A Set of Performance and Dependability Analysis Components for CADP

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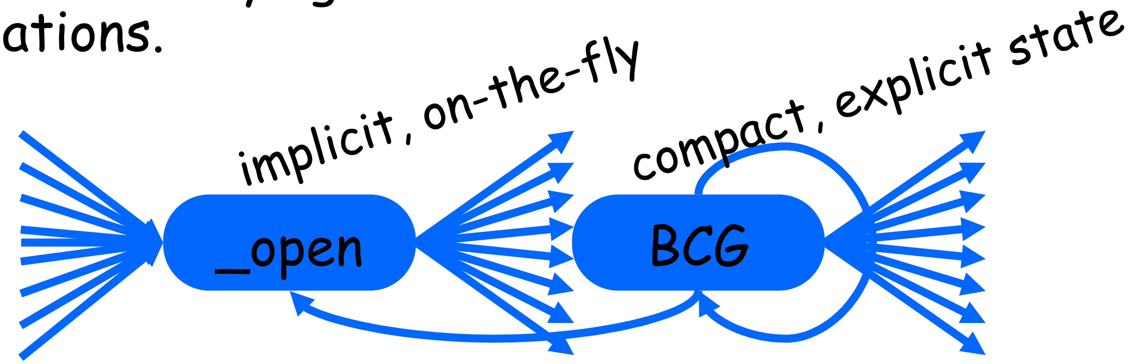
Overview

- What's the tool?
- What's the extension?
- What's the basis?
- What's the example?
- What's under the hood?

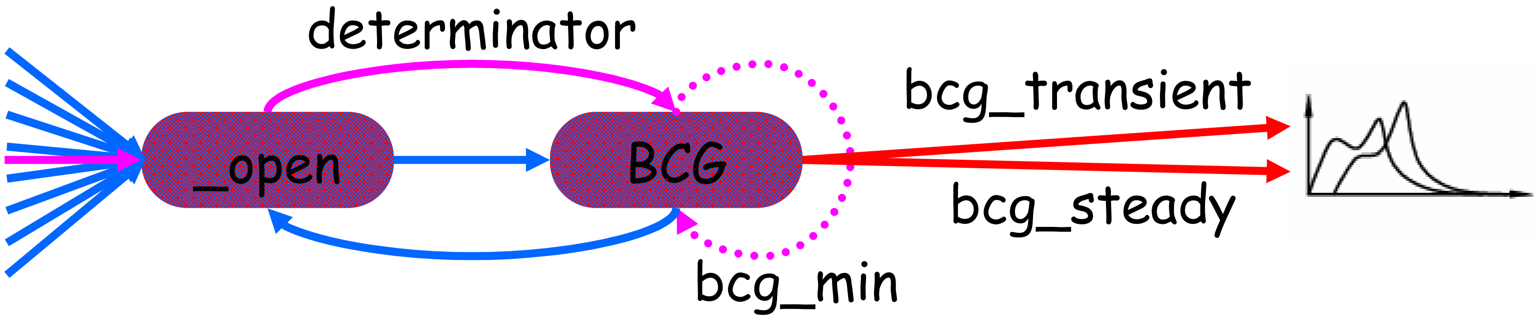
What's the tool?

CADP

- One of the leading verification toolboxes in academia.
- Offers various tools for
  - visualization, simulation,
  - equivalence checking,
  - model checking.
- Open platform supporting integration of other specification, verification and analysis techniques.
- Originally designed for verifying correctness of LOTOS specifications.



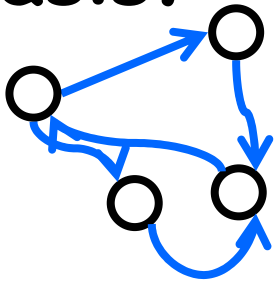
What's the extension?



- Means to specify performance and dependability characteristics.
- Algorithms to construct performance and dependability models.
- Basic analysis algorithms.

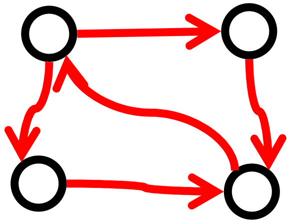
What's the basis?

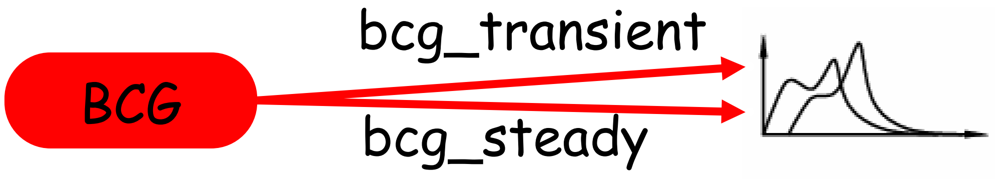
- Labelled transition systems



BCG

- Markov chains





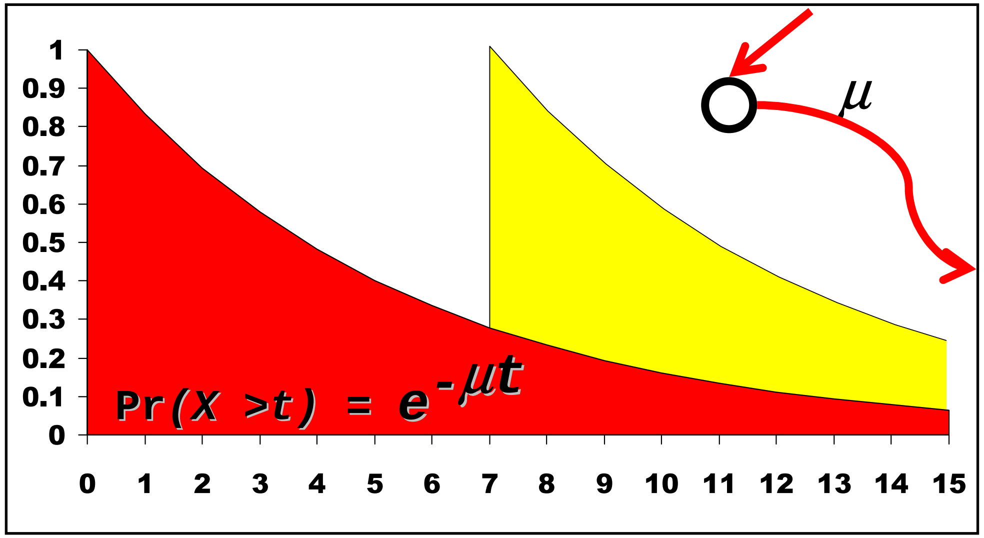
BCG

bcg_transient

bcg_steady

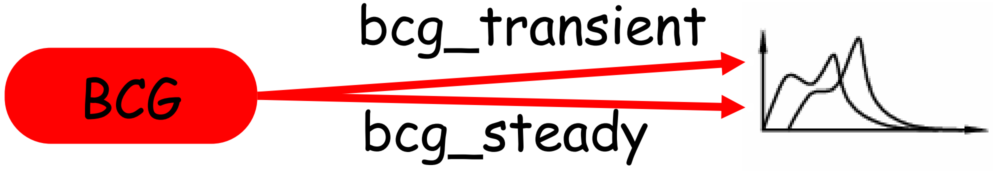
(Continuous-time) Markov chains (MC)

- (finite-state) automata,
- all times are *exponentially distributed*,



$Pr(X > t) = e^{-\mu t}$

- sojourn time in states are *memory-less*,



bcg_transient

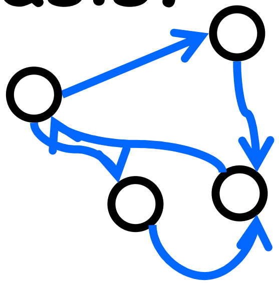
BCG

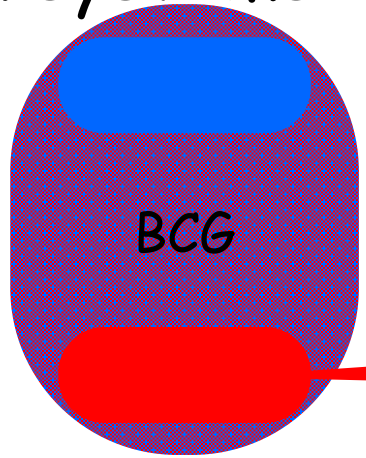
bcg_steady

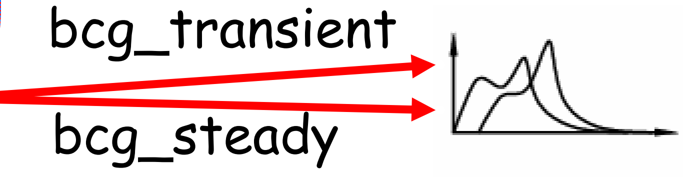
- very well investigated class of stochastic processes,
- widely used in practice,
- best guess, if only mean values are known,
- superpositions can approximate arbitrary continuous distributions,
- *efficient* and numerically *stable* algorithms for *steady-state* and *transient* analysis are available.

What's the basis?

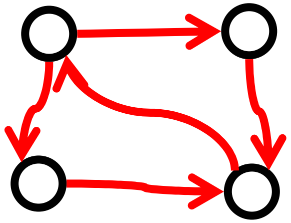
- Labelled transition systems



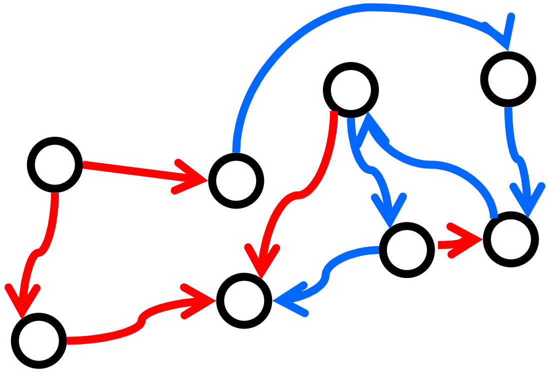


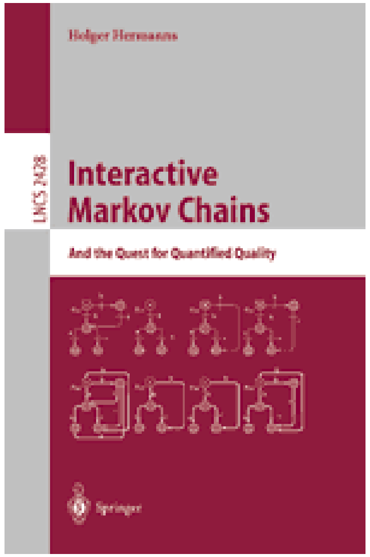


- Markov chains



- Interactive Markov Chains





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LNCS 2428

Interactive Markov Chains

And the Quest for Quantified Quality

Springer

Interactive Markov Chains in CADP

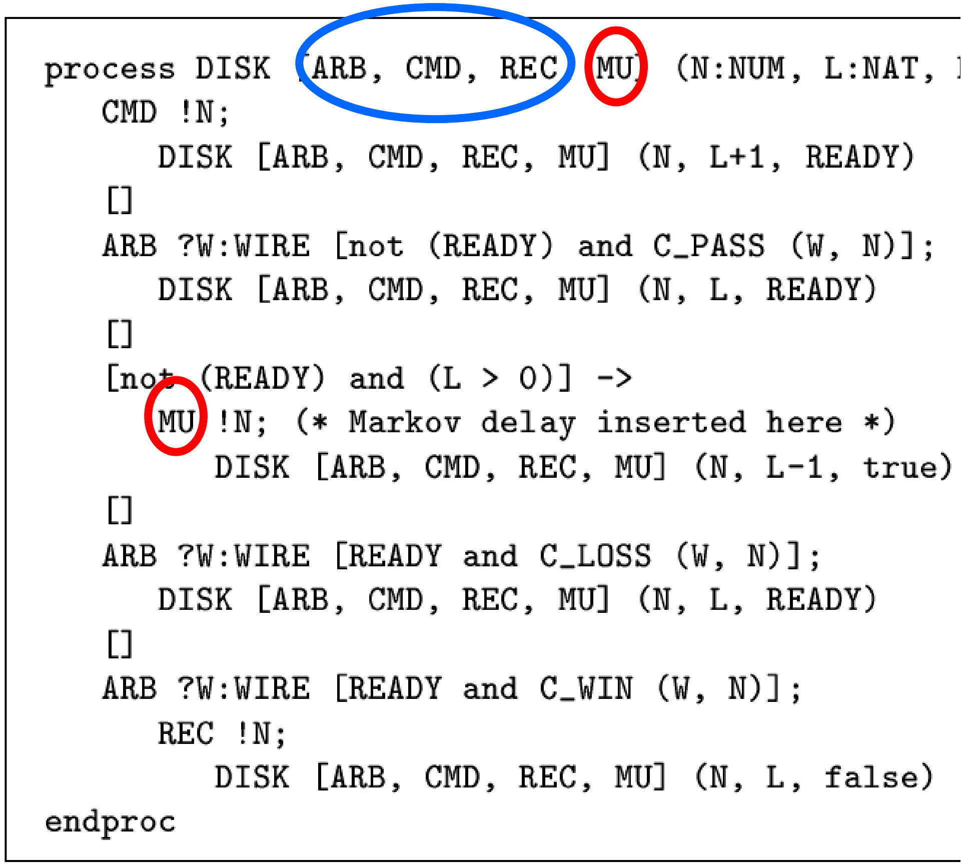
BCG level

- two types of transititions
  - $\underset{\texttt{CMD}}{\longrightarrow}$
  - $\underset{\texttt{rate 24.0}}{\longrightarrow}$

  in the state space representation

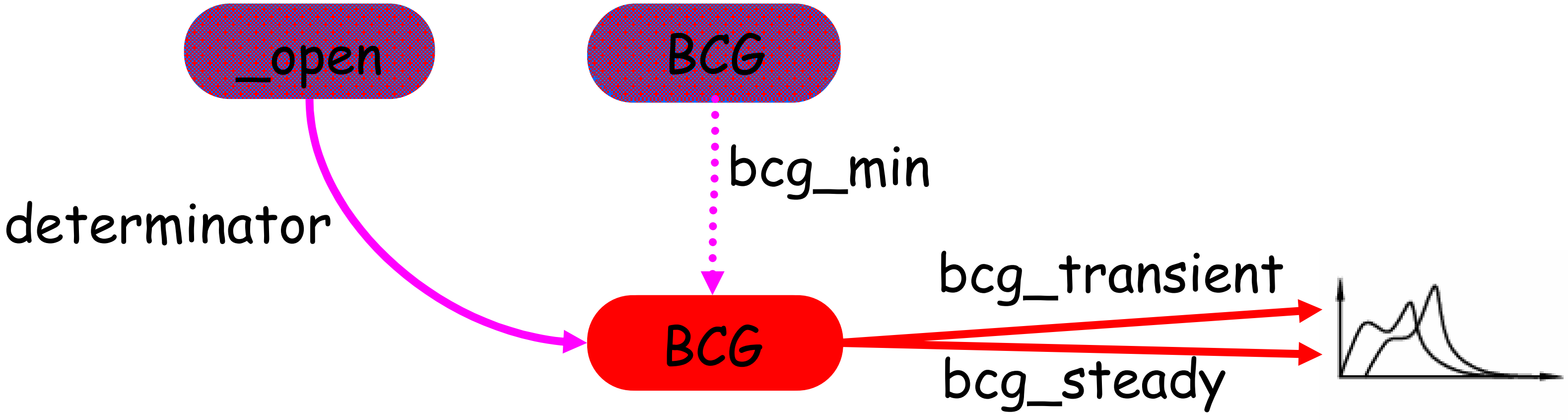
Specification level

- pragmatic
- user defined
  (and user maintained)
  separation of 'gates' into two types
  - gates
  - rates
- mapped on concrete values via generalised renaming (bcg_labels)



```
process DISK [ARB, CMD, REC, MU] (N:NUM, L:NAT, I
   CMD !N;
      DISK [ARB, CMD, REC, MU] (N, L+1, READY)
   []
   ARB ?W:WIRE [not (READY) and C_PASS (W, N)];
      DISK [ARB, CMD, REC, MU] (N, L, READY)
   []
   [not (READY) and (L > 0)] ->
      MU !N; (* Markov delay inserted here *)
         DISK [ARB, CMD, REC, MU] (N, L-1, true)
   []
   ARB ?W:WIRE [READY and C_LOSS (W, N)];
      DISK [ARB, CMD, REC, MU] (N, L, READY)
   []
   ARB ?W:WIRE [READY and C_WIN (W, N)];
      REC !N;
         DISK [ARB, CMD, REC, MU] (N, L, false)
endproc
```

What's under the hood?



determinator

- on-the-fly generation of *MC*
- implements a determinacy check *partial!*

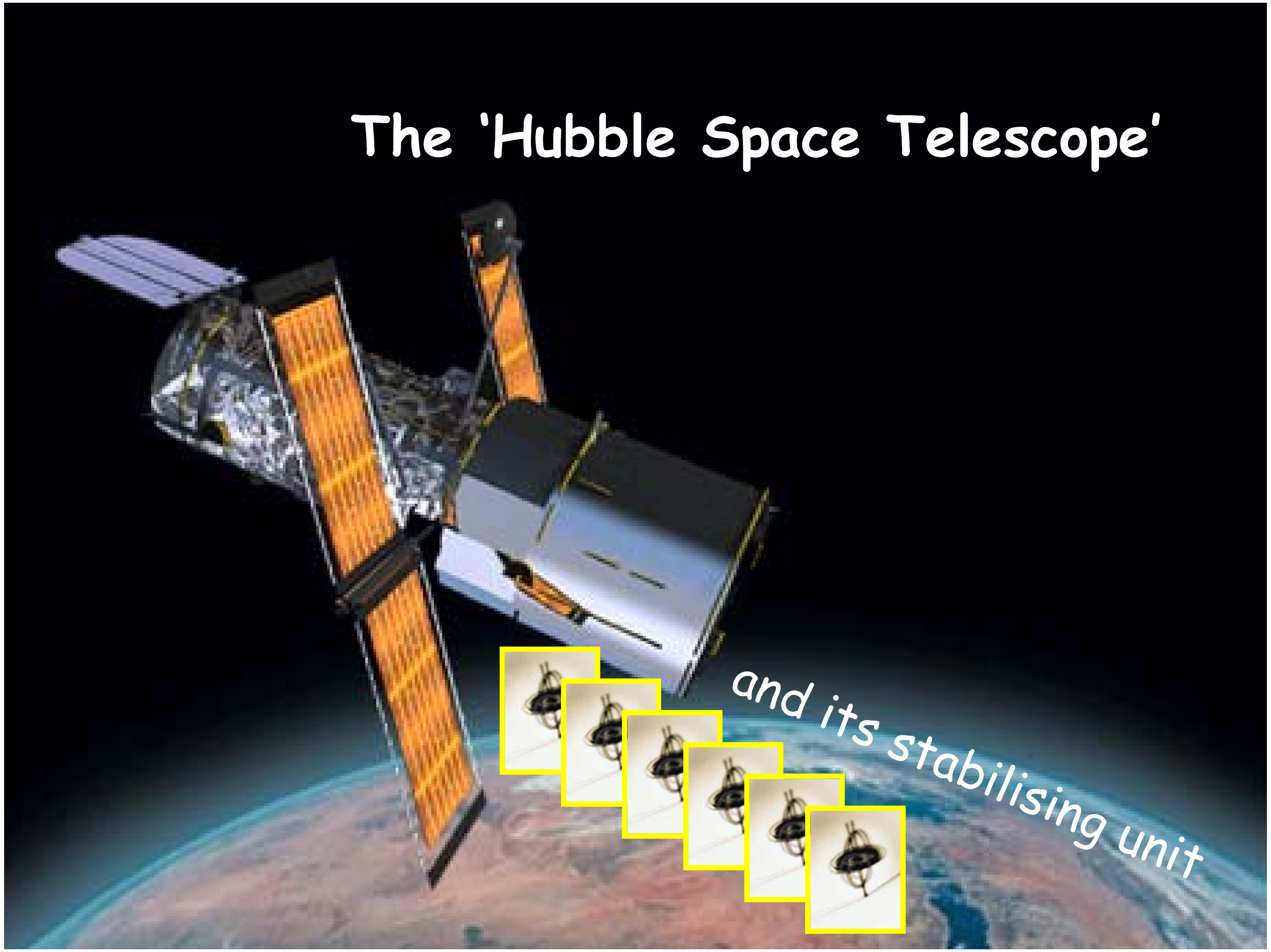
  based on [Ciardo/Zijal,Deavours/Sanders]

bcg_min

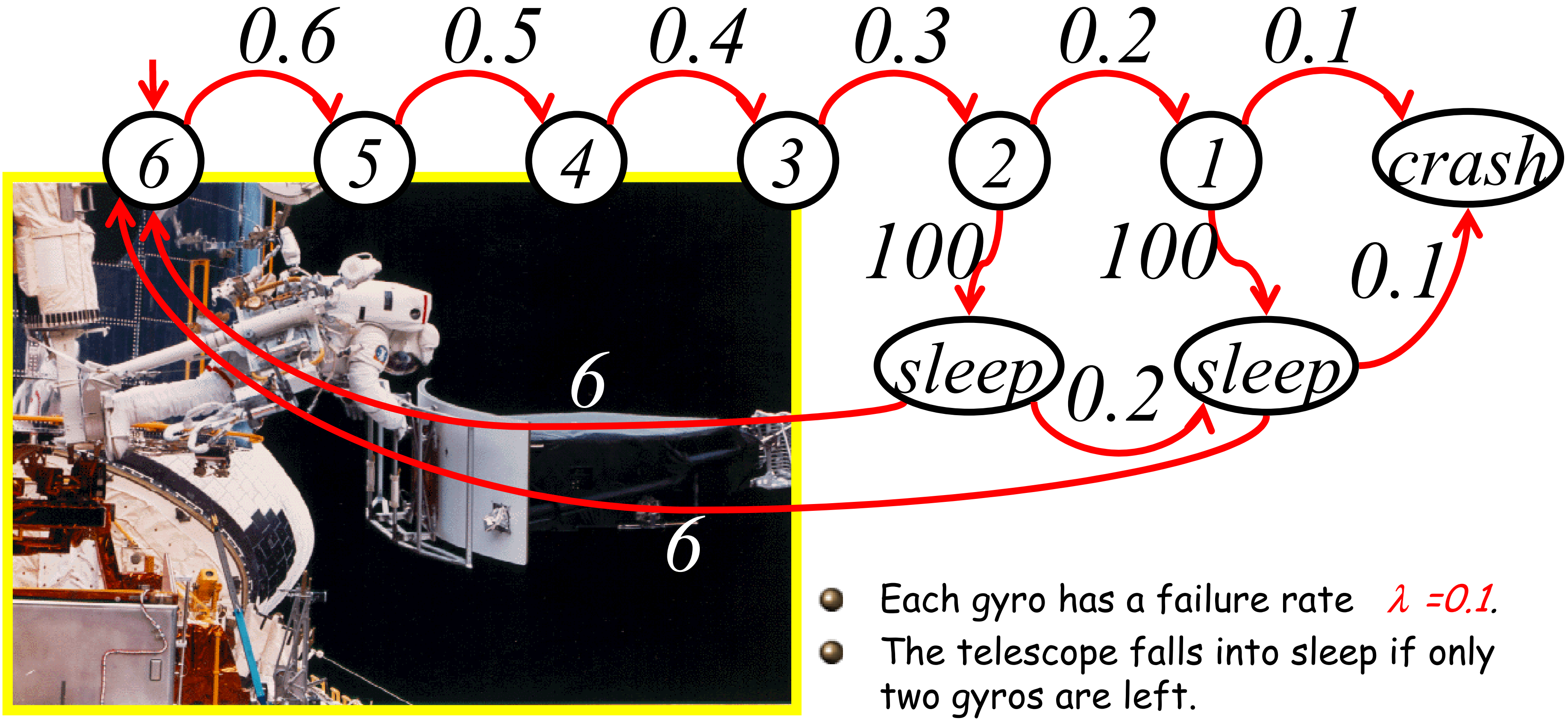
- branching bisimulation minimizer for LTS, for IMC and MC
- can turn an IMC into a minmal MC *partial!*

What's the example?

- A toy example we can demo online



A simple Markov model of the Hubble



- Each gyro has a failure rate λ =0.1.
- The telescope falls into sleep if only two gyros are left.
- To turn on sleep mode requires some time (μ = 100).
- Without operational gyro, the telescope crashes.

- The base station prepares a shuttle mission to repair the telescope which takes about two months (ν =6).

The Hubble in LOTOS

```
behaviour
   HUBBLE [LAMBDA, MU, NU]
where

process HUBBLE [LAMBDA, MU, NU] : noexit :=
      hide FAIL in
         (
            (
               GYRO [LAMBDA, FAIL] (true of Bool)
               |||
               GYRO [LAMBDA, FAIL] (true of Bool)
               |||
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               |||
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               |||
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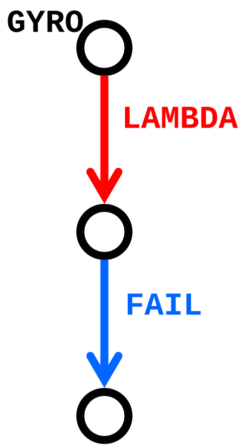
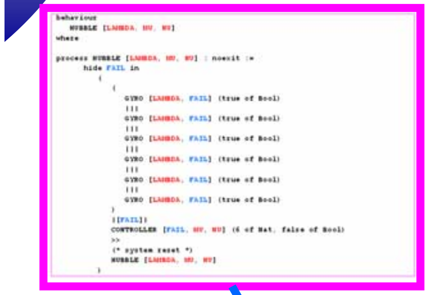
               |||
               GYRO [LAMBDA, FAIL] (true of Bool)
            )
            |[FAIL]|
            CONTROLLER [FAIL, MU, NU] (6 of Nat, false of Bool)
            >>
            (* system reset *)
            HUBBLE [LAMBDA, MU, NU]
         )
```



The Hubble in LOTOS (cont.)

```
process CONTROLLER [FAIL, MU, NU] (C : Nat, SLEEP : Bool) : exit :=
         (* Still gyros left *)
         [(C > 0)] ->
            (* Ah, a gyro failed. Let's count down. *)
            FAIL;
               CONTROLLER [FAIL, MU, NU] (C - 1, SLEEP)
         []
         (* Hubble starts tumbling. *)
         [(C < 3) and (SLEEP eq false)] ->
            (* Time to turn on the SLEEP mode. *)
            MU;
               CONTROLLER [FAIL, MU, NU] (C, true)
         []
         (* Sleep mode is on. *)
         [(SLEEP eq true)] ->
            (* Let's wait for the space mission to reset the system. *)
            NU;
               exit
         []
         (* No gyros left. *)
         [C == 0] ->
            (* Crash! *)
            i;
               stop
      endproc
   endproc
```

Analysis trajectory for the Hubble example



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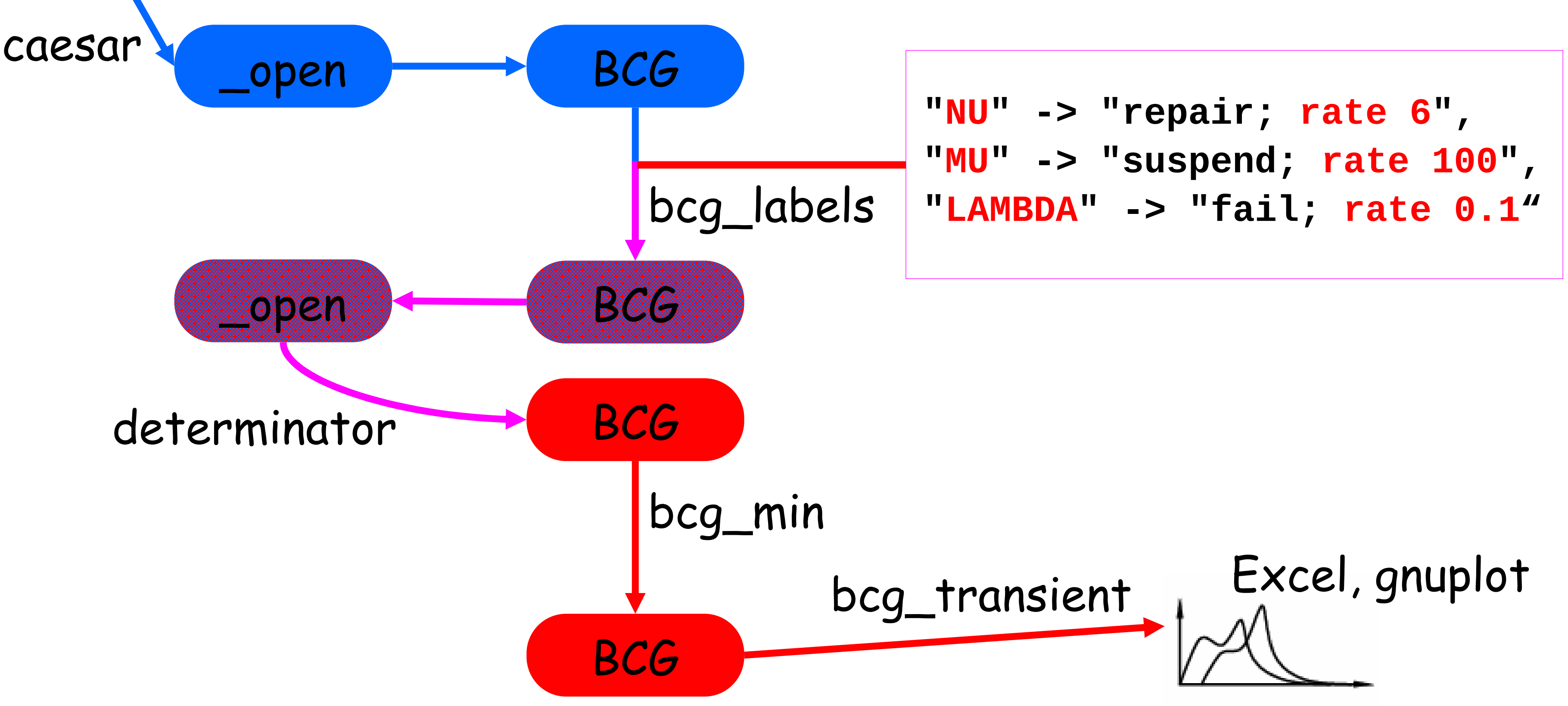
               |||
               GYRO [LAMBDA, FAIL] (true of Bool)
            )
            |[FAIL]|
            CONTROLLER [FAIL, MU, NU] (6 of Nat, false of Bool)
            >>
            (* system reset *)
            HUBBLE [LAMBDA, MU, NU]
         )
```



```
"NU" -> "repair; rate 6",
"MU" -> "suspend; rate 100",
"LAMBDA" -> "fail; rate 0.1“
```

…a good canditate for the SVL scripting language

Conclusion

- Broaden the CADP toolkit to performance and dependability modelling and analysis.

- Pragmatic approach
  - no syntax extension;
  - uses various parts of the toolset and SVL scripting;
  - partial algorithms to construct MC;
  - MC analysis algorithms.

- Part of forthcoming CADP 2003

  http://www.inrialpes.fr/vasy/cadp

- Future work
  - MC Model Checking
  - direct IMC analysis