NWEN302

Lab 1

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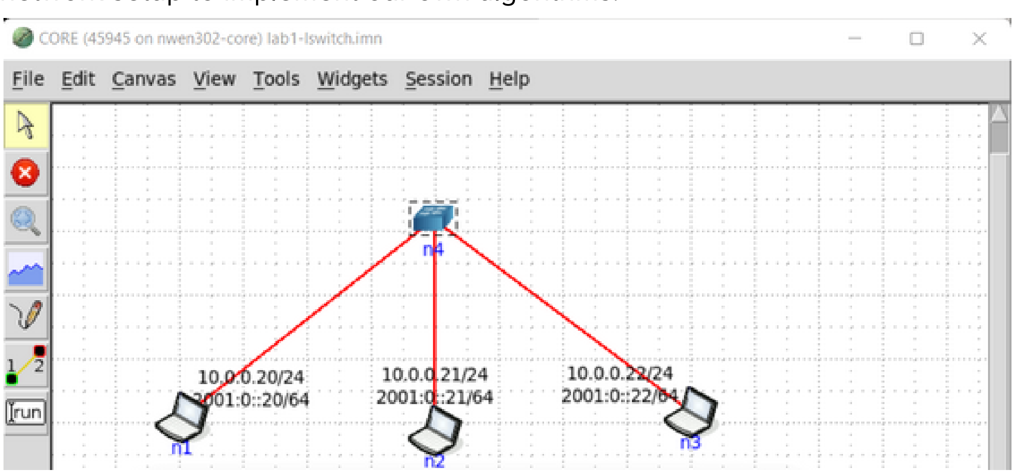
NPD Address Solution

Introduction

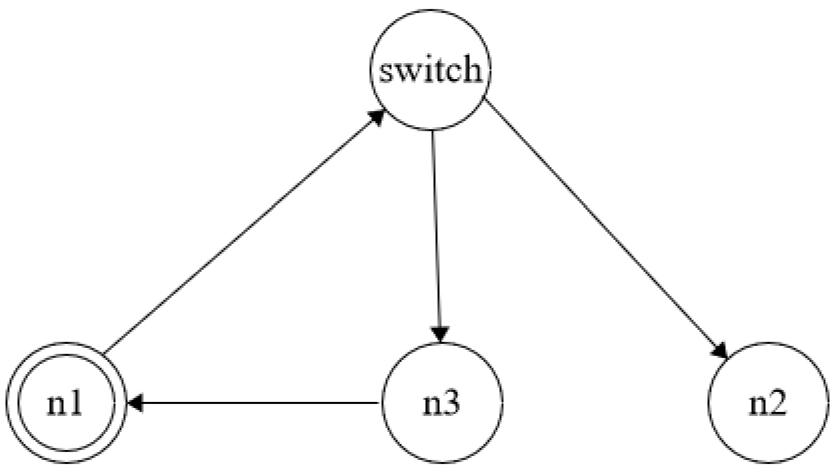
The NPD, Neighbor Discovery Protocol is a protocol operated within the link layer of the OSI model - internet protocol suite. The link layer is responsible for communications related to the link that a host is connected to. In this report we will be discerning the two main concepts of NPD, one of which being; Address Resolution which is responsible for multiple-address access network functioning. Another key feature and resource we will be assessing is the use of learning switches. Switches are used as a means to ensure traffic is only sent to the destination IP rather than every device on the network. We will be implementing a 'learning switch' which is the process of obtaining the MAC of all devices to a connected network and comparing it to the MAC addresses stored on the switch table.

Design

We will be utilizing core GUI inbuilt into the Linux OS, the GUI output is a blank canvas that we can use to create network structure within the virtual machine. We can make use of the guis network setup to implement our own algorithms.



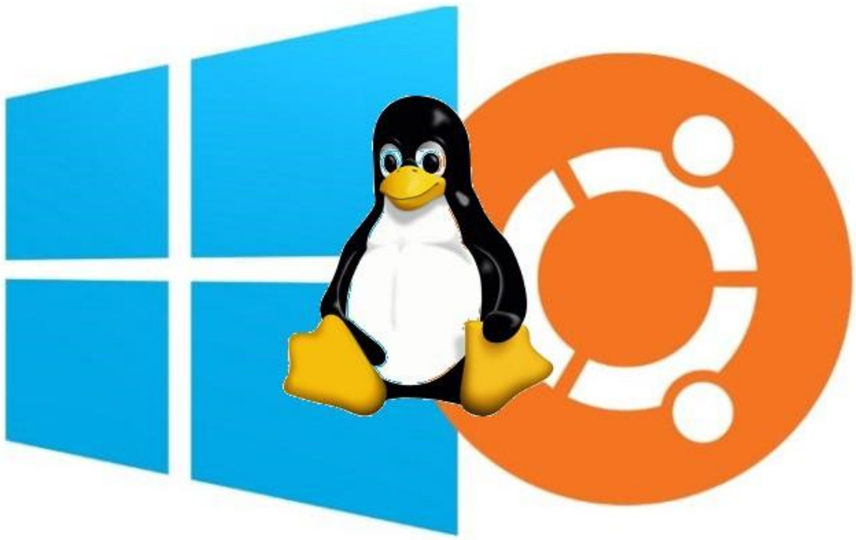
With the correct implementation a node will broadcast through the switch to each of the other nodes and add them to the nodes ARP table, this will allow for an ARP packet to be sent and received from only the destination address and not every other node on the network.
Below is an example of a successful ARP delivered and received packet, If we were to send an ARP packet from node 1 to node 3 but we do not know node 3's MAC address yet the switch will send a broadcast message to each node. Once we have found the MAC associated with the destination (node 3's) IP address we add it to our table and successfully send the ARP packet to the destination.



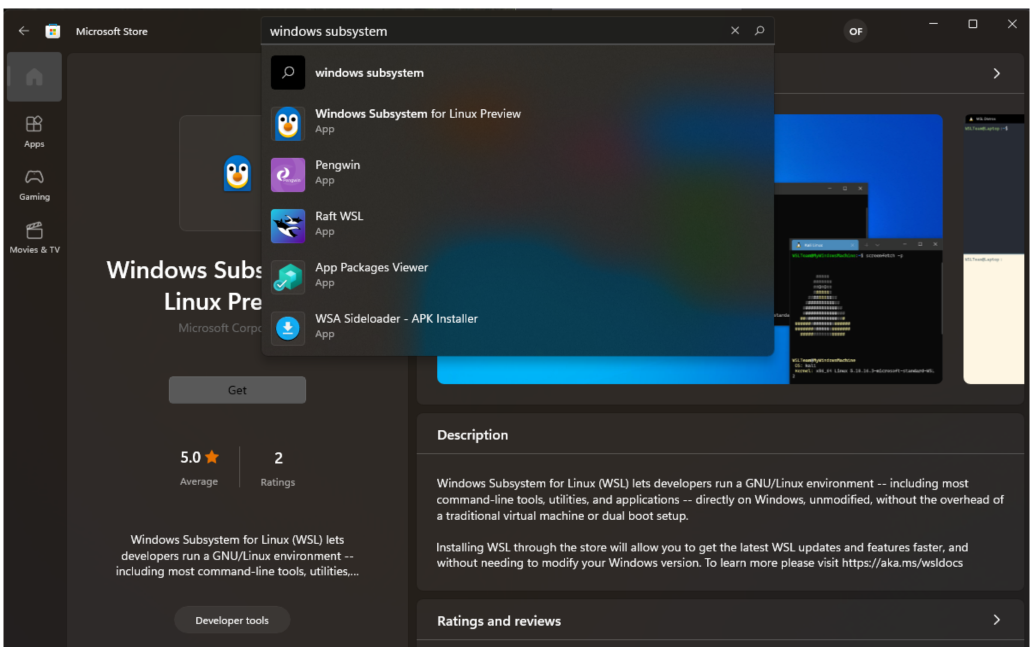
In regards to the learning switch algorithm we will employ a similar design pattern but instead of sending/receiving arp packets we will be evaluating the frames that the switch receives and adding the device data to the kernel switch table, this is how a node will "learn" another node's MAC address.

Procedures

The software used to complete this investigation was; WSL, WinSCP, PuTTY and VirtualBox VMS. The setup necessary for completing this investigation are such as;

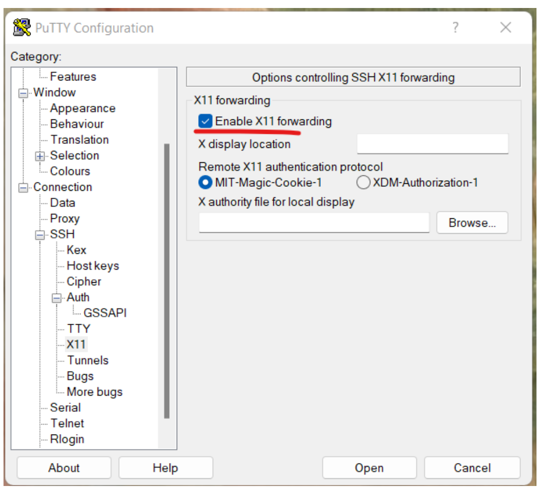


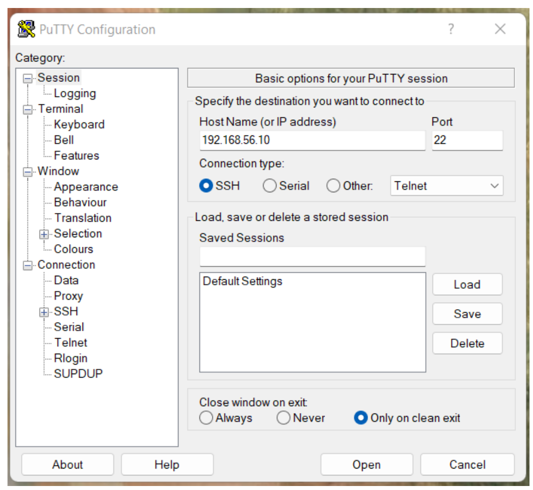
- As my default device OS is Windows I needed to configure the Linux subsystem to allow for Linux capabilities. To set up WSL linux onto our system we need to install WSL offered in the Windows app store.



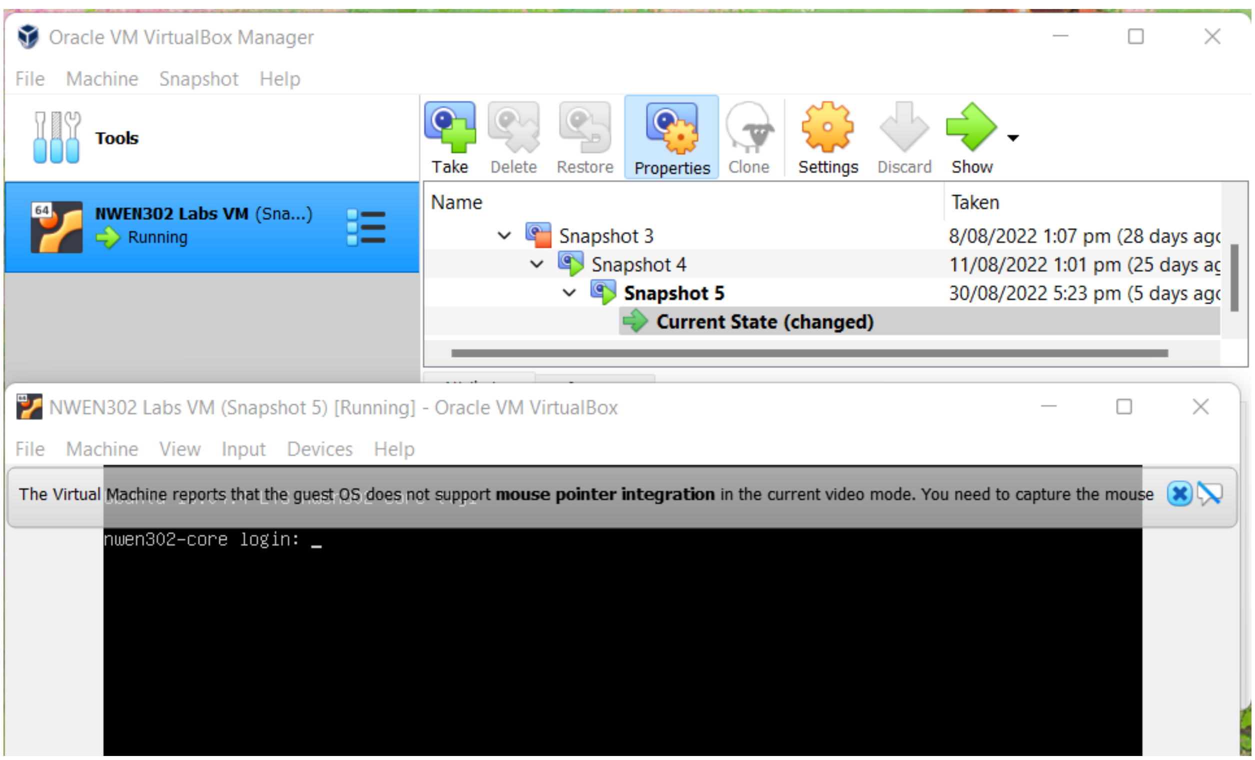
Now with WSL fully implemented onto our windows device we can now use the Linux command line to complete the rest of the investigation.

- PuTTY, allows for remote SSH session capabilities, and we will be using this as our terminal to connect to the network simulation. Only needed settings are; checking "Enable X11 forwarding" in the X11 category under SSH in the menu bar so we can connect to the host address; (using SSH, port 22) 192.168.56.10

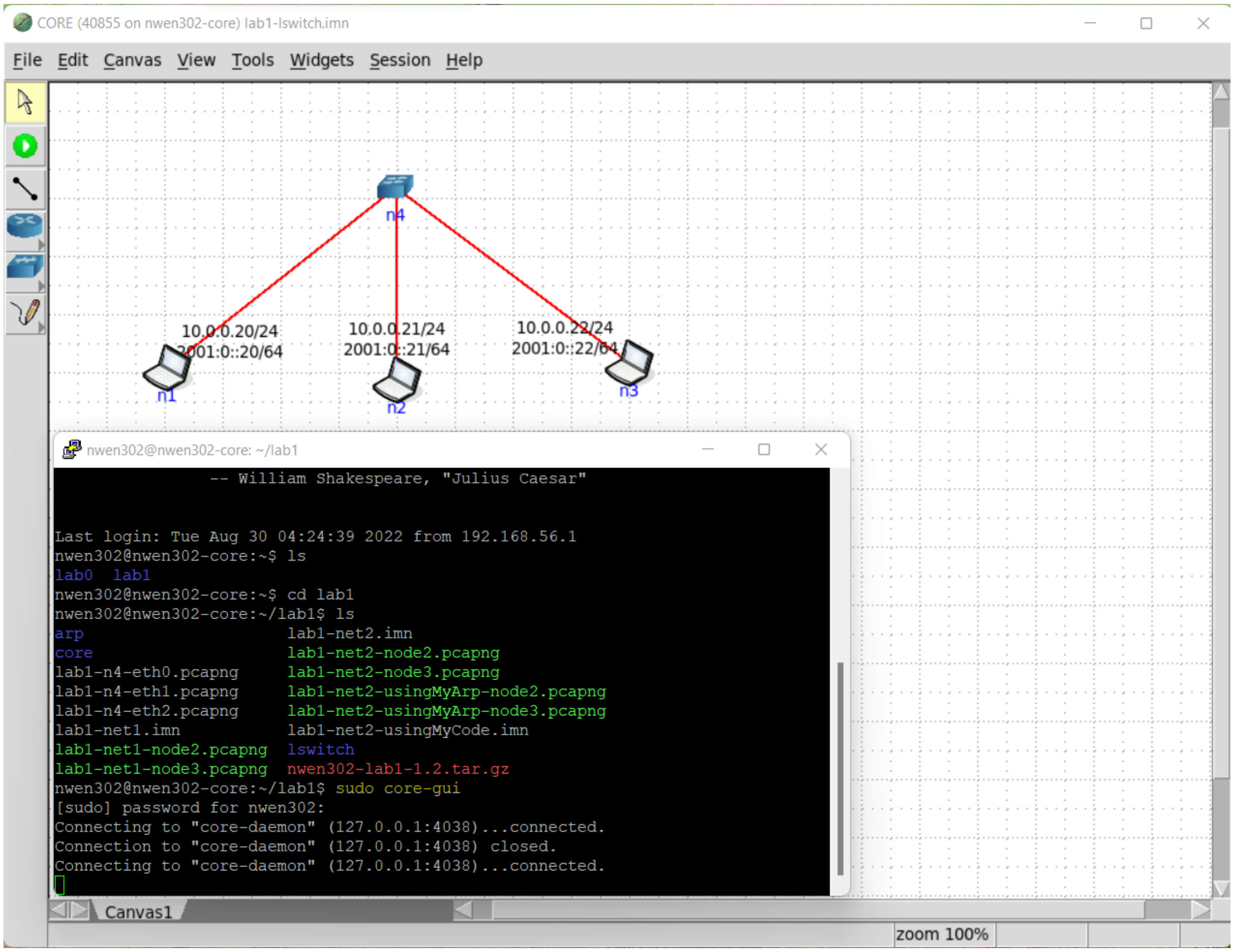




- VirtualBox VMs is a tool used for creating a virtualized environment, this will allow for us to extend our existing device to run another OS. We will be importing an already set image for the VM to base our work on, once starting the machine a terminal will open with a logon screen, at this point we can now connect to the VM in a separate terminal using PuTTy. Once connected with Putty we can begin the investigation with our code based algorithms running through the GUI screen. Below shows the running VM.



At the moment of running the machine we will open a PuTTy session, connect to the VM and begin implementing our algorithms.



CORE (40855 on nwen302-core) lab1-lswitch.imn
File Edit Canvas View Tools Widgets Session Help
n4
10.0.0.20/24
2001:0::20/64
n1
10.0.0.21/24
2001:0::21/64
n2
10.0.0.22/24
2001:0::22/64
n3
nwen302@nwen302-core: ~/lab1
-- William Shakespeare, "Julius Caesar"
Last login: Tue Aug 30 04:24:39 2022 from 192.168.56.1
nwen302@nwen302-core:~$ ls
lab0 lab1
nwen302@nwen302-core:~$ cd lab1
nwen302@nwen302-core:~/lab1$ ls
arp lab1-net2.imn
core lab1-net2-node2.pcapng
lab1-n4-eth0.pcapng lab1-net2-node3.pcapng
lab1-n4-eth1.pcapng lab1-net2-usingMyArp-node2.pcapng
lab1-n4-eth2.pcapng lab1-net2-usingMyArp-node3.pcapng
lab1-net1.imn lab1-net2-usingMyCode.imn
lab1-net1-node2.pcapng lswitch
lab1-net1-node3.pcapng nwen302-lab1-1.2.tar.gz
nwen302@nwen302-core:~/lab1$ sudo core-gui
[sudo] password for nwen302:
Connecting to "core-daemon" (127.0.0.1:4038)...connected.
Connection to "core-daemon" (127.0.0.1:4038) closed.
Connecting to "core-daemon" (127.0.0.1:4038)...connected.
Canvas1
zoom 100%

Address resolution pseudo code;

```c
void my_arp_resolve (uint32_t ip_address) {

    // Create a char array (for the destination MAC) with a set size of 6
    // Set the destination MAC array to the broadcast address as seen below;

    // {0xff, 0xff, 0xff, 0xff, 0xff, 0xff};

    // Call the arp_send_query function from the arp_functions class passing in
    // the ip_address parametre stored in this method and passing in our created
    // broadcast address

    // Set the method call to an int for later use

    // If the arp_send_query function call is equal to 0
    // Add a print statement for error checking
    // Otherwise, successfully broadcasted !
}

void my_arp_handle_request(uint32_t ip_address, const unsigned char *mac_address) {

    // Create an empty chararray for the buffer and set to 1000
    // Create another array specifically for our MAC address and set size to 6

    // Call the arp_get_my_ipaddr function from the arp_functions class
    // and set to a char variable for our ip_address needed for later use

    // Now -
    /* Compose Ethernet Header */

    /* Compose Arp Header */

    /* Filling in Contents */

    /* Reply */
    // Use the created structures from the ethernet header, arp header and arp packet contents
    // Send a reply using the arp_send_reply with the eth frame and size of the each of
    // above structures

}

void my_arp_handle_reply(uint32_t ip_address, const unsigned char *mac_address) {
    // Call the arp_insert_cache function with the above parametres
}
```

Learning switch pseudo code;

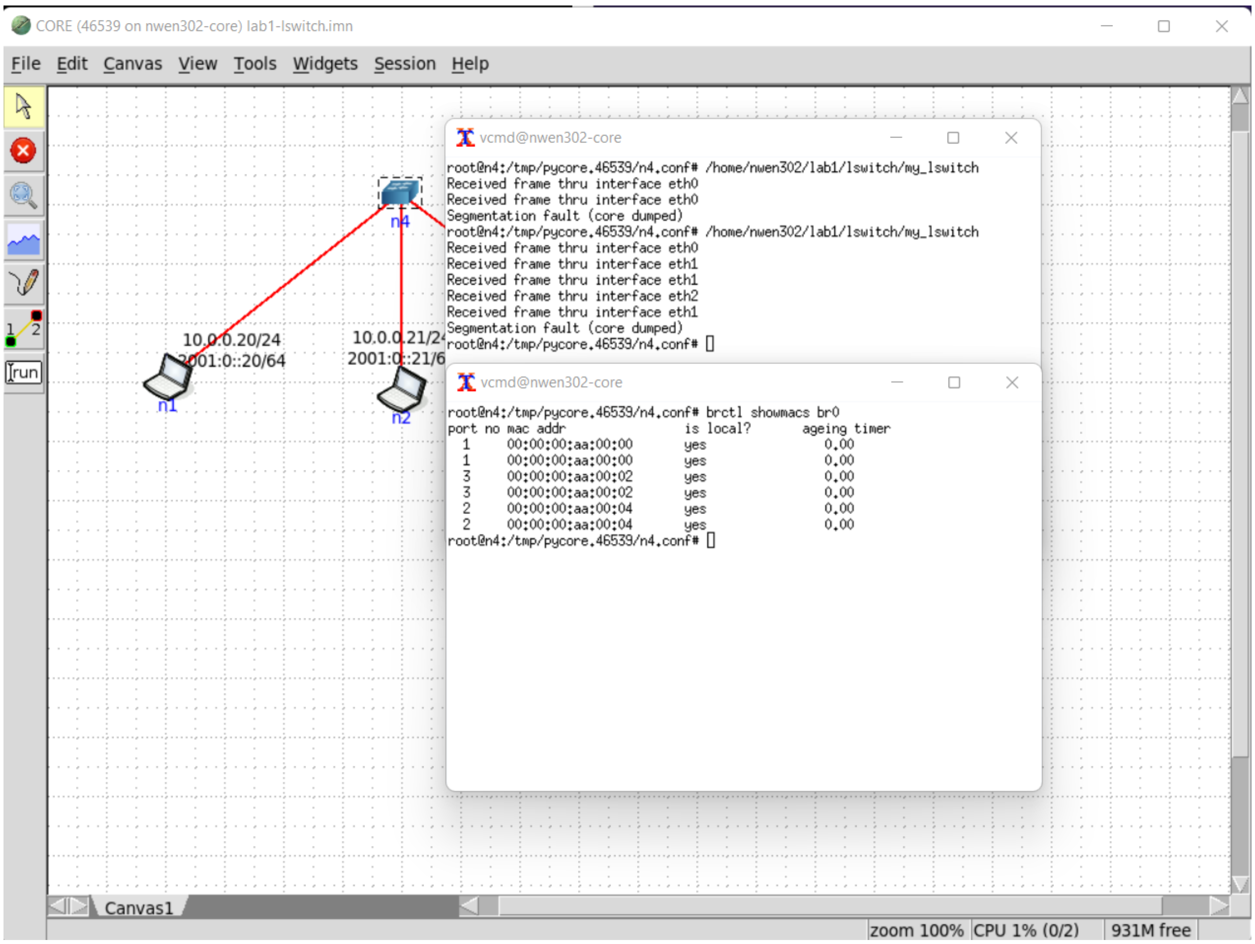
```c
// Required field;
// int value for our Interface data
// int value for our Position data needed to assign the position in the structure

// Create a structure used for our kernal entries with;
// A source_mac address pointer
// A interface pointer
// A timer function

// Create an array with the structure and set to a size of 3 (one for each device)

void my_lswitch_frame_receive(const unsigned char *source_mac_address,
    const unsigned char *dest_mac_address, const char *device) {

    // Created a "found" boolean and set to false for later use
    // Create a copy of the entry structure for temporary use

    // Debugging,
    // Create a copy of the parametre source_mac_address and use memory allocation
    // to take the source_mac_address data into our copies version

    // Set the copied MAC & device info to the temp structure

    // Loop through the size of the structure (3) {
    // Compare the current item in the tabel to the one stored on our
    // temporary structure {
    // If the items are the same, set the found boolean to 'true' }}

    // Using the found boolean check if the table is empty {
    // If the table contains no items add entries to the table using the
    // lswitch_insert_table function call with our tempStruct data
    // Increment the position variable }
}

void expired_arp_entries(const unsigned char *source_mac_address, const char *device) {
    // Using the entry struct data compare items within in the structure and set
    // a timer once an entry has been made, after 30 seconds remove the entry from
    // the table
}
```

With my switch algorithm I created an empty instance of structure which will be used to store arp entries. The function itself is quite simple, only being a for loop which checks each position in the array against the data stored within the table, then adds a kernel to the table position that is free.

Results

In order to resolve address resolution in neighbor discovery we successfully implemented our own ARP algorithm which is able to obtain a target's MAC address by broadcasting to each node in the network and adding it to the ARP cache table. Once the target MAC address has been found only then can the node successfully be able to handle the ARP request and correct ARP reply functionality. The results show that every node receives the initial broadcast request while only the destination and source nodes receive the packet data.

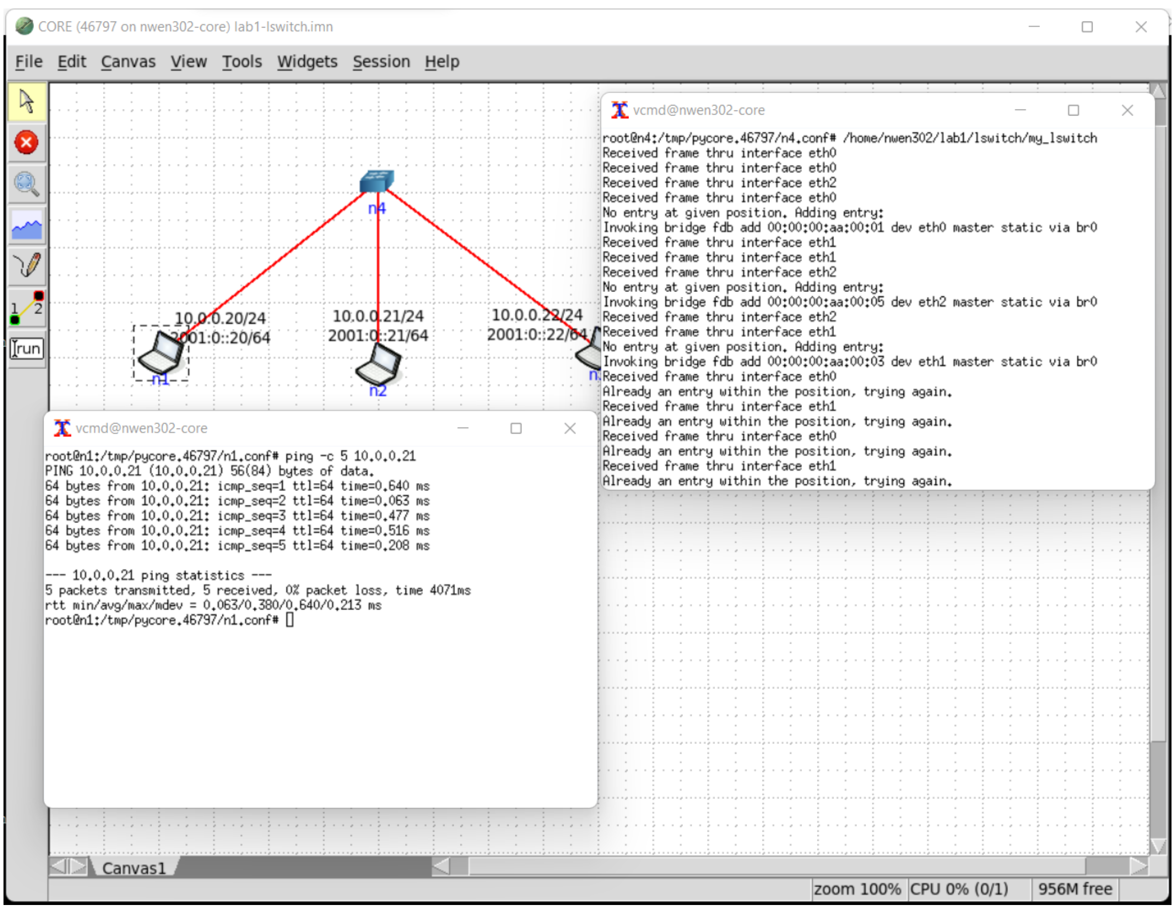
When compiling my code for the switch I didn't encounter any errors with the compiler itself but when I went to run the code through the network simulation I encountered a "segmentation fault".



From resources online, a segmentation fault could be due to a memory allocation error. When debugging my code from below I believe it is to do with my for loop where inside I compare the temporary structures entry to the one at the looped position.

```c
void my_lswitch_frame_receive(const unsigned char *source_mac_address,
    const unsigned char *dest_mac_address, const char *device) {
        bool found = false;
        struct entryStruct tempStruct;
        unsigned char* copy_source_mac = malloc(strlen(source_mac_address) + 1);
        memcpy(copy_source_mac, source_mac_address, sizeof(source_mac_address));
        // Set the copied MAc to the temp structure
        tempStruct.source_mac = copy_source_mac;
        tempStruct.interface = device;
        // if array empty add items
        for(int i = 0; i < 3; i++) {
            // get the source mac within our struct
            if(strcmp(tempStruct.source_mac, switchTable[i].source_mac) == 0
            && strcmp(tempStruct.interface, switchTable[i].interface) == 0) {
                found = true;
            }
        }
        // If the entry table is empty add the entries to the table using the stored data
        if(!found) {
            printf("here");
            switchTable[position] = tempStruct;
            position++;
            lswitch_insert_table(tempStruct.source_mac, tempStruct.interface);
        }
}
```

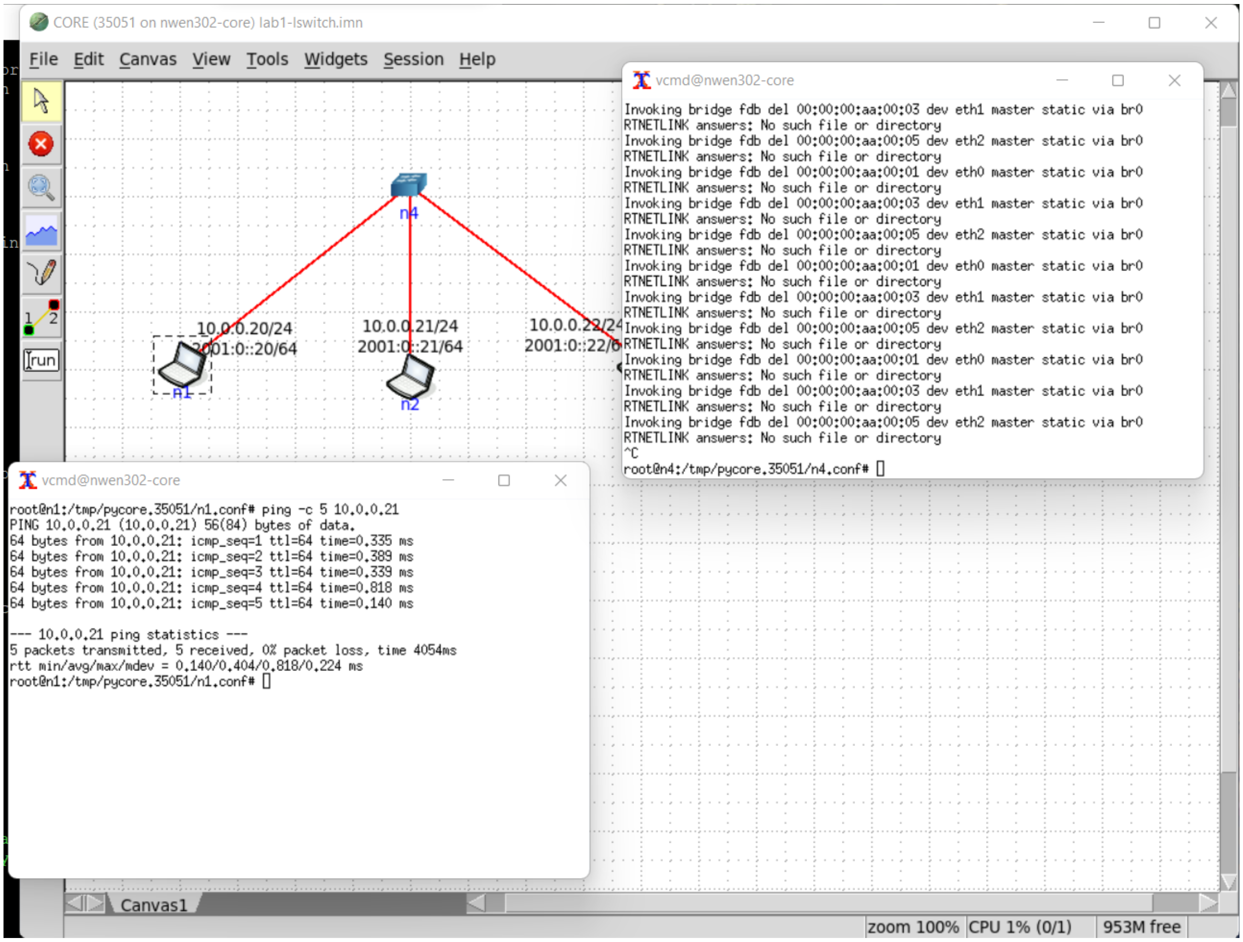
To fix this, I changed the loop so that it's maximum counts to the position variable, not the "3". This ensures that if it goes back through at the same position it doesn't mess up the memory allocation of the string compare statement. When running the code with this fix we no longer get a segmentation fault:



nwen302@nwen302-core: ~/lab1/lswitch

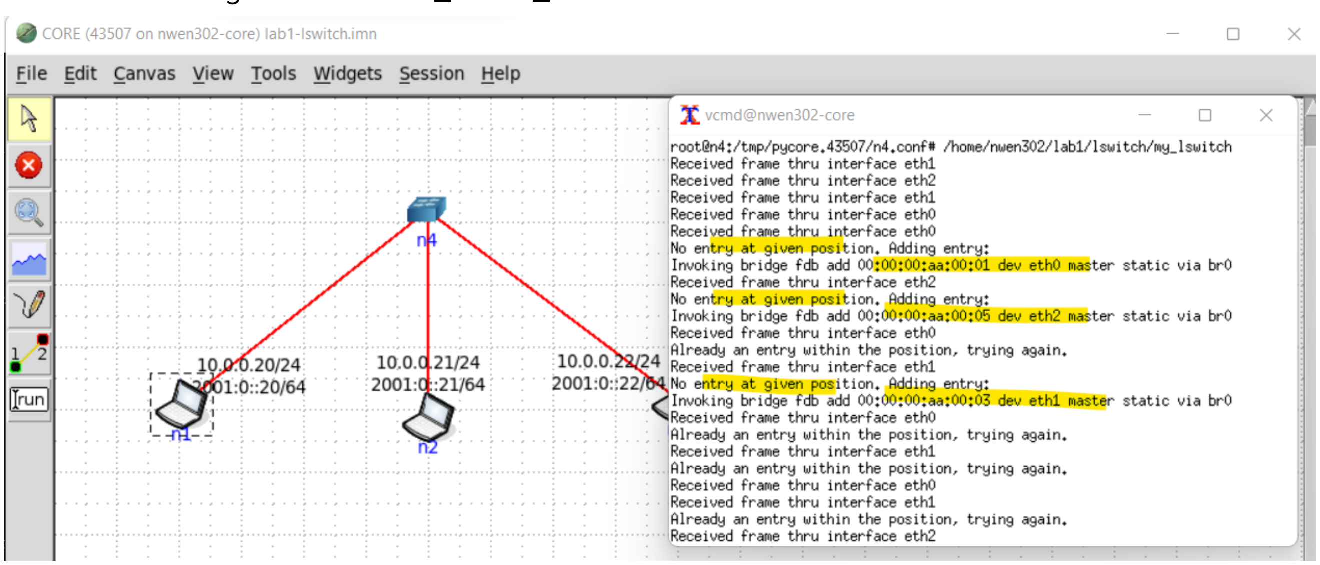
```
 [1/1]                                my_lswitch.c


/**
 * CORE //
 * A node is able to know the location of hosts by looking at
 * the frames passing through the node and insert it to the
 * kernal switch table
 *
 * This is a function that you should implement in my_lswitch.c
 * This function is called whenever a frame is received by the switch.
 *
 * @param source_mac_address Source MAC address of the frame.
 * @param dest_mac_address Destination MAC address of the frame.
 * @param device Name of interface where the frame was received.
 */
void my_lswitch_frame_receive(const unsigned char *source_mac_address,
    const unsigned char *dest_mac_address, const char *device) {

    bool found = false;
    struct entryStruct tempStruct; // Used to organise the table entries
    // Create a copy of the source_mac_address and memory allocate to the copy
    unsigned char* copy_source_mac = malloc(strlen(source_mac_address) + 1);
    memcpy(copy_source_mac, source_mac_address, sizeof(source_mac_address));
    // Set the copied MAC to the temp structure
    tempStruct.source_mac = copy_source_mac;
    tempStruct.interface = device;
    // Loop through the table by the position
    for(int i = 0; i < position; i++) {
        // Compare the table entry to the main table to our temporary table by the position
        if(strcmp(tempStruct.source_mac, switchTable[i].source_mac) == 0 && strcmp(tempStruct.interface, swi$
            printf("Already an entry within the position, trying again.\n");
            // If there the entries are the same, set found boolean to true and loop through again
            found = true;
        }
    }
    // If the entry table is empty add the entries to the table using the stored data
    if(!found) {
        switchTable[position] = tempStruct;
        position++;
        printf("No entry at given position. Adding entry: \n");
        lswitch_insert_table(tempStruct.source_mac, tempStruct.interface);
    }
}


^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify     ^C Cur Pos     M-U Undo
^X Exit        ^R Read File   ^\ Replace     ^U Uncut Text  ^T To Spell    ^_ Go To Line  M-E Redo
```

My next step was to implement a timer function which checks the age of each entry on the table and removes it after 30 seconds. I implemented the time_t which uses an alarm() function, the way I structured it was just a simple for loop and if statement which compares the current entries age on the table to the started timer. Once the difference is 30 seconds, call the lswitch_delete_table function provided. I believe this is the correct implementation but as we can see in the screenshot below, we need to also include a way where the program records what the entries position was when it was deleted.



The “RTNETLINK answers: No such file or directory” is due to a problem with the kernel modules due to the above reason.

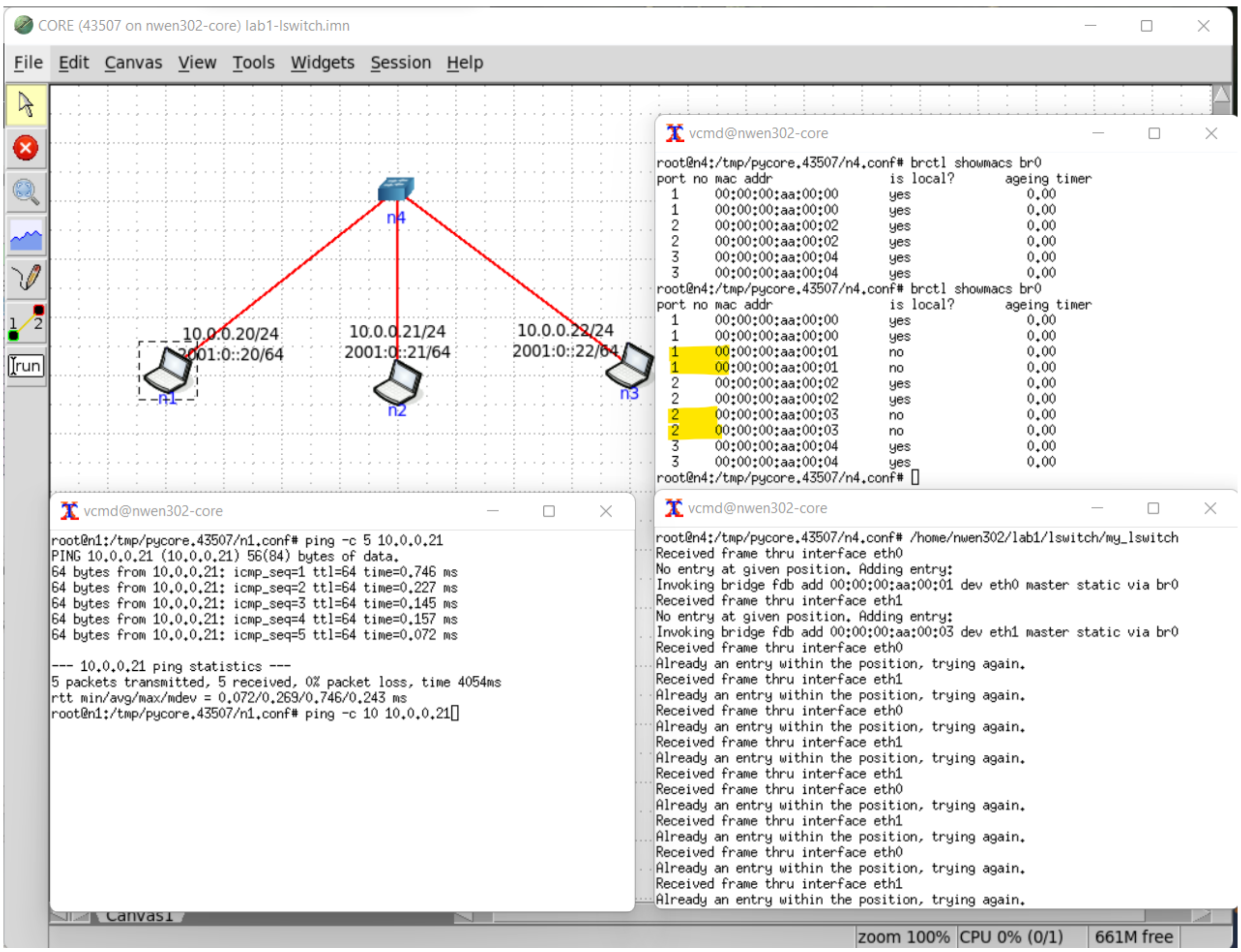
When commenting out the lswitch_delete_table function the simulation works as follows:



Successfully learning (adding to table) but not resetting and removing kernels.

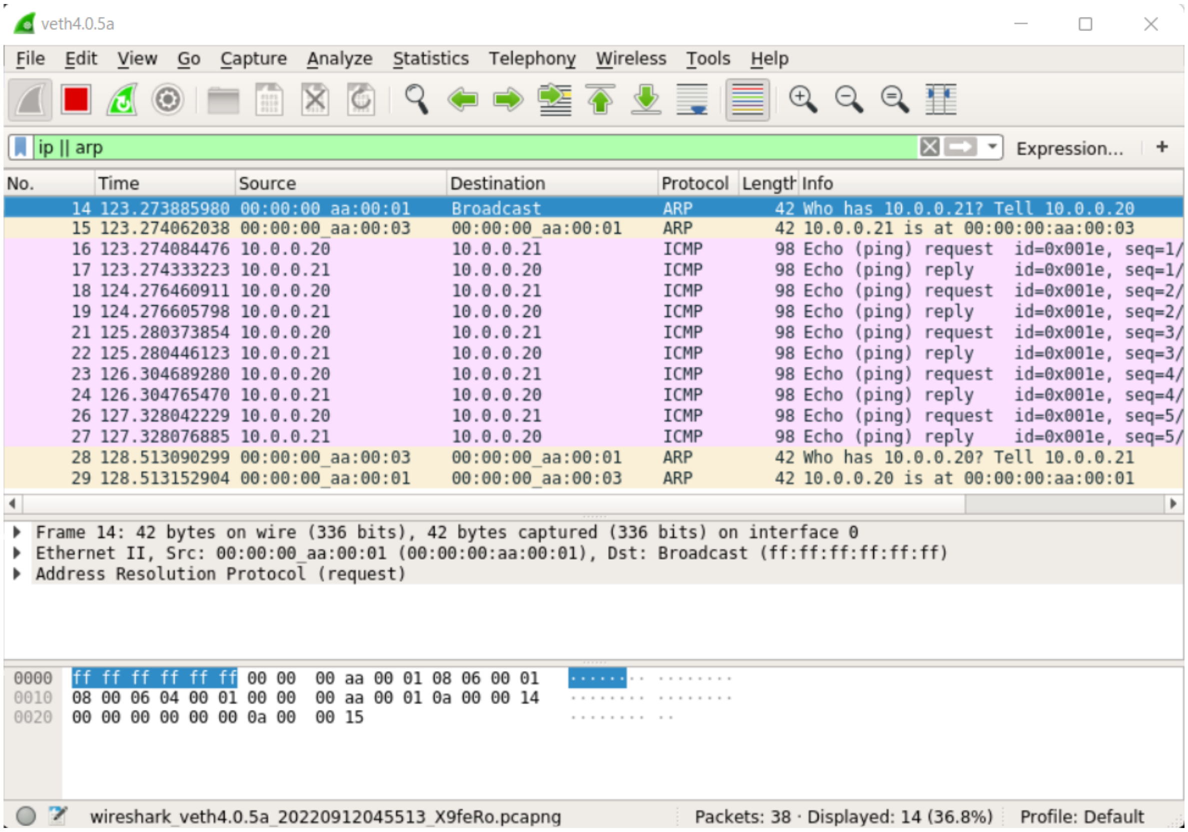
The brctl showmacs br0 before running the simulation:

After:

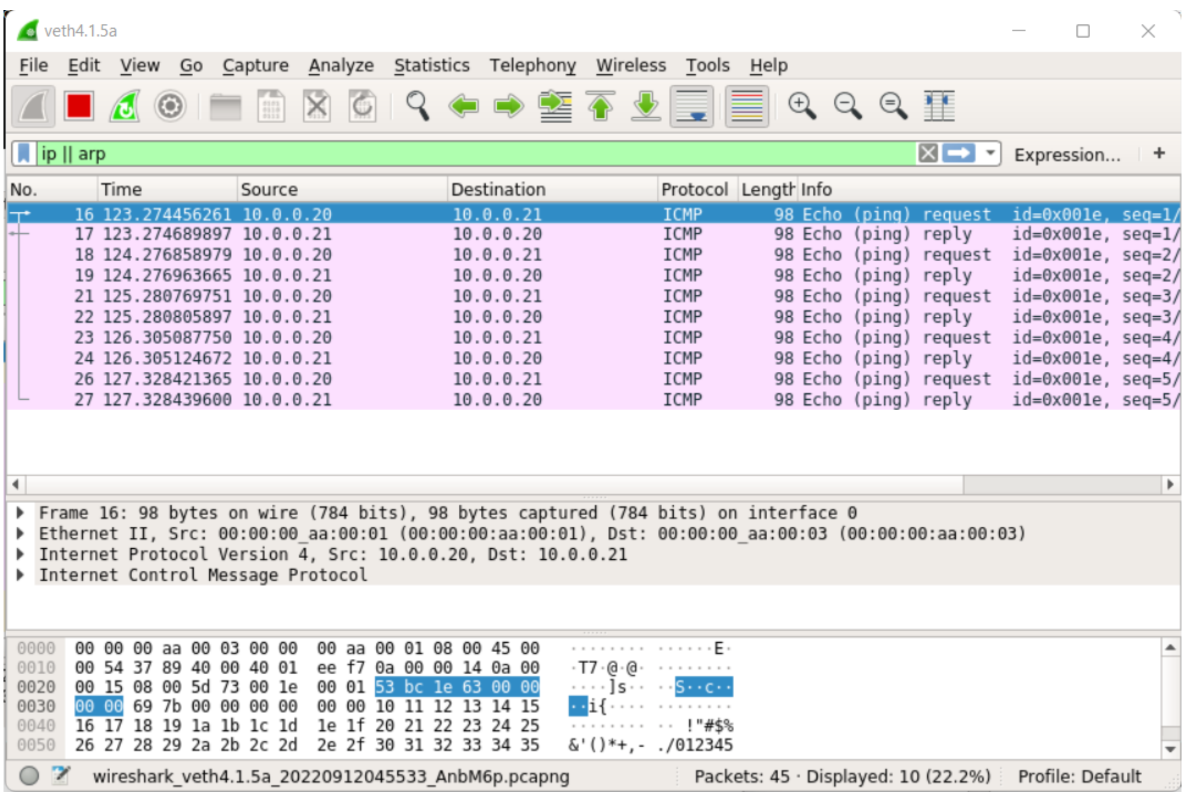


This shows the learning is working. On node 1, I sent a ping to node 2 and showed the mac table on the switch had added the entries of node1 and 2's communication (but not 3 as 3 was not included). Below are each interfaces wireshark (from the switch n4)

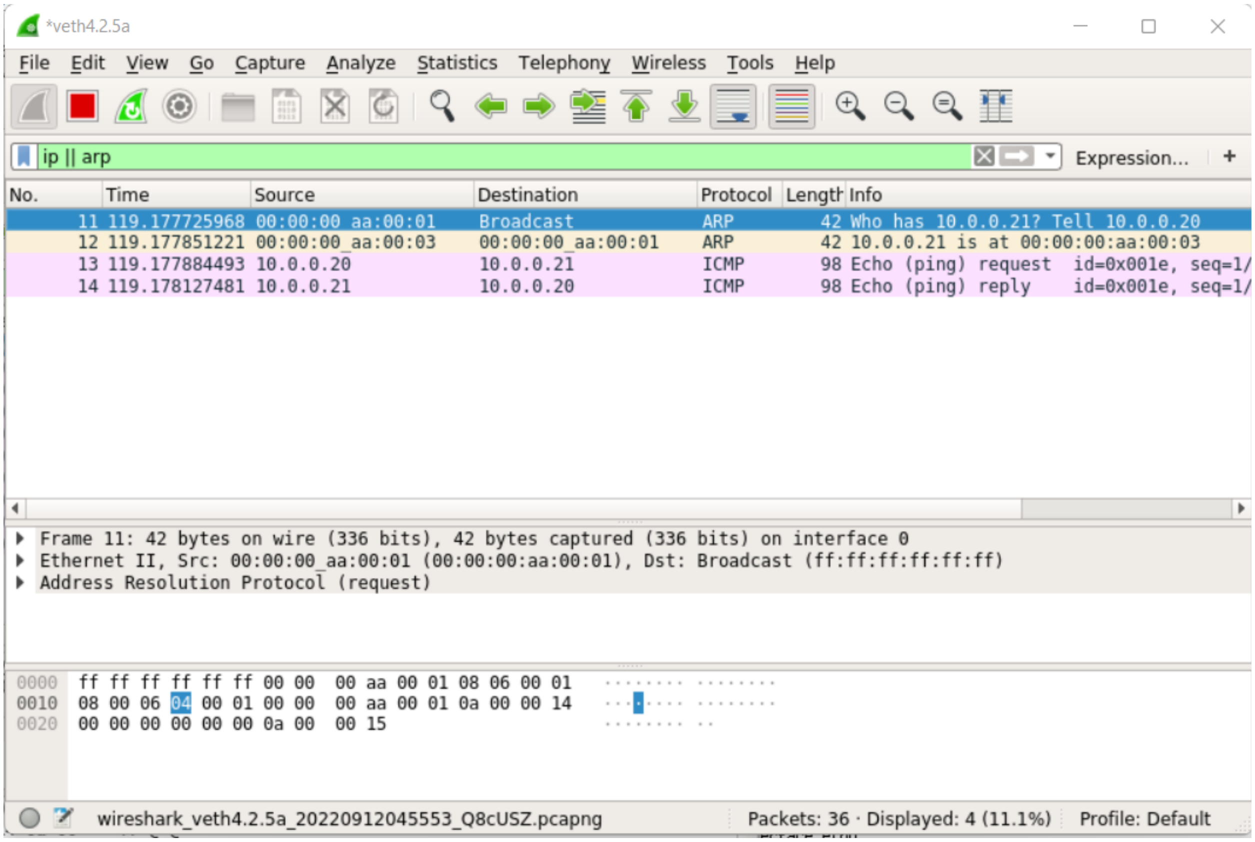
Interface 0: (node 1)



Interface 1: (node2)



Interface 2: (node3)



Conclusion

Overall I believe we found and were able to complete the investigation with satisfaction however there are some things I would do differently next time such as adding a predefined time internal entry removal for unused cache in the arp table. This would make the overall program more responsible by allowing for monitoring of the ARP data in the table with added removal capabilities.

For the learning switch I was overall satisfied with my completion but felt I should have been able to implement a proper timing function to remove kernels from the table. However, next time I would not only ensure that functioning is successful I would also implement a monitoring method which is responsible for recording the number of entries in the table and ensuring it does not exceed the pre-defined values. This method will be able to prioritize entries and remove unused entries even when the expiration has not finished.

References

Add/remove/modify ARP tables, Code Project,
https://www.codeproject.com/Articles/22483/Edit-Add-Remove-Modify-ARP-Tables

Get the interface Name/Data, MicroHowto,
http://www.microhowto.info/howto/get_the_mac_address_of_an_ethernet_interface_in_c_using_siocgifhwaddr.html

Fix Segmentation Fault in C++, DelftStack
https://www.delftstack.com/howto/cpp/cpp-fix-segmentation-fault/

Appendices

1. Appendix A - Software
   Windows Linux Subsystem, WSL & Ubuntu
   https://ubuntu.com/tutorials/install-ubuntu-on-wsl2-on-windows-11-with-gui-support#1-overview
   WinSCP 5.21.2, Windows 64bit
   https://winscp.net/eng/download.php
   PuTTY 0.77, Windows 64bit
   https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html
   VirtualBox VM 6.1.38, Windows 64bit
   https://www.virtualbox.org/wiki/Downloads

2. Appendix B - Diagram
   Finite State Machine, Diagram
   https://madebyevan.com/fsm/

3. Appendix C - Source Code Part 1
   arp_functions.c
   arp_main.c
   my_arp.c
   Source Code Part 2
   lswitch_functions.c
   lswitch_main.c
   My_lswitch.c
4. CPlusPlus C++ Library
   Malloc, strlen, memcpy
   https://cplusplus.com/reference/cstdlib/malloc/
   https://cplusplus.com/reference/cstring/strlen/
   https://cplusplus.com/reference/cstring/memcpy/

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