Lab 4: Simple Router

CS144 Lab 4 Screencast

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Based on slides by Clay Collier and Martin Casado

Assignment Overview

- You create a virtual network topology, using a topology creation tool
  - Covered in intro screencast
- You write a router in C
- Your router will route real IP packets over the Internet from standard clients (i.e. ping, traceroute, ftp, Firefox…)
- Due Wednesday, May 14th before class
  - Extended to Saturday, May 17th @ 5:00 PM if you attend class
- Get started early!

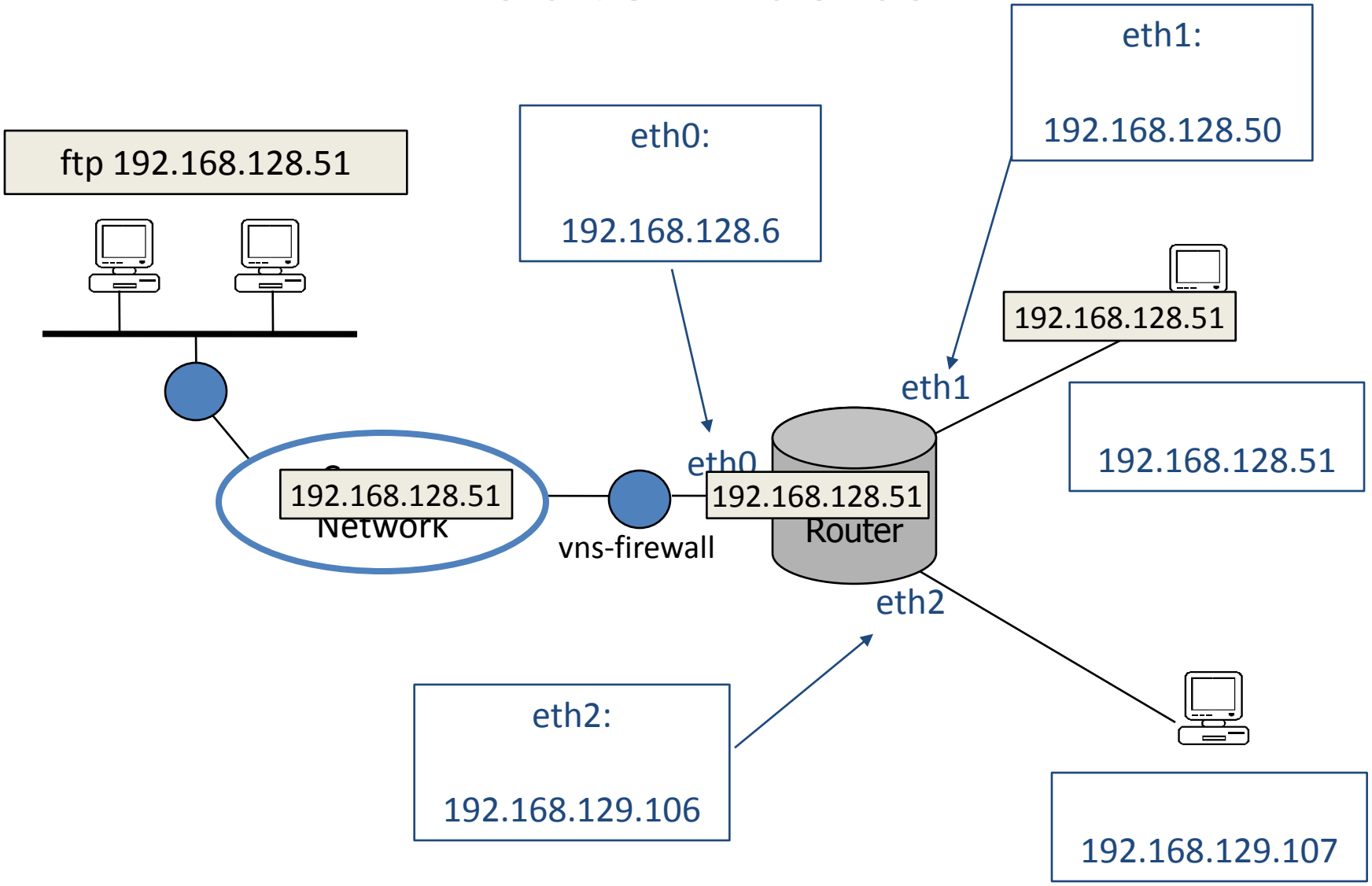
Getting Started

- Copy the assignment code from: `/usr/class/cs144/src/router`
- Watch the intro screencast to:
  - Create a topology
  - Create a routing table for the topology
  - Compile and run the stub code with a routing table for your topology

Protocols You Need to Handle

- Ethernet
  - All packets given to you are raw Ethernet frames
- IP
- ARP
  - Needed to resolve IP addresses to MAC addresses
- ICMP requests/replies
  - Used by some programs to send requests (ping)
  - Needed to send control messages back to host
- See sr_protocol.h and Network Sorcery to deal with the raw bits
- Make sure you understand your pointer arithmetic!

Router Basics



Routing Table

- Static routing table in this assignment
- Make sure you understand LPM (Section 3)
- Loaded for you from the command line into the router context of type *struct sr_instance* (sr_router.h)
- Entries are a linked list of type *struct sr_rt* (sr_rt.h)
- Walk over the routing table linearly to do a longest prefix match on it

IP address	Next-hop	Network Mask	Interface
192.168.128.51	192.168.128.51	255.255.255.255	eth1
192.168.129.106	192.168.129.106	255.255.255.255	eth2
0.0.0.0	172.24.74.17	0.0.0.0	eth0

Basic Forwarding Principles

- Remove IP datagram from Ethernet frame
  - Could also be an ARP payload in Ethernet frame
- Inspect the packet's DA. Assuming the packet is destined for someone else:
  - Look up next-hop address by doing a LPM on the routing table using the packet's DA
    - If it does not exist, send ICMP host unreachable
  - Decrement TTL, update header checksum
    - If TTL <= 1, send ICMP time exceeded
    - If checksum invalid, drop
  - From next-hop address, determine outgoing interface and next-hop MAC address
    - If necessary, send ARP request to determine MAC address
  - Encapsulate IP datagram in Ethernet packet
  - Forward packet to outgoing interface

Packets Destined for the Router

- If the packet's DA is destined towards one of our interfaces:
  - If it's an ICMP echo request, generate an ICMP echo reply
  - Otherwise if it's a TCP or UDP packet, generate an ICMP port unreachable (needed for traceroute to work)

Checksums

- IP checksum
  - Need to check for all IP packet headers; drop packet if checksum is bad
- ICMP checksum
  - Need to validate for incoming packets destined for us
  - Need to calculate for outgoing packets
  - Ignore if forwarding
- TCP/UDP checksum
  - End-to-end checksum, ignore
- Use in_cksum from Lab 3 to calculate checksums

Handling ARP

- Routing table contains next-hop IPs, but you need both a next-hop IP *and* and a next-hop MAC address
- What you have to do:
  - Generate ARP requests and parse ARP replies
  - Listen to ARP requests and send ARP replies
  - Don't send a request for each packet; instead, use an ARP cache
  - Requests should time out after 5 tries of about 1 second each
  - ARP cache entries should time out after about 15 seconds

ARP Cache	
IP address	Ethernet MAC Address
172.24.74.130	00:e0:81:04:08:9b
…	…

ARP Cache Class

- We've given you an ARP cache class containing
  - ARP request queue
  - ARP cache
- ARP cache entries time out automatically after 15 seconds
- ARP request queue written so that it is easy consolidate ARP requests across multiple packets, and enforce the ARP request timeout
- See pseudocode in sr_arpcache.h

Required Functionality

- Forwarding packets should work
- Handles and generates ARP requests/replies correctly
- You can download a file using http and ftp from one of the app servers behind the router
- You can traceroute to and through the router
- You can ping to and through the router
- ICMP host and port unreachable messages are generated correctly
- ICMP time exceeded messages are generated correctly
- No shortcuts taken (don’t forward a packet to every interface)
- Should not crash, even with a malformed packet

Main Functions and Structures

- In sr_router.h:
  - struct sr_instance is the context of the router
- In sr_router.c:
  - sr_handlepacket is called for every packet that goes through the router—you have to fill it out
- sr_protocol.h contains convenience structs for accessining fields in packets
- sr_if.h contains methods for getting information about the router's interfaces
- ARP Cache in sr_arpcache.h

Suggestions

- Think before coding—there's a good amount of code to write
- Don't put everything in one file, if you want to be able to navigate your code
- Read through the Network Sorcery pages to understand the protocols
- Read the FAQ
- Post and check the newsgroup
- Start early

Demo

- Look at working solution