A cellular solution to Subset Sum using non-elementary division and dissolution, with time and initial resources bounded by log k

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P systems with active membranes

with weak non-elementary division and without polarizations

Formal Definition

- Γ (working alphabet)
- H (labels for membranes)
- μ (membrane structure)
- M (initial multisets)
- Rules:

  (a) $[\, a \rightarrow u \,]_h$
  (b) $a\,[\ \ ]_h \rightarrow [\, b \,]_h$
  (c) $[\, a \,]_h \rightarrow b\,[\ \ ]_h$
  (d) $[\, a \,]_h \rightarrow b$
  (e) $[\, a \,]_h \rightarrow [\, b \,]_h\,[\, c \,]_h$

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Recognizing P systems

- Decision problems.
- First receive an input (via a multiset).
- Creation of an exponential number of membranes.
- Parallel evolution.
- Final stage check/answer

Recognizing P systems (cont.)

Definition

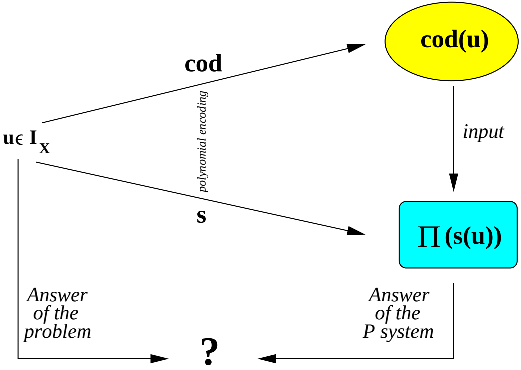
A *recognizing P system* is a P system with input membrane and external output such that:

- *Yes*, *No* $\in \Gamma$ (working alphabet).
- all the computations halt.
- for every computation, one symbol *Yes* or one symbol *No* (but not both) is sent out (and in the last step of the computation).

$\mathcal{AM}^0(+d, +ne)$: class of *polarizationless P systems using weak division of non-elementary membranes and dissolution*.

Uniform designs: sketch

$$X = (I_X, \theta_X) \quad \rightsquigarrow \quad F_X = (\Pi(n))_{n \in \mathbb{N}}$$



Computational complexity framework (informal)

M.J. Pérez, A. Romero, F. Sancho, 2002

Definition

Let $\mathcal{R}$ be a class of recognizing P systems. A decision problem X is solvable in polynomial time by a family F_X, of $\mathcal{R}$, if

- elements of F_X can be built polynomially.

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- elements of F_X can be built polynomially.
- There exists a pair (cod, s) of pol-time computable functions such that
  - elements of F_X run polynomially, with regard to (X, cod, s).
  - F_X is sound and complete, with regard to (X, cod, s).

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We denote this by $X \in \mathbf{PMC}_{\mathcal{R}}$.

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Solving the Subset Sum Problem

Subset Sum problem

Given a finite set A, a weight function $w : A \to \mathbb{N}$, and a constant $k \in \mathbb{N}$, determine whether or not there exists a subset $B \subseteq A$ such that $w(B) = k$.

Stages of the solution

- *Preparation:* $\log k$ membranes $ch \Rightarrow k$ membranes.
- *Generation:* obtain by division 2^n membranes e (non-elem).
- *Weight calculation:* for each possible subset.

  WAIT / SYNCHRO
- *Checking:* $w(B) = k$?

  WAIT / SYNCHRO
- *Output:* send either `yes` or `no`.

A small example: $n = 3, \; k = 5$

$$A = \{a_1, a_2, a_3\}, \; w(a_1) = 3, \; w(a_2) = 1, \; w(a_3) = 6$$

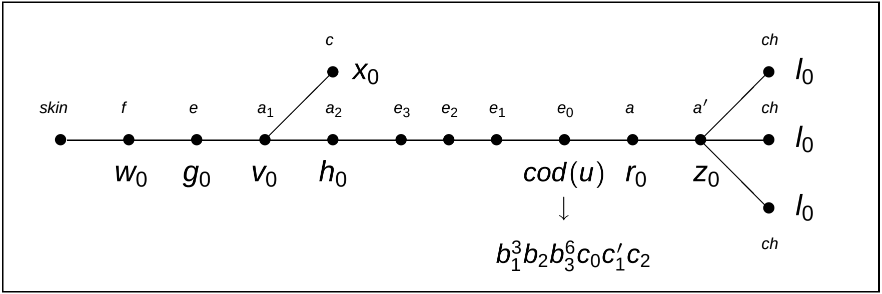

Figure: Initial Configuration

$$A = \{a_1, a_2, a_3\},\ w(a_1) = 3,\ w(a_2) = 1,\ w(a_3) = 6$$

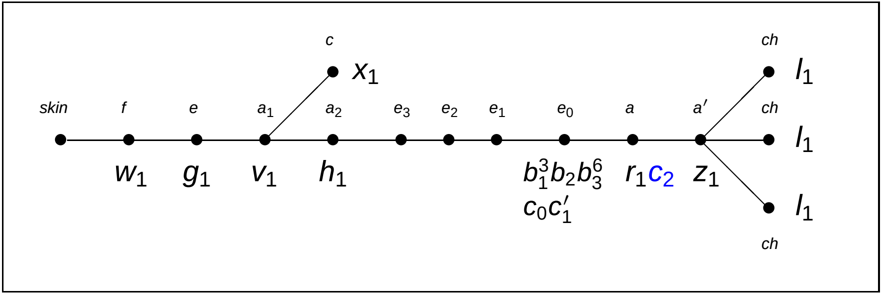

Figure: $Time = 1$

$$A = \{a_1, a_2, a_3\},\ w(a_1) = 3,\ w(a_2) = 1,\ w(a_3) = 6$$

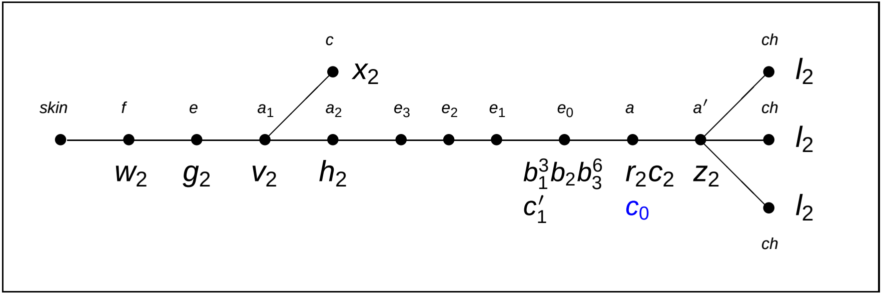

Figure: $Time = 2$

$$A = \{a_1, a_2, a_3\},\ w(a_1) = 3,\ w(a_2) = 1,\ w(a_3) = 6$$

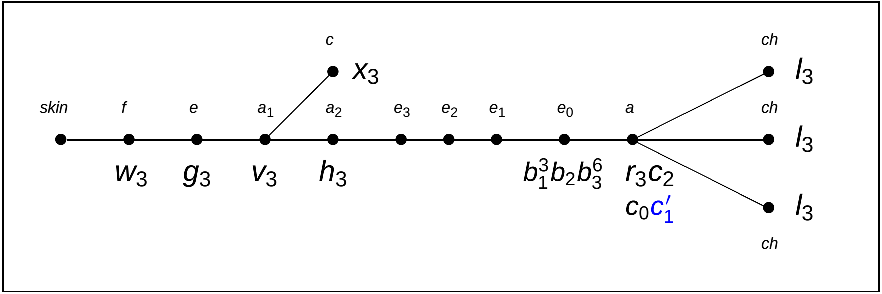

Figure: $Time = 3$ (z_2 dissolves membrane a')

$$A = \{a_1, a_2, a_3\},\ w(a_1) = 3,\ w(a_2) = 1,\ w(a_3) = 6$$

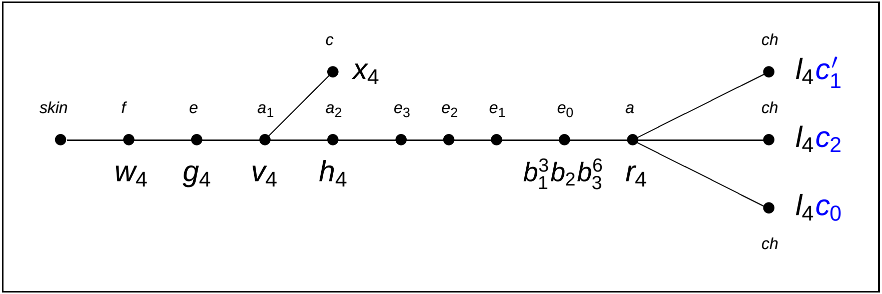

Figure: $Time = 4$

$$A = \{a_1, a_2, a_3\},\ w(a_1) = 3,\ w(a_2) = 1,\ w(a_3) = 6$$

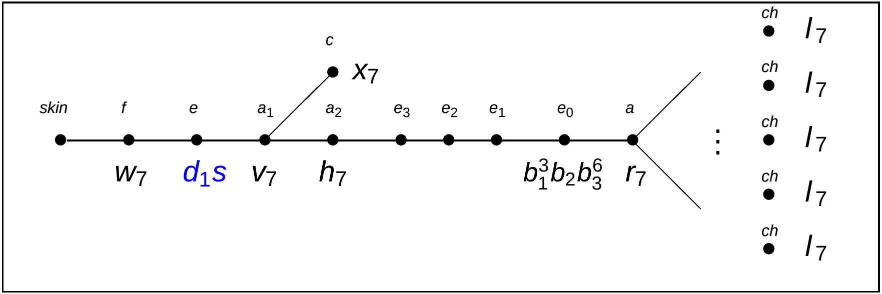

Figure: $Time = 7 = 2\lfloor \log k \rfloor + 3$

Final remarks

Looking for Computational Power / Efficiency

Can objects be “aware” of the situation in their region?

- Context sensitivity
- Changing membrane charge / label
- Dissolution rules (irreversible)

Future work

- Decreasing number of counters
- Removing / restricting other ingredients
- . . .

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THANK YOU!