

## Remarks of Murray Wonham read by Peter Caines at WODES'06 Banquet Dinner, July 11, 2006

### EARLY DAYS OF SUPERVISORY CONTROL

Stéphane has asked me for some reminiscences of the early days of Supervisory Control in the "Ramadge-Wonham" (say "RW") sense of that term.

This will be short, as no doubt everyone is eagerly waiting for what I think has been billed as "live entertainment". As distinct from history, for example.

Peter Ramadge had joined my research group as a Ph.D. student (via Newcastle, Australia, and Harvard) in Fall, 1979. RW was born sometime in 1980. The plan was to bring together ideas from control theory and ideas from the discrete world of languages and automata. We had read some computer engineering textbooks on subjects like operating systems and concurrent programming, as well as simulation texts on languages like Simula. These books were quite interesting, as much for what they didn't say as what they did.

They were full of control problems, although not stated that way at all. As many here will recall, control problems were always of the form, "Given data X, find Y, subject to constraints C, such that Z is optimized." By contrast, the computer problems were stated something like, "Write a program which guarantees that some logic condition is satisfied and the program doesn't hang up." The books were somewhat in the style of 1950s classical control – a series of "solutions", in this case programs, were presented, with each one presumably an improvement on the one before, until you were supposed to be convinced that at last they'd gotten it right. As in classical control, however, you never knew exactly what the problem was in the first place. In retrospect you might say, it was the difference between "design" and "synthesis".

It seemed to us that the formal style of a control problem might make for some clarity, and then the problems themselves could indeed be quite relevant and interesting to the control community. And this would be a good topic for Peter's thesis. It only remained to decide on the framework. One day as we sat pondering, it occurred to us that it would be natural to have "states" (because that was the basis of all control in 1980), and then to have transitions (just as in Markov chains, for instance, because the mechanism was to be discrete), and thirdly that the transitions themselves should be capable of being activated or deactivated, just as Petri net transitions could be "fired" or not, depending on circumstances. Putting this together led to the model of a "controlled discrete-event system" that we still use today.

In the work that followed, quite a number of new ideas emerged, the foremost being the notion of a controllable language. And the pleasant result was that the setup began to look a lot like previous \*linear\* control theory, notably the geometric approach of the 1970s. This time we had languages, instead of vector spaces; the lattice of sublanguages, instead of the lattice of subspaces; and the resulting miraculous existence of supremal elements - "supremal controllable sublanguages" - as the counterpart of "supremal controllable subspaces". A very appealing unity! The moral: keep it simple, and trust in your esthetics.

Naturally we expected the world to take fire at once. Especially control people. Our first target, a control journal, declared "Automata have no place in control engineering," because they were too hard. Our next target, a sort of computer science journal, declared "Finite automata and regular languages are nothing new at best and trivial at worst," namely our stuff was much too simple-minded. Indeed, had there been anything in it at all, they (the computer people) would surely have already done it. Finally, after a few years of these encouraging responses, we persuaded the Editor, Len Berkovitz, to give us a niche in the SIAM Journal of Control and Optimization (after the usual review process, of course). I think Len agreed mainly because we had the word "optimal" in the paper's Introduction. After the hero in the movie "Titanic," the slogan had to be, "Never let go."

To close on this, before the live entertainment, let me briefly pay tribute to the many more students in various places who followed up on these ideas and made wonderful original contributions. No need to mention names, except to say that historically DES research benefited hugely in the aftermath of the Chinese Cultural Revolution, with so many talented young people suddenly appearing on the doorstep. Others from other places too, of course, and gosh, even from darkest Québec.

Thanks.

wmw