SC250
Computer Networking I

Wireless Networks and Conclusion

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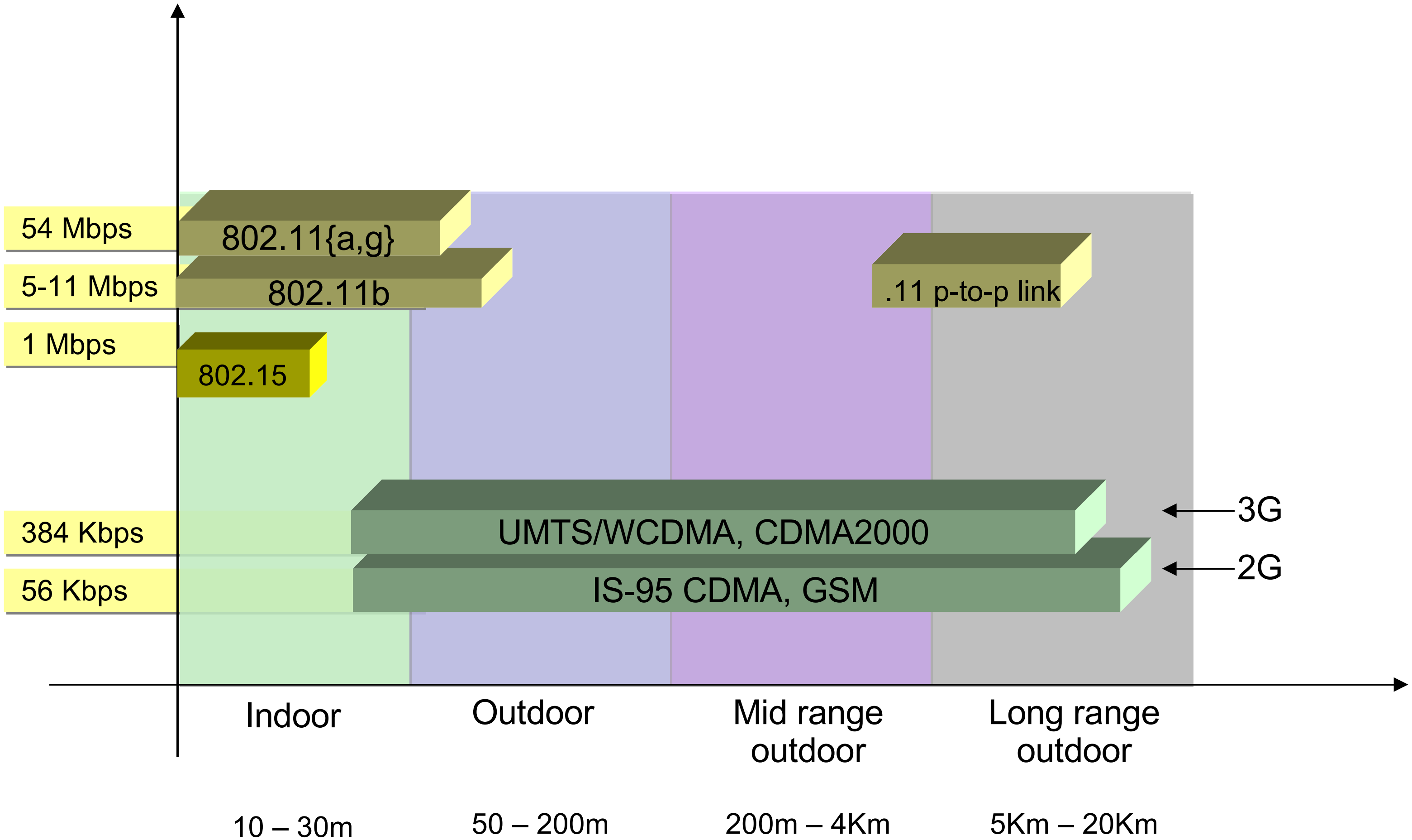
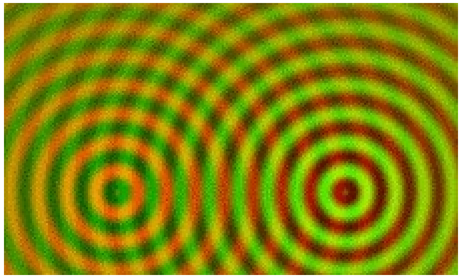
Characteristics of Selected Wireless Standards



Wireless Link Characteristics

- Differences from wired link:
  - <u>Decreased signal strength</u>: radio signal attenuates as it propagates through matter (path loss)
  - <u>Interference from other sources</u>: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., cordless phone, microwave oven)
  - <u>Multipath propagation</u>: radio signal reflects off objects and ground, arriving ad destination at slightly different times -> interference

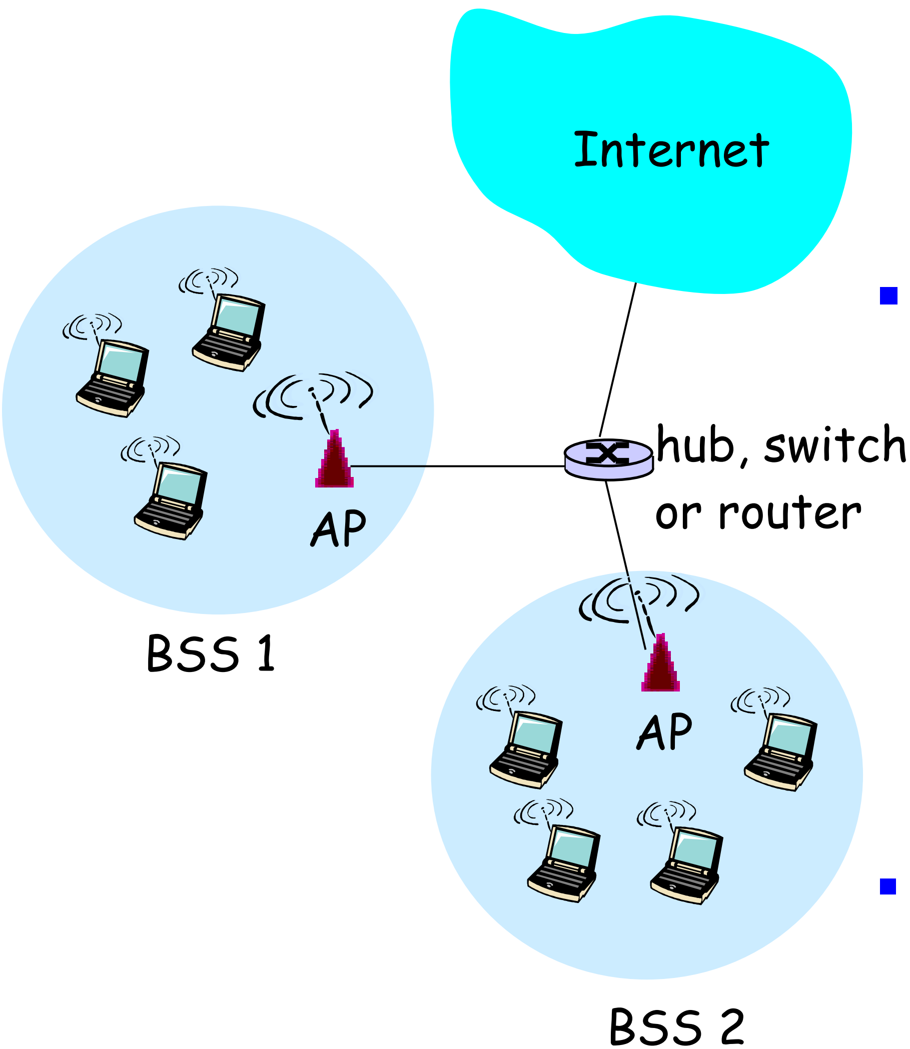


- Communication across wireless link much more "difficult"
  - bit errors and loss are unavoidable
  - mobility makes things worse: fluctuations

IEEE 802.11 Wireless LAN

- 802.11b
  - most common today
  - 2.4-5 GHz unlicensed radio spectrum
  - up to 11 Mbps
  - widely deployed, using base stations
- 802.11a
  - 5-6 GHz range
  - up to 54 Mbps
- 802.11g
  - 2.4-5 GHz range
  - up to 54 Mbps
- All use CSMA/CA for multiple access
- All have two modes:
  - base-station
  - ad hoc

802.11 LAN Architecture



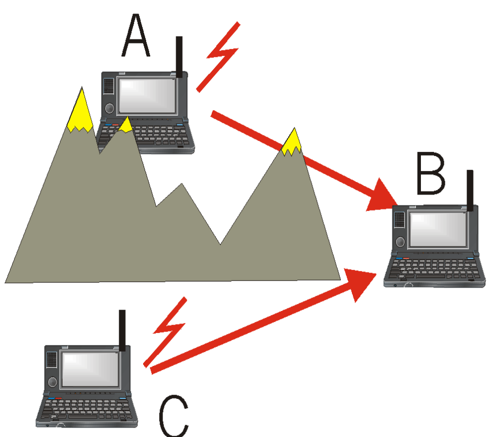
- Wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only
- BSSs combined to form distribution system (DS)
  - DS = "one wireless LAN"

802.11: Channels, Association

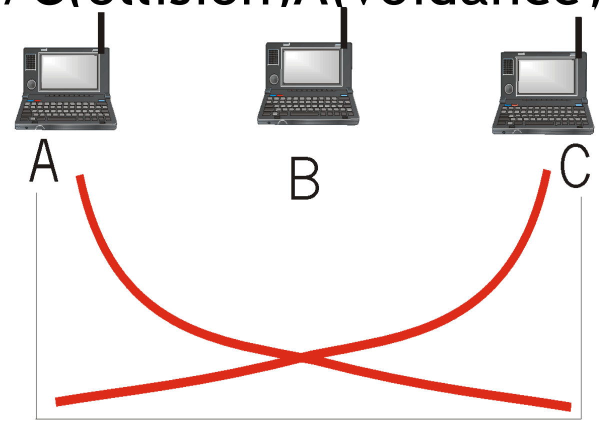
- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
  - 3 independent channels (1,6,11)
  - AP admin chooses frequency for AP
  - Interference possible: channel can be same as that chosen by neighboring AP!
- Host: must *associate* with an AP
  - Scans channels, listening for *beacon frames* containing AP's name (SSID) and MAC address
  - Selects AP to associate with
  - May perform authentication
  - Will typically run DHCP to get IP address in AP's subnet

IEEE 802.11: Multiple Access

- Avoid collisions: 2+ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
  - Don’t collide with ongoing transmission by other node
- 802.11: no collision detection possible!
  - Difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - Can’t sense all collisions in any case: hidden terminal, fading
  - Goal: avoid collisions: CSMA/C(ollision)A(voidance)



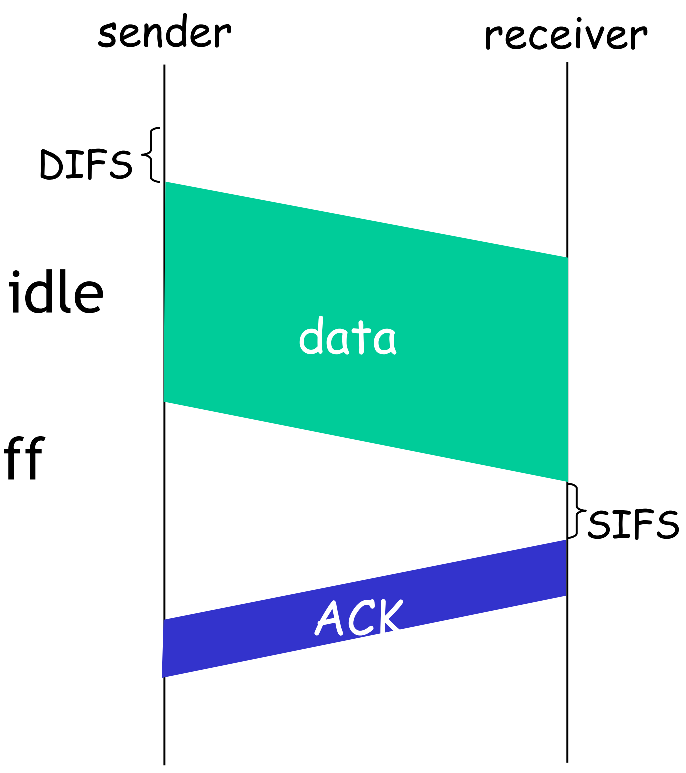
(a)



(b)

IEEE 802.11 MAC Protocol: CSMA/CA

- 802.11 sender
  - If sense channel idle for DIFS then
    - transmit entire frame (no CD)
  - If sense channel busy then
    - start random backoff time
    - timer counts down while channel idle
    - transmit when timer expires
    - if no ACK, increase random backoff interval, repeat 2
- 802.11 receiver
  - if frame received OK:
    return ACK after SIFS
  - (ACK needed due to hidden terminal problem)

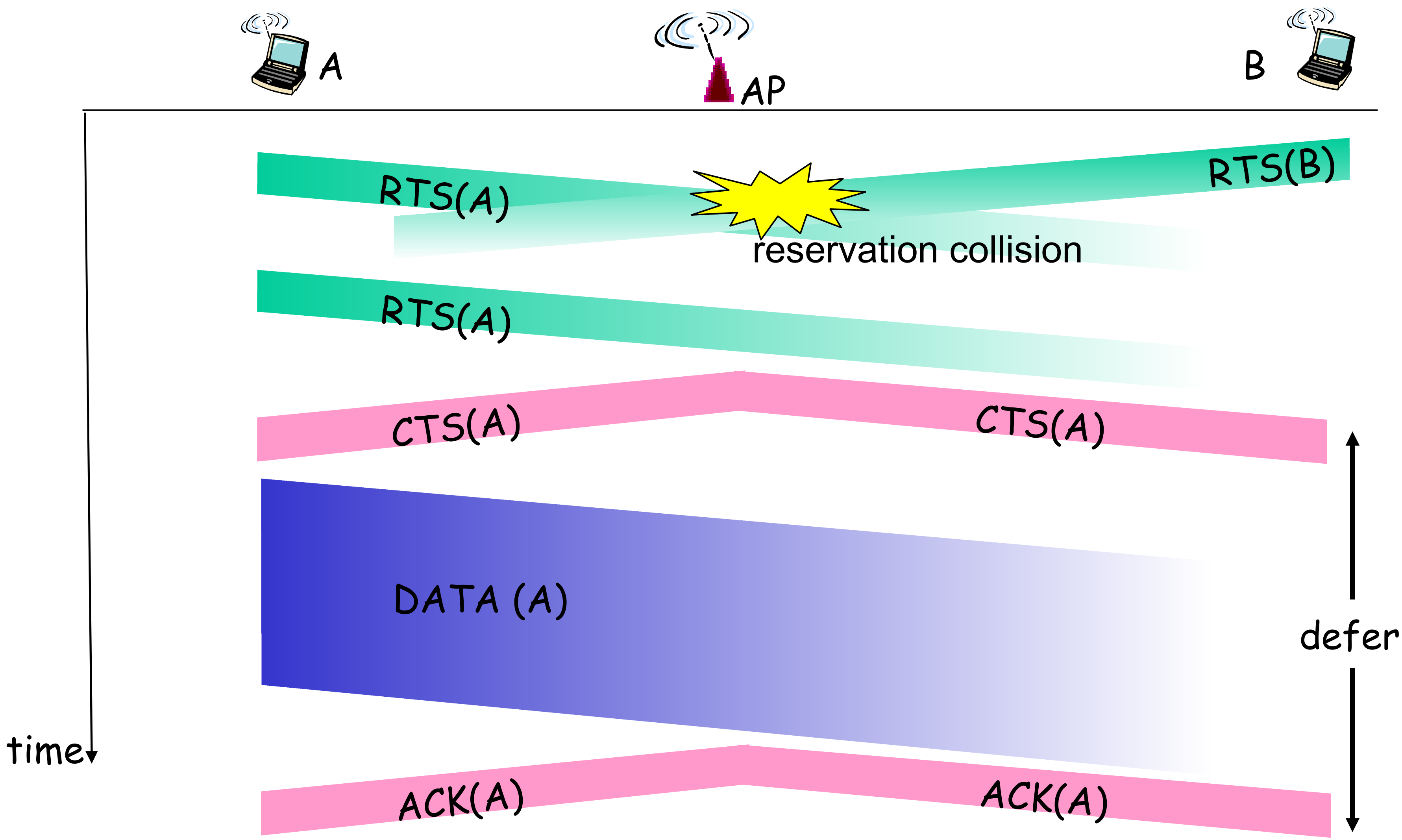


Avoiding Collisions (more)

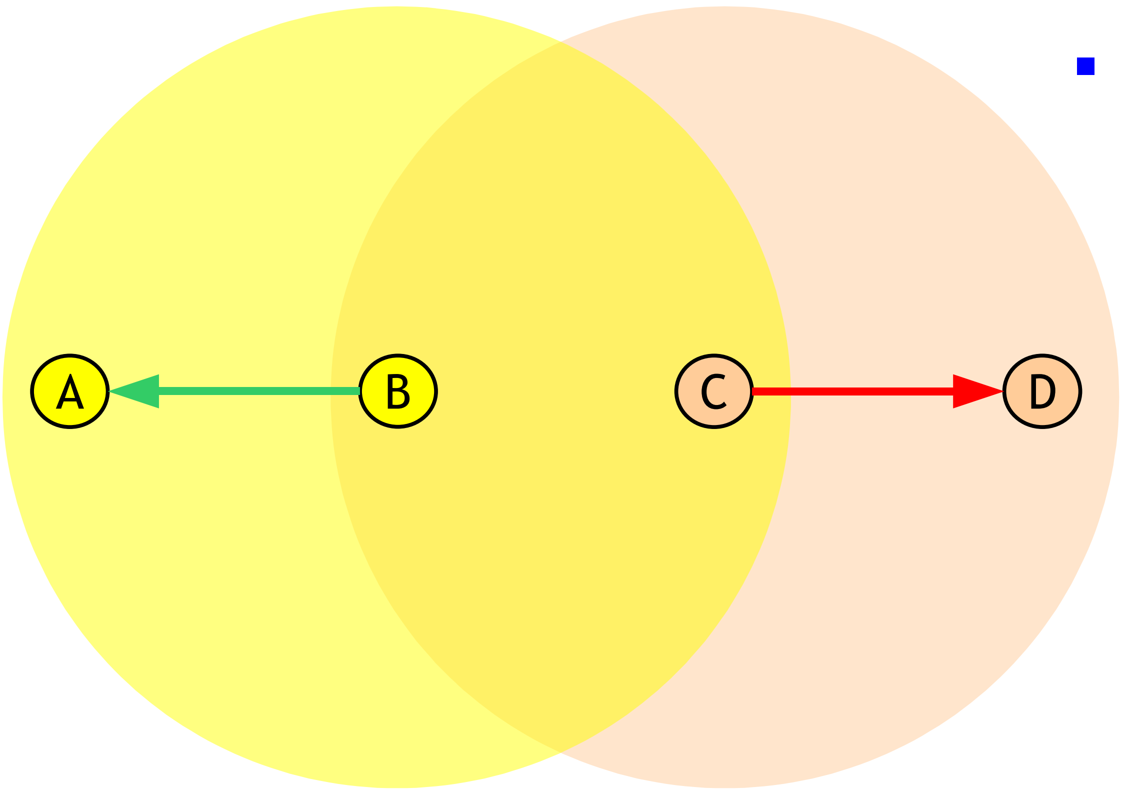
- Refinement:
  - Allow sender to “reserve” channel rather than random access of data frames: avoid collisions of long data frames
- Sender first transmits small request-to-send (RTS) packets to BS using CSMA
  - RTSs may still collide with each other (but they’re short)
- BS broadcasts clear-to-send CTS in response to RTS
- RTS heard by all potential interferers
  - Sender transmits data frame
  - Other stations defer transmissions

Avoid data frame collisions completely
using small reservation packets!

Collision Avoidance: RTS-CTS Exchange



Another Problem: Exposed Terminal



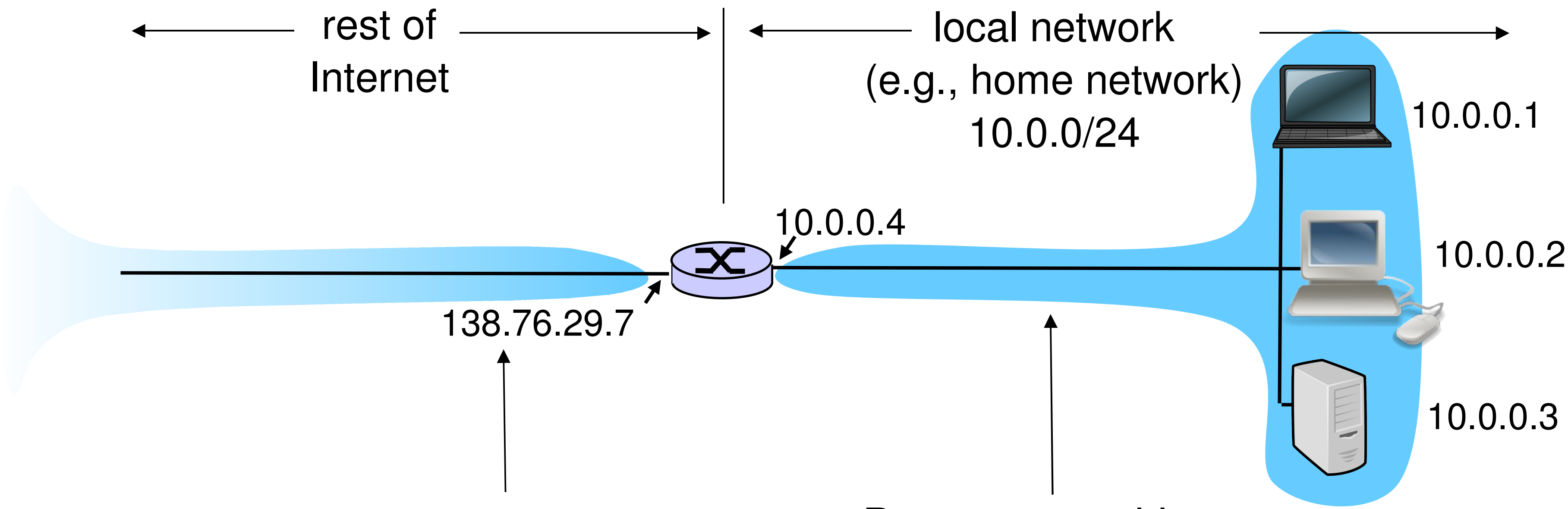
- Solution:
  - RTS/CTS again
  - C had heard RTS(B) before, but not CTS(B) sent by A
  - This means: A cannot hear C, therefore C can send without interfering with B->A

- C wants to send to D
  - ok, B's signal to weak at D to interfere
  - but C does not send because of carrier sensing

Conclusion

- TCP/IP architecture:
  - Concept of layers:
    - each protocol belongs to one layer **only**
    - each layer can only rely on services of layer below
  - Such an architecture doesn't just happen – its benefits have to be formulated, players (equipment and software vendors, developers, etc.) have to commit
  - TCP/IP has no certification authority for compliance
  - The architecture can evolve or fall apart if it does not satisfy needs
- Case study: layer violation in NATs
  - NAT: “hides” several IP addresses behind a single IP address
  - Breaks the TCP/IP layers
  - Why? Mainly shortage of IP addresses

NAT: Network Address Translation



All datagrams *leaving* local network have same single source NAT IP address: 138.76.29.7, different source port numbers

Datagrams with source or destination in this network have 10.0.0/24 address for source, destination (as usual)

NAT: Network Address Translation

- Motivation: local network uses just one IP address as far as outside world is concerned:
  - no need to be allocated range of addresses from ISP:
    - just one IP address is used for all devices
  - can change addresses of devices in local network without notifying outside world
  - can change ISP without changing addresses of devices in local network
  - devices inside local net not explicitly addressable, visible by outside world (a security plus).

NAT: Network Address Translation

Implementation: NAT router must:

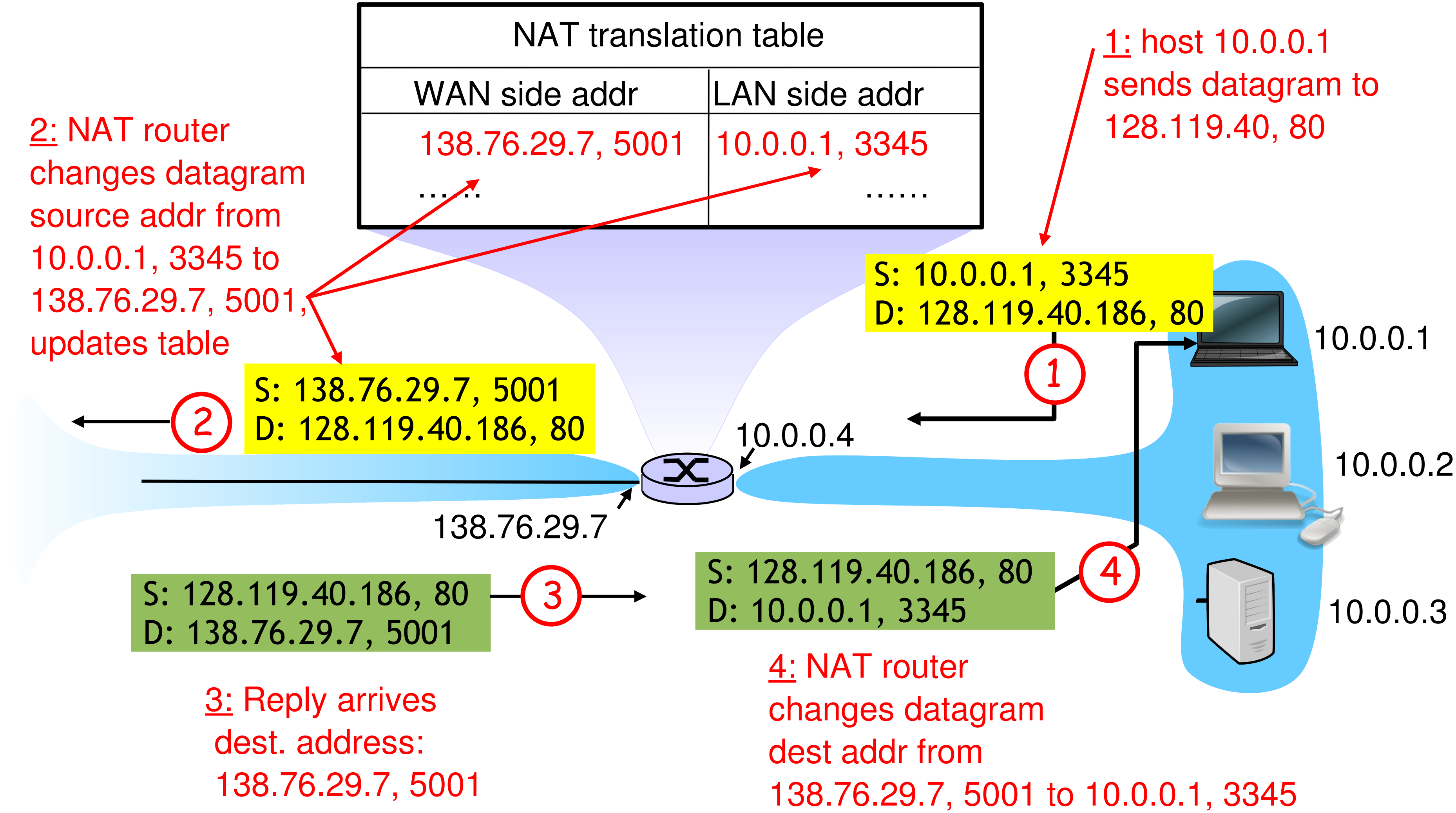
- *outgoing datagrams: replace* (source IP address, port #) of every outgoing datagram to (NAT IP address, new port #)

  . . . remote clients/servers will respond using (NAT IP address, new port #) as destination addr.

- *remember (in NAT translation table)* every (source IP address, port #) to (NAT IP address, new port #) translation pair

- *incoming datagrams: replace* (NAT IP address, new port #) in dest fields of every incoming datagram with corresponding (source IP address, port #) stored in NAT table

NAT: Network Address Translation

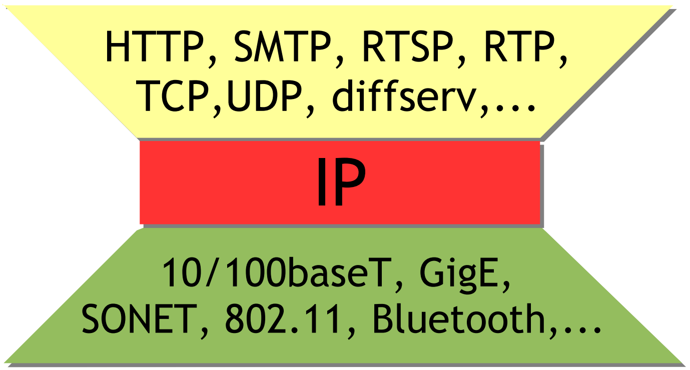


NAT: Network Address Translation

- 16-bit port-number field:
  - >60,000 simultaneous connections with a single LAN-side address!
- NAT is controversial:
  - Routers should only process up to layer 3
  - Violates end-to-end argument
    - NAT possibility must be taken into account by app designers, e.g., P2P applications
  - Address shortage should instead be solved by Ipv6
- Other examples of layer violations:
  - Firewalls
  - Application-layer switches
  - Transparent proxies
  - ...

SC250: Summary and Outlook

- Topics covered:
  - Principles underlying computer networks
  - Architecture of TCP/IP and the Internet: end-to-end principle, layers, protocols
  - Touched on many topics, not always with sufficient level of detail (but there are more classes coming...)
  - You now understand the Internet, its underlying principles, and you are able to design & implement Internet applications
- The IP hourglass... will it withstand the test of time?



SC250: Summary and Outlook

- Anything left to learn? Don't worry... :-)
  - Network design: as a networking engineer, how do you design a network, given some specifications?
    - User population, cost, robustness and security requirements, manageability/operations support...
    - Architecture? Protocols? Topology? Outsourcing vs. in-house? Standards or proprietary? Vendors and service providers? ...
  - Error control and correction: coding, information theory
  - Physical layer: digital communications, information theory
  - Security: cryptography, systems aspects
  - More sophisticated service models for multimedia
  - Wireless and mobile networking: mobile IP, ad hoc (infrastructure-less networks),...