Improving IaaS Cloud Analyses by Black-Box Resource Demand Modeling

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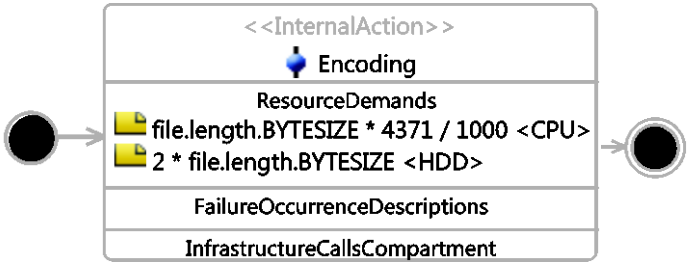
FZI FORSCHUNGSZENTRUM INFORMATIK

cactos

Modeling Resource Demands of Applications

- Classical Palladio component-based application models
  - Resource demand per action
  - Resource demands issued on resources based on user calls



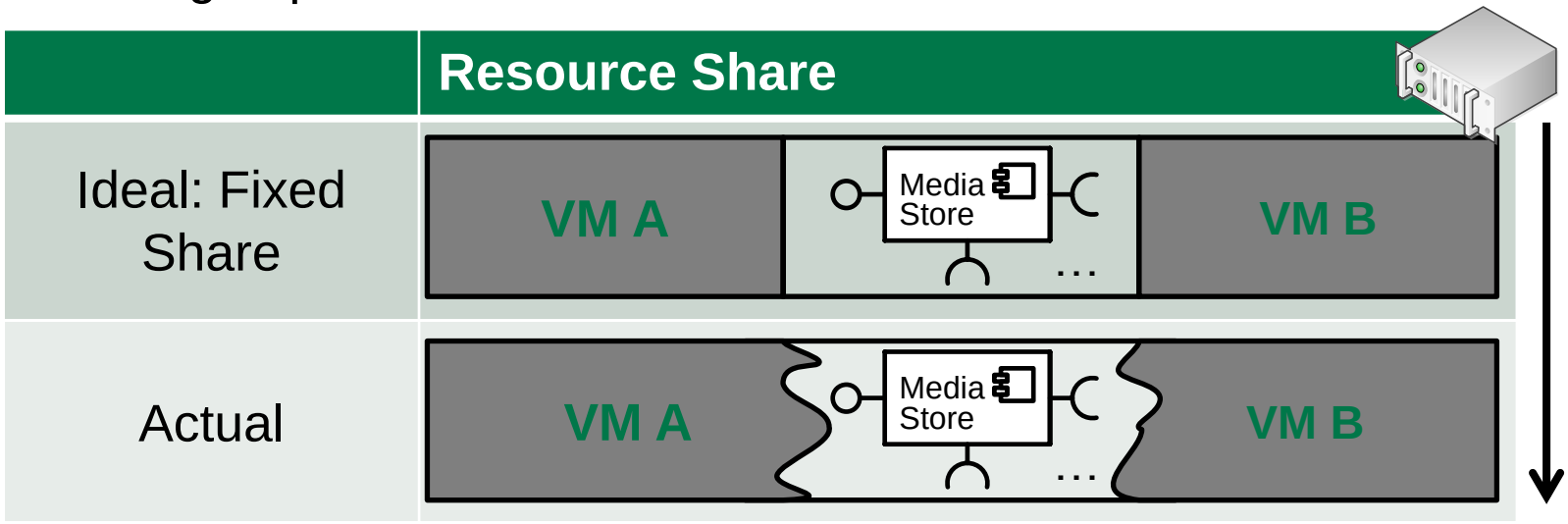
- Influence of other load on the same resource, e.g. Virtual Machines (VMs)?
  - Infrastructure as a Service (IaaS): User interactions not monitorable
  - But: Monitoring of resource demand on hypervisor layer possible
    - Performance counters
    - (Potentially) system traces

→ Describe resource demand of VM as function $P(t)$ over time

Use cases

- Capture-replay of black-box VM resource profiles
  - What-if analyses for data center planning
  - Reasoning on the impact of placement and optimisation decisions on
    - Resource utilization
    - Energy consumption

- Modeling of performance interferences in virtualized environments



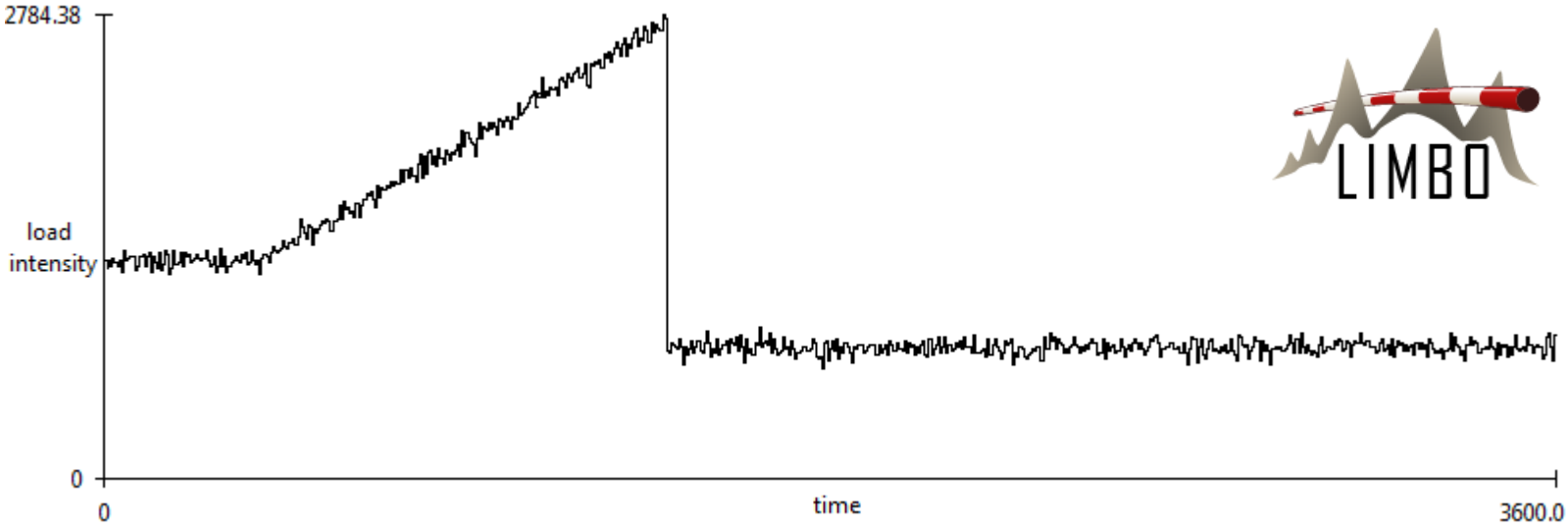
Foundations – SimuLizar

SimuLizar [Becker2013a, Becker2013b]

- Set of extensions to core Palladio [Becker2009]
- Modeling and analysis of self-adaptive software systems
- Supports
  - Design and evaluation of self-adaptation strategies
  - Modular extension of evaluated system characteristics
  - Variances in usage profiles: **Usage Evolution** [Lehrig2015]

Foundations – Usage Evolution

- Model variations in user load and behavior over time [Lehrig2015]
  - (1) User load described in terms of
    - Interarrival time (open workload)
    - Number of concurrent users (closed workload)
  - (2) User behavior: Change value assigned to VariableCharacterisation
- Descartes Load Intensity Model (DLIM) [Kistowski2015] used to describe variations in (1) and (2)



Relaxing Assumptions for Usage Evolution

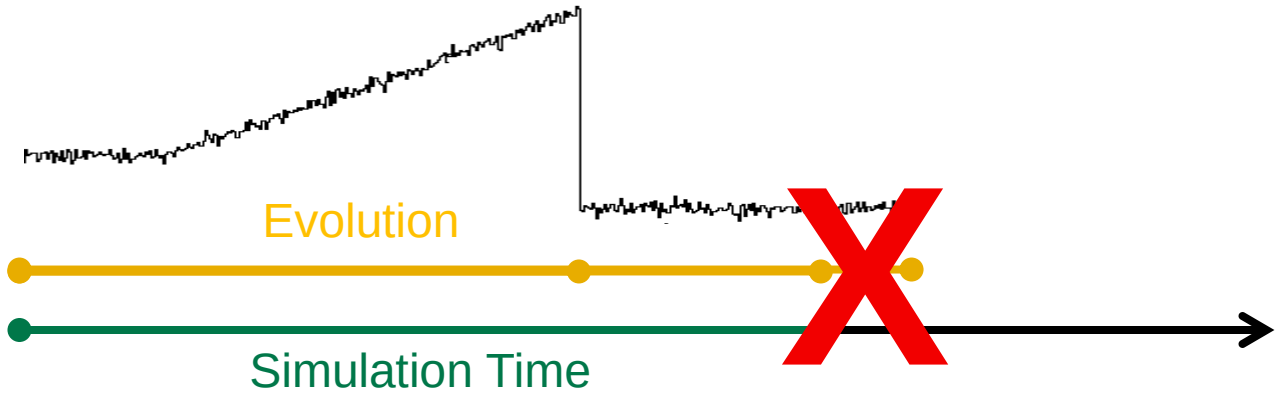
Usage Evolution made the following Assumptions and Limitations

A1) The evolution has the maximum simulation time as its only stop condition

A2) The evolution model's length of each Usage Scenario is less than or equal to the simulation time

L1) The evolution duration is always scaled to the maximum simulation time

L2) Only the first Usage Scenario is evolved



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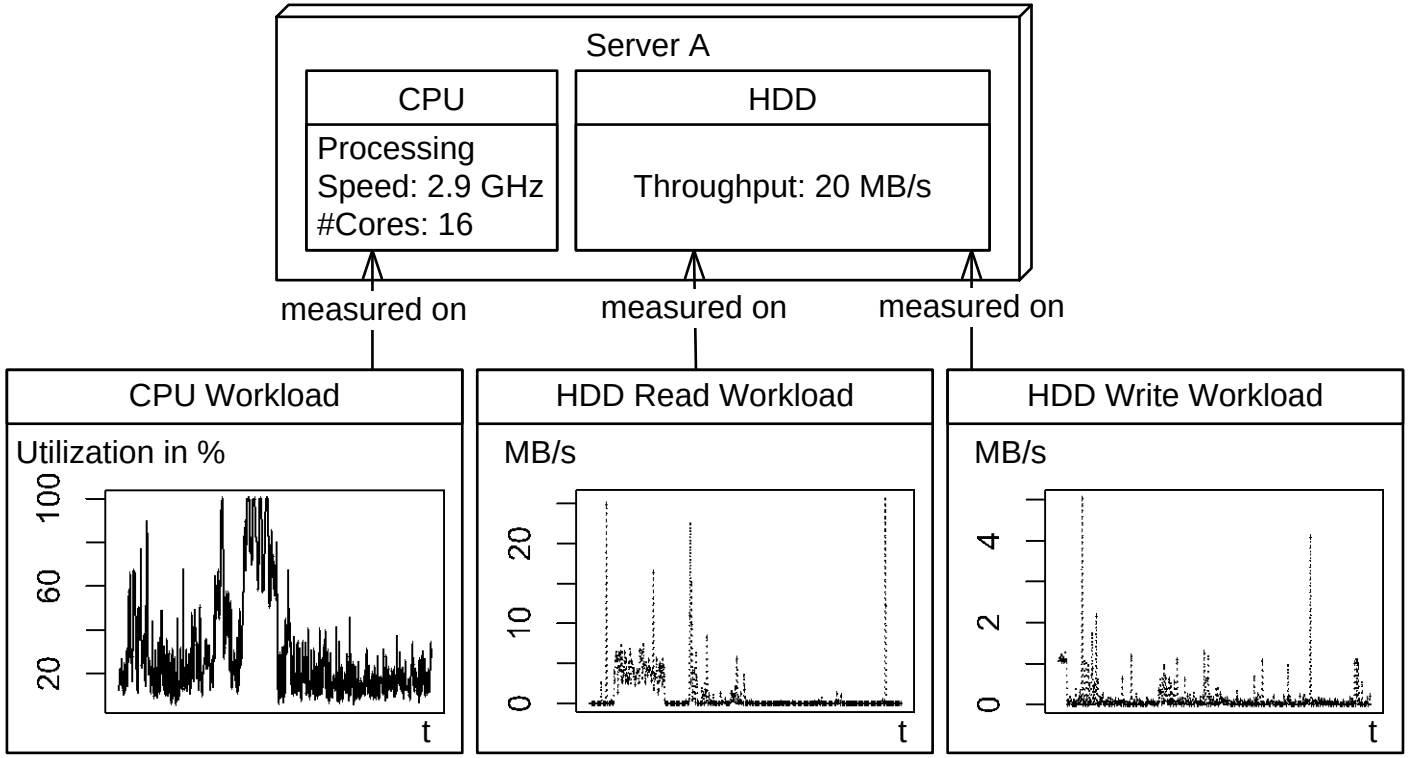
L1) The evolution duration is always scaled to the maximum simulation time

→ Decoupling of evolution duration and simulation time

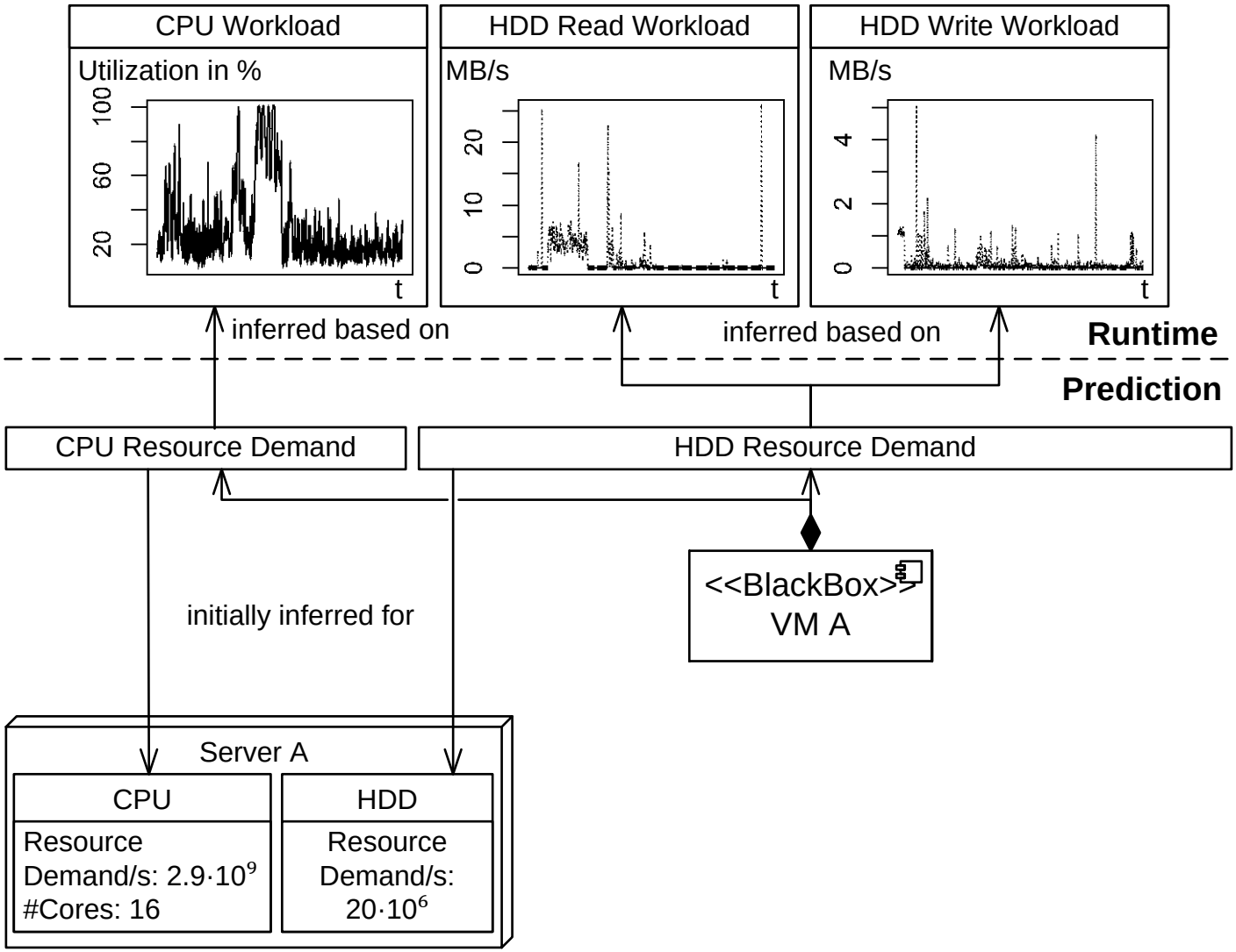
- Specification of evolution sampling rate
- Specification of (non-)repeating evolution interval

Modeling the Behavior of Black-Box Virtual Machines

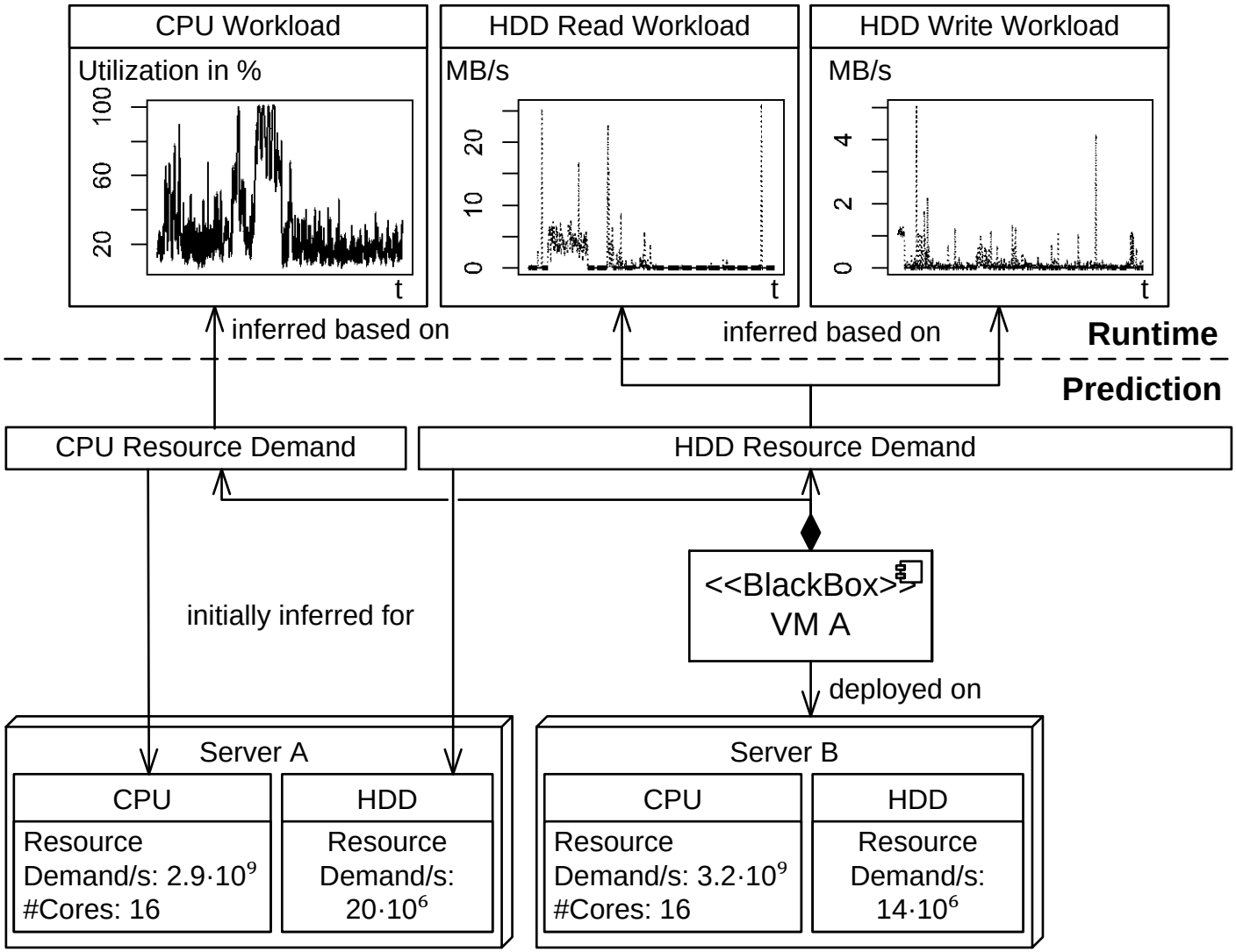
- Workload description extracted from deployment environment
- Runtime measurements
- How to transfer to prediction models?



Modeling the Behavior of Black-Box Virtual Machines



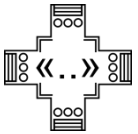
Modeling the Behavior of Black-Box Virtual Machines



Simulation of Black-Box Virtual Machines

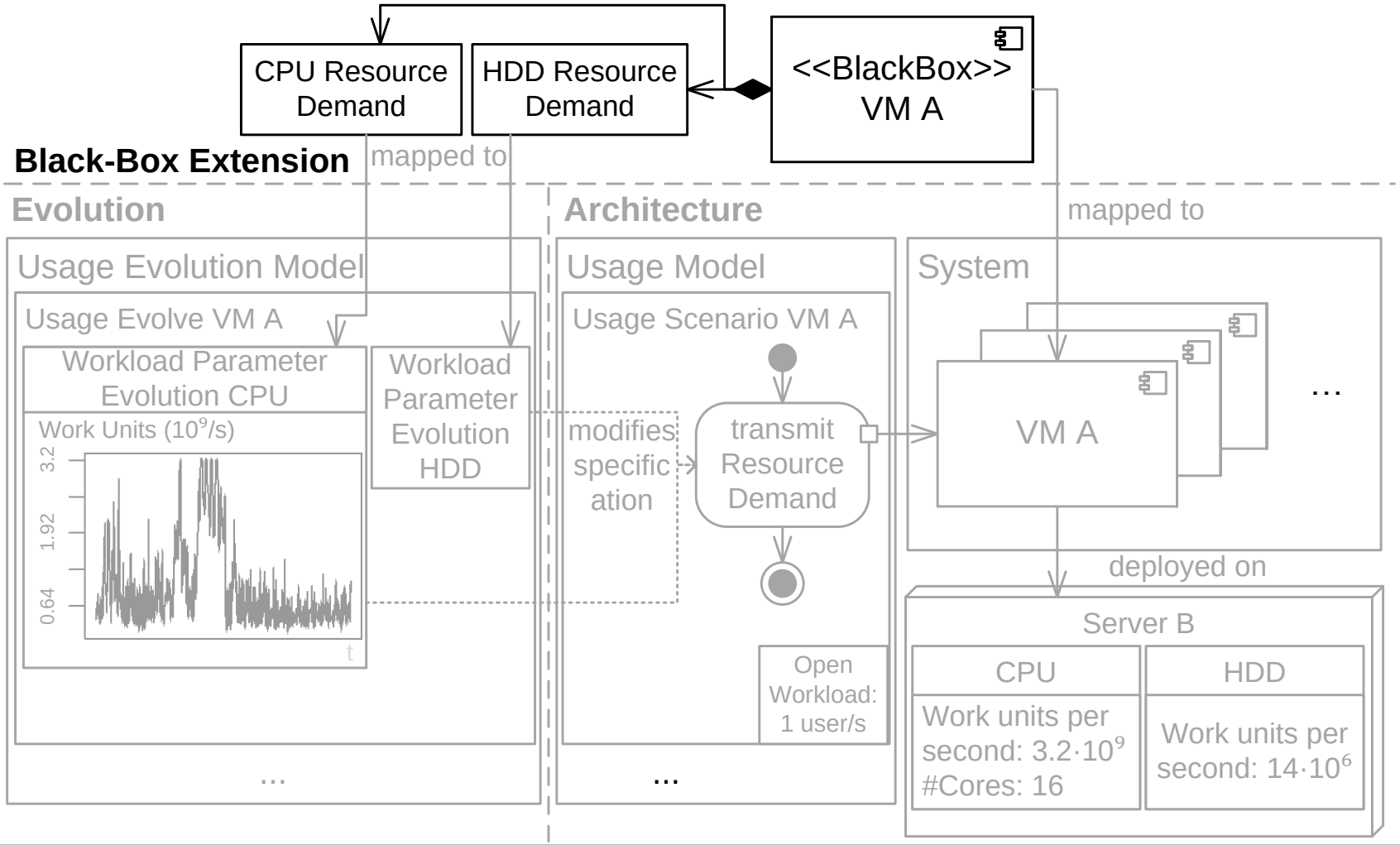
- Black-Box VMs are not first-level entities in PCM
- But: Can be mapped to Core PCM + Usage Evolution
- Mapping realized as refinement transformation
  - CACTOS-specific transformation
  - Transformation for light-weight PCM extension

- Modeling of black-box VMs supported via MDSD Profile [Kramer2012]



- Simulation of refined model via SimuLizar

Mapping of Black-Box Models to SimuLizar and PCM



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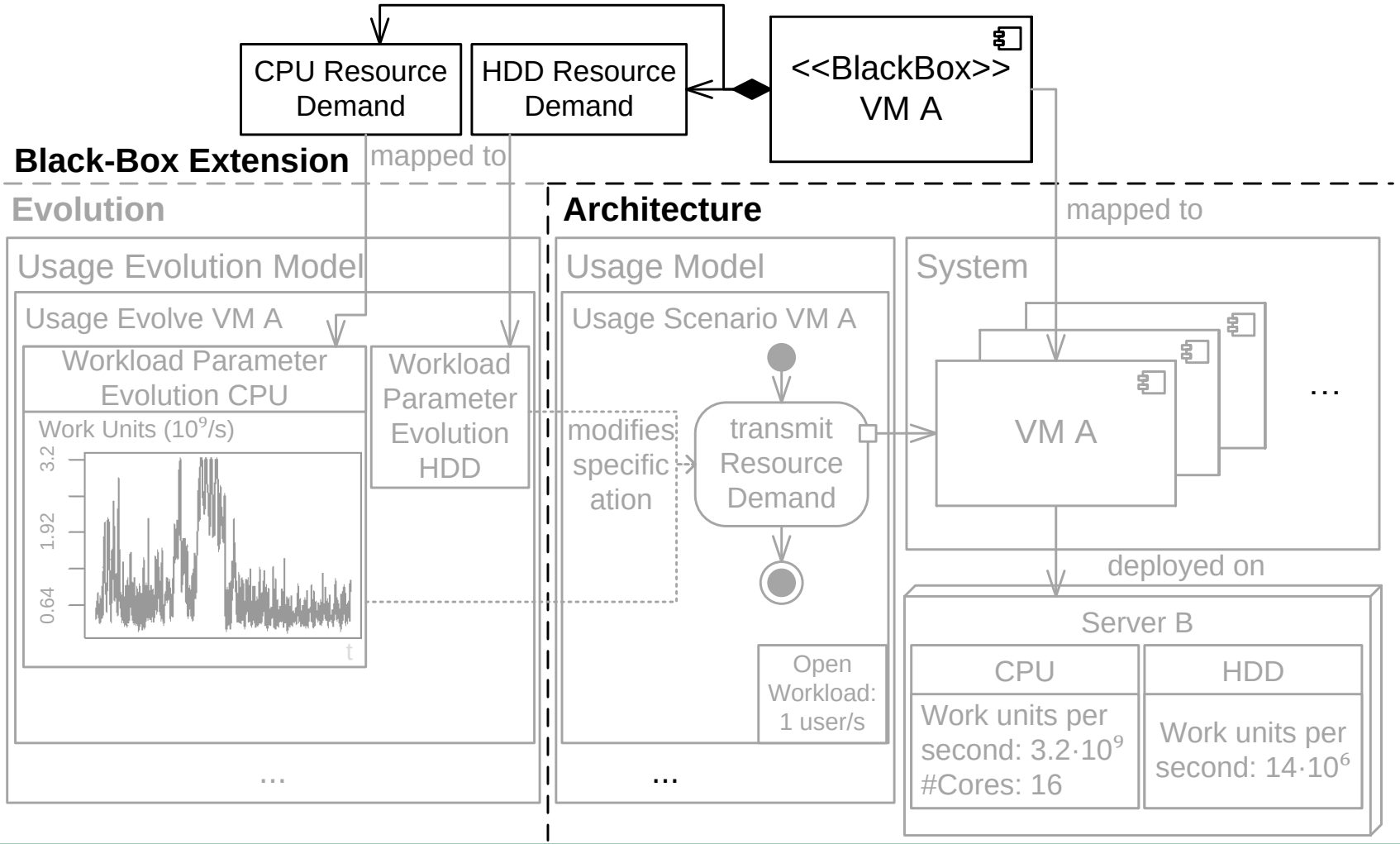

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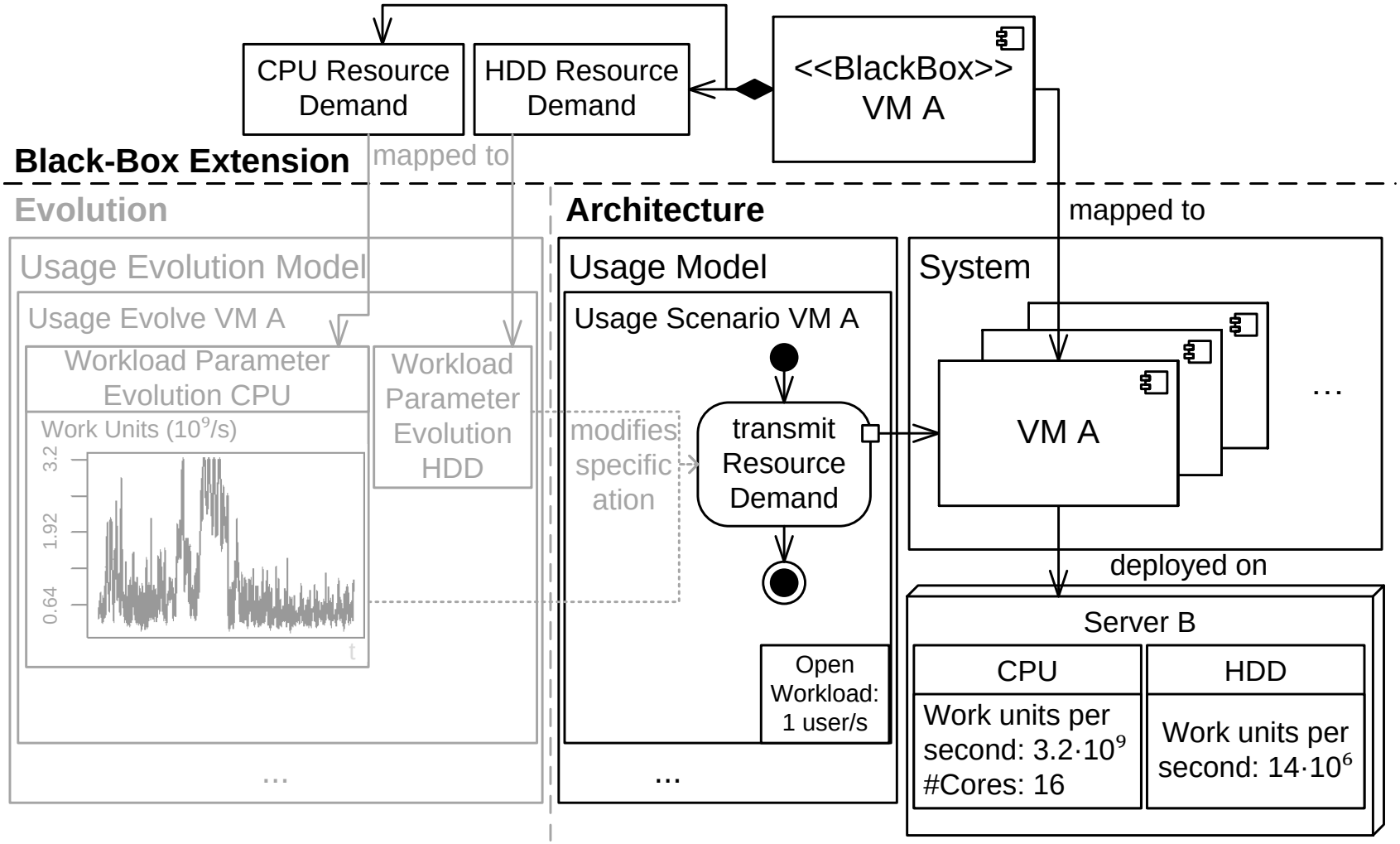
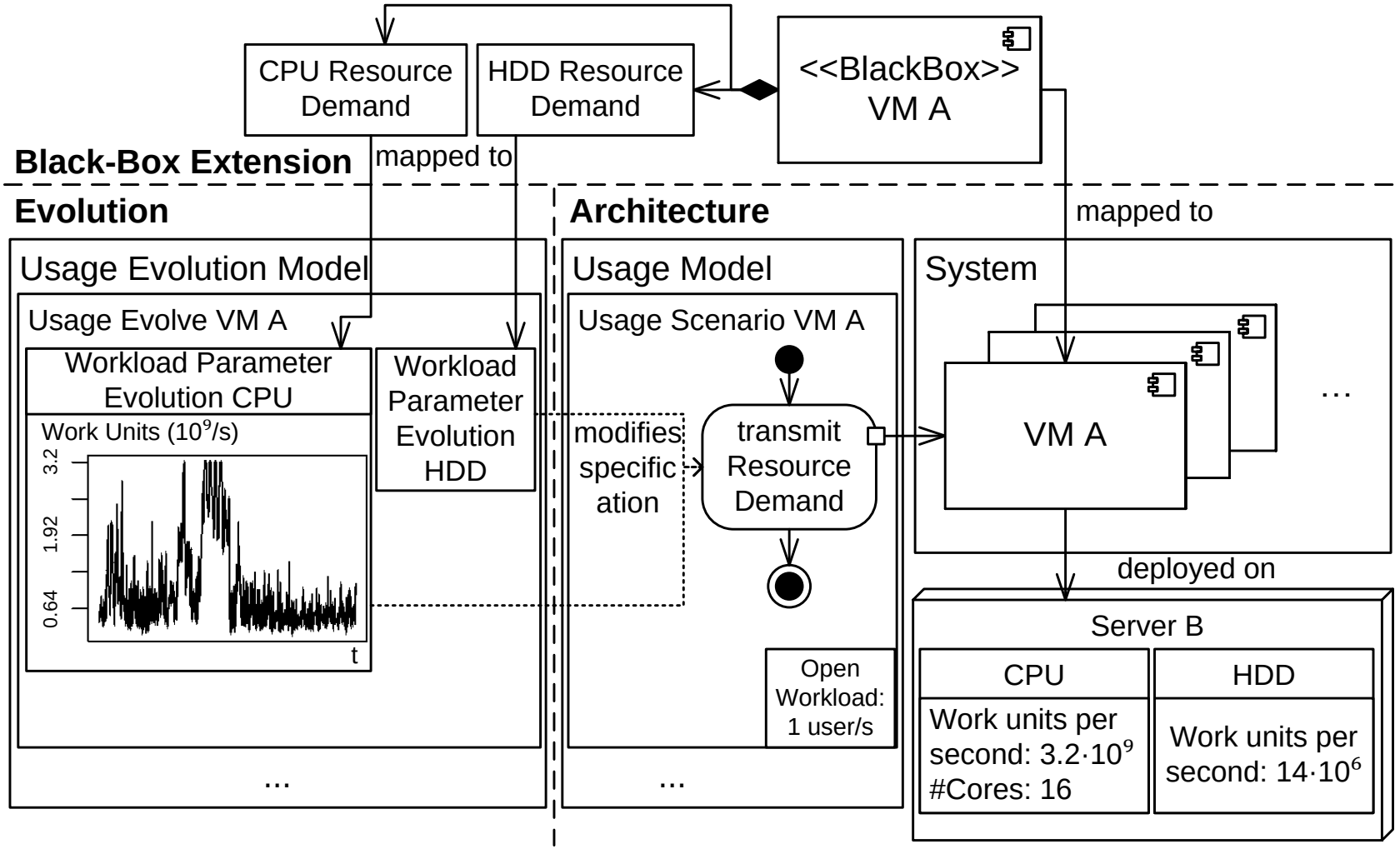
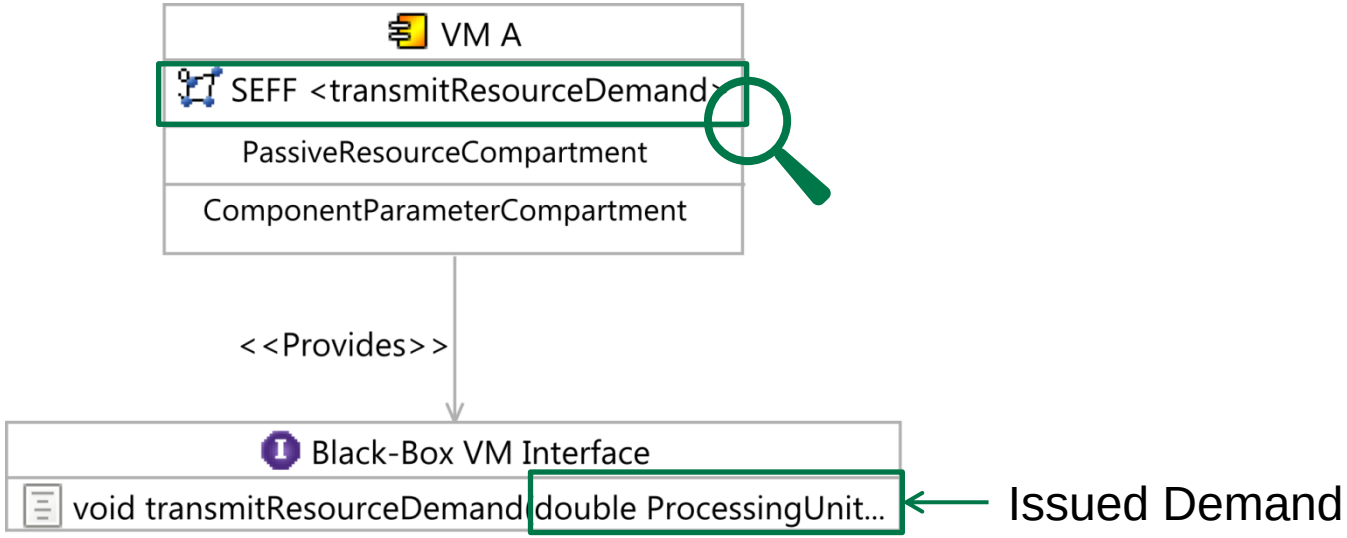


Mapping of Black-Box Models to SimuLizar and PCM



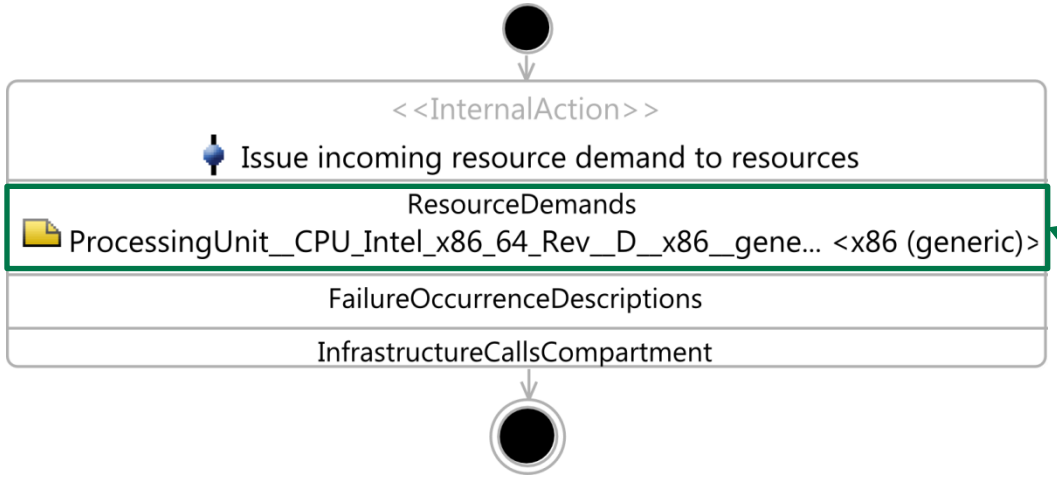
Mapping – Example

- Repository – VM Component Specification



Mapping – Example

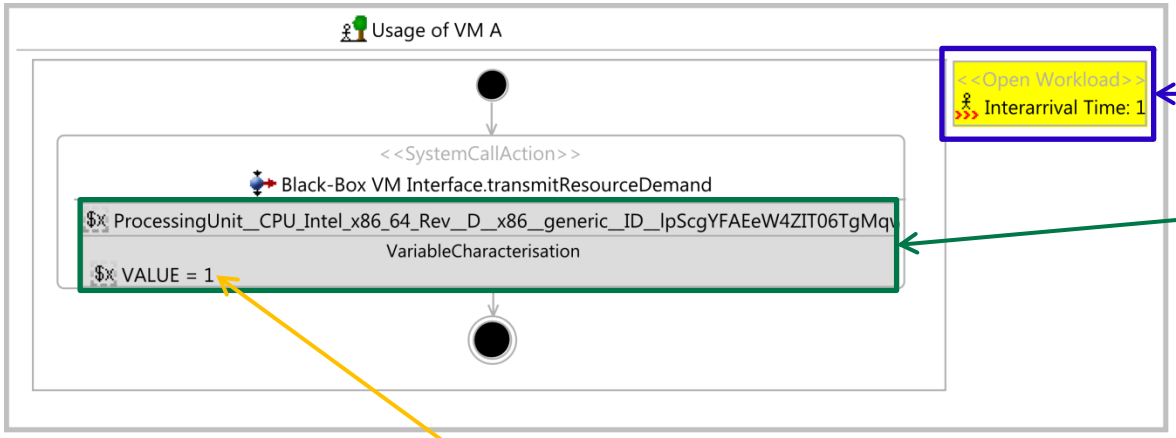
- VM Component Specification – Service Effect Specification (SEFF)



Issued Demand (specific per resource)

Mapping – Example

- Usage Model

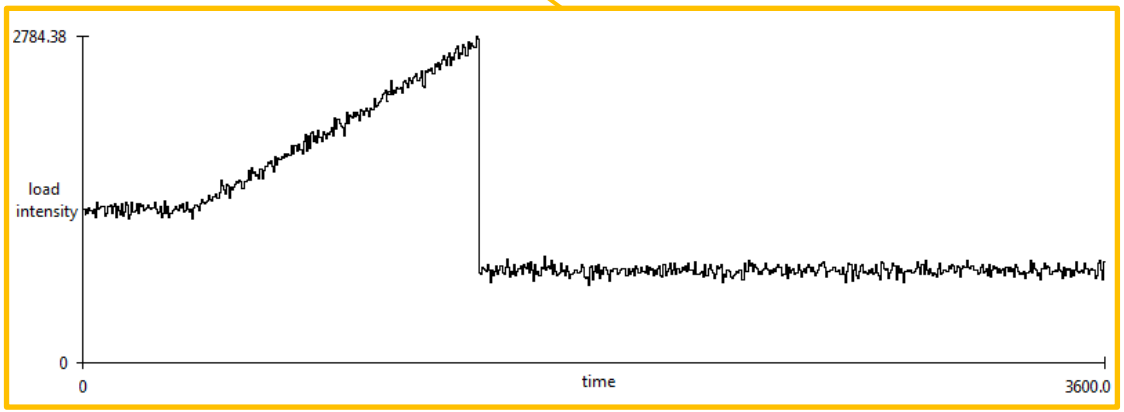


Sampling Rate

Issued Demand

- Usage Evolution

Evolved VariableCharacterisation



Overview

Summary

- Extension to SimuLizar's Usage Evolution to support complex user behavior patterns
- Behavior of black-box VMs captured as load curves
- Mapping of black-box VM behavior model to PCM + Usage Evolution

Application scenarios

- What-if-analyses in an IaaS data center environment
- Modeling resource contention in virtualized environment with limited monitoring data

Future work

- Integration over DLIM curves instead of sampling
- Improved handling of delayed start and early termination of Usage Evolutions

References (1)

- **[Becker2013a]** M. Becker, S. Becker, and J. Meyer. Simulizar: Design-time modeling and performance analysis of self-adaptive systems. In Software Engineering 2013: Fachtagung des GI-Fachbereichs Softwaretechnik, Volume 213 of LNI, pp. 71-84. GI, 2013.
- **[Becker2013b]** M. Becker, M. Luckey, and S. Becker. Performance analysis of self-adaptive systems for requirements validation at design-time. In Proceedings of the 9th International ACM Sigsoft Conference on Quality of Software Architecture
- **[Becker2009]** The palladio component model for model-driven performance prediction. Journal of Systems and Software, 82(1):3 – 22, 2009. Special Issue: Software Performance - Modeling and Analysis

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- **[Lehrig2015]** The cloudscale method for software scalability, elasticity, and effciency engineering: A tutorial. In Proceedings of the 6th ACM/SPEC International Conference on Performance Engineering, ICPE '15, pp. 329-331, New York, NY, USA, 2015. ACM.
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- **[Kramer2012]** Extending the Palladio Component Model using Profiles and Stereotypes. In Palladio Days Proceeedings (appeared as technical report), Karlsruhe Reports in Informatics; 2012, 21, pp. 7-15. KIT, Faculty of Infomatics, Karlsruhe. 2012.