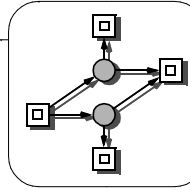
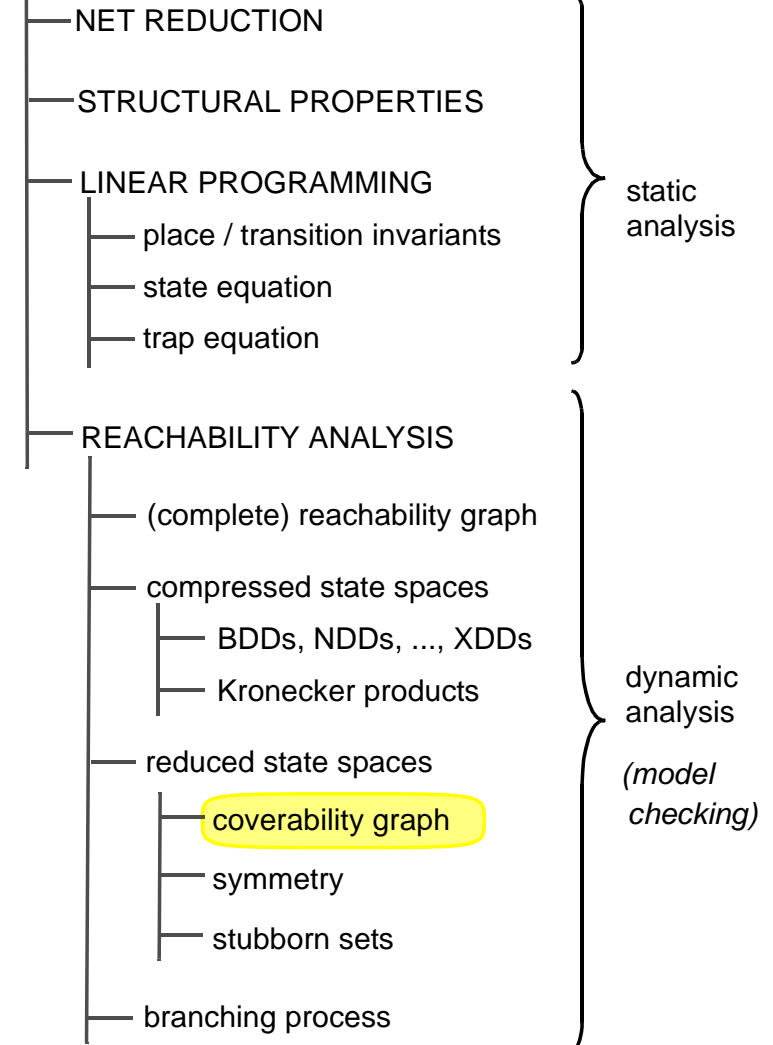
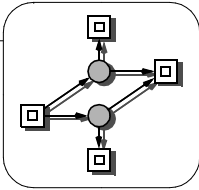


REDUCED STATE SPACE CONSTRUCTION - COVERABILITY GRAPH



QUALITATIVE ANALYSIS METHODS, OVERVIEW





REACHABILITY GRAPH, CONSTRUCTION ALGORITHM

PROCEDURE rg (IN Net pn , IN Marking m_0 ,
OUT MSet $nodes$, OUT ArcSet $arcs$);

MSet $U = \{m_0\}$, // 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;

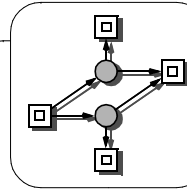
$E = E \cup \{(m, m', t)\}$

ENDFOR

ENDWHILE;

$nodes = N$; $arcs = E$;

ENDPROC rg.



COVERABILITY GRAPH, CONSTRUCTION ALGORITHM

-> TWO CHANGES IN PROCEDURE RG

□ **PROCEDURE** cg

(IN Net pn , IN Marking m_0 ,
OUT OmegaMSet $nodes$, OUT ArcSet $arcs$);

OmegaMSet // omega for infinite
 $U = \{m_0\}$, // unprocessed markings
 $N = \emptyset$; // rg nodes

□ **FOR ALL** t enabled at m **DO**

$m' = m + \Delta t$;

IF m' covers some $m_{Old} \in N \cup U$
with path (m_{Old}, m') in E

THEN

FOR ALL $p \in P$ **DO**

IF $m_{Old}(p) < m'(p)$

THEN $m'(p) = \omega$

ENDIF

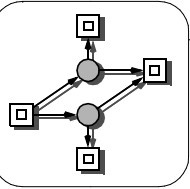
ENDFOR

ENDIF

IF $m' \notin N \cup U$

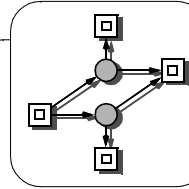
...

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