FROM BACTERIAL COMMUNICATION TO THE DEVELOPMENT OF SYNTHETIC DISTRIBUTED SYSTEMS

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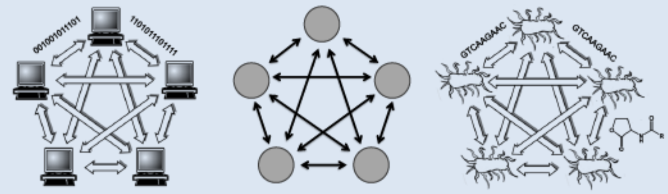
INTRODUCTION

Synthetic biology studies the design of living systems capable of performing computations on an organic support. It also allows the implementation of information processing mechanisms in distributed communities of cells. Our work aims to provide a network-oriented point of view over this emerging science. We address Bacterial Computing from the study of bacterial communication mechanisms, by assuming a conceptual framework between Computer Science and Biology in which cells are conceived as nodes. This nodes process information through modules formed of DNA as encoded software (biobricks) and are connected to other nodes. In order to understand how peer-to-peer mechanisms operate in bacteria, we have studied Quorum sensing and Conjugation with an engineering perspective. Learning how cells process and exchange information we try to glimpse new theoretical approaches to develop synthetic networks and to transfer complex algorithms to natural environments.

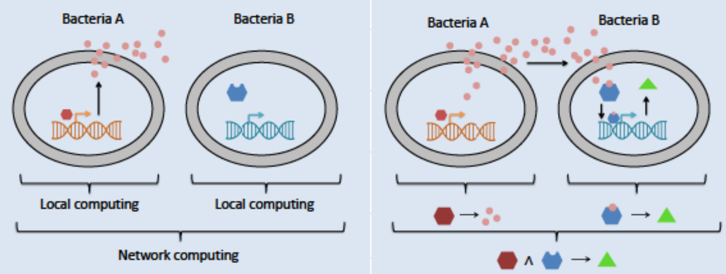
NETWORK PERSPECTIVE



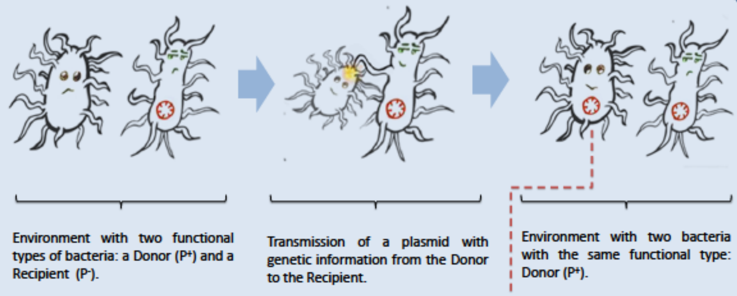
P2P Exchanges of information: In peer-to-peer (P2P) networks there is not any node with central control, they follow a distributed network architecture. Furthermore, all the nodes or peers act as consumers and providers of resources. From an information-processing perspective, peers are able to exchange data leading to decentralized computation processes.

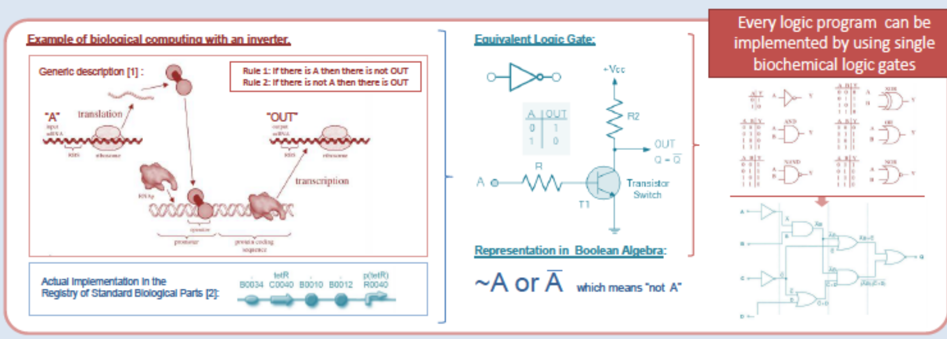
BACTERIAL COMMUNICATION SYSTEMS

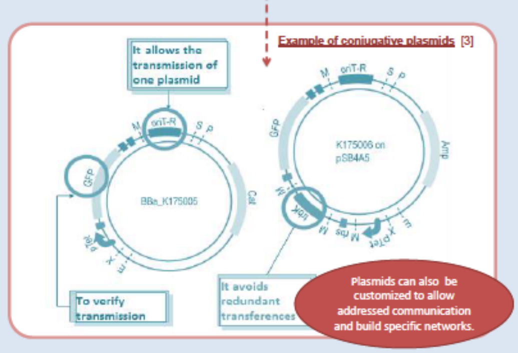
Quorum Sensing is a biochemical communication system dependent on cell density. It is the process by which bacteria announce their presence in a medium, as well as a tool to detect the presence of other members of the colony. Quorum sensing notification takes place by the release of a peptide that in Gram negative bacteria is usually an acyl-homoserine lactone. In this type of communication, propagation occurs by broadcast signals, so receptors of any bacteria may identify the signal within the same broadcast domain. However, we can design addressed communication by using addressed plasmids. That is, requiring bacteria to express specific receptors and release specific auto-inducers in order to avoid the default broadcast and define peer connections.



Conjugation is the second communication system that is important in our research. It is based on bacteria transmission of genetic information and allows bacteria to donate its genetic code to other cells. It works as a peer-to-peer system to share software implemented on DNA, that is, to produce in another bacteria specific behaviors such as bioluminescence, lysis or the expression of particular proteins. The mechanism leading to this protocol of genetic exchange can be manipulated to turn a donor in a recipient bacteria or vice versa. The expression of certain genes allows a Gram-negative bacteria to have elements like relaxase and pilus, fundamental elements in communication by conjugation. Conjugation can also be used to synthesize the building blocks of organelles and to operate remotely with them.







CONCLUSIONS

Considering the advantages of Synthetic Biology and following an engineering perspective we can use biobricks to design complex and scalable distributed computing systems. Extending bacterial communications we can implement P2P networks and provide the basis for the emergence of parallel computing in biological hardware, letting us understand better how nature itself computes.

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