Equivalence between Population Protocols and Turing Machines

Jonas Lefèvre

LIX, École Polytechnique, Palaiseau, France
`jlefevre@lix.polytechnique.fr`

Nowadays the size and the diversity of networks is greatly increasing. Very large networks of tiny agents, like cellphones for instance, becomes quite common. In such networks, it may become expensive in time or space to consider a unique identifier per device. To model such a situation, Angluin et al. introduce an abstract model of a network of devices: the population protocols [1].

In this model we consider a large population of anonymous and passively mobile agents with the computational power of finite automata. Every agent has the same transition rules. But we do not have any control on which pair of agent will interact. Due to the minimalistic nature of their model, the class of computable predicates was proved to be fairly small: it exactly is the class of semi-linear predicates, which are the predicates described by a formula from the Pressburger arithmetic. For more details, please read the survey [3]. In order to improve the power of the model, a lot of variants were proposed and studied: one-way or delayed communications [2], agent with identifier and a memory of size $\log(n)$ [5] [4], byzantine agents [5], and any combination.

The variant we study is a restriction of the interaction graph. The computational power increases when we delete edges in the interaction graph. Agents can not communicate with any agent anymore. In the case when the interaction graph is a string the model is equivalent to linear-space non-deterministic Turing machines. We are able to construct a hierarchy of population protocols by permitting more or less interaction within the population.

This work had lead us to study an other variant: the agent receive an identifier among a given set of identifiers, some agent may have the same identification. We hope to recycle the results of our first variant and to prove more. We aim to determine the set of computed formula and the equivalent Turing machine class in function of the quantity of identifiers.

References

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