OpenNet – Open Network Emulator

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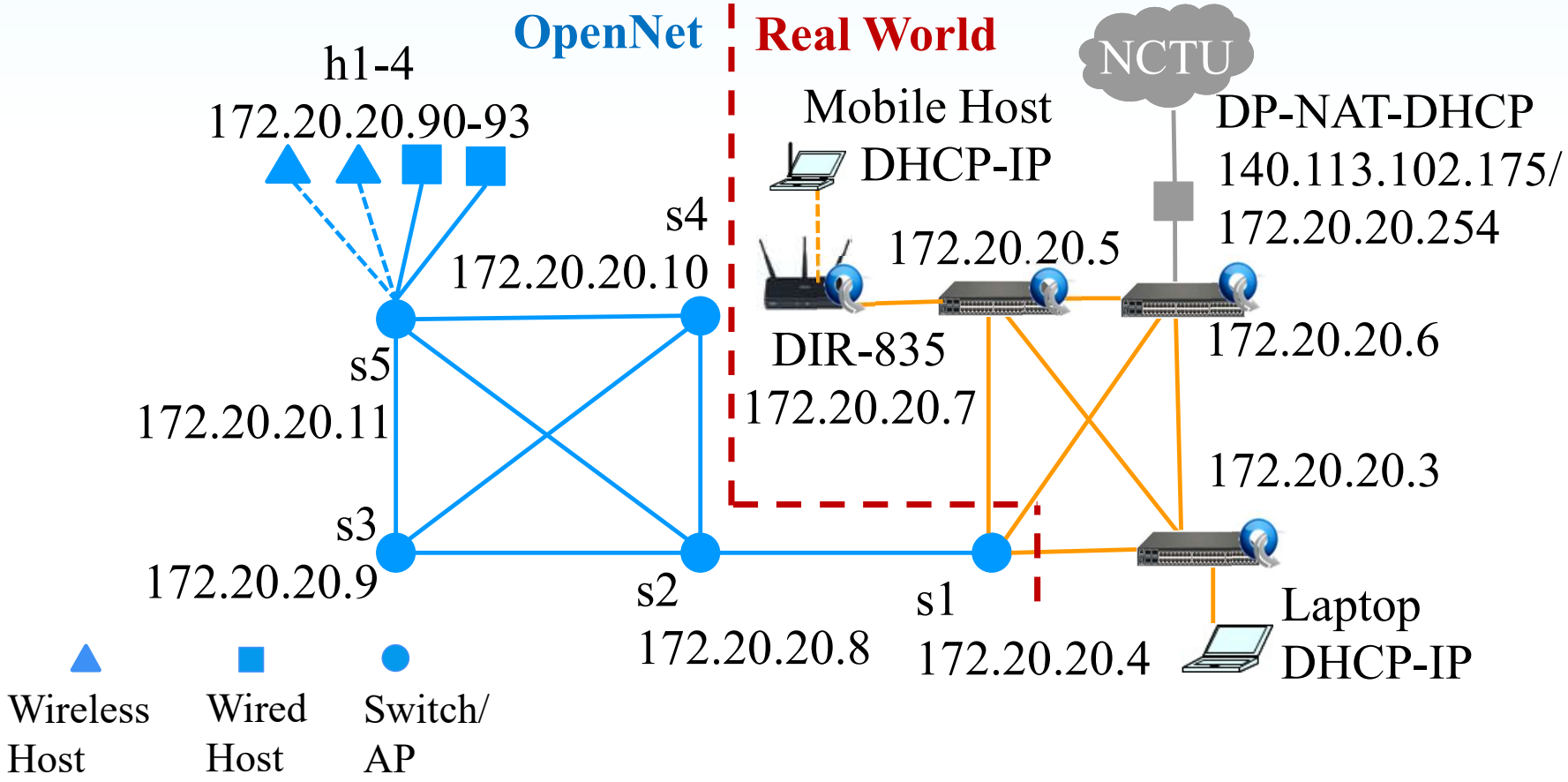
Reference:
OpenNet: https://github.com/dlinknctu/OpenNet

Open Network Emulator (**OpenNet**)

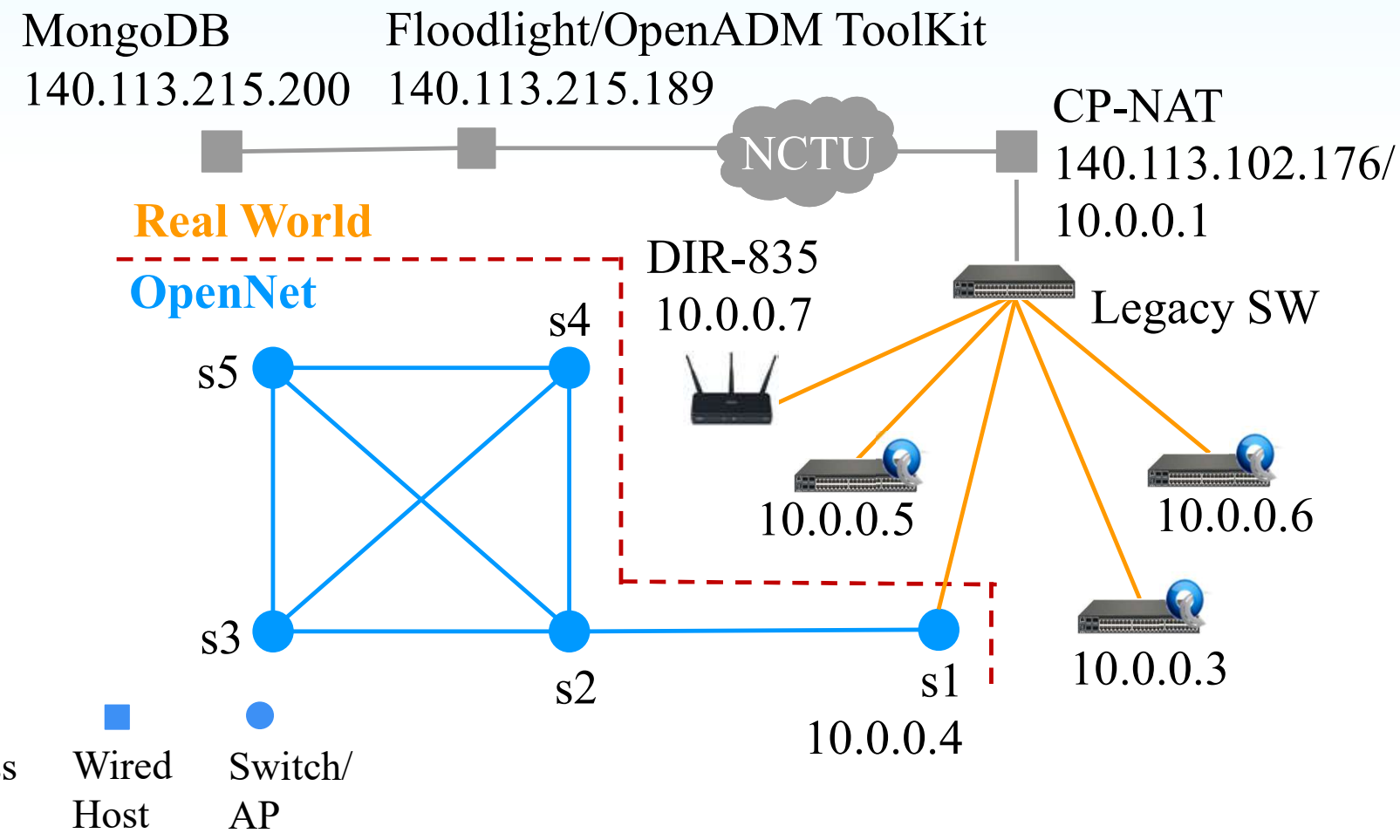
- **OpenNet**
  - An open source SDN simulator extended from Mininet
  - In-lab Testbed and Performance Evaluation tool for SDNs
    - with both physical and virtual
      - Controller,
      - Switches,
      - WiFi APs
      - LTE Femto Cells
      - Hosts (fixed/mobile)
- **Project Site:** http://github.com/dlinknctu/OpenNet
- Published paper: "OpenNet: A simulator for software-defined wireless local area network," WCNC 2014

Testbed Environment – Data Plane

- SDN-enabled Wireless Network Testbed with virtual and physical devices

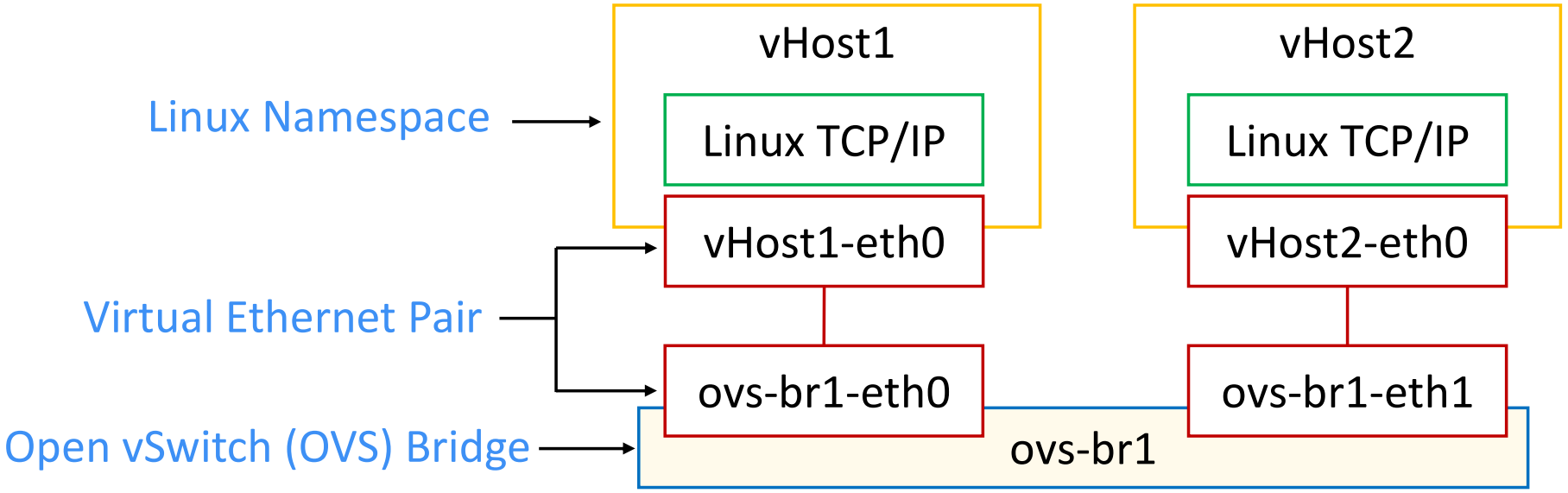


Testbed Environment – Control Plane



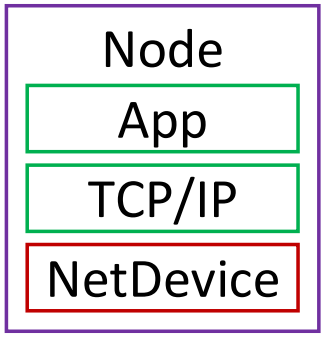
Mininet

- A network emulator which supports OpenFlow-based SDN
- Emulates **virtual host** (vHost) via Linux **namespace instance**
  - Linux namespace can isolate global system resources to emulate a host
- Uses Open vSwitch (OVS) as underlying virtual switch (vSwitch)
- OpenNet uses customized version of Mininet: NCTU-Mininet



NS-3

- A network simulator with various modules, including Wi-Fi and LTE
- Network simulation accomplished by the interactions of **nodes** and **channels**
  - **NS-3 node**: network node entity which has following objects:
    - Application: network applications
    - TCP/IP Stack: transport/network layer protocols
    - NetDevice: represents a physical interface on a node, e.g., Ethernet interface
  - **NS-3 channel**: **propagation media model**
    - Schedules transmit/receive events according to delay and signal strength

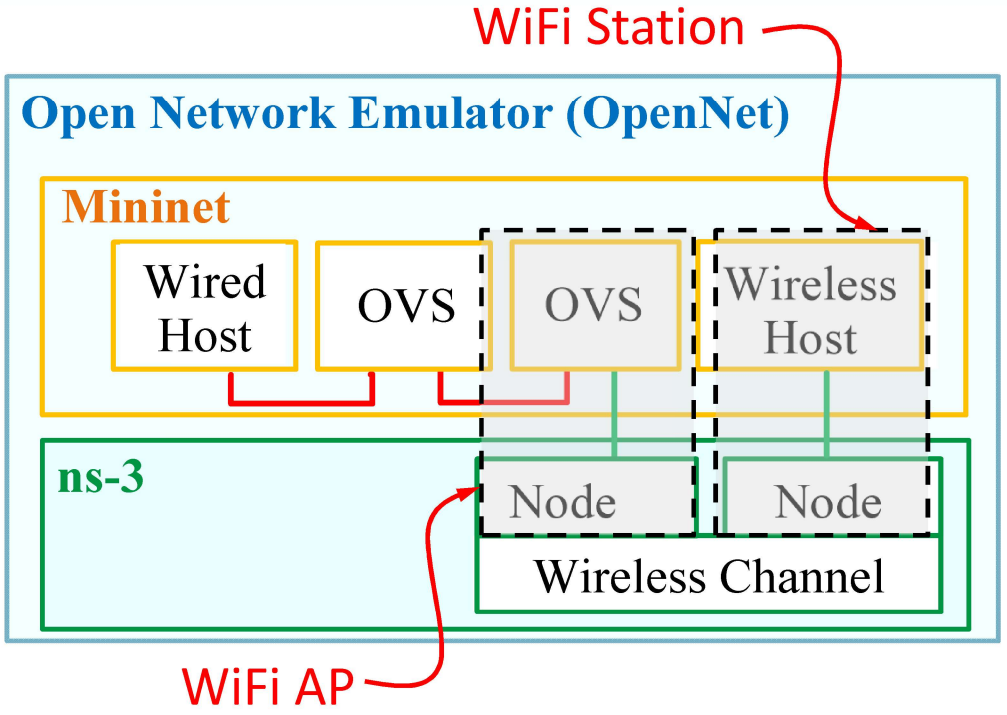


NS-3 Node

NS-3 Channel

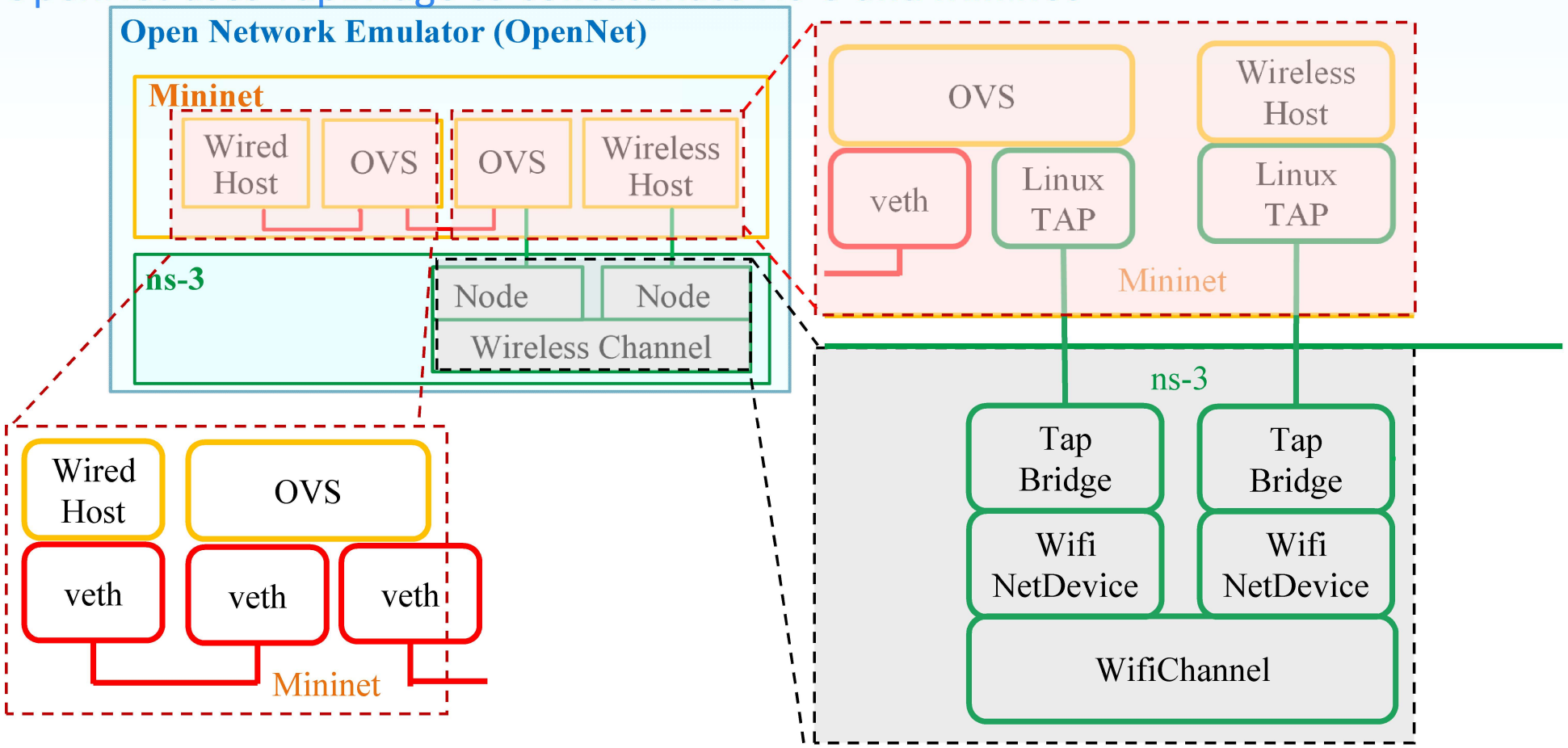
OpenNet and Features

- OpenNet
  - A simulator for software-defined wireless local area network
  - Built on top of Mininet and NS-3
    - Mininet for SDN
    - NS-3 for wireless channel
- OpenNet features
  - Interworking with various OF controllers
  - Wired and wireless network device emulation
  - Configurable common network attributes
    - E.g., bandwidth, delay, loss
  - Real network traffic generation



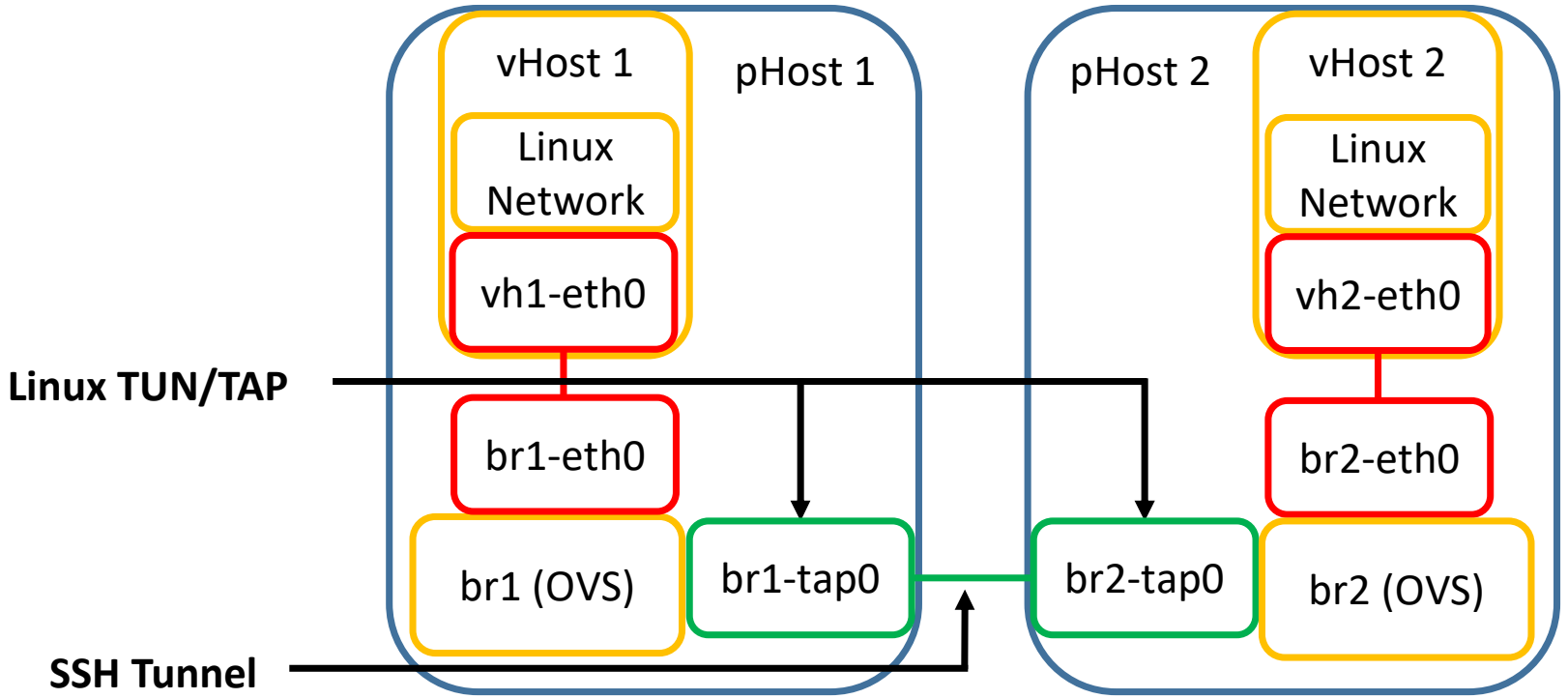
OpenNet Architecture (SDN-WiFi)

- OpenNet uses TapBridge to concatenate NS-3 and Mininet



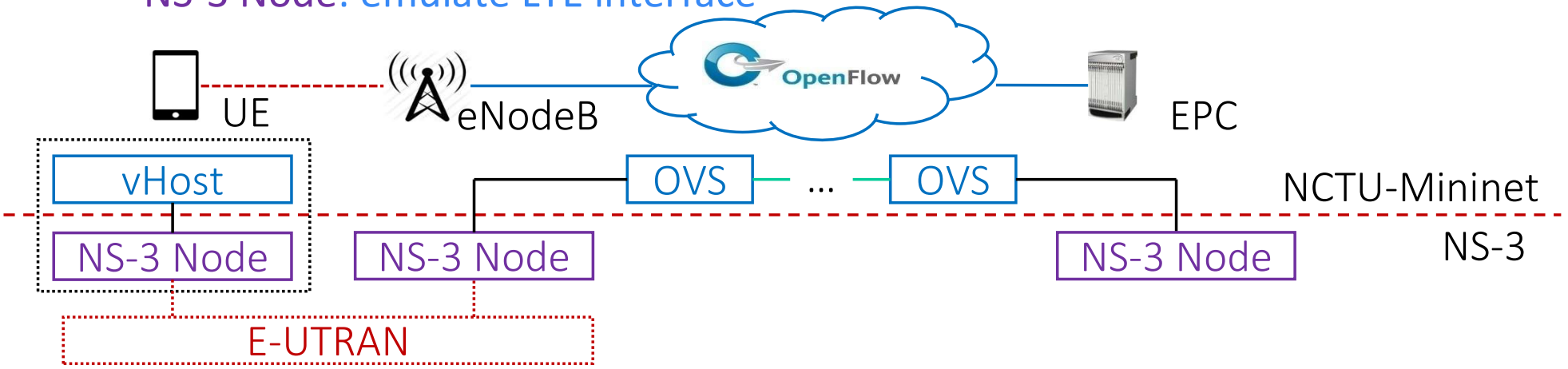
Mininet Distributed Cluster Emulation

- Use Linux TUN/TAP and SSH Tunnel to handle inter-Physical-host comm.
  - TUN device operates with network layer
  - TAP device operates with data link layer



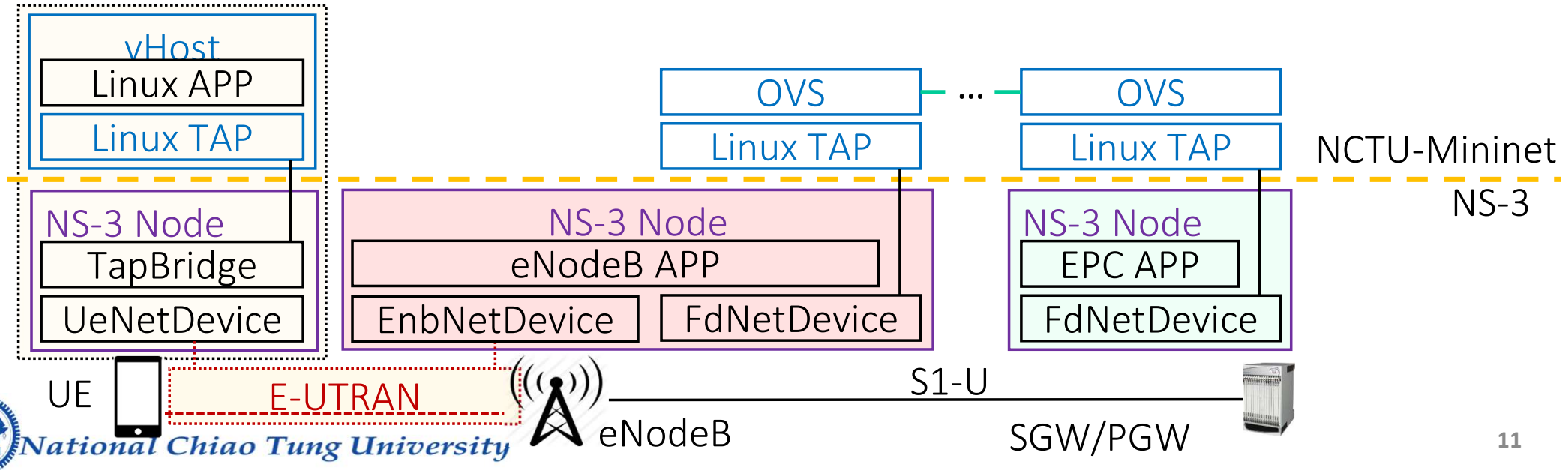
OpenNet HSDN: An Open Platform for Heterogeneous and Software Defined Networks Emulation

- Design of OpenNet HSDN components:
  - Open vSwitch (OvS): Use OVS to emulate SDN-based backhaul network
  - eNodeB and EPC (SGW/PGW/MME): NS-3 Node
    - Use existing NS-3 eNodeB and EPC emulation codes
  - UE: vHost + NS-3 Node with LTE Interface
    - vHost: run real Linux programs on emulated UE
    - NS-3 Node: emulate LTE interface



Integration of NCTU-Mininet and NS-3 LTE

- Enhanced NCTU-Mininet
  - Create Linux TAP as junction between NCTU-Mininet and NS-3
  - Create OVS as SDN switches in backhaul network
- Enhanced NS-3 EPC manager
  - Use FdNetDevice and TapBridge to interwork with NCTU-Mininet
  - Patch UeNetDevice for compatibility with TapBridge



Time Dilation Mechanism in OpenNet HSDN

- Use Time Dilation Factor (TDF) to adjust ratio btw real time & virtual time
  - User can specify TDF in OpenNet UDN emulation script
  - E.g., TDF = 100, every 100 real seconds equal to 1 virtual second.

1. Virtual time in Mininet namespaces
   - ➢ Make system call returns virtual time instead of system time
2. Network delay on virtual interfaces
   - ➢ Use Linux traffic control to add network delay and slowdown interfaces
3. Virtual time in NS-3 LTE
   - NS-3 LTE uses Linux system time to schedule LTE message
   - Change behavior of system call in root namespace may affect other programs
   - ➢ Make scheduling in NS-3 LTE use virtual time