Computer Networks LECTURE 13 Switches, Transport Layer

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MAC addresses

- 32-bit IP address:
 - network-layer address for interface
 - used for layer 3 (network layer) forwarding
- MAC (or LAN or physical or Ethernet) address:
 - function: used 'locally" to get frame from one interface to another physically-connected interface (same network, in IPaddressing sense)
 - 48 bit MAC address (for most LANs) burned in NIC ROM, also sometimes software settable
 - e.g.: IA-2F-BB-76-09-AD

hexadecimal (base 16) notation (each "numeral" represents 4 bits)

Link Layer and LANs 6-3



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LAN addresses (more)

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- analogy:
 - MAC address: like Social Security Number
 - IP address: like postal address
- MAC flat address → portability
 - · can move LAN card from one LAN to another
- IP hierarchical address not portable
 - address depends on IP subnet to which node is attached

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ARP: address resolution protocol Question: how to determine interface's MAC address, knowing its IP address? ARP table: each IP node (host, router) on LAN has table IP/MAC address -137.196.7.78 mappings for some LAN nodes: 137.196.7.23 < IP address: MAC address: TTL> 137.196.7.14 TTL (Time To Live): time after which address LAN mapping will be 71-65-F7-2B-08-53 58-23-D7-FA-20-B0 forgotten (typically 20 min) 137.196.7.88 -

ARP protocol: same LAN

- A wants to send datagram to B
 - B' s MAC address not in A' s ARP table.
- A broadcasts ARP query packet, containing B's IP address
 - destination MAC address = FF-FF-FF-FF-FF
 - all nodes on LAN receive ARP query
- B receives ARP packet, replies to A with its (B's) MAC address
 - frame sent to A' s MAC address (unicast)

- A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
 - soft state: information that times out (goes away) unless refreshed
- ARP is "plug-and-play":
 nodes create their ARP
 - tables without intervention from net administrator

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Addressing: routing to another LAN

Link Layer and LANs 6-6

walkthrough: send datagram from A to B via R

- focus on addressing at IP (datagram) and MAC layer (frame)
- assume A knows B's IP address
- assume A knows IP address of first hop router, R (how?)
- assume A knows R's MAC address (how?)





Addressing: routing to another LAN

- frame sent from A to R
- frame received at R, datagram removed, passed up to IP



Addressing: routing to another LAN R forwards datagram with IP source A, destination B • R creates link-layer frame with B's MAC address as destination address, frame contains Á-to-B IP datagram MAC src: 1A-23-F9-CD-06-9B MAC dest: 49-BD-D2-C7-56-2A P src: 111.111.111.111 IP dest: 222.222.222.222 IP Eth IP Phy Eth Phy 111.111.111.111 222.222.222.222 74-29-9C-E8-FF-55 49-BD-D2-C7-56-2A 222.222.222.220 1A-23-F9-CD-06-9B 111.111.111.110 222 222 222 222 221 111.111.111.112 E6-E9-00-17-BB-4B 88-B2-2F-54-1A-0F CC-49-DE-D0-AB-7D Link Layer and LANs 6-11

Addressing: routing to another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as destination address, frame contains A-to-B IP datagram





Ethernet switch link-layer device: takes an active role store, forward Ethernet frames examine incoming frame's MAC address, relactively forward, frame to one or mon

- selectively forward frame to one-or-more outgoing links when frame is to be forwarded on segment, uses CSMA/CD to access segment
- Extends network at link layer
- transparent
 - · hosts are unaware of presence of switches
- plug-and-play, self-learning
 - · switches do not need to be configured

Link Layer and LANs 6-14

























Synthesis: a day in the life of a web request

- journey down protocol stack complete!
 - application, transport, network, link
- putting-it-all-together: synthesis!
 - *goal*: identify, review, understand protocols (at all layers) involved in seemingly simple scenario: requesting www page
 - scenario: student attaches laptop to campus network, requests/receives www.google.com



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A day in the life... connecting to the Internet DHCP DHCP server formulates DHCP DHCP UDP **DHCP ACK** containing DHCP IP client's IP address, IP DHC Eth address of first-hop router Phy for client, name & IP address of DNS server encapsulation at DHCP server, frame forwarded DHCF (switch learning) through UDP IP LAN, demultiplexing at client Eth (runs DHCP) Phy DHCP client receives DHCP ACK reply Client now has IP address, knows name & addr of DNS server, IP address of its first-hop router Link Layer and LANs 6-30









Chapter 6: Summary

- principles behind data link layer services:
 - error detection, correction
 - sharing a broadcast channel: multiple access
 - link layer addressing
- instantiation and implementation of various link layer technologies
 - Ethernet
 - Bridging and switching



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Transport Layer 3-39



















Recall: Internet checksum

















rdt2.1: discussion

sender:

- seq # added to pkt
- two seq. #'s (0,1) will suffice. Why?
- must check if received ACK/NAK corrupted
- twice as many states
 - state must "remember" whether "expected" pkt should have seq # of 0 or 1

receiver:

- must check if received packet is duplicate
 - state indicates whether 0 or 1 is expected pkt seq #
- note: receiver can not know if its last ACK/NAK received OK at sender

Transport Layer 3-57



- instead of NAK, receiver sends ACK for last pkt received OK
 - receiver must explicitly include seq # of pkt being ACKed
- duplicate ACK at sender results in same action as NAK: retransmit current pkt

Transport Layer 3-58





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Go-back-N:

- sender can have up to N unacked packets in pipeline
- receiver only sends cumulative ack
 - doesn' t ack packet if there's a gap
- sender has timer for oldest unacked packet
 - when timer expires, retransmit all unacked packets

Selective Repeat:

- sender can have up to N unack' ed packets in pipeline
- rcvr sends individual ack for each packet
- sender maintains timer for each unacked packet
 - when timer expires, retransmit only that unacked packet

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