The University of Leeds

CTCS

*Centre for Theoretical
Computer Science*

Leeds LS2 9JT, United Kingdom
Telephone 0532-431751

The University of Leeds has established a Centre for Theoretical Computer Science bringing together computer scientists, pure mathematicians, philosophers, and engineers to pursue interdisciplinary research in the theoretical foundations of computer science. In this article the first Director, Dr J.V. Tucker of the Department of Computer Studies, introduces the Centre.

> **A Vulgar Mechanick can practise what he has been taught or seen done, but if he is in an error he knows not how to find it out and correct it, and if you put him out of his road, he is at a stand; Whereas he that is able to reason nimbly and judiciously . . . is never at rest till he gets over every rub.**
>
> Isaac Newton
> 25 May 1694

WHAT IS THEORETICAL COMPUTER SCIENCE?

Computer science is about computers and computation. It is concerned with the invention and analysis of algorithms; with the design of programs and programming languages for expressing algorithms; and with the construction of computer systems, including machines, for implementing programming languages. Computer science is an empirical subject, dependent upon experiments with elaborate equipment. However, it aims to abstract from the physical devices and view its machines through the formalisms used for their operation and programming.

This emphasis on formalisms - software - gives computer science a coherence and continuity in the face of changes in the physical technologies of computer construction. Our thinking has not lost touch with that of Charles Babbage (1791-1871), for whom computers were made of wood and brass; while the writings of Alan Turing (1912-1954) and John von Neumann (1903-1957) on the first generation of electronic computers address questions that are still of interest to contemporary computer science. In our turn we want a computer science that can accommodate a change from our present silicon transistor technologies to some future optical or biochemical technologies, for example. Formalisms, and the extent to which they are machine and technology independent, are an important concern in computer science, one especially dear to theorists.

Theoretical computer science seeks to establish and analyse the concepts, organising principles, mathematical tools, heuristic techniques, methodologies and ideologies that are, or may be, of use in practical computation. By enlarging the subject with theoretical explanation and speculation, it attacks the pressing problem of making scientific foundations for computer science.

INFORMATION TECHNOLOGY

Computer science is widely applicable and immensely useful in the world's work. The demands of society for computer systems for houses, shops, banks, hospitals, factories, laboratories, ships, aircraft, battlefields, . . . (and a fear of foreign competition) place the subject at the centre of the £350m Alvey Programme, an ambitious national information technology initiative which aims to direct and accelerate research and its exploitation in industry over the five

years 1983-88. However, an equally urgent national problem, indeed an urgent international problem of the day, is the academic development of a new kind of engineering discipline, within computer science, concerned with **software technologies.** The discipline will be quite different from present engineering disciplines, for software is artificial and abstract and is not governed by the laws of the physical world. Software science and engineering is in its infancy and I firmly believe that its growth and maturation requires an **enormous** expansion of our theoretical understanding of computation. At present, like Newton's Vulgar Mechanick, the best software engineers can only be trained to muddle through.

THE ROLE OF FORMAL LOGIC

The scientific study of software owes much to the studies of other symbolic formalisms, inaugurated by pure mathematicians and philosophers interested in logic and the foundations of mathematics. A tradition of **formal logic,** begun by George Boole and Gottlob Frege in the last century, was established by the work of Bertrand Russell, David Hilbert, Kurt Gödel, Alan Turing and Alfred Tarski in the early decades of this century. The first electronic computers in the 1940's were the result of a joint venture by two young fields: electronics and formal logic.

Formal logic has been extensively developed in mathematics, philosophy and, more recently, in linguistics. It has continued to inspire, and to influence technically, research in theoretical computer science. We owe to formal logic important ideas such as the stored program universal computer (Turing); the distinction between syntax and semantics in programming languages (Frege, Tarski); mathematical tools for the machine invariant definition of syntax and semantics (Post, Chomsky, Scott). The functional languages, such as LISP, are founded on Church's lambda-calculus; and the logic programming languages begin with Robinson's resolution logic. In return, theoretical computer science gives rise to new problems and tools for research in formal logic.

This synergy is very well understood and actively cultivated in the University of Leeds; it is the foundation for the University's new interdisciplinary **Centre for Theoretical Computer Science.**

ORIGINS OF CENTRE

Since the War, members of the Departments of Mathematics and Philosophy have earned the University an international reputation for the breadth and quality of its research and teaching in logic. This esteem was firmly established by Robin Gandy (now at Oxford), Martin Löb (Amsterdam) and John Myhill (SUNY, Buffalo) in the Department of Pure Mathematics, and Peter Geach in the Department of Philosophy. In the context of the Centre, it is interesting to mention that it was Gandy and Löb who founded our seminar on the **Philosophy of Mathematics** in the late 1950's, thanks to which J.R. Lucas (Oxford) came to write his paper **Minds, machines and Gödel,** now famous in artificial intelligence, while on a year's fellowship in the Department of Philosophy. In recent times, the society of mathematical and philosophical logicians at Leeds has been enriched by theoreticians in the Department of Computer Studies, the first of whom was L.G. Valiant (Harvard).

Since 1983 collaboration between the pure mathematicians, philosophers and computer scientists has intensified and led to a number of new joint seminars and other academic initiatives. For example, since that year, my own Department and the Department of Pure Mathematics have run a weekly seminar on the **Theory of Computation** that has attracted experts from Germany, Holland, Israel, Sweden and the USA, and our own country and University; we have devoted these two years to the logical foundations of programming languages, and the seminar has been of great

value to its members in acquiring a common working knowledge of new areas of research. The Departments of Computer Studies and Pure Mathematics recently obtained a joint Lectureship on the mathematical theory of computation, under the UGC Information Technology Scheme. The Departments of Computer Studies and Philosophy have also sponsored a joint seminar series on the foundations of AI, obtained a joint lectureship on the theoretical foundations of expert systems under the UGC 'New Blood' Scheme, and established a carefully designed new BSc Degree in Computer Science and Philosophy. Arising from this successful mobilization of interests and expertise, the University has established an interdisciplinary **Centre for Theoretical Computer Science**, the first of its kind in this country and, we believe, in Europe. In the USA we know of only Stanford University's new **Center for the Study of Language and Information** for comparison.

AIMS OF THE CENTRE

The construction of theoretical foundations for information technology is an essential and massive task, and one for which the Universities must take the major responsibility. Comprehensive, elegant and deep formal theories have a crucial role in research and subsequent teaching of computer science; in addition, I believe they may find profound applications in natural science.

The Centre has been established to make an academic space within which members from different disciplines may learn, easily and routinely, about research that is relevant to the theoretical foundations of computer science. A Centre with focussed interdisciplinary activities is our ideal and, with the experiences of the past few years, I believe we underestimate neither the difficulties nor the rewards.

We have begun our development of the Centre with programmes of research in three areas well suited to interests at Leeds, namely: **Mathematical Theory of Computation; Theoretical Foundations of Expert Systems; Theoretical Foundations of VLSI System Design.** Our activities in these areas include seminars, short courses and meetings serving both University and national audiences. Of course, to support our programmes of research properly we will be dependent on outside funds.

Since its establishment, many existing activities have been incorporated under the Centre's aegis. The Centre made its national debut in April when we instituted the **British Theoretical Computer Science Colloquium.** This first gathering of 60 British theorists at Charles Morris Hall was a great success and the idea to continue the colloquium was warmly received by the community: the second British Theoretical Computer Science Colloquium will be held next Easter at Warwick University.

On the afternoon of Thursday 31 October 1985 we will hold an Inaugural Meeting of the Centre, for the University and invited guests. We cordially invite all interested individuals to attend.

Membership of the Centre is open to members of Leeds University who are interested in the theoretical foundations of computer science, and who are recommended to the University Council by the Executive Committee, which consists of: Dr J.V. Tucker (Director), Dr H.A. Lewis and Dr S.S. Wainer (Deputy Directors), Mr P.J.R. Millican (Secretary), Mr J. Derrick, Dr P.M. Dew, Professor D. Holdcroft, Mr D. Hutchinson and Dr I. Torsun. For further information, please contact the Secretary of the Centre at The Department of Computer Studies, University of Leeds, LS2 9JT (0532-431751 ext. 6106).

J. V. TUCKER
September 1985