

Simulation of Congestion Control AODV (CC-AODV) in NetSim

Software Recommended: NetSim Standard v12.2 (64 bit), Visual Studio 2019 or Higher version.

Reference: Y. Mai, F. M. Rodriguez and N. Wang, "CC-AODV: An effective multiple path congestion control AODV," 2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, 2018, pp. 1000-1004.

Follow the instructions specified in the following link to clone/download the project folder from GitHub using Visual Studio:

<https://support.tetcos.com/en/support/solutions/articles/14000128666-downloading-and-setting-up-netsim-file-exchange-projects>

Other tools such as GitHub Desktop, SVN Client, Source tree, Git from the command line, or any client you like to clone the Git repository.

Note: It is recommended not to download the project as an archive (compressed zip) to avoid incompatibility while importing workspaces into NetSim.

For NetSim v12.1 refer to the documentation at https://www.tetcos.com/pdf/v12.1/CC-AODV_v12.1.pdf

Secure URL for the GitHub repository:

<https://github.com/NetSim-TETCOS/CC-AODV-v12.2.git>

Introduction

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is a prominent algorithm in the field of wireless communication. Extensive research has been conducted to optimize its performance. In this referenced paper, the authors introduce a novel control scheme, termed Congestion Control AODV (CC-AODV), designed to enhance routing efficiency. Implementing this scheme substantially improves package delivery rates and reduces package drop rates, albeit at the cost of package overhead.

CC-AODV's primary objective is to mitigate performance degradation due to packet congestion during data transmission via AODV. The protocol establishes a data path using a metric we refer to as the "congestion counter label". This metric quantifies the congestion level of a node, which is then stored in a table. Upon the generation and transmission of a Route Reply (RREP) packet, the congestion counter is incremented.

The CC-AODV procedure to set up a route is as follows:

1. The source node initiates a Route Request (RREQ) broadcast throughout the network.
2. As the RREQ is received by an intermediate node, the router consults the congestion counter. If the value is below a predefined threshold, the routing table is updated and the RREQ is forwarded to the subsequent router. Otherwise, the RREQ is discarded.
3. On reaching the intended destination, an RREP is produced. Within the CC-AODV framework, an additional 'congestion flag' is integrated into the RREP header.

There are two scenarios in which an RREP is generated in response to an RREQ:

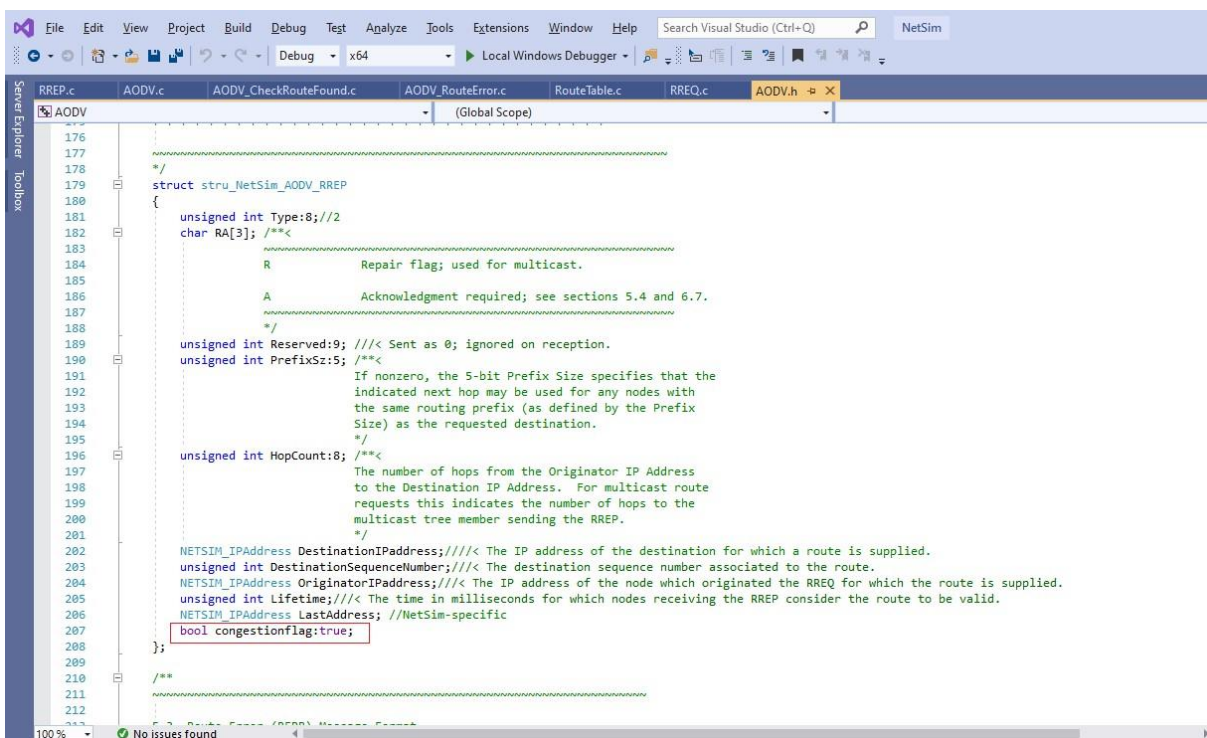
- By the source node to establish a route.
- By neighbouring nodes to maintain an existing route.

When the destination node intercepts the RREQ from the source node, it issues an RREP with the congestion flag activated. As the RREP is unicasted back towards the source node via intermediate nodes, each router checks the congestion flag. If activated, the counter increments. Otherwise, it remains unchanged. Subsequently, the router updates its routing information.

Procedure to implement CC-AODV in NetSim:

To implement CC-AODV following code modification in AODV Protocol

1. The RREP structure `stru_NetSim_AODV_RREP` is defined in `AODV.h` has been modified to include a Congestion flag for implementing CC-AODV



```
176
177
178
179 struct stru_NetSim_AODV_RREP
180 {
181     unsigned int Type:8; //2
182     char RA[3]; /**<
183
184         R          Repair flag; used for multicast.
185
186         A          Acknowledgment required; see sections 5.4 and 6.7.
187
188     /**<
189     unsigned int Reserved:9; /**< Sent as 0; ignored on reception.
190     unsigned int PrefixSz:5; /**<
191         If nonzero, the 5-bit Prefix Size specifies that the
192         indicated next hop may be used for any nodes with
193         the same routing prefix (as defined by the Prefix
194         Size) as the requested destination.
195     /**<
196     unsigned int HopCount:8; /**<
197         The number of hops from the Originator IP Address
198         to the Destination IP Address. For multicast route
199         requests this indicates the number of hops to the
200         multicast tree member sending the RREP.
201     /**<
202     NETSIM_IPAddress DestinationIPaddress; /**< The IP address of the destination for which a route is supplied.
203     unsigned int DestinationSequenceNumber; /**< The destination sequence number associated to the route.
204     NETSIM_IPAddress OriginatorIPaddress; /**< The IP address of the node which originated the RREQ for which the route is supplied.
205     unsigned int Lifetime; /**< The time in milliseconds for which nodes receiving the RREP consider the route to be valid.
206     NETSIM_IPAddress LastAddress; //NetSim-specific
207     bool congestionFlag:true;
208 };
209
210 /**<
211
212
```

Figure 1: Changes inside `stru_NetSim_AODV_RREP` function in `AODV.h`

2. The DeviceVariable Structure `stru_AODV_DeviceVariable` is defined in `AODV.h` file has been modified to include a congestion counter for implementing CC-AODV

```

374  /**
375  This is the AODV DeviceVariable Structure which contains -
376  FIFO - a packet is added in FIFO buffer if the device does not have route to the target<br>
377  routeTable - this contains the next HOP ip of the routes to the target<br>
378  RREQ_SEEN_TABLE - this contains list differnet RREQ a device encounters.
379  */
380  struct stru_AODV_DeviceVariable
381  {
382      unsigned int nSequenceNumber;
383      AODV_FIFO* fifo;
384      AODV_ROUTETABLE* routeTable;
385      AODV_RREQ_SEEN_TABLE* rreqSeenTable;
386      AODV_RREQ_SENT_TABLE* rreqSentTable;
387      AODV_PRECURSORS_LIST* precursorsList;
388      double dLastBroadcastTime;
389      unsigned int nRerrCount;
390      double dFirstRerrTime;
391      AODV_METRICS_aodvMetrics;
392      unsigned int ncounter;
393  };
394
395

```

Figure 2: Adding congestion counter in stru_AODV_DeviceVariable

3. The source codes of functions in **RREP.c**, **RouteTable.c** and **AODV_RouteError.c** has been modified suitably to Increment, Decrement the congestion counter accordingly.

```

163  /**
164  This function adds the timeout event of a Route Table which is equal to the table_LifeTime
165  */
166  int fn_NetSim_AODV_ActiveRouteTimeout(Netsim_EVENTDETAILS* pstruEventDetails)
167  {
168      int flag = 0;
169      NETSIM_IPAddress dest = (NETSIM_IPAddress)pstruEventDetails->szOtherDetails;
170      AODV_ROUTETABLE* table = AODV_DEV_VAR(pstruEventDetails->nDeviceId)->routeTable;
171      while(table)
172      {
173          if(!IP_COMPARE(table->DestinationIPAddress,dest))
174          {
175              if(table->Lifetime <= pstruEventDetails->dEventTime)
176              {
177                  AODV_ROUTETABLE* temp = LIST_NEXT(table);
178                  IP_FREE(table->DestinationIPAddress);
179                  IP_FREE(table->NextHop);
180                  LIST_FREE(&AODV_DEV_VAR(pstruEventDetails->nDeviceId)->routeTable,table);
181                  AODV_DEV_VAR(pstruEventDetails->nDeviceId)->ncounter--;
182                  table = temp;
183                  continue;
184              }
185              else
186              {
187                  //Add new time out event
188                  pstruEventDetails->dEventTime = table->Lifetime;
189                  fnpAddEvent(pstruEventDetails);
190                  flag = 1;
191              }
192              table=(AODV_ROUTETABLE*)LIST_NEXT(table);
193          }
194      }
195      if(flag)
196          IP_FREE(dest);
197      return 1;
198  }
199

```

Figure 3: Changes in RREP.c

```

14 #include "main.h"
15 #include "AODV.h"
16 #include "List.h"
17 /**
18  * This function Generates a route error and sends it to the previous HOP.
19  */
20 int fn_NetSim_AODV_GenerateRERR(NETSIM_ID nDeviceId,
21 NETSIM_IPAddress UnreachableIP,
22 NetSim_EVENTDETAILS* pstruEventDetails)
23 {
24     AODV_DEV_VAR(nDeviceId)->ncounter--;
25
26     int DestCount=0;
27     NETSIM_IPAddress* DestinationList=NULL;
28     unsigned int* DestinationSequence=NULL;
29     AODV_DEVICE_VAR* pstruDeviceVar = AODV_DEV_VAR(nDeviceId);
30
31     AODV_ROUTE_TABLE* routeTable = pstruDeviceVar->routeTable;
32     AODV_PRECURSORS_LIST* precursorList = pstruDeviceVar->precursorList;
33     while(routeTable)
34     {
35         if(!IP_COMPARE(routeTable->NextHop,UnreachableIP))
36         {
37             routeTable->routingFlags = AODV_RoutingFlag_Invalid;
38             routeTable->Lifetime = pstruEventDetails->dEventTime+AODV_DELETE_PERIOD;
39             DestCount++;
40             DestinationList = realloc(DestinationList,DestCount*(sizeof* DestinationList));
41             DestinationSequence = realloc(DestinationSequence,DestCount*(sizeof* DestinationSequence));
42             DestinationList[DestCount-1] = IP_COPY(routeTable->DestinationIPAddress);
43             DestinationSequence[DestCount-1] = routeTable->DestinationSequenceNumber;
44         }
45         routeTable = LIST_NEXT(routeTable);
46     }
47     if(precursorList->count)
48     {
49         int loop;
50         bool flag=false;
51         for(loop=0;loop<precursorList->count;loop++)

```

Figure 4: Changes in AODV_RouteError.c

- The source codes and functions related to Route request are defined in the file **RREQ.c**. The **fn_NetSim_AODV_ProcessRREQ()** function that is part of this file has been modified suitably to check the value of the congestion counter in the received RREQ packet and accordingly forward or drop the packet.

```

317 //Free the rreq packet
318 fn_NetSim_Packet_FreePacket(packet);
319 pstruEventDetails->pPacket=NULL;
320 }
321 else
322 {
323     int dev_counter = AODV_DEV_VAR(pstruEventDetails->nDeviceId)->ncounter;
324     if (dev_counter > 25)
325     {
326         fn_NetSim_Packet_FreePacket(packet);
327         pstruEventDetails->pPacket = NULL;
328         return 1;
329     }
330
331     if(AODV_CHECK_ROUTE_FOUND(rreq->DestinationIPAddress) &&
332        rreq->JRGDU[3] != '1' /* Destination only flag*/)
333     {
334         if(AODV_GENERATE_RREP_BY_IN())
335         {
336             fn_NetSim_Packet_FreePacket(packet);
337             pstruEventDetails->pPacket=NULL;
338         }
339     }
340 }

```

Figure 5: Modifications within the fn_NetSim_AODV_ProcessRREQ() in RREQ.c

The above code modifications are done to the provided workspace, user can follow the below procedure for importing the workspace and run the simulation.

Steps to simulate:

- After you unzip the downloaded project folder, Open NetSim Home Page click on Open Simulation

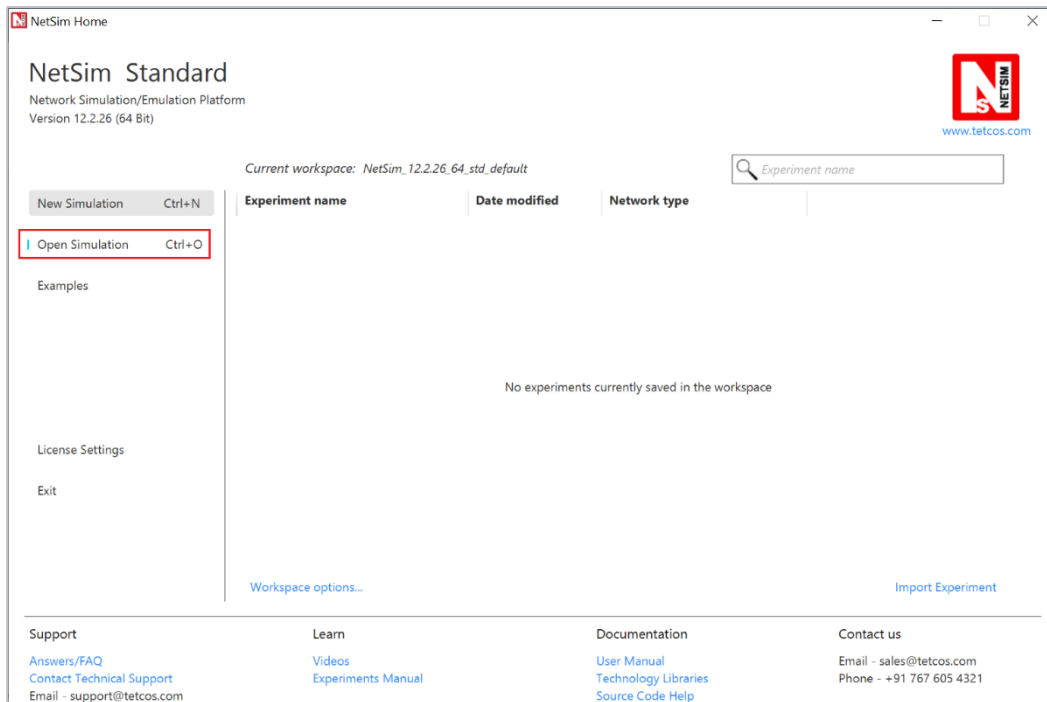


Figure 6: Selecting “Open simulation” from NetSim home page

2. Click on **Workspace options.**

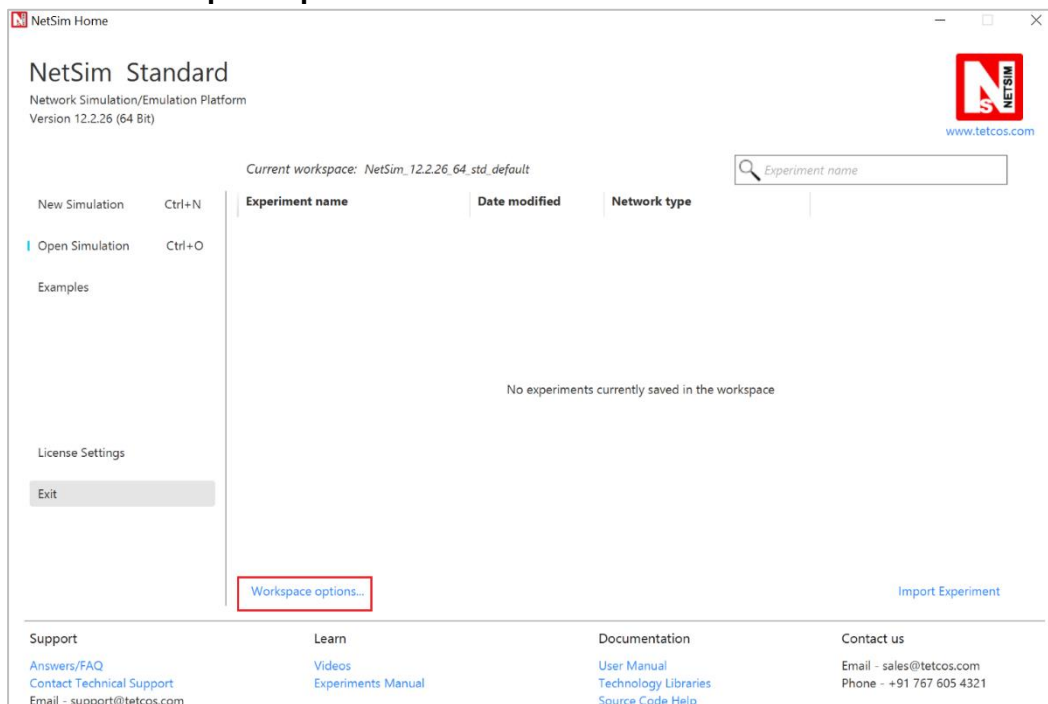


Figure 7: Selecting workspace option from NetSim home page.

3. Click on **More Options**

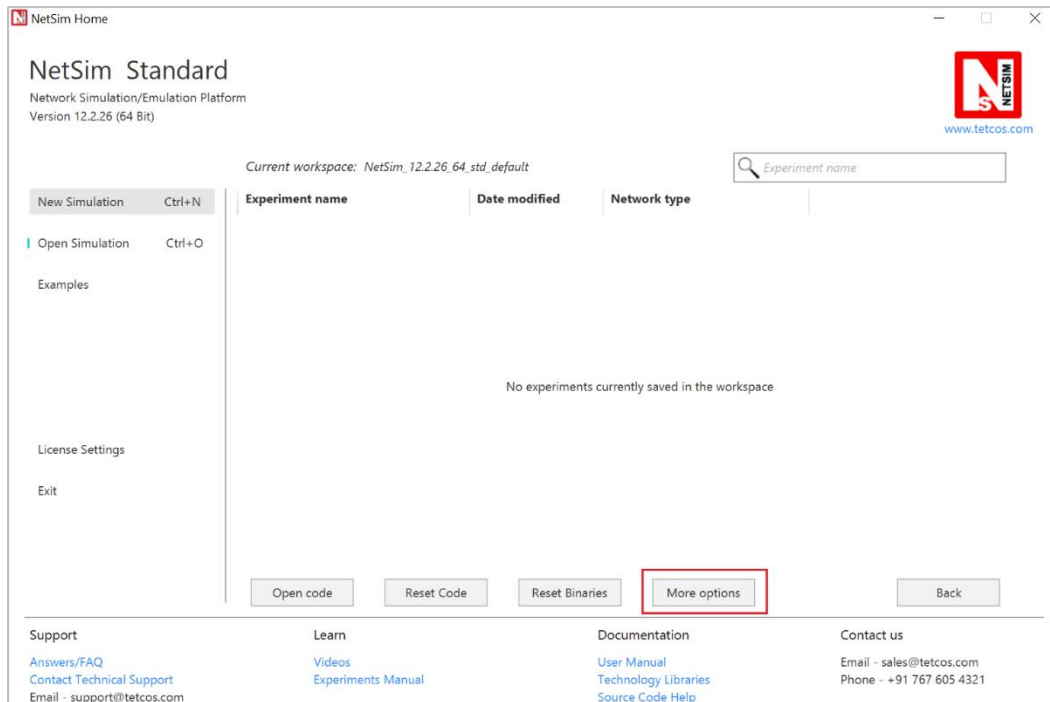


Figure 8: Selecting more options to import the workspace into NetSim

4. Click on **Import**, browse the extracted folder and go into the Performance_Analysis_CC_AODV directory, select the workspace folder and then click on OK.

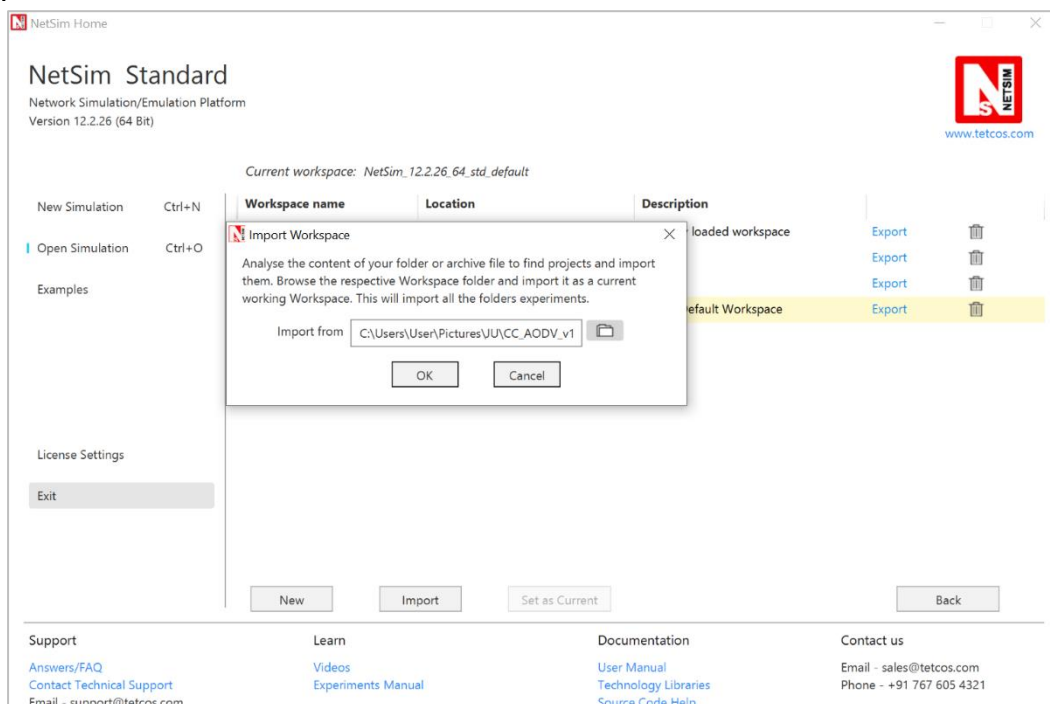


Figure 9: Importing the performance analysis of CC AODV workspace into NetSim.

5. Go to home page, Click on **Open Simulation**-> **Workspace options**-> **Open code**.

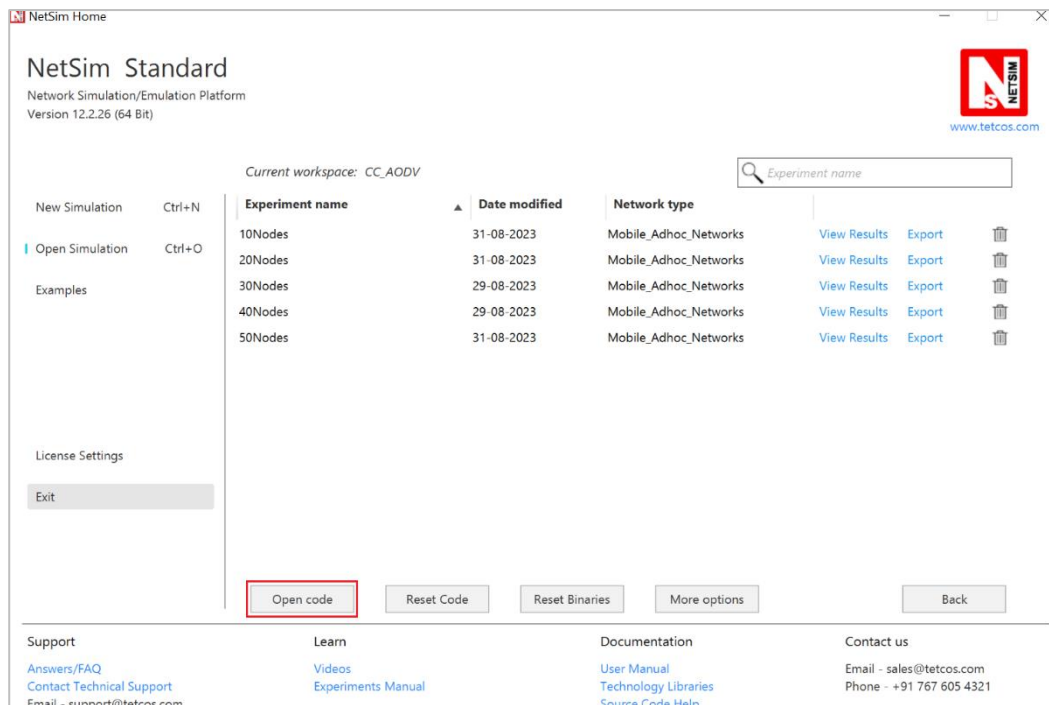


Figure 10: List of experiments in CC AODV workspace

6. Right click on the AODV Project and select rebuild.

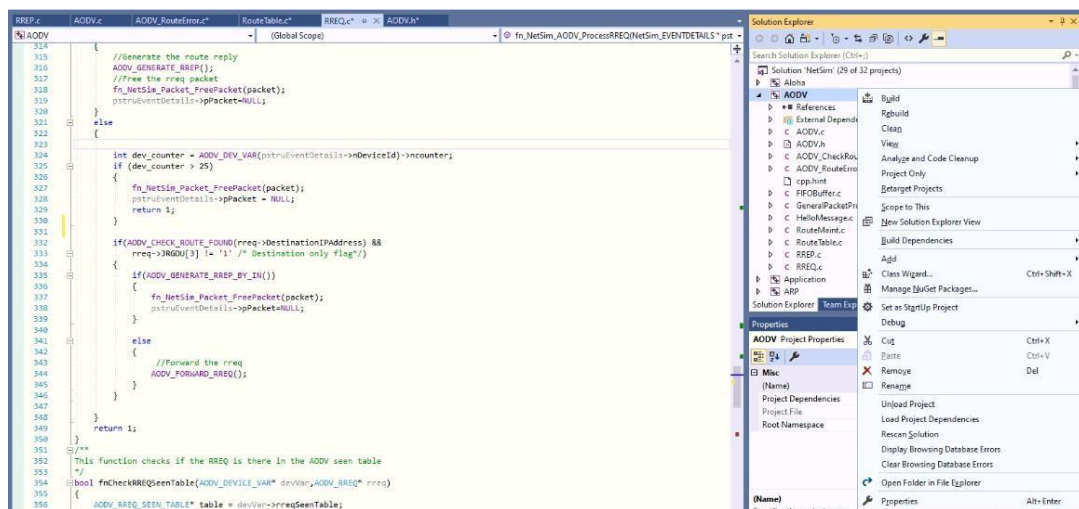


Figure 11: Screenshot of rebuilding the AODV project.

7. Upon rebuilding, **libAodv.dll** will automatically get updated in the respective bin folder of the current workspace.

Note:

a) Based on whether you are using NetSim 32 bit or 64-bit setup you can configure Visual studio to build 32 bit or 64-bit DLL files respectively as shown below:

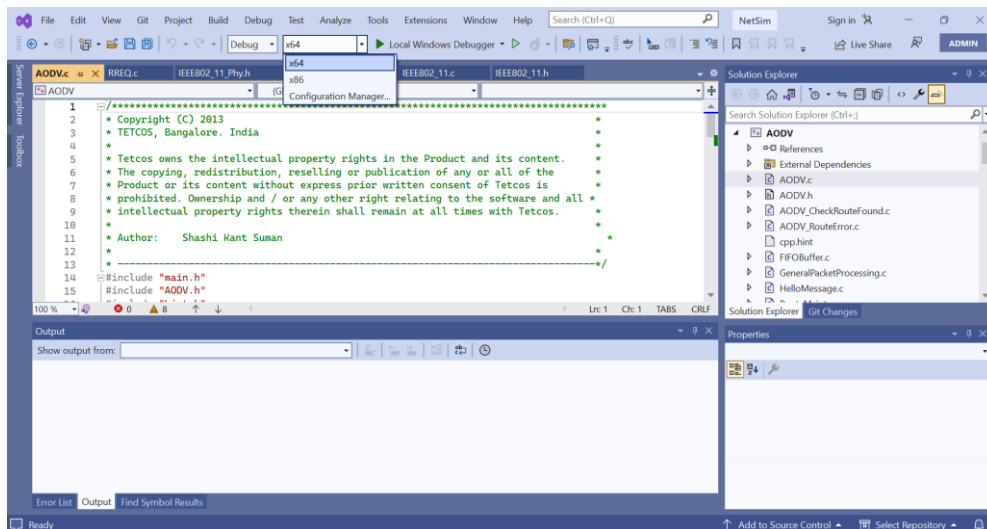


Figure 12: Screenshot showing changing of the solution platform for 32 and 64-bit version of NetSim.

- b) While importing the workspace, if the following warning message indicating Software Version Mismatch is displayed, you can ignore it and proceed.

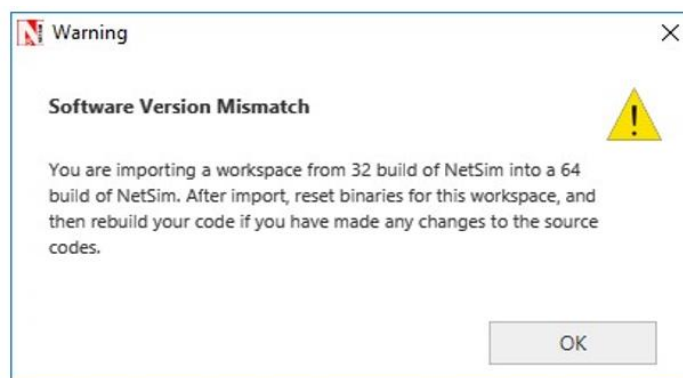


Figure 13: Software mismatch warning message

8. Go to NetSim home page, click on **Open Simulation**, Click on **20Nodes Example**.

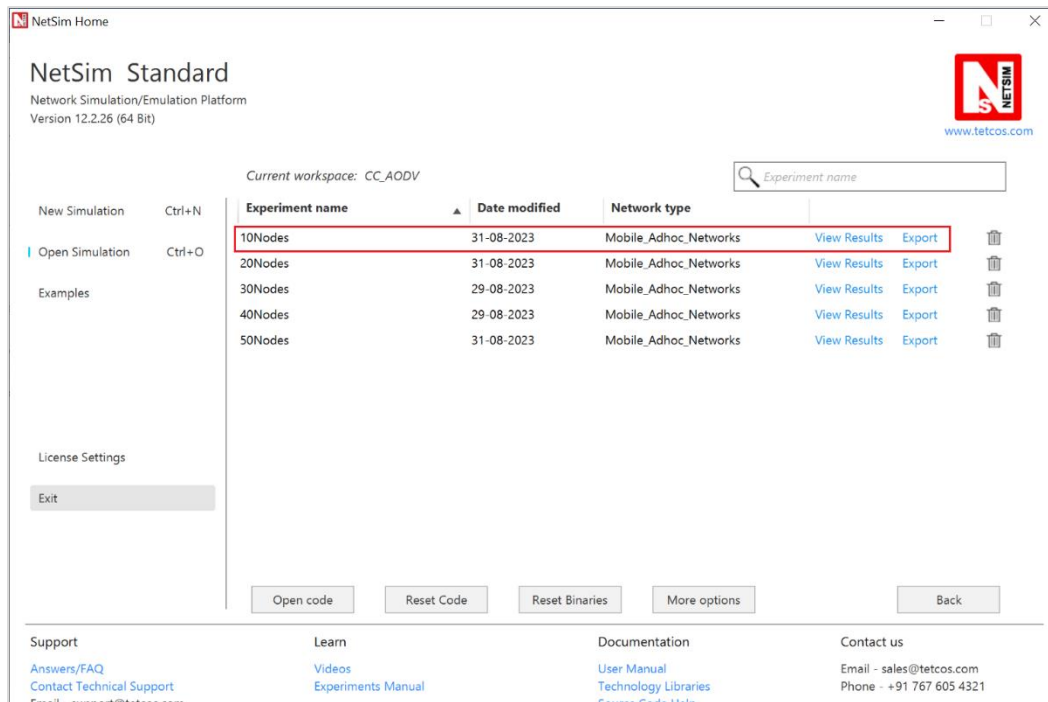


Figure 14: Opening 10nodes example from CC AODV workspace

9. 10 Node example is created in MANET as per the below screenshot.

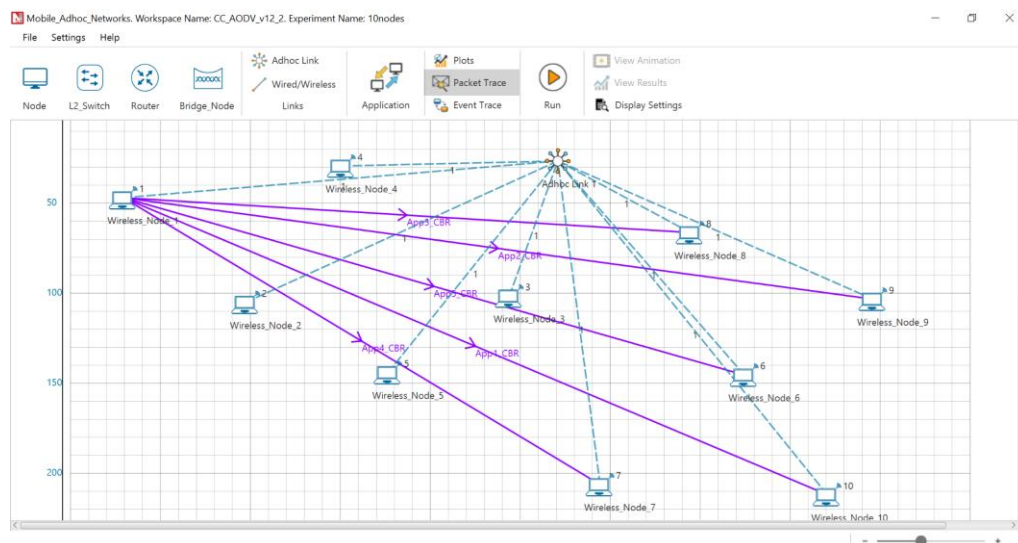


Figure 15: Network topology in this project

10. Run the simulation for 100sec.

Simulations have been carried out using a different number of nodes in a network to symbolize different practical applications of wireless network. For example, 10 to 20 nodes symbolize a small network that can be used in an agricultural setup. 30 to 40 nodes symbolize a medium size network that can be used in an industrial setup and a large 50 nodes network that can be used in an army base.

Result and discussion:

Performance of CC-AODV has been compared against AODV with respect to Throughput and End to End delay.

Number of Nodes	AODV Aggregate throughput (Mbps)	CC AODV Aggregate throughput (Mbps)
10 Nodes	0.67	0.69
20 Nodes	0.69	0.70
30 Nodes	0.96	1.04
40 Nodes	1.09	1.20
50 Nodes	1.55	1.64

Table 1: Aggregate Throughput comparison between AODV and CC-AODV

Per Table 1 we see that CC-AODV has higher throughput than the AODV. This enhancement in CC-AODV can be attributed to its more efficient utilization of internal nodes. Specifically, the incorporated counter in CC-AODV facilitates path rerouting if an internal node is occupied, leading to improved network channel utilization.

The results of Table 1 are plotted below.

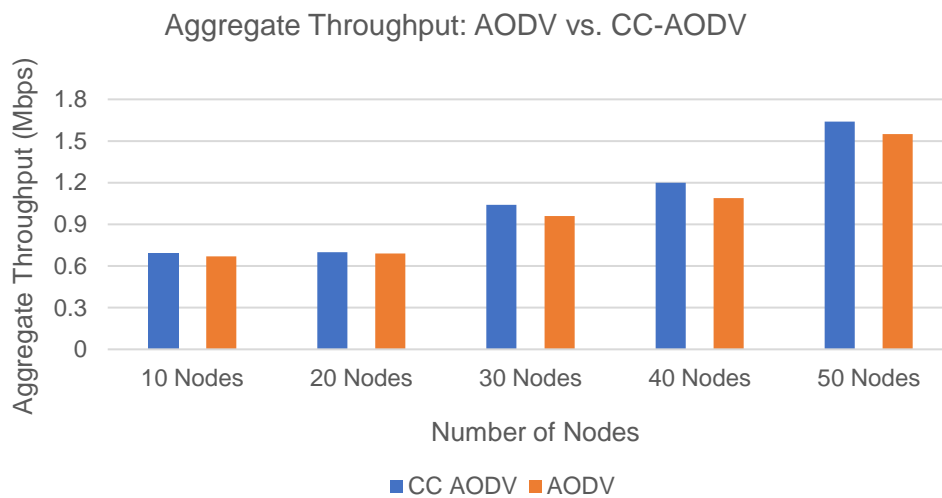


Figure 16: Comparison of aggregate throughputs of AODV and CC-AODV

Number of Nodes	AODV Average Delay (seconds)	CC AODV Average Delay (seconds)
10 Nodes	0.542	0.512
20 Nodes	0.522	0.462
30 Nodes	0.523	0.517
40 Nodes	0.508	0.430
50 Nodes	0.511	0.476

Table 2: End to End delay comparison between AODV and CC-AODV

In Table 2 we observe that CC-AODV has a lower delay than AODV due to re-routing the path of the data if the router is on a busy state. The results of Table 2 are plotted below.

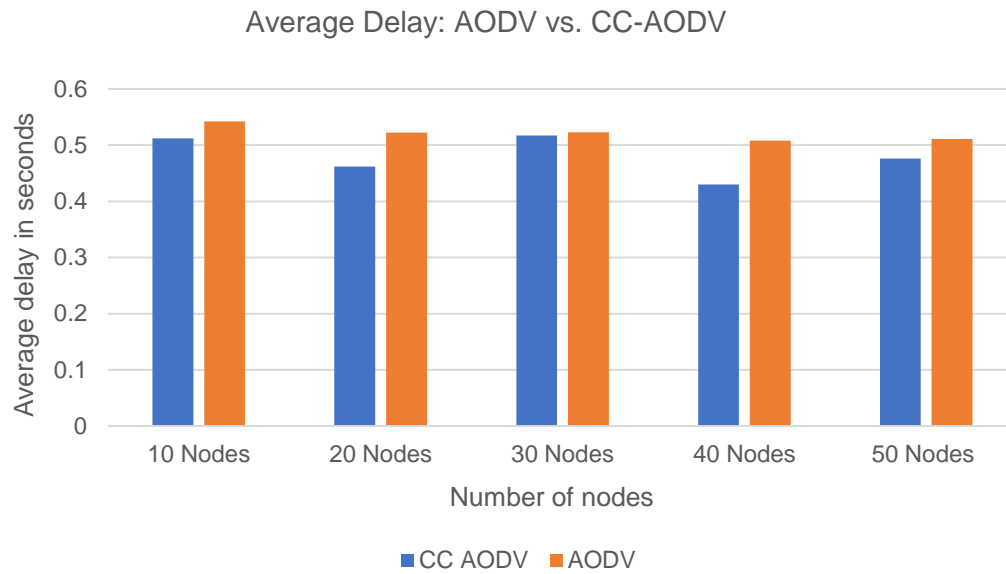


Figure17: Comparison between of Average delay of AODV and CC-AODV

From the table below, we observe that the number of collided packets is higher in the case of AODV than in CC AODV. This is because CC AODV selects paths with a lower collision rate, leading to improved overall packet delivery.

Number of Nodes	Collision packets in AODV	Collision packets in CC AODV
10 Nodes	1664	1220
20 Nodes	2202	1178
30 Nodes	1028	578
40 Nodes	1020	584
50 Nodes	108	58

Table 3: Comparison of collided packets between AODV and CC-AODV

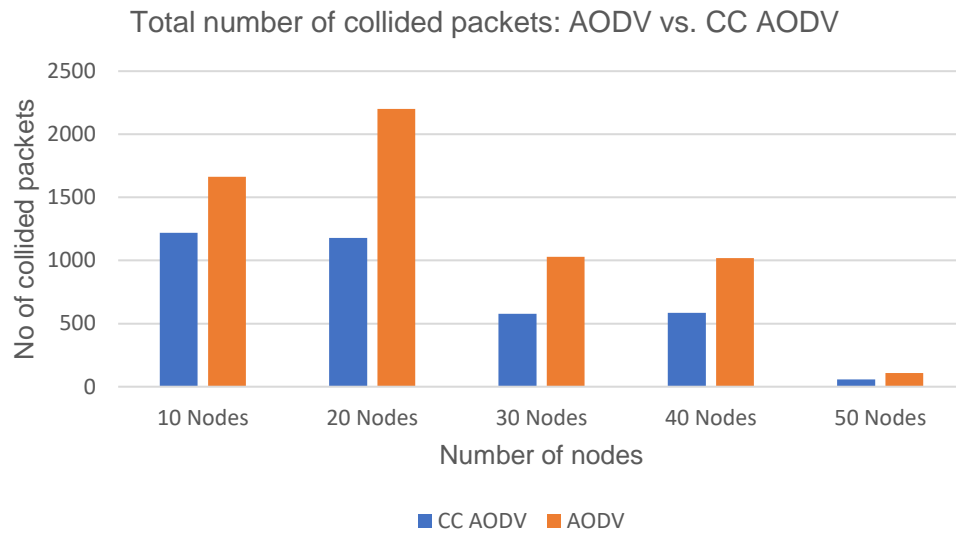


Figure 18: Comparison between AODV and CC-AODV collided packets