Configuration Management

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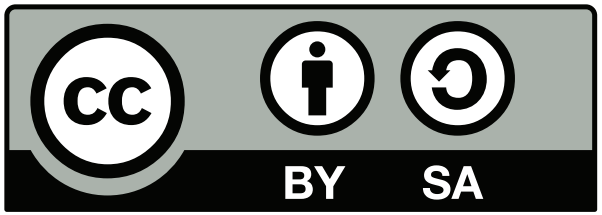


Organization

Schedule:

- 15.6.2018: last corrections of team exercise
- 22.6.2018: oral test

Popular Topics

- 4 validation
- 4 user interface
- 3 tools (benefits?)
- 3 testability
- 3 complexity reduction (when conf. needed?)
- 3 architectural decisions
- 2 Puppet
- 2 modularity
- 2 environment variables
- 2 documentation
- 2 configuration specification
- 2 command-line args
- 2 code generation
- 1 variability
- 1 self-description
- 1 round-tripping
- 1 early detection
- 1 introspection
- 1 dependences
- 1 auto-detection
- 1 context-awareness
- 1 administrators

User View

User View

Who is the user of CM?

- End Users?
- Developers (devs)?
- System Administrators (admins)?

System Administrator Research

- System administrators: the unsung heroes!
- Interest of understanding administrators emerged around 2002 [1].
- Typical methods are surveys, diary studies, interviews and observations (ethnographic field studies).
- Field studies also done in industry [3].
- Barrett [2] tried to initiate a workshop at CHI 2003 to draw the attention of the HCI community towards system administration.
- The workshop was already dropped in the next year.
- The tenor is that “tools ... are not well aligned” [6].
- Research mainly looks at pre-CM. Manual administration is still standard (Source: e.g., Luke Kanies).

CM research

In the meanwhile at Large Installation System Administrator Conference (LISA):

- began at CFengine Workshop at LISA 2001
- CM workshop by Paul Anderson [1]
- 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 [5]
- it is easy to invent CM tools (and configuration file formats)
- it is difficult to make it useful beyond your own goals

Tasks

What do system administrators do?

- keep our infrastructure running
- coordinate
- do backups
- manage hardware
- do inventory
- install applications
- manage security
- configure applications
- troubleshoot

7 people, 1 command-line [3]

- system administrator misunderstood problem (had a wrong assumption)
- 7 people sought attention and trust, competing to tell the admin what to do
- 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

other cases [3]

- 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 [6]

Later Haber and Bailey [6] 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 [6]

- frequent contact via phone, e-mail and IM
- needs to work on weekends
- pair-programming for new tasks
- typical errors: stopping wrong database process

Web Administrator [6]

- crit sit
- deploying new Web applications
- about 20-400 steps to deploy an application
- moving from test to production done by hand

Security Administrator [6]

- gets emails on suspicious activities
- multi-user chat
- ad-hoc scripts

Haber and Bailey [6]

- "if data is lost...that is when you write your résumé."
- 90 % is spent with communicating with other admins
- 20 % of the time is spent in diversions [3]
- 20 % of the time people communicated about *how to communicate* [3]
- 6 % is gathering information and running commands
- quality control: monitoring found that non-functional service was down two days
- CLIs were generally preferred
- configuration and log files are scattered, poorly organized and often used inconsistent terminology

Findings [3]

- syntax checking is essential
- replicating actions (e.g., to production) is error-prone
- undo not available
- do not assume a complete mental model ("if understand the system is a prerequisite [...], we are lost")
- do not assume programming skills (only 35 % reported having a bachelor's degree)
- trust in CLI tools but little trust in GUIs (is the information up-to-date?)
- errors while executing scripts lead to inconsistent state, rerunning often does not work (if not idempotent)

Design Principles [6]

Many design principles for tools were given [6]:

- configuration and logs should be displayed in a uniform way
- APIs/plugins for tools should be provided
- errors in configuration need to be discovered quickly
- confusion of similar settings should be avoided: add links, explain interactions
- provide means of comparing configuration settings
- provide consistent profiles of information
- both transient and persistent settings should be visible
- when errors occur: always display which changes have been made (modern approach is idempotence)

Configuration Management

Apply to CM

What can we learn from system administration?

- \+ intensive review process catches errors
- – collaboration ineffective
- – context/situational awareness is essential
- \+ precise editing of configuration files works well
- – global optimizations difficult
- \+ self-written tools are very efficient

Idea

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

Precise Editing

Partial modifications (precise editing) is natural for humans.
It ensures preservations of (potentially security-relevant!) defaults.
In CM, however, following methods are used:

- embed shell commands to do the work
- replace full content of configuration files
- replace full content of configuration files with templates
- line based manipulation (e.g., file_line): match line and replace it
- Augeas/XML: match a key with XPath and replace it
- Elektra: set the value of a key

Key/value access in puppet-libelektra:

```
1  kdbmount {'system/sw/samba':
2       ensure => 'present',
3       file => '/etc/samba/smb.conf',
4       plugins => 'ini'
5  }
6  kdbkey {'system/sw/samba/global/workgroup':
7       ensure => 'present',
8       value => 'MY_WORKGROUP'
9  }
10 kdbkey {'system/sw/samba/global/log level':
11      ensure => 'absent'
12 }
```

Uniqueness of keys is essential. Ideally, applications already mount their configuration at installation.

Apply to CM

Elektra's goals are that it should:

- be easy to develop new high-level tools
- support manual workflows and scripts
- support precise editing:
  only change the configuration value as specified
- provide a language for both devs and admins

Admins/devs still need to:

- reduce the configuration space
- intensively review and improve the specifications
- test (and debug) configuration settings

Key/value specifications in puppet-libelektra:

```
kdbkey {'system/sw/samba/global/log level':
    ensure => 'present',
    value => 'MY_WORKGROUP',
    check => {
        'type' => 'short',
        'range' => '0-10',
        'default' => '1',
        'description' => 'Sets the amount of log/
            debug messages that are sent to the
            log file. 0 is none, 3 is consider-
            able.'
}
```

Ideally, applications already specify their settings.

Key/Values Revisited

Decide the **changeability** per key:

- Who is responsible (end user, packages, admin manual or CM).
- In which namespaces apps search the key (cascading lookup).
- Who can see it (visibility).
- Who can edit it (admin, end user, both).
- Which configuration values are allowed (validation).

Changeability

Ownership of every key must be very clear and documented.

Key/value specifications in puppet-libelektra:

```
kdbkey {'spec/xfce/pointers/Mouse/RightHanded':
    ensure => 'present',
    check => {
        'namespaces/#0' => 'user',
        'namespaces/#1' => 'system',
        'visibility' => 'important',
        'default' => 'false',
        'check/type' => 'boolean'
}
```

Ideally, applications already specify their settings.

Layers of Abstractions

Recursively define useful abstractions (meta-levels):

- Bits in (configuration) files and memory
- Key/value view of configuration settings
- Goals/specifications of settings per node and instantiations of modules

- CM code to instantiate settings in the whole network
- Global optimization: allocation of nodes and decision regarding topology in the whole network
- Global goals/specifications of the whole network

Design Rules [5]

- Factor processes into containers to avoid overlaps in settings.
- Maintain clear separation of ownership (for every key).
- Specify replicated settings in a single source (use links and derivations).
- Document all remaining overlaps (in the specification).
- The manageability of settings is reduced by the number of possible configuration values.
- Do not separate configuration management and monitoring.

Open Topics

- global optimizations/self-healing
- configuration integration
- safe migrations of settings and data
- collaboration
- management (including knowledge)
- centralized vs. distributed

Conclusion

- create stateless transactions with key/values (get/set)
- be aware of the specifications, solving CM is solving constraints
- do not design around tools but design tools around you
- be brave and remove all configuration settings you can
- use all help you can get: e.g. build tools, preseeding, installer automation, virtualization, package managers, distributions
- complexity in CM vs. complexity in applications' specification
- modularity is essential for validation and legacy support
- artifact generation improves consistency and type safety

Recapitulation

Introspection (Recapitulation)

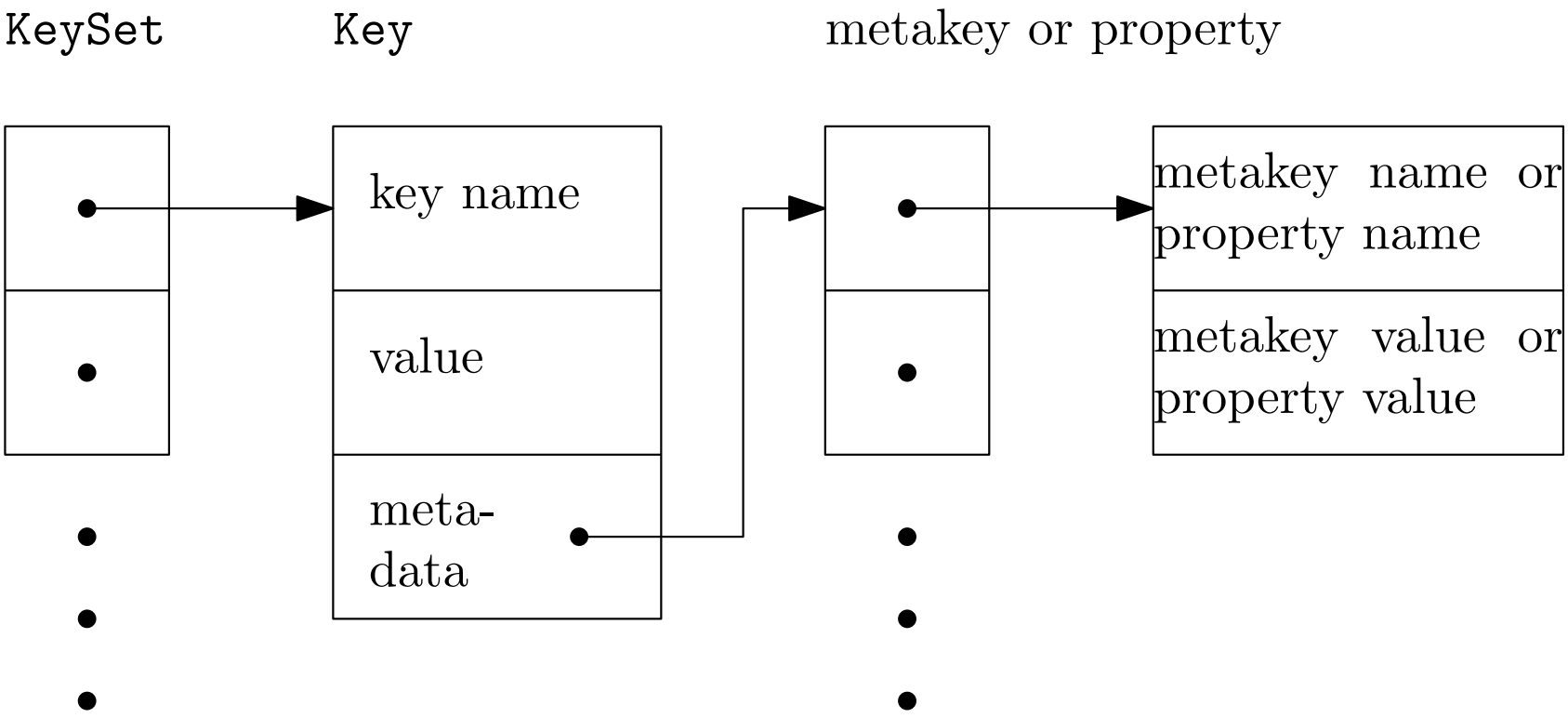
Task

What is internal and external specification? What is introspection?

- *internal*: within applications' source code
- *introspection*: unified get/set access to (meta*)-key/values
- access via applications, CLI, GUI, web-UI, ...
- access via any programming language (similar to file systems)
- GUI, web-UI can semantically interpret metadata
- assemble modular parts (validation, logging, ...)
- needed as communication between producers and consumers
- essential for ***no-futz computing*** Holland et al. [7]

KeySet (Recapitulation)

The common data structure of Elektra:



Testing (Recapitulation)

Task

What do we want to test?

- That settings do what they should (devs and admins)
- That settings are properly validated (devs [18])
- Regression tests (devs [12])

- Are all settings implemented? (devs)
- Are all settings used in tests? (devs)
- Are there unused settings in the code? (devs)
- Do the chosen settings work? (admins)

Early detection (Recapitulation)

Task

When do we want to detect misconfiguration?

Phases when we can detect misconfigurations:

- Compilation stage in configuration management tool
- Writing configuration settings on nodes
- Starting applications (load-time)
- When configuration setting is actually used (run-time)

Problem

Earlier versus more context.

Notification (Recapitulation)

Task

Why do we need notification?

1. to keep transient and persistent configuration settings always in sync [9]
2. to avoid polling of configuration settings
3. to better integrate into already existing mechanisms (main loops)[1]

Requirement

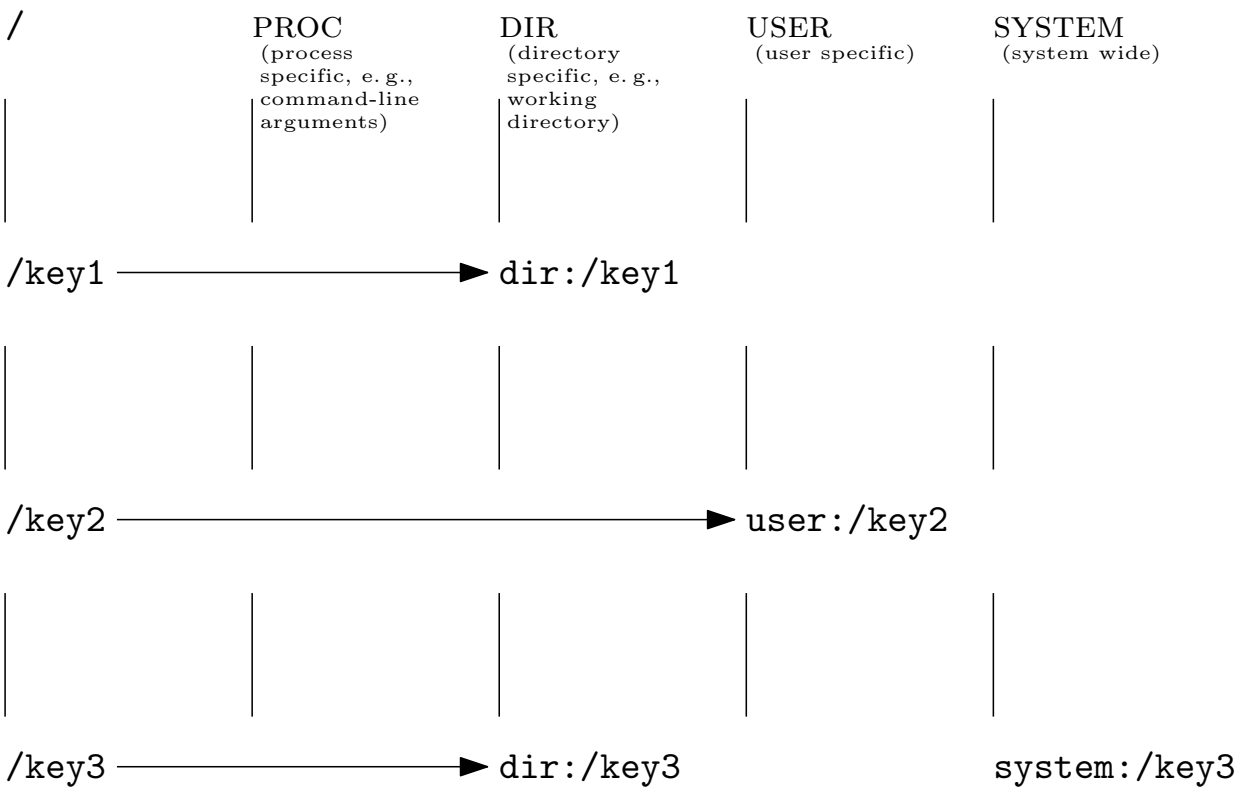
Configuration libraries must provide ways to keep transient and persistent views consistent.

[1] Is one of the main reasons why most framework already integrate configuration settings.

Cascading (Recapitulation)

Task

What is cascading configuration?



Contextual Values (Recapitulation)

Task

What are contextual values?

Tanter [16] introduced a lightweight extension to context-oriented programming: ***Contextual values*** are variables whose values depend on the context in which they are read and modified. They *"boil down to a trivial generalization of the idea of thread-local values"*. The key idea is to use layers as *"discriminate amongst possible values, not only the current thread"* [16]. Side effects are limited to the respective context [13].

Introspection vs. Code Generation (Recapitulation)

Task

Advantages/Disadvantages of key database (vs. code generation)?

- \+ specification can be updated live on the system without recompilation
- \+ tooling has generic access to all specifications
- \+ new features the key database (e.g., better validation) are immediately available consistently
- – less techniques for performance improvements
- – contextual values cannot be used if context differs within same thread

Implication

We generally prefer introspection, except for a very thin configuration access API.

Definition Configuration Management (Recapitulation)

Task

What is Configuration Management?

- is a discipline in which configuration (in the broader sense) is administered.
- makes sure computers are assembled from desired parts and the correct applications are installed.
- has means to describe the desired configuration of the whole managed system.
- ensures that the execution environment of installed applications is as required.

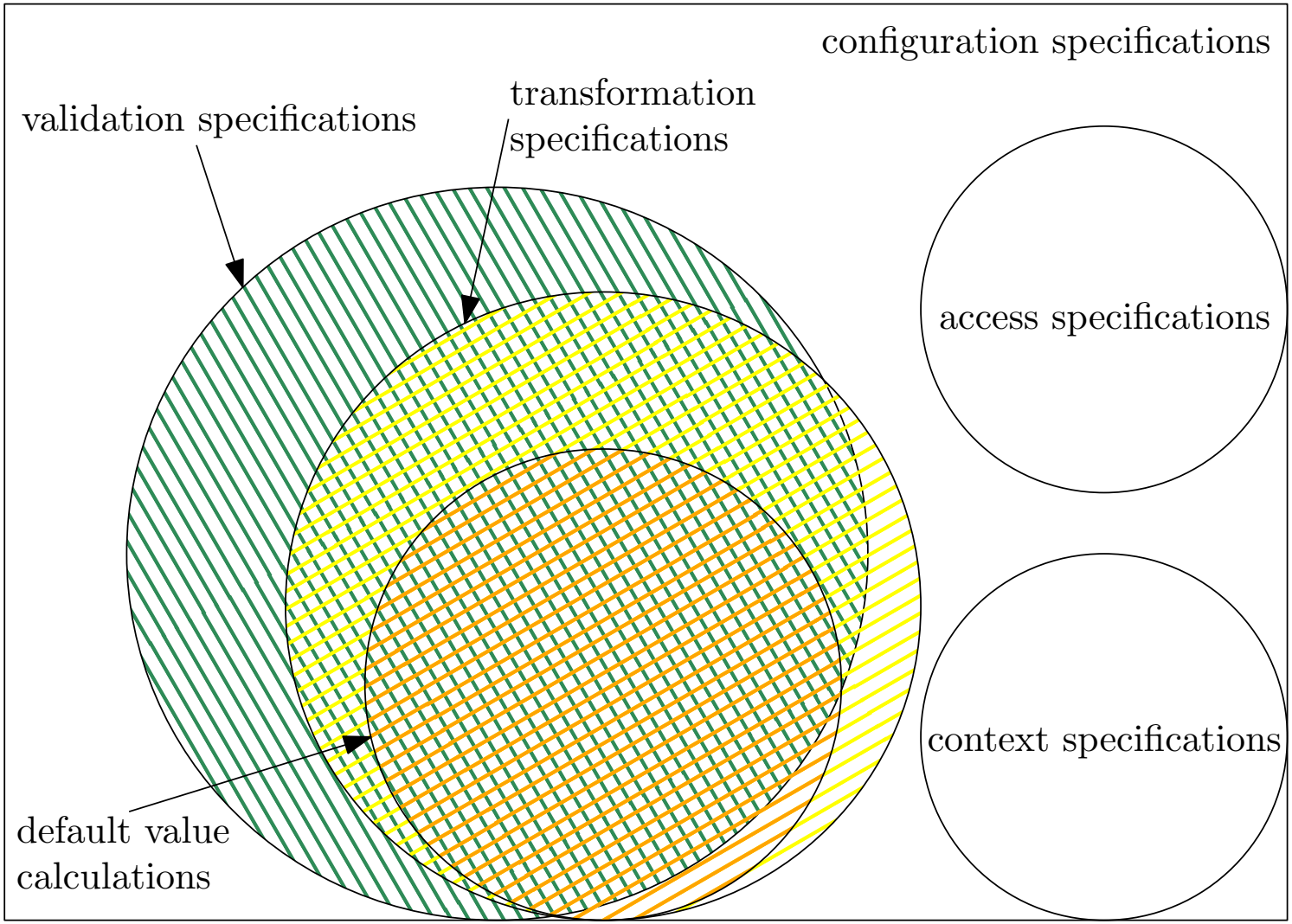
Possible Benefits of CM (Recapitulation)

Task

What are the goals of Configuration Management?

- The same goals scripts have:
  Documentation, Customization, Reproducability
- Declarative description of the system
  Single Source of Truth (Infrastructure as Code [8])
- Auditability
- Less configuration drift
- Error handling
- Pull vs. Push
- Reusability

Types of Specifications (Recapitulation)



Configuration Specification (Recapitulation)

Task

How can we combine configuration specifications and configuration management?

- configuration settings are simply an instantiation of the configuration specifications. Code describing the instantiation is **CM code**.
- 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?

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
- ...

Idempotence (Recapitulation)

Task

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

Idempotent yield the same configuration with any number of applications from CM code ($n \geq 1$) [8]:

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

needed to guarantee repeatability

Self-describing means that from the configuration file alone we are able to derive the correct internal representation. [15]

Round-tripping means that if a file is serialized and then parsed again, we end up with an identical internal representation. [15]

Checking Configurations (Recapitulation)

Task

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)

Popular CMs today (Recapitulation)

- CFengine
- LCFG
- Config Mgmt
- Quattor
- Puppet
- Chef
- Ansible (Talk next week)
- SaltStack (Talk today)
- Rudder
- Spacewalk

Elektra (Recapitulation)

Task

What is Elektra?

- is not only a key database but a specification language to describe a key database
- plugins implement the specification (could be distributed but focus is configuration files)
- is library based (no single point of failure, no distributed coordination needed)
- supports transactions (persisting whole KeySets at once)
- supports integration of existing configuration settings

Error Messages (Recapitulation)

Task

What needs to be considered when designing error messages?

- error messages are often the sole data source for admins
- configuration design first: avoid errors if possible
- error messages should not leak internals [4]
- "edit here mentality": do not point to correct statements [11]
- Precisely locate the cause (and do not report aftereffects)
- Personification [10]
- give context: providing enough information vs. not overwhelming the user [17]

Context for error messages (Recapitulation)

Task

What should error messages contain?

- pin-point key (which also pin-points to the specification)
- repeat relevant parts of values and the specification
- show mountpoint (to make relative keys unique)
- show file name and line number
- ? show module and source code lines (for bugs)

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