



Mobile Computing

Introduction



Mobile Computing

- **Mobile computing starts from late 1990s due to the development of wireless communication and mobile devices**
 - Mobile Computing = Mobile + Computation
 - Users may move around with computing units (notebooks, smartphones, etc.) while connections are maintained
 - The system supports computing tasks/requests from mobile users through a wireless network (i.e., download files, web browsing, WeChat)
- **wireless \neq mobile (cordless phone \neq mobile phone)**
 - Wireless: no wire (but maybe stationary). The mobility is limited in scope, e.g., download files from a notebook through infra red
 - Mobile: able to move freely while connectivity is maintained



Mobile Components

- Mobile communication only provides connectivity between distributed entities (mobile units – mobile servers). We also need mobile computing and applications.
- Mobile computing has three basic components:
 - Networks: mobile/wireless networks + wired networks
 - Mobile units: usually with limited resources, i.e., CPU power, memory, battery power, ...
 - Mobile applications and back-end servers: mobile apps, cloud servers, ...



Mobile Communications

- Mobile communication requires integration of wireless networks into existing fixed networks:
 - WLAN: standard of IEEE 802.11
 - Cellular networks: GSM (2G), 3G, 4G ...
 - Internet: Mobile IP extension of the Internet protocols

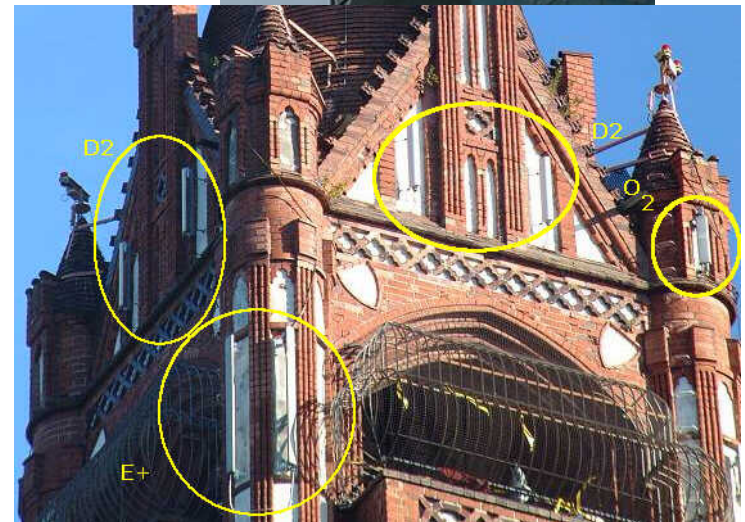


Mobile Services

Mobile services include the following:

- Location-based services
 - Services that depend on the locations of the users, such as Google map, shopping malls, gas stations, restaurants, ...
- Context-aware services
 - Services that depend on the context detected by the system, such as weather condition, users' health/mood, ...
- Surveillance and event-triggering services
 - Detecting system status, e.g. intruders, crisis, ...
 - Emergency events that require timely responses, e.g., health care, ...

Wireless Network Infrastructure: Antennas



Wireless Network Infrastructure: Base Stations

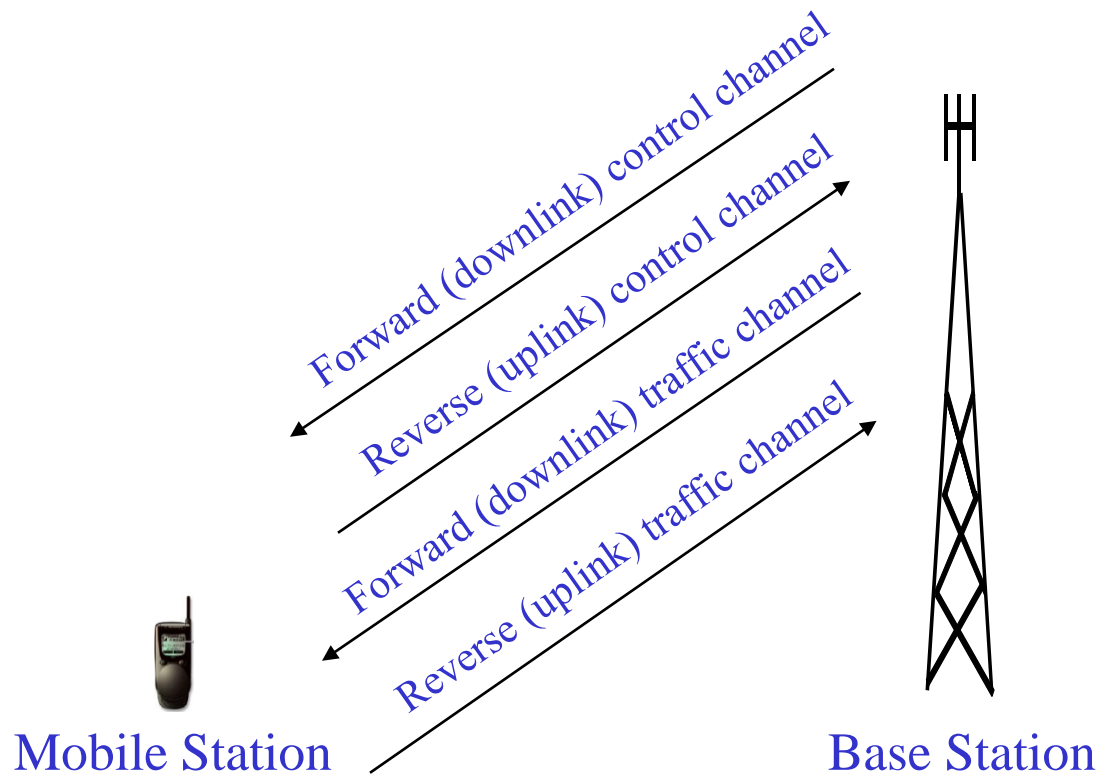


Microwave
links

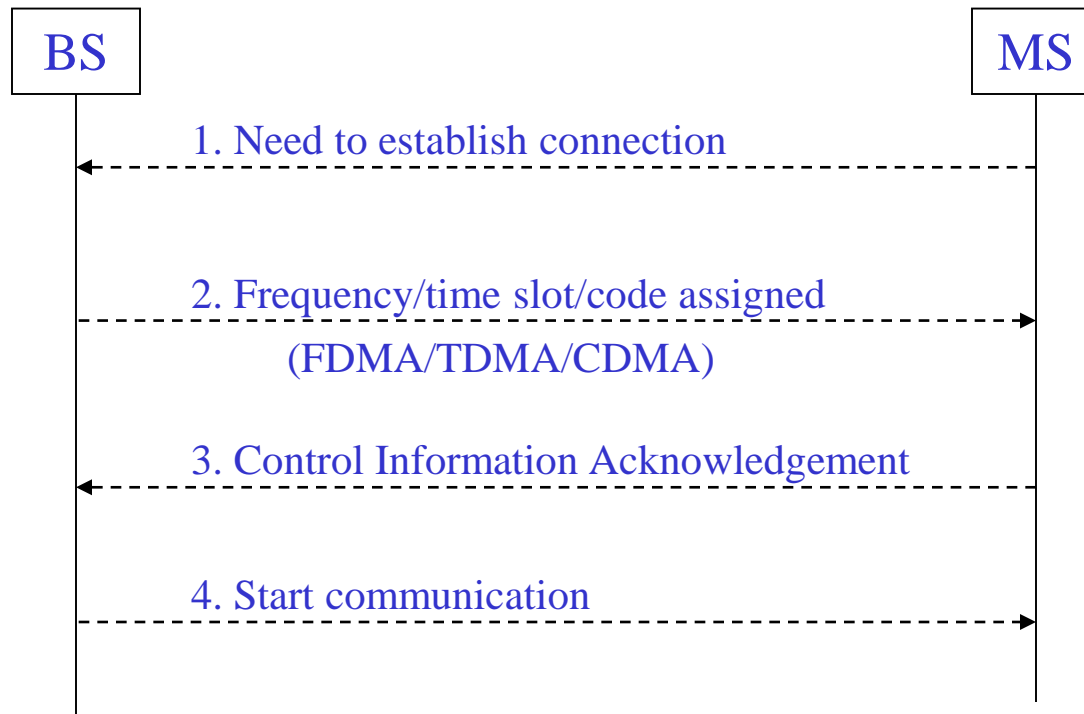


Base Stations

Control and Traffic Channels

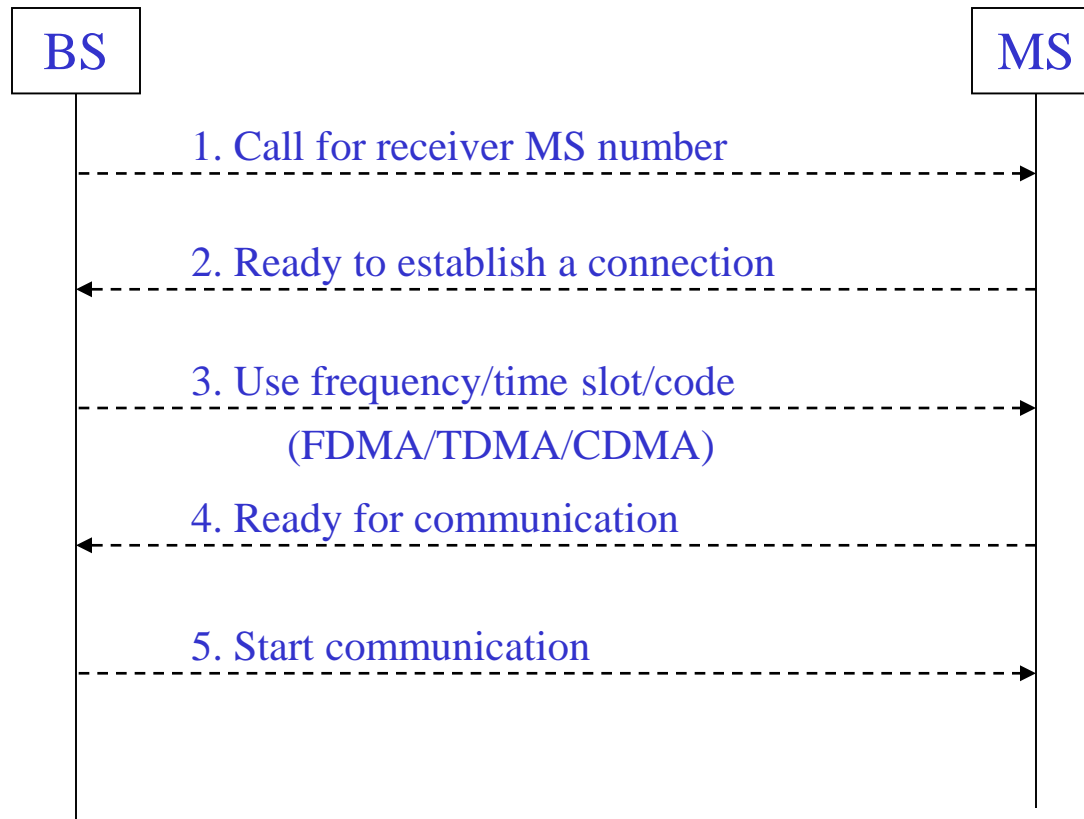


Steps for Call Setup Initiated from MS

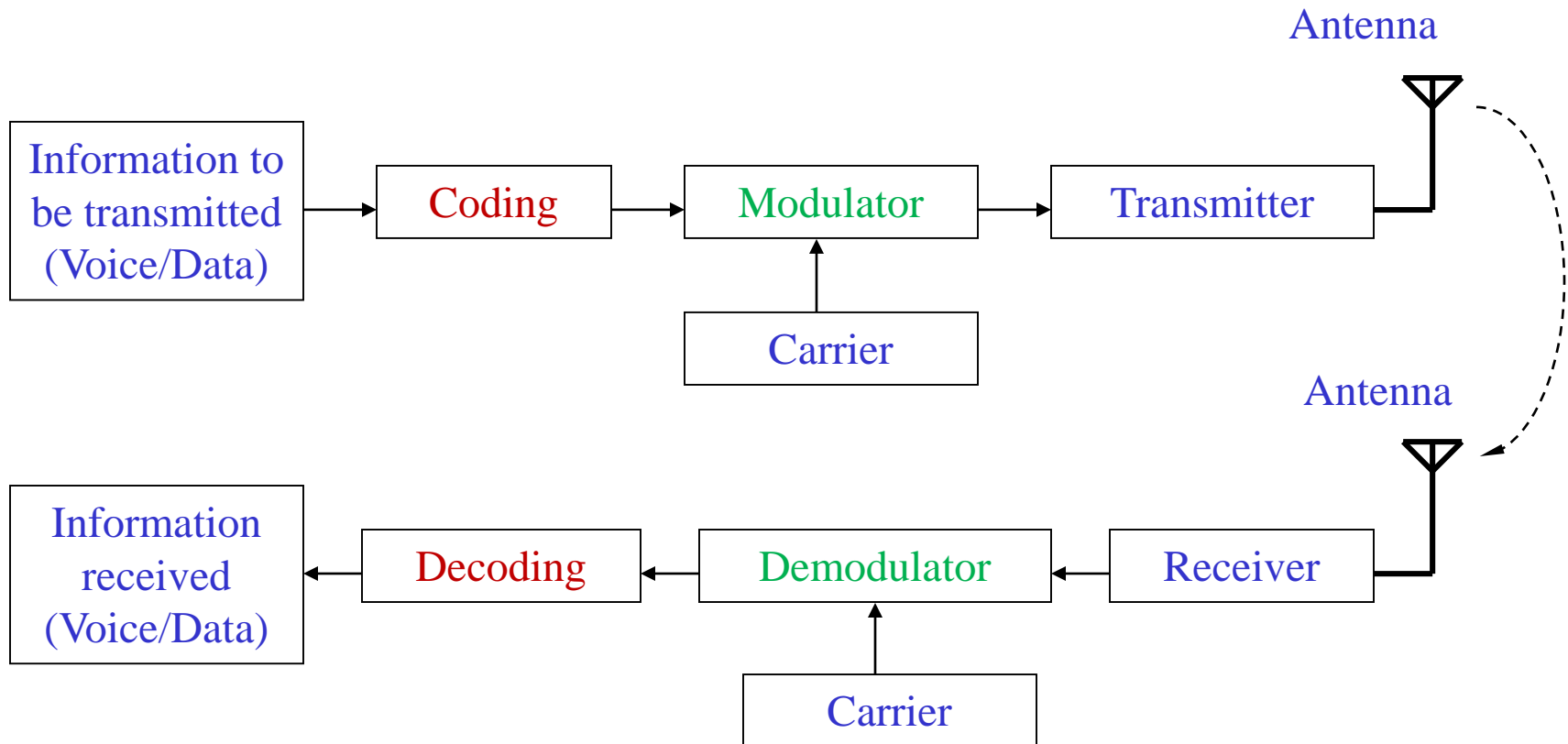




Call Setup from Base Station to MS



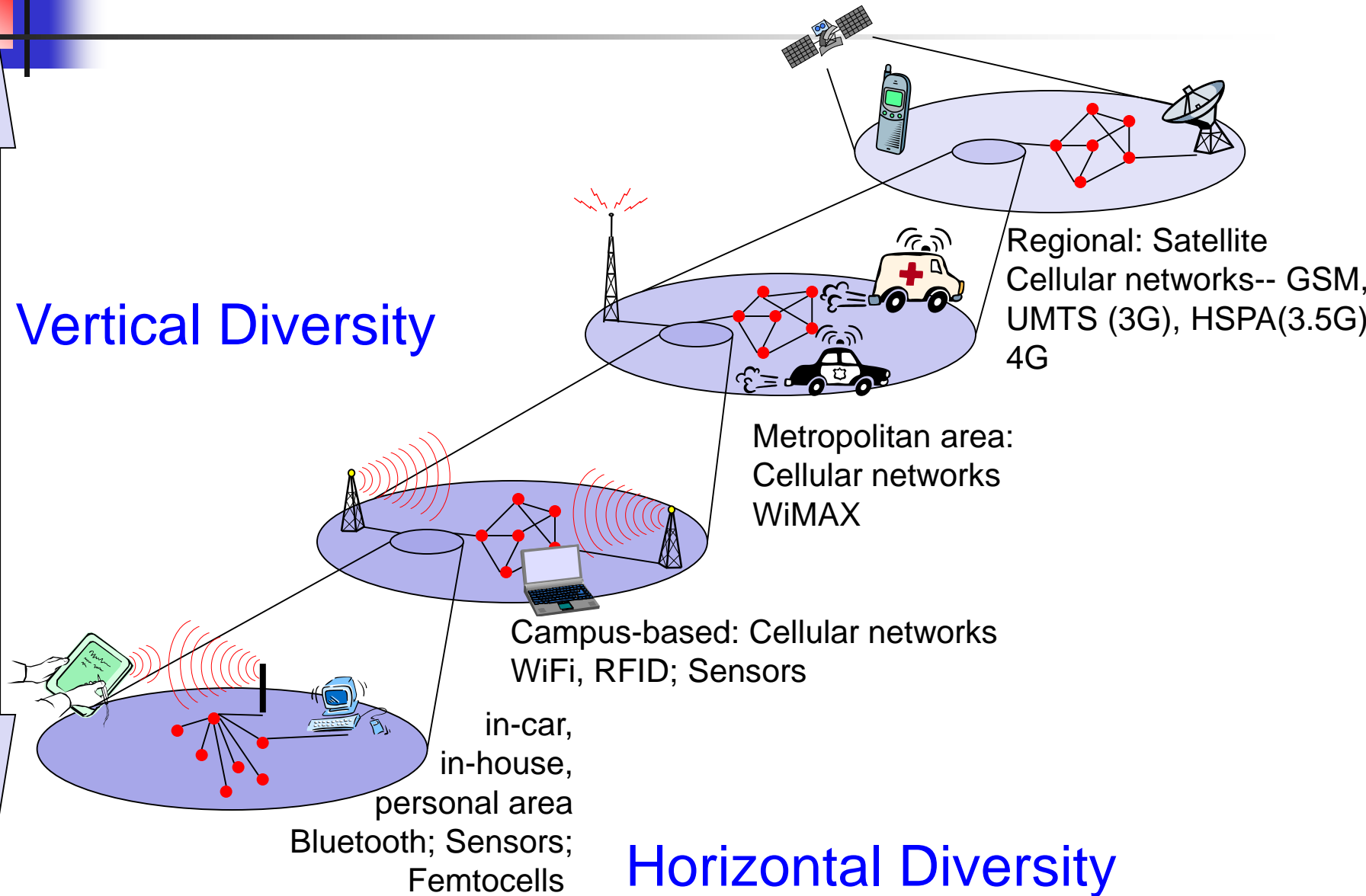
A Simplified Wireless Communication System



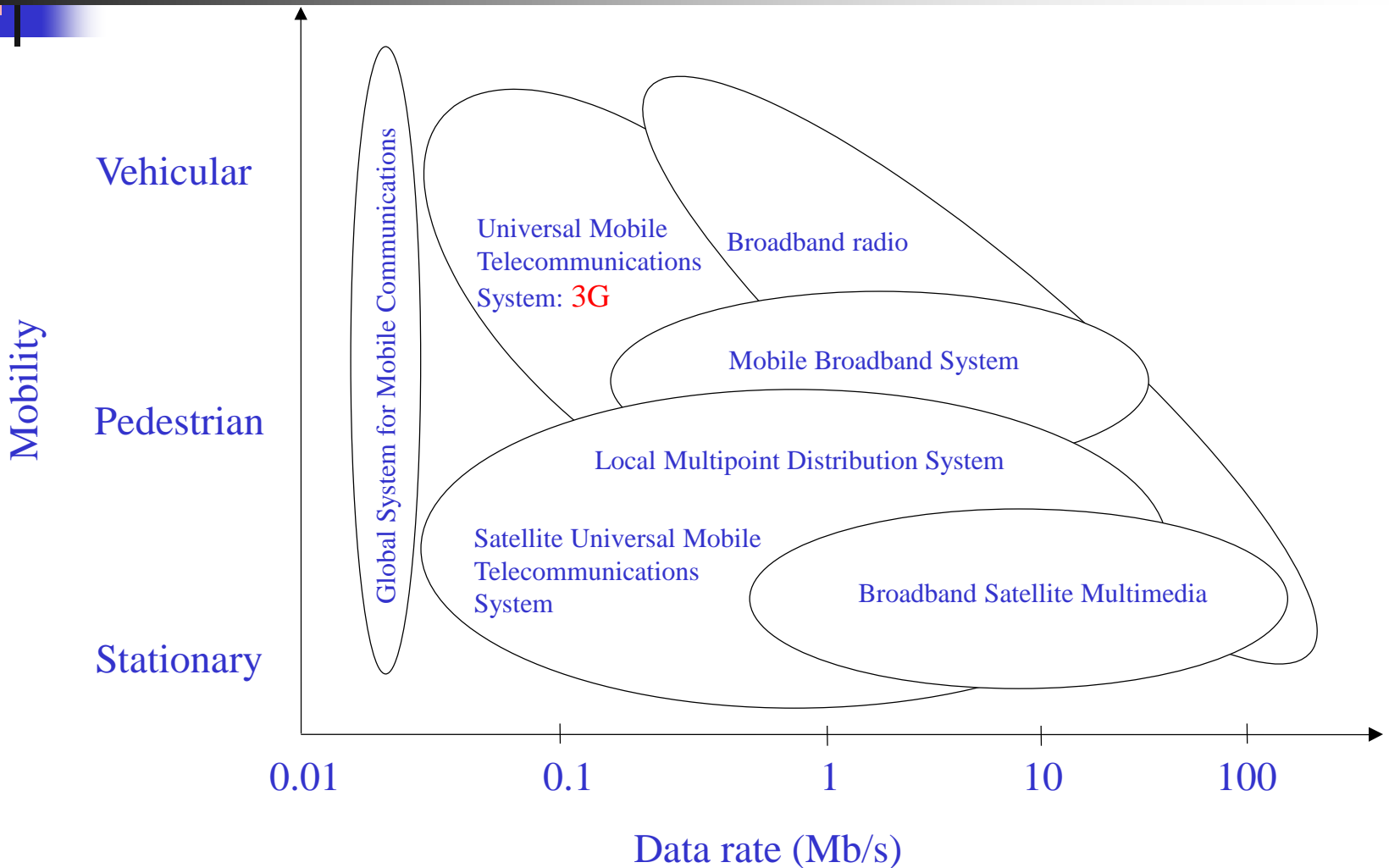
Network Diversities

Vertical Diversity

Horizontal Diversity

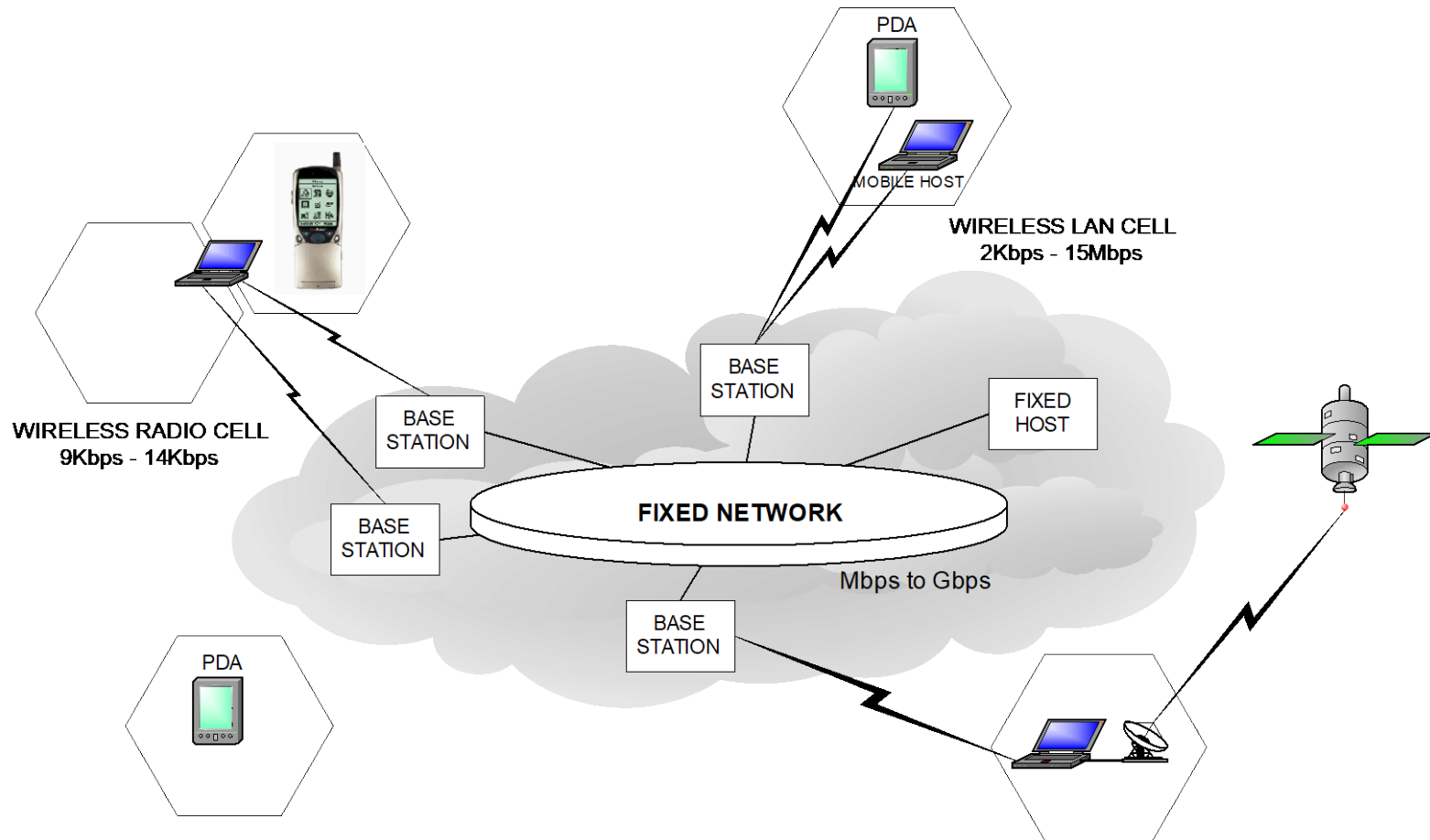


Transmission Capacity



Transmission capacity as a function of mobility in some radio access systems

Networks in Mobile Computing Systems





Mobile Communication: Layer Model

◆ Application layer

- service location
- multimedia
- adaptive applications

◆ Transport layer

- congestion and flow control
- quality of service

◆ Network layer

- addressing, routing, device location
- hand-over

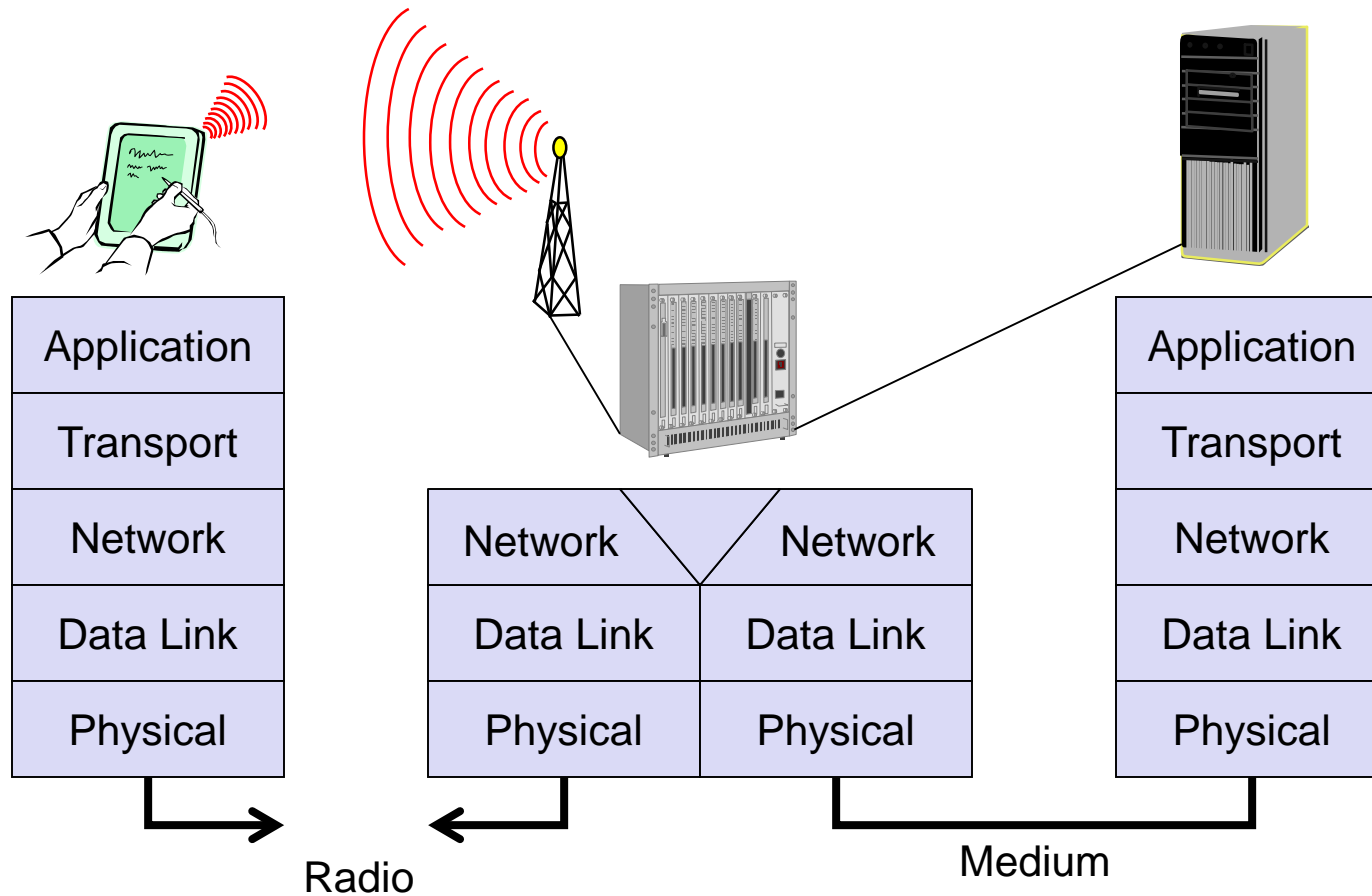
◆ Data link layer

- authentication
- media access
- multiplexing

◆ Physical layer

- modulation
- interference
- attenuation
- frequency

Layer Model for Wireless Communication





Wireless Technologies

- Cellular Networks
- Wireless LAN/PAN
- Home Networking (Bluetooth)
- Ad Hoc Networks
- Sensor Networks
- Vehicular Networks
- Satellite Networks and GPS



Cellular Networks

- Generations of Cellular Networks
 - 0G: Briefcase-size mobile radio phones
 - 1G: Analog cellular phones
 - 2G: Digital cellular phones
 - 3G: High-speed digital cellular phones (video phone)
 - 4G: IP-based voice, data, and multimedia phones
 - faster than 3G
 - 5G: Improved wireless network technologies
 - millimeter wave bands (e.g., 60 GHz), offering as high as 20 Gbps, starting deployment from 2019



Wireless LAN

- Wireless LAN (WLAN) uses IEEE 802.11
- HiperLAN is an European Standard
 - 50m in range
 - Support 1.4m/s mobility and 23.2Mbits/s
- Most mobile phones support both cellular telephony and wireless LAN:
 - IEEE 802.11 (longer range)
 - Bluetooth (100m max, 10m for handsets)
 - Infrared Data Association (IrDA)

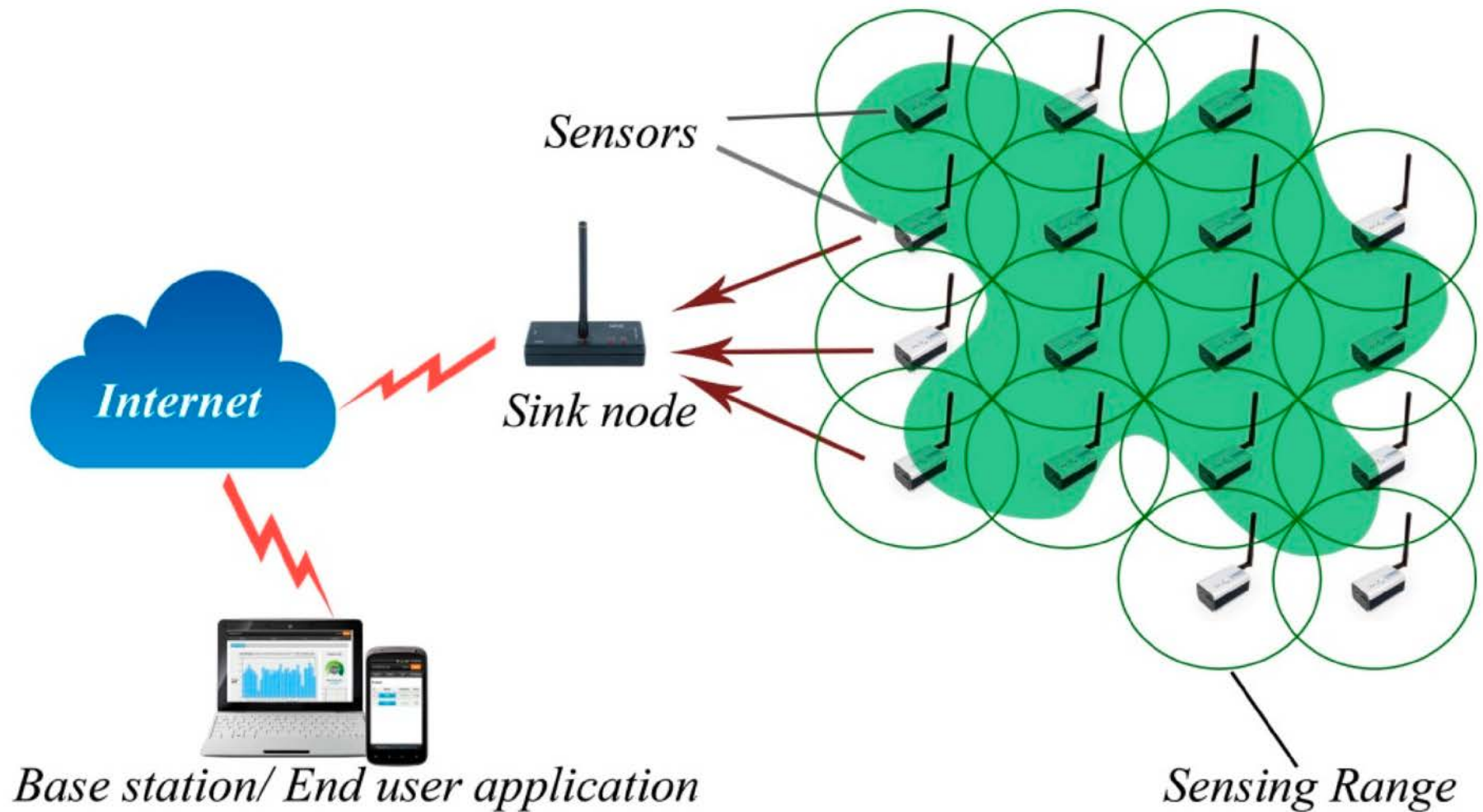
IEEE 802.11 Networks

Wireless Fidelity (Wi-Fi)





Wireless Sensor Networks (WSN)



RFIDs (Radio Frequency Identification)

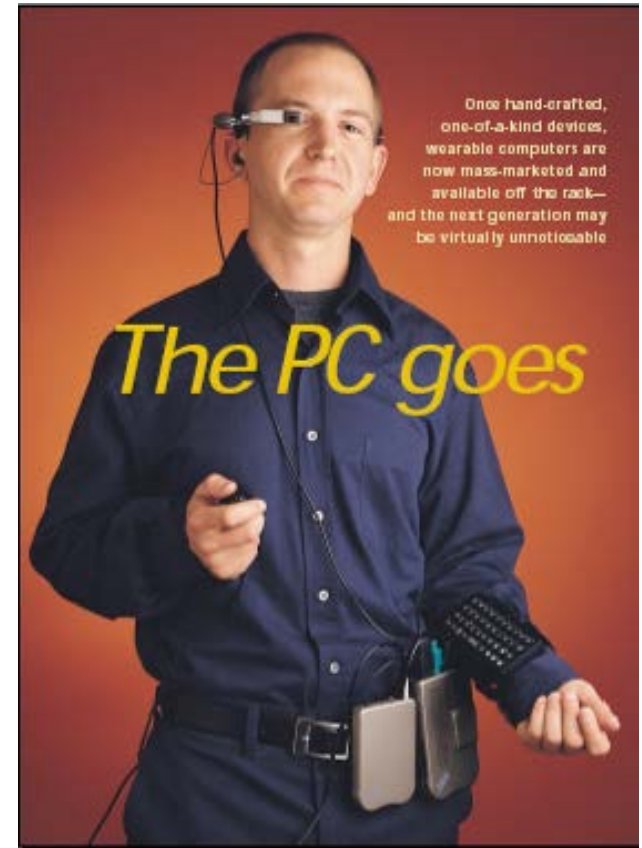
- A label for identification and counting, i.e., a low-end smart card with storage, small IC, and RF-transponder
- Identifying objects in a short distance
 - ~10m to 100m
- Wireless energy supply
 - magnetic field
- Low Cost (~\$0.1 .. \$1)
 - consumable and disposable
- Flexible tags
 - Stick on papers



Chip (without antenna):
~ 2 mm x 2 mm x 10 μ m
(fits into 80 μ m thick paper!)

Wearable Devices

- Wearable devices: computing devices that you can wear
 - Simplified I/O (reduced display), or voice input to make it easy to use
 - Compact design to make it easy to carry (reducing unnecessary components)
- What can you do with the devices?
- What will be the future of wearable computers?



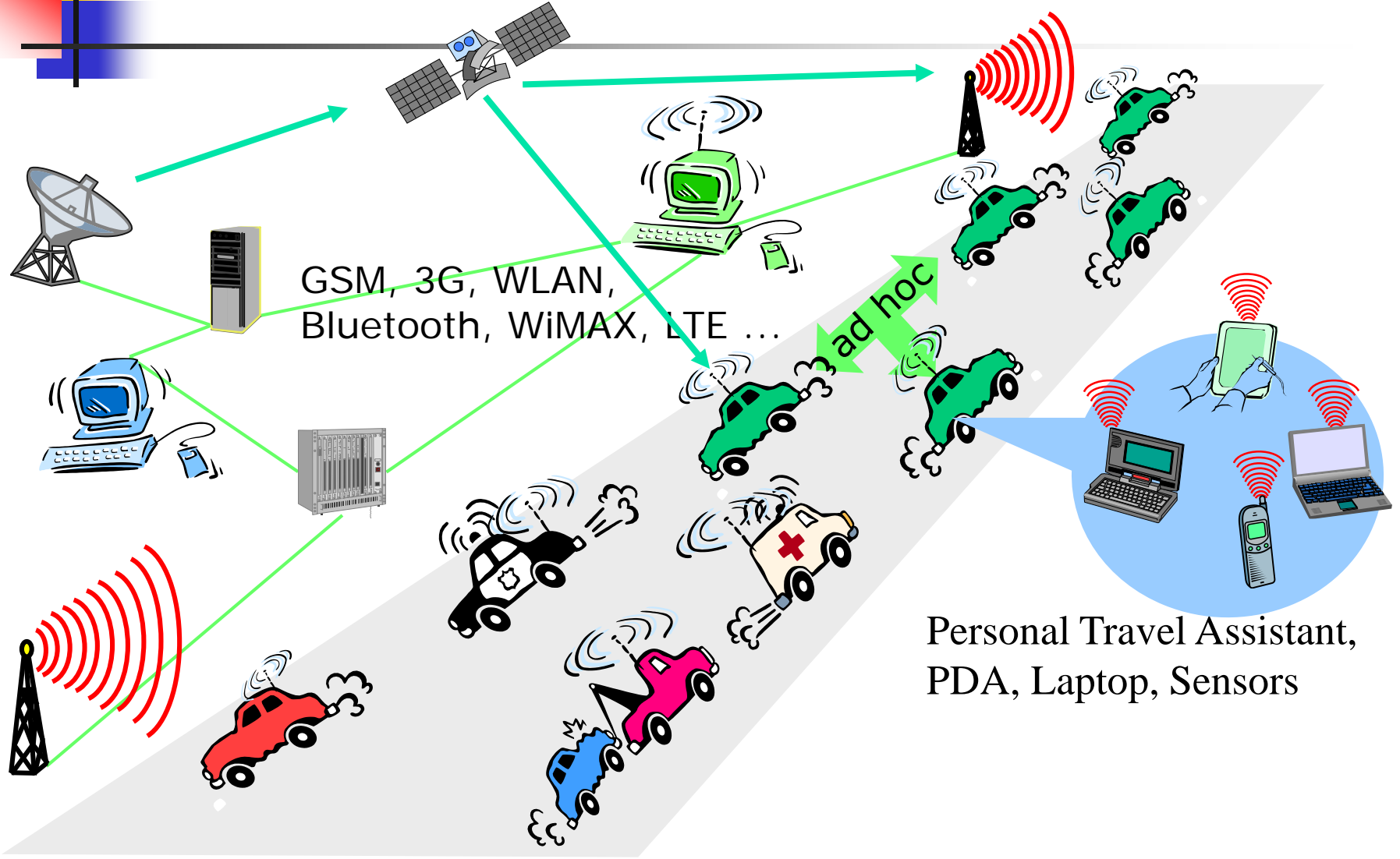
www.xybernaut.com

Body Area Networks (BAN)

- Network of body wearing devices
- Possible applications:
 - Health monitoring
 - Person surveillance and tracking
 - E-payment
 - Integrate with smart phones for data collection and transmission
 -



Vehicular Networks





Satellite Systems

- Traditional Applications
 - Weather satellite
 - Radio and TV broadcasting
 - Military satellites
- Telecommunication Applications
 - Global telephone connections
 - Backbone for global network
 - GPS

Mobile Handsets (MH)

■ MHs (smartphones, PDA, PAD, etc.) provide services to users:

- Cellular telephony
- Managing address book
- Scheduling calendar
- Accessing Internet, email,
-



Example handsets:
Apple iPhone, iPad, BlackBerry Storm, Palm TreoPro, T-Mobile



Microprocessors inside MHs

- MHs use embedded processors
 - Intel and ARM dominate:
 - BlackBerry 8700 -- Intel PXA901 chip
 - iPhone -- Samsung ARM 1100 chip
 - Integrate all functionality in a single chip (system-on-chip, SoC) for maximum flexibility
 - Limited computing resources and battery power



MH Operating Systems

- MHs run several OSes:
 - Symbian OS
 - Android
 - BlackBerry OS
 - iOS (iPhones)
 - Windows Phone 7



Symbian OS

- Owned by Symbian Ltd, established in 1998 as a partnership between Ericsson, Nokia, Motorola to exploit the merging of PDAs and smartphones
- Nokia bought Symbian in 2008, forming Symbian Foundation to focus on Symbian OS development
- Open source code was made available in 2010
- Was the most popular smartphone OS until the end of 2010, when it was overtaken by Android
- Runs exclusively on ARM processors



Android OS

- Android Inc., founded by Andy Rubin in 2003, aiming to develop “*smarter mobile devices that are more aware of its owner's location and preferences*”
 - Android OS is based on the Linux kernel
 - Android Inc. was bought by Google in 2005
- The OS uses touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects
- Android's source code is released by Google under open source licenses, attracting large number of developers to develop mobile apps on Android



iOS: iPhone OS

- iOS is a mobile operating system developed by Apple Inc. and distributed exclusively for Apple hardware.
- It has been extended to support other Apple devices, such as the iPod, iPad, Apple TV, etc.
- Apple's native Software Development Kit (SDK) provides development tools, iPhone emulator, upload to App Store, etc.
- A membership fee is required to download SDK
 - Exception: a special version free for universities



Windows OS

- Windows Mobile Development tools include:
 - Plugins for MS Visual Studio 2005, 2008, etc.
 - SDKs for Windows Mobile-based handsets
 - Microsoft gives away Visual Studio to students for free with its DreamSpark program
- Microsoft obsoleted the old Windows Mobile and released Windows 10 Mobile in 2015
 - Has ceased active development of windows 10



Challenges in Mobile Computing

- Communication challenges:
 - No stable connections, bandwidth shortage.
- Hardware challenges:
 - Small display, slow processor, limited battery power
- Interoperability challenges:
 - Data formats, codec and protocols may not be compatible
- Software and storage challenges:
 - limited storage capacity and processing power
- Security challenges:
 - vulnerable to various attacks (wireless link, data access, data storage and privacy, etc.).