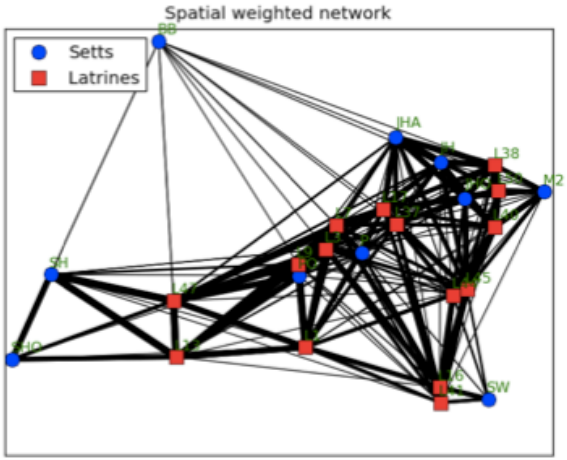
Mobile and Sensor Systems

Lecture 1: Introduction to Mobile Systems

Prof Cecilia Mascolo

About Me


Spatial weighted network
Setts
Latrines
BB
IHA
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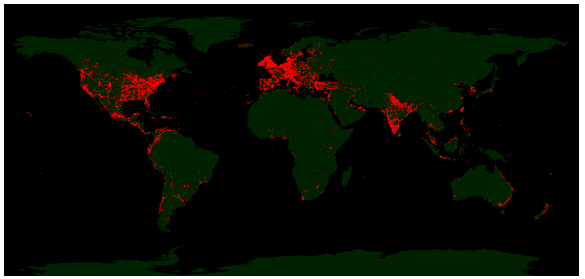
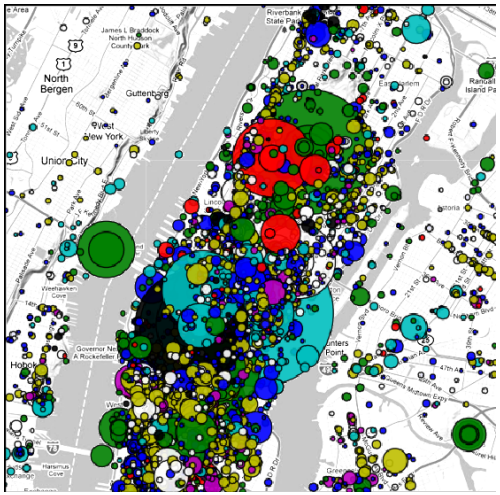
SH
SW




North Bergen
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West New York
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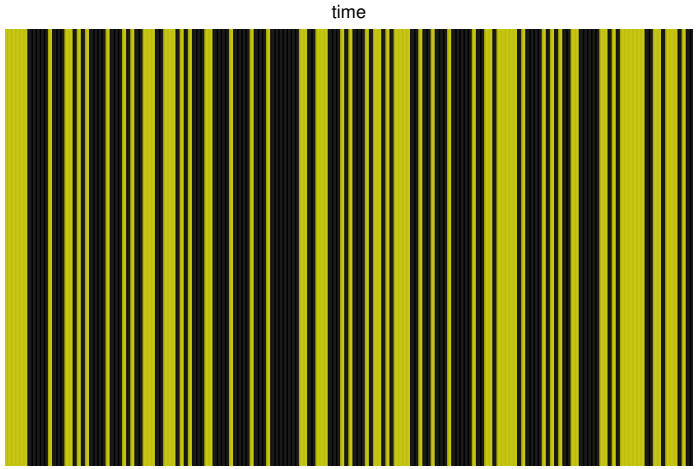
time

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.
- Lecture 2: Mobile Medium Access Control and Wireless Systems.
- Lecture 3: Infrastructure, Ad-hoc and Delay Tolerant Mobile Networks.
- Lecture 4: Sensor Systems and MAC Layer Protocols.
- Lecture 5: Sensor Networking Routing Protocols.
- Lecture 6: Sensor Systems Reprogramming and Mobile Sensing.
- Lecture 7: Mobile Phone Sensing.
- Lecture 8: Practical: Mobile Phone Programming.

Teaching Material

- No required textbook.
- Some suggested 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.
- Specific lectures will reference research papers which can be used for additional reading.

In this lecture

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

Smart Phones:
the Computing Platform of the Future

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Smart Phones: **the** Computing Platform

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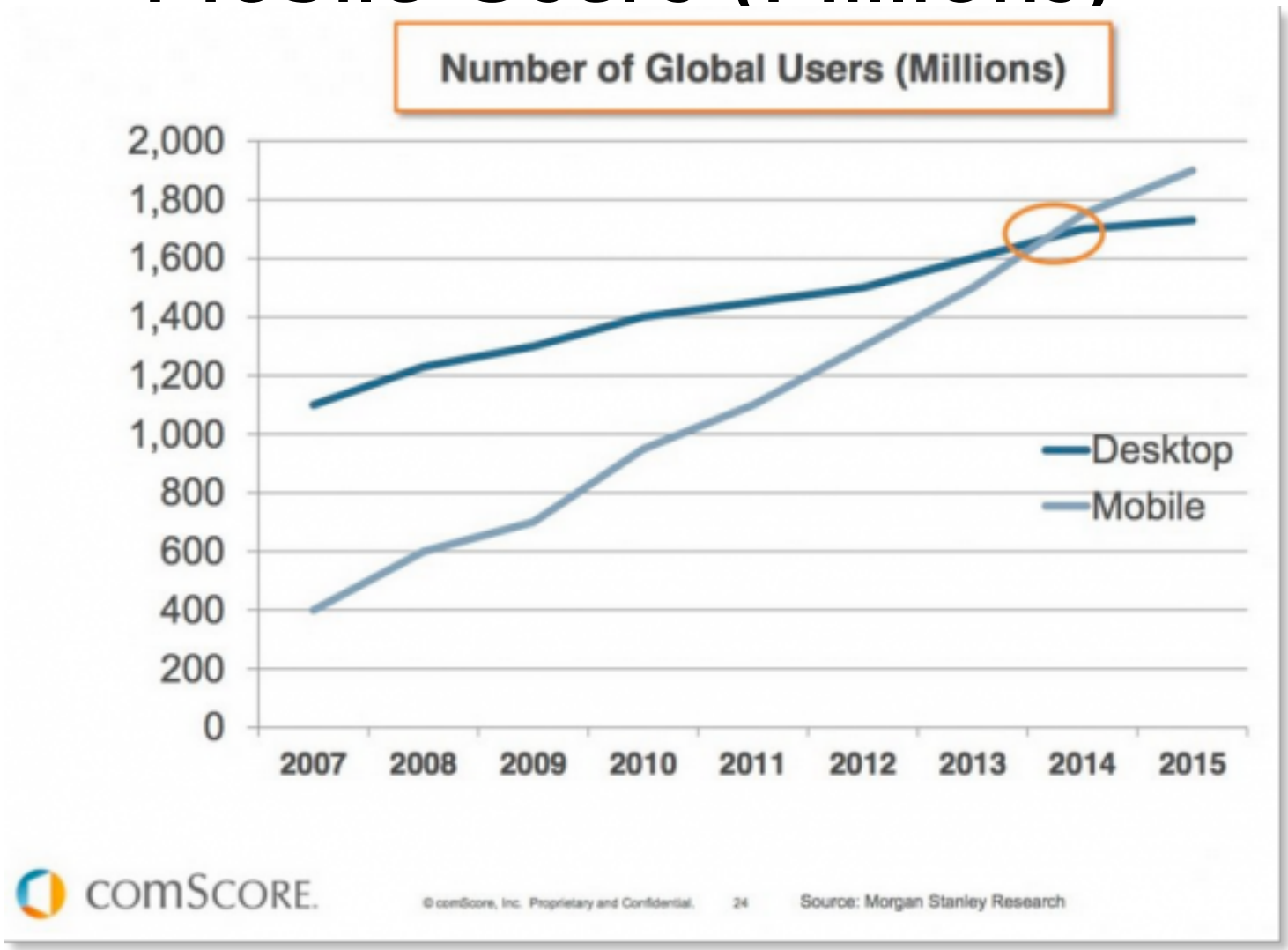
Some Numbers

- 7 billion mobile subscriptions worldwide, estimates The International Telecommunication Union (May 2014). This is equivalent to 95.5 percent of the world population.
- A billion extra mobile subscriptions in three years, but growth is slowing – 2011: 5.9 billion; 2012: 6.2 billion; 2013: 6.7 billion; 2014: 6.9 billion.
- The number of cellular subscribers surpasses the number of wired phone lines.

Mobile Users (Millions)



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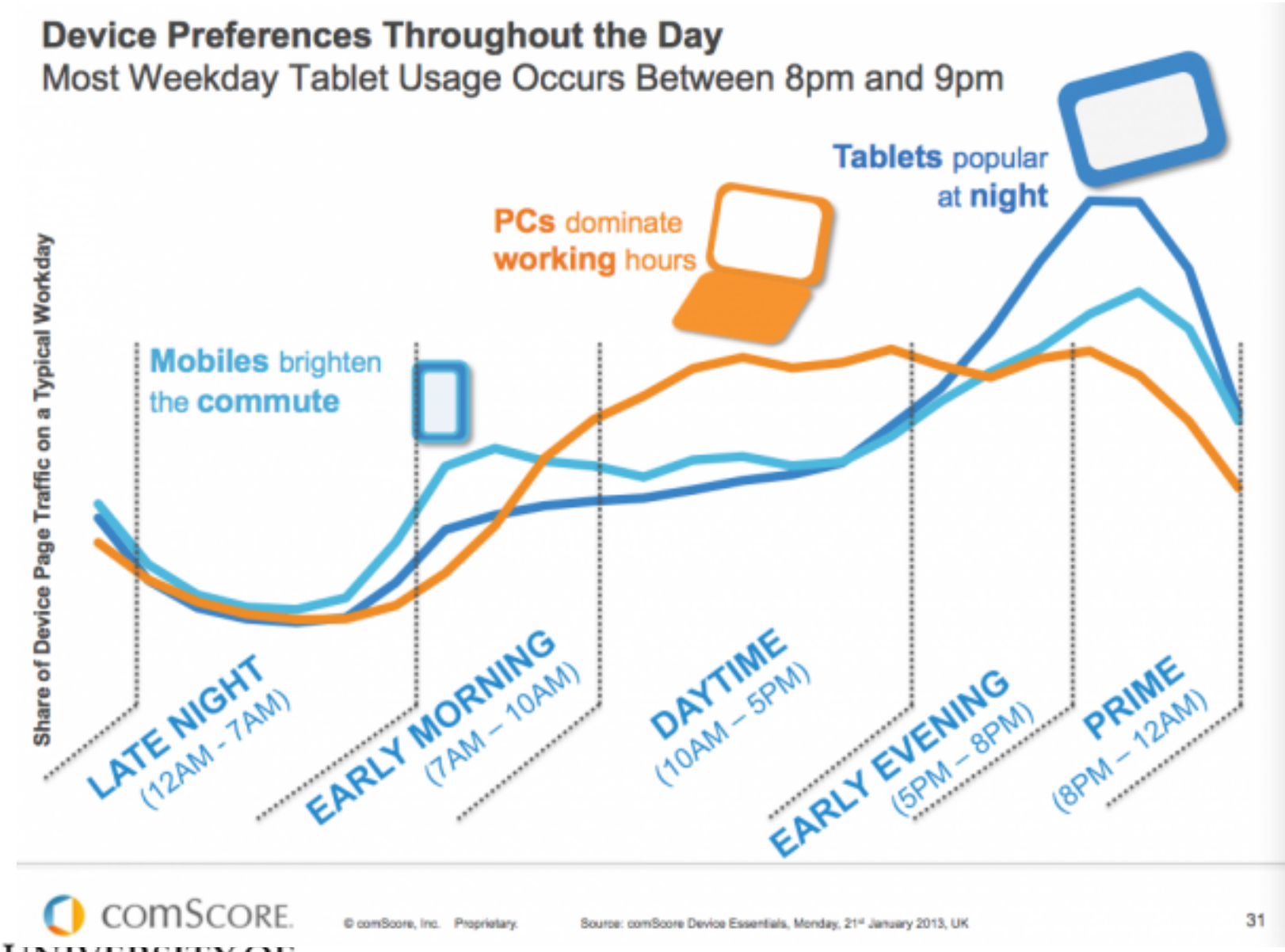

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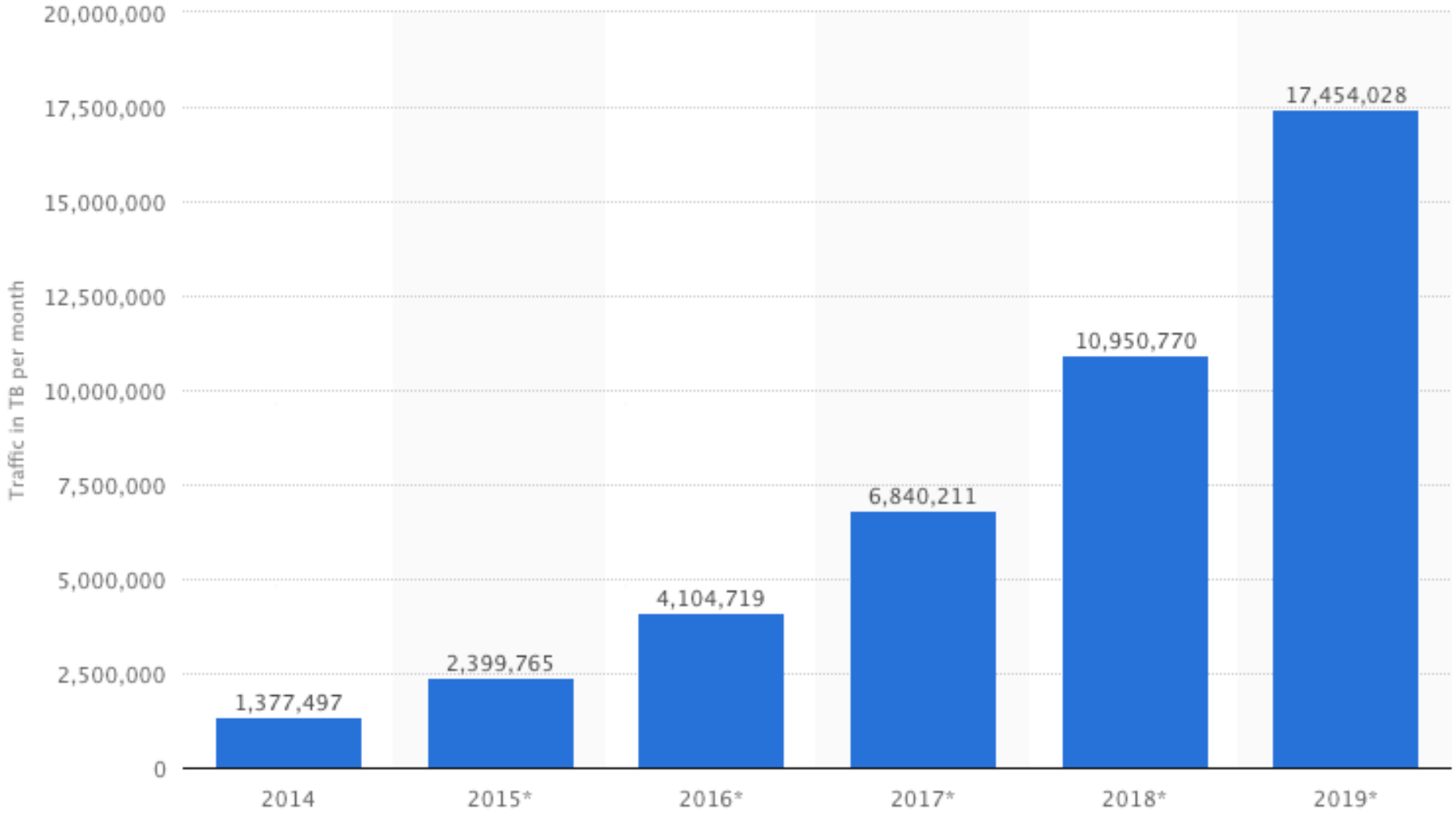
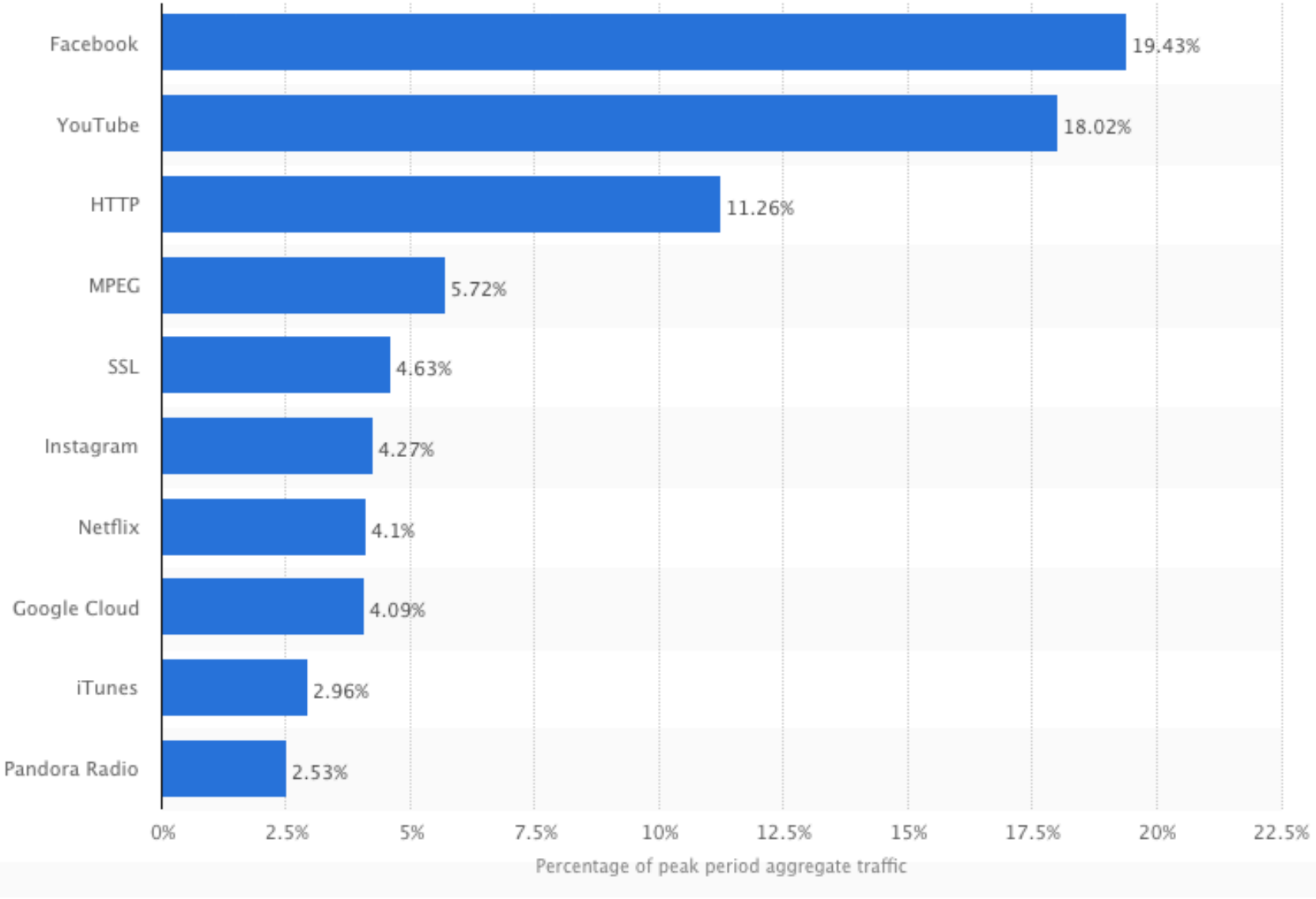
Video Traffic



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

Location-based Social Network Systems

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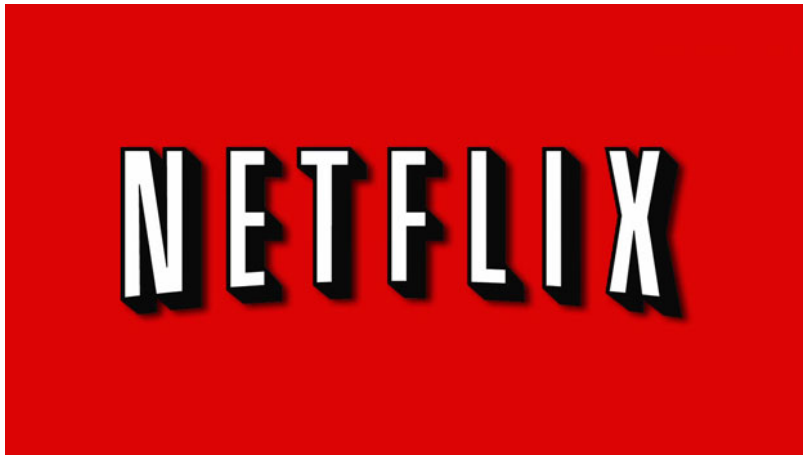
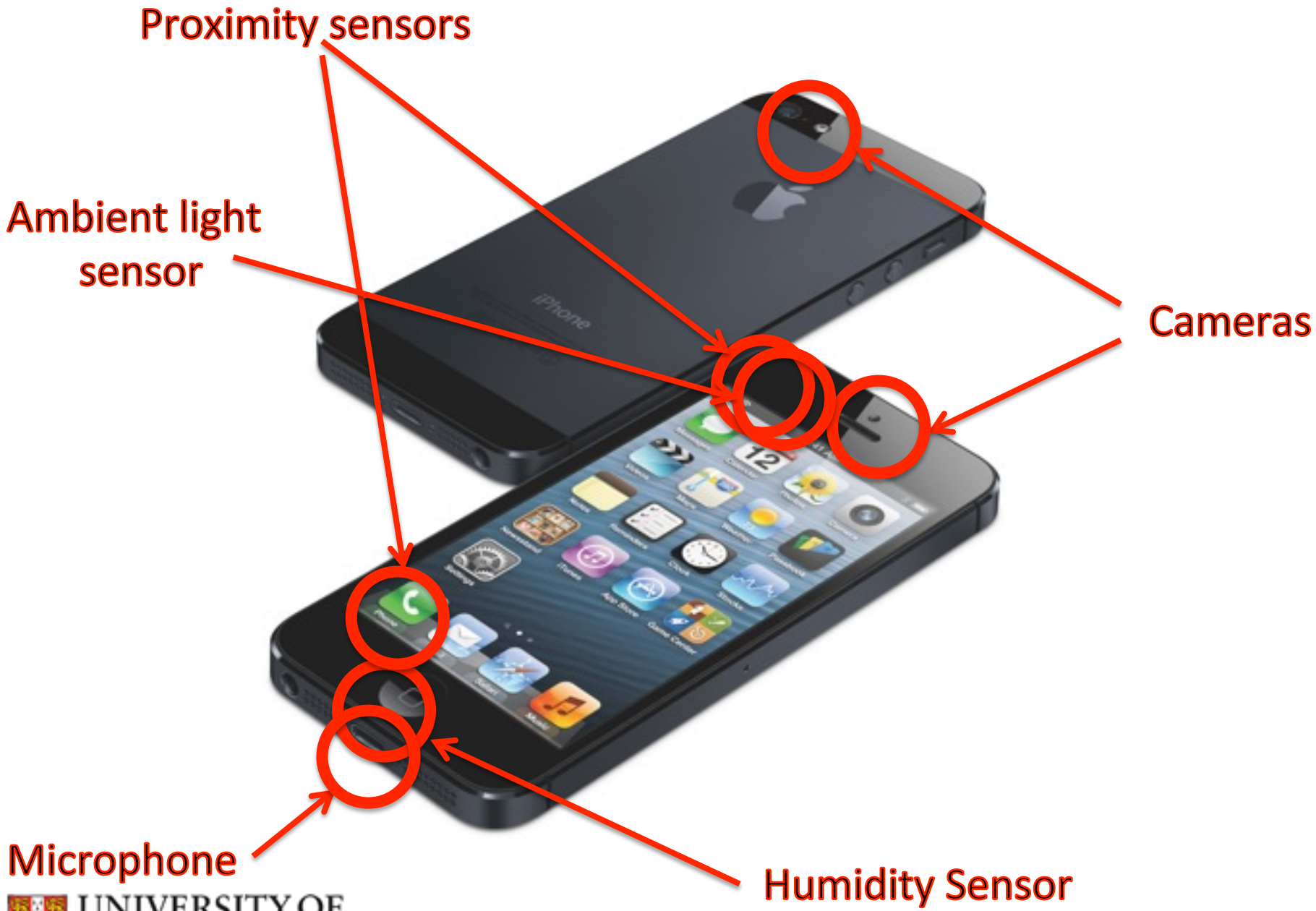
Geographic Recommender Systems





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Credit: CNet

Accelerometer
GPS

Gyroscope
Bluetooth [colocation]

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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 Devices are Inherently Resource Constrained

- Computational constraints
  - But, for example, in the Samsung Galaxy SIII you have 1.4 GhZ quad-core Cortex A-9 +GPU
- Memory constraints
  - But, for example, in the Samsung Galaxy SIII you have 1GB or 2GB of RAM

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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."

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Copyright: PARC


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

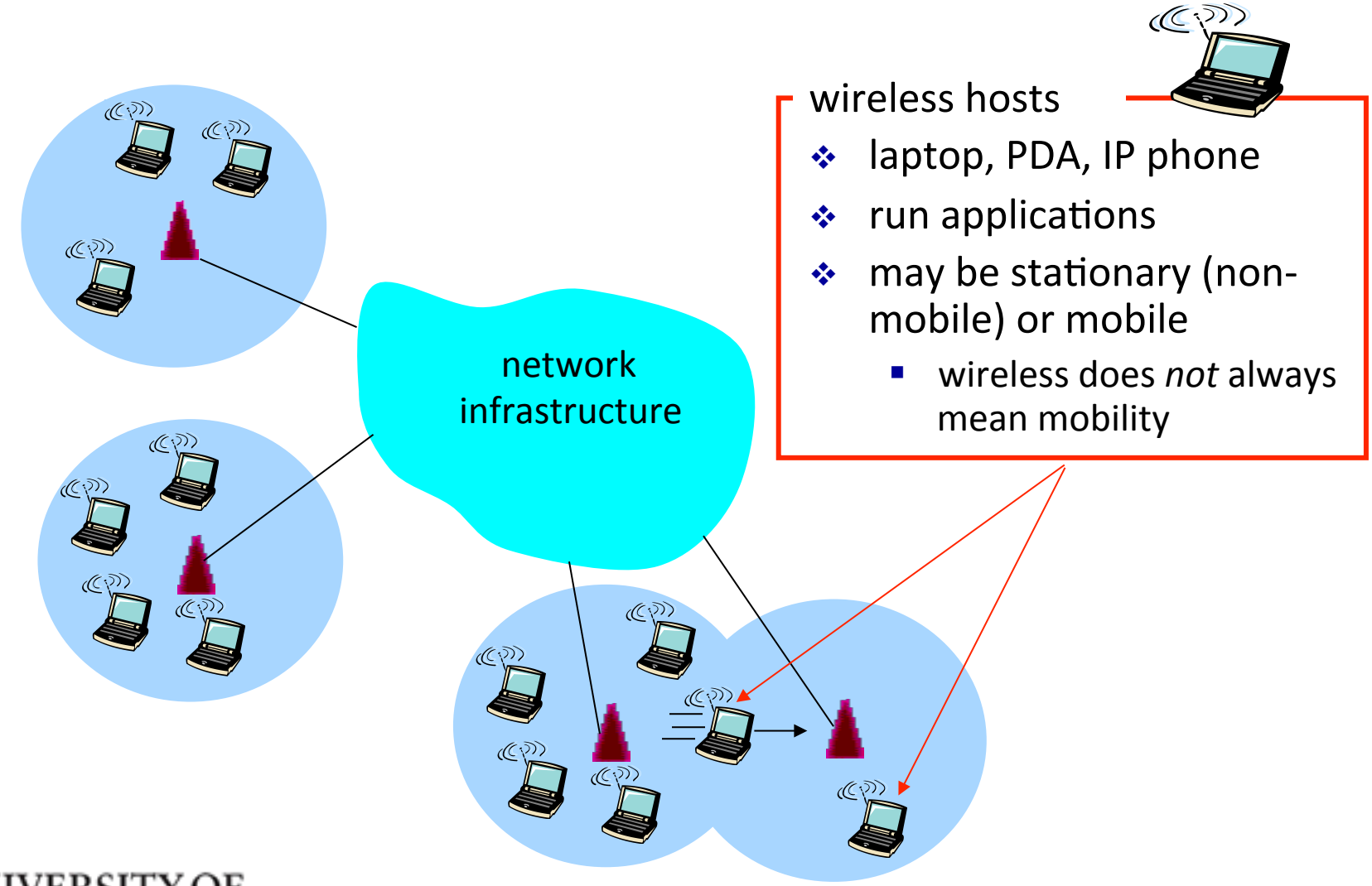
Issues in Designing Mobile Computing Systems

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

Wireless and Mobile Networks

- Two important (but different) challenges
  - *wireless:* communication over wireless link
  - *mobility:* handling the mobile user who changes point of attachment to network

Elements of a wireless network



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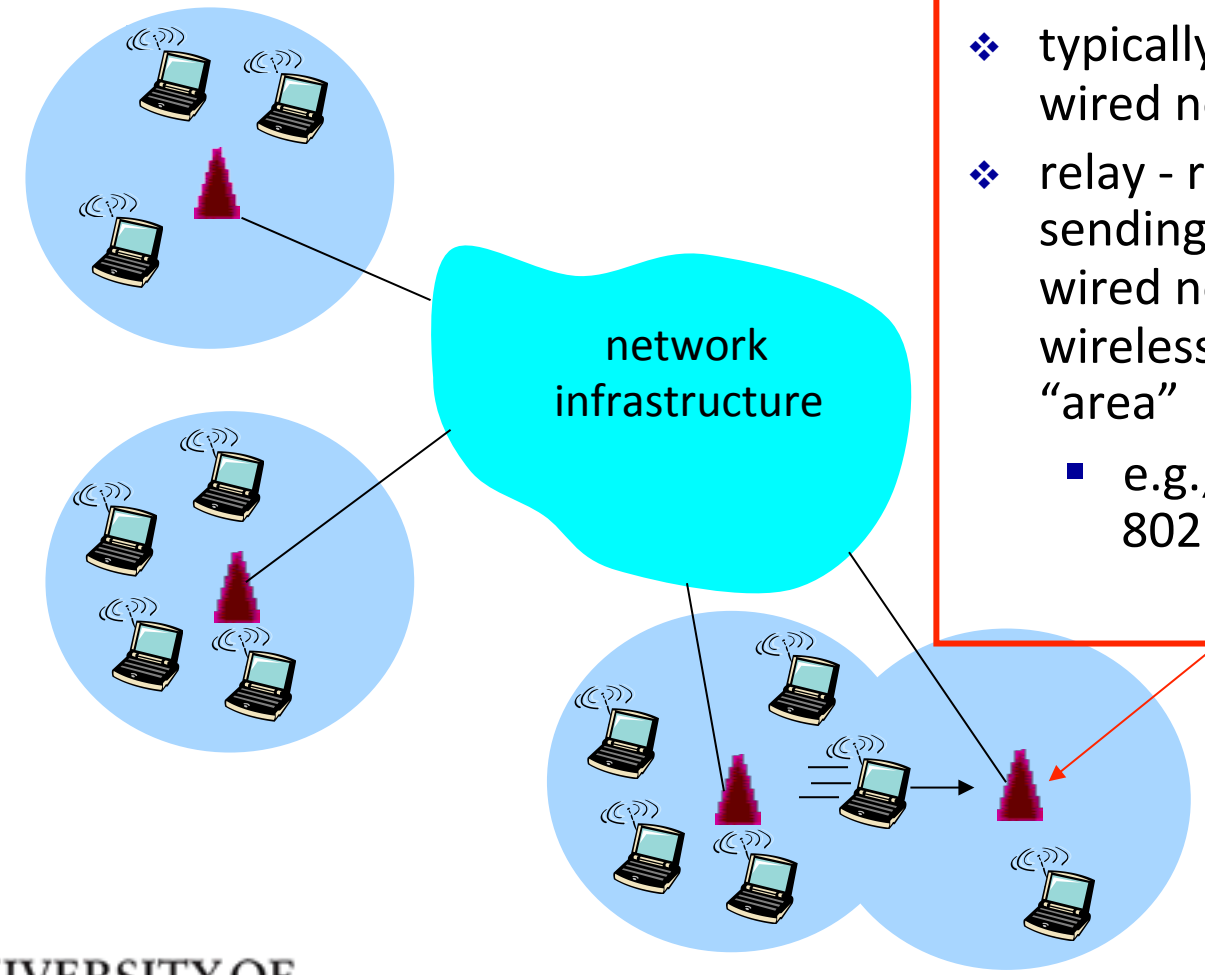
Elements of a wireless network



base station

- typically connected to wired network
- relay - responsible for sending packets between wired network and wireless host(s) in its "area"
  - e.g., cell towers, 802.11 access points

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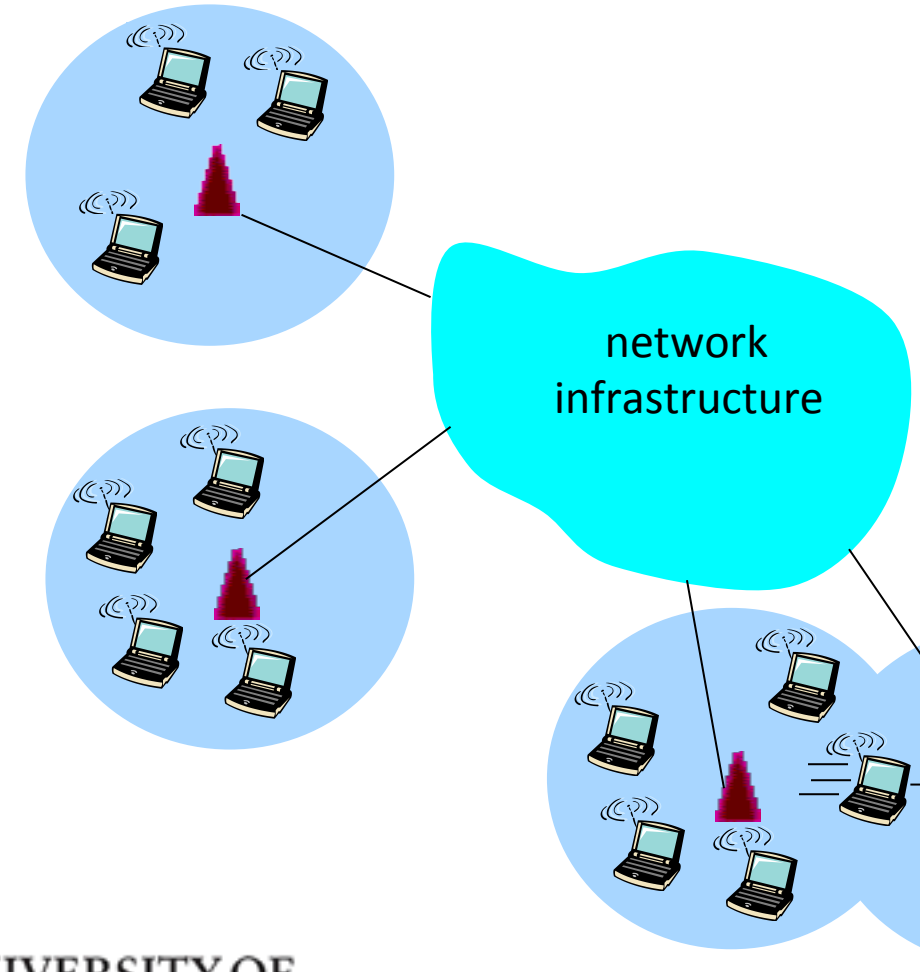
Elements of a wireless network



wireless link

- typically used to connect mobile(s) to base station
- also used as backbone link
- multiple access protocol coordinates link access
- various data rates, transmission distance

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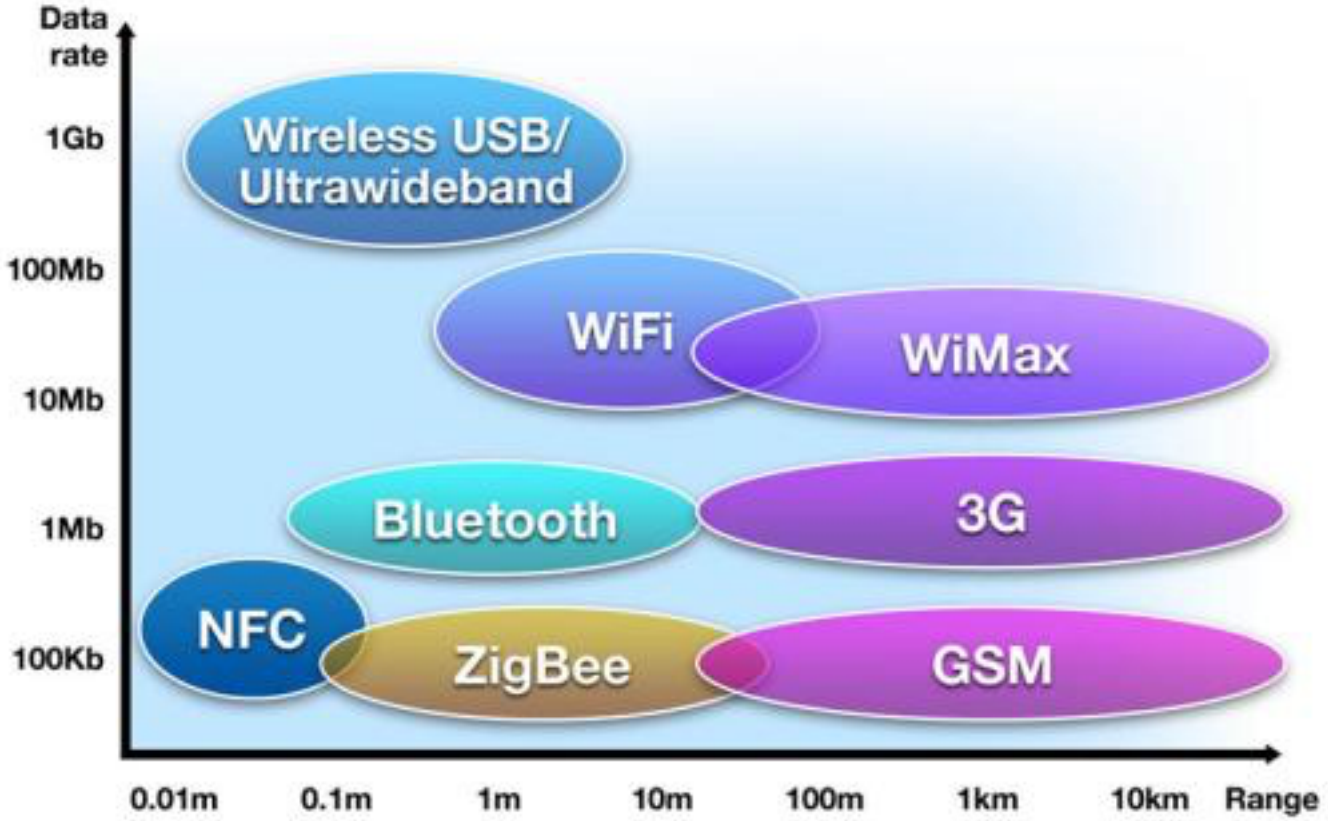
Wireless rate vs distance



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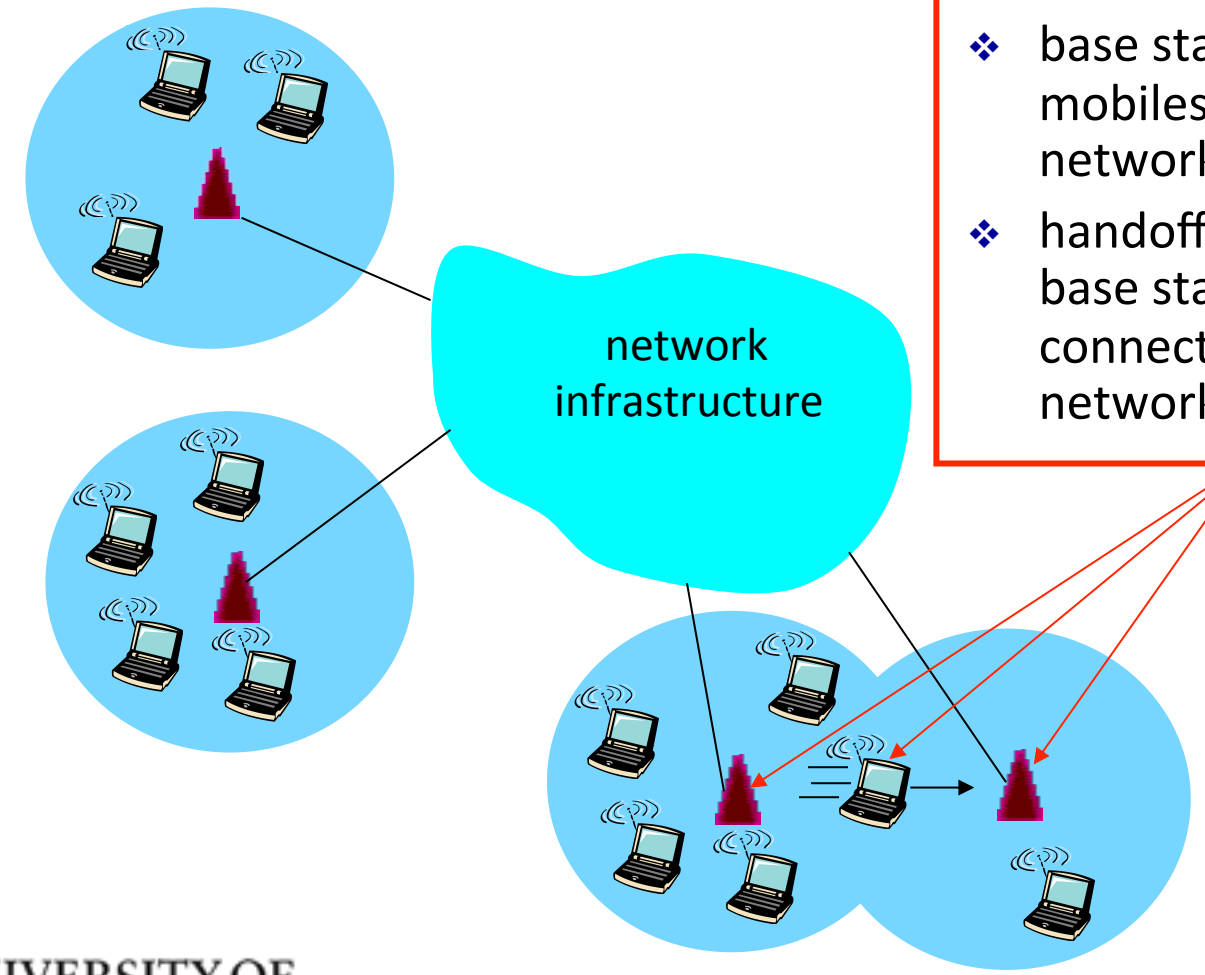
Elements of a wireless network



infrastructure mode

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

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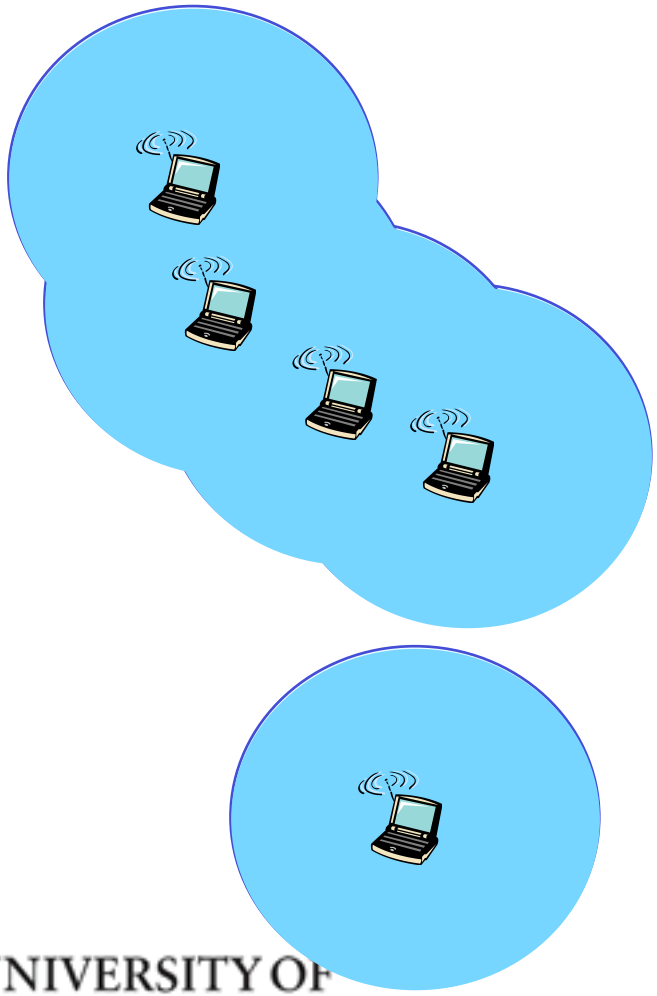
Elements of a wireless network



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 network taxonomy

	single hop	multiple hops
infrastructure (e.g., APs)	host connects to base station (WiFi, WiMAX, cellular) which connects to larger Internet	host may have to relay through several wireless nodes to connect to larger Internet: *mesh net*
no infrastructure	no base station, no connection to larger Internet (Bluetooth, ad hoc nets)	no base station, no connection to larger Internet. May have to relay to reach other a given wireless node MANET, VANET

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.

Acks

- Some material for the slides of this course has been contributed by:
- Dr Christos Efstratiou,
- Dr Nicholas Lane,
- Dr Mirco Musolesi,
- Dr Sarfraz Nawaz.