

Chapter 1

INTRODUCTION



The History of Mobile Radio Communication (1/3)

- 1880: Hertz – Initial demonstration of practical radio communication
- 1897: Marconi – Radio transmission to a tugboat over an 18 mi path
- 1921: Detroit Police Department: -- Police car radio dispatch (2 MHz frequency band)
- 1933: FCC (Federal Communications Commission) – Authorized four channels in the 30 to 40 MHz range
- 1938: FCC – Ruled for regular service
- 1946: Bell Telephone Laboratories – 152 MHz (Simplex)
- 1956: FCC – 450 MHz (Simplex)
- 1959: Bell Telephone Laboratories – Suggested 32 MHz band for high capacity mobile radio communication
- 1964: FCC – 152 MHz (Full Duplex)
- 1964: Bell Telephone Laboratories – Active research at 800 MHz
- 1969: FCC – 450 MHz (Full Duplex)
- 1974: FCC – 40 MHz bandwidth allocation in the 800 to 900 MHz range
- 1981: FCC – Release of cellular land mobile phone service in the 40 MHz bandwidth in the 800 to 900 MHz range for commercial operation



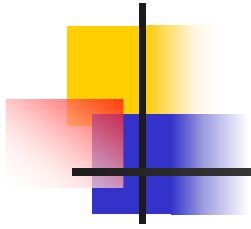
The History of Mobile Radio Communication (2/3)

- 1981: AT&T and RCC (Radio Common Carrier) reach an agreement to split 40 MHz spectrum into two 20 MHz bands. Band A belongs to nonwireline operators (RCC), and Band B belongs to wireline operators (telephone companies). Each market has two operators.
- 1982: AT&T is divested, and seven RBOCs (Regional Bell Operating Companies) are formed to manage the cellular operations
- 1982: MFJ (Modified Final Judgment) is issued by the government DOJ. All the operators were prohibited to (1) operate long-distance business, (2) provide information services, and (3) do manufacturing business
- 1983: Ameritech system in operation in Chicago
- 1984: Most RBOC markets in operation
- 1986: FCC allocates 5 MHz in extended band
- 1987: FCC makes lottery on the small MSA and all RSA licenses
- 1988: TDMA (Time Division Multiple Access) voted as a digital cellular standard in North America
- 1992: GSM (Groupe Speciale Mobile) operable in Germany D2 system

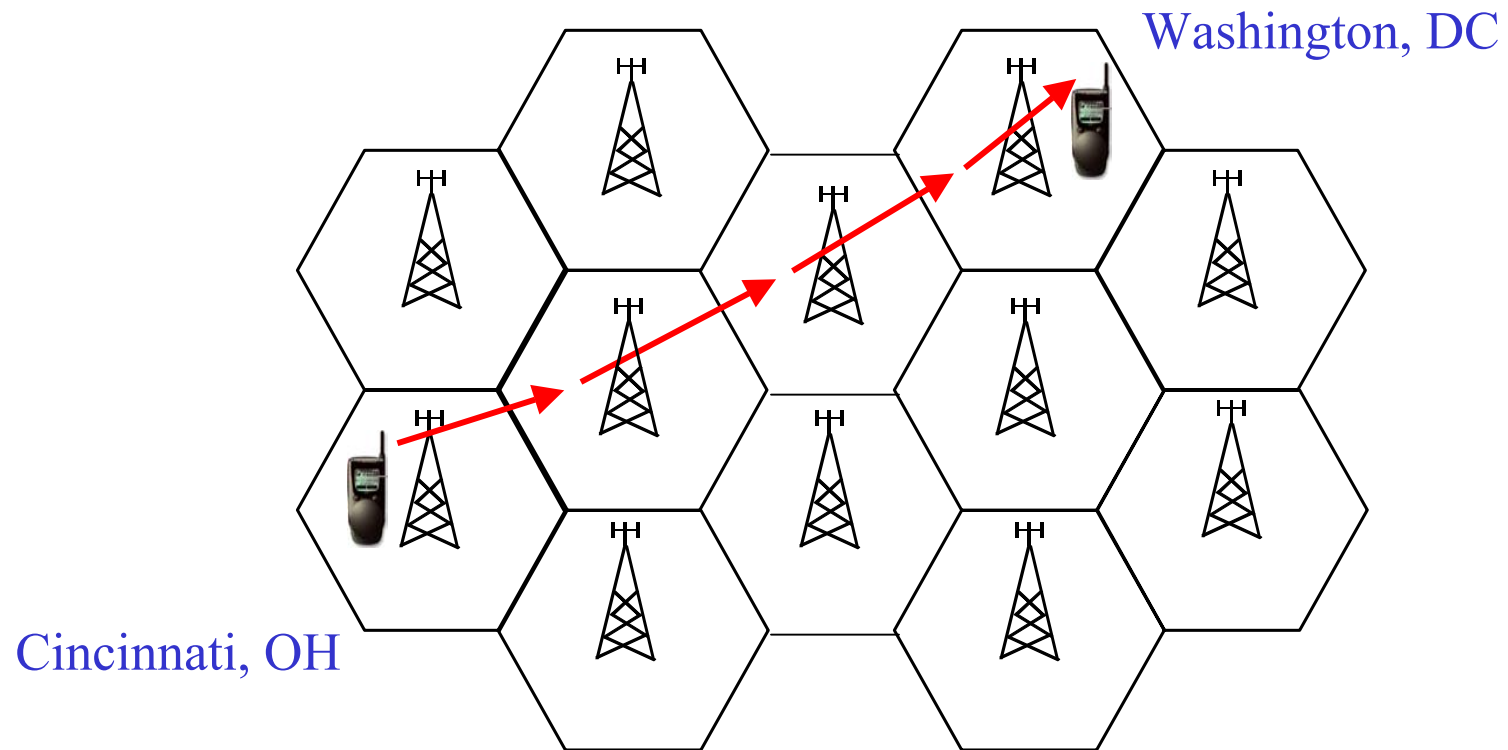


The History of Mobile Radio Communication (3/3)

- 1993: CDMA (Code Division Multiple Access) voted as another digital cellular standard in North America
- 1994: American TDMA operable in Seattle, Washington
- 1994: PDC (Personal Digital Cellular) operable in Tokyo, Japan
- 1994: Two of six broadband PCS (Personal Communication Service) license bands in auction
- 1995: CDMA operable in Hong Kong
- 1996: US Congress passes Telecommunication Reform Act Bill
- 1996: The auction money for six broadband PCS licensed bands (120 MHz) almost reaches 20 billion US dollars
- 1997: Broadband CDMA considered as one of the third generation mobile communication technologies for UMTS (Universal Mobile Telecommunication Systems) during the UMTS workshop conference held in Korea
- 1999: ITU (International Telecommunication Union) decides the next generation mobile communication systems (e.g., W-CDMA, cdma2000, etc)



Applications



Maintaining the telephone number across geographical areas in a wireless and mobile system



First Generation Cellular Systems and Services

1970s	Developments of radio and computer technologies for 800/900 MHz mobile communications
1976	WARC (World Administrative Radio Conference) allocates spectrum for cellular radio
1979	NTT (Nippon Telephone & Telegraph) introduces the first cellular system in Japan
1981	NMT (Nordic Mobile Telephone) 900 system introduced by Ericsson Radio System AB and deployed in Scandinavia
1984	AMPS (Advanced Mobile Phone Service) introduced by AT&T in North America



Second Generation Cellular Systems and Services

1982	CEPT (Conference Europeenne des Post et Telecommunications) established GSM to define future Pan-European cellular Radio Standards
1990	Interim Standard IS-54 (USDC) adopted by TIA (Telecommunications Industry Association)
1990	Interim Standard IS-19B (NAMPS) adopted by TIA
1991	Japanese PDC (Personal Digital Cellular) system standardized by the MPT (Ministry of Posts and Telecommunications)
1992	Phase I GSM system is operational
1993	Interim Standard IS-95 (CDMA) adopted by TIA
1994	Interim Standard IS-136 adopted by TIA
1995	PCS Licenses issued in North America
1996	Phase II GSM operational
1997	North American PCS deploys GSM, IS-54, IS-95
1999	IS-54: North America IS-95: North America, Hong Kong, Israel, Japan, China, etc GSM: 110 countries



Third Generation Cellular Systems and Services (1/2)

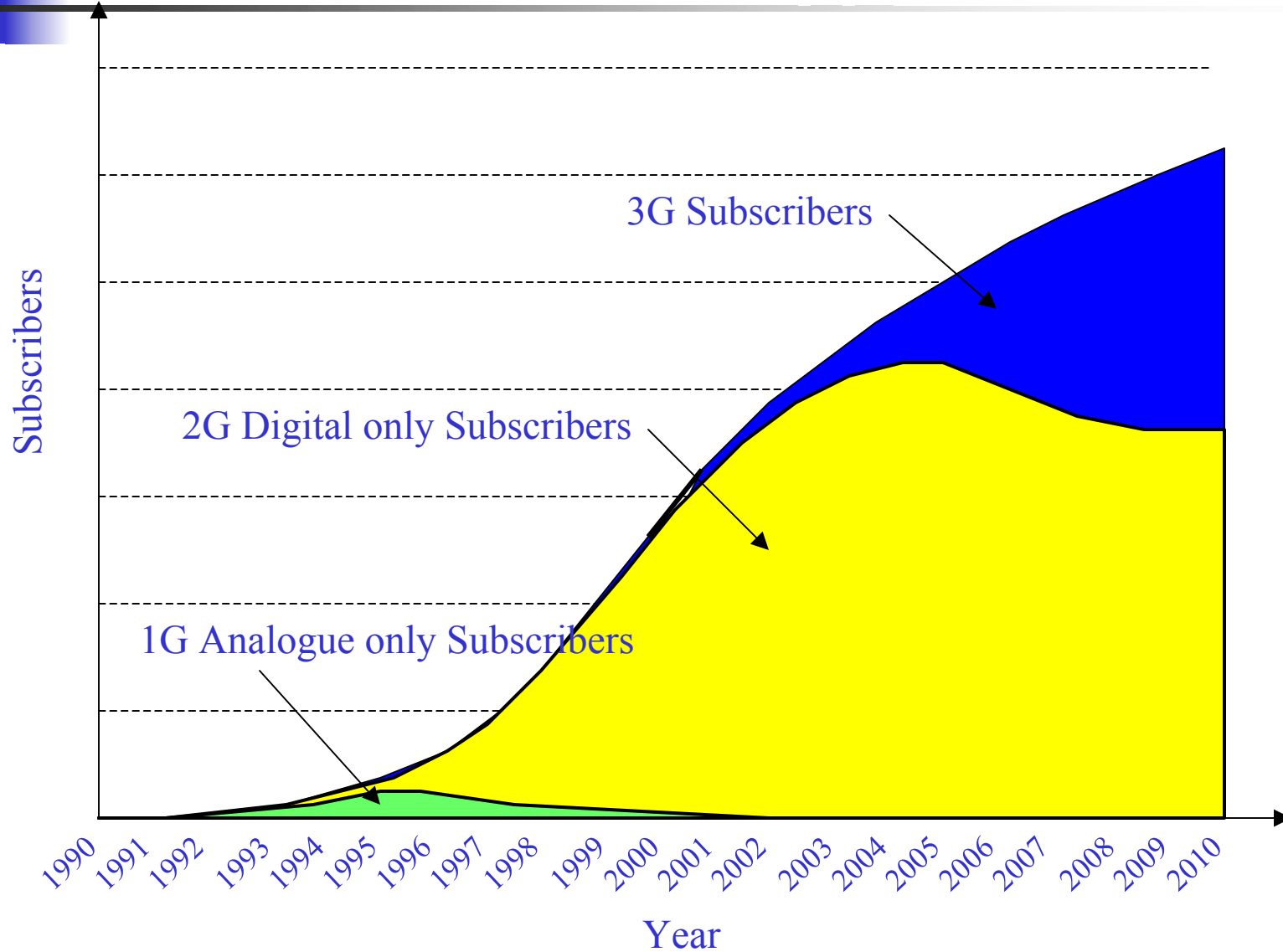
- **IMT-2000 (International Mobile Telecommunications-2000):**
 - Fulfill one's dream of anywhere, anytime communications a reality.
- **Key Features of IMT-2000 include:**
 - High degree of commonality of design worldwide;
 - Compatibility of services within IMT-2000 and with the fixed networks;
 - High quality;
 - Small terminal for worldwide use;
 - Worldwide roaming capability;
 - Capability for multimedia applications, and a wide range of services and terminals.



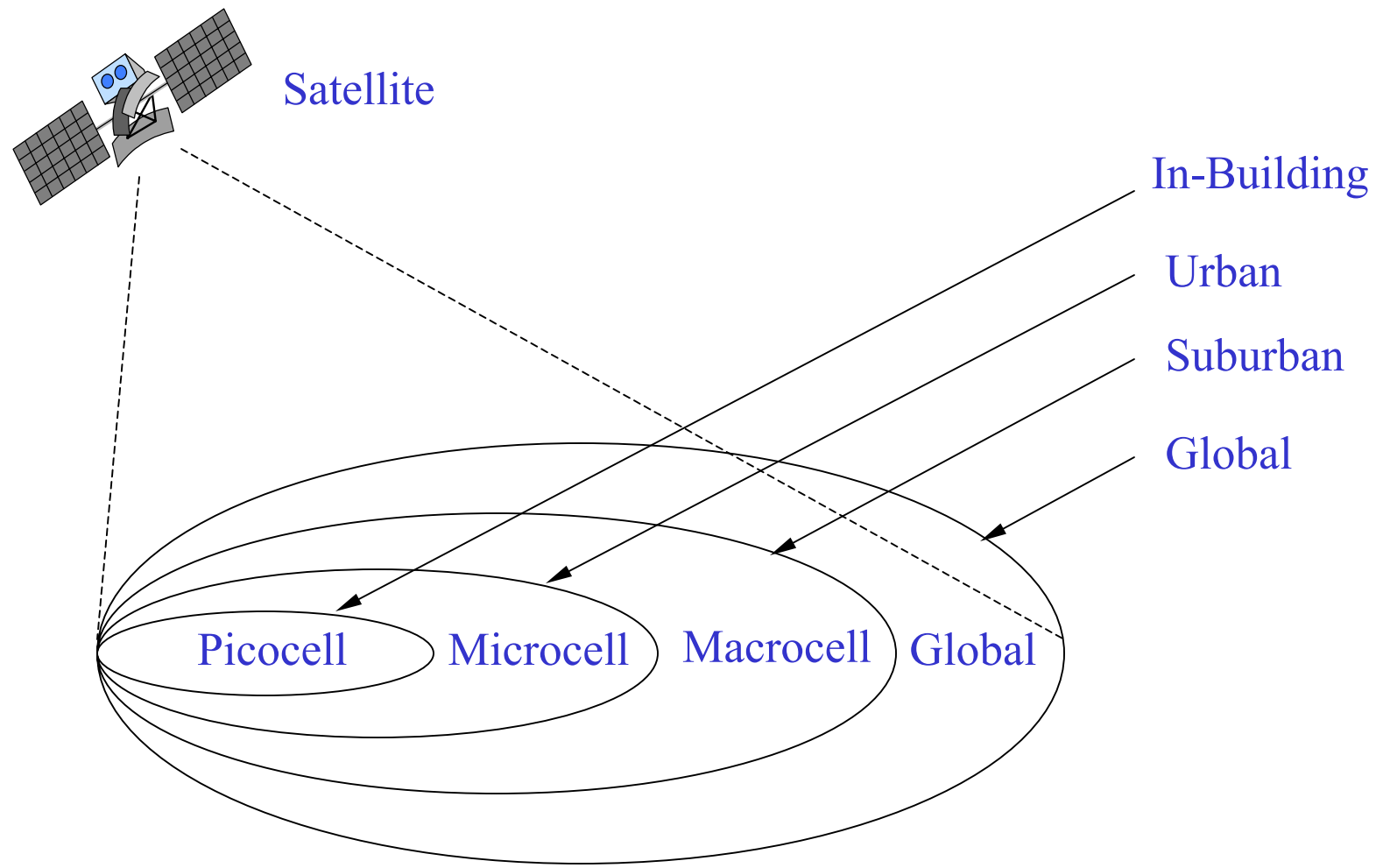
Third Generation Cellular Systems and Services (2/2)

- **Important Component of IMT-2000 is ability to provide high bearer rate capabilities:**
 - 2 Mbps for fixed environment;
 - 384 Kbps for indoor/outdoor and pedestrian environment;
 - 144 kbps for vehicular environment.
- **Standardization Work:**
 - In processing
- **Scheduled Service:**
 - Started in October 2001 in Japan (W-CDMA)

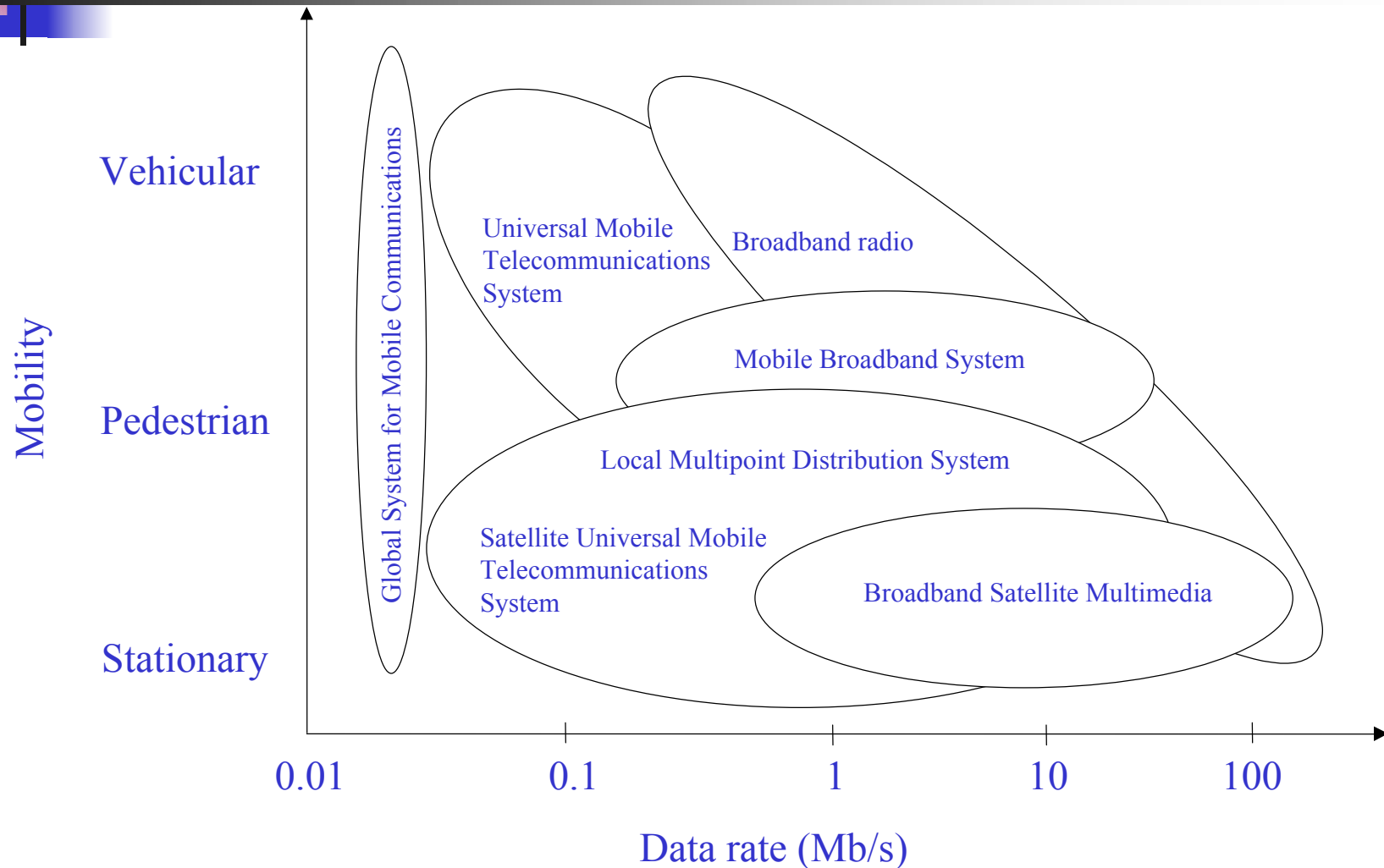
Subscriber Growth



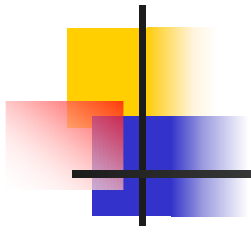
Coverage Aspect of Next Generation Mobile Communication Systems



Transmission Capacity



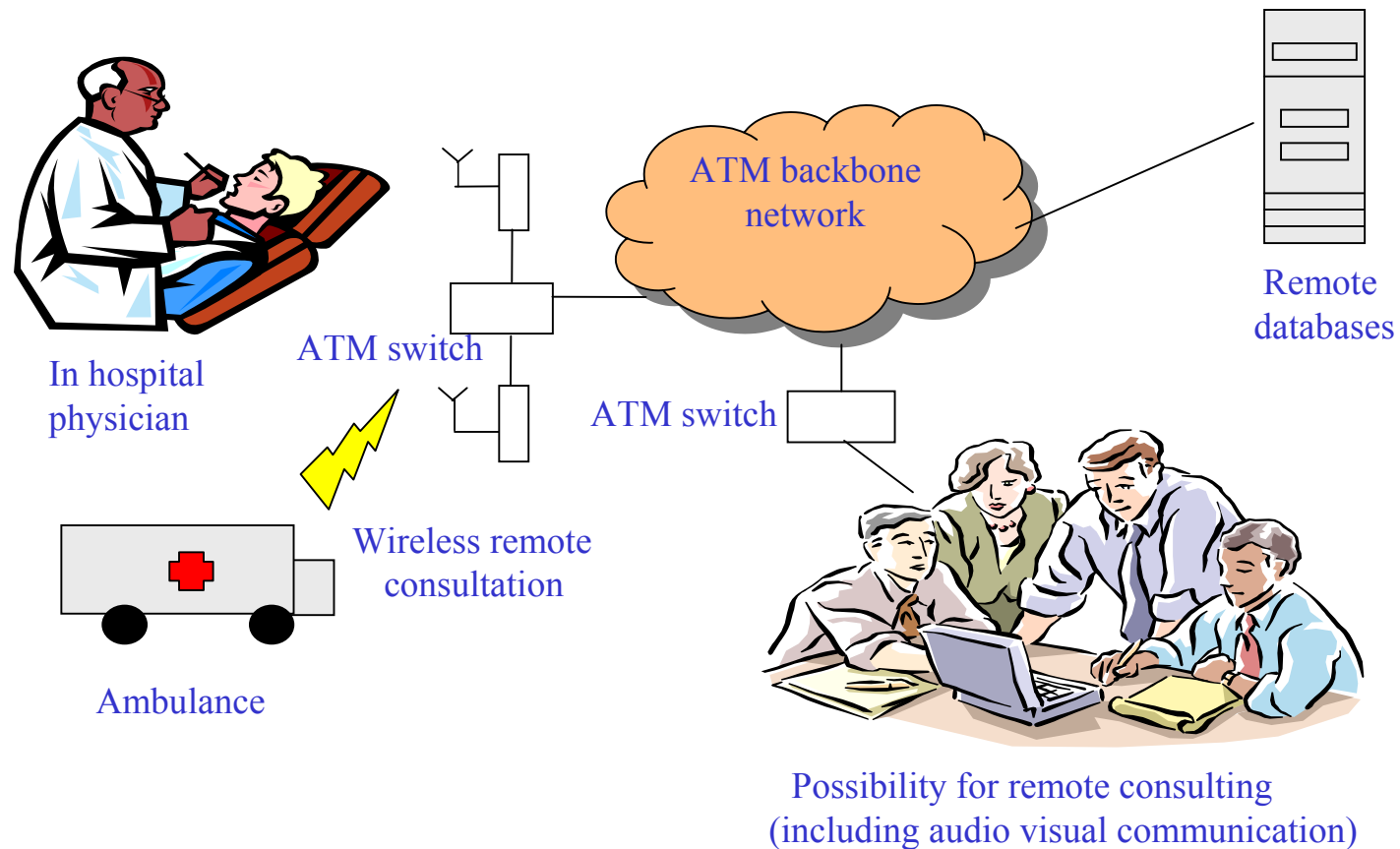
Transmission capacity as a function of mobility in some radio access systems

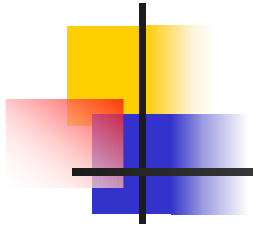


Wireless Technology and Associated Characteristics

- Cellular
- Wireless LAN/PAN
- GPS
- Satellite Based GPS
- Home Networking
- Ad Hoc Networks
- Sensor Networks
- Bluetooth

Medical Application





Fundamentals of Cellular Systems

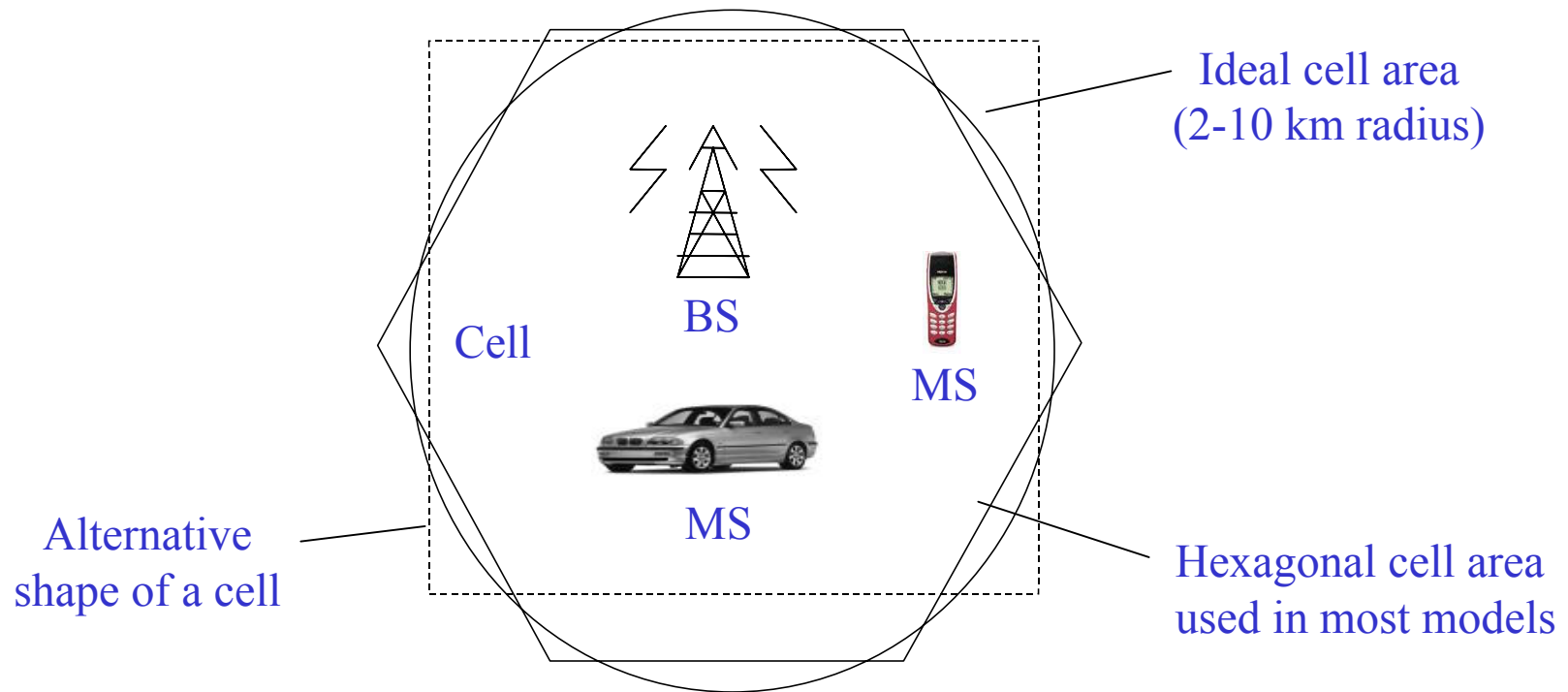
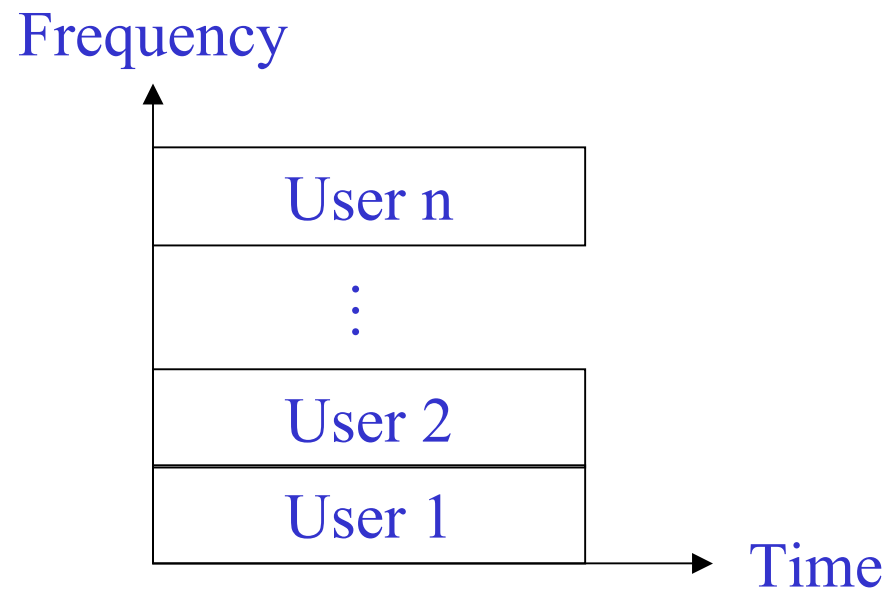
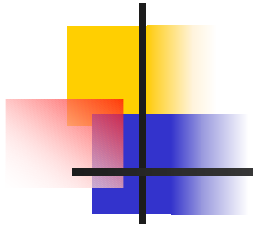


Illustration of a cell with a mobile station and a base station

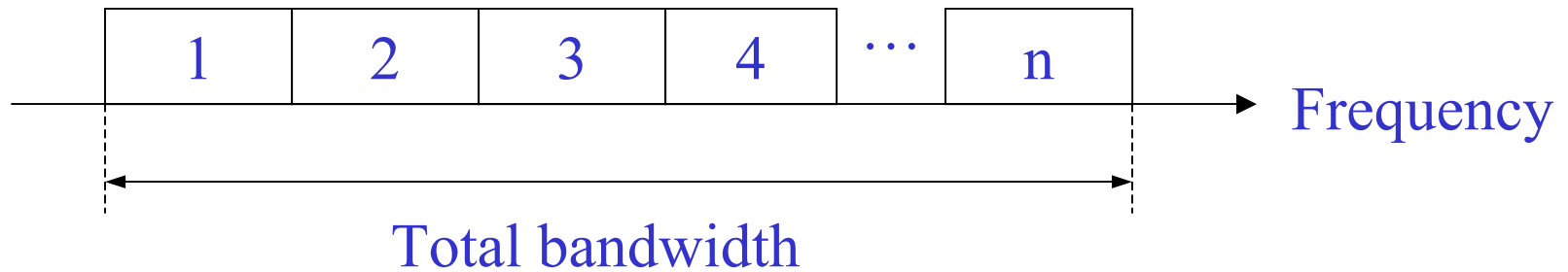


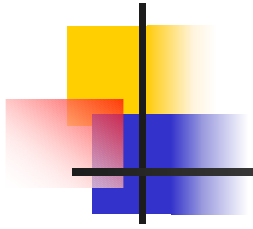
FDMA (Frequency Division Multiple Access)



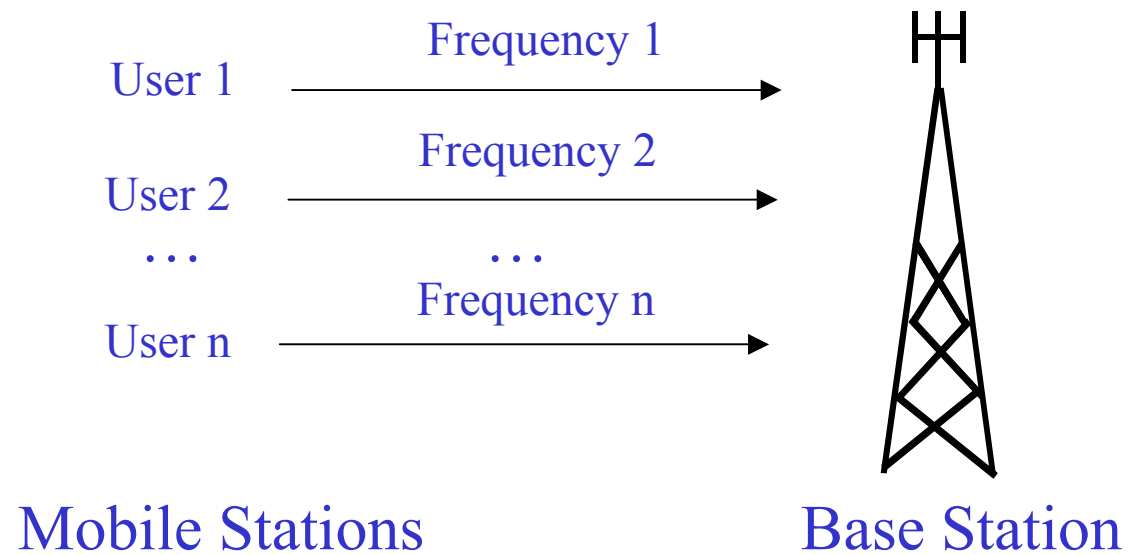


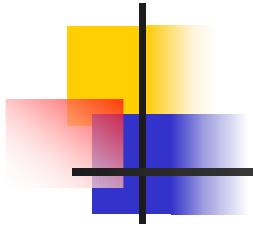
FDMA Bandwidth Structure



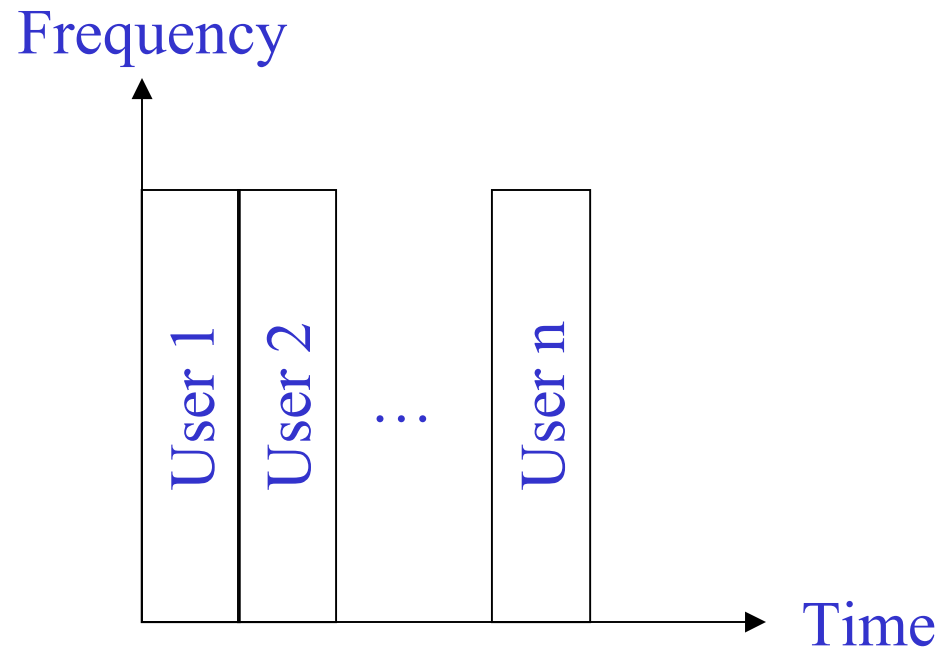


FDMA Channel Allocation



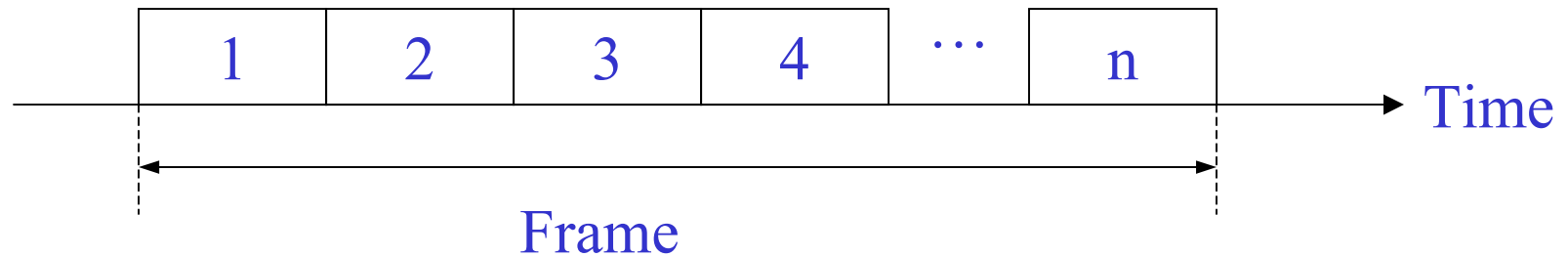


TDMA (Time Division Multiple Access)

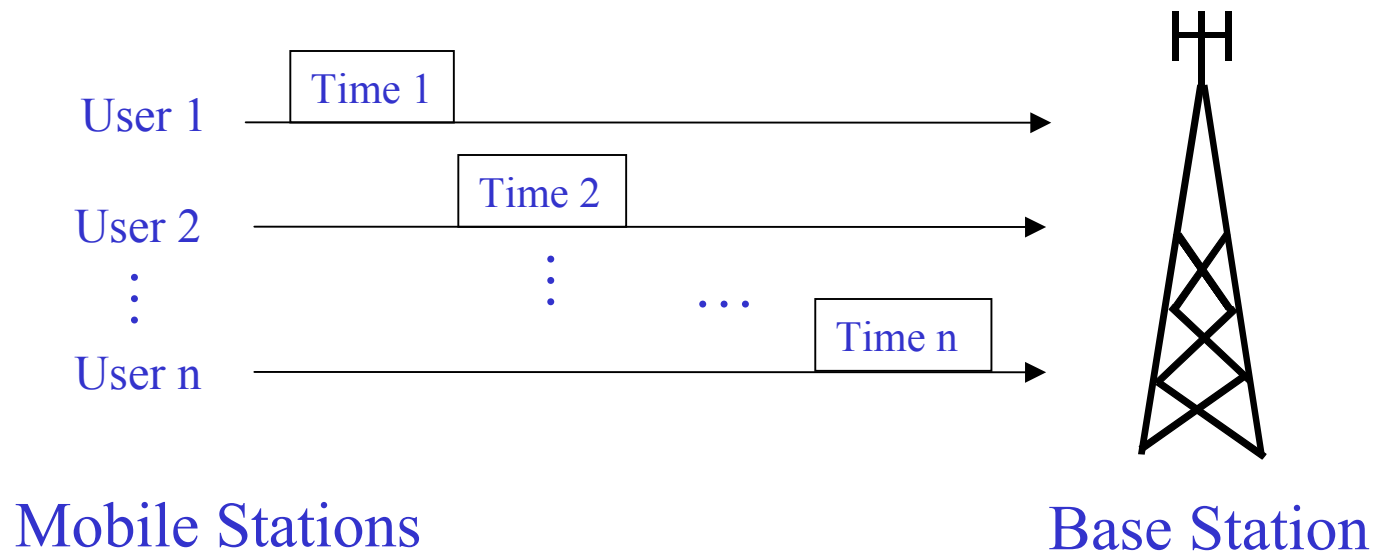


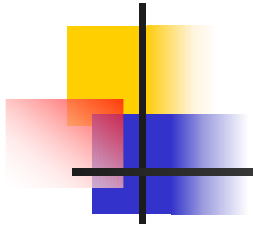


TDMA Frame Structure

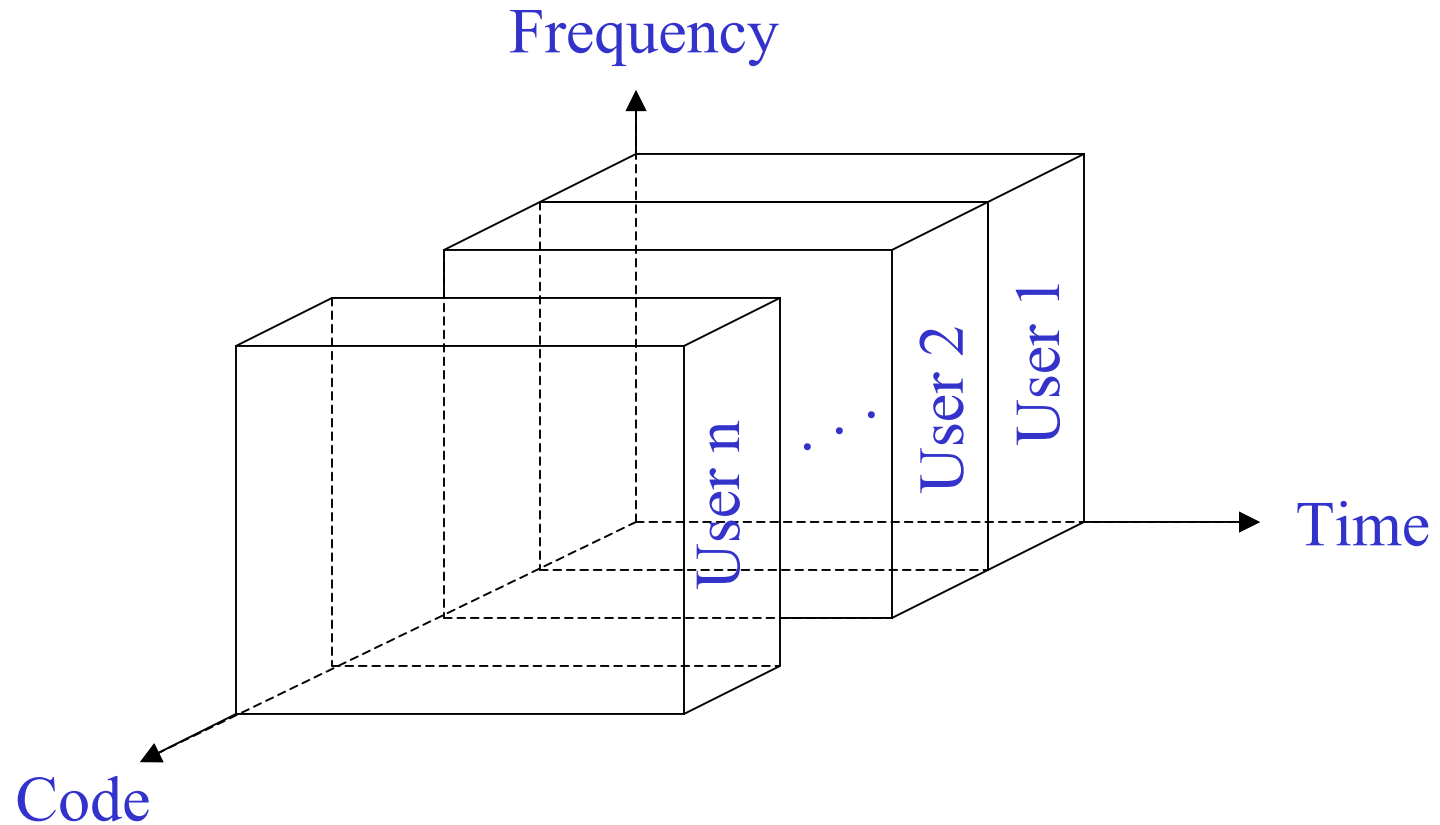


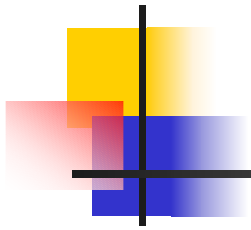
TDMA Frame Illustration for Multiple Users



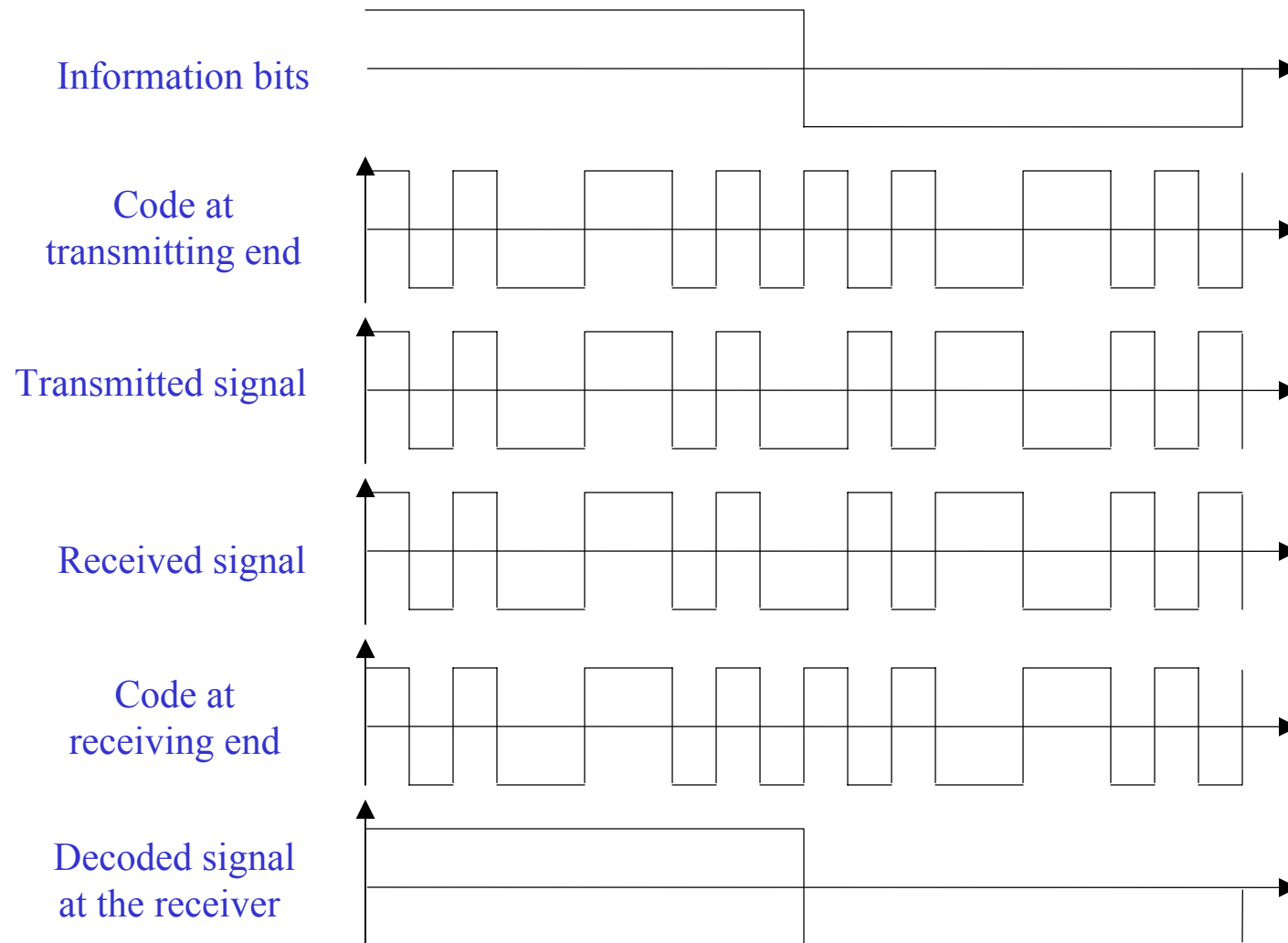


CDMA (Code Division Multiple Access)



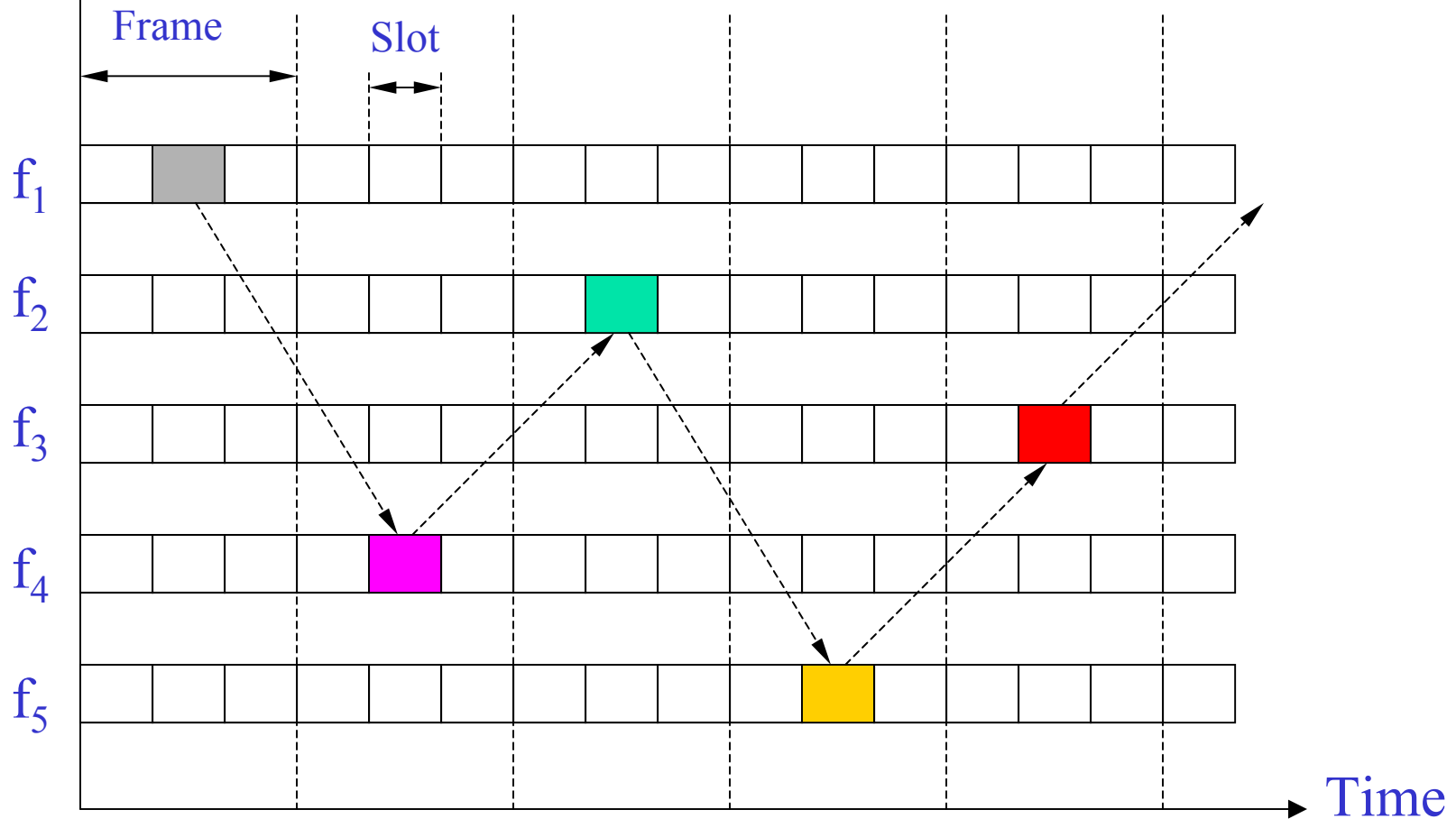


Transmitted and Received Signals in a CDMA System

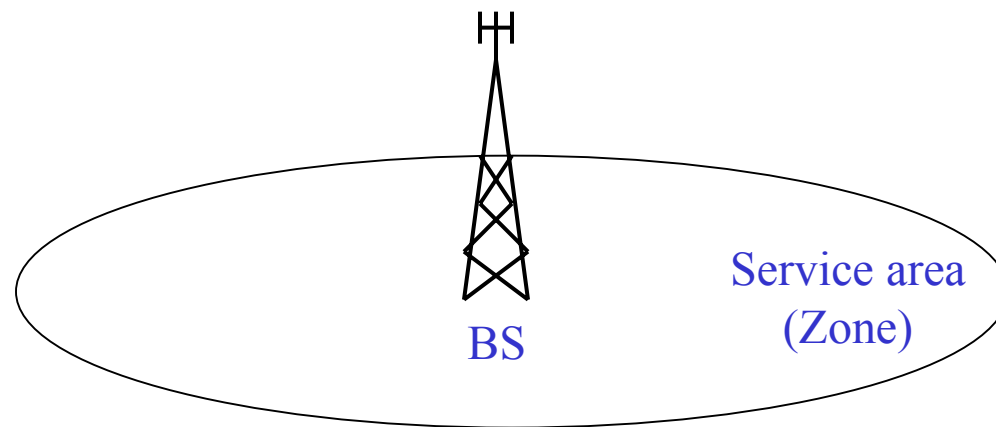


Frequency Hopping

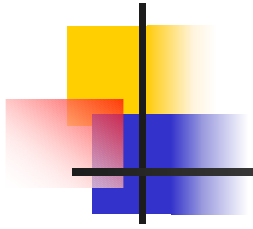
Frequency



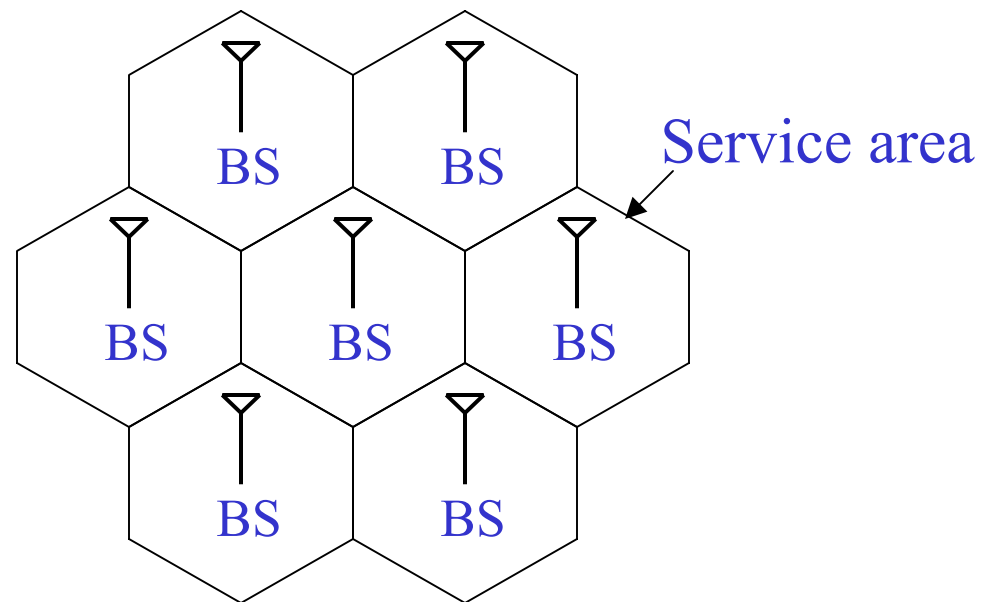
Cellular System Infrastructure



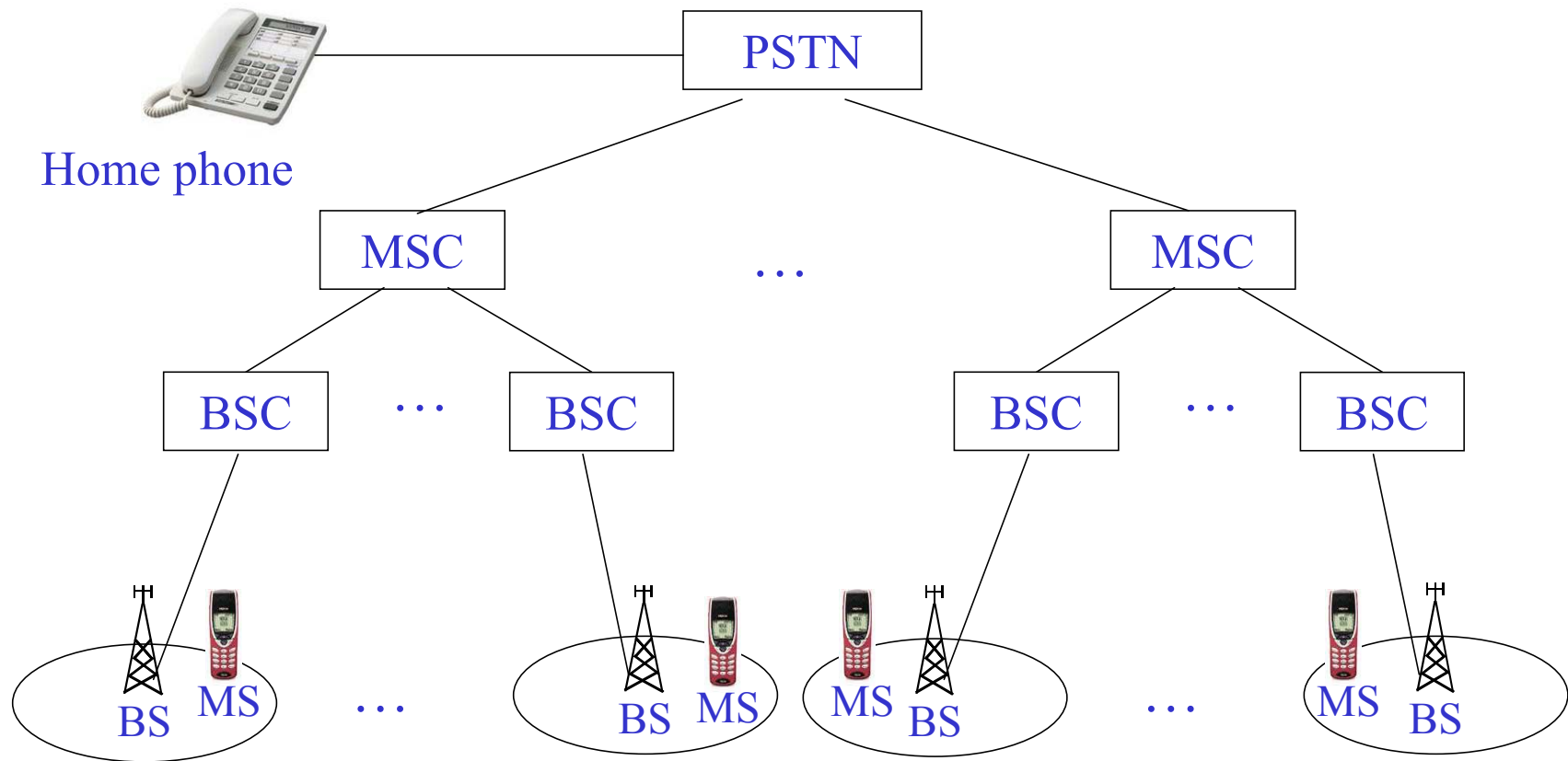
Early wireless system: *Large zone*

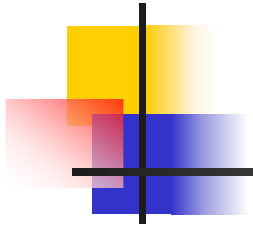


Cellular System: Small Zone

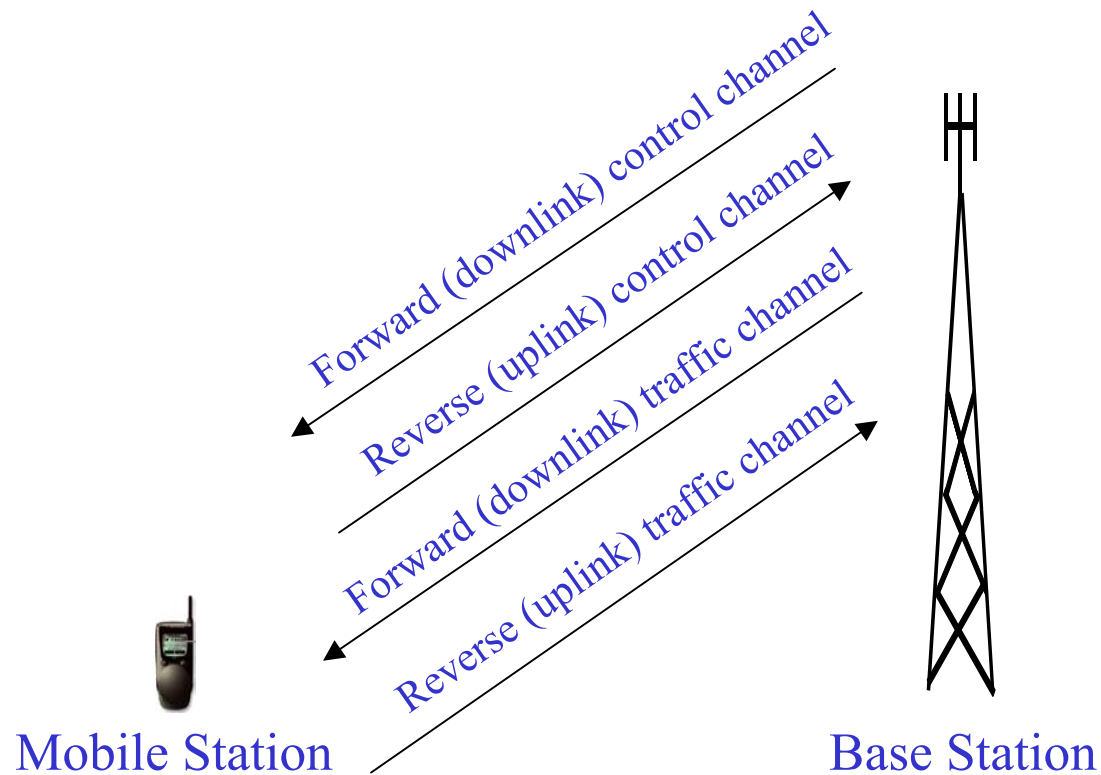


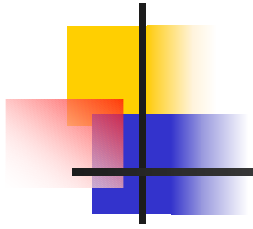
MS, BS, BSC, MSC, and PSTN



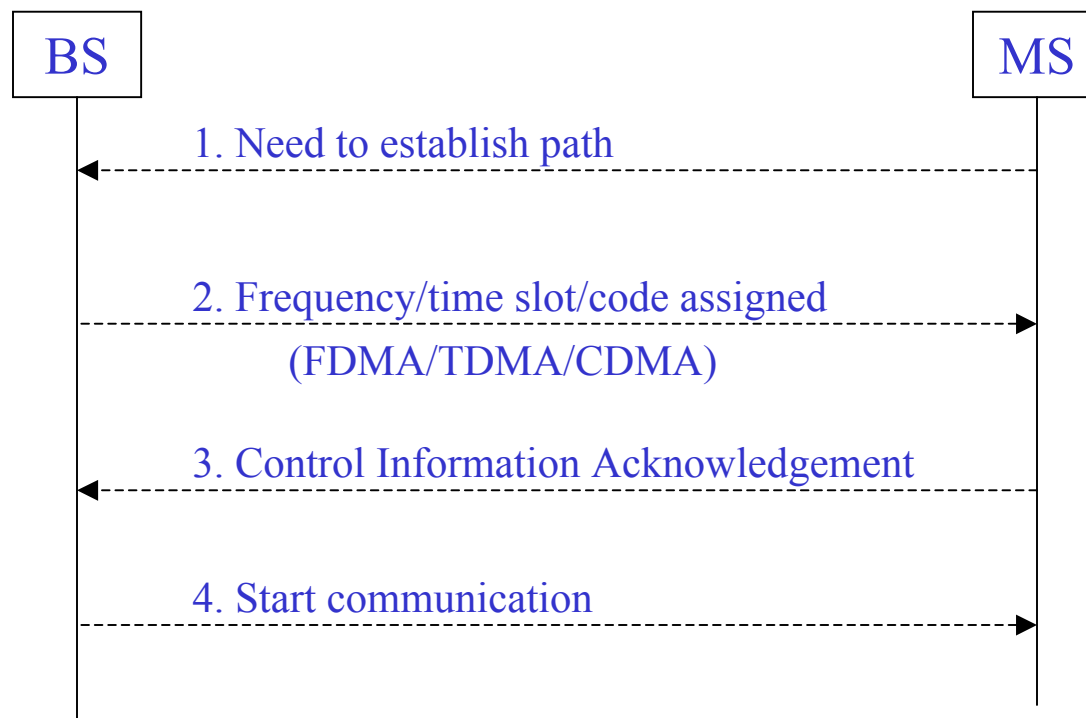


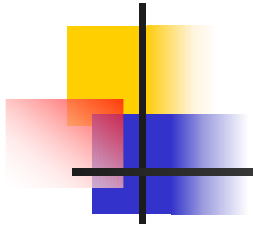
Control and Traffic Channels



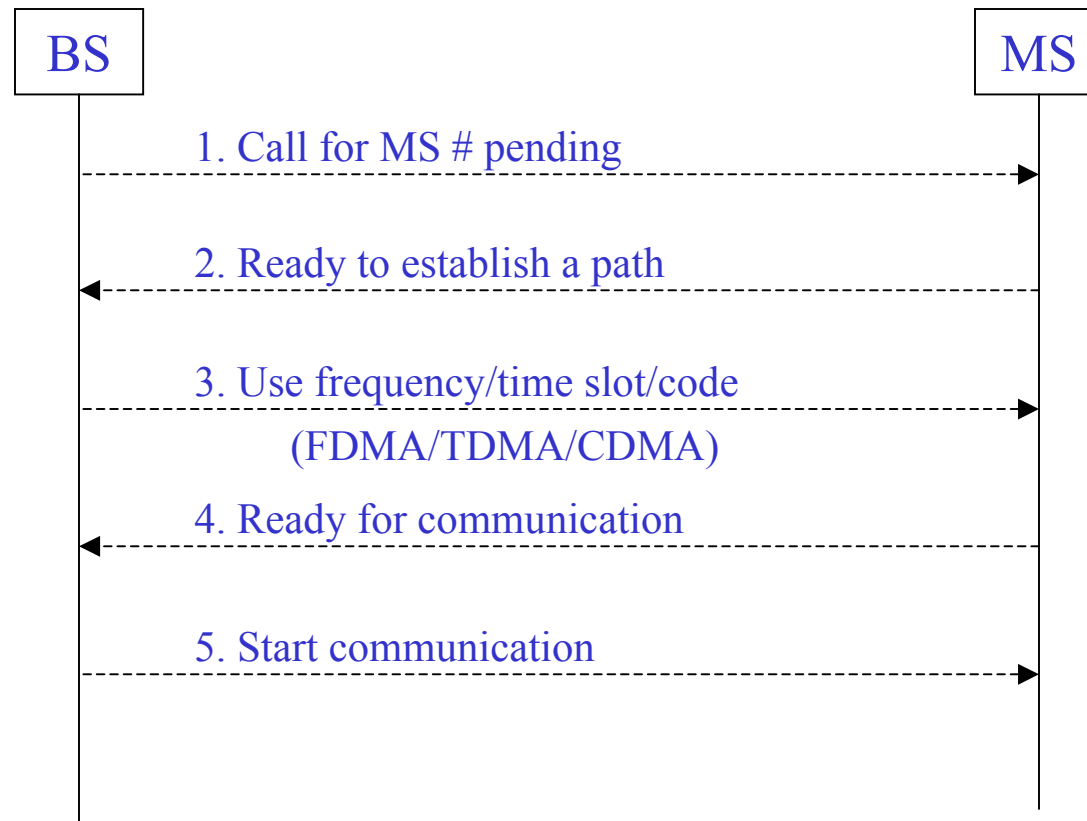


Steps for a Call Setup from MS to BS

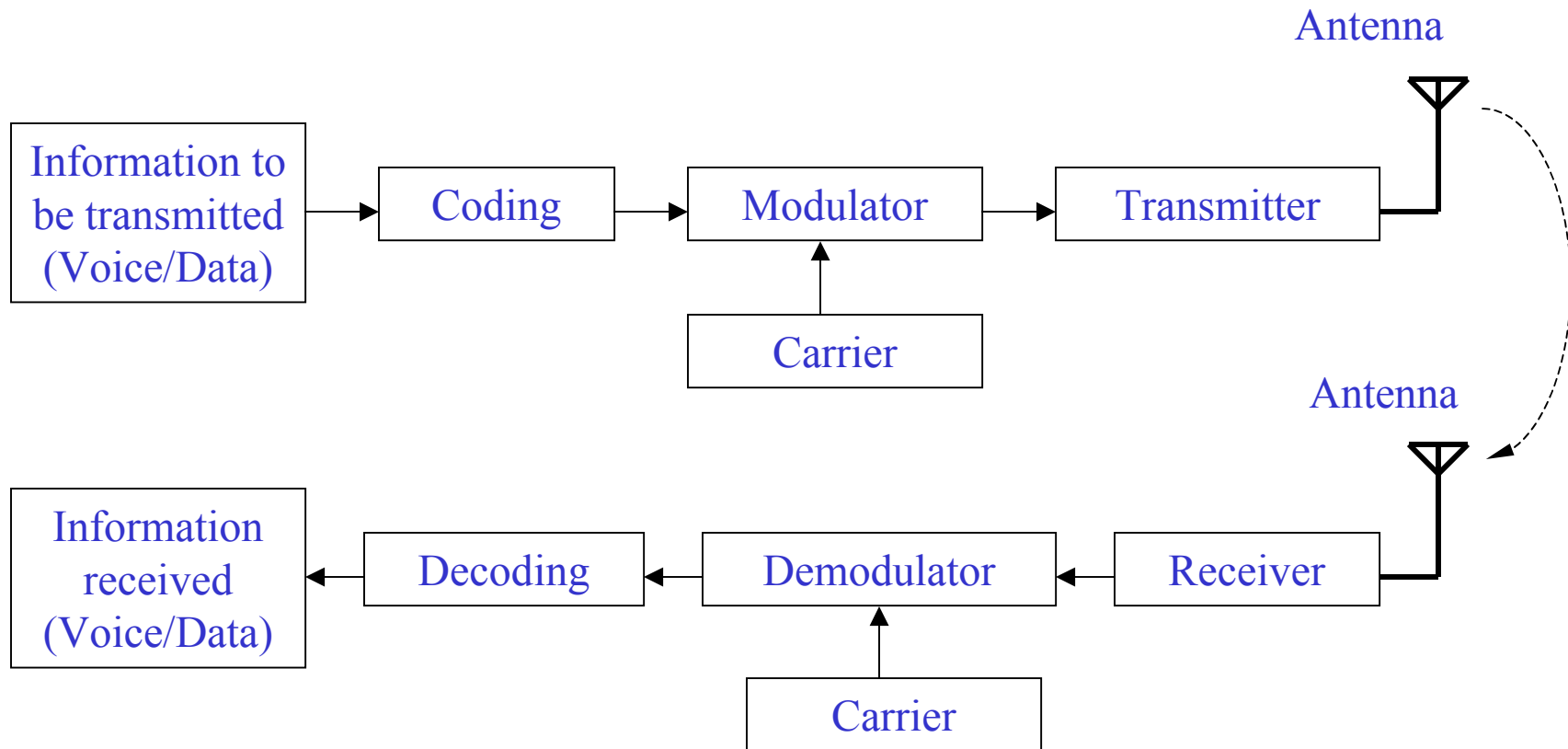


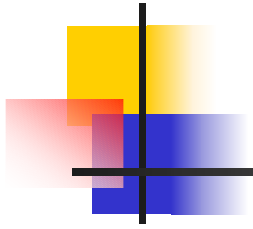


Steps for a Call Setup from BS to MS



A Simplified Wireless Communication System Representation





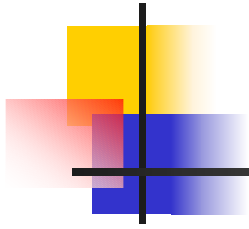
Satellite Systems

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

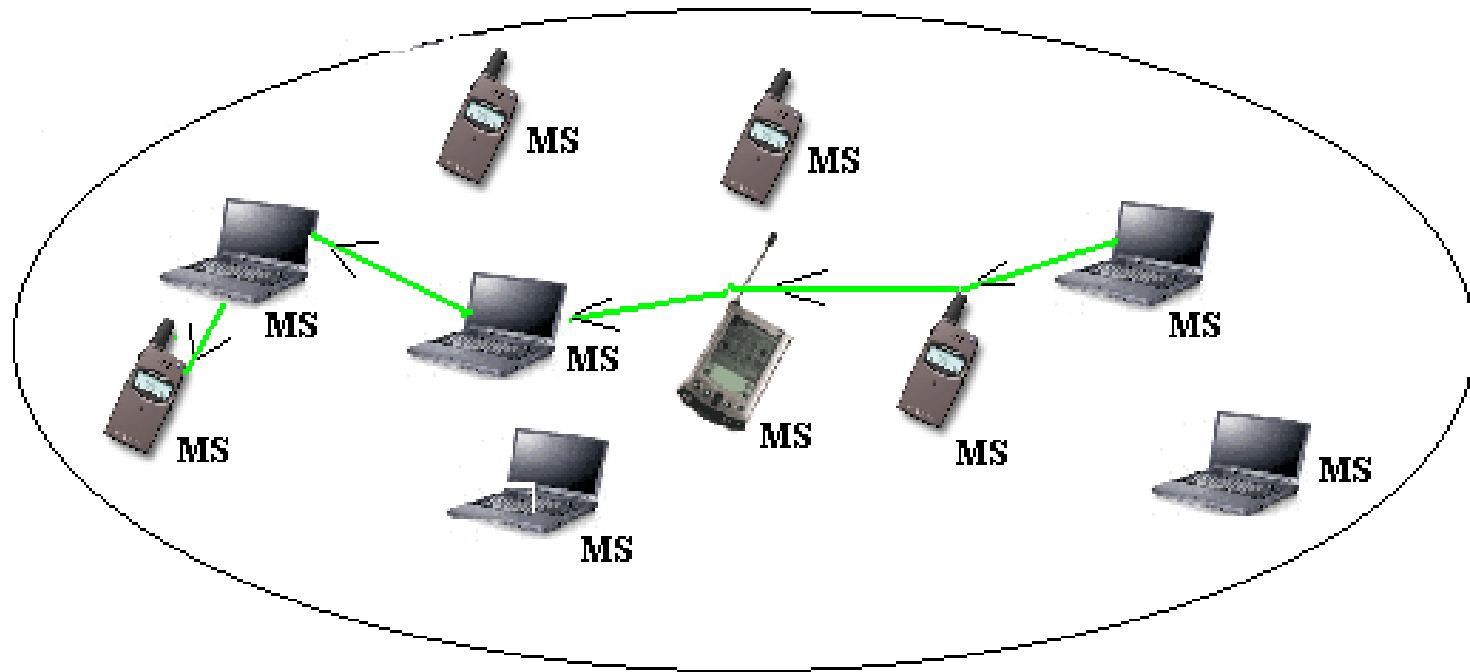


Network Architectures and Protocols

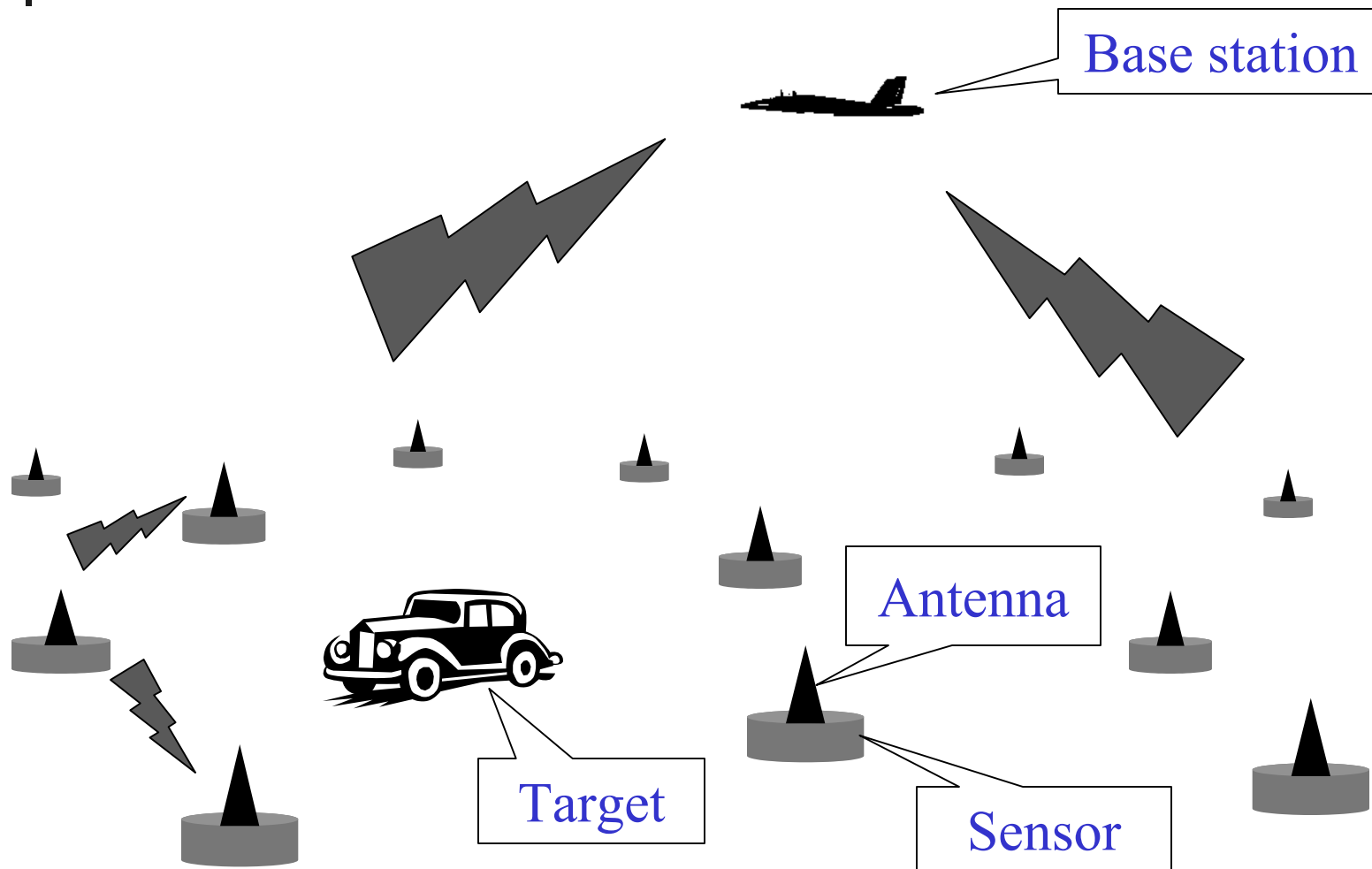
- Systematic Signaling Steps for Information Exchange
- Open Systems Interconnections (OSI)
- Transmission Control Protocol (TCP)
- Internet Protocol (IP)
 - Internet Protocol Version 4 (IPv4)
 - Internet Protocol Version 6 (IPv6) – Work in progress
 - Mobile IP



Ad Hoc Network



Wireless Sensor Networks





Wireless LAN and PAN

- Wireless Local Area Network (LAN) using the IEEE 802.11
- HiperLAN is a European Standard
- Wireless Personal Area Network (PAN)
 - Bluetooth
- HomeRF