



Faculty of Engineering, Alexandria University
Computer and Systems Engineering Department
Networks: Fall 2018

Assignment 2
Implementing a Reliable Data Transport Protocol

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Contribution to code:

- System.cc

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/global-route-manager.h"
#include "ns3/ipv4-global-routing-helper.h"
#include "ns3/netanim-module.h"

#include <iostream>
#include <vector>

#define DATA_RATE "1Mbps"
#define PROPAGATION_DELAY "1ms"
#define DEVICE_NUMBER 6

using namespace ns3;
using namespace std;

#define CONNECTION_NUMBER 8
static const int connections[][2] = {
    {0, 1}, {0, 2}, {1, 2}, {1, 3}, {1, 4}, {2, 4}, {3, 4}, {4, 5}
};
/*
#define CONNECTION_NUMBER 6
static const int connections[][2] = {
    {0, 1}, {0, 4}, {1, 2}, {2, 3}, {3, 5}, {4, 5}
};
*/
NS_LOG_COMPONENT_DEFINE ("Our topology");
```

```
NetDeviceContainer makeP2Pconnection(int i, int j, Ptr<Node>[]);

int main (int argc, char *argv[]) {
    CommandLine cmd;
    cmd.Parse (argc, argv);

    Time::SetResolution (Time::NS);
    LogComponentEnable("UdpEchoClientApplication", LOG_LEVEL_INFO);
    LogComponentEnable("UdpEchoServerApplication", LOG_LEVEL_INFO);
    //LogComponentEnable("GlobalRouteManagerImpl", LOG_LEVEL_LOGIC);
    // Construct basic topology.
    NodeContainer nodes;
    Ptr<Node> nodesP[DEVICE_NUMBER];
    vector<Ipv4Address> nodesIP[DEVICE_NUMBER];
    vector<uint32_t> nodesInter[DEVICE_NUMBER];
    nodes.Create (DEVICE_NUMBER);
    for (uint32_t i = 0; i < nodes.GetN(); i++) {
        nodesP[i] = nodes.Get(i);
        nodesIP[i] = vector<Ipv4Address>();
        nodesInter[i] = vector<uint32_t>();
    }

    vector<NetDeviceContainer> devices;

    cout << "-----" << endl;
    for (uint32_t i = 0; i < CONNECTION_NUMBER; i++) {
        NetDeviceContainer device = makeP2Pconnection(connections[i][0], connections[i][1], nodesP);
        devices.push_back(device);
        nodesP[connections[i][0]]->AddDevice(device.Get(0));
        nodesP[connections[i][1]]->AddDevice(device.Get(1));
    }
}
```

```

cout << "-----" << endl;

// Construct Network Layer.
InternetStackHelper stack;
stack.Install (nodes);
Ipv4AddressHelper address;
Ipv4InterfaceContainer interfaces;
for (uint32_t in = 0; in < devices.size(); in++) {
    string net_domain = string("10.1." + to_string(in + 1) + ".0");
    address.SetBase (net_domain.c_str(), "255.255.255.0");
    int i = devices[in].Get(0)->GetNode()->GetId();
    int j = devices[in].Get(1)->GetNode()->GetId();
    cout << net_domain << " assigned to Point-to-point connection between " << i << " and " << j << endl;
    Ipv4InterfaceContainer interface = address.Assign(devices[in]);
    interfaces.Add(interface);
    nodesIP[i].push_back(interface.GetAddress(0));
    nodesIP[j].push_back(interface.GetAddress(1));
    nodesInter[i].push_back(interface.Get(0).second);
    nodesInter[j].push_back(interface.Get(1).second);
}
cout << "-----" << endl;
cout << "Devices and IP's" << endl;
for (uint32_t i = 0; i < nodes.GetN(); i++) {
    cout << "\tNode " << i << " : " << endl;
    for (uint32_t j = 0; (j) < nodesIP[i].size(); j++) {
        cout << "\t\tInterface " << nodesInter[i][j] << " : " << nodesIP[i][j] << endl;
    }
}
cout << "-----" << endl;

```

```

for (uint32_t i = 0; i < nodes.GetN(); i++) {
    Ptr<GlobalRouter> rtr =
        nodesP[i]->GetObject<GlobalRouter> ();
    cout << "Node " << i << " has router ip of " << rtr->GetRouterId () << endl;
}
cout << "-----" << endl;

// Establish Routes and print them.
cout << "SPF trees : " << endl;
Ipv4GlobalRoutingHelper::PopulateRoutingTables ();
OutputStreamWrapper wrapper = OutputStreamWrapper(&std::cout);
Ipv4GlobalRoutingHelper::PrintRoutingTableAllAt(Time(), &wrapper, Time::NS);

// Application layer to test topology.
UdpEchoServerHelper echoServer (9);

ApplicationContainer serverApps = echoServer.Install (nodes.Get (5));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));

UdpEchoClientHelper echoClient (interfaces.GetAddress (interfaces.GetN() - 1), 9);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));

```

```

clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));

// Animation to see in gui our system.
AnimationInterface anim ("system.xml");
anim.SetConstantPosition (nodes.Get(0), 0.0, 10.0);
anim.SetConstantPosition (nodes.Get(1), 20.0, 20.0);
anim.SetConstantPosition (nodes.Get(2), 20.0, 0.0);
anim.SetConstantPosition (nodes.Get(3), 30.0, 20.0);
anim.SetConstantPosition (nodes.Get(4), 30.0, 0.0);
anim.SetConstantPosition (nodes.Get(5), 40.0, 0.0);
cout << "-----" << endl;
Simulator::Run ();
Simulator::Destroy ();
return 0;
}

NetDeviceContainer makeP2Pconnection(int i, int j, Ptr<Node> ptrs[]) {
    NodeContainer e = NodeContainer();
    e.Add(ptrs[i]);
    e.Add(ptrs[j]);
    cout << "Point-to-point established between nodes " << i << " and " << j << endl;
    PointToPointHelper pointToPoint;
    pointToPoint.SetDeviceAttribute ("DataRate", StringValue (DATA_RATE));
    pointToPoint.SetChannelAttribute ("Delay", StringValue (PROPAGATION_DELAY));
    return pointToPoint.Install(e);
}

```

- global-route-manager-impl.cc

```

*/
SPFVertex* cw;
cw = candidate.Find (w_lsa->GetLinkStateId ());
if (cw->GetDistanceFromRoot () <= distance)
{
    //
    // This is not a shorter path, so don't do anything.
    //
    continue;
}
else if (cw->GetDistanceFromRoot () == distance)
{
    //

```

We won't do anything if distance is equal to the optimal distance so there will be only one route which is shortest (modify condition to ignore equal cost paths, which while is allowed by ospf(multiple path equal cost), is the thing that can minimize routes saved in database).

Sample test

- Printed routing tables

```
Node: 0, Time: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 0, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table
Destination      Gateway          Genmask          Flags Metric Ref    Use Iface
10.1.1.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.1.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.3.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.3.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.4.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.4.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.5.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.5.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.2.2         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.2.2         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.3.2         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.3.2         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.6.1         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.6.1         10.1.2.2        255.255.255.255  UH       -      -    -    2
10.1.4.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.4.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.7.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.7.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.5.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.5.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.6.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.6.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.7.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.7.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.8.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.8.1         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.8.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.8.2         10.1.1.2        255.255.255.255  UH       -      -    -    1
10.1.1.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.1.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.3.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.3.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
```

```
10.1.4.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.4.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.5.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.5.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.4.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.4.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.7.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.7.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.5.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.5.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.6.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.6.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.7.0         10.1.1.2        255.255.255.0     UG       -      -    -    1
10.1.7.0         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
10.1.8.0         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
10.1.2.0         10.1.2.2        255.255.255.0     UG       -      -    -    2
10.1.3.0         10.1.2.2        255.255.255.0     UG       -      -    -    2
10.1.3.0         10.1.2.2        255.255.255.0     UG       -      -    -    2
10.1.6.0         10.1.2.2        255.255.255.0     UG       -      -    -    2
10.1.6.0         10.1.2.2        255.255.255.0     UG       -      -    -    2
```



```

Node: 1, Time: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 1, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table
Destination      Gateway      Genmask      Flags Metric Ref    Use Iface
10.1.1.1         10.1.1.1     255.255.255.255 UH     -      -    -    1
10.1.1.1         10.1.1.1     255.255.255.255 UH     -      -    -    1
10.1.2.1         10.1.1.1     255.255.255.255 UH     -      -    -    1
10.1.2.1         10.1.1.1     255.255.255.255 UH     -      -    -    1
10.1.2.2         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.2.2         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.3.2         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.3.2         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.6.1         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.6.1         10.1.3.2     255.255.255.255 UH     -      -    -    2
10.1.4.2         10.1.4.2     255.255.255.255 UH     -      -    -    3
10.1.4.2         10.1.4.2     255.255.255.255 UH     -      -    -    3
10.1.7.1         10.1.4.2     255.255.255.255 UH     -      -    -    3
10.1.7.1         10.1.4.2     255.255.255.255 UH     -      -    -    3
10.1.5.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.5.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.6.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.6.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.7.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.7.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.8.1         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.8.1         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.8.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.8.2         10.1.5.2     255.255.255.255 UH     -      -    -    4
10.1.1.0         10.1.1.1     255.255.255.0    UG     -      -    -    1
10.1.1.0         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         10.1.1.1     255.255.255.0    UG     -      -    -    1
10.1.2.0         10.1.3.2     255.255.255.0    UG     -      -    -    2
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
10.1.3.0         10.1.3.2     255.255.255.0    UG     -      -    -    2
10.1.6.0         10.1.3.2     255.255.255.0    UG     -      -    -    2
10.1.6.0         10.1.3.2     255.255.255.0    UG     -      -    -    2
10.1.4.0         10.1.4.2     255.255.255.0    UG     -      -    -    3
10.1.4.0         10.1.4.2     255.255.255.0    UG     -      -    -    3
10.1.7.0         10.1.4.2     255.255.255.0    UG     -      -    -    3
10.1.7.0         10.1.4.2     255.255.255.0    UG     -      -    -    3
10.1.5.0         10.1.5.2     255.255.255.0    UG     -      -    -    4
10.1.5.0         10.1.5.2     255.255.255.0    UG     -      -    -    4
10.1.6.0         10.1.5.2     255.255.255.0    UG     -      -    -    4
10.1.6.0         10.1.5.2     255.255.255.0    UG     -      -    -    4
10.1.7.0         10.1.5.2     255.255.255.0    UG     -      -    -    4
10.1.7.0         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
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: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 2, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table
Destination      Gateway      Genmask      Flags Metric Ref    Use Iface
10.1.1.1         10.1.2.1     255.255.255.255 UH       -      -    -    1
10.1.1.1         10.1.2.1     255.255.255.255 UH       -      -    -    1
10.1.2.1         10.1.2.1     255.255.255.255 UH       -      -    -    1
10.1.2.1         10.1.2.1     255.255.255.255 UH       -      -    -    1
10.1.1.2         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.1.2         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.3.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.3.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.4.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.4.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.5.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.5.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.5.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.5.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.6.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.6.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.7.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.7.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.8.1         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.8.1         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.4.2         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.4.2         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.7.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.7.1         10.1.3.1     255.255.255.255 UH       -      -    -    2
10.1.8.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.8.2         10.1.6.2     255.255.255.255 UH       -      -    -    3
10.1.1.0         10.1.2.1     255.255.255.0   UG       -      -    -    1
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
10.1.2.0         10.1.2.1     255.255.255.0   UG       -      -    -    1
10.1.1.0         10.1.3.1     255.255.255.0   UG       -      -    -    2

```

```

10.1.1.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.3.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.3.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.4.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.4.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.5.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.5.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.4.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.4.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.7.0         10.1.3.1     255.255.255.0   UG       -      -    -    2
10.1.7.0         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         10.1.6.2     255.255.255.0   UG       -      -    -    3
10.1.6.0         10.1.6.2     255.255.255.0   UG       -      -    -    3
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
10.1.7.0         10.1.6.2     255.255.255.0   UG       -      -    -    3
10.1.8.0         10.1.6.2     255.255.255.0   UG       -      -    -    3
10.1.8.0         10.1.6.2     255.255.255.0   UG       -      -    -    3
10.1.8.0         10.1.6.2     255.255.255.0   UG       -      -    -    3
10.1.8.0         10.1.6.2     255.255.255.0   UG       -      -    -    3

```

Node: 3, Time: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table								
Priority: 0 Protocol: ns3::Ipv4StaticRouting								
Node: 3, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table								
Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface	
10.1.1.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.1.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.3.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.3.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.4.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.4.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.5.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.5.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.5.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.5.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.6.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.6.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.7.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.7.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.8.1	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.8.1	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.1.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.1.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.2.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.2.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.2.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.2.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.3.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.3.2	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.6.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.6.1	10.1.4.1	255.255.255.255	UH	-	-	-	1	
10.1.8.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.8.2	10.1.7.2	255.255.255.255	UH	-	-	-	2	
10.1.1.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.1.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.3.0	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	
10.1.4.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.5.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.5.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.1.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.1.0	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	
10.1.2.0	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	
10.1.3.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.6.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.6.0	10.1.4.1	255.255.255.0	UG	-	-	-	1	
10.1.5.0	10.1.7.2	255.255.255.0	UG	-	-	-	2	
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	
10.1.6.0	10.1.7.2	255.255.255.0	UG	-	-	-	2	
10.1.7.0	10.1.7.2	255.255.255.0	UG	-	-	-	2	
10.1.7.0	10.1.7.2	255.255.255.0	UG	-	-	-	2	
10.1.8.0	10.1.7.2	255.255.255.0	UG	-	-	-	2	
10.1.8.0	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: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table
  Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 4, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table
Destination      Gateway      Genmask      Flags Metric Ref    Use Iface
10.1.1.2         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.1.2         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.3.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.3.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.4.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.4.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.5.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.5.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.2.2         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.2.2         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.3.2         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.3.2         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.6.1         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.6.1         10.1.6.1     255.255.255.255 UH       -      -     -    2
10.1.4.2         10.1.7.1     255.255.255.255 UH       -      -     -    3
10.1.4.2         10.1.7.1     255.255.255.255 UH       -      -     -    3
10.1.7.1         10.1.7.1     255.255.255.255 UH       -      -     -    3
10.1.7.1         10.1.7.1     255.255.255.255 UH       -      -     -    3
10.1.8.2         10.1.8.2     255.255.255.255 UH       -      -     -    4
10.1.8.2         10.1.8.2     255.255.255.255 UH       -      -     -    4
10.1.1.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.1.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.2.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.2.1         10.1.5.1     255.255.255.255 UH       -      -     -    1
10.1.1.0         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.1.0         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.3.0         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.3.0         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.4.0         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.4.0         10.1.5.1     255.255.255.0   UG       -      -     -    1

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10.1.5.0         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
10.1.1.0         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         10.1.5.1     255.255.255.0   UG       -      -     -    1
10.1.2.0         10.1.6.1     255.255.255.0   UG       -      -     -    2
10.1.2.0         10.1.6.1     255.255.255.0   UG       -      -     -    2
10.1.3.0         10.1.6.1     255.255.255.0   UG       -      -     -    2
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
10.1.6.0         10.1.6.1     255.255.255.0   UG       -      -     -    2
10.1.4.0         10.1.7.1     255.255.255.0   UG       -      -     -    3
10.1.4.0         10.1.7.1     255.255.255.0   UG       -      -     -    3
10.1.7.0         10.1.7.1     255.255.255.0   UG       -      -     -    3
10.1.7.0         10.1.7.1     255.255.255.0   UG       -      -     -    3
10.1.8.0         10.1.8.2     255.255.255.0   UG       -      -     -    4
10.1.8.0         10.1.8.2     255.255.255.0   UG       -      -     -    4

```

```

Node: 5, Time: +0.0ns, Local time: +0.0ns, Ipv4ListRouting table
Priority: 0 Protocol: ns3::Ipv4StaticRouting
Node: 5, Time: +0.0ns, Local time: +0.0ns, 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: +0.0ns, Local time: +0.0ns, Ipv4GlobalRouting table
Destination      Gateway          Genmask          Flags Metric Ref      Use Iface
10.1.5.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.5.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.6.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.6.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.7.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.7.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.8.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.8.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.1.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.1.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.3.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.3.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.4.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.4.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.5.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.5.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.2.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.2.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.3.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.3.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.3.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.6.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.6.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.4.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.4.2         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.7.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.7.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.1.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.1.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.2.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.2.1         10.1.8.1        255.255.255.255 UH     -      -      -    1
10.1.5.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.5.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.6.0         10.1.8.1        255.255.255.0   UG     -      -      -    1

```

```

10.1.6.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.7.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.7.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.8.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.8.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.1.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.1.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.3.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.3.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.4.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.4.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.5.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.5.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.1.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.1.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.2.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.2.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.2.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.2.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.3.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.3.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.6.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.6.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.4.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.4.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.7.0         10.1.8.1        255.255.255.0   UG     -      -      -    1
10.1.7.0         10.1.8.1        255.255.255.0   UG     -      -      -    1

```

- Routes taken when transferring packets

```
-----  
Node 0 has router ip of 0.0.0.0  
Node 1 has router ip of 0.0.0.1  
Node 2 has router ip of 0.0.0.2  
Node 3 has router ip of 0.0.0.3  
Node 4 has router ip of 0.0.0.4  
Node 5 has router ip of 0.0.0.5  
-----
```

```
-----  
Point-to-point established between nodes 0 and 1  
Point-to-point established between nodes 0 and 2  
Point-to-point established between nodes 1 and 2  
Point-to-point established between nodes 1 and 3  
Point-to-point established between nodes 1 and 4  
Point-to-point established between nodes 2 and 4  
Point-to-point established between nodes 3 and 4  
Point-to-point established between nodes 4 and 5  
-----
```

```
10.1.1.0 assigned to Point-to-point connection between 0 and 1  
10.1.2.0 assigned to Point-to-point connection between 0 and 2  
10.1.3.0 assigned to Point-to-point connection between 1 and 2  
10.1.4.0 assigned to Point-to-point connection between 1 and 3  
10.1.5.0 assigned to Point-to-point connection between 1 and 4  
10.1.6.0 assigned to Point-to-point connection between 2 and 4  
10.1.7.0 assigned to Point-to-point connection between 3 and 4  
10.1.8.0 assigned to Point-to-point connection between 4 and 5  
-----
```

Devices and IP's

```
Node 0 :  
    Interface 1 : 10.1.1.1  
    Interface 2 : 10.1.2.1  
Node 1 :  
    Interface 1 : 10.1.1.2  
    Interface 2 : 10.1.3.1  
    Interface 3 : 10.1.4.1  
    Interface 4 : 10.1.5.1  
Node 2 :  
    Interface 1 : 10.1.2.2  
    Interface 2 : 10.1.3.2  
    Interface 3 : 10.1.6.1  
Node 3 :  
    Interface 1 : 10.1.4.2  
    Interface 2 : 10.1.7.1  
Node 4 :  
    Interface 1 : 10.1.5.2  
    Interface 2 : 10.1.6.2  
    Interface 3 : 10.1.7.2  
    Interface 4 : 10.1.8.1  
Node 5 :  
    Interface 1 : 10.1.8.2  
-----
```



```

node 2 has received up to 100000
-----
SPF trees :
-----
Root at 0.0.0.0
0.0.0.0 --> 0.0.0.1 --> 0.0.0.3
0.0.0.0 --> 0.0.0.1 --> 0.0.0.4 --> 0.0.0.5
0.0.0.0 --> 0.0.0.2
-----
Root at 0.0.0.1
0.0.0.1 --> 0.0.0.0
0.0.0.1 --> 0.0.0.2
0.0.0.1 --> 0.0.0.3
0.0.0.1 --> 0.0.0.4 --> 0.0.0.5
-----
Root at 0.0.0.2
0.0.0.2 --> 0.0.0.0
0.0.0.2 --> 0.0.0.1 --> 0.0.0.3
0.0.0.2 --> 0.0.0.4 --> 0.0.0.5
-----
Root at 0.0.0.3
0.0.0.3 --> 0.0.0.1 --> 0.0.0.0
0.0.0.3 --> 0.0.0.1 --> 0.0.0.2
0.0.0.3 --> 0.0.0.4 --> 0.0.0.5
-----
Root at 0.0.0.4
0.0.0.4 --> 0.0.0.1 --> 0.0.0.0
0.0.0.4 --> 0.0.0.2
0.0.0.4 --> 0.0.0.3
0.0.0.4 --> 0.0.0.5
-----
Root at 0.0.0.5
0.0.0.5 --> 0.0.0.4 --> 0.0.0.1 --> 0.0.0.0
0.0.0.5 --> 0.0.0.4 --> 0.0.0.2
0.0.0.5 --> 0.0.0.4 --> 0.0.0.3
-----

```

```

At time 2s client sent 1024 bytes to 10.1.8.2 port 9
At time 2.0283s server received 1024 bytes from 10.1.1.1 port 49153
At time 2.0283s server sent 1024 bytes to 10.1.1.1 port 49153
At time 2.05659s client received 1024 bytes from 10.1.8.2 port 9

```


Netanim :

