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Descartes research

Trade-offs in Different Modeling Approaches for Performance Prediction of Software Systems

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Slides available at **http://descartes.tools**

Software Engineering 2016, Vienna, February 24, 2016

Main References

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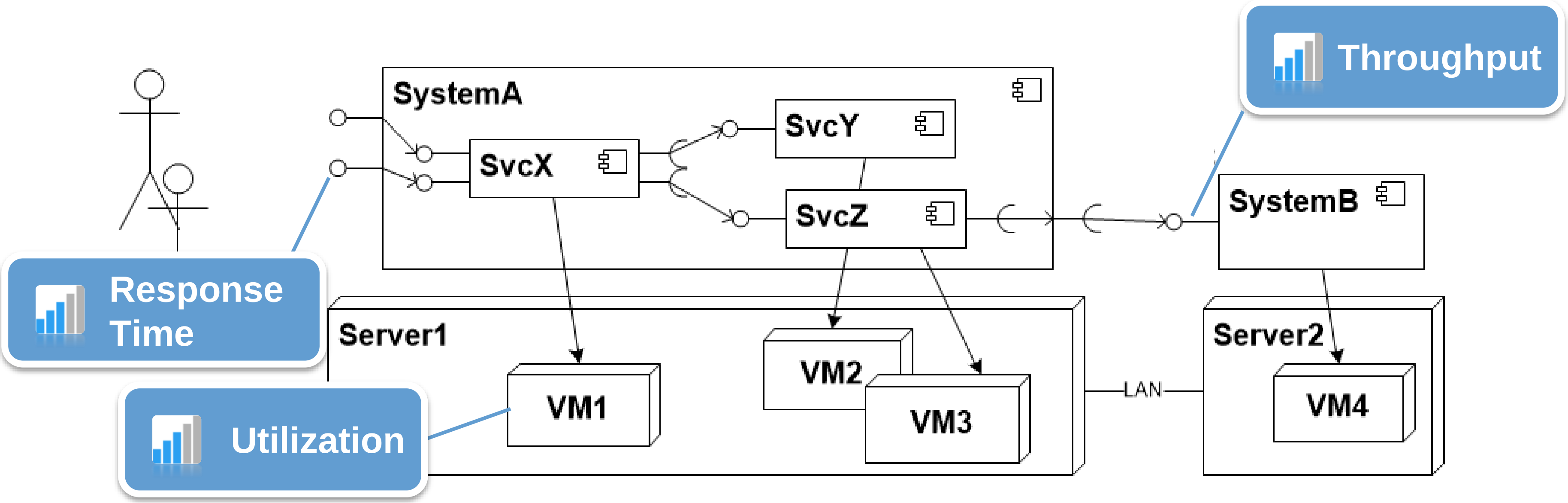
Research Context
Software Performance Engineering

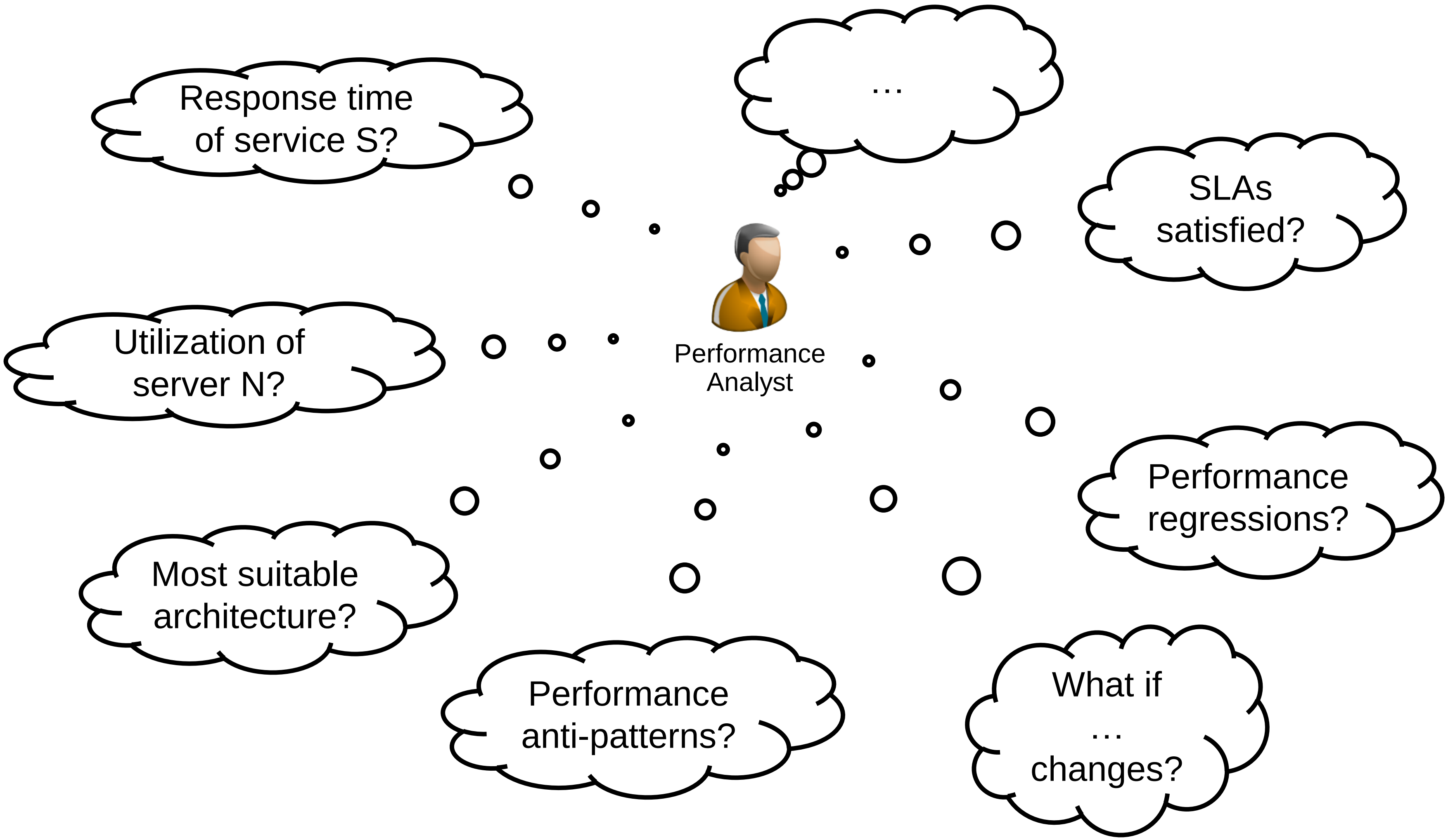
Performance = timing behavior + resource usage



Software Performance Engineering (SPE)

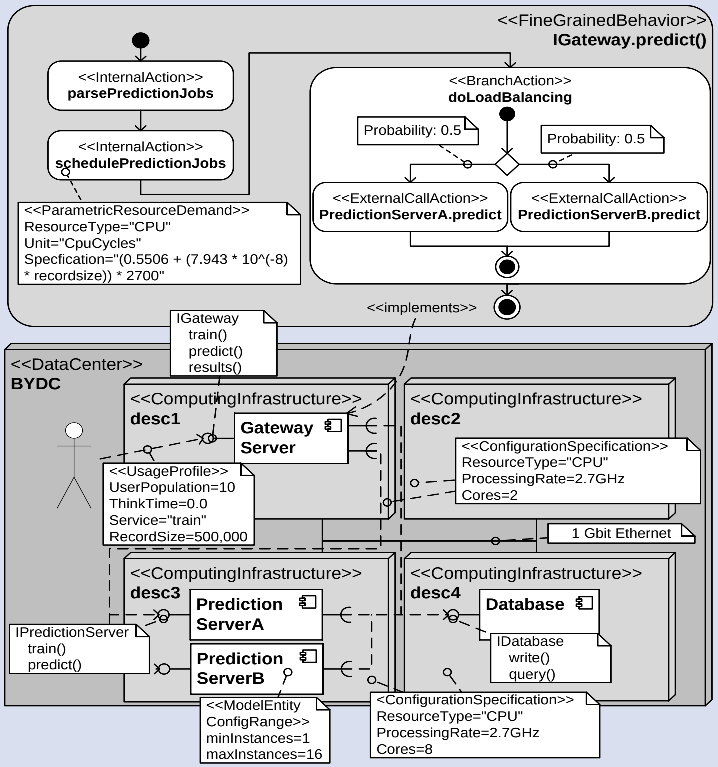
"the entire collection of **software engineering activities and related analyses** used throughout the **software development cycle**, which are directed to meeting **performance requirements**."

Performance-Relevant Concerns Spanning the Software Lifecycle



Performance Prediction

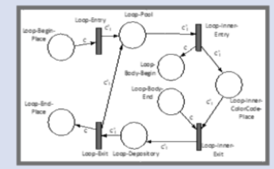
Performance-annotated Software Architecture Model



Transformation to Stochastic Performance Model

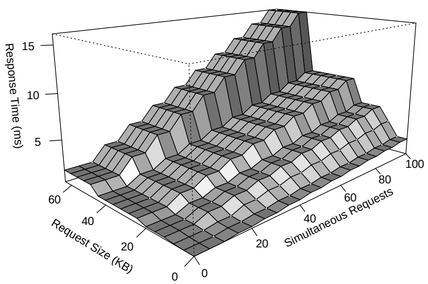
$$\overline{X} \le min\left\{\frac{N}{\sum_{i=0}^{n} D_i^{sync}}, min_{1\le i\le n}\left\{\frac{1}{D_i}\right\}\right\}$$

$$\overline{R} = \frac{N}{\overline{X}} \ge max\left\{\sum_{i=0}^{n} D_i^{sync}, N * max_{1\le i\le n}\{D_i\}\right\}$$

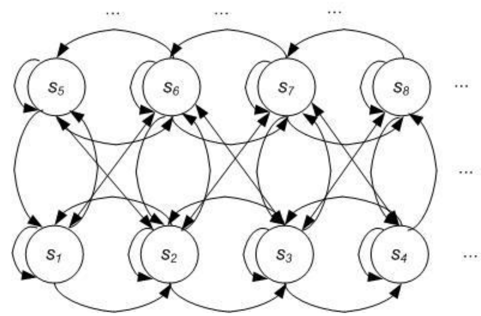


Predicted Performance Metrics

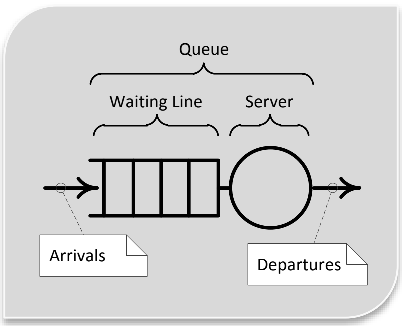
Stochastic Performance Models



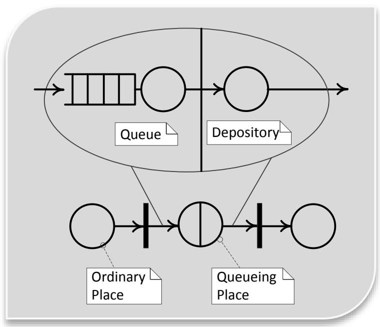
Statistical Regression



Markov Model



Queueing Network (QN)

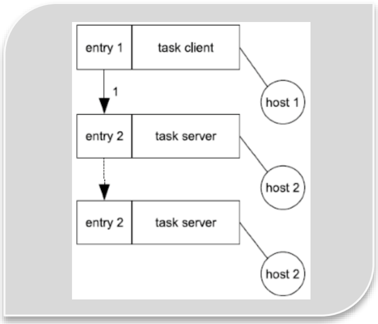


Queueing Petri net

$$R \geq \max\left[N \times \max\{D_i\}, \sum_{i=1}^{K} D_i\right] \qquad X_0 \leq \min\left[\frac{1}{\max\{D_i\}}, \frac{N}{\sum_{i=1}^{K} D_i}\right]$$

$$\frac{N}{\max\{D_i\}[K+N-1]} \leq X_0 \leq \frac{N}{avg\{D_i\}[K+N-1]}$$

Analytical Bounds Analysis



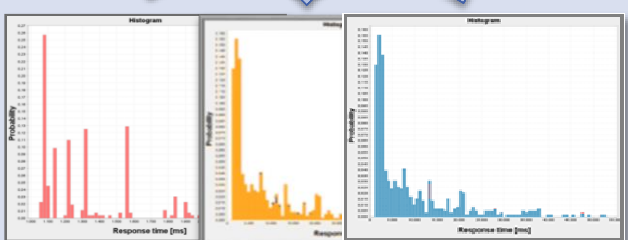
Layered Queueing Network (LQN)

Model Solution

Analytical Analysis

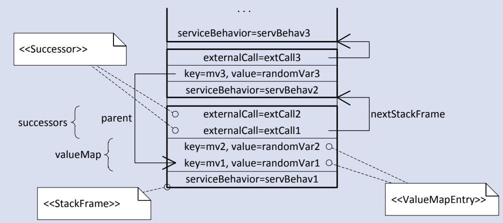
$$R \geq \max\left[N \times \max\{D_i\}, \sum_{i=1}^{K} D_i\right] \qquad X_0 \leq \min\left[\frac{1}{\max\{D_i\}}, \frac{N}{\sum_{i=1}^{K} D_i}\right]$$

$$\frac{N}{\max\{D_i\}[K+N-1]} \leq X_0 \leq \frac{N}{avg\{D_i\}[K+N-1]}$$



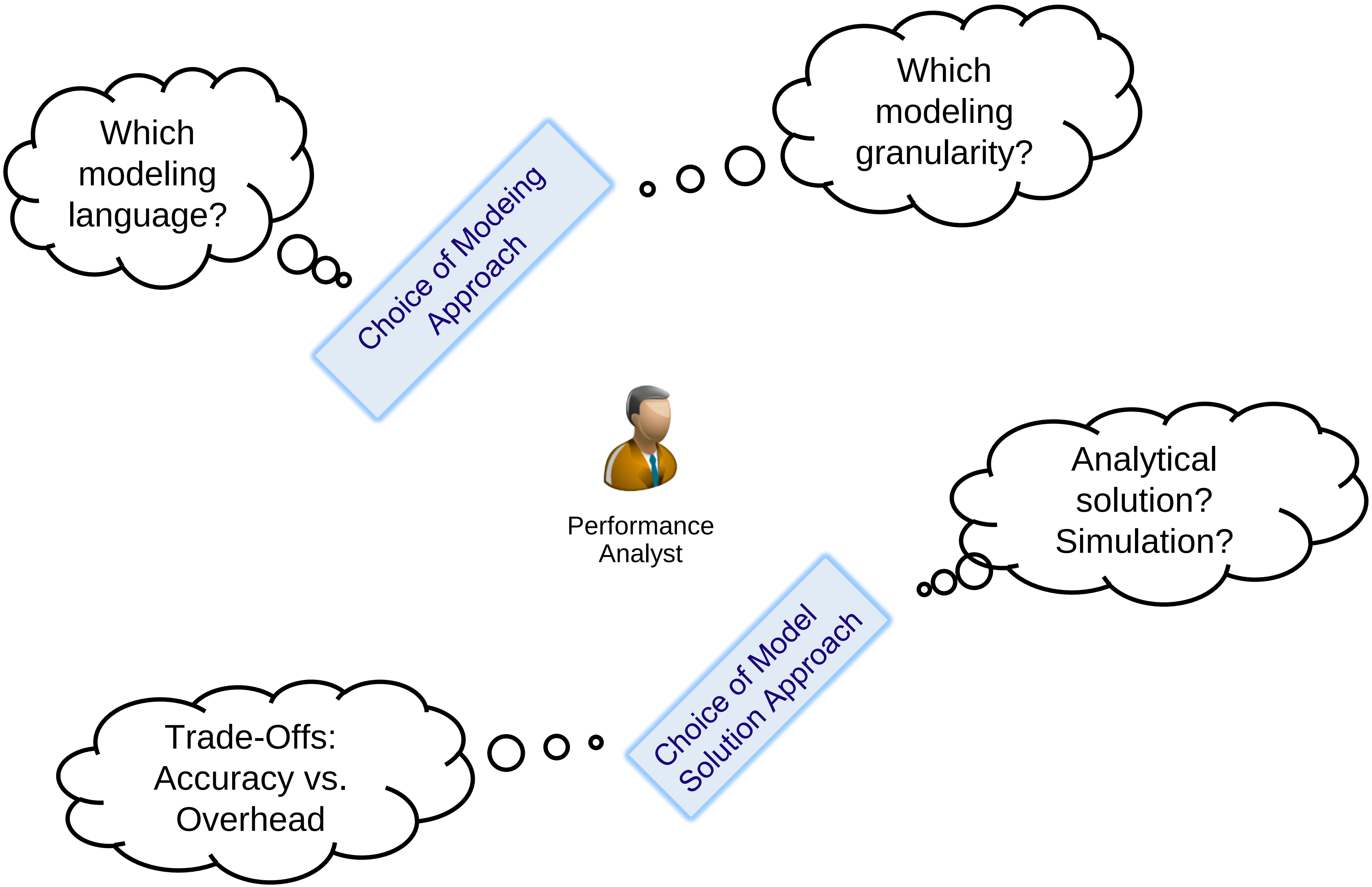
Analysis Results

Simulative Analysis

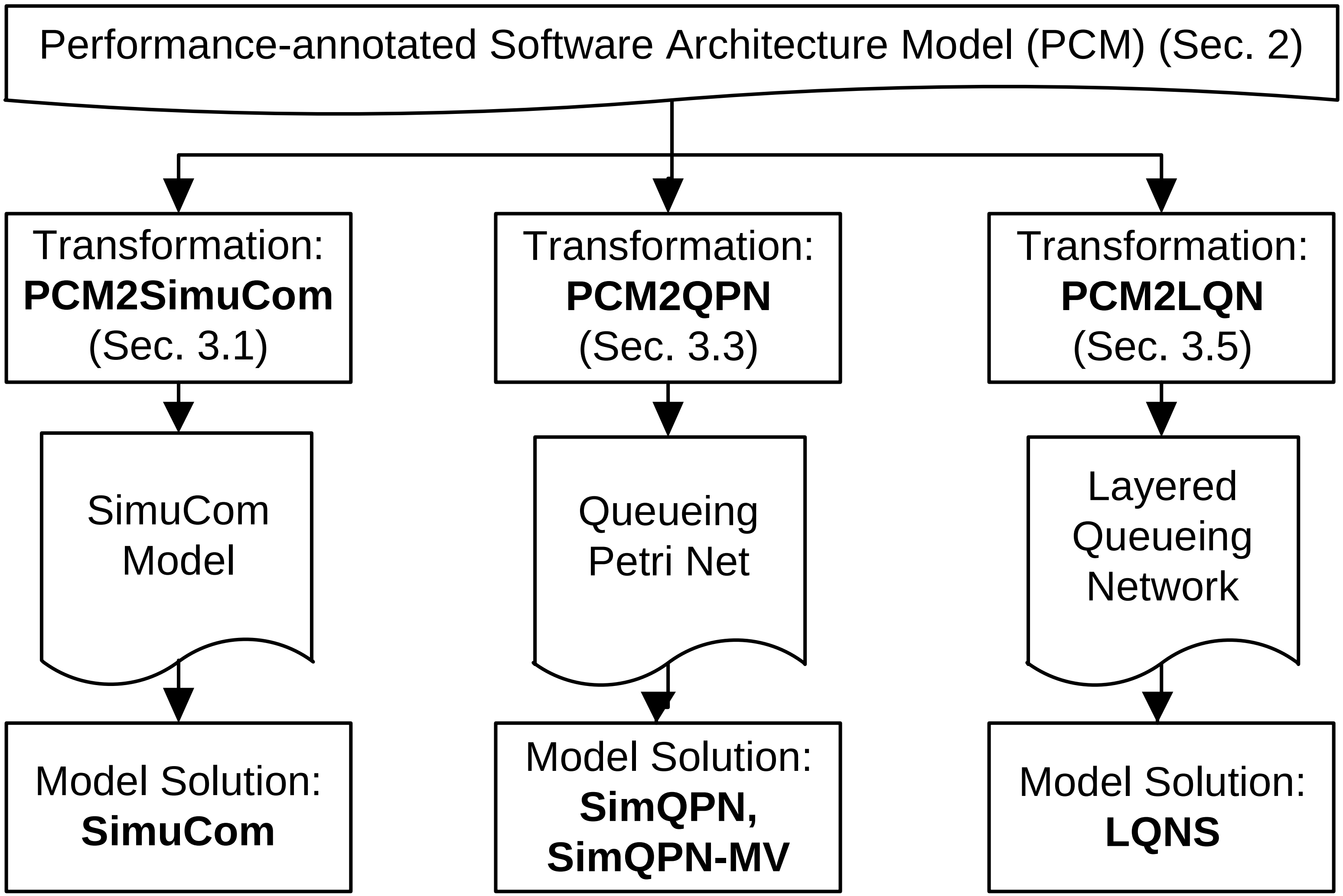


Analysis Results

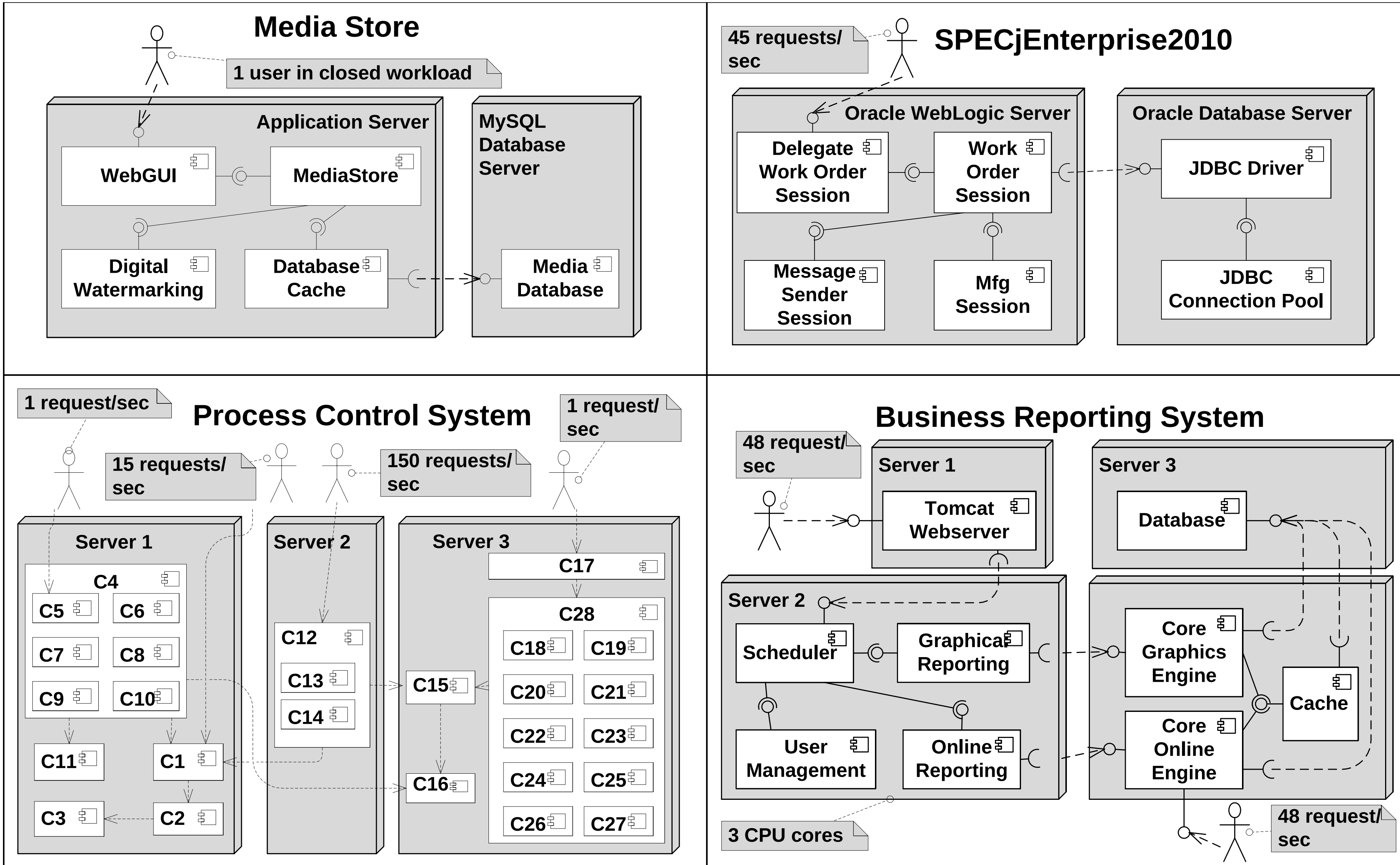
Modeling Challenges



Considered Prediction Approaches



Case Studies



Semantic Gaps

Modeling feature	SimuCom	SimQPN	SimQPN-MV	LQNS
Loops	X	(X)	(X)	(X)
Forks with synchronization barrier	X	(X)	(X)	(X)
Parameter dependencies	X	(X)	(X)	(X)
Response time distributions	X	X	-	-
Flexible parameter characterizations	X	X	X	-
Blocking behavior	X	X	X	(X)
X support	(X) partial support	- no support		

TABLE 1
Semantic gaps.

Quantitative Evaluation: Accuracy

	SimuCom (reference)	SimQPN	SimQPN (relDiff)	SimQPN-MV	SimQPN-MV (relDiff)	LQNS	LQNS (relDiff)
Media Store							
RT(Scenario1)	1.332	1.331	0.0%	1.324	-0.6%	1.288	-3.3%
TP(Scenario1)	0.751	0.751	0.0%	0.755	0.6%	0.753	0.3%
U(AppServer_CPU)	0.341	0.345	1.2%	0.340	-0.3%	0.342	0.2%
U(DBServer_CPU)	1.4%	1.4%	1.6%	1.4%	2.6%	1.4%	2.2%
U(DBServer_HDD)	64.4%	64.0%	-0.6%	64.5%	0.2%	64.4%	-0.1%
SPECjEnterprise2010							
RT(Scenario1)	1.060	1.058	-0.2%	1.065	0.4%	1.065	0.4%
TP(Scenario1)	24.567	24.970	1.6%	24.792	0.9%	25.000	1.8%
U(Oracle_CPU)	29.1%	29.6%	1.7%	29.5%	1.3%	29.6%	1.8%
U(WLS_CPU)	51.2%	52.0%	1.5%	51.9%	1.3%	52.2%	2.0%
Process Control System							
RT(Scenario1)	0.00787	0.00764	-2.9%	0.00763	-3.0%	0.00790	0.4%
RT(Scenario2)	0.06690	0.06636	-0.8%	0.06903	3.2%	0.06710	0.3%
TP(Scenario1)	149.258	149.254	0.0%	149.254	0.0%	149.254	0.0%
TP(Scenario2)	15.001	15.000	0.0%	15.000	0.0%	14.999	0.0%
U(Server1_CPU)	6.5%	6.4%	-2.2%	6.4%	-2.0%	6.5%	-0.5%
U(Server1_HDD)	45.0%	45.0%	0.0%	45.0%	0.0%	45.0%	0.0%
U(Server2_CPU)	1.1%	1.1%	-4.0%	1.1%	-4.0%	1.1%	-4.0%
U(Server3_CPU)	55.0%	54.1%	-1.6%	54.0%	-1.8%	55.1%	0.2%
Business Reporting System							
RT(Scenario1 - cons1)	5.223	5.918	13.3%	5.921	13.4%	7.391	41.5%
TP(Scenario1 - cons1)	1.000	1.000	0.0%	1.000	0.0%	1.000	0.0%
U(Server1_CPU) Scen. 1	45.0%	44.8%	-0.5%	44.9%	-0.2%	45.0%	0.0%
U(Server2_CPU) Scen. 1	68.8%	68.6%	-0.3%	68.8%	-0.1%	68.9%	0.1%
U(Server3_CPU) Scen. 1	74.3%	74.8%	0.7%	74.5%	0.3%	74.3%	0.0%
U(Server4_CPU) Scen. 1	23.5%	23.5%	-0.2%	23.5%	0.1%	23.5%	0.2%
RT(Scenario2 - Exp(1))	7.302	7.256	-0.6%	7.500	2.7%	7.391	1.2%
TP(Scenario2 - Exp(1))	1.002	1.000	-0.2%	0.996	-0.6%	1.000	-0.2%

KEY: RT = Response Time (sec), TP = Throughput (requests / sec), U = Utilization (%), relDiff = relative difference

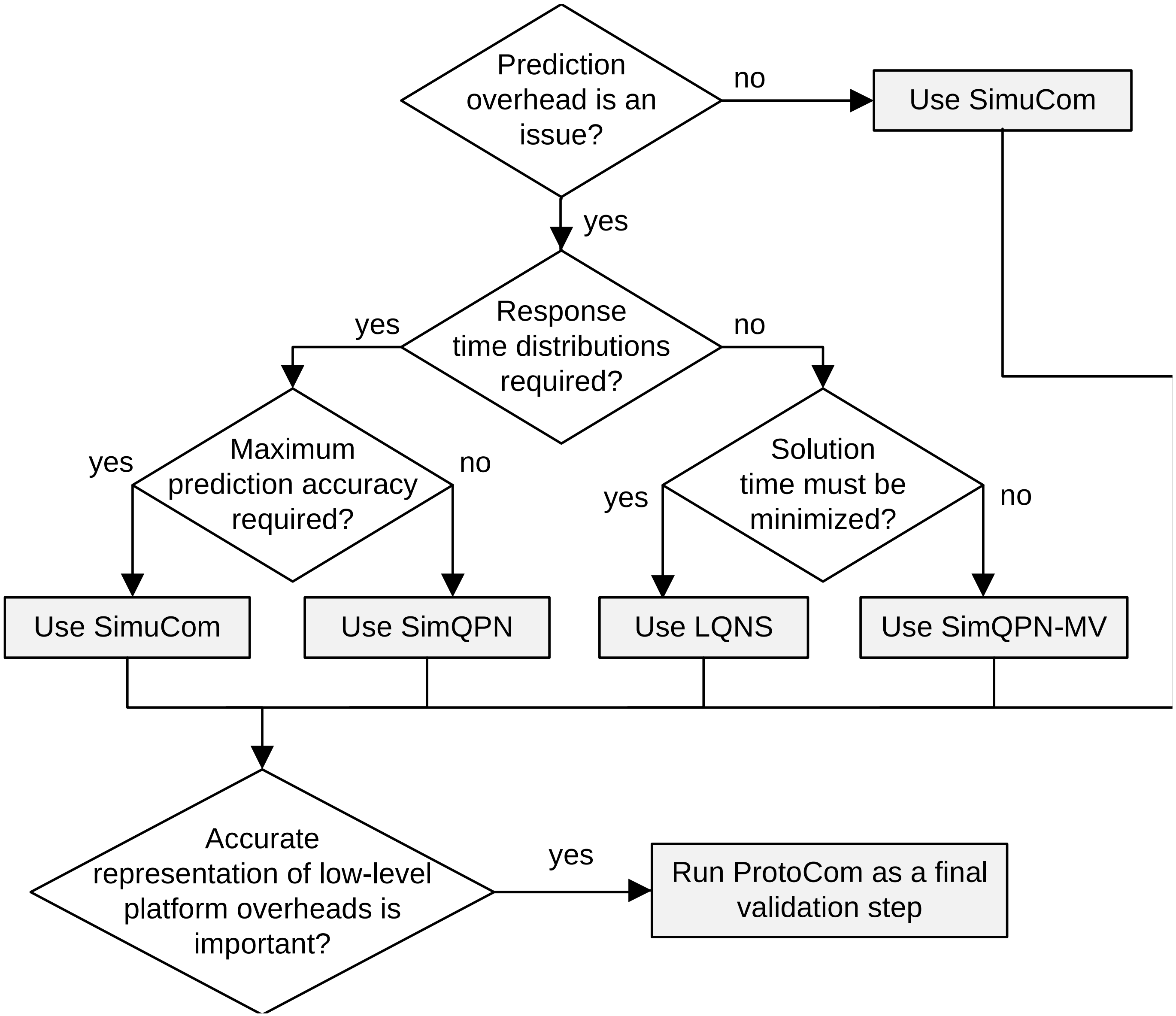
Quantitative Evaluation: Overhead

	SimuCom (reference)	SimQPN	SimQPN (relDiff)	SimQPN-MV	SimQPN-MV (relDiff)	LQNS	LQNS (relDiff)
Media Store							
Logical Simulation Time	25000	25000	0.0%	25000	0.0%	n/a	n/a
Number of Measurements	18773	18775	0.0%	18775	0.0%	n/a	n/a
Total Execution Time	31.4	6.4	-79.6%	3.6	-88.5%	1.3	-96.0%
Wall-clock Sim./Ana. Time	25.6	1.7	-93.4%	0.9	-96.5%	0.2	-99.1%
SPECjEnterprise2010							
Logical Simulation Time	500	500	0.0%	500	0.0%	n/a	n/a
Number of Measurements	12257	12485	1.9%	12485	1.9%	n/a	n/a
Total Execution Time	72.6	7.9	-89.1%	5.6	-92.3%	1.8	-97.6%
Wall-clock Sim./Ana. Time	55.6	3.8	-93.3%	2.1	-96.3%	0.5	-99.2%
Process Control System							
Logical Simulation Time	500	500	0.0%	500	0.0%	n/a	n/a
Number of Measurements	74627	74627	0.0%	74627	0.0%	n/a	n/a
Total Execution Time	96.7	11.9	-87.7%	7.2	-92.6%	3.9	-95.9%
Wall-clock Sim./Ana. Time	65.4	1.6	-97.6%	2.6	-96.0%	2.0	-96.9%
Business Reporting System							
Logical Simulation Time	9994	10000	0.1%	10000	0.1%	n/a	n/a
Number of Measurements	10016	9997	-0.2%	9997	-0.2%	n/a	n/a
Total Execution Time	591.5	74.5	-87.4%	34.1	-94.2%	4.0	-99.3%
Wall-clock Sim./Ana. Time	587.6	35.4	-94.0%	26.6	-95.5%	1.8	-99.7%
All times in seconds							

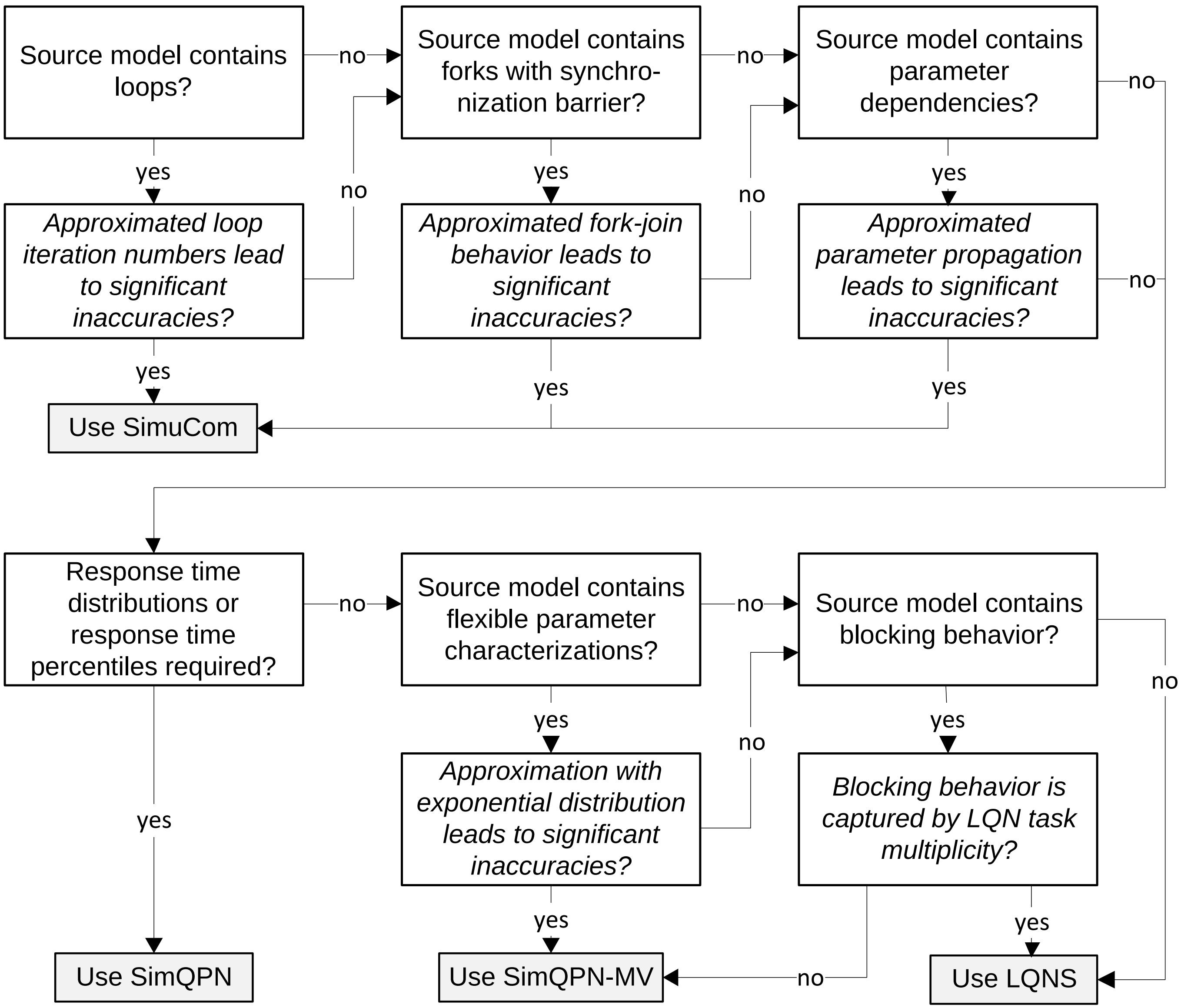
Quantitative Evaluation: Impact of Load

	SimuCom	SimQPN	SimQPN-MV	LQNS
Media Store (low load)				
Total Execution Time	21.5	5.7	3.4	1.3
Wall-clock Sim./Ana. Time	16.0	1.1	0.6	0.2
Media Store (medium load)				
Total Execution Time	31.4	6.4	3.6	1.3
Wall-clock Sim./Ana. Time	25.6	1.7	0.9	0.2
Media Store (high load)				
Total Execution Time	40.7	7.3	4.0	1.4
Wall-clock Sim./Ana. Time	34.1	2.4	1.2	0.2
All times in seconds				

Decision Tree (simplified)



Decision Tree



DECLARE Project
Declarative Performance Engineering

DFG Priority Programme 1593

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Declare

Declarative Performance Engineering

Performance Concerns

Performance Analyst

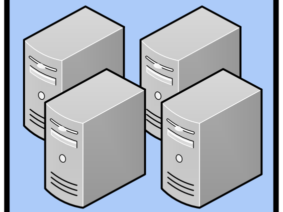
Software Performance Engineering

Established Methods, Techniques, and Tools

Asking “What?“,
Automating the “How?“

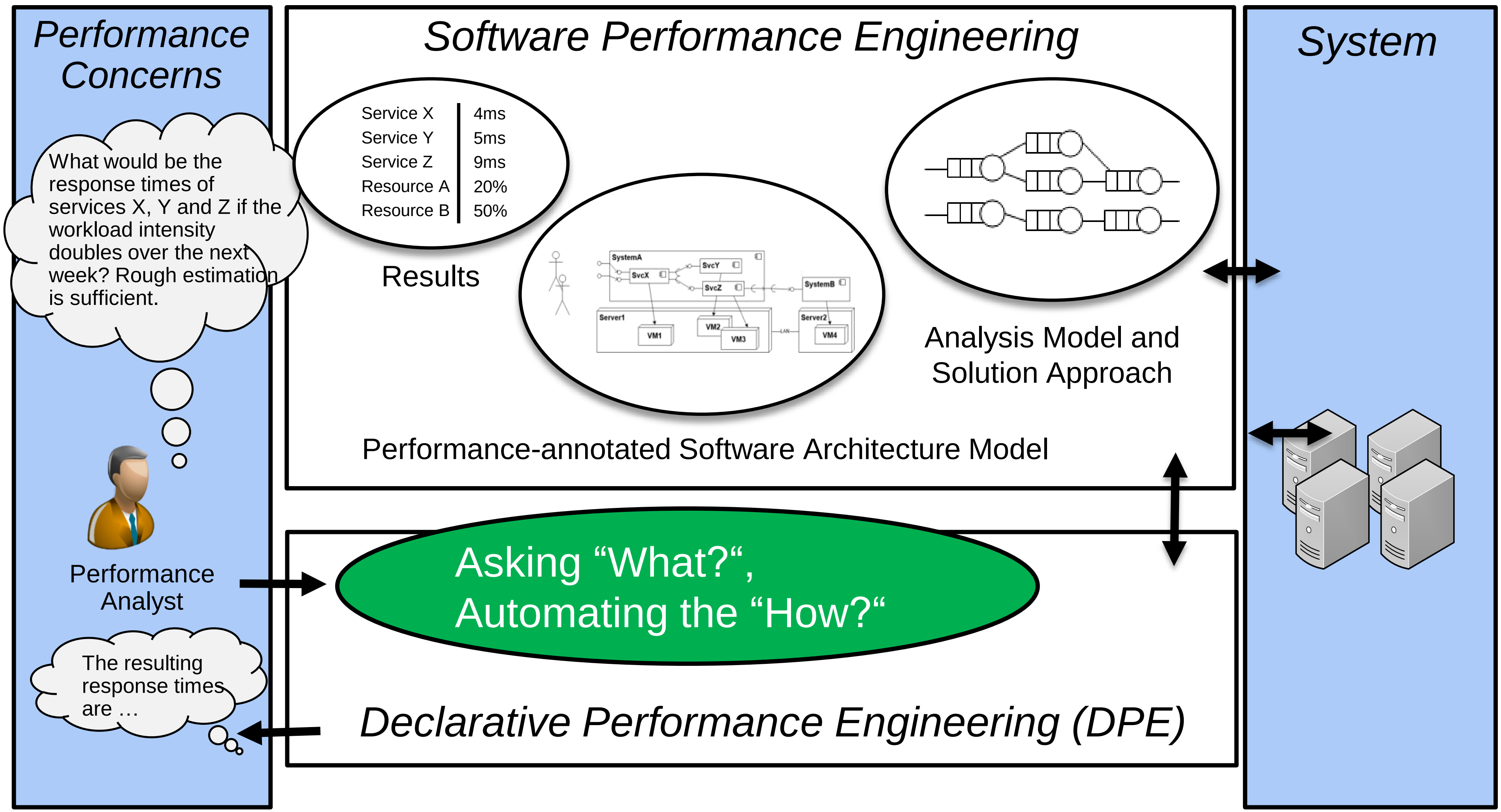
Declarative Performance Engineering (DPE)

System



Jürgen Walter, Andre van Hoorn, Heiko Koziolek, Dusan Okanovic, and Samuel Kounev. Asking “What?”, Automating the “How?”:The Vision of Declarative Performance Engineering. In *Proceedings of the 7th ACM/SPEC International Conference on Performance Engineering (ICPE 2016)*, Delft, the Netherlands, March 12, 2016. [.pdf]

Declarative Performance Engineering



van Hoorn/Kounev, Declare, Renewal Kickoff of SPP1593, Hannover, Jan. 14 – 15, 2016

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Questions?

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