Artiom, Rudi, and Sergiu at BWMC 2019

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Overview

Anti-Membranes, Anti-Cells, and Anti-Rules

Rule Forms in (Tissue) P Systems

Entanglement

Limited Capacities

Conclusion

The Idea of Anti-Matter

For any object *a (matter)*, we consider its anti-object *(anti-matter)* a^- and the corresponding *annihilation rule* $aa^- \rightarrow \lambda$.

This rule is assumed to exist in all membranes.

These annihilation rules may have (weak) priority over all other rules.

Artiom Alhazov, Bogdan Aman, Rudolf Freund: P Systems with Anti-Matter. In: Marian Gheorghe, Grzegorz Rozenberg, Arto Salomaa, Petr Sosík, Claudio Zandron (eds.), Membrane Computing - 15th International Conference, CMC 2014, Prague, Czech Republic, August 20-22, 2014, Revised Selected Papers, LNCS 8961, Springer, 66–85, 2014.

The Concept of Anti-Matter

- A. Alhazov, B. Aman, R. Freund, Gh. Păun: *Matter and Anti-Matter in Membrane Systems.* Descriptional Complexity of Formal Systems - 16th International Workshop, DCFS 2014, Turku, Finland, August 5-8, 2014. Proceedings, 65–76, (2014).

- Artiom Alhazov, Rudolf Freund, Petr Sosík: Small P Systems with Catalysts or Anti-Matter Simulating Generalized Register Machines and Generalized Counter Automata. The Computer Science Journal of Moldova **23** 3, 304–328, 2015.

Anti-Matter as a Frontier of Tractability

Adding the concept of anti-matter may increase the power of a kind of P system even with respect to complexity.

Daniel Díaz-Pernil, Francisco Peña-Cantillana, Artiom Alhazov, Rudolf Freund, Miguel A. Gutiérrez-Naranjo: Antimatter as a Frontier of Tractability in Membrane Computing. Fundam. Inform. **134**, 1–2, 83–96, 2014.

Anti-Membranes

During BWMC 2019 we proposed that instead of considering *a (matter)* and its anti-object a^- and the corresponding *annihilation rule* $aa^- \to \lambda$ we may consider the anti-membrane $[\ ]_{\bar{h}}$ for each membrane $[\ ]_h$.

Then there are several semantics for the *annihilation rule* $[\ ]_h[\ ]_{\bar{h}} \to \lambda$.

For example, only the surrounding membranes may be eliminated by the annihilation rule. On the other hand, both membranes with their whole contents may be eliminated.

Anti-Membranes and Anti-Cells

Submitted to JMC:
Artiom Alhazov, Rudolf Freund, Sergiu Ivanov:
P Systems with Anti-Membranes and Tissue P Systems with Anti-Cells.

elementary membrane division $[\,]_h \to [\,]_{h'}[\,]_{h''}$
changing membrane label $[\,]_h \to [\,]_{h'}$
elementary membrane deletion $[\,]_h \to \lambda$
membrane / anti-membrane ann. $[\,]_h[\,]_{h^-} \to \lambda$

cell division $\bigcirc_h \to \bigcirc_{h'}\bigcirc_{h''}$
changing cell label $\bigcirc_h \to \bigcirc_{h'}$
cell deletion $\bigcirc_h \to \lambda$
cell / anti-cell annihilation $\bigcirc_h\bigcirc_{h^-} \to \lambda$

Anti-Membranes and Tractability

Based on

Artiom Alhazov, Rudolf Freund, Sergiu Ivanov: P Systems with Anti-Membranes and Tissue P Systems with Anti-Cells.

we would like to ask the Sevillan team:

How could our results for Tissue P Systems with Anti-Cells be used for being considered within the framework of tractabilty?!

cell / anti-cell annihilation $\bigcirc_h \bigcirc_{h^-} \rightarrow \lambda$

Anti-Rules

Idea from Mario at BWMC 2019: anti-rules

Brainstorming 2019 volume:

Artiom Alhazov, Rudolf Freund, Sergiu Ivanov, Mario J. Pérez-Jiménez
P Systems: from Anti-Matter to Anti-Rules

Main Concept:

- By applying a rule, rules and/or anti-rules are activated for the next derivation step.
- Activations are treated in a multiset sense.
- Rule/anti-rule annihilation rules are executed before other rules are applied in the next step.

Anti-Rules

Discussed at BWMC 2020:

- Using only insertion and deletion rules.
- Anti-rules are executable rules, too, not just annihilating the corresponding rule.
- Activation of rules seen in a set sense.
- Combination of activation of rules seen in a multiset or set sense and maximally parallel derivation modes in multiset or set way.
  Activation of rules in set sense and maximally parallel derivation mode yields (p)ET0L.

Rule Forms in (Tissue) P Systems

Given a specific kind of (tissue) P system we may ask if for every system of that given type there exists an equivalent system of that type which fulfills the requirement that all rules are of restricted forms.

On the flights from Vienna to Sevilla, Artiom and Rudi discussed specific problems with respect to catalytic P systems.

Purely catalytic rule forms:

- $ca \rightarrow cAB$
- $ca \rightarrow c$

Catalytic Rule Forms

Results:

- With multiple catalysts, register machines can be simulated in real time.
- With multiple catalysts, register machines can be simulated in real time with a bounded time shift even with the rule forms given above.

Open question: Are the following catalytic rule forms sufficient for obtaining computational completeness:

- $D \to AB$
- $ca \to c$

Hijacking the Idea of Entanglement for Membrane Computing

One of the ideas proposed by Gheorghe was to look at the concepts from Quantum Computing, for example entanglement.

Some first results:

Entanglement allows for generating 2^n.

Consider the rules $a \to b$ and $a \to \langle aa \rangle$, in which the notation $\langle aa \rangle$ means that the two instances of a are produced as being entangled. The system is doubling the number of a's until one of the a's undergoes $a \to b$, thus causing all a's to undergo this rule, and the system halts with 2^n b's.

Hijacking the Idea of Entanglement for Membrane Computing

On the other hand, non-cooperative rules with entanglement do not go beyond ET0L, even different symbols are entangled and they are allowed to undergo different transitions.

Proof idea:

Entangled instances are produced with some particular labels, which are unique at the rule level. Then, any table which transforms one of the entangled symbols must include a rule transforming its entangled counterpart.

Entanglement Through Time

When investigating possibilities to *go beyond Turing*, we considered infinite computations, where in order to get the answer already at the beginning of the computation, signals were sent back.

Sending back signals could also be accomplished by generating entangled symbols NO in the first time step and letting one of them back in time 2 and the other one go further in time. Whenever the second one possible is changed to YES, the first one would be changed to YES, too.

Catalytic Rule Forms

Results:

- With multiple catalysts, register machines can be simulated in real time.
- With multiple catalysts, register machines can be simulated in real time with a bounded time shift even with the rule forms given above.

Open question:

Are the following catalytic rule forms sufficient for obtaining computational completeness:

- $D \to cAB$
- $ca \to c$

Limited Capacities

Given a specific kind of (tissue) P system we may limit the number of symbols of a specific kind which can be present in the membrane region or cell after the application of a multiset of rules.
Only those multisets applicable in the given derivation mode and fulfilling the condition of limited capacities are allowed to be applied.

We may also bound the total capacity of the membrane region/cell.

Conclusion

- As usual, the spirit of the BWMC has been very inspiring for us!
- We had several new ideas and very interesting discussions.
- Hopefully we will be able to write a lot of contributions for conferences and journals.
  WRITE – SUBMIT – CITE
- And we had a lot of great food, chocolate, churros, ...

THANK YOU VERY MUCH!

¡MUCHAS GRACIAS!