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INFO 6205

Program Structures & Algorithms

Fall 2020

Final Project – Virus Simulation

Project Topic: Covid19 Virus Simulation

A novel coronavirus (CoV) named '2019 novel coronavirus' or 'COVID-19' by the World Health Organization (WHO) is in charge of the current outbreak of pneumonia that began at the beginning of December 2019 near in Wuhan City, Hubei Province, China. COVID-19 is a pathogenic virus.

Direct person-to-person respiratory transmission is the primary means of transmission of severe acute respiratory syndrome coronavirus (2SARS-CoV-2)

It is thought to occur mainly through close-range contact (i.e. within approximately six feet or two meters) via respiratory droplets; virus released in the respiratory secretions when a person with infection coughs, sneezes, or talks can infect another person if it is inhaled or makes direct contact with the mucous membranes. Infection might also occur if a person's hands are contaminated by droplets or by touching contaminated surfaces and then they touch their eyes, nose, or mouth.

Aim of Project:

The project is the focus of covid19 spread in one region. Graph is used to simulate the situation of corona virus spread in one region over a specific period.

With the help of this project, government of a region can easily measure coronavirus spread on each day. So, based on up and down scale of graph of infected people, government can take steps accordingly.

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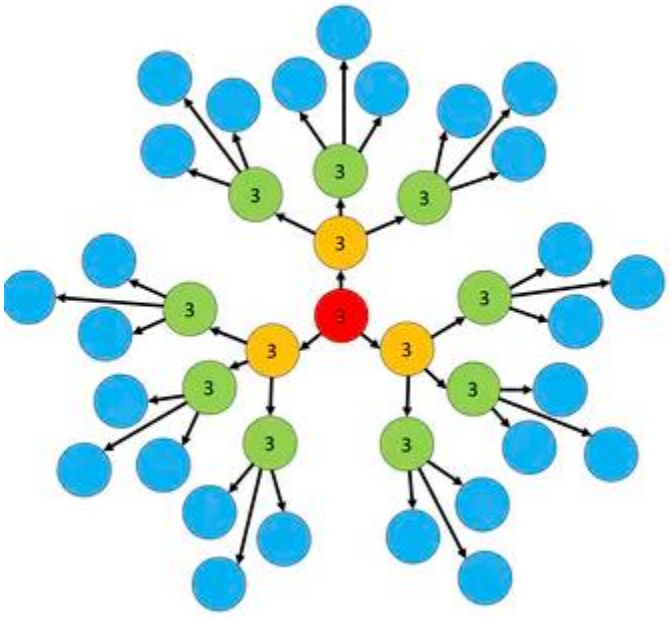
Project Details:

When the project is first run the user is asked to select a location from google maps (Ex. Boston, USA and so on). The region's geographic area is fixed so each time number of people increase, the infection rate also increases.

(Note: The idea was to get a location from google maps and then get the population density from that location. But unable to find a way to get the population density of a location in the given time, only the first part of getting location was implemented with a fixed area and second input field population density was added.)

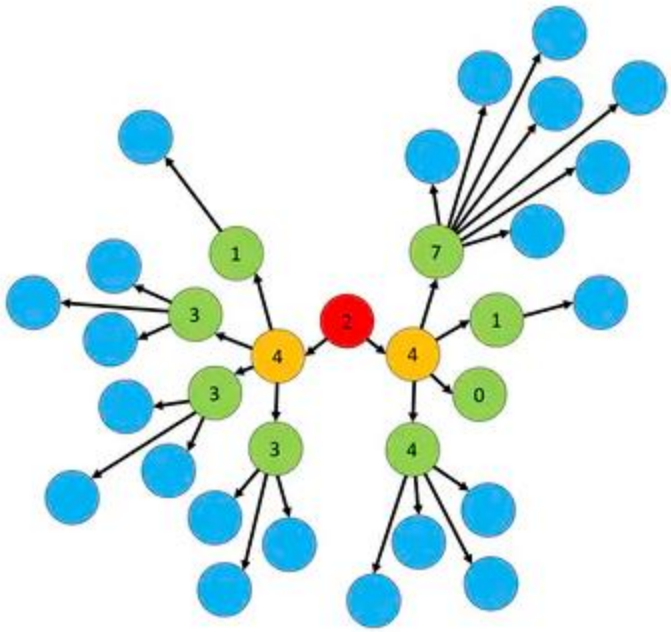
Based on the following input factors, the graph will show no of infected people at each day.

1. R_Factor: R factor is a number which shows an infected person can infect how many other people on average. Its value should be and one or greater than one. If R factor increases, which mean the spread of disease increases.
   - Its value is in general case 2 or 3



   - In the image above, each person is infecting other 3 persons. So disease is spreading quiet faster.

2. K_Factor : K factor is a number which shows that no of infected people who are responsible to spread disease among group of people.
   - Ex. If K_Factor is below 1 then small no of people are responsible to spread the virus
   - It's value between 0 and 1 will gives higher no of positive cases



- In the image above, Person named 2 infected two Persons named 4. Each Person named 4 infected other 4 persons. Person named 3 infected other 3 persons. Person named 7 infected other 7 persons. So one person is responsible for disease spread in clusters at that time K value comes. Large outbreaks initiated by only few super spreaders.

3. Population_Density : The no of people who are living in a region
- It will vary accordingly no of people living in a region.
  (Note: Here Population_Density is taken as just population as fixed area is taken here as mentioned above)

4. Social_Distancing : The minimum distance which is also responsible to spread of a virus. Ex. For covid19, the social distancing is 2 meters mean when two people are 2 meters apart from each other and one person between two is covid positive then he will pass covid virus to another person and the other person also becomes covid positive.
   - It's value for covid19 is 2 meters or 6 feets.

5. Usage_of_Mask : This factor shows how many people have worn masks among total population.
   - Its general value is between 0 and 1 (0 mean 0% and 1 mean 100%)

6. Effectiveness of Mask: This factor is used to show how mask is effective and protect other people from spread of virus
   - Its general value is between 0 and 1 (0 mean 0% and 1 mean 100%)

7. NO_OF_DAYS_FROM_TODAY: This factor is used to get data of specific no of days from today
   - Ex: NO_OF_DAYS_FROM_TODAY=60 mean the system will calculate infected persons from today to next 60 days. 3.
   - The program gets infected people count at each day from current day. So for large input of NO_OF_DAYS_FROM_TODAY, the graph will not show x-axis data and y-axis data(factors)

Implementation

1. Algorithm: Breadth First Search

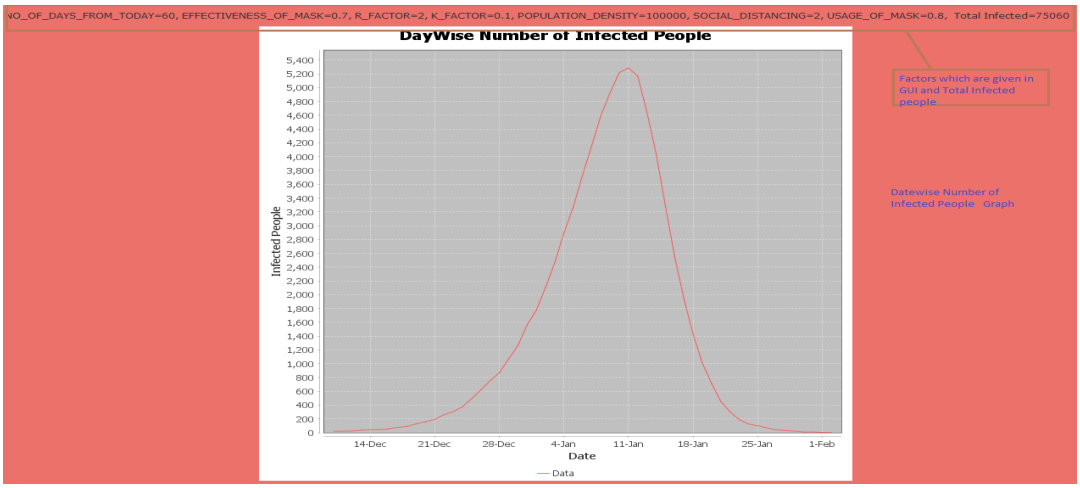
- In first day 0.02% of total population got infected and added into queue.
- On second day, that population perform random walk and infect other people.
- The people who infect on any day, will added into queue and will infect other people on the other day.
- Thus, breadth first search algorithm is used to perform virus spread.

2. The whole project works on Random number generator. Each time the graph will display different result because of random number generator.
3. There is one configuration file named config.properties, which is used to set factors which affects virus spread. Each disease has different values of these factors so GUI is provided for these factors to change them whenever needed.
4. Google Map api is implemented to select exact location for which government wants to get virus update.

Output of Program:

The program generates exponential graph for Coronavirus disease. It means it spreads quickly. In the graph below, every two day, the no of infected people doubles.

Infection rate = log(Total no of infections) = log(75000) ~ 4



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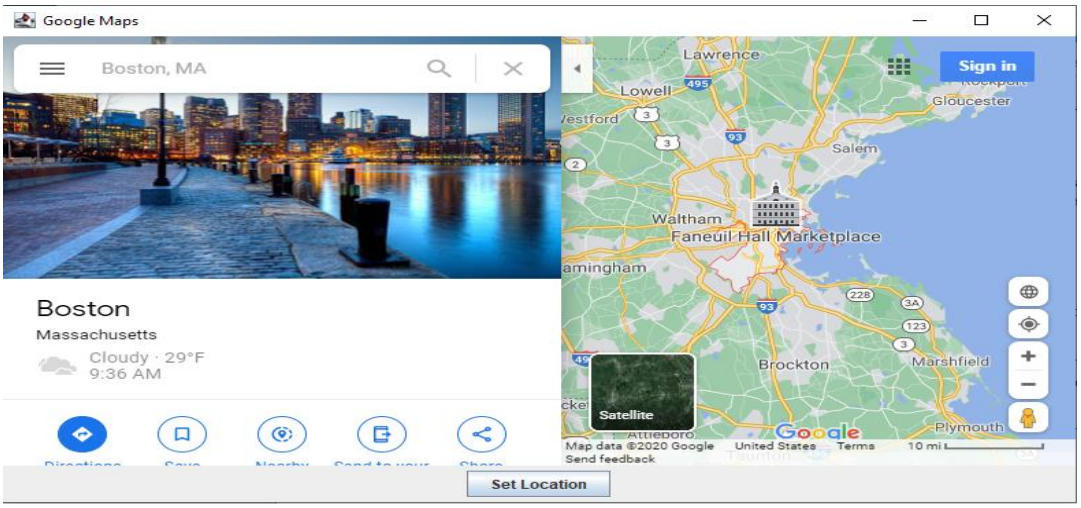
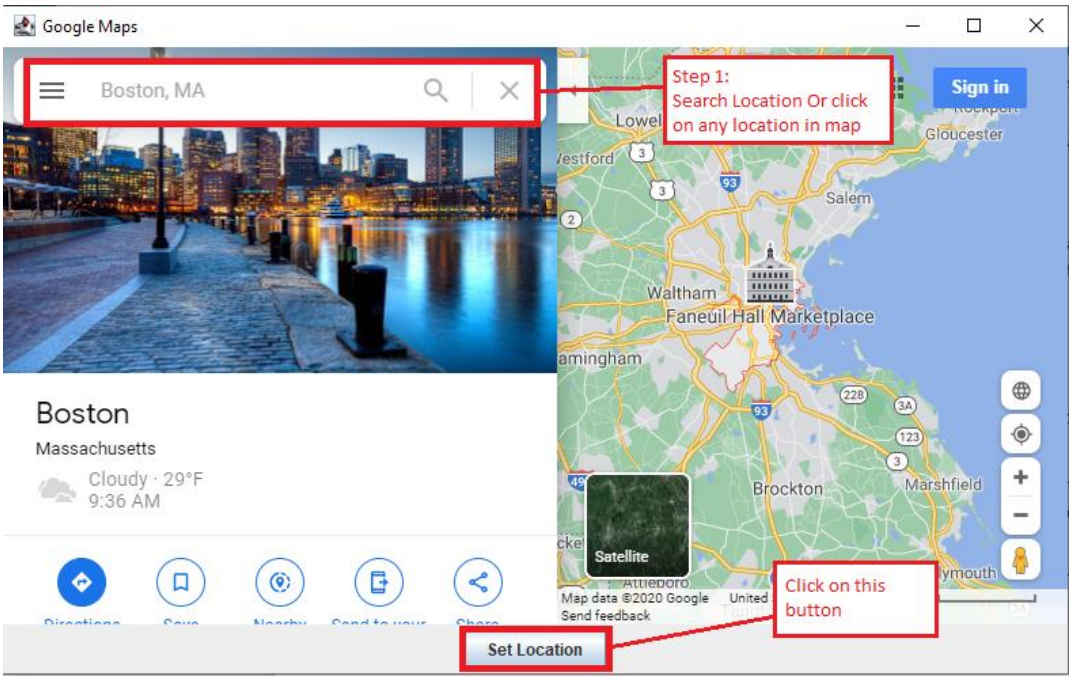
GUI:

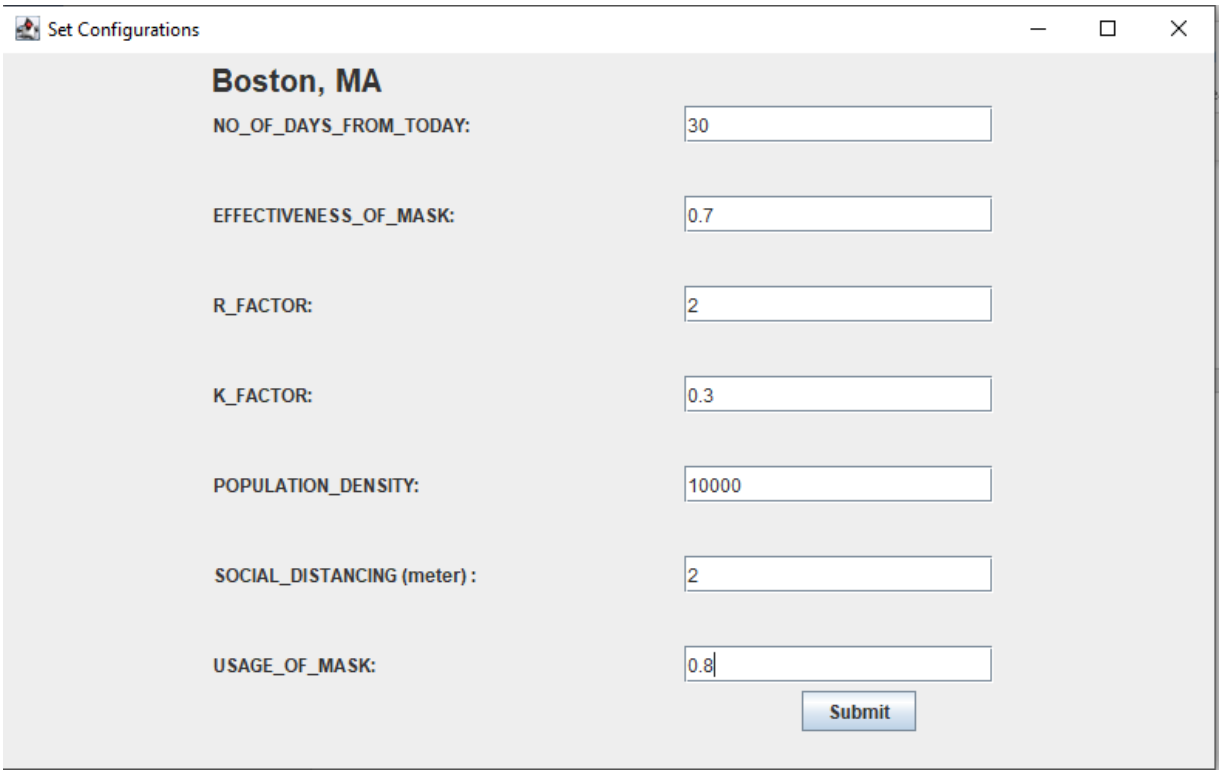
1. From google map, one needs to select location by clicking one any place and then press set Location button or first search in search box and then click on Set Location button to select that location.





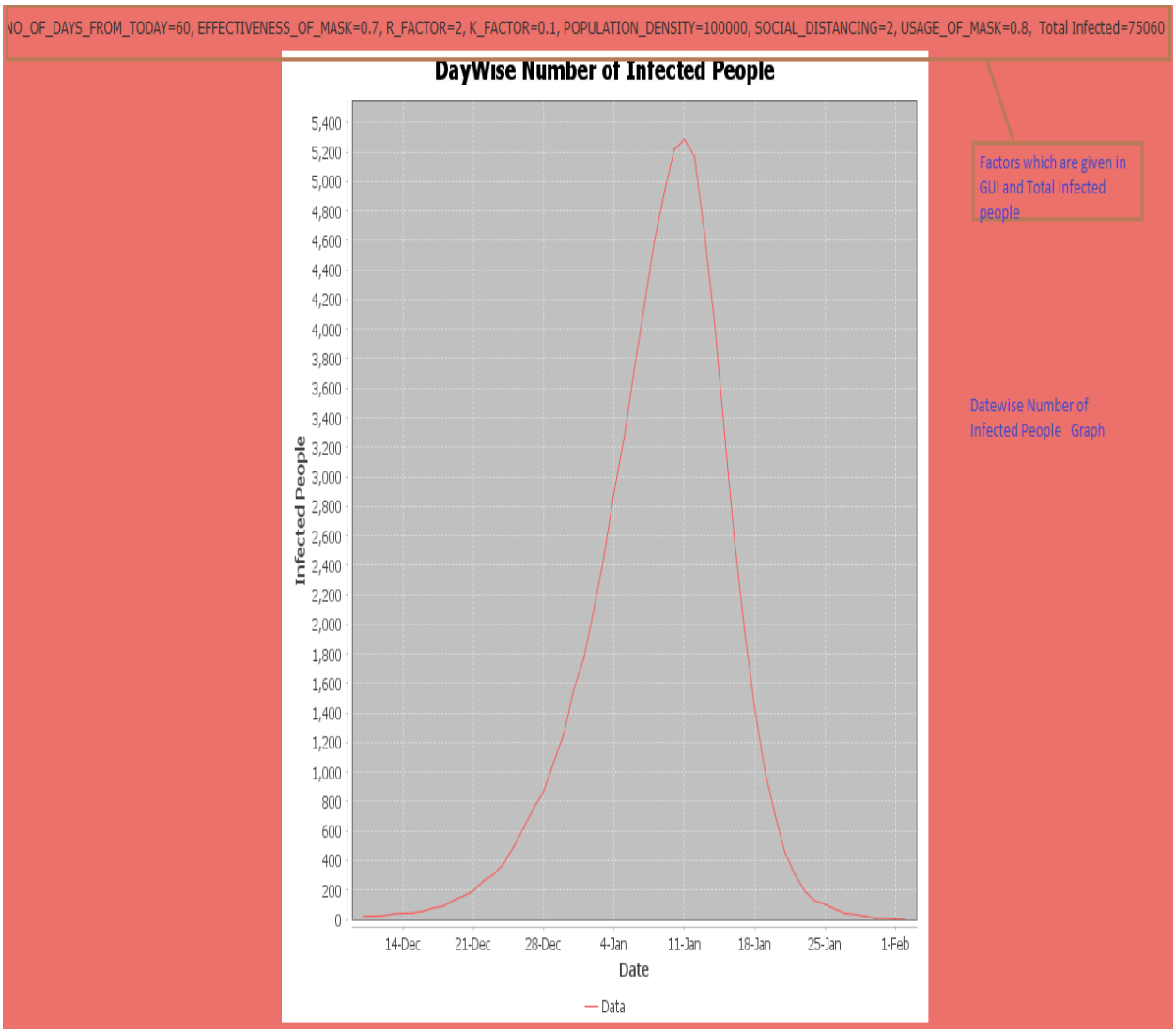
2. Add values in UI for the factors which are responsible for virus spread.

The factors need to be added in number only and not percentage



3. Graph will generate based on input factors

In graph, the first line above graph is factors from config file and their given values. The graph shows date wise number of infected people.



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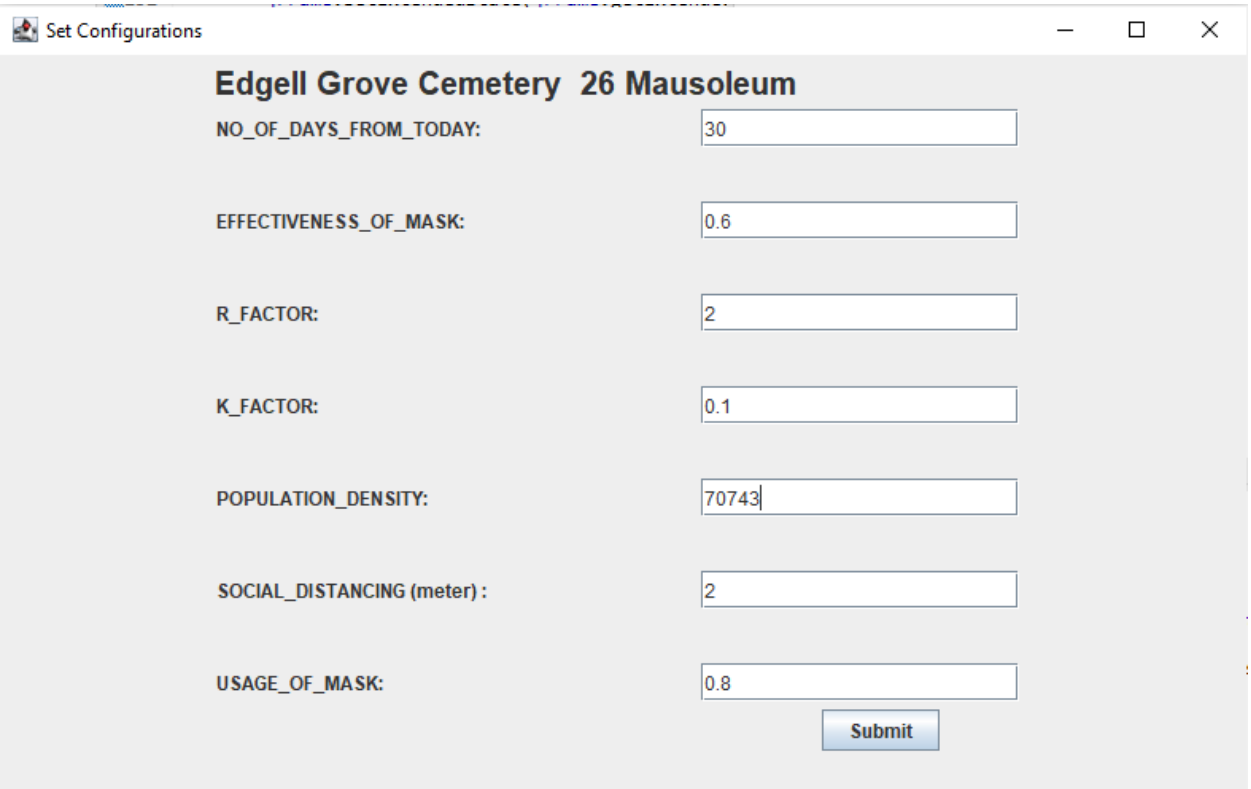
Mathematical Analysis:



Case 1: R_Factor = 2

As shown in the figure above, In Framingham the population density is now 70,743. If we take R_Factor=2 it means one infected person can infect other two persons on average.

If there are 20 infected people in Framingham in the beginning, then they will infect maximum 60 (20*3) people and then that 60 infected people will infect others and so on.

If R_Factor = 2 But Usage_of_Mask = 1 and Effectiveness_of_Mask = 1
Usage_of_Mask = 1 which mean 100% people have worn mask.
Effectiveness_of_Mask = 1 mean the mask is 100% effective and it will protect the person from infection.

So, the result of this is 0.02% infected people of total population in beginning. Which mean if there is one person infected initially, he can not spread infection to other people because all other people have worn masks and masks are 100% effective to protect a person from infected person.

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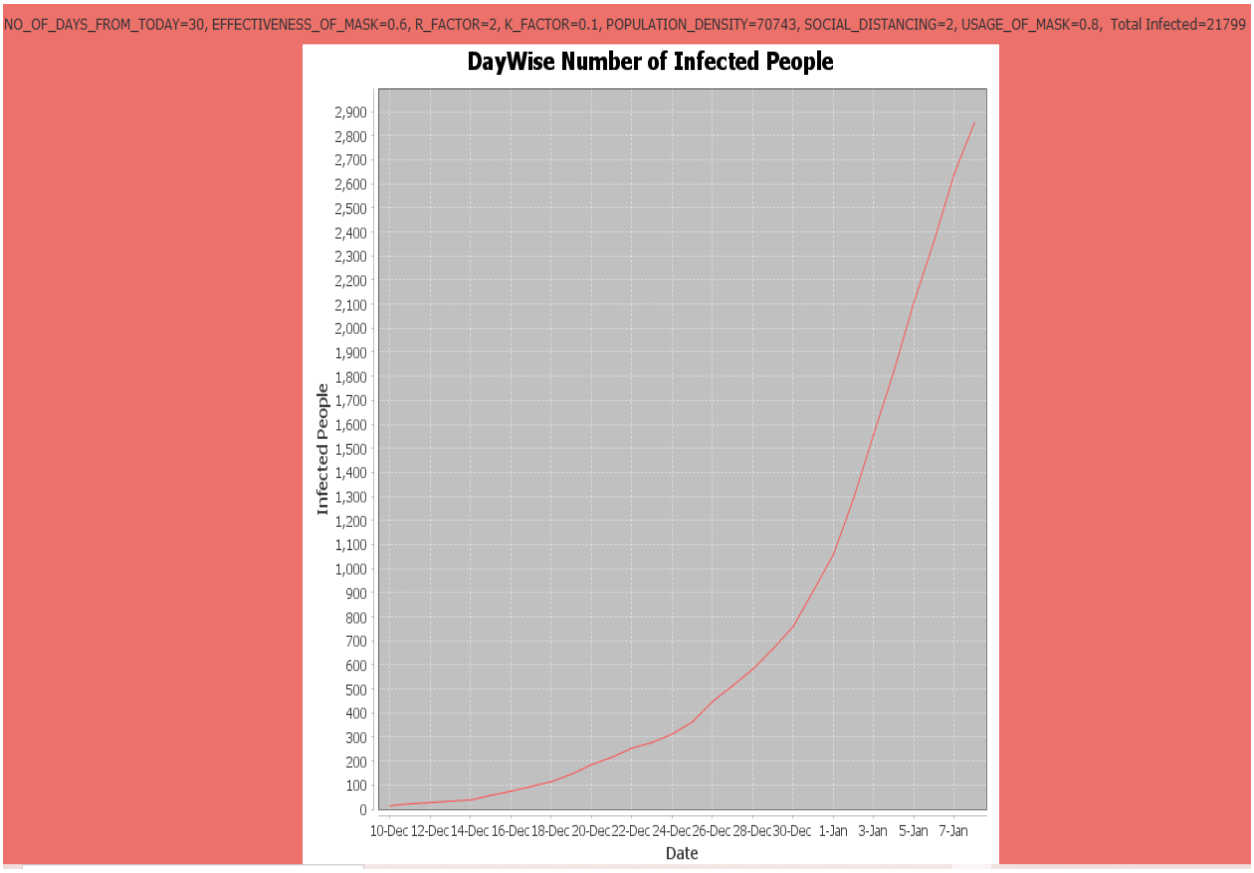
Output:



On the first day, there are 14 infected person but infection rate becomes zero for all other days.

Infection rate = (No of infected people on other day)/(No of total people in a region)

= 0/70743

= 0

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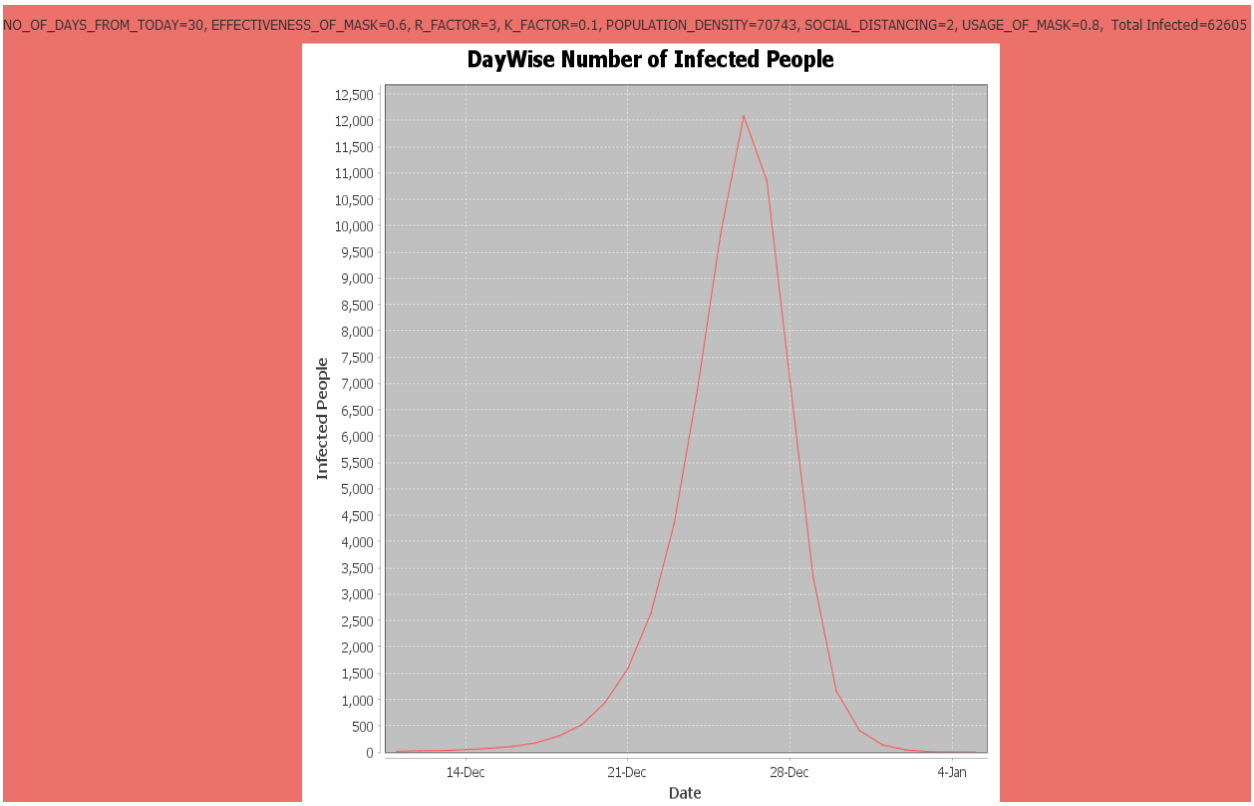
Case 2: R_factor = 3 and all other factors remain same as in case 1

As R_Factor changes from 2 to 3, no of infected people will increase because one infected person can infect other 3 people.

As R_Factor increases, an infected person can infect more no of people on average.

In graph below, total number of infections are higher because of R factor increases from 2 to 3.

The output for R-Factor = 2 and all other factors remain same from case1 is as below:



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Case 3: Usage of Mask = 0.8 and Effectiveness of Mask = 0.8

As Usage_of_Mask factor decreases, more number of people are likely to infect

As Effectiveness_of_Mask factor decreases, more number of people are likely to infect

As the population density is 70743, only 56594 (70743 * 0.8) people have worn mask so 14149 people are likely to infect because they have not worn mask.

In that case effectiveness_of_mask is calculated. If anyone person's mask is effective then the other person will not get infected.

Two graphs below are showing no of infected people in 15 days when Usage_Of_Mask is changed from 0.8 to 0.6.

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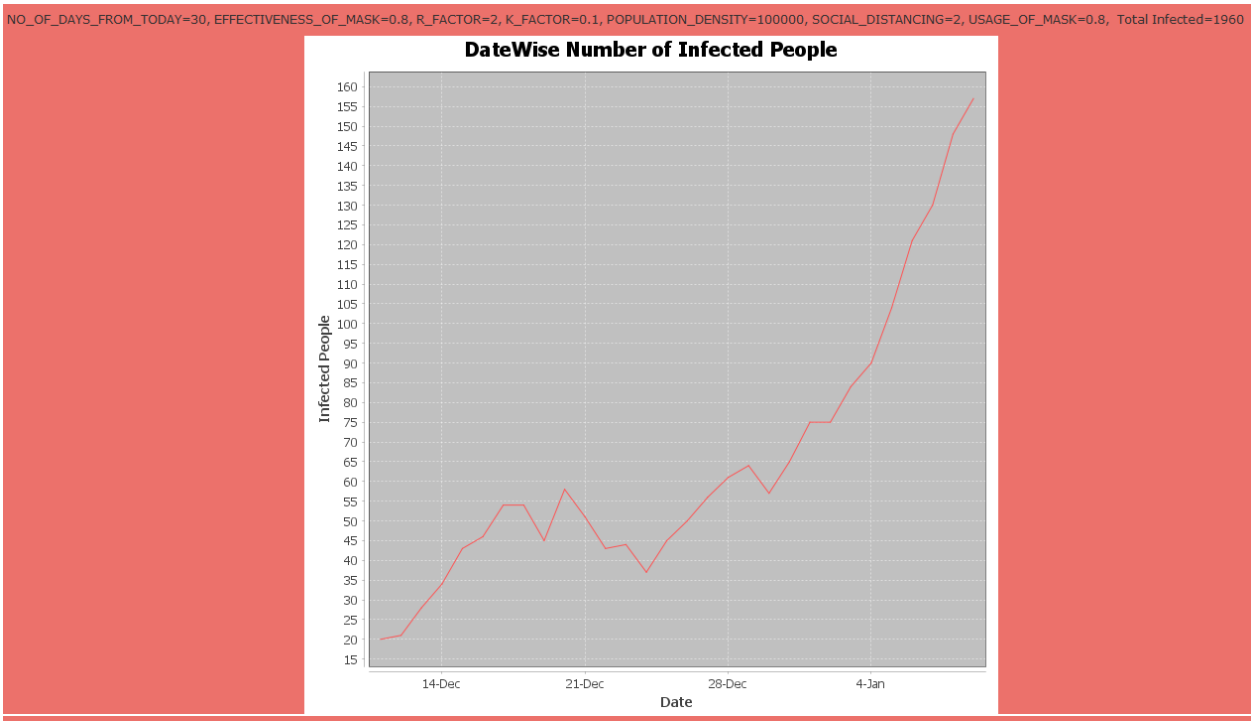

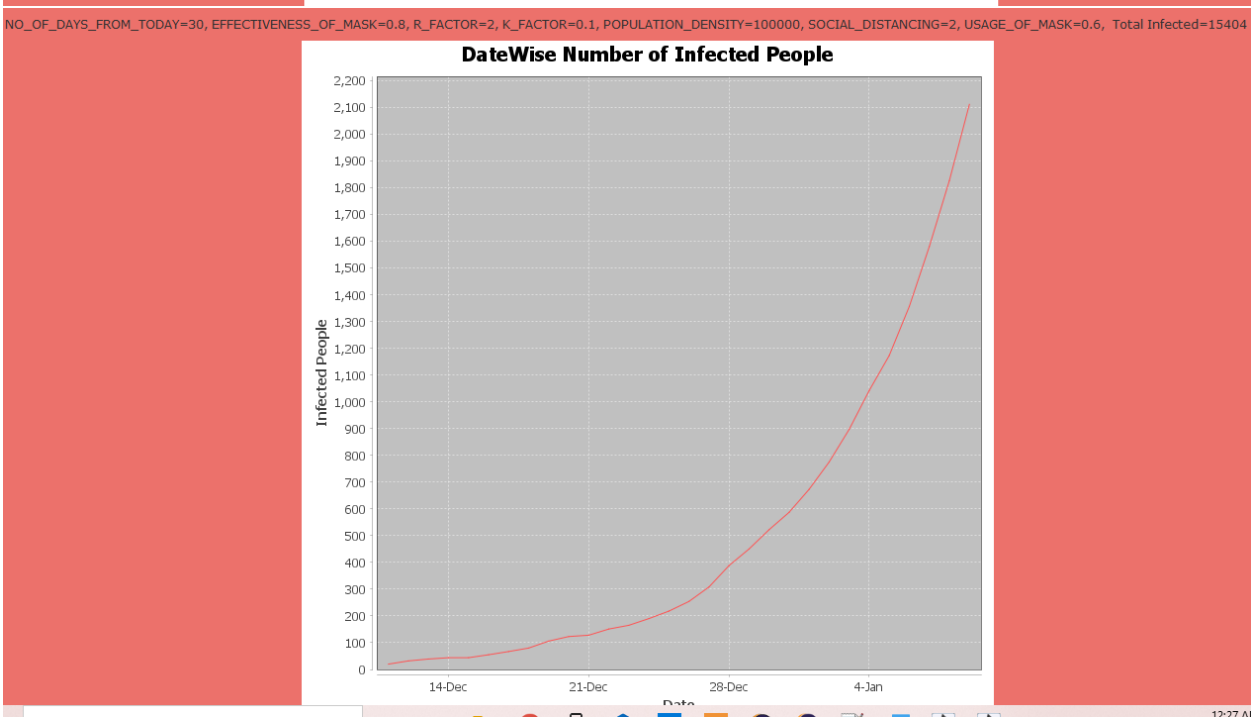

When mask_usage is 0.8, no of infected people are 1960. When mask_usage decreases from 0.8 to 0.6, no of infected people increases and it is 15404.

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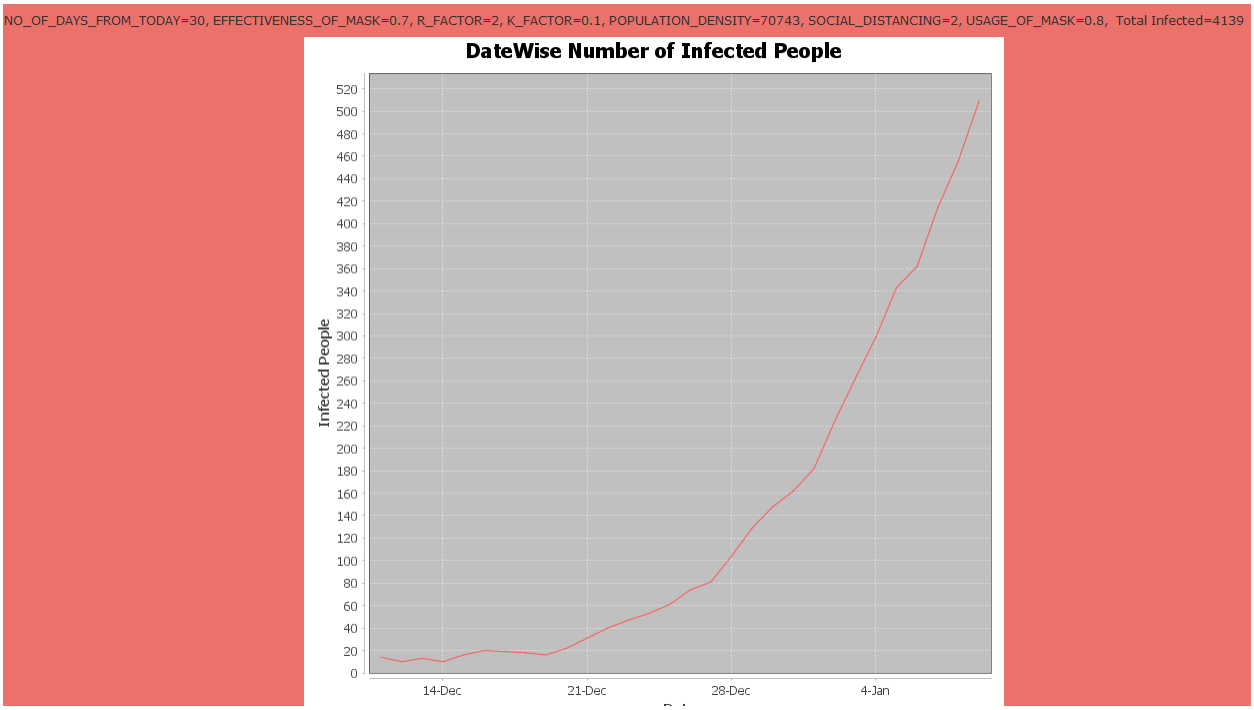
Case 4: As Effectiveness of mask increases, the infected people decreases.

In below graph, mask effectiveness is 0.7. In 70% cases only mask is effective and in other 20% cases mask is not effective. Based on random number generator mask effectiveness is calculated. Is random number is less than or equal to 70 which mean mask is effective and a person will not infect but the number between 70 and 100, mask is not effective so he will be infected by other infected person. In below graphs when mask_effectiveness is 0.7 at that time no of infected people are 4139. When mask effectiveness increases from 0.7 to 0.9, at that time no of infected people decreases to 39.



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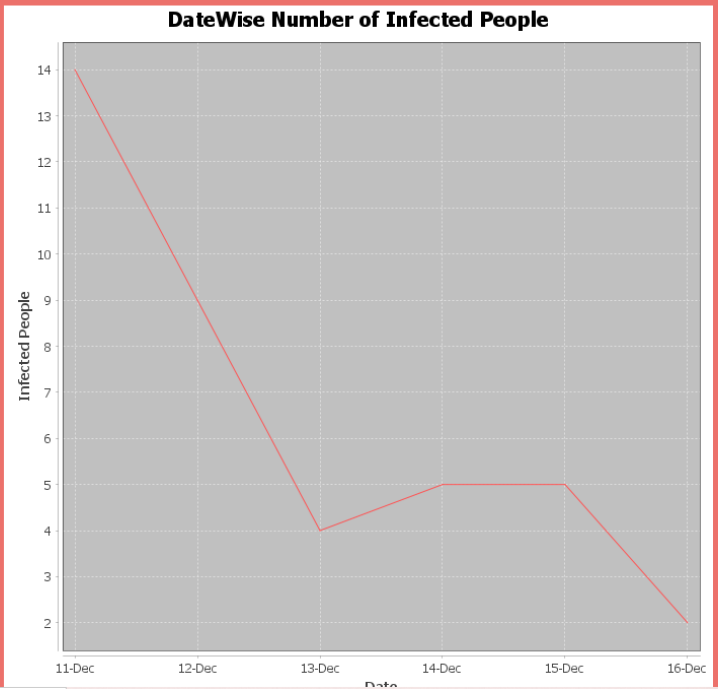
NO_OF_DAYS_FROM_TODAY=30, EFFECTIVENESS_OF_MASK=0.9, R_FACTOR=2, K_FACTOR=0.1, POPULATION_DENSITY=70743, SOCIAL_DISTANCING=2, USAGE_OF_MASK=0.8, Total Infected=39



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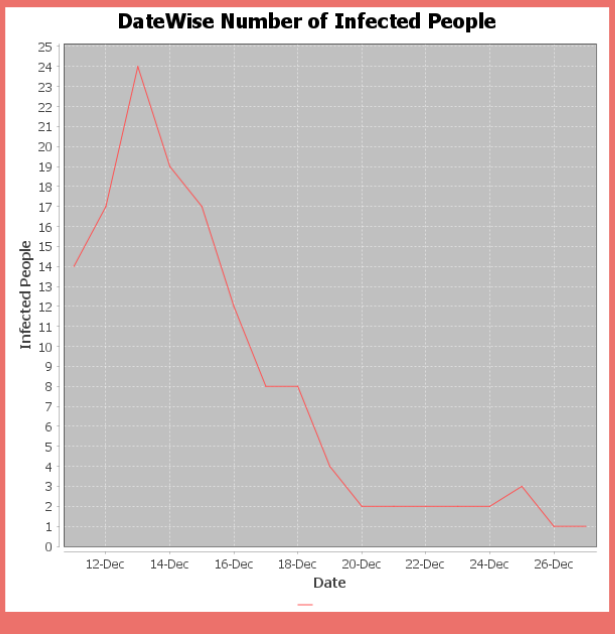
Case 5: Difference in graph when social distance is 2 and 3

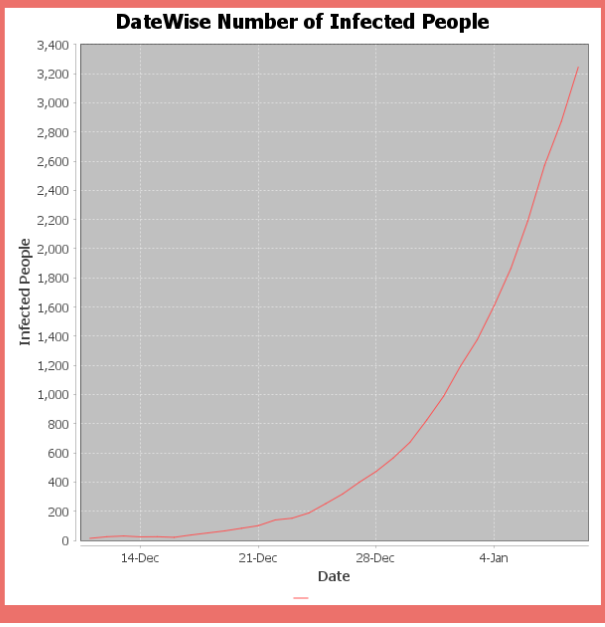
When social distance is increased, total number of infected people also increases. In the first graph, when social distance is 2 meters, total no of infected people is 138 in 1-month period.

In the second graph, when social distance is increased to 3, the total no of infected people increases to 22367.

NO_OF_DAYS_FROM_TODAY=30, EFFECTIVENESS_OF_MASK=0.8, R_FACTOR=2, K_FACTOR=0.1, POPULATION_DENSITY=70743, SOCIAL_DISTANCING=2, USAGE_OF_MASK=0.8, Total Infected=138



NO_OF_DAYS_FROM_TODAY=30, EFFECTIVENESS_OF_MASK=0.8, R_FACTOR=2, K_FACTOR=0.1, POPULATION_DENSITY=70743, SOCIAL_DISTANCING=3, USAGE_OF_MASK=0.8, Total Infected=22367



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Comparison between Covid 19 and Flu

- COVID-19 and the flu have several differences. COVID-19 and the flu are caused by different viruses. COVID-19 is caused by a new coronavirus called SARS-CoV-2, while influenza is caused by influenza A and B viruses.
- COVID-19 appears to be more contagious and to spread more quickly than the flu
- For flu, people do not need to wear mask because flu will infect people though they have worn mask in most cases. If one is infected by flu and other person is at an arm's length from infected person then he will be infected.
- Flu symptoms generates in people between 1 and 4 days and it lives for a week in a person. While covid symptoms generates between 2nd and 14th days and lives in a body till 14 days so covid infect people for longer period and thus it's spread rate is also higher than flu.
- In below graph flu infect 2644 people total in 15 days period. While Covid infect 7600 people when usage of mask and effectiveness of mask is 0.8, social distance is 2 meteres and R_Factor is 3. Thus, there are many factors that affect rate of infected people in covid.
- In flu as shown in graph, total number of infected people are 33 in 1-month period while In Coronavirus, total number of infected people are 5597 in one month period as shown in below graph. Thus, Covid19 spreads more rapidly than flu.
- Also, for Flu, there is vaccine available while for Coronavirus there is no vaccine so it's death rate, infection rate are also high.

As shown in below graph, Flu factors are taken as

- Usage_of_Mask = 0, Effectiveness_of_Mask = 0, R_Factor = 1, K_Factor = 1. Flu has R Factor 1 which mean one infected person on average infect 1 person also K Factor is also 1 which mean in group people who got infection from infected person is less.
- While in Coronavirus, R_Factor = 2 which mean one infected person can infect 2 persons on average.
- K_Factor is also very much less which mean in group, one infected person can infect many people.

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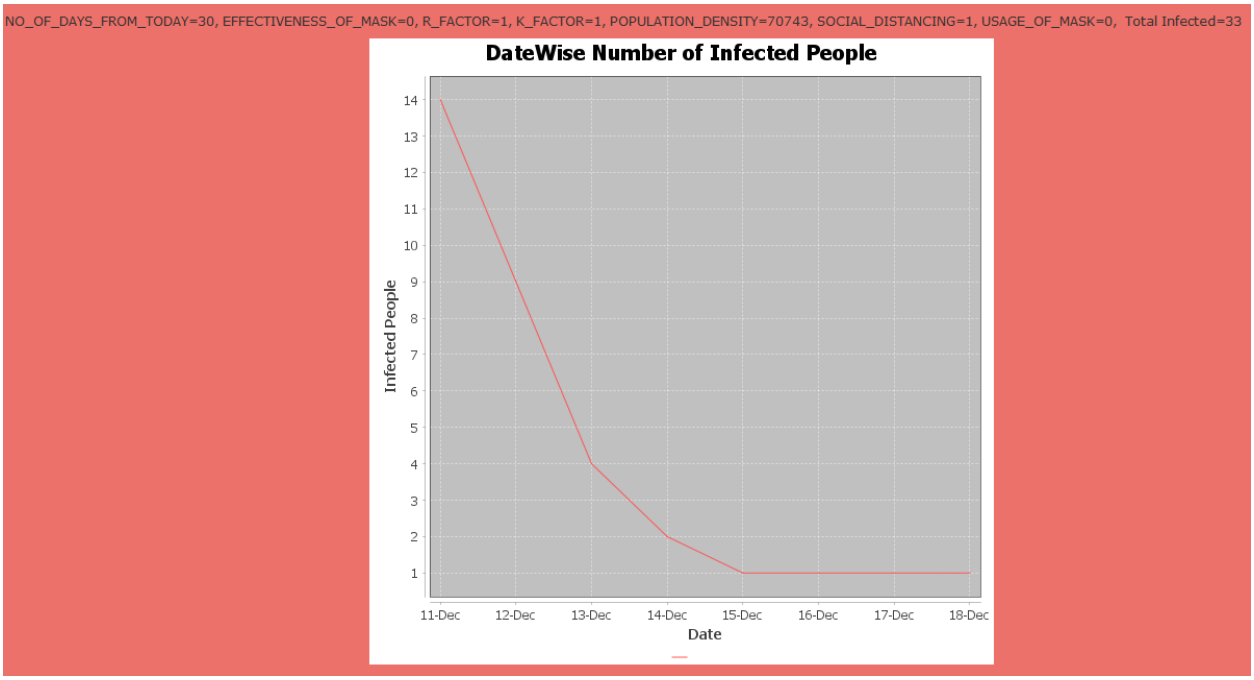
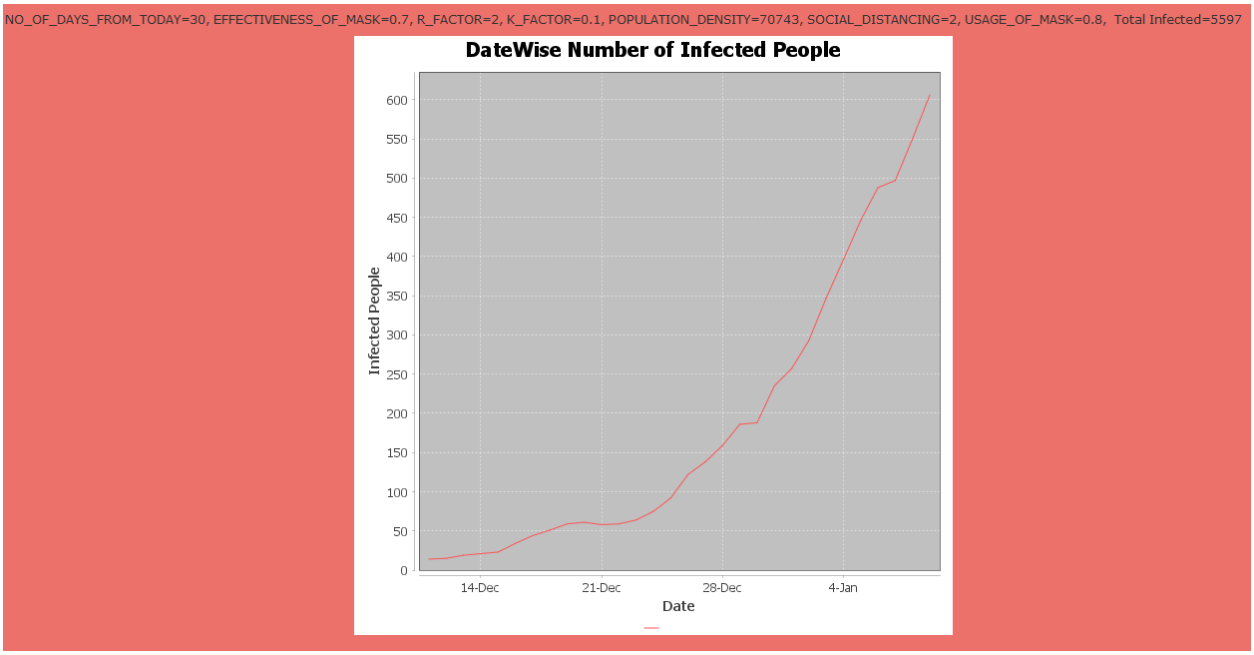
Flu Graph



Covid19 graph



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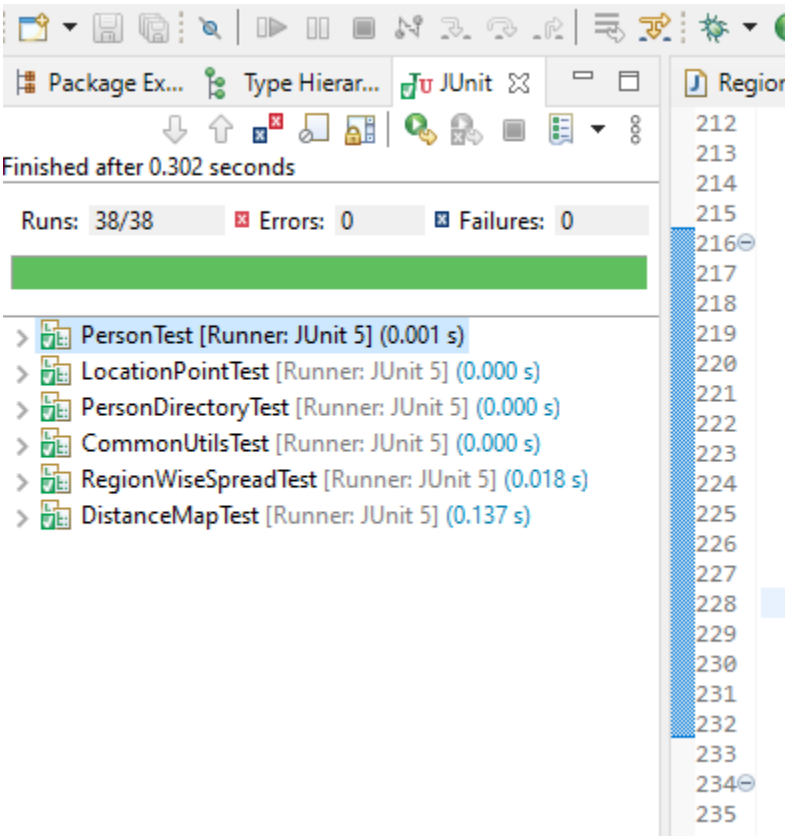
Test Case Output :



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Test Cases from Code

Test Case 1 : For Euclidian Distance:

```
@Test
public void testEuclidianDistance() {

    int x1 = 3;
    int y1 = 4;
    int x2 = 7;
    int y2 = 1;

    double distance = CommonUtils.euclidianDistance(x1, x2, y1, y2);

    assertEquals(5, distance, 0.01);
    assertEquals(8.48, CommonUtils.euclidianDistance(8,2,10,4), 0.01);
}
```

Test Case 2 : Check if object is NULL

```
@Test(expected=NullPointerException.class)
public void testGotoAnotherPlace() {
    Person person = new Person();
    person.gotoAnotherPlace(null, 1, 1);
    fail();
}
```

Test Case 3 : Check if two dates are equal

```
@Test
public void testGetNextDate() {
    Calendar calendar = Calendar.getInstance();
    PersonDirectory directory = new PersonDirectory();
    Date date = directory.getNextDate(2, calendar);


    calendar.setTime(new Date());
    calendar.add(Calendar.DAY_OF_YEAR, 2);
    calendar.set(Calendar.MILLISECOND, 0);
    calendar.set(Calendar.SECOND, 0);
    calendar.set(Calendar.MINUTE, 0);
    calendar.set(Calendar.HOUR, 0);
    Date nextDate = calendar.getTime();

    assertEquals(date, nextDate, "Both Dates are same.");
}
```

Test Case 4 : Check Mask Effectiveness

```
@Test
public void checkMaskEffectiveness() {
    Person person = new Person();
    person.setWearMask(true);

    Person nextPerson = new Person();
    nextPerson.setWearMask(false);

    RegionWiseSpread spread = new RegionWiseSpread();
    spread.setEffectivenessOfMask(1);

    PersonDirectory directory = new PersonDirectory();
    directory.checkMaskEffectiveness(person, nextPerson, spread, new Random());

    assertEquals(true, person.isMaskEffective());
    assertEquals(false, nextPerson.isMaskEffective());
}
```

Test Case 5 : Check if file exists

```
@Test
public void testConfigFile() {
    File file = new File("config.properties");
    assertTrue(file.exists());
}
```

Test Case 6 : Test if factor exists in file

```
@Test
public void testLoadPropertiesFile() {
    try{
        FileInputStream in = new FileInputStream("config.properties");
        Properties p = new Properties();
        p.load(in);
        RegionWiseSpread spread = new RegionWiseSpread();
        Properties properties = spread.loadPropertiesFile();
        assertEquals(properties.getProperty("SOCIAL_DISTANCING"), p.getProperty("SOCIAL_DISTANCING"));
    }catch(Exception e) {
        e.printStackTrace();
    }
}
```

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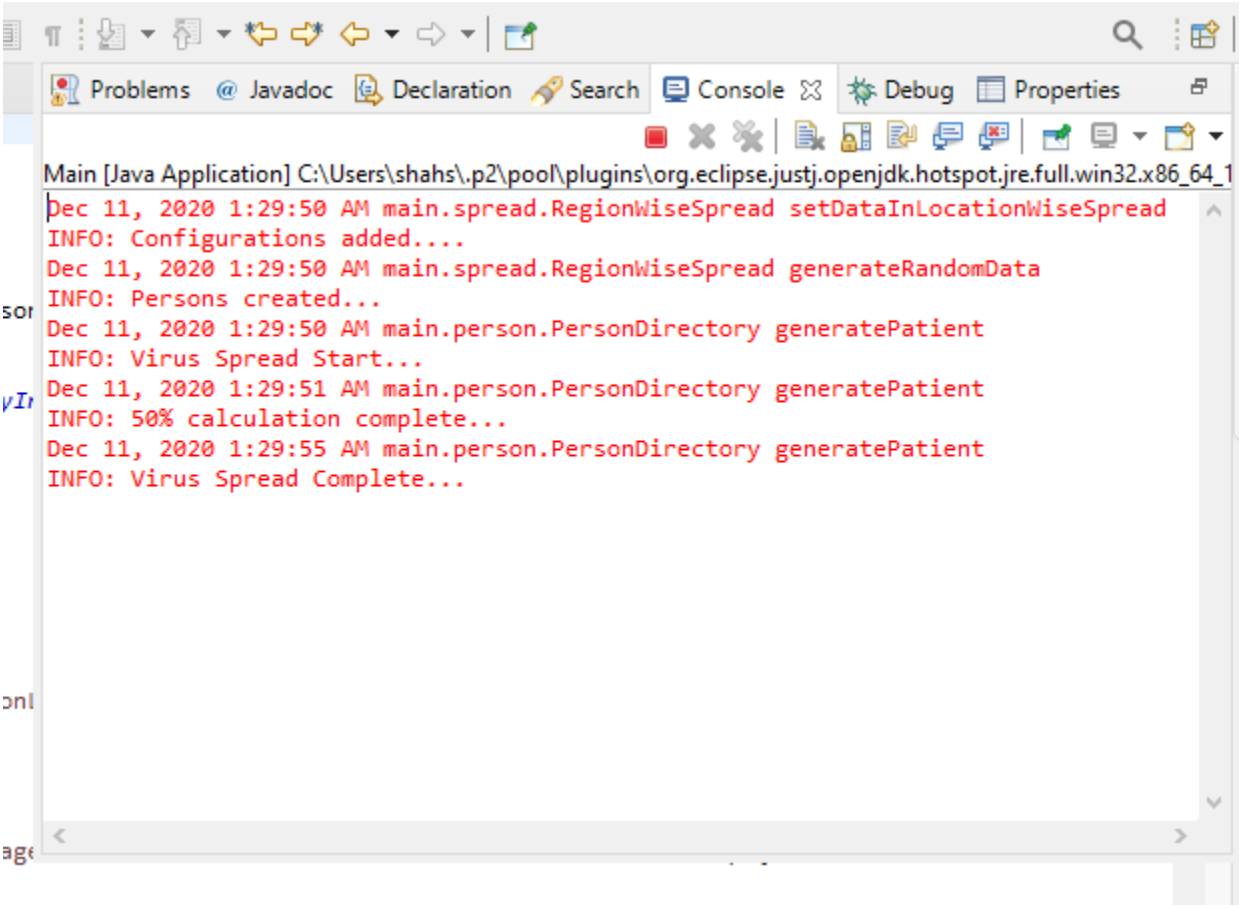
Program output:



In output, there are loggers which are used to show message where the program reached. Like in above image one by one information messages display in console like

1. Configuration added…
2. Virus Spread Start…
3. 50% Calculation complete…
4. Virus Spread complete…

Based on the logger messages, the one who run program gets idea about where the project has reached.