Mobile Information Systems

Lecture 02 – Big Issues

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Key issues of MIS (recap)

- Limited power supply
- Limited storage
- Wireless communication channels
- Limited/different I/O capabilities
- Unpredictable usage context
- Privacy & Security
- Sustainability

Key issue: power (1)

Image source (CC): https://www.flickr.com/photos/intelfreepress/10190082395/

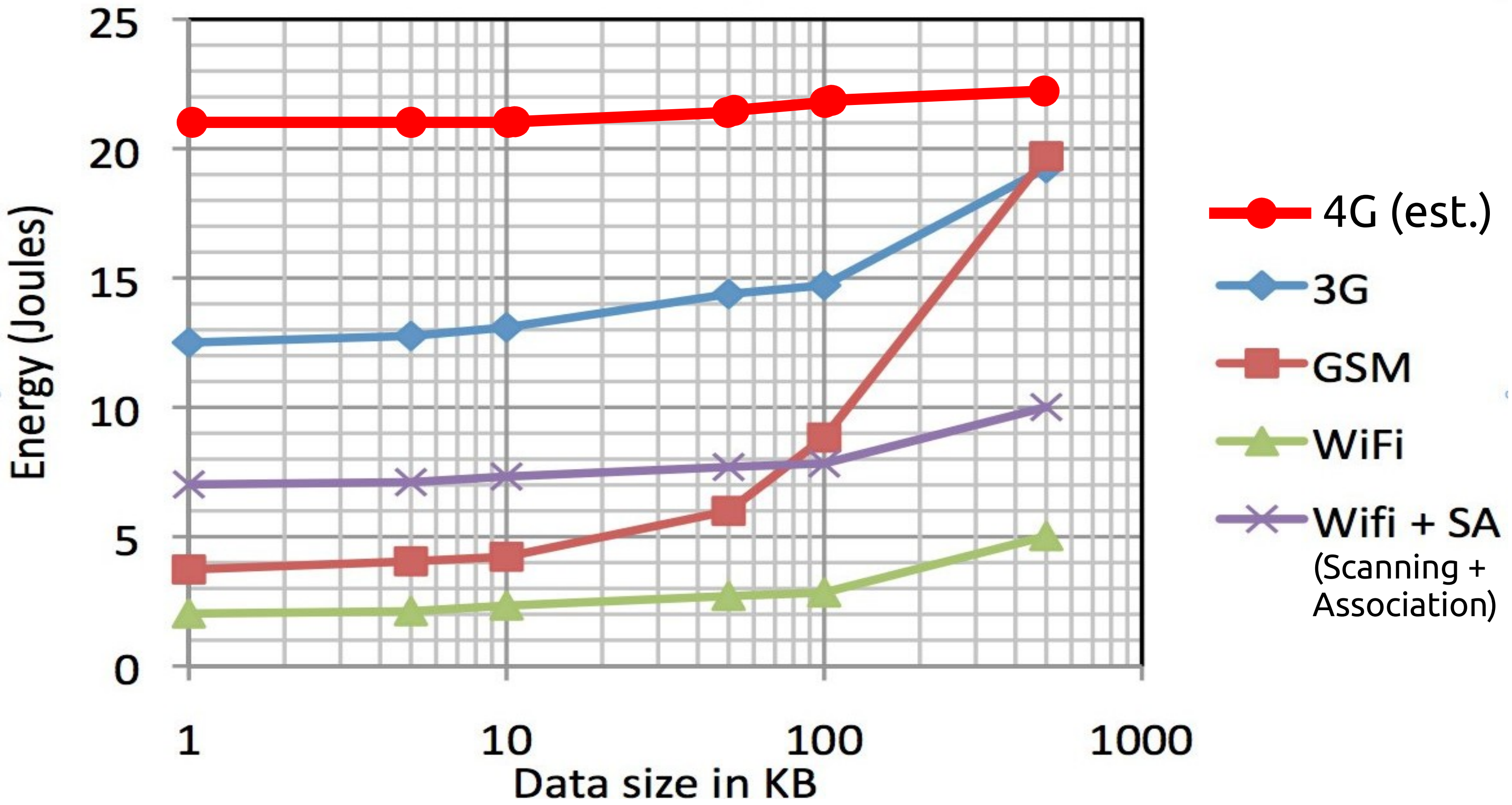
- Limited power supply
  - Tradeoff: capacity   size/weight/portability
  - Energy consumption becomes important
- Two possible solutions:
  - Increase energy   size/weight ratio
    - Requires chemistry & physics knowledge
    - Out of scope for this course :-)
  - Decrease energy consumption
    - Requires CS/EE knowledge
    - *In scope* for this course

Key issue: power (2)

- Biggest energy consumers (highest first):
  - Display backlight
  - GPS receiver, camera
  - Wireless modules (4G, 3G, WiFi, Bluetooth)
  - Sensors (touchscreen, accelerometer/IMU, ...)
- Energy-saving approaches:
  - Whenever possible, disable unused subdevices
  - Alternative: use lower polling frequency
  - Look for possible tradeoffs, e.g. move computation-intensive tasks to cloud service

Energy demand of wireless transfers

Image source (FU): http://people.cs.umass.edu/~arun/papers/TailEnder.pdf



Key issue: storage (1)

- Limited storage
  - Standard is ~ 8 GB in entry-level smartphones
  - Data (partially) stored in „cloud“ services
  - Requires network connection for access
  - Tradeoff: bandwidth storage
- Reason: flash memory – why?
  - Many related tradeoffs:
    price volume capacity power consumption

Key issue: storage (2)

Image source (CC): https://en.wikipedia.org/wiki/Hard_disk_drive#/media/File:Laptop-hard-drive-exposed.jpg

	Hard disk	Flash memory
Price (2023)	~ 15 € / TB	~ 50 € / TB
Density	~ 0.1 GB/mm³	~ 1.5 GB/mm³
Power consumption	~ 1 W (idle), 2-3 W (operation)	~ 0.1 W (idle), 0.5W (operation)
Typical capacity	~ 8-12 TB	~ 512 GB

Power/storage: summary

- Primary tradeoff: size/weight capacity
- Secondary tradeoffs:
  - Power: conserve power, turn off consumers
  - Storage: “outsourcing” to cloud service
    - Increased traffic due to cloud communication may increase power consumption!

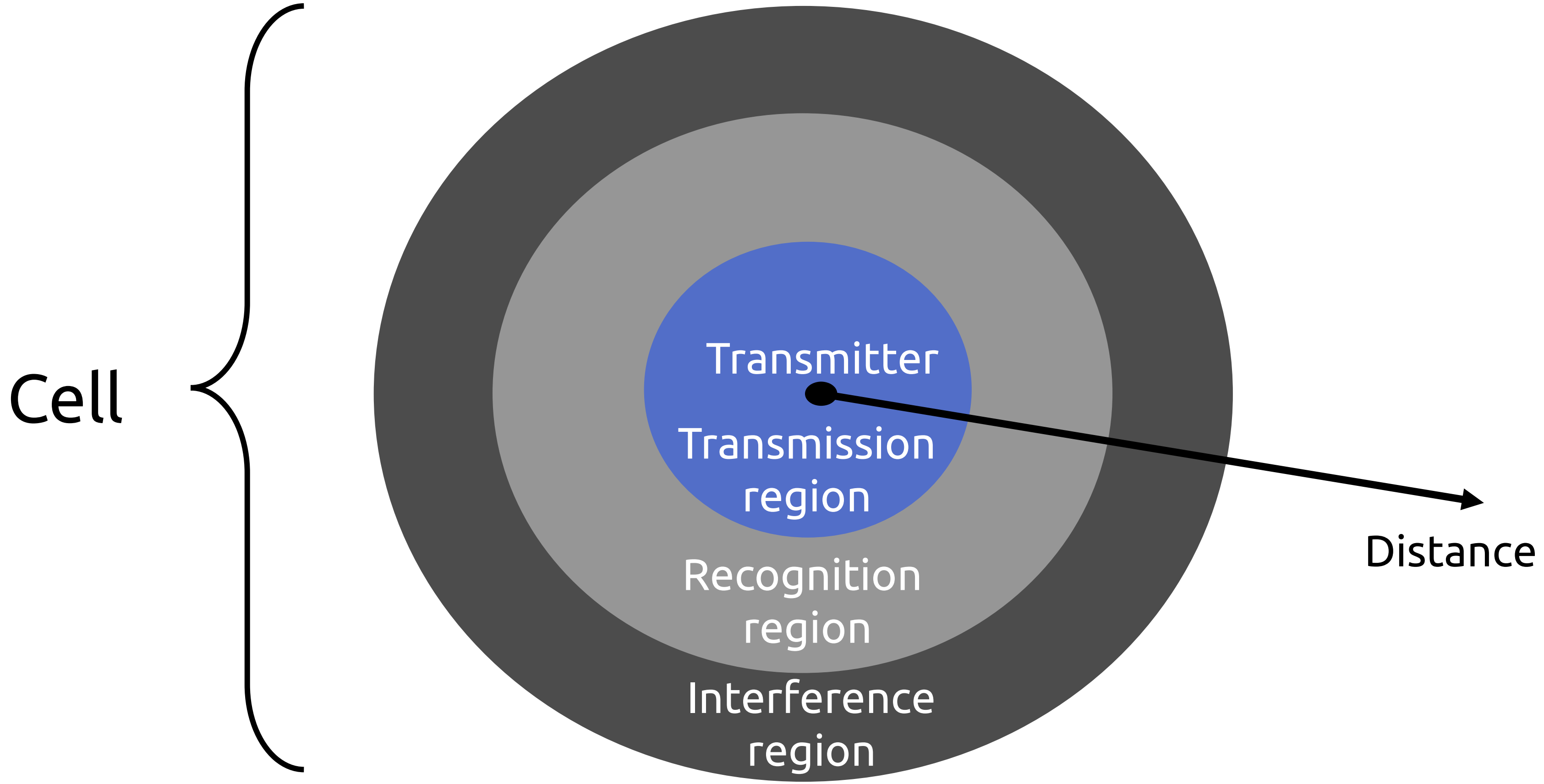
Key issue: wireless

- Wireless communication
  - Unpredictable availability & throughput
  - Tradeoff: bandwidth energy consumption
  - Media size growing faster than bandwidth (4K)
  - Abrupt quality-of-service changes
  - Round-trip-time (RTT) may be too high for interactive applications

Wireless basics

- Basics of signal theory
- Signal transmission & interference
- Classification of wireless networks
- ISO/OSI model, TCP/IP stack

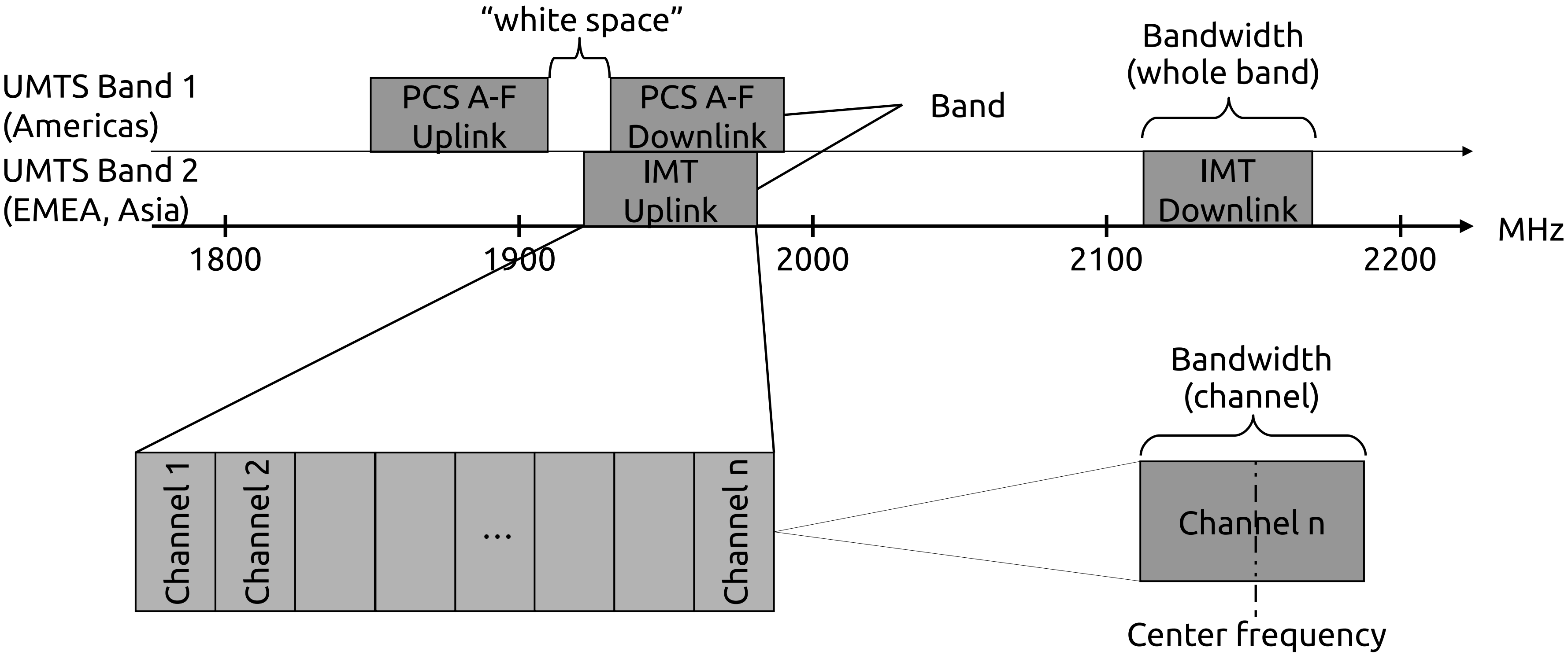
Wireless basics: signal transmission



Wireless basics: signal theory (1)

- Communication with electromagnetic waves
  - Frequency ~ 0.5 – 5 GHz → no line-of-sight required
- Channel capacity/throughput depends on:
  - Channel bandwidth
    - Given in MHz (e.g. 60 MHz for common UMTS bands)
    - Limited by hardware/cost as well as regulations
  - Modulation method
    - Encodes data on the carrier wave (“center frequency”)
    - Analog (AM/FM, known from radio) or digital (usually QAM, quadrature amplitude modulation)

Wireless basics: signal theory (1)



US Frequency Allocation Chart 2011

Image source (PD): https://en.wikipedia.org/...The_Radio_Spectrum.pdf

Wireless basics: signal theory (2)

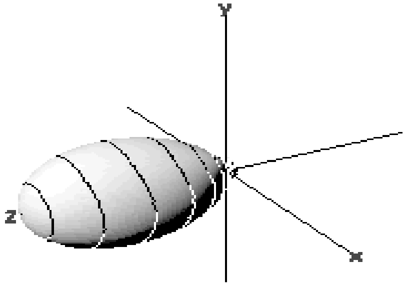
- Channel capacity/throughput (continued):
  - Channel sharing (time/frequency slots)
    - Multiple simultaneous transmissions on same frequency will cause interference (sometimes also on adjacent channels)
    - Arbitration scheme required, either time-domain (round-robin) or frequency-domain (sub-channels)
  - Signal-to-noise ratio (SNR) at receiver
    - Signal: energy of the data I want to receive
    - Noise: energy of everything else (thermal noise, other transmitters, cosmic radiation, …)

Wireless basics: antennas

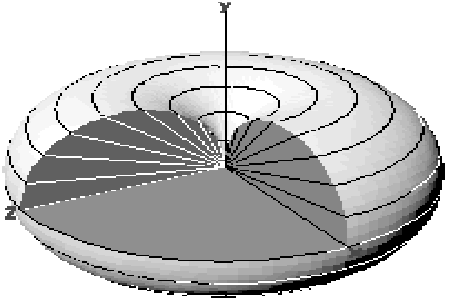
Image source (PD): https://en.wikipedia.org/wiki/Radiation_pattern#/media/File:Radiation-patterns-v.png

- Antennas: multiple characteristics
  - Gain (~ efficiency)
  - Radiation pattern (horn/dipole →)
- Ideal omnidirectional antenna:
  - Does not exist in reality
  - Can be “simulated” through multiple real antennas
- Antenna selection can help improve SNR

pyramidal horn



short dipole



Wireless basics: negative effects (1)

- Refraction
  - Varying densities of the transmission media disrupt/redirect electromagnetic (EM) waves
- Reflection
  - Material smooth in the same size range as the EM wavelength (cf. RADAR dish, microwave oven door)
- Absorption
  - EM energy is absorbed by matter
- Diffraction
  - EM waves bend around small obstacles

Wireless basics: negative effects (2)

- Interference
  - Multiple transmitters on the same frequency band/ channel or reflections of a single transmitter
  - Can lead to crosstalk and areas without signal
- Multipath scattering
  - Multiple different transmission paths between sender and receiver
  - Can be used as advantage by MIMO systems with multiple antennas

Wireless basics: classification (1)

- Wireless local area networks (WLAN)
  - Replacement for wired LAN (e.g. Ethernet)
  - 802.11x protocol family (currently x = a/g/n/ac/x)
  - up to ~ 800 Mbit/s (in theory), 20-50 m indoor range
- Wireless personal area networks (WPAN)
  - Short-range communication between peripherals
  - 2-10 m range, ~ 3 Mbit/s, Bluetooth protocol family
- WiGig (802.11ad)
  - WLAN in 60 GHz band → very high data rate (up to DisplayPort), but needs line-of-sight, low range

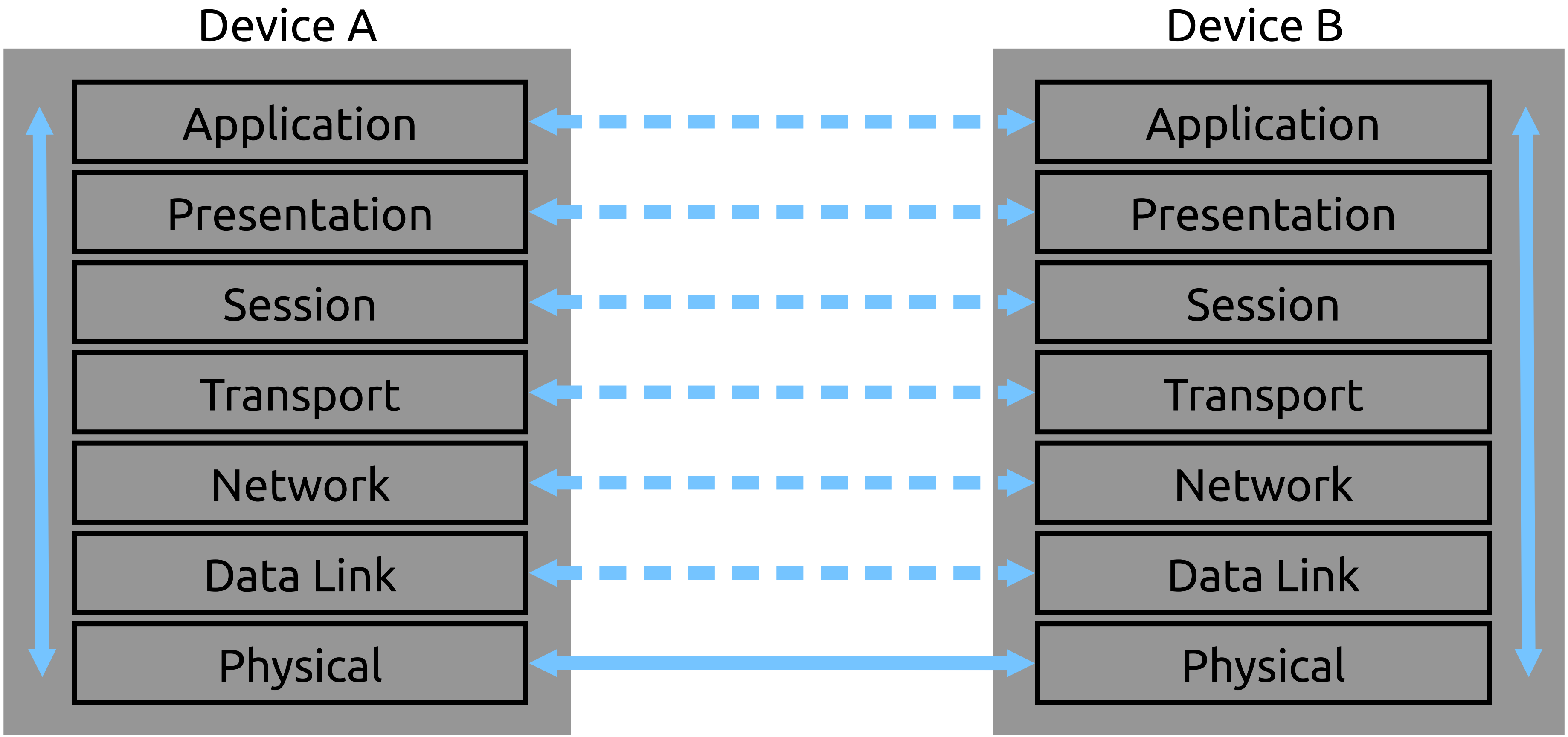
Wireless basics: classification (2)

- Cellular networks (WWAN, … wide area …)
  - Terrain-based – 2G (GSM), 3G (UMTS), 4G (LTE), 5G
  - Satellite-based – Globalstar, Iridium
  - Asymmetric bandwidth allocation (mostly downstream, to device)
- Mesh networks
  - No central access point, peer-to-peer network
  - Used for low-power sensors, “Freifunk” networks
  - Can be based on WLAN, Bluetooth, Zigbee, …
- 5G: has substandards for WLAN, WWAN, …

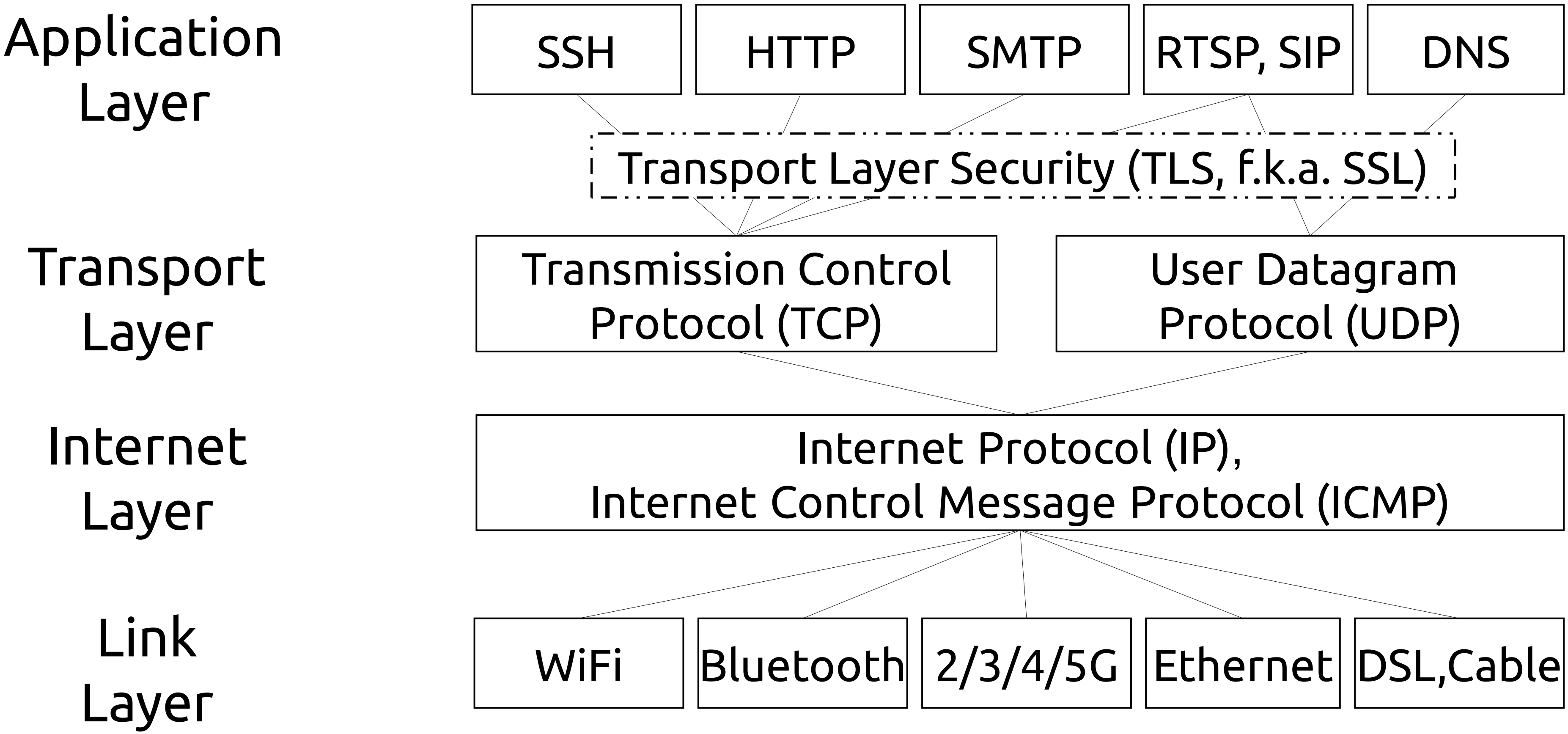
Wireless basics: ISM bands

- ISM = Industrial/Scientific/Medical
  - Bands designated for unlicensed use, commonly 434 MHz/915 MHz (US/EMEA), 2.45 GHz, 5.8 GHz
- Any equipment may transmit on these bands:
  - Microwave ovens (commonly 2.4 GHz)
  - Industrial processes (e.g. plastic welding)
  - Tumor treatment (also with microwaves)
- Also allowed for communications devices
  - E.g. WLAN & Bluetooth in 2.45 GHz band, must be able to deal with ISM device interference

Wireless basics: ISO/OSI model

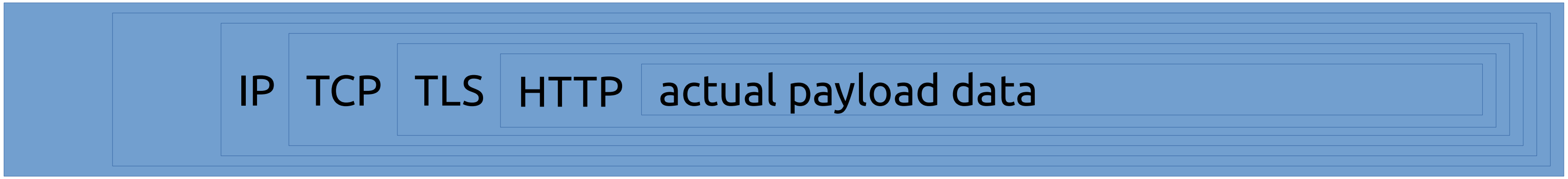


Wireless basics: TCP/IP stack



Recap: network stack protocols

- Layered protocols → nested data packets
- Packets consist of header + payload
- Payload of protocol 1 = packet of protocol 2



Wireless: summary

- Many physical issues (refraction, absorption, antenna geometry, power limits …)
- Wireless spectrum is highly contested
  - Many sources of interference
  - Limited bandwidth available
- Complex interleaved HW/SW stack

Key issue: I/O

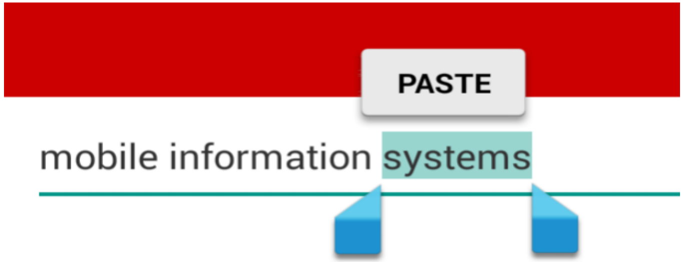
Image source (FU): The Simpsons (S21E11), Fox Broadcasting Company

- Different I/O capabilities
  - Small screens, often no physical keyboard
  - Text entry/precision work much slower ("Fat finger problem")
  - Less room for displaying data (cf. InfoVis)
  - Use other channels …
    - For input: touch, gestures, motion, camera, location, …
    - For output: vibration, sound, speech, notification LED, …
  - Tradeoff: size/weight I/O features?

I/O issues: touch (1)

Image source (FU): http://tactustechnology.com/wp-content/uploads/2014/08/White-Paper-New-Tagged-PDF.pdf

- No haptic feedback (unlike keyboards)
  - “Phorm” overlay by Tactus
- Occlusion
  - Hand/fingers covers part of display
  - Choose suitable screen layout in advance
- Precision
  - finger hits multiple pixels at once & covers target
  - Use handles, menus with offset



I/O issues: touch (2)

Image source (PD): https://en.wikipedia.org/wiki/Midas#/media/File:Midas_gold2.jpg

- No “hover” state (unlike mouse)
  - Every touch immediately triggers an action
  - “Midas Touch Problem”
    - Everything touched turns to gold
    - Problems with food, relatives etc.
  - Also in eye-tracking
  - (Partial) solution: wait with action until touch lifted off

I/O issues: gestures

- Discoverability
  - How do I know which gestures are available?
  - Even more difficult for complex gestures
- "Natural" interaction
  - What's a natural gesture?
  - Strong personal & cultural preferences
- No standards
  - E.g. tap-and-hold, swipe, double tap can have very different meanings depending on app/OS
  - Exception: pinch-zoom

I/O issues: bimanual interaction

Image source (CC): https://en.wikipedia.org/wiki/Text_messaging#/media/File:Texting.jpg

- Symmetric
  - Both hands have same role, e.g. typing with both thumbs
- Asymmetric
  - Hands have different roles, e.g. one hand holds device, other hand types
- Often not possible:
  - One hand may be required for other tasks
  - Thumb-only usage sometimes difficult

I/O issues: speech

- Speech input
  - Mostly used for hands-free dialing (in car)
  - Siri, Cortana, Google Now: more complex speech recognition offloaded to cloud service
  - Apparently not widely used (have you ever seen someone talk to Siri like in the commercial?)
- Speech output
  - Mostly used for car navigation
  - Again, not widely used otherwise
- Cultural differences (e.g. US vs. Europe)?

I/O issues: motion

- Motion as output
  - Mostly vibration alerts (binary channel, sometimes with patterns)
  - Moving/shape-changing phones exist as concepts (cf. http://www.fabianhemmert.com/projects)
- Motion as input
  - Accelerometer, inertial measurement unit (IMU)
  - Can only sense *relative* position, not absolute
  - Needs combination with GPS, marker tracking, …
  - Sensitive to interference (magnetic fields)
  - Use secondary device, e.g. smartwatch?

I/O issues: vision

- Vision as input (camera)
  - Input of barcodes/QR codes, text recognition (OCR), 3D structure reconstruction (SLAM)
  - Computer vision needs to deal with wildly different lighting conditions (indoor/outdoor)
- Vision as output: display
  - Size/resolution: very high information density, suitable information visualization required
  - Brightness/contrast: readable in sunlight?
- Combination: augmented reality

I/O issues: other channels

- Bio sensors
  - Fingerprint, heart rate, skin conductivity
  - Privacy issues?
- Miscellaneous
  - Back-of-device touch sensors
  - Notification LEDs and sounds
  - Location sensors (GPS etc.)
  - Buttons
- Spoilt for choice? Too “exotic” for user?

I/O: summary

- Wide variety of very different I/O channels
  - Primary: touch input, visual output
  - Secondary: motion, camera, audio, …
- Not necessarily limited by size, other tradeoffs (e.g. features   learning curve)

Key issue: context

- Unpredictable usage context
  - Environment
  - Location/position
  - Social context
  - Activity context
  - Context recognition?

Context: environment

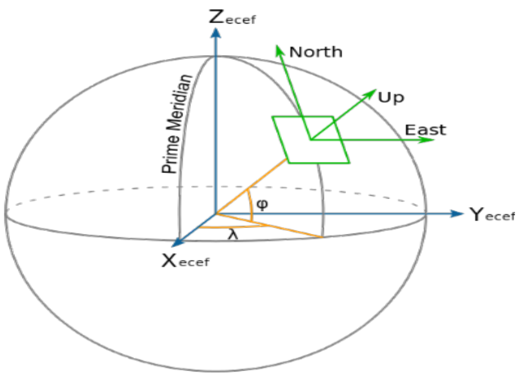
Image source (CC): https://en.wikipedia.org/.../File:Cell_phone_use_while_driving.jpg

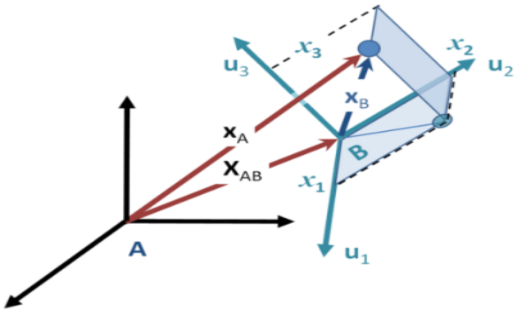
- Motion
  - User moving on her/his own
  - User being moved (bus, car)?
- Sound
  - Noisy or quiet?
  - Should remain quiet (concert)?
- Light
  - Bright or dark?
  - Should remain dark (movie theatre)?

Context: geometric

Image source (CC): ECEF_ENU_Longitude_Latitude_relationships.svg, Moving_coordinate_system.PNG

- Geographic context
  - Moves with the user
  - Absolute location (~ 3DOF)
  - Use GPS/compass
- User/device context
  - Moves relative to the user
  - Relative location/orientation (6DOF)
  - Often more difficult to determine
  - Higher precision required?





Context: social

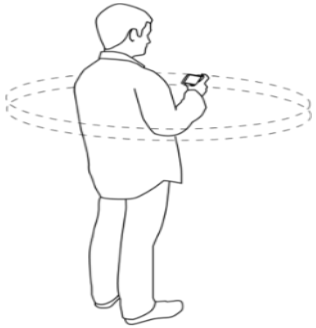
Image source (CC0): http://pixabay.com/p-193357/?no_redirect

- Expected user base?
  - "Techies", grannies, "normal" users, …
- Acceptable behaviour?
  - Talking loudly, taking pictures, …
  - Depends on location: subway car or church?
- Privacy
  - "Shoulder surfers" snooping on passwords
  - Temporary sharing with other persons (e.g. map)

Context: activities

Image source (FU): LMU lecture by J. Wagner

- Physical activities of the user
  - Walking, standing, sitting at a table, …
  - Influences available precision & attention
- “Virtual” activities
  - Taking pictures, looking at maps, using social networks, reading website, …
  - Quick access to related activities
- Seamless context switching?
  - Continuing activities in different context, e.g. on desktop computer?



Context: recognition

Image source (FU): http://www.gettyimages.com/gi-resources/ub/unfinishedbusiness/index.html

- Example: automatic meeting detection

  → Disable audible notifications,
  send all calls to voicemail

- Problem: what if it fails?
  - False positive: user misses important call
  - False negative: phone plays embarrassing ringtone in meeting
- Must be very, very accurate to earn user trust

Context: summary

- Very broad range of possible usage contexts
  - Consequently, automatic classification is hard
  - Influence on possible/allowed user actions
- Related issues: safety, privacy, security

Key issue: security/privacy (1)

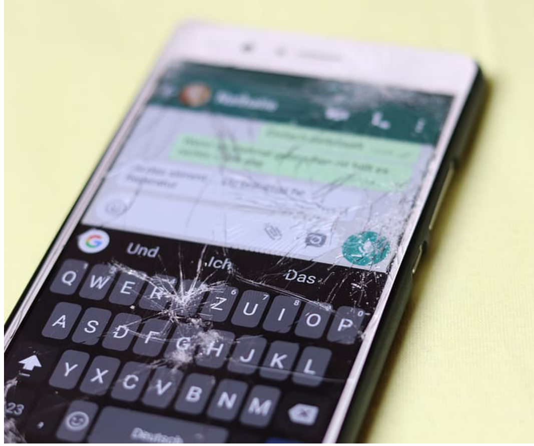
- Huge amounts of private & personal data on mobile devices
  - Contact information, messages & e-mails
  - Visited websites, pictures
  - PIN/TAN codes
- Many people want access to that data
  - Google, Facebook, Microsoft (for selling ads)
  - NSA, GCHQ, BND etc. (for catching criminals)
  - Hackers (for stealing/extorting your money)

Key issue: security/privacy (2)

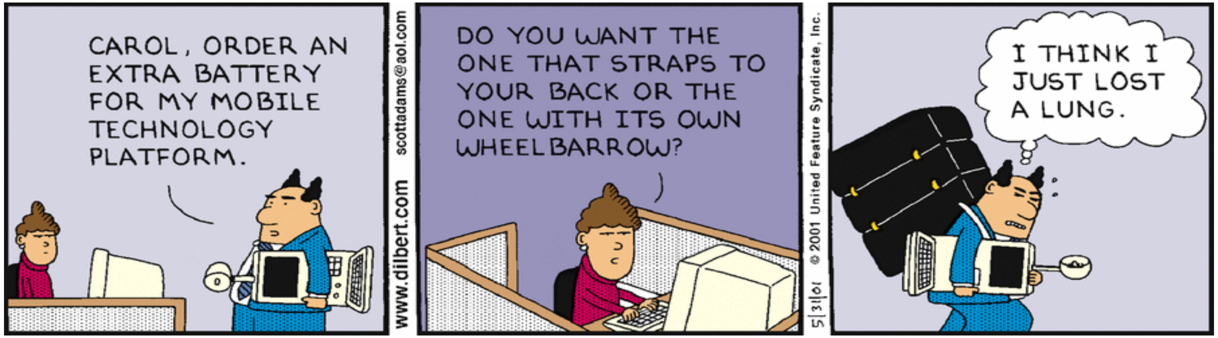
- Problem 1: no pervasive encryption
  - Strong opposition from government snoopers (up to demanding "key escrow", cf. WhatsApp)
  - Lost/found phones often trivial to access
- Problem 2: voluntary use of cloud services
  - Reasons discussed earlier (storage, processing)
  - Requires trusting at least one, usually several 3rd parties (outsourcing)

Key issue: sustainability

- Current: ~ 2 year lifecycle of mobile phones
- Fundamental feature set hasn’t change since ~ 2015
- Mostly due to lack of software updates (on Android)
- Alternatives: FairPhone, LineageOS, etc.
- “Right to Repair”?



The End



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DO YOU WANT THE ONE THAT STRAPS TO YOUR BACK OR THE ONE WITH ITS OWN WHEELBARROW?
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5/31/01
I THINK I JUST LOST A LUNG.