

COL334 - Assignment 4 - Part B

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Description for Part B:

In this part of the assignment we are going to analyse the routing protocol on the topology given in the assignment by varying various parameters as given in the sub parts and create plots via studying the routing tables for each of the routers present in the given topology.

Code Explanation:

The code files used to analyse this part are **partB1.cc, partB2.cc, partB3.cc, plotB1.py, plotB2.py, plotB3.py** where the files **partB1.cc, partB2.cc, partB3.cc** are used to print the corresponding routing tables in the terminal when ran using ns3 and the files **plotB1.py, plotB2.py and plotB3.py** are the corresponding plotting scripts to generate the manual plots of convergence generated using **Matplotlib** library.

In order to implement this part B, I have taken the reference code from **rip-simple-network.cc** file and just edited the code to match the topology given in the assignment and then printed the routing tables at various instances in the terminal by varying the different parameters.

Part B(i)

(A) Routing Tables as well as Graphs:

(a) For CSMA Delay equal to 100 Millisecond

For this delay value, we get the following routing tables (Here Node 2 means router 1, Node 3 means router 2 and Node 4 means router 3):

```
Node: 2, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table
```

```
Priority: 0 Protocol: ns3::Rip
```

```
Node: 2, Time: +0.0s, Local time: +0.0s, IPv4 RIP table
```

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	3

```
Node: 3, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table
```

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						

10.0.1.0	10.0.3.1	255.255.255.0	UGS	2	-	-	2
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	-	2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	-	1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	-	2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	-	3

Node: 2, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
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Iface							
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	-	3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	-	3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	-	3

Node: 3, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

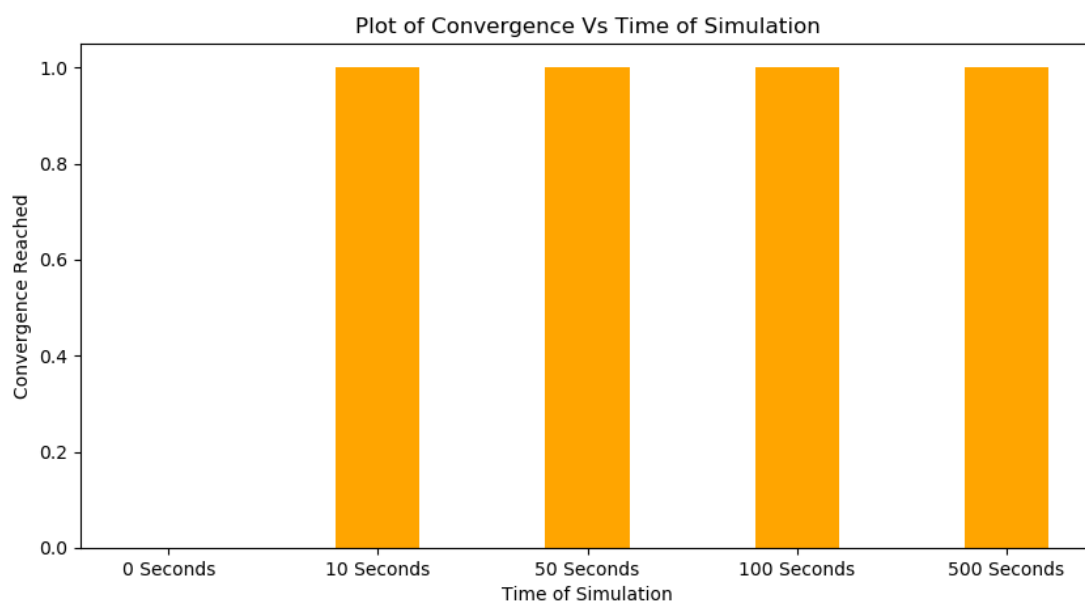
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.1.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

From the above routing tables we can see that at time 10 seconds, all the routers have the information about all the nodes that are reachable from that router, hence we can say that the routing tables converge after 10 seconds.

The corresponding plot of convergence is as follows:



(b) For CSMA Delay equal to 1000 Millisecond

For this delay value, we get the following routing tables (Here Node 2 means router 1, Node 3 means router 2 and Node 4 means router 3):

Node: 2, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	10.0.2.1	255.255.255.0	UGS	2	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
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Iface							
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	-	2
10.0.1.0	10.0.2.1	255.255.255.0	UGS	2	-	-	1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	-	1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	-	2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	-	3

Node: 2, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.1.0	10.0.2.1	255.255.255.0	UGS	2	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

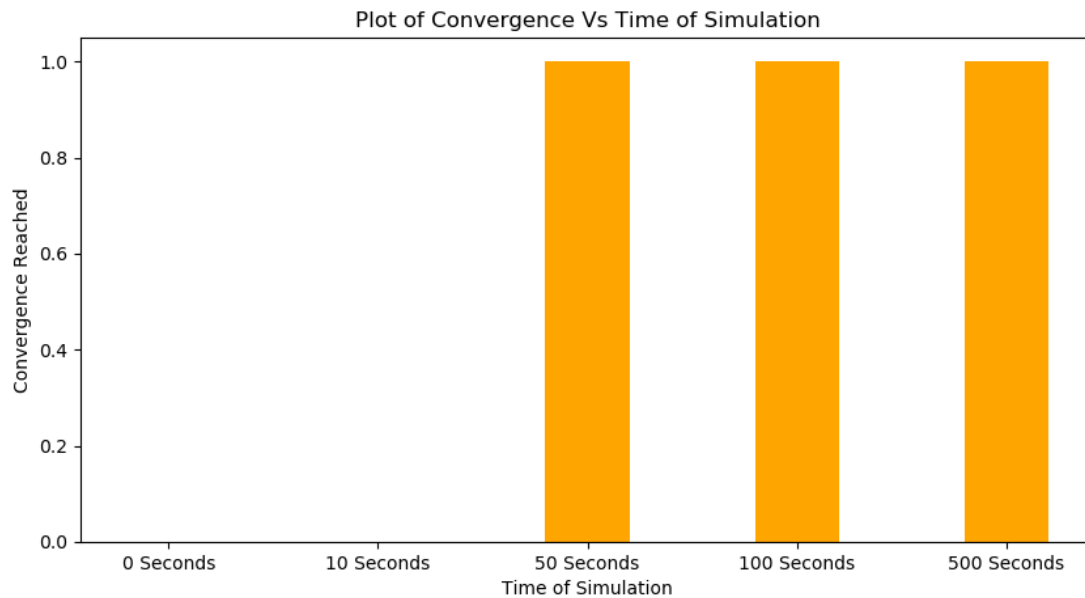
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.1.0	10.0.2.1	255.255.255.0	UGS	2	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

From the above routing tables we can see that at time 50 seconds, all the routers have the information about all the nodes that are reachable from that router, hence we can say that the routing tables converge after 50 seconds.

The corresponding plot of convergence is as follows:



(c) For CSMA Delay equal to 20000 Millisecond

For this delay value, we get the following routing tables (Here Node 2 means router 1, Node 3 means router 2 and Node 4 means router 3):

Node: 2, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2

10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	-	3
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Node: 2, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 3, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	2

Node: 4, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 2, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 3, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	1

10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	-	2
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Node: 4, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	10.0.1.1	255.255.255.0	UGS	2	-	- 1
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

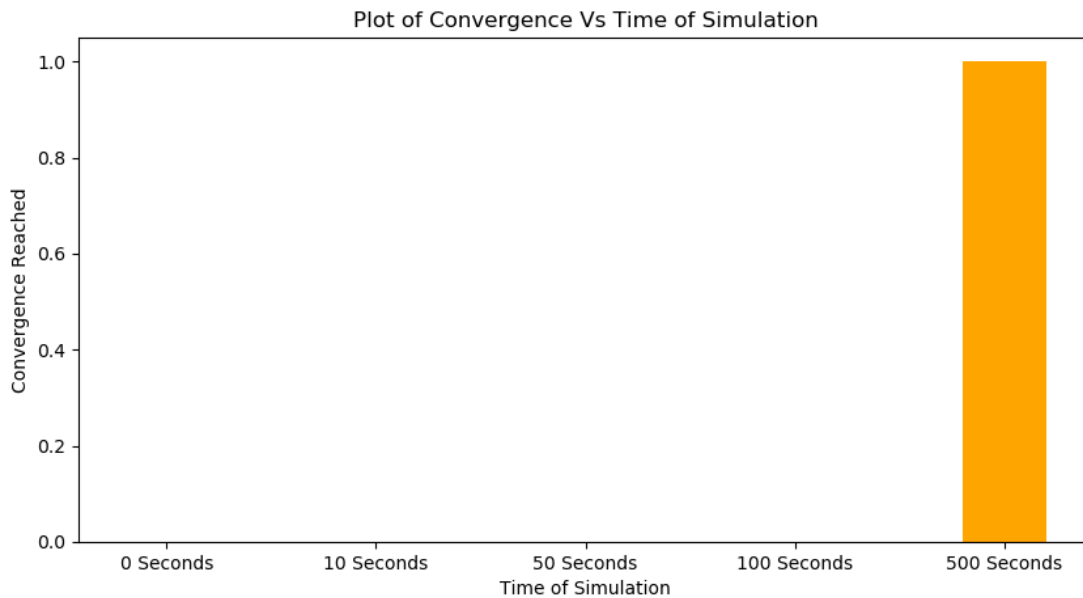
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.1.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.0.0	10.0.3.1	255.255.255.0	UGS	2	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

From the above routing tables we can see that at time 500 seconds, all the routers have the information about all the nodes that are reachable from that router, hence we can say that the routing tables converge after 500 seconds.

The corresponding plot of convergence is as follows:



(d) For CSMA Delay equal to 80000 Millisecond

For this delay value, we get the following routing tables (Here Node 2 means router 1, Node 3 means router 2 and Node 4 means router 3):

Node: 2, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +0.0s, Local time: +0.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +0.0s, Local time: +0.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2

10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	-	3
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Node: 2, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 3, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	2

Node: 4, Time: +10.0s, Local time: +10.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +10.0s, Local time: +10.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 2, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	3

Node: 3, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	1

10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	-	2
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Node: 4, Time: +50.0s, Local time: +50.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +50.0s, Local time: +50.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 3, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +100.0s, Local time: +100.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +100.0s, Local time: +100.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

Node: 2, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.4.0	10.0.3.2	255.255.255.0	UGS	2	-	- 3

10.0.2.0	10.0.3.2	255.255.255.0	UGS	2	-	-	3
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	-	1
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	-	2
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	-	3

Node: 3, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.1.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +500.0s, Local time: +500.0s, Ipv4ListRouting table

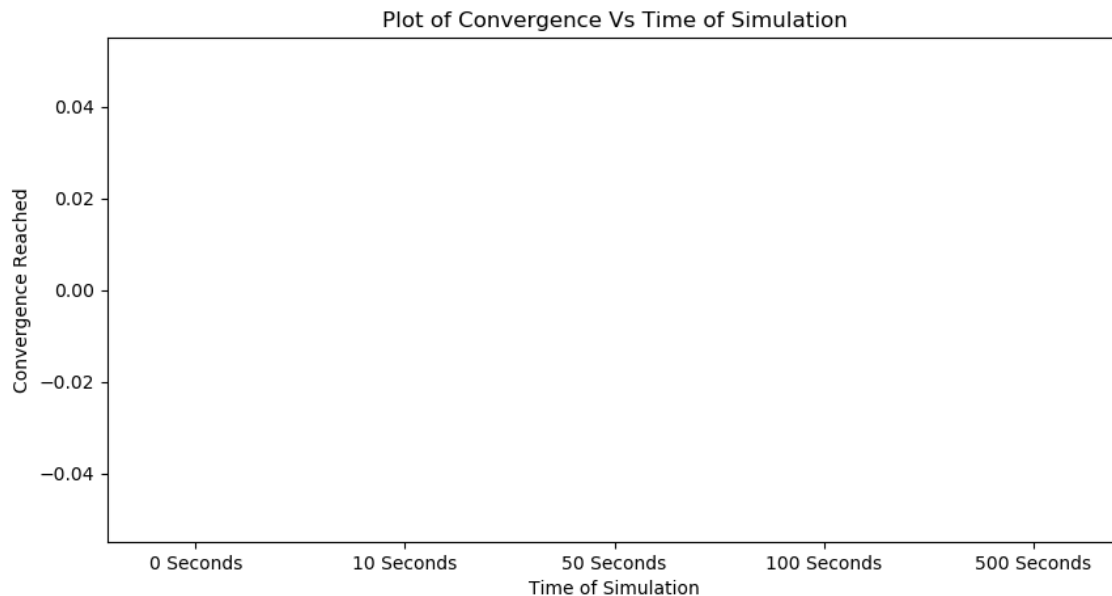
Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +500.0s, Local time: +500.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
10.0.1.0	10.0.2.1	255.255.255.0	UGS	2	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	- 2
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

From the above routing tables we can see that even at time 500 seconds, all the routers do not have the information about all the nodes that are reachable from that router, hence we can say that the routing tables does **not converge** hence all values are 0 in the below bar graph till 500 seconds.

The corresponding plot of convergence is as follows:



(B) Observation and Explanation for Part B(i):

Here after observing these routing tables, my observation is that as we increase the value of channel delay (CSMA channel here), then the time taken for the information to reach across each subnet increases, resulting in a **more time required for convergence**. This happens because of **increased travelling time** per frame to propagate information via the routing protocol.

Part B(ii)

(a) Here the routing tables printed at time 121 seconds are:

Labels: Node2 → Router1, Node3 → Router2, Node4 → Router3

```
Node: 2, Time: +121.0s, Local time: +121.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip
```

```
Node: 2, Time: +121.0s, Local time: +121.0s, IPv4 RIP table
```

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1

```
Node: 3, Time: +121.0s, Local time: +121.0s, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Rip
```

```
Node: 3, Time: +121.0s, Local time: +121.0s, IPv4 RIP table
```

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.3.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.0.0	10.0.2.2	255.255.255.0	UGS	3	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

Node: 4, Time: +121.0s, Local time: +121.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +121.0s, Local time: +121.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.1.0	10.0.2.1	255.255.255.0	UGS	16	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

The routing tables at time 180 seconds are as follows with same labelling convention:

Node: 2, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +180.0s, Local time: +180.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	- 1

Node: 3, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +180.0s, Local time: +180.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	- 2
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 2

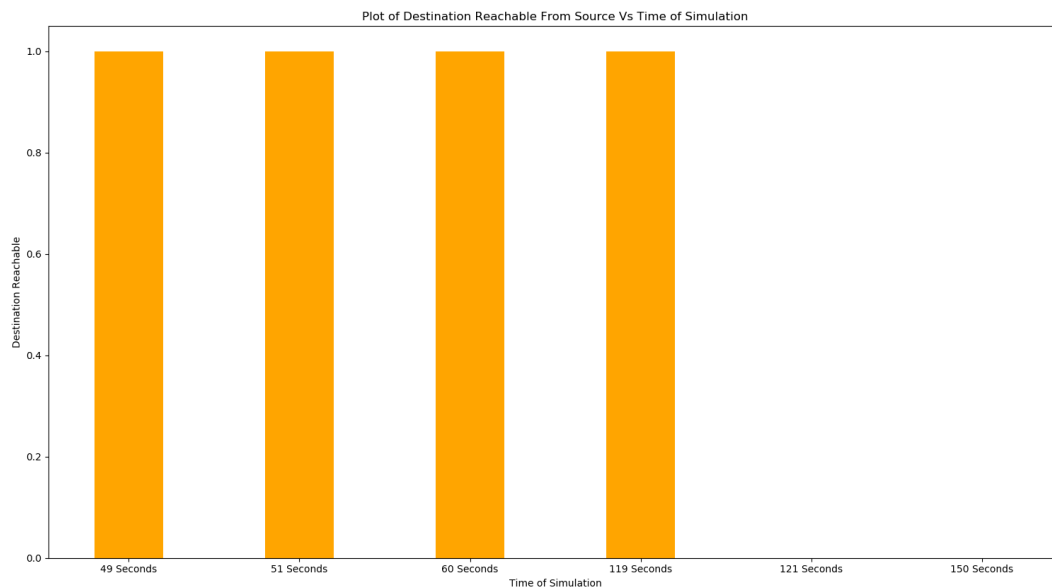
Node: 4, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 4, Time: +180.0s, Local time: +180.0s, IPv4 RIP table

Destination Iface	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.1.0	10.0.2.1	255.255.255.0	UGS	16	-	- 1
10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	- 1
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	- 3

(b) In order to check the reachability to destination from the source, we will print the routing table of the router next to source (i.e. router 1) and check if the subnet in which the destination node lies is present in that routing table or not (Note: In order to do this, I have left some commented portion in its code file which can be uncommented to check for the routing tables at corresponding time stamps). The graph of reachability is as follows:



(c) By seeing the above reachability graph and observing the routing table of router 1 (connected to source) at time 51 seconds, 119 seconds and 121 seconds. We observe a **similarity** between the behaviour of reachability at time 51 seconds and 119 seconds because at both these time stamps the only possible way from source datagram to reach the destination is to take the path via the link R1-R3 while we observe a **difference** between behaviour of reachability at time 119 seconds and time 121 seconds since there is path for a datagram from source to destination at time 121 seconds as all the connections from router 1 going towards destination have torn down.

Part B(iii)

(a) Here the routing tables at time 70 seconds are:

Labels : Node2 → Router1, Node3 → Router2, Node4 → Router3

Node: 2, Time: +70.0s, Local time: +70.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 2, Time: +70.0s, Local time: +70.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.0.0	0.0.0.0	255.255.255.0	U	1	-	1

Node: 3, Time: +70.0s, Local time: +70.0s, Ipv4ListRouting table

Priority: 0 Protocol: ns3::Rip

Node: 3, Time: +70.0s, Local time: +70.0s, IPv4 RIP table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
10.0.4.0	10.0.2.2	255.255.255.0	UGS	2	-	2

```

10.0.2.0      0.0.0.0      255.255.255.0  U    1    -    -    2

Node: 4, Time: +70.0s, Local time: +70.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Rip
Node: 4, Time: +70.0s, Local time: +70.0s, IPv4 RIP table
Destination      Gateway      Genmask      Flags Metric Ref    Use
Iface
10.0.2.0      0.0.0.0      255.255.255.0  U    1    -    -    1
10.0.4.0      0.0.0.0      255.255.255.0  U    1    -    -    3

```

The routing tables at time 180 seconds are as follows with the same labelling convention:

```

Node: 2, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Rip
Node: 2, Time: +180.0s, Local time: +180.0s, IPv4 RIP table
Destination      Gateway      Genmask      Flags Metric Ref    Use
Iface
10.0.4.0      10.0.3.2      255.255.255.0  UGS    2    -    -    3
10.0.2.0      10.0.1.2      255.255.255.0  UGS    2    -    -    2
10.0.0.0      0.0.0.0      255.255.255.0  U    1    -    -    1
10.0.1.0      0.0.0.0      255.255.255.0  U    1    -    -    2
10.0.3.0      0.0.0.0      255.255.255.0  U    1    -    -    3

Node: 3, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Rip
Node: 3, Time: +180.0s, Local time: +180.0s, IPv4 RIP table
Destination      Gateway      Genmask      Flags Metric Ref    Use
Iface
10.0.4.0      10.0.2.2      255.255.255.0  UGS    2    -    -    2
10.0.3.0      10.0.1.1      255.255.255.0  UGS    2    -    -    1
10.0.0.0      10.0.1.1      255.255.255.0  UGS    2    -    -    1
10.0.1.0      10.0.2.2      255.255.255.0  UGS    3    -    -    2
10.0.2.0      0.0.0.0      255.255.255.0  U    1    -    -    2
10.0.1.0      0.0.0.0      255.255.255.0  U    1    -    -    1

Node: 4, Time: +180.0s, Local time: +180.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Rip
Node: 4, Time: +180.0s, Local time: +180.0s, IPv4 RIP table
Destination      Gateway      Genmask      Flags Metric Ref    Use
Iface
10.0.1.0      10.0.3.1      255.255.255.0  UGS    2    -    -    2
10.0.0.0      10.0.3.1      255.255.255.0  UGS    2    -    -    2

```

10.0.2.0	0.0.0.0	255.255.255.0	U	1	-	-	1
10.0.3.0	10.0.2.1	255.255.255.0	UGS	3	-	-	1
10.0.4.0	0.0.0.0	255.255.255.0	U	1	-	-	3
10.0.3.0	0.0.0.0	255.255.255.0	U	1	-	-	2

(b) In order to check the reachability to destination from the source, we will print the routing table of the router next to source (i.e. router 1) and check if the subnet in which the destination node lies is present in that routing table or not (Note: In order to do this, I have left some commented portion in its code file which can be uncommented to check for the routing tables at corresponding time stamps). The graph of reachability is as follows:

