Report

(a) Program Structure and Design

We use a `unordered_map` with key of ipv4 address and value of struct `ARPState` to manage everything related to specific ipv4 address, including:

- `found`: is the ARP record found or not.
- `request`: timeout before sending a next ARP request.
- `expire`: timeout before ARP expires.
- `eth_address`: the ARP record if found.
- `cache`: vector of messages that pending ARP request to resolve.

We also use some helper functions for better coding:

- `update_arp()`: Updates the ARP `cache` when a new mapping is received, sends any queued datagrams to the resolved address, and clears the `cache` for that IP.
- `send_ipv4()`: Encodes and sends an IPv4 datagram within an Ethernet frame.
- `send_arp()`: Encodes and transmits an ARP message within an Ethernet frame.

Other implementation is written as-is.

(b) Implementation Challenges

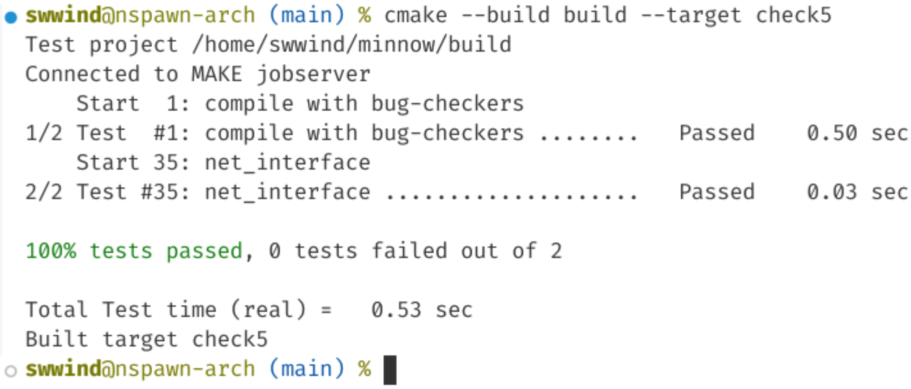
- Caching is required if ARP is not resolved, which requires additional memory usage.
- Managing queued datagrams for unresolved ARP addresses required careful design to ensure datagrams are sent only after resolution.

(c) Remaining Bugs

- Cache may exist forever if ARP is never resolved. However we don't need to mind this situation in this lab, and so as other edge situations.

(d) Experimental Results and Performance

The test runs every fast!



```
swwind@nspawn-arch (main) % cmake --build build --target check5
Test project /home/swwind/minnow/build
Connected to MAKE jobserver
    Start  1: compile with bug-checkers
1/2 Test  #1: compile with bug-checkers ........   Passed    0.50 sec
    Start 35: net_interface
2/2 Test #35: net_interface ....................   Passed    0.03 sec

100% tests passed, 0 tests failed out of 2

Total Test time (real) =   0.53 sec
Built target check5
swwind@nspawn-arch (main) %
```

Figure 1: Results