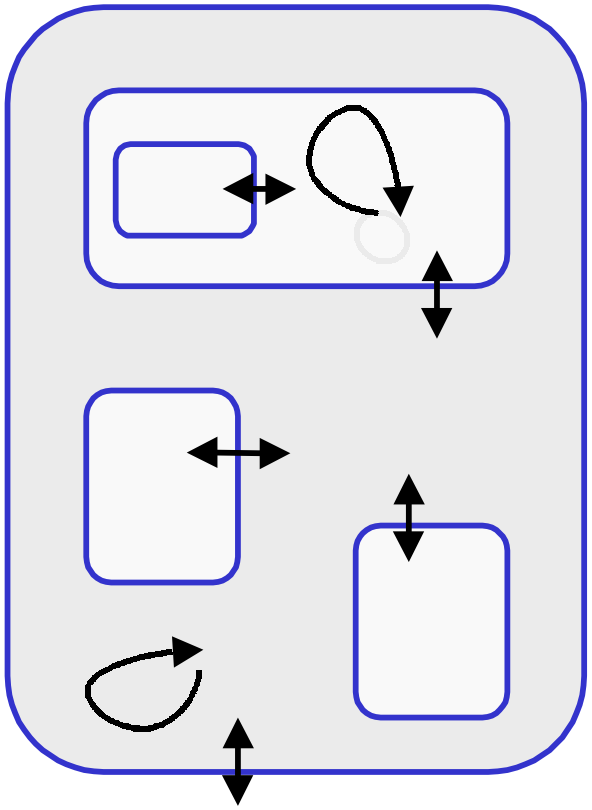
Membrane Computing

Păun 2000 JCSS



nested membranes

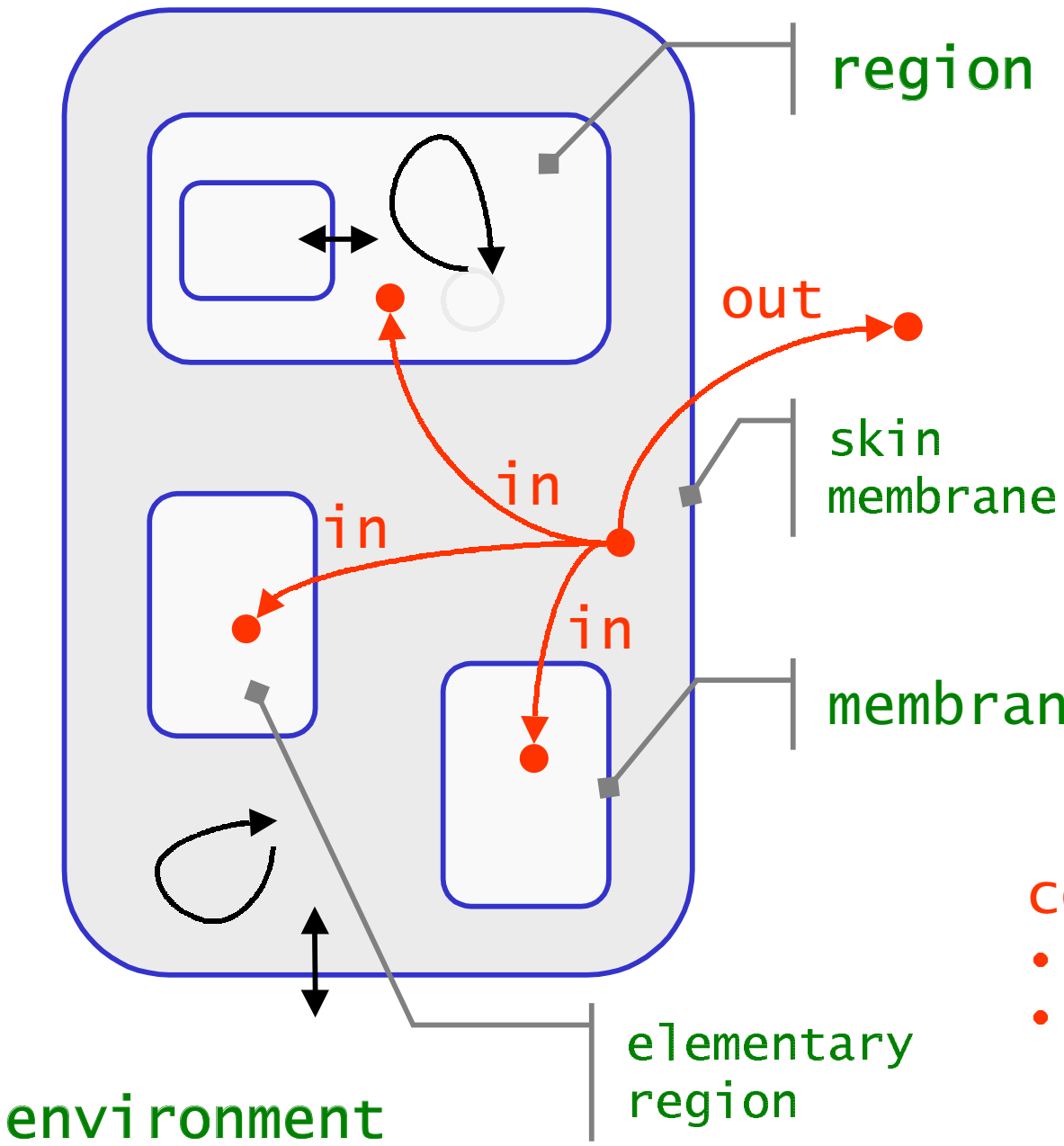
R objects
- 8 strings
- 4 unstructured

R rules
- 4 communication

  $ac \rightarrow ba_{out}c_{in}$
- 8 evolution
  - 2 rewriting

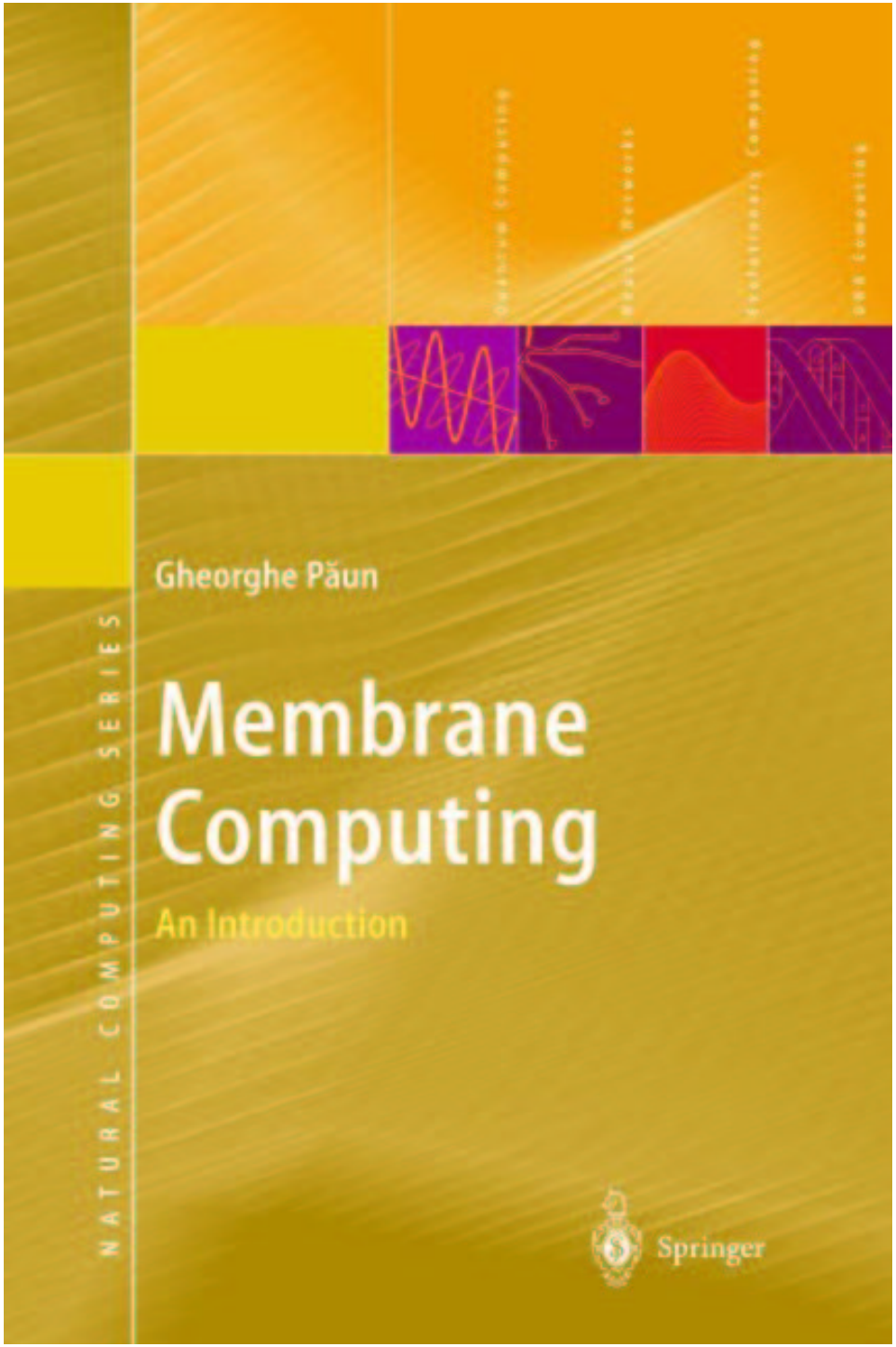
    $(A \rightarrow aAb)_{out}$
  - 2 splicing

Structure



communication

- explicit addressing
- relative in/out
  non-deterministic



Gheorghe Păun

Membrane Computing

An Introduction

Natural Computing Series

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Carriers and Counters

P systems with Carriers
vs.
(Blind) Counter Automata

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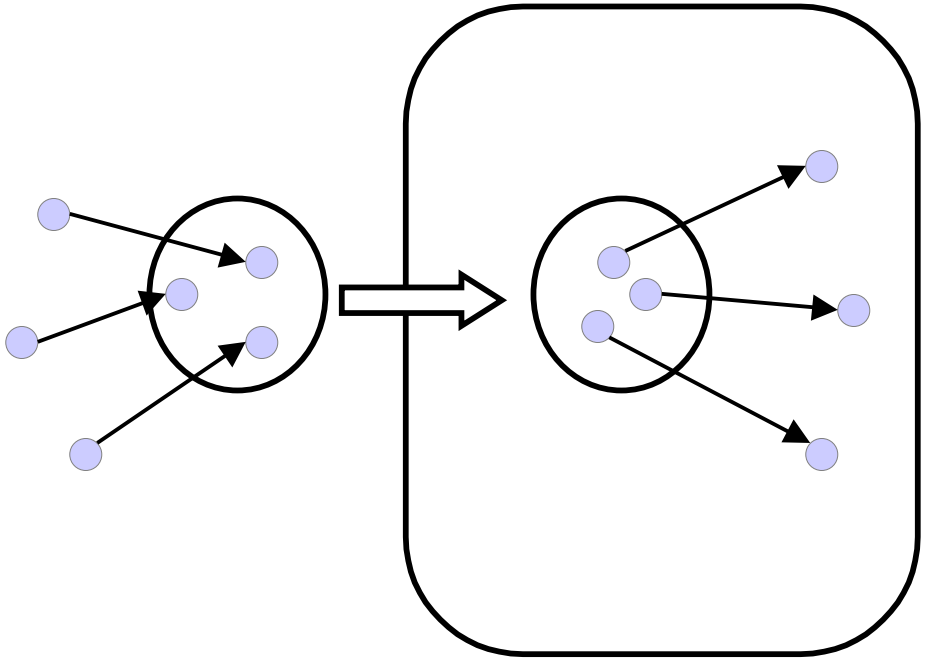
as presented at
Developments in Language Theory ’02
Kyoto Japan

P systems with carriers

Martín-Vide Păun Rozenberg



Contents

- objects
  - multiset symbols
  - infinite supply
    - in environment
- carriers
  - finite number

Rules

$va_1 \ldots a_k \rightarrow v[a_1 \ldots a_k]$ attaching

$v[a_1 \ldots a_k] \rightarrow in$ carry in

$v[a_1 \ldots a_k] \rightarrow out$ carry out

$v[a_1 \ldots a_k] \rightarrow va_1 \ldots a_k$ detaching

$va_1 \ldots a_k \leftrightarrow v[a_1 \ldots a_k]$

$v[a_1 \ldots a_k] \rightarrow$ in/out

Computations

evolving multisets

infinite supply environment

fixed carriers

maximal parallellism

halting by 'blocking'

counting objects

'output' membrane

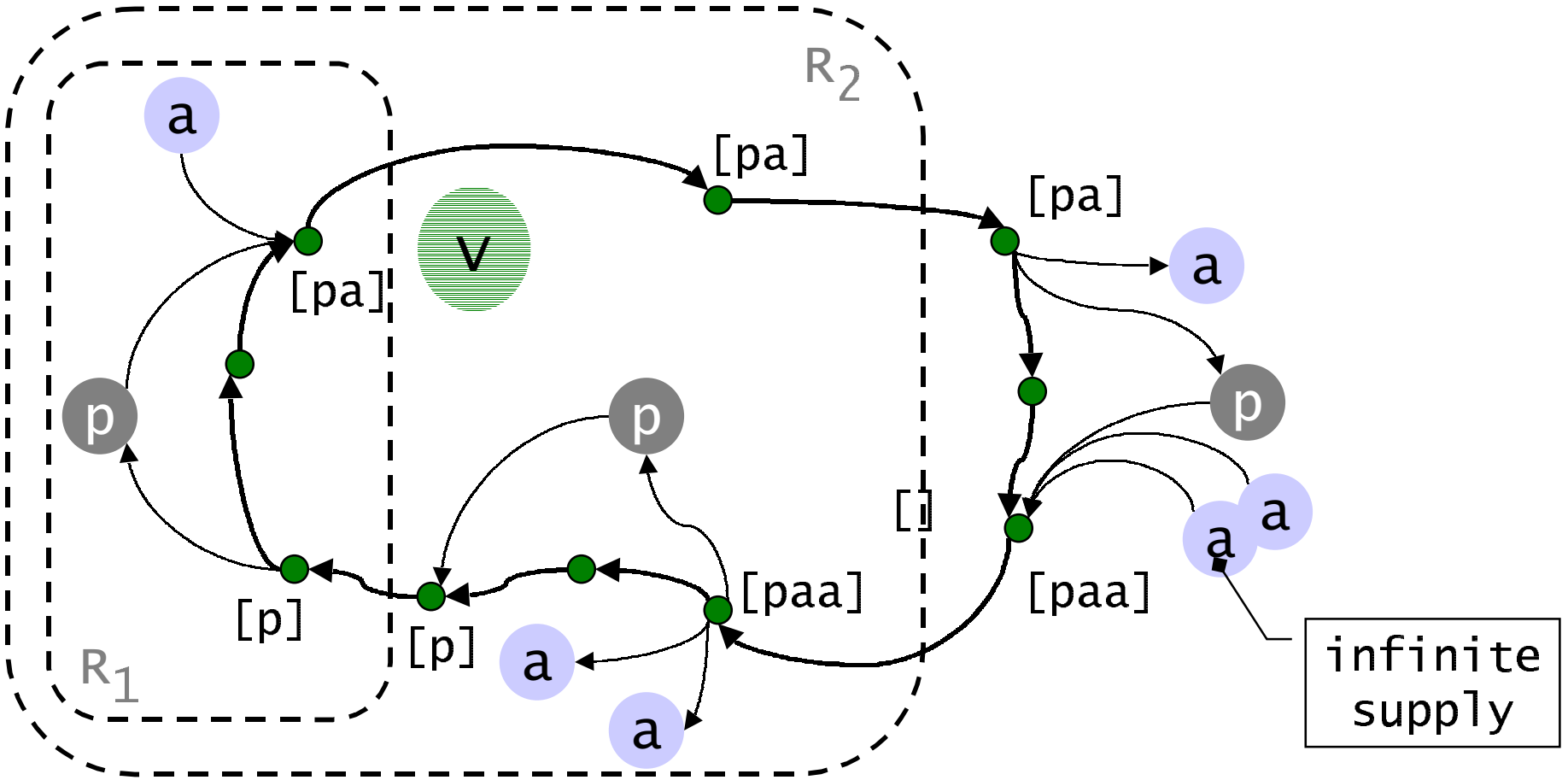
$\mathbb{N}^k CP_m(c,p)$

- membranes
- carriers
- passengers

(here k=1)

P systems with carriers

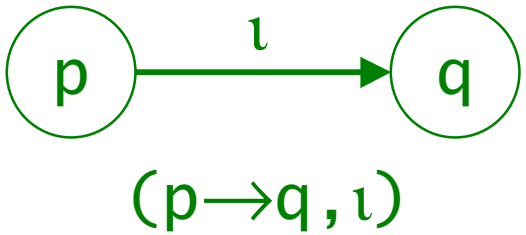
example



E	R_2	R_1
v[pa]→vpa vpaa→v[paa]→in	vp→v[p]→in v[pa]→out v[paa] →vpaa	v[p]→vp vpa→v[pa]→out

counter automata

Minsky, Fischer



ε	nil
+A	add one
-A	substract one
A=0	zero test

several counters
acceptance by final state
& empty counters

output counter

Recursively Enumerable sets

ℕRE

blind counter automata

Greibach

no zero test,
except final test for acceptance

Petri nets

ℕBC

DLT'02 paper

MaVi-Pău-Roz '02

$$\mathbb{NRE} = \mathbb{NCP}_2(3,3)$$

$\mathbb{NCP}_m(c,p)$

- membranes
- carriers
- passengers

$$\mathbb{NRE} = \mathbb{NCP}_1(2,3)$$

$$\mathbb{NRE} = \mathbb{NCP}_1(*,2)$$

1. single membrane

$$\mathbb{NBC} = \mathbb{NCP}_*(1,*) = \mathbb{NCP}_1(1,3)$$

2. single carrier

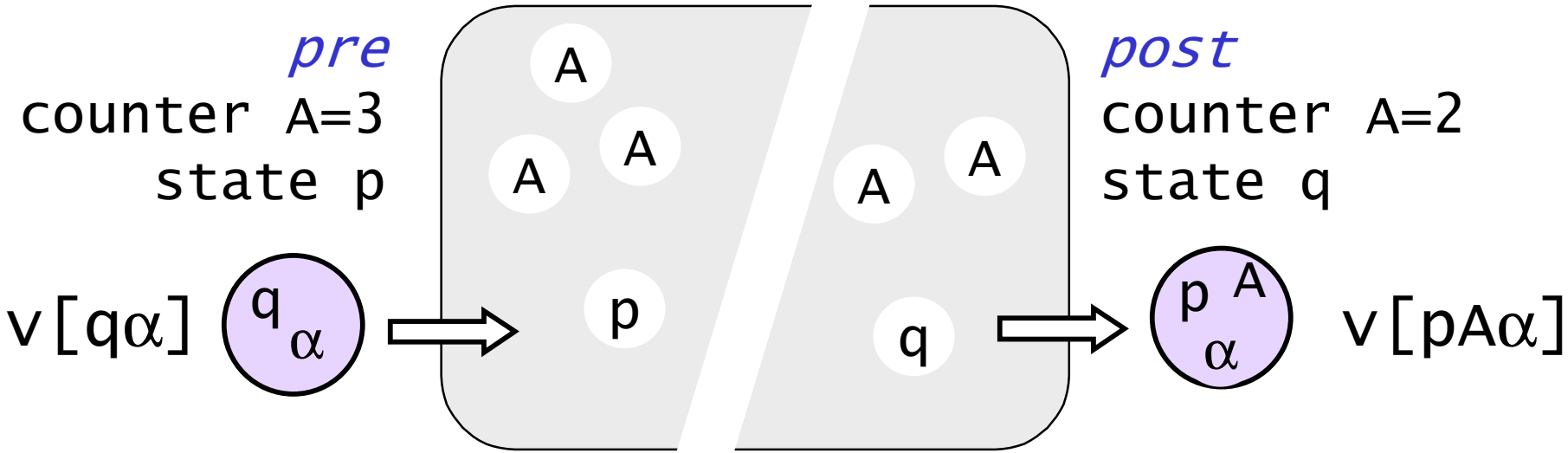
$$\mathbb{NRE} = \mathbb{NCP}_*(*,1)$$

3. single passenger

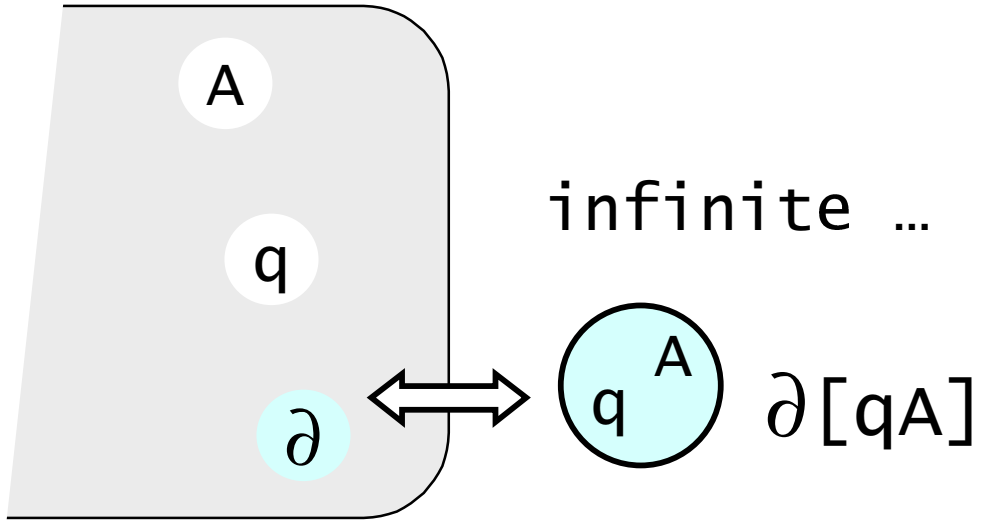
1. single membrane

$\mathbb{N}RE \subseteq \mathbb{N}CP_1(2,3)$

α:(p→q,-A)



α:(p→q,A=0)



2. single carrier

P without parallellism
carriers + objects
P system halting:
no applicable rules

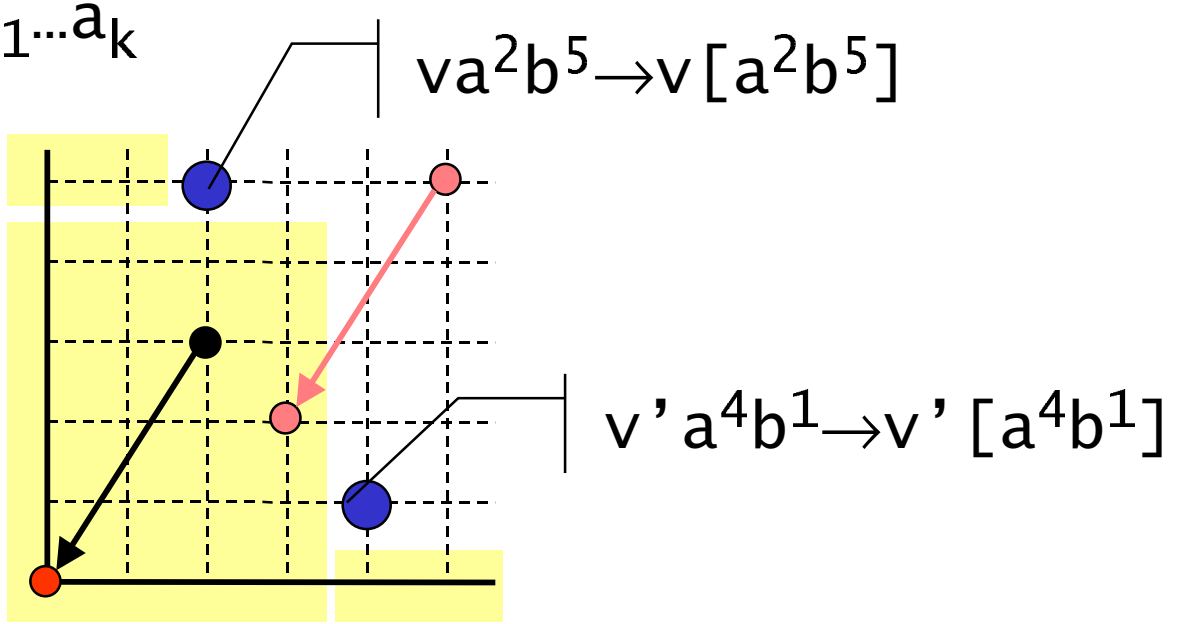
blind counter aut.
state + counters
final state
& empty counters

* $va_1 \ldots a_k \rightarrow v[a_1 \ldots a_k]$

3 $v[a_1 \ldots a_k] \rightarrow$ in/out

3 $v[a_1 \ldots a_k] \rightarrow va_1 \ldots a_k$

guess vector
& test by zero
acceptance



2. single carrier

$\mathbb{N}\mathbf{BC} = \mathbb{N}\mathbf{CP}_1(1,3)$

$\mathbb{N}\mathrm{BC} \subseteq \mathbb{N}\mathrm{CP}_1(1,3)$

$\mathbb{N}\mathrm{RE} \subseteq \mathbb{N}\mathrm{CP}_1(2,3)$

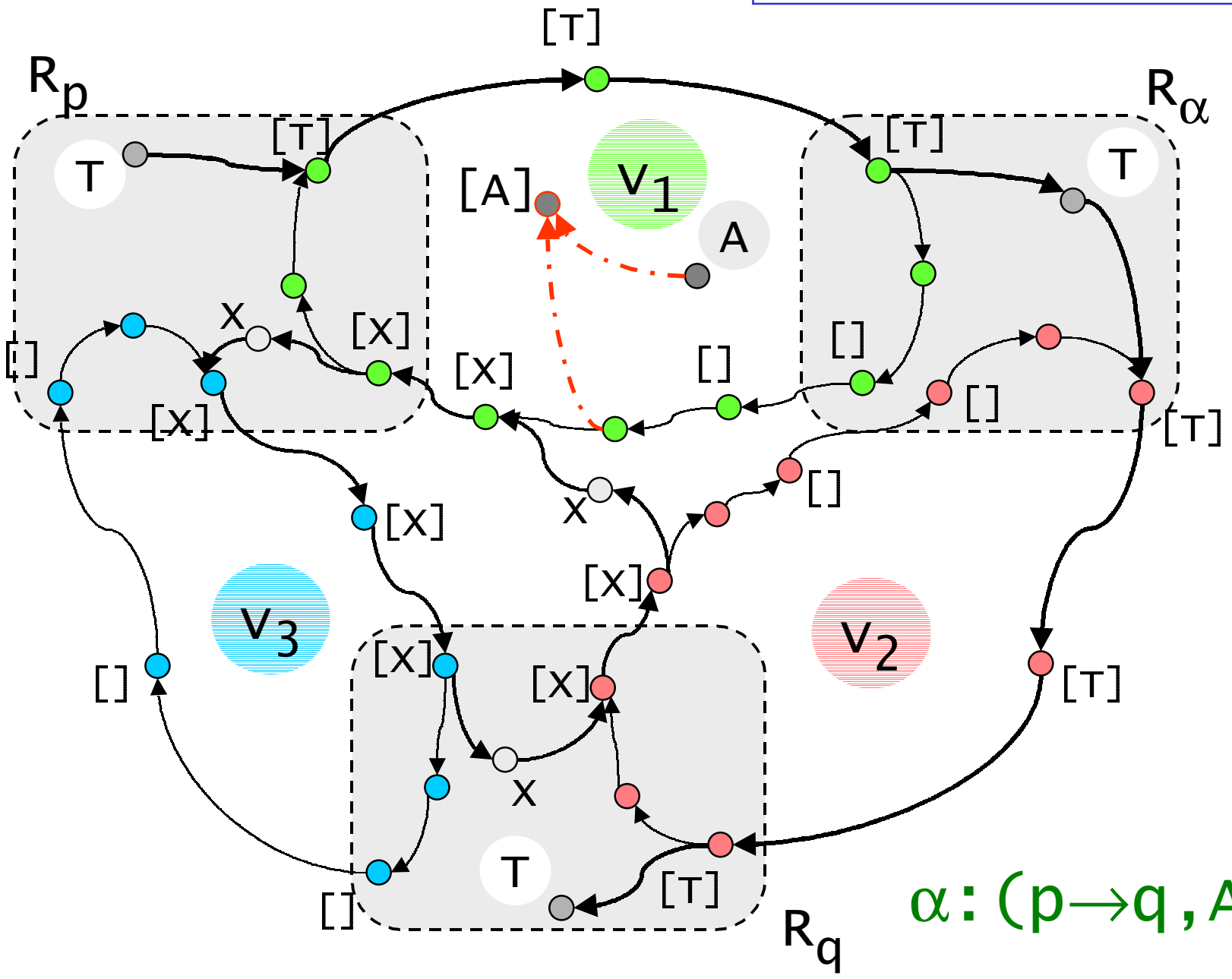
forget about ‘zero test’ ∂

$\mathbb{N}\mathrm{BC} \supseteq \mathbb{N}\mathrm{CP}_*(1,*)$

no parallellism !

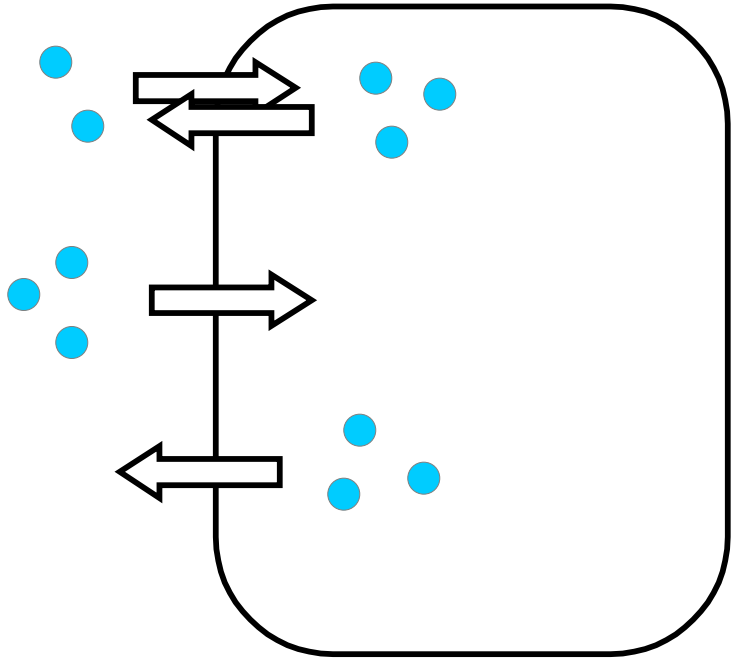
3. single passenger

$\mathbb{NRE} \subseteq \mathbb{NCP}_*(*,1)$



P systems with symport/antiport

Păun & Păun



Contents

- objects
  - multiset symbols
  - infinite supply
    - in environment

Rules

$(a_1 \ldots a_k, \text{in}; b_1 \ldots b_\ell, \text{out})$ antiport

$(a_1 \ldots a_k, \text{in})$ symport

$(a_1 \ldots a_k, \text{out})$

WMC paper (& Frisco)

Păun-Păun '02

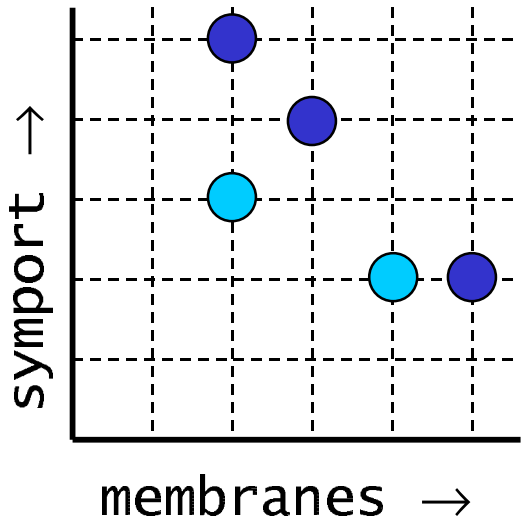
$$\mathbb{N}RE = \mathbb{N}PP_2(2,2)$$

$$\mathbb{N}PP_m(s,a)$$

- membranes
- symport
- antiport

$$\mathbb{N}RE = \mathbb{N}PP_1(1,2)$$

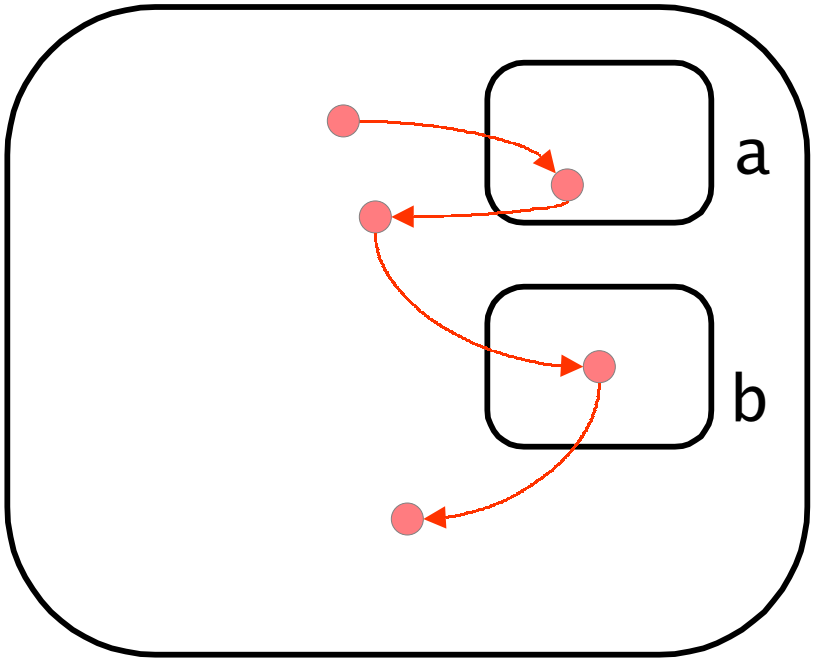
1. single membrane



2. symport only

symport/antiport : following the traces

Ionescu, MartínVide, Păun & Păun



Contents

- objects
  - multiset symbols
  - infinite supply
  - in environment
- traveller

Rules

$(a_1 \ldots a_k, \text{in};\ b_1 \ldots b_\ell, \text{out})$ antiport

$(a_1 \ldots a_k, \text{in})$ symport

$(a_1 \ldots a_k, \text{out})$

WMC paper

$\ell \cdot LP_m(s,a)$

- letters
- membranes
- symport
- antiport

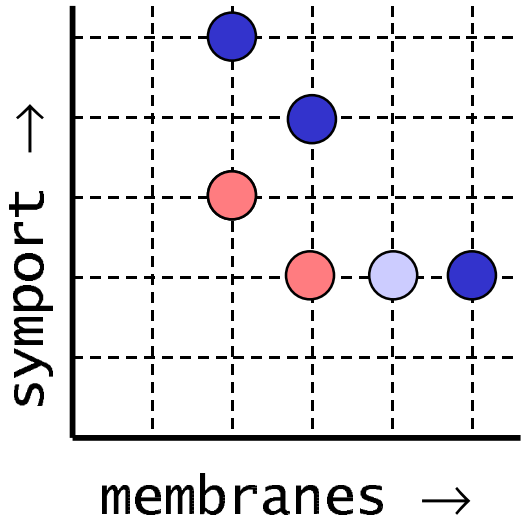
Ion-MaVi-Pău-Pău '02

$$1 \cdot RE = 1 \cdot LP_2(2,2)$$

$$\ell \cdot RE = \ell \cdot LP_{\ell+1}(0,2)$$

$$\ell \cdot RE = \ell \cdot LP_{\ell+1}(3,0)$$

1. two+ letters



2. single letter
   symport only

conclusion … after WMC'02 …

carrier P systems ↔ counter automata
maximal parallellism ↔ zero test

Petri nets!

single membrane	RE
single carrier	BC
single passenger	RE

P systems with unstructured objects

- / catalists & communicative [Sosík]
- / P-automata [Csuhaj-Varjú & Vaszil]
- / analysing systems [Freund & Oswald]
- / with symport/antiport
- / following traces