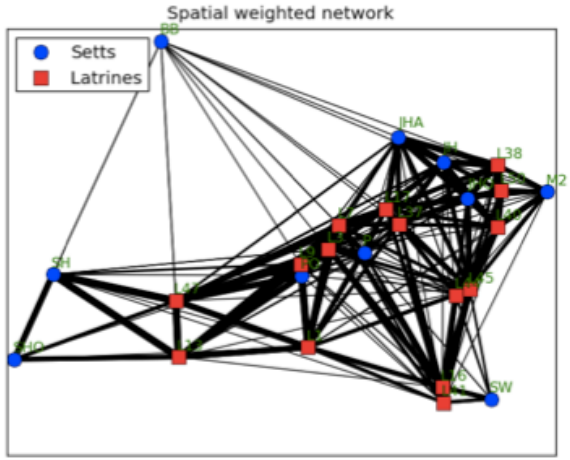
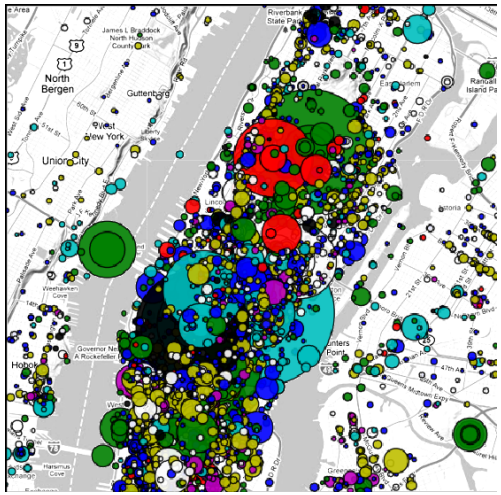
# Mobile and Sensor Systems

Lecture 1: Introduction to Mobile Systems

Dr 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

- 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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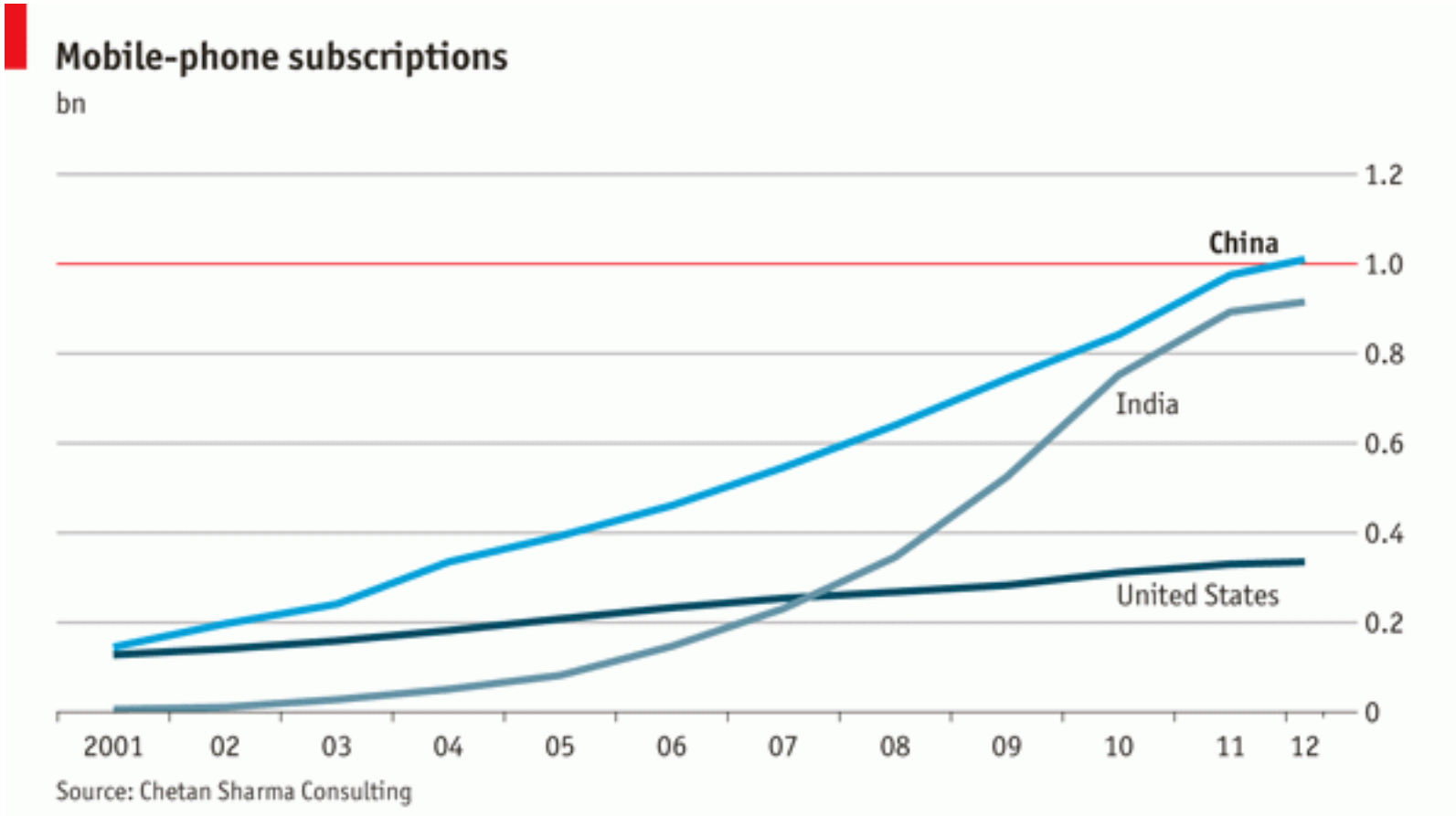
# Some Numbers

- Number of worldwide mobile cellular subscribers increased from 34 million in 1993 to nearly 5.5 million subscribers by 2011.
- The number of cellular subscribers surpasses the number of wired phone lines.




Source: The Economist

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# Location-based Social Network Systems


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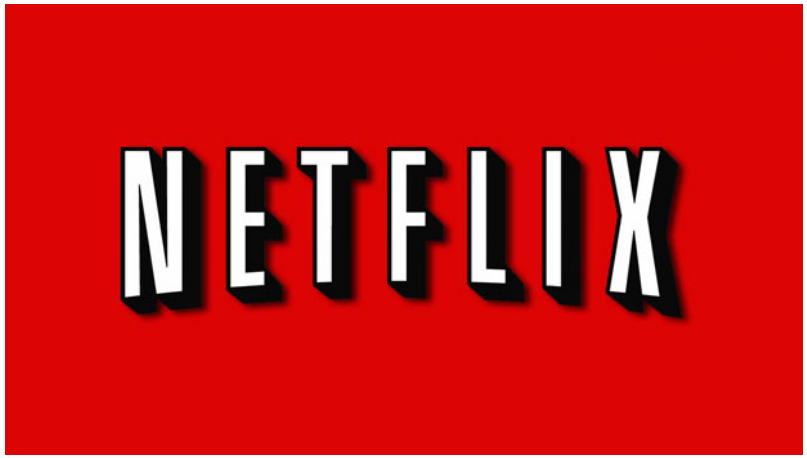
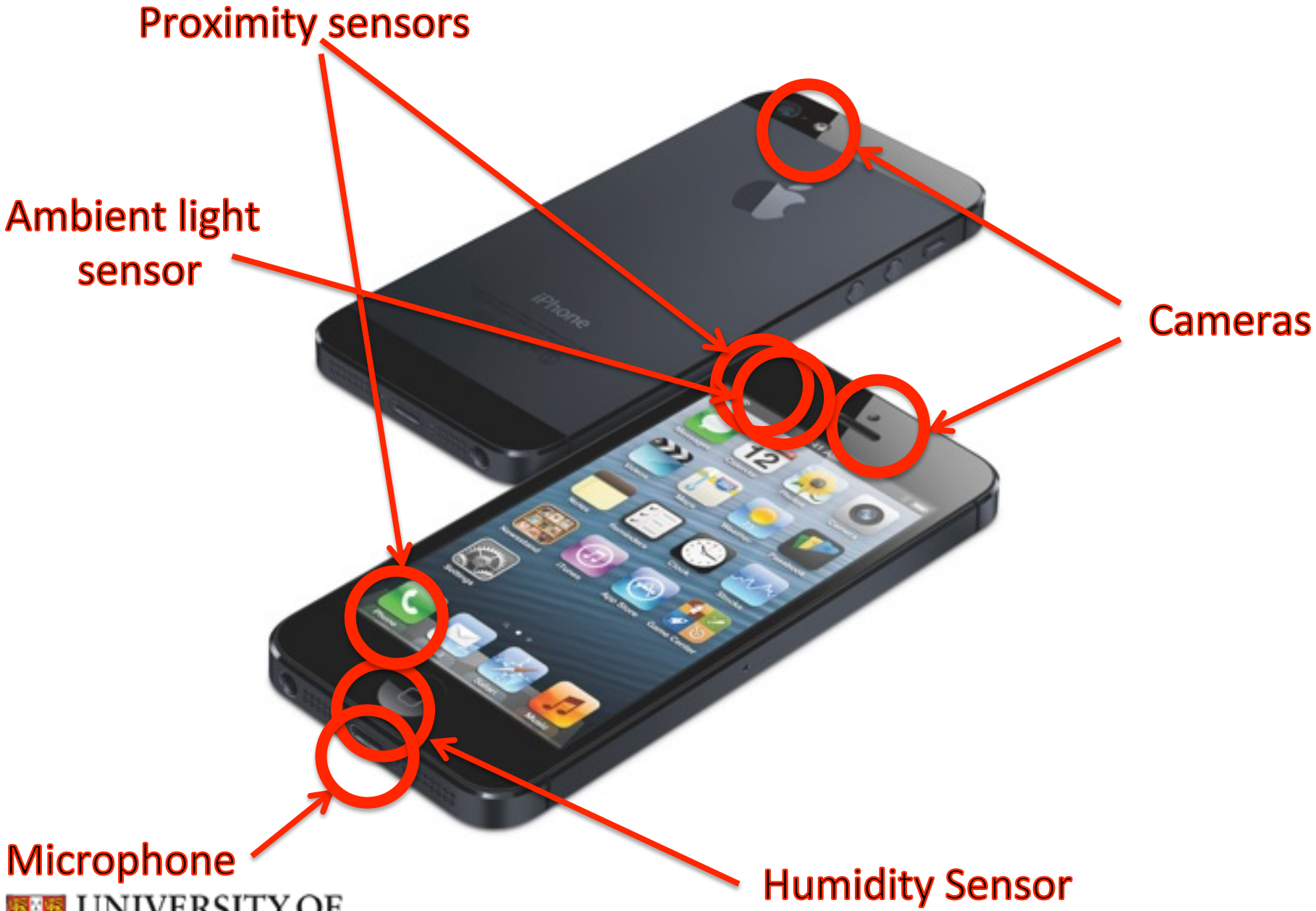
# Geographic Recommender Systems



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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

# 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

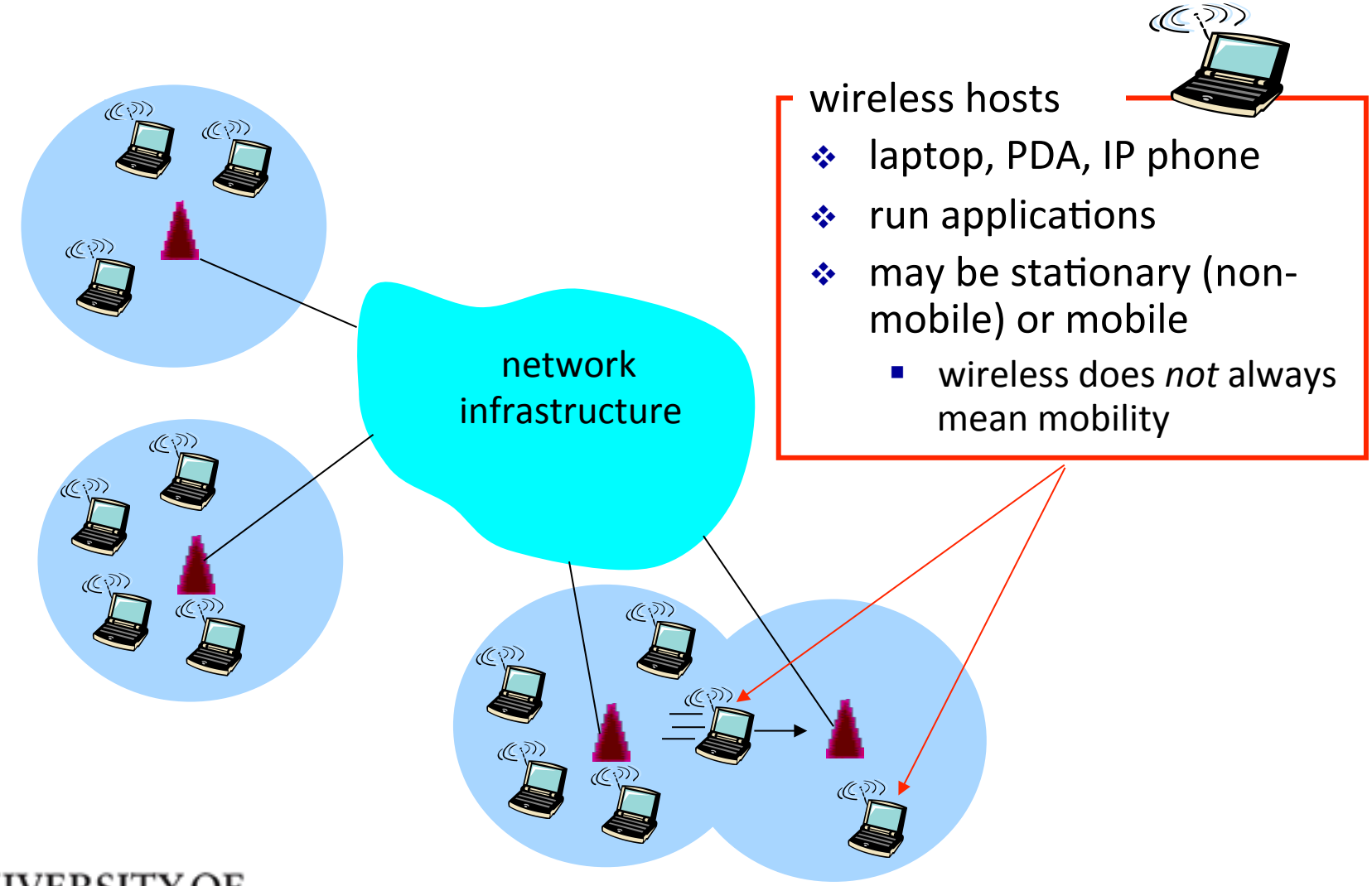
- HCI issues:
  - Limited interface
  - Interaction with the devices (input, etc.)
  - Ergonomics
- Privacy issues:
  - Location sharing
  - Activity recognition
- Security issues:
  - Encrypted communication

# Wireless and Mobile Networks

Background:

- Number of wireless (mobile) phone subscribers now exceeds number wired phone subscribers!
- Number of wireless Internet-connected devices soon to exceed number of wired Internet-connected devices
  - laptops, Internet-enabled phones promise anytime Internet access
- 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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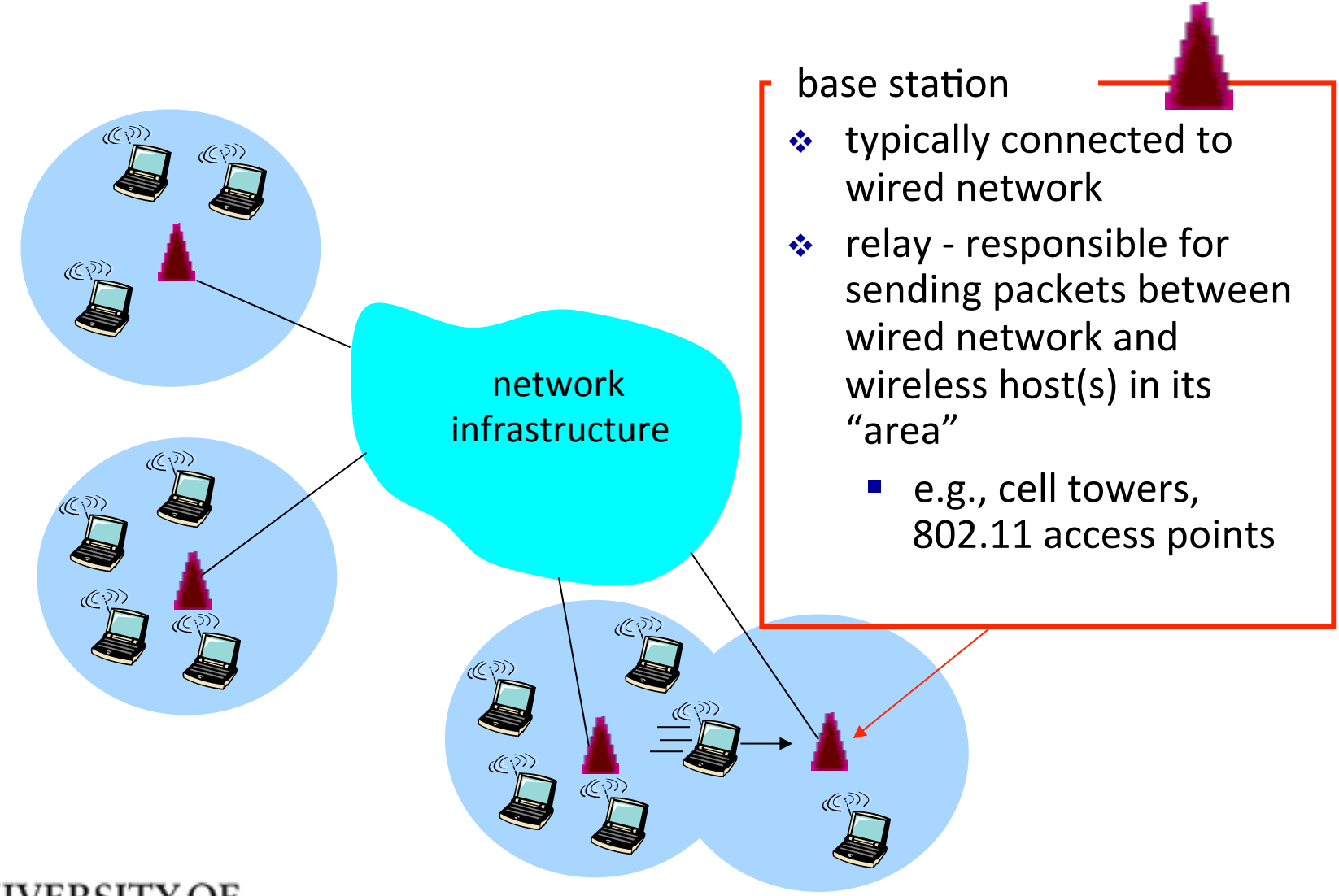
# Elements of a wireless network

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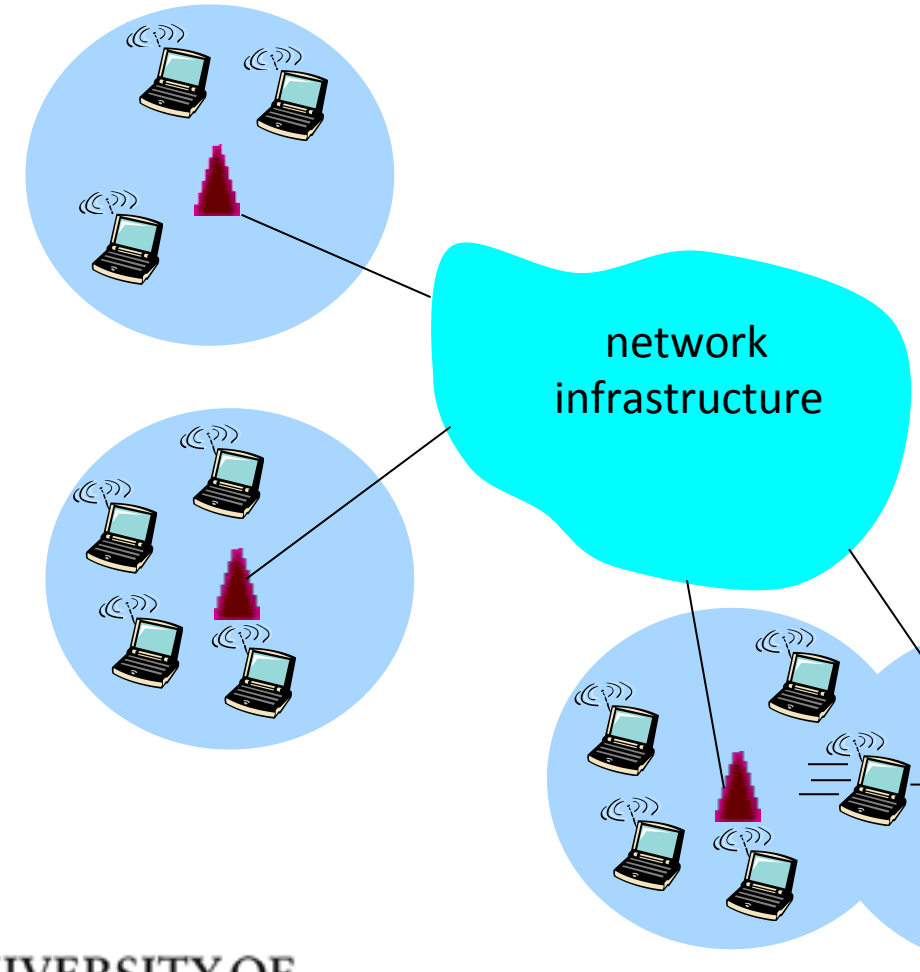
# Elements of a wireless network




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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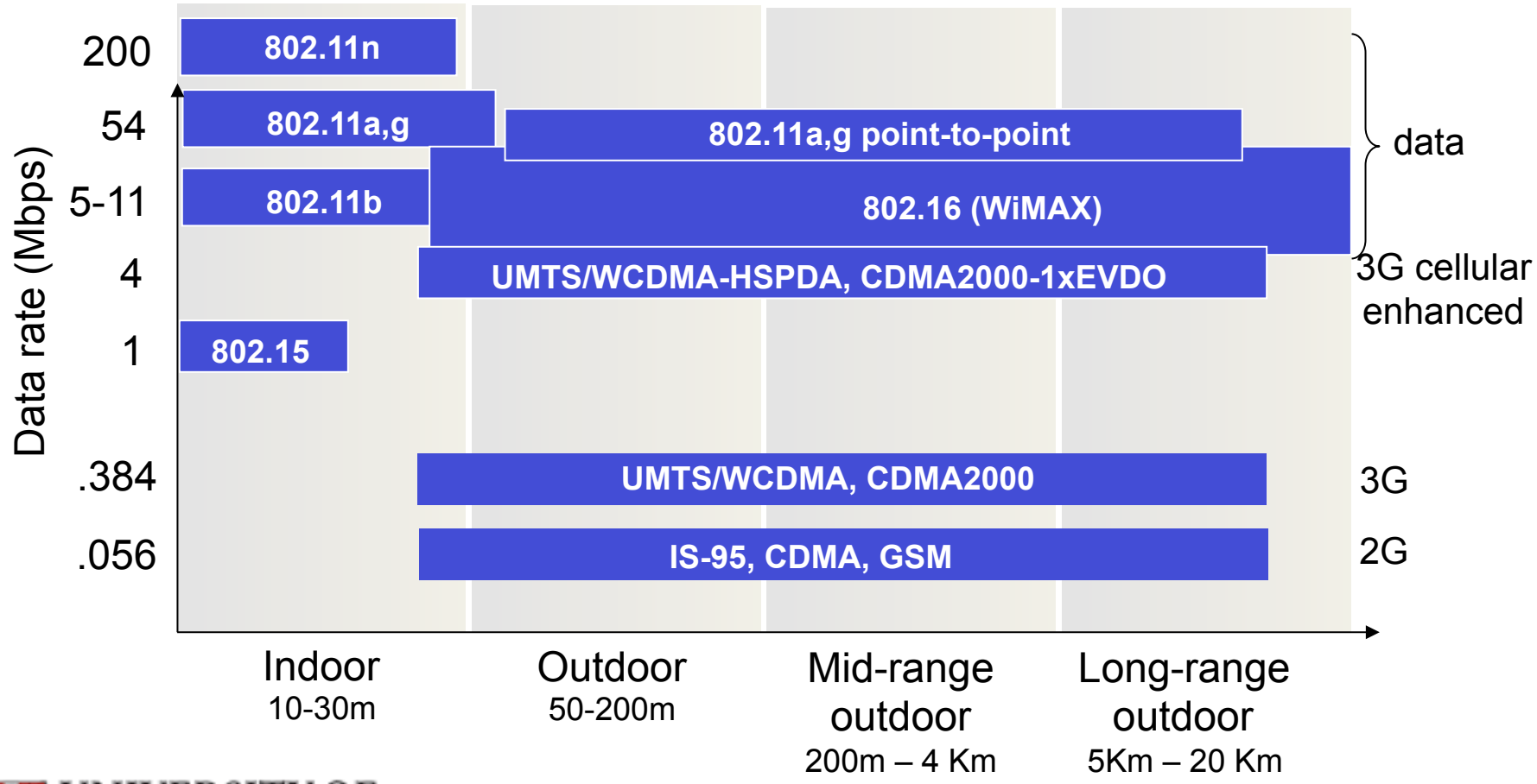
# Characteristics of selected wireless link standards

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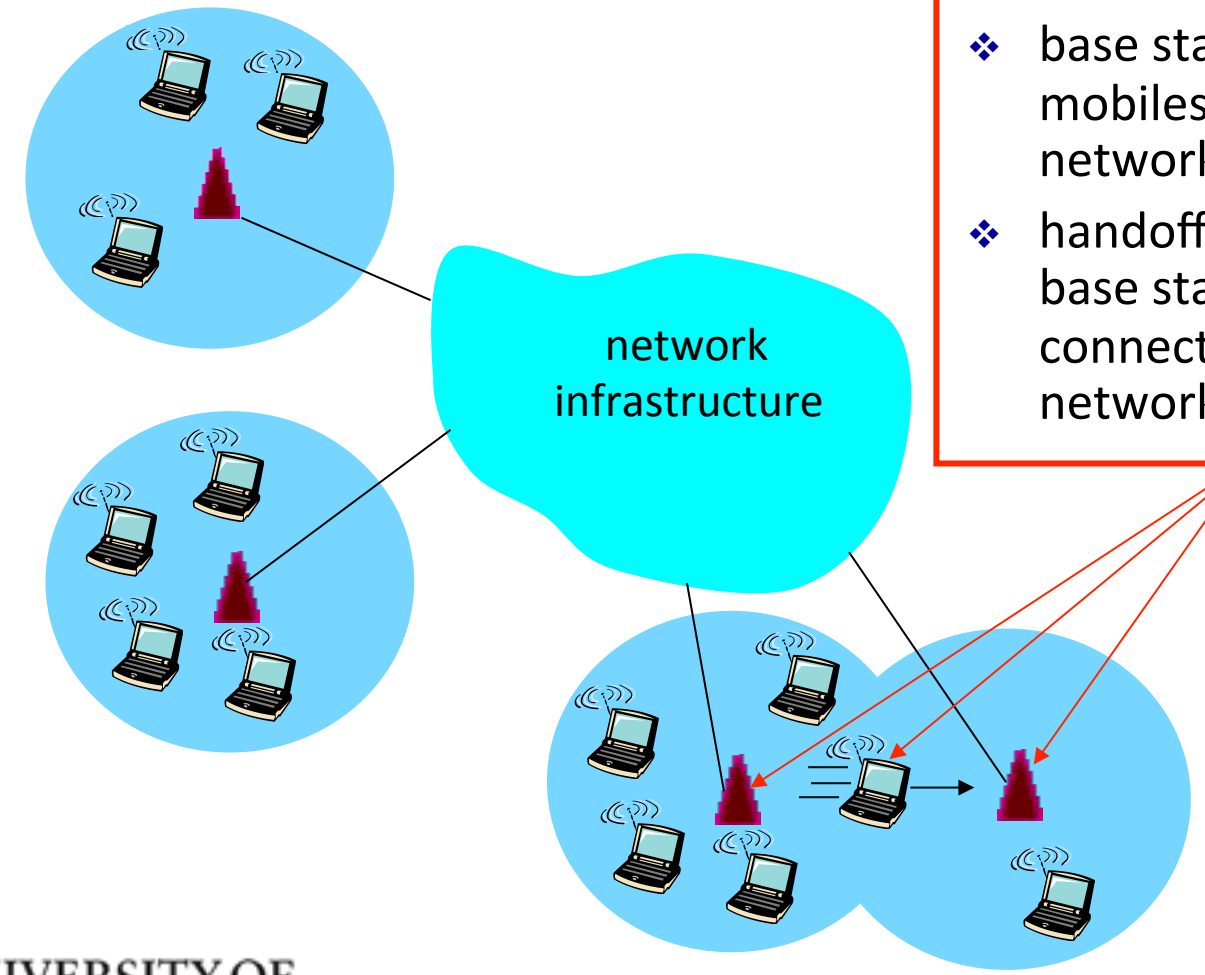


infrastructure mode

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

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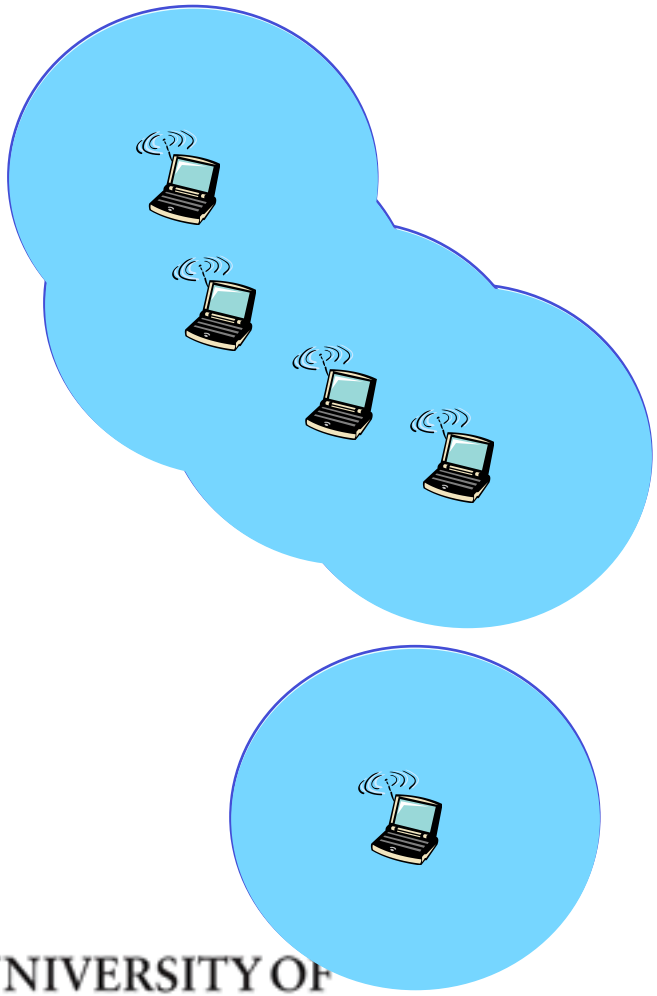
# Elements of a wireless network



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,
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- Dr Mirco Musolesi,
- Dr Sarfraz Nawaz.