

# ETERNITY: NUMBERS - Silver Ratio ( $\delta_s$ )

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## 1 Introduction

This document provides an understanding of only an irrational number called Silver Ratio ( $\delta_s$ ). An irrational number is not a rational number, it is not possible to express an irrational number as a quotient of two integers.

### 1.1 History

Silver Ratio is studied from the time of Greek knowledge, which discusses the fundamental characteristics of the number system. Though it is not used by normal people intentionally. Silver ratio is the limiting of consecutive of infinite sequence of integers, The silver ratio is presented in a Greek symbol ( $\delta_s$ ).

### 1.2 Mathematical Definition

The value of silver ration is 2.4142135623 [1]. A ratio of the sequential sum of smaller number and twice of the larger number, which will produce an infinite sequence and the ration between smaller and larger number will be always same [2]. This can be presented in mathematical equation:-

$$\frac{2a + b}{a} = \frac{b}{a} = \delta_s$$

It will be easier to understand if it can be compared with Fibonacci number. In Fibonacci, the smaller and larger number are added to get the next one. Example:-

1, 1, 2, 3, 5, 8, 13, ..

For silver ratio, the smaller and twice of the larger number are added to get the next one. Example:-

1, 2, 5, 12, 29, 70, ..

Then the latest number is divided by the previous larger number.

## 2 Interview

I interviewed a undergraduate student from Dhaka University - Bangladesh with math background. Her name is Esrat Jahan Tonni. As she is currently studying, she might need to use irrational numbers in her undergraduate career. The interview questions and the answers are given below:-

### 2.1 Question and Answer

Q1: How long you are in math domain?

Ans: Almost 3 years.

Q2: How often you use calculator?

Ans: Very often. I mean almost daily.

Q3: What type of device you use to calculate complex equation.

Ans: It is obviously scientific calculator for me but for advance user there are many software available.

Q4: Can you tell me some of the tools name?

Ans: No. I can't remember the names but if you search it in Google you will find some.

Q5: Do you know about the irrational number?

Ans: Yes. I Know,

Q6: Do you know about Silver Ratio?

Ans: I am not sure. I think, I know about it but never used it . But have some basic idea about it.

Q7: Can you explain me what you know about it?

Ans: I am not sure. But so far I can remember i will try to give you a basic idea of it. Hopefully you heard the name of Fibonacci number. It is related to Golden Ratio. Same as there is Silver ratio. It has some difference with golden ratio. It actually describe the twice of the larger number added with the previous number and ratio with previous number.

Q8: Do you know the value of silver ratio?

Ans: It is something one plus square root of two. I forget the value. It will be something 2.414 and more

Q9: What do you think are the applications of the Golden Ratio in mathematics?

Ans: The silver ratio is used mostly in the Geometry to create designs that are in proportions. It is not used as such in Mathematics directly but even the ratio of consecutive numbers in Pell sequence are close to the silver ratio.

Q10: What are the other places where it can help?

Ans: It is usually used in the geometrical calculation. As well as the architect and engineers use this to make shapes calculation. It may be used in art and design, some time it helps in surgery to measure some points.

Q11: Can you give me some example where it can be implemented

Ans: To make a perfect square it helps. Octagon is another example where you need this.

Q12: Do your scientific calculator support silver ratio?

Ans: Never used that. so I am not sure about it. it may be or may not be.

Q13: Would you like to include Irrational constants like silver ratio and others in the calculator?

Ans: Yes. Why not may be in future i need them.

Q14: Do you have any other suggestion that can help me to find your necessity in a scientific calculator?

Ans: Currently, I don't need any other feature in my calculator. but who knows if can come up with something new it may help others.

## 2.2 Interview Analysis

Though the interviewee is not expert in the area of the irrational numbers, She has decent idea about the silver ratio. As she has a math background, she gave a lots of insights about the silver ratio. She is 4th Year student and completed 3 years in math domain. As a math student she has to use calculator almost everyday and she uses scientific calculator for the complex equations. From the interview, it is clear that the silver ratio is used in calculation of geometrical shapes. Also the architect, designer, engineers and Sometimes doctors (Plastic Surgery) uses this. Also stated that in regular scientific calculator the irrational numbers are not available. Then she describe about the silver ratio . which has the value of 4142135623. Its convergent are square triangular numbers, Pell numbers and octagons. According to her it will be good if the irrational numbers are included in the scientific calculator. According to him the calculation can be done here in the scientific calculators but they needs extra effort. But inclusion of these can make few peoples life easier.

## 3 Persona

The persona is given below:

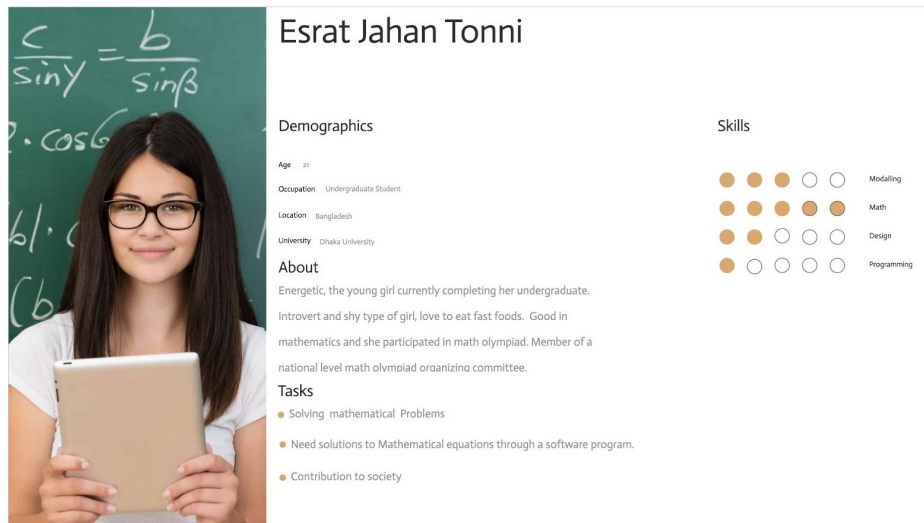


Figure 1: Persona based on the analysis of interview

## 4 Problem Domain Model

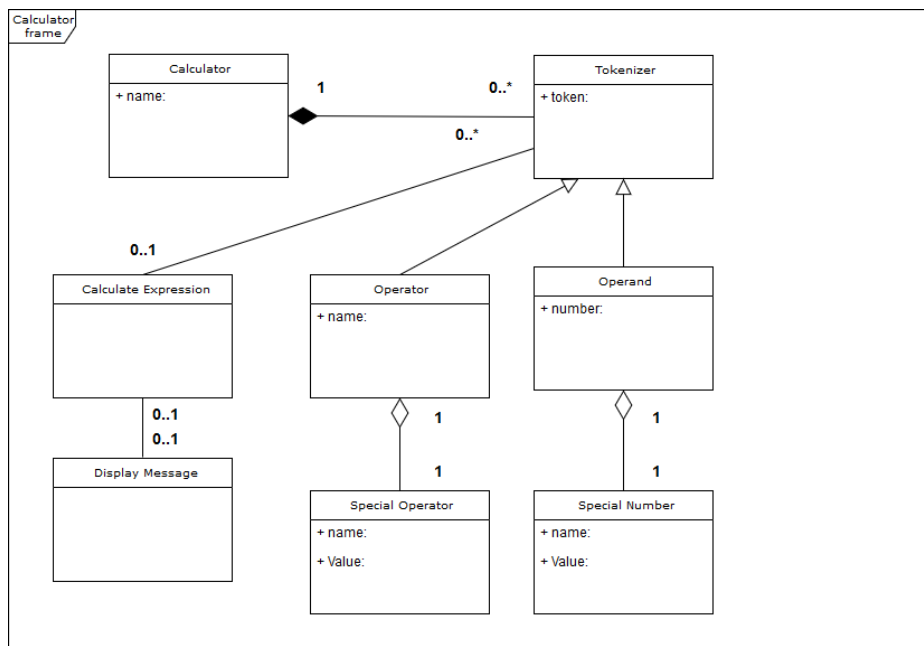


Figure 2: Class diagram for calculator with special number and operator

## 5 Use case Model

### 5.1 Use Case Diagram

Actor of this system will be an user. The user will give inputs of operator and operands. User can sometimes use special operator. but it is optional to use. Same for the operand input field can have any number. but if the user wants can have special number like Silver Ratio. With the Operator and operand it makes an mathematical expression. Calculate the expression and display the result.

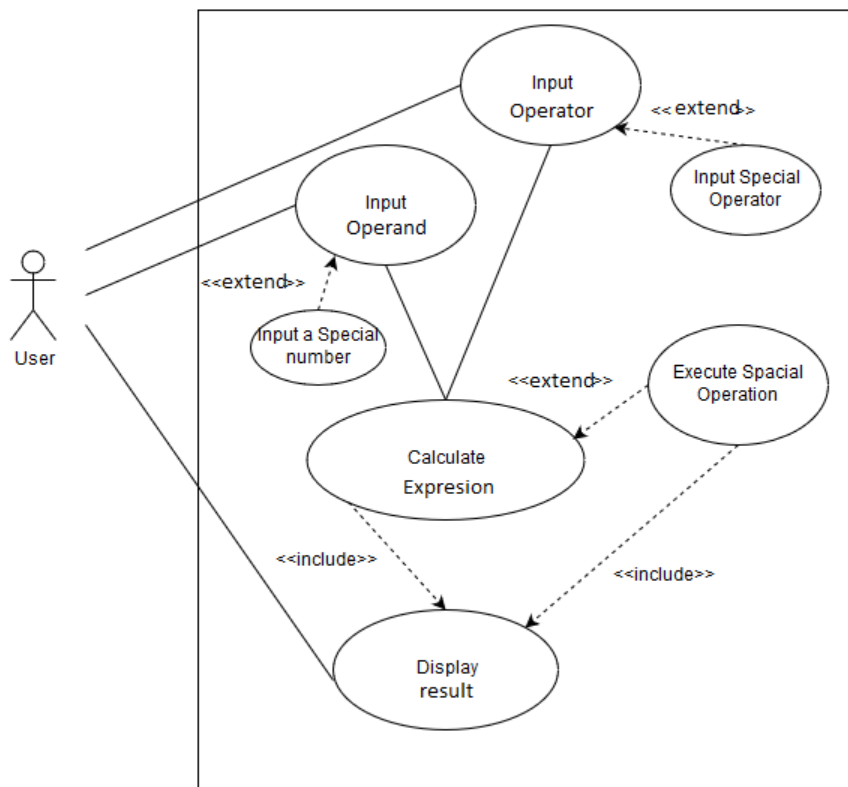


Figure 3: Use case diagram for calculator with special number and operator

### 5.2 Activity Diagram

Here it will work like a regular calculator with an extra feature of an operand silver ratio number and operator for getting a value from a number using the

silver ratio content. If silver ratio is used as a operand it will work like a double number. An example is given below :-

$$2 + \delta_s = 4.4142$$

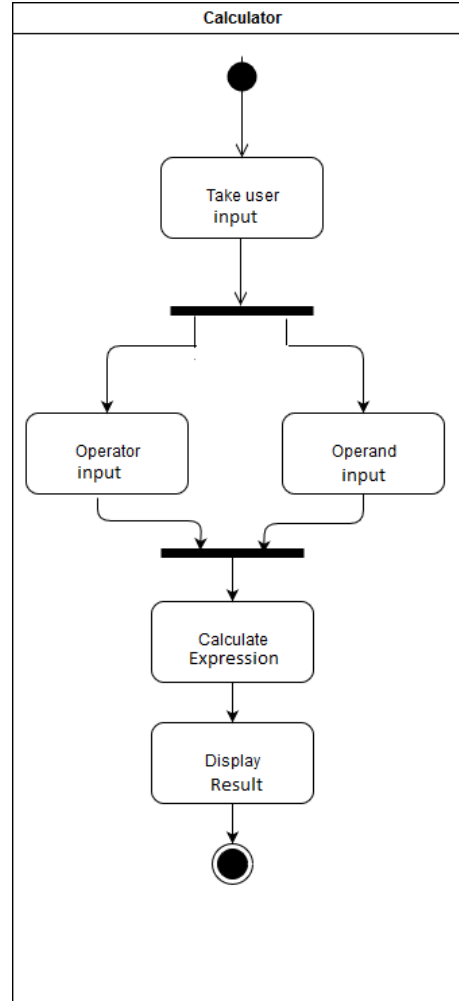


Figure 4: Activity diagram for calculator with special number and operator

if it uses like an operator than it will give the value of the another number which ratio is  $\delta_s$ . If one value is 2 than the silver ratio operand will give the another value (0.82842712474619 )based on the silver ratio equation. the equation is give below: -

$$\begin{aligned}\frac{2a+b}{a} &= \delta_s \\ \Rightarrow 2a+b &= a * \delta_s \\ \Rightarrow b &= (a * \delta_s) - 2a\end{aligned}$$

## References

- [1] John D. Cook. *The silver ratio*. 2009. URL: <https://www.johndcook.com/blog/2009/05/20/the-silver-ratio/> (visited on 05/20/2009).
- [2] Tony Padilla. *The Silver Ratio - Numberphile*. Youtube. 2018. URL: <https://www.youtube.com/watch?v=7lRgeTmxnlg> (visited on 05/11/2018).