L06 Strategies for Validation and Modularization

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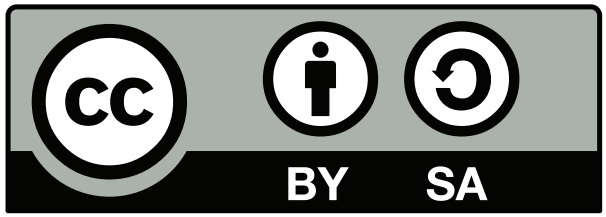
28.04.2021



Validation

1. Validation
2. Modularity
   - Vertical
   - Horizontal
3. Plugins
   - Why?
   - How?

Checking Configurations

Following properties of configuration settings can be checked:

- values (data types)
- structure
- constraints
- semantic checks (e.g., IP, folder)
- domain-specific checks (e.g., databases)
- requirements (suitable configurations)
- context (context-aware configurations)

ELEKTRA supports many other data types, each implemented in its own plugin(s):

- **check/type** allows us to specify CORBA data types. Checking "any" (default) is always successful. The record and enum types defined by CORBA are not part of this plugin but of others as explained below.
- **check/enum** supports a list of supported values denoted by array indexes.
- **check/ipaddr** checks if a string is a valid IP address.
- **check/path** checks presence, permissions, and type of paths in the file system.
- **check/date** supports to check date formats such as POSIX, ISO8601, and RFC2822.
- **check/range** allows us to check if numerical values are within a range.

check/validation checks the configuration value with regular expressions.

check/condition checks using conditionals and comparisons.

check/math checks using mathematical expressions.

trigger/error allows us to express unconditional failures.

check/rgbcolor allows us to check for RGB colors.

check/macaddr allow us to check for MAC addresses.

Checking Specifications

The goals of checking SpecElektra are:

- Defaults must be present for safe lookups. This goal also implies that there must be at least one valid configuration setting.
- Types of default values must be compatible with the types of the keys.
- Every contextual interpretation of a key must yield a compatible type.
- Links must not refer to each other in cycles.
- Every link and the pointee must have compatible types.

Example

```
1 [sw/org/abc/has_true_arg]
2   type:=boolean
3   default:=0
4   override/#0:=/sw/org/abc/arg0
5   override/#1:=/sw/org/abc/arg1
```

Logfile Example

```
1 [slapd/logfile]
2   check/path:=file
```

Logfile Extensions

```
1 [slapd/logfile]
2   check/path:=file
3   check/validation:=^/var/log/
4   check/validation/message:=Policy violation:
5     log files must be below /var/log
```

Error Messages

Error messages are extremely important as they are the main communication channel to system administrators.
Example specification:

```
1 [a]
2   check/type:=long
3 [b]
4   check/type:=long
5 [c]
6   check/range:=0-10
7   assign/math:=../a+../b
```

Error Messages

Problems:

- Generic vs. specific plugins
- General principles of good error messages [1]
- Give context
- Precisely locate the cause:

```
1 a=5   ; unmodified
2 b=10  ; modification bit in metadata
3       ; is only set here
4 c=15  ; unmodified by user but changed
5       ; later by assign/math
```

Example Error Message

```
Sorry, I was unable to change the configuration settings!
I tried to modify b to be 10 but this caused c to be
outside of the allowed range (0-10).
```

With additional verbose/debug output:

```
Module: range
At: sourcefile.c:1234
Mountpoint: /test
Configfile: /etc/testfile.conf
```

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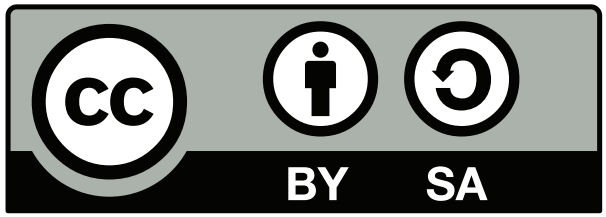


Modularity

1 Validation

2 Modularity
- Vertical
- Horizontal

3 Plugins
- Why?
- How?

Status Quo in Free Systems

- nearly all applications use their own configuration system
- immense differences in configuration file formats and configuration access
- very high modularity

Status Quo in Frameworks and Proprietary Systems

- obvious ways how to deal with configuration
- no differences in configuration access
- very low modularity

Types of Modularity

Vertical modularity describes how strongly separated the configuration accesses of different applications is. *Horizontal modularity* describes how strongly separated modules implementing configuration access for a single application is.

Vertical Modularity [2]

Vertical modularity is the degree of separation between different applications. If all applications use the same key database with a single backend or a single configuration file, applications would be coupled tightly. [...]
If coupling between applications is low, for example every application uses a different configuration library or a different backend, we have a high degree of vertical modularity.

Retain Vertical Modularity [2]

ELEKTRA provides two mechanisms to retain vertical modularity:

- **Mounting** configuration files facilitates different applications to use their own backend and their own configuration file. Furthermore, mounting enables integrating existing configuration files into the key database. Configuration specifications written in SPECELEKTRA allow different applications to share their configuration files with each other in a controlled way.
- Having frontends that implement existing **APIs** decouple applications from each other. These applications continue to use their specific configuration accesses, but ELEKTRA redirects their configuration accesses to the shared key database.

Vertical Modularity [2]

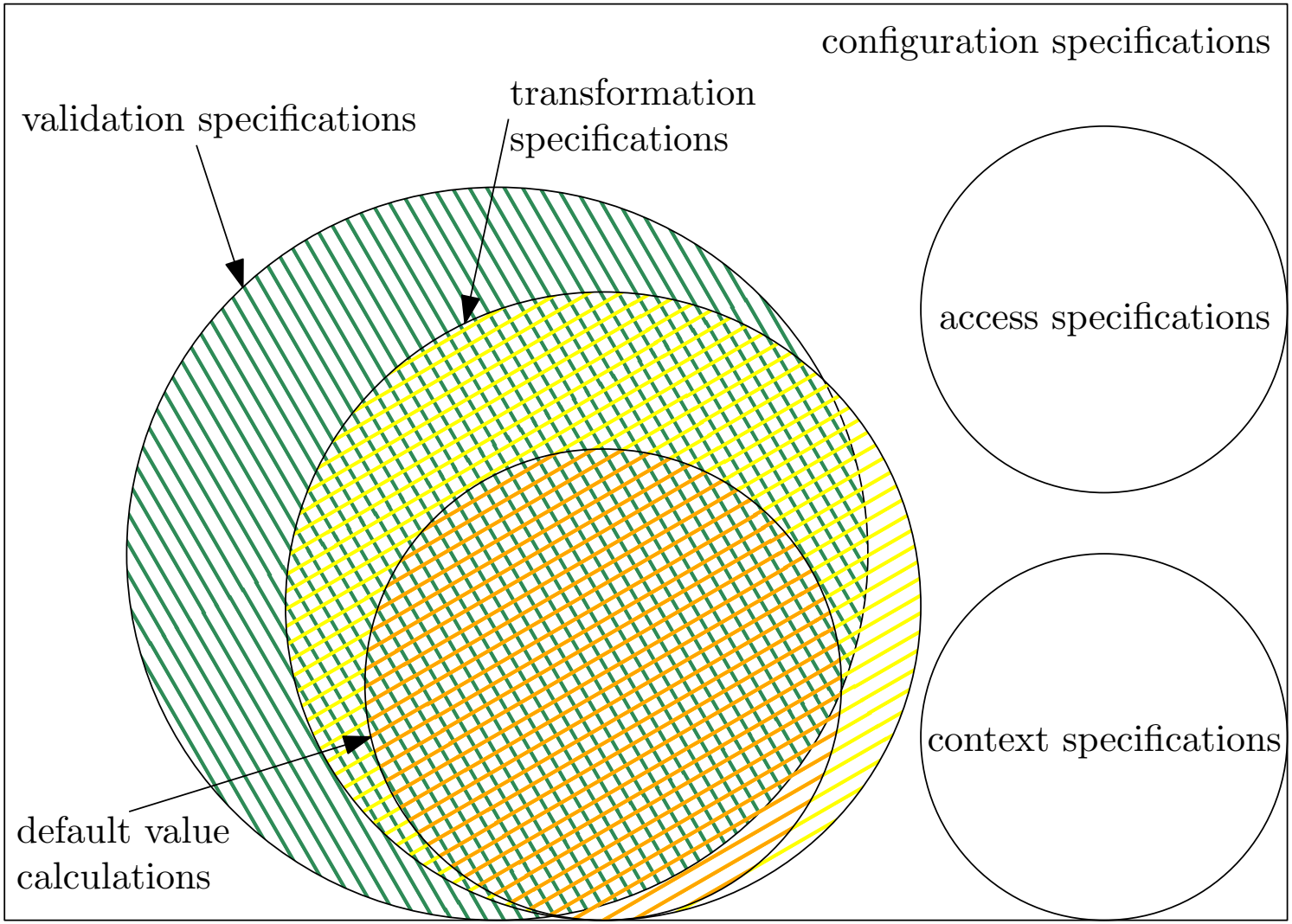
Mountpoints can also be a part of the specification:

```
1 [ntp]
2   mountpoint:=ntp.conf
3 [sw/libreoffice]
4   mountpoint:=libreoffice.conf
```

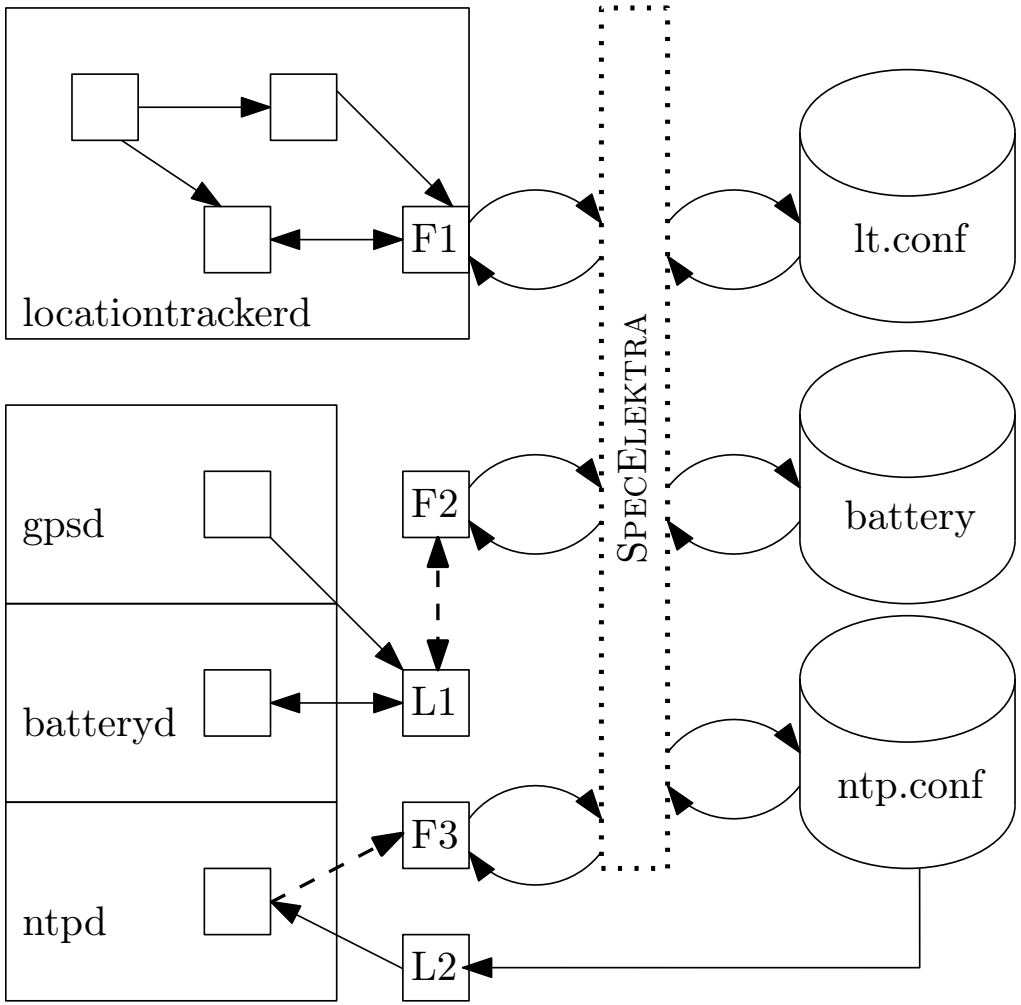
Task

Which type of specification is this?

Types of Specifications



Vertical Modularity



Needed to keep applications independently.
Boxes are applications, cylinders are configuration files, F? are frontends or frontend adapters, L? are configuration libraries [2].

Task

Break.

Horizontal Modularity [2]

Horizontal modularity is "the degree of separation in configuration access code" [2]. A higher degree of horizontal modularity allows us to better separate configuration access code and plug the code together as needed.

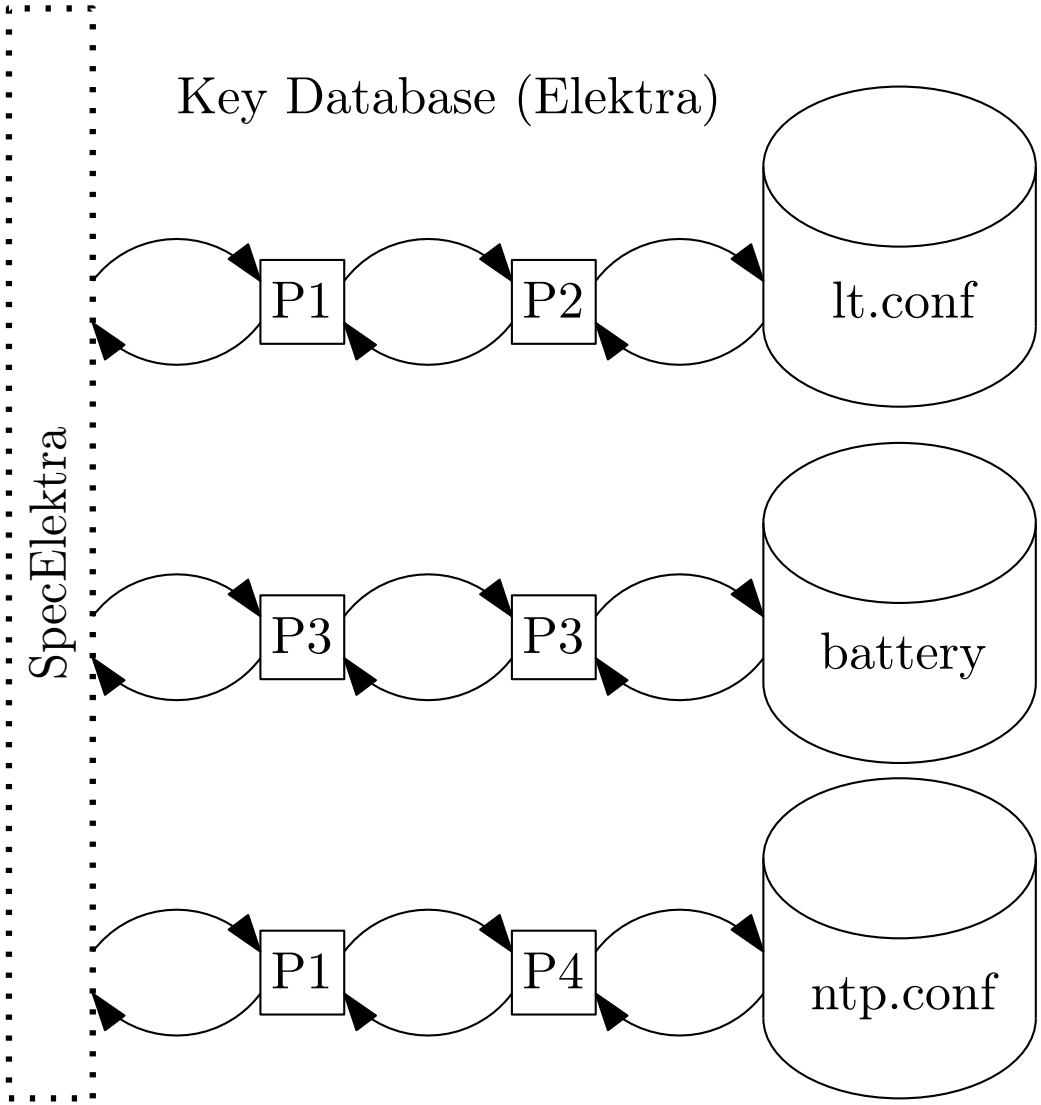
Three factors of SpecElektra improve horizontal modularity:

1. Using SpecElektra, applications are completely decoupled from configuration specifications.
2. Specifications and their implementation are decoupled.
3. Abstract dependences within the implementation of specifications.

Task

This is very vague.
Can you describe a system that would (not) fulfil this?

Horizontal Modularity



Needed for validation, auto-detection, ...

Cylinders are configuration files, P? are plugins [2]

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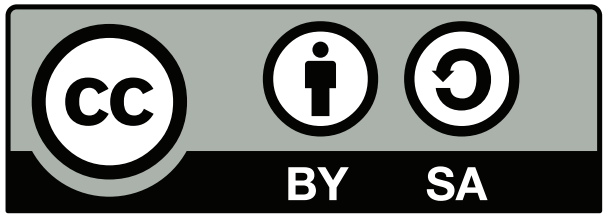

Plugins

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Acceptable Effort

Q: "Which effort do you think is worthwhile for providing better configuration experience?"

- 44 % would use other configuration access APIs next to `getenv`.
- 30 % would use OS-specific sources.
- 21 % would use dedicated libraries.
- 19 % would read other application's configuration settings,
- 16 % would use external configuration access APIs that add new dependences.

Why?

Finding

Q: Most developers have concerns adding dependences for more validation (84 %) but consider good defaults important (80 %).

Requirement

Dependences exclusively needed to validate configuration settings must be avoided.

Rationale

Why is it difficult to have good defaults?

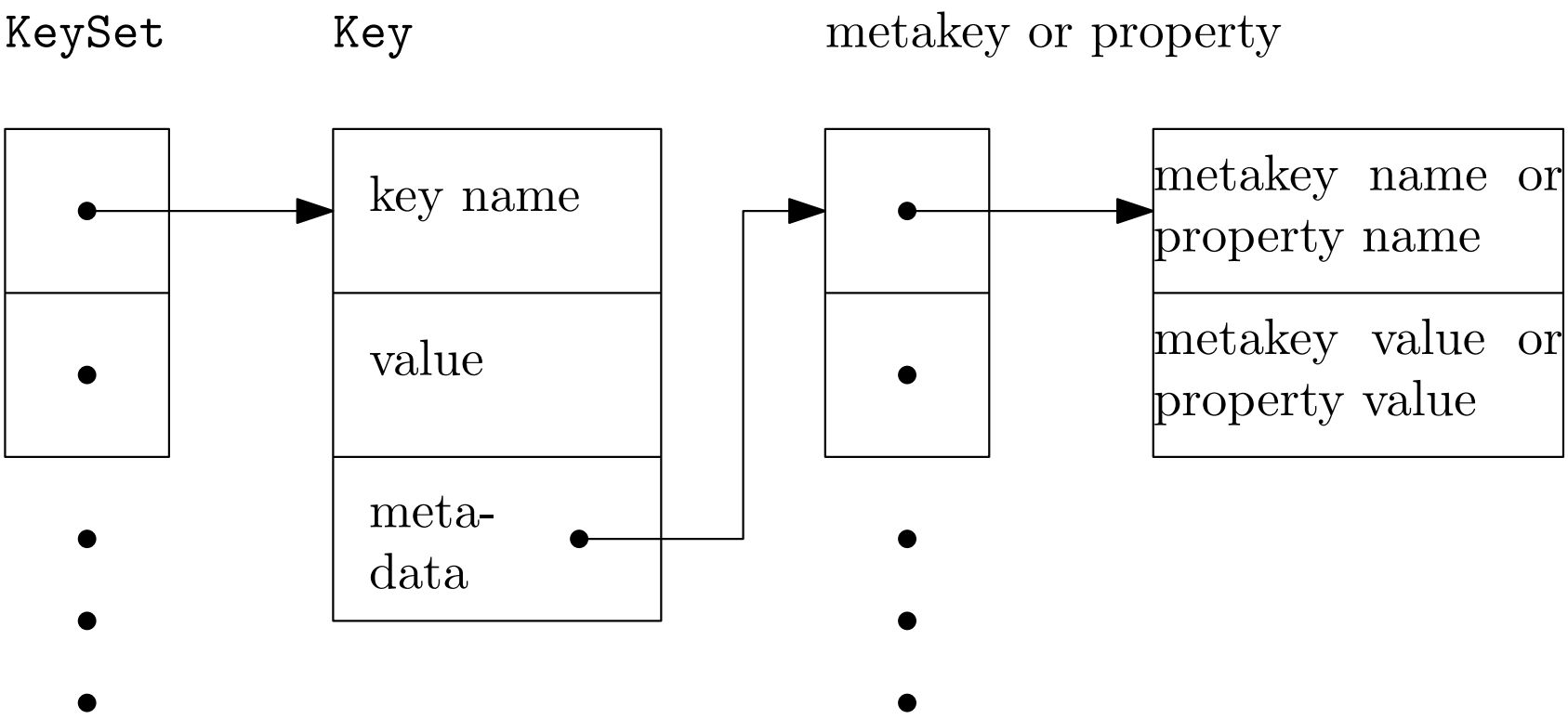
- **Modularity:** diverse and conflicting requirements between applications. Especially in validation, for example, constraint solvers vs. type systems vs. model checkers.
- **System-level:** specification must always be enforced. Examples:
  - which desktop is the application started in?
  - how many CPUs does the system have?
  - get the correct proxy of the system.
  - get available network bandwidth.
  - is the filesystem local?

Plugins are filters, sinks, and sources processing a key set. We aim at SpecElektra to be as modular as possible and make extensive use of plugins:

1. SpecElektra does not have any built-in feature, all features are (or can be) implemented as plugins.
2. Elektra works completely without SpecElektra's specifications.
3. Configuration specifications are present within the execution environment. Thus any tool and plugin can introspect and use the specifications.

KeySet

The common data structure between plugins:



Plugin Assembly

automatic assembling of plugins:

- iterate over the specification and collect all key words
- iterate over all plugins and check if they offer key words
- check contract between plugins and specification
- of the remaining plugins: use best suited or rated

(implemented in `kdb mount` / `kdb spec-mount` in Elektra)

SpecElektra is a dependency injection mechanism:

- By extending the specification, new plugins are being injected into the system.
- The *provider* abstractions in the dependences between the plugins abstract over concrete implementations of configuration access code.
- We have a modular implementation of SpecElektra.

Task

Which kind of modularity does *provider* improve?

Answer

3rd point of horizontal modularity on Slide 25

Examples

calculation with context:

```
1 [gps/status]
2 assign:=(battery > 'low') ? ('on') : ('off')
3 [battery]
4 plugins:=battery
```

Examples

resolve names of configuration files

```
1 [example]
2   mountpoint:=/example.ini
```

depending on operating system, e.g. UNIX:

namespace	resolved path
spec	/example.ini
dir	${PWD}/example.ini
user	${HOME}/example.ini
system	/example.ini

[1] Michael J. Lee and Andrew J. Ko. Personifying programming tool feedback improves novice programmers' learning. In *Proceedings of the Seventh International Workshop on Computing Education Research*, ICER '11, pages 109–116, New York, NY, USA, 2011. ACM. ISBN 978-1-4503-0829-8. doi: 10.1145/2016911.2016934. URL http://dx.doi.org/10.1145/2016911.2016934.

[2] Markus Raab. Improving system integration using a modular configuration specification language. In *Companion Proceedings of the 15th International Conference on Modularity*, MODULARITY Companion 2016, pages 152–157, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-4033-5. doi: 10.1145/2892664.2892691. URL http://dx.doi.org/10.1145/2892664.2892691.

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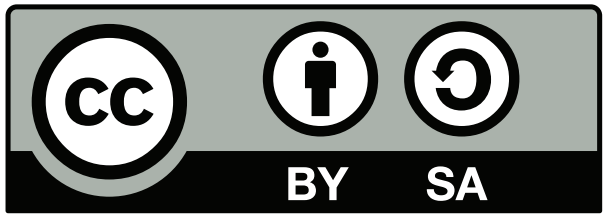

Meeting

4 Meeting