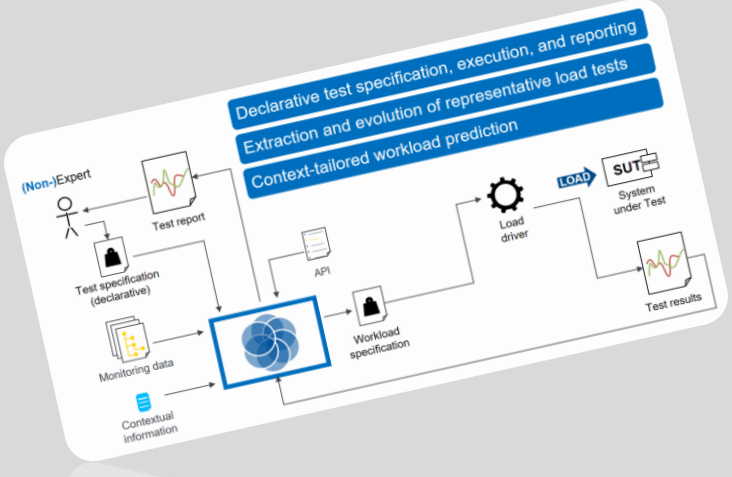


Test-based Scalability and Resilience Assessment of Microservice-based Software Systems

André van Hoorn @andrevanhoorn

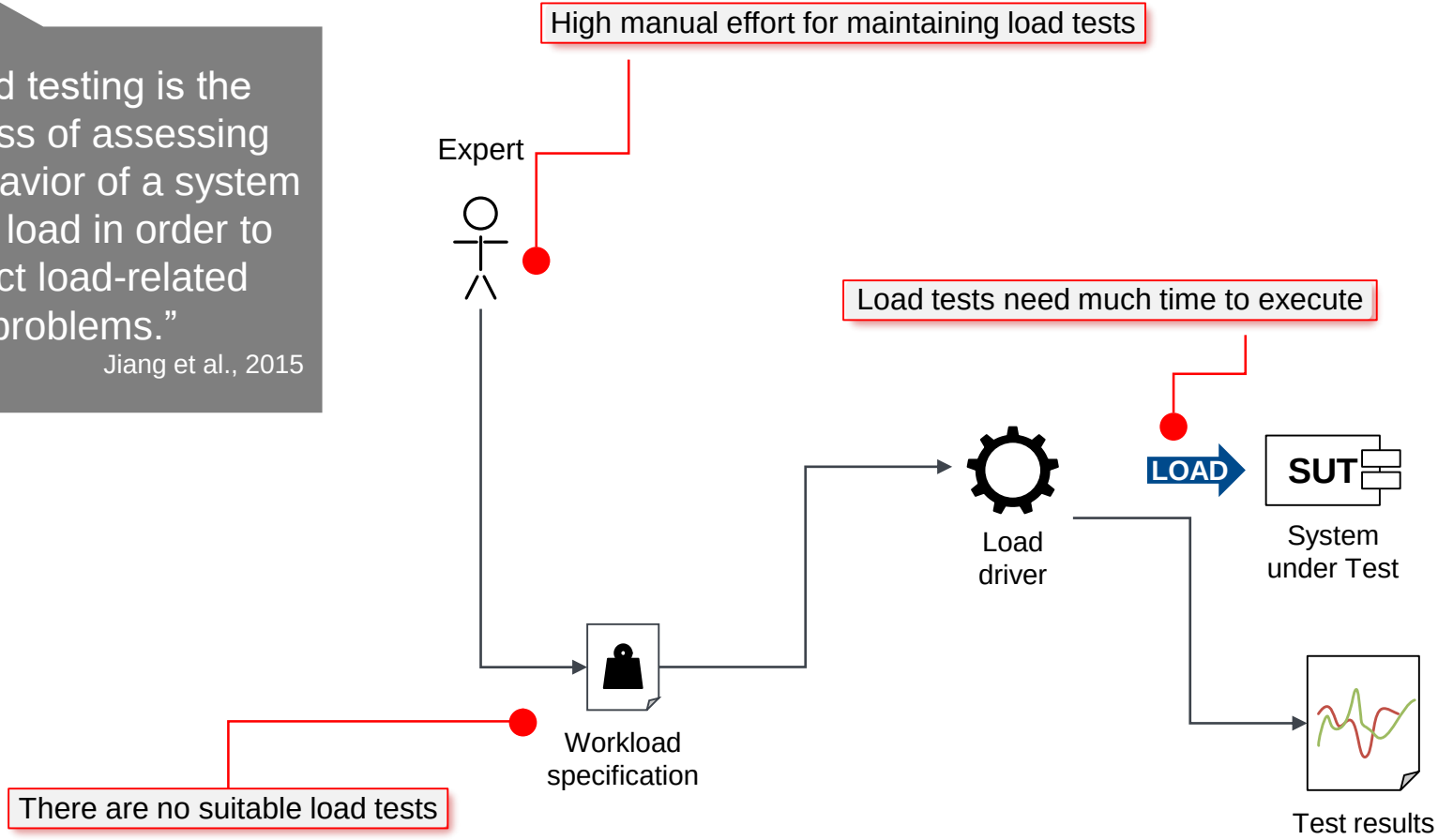
October 28, 2019, Berlin Germany

International Workshop on Governing Adaptive and Unplanned Systems of Systems (GAUSS) @ ISSRE 2019

University of Stuttgart
Baden-Württemberg Stiftung
DFG
Gefördert vom Bundesministerium für Bildung und Forschung

Load Testing – Approach and Challenges

> “Load testing is the process of assessing the behavior of a system under load in order to detect load-related problems.”
>
> Jiang et al., 2015

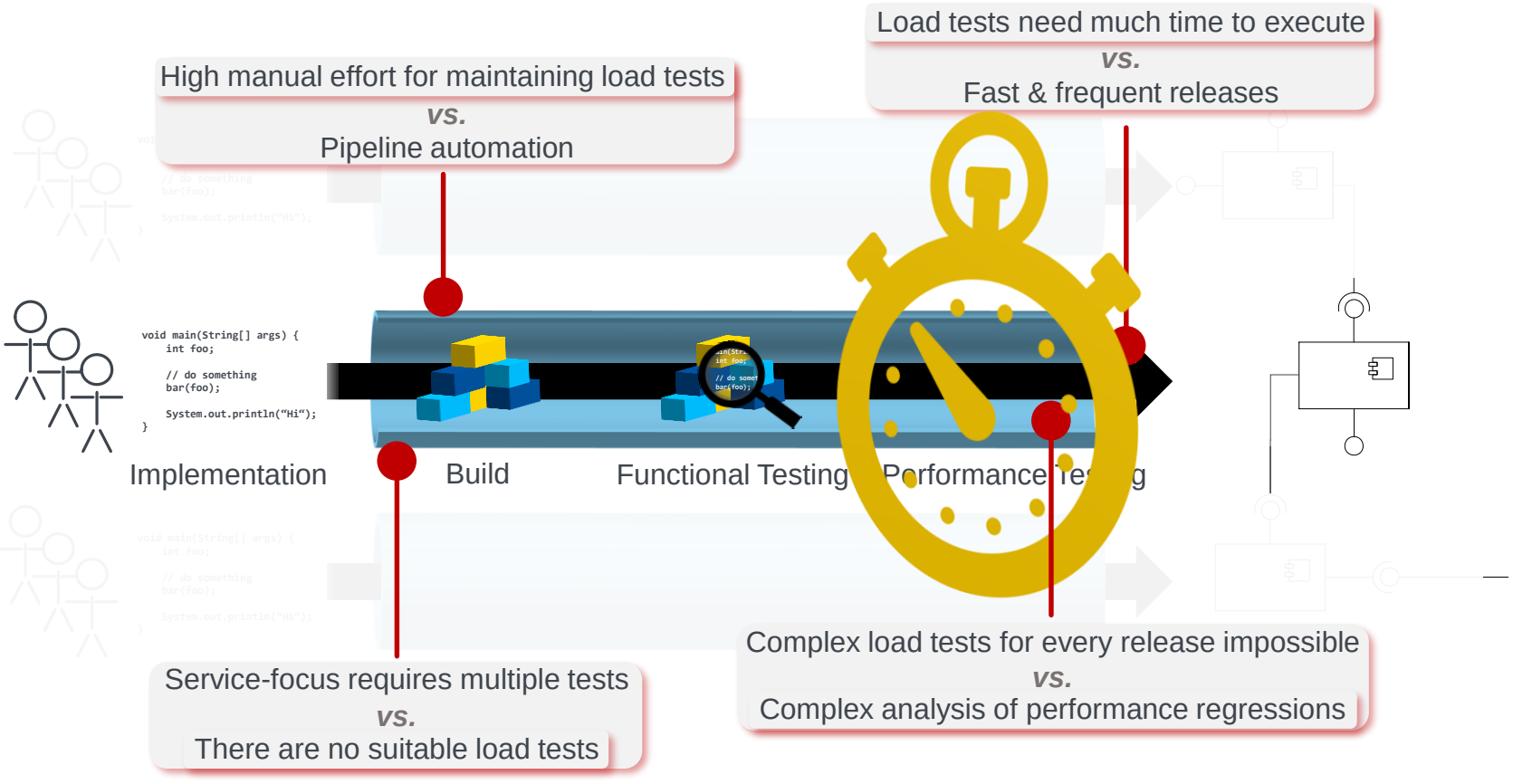


Bezemer et al., ICPE 2019

Schulz et al., ICPE 2018

Load Testing of Microservices in Continuous Delivery Pipelines

… How Problems Get Worse

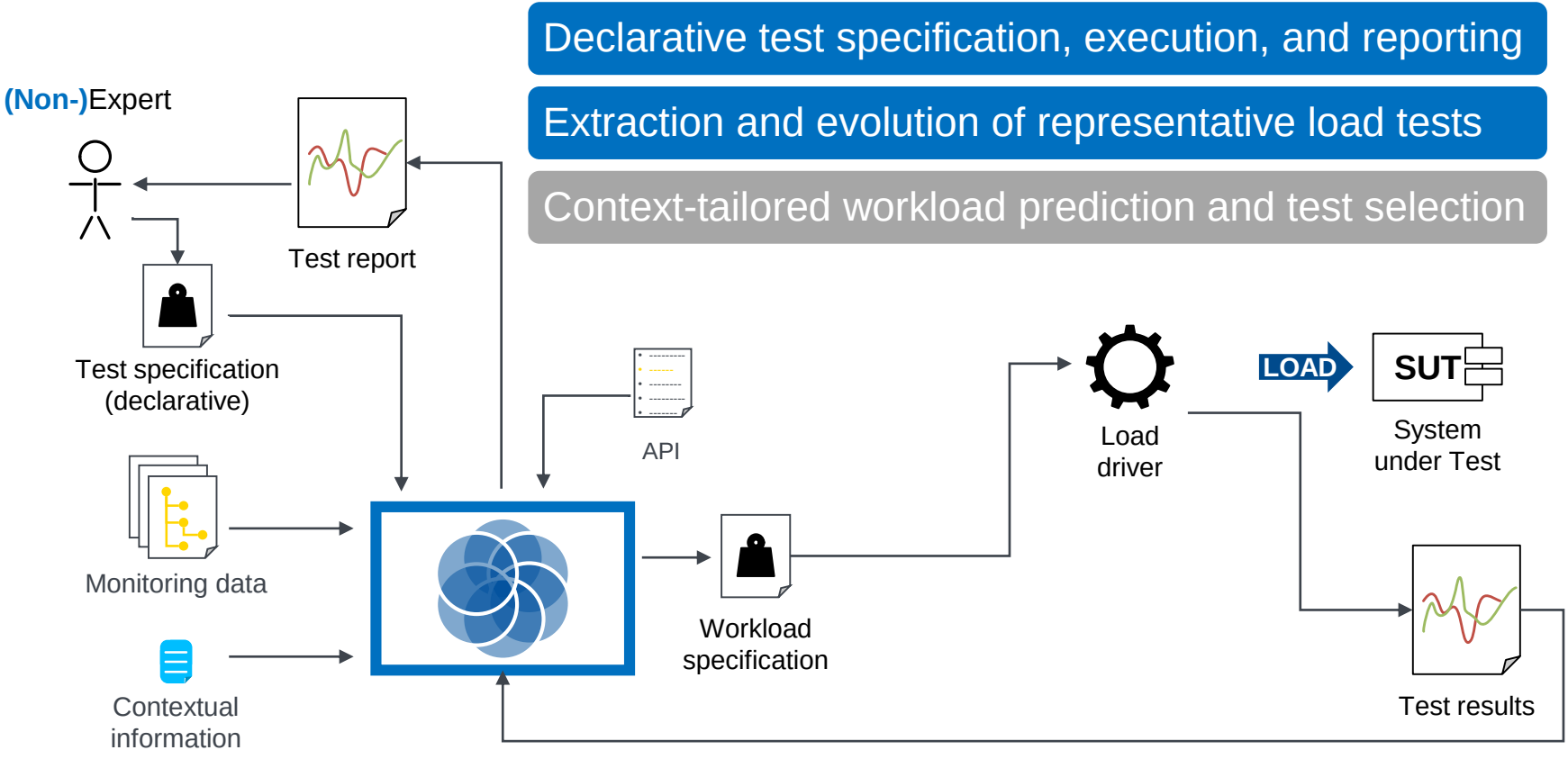


Schulz et al., ICPE 2018

Heinrich et al., ICPE 2017

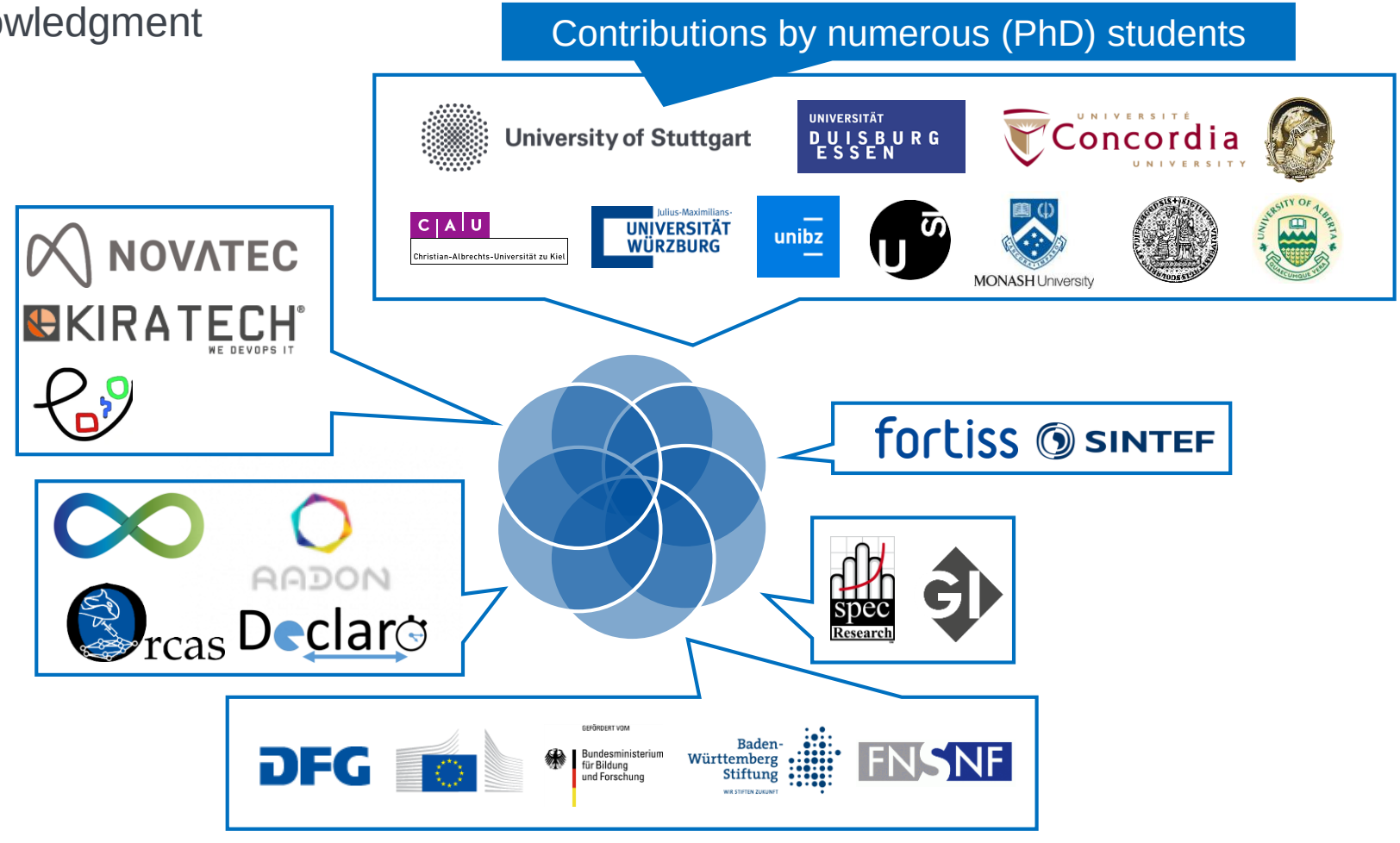
Our Approach

Overview of our Approach



This Work is a Joint Effort!

Acknowledgment



Declarative test specification, execution, and reporting

Extraction and evolution of representative load tests

Context-tailored workload prediction and test selection

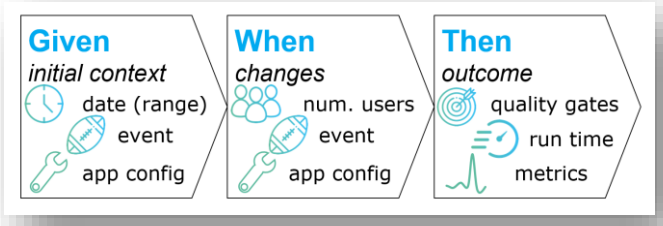
Behavior-Driven Load Testing

Adopting idea from Behavior-Driven Development (BDD)

Schulz et al., ICPE 2019

For *functional* testing

- BDLT language – structure and example

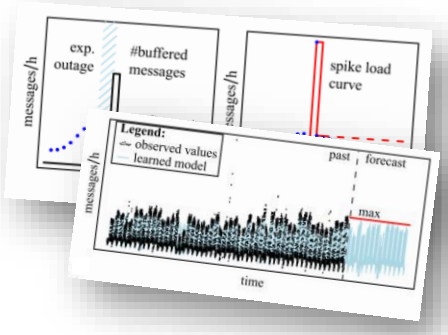


Given the next Black Friday,
when varying the CPU cores between 1 and 4,
then run the experiment for 1h
and
ensure the maximum CPU utilization is less than 60%.

- Mapping to ContinuITy and BenchFlow for load test generation

- Evaluation:

Expressiveness? Use?
Benefits and Limitations?



Formulated industrial load test scenarios, using operational data

"NL helps understanding and communication (with non-experts)"

"Could replace manual tests"

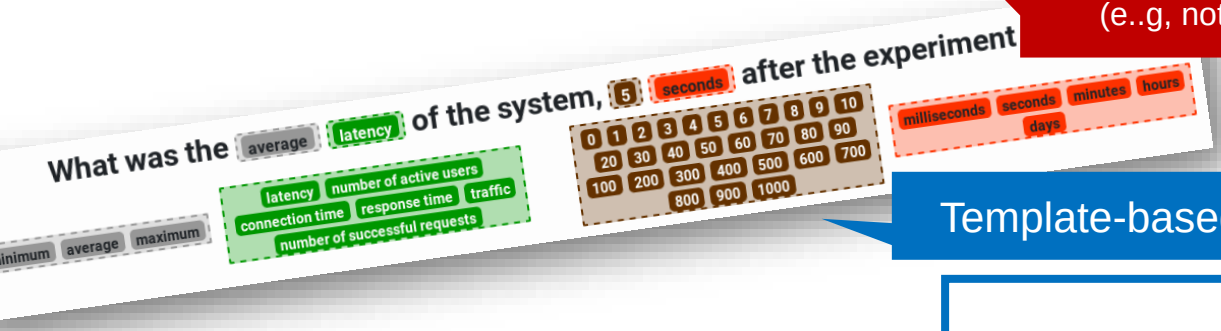
"Some concerns hard to express"

Expert interviews

Concern-driven Analysis and Reporting

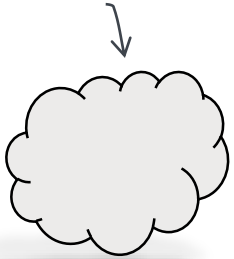
Okanovic et al., ICPE 2019

Addressed problem:
- Exact concerns not made explicit before performance evaluation
- Performance evaluation reports not appropriate (e..g, not tailored to concern, results not explained)

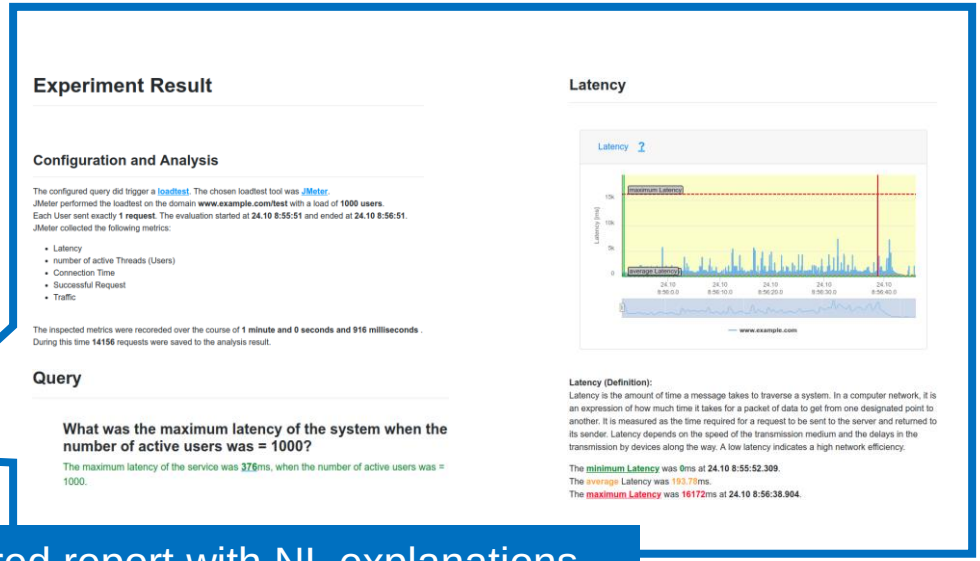


Template-based NL specification of concerns

- Performance evaluation (configuration, execution)
- Data filtering
- Report generation



The average latency of the system was 140.35ms, 5 seconds after the experiment start.

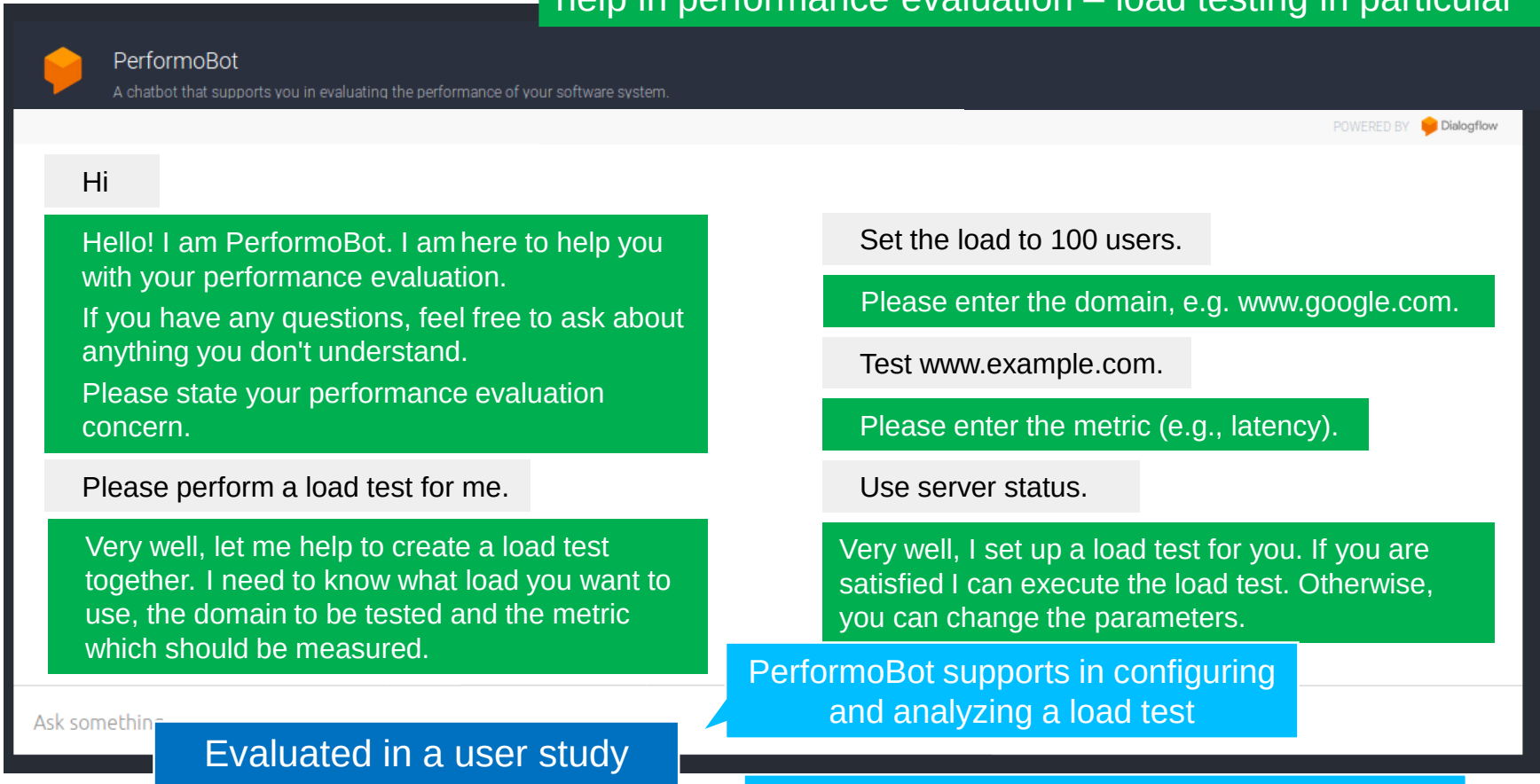


Tailored report with NL explanations

Concern-driven Analysis and Reporting – Chatbot Extension

Okanović et al., under review

Hypothesis: Chatbots used in various domains and could help in performance evaluation – load testing in particular



PerformoBot supports in configuring and analyzing a load test

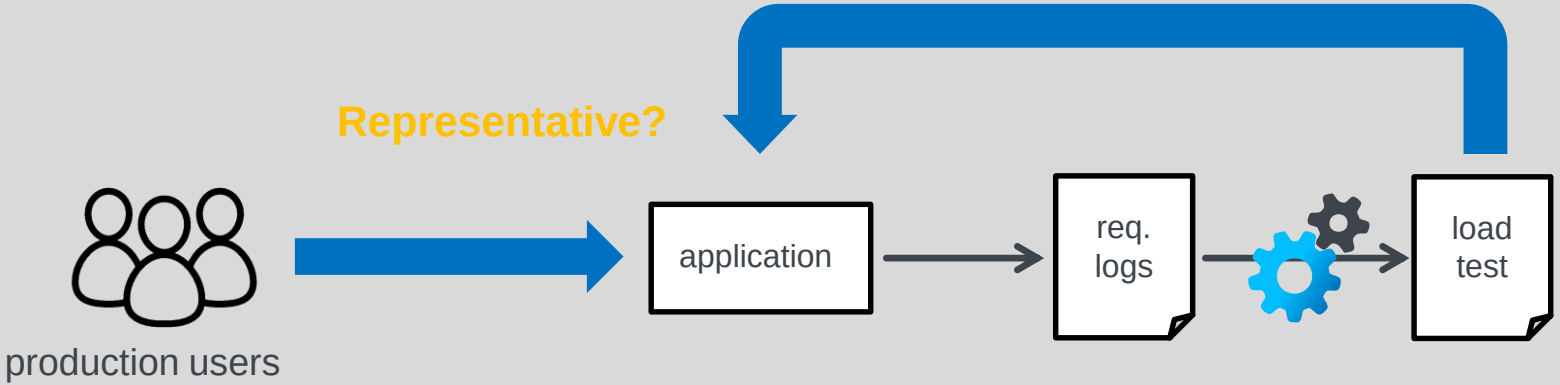
Evaluated in a user study with 47 participants

Most helpful to non-experts – incl. education

Declarative test specification, execution, and reporting

Extraction and evolution of representative load tests

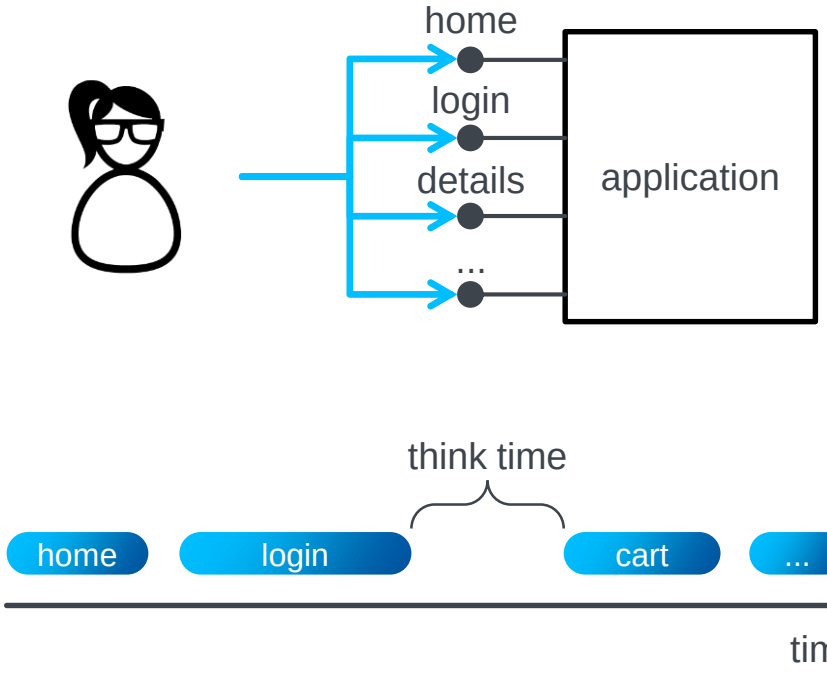
Context-tailored workload prediction and test selection



Background: Session-based Workload

Vögele et al., SoSyM 2018

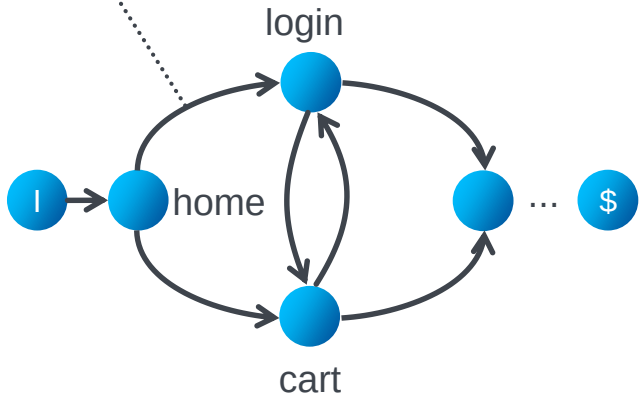
Schulz et al., MASCOTS 2019



aggregation to Markov chains

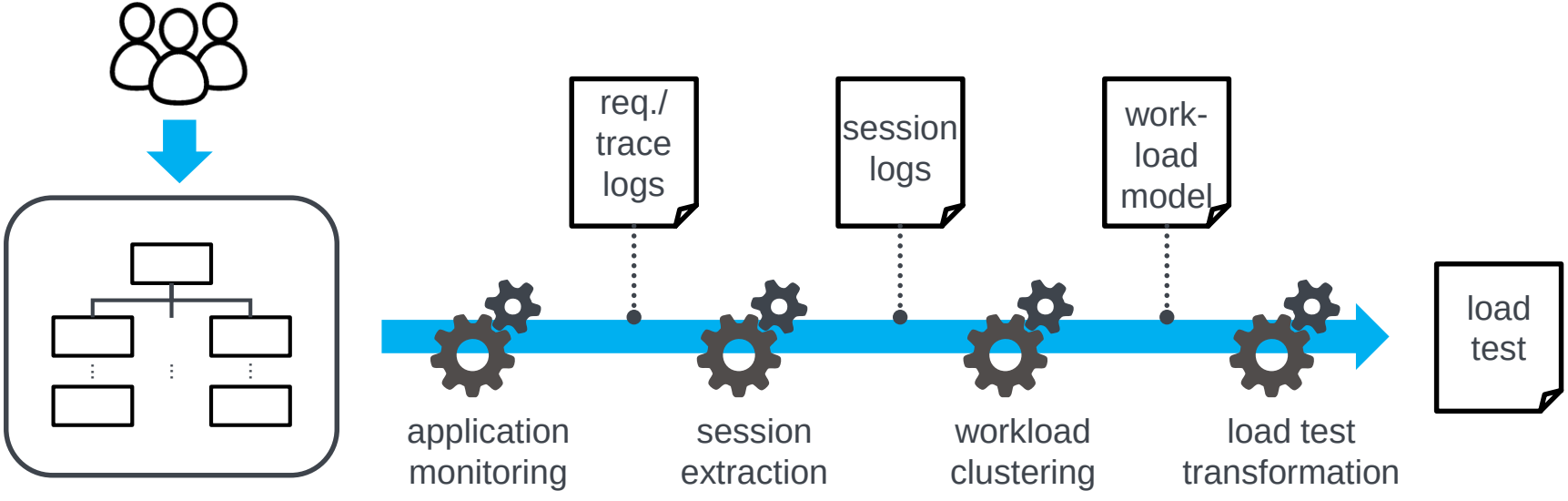
probability: 0.7

think time: $\mathcal{N}(10, 5)$



Extraction of Session-based Workload Models and Load Tests

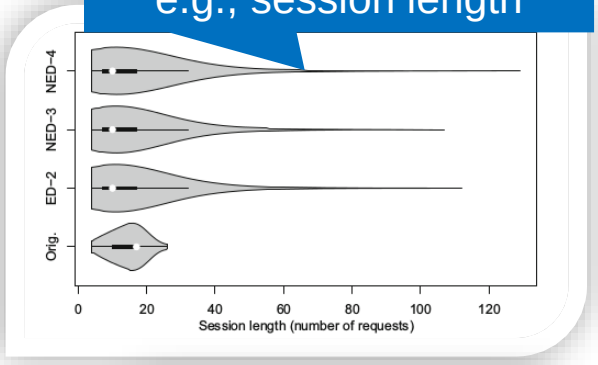
Vögele et al., SoSyM 2018 | Schulz et al., MASCOTS 2019



Evaluation of the Representativeness

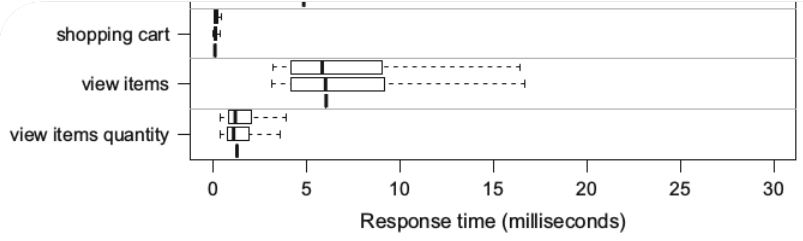
Vögele et al., SoSyM 2018

Session-based metrics, e.g., session length

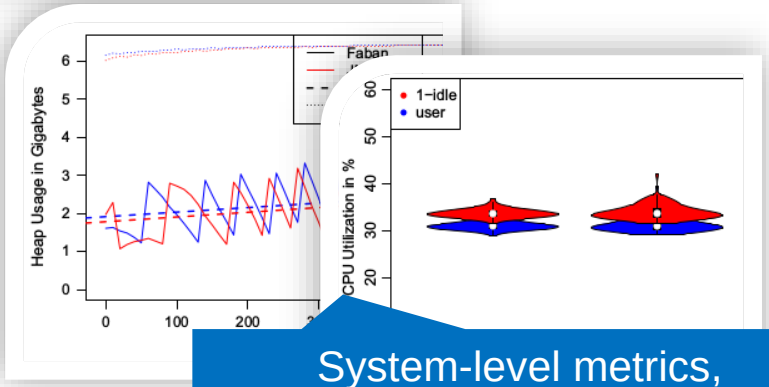


Request-based metrics, e.g., request mix

Request	Orig.	ED-2	NED-3	NED-4	Rel.
(a) Absolute and relative (Rel.) counts (JMeter)					
1. Add to cart	20,625	21,474	21,129	21,217	0.07
2. Cancel order	191	198	176	168	0.00
3. Clear cart	1932	2129	2011	1976	0.01
4. Defer order	2236	2228	2218	2312	0.01
5. Home	19,371	20,119	20,358	20,299	0.07



End-user metrics, e.g., response times

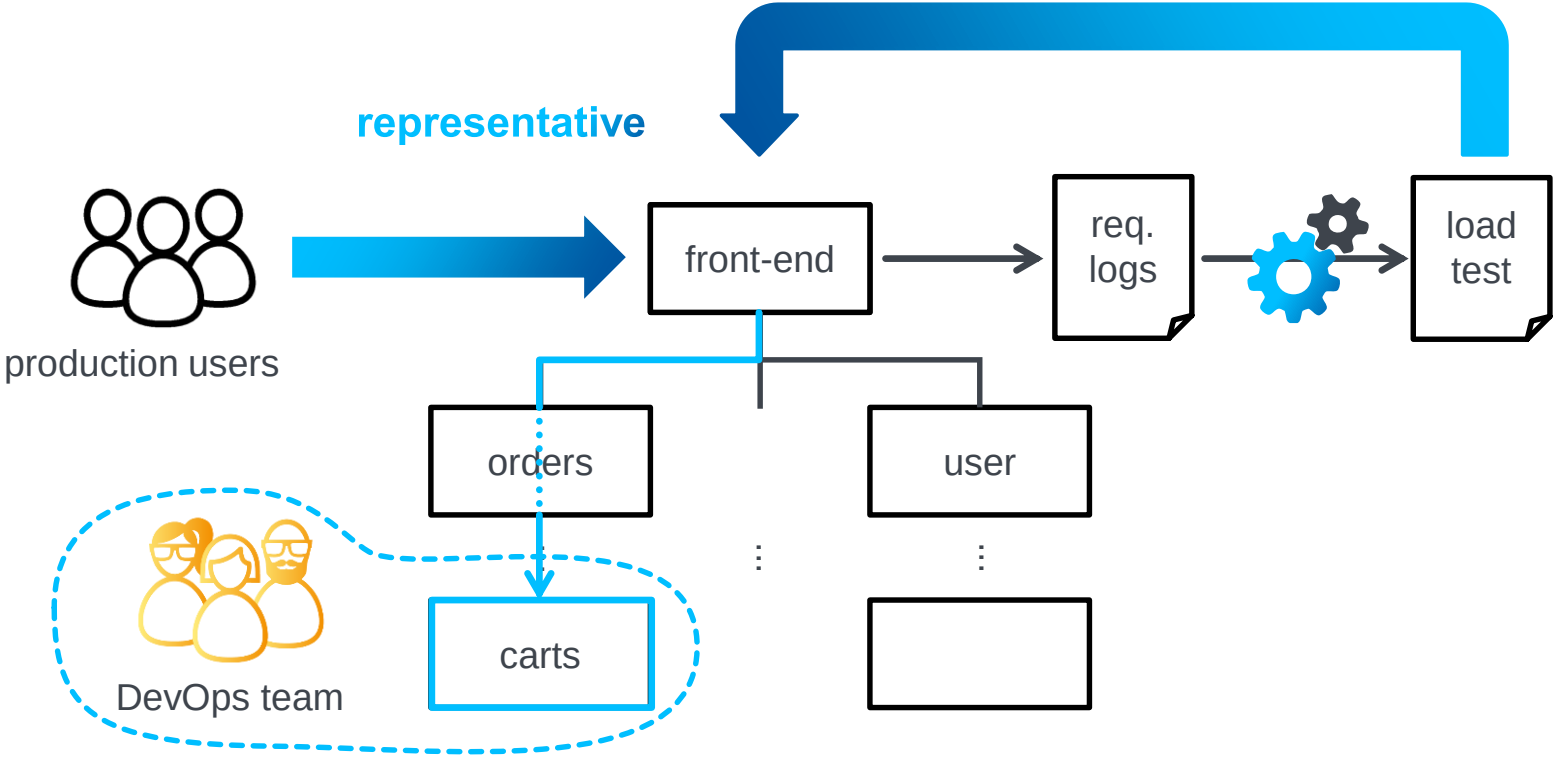


System-level metrics, e.g., CPU and memory

Not considered in this study: varying workload intensities

Representative Load Testing Lacks in Support for Microservices

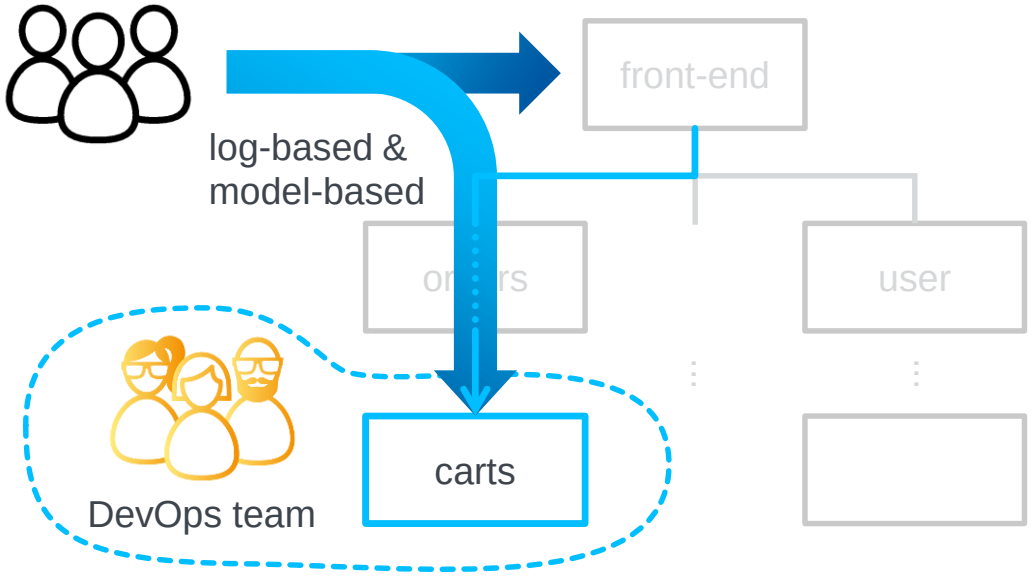
Schulz et al., MASCOTS 2019



Microservice-tailored Generation of Session-based Workload Models

Schulz et al., MASCOTS 2019

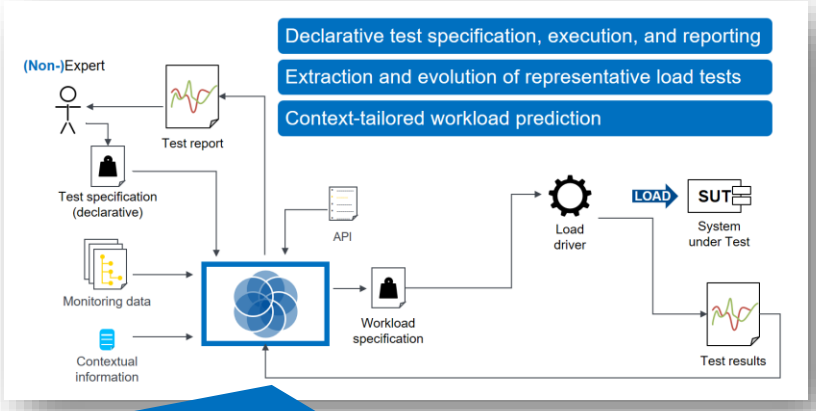
Idea: Derive representative load tests tailored to individual microservices from the global application workload



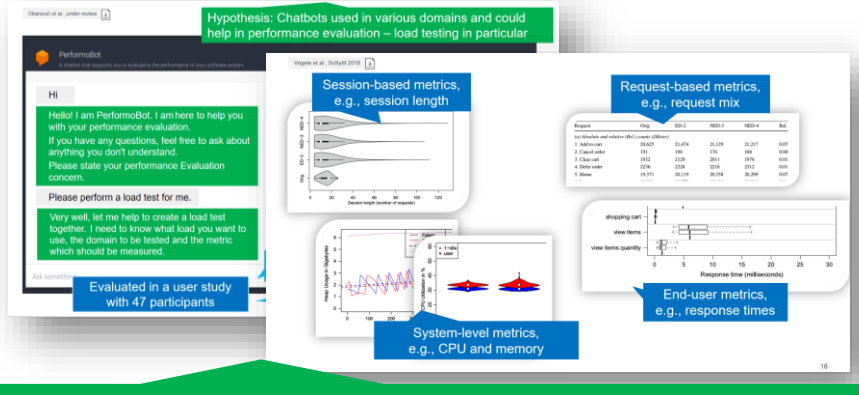
- ✓ less resources
- (✓) shorter execution
- ✓ representative
- ✓ DevOps ready

> “Load testing is the process of assessing the behavior of a system under load in order to detect load-related problems.”
>
> Jiang et al., 2015

Load testing is challenging – and even more in the context of microservices and DevOps



Overview of our collaborative approach

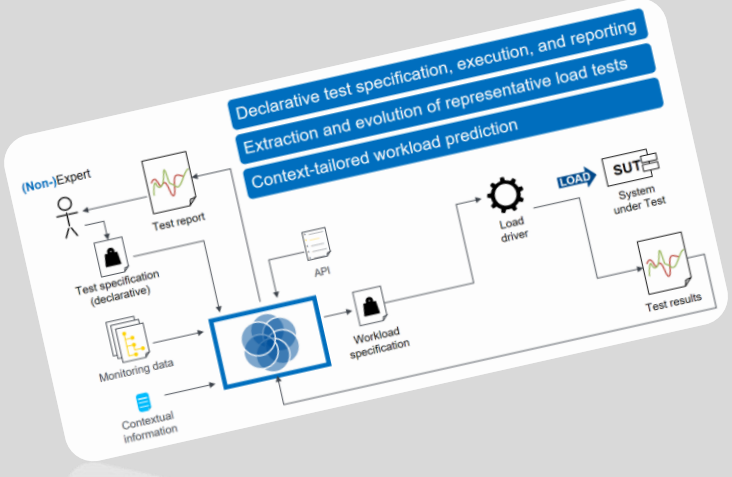


Selected results:

- declarative specification and reporting
- extraction and evolution of representative load tests

Additional pointers

- Efficient resilience testing — van Hoorn et al., ISSRE 2018
- Domain-based scalability testing — Avritzer et al., ECSA 2018
- Scalability testing in Scrum — Brataas et al., Software 2019
- Automated load test evolution — Schulz et al., STVR 2019



Test-based Scalability and Resilience Assessment of Microservice-based Software Systems

André van Hoorn @andrevanhoorn

October 28, 2019, Berlin Germany

International Workshop on Governing Adaptive and Unplanned Systems of Systems (GAUSS) @ ISSRE 2019

University of Stuttgart
Baden-Württemberg Stiftung
DFG
Gefördert vom Bundesministerium für Bildung und Forschung

References

Schulz et al., STVR 2019 — Henning Schulz, André van Hoorn, Alexander Wert: Reducing the Maintenance Effort for Parameterization of Representative Load Tests Using Annotations. Software Testing, Verification & Reliability (2019)

Schulz et al., MASCOTS 2019 — Henning Schulz, Tobias Angerstein, Dušan Okanović, and André van Hoorn. Microservice-tailored generation of session-based workload models for representative load testing. MASCOTS 2019

Brataas et al., Software 2019 — Gunnar Brataas, Geir Kjetil Hanssen, Nikolas Herbst, and André van Hoorn. Agile scalability engineering: The ScrumScale method. IEEE Software (2019)

Okanovic et al., ICPE 2019 — Dusan Okanovic, André van Hoorn, Christoph Zorn, Fabian Beck, Vincenzo Ferme, Jürgen Walter: Concern-driven Reporting of Software Performance Analysis Results. ICPE Companion 2019: 1-4

Avritzer et al., ICPE 2019 — Alberto Avritzer, Daniel S. Menasché, Vilc Rufino, Barbara Russo, Andrea Janes, Vincenzo Ferme, André van Hoorn, Henning Schulz: PPTAM: Production and Performance Testing Based Application Monitoring. ICPE Companion 2019: 39-40

Bezemer et al., ICPE 2019 — Cor-Paul Bezemer, Simon Eismann, Vincenzo Ferme, Johannes Grohmann, Robert Heinrich, Pooyan Jamshidi, Weiyi Shang, André van Hoorn, Mónica Villavicencio, Jürgen Walter, Felix Willnecker: How is Performance Addressed in DevOps? A Survey on Industrial Practices. ICPE 2019: 45-50

References

Schulz et al., ICPE 2019 — Henning Schulz, Dusan Okanovic, André van Hoorn, Vincenzo Ferme, Cesare Pautasso: Behavior-driven Load Testing Using Contextual Knowledge - Approach and Experiences. ICPE 2019: 265-272

Trubiani et al., IST 2018 — Catia Trubiani, Alexander Bran, André van Hoorn, Alberto Avritzer, Holger Knoche: Exploiting load testing and profiling for Performance Antipattern Detection. Information & Software Technology 95: 329-345 (2018)

Pitakrat et al., JSS 2018 — Teerat Pitakrat, Dusan Okanovic, André van Hoorn, Lars Grunske: Hora: Architecture-aware online failure prediction. Journal of Systems and Software 137: 669-685 (2018)

Vögele et al., SoSyM 2018 — Christian Vögele, André van Hoorn, Eike Schulz, Wilhelm Hasselbring, Helmut Krcmar: WESSBAS: extraction of probabilistic workload specifications for load testing and performance prediction - a model-driven approach for session-based application systems. Software and Systems Modeling 17(2): 443-477 (2018)

Avritzer et al., ECSA 2018 — Alberto Avritzer, Vincenzo Ferme, Andrea Janes, Barbara Russo, Henning Schulz, André van Hoorn: A Quantitative Approach for the Assessment of Microservice Architecture Deployment Alternatives by Automated Performance Testing. ECSA 2018: 159-174

van Hoorn et al., ISSRE 2018 — André van Hoorn, Aldeida Aleti, Thomas F. Düllmann, Teerat Pitakrat: ORCAS: Efficient Resilience Benchmarking of Microservice Architectures. ISSRE Workshops 2018: 146-147

References

Schulz et al., ICPE 2018 — Henning Schulz, Tobias Angerstein, André van Hoorn: Towards Automating Representative Load Testing in Continuous Software Engineering. ICPE Companion 2018: 123-126

van Hoorn et al., DATACOM 2018 — André van Hoorn and Stefan Siegl. Application Performance Management: Measuring and Optimizing the Digital Customer Experience (e-Book). SIGS DATACOM GmbH (2018)

Düllmann et al., ICPE 2017 — Thomas F. Düllmann, André van Hoorn: Model-driven Generation of Microservice Architectures for Benchmarking Performance and Resilience Engineering Approaches. ICPE Companion 2017: 171-172

Heinrich et al., ICPE 2017 — Robert Heinrich, André van Hoorn, Holger Knoche, Fei Li, Lucy Ellen Lwakatare, Claus Pahl, Stefan Schulte, Johannes Wettinger: Performance Engineering for Microservices: Research Challenges and Directions. ICPE Companion 2017: 223-226

Heger et al., ICPE 2017 — Christoph Heger, André van Hoorn, Mario Mann, Dusan Okanovic: Application Performance Management: State of the Art and Challenges for the Future. ICPE 2017: 429-432

Walter et al., ICPE 2016 — Jürgen Walter, André van Hoorn, Heiko Koziolek, Dusan Okanovic, Samuel Kounev: Asking "What"?, Automating the "How"?: The Vision of Declarative Performance Engineering. ICPE 2016: 91-94

van Hoorn et al., ICPE 2012 — André van Hoorn, Jan Waller, Wilhelm Hasselbring: Kieker: a framework for application performance monitoring and dynamic software analysis. ICPE 2012: 247-248

References (submitted papers)

Okanović et al., <under review>

Dušan Okanović, Samuel Beck, Lasse Merz, Christoph Zorn, Leonel Merino, André van Hoorn, Fabian Beck: Can a Chatbot Support Software Engineers with Load Testing? Approach and Experiences. *Under review*