1. Explain how the tracepath/tracert works in details after researching about it and cite all your sources properly and fully. No copy-paste please. Paraphrasing is OK as well as some limited quoting.

1. Traceroute makes use of a field in IP packet headers that wasn't really designed for path or route tracing.
2. Each IP packet must have a Time-to-Live (TTL) value as required by the IP standard. This TTL value functions as a form of self-destruct mechanism to prevent undelivered packets from circling the Internet indefinitely.
3. Before transmitting a packet farther along the line, every router on a path is expected to reduce the TTL value by one.
4. The routing process halts abruptly when the TTL reaches zero, and the final router to process the packet will reply with a "Time to live exceeded" response.
5. It is not desirable to exceed the TTL value in normal data packets, so the value for normal packets is 64-255. But otherwise frustrating error messages are an important part of how Traceroute works. By manipulating the TTL field, Traceroute and similar programs can trigger TTL exceeded messages from every hop along a given path. How it works:
6. The user invokes the traceroute (or tracert) command and specifies the target host. If the host is specified as a domain name, traceroute will try to resolve it.
   1. traceroute sends data packets with TTL set to 1 to destination. The first router in the path decrements the value by 1. This will trigger a TTL overflow message sent back to the host
   2. Using the first hop details, Traceroute increases the TTL value to '2'. The first router in the path decrements the value by 1, but the packet can survive another hop because the TTL does not drop to zero just before the gate. When the TTL reaches zero (in this case at the second router in the path) another TTL exceeded message is generated and sent back
7. This process repeats and Traceroute increments the TTL by 1 each time until the destination is reached or the hop limit is reached. By default, the limit is 30 hops, but you can specify a different value when running the command.
8. Once complete, Traceroute prints all the hops in the path, along with each hop and the round trip time (this is called the round-trip time).
9. By default, Traceroute sends 3 packets to each hop in the path. The exact packet type varies by implementation and can be changed with different flags, but the same basic methodology is used in all cases.
10. Traceroute ouptuts of different websites from different continents.

C:\Users\ashok>tracert www.ultrasawt.com

Tracing route to fp2da4.wac.edgecastcdn.net [192.229.144.30]

over a maximum of 30 hops:

1 3 ms 3 ms 7 ms 192.168.37.113

2 \* \* \* Request timed out.

3 49 ms 34 ms 34 ms 10.0.240.125

4 46 ms 33 ms 41 ms 10.50.135.113

5 43 ms 32 ms 52 ms abts-north-static-53.1.160.122.airtelbroadband.in [125.21.37.53]

6 187 ms 201 ms 49 ms 182.79.208.202

7 60 ms 40 ms 55 ms 182.79.164.109

8 64 ms 59 ms 57 ms 192.229.144.30

Trace complete.

C:\Users\ashok>tracert www.politico.eu

Tracing route to www.politico.eu [104.22.71.225]

over a maximum of 30 hops:

1 2 ms 2 ms 2 ms 192.168.37.113

2 \* \* \* Request timed out.

3 49 ms 63 ms 71 ms 10.0.240.125

4 42 ms 41 ms 36 ms 10.50.135.113

5 39 ms 40 ms 39 ms abts-north-static-53.1.160.122.airtelbroadband.in [125.21.37.53]

6 136 ms 105 ms 116 ms 182.79.149.253

7 108 ms 114 ms 113 ms 182.79.161.213

8 105 ms 108 ms 106 ms 104.22.71.225

Trace complete.

C:\Users\ashok>tracert www.latindispatch.com

Tracing route to www.latindispatch.com [50.62.89.79]

over a maximum of 30 hops:

1 2 ms 4 ms 2 ms 192.168.37.113

2 \* \* \* Request timed out.

3 41 ms 45 ms 47 ms 10.0.240.125

4 73 ms 44 ms 46 ms 10.50.135.113

5 71 ms 58 ms 48 ms abts-north-static-53.1.160.122.airtelbroadband.in [125.21.37.53]

6 221 ms 191 ms 195 ms 116.119.35.51

7 226 ms 177 ms 186 ms mei-b5-link

8 224 ms 198 ms 202 ms prs-bb1-link.ip.twelve99.net [62.115.124.54]

9 326 ms 315 ms 298 ms ash-bb2-link.ip.twelve99.net [62.115.112.242]

10 333 ms 303 ms 302 ms atl-b24-link.ip.twelve99.net [62.115.125.128]

11 \* \* \* Request timed out.

12 310 ms 304 ms 319 ms phx-b6-link.ip.twelve99.net [62.115.125.55]

13 311 ms 296 ms 291 ms hosteurope-svc074918-lag003647.ip.twelve99-cust.net [62.115.61.31]

14 \* \* \* Request timed out.

15 359 ms 324 ms 312 ms ae3.phx3-bbmb1001-02.bb.gdinf.net [148.72.32.9]

16 357 ms 321 ms 306 ms ae2.phx3-pemc0215-01.bb.gdinf.net [148.72.32.67]

17 \* \* \* Request timed out.

18 \* \* \* Request timed out.

19 \* \* \* Request timed out.

20 \* \* \* Request timed out.

21 312 ms 1121 ms 284 ms 79.89.62.50.host.secureserver.net [50.62.89.79]

Trace complete.

C:\Users\ashok>tracert aninews.in

Tracing route to aninews.in [13.126.121.254]

over a maximum of 30 hops:

1 34 ms 3 ms 2 ms 192.168.37.113

2 \* \* \* Request timed out.

3 42 ms 38 ms 41 ms 10.0.240.125

4 48 ms 38 ms 42 ms 10.50.135.113

5 38 ms 43 ms 33 ms abts-north-static-53.1.160.122.airtelbroadband.in [125.21.37.53]

6 62 ms 51 ms 42 ms 182.79.236.125

7 62 ms 52 ms 51 ms 99.82.179.122

8 49 ms 56 ms 58 ms 52.93.141.109

9 45 ms 51 ms 52 ms 52.93.19.141

10 \* \* \* Request timed out.

11 72 ms 82 ms 90 ms 52.95.66.186

12 82 ms 77 ms 60 ms 52.95.64.172

13 71 ms 96 ms 77 ms 52.95.64.163

14 104 ms 101 ms 76 ms 99.83.76.75

15 84 ms 91 ms 65 ms 99.83.76.94

16 \* \* \* Request timed out.

17 \* \* \* Request timed out.

Trace complete.

C:\Users\ashok>tracert www.similarweb.com

Tracing route to a1812.b.akamai.net [23.53.240.136]

over a maximum of 30 hops:

1 2 ms 3 ms 2 ms 192.168.37.113

2 \* \* \* Request timed out.

3 43 ms 49 ms 41 ms 10.0.240.125

4 54 ms 42 ms 45 ms 10.50.135.113

5 51 ms 48 ms 59 ms abts-north-static-53.1.160.122.airtelbroadband.in [125.21.37.53]

6 43 ms 42 ms 50 ms 182.79.240.135

7 44 ms 38 ms 34 ms a23-53-240-136.deploy.static.akamaitechnologies.com [23.53.240.136]

Runs Vs delay GraphsA picture containing text, clock, antenna

Description automatically generated

- No, the traceroute output for the same sites did not generate identical routes for all the sites.

- Outputs are not supposed to be identical. As for every request , the path may change as many hops involve in it.

1. **Briefly summarize the categories of the ISPs as discussed in class.** 
   1. Categories of ISPs as discussed in class.

Internet Service Provider (ISP) is a company which provides internet connection to end user, but there are basically three levels of ISP. There are 3 levels of Internet Service Provider (ISP): Tier-1 ISP, Tier-2 ISP, and Tier-3 ISP.

* Tier-1 ISP:
  + Tier 1 Internet service providers operate the networks that serve as the Internet's backbone. They are also known as backbone Internet providers.
  + These ISPs construct infrastructure like the Atlantic Internet sea cables. They only supply traffic to other ISPs, not to end consumers.
  + Tier 1 ISPs own and operate their operating infrastructure, which includes routers and other intermediary equipment (such as switches) that comprise the Internet backbone. AT&T, Verizon, Sprint, NTT, Singtel, PCCW, Telstra, Deutsche Telekom, and British Telecom are among the top Tier 1 ISPs.
  + They don't pay to have their traffic delivered though similar-sized networks.
  + They can deliver traffic to the entire Internet routing table solely through their peering relationships.
  + They peer on more than one continent.
  + They own or lease transoceanic fiber optic transport.
  + They deliver packets to and from customers and to and from peers around the world.

* Tier-2 ISP:
  + A Tier 2 ISP is a service provider that delivers Internet traffic to end users through Tier 3 ISPs using a mix of paid transit via Tier 1 ISPs and peering with other Tier 2 ISPs.
  + Usually, regional or national providers make up Tier 2 ISPs. Customers on more than two continents can only be served by a small number of Tier 2 ISPs.
  + They are frequently farther from the Internet's backbone and offer slower access speeds than Tier 1 ISPs.
  + Few of the Tier-2 ISPs are Vodafone, Easynet, BT

* Tier-3 ISP:
  + A Tier 3 ISP is a company that only buys Internet traffic. By definition, a Tier 3 provider's main business is providing Internet connectivity to end users.
  + Tier 3 ISPs concentrate on the state of the local consumer and corporate markets. They offer end users local access to the Internet through cable, DSL, fibre, or wireless access networks as a "on-ramp" or gateway.
  + Their coverage is restricted to particular nations or smaller geographic areas, such a metro area. Higher-tier ISPs are used by and compensated by Tier 3 ISPs for access to the rest of the Internet.
  + Few of the Tier-3 ISPs are Comcast, Deutsche Telekom, verizon Communications

1. **Briefly explain the standardization process for the Internet related protocols.**
   1. The process of standardisation. Within the Internet Standards Process, becoming a standard is a two-step process: Proposed Standard and Internet Standard.
   2. These are known as maturity levels, and the procedure is known as the Standards Track.
   3. The IETF creates these standards in order to coordinate the growth of Internet protocols.
   4. As Internet protocols have grown more widely used in commercial settings, this coordination has become increasingly vital.
   5. The IETF's working groups are where the majority of Internet protocol development and standardisation takes place.
   6. To become a standard, a specification must meet the following criteria:
      1. Be stable and well understood
      2. Be technically competent
      3. Have multiple, independent, and interoperable implementations with substantial operational experience
      4. Enjoy significant public support.
      5. Be recognizably useful in some or all parts of the Internet
   7. All Internet standards are classified into one of two groups:
   8. A protocol, service, process, convention, or format is defined by a technical specification (TS). Most Internet standards are TSs.
   9. An application statement (AS) outlines how and under what conditions one or more TSs may be used to support a certain Internet feature.
   10. An AS specifies one or more TSs pertinent to the capability and may define values or ranges for specific parameters connected with a TS or functional subsets of a TS pertinent to the capability.
2. **Define the network parameters discussed in class and briefly explain them with their units of measurements.**
   1. A set of methods that permit, control, and certify the computer network optimal performance levels is known as network performance parameters.
   2. the system of network performance provides regular observation for the performance quality and the service of the network device.
   3. The following measures are often considered important:
      1. Bandwidth
      2. Throughput
      3. Latency
      4. Jitter
      5. Error Rate
   4. **Bandwidth**
      1. Bandwidth usually measured in bits per second, is the maximum rate at which information can be transmitted. Bandwidth is the maximum data transfer rate for a particular route.
      2. Bandwidth can be described as network bandwidth, data bandwidth, or digital bandwidth.
      3. the actual transmission rate that can be achieved depends not only on the signal bandwidth but also on the noise in the channel.
      4. Network Bandwidth Capacity
      5. Network Bandwidth Consumption
      6. Asymptotic Bandwidth
      7. Multimedia Bandwidth
      8. Bandwidth in Web Hosting
      9. Internet Connection Bandwidth
   5. **Throughput**
      1. The throughput is the real transfer rate.
      2. Several factors can affect the throughput of a communication system, including the limitations of basic analog physical media, the available processing performance of system components, and end-user behaviour.
      3. If we take into account several total costs for the protocol, the useful speed of the transmitted data can be considerably lower than the maximum performance that can be achieved; the useful part is commonly referred to as Goodput.
         1. Maximum Throughput
         2. Maximum Theoretical Throughput
         3. Asymptotic Throughput
         4. Peak Measured Throughput
         5. Maximum Sustained Throughput
   6. **Latency**
      1. It is the delay between the transmitter and the receiver, which decodes it. Roughly, it is a function of the time of passage of the signal and the processing time of any node through which the information is transmitted
      2. Latency is the time interval between stimulation and reaction of response or, from a more general point of view, the delay between the cause and the effect of a physical change in the observed system.
      3. The latency is physically a consequence of the limited speed with which any physical interaction can spread.
      4. The magnitude of this speed is always less than or equal to the speed of light. As a result, each physical system will suffer some type of latency, regardless of the nature of the stimulation to which it has been subjected. The following parameters measure the latency.
      5. Communication Latency
      6. Audio Latency
      7. Operational Latency
      8. Mechanical Latency
      9. Computer Hardware and Operating System Latency
   7. **Jitter**
      1. Jitter is an undesirable deviation from the actual periodicity of the periodic signal assumed in electronics and telecommunications, often compared to a reference clock source
      2. Jitter can be caused by electromagnetic interference and crosstalk with carriers of other signals. The amount of jitter tolerance depends on the application used.
      3. There are three types of jitter.
         1. Random Jitter
         2. Deterministic Jitter
         3. Total Jitter
   8. **Error Rate**
      1. the number of bit errors corresponds to the number of bits received from the data stream over the communication channel, which have been modified due to noise, interference, distortion or synchronization error bits.
      2. Bit Error Rate (BER) is the number of bit errors divided by the total number of bits transmitted during the time interval. The bit error rate pe is the expected BER value.
3. **What are the four initial Internetting principles from Leiner, et al paper?**
   1. Four Initial internetting principles
      1. Freedom to Access Content. Consumers should have access to their choice of legal content.
      2. Freedom to Use Applications. Consumers should be able to run applications of their choice.
      3. Freedom to Attach Personal Devices. ...
      4. Freedom to Obtain Service Plan Information.
   2. The original ARPANET grew into the Internet. Internet was based on the idea that there would be multiple independent networks of rather arbitrary design,
   3. beginning with the ARPANET as the pioneering packet switching network, but soon to include packet satellite networks,
   4. ground-based packet radio networks and other networks.
   5. The Internet as we now know it embodies a key underlying technical idea, namely that of open architecture networking.