The Descartes Modeling Language: Status Quo

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Main References

- **Fabian Brosig.** *Architecture-Level Software Performance Models for Online Performance Prediction.* PhD thesis, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, 2014. [http](http) [http](http)

- **Nikolaus Huber.** *Autonomic Performance-Aware Resource Management in Dynamic IT Service Infrastructures.* PhD thesis, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, 2014. [http](http) [http](http)
Elastic Resource Provisioning

Challenges

- When exactly should a reconfiguration be triggered?
- Which particular resources should be scaled?
- How quickly and at what granularity?
Semantic Gap Problem

Applications
- Multiple tiers
- Multiple resource types

Resource Allocation

Complex Software Stacks
- Multiple layers
- Heterogeneous

End-to-end QoS metrics
Application SLAs

Resource Allocations in Each Tier & Each Layer
Modeling methods for predicting at run-time the effect of dynamic changes on the system Quality-of-Service (QoS)
  - Current focus: availability and performance (response time, throughput and resource/energy efficiency)

Model-based algorithms and techniques for autonomic system adaptation during operation

Goal:
  - End-to-end QoS guarantees
  - High resource/energy efficiency
  - Low operating costs
Descartes Modeling Language

Adaptation Process Model

Strategies  Tactics  Actions

Adaptation Points Model

Architecture-level Performance Model

Application Architecture Model

Resource Landscape Model

Usage Profile

Degrees-of-Freedom

Descartes Modeling Language (DML)

Software

Infrastructure
The Descartes Modeling Language

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http://descartes.tools/dml
Online Performance Prediction

Architecture-Level Performance Model

Online Performance Prediction

# VM-Instances = (1...16)

# vCPU = (2...4)

Autonomic Decision Making
Model-Based System Adaptation

1. Problem Anticipation
   - Load Forecasting

2. Adaptation on the Model Level
   - Adaptation Process Model
   - Architecture-Level Performance Model

3. Adaptation Impact Prediction
   - Online Perf. Prediction

4. Adaptation Execution on Real System
   - System

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Language

Tool Chain

Summary
Descartes Tool Chain

http://descartes.tools
Descartes Tools

Below you see a list of the tools we develop. Please click on the tool name to get more information:

**Descartes Modeling Language:**
- DML Specification
  - Implementation in EMF (Eclipse Modeling Framework)
- DML Bench
- DNI - Descartes Network Infrastructures Modeling

**Workload Characterization & Model Extraction:**
- LIMBO Load Intensity Modeling Tool
- WCF (Workload Characterization and Forecasting Tool)
- LibReDE (Library for Resource Demand Estimation)
- SPA (Storage Performance Analyzer)

**Declarative Performance Engineering:**
- DQL (Descartes Query Language)

**Benchmarking:**
- BUNGEE Cloud Elasticity Benchmark
- hinjector Hypercall Attack Injector

**Stochastic Modeling:**
- QPME (Queueing Petri net Modeling Environment)
DML Bench

- Editors
  - Textual and graphical editors for DML models
- Solvers
  - Solvers for conducting performance prediction
- S/T/A Adaptation Framework
  - Execution of adaptation process on the model level

http://descartes.tools/dml_bench
Example of a performance query specified with DQL

```
SELECT s.avgResponseTime,
app.utilization,
dbs.utilization
CONSTRAINED AS FAST
FOR RESOURCE
  'ApplicationServer' AS app,
RESOURCE 'DBServer' AS dbs,
SERVICE 'processOrder' AS s;
```
DNI - Descartes Network Infrastructure Modeling

- Language for perf. modeling of data center networks
  - network topology, switches, routers, virtual machines, network protocols, routes, flow-based configuration, ...

- Model solvers based on simulation (OMNeT)

http://descartes.tools/dni
LibReDE

- Library for Resource Demand Estimation
  - Ready-to-use implementations of estimation approaches
  - Comparison of the accuracy of different approaches
  - Selection of a suitable approach for a given scenario

http://descartes.tools/librede
LIMBO

- Load Intensity Modeling Tool
  - Automated model extraction from recorded traces
  - Creation and composition of custom models
  - Emulation of job arrivals for load generation

http://descartes.tools/limbo
WCF

- **Workload Classification & Forecasting Tool**
  - Use of multiple alternative forecasting methods in parallel
  - Selection of method based on its accuracy in the recent past

http://descartes.tools/wcf
BUNGEE

- Framework for benchmarking elasticity
  - Current focus: IaaS cloud platforms

http://descartes.tools/bungee
Summary

- Descartes Tool Chain
  - **DML Bench** - Editors, solvers and adaptation framework
  - **DQL** – Declarative query language
  - **DNI** – Descartes network infrastructure modeling
  - **LibReDE** - Library for resource demand estimation
  - **LIMBO** – Load intensity modeling tool
  - **WCF** – Workload classification & forecasting tool
  - **BUNGEE** - Framework for benchmarking elasticity
Questions?

http://www.descartes-research.net

http://descartes.tools
Employed Modeling & Analysis Methods

Descriptive Architecture-level Models → DML
- OMG Meta Object Facility (MOF)
- MOF-based meta-models
- (UML MARTE)
- (UML SPT)

Predictive Performance Models
- Bounding techniques
- Operational analysis
- Statistical regression models
- Stochastic process algebras
- (Extended) queueing networks
- Layered queueing networks
- Queueing Petri nets
- Machine learning-based models
- Detailed simulation models

Workload Forecasting
- AR(I)MA
- Extended exp. smoothing
- tBATS
- Croston’s method
- Cubic smoothing splines
- Neural network-based

Resource Demand Estimation
- Regression-based techniques
- Kalman filter
- Nonlinear optimization
- Maximum likelihood estimation
- Independent component analysis

Regression Analysis
- MARS
- CART
- M5 trees
- Cubist forests
- Quantile regression forests
- Support vector machines

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