Athena Lecture: Distributed Computing Theory for Wireless Networks and Mobile Systems

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ABSTRACT

Modern distributed computer systems are based on platforms that change dynamically. Many of these platforms utilize wireless communication, and many involve mobile nodes. These systems must handle complications like changing sets of participants, changing connectivity, and message collisions with resulting losses. Consequently, designing and analyzing algorithms for these systems is very hard.

What I would like to see is a *comprehensive theory* for dynamic distributed systems, and particularly for wireless networks and mobile systems. Such a theory would start with plausible physical network models. It would allow us to design and analyze low-level communication protocols, algorithms for data-oriented and control-oriented applications, and everything in between. The theory would identify key problems and sub-problems, and would include algorithms, algorithm design principles, ways of composing algorithms to build more elaborate algorithms, abstraction layers, lower bound theorems, impossibility results, and theorems comparing the power of different platforms. And all of this should rest on a common concurrency theory foundation.

Most of this talk will be devoted to a high-level overview of my research group's work in the past few years on theory for dynamic systems, especially wireless networks and mobile systems. I will first describe our work on algorithms for networks with reliable communication channels—algorithms for managing data, communicating, computing functions, and coordinating robots—and then our work on algorithms for wireless networks with channels that exhibit message collisions and losses. Although this work provides many pieces for the needed theory, a great deal of work is still needed. I will close by describing what remains to be done.

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distributed algorithms; dynamic systems; mobile systems; wireless networks

Biography

Nancy Lynch is the NEC Professor of Software Science and Engineering in the Department of Electrical Engineering and Computer Science at MIT. She heads the Theory of Distributed Systems research group in MIT's Computer Science and Artificial Intelligence Laboratory. She is also currently a Fellow at the Radcliffe Institute for Advanced Study.

Lynch received her B.S. degree in mathematics from Brooklyn College in 1968, and her PhD in mathematics from MIT in 1972. She has written numerous research articles about distributed algorithms and impossibility results, and about formal modeling and verification of distributed systems. Her best-known research contribution is the “FLP” impossibility result for distributed consensus in the presence of process failures, developed with Fischer and Paterson in 1982. Other well-known research contributions include the I/O automata mathematical system modeling frameworks, with Tuttle, Vaandrager, Segala, and Kaynar. Her recent work is focused on algorithms for mobile ad hoc networks.

Lynch has written books on “Atomic Transactions” (with Merritt, Weihl, and Fekete), on “Distributed Algorithms”, and on “The Theory of Timed I/O Automata” (with Kaynar, Segala, and Vaandrager). She is an ACM Fellow, and a member of both the National Academy of Engineering and the American Academy of Arts and Sciences. With co-authors, she won the Dijkstra Prize in 2001 and again in 2007. She was co-winner of the first (2006) van Wijngaarden prize, and was awarded the 2007 Knuth Prize, and the 2010 IEEE Emanuel Piore award, as well as the 2012-2013 Athena award. Lynch has supervised over 27 PhD students and over 50 Masters students, as well as numerous postdoctoral research associates.