The Formal Specification Column

by

Hartmut Ehrig

Technical University of Berlin, Department of Computer Science
Franklinstraße 28/29, D-10587 Berlin, Germany
`ehrig@cs.tu-berlin.de`

Footprints of HR in Initial Algebra and Final Coalgebra

by Hartmut Ehrig
Technische Universität Berlin, Germany

Summary

This essay on the occasion of the Festkolloquium for the 65th birthday of **H**orst **R**eichel in November 2005 at TU Dresden reveals his footprints in the following periods:

- 1st Period (1970-79)
  The Hidden Success Story of ROBOTRON

- 2nd Period (1980-89)
  Warm Up in spite of Cold War

- 3rd Period (1990-2005)
  Footprints in the International Society

1st Period (1970-79)
The Hidden Success Story of ROBOTRON

In the 70s - this means in the middle of the Cold War between the West and the East - there were two important computer manufacturers: IBM in the West and ROBOTRON in the East.

In fact, there was a big gap between West and East in almost all areas, especially concerning Theory and Practice in Computer Science and Technology.

IBM was world-wide number 1 of the computer manufacturers. The IBM T.J. Watson Research Center in Yorktown Heights, USA, was the most prestigious research center for computer science and technology. IBM had hired the most well-known scientists in this area and was able to support theoretical and mathematical research independent of immediate applications. ADJ - an *Adjunction* between *Category* and *Computer Science* - was such a topic, considered as *Ivory Tower Research* by the majority of computer scientists at that time. ADJ, on the other hand, became a synonym for the researcher group - consisting of Joseph Goguen, Jim Thacher, Eric Wagner and Jesse Wright - which was working on this topic in the 1970s.

Motivated by the algebraic view of *Abstract Data Types* as *Many Sorted Algebras* - advocated by Barbara Liskov and Steve Zilles - the ADJ-group proposed the *Initial Algebra Approach of Abstract Data Types*. In the initial algebra approach abstract data types are presented by *Algebraic Specifications* **SPEC** with semantics defined by the *Initial Algebra* $\mathbf{T}_{SPEC}$ in the category **Alg(SPEC)** of all algebras satisfying **SPEC**.

This initial algebra approach, however, was not the only one: John Guttag proposed in this PhD thesis a different approach based on loose semantics and final algebras. At first sight this seemed to be stupid, because the final algebra in **Alg(SPEC)** is the trivial algebra with one element only in each domain. But this was a misinterpretation of his ideas, because he had advocated to take the final algebra in the subcategory of **Alg(SPEC)** consisting of all algebras with the same *Observational Semantics*. In any case, the Golden Age of Algebraic Specifications in the 1970s and begin of the 1980s was dominated by the discussion about the following topic:

Initial Algebra Versus Loose and Final Algebra Semantics.

ROBOTRON on the other hand was number 1 of the computer manufacturers in the GDR (German Democratic Republic), also known as East-Germany. Concerning the technology ROBOTRON was very successful in applying the Copy

and Paste technique, so that the chief scientists, like Heinz Kaphengst and Horst Reichel, were free to care about other problems: They developed the categorical foundations of free algebras with partial operations based on a generalization of Lawvere's theories from finite products to finite projective limits.

On this categorical basis the chief scientists of ROBOTRON developed in the 1970s the theory of *Partial Algebraic Specifications* including the important concept of *Canons* for *Parameterized Abstract Data Types*. Several years later it turned out that the concept of *Free Generating Constraints* developed in the West had been invented already before in the East as *Canons*. In fact the concept of Canons is one of the main concepts in " Theorie der Äquoide ", published in German as *Habilitation Thesis* of Horst Reichel in 1979. The publication in German language was one cornerstone of the information hiding policy between East and West in response to intended technology hiding between West and East.

The hidden success of ROBOTRON is the fact that IBM was not aware of this theory advantage of ROBOTRON, while ROBOTRON was fully aware of the technology advantage of IBM.

2nd Period (1980-89)
Warm Up in spite of Cold War

The period 1980-89 was the final period of the *Cold War* between the West and the East. Travel from East to West was almost impossible, while travel from West to East was possible, but in general not very attractive. An exception was the conference on *Mathematical Foundations of Computer Science* (MFCS'80) in Rydzyna (Poland), 1980.

In retrospective one of the main success stories of MFES'80 was the *know-how transfer: East - West – West - East*, represented by Hupbach and Horst Reichel (GDR School) and two different schools of the West: The initial algebra approach in the sense of ADJ was represented by Hartmut Ehrig and Hans-Jörg Kreowski (Berlin School), while the loose and final algebra approach in the sense of Guttag was represented by Manfred Broy and Martin Wirsing (Munich School).

In fact, this was the first meeting between these three schools - but not the last one - leading to a first warm up between the three schools representing - in view of Eastern politics - three different states: GDR, West Berlin and FRG (Federal Republic of Germany).

Fortunately it was not the last meeting, but a starting point of a fruitful competition and cooperation in the algebraic specification community. This cooperation was continued by a two-month visit of Horst Reichel in Edinburgh in 1982 on

invitation by Rod Burstall, who had started his cooperation with Joe Goguen on algebraic specifications already in the late 1970s. An important contribution concerning the topic "Initial Algebra versus Final Algebra Semantics" was the paper of Horst Reichel at the Hungarian Computer Science Conference 1981 with the title "Behavioral Equivalence: A Unifying Concept for Initial and Final Specification Methods".

The Golden Age of Algebraic Specification Schools and Languages - started in the 1970s and continued until the late 1990s - can be summarized roughly by the following development steps:

- Initial Algebra Approach (Liskov-Zilles-ADJ ...)

- Initial Partial Algebra Approach (Hupbach-Kephengst-Reichel ...)

- Loose and Final Algebra Approach (Guttag-Horning ...)

- CLEAR-OBJ (Burstall-Goguen-Tardo)

- LOOK (ADJ-Ehrig-Lucas-Zilles)

- ACT ONE/TWO (Ehrig-Kreowski-Mahr-Weber ...)

- CIP-ASL-SPECTRUM (Broy-Wirsing ...)

- LARCH (Guttag-Horning-Wing ...)

- PLUSS (Gaudel ...)

- European Variety of Algebraic Languages (Orejas, Bidoit ...)

- CASL (COMPASS/CASL WG)

- COCASL - HASCASL (Reichel-Bremen Group ...).

Coming back to the title of the 2nd Period: The publication of his book "Structural Induction on Partial Algebras" in the Akademie Verlag, Berlin, 1984, and the revised version "Initial Computability, Algebraic Specifications and Partial Algebras", in the Oxford University Press in 1987 can be considered as Warm Up Steps of HR in East and West respectively.

As a side effect of his warm up period Horst Reichel became "Professor für Algebra" at the "Technische Hochschule Magdeburg" from 1980 till 1987 and "Professor für Algebraische und Logische Grundlagen der Informatik" at the "Universität Dresden" since 1987.

The *Scientific Warm Up Steps* of HR in the *West* were accompanied by *Political Warm Up Steps* in the *East* by the following events:

- Solidarnosc (Lech Walensa, Gdansk)

- Glasnost (Michael Gorbachow, Moscow)

- Escape of East Germans via Hungary/CSSR

- Monday Demonstrations "Wir sind das Volk" (Leipzig)

- Opening/Turn Down of the Berlin Wall (Nov 9, 1989, Berlin).

In this period HR was lucky to participate in several different kinds of "Reise-kader", which allowed a small number of East German scientists to attend conferences and workshops in the capitalistic world, like FRG and other Western European countries. Especially HR was able to join several ADT-workshops, starting in the begin of the 1980s.

3rd Period (1990-2005)
Footprints in the International Society

The opening of the Berlin Wall on November 9, 1989, was the - almost unexpected - culmination of the soft revolution in East Germany leading to the German Reunion on October 3, 1990. This was not only the most important historical event for Germany after the 2nd World War, but - almost at the same time - the end of the Cold War between East and West, also on the international level.

What have been the consequences for the people in East Germany?

On one hand free movement between East and West and access to all kinds of goods ranging from bananas to fancy cars. The West German DM was the most obvious symbol for the transfer of West German standards from West to East.

On the other hand the most dangerous side effect of the reunion was the "Abwicklung" of almost all institutions and companies in East Germany leading immediately to a very high rate of unemployment for people in the former GDR. This kind of "Abwicklung" had also significant consequences for the Academy of Science in the GDR and for all universities in East Germany. Within a short period all professors and scientists at the Academy of Science and at all the universities were evaluated not only from a scintific but also from a political point of view. Even more, almost all old contracts were cancelled and also a large number of the corresponding positions. For the remaining positions of professors new calls were launched. Even HR had to reapply for his own professorship at TU Dresden.

Due to his excellent scientific reputation in East and West his reapplication was successful.

After all these political changes HR could finally continue his scientific career. An important cornerstone was his article "An approach to object semantics based on terminal co-algebras" published in MSCS, 1995, where he showed how to use final co-algebras as basis for the axiomatic specification of reactive systems. He became one of the fathers of co-algebraic methods and founding member of the CMCS-Workshops on "Coalgebraic Methods in Computer Science", where the first CMCS-workshop 1998 in Lisbon was a satellite event of the first ETAPS conference.

Moreover HR became founding member of IFIP WG 1.3 on "Foundations of System Specifications" and of the DFG Graduate School at TU Dresden. Together with Till Mossakowski, Lutz Schröeder and Markus Roggenbach in Bremen he developed the coalgebraic specification language CoCASL as extension of the "Common Algebraic Specification Language" CASL.

Finally he became founding member of the steering committee of CALCO, with first CALCO-conference in Swansea (UK), 2005.

Altogether the footprints of HR in the international society can be summarized by the following main contributions of HR:

- Partial Algebras and Constraints/Canons for Abstract Data Types

- Behavior Equivalence as Unifying Concept for Initial and Final Specification Methods

- Final Coalgebras as Semantics for Reactive Systems

This means that HR is not only one of the fathers of initial algebra as well as of final coalgebra, but certainly also one of the most experienced scientists on the interaction of both fields from the mathematical and the computer science point of view.