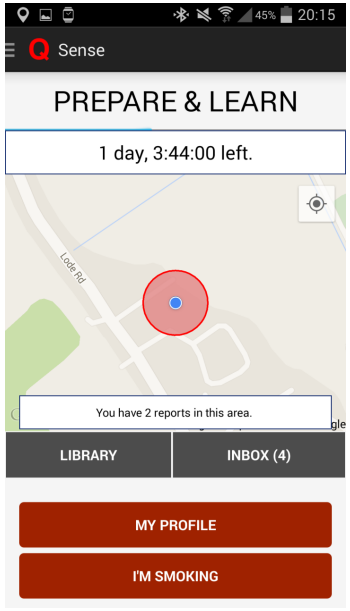
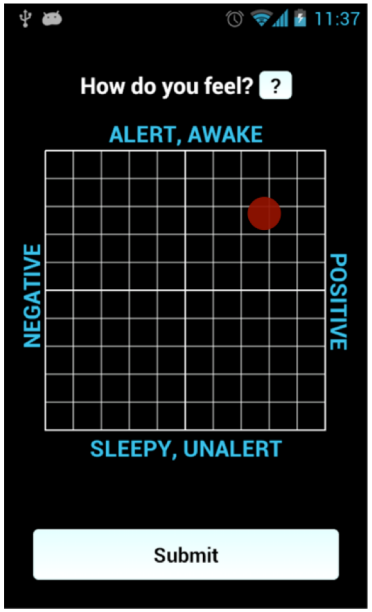
Mobile and Sensor Systems

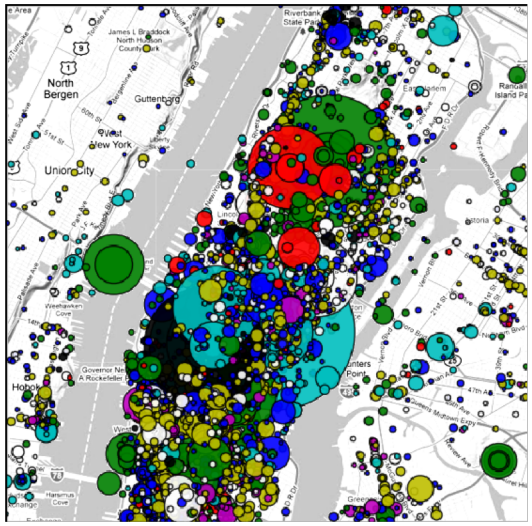
Lecture 1: Mobile Systems and Medium Access Control

Prof Cecilia Mascolo

About Me







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In this course

- The course will include aspects related to general understanding of
  - Mobile and ubiquitous systems and networks
  - Sensor systems and networks

List of Lectures (1)

- Lecture 1: Intro to Mobile Systems and MAC Layer Concepts.
- Lecture 2: Infrastructure and Opportunistic Mobile Networks.
- Lecture 3: Intro to Sensor Systems, MAC and IoT.
- Lecture 4: Sensor Routing Layer Protocols.
- Lecture 5: Mobile Sensing Modelling and Inference

List of Lectures (2)

- Lecture 6 Mobile Sensing: Systems Considerations
- Lecture 7: Privacy in Mobile and Sensor Systems
- Lecture 8: Indoor Localization
- Lecture 9: Compressed Sensing
- Lecture 10: BLE 1
- Lecture 11: BLE 2
- Lecture 12: Mobile Robots

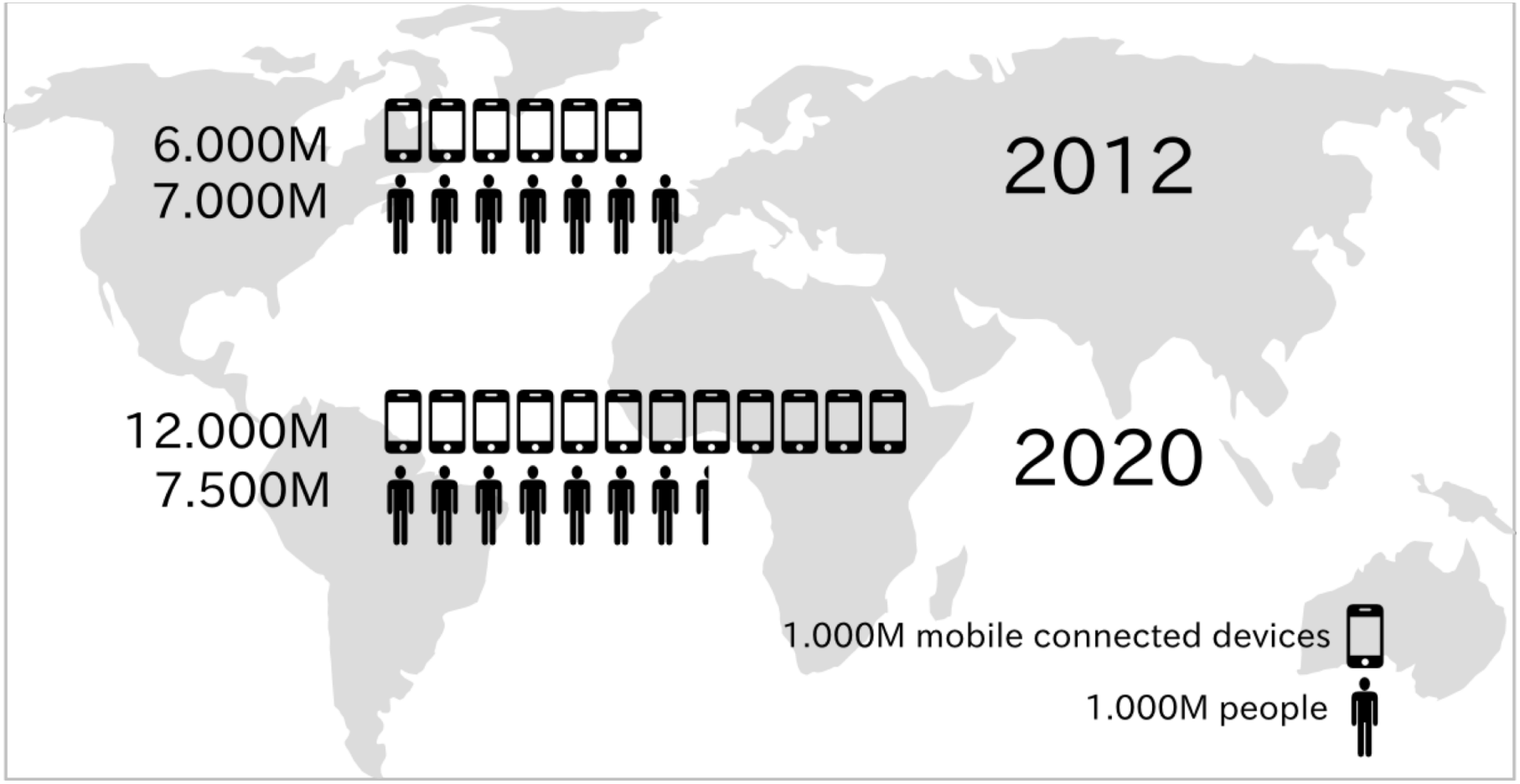
Teaching Material

- Specific lectures will reference research papers which can be used for additional reading.
- No required textbook.
- Some suggested general readings:
  - Schiller, J. (2003). Mobile communications. Pearson (2nd ed.).
  - Karl, H. & Willig, A. (2005). Protocols and architectures for wireless sensor networks. Wiley.
  - Agrawal, D. & Zheng, Q. (2006). Introduction to wireless and mobile systems. Thomson.

In this lecture

- We will describe mobile systems and their applications and challenges.
- We will start talking about wireless networks and medium access layer protocols.

World Population vs Devices



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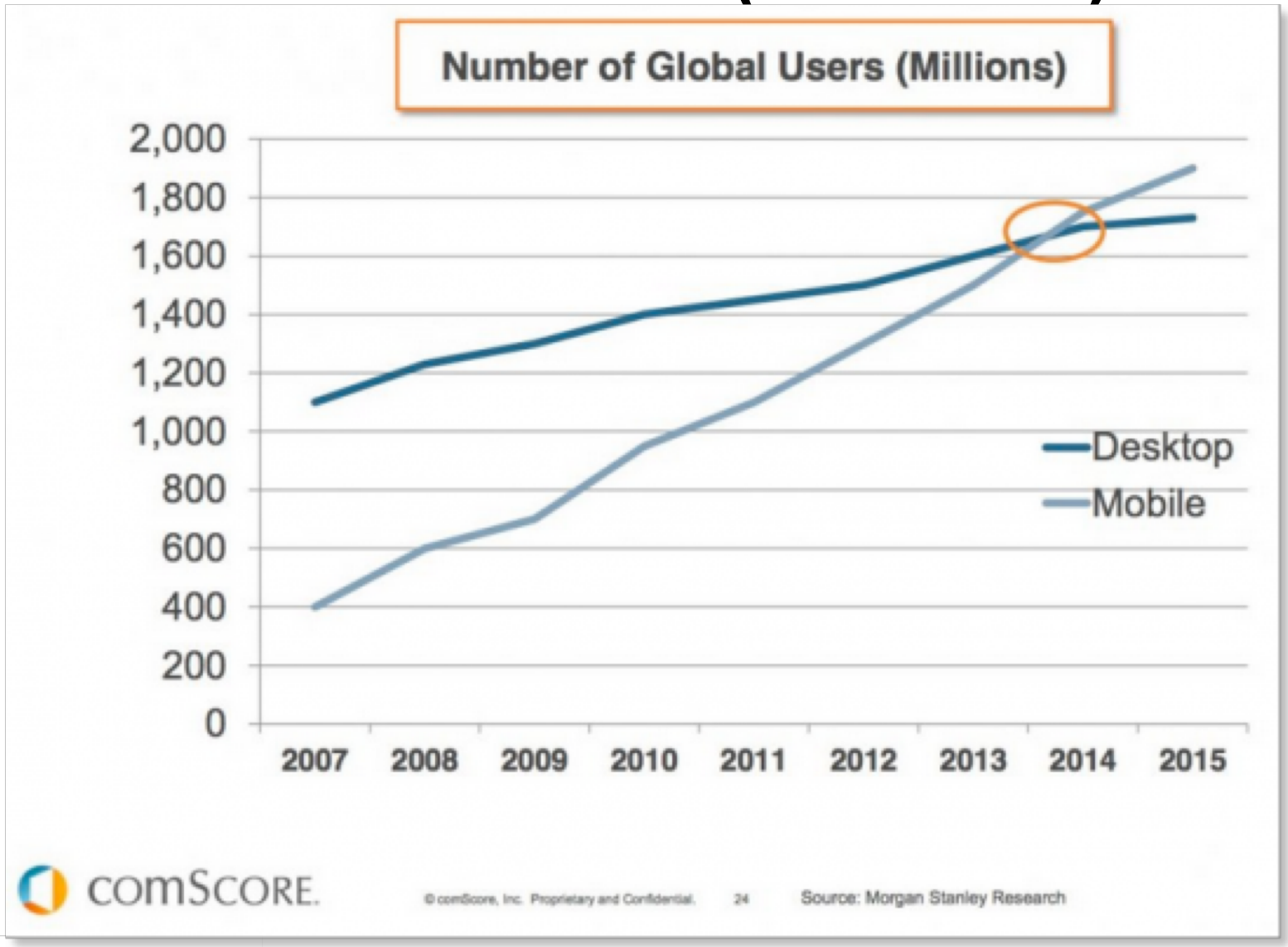
Mobile Users (Millions)



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For many, a mobile device is the only way to access the Internet

Country	Mobile-Only Internet Users
Egypt	70%
India	59%
South Africa	57%
Indonesia	44%
United States	25%

Source: OnDevice Research

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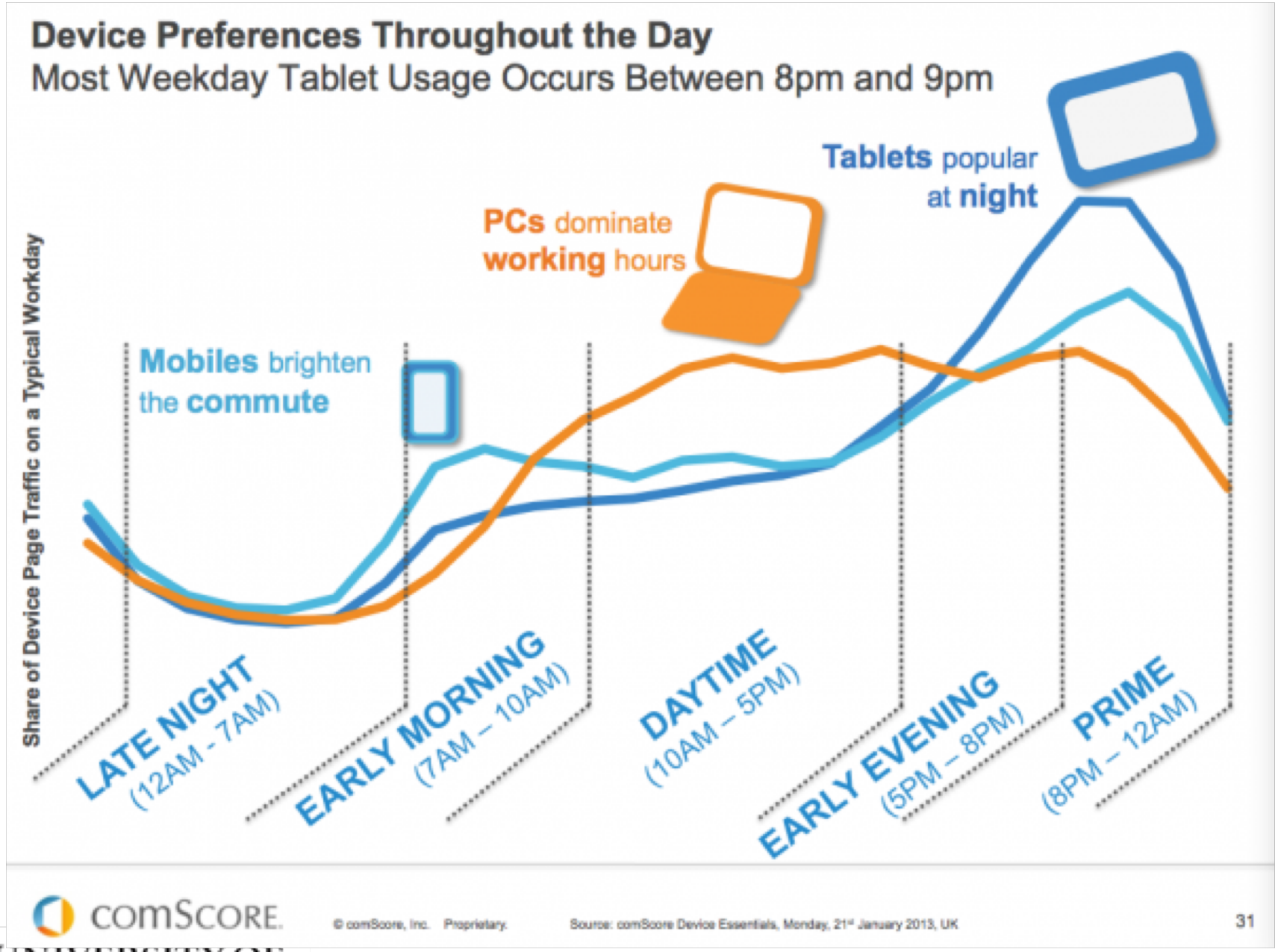
Some Numbers

- The number of cellular subscribers surpasses the number of wired phone lines.
- Over 36% of mobile subscribers use iPhones or iPads to read email and 34% of subscribers only use mobile devices to read emails.
- Over half of an average adult's daily Internet usage time is spent on mobile devices.
- From June 2013 to June 2015, mobile app usage time grew by 90%.
- Over 50% of smartphone users grab their smartphone immediately after waking up.



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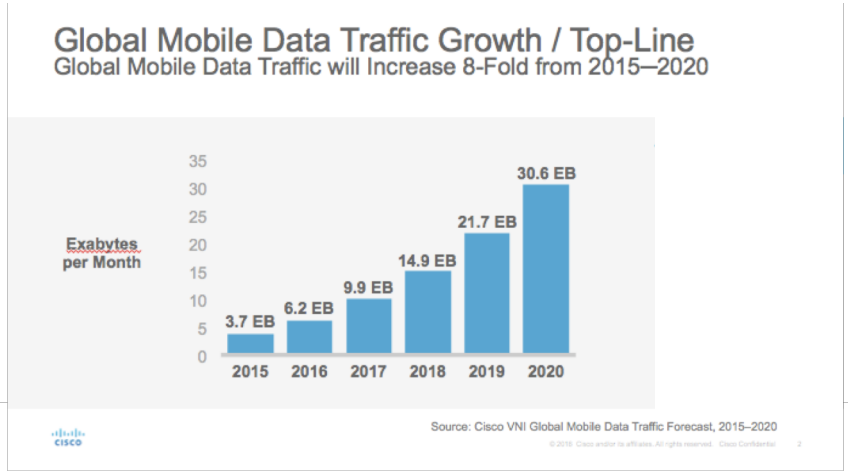
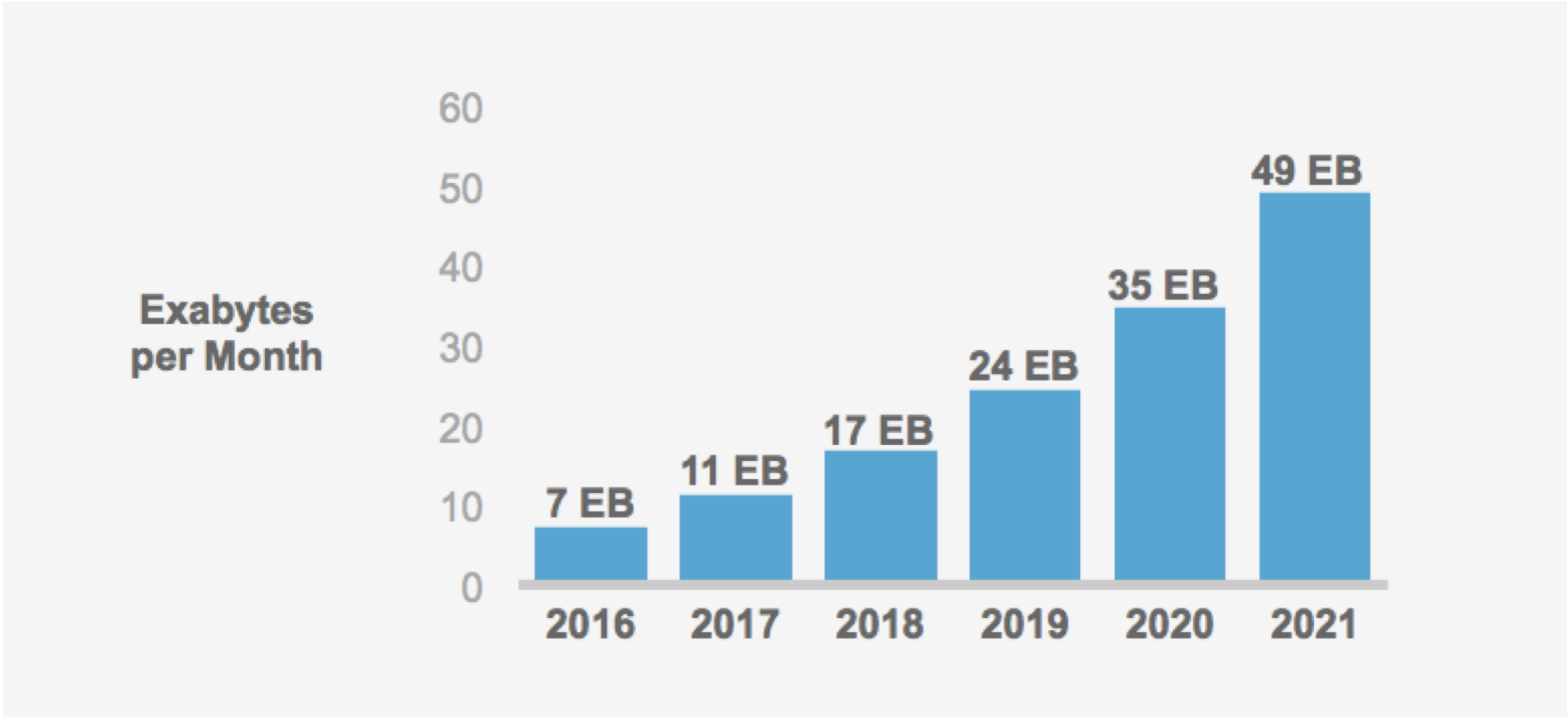
Mobile Data



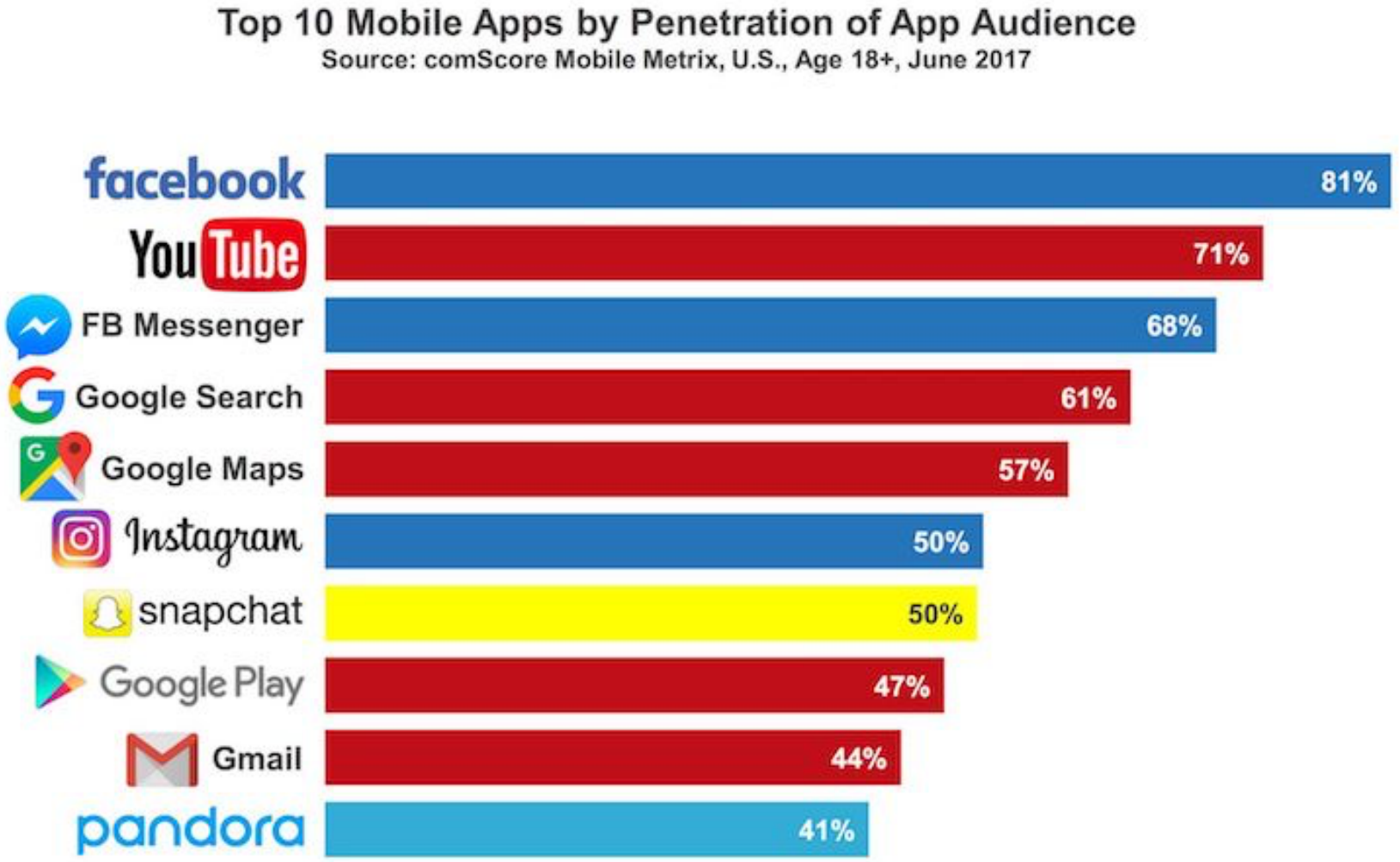
Global Mobile Data Traffic Growth / Top-Line

Global Mobile Data Traffic will Increase 7-Fold from 2016–2021



Source: Cisco VNI Global Mobile Data Traffic Forecast, 2016–2021

Which App…



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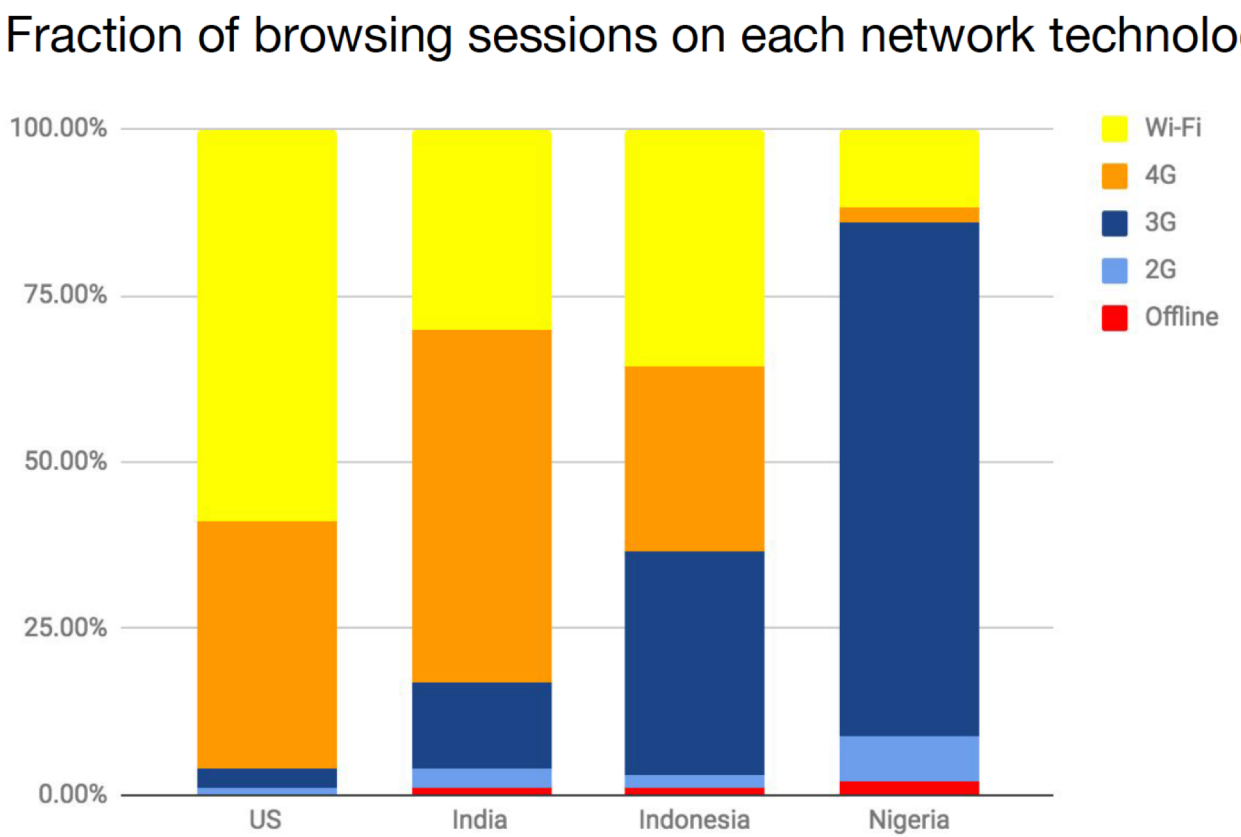

Source: Chrome logs

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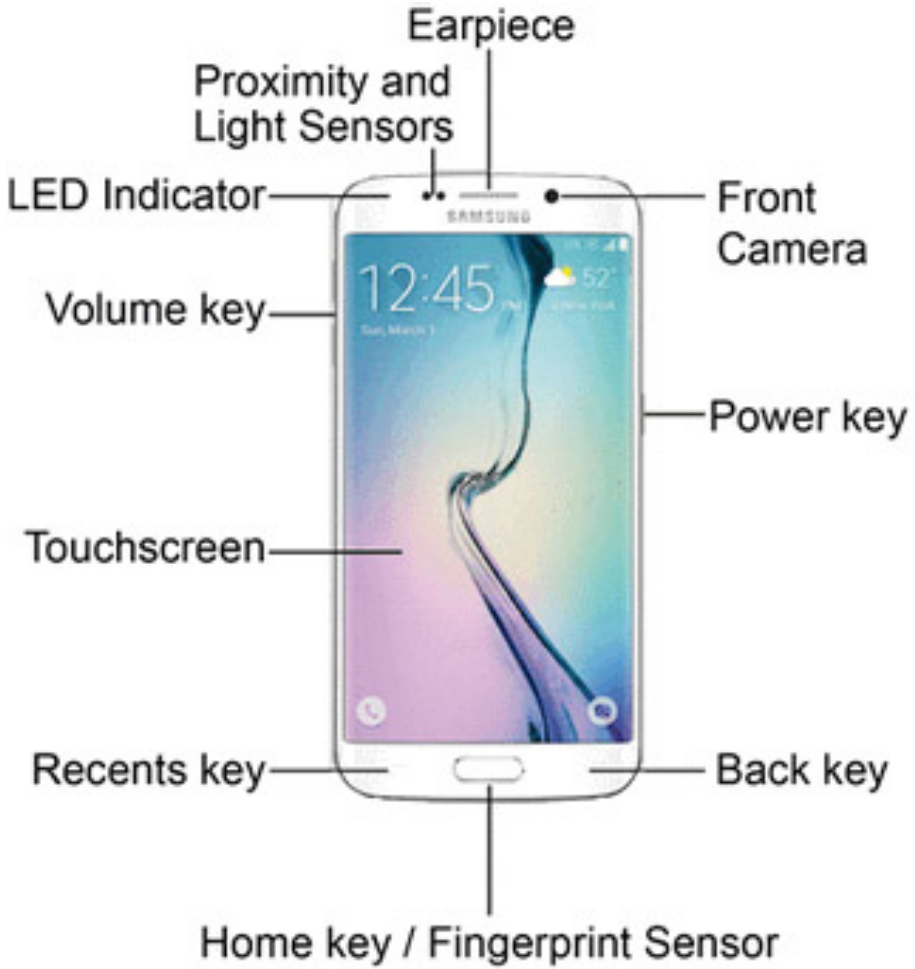
Phone Sensors and Radios



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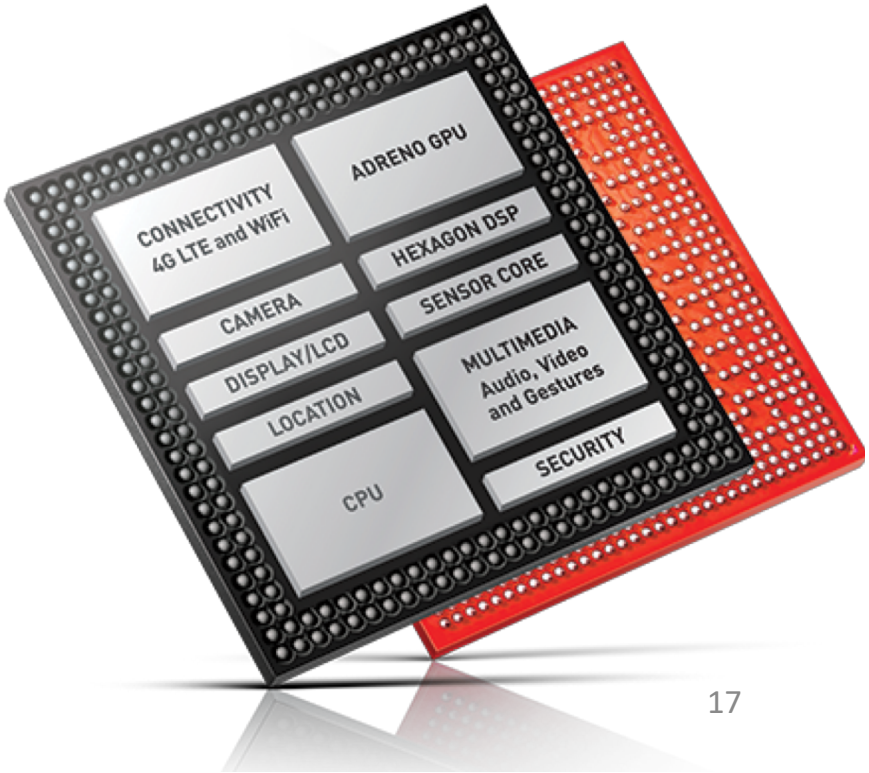
Phone Computation Units



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Fundamental Challenges in Mobile Computing

- Mobile devices are resource-constrained.
- Mobile connectivity is highly variable in performance and reliability.
- Mobile devices are inherently less secure.

Mobile Devices are Inherently Resource Constrained

- Mobile devices rely on batteries.
- Energy consumption due to:
  - Computation (CPU, co-processors)
  - Display
  - Communication
  - Sensing
- Energy-efficient algorithms are needed.

Mobile Connectivity is Highly Variable in Performance and Reliability

- Various types of connectivity:
  - Cellular (GSM, 3G, 4G, etc.)
  - WiFi
  - Bluetooth
  - Near Field Communication (NFC)
  - …
- Constraints related to:
  - Coverage issues
  - Trade-offs: energy consumption, throughput, costs

Mobile Devices are Inherently Less Secure

- Wireless not wired communication:
  - Eavesdropping.
  - Need for encrypted communication.
- Devices can be stolen:
  - Devices might also be accessible by everyone (for example, sensors).

Issues in Designing Mobile Computing Systems

- Distributed systems issues:
  - Remote communication
  - Fault tolerance
  - Remote information access
  - Distributed security
- Networking issues:
  - Wireless communication
  - Transport layer for wireless channel

Issues in Designing Mobile Computing Systems

- Databases issues:
  - Disconnected operations
  - Weak consistency
- Energy issues:
  - Adaptation in terms of communication
  - Intelligent uploading of data
  - Hardware aspects

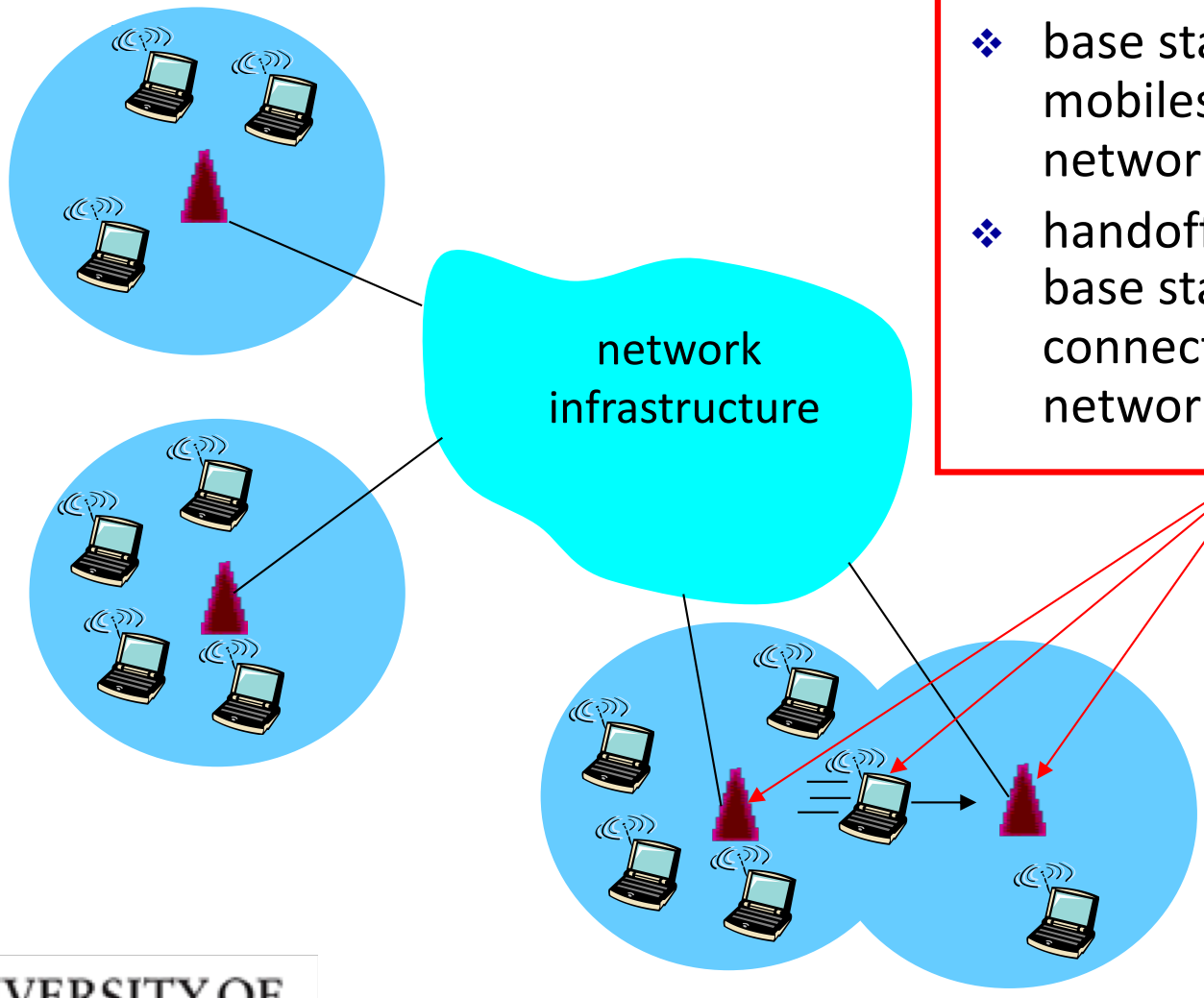
Issues in Designing Mobile Computing Systems

- HCI issues:
  - Limited interface
  - Interaction with the devices (input, etc.)
  - Ergonomics
- Privacy issues:
  - Location sharing
  - Activity recognition
- Security issues:
  - Encrypted communication

Infrastucture-based sv Ad-hoc

- Wireless communication can be organized in two different fashions :
  - This might depend on the application and on the network set up.

Infrastructure-based



infrastructure mode

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

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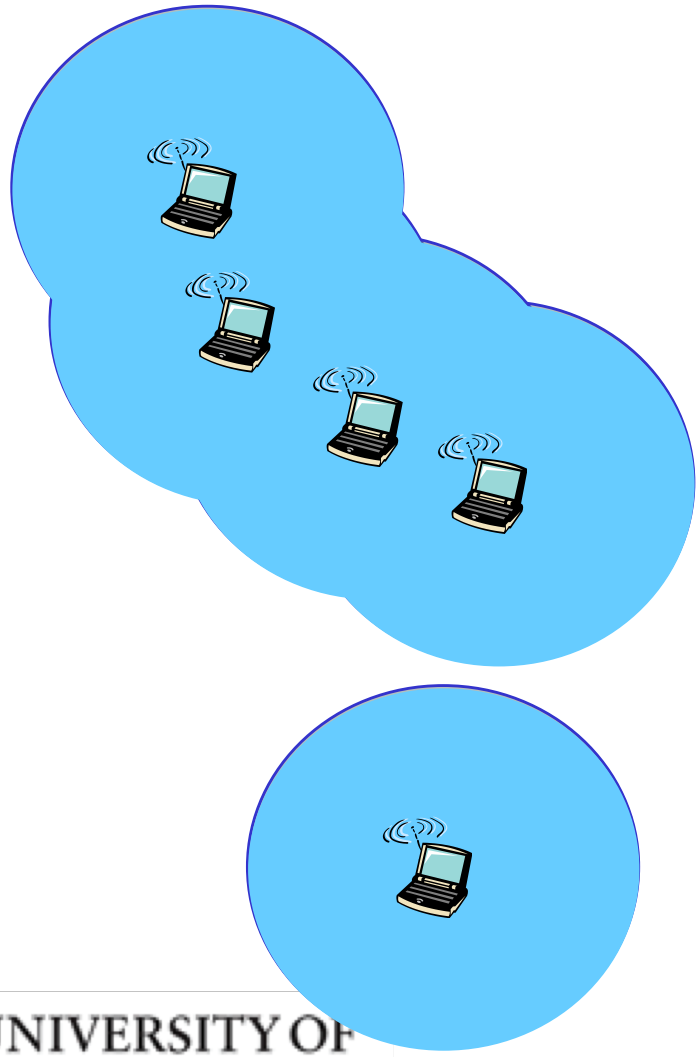
Ad-hoc



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

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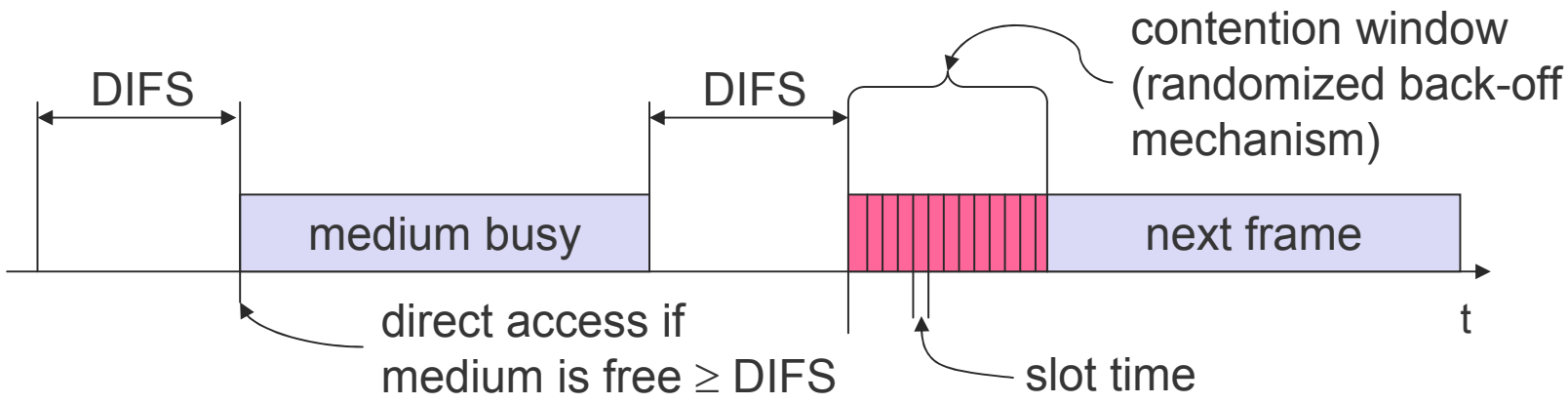
Wireless Medium as Shared Medium

- The access to the wireless needs to be shared among the various transmitters.
- How?
  - Multiplexing the medium:
    - Time (fixed or dynamic)
    - Space
    - Frequency
    - Code

Limitations of multiplexing

- Multiplexing is one way to share the medium through the definition of "channels".
- Once channels are established, packets will be sent through that:
  - Might be a bit rigid as a method; for example, frequency division multiplexing would have issues with large numbers of users.
  - Also depending on traffic and time some users might want to send more or less;
- More ad hoc approaches exist which allow channels to be shared in a "statistical" way.

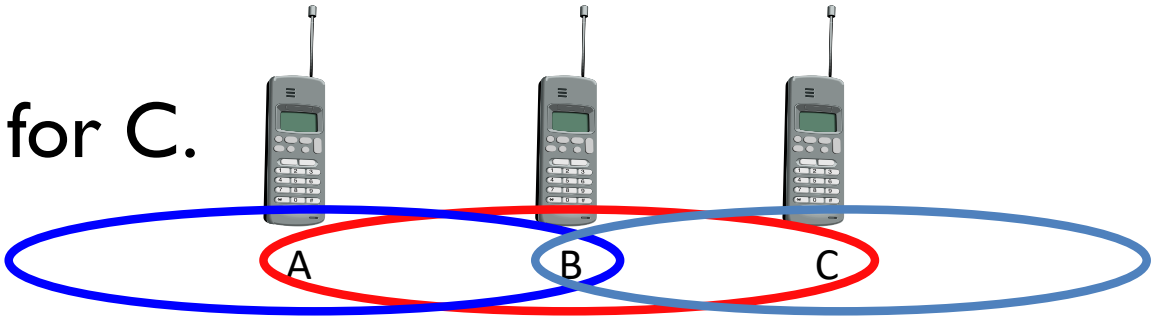
CSMA/CA: Carrier Sensing Multiple Access Protocol with Collision Avoidance



CSMA/CA: sense medium. If free transmit (although this might generate collision at the receiver). If not, wait with a back off strategy. Transmit when medium is sensed free.

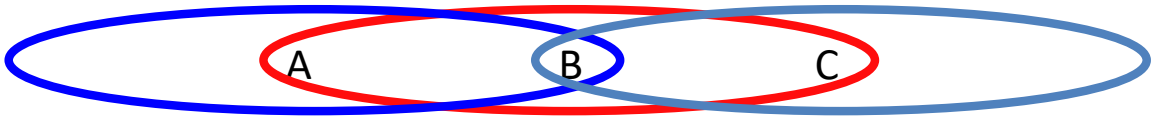
Hidden Terminal

- Hidden terminals:
  - A sends to B, C cannot receive from A.
  - C wants to send to B, C senses a "free" medium (CS fails).
  - Collision at B, A cannot receive the collision (CD fails).
  - A is "hidden" for C.



Exposed Terminal

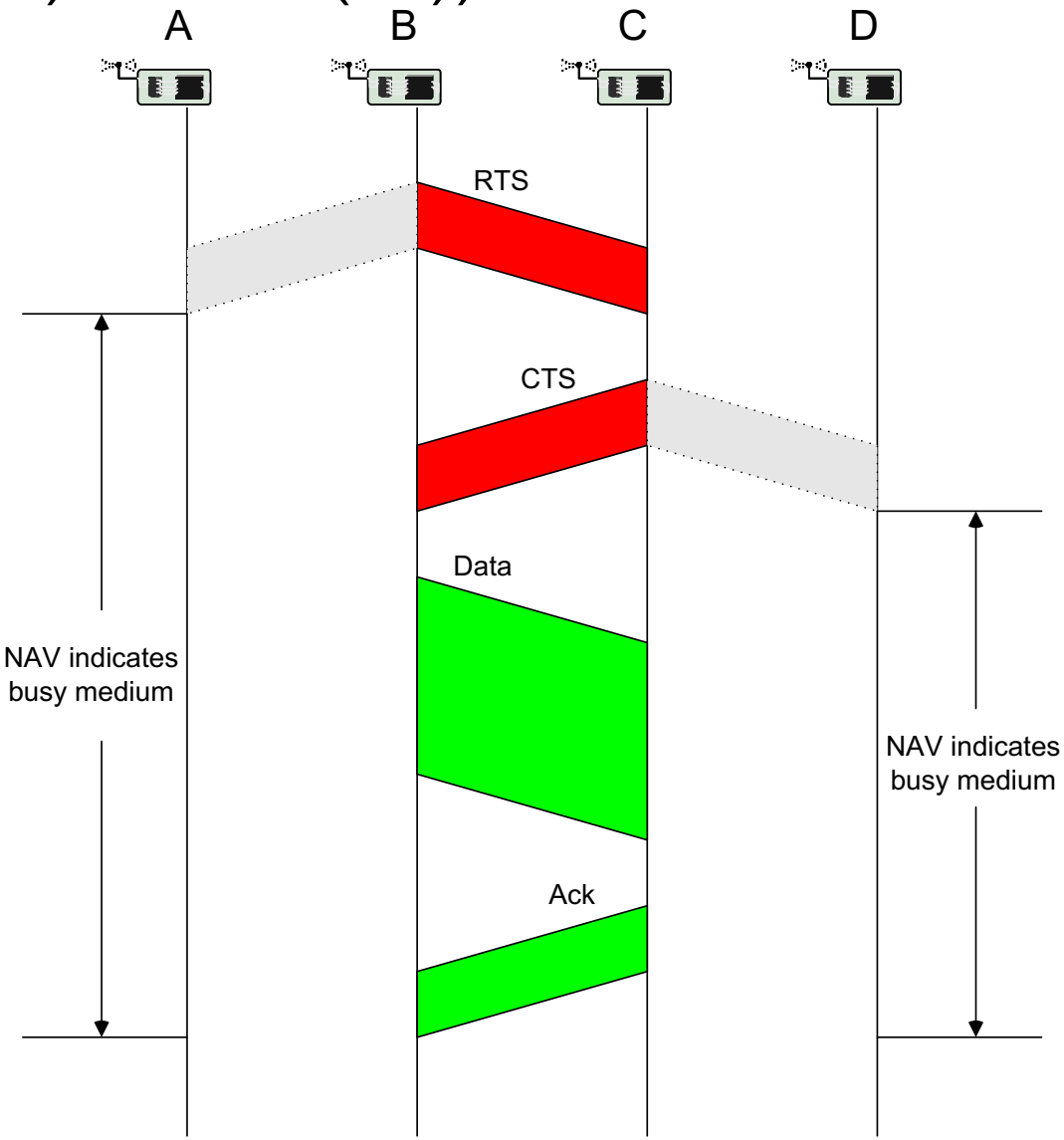
- Exposed terminals:
  - B sends to A, C wants to send to another terminal (not A or B).
  - C has to wait, CS signals a medium in use.
  - but A is outside the radio range of C, therefore waiting is not necessary.
  - C is "exposed" to B.



Multiple Access with Collision Avoidance (for Wireless): MACA(W))

- Sender B asks receiver C whether C is able to receive a transmission ***Request to Send (RTS).***
- Receiver C agrees, sends out a ***Clear to Send*** (***CTS***).
- Potential interferers overhear either RTS or CTS and know about impending transmission and for how long it will last.
  - Store this information in a ***Network Allocation Vector.***
- B sends, C acks:

! ***MACA(W) protocol*** (used e.g. in ***IEEE 802.11***).



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Summary

- We have introduced Mobile Systems, its peculiarities and challenges.
- We have talked about medium access control for mobile communication.

Suggested Readings

- Mark Weiser. The Computer for the 21th Century. Scientific American. September 1991.
- Mark Weiser. Some Computer Issues in Ubiquitous Computing. Communications of the ACM. Vol. 36. Issue 7. July 1993.
- M. Satyanarayanan. Pervasive Computing: Vision and Challenges. IEEE Personal Communications. Vol. 8 Issue 4. August 2001.
- Chapter 6 of James F. Kurose and Keith W. Ross Computer Networking. A Top Down Approach. 6th Edition. Pearson 2012.