ECE/CS 658: Lab4

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1 Design and Implementation

The purpose of this project was to develop an overlay network which will have network connections as given by a Bootstrap Server. Each node wishing to join the network first sends a Registration request to the Bootstrap Server which gives it 2 more nodes to connect to. The main feature of this overlay network is to search a file which is present in one or more nodes of the network. The node sending the query must get the IP Address and Port of the Node containing the filename as a Response.

We implemented this distributed system by using SuperNodes. A node becomes a SuperNode when it gets connected to a specified number of nodes as neighbours (by default 4). The SuperNode contains the information about what files its ChildNodes have and their IP Addresses and Ports. Also all SuperNodes are connected with all the other SuperNodes in the network. All nodes in the network are either SuperNode or connected to a SuperNode. Thus the Routing table of a ChildNode contains the IP Address and Port numbers of its directly connected neighbours and the list of filenames it has in its own node. The Routing table of a SuperNode consists of the IP Addresses and Port Numbers of its Child Nodes, their filenames and the IP Addresses and Port numbers of all the other SuperNodes. When the network is up and running, the search request is sent. The node which receives the query request first searches in its own routing table, whether it itself has the file. If not, the node sends the query to its SuperNode. The SuperNode checks in its routing table whether it has an entry for the filename. If it does, then it sends the IP Address and Port number of the corresponding Node. If it does not find the filename in its routing table, then it sends the query to all the other SuperNodes. Since all nodes are connected to one or the other SuperNode, the search always results in a success provided, the file is present in the system. The search result is sent back to the requesting node.

2 Formats of Messages

The following Formats were used for communication with BootStrap Server and communication among the network:

1. **Register Request by New Node to BootStrap Server**
   length REG IP-address port-no username
2. **Register Response Message by BootStrap Server to Node**
   length REGOK no-nodes IP-1 port-1 IP-2 port-2
3. **Join message sent by node to its neighbour to create connection**
   length JOIN IP Port
4. **Response message sent by neighbours**
   length JOIN-OK IP Port
5. **Request SuperNode List**
   Length REQ-SN-LIST IP Port
6. **Inform Other SuperNodes About Self**
   Length INFORM-SN IP Port
7. **Join SuperNode as a child**
   Length JOIN-AS-CHILD IP Port hop-count num-files filename1 filename2 .
8. **Broadcast about forming of new SuperNode**
   Length BROADCAST-SN SuperNode-IP SuperNode-Port hop-count Flag-First-SuperNode
9. **Search in SuperNode**
   Length SEARCH-SN RequestingNode-IP RequesetingNode-Port Flag-From-SN hop-count Search-Query

10. **File Found**
    Length FOUND Found-At-Node-IP Found-At-Node-Port hop-count filename1 filename2
11. **Unregister Request message sent by node to BootStrap Server**
    Length UNREG IP Port
12. **Leave request sent by node to its neighbours**
    Length LEAVE IP Port Flag-Neighbour-Or-SN

3 Results and Observations

The performance of the distributed system was measured using the following performance parameters:

1. **Latency and Hop Count**
   The time from which a node sends a query to the time when it gets the result is recorded. This gives the latency for the query search. The number of hops the query has to undergo to get its result is also noted. Table 1, Table 2 and Table 3 show the results for latency and hop counts for each of the queries.

   For Network Scale : 20

   The minimum latency is **0 Secs**
   The maximum latency is **0.153 sec**
   The average latency is **0.29756 sec**
   The standard deviation for latency measurements is **0.028677 sec**

   The minimum hop count is **0**
   The maximum hop count is **3**
   The average hop count is **1.74**
   The standard deviation for hop count measurements is **0.927275**

   For Network Scale : 40

   The minimum latency is **0 Secs**
   The maximum latency is **0.279 sec**
   The average latency is **0.0766**
   The standard deviation for latency measurements is **0.07971 sec**

   The minimum hop count is **0**
   The maximum hop count is **3**
   The average hop count is **1.476**
   The standard deviation for hop count measurements is **0.807485**

   For Network Scale : 80

   The minimum latency is **0 Secs**
   The maximum latency is **0.112 sec**
   The average latency is **0.027028 sec**
   The standard deviation for latency measurements is **0.029164**

Figure 1: Hop Count for network Scale 20

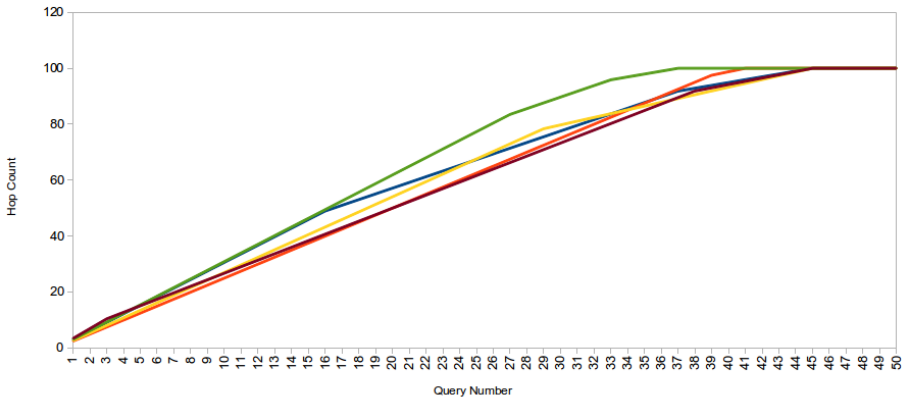
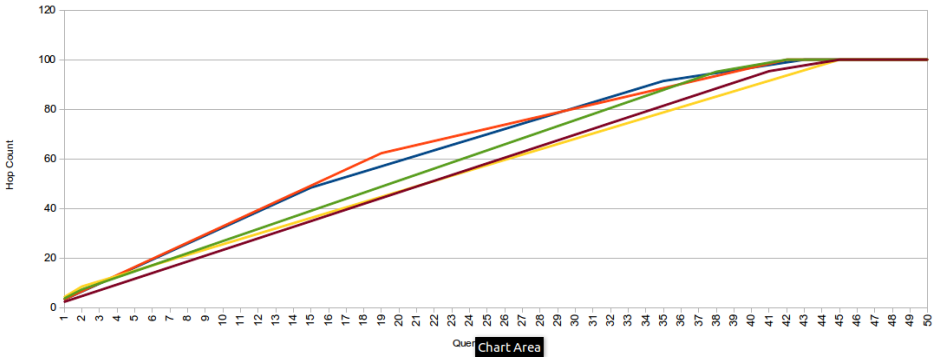


Figure 2: Hop Count for network Scale 40



The minimum hop count is **0**
The maximum hop count is **3**
The average hop count is **1.525**
The standard deviation for hop count measurements is **0.776657**

The CDF for the 5 queries are shown in figure 1-6.

2. **Number of Queries handled by the nodes**
   10 randomly chosen nodes are used to find out the number of received, forwarded and answered by the corresponding nodes. The results are given in Table 4.

   For Network Scale : 20

   The minimum queries handled are **0**
   The maximum queries handled are **82**
   The average queries handled are **16.2**
   The standard deviation for queries handled are **26.710**

   For Network Scale : 40

Figure 3: Hop Count for network Scale 80

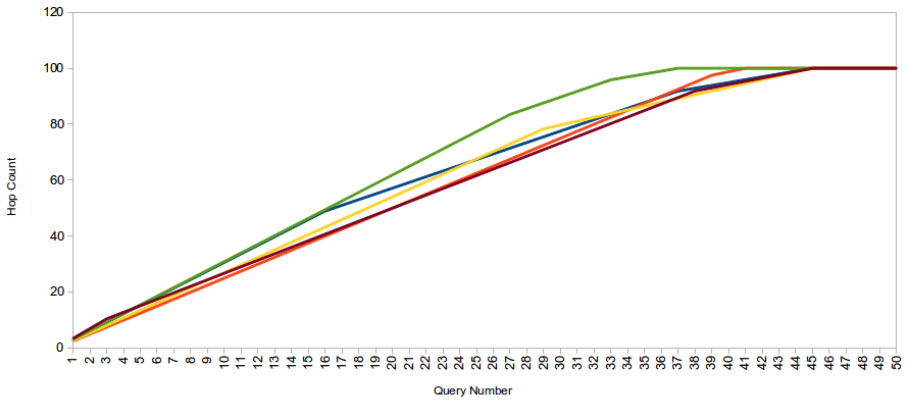


Figure 4: Latency for network Scale 20

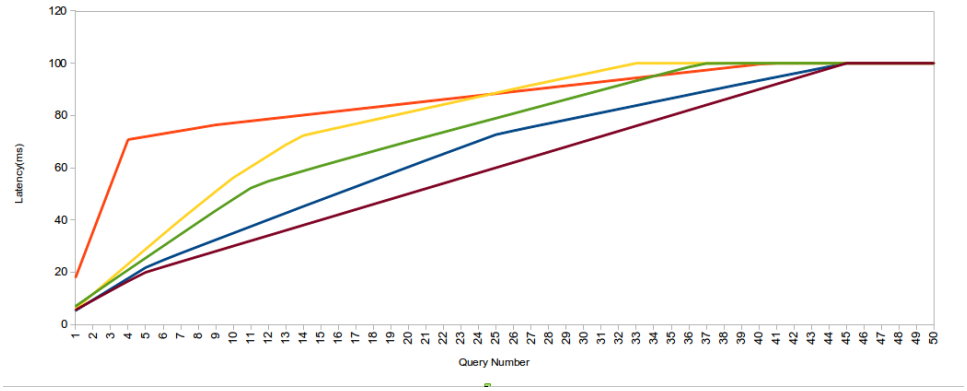


Figure 5: Latency for network Scale 40

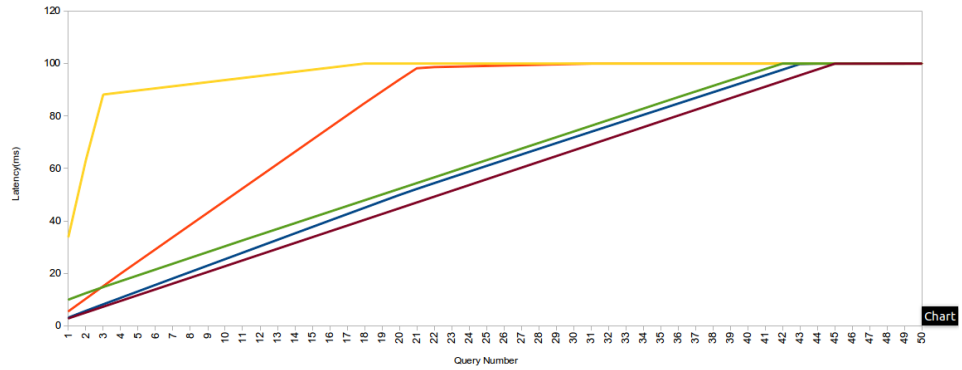


Figure 6: Latency for network Scale 80

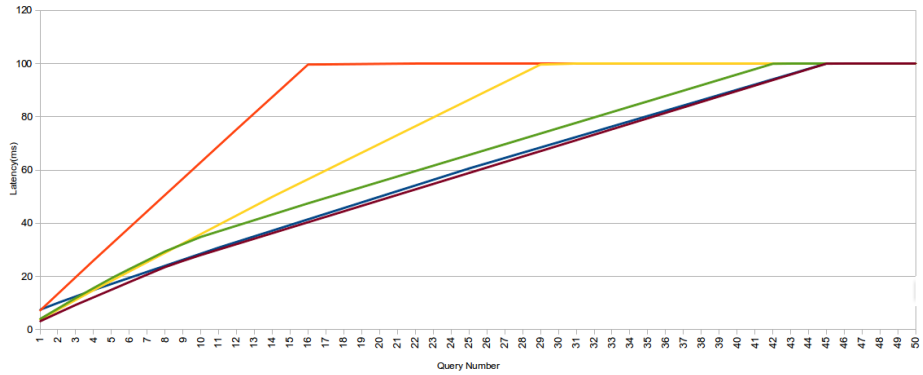
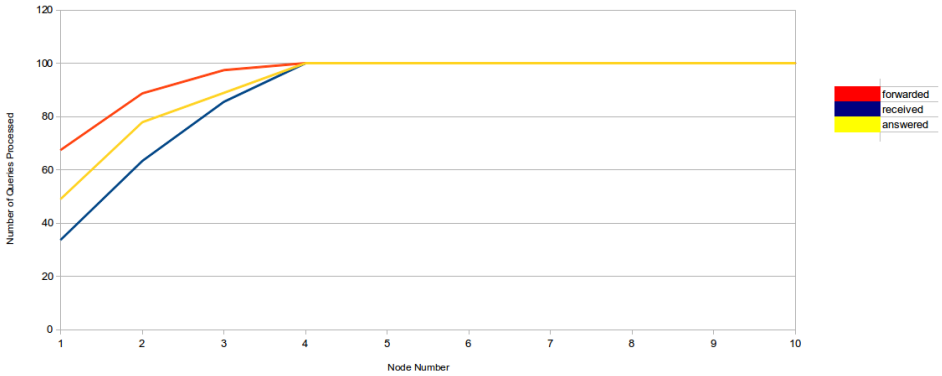


Figure 7: Number of Queries for network Scale 20



The minimum queries handled are **0**
The maximum queries handled are **130**
The average queries handled are **33.06**
The standard deviation for queries handled are **37.53**

For Network Scale : 80

The minimum queries handled are **0**
The maximum queries handled are **98**
The average queries handled are **32.4**
The standard deviation for queries handled are **29.76**

The CDF for the number of Queries handled by the nodes are shown in figure 7-9.

4 Conclusions

In this Distributed System topology with SuperNodes, we get a 100% success rate for search queries. Also, files are found at a maximum of 3 hop distances away from the searching node. If the searching node is a

Figure 8: Number of Queries for network Scale 40

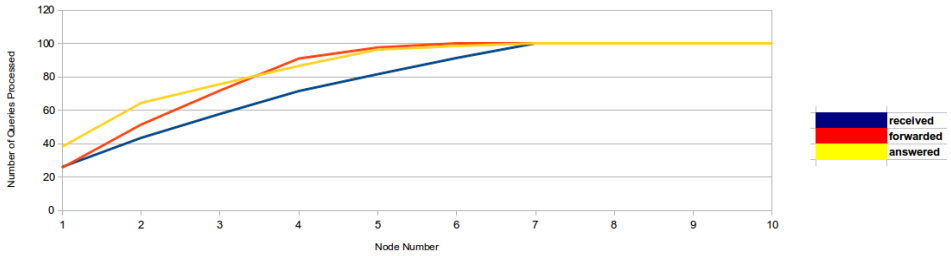
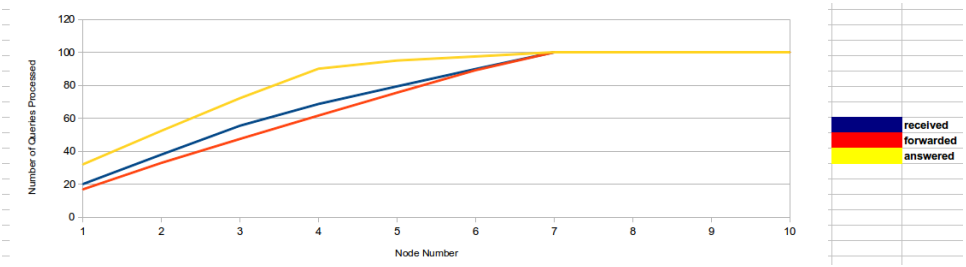


Figure 9: Number of Queries for network Scale 80



Supernode, it will find the file at a maximum hop distance of 2.
For each node searching for a file, the latency observed is different. This is because a SuperNode will search faster than a ChildNode. Also, the distance between nodes plays a role. The latencies for a particular node are observed to be consistent.
The increase in number of queries than the number of nodes does not affect the performance of the network. Network Scaling is also handled very properly by the network.

5 Future Works

We can use a Hash Table instead of a bootstrap Server to avoid loading of a single node.

Table 1: Hop Count and Latency for Network Scale:20

	Query1		Query2		Query3		Query4		Query5	
Query Name	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**
Twilight	2	0.117	1	0.003	2	0.019	3	0.153	2	0.081
Jack	1	0.029	0	0	2	0.057	3	0.041	1	0.029
American Idol	1	0.029	0	0	1	0.02	2	0.039	1	0.029
Life of Pi	3	0.056	2	0.003	2	0.078	3	0.099	2	0.029
Twilight saga	-	-	-	-	-	-	-	-	-	-
Life	3	0.055	2	0.003	2	0.077	3	0.099	2	0.029
Sky fall	-	-	-	-	-	-	-	-	-	-
Happy Feet	2	0.03	2	0.002	1	0	0	0	2	0.03
Prometheus	2	0.03	2	0.002	2	0.077	3	0.102	2	0.029
Happy Feet	2	0.03	2	0.002	1	0	0	0.001	2	0.029
Gungry	-	-	-	-	-	-	-	-	-	-
Twilight	3	0.058	1	0.003	2	0.019	3	0.03	2	0.029
Windows	1	0.032	0	0	2	0.02	3	0.041	2	0.029
Happy Feet	2	0.03	2	0.002	1	0	0	0	2	0.029
Mission Impossible	3	0.062	2	0.002	0	0	1	0.039	2	0.029
Twilight	3	0.056	2	0.002	2	0.019	3	0.039	2	0.029
Windows 8	3	0.056	2	0.047	2	0.02	3	0.039	2	0.029
The	0	0	0	0	1	0	0	0.001	0	0
Happy	2	0.03	2	0.002	1	0	0	0	2	0.029
Windows 8	3	0.055	2	0.048	2	0.02	3	0.043	3	0.054
Happy Feet	2	0.03	2	0.002	1	0	0	0	2	0.029
Super Mario	2	0.09	2	0.003	2	0.02	3	0.04	2	0.029
Hotel Transylvania	2	0.056	2	0.002	0	0	1	0.038	2	0.029
Jack and Jill	1	0.029	0	0	2	0.02	3	0.039	1	0.029
Happy Feet	2	0.03	2	0.002	1	0	0	0	2	0.029
The Hunger Games	0	0	2	0.002	2	0.081	3	0.099	0	0
Hobbit	2	0.09	2	0.002	2	0.02	3	0.04	2	0.029
Turn Up The Music	3	0.055	2	0.002	1	0.02	2	0.039	2	0.029
Adventures of Tintin	2	0.03	2	0.002	0	0	0	0	2	0.029
Twilight saga	-	-	-	-	-	-	-	-	-	-
Happy Feet	2	0.029	2	0.002	1	0	0	0	2	0.029
Super Mario	2	0.09	2	0.002	2	0.02	3	0.039	2	0.029
American Pickers	2	0.09	2	0.002	2	0.02	3	0.039	2	0.029
Microsoft Office 2010	3	0.055	2	0.002	1	0.02	2	0.039	2	0.029
Twilight	3	0.055	2	0.001	2	0.019	3	0.043	2	0.029
Modern Family	0	0	2	0.002	1	0.019	2	0.039	0	0
Jack and Jill	1	0.03	0	0	2	0.057	3	0.039	1	0.029
Jill	1	0.03	0	0	2	0.057	3	0.039	1	0.029
Spider-Man	-	-	-	-	-	-	-	-	-	-
Glee	3	0.054	2	0.002	2	0.077	3	0.093	2	0.029
The Vampire Diarie	1	0.031	0	0	1	0	0	0	1	0.029
King Arthur	3	0.054	2	0.002	2	0.071	2	0.099	2	0.029
Dark Knight	0	0	2	0.002	2	0.02	3	0.041	0	0
King Arthur	3	0.055	2	0.002	2	0.073	3	0.095	2	0.029
Windows XP	1	0.029	0	0	2	0.048	3	0.057	1	0.049
Harry Potter	2	0.03	2	0.002	2	0.078	3	0.101	2	0.029
Men in Black	0	0	2	0.002	1	0	0	0	0	0
Feet	2	0.03	2	0.002	1	0	0	0	2	0.029
Kung Fu Panda	2	0.056	2	0.002	2	0.076	3	0.098	2	0.029
Lady Gaga	3	0.054	2	0.047	0	0	1	0.038	3	0.053
Gaga	3	0.054	2	0.047	0	0	1	0.038	3	0.053
Happy Feet	2	0.029	2	0.002	1	0	0	0	2	0.029
Twilight	2	0.056	2	0.002	2	0.019	3	0.039	2	0.029
Hacking	2	0.056	2	0.002	2	0.021	3	0.042	2	0.029
King	3	0.055	2	0.002	2	0.073	2	0.1	2	0.029

Table 2: Hop Count and Latency for Network Scale:40

	Query1		Query2		Query3		Query4		Query5	
Query Name	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**
Twilight	2	0.211	1	0.037	1	0.043	2	0.279	2	0.252
Jack	1	0.145	0	0.001	1	0	0	0	2	0.195
American Idol	1	0.145	1	0.001	0	0	1	0.061	2	0.195
Life of Pi	2	0.146	1	0.001	2	0.037	3	0.063	2	0.195
Twilight saga	-	-	-	-	-	-	-	-	-	-
Life	2	0.147	1	0.001	2	0.032	3	0.062	2	0.195
Sky fall	-	-	-	-	-	-	-	-	-	-
Happy Feet	3	0.167	2	0.031	1	0	2	0.061	2	0.195
Prometheus	3	0.165	2	0.031	1	0	0	0	2	0.195
Happy Feet	3	0.165	2	0.031	1	0	2	0.061	2	0.195
Gungry	-	-	-	-	-	-	-	-	-	-
Twilight	2	0.145	1	0.001	1	0.001	2	0.061	2	0.195
Windows	0	0	1	0	1	0.001	2	0.061	0	0.001
Happy Feet	3	0.166	2	0.003	1	0	2	0.061	2	0.195
Mission Impossible	3	0.165	0	0	1	0	2	0.061	2	0.195
Twilight	2	0.146	1	0	1	0.001	2	0.061	2	0.195
Windows 8	0	0.011	1	0	1	0.001	2	0.069	2	0.196
The	1	0.145	0	0	0	0	0	0	0	0.001
Happy	3	0.165	2	0.032	1	0	2	0.062	2	0.195
Windows 8	0	0	1	0.001	1	0.001	2	0.062	2	0.196
Happy Feet	3	0.167	2	0.032	1	0	2	0.062	2	0.195
Super Mario	3	0.166	1	0.001	1	0.001	2	0.061	2	0.196
Hotel Transylvania	2	0.146	2	0.031	1	0	2	0.061	2	0.195
Jack and Jill	1	0.145	0	0	1	0.001	0	0	2	0.195
Happy Feet	3	0.165	2	0.031	1	0	2	0.062	2	0.195
The Hunger Games	2	0.145	1	0.032	1	0.001	2	0.065	1	0.195
Hobbit	2	0.147	1	0	1	0	2	0.062	2	0.195
Turn Up The Music	2	0.156	1	0	0	0	1	0.061	2	0.195
Adventures of Tintin	2	0.145	2	0.029	1	0	2	0.061	0	.001
Twilight saga	-	-	-	-	-	-	-	-	-	-
Happy Feet	3	0.165	2	0.031	1	0	2	0.061	2	0.195
Super Mario	3	0.165	1	0	1	0.001	2	0.061	2	0.195
American Pickers	2	0.145	2	0.031	1	0	2	0.061	2	0.195
Microsoft Office 2010	3	0.166	1	0.03	0	0	1	0.061	2	0.195
Twilight	2	0.164	1	0	1	0.001	2	0.061	2	0.195
Modern Family	2	0.164	1	0	0	0	1	0.059	1	0.194
Jack and Jill	1	0.145	0	0	1	0	0	0	2	0.195
Jill	1	0.146	0	0	1	0	0	0	2	0.195
Spider-Man	-	-	-	-	-	-	-	-	-	-
Glee	3	0.174	2	0.03	1	0.001	2	0.062	2	0.195
The Vampire Diarie	1	0.145	0	0	1	0	0	0	0	0.001
King Arthur	2	0.146	2	0.031	1	0.001	2	0.059	2	0.195
Dark Knight	2	0.163	2	0.031	1	0	0	0	1	0.195
King Arthur	2	0.147	2	0.031	1	0.001	2	0.06	2	0.195
Windows XP	1	0.145	1	0	1	0	2	0.061	0	0.001
Harry Potter	2	0.149	2	0.031	1	0	2	0.061	2	0.194
Men in Black	2	0.164	0	0	1	0	2	0.06	1	0.194
Feet	3	0.165	2	0.031	1	0	2	0.061	2	0.194
Kung Fu Panda	0	0.001	1	0.001	1	0.001	2	0.06	2	0.195
Lady Gaga	0	0	1	0	1	0	2	0.061	2	0.195
Gaga	0	0	1	0	1	0	2	0.061	2	0.195
Happy Feet	3	0.165	2	0.031	1	0	2	0.061	2	0.194
Twilight	2	0.145	1	0.001	1	0	2	0.061	2	0.194
Hacking	0	0	1	0	1	0.001	2	0.06	2	0.195
King	2	0.145	2	0.031	1	0	2	0.061	2	0.195

Table 3: Hop Count and Latency for Network Scale:80

	Query1		Query2		Query3		Query4		Query5	
Query Name	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**	**Hop Count**	**Latency**
Twilight	2	0.049	0	0	1	0.001	2	0.024	2	0.067
Jack	2	0.014	1	0	0	0	0	0	2	0.059
American Idol	2	0.013	1	0	0	0	2	0.024	2	0.059
Life of Pi	2	0.016	1	0	2	0.018	2	0.023	2	0.059
Twilight saga	-	-	-	-	-	-	-	-	-	-
Life	2	0.016	1	0	2	0.019	2	0.024	2	0.059
Sky fall	-	-	-	-	-	-	-	-	-	-
Happy Feet	0	0	1	0	2	0.019	2	0.023	2	0.059
Prometheus	0	0	2	0.097	1	0	0	0	2	0.059
Happy Feet	2	0.013	1	0	2	0.018	2	0.023	2	0.059
Gungry	-	-	-	-	-	-	-	-	-	-
Twilight	2	0.013	1	0	1	0	2	0.024	2	0.059
Windows	2	0.013	1	0	0	0	2	0.023	2	0.059
Happy Feet	2	0.013	1	0	2	0.018	2	0.023	2	0.059
Mission Impossible	1	0.013	2	0.112	2	0.018	2	0.023	0	0
Twilight	2	0.014	1	0	1	0	2	0.023	2	0.059
Windows 8	2	0.013	1	0	0	0	2	0.024	2	0.059
The	0	0	0	0	1	0	0	0.001	1	0.059
Happy	2	0.013	1	0.001	2	0.019	2	0.023	2	0.059
Windows 8	2	0.014	1	0	0	0	2	0.023	2	0.059
Happy Feet	2	0.015	1	0	2	0.018	2	0.023	2	0.059
Super Mario	2	0.014	1	0	2	0.018	2	0.023	2	0.059
Hotel Transylvania	0	0	2	0.097	1	0	2	0.023	0	0.001
Jack and Jill	2	0.014	1	0	0	0	0	0	2	0.059
Happy Feet	2	0.014	1	0	2	0.018	2	0.023	2	0.059
The Hunger Games	2	0.013	2	0.097	2	0.017	1	0.023	1	0.059
Hobbit	2	0.015	2	0.097	2	0.017	3	0.045	3	0.089
Turn Up The Music	2	0.015	0	0	2	0.019	2	0.023	2	0.059
Adventures of Tintin	2	0.013	2	0.096	2	0.018	1	0.023	0	0
Twilight saga	-	-	-	-	-	-	-	-	-	-
Happy Feet	2	0.014	1	0	2	0.017	2	0.023	2	0.059
Super Mario	2	0.017	1	0	2	0.018	2	0.023	2	0.059
American Pickers	2	0.014	2	0.099	2	0.017	3	0.045	3	0.082
Microsoft Office 2010	2	0.014	2	0.097	2	0.017	2	0.031	2	0.059
Twilight	2	0.013	0	0	1	0	2	0.023	2	0.059
Modern Family	2	0.013	2	0.099	1	0	2	0.023	2	0.059
Jack and Jill	2	0.013	1	0	0	0	0	0	2	0.059
Jill	2	0.013	1	0	0	0	0	0	2	0.059
Spider Man	-	-	-	-	-	-	-	-	-	-
Glee	2	0.014	2	0.099	2	0.017	3	0.039	3	0.088
The Vampire Diarie	2	0.015	2	0.097	1	0	0	0	1	0.059
King Arthur	2	0.013	2	0.097	2	0.017	2	0.038	3	0.082
Dark Knight	0	0	2	0.096	2	0.018	0	0	2	0.059
King Arthur	2	0.013	2	0.096	2	0.017	2	0.038	3	0.081
Windows XP	2	0.015	1	0	1	0	3	0.043	2	0.089
Harry Potter	2	0.013	2	0.096	1	0.001	3	0.045	3	0.081
Men in Black	2	0.013	1	0.001	2	0.017	2	0.023	2	0.059
Feet	2	0.013	1	0.001	2	0.017	2	0.023	2	0.059
Kung Fu Panda	2	0.014	1	0	2	0.017	2	0.023	2	0.059
Lady Gaga	2	0.013	0	0.001	2	0.017	2	0.023	0	0
Gaga	2	0.014	1	0.001	2	0.017	2	0.023	0	0
Happy Feet	2	0.014	1	0.001	2	0.017	2	0.031	2	0.059
Twilight	2	0.014	0	0	1	0	2	0.024	2	0.059
Hacking	1	0.015	0	0	1	0	2	0.023	2	0.063
King	2	0.015	2	0.097	2	0.017	2	0.042	3	0.082

Table 4: Number Queries handled

Network Scale	Node Number	Received Queries	Forwarded Queries	Answered Queries
20 nodes	1	72	54	18
	2	0	0	0
	3	35	17	18
	4	0	0	0
	5	82	2	80
	6	54	7	47
	7	0	0	0
	8	0	0	0
	9	0	0	0
	10	0	0	0
40 nodes	1	48	43	5
	2	50	43	7
	3	130	4	126
	4	71	34	37
	5	0	0	0
	6	86	0	86
	7	0	0	0
	8	0	0	0
	9	43	11	32
	10	68	32	36
80 nodes	1	49	45	4
	2	98	46	52
	3	64	35	29
	4	87	55	32
	5	0	0	0
	6	52	44	8
	7	51	47	4
	8	0	0	0
	9	85	52	33
	10	0	0	0