

**Research Trends in Formal Semantics**

Michael Main & Michael Mislove

CU-CS-404-88 June 1988

Department of Computer Science  
Campus Box 430  
University of Colorado  
Boulder, Colorado 80309



**Research Trends in Formal Semantics**  
*Report by Michael Main and Michael Mislove*  
June 1988

The Fourth Workshop on Mathematical Foundations of Programming Semantics was held in Boulder Colorado on May 18-21. The following week, some of the workshop participants retreated to Manhattan, Kansas, for four days of informal discussions and in-depth presentations, centered around the theme of data flow analysis. One evening, some of this group got together to discuss research trends in formal semantics. Participating in the discussion were David Schmidt (Kansas State), Bob Neufeld (Wichita State), Flemming Nielson (Danmarks Tekniske Hojskole), Hanne Nielson (Aalborg), Austin Melton (Kansas State), He Jifeng (Oxford), George Strecker (Kansas State), Steve Brookes (Carnegie-Mellon), Mike Mislove (Tulane), Mike Main (Colorado) Tony Hoare (Oxford), Rebecca Tucker (Wichita State) and David Benson (Washington State). This report recounts some of the general indications that emerged during the discussion, although it may also contain the biases and additional thoughts of the reporters.

### **Focus of the Discussion**

The discussion focused on research in the formal semantics of languages and systems, and its mathematical foundations. This research includes:

- Fundamental mathematical research in areas such as logic, universal algebra, lattice theory, domain theory and category theory.
- The basic formulation and study of mathematical models of languages and systems, including features such as concurrency and distributed processing which are motivated by empirical considerations.
- The transfer of the mathematical principles to emerging applications, usable by computer scientists at all levels, with a goal of efficiently providing reliable and effective software.

### **Fundamental and Basic Research**

Fundamental mathematical research and the basic formulation and study of mathematical models is often carried out without any immediate applications in mind, although the choice of topics studied is sometimes driven by applications. High quality research is generally carried out by bright individual researchers, producing small pieces of a larger understanding that emerges only over a period of several years. Some examples of fundamental topics familiar to the discussion participants include the study of Cartesian Closed Categories (driven by models of the lambda calculus), the study of well-founded orders (with motivation from proofs of program termination), and a renewed interest in  $T_0$ -topologies (since the topological spaces used by computer scientists fail to meet the stronger  $T_1$  axiom). A list of similar topics has been recently written by M. Nivat (Section II of [5]).

We anticipate that much of the new fundamental research will be motivated by recent important applications such as concurrent and distributed computing, polymorphism, graphics, hypertext, and automated program generation. Further basic research may be motivated from applying techniques of formal semantics to areas of computer science outside of programming languages and systems. Possible candidates are data base theory and artificial intelligence.

It is difficult to identify short-term goals for fundamental research, even when the areas of research are known. However, it is important to evaluate short-term accomplishments by the traditional methods of assessment by peers. A long-term goal of fundamental research is the identification of a body of knowledge and mathematical tools needed by researchers and programmers in the design, analysis, and maintenance of software systems.

With regard to both long and short term goals, it should be kept in mind that this sort of research is basic to further development of theoretical computer science. Indeed, the mathematical underpinnings of the subject are its theoretical basis, without which there would be no firm foundation upon which to build. Continued support for this type of research is crucial to the proper development of theoretical computer science. It is also important for another reason. Given the low numbers of Ph.D. graduates in mathematics and computer science, it is important to demonstrate that these fields are well supported. Providing support for basic research has the effect of showing prospective researchers that the system does provide adequate support, and thus encourages them to pursue careers in the area.

## Applications

The participants agreed that better tools and methods are needed for writing, verifying and testing reliable, easily maintained, secure software — and that these tools will come from applications of current and future theory. An analogy can be drawn between applied research in algorithms and applied research in semantics. Whereas applied algorithms research strives to achieve practical improvements in time and space requirements of computations, applied semantics research attempts to achieve practical improvements in the productivity, reliability, maintainability and security of software. The future should see better uses of the software support tools that are available, as well as development of new tools such as program generators and tools for automatic or assisted program verification.

The group has high hopes for successful applications along these lines in the next five to ten years, and pointed to some recent successes. For example, the use of CSP in the development of Occam, and its subsequent use to program MIMD machines is a good example of how theoretical results can lead to practical ones. However, it was recognized that many of the problems currently being faced in semantics are at least as difficult as problems posed by researchers in artificial intelligence some 35 years ago, some of which have still not been successfully handled (despite similar high hopes). But, some progress has been made on these AI problems, and we expect at least similar short-term progress toward the semantics applications problems outlined above.

### Some Recent Similar Writings from the *Bulletin*

[1] M. Broy, On the role of theory for software engineering : computing science as an independent science with its own rights, *Bulletin of the EATCS* 32 (June 1987), 29-30.

[2] D. Bjorner, Aspects of the role of theory in the computation sciences and engineering, *Bulletin of the EATCS* 32 (June 1987), 31-38.

[3] J. Gruska, Some observations on theory and practice in computer science, *Bulletin of the EATCS* 32 (June 1987), 54-63.

[4] Declaration of the participants of the International Symposium FCT'87, *Bulletin of the EATCS* 34 (February 1988), 309-310.

[5] M. Nivat, Mathematical tools for computer science, *Bulletin of the EATCS* 34 (February 1988), 313-316.

Michael Main, Boulder, Colorado  
Michael Mislove, New Orleans, Louisiana

ANY OPINIONS, FINDINGS, AND CONCLUSIONS OR RECOMMENDATIONS EXPRESSED IN THIS PUBLICATION ARE THOSE OF THE AUTHOR AND DO NOT NECESSARILY REFLECT THE VIEWS OF THE NATIONAL SCIENCE FOUNDATION.

