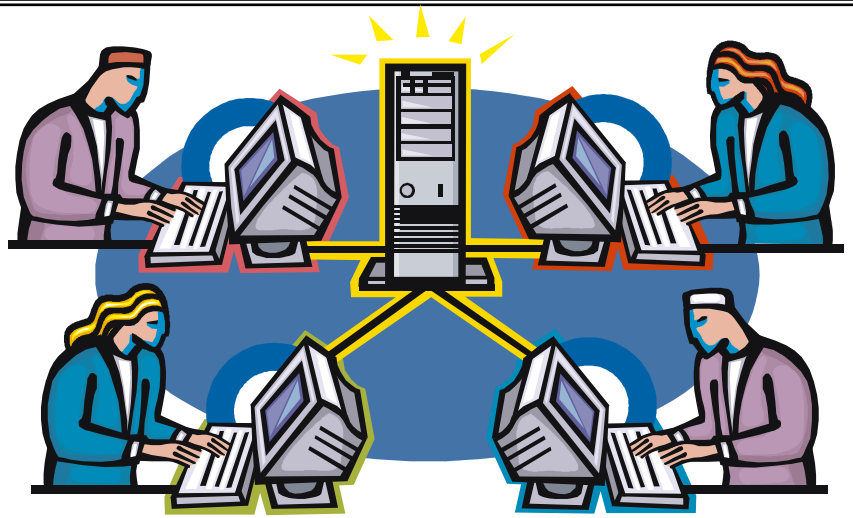
CSE150
Operating Systems
Lecture 23

Distributed Systems and Networking 2

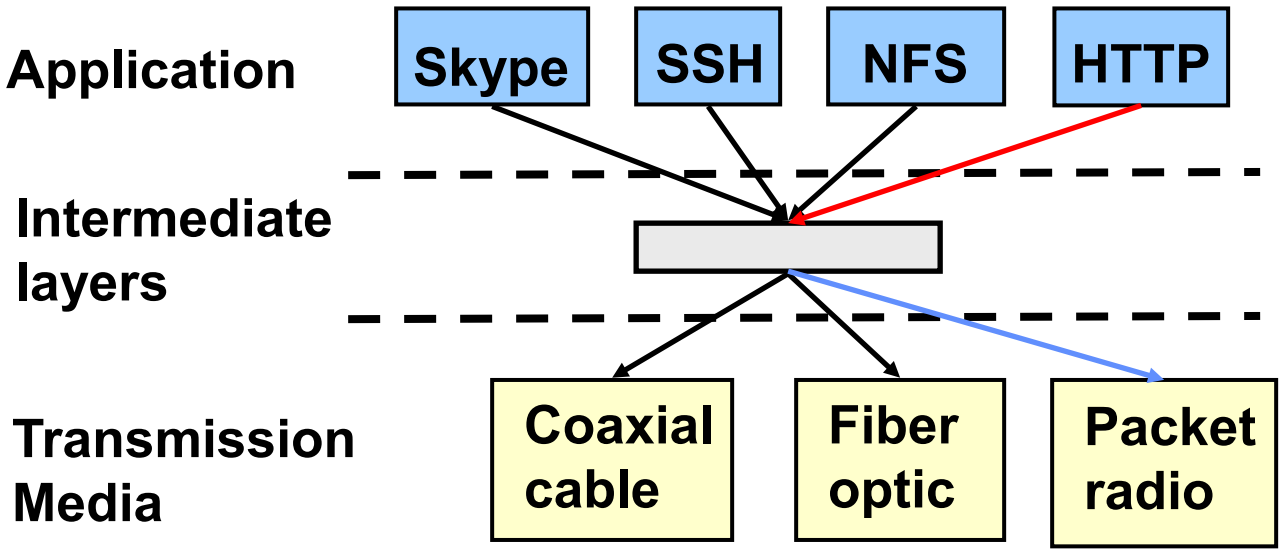
Networking Definitions



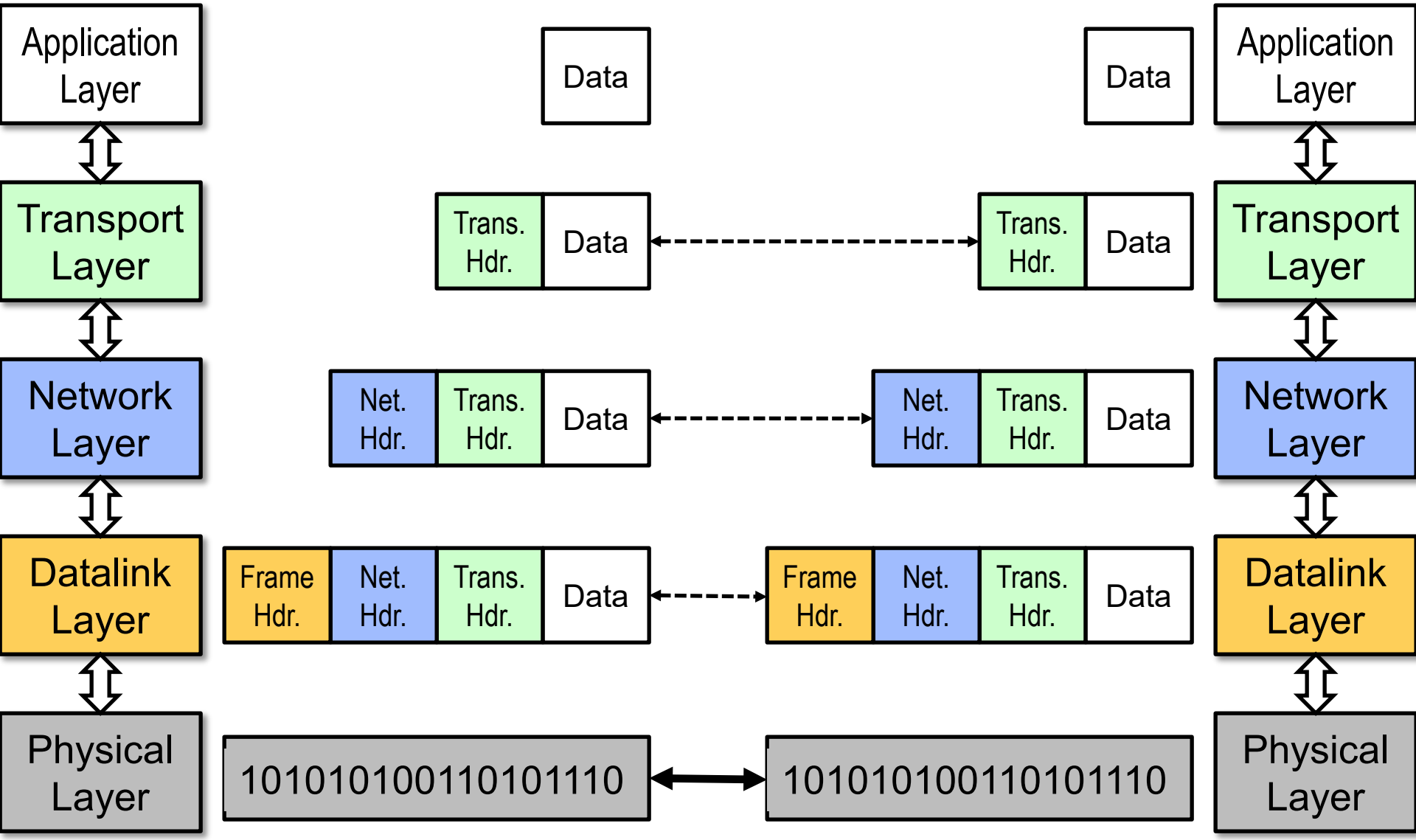
- Network: physical connection that allows two computers to communicate
- Packet: unit of transfer, sequence of bits carried over the network
  - Network carries packets from one CPU to another
  - Destination gets interrupt when packet arrives
- Protocol: agreement between two parties as to how information is to be transmitted

Intermediate Layers

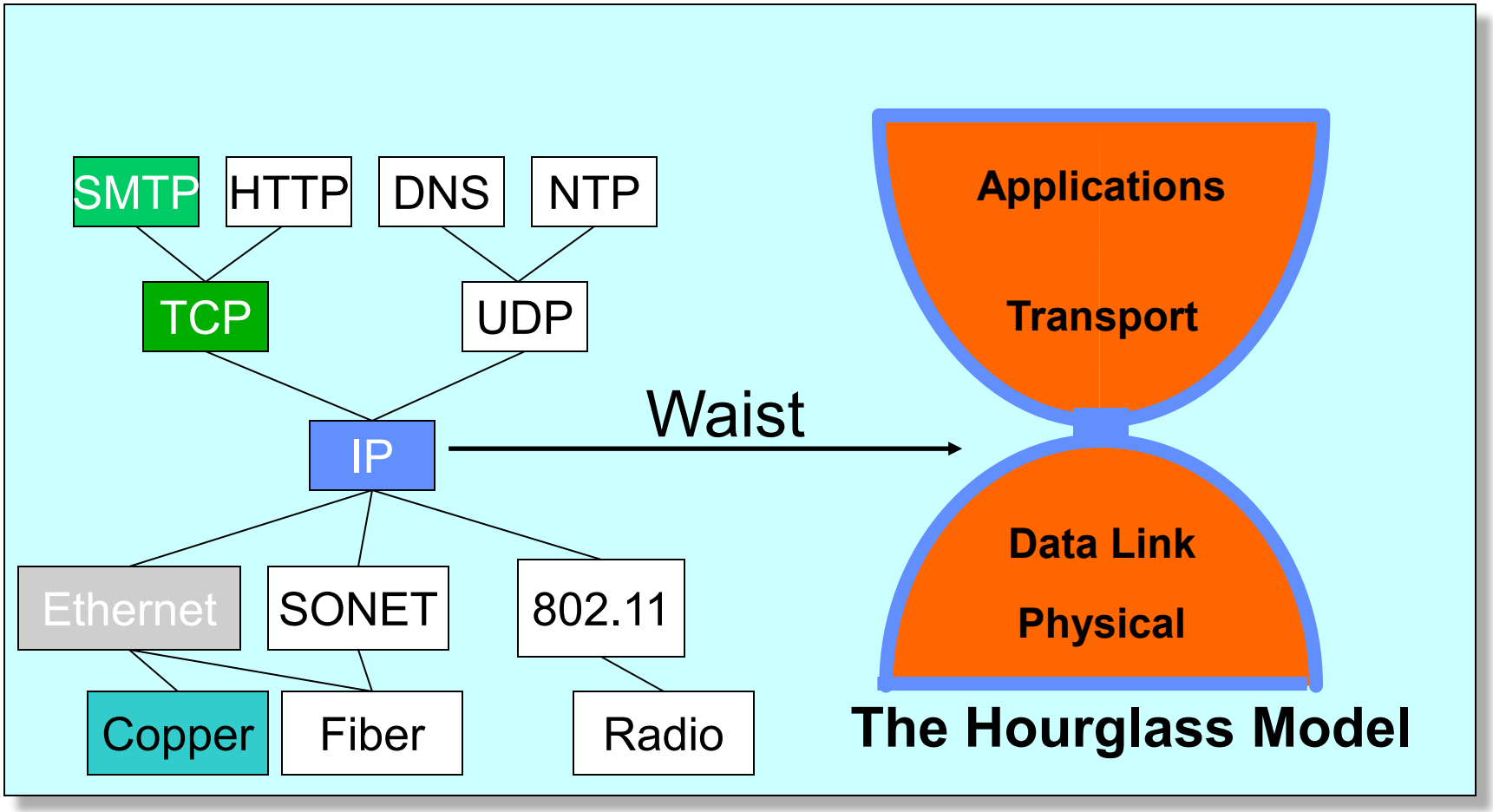
- Introduce intermediate layers that provide set of abstractions for various network functionality & technologies
  - A new app/media implemented only once
  - Variation on "add another level of indirection"



Layering: Packets in Envelopes



The Internet *Hourglass*



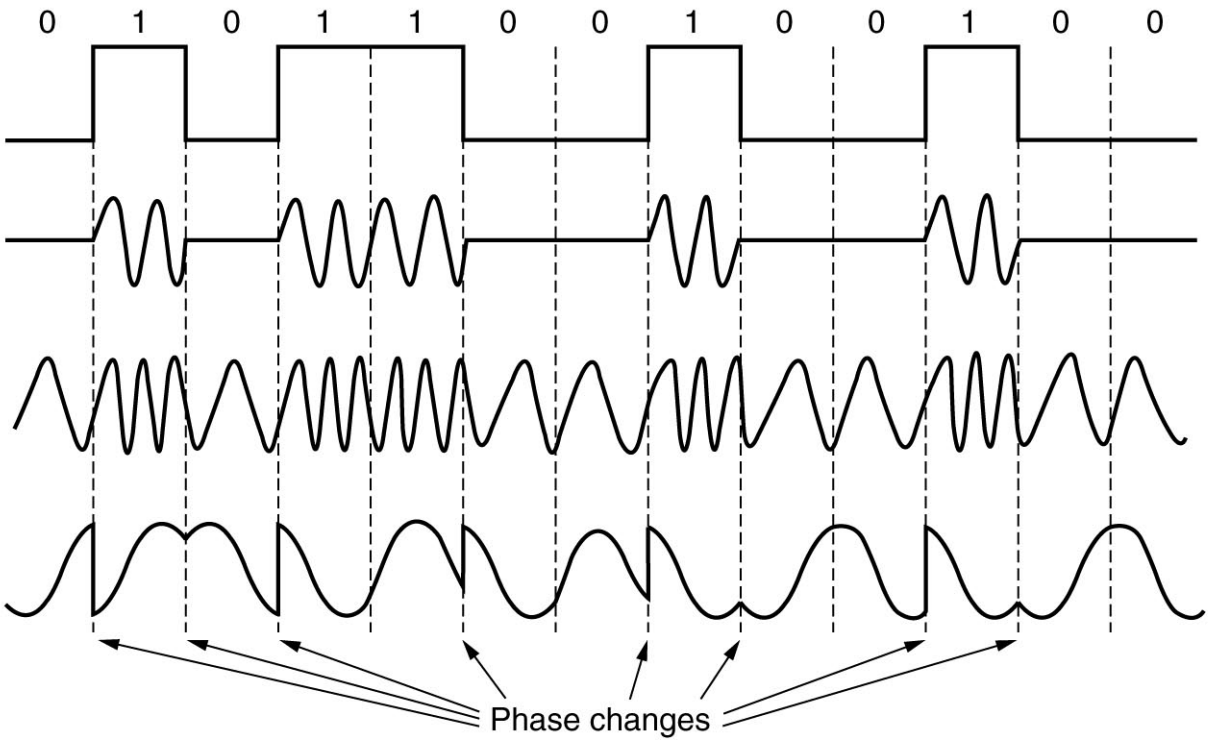
There is just one network-layer protocol, **IP**

The "narrow waist" facilitates interoperability

Today

- Physical Layer
- Cyber Physical Systems & Wireless networks
- Medium Access Control (MAC) Protocols
  - Contention-based vs. Contention-free
- Wireless issues in MAC
  - Hidden terminal and Exposed terminal

Physical layer - Modulation



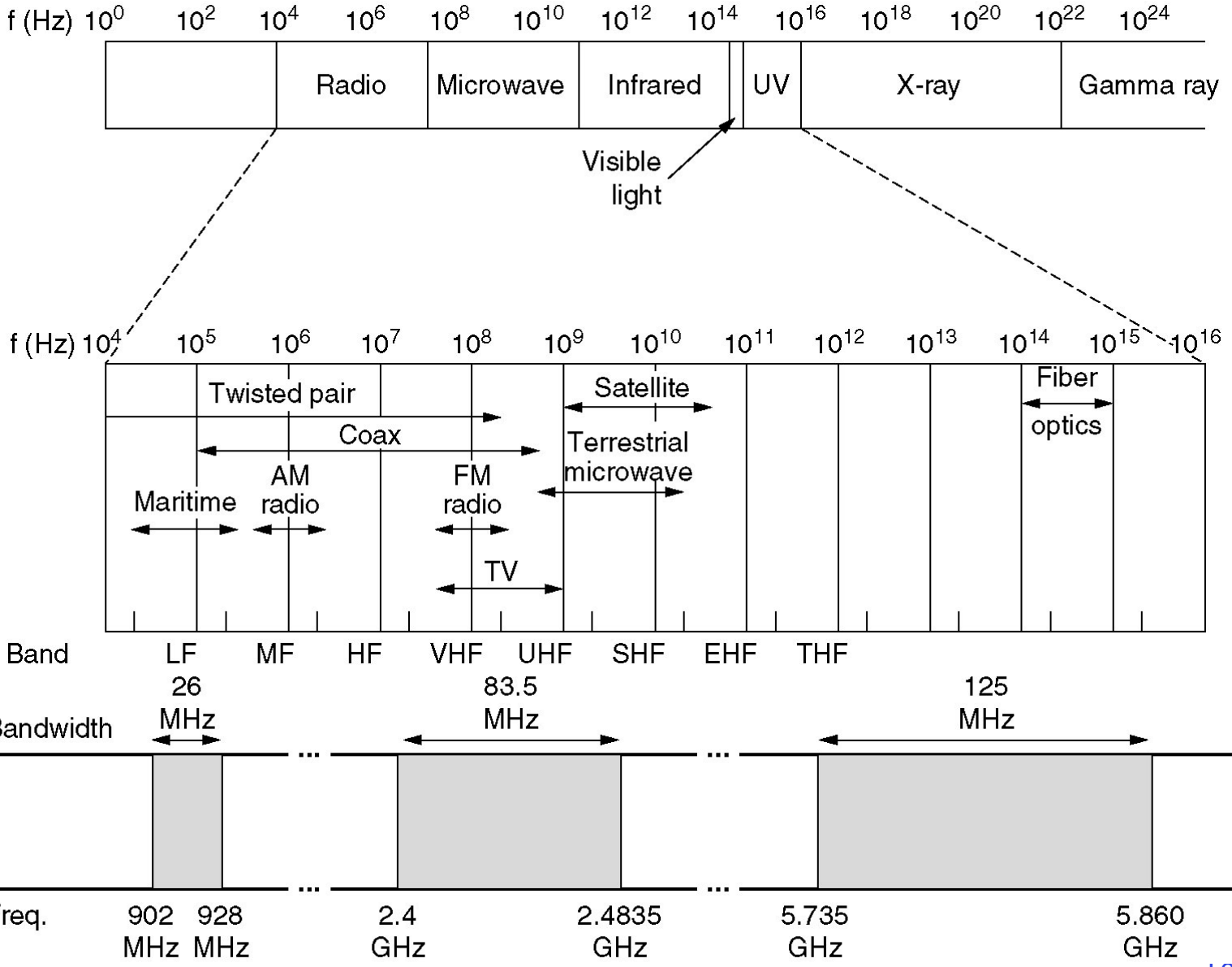
Binary signal

Amplitude modulation

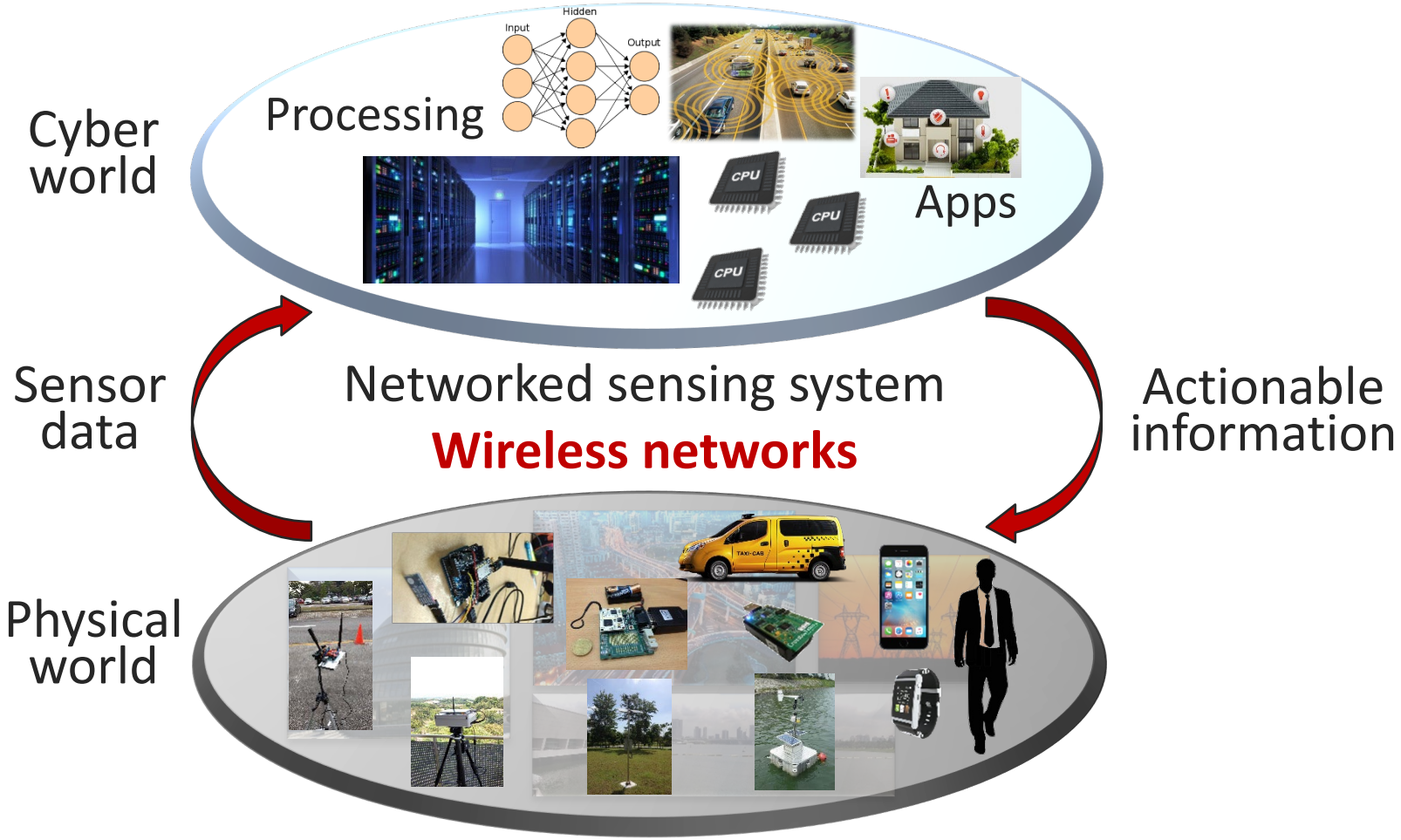
Frequency modulation

Phase modulation

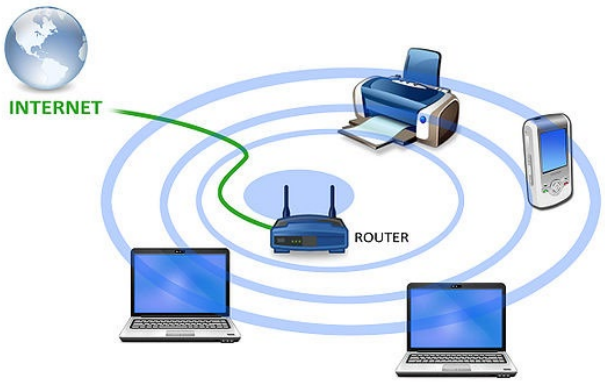
The Electromagnetic Spectrum



Cyber physical systems



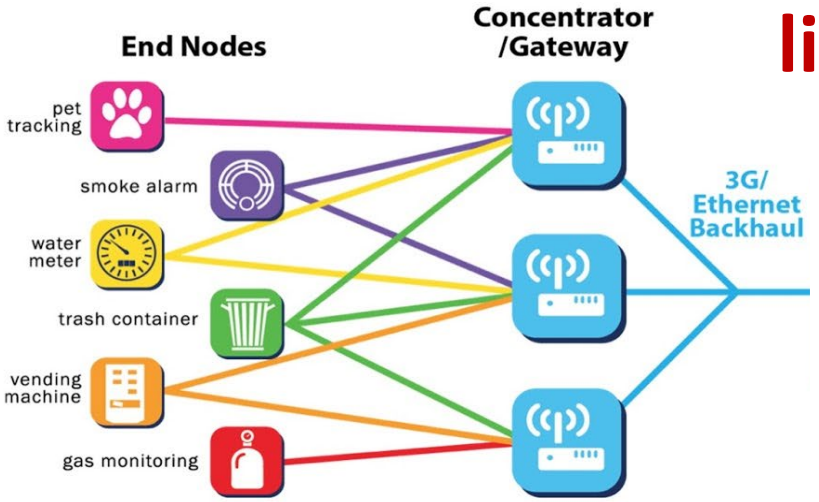
Wireless networks used in CPS



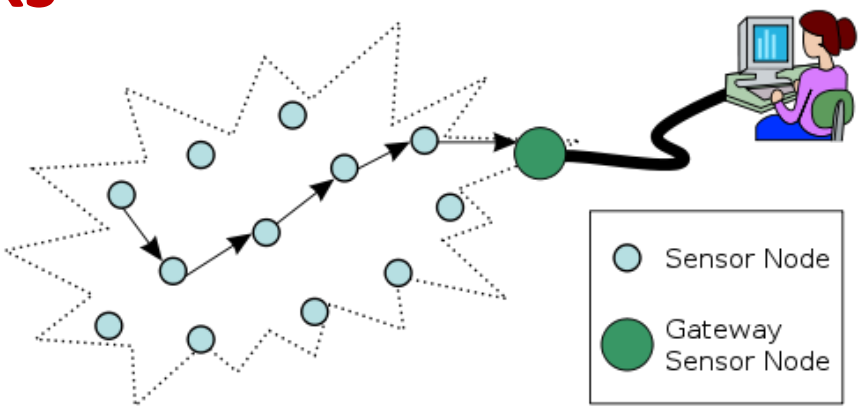
WiFi networks

Cellular networks

Wireless links

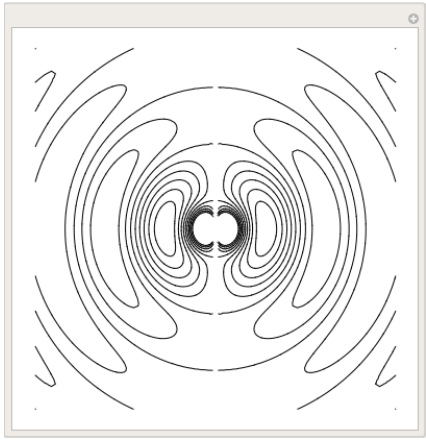


Low power wide area networks

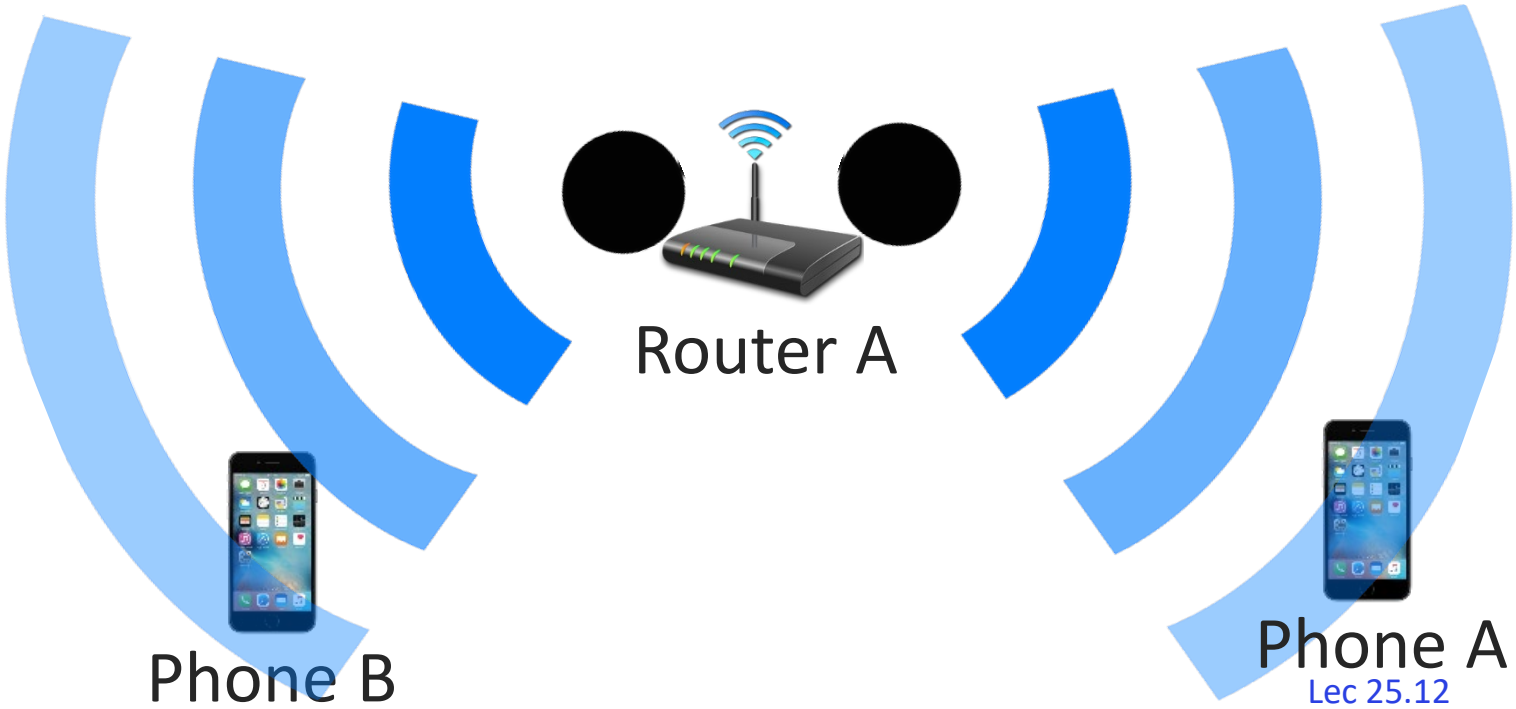


Autonomous multi-hop networks

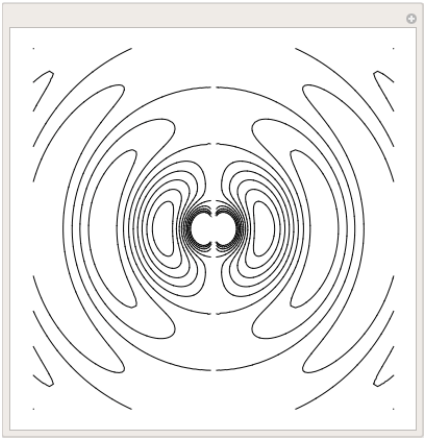
Wireless links



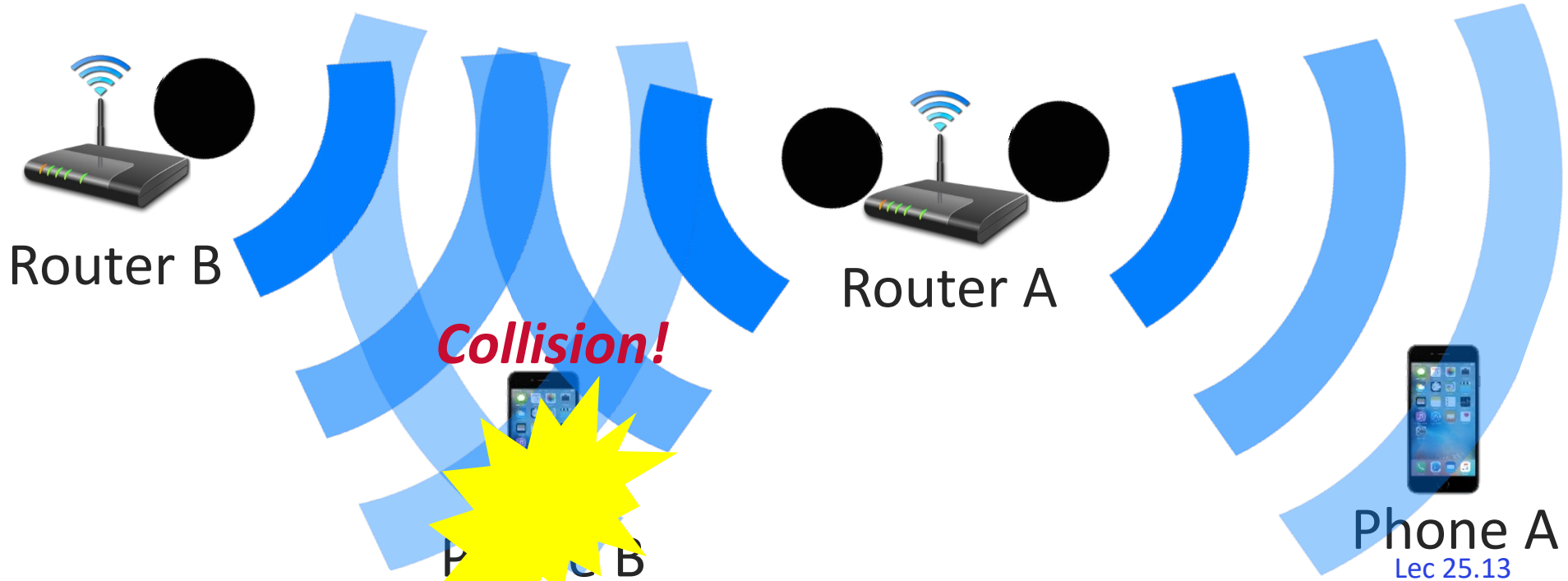
- Differences between wireless links and wired links?
  - Broadcasting



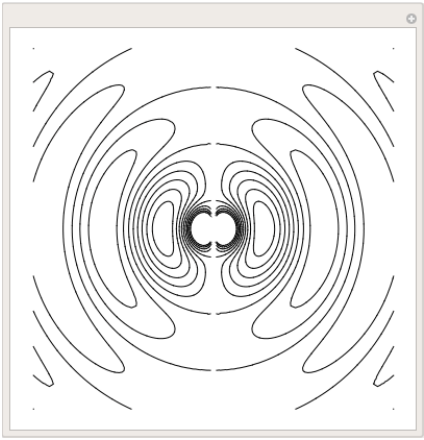
Wireless links



- Differences between wireless links and wired links?
  - Broadcasting
  - Omnidirectional interference



Wireless links



- Differences between wireless links and wired links?
  - Broadcasting
  - Omnidirectional interference
  - Attenuation

Router B

Router A

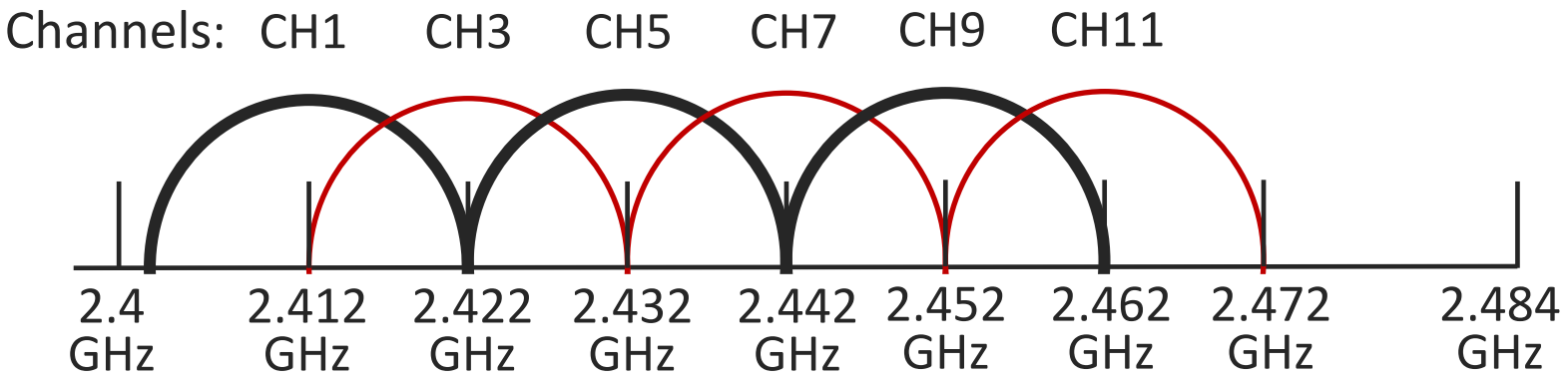
Phone B

Phone A

Medium Access Control (MAC)

- Contention-free protocols
  - TDMA (Time Division Multiple Access)
  - FDMA (Frequency Division Multiple Access)
- Contention-based protocols
  - ALOHA (random access)
  - CSMA (Carrier Sense Multiple Access)

Frequency Division Multiple Access

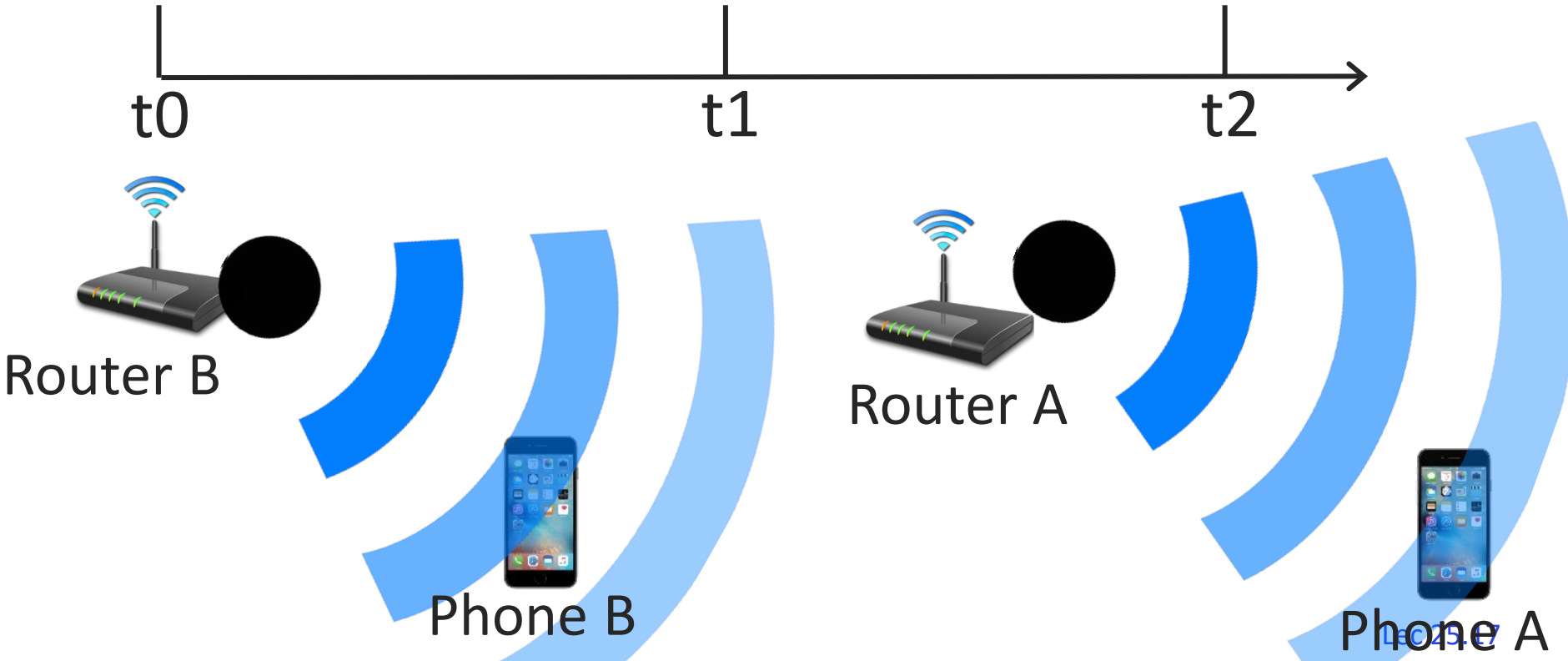


Limited channels

Carrier Sense Multiple Access (CSMA)

Sense by measuring the received signal strength.

If the channel is busy, retry after a random backoff.



Outline

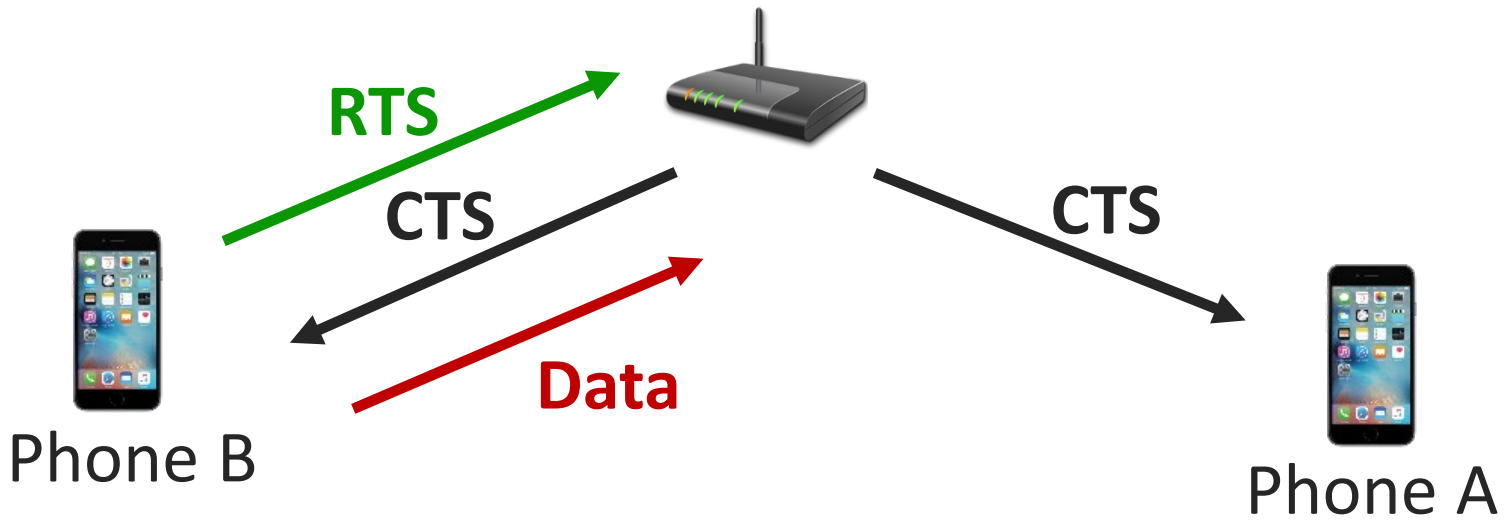
- Wireless networks in Cyber Physical Systems
- Medium Access Control (MAC) Protocols
  - Contention-based vs. Contention-free
- Wireless issues in medium access
  - Hidden terminal and Exposed terminal

Hidden terminal

Two phones cannot sense each other, but can impact the signal arriving at the router.

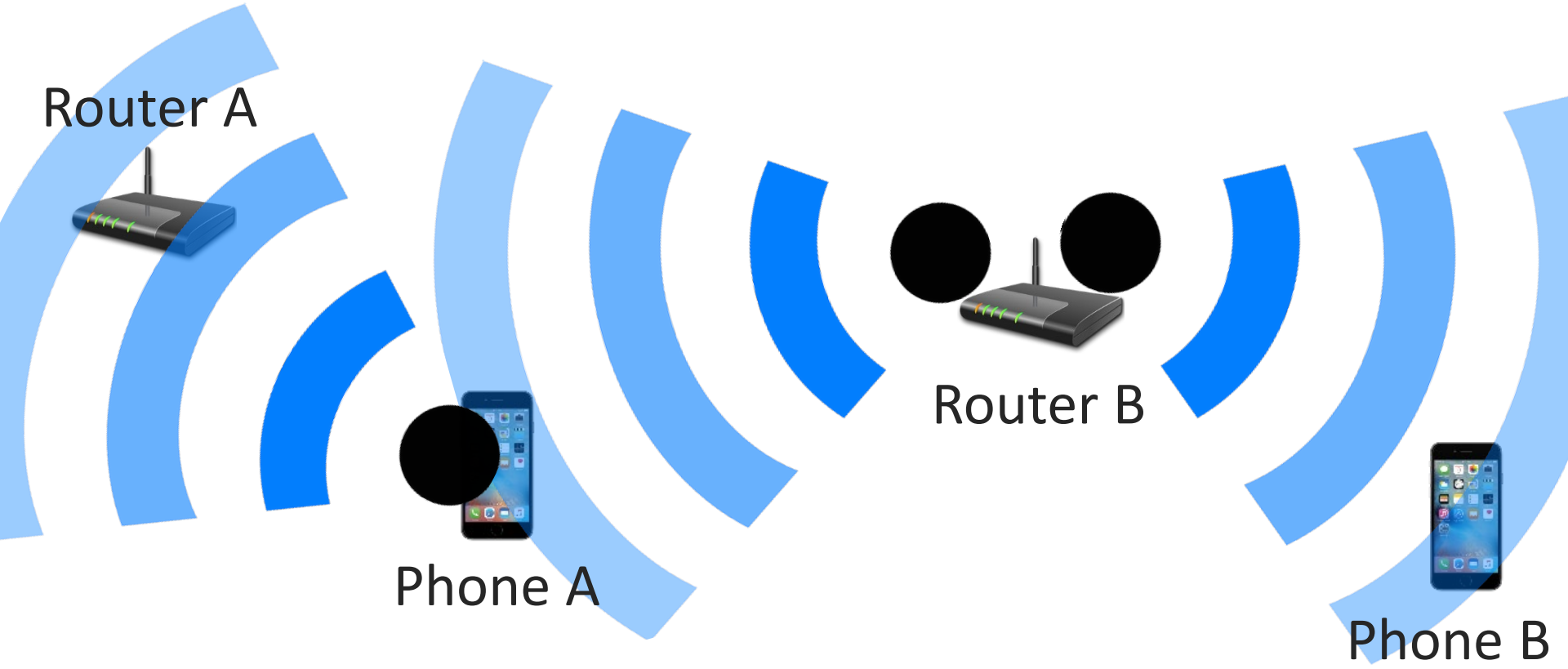
Hidden terminal: Collision avoidance

Small RTS
Few collision



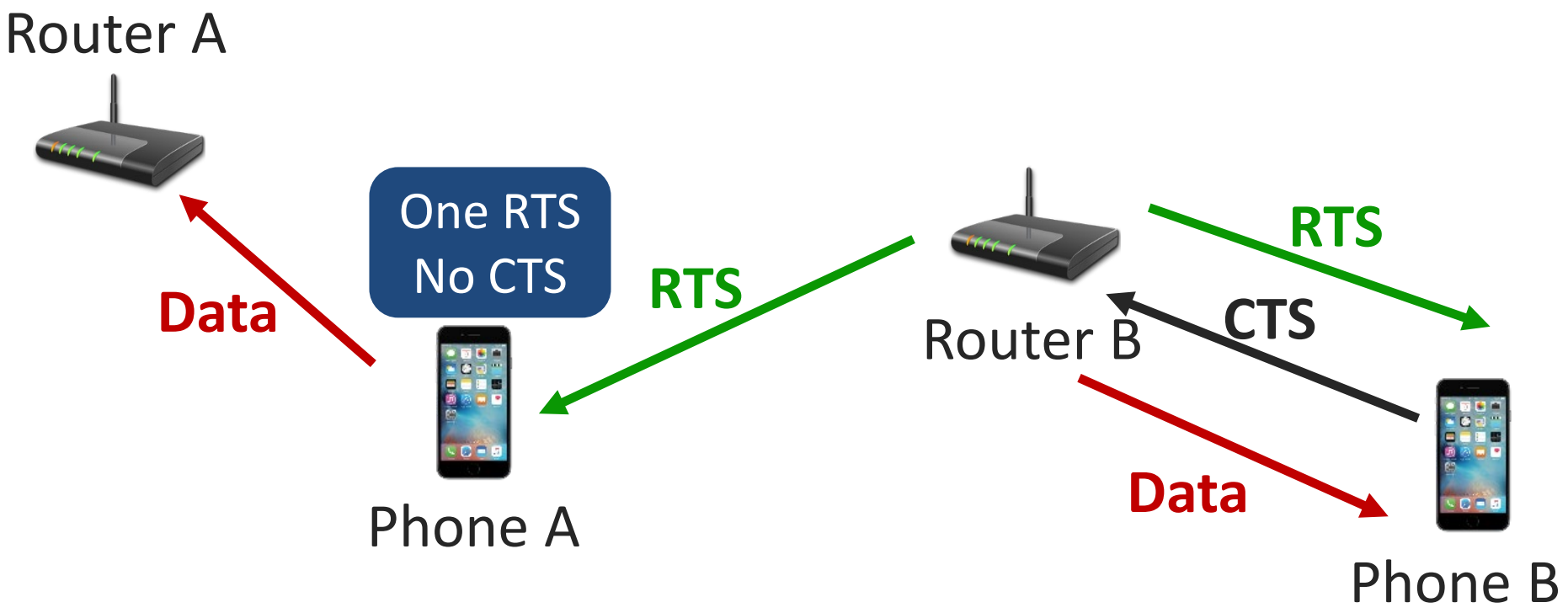
Reserve the channel first by RTS/CTS (Request To Send, Clear To Send)

Exposed terminal



Phone A can sense **Router B**, but **Router B** cannot interfere with **Router A's** reception.

Exposed terminal: Collision avoidance



Reserve the channel first by RTS/CTS (Request To Send, Clear To Send)

Take-home messages

- Modulation for the Physical layer.
- Wireless MAC protocols are essential to Cyber Physical Systems.
- Wireless issues
  - Hidden terminal and Exposed terminal

Thank you!