CS 655
Computer Networks

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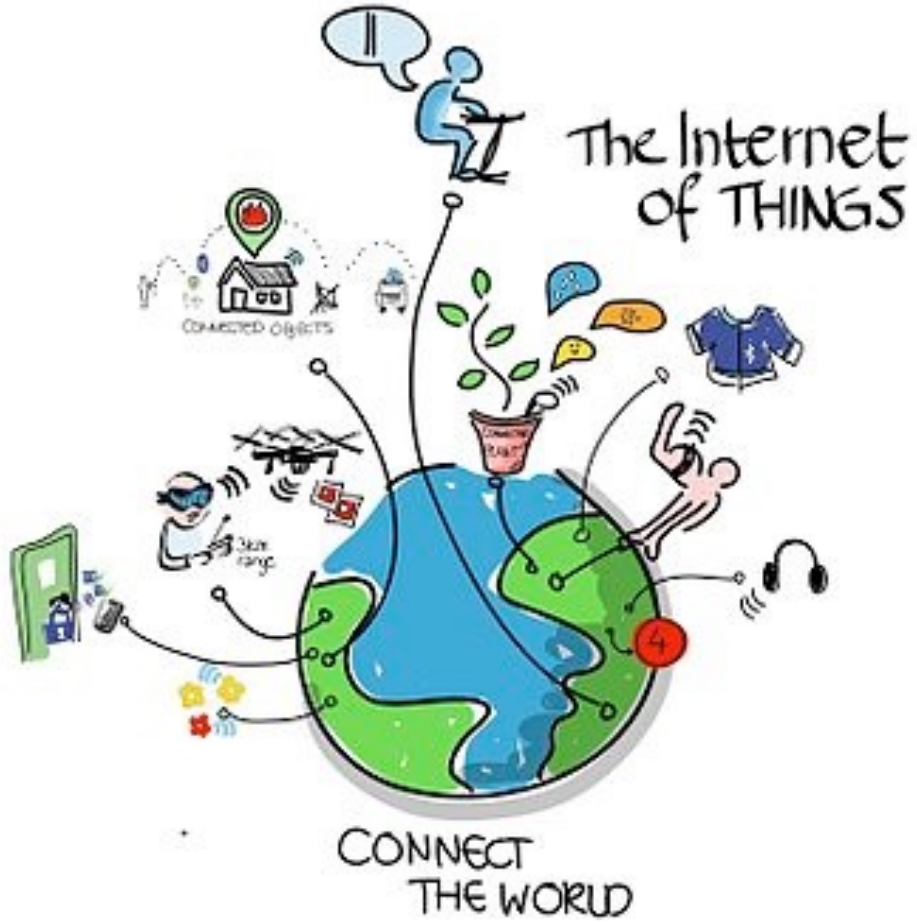
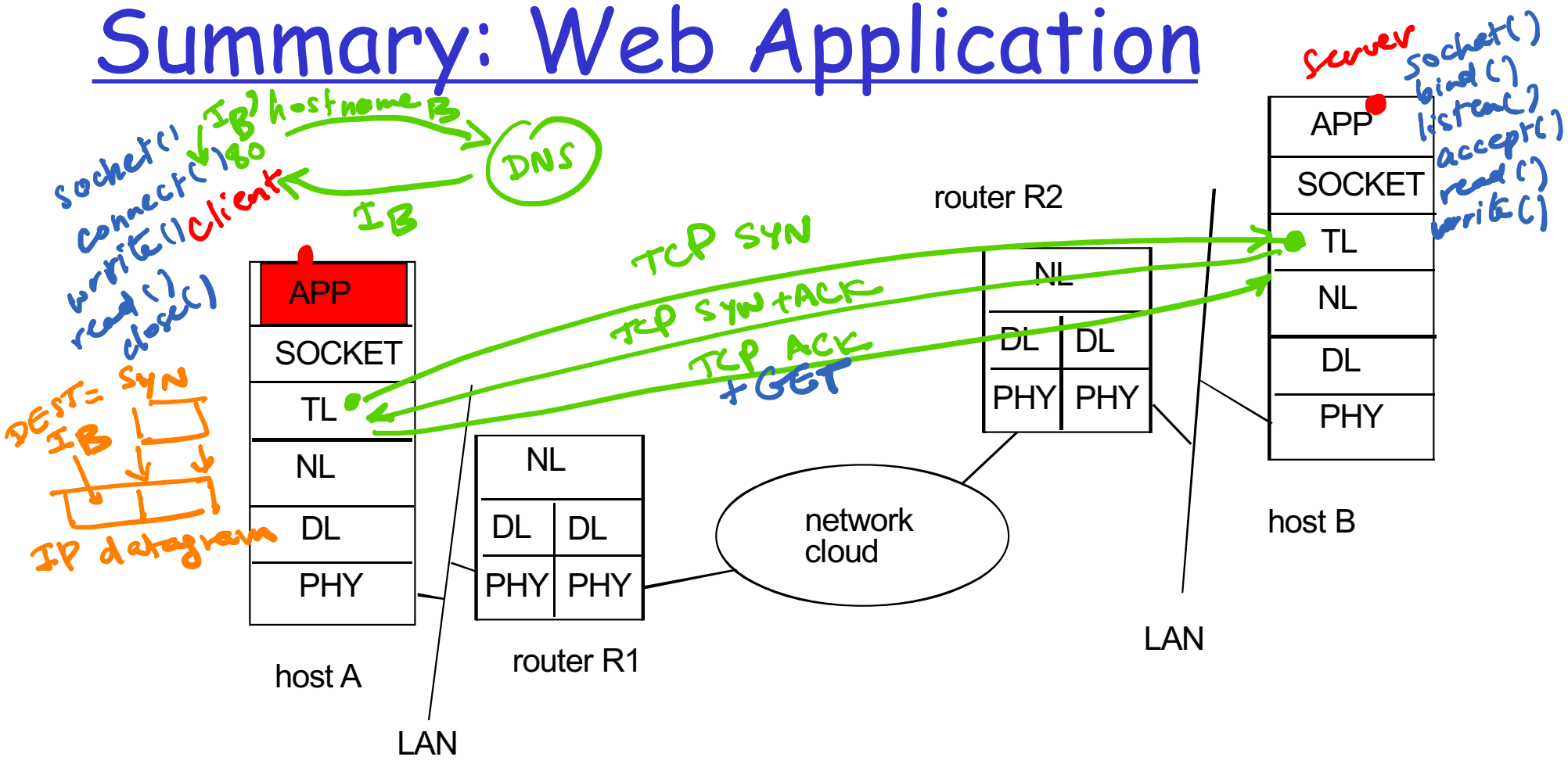
Putting it Together & Closing Remarks

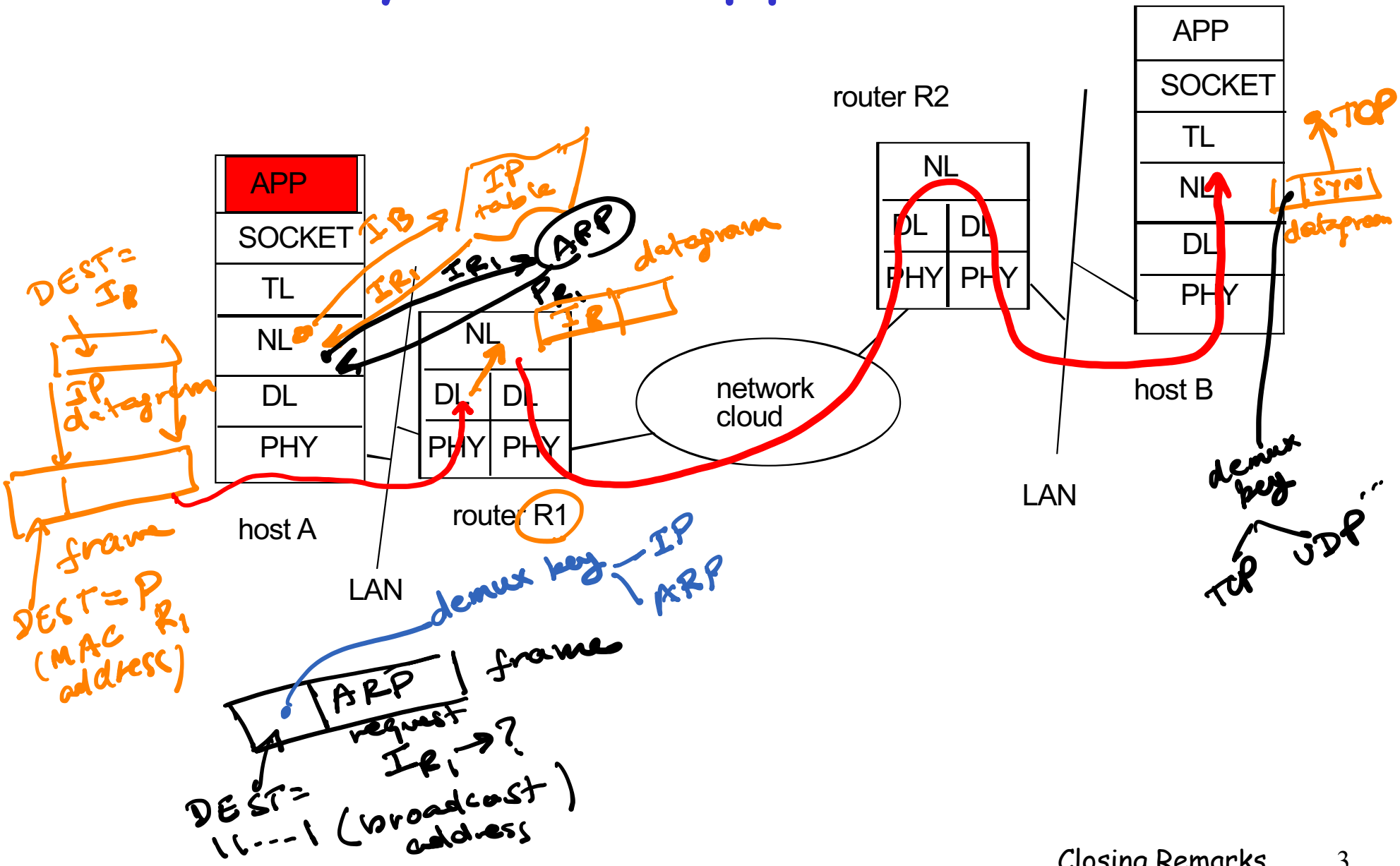


Summary: Web Application

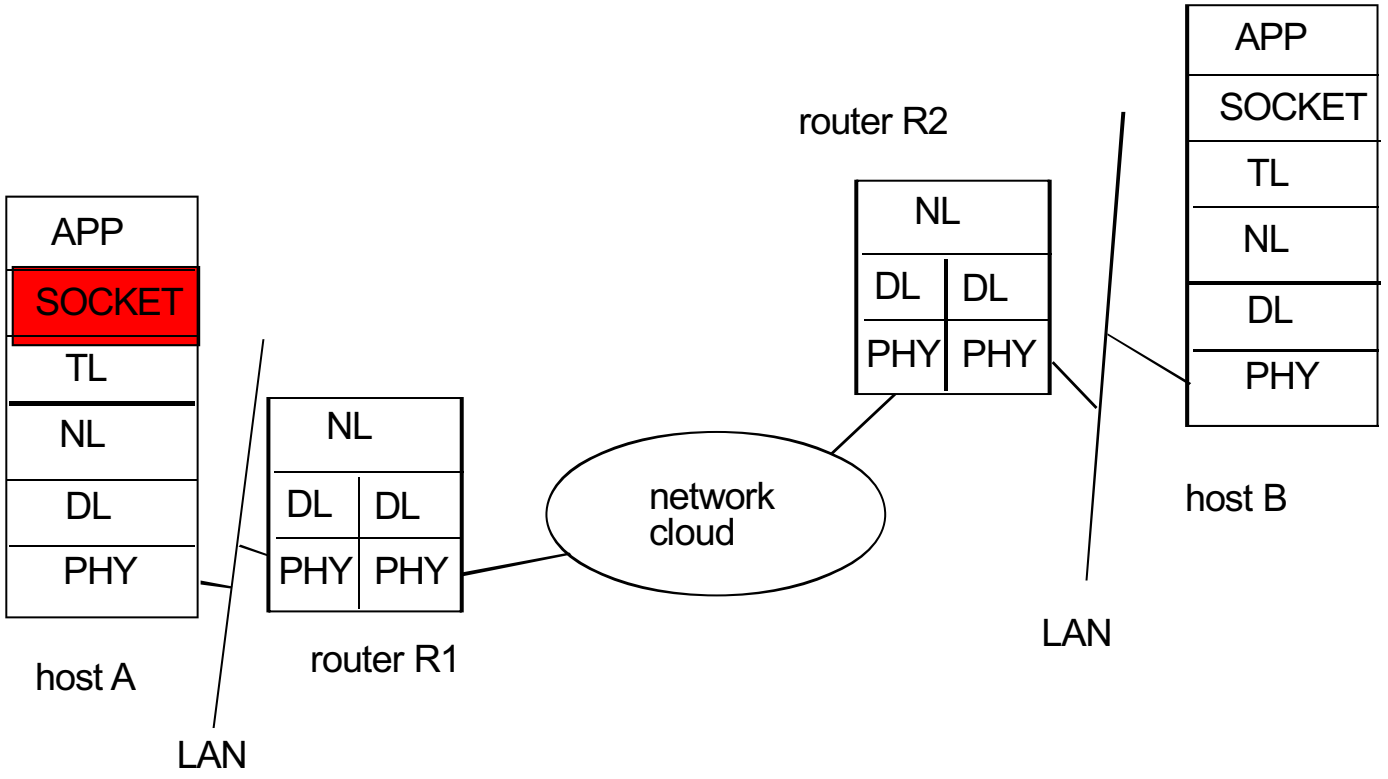


- user enters URL (e.g., www.wireshark.org/download.html) into WWW browser

Summary: Web Application



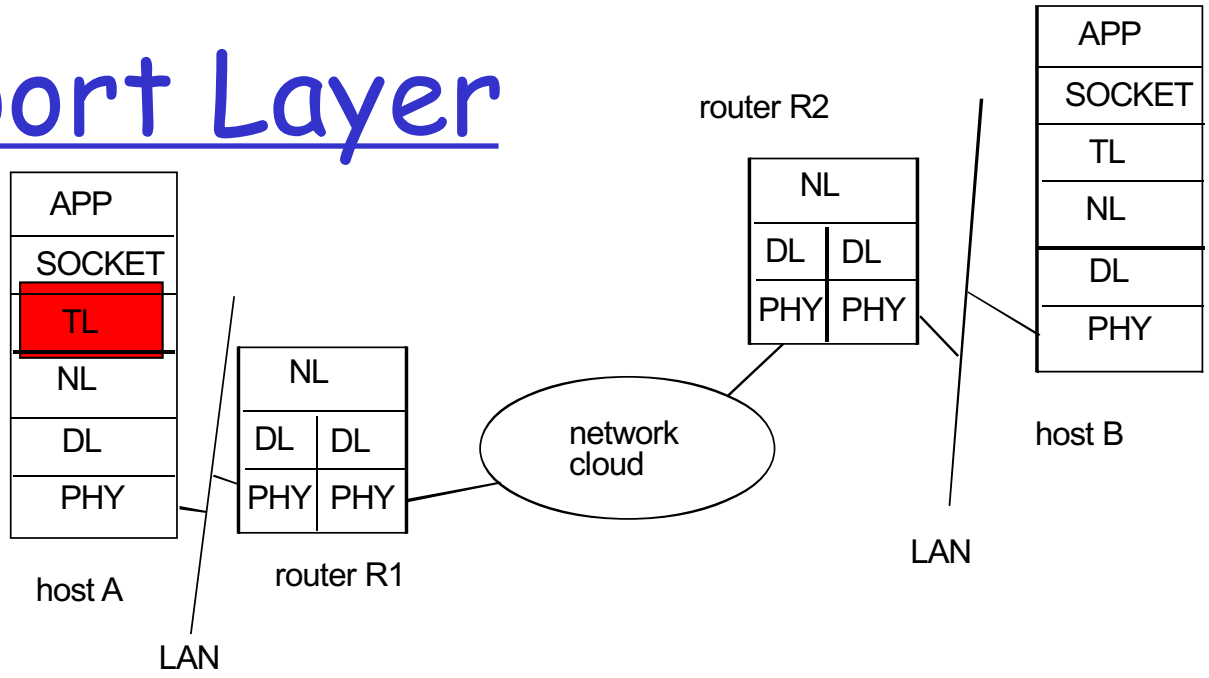
API



- browser (client) determines host name, uses DNS to get server's IP address, gethostbyname()
- client creates stream socket, socket()
- client calls connect(), server port 80

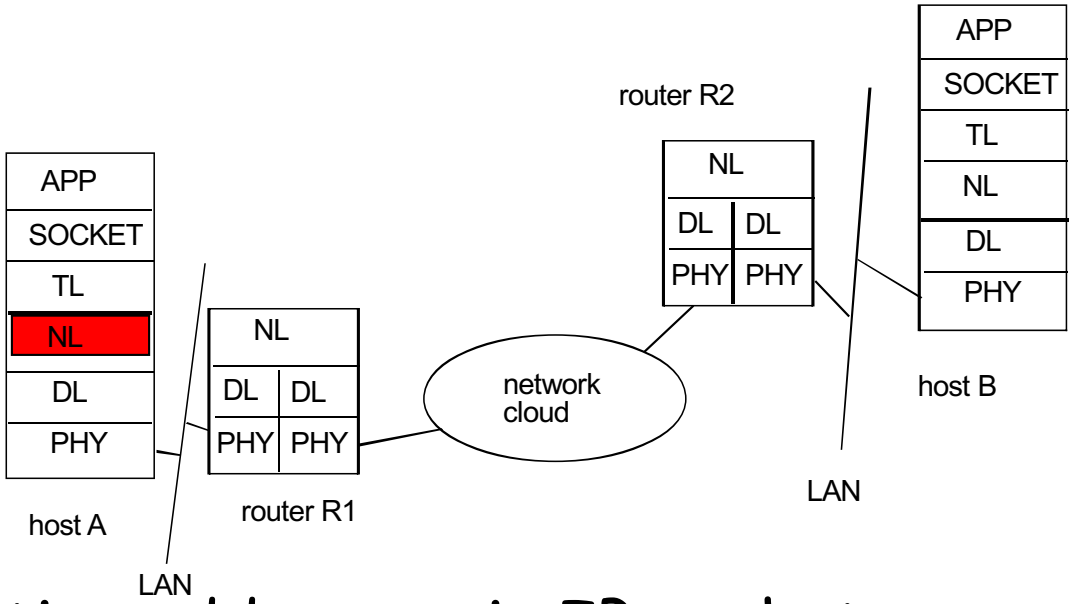
A DNS packet walks into a liquor store – where do I find beer "ABC"?. Clerk: aisle 4, top row on the right.
@fsmontenegro

Transport Layer



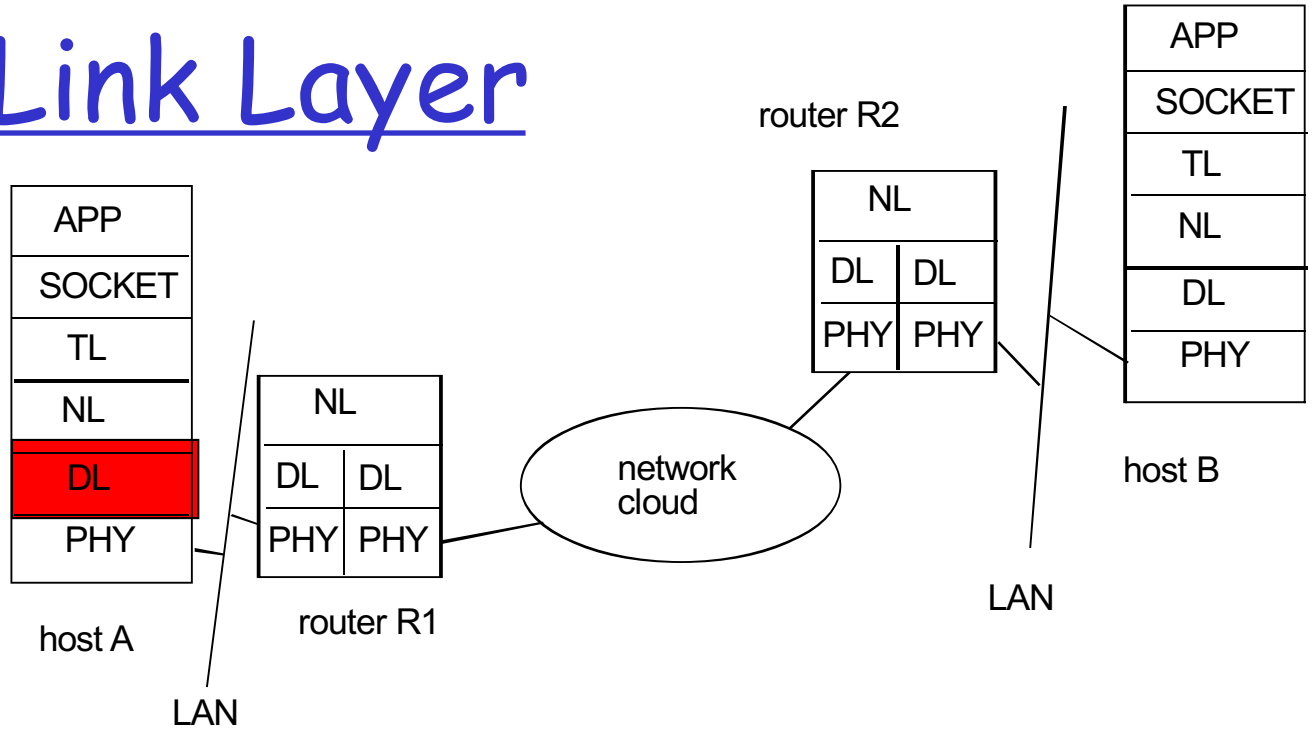
- connect() call causes TCP connection establishment
- choose initial sequence number
- generate SYN segment, server IP address, port 80
- TCP forms segment, computes checksum
- TCP calls IP, passing SYN segment and IP address information

Network Layer



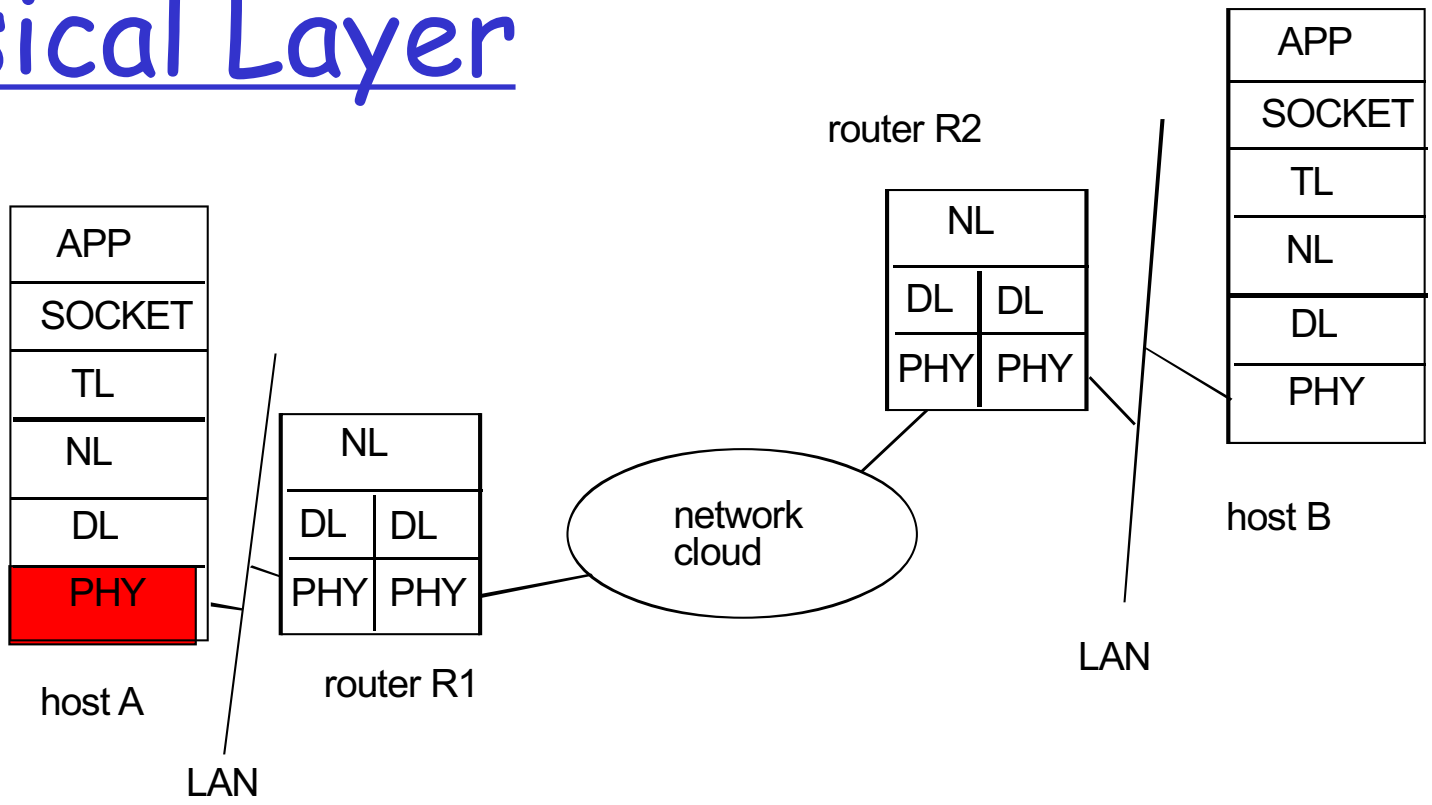
- adds IP source, destination addresses in IP packet
- IP forwarding consults routing table
  - routing table gives IP address of, and local interface to get to next router (i.e., on its LAN), R, on route to destination
- runs ARP to get 802.3 physical address corresponding to R's IP address
- ARP will generate Ethernet broadcast frame on LAN, requesting R to reply with its physical address
- R replies with physical address

Data Link Layer



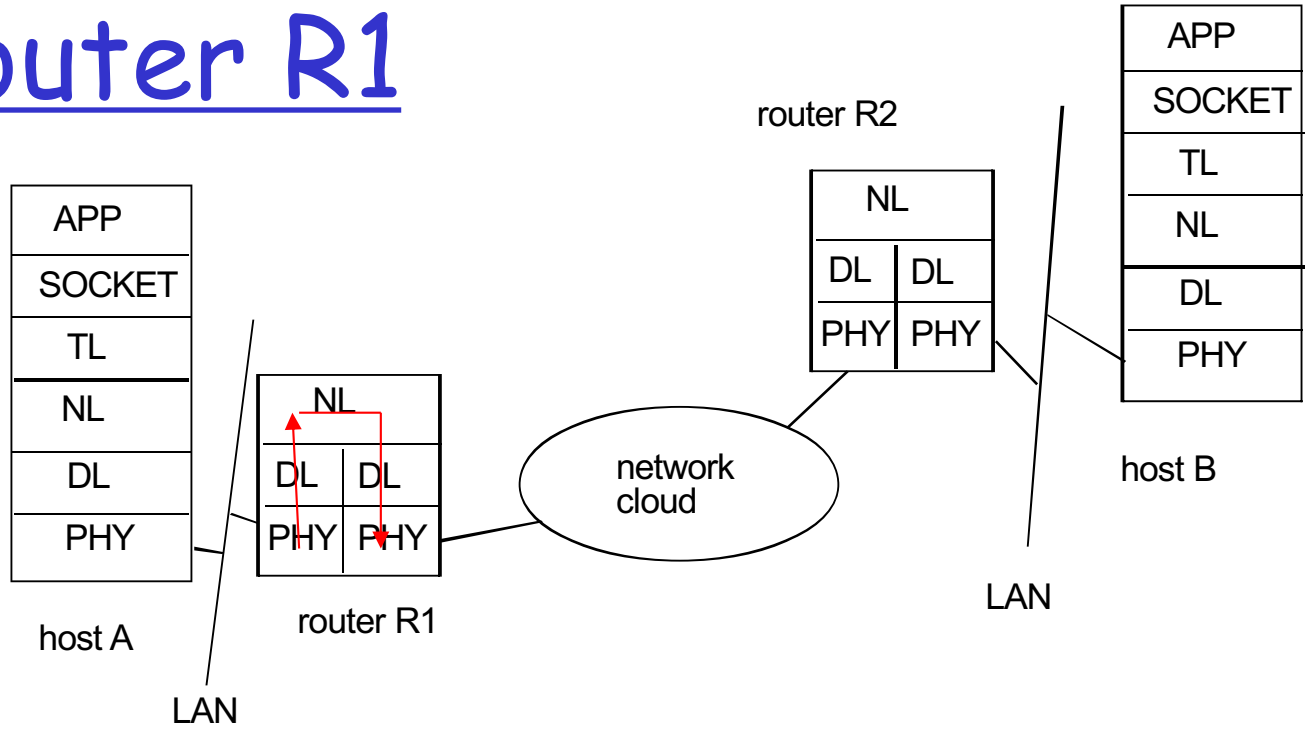
- TCP SYN segment (inside IP packet), as payload in Ethernet frame sent onto LAN using Ethernet protocol
- transparent bridge may be involved (not shown)

Physical Layer



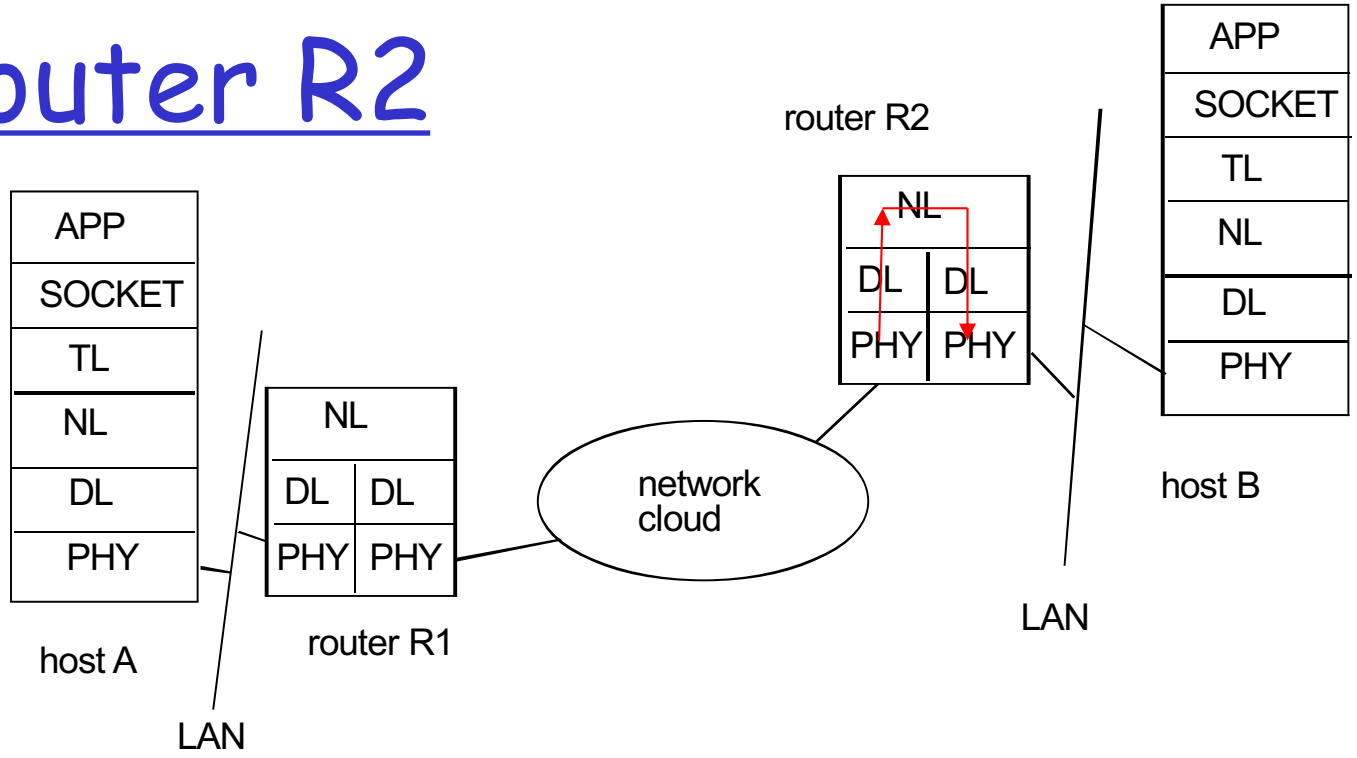
- Ethernet frame transmitted at 100Mbps

At Router R1



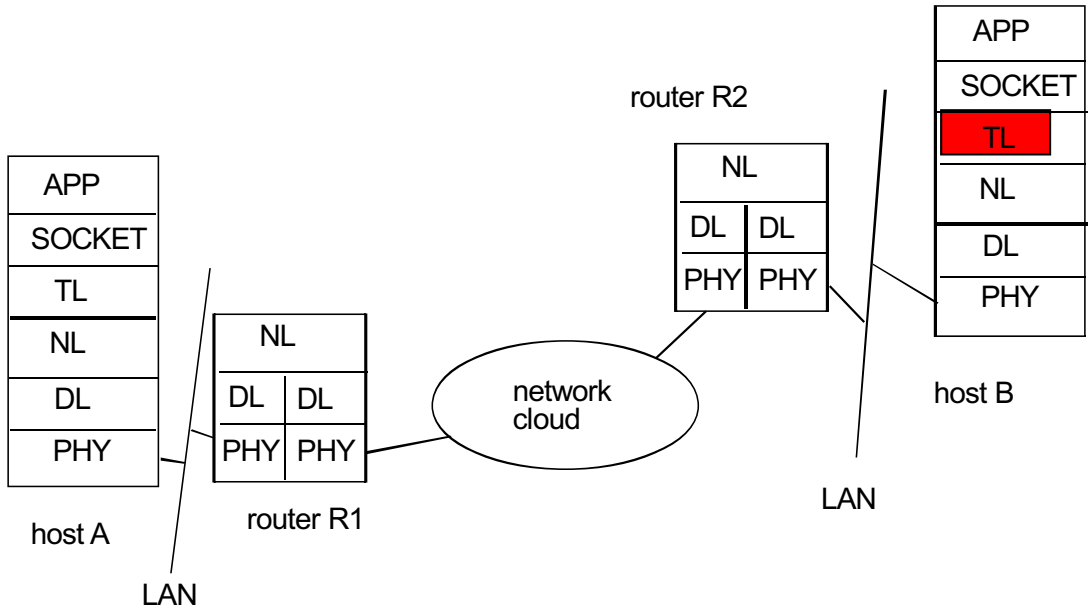
- physical layer receives Ethernet frame bits, passes up
- data link layer recognizes frame, computes OK checksum, removes IP packet, passes up
- network layer consults routing table
  - passes IP packet down to data link layer

At Router R2



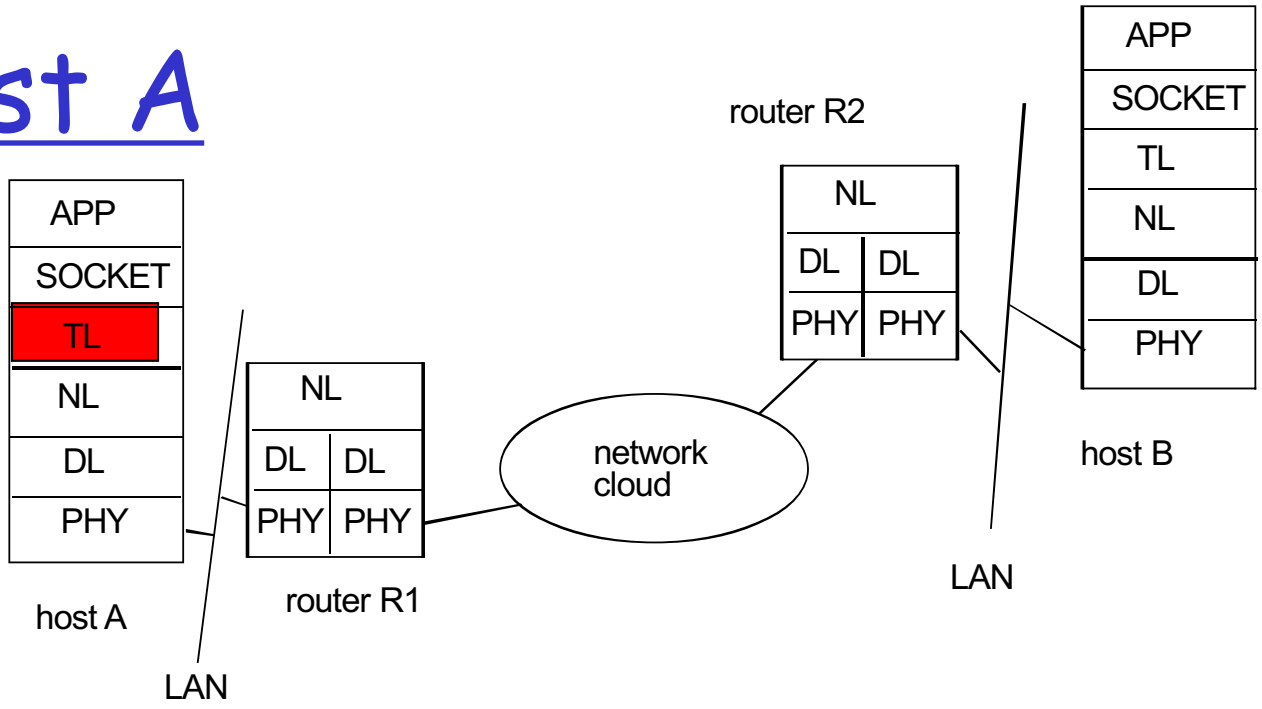
- frame arrives, passed up to network layer
- network layer determines outgoing interface to get to host B
- Ethernet frame sent (R2 knew/learned B's physical address)

At Host B



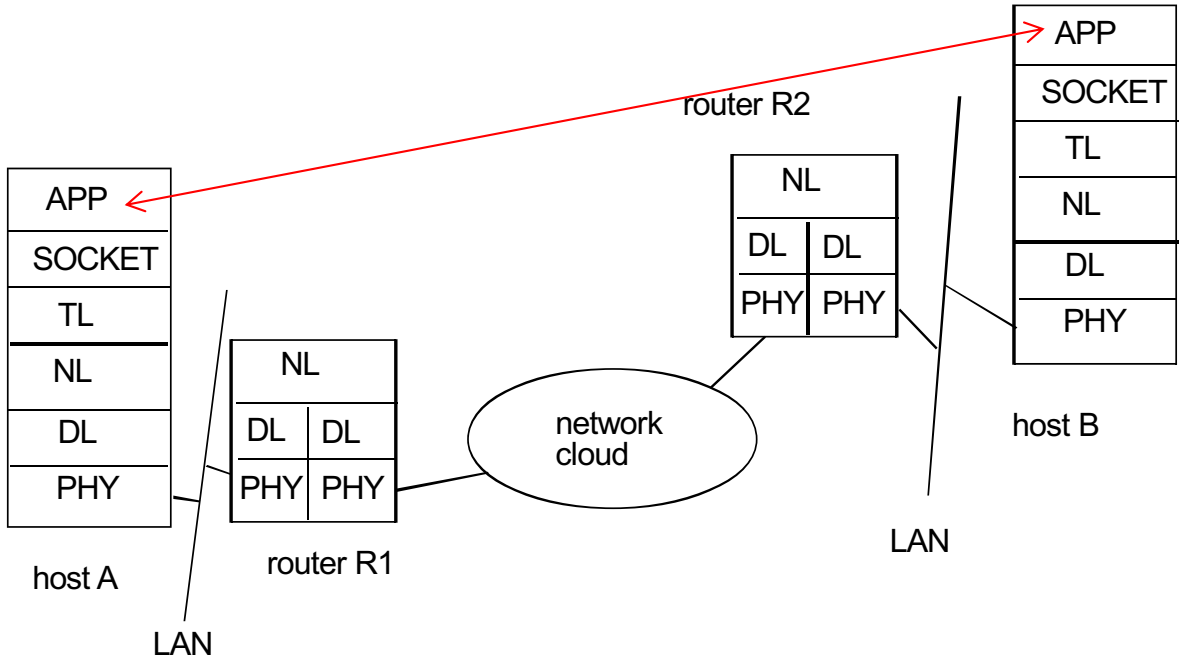
- Ethernet frame arrives, checksum OK, pass up to IP
- IP layer extracts TCP segment, demultiplexes up to TCP (note: not UDP message)
- TCP sees SYN segment
  - server must have previously opened socket and made accept(), else SYN dropped
  - TCP determines flow control window, chooses initial sequence no
  - sends SYN+ACK back

At Host A



- SYN+ACK eventually received
- send transport-level ACK to B
- move to established state
- return from connect() system call

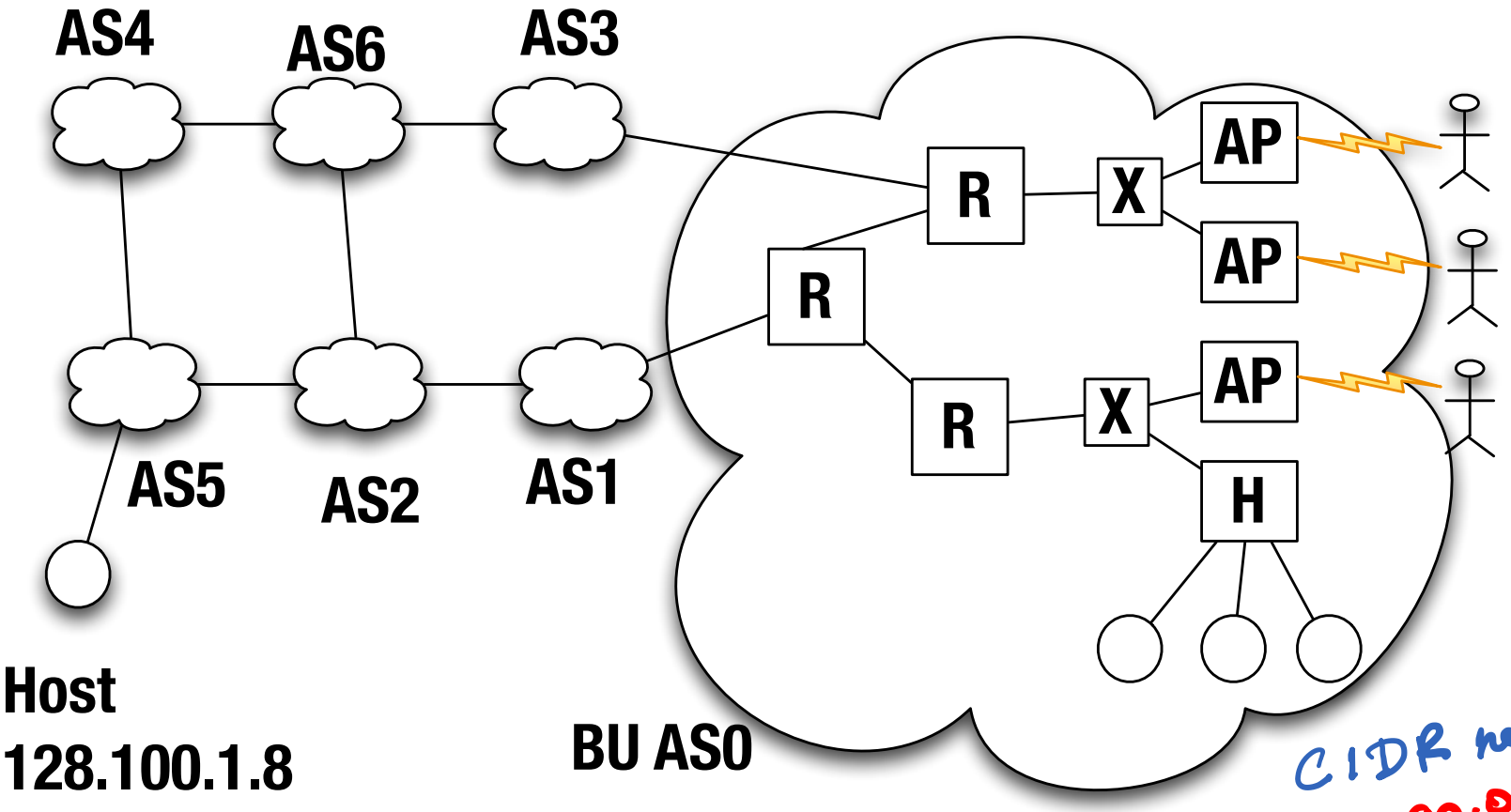
Finally!



- Host A can now request .html file, write()
- Host B reads request, read()
- Host B sends requested file, write()
- Host A reads requested file, read()
- Data is transferred using TCP
  - Error, flow and congestion control
  - R1, R2 and A,B (network layer and below) act exactly the same with data as with SYN/ACK segments

A TCP packet walks in to a bar and says "I want a beer", barman says "you want a beer?" and TCP packet says "yes, a beer" @stevie_chambers

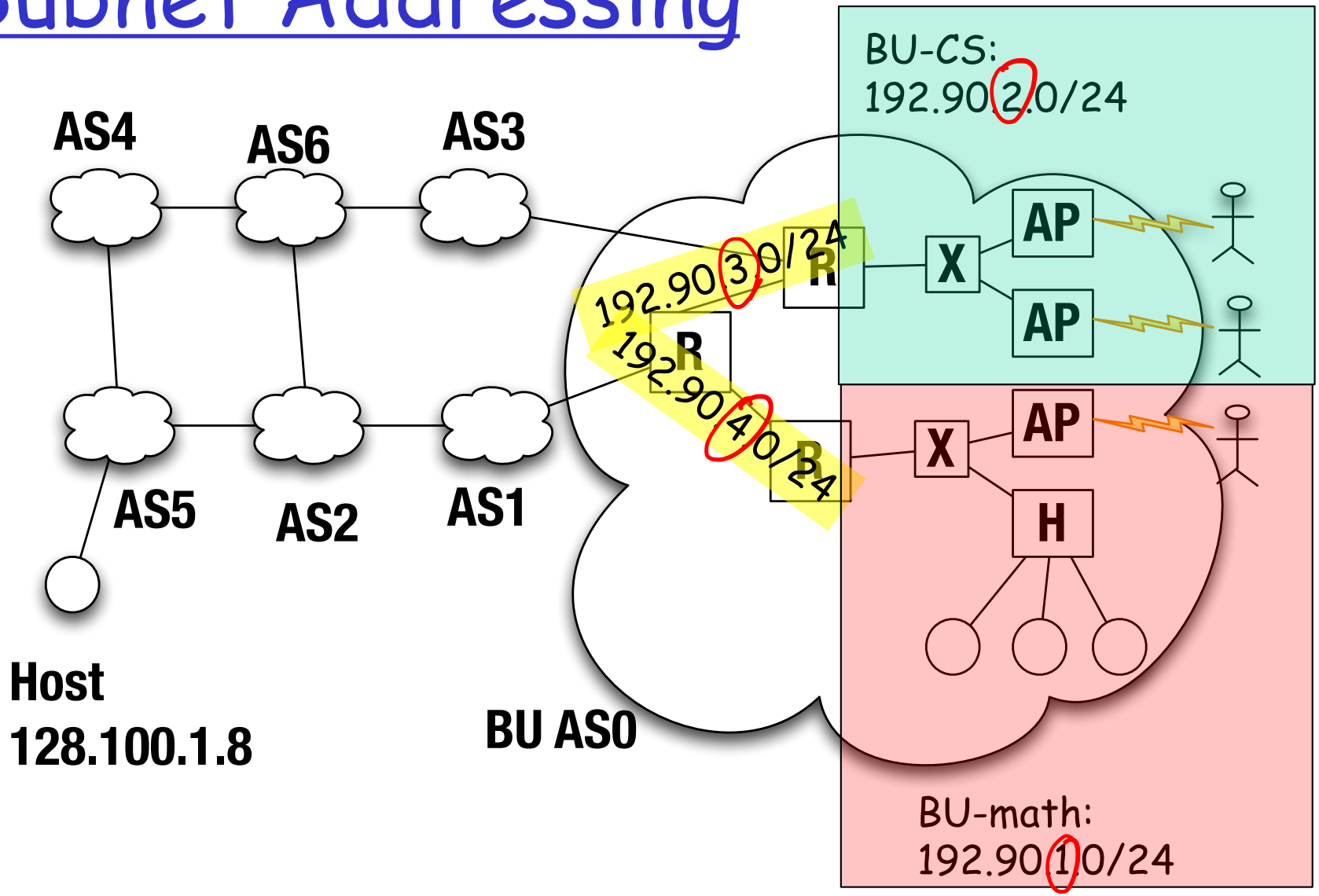
Summary: Addressing & Routing



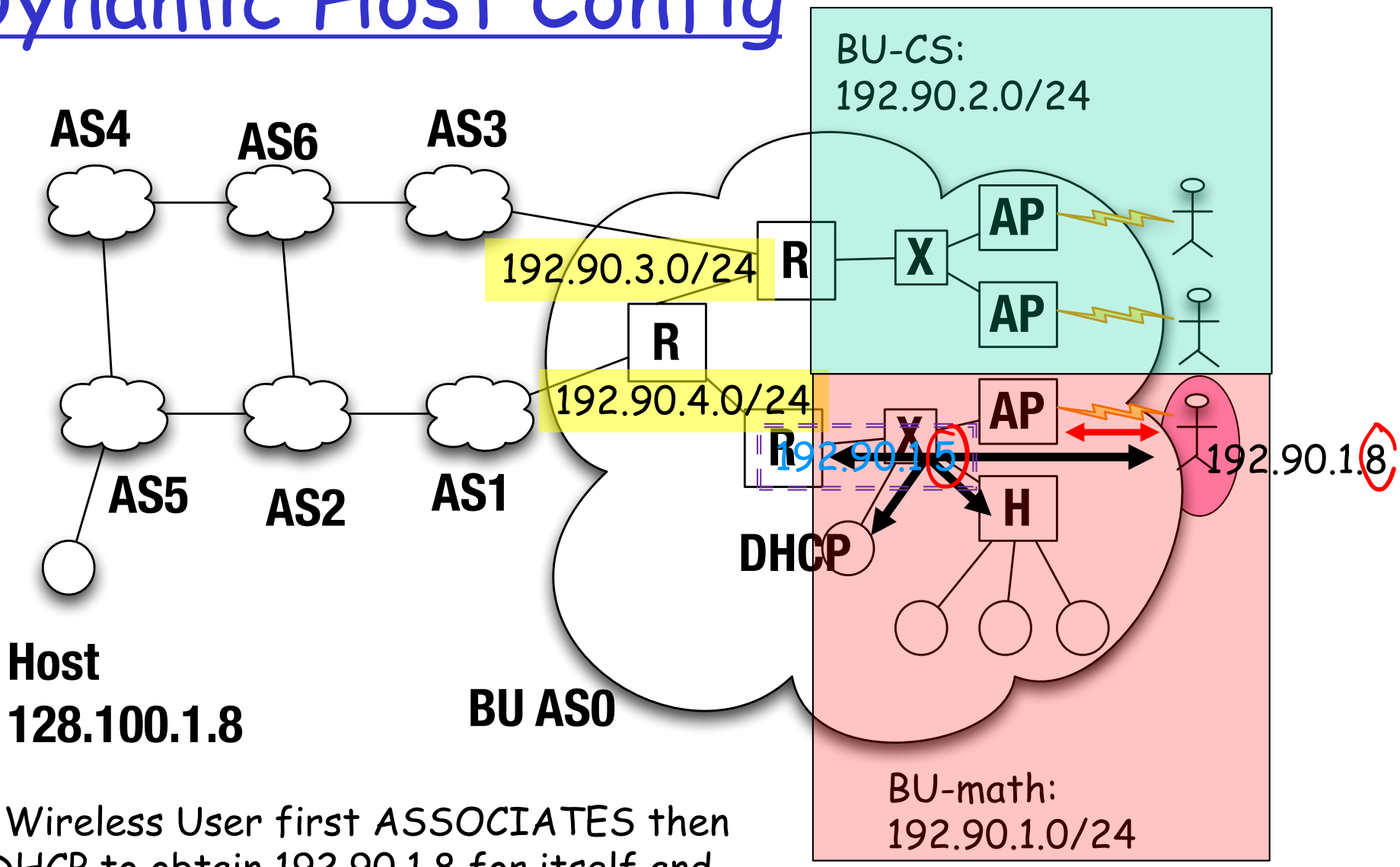
BU's address range:
192.90.0.0 – 192.90.255.255
(256 subnets)

CIDR notation
192.90.0.0/16

Subnet Addressing



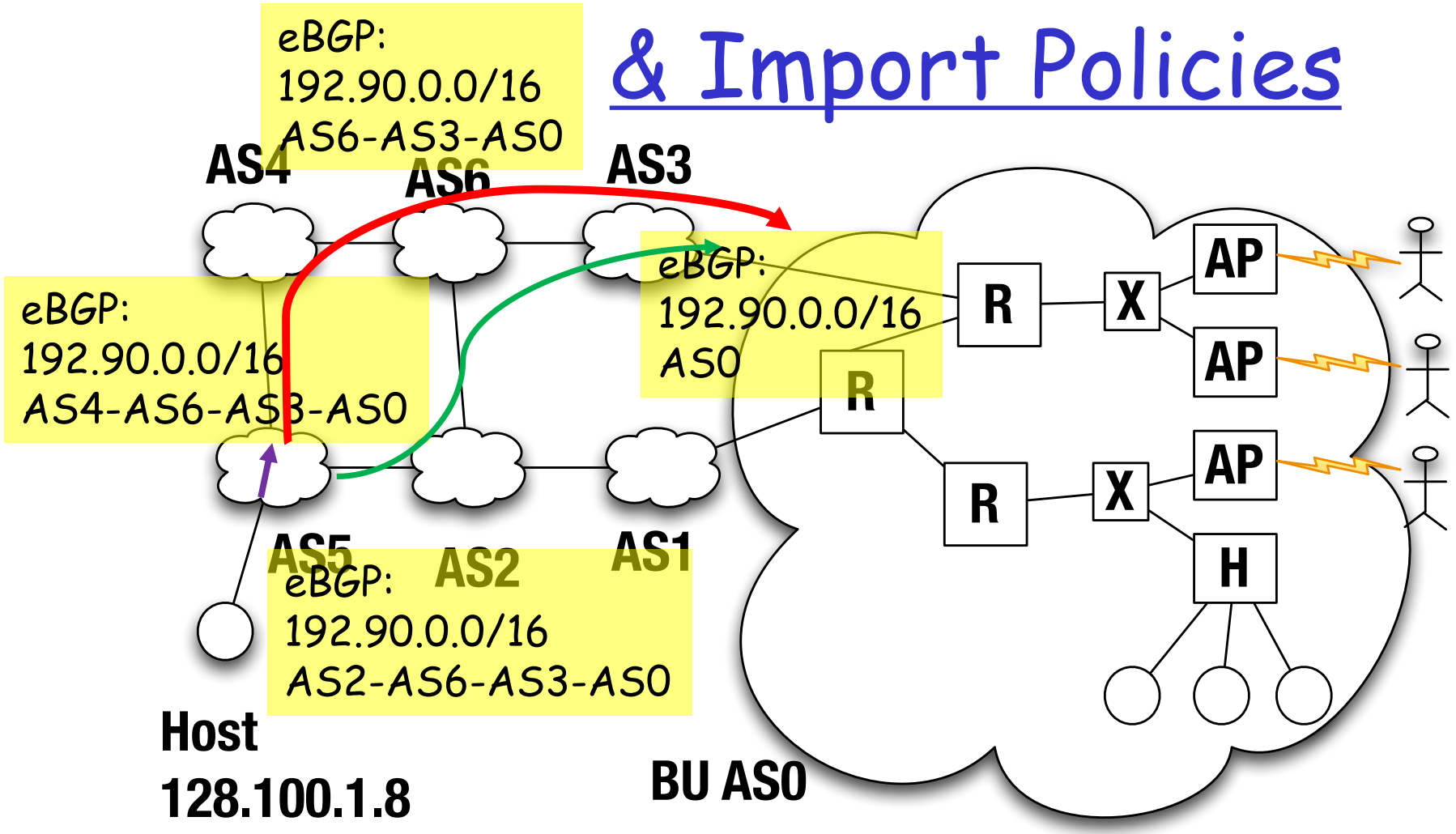
Dynamic Host Config



Math Wireless User first ASSOCIATES then runs DHCP to obtain 192.90.1.8 for itself and learns of 192.90.1.5 (gateway router)

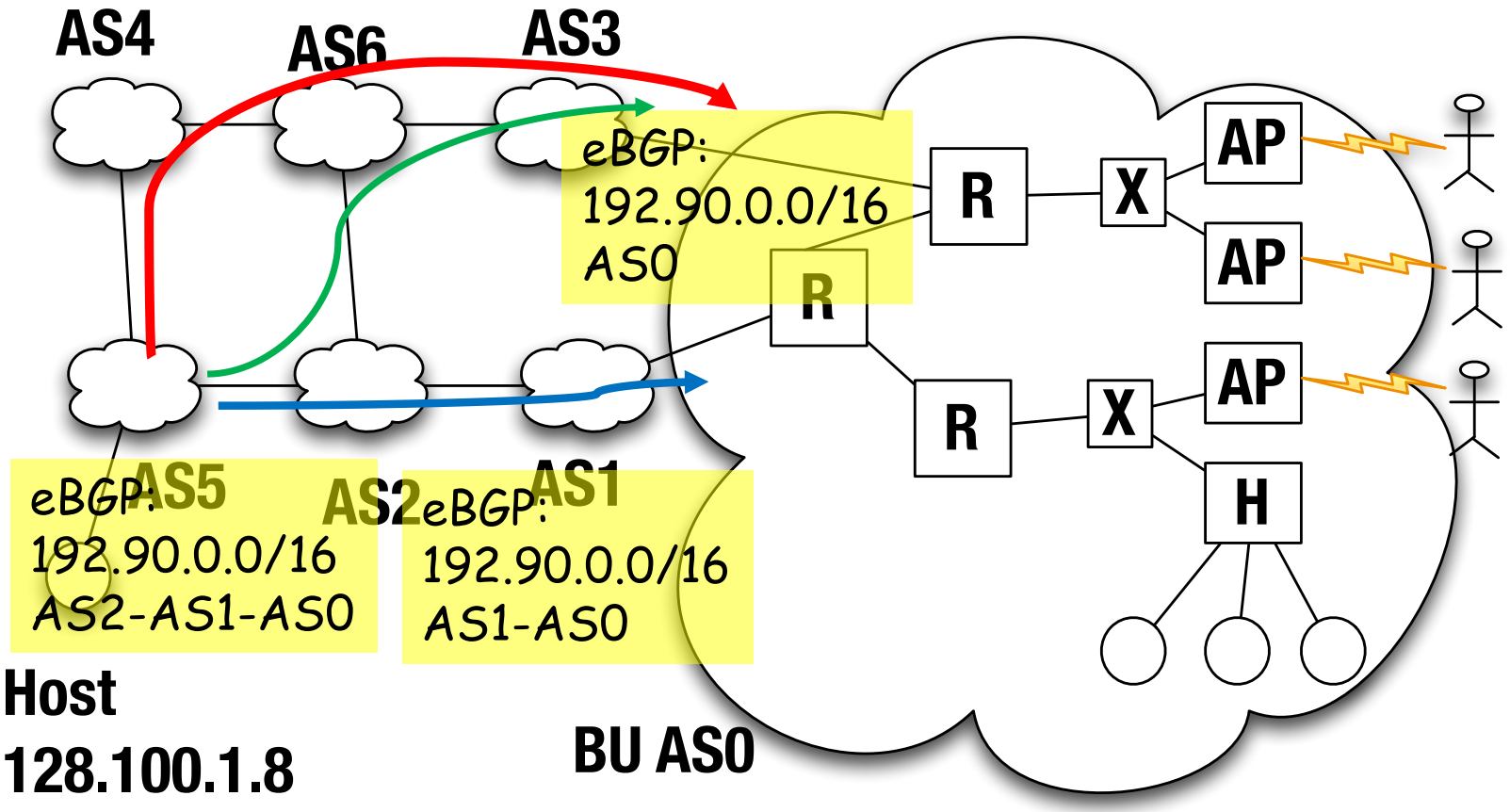
A DHCP packet walks into a bar and asks for a beer. Bartender says , "here, but I'll need that back in an hour!"
@brandoncarroll

Inter-domain Routing & Import Policies



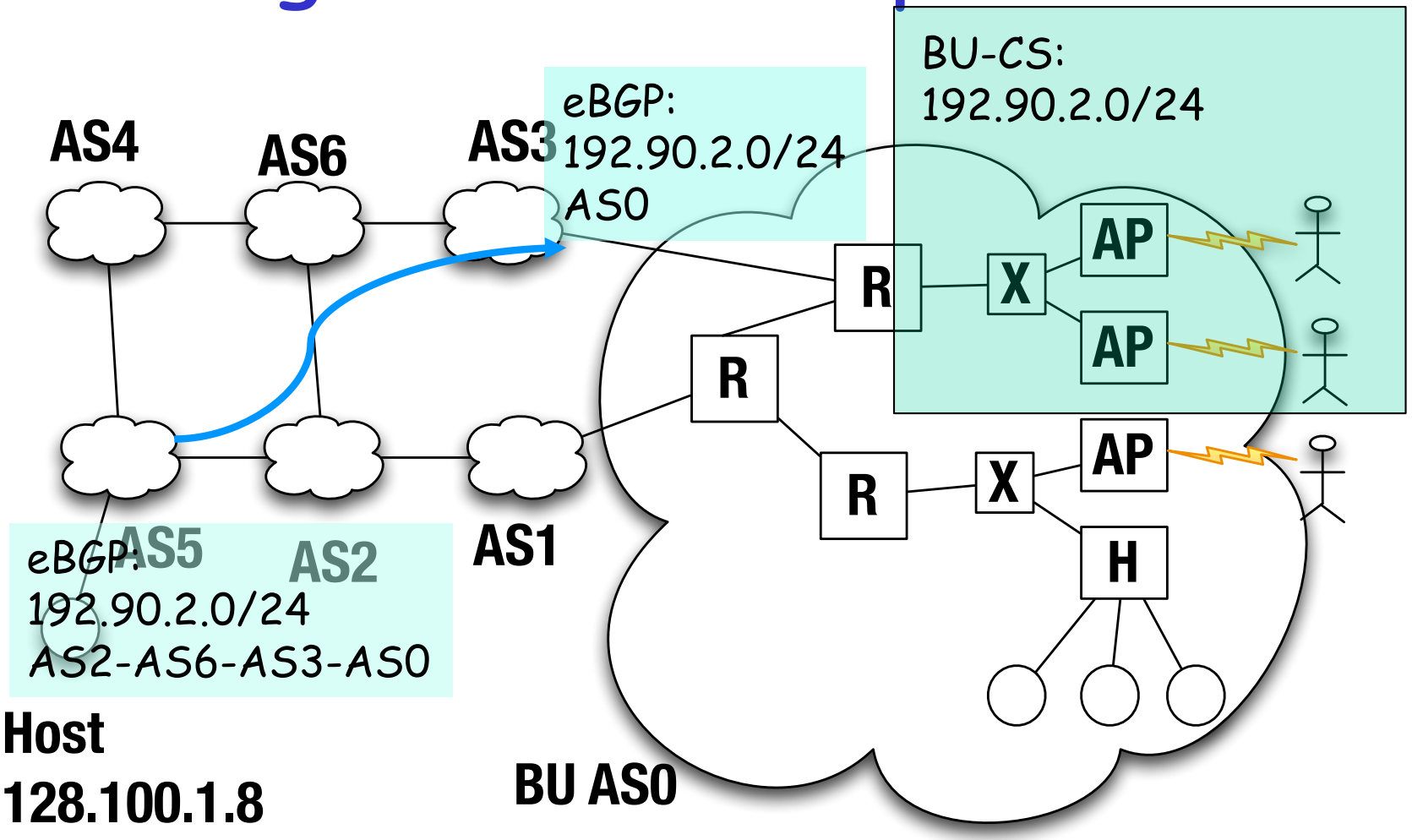
- AS5 learns of AS4-AS6-AS3-AS0 (LOC_PREF=X), AS2-AS6-AS3-AS0 (LOC_PREF=Y).
  - Pick AS path with higher LOC_PREF. E.g., AS2-AS6-AS3-AS0 if Y > X.
  - Otherwise (X=Y), router inside AS5 picks closest border router (hot potato routing)

AS Path Selection



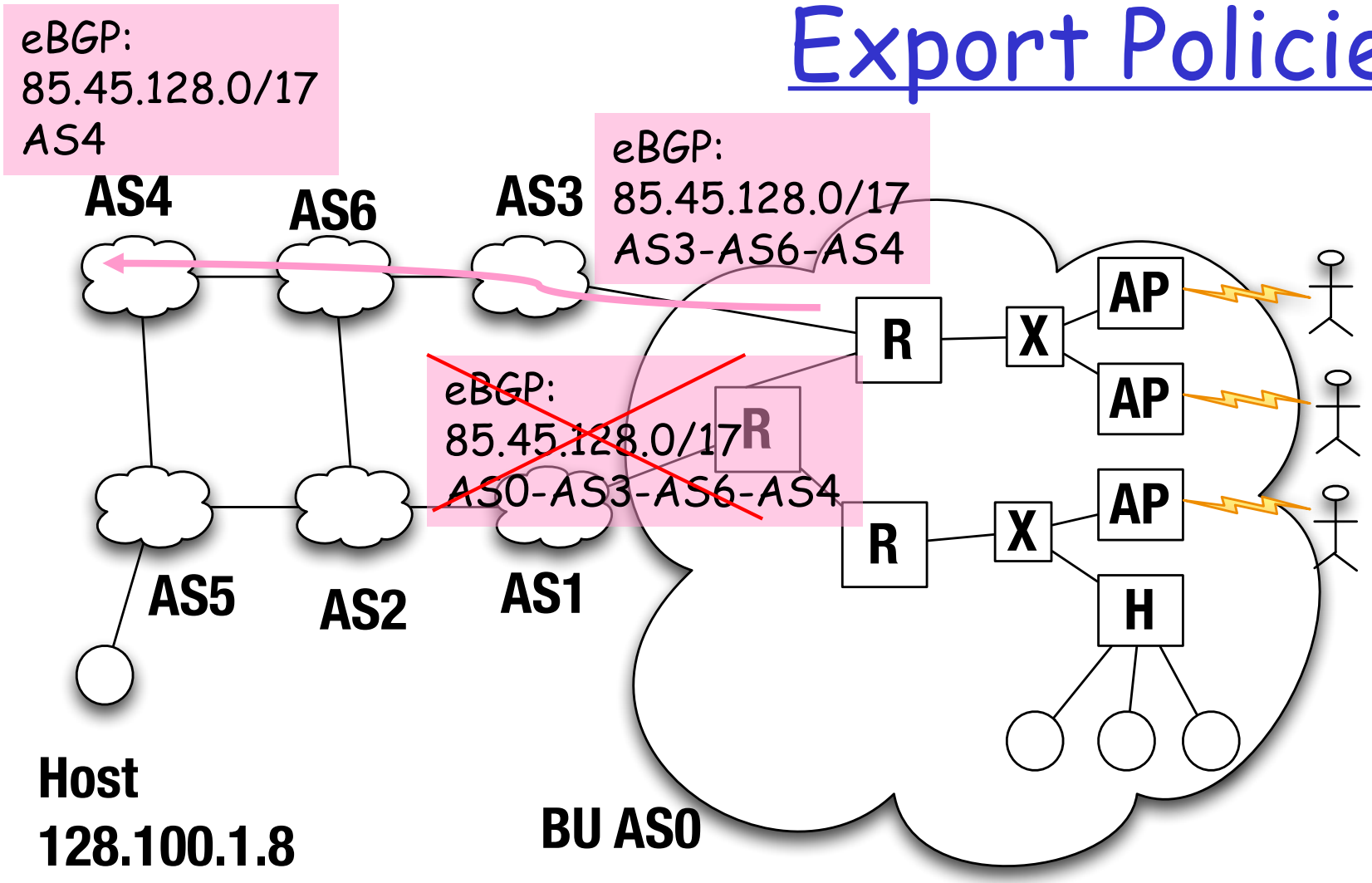
- AS5 learns of 192.90.0.0/16, AS2-AS1-AS0.
- Under equal LOC_PREF, AS5 picks it since it is the shortest AS path

IP Routing Table Lookup



- AS5 learns of 192.90.2.0/24, AS2-AS6-AS3-AS0.
- AS5 uses this path to route to BU-CS (longest prefix matching)

Export Policies



- AS0 does NOT advertise 85.45.128.0/17 to AS1 since BU is a multi-homed stub AS and not a "transit" AS. This is set by BU's "export policies"

An IPv6 packet walks into a bar. Nobody talks to him. @fsmontenegro

So what's more / next?

- Further study: multimedia, mobility, high-speed, traffic engineering, virtual networks, … (CS 556)
- Security (CS 558, CS 511 & 512, …)
  - CS 511 & 512 teaches formal methods to verify protocol correctness
- Data center networks (CS 528, …)
- Application management (CS 451/651, …)
- Internet of Things (CS 552, CS 654 , …)
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- Certification programs!
  - Network Programmability (e.g. Cisco), Network Virtualization (e.g. VMware), Risk & Information Systems Control, Cloud Networking (e.g. Amazon), Wireless Networking, Storage Networking, …