Advanced Networking Topics: BGP, BGP Hijacking, MPLS, MPLS-based VPNs, Segment Routing, and others

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Lab Series: Border Gateway Protocol

- **Lab 1: Introduction to Mininet**
- **Lab 2: Introduction to Free Range Routing (FRR)**
- **Lab 3: Introduction to BGP**
- Lab 4: Configure and verify EBGP
- Lab 5: BGP Authentication
- Lab 6: Configure BGP with Default Route
- Lab 7: Using AS_PATH BGP Attribute
- Lab 8: Configuring IBGP and EBGP Sessions, Local Preference, and MED
- Lab 8.1: Configuring OSPF, IBGP and EBGP Sessions, Local Preference, and MED
- Lab 9: IBGP, Next Hop and Full Mesh Topology
- Lab 10: BGP Route Reflection

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Organization of Lab Manuals

Each lab starts with a section *Overview*
- ➢ Objectives
- ➢ Lab topology
- ➢ Lab settings: passwords, device names
- ➢ Roadmap: organization of the lab

Section 1
- ➢ Background information of the topic being covered (e.g., fundamentals of BGP)
- ➢ Section 1 is optional (i.e., the reader can skip this section and move to lab directions)

*Section 2… n*
- ➢ Step-by-step directions

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Introduction to Mininet

Lab activities are described in Lab 1, BGP Lab Series

What is Mininet?

- A virtual testbed capable of recreating realistic scenarios[1]
- It enables the development and testing of network protocols
- Inexpensive solution, real protocol stack, reasonably accurate

Mininet Emulated Network

Hardware Network

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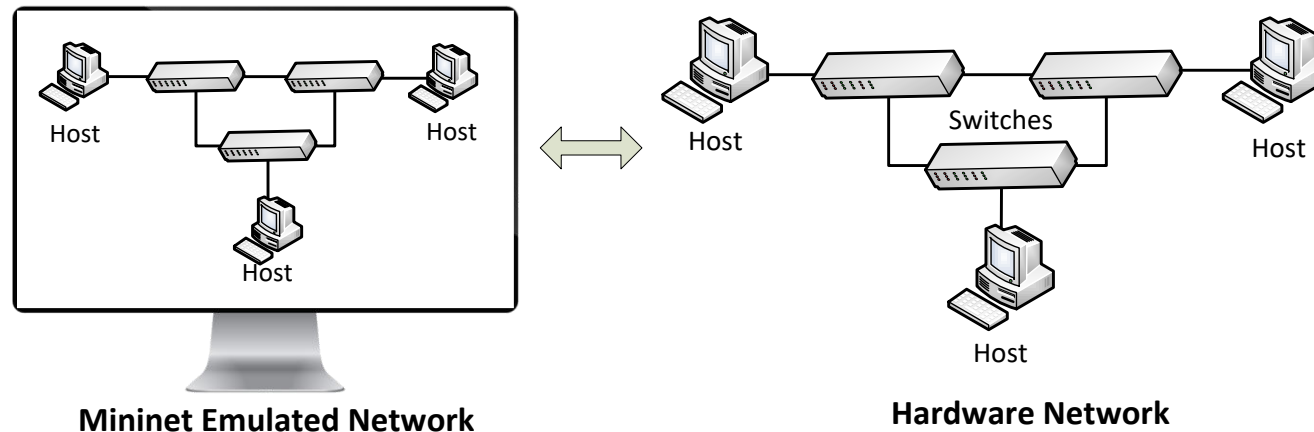
[1]Mininet website, http://mininet.org/

What is Mininet?

- Mininet nodes are network namespaces
  - ➢ Each node has different / separate virtual interfaces, routing tables
- Nodes use the underlying protocol stack of the host device
- Nodes are connected via virtual Ethernet (veth) links, which behave as Ethernet links
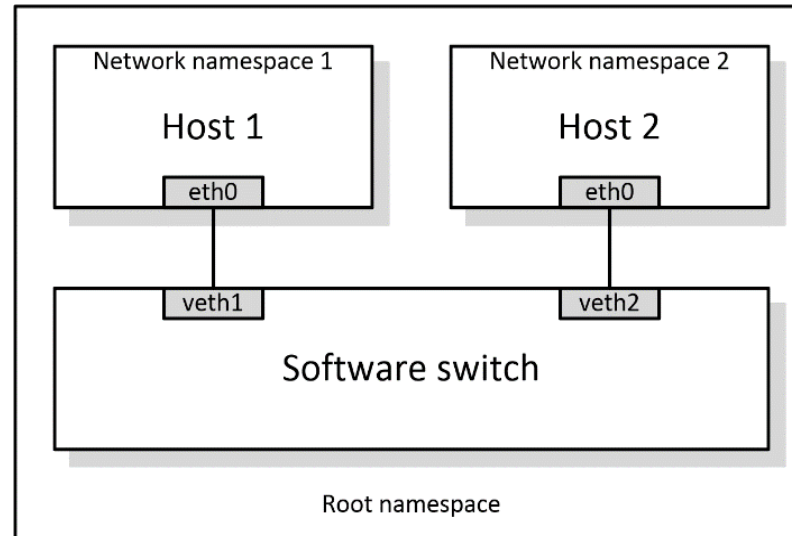
Pod Design with Mininet

- A pod is a set of virtual equipment (routers, switches, etc.)
- A pod is created every time a lab reservation is made
- For the Border Gateway Protocol (BGP) Lab series, pods are embedded into Mininet
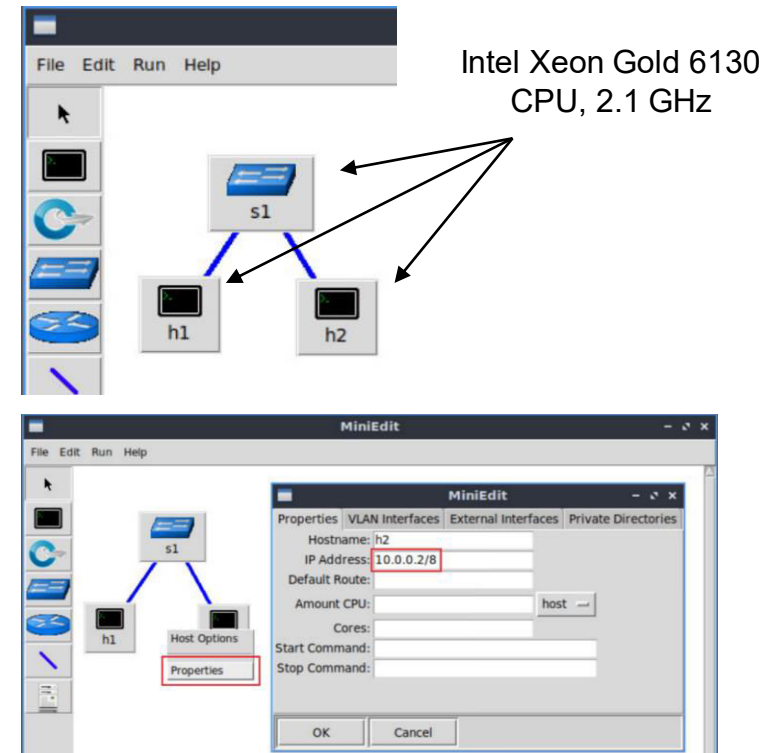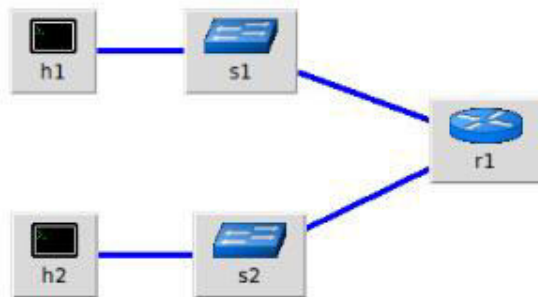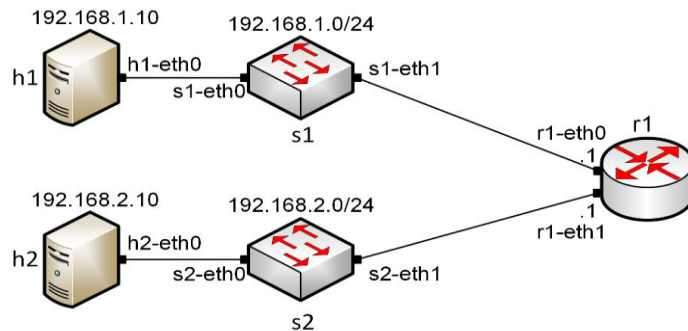
Introduction to FRR

Lab activities are described in Lab 2, BGP Lab Series

What is FRR?

- FRR is an open source routing protocol stack[1]
- The configuration is similar to other vendors
  - Command-line shell and configuration file
- Protocols are implemented as independent processes
- Zebra is the process that controls the routing information base (RIB)

vtysh — Command-line interface

bgpd   ripd   ospfd   . . . — Protocol daemons

Zebra (RIB) — Service daemon
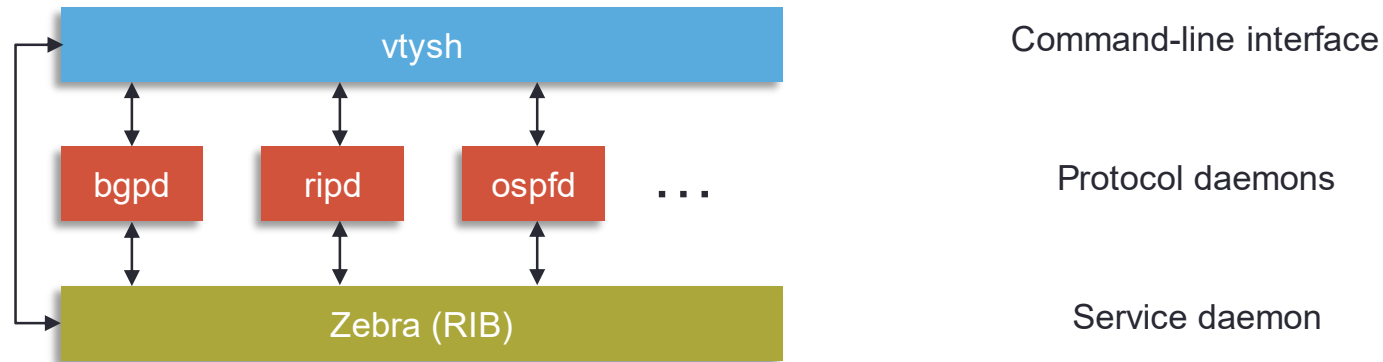
[1]FRRouting website, https://frrouting.org

FRR and Mininet Integration

- Mininet provides network emulation, allowing all network software at any layer to be simply run as is

- The set of commands provided by FRR are inherited and can be run using Mininet's command-line interface

Lab Topology

- Two hosts: h1 and h2; two switches: s1 and s2; two routers: r1 and r2
- Static routing is configured on both routers so that the hosts can ping
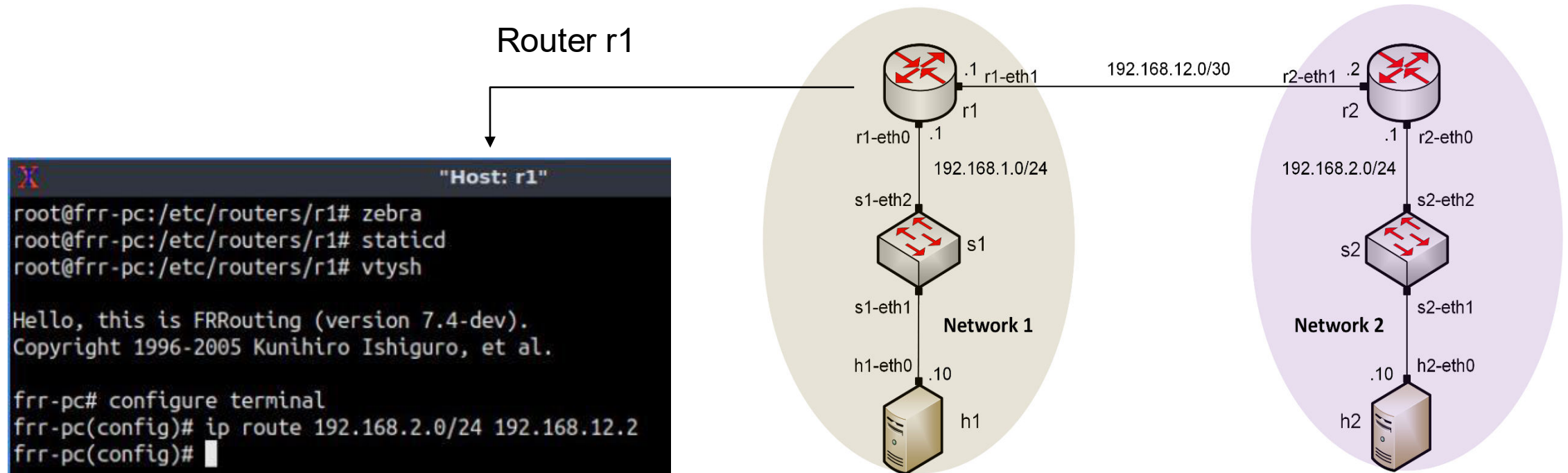
Introduction to BGP

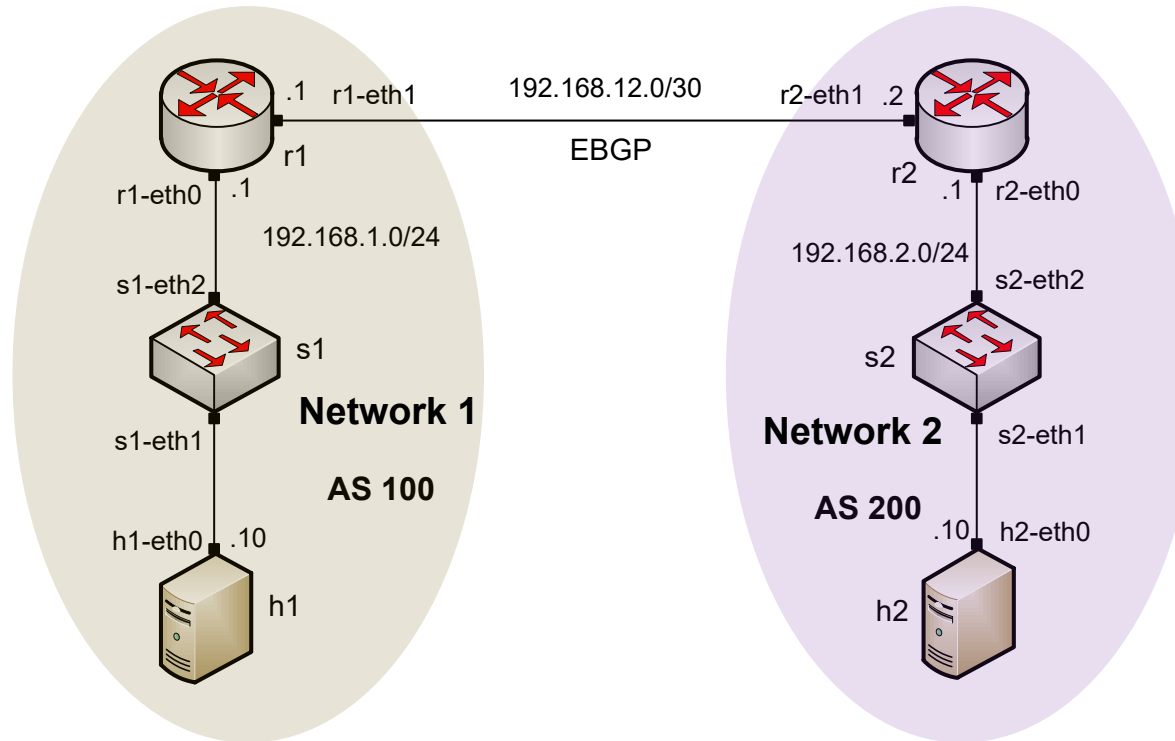Lab activities are described in Lab 3, BGP Lab Series

What is BGP?

- The Internet can be viewed as a collection of networks or Autonomous Systems (ASes) that are interconnected

- BGP is an exterior gateway protocol designed to exchange routing and reachability information among ASes on the Internet
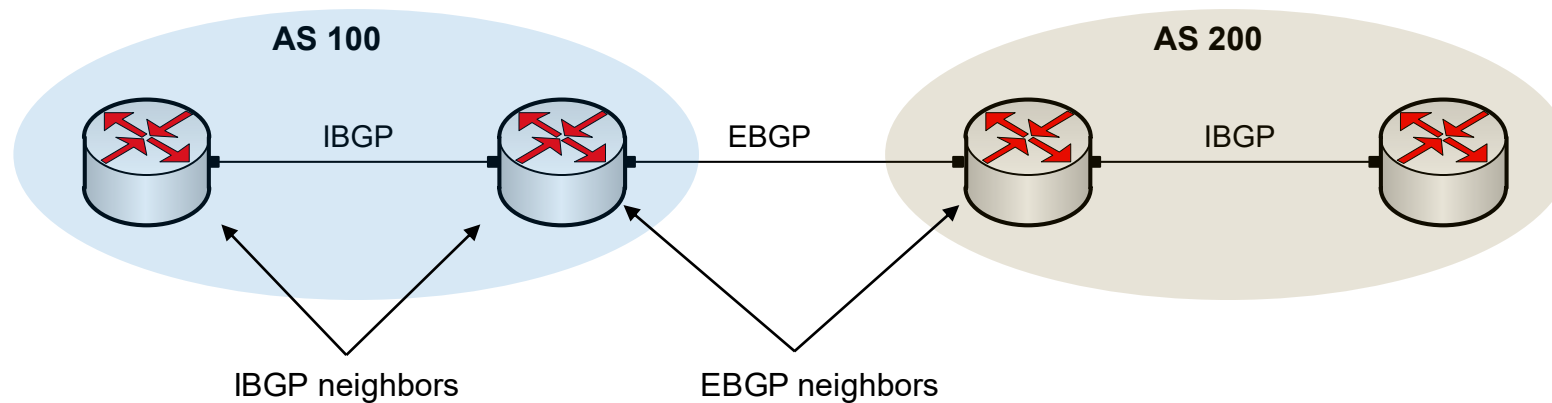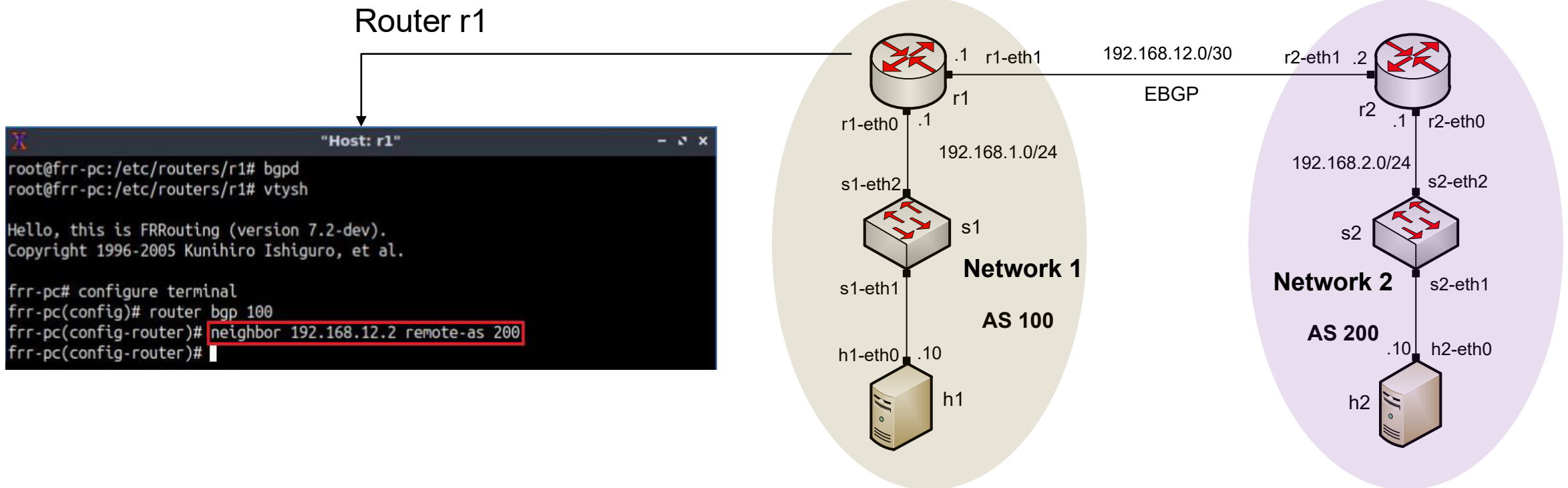
Lab Topology

- Network 1 in AS 100 consists of a host, a switch, and a router
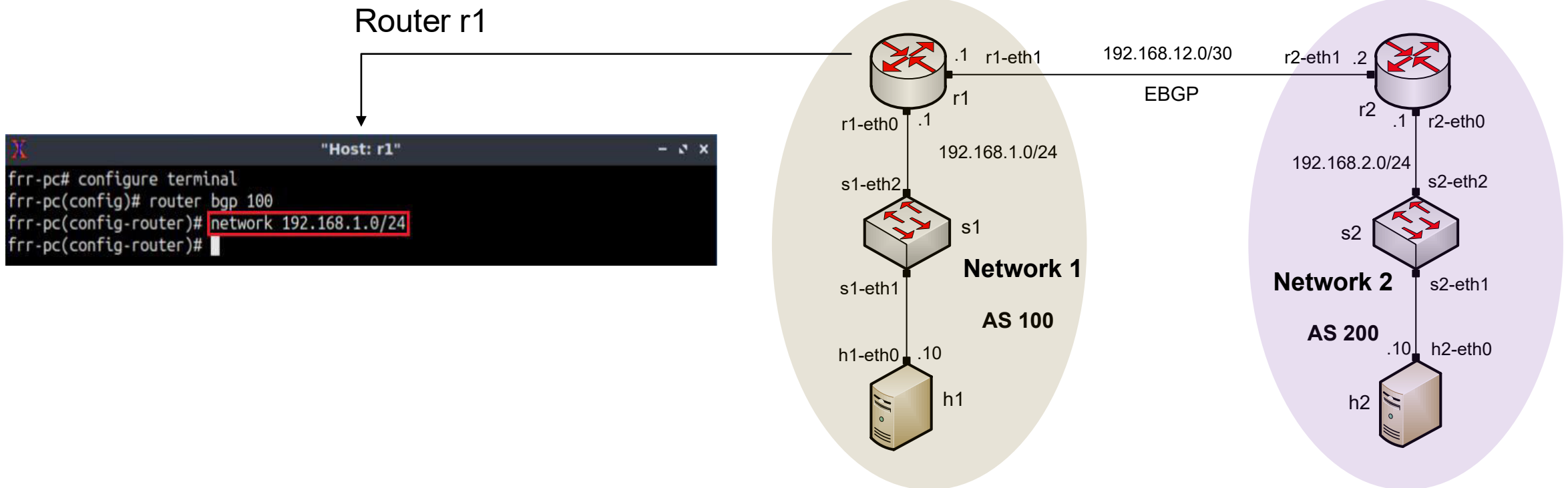- Network 2 in AS 200 consists of a host, a switch, and a router

Lab Configuration

- Establishing BGP neighborhood

Router r1

```
"Host: r1"
root@frr-pc:/etc/routers/r1# bgpd
root@frr-pc:/etc/routers/r1# vtysh

Hello, this is FRRouting (version 7.2-dev).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

frr-pc# configure terminal
frr-pc(config)# router bgp 100
frr-pc(config-router)# neighbor 192.168.12.2 remote-as 200
frr-pc(config-router)#
```

Lab Configuration

- Advertising a network in BGP

Lab Configuration

- Routing table: lists the routes learned from different routing protocols

Lab Configuration

- BGP table: lists the routes learned from BGP routing protocol

Router r2

```
"Host: r2"                                              –  ⤢  ✕

frr-pc# show ip bgp
BGP table version is 2, local router ID is 192.168.12.2, vrf id 0
Default local pref 100, local AS 200
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete

   Network          Next Hop         Metric LocPrf Weight Path
*> 192.168.1.0/24   192.168.12.1          0             0 100 i
*> 192.168.2.0/24   0.0.0.0               0         32768 i

Displayed  2 routes and 2 total paths
frr-pc# █
```