Written Report

A Biological Solution to a Fundamental Distributed Computing Problem[1]

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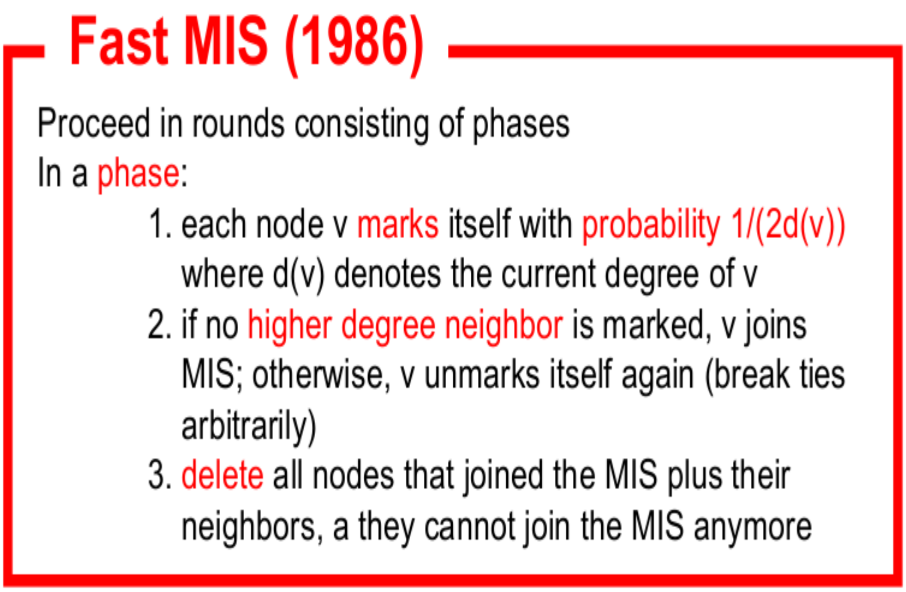
Summary of the paper: By studying the Sensory Organ Precursor (SOP) selection in fly's nervous system, they improved the distributed algorithm for Maximal Independent Set (MIS) problem-- with one bit optimal message complexity and without the prior knowledge of network topology. Later on by considering the local feedback from neighboring cells, their algorithms also achieved O(log N) time complexity[2].

Section I: Significance of the contributions:

Although their simulation methods are under question whether it really mirrors biological system[3]. Their result really heartened computer scientists not only (1) MIS algorithm do improved and achieved optimal message complexity that had been conceived by decades of computer scientists, not only (2) it is anther biologically inspired optimization solution to one problem that heartened back IBM's decision for their AIS. More importantly (3)it is the simple observations that "cells are distributed processors", established the link between biological network and distributed system and networking, which inspired a new field of study.

Section II: A brief survey of related algorithms:

MIS is one of the fundamental method in sensor network to recover the its framework and efficient routing. While other are rapid method which takes O(log n) time, but the network is inundated with messages because all nodes must continuous monitor how they are connected[4,]. However, in a sensor network message send by a node may interfere with concurrent transmission, and there are other message overhead such as broadcast, wakeup, as well as message processing. Previous work try to reduce message complexity gives a O(log^2n/ loglog n) lower bound[5.] So this new algorithm which achieved one-bit optimal message complexity not only reduced message processing overhead also reduce the expense for the devises.



Section IV:Current and future trends:

Inspired by this paper, researchers begin to look for biological solutions or similarity an other wireless networks algorithms [7,8]. The influence of this paper goes beyond sensor work. A lot study springs up to establish the similarity and link between biological and computation system [9].

Table III The five primary studies highlighted in this review (rows) each annotated with the principles it shares with computational systems (columns)

	Distributed	Robust	Networks	Modular	Stochastic	Adaptive
Fly SOP selection	✓	✓	✓	✓	✓	×
Slime mold tunneling	✓	✓	✓	×	✓	✓
Gene regulation	✓	✓	✓	✓	×	✓
Bat localization	×	✓	×	×	×	✓
Brain processing	✓	✓	✓	✓	×	✓

Most biological systems operate distributedly and seek a design that is robust and adaptive to changing environments. Networks often serve as a basis for carrying forth interactions and propagating information. These similarities provide a deep basis for the shared analysis of biological processes and computational algorithms.

And a summary of papers

Table II Examples of new synergistic relationship between biology and computer science

Area	Biological system	Computational problem	References	Model	Algorithm
Coordination	Fly SOP selection	Maximal independent set	Afek *et al* (2011)	✓	✓
	Fireflies flashing	Synchronization	Glass (2001), Lucarelli and Wang (2004), Hong and Scaglione (2005), Werner-Allen *et al* (2005), Babaoglu *et al* (2007), Pagliari and Scaglione (2011)	✓	✓
	*Octopus neural control	Hierarchical computing	Sumbre *et al* (2001)	×	×
	*Fish shoals/honeybees	Ensemble methods	Marshall *et al* (2009), Conradt (2011), Ward *et al* (2011)	✓	×
	*Quorum sensing	Consensus	(Marshall *et al*, 2009)	✓	×
	*DNA replication	Resource allocation	Farkash-Amar *et al*, (2008)	×	×
	*Mate selection	Graph matching	—	×	×
Networks	Slime mold tunneling	Network design	Li *et al* (2010), Tero *et al* (2010), Watanabe *et al* (2011)	✓	✓
	Gene regulation	Fault tolerance	Gu *et al* (2003), Balaji *et al* (2006), Gitter *et al* (2009), Pomerance *et al* (2009)	✓	✓
	*Protein localization	Routing	Shapiro *et al* (2009)	×	×
	*Brain networks	Network design	Chen *et al* (2006)	×	×
	*Cell signaling	Clustering	Wokoma *et al* (2005), Charalambous and Cui (2008)	✓	✓
Tracking and Vision	Visual cortex	Object recognition	Riesenhuber and Poggio (1999), Serre *et al* (2007a, b)	✓	✓
	Echolocation in bats	Localization	Ghose *et al* (2006), Yovel *et al* (2010)	✓	✓
	*Visual cortex	One-shot machine learning	Li *et al* (2006), Serre and Poggio (2010)	×	×

The biological systems are divided into three areas: coordination, networks, and tracking and vision. For each system, we show the analogous computational problem and whether a model or algorithm was derived by previous works. Rows beginning with a star denote potential future work.

Section V: References:

1. Afek, Yehuda, et al. "A biological solution to a fundamental distributed computing problem." *Science Signaling* 331.6014 (2011): 183.
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5. Moscibroda, Thomas, and Roger Wattenhofer. "Maximal independent sets in radio networks." *Proceedings of the twenty-fourth annual ACM symposium on Principles of distributed computing*. ACM, 2005.
6. Agarwal, Rachit, et al. "Achieving small-world properties using bio-inspired techniques in wireless networks." *The Computer Journal* 55.8 (2012): 909-931.
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8. Liu, Liang, et al. "Physarum optimization: A biology-inspired algorithm for minimal exposure path problem in wireless sensor networks." *INFOCOM, 2012 Proceedings IEEE*. IEEE, 2012.
9. Navlakha, Saket, and Ziv Bar-Joseph. "Algorithms in nature: the convergence of systems biology and computational thinking." *Molecular Systems Biology* 7.1 (2011).