Network vs. Link Addresses

Network addresses as **IP** addresses:

Link addresses as **MAC** (medium access control) addresses:

Network vs. Link Addresses

Network addresses as **IP** addresses:

`155.98.69.112` — 32 bytes

`2607:f8b0:4025::2004` — 128 bytes

Link addresses as **MAC** (medium access control) addresses:

`A4-CF-99-90-44-DE` — 48 bytes

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Interface always knows its MAC more like an *identity* than an *address*

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Phones may randomize identity, though

Interface always knows its MAC

more like an *identity* than an *address*

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Hierarchical by proximity

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MAC addresses are shown by `ifconfig`

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Address Resolution Protocol (ARP)

Ethernet	**IP**	**TCP**	`GET / HTTP/1.1`
src: `A0-44-5F-63-8B-BC`	src: `10.0.1.23`	src port: `7786`	`Host: cs.utah.edu"`
dest: `???`	dest: `141.193.213.10`	dest port: `80`	

Address Resolution Protocol (ARP)

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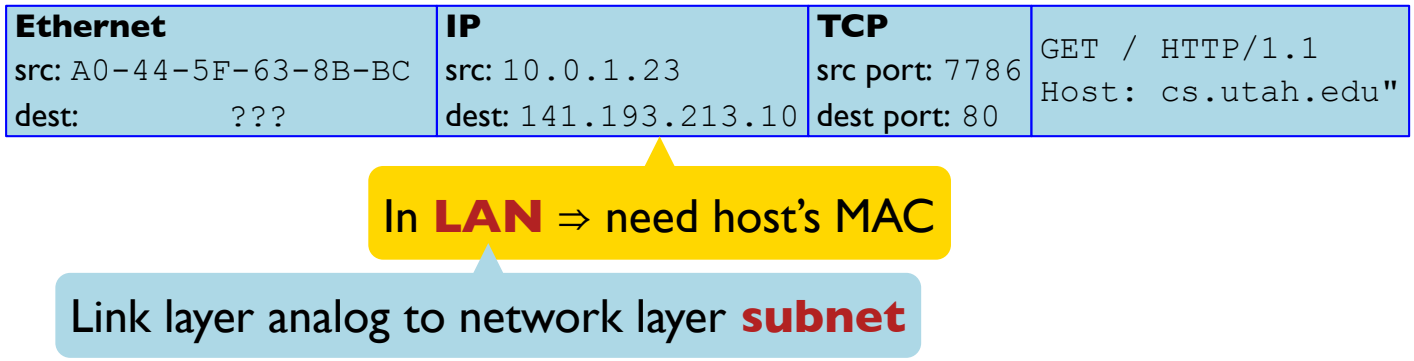
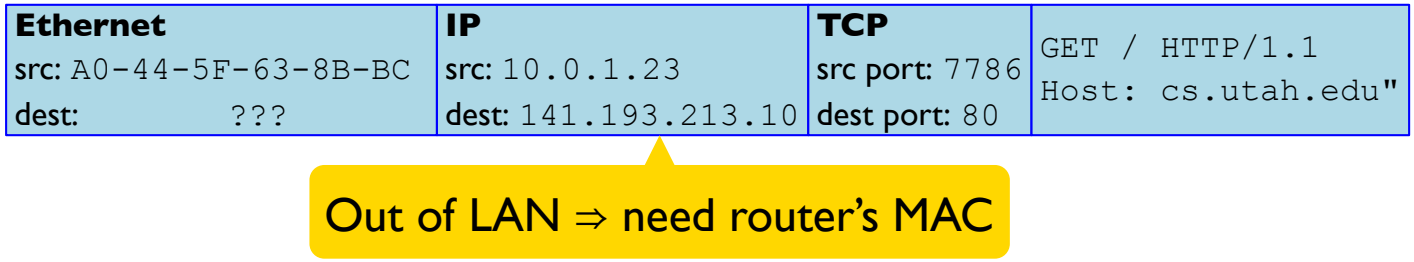
src: A0-44-5F-63-8B-BC	src: 10.0.1.23	src port: 7786	GET / HTTP/1.1
dest: ???	dest: 141.193.213.10	dest port: 80	Host: cs.utah.edu"

In **LAN** ⇒ need host's MAC

Address Resolution Protocol (ARP)



Address Resolution Protocol (ARP)



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src: A0-44-5F-63-8B-BC	src: 10.0.1.23	src port: 7786	GET / HTTP/1.1
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ARP is a LAN protocol to get IP → MAC mappings

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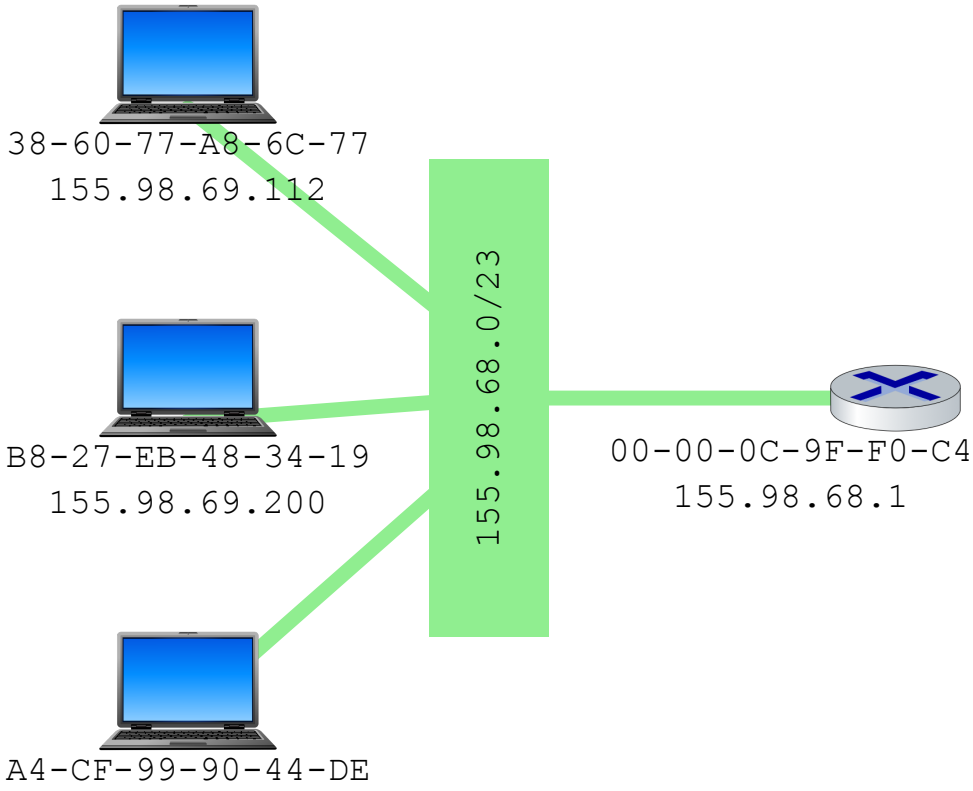
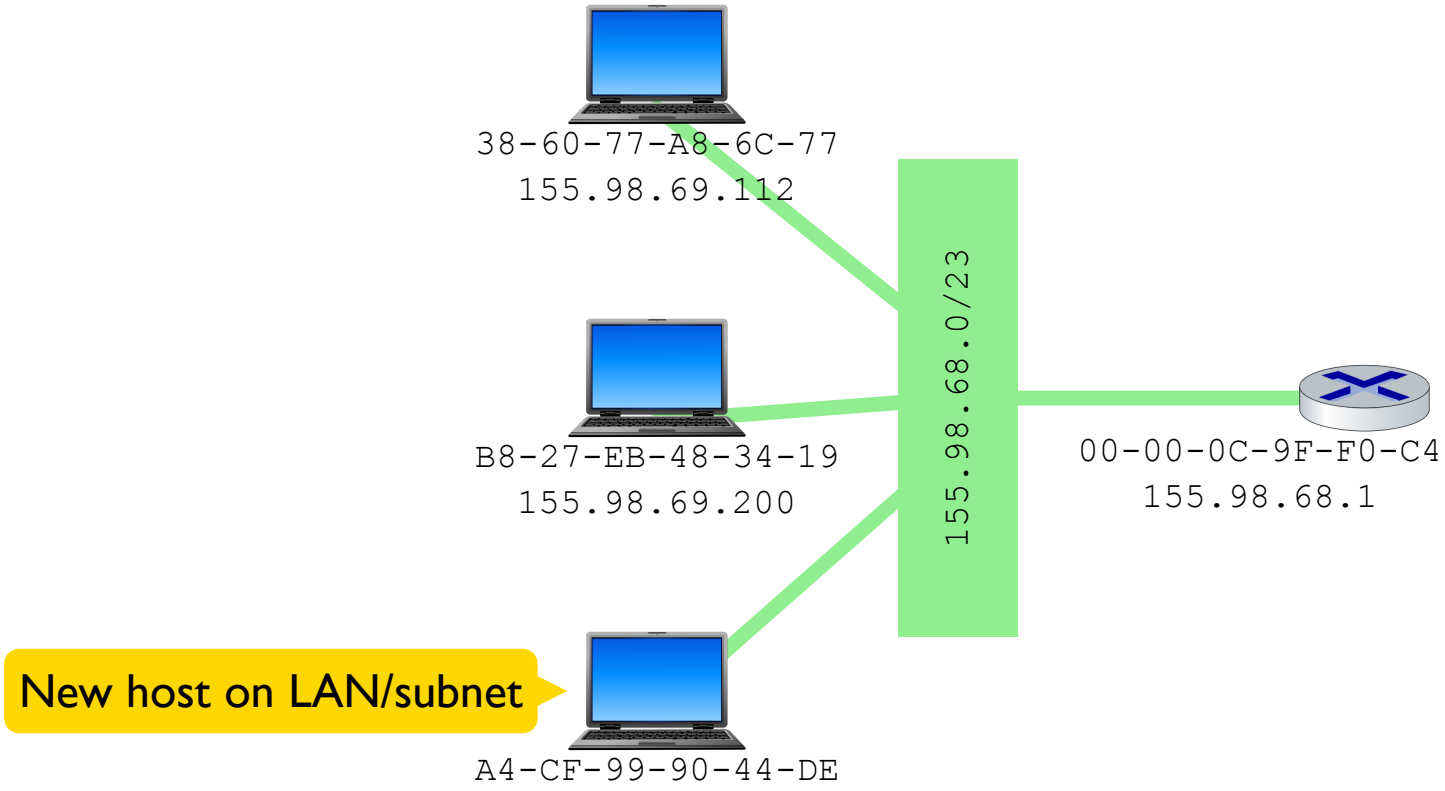
ARP is a LAN protocol to get IP → MAC mappings

Uses FF-FF-FF-FF-FF-FF broadcast address

From DHCP to ARP to HTTP



From DHCP to ARP to HTTP



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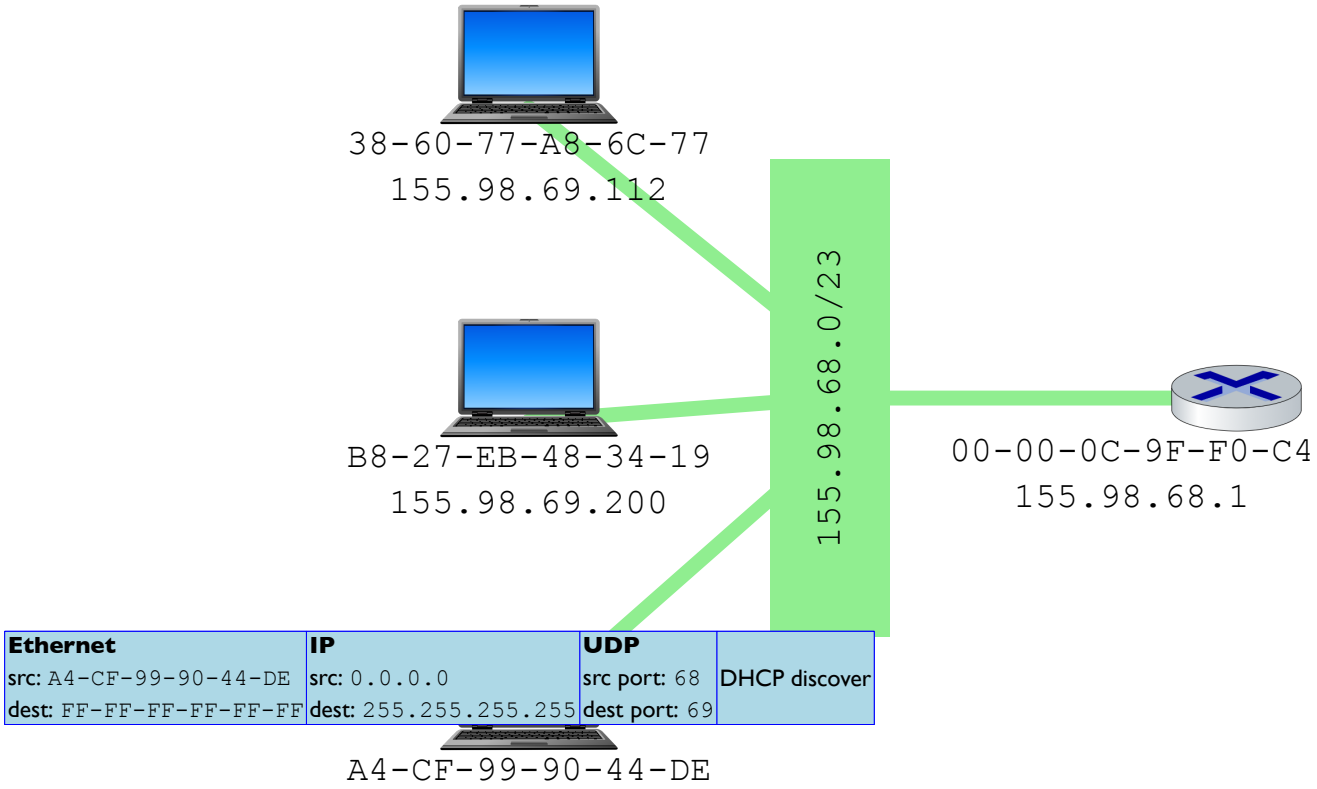
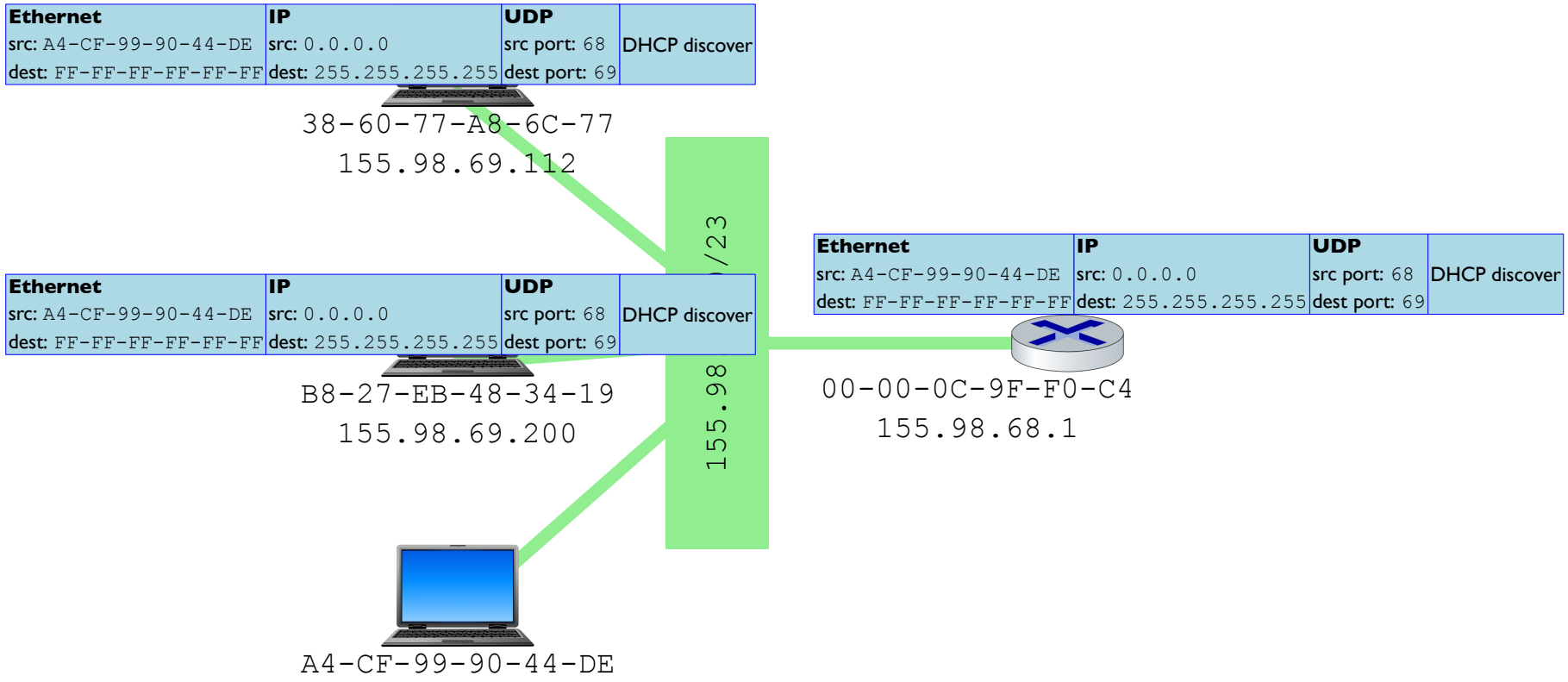


From DHCP to ARP to HTTP



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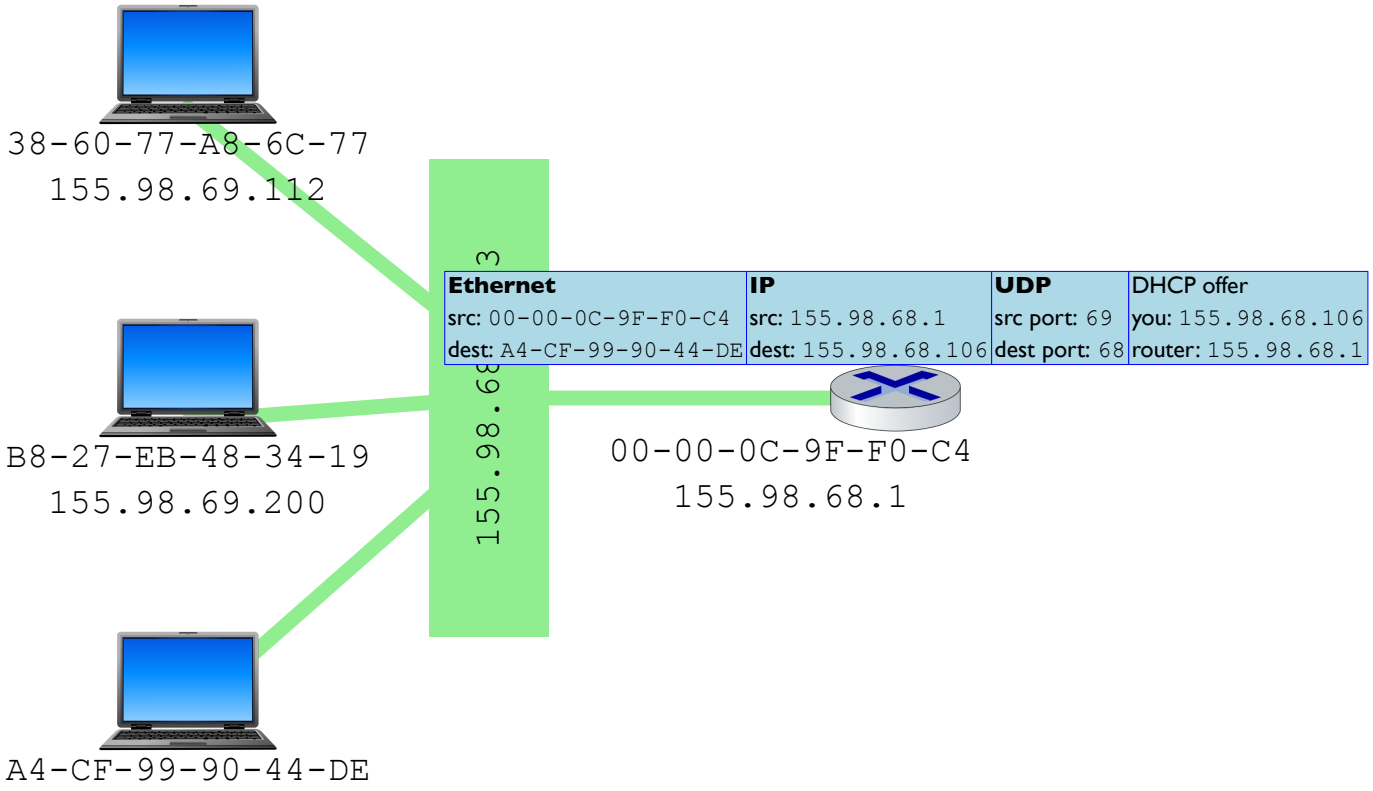

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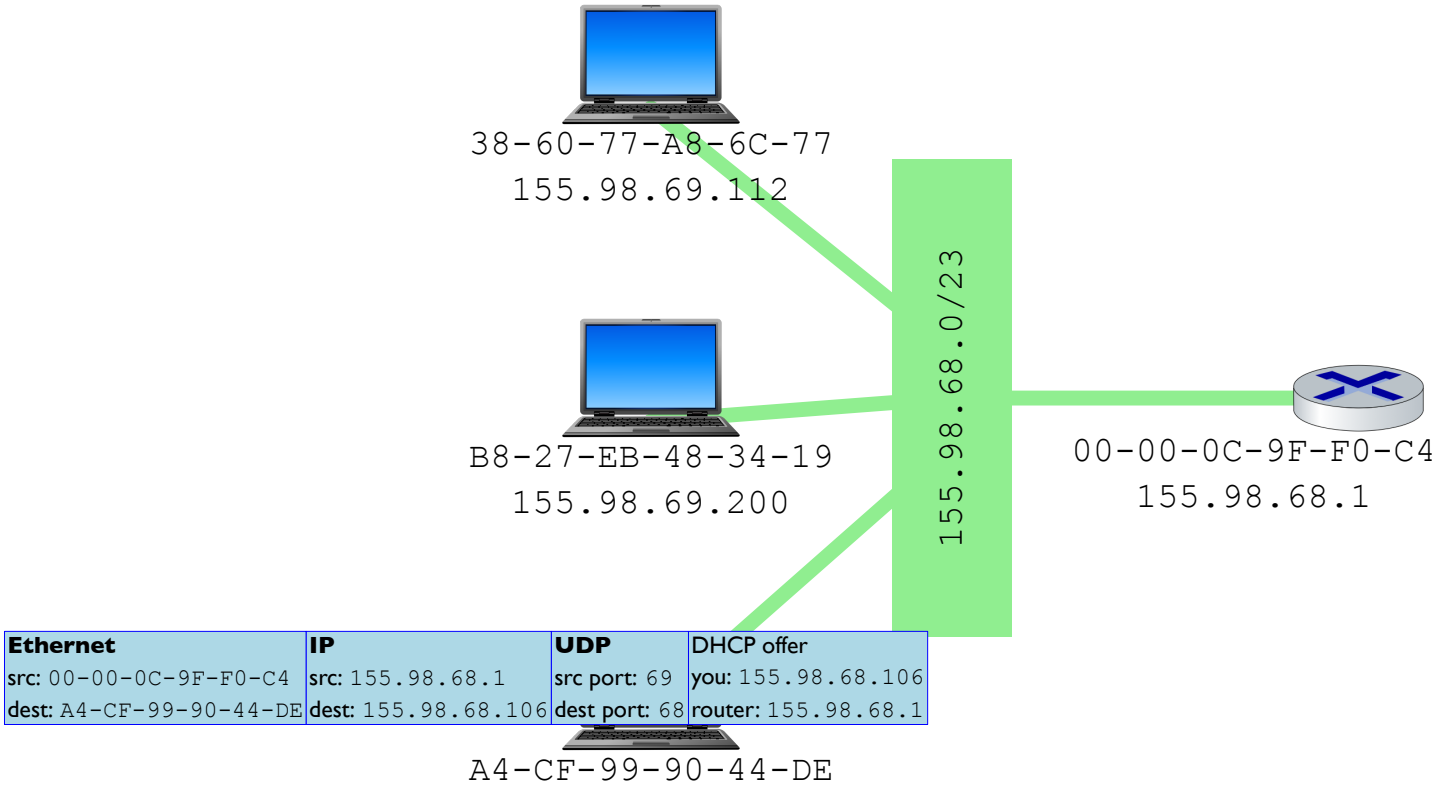
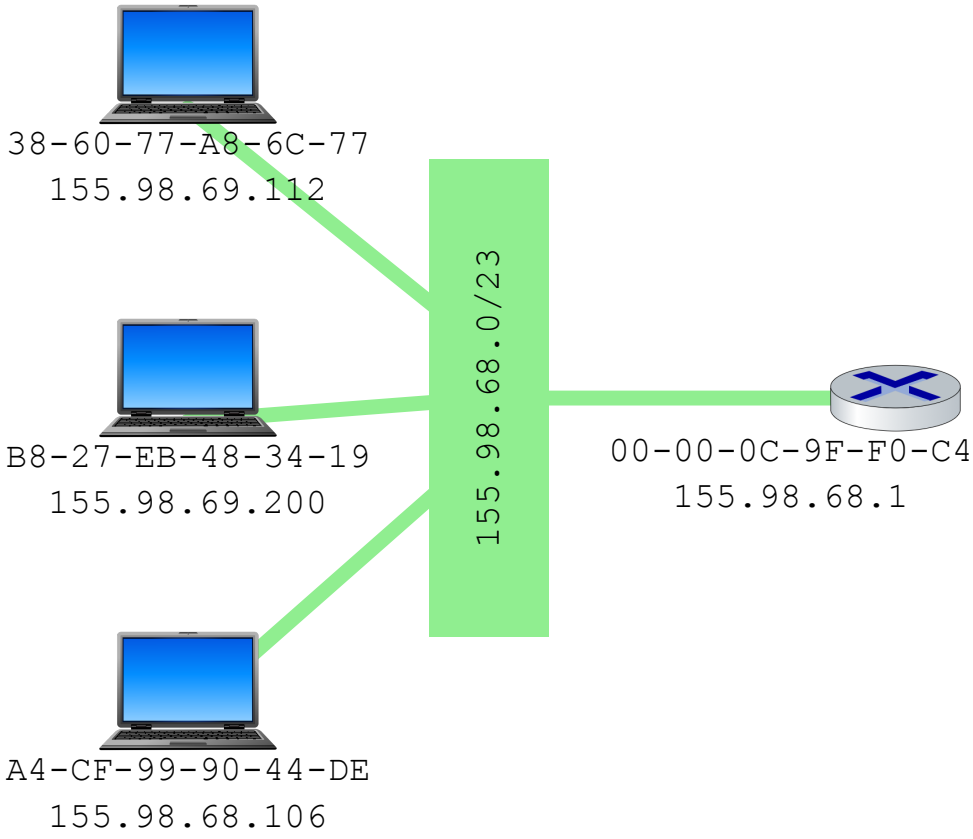


Ethernet	**IP**	**UDP**	DHCP offer
src: 00-00-0C-9F-F0-C4	src: 155.98.68.1	src port: 69	you: 155.98.68.106
dest: A4-CF-99-90-44-DE	dest: 155.98.68.106	dest port: 68	router: 155.98.68.1

From DHCP to ARP to HTTP



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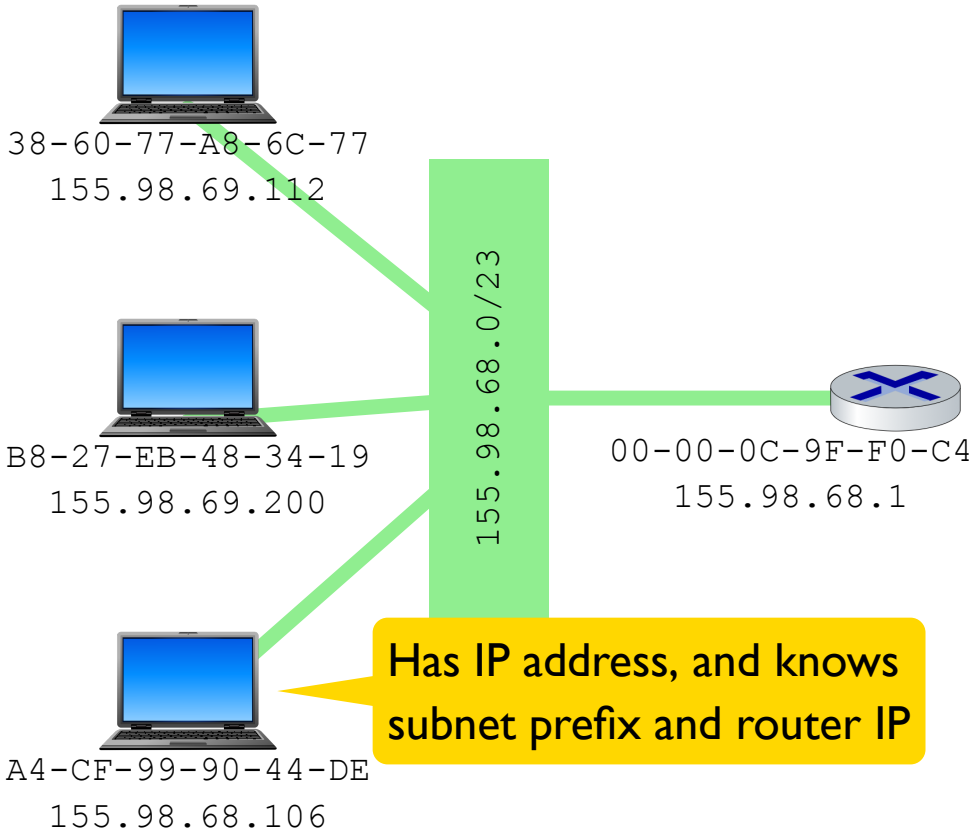

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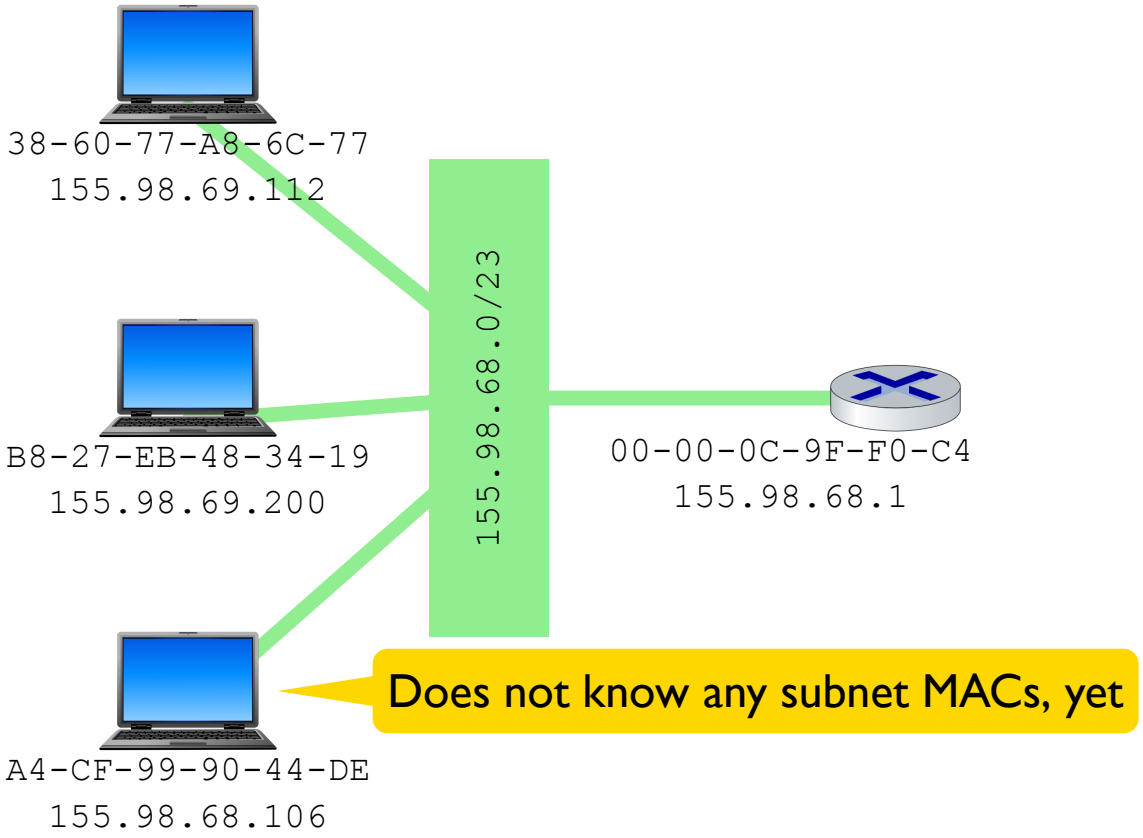

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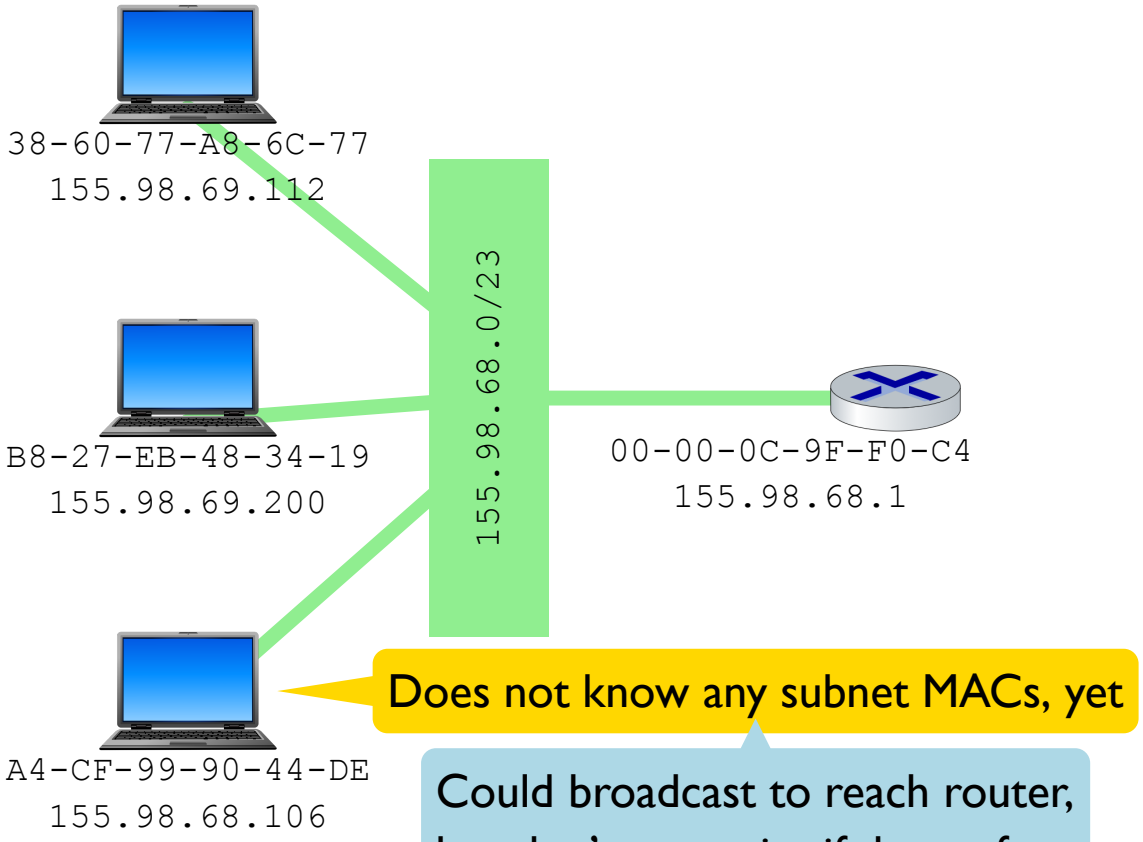

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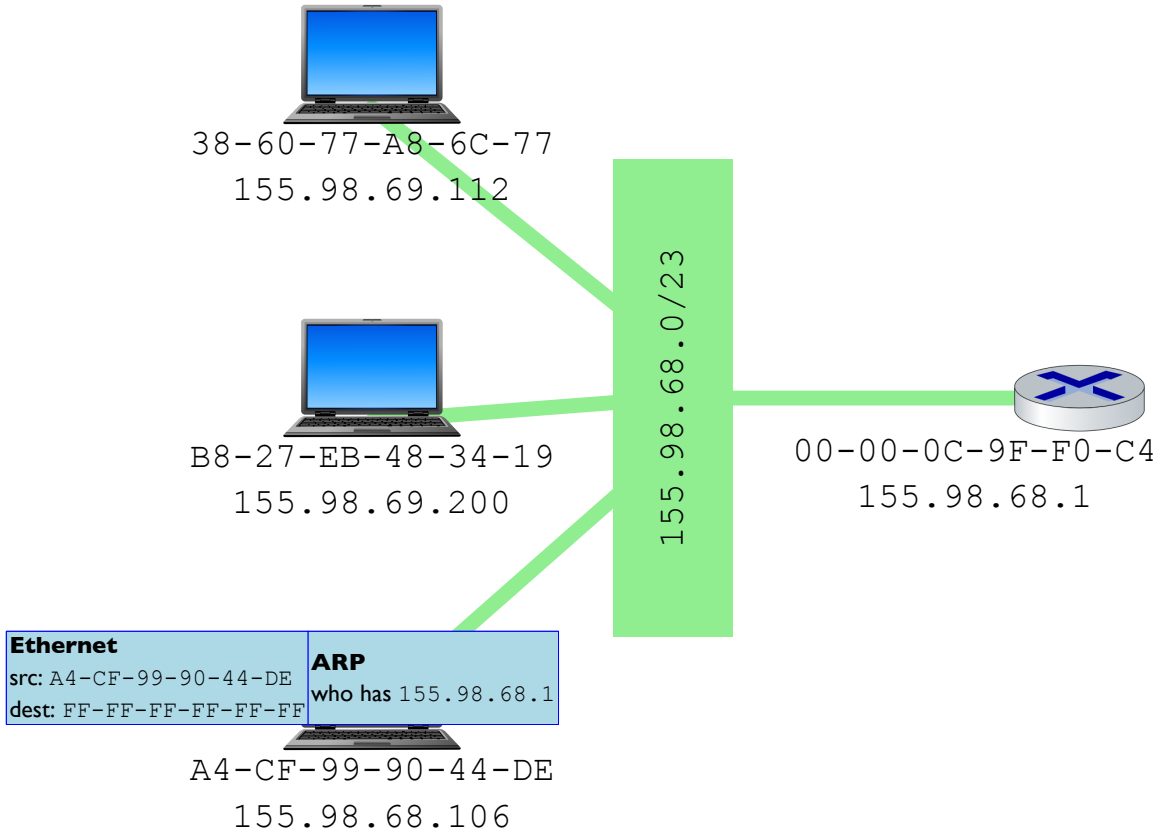

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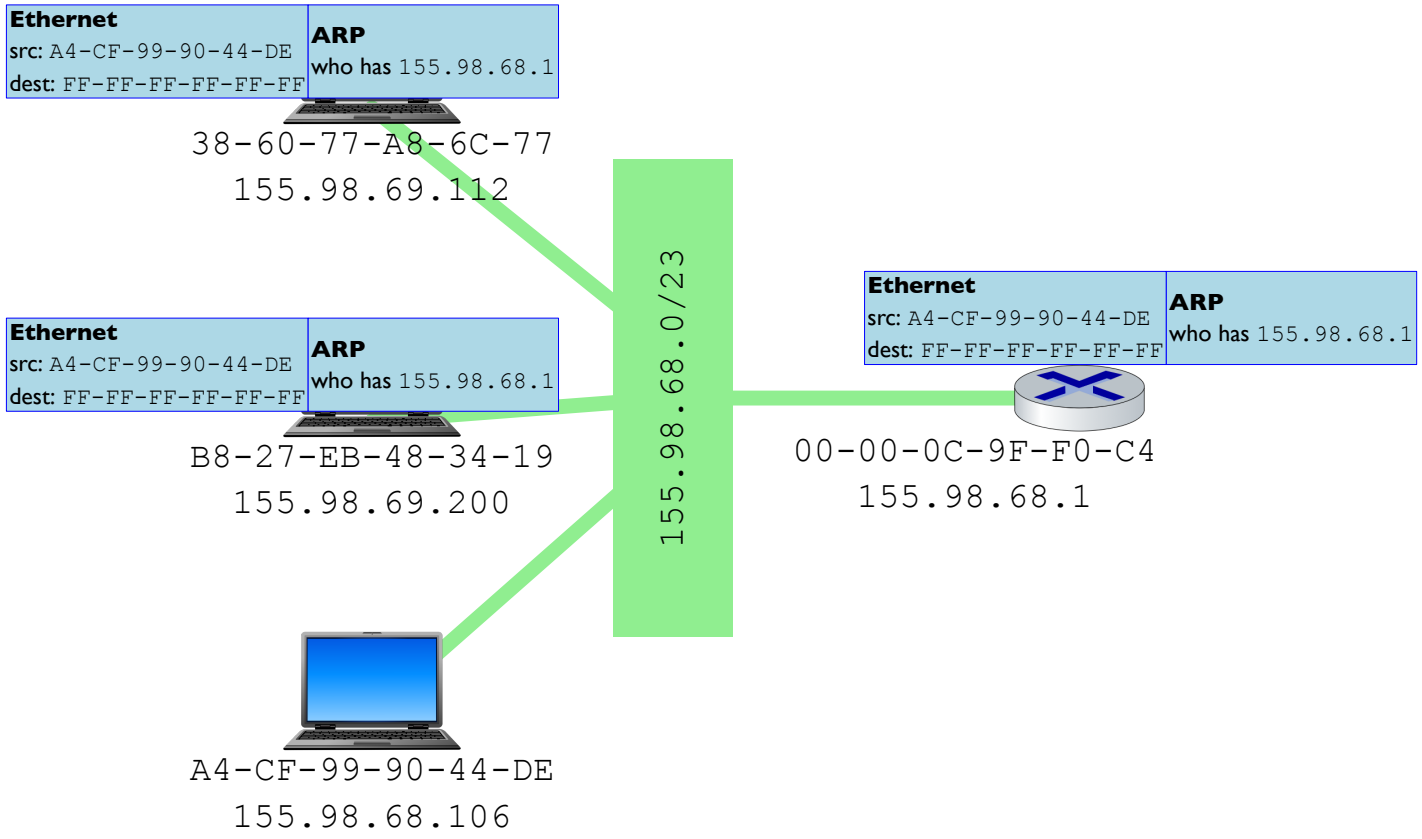

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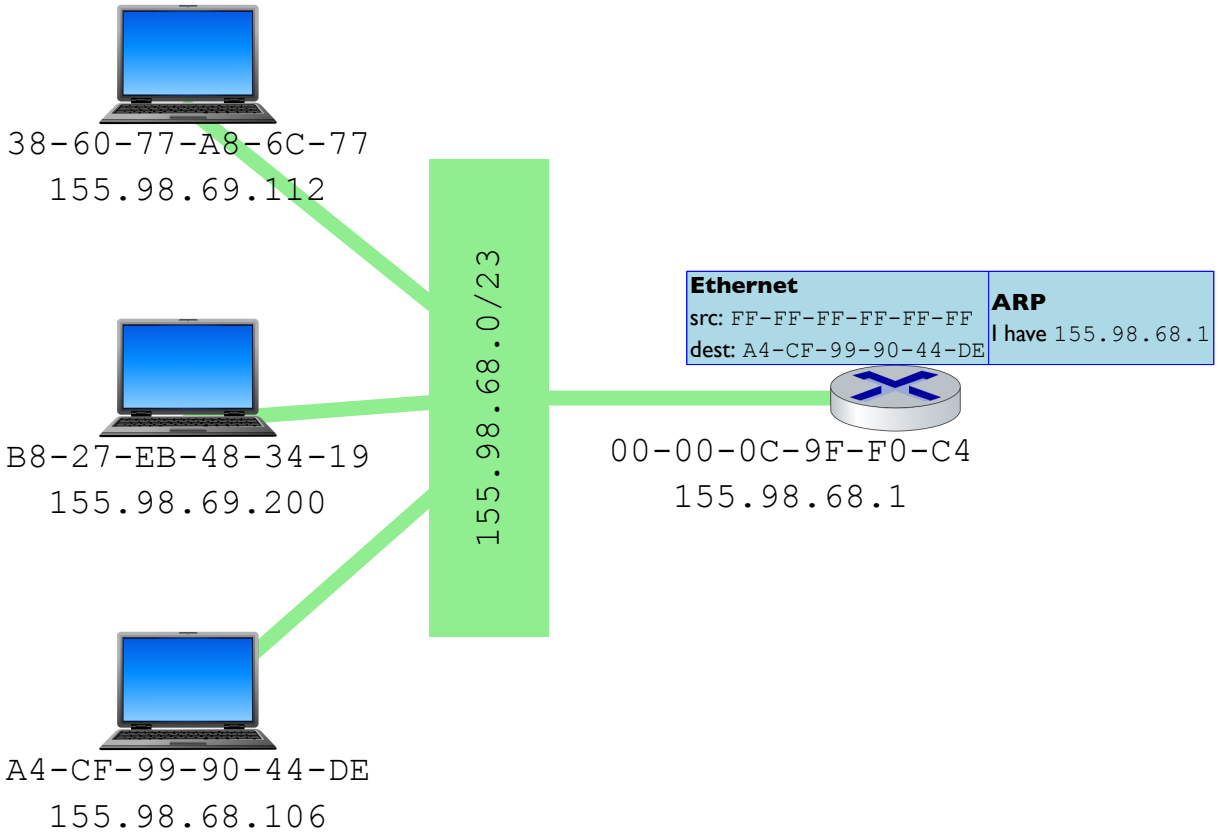
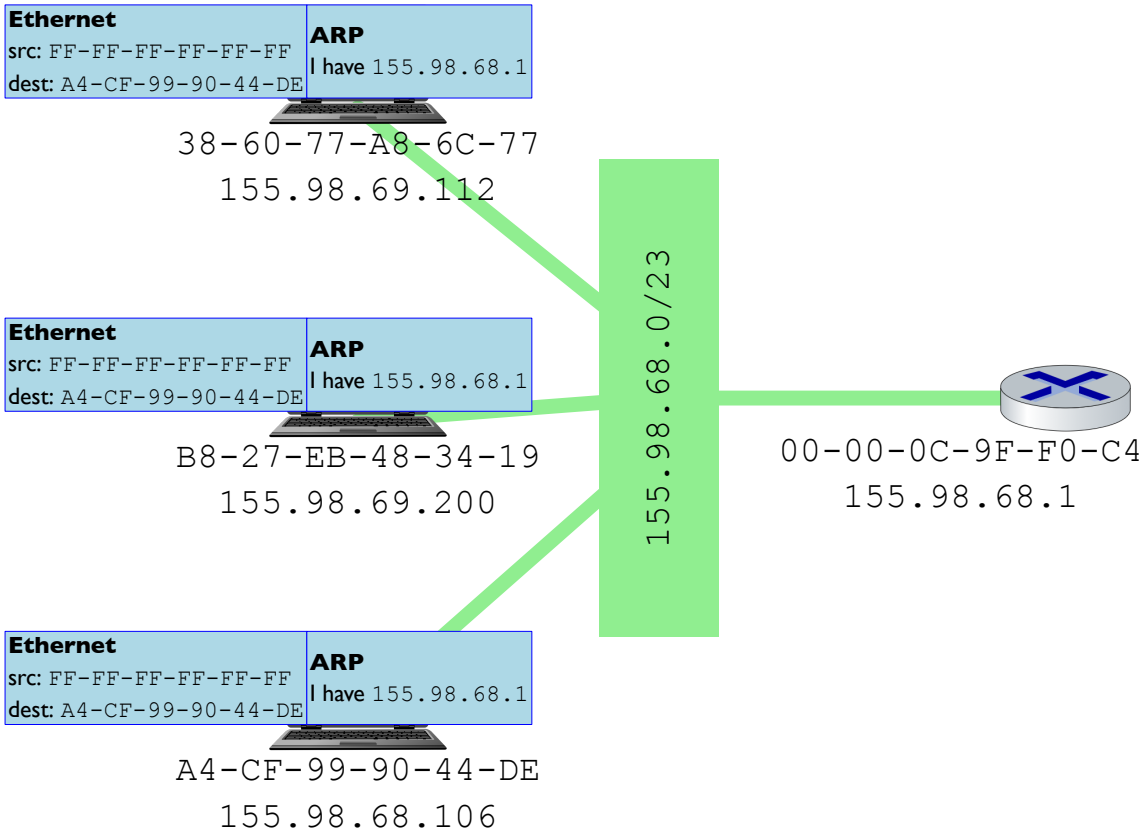


From DHCP to ARP to HTTP



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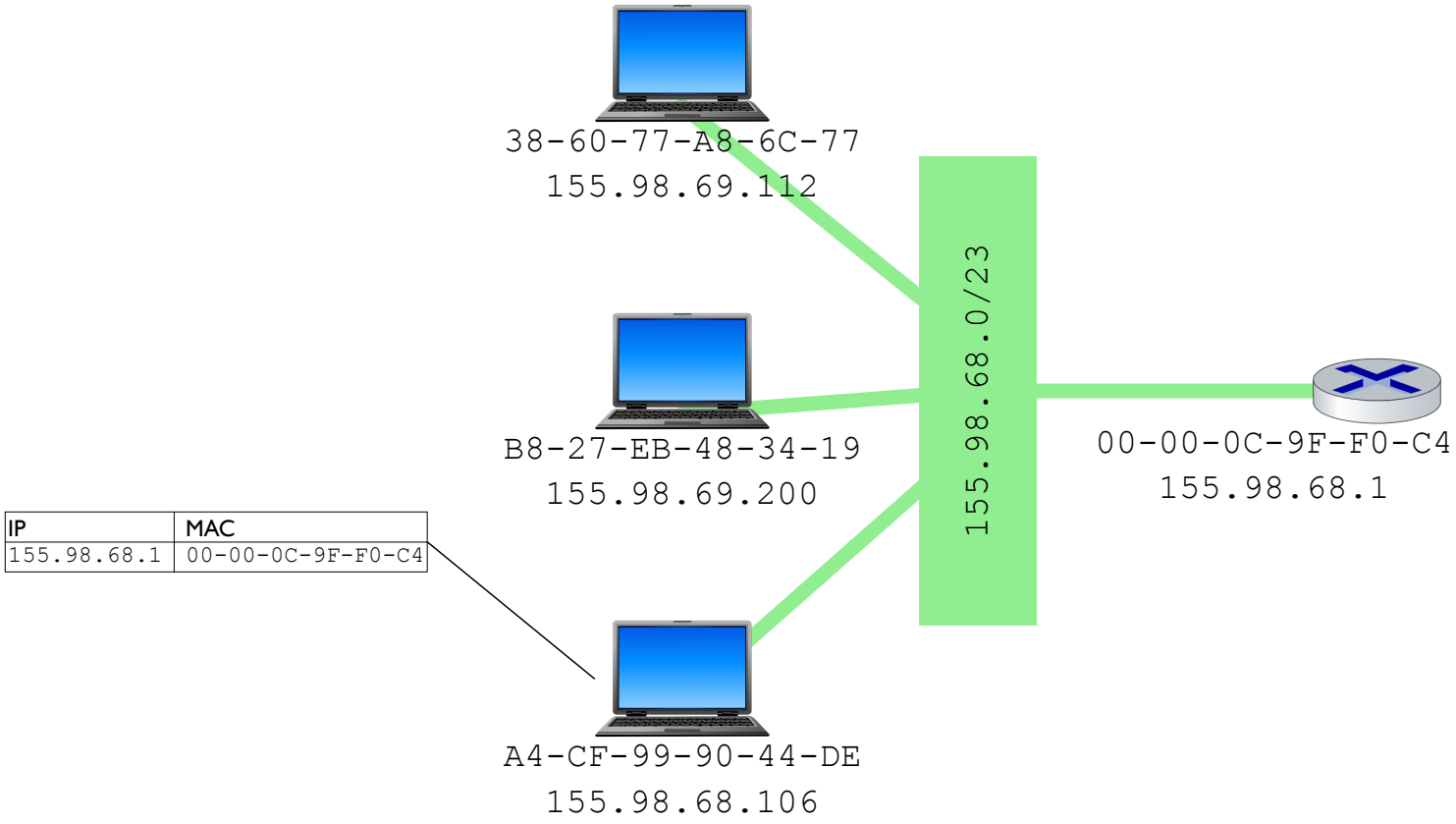

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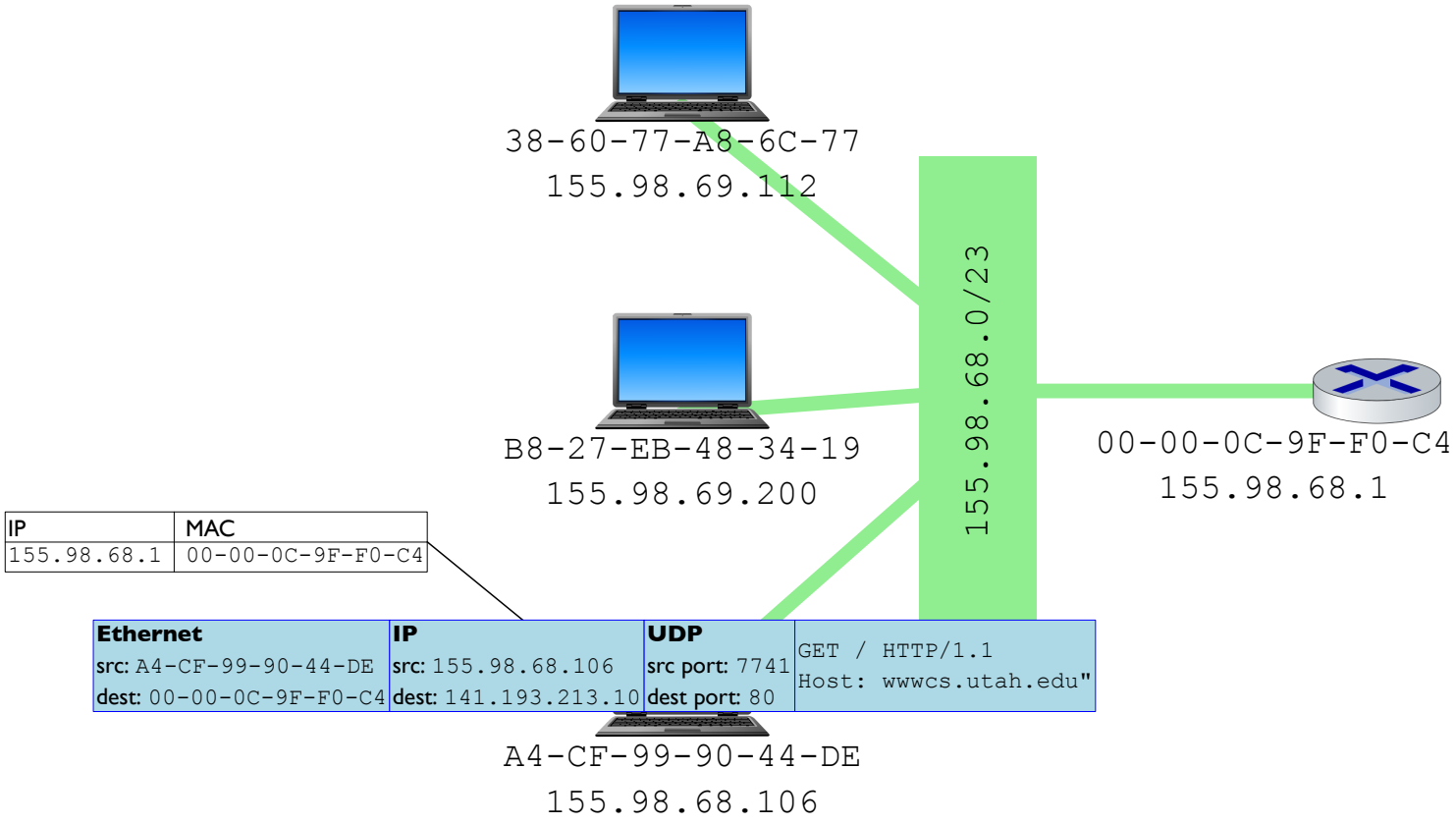

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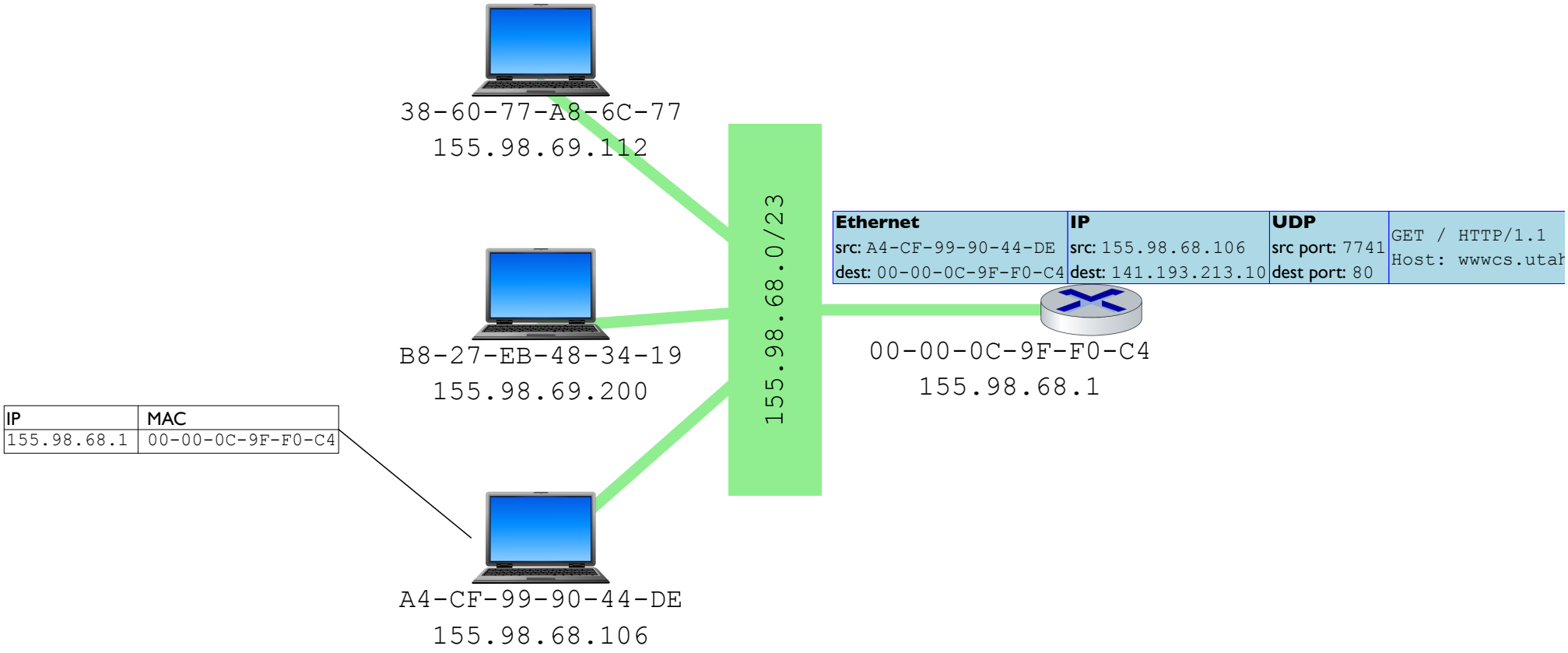

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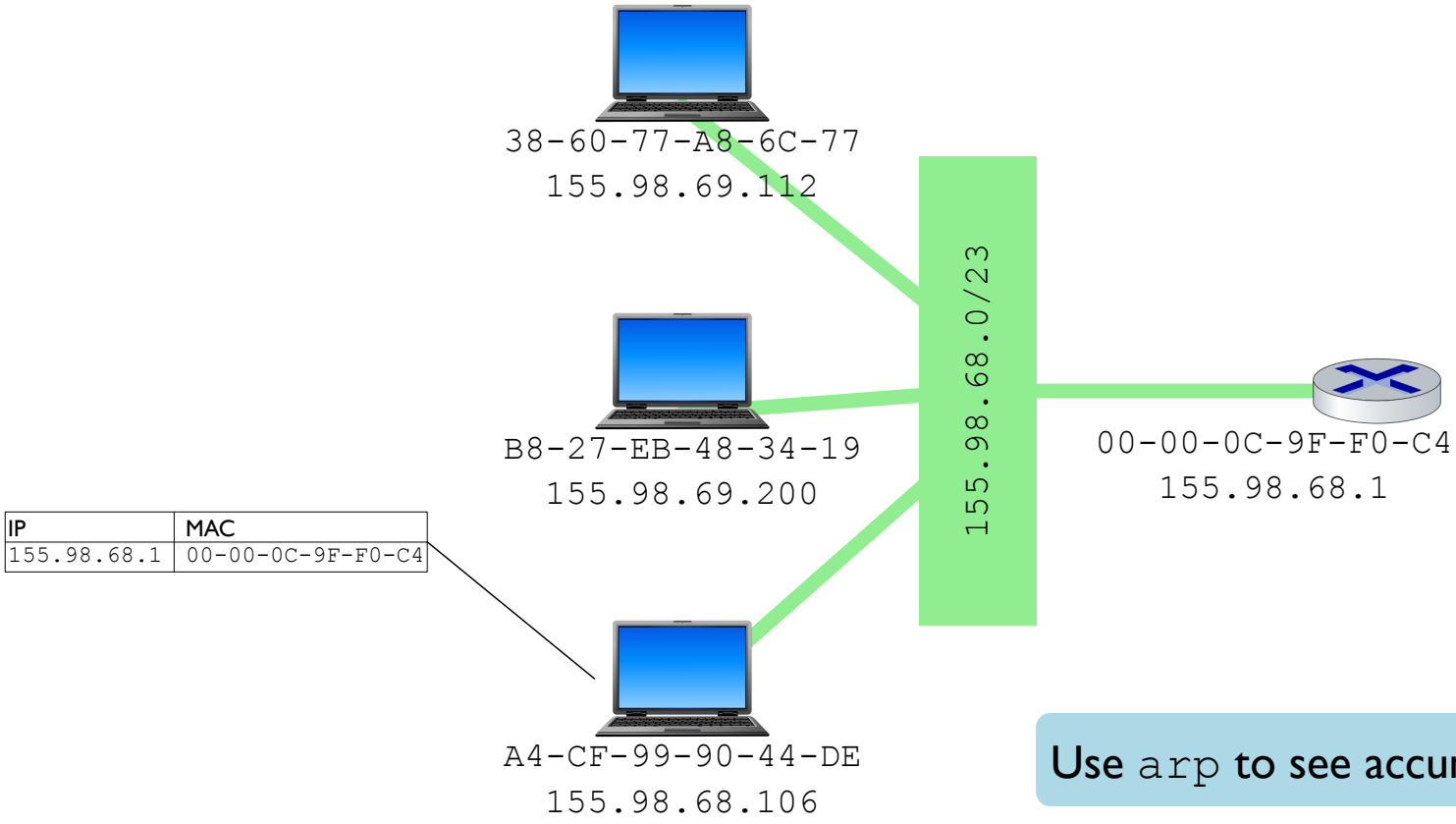
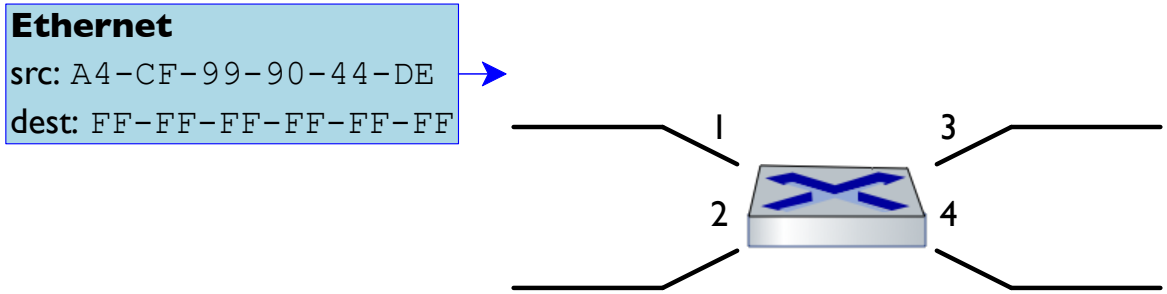


Use `arp` to see accumulated IP → MAC table

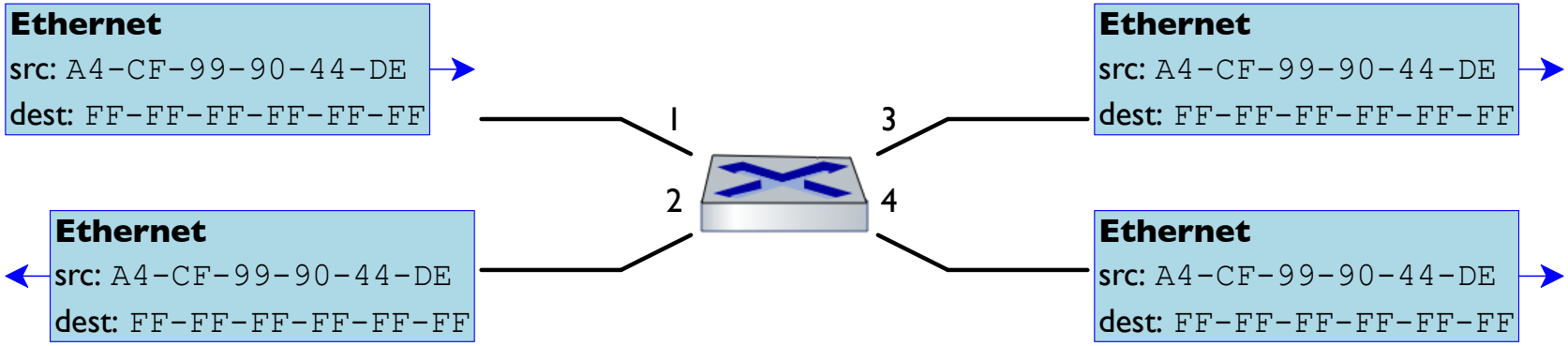
Switches

Switches

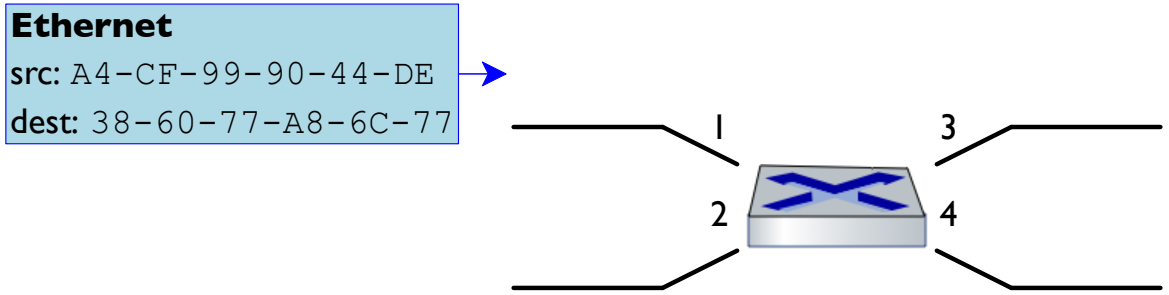
Switches



Switches


Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
1
2
3
4

Switches



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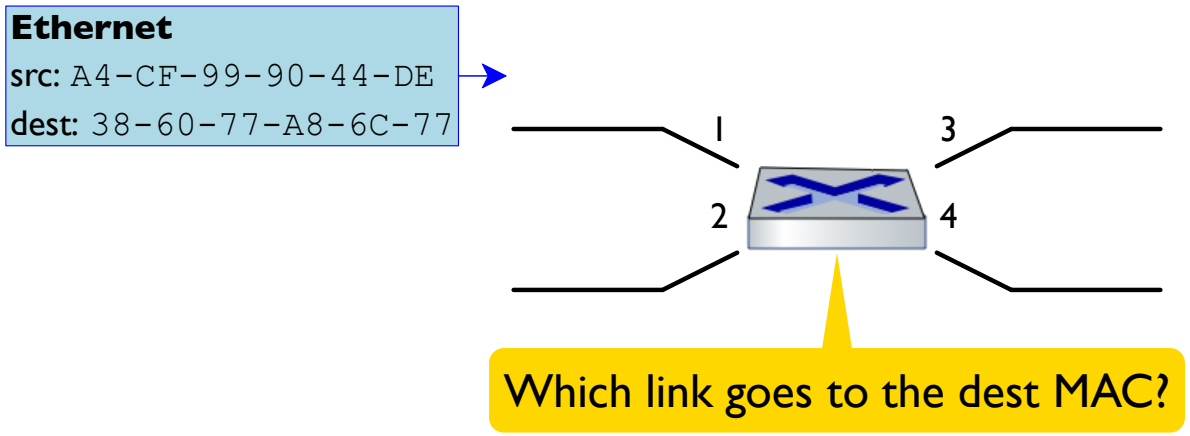

Ethernet
src: A4-CF-99-90-44-DE
dest: 38-60-77-A8-6C-77
1
2
3
4
Which link goes to the dest MAC?

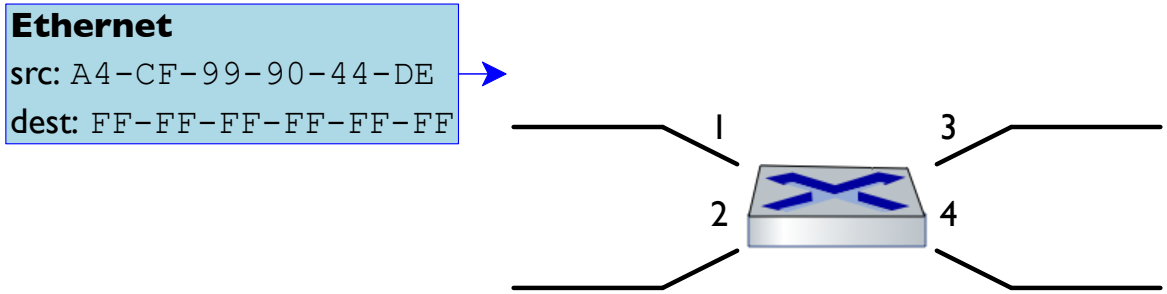
Switches

Ethernet
src: A4-CF-99-90-44-DE
dest: 38-60-77-A8-6C-77

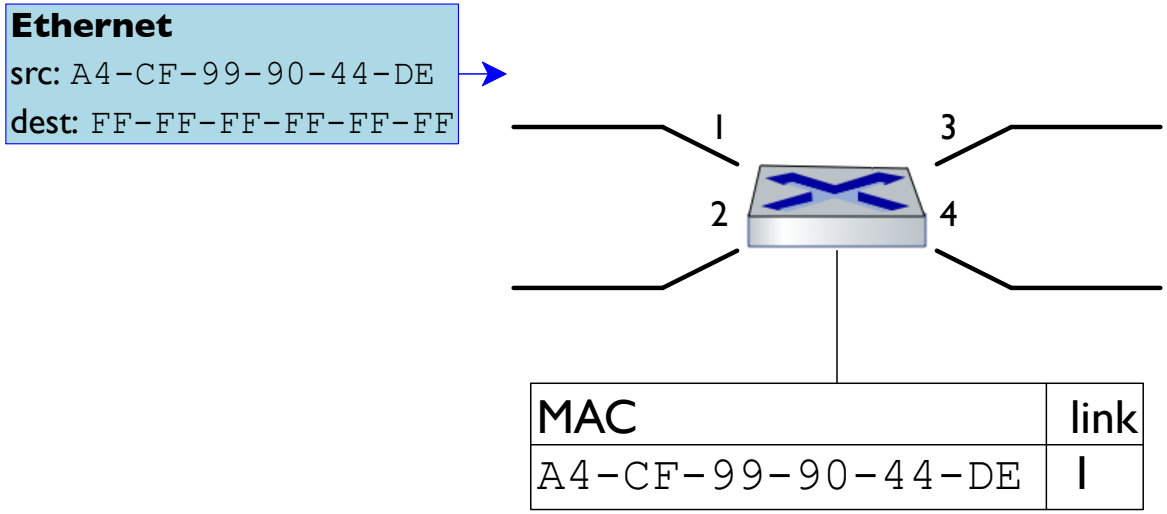
Which link goes to the dest MAC?

Instead of having to configure a switch, rely on the fact that some earlier broadcast was needed for anyone to find another MAC

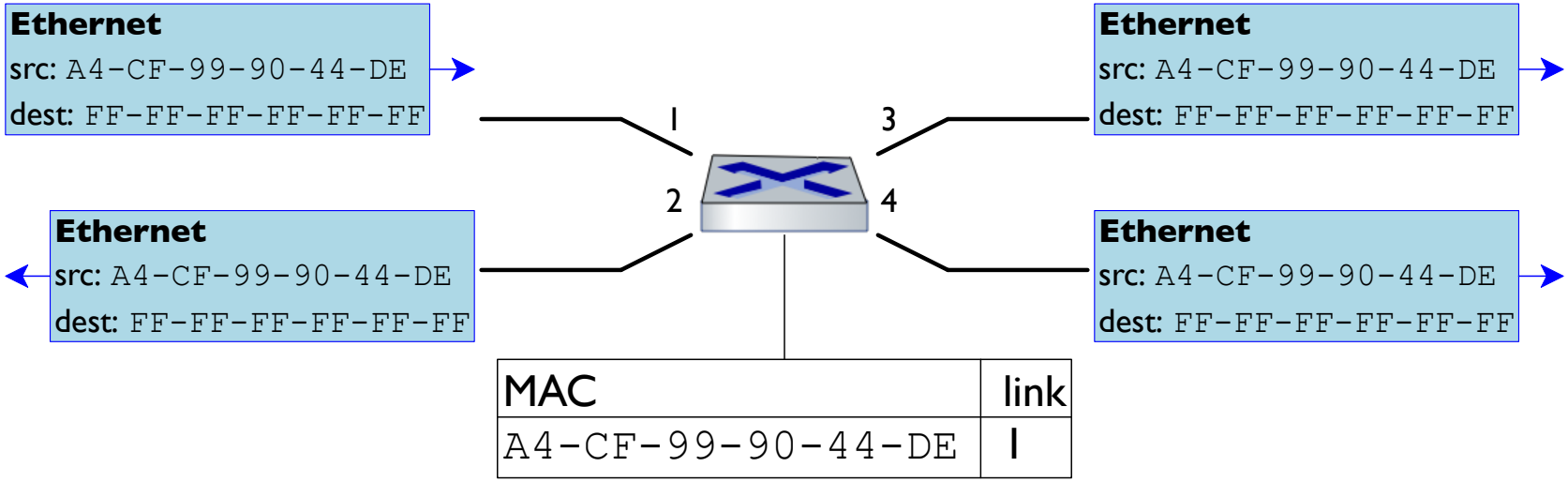
Switches



Switches


Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
1
2
3
4
MAC
link
A4-CF-99-90-44-DE
1

Switches


Ethernet
src: A4-CF-99-90-44-DE
dest: FF-FF-FF-FF-FF-FF
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2
3
4
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A4-CF-99-90-44-DE
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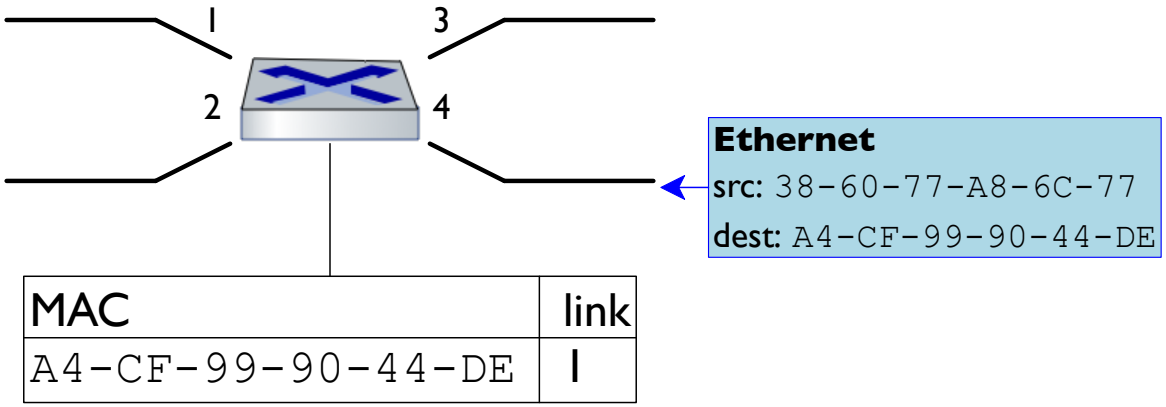
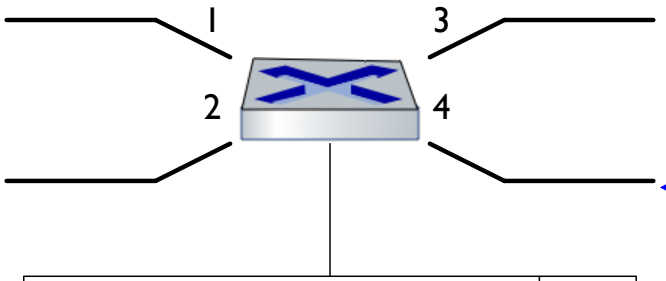
Switches


1
3
2
4
Ethernet
src: 38-60-77-A8-6C-77
dest: A4-CF-99-90-44-DE
MAC
link
A4-CF-99-90-44-DE
1

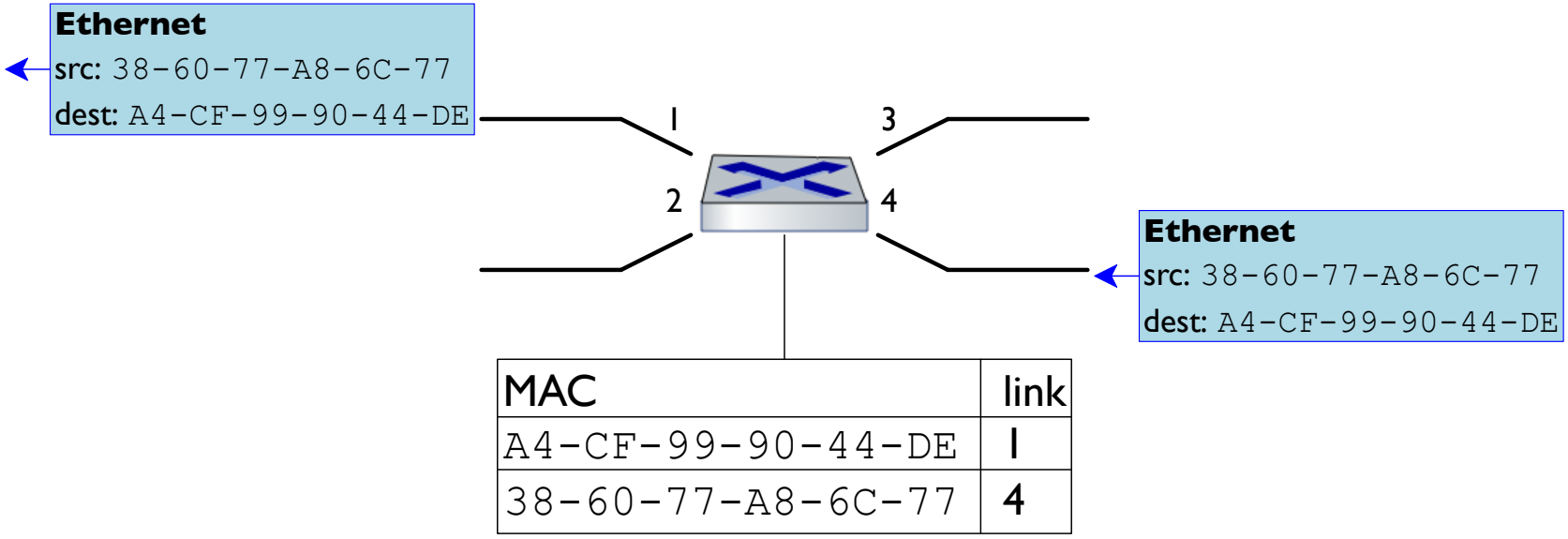
Switches



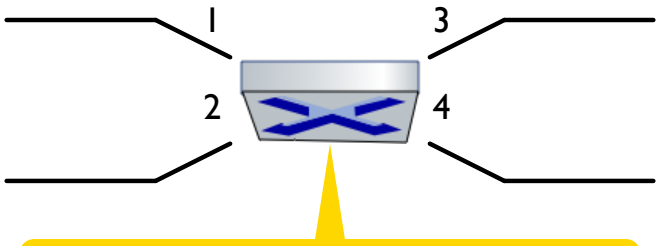
Ethernet
src: `38-60-77-A8-6C-77`
dest: `A4-CF-99-90-44-DE`

MAC	link
`A4-CF-99-90-44-DE`	1
`38-60-77-A8-6C-77`	4

Switches


Ethernet
src: 38-60-77-A8-6C-77
dest: A4-CF-99-90-44-DE
1
3
2
4
Ethernet
src: 38-60-77-A8-6C-77
dest: A4-CF-99-90-44-DE
MAC
link
A4-CF-99-90-44-DE
1
38-60-77-A8-6C-77
4

Hubs

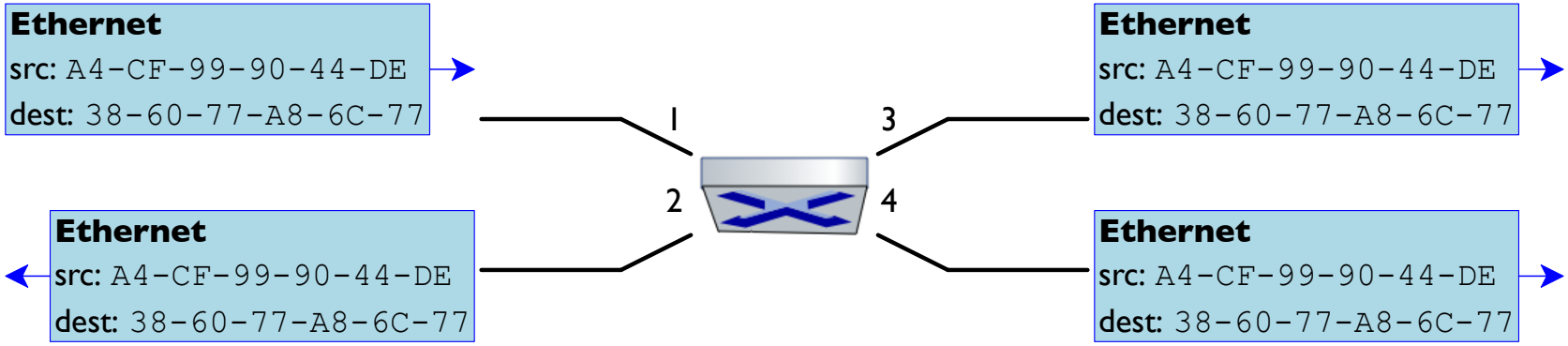


A **hub** is older technology that just broadcasts everything

Hubs

Ethernet
src: A4-CF-99-90-44-DE
dest: 38-60-77-A8-6C-77

Hubs


Ethernet
src: A4-CF-99-90-44-DE
dest: 38-60-77-A8-6C-77
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src: A4-CF-99-90-44-DE
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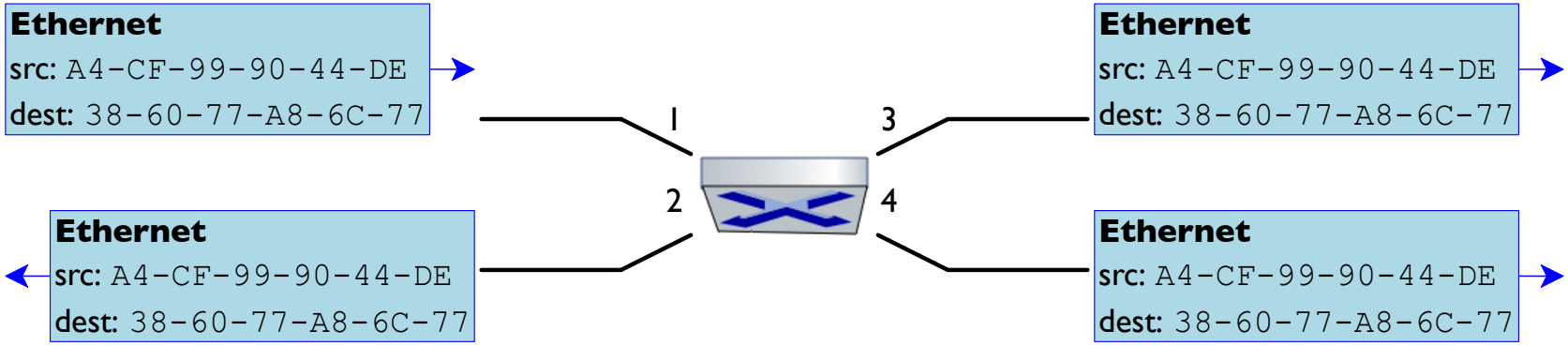
Ethernet
src: A4-CF-99-90-44-DE
dest: 38-60-77-A8-6C-77
1
2
3
4

Hubs



Switch vs. hub: always choose a switch

Router vs. Switch

Router

Switch

Router vs. Switch

Router

– Must configure

Switch

+ Infers routing

Router vs. Switch

Router

- Must configure
+ Prefix routing

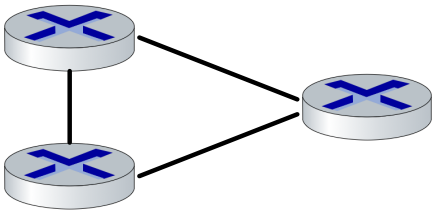
Switch

+ Infers routing
- Entry per address

Router vs. Switch

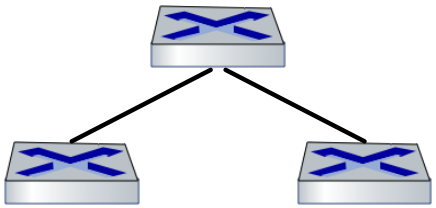
Router

- Must configure
+ Prefix routing
+ Any topology

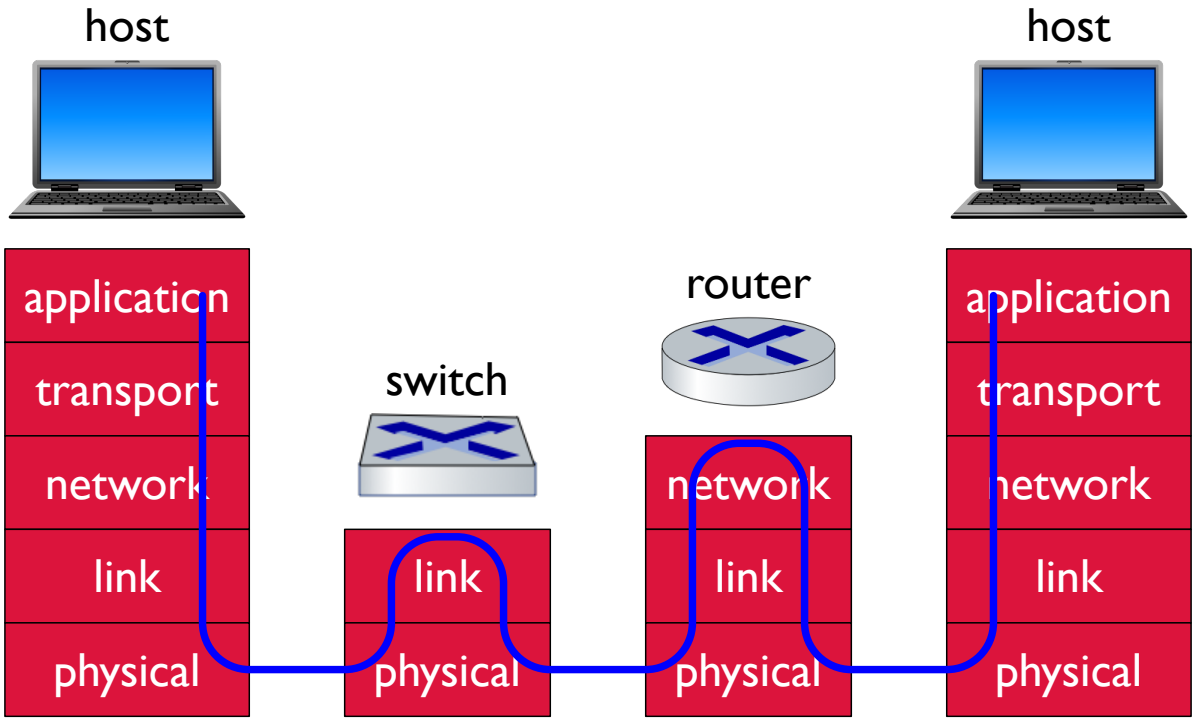


Switch

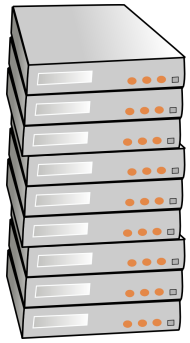
+ Infers routing
- Entry per address
- Tree topology only



Router vs. Switch

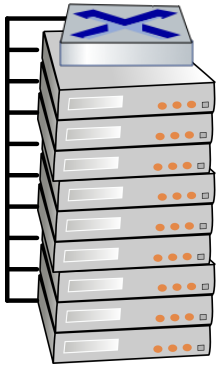


Traditional Data Center Organzation



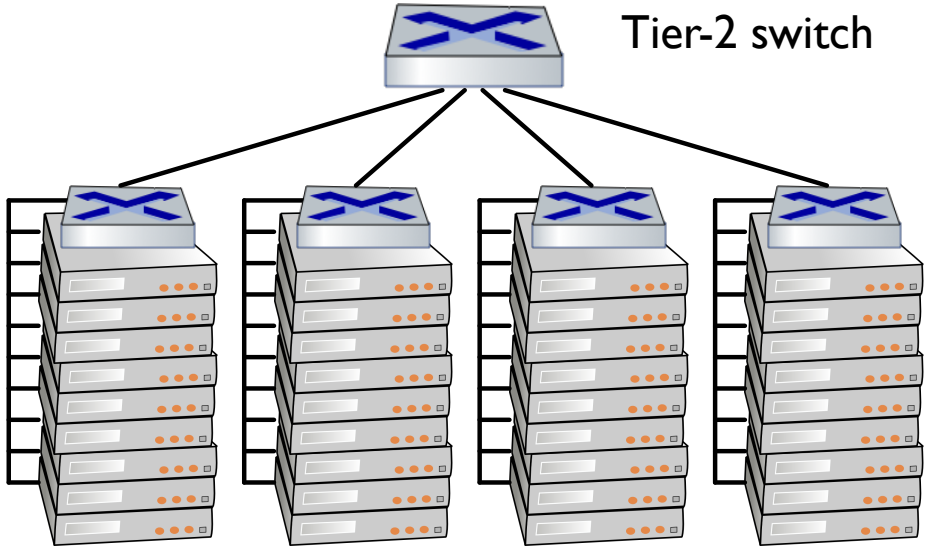
Server rack

Traditional Data Center Organzation

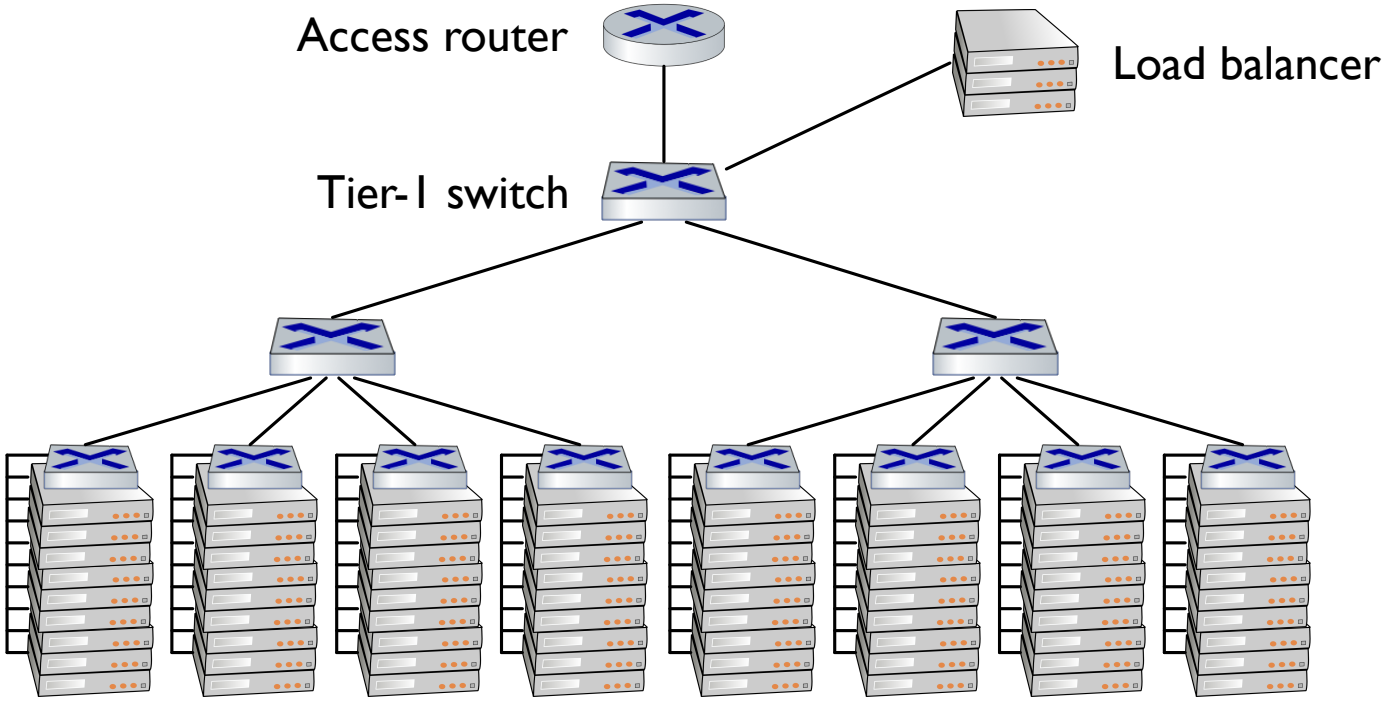


Top of rack (TOR) switch

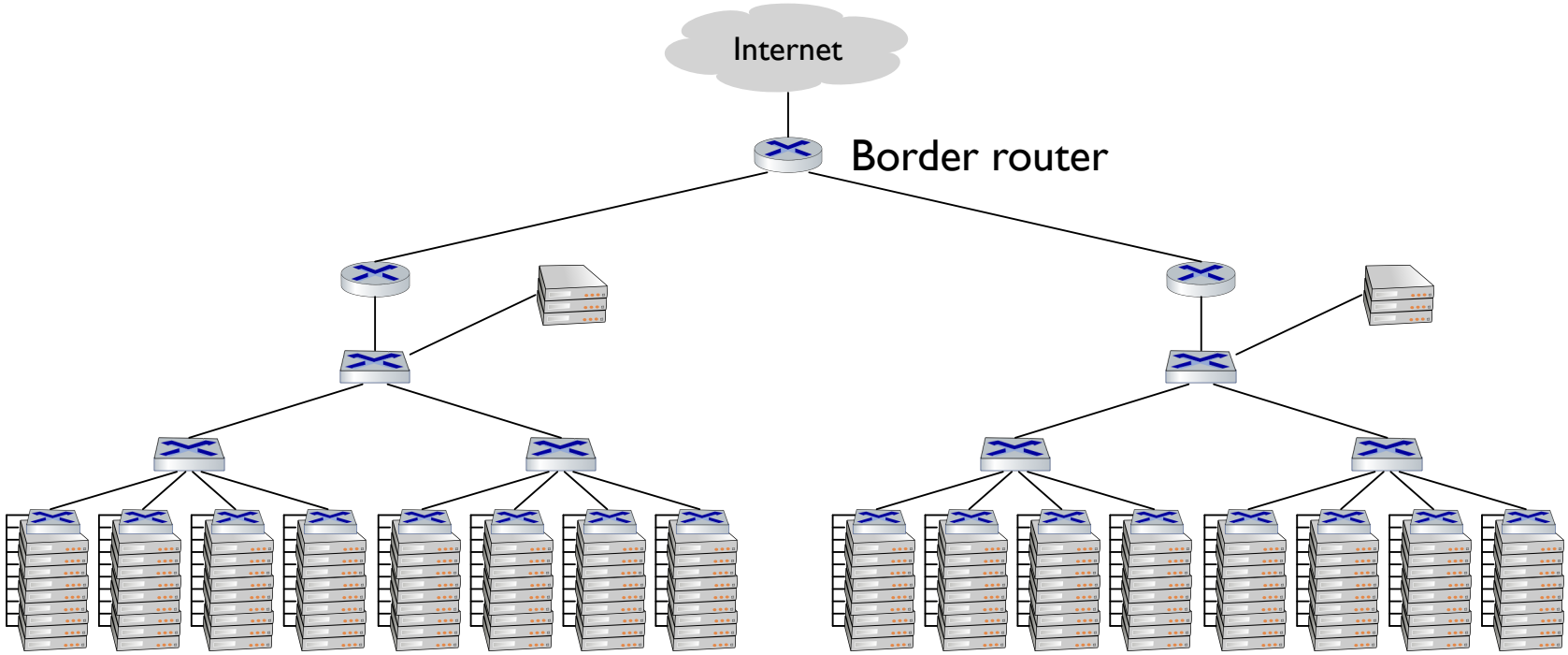
Traditional Data Center Organzation



Traditional Data Center Organzation



Traditional Data Center Organzation



Virtual LAN

Becase LAN-level organzation has traditionally implied “local,” various tools have built on that concept

example: a network printer available only within the LAN

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Becase LAN-level organzation has traditionally implied "local," various tools have built on that concept

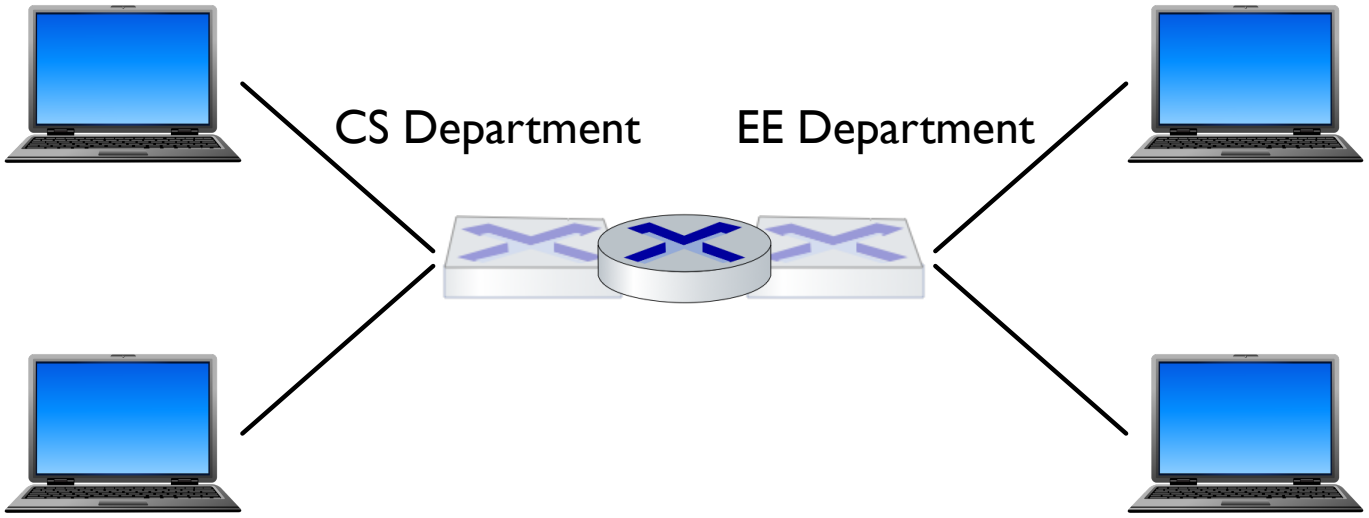
example: a network printer available only within the LAN

Any time a concept like that becomes established, though, eventually is gets *virtualized*

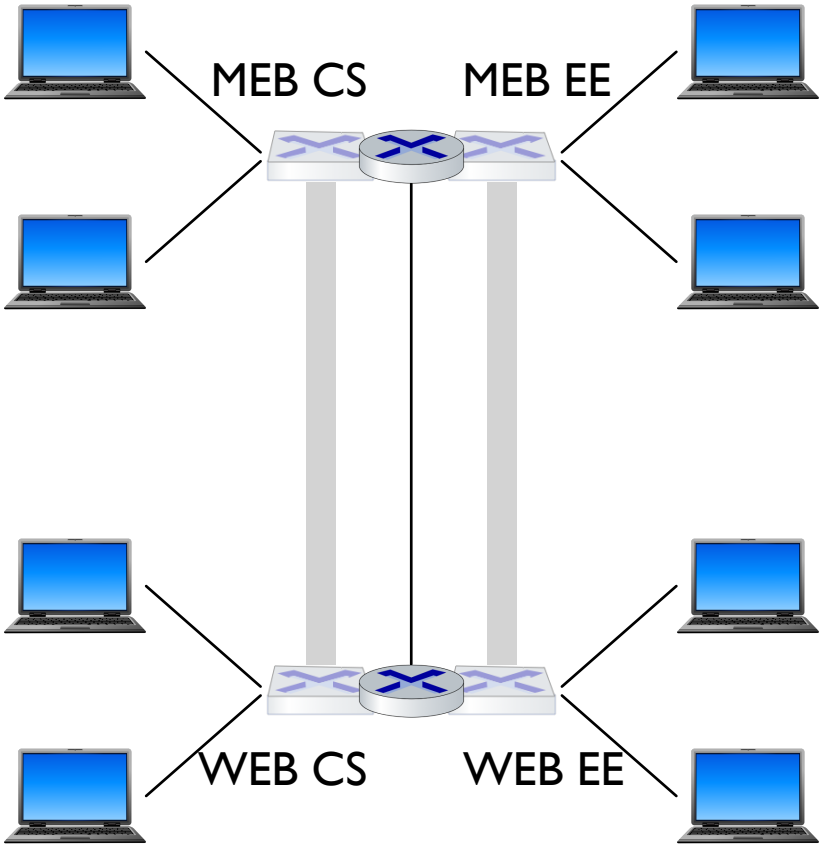
example: splitting an office into two LANs

example: sharing filesystem access across remote locations

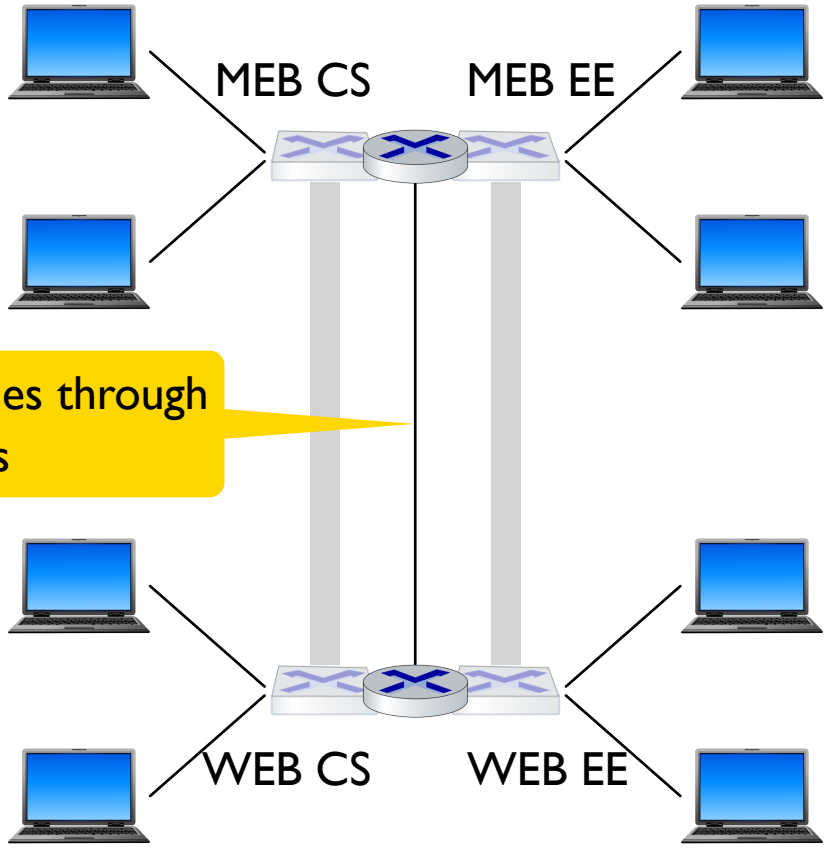
Virtual LAN



Virtual LAN

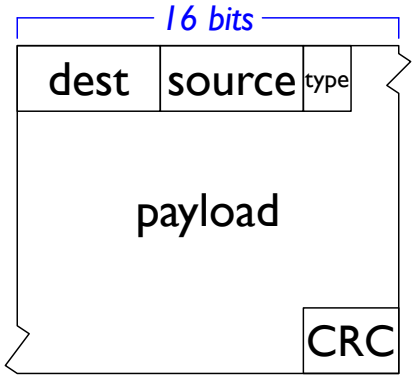


Virtual LAN

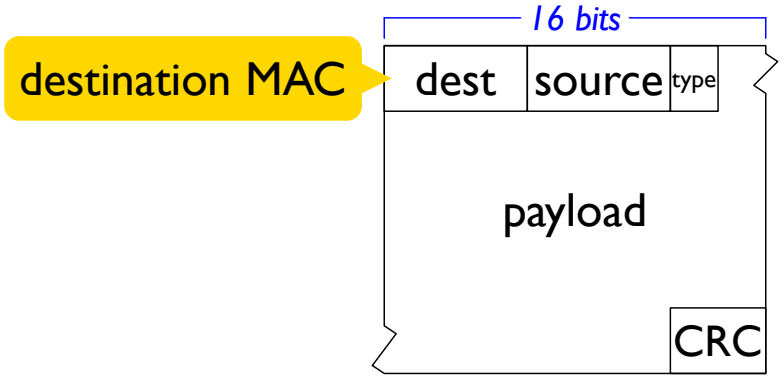


Tunnel link-leyer frames through network-layer packets

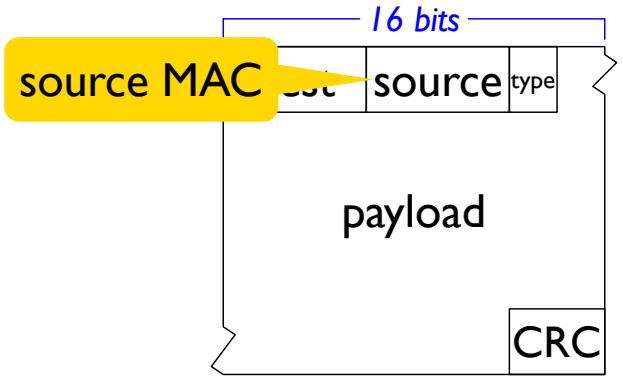
Ethernet Frame Layout



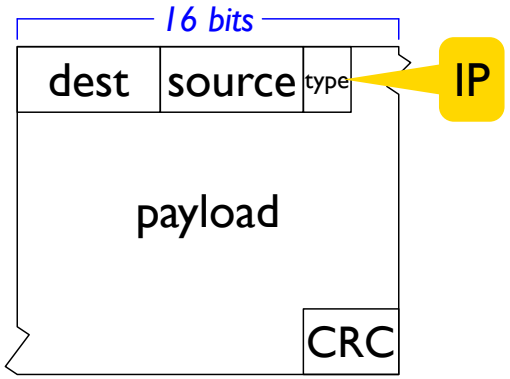
Ethernet Frame Layout



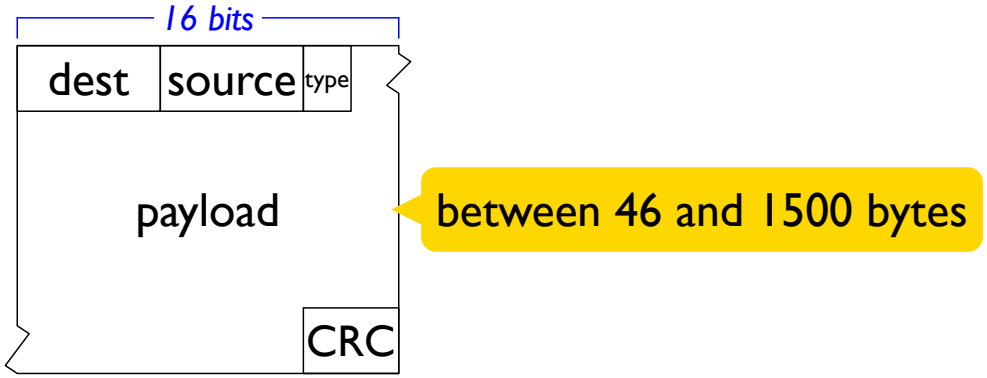
Ethernet Frame Layout



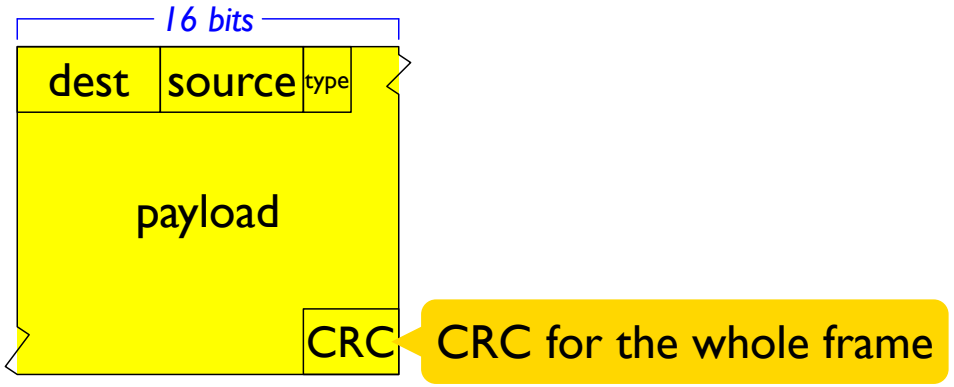
Ethernet Frame Layout



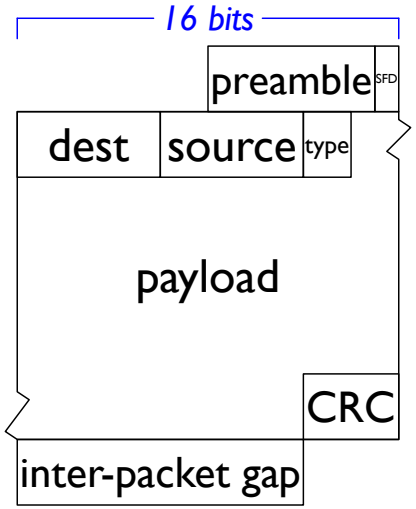
Ethernet Frame Layout



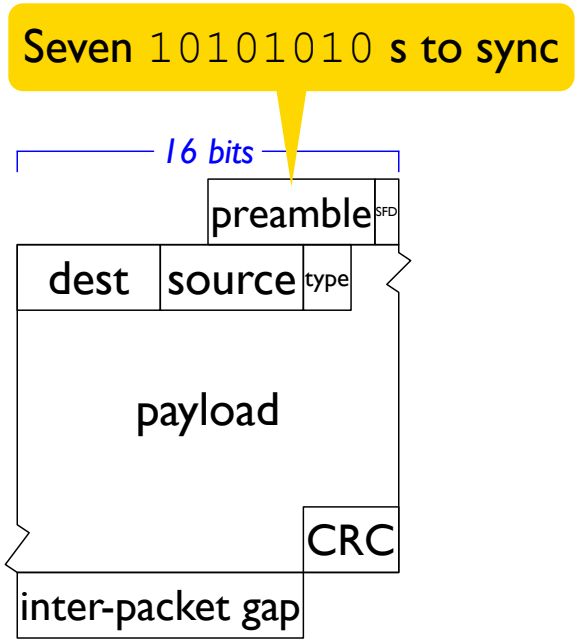
Ethernet Frame Layout



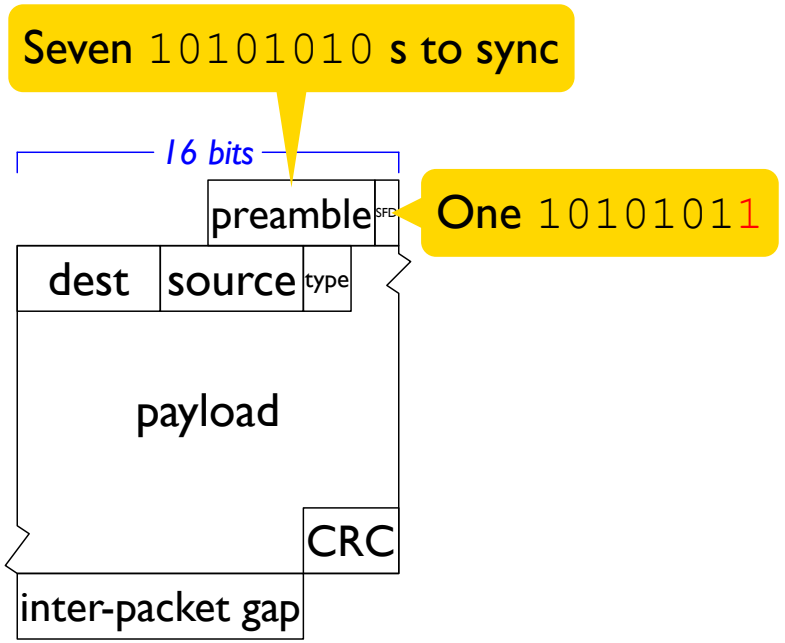
Ethernet Physical Layer Layout



Ethernet Physical Layer Layout



Ethernet Physical Layer Layout



Ethernet Physical Layer

Originally, machines on an ethernet LAN shared a wire

Modern ethernet is always **switched**: there's a dedicated wire from each machine to the switch

This makes MAC addresses somewhat redundant!

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Many ethernet frames are not phsyically ethernet at all, because the easiest way to create a new physical layer is to emulate an ethernet device