Project Report

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Abstract

This document is a project report the problem domain model Calculator System. Domain is a calculator that computes the value of certain established irrational numbers. The purpose of the project is to carry out a number of activities, resulting in a set of interrelated artifacts for the problem domain of such a calculator.

Contents

Chapter 1

Background

1.1 Introduction

This document is a project report the problem domain model Calculator System. Domain is a calculator that computes the value of certain established irrational numbers. The purpose of the project is to carry out a number of activities, resulting in a set of interrelated artifacts for the problem domain of such a calculator.

Chapter 2

A brief description of Silver Ratio Number

2.1 Introduction

The silver ratio (also known as silver mean or silver constant) is an irrational mathematical constant whose value is approximately 2.4142135623. It is denoted by the greek letter δs.

Definition [Silver Ratio] [Wikipedia]. In mathematics, two quantities are in the silver ratio if the ratio of the sum of the smaller and twice the larger of those quantities, to the larger quantity, is the same as the ratio of the larger one to the smaller one[1].

Explanation:
Let's say $n1$ and $n2$ are given two numbers where $n1 > n2$. The ratio $n1/n2$ of both the numbers is silver ratio if it equals to the ratio of the sum of the smaller number $n1$ and twice the larger number $n2$ to the larger number $n2$.
So, $n1/n2$ is the silver ratio if:

$$\frac{n1}{n2} = \frac{2n1 + n2}{n1}$$

2.2 Characteristics

1. The silver ratio is the second smallest quadratic PisotVijayaraghavan number (PV number) number after the golden ratio. This means the distance from δs^n to the nearest integer is $\frac{1}{\delta s^n} \approx 0.41^n$.

2. Pell number sequence (1, 2, 5, 12, 29...) tends to the silver ratio. In other words, ratio between two consecutive numbers from the Pell number sequence tends to the silver ratio. If we calculate the ratios of two consecutive Pell numbers $\frac{Pn}{Pn-1}$, we get:
$$\delta s = \sqrt{2} + 1$$

3. If we draw a rectangle whose sides have ratio same as the silver ratio, that is $(\sqrt{2}+1)+1:1$, it is called *Silver Rectangle*.
   Let's draw a large silver rectangle. Now if we remove the largest possible square from the drawn silver rectangle, it will yield a silver rectangle of the other kind, removing once again the largest possible square from it, will again yield an another silver rectangle. Repeating the process will always give us a silver rectangle (of course smaller silver rectangle each time).

4. There is a relation between the silver ratio and the octagon. That is, in a regular octagon, the ratio between the orthogonal diagonal to a side is the silver ratio.

2.3 Usage Examples

1. The paper sizes under ISO 216 are rectangles, which has a proportion ratio of $1:\sqrt{2}$. This ratio is same as the silver ratio.

2. The silver ratio is used in classical architectures and arts. For example, The architectures in the temples of Japan.

Chapter 3

Interview

3.1 Interviewer

Samir Anghan, is a student at Concordia University Gina Cody School of Engineering and Computer Science.

3.2 Interviewee

Mehul Patel, is an Electronics circuit design engineer at Rambus Chip Technologies (India) Private Limited. He is graduated in Electrical Engineering with specialization Electronic Systems from 'Indian Institute of Technology Bombay - India'

3.3 The rationale for choosing interviewee

Mehul Patel is an Electronics Circuit Design Engineer with a background of mathematics. An electronics circuit design engineer is a person who uses mathematics in their everyday tasks at his/her work. My interviewee, Mehul Patel, also confirmed that almost all electronics circuit design engineers do use of mathematics and an electric circuit simulator using MATHEMATICA Software. They often need to provide numerical values to circuit parameters. This brings to a conclusion that a person who is an electronics circuit design engineer is usually close to the use of mathematics and all numbers including irrational numbers. Hence, I believe that my interviewee is a potential user of given ETERNITY: NUMBERS.

3.4 Interview questions and responses

Question 1: As an engineer, which of the following irrational numbers you use or ever used in your everyday tasks or during your work?

1. Champernowne Constant
2. Eulers Number

3. Gaussian Integral
4. Gelfonds Constant
5. Golden Ratio
6. Liouville Constant
7. Natural Logarithm of 2
8. Pi
9. Silver Ratio
10. Universal Parabolic Constant
11. Plastic Number
12. Hilbert Number

Response: Champernowne Constant, Universal Parabolic Constant and Plastic Number.

Question 2: Do you know any real-life application that uses irrational numbers?
Answer in Yes or No. If yes, please mention.

Response: There are lots of real-life application that uses irrational numbers. Like PI is used in almost all geometric calculation in real life. e is used in compound interest.

Question 3: If you ever want to use a calculator that computes the value of certain irrational numbers, what other additional functionality from below list you would like to have in that calculator.

Function 1: Calculate the value of irrational number up to given certain decimal places.
Function 2: Addition, Subtraction, Multiplication, Division of the Irrational Numbers.
Function 3: Classify the given number whether it is rational or irrational.
Function 4: Other (Please describe)

Response: I would like to have Function 1 to 3. I would also like to have below functions:

1. I could enter the symbol of some usually used irrational number such as Pi, euler's number.
2. Common root calculation (squared, cubed etc.) and trigonometric calculation.
3. Equation having irrational numbers build up the facility storage of some calculated irrational parameter.

Question 4: Are you using any existing mathematical software for any required mathematical operations on irrational numbers?
Answer Yes or No. If Yes, please provide information.

Response: Yes, I have used MATLAB and MATHEMATICA software for any required mathematical operation on irrational numbers during my education period.

Question 5: Silver Ratio (δs) is an irrational number, whose value is one plus the square root of 2 and is approximately 2.4142135623. Have you ever used Silver Ratio during your education or at your work?
Answer in"Yes" or "No" . If "Yes", please provide information on why or how you used the Silver Ratio number.

Response: Not practically, but just because of my curiosity in this magic number (silver ratio), I have studied a little about this silver ratio number during my education period.

Question 6: The area of a regular octagon with side length of a can be calculated by following formula which uses Silver Ratio.

$$A = 2(\sqrt{2} + 1)a^2$$

Here the value of the square root of 2 is 1.4142135623730951... (no finite number of digits).
According to you, up to what number of certain decimal places, the value of the $\sqrt{2}$ should be used in the above formula to calculate the area of a regular octagon?

Response: It depends on how accurate the area number you want. Generally, a standard scientific calculator uses around 9-10 digit after the decimal point.

Question 7: Do you know any other possible uses of Silver Ratio number, by itself, or in combination with other numbers? (e.g. Silver Ratio can be used to calculate the area of a regular octagon)
Answer Yes or No. If Yes, please provide information.

Response: Yes, the Silver ratio can be connected to the trigonometric ratio for Pi/8 value.

3.5 Analysis of an interview

After having an interview with Mehul Patel, an electronics circuit design engineer, I came to discover a few things regarding the irrational numbers. An interviewee is currently an employee at Rambus Chip Technologies (India) Private Limited and had M.tech in Electrical Engineering with specialization Electronic Systems. He has a passion for mathematics. From the responses of the question, I conclude the following things:

- An interviewee has used or studied many irrational numbers but mostly during his education period.
- An interviewee is aware of some real-life application that uses irrational numbers.

- An interviewee suggested some functions to include in the Calculator (e.g. storage of some calculated irrational parameter).
- An interviewee has some knowledge of Silver Ratio (δs) number, but he has not used the number practically yet.
- An interviewee suggested to consider up to 9-10 digits after the decimal point of an irrational number for any applications that use the value of an irrational number.

Chapter 4

Persona of an interviewee

Rahul Patel

Electronics circuit engineer & Mathematician

Gender : Male

Age : 40-45 years

Email: samir.al@gmail.com

Country: India

Skills

Experience

Rahul Patel is an Electronics circuit design engineer at Rambus Chip Technologies (India) Private Limited. He is graduated in Electrical Engineering with specialization Electronic Systems from 'Indian Institute of Technology Bombay - India. He has been remain close to Mathematics for more than 5 years. As an electronics circuit design engineers, he uses mathematics in electric circuit simulation using MATHEMATICA Software.

Interest

His interests are in solving mathematical equations. He is already doing that using using MATHEMATICA Software. He has used or studied many irrational numbers but mostly during his education period. He is familiar with Siver Ratio Number but never used practically. He knows real-life application that uses irrational numbers. He is open to work with Silver Ratio Number in future if required.

Likes|Dislikes

He like to push the boundaries of what is possible. He is likes to learn new things, in-fact he always keep his self busy learning new things. He likes to give suggestions on any mathematical calculations. He do not like to work with a person who is not self motivated.

Business Values

He believe that some day he will become an expert in solving mathematical problems. He thinks that his such expertises can help his company in research and development work.

Chapter 5

A Domain Model

5.1 The List of Concepts

1. **Calculator**
   The main concepts that centralize all other concepts.

2. **IrrationalNumber** $<< Abstract >>$
   Holds value of an irrational number.

3. **SilverRatioNumber**
   Holds value of Silver Ratio Number.
   And it is a extended from the base concept $IrrationalNumber$.

4. **Pi**
   Holds value of Pi Number.
   And it is a extended from the base concept $IrrationalNumber$.

5. **EulerNumber**
   Holds value of Euler's Number.
   And it is a extended from the base concept $IrrationalNumber$.

6. **Operator** $<< Abstract >>$
   Represents the operators.

7. **Adder**
   Represents addition operator.
   And it is a extended from the base concept $Operator$.

8. **Subtractor**
   Represents subtraction operator.
   And it is a extended from the base concept $Operator$.

9. **Multiplier**
   Represents multiplication operator.
   And it is a extended from the base concept $Operator$.

10. **Divider**
    Represents division operator.
    And it is a extended from the base concept $Operator$.

11. **Operand**
    Represents the operands.

12. **Expression** $<< Abstract >>$
    Represents expressions and evaluate expression function.

13. **AreaOfRegularOctagonExpression**
    Represents expression to calculate area of regular octagon using $SilverRatioNumber$.
    And it is a extended from the base concept $Expression$.

14. **IrrationalValueGenerationExpression**
    Represents expression to calculate the value of irrational number up to given certain decimal places.
    And it is a extended from the base concept $Expression$.

15. **IrrationalAlgebraicExpression**
    Represents irrational algebraic expressions.
    And it is a extended from the base concept $Expression$.

16. **IrrationalArithmaticExpression**
    Represents irrational arithmetic expressions.
    And it is a extended from the base concept $Expression$.

17. **AreaOfCircleExpression**
    Represents expression to calculate area of a circle using Pi.
    And it is a extended from the base concept $Expression$.

5.2 Relationships between the Concepts

1. IrrationalNumber, Operator and Operand **are part of** Calculator **(Aggregation Relationship)**.
   Calculator **has one or more** IrrationalNumber, Operator and Operand.

2. SilverRatioNumber, EulerNumber and Pi **extends (Generalization Relationship)**.

3. Adder, Subtractor, Multiplier and Divider **extends** Operator **(Generalization Relationship)**.

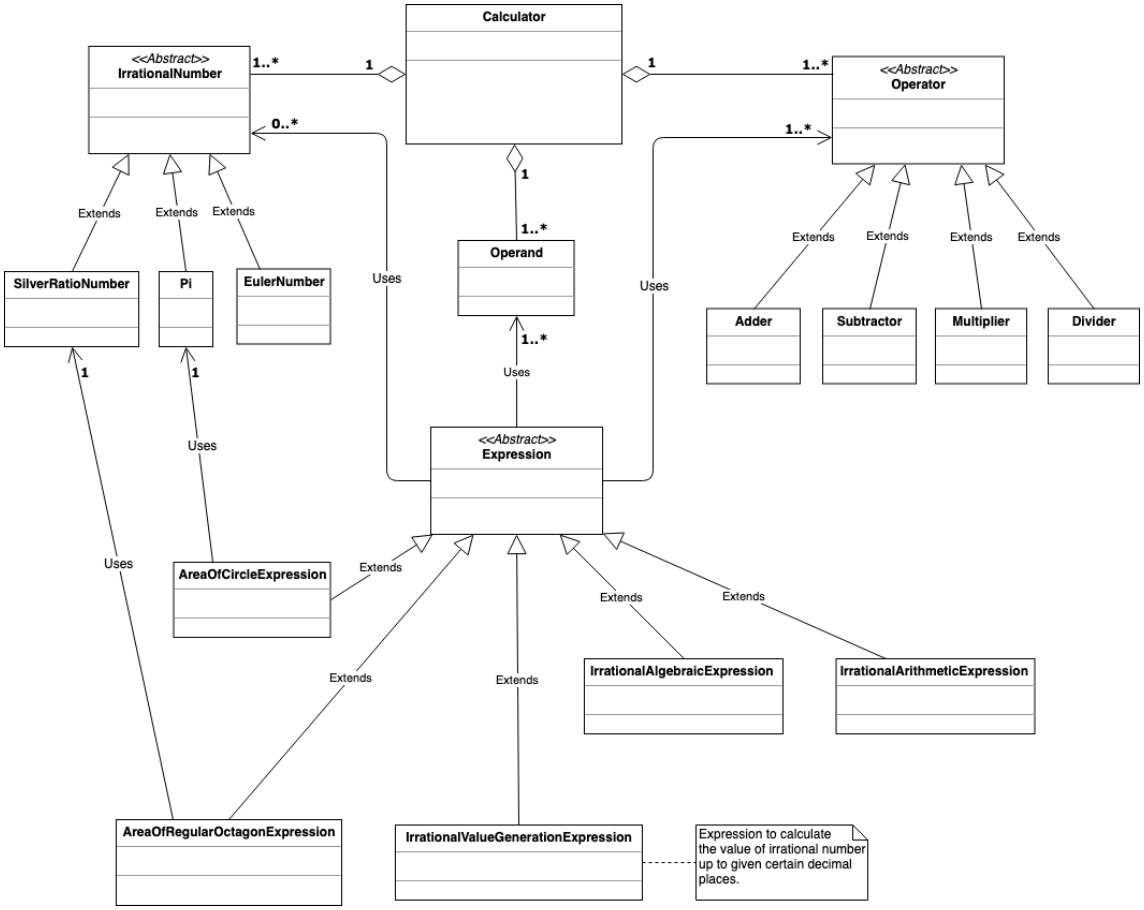
4. Expression **uses one or more** Operand and Operator **(Association Relationship)**.

5. AreaOfRegularOctagonExpression, IrrationalValueGenerationExpression, IrrationalAlgebraicExpression, IrrationalArithmaticExpression and AreaOfCircleExpression **extends** Expression **(Generalization Relationship)**.

6. AreaOfRegularOctagonExpression **uses one** SilverRatioNumber (**Association Relationship**).

7. AreaOfCircleExpression **uses one** Pi (**Association Relationship**).

5.3 A Domain Model diagram



Chapter 6

A Use Case Model

6.1 Description of a use case model

System: Calculator System

Actor: Calculator User

User cases:

1. Evaluate Expression
2. Evaluate Irrational Number Value
3. Evaluate Irrational Algebraic Expression
4. Evaluate Irrational Arithmetic Expression
5. Evaluate Area of Regular Octagon Expression
6. Evaluate Area of Circle Expression
7. Save Value of Evaluated Expression
8. Display Answer

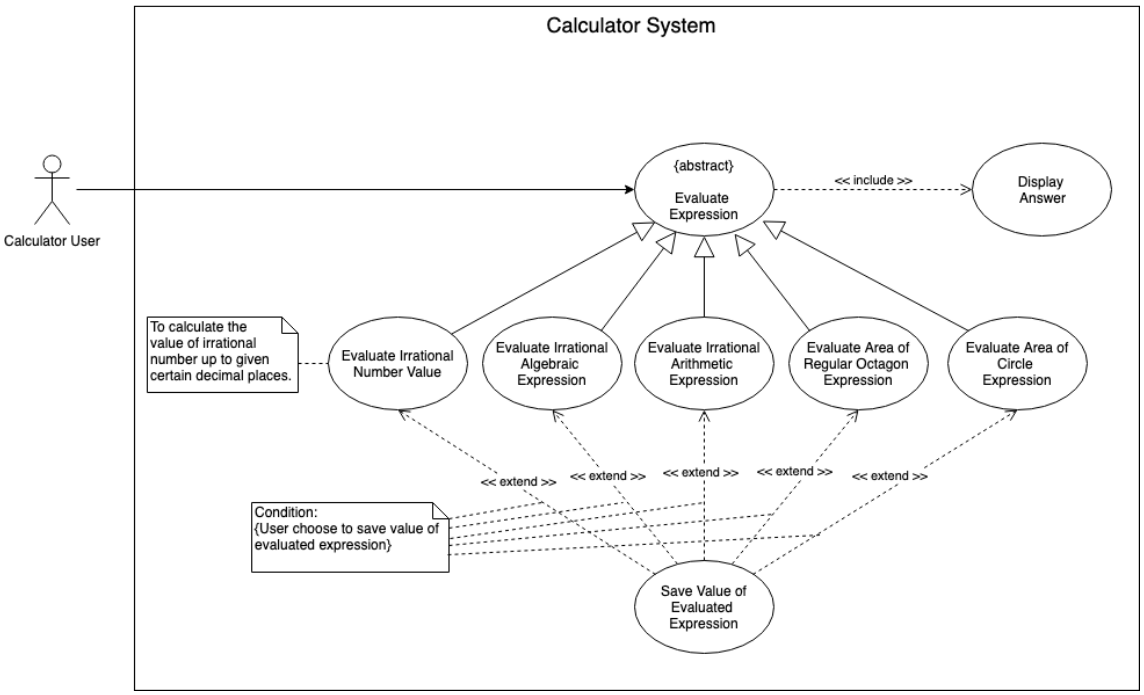
Relationships between use cases:

1. Evaluate Irrational Number Value, Evaluate Irrational Algebraic Expression, Evaluate Irrational Arithmetic Expression, Evaluate Area of Regular Octagon Expression, Evaluate Area of Circle Expression **are-kind of** Evaluate Expression **(Generalization Relationship)**.
2. Save Value of Evaluated Expression **extends** Evaluate Irrational Number Value, Evaluate Irrational Algebraic Expression, Evaluate Irrational Arithmetic Expression, Evaluate Area of Regular Octagon Expression, Evaluate Area of Circle Expression **based on the condition** if user choose to save value of evaluated expression.

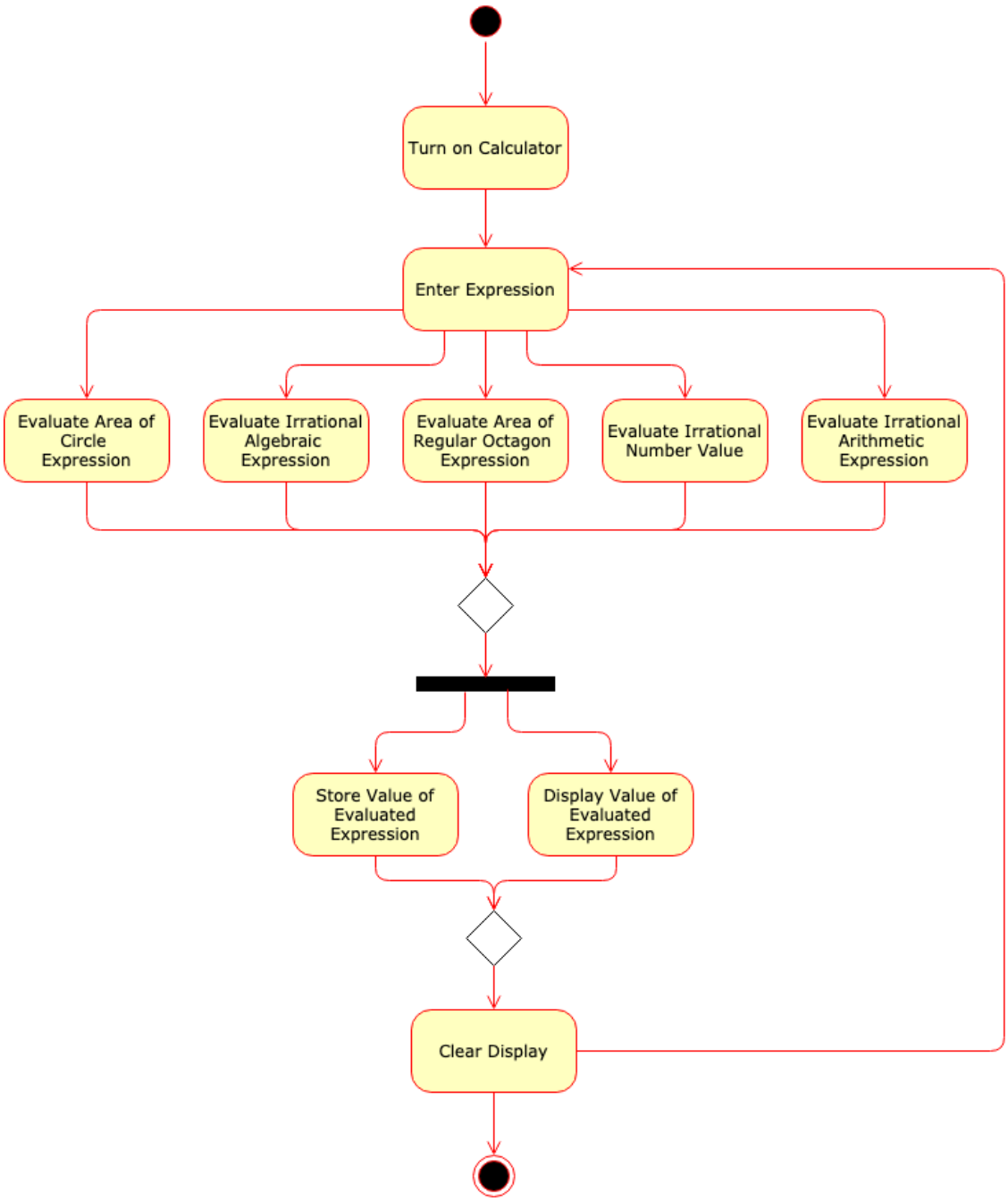
3. Evaluate Expression **includes** Display Answer.

Relationships between actor and use cases: Calculator user Evaluates Expression.

6.2 View 1: Use case model diagram

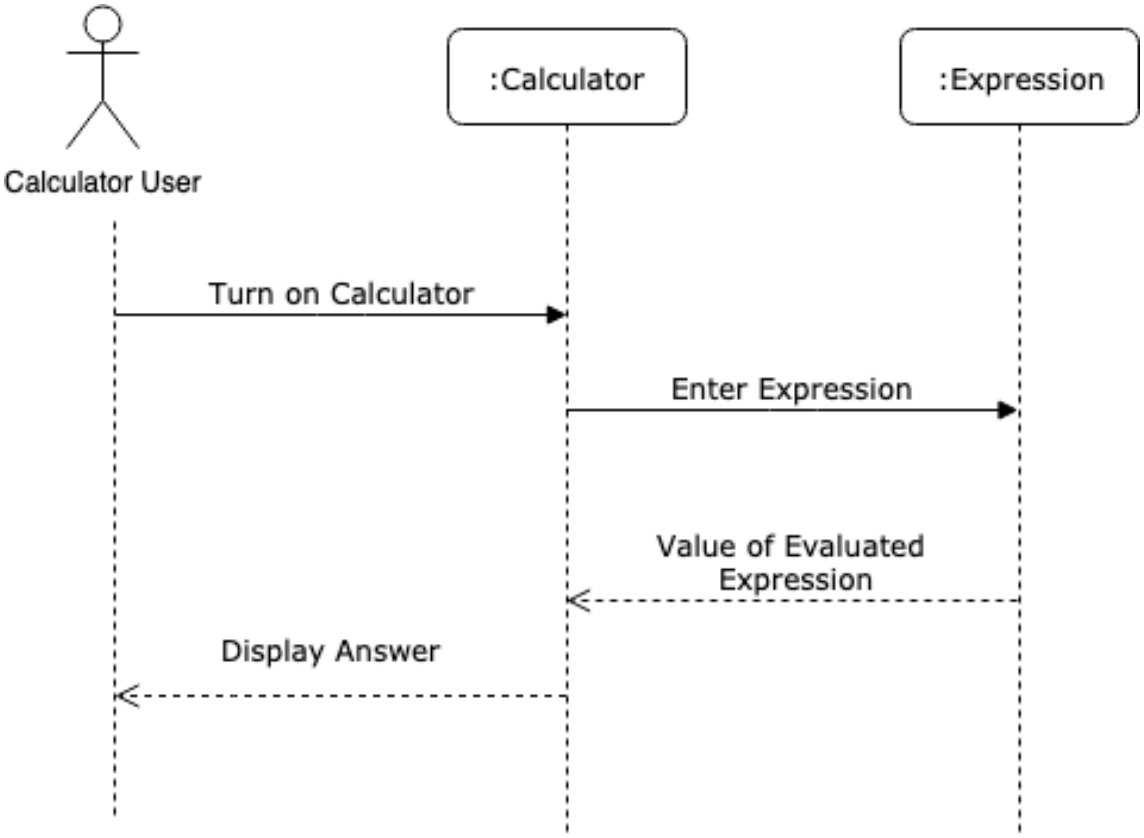


6.3 View 2: Activity Diagram

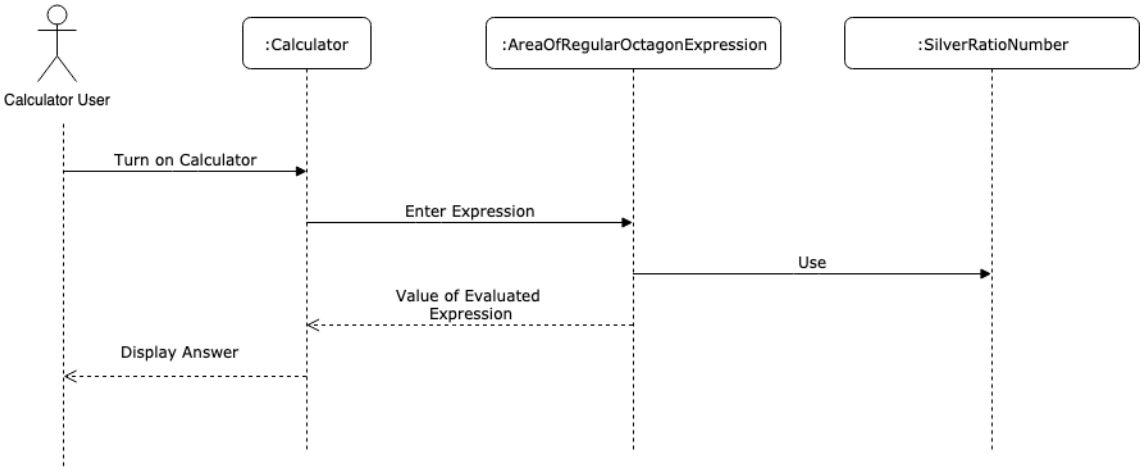


6.4 Scenarios of use cases

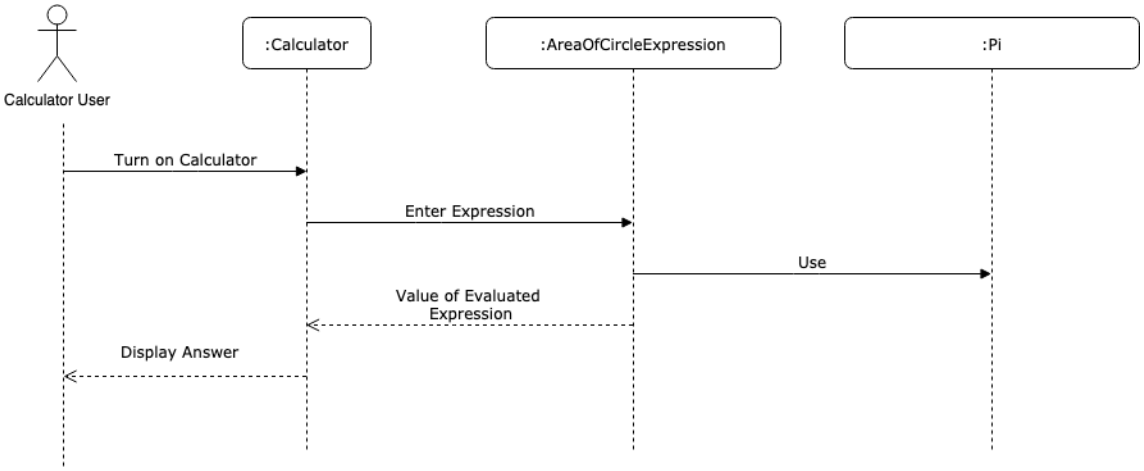
Scenario 1: Following UML Sequence Diagram shows a scenario that is the evaluation of any general expression.



Scenario 2: Following UML Sequence Diagram shows a scenario that is the evaluation of the expression to find the area of regular octagon using the Silver Ratio number.



Scenario 3: Following UML Sequence Diagram shows a scenario that is the evaluation of the expression to find the area of circle using the Pi number.


Calculator User
:Calculator
:AreaOfCircleExpression
:Pi
Turn on Calculator
Enter Expression
Use
Value of Evaluated Expression
Display Answer

Chapter 7

Conclusion and Discussion

7.1 Conclusions

I learn lot of things such as Brainstorming and Mind Mapping, Domain Modeling, Use case modeling. I believe this will help me in future towards my carrier.

7.2 Future Directions

Creation of user stories from the user cases, implementation of those user stories using Java programming language.

Bibliography

[1] W. Foundation, “Silver ratio.,” *Wikipedia*, 2019.