REDUCED STATE SPACE CONSTRUCTION
-
COVERABILITY GRAPH

QUALITATIVE ANALYIS METHODS, OVERVIEW

- NET REDUCTION
- STRUCTURAL PROPERTIES
- LINEAR PROGRAMMING
  - place / transition invariants
  - state equation
  - trap equation

} static analysis

- REACHABILITY ANALYSIS
  - (complete) reachability graph
  - compressed state spaces
    - BDDs, NDDs, ..., XDDs
    - Kronecker products
  - reduced state spaces
    - coverability graph
    - symmetry
    - stubborn sets
  - branching process

} dynamic analysis *(model checking)*

REACHABILITY GRAPH, CONSTRUCTION ALGORITHM

PROCEDURE rg (**IN** Net *pn*, **IN** Marking *m0*,
OUT MSet *nodes*, **OUT** ArcSet *arcs*);

MSet $U = \{m0\}$, // unprocessed markings
$N = \emptyset$; // rg nodes
ArcSet $E = \emptyset$; // rg arcs (pre, post, t)
Marking m'; // successor marking
Transition t;

WHILE $U \neq \emptyset$ **DO**
choose one $m \in U$;
$U = U - \{m\}$; $N = N \cup \{m\}$;

FOR ALL t enabled at m **DO**
$m' = m + \Delta t$;
IF $m' \notin N \cup U$ // new marking
THEN $U = U \cup \{m'\}$
ENDIF;
$E = E \cup \{(m, m', t)\}$
ENDFOR

ENDWHILE;

nodes = *N*; *arcs* = *E*;

ENDPROC rg.

COVERABILITY GRAPH, CONSTRUCTION ALGORITHM -> TWO CHANGES IN PROCEDURE RG

- **PROCEDURE** cg
(**IN** Net *pn*, **IN** Marking *m0*,
OUT OmegaMSet *nodes*, **OUT** ArcSet *arcs*);

OmegaMSet // omega for infinite
$U = \{m0\}$, // unprocessed markings
$N = \emptyset$; // rg nodes

- **FOR ALL** t enabled at m **DO**
$m' = m + \Delta t$;

IF m' covers some $mOld \in N \cup U$
with path $(mOld, m')$ in E
THEN
FOR ALL $p \in P$ **DO**
IF $mOld(p) < m'(p)$
THEN $m'(p) = \omega$
ENDIF
ENDFOR
ENDIF

IF $m' \notin N \cup U$
...
ENDFOR

COVERABILITY GRAPH

- finite also for unbounded nets
- omega-marking
  - -> generalization of marking
  - -> omega stands for infinite token numbers
- for bounded nets pn:
  rg(pn) = cg(pn)
- decidable properties
  - -> place unboundedness
  - -> simultaneous unboundedness of places
  - -> m_0-dead transitions
- semi-decidable property
  - -> non-reachability of states
- non-decidable properties
  - -> deadlock freedom,
  - -> liveness
  - -> reversibility

COVERABILITY GRAPH

- the result of this Karp-Miller algorithm
  - -> depends on the order markings are considered
  - -> is, generally, not minimal
- Finkel algorithm constructs always the minimal cg
  - -> but much more expensive

BUT

- All basic Petri net properties are known
  to be generally decidable!
- What we do not know is whether there is a primitive
  recursive algorithm to decide it practically.

Examples:

cg1 .. cg8.spped