MC, Close to 20 Years

Gheorghe Păun[1]
Romanian Academy, Bucharest,
RGNC, Sevilla University, Spain

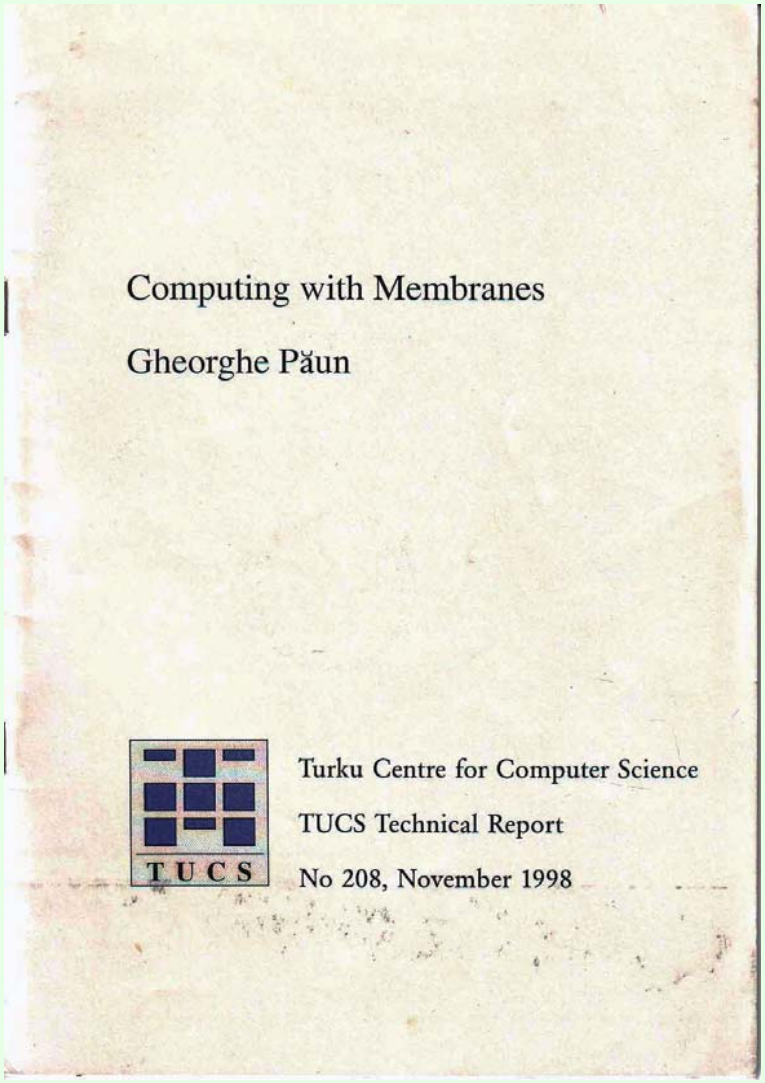
gpaun@us.es, curteadelaarges@gmail.com

[1] Already one year pensioner – *but still not retired*!. . .

Everything started in the fall of 1998, in Turku, Finland...

...after writing the book on DNA computing

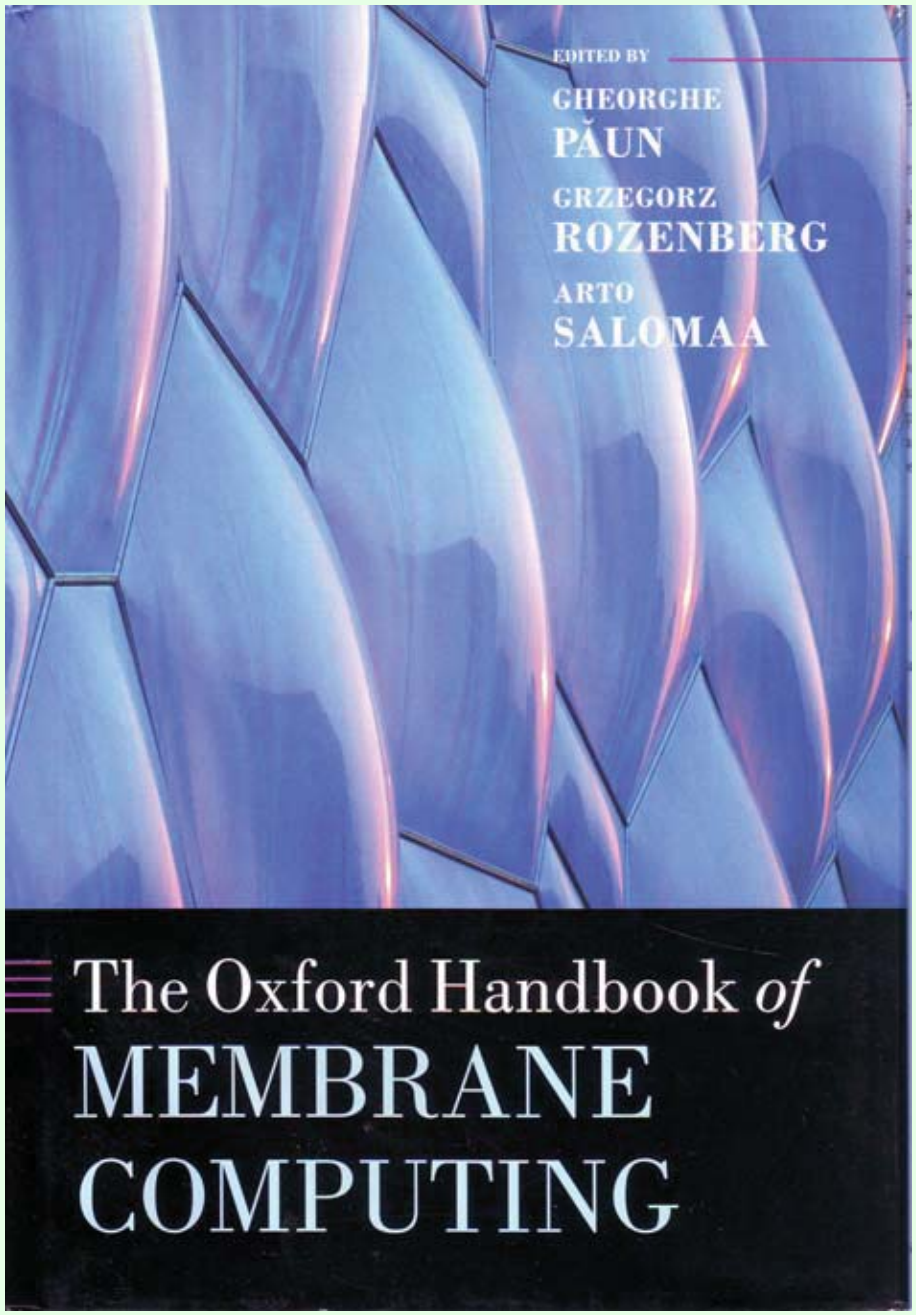
The first paper:



And then the *avalanche* started...

- in August 2000, the first international meeting: Workshop on Membrane Computing (WMC), Curtea de Argeș, Romania (after the tenth edition, Conference on Membrane Computing)
- in 2001, the first PhD theses: S.N. Krishna, *Languages of P Systems: Computability and Complexity*, Chennai, India,
  and C. Zandron, *A Model for Molecular Computing: Membrane Systems*, University of Milano-Bicocca, Milano, Italy (now, over 85 theses)
- in 2002, the first monograph was published (Springer-Verlag), translated in Chinese in 2012
- in February 2003, the first Brainstorming Week on Membrane Computing, Tarragona, Spain
- in February 2003, ISI (Institute for Scientific Information; see `http://esi-topics.com`) considered the first paper as "fast breaking paper" and membrane computing as "Emergent Research Front in Computer Science"
- in 2006, the first book with applications was published (Springer-Verlag)

- in 2010, the *Oxford Handbook of Membrane Computing* was published
- in October 2012, the first edition of Asian Conference on Membrane Computing, ACMC, was held, in Wuhan (second edition in Chengdu)
- in 2014, the first Chinese volume was published: Gexiang Zhang et al.: *Membrane Computing. Theory and Applications*
- up to now, over 2500 papers – theory, applications, software
- powerful groups in Sevilla, Madrid (Spain), Milano, Verona, Pisa (Italy), Budapest (Hungary), Vienna (Austria), Sheffield/Bradford (UK), Chișinău (Rep. of Moldova), Paris (France), Leiden (The Netherlands), Bucharest, Iași (Romania), Chennai (India), Tokyo (Japan), Auckland (New Zealand), Santa Barbara, Ruston (USA), Opava (Czech Rep.), London-Ontario (Canada), Wuhan, Chengdu, ?? (China), etc., etc. Greece, Australia, Malaysia, Poland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The Oxford Handbook of
MEMBRANE
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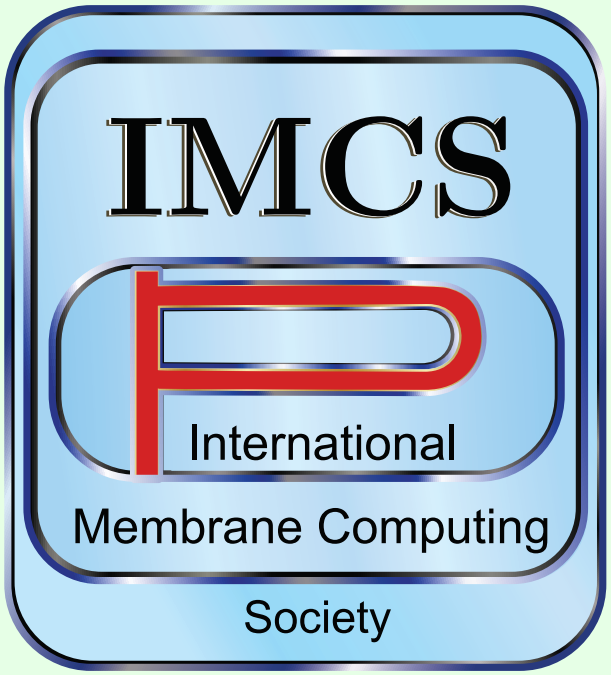
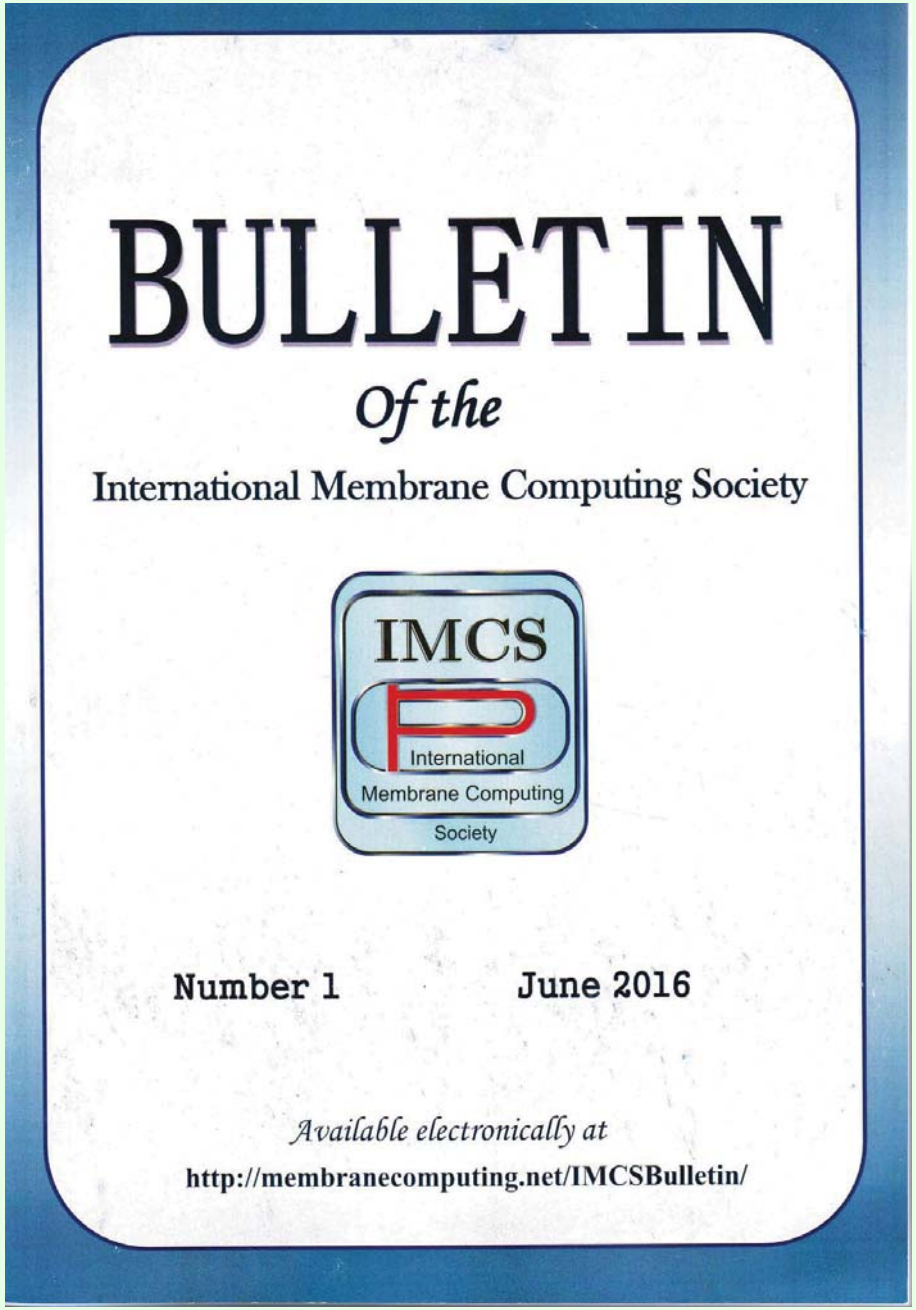
News in Membrane Computing:

creation (2016) of IMCS = International MC Society



1. three yearly meetings: CMC, ACMC, BWMC
2. *Bulletin of the IMCS*: `http://membranecomputing.net/IMCSBulletin/`
3. three yearly prizes (PhD, theory, application of the year)
4. *International Journal of MC*
5. a series of books
6. others ("connecting people")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Number 1
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http://membranecomputing.net/IMCSBulletin/

Important:

- Please contribute to the *IMCS Bulletin*
- Please join and work for IMCS

Eternal (maybe false...) problem: implementations

However: US Patent 20090124506 A1/Membrane Computing/Ehud Keinan (Technion, Haifa, Israel)/ A method of implementation of a P-system in membrane computing comprising: placing three mutually immiscible liquids into a container...

However, there is a commercial implementation:

???

However, there is a commercial implementation:

Still, some research suggestions...

about SN P systems (exactly 10 years old):

M. Ionescu, Gh. Păun, T. Yokomori: Spiking neural P systems, *Fundamenta Informaticae*, 71, 2-3 (2006), 279–308

Recent bibliography: Linqiang Pan, Tingfang Wu, Zhiqiang Zhang: A bibliography of spiking neural P systems, *Bulletin of IMCS*, 1 (June 2016), 63–78 (246 titles)

Open problems: Gh. Păun, Tingfang Wu, Zhiqiang Zhang: Open problems and research topics on numerical and spiking neural P systems (The "Curtea de Argeș 2015 series"), *Bulletin IMCS*, 1 (June 2016), 79–95

Open problems and research topics: many!

1. hypercomputation (suggestions from the brain organization/functioning?)
2. what further ideas (division/budding, non-determinism, pre-computed resources) can help in solving hard problems in a feasible time? if efficiency results cannot be proved, then try to prove Milano theorems
3. prove efficiency results (using any of the three ideas mentioned above for SN P systems with rules on synapses, axon systems, etc.
4. mix features of SN P systems and numerical P systems
   (see recent papers by Linqiang Pan, Tingfang Wu, Zhiqiang Zhang)
5. consider SN P systems with a cell-like structure (rules $E/a^c \to u$ with u containing couples (a^p, tar))
   Tingfang Wu, Zhiqiang Zhang, Gh. Păun, Linqiang Pan: Cell-like spiking neural P systems, *Theor. Comput. Sci.*, 623 (2016), 180–189
6. encode the spike train ($\varphi_k : B^k \longrightarrow V_k$), so that a family of languages can be associated with an SN P system
   Gh. Păun, José M. Sempere: Families of languages associated with SN P systems. Preliminary ideas, open problems, *Bulletin IMCS*, 2 (December 2016), 161–164
7. applications (in biology)

Very recent recent research ideas – Wuhan, October 2016

SN P systems with request rules:

1. $E/Q(a^s, j)$
   if the contents of the neuron σ_i is described by the regular expression E, then s spikes are requested from neuron σ_j

2. $E/Q(a^\infty, j)$,
   all spikes of neuron σ_j should be moved to neuron σ_i.

A *spiking neural P system with communication by request* (shortly, SNQ P system), with k types of spikes, is a construct

$$\Pi = (O, \sigma_1, \ldots, \sigma_m, a_{i_0}, out), \text{ where :}$$

1. $O = \{a_1, a_2, \ldots, a_k\}$ is an alphabet (a_i is a type of spikes), $k \geq 1$;

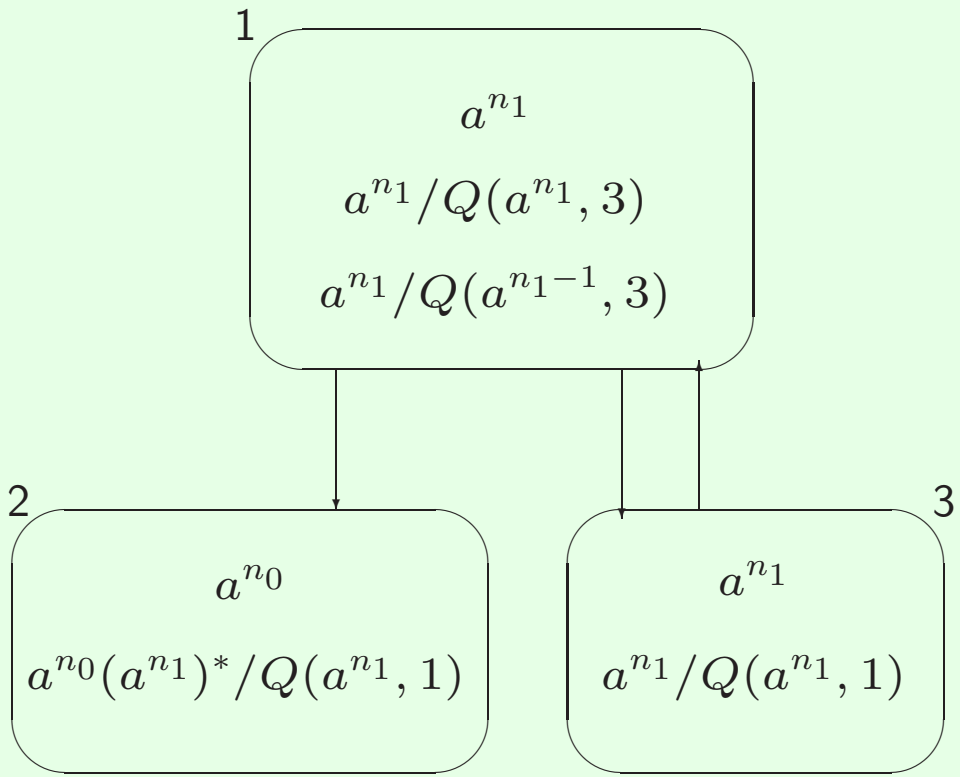
2. $\sigma_1, \ldots, \sigma_m$ are *neurons*, of the form $\sigma_i = (a_1^{n_1} a_2^{n_2} \ldots a_k^{n_k}, R_i), 1 \leq i \leq m$, $n_t \geq 0$, $1 \leq t \leq k$, where:

   a) $n_j \geq 0$ is the *initial number of spikes of type* a_j contained in neuron σ_i, $1 \leq j \leq k$;

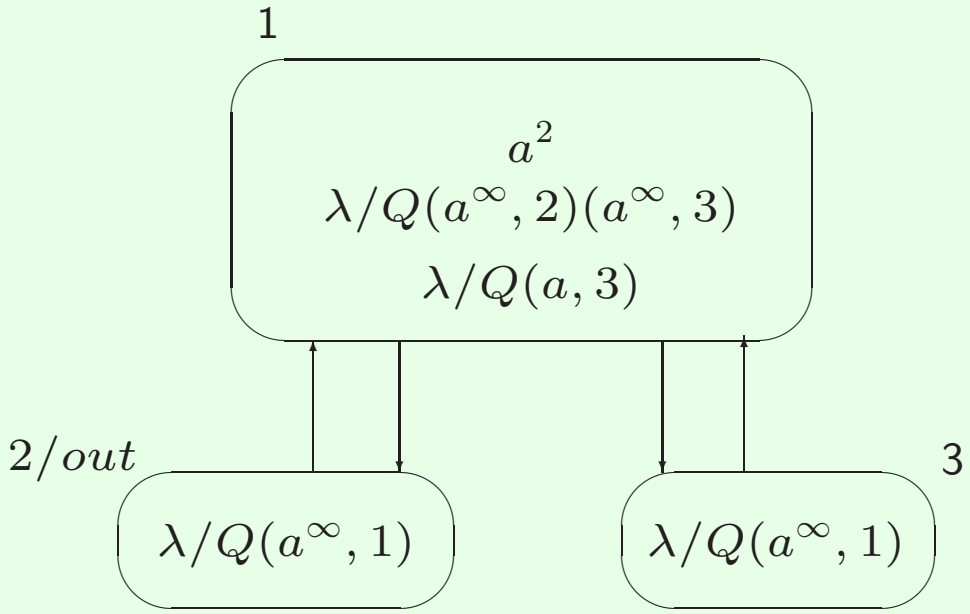
   b) R_i is a finite set of *rules* of the form E/Qw, with w a finite non-empty list of *queries* of the forms (a_s^p, j) and (a_s^∞, j), $1 \leq s \leq k, p \geq 0, 1 \leq j \leq m$;

3. $a_{i_0}, 1 \leq i_0 \leq k$, is the *type of output spikes* and $out \in \{1, 2, \ldots, m\}$ indicates the *output neuron*.

Two examples:



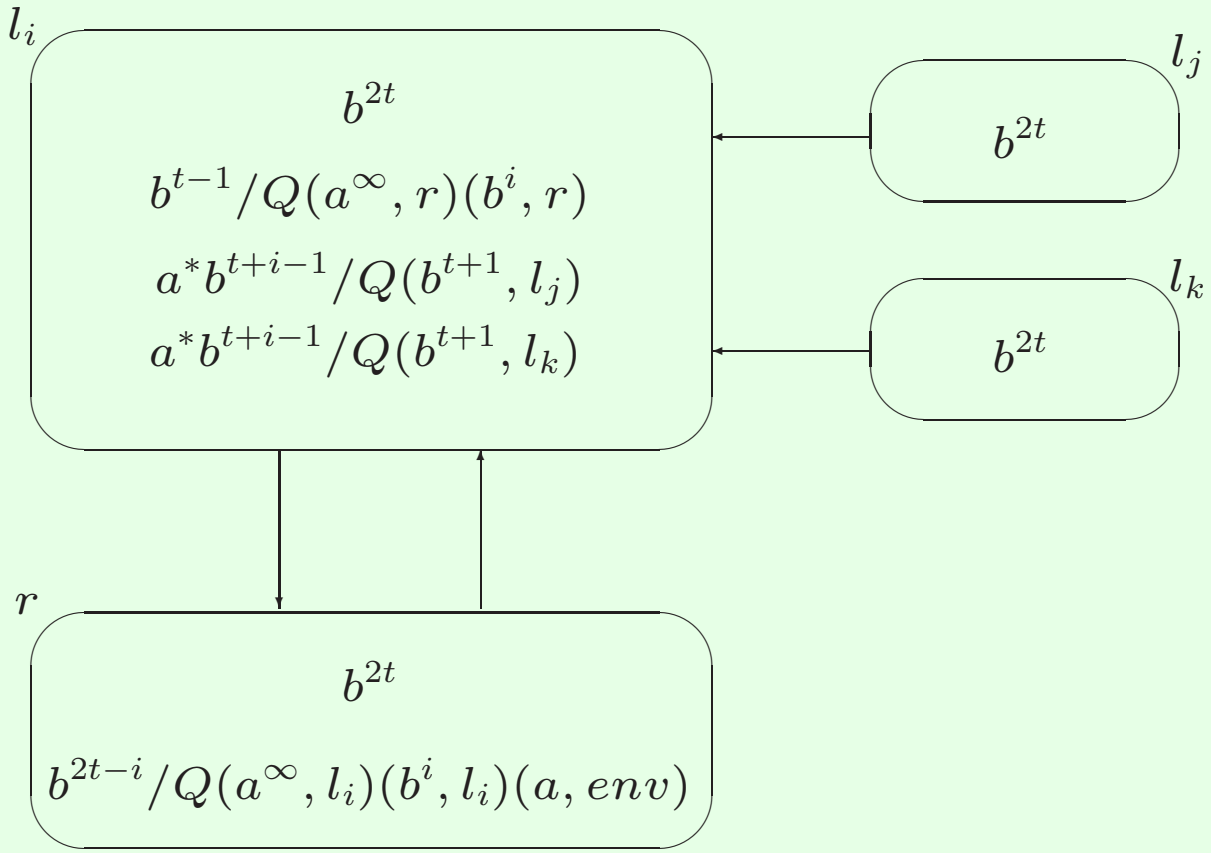
An SNQ P system generating the arithmetical progression $\{n_0 + i \cdot n_1 \mid i \geq 1\}$



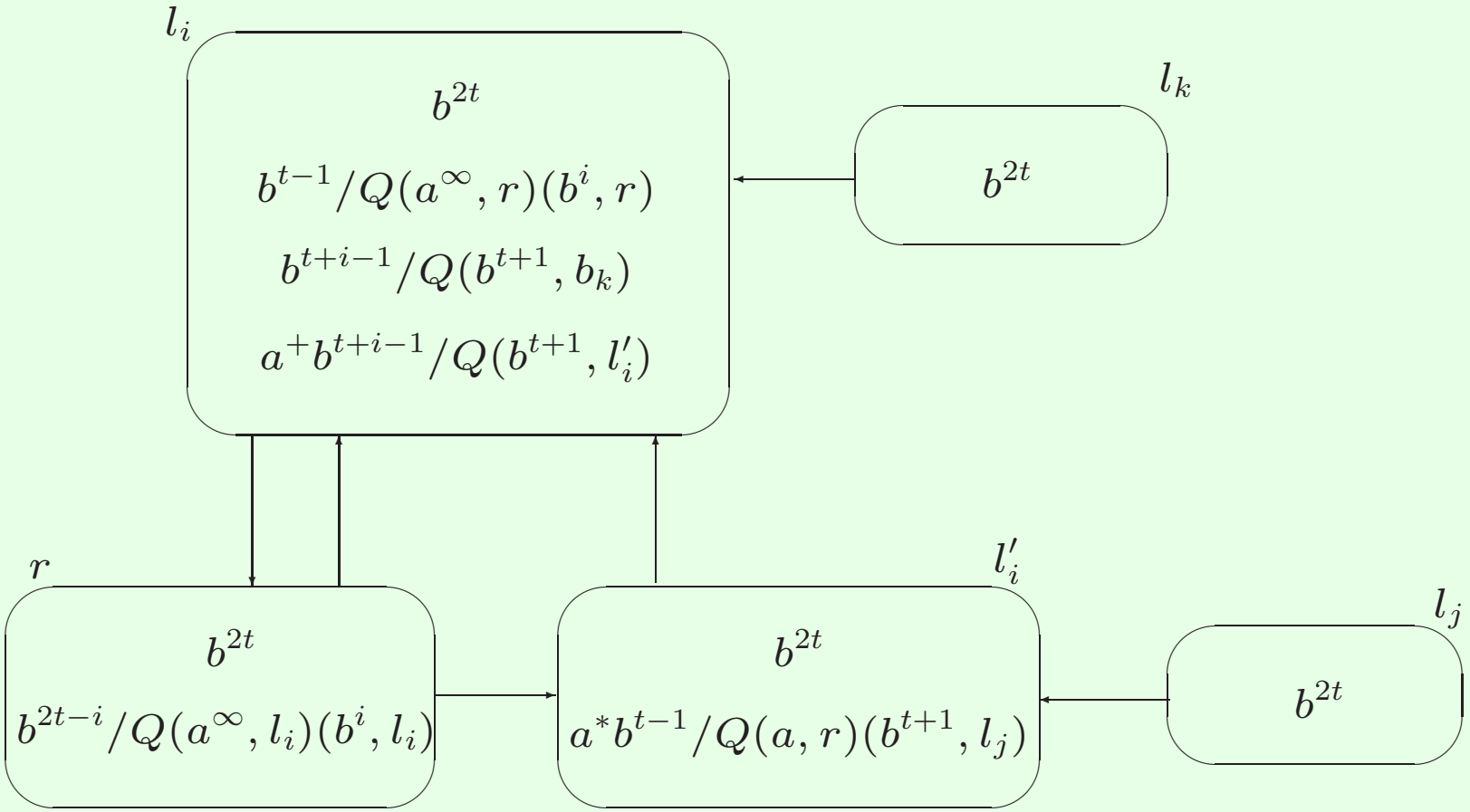
An SNQ P system generating the non-semilinear set $\{2^n \mid n \geq 1\}$

Using two types of spikes – universality: $NRE = NSN_2P_*(Q)$.

The ADD module – simplified form



The SUB module



Many research topics:

1. Universality for only one type of spikes (Conjecture: NO)
2. Solve **NP**-complete problems (replication provides exponential workspace)
3. Further study of SNQ P systems with a small number of neurons.
4. What about SN P systems with communication by request without regular expressions, but with polarizations?
5. What about queries of the form $(a^{\infty-s}, j)$?
6. We do not have a spike train, but we can consider the trace languages.

Thank you!

...and please do not forget: CMC 18 – Bradford, UK, July
ACMC 6 – Chengdu, China

and, of course,

CMC 20 – Curtea de Argeș, 2019
Bulletin of the IMCS:
`http://membranecomputing.net/IMCSBulletin/`