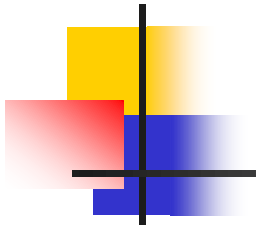

Chapter 1

INTRODUCTION

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4th edition

Introduction to Wireless & Mobile Systems

Dharma Prakash Agrawal

Qing-An Zeng

USE — Agrawal/Zeng — Intro to Wireless and Mobile Systems, 4e ISBN-9781305087132 ©2016 Designer: Kathy Heming
Text & Cover printer: XXXXXXXX Binding: Case Trim: 8" x 10" CMYK

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The History of Mobile Radio Communication (1/4)

- 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

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The History of Mobile Radio Communication (2/4)

- 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

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The History of Mobile Radio Communication (3/4)

- 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)

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The History of Mobile Radio Communication (4/4)

- 2001: W-CDMA commercial service beginning in Japan and Europe
- 2002: W-CDMA commercial service beginning in South Korea
- 2002: FCC approves additional frequency band for Ultra-Wideband (UWB)
- 2003: cdma2000 commercial service beginning in USA
- 2009: cdma200 and W-CDMA commercial services beginning in China
  FDD-LTE commercial service beginning in Sweden
- 2010: FDD-LTE commercial service beginning in USA.
- 2011: FDD-LTE commercial service beginning in South Korea
- 2013: TD-LTE commercial service beginning in China

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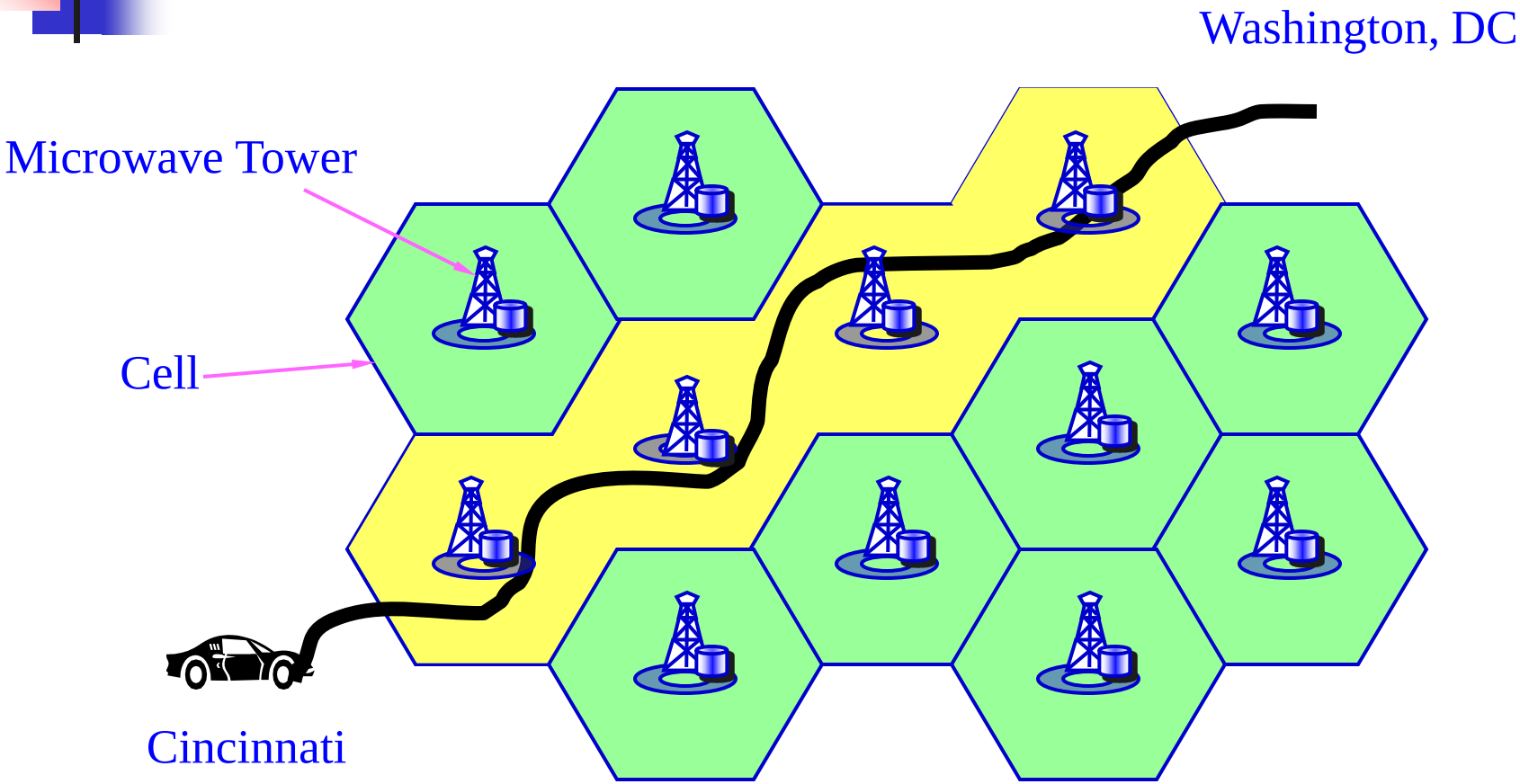
Universal Cell Phone Coverage



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

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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

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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

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Third Generation Cellular Systems and Services

IMT-2000	Fulfill One's Dream of Anywhere, Anytime Communications
Key Features	- 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
Important Component	- 2 Mbps for fixed environment - 384 kbps for indoor/outdoor and pedestrian environment - 144 kbps for vehicular environment
Standardization Work	- In progress (see Table 1.6)
Scheduled Service	- Started in October 2001 in (W-CDMA) - Started in December 2001 in Europe - Started in January 2002 in South Korea - Started in October 2003 in USA - Started in April 2009 in China

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3GPP Release Dates and Contents (1/2)

3GPP Release	Release Date	Summary
Release 99	1999	First release of the UMTS standard
Release 4	2001	This release was originally referred to as Release 2000 and added features including an all-IP core network.
Release 5	2002	This release introduced the IP multimedia subsystem, IMS (IP multimedia subsystem), and high-speed packet downlink access, HSDPA (high-speed downlink packet access).
Release 6	2004	This release integrated the operation of UMTS with wireless LAN networks and added enhancements to IMS (including Push to talk over cellular), and GAN (generic access network). It also added high speed packet uplink access, HSUPA (high-speed uplink packet access).
Release 7	2007	This release detailed improvements to QoS (Quality of Service) for applications such VoIP (Voice over IP). It also detailed upgrades for high-speed packet access evolution, HSPA+ (high-speed packet access), as well as changes for EDGE (enhanced data rates for GSM evolution) evolution and also provided interfaces to enable operation with NFC (near field communication) technology.

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3GPP Release Dates and Contents (2/2)

3GPP Release	Release Date	Summary
Release 8	2008	This release provided the details of the LTE (long-term evolution) system architecture evolution (SAE), and an all-IP network architecture providing the capacity and low latency required for LTE and future evolutions.
Release 9	2009	This release added further enhancements to the SAE as well as allowing for WiMAX (worldwide interoperability for microwave access) and LTE/UMTS interoperability.
Release 10	2011	LTE Advanced fulfilling IMT Advanced 4G requirements. Backwards compatible with Release 8 (LTE). Multi-cell HSDPA (4 carriers).
Release 11	2012	Advanced IP interconnection of services. Service layer interconnection between national operators/carriers as well as third party application providers. Heterogeneous networks (HetNet) improvements, coordinated multi-point operation (CoMP). In-device co-existence (IDC).
Release 12	Planned to 2014	Content still open

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Fourth Generation Cellular Systems and Services

IMT-Advanced	Major Features and Services
Key Feature	- High speed of communication - High quality - Wide spectrum - Full integration of a variety of business - Great compatibility - Channel-dependent Scheduling - Link Adaptation - Mobile-IP utilized for mobility - IP-based Femtocells
Access Technique	- FDD-LTE: Frequency Division Duplex Long Term Evolution - TD-LTE： Time Division Long Term Evolution
Important Component	- FDD-LTE: Uplink rate is 150Mbps; Downlink rate is 40Mbps - TD-LTE: Uplink rate is 100Mbps; Downlink rate is 50Mbps
Scheduled Service	- FDD-LTE started in December 2009 in Sweden - FDD-LTE started at the end of 2010 in USA - FDD-LTE started in July 2011 in South Korea - TD-LTE started in December 2013 in China

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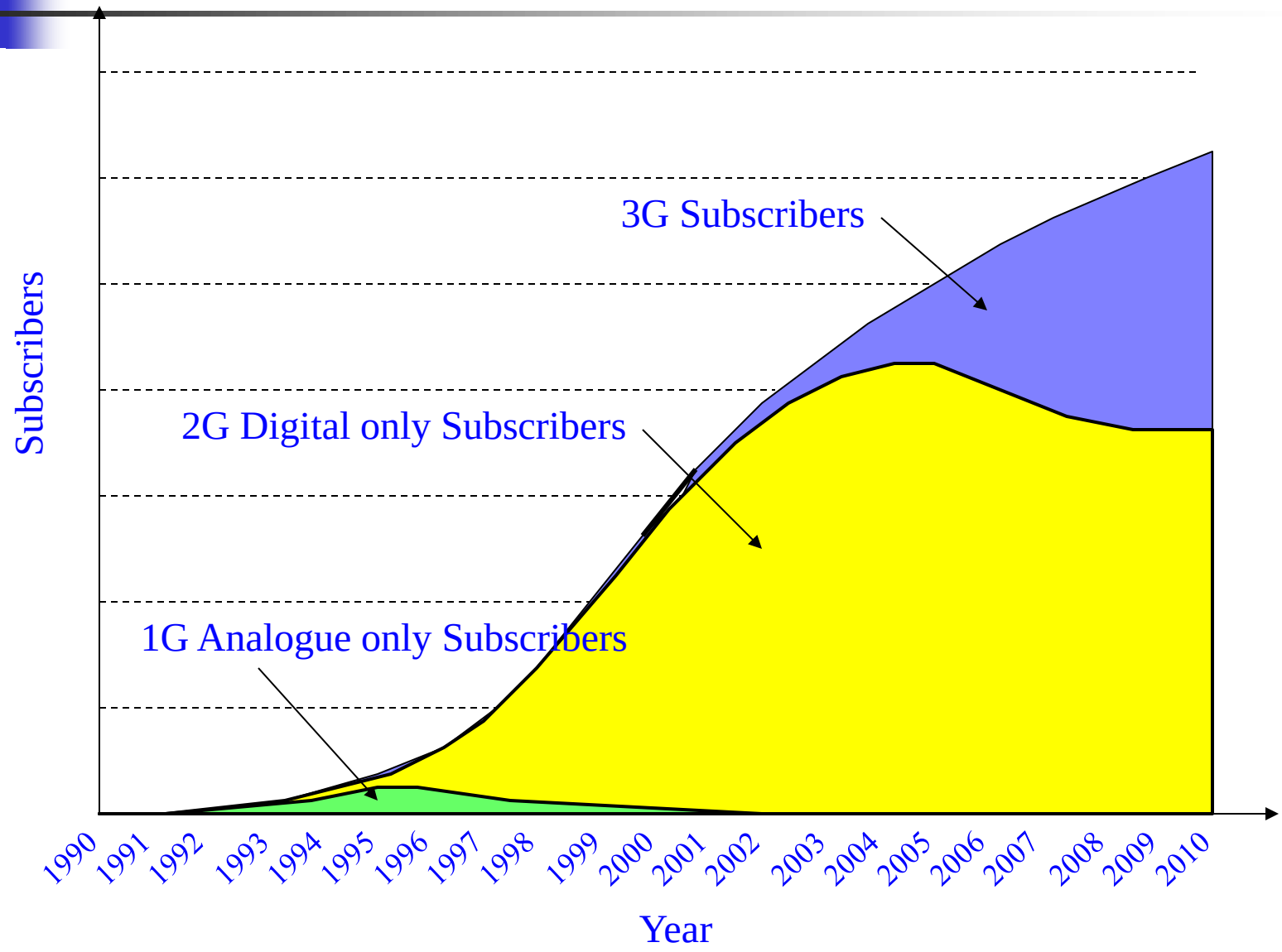
Subscriber Growth



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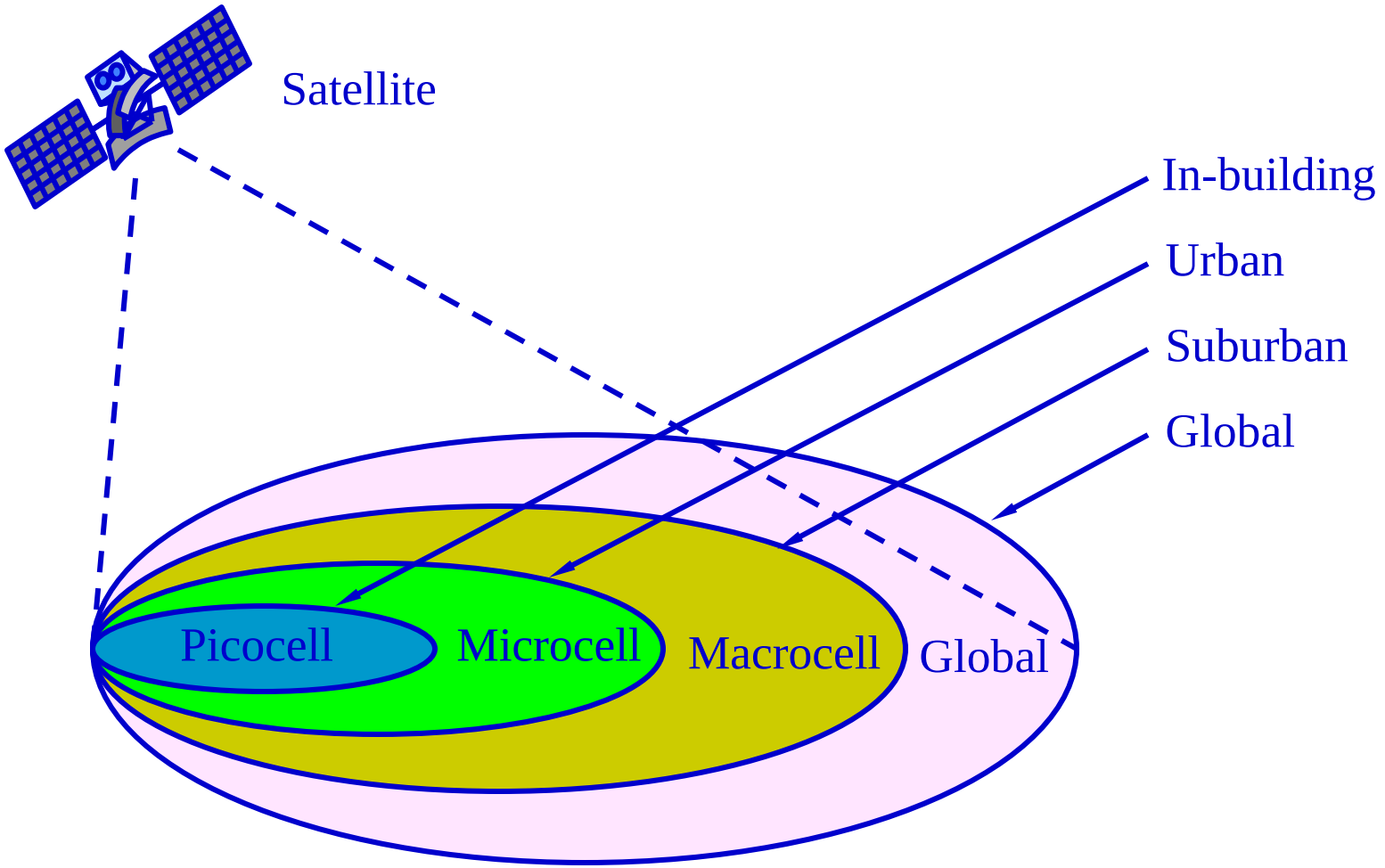
Coverage Aspect of Next Generation Mobile Communication Systems



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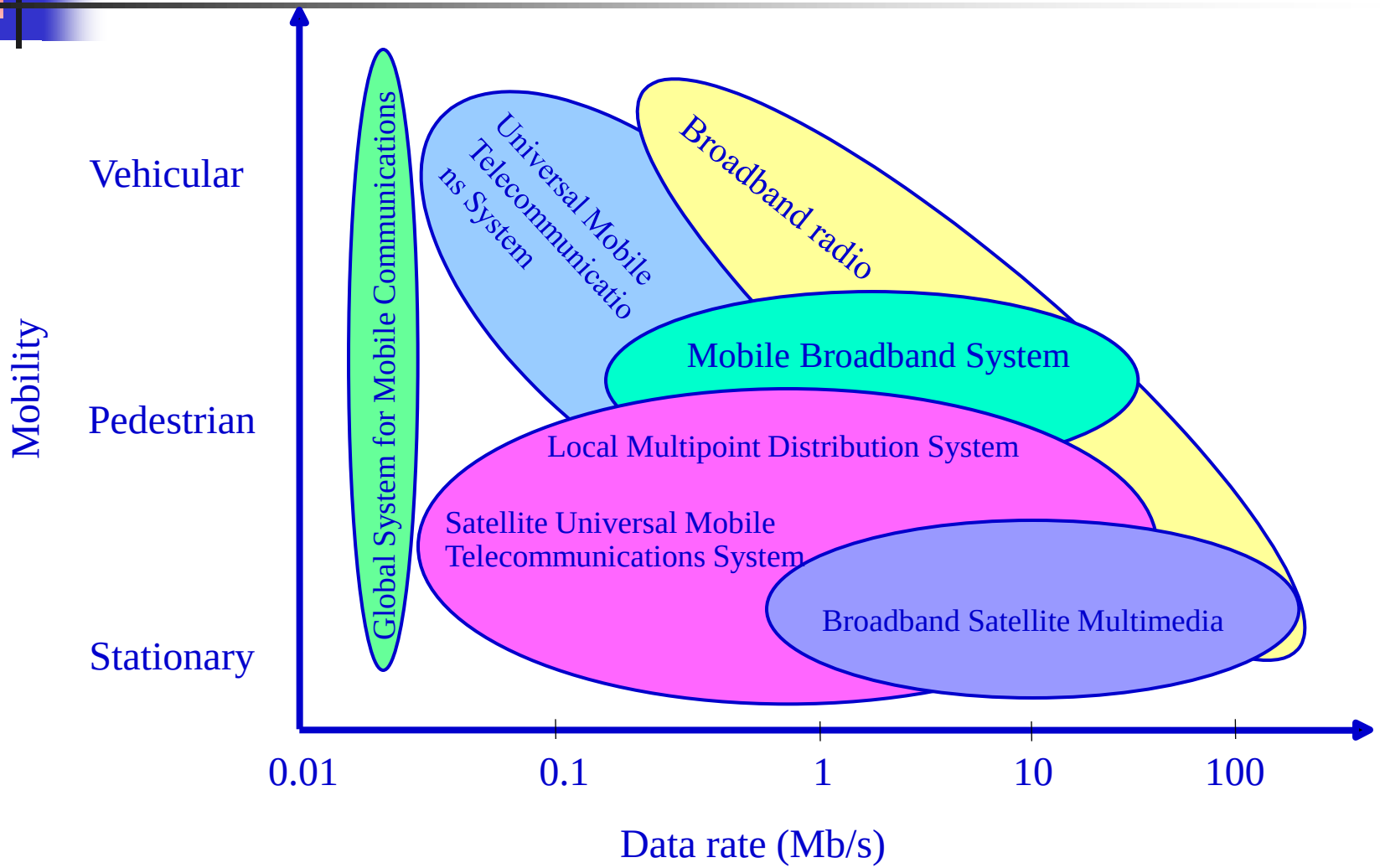
Transmission Capacity



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

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Wireless Technology & Associated Characteristics

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

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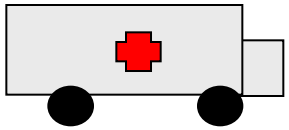
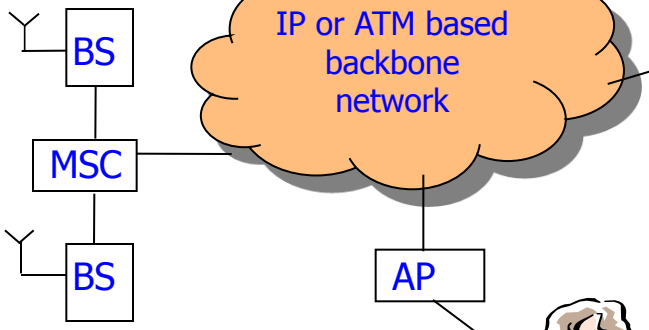
Medical & Healthcare Applications

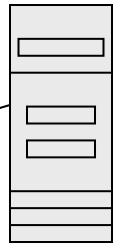
In-hospital physician



Ambulance



Wireless remote consultation



Databases

Possibility for remote consulting (including audio-visual communication)

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Fundamentals of Cellular Systems

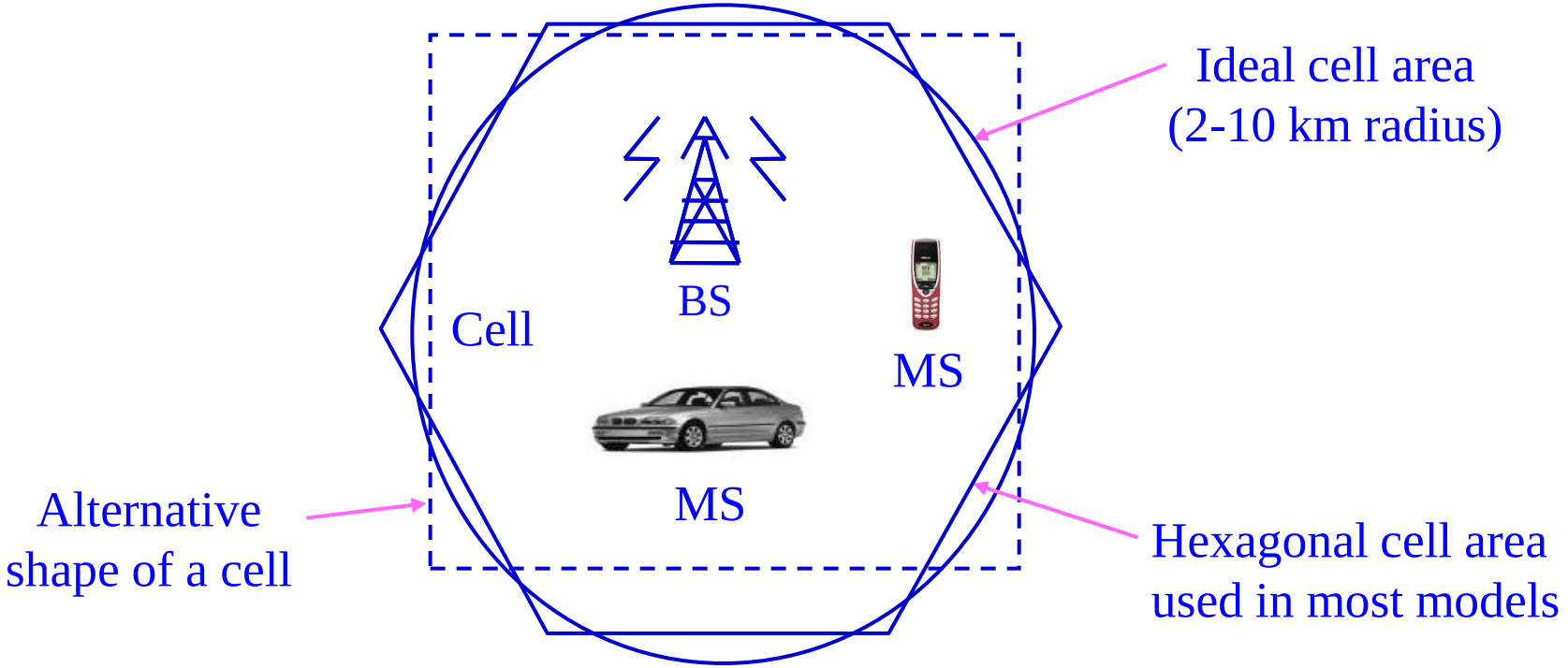

Illustration of a cell with a mobile station and a base station

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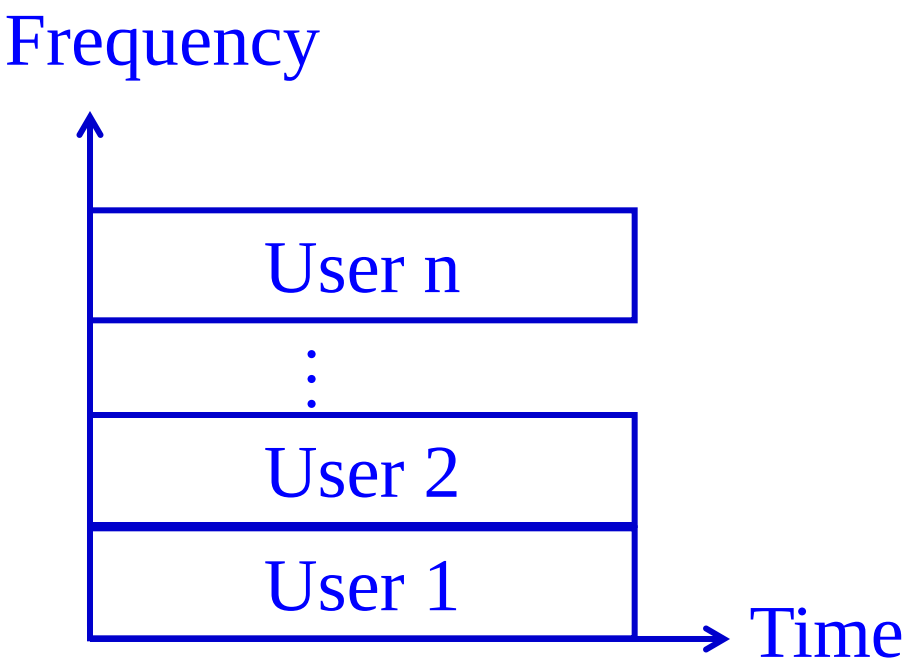
FDMA (Frequency Division Multiple Access)



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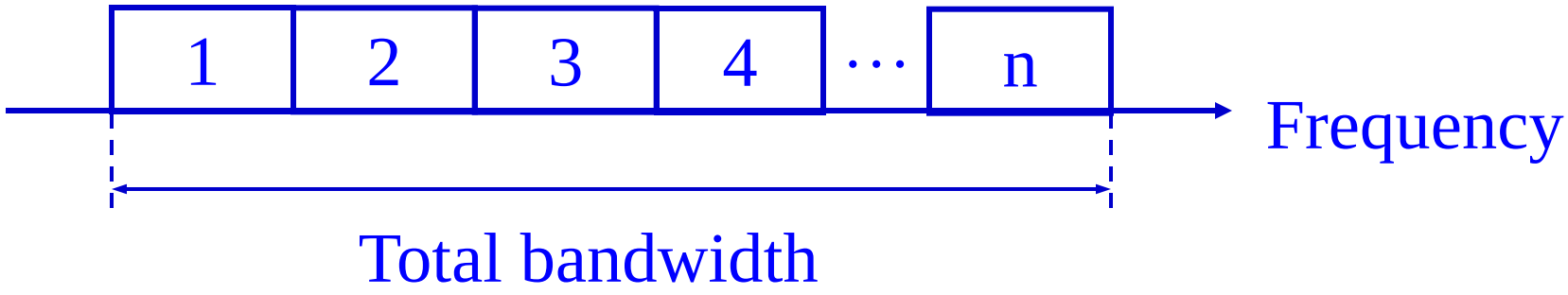
FDMA Bandwidth Structure



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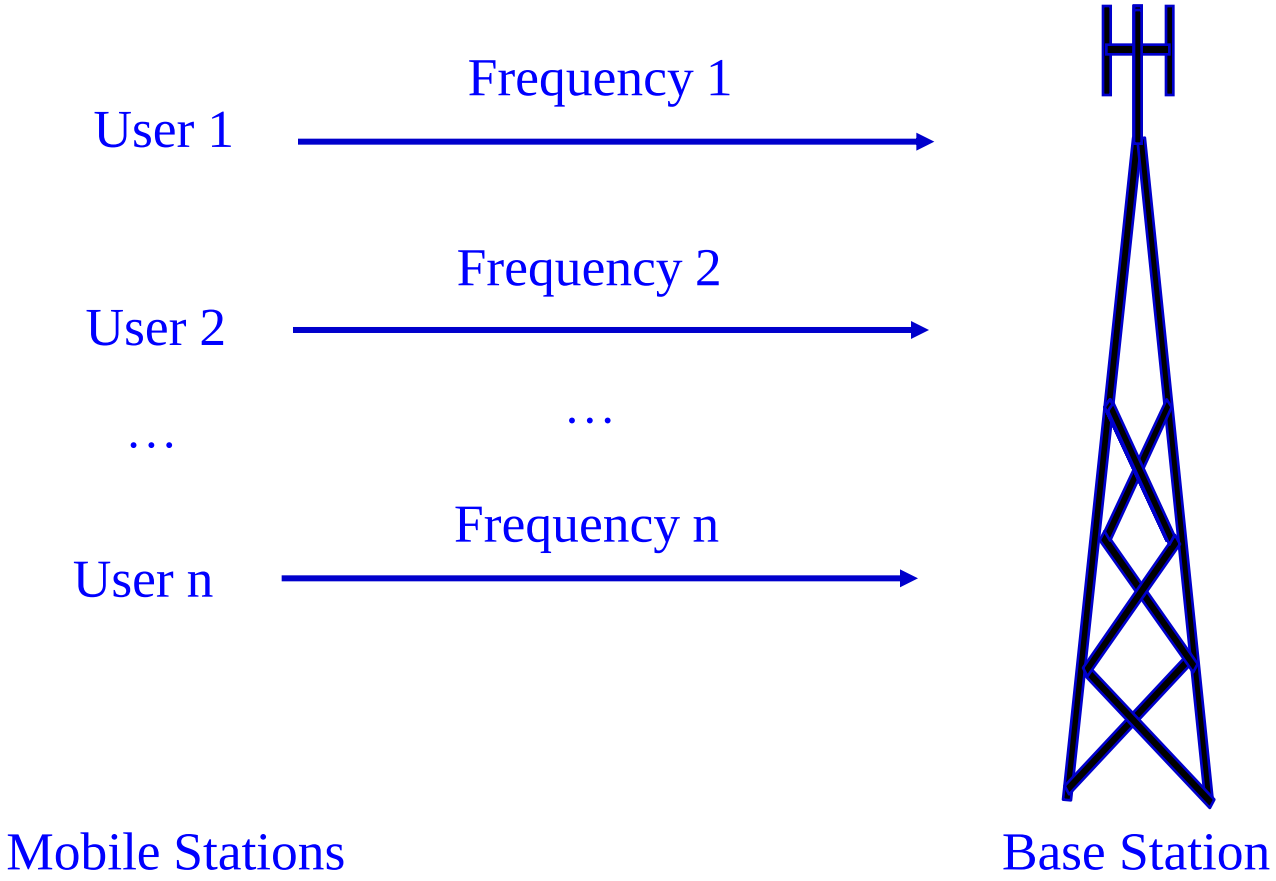
FDMA Channel Allocation



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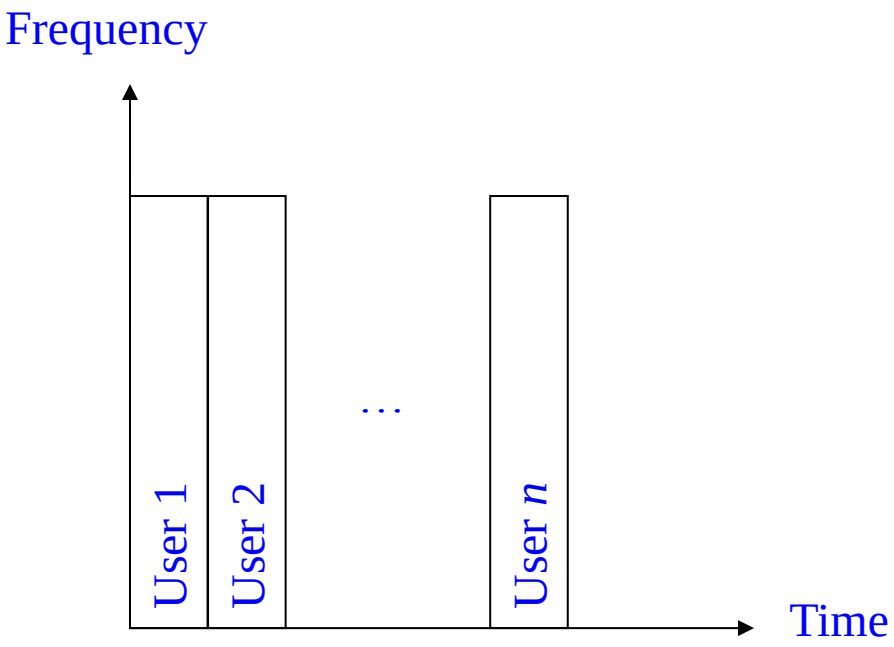
TDMA (Time Division Multiple Access)



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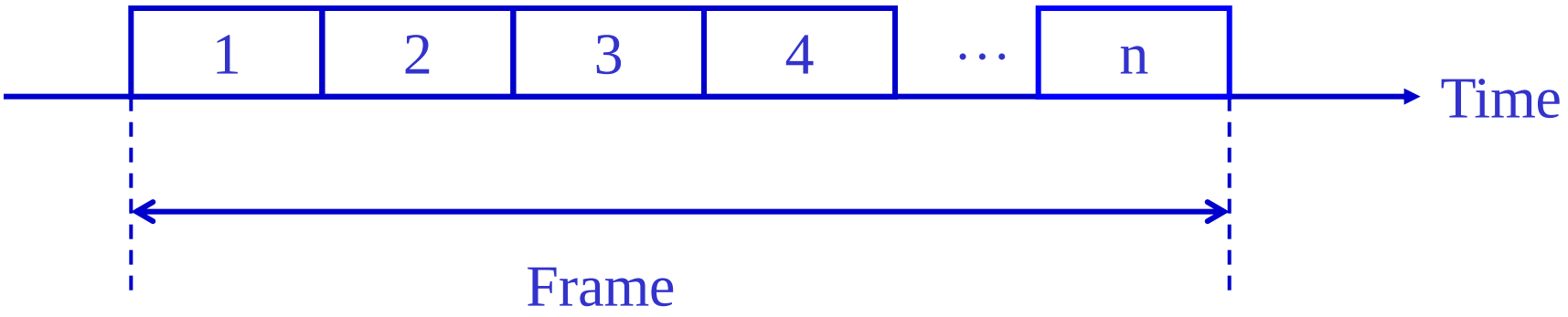
TDMA Frame Structure



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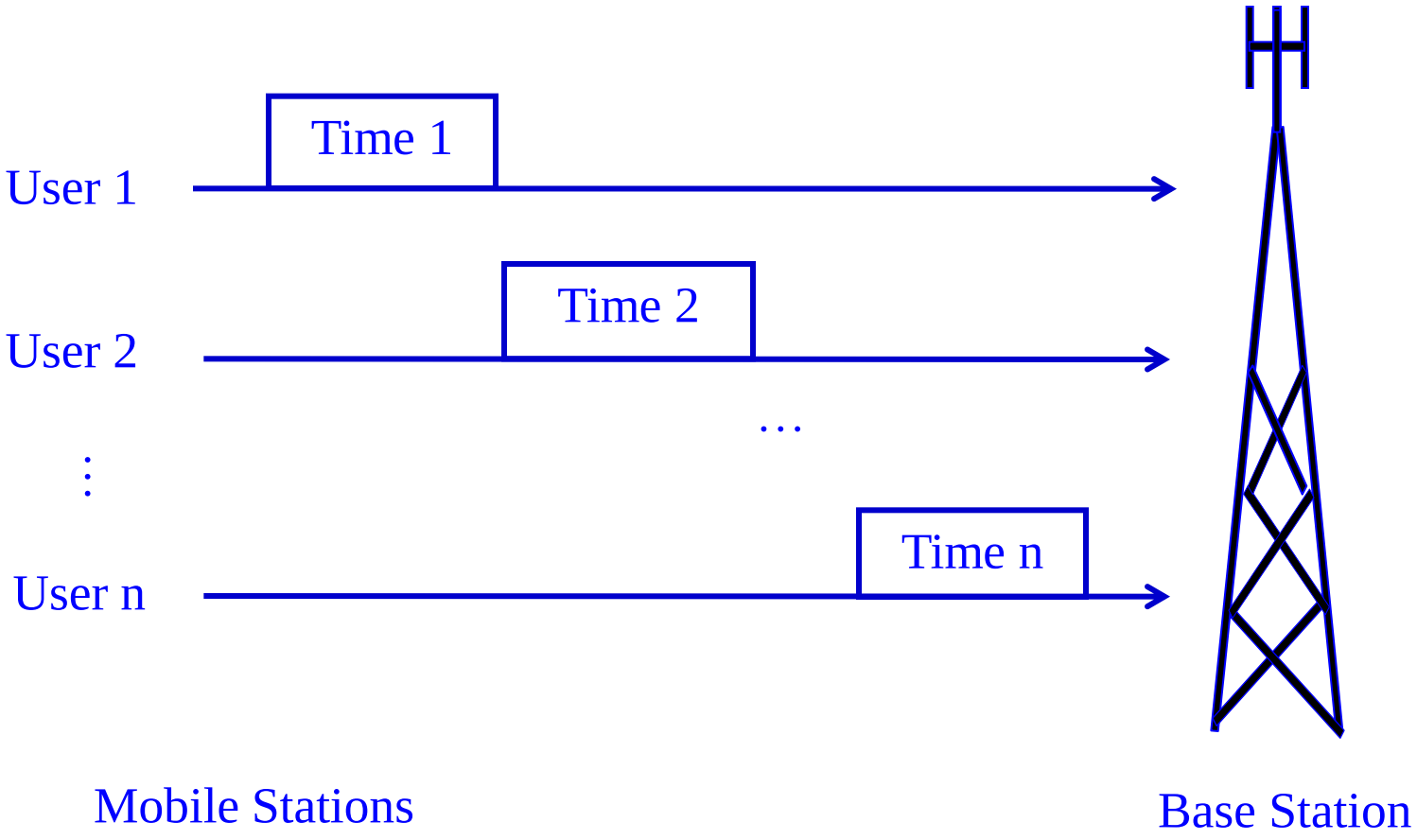
TDMA Frame Illustration for Multiple Users



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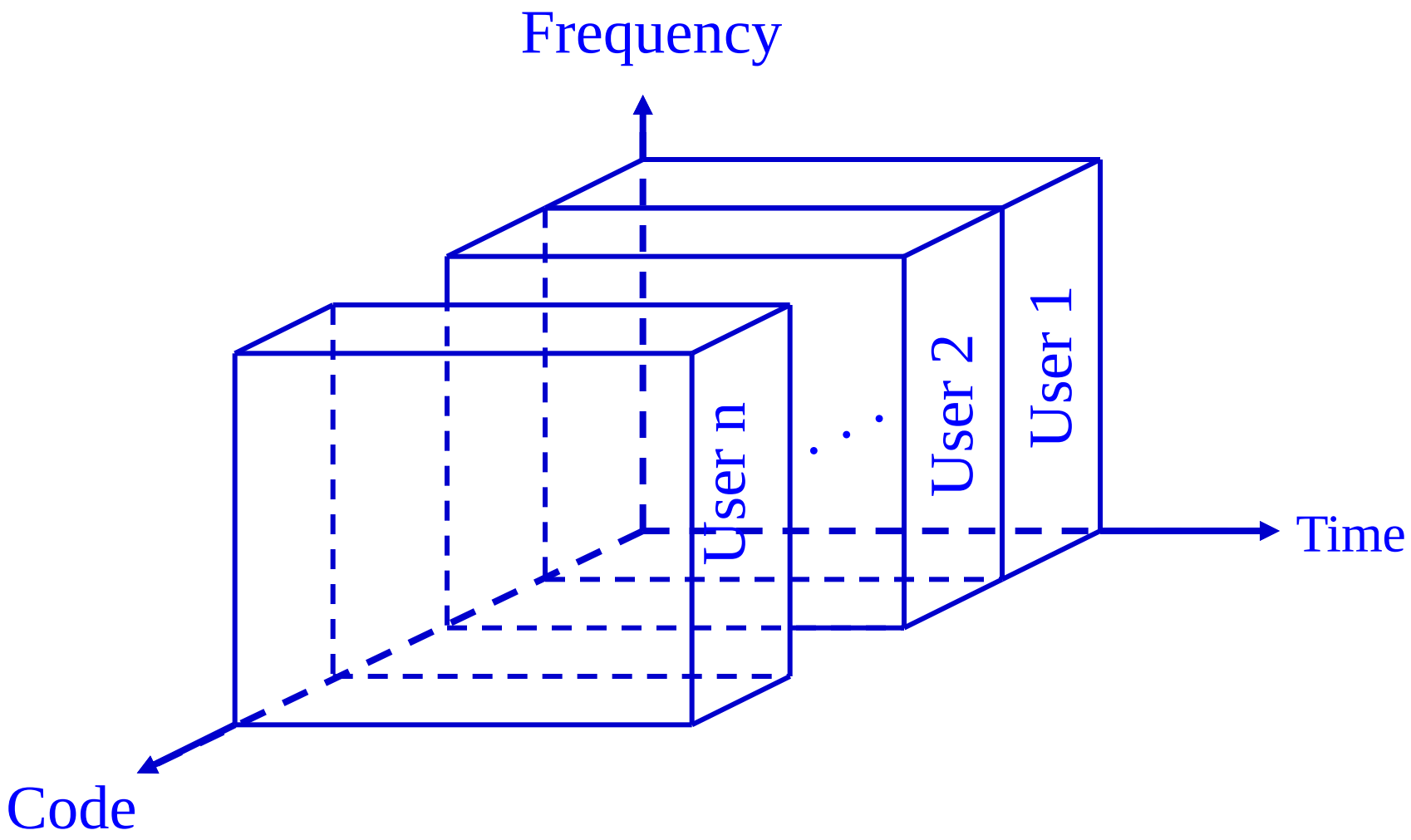
CDMA (Code Division Multiple Access)



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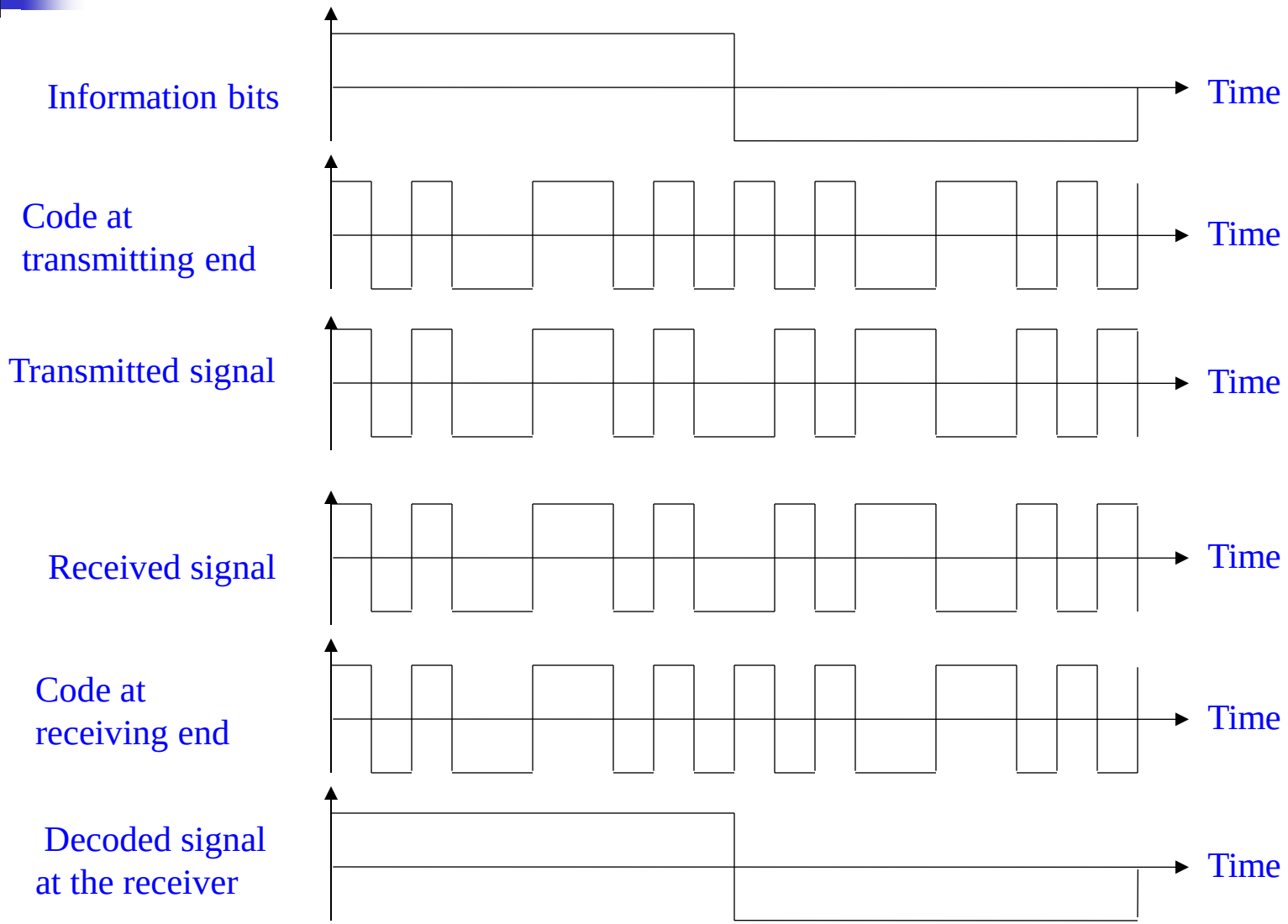
Transmitted & Received Signals in CDMA System



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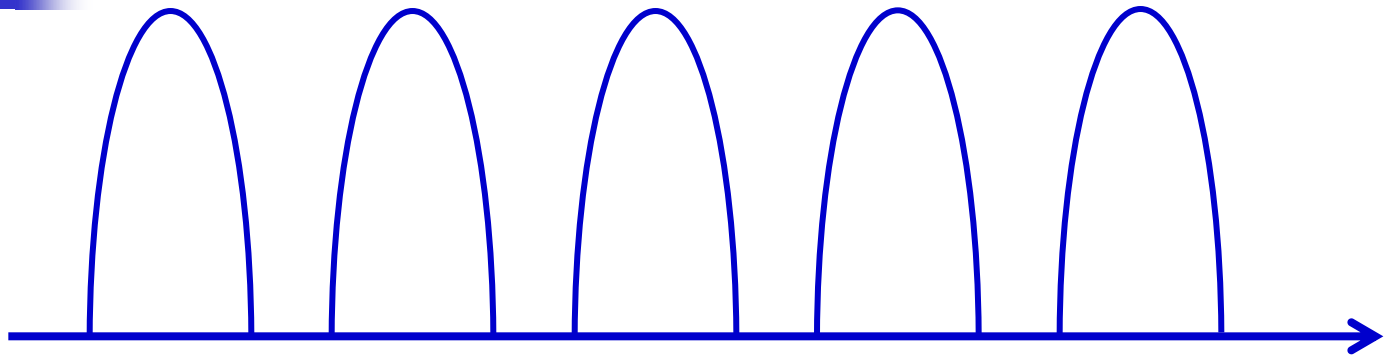
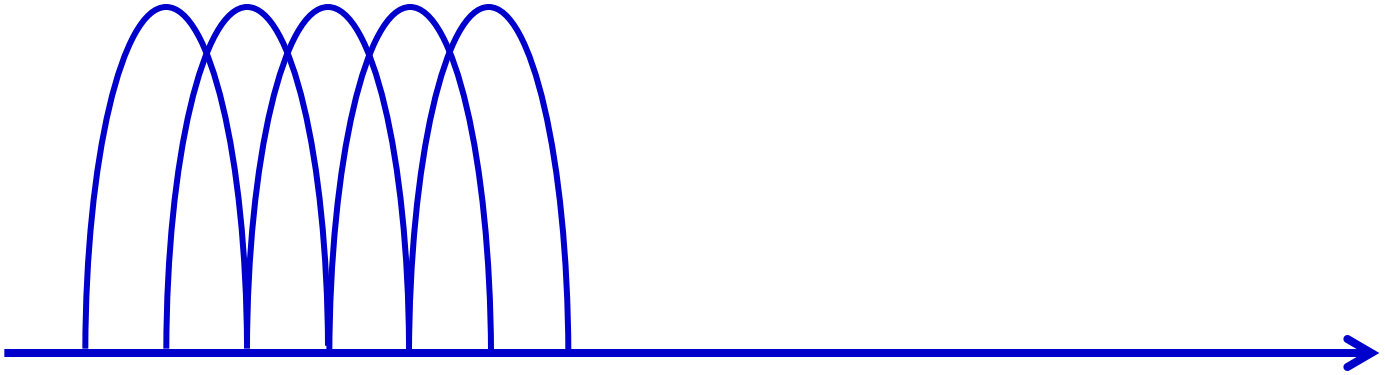
OFDM (Orthogonal Frequency Division Multiplexing)



Conventional multicarrier modulation used in FDMA



Orthogonal multicarrier modulation used in OFDM

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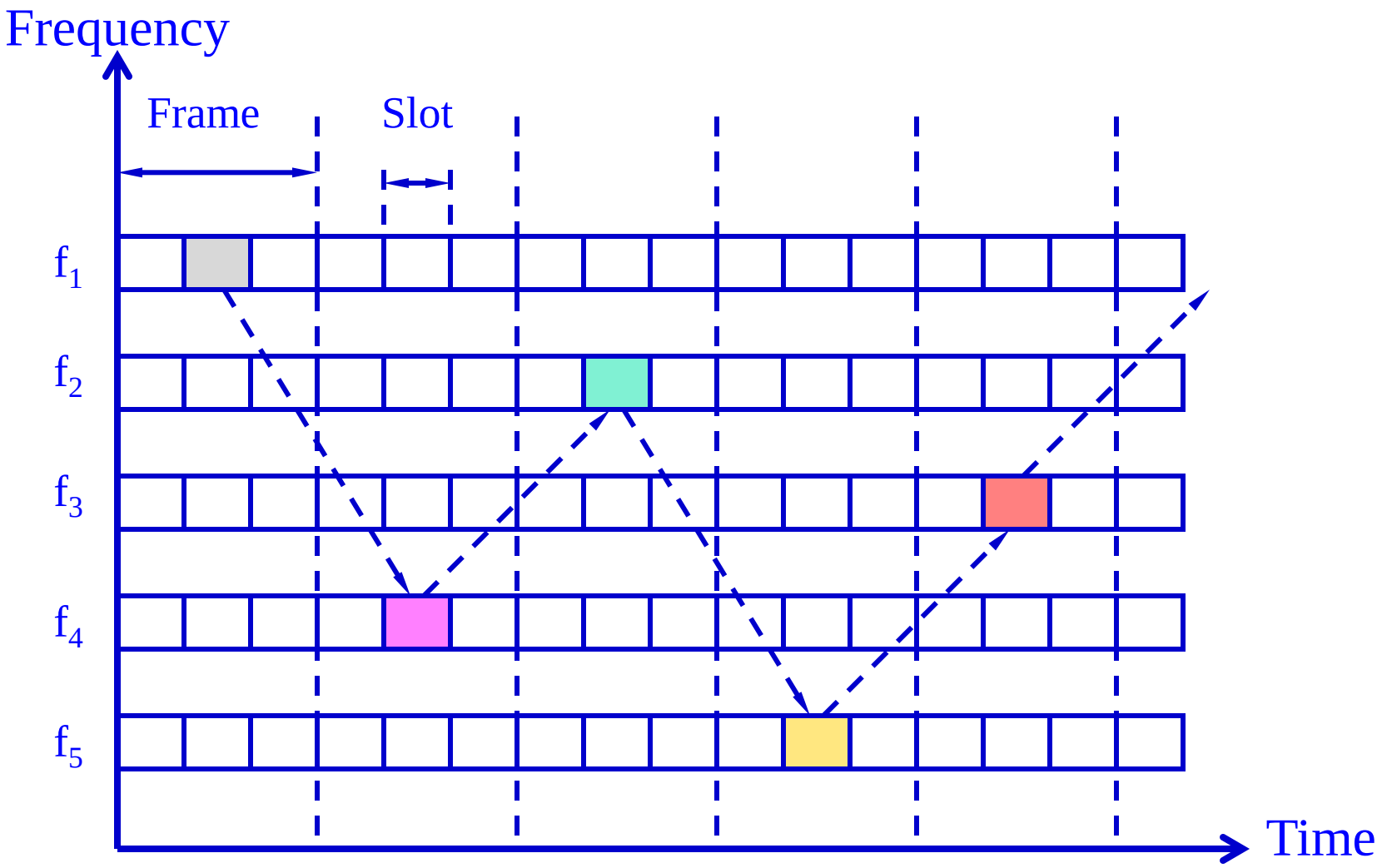
Frequency Hopping



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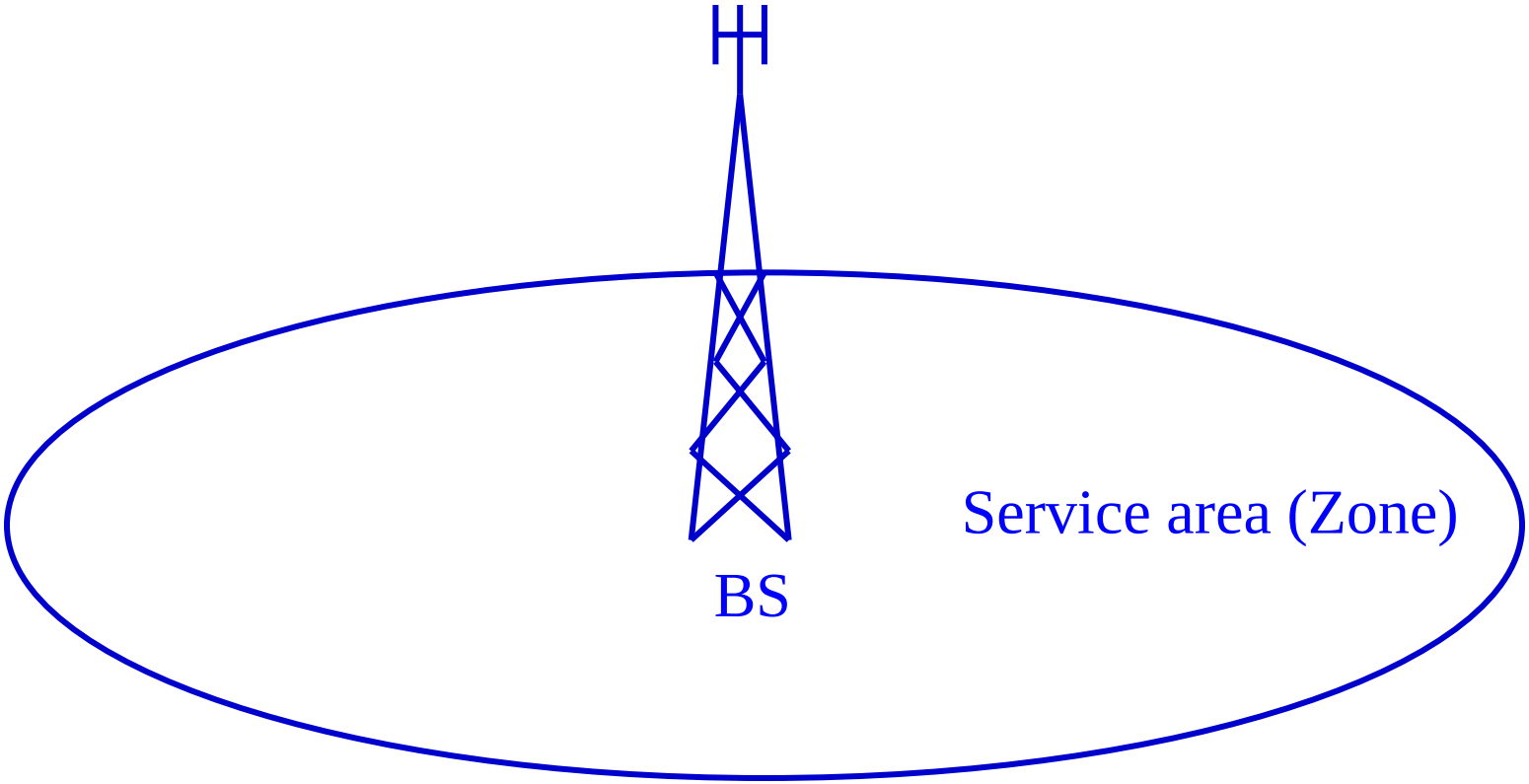
Cellular System Infrastructure



Early wireless system: *Large zone*

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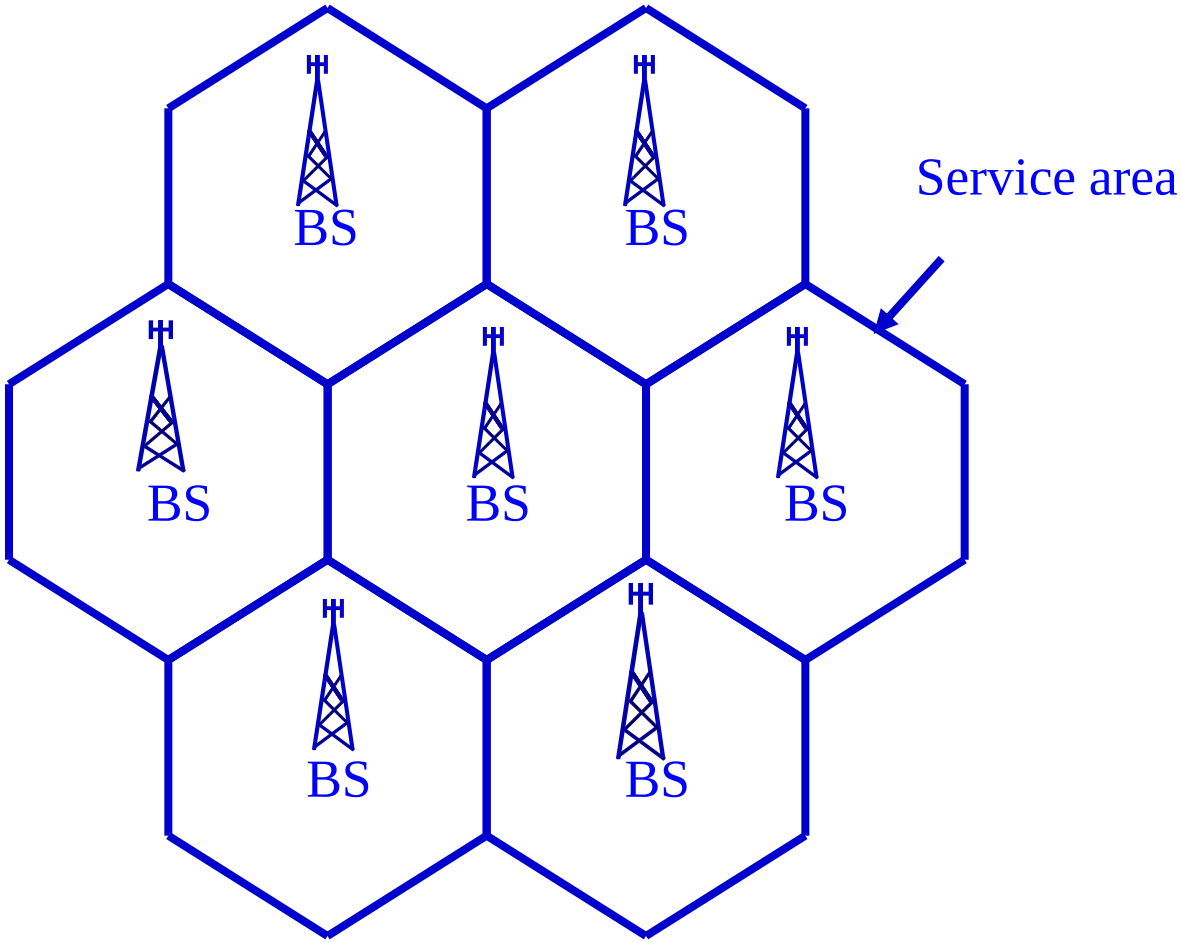
Cellular System: Small Zone



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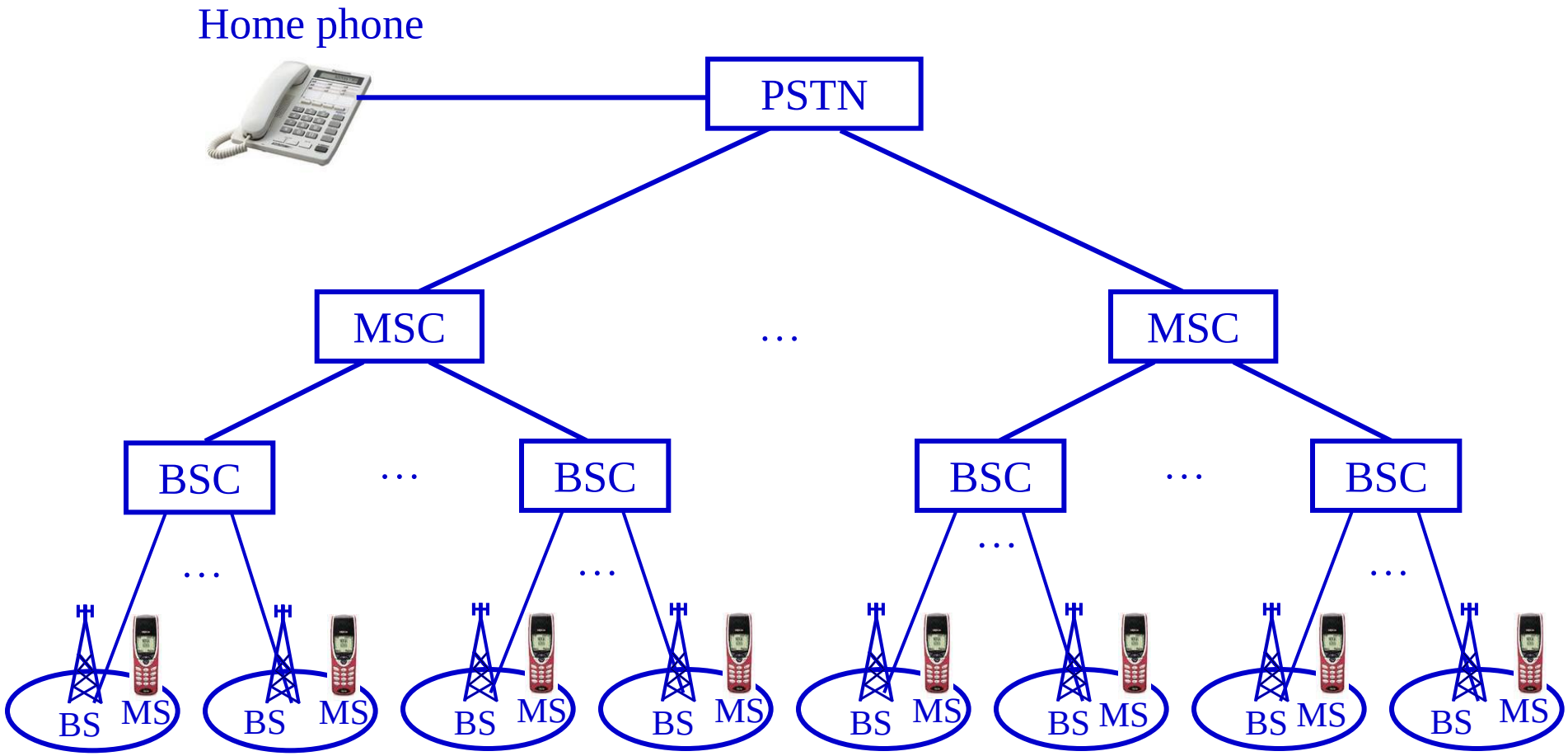
MS, BS, BSC, MSC, and PSTN



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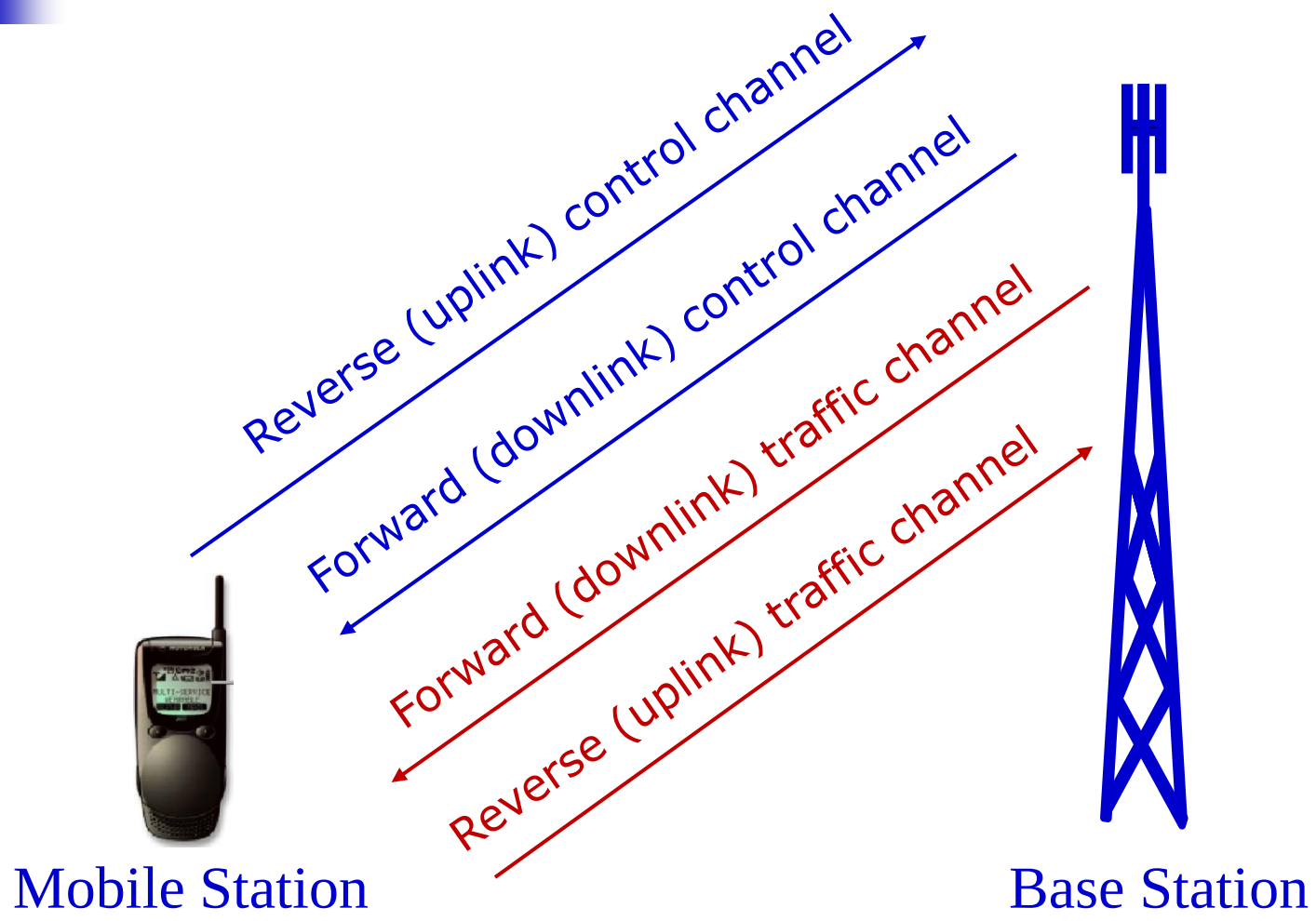
Control and Traffic Channels



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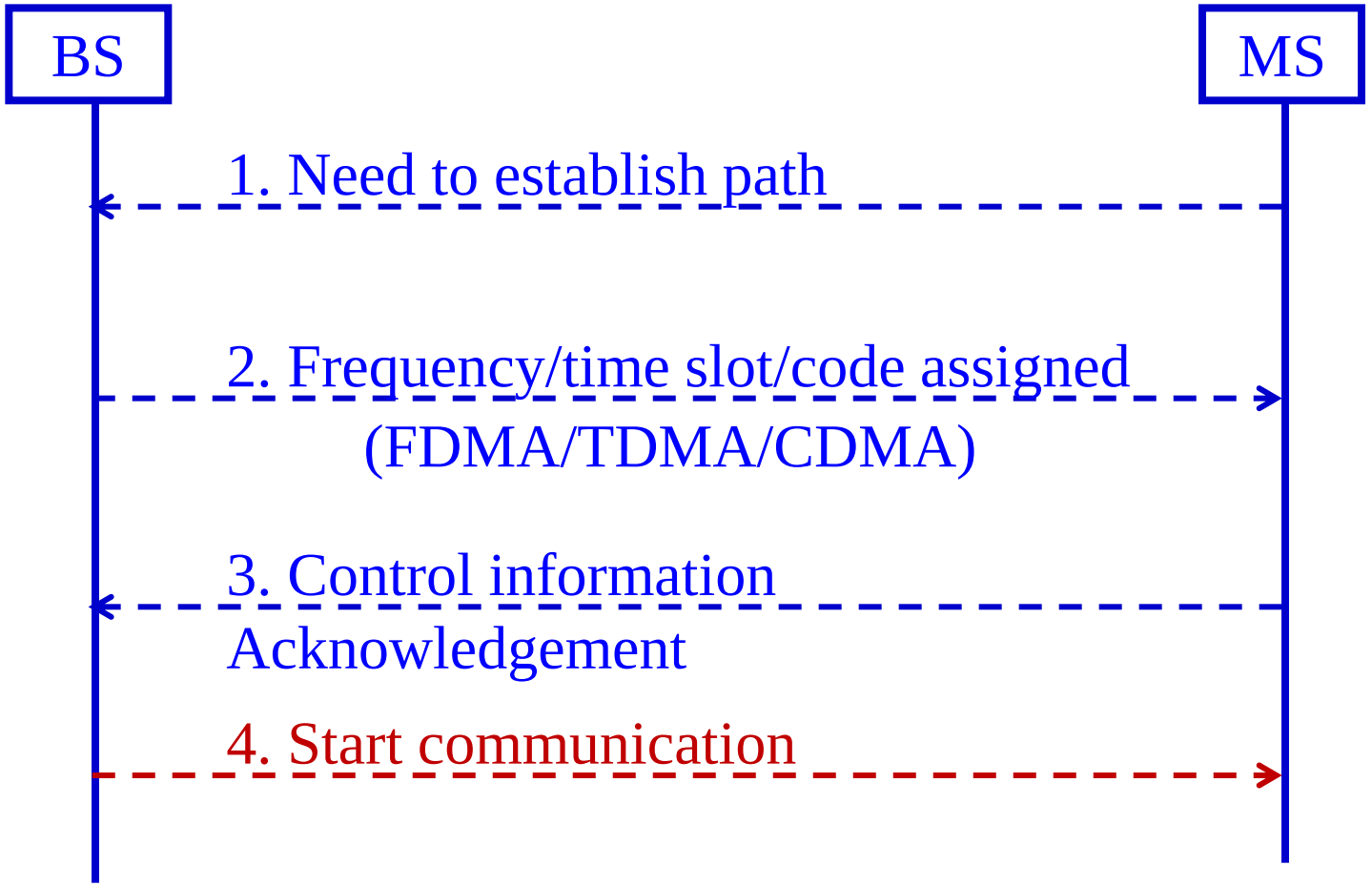
Call Setup from MS (Cell Phone) to BS?



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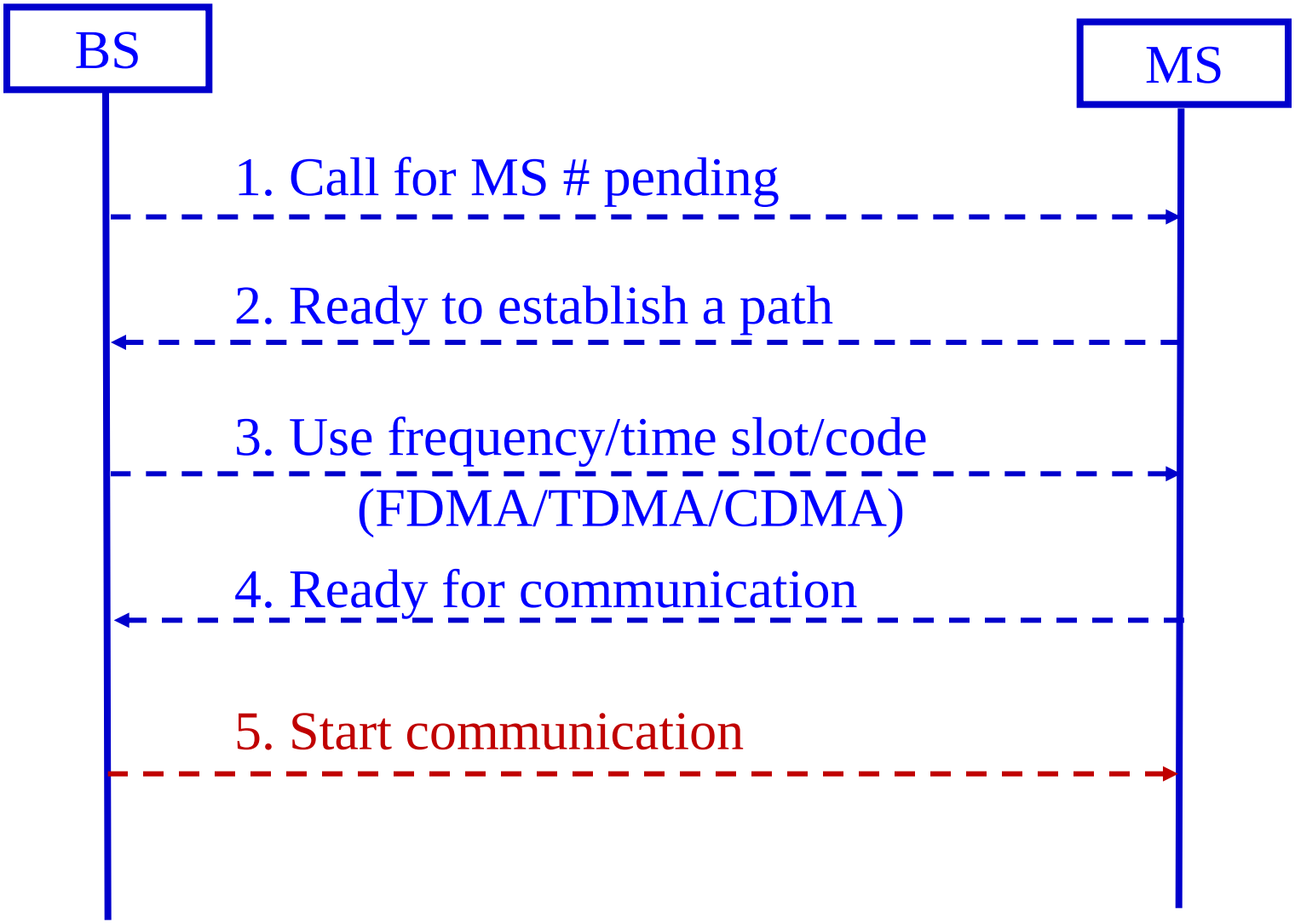
Steps for A Call Setup from BS to MS



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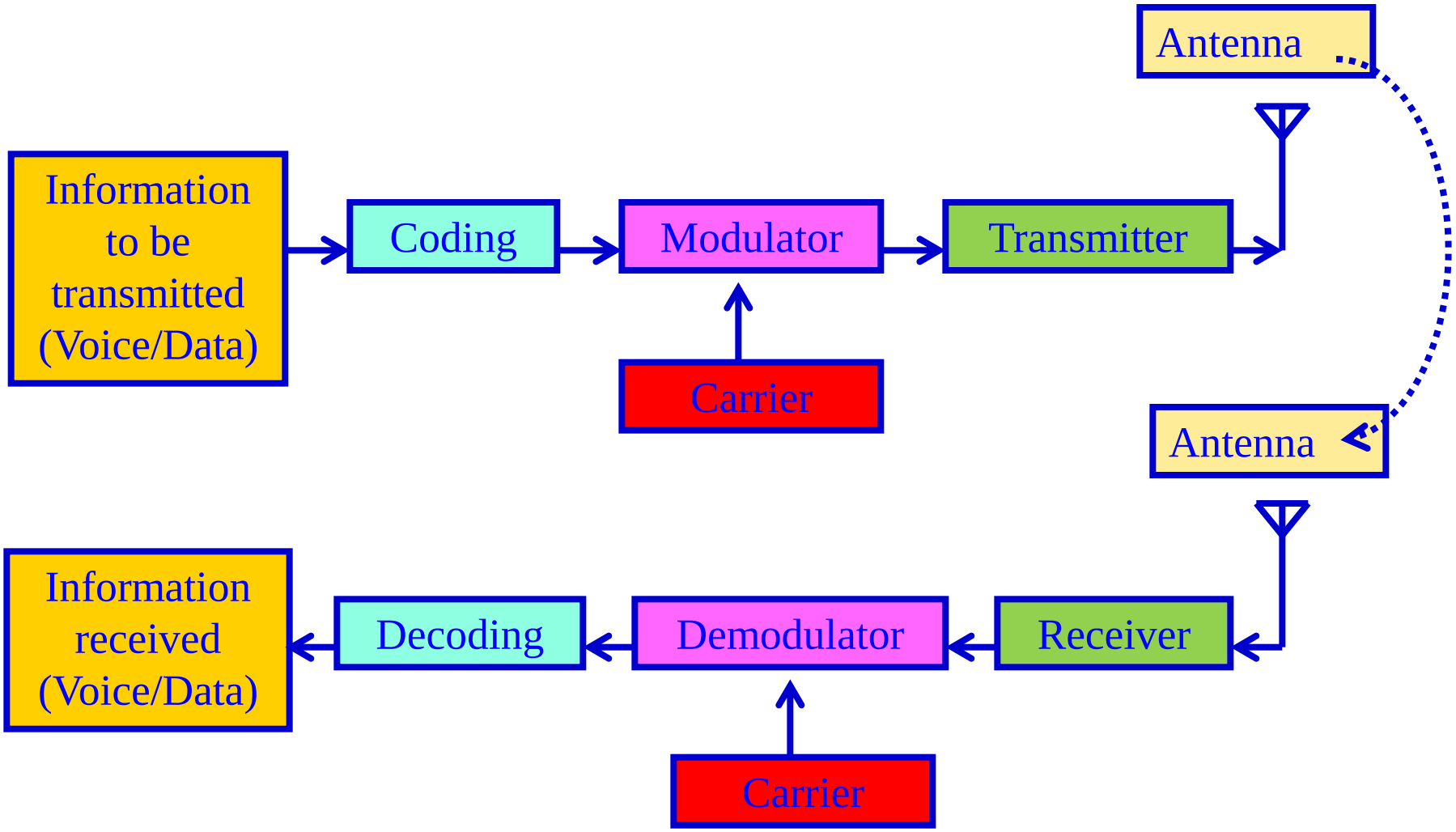
A Simplified Wireless Communications System Representation



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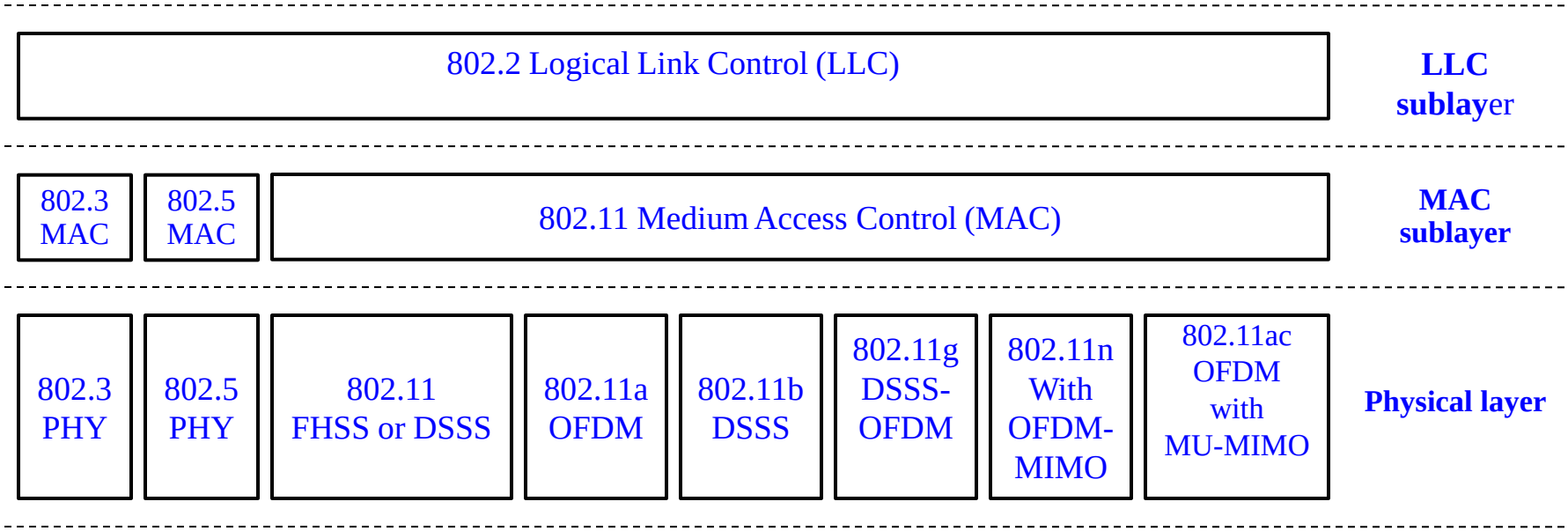
IEEE 802 Series Protocol Stack



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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

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Existing Wireless Technologies

- AMPS
- IS-41
- GSM
- PCS
- IMT-2000
  - International Spectrum Allocation
  - Services Provided by Third-Generation Cellular Systems
  - Harmonized 3G Systems
  - Multimedia Messaging Service (MMS)
  - Universal Mobile Telecommunications System (UMTS)

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Access Points and Variants

- **Introduction**
- **Downlink Transfer of Information**
- **Uplink Transfer of Information**
  - **Uplink Transfer of Information with RTS/CTS**
- Variants of 802.11 Series Protocols
  - 12.4.1. IEEE 802.11b
  - 12.4.2 IEEE 802.11g
  - 12.4.3 IEEE 802.11n
  - 12.4.4 IEEE 802.11ac
- **WiFi in the airplane**

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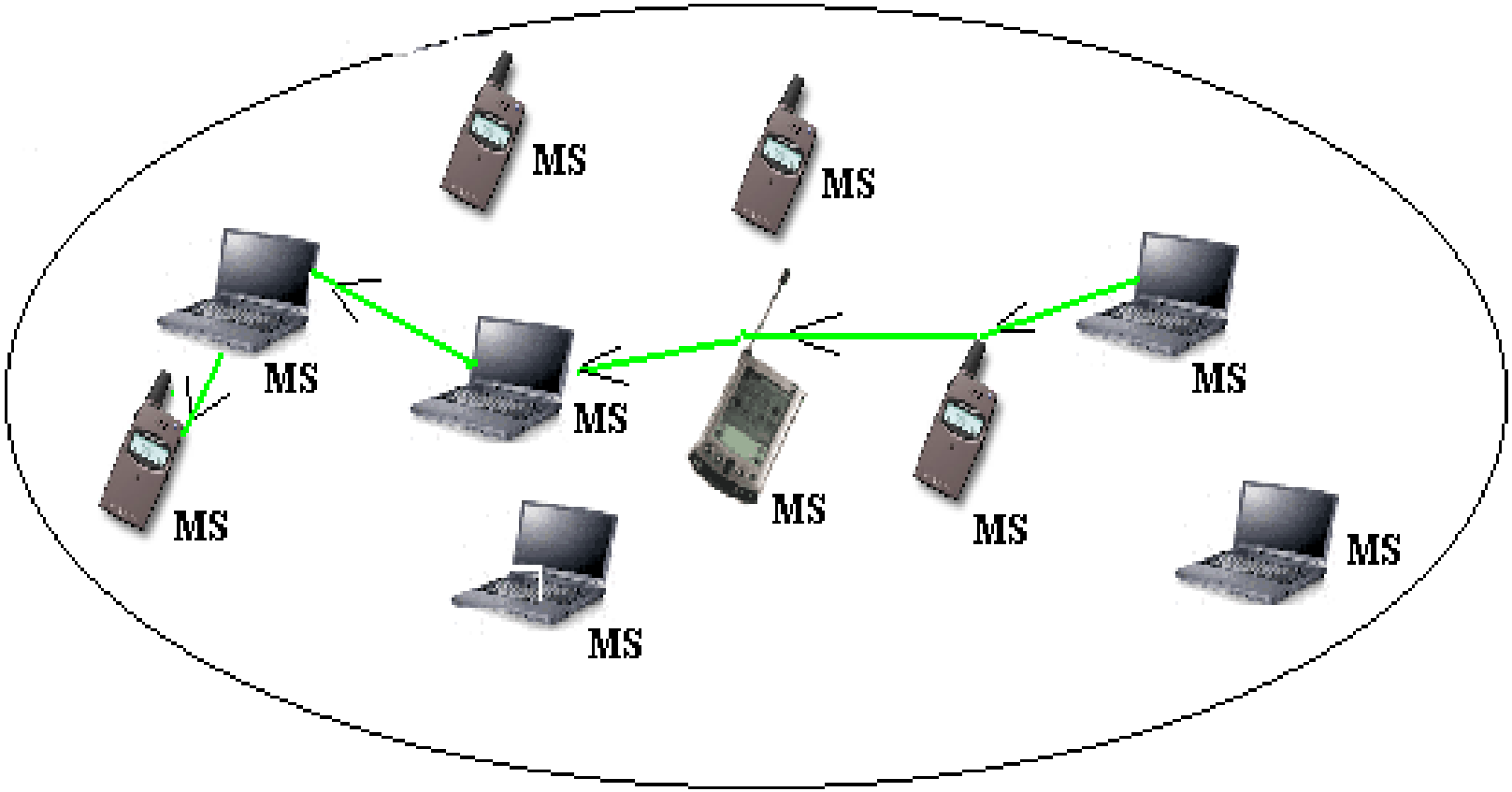
Ad Hoc Network



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Ad Hoc Network

- Characteristics of MANETs
- Applications
- Routing
  - Need for Routing
  - Routing Classification
- Table-Driven Routing Protocols
- Source-Initiated On-Demand Routing
- Hybrid Protocols
- Multipath Routing Protocols
- Vehicular Area Network (VANET)
- Network Simulators
  - ns-2 and ns-3
  - Other Network Simulators

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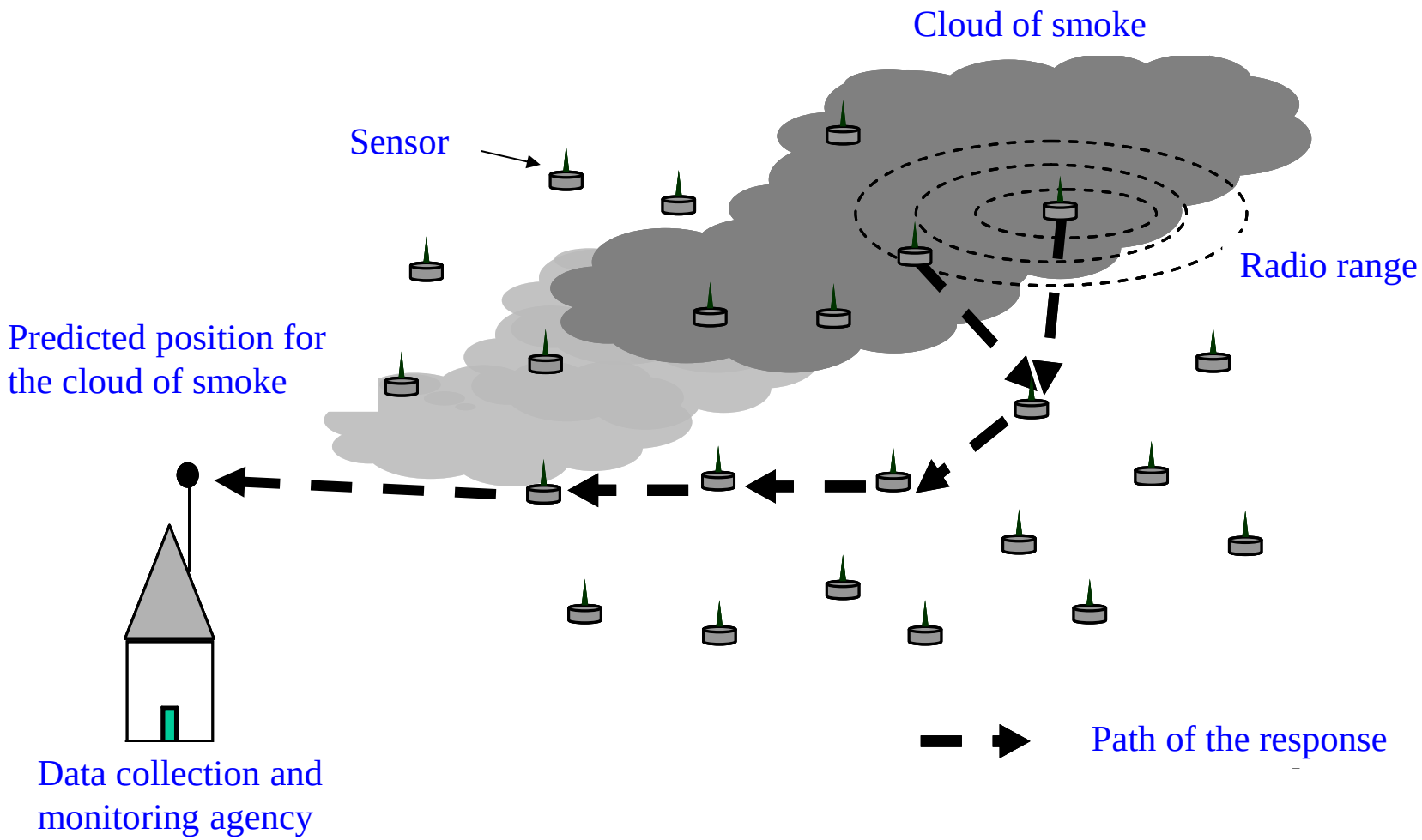
Wireless Sensor Networks



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Wireless Sensor Networks

- Adapting to the Inherent Dynamic Nature of Wireless Sensor Networks
  - DARPA Efforts toward Wireless Sensor Networks
- Functional Units of a Wireless Sensor Networks
- Sensing Area, Communication Range, and Sensor Placement
- Randomly Deployed Sensor Networks
- Placing Sensors at fixed Locations
  - Regularly Deployed Sensor Networks
- Network Characteristics
  - Classification of Sensor Networks
  - Fundamentals of MAC Protocol for Wireless Sensor Networks
  - Flat Routing in Sensor Networks
  - Routing Schemes
- Hierarchical Routing in Sensor Networks
- Sensor Databases
- Operating System Design

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Wireless LAN, PAN, BAN, and MAN

- HiperLAN and HiperLAN
  - HomeRF and Ricochet
- Wireless Personal Area Network (PAN)
  - IEEE 802.15.1 Bluetooth, IEEE 802.15.3 and 802.15.4
  - ZigBee
- Wireless Body Area Network (BAN)
- Wireless Metropolitan Area Network (WMAN)
  - Using WiMAX
  - Using a Mesh network
  - Using 3GPP and LTE
  - Using 3G and 4G
  - Using LTE and LTE-A

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Security and Privacy

- Encryption Techniques
- Wireless System Security
- Security in Cell Phones
- Security in LTE networks
- Authentication in WiFi-based AP Networks
  - Diffie-Hellman protocol
  - Elliptic curve cryptography (ECC)
- Security Issues in Mobile Ad Hoc Networks (MANETs)
  - Requirements for an IDS for MANETs
  - Mobile Agents for Intrusion Detection and Response in a MANET
  - Cluster-Based Intrusion Detection System in MANETs
  - Selfishness in a MANET
- Secured Communication in Wireless Sensor Networks
  - Shared Symmetric Key between two sensors in a randomly deployed WSN
  - Bivariate Polynomial in establishing a Shared Secret Key between two sensors
  - Intrusion Detection Schemes
- DDoS Attack Detection
- Covariance Analysis Method

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Satellite Systems

- Traditional Applications
  - Weather satellite
  - Radio and TV broadcasting
  - Military satellites
- Satellite System Infrastructure
  - Call Setup
- Telecommunication Applications
  - Global telephone connections
  - Backbone for global network
  - Global Positioning System
  - Limitations of GPS
- Internet Access

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Recent Advances

- SIM Card
- Push-to-Talk (PTT) Technology for SMS
- PTT Network Technology
- PTT in iDEN Cellular Networks
  - PTT in Non-iDEN Cellular Networks: PoC
  - Limitations of Current Services
- RFID
- Cognitive Radio
- Recent Advances in Resource Management
- Two-Tier Visual Sensor Network
  - Multimedia Services Requirements
- HTTP
- Directional and Smart Antennas
- Types of Antenna
  - Smart Antennas and Beamforming
  - Smart Antennas and SDMA
- Application of Coding in wireless multi-hop networks
- Delay Tolerant and Mobile Opportunistic Network
- 5-G and beyond
- Low-Power Design
- XML

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