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**Computer Networks Lab Manual**

**(Course Code:** **B22EF0506)**

**3rd Year—5thSem**

Batch 2023-2027

**SCHOOL OF COMPUTER SCIENCE & ENGINEERING**

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| I. **Lab DESCRIPTION** |

This laboratory course supplements the material taught in the theory course Computer Networks. The objective of this lab is to get hands-on experience in Computer Networks concept using simulation tools Viz. NS3, NetAnim, Wireshark, Packet Tracer and Nmap. Laboratory exercises will normally be conducted on UNIX Operating system. The students will be exposed to simulating and analyzing concepts.

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| **II. LAB OBJECTIVES** |

The objectives of this lab course are to make students to:

* Understand Computer Network Concepts.
* Install simulation tools like NS3,NetAnim,Wireshark,Packet Tracer and Nmap
* Analyze the Network performance concepts and Traffic flow analysis for wired and wireless protocols.
* Build virtual LAN’s using NS3 and Packet Tracer.

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| **III. LAB OUTCOMES** |

On successful completion of this course; the student will be able to:

CO1: Describe the knowledge of the basic protocols involved in wired/wireless communication process.

CO2: Identify the key issues for the realization of errors detection and correction in Packets.

CO3: Analyse different network performance concepts and traffic issues for Quality of Service (QoS) in communication.

CO4: Implement concepts of classical computer and network security paradigms for Real world Applications.

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| **IV. LAB REQUIREMENTS** |

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| Followingarethe requiredhardwareandsoftwareforthislab, which is availableinthelaboratory.   * **Hardware:** Desktop system or Virtualmachine in a cloud with OS installed.Presently in the Lab, i3Process or having 4GBRAM and 250GB HardDisk is available.Desktop systems are dual boot having Windows as well as LinuxOS installed on them. * **Software:** NS3 compiler with other tools viz. NS3, NetAnim, Wireshark, Packet Tracer and Nmap. | | |
| **Program 1** | | |
| **1** | **Problem Statement** | |
| Introduction to: (a) discrete event simulation, (b) NS3, (c) NS 3 Installation, (d) NetAnim. | | |
| **2** | **Student Learning Outcomes** | |
| After successful completion of this lab, the student shall be able to   * Understand the meaning of dicrete event simulatior like NS3 * Gain knowledge to install the ns3 software in Ubuntu. * Understand NetAnim and its installation. | | |
| **(a)** | **Introduction to dicrete event simulation** | |
| System: A collection of entities that act and interact together toward the accomplishment of some logical end.Discrete system: State variables change instantaneously at separated point in time, e.g., a bank, since state variables - number of customers, change only when a customer arrives or when a customer finishes being served and departsContinuous system: State variable change continuously with respect to time, e.g., airplane moving through the air, since state variables - position and velocity change continuously with respect to timeWhy Simulation?Many systems are highly complex, precluding the possibility of analytical solutionThe analytical solutions are extraordinarily complex, requiring vast computing resourcesThus, such systems should be studied by means of simulationNumerically exercising the model for inputs in question to see how they affect the output measures of performance“Simulationis the process of designinga model of a real system and conductingexperimentswith this model for the purpose eitherof understandingthe behavior of the system or of evaluatingvarious strategies (within the limits imposed by a criterion or set of criteria) for theoperationof a system.”What is Discrete-Event Simulation (DES)?A discrete-event simulationmodels a system whose state may change only at discrete pointmodels a system whose state may change only at discrete pointin time.System:is composed of objects called entities that have certain properties called attributes.State:a collection of attributes or state variables that represent theentities of the system.Event:an instantaneous occurrence in time that may alter the state ofthe system | | |
| **(b)** | **Introduction to ns3** | |
| ns-3 is a discrete-event network simulator, targeted primarily for research and educational use. ns-3 is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use.  The goal of the ns-3 project is to develop a preferred, open simulation environment for networking research: it should be aligned with the simulation needs of modern networking research and should encourage community contribution, peer review, and validation of the software. | | |
| **(c)** | **ns3 installation** | |
| Download the ns3 package (ns-allinone-3.28 or any other version) from https://www.nsnam.org and follow following steps:  $cd Desktop  $cd ns-allinone-3.28  $./build.py --enable-examples --enable-test  $cd ns-3.28  $./waf --build-profile=debug --enable-examples --enable-test configure  once all the configuration is done NS-3 is inastallation is completed.  To ckeck whether NS-3 is successfully installed verify with this:  $./waf --run hello-simulator  U will see the output as hello-simulator | | |
| **(d)** | | **NetAnim Installation** |
| $ Sudo apt install qt4-default qt4-make  $ cd NetAnim  $ qmake NetAnim.pro  $ make  Execution of NetAnim  $ Cd to NetAnim from ns3.28...  $ ./NetAnim | | |

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| **Program 2** | | | | | | | |
| **1** | **Problem Statement** | | | | | | |
| Write a NS3 program to connect two nodes with a point to pint link, which have unique interface. Analyze the network performance using UDP client server. | | | | | | | |
| **2** | | **Student Learning Outcomes** | | | | | |
| After successful completion of this lab, the student’s shall be able to   * Understand to establish point to point network. * Create an interface to point to point link * Anylize the Network performance usibg client server | | | | | | | |
| **3** | | **Design of the Program** | | | | | |
| **3.1** | | **Theory** | | | | | |
| **Point to Point Network**  http://www.highteck.net/images/167-Datalink-point-to-point.jpg  Fig:Point to Point Network  This type of network consists of many connections between individual pairs of machines. To go from the source to the destination, a packet of information on this type of network may have to first visit one or more intermediate machines. Often multiple routes, of different length are possible, so routing algorithms play an important role in point-to-point networks.  **Network performance**    Network Performance refers to measures of [service quality](https://en.wikipedia.org/wiki/Service_quality) of a network  **UDP: User Datagram Protocol**  The User Datagram Protocol (UDP) is the simpler of the two standard TCP/IP transport protocols. It is a process-to-process protocol that adds only port addresses, checksum error control, and length information to the data from the upper layer. | | | | | | | |
| **3.2** | | | **Coding using C++ Language** | | | | |
| #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/netanim-module.h"  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("FirstScriptExample");  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);  NodeContainer nodes;  nodes.Create (2);  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  NetDeviceContainer devices;  devices = pointToPoint.Install (nodes);  InternetStackHelper stack;  stack.Install (nodes);  Ipv4AddressHelper address;  address.SetBase ("10.1.1.0", "255.255.255.0");  Ipv4InterfaceContainer interfaces = address.Assign (devices);  UdpEchoServerHelper echoServer (9);  ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));  serverApps.Start (Seconds (1.0));  serverApps.Stop (Seconds (10.0));  UdpEchoClientHelper echoClient (interfaces.GetAddress (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));  AnimationInterface anim ("first.xml");  anim.SetConstantPosition(nodes.Get (0), 10.0, 10.0);  anim.SetConstantPosition(nodes.Get (1), 20.0, 30.0);  Simulator::Run ();  Simulator::Destroy ();  return 0;  } | | | | | | | |
| **3.3** | | | | | | | **Expected Results** |
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| **Program 3** | | | | | | | | |
| **1** | | | **Problem Statement** | | | | | |
| Write a NS 3 program to demonstrate bus topology. Analyze the performance using UDP based applications. | | | | | | | | |
| **2** | | | | **Student Learning Outcomes** | | | | |
| After successful completion of this lab, the student will able to   * Create Bus Topology * Analyze the performance using UDP based applications. | | | | | | | | |
| **3** | | | | **Design of the Program** | | | | |
| **3.1** | | | | **Theory** | | | | |
| **Bus Topology**  https://upload.wikimedia.org/wikipedia/commons/thumb/4/47/BusNetwork.svg/800px-BusNetwork.svg.png  A **bus network** is a [network topology](https://en.wikipedia.org/wiki/Network_topology) in which [nodes](https://en.wikipedia.org/wiki/Node_(networking)) are directly connected to a common [half-duplex](https://en.wikipedia.org/wiki/Half-duplex) link called a [bus](https://en.wikipedia.org/wiki/Bus_(computing))  A [host](https://en.wikipedia.org/wiki/Host_(network)) on a bus network is called a station. In a bus network, every station will receive all network traffic, and the traffic generated by each station has equal transmission priority.[[3]](https://en.wikipedia.org/wiki/Bus_network#cite_note-3) A bus network forms a single [network segment](https://en.wikipedia.org/wiki/Network_segment) and [collision domain](https://en.wikipedia.org/wiki/Collision_domain). In order for nodes to share the bus, they use a [medium access control](https://en.wikipedia.org/wiki/Medium_access_control) technology such as [carrier-sense multiple access](https://en.wikipedia.org/wiki/Carrier-sense_multiple_access) (CSMA) or a [bus master](https://en.wikipedia.org/wiki/Bus_master).  **etwork performance**    Network Performance refers to measures of [service quality](https://en.wikipedia.org/wiki/Service_quality) of a network  **UDP: User Datagram Protocol**  The User Datagram Protocol (UDP) is the simpler of the two standard TCP/IP transport protocols. It is a process-to-process protocol that adds only port addresses, checksum error control, and length information to the data from the upper layer. | | | | | | | | |
| **3.2** | | | | | **Coding using C++ Language** | | | |
| #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"  #include "ns3/ipv4-global-routing-helper.h"  #include "ns3/netanim-module.h"  // Default Network Topology  //  // 10.1.1.0  // n0 -------------- n1 n2 n3 n4  // point-to-point | | | |  // ================  // LAN 10.2.1.0-csma  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("SecondScriptExample");  int  main (int argc, char \*argv[])  {  LogComponentEnable ("UdpEchoClientApplication", LOG\_LEVEL\_INFO);  LogComponentEnable ("UdpEchoServerApplication", LOG\_LEVEL\_INFO);  NodeContainer p2pNodes;  p2pNodes.Create (2);  NodeContainer csmaNodes;  csmaNodes.Add (p2pNodes.Get (1));  csmaNodes.Create (3);  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  NetDeviceContainer p2pDevices;  p2pDevices = pointToPoint.Install (p2pNodes);  CsmaHelper csma;  csma.SetChannelAttribute ("DataRate", StringValue ("100Mbps"));  csma.SetChannelAttribute ("Delay", TimeValue (NanoSeconds (6560)));    NetDeviceContainer csmaDevices;  csmaDevices = csma.Install (csmaNodes);  InternetStackHelper stack;  stack.Install (p2pNodes.Get(0));  stack.Install (csmaNodes);  Ipv4AddressHelper address;  address.SetBase ("10.1.1.0", "255.255.255.0");  Ipv4InterfaceContainer p2pInterfaces;  p2pInterfaces = address.Assign (p2pDevices);  address.SetBase ("10.2.1.0", "255.255.255.0");  Ipv4InterfaceContainer csmaInterfaces;  csmaInterfaces = address.Assign (csmaDevices);  UdpEchoServerHelper echoServer (9);  ApplicationContainer serverApps = echoServer.Install (csmaNodes.Get (3));  serverApps.Start (Seconds (1.0));  serverApps.Stop (Seconds (10.0));  UdpEchoClientHelper echoClient (csmaInterfaces.GetAddress (3), 9);  echoClient.SetAttribute ("MaxPackets", UintegerValue (1));  echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));  echoClient.SetAttribute ("PacketSize", UintegerValue (1024));  ApplicationContainer clientApps = echoClient.Install (p2pNodes.Get (0));  clientApps.Start (Seconds (2.0));  clientApps.Stop (Seconds (10.0));  Ipv4GlobalRoutingHelper::PopulateRoutingTables ();  pointToPoint.EnablePcapAll ("p2p");  csma.EnablePcapAll("csma");    AnimationInterface anim("p3.xml");  anim.SetConstantPosition(p2pNodes.Get(0),10.0,10.0);  anim.SetConstantPosition(csmaNodes.Get(0),20.0,20.0);  anim.SetConstantPosition(csmaNodes.Get(1),30.0,30.0);  anim.SetConstantPosition(csmaNodes.Get(2),40.0,40.0);  anim.SetConstantPosition(csmaNodes.Get(3),50.0,50.0);  Simulator::Run ();  Simulator::Destroy ();  return 0;  } | | | | | | | | |
| **3.3** | | | | | | **Expected Results** | | |
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| **Program.4** | | |
| **1** | **Problem Statement** | |
| Write a NS 3 program to demonstrate star topology. Analyze the performance using UDP based applications. | | |
| **2** | **Student Learning Outcomes** | |
| After successful completion of this lab, the student will able to   * Create Star Topology * Analyze the performance using UDP based applications | | |
| **3** | | **Design of the Program** |
| **3.1** | | **Theory** |
| **Star Topology**  https://upload.wikimedia.org/wikipedia/commons/thumb/d/d0/StarNetwork.svg/800px-StarNetwork.svg.png  A star network is an implementation of a [spoke–hub distribution paradigm](https://en.wikipedia.org/wiki/Spoke%E2%80%93hub_distribution_paradigm) in [computer networks](https://en.wikipedia.org/wiki/Computer_network). In a star network, every [host](https://en.wikipedia.org/wiki/Host_(network)) is connected to a central [hub](https://en.wikipedia.org/wiki/Hub_(network_science)). In its simplest form, one central hub acts as a conduit to transmit messages.[[1]](https://en.wikipedia.org/wiki/Star_network#cite_note-1) The star network is one of the most common [computer network topologies](https://en.wikipedia.org/wiki/Network_topology).  The hub and hosts, and the transmission lines between them, form a [graph](https://en.wikipedia.org/wiki/Graph_(discrete_mathematics)) with the [topology of a star](https://en.wikipedia.org/wiki/Star_(graph_theory)). Data on a star network passes through the hub before continuing to its destination. The hub manages and controls all functions of the network. It also acts as a [repeater](https://en.wikipedia.org/wiki/Repeater) for the data flow.  The star topology reduces the impact of a transmission line failure by independently connecting each host to the hub. Each host may thus communicate with all others by transmitting to, and receiving from, the hub. The failure of a transmission line linking any host to the hub will result in the isolation of that host from all others, but the rest of the network will be unaffected.  **Network performance**    Network Performance refers to measures of [service quality](https://en.wikipedia.org/wiki/Service_quality) of a network  **UDP: User Datagram Protocol**  The User Datagram Protocol (UDP) is the simpler of the two standard TCP/IP transport protocols. It is a process-to-process protocol that adds only port addresses, checksum error control, and length information to the data from the upper layer. | | |
| **3.2** | | **Coding using C++ Language** |
| #include "ns3/core-module.h"  #include "ns3/network-module.h"  #include "ns3/netanim-module.h"  #include "ns3/internet-module.h"  #include "ns3/point-to-point-module.h"  #include "ns3/applications-module.h"  #include "ns3/point-to-point-layout-module.h"  // Network topology (default)  //  // n2 n3 n4 .  // \ | / .  // \|/ .  // n1--- n0---n5 .  // /|\ .  // / | \ .  // n8 n7 n6 .  //  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("Star123");  int  main (int argc, char \*argv[])  {  //  // Set up some default values for the simulation.  //  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (137));  // ??? try and stick 15kb/s into the data rate  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("14kb/s"));  //  // Default number of nodes in the star. Overridable by command line argument.  //  uint32\_t nSpokes = 8;  std::string animFile1 = "star-animation1.xml";  CommandLine cmd;  cmd.AddValue ("nSpokes", "Number of nodes to place in the star", nSpokes);  cmd.AddValue ("animFile1", "File Name for Animation Output", animFile1);  cmd.Parse (argc, argv);  NS\_LOG\_INFO ("Build star topology.");  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  PointToPointStarHelper star (nSpokes, pointToPoint);  NS\_LOG\_INFO ("Install internet stack on all nodes.");  InternetStackHelper internet;  star.InstallStack (internet);  NS\_LOG\_INFO ("Assign IP Addresses.");  star.AssignIpv4Addresses (Ipv4AddressHelper ("10.1.1.0", "255.255.255.0"));  NS\_LOG\_INFO ("Create applications.");  //  // Create a packet sink on the star "hub" to receive packets.  //  uint16\_t port = 50000;  Address hubLocalAddress (InetSocketAddress (Ipv4Address::GetAny (), port));  PacketSinkHelper packetSinkHelper ("ns3::TcpSocketFactory", hubLocalAddress);  ApplicationContainer hubApp = packetSinkHelper.Install (star.GetHub ());  hubApp.Start (Seconds (1.0));  hubApp.Stop (Seconds (10.0));  //  // Create OnOff applications to send TCP to the hub, one on each spoke node.  //  OnOffHelper onOffHelper ("ns3::TcpSocketFactory", Address ());  onOffHelper.SetAttribute ("OnTime", StringValue ("ns3::ConstantRandomVariable[Constant=1]"));  onOffHelper.SetAttribute ("OffTime", StringValue ("ns3::ConstantRandomVariable[Constant=0]"));  ApplicationContainer spokeApps;  for (uint32\_t i = 0; i < star.SpokeCount (); ++i)  {  AddressValue remoteAddress (InetSocketAddress (star.GetHubIpv4Address (i), port));  onOffHelper.SetAttribute ("Remote", remoteAddress);  spokeApps.Add (onOffHelper.Install (star.GetSpokeNode (i)));  }  spokeApps.Start (Seconds (1.0));  spokeApps.Stop (Seconds (10.0));  NS\_LOG\_INFO ("Enable static global routing.");  //  // Turn on global static routing so we can actually be routed across the star.  //  Ipv4GlobalRoutingHelper::PopulateRoutingTables ();  NS\_LOG\_INFO ("Enable pcap tracing.");  //  // Do pcap tracing on all point-to-point devices on all nodes.  //  pointToPoint.EnablePcapAll ("star123");  // Set the bounding box for animation  star.BoundingBox (1, 1, 100, 100);  // Create the animation object and configure for specified output  AnimationInterface anim (animFile1);  NS\_LOG\_INFO ("Run Simulation.");  Simulator::Run ();  Simulator::Destroy ();  NS\_LOG\_INFO ("Done.");  return 0;  } | | |
| **3.3** | | **Expected Results** |
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| **Program 5** | | | | |
| **1** | **Problem Statement** | | | |
| Write a NS3 program to implement FTP using TCP bulk transfer, Analyze the performance | | | | |
| **2** | **Student Learning Outcomes** | | | |
| After successful completion of this lab, the student will able to   * Impliment FTP protocol to analyze the flow of bulk transfer. * Anlyze the performance of Application Protocols. | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory** | |
| **File Transfer Protocol**  The File Transfer Protocol (FTP) is a standard [network protocol](https://en.wikipedia.org/wiki/Network_protocol) used for the transfer of [computer files](https://en.wikipedia.org/wiki/Computer_file) between [a client and server](https://en.wikipedia.org/wiki/Client%E2%80%93server_model) on a [computer network](https://en.wikipedia.org/wiki/Computer_network).  FTP is built on a client-server model architecture using separate control and data connections between the client and the server.[[1]](https://en.wikipedia.org/wiki/File_Transfer_Protocol#cite_note-for-1) FTP users may authenticate themselves with a [clear-text](https://en.wikipedia.org/wiki/Clear_text) sign-in protocol, normally in the form of a username and password, but can connect anonymously if the server is configured to allow it. For secure transmission that protects the username and password, and encrypts the content, FTP is often [secured](https://en.wikipedia.org/wiki/File_Transfer_Protocol#Security) with [SSL/TLS](https://en.wikipedia.org/wiki/Transport_Layer_Security) ([FTPS](https://en.wikipedia.org/wiki/FTPS)) or replaced with [SSH File Transfer Protocol](https://en.wikipedia.org/wiki/SSH_File_Transfer_Protocol) (SFTP)  **TCP Bulk Data Flow**  The sender of a data block required an acknowledgment for that block before the next block was sent. In this chapter we'll see that TCP uses a different form of flow control called a sliding window protocol. It allows the sender to transmit multiple packets before it stops and waits for an acknowledgment. This leads to faster data transfer, since the sender doesn't have to stop and wait for an acknowledgment each time a packet is sent.  **Network performance**    Network Performance refers to measures of [service quality](https://en.wikipedia.org/wiki/Service_quality) of a network | | | | |
| **3.2** | | | **Coding using C++ Language** | |
| // Network topology  //  // n0 ----------- n1  // 500 Kbps  // 5 ms  //  // - Flow from n0 to n1 using BulkSendApplication.  // - Tracing of queues and packet receptions to file "tcp-bulk-send.tr"  // and pcap tracing available when tracing is turned on.  #include <string>  #include <fstream>  #include "ns3/core-module.h"  #include "ns3/point-to-point-module.h"  #include "ns3/internet-module.h"  #include "ns3/applications-module.h"  #include "ns3/network-module.h"  #include "ns3/packet-sink.h"  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("TcpBulkSendExample");  int  main (int argc, char \*argv[])  {  bool tracing = false;  uint32\_t maxBytes = 0;  // Allow the user to override any of the defaults at  // run-time, via command-line arguments  CommandLine cmd;  cmd.AddValue ("tracing", "Flag to enable/disable tracing", tracing);  cmd.AddValue ("maxBytes",  "Total number of bytes for application to send", maxBytes);  cmd.Parse (argc, argv);  // Explicitly create the nodes required by the topology (shown above).  NS\_LOG\_INFO ("Create nodes.");  NodeContainer nodes;  nodes.Create (2);  NS\_LOG\_INFO ("Create channels.");  // Explicitly create the point-to-point link required by the topology (shown above).  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("500Kbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("5ms"));  NetDeviceContainer devices;  devices = pointToPoint.Install (nodes);  // Install the internet stack on the nodes  InternetStackHelper internet;  internet.Install (nodes);  // We've got the "hardware" in place. Now we need to add IP addresses.  NS\_LOG\_INFO ("Assign IP Addresses.");  Ipv4AddressHelper ipv4;  ipv4.SetBase ("10.1.1.0", "255.255.255.0");  Ipv4InterfaceContainer i = ipv4.Assign (devices);  NS\_LOG\_INFO ("Create Applications.");  // Create a BulkSendApplication and install it on node 0  uint16\_t port = 9; // well-known echo port number  BulkSendHelper source ("ns3::TcpSocketFactory",  InetSocketAddress (i.GetAddress (1), port));  // Set the amount of data to send in bytes. Zero is unlimited.  source.SetAttribute ("MaxBytes", UintegerValue (maxBytes));  ApplicationContainer sourceApps = source.Install (nodes.Get (0));  sourceApps.Start (Seconds (0.0));  sourceApps.Stop (Seconds (10.0));  // Create a PacketSinkApplication and install it on node 1  PacketSinkHelper sink ("ns3::TcpSocketFactory",  InetSocketAddress (Ipv4Address::GetAny (), port));  ApplicationContainer sinkApps = sink.Install (nodes.Get (1));  sinkApps.Start (Seconds (0.0));  sinkApps.Stop (Seconds (10.0));  // Set up tracing if enabled  if (tracing)  {  AsciiTraceHelper ascii;  pointToPoint.EnableAsciiAll (ascii.CreateFileStream ("tcp-bulk-send.tr"));  pointToPoint.EnablePcapAll ("tcp-bulk-send", false);  }  // Now, do the actual simulation.  NS\_LOG\_INFO ("Run Simulation.");  Simulator::Stop (Seconds (10.0));  Simulator::Run ();  Simulator::Destroy ();  NS\_LOG\_INFO ("Done.");  Ptr<PacketSink> sink1 = DynamicCast<PacketSink> (sinkApps.Get (0));  std::cout << "Total Bytes Received: " << sink1->GetTotalRx () << std::endl; | | | | |
| **3.3** | | | **Expected Results** | |
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| **Program 6** | | | | |
| **1** | | **Problem Statement** | | |
| Write a NS3 program to connect two nodes with a point to point link, which have unique interface. Analyse the traffic control using TCP by changing suitable parameters. | | | | |
| **2** | | **Student Learning Outcomes** | | |
| After successful completion of this lab, the student will able to   * Create Point to point link with unique interface * Analyze the flow of traffic control of Application Protocols. | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory** | |
| **Network Traffic Control**  In [computer networking](https://en.wikipedia.org/wiki/Computer_networking), network traffic control is the process of managing, controlling or reducing the network traffic, particularly Internet [bandwidth](https://en.wikipedia.org/wiki/Bandwidth_(computing)), e.g. by the [network scheduler](https://en.wikipedia.org/wiki/Network_scheduler).[[1]](https://en.wikipedia.org/wiki/Network_traffic_control#cite_note-architecture-1) It is used by network administrators, to reduce [congestion](https://en.wikipedia.org/wiki/Network_congestion), [latency](https://en.wikipedia.org/wiki/Lag) and [packet loss](https://en.wikipedia.org/wiki/Packet_loss). This is part of [bandwidth management](https://en.wikipedia.org/wiki/Bandwidth_management). In order to use these tools effectively, it is necessary to [measure the network traffic](https://en.wikipedia.org/wiki/Network_traffic_measurement) to determine the causes of network congestion and attack those problems specifically.  Network traffic control is an important subject in [datacenters](https://en.wikipedia.org/wiki/Data_center) as it is necessary for efficient use of [datacenter network](https://en.wikipedia.org/wiki/Data_center_network_architectures) bandwidth and for maintaining service level agreements  **TCP: Transmission Control Protocol**  The Transmission Control Protocol (TCP) provides full transport-layer services to applications.TCP is a reliable stream transport protocol. The term stream, in this context, means connection- oriented: A connection must be established between both ends of a transmission before either can transmit data.  At the sending end of each transmission, TCP divides a stream of data into smaller units called segments. Each segment includes a sequence number for reordering after receipt, together with an acknowledgment number for the segments received. Segments are carried across the internet inside of IP datagrams. At the receiving end, TCP collects each datagram as it comes in and reorders the transmission based on sequence numbers | | | | |
| **3.2** | | | **Coding using C++ Language** | |
| #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/netanim-module.h"  //step1: add the following header files  #include "ns3/flow-monitor.h"  #include "ns3/flow-monitor-helper.h"  #include "ns3/traffic-control-module.h"  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("FirstScriptExample");  int  main (int argc, char \*argv[])  {    //step2: declare the variable tracing  bool tracing = false;  CommandLine cmd;  cmd.Parse (argc, argv);    Time::SetResolution (Time::NS);  LogComponentEnable ("UdpEchoClientApplication", LOG\_LEVEL\_INFO);  LogComponentEnable ("UdpEchoServerApplication", LOG\_LEVEL\_INFO);  NodeContainer nodes;  nodes.Create (2);  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  NetDeviceContainer devices;  devices = pointToPoint.Install (nodes);  InternetStackHelper stack;  stack.Install (nodes);  Ipv4AddressHelper address;  address.SetBase ("10.1.1.0", "255.255.255.0");  Ipv4InterfaceContainer interfaces = address.Assign (devices);  UdpEchoServerHelper echoServer (9);  ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));  serverApps.Start (Seconds (1.0));  serverApps.Stop (Seconds (10.0));  UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 9);  echoClient.SetAttribute ("MaxPackets", UintegerValue (6));  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));  //step3: add the following code for Flow monitor  Ptr<FlowMonitor> flowMonitor;  FlowMonitorHelper flowHelper;  flowMonitor = flowHelper.InstallAll();  Simulator::Stop(Seconds(10.0));  if (tracing==true)  {    pointToPoint.EnablePcapAll ("p2p");  }  Simulator::Run ();  //step 4: add the following statement for xml file  flowMonitor->SerializeToXmlFile("newprg6.xml", true, true);  Simulator::Destroy ();  return 0; | | | | |
| **3.3** | | | **Expected Results** | |
| **Steps for Exexution:**  run the program: ./waf --run scratch/newprg6 to genetrate xml file.  check the xml file  copy the file "flowmon-parse-results.py" from src/flow monitor/examples to /ns-3.27 folder  use the following command to read the xml file  python flowmon-parse-results.py newprg6.xml | | | | |
| **Program 7** | | | | |
| **1** | | **Problem Statement** | | |
| Write NS 3 Program to configure two nodes on an 802.11b physical layer, with802.11b NICs in adhoc mode, and by default, sends one packet of 1000 (application) bytes to the other node. The physical layer is configured to receive at a fixed RSS (regardless of the distance and transmit power); therefore, changing position of the nodes has no effect. Analyze the performance. | | | | |
| **2** | | **Student Learning Outcomes** | | |
| After successful completion of this lab, the student will able to   * Implement the wireless Technology in Adhoc mode. * Anayze the performace by changing the position of nodes. | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory** | |
| **802.11ax Wi-Fi**  The next-generation 802.11ax Wi-Fi standard, also known as Wi-Fi 6, is the latest step in a journey of nonstop innovation. The standard builds on the strengths of 802.11ac, adding efficiency, flexibility, and scalability that allows new and existing networks increased speed and capacity with next-generation applications.  The Institute of Electrical and Electronics Engineers (IEEE) proposed the 802.11ax standard so that it can couple the freedom and high speed of Gigabit Ethernet wireless with the reliability and predictability found in licensed radio | | | | |
| **3.2** | | | **Coding using C++ Language** | |
| #include "ns3/core-module.h"  #include "ns3/point-to-point-module.h"  #include "ns3/network-module.h"  #include "ns3/applications-module.h"  #include "ns3/wifi-module.h"  #include "ns3/mobility-module.h"  #include "ns3/csma-module.h"  #include "ns3/internet-module.h"  #include "ns3/netanim-module.h"  // Default Network Topology  //  // Wifi 10.1.3.0  // AP  // \* \* \* \*  // | | | | 10.1.1.0  // n5 n6 n7 n0 -------------- n1 n2 n3 n4--10.1.2.4  // point-to-point | | | |  // ================  // LAN 10.1.2.0  using namespace ns3;  NS\_LOG\_COMPONENT\_DEFINE ("ThirdScriptExample");  int  main (int argc, char \*argv[])  {    LogComponentEnable ("UdpEchoClientApplication", LOG\_LEVEL\_INFO);  LogComponentEnable ("UdpEchoServerApplication", LOG\_LEVEL\_INFO);  NodeContainer p2pNodes;  p2pNodes.Create (2);  PointToPointHelper pointToPoint;  pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));  pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));  NetDeviceContainer p2pDevices;  p2pDevices = pointToPoint.Install (p2pNodes);  NodeContainer csmaNodes;  csmaNodes.Add (p2pNodes.Get (1));  csmaNodes.Create (3);  CsmaHelper csma;  csma.SetChannelAttribute ("DataRate", StringValue ("100Mbps"));  csma.SetChannelAttribute ("Delay", TimeValue (NanoSeconds (6560)));  NetDeviceContainer csmaDevices;  csmaDevices = csma.Install (csmaNodes);  NodeContainer wifiStaNodes;  wifiStaNodes.Create (3);  NodeContainer wifiApNode = p2pNodes.Get (0);  YansWifiChannelHelper channel = YansWifiChannelHelper::Default ();  YansWifiPhyHelper phy = YansWifiPhyHelper::Default ();  phy.SetChannel (channel.Create ());  WifiHelper wifi;  wifi.SetRemoteStationManager ("ns3::AarfWifiManager");    WifiMacHelper mac;  Ssid ssid = Ssid ("ns-3-ssid");  mac.SetType ("ns3::StaWifiMac",  "Ssid", SsidValue (ssid),  "ActiveProbing", BooleanValue (false));  NetDeviceContainer staDevices;  staDevices = wifi.Install (phy, mac, wifiStaNodes);  mac.SetType ("ns3::ApWifiMac",  "Ssid", SsidValue (ssid));  NetDeviceContainer apDevices;  apDevices = wifi.Install (phy, mac, wifiApNode);  MobilityHelper mobility;  mobility.SetPositionAllocator ("ns3::GridPositionAllocator",  "MinX", DoubleValue (0.0),  "MinY", DoubleValue (0.0),  "DeltaX", DoubleValue (5.0),  "DeltaY", DoubleValue (10.0),  "GridWidth", UintegerValue (3),  "LayoutType", StringValue ("RowFirst"));  mobility.SetMobilityModel ("ns3::RandomWalk2dMobilityModel",  "Bounds", RectangleValue (Rectangle (-50, 50, -50, 50)));  mobility.Install (wifiStaNodes);  mobility.SetMobilityModel ("ns3::ConstantPositionMobilityModel");  mobility.Install (wifiApNode);  InternetStackHelper stack;  stack.Install (csmaNodes);  stack.Install (wifiApNode);  stack.Install (wifiStaNodes);  Ipv4AddressHelper address;  address.SetBase ("10.1.1.0", "255.255.255.0");  Ipv4InterfaceContainer p2pInterfaces;  p2pInterfaces = address.Assign (p2pDevices);  address.SetBase ("10.1.2.0", "255.255.255.0");  Ipv4InterfaceContainer csmaInterfaces;  csmaInterfaces = address.Assign (csmaDevices);  address.SetBase ("10.1.3.0", "255.255.255.0");  address.Assign (staDevices);  address.Assign (apDevices);  UdpEchoServerHelper echoServer (9);  ApplicationContainer serverApps = echoServer.Install (csmaNodes.Get (3));  serverApps.Start (Seconds (1.0));  serverApps.Stop (Seconds (10.0));  UdpEchoClientHelper echoClient (csmaInterfaces.GetAddress (3), 9);  echoClient.SetAttribute ("MaxPackets", UintegerValue (1));  echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));  echoClient.SetAttribute ("PacketSize", UintegerValue (1024));  ApplicationContainer clientApps = echoClient.Install (wifiStaNodes.Get (2));  clientApps.Start (Seconds (2.0));  clientApps.Stop (Seconds (10.0));  Ipv4GlobalRoutingHelper::PopulateRoutingTables ();  pointToPoint.EnablePcapAll ("p2p7");  csma.EnablePcapAll("csma");  phy.EnablePcapAll("wifi");      AnimationInterface anim("wifi7.xml");  anim.SetConstantPosition(p2pNodes.Get(0),10.0,10.0);  anim.SetConstantPosition(csmaNodes.Get(0),20.0,20.0);  anim.SetConstantPosition(csmaNodes.Get(1),30.0,30.0);  anim.SetConstantPosition(csmaNodes.Get(2),40.0,40.0);  anim.SetConstantPosition(csmaNodes.Get(3),50.0,50.0);    Simulator::Stop(Seconds (10.0));  Simulator::Run ();  Simulator::Destroy ();  return 0;  } | | | | |
| **3.3** | | | **Expected Results** | |
|  | | | | |
| **Program 8** | | | | |
| **1** | | **Problem Statement** | | |
| Install wireshark, and analyze the packets using it on a selected interface. Apply filters and check the packets. | | | | |
| **2** | | **Student Learning Outcomes** | | |
| After successful completion of this lab, the student shall be able to   * Install the wireshark tool for packet analysis * Apply the filters and anlysze the packet parameters. | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory** | |
| **Wireshark**  Wireshark is a [free](https://en.wikipedia.org/wiki/Free_software) and [open-source](https://en.wikipedia.org/wiki/Open-source_software) [packet analyzer](https://en.wikipedia.org/wiki/Packet_analyzer). It is used for [network](https://en.wikipedia.org/wiki/Computer_network) troubleshooting, analysis, software and [communications protocol](https://en.wikipedia.org/wiki/Communications_protocol) development, and education. Originally named Ethereal, the project was renamed Wireshark in May 2006 due to trademark issues.[[4]](https://en.wikipedia.org/wiki/Wireshark#cite_note-4)  Wireshark is [cross-platform](https://en.wikipedia.org/wiki/Cross-platform), using the [Qt](https://en.wikipedia.org/wiki/Qt_(software)) [widget toolkit](https://en.wikipedia.org/wiki/Widget_toolkit) in current releases to implement its user interface, and using [pcap](https://en.wikipedia.org/wiki/Pcap) to capture packets; it runs on [Linux](https://en.wikipedia.org/wiki/Linux), [macOS](https://en.wikipedia.org/wiki/MacOS), [BSD](https://en.wikipedia.org/wiki/BSD), [Solaris](https://en.wikipedia.org/wiki/Solaris_(operating_system)), some other [Unix-like](https://en.wikipedia.org/wiki/Unix-like) operating systems, and [Microsoft Windows](https://en.wikipedia.org/wiki/Microsoft_Windows). There is also a terminal-based (non-GUI) version called TShark. Wireshark, and the other programs distributed with it such as TShark, are [free software](https://en.wikipedia.org/wiki/Free_software), released under the terms of the [GNU General Public License](https://en.wikipedia.org/wiki/GNU_General_Public_License).  **Packet**  A network packet is a formatted unit of [data](http://en.wikipedia.org/wiki/Data) carried by a [packet-switched network](http://en.wikipedia.org/wiki/Packet-switched_network). Computer communications links that do not support packets, such as traditional [point-to-point telecommunications links](http://en.wikipedia.org/wiki/Point-to-point_link), simply transmit data as a [bit stream](http://en.wikipedia.org/wiki/Bit_stream). When data is formatted into packets, the [bandwidth](http://en.wikipedia.org/wiki/Bandwidth_(computing)) of the communication medium can be better shared among users than if the network were [circuit switched](http://en.wikipedia.org/wiki/Circuit_switching).  A packet consists of two kinds of data: control information and user data (also known as [payload](http://en.wikipedia.org/wiki/Payload_(computing))). The control information provides data the network needs to deliver the user data, for example: source and destination [network addresses](http://en.wikipedia.org/wiki/Network_address), [error detection](http://en.wikipedia.org/wiki/Error_detection) codes, and sequencing information. Typically, control information is found in packet [headers](http://en.wikipedia.org/wiki/Header_(computing)) and [trailers](http://en.wikipedia.org/wiki/Trailer_(computing)), with payload data in between. | | | | |
| **3.2** | | | **Intallation steps** | |
| **Installation of Wireshark**  $ sudo apt install wireshark  **Opening wireshark**  $sudo wireshark    Filteration can be applied for a pcap (Packet capturing) file for our code output.  Also, live streaming can be analysed by applying suitable filter  In the output, filtering of UDP packets is recorded for that particular session  Enter the filter in the text area and click enter | | | | |
| **3.3** | | | **Expected Results** | |
|  | | | | |
| **Program 9** | | | | |
| **1** | | **Problem Statement** | | |
| Install packet tracer, and consider a topology and configure VLAN | | | | |
| **2** | | **Student Learning Outcomes** | | |
| After successful completion of this lab, the student shall be able to   * Install the Packet tracer * Create and Configure a simple Virtual Local Area Network(VLAN) | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory**  **Packet Tracer**  Packet Tracer is a [cross-platform](https://en.wikipedia.org/wiki/Cross-platform) visual [simulation](https://en.wikipedia.org/wiki/Simulation) tool designed by [Cisco Systems](https://en.wikipedia.org/wiki/Cisco_Systems) that allows users to create [network topologies](https://en.wikipedia.org/wiki/Network_topologies) and imitate modern [computer networks](https://en.wikipedia.org/wiki/Computer_networks). The software allows users to simulate the configuration of Cisco routers and switches using a simulated command line interface. Packet Tracer makes use of a [drag and drop](https://en.wikipedia.org/wiki/Drag_and_drop) user interface, allowing users to add and remove simulated network devices as they see fit. The software is mainly focused towards Certified Cisco Network Associate Academy students as an educational tool for helping them learn fundamental CCNA concepts  **VLAN**  A Virtual LAN (**VLAN)** is simply a logical LAN, just as its name suggests. VLANs have similar characteristics with those of  physical LANs, only  that  with VLANs, you can logically group  hosts even if they are physically  located on separate LAN segments.  We treat each VLAN as a separate subnet or broadcast domain. For this reason, to move packets from one VLAN to another, we have to use a router or a layer 3 switch.  VLANs are configured on switches by placing some interfaces into one broadcast domain and some interfaces into another. | |
|  | | | | |
| **3.2** | | | **Coding using C++ Language** | |
| 1. Go to this web link <https://www.netacad.com/courses/packet-tracer> and register to download packet tracer and install 2. Steps to create VLAN   In Cisco Packet Tracer, **create the network topology**with two VLAN viz. VLAN 10 and VLAN 20 as shown below:    **Steps**  Open and choose switch and four computers  Choose the link and join with fast Ethernet  Select now pc1 by double click->desktop->IP address  192.168.10.2 Keeping subnet mask as 192.168.10.1  Select now pc2 by double click->desktop->IP address  192.168.10.3 Keeping subnet mask as 192.168.10.1  Select now pc3 by double click->desktop->IP address  192.168.20.2 Keeping subnet mask as 192.168.20.1  Select now pc4 and double click->desktop->IP address  192.168.20.3 Keeping subnet mask as 192.168.20.1  After this we need to configure the switch  For this double click on switch  Choose the tab CLI  Type the following command to configure and name of VLAN  $en  $config  $vlan 10  $name Farooque  $exit  $en  $config  $vlan 20  $name Yerri  $exit  After this you can type show vlan  Once done, now your task is to map this to the PC from VLAN 10 and VLAN 20  $en  $interface f0/1 (check it while building the network)  $switchport access vlan 10  $exit  $interface f0/2 (check it while building the network)  $switchport access vlan 10  $exit  $interface f0/3 (check it while building the network)  $switchport access vlan 20  $exit  $interface f0/4 (check it while building the network)  $switchport access vlan 20  $exit  $exit  Then finally simulate topology | | | | |
| **3.3** | | | **Expected Results** | |
|  | | | | |
| **Program 10** | | | | |
| **1** | | **Problem Statement** | | |
| Install NMAP, and execute atleast 5 commands to demonstrate the scanning of networks hosts and ports. | | | | |
| **2** | | **Student Learning Outcomes** | | |
| After successful completion of this lab, the student shall be able to   * Install Nmap in both Windows and Ubantu Platform. * Demonstrate the scanning of networks hosts and ports using suitable commends. | | | | |
| **3** | | | **Design of the Program** | |
| **3.1** | | | **Theory**  Nmap is a network mapper that has emerged as one of the most popular, free network discovery tools on the market. Nmap is now one of the core tools used by network administrators to map their networks. The program can be used to find live hosts on a network, [perform port scanning](https://www.varonis.com/blog/port-scanning-techniques/), ping sweeps, OS detection, and version detection. | |
| **3.2** | | | | **Installation steps and Commands** |
| $sudo apt install nmap  Commands:  **1. Basic Nmap Scan against IP or host**  nmap www.reva.edu.in  Now, if you want to scan a hostname, simply replace the IP for the host, as you see below:  nmap [www.reva.edu.in](http://www.reva.edu.in)  **2. Scan specific ports or scan entire port ranges on a local or remote server**  nmap -p 1-50www.google.com  In this example, we scanned all 50 ports for [www.google.com](http://www.google.com)  **3. Scan multiple IP addresses**  Let’s try to scan multiple IP addresses. For this you need to use this syntax:  nmap 1.1.1.1 8.8.8.8  You can also scan consecutive IP addresses:  nmap -p 1.1.1.1,2,3,4  This will scan 1.1.1.1, 1.1.1.2, 1.1.1.3 and 1.1.1.4.  **4. Scan the most popular ports**  Using “–top-ports” parameter along with a specific number lets you scan the top X most common ports for that host, as we can see:  nmap --top-ports 5[www.google.com](http://www.google.com)  Replace “5” with the desired number. Output example:  **5. Scan using TCP or UDP protocols**  One of the things we love most about Nmap is the fact that it works for both TCP and UDP protocols. And while most services run on TCP, you can also get a great advantage by scanning UDP-based services. Let’s see some examples.  Standard TCP scanning output:  nmap -sT www.reva.edu.in  nmap -sU 192.168.1.1 | | | | |
| **3.3** | | | | **Expected Results** |
| nmap [www.reva.edu.in](http://www.reva.edu.in)    nmap -p 1-50www.google.com    nmap --top-ports 5[www.google.com](http://www.google.com)    nmap -sT www.reva.edu.in | | | | |

**Viva Questions**

* What is Simulator?
* What is tha difference between Simulator and Emulator?
* What is NetAnim?
* What is the ise of Waf Tool in NS3?
* What is Packet?
* What is a Link?
* What is a Gateway or Router?
* What is Point-Point Link?
* What is topology?
* List the types of Topologies?
* Name the Factors that affect the performance of Network?
* What is ptotocol?
* Name protocols in Application Layer.
* What is TCP congestion control?
* What is Descrete event simulator?
* What is VLAN?
* What is the use of NMAP?
* What is the protocol number for TCP?
* Which protocol gets a hardware address from a known IP address?
* **What Is Wireshark?**
* **How Would You Setup Wireshark To Monitor Packets Passing Through An Internet Router?**
* **Can Wireshark Be Setup On A Cisco Router?**
* **Which Wireshark Filter Can Be Used To Check All Incoming Requests To A Http Web Server?**
* **What Kind Of Shark Is Wireshark?**
* **What Do You Think Of Wireshark?**
* **How To Remove Wireshark Antivirus From My Computer?**
* **How Do I Use Wireshark To Find A Password In My Network?**
* **What Exactly Does Wireshark Do?**
* Name a popular tool used for network analysis in multiprotocol diverse network?
* List port numbers for wired and wireless protocols?

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