Modelling Biological Processes in P Systems: Handling Imprecision and Constructing New Models

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Abstract. Membrane systems (P systems) are computational devices inspired from cell functioning, [8]. For this reason, it is important to introduce, in the P systems area, instruments to handle the imprecision that arises from (our) partial knowledge of many cellular phenomena.

We present two possible ways to tackle imprecision in P systems.

A first way consists in handling imprecision by using known mathematical devices (for instance, probability). This approach has been considered in [1, 2]. There has been shown how, using a model of P systems called *evolution-communication*, [3], enriched with probabilities, it is possible to simulate simple (and important) biological processes that occur in living cells. In particular, in [2] has been presented the modelling of respiration in escherichia coli and the modelling of respiration-photosynthesis interaction in cyanobacteria.

A second way to handle imprecision in P systems can be considered more "drastic": one tries to construct P systems that work independently from imprecision. This approach has been presented in [4], where time imprecision has been considered. In particular, in [4], have been introduced *timed P systems* and *time-free P systems*.

The motivation for these models comes from the following consideration: a standard feature of P systems is that each rule is executed in exactly one (clock) step; this mathematical assumption does not have a corresponding counterpart in cell biology, where different chemical reactions might take different times to be executed. Therefore, it is natural to consider a model of P systems (timed P systems) where to each rule is associated a certain time of execution.

On the other hand, we want to avoid "problems" that could derive from time imprecision; for this reason, it would be extremely useful to investigate P systems producing always the same result independently from the time of executions of the rules. In this respect, a special model of P systems, called *time-free*, has been introduced and investigate in [4].

Formally, a P system is called time-free when it produces always the same set of vectors of natural numbers independently from the time of executions of its rules. In this way, time-free P systems can be considered "safe" against time imprecision.

A third way to handle time imprecision would be to mix the first two approaches: one tries to construct time-free P systems that are "safe" against "controlled" imprecision. In this respect, in [4, 6] has been considered the class of *partially time-free P systems*.

Preliminary results concerning time-free P systems have been obtained in [4, 5, 6, 7]. There, several computational results have been obtained but many (interesting) open problems still need to be afforded.

References

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