Practical aspects of solving the incompatibility of 64-bit MAC addresses in IEEE Stds 802.15 with the IEEE Std 802.1Q-2022

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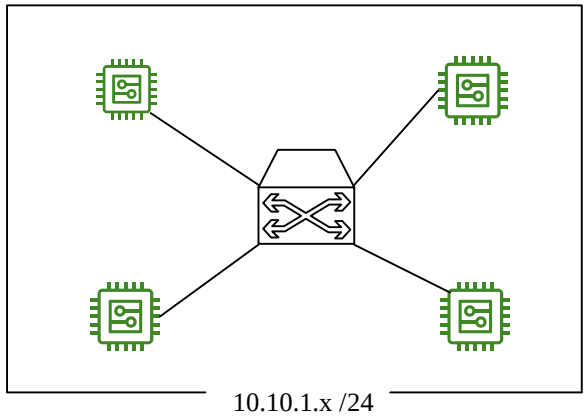
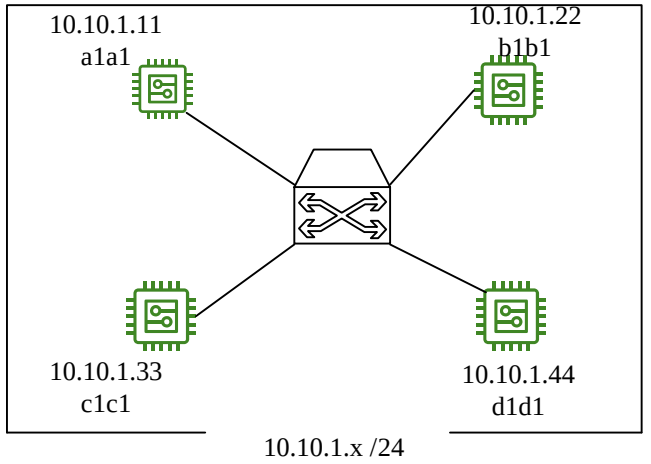
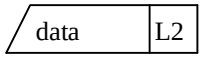
Introduction

- IEEE Stds that use a Network Interface Controller (NIC) with a 64-bit MAC address cannot make use of bridges and bridged networks defined in IEEE Stds 802.1Q and 802.1D as those are restricted to employ 48-bit MAC addresses.
- Previous proposals try to figure out the mapping of 64-bit MAC address encoding onto 48-bit encoding in a way there is no conflict or collision.
- Currently, the revision of IEEE Std 802-2014 considers to leverage the interoperability in L3. However, using a device in L3 such as a router, still has MAC addresses incompatibility.
- The presentation delineates how to modify current hardware for switching devices.
- The MAC address incompatibility can be solved by a device similar to a Network Address Translator (NAT), but operating in L3 and/or L2, a Switch Address Translator.

Interconnecting devices with 64-bit MAC addresses







SRC c1c1
DST d1d1

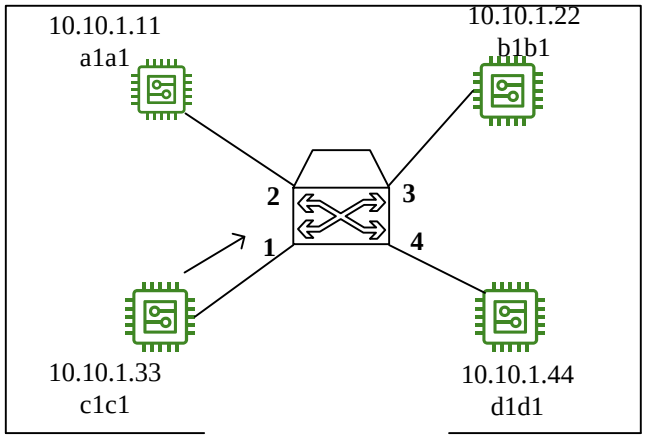
It is possible to interconnect devices with a switch in L2 as long as:

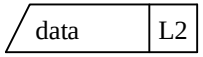
1) The switch has 64-bit NICs in each port interconnecting devices with 64-bit MAC addresses.

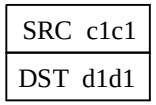
2) Such devices are in the same collision domain (network domain/ IP address space).

Quick overview of switches

- Switches maintain a MAC address Table
  - Mapping switch ports to MAC addresses
- Perform 3 actions:
  - *Learn*: update the MAC address Table with the port and the source MAC address of an incoming MAC frame.
  - *Flood*: duplicate and send the frame out from all ports (except the port where the frame came in), when the destination MAC address is not in the MAC address Table.
  - *Forward*: send the frame out from the port that matches the frame's destination MAC address with the MAC address in the MAC address Table.

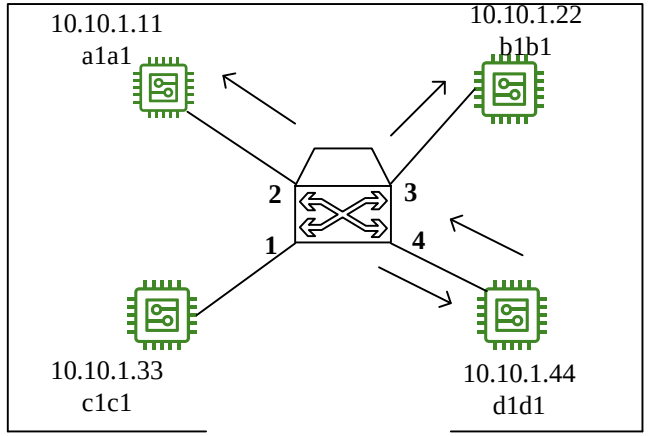


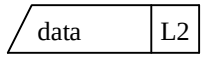




MAC address Table

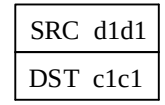
Port	S.M.A.
1	c1c1





MAC address Table

Port	S.M.A.
1	c1c1
4	d1d1



The point is to see why the switch's NICs are relevant:

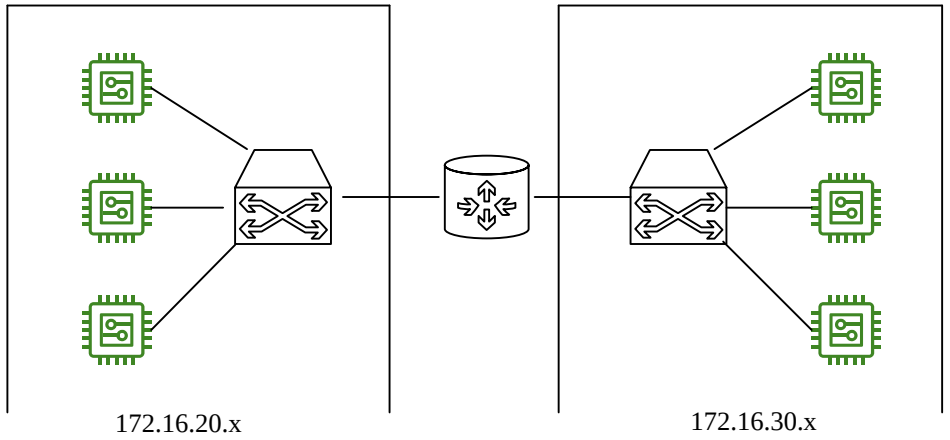
1) The switch runs in promiscuous mode (it accepts all incoming frames).

2) The switch is not an endpoint of traffic (apparently, the switch's NIC address is irrelevant).

3) However, the switch has to input the Source MAC address (S.M.A.) into the MAC address Table.

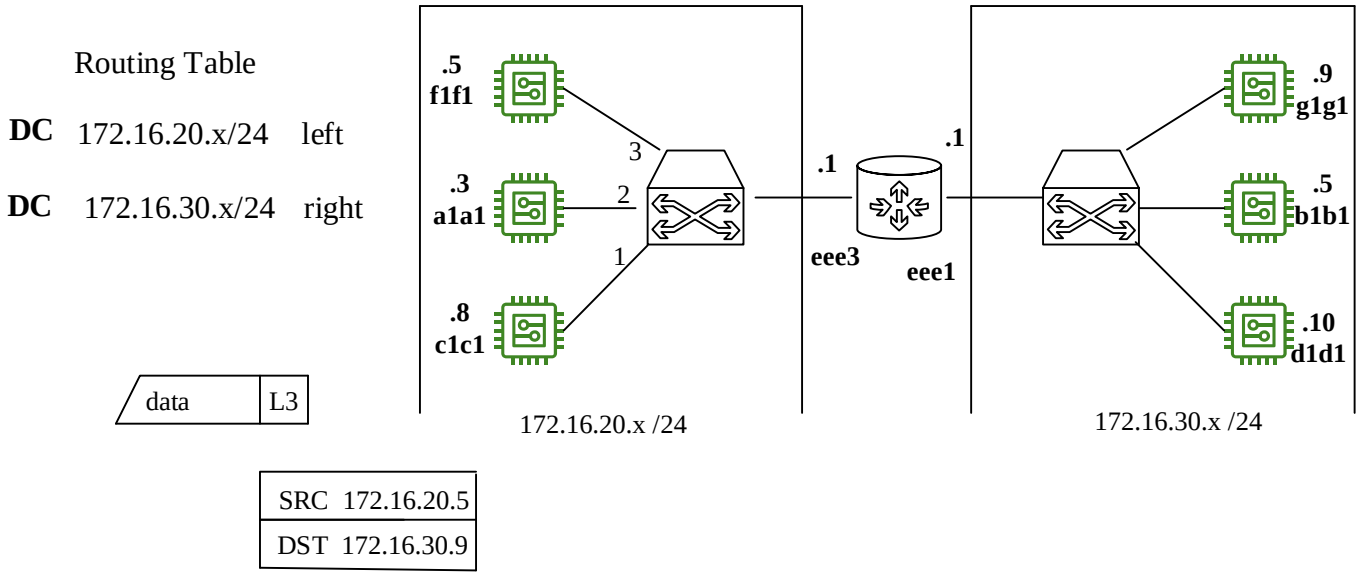
Interconnectivity 64 and 48: the router

- Assuming devices (stations, IoT, bridge) with 64-bit and 48-bit MAC addresses:
- A workaround is to have the interconnectivity in L3 with IP addresses
  - Assuming an IP network
  - Out of scope of 802 Stds
- Routing is the process of moving data between networks (different collision domains, IP address spaces)



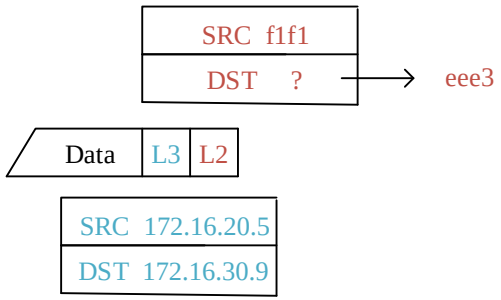
Routing

- Routing is the process of moving data between networks (different collision domains, IP address spaces)
- All devices must use a MAC address (L2) and an IP address (L3), except the switch (L2 device).
- Routers must have a MAC address and IP address in each network interface it connects to.
- Routers maintain a Routing Table.
- Mapping of IP addresses between networks or devices in the same network interface (IP address space).
  - Directly connected
  - Static routes (not shown)
  - Dynamic routes (not shown)
- Switches are abstracted



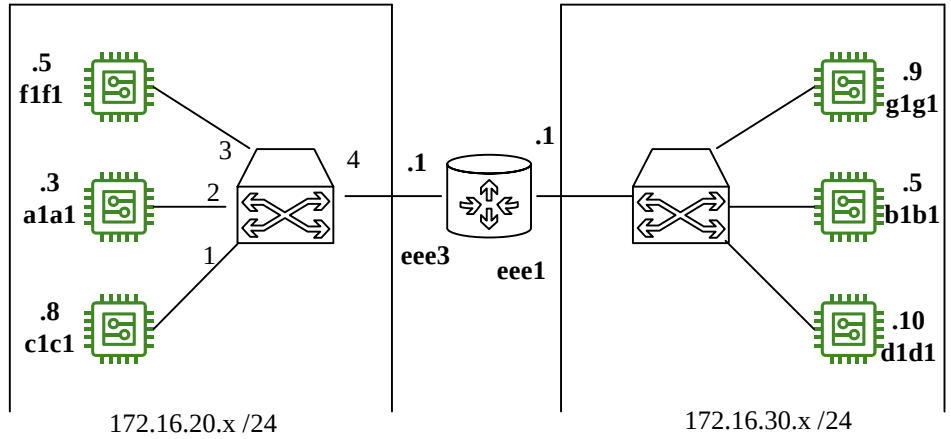
Key points

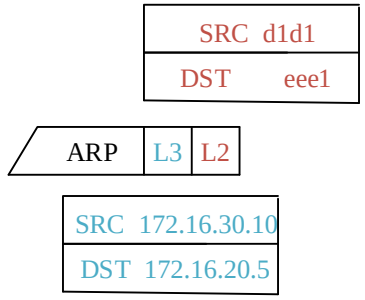
- Routers have a MAC address and IP address for each network (domain) they are connected to
  - Not for every device is connected to the router.
  - This is how L2 comes into play with a switch.
- Routers and devices in L3 maintain another table: ARP Table (Cache)
  - The Address Resolution Protocol (ARP) is an L3 protocol used for discovering the MAC address associated with an IP address.
  - Mapping between IP address and MAC address
    - Populating the ARP Table using an ARP packet



Router ARP Table

172.16.20.5	f1f1
172.16.20.3	a1a1
172.16.20.8	c1c1
172.16.30.9	g1g1
172.16.30.5	b1b1
172.16.30.10	d1d1





Moving data in IP networks

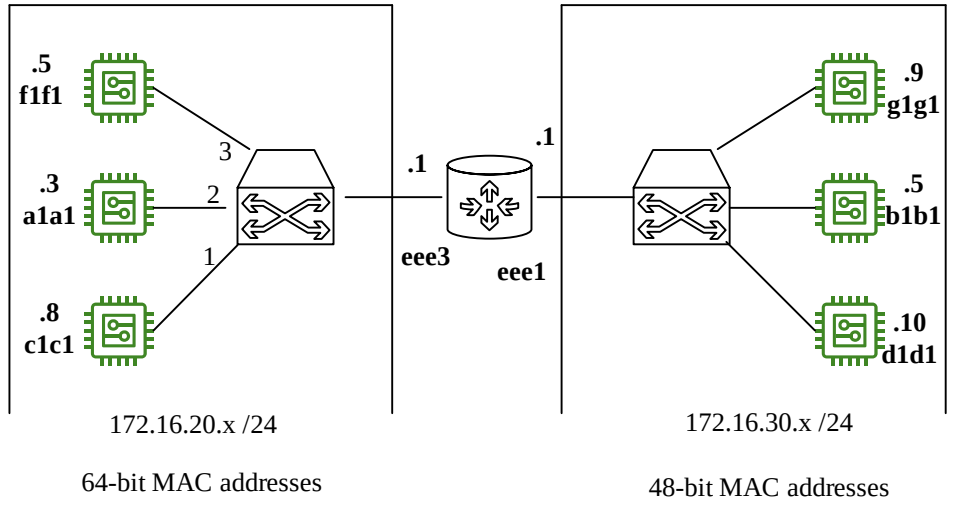
Once the MAC address Tables, ARP Tables, and Routing Tables are populated, we can move data between devices over the interconnected networks.

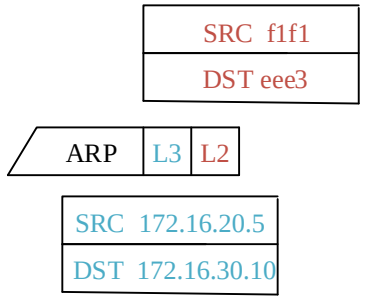
Notice: L3 frames do not appear out of the blue in the router.

There is a PHY layer and MAC layer with a NIC in the router per interface.

A “conventional” router has the same problem of incompatibility of MAC addresses.

The obvious solution is to equip the router with NIC(s) with 64-bit MAC addresses to interconnect devices with 64-bit MAC addresses and NIC(s) with 48-bit MAC address to interconnect devices with 64-bit MAC addresses.





Another solution in L2 and L3

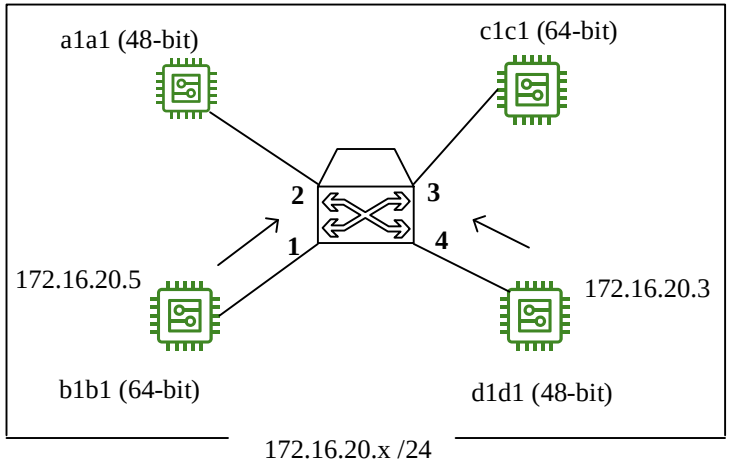
- Similar to a NAT or PAT, using a device for mapping MAC addresses, like a Switch Address Translator.
- A modification of a managed switch with ports equipped with NICs of 64-bit MAC addresses and an extra column entry in the MAC address Table for the mapped addresses.

MAC address Table

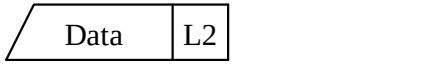
Port	S.M.A.	Mapped S.M.A.

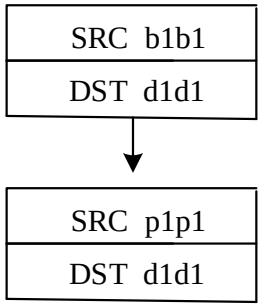
- The switch's programming (hardware or software) would be able to detect the source MAC address of an incoming MAC frame in a given port is 48-bit and ignore 16 bits in the MAC address Table.
- If connected devices to the switch are all 64-bit or 48-bit, the Mapped S.M.A. column is empty.
- If there is a mixture of devices with 64-bit and 48-bit, an incoming MAC frame with a 64-bit source MAC address will be mapped to a *private* 48-bit MAC address. That will keep interoperability.

Another solution in L2 and L3



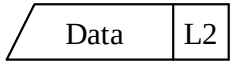
The destination MAC address is known after running the ARP protocol.

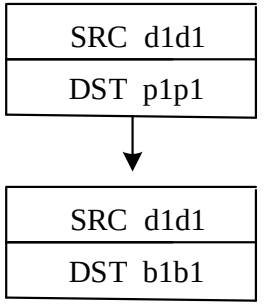




MAC address Table

Port	S.M.A.	Mapped S.M.A.
1	b1b1	p1p1 (48-bit)
4	d1d1	





IEEE 802.15.4 Stds

IEEE 802.1Q Stds

Conclusion

- An L3 Switch equipped with 64-bit NICs in every port
  - An L3 Switch supports a Routing Table, but it is less sophisticated than a router
- An extra column entry for the Mapped Source MAC address in the MAC address Table
- Private (locally administered) MAC addresses
- Simple solution that is in the domain of IEEE 802 Stds (L2)
  - L3 would be required in case the devices are in different networks (collision domains, IP address spaces) to run the ARP protocol.
  - If devices are in the same network, operations in L3 are not required. A managed switch is enough.

Private MAC address

- *Private* MAC addresses, at least as implemented by Apple and Android, set the locally administered bit (Local bit) for their randomized 48-bit MAC addresses.
  - There are new initiatives to specify ways in which these locally administered addresses should be assigned…
- RFC7042 section 2.1 specifies the Local bit as:
- “The Local bit is zero for globally unique EUI-48 identifiers assigned by the owner of an OUI or owner of a longer prefix. If the Local bit is a one, the identifier has been considered by IEEE 802 to be a local identifier under the control of the local network administrator …”
- The 2nd bit of the first octet in the MAC address is set to one, a locally-administered MAC address:

x2:xx:xx:xx:xx:xx

x6:xx:xx:xx:xx:xx

xA:xx:xx:xx:xx:xx

xE:xx:xx:xx:xx:xx