2.3 THE PRESENT GREAT CRISIS IN MATHEMATICS:

THE FOURTH

So far we have shown that the absence of the time concept in the foundations of mathematics is the prime motive for the occurrence of the three well-known great crisis already described.

Fraenkel [08], in the conclusion about the significance of the set theory for mathematics and logic says that, “in spite of the old and recent attacks on the set theory, the majority of present-day mathematicians presumably agree with Hilbert’s dictum that nobody will expel us from the paradise created by Cantor. We should, therefore, include set theory among the great scientific revolutions which have transformed our outlook so deeply and surprisingly since the end of the nineteenth century”.

Particularly, we prefer another Hilbert’s quotation, namely: “We hear within us the perpetual call: There is the problem. Seek its solution. You can find it by pure reason...”.

Kleene states in his book [09] that the sets include the empty (also called null, vacuous, or void) sets which have no elements, and the unit sets which have a single element each. The empty set is written as “0” or “φ”; the unit set with a sole element “a” as “{a}”; and the set having “a, b, c, ...” as its elements, as “{a, b, c, ...}”. A set may also be called aggregate, collection, class, domain, or totality. Set means, explicitly, “things given in the same time” or “conjunctive things”. But these different subsets mentioned by Kleene, have their existence in different times, that is, they are in disjunction times; for this reason it is not possible to accept Kleene’s inclusion, because these sets are not in the same time, that is, they are not conjunctive sets.

As we mentioned above, our introduction of the time concept in the foundation of mathematics brings goods results as we will see latter on.

The third great crisis in the foundations of mathematics [02] as reported, occurred at the beginning of this century. In our opinion, it was reactivated in 1931 when Gödel [10], introduced his famous Incompleteness Theorem, known as Gödel's Proof [11].

Professor Gödel's conception of recursive function, given through the succession of prime number to obtain his famous “Godel’s Numbering”, was arbitrary. That is, it was not mathematically isomorphic, as we had used in our Numerical Transform.
In 1938, Shannon, made the first application of Boolean Algebra concepts in switching circuits [12]. In 1943, the so-called Illinois Group led by McCullogh and Pitt [13], showed the feasibility of artificial thought.

Since then, there has been a series of swift and remarkable developments in binary techniques. Among these we have: The EDVAC report [14]; the construction of the first thinking machine (ENIAC, 1946); the development of the transistor (Bell Telephone Staff, 1948); the tiristor (General Electric Staff, 1957); shrinking transistor followed by the successive miniaturisation: canned transistor (1958); salt-size transistor (1964); 2,000-bit chip (1973); boards with 185,000 circuits and 2.3 megabits of memory apiece (1985); 64 megabits memory chip (1992) [15], etc.

Because of these recent technological developments, Boolean Arithmetic emerged. In turn, it brought about a conceptual evolution derived from a series of researches carried out since our creation of the Numerical Transform (NT) concept [16]. It is an immediate consequence of the introduction of the concepts of time in the foundations of mathematics. This new symbolic and logical arithmetic is isomorphic to the well-known Boolean Algebra according to the mathematical conditions given by Whitesit [17]. For this reason it replaces literal symbolism with numerical symbolism (bits) from the arithmetic language. In other words, this new Boolean Arithmetic makes use of an essentially numeric symbolism for its language, in the same manner as the Boolean Algebra employs an essentially literal symbolism.

These isomorphic conditions also brought about a third aspect of the most general Boolean Mathematics, called Boolean Geometry where graphical language replaces the other corresponding arithmetic and literal languages of aspects of Boolean Arithmetic and Boolean Algebra.

With this new Boolean Geometry, in which we have the concepts of “Spaces ($S_n$) / Times($T_n$)”; it was possible to obtain the graphical representation of unification of the finite and transfinite numerical field, as we can see further on.

On the other hand, this new geometry in particular, can justify with its graphical representation (discovered by technologists, not by mathematicians) that it was possible to obtain the miniaturisation of the chip employed in the present state of the art of Microelectronics.
Boolean Mathematics, therefore, is made up of aspects from Boolean Algebra, Arithmetic and Geometry, which are different symbolic expressions of the same abstract symbolic thought.

The abstract symbolic thought is an interface between the human thought and the artificial thought. The human thought externalises its logical propositions by the use of speech and it has its own *mental space* and *mental time*. The artificial thought enables the processing of the above logic and has its own *physical space* and *physical time*. Thus, we can say that the *human logic thought* is represented through the *mathematicalization* of its *abstract symbolic thought*. Therefore, this interface needs by analogy with the other two, the well-known *mathematical space*, as well as the *mathematical time*, as defended by us. It should be mentioned that the *mathematical space* and *mathematical time* can be completely processed in the domain of world’s present technological evolution.

The emergence of Boolean Arithmetic, as a numerical aspect of Boolean Mathematics, provides new perspectives in the mathematical training of electrical engineers. Moreover, it represents a common nucleus in the field of artificial intelligence (AI), and therefore allows another step forward in the analysis and synthesis of logical circuits and computation.

By means of Boolean Arithmetic it has been possible to obtain the complete solution of any simultaneous Boolean Equation Systems, still not widely known, a subject of extreme relevance to the computational mathematical logic [16]. In other words, the emergence of Boolean Arithmetic, has as a consequence the obtention of a general and practical numerical method of solving Boolean Equation Systems, as we can see in Chapter 6. An equivalent analytical method we can be seen in Chapter 5. This analytical method was obtained after that numerical method was discovered. In Boolean Algebra, a similar method has not yet been obtained ([18], [19] and [20]).

The application of Boolean Arithmetic to computing has made the creation of the Technical Linguistics possible and has determined the launching of the new computational language called “*Esperangol, Direct and Reverse*”, whose fundamental concepts are given in Chapter 9. Such new computational language is unique and reversible, since it is based on *machine mathematical language*, which replaces the present *chaotic* machine language. In other words, Technical Linguistics has been developed as an immediate consequence of the above-mentioned Boolean arithmetical method. This is a new sector within the area of *artificial thought*. Traditionally, it is said that linguistic texts can be
interpreted, whereas in technological linguistics, we foresee the possibility of introducing the concept of mathematical deduction of texts, as we can see in Chapter 11.

Therefore, it was possible to introduce the rigor of Boolean Algebra in the design of real time software. Its eventual failure blocks the computer and might even provoke big accidents. Examples of current real time computing systems include flight control systems [21], railway-signalling [22], control of automatic engines, nuclear power, space shuttle and aircraft avionics, robotics, etc.

The risks of software, especially in systems working in real time computing, have brought several well-documented horror problems. Independent teams, working with Chinese walls between them write software for each computer operating in the great majority of the decision systems. Would you trust your life to a computer? [21]. A software problem may have prevented the Patriot missile system from tracking the Iraq Scud missile that killed 28 American soldiers during the recent Gulf War [22].

Furthermore, such an approach shall make the introduction of any kind of virus in the computation processes impossible, besides allowing the automatic production of software and firmware program mathematically free of failures. In other words, that new mathematical machine language mentioned above, which is a consequence of Boolean Arithmetic will make the viral proliferation impossible. This solution being mathematical and therefore, abstract as Hilbert would desire, will be universal. This new language, Esperangol, Direct and Reverse (Chapter 9), disrupts some current conclusions about the completeness of linguistic axiomatic system [11].

As we have seen above, when Gordon [02] refers to this crisis in mathematics, in our opinion, it was pointed out that the common cause was represented by the absence of the concept of time in the mathematical foundations, i.e., this lack was responsible for those successive appearances of such crisis.

This problem has not been solved yet, except by our group, Group of Studies of Technological Mathematician’s Movement (GEMMT). As we can see in Chaitin [23], it reinforces our idea that the 4th Great Crisis in Mathematics, due to the growing need for mathematicalization of Information Science.

In effect, the contribution of Shannon [12] in 1938 is a landmark in the Information Science Age, despite Von Neumann’s contributions, which only occurred in 1942 [14]. In an interview [24], there was a reference to Shannon’s phrase: “I’ve always loved that word ‘Boolean’.”
This phrase summarises the unforgettable and pioneer contribution (1938) of Professor Shannon to apply Boolean Algebra to the relay switching circuits, seven years before Von Neumann obtained the technological conditions (1945), that allowed the initiation of the Information Science Age. But, this happening is a very important one, since it was the last time that Mathematics was successfully applied to this new field of scientific development, represented by Information Science.

Nowadays, Mathematics is not used in present microelectronics in order to obtain a mathematically zero failure programming. Even the present name, *Software Engineering*, is no longer adequate, and it should be called *Empirical Software*, because of the absence of mathematics. It was, in fact, the belief that systematic engineering methods could be applied to the software process that led to the coining of the term *Software Engineering* in 1978 [25].

We are sure that Professor Shannon would love the word ‘Boolean’ even more, if he had been able to know that it was already possible to do the same thing as he did in the relay age (1938) with the isomorphic Boolean Arithmetic, but now in the microelectronic age. The mathematical programming without any logic ‘bugs’, that is, without human failures, could be obtained through Boolean Mathematics.

Recently, the magazine Byte review [26], presented the state of the art of artificial intelligence, in which the lack of a common nucleus of the different applications is emphasised at the beginning and at the end of the presentation of the articles. The editor tries to justify the proposed dilemma, “AI: Metamorphosis or death?”, as follows:

In the beginning...

"Is artificial intelligence dead?" If it’s not, it is without doubt undergoing a major transition, but whether that change precedes a death or a rebirth into different form, I cannot say. The chasms within the AI community are widening to create the appearance of various disciplines, rather than different branches of the same tree. *Which way AI as a whole – if such a concept exists anymore – is headed is a good question*.

In the end...

"Is AI dead?"

Not yet, but it’s either going through the throes of a terminal illness or the agony of childbirth. Certainly some areas once considered the exclusive domain of AI are alive and well. But whether they will move out permanently on their own or regroup
under AI’s umbrella, I don’t know. And I won’t pretend to match my predictive powers against the likes of Minsk and Winograd”.

We think now that the absence of Boolean Mathematics in the various aspects is the prime motive for the occurrence of this fourth crisis in mathematics, represented by some of the related facts.

We believe, for instance, that with the employment of Esperangol, a direct and reverse computer language (Chapter 9), it is possible to obtain immediate results according to the theoretical findings we have made. Clear, some application to back up these findings are still needed, but it is possible to obtain the following results immediately:

1) This new language makes the introduction of any kind of virus in the computer process impossible;

2) It allows the automatic production of software mathematically free of failures caused by human factors;

3) It allows complete safety in computer real time operation, where there will be no more need for the Ctrl+Alt+Del or Reset keys;

4) It replaces the present chaotic machine language because it is based on mathematical machine language and therefore, it is universal as well as being unique.

On the other hand, the complete and general solution of a Boolean Equation System [16] has allowed reaching the following:

a) The stored program concept without the microprocessor unit from the present Von Neumann’s machine, as we can see in Chapter 14. Then, it will be shown that it is possible because it has been obtained from the general solution of the basic mathematical model of any digital system. This solution was unknown until now, as a stored program concept [27];

b) The complete solution of the Real Time Computing Problem because of its failure to meet timing constraints will result in economic, human and ecological catastrophes. As we can see in Stankovic [28], Real Time Design has not attracted the attention of academic computer scientists and basic research funding agencies that it deserves. However, this lack of adequate attention is due, in our opinion, to this present fourth great crisis in the mathematical foundations described above. This lack is even greater because of the existing
misconception about real-time system. After describing the very common misconception, Stankovic concludes that:

“Real-time systems have brought about unmet challenges in a wide range of computer science disciplines. Each of these challenges must be overcome before a science of large-scale real time systems can become a reality. The task is formidable, and success will require a concerted effort by many different participants in the computer science community. It will require the enticement of new researches into the field, especially in academia, where relatively little work of this nature is being done. We must co-ordinate interaction between research efforts in universities and development efforts in industry so that academic researchers will be familiar with key problems faced by system developers, and system developers will be aware of relevant new theories and technologies”.

This article [28] is recommended as a useful starting point for readers unfamiliar with this field. In another article by the guest editor’s about real-time system [29], we came across the following reasoning:

“We hope this special issue stimulates more readers to conduct research in this field. It is relatively new, even by the standards of computer engineering. As a result, there are many important problems in specification, design, validation, task scheduling, and quick fault recovery that must be solved. As we mentioned before, almost every research problem in fault-tolerant computing is also a problem in real-time computing. However, because of the deadlines that characterise real-time systems, the solutions to these problems in real-time computing are frequently more challenging”.

Therefore, recent trends in computing about software’s chronic crisis [30], are expressed by the following very representative words:

“The picture is not entirely bleak. Intuition is slowly yielding to analysis as programmers begin using quantitative measurements of the quality of the software they produce to improve the way to produce it. The mathematical foundations of programming are solidifying as researcher work on ways of expressions program designs in algebraic forms that make easier to avoid serious mistakes. Academic computer scientists are starting to address their failure to produce a solid corps of software professionals.
Perhaps most important, many in the industry are turning their attention towards inventing the technology and market structures needed to support interchangeable, reusable software parts”.

What we offer to this picture is the use of Boolean arithmetic forms to develop program designs instead of algebraic forms, to avoid serious mistakes, including the present undesirable logical bugs.

c) In this very important academic field, it was possible to present three Ph.D. theses ([31], [32], [33]), in 1993, at the Department of Electrical Energy and Automation of the Polytechnic School of Sao Paulo University. The thesis “C.L. P. – A ‘Non-Von’ real-time mathematically programmable” [31], in Chapter 14, is about the search of a solution independently of the problem of the Gray-Code use. The thesis “The engineering of text deduction and the mathematical elimination of nodal real-time incompatibility” [32], in Chapter 11, is about the search of an application in the interpretation of Medical Diagnosis. The Thesis “Real-time block and electronic mathematically microprogrammed interlocking” [33], in Chapter 14, is about the search of an application in the design of firmware microprogrammed interlocking to the railway signalization, with fail safe in its real-time normal operations.