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NOTE FROM THE EDITOR

After an absence of two years we are happy to announce that we are now in a position to continue the publication of Quaestiones Informaticae. The first Volume of QI consists of three numbers, and appeared during the period June 1979 till March 1980 under the editorship of Prof Howard Williams. Because Prof Williams took up a post at the Herriot-Watt University in Edinburgh, he had to relinquish his position as editor. The Computer Society of South Africa, which sponsors the publication of QI, appointed me as editor, whereas Mr Peter Pirow took over the administration of the Journal. The editorial board functions under the auspices of the Publications Committee of the CSSA.

The current issue is Number 1 of Volume 2. It is planned to publish altogether three issues in the Volume, with most of the papers coming from the Second South African Computer Symposium on Research in Theory, Software and Hardware. This Symposium was held on 28th and 29th October, 1981. At present it appears that most of the material published in this Journal comes from papers read at conferences. We invite possible contributors to submit their work to QI, since only the vigorous support of researchers in the field of Computer Science and Information Systems will keep this publication alive.

G WIECHERS

November, 1983

The Design Objectives of Quadlisp

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Abstract
Quadlisp is a symbol manipulation language for sophisticated users, and it is an improper extension of Lisp 1.5 (in the same sense that Pascal is an improper extension of Algol). Elements from Lisp thus are basic to the language, but other objectives such as data-typing and general principles of modern language design have also been incorporated. Pertinent aspects of these considerations are discussed, followed by a discussion of the pragmatic considerations. Pragmatics relate to the use of the language on machines, or just by people as a tool for developing programs.

1. Introduction

The design objectives of a language constitute not only a set of principles, guidelines and constraints that are applied during the development of the language, but also a set of criteria for judging the final product: the language in its environment. As usual in Computer Science, the objectives may be in conflict, and the designer has to consider trade-offs, which is one reason why Allen [1] says:

> 'Language design is not a pastime to be entered into lightly . . .'

The design objectives of Quadlisp [8] may be summarized:

> Quadlisp is a sophisticated language with extensive data types and control structures. It is an improper extension of Lisp 1.5, with a unity and integrity based on a small number of language principles.

The objectives that are summarized above are classified and discussed under:

1. *Usage:* Objectives relating to the areas of endeavour where the language may be used, and also relating to the type of programmer who will use the language.
2. *Lisp Philosophy:* The ideas and principles from Lisp 1.5 that form the basis of Quadlisp.
3. *General Principles* of language design: The objectives that concern language designers in general.
4. *Pragmatics:* Objectives relating to the implementation and use of the language.

2. Usage

2.1 The Quadlisp Programmer

Quadlisp is a sophisticated language for programmers who have mathematical maturity [4]. They should not only have programming experience, but also algorithmic maturity. The language is not designed to be a tool for the novice, and a solid background in Lisp 1.5 or in functional programming [5] is recommended to prospective users, as is an exposure to Dijkstrassian nondeterminism [3].

2.2 Application Areas:

Quadlisp is a language for symbol manipulation, and for the manipulation of symbolic objects, in particular programs. The particular areas of meta-programming to be addressed are:

1. Operational Semantics: The language must make it easy to derive a VDL interpreter for a given program from the VDL semantics of a given language. From a VDL interpreter it should be easy to derive a contour model of the program to be used for automated desk-checking and an empirical assessment of the program complexity.

2. Program Verification and Equivalence: The language must enable interactive program verification systems to be implemented and should allow for the investigation into the equivalence problem of specific programs.

3. Meta-Theory of Computing: The results of the meta-theory of computing [2] i.e. automata and formal language theory, must be expressable in the language for use by programmers in program development and for cases 1 and 2 above.

3. Lisp Philosophy

A sound principle of language design is that a new language should be based on a known language. The new language typically is an improper extension of the old language, i.e. the base language is not a proper subset of its extension (cf. Algol and Pascal). The principles taken over from the base language should however be clearly stated. Quadlisp then is based on the following aspects of Lisp (see e.g. [6]).

1. Programs in Quadlisp may be treated as data: a program (strictly speaking, a function call), and a function, may be the result of a computation.

2. The macroscopic semantics of the Quadlisp interpreter is defined in Quadlisp in the form of an EVAL/APPLY pair of functions with their subsidiary functions. The Read-Evaluate-Print cycle of interactive computation uses an interpreter which is an implementation of the EVAL/APPLY functions.

3. λ-Notation is used but not the λ-calculus.

4. Internal and external data structures are the same, in particular, files are kept in any one of the standard Quadlisp data structure forms.

5. All programs are of the Lisp type FSUBR in the sense that functions are called before the arguments are evaluated, and arguments are evaluated as late as possible or not at all.

4. General Principles of Language Design

A number of well-known computer scientists have given criteria for language design, and these criteria have been summarized and classified by [7]. The specific criteria that were used in the design of Quadlisp are:

1. A variety of data structures

2. A variety of control structures
3. Nondeterminism
4. Sound evaluation
5. Declarations
6. Compactness
7. Verification

4.1 A Variety of Data Structures

A variety of typed data structures should be available, together with appropriate functions to manipulate these structures. The user must be able to recursively define his own data structures in terms of the data structures that are available in the language.

The functions or operators on the data structures may be classified into the following set of not necessarily mutually exclusive classes. Furthermore the classification is indicative only and is not intended to be complete:

Function types:

1. Predicates: Existence eg. testing for type
   Comparison eg. equality, order, substructure
   Element eg. components, values
   Structures eg. isomorphism
2. Creation — static and dynamic
3. Destruction — removal of parts or whole structure
4. Combination — eg. set union, list catenation
5. Modification — eg. replacement of elements
6. Traversal
7. Selection: access to substructures and elements.

4.2 A Variety of Control Structures

A language should have control structures that are powerful enough to enable the programmer to do the ordinary types of control namely:

1. Conditional and case
2. Iteration: do-while, do-until
3. Recursion
4. Functions, subroutine and co-routine calls
5. Sequential and parallel processing

4.3 Nondeterminism

Nondeterminism is one way of allowing the programmer not to over-constrain his solution. The major techniques in nondeterminism are:

1. Backtracking — depth first
   — breadth first
2. Dijkstrassian guarded constructs.

4.4 Sound Evaluation

The values of function calls should be the same as in mathematics, and extensions to functions must be defined by rules and not by an ad hoc assignment of values to particular calls with extremal values of the arguments.

4.5 Declarations

Variables should be typed, and there are two aspects to this typing:

1. A variable may be data-typed, i.e. it can only assume values out of certain classes of data.
2. A variable may be control and scope-types, i.e. it can only be accessed in certain circumstances.

All Quadlisp variables are typed with respect to scope. No variables are typed with respect to the values that they may assume except in λ-expressions where the λ-variable may be typed.

4.6 Compactness: Unity and Integrity

The language must be compact, and gothic extensions must be eschewed: the user must feel that he knows and controls the language.

4.7 Verification

Programs in the language must be verifiable: this implies that the language must be formally defined and that it must be axiomatizable and that a proof theory can be given for the programs written in the language.

5. Pragmatics

Most of the points given here under pragmatics are actually covered in one of the criteria already given. The use of the language was a major concern throughout the design and it is therefore desirable to name the pragmatic concerns of the designer explicitly.

1. **Representation:** The data structures and the control structures must have clear, unambiguous, useful representations in the following ways:
1.1 Linear — for writing programs.
1.2 Graphic — for representing data structures.
1.3 Machine — for implementing the language, which of course, must be machine independent.
2. **Documentation:** The language must allow for:
2.1 Comments.
2.2 Assertions.
2.3 Program layout.
3. **Symbols:** Mathematical and programming symbols should be used in their customary meanings when possible. All symbols should have names, and symbols only used if they convey their intended meaning, e.g. for set intersection.
4. **Principles:** The language should have a clear set of principles — in addition to the Eval/Apply semantics — to allow human interpretation of programs. The principles are listed below and a full discussion is given elsewhere [9].
4.1 A classification of the data structures from the abstract point of view.
4.2 Three evaluation strategies are available:
Sequential evaluation.
Parallel evaluation.
Equi-simultaneous evaluation: similar to multiprogram ming but it is not deterministic.
4.3 Structures together with evaluation strategy yield the evaluation tactics, eg. depth-or breadth-first backtracking.
4.4 Typing and declarations of use and scopes of variables.
4.5 In a function call (or a functional, eg. the conditional) — eg. (F A_0 A_1 A_2) — the A_0,...A_n are called the proto-arguments. These proto-arguments yield the arguments when they are evaluated: evaluation is done as late as possible, depending on structure.
4.6 Control structure principles: these are:
Conditional: return the first available value.
Program form: all available values are returned.
Repeat while: repeat over the minimum number of component forms.
Do all until: repeat over the maximum number of component forms.
4.7 In all basic pairs of objects in Quadlisp, the left-hand side of pair controls access to the right-hand side of the pair. The hand side can be considered to be a guard, or an address, of the right-hand side.

6. Conclusion

The author would like to acknowledge his indebtedness and gratitude to Prof Gerrit Wiechers and Dr Nick Phillips who contributed much to Quadlisp achieving its objectives. Their timeous (and often harsh) criticisms had the effect that much exuberent growths were pruned from the language to give it its final compact and unified gestalt.

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[8] S.W. Postma, Quadlisp Language Reference Manual, UNISA CS Colloquia, **CS. 1. 81**, (1981.

[9] S.W. Postma, The Principles of Quadlisp, 2nd SA Computer Symp., Pretoria 1981.

Notes for Contributors

The purpose of this Journal will be to publish original papers in any field of computing. Papers submitted may be research articles, review articles, exploratory articles of general interest to readers of the Journal. The preferred languages of the Journal will be the congress languages of IFIP although papers in other languages will not be precluded.

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References

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1. ASHCROFT, E. and MANNA, Z. (1972). The Translation of 'GOTO' Programs to 'WHILE' Programs, in *Proceedings of IFIP Congress 71,* North-Holland, Amsterdam, 250-255.
2. BÖHM, C. and JACOPINI, G. (1966). Flow Diagrams, Turing Machines and Languages with only Two Formation Rules, *Comm. ACM,* **9**, 366-371.
3. GINSBURG, S. (1966). *Mathematical Theory of context-free Languages,* McGraw Hill, New York.

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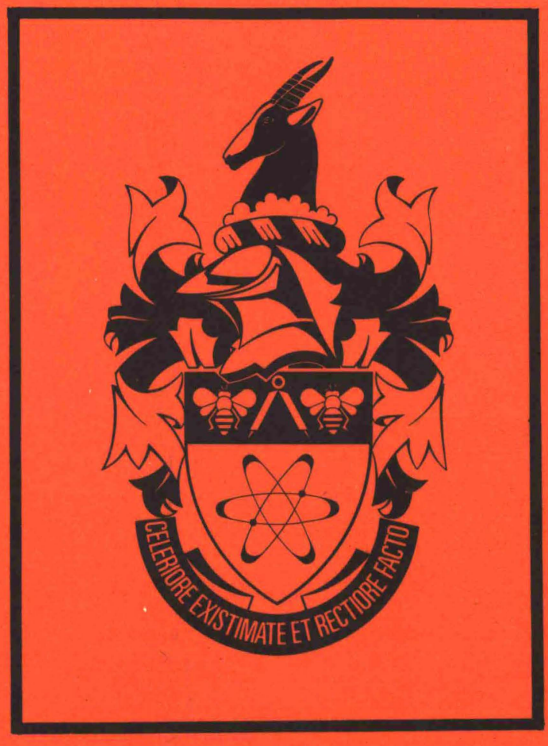

Contents/Inhoud

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