Installation of NS-3 and Network Tools in Linux

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1. What is NS-3 and what is its use in networking?

Answer:

 NS-3 (Network Simulator 3) is a discrete-event network simulator primarily used for research and educational purposes. It is used to simulate the behavior of computer networks, enabling users to test and analyze network protocols, routing, and communication patterns without needing physical hardware.

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2. Which Linux packages are necessary to install NS-3?

Answer:

 To install NS-3, the following packages are commonly required:

bash
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```
sudo apt update
sudo apt install gcc g++ python3 cmake qt5-default mercurial git
pkg-config sqlite \
libsqlite3-dev libgtk-3-dev libboost-all-dev libxml2 libxml2-dev \
python3-dev python3-pip
```

---

3. How do you download and build NS-3 in Ubuntu?

Answer:

bash
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```
# Clone NS-3 repository
git clone https://gitlab.com/nsnam/ns-3-dev.git
cd ns-3-dev

# Build the project
./ns3 configure --enable-examples --enable-tests
./ns3 build
```

4. What is NetAnim and how is it useful in NS-3?

Answer:
NetAnim is a visualization tool for NS-3 simulations. It allows users to visualize node movement, packet transmissions, and network topology over time using an animated GUI. It uses `.xml` files generated by NS-3.

5. How to install NetAnim in Ubuntu?

Answer:

```bash
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sudo apt-get install qt5-qmake qtbase5-dev
git clone https://gitlab.com/nsnam/netanim.git
cd netanim
qmake NetAnim.pro
make
./NetAnim
```

6. What is Wireshark? How is it useful in network simulation?

Answer:
Wireshark is a network protocol analyzer that captures and displays packet data in real-time. In NS-3, it helps in analyzing PCAP (packet capture) files generated during simulations.

7. How to install Wireshark on Linux?

Answer:

```bash
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sudo apt install wireshark
```

8. What is PyViz in NS-3?

Answer:

PyViz is a Python-based visualization tool integrated with NS-3. It provides a live GUI view of the simulation, showing packet transmissions and node positions in real time.

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9. How do you enable and run PyViz in NS-3?

Answer:

bash
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```bash
./ns3 configure --enable-examples --enable-tests --with-python
./ns3 build

# Run example with PyViz
./ns3 run "wifi-wired-bridging --viz"
```

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10. What is tcpdump and how is it used in NS-3?

Answer:

tcpdump is a command-line packet analyzer. In NS-3, you can enable packet capture (PCAP) during simulations and use tcpdump to view or analyze them.

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11. How to install and use tcpdump on Linux?

Answer:

bash
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```bash
# Install
sudo apt install tcpdump

# Use with a pcap file
tcpdump -nn -r filename.pcap
```

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12. Where are PCAP files stored in NS-3 simulations?

Answer:
 PCAP files are usually stored in the `ns-3-dev` directory or in the folder where the simulation script is run, typically with `.pcap` extensions.

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13. How to enable PCAP tracing in NS-3?

Answer:
 In your simulation script, add:

```cpp
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pointToPoint.EnablePcapAll("tracefile");
```

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14. What is the difference between NetAnim and PyViz?

Answer:

- **NetAnim** is a post-simulation animation tool (uses XML files).

- **PyViz** provides real-time simulation visualization (integrated with Python).

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15. How do you verify that NS-3 has been installed successfully?

Answer:
 Run a sample simulation:

```bash
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./ns3 run hello-simulator
```

If it compiles and runs without errors, the installation is successful.

Linux Network Commands

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1. What is `ifconfig` and how is it used?

Answer:
`ifconfig` (interface configuration) is used to view and configure network interfaces in Linux.
Example:

bash
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```bash
ifconfig
```

Shows IP address, MAC address, and interface status.

---

2. What is the difference between `ifconfig` and `ip` command?

Answer:
`ifconfig` is deprecated in many modern Linux systems. `ip` is the newer, more powerful replacement.
For example:

bash
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```bash
ip addr show
```

is equivalent to `ifconfig`.

---

3. How do you assign an IP address using the `ip` command?

Answer:

bash
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```bash
sudo ip addr add 192.168.1.100/24 dev eth0
```

This assigns the IP `192.168.1.100` to the `eth0` interface.

---

4. What is the purpose of the `ping` command?

Answer:
`ping` checks network connectivity between the host and another device using ICMP echo requests.
 Example:

bash
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```
ping google.com
```

---

5. What does the `ns` command refer to in Linux?

Answer:
The `ns` command could refer to **network namespaces** (`ip netns`) or might be a typo for `nslookup`.
 If meant as `ip netns`, it is used to manage isolated network environments.
 Example:

bash
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```
ip netns list
```

---

6. What is `netstat` and how is it used?

Answer:
`netstat` displays active connections, listening ports, and routing tables.
 Example:

bash
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```
netstat -tuln
```

Shows TCP/UDP listening ports with numeric output.

7. What replaced `netstat` in modern Linux distributions?

Answer:
The `ss` command is used as a modern alternative to `netstat`.
Example:

bash
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```
ss -tuln
```

8. What is the function of `traceroute`?

Answer:
`traceroute` displays the path taken by packets to reach a destination by showing each hop and its response time.
Example:

bash
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```
traceroute google.com
```

9. How is `nslookup` useful in networking?

Answer:
`nslookup` is used to query DNS servers for domain name resolution.
Example:

bash
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```
nslookup google.com
```

10. What is the use of the `route` command?

Answer:
`route` shows or modifies the IP routing table.
 Example:

bash
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```
route -n
```

Displays the kernel routing table with numeric addresses.

---

11. How do you add a default gateway using the `route` command?

Answer:

bash
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```
sudo route add default gw 192.168.1.1
```

---

12. What does the `hostname` command do?

Answer:
 It displays or sets the system's hostname.
 Example:

bash
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```
hostname
```

Returns the current hostname.

---

13. How can you temporarily change the hostname in Linux?

Answer:

bash
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```
sudo hostname newname
```

(This change lasts only until reboot.)

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14. What does `hostname -I` show?

Answer:
It displays the IP addresses assigned to the system.

---

15. How do you check the DNS server being used by your system?

Answer:
Check the contents of `/etc/resolv.conf`

bash
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```
cat /etc/resolv.conf
```

Program 3: Point-to-Point Topology Simulation

1. What is a point-to-point topology?

A direct link between two nodes with no intermediate device.

2. Which helper class is used to set up point-to-point links in NS-3?

`PointToPointHelper`

3. How do you set the data rate and delay for the point-to-point link?

cpp
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```cpp
pointToPoint.SetDeviceAttribute("DataRate", StringValue("5Mbps"));
pointToPoint.SetChannelAttribute("Delay", StringValue("2ms"));
```

4. What does the `.SetDeviceAttribute()` do?

It sets the transmission characteristics (e.g., data rate).

5. What is the role of `NetDeviceContainer`?

It holds the network devices installed on nodes.

6. How do you assign IP addresses to devices?

Using `Ipv4AddressHelper`

7. What protocol can be used to simulate traffic in point-to-point?

UDP or TCP Echo applications.

8. How do you start applications on nodes?

By using `Start()` and `Stop()` methods on application instances.

9. What is the purpose of `EnablePcapAll()`?

To generate `.pcap` files for packet analysis.

10. How can you visualize the network?

By enabling animation using `AnimationInterface`

11. What is the benefit of simulating a point-to-point network?

It helps understand basic communication between two nodes.

12. What tool is used to analyze `.pcap` files?

Wireshark or `tcpdump`

13. What file format does NetAnim use?

`.xml` animation files

14. How can you view packet transfers live during simulation?

Using `PyViz` with `UseVisualAid = true`

15. Can you simulate link failure in NS-3?

Yes, by stopping the channel or interface programmatically.

🔷 Program 4: Bus Topology Simulation

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1. What is bus topology?

A single communication line (backbone) that connects all devices.

2. Which helper is used in NS-3 to simulate bus topology?

`CsmaHelper`

3. What does `CsmaHelper.SetChannelAttribute()` configure?

The data rate and propagation delay on the shared bus.

4. How is the bus different from point-to-point in NS-3?

All nodes share the same channel instead of dedicated links.

5. How do collisions get handled in CSMA?

Through the Carrier Sense Multiple Access protocol.

6. What are the limits of a bus topology?

One cable failure can break communication for all nodes.

7. How to simulate traffic among nodes in bus topology?

Using UDP/TCP Echo apps or OnOff applications.

8. How to visualize the layout in NetAnim?

Manually set node positions using `anim.SetConstantPosition()`

9. How to enable packet capture on CSMA devices?

`csma.EnablePcap("filename", device)`

10. What is the default data rate of CSMA links in NS-3?

100 Mbps (can be changed)

11. What file shows the network animation?

`bus.xml` or the one given in `AnimationInterface`

12. What happens if one node on the bus is overloaded?

It may delay or disrupt shared communication.

13. Is routing needed in bus topology?

No, because all nodes are on the same link.

14. Which tool shows dropped packets and their reasons?

Wireshark with appropriate filters.

15. How do you check for packet loss?

Analyze `.pcap` files or NS-3 simulation stats.

🔷 Program 5: Star Topology Simulation

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1. What is star topology?

All nodes connect to a central hub (like a switch/router).

2. What is the central node's role in star topology?

It routes traffic between connected devices.

3. Which NS-3 helpers can be used to create star topology?

`PointToPointHelper` or `CsmaHelper` for connecting leaf nodes.

4. Why is star topology more reliable than bus?

Because a single node failure doesn't affect others.

5. How can one simulate the hub device in NS-3?

Use one node and connect all others to it via point-to-point or CSMA.

6. What are the downsides of star topology?

If the hub fails, the entire network is down.

7. How do you animate a star topology in NetAnim?

Place the hub in the center, and other nodes around it.

8. Can the central node act as a router?

Yes, using the InternetStackHelper and routing protocols.

9. How to simulate application layer traffic?

Using `UdpEchoClientHelper` and `UdpEchoServerHelper`.

10. How to analyze captured traffic?

Using `.pcap` files in Wireshark or tcpdump.

11. Which layers can be analyzed in Wireshark?

All layers from Ethernet to TCP/UDP to Application.

12. What is the difference between star and mesh?

Star has a central hub; mesh has every node connected to every other node.

13. Which parameter defines the connection speed?

`DataRate`

14. How is delay configured?

Using `SetChannelAttribute("Delay", TimeValue())`

15. Can you simulate packet drops in star?

Yes, by introducing congestion or buffer overflow.

🔷 Program 6: Mesh Topology Simulation

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1. What is mesh topology?

Each node connects to every other node.

2. What are the benefits of mesh topology?

Redundancy, fault tolerance, and high reliability.

3. Is mesh topology scalable?

It is reliable but not scalable due to the number of links needed.

4. How to simulate it in NS-3?

Use nested loops to connect every node with every other using `PointToPointHelper`.

5. How many connections in full mesh with N nodes?

`N(N-1)/2`

6. How to visualize mesh topology in NetAnim?

Set nodes in grid form using `anim.SetConstantPosition()`.

7. How is traffic routing handled in mesh?

Using routing protocols like static, OLSR, AODV, etc.

8. Can mesh be simulated wirelessly?

Yes, using `WifiHelper` with mesh configurations.

9. How do you manage congestion in mesh?

Monitor queue sizes and optimize routing.

10. How can you trace traffic from one node to another?

Enable `pcap` or use `traceroute` in simulation.

11. What protocol helps in dynamic routing?

AODV or OLSR

12. What is the significance of bandwidth in mesh links?

Higher bandwidth ensures minimal packet loss despite multiple hops.

13. How to analyze mesh performance?

Check throughput, delay, packet delivery ratio in logs/pcap.

14. What are the challenges in large mesh topologies?

Routing overhead, link failure management.

15. How can you simulate node failure in mesh?

Turn off a node during simulation using `Stop(Time)`

🔷 Program 7: Hybrid Topology Simulation

---

1. What is hybrid topology?

A combination of two or more topologies (e.g., star + bus).

2. Why use hybrid topology?

To get the benefits of multiple types (reliability, scalability).

3. How is hybrid topology structured in NS-3?

Build components (star, mesh, bus) separately and connect them.

4. What helpers are used in hybrid topology?

`PointToPointHelper`, `CsmaHelper`, and optionally `WifiHelper`.

5. How to manage routing between subnetworks?

Use static routing or dynamic protocols (e.g., RIP, OSPF).

6. Can NetAnim show multiple topologies together?

Yes, place nodes accordingly with `SetConstantPosition()`.

7. What are real-world examples of hybrid topologies?

Campus networks, corporate LANs with core, distribution, access layers.

8. How do you simulate a backbone in hybrid?

Use high-speed `PointToPoint` links.

9. How to simulate multiple traffic types?

Use TCP and UDP traffic in different segments.

10. Can you simulate wired + wireless in hybrid?

Yes, using `WifiHelper` and `PointToPointHelper`.

11. How to capture traffic across topologies?

Enable PCAP on all required interfaces.

12. What are hybrid topology challenges?

Complex setup and routing configurations.

13. How do you analyze inter-segment communication?

Trace packet flows in `.pcap` and measure delay.

14. What visualization tools are suitable?

NetAnim or PyViz with logical grouping.

15. How can hybrid be optimized in NS-3?

Use efficient protocols, reduce broadcast domains.

Program 8: UDP Client-Server Simulation

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1. What is UDP?

UDP (User Datagram Protocol) is a connectionless transport protocol that provides fast, unreliable communication without handshaking.

2. How does UDP differ from TCP?

UDP is faster but does not guarantee delivery, ordering, or error checking, unlike TCP.

3. Which NS-3 helper is used for UDP client-server?

`UdpEchoServerHelper` and `UdpEchoClientHelper`

4. What parameter defines packet size in UDP client?

```
SetAttribute("MaxPackets", UintegerValue(n));
 SetAttribute("PacketSize", UintegerValue(size));
```

5. How do you set the start and stop time for the application?

Using `clientApp.Start(Seconds(1.0)); clientApp.Stop(Seconds(10.0));`

6. What kind of topology is used for UDP simulation in NS-3?

Usually Point-to-Point or CSMA.

7. Can you capture UDP traffic in NS-3?

Yes, using `EnablePcap()` to generate `.pcap` files.

8. How is the server configured to listen on a port?

Using `UdpEchoServerHelper(port_number);`

9. What is the default port used in your simulation?

Any user-defined port (commonly 9, 8000, etc.)

10. What is the output of a successful UDP simulation?

Packet sent/received messages and `.pcap` files.

11. Can you visualize UDP packet flow?

Yes, using NetAnim or PyViz.

12. How do you analyze if packets are lost in UDP?

Compare sent and received packet count or use Wireshark filters (udp).

13. Can you simulate UDP flooding?

Yes, by increasing packet rate and disabling delay.

14. Is flow control or congestion control available in UDP?

No, UDP does not provide such mechanisms.

15. Where is UDP preferred over TCP?

In real-time applications like VoIP, video streaming, DNS.

🔷 Program 9: DHCP Server and Clients Simulation

---

1. What does DHCP stand for?

Dynamic Host Configuration Protocol.

2. What is the purpose of DHCP?

To assign IP addresses dynamically to clients.

3. Does NS-3 have a built-in DHCP server class?

No, DHCP is not implemented directly in NS-3. It is typically simulated using socket programming or emulated manually.

4. How can DHCP behavior be mimicked in NS-3?

By manually assigning IPs during simulation time or using external modules.

5. What happens during a DHCP lease?

The server assigns an IP for a specific time duration.

6. What are the key DHCP messages?

Discover, Offer, Request, Acknowledgment (DORA process).

7. Can you visualize DHCP activity in NS-3?

Yes, but manually through logs and animations.

8. What is the alternative to DHCP in NS-3 for dynamic IPs?

Use a script to assign IPs or extend NS-3 with socket programming.

9. Which file shows the IP configuration assigned?

The log or console output of assigned IPs.

10. What protocol does DHCP use for communication?

UDP, port 67 (server) and port 68 (client).

11. Can you simulate multiple DHCP clients in NS-3?

Yes, with multiple nodes requesting IPs from a single simulated server.

12. Is DHCP more suitable for static or mobile environments?

Mobile and dynamic environments.

13. What topology is common for DHCP simulation?

Star or bus topology with a central server.

14. Can Wireshark detect DHCP packets in real networks?

Yes, with filter `bootp` or `udp.port==67`.

15. What happens if the DHCP server is down?

Clients cannot obtain IP addresses and will not communicate.

🔷 Program 10: FTP using TCP Simulation

---

1. What is FTP?

FTP (File Transfer Protocol) is used to transfer files over TCP.

2. Which transport layer protocol does FTP use?

TCP.

3. Why does FTP require a reliable connection?

To ensure file integrity during transfer.

4. How is FTP simulated in NS-3?

Using bulk send and packet sink applications to simulate file transfer.

5. What does `BulkSendHelper` do?

It simulates sending a large amount of data (as in FTP).

6. Which helper is used as the receiver?

`PacketSinkHelper`

7. How do you specify the amount of data to send?

Using the attribute `"MaxBytes"`

8. How do you monitor transfer success?

By checking the number of bytes received at the sink.

9. How is TCP reliability simulated in NS-3?

Through retransmissions, congestion control, and ordered delivery.

10. What is the typical topology for FTP simulation?

Point-to-point or star topology.

11. Can you simulate congestion in TCP?

Yes, by limiting bandwidth or increasing data rate.

12. What is the output of FTP simulation in NS-3?

Console logs, `.pcap` files showing TCP segments.

13. How to view TCP packet flow in Wireshark?

Use filter `tcp.port==5001` (or custom port)

14. What are some FTP-specific TCP behaviors?

ACKs, congestion window control, three-way handshake.

15. What causes delay in FTP simulation?

High latency, low bandwidth, or packet loss.

Practical 11: Analyzing Network Protocols using Wireshark

✅ *Task:* Capture packets while browsing any website and analyze protocol headers (HTTP, TCP/IP, DNS, etc.)

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1. What is Wireshark?

Wireshark is a network protocol analyzer used to capture and inspect data packets in real time.

---

2. How do you start capturing packets in Wireshark?

Select the active network interface and click the **shark fin (Start Capture)** button.

---

3. What protocols can be captured with Wireshark?

TCP, UDP, HTTP, DNS, ARP, ICMP, FTP, TLS/SSL, DHCP, etc.

4. What filter can you apply to view only HTTP traffic?

`http`

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5. Which filter shows DNS traffic?

`dns` or `udp.port == 53`

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6. What does the TCP 3-way handshake include?

SYN → SYN-ACK → ACK

---

7. How can you identify a TCP packet in Wireshark?

Look at the protocol column or apply the filter `tcp`.

---

8. What information does the IP header provide?

Source and destination IP, TTL, protocol, version, etc.

---

9. What is the purpose of analyzing headers in Wireshark?

To understand communication flow, diagnose issues, and study protocol behavior.

---

10. How can you inspect a packet's detailed header information?

Click on the packet → Expand the protocol layer in the middle pane.

---

11. What is the difference between TCP and UDP headers?

TCP has sequence number, ACK, flags; UDP is simpler with length and checksum.

---

12. Can Wireshark decrypt HTTPS?

Not unless you provide the session keys; by default HTTPS is encrypted.

---

13. What does TTL in an IP header represent?

Time To Live – limits packet lifetime to avoid infinite looping.

---

14. What tool helps trace a webpage request in Wireshark?

Use `Follow TCP Stream` to view full HTTP conversation.

---

15. How do you save and share a Wireshark capture?

Use **File → Save As**, and share the `.pcap` file.

🔷 Practical 12: Evaluate Network Performance using Metrics

✅ *Task:* **Use any topology to measure throughput, delay, response time, packet loss, dropped packets in NS-3.**

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1. What is network throughput?

The rate of successful data delivery over the network, usually in Mbps or Kbps.

---

2. How is delay defined in networking?

Time taken for a packet to travel from source to destination.

---

3. What is response time?

Time taken between sending a request and receiving a response.

---

4. What is packet loss?

Packets that are sent but never reach their destination.

---

5. How do dropped packets differ from lost packets?

Dropped packets are intentionally discarded (e.g., congestion); loss can be due to errors.

---

6. How can you measure throughput in NS-3?

Use FlowMonitor or manually compute `(bytes received * 8) / time`.

---

7. What NS-3 tool helps evaluate these metrics?

`FlowMonitor` class.

---

8. Can you use Wireshark with NS-3 to evaluate performance?

Yes, by generating `.pcap` files using `EnablePcap()` and analyzing in Wireshark.

---

9. How do you simulate network congestion in NS-3?

By increasing traffic rate or reducing bandwidth.

---

10. Which topology gives best throughput: star, bus, or mesh?

Mesh usually offers more redundancy and potentially better throughput.

---

11. How is average delay calculated in NS-3?

(Receive Time - Send Time) for each packet, averaged over all packets.

---

12. What does FlowMonitor's XML output show?

Per-flow data: delay, jitter, throughput, lost packets, etc.

---

13. How do you identify if a topology is performing poorly?

High delay, high packet loss, low throughput, many dropped packets.

---

14. What causes delay variation (jitter)?

Network congestion, routing changes, and queueing.

---

15. What is the significance of evaluating these metrics?

To optimize network design, detect issues, and ensure QoS.