

The Beeping Squad Problem

Encadrant: Emmanuel Godard (prenom.nom@lif.univ-mrs.fr)
Laboratoire: LIS – équipe DALGO

The Firing Squad Problem

The Firing Squad Problem is a fundamental synchronization problem in Distributed Computing. Given a line of unknown size of processes, and a distinguished process (*the general*) at the start of the line, the problem is to make all processes enter a final state at the same step. It has been investigated in many settings for more than 60 years. The main constraint is that the distributed algorithm has to actually be a finite state machine (the smallest one that is known has 6 states and the proved lower bound is 4, the existence of a firing squad solution with 5 states is an open problem), but it has also been investigated on arbitrary graphs, even on dynamic networks.

It should be noted that although synchronism is assumed – the system evolves in rounds – the firing squad problem is actually tantamount to a *synchronous start*.

The Beeping Model : A Biological Distributed Model

The Beeping Model is a Distributed Computing model that is inspired by biological systems. At each round, a *cell* can listen or beep. A beep is a simple signal that can encode no further information than the very fact it has been emitted. If a cell is listening, and at least one of its neighbours is beeping then the cell will receive the signal, without knowing precisely from where it was sent.

This computing model actually originates from the study of collision systems in radio ad hoc networks. It has also been proved to have counterpart in biological systems.

Main Goal

Surprisingly, given the small capabilities of beeping systems, it has been proved that various distributed tasks can be solved efficiently with probabilistic algorithms. However, all the solutions so far, require that the cells have a synchronous start or some knowledge about the system size.

The main goal is to characterize when the Firing Squad Problem can be solved with beeping cells without synchronous start and as few knowledge as possible. We will investigate the standard line, but also arbitrary graphs.

Conditions:

Standard allowance for research internship

PhD follow-up could be feasible.

References

- [CK10] Alejandro Cornejo and Fabian Kuhn. Deploying wireless networks with beeps. In *DISC*, volume 6343 of *Lecture Notes in Computer Science*, pages 148–162. Springer, 2010.

- [CMML96] Joanne R. Collier, Nicholas A.M. Monk, Philip K. Maini, and Julian H. Lewis. Pattern formation by lateral inhibition with feedback: a mathematical model of delta-notch intercellular signalling. *Journal of Theoretical Biology*, 183(4):429 – 446, 1996.
- [Maz87] Jacques Mazoyer. A six-state minimal time solution to the firing squad synchronization problem. *Theor. Comput. Sci.*, 50:183–238, 1987.
- [NB15] Saket Navlakha and Ziv Bar-Joseph. Distributed information processing in biological and computational systems. *Commun. ACM*, 58(1):94–102, 2015.
- [SW10] Johannes Schneider and Roger Wattenhofer. What is the use of collision detection (in wireless networks)? In *DISC*, volume 6343 of *Lecture Notes in Computer Science*, pages 133–147. Springer, 2010.

Scientific Environment

Laboratoire d’Informatique Fondamentale

The Laboratoire d’Informatique Fondamentale de Marseille (LIF) is a joint research unit of CNRS – Université Aix-Marseille. LIF has more than 80 permanent members and around thirty non permanent members. It is located on the Luminy Campus, south of Marseille. LIF is made of seven teams:

Overall, the themes of research of these teams cover a significant part of modern computer science. The members of LIF share the same demanding approach to research, be it theoretical or more application-oriented: they aim at producing results that may actually contribute to computer science, viewed as a whole scientific field on its own.

The LIF and LSIS are merging in 2018 to form the Laboratoire d’Informatique et des Systèmes, with about 200 permanent members.

DALGO Team

The Distributed Algorithms (DALGO) team is part of the CNRS laboratory on Theoretical Computer Science called LIF (Laboratoire d’Informatique Fondamentale), UMR CNRS 7279, situated in the Luminy campus of Aix-Marseille University. The DALGO team is concerned with the study of distributed and decentralized systems with a focus on the algorithmic aspects. In particular we are interested in the computational power of various models for distributed computing and the communication complexity of distributed solutions to fundamental problems in these models. Members of our team work on the following themes of research:

- Design and Analysis of Distributed Algorithms
- Distributed Computing with Mobile Agents or Mobile Robots
- Dynamic Network Models
- Embedded Systems and Synchronous Programming Languages

The team head is *Jérémie Chalopin*.

See website at <http://www.lif.univ-mrs.fr/recherche/equipes/10/presentation>