Evolution of simple systems to complex behaviours

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INTRODUCTION

Biological switches drive changes in the functional state of a system in an all-or-none fashion. These switch-like behaviours have been observed in different biological processes, like the transitions between phases of the cell cycle¹, the epigenetic changes², the regulation of polarity³, or the septation initiation⁴. A simple model able to capture the dynamics of these complex processes is a population protocol, Approximate Majority⁵ (AM), widely used in distributed computing. This algorithm describes how to drive a population of agents (molecules), initially in two different states, into a final population where all agents (molecules) are in the same state.

We investigate if this type of system could have been the ancestor of a class of biological switches, where the transitions between functional states should happen in a fast, reliable and robust way.

RESULTS

We assumed that dynamical behaviours must be kept to obtain new systems with new functions, while keeping original features. Evolving AM, we have shown that:
- An increasing of complexity from AM is feasible. We obtain the mutual inhibition system (MI), a system usually observed in biological networks. It resembles a kinase – phosphatase pair.
- From a switch-like behaviour an oscillatory behaviour can arise, keeping the dynamical properties of a switch in previous steps.

SUMMARY

The system resembles a mutual inhibition (MI) system. It restores AM’s dynamics. Faster system. Bistability is kept.

REFERENCES