Group Henzinger

Software Systems Theory

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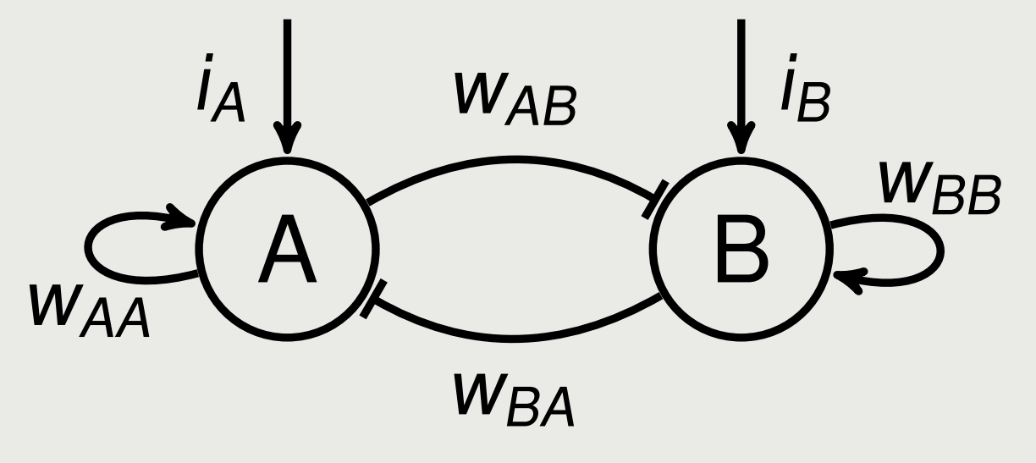
Systems Biology

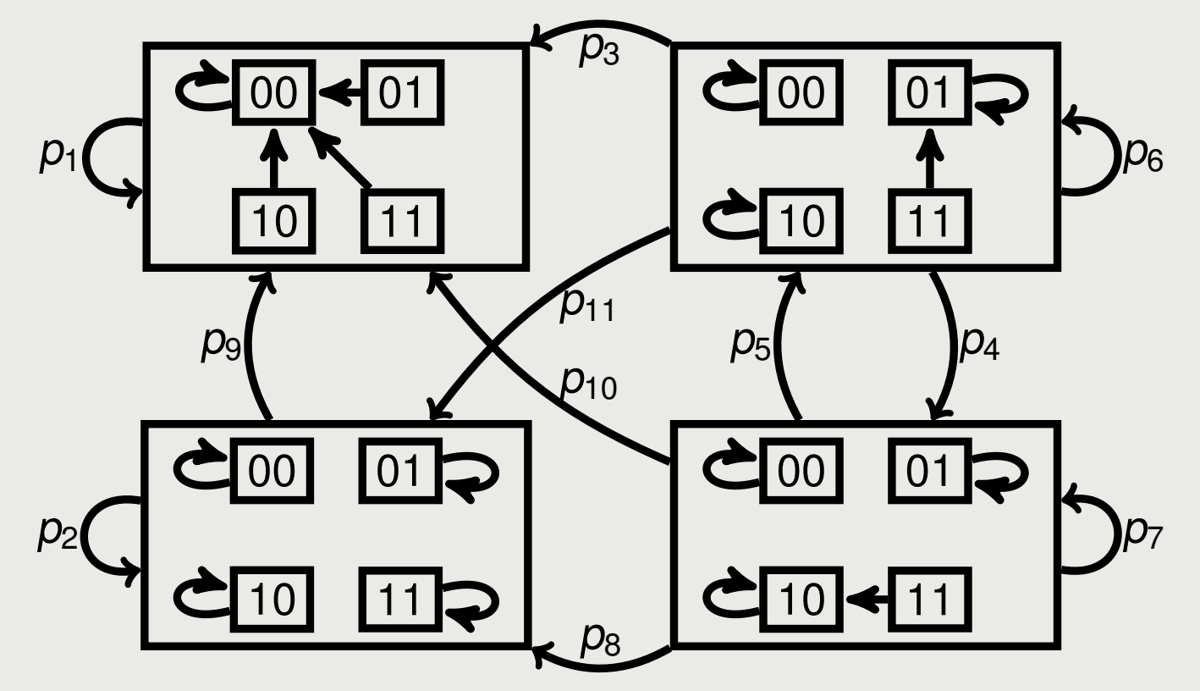
Biological systems can be seen as **reactive systems**, namely dynamical systems which interact with their environment by receiving and transmitting signals. **Gene regulatory networks** (GRNs) are systems for which proteins are produced and fed to the environment in response to proteins coming from the environment. Moreover, GRNs are subject to **evolution** which vary their behaviour.

How to reason about evolving reactive systems?

We use parametric model checking to compute the probability of an evolving system to satisfy a property, i.e. its mutational robustness.



Syntax: Gene regulatory network



Semantics: Markov chain of transition systems

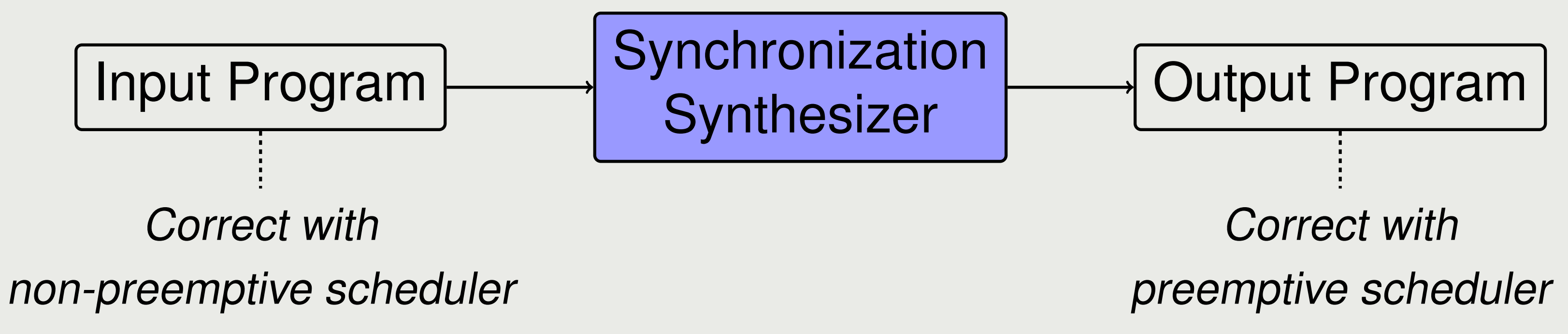
M. Giacobbe, T. Petrov, and external collaborators

Computer-aided Concurrent Programming

Typical concurrency bugs such as data races are caused by subtle synchronization errors. We aim to make concurrent programming easier by **automatically synthesizing tricky synchronization primitives** (locks). The programmer programs assuming a non-preemptive (cooperative) scheduler that does not interrupt threads. The synthesis procedure makes the program safe for a preemptive scheduler.

How to automatically infer locks to ensure correctness?
How to infer minimal locks required for correctness?

Our solution is based on a a finitary abstraction, an automata-theoretic language inclusion check, trace-generalization, rewrite rules for synchronization inference and constraint-solving.



Input Program
Synchronization Synthesizer
Output Program
Correct with non-preemptive scheduler
Correct with preemptive scheduler

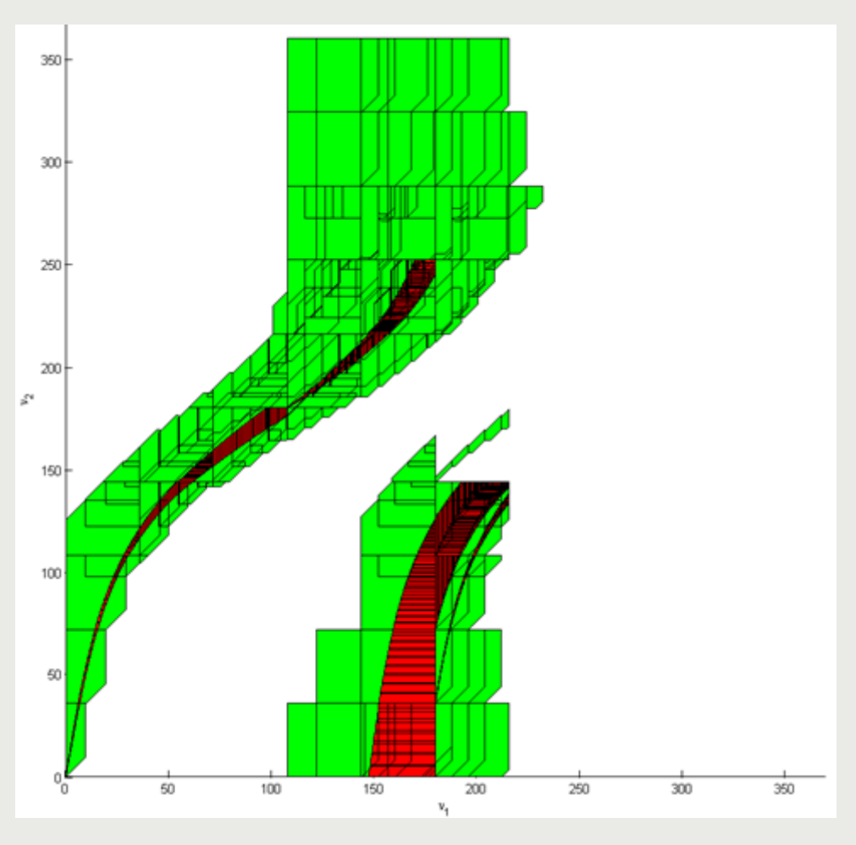
R. Samanta, T. Tarrach, and external collaborators

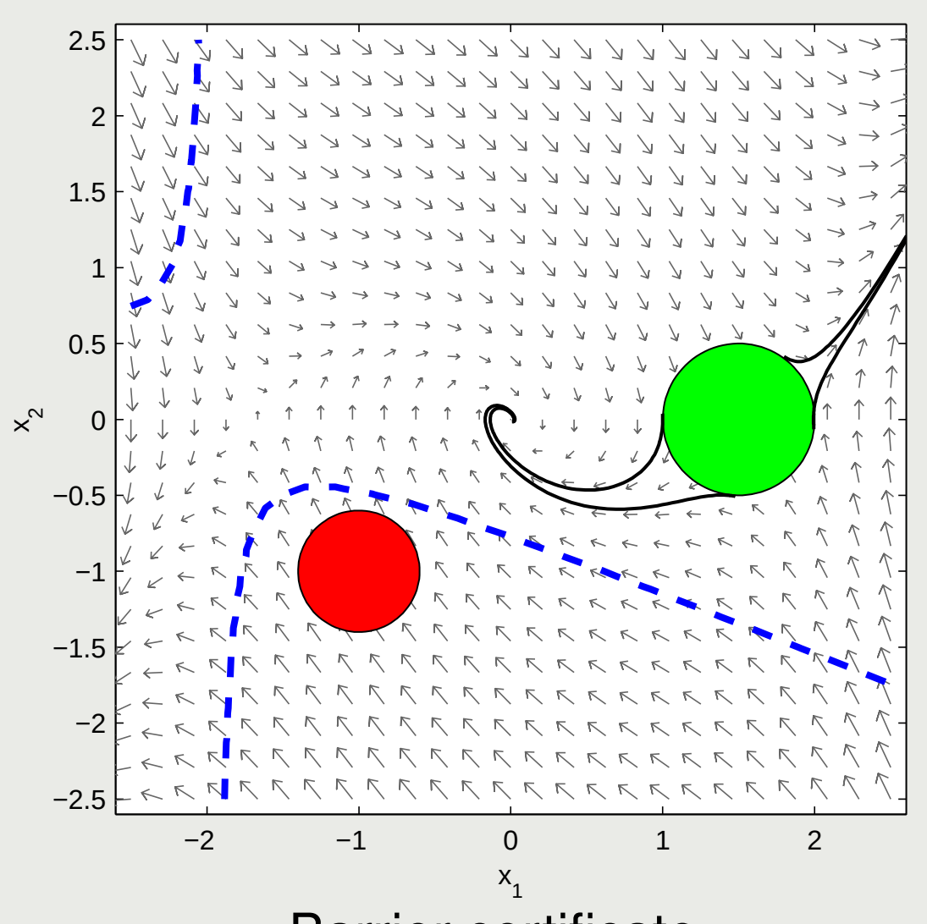
Hybrid Systems

We develop automatic techniques to verify and synthesize **hybrid systems**. Hybrid systems consist of discrete software controllers interacting with continuous physical environments.

*How to **automatically** compute a system **abstraction** that provides **enough information** to **efficiently** check a property?*

In our work, we build system abstractions using flow-pipe construction, barrier-certificates and moment closures.


Flow-pipe construction



Barrier certificate

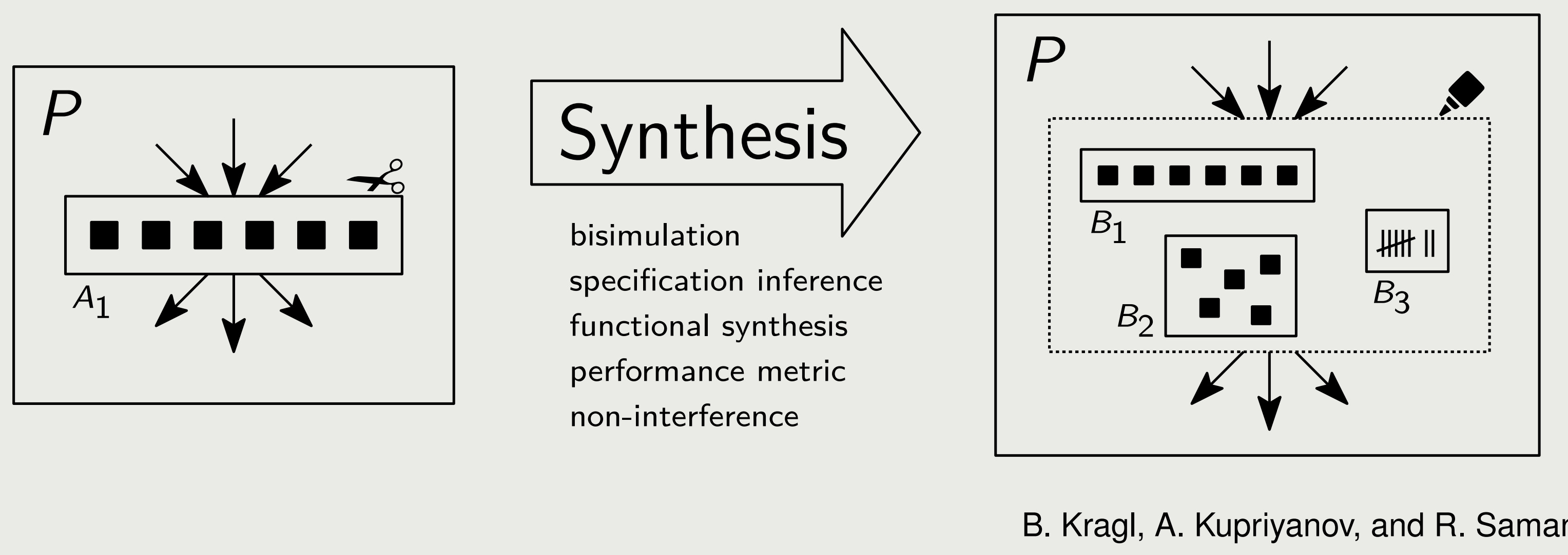
S. Bogomolov, M. Giacobbe, H. Kong, J. Ruess, and external collaborators

Performance-Aware Software Synthesis

Software systems are built using components such as counters, pools, and queues. Components with strong guarantees (e.g., queues) are easier to reason about, while those with relaxed guarantees (e.g., pools) provide better performance.

How to ease the programming burden by automatically optimizing the performance of component-based programs?

We allow the programmer to write a program P using components $\{A_i\}$, and **automatically synthesize glue code** that dynamically redirects calls to more efficient components $\{B_i\}$ while ensuring that $P(\{A_i\})$ is **observationally equivalent** to $P(\{B_i\})$.



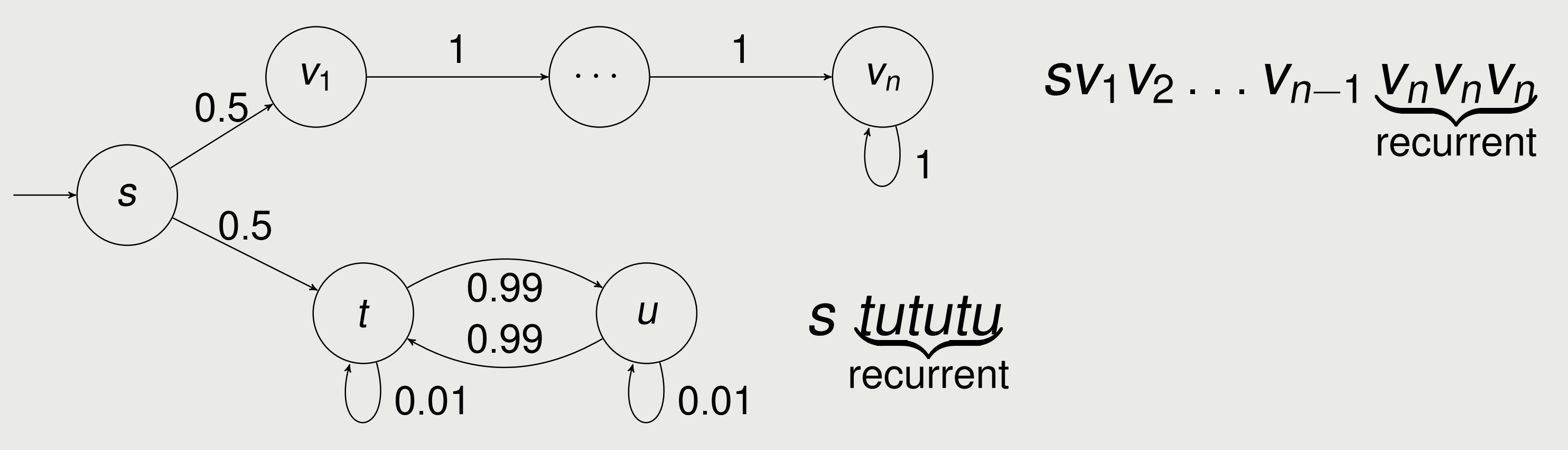
B. Kragl, A. Kupriyanov, and R. Samanta

Probabilistic Systems

Statistical model checking (SMC) is an approach to verification of probabilistic systems, where we sample from the system, and apply statistics to infer conclusions. We propose an SMC algorithm for **unbounded properties**, e.g.:

What is the probability we reach state u once?
How about infinitely many times?

Our key idea is to detect **recurrent states** by observing simulations.



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$s \underbrace{tututu}_{\text{recurrent}}$

P. Daca, T. Petrov, and external collaborators