

The Zero Sign on Inscriptions and Manuscript Based on the Historical Supply Chain Management: A Case Study of Indonesia Archipelago before Majapahit Era

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Abstract- The widespread recognition of the term “supply chain” has come primarily as a result of the globalization of manufacturing since the mid 1990s, particularly the growth of manufacturing in China. U.S. imports from China grow. Indonesian people have been acquainted with the place value and a base of 10 and have used them since the early 5th century. The place value is related to the number of positions on units, tens, hundreds and so on. A base of ten number is similar to the digits of the numbers 0, 1, 2, ..., 9 that should be inserted into each of the place value. This paper observes the existence of 0 digits that is used in Nusantara, in specific, by gaining some sources in the inscriptions, temples, gravestones, and coins shapes. This article is written as the result of an observation by using literary observation method; in the inscription shape whose aim research to give the evidence that the number 0 has been used in Nusantara. As a result, the 0 digits have been first discovered in Sumatera; it was on *Kedukan Bukit* inscription numbered 604 *Saka* (682 C.E.) The existence of the zero number has also been discovered in the original Nusantara numbers.

Keywords- the digit of zero, Supply chain management history, the enunciation of zero, Nusantara, inscription.

1. Introduction

Supply chain management is the process and activity of sourcing the raw materials or components an enterprise needs to create a product or service and deliver that product or service to customers. A number at least contains a digit with the result that number is often acknowledged as a digit. On a base of ten (decimal) that uses the values of units, tens, hundreds and so on, each

place value can be fulfilled by one of ten digits 0, 1, 2, ..., 9. Since the beginning of the script acknowledgment, the Indonesian people have calculated numbers by using a base of ten and the place values. The early inscriptions which have been discovered and have been read its contents, sculpting the calculation skills by using the Sanskrit and the Old Malay languages [1]. Sanskrit language is the influence of Indian people, along with the entrance of Pallava script from South India. Before the Indian arrival, the people in Nusantara have not been able to read and write, yet they have developed and used the Old Malay language. It has yet to be acknowledged definitely about how the people in Nusantara calculated by using the Old Malay language before the influence of India. The inscriptions that use Old Malay language at once with the inscriptions that use the Sanskrit language have sculpted the enunciation of numbers sunya, satu, dua, tlu or tiga (zero one, two, and three) and so on. That enunciation is different from the same enunciation in Sanskrit language: sunya, eka, dwi, tri (and so on and Old Javanese (Kawi) language: das/sunya, sa, rwa, telu and so on. It seems proper to estimate that those Old Malay enunciations have existed before Sanskrit language and Early Pallava script existence in Nusantara. Yet, it is likely too early to predict that the computation skills with a base of ten and the place value use Old Malay language is the original creation of the people in Nusantara, and not as the influence from India. The 1980s marked the

beginning of a sea-change in logistics in the history of supply chain management. The emergence of personal computers in the early 1980s provided tremendously better computer access to planners and a new graphical environment for planning.

It appears that historians seem more agree with the idea that the skill of computation by using a base of ten and the place value that has been recorded on the inscription in Old Malay language is an influence from India, not an achievement of the origin people's intelligences. It is because there is no transcript before the Indian influence came so that there is no evidence that can be progressed to support the hypothesis of the use of the place value with a base of ten in the enunciation in Old Malay language is the real skill of Nusantara. The existence of Indian influences that has brought the place value with a base of ten has impacted on the use of a base of ten with the place value using Old Malay language. The information that can be developed based on the transcripts on the inscriptions is the skill of computation has been used and gained by using a base of ten and the place values in Old Malay language once the Indian influences has entered Nusantara. The Yupa from East Borneo and Tugu inscription from West Java have sculpted the number enunciation by using a base of ten and the place value in Sanskrit language, two centuries before the existence of the Old Malay inscriptions [2]. [2] has presented evidence of the existence of number 0 on the inscriptions of the Sriwijaya Kingdom, Indonesia. Existence of number 0 is also found on inscriptions from Vietnam and India [2]. This article provides more in-depth analysis results with more evidence of the existence of number 0 in Indonesia. The enunciation in Old Malay language that has used the place value by using a base of ten is related to the enunciation of number zero. The enunciation of the number zero is related to the existence of number zero. This article will observe the existence of number zero on various inscription in all over Nusantara. The mathematical discussion about zero is related to three things those are (1) the concepts zero in the place values system, (2) the symbol that is used to represent zero, and (3) the mathematical operation that involves zero [3]. It requires to add the forth discussion, it is the enunciation for zero, so that its history becomes clear.

2. Research Method

This article observes the existence of zero number and its varieties enunciation in Nusantara, since the

first time the people in Nusantara have recognized the letters or left prehistory periods and have entered the historical period. The discussion also encloses the concept zero as the place value and mathematical operation with zero.

The method that is used is the observation of historical sources in the inscriptions shape and the other ones. As an ancient artifact, the inscription has functioned not only as approbation but also as a charter, declaration, decree, and ordinances [4,5]. The inscription is made by using solid materials and hold out longer, such as stone (it is called upala prasasti) or metal (tamra prasasti). The use of palm leaves that are durable enough produces the term tripta prasasti [4]. Another resource that has been selected which has the characteristic of the inscription is old, formal and sculpted number in the stable and durable such as temple, gravestone, and coin.

3. The Result and the Discussion

3.1 The Existence of Number Zero in Nusantara

The beginning acknowledgment of the people in Nusantara about the number enunciation with the recent number enunciation is being used all over the world are the number enunciation with a base of ten and the place value. It is about two centuries later (682 C.E.) the recent people in Nusantara are recognized sculpting numbers. The number that has been used is the Later Pallava which has been discovered in the inscription with the Later Pallava script in Old Malay language. The numbers 682 C.E. are the conversion from year number 604 Saka that have been sculpted in the Kedudukan Bukit inscription. The numbers have been written with a base of ten and the place value. The numbers 604 Saka at have once become the evidence of the first existence of zero number in Nusantara. Thus, Palembang people are the first people in Nusantara who have been recognized that they have used the numeric symbol and number 0. [1] stated that the year number on Kedukan Bukit inscription is 683 C.E. The discoveries of number zero immediately are following. It is still in Palembang; it has been discovered the Talang Tuo inscription that has sculpted 0 on year number 606 Saka (684 C.E.). Then, in Bangka Belitung, it has been discovered 0 number in the Kota Kapur inscription that has sculpted year number 608 Saka (686 C.E.). The shape of number 0 in the Kedukan Bukit inscription (604 Saka), Talang Tuo (606 Saka) and Kota Kapur (608 Saka) is presented in figure 1 [2].



Figure 1. The shape of number 0 in the number year 604, 606 and 608[2]

The scholars who have done the transcription of the Talang Tuo inscription are Van Ronkel and F.D.K. de Bosch. Meanwhile, J.G [1] has examined and done the transcription of the Kedukan Bukit inscription. H. Kern, a Dutch epigrapher expert, is the first man who has done the transcription of the Kota Kapur inscription. The form of number 6 on 604 and 606 describes the differences in the form. Wear and tear disappear some certain parts on 604 at the Kedukan Bukit inscription. The writer suggests that number 604 in the Kedukan Bukit inscription and number 606 in the Talang Tuo inscription, both of them are the Later Pallava number. Then, number 6 in the Kota Kapur inscription (608) is also the Later Pallava number. According to [1], the Early Pallava script has been used before 650 C.E., and the Later Pallava script (including number) has been used in 650-750 C.E. The form of number 0 remains to be seen clearly in the Talang Tuo inscription that sculpts dot shape (a full circle/dot). The shape is called bindu [3]. The shape of zero in the Kedukan Bukit inscription no longer appears. Also, the shape of zero in the Kota Kapur inscription describes shape that is, later on, used in India and the world. The shape that resembles orb with the middle part is empty; it is called shunya [3]. [3] Asserts, “The symbol for shunya began as a dot (bindu), found in inscription both in India and in Cambodia and Sumatera around the seventh and eighth century and then became a circle (chidra or randra meaning a hole).” The evidence that are given in this article supports the view from [3].

3.2 The Concept of Zero in the Place Values

There are only two nations that are recognized to own number 0; they are India and Maya. [3] writes, “Such a zero occurred only twice in history –the Indian zero which is now the universal zero and the Mayan which occurred in solitary isolation in Central America.” The Mayan zero is symbolized with a shape [6] that resembles eyes () or snails (). It has been used by the Mayan people community in a region which is now located in Mexico, Guatemala, Belize, and Honduras. They

use a base of twenty (vigesimal) by only using three numeral symbols for 0, 1, and 5. The calendar of the Mayan people from the first century has presented number 0 [7]. This fact explains that the Mayan people are the early people that have recognized number 0 compared to the Indian people. It is different from [7,8] has recorded the new zero of Mayan has been discovered with its fact on the stellae in the 665 C.E. This year also precedes the discovery of the Indian zero in Gwalior, 876 C.E. [6]. The Mayan zero indicates the same functions with the Indian zero. The Mayan zero has not spread; it has only been used by the Mayan. One of the reasons is the Mayan people have built their big cities in the middle of the jungle so that it has made them isolated from other people. The idea in the mathematical view is the Mayan numeracy system does not seem useful. The Mayan numeracy system has been used to build many Mayan calendar systems. It has been carried out since 400 B.C. with the base 20. Notwithstanding, the Mayan numeracy system does not seem practical because its place value is not (19×20^0) , (19×20^1) , (19×20^2) , (19×20^3) and so on, yet (19×20^0) , (17×20^1) , (19×20^2) , (19×20^3) and so on. The use of this numeral has existed in India since Asoka Dynasty period (273-235 B.C.) in the number 1, 2, 4, and 6 [8]. Later on, the manuscript of the use of the numbers came from 2nd century once the Sugha and Magadha Dynasty. In the 1st and 2nd centuries, there has been discovered the approximate completed numeral system in all over India, it is the use of Brahmi number. Brahmi script is the stem of all scripts [5]. In the book Surya Siddhanta (600 C.E.) has been described numbers 488.203 and 232.238 [8]. The Jainism texts by Lokavibhaga (458 C.E.) is the first text that uses the place value, but without number 0. Aryabhata (500 C.E.) has constructed the number enunciation by using Dewanagari script [8]. In the beginning, the Indian zero is a dot and it is called bindu and later it changed into an oval with the empty part in the middle, it is called shunya [3]. Varahamihira (575 C.E.) uses dot in its mathematical operation [8]. Brahmagupta has written Brahma Sphuta Siddhanta (628 C.E.) and one of them defines adding, subtracting, multiplying and dividing with zero. Brahmagupta wrote. “Zero divided by zero is zero.” Mahavira (830 C.E.) has written Ganita Sangraha to collaborate all Brahmagupta’s works and has given a definition about zero that is divided zero, “A number remains unchanged when divided

by zero.”. Bhaskara (1150 C.E.) has written Lilavati for correcting Mahavira’s misunderstanding [9]. Number/digit zero has been used the end of the number (for example 270). The use of zero indicates the position of zero as unit. The use of zero has been discovered on the inscription from the Chatur-bhuja Temple, Gwalior, India. This inscription used year number 875/6 C.E.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|--|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 5 | = | 9 | 5 | | 9 | 0 | 5 | = | 9 | 5 | 0 | = | 9 | 5 | . |
|---|---|---|---|---|--|---|---|---|---|---|---|---|---|---|---|---|

Even in the year 662 C.E., Severus Sebokt, a clergyman from Syria has given his comment about the computation method by using the Indian nine digits (without digit zero) with the calculation method that is called surpass description [3].

Finally, the 10th digit for number zero has been used after the Arabian people have interacted with

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|--|---|---|---|---|---|---|---|--|---|---|---|---|---|---|---|
| 9 | 5 | = | 9 | 5 | | 9 | 0 | 5 | = | 9 | . | 5 | | 9 | 5 | 0 | = | 9 | 5 | . |
|---|---|---|---|---|--|---|---|---|---|---|---|---|--|---|---|---|---|---|---|---|

Muhammad Ibn Musa Al Khawarizmi is Persian mathematician who has introduced the use of number zero and the place value in the writing of Arabic numbers in the early 9th C.E. Number zero has been recognized in Europe in the 11st C.E., precisely in Spain. At that time in Spain, there have been Muslim and Christian scholars. Christian scholars have not acquired zero directly, either it is practical or ideologies [2]. Leonardo Fibonacci from Italy is the Christian scholar who has could see the strength of zero. In the early 13rd C.E., he has spread zero to be acceptable by scholars, bankers, and European merchants. Due to Fibonacci effort, Europe accepted zero as the last digit (10th digit) [2]. Other cultures have developed the numeral symbol that has taken some functions of the Indian zero and the Mayan zero. Ancient Egyptians have nfr. The symbol of ancient Egyptian zero, nfr, means beautiful or perfect has been used to separate the upper top and the bottom; it is about four hundred years ago [3]. The practical use of nfr has been discovered in the pyramid and cemetery, by positioning nfr as zero lines. With a distance of cubit, the upper part of nfr position successively is 1 cubit above nfr, then 2 cubits, 3 cubits and so on. The opposite position is 1 cubit under nfr, and so on. That function of nfr is called signed numbers or

Table1. The writing of the Babylonian numbers

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|-----|---|---|---|---|---|---|---|
| | 9 | 5 | = | | 9 | 5 | | | 9 | 5 | = | | 9 | 5 |
| 9 | 0 | 5 | = | 9 | | 5 | | 9 | 0 | 5 | = | 9 | | 5 |
| 9 | 5 | 0 | = | 9 | 5 | | not | 9 | 5 | 0 | = | | 9 | 5 |

The symbol of the Babylonian zero indicates the use of zero as the place value of tens on a base of ten so that it can be distinguished between 905 and

Before 750 C.E., Arabian mathematicians remained to use nine digits in the calculation [7]. With nine digits without the digit of zero, a dot above the digit means that it multiplies with 10. Henceforth, until 90 that is written $90 = \overset{\cdot}{9}$ [6]. This step does not exhibit the use of the place values of units, tens, and so on. To make it clear, these are other examples for number 95, 905, 950.

Hindus from India. The shape of Arabic zero remains in the dot shape (•); it is not an empty circle. With this new step, 95, 905 and 950 are written as follow

references for directed [3]. The Babylonian zero symbol has existed in the 17th B.C., it has been discovered on the tablet that has been written by Bel-Ban-Aplu in Kish, Iraq. Its shape is in three relevancy form. The shape of zero has experienced the change. In the middle of 6th – 3rd B.C., it has been used single and double wedge [8]. Corresponded to [8,7] stated that the Babylonian people in Mesopotamia (± 3rd B.C.) used the symbol that has had function as zero, but it is not zero. Its shape is space or wedge.

At least, the Babylonian people have used three shapes for zero, those are single wedge (◀), double wedges (◀◀), and space, beside triple hooks. Georges If rah gives some symbols for the Babylonian zero which functioned as separator [10], it is ◀ or ◀◀ or ◀◀◀ or ◀◀◀◀.

One of the uses of the Babylonian zero is as the place value. The example of the use of the Babylonian zero as the place value such as in the number 905 will written by using symbol zero between 9 and 5. The number 950 will be written by using symbol zero after number 5, yet its number process of writing tends to right side (see Table 1).

95. Notwithstanding, the symbol of the Babylonian zero has never been discovered that has been used as the place value of units on a base of ten so that

950 seems difficult to be distinguished from 95. Thus, the symbol of the Babylonian zero is not the real zero.

The Babylonian people used the place value on base 60 but without zero as number. One of the shapes of the Babylonian zero is . To make the explanation easier, the next example will give an illustration about the use of the Babylonian zero on base 10 (not base 60) by using symbol . The function of zero () in number 95 as tens. In the kind of that function has been used by the

Table2. The Writing of the Numbers with the Babylonian Zero

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|-----|---|---|---|---|---|---|---|---|---|
| | | 9 | 0 | = | | | 9 | | not | | | 9 | 0 | = | | | 9 |  |
| | | 9 | 5 | = | | | 9 | 5 | | | | 9 | 5 | = | | | 9 | 5 |
| | 9 | 0 | 5 | = | | 9 |  | 5 | | | 9 | 0 | 5 | = | | 9 |  | 5 |
| | 9 | 5 | 0 | = | | 9 | 5 | | not | | 9 | 5 | 0 | = | | 9 | 5 |  |
| 9 | 0 | 5 | 0 | = | 9 |  | 5 | | not | 9 | 0 | 5 | 0 | = | 9 |  | 5 |  |

If the Babylonians have yet to develop zero, then 405 would have been written with 45 which is not almost different from 45 that states 45. Thus, the Babylonian zero seems to be able to differ 45 with 45. With the symbol of the Babylonian zero, there has never existed number 450 that is written as 45, because symbol  has never positioned on the place value of the unit. Thus, the Babylonian zero () has never exactly functioned yet as the place value; it is only as separator units with tens, tens with hundred and so on [5].

The Greek people have zero that is called omicron that is symbolized with o; it is the first letter from word ouden which means space [11]. When the Arabic people used dot as number zero in a base of ten with the place value, the European selected letter o as a symbol for zero. The next development, number zero is no longer in the circle shape (o), yet it tends to be oval upward, 0.

Ptolemy has used space for 0 when it has been working with a base of 60 (sexagesimal) in the astronomical computation that one has done. Ptolemy has had a problem in writing the big astronomical numbers by using Roman numbers so that he decides to use the Babylonian numbers by using a base of 60, such as in his work, Almagest in the year 130 C.E. [8]. Ptolemy must have used the symbol of zero; it is the Babylonian zero ()

The symbol of n is the initial letter for word nulla (zero, space) has been used once at least by Bede, ± 725 C.E. to present null. The symbol of n is no longer popular, yet the enunciation of nulla maintains until now, and it has transformed into null (English) and nol (Indonesian) [2]. In the next discussion, it will be presented about the concept of

Babylonian people long before the Indian people have invented zero. Yet, it has never been discovered the zero function as units. Nine hundred and fifty will never be written with 95 but by shifting leftward number 95 a little bit. The Babylonian zero has indicated its function as the place value, yet it has never functioned as the place value of units. Table 2 gives the comparison of the writing of the numbers by using the Babylonian zero ()

zero in the place value that has been used in Nusantara since the middle of 7th C.E.

3.3 The Symbol for Zero: from Bindu to Shunya

Subhash [6] explains about the history of the symbol of zero. According to [6], the symbol of zero is derived from the Brahmi zero number that has three shapes, they are and . The Brahmi numbers and scripts have been used in the Asoka Dynasty period, and it is about 273-235 B.C., it has been discovered about the use of the numerical notation in the Brahmi number for the first time [8]. The Brahmi number later has been often used in the period of Shuga and Maghada Dynasty, the century, 2nd B.C. [8]. In the first and second centuries, approximately all regions in India have acknowledged and used the numerical system [8].

Nowadays, the number 10 in the Brahmi number is symbolized in the first . The second shape has been () used in the 1 and 2 C.E., for example in the Nasik inscription [5] also in the century, 1st C.E. and the century, 3rd C.E. in the Andra and Ksatrapa inscriptions [5]. The third shape has been () used in the 4th C.E., for example in the Jaggayapeta and Pallava scripts (Data and Singh, 1938 in [5]).

To explain the number 0 history, [6,5] gives an illustration as follow. The symbol for number 15 in the 1st - 4th C.E., it is written as the combination of number 10 with number 5 ( ) they are  and 

In this time, the symbol for 15 in the Brahmi number is written in the shape that is according to [5] is the transformation from the number 15 in the 1st - 4th C.E.



In Brahmi language, the symbol of  is called kha it is tailed circle with a hook [5]. The transformation of kha shape  has produced two symbols for 15 and set aside the symbol for number 0 that is enunciated shunyo or sunya in Sanskrit language. [10] also asserts in Sanskrit language, the shape is named shunya, chidra or ndra. It does not explain further since when the number 0 has been used for the first time. According to [5] the use of the symbol  to present zero; it seems the most quickly has happened in the 3rd C.E.

How does the number zero form that have been used in Indonesian Archipelago (Nusantara)? In Nusantara, it has yet to discover the development process of the number zero. The appearance of the number zero has been in the shape that is ready to use, either the number 0 in the bindu shape or in the shunya one. Moreover, the historical evidences that have been written on the stones, metal and glazed porcelain in the inscription shapes are used not to immortalize the manuscripts about Mathematics.

The number 0 shape that has been described by [6], it has been discovered in Sumatera in the 7th C.E. Its shape is orb and it is quite oval with its middle part is space. The shape is called shunya or shunya and it has been discovered in the Kota Kapur inscription, 608 Saka that has been sculpted by using the Later Pallava number.

According to [3], the earliest zero shape is in dot shape or orb but quite oval with its middle part is solid/full. That zero is enunciated bindu in Sanskrit language. Bindu also has been discovered in Sumatera. The Talang Tuo inscription that has come from 684 C.E. sculpting the Later Pallava that indicates 606 Saka. The zero shape on this inscription is called bindu. To abreast with [3], the appearance of bindu that precedes the zero shape is called shunya, chidra or randra. [3] does not explain the zero shape transformation from bindu to [6] also does not explain the same thing. [6] only explains about the history of the zero shape that is called shunya from the shape that is called kha. [6] estimates that shunya has been used quickly since 3rd C.E. The Kedudukan Bukit inscription (604 Saka) uses the Later Pallava script. The shape of zero in the Talang Tuo inscription that has been detected, it is estimated that it remains in bindu shape; it has yet to transform to shunya. The Sambor inscription from Cambodia also sculpt the year number that difference one year from the

Kedudukan Bukit inscription; it is 605 Saka, by using the Pallava number. The zero shape on the Sambor is bindu. Four inscriptions that sculpt the zero number (one is from Cambodia and three are from Indonesia) indicating the existence of the zero number that is called bindu (the Kedudukan Bukit, Talang Tuo, and Sambor inscriptions) also the zero shape that is called shunya (the Kota Kapur inscription). In the next years (the evidence has been presented in the next part), the inscriptions are in Indonesia will present shunya, unless if the inscriptions had been written in Arabic script or their modifications of the zero number were in bindu shape. This case corresponds to statement [3], “The symbol for shunya began as a dot (bindu), found in inscriptions both in India and in Cambodia and Sumatera around the seventh and eighth century and then became a circle (chidra or randra meaning a hole).” In Nusantara, the transformation from bindu to shunya for the first time has been discovered in the Kota Kapur inscription (686 C.E.), whereas the previous two and four years, it has remained to use bindu (the Kedudukan Bukit 682 C.E. and the Talang Tuo 684 C.E.). The existence evidences of the zero number in India as the civilization that has created number 0 seems quite slow if it is compared to the discovery of number 0 in Southeast Asia regions that has been influenced by India. The discovery of number zero in India has just begun in the year 876 C.E., it has been discovered in inscription disembodied clay tablet from Gwalior, the central India. [12] it is quite different to write by using the use of the completed place value notation by being discovered the digit 0 in India in the year 875 C.E. [3] does not state in specific that it has been used the number 0 yet the use of the Indian numerical system has existed in the year 876 C.E. Joseph also has based his opinion in Gwalior inscription that has sculpted inscription in the year number “Samvat 933”. [3] has written, “The earliest inscription in India of a recognisable antecedent of our numeral system is found in an inscription from Gwalior dated “Samvat 933” or 876 C.E. It means, samvat (year) is not the Saka calendar such as what has been used in Nusantara and the other Southeast Asian, but Vikrama calendar. At the inscription, digit 0 sculpted on number 50 and 270 [2]. On the foot note, [3] also clarifies that the influence of India in the use of the Indian numerical system has been delivered earlier in Southeast Asia in the region is now included in some regions in Indonesia, Cambodia, and Malaysia. If [3] explains that the

common thing about the use of the Indian numerical system in Indonesia, Malaysia and Cambodia, in the specific, [12] has pointed out the existence of the number of zero in Indonesia and Cambodia. [12] states that the use of zero digits has been discovered 683 C.E. in Indonesia and Cambodia, "683 C.E. in Hindu colonies in Khmer (Cambodia) and Sumatra." Joyce's opinion corresponds to the use of the year number of 604 Saka in Kedukan Bukit inscription in Sumatera and 605 Saka of the Sambor inscription in Cambodia [2]. The conversion of the Christian calendar will produce 604 Saka = 682 C.E. and 605 Saka = 683 C.E.

3.4 Shunya-Ganita

Shunya-Ganita is the Indian term meaning the mathematical operation that involves the zero number or calculating with zero [2]. Shunya-Ganita terms have been used by Brahmagupta. The use of that term has indicated that Brahmagupta works with zero in the shunya shape, not in the bindu shape. It means, it is about in 608 C.E., Brahmagupta and Indian people have used zero in the shunya enunciation. In the next session, it will be presented the evidence that the people in Nusantara (Indonesian Archipelago) have remained to use bindu in 682 and 684 C.E. Yet, two years later, (686 C.E.) they have used shunya.

The proof that the Indian have developed mathematics far off the day is indicated by some terms that contain phrase of ganita, one of them is patiganita (arithmetics, it is finite in adding, subtracting and multiplying with zero) bijaganita (algebra, the continuance of patiganita by involving the negative and positive numerals, the division with zero and the relation between zero and ananta/infinite) and gruhaganita, it is mathematics concerning to the planets movement [12].

In addition, a few mathematics texts that have been written by Indian mathematician for the first time using the place value system by enclosing the zero numeral already. In the same time with Lokavibhaaga, Aryabhata is also recognized that he has used the zero number in a base of ten. Both of them were astronauts and mathematicians.

Lokavibhaaga has developed Mathematics as part of Jainism ideology that one has been believed so that Lokavibhaaga is known as Jainism Mathematician. There are Jainism followers who contribute excessively in Indian Mathematics, so that it produces Mathematics of Jainas. This process has been commenced since 500 B.C. by

Gantanuyoga (500-300 B.C.), it has been continued by Mahaviracharya (850 C.E.) the one who has written Ganita Sara Sangraha, and Halayudha (10th C.E.) that precedes Pascal in discussing Pascal triangle [12].

Brahmagupta and Varamihira have lived at the same time approximately and have worked with the zero numeral. Brahmagupta's strengthness compared to Varahimira is Brahmagupta (628 C.E.) has presented the mathematics operation rules, meanwhile Varahimira (575 C.E.) has only presented the examples.

Brahmagupta from India has become the first man who has given the adding, subtracting, multiplying and dividing operation rules by using the zero numeral. It indicates that Brahmagupta is the first man that has invented zero as integer [8].

Brahmagupta was Sind-Hindu born. In his work entitled Brahma Sphuta Siddhanta, one of them, he explains about zero as the entity that separates between dhana (positive) and rhna (negative) [3]. That work has been translated into Arabic in the year 770 C.E. [12]. [3] Asserts the three later on has recorded that there has been the intellectual diplomacy by Sind-Hindu people to Khalifah Al Mansyur in Baghdad (773 C.E.).

Lilavati has been written by Bhaskara, 1150 C.E. and Ganitasangraha has been written by Mahavira, 830 C.E. [8]. Much earlier, Brahmagupta (628 C.E.) has formulated the rules about shunya-ganita in his book Brahma Sphuta Shiddhanta which discusses about the adding, subtracting, multiplying and dividing operation by using zero [3]. Brahmagupta has experienced the misunderstanding when he has been formulating dividing operation by using zero. Brahmagupta's misunderstanding is corrected by Mahavira then Mahavira's opinion is corrected by Bhaskara.

Besides Lilavati, the other Bhaskara's works (1114-1185 C.E.) are Bijaganita (algebra), Goladhyaya (the earth navigation), Gruhaganita, and Siddhanta Siromani that have been written in the year 1150 C.E. [12]. Bhaskara has made the Indian Mathematics reached its glory.

3.5 The Zero Number Existence in Various Numbers Types in Nusantara

Manasollasa, a text from the 7th C.E. asserts [3], "Basically, there are only nine digits from one to nine. With the addition of zero digits, it produces units, tens, and hundred and so on". It remains in the same century, Yogasutra, Patanjali's work

associating the place value with mother, kids, and grandson and so on.

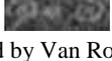
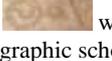
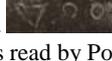
The people in Nusantara have not had chance to calculate by using nine digits. They directly acknowledged with civilization that has introduced the place value and a base of ten with ten digits.

All numerical systems in Nusantara used a base of ten with the place value. The number writing process that has been used by Arabic people before 750 C.E. (with nine digits without zero digits) is not discovered in Nusantara, either by using the Arabic number or the Pallava number and the other ones. The use of numeric symbols or zero number has been discovered in all numbers that have been used in Nusantara. The zero number shape seems the same relatively notwithstanding its number type is different, unless the Later Pallava zero number that is in bindu shape. The zero number shape in the Later Pallava is not much more different from the

zero number in the Majapahit number; notwithstanding big-small its size is different. The general shape is space. That shape is called shunya. When the people in Nusantara have used Sanskrit language, zero has been enunciated shunya. Some of them enunciate it bindu and until nowadays bindu and windu terms remain to be used for enunciating zero in Bali [2].

In the script there is script-alphabet (letter) and script-numeral (number). Based on the scripts that once used in Nusantara, then there will be the Early Pallava number, the Later Pallava number, the Archaic Phase of Early Kawi, Standard Form of Early Kawi, the Later Kawi, Pranagari, Nagari, Kadiri-Quadrate, Majapahit and Buda/Gunung. From the research that has been carried out in various inscriptions, statues, temples, gravestones, and coins have been discovered the use of zero numbers (table 3)

Table3. The existence of zero number in each number type in Nusantara (Indonesian Archipelago)

| The Number Type | The Zero Form | The Existence of Zero Number |
|---|---------------|--|
| The Early Pallava 400-650 C.E. | - | Not found. Yupa and Tugu inscription [13] do not contain numbers. |
| The Later Pallava 650-750 C.E. | ● | Kedukan Bukit, 604 Saka  with Old Malay language. This inscription is read by J.G. [1]. Talang Tuo, 606 Saka  with Old Malay language. This inscription is read by Van Ronkel and F.D.K. de Bosch. |
| | ○ | Kota Kapur, 608 Saka  with Old Malay language. This inscription is read by epigraphic scholars from Netherland, H. Kern. |
| Archaic Phase of Early Kawi 750-856 C.E. | ○ | It has yet to discover. The year number that has been discovered contain digit 1, 2, 3, 4, 5, 6, 7, 8, and 9. The existence of zero because Early Kawi is the evolution from Pallava [1]. |
| Standard Form of Early Kawi 856-925 C.E. | ○ | Kapuhunan/Pintang Mas, 800 Saka  with Old Javanese language. This inscription is read by Poerbatjaraka. |
| The Later Kawi 925 C.E.-1250 C.E. | ○ | Karangreja, 1065 Saka  with Old Javanese language. This inscription is read by Louis-Charles Damais. |
| Kadiri-Quadrate 1000-1250 C.E. 1400-1500 C.E. | ○ | The inscription in Sukuh Temple, 1360 Saka  with Old Javanese language. This inscription is read by K.C. Crug. |
| Pranagari 750-1100 C.E. | ○ | Kelurak, 704 Saka with Sanskrit language. The part of picture that contains zero is breaking. This inscription is read F.D.K. de Bosch. |
| Nagari 1100-1400 C.E. | ○ | It has yet to discover. The year number that has been discovered, it does not contain number 0. The existence of zero because Nagari is the evolution from Pranagari. |
| Majapahit 1250-1450 C.E. | ○ | Mirigambar temple, 1310 Saka  |
| Buda/Gunung 1450-1800 C.E. | ○ | Merbabu-Merapi manuscript with the code PN 7 L 29: anggara pahing, sirah, 0, tenggek, 6, tusun, 5, pewon, 7 [14]. This inscription is read Louis- Charles Damais. This manuscript used Old Javanese language. |

The evidences in the year number shape and its other numbers that is presented on table 3 indicating that the existences of zero in Nusantara is absolutely real. Its shape indicates the characteristic similarity, notwithstanding it remains distinguishable between zero in each number type. All numbers on the table 3, unless the shaded-in areas (the Early Pallava and Pranagari) are the real numbers from Nusantara that have been developed from the Early Pallava from South India and Pranagari/Dewanagari from North India [15, 16].

The zero shape in Nusantara indicates the existence of two types, those are bindu and shunya. Bindu is used in the Talang Tuo inscription that sculpts the Later Pallava. The Kedukan Bukit inscription is estimated that it remains to use bindu shape because its year number only one year interval and it is discovered in contiguous geographic area. The year number in the Kota Kapur inscriptions has been sculpted by using the Later Pallava number. The zero shape has been in shunya shape [17]. This shunya shape will remain to be used in the next period in various script types and the numbers in Nusantara.

The zero from Nusantara indicates its function that has exceeded the Babylonian zero. The zero from Nusantara has been sculpted in a base of ten with the place value with the other nine digits. The zero from Nusantara that has been found, it has been used as the place value of hundreds, tens, and units (the calendar for year number is Saka): (i) Zero in the place value of hundreds: the Karangreja inscription and the Pagiliran inscription which both of them presents the numbers 1056, along with Plumbangan 1042. (ii) Zero in the place value of tens: the Kedukan Bukit (604), the Talang Tuo (606), the Kota Kapur (608), the Karang Brahi (608), the Kapuhunan (800), the Ra Tawun (803), the Kwak I (801), the Tugu Upit II and III (800 and 801), the Janggala (1307), the Munggu Antan (808), the Buleleng (903), and the Kelurak (704) inscriptions. (iii) Zero in the place value of units: the Penampihan (820), the Central Wanua III inscription (830), the Kapuhunan inscription (800), the Tugu Upit II inscription (800), the Suku Temple (1360) and the Miri Gambar Temple (1310).

The zero function that indicates the place value of units is not discovered in the Babylonian zero so that the Babylonian zero only has function as direction separator. The zero from Nusantara has proved that it has been used in all the place values (units, tens and hundreds). This case explains that

the Nusantara zero has, since 682 C.E. has functioned as the place value. In inscriptions, the writing of numbers that involves the place values of hundreds, thousands, and tens-thousand has used the numeric enunciation, not number.

The Ra Tawun inscription, besides sculpting the number 803 C.E. also has been sculpting the cardinal numbers. This case indicates that the use of ten digits, including zero number is not only in the year number but also in the cardinal numbers that presents the amount of something. Then, 0 in the number 10 indicates the use of zero as the place value of units. [3] states that India has owned the completed multi-functions, those are (1) symbols, (2) numbers, (3) magnitude, (4) direction separator, and (5) the place value. All of them are working in the positional numeric system (place value). The zero in Nusantara indicates its function as a symbol that has been discovered in the bindu and shunya shapes. The shunya shape is various. It depends on the number that is used, as we can see on the table 3 and table 4. The use of zero as a number and the place value can be discovered in the year number and the cardinal number which have been presented before.

The other cardinal numbers that have been sculpted in the inscriptions are only in the forms of units and tens with the highest cardinal number is 18, which has been discovered in the Mantyasih (829 Saka = 907 C.E.). Nevertheless, zero as a number has yet to discover about its evidence for the calculation activity which involves zero (shunya ganita). The use of zero as direction separator, one of them is as a number (line) the separator between the upper part and the bottom part of the pyramid (the Ancient Egypt) and the separator number of dhana and rhna (India). In Nusantara, it has been discovered that zero as the direction separator concept that separates between death and alive (mokta/moksa). The Batu Tulis Bogor inscription (1455 Saka = 1533 C.E.) records that it has been discovered the term of mokta two times. The word vatsare that exists in the Tugu inscription (Cilincing, West Java), it has been used to separate time before and after being a king. The use of suklapaksa term (moon-half) and kresnapaksa (dark-half) on the Saka calendar has been discovered in all inscriptions that is indicating the existence of zero as the direction separator more explicitly. After a full moon, the date has been marked with 1 kresnapaksa, then 2 kresnapaksa and so on until 14/15 kresnapaksa. Before a full moon, the date has been marked with 15 suklapaksa, then

it declines to 14 suklapaksa until it reaches 1 suklapaksa.

4. Conclusion

The use of a base of ten and the place value has existed since the early the 5th C.E. The Tugu inscription from West Java is from 403 C.E., it has sculpted the enunciation of numeric by using a base of ten and the place value. Thus, as well as yupa that has been discovered in East Kalimantan (\pm the early 5th C.E). The Tugu inscription and Yupa use the Early Pallava and the numerical enunciation in Sanskrit language.

The use of a numerical base of ten and the place value in the numbers have been discovered in the middle of seventh century. The Kedukan Bukit inscription from South Sumatera comes from 682 C.E. is the first inscription that has sculpted the Later Pallava numbers. The year number that has been sculpted is 604 Saka. That number indicates the existence of the first zero number in Nusantara. The Kedukan Bukit inscription have also sculpted the numerical enunciation with a base of ten and the place value, yet by using Old Malay language. The inscription evidences indicate that 682 C.E., the people in Sumatera (Indonesia) and Cambodia (683 C.E.) have used a base of ten and the place value that involve ten digits, including the digit zero. The evidence from India has just discovered in the year 875 C.E. or 876 C.E. the first shape of the number zero in Indonesia is dot, it is called bindu. Two inscriptions in Nusantara and one inscription in Cambodia have used bindu. Later on, its shape has transformed into shunya. The Kota Kapur inscription is the first inscription that has sculpted its shunya. In India is also used the term chidra or randra that has meaning with shunya, yet both of those terms are not discovered in inscriptions. The digit 0 on inscription from Gwalior, India used shunya[18-34].

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