Continuous Performance Testing: Challenges and Approaches

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- Senior Performance Engineer at AWS – Amazon Aurora
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Adjusting Performance Engineering to Industry Trends

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Industry Trends

- Web
  - Centralization, open / unlimited workload
- Cloud
  - Further centralization, price tag (FinOps)
  - Dynamic configurations / Self-Management
- Agile / iterative development
  - Continuous Integration / Delivery / Deployment
  - DevOps / SRE

The Past, Present, and Future of Performance Engineering

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All Interconnected

Centralization
=> Control over deployments
=> Ability to deploy small changes
=> Agile development
=> Fuzzier line between Dev and Ops (DevOps, SRE)
=> Need for continuous performance engineering

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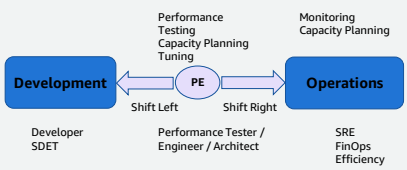
Integrating Performance Engineering into DevOps



Expand or be Squeezed Out ?

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Adjusting Performance Testing to Agile and CI

- Agile development should be rather a trivial case for performance testing
  - Working system on each iteration by definition
  - You need performance engineer for the whole project
    - Savings come from detecting problems early
- Addressing deficiencies of the traditional performance testing
  - Early Performance Testing
  - Continuous Performance Testing

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Early Performance Testing

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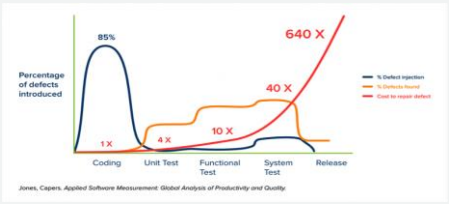
Cost of Fixing Defects Earlier Is Significantly Lower



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Early Testing - Mentality Change

- Making performance everyone's job
- Late record/playback performance testing -> Early Performance Engineering
- System-level requirements -> Component-level requirements
- Record/playback approach -> Programming to generate load/create stubs
- "Black Box" -> "Grey Box"

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Continuous Performance Testing

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Integration into Agile and CI/CD

- Continuous performance testing
  - To catch regressions early
- Collecting all info needed to investigate regressions
  - In the form convenient for further analysis
- Foundation to build further automation on the top of it
  - For further performance optimization
- All context-dependent
  - Don't wait for an exact recipe, figure it out depending on your needs

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Performance Testing Traditional vs Continuous

• Before releases	• Often (maybe even each build)
• Realistic Mix	• Different tests
▪ As close to production as possible	▪ To maximize coverage
• Checking Service Level Objectives (SLOs)	• Checking the difference between builds
• Using a load testing tool or harness	• Using an additional layer of automation on the top of load testing tool
• The approach is relatively consistent and well described	• All context-dependent

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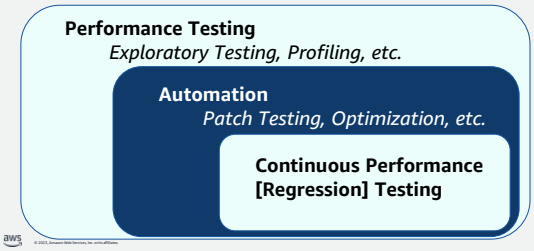
My View / Use of Terminology



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Challenges of Continuous Performance Testing

- Integration
- Coverage Optimization
- Variability / Noise Reduction
- Change Detection
- Advanced Analysis
- Operations / Maintenance

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The Challenge of Integration

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Continuous Integration: Load Testing Tools

- CI support in load testing tools
  - Integration with CI Servers (Jenkins, Hudson, etc.)
  - Automation support
- CI tools support for performance testing
  - Jenkins Performance Plugin
- Performance Testing Frameworks
  - Combining multiple tools

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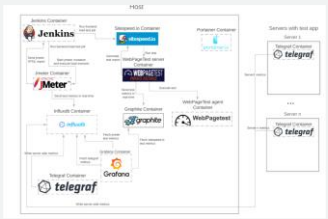
A Performance Testing Framework



An example:
https://github.com/serputko/performance-testing-framework

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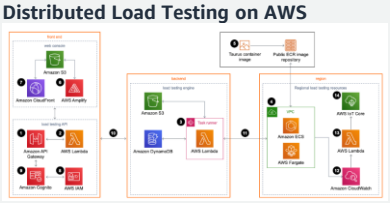
Distributed Load Testing on AWS



From AWS Solutions Library
https://aws.amazon.com/solutions/implementations/distributed-load-testing-on-aws/

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Closely Integrated Systems

- Sophisticated, but proprietary closely integrated systems
  - Creating a Virtuous Cycle in Performance Testing at MongoDB
  - Fallout: Distributed Systems Testing as a Service (DataStax)
  - Tracking Performance of the Graal Compiler on Public Benchmarks (Charles University / Oracle Labs)
  - Introducing Ballast: An Adaptive Load Test Framework (Uber)

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Unified Development Services

Such as AWS CodeCatalyst
https://aws.amazon.com/codecatalyst/

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The Challenge of Coverage Optimization

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Time / Resource Considerations

- Performance tests take time and resources
  - The larger tests, the more
- May be not an option on each commit
- Need of a tiered solution
  - Some performance measurements each commit
  - Daily mid-size performance tests
  - Periodic large-scale / uptime tests ***outside CI***

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Coverage Optimization

- A multi-dimensional problem
  - Configuration
  - Workloads / Tests
  - Frequency of runs
- A trade off between coverage and costs
  - Costs of running, analyzing, maintenance, etc.

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The Challenge

- If addressed seriously, the number of workloads / tests / configurations is growing
- No good way to optimize
- One approach is to see if some results are correlated
  - If we find same problems on the same set of tests, we can use just one or few tests from this group
  - Tracking Performance of the Graal Compiler on Public Benchmarks (Charles University / Oracle Labs)
- Combinatorial testing approaches (PairWise / Covering Arrays)
  - From functional testing

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The Challenge of Variability

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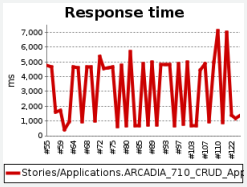
Variability - Environment

- Due to difference in environments



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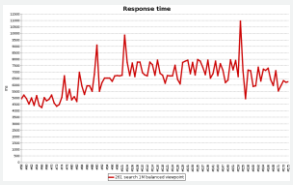
Variability - System

- Inherent to the test setup



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Addressing Variability

- Methodological principles for reproducible performance evaluation in cloud computing. 2019 (SPEC RG – Cloud)
- Reducing variability in performance tests on EC2: Setup and Key Results (MongoDB)
- Tracking Performance of the Graal Compiler on Public Benchmarks

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Addressing Variability

- Same environment / starting config
  - For example, AWS cluster placement groups
- No other load
- Multiple iterations
- Reproducible multi-user tests
  - Restarts between tests
  - Clearing caches / Warming up caches
  - Staggering / Sync points

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The Challenge of Change Detection

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Complex Results

- No easy pass/fail
  - Individual responses, monitoring results, errors, etc.
- No easy comparison
  - Against SLA
  - Between builds
- Variability

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Simple Comparison

Jenkins Performance Plugin

URI	Samples	Samples diff	Average (ms)	Average diff (ms)
001 home	1	0	347	-22
005 login	1	0	2438	-66
157 views	1	0	117	-33
173 open volume view	1	0	84792	3945
261 search 1M balanced viewpoint	1	0	10964	4295
262 navigate 1M balanced viewpoint	1	0	208	-47
268 open 1M flat viewpoint	1	0	17462	-1562
272 open 1M grid	1	0	5040	572
282 search 1M grid	1	0	2247	8
283 navigate 1M grid	1	0	8343	-181
286 open 200k balanced viewpoint	1	0	16890	-3703
289 search 200k balanced viewpoint	1	0	1261	-1027
290 navigate 200k balanced viewpoint	1	0	148	10
296 validate 200k viewpoint	1	0	81126	723

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keptn.sh

```
---
spec_version: "1.0"
comparison:
  aggregate_function: "avg"
  compare_with: "single_result"
  include_result_with_score: "pass"
  number_of_comparison_results: 1
filter:
objectives:
  - sli: "response_time_p95"
    key_sli: false
    pass:             # pass if (relative change <= 10% AND absolute value is < 600ms)
      - criteria:
          - "<=+10%"  # relative values require a prefixed sign (plus or minus)
          - "<600"    # absolute values only require a logical operator
    warning:          # if the response time is below 800ms, the result should be a warning
      - criteria:
          - "<=800"
    weight: 1
total_score:
  pass: "90%"
  warning: "75%"
```

Quality Gates
SLIs / SLOs as code

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Change Point Detection

- Statistical methods taking noise in consideration
- E-Divisive means algorithm
  - ICPE Paper: Change Point Detection in Software Performance Testing
  - Fixing Performance Regressions Before they Happen, Netflix Technology Blog
  - https://github.com/mongodb/signal-processing-algorithms
    – Open sourced, generic
  - Need several data points. May miss a gradual degradation.

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The Challenge of Advanced Analysis

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Keep All Artifacts for Further Analysis

- Get all metrics
  - Throughputs, latencies, resource utilizations, etc.
- Save all related artifacts
  - Exact code / configuration
  - Logs, etc.
- Ability to re-run the test in the exactly same configuration is helpful

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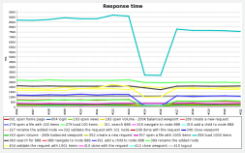
Visualization

- Visualizing systems and software performance - Report on the GI-Dagstuhl
- Sometimes helps to catch an issue



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Looking Beyond Aggregate Info

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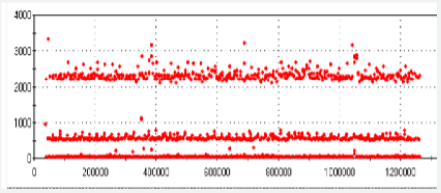
Looking at Individual Results Patterns

Scatter charts – a "banding" pattern from
http://www.perftestplus.com/resources/BPT6.pdf



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The Challenge of Operations and Maintenance

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Operations

- Scheduling / execution tests
- Results analysis
- Triaging and escalating issues
- Maintenance

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Coverage / Maintenance Trade-Off

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Catching / Troubleshooting Errors

- Catching errors is not trivial
  - Building in checks
  - Depends on interfaces used
    - Protocol-level [recording]
    - GUI
    - API/Programming
    - Production Workloads
- Keeping logs / all info needed to investigate issues

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Changing Interfaces

- If using protocol-level or GUI scripts, minor changes may break them
  - It may be not evident
  - If recording used, a change in interfaces may require to recreate the whole script
- API / Programming is usually more stable / easier to fix
- AI to catch the changes / self-healing scripts

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Who Is Doing Maintenance?

- Who is responsible for what?
- Infrastructure Code
  - Tools, plumbing code, integration
- Specific tests
- Integrated workloads
  - Covered multiple functional areas

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Performance Skills Trends

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Skills in Demand

- All old good performance knowledge / skills
  - Not as much around load testing tools anymore
- Development / Scripting / Automation
  - Needed for early / continuous testing
- Performance understanding becoming a must in the industry
  - Need to go one level deeper

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Algorithmic Complexity

- Time Complexity
- Space Complexity
- Big-O notation

Almost in every interview around the globe !

- Connect it with practical performance engineering?

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[System Design Interview Cheat Sheet](#)
by Vahid Dejwakh

Just ***an example*** of the changing attitude

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AWS Well-Architected Framework

[The 6 Pillars of the AWS Well-Architected Framework](#)

- Operational Excellence
- Security
- **Reliability**
- **Performance Efficiency**
- **Cost Optimization**
- Sustainability

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Less Attention to Load Testing Tools

- Performance engineering shifted to
  - Other ways to mitigate performance risk
  - More closely integrated continuous performance testing
- Proliferation of APIs / simple open-source tools

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SUMMARY

- Adjusting Performance Testing to Agile and CI is the main trend
- Specific challenges should be addressed:
  - Integration
  - Coverage Optimization
  - Variability / Noise Reduction
  - Change Detection
  - Advanced Analysis
  - Operations / Maintenance
- Performance engineering gets more integrated, context-dependent
  - Integrated into both **Dev**elopment and **Op**eration**s**

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Thank you!

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