Part I

Invited Lectures

Theoretical Computer Science and Software Science: The Past, the Present and the Future (Position Paper)

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The most compact statement I can say about the theme of this session is "Computer Science is just beginning now". This is about all I want to say about the present. More interesting are the slow progress and improvements of the past and the quickly changing perspectives of the future.

The Past Age

The first computing or calculating machines were invented by mathematicians i.e., Pascal and Leibnitz. Only at the end of the last century engineers designed punched-card machines for computing. Zuse invented a relais computer before the start of the war in Germany. The first computers were constructed during World War II in the UK and in the USA by logicians and/or mathematicians together with electronic engineers working at (some) universities.

I believe that the first theoretical computer scientists were Post, Thue (rewriting systems),Gödel (recursive functions), Turing (tapes machines), Church (lambda-calculus) and Curry (combinatory logic), all working before the forties. In fact all the constructions they conceived may be called abstract computers or abstract machines. The succeeding theoretical computer scientists were strongly influenced by the concomitant development of the *information technology*. The latter is a comprehensive designation that includes both software and hardware technologies, whose relationship has become progressively more intricate.

For example, in 1947-1951, I became interested in the automatic construction of machine programs starting from a mathematical-like language to describe algorithms. I knew the flow diagram technique invented by Golstine and Von Neumann and a paper by Zuse containing suggestions for preparing programs for his machine. The result (my Ph.D. thesis, 1952) was the description of a compiler written in its own language. The existence and the general applicability of this compiler were based upon the existence of universal Turing machines.

Sometimes, similarly, some device was discovered theoretically before becoming hardware. Take as example the stack notion . Since machine language syntax is parenthesis-free it was very natural to adopt a variant of the Lukasiewicz notation, allowing a parenthesis-free representation of logical terms (reverse polish notation). Since, mainly, arguments of functions are to be evaluated before the functional transform takes place, the reverse polish notation has the property to be invariant respect to a sequential computation of any expression filling a stack [Samelson and Bauer, CACM, 1960].

Another device coming from the theory is the cache-memory, based on the principle of the associative memory, first introduced, if I remember correctly, by McCarthy in the sixties.

The last two examples refer to the theory-inspired hardware. More recent examples of theories influencing software constructions are:

- Lambda-calculus and the LISP language
- Böhm and Jacopini theorem and structured programming
- Denotational semantics and ML language
- Logic and logic programming
- Combinator theory and functional programming languages (FL, MIRANDA, HASKELL etc.)
- Constructions theory and COQ language
- Intersection type theory (Coppo, Dezani, etc.) and Forsythe language

All this sounds very reassuring for theoretical computer scientists. It seems to be sufficient to continue in the same direction to remain in the best of possible worlds ...

The Present Age

One cannot ignore the software crisis, the tiresome, but never-ending money-consumer problem of millennium change at year 2000 and, last but not least the crisis of computer manufacturers. Positive answers to all these problems are:

- The technological leaps in personal computers: hard disk capacity reaching several Gigabytes, microprocessor with clock-speed exceeding 200 MHz and equipped with multimedial features, new operating systems, etc.
- The increasing economic impact of the information highways (the network called Internet) and the tendency to integrate television, cellular phone and computer into a single, handy object.

The Future Age

It is well known that it is much easier to interpolate than extrapolate event series. If the external conditions are quickly changing, as it is the case now with the computer industry, it is almost impossible to make any prediction. Especially in the case of the future impact of theoretical computer science upon the information technology. This is the reason why I stated, at the beginning of this report, that "Computer Science is just beginning now". The only feasible thing is a rapid analysis of how the computer environment has changed 50 years from the start. Now the input-output belongs to very different information types. No more punched cards or punched films, but, just to give a sample:

- Scanning of:
  - analog coloured images done by hands, or any other instrument
  - printed text with different alphabets and fonts,
- The electrical equivalent of tactile stimulation in virtual reality environment
- CD-ROM's contents downloading or audio CD recordings,
- Electrical signals of different nature, such as:
  - laboratory medical tests,
  - radio-emission from stars or satellites.

The kind of required information processing consequently varies very much. We can interpret all the evolution of computer science to date as an uninterrupted and progressive prevailing of the communication over all other computational activities. With the advent of the computer network (net) it does not matter *where* the circulating information really originates. Some *ethical* problems of the net will become interesting from theoretical point of view:

- To warrant the "robustness" of the net without to breaching the right to "privacy" of its participants.
- To warrant the "selectivity" of a search in the net, cutting off all collateral and parasitic information.

Probably some type theory must be invoked together with cryptarithmetic concepts for the first case, and severe learning and compression techniques must be adopted in the second case. Concluding, the most ambitious bet will probably be, from my point of view, to guess the new omni-comprehensive style of operatiing system delegated to choose the communication medium as well as the aim of the communication. I am inclined to believe that such a system will appear as iconic but its essence will be functional.