of the class.

```
{  
    'netjsonconfig.backends': [  
        # name=path:class_name  
        'example=example_backend.__init__:ExampleBackend',  
    ]  
}
```

The previous example can be used with the following class definition

```
# example_backend/example_backend/__init__.py  
from netjsonconfig.backends.base.backend import BaseBackend  
from netjsonconfig.backends.base.renderer import BaseRenderer  
from netjsonconfig.backends.base.parser import BaseParser  
  
from netjsonconfig.schema import schema as default_schema  
  
class ExampleBackend(BaseBackend):  
    schema = default_schema  
    converter = []  
    parser = BaseParser  
    renderer = BaseRenderer
```

Once you have your python package configured with the correct entry points you should have a directory tree that looks like this.

```
$ tree example_backend  
example_backend  
├── example_backend  
│   └── __init__.py  
└── setup.py
```

And now you can install your package using `pip install -e ./example_backend` or `python setup.py install`.

As `netjsonconfig` is a dependency for `example_backend` you can use your backend directly from the command line, e.g.


```
$ netjsonconfig
usage: netjsonconfig [-h] [--config CONFIG]
                    [--templates [TEMPLATES [TEMPLATES ...]]]
                    [--native NATIVE] --backend
                    {openwrt,openwisp,openvpn,example} --method
                    {render,generate,write,validate,json}
                    [--args [ARGS [ARGS ...]]] [--verbose] [--version]
netjsonconfig: error: the following arguments are required: --backend/-b, --method/-m
```

Notice the *example* in {openwrt,openwisp,openvpn,example}? That's your backend!

The name exposed is the one chosen in the *name, path, class* triple from before

```
# name=path:class
'example=example_backend.__init__:ExampleBackend',
```


CHAPTER 7

Command line utility

netjsonconfig ships a command line utility that can be used from the interactive shell, bash scripts or other programming languages.

Check out the available options yourself with:

```
$ netjsonconfig --help
usage: netjsonconfig [-h] [--config CONFIG]
                  [--templates [TEMPLATES [TEMPLATES ...]]]
                  [--native NATIVE] --backend {openwrt,openwisp,openvpn}
                  --method {render,generate,write,validate,json}
                  [--args [ARGS [ARGS ...]]] [--verbose] [--version]

Converts a NetJSON DeviceConfiguration object to native router configurations.
Exhaustive documentation is available at: http://netjsonconfig.openwisp.org/

optional arguments:
  -h, --help            show this help message and exit

input:
  --config CONFIG, -c CONFIG
                        config file or string, must be valid NetJSON
                        DeviceConfiguration
  --templates [TEMPLATES [TEMPLATES ...]], -t [TEMPLATES [TEMPLATES ...]]
                        list of template config files or strings separated by
                        space
  --native NATIVE, -n NATIVE
                        path to native configuration file or archive

output:
  --backend {openwrt,openwisp,openvpn}, -b {openwrt,openwisp,openvpn}
                        Configuration backend
  --method {render,generate,write,validate,json}, -m {render,generate,write,validate,
  → json}
                        Backend method to use. "render" returns the
                        configuration in text format; "generate" returns a
```

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```

tar.gz archive as output; "write" is like generate but
writes to disk; "validate" validates the combination
of config and templates passed in input;
"json" returns NetJSON output:
--args [ARGS [ARGS ...]], -a [ARGS [ARGS ...]]
Optional arguments that can be passed to methods

debug:
--verbose           verbose output
--version, -v       show program's version number and exit

```

Here's the common use cases explained:

```

# generate tar.gz from a NetJSON DeviceConfiguration object and save its output to a
↪file
netjsonconfig --config config.json --backend openwrt --method generate > config.tar.gz

# convert an OpenWRT tar.gz to NetJSON and print to standard output (with 4 space
↪indentation)
netjsonconfig --native config.tar.gz --backend openwrt --method json -a indent="    "

# use write configuration archive to disk in /tmp/routerA.tar.gz
netjsonconfig --config config.json --backend openwrt --method write --args
↪name=routerA path=/tmp/

# see output of OpenWrt render method
netjsonconfig --config config.json --backend openwrt --method render

# same as previous but exclude additional files
netjsonconfig --config config.json --backend openwrt --method render --args files=0

# validate the config.json file against the openwrt backend
netjsonconfig --config config.json --backend openwrt --method validate

# abbreviated options
netjsonconfig -c config.json -b openwrt -m render -a files=0

# passing a JSON string instead of a file path
netjsonconfig -c '{"general": { "hostname": "example" }}' -b openwrt -m render

```

Using templates:

```

netjsonconfig -c config.json -t template1.json template2.json -b openwrt -m render

# validate the result of merging config.json, template1.json and template2.json
# against the openwrt backend schema
netjsonconfig -c config.json -t template1.json template2.json -b openwrt -m validate

```

7.1 Environment variables

Environment variables are automatically passed to the `context` argument (if you don't know what this argument does please read "[Context \(configuration variables\)](#)"), therefore you can reference environment variables inside *configurations* and *templates*:

```
export HOSTNAME=freedom
netjsonconfig -c '{"general": { "hostname": "{{ HOSTNAME }}" }}' -b openwrt -m render
```

You can also avoid using `export` and write everything in a one line command:

```
PORT=2009; netjsonconfig -c config.json -t template1.json -b openwrt -m render
```


Running the test suite is really straightforward!

8.1 Using runtests.py

Install your forked repo:

```
git clone git://github.com/<your_fork>/netjsonconfig  
cd netjsonconfig/  
python setup.py develop
```

Install test requirements:

```
pip install -r requirements-test.txt
```

Run tests with:

```
./runtests.py
```

8.2 Using nose2

Alternatively, you can use the `nose2` tool (which has a ton of available options):

```
nose2
```

See test coverage with:

```
coverage run --source=netjsonconfig runtests.py && coverage report
```


Thank you for taking the time to contribute to netjsonconfig.

Follow these guidelines to speed up the process.

Table of Contents:

- *Contributing*
 - *Reach out before you start*
 - *Create a virtual environment*
 - *Fork repo and install your fork*
 - *Ensure test coverage does not decrease*
 - *Follow style conventions (PEP8, isort)*
 - *Update the documentation*
 - *Send pull request*

9.1 Reach out before you start

Before opening a new issue, try the following steps:

- look if somebody else has already started working on the same issue by looking in the [github issues](#) and [pull requests](#)
- look also in the [OpenWISP mailing list](#)
- announce your intentions by opening a new issue
- present yourself on the mailing list

9.2 Create a virtual environment

Please use a [python virtual environment](#) while developing your feature, it keeps everybody on the same page and it helps reproducing bugs and resolving problems.

We suggest you to use [virtualenvwrapper](#) for this task (consult install instructions in the [virtualenvwrapper docs](#)).

```
mkvirtualenv netjsonconfig # create virtualenv
```

9.3 Fork repo and install your fork

Once you have forked this repository to your own github account or organization, install your own fork in your development environment:

```
git clone git@github.com:<your_fork>/netjsonconfig.git
cd netjsonconfig
workon netjsonconfig # activate virtualenv
python setup.py develop
```

9.4 Ensure test coverage does not decrease

First of all, install the test requirements:

```
workon netjsonconfig # activate virtualenv
pip install -r requirements-test.txt
```

When you introduce changes, ensure test coverage is not decreased with:

```
nose2 --with-coverage --coverage netjsonconfig
```

9.5 Follow style conventions (PEP8, isort)

First of all, install the test requirements:

```
workon netjsonconfig # activate virtualenv
pip install -r requirements-test.txt
```

Before committing your work check that your changes are not breaking the style conventions with:

```
flake8
isort --check-only --recursive .
```

For more information, please see:

- [PEP8: Style Guide for Python Code](#)
- [isort: a python utility / library to sort imports](#)

9.6 Update the documentation

If you introduce new features or change existing documented behavior, please remember to update the documentation!

The documentation is located in the `/docs` directory of the repository.

To do work on the docs, proceed with the following steps:

```
workon netjsonconfig # activate virtualenv
pip install sphinx
cd docs
make html
```

9.7 Send pull request

Now is time to push your changes to github and open a [pull request](#)!

Motivations and Goals

In this page we explain the goals of this project and the motivations that led us on this path.

10.1 Motivations

Federico Capovano (@nemesisdigital) has written in detail the motivations that brought us here in a blog post: [netjson-config: convert NetJSON to OpenWRT UCI](#).

10.2 Goals

The main goal of this library is to replace the configuration generation feature that is shipped in [OpenWISP Manager](#).

We have learned a lot from *OpenWISP Manager*, one of the most important lessons we learned is that the configuration generation feature must be a library decoupled from web framework specific code (eg Rails, Django), this brings many advantages:

- the project can evolve independently from the rest of the OpenWISP modules
- easier to use and integrate in other projects
- more people can use it and contribute
- easier maintainance
- easier to document

Another important goal is to build a tool which is **flexible** and **powerful**. We do not want to limit our system to OpenWISP Firmware only, we want to be able to control vanilla OpenWRT devices or other OpenWRT based devices too.

We did this by starting out with the *OpenWrt backend* first, only afterwards we built the *OpenWisp backend* on top of it.

To summarize, our goals are:

- build a reusable library to generate router configurations from [NetJSON](#) objects
- support the widely used router specific unix/linux distributions
- provide good and extensive documentation
- keep it simple stupid
- avoid complexity unless extremely necessary
- provide ways to add custom configuration options easily
- provide ways to extend the library
- *encourage contributions*

11.1 Version 0.7.0 [2020-01-14]

- Dropped support for python 2.7
- Updated github buttons in documentation which were causing an unintended redirect
- Updated the jsonschema library to version 3.x

11.2 Version 0.6.4 [2019-12-09]

- #113: [bugfix] Made “encryption none” explicit in OpenWRT
- 5ddc201: [bugfix] Fixed invalid UCI name bug in default OpenWRT renderer
- #118: [bugfix] Fixed `TypeError: can only concatenate list (not "str") to list`
- #137: [tests] Migrated tests to nose2

11.3 Version 0.6.3 [2018-07-09]

- #106 [extensions] Query backends from installed packages (thanks to @EdoPut)
- #109 [doc] Added reference to plugin interface (thanks to @EdoPut)
- #99 [cli] print traceback fully if the verbose flag is passed (thanks to @EdoPut)
- #108 [openvpn] Added more options to the OpenVPN backend (thanks to @okraits)

11.4 Version 0.6.2 [2017-08-29]

- [#78](#) [base] Added support for multiple renderers
- [#94](#) [schema] Made `bssid` not required for wireless stations
- [#97](#) [python2] Fixed `py2-ipaddress` related unicode bug

11.5 Version 0.6.1 [2017-07-05]

- [5ddc201](#): [general] Avoid default mutable arguments
- [dde3c9b](#): [openvpn] Added explicit `list_identifiers` attribute
- [8c26cd6](#): [docs] Updated outdated OpenWRT rendering examples
- [5f8483e](#): [openwrt] Fixed repeated bridge gateway case
- [#84](#) [exceptions] Improved validation errors (thanks to [@EdoPut](#))
- [#85](#) [openwrt] Added “vid” option in “switch”
- [#86](#) [openwrt] Added support for “ip6gw” option
- [#70](#) [feature] Backward conversion
- [#87](#) [openwrt] Removed automatic timezone

11.6 Version 0.6.0 [2017-06-01]

- [#70](#) [general] Preliminary work for backward conversion, more info in the [OpenWISP Mailing List](#)
- [#58](#): [openwrt] Dropped obsolete code in `OpenVpn` converter
- [#59](#): [openwrt] Improved multiple ip address output

11.7 Version 0.5.6 [2017-05-24]

- [#69](#): [docs] Improved contributing guidelines (thanks to [@EdoPut](#))
- [#71](#): [bin] Added `validate` to available methods of command line tool (thanks to [@EdoPut](#))
- [845ed83](#): [version] Improved `get_version` to follow PEP440
- [#73](#): [netjson] Fixed compatibility with [NetJSON](#) specification

11.8 Version 0.5.5.post1 [2017-04-18]

- [d481781](#): [docs] Added OpenWRT PPPoE example
- [beb435b](#): [docs] Fixed Basic Concepts summary

11.9 Version 0.5.5 [2017-03-15]

- [#65](#): [openwrt] Added missing zonename attribute

11.10 Version 0.5.4.post1 [2017-03-07]

- [4aaecae](#): [docs] Added documentation regarding template overrides

11.11 Version 0.5.4 [2017-02-14]

- [6f712d1](#): [utils] Implemented identifiers as parameters in `utils.merge_list`
- [fcae96c](#): [openwrt] Added `config_value` identifier in `utils.merge_list`
- [eaa04de](#): [docs] Improved “All the other settings” section in OpenWrt backend
- [#60](#) [openvpn] Fixed `resolv_retry` bug; **minor backward incompatible change**: handled in [django-netjsonconfig with a migration](#)
- [f25e77e](#): [openvpn] Added `topology` attribute to schema
- [c4aa07a](#): [openvpn] Allow to omit seconds in status attribute

11.12 Version 0.5.3 [2017-01-17]

- [#56](#): [general] Implemented smarter merge mechanism
- [#57](#): [openwrt] Fixed interface enabled bug
- [7a152a3](#): [openwrt] Renamed `enabled` to `disabled` in OpenVPN section (for consistency)

11.13 Version 0.5.2 [2016-12-29]

- [#55](#): [vars] Fixed broken evaluation of multiple variables

11.14 Version 0.5.1 [2016-09-22]

- [b486c4d](#): [openvpn] corrected wrong `client` mode, renamed to `p2p`
- [c7e51c6](#): [openvpn] added `pull` option for clients
- [dde3128](#): [openvpn] differentiate server between manual, routed and bridged

11.15 Version 0.5.0 [2016-09-19]

- added OpenVpn backend
- [afbc3a3](#): [openwisp] fixed openvpn integration (partially backward incompatible)

- [1234c34](#): [context] improved flexibility of configuration variables
- [#54](#): [openwrt] fixed netmask issue on ipv4

11.16 Version 0.4.5 [2016-09-05]

- [#53](#): [docs] avoid ambiguity on dashes in context
- [#52](#): [schema] added countries list as `enum` for radios (thanks to [@zachantre](#))

11.17 Version 0.4.4 [2016-06-27]

- [#50](#): [openwrt] add logical name to all generated configuration items

11.18 Version 0.4.3 [2016-04-23]

- [c588e5d](#): [openwrt] avoid adding `dns` and `dns_search` if `proto` is `none`

11.19 Version 0.4.2 [2016-04-11]

- [92f9a43](#): [schema] added human readable values for mode `access_point` and `802.11s`
- [#47](#): [openwrt] improved encryption support
- [1a4c493](#): [openwrt] `igmp_snooping` now correctly defaults to `True`
- [#49](#): [schema] added descriptions and titles

11.20 Version 0.4.1 [2016-04-04]

- [b903c6f](#): [schema] corrected wrong `ipv4` `minLength` and `maxLength`
- [de98ae6](#): [schema] fixed interface `minLength` attribute
- [4679282](#): [schema] added regexp pattern for interface `mac` address (can be empty)
- [067b471](#): [schema] switched order between `MTU` and `MAC` address properties
- [26b62dd](#): [schema] added pattern for wireless `BSSID` attribute
- [11da509](#): [openwrt] added regexp pattern to `maclist` elements
- [b061ee4](#): [openwrt] fixed empty output bug if `addresses` is empty list
- [7f74209](#): [openwrt] removed support for `chanbw` for types `ath5k` and `ath9k` (**backward incompatible change**)
- [#46](#): [schema] introduced different profiles for radio settings
- [6ab9d5b](#): [openwrt] added support for “Automatic Channel Selection”
- [#48](#): [openwrt] improved support for config lists
- [9f93776](#): [openwrt] simplified definition of custom interface “proto” options

- [a5f63f0](#): [openwrt] allow to override general dns and dns_search settings
- [1b58f97](#): [schema] added stp (spanning tree protocol) property on bridge interfaces
- [bfbf23d](#): [openwrt] added igmp_snooping property on bridge interfaces
- [269c7bf](#): [openwrt] added isolate property on wireless access points
- [2cbc242](#): [openwrt] fixed autostart when False
- [85bd7dc](#): [openwrt] fixed mac address override on interfaces
- [45159e8](#): [openwrt] allow overriding htmode option
- [b218f7d](#): [schema] added enum_titles in encryption protocols
- [ef8c296](#): [schema] validate general hostname format
- [2f23cfd](#): [schema] validate interface ipv4 address format
- [612959e](#): [openwrt] validate ntp server hostname format
- [f1116f0](#): [schema] validate dns_search hostname format #42
- [372d634](#) [openwrt] do not set dns to dhcp interfaces

11.21 Version 0.4.0 [2016-03-22]

- [#40](#): [openwrt] added support for ULA prefix
- [#44](#): [schema] added none to encryption choices
- [#45](#): [schema] improved address definition
- [#43](#): [openwrt] improved static routes
- [#41](#): [schema] added wds property & removed wds mode
- [#36](#): [schema] added specific settings for 802.11s (mesh) mode
- [3f6d2c6](#): [schema] removed NetJSON type from schema
- [04c6058](#): [openwrt] made file mode property required (**backward incompatible change**)
- [00e784e](#): [openwrt] added default switch settings
- [dd708cb](#): [openwrt] added NTP default settings
- [f4148e4](#): [schema] removed txqueuelen from interface definition
- [574a48d](#): [schema] added title and type to bridge_members
- [c6276f2](#): [schema] MTU title and minimum value
- [d8ab0e0](#): [schema] added minLength to interface name
- [67a0916](#): [schema] added minLength to radio name
- [258892e](#): [schema] added possible ciphers
- [2751fe3](#): [schema] improved definition of wireless interface fields
- [478ef16](#): [openwrt] added wmm property for wireless access points
- [b9a14f3](#): [schema] added minLength and maxLength to interface mac property
- [526c2d1](#): [schema] added minLength and maxLength to wireless bssid property

- [c8c95d6](#): [schema] improved ordering and titles of wireless properties
- [a226e90](#): [openwrt] ignore advanced wifi options if zero
- [e008ef6](#): [openwrt] added `macfilter` to wireless access points
- [c70ab76](#): [openwrt] fixed empty dns and dns-search bug
- [778615a](#): [openwrt] increased network `maxLength`

11.22 Version 0.3.7 [2016-02-19]

- [007da6e](#): renamed “Coordinated Universal Time” to “UTC”
- [2c1e72e](#): fixed ‘`tx_power`’ `KeyError`, introduced in [71b083e](#)
- [aa8b485](#): added `utils.evaluate_vars` function
- [7323491](#): simplified implementation of *configuration variables*

11.23 Version 0.3.6 [2016-02-17]

- fixed `flake8` and `isort` warnings
- added `flake8` and `isort` checks to travis build
- [6ec5ce8](#): minor regexp optimization for `generate` method
- [#39](#): added *configuration variables* feature
- [a3486d2](#): the shell utility can now use environment variables in `config` and `templates`, [read relevant docs](#)

11.24 Version 0.3.5 [2016-02-10]

- [18ecf28](#): removed `hardware` and `operating_system` sections
- [75c259d](#): reordered schema sections
- [010ca98](#): file contents can now be only strings (**backward incompatible change**)
- [e2bb3b2](#): added non-standard `propertyOrder` attributes to schemas to facilitate UI ordering
- [#37](#): [schema] radio `tx_power` not required anymore
- [#38](#): [openwrt schema] hardened file mode constraints
- [c2cc3fc](#): [schema] added `minlength` and `maxlength` to `hostname`

11.25 Version 0.3.4 [2016-01-14]

- [#35](#) wifi inherits `disabled` from interface

11.26 Version 0.3.3 [2015-12-18]

- 219f638 [cli] fixed binary standard output for `generate` method
- a0b1373 removed timestamp from generated configuration archive to ensure reliable checksums

11.27 Version 0.3.2 [2015-12-11]

- #31 added files in `render` output
- #32 `generate` now returns an in-memory file object
- badf292 updated command line utility script and examples
- #33 added `write` method
- 5ff7360 [cli] positional `config` param is now `--config` or `-c`
- 28de4a5 [cli] marked required arguments: `--config`, `--backend` and `--method`
- f55cc4a [cli] added `--arg` option to pass arguments to methods

11.28 Version 0.3.1 [2015-12-02]

- 69197ed added “details” attribute to `ValidationError`
- 0005186 avoid modifying original `config` argument

11.29 Version 0.3 [2015-11-30]

- #18 added OpenWisp backend
- 66ee96 added file permission feature
- #19 added sphinx documentation (published at netjsonconfig.openwisp.org)
- 30348e hardened ntp server option schema for OpenWrt backend
- c31375 added madwifi to the allowed drivers in schema OpenWrt backend
- #30 updated schema according to latest NetJSON spec

11.30 Version 0.2 [2015-11-23]

- #20 added support for array of lines in files
- #21 date is now correctly set in tar.gz files
- 82cc5e configuration archive is now compatible with `sysupgrade -r`
- #22 improved and simplified bridging
- #23 do not ignore interfaces with no addresses
- #24 restricted schema for interface names

- #25 added support for logical interface names
- #26 `merge_dict` now returns a copy of all the elements
- d22d59 restricted SSID to 32 characters
- #27 improved wireless definition
- #28 removed “enabled” in favour of “disabled”

11.31 Version 0.1 [2015-10-20]

- Added OpenWrt Backend
- Added command line utility `netjsonconfig`
- Added multiple templating feature
- Added file inclusion feature

CHAPTER 12

Indices and tables

- `genindex`
- `modindex`
- `search`

Symbols

`__init__()` (*netjsonconfig.OpenWrt method*), 15

A

`auto_client()` (*netjsonconfig.OpenVpn class method*), 62

G

`generate()` (*netjsonconfig.OpenWrt method*), 17

J

`json()` (*netjsonconfig.OpenWrt method*), 19

M

`merge_config()` (*in module netjsonconfig.utils*), 12

`merge_list()` (*in module netjsonconfig.utils*), 12

P

`parse()` (*netjsonconfig.OpenWrt method*), 19

R

`render()` (*netjsonconfig.OpenWrt method*), 16

W

`write()` (*netjsonconfig.OpenWrt method*), 18