L07 Strategies for Reduction of Misconfiguration

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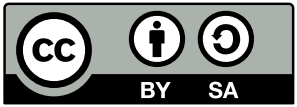

Terms and Properties

Learning Outcomes

Students will be able to

- remember terms of properties of CM.
- remember various strategies for reduction of misconfiguration.
- find unused settings.

Infrastructure as Code

Question

What is CM code? What is auditability? What is the goal of CM?

Configuration settings are an instantiation of the configuration specifications.

The instantiation code is implemented by **CM code**.

Auditability: Being informed about status and changes in the infrastructure.

Goal

Single Source of Truth

Configuration Drift

is a derivation of the "Single Source of Truth" (the CM code).

It is 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
- non-idempotent CM Code
- ...

Idempotence

idem + potence (same + power)

Yield same result with any number of applications ($n \geq 1$):

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

Example

Hummer et al. [1] tested 298 Chef scripts, of which 92 were non-idempotent:

- `/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

Siméon and Wadler [5] describe two further properties:

Self-describing means that from the configuration file alone we are able to derive the correct data structure [5].

Round-tripping means that if a data structure is serialized and then parsed again, we end up with an identical data structure [5].

The data structure could be a KeySet.

Round-tripping is a prerequisite of idempotence.

Examples

XML has neither of the last two properties Siméon and Wadler [5]:

- internal representation crucially depends on XML schema
- union of integer and strings

```
1 intOrStr { "one", "2", 3 }
2 <fact>one 2 3</fact>
3 intOrStr { "one",  2,  3 }
```

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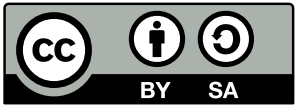

Pitfalls

Harmful Defaults [7]

- 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

Question

What do we want to test?

- That settings do what they should (devs and admins)
- That settings are properly validated (devs [6])
- Regression tests [4]

- Are all settings implemented?
- Are all settings used in tests?
- Are there unused settings in the code?

Matt Welsh from Google wrote in 2013:[1]

"Of course we have extensive testing infrastructure, but the 'hard' problems always come up when running in a real production environment, with real traffic and real resource constraints. Even integration tests and canarying are a joke compared to how complex production-scale systems are."

[1] What I wish systems researchers would work on. Retrieved from http://matt-welsh.blogspot.com/2013/05/what-i-wish-systems-researchers-would.html.

Jin et al. [2]

- Wants to improve configuration-aware testing and debugging
- Manual investigations for three applications
- Finds 1957 settings in Firefox ($2^{846} * 3^{1111}$) and 36322 in LibreOffice ($2^{4433} * 3^{31889}$)
- Finds unused settings: settings only in the source code
- Finds configuration settings which are not specified

Requirement

Configuration setting traceability is a necessity.

Idea

Code generation helps to trace settings and to find unused settings.

Testing by developers:

- ConfErr [3] uses models of key board layout, psychology and linguistics. Tool injects possible misconfiguration.
- Spex [6] analyzes the source code to find misconfigurations. As by-product it extracts internal specifications (including transformation bugs).
- External specification can be directly used to generate test cases.
- Find unused configuration settings.

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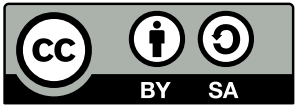
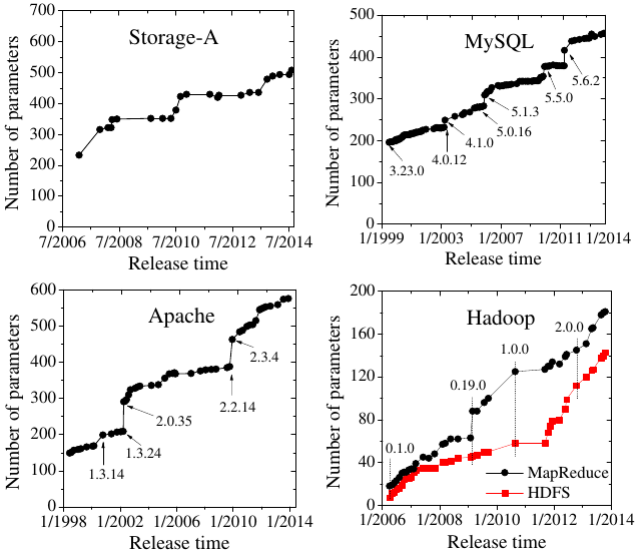


Unused Settings

Trend Configuration Files (Recapitulation)



Xu et al. [7]

Unnecessary Settings [7]

- 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 [7]

- 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 %)

Limitations of Zero-Configuration

- e.g. gpsd[1]
- broken hardware or protocols
- auto-detection may go wrong
- the configuration actually lives elsewhere (e.g., in the GPS devices)

[1] `www.aosabook.org/en/gpsd.html`

Visibility

- idea: show only relevant settings for specific user group
- or disallow editing: accessibility
- requires user-feedback loops [7]
- most-used settings should be best visible (or even enforce them to be changed: against harmful defaults)
- think of your users (administrators),
  only expose what users need
- write an rationale why someone needs it
- visibility should not be an excuse to add not-needed settings

Example

```
1 [slapd/threads/listener]
2 visibility:=developer
3
4 [slapd/access/#]
5 visibility:=user
```

Find Unused Settings

The first (optional) step of the algorithm is:

- Run all tests with code coverage.
- Check if generated code is executed.
- If it is, we know that the configuration setting is used in a test case. Otherwise, we know it is not tested by the test suite. All these untested configuration settings are remembered as candidates for the second step.

```
1  KeySet findUnusedSettings (KeySet untestedSettings,
2                 KDB kdb,
3                 Builder build)
4  {
5     KeySet unusedSettings = {};
6     KeySet configurationSpecification;
7     kdb.get (configurationSpecification);
8
9     for (candidate: untestedSettings)
10    {
11        configurationSpecification.remove (candidate);
12        kdb.set (configurationSpecification);
13        build.recompile ();
14        if (build.wasSuccessful ())
15        {
16           unusedSettings.append (candidate);
17        }
18        configurationSpecification.append (candidate);
19    }
20
21    kdb.set (configurationSpecification);
22    return unusedSettings;
23 }
```

Conclusion

- Definition and challenges in configuration management.
- Properties: self-describing, idempotent, round-tripping.
- Awareness and responsibility needed.
- Avoidance of misconfiguration is combined effort of devs and admins.

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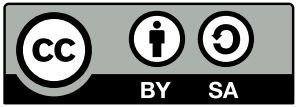

Meeting

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Single Source of Truth

Brainstorming: Strategies for Reducing Misconfiguration

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Properties (Recapitulation)

Task

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

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

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

needed to guarantee repeatability

Self-describing means that from the configuration file alone we are able to derive the correct data structure [5].

Round-tripping means that if a data structure is serialized and then parsed again, we end up with an identical data structure [5].

The data structure could be a KeySet.

Pitfalls of CM

- too many (unused) settings
- no external specification
- too complicated configuration design
- harmful defaults
- no configuration-aware tests
- settings and specs not synchronized

Reduction of Configuration Settings

- Zero-Configuration (auto detection)
- Visiblity
- Find unused settings (code generator needed)

T2 Plugin

Any open questions?
Today 13:00 office hour with tutor.

H3 Configuration Management Tools

- Install with given installation scripts
- Configure with your own CM code and your own configuration settings

Steps

1. In the meeting before the LWS meeting:
   Give yourselves roles (leader, admin, dev, user, ...).
2. Before the LWS meeting: do the preparation as described the LWS document (TUWEL).
3. In the LWS meeting: Create together an architecture that fulfils the goals and present some part of that architecture.

Today

1. Give yourselves roles (admin, dev, user)

Outlook

In the next lecture (LWS):

1. Create together an architecture that fulfils the goals.
2. Present that architecture, explain the concepts, show which technologies you found.

[1] Waldemar Hummer, Florian Rosenberg, Fábio Oliveira, and Tamar Eilam. Testing idempotence for infrastructure as code. In David Eyers and Karsten Schwan, editors, *Middleware 2013*, pages 368–388, Berlin, Heidelberg, 2013. Springer Berlin Heidelberg. ISBN 978-3-642-45065-5.

[2] 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`.

[3] Lorenzo Keller, Prasang Upadhyaya, and George Candea. Conferr: A tool for assessing resilience to human configuration errors. In *Dependable Systems and Networks With FTCS and DCC, 2008.*, pages 157–166. IEEE, 2008.

[4] Xiao Qu, Myra B. Cohen, and Gregg Rothermel. Configuration-aware regression testing: An empirical study of sampling and prioritization. In *Proceedings of the 2008 International Symposium on Software Testing and Analysis*, ISSTA '08, pages 75–86, New York, NY, USA, 2008. ACM. ISBN 978-1-60558-050-0. doi: 10.1145/1390630.1390641. URL http://doi.acm.org/10.1145/1390630.1390641.

[5] Jérôme Siméon and Philip Wadler. The essence of xml. pages 1–13, 2003. doi: 10.1145/604131.604132. URL http://dx.doi.org/10.1145/604131.604132.

[6] Tianyin Xu, Jiaqi Zhang, Peng Huang, Jing Zheng, Tianwei Sheng, Ding Yuan, Yuanyuan Zhou, and Shankar Pasupathy. Do not blame users for misconfigurations. In *Proceedings of the Twenty-Fourth ACM Symposium on Operating Systems Principles*, pages 244–259. ACM, 2013.

[7] 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: 10.1145/2786805.2786852. URL `http://dx.doi.org/10.1145/2786805.2786852`.