

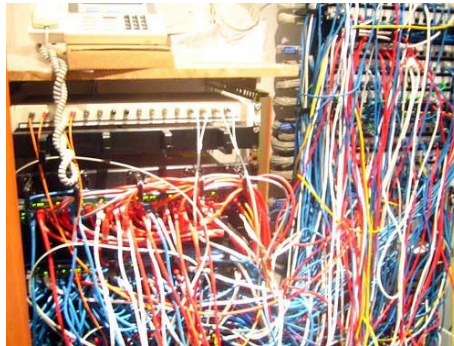
Wireless characteristics

Slides used in TDDE48 (Mobile Networks) @ LiU, Sweden, Fall 2023
Niklas Carlsson (<https://www.ida.liu.se/~nikca89/>)

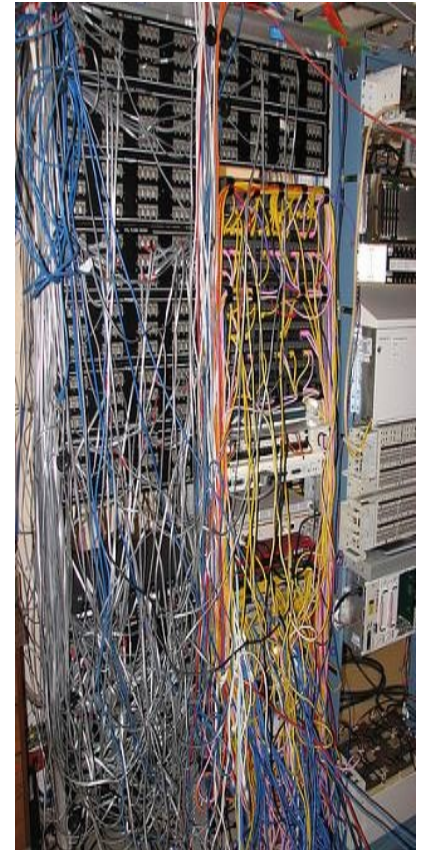
Slides in this course are adapted or based on various on-line resources (including lectures notes by Juha Takkinen, Anirban Mahanti, Carey Williamson, Jim Kurose, and Keith Ross)

What is Wireless Networking?

- Use of infra-red (IR) or radio frequency (RF) signals to share information between devices
- Promises *anytime, anywhere* connectivity
- No wires!



- Lots of acronyms



What is mobile device?



camera



camcorder



TV



radio



game



PDA



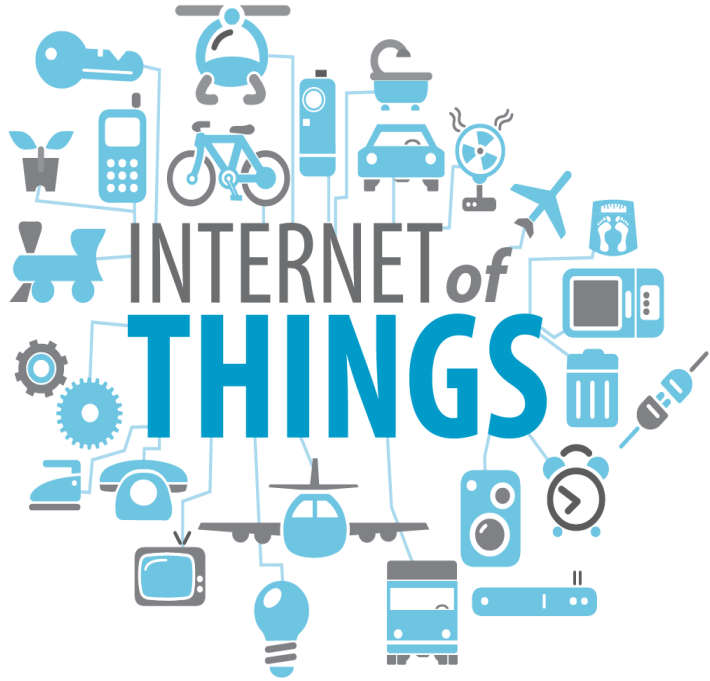
makeup device?



Swiss army knife?



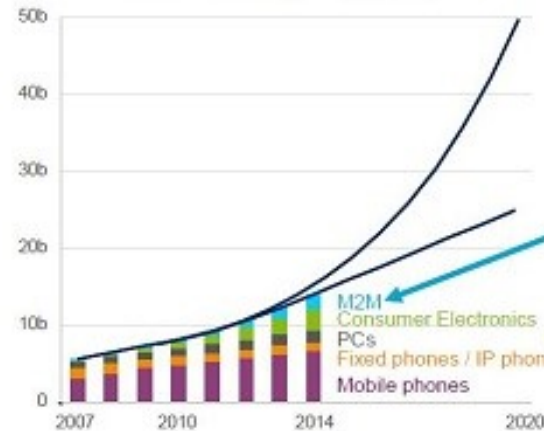
... trends towards the future ...



NEW DEVICES AND NEW INDUSTRIES BRING NEW BUSINESS OPPORTUNITIES



Connected Devices Worldwide



Addressing Industries

Traffic systems, Automotive
Transport and logistics
Utilities – smart grid
Security – connected buildings
Home appliances
Medical automation, Remote healthcare
ATM, Point of sale, Vending
Critical infrastructures
Monitoring and control

More devices per person

eBook readers, Music players, DVD players, Gaming devices, Cameras, Home appliances, In-vehicle entertainment etc.

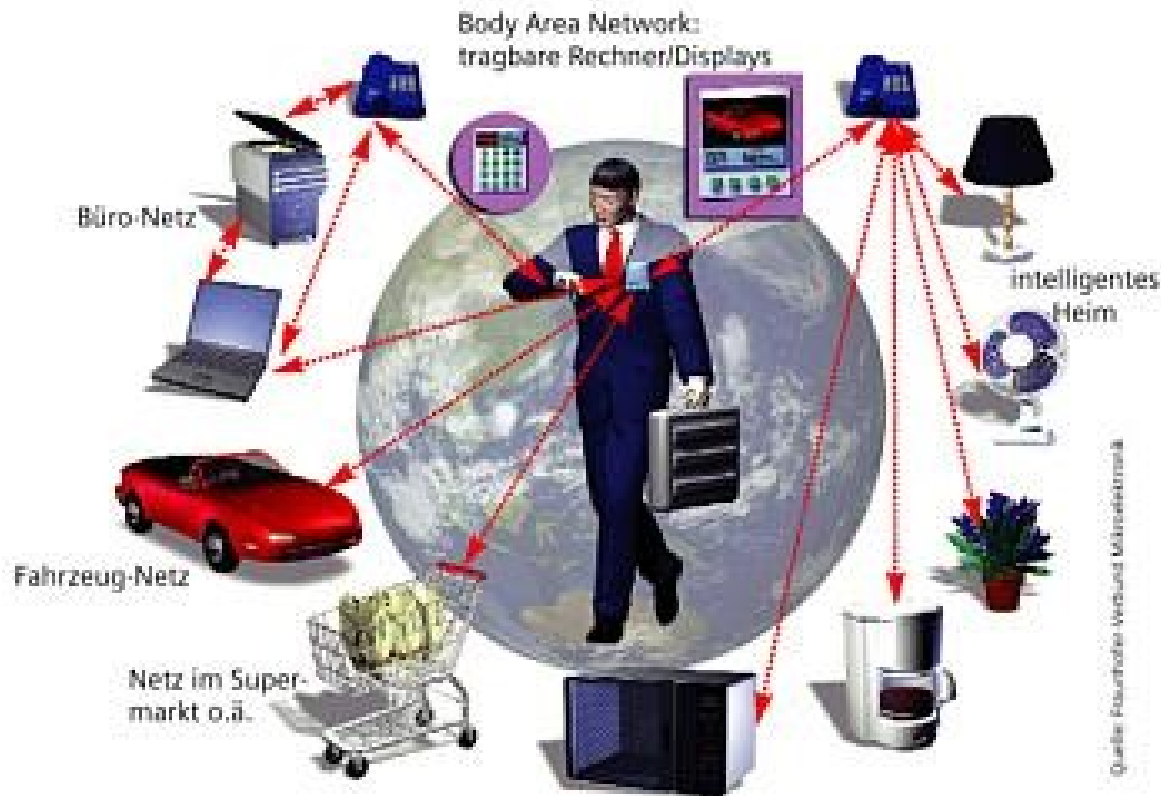
New telecom cycle: 10x devices, 10x industries

Example trends

- ❑ Everything that can be connected will be connected
- ❑ IoT and smart cities
 - Machine-to-machine
- ❑ High-definition VR+3D streaming to heterogeneous clients



A connected world ...



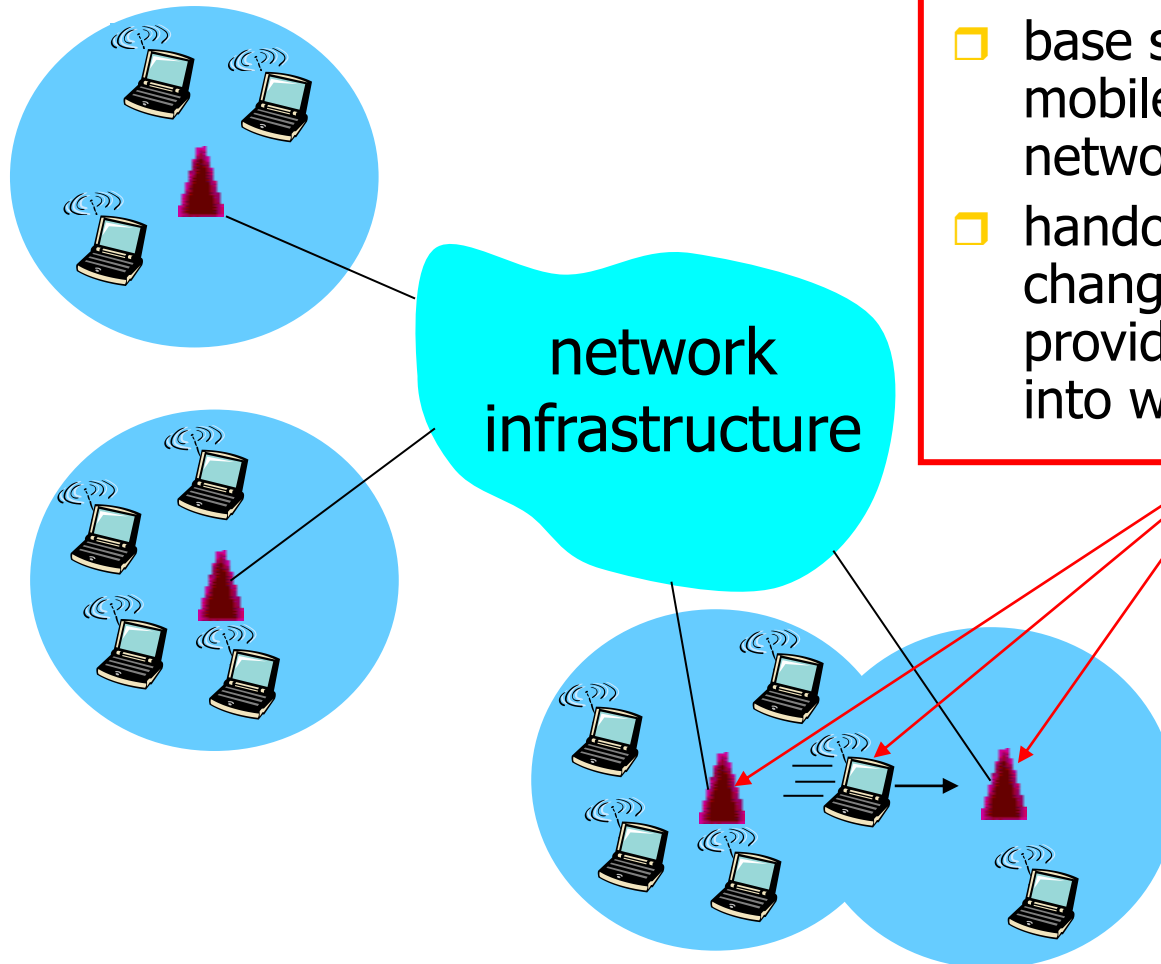
Also comes with privacy issues ...

- Yes, many entities know where you are and what you do
- E.g., phone: apps + services, OS, cellular/wifi providers, location services, Google/Apple services, third parties (e.g., ad providers), "fourth parties", malicious apps, hackers, governments and law enforcement, ...

Wireless Networking Technologies

- Operating modes
 - Infrastructure mode
 - Ad-hoc mode

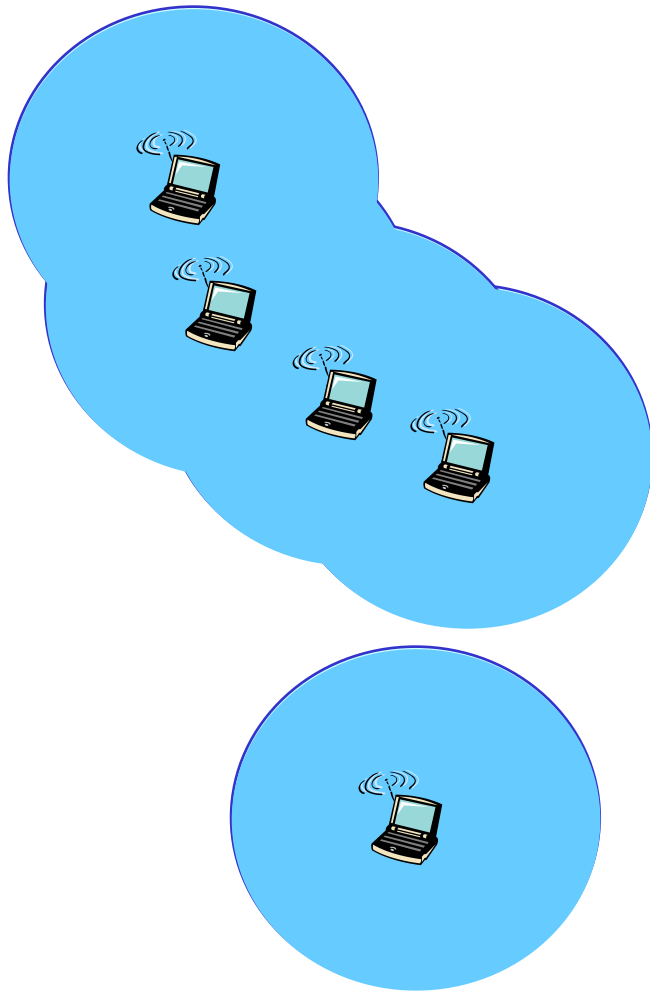
Infrastructure Mode



Infrastructure mode

- ❑ base station connects mobiles into wired network
- ❑ handoff: mobile changes base station providing connection into wired network

Ad hoc Mode



Ad hoc mode

- ❑ no base stations
- ❑ nodes can only transmit to other nodes within link coverage
- ❑ nodes organize themselves into a network: route among themselves

Two important (but different!) challenges

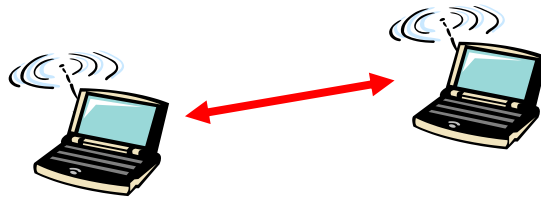
Two important (but different!) challenges

- Communication over wireless link

- Handling mobile user who changes point of attachment to network

Two important (but different!) challenges

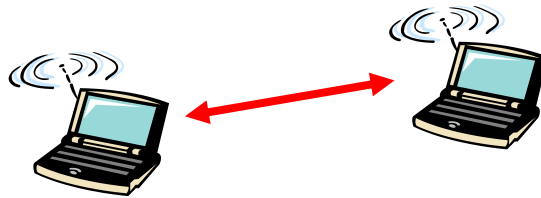
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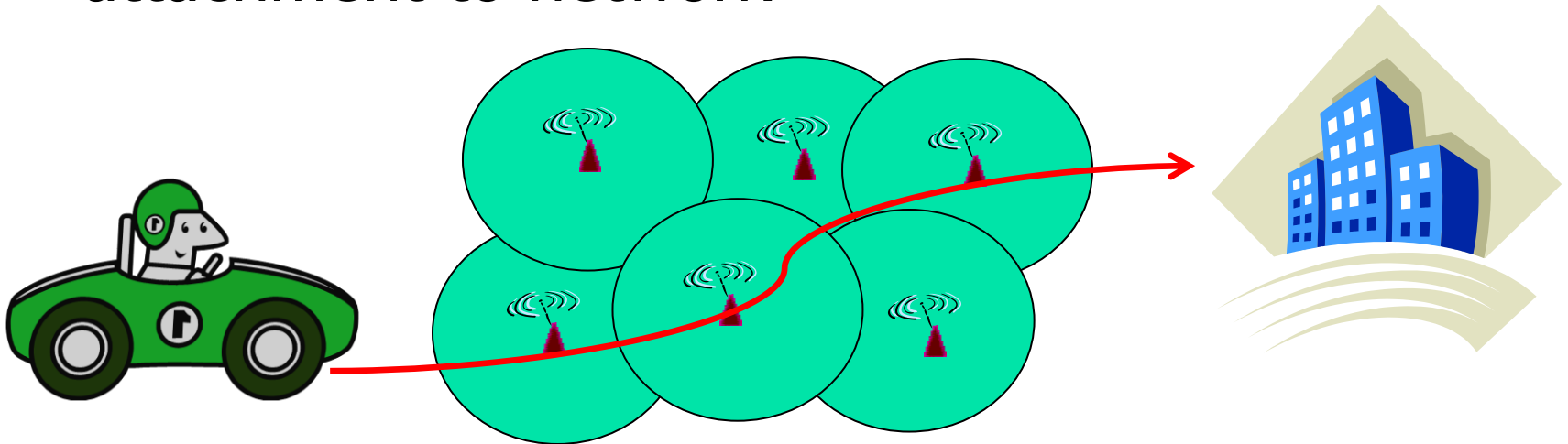
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Two important (but different!) challenges

- Communication over wireless link

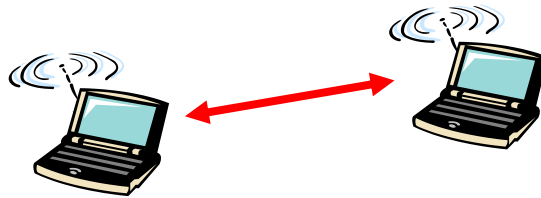


- Handling mobile user who changes point of attachment to network



Two important (but different!) challenges

- Communication over wireless link



- Handling mobile user who changes point of attachment to network

** In this course we will look at **unique challenges and opportunities** in wireless communication, including the two above.

Wireless Link Characteristics

Differences from wired link

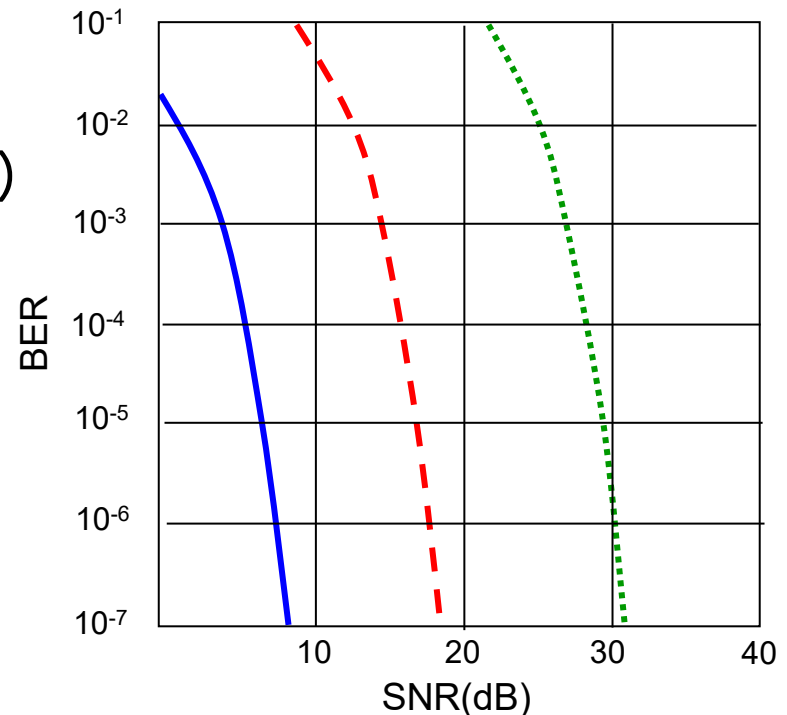
- **Decreasing signal strength:** radio signal attenuates as it propagates through matter (path loss)
- **Interference from other sources:** standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- **Multi-path propagation:** radio signal reflects off objects ground, arriving at destination at slightly different times

.... make communication across (even a point to point) wireless link much more "difficult"

- Higher error rates; lower bandwidths; non-uniform transmission characteristics; increased usage costs; and increased susceptibility to interference and eavesdropping

Wireless Link Characteristics

- SNR: signal-to-noise ratio
 - larger SNR – easier to extract signal from noise (a “good thing”)
- *SNR versus BER tradeoffs*
 - *given physical layer*: increase power -> increase SNR -> decrease BER
 - *given SNR*: choose physical layer that meets BER requirement, giving highest throughput



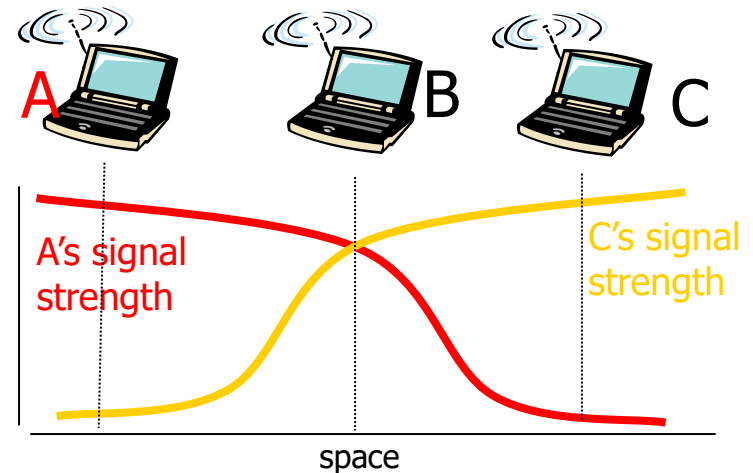
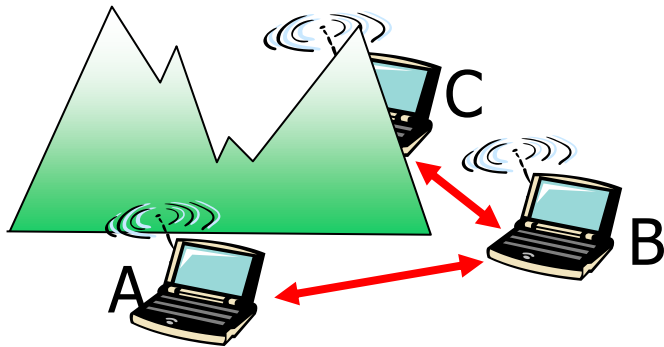
..... QAM256 (8 Mbps)

- - - QAM16 (4 Mbps)

— BPSK (1 Mbps)

Wireless Network Characteristics

Multiple wireless senders and receivers create additional problems (beyond multiple access):



Hidden terminal problem

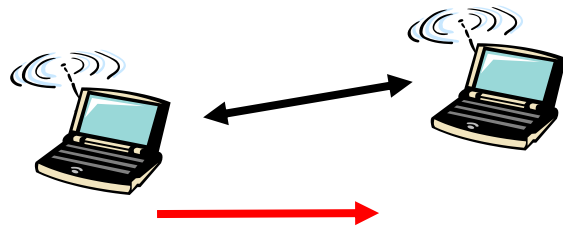
- ❑ A and B can hear each other
- ❑ B and C can hear each other
- ❑ A and C can't hear each other
- ❑ thus A and C are unaware of their interference at B

Signal fading:

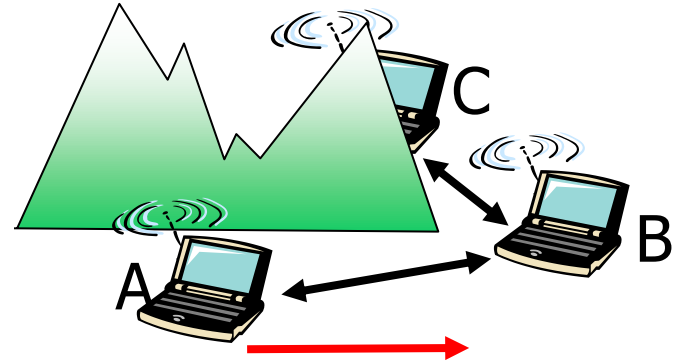
- ❑ A and B hear each other
- ❑ B and C hear each other
- ❑ A and C can't hear each other interfering at B

Now add mobility ...

1)



2)



3)

