Assessing Performance Evolution for Configurable Systems

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September 27, 2017

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Configurable Systems

- Software systems provide configuration options (features)
- (De-)selecting options tune, dis- or enable functionality


```
~$ zip -e -9 file.txt
```

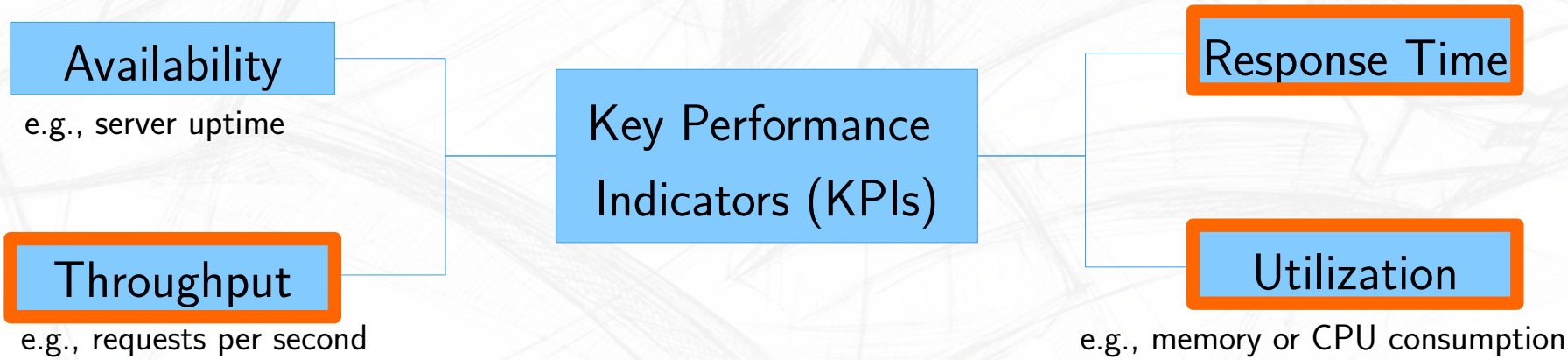
- Unanticipated behavior can emerge with selections of multiple features (feature interaction)
  - Example: Compression and Encryption

    *Compressing encryped data can be **faster** than compressing raw data, since encrypted data is already more „compact“.*

Performance

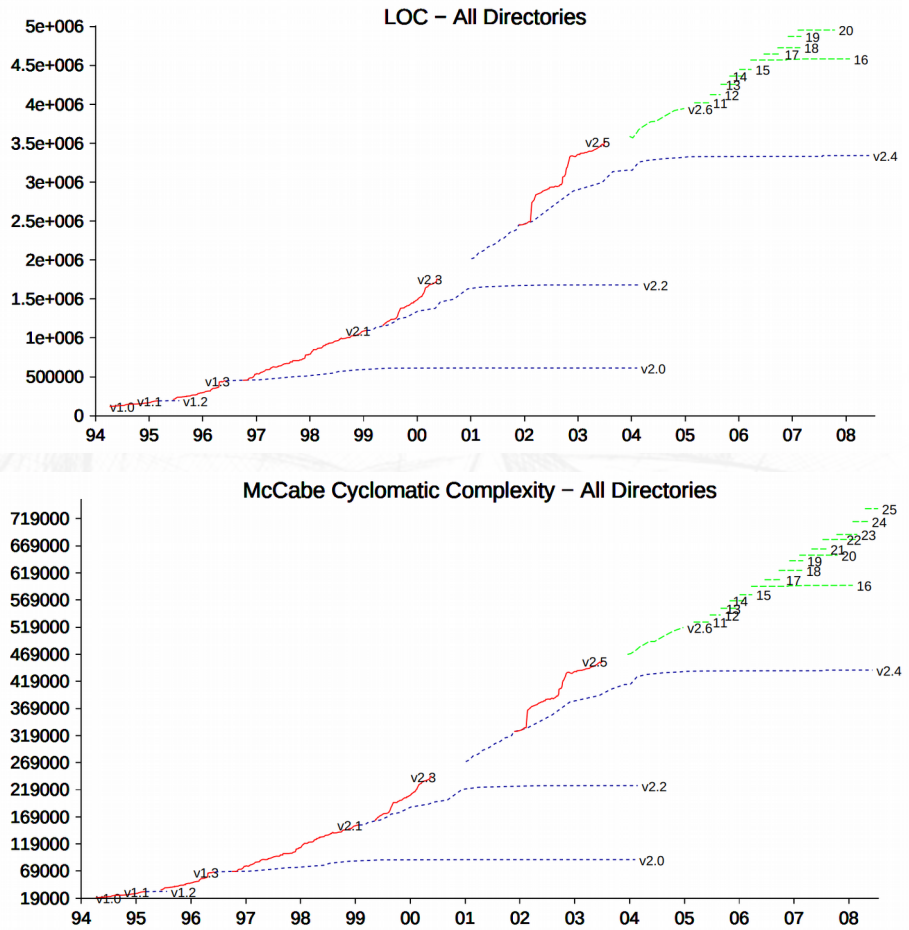
- Performance: How *successfully* is a task being performed?

- Software performance is described by four categories:



Software and Performance Evolution

- Evolution: Adaption to changing contexts/requirements
- Example: The Linux Kernel
- Performance regression
  - A symptom of software evolution
  - Degradation of performance quality of software over time



Source: Fig. 2 and 4 of [4]

Assessing Performance Evolutions

- Performance evolution is the change of performance over time

- Performance assessment for multiple revisions **required** to capture performance evolution

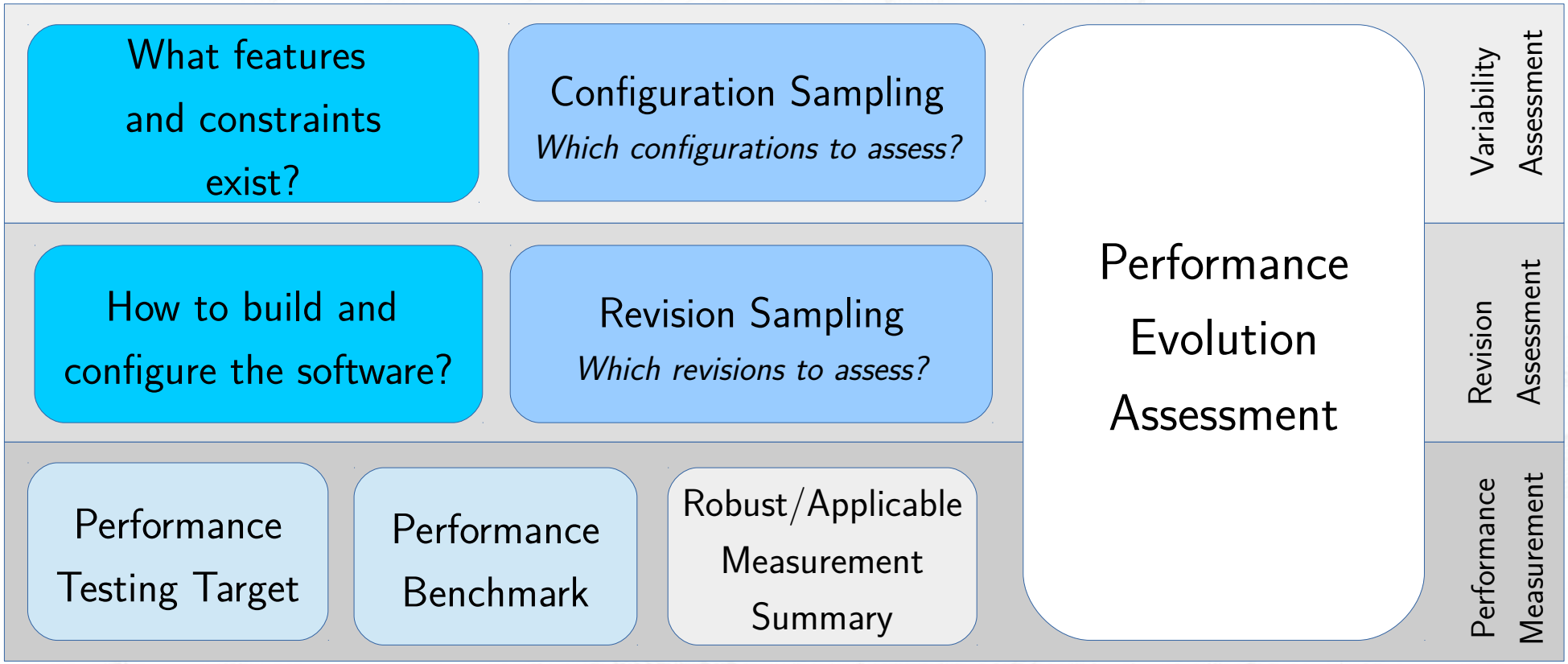
Motivation

- Problem: Performance Assessment – How?

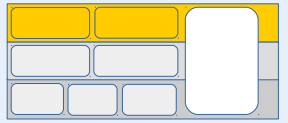
- Goal: Description of performance assessment process with regard to variability, evolution, and statistical accuracy.

- Objectives
  - How to derive variability models and select configurations to assess?
  - How to select revisions to assess from revision history?
  - How to select robust and sound statistical measures?

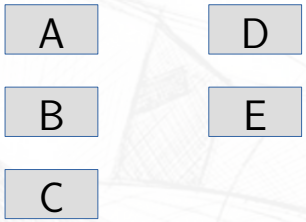
Performance Evolution Assessment



Feature Model Synthesis



- Manually: Extracting information from non-code artifacts, such as documentation, man pages, ...
- Automated Feature Extraction [2]
  - Exploit used configuration APIs
  - Recover feature names, types and domains
- Automated Constraint Extraction [3]
  - Infer constraints from rule violations:
    - "Every valid configuration compiles"
    - "Every valid configuration yields a different product"



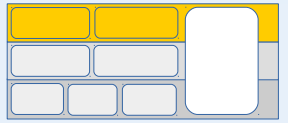
$B \rightarrow A \vee \neg D$

$D \rightarrow C \vee \neg E$

$E \rightarrow C \vee \neg D$

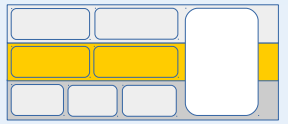
$C \rightarrow A$

Configuration Sampling

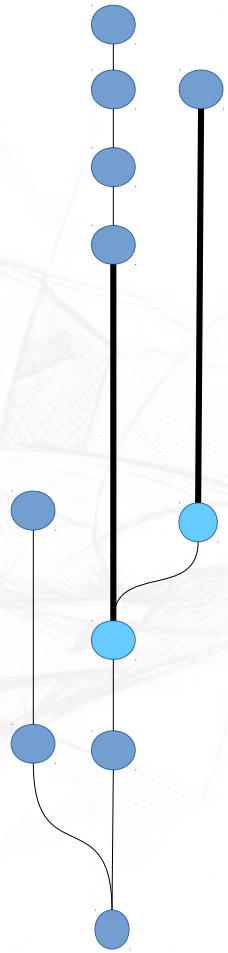


- Sampling: Finding a ‘representative’ subset of configurations
- Sampling strategies: Isolated solutions with coverage criteria
  - Pair- or n-wise: Coverage of simple and higher feature interactions
  - Feature coverage: Every feature is selected at least once
  - ...

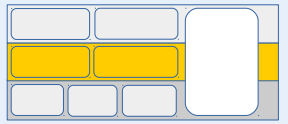
Revision Sampling (1)



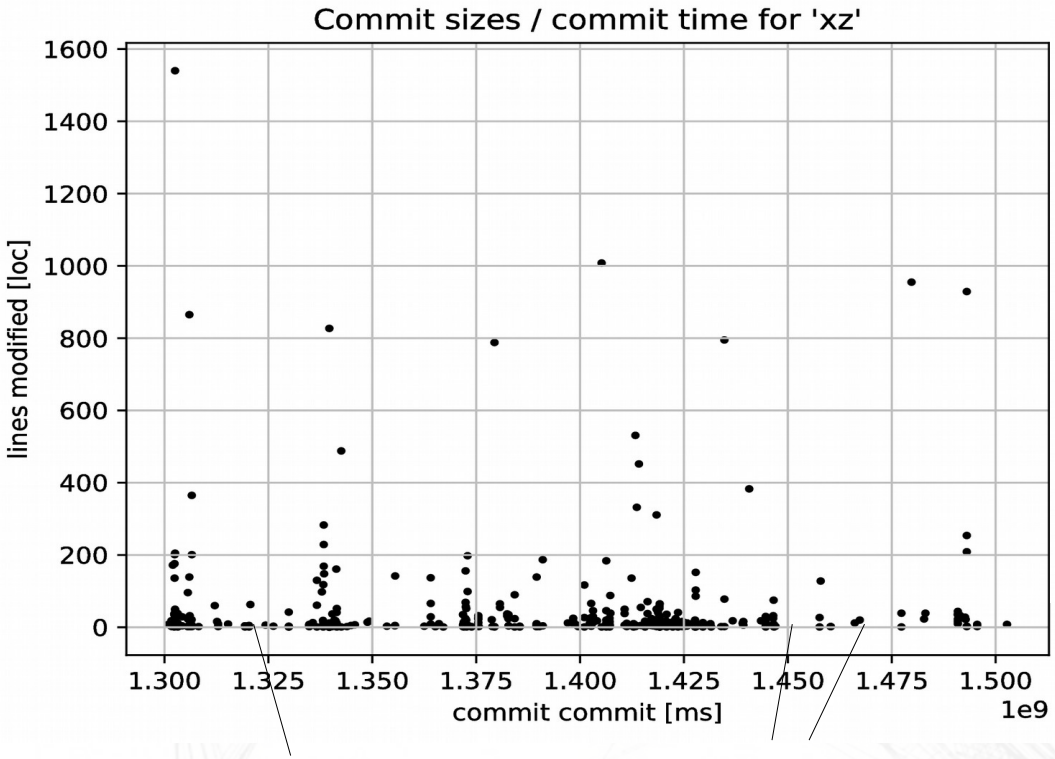
- Which revisions do we want to assess performance for?
  - Releases, release candidates,
  - bugs, and corresponding bug-fixes
- Information we can use to classify include
  - Revision history metadata (commit messages, ...)
  - Release notes
  - ...
- Which revisions best describe performance evolution?



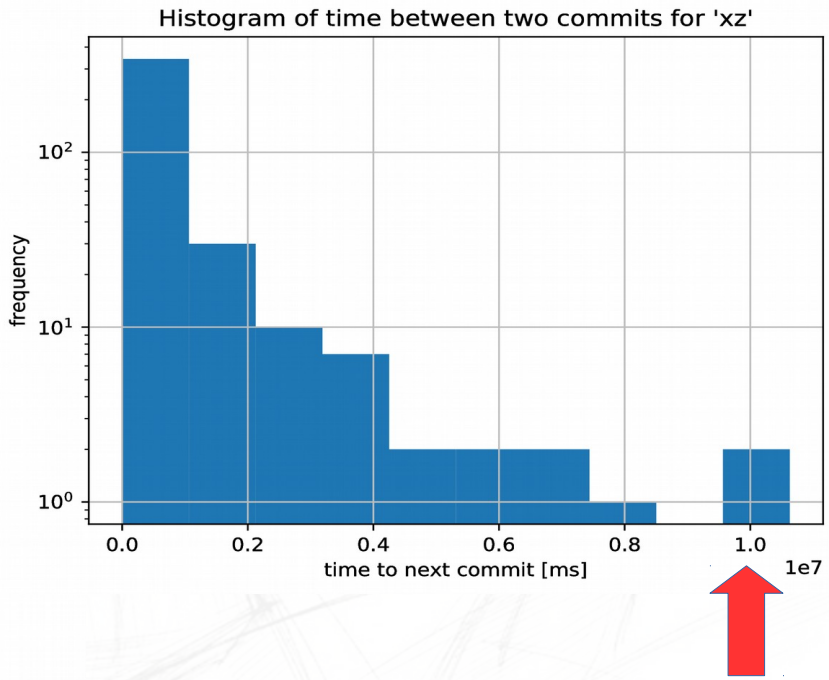
Revision Sampling (2)



- Idea: Revisions which have been the latest ones for a long time

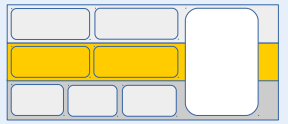


„commit streaks“ followed by sparse sections



Very few commits with high temporal distance to next commit

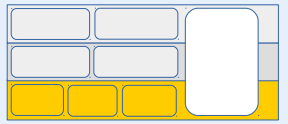
Semi-automated Integration



- How to automatically build a software system?
  - Usually: Manually predefined build routine, e.g., Makefile
  - Possible extensions: Pattern matching for ‘characteristic’ files?

- How are configurations read by the software system?
  - Usually: Manually predefined templates, e.g., .properties file
  - Possible extensions: Pattern matching for ‘characteristic’ files?

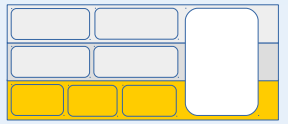
Performance Benchmarks



- What performance properties are relevant for an application?

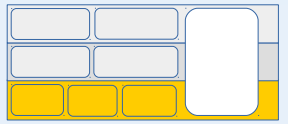
- Which benchmark can be used to assess performance?
  - Application-specific benchmarks (rare)
  - Domain-specific or standardized benchmarks (e.g., SPEC)
  - Test cases

Measurement: Applicability

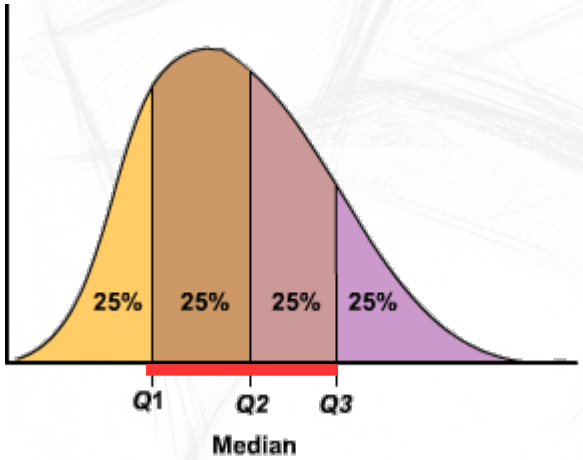


- Applicability: Is a chosen means appropriate to describe the data?
  - Example: Use harmonic mean for rates, not the arithmetic mean
    - Two machines processing 100 requests with 100 and 10 hits/s each
    - Arithmetic mean: 55 hits/s, harmonic mean: 18.182 hits/s
    - Time required for processing requests: 1 s + 10 s = 11 s
    - Two ‘average’ machines should take 11 seconds
    - Arithmetic mean: 3.64 s, harmonic mean: 11 s

Measurement: Robustness



- Robustness: Is the measure affected by extreme measurements?
  - Example: Series 1, 1, 2, 3, 8, arithmetic mean of 3, median of 2
- Measure of central tendency: Median (2nd quartile)
- Measure of dispersion: Interquartile range (IQR)
  - Difference between the 3rd and 1st quartile



- Semantics of extreme measurements

  What is an outlier, what an optimal measurement?

Outlook for Evaluation

- Questions to address:
  - Do “commit streaks” and sparse sections exist? Is this a good idea?
  - How can we detect release commits?
  - Can we assess performance evolution with our strategy?

- Evaluation corpus
  - GNU xz utils (free compression tool)
  - x264 (free audio and video encoder)
  - ...

Literature

[1] Molyneaux, I. (2014). T*he Art of Application Performance Testing: Help for Programmers and Quality Assurance* (2nd ed.). O'Reilly Media, Inc.

[2] Rabkin, A., & Katz, R. (2011). *Static extraction of program configuration options*. In Proceedings of the 33rd ICSE (pp. 131–140). ACM.

[3] Nadi, S., Berger, T., Kästner, C., & Czarnecki, K. (2015). *Where do configuration constraints stem from? an extraction approach and an empirical study*. IEEE Transactions on Software Engineering, 41(8), 820–841.

[4] Israeli, A., & Feitelson, D. G. (2010). *The Linux kernel as a case study in software evolution*. Journal of Systems and Software, 83(3), 485-501.