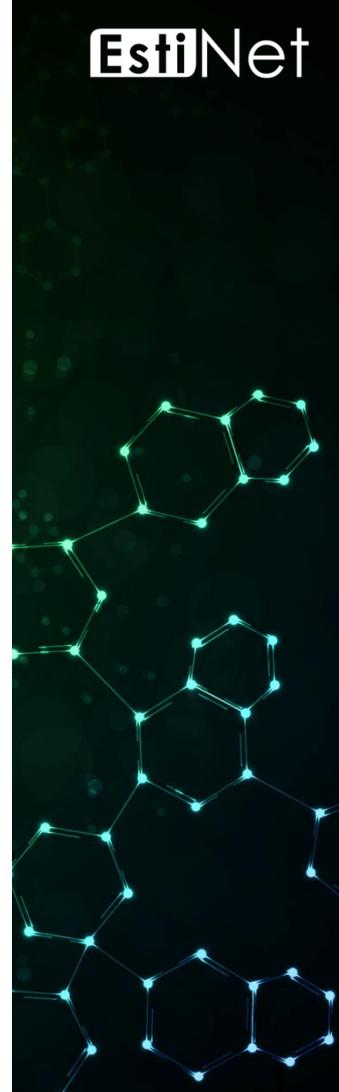


# The Addressing of Data Link Layer



# Outline

- ◆ Unicast Addressing
- ◆ Broadcast Addressing
- ◆ Multicast Addressing
- ◆ Promiscuous Mode
- ◆ Summary
- ◆ Appendix

# <Simulation Case> mac\_addressing.xtpl

The screenshot displays the EstiNet simulation environment. The title bar shows the file path `/root/course_case_estinets/data_link_layer/mac_addressing.xtpl` and the date range `2018/06/06 ~ 2018/10/31`. The interface includes a menu bar with `File`, `D-Tools`, `E-Tools`, `Run-Panel`, `P-Tools`, and `Misc`. A toolbar contains various icons for navigation and simulation control. On the left, the `Network Node Portfolio` lists node types: `Host`, `Switch`, `Router`, `Hub`, and `Open vSwitch (OVS)`. The main workspace is divided into four panels, each illustrating a different MAC addressing scenario:

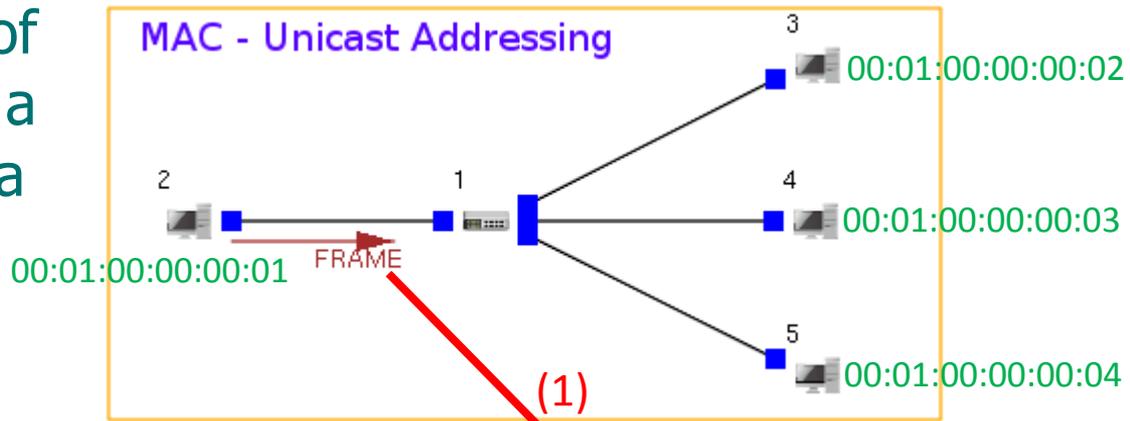
- MAC - Unicast Addressing:** A central switch (node 1) is connected to three hosts (nodes 2, 3, and 4). Node 2 is connected to node 1, which is connected to nodes 3 and 4.
- MAC - Broadcast Addressing:** A central switch (node 7) is connected to three hosts (nodes 8, 9, and 10). Node 8 is connected to node 7, which is connected to nodes 9 and 10.
- MAC - Multicast Addressing:** A central switch (node 13) is connected to three hosts (nodes 14, 15, and 16). Node 14 is connected to node 13, which is connected to nodes 15 and 16.
- Unicast Addressing + Promiscuous Mode:** A central switch (node 19) is connected to three hosts (nodes 20, 21, and 22). Node 20 is connected to node 19, which is connected to nodes 21 and 22.

The bottom status bar shows a timer at `000000.000000 sec`, a simulation progress indicator at `000030.000000`, and playback controls including a `Playback Speed` dropdown set to `5 (10 ns)`. The bottom right corner displays `[100%] (55.86, 1.35)`.

# Unicast Addressing

Fill the destination address of a data-link-layer frame with a unicast address to address a single target node.

- (1) Node 2 sends a echo-request frame.
- (2) In the frame's header, the source address is filled with Node 2's MAC address while the destination address is filled with Node 3's MAC address.



The screenshot shows a Wireshark capture of a packet. The packet list pane shows two packets: an ICMP Echo (ping) request and an ICMP Echo (ping) reply. The packet details pane for the first packet (Frame 1) is expanded to show the Ethernet II header. The Destination field is highlighted with a red box and labeled '(2)'. The Source field is also highlighted with a red box. The packet bytes pane shows the raw data of the frame.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	1.0.1.1	1.0.1.2	ICMP	98	Echo (ping) request id=0xf16, seq=1/256, ttl=64 (re
2	0.000199	1.0.1.2	1.0.1.1	ICMP	98	Echo (ping) reply id=0xf16, seq=1/256, ttl=64 (re

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

Ethernet II, Src: EquipTra 00:00:01 (00:01:00:00:00:01), Dst: EquipTra 00:00:02 (00:01:00:00:00:02)

Destination: EquipTra 00:00:02 (00:01:00:00:00:02)

Source: EquipTra 00:00:01 (00:01:00:00:00:01)

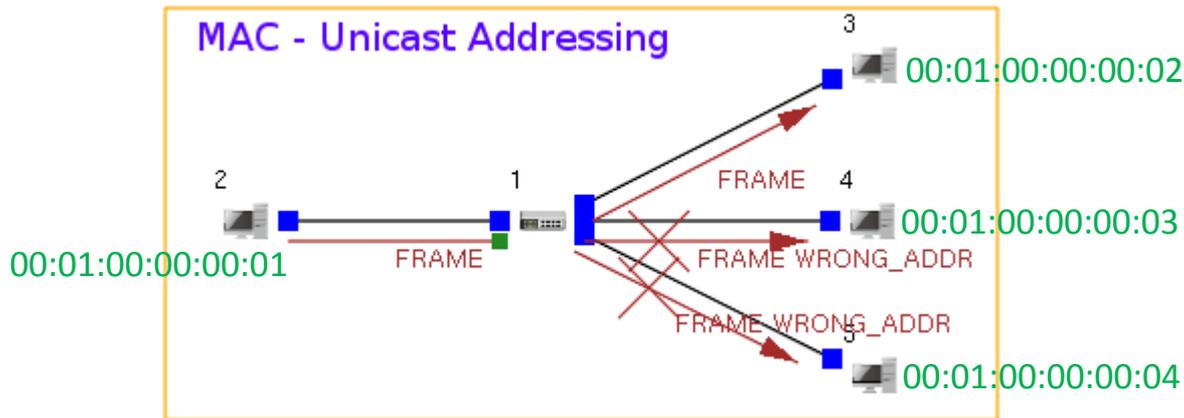
Type: IPv4 (0x0800)

Internet Protocol Version 4, Src: 1.0.1.1, Dst: 1.0.1.2

Internet Control Message Protocol

# A frame receiver decides if the frame is for itself according to the frame's destination address.

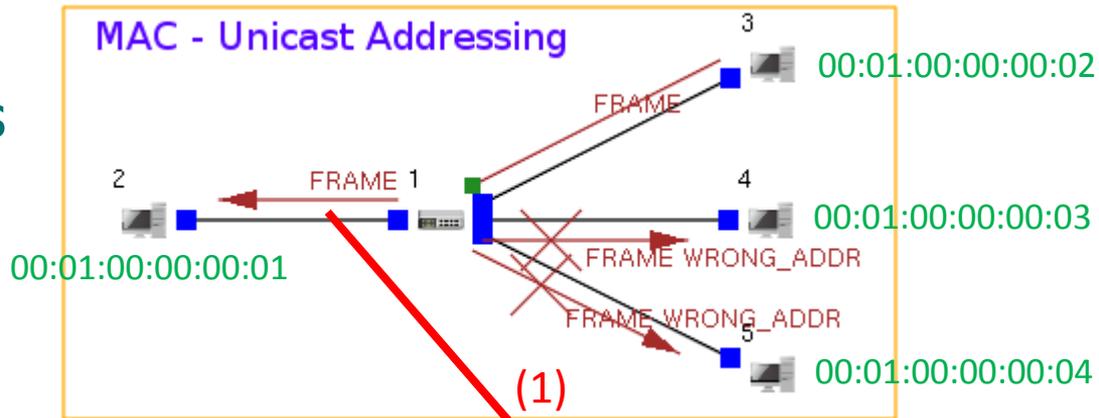
- ◆ Among the three nodes receiving the frame, only Node 3 accepts the frame. That is because the frame's destination address is filled with Node 3's MAC address.
- ◆ Node 4 and Node 5 drop the frame because they are not the target of the frame.



# The node that accepts the echo-request frame responds to the request.

- (1) Node 3 sends an echo-reply frame.
- (2) In the frame's header, the source address is filled with Node 3's MAC address while the destination address is filled with Node 2's MAC address.

- ◆ Among the three nodes receiving the frame, only Node 2 accepts the frame. That is because the frame's destination address is filled with Node 2's MAC address.
- ◆ Node 4 and Node 5 drop the frame because they are not the target of the frame.



tcpdump\_at\_node\_2.pcap [Wireshark 2.1.1 (Git Rev Unknown from unknown)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	1.0.1.1	1.0.1.2	ICMP	98	Echo (ping) request id=0xf16, seq=1/256, ttl=64 (re...
2	0.000199	1.0.1.2	1.0.1.1	ICMP	98	Echo (ping) reply id=0xf16, seq=1/256, ttl=64 (re...

Frame 2: 98 bytes on wire (784 bits), 98 bytes captured (784 bits)

Ethernet II, Src: EquipTra\_00:00:02 (00:01:00:00:00:02), Dst: EquipTra\_00:00:01 (00:01:00:00:00:01)

Destination: EquipTra\_00:00:01 (00:01:00:00:00:01)

Source: EquipTra\_00:00:02 (00:01:00:00:00:02)

Type: IPv4 (0x0800)

Internet Protocol Version 4, Src: 1.0.1.2, Dst: 1.0.1.1

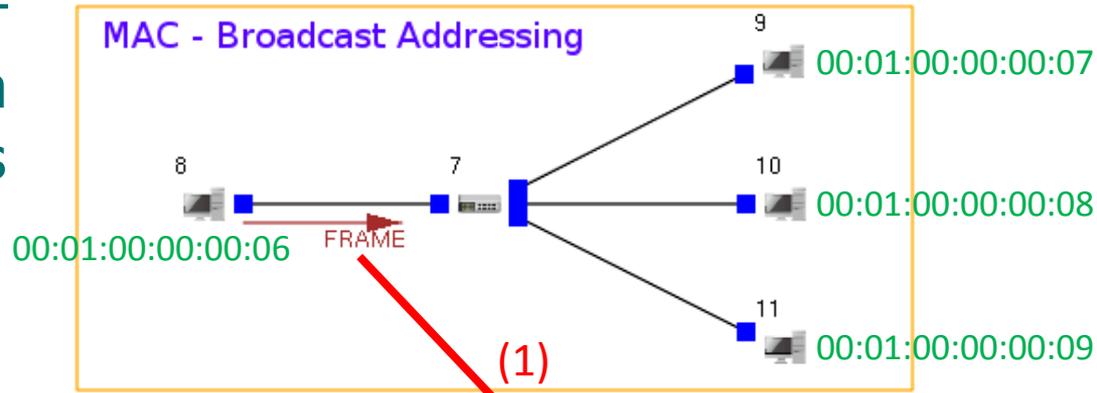
Internet Control Message Protocol

0000 00 01 00 00 01 00 01 00 00 00 02 08 00 45 00 .....E.  
0010 00 54 c6 ea 00 00 40 01 af bc 01 00 01 02 01 00 .T...@.....  
0020 01 01 00 00 1f 16 1f 16 00 01 03 00 00 00 00 00 .....  
0030 00 00 00 00 00 00 00 00 00 00 11 00 33 14 15 .....  
.....

# Broadcast Addressing

Fill the destination address of a data-link-layer frame with a broadcast address to address all nodes.

- (1) Node 8 sends a echo-request frame.
- (2) In the frame's header, the source address is filled with Node 8's MAC address while the destination address is filled with the broadcast MAC address (ff:ff:ff:ff:ff:ff).



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	1.0.2.1	1.0.2.255	ICMP	98	Echo (ping) request id=0x1f18, seq=1/256, ttl=64 (no...
2	0.000216	1.0.2.3	1.0.2.1	ICMP	98	Echo (ping) reply id=0x1f18, seq=1/256, ttl=64
3	0.000550	1.0.2.4	1.0.2.1	ICMP	98	Echo (ping) reply id=0x1f18, seq=1/256, ttl=64
4	0.000649	1.0.2.2	1.0.2.1	ICMP	98	Echo (ping) reply id=0x1f18, seq=1/256, ttl=64

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

Ethernet II, Src: EquipTra\_00:00:06 (00:01:00:00:00:06), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

- Destination: Broadcast (ff:ff:ff:ff:ff:ff)
- Source: EquipTra\_00:00:06 (00:01:00:00:00:06)
- Type: IPv4 (0x0800)

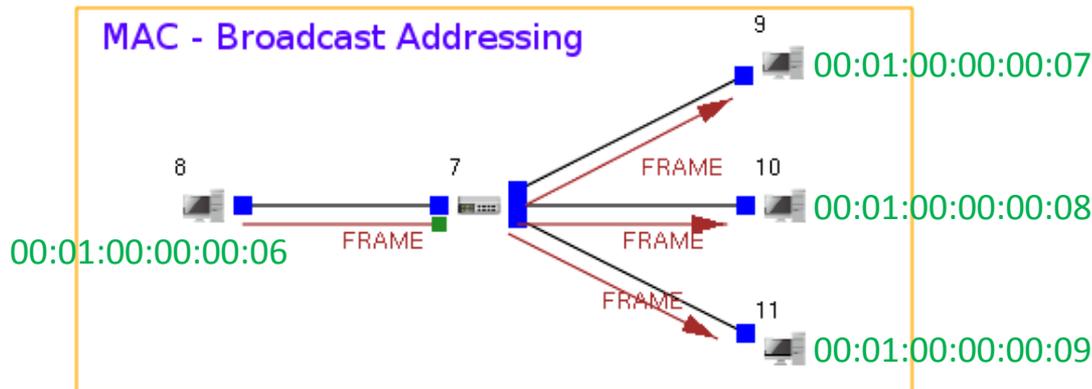
Internet Protocol Version 4, Src: 1.0.2.1, Dst: 1.0.2.255

Internet Control Message Protocol

```
0000 ff ff ff ff ff ff 00 01 00 00 00 06 08 00 45 00 .....E.
0010 00 54 00 00 40 00 40 01 33 aa 01 00 02 01 01 00 .T.@.@.3.....
0020 02 ff 08 00 14 14 1f 18 00 01 06 00 00 00 00 00 .....
0030 02 00 00 00 04 00 00 00 00 00 10 11 03 14 1f .....
0040 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
```

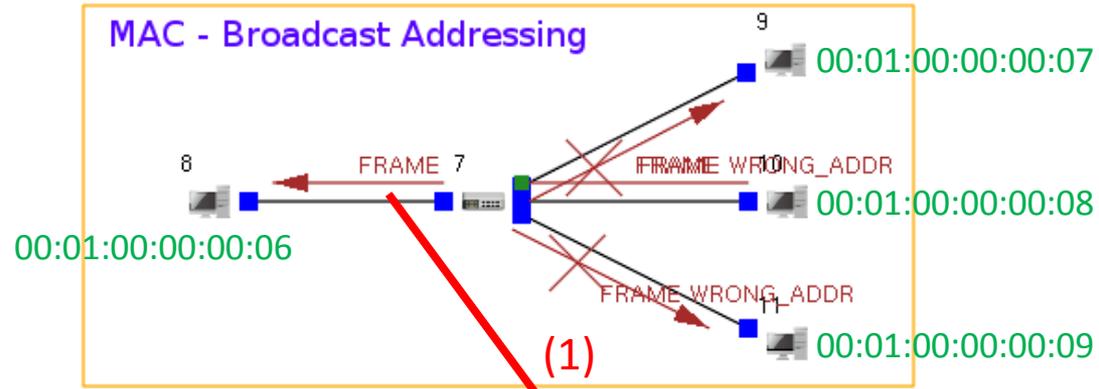
# A frame receiver decides if the frame is for itself according to the frame's destination address.

- ◆ All the three nodes receiving the frame accept the frame because the frame's destination address is filled with the broadcast MAC address. In other words, all nodes are the frame's target.



# The node that accepts the echo-request frame responds to the request.

- (1) Node 10 sends a echo-reply frame.
- (2) In the frame's header, the source address is filled with Node 10's MAC address while the destination address is filled with Node 8's MAC address.



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	1.0.2.1	1.0.2.255	ICMP	98	Echo (ping) request id=0xf18, seq=1/256, ttl=64 (no...
2	0.000216	1.0.2.3	1.0.2.1	ICMP	98	Echo (ping) reply id=0xf18, seq=1/256, ttl=64
3	0.000550	1.0.2.4	1.0.2.1	ICMP	98	Echo (ping) reply id=0xf18, seq=1/256, ttl=64
4	0.000649	1.0.2.2	1.0.2.1	ICMP	98	Echo (ping) reply id=0xf18, seq=1/256, ttl=64

Frame 2: 98 bytes on wire (784 bits), 98 bytes captured (784 bits)

Ethernet II, Src: EquipTra\_00:00:08 (00:01:00:00:00:08), Dst: EquipTra\_00:00:06 (00:01:00:00:00:06)

- Destination: EquipTra\_00:00:06 (00:01:00:00:00:06)
- Source: EquipTra\_00:00:08 (00:01:00:00:00:08)

Type: IPv4 (0x0800)

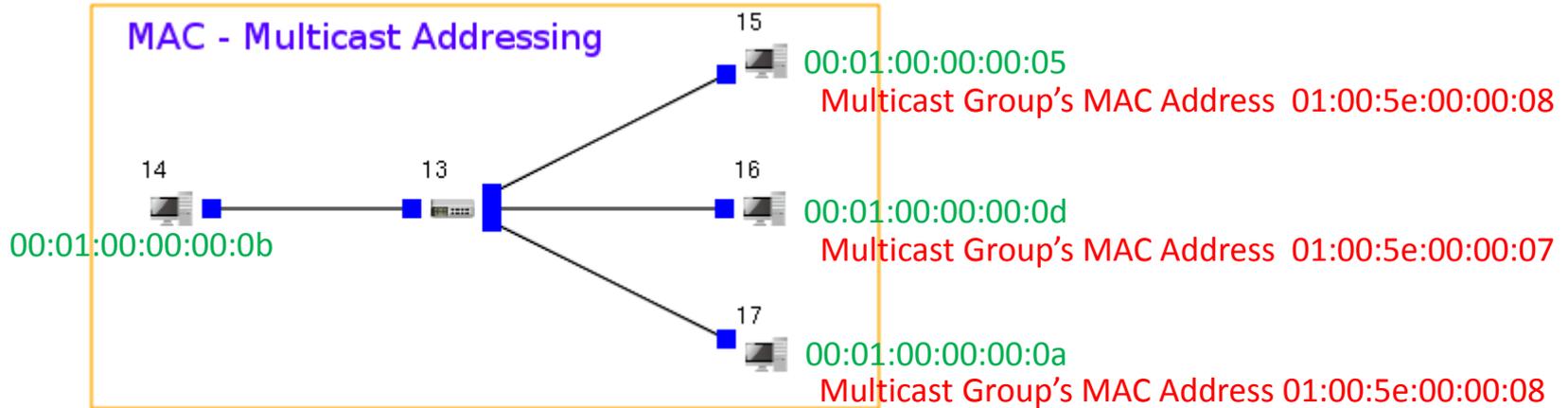
Internet Protocol Version 4, Src: 1.0.2.3, Dst: 1.0.2.1

Internet Control Message Protocol

# Multicast Addressing

# Multicast Group

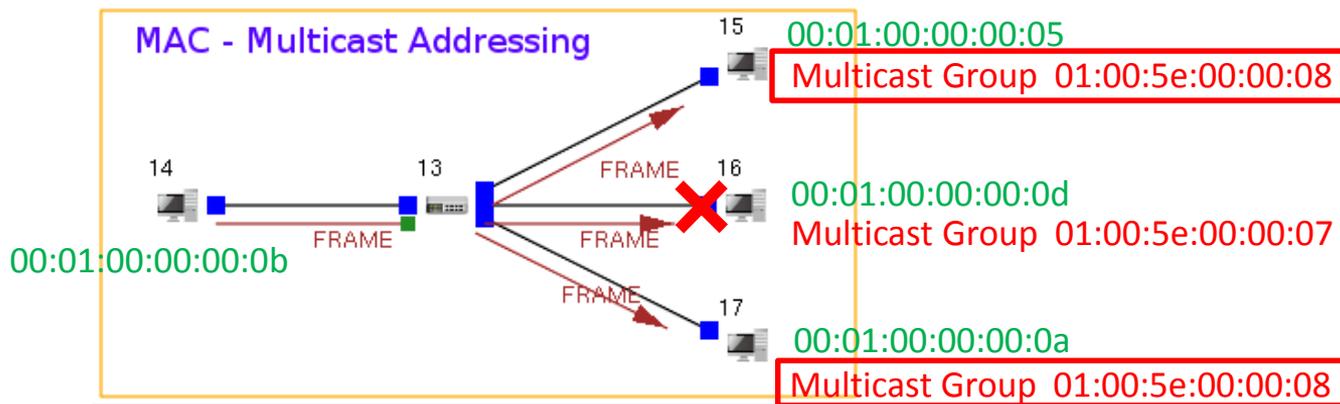
- ◆ The target nodes of a multicast frame are those nodes that join a specific multicast group.
- ◆ The following graph shows that Node 15 and Node 17 join the same multicast group while Node 16 joins another multicast group.





# A frame receiver decides if the frame is for itself according to the frame's destination address.

- ◆ In the implementation of EstiNet X network simulator, the MAC module does not filter multicast addresses. Thus, all the three nodes receiving the frame accept the frame first and hand it over to the multicast processing procedure on the upper layer. In fact, the frame that targets multicast group 01:00:5e:00:00:08 is eventually discarded by Node 16. Only Node 15 and Node 17 eventually accept the frame.

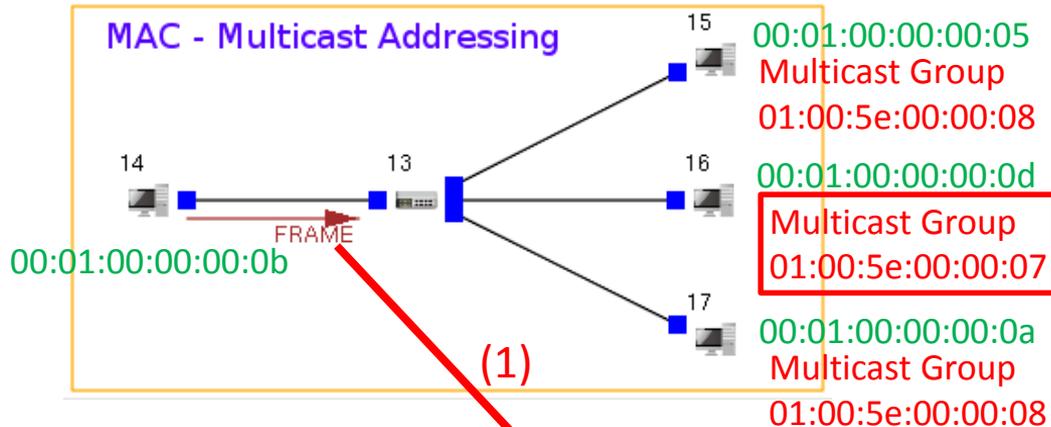




Fill the destination address of a data-link-layer frame with a multicast address to address those nodes that join a specific multicast group.

(1) Node 14 sends an echo-request frame.

(2) In the frame's header, the source address is filled with Node 14's MAC address while the destination address is filled with a multicast group's MAC address (01:00:5e:00:00:07).



tcpdump\_at\_node\_14.pcap [Wireshark 2.1.1 (Git Rev Unknown from unknown)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	In...
7	0.997914	1.0.3.1	224.0.0.8	ICMP	98	Echo (ping) request id=0x1f1d, seq=1/256, ttl=1 (mul...
8	0.998262	1.0.3.2	1.0.3.1	ICMP	98	Echo (ping) reply id=0x1f1d, seq=1/256, ttl=64
9	0.998361	1.0.3.4	1.0.3.1	ICMP	98	Echo (ping) reply id=0x1f1d, seq=1/256, ttl=64
10	4.997914	1.0.3.1	224.0.0.7	ICMP	98	Echo (ping) request id=0x1f1e, seq=1/256, ttl=1 (mul...
11	4.998113	1.0.3.3	1.0.3.1	ICMP	98	Echo (ping) reply id=0x1f1e, seq=1/256, ttl=64

▶ Frame 10: 98 bytes on wire (784 bits), 98 bytes captured (784 bits)

▶ Ethernet II, Src: EquipTra\_00:00:0b (00:01:00:00:00:0b), Dst: IPv4mcast\_07 (01:00:5e:00:00:07)

▶ Destination: IPv4mcast\_07 (01:00:5e:00:00:07)

▶ Source: EquipTra\_00:00:0b (00:01:00:00:00:0b)

Type: IPv4 (0x0800)

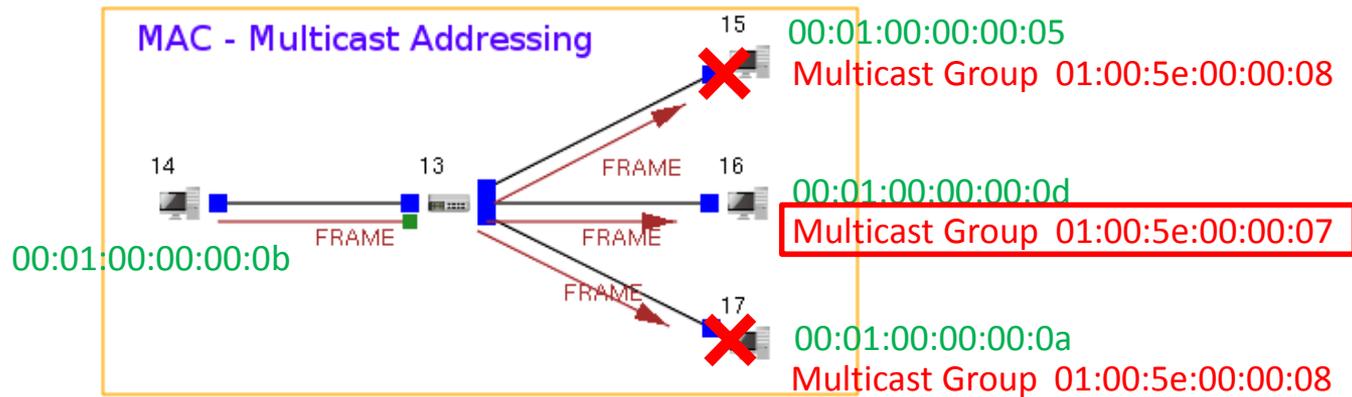
▶ Internet Protocol Version 4, Src: 1.0.3.1, Dst: 224.0.0.7

▶ Internet Control Message Protocol

0000 01 00 5e 00 00 07 00 01 00 00 00 0b 08 00 45 00 ..^.....E.  
0010 00 54 00 00 40 00 01 01 95 a1 01 00 03 01 e0 00 .T.@.....  
0020 00 07 08 00 0b 0e 1f 1e 00 01 0f 00 00 00 00 00 .....  
0030 00 00 00 00 00 00 00 00 00 00 11 33 14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 36 37 38 39 3a 3b 3c 3d 3e 3f 40 41 42 43 44 45 46 47 48 49 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59 5a 5b 5c 5d 5e 5f 60 61 62 63 64 65 66 67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76 77 78 79 7a 7b 7c 7d 7e 7f 80 81 82 83 84 85 86 87 88 89 8a 8b 8c 8d 8e 8f 80 81 82 83 84 85 86 87 88 89 8a 8b 8c 8d 8e 8f 90 91 92 93 94 95 96 97 98 99 9a 9b 9c 9d 9e 9f a0 a1 a2 a3 a4 a5 a6 a7 a8 a9 aa ab ac ad ae af b0 b1 b2 b3 b4 b5 b6 b7 b8 b9 ba bb bc bd be bf c0 c1 c2 c3 c4 c5 c6 c7 c8 c9 ca cb cc cd ce cf d0 d1 d2 d3 d4 d5 d6 d7 d8 d9 da db dc dd de df e0 e1 e2 e3 e4 e5 e6 e7 e8 e9 ea eb ec ed ee ef f0 f1 f2 f3 f4 f5 f6 f7 f8 f9 fa fb fc fd fe ff

# A frame receiver decides if the frame is for itself according to the frame's destination address.

- ◆ In the implementation of EstiNet X network simulator, the MAC module does not filter multicast addresses. Thus, all the three nodes receiving the frame accept the frame first and hand it over to the multicast processing procedure on the upper layer. In fact, the frame that targets multicast group 01:00:5e:00:00:07 is eventually discarded by Node 15 and Node 17. Only Node 16 eventually accepts the frame.





# Promiscuous Mode

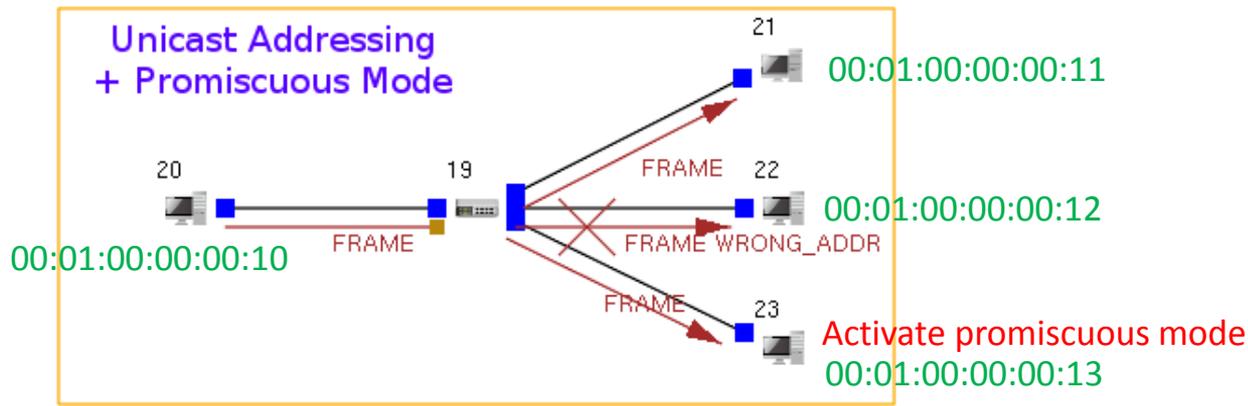
# Promiscuous Mode

- ◆ The data link layer of a network node filters an incoming frame according to the frame's destination address to see if the frame is for this network node.
- ◆ If a network node wants to stop the filtering mechanism, it activates the promiscuous mode. In this way, the network node accepts all incoming frames. Some network packet analyzer software, such as Wireshark, uses this way to analyze all network packets.



# A frame receiver decides if the frame is for itself according to the frame's destination address.

- ◆ The frame is accepted by not only Node 21 but also Node 23. The former accepts the frame because it is the frame's target node. The latter accepts the frame because it activates the promiscuous mode.
- ◆ Node 22 drops the frame because it is not the target of the frame.





# Summary

# Review of Points

- ◆ What kinds of addressing does the data link layer have? What characteristics does each addressing have? What kinds of network application is each addressing suitable for?
- ◆ What will happen after a network node activates the promiscuous mode? What kinds of network application is this mode suitable for?

# Appendix

# Special Parameter Configuration for This Simulation Case

- ◆ Broadcast Addressing
  - On those nodes that are the target of a broadcast echo-request frame, the command “`sysctl net.ipv4.icmp_echo_ignore_broadcasts=0`” has to be executed so that these nodes can send back echo-reply frames.
- ◆ Multicast Addressing
  - All nodes have to execute the command “`ip route add 224.0.0.0/4 dev eth0`” so that the multicast frames are able to be sent out. (note that eth0 is the interface name)
  - On the node that is the target of a broadcast echo-request frame, the command “`ttcp -r -4 -u 224.x.x.x`” has to be executed to let the node join a multicast group.
  - On those nodes that are the target of a multicast echo-request frame, the command “`sysctl net.ipv4.icmp_echo_ignore_broadcasts=0`” has to be executed so that these nodes can send back echo-reply frames.
- ◆ Promiscuous Mode
  - Execute the command “`ip link set eth0 promisc on`” on a node to activate the promiscuous mode. (note that eth0 is the interface name)