Università degli Studi Roma Tre
Dipartimento di Informatica e Automazione
Computer Networks Research Group

netkit lab

two-switches

Version	2.1
Author(s)	G. Di Battista, M. Patrignani, M. Pizzonia, F. Ricci, M. Rimondini
E-mail	contact@netkit.org
Web	http://www.netkit.org/
Description	experiments with the source address tables of network switches

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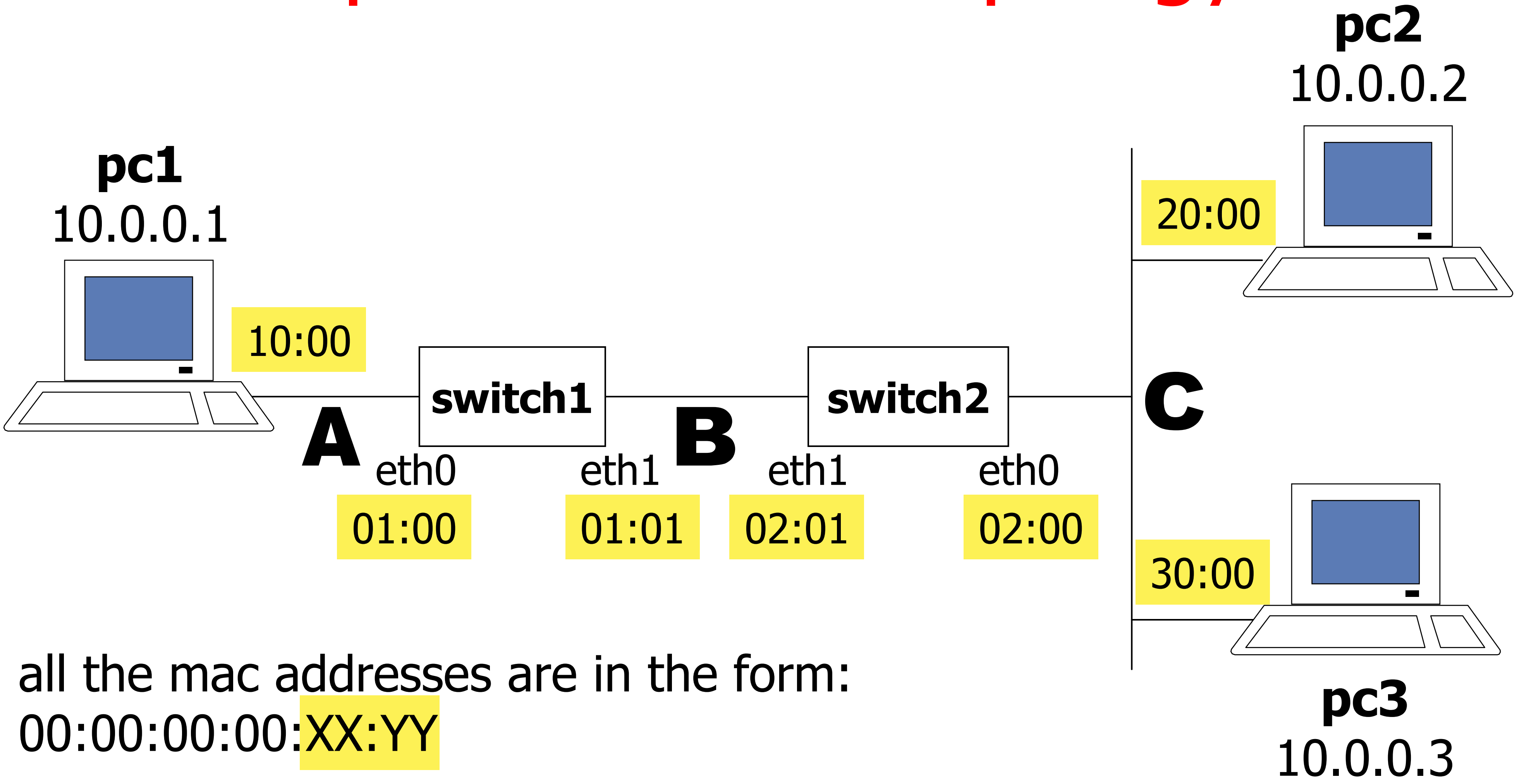
step1 – network topology



all the mac addresses are in the form:
00:00:00:00:XX:YY

ABC are collision domains

step 2 – starting the lab

host machine

```
user@localhost:~$ cd netkit-lab_two-switches
user@localhost:~/netkit-lab_two-switches$ lstart
```

- the started lab is made up of
  - 3 virtual machines that implement the **pcs**
  - 2 virtual machines that implement the **switch**es
    - automatically configured to perform switching
  - all the virtual machines and their network interfaces are automatically configured

step 3 – configuring network interfaces

- real network interfaces have a wired in mac address
  - the first three bytes make up the Organizationally Unique Identifier (OUI), a sequence that matches the vendor of the nic
  - the remaining three bytes are the interface serial number
- mac address of an interface card manufactured by Asustek inc.:

00:13:D4	:	AC:55:4E
oui		serial

step 3 – configuring network interfaces

- virtual network interfaces are automatically assigned a mac address

pc

```
pc:~# ifconfig eth0 14.0.0.2 up
pc:~# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr FE:FD:0E:00:00:02
          inet addr:14.0.0.2  Bcast:14.255.255.255  Mask:255.0.0.0
          inet6 addr: fe80::fcfd:eff:fe00:2/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:72 (72.0 b)  TX bytes:336 (336.0 b)
          Interrupt:5
pc:~# █
```

  - depending on the version of netkit in use, the mac address might be derived from the ip address

step 3 – configuring network interfaces

- the mac address of a virtual network interface can be forcedly configured in the following way:

switch1

```
switch1:~# ifconfig eth0 up
switch1:~# ifconfig eth0 hw ether 00:00:00:00:01:00
switch1:~# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:00:00:00:01:00
          inet6 addr: fe80::fcfd:ff:fe00:0/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:13 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:828 (828.0 b)  TX bytes:378 (378.0 b)
          Interrupt:5

switch1:~#
```

step 3 – configuring network interfaces

- the mac address of a virtual network i... be forcedly configured in the followin...

switch1

```
switch1:~# ifconfig eth0 up
switch1:~# ifconfig eth0 hw ether 00:00:00:00:01:00
switch1:~# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:00:00:00:01:00
          inet6 addr: fe80::fcfd:ff:fe00:0/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:13 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:828 (828.0 b)  TX bytes:378 (378.0 b)
          Interrupt:5

switch1:~#
```

at this point the interface has a default address

step 3 – configuring network interfaces

- the mac address of a virtual network i
be forcedly configured in the followin

at this point the interface has the desired address

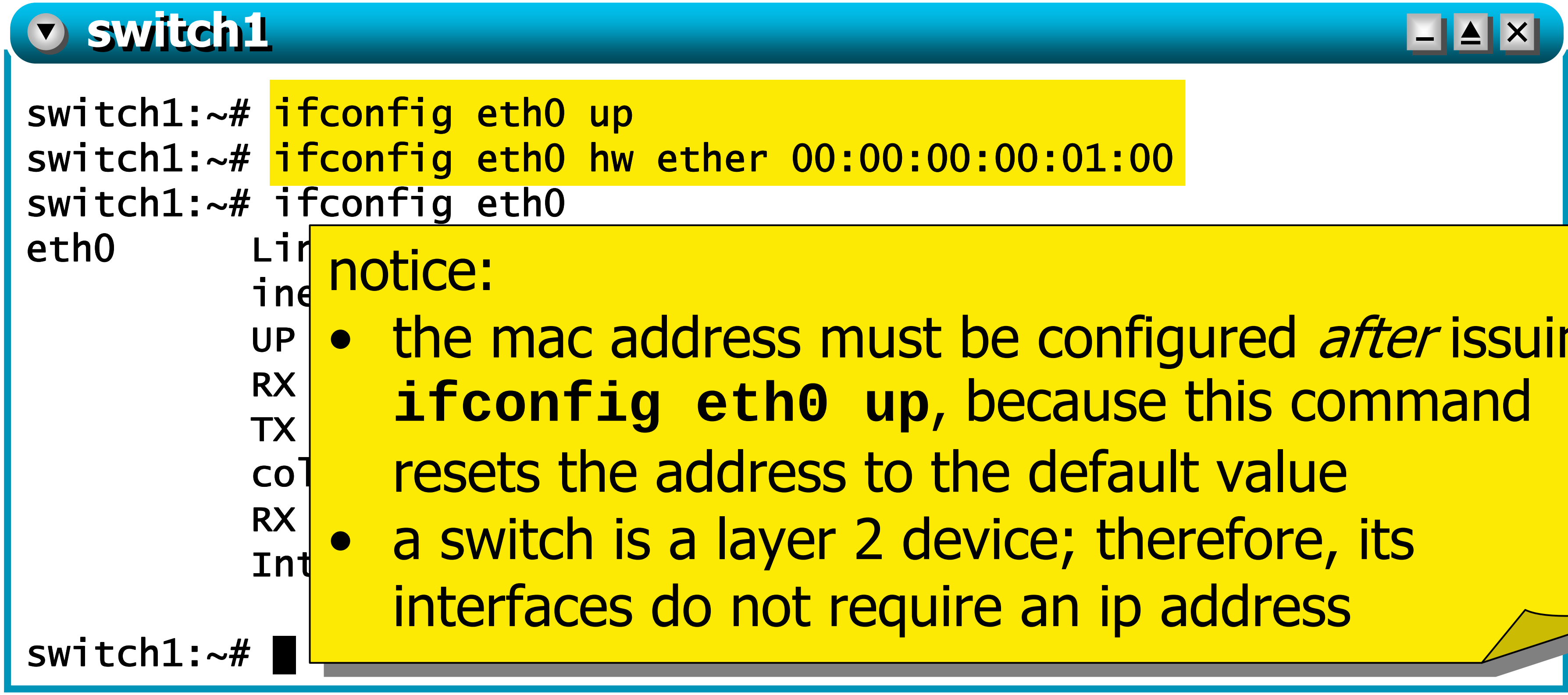
switch1

```
switch1:~# ifconfig eth0 up
switch1:~# ifconfig eth0 hw ether 00:00:00:00:01:00
switch1:~# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:00:00:00:01:00
          inet6 addr: fe80::fcfd:ff:fe00:0/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:13 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:828 (828.0 b)  TX bytes:378 (378.0 b)
          Interrupt:5

switch1:~# █
```

step 3 – configuring network interfaces

- the mac address of a virtual network interface can be forcedly configured in the following way:



notice:

- the mac address must be configured *after* issuing **`ifconfig eth0 up`**, because this command resets the address to the default value
- a switch is a layer 2 device; therefore, its interfaces do not require an ip address

step 4 –bridging capabilities

- **`brctl`** allows to check and configure the settings of the bridging capabilities of a virtual machine

switch1

```
switch1:~# brctl show
bridge name     bridge id               STP enabled     interfaces
br0             8000.000000000100       yes             eth0
                                                        eth1

switch1:~# █
```

switch2

```
switch2:~# brctl show
bridge name     bridge id               STP enabled     interfaces
br0             8000.000000000200       yes             eth0
                                                        eth1

switch2:~# █
```

step 4 – bridging capabilities

- **`brctl`** allows to check and configure the settings of the bridging capabilities of a virtual machine

switch1

```
switch1:~# brctl addbr br0
```

create a new bridge **`br0`**

```
switch1:~# brctl addif br0 eth0
switch1:~# brctl addif br0 eth1
```

attach network interfaces to bridge **`br0`**

```
switch1:~# brctl stp br0 on
```

enable the spanning tree protocol on bridge **`br0`**

```
switch1:~# ifconfig br0 up
```

enable the bridge

  - a virtual machine may enable several bridging processes (on different network interfaces)
  - once configured, a bridge is visible as a network interface that must be brought up in order to function properly

step 5 – investigating source address tables

- if the **pcs** do not generate any traffic, the source address tables only contain information about local ports

switch1

```
switch1:~# brctl showmacs br0
port no mac addr                is local?       ageing timer
  1     00:00:00:00:01:00       yes                0.00
  2     00:00:00:00:01:01       yes                0.00
```

switch2

```
switch2:~# brctl showmacs br0
port no mac addr                is local?       ageing timer
  1     00:00:00:00:02:00       yes                0.00
  2     00:00:00:00:02:01       yes                0.00
```

step 5 – investigating source address tables

- depending on the configuration, a machine may generate traffic even if not solicited (e.g., broadcast packets)
  - the source address tables of **`switch1`** and **`switch2`** may already contain non-local entries
  - hard to prevent
- ports(=interfaces) are numbered according to the 802.1d standard
  - the correspondence between kernel interface numbering (**`ethX`**) and 802.1d numbering can be obtained by using **`brctl showstp`**

step 5 – investigating source address tables

switch1

```
switch1:~# brctl showstp br0
br0
 bridge id              8000.000000000100
 designated root        8000.000000000100
.....
eth0 (1)
 port id                8001                    state                forwarding
.....
eth1 (2)
 port id                8002                    state                forwarding
.....
```

switch2

```
switch2:~# brctl showstp br0
br0
 bridge id              8000.000000000200
 designated root        8000.000000000100
.....
eth0 (1)
 port id                8001                    state                forwarding
.....
eth1 (2)
 port id                8002                    state                forwarding
.....
```

step 6 – evolution of the address tables

- start a sniffer on **pc3**:

```
pc3:~# tcpdump -e -q
```

dump link-level headers (-e)

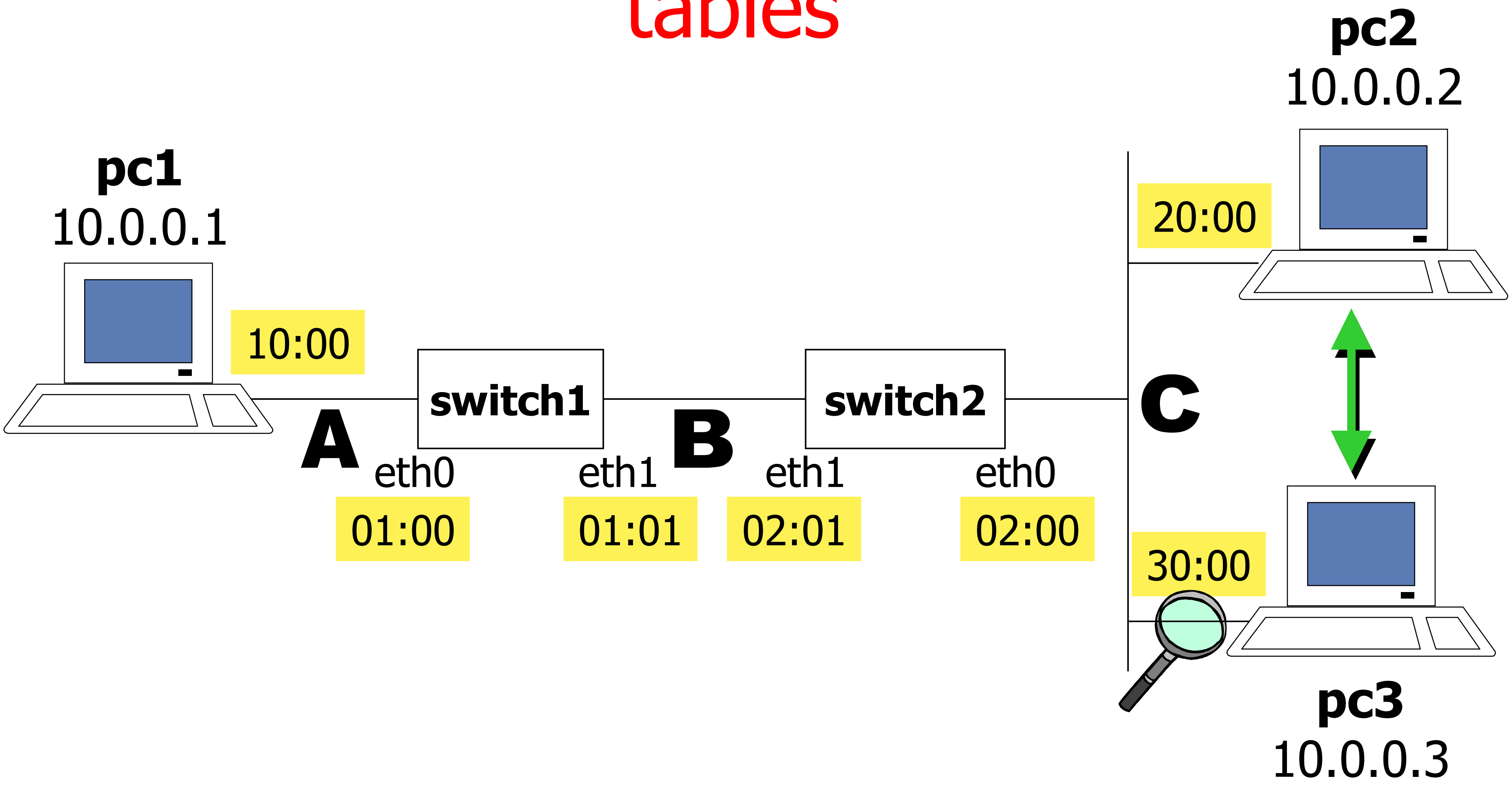
shorter output (-q)

- generate traffic between **pc2** and **pc3**:

```
pc2:~# ping 10.0.0.3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.237 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.184 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.182 ms

--- 10.0.0.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 0.182/0.201/0.237/0.025 ms
pc2:~#
```

step 6 – evolution of the address tables



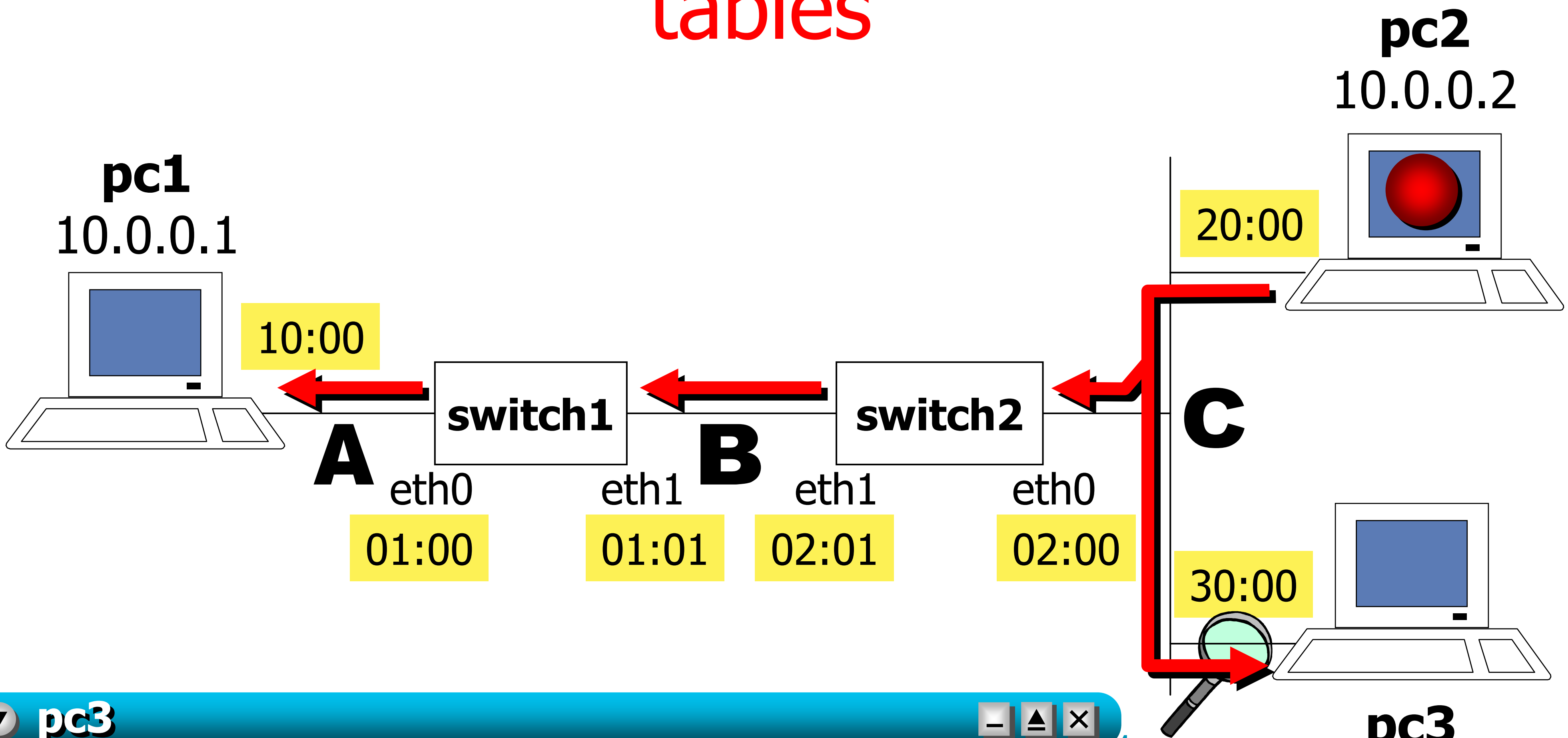
step 6 – evolution of the address tables

- **pc3** sees the traffic exchanged on its collision domain (**C**)

pc3

```
pc3:~# tcpdump -e -q
tcpdump: verbose output suppressed, use -v or -vv for full protocol
decode
listening on eth0, link-type EN10MB (Ethernet), capture size 96 bytes
14:32:32.167034 00:00:00:00:20:00 > Broadcast, ARP, length 42: arp who-
has 10.0.0.3 tell 10.0.0.2
14:32:32.167180 00:00:00:00:30:00 > 00:00:00:00:20:00, ARP, length 42:
arp reply 10.0.0.3 is-at 00:00:00:00:30:00
14:32:32.171178 00:00:00:00:20:00 > 00:00:00:00:30:00, IPv4, length 98:
IP 10.0.0.2 > 10.0.0.3: icmp 64: echo request seq 1
14:32:32.171379 00:00:00:00:30:00 > 00:00:00:00:20:00, IPv4, length 98:
IP 10.0.0.3 > 10.0.0.2: icmp 64: echo reply seq 1
14:32:33.164562 00:00:00:00:20:00 > 00:00:00:00:30:00, IPv4, length 98:
IP 10.0.0.2 > 10.0.0.3: icmp 64: echo request seq 2
.....
```

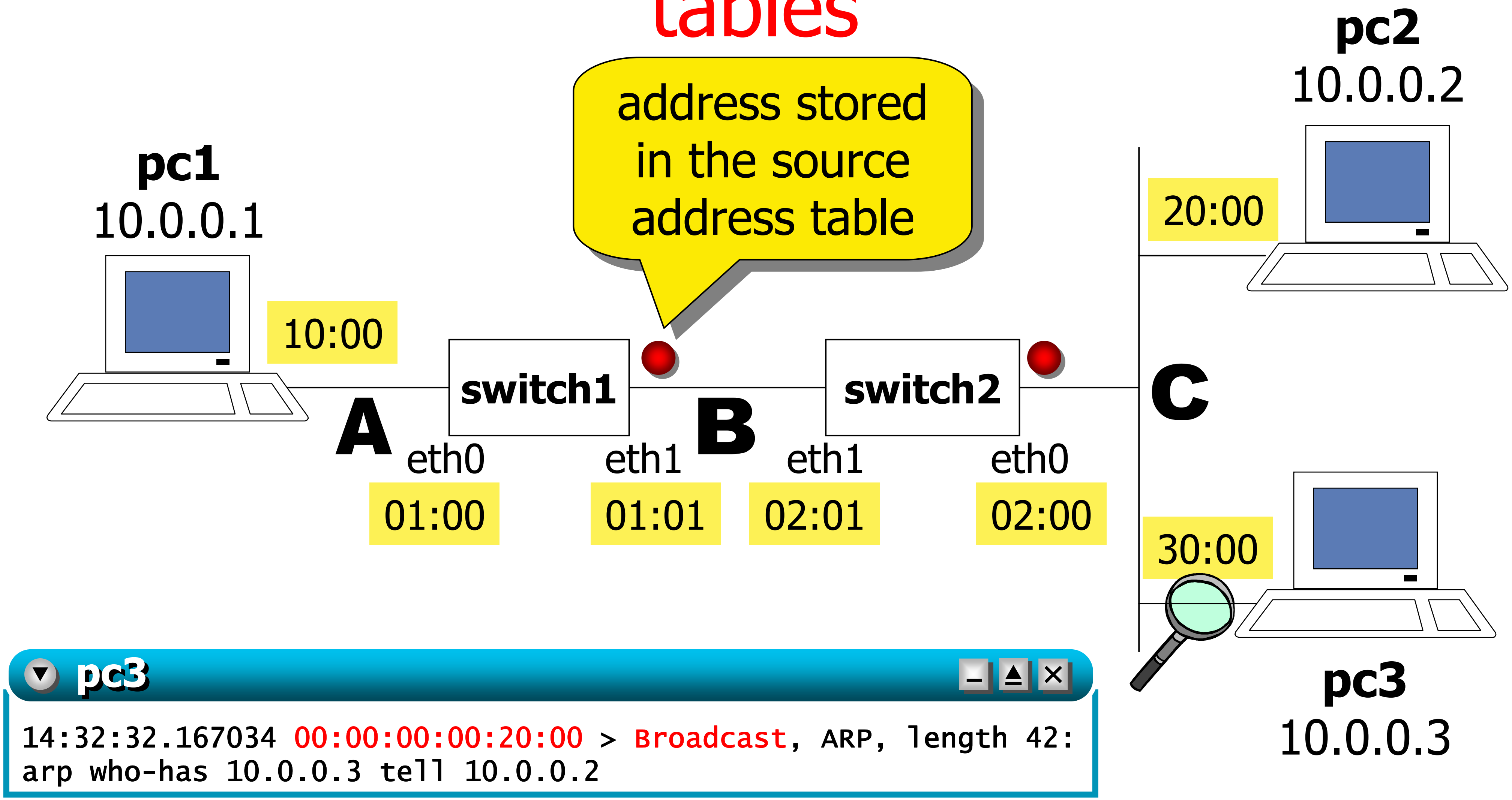
step 6 – evolution of the address tables



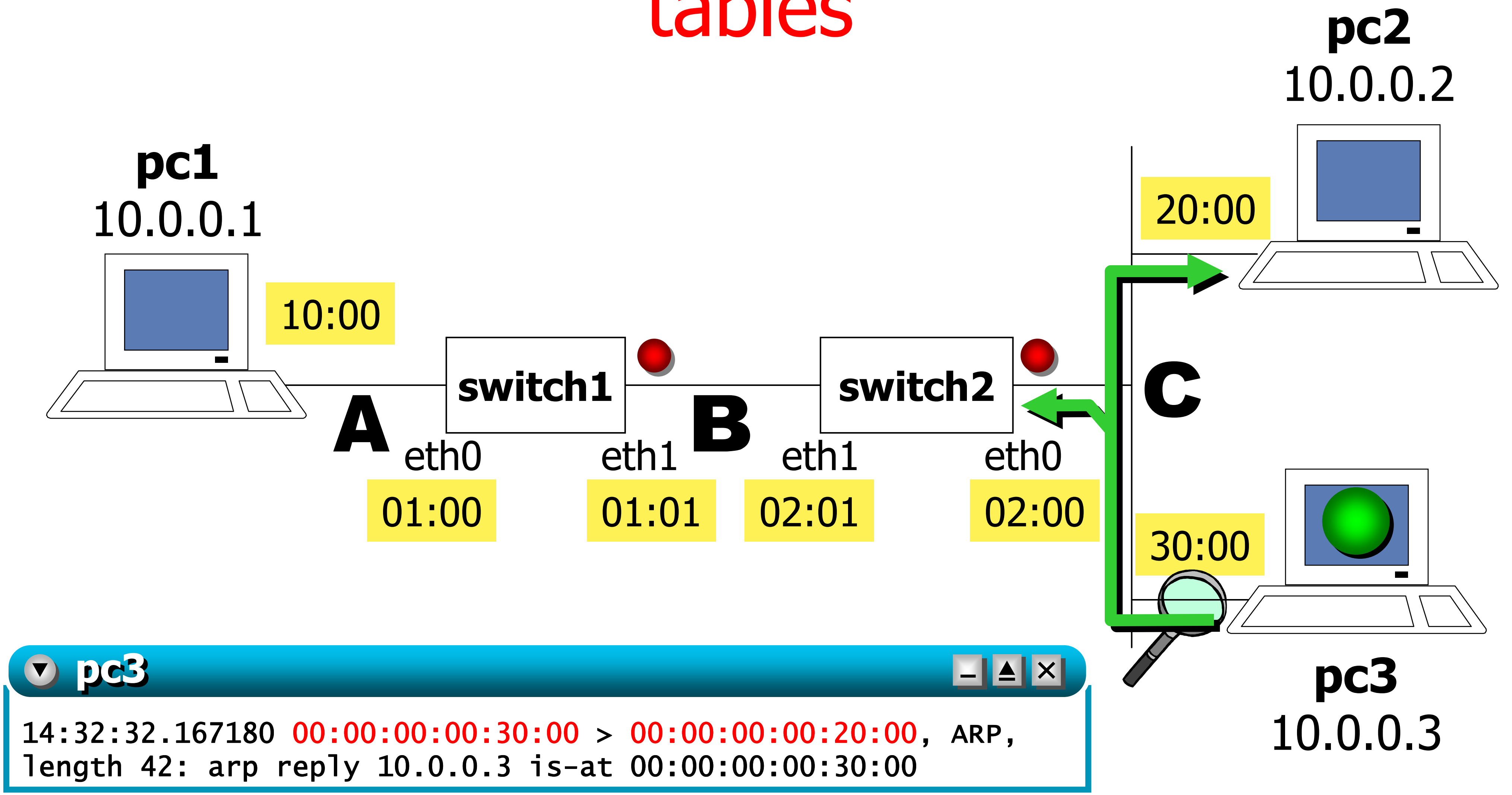
pc3

```
14:32:32.167034 00:00:00:00:20:00 > Broadcast, ARP, length 42:
arp who-has 10.0.0.3 tell 10.0.0.2
```

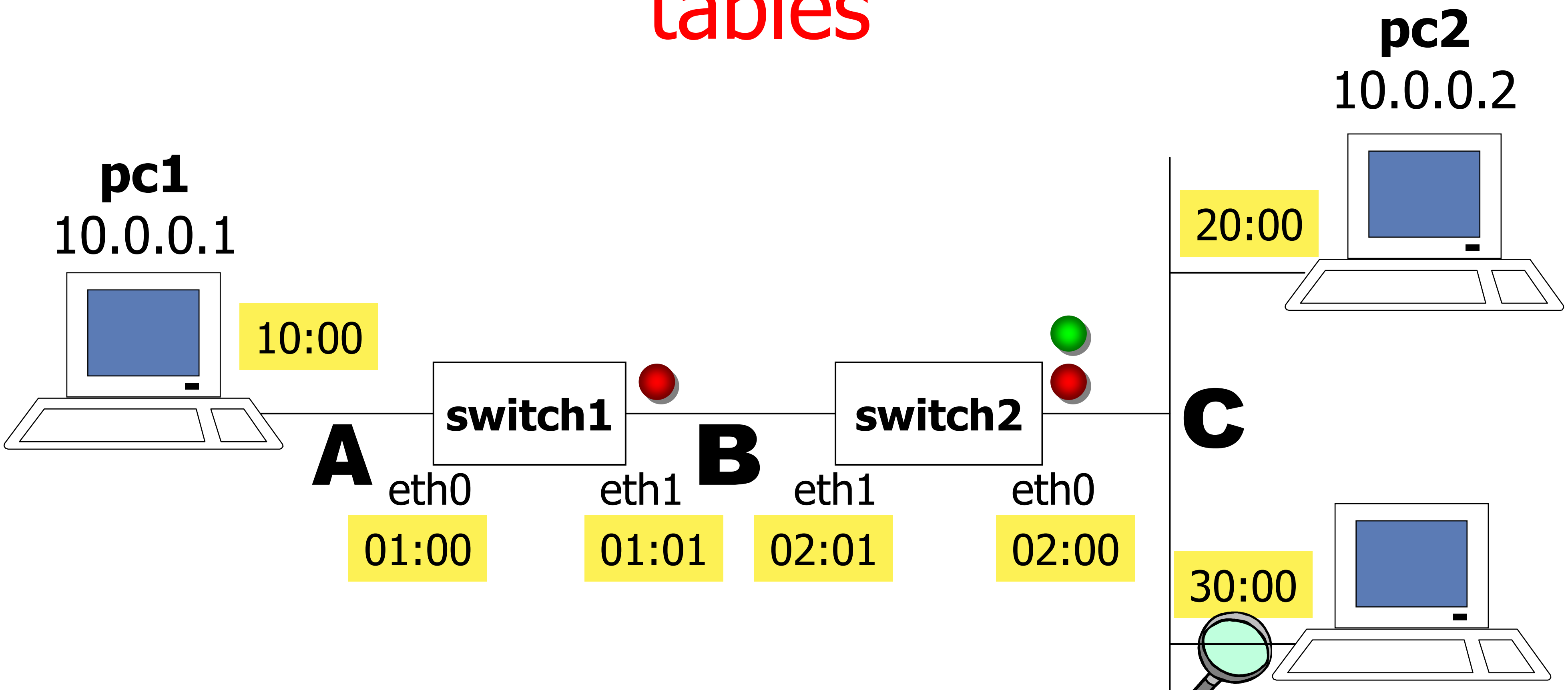
step 6 – evolution of the address tables

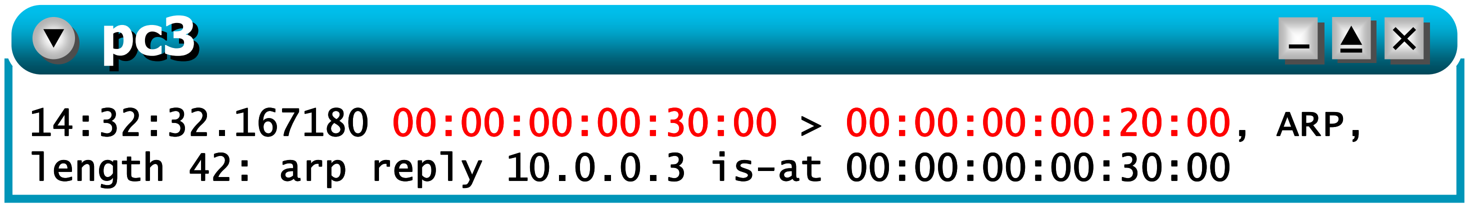


step 6 – evolution of the address tables

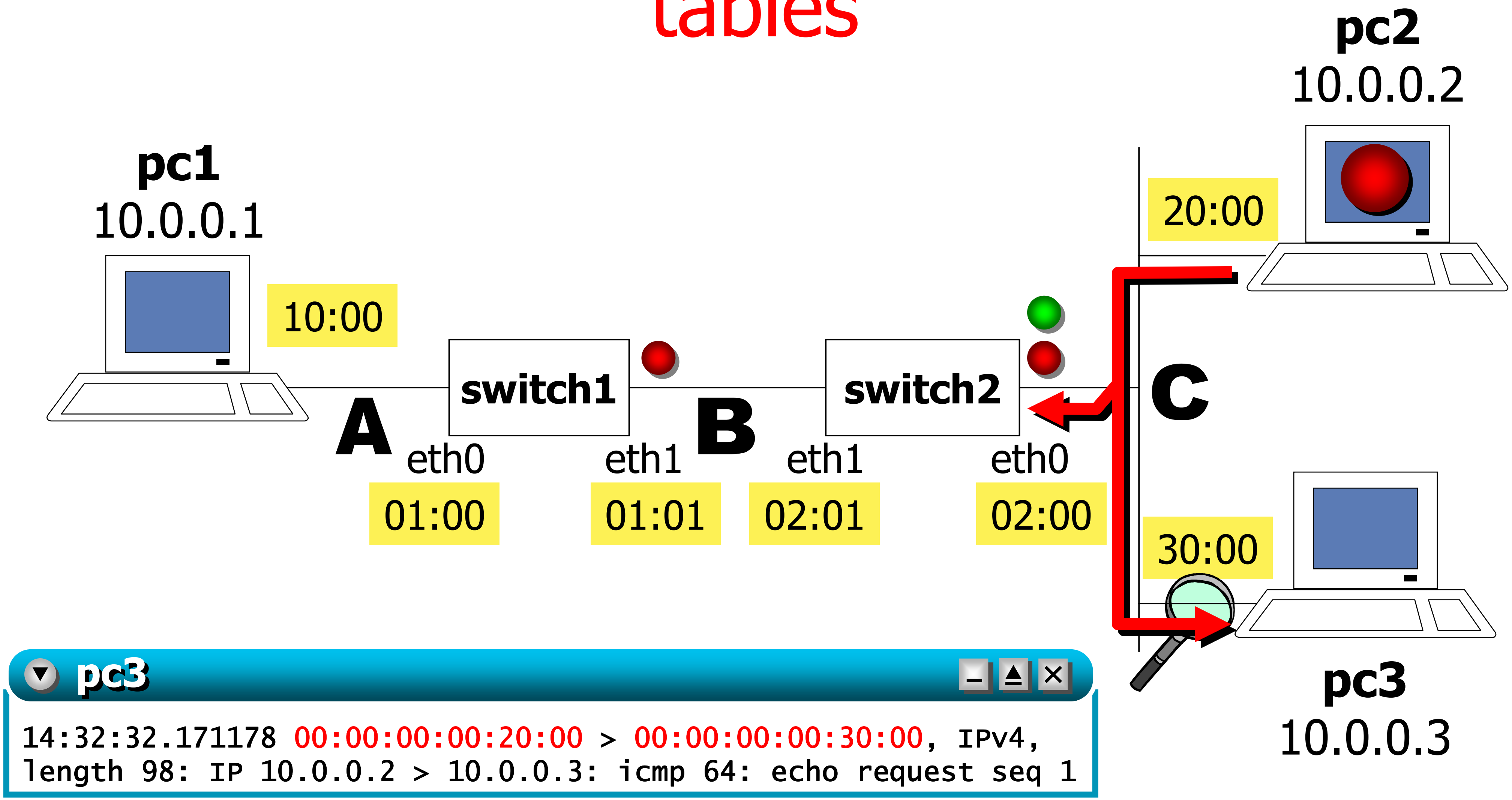


step 6 – evolution of the address tables

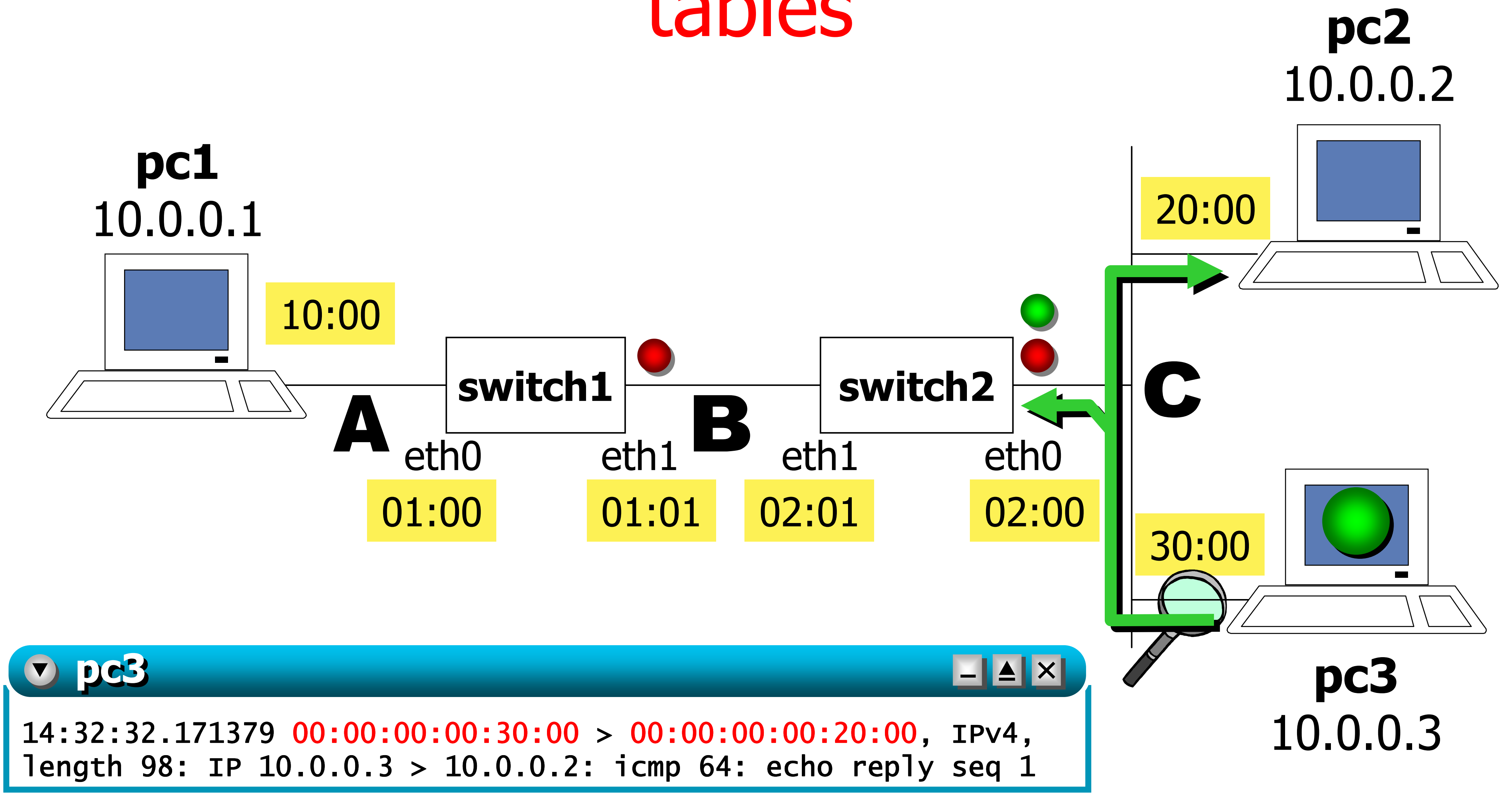




step 6 – evolution of the address tables



step 6 – evolution of the address tables



step 6 – evolution of the address tables

switch1

```
         switch1:~# brctl showmacs br0
         port no mac addr              is local?       ageing timer
switch1/eth0   1     00:00:00:00:01:00  yes               0.00
switch1/eth1   2     00:00:00:00:01:01  yes               0.00
         pc2   2     00:00:00:00:20:00  no                1.97
```

switch2

```
         switch2:~# brctl showmacs br0
         port no mac addr              is local?       ageing timer
switch1/eth1   2     00:00:00:00:01:01  no                0.59
switch2/eth0   1     00:00:00:00:02:00  yes               0.00
switch2/eth1   2     00:00:00:00:02:01  yes               0.00
         pc2   1     00:00:00:00:20:00  no                0.55
         pc3   1     00:00:00:00:30:00  no                0.55
```

step 6 – evolution of the address tables

switch1

```
switch1:~# brctl showmacs br0
```

	port no	mac addr	is local?	ageing timer
switch1/eth0	1	00:00:00:00:01:00	yes	0.00
switch1/eth1	2	00:00:00:00:01:01	yes	0.00
pc2	2	00:00:00:00:20:00	no	1.97

switch2

```
switch2:~# brctl showmacs br0
```

	port no	mac addr	is local?	ageing timer
switch1/eth1	2	00:00:00:00:01:01	no	0.59
switch2/eth0	1	00:00:00:00:02:00	yes	0.00
switch2/eth1	2	00:00:00:00:02:01	yes	0.00
pc2	1	00:00:00:00:20:00	no	0.55
pc3	1	00:00:00:00:30:00	no	

this entry is due to packets exchanged for spanning tree calculation

step 6 – evolution of the address tables

- **`switch2`** knows the positions of **`pc2`** and **`pc3`** since it has seen their traffic
- **`switch1`** does not know the position of **`pc3`** since **`pc3`**'s traffic has been filtered out by **`switch2`**
- the two switches are not aware of **`pc1`**

step 7 – filtering in action

- clear the address tables by setting the lifetime (*ageing*) of the entries to 10 seconds:

switch1
```
switch1:~# brctl setageing br0 10
```

switch2
```
switch2:~# brctl setageing br0 10
```

- after 10 seconds of "silence" only the local interfaces remain in the source address tables

step 7 – filtering in action

- repeat the **ping** experiment with a 3 seconds interval and place a sniffer on **pc1**:

pc1

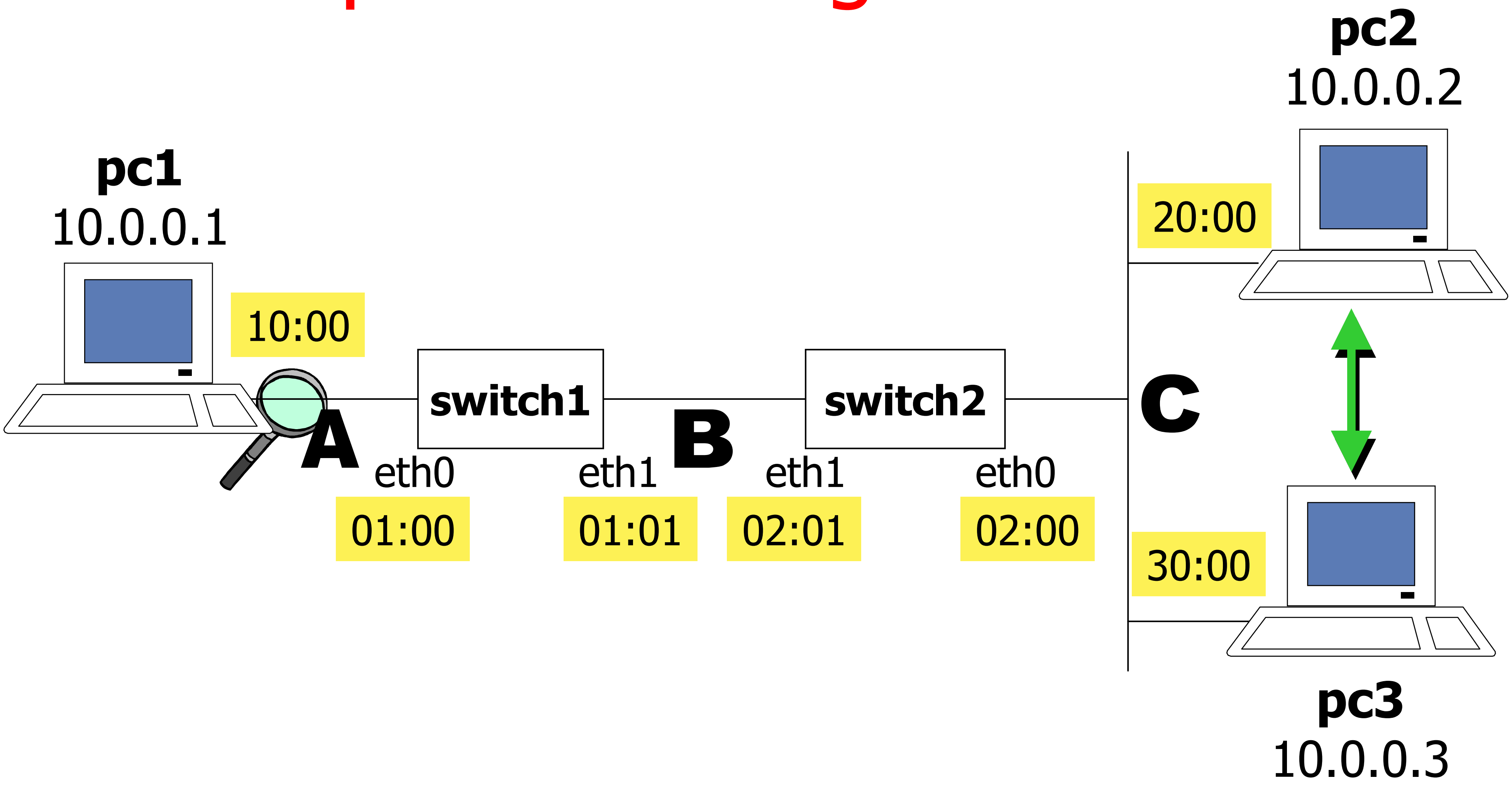
```
pc1:~# tcpdump -e -q █
```

pc2

```
pc2:~# ping -i 3 10.0.0.3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.237 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.184 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.182 ms

--- 10.0.0.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 0.182/0.201/0.237/0.025 ms
pc2:~# █
```

step 7 – filtering in action



step 7 – filtering in action

- since the **switch**es filter traffic, only broadcast packets can reach **pc1**:

pc1

```
pc1:~# tcpdump -e -q
tcpdump: verbose output suppressed, use -v or -vv for full
protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size
96 bytes
15:45:50.142942 00:00:00:00:20:00 > Broadcast, ARP, length 42:
arp who-has 10.0.0.3 tell 10.0.0.2
```

step 7 – filtering in action

- keep the **`ping`** active and reduce the lifetime of the entries of the source address table:

switch1
```
switch1:~# brctl setageing br0 1
```

switch2
```
switch2:~# brctl setageing br0 1
```

- in this way, the entries expire after each echo request has been sent (echo requests are sent every 3 seconds)
  - every time **`pc2`** generates an echo request:
    - **`switch2`** does not know about **`pc3`**, hence performs flooding
    - **`switch1`** does not know about **`pc3`**, hence performs flooding
    - as a consequence, **`pc1`** sees the echo request sent by **`pc2`**
  - every time **`pc3`** generates an echo reply:
    - **`switch2`** knows about **`pc2`** (thanks to the echo request) and filters traffic
    - as a consequence, neither **`switch1`** nor **`pc1`** see the echo reply
    - note that echo replies are sent within the 1 second lifetime

step 7 – filtering in action

- **pc1** only sees the echo requests:

pc1

```
pc1:~# tcpdump -e -q
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size 96 bytes
16:38:49.305818 00:00:00:00:20:00 > Broadcast, ARP, length 42: arp who-has
10.0.0.3 tell 10.0.0.2
16:38:52.305602 00:00:00:00:20:00 > 00:00:00:00:30:00, IPv4, length 98: IP
10.0.0.2 > 10.0.0.3: icmp 64: echo request seq 2
16:38:55.322456 00:00:00:00:20:00 > 00:00:00:00:30:00, IPv4, length 98: IP
10.0.0.2 > 10.0.0.3: icmp 64: echo request seq 3
16:38:58.333206 00:00:00:00:20:00 > 00:00:00:00:30:00, IPv4, length 98: IP
10.0.0.2 > 10.0.0.3: icmp 64: echo request seq 4
.....
```

- the arp reply sent by **pc3** to **pc2** is filtered because **switch2** knows about **pc2** (thanks to the arp request)
- the first echo request is also filtered because immediately after the arp exchange **switch2** still knows about **pc3**