Midterm for Computer Networks, November 2010

Open Book (Total: 100 points), Prof. Ying-Dar Lin, ydlin@cs.nctu.edu.tw

1. (12%) **Routing vs. Switching**

Routing is stateless processing of packets, while switching is stateful.

(a) (4%) Why switching is faster than routing in general?

Switching: indexing by virtual circuit number or flat address, say MAC address

Routing: Longest prefix matching, which takes more time

(b) (4%) Why the Internet was not designed as a switched network in the first place? (Hints: What additional overheads will be introduced to the control plane? Routing or switching fits data communications better?)

Stateless routing is better because

(1) bursty traffic makes the overheads of state establishment relatively expensive

(2) switching needs to keep states of each flow, which may not be scalable

(c) (4%) Multi-Protocol Label Switching (MPLS) tries to impose switching into the routed Internet by switching more packets and route less packets. Explain what kinds of packets are more likely to be switched?

Long-lived, continuous data stream because more packets are switched

2. (12%) **Interface Between Hardware and Driver**

We need to understand how the hardware and its driver co-work.

(a) (4%) What is the interface between the driver of a network adaptor and the controller of the network adaptor?

registers and IRQ (hardware interrupt number) in the controller; the driver routine corresponding to an IRQ.

(b) (4%) How does the driver ask the controller to send a packet and how does the controller report it has completed the job?

The driver writes a command into the command register along with an address showing where the packet is. The controller interrupts CPU with an IRQ number to invoke the driver routine that handles the transmit completion.

(c) (4%) How does the controller report to the driver when a packet has arrived to the network adaptor?

The controller interrupts CPU with an IRQ number to invoke the driver routine that handles the receive procedures.

3. (9%) **Issues in Line Coding**

Among unipolar NRZ-L, Polar NRZ-L, NRZ-I, and RZ, Manchester, differential Manchester, AMI, and MLT-3, which schemes have no issues on synchronization, baseline wandering, and DC components, respectively?

Without self-synchronization problem: polar RZ, Manchester, differential Manchester
Without baseline wandering problem: Manchester, differential Manchester
Without or with very little DC components problem: polar RZ, Manchester, differential Manchester, AMI

4. (10%) **Constraints on CSMA/CD**
   There have been some constraints on the applicability of CSMA/CD in half-duplex Ethernet.
   (a) (4%) Why is big bandwidth delay product bad for both CS (carrier sense) and CD (collision detection)?
   For CS: sensed info is not up to date; for CD: small packets running on a long link → low efficiency
   (b) (3%) Why is there no half-duplex gigabit Ethernet in the market?
   High BDP → round-trip-time > frame transmission time → bad for CS and CD → needs frame bursting and carrier extension → overhead
   (c) (3%) Why cannot you apply CSMA/CD directly onto WLAN?
   CS for WLAN: not accurate due to hidden terminals; CD for WLAN: cannot receive while transmitting

5. (8%) **Frame Length in Meter**
   In 1000BASE-X, a frame of 64 bytes is first block coded with 8B/10B before transmitting. Suppose the propagation speed is 2×10^8. What is the frame "length" in "meter"? (Suppose the cable is 500 m long.)
   $64 * (10/8) * 8 / (1000*10^6) * 2 * 10^8 = 128$ m.

6. (12%) **Layer-2 Bridging or Layer-3 Routing**
   Packet forwarding between LANs, or subnets, can be done by layer-2 bridging or layer-3 routing.
   (a) (4%) What *data-plane* scheme is needed for layer-2 bridging and layer-3 routing, respectively?
   layer-2 bridging: self-learning of source addresses into the forwarding table
   MAC address lookup at the forwarding table
   layer-3 routing: longest prefix matching
   (b) (4%) What are the differences between the forwarding tables at a layer-2 bridge and a layer-3 router?
   MAC address (per-interface entry) vs. IP address (per-network entry)
   (c) (4%) Why is the layer-2 bridging not suitable to interconnect subnets in a large organization with over 10,000 hosts?
   Number of entries in the forwarding table may be too large to learn, making flooding too often.

7. (10%) **Longest Prefix Matching**
   In IP packet forwarding, longest prefix matching is exercised to find the entry that matches the destination address most.
   (a) (5%) In the Linux kernel, the first matched entry is guaranteed the longest prefix match. How is that guaranteed?

(1) Store prefixes of the same length into the same hash table

(2) Search the hash table with the longest prefix first

(b) (5%) A routing cache is placed ahead of the forwarding table in the Linux kernel to speed up the process. Describe, in text, the data structure for the cache and the algorithm to lookup the cache.

Data structure: hash table

Algorithm: hashed by (source IP address, destination IP address, TOS) + linear matching

8. (12%) **RIP vs. OSPF**

RIP and OSPF run Bellman-Ford and Dijkstra algorithms, respectively.

(a) (3%) Compare their speed of convergence of routing table.

RIP: slow, N iterations, N: network diameter, an iteration: usually seconds of tens of seconds; OSPF: fast, 1 iteration.

(b) (3%) Compare their scalability in terms of network size.

RIP: more scalable; OSPF: less scalable.

(c) (3%) How does RIP resolve the count-to-infinity problem?

Poison reverse, split horizons, stabilization timer.

(d) (3%) In the Zebra implementation, how do these two protocol entities update the routing table entries and exchange messages with other routers.

Update routing table: through zebra client/server protocol to talk with zebra daemon which in turn use netlink interface; exchange messages with other routers: through socket interface.

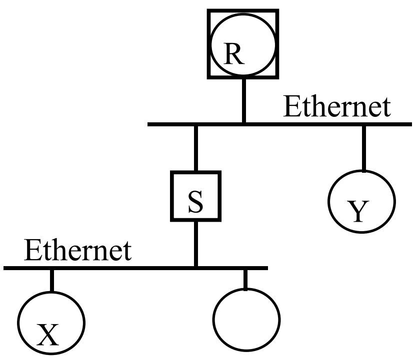
9. (15%) **Routing and Address Resolution**

Consider the following LAN with one Ether switch, S, one intradomain router, R, and two hosts, X, Y. Assume switch S has been just powered on.

(a) (5%) Describe the routing and address resolution steps performed at X, Y, and S when X sends an IP packet to Y.

(b) (5%) Describe the routing and address resolution steps performed at X, Y, and S when Y replies an IP packet to X.

(c) (5%) Describe the routing and address resolution steps performed at X, S and R when X sends an IP packet to a host that is outside the domain. (Hint: do not forget to explain how X knows of the router R.)



(a) When X wants to send a packet to Y, it performs IP routing by checking whether they are in the same subnet. The answer is yes, therefore, X invokes an ARP request to find Y's MAC address. Since the ARP request is broadcasted, switch S will forward it to Y (while remember the incoming port for X at the same time). When Y replies X's ARP request, it knows X's MAC address directly from X's ARP request. So Y will reply a unicast ARP response to X. Upon receiving the packet, switch S already has X's port information. Therefore, S will forward the packet to X on the appropriate port.

(b) Similar to answer (a), when Y wants to send an IP packet to X, it also checks whether X and Y are in the same subnet. Since they are in the same subnet and Y already has X's MAC address in its ARP cache, it can send the packet to X directly. Again, no routing is required in this case.

(c) X first checks if the destination is within the same IP subnet. Since it is not, X then searches its routing table to find the next hop router toward this destination. In most cases, X will use the default router. Once the next hop router is determined, X then sends an ARP request to ask for the router's MAC address. Since switch S does not know where the router is, it will broadcast the ARP request. The router, R, will reply the ARP request by unicast. Since switch S knows X already, the ARP reply is forwarded to X directly. Upon receiving the ARP reply, X then sends the packet to the router with the destination IP in the IP header and router's MAC address in the Ethernet header.