Tissue P Systems with Multiset Splicing or Multiset Cut & Paste

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DNA Computing - Splicing

SPLICING RULE $r = u_1 \# u_2 \$ u_3 \# u_4$

$x = x_1 u_1 u_2 x_2 , \quad y = y_1 u_3 u_4 y_2 ,$

$z = x_1 u_1 u_4 y_2 , \quad w = y_1 u_3 u_2 x_2$

SPLICING $(x, y) \Rightarrow_r (z, w)$

T. Head: Formal language theory and DNA: An analysis of the generative capacity of specific recombinant behaviors. *Bull. Math. Biology,* 49 (1987), 737-759.

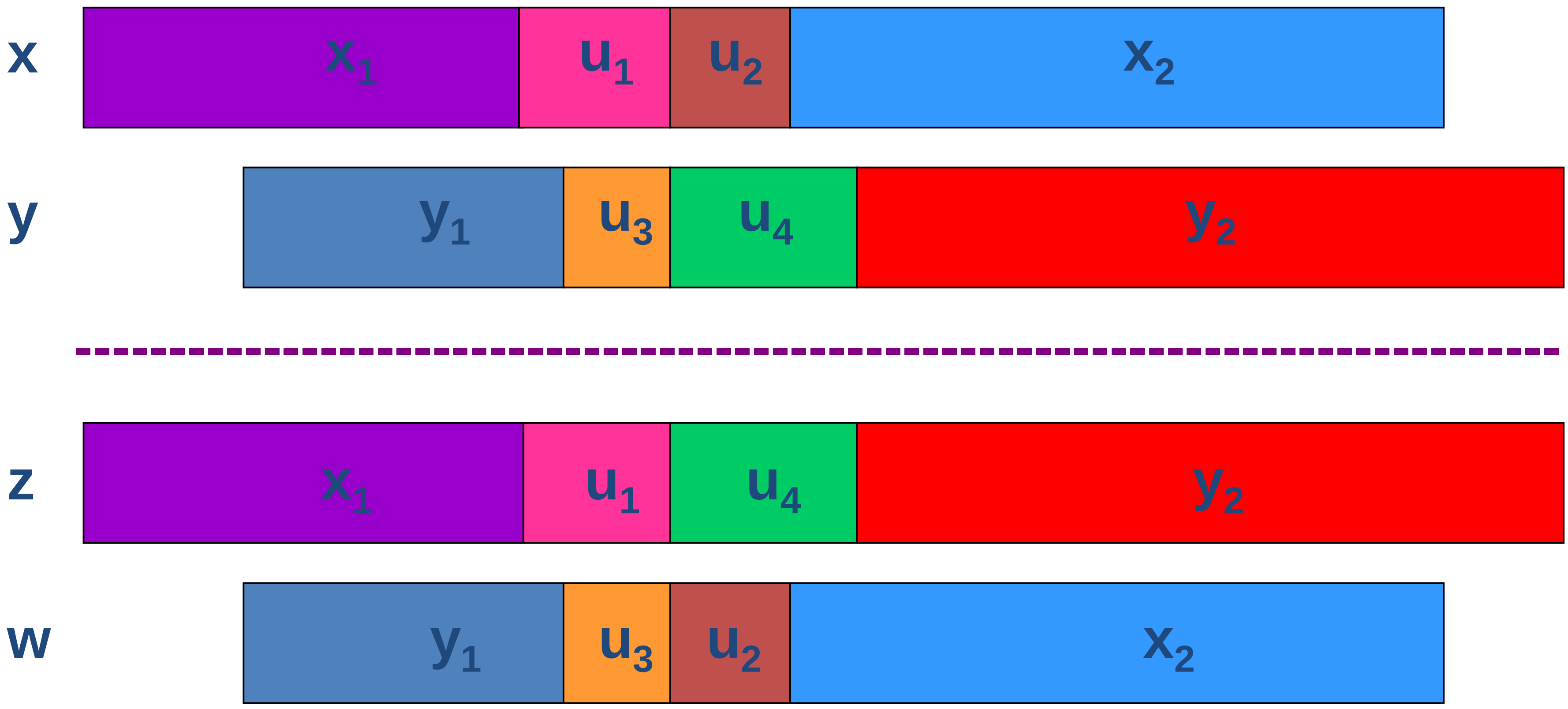
E. Csuhaj-Varjú, R. Freund, L. Kari, Gh. Păun:
DNA computing based on splicing: universality results.
In: L. Hunter, T. Klein (Eds.): *Pacific Symposium on Biocomputing '96*, WSP (1996), 179-190.

D. Pixton: Splicing in abstract families of languages.
Theoretical Computer Science 234 (2000), 135-166.

Splicing for Strings

Splicing: $r = u_1 \# u_2 \$ u_3 \# u_4$, $(x, y) \Rightarrow_r (z, w)$

$x = x_1 u_1 u_2 x_2$, $y = y_1 u_3 u_4 y_2$, $z = x_1 u_1 u_4 y_2$, $w = y_1 u_3 u_2 x_2$



Cut and Recombine (CR)

CUTTING RULE $u_1 \# [m] \$ [n] \# u_2$

$x = x_1 u_1 u_2 x_2, \quad y = x_1 u_1 [m], \quad z = [n] u_2 y_2$

CUTTING $x \Rightarrow_r (y, z)$

RECOMBINATION RULE $([m], [n])$

$x = x_1 u_1 u_2 x_2, \quad y = x_1 u_1 [m], \quad z = [n] u_2 y_2$

RECOMBINATION $(y, z) \Rightarrow_r x$

R. Freund, F. Wachtler: Universal systems with operations related to splicing. *Computers and Art. Intelligence* 15 (4).

Cut and Paste (CP)

CUTTING RULE $u_1 \# [m] c [n] \# u_2$

$x = x_1 u_1 c u_2 x_2$, $y = x_1 u_1 [m]$, $z = [n] u_2 y_2$

CUTTING $x \Rightarrow_r (y, z)$

PASTING RULE $([m], c, [n])$

$x = x_1 u_1 c u_2 x_2$, $y = x_1 u_1 [m]$, $z = [n] u_2 y_2$

PASTING $(y, z) \Rightarrow_r x$

Splicing Systems / CR/CP Systems

Without additional mechanisms only part of the *regular languages* can be generated.

Computational completeness (Universality):

- **Infinite number of rules**
- **Multisets**
- **Periodic rule sets**
- **Control mechnisms (control graph,...)**
- **Test Tube Systems**
- **Membrane Systems**

Splicing of Multisets

SPLICING RULE $r = u_1 \# u_2 \$ u_3 \# u_4$

$x = x_1 u_1 u_2 x_2$, $y = y_1 u_3 u_4 y_2$,

$z = x_1 u_1 u_4 y_2$, $w = y_1 u_3 u_2 x_2$

?

SPLICING $(x, y) \Rightarrow_r (z, w)$

Multisets do not have „left" or „right" sides, hence, we use a kind of one-sided splicing putting the whole rest of one multiset in one of the resulting multisets:

$x = x_1 u_1 u_2$, $y = u_3 u_4 y_2$,

$z = x_1 u_1 u_4 y_2$, $w = u_3 u_2$

$x = x_1 u_1 u_2$, $y = y_1 u_3 u_4$,

$z = x_1 u_1 u_4$, $w = y_1 u_3 u_2$

just exchanges u_2 and u_4

Cutting & Recombination/Pasting of Multisets

CUTTING RULE $u_1 \# [m]\, c\, [n] \# u_2$

$x = su_1\, c\, u_2$, $y = su_1 [m]$, $z = [n] u_2$

CUTTING $x \Rightarrow_r (y, z)$

RECOMBINATION RULE $([m], [n])$

$x = st$, $y = s [m]$, $z = [n] t$

RECOMBINATION $(y, z) \Rightarrow_r x$

PASTING RULE $([m], c, [n])$

$x = sct$, $y = s[m]$, $z = [n] t$

RECOMBINATION $(y, z) \Rightarrow_r x$

Tissue P Systems with Cutting & Pasting of Multisets

Take a tissue P systems with the rules working on bags of multisets with cutting & pasting on multisets, now also containing targets for the resulting multiset bags. Initially, finte multisets of bags of multisets are available in the cells.

CUTTING RULE (u_1 # [m] c [n] # u_2 , tar_1 , tar_2) in cell i,

x = su_1 c u_2 in cell i yields

y = su_1 [m] in cell tar_1 and z = [n] u_2 in cell tar_2

PASTING RULE ([m] , c , [n] , tar) in cell i,

y= s[m] and z = [n] t in cell i yields x = sct in cell tar

Tissue P Systems with Splicing of Multisets

Take a tissue P systems with the rules working on bags of multisets with splicing rules for multisets now also containing targets for the resulting multiset bags. Initially, finite multisets of bags of multisets are available in the cells as well as some axioms in an unbounded number.

SPLICING RULE $r = (u_1 \# u_2 \$ u_3 \# u_4 , tar_1 , tar_2)$ in cell i,

$x = x_1 u_1 u_2$, $y = u_3 u_4 y_2$ in cell i yields

$z = x_1 u_1 u_4 y_2$ in cell tar_1 and $w = u_3 u_2$ in cell tar_2

A Small Rudi Challenge Until Tomorrow

Check out for references already dealing with some kind of splicing or cutting & pasting on bags of multisets !

REWARD: payed in sweet currency ;-)

A Small Rudi Challenge Until Today

Check out for references already dealing with some kind of splicing or cutting & pasting on bags of multisets !

REWARD: payed in sweet currency ;-)

The Rudi Challenge of 2017:

Prove a Pixton-like theorem showing an upper bound for tissue P systems with the rules working on bags of multisets with splicing rules for multisets with only one actor cell and an ouput cell without rules!

REWARD:

(65 – age) Euros

Co-authorship

Condition to be fulfilled for obtaining the Reward:

Proof approved by Rudi and Gheorghe!