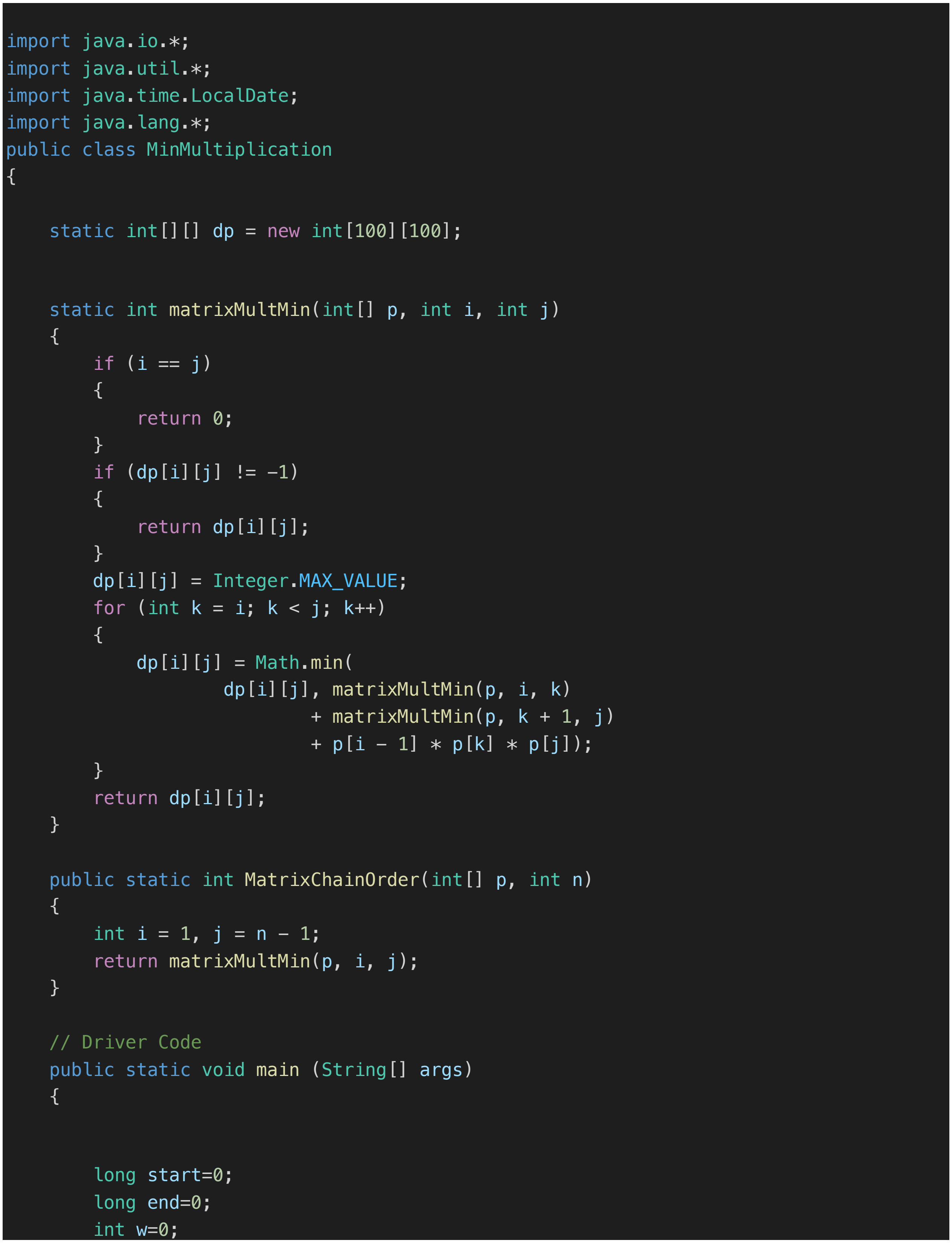
1) Minimum matrix multiplication algorithm



```java
import java.io.*;
import java.util.*;
import java.time.LocalDate;
import java.lang.*;
public class MinMultiplication
{

    static int[][] dp = new int[100][100];


    static int matrixMultMin(int[] p, int i, int j)
    {
        if (i == j)
        {
            return 0;
        }
        if (dp[i][j] != -1)
        {
            return dp[i][j];
        }
        dp[i][j] = Integer.MAX_VALUE;
        for (int k = i; k < j; k++)
        {
            dp[i][j] = Math.min(
                    dp[i][j], matrixMultMin(p, i, k)
                            + matrixMultMin(p, k + 1, j)
                            + p[i - 1] * p[k] * p[j]);
        }
        return dp[i][j];
    }

    public static int MatrixChainOrder(int[] p, int n)
    {
        int i = 1, j = n - 1;
        return matrixMultMin(p, i, j);
    }

    // Driver Code
    public static void main (String[] args)
    {


        long start=0;
        long end=0;
        int w=0;
        int arr[] = { 1,2,3,4,5,10,20,30,34, 354, 567, 987, 636 ,678,789,799};
        int n= arr.length;
        start=System.nanoTime();
        end=System.nanoTime();
        for (int[] row : dp)
            Arrays.fill(row, -1);

        System.out.println("n = "+n+" and time taken in nanoseconds is "+(end-start));
    }
}
```

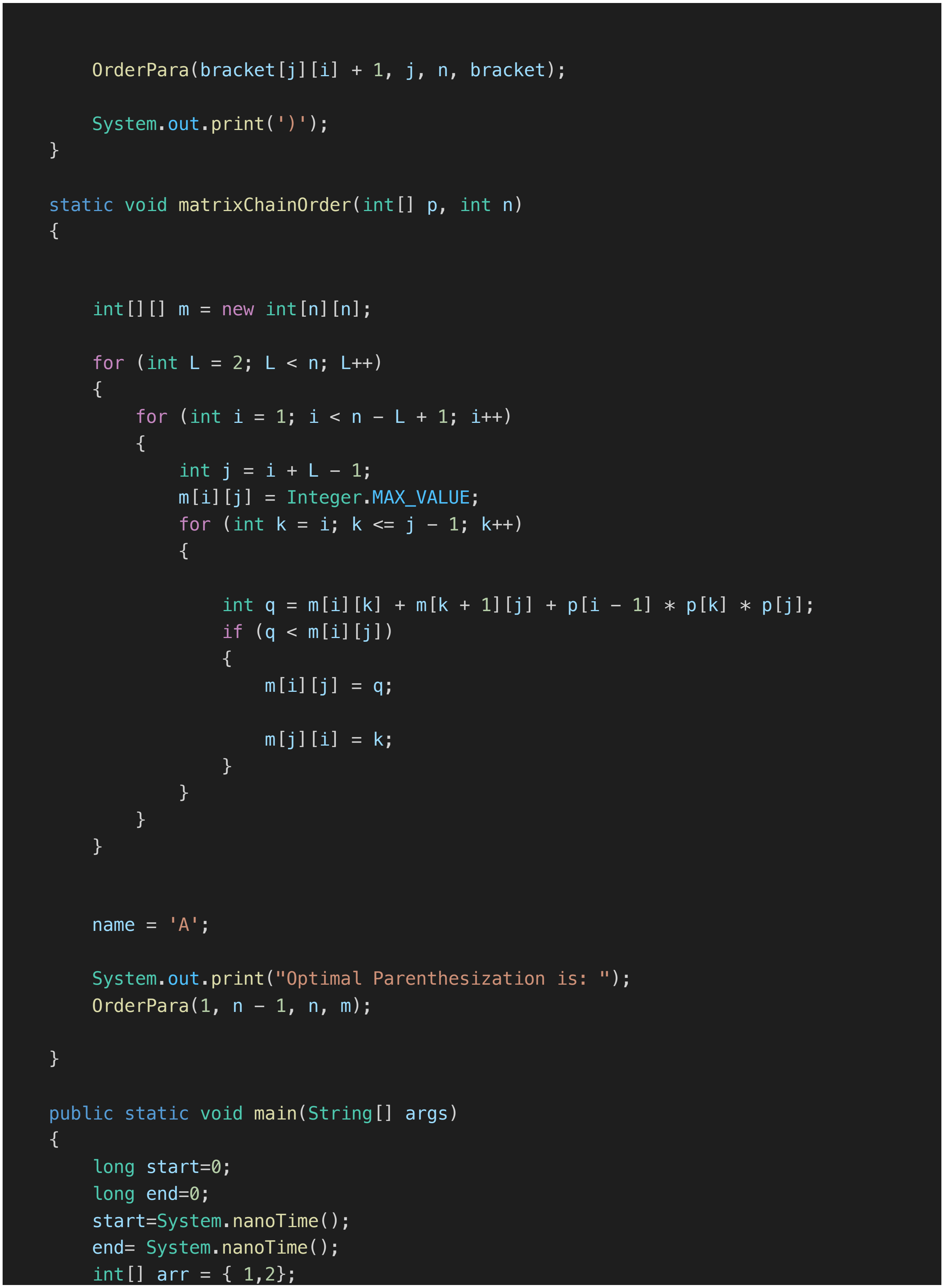
Output:

```
harshavaidhyam@Harshas-MacBook-Pro Pitt term-1 %  /usr/bin/env
/Library/Java/JavaVirtualMachines/temurin-17.jdk/Contents/Home/bin/java -
XX:+ShowCodeDet
ailsInExceptionMessages -cp /Users/harshavaidhyam/Library/Application\
Support/Code/User/workspaceStorage/91b3d36993f9364f97484f699e8e3b35/redhat.java/
jdt_ws/jdt.ls-java-project/bin MinMultiplication
```

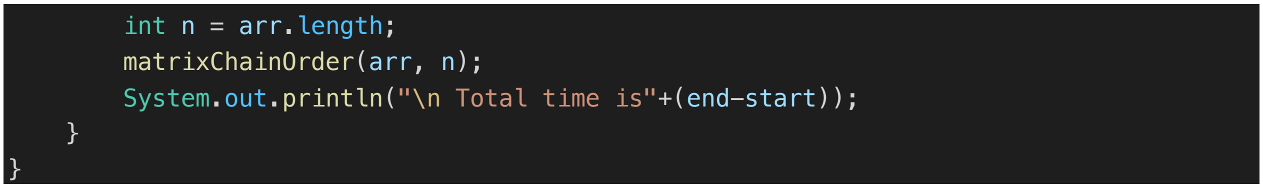
n = 16 and time taken in nanoseconds is 125

2) Print optimal order algorithm

```
import java.io.*;
import java.util.*;
import java.time.LocalDate;
import java.lang.*;

public class OptimalOrder
{

    static char name;


    static void OrderPara(int i, int j, int n, int[][] bracket)
    {

        if (i == j)
        {
            System.out.print(name++);
            return;
        }

        System.out.print('(');


        OrderPara(i, bracket[j][i], n, bracket);
```



```
        OrderPara(bracket[j][i] + 1, j, n, bracket);

        System.out.print(')');
    }

    static void matrixChainOrder(int[] p, int n)
    {


        int[][] m = new int[n][n];

        for (int L = 2; L < n; L++)
        {
            for (int i = 1; i < n - L + 1; i++)
            {
                int j = i + L - 1;
                m[i][j] = Integer.MAX_VALUE;
                for (int k = i; k <= j - 1; k++)
                {

                    int q = m[i][k] + m[k + 1][j] + p[i - 1] * p[k] * p[j];
                    if (q < m[i][j])
                    {
                        m[i][j] = q;

                        m[j][i] = k;
                    }
                }
            }
        }


        name = 'A';

        System.out.print("Optimal Parenthesization is: ");
        OrderPara(1, n - 1, n, m);

    }

    public static void main(String[] args)
    {
        long start=0;
        long end=0;
        start=System.nanoTime();
        end= System.nanoTime();
        int[] arr = { 1,2};
```

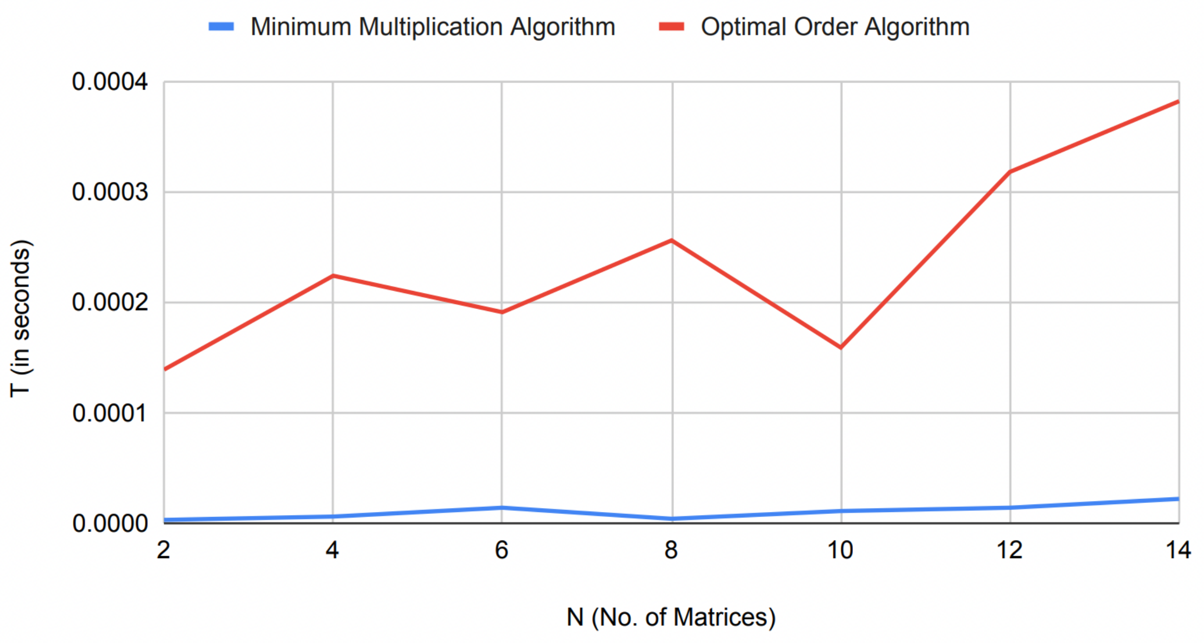


```
        int n = arr.length;
        matrixChainOrder(arr, n);
        System.out.println("\n Total time is"+(end-start));
    }
}
```

Output:

```
harshavaidhyam@Harshas-MacBook-Pro Pitt term-1 %  /usr/bin/env
/Library/Java/JavaVirtualMachines/temurin-17.jdk/Contents/Home/bin/java -
XX:+ShowCodeDet
ailsInExceptionMessages -cp /Users/harshavaidhyam/Library/Application\
Support/Code/User/workspaceStorage/91b3d36993f9364f97484f699e8e3b35/redhat.java/
jdt_ws/jdt.ls-java-project/bin OptimalOrder
Optimal Parenthesization is: A
 Total time in nano seconds is125
```

PLOT:


🟦 Minimum Multiplication Algorithm
🟥 Optimal Order Algorithm
T (in seconds)
N (No. of Matrices)