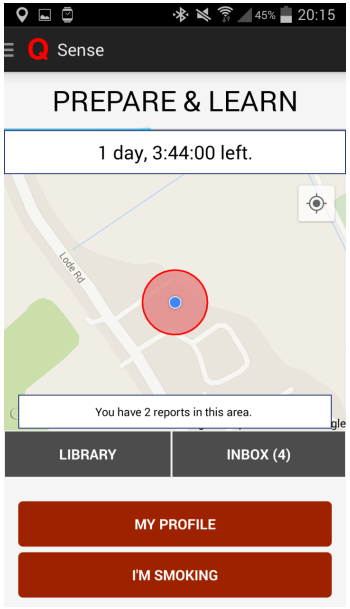
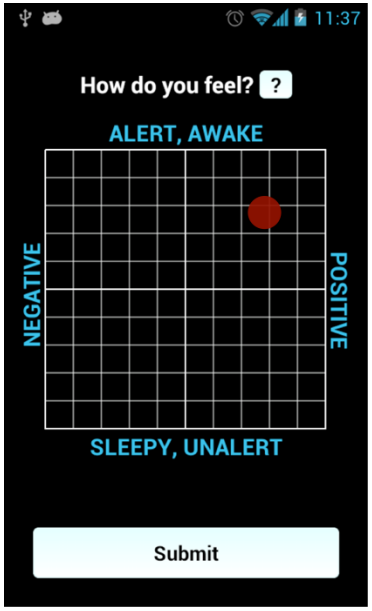
Mobile and Sensor Systems

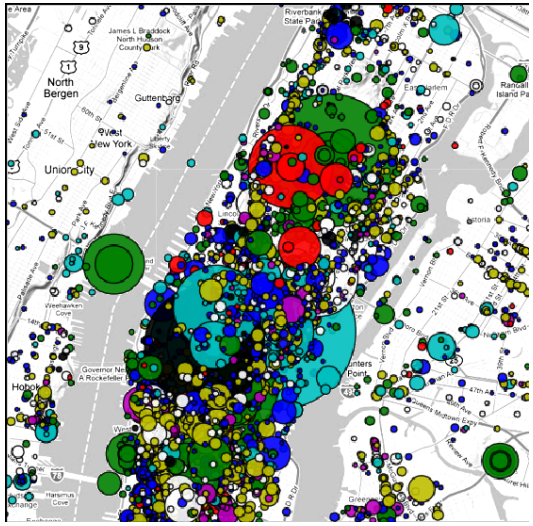
Lecture 1: Mobile Systems and Medium Access Control

Prof Cecilia Mascolo

About Me







UNIVERSITY OF CAMBRIDGE

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

- Lecture 1: Introduction to Mobile Systems and MAC Layer Concepts.
- Lecture 2: Infrastructure, Ad-hoc and Delay Tolerant Mobile Networks.
- Lecture 3: Introduction to Sensor Systems and MAC Layer Protocols.
- Lecture 4: Sensor Routing Protocols.
- Lecture 5: Mobile Sensing: Modelling and Inference
- Lecture 6 Mobile Sensing: Systems Considerations
- Lecture 7: Privacy in Mobile and Sensor Systems
- Lecture 8: Internet of Things and Sensor Integration

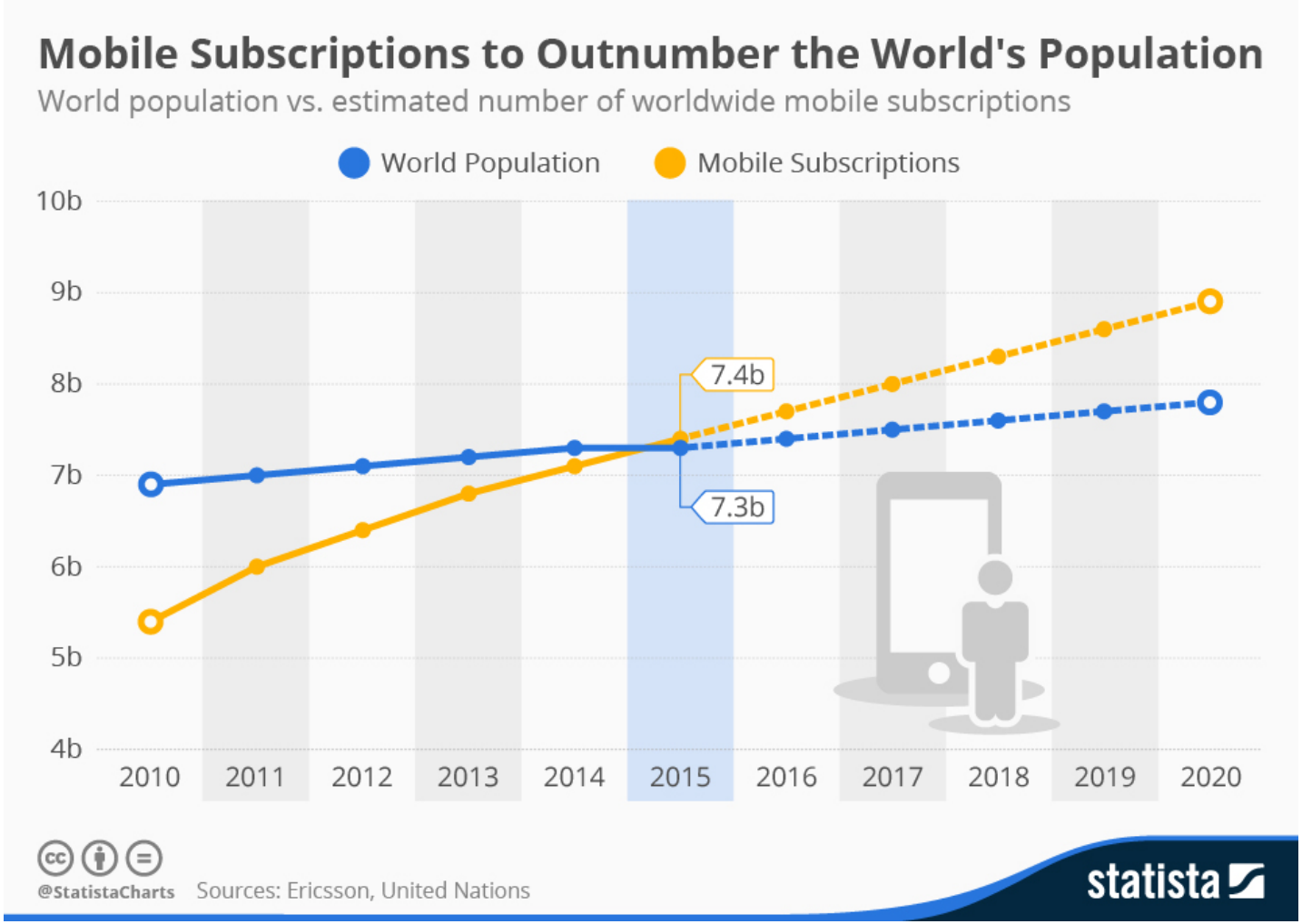
Teaching Material

- 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

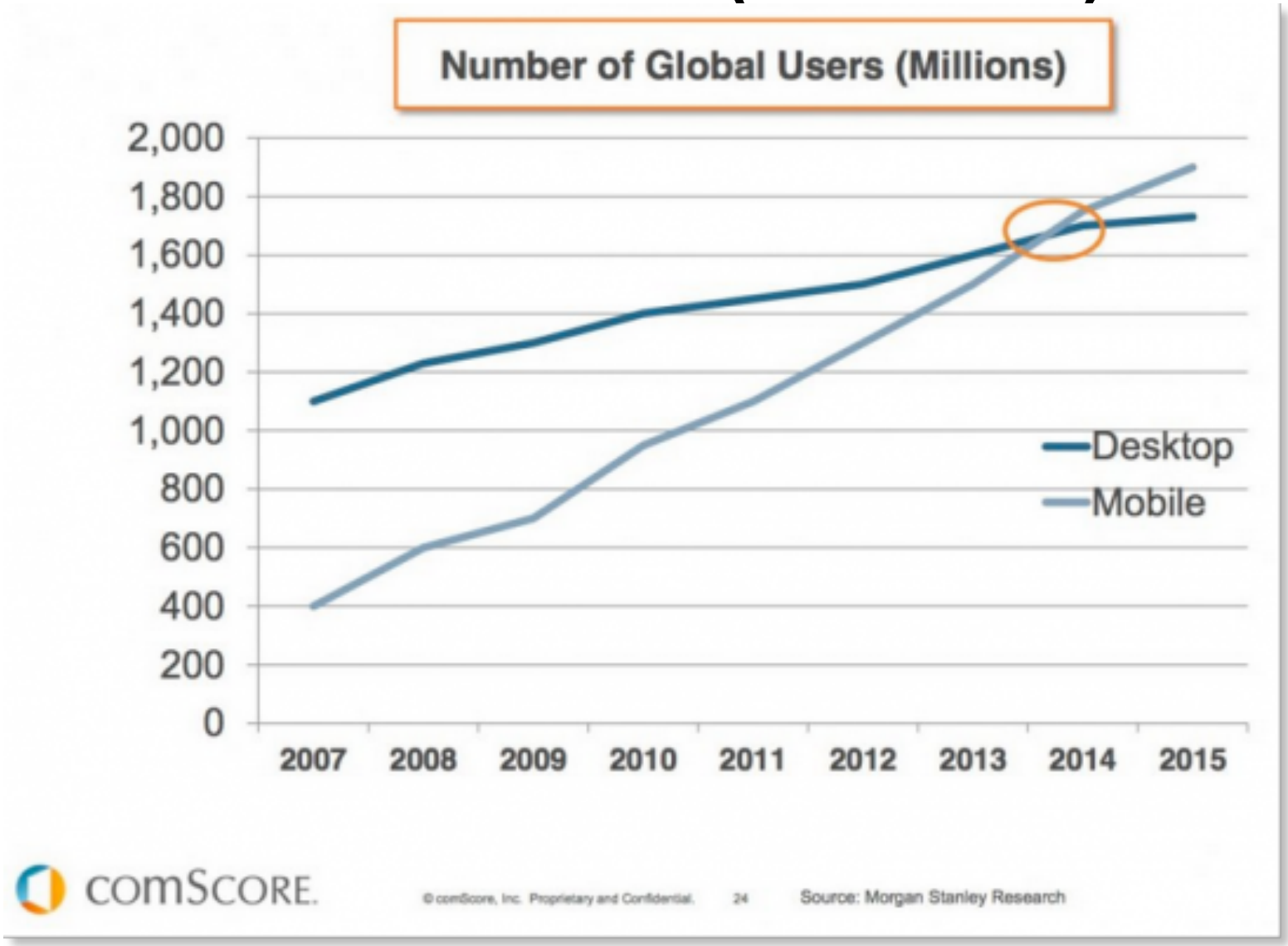
- We will describe mobile systems and their applications and challenges.
- We will start talking about wireless networks and medium access layer protocols.

Why Mobile Systems are Important



UNIVERSITY OF CAMBRIDGE

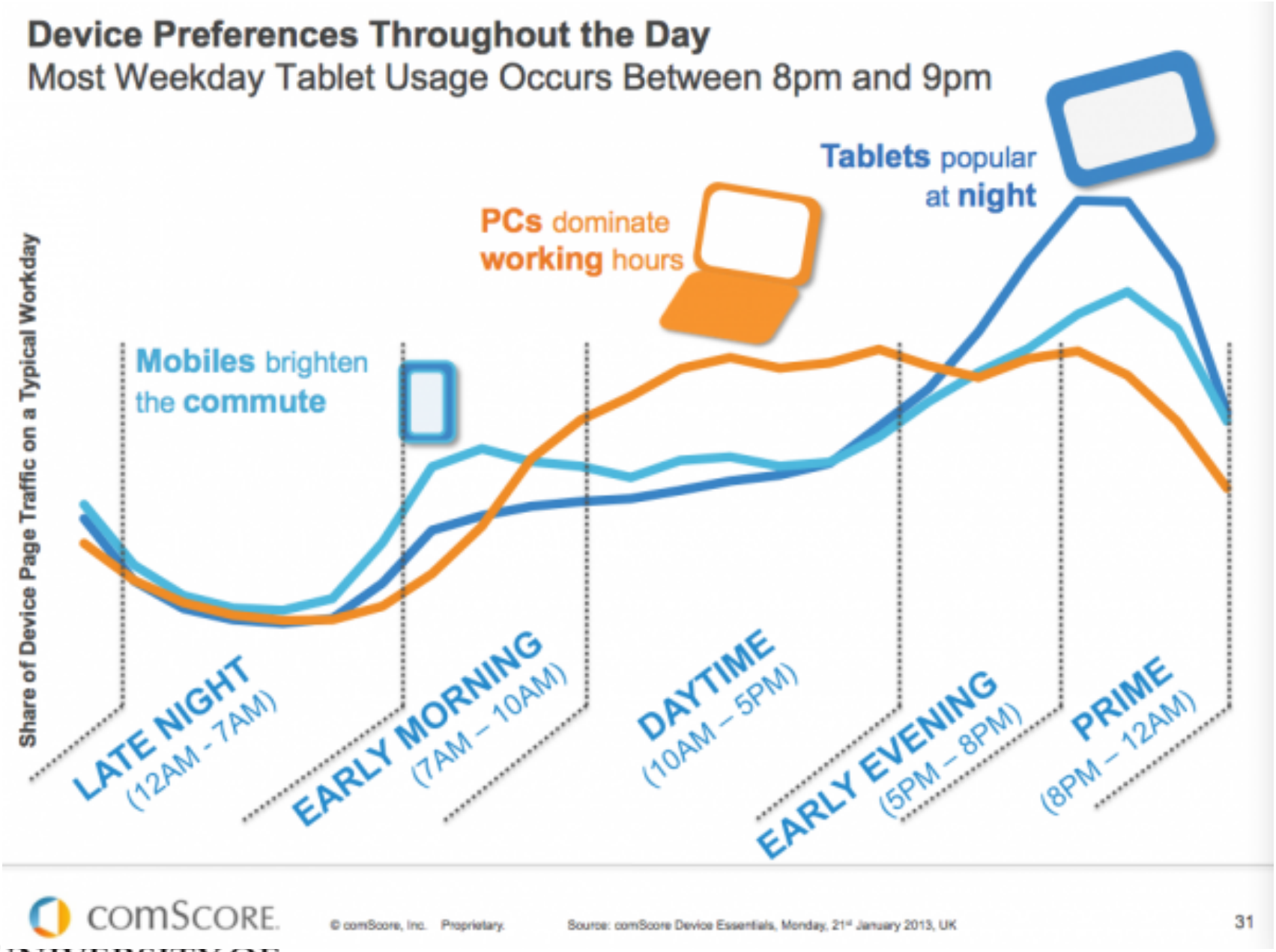
Mobile Users (Millions)



UNIVERSITY OF CAMBRIDGE

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.

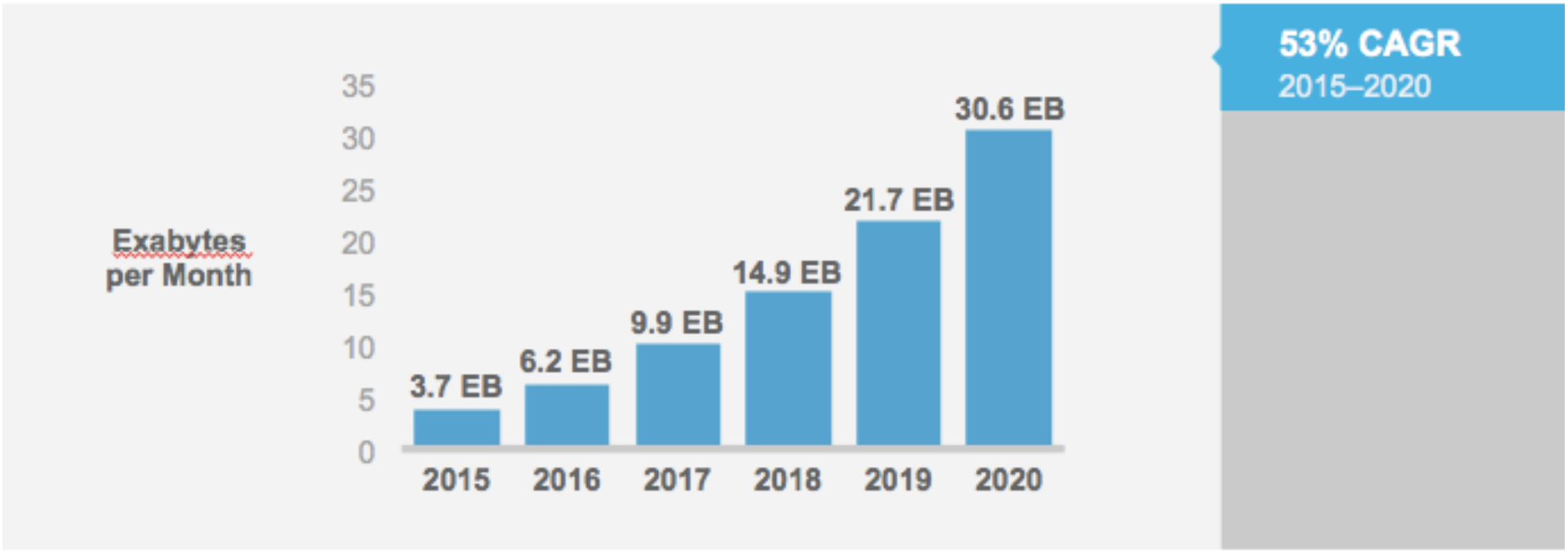


UNIVERSITY OF CAMBRIDGE

Mobile Data

Global Mobile Data Traffic Growth / Top-Line

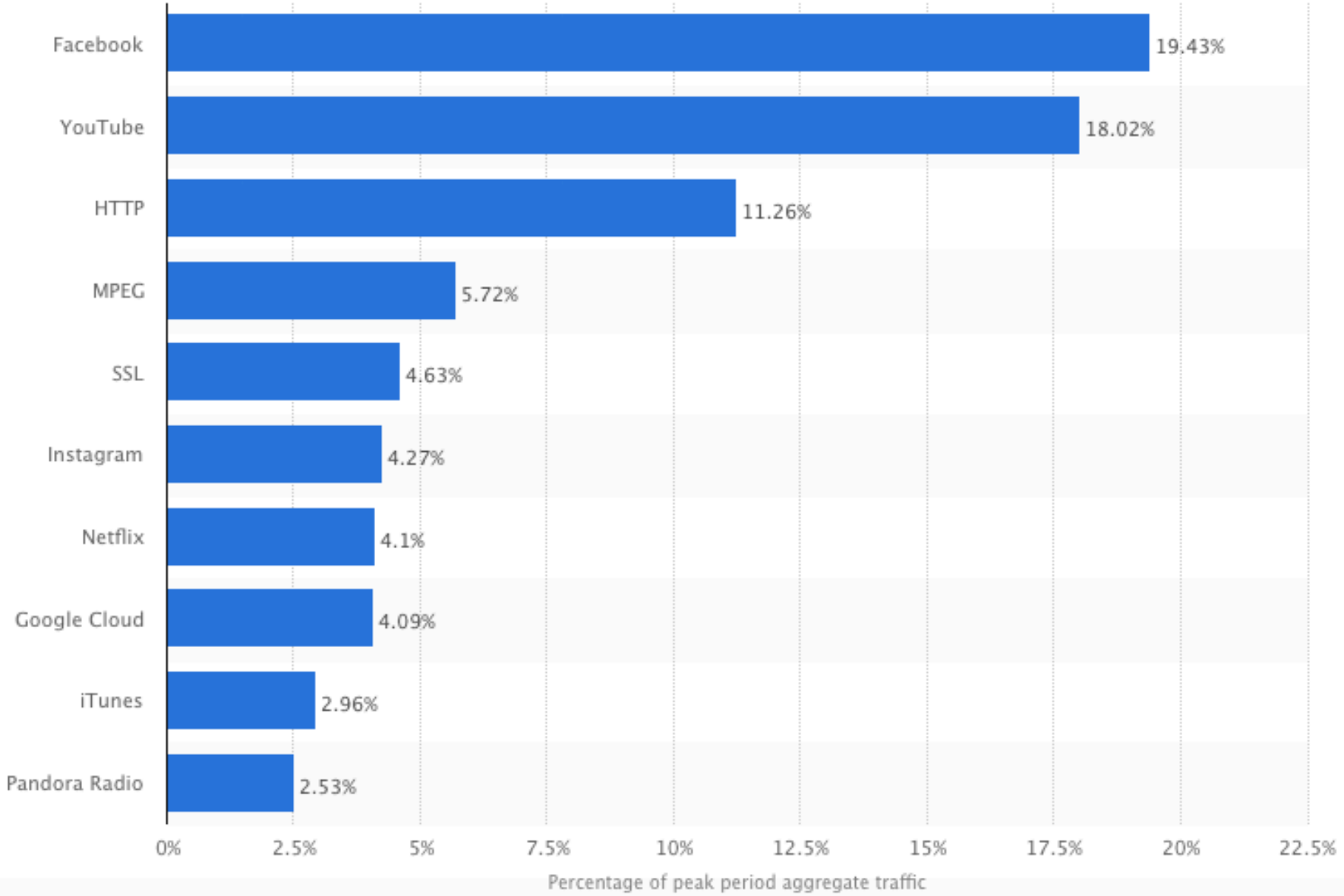
Global Mobile Data Traffic will Increase 8-Fold from 2015–2020



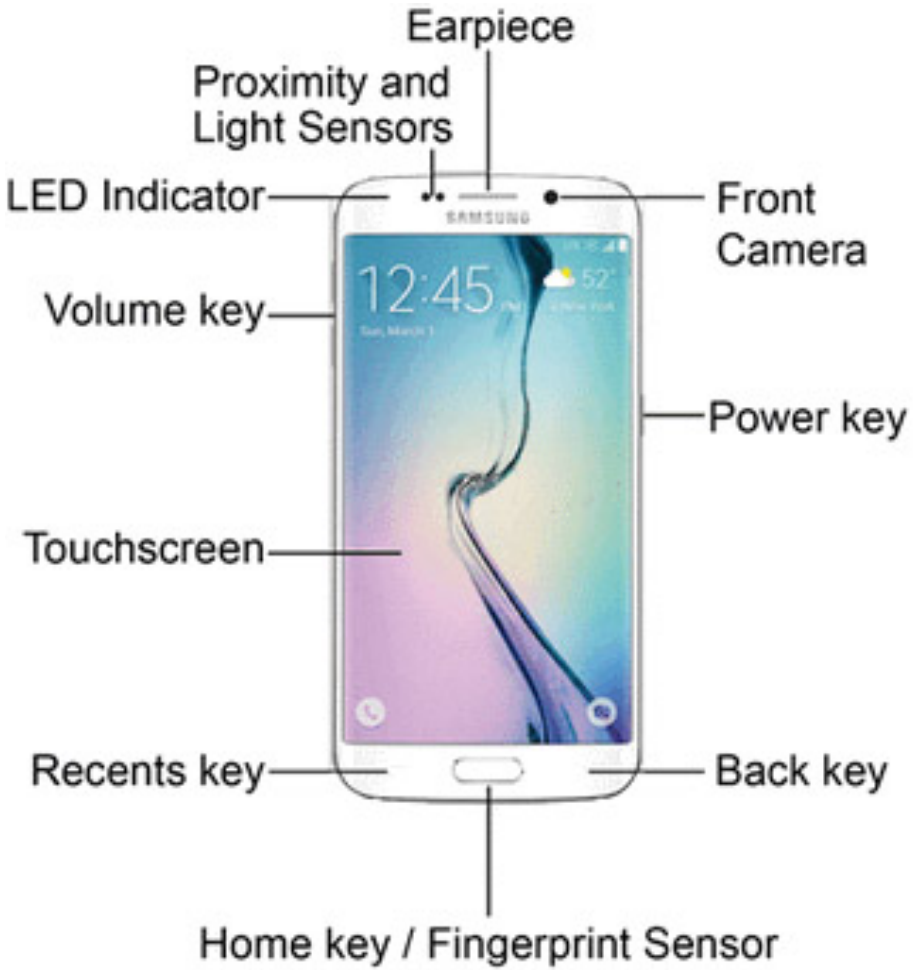
Source: Cisco VNI Global Mobile Data Traffic Forecast, 2015–2020

UNIVERSITY OF CAMBRIDGE

Which App…

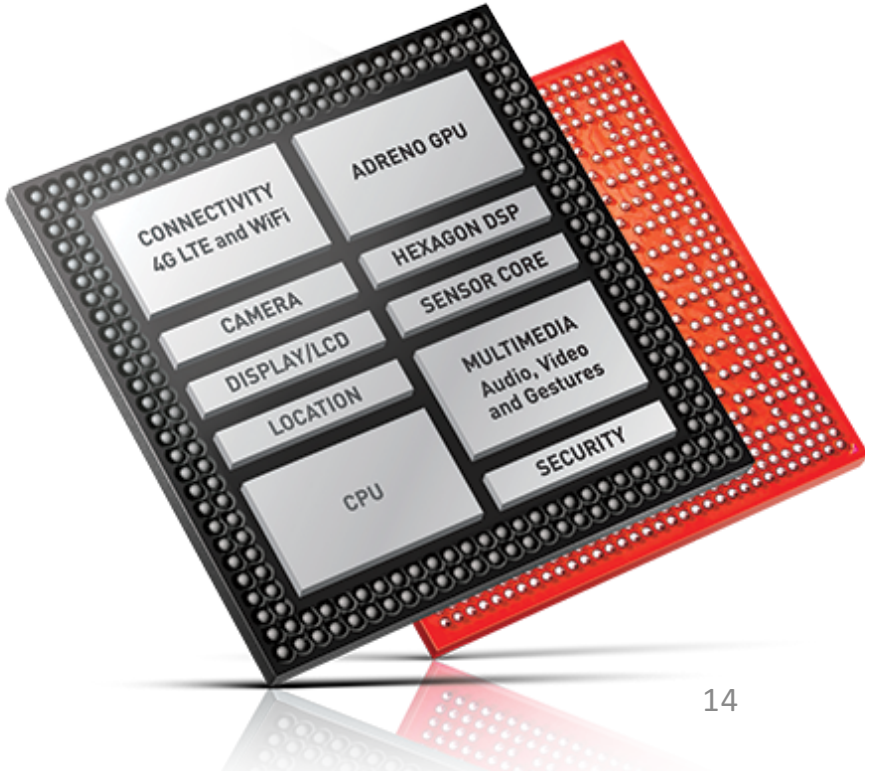

Facebook
19.43%
YouTube
18.02%
HTTP
11.26%
MPEG
5.72%
SSL
4.63%
Instagram
4.27%
Netflix
4.1%
Google Cloud
4.09%
iTunes
2.96%
Pandora Radio
2.53%
0%
2.5%
5%
7.5%
10%
12.5%
15%
17.5%
20%
22.5%
Percentage of peak period aggregate traffic

Phone Sensors and Radios



UNIVERSITY OF CAMBRIDGE

Phone Computation Units



UNIVERSITY OF CAMBRIDGE

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).

Ubiquitous and Mobile Computing

Mark Weiser (1952-1999)

"The most profound technologies are those that disappear."

UNIVERSITY OF CAMBRIDGE


Copyright: PARC
XEROX PARC
***** PARC TAB *****
XEROX


iPad
9:41 AM
Messages
FaceTime
Photos
Camera
Maps
Clock
Photo Booth
Tuesday
23
Calendar
Contacts
Notes
Reminders
Newsstand
iTunes
App Store
Game Center
Settings
Safari
Mail
Videos
Music
iPad

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

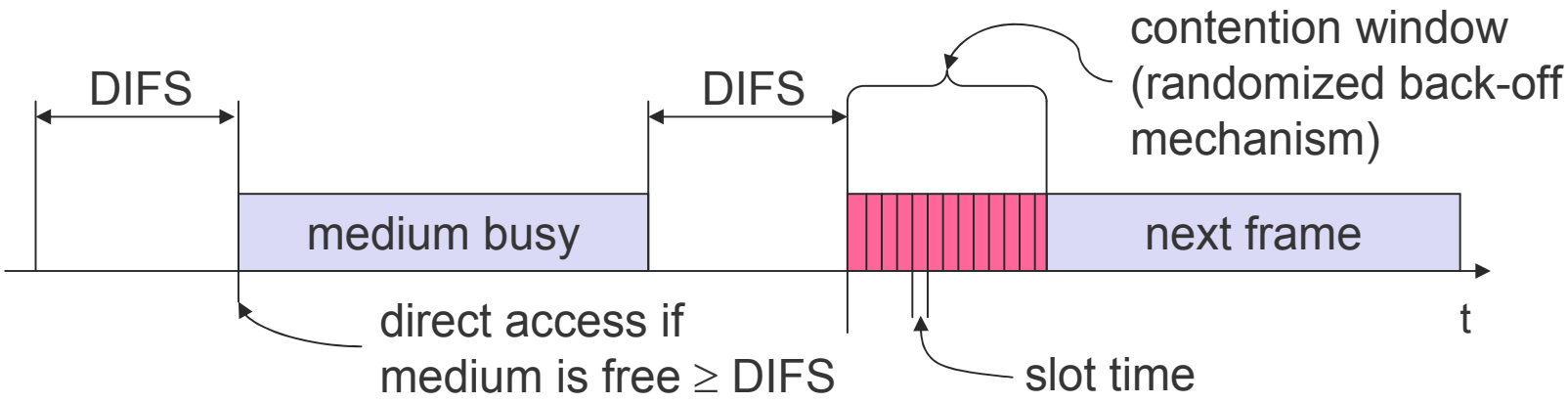
Wireless Medium as Shared Medium

- 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.

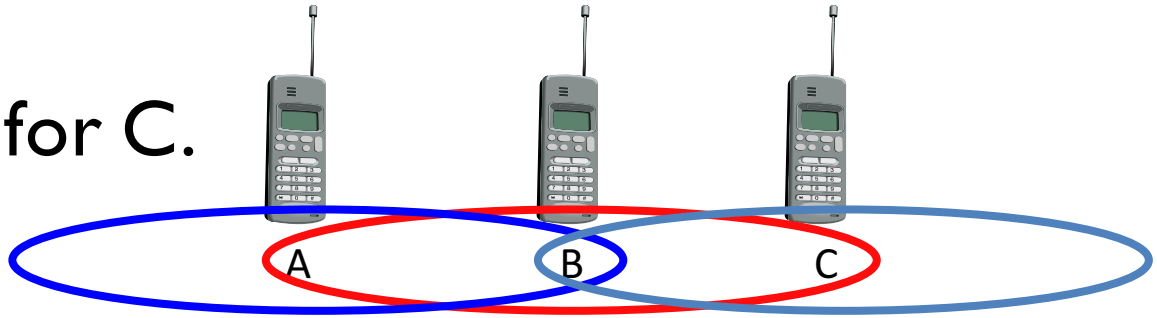
CSMA/CA: Carrier Sensing Multiple Access Protocol with Collision Avoidance



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.

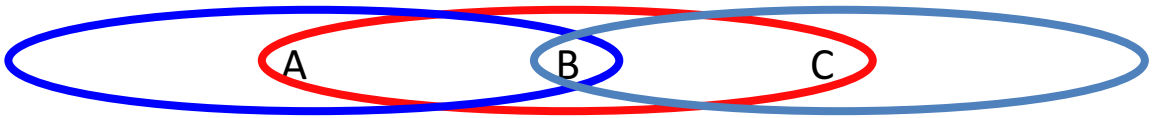
Hidden Terminal

- 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

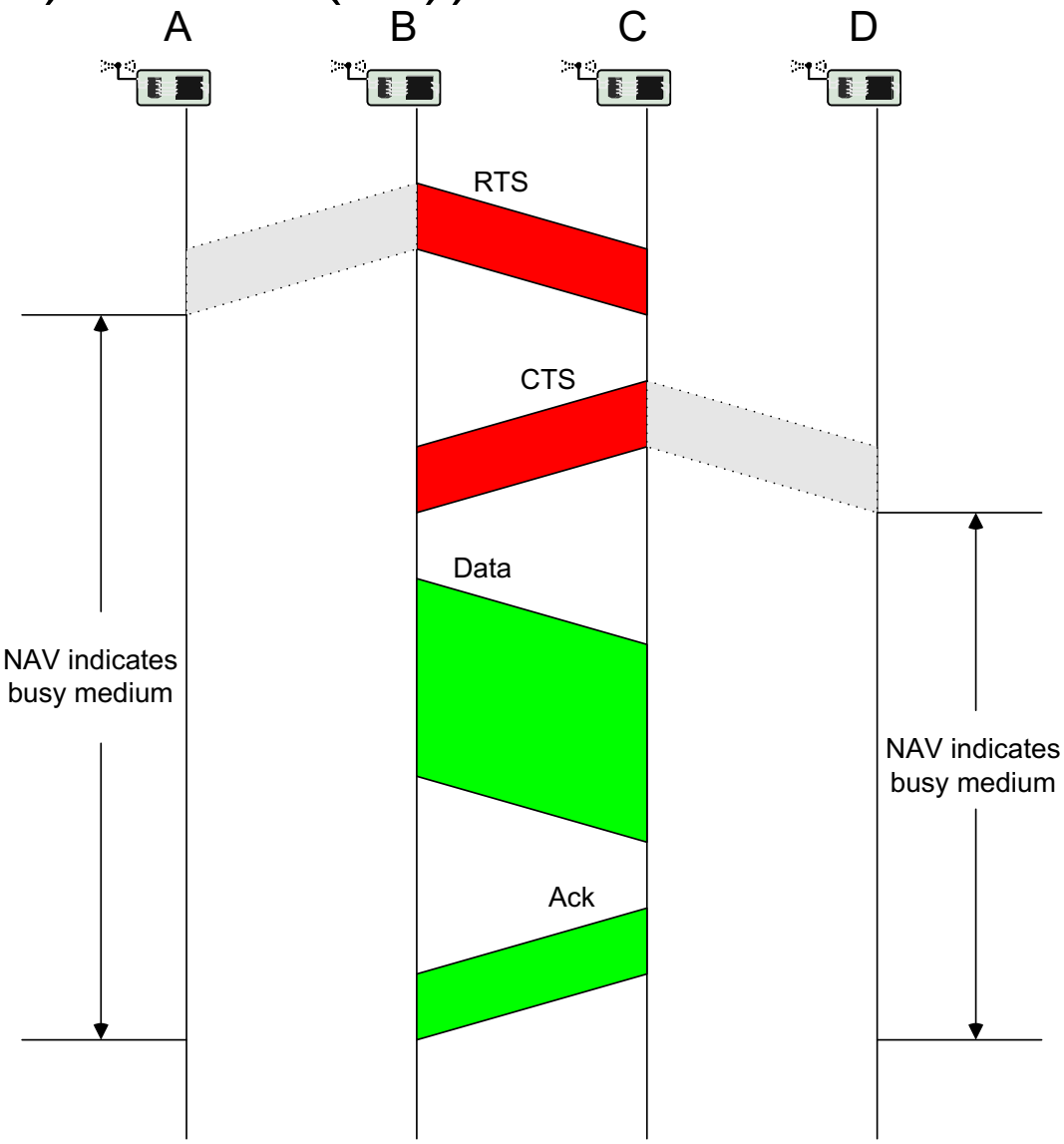
- Exposed terminals:
  - B sends to A, C wants to send to another terminal (not A or B).
  - C has to wait, CS signals a medium in use.
  - but A is outside the radio range of C, therefore waiting is not necessary.
  - C is "exposed" to B.



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***).



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.