

1983 Invited Address

Solved Problems, Unsolved Problems and Non-Problems in Concurrency

Leslie Lamport¹

This is an edited transcript of a talk given at last year's conference. To preserve the flavor of the talk and the questions, I have done very little editing—mostly eliminating superfluous words and phrases, correcting especially atrocious grammar, and making the obvious changes needed when replacing slides by figures. The tape recorder was not functioning for the first few minutes, so I had to recreate the beginning of the talk.

It's an honor to be invited to speak here at the second PODC conference. I'd like to think that it was because of my work, but I suspect that the real reason is that I tend to be controversial, saying all sorts of things that will offend people and lives things up. To paraphrase Isaac Newton:

If I have received more notice than other men, it was by stepping on the toes of giants.

Well, I'll try not to disappoint you.

What I'm going to present here are my own personal views. Needless to say, I don't expect most of you to agree with these views. Saying what is and is not a problem involves prediction—deciding just what will be regarded in the future as the real problems in concurrency. To show how successful I am, I'll just tell you that when Susan Owicki first described Pnueli's use of temporal logic—in a seminar she gave around the summer of '79 or '80—I knew immediately that it was formal nonsense that wasn't really good for anything.² So, with that piece of prognostication to vouch for my abilities as a fortune teller, I'll begin.

¹Work supported in part by the National Science Foundation under grant number MCS-8104455, and by the Army Research Office under grant number DAAG29-83-K-0429.

²After the talk, I was told that some people didn't get the joke and thought I was insulting Pnueli. In fact, much of my recent research has been based upon Pnueli's work in temporal logic.

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³1984 ACM 0-89791-143-1 84 0000 0001 \$00.75

Shared Variables	1965
Semaphores	1968
Monitors	1973
CSP	1978

Figure 1: The history of standard concurrency.

The first unsolved problem I want to talk about is the problem of developing a fundamental theory of concurrency. By a fundamental theory, I mean one that's not based upon arbitrary formal models or specific languages, but one that's really fundamental.

I recently heard a speaker use the phrase "standard concurrency". After listening to him for a while, it turned out that by "standard concurrency" he meant CSP.

Those who cannot remember the past are condemned to repeat it.

George Santayana

The history of standard concurrency is shown in Figure 1. When I started working in concurrency, standard concurrency meant semaphores. (Actually, conditional critical regions started challenging semaphores, but monitors became the standard before conditional critical regions had a chance.) Papers that claimed to be about synchronization were really about semaphores.

Well, synchronization isn't really semaphores, or monitors or CSP. Synchronization is something more fundamental. I don't mean to put down CSP. It's a fine language—or, more precisely, a fine set of communication constructs. Hoare deserved his Turing award. But, so did Dijkstra.

Some of you may think that was way back then, but now we really know what concurrency is all about, and we really know that CSP is the right way of doing things. For those of you who think that way, I'd like to remind you that while we theoreticians are busy studying CSP, people out there in the real world are building Ethernets. And CSP doesn't seem to me to be a very good model of Ethernets.

Anyway, what I really want to talk about is a fundamental theory of synchronization or concurrency. To give you an example of what it is that I would like to see, I'll talk about something that I do understand a little about—

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