

Computing at Population Level in P systems (Extended Abstract)

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P systems represent a class of distributed and parallel computing devices of a biological type that was introduced in [8]. Several variants of this model have been investigated and the literature on the subject is now rapidly growing. The main results in this area show that P systems are a very powerful and efficient computational models [9], [12], [7]. Two main classes of P systems can be identified in the area of membrane computing [9]: cell-like P systems and tissue-like P systems. The former type is inspired by the internal organization of living cells with different compartments and membranes hierarchically arranged; formally, this structure is associated with a tree. Tissue P systems have been motivated by the structure and behaviour of multicellular organisms where they form a multitude of different tissues performing various functions [1]; the structure of the system is instead represented as a graph where nodes are associated with the cells which are allowed to communicate alongside the edges of the graph.

More recently, a notion of population P systems has been introduced [2], [3] as a model for tissue P systems where the structure of the underlying graph can be modified during a computation by varying the set of nodes and the set of edges in the graph. Specifically, nodes are associated with cells, each of them representing a basic functional unit of the system, and edges model bonds among these cells that are dynamically created and destroyed. Although mainly inspired by the cell behaviour in living tissues, population P systems may be also regarded as an abstraction of a population of bio-entities aggregated together in a more complex bio-unit (e.g., social insects like ants, bees, wasps etc, organized in colonies). This is the main reason why we use the term population instead of tissue albeit the term cell is retained to denoting an individual in the system.

Here we first report the universality results obtained in [3] that concern the power of a variant of population P systems where the following different rules are considered: transformation rules for modifying the objects that are present inside the cells, communication rules for moving objects from a cell to another one, cell division rules for introducing new cells in the system, cell differentiation rules for changing the types of the cells, and cell death rules for removing cells from the system. As well as this, bond making rules are considered that are used to modify the links between the existing cells (i.e., the set of edges in the graph) at the end of each step of evolution performed by means of the aforementioned rules. In other

words, a population P system [3] is basically defined as an evolution-communication P system [5] but with the important difference that the structure of the system is not rigid and it is represented as an arbitrary graph. In particular, bond making rules are able to influence cell capability of moving objects from a place to another one by varying the set of edges in the underlying graph. Moreover, communication rules are of the forms $(a; b, in)$ (i.e., in the presence of an object a , a cell can receive an object b from one of its neighbouring cells, non-deterministically chosen), $(a; b, enter)$ (i.e., in the presence of an object a , a cell can bring an object from the environment), and $(a, exit)$ (i.e., an object a can be moved from a cell into the environment). These rules were previously considered in [4] where an universality result is provided for evolution-communication tissue P systems with communication rules of these forms and non-cooperative transformation rules.

Next we want to address the problem of investigating the generative capacity of purely communicative P systems in the context of population P systems. In the framework of P systems with symport/antiport rules, the universality results obtained in the case of purely communicative systems are similar or the same with the universality results proved for evolution-communication systems [9], [12], [7]. So far it has been proved that population P systems using evolution-communication rules are computationally complete [4] but it is not immediate to obtain a similar result for the purely communicative case by using only the aforementioned communication rules. However, we expect this result to be proved for population P systems that use also bond making rules.

A case study using population P systems paradigm in order to model the behaviour of an ant species colony inside of the nest is presented. References to implementations and further results are also mentioned.

Further developments of the area of population P systems are briefly summarised (see also [2]). Many different variants of population P systems can be considered according to the choice of evolution-communication models, the choice of mechanisms for adding/removing cells, and the choice of the mechanism for creating/destroying bond among the cells. For instance, the general mechanism of cell communication based on signal molecules may be introduced in P systems as a mechanism for triggering particular transformations inside a cell once a particular signal-object has been received from some other cell in the system. A few proposals about the use of signals as activators/de-activators for sets of rules can be found in [11]. From a population P systems point of view, it is of particular interest the case of communication among bacteria, which is achieved by exchanging signal molecules through the environment in a process called quorum sensing [13]. This process allows bacteria to monitor their environment in the presence of other bacteria and to respond to fluctuations in the number and/or species present by altering particular internal behaviours. Furthermore, another interesting variant of tissue P systems is proposed in [6] where states are associated with the links among the cells and these states control the movement of objects alongside the links by activating particular channels of communication. In the context of population P systems, this may be considered as a feature of bond making rules which, depending on the state of the cells, assign particular channels of communication to the bonds once they are created.

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