A unified approach to performance modelling and verification

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Motivation

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• Performability = performance + dependability.

• It is better to know about problems early. If performance design flaws are found early in the development process then they can be corrected at a relatively low cost. In contrast, if they are found after the development process is long underway then they may be expensive or even unrealistic to repair.
Summary of this talk

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- The technology which provides the efficient representation capability for the underlying performance model is the Multi-Terminal Binary Decision Diagram-based PRISM probabilistic model checker.
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- The notation which we use for our high-level designs is the UML graphical modelling language.

- The technology which provides the efficient representation capability for the underlying performance model is the Multi-Terminal Binary Decision Diagram-based PRISM probabilistic model checker.

- The UML models are compiled through an intermediate language, the stochastic process algebra PEPA, before translation into MTBDDs for solution.
Contribution

- We provide a structured performability modelling platform by connecting a specification environment (SENV) and a verification environment (VENV) so that each may communicate with the other.

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Contribution

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- The SENV and VENV are connected by a bridge which consists of two categories of software tools. These are:
  - *extractors* which translate designs from the SENV into inputs for the VENV, omitting any aspects of the design which are not relevant for the verification task at hand; and
  - *reflectors* which convert the results from the analysis performed by the VENV back into a form which can be processed and displayed by the SENV.
UML modelling

- A UML model is represented by a collection of diagrams describing parts of the system from different points of view; there are seven main diagram types. For example, there will typically be a static structure diagram (or class diagram) describing the classes and interfaces in the system and their static relationships (inheritance, dependency, etc.).
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- As usual we expect that the UML modeller will make a number of diagrams of different kinds. Our analysis is based on state and collaboration diagrams.
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  - A customer arrival causes a change in the state of a queue so this would be one example of an action. Concretely, arrive / λ and serve / μ would be suitable arc adornments for a state diagram for a queue.

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- State machines are sequential components. The collaboration diagram specifies the concurrent composition of instances of these state machines. Collaborating state machines synchronise on all of their common action types. Analysing such a UML model begins by mapping it to a model in the PEPA stochastic process algebra.
Analysing PEPA models

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  - ▶ *MTBF* and *MTTF* computation
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PWB

PRISM

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- A long-run performance measure can be specified by using stochastic probes to capture the property of interest. The probe can be described as simply another UML state machine diagram or using a special-purpose description language due to Bradley and Argent-Katwala.

ϕ ::= true | false | a | ϕ ∧ ϕ | ϕ ∨ ϕ | ¬ ϕ | P ⊥ ◁p [ψ] | S ⊥ ◁p [φ]

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\[
\begin{align*}
\phi & ::= \text{true} \mid \text{false} \mid a \mid \phi \land \phi \mid \phi \lor \phi \mid \neg \phi \mid P_{\triangleright p}[\psi] \mid S_{\triangleright p}[\phi] \\
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Example: hierarchical cellular network

- We conducted a case study with the tool to investigate its use in practical modelling.

- We modelled a *hierarchical cellular phone network* consisting of two tiers of cells, a level of macrocells overlying a level of microcells.

- In this study, we considered the *Manhattan model* where the reuse pattern is based on a five squared microcell cluster, a central cell surrounded by four peripheral cells.

- We considered a *Fixed Channel Allocation scheme* where a fixed number of channels are distributed among the different cells.
State diagrams
Results reflected in Argo/UML
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Related work

- Petriu and Shen automatically extract a *layered queueing network model* from an input UML model with performance annotations in the format specified by the *OMG Profile for Schedulability, Performance, and Time*.

- López-Grao, Merseguer and Campos map UML diagrams into Generalised stochastic Petri nets which can be solved by *GreatSPN*.

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- One feature of our work which is distinctive from the above is the role of a reflector in the system to present the results of the performance evaluation back to the UML modeller in the terms of their input model.
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Conclusions

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• We hope that we have gone some way to providing automated support for computing simple performability measures and to circumventing an unnecessary notational hurdle if this was acting as an impediment to the understanding and uptake of modern performability analysis technology.
Acknowledgements

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