Final Project

Virtual Customer Premise Equipment

Date	2021/04/13
Deadline	2021/04/26 23:59:59

Outline

- Objective
- Environment
- Customer Premise Equipment
- Virtual Customer Premise Equipment
- Project

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Objective

- Learn and Practice the concepts of
  - NAT Traversal and Tunneling
  - Remote Gateway and DHCP server
  - Docker Container
  - Virtual Networking

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Environment

- Ubuntu 18.04
- Docker
- Auto Tunnel Creation Program from Lab4

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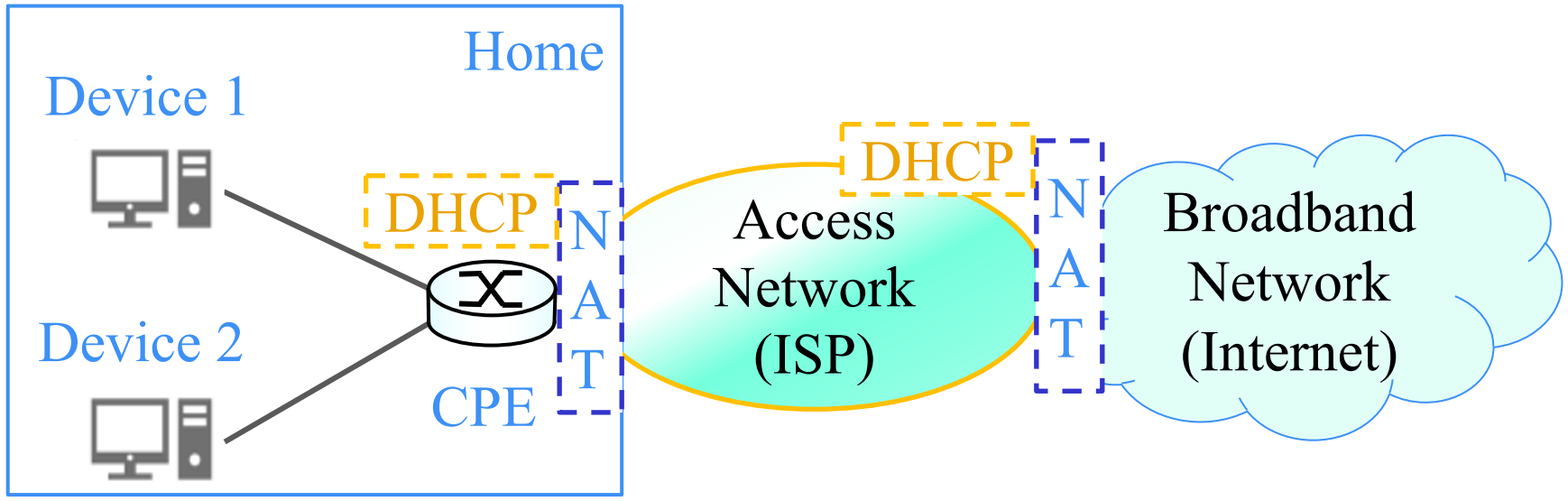
Custom Premise Equipment

- An Internet Access Gateway for home devices
  - Acquires an IP address from an access network (ISP)
    - Likely a private IP
  - Runs DHCP Server
    - Assigns private IP addresses to home devices

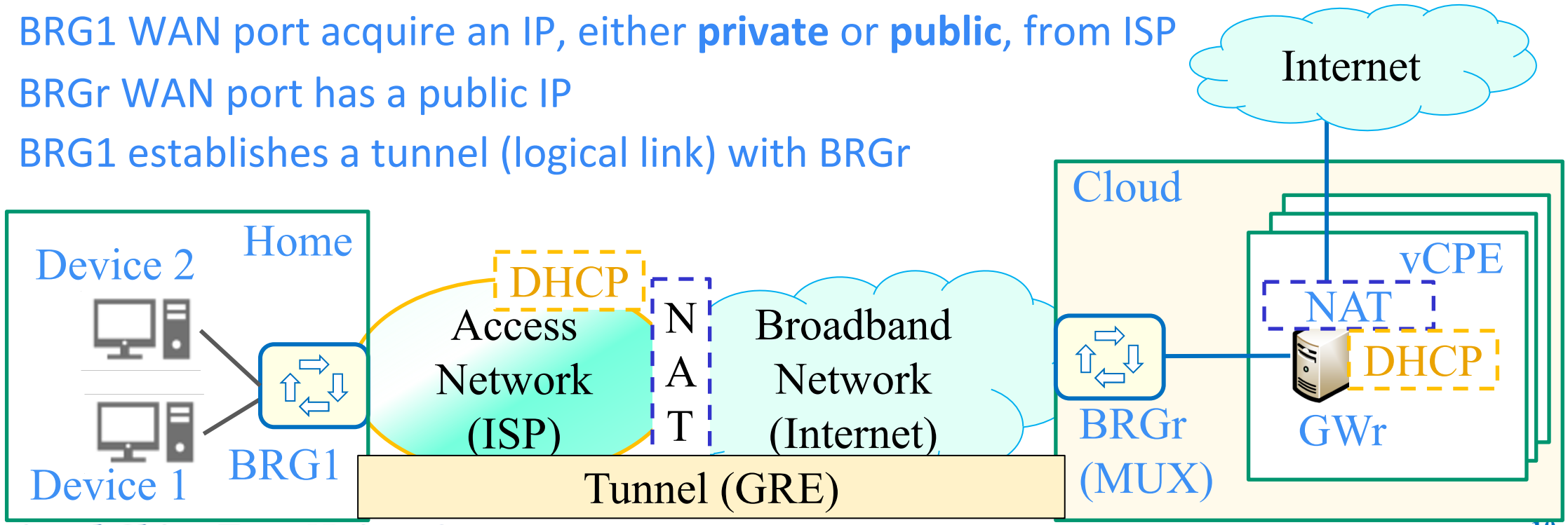


Outline

- Objective
- Environment
- Customer Premise Equipment
- Virtual Customer Premise Equipment
  - Architecture
  - Overview
- Project

vCPE Architecture

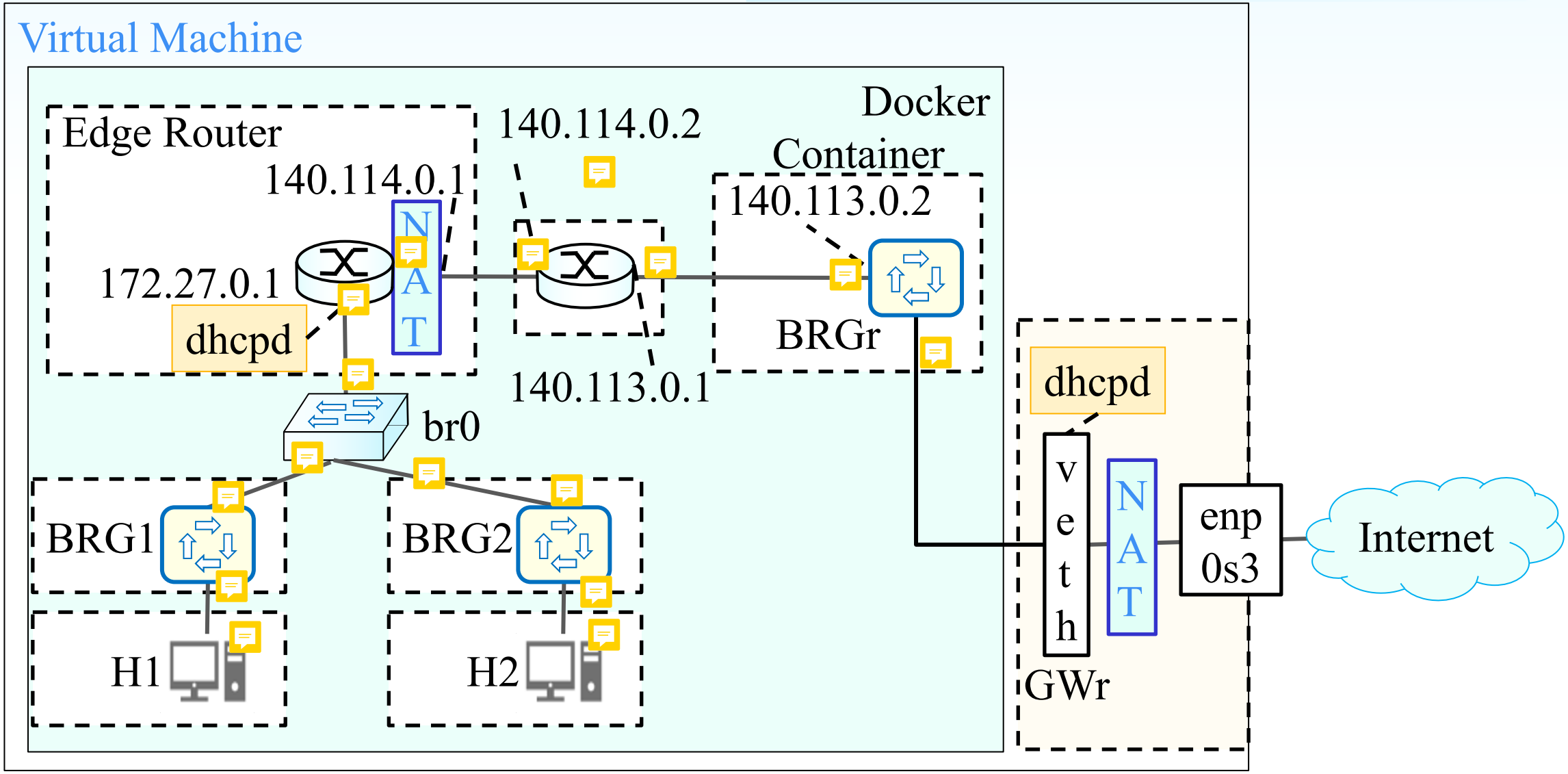
- Physical CPE replaced by
  - a home bridge (BRG1) at home and
  - a remote virtual CPE (vCPE)
    - acts as a remote default gateway (GWr) of home devices
    - runs a DHCP server and assigns private IPs to home devices
- BRG1 WAN port acquire an IP, either **private** or **public**, from ISP
- BRGr WAN port has a public IP
- BRG1 establishes a tunnel (logical link) with BRGr



Outline

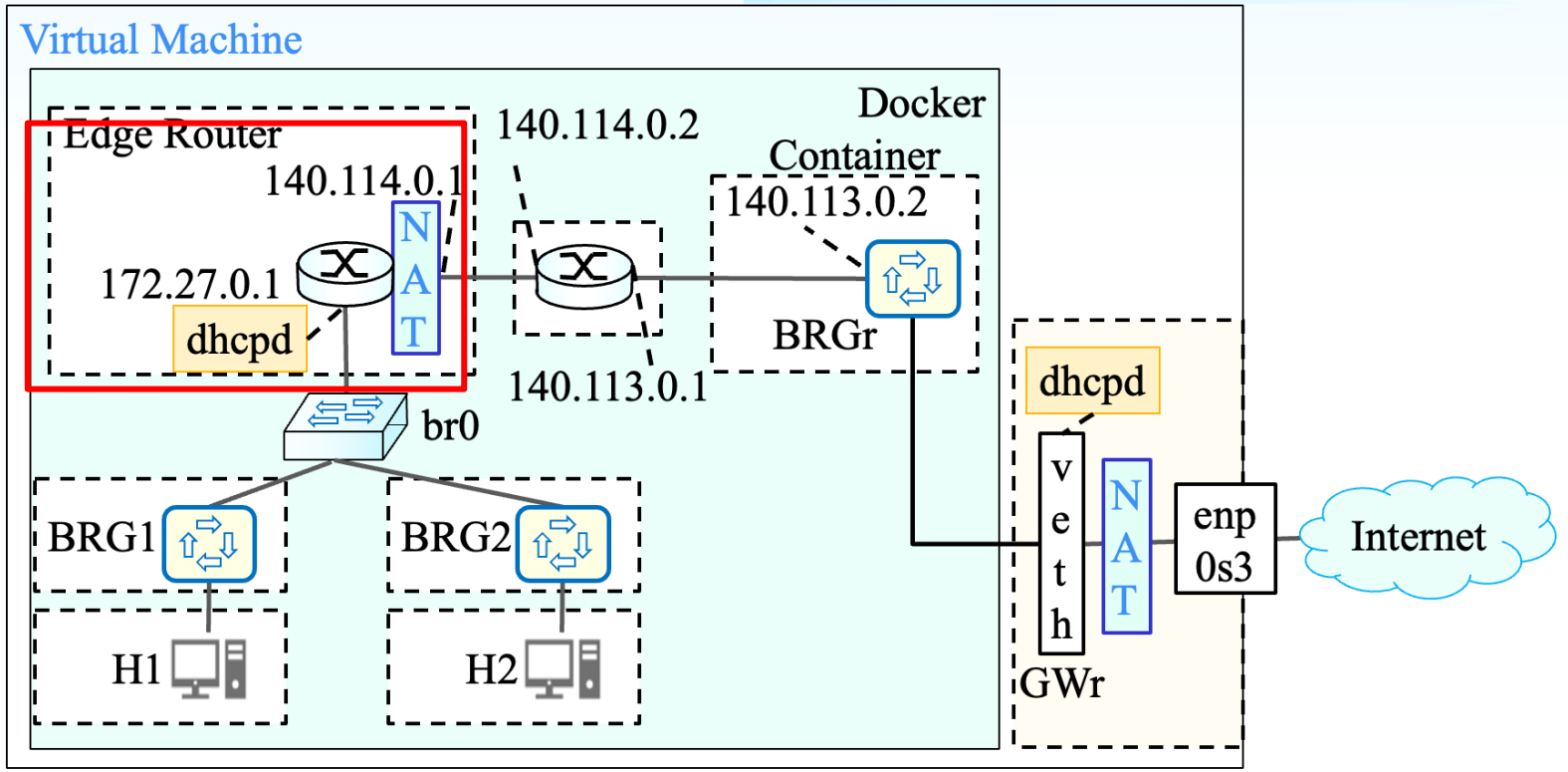
- Objective
- Environment
- Customer Premise Equipment
- Virtual Customer Premise Equipment
- Project
  - Topology
  - Node Functions
  - Requirement

Lab Topology



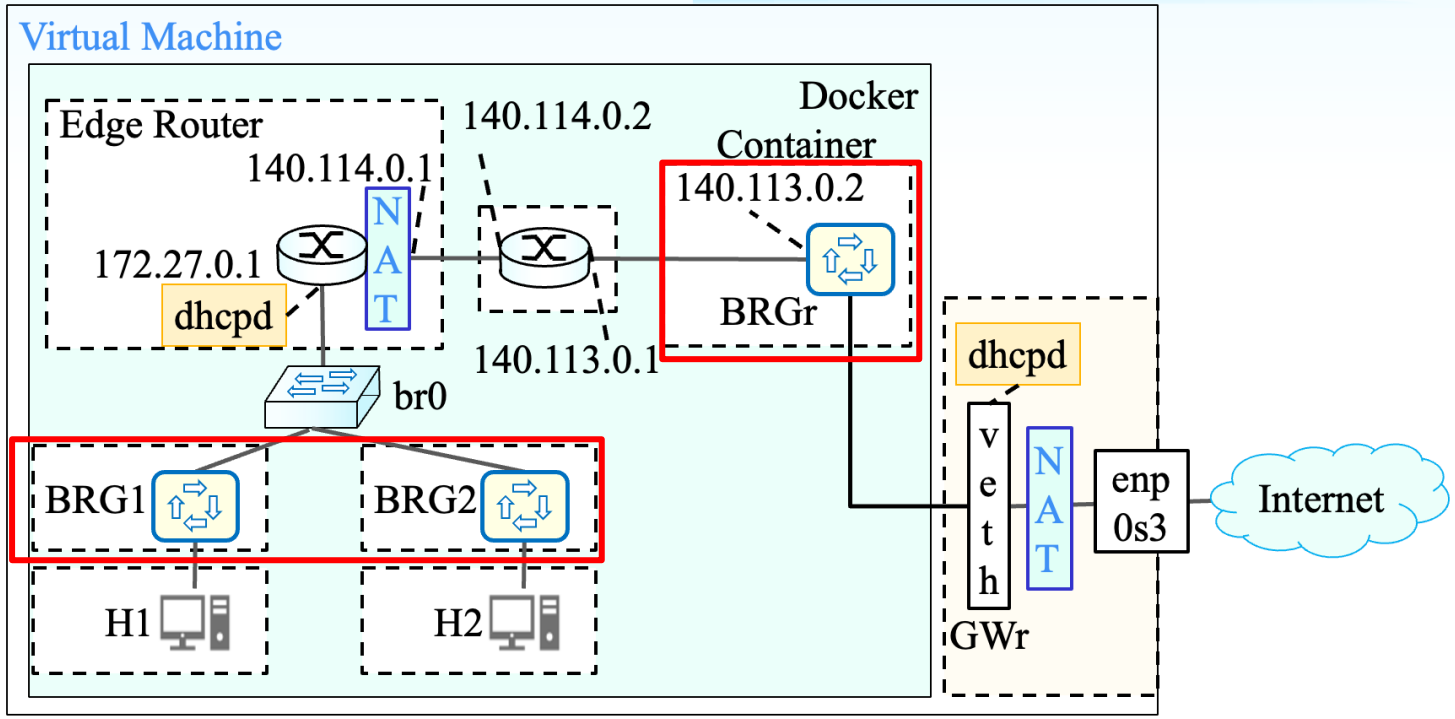
Functionality of Edge Router Node

- Has a static Public IP for WAN port
- Provides basic routing function
- Runs a DHCP server on internal interface (LAN port)
  - Assigns IP addresses to WAN ports of BRG1, BRG2
- Perform NAT for BRG1
  - Implemented with iptables rules



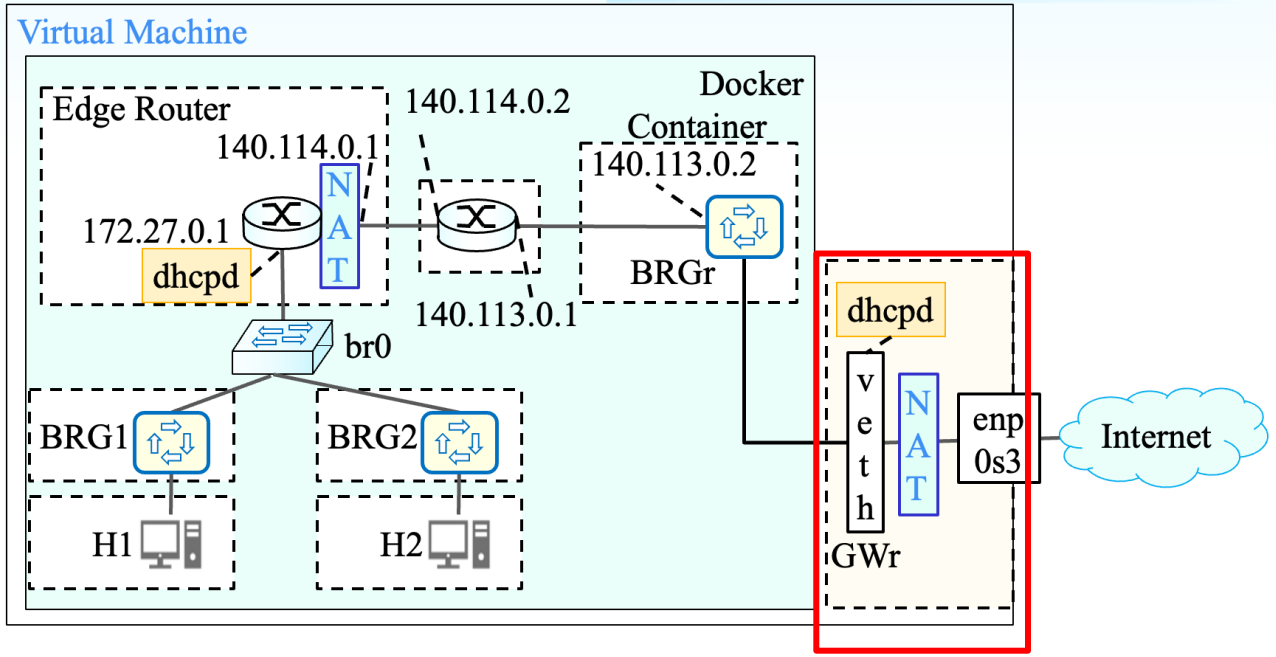
Functionality of BRG Node

- BRG1
  - Acquires a dynamic IP address from Edge Router for WAN port
  - Creates a GRE over UDP tunnel on WAN port
  - Set routing rules to BRGr for GRE over UDP tunnel
- BRGr
  - Run Auto Tunnel Creation to create GRE over UDP tunnel
    - Corresponding to IP/Port after NAT translation
  - Set routing rules for tunneling to BRG1 , BRG2



Functionality of GWr Node

- Runs DHCP server on veth interface
  - Assigning IP address and DNS server to hosts (in BRG1, BRG2)
    - Subnet 20.0.0.0/8
    - DNS server 8.8.8.8
    - Default gateway (veth as a gateway)
- Acts as default gateway for H1
- Set routing rules for packets
  - from hosts to Internet
  - from Internet to hosts
- NAT rules for hosts



Demo Requirement

- Edge Router functionality
  - DHCP server
    - BRG1 can acquire an IP address from Edge Router
  - NAT rules
    - Perform NAT translation for BRG1
  - Routing rule setup
- BRG1, BRG2
  - Can acquire an IP address from Edge Router
  - Build a GRE tunnel to BRGr
  - Routing rule setup
- BRGr
  - Run Auto Tunnel Creation to create GRE over UDP tunnel to BRG1
  - Routing rule setup

Demo Requirement (cont.)

- GWr functionality
  - Dynamic IP assignment with default gateway and DNS configuration
  - NAT translation
  - Routing rule setup
- Hosts
  - Can acquire an IP address from GWr
  - Can ping hosts on Internet

Report

1. Show the configuration commands you made on each node to provide Internet connectivity for hosts and briefly explain the purpose of the commands (10%)
   a) BRG1
      - GRE over UDP (statically)
   b) BRGr
      - GRE over UDP (dynamically)
   c) Edge Router
      - DHCP for BRG1, BRG2
      - NAT rules for BRG1 (show NAT tables to justify your answer)
   d) GWr
      - DHCP for hosts
      - NAT rules for hosts (show NAT tables to justify your answer)
2. Show interfaces list on node BRGr and BRG1, 2 (10%)

Report (cont.)

- Let h1 ping google DNS server 8.8.8.8.

```
h1 container> ping 8.8.8.8 –c 1
```

3. Capture packets and take screenshots on node (10%)
   - BRG1 input/output
   - Access Router input/output
   - BRGr input/output
   - GWr input/output

   Briefly describe the header changes made by each node, by using the screenshots, to deliver packets from h1 to 8.8.8.8, and from 8.8.8.8 to h1, and briefly explain why such changes are required.
4. BRGr will receive ping responses from Google DNS. Briefly describe how BRGr determines the GRE interface to tunnel the response packets back to BRG1. (10%)

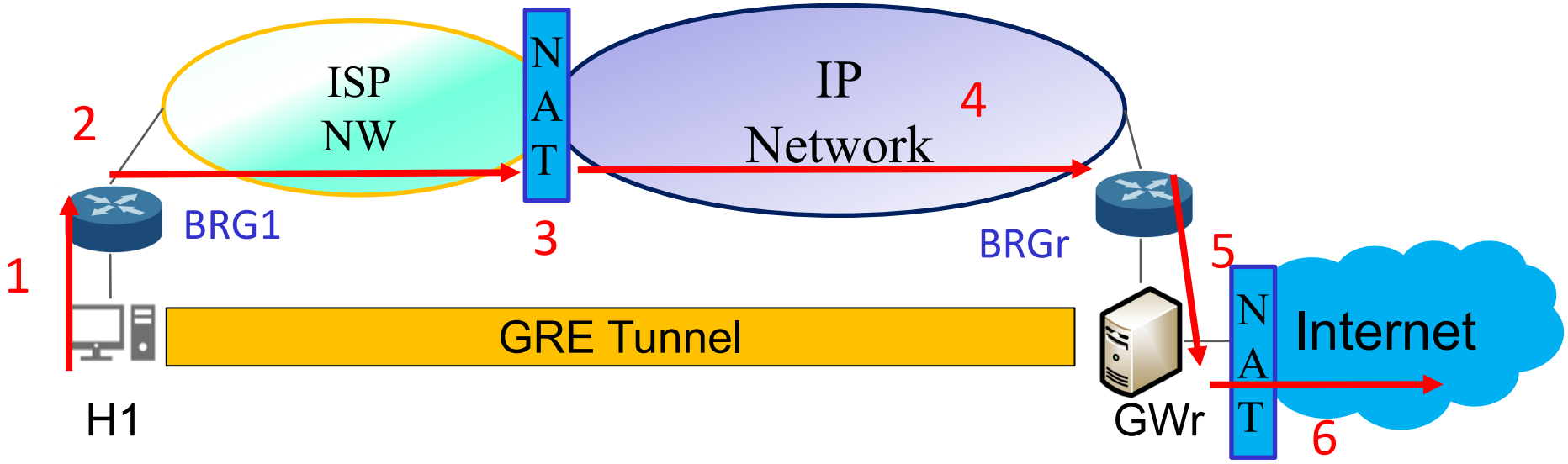
Report Submission

- Files
  - <student_ID>_project.pdf (40%)
  - <student_ID>.c/cpp/go (60%, with demo)
- Submission
  - Zip all files in a zip file
- Report with incorrect file name or format subjects to a deduction of 5% scores.

Q & A

Packet Workflow

1. H1 send a request to Internet (e.g. request google DNS server)
2. BRG1 encapsulate packets with GRE over UDP(srcIP: private IP)
3. ISP NAT translate Outer IP from private to public (srcPort may be changed), then forward packets to BRGr
4. Program on BRGr parse incoming GRE packets, build corresponding GRE interface
5. BRGr decapulate GRE packets and forward inner packets to GWr
6. GWr NAT translate inner srcIP to public IP then forward to Internet



vCPE overview

- vCPE with GRE/VXLAN supporting
  - Multiple LANs can regard as a logically large LAN
  - No need to deploy physical CPE to each home subscriber
  - A single virtual CPE platform is able to serve multiple home subscribers