

Peter Landin Semantics Seminar 2020 Algol 60 @ 60

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Introduction: Rationale

- Algol 60 is 60 years old.
- Algol 60 was defined with semantics in mind.
- Peter Landin's formal semantics of Algol 60.
- An example of burgeoning new interest in formal semantics of programming languages in 60-70s
- So: an apposite topic for PL Semantics Seminar.



Content of seminar

- Short history of Algol 60.
- The authors of the *Revised Report*.
- Relationship of Algol with formal ideas, λ -calculus.
- Peter Landin's approach to formal description.
- Overview of semantics zeitgeist.
- Other formal descriptions.
- Fascination with Algol: why?
- Postscript; quote from Wittgenstein in *Algol 60 Report*.



Short History of Algol 60

- Conference in Zurich 1958
- Preliminary Report: Algol 58/IAL, Comm ACM
- Informal meeting in Mainz Nov. 1958 prompted:
- Algol implementation conference (40) Copenhagen Feb. 1959: “hardware group” (character sets, input eqp)
- Algol Bulletin ed. Peter Naur Regnecentralen Copenhagen 1959-88, 52 issues: discussion forum
- European Algol conference Paris Nov. 1959 (c50):



January 1960 Conference

7 European representatives

- Association Française de Calcul
- British Computer Society
- Gesellschaft für Angewandte Mathematik und Mechanik (GAMM)
- Nederlands Rekenmachine Genootschap
- (Learned Societies for Computer Science in Europe)



USA Contributions

- Algol working groups on ACM Committee on Programming Languages
- 7 representatives to Jan. 1960 conference after preparatory meeting in Boston Dec.1959
- (William Turanski killed in road accident just before Jan. 60 conference)
- New draft Report developed from Preliminary Report, formed basis of **Revised Report** at Jan. 60 conference
- *Finally* conference in Rome April 1962 to correct, eliminate ambiguities, clarify; ed. Mike Woodger.



Authors of Revised Report 1

- 13 authors: 7 countries: Denmark, France, Netherlands, Switzerland, UK (1 each), Germany 2, USA 6.
- Report dedicated to memory of William Turanski



Authors 2

- Peter Naur 1928-2016 Denmark. U Copenhagen etc., Regnecentralen (Danish computer company). ACM Turing Award 2005. SW Engineering, SW Architecture, BNF; Calculated orbits of comets on Cambridge EDSAC. Edited Algol Bulletin and Revised Report.
- F L Bauer 1924-2015 Germany. Maths, Theoretical physics, CompSci, Stanislaus early computer 1951-58, coined term SW Engineering 1968 NATO conference. PhD supervisor of Manfred Broy and David Gries.
- Adriaan van Wijngaarden 1916-1987 Netherlands. Director Mathematisch Centrum Amsterdam, first Dutch computer ARRA 1952, background in engineering and hydrodynamics but soon moved to computing.

Authors 3

- Klaus Samelson 1918-1980 Germany. Maths, Physicist, computer pioneer, Numerical Analysis. Early computer PERM (1955).
- Heinz Rutishauser 1918-1970 Switzerland. Numerical maths (Analysis). First Swiss computer ERMETH.
- Bernard Vauquois 1929-1985 France. MIT. Maths, Astrophysics, computing, formal grammars, natural language translation (Russian → French 1960-85), computational linguistics.
- Mike Woodger 1923-present UK. NPL. ACE, Algol, ADA, IFIP WGs, profile in *Resurrection 50*, early grounding in mathematical logic.

Authors 4

- J W Backus 1924-2007 USA. ACM Turing Award 1977 “Can Programming be liberated from the von Neuman style?”, W W McDowell award 1967, US National Medal of Science 1975; devised Fortran, BNF, FP.
- Alan J Perlis 1922-1990 USA. Maths, MIT, Purdue, CMU. First ACM Turing Award. Early computers, compilers.
- John McCarthy 1927-2011 USA. Stanford U. Mathematician. ACM Turing Award 1971, National Medal of Science 1990, Benjamin Franklin Medal 2003. AI, LISP, Math Logic. Coined term “Artificial Intelligence”.
- Joseph H Wegstein 1922-1985 USA. Physics, engineering physics, international standards in information processing, automated fingerprint recognition.
- J (Julien) Green USA. IBM NY but also U Delft. Papers on IAL and Algol c1958-9. Algol implementation? Dates unknown.
- C (Charlie) Katz USA. GEC Phoenix but also U Delft. Moderated at ACM conference 1982, IAL. Dates unknown.





Frame 8. Paris conference on ALGOL 60. Seated clockwise from left: Julien Green, Klaus Samelson, Charlie Katz, Peter Naur, Mike Woodger, Joe Wegstein, Bernard Vauquois, Aad v. Wijngaarden, Alan Perlis, Heinz Rutishauser, Fritz Bauer, and John Backus.

Algol 60 and λ -calculus 1

- **4.7.3.2 Name replacement (call by name).** Any formal parameter not quoted in the value list is replaced, throughout the procedure body, by the corresponding actual parameter, after enclosing this latter in parentheses wherever syntactically possible. Possible conflicts between identifiers inserted through this process and other identifiers already present within the procedure body will be avoided by suitable systematic changes of the formal or local identifiers involved.



Algol 60 and λ -calculus 2

- **4.7.3.3 Body replacement and execution.** Finally the procedure body, modified as above, is inserted in place of the procedure statement and executed. If the procedure is called from a place outside the scope of any non-local quantity of the procedure body the conflicts between the identifiers inserted through this process of body replacement and the identifiers whose declarations are valid at the place of the procedure statement or function designator will be avoided through suitable systematic changes of the latter identifiers.



Algol 60 and λ -calculus 3

- “suitable systematic changes of... identifiers...”

α -conversion $\lambda V.E \rightarrow \lambda V'.E[V'/V]$

- “the procedure body, modified as above, is inserted in place of the procedure statement...”

β -conversion $(\lambda V.E_1)E_2 \rightarrow E_1[E_2/V]$



Algol Bulletin

- Edited by Peter Naur
- 1959-1988, 52 issues
- Initiated at Algol Implementation conference in Feb. 1959
- Forum for discussion of definition issues
- IFIP TC 2.1 Working Group Algol
- April 1962 conference, Editor M. Woodger to correct errors and remove ambiguities: Bulletin 14
- “Algol lawyers” (Marshall Harris)



Early Algol Implementations 1

- Dijkstra & Zonneveld's compiler for Electrologica X1 (August 1960; the first).
- Randell & Russell's Whetstone compiler for KDF9 (reduced version for DEUCE because of delay to KDF9). Randell in *Resurrection* 50. c1964.
- Tony Hoare's Elliott 803 Algol 1961-2. Hoare in *Resurrection* 48.



Early Algol Implementations 2

- Atlas Algol, Bob Hopgood, Alex Bell & others: c1965. Hopgood in *Resurrection 50*. Used for years in an ever increasing program to simulate the Atlantic ocean for the meteorological office (Chris Hobson).
- Roger Abbot, PDP8, used by Richard Dawkins, late 1960s (*An Appetite for Wonder*, 2013, p234).
- Wikipedia list 20 compilers by end 1965 and 26 by end 1972, but there are **many more**.



Early Algol Implementations 3

- The first 26 compilers listed:

Netherlands 3

USA 7

Denmark 2

Sweden 1

West Germany 1

East Germany 1

UK 3

Comecon 1

Italy 1

Canada 1

Norway 1

USSR 1

Estonia 1

Poland 1

China 1

Peter Landin's Semantic Description

- P. J. Landin: A Correspondence Between Algol 60 and Church's Lambda-Notation Part I. CACM Vol. 8 No. 2 Feb. 1965; Part II Vol. 8 No. 3 Mar. 1965.
- Landin's CACM paper based on lectures invited by George Couloris at ULICS in spring 1963: "Logical Foundations of Programming".
- Presented "A Formal Description of Algol 60" IFIP working conference Baden Sept. 1964.



Landin's Semantic Description 2

- Peter Landin was not an author of the Algol 60 report but **was** an adviser at the April 1962 conference in Rome.
- “Anyone familiar with both Church's λ -calculi and Algol 60 will have noticed a superficial resemblance...”
- “Some of the semantics of Algol 60 can be formalised by establishing a correspondence between expressions of Algol 60 and expressions in a modified form of Church's λ -notation” CACM paper Part I.



Landin's Semantic Description 3

- “Formal syntax has been used to practical advantage by language designers and implementers. There might be analogous advantages in formal semantics” CACM paper Part I again.
- Landin makes much use of terms defined in a previous paper [The mechanical evaluation of expressions. Computer Journal Vol. 6 No. 4, Jan. 1964].



Landin's Semantic Description 4

- Semantics described in an operational way in terms of an abstract machine that interprets a language similar to λ -notation into which an “abstract Algol” has been translated.
- Reflects an ambivalence in Algol: it tries to be simultaneously an abstraction of what an imperative computer can do and an expression of some mathematics that can be evaluated by a computing machine.



Landin's Semantic Description 5

- Landin's "Abstract Algol" is "over-tolerant", "in that a mismatch will not lead to a rejection if the procedure is never applied, or if it is exited unnaturally and thus evades producing a result"
- Nonchalant? A compiler built to this model would run programs that would be legitimately rejected by other "correct" compilers. Not good for portability!
- Furthermore: "Declarations are considered as giving initial values to the local identifiers. For instance, integer and real identifiers are initialised... to... zero. A Boolean is initialised to false". Could radically alter the progress of an execution. The dangers of over-design!



Landin's Semantic Description 6

- But Landin's semantic description is a demonstration, not a definition. And a domain-theoretic approach to program language semantics, which gives a convenient meaning to undefined values, was not to be conceived for some further eight or so years [Scott 1976]. Perhaps we in turn should be tolerant.
- The Introduction to the Algol 60 Report ends: "The present report represents the union of the Committee's concepts and the intersection of its agreements". Authors firmly grounded in set theory!



Report starts with a Wittgenstein quote:

- Was sich überhaupt sagen läßt, läßt sich klar sagen; und wovon man nicht reden kann, darüber muß man schweigen.
- What can be said at all, can be said clearly; and whereof one cannot speak, thereof one must be silent.
- *Tractatus* 4.116; 7 (last sentence).



Wittgenstein's *Tractatus*

- The world is everything that is the case. The world is the totality of facts, not of things. The world is determined by the facts, and by these being all the facts.
- Presaging Programs as Predicates?



References and Acknowledgements

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- [5] D. Scott: Data Types as Lattices, SIAM Journal on Computing, Vol. 5, 1976, pp 522-587.
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- [7] Tim Denvir: Algol 60 @ 60. FACS-FACTS 2020-1. <https://www.bcs.org/media/5842/facs-jun20.pdf>
- [8] Michael J.C. Gordon: Programming Language Theory and its Implementation, Prentice Hall 1988.
- [9] Kees Pronk : private communications.

