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Module 13: ICMP

Introduction of Networks

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Module Objectives

- Module Title: ICMP
- Module Objective: Use various tools to test network connectivity.

Topic Title	Topic Objective
13.1 ICMP Messages	Explain how ICMP is used to test network connectivity.
13.2 Ping and Traceroute Testing	Use ping and traceroute utilities to test network connectivity.

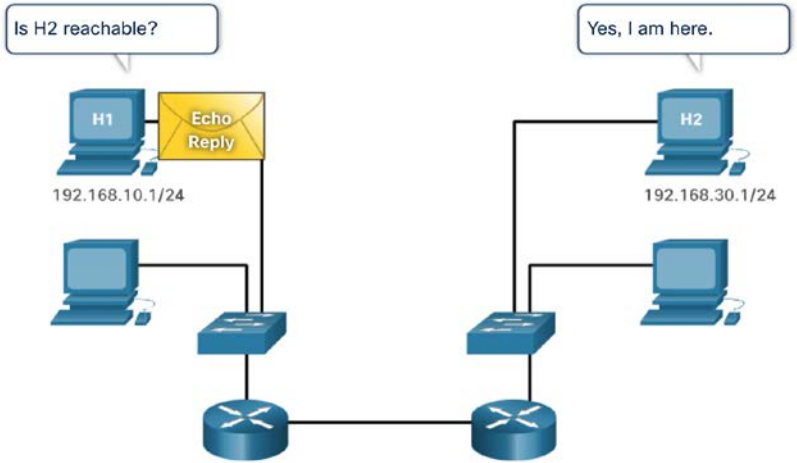
13.1 ICMP Messages

ICMPv4 and ICMPv6 Messages

- **Internet Control Message Protocol** (ICMP) provides feedback about issues related to the processing of IP packets under certain conditions.
- ICMPv4 is the messaging protocol for IPv4. ICMPv6 is the messaging protocol for IPv6 and includes additional functionality.
- The ICMP messages common to both ICMPv4 and ICMPv6 include:
  - Host reachability
  - Destination or Service Unreachable
  - Time exceeded
- Note: ICMPv4 messages are not required and are often not allowed within a network for security reasons.

Host Reachability

- ICMP Echo Message can be used to test the reachability of a host on an IP network.
- In the example:
  - The local host sends an ICMP **Echo Request** to a host.
  - If the host is available, the destination host responds with an **Echo Reply**.



Destination or Service Unreachable

- An ICMP Destination Unreachable message can be used to notify the source that a destination or service is unreachable.
- The ICMP message will include a code indicating why the packet could not be delivered.

A few Destination Unreachable codes for ICMPv4 are as follows:

- 0 - Net unreachable
- 1 - Host unreachable
- 2 - Protocol unreachable
- 3 - Port unreachable

A few Destination Unreachable codes for ICMPv6 are as follows:

- 0 - No route to destination
- 1 - Communication with the destination is administratively prohibited (e.g., firewall)
- 2 – Beyond scope of the source address
- 3 - Address unreachable
- 4 - Port unreachable

- Note: ICMPv6 has similar but slightly different codes for Destination Unreachable messages.

Time Exceeded

- When the Time to Live (TTL) field in a packet is decremented to 0, an ICMPv4 Time Exceeded message will be sent to the source host.
- ICMPv6 also sends a Time Exceeded message. Instead of the IPv4 TTL field, ICMPv6 uses the IPv6 Hop Limit field to determine if the packet has expired.

```
Pinging 8.8.8.8 with 32 bytes of data:
Reply from 192.168.1.1: TTL expired in transit.
Reply from 192.168.1.1: TTL expired in transit.
Reply from 192.168.1.1: TTL expired in transit.
Reply from 192.168.1.1: TTL expired in transit.

Ping statistics for 8.8.8.8:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

- Note: Time Exceeded messages are used by the traceroute tool.

ICMPv6 Messages

- ICMPv6 has new features and improved functionality not found in ICMPv4, including four new protocols as part of the **Neighbor Discovery Protocol** (ND or NDP).

Messaging between an IPv6 router and an IPv6 device, including dynamic address allocation are as follows:

- **Router Solicitation** (RS) message
- **Router Advertisement** (RA) message

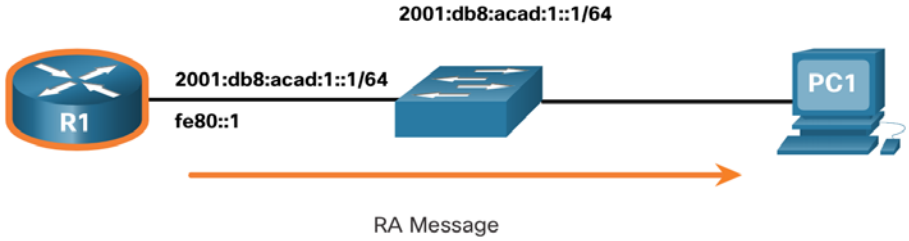
Messaging between IPv6 devices, including duplicate address detection and address resolution are as follows:

- **Neighbor Solicitation** (NS) message
- **Neighbor Advertisement** (NA) message

- Note: ICMPv6 ND also includes the redirect message, which has a similar function to the redirect message used in ICMPv4.

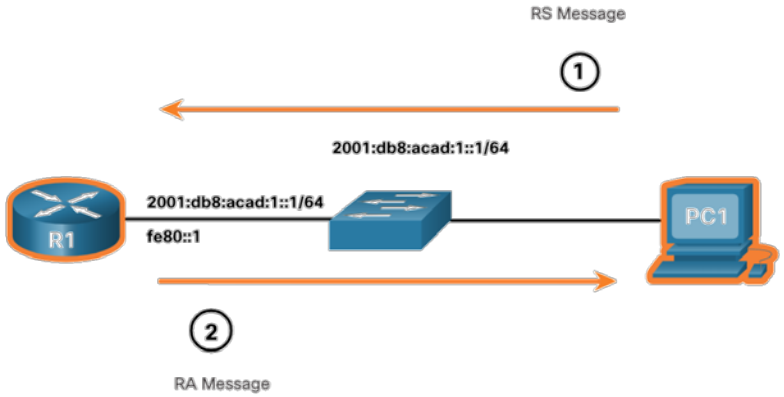
ICMPv6 Messages

- RA messages are sent by IPv6-enabled routers every 200 seconds to provide addressing information to IPv6-enabled hosts.
- RA message can include addressing information for the host such as the prefix, prefix length, DNS address, and domain name.
- A host using Stateless Address Autoconfiguration (SLAAC) will set its default gateway to the link-local address of the router that sent the RA.



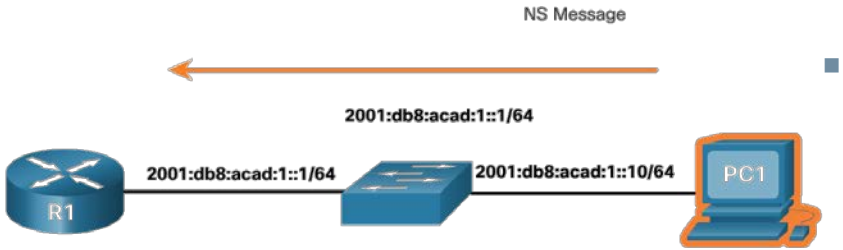
ICMPv6 Messages

- An IPv6-enabled router will also send out an RA message in response to an RS message.
- In the figure, PC1 sends a RS message to determine how to receive its IPv6 address information dynamically.
  - R1 replies to the RS with an RA message.
  - PC1 sends an RS message, “Hi, I just booted up. Is there an IPv6 router on the network? I need to know how to get my IPv6 address information dynamically.”
  - R1 replies with an RA message. “Hi all IPv6-enabled devices. I’m R1 and you can use SLAAC to create an IPv6 global unicast address. The prefix is **2001:db8:acad:1::/64**. By the way, use my link-local address **fe80::1** as your default gateway."



ICMPv6 Messages

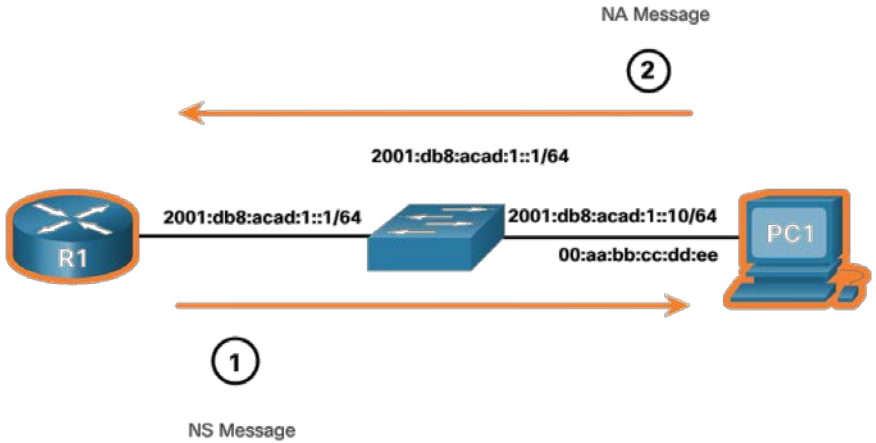
- A device assigned a global IPv6 unicast or link-local unicast address, may perform duplicate address detection (DAD) to ensure that the IPv6 address is unique.
- To check the uniqueness of an address, the device will send an NS message with its own IPv6 address as the targeted IPv6 address.
- If another device on the network has this address, it will respond with an NA message notifying to the sending device that the address is in use.



- Note: DAD is not required, but RFC 4861 recommends that DAD is performed on unicast addresses.

ICMPv6 Messages

- To determine the MAC address for the destination, the device will send an NS message to the solicited node address.
- The message will include the known (targeted) IPv6 address. The device that has the targeted IPv6 address will respond with an NA message containing its Ethernet MAC address.
- In the figure, R1 sends a NS message to **2001:db8:acad:1::10** asking for its MAC address.



Internet Control Message Protocol

- ICMP message types:
  - **Echo Request, Echo Reply** – Used to test destination accessibility and status. A host sends an Echo Request and listens for a corresponding Echo Reply. This is most commonly done using the ping command.
  - **Destination Unreachable, Echo Reply** – Sent by a router when it cannot deliver an IP datagram. A datagram is the unit of data, or packet, transmitted in a TCP/IP network.
  - **Source Quench** – Sent by a host or router if it is receiving data too quickly for it to handle. The message is a request that the source reduce its rate of datagram transmission.
  - **Redirect Message** – Sent by a router if it receives a datagram that should have been sent to a different router. The message contains the address to which the source should direct future datagrams. This is used to optimize the routing of network traffic.

Internet Control Message Protocol

- ICMP message types:
  - **Router Advertisement, Router Solicitation** – Allow hosts to discover the existence of routers. Routers periodically broadcast their IP addresses via Router Advertisement messages. Hosts may also request a router address by broadcasting a Router Solicitation message to which a router replies with a Router Advertisement.
  - **Time Exceeded** – Sent by a router if the datagram has reached the maximum limit of routers through which it can travel.
  - **Parameter Problem** – Sent by a router if a problem occurs during the transmission of a datagram such that it cannot complete processing. One potential source of such a problem is invalid datagram header.
  - **Timestamp Request, Timestamp Reply** – Used to synchronize the clocks between hosts and to estimate transit time.
  - **Address Mask Request, Address Mask Reply** – Used to find the mask of the subnet (i.e. what address bits define the network). A host sends an Address Mask Request to a router and receives an Address Mask Reply in return.

13.2 Ping and Traceroute Tests

Ping – Test Connectivity

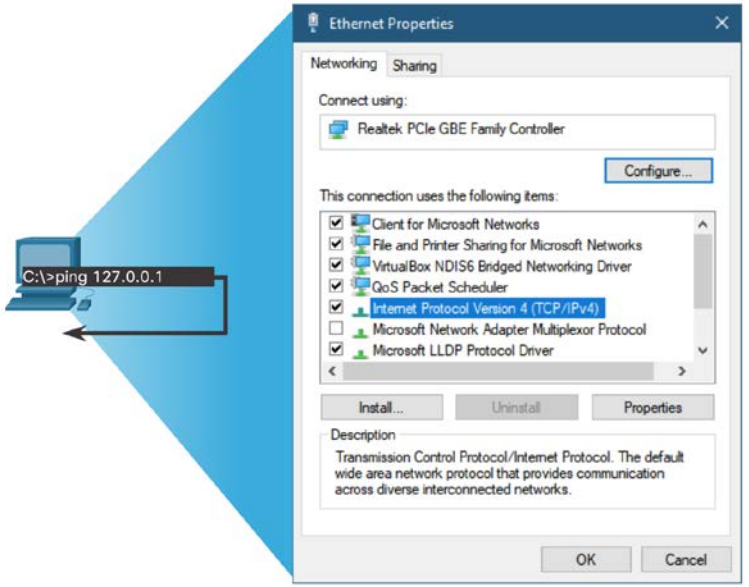
- The **ping** command is an IPv4 and IPv6 testing utility that uses ICMP echo request and echo reply messages to test connectivity between hosts and provides a summary that includes the success rate and average round-trip time to the destination.
- If a reply is not received within the timeout, ping provides a message indicating that a response was not received.
- It is common for the first ping to timeout if address resolution (ARP or ND) needs to be performed before sending the ICMP Echo Request.

```
S1#ping 192.168.20.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/1 ms
```

```
R1#ping 2001:db8:acad:1::2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:db8:acad:1::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/1 ms
```

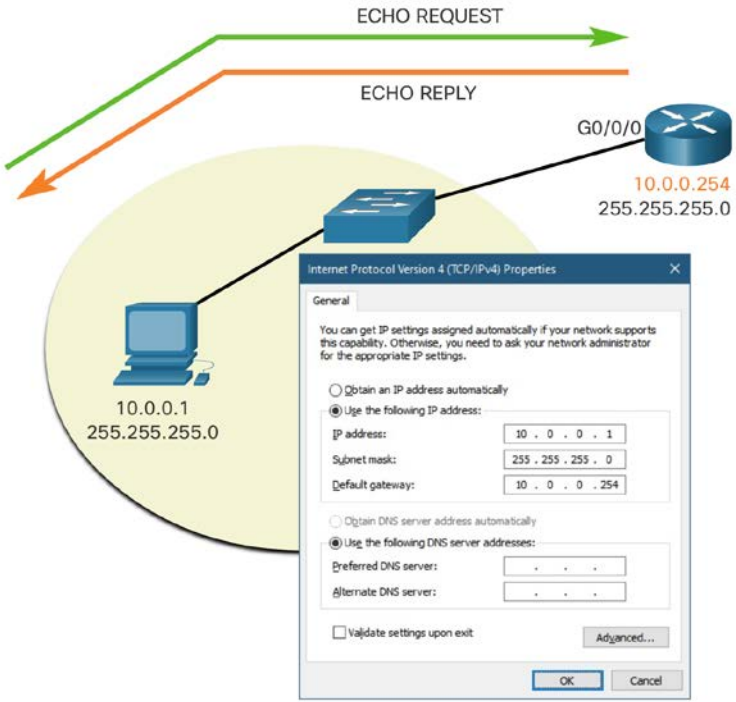
Ping the Loopback

- Ping can be used to test the internal configuration of IPv4 or IPv6 on the local host.
  - To do this, ping the local loopback address of 127.0.0.1 for IPv4 (::1 for IPv6).
- A response from 127.0.0.1 for IPv4, or ::1 for IPv6, indicates that IP is properly installed on the host.
- An error message indicates that TCP/IP is not operational on the host.



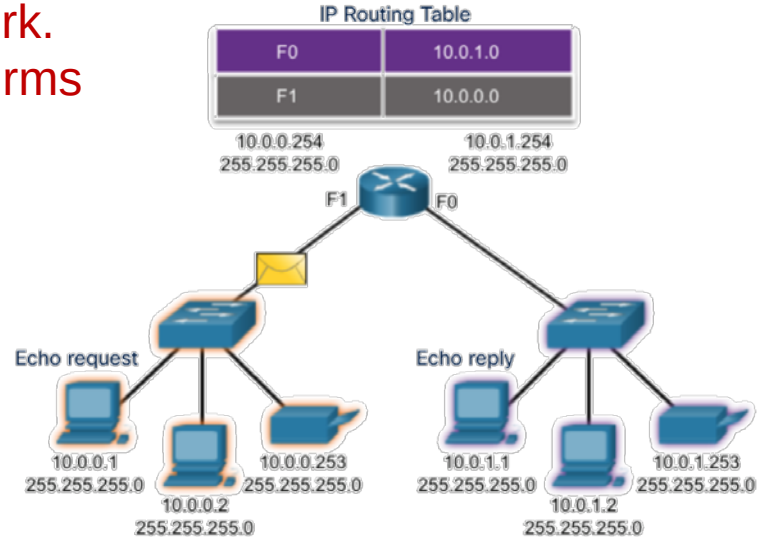
Ping the Default Gateway

- The **`ping`** command can be used to test the ability of a host to communicate on the local network.
- The default gateway address is most often used because the router is normally always operational.
  - A successful ping to the default gateway indicates that the host and the router interface serving as the default gateway are both operational on the local network.
  - If the default gateway address does not respond, a ping can be sent to the IP address of another host on the local network that is known to be operational.



Ping a Remote Host

- Ping can also be used to test the ability of a local host to communicate across an internetwork.
- A local host can ping a host on a remote network. A successful ping across the internetwork confirms communication on the local network.



- Note: Many network administrators limit or prohibit the entry of ICMP messages therefore, the lack of a ping response could be due to security restrictions.

Traceroute – Test the Path

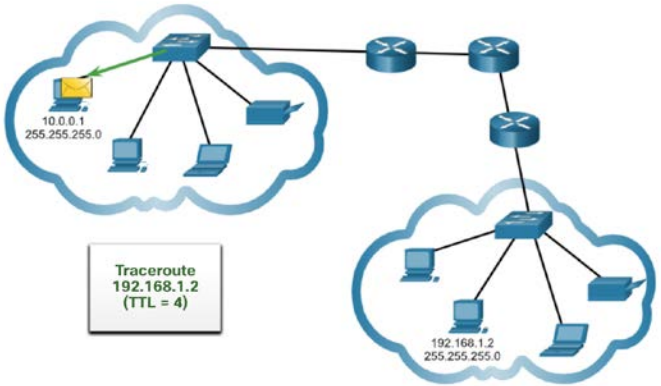
- **Traceroute** or **tracert** is a utility that is used to test the path between two hosts and provide a list of hops that were successfully reached along that path.
- Traceroute uses the IP address of the outbound interface as the source.
- Traceroute provides round-trip time for each hop along the path and indicates if a hop fails to respond. An asterisk (*) is used to indicate a lost or unreplied packet.
- Uses ICMP echo-requests and echo-replies to communicate.
- This information can be used to locate a problematic router in the path or may indicate that the router is configured not to reply.

```
R1#traceroute 192.168.40.2
Type escape sequence to abort.
Tracing the route to 192.168.40.2

  1   192.168.10.2    1 msec    0 msec    0 msec
  2   192.168.20.2    2 msec    1 msec    0 msec
  3   192.168.30.2    1 msec    0 msec    0 msec
  4   192.168.40.2    0 msec    0 msec    0 msec
```

- Note: Traceroute makes use of a function of the TTL field in IPv4 and the Hop Limit field in IPv6 in the Layer 3 headers, along with the ICMP Time Exceeded message.

Traceroute – Test the Path

- The first message sent from traceroute will have a TTL field value of 1. This causes the TTL to time out at the first router. This router then responds with a ICMPv4 Time Exceeded message.
- Traceroute then progressively increments the TTL field (2, 3, 4...) for each sequence of messages. This provides the trace with the address of each hop as the packets time out further down the path.
- The TTL field continues to be increased until the destination is reached, or it is incremented to a predefined maximum.
- A time exceeded message from ICMPv6 when the hop limit field of a packet is decremented to zero and the packet cannot be forwarded and dropped.



13.3 Module Practice and Quiz

What did I learn in this module?

- The purpose of ICMP messages is to provide feedback about issues related to the processing of IP packets under certain conditions.
- The ICMP messages common to both ICMPv4 and ICMPv6 are: Host reachability, Destination or Service Unreachable, and Time exceeded.
- The messages between an IPv6 router and an IPv6 device including dynamic address allocation include RS and RA. The messages between IPv6 devices include the redirect (similar to IPv4), NS and NA.
- Ping (used by IPv4 and IPv6) uses ICMP echo request and echo reply messages to test connectivity between hosts
- Ping can be used to test the internal configuration of IPv4 or IPv6 on the local host.
- Traceroute (tracert) generates a list of hops that were successfully reached along the path.

New Terms and Commands

- ICMP
- ICMPv4
- ICMPv6
- ping
- traceroute
- tracert
- Network Discovery Protocol
- Router Solicitation (RS)
- Router Advertisement (RA)
- Neighbor Solicitation (NS)
- Neighbor Advertisement (NA)
- TTL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