Configuration Management

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Lecture is every week Wednesday 09:00 - 11:00.

- 06.03.2019: topic, teams
- 13.03.2019: TISS registration, initial PR
- 20.03.2019: other registrations, guest lecture
- 27.03.2019: PR for first issue done, second started
- 03.04.2019: first issue done, PR for second
- 10.04.2019: mid-term submission of exercises
- 08.05.2019: different location: Complang Libary
- 15.05.2019:
- 22.05.2019: all 5 issues done
- 29.05.2019:
- 05.06.2019: final submission of exercises
- 12.06.2019:
- 19.06.2019: last corrections of exercises and register for exam
- 26.06.2019: exam

Tasks

Task

- personal feedback about me in TISS Stimmungszettel (anonym) or by email (markus.raab@complang.tuwien.ac.at).

Popular Topics

- 14 tools
- 9 testability
- 9 code-generation
- 7 context-awareness
- 6 specification
- 6 misconfiguration
- 6 complexity reduction
- 5 validation
- 5 points in time
- 5 error messages
- 5 auto-detection
- 4 user interface
- 4 introspection
- 4 design
- 4 cascading
- 4 architecture of access
- 3 configuration sources
- 3 config-less systems
- 2 secure conf
- 2 architectural decisions
- 1 push vs. pull
- 1 infrastructure as code
- 1 full vs. partial
- 1 convention over conf
- 1 CI/CD
- 0 documentation

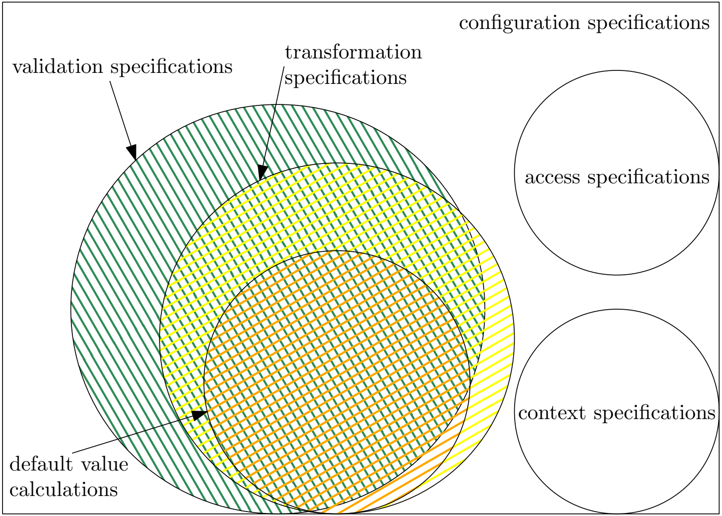
Learning Outcomes

Students will be able to

- connect needs of CM tools with configuration specifications.
- remember differences between different CM languages.
- contextualize CM languages with the view point of administrators.

Recapitulation

Types of Specifications (Recapitulation)



Configuration Specification (Partly Recapitulation)

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- CM code can even be generated from the specification.

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- Access specifications make access trivial via uniform interface.

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How can we combine configuration specifications and configuration management? (Think, Pair, Share)

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- Configuration design is explicit (like transformations and default values) and can help while writing CM code.
- CM code can even be generated from the specification.
- Access specifications make access trivial via uniform interface.
- Visibility and similar techniques may help dealing with complexity.

Configuration Drift (Recapitulation)

Task

What is configuration drift? What are its causes?

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What is configuration drift? What are its causes?

Are derivations of the “Single Source of Truth” (the CM code).
Caused by:

- manual configuration changes by administrators
- manual configuration changes by end users
- differences in updates (e.g., skipped or failed updates)
- failed attempts to change configuration
- applying different versions of CM code
- ...

Push vs. Pull (Recapitulation)

Task

Explain the Push and the Pull Model. What are their (dis)advantages?

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Task

Explain the Push and the Pull Model. What are their (dis)advantages?

- Push is more interactive.
- Push cannot do its job if nodes are not reachable.
- Push needs additional techniques to scale with many nodes.
- Push demands access to servers from a single server.
- Pull needs additional monitoring to know when a patch has been applied.
- Pull needs resources even if nothing is to do.

Properties (Recapitulation)

Task

What is idempotent, self-describing, round-tripping configuration?

Properties (Recapitulation)

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What is idempotent, self-describing, round-tripping configuration?

Idempotent yield the same configuration with any number of applications from CM code ($n \geq 1$) [15]:

$$f(f(x)) = f(x)$$

needed to guarantee repeatability

Self-describing means that from the configuration file alone we are able to derive the correct data structure [20].

Round-tripping means that if a data structure is serialized and then parsed again, we end up with an identical data structure [20].

The data structure could be a KeySet.

Examples

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- `/etc/timezone` rewritten by package tzdata
- tomcat6: files copied by user if `/etc/tomcat6/tomcat6.conf` does not exist but copy fails because later step creates `/etc/tomcat6/logging.properties` as root.

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- `/etc/timezone` rewritten by package tzdata
- tomcat6: files copied by user if `/etc/tomcat6/tomcat6.conf` does not exist but copy fails because later step creates `/etc/tomcat6/logging.properties` as root.
- mongodb: if installation fails, the group "mongodb" does not exist, failing at later tasks creating directories using this group

Checking Configurations (Recapitulation)

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Which properties of configuration settings can be checked?

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Which properties of configuration settings can be checked?

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

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What are the goals of checking SpecElektra?

- 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.

CM languages

Proteus (PCL)

Proteus [21] shows the tight relation between software configuration management, like Git or Svn, and configuration specification languages. Proteus (PCL) combines both worlds in a powerful build system.

```
family CalcProg
    attributes
        HOME : string default "/home/ask/proteus/test";
        workspace := HOME ++ "/calc/src/"; // string concatenation
        repository := "calc/";
        end
    physical
        main => "main.C";
        defs => "defs.h";
        exe => "calc.x" attributes workspace := HOME ++ "/calc/bin"; end
        classifications status := standard.derived; end;
    end
end
```

NIX

The NIX language [9] claims to be purely functional as a novel feature. The main concept is the referential transparency both for the configuration specification language and for the system itself.

Expressiveness: NIX expressions, for example functions, describe how to build software packages.

Reasoning: Because of the referential transparency of the system itself, every solution derived from the NIX expressions should be valid, so no reasoning or conflict handling is necessary.

Modularity: The NIX expressions are modular because they ensure absence of side effects and thus can be easily composed.

Reusability: Derivations that describe atomic build actions are reused in other derivations.

UML

Felfernig et al. [10, 11, 12] describe an approach where the unified modeling language (UML) is used as notation.

Expressiveness: All UML features, including cardinality, domain-specific stereotypes and OCL-constraints are available. The basic structure of the system is specified using classes, generalization and aggregation.

Reasoning: Customers provide additional input data and requirements for the actual variant of the product.

Modularity: Generalization is present without multiple inheritance with disjunctive semantics, i. e., only one of the given subtypes will be instantiated.

Reusability: For shared aggregation additional ports are defined for a part.

CFEngine

CFEngine [5, 6, 18] is a language-based system administration tool that pioneered idempotent behavior.

Expressiveness: CFEngine allows us to declare dependences and facilitates some high-level configuration specification constructs. In its initial variants it neither had validation specifications, cardinalities, nor higher-level relationships.

Reasoning: Not supported.

Modularity: Not supported.

Reusability: Existing system administrator scripts can be profitably run from CFEngine.

Quattor (Pan)

Cons and Poznanski [8] invented and used PAN for many machines within CERN.

Expressiveness: The Pan language allows users to specify data types, validation with code snippets and constraints. The compiler uses a 5 step process: compilation, execution, insertions-of-defaults, validation, and serialization.

Reasoning: Pan focuses on validating configurations, it is not able to generate new configurations. Pan provides type enforcement with embedded validation code.

Modularity: The language has user-defined data types (called templates) but otherwise has only minimal support for modularity.

Reusability: Reusability and collaboration is only possible via simple include statements and a simple inheritance mechanism of templates.

ConfValley (CPL)

Huang et al. [14] introduce systematic validation for cloud services. ConfValley uses a unified configuration settings representation for tens of different configuration file formats.
Expressiveness: CPL is not able to specify dynamic and complex requirements.
Reasoning: Constraints can be inferred by running an inference engine on configuration settings that are considered good (black-box approach). Within the validation engine, however, no constraint solver is available.
Modularity: CPL aims at easy grouping of constraints. Adding language primitives need modifications in the compiler.
Reusability: Using transformations and compositions, predicates can be reused in different contexts. Also with language constructs like `let`, specifications can be reused.

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- OpsMops (2019)

Error Messages

Motivation (Recapitulation)

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

```
[a]
  check/type:=long
[b]
  check/type:=long
[c]
  check/range:=0-10
  assign/math:=../a+../b
```

Task

Where should the error message point to if we change b to 10 (a is unchanged 1)?

Considerations (Recapitulation)

Task

What needs to be considered when designing error messages?

- Generic vs. specific plugins
- Precisely locate the cause (and do not report aftereffects)
- Give context
- Personification [16]

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[1] terms from classification, it is the numerical counterpart of soundness and completeness

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Implication

Missing error message means the configuration specification is not complete.

Context for error messages

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- for reporting bugs: show source code lines

Precise Location (Recapitulation)

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

Example Error Messages (Recapitulation)

```
Sorry, I was unable to change the configuration settings!
Description: I tried to set a value outside the range!
Reason: I tried to modify b to be 10 but this caused c to
        be outside of the allowed range (0-10).
Module: range
At: sourcefile.c:1234
Mountpoint: /test
Configfile: /etc/testfile.conf
```

Example Error Messages (Improvement)

```
Sorry, module range issued error C03100:
I tried to modify b to be 10 but this caused c to
be outside of the allowed range (0-10).
```

User View

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Who is the user of CM?

- End Users?

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- System Administrators (admins)?

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- The workshop was already dropped in the next year.
- The tenor is that “tools ... are not well aligned” [13].
- Research mainly looks at pre-CM. Manual administration is still standard (Source: e.g., Luke Kanies).

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- in LISA 2003 an informal poll asked about CM tools: the only user of each tool in the room at the time was its author [7]
- it is easy to invent CM tools (and configuration file formats)
- it is difficult to make it useful beyond your own goals

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- keep our infrastructure running

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- $\Longrightarrow$ the unsung heroes!

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- due to wrong assumption the admin communicated to everyone, people could not help
- there were several instances in which the admin ignored or misinterpreted evidence of the real problem
- eventually someone else solved the problem: admin confused "from"/"to" port in the settings and firewall blocked requests

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- lost semicolon: execution of script failed due to missing semicolon, then they tried to delete a non-existent table.
- crontab: onltape/ofltape confused because of discussion about offline backup (although an online backup should be performed).
- crit sit: many system administrators competed against each other trying to write a simple script. The crit sit continued for two weeks.

Haber and Bailey [13]

Later Haber and Bailey [13] repeated an ethnographic field study. The stories are similar to Barrett et al. [3]. Their study was also conducted in the same company. They created personas:

- database administrator
- web administrator
- security administrator

Database Administrator [13]

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- typical errors: stopping wrong database process

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Web Administrator [13]

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- moving from test to production done by hand

Security Administrator [13]

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- ad-hoc scripts

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- 90 % is spent with communicating with other admins
- only 6 % is gathering information and running commands
- quality control: monitoring found that non-functional service was down two days

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- CLIs were generally preferred
- configuration and log files are scattered, poorly organized and often used inconsistent terminology

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- both transient and persistent settings should be visible
- when errors occur: always display which changes have been made (modern approach is idempotence)

Apply to CM

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Idea

Replicate parts that work well, automate error-prone parts.

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- Elektra: set the value of a key

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- management (including knowledge)

Conclusion

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- Configuration specifications are helpful in different ways.
- Do not design around tools but design tools around you.
- Outlook: Go more in-depth into CM languages, contextualize with our topics

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