NETWORKS
ASSIGNMENT 3 - ROUTING PROTOCOLS
8th January 2021

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1. Download NS3, build it and run the hello world example

Because of this issue :
E: Unable to locate package python python-pygoocanvas
E: Unable to locate package libgoocanvas-dev

I found it here: https://itectec.com/ubuntu/ubuntu-unable-to-locate-package-python-pygoocanvas/

The solution was to use an ns -3 version above 29 because I had Ubuntu above 18 so I used version **31.**

Tests: →

Hello Simulation:

2. NS3 source code updated.

The updated part for adding only one route with minimum cost is to remove this part "Make it a comment" and add continue to be as the previous condition of routs not has lower cost. In "global-route-manager-impl.cc" file

```
        else if (cw->GetDistanceFromRoot () == distance)
          {
//
// This path is one with an equal cost.
//
            NS_LOG_LOGIC ("Equal cost multiple paths found.");

// At this point, there are two instances 'w' and 'cw' of the
// same vertex, the vertex that is currently being considered
// for adding into the shortest path tree. 'w' is the instance
// as seen from the root via vertex 'v', and 'cw' is the instance
// as seen from the root via some other vertices other than 'v'.
// These two instances are being merged in the following code.
// In particular, the parent nodes, the next hops, and the root's
// output interfaces of the two instances are being merged.
//
// Note that this is functionally equivalent to calling
// ospf_nexthop_merge (cw->nexthop, w->nexthop) in quagga-0.98.6
// (ospf_spf.c::859), although the detail implementation
// is very different from quagga (blame ns3::GlobalRouteManagerImpl)

// prepare vertex w
        /*    w = new SPFVertex (w_lsa);
            SPFNexthopCalculation (v, w, l, distance);
            cw->MergeRootExitDirections (w);
            cw->MergeParent (w);
// SPFVertexAddParent (w) is necessary as the destructor of
// SPFVertex checks if the vertex and its parent is linked
// bidirectionally
            SPFVertexAddParent (w);
            delete w;
            */
            continue;
          }
```

3. A description of the contribution introduced to code.

```
#include <iostream>
#include <fstream>
#include <string>
#include <cassert>
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/csma-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
```

```cpp
#include "ns3/ipv4-global-routing-helper.h"
#include "ns3/netanim-module.h"

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("Assignment3");

int
main (int argc, char *argv[])
{

  CommandLine cmd (__FILE__);
  cmd.Parse (argc, argv);

  NS_LOG_INFO ("Create nodes.");

  NodeContainer c;
  c.Create (6);
  NodeContainer n0n1 = NodeContainer (c.Get (0), c.Get (1));
  NodeContainer n0n2 = NodeContainer (c.Get (0), c.Get (2));
  NodeContainer n1n2 = NodeContainer (c.Get (1), c.Get (2));
  NodeContainer n1n3 = NodeContainer (c.Get (1), c.Get (3));
  NodeContainer n1n4 = NodeContainer (c.Get (1), c.Get (4));
  NodeContainer n2n4 = NodeContainer (c.Get (2), c.Get (4));
  NodeContainer n3n4 = NodeContainer (c.Get (3), c.Get (4));
  NodeContainer n4n5 = NodeContainer (c.Get (4), c.Get (5));

  InternetStackHelper internet;
  internet.Install (c);

  // As in Example of Global Routing Protocol in NS-3
  // We create the channels first without any IP addressing information
  NS_LOG_INFO ("Create channels.");
  PointToPointHelper p2p;
  p2p.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
  p2p.SetChannelAttribute ("Delay", StringValue ("2ms"));

  NetDeviceContainer d0d1 = p2p.Install (n0n1);
  NetDeviceContainer d0d2 = p2p.Install (n0n2);
  NetDeviceContainer d1d2 = p2p.Install (n1n2);
  NetDeviceContainer d1d3 = p2p.Install (n1n3);
  NetDeviceContainer d1d4 = p2p.Install (n1n4);
  NetDeviceContainer d2d4 = p2p.Install (n2n4);
  NetDeviceContainer d3d4 = p2p.Install (n3n4);
  NetDeviceContainer d4d5 = p2p.Install (n4n5);

  // Later, we add IP addresses.
  NS_LOG_INFO ("Assign IP Addresses.");
  Ipv4AddressHelper ipv4;

  ipv4.SetBase ("10.1.1.0", "255.255.255.0");
  Ipv4InterfaceContainer i0i1 = ipv4.Assign (d0d1);
```
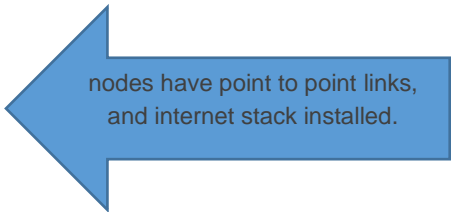
nodes have point to point links, and internet stack installed.

```
ipv4.SetBase ("10.1.2.0", "255.255.255.0");
Ipv4InterfaceContainer i0i2 = ipv4.Assign (d0d2);

ipv4.SetBase ("10.1.3.0", "255.255.255.0");
Ipv4InterfaceContainer i1i2 = ipv4.Assign (d1d2);

ipv4.SetBase ("10.1.4.0", "255.255.255.0");
Ipv4InterfaceContainer i1i3 = ipv4.Assign (d1d3);

ipv4.SetBase ("10.1.5.0", "255.255.255.0");
Ipv4InterfaceContainer i1i4 = ipv4.Assign (d1d4);

ipv4.SetBase ("10.1.6.0", "255.255.255.0");
Ipv4InterfaceContainer i2i4 = ipv4.Assign (d2d4);

ipv4.SetBase ("10.1.7.0", "255.255.255.0");
Ipv4InterfaceContainer i3i4 = ipv4.Assign (d3d4);

ipv4.SetBase ("10.1.8.0", "255.255.255.0");
Ipv4InterfaceContainer i4i5 = ipv4.Assign (d4d5);


// Create router nodes, initialize routing database and set up the routing
// tables in the nodes.
Ipv4GlobalRoutingHelper: PopulateRoutingTables ();



// Create a server and 5 clients
// As in Example of tutorail for NS-3 in https://www.nsnam.org/docs/release/3.18/doxygen/first_8cc_source.html

NS_LOG_INFO ("Create Applications.");


uint16_t port = 9;
UdpEchoServerHelper echoServer (port);

ApplicationContainer server = echoServer.Install (c.Get (5));
server.Start (Seconds (1.0));
server.Stop (Seconds (15.0));

UdpEchoClientHelper echoClient (i4i5.GetAddress (1), port);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer client0 = echoClient.Install (c.Get (0));
client0.Start (Seconds (2.0));
client0.Stop (Seconds (15.0));

ApplicationContainer client1 = echoClient.Install (c.Get (1));
```

Adding IP Addresses for each channel

Creating 1 Server and 5 Clients

```
client1.Start (Seconds (4.0));
client1.Stop (Seconds (15.0));

ApplicationContainer client2 = echoClient.Install (c.Get (2));
client2.Start (Seconds (6.0));
client2.Stop (Seconds (15.0));

ApplicationContainer client3 = echoClient.Install (c.Get (3));
client3.Start (Seconds (8.0));
client3.Stop (Seconds (15.0));

ApplicationContainer client4 = echoClient.Install (c.Get (4));
client4.Start (Seconds (10.0));
client4.Stop (Seconds (15.0));

// Trace routing tables
Ipv4GlobalRoutingHelper g;
Ptr<OutputStreamWrapper> routingStream = Create<OutputStreamWrapper> ("Assignment3.routes", std::ios::out);
g.PrintRoutingTableAllAt (Seconds (12), routingStream);

// make animation for our topology
// From this tutorial of NS-3 https://www.nsnam.org/docs/release/3.13/models/html/animation.html
AnimationInterface anim ("assignment3.xml");

// set positions as in assignment pdf

anim.SetConstantPosition(c.Get(0), 10,20);
anim.SetConstantPosition(c.Get(1), 20,30);
anim.SetConstantPosition(c.Get(2), 20,10);
anim.SetConstantPosition(c.Get(3), 40,30);
anim.SetConstantPosition(c.Get(4), 40,10);
anim.SetConstantPosition(c.Get(5), 50,10);

NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
```

Printing Routing table

Add Animation for topology and set positions for nodes

4. Sample test runs to illustrate the printed routing tables, and the routes taken by transferring packets between nodes

Before Changing Source Code:

```
  1 Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  2   Priority: 0 Protocol: ns3::Ipv4StaticRouting
  3 Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
  4 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
  5 127.0.0.0       0.0.0.0         255.0.0.0       U     0      -        -   0
  6 10.1.1.0        0.0.0.0         255.255.255.0   U     0      -        -   1
  7 10.1.2.0        0.0.0.0         255.255.255.0   U     0      -        -   2
  8
  9   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
 10 Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
 11 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
 12 10.1.1.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 13 10.1.3.1        10.1.1.2        255.255.255.255 UH    -      -        -   1
 14 10.1.4.1        10.1.1.2        255.255.255.255 UH    -      -        -   1
 15 10.1.5.1        10.1.1.2        255.255.255.255 UH    -      -        -   1
 16 10.1.2.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 17 10.1.3.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 18 10.1.6.1        10.1.2.2        255.255.255.255 UH    -      -        -   2
 19 10.1.4.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 20 10.1.7.1        10.1.1.2        255.255.255.255 UH    -      -        -   1
 21 10.1.5.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 22 10.1.5.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 23 10.1.6.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 24 10.1.6.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 25 10.1.7.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 26 10.1.7.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 27 10.1.8.1        10.1.1.2        255.255.255.255 UH    -      -        -   1
 28 10.1.8.1        10.1.2.2        255.255.255.255 UH    -      -        -   2
 29 10.1.8.2        10.1.1.2        255.255.255.255 UH    -      -        -   1
 30 10.1.8.2        10.1.2.2        255.255.255.255 UH    -      -        -   2
 31 10.1.1.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 32 10.1.3.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 33 10.1.4.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 34 10.1.5.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 35 10.1.4.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 36 10.1.7.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 37 10.1.5.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 38 10.1.5.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 39 10.1.6.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 40 10.1.6.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 41 10.1.7.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 42 10.1.7.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 43 10.1.8.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 44 10.1.8.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 45 10.1.8.0        10.1.1.2        255.255.255.0   UG    -      -        -   1
 46 10.1.8.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 47 10.1.2.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 48 10.1.3.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 49 10.1.6.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 50
 51 Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
 52   Priority: 0 Protocol: ns3::Ipv4StaticRouting
 53 Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
```

```
 49 10.1.6.0        10.1.2.2        255.255.255.0   UG    -      -        -   2
 50
 51 Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
 52   Priority: 0 Protocol: ns3::Ipv4StaticRouting
 53 Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
 54 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
 55 127.0.0.0       0.0.0.0         255.0.0.0       U     0      -        -   0
 56 10.1.1.0        0.0.0.0         255.255.255.0   U     0      -        -   1
 57 10.1.3.0        0.0.0.0         255.255.255.0   U     0      -        -   2
 58 10.1.4.0        0.0.0.0         255.255.255.0   U     0      -        -   3
 59 10.1.5.0        0.0.0.0         255.255.255.0   U     0      -        -   4
 60
 61   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
 62 Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
 63 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
 64 10.1.1.1        10.1.1.1        255.255.255.255 UH    -      -        -   1
 65 10.1.2.1        10.1.1.1        255.255.255.255 UH    -      -        -   1
 66 10.1.2.2        10.1.3.2        255.255.255.255 UH    -      -        -   2
 67 10.1.3.2        10.1.3.2        255.255.255.255 UH    -      -        -   2
 68 10.1.6.1        10.1.3.2        255.255.255.255 UH    -      -        -   2
 69 10.1.4.2        10.1.4.2        255.255.255.255 UH    -      -        -   3
 70 10.1.7.1        10.1.4.2        255.255.255.255 UH    -      -        -   3
 71 10.1.5.2        10.1.5.2        255.255.255.255 UH    -      -        -   4
 72 10.1.6.2        10.1.5.2        255.255.255.255 UH    -      -        -   4
 73 10.1.7.2        10.1.5.2        255.255.255.255 UH    -      -        -   4
 74 10.1.8.1        10.1.5.2        255.255.255.255 UH    -      -        -   4
 75 10.1.8.2        10.1.5.2        255.255.255.255 UH    -      -        -   4
 76 10.1.1.0        10.1.1.1        255.255.255.0   UG    -      -        -   1
 77 10.1.2.0        10.1.1.1        255.255.255.0   UG    -      -        -   1
 78 10.1.2.0        10.1.3.2        255.255.255.0   UG    -      -        -   2
 79 10.1.3.0        10.1.3.2        255.255.255.0   UG    -      -        -   2
 80 10.1.6.0        10.1.3.2        255.255.255.0   UG    -      -        -   2
 81 10.1.4.0        10.1.4.2        255.255.255.0   UG    -      -        -   3
 82 10.1.7.0        10.1.4.2        255.255.255.0   UG    -      -        -   3
 83 10.1.5.0        10.1.5.2        255.255.255.0   UG    -      -        -   4
 84 10.1.6.0        10.1.5.2        255.255.255.0   UG    -      -        -   4
 85 10.1.7.0        10.1.5.2        255.255.255.0   UG    -      -        -   4
 86 10.1.8.0        10.1.5.2        255.255.255.0   UG    -      -        -   4
 87 10.1.8.0        10.1.5.2        255.255.255.0   UG    -      -        -   4
 88
 89 Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
 90   Priority: 0 Protocol: ns3::Ipv4StaticRouting
 91 Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
 92 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
 93 127.0.0.0       0.0.0.0         255.0.0.0       U     0      -        -   0
 94 10.1.2.0        0.0.0.0         255.255.255.0   U     0      -        -   1
 95 10.1.3.0        0.0.0.0         255.255.255.0   U     0      -        -   2
 96 10.1.6.0        0.0.0.0         255.255.255.0   U     0      -        -   3
 97
 98   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
 99 Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
100 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
101 10.1.1.1        10.1.2.1        255.255.255.255 UH    -      -        -   1
```

```
103 10.1.1.2        10.1.3.1        255.255.255.255 UH    -      -        -   2
104 10.1.3.1        10.1.3.1        255.255.255.255 UH    -      -        -   2
105 10.1.4.1        10.1.3.1        255.255.255.255 UH    -      -        -   2
106 10.1.5.1        10.1.3.1        255.255.255.255 UH    -      -        -   2
107 10.1.5.2        10.1.6.2        255.255.255.255 UH    -      -        -   3
108 10.1.6.2        10.1.6.2        255.255.255.255 UH    -      -        -   3
109 10.1.7.2        10.1.6.2        255.255.255.255 UH    -      -        -   3
110 10.1.8.1        10.1.6.2        255.255.255.255 UH    -      -        -   3
111 10.1.4.2        10.1.3.1        255.255.255.255 UH    -      -        -   2
112 10.1.4.2        10.1.6.2        255.255.255.255 UH    -      -        -   3
113 10.1.7.1        10.1.3.1        255.255.255.255 UH    -      -        -   2
114 10.1.7.1        10.1.6.2        255.255.255.255 UH    -      -        -   3
115 10.1.8.2        10.1.6.2        255.255.255.255 UH    -      -        -   3
116 10.1.1.0        10.1.2.1        255.255.255.0   UG    -      -        -   1
117 10.1.2.0        10.1.2.1        255.255.255.0   UG    -      -        -   1
118 10.1.1.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
119 10.1.3.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
120 10.1.4.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
121 10.1.5.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
122 10.1.4.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
123 10.1.4.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
124 10.1.7.0        10.1.3.1        255.255.255.0   UG    -      -        -   2
125 10.1.7.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
126 10.1.5.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
127 10.1.6.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
128 10.1.7.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
129 10.1.8.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
130 10.1.8.0        10.1.6.2        255.255.255.0   UG    -      -        -   3
131
132 Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
133   Priority: 0 Protocol: ns3::Ipv4StaticRouting
134 Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
135 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
136 127.0.0.0       0.0.0.0         255.0.0.0       U     0      -        -   0
137 10.1.4.0        0.0.0.0         255.255.255.0   U     0      -        -   1
138 10.1.7.0        0.0.0.0         255.255.255.0   U     0      -        -   2
139
140   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
141 Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
142 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
143 10.1.1.2        10.1.4.1        255.255.255.255 UH    -      -        -   1
144 10.1.3.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
145 10.1.4.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
146 10.1.5.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
147 10.1.5.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
148 10.1.6.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
149 10.1.7.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
150 10.1.8.1        10.1.7.2        255.255.255.255 UH    -      -        -   2
151 10.1.1.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
152 10.1.2.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
153 10.1.2.2        10.1.4.1        255.255.255.255 UH    -      -        -   1
154 10.1.2.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
155 10.1.3.2        10.1.4.1        255.255.255.255 UH    -      -        -   1
```

```
151 10.1.1.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
152 10.1.2.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
153 10.1.2.2        10.1.4.1        255.255.255.255 UH    -      -        -   1
154 10.1.2.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
155 10.1.3.2        10.1.4.1        255.255.255.255 UH    -      -        -   1
156 10.1.3.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
157 10.1.6.1        10.1.4.1        255.255.255.255 UH    -      -        -   1
158 10.1.6.1        10.1.7.2        255.255.255.255 UH    -      -        -   2
159 10.1.8.2        10.1.7.2        255.255.255.255 UH    -      -        -   2
160 10.1.1.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
161 10.1.3.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
162 10.1.4.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
163 10.1.5.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
164 10.1.1.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
165 10.1.2.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
166 10.1.2.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
167 10.1.2.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
168 10.1.3.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
169 10.1.3.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
170 10.1.6.0        10.1.4.1        255.255.255.0   UG    -      -        -   1
171 10.1.6.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
172 10.1.5.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
173 10.1.6.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
174 10.1.7.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
175 10.1.8.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
176 10.1.8.0        10.1.7.2        255.255.255.0   UG    -      -        -   2
177
178 Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
179   Priority: 0 Protocol: ns3::Ipv4StaticRouting
180 Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
181 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
182 127.0.0.0       0.0.0.0         255.0.0.0       U     0      -        -   0
183 10.1.5.0        0.0.0.0         255.255.255.0   U     0      -        -   1
184 10.1.6.0        0.0.0.0         255.255.255.0   U     0      -        -   2
185 10.1.7.0        0.0.0.0         255.255.255.0   U     0      -        -   3
186 10.1.8.0        0.0.0.0         255.255.255.0   U     0      -        -   4
187
188   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
189 Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
190 Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
191 10.1.1.2        10.1.5.1        255.255.255.255 UH    -      -        -   1
192 10.1.3.1        10.1.5.1        255.255.255.255 UH    -      -        -   1
193 10.1.4.1        10.1.5.1        255.255.255.255 UH    -      -        -   1
194 10.1.5.1        10.1.5.1        255.255.255.255 UH    -      -        -   1
195 10.1.2.2        10.1.6.1        255.255.255.255 UH    -      -        -   2
196 10.1.3.2        10.1.6.1        255.255.255.255 UH    -      -        -   2
197 10.1.6.1        10.1.6.1        255.255.255.255 UH    -      -        -   2
198 10.1.4.2        10.1.7.1        255.255.255.255 UH    -      -        -   3
199 10.1.7.1        10.1.7.1        255.255.255.255 UH    -      -        -   3
200 10.1.8.2        10.1.8.2        255.255.255.255 UH    -      -        -   4
201 10.1.1.1        10.1.5.1        255.255.255.255 UH    -      -        -   1
202 10.1.1.1        10.1.6.1        255.255.255.255 UH    -      -        -   2
203 10.1.2.1        10.1.5.1        255.255.255.255 UH    -      -        -   1
```

```
203 10.1.2.1      10.1.5.1      255.255.255.255 UH   -    -    -  1
204 10.1.2.1      10.1.6.1      255.255.255.255 UH   -    -    -  2
205 10.1.1.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
206 10.1.3.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
207 10.1.4.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
208 10.1.5.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
209 10.1.1.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
210 10.1.1.0      10.1.6.1      255.255.255.0   UG   -    -    -  2
211 10.1.2.0      10.1.5.1      255.255.255.0   UG   -    -    -  1
212 10.1.2.0      10.1.6.1      255.255.255.0   UG   -    -    -  2
213 10.1.2.0      10.1.6.1      255.255.255.0   UG   -    -    -  2
214 10.1.3.0      10.1.6.1      255.255.255.0   UG   -    -    -  2
215 10.1.6.0      10.1.6.1      255.255.255.0   UG   -    -    -  2
216 10.1.4.0      10.1.7.1      255.255.255.0   UG   -    -    -  3
217 10.1.7.0      10.1.7.1      255.255.255.0   UG   -    -    -  3
218 10.1.8.0      10.1.8.2      255.255.255.0   UG   -    -    -  4
219
220 Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
221   Priority: 0 Protocol: ns3::Ipv4StaticRouting
222 Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
223 Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
224 127.0.0.0     0.0.0.0       255.0.0.0       U    0     -     -  0
225 10.1.8.0      0.0.0.0       255.255.255.0   U    0     -     -  1
226
227   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
228 Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
229 Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
230 0.0.0.0       10.1.8.1      0.0.0.0         UG   -     -     -  1
231
```

After Changing Source Code

```
Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
127.0.0.0     0.0.0.0       255.0.0.0       U    0     -     -  0
10.1.1.0      0.0.0.0       255.255.255.0   U    0     -     -  1
10.1.2.0      0.0.0.0       255.255.255.0   U    0     -     -  2

  Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 0, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
10.1.1.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.3.1      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.4.1      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.5.1      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.2.2      10.1.2.2      255.255.255.255 UH   -    -    -  2
10.1.3.2      10.1.2.2      255.255.255.255 UH   -    -    -  2
10.1.6.1      10.1.2.2      255.255.255.255 UH   -    -    -  2
10.1.4.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.7.1      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.5.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.6.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.7.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.8.1      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.8.2      10.1.1.2      255.255.255.255 UH   -    -    -  1
10.1.1.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.3.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.4.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.5.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.4.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.7.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.5.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.6.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.7.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.8.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.8.0      10.1.1.2      255.255.255.0   UG   -    -    -  1
10.1.2.0      10.1.2.2      255.255.255.0   UG   -    -    -  2
```

```
10.1.3.0      10.1.2.2      255.255.255.0   UG   -    -    -  2
10.1.6.0      10.1.2.2      255.255.255.0   UG   -    -    -  2

Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
127.0.0.0     0.0.0.0       255.0.0.0       U    0     -     -  0
10.1.1.0      0.0.0.0       255.255.255.0   U    0     -     -  1
10.1.3.0      0.0.0.0       255.255.255.0   U    0     -     -  2
10.1.4.0      0.0.0.0       255.255.255.0   U    0     -     -  3
10.1.5.0      0.0.0.0       255.255.255.0   U    0     -     -  4

  Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 1, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination   Gateway       Genmask         Flags Metric Ref   Use Iface
10.1.1.1      10.1.1.1      255.255.255.255 UH   -    -    -  1
10.1.2.1      10.1.1.1      255.255.255.255 UH   -    -    -  1
10.1.2.2      10.1.3.2      255.255.255.255 UH   -    -    -  2
10.1.3.2      10.1.3.2      255.255.255.255 UH   -    -    -  2
10.1.6.1      10.1.3.2      255.255.255.255 UH   -    -    -  2
10.1.4.2      10.1.4.2      255.255.255.255 UH   -    -    -  3
10.1.7.1      10.1.4.2      255.255.255.255 UH   -    -    -  3
10.1.5.2      10.1.5.2      255.255.255.255 UH   -    -    -  4
10.1.6.2      10.1.5.2      255.255.255.255 UH   -    -    -  4
10.1.7.2      10.1.5.2      255.255.255.255 UH   -    -    -  4
10.1.8.1      10.1.5.2      255.255.255.255 UH   -    -    -  4
10.1.8.2      10.1.5.2      255.255.255.255 UH   -    -    -  4
10.1.1.0      10.1.1.1      255.255.255.0   UG   -    -    -  1
10.1.2.0      10.1.1.1      255.255.255.0   UG   -    -    -  1
10.1.2.0      10.1.3.2      255.255.255.0   UG   -    -    -  2
10.1.3.0      10.1.3.2      255.255.255.0   UG   -    -    -  2
10.1.6.0      10.1.3.2      255.255.255.0   UG   -    -    -  2
10.1.4.0      10.1.4.2      255.255.255.0   UG   -    -    -  3
10.1.7.0      10.1.4.2      255.255.255.0   UG   -    -    -  3
10.1.5.0      10.1.5.2      255.255.255.0   UG   -    -    -  4
10.1.6.0      10.1.5.2      255.255.255.0   UG   -    -    -  4
```

```
10.1.7.0        10.1.5.2        255.255.255.0   UG  -  -  -  4
10.1.8.0        10.1.5.2        255.255.255.0   UG  -  -  -  4
10.1.8.0        10.1.5.2        255.255.255.0   UG  -  -  -  4

Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
127.0.0.0       0.0.0.0         255.0.0.0       U   0   -   -  0
10.1.2.0        0.0.0.0         255.255.255.0   U   0   -   -  1
10.1.3.0        0.0.0.0         255.255.255.0   U   0   -   -  2
10.1.6.0        0.0.0.0         255.255.255.0   U   0   -   -  3

   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 2, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
10.1.1.1        10.1.2.1        255.255.255.255 UH  -  -  -  1
10.1.2.1        10.1.2.1        255.255.255.255 UH  -  -  -  1
10.1.1.2        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.3.1        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.4.1        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.5.1        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.5.2        10.1.6.2        255.255.255.255 UH  -  -  -  3
10.1.6.2        10.1.6.2        255.255.255.255 UH  -  -  -  3
10.1.7.2        10.1.6.2        255.255.255.255 UH  -  -  -  3
10.1.8.1        10.1.6.2        255.255.255.255 UH  -  -  -  3
10.1.4.2        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.7.1        10.1.3.1        255.255.255.255 UH  -  -  -  2
10.1.1.0        10.1.2.1        255.255.255.0   UG  -  -  -  1
10.1.2.0        10.1.2.1        255.255.255.0   UG  -  -  -  1
10.1.1.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.3.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.4.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.5.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.4.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.7.0        10.1.3.1        255.255.255.0   UG  -  -  -  2
10.1.5.0        10.1.6.2        255.255.255.0   UG  -  -  -  3


10.1.5.0        10.1.7.2        255.255.255.0   UG  -  -  -  2
10.1.6.0        10.1.7.2        255.255.255.0   UG  -  -  -  2
10.1.7.0        10.1.7.2        255.255.255.0   UG  -  -  -  2
10.1.8.0        10.1.7.2        255.255.255.0   UG  -  -  -  2

Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
127.0.0.0       0.0.0.0         255.0.0.0       U   0   -   -  0
10.1.5.0        0.0.0.0         255.255.255.0   U   0   -   -  1
10.1.6.0        0.0.0.0         255.255.255.0   U   0   -   -  2
10.1.7.0        0.0.0.0         255.255.255.0   U   0   -   -  3
10.1.8.0        0.0.0.0         255.255.255.0   U   0   -   -  4

   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 4, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
10.1.1.2        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.3.1        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.4.1        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.5.1        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.2.2        10.1.6.1        255.255.255.255 UH  -  -  -  2
10.1.3.2        10.1.6.1        255.255.255.255 UH  -  -  -  2
10.1.6.1        10.1.6.1        255.255.255.255 UH  -  -  -  2
10.1.4.2        10.1.7.1        255.255.255.255 UH  -  -  -  3
10.1.7.1        10.1.7.1        255.255.255.255 UH  -  -  -  3
10.1.8.2        10.1.8.2        255.255.255.255 UH  -  -  -  4
10.1.1.1        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.2.1        10.1.5.1        255.255.255.255 UH  -  -  -  1
10.1.1.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.3.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.4.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.5.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.1.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.2.0        10.1.5.1        255.255.255.0   UG  -  -  -  1
10.1.2.0        10.1.6.1        255.255.255.0   UG  -  -  -  2
```

```
10.1.6.0        10.1.6.2        255.255.255.0   UG  -  -  -  3
10.1.7.0        10.1.6.2        255.255.255.0   UG  -  -  -  3
10.1.8.0        10.1.6.2        255.255.255.0   UG  -  -  -  3

Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
127.0.0.0       0.0.0.0         255.0.0.0       U   0   -   -  0
10.1.4.0        0.0.0.0         255.255.255.0   U   0   -   -  1
10.1.7.0        0.0.0.0         255.255.255.0   U   0   -   -  2

   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 3, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
10.1.1.2        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.3.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.4.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.5.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.5.2        10.1.7.2        255.255.255.255 UH  -  -  -  2
10.1.6.2        10.1.7.2        255.255.255.255 UH  -  -  -  2
10.1.7.2        10.1.7.2        255.255.255.255 UH  -  -  -  2
10.1.8.1        10.1.7.2        255.255.255.255 UH  -  -  -  2
10.1.1.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.2.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.2.2        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.3.2        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.6.1        10.1.4.1        255.255.255.255 UH  -  -  -  1
10.1.1.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.3.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.4.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.5.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.1.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.2.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.2.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.3.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
10.1.6.0        10.1.4.1        255.255.255.0   UG  -  -  -  1
```

```
10.1.3.0        10.1.6.1        255.255.255.0   UG  -  -  -  2
10.1.6.0        10.1.6.1        255.255.255.0   UG  -  -  -  2
10.1.4.0        10.1.7.1        255.255.255.0   UG  -  -  -  3
10.1.7.0        10.1.7.1        255.255.255.0   UG  -  -  -  3
10.1.8.0        10.1.8.2        255.255.255.0   UG  -  -  -  4

Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4StaticRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
127.0.0.0       0.0.0.0         255.0.0.0       U   0   -   -  0
10.1.8.0        0.0.0.0         255.255.255.0   U   0   -   -  1

   Priority: -10 Protocol: ns3::Ipv4GlobalRouting
Node: 5, Time: +12.0s, Local time: +12.0s, Ipv4GlobalRouting table
Destination     Gateway         Genmask         Flags Metric Ref     Use Iface
0.0.0.0         10.1.8.1        0.0.0.0         UG  -  -  -  1
```

Run

ns-3.31$ ./waf --run scratch/assignment3
netanim-3.108$ ./NetAnim
choose Assignment3.xml