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String-Object Transduction with Dogmatic P systems

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Thank you !!

Questions ?

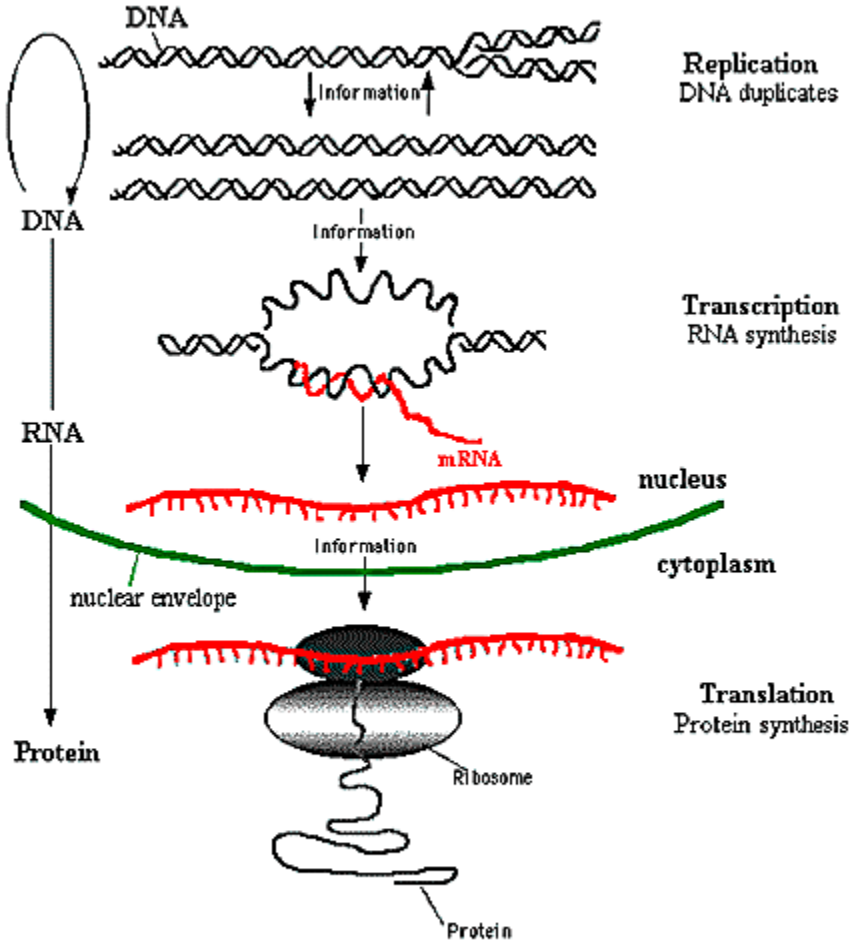
Abstract

In this work, we approach the translations of strings to strings in the framework of P systems. We use a variant of P systems with *string objects* in the regions and transduction rules to transform them. Here, our source of inspiration comes from the "*Central Dogma*" in Computational Biology which establishes the following transformation of biological sequences in living beings

DNA → RNA → *proteins*

We will show how these transformations can be captured in order to simulate finite-state transducers.

The Central Dogma in Computational Biology



The Central Dogma of Molecular Biology

Replication makes a copy of a DNA strand

RNA Transcription makes a complementary DNA strand and substitutes the thymine (T) by the uracil (U) to obtain a RNA strand

Splicing (tRNA is compacted into significant units)

Transduction (every triplet of RNA nucleotides encodes a protein amino acid)

The Central Dogma in Computational Biology

DNA → RNA → *proteins*

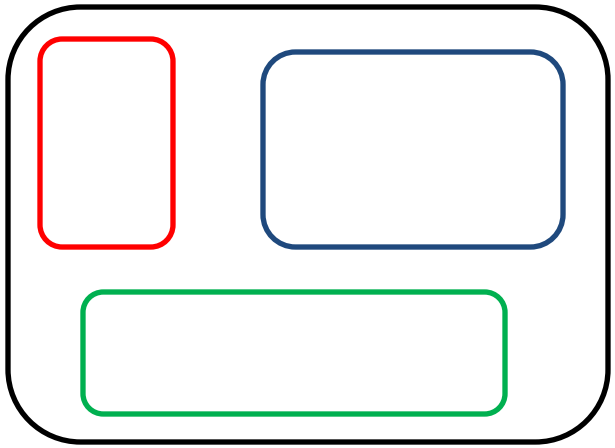
- **Different processes in different regions**
- **Different alphabet sizes and symbols**
- **Finite transduction-like operations**
- **Different products at every stage**

Our Goal: **Propose a model to catch the main features of the Central Dogma in the living cell (hence in a membrane structure) to transduce string languages**

Dogmatic P systems

Main ingredients

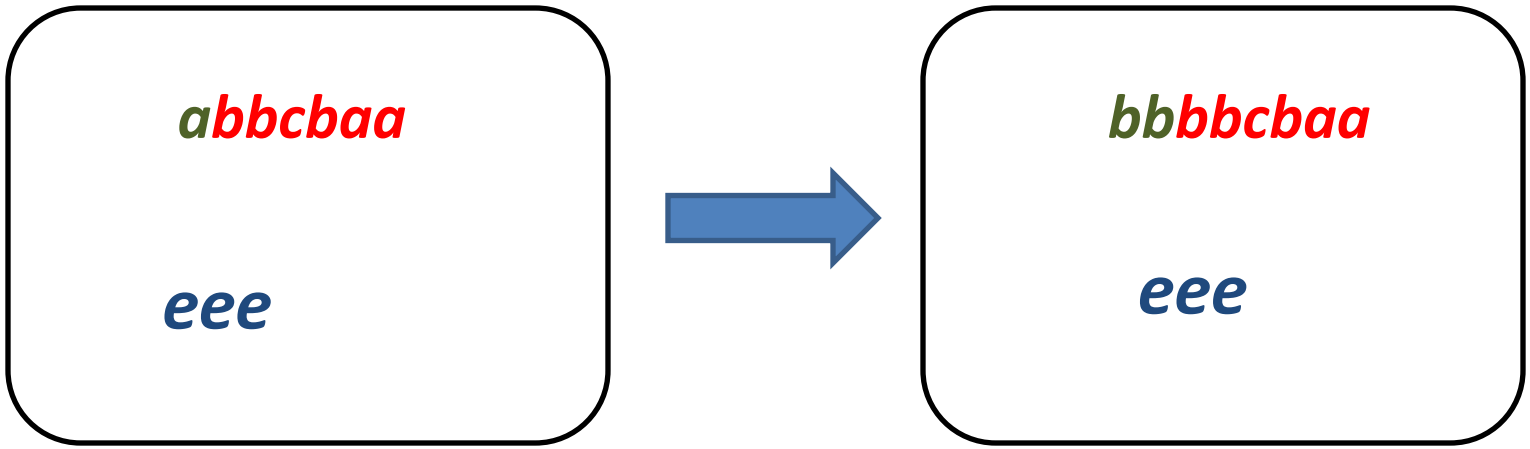
- **string objects instead of multisets of symbol objects**
- **(here,out, in_j) addressing**
- **Language transducers (explicit input/output regions, or skin output)**
- **New transduction rules (with priorities)**



Introducing transduction-like rules in the regions

$$u : v_{pos} \rightarrow w_{ad_1, ad_2, \ldots, ad_k} \qquad pos \in \{l, r, *\} \qquad ad_i \in \{here, out, in_j\}$$

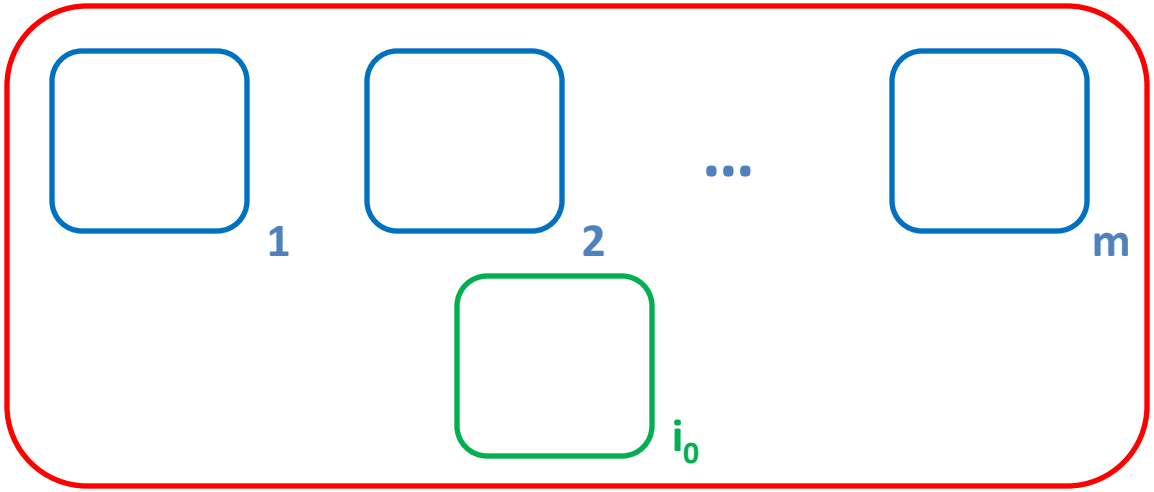
The rule is applied whenever there exists string objects *u* and *x* such that *x* contains the substring *v* at position established by *pos*. Then *v* is replaced by *w* in *x* and the resulting string is sent to the regions established by ad_j.



$$eee : a_l \rightarrow bb_{here}$$

Dogmatic P systems

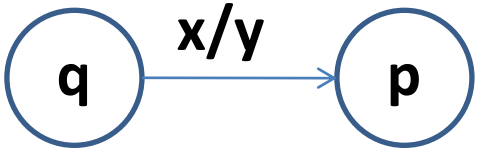
$$\Pi = (V, \mu, A_1, A_2, \ldots, A_m, (R_1, \rho_1), (R_2, \rho_2), \ldots, (R_m, \rho_m), i_0)$$



Note: The in_j address in any rule of region k sends the resulting string object directly from region k to region j (RNA migration)

Simulating Transducers by Dogmatic P systems

A Transducer is defined by the tuple $(Q,\Sigma,\Gamma,q_0,E,F)$ where the transitions in E take the form $qx \rightarrow yp$



$$T(x) = \{y \in \Gamma^* : q_0 x \overset{*}{\mapsto} yp,\ p \in F\}$$

$$T(L) = \bigcup_{x \in L} T(x)$$

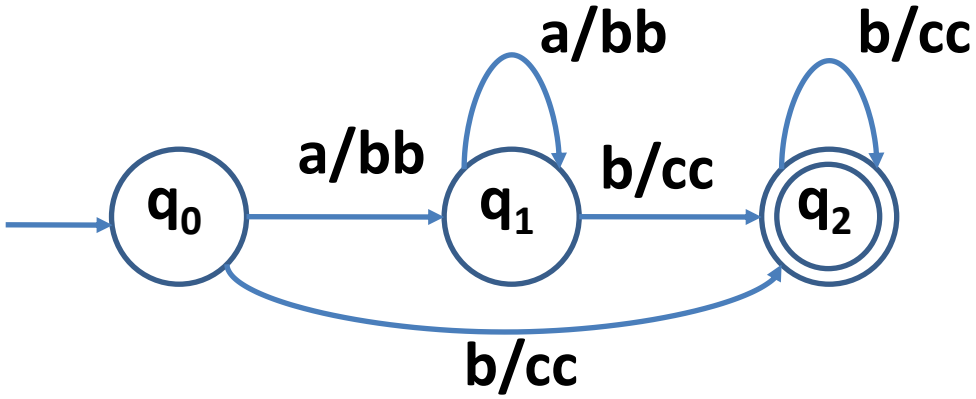
A normal form

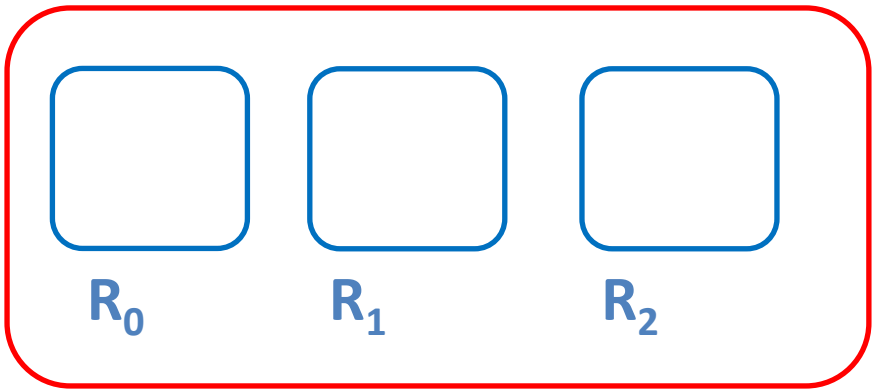
$F=\{q_f\}$

$E \subset Q - \{q_f\} \times (\Sigma \cup \{\lambda\}) \times (\Gamma \cup \{\lambda\}) \times Q - \{q_0\}$

Simulating FTs by Dogmatic P systems

An small example: (formal proposal in the abstract)





R_0

$$\#a_l \to \widehat{b}\widehat{b}_{in_1}$$

$$\#b_l \to \hat{c}\widehat{c}_{in_2}$$

...

R_1

$$\hat{b}a_l \to \widehat{b}\widehat{b}\widehat{b}_{here}$$

$$\hat{c}a_l \to \hat{c}\widehat{b}\widehat{b}_{here}$$

...

R_2

$$\hat{b}_r \to b_{out}$$

$$\hat{c}_r \to c_{out}$$

...

skin

$$\hat{b}_l \to b_{here}$$

$$\hat{c}_l \to c_{here}$$

$$\#_l \to \lambda_{out}$$

Future Research

- **Exploring the generation power of the *dogmatic* P Systems with a restricted number of regions (IFTs hierarchy collapses at 4 states)**
- **Exploring the effects of different transductions (rational, recognizable, (sub)sequential, etc.) over the model**
- **Use of general context in the transduction rules ?**
- **Computing by carving with dogmatic P systems**

Thank you (again) !!

Questions ?