Kevin San Gabriel
301342241
CMPT 371 Project 2

1)

1) The IP address used by the source is 209.87.56.144 and the source port number is 52724.

2) The IP address gaia.cs.umass.edu is 128.119.245.12 and it is sending and receiving TCP segments from port number 80.

3) The IP address used by the source is 209.87.56.144 and the source port number is 52724

We will refer to the trace file tcp-ethereal-trace for the rest of the questions.

Figure 1:

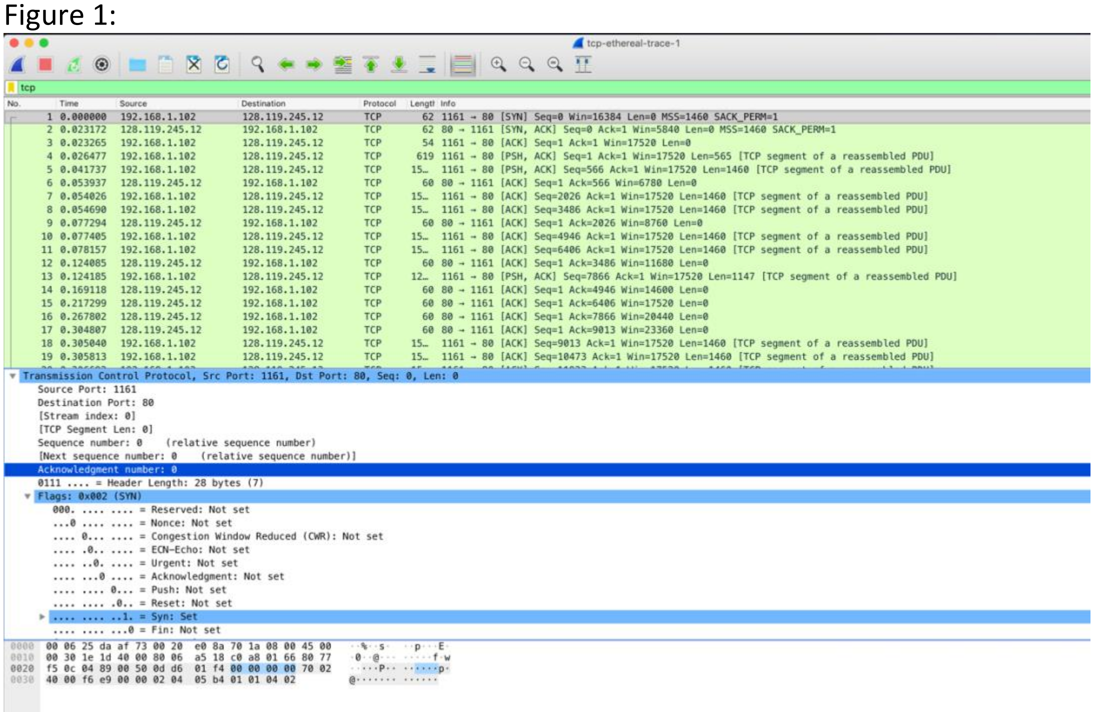


Figure 1: SYN flag set and sequence number of SYN segment is 0.

4) The sequence number of the SYN segment is 0. The SYN flag is set to 1; this indicates that the segment is a SYN segment.

5) The sequence number of the SYNACK segment in response to the SYN segment is 0. The value of the acknowledgement field is 1. Gaia.cs.umass.edu determines the value of the acknowledgement field by adding one to the initial sequence number of the SYN segment sent from the source. The SYN and acknowledgement flags are both set to 1, this identifies this segment as a SYNACK segment

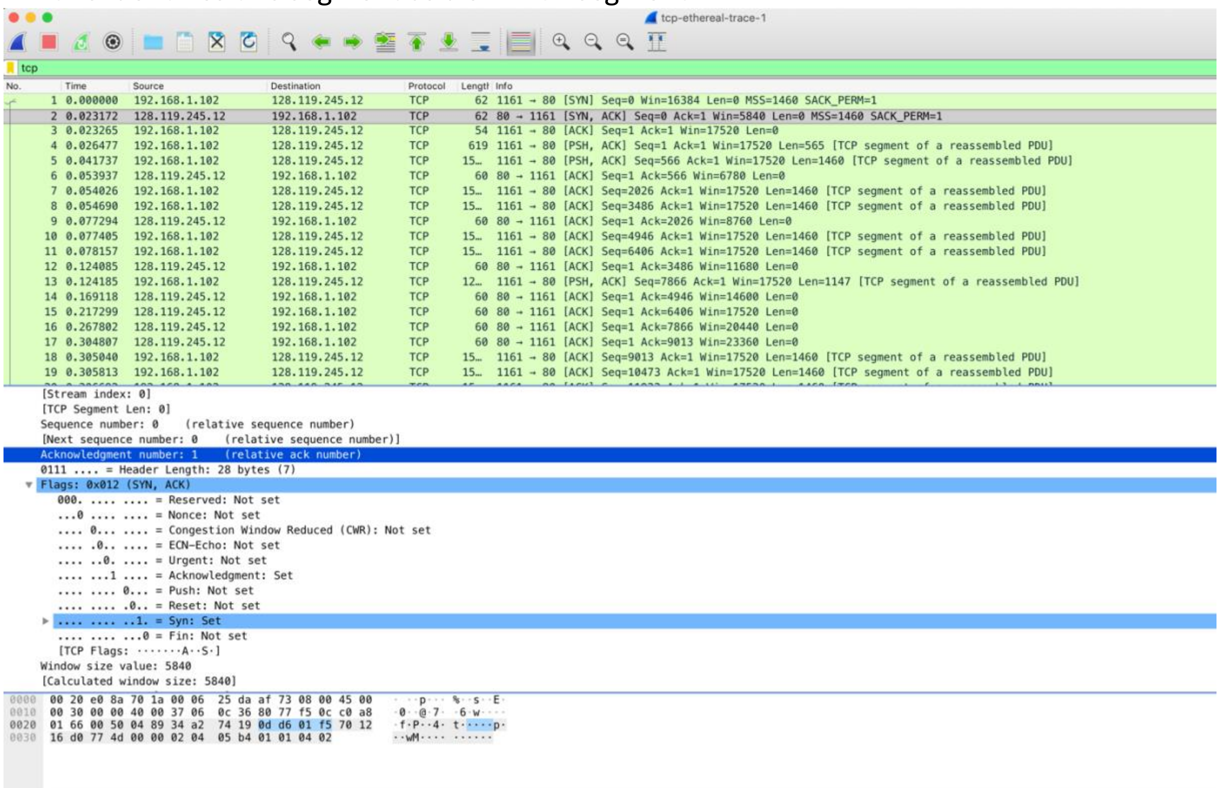


Figure 2: SYN flag and ACK flag of the SYNACK segment is set.

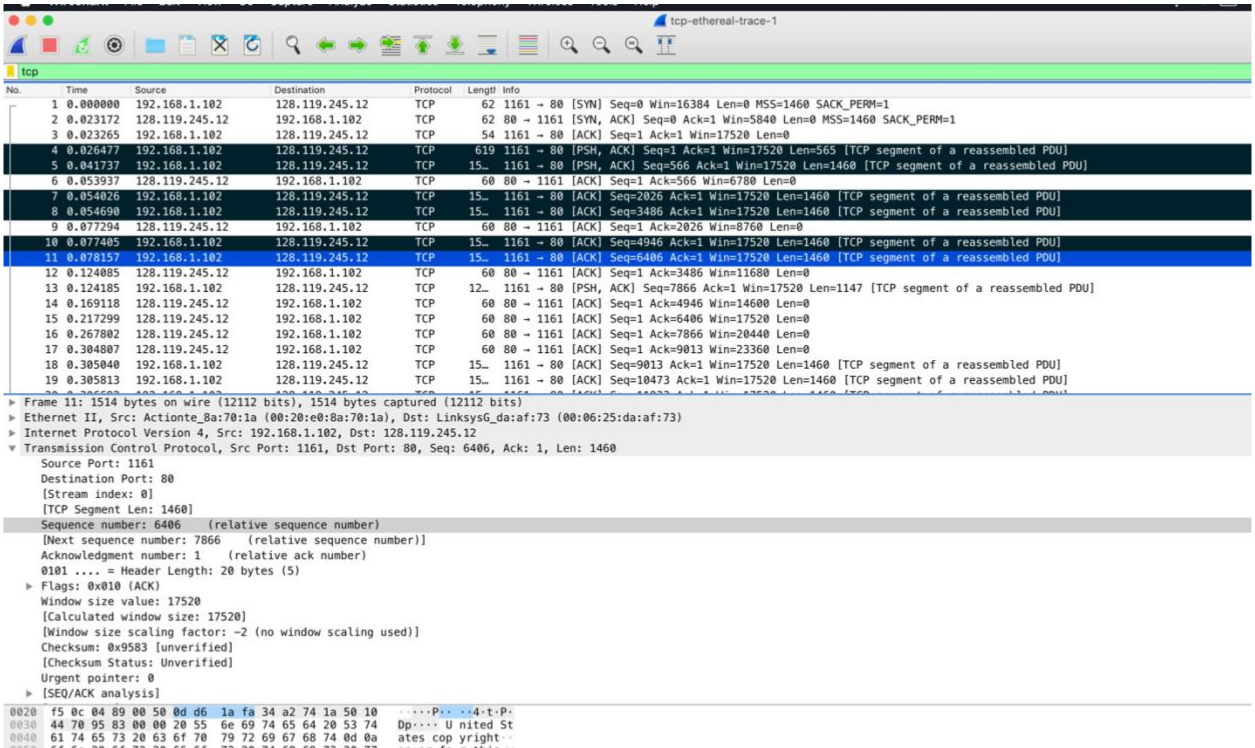


Figure 3: First 6 segments

6) The sequence number of the segment containing the HTTP POST command is 1

7) The first six segments are no.4,5,7,8,10,11 in the trace.

Segment 1 sequence number: 1
Segment 2 sequence number: 566
Segment 3 sequence number: 2026
Segment 4 sequence number: 3486
Segment 5 sequence number: 4946
Segment 6 sequence number: 6406

Segment 1
Send time = 0.026477
ACK received time = 0.053937
RTT = 0.02746

Segment 2
Send time = 0.041737
ACK received time = 0.077294
RTT = 0.035557

Segment 3
Send time = 0.054026
ACK received time = 0.124085
RTT = 0.070059

Segment 4
Send time = 0.054690
ACK received time = 0.169118
RTT = 0.11443

Segment 5
Send time = 0.077405
ACK received time = 0.217299
RTT = 0.13989

Segment 6
Send time = 0.078157
ACK received time = 0.267802
RTT = 0.18964

EstimatedRTT = 0.875 * EstimatedRTT + 0.125 * SampleRTT

After segment 1 ACK

EstimatedRTT = 0.02746

After segment 2 ACK

EstimatedRTT = 0.875 * 0.02746 + 0.125 * 0.035557 = 0.0285

After segment 3 ACK

EstimatedRTT = 0.875 * 0.0285 + 0.125 * 0.070059 = 0.0337

After segment 4 ACK

EstimatedRTT = 0.875 * 0.0337 + 0.125 * 0.11443 = 0.0438

After segment 5 ACK

EstimatedRTT = 0.875 * 0.0438 + 0.125 * 0.13989 = 0.0558

After segment 6 ACK

EstimatedRTT = 0.875 * 0.0558 + 0.125 * 0.18964 = 0.0725

8) Length of the first TCP segment (HTTP POST command) = 565 bytes
   Length of segment 2,3,4,5,6 = 1460 bytes

9) The minimum amount of available buffer space advertised at the receiving end is 5840 bytes. The receiving end's window grows until it reaches a maximum size of 62780 bytes. The lack of buffer space never throttles the sender.

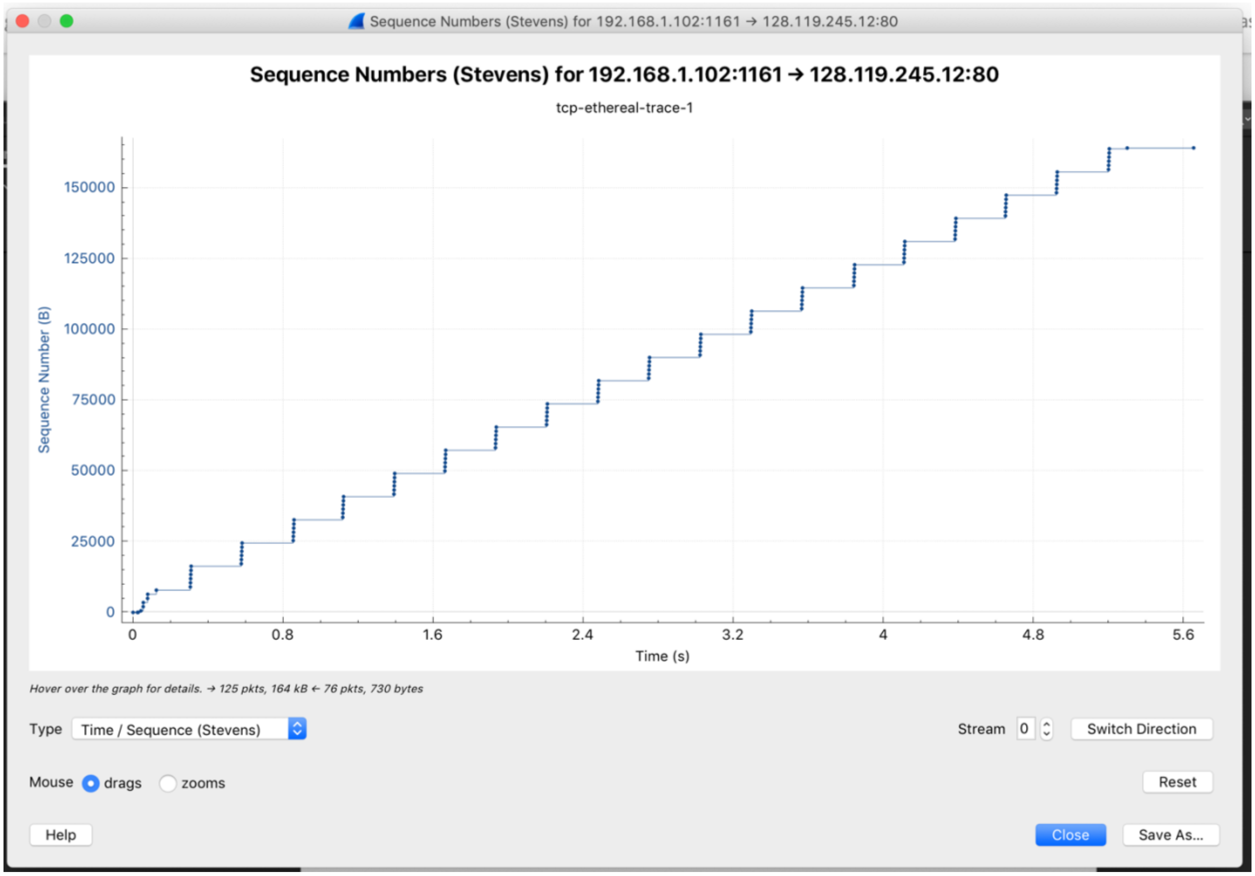
10) There are no re-transmitted segments in the trace file. In order to answer this question, I checked the sequence numbers of the TCP segments in the trace file. The sequence numbers are increasing. If there are any retransmitted segments, its sequence number will not be consistent with segments that are sent for the first time (its sequence number will be smaller.

11) The receiver will typically acknowledge 1460 bytes for segments it receives with the exception of the first segment (HTTP POST command segment) where it will acknowledge 566 bytes. There are cases where the receiver is acking every other segment. This happens with segment 80 where the receiver acknowledges 2920 = 1460 * 2 bytes. The receiver also acknowledges every other segment on segment 87, 88

12) The throughput for the TCP connection is the ratio between the total amount of data and the total transmission time. We can compute the total amount of data transmitted by subtracting the sequence number of the first TCP segment from the acknowledged sequence number of the final ack. Thus, the total amount of data transmitted will be 164091 – 1 = 164090 bytes.

    The total transmission time can be computed by subtracting the time instant of the first TCP segment from the last segment. Thus, we get 5.455830 – 0.026477 = 5.4294 seconds.

    The average throughput for the TCP connection will be 164090/5.4294 = 30.2 KB/s



13) TCP slow-start only lasts for the first 0.1 seconds. Afterwards, the TCP session is consistently in the congestion avoidance state. The sender appears to send segments in groups of 6. This is not caused by flow control because the receiver has a window greater than 6. Thus, the receiver probably have a limitation on the number of packets it receives.

14) TCP slow start seems to occur for the first 5.6-5.7 seconds, after which we reach the congestion avoidance phase. The sender seems to send segments in groups of 1-2 segments. Similar to 13, this does not seem to be caused by flow control because the receiver has a much larger window.

2) source code:

```
from collections import defaultdict
import math


class Graph:

  def __init__(self):
    self.nodes = set()
    self.edges = defaultdict(list)
    self.distances = {}
```

```
    def add_node(self,value):
        self.nodes.add(value)

    def add_edge(self, from_node, to_node, distance):
        self.edges[from_node].append(to_node)
        self.edges[to_node].append(from_node)
        self.distances[(from_node, to_node)] = distance
        self.distances[(to_node, from_node)] = distance


first_node = None
Q = None

# Specify graph properties by taking an input file from the user.
input_file_name = input("Enter input file name: ")


with open(input_file_name, "r") as input_file:
    num_lines = sum(1 for line in input_file)

#constructGraph will determine the network properties by reading the input file
def constructGraph():

    i = 0
    graph = Graph()

    with open(input_file_name, "r") as input_file:

        while i < num_lines:

            #Read the first line in the input file.
            if i == 0:
                line1 = input_file.readline()
                line1_arr = line1.split()

                num_nodes = int(line1_arr[0])
```

```
            num_links = int(line1_arr[1])

            i += 1

        #Read the second line in the input file. (list of node names)
        if i == 1:
            line2 = input_file.readline()
            node_names = line2.split()

            for node_name in node_names:
                graph.add_node(node_name)

            global Q
            Q = node_names


            global first_node
            first_node = node_names[0]

            i += 1
            continue

        #For the rest of the lines, connect edges to nodes given the input.
        line = input_file.readline()
        line_arr = line.split()
        graph.add_edge(line_arr[0], line_arr[1], line_arr[2])

        i += 1

    #The distance from each node to itself is 0
    for node in graph.nodes:
        graph.distances[(node,node)] = "0"

    return graph



def ls_routing(graph, src_node, outputfile):
```

```
print("Link state routing results: ")
dist = dict() #dist will be a dictionary of all the nodes in the graph and their distances from the source node
prev = dict() #prev will be used to construct the least costly path by backtracking each node
min_path = dict()

global Q
temp_Q = list()

for node in Q:
    temp_Q.append(node)



dist[src_node] = 0 #Distance from intitial node to initial node is 0
prev[src_node] = None



while temp_Q:

    #The source node will be selected first, it's distance from itself is 0
    u = None
    for node in temp_Q:
        if node in dist:
            if u is None:
                u = node
            elif dist[node] < dist[u]:
                u = node

    temp_Q.remove(u)

    #For each node in the network, compute the shortest path to it from the source node
    for edge in graph.edges[u]:

        alt = dist[u] + int(graph.distances[(u, edge)])

        if edge not in dist:
            dist[edge] = math.inf
```

```
        if alt < dist[edge]:
            dist[edge] = alt
            prev[edge] = u

#Construct the paths for each node for the output file by backtracking with prev
for node in Q:
    temp_Q.append(node)
temp_Q.remove(src_node)

for node in temp_Q:
    curr_node = node
    min_path[curr_node] = [curr_node]

    while prev[curr_node] != None:
        if prev[curr_node] not in min_path[node]:
            min_path[node].append(prev[curr_node])
        curr_node = prev[curr_node]

for node in temp_Q:
    min_path[node] = list(reversed(min_path[node]))

#Write our results to the output file
with open(outputfile, "w") as outputfile:
    for node in temp_Q:
        outputfile.write(str(node) + ": ")
        print(str(node) + ": ", end = '')
        for edge in min_path[node]:
            outputfile.write(str(edge))
            print(str(edge), end = '')

            if edge == min_path[node][-1]:
                outputfile.write(" "+ str(dist[node]))
                print(" "+ str(dist[node]), end = '')
                outputfile.write("\n")
                print("\n", end = '')
                continue
```

```python
            outputfile.write("-")
            print("-", end = '')



def dv_routing(graph, src_node, outputfile):

    print("Distance vector routing results: ")
    dist = dict()
    prev = dict()
    global Q
    temp_Q = list()

    iterations = 0

    for node in Q:
        temp_Q.append(node)

    #Initialize the distances from the source node to each node in the network to infinity
    for node in Q:
        dist[node] = math.inf
    #Initialize the distance from the source node to itself to 0
    dist[src_node] = 0

    #Main part of the algorithm
    for i in range(0,len(graph.nodes)):
        for node in graph.nodes:
            for edge in graph.edges[node]:
                dist[edge] = min(dist[edge], dist[node] + int(graph.distances[(node,edge)]))

        iterations += 1



    #Initialize a table with all 0s
    table = []
    for i in range(0, len(graph.nodes) +1):
```

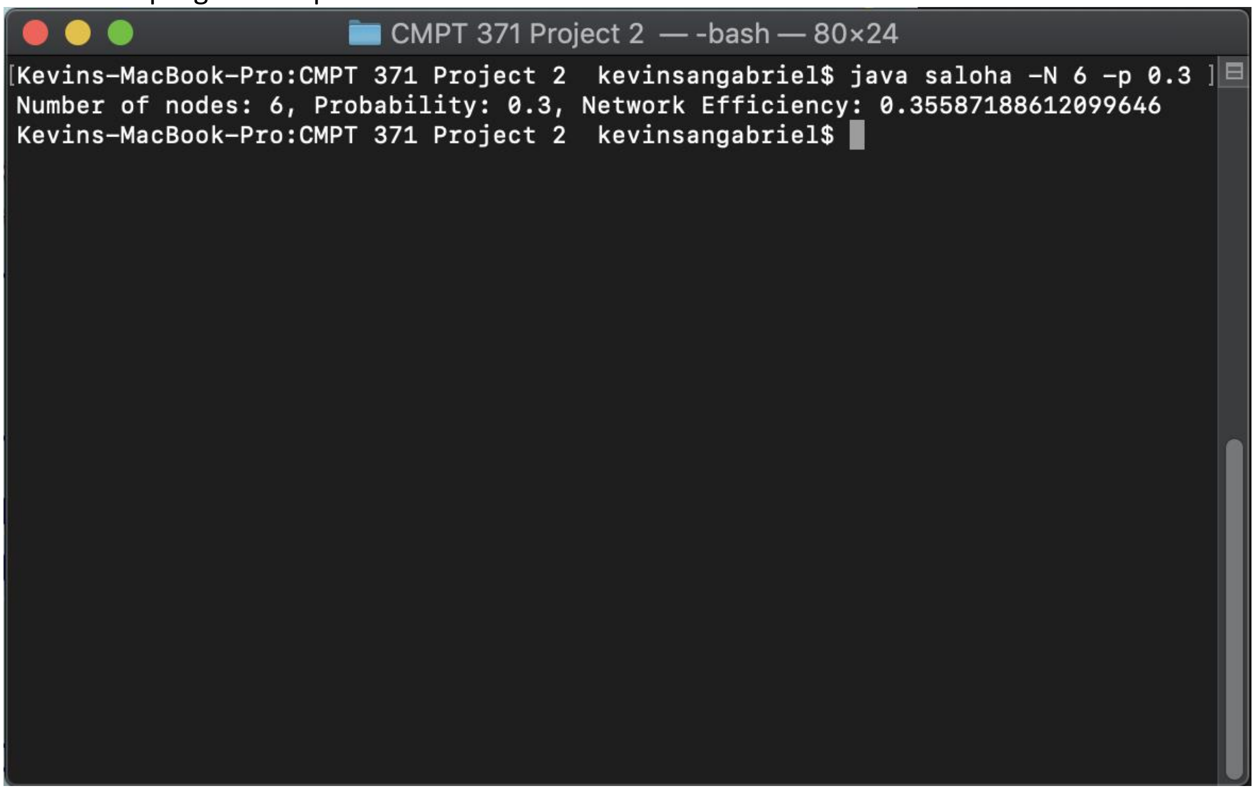
```
    table.append([])
    for j in range(0, len(graph.nodes)+1):
        table[i].append("0")



#Fill in the first row and first column of the table
for row in table:
    for val in row:

        if table.index(row) == 0 and row.index(val) == 0:
            table[table.index(row)][row.index(val)] = " "

        elif table.index(row) == 0:
            for node in temp_Q:
                if temp_Q.index(node)+1 == row.index(val):
                    table[table.index(row)][row.index(val)] = node

        if table.index(row) > 0 and row.index(val) == 0:
            for node in temp_Q:
                if temp_Q.index(node) + 1 == table.index(row):
                    table[table.index(row)][row.index(val)] = node



#Fill in the rest of the table with distance values
for row in table:
    for val in row:

        for node in temp_Q:
            if table.index(row) > 0:
                if table[table.index(row)][row.index(val)] == node:
                    for i in range(1, len(graph.nodes)+1):

                        table[table.index(row)][row.index(val)+i] = graph.distances[(node, table[0][i])]
i = 0

#Print our results to system.out
print("\t\tCost to\n")
```

```
    for row in table:
        if i == 1:
            print("From\t"+str(row)+"\n")
        else:
            print("\t\t"+str(row)+"\n")
        i +=1
    print("Number of rounds: ",iterations)

    #Write our results to the output file
    with open(outputfile, "w") as outputfile:
        outputfile.write("\t")
        outputfile.write("Cost to")
        outputfile.write("\n\n")
        i = 0
        for row in table:
            if i == 1:
                outputfile.write("From\t" + str(row))
                outputfile.write("\n")
            else:
                outputfile.write("\t" +str(row))
                outputfile.write("\n")
            i +=1
        outputfile.write("\n")
        outputfile.write("Number of rounds: "+str(iterations))


ls_routing(constructGraph(), first_node, "LS_output.txt")
print("\n")


dv_routing(constructGraph(), first_node, "DV_output.txt")
```

3)

$Np(1-p)^{N-1} = (6)(0.3)(0.7)^5 = 0.302526$

Simulation program output results:



The network efficiency obtained by the simulation was nearly consistent with the theoretical model. The network efficiency of the simulation was more efficient by a utilization magnitude of 0.355871 – 0.302256 = 0.053615.