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Descartes
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TeaStore

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

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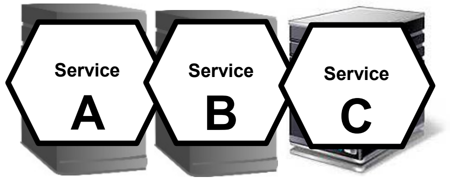
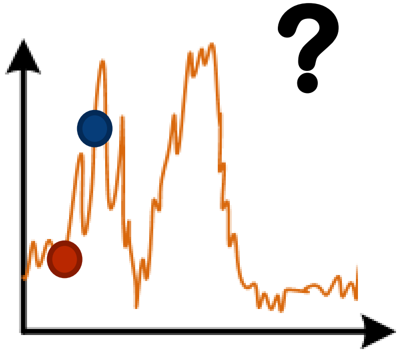
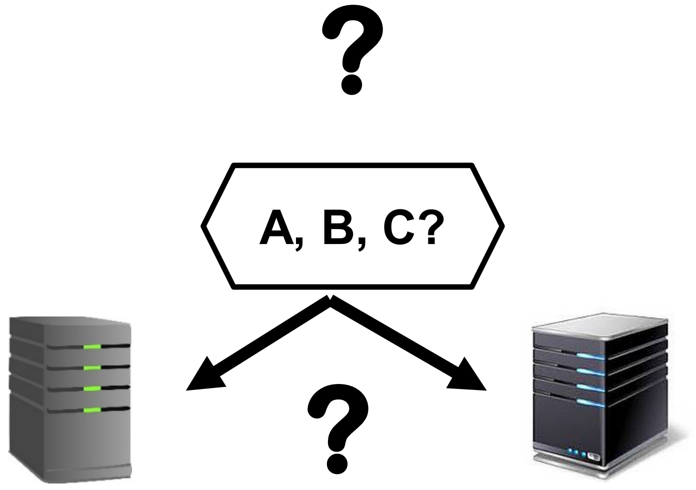
November 9, 2018

https://github.com/DescartesResearch/TeaStore

Example Research Scenario







Many solutions for these questions have been proposed, however…

Challenge

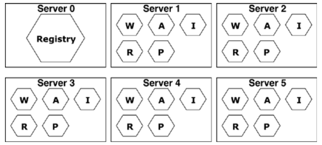
How to evaluate

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

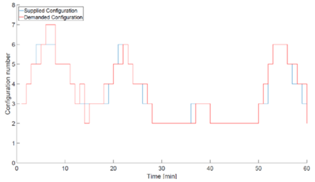
➢ Require realistic **reference and test applications**

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 Kieker
- Load profiles

- Simple setup
- Modern, representative technology stack

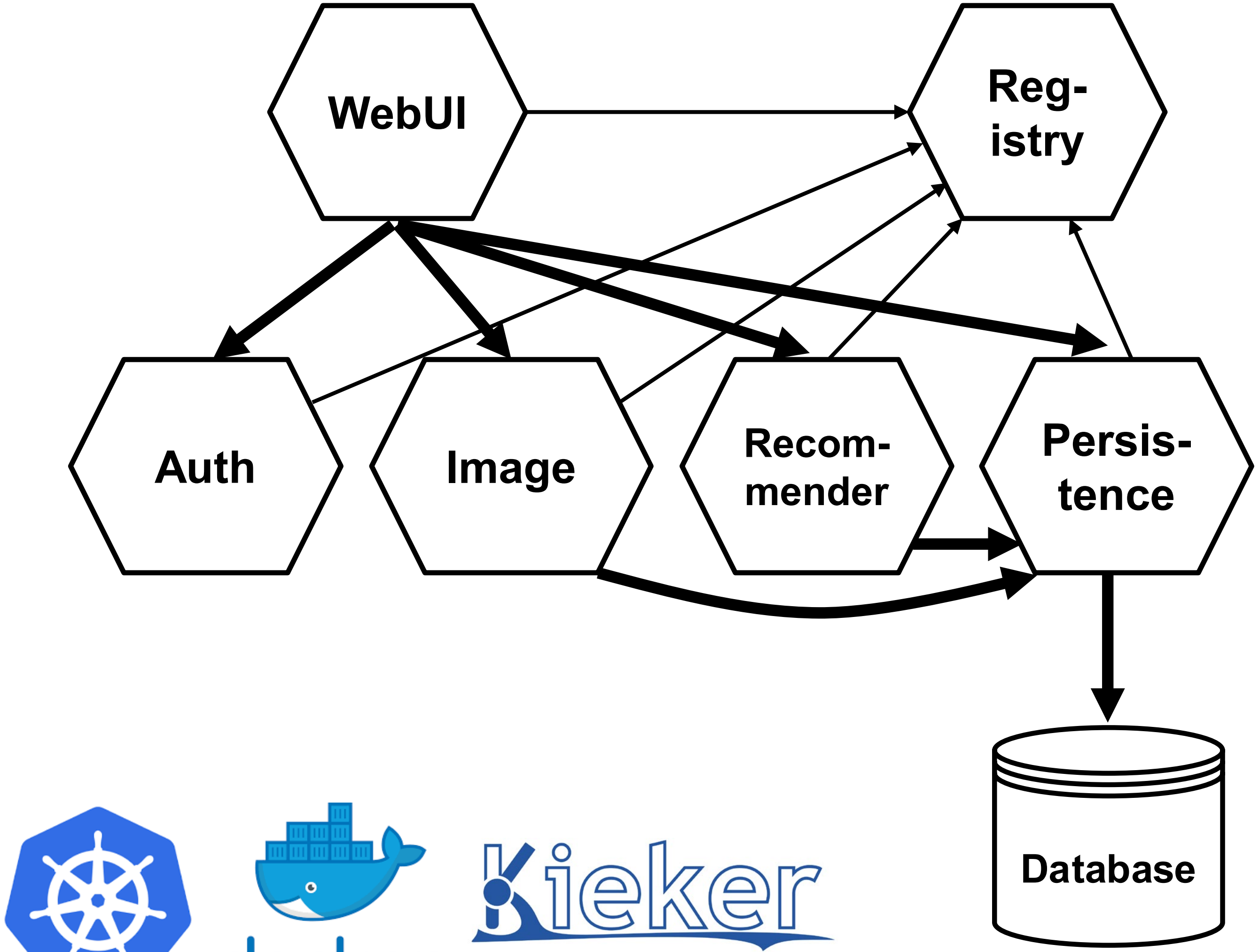
Existing Test Applications

- 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**

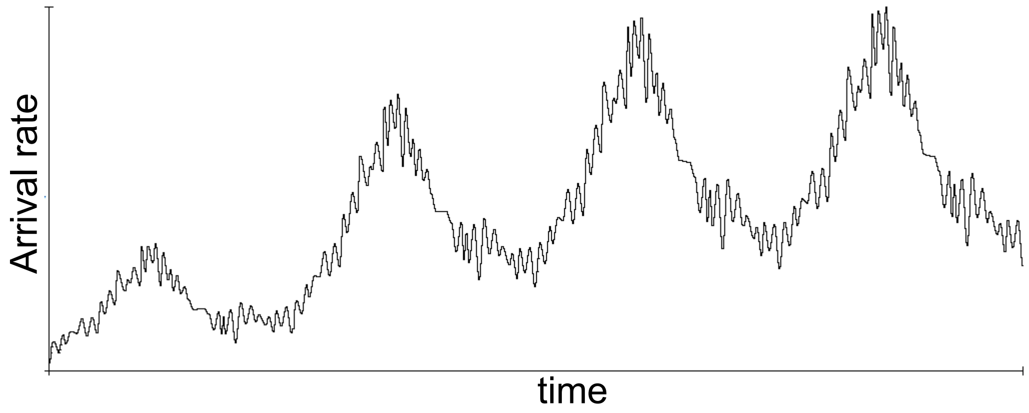
TraceRepository

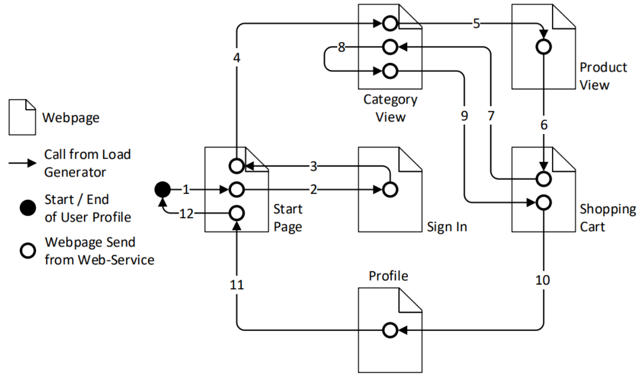
- AMQP Server
- Collects traces from all services

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



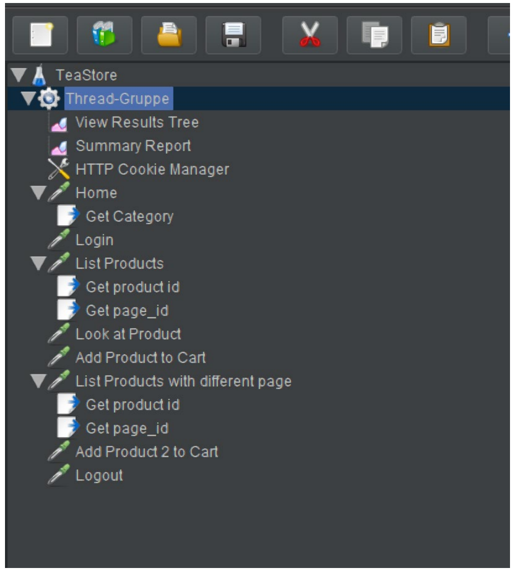


https://github.com/joakimkistowski/HTTP-Load-Generator

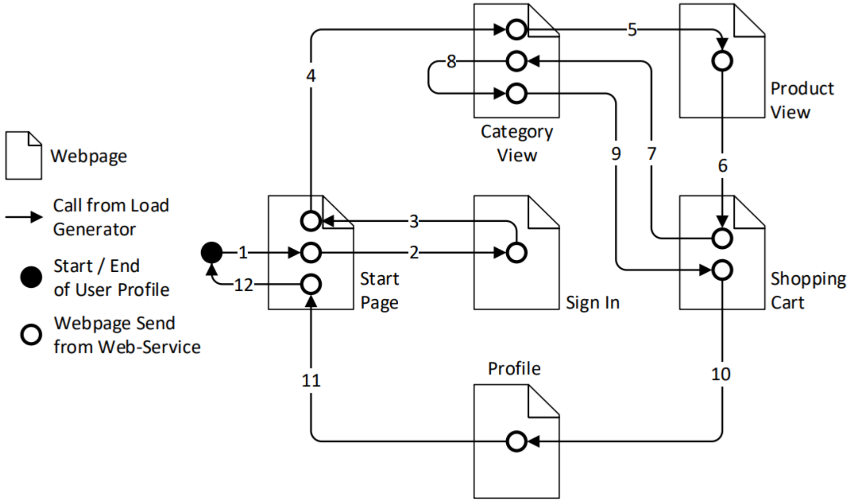
Load and Usage Profiles (2/2)

JMeter

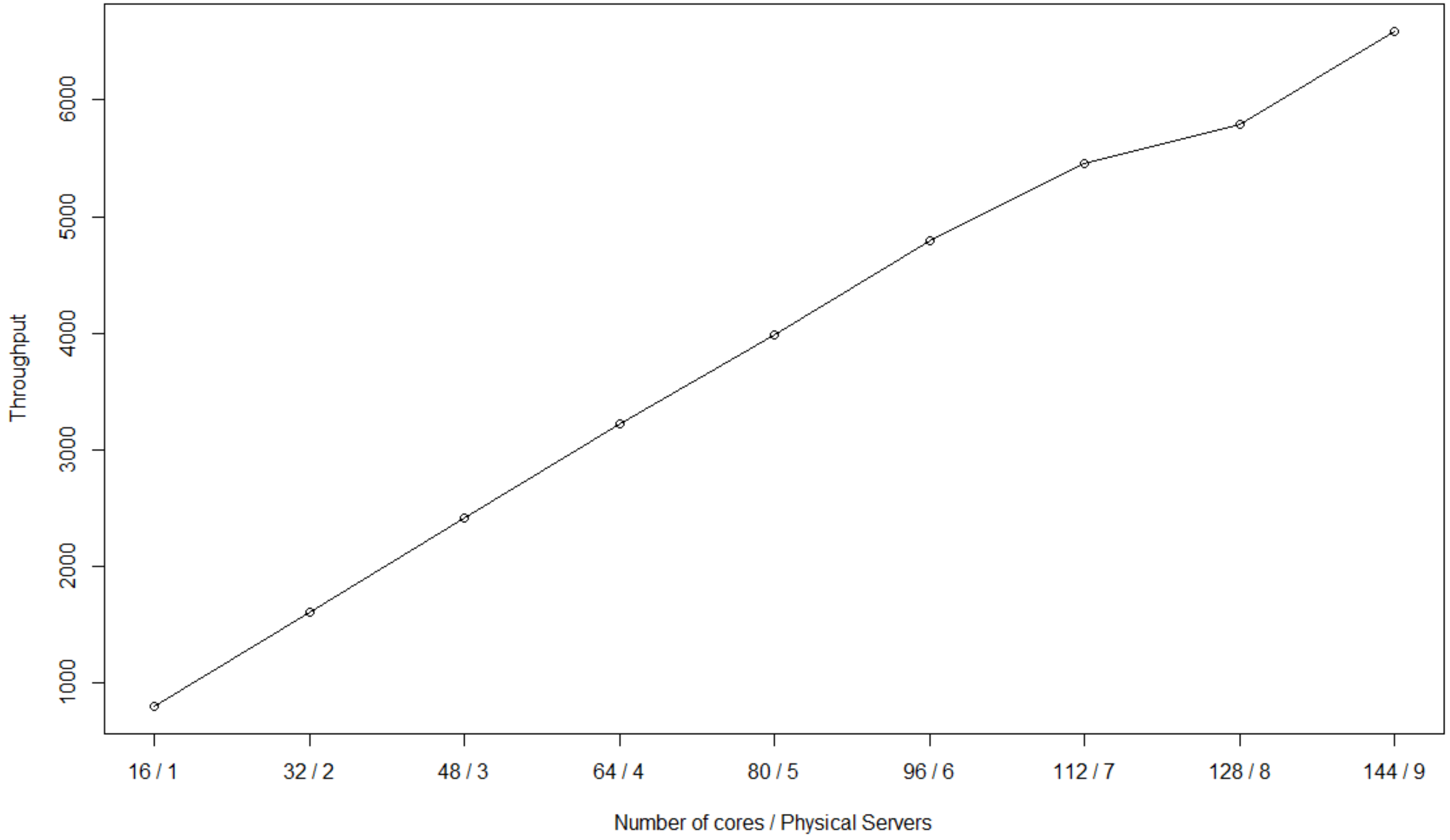
- Commonly used load generator
- Browse profile for JMeter
- Identical to HTTP Load Generator profile



- TeaStore
  - Thread-Gruppe
    - View Results Tree
    - Summary Report
    - HTTP Cookie Manager
    - Home
      - Get Category
    - Login
    - List Products
      - Get product id
      - Get page_id
    - Look at Product
    - Add Product to Cart
    - List Products with different page
      - Get product id
      - Get page_id
    - Add Product 2 to Cart
    - Logout



Evaluation Teaser: Does it scale?



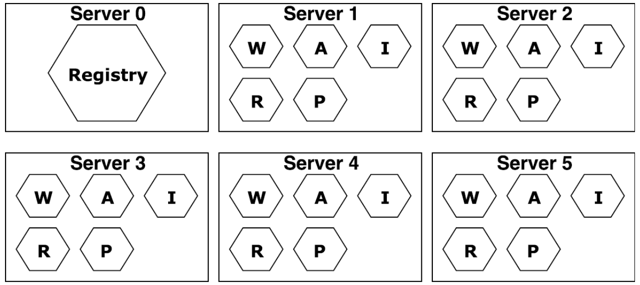
- Scales linearly
- Stresses 144 cores on 9 physical hosts
- HTTP Load Generator handles > 6000 requests per second

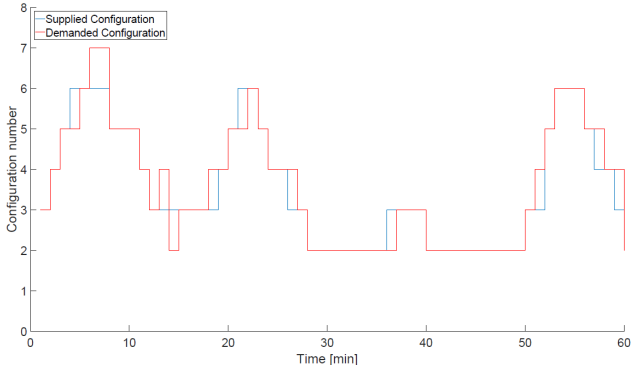
Evaluation

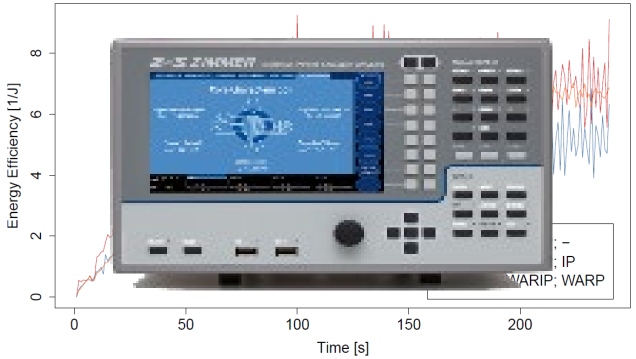
Three Use-Cases

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

Goal: Demonstrate TeaStore's use in these contexts

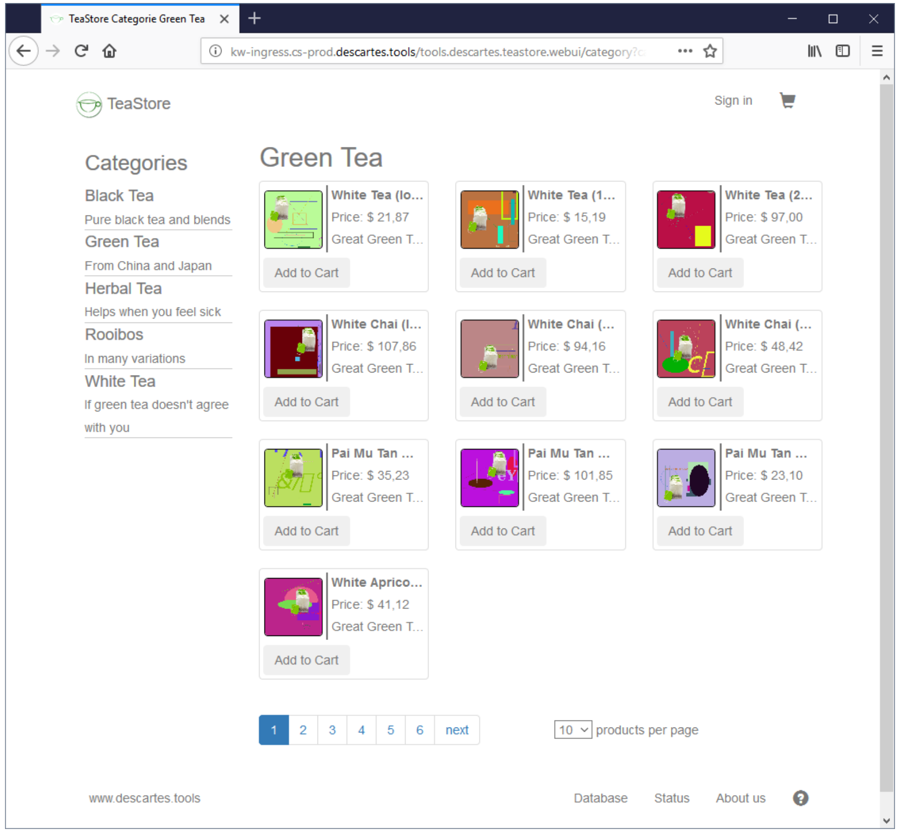






Performance Model - Scenario

- 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



TeaStore Categorie Green Tea

kw-ingress.cs-prod.descartes.tools/tools.descartes.teastore.webui/category?c

TeaStore

Categories

Black Tea
Pure black tea and blends

Green Tea
From China and Japan

Herbal Tea
Helps when you feel sick

Rooibos
In many variations

White Tea
If green tea doesn't agree with you

Green Tea

White Tea (lo...
Price: $ 21,87
Great Green T...

White Tea (1...
Price: $ 15,19
Great Green T...

White Tea (2...
Price: $ 97,00
Great Green T...

White Chai (l...
Price: $ 107,86
Great Green T...

White Chai (...
Price: $ 94,16
Great Green T...

White Chai (...
Price: $ 48,42
Great Green T...

Pai Mu Tan ...
Price: $ 35,23
Great Green T...

Pai Mu Tan ...
Price: $ 101,85
Great Green T...

Pai Mu Tan ...
Price: $ 23,10
Great Green T...

White Aprico...
Price: $ 41,12
Great Green T...

10 products per page

www.descartes.tools

Performance Model - Models

Products per Page Distribution

Calibration

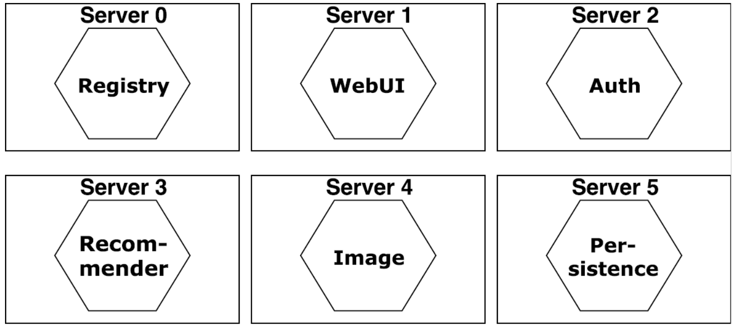
$$P_5(x) = \begin{cases} \boxed{0.9 \quad \text{if } x = 5} \\ 0.09 \quad \text{if } x = 10 \\ 0.01 \quad \text{if } x = 20 \\ 0 \quad \text{else.} \end{cases}$$

To Predict

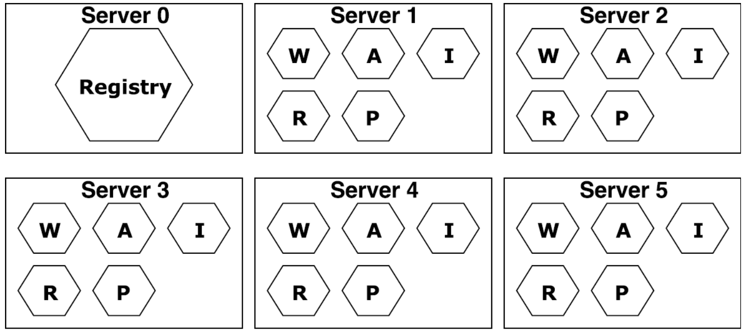
$$P_{10}(x) = \begin{cases} 0 \quad \text{if } x = 5 \\ \boxed{0.99 \quad \text{if } x = 10} \\ 0.01 \quad \text{if } x = 20 \\ 0 \quad \text{else.} \end{cases}$$

Deployment

Calibration

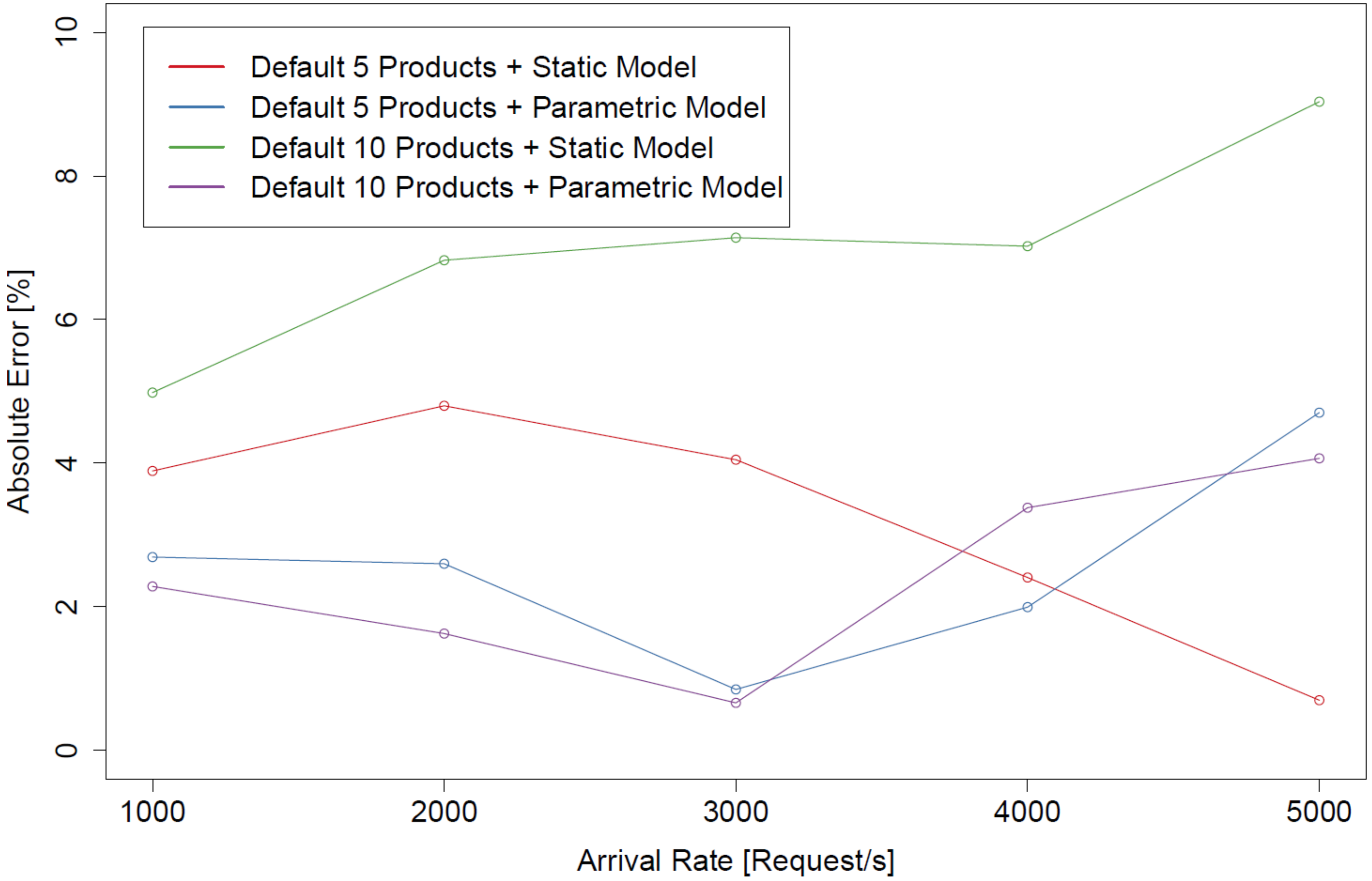


To Predict



Performance Model - Results

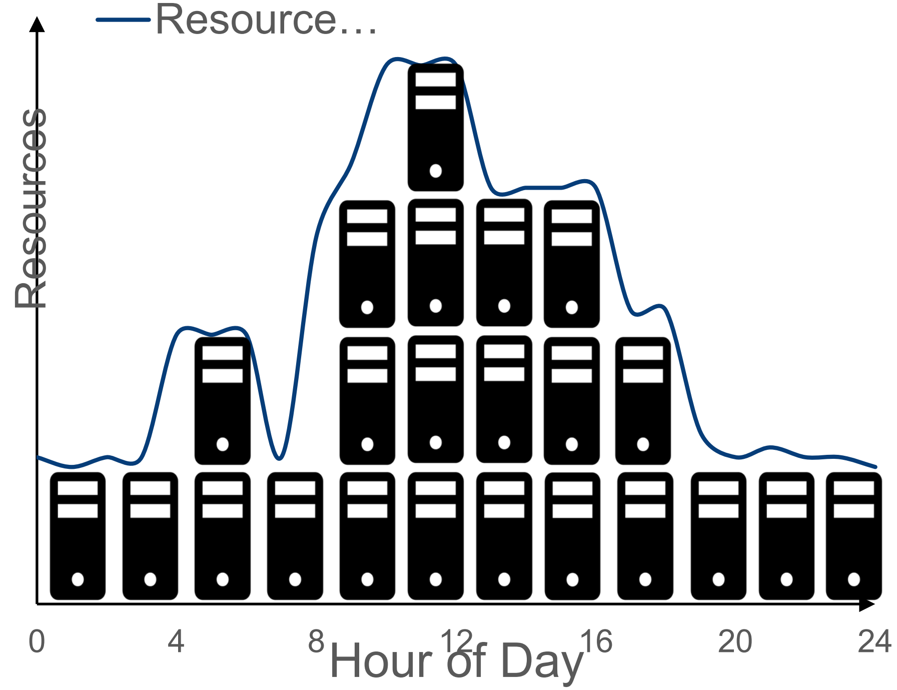
Results with and without considering the parametric dependency using Service Demand Law-based model



Auto-Scaling - Scenario

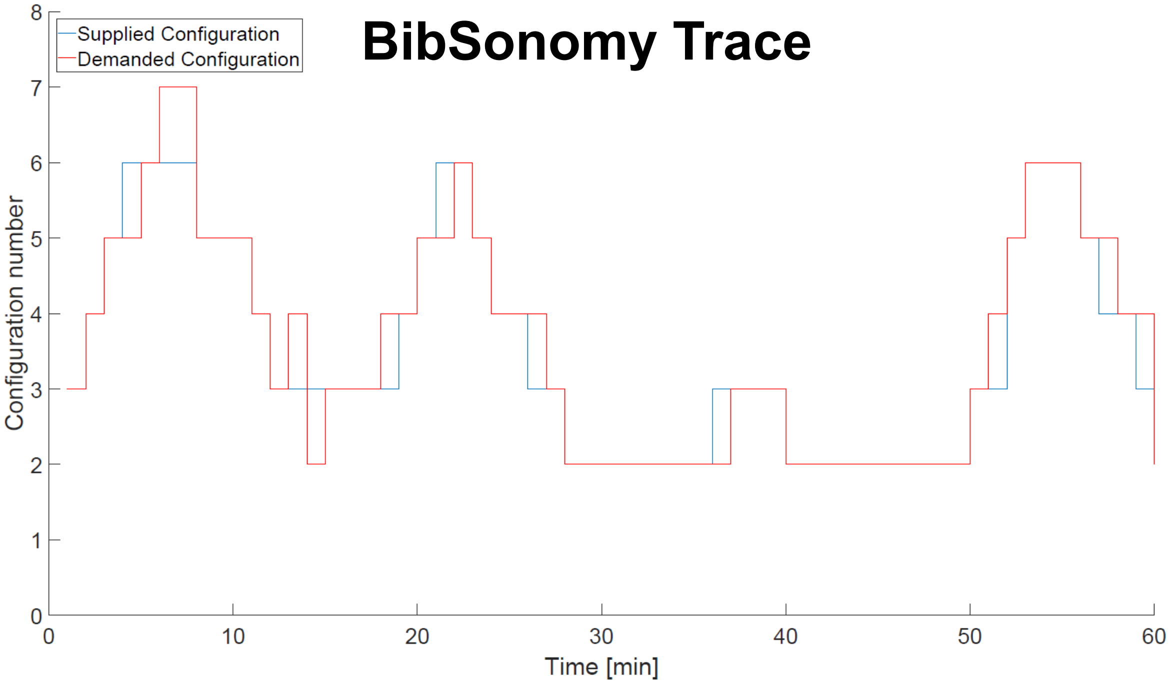
Reactive Auto-Scaling Scenario

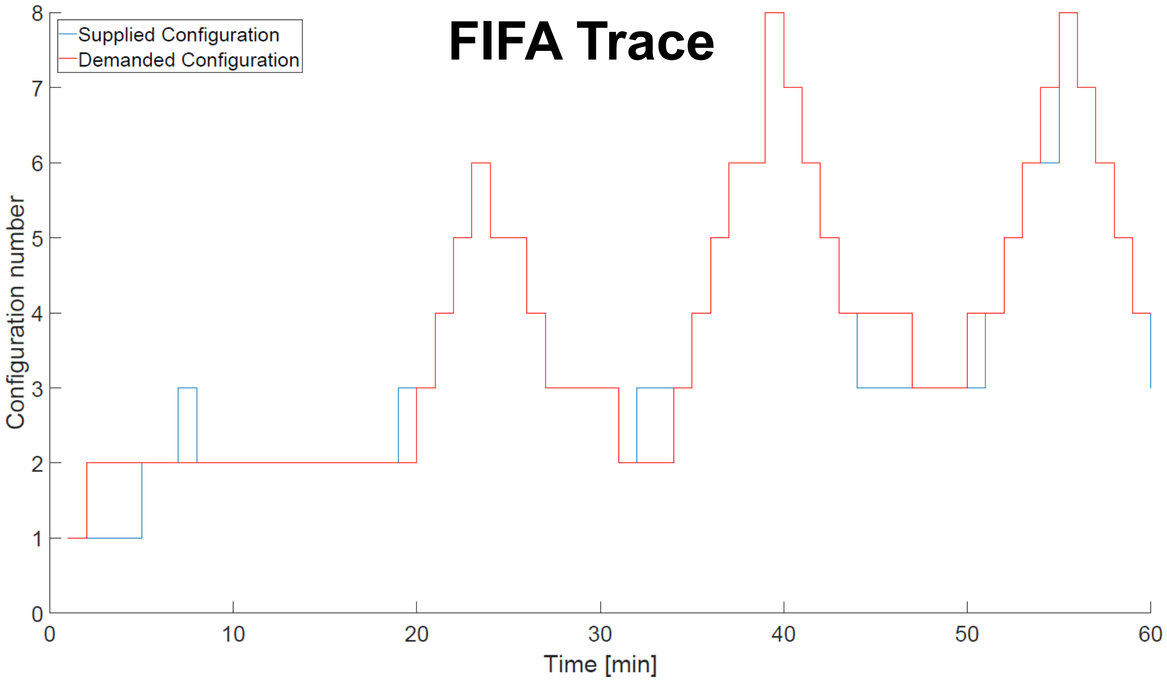
- Challenge: Scale in an elastic manner so that # *services* matches demand
- Additional Challenge: Which service to scale?
- Approach:
  - Create heterogeneous configuration order
  - Put TeaStore under varying load
  - Decide scale-up / scale-down using research auto-scaler REACT [7]



Service	Configuration								
	#1	#2	#3	#4	#5	#6	#7	#8	#9
WebUI	1	1	2	3	3	4	5	5	6
Image Provider	1	1	2	3	3	4	5	5	6
Authentication	1	2	3	4	5	6	7	8	9
Recommender	1	1	1	2	2	2	3	3	3
Persistence	1	2	2	3	4	4	5	6	6

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

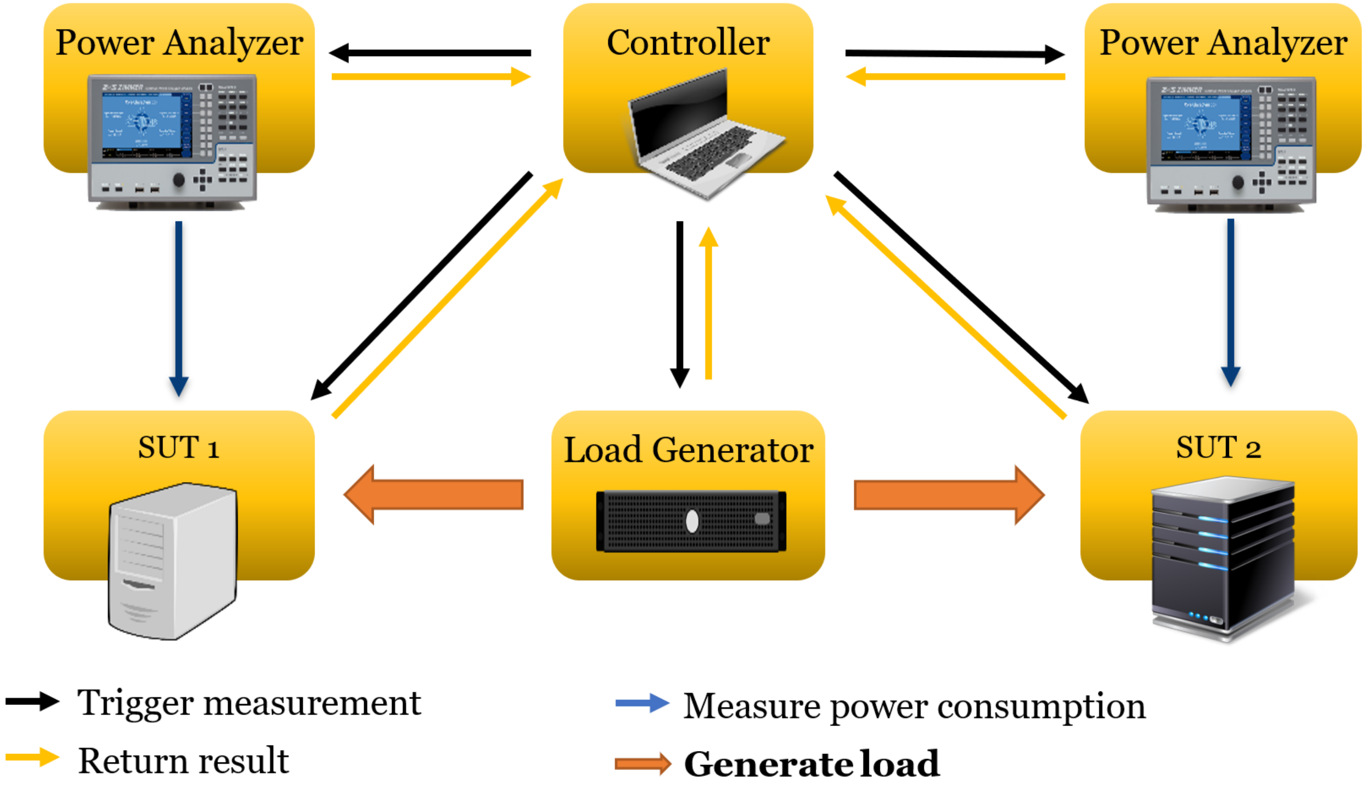
Energy efficiency of placements

- 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

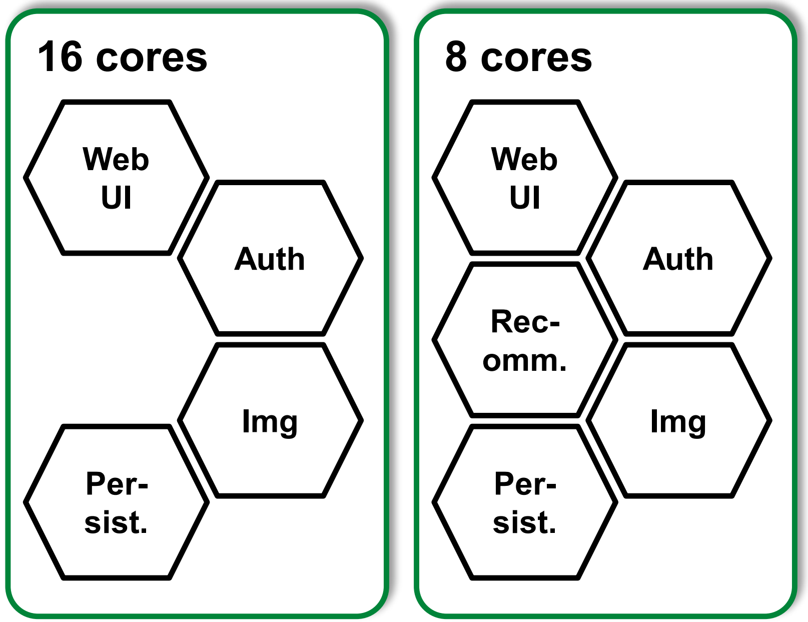
Measurements in homogeneous and heterogeneous setting

- SUT 1:
  - 16 core Haswell
  - 32 GB RAM
- SUT 2 (Heterogeneous):
  - 8 core Skylake
  - 16 GB RAM
- Metrics:
  - Throughput
  - Power
  - Energy Efficiency
    - Throughput / Power



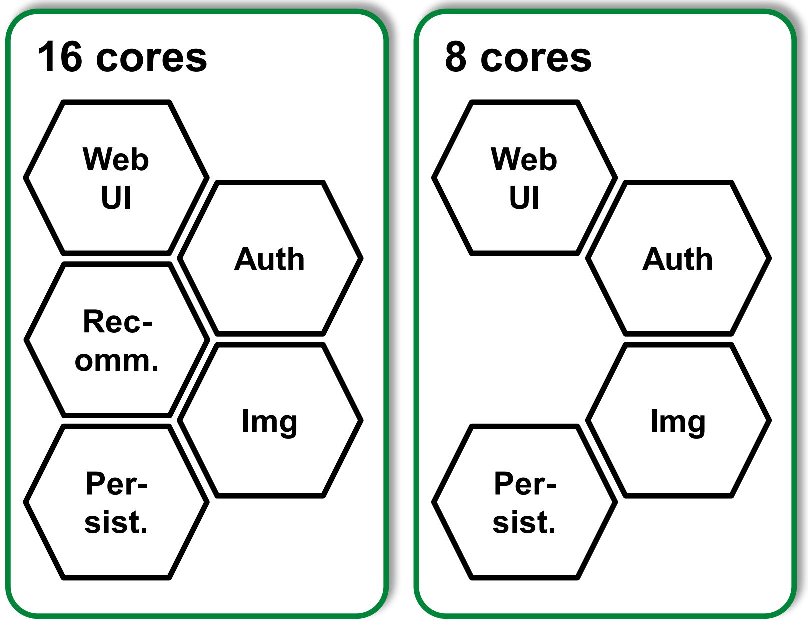
Energy Efficiency – Optima for Heterogeneous Placement

Placement Candidate 1



Max	⏱	1011.9 Tr/s
Max	🔌	**179.6** W
Geo	⏱/🔌	**4.4** Tr/J

Placement Candidate 2



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/

References

[1] RUBiS User's Manual, May 2008.

[2] Standard Performance Evaluation Corporation (SPEC). SPEC jEnterprise 2010 Design Document. https://www.spec.org/jEnterprise2010/docs/DesignDocumentation.html, May 2010, Accessed: 16.10.2017.

[3] Weaveworks Inc. Sock Shop: A Microservice Demo Application. https://github.com/microservices-demo/microservices-demo, 2017, Accessed: 19.10.2017.

[4] A. van Hoorn, J. Waller, and W. Hasselbring. Kieker: A framework for application performance monitoring and dynamic software analysis. In *Proceedings of the 3rd joint ACM/SPEC International Conference on Performance Engineering (ICPE 2012)*, April 2012.

[5] J. von Kistowski, M. Deffner, and S. Kounev. Run-time Prediction of Power Consumption for Component Deployments. In *Proceedings of the 15th IEEE International Conference on Autonomic Computing (ICAC 2018)*, Trento, Italy, September 2018.

[6] J. von Kistowski, N. Herbst, S. Kounev, H. Groenda, C. Stier, and S. Lehrig. Modeling and Extracting Load Intensity Profiles. *ACM Transactions on Autonomous and Adaptive Systems (TAAS)*, 11(4):23:1 - 23:28, January 2017.

[7] T. C. Chieu, A. Mohindra, A. A. Karve, and A. Segal. Dynamic scaling of web applications in a virtualized cloud computing environment. In *International Conference on E-Business Engineering*, 2009.

[8] N. R. Herbst, S. Kounev, and R. Reussner. Elasticity in Cloud Computing: What it is, and What it is Not. In *Proceedings of the 10th International Conference on Autonomic Computing (ICAC 2013)*, San Jose, CA, June 2013.