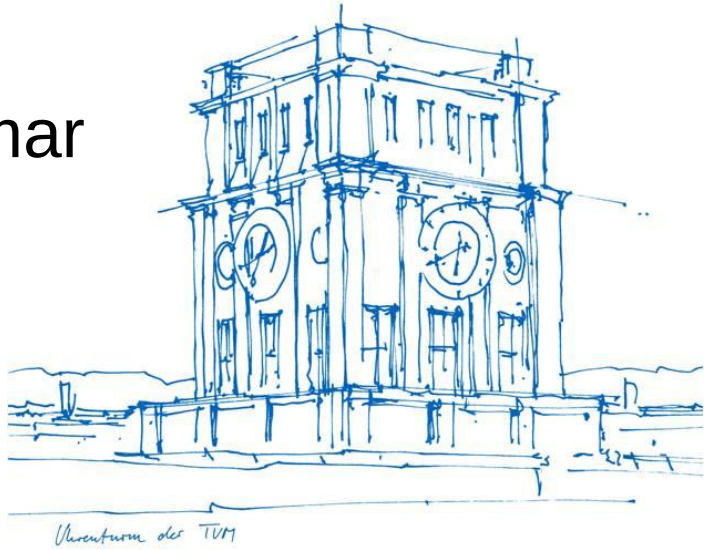
# Supporting Backward Transitions within Markov Chains when Modeling Complex User Behavior in the Palladio Component Model

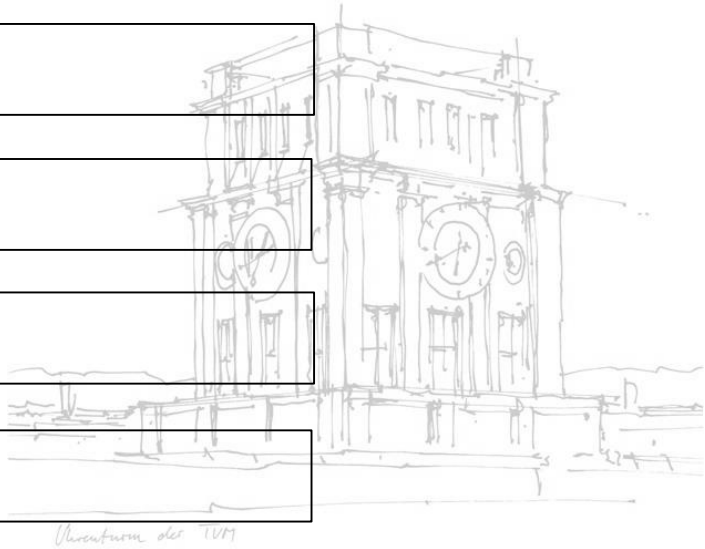
Maximilian Barnert, Helmut Krcmar

Technical University of Munich,
Chair for Information Systems, Munich, Germany



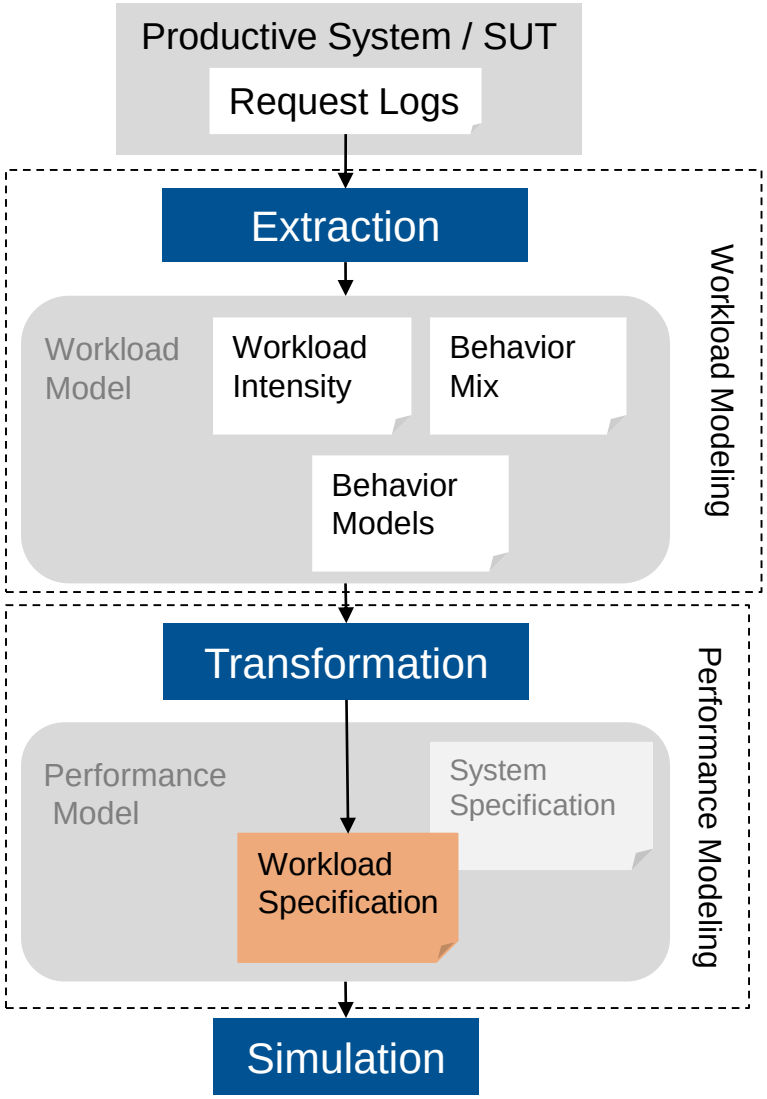
# Agenda

1. Motivation
2. Transformation of Behavior Models to PCM
3. Problem Statement
4. Modeling Backward Transition
6. Limitations
5. Conclusion and Future Work



# Motivation

- WESSBAS approach enables modeling and extraction of probabilistic user behavior for session-based application systems. (Van Hoorn et al., 2008/2014) (Vögele et al., 2015/2018)
- Two approaches (Vögele et al., 2015) & (Vögele et al., 2018) transform WESSBAS workload specifications to PCM performance models:
  - ➢ Vögele et al. (2015) use the PCM usage model to represent behavior models.
  - ➢ Vögele et al. (2018) reflects the behavior models in the default PCM repository model.



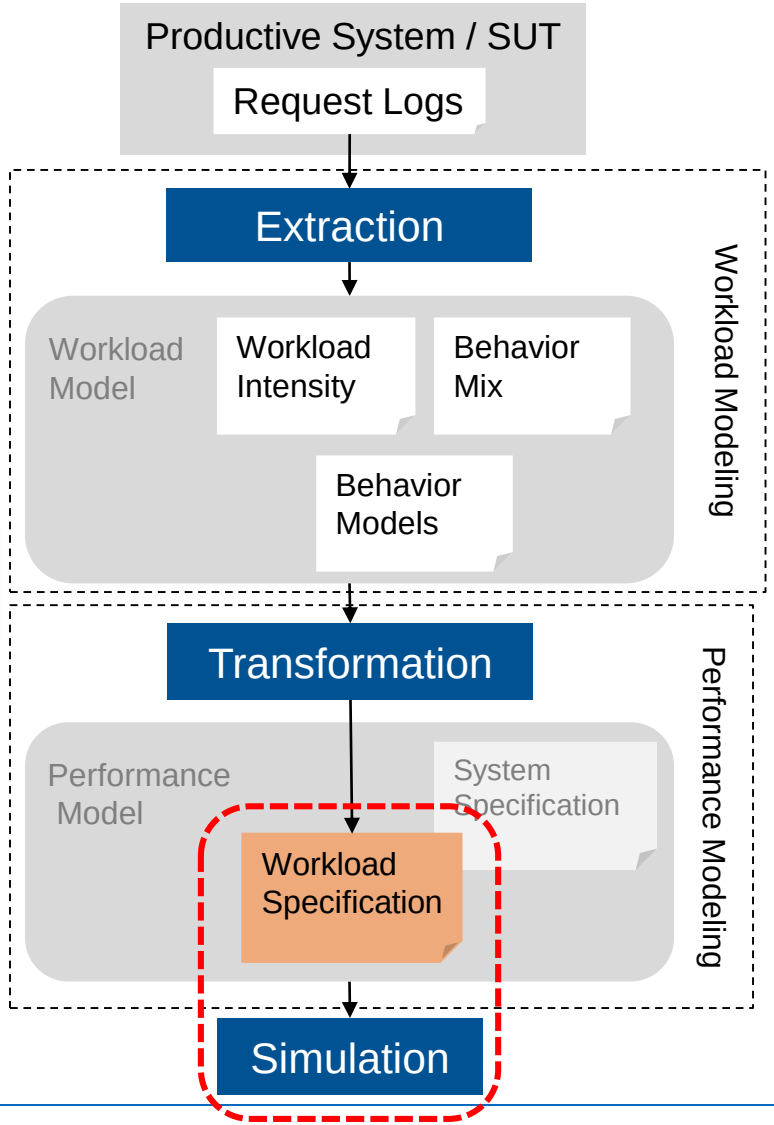
# Motivation (2)

- WESSBAS approach enables modeling and extraction of probabilistic user behavior for session-based application systems. (Van Hoorn et al., 2008/2014) (Vögele et al., 2015/2018)
- Two approaches (Vögele et al., 2015) & (Vögele et al., 2018) transform WESSBAS workload specification models:
  - Vögele et al. (2015) use the PCM usage model to represent behavior models.
  - Vögele et al. (2018) [illegible] in the default PCM [illegible]

**Extension of the default PCM meta model** to reflect complexity in user behavior.

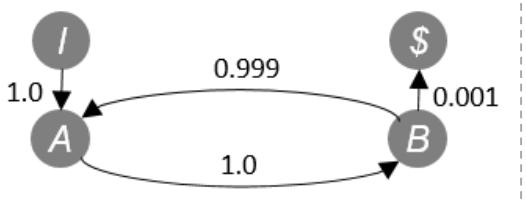
Simulation of models is not possible for **activity cycles** within user sessions.

**How to enable the simulation of performance models reflecting activity cycles within user sessions by using the default PCM meta model?**

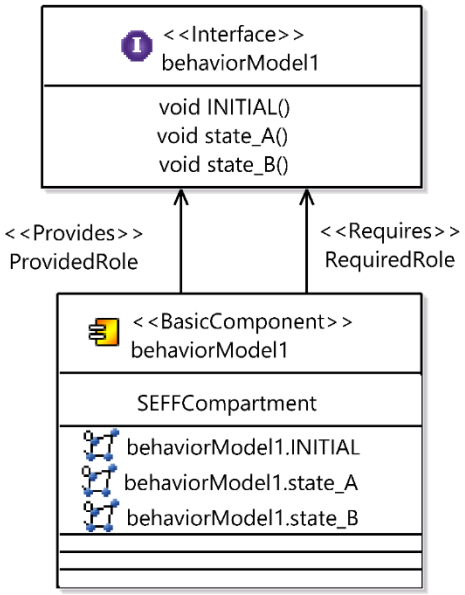


# Transformation of Behavior Models to PCM

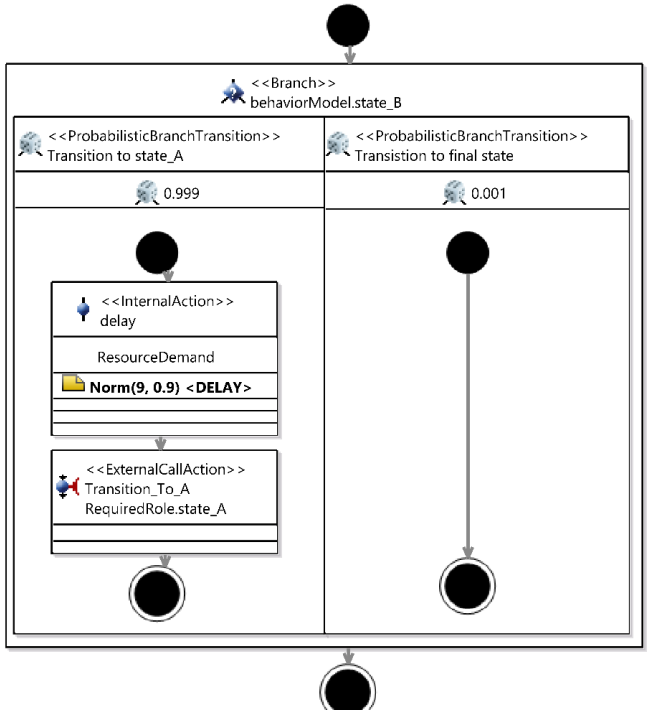
Transformation of behavior models to PCM using the approach of Vögele et al. (2018)




Behavior model
(specified as Markov chain)




PCM repository model

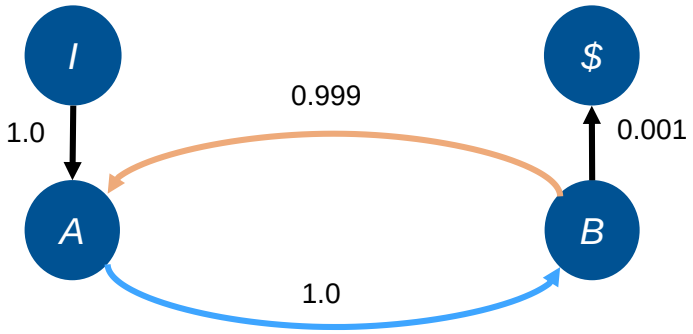


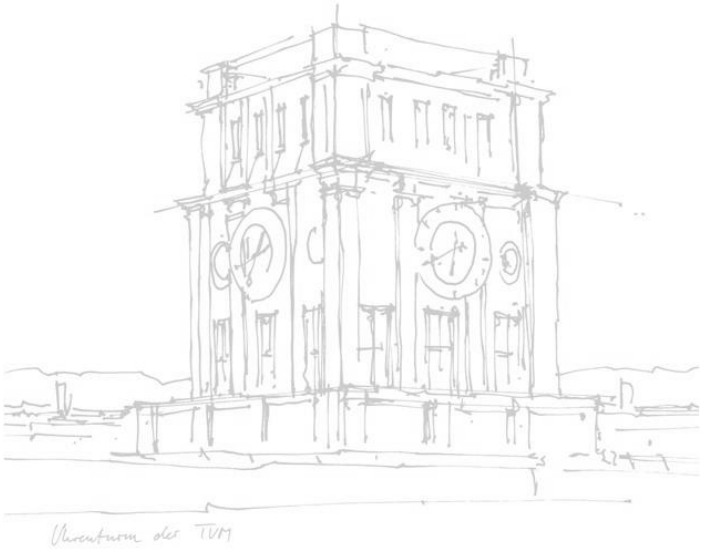

SEFF (Markov state B)

# Problem Statement

Running through an activity cycle (represented in the PCM repository model as backward transition) during simulation:

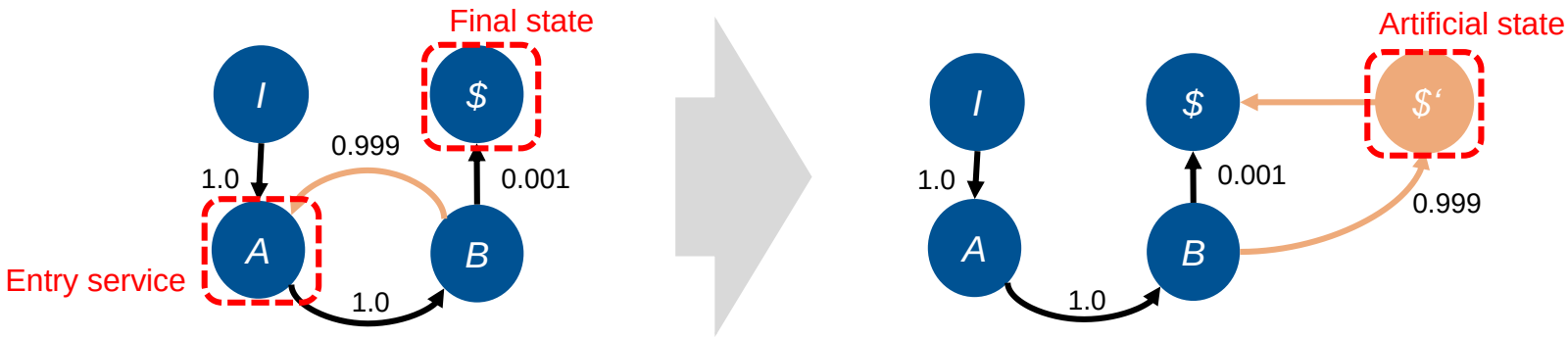
**But**: Simulation engine needs to attach measurements although previous series of the same context is not yet finished



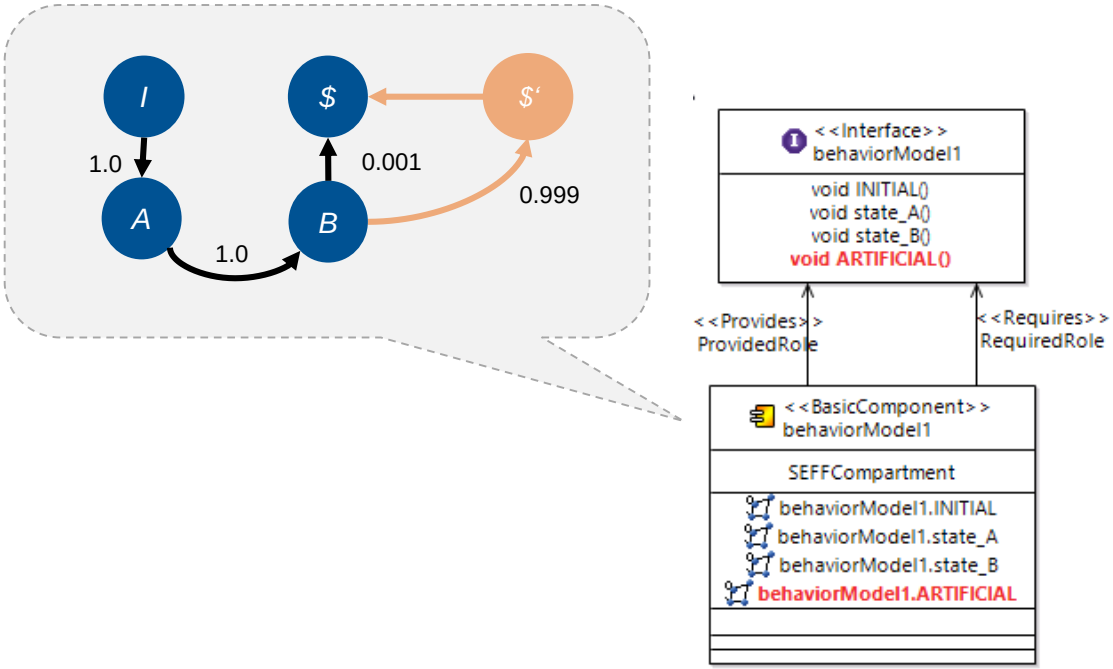



# Modeling Backward Transitions

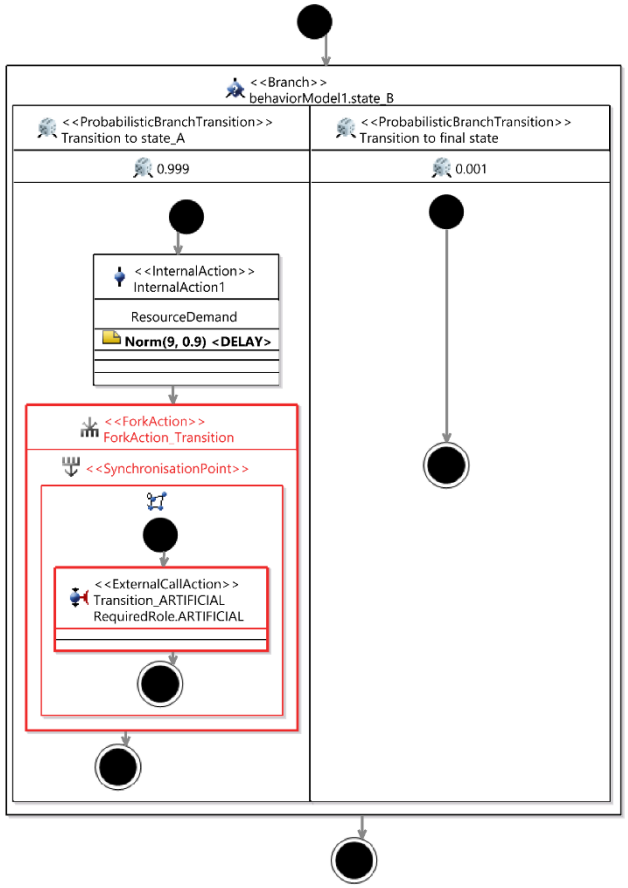
1. Encapsulating outgoing transitions (i.e., *ExternalActions*) with *ForkedBehaviors in the Markov states' SEFFs*
2. Modified Markov chain represented in the PCM repository model: Replace backward transitions (B -> A) to the entry service (A) with a link to the final state $
   - New artificial state *$'* directly linked to the final state *$* (allows to preserve information about normal distribution)
   - Backward transitions to the entry service are replaced by links to artificial state *$'*



# Modeling Backward Transitions (2)



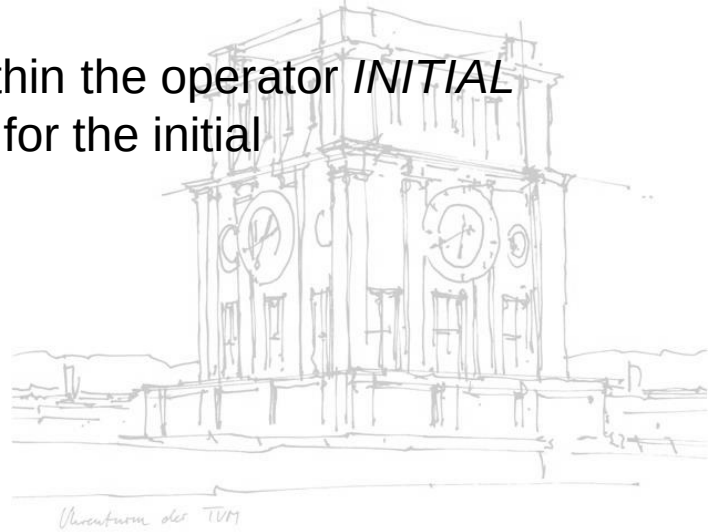

Behavior model in the PCM repository model




PCM SEFF for Markov state B

# Limitations

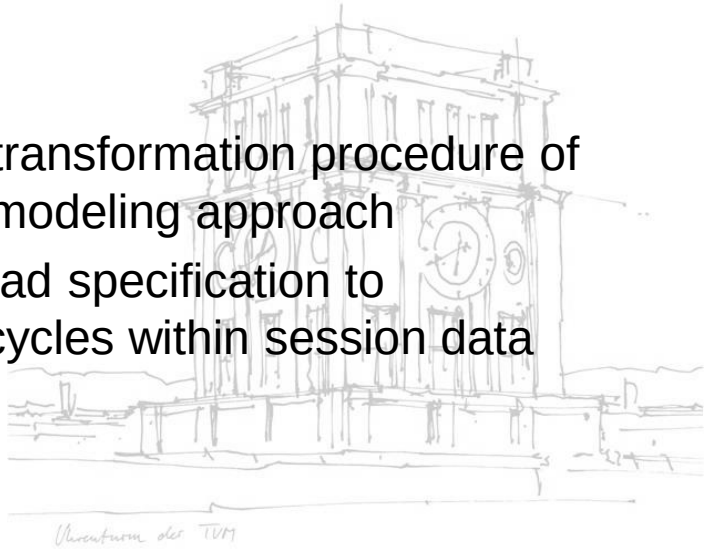
- Following the approach of Vögele et al. (2018) prevents extending the default PCM meta model.
  → Violates the separation of PCM models
- The PCM usage model is linked to exactly one behavior model (basic component) in the PCM repository model.
  → Workload needs to be represented in single behavior model
- One distinct outgoing transition is defined within the operator *INITIAL*
  → Exactly one outgoing transition is needed for the initial state in the behavior model.



# Conclusion and Future Work

- Adaptions to the approach of Vögele et al. (2018) in this work:
  - **No extensions to the PCM meta model** needed to transform workload specifications to PCM performance models
  - **Minor changes** to the original approach to **allow simulating activity cycles** taking place within complex user behavior

- Future work:
  - Adaption of the workload extraction and transformation procedure of Vögele et al. (2018) to support modified modeling approach
  - Goal: Automatic transformation of workload specification to performance models supporting activity cycles within session data



# Thank you for your attention!

Maximilian Barnert

maximilian.barnert@tum.de

Technical University of Munich

Department of Computer Science

Botzmannstr. 3

85748 Garching