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Why Computers Should Work Only on 0 and 1 ?

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Introduction:

The digitized form of data would be in 0000101011110, 1111010101000011, 11000010101010100110000111, 01010101110100001111 11, 11000101010101010 1. What is this? Why this should contain only two numbers **0** and **1** and why not any other numbers? Computer engineers claim that these – 0 and 1 – are the two levels or states of signal low and high, the absence and presence of signal, low and high potential, no or yes, and so on.

Then, why not any other combination – 0 and 2, 0 and 9 and so on cannot be used. Perhaps, the most suitable may be 0 and ¥, as the smallest imaginable, discernable and recognizable number is zero and the largest is infinity, and they are represented by the symbols – 0 and ¥. But, there has been a debate as to whether ¥ is a number or not. In fact, the western scholars had not accepted that 0 was a number till 12th century and the concept of infinity was not well perceived, defined but the symbol ¥ was adopted only in the 18th century by John Wallis. Moreover, when Computing experts wanted to have only two numbers in the conceived binary number system, besides 0, naturally, the next first and the last and also the biggest number 1 automatically suited their mathematical and logical thinking and computing processes. How the choice could have been made is studied in this paper. Let us study the Binary Number System.

The Binary Mathematics: The "Binary mathematics" or "Binary number system" connotes usage of only two numbers, as "Decimal system" uses ten numbers from 0 to 9. Th usage of 10 numbers is also incorporated in radix or base of the number system and the numbers have positional notation / place values. They are:

Condition for positional notation / place values	Decimal	Binary
The number of digits is equal to the base.	10	2
The largest digit is one less than the base.	10-1=9	2-1=1
Each digit is multiplied by the base raised to the appropriate power for the digit position.	N x 10^n 1 x 10^1	$2^3 2^2 2^1 2^0$

These number systems are based on two concepts:

1. Absolute value.
2. Positional value.

We know the decimal system has absolute values for the numbers 0 to 9 and the positional values allied to powers of 10. Similarly, the binary system has to have 0 and 1 the absolute values and the positional values allied to powers of 2. Thus the 1s and 0s used are known as **Binary Digits** or **BITS**. In computer, in a cell of a chip / integrated circuit, 1 would be electronically **charged state or ON** and 0 and electronically **discharged state or OFF**.

	Decimal Value	Pure Binary	Binary coded decimal (BCD)	
The numerals 0 to 9 and other numbers are converted into binary numbers as shown in the table. Similarly, the alphabets are also converted to digital numbers. However, there is difference between decimal numbers written in the form of binary numbers and Binary Coded Decimals (BCD). However, it may be noted that in writing the binary numbers, the same logic, sequence and procedure as in decimal system is followed implying the connection between them.	0	0000		0000
	1	0001		0001
	2	0010		0010
	3	0011		0011
	4	0100		0100
	5	0101		0101
	6	0110		0110
	7	0111		0111
	8	1000		1000
	9	1001		1001
	10	1010	0001	1010
	11	1011	0001	0011
	12	1100	0001	0100
	13	1101	0001	0101
	14	1110	0001	0111
	15	1111	0001	1000

For the mathematical operations, the working of diodes, transistors and ICs on this Binary system, they have to be designed to suit it. Here, comes the Boolean Algebra.

Boolean Algebra: Much of the logic has gone into the development of Boolean Algebra. The logical usage of numbers 0 and 1 for the computing a system was developed by the mathematician George Boole[1] known as Boolean Algebra. It was originally developed to produce a means for representing and solving problems in logic. The variables are assigned only two sets of values, TRUE and FALSE. It is defined to use three fundamental connectives or prepositional operations:

1. NOT – negative or complementation function.
2. AND – Multiplication and addition functions.
3. OR – Multiplication and addition functions.

George Boole since childhood took interest in different lkanguages and logic, particularly, he was interested in the application of logic to Mathematics. He, depending mainly on mathematical journals borrowed from the local Mechanic's Institute,

George Boole (1815-64)

"Nós more than does not need to associate Logic and Metaphysics, but yes Logical and Mathematical".

Boole struggled with Isaac Newton's "Principia" and the works of 18th and 19th century French mathematicians Pierre-Simon Laplace and Joseph-Louis Lagrange. He had soon mastered the most intricate mathematical principles of his day. Boole soon began to see the possibilities for applying his algebra to the solution of logical problems - his 1847 work, "The Mathematical Analysis of Logic", not only expanded on Gottfried Leibniz' earlier speculations on the correlation between logic and math, but argued that logic was principally a discipline of mathematics, rather than philosophy.

Claude Elwood Shannon (1916 - 2001)

Then, Claude E. Shannon[2] using such concepts had systematized the mathematics for variables using these only two values. Here, 0 and 1 are considered variables but can have only two states.

Augustus De Morgan (1806-1871)

DeMorgan comes now. His laws are also based on logic and applied to Boolean Algebra and used in logical gates and circuitry. He was born (blind in one eye) in 1806 in Madurai, the erstwhile Madras Presidency (now Tamilnadu State), where his father wasassociated with the East India Company. In 1847, Boole published a pamphlet entitled *The Mathematical Analysis of Logic*, which De Morgan praised as epoch making.

His DeMorgan's laws, which were named after him, stated:

> "The negation of an "and" statement is logically equivalent to the "or" statement in which each component is negated.
>
> "The negation of an "or" statement is logically equivalent to the "and" statement in which each component is negated."

The laws were an important element in the field of symbolic logic. It made things easier for other mathematicians to study symbolic logic and made them more receptive towards this abstract and radical study. They also played an important role in the study of sets theory that sprang up after his death.

Boolean Algebra is just like ordinary algebra (B; . , +, '; 0,1) consisting of a set B (which contains at least the two elements 0 and 1) together with three operations, the AND (Boolean product) operation ., the OR (Boolean sum) operation and the NOT (complement) operation ' defined on the set, such that for any element x,y and z of B,x,y (the product of x and y), x+y (the sum of x and y) and x' (the complement of x are in B. Thus, like algebraic operations, the following axioms follow

A1	Idempotent	$x . x = x$	$x + x = x$
A2	Commutative	$x . y = y . x$	$x + y = y + x$
A3	Associative	$x.(y + y) = x$	$x + (y + z) = (x + y) + z$
A4	Absorptive	$x . (y . z) = (x . y) . z$	$x + (x . y) = x$
A5	Distributive	$x . (y + z) = (x . y) . (x . z)$	$x + (y . z) = (x + y) . (x+z)$
A6	Zero(null, smallest) and one (universal, largest) elements	There exists a unique element (the one element) 1e B such that for each 1e B, $x . 1 = 1 . x = x$	There exists a unique element (the zero element) 0e B such that for each x e B,
A7	Complement	For each x e B there exists a unique element x' e B, called the complement of x, such that $X . x' + 0$	$x + 0 = 0 + x = x.$ $x + x' = 1$

The Boolean Algebra plays a crucial role in the design, manufacture, application and working of semiconductor devices. The wafers themselves are doped to function mathematically and logically in the circuits. Therefore, whether such mathematical epistemology and logic have been there behind such processes have to be studied. For that we have to study the Western Number System to know how it could have inspired them to conceive such binary system.

The Western Number System and the Logic Behind It: The "Western Number System" is nothing but, the so called "Roman Number System", which has numbers like I, II, II, IV, V, VI, VII, VIII, IX, X, XI……and so on. The Greeks used their alphabets for their numbers. There is nothing specific about the basis of the system of numbers used, represented in symbols, etc. In fact, any writer has not explained the actual mathematical working with such numbers, though much has been credited to the Greeks and Romans. For example, even the fundamental operations like addition, subtraction, multiplication and division have not been explained. Garry Gasporov[3], the International Chess Champion provoked by this, raises the following objections and questions about Roman Number System:

1. The Roman numeral system discouraged serious calculations. How could the ancient Romans build elaborate structures such as temples, bridges, and aqueducts without precise and elaborate calculations?

2. The most important deficiency of Roman numerals is that they are completely unsuitable even for performing a simple operation like addition, not to mention multiplication, which presents substantial difficulties (see the figure below).

3. In early European universities, algorithms for multiplication and division using Roman numerals were doctoral research topics. It is absolutely impossible to use clumsy Roman numbers in multi-stage calculations.

4. The Roman system had no numeral "zero." Even the simplest decimal operations with numbers cannot be expressed in Roman numerals. N.P. Just try to add Roman numerals:

MCDXXV + MCMLXV[22] or multiply : DCLIII × CXCIX[23]

Try to write a multiplication table in Roman numerals. What about fractions and operations with fractions?

5. Despite all these deficiencies, Roman numerals supposedly remained the predominant representation of numbers in European culture until the 14th century. How did the ancient Romans succeed in their calculations and complicated astronomical computations?

6. It is believed that in the 3rd century, the Greek mathematician Diophantus was able to find positive and rational solutions to the following system of equations, called Diophantic today

$x^3_1 + x_2 = y^3$
$x1 + x_2 = y.$

According to historians, at the time of Diophantus, only one symbol was used for an unknown, a symbol for "plus" did not exist, neither was there a symbol for "zero." How could Diophantic equations be solved using Greek letters or Roman numerals?

7. Can these solutions be reproduced? Are we dealing here with another secret of ancient history that we are not supposed to question? Let us point out that even Leonardo da Vinci, at the beginning of the 16th century, had troubles with fractional powers. It is also interesting that in all of da Vinci's works, there is no trace of "zero" and that he was using 22/7 as the approximation of P - probably it was the best approximation of P available at that time.

It is also interesting to look at the invention of the logarithm. The logarithm of a number x (to the base 10) expresses simply the number of digits in the decimal representation of x, so it is clearly connected to the idea of the positional numbering system. Obviously, Roman numerals could not have led to the invention of logarithms

Had the western scholars delved only on the Greek philosophy, then, the concept of binary numbers, particularly, the concept of zero and infinity must have been there in the Greek or Babylonian or any other Number system. Only one example can be given to prove that the Greeks or Romans or Babylonians could not have conceived and evolved zero and infinity – the failure in the solving the problem of squaring the circle and vice versa proves the fact, whereas, it is proved with many examples in Satapata Brahmana and Sulba Sutras.

The Background of George Boole, DeMorgan and Shannon: George Boole took much interest in classical languages and this led him to take interest in logic and its application to mathematics. His biographical sources trace to Greek philosophy for such development of his logical ideas in the evolution of Boolean algebra. But, as shown above, the Greek Number system had no Zero and the philosophy never talked about the two states of Universe, World, Man, Man's Life and other dual factors existing and non-existing. There was no Pingala Sutra to codify syllables and relate them to numbers and ultimately invent binary numbers and the method to convert decimal to binary and so on. DeMorgan coincidentally or otherwise, born in Madurai, the erstwhile Madras Presidency and then shifted to England. Shannon, the American Electrical Engineer too took much interest in logical mathematics. The archetype for digital communication is Man. The Binary numbers associated with syllables, spoken speech etc., have been important factors. The Binomial series, which control the Binary number system and also give rise to infinite number of series, display the unique form of wave plots depicting Binary representation. Thus, the waveforms and Number forms coincide (with the allowance of technical noise, distortion etc). Thus, the Binary logic works perfectly with the both. This is the starting point of application of Binary numbers not only to Boolean algebra, but also to Machine languages, machines / Computers and parts / logical circuits / Microprocessors themselves. As technology is perfected approaching digital / binary sound based communication and working, the parts get miniaturized within decades.

The numbers and the logic involved etc., are tabulated as follows for comparison:

Decimal / Indian Number System	Western / Roman Number System	Greek	Mathematics and Logic involved	Difficulties and inconsistencies involved
1	I	a^-	In Roman system, for one, simply one line is represented. For two, two lines and so on. For five, the hand is imagined, thus it is represented as V. Then, one line is added to get VI, VII, VIII and IX , thus, X is meant for 10. Then the numbers are written accordingly. But, see, there is no zero in their system! Coming to the Greek, the numbers are nothing but the their alphabets used! Here, the logic is incomprehensible, as the base or positional system is not followed in the series used i.e, a, b, g,……..and so on. This clearly proves that they never used decimal system.	Multiplication and division with Roman numbers are unimaginable. For example, XXLC multiplied by CLIX or divide LCXI by XIL. Such operations with fractions, completely unthinkable!! And the algebraic and other representation and calculations are totally incomprehensible!!! When the case is like this with Roman, the Greek is totally *Greek*! How then the Greek scientists were working with their numbers discovering theories and theorems with geometry, trigonometry and so on! Thus, for the inspiration and discovery of binary number system, logic and their application, the Greek or Roman number system has no basis.
2	II	b^-		
3	III	g^-		
4	IV	d^-		
5	V	e^-		
6	VI	V^-		
7	VII	z^-		
8	VIII	h^-		
9	IX	q^-		
10	X	e^-		
20	XX	d^-		
30	XXX			
50	L	n^-		
90	LXXXX			
100	C	r^-		
200	CC	s^-		
500	D	f^-		
900	DCCC			
1000	M	$\_a^-$		
10,000	M			
20,000	MM			
1,00,000	M			

With this mathematical background, how the westerners suddenly switched over to Indian Numerical / Decimal system and discovered Binary number system, computers and the wonderful computing system is interesting, but intriguing and it is studied.

The Indian Decimal System and Mathematical Epistemology: The Indian Decimal System had been in vogue since the Indus Valley Civilization (c.2500-1950 BCE), as has been proven by the archaeological evidences of weights and measures used, such mathematics used in the building technology and metallurgy[4]. Therefore, the continuation of such intellectuality thereafter and through Mauryan Empire could be easily discernable[5]. When Indians could have excelled in mathematics and its application, then, they need not have waited for Mauryans all of sudden to produce everything Indian only from 3rd century BCE onwards. Mathematics does not die with civilization as long as the culture, tradition, heritage behind it is continued knowingly or unknowingly. I have dealt with the concept and evolution of binary numbers separately[6].

The Attitude of Westerners towards Zero and Infinity: The westerners themselves have faithfully recorded to accept that in the late 12th century only, the Europeans actually began to make use of the Zero and decimal system, reportedly introduced to them through Arab traders bringing them from India. Though they were having idea about the numbers 1 to 9, they could not understand zero, as it affected considerably all of their thinking processes. Their concept of Number was only associated and imbibed with counting, calculation and quantification. Moreover, their calendar had never any zero year, though, they claim that their calendar start from B.C.E. They considered zero as an intellectual obstacle[7]. Without understanding the significance of it, they even opposed the use of it. The resistance took two forms. Some considered them as the creation of Devil, while others made fun and ridiculed them[8]. As for as Infinity is concerned, its usage was in 17th -18th centuries. John Wallis (1616-1703) is claimed to have introduced the Infinity symbol. Even after the introduction of Calculus in 17th century, the western mind was puzzled with infinity and infinistemals. The puzzle persisted for nearly two centuries, until Cauchy (1789-1857) and Weirstrass (1815-97) showed how the awkward notion could be eliminated[9].

Why ∞ Cannot be a Number? The Hindu mathematicians initially considered infinity as a number like zero, though modern mathematicians do not consider so. As the quantity of "limitless, boundless, very great" is limited mathematically, "Infinity" is finitely defined. With the conceptual development, we can understand that infinity can only be approached, but not reached! The operations of infinity with zero and other numbers explained by Bhaskara II, Ganesa and Krishna clearly show that slowly, they too considered it as a mathematical entity, but not a number[10]. Any number how much it might great is Finite only. George Canter in his set theory shows that the existence of many infinities. He also discovered the ***transinfinite numbers***, which are related to the concept of Infinity. This again amounts to acceptance of many distinct infinities, but they are identified finitely.

The Signifiucance of "Na Sat Na Asat" in the the Hymn of Creation (nAsad' Sukta), Rgved Samhita, Volume 10 Verse 129: A translation of the hymn goes like thus (http://www.geocities.com/augustfour/vedic.html). At first was neither Being nor Nonbeing. There was not air nor yet sky beyond. What was wrapping? Where? In whose protection? Was Water there, unfathomable deep? There was no death then, nor yet deathlessness; of night or day there was not any sign. The One breathed without breath by its own impulse. Other than that was nothing at all. Darkness was there, all wrapped around by darkness, and all was Water indiscriminate, Then that which was hidden by Void, that One, emerging, stirring, through power of Ardor, came to be. In the beginning desire arose, which was primal germ cell of mind. The Seers, searching in their hearts with wisdom, discovered the connection of Being in Nonbeing. A crosswise line cut Being from Nonbeing. What was described above it, what below? Bearers of seed there were and mighty forces, thrust from below and forward move above. Who really knows? Who can presume to tell it? Whence was it born? Whence issued this creation? Even the Gods came after its emergence. Then who can tell from whence it came to be? That out of which creation has arisen, whether it held it firm or it did not, He who surveys it in the highest heaven, He surely knows - or maybe He does not!

To explain this, first let us understand that to realise the Absolute (here OM), there are ways or paths of Negation and ways/paths of Affirmation. Neti, neti (Not this, not this) of the Hindu teachings is the way of Negation. In short, it negates everything that is not Absolute. Hence Absolute is the last remainder. (speaking under the limits of language). Another example of the way of Negation is Buddhist Master Nagarjuna's teachings. In his dialectics, he also negates all the possibilities of vocabulary and conceptions. (na sat, na asat .)

Thus, the connotation of ***na sat na asat*** is that there is no truth and there is also no untruth, but only two realizable, recognizable and acceptable states are asserted. The meanings of ***sat*** are as follows:

i. Being, existing, existent.
ii. Real, essential, true.
iii. Good, virtuous, chaste.
iv. Noble, worthy, high.
v. Right, proper.
vi. Best, excellent
vii. Venerable, respectable,
viii. Wise, learned
ix. Handsome, beautiful
x. Firm, steady.

From this, the meanings of ***asat*** can be unterstood. In Sanskrit the expression sat-asat is used figuratively to represent the following:

i. Existent and non-existent.
ii. Real and unreal.
iii. True and false.
iv. Good and bad.
v. Virtuous and wicked.
vi. Entity and non-entity.

Thus, the two states have been clearly brought out. However, we cannot blow up much in this regard, as the computer was not designed and invented by any Indian. However, it is remarkable to note that most of the software engineers have been Indians today.

The Fundamental Processes Involved in Computation and Computers: The fundamental processes involved in the binary computation and their application in computers are depended on the following:

1. Syllable (perception, conception, evolution depends on the man's psycho-somatic factors).

2. Number (as above).
3. Formation of syllables (consistent with biorhythms and biological and natural processes).
4. Formation of numbers (consistent with such representation).
5. Number related to syllable (breaking or representing syllables into numbers – Katyapadi system etc).
6. Pronunciation (individual, group, system).
7. Flow of syllables (words – speech / song, rhythmic).
8. Flow of numbers (successive, progressive, sequential, consecutive - series).
9. Control of syllables and numbers (modulation, summation, with limits).
10. Reproduction / Perfect Reception / Correct result.

0 and 1 are two perfect states and 2, 3, 4, 5, 6, 7, 8, 9,............are modulated, changed, disturbed sates. Thus, in transmission, from zero the numbers increase to Infinity, and then in reception, decrease to Zero to attain perfection. As there are limitations in transmission and reception in between the transmitter and receiver, there have been imperfections, deformities and distortions. Thus, the Binomial triangle increases with numbers from base level and then gets reduced to base level. Of course, the zero is not figured in the Triangles, though, it plays a crucial rule in the beginning and ending. The series also emerge and converge. The pulse and waveforms involute and convolute.

<u>Conclusion</u>: Pingala Sastras amply proves that Pingala not only used the binary numbers but also the method of decimal to binary conversion and vice versa exactly like us. The concept, evolution and formation of 'number system' with '0' have been the greatest ever invention. The thorough study of syllables, words and their association with numbers lead to formation of number series, later represented as Number Triangles by Pingala. The "Binomial series", "binomial theorem", binomial triangle" etc., with two variables played a crucial role in the Vedic period, thus, Pingala immediately codified it in Chandas. The concept, evolution and application of the two states existence and non-existence have been consistent with Vedic literature and continuous. The Rigvedic description of Creation spells out step by step development of logic of existence and non-existence with only two possibilities. The unique properties of 0 and 1 made them to be qualified for "binary numbers" and a definition for "binary numbers" is proposed perhaps, for the first time. The concept and evolution of "binary number system" also led to the conception of negative numbers, C0-ordinates with origin (0,0) etc. The formation of Pingala / Binomial Triangle with zeros led to the thinking of Binary Triangles using 0 and 1. The AND Triangle (using AND addition) and OR Triangle (using OR addition) give unique results to understand the logic behind gates. The "Binary Binomial Triangle" constructed reveals the concept of "Meru" and also leads to "Binary Co-ordinates".

<u>Notes and References</u>

1. George Boole, ***<u>An Investigation of the Laws of Thought</u>***, Open Court, Chicago, 1854/1940; Also by Dover Publications, New York, 1954.

2. C. E. Shannon, ***Symbolic Analysis of Relay and Switching Circuits***, in Transactions of AIEE, Viol.57, 1938, pp.713-723.

3. Garry Kasparov, ***<u>Mathematics of the Past</u>***, Garry Kasparov has been the chess world champion since 1985, when he won the title at the age of 22. In 1997, during a historical chess challenge that made headlines all over the world, he defeated IBM's Deep Blue supercomputer. There are many web sides devoted to Garry, but we recommend : **<u>Http://www.kasparovchess.com/</u>**. A biography can be found at **<u>http://www.chennaiweb.com/sp/chess/bio/garyk/</u>**. All comments and other points of view are invited. Correspondence can be sent directly to p in the Sky by email at **<u>info@new-tradition.org</u>**, or by snail mail. All letters will be forwarded to Garry Kasparov.

4. The archaeological evidences (bricks, the weights and measures used etc.,) of Indus Valley Civilization amply prove the usage of decimal Number System.

5. The sculptural features prove the continuity. Indian sculptural design is based on Number system. So also Indian Music. Both music and mathematical systems are based on binary concepts.

6. A separate paper "The Concept and Evolution of Binary Numbers" is presented.

7. International Encyclopedia of Communications, Oxford University Press, USA, 1989, Vil.3, p.213.
Peter Barlow (1776-1862) in his New Mathematical and Philisophical Dictionary (1814) says that the discovery of the decimal system with zero, ".........was perhaps one of the most important steps that has ever been made in mathematics, and does as much honour to inventor as any other in the history of this science" (The Encyclopedia of Americana, USA, 1969, Vol.22, p.542).

8. Karl Menninger, ***<u>Number Words and Number Symbols – A Cultural History of Numbers</u>***, The MIT Press, England, 1969, pp.422-424, 428, 438-439.
International Encyclopedia of Communications, opt.cit, p.213.
John Allen Paulos, the sectional compiler notes that the so called abacus of any civilization had no zero to count numbers in terms of ten, hampering the discoveries!

9. Karl Menninger, opt.cit, p.422.
An educated French man wrote as late as in the 15th century, ***"Just as the rag doll wanted to be an eagle, the donkey a lion, and the monkey a queen, the cifra put on airs and pretended to be a digit"***.

10. The Oxford Companion to Philosophy, 1995, USA, p.5.