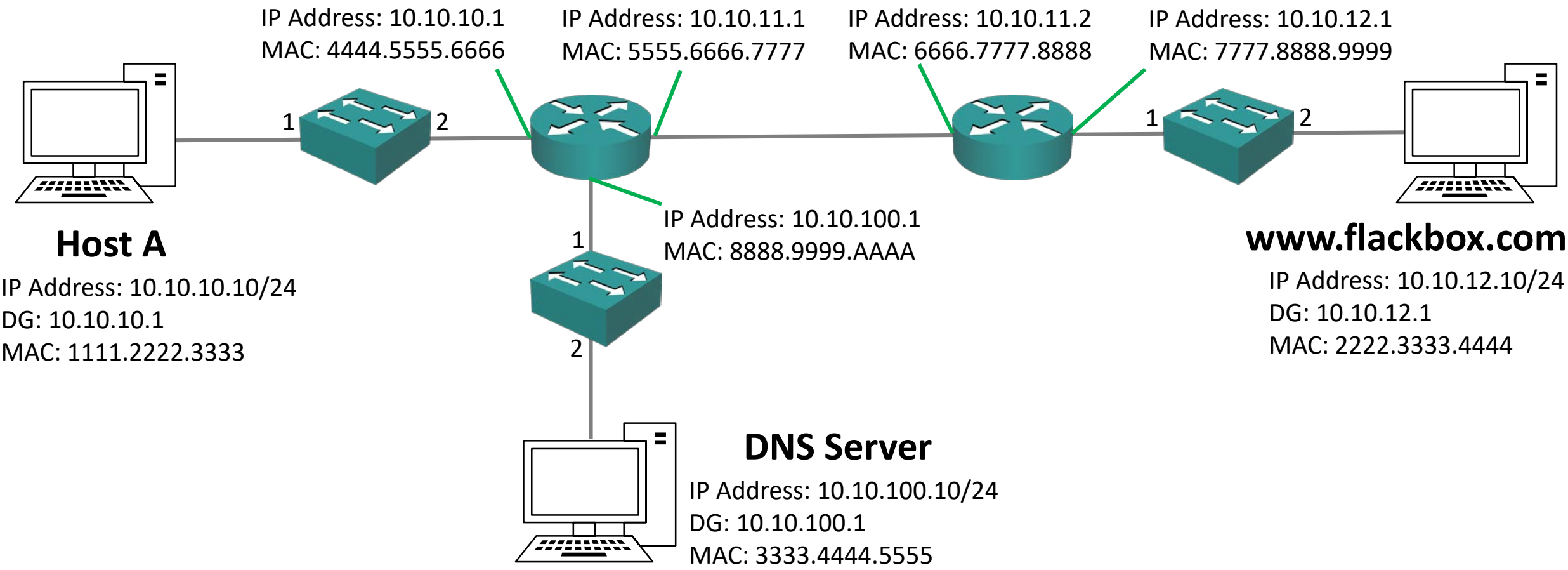
The Life of a Packet



OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7		
6		
5		
4		
3		
2		
1		

OSI Reference Model - Encapsulation

Sender

Receiver

Layer	Name	Includes
7	Application	
6		
5		
4		
3		
2		
1		

OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5		
4		
3		
2		
1		

L6 L7

OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4		
3		
2		
1		

L5 L6 L7

OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3		
2		
1		

OSI Reference Model - Encapsulation

Sender **Receiver**

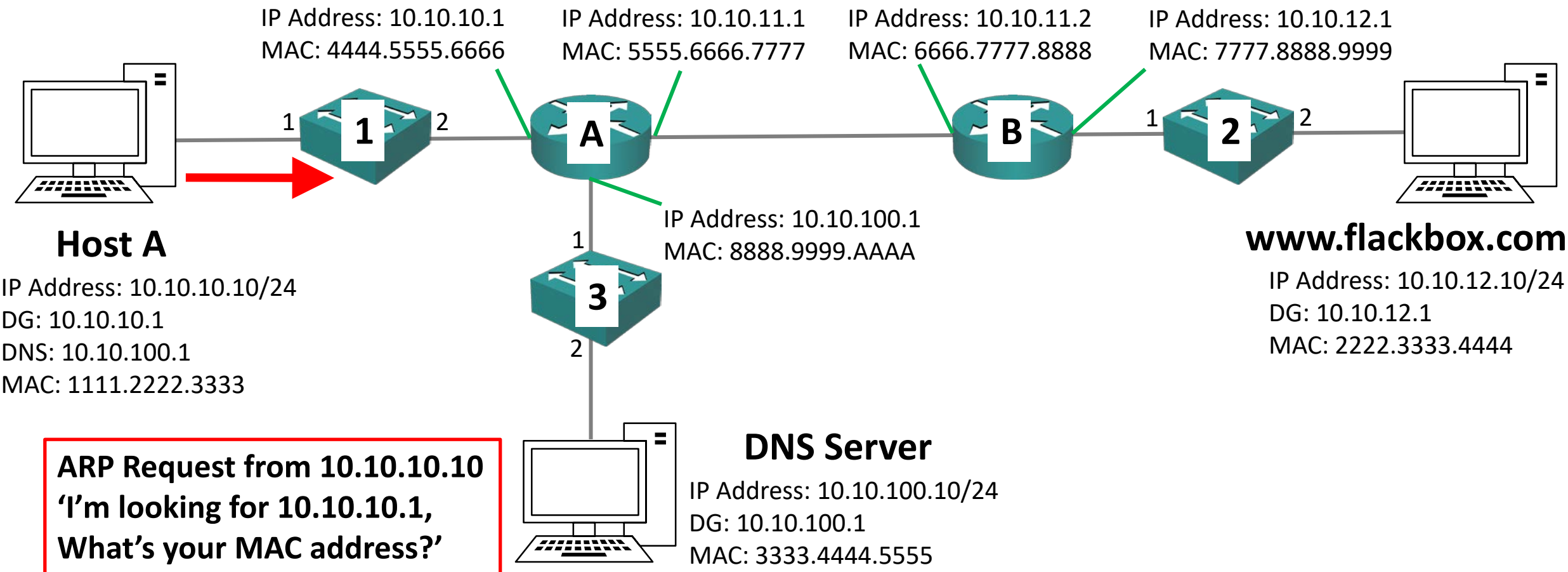
Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3	Network	IP Address?
2		
1		

L3 L4 L5 L6 L7

The Life of a Packet

- Host A (10.10.10.10/24) wants to send a packet to the FQDN www.flackbox.com, but it doesn't know the destination IP address
- It will hold the packet and send a DNS request to its DNS server at 10.10.100.10
- Host A compares its IP address and subnet mask to the destination address of the DNS server and sees it is on a different subnet, so the DNS request needs to be sent via its default gateway
- Host A will hold the DNS request and send a broadcast ARP request for its default gateway at 10.10.10.1

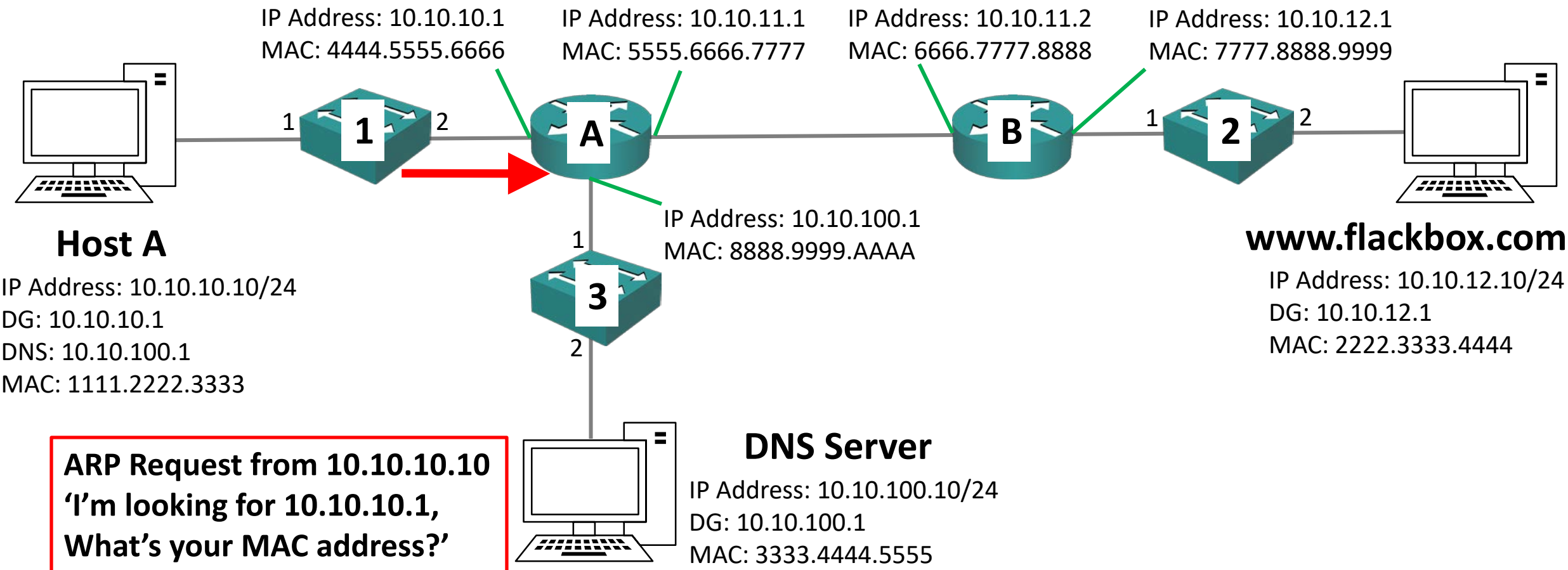
The Life of a Packet



The Life of a Packet

- The ARP request will be received by Switch 1
- Switch 1 will add an entry in its MAC address table mapping Host A's MAC address 1111.2222.3333 to Port 1
- Switch 1 will flood the broadcast traffic out all ports apart from the one it was received on

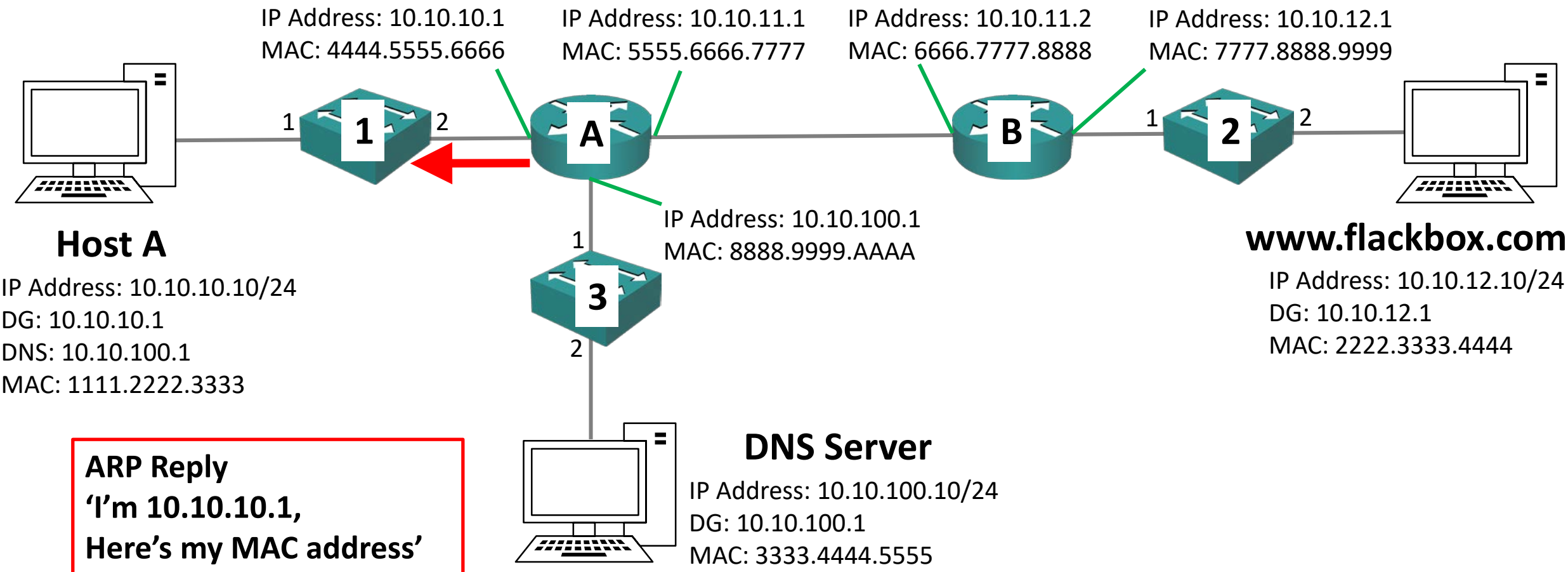
The Life of a Packet



The Life of a Packet

- The ARP request will hit Router A's interface 10.10.10.1
- Router A will process the ARP request and see it is for itself
- Router A will send a unicast ARP reply to Host A
- Router A will add an entry for Host A mapping IP address 10.10.10.10 to MAC address 1111.2222.3333 to its ARP cache

The Life of a Packet

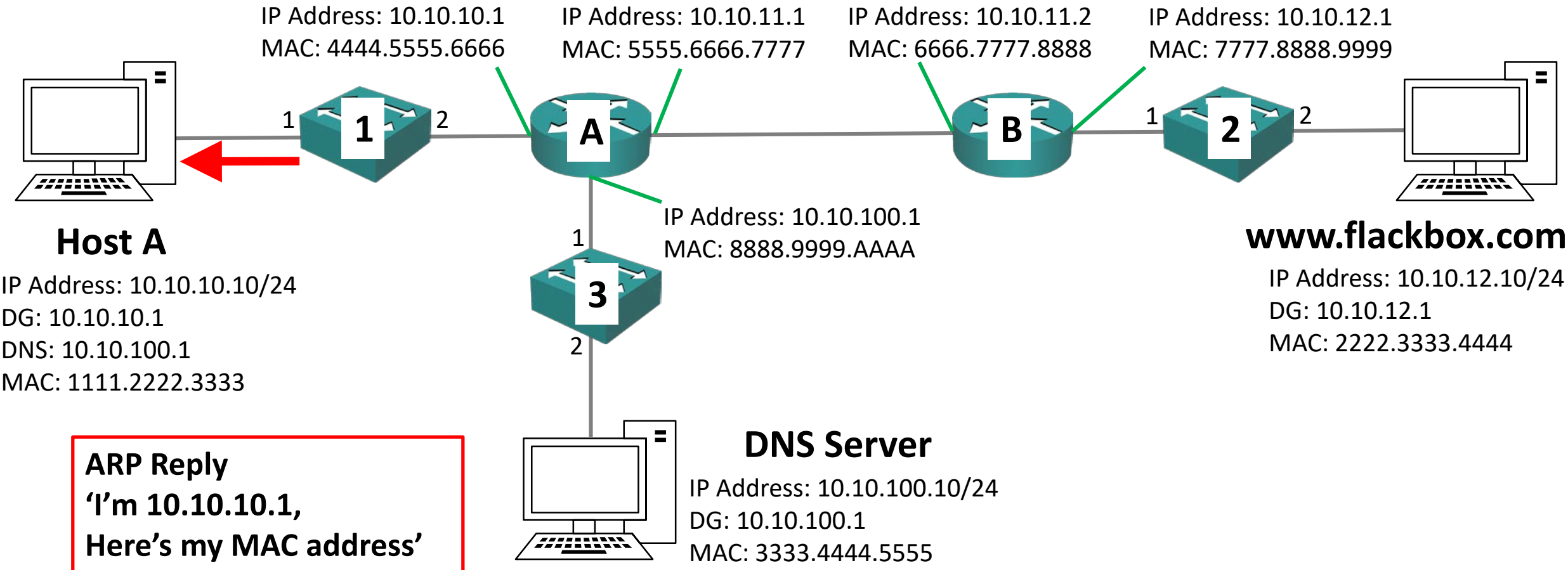


ARP Reply
'I'm 10.10.10.1,
Here's my MAC address'
Src MAC: 4444.5555.6666
Dst MAC: 1111.2222.3333

The Life of a Packet

- Switch 1 will add an entry in its MAC address table mapping Router A's MAC address 4444.5555.6666 to Port 2
- Switch 1 will send the ARP reply out only Port 1 which Host A is plugged into (which it already has in its MAC address table)

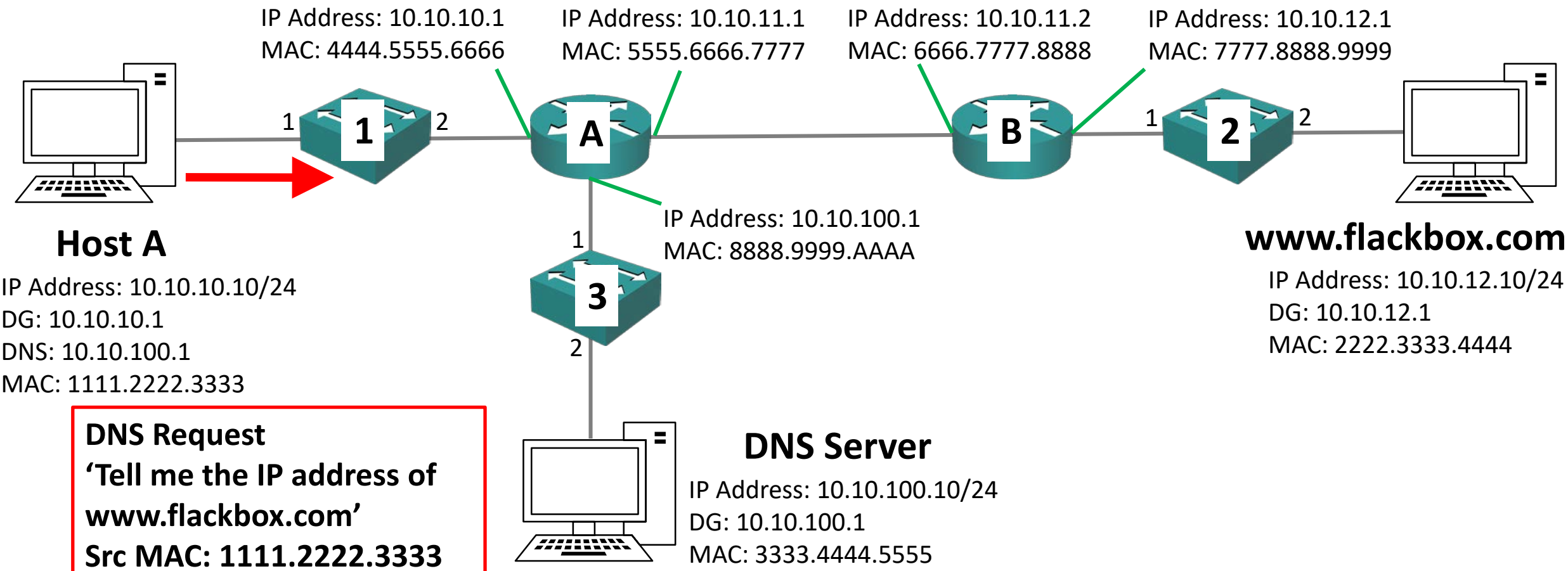
The Life of a Packet



The Life of a Packet

- Host A will add an entry for Router A mapping IP address 10.10.10.1 to MAC address 4444.5555.6666 to its ARP cache
- It will use this whenever it needs to send traffic to another IP subnet
- Host A will send the DNS request for www.flackbox.com

The Life of a Packet

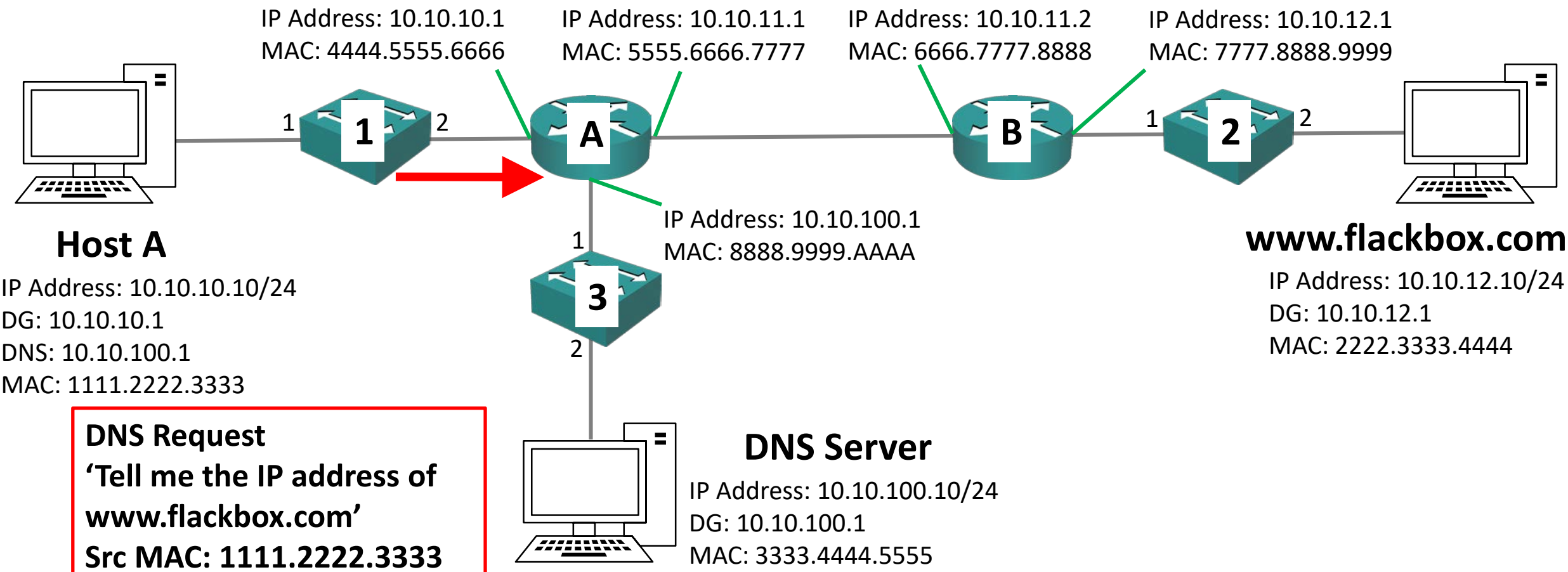


DNS Request
'Tell me the IP address of www.flackbox.com'
Src MAC: 1111.2222.3333
Dst MAC: 4444.5555.6666
Src IP: 10.10.10.10
Dst IP: 10.10.100.10

The Life of a Packet

- Switch 1 will send the DNS request out only Port 2 which Router A is plugged into (which it already has in its MAC address table)

The Life of a Packet

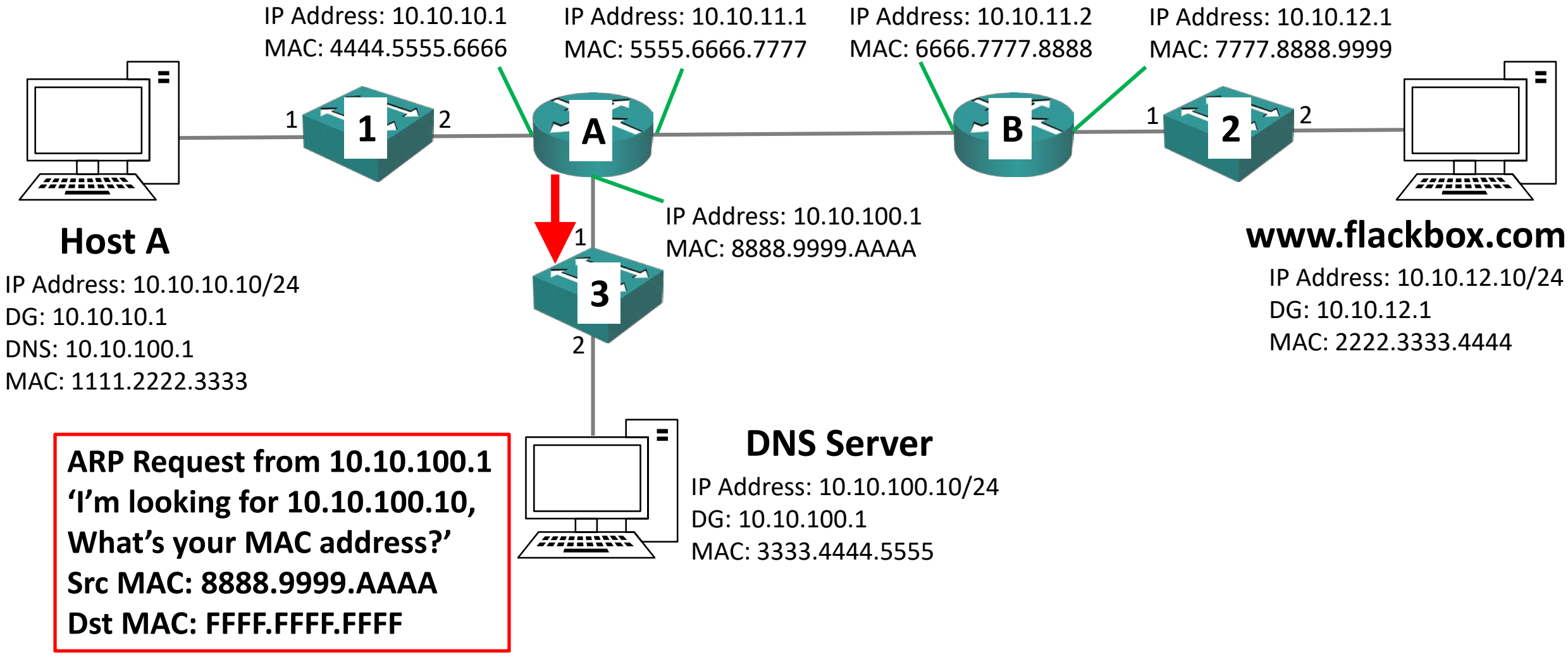


DNS Request
'Tell me the IP address of www.flackbox.com'
Src MAC: 1111.2222.3333
Dst MAC: 4444.5555.6666
Src IP: 10.10.10.10
Dst IP: 10.10.100.10

The Life of a Packet

- Router A will receive the DNS request packet and see that the destination IP address is 10.10.100.10
- Router A has an interface in the subnet 10.10.100.0/24, so it knows the destination should be available out that port
- It doesn't know the MAC address of 10.10.100.10 so it will hold the DNS request packet and send an ARP request out of the 10.10.100.1 interface

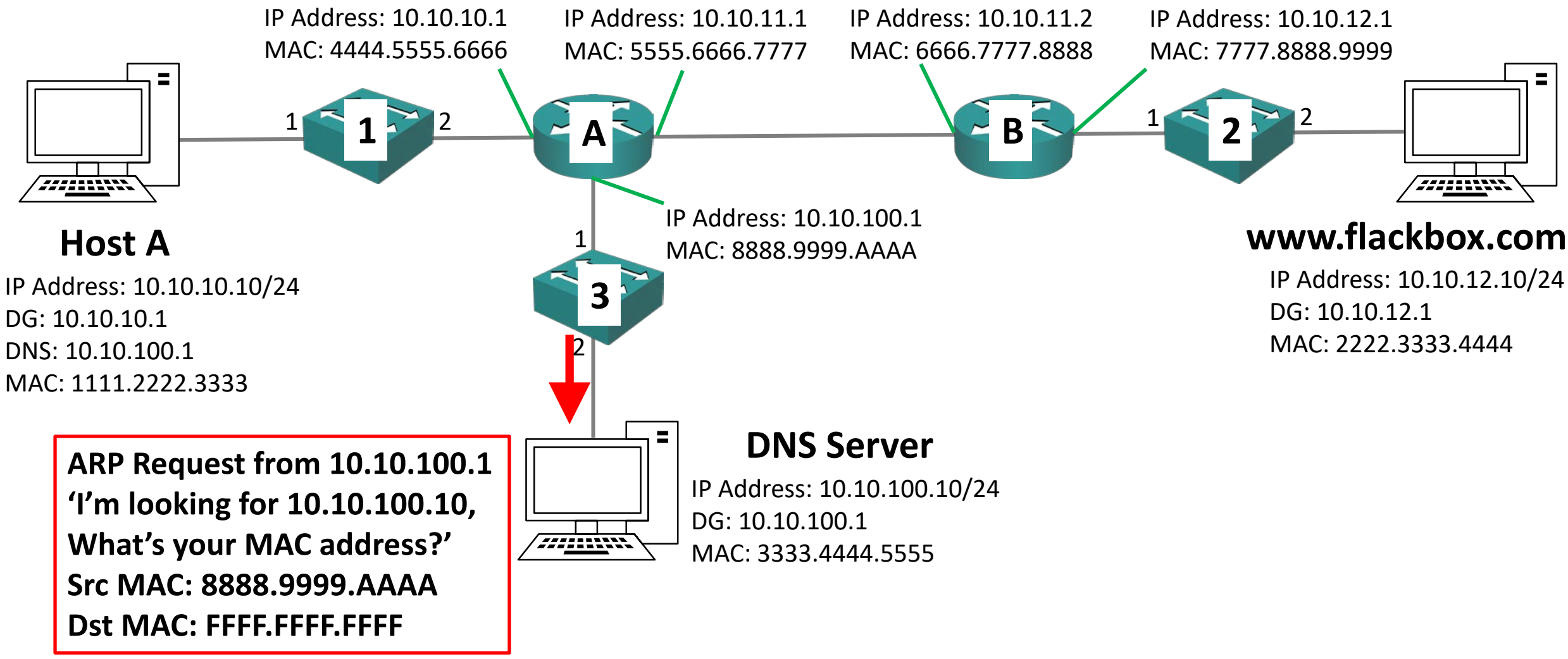
The Life of a Packet



The Life of a Packet

- The ARP request will be received by Switch 3
- Switch 3 will add an entry in its MAC address table mapping Router A's MAC address 8888.9999.AAAA to Port 1
- Switch 3 will flood the broadcast traffic out all ports apart from the one it was received on

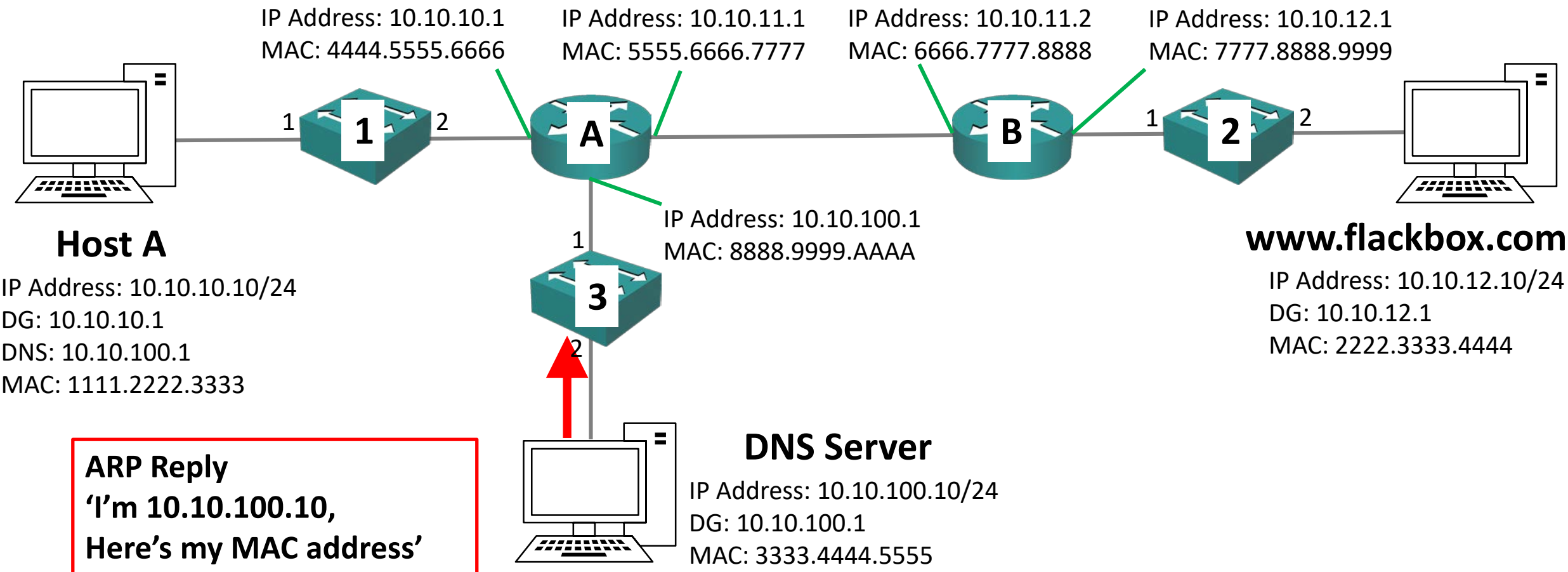
The Life of a Packet



The Life of a Packet

- The ARP request will hit the DNS Server's interface 10.10.100.10
- The DNS Server will process the ARP request and see it is for itself
- The DNS Server will send a unicast ARP reply to Router A
- The DNS Server will add an entry for Router A mapping IP address 10.10.100.1 to MAC address 8888.9999.AAAA to its ARP cache
- It will use this whenever it needs to send traffic to another IP subnet

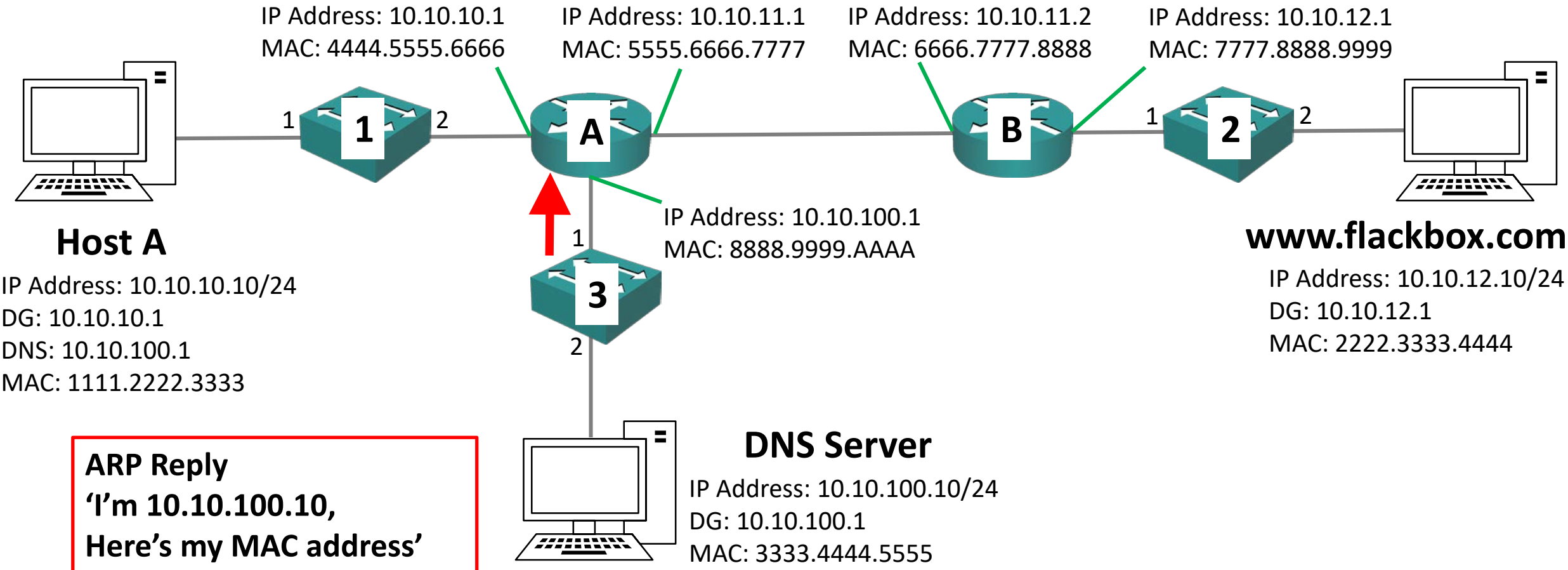
The Life of a Packet



The Life of a Packet

- Switch 3 will add an entry in its MAC address table mapping the DNS Server's MAC address 3333.4444.5555 to Port 2
- Switch 3 will send the ARP reply out only Port 1 which Router A is plugged into (which it already has in its MAC address table)

The Life of a Packet



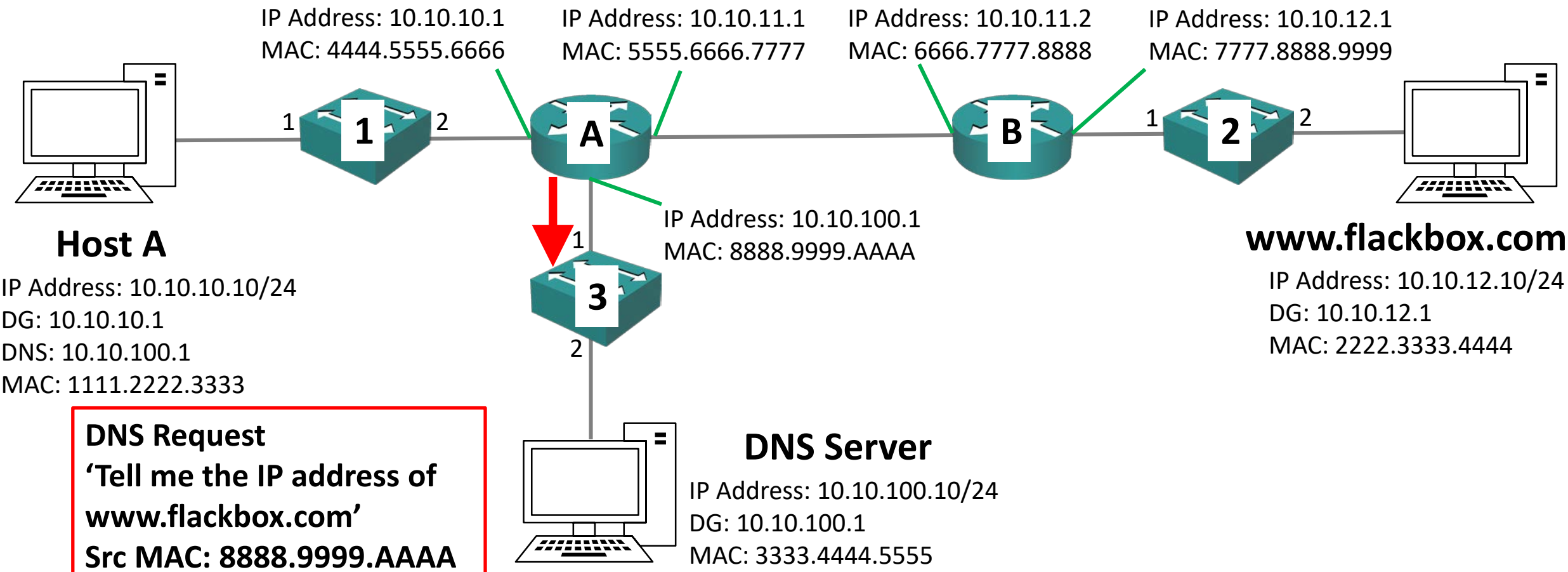
The Life of a Packet

- Router A will add an entry for the DNS Server mapping IP address 10.10.100.10 to MAC address 3333.4444.5555 to its ARP cache
- Router A will send the DNS request it was holding to the DNS Server

The Life of a Packet

- **The source and destination MAC addresses of a packet are updated hop by hop, the source and destination IP addresses always remain unchanged end to end**
- The source and destination MAC addresses will be updated to come from Router A and go to the DNS Server
- The source and destination IP addresses are still Host A 10.10.10.10 and the DNS Server 10.10.100.10

The Life of a Packet

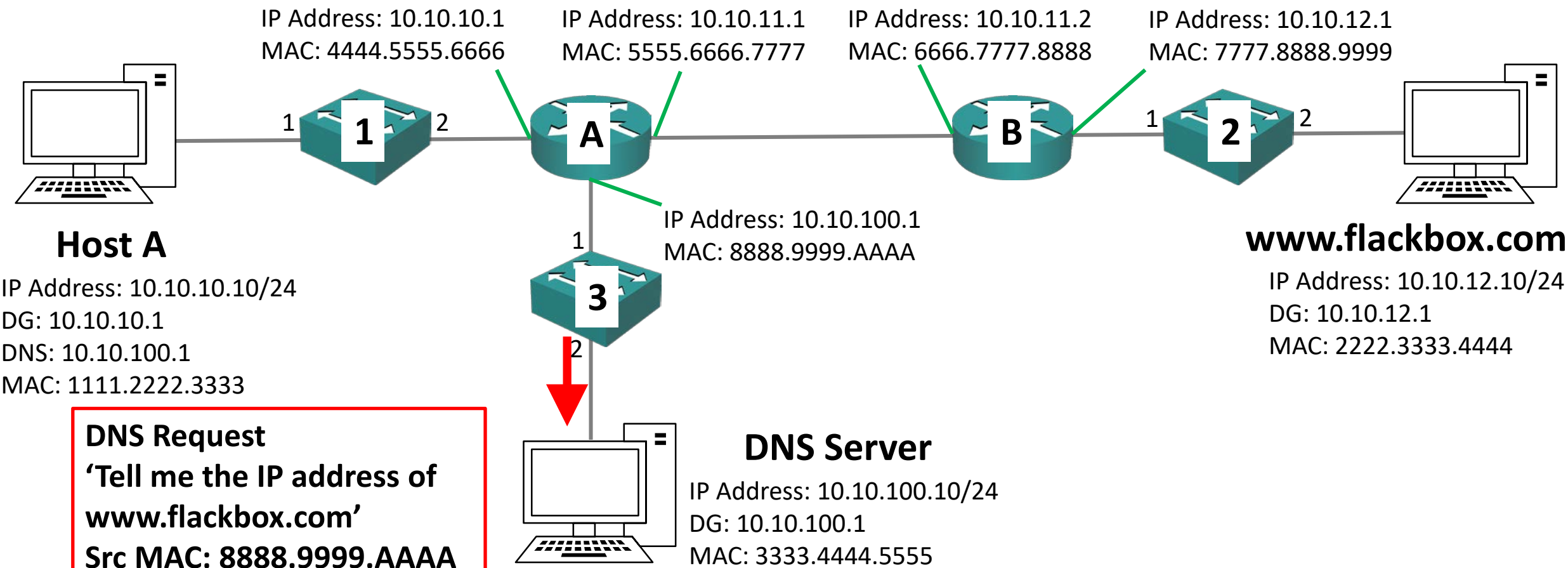


DNS Request
'Tell me the IP address of www.flackbox.com'
Src MAC: 8888.9999.AAAA
Dst MAC: 3333.4444.5555
Src IP: 10.10.10.10
Dst IP: 10.10.100.10

The Life of a Packet

- Switch 3 will send the DNS request out only Port 2 which the DNS Server is plugged into (which it already has in its MAC address table)

The Life of a Packet

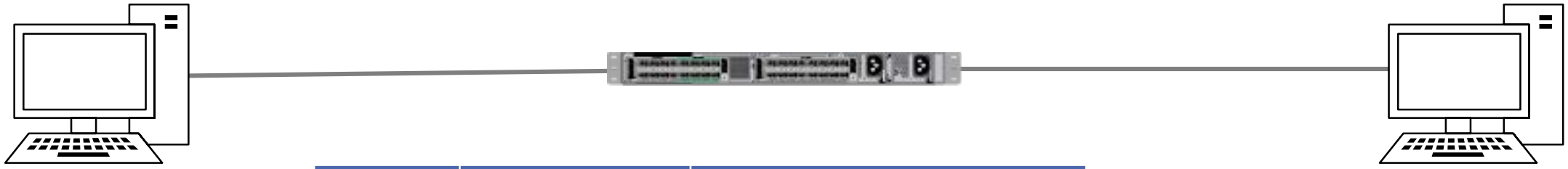


DNS Request
'Tell me the IP address of www.flackbox.com'
Src MAC: 8888.9999.AAAA
Dst MAC: 3333.4444.5555
Src IP: 10.10.10.10
Dst IP: 10.10.100.10

The Life of a Packet

- The DNS Server will receive the DNS request packet and see that the destination is itself

OSI Reference Model – De-encapsulation

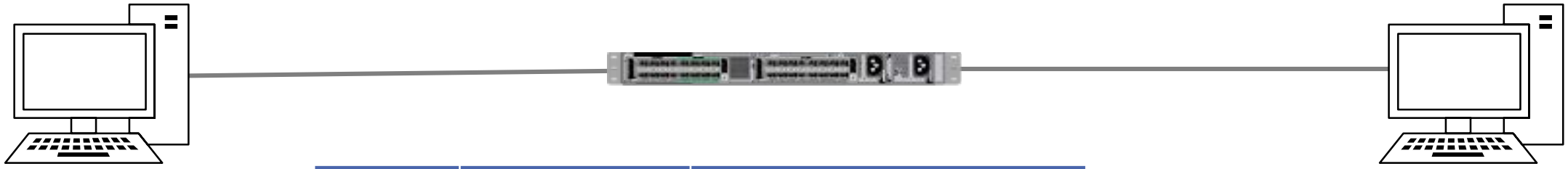


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	
2	Data-Link	
1	Physical	

OSI Reference Model – De-encapsulation

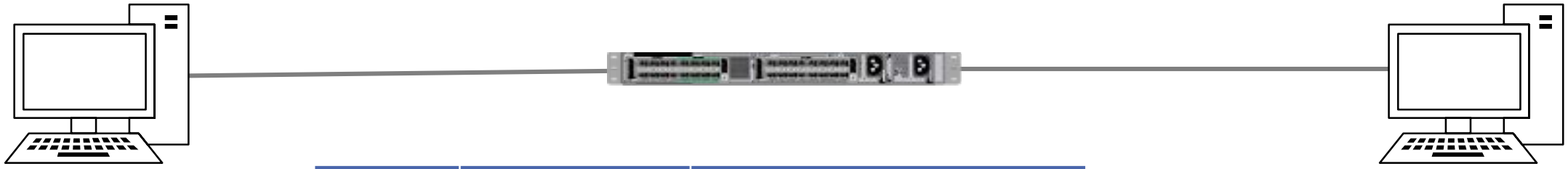


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

OSI Reference Model – De-encapsulation

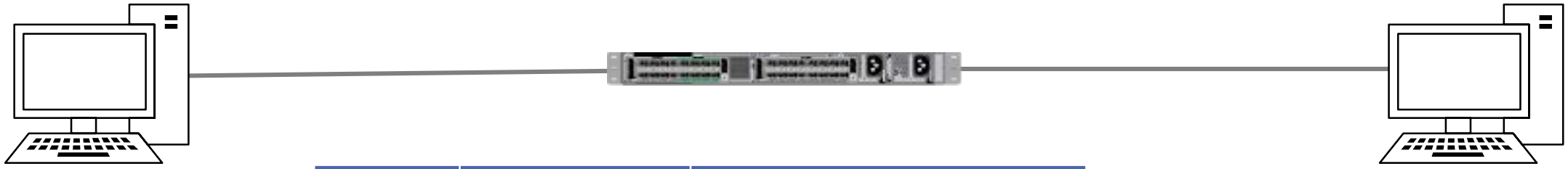


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	Dst: 10.10.100.10
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

OSI Reference Model – De-encapsulation

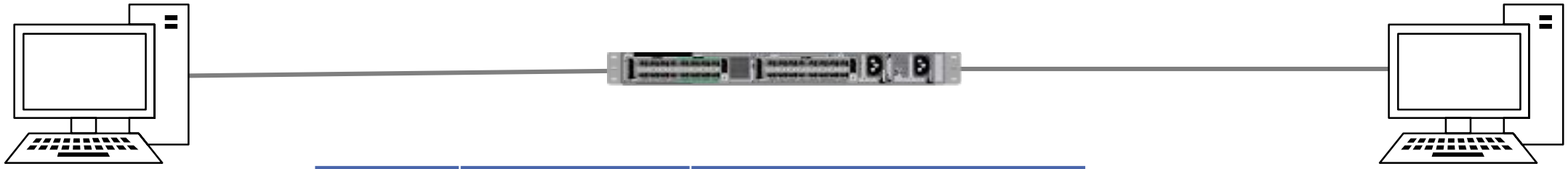


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	UDP Port 53
3	Network	Dst: 10.10.100.10
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

OSI Reference Model – De-encapsulation

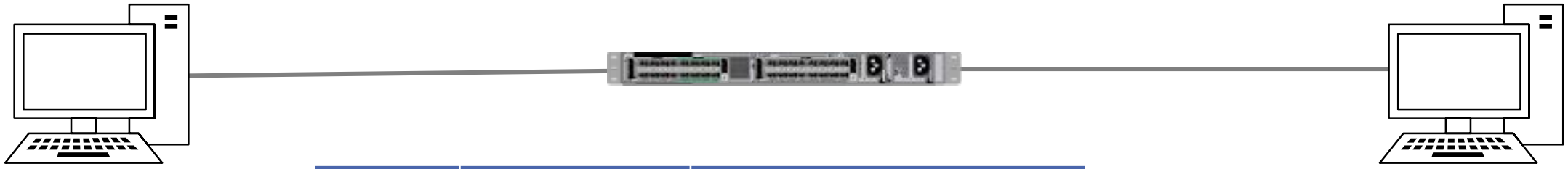


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	UDP Port 53
3	Network	Dst: 10.10.100.10
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

OSI Reference Model – De-encapsulation

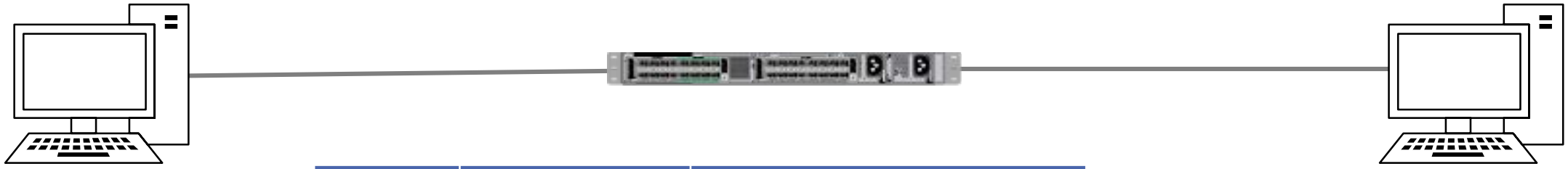


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	UDP Port 53
3	Network	Dst: 10.10.100.10
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

OSI Reference Model – De-encapsulation



Sender

Receiver

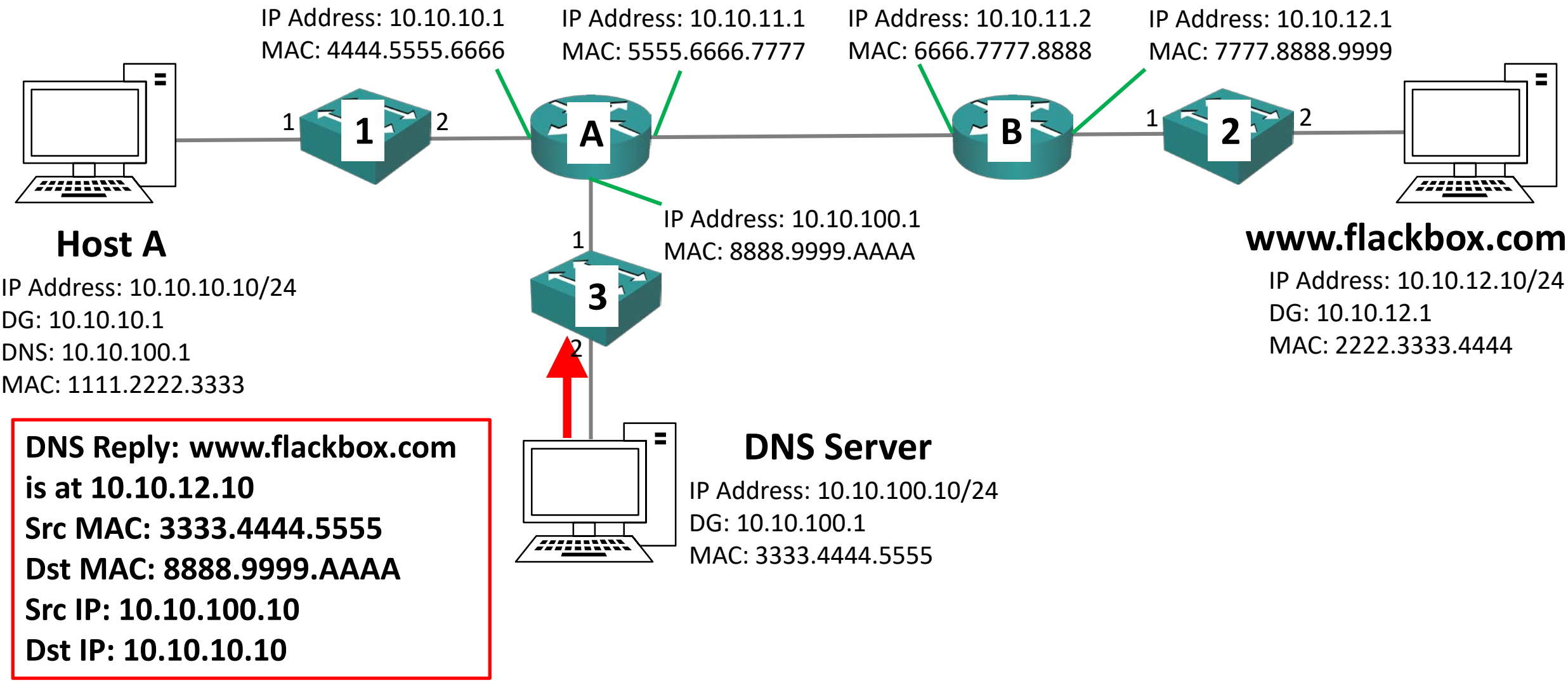
Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	UDP Port 53
3	Network	Dst: 10.10.100.10
2	Data-Link	Dst: 3333.4444.5555
1	Physical	

L7

The Life of a Packet

- The DNS Server will look in its DNS database and see an Address record for www.flackbox.com at 10.10.12.10
- It will send this information to Host A in a DNS response
- It knows to send the response to 10.10.10.10 from the source IP address in the DNS request
- It knows to send it via Router A because the destination is in another subnet
- It already has Router A's MAC address in its ARP cache

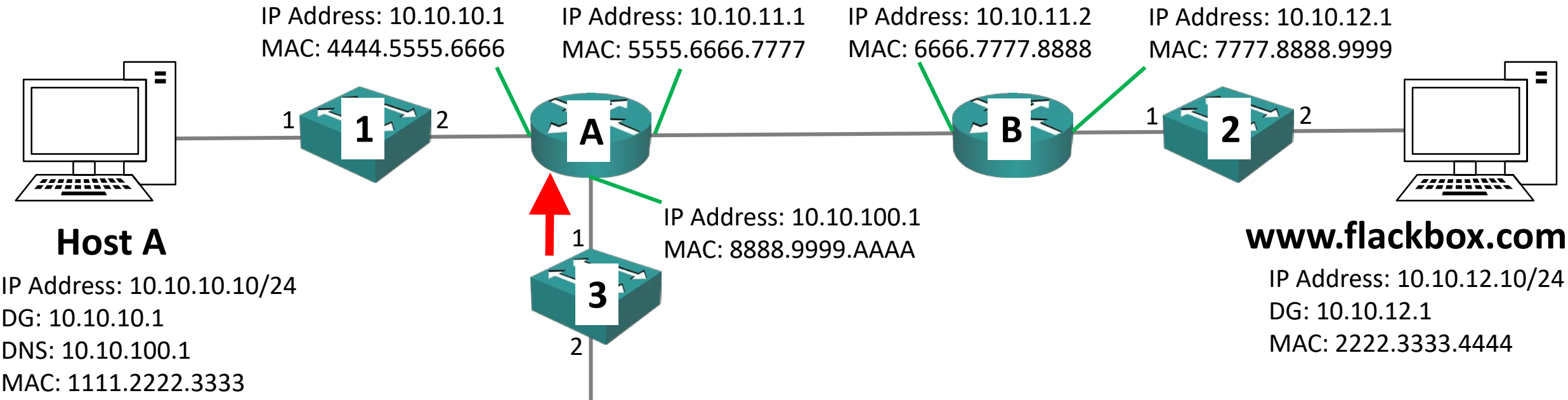
The Life of a Packet



The Life of a Packet

- Switch 3 will receive the DNS response and send it out only Port 1 which Router A is plugged into (which it already has in its MAC address table)

The Life of a Packet



Host A

IP Address: 10.10.10.10/24
DG: 10.10.10.1
DNS: 10.10.100.1
MAC: 1111.2222.3333

www.flackbox.com

IP Address: 10.10.12.10/24
DG: 10.10.12.1
MAC: 2222.3333.4444

DNS Server

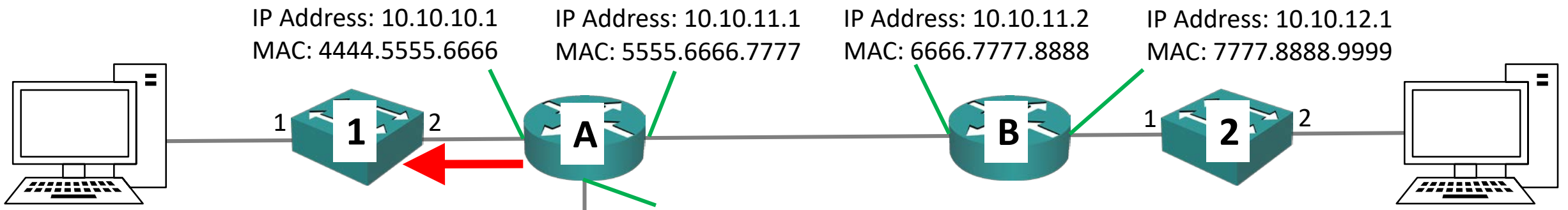
IP Address: 10.10.100.10/24
DG: 10.10.100.1
MAC: 3333.4444.5555

DNS Reply: www.flackbox.com is at 10.10.12.10
Src MAC: 3333.4444.5555
Dst MAC: 8888.9999.AAAA
Src IP: 10.10.100.10
Dst IP: 10.10.10.10

The Life of a Packet

- Router A will receive the DNS response packet and see that the destination IP address is 10.10.10.10
- Router A has an interface in the subnet 10.10.10.0/24, so it knows the destination is available out that port
- Router A already has the MAC address for 10.10.10.10 in its ARP cache

The Life of a Packet



Host A

IP Address: 10.10.10.10/24
DG: 10.10.10.1
DNS: 10.10.100.1
MAC: 1111.2222.3333

www.flackbox.com

IP Address: 10.10.12.10/24
DG: 10.10.12.1
MAC: 2222.3333.4444

DNS Server

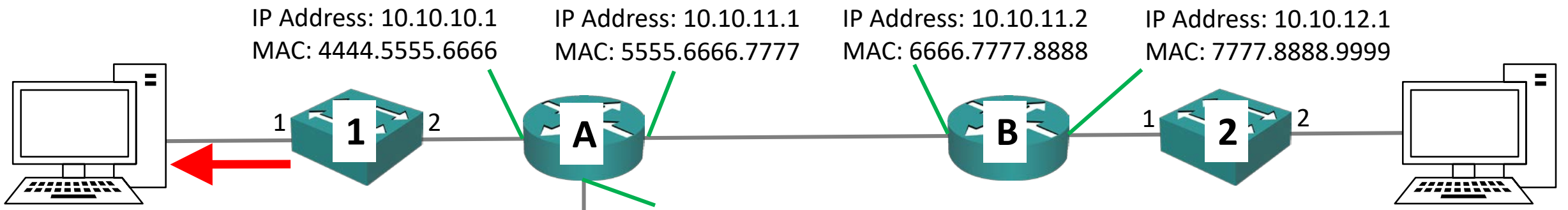
IP Address: 10.10.100.10/24
DG: 10.10.100.1
MAC: 3333.4444.5555

DNS Reply: www.flackbox.com is at 10.10.12.10
Src MAC: 4444.5555.6666
Dst MAC: 1111.2222.3333
Src IP: 10.10.100.10
Dst IP: 10.10.10.10

The Life of a Packet

- Switch 1 will receive the DNS response and send it out only Port 1 which Host A is plugged into (which it already has in its MAC address table)

The Life of a Packet



Host A

IP Address: 10.10.10.10/24
DG: 10.10.10.1
DNS: 10.10.100.1
MAC: 1111.2222.3333

www.flackbox.com

IP Address: 10.10.12.10/24
DG: 10.10.12.1
MAC: 2222.3333.4444

DNS Server

IP Address: 10.10.100.10/24
DG: 10.10.100.1
MAC: 3333.4444.5555

DNS Reply: www.flackbox.com is at 10.10.12.10
Src MAC: 4444.5555.6666
Dst MAC: 1111.2222.3333
Src IP: 10.10.100.10
Dst IP: 10.10.10.10

The Life of a Packet

- Host A learns that www.flackbox.com is available at 10.10.12.10
- It can now update the packet it was waiting to send to www.flackbox.com with that destination IP address
- Host A sees that www.flackbox.com is not on its own subnet so it knows any packets it sends there must go via its default gateway

OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3	Network	IP Address?
2		
1		

L3 L4 L5 L6 L7

OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3	Network	Dst: 10.10.12.10
2		
1		

L3 L4 L5 L6 L7

OSI Reference Model - Encapsulation

Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 4444.5555.6666
1		

L2 | L3 | L4 | L5 | L6 | L7

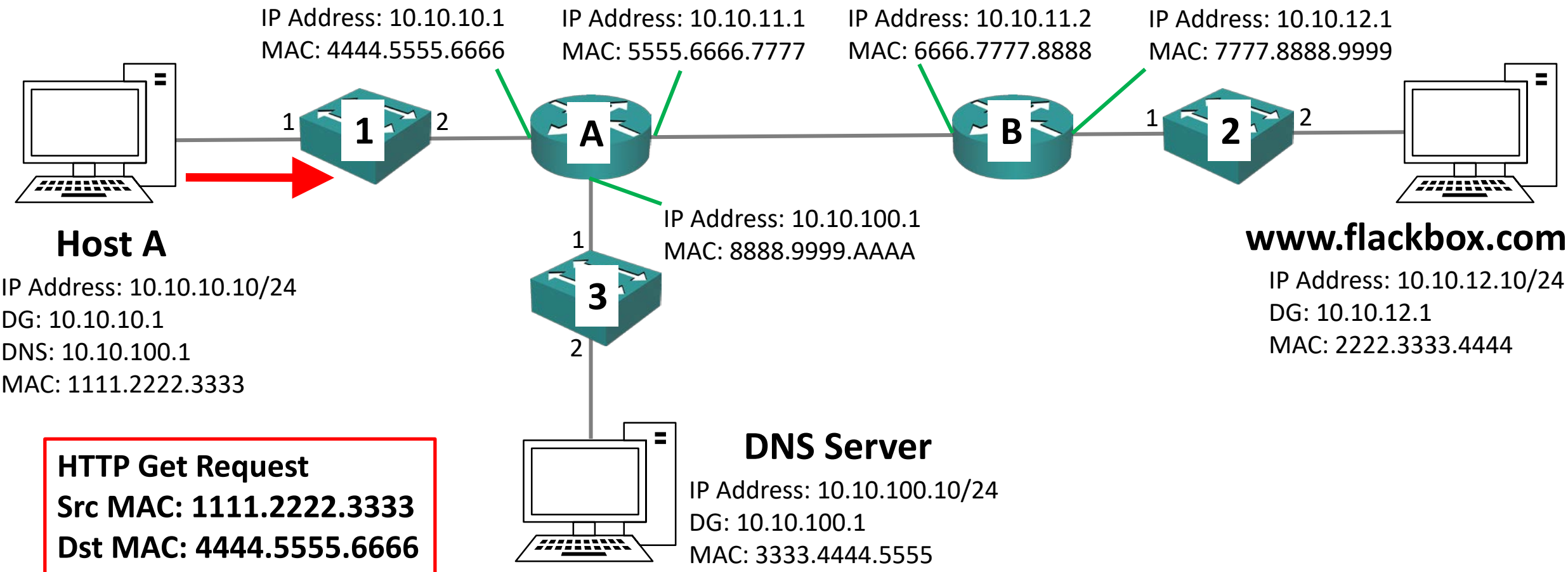
OSI Reference Model - Encapsulation

Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP, Dst. Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 4444.5555.6666
1	Physical	

L2 L3 L4 L5 L6 L7

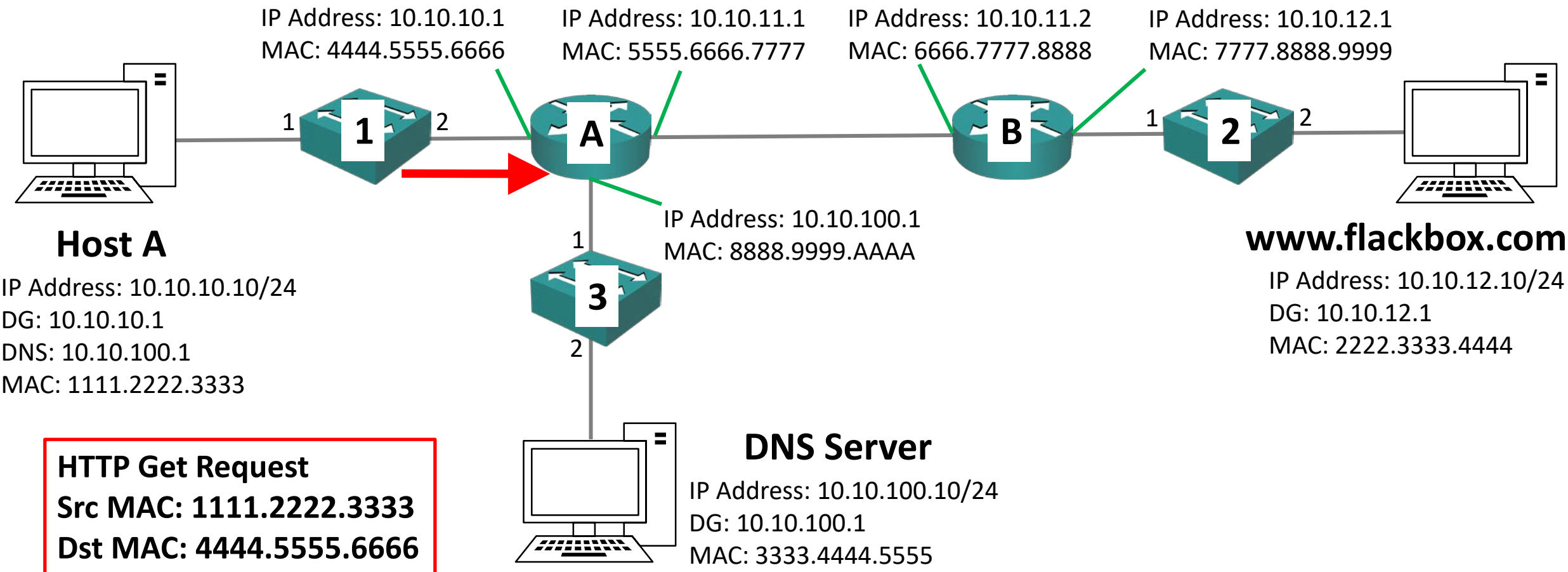
The Life of a Packet



The Life of a Packet

- Switch 1 will send the packet to Router A which it already has in its MAC address table

The Life of a Packet



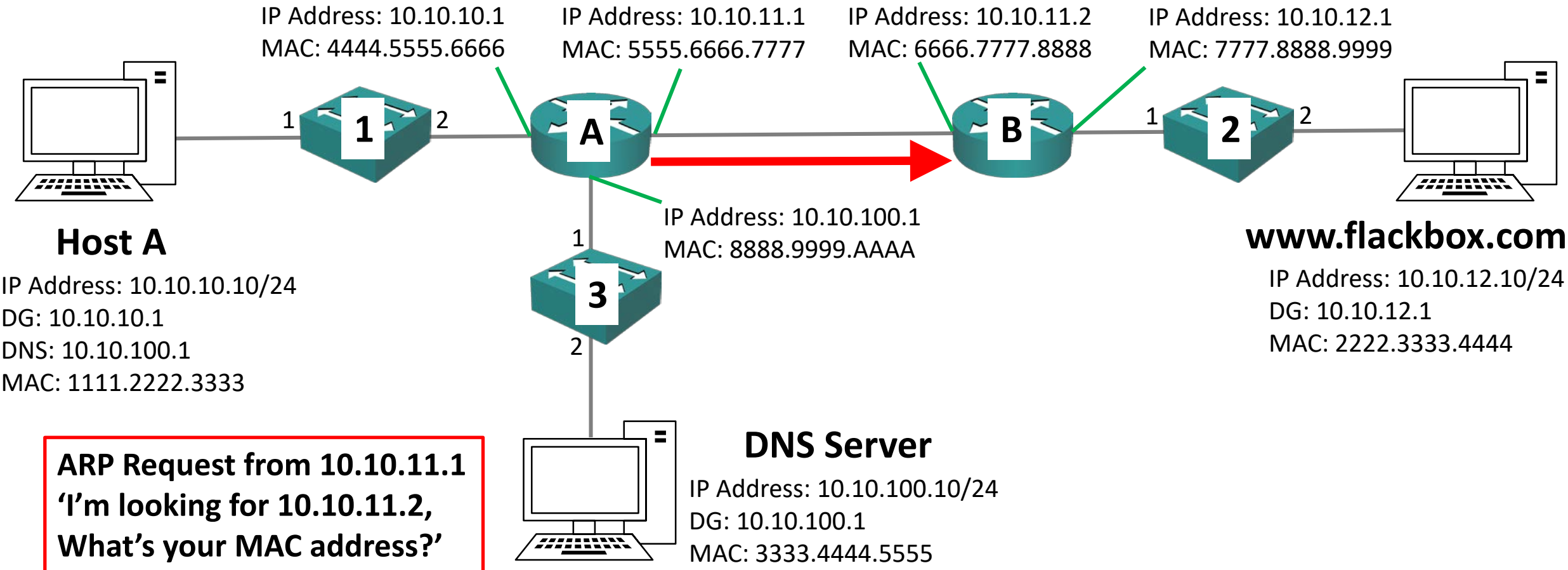
The Life of a Packet

- Router A will receive the packet with destination IP address 10.10.12.10
- Router A does not have any interfaces in the 10.10.12.0/24 subnet
- In this case it will need a route to get there
- The route can be either statically configured by an administrator or learned dynamically through a routing protocol

The Life of a Packet

- In this example the administrator has configured a static route for 10.10.12.0/24 with the next hop address 10.10.11.2
- Router A has an Ethernet interface in the 10.10.11.0 subnet
- It doesn't know the MAC address for the next hop address 10.10.11.2 yet
- It will hold the HTTP packet and send an ARP request for 10.10.11.2

The Life of a Packet

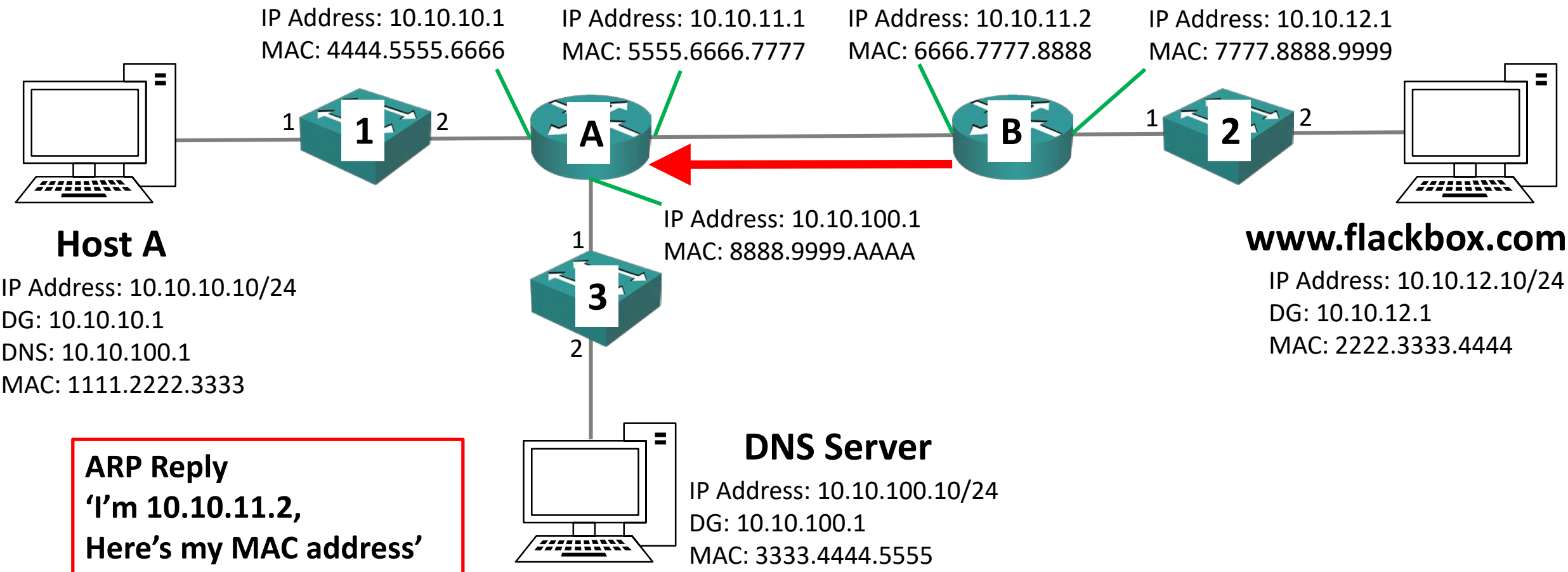


ARP Request from 10.10.11.1
'I'm looking for 10.10.11.2,
What's your MAC address?'
Src MAC: 5555.6666.7777
Dst MAC: FFFF.FFFF.FFFF

The Life of a Packet

- The ARP request will hit Router B's interface 10.10.11.2
- Router B will process the ARP request and see it is for itself
- Router B will send a unicast ARP reply to Router A
- Router B will add an entry for Router A mapping IP address 10.10.11.1 to MAC address 5555.6666.7777 to its ARP cache

The Life of a Packet

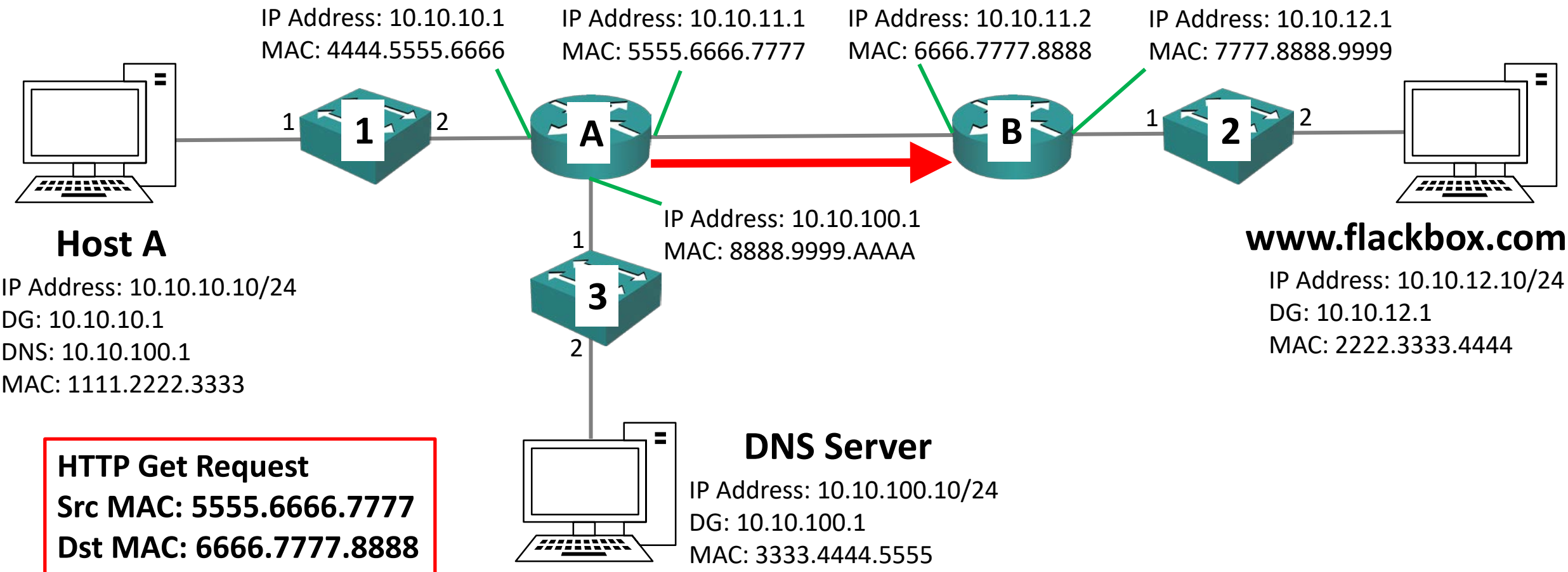


ARP Reply
'I'm 10.10.11.2,
Here's my MAC address'
Src MAC: 6666.7777.8888
Dst MAC: 5555.6666.7777

The Life of a Packet

- Router A will forward the HTTP packet it was holding to Router B

The Life of a Packet

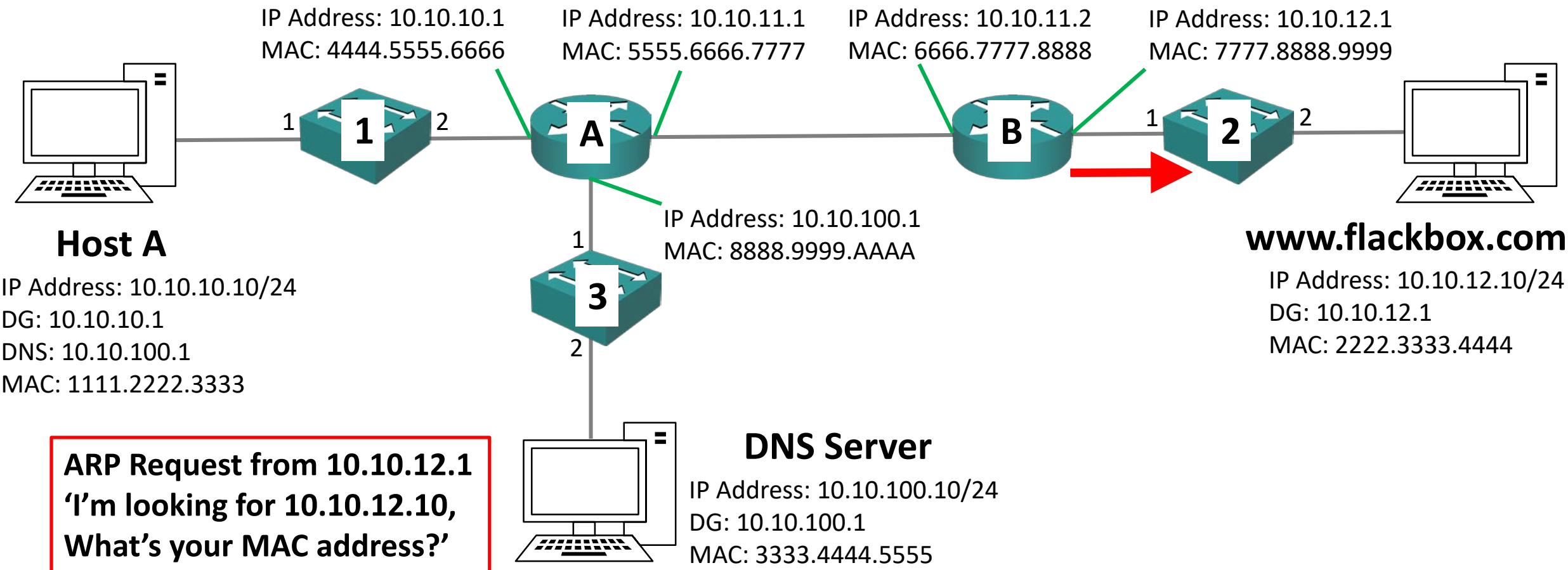


HTTP Get Request
Src MAC: 5555.6666.7777
Dst MAC: 6666.7777.8888
Src IP: 10.10.10.10
Dst IP: 10.10.12.10

The Life of a Packet

- Router B will receive the HTTP packet and see that the destination IP address is 10.10.12.10
- Router B has an interface in the subnet 10.10.12.0/24, so it knows the destination should be available out that port
- It doesn't know the MAC address of 10.10.12.10 so it will hold the HTTP packet and send an ARP request out of the 10.10.12.1 interface

The Life of a Packet

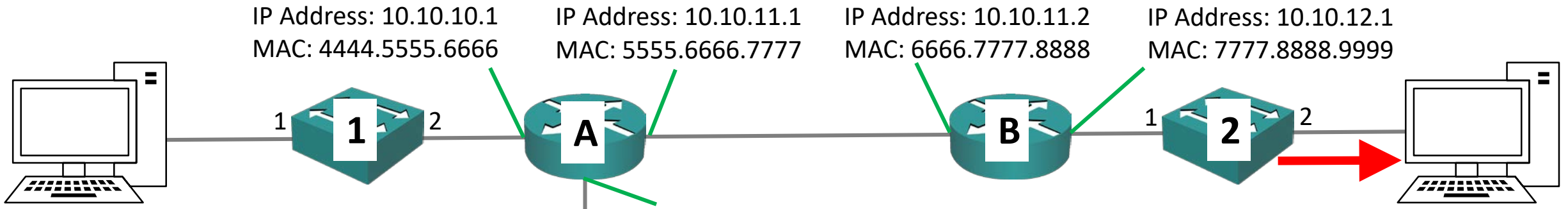


ARP Request from 10.10.12.1
'I'm looking for 10.10.12.10,
What's your MAC address?'
Src MAC: 7777.8888.9999
Dst MAC: FFFF.FFFF.FFFF

The Life of a Packet

- The ARP request will be received by Switch 2
- Switch 2 will add an entry in its MAC address table mapping Router B's MAC address 7777.8888.9999 to Port 1
- Switch 2 will flood the broadcast traffic out all ports apart from the one it was received on

The Life of a Packet



Host A

IP Address: 10.10.10.10/24
DG: 10.10.10.1
DNS: 10.10.100.1
MAC: 1111.2222.3333

www.flackbox.com

IP Address: 10.10.12.10/24
DG: 10.10.12.1
MAC: 2222.3333.4444

DNS Server

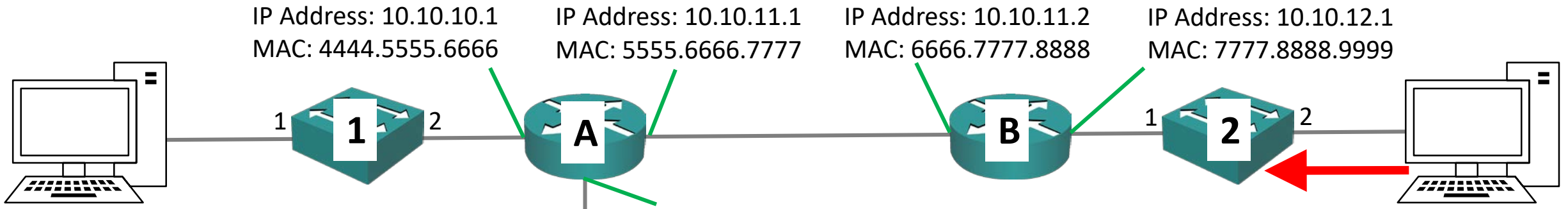
IP Address: 10.10.100.10/24
DG: 10.10.100.1
MAC: 3333.4444.5555

ARP Request from 10.10.12.1
'I'm looking for 10.10.12.10,
What's your MAC address?'
Src MAC: 7777.8888.9999
Dst MAC: FFFF.FFFF.FFFF

The Life of a Packet

- The ARP request will hit the Web Server's interface 10.10.12.10
- The Web Server will process the ARP request and see it is for itself
- The Web Server will send a unicast ARP reply to Router B
- The Web Server will add an entry for Router B mapping IP address 10.10.12.1 to MAC address 7777.8888.9999 to its ARP cache
- It will use this whenever it needs to send traffic to another IP subnet

The Life of a Packet



Host A

IP Address: 10.10.10.10/24
DG: 10.10.10.1
DNS: 10.10.100.1
MAC: 1111.2222.3333

www.flackbox.com

IP Address: 10.10.12.10/24
DG: 10.10.12.1
MAC: 2222.3333.4444

DNS Server

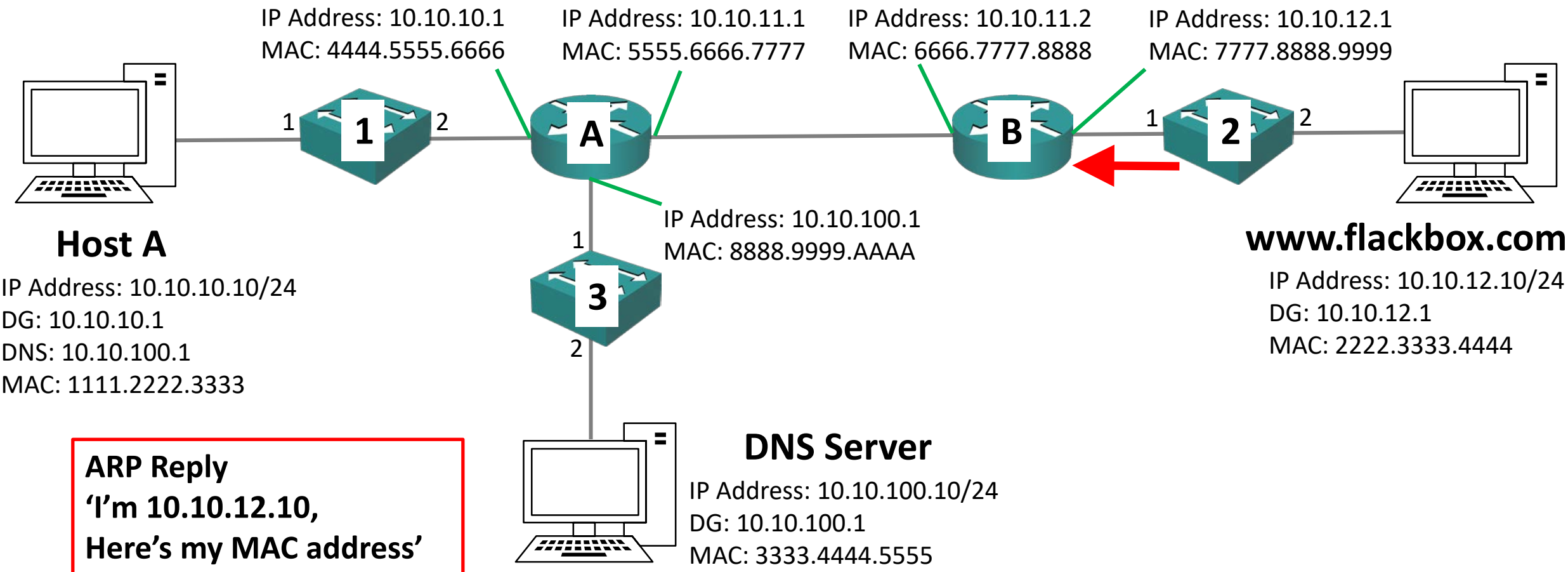
IP Address: 10.10.100.10/24
DG: 10.10.100.1
MAC: 3333.4444.5555

ARP Reply
'I'm 10.10.12.10,
Here's my MAC address'
Src MAC: 2222.3333.4444
Dst MAC: 7777.8888.9999

The Life of a Packet

- Switch 2 will add an entry in its MAC address table mapping the Web Server's MAC address 2222.3333.4444 to Port 2
- Switch 2 will send the ARP reply out only Port 1 which Router B is plugged into (which it already has in its MAC address table)

The Life of a Packet

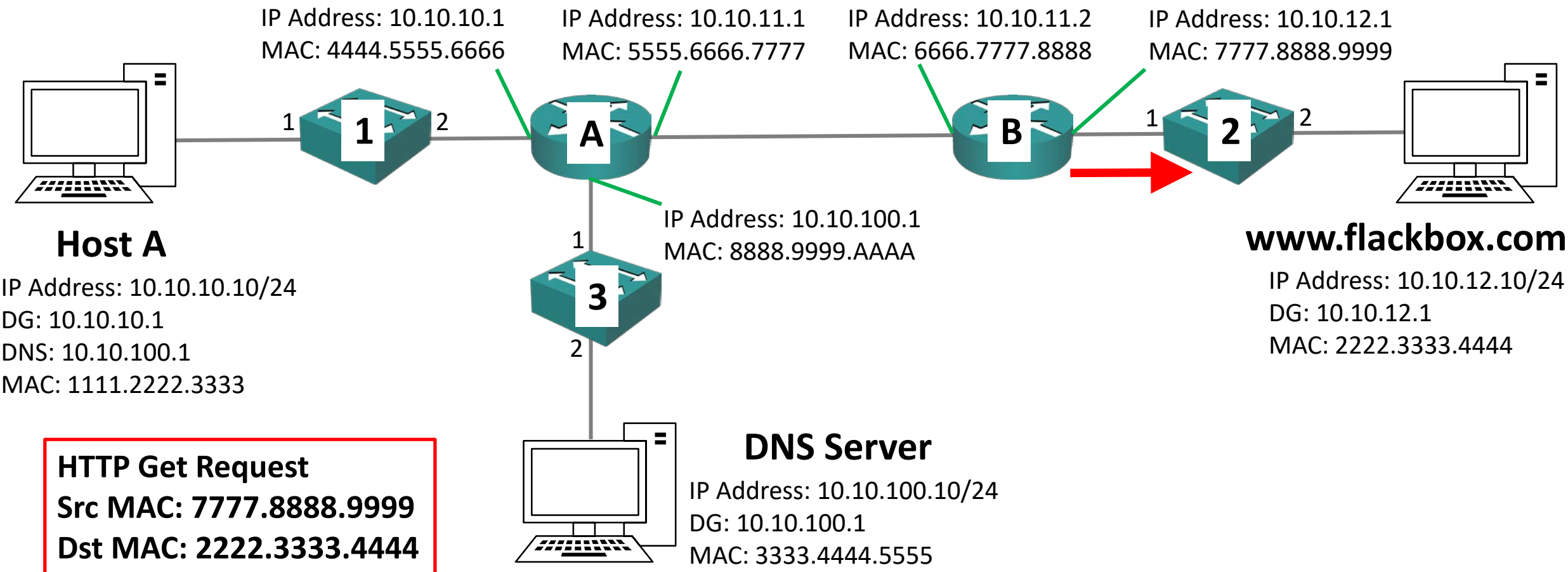


ARP Reply
'I'm 10.10.12.10,
Here's my MAC address'
Src MAC: 2222.3333.4444
Dst MAC: 7777.8888.9999

The Life of a Packet

- Router B will add an entry for the Web Server mapping IP address 10.10.12.10 to MAC address 2222.3333.4444 to its ARP cache
- Router B will send the HTTP request it was holding to the Web Server

The Life of a Packet

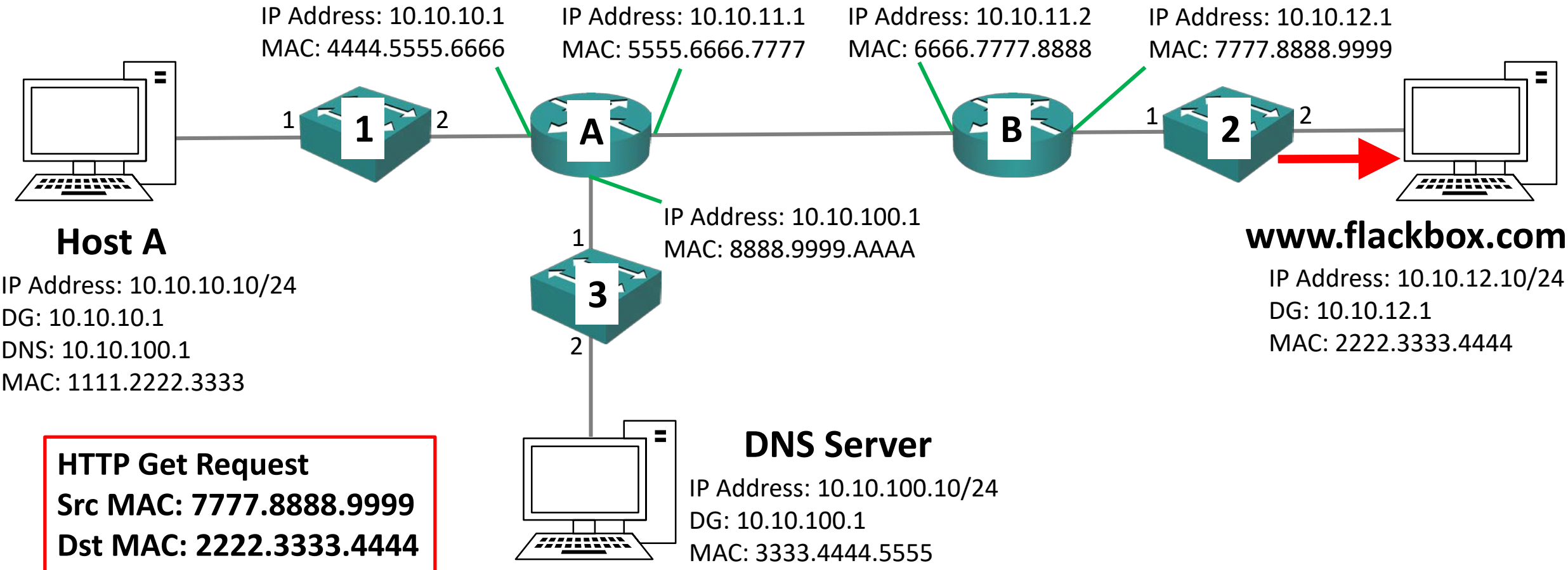


HTTP Get Request
Src MAC: 7777.8888.9999
Dst MAC: 2222.3333.4444
Src IP: 10.10.10.10
Dst IP: 10.10.12.10

The Life of a Packet

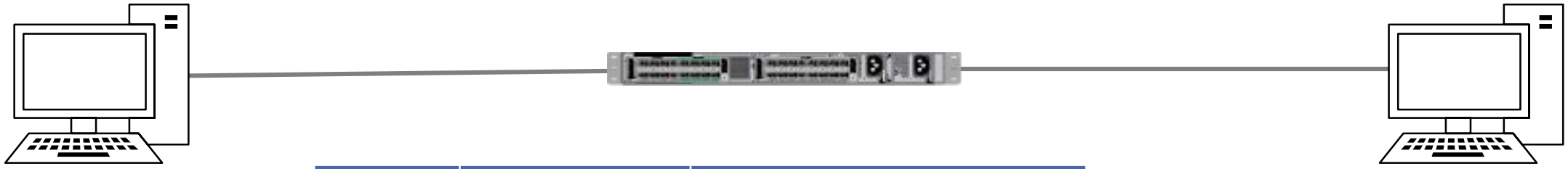
- Switch 2 will send the HTTP request out only Port 2 which the Web Server is plugged into (which it already has in its MAC address table)

The Life of a Packet



HTTP Get Request
Src MAC: 7777.8888.9999
Dst MAC: 2222.3333.4444
Src IP: 10.10.10.10
Dst IP: 10.10.12.10

OSI Reference Model – De-encapsulation

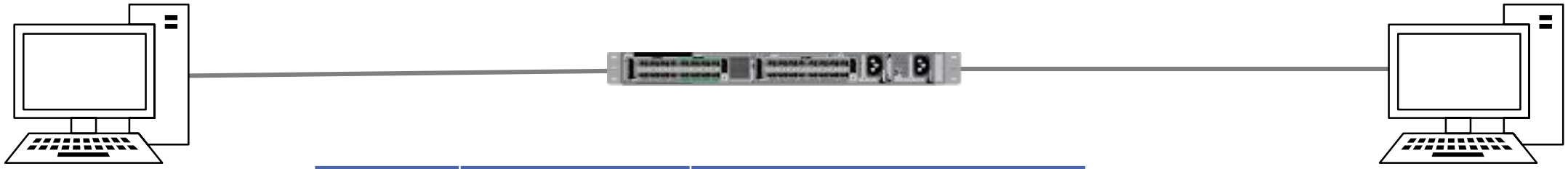


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	
2	Data-Link	
1	Physical	

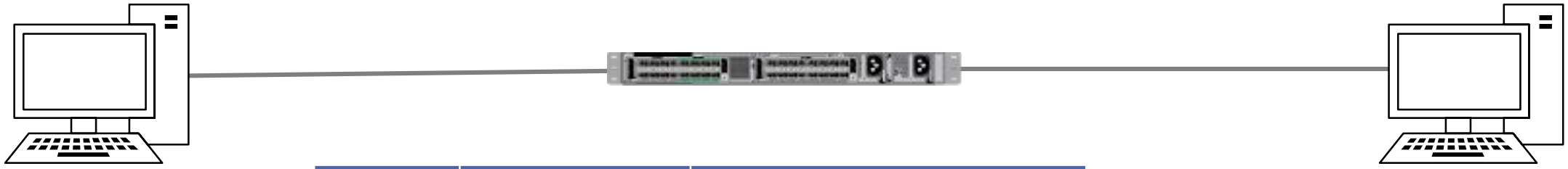
OSI Reference Model – De-encapsulation



Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

OSI Reference Model – De-encapsulation

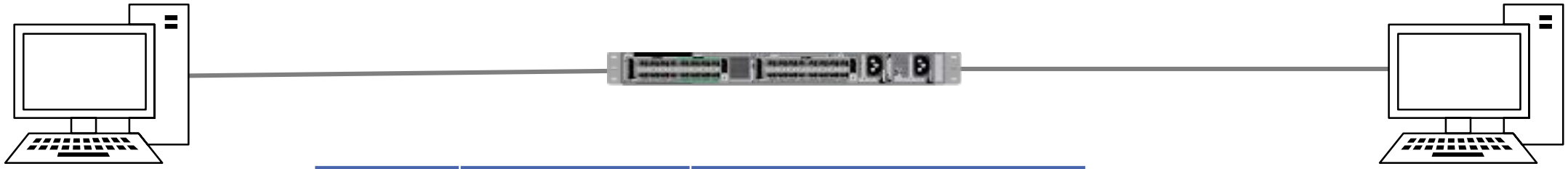


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

OSI Reference Model – De-encapsulation

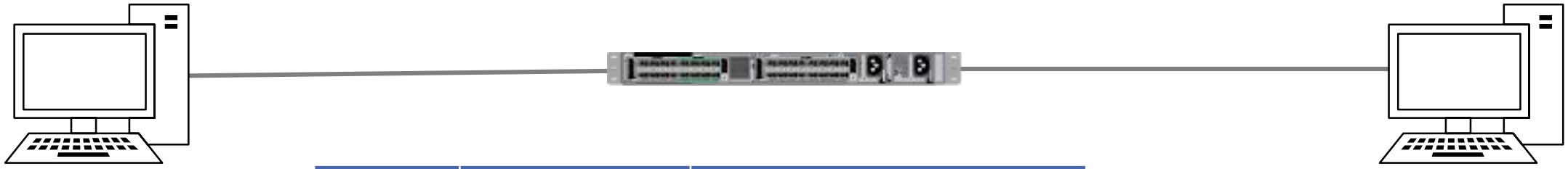


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

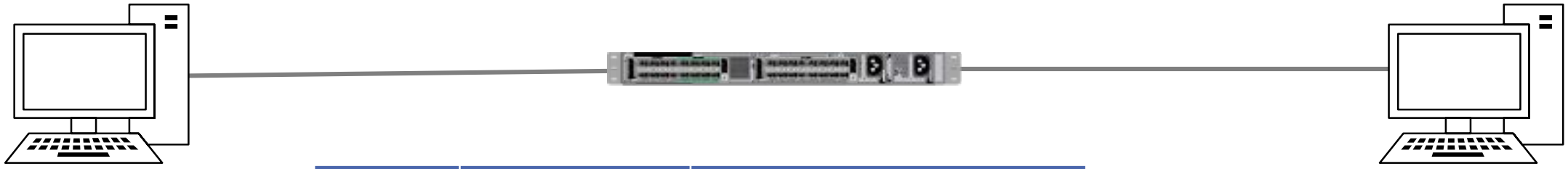
OSI Reference Model – De-encapsulation



Sender **Receiver**

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

OSI Reference Model – De-encapsulation

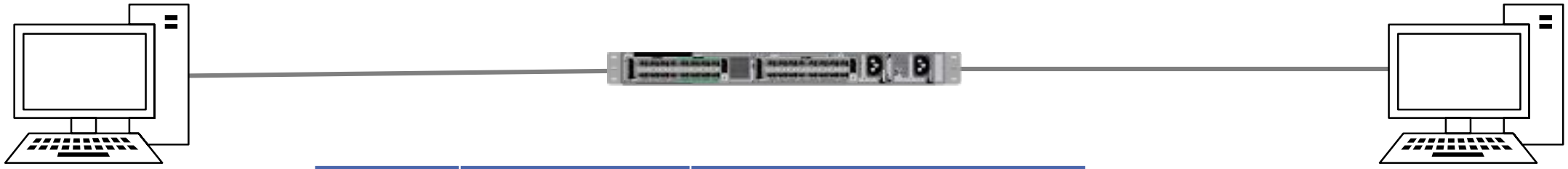


Sender

Receiver

Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

OSI Reference Model – De-encapsulation



Sender

Receiver

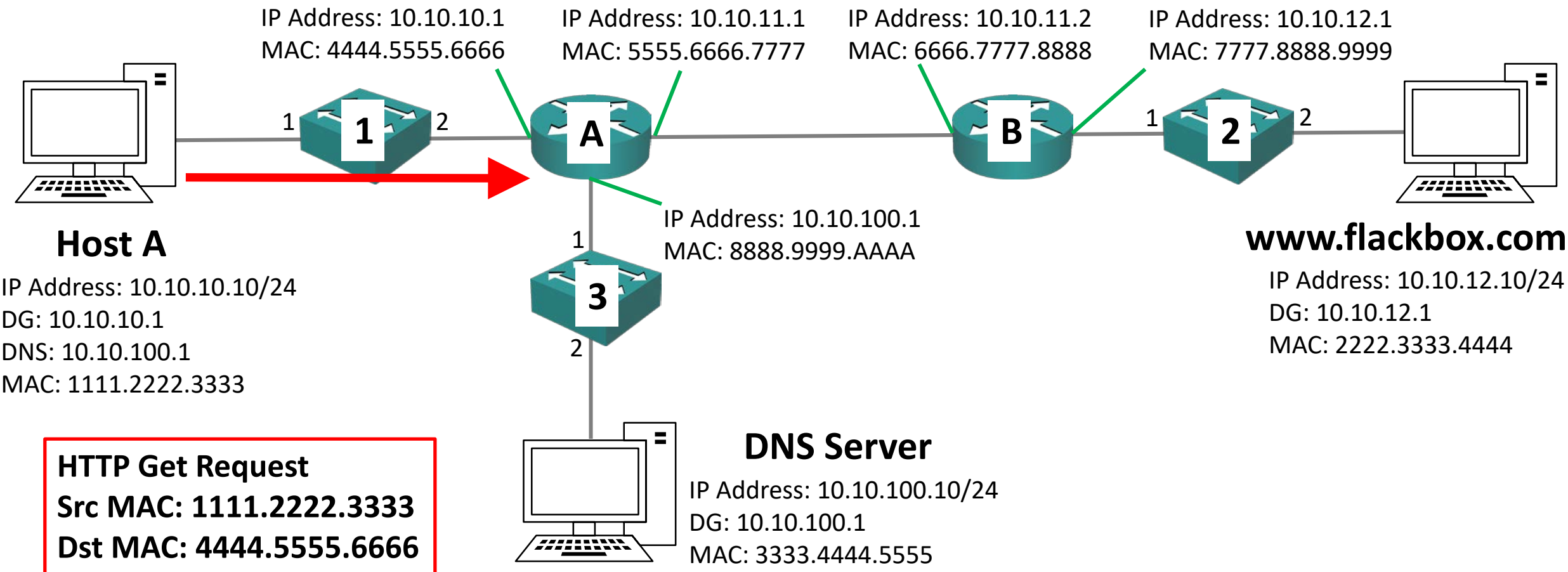
Layer	Name	Includes
7	Application	
6	Presentation	
5	Session	
4	Transport	TCP Port 80
3	Network	Dst: 10.10.12.10
2	Data-Link	Dst: 2222.3333.4444
1	Physical	

L7

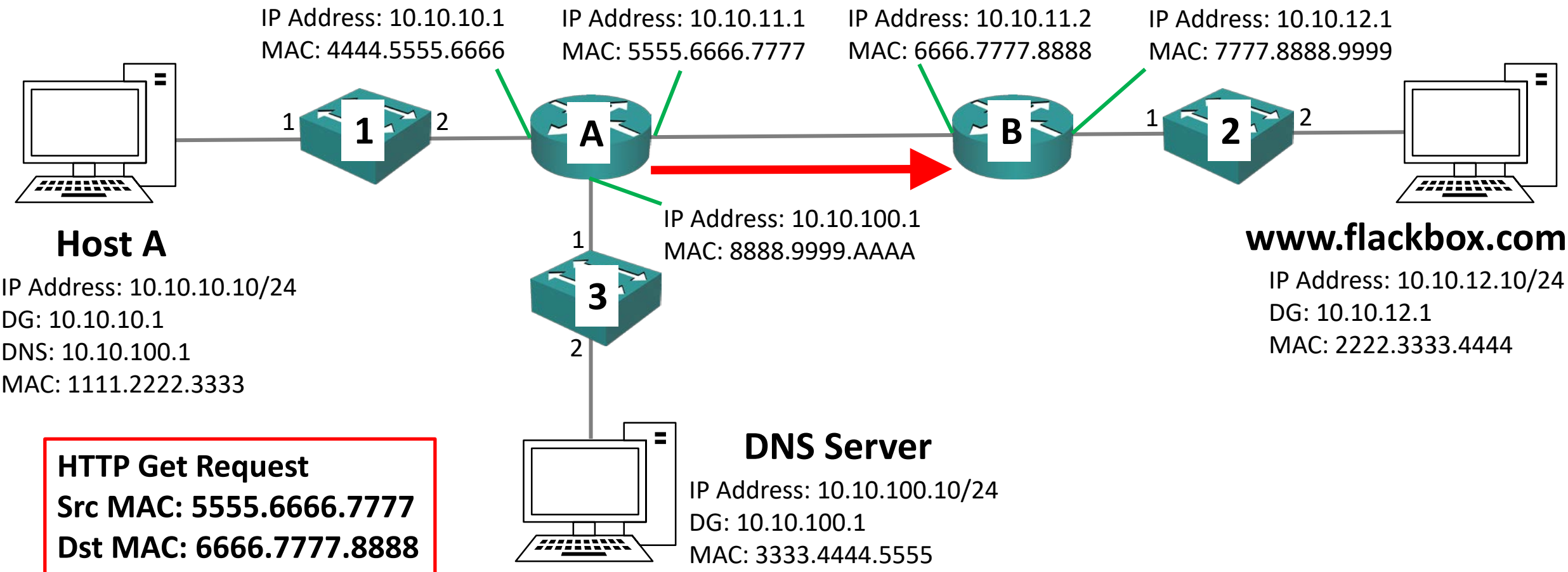
The Life of a Packet

- The ARP and MAC addresses tables are already built so subsequent packets in either direction will flow without any need for ARP requests or switch flooding

The Life of a Packet

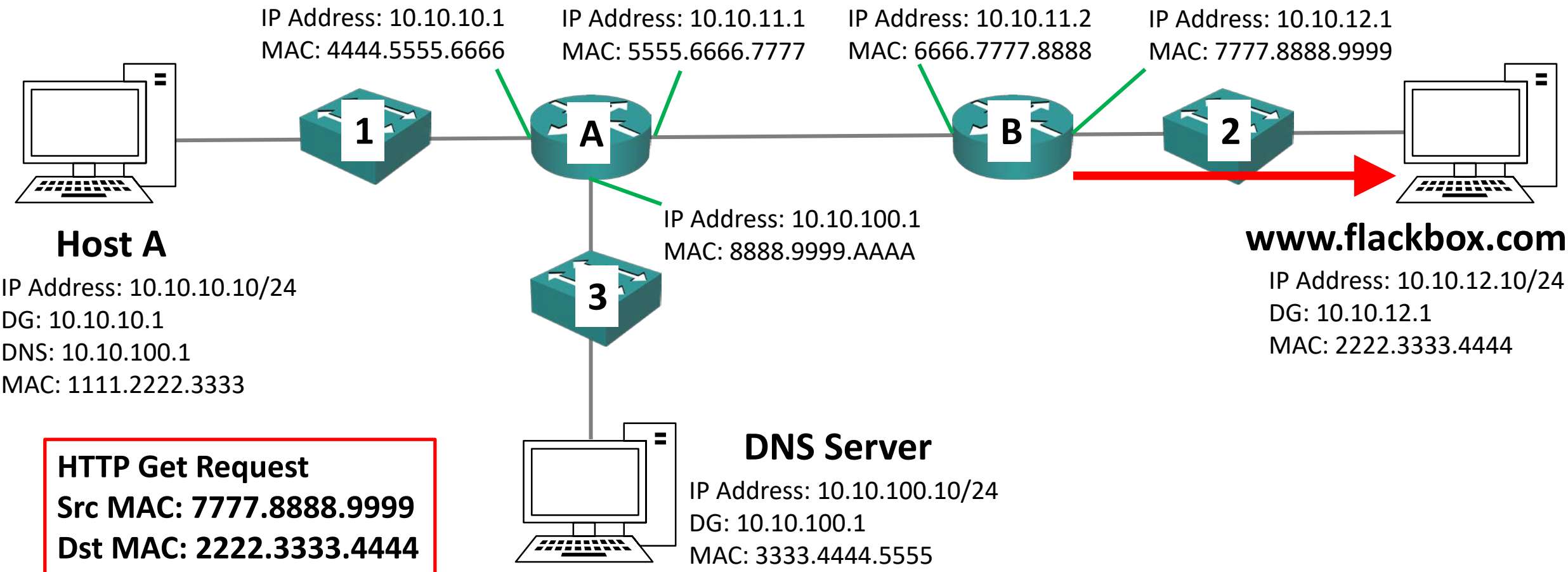


The Life of a Packet



HTTP Get Request
Src MAC: 5555.6666.7777
Dst MAC: 6666.7777.8888
Src IP: 10.10.10.10
Dst IP: 10.10.12.10

The Life of a Packet



HTTP Get Request
Src MAC: 7777.8888.9999
Dst MAC: 2222.3333.4444
Src IP: 10.10.10.10
Dst IP: 10.10.12.10