PRISM - An Update

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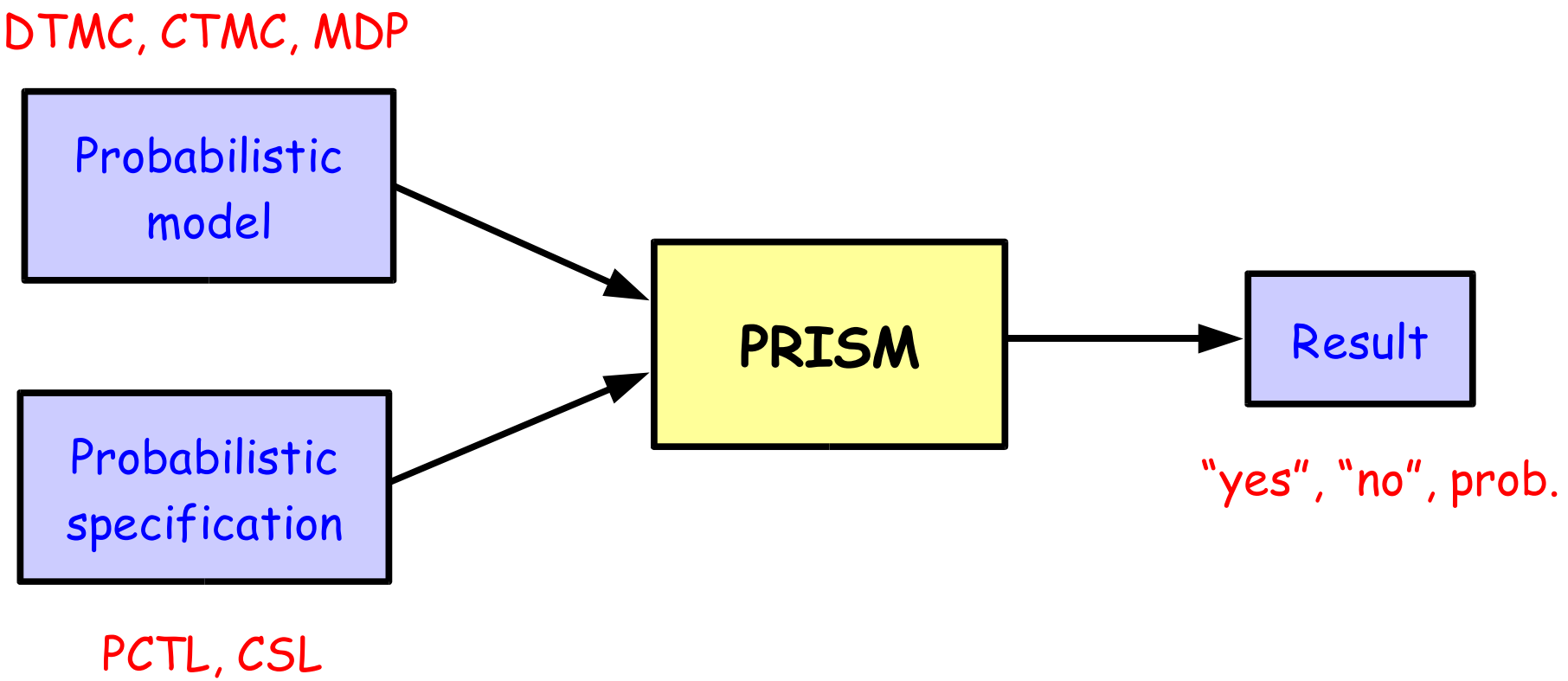
PRISM Overview

- Automatic verification of probabilistic systems



Probabilistic Models

- Discrete-time Markov chains (DTMCs)
  - Discrete time/probabilities
- Continuous-time Markov chains (CTMCs)
  - Real time (exponential distributions)
- Markov decision processes (MDPs)
  - Discrete time/probabilities + nondeterminism

PRISM Language

- Simple, state-based language for DTMCs/CTMCs/MDPs
  - based on Reactive Modules [Alur/Henzinger]
- Modules (system components, composed in parallel)
- Variables (local or global)
- Guarded commands (labelled with probabilities/rates)
- Action labellings (synchronisation between modules)

Language developments

- Types and type checking (ints, doubles, booleans)
- Variable probabilities/rates/etc.
  - e.g. [] (x=0 & n>0) -> 1/n : (x'=1) + 1-1/n : (x'=2)
- Process algebra style constructions
  - More flexible parallel composition of modules
    - P1 ||| P2 P1 |[a,b]| P2 P1 || P2
  - Action hiding/renaming
  - Aim: translation from (probabilistic) CSP

Property Specifications

- PCTL/CSL – prob. extensions of CTL
- $P_{>p}[\Diamond A]$
  - "the probability that event A eventually occurs is > p"
- Also: $\Diamond_{\leq T} A$ "within time T", $A \, U \, B$ "until"
- $S_{<p}[A]$
  - "in the long-run, the probability that A is true is < p"

Property Specifications…

- Can now write "unbounded" formulae:
  - e.g. P=? [◊ *A*] "what is the probability that…"
- Future:
  - Implement linear time (LTL) model checking
  - 2 new algorithms:
    - [Eliosoff/Panangaden]
    - [Couvreur/Saheb/Sutre]

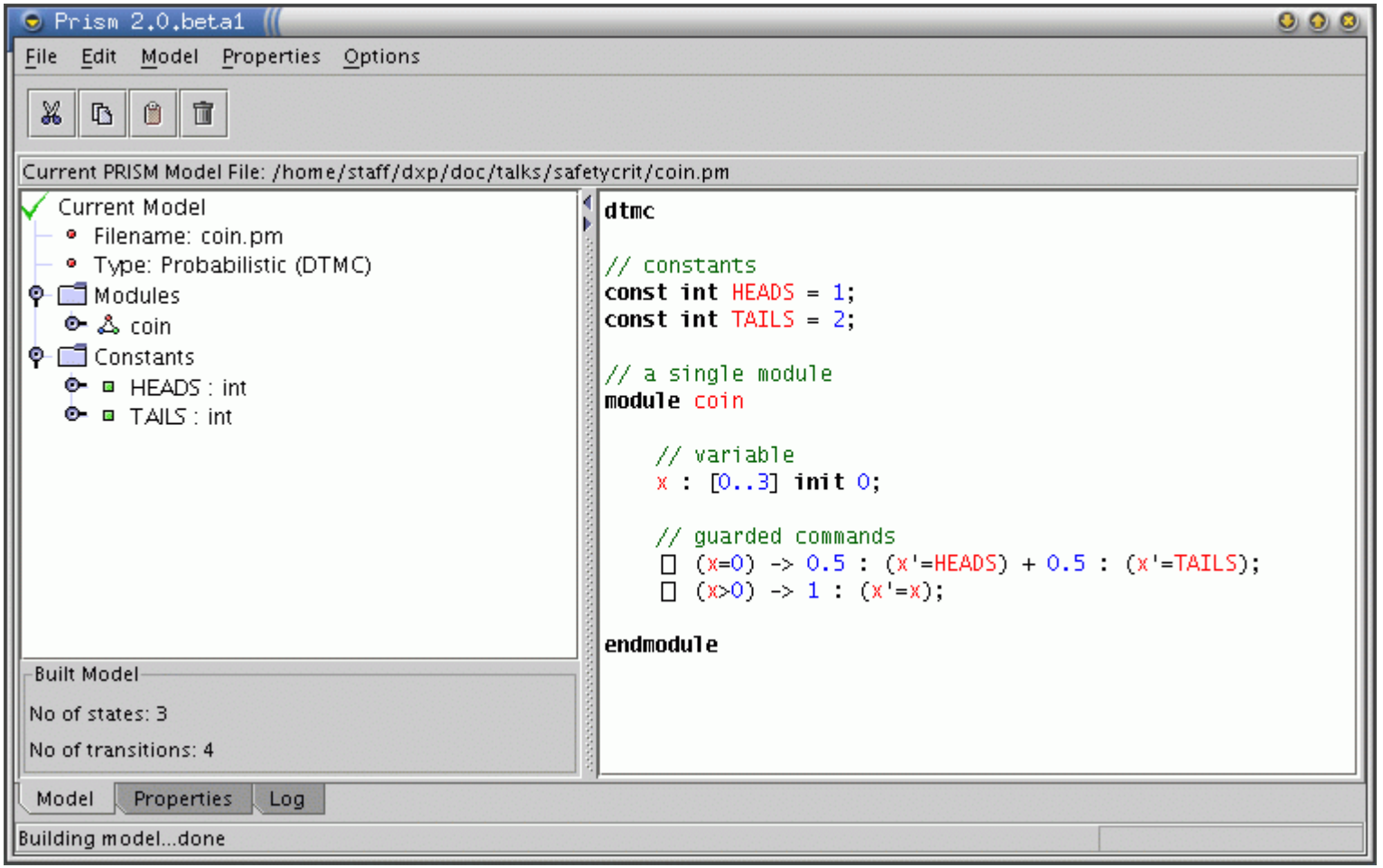
Costs And Rewards

- Extend model with real-valued costs/rewards
  - State or transition based
  - e.g. "time", "num. messages sent", "power consumption", "downtime", ...
- Example properties:
  - "expected cost to reach a ?-state"
  - "expected cumulated cost by time T"
  - "expected cost at time instant t"

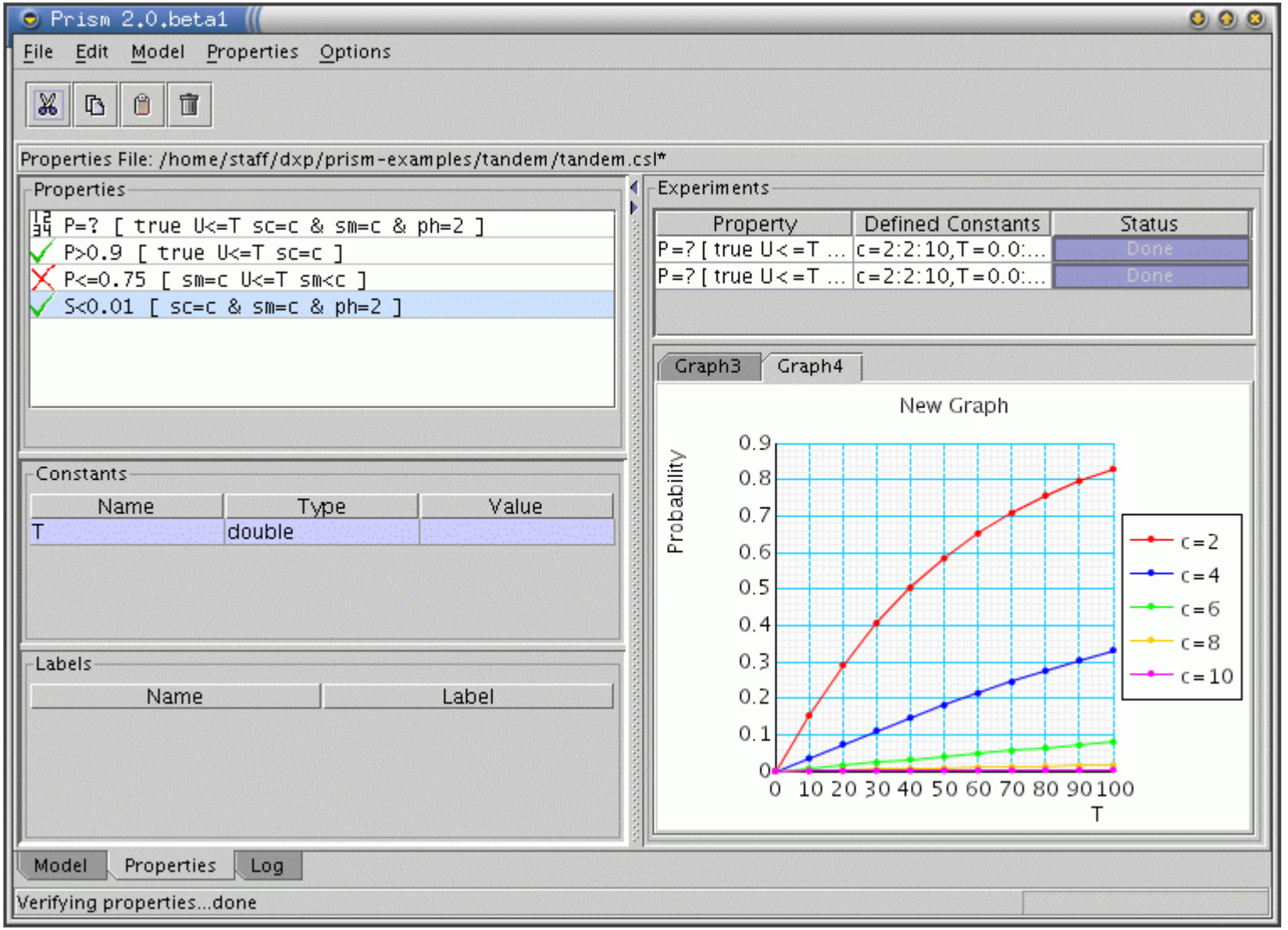
Graphical User Interface

- Complete redesign/implementation
- Integrated editor for PRISM language
- Support for "experiments"
  - e.g. check: P~p[true U<=T error] for T=1..100
- Automatic graph plotting

Screenshots

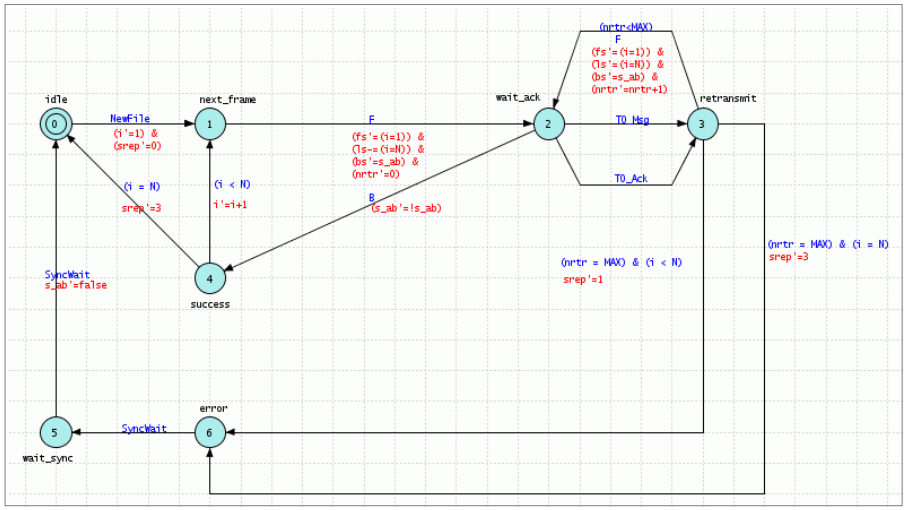


Screenshots...



GUI Prototypes

- Graphical modelling language
  - Based on UPPAAL



- Simulator
  - Manual exploration
    - e.g. counter examples?
  - Automatic simulations

Case Studies - Recent

- IPv4 ZeroConf protocol [FORMATS'03]
- Nanotechnology: multiplexing [VLSI'04]
- Wireless LAN: extension using costs
- Probabilistic fair exchange protocol

Case Studies - Ongoing

- Bluetooth wireless protocol
  - quality of service properties
- Quantum cryptography
  - BB84 key distribution protocol

External Uses of PRISM

- Model checking probabilistic extensions of UML state charts [Twente/Saarland]
- Performance analysis of PEPA nets (stochastic process algebra + Petri nets) [Edinburgh]
- Comparison with probabilistic extension of Murphi verifier [Rome/L'Aquila]
- Probabilistic model checking of fault-tolerant architectures [Monash]

Implementation

- "Symbolic" model checker (BDD-based)
  - Ongoing efficiency improvements
- Parallel, distributed versions
- Disk-based ("out-of-core") version
- Alternative solution techniques
  - Sampling-based [Younes, Simmons]
  - Monte-Carlo approximations [Peyronnet et al.]

PRISM Research Directions

- Abstraction
  - Ordsets/scalar sets
  - Symmetry reduction
- Compositional approaches
- Mobility (pi calculus)
- Native support for PTAs
  - Add clocks to PRISM language