Configuration Management

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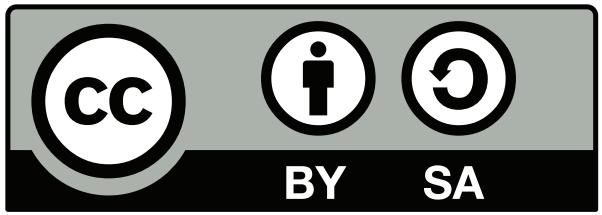


Lecture is every week Wednesday 09:00 - 11:00.

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, HS: kleiner Schiffbau
03.04.2019: first issue done, PR for second
10.04.2019: mid-term submission of exercises
08.05.2019: (HS?)
15.05.2019:
22.05.2019:
29.05.2019:
05.06.2019: final submission of exercises
12.06.2019:
19.06.2019: last corrections of exercises
26.06.2019: exam

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

Tasks for today

(until 27.03.2019 23:59)

Task

Description of homework as pull request in private repo. (Inside a folder for you, use GitHub name.)

Task

Description of teamwork (which application, which CM tool) as pull request in private repo. (Inside a folder for your team.)

Task

Fix at least one issue and write some text in at least one other issue.

Slides

- slide numbering: 02a is after 02
- old slides in same repo: always check date

Some misconfigurations

- studycode is Studienkennzahl
- same name twice in TALKS.xml
- ...

Task

How did these misconfigurations happened?

Tasks for next week

(until 03.04.2019 23:59)

Task

Fix misconfigurations in private repo.

Task

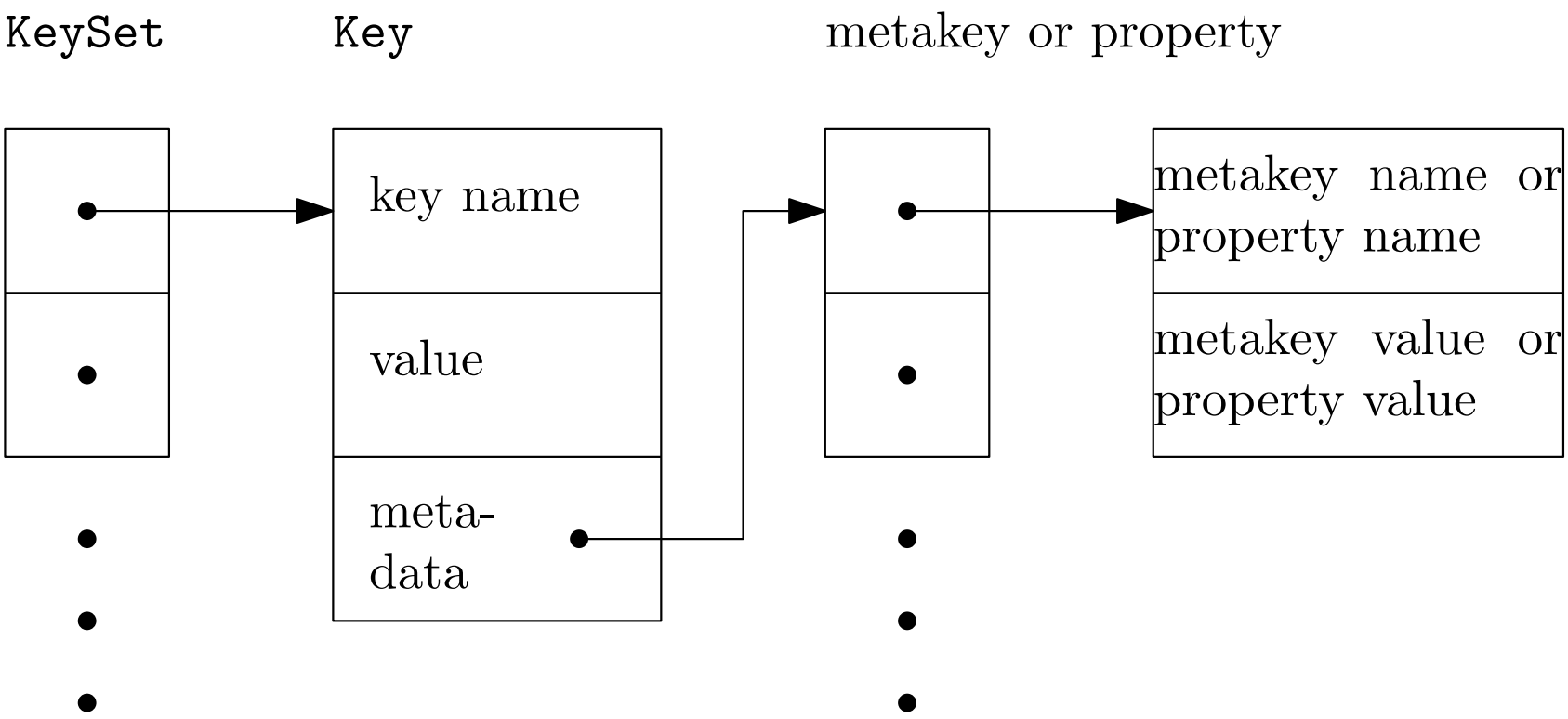
Fix feedback about homework/teamwork. Calculate complexity of your teamwork.

Task

First issue done, PR for second issue and write some text in at least one other issue (if 5 issues are not yet assigned to you).

KeySet (Recapitulation)

The common data structure between plugins:



Recapitulation

Q: "Which configuration systems/libraries/APIs have you already used or would like to use in one of your FLOSS project(s)?"

- command-line arguments (92 %, $n = 222$)
- environment variables (79 %, $n = 218$)
- configuration files (74 %, $n = 218$))

Semantics of Command-line Arguments (cont.)

- passed by main for a new process via (`int argc, char ** argv`)
- visible from other processes (e.g., via `ps aux`)
- could be passed along to subprocesses but hardly done
- need to be parsed by process
- portability: differences in parsing
- cannot be changed from outside (requires restart, no IPC)

Talk

Miruna Orsa
Using XML in the day to day work life

Environment Variables

Semantics

- are also per-process (`/proc/self/environ`)
- are not visible from other processes
- are automatically inherited by subprocesses
- need to be parsed by process (`[extern] char **environ`) but API is provided (`getenv`)
- cannot be changed from outside (requires restart or an additional IPC mechanism)

getenv

- is widely standardized, including SVr4, POSIX.1-2001, 4.3BSD, C89, C99 [1],
- is supported by many programming languages, and
- enforces `key=value` convention.

Usage

1. bypassing other configuration accesses (*Q:* 45 %)
2. locating configuration files
3. debugging and testing (*Q:* 55 %, *S:* 1,152, i. e. 43 %)
4. sharing configuration settings across applications (*Q:* 53 %, *S:* 716, i. e. 47 %)
5. for configuration settings unlikely to be changed by a user (*Q:* 20 %)
6. *"even when it is used inside a loop"* (*Q:* 2 %)

Portability

- no separators for values defined
- case sensitivity problems
- often many environment variables for the same purpose: TMP, TEMP, or TMPDIR
- sometimes one environment variable for different purposes: PATH

Task

What is wrong with the code in the book?

How can we deal with the many sources?

Requirement

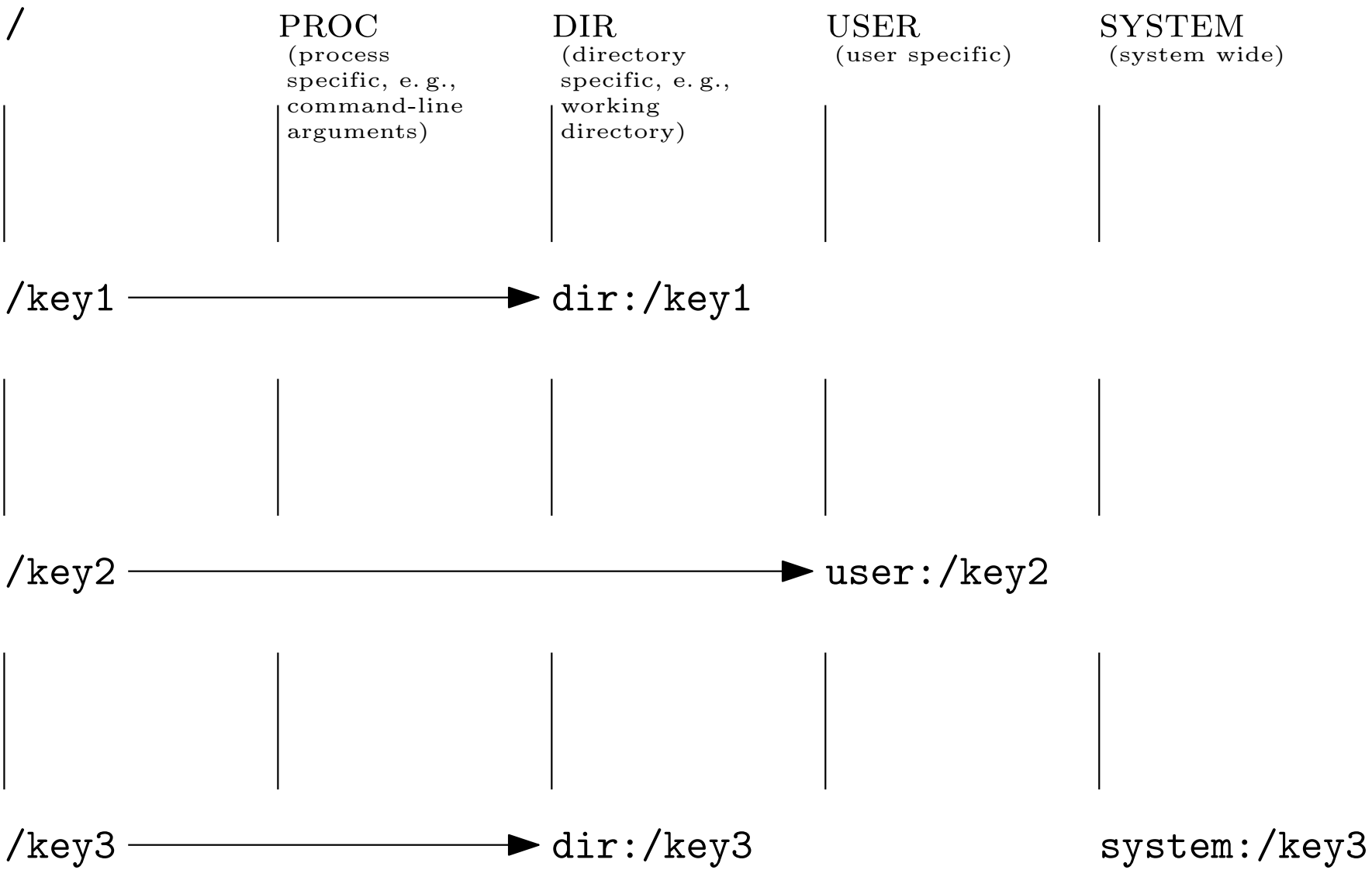
A configuration library must support all three popular ways for configuration access: configuration files, command-line options, and environment variables.

Example: Elektra

- includes library libopts
- which provides the function
  `int elektraGetOpts (KeySet, argc, argv, environ, Key)`
- which puts Keys in the `proc` namespace
- `https://www.libelektra.org/tutorials/command-line-options`

What is a namespace?

Cascading


/
PROC
(process specific, e. g., command-line arguments)
DIR
(directory specific, e. g., working directory)
USER
(user specific)
SYSTEM
(system wide)
/key1
dir:/key1
/key2
user:/key2
/key3
dir:/key3
system:/key3

Task

Discuss the differences of mounting and cascading with your neighbor.

User View

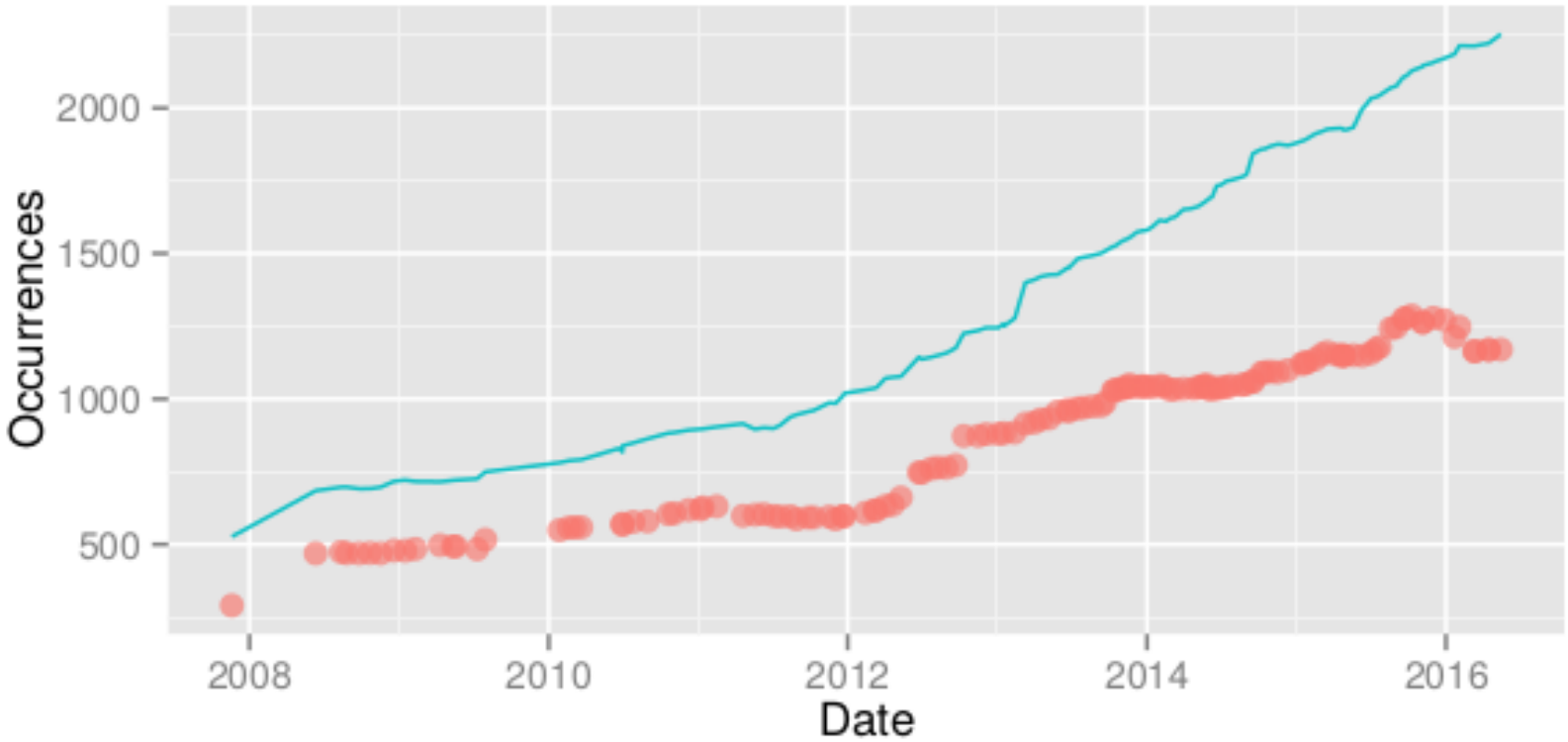
- command-line for trying out configuration settings
- environment variables for configuration settings within a shell
- configuration files for persistent configuration settings

Conclusion

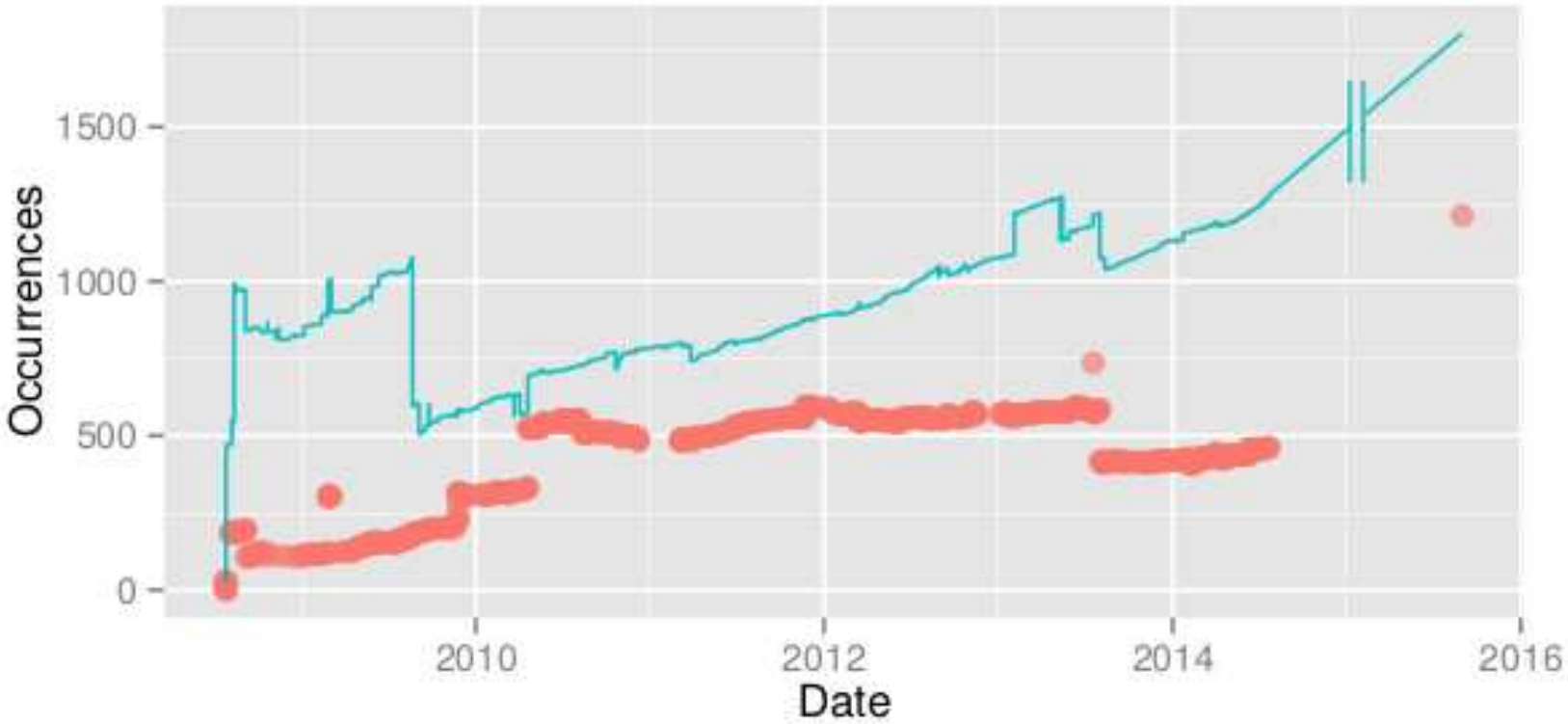
- three different configuration sources widely used
- all three used for different reasons but often for the same configuration settings
- many different configuration file formats
- abstractions: key-value, mounting, and cascading

Complexity

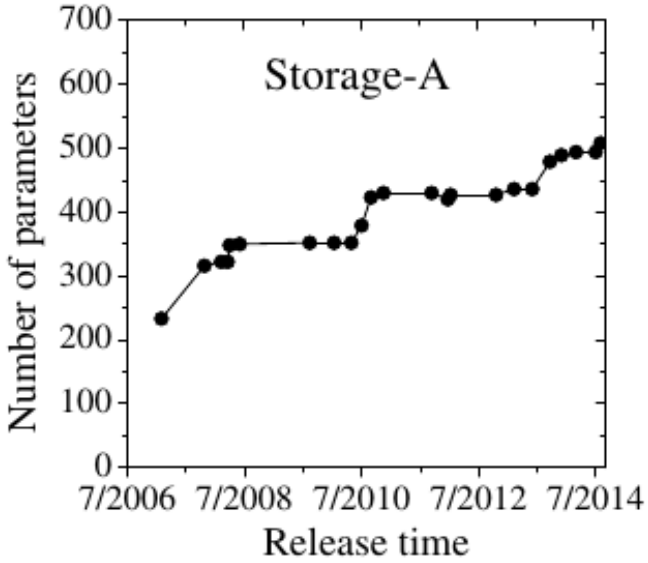
Trend Firefox

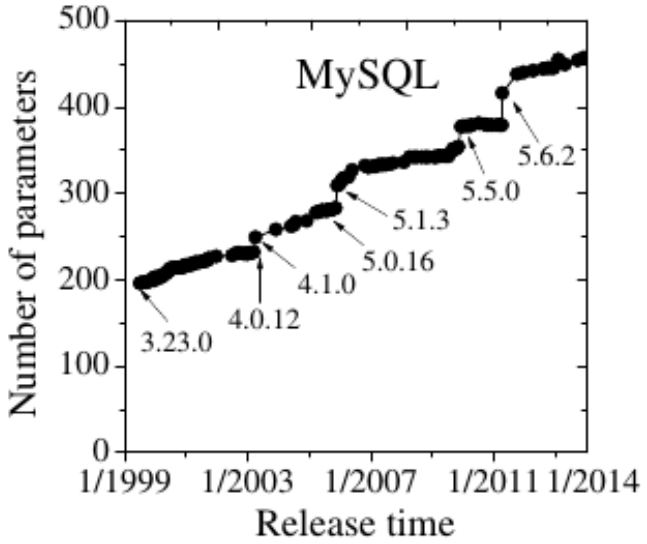


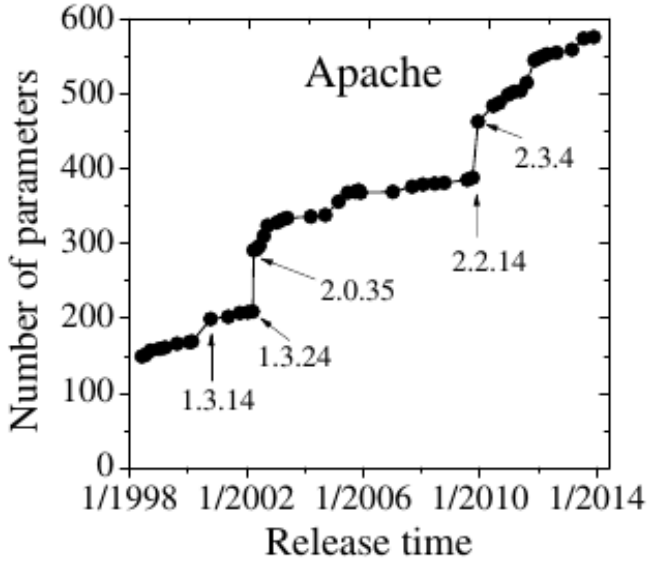
Trend Chromium

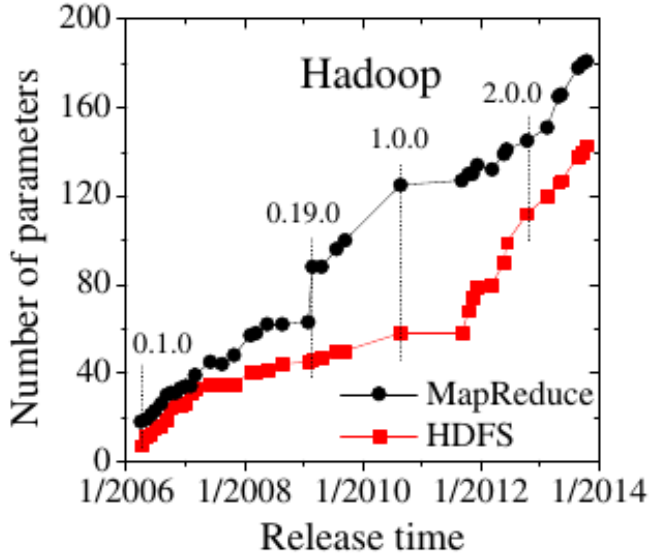


Trend Configuration Files









Xu et al. [8]

Types of Complexity

- complexity in access:
  - many different formats
  - non-uniformity
  - transformations
- configuration settings
  - number of settings s
  - number of values n
  - dependences between settings

Calculation of Complexity

Using enumerative combinatorics:

- number of configurations: n^s
- for N groups of different n and s (i.e., $n_1 \ldots n_N$ with $s_1 \ldots s_N$ occurrences):

$$\prod_{i=1}^{N} n_i^{s_i}$$

- more difficult to calculate (or unbounded) for dependences, module instantiations, arrays, ...

Calculation of Complexity

Examples:

- 600 boolean settings in Apache httpd (let us assume $n = 2$): $2^{600} \approx 10^{180}$
- 19 integer settings: $2^{32^{19}} = 2^{32 \cdot 19} = 2^{609} \approx 10^{183}$
- 2000 boolean settings in Firefox [4]: $2^{2000} \approx 10^{602}$

Task

Break.

Calculation of Complexity (cont.)

Examples:

- for 20 boolean and 20 enums with 5 possibilities:

$$2^{20} * 5^{20} = 10^{20}$$

- MySQL has 461 settings, of which 216 are non-simple types [8] (let us assume $n = \{3, 20\}$): $3^{245} * 20^{216} \approx 10^{397}$ (settings are explained in 5560 pages[1])
- an array with $1 - 20$ boolean settings: 2^{20}

[1] https://downloads.mysql.com/docs/refman-5.7-en.pdf

Task

Calculate complexity of your teamwork and add to PR.

See scripts/complexity.rb

Decision Tree

- configuration settings may depend on each other
- form a decision tree [2, 7]
- the decision tree is an instantiation of chosen configuration settings
- calculation only needs to consider instantiations which make a difference:
  essential configuration complexity [5]

Harmful Defaults [8]

- Problem: Two major data losses on a dozen machines.
- Cause: Stayed with the default values of the data-path settings (e.g., `dfs.name.dir`, `dfs.data.dir`) which point to locations in `/tmp`. Thus, after the machines reboot, data losses occur. "One of the common problems from users." (from Cloudera)
- up to 53 % of misconfigurations is due to staying at defaults
- 17 % to 48 % of configuration issues are about difficulties in finding settings

Unnecessary Settings [8]

- Configuration Parameter: `dfs.namenode.tolerate.heartbeat.multiplier`
- Developers' Discussion: Since we are not sure what is a good choice, how about making it configurable? We should add a configuration option for it. Even if it's unlikely to change, if someone does want to change it they'll thank us that they don't have to change the code/recompile to do so.
- Real-World Usage:
  - No usage found by searching the entire mailing lists and Google.
  - No usage reported in a survey of 15 Hadoop users in UCSD.

Unnecessary Settings [8]

- 6 % to 17 % of settings set by majority
- up to 54 % are seldom set
- up to 47 % of numeric settings have no more than five distinct values

Reduction

Q: "Why do you think configuration should be reduced?"

- to simplify code maintenance (50 %),
- to prevent errors and misconfiguration (43 %),
- to provide better user experience (40 %),
- ***"I do not think it should be reduced"* (30 %)**,
- because they prefer auto-detection (29 %)
  (with a possibility to override configuration settings: 32 %),
- *"because use-cases which are rarely used should not be supported"* (13 %),
- *"never find time for this task"* (9 %), and
- *"because only standard use-cases should be supported"* (1 %)

Question

How to specify reduction strategies of configuration settings?

Answer

Configuration Specification

Configuration Specification

Rationale

- without specification you and others do not even know which settings are available
- needed for any further techniques we will discuss
- essential for ***no-futz computing*** Holland et al. [3]
- the foundation for any advanced tooling like configuration management tools
- needed as communication of producers and consumers of configuration

[1] *getenv(3) Linux User's Manual*, March 2017.

[2] Krzysztof Czarnecki, Paul Grünbacher, Rick Rabiser, Klaus Schmid, and Andrzej Wąsowski. Cool features and tough decisions: A comparison of variability modeling approaches. In *Proceedings of the Sixth International Workshop on Variability Modeling of Software-Intensive Systems*, VaMoS '12, pages 173–182, New York, NY, USA, 2012. ACM. ISBN 978-1-4503-1058-1. doi: 10.1145/2110147.2110167. URL `http://dx.doi.org/10.1145/2110147.2110167`.

[3] David A. Holland, William Josephson, Kostas Magoutis, Margo I. Seltzer, Christopher A. Stein, and Ada Lim. Research issues in no-futz computing. In *Hot Topics in Operating Systems, 2001. Proceedings of the Eighth Workshop on*, pages 106–110. IEEE, May 2001. doi: 10.1109/HOTOS.2001.990069.

[4] Dongpu Jin, Xiao Qu, Myra B. Cohen, and Brian Robinson. Configurations everywhere: Implications for testing and debugging in practice. In *Companion Proceedings of the 36th International Conference on Software Engineering*, ICSE Companion 2014, pages 215–224, New York, NY, USA, 2014. ACM. ISBN 978-1-4503-2768-8. doi: 10.1145/2591062.2591191. URL http://dx.doi.org/10.1145/2591062.2591191.

[5] J. Meinicke, C. P. Wong, C. Kästner, T. Thüm, and G. Saake. On essential configuration complexity: Measuring interactions in highly-configurable systems. In *2016 31st IEEE/ACM International Conference on Automated Software Engineering (ASE)*, pages 483–494, Sept 2016.

[6] Markus Raab and Gergö Barany. Introducing context awareness in unmodified, context-unaware software. In *Proceedings of the 12th International Conference on Evaluation of Novel Approaches to Software Engineering - Volume 1: ENASE,*, pages 218–225. INSTICC, ScitePress, 2017. ISBN 978-989-758-250-9. doi: 10.5220/0006326602180225.

[7] Mark-Oliver Reiser. *Core Concepts of the Compositional Variability Management Framework (CVM): A Practitioner's Guide*. TU, Professoren der Fak. IV, 2009.

[8] Tianyin Xu, Long Jin, Xuepeng Fan, Yuanyuan Zhou, Shankar Pasupathy, and Rukma Talwadker. Hey, you have given me too many knobs! Understanding and dealing with over-designed configuration in system software. In *Proceedings of the 2015 10th Joint Meeting on Foundations of Software Engineering*, ESEC/FSE 2015, pages 307–319, New York, NY, USA, 2015. ACM. ISBN 978-1-4503-3675-8. doi:

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