TeaStore
A Micro-Service Application for Benchmarking, Modeling and Resource Management Research

Jóakim von Kistowski, Simon Eismann, André Bauer, Norbert Schmitt, Johannes Grohmann, Samuel Kounev

November 9, 2018

https://github.com/DescartesResearch/TeaStore
Many solutions for these questions have been proposed, however…
Challenge

How to evaluate

- Placement algorithms
- Auto-scalers
- New modeling formalisms
- Model extractors

- Require realistic reference and test applications

Reference applications help to

- Evaluate model (extractor) accuracy
- Measure auto-scaler elasticity
- Measure placement power consumption and performance
Requirements for a Test Application

- Scalable
- Allows for changes at run-time
- Reproducible performance results
- Diverse performance behavior
- Dependable and stable
- Online monitoring
- Load profiles
- Simple setup
- Modern, representative technology stack
Existing Test Applications

- **RUBiS [1]**
  - eBay-like bidding platform
  - Created 2002
  - Single service

- **SPECjEnterprise 2010 [2]**
  - SPEC Java Enterprise benchmark
  - Three tier architecture
  - No run-time scaling
  - Database is primary bottleneck

- **Sock Shop [3]**
  - Microservice network management demo application
  - Created 2016
  - Low load on non-network resources

- **Dell DVDStore, ACME Air, Spring Cloud Demo, and more in our MASCOTS paper [4]**
The TeaStore

Micro-service test application

- Five services + registry
- Netflix “Ribbon” client-side load balancer
- Kieker APM [5]
- Documented deployment options:
  - Manual
  - Docker images
  - Kubernetes
Services I

Registry
- Simplified Netflix Eureka
- Service location repository
- Heartbeat

RegistryClient
- Dependency for every service
- Netflix “Ribbon”
- Load balances for each client

WebUI
- Servlets/Bootstrap
- Integrates other services into UI
  - CPU + Memory + Network I/O

Authentication
- Session + PW validation
- SHA512 + BCrypt
  - CPU
Services II

**PersistenceProvider**
- Encapsulates DB
- Caching + cache coherence
  - **Memory**

**ImageProvider**
- Loads images from HDD
- 6 cache implementations
  - **Memory + Disk I/O**

**Recommender**
- Recommends products based on history
- 4 different algorithms
  - **Memory or CPU**

**TraceRepository**
- AMQP Server
- Collects traces from all services
Load and Usage Profiles (1/2)

HTTP load generator [5]

- Supports varying load intensity profiles
  - Can be created manually
  - Or using LIMBO [6]
- Scriptable user behavior
  - Uses LUA scripting language
  - “Browse” and “Buy” profiles on GitHub

https://github.com/joakimkistowski/HTTP-Load-Generator
Load and Usage Profiles (2/2)

JMeter
- Commonly used load generator
- Browse profile for JMeter
- Identical to HTTP Load Generator profile
Evaluation Teaser: Does it scale?

- Scales linearly
- Stresses 144 cores on 9 physical hosts
- HTTP Load Generator handles > 6000 requests per second
Three Use-Cases

- Performance modeling
- Auto-scaling
- Measuring energy-efficiency of placements

**Goal:** Demonstrate TeaStore’s use in these contexts
Question: How does utilization change with the default # products per page?

Approach:
- Create two workloads with different products per page distributions
- Create and calibrate performance model with default distribution
- Predict performance for
  - Different products per page distribution
  - Different service placement
Performance Model - Models

Products per Page Distribution

Calibration

\[ P_5(x) = \begin{cases} 
0.9 & \text{if } x = 5 \\
0.09 & \text{if } x = 10 \\
0.01 & \text{if } x = 20 \\
0 & \text{else.} 
\end{cases} \]

To Predict

\[ P_{10}(x) = \begin{cases} 
0 & \text{if } x = 5 \\
0.99 & \text{if } x = 10 \\
0.01 & \text{if } x = 20 \\
0 & \text{else.} 
\end{cases} \]

Deployment

Calibration

To Predict
Results with and without considering the parametric dependency using Service Demand Law-based model
Auto-Scaling - Scenario

Reactive Auto-Scaling Scenario

- Challenge: Scale in an elastic manner so that \# services matches demand
- Additional Challenge: Which service to scale?
- Approach:
  - Create heterogeneous configuration order
  - Put TeaStore under varying load
  - Decide scale-up / scale-down using research auto-scaler REACT [7]
Auto-Scaling - Results

- Under- and overprovisioning-timeshare <= 15%
- TeaStore can be used for auto-scaler evaluation
- Open challenge: Which service to scale next?
Energy Efficiency - Scenario

Energy efficiency of placements

- **Goal:** Show that power consumption, energy efficiency, and performance scale differently
  - Different optima for service placements

- **Approach:**
  - Distribute TeaStore on homogeneous and heterogeneous servers
  - Put TeaStore under load using increasing stress-test load intensity
  - Measure TeaStore performance and server wall power
Energy Efficiency - Measurement

Measurements in homogeneous and heterogeneous setting

- **SUT 1:**
  - 16 core Haswell
  - 32 GB RAM

- **SUT 2 (Heterogeneous):**
  - 8 core Skylake
  - 16 GB RAM

- **Metrics:**
  - Throughput
  - Power
  - Energy Efficiency
    - Throughput / Power
Energy Efficiency – Optima for Heterogeneous Placement

Placement Candidate 1

16 cores
- Web UI
- Auth
- Img
- Persist.

8 cores
- Web UI
- Auth
- Recomm.
- Img
- Persist.

Max: 1011.9 Tr/s
Max: 179.6 W
Geo: 4.4 Tr/J

Placement Candidate 2

16 cores
- Web UI
- Auth
- Persist.

8 cores
- Web UI
- Auth
- Recomm.
- Img
- Persist.

Max: 1067.7 Tr/s
Max: 187.0 W
Geo: 4.3 Tr/J
TeaStore - Conclusions

- Teastore can be used for
  - Performance modeling evaluation
  - Auto-Scaler evaluation
  - Placement and energy-efficiency evaluation

- Micro-service reference application
  - Five Services + Registry
  - Different resource usage characteristics
  - Kieker monitoring
  - Load Generators and Load Profiles
  - Kubernetes support

- Under Review by SPEC RG

https://github.com/DescartesResearch/TeaStore
Thank You!

From the TeaStore Dev Team

https://github.com/DescartesResearch/TeaStore

- **HTTP Load Generator**
  https://github.com/joakimkistowski/HTTP-Load-Generator

- **LIMBO Load Intensity Modeling Tool**
  http://descartes.tools/limbo

- **Kieker Application Monitoring**
  http://kieker-monitoring.net

All tools available at:
http://descartes.tools/

https://www.spec.org/jEnterprise2010/docs/DesignDocumentati 


