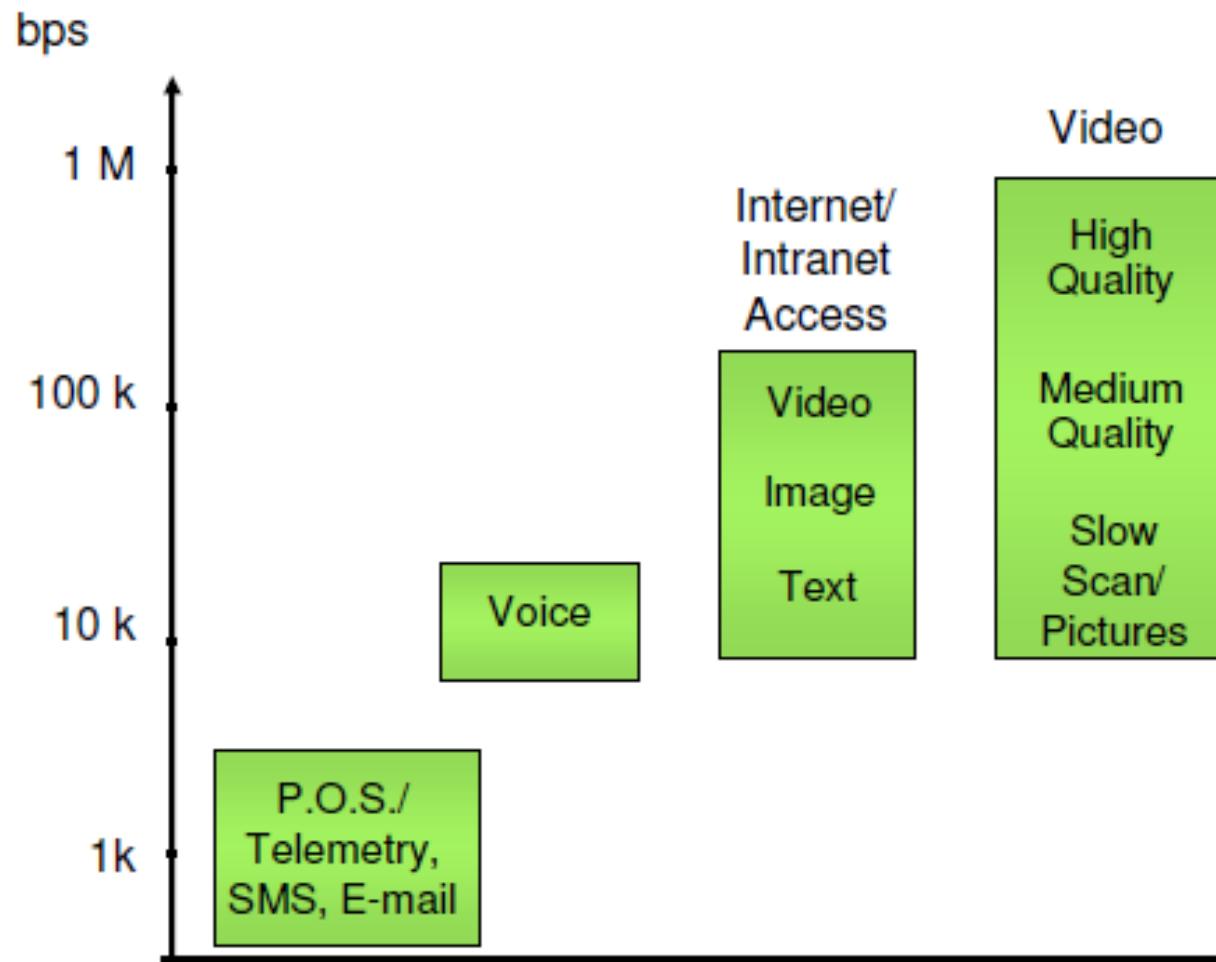
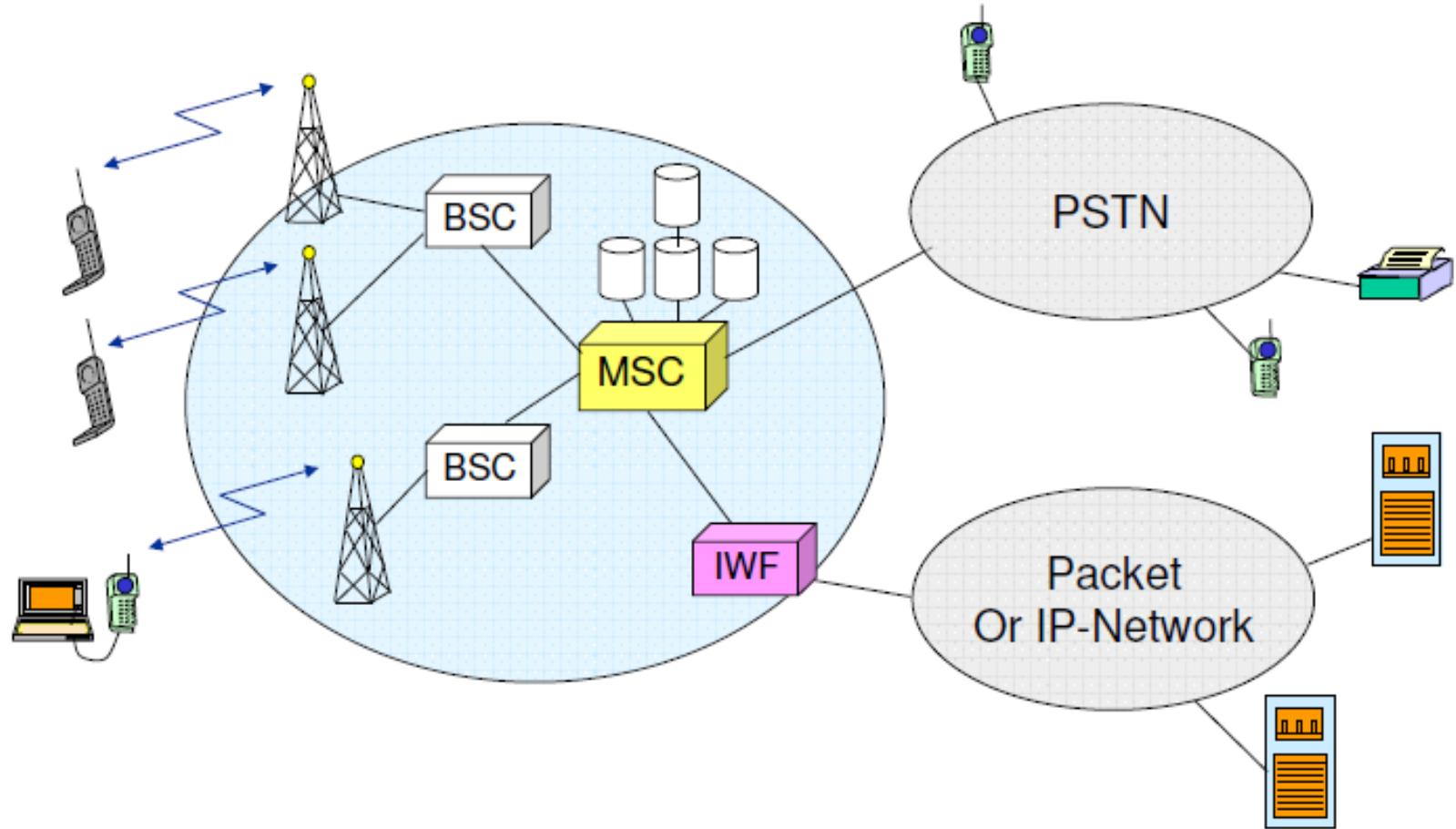


CHAPTER 11: 3G – 4G

Multimedia Data Rate Requirements



Data support in 2G systems



Limitations of 2G Systems

- Voice centric
- Too many standards globally

Jargons

- Mobile networks use many jargon and abbreviations
 - LTE, EPS, Node B, eNodeB
 - Nested acronyms are common
 - GERAN = GPRS Evolution Radio Access Network
 - LTE is often referred to as Evolved Packet System (EPS) in technical situations

Ubiquitous Mobile Network Services



Indoor



Outdoor



Walking



Driving



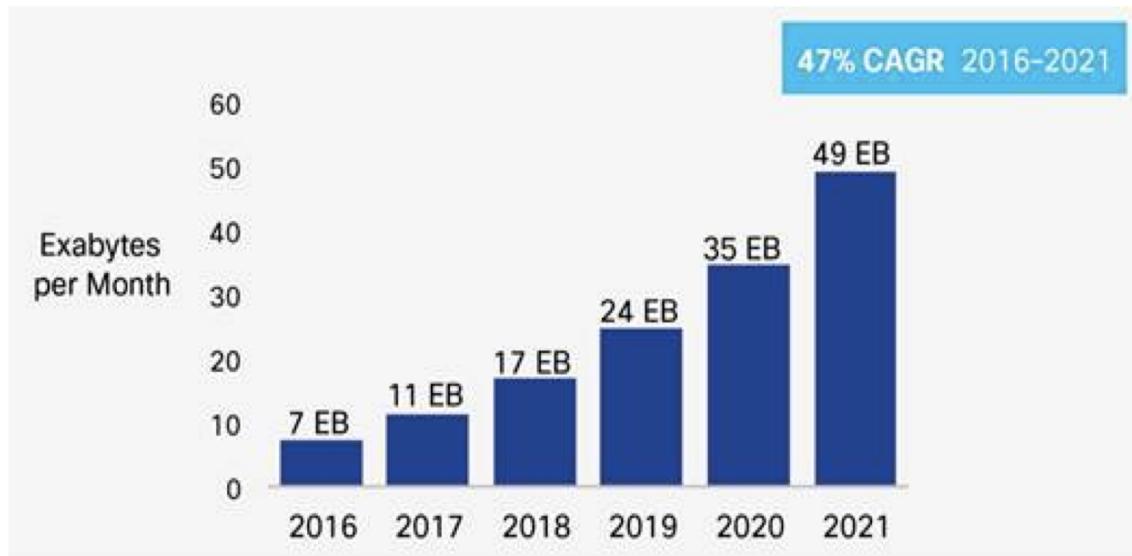
Subway



High-speed train

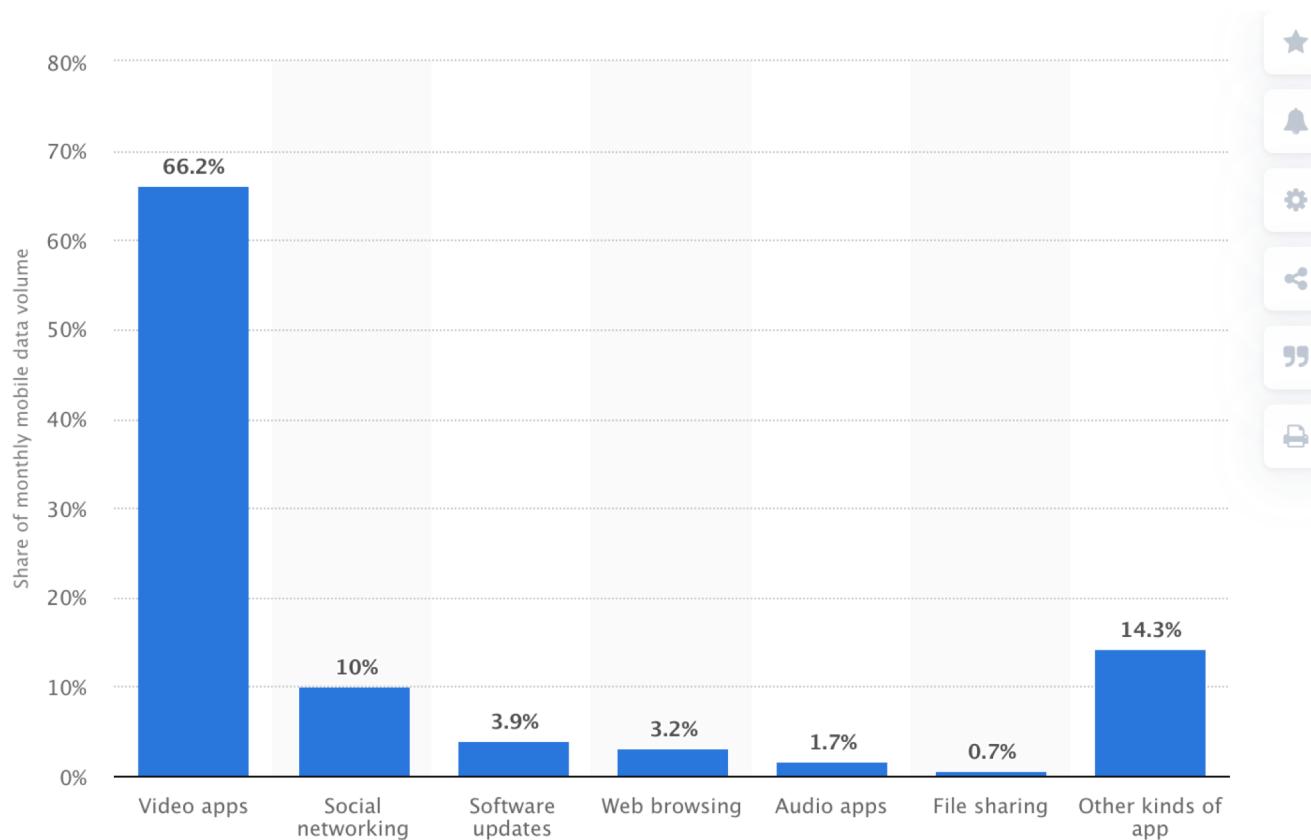
Ubiquitous Mobile Network Services

- Global Mobile Data Traffic
 - 7.2 exabytes/month in 2016 (63% growth)
 - 18 fold growth in the past five years
 - 7 fold growth by 2021 (49 exabytes/month)



Source: Cisco Visual Networking Index, 2017: Global Mobile Data Traffic Forecast Update, 2016–2021 White Paper

Ubiquitous Mobile Network Services



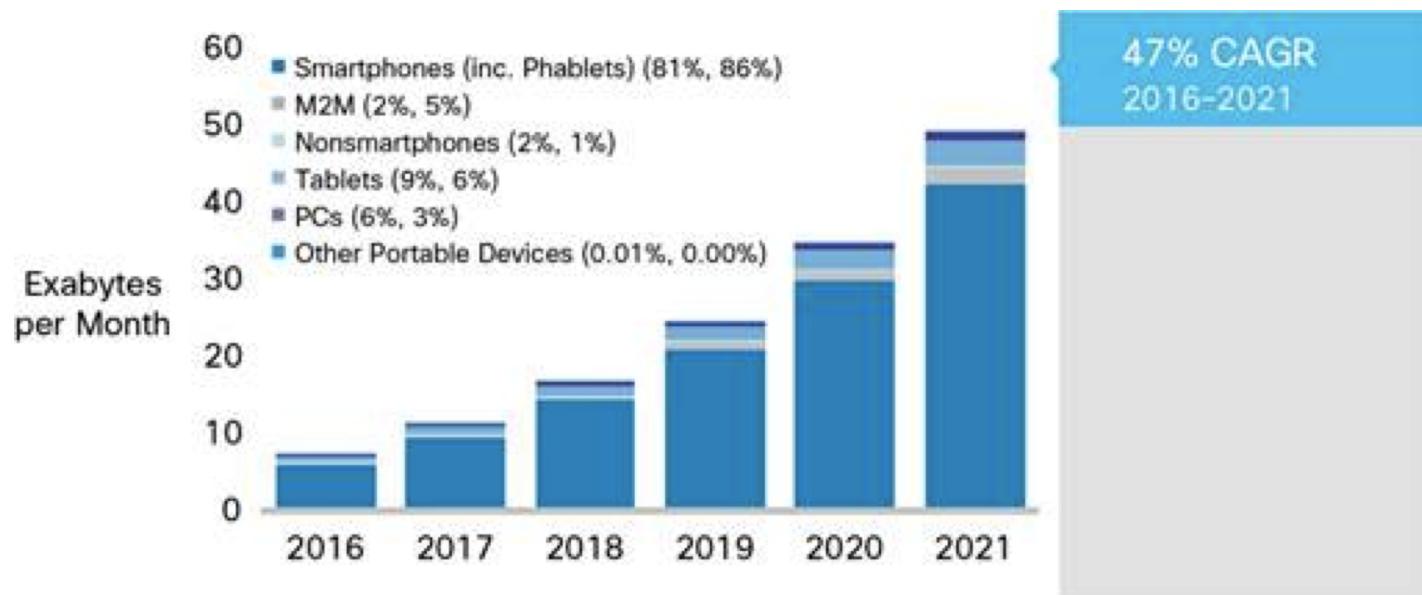
© Statista 2020

As of October 2020, the global monthly mobile data volume amounted to 46.1 exabytes.

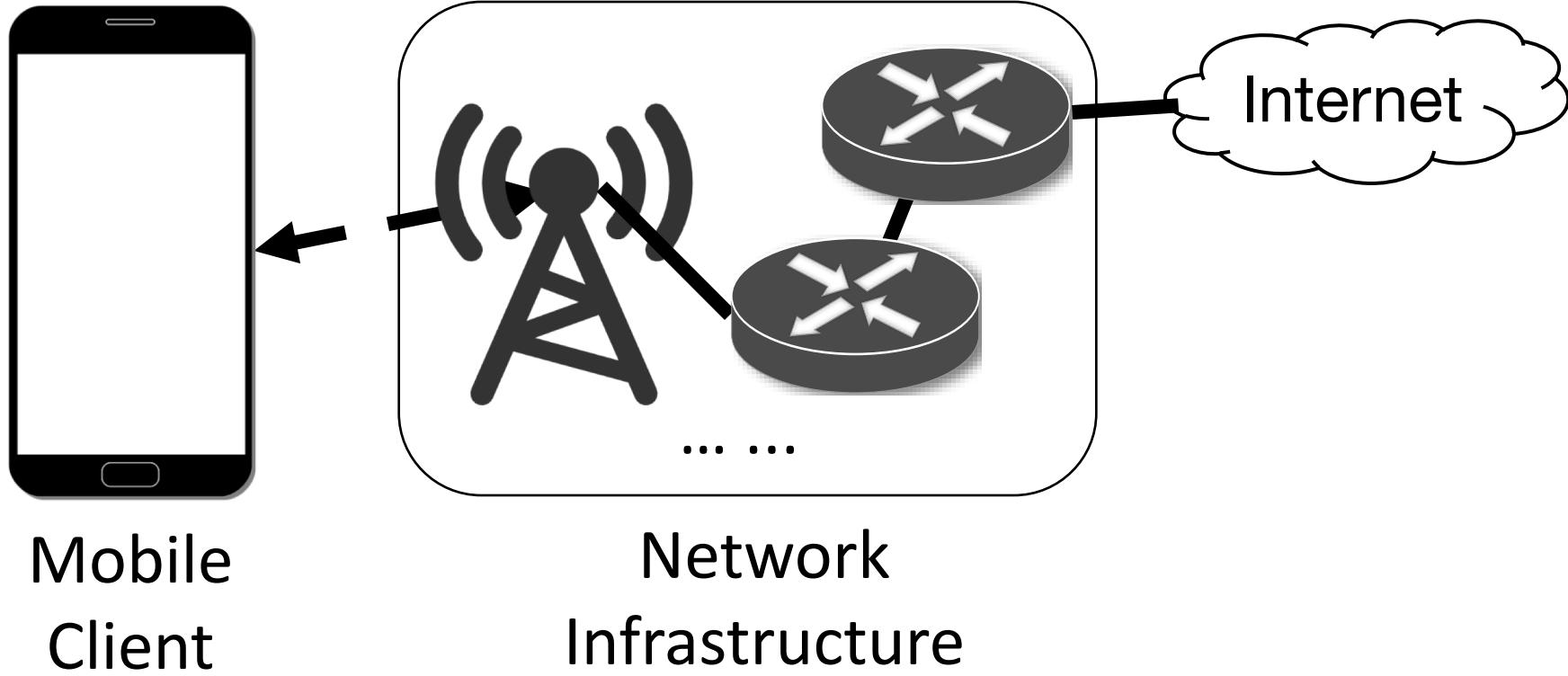
Ubiquitous Mobile Network Services

- Smartphones: primary internet access points

- By 2021, 98% traffic and 75% connections from “smart” devices
- 4G: 75% traffic and 53% connections
- 5G: 1.5% traffic and 0.2% connections

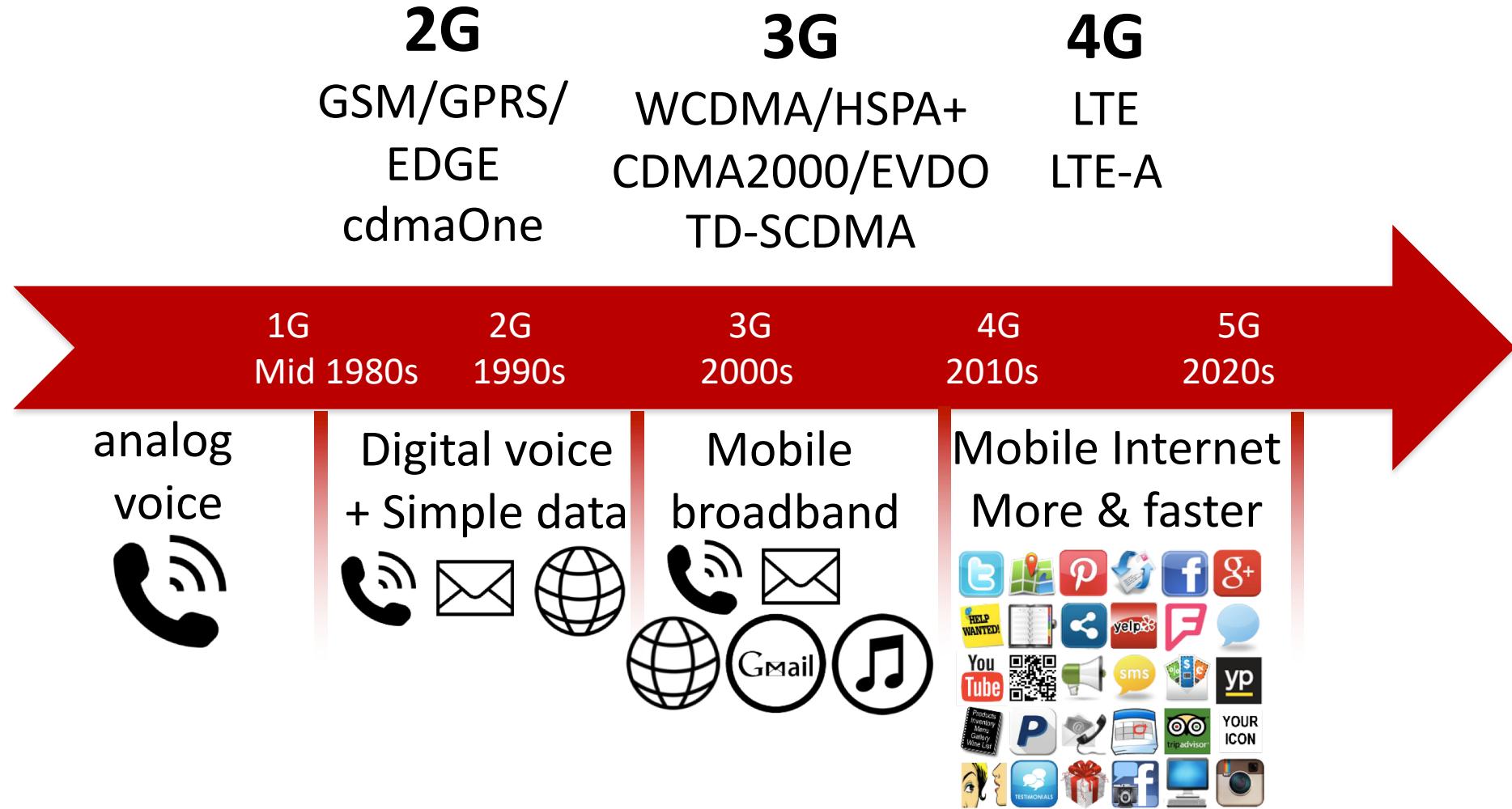


Empowered by Mobile Networks



- the **only** large-scale, wide-area wireless network system in par with the Internet

Mobile Network Evolution



Standards Body: 3GPP

- An international standards body
- Evolves and standardizes GSM, UMTS, LTE among others

The 3rd Generation Partnership Project (3GPP) unites [Six] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TTA, TTC), known as “Organizational Partners” and provides their members with a stable environment to produce the highly successful Reports and Specifications that define 3GPP technologies

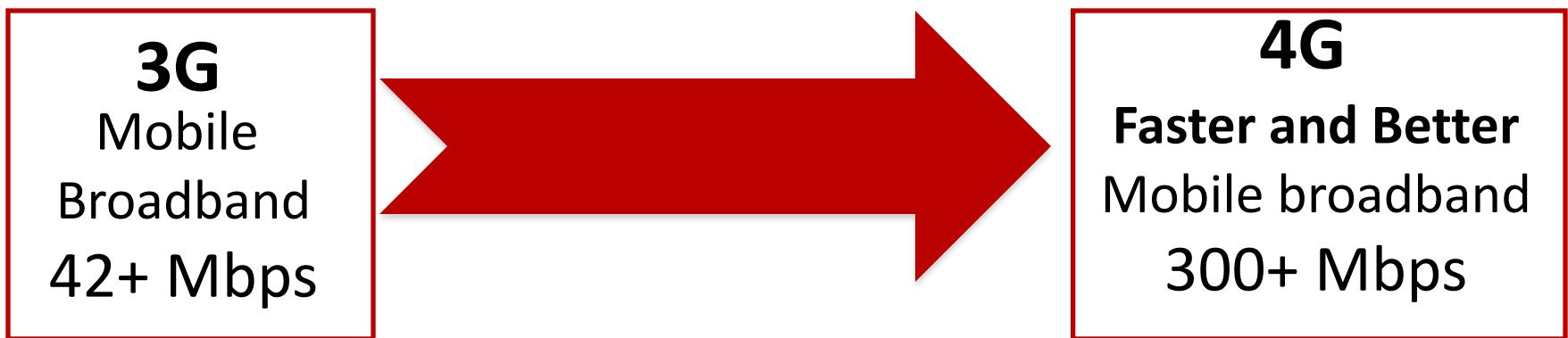
Cellular Network Standards

| Generation | 3GPP Circuit Switched | 3GPP Packet Switched | 3GPP2 | Wimax Forum |
|------------|-----------------------------|----------------------------|------------|----------------|
| 2G | GSM | | cdmaOne | |
| 2.5G | | GPRS | | |
| 2.75G | | EDGE | | |
| 3G | UMTS | | CDMA2000 | |
| 3.5G | | HSPA/+ | CDMA EV-DO | |
| 4G | | LTE | | WiMAX |

What is LTE?

- LTE stands for “Long Term Evolution”
- Fourth-generation (4G) cellular technology from 3GPP
- Deployed worldwide
- 4G LTE: First global standard
 - Increased speed
 - IP-based network (All circuits are gone/fried!)
 - New air interface: OFDMA (Orthogonal Frequency-Division Multiple Access), MIMO (multiple antennas)
 - Also includes duplexing, timing, carrier spacing, coding...
 - New service paradigm (e.g., VoLTE)

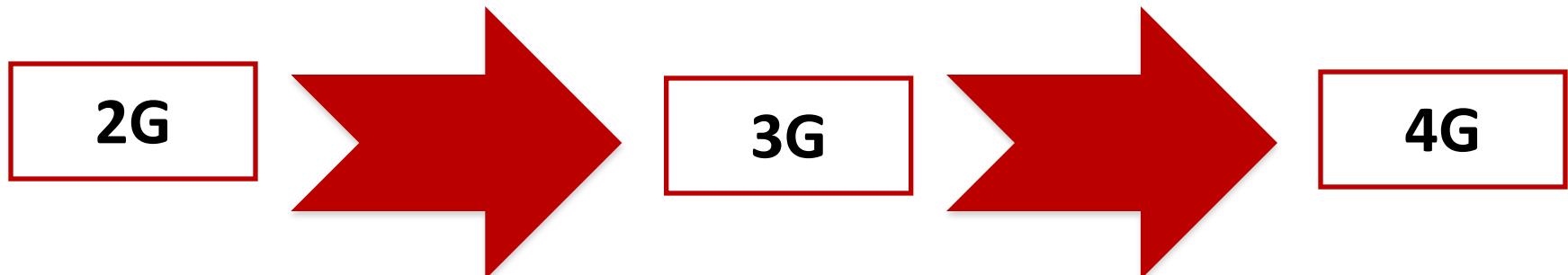
Evolution from 3G to 4G LTE



What is LTE?

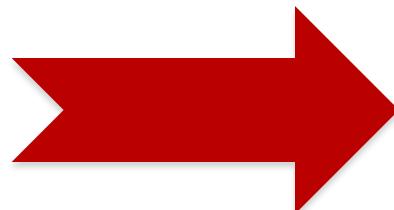
- LTE is always evolving and 3GPP often has new “releases”
 - First release: Rel-8
 - Current: Rel-11, Rel-12
 - Toward LTE-Advanced (4.5G)

Network Architecture Evolution



- Circuit-switching for voice
- Circuit-switching for voice
- Packet-switching for data

**Telecomm
Infrastructure**

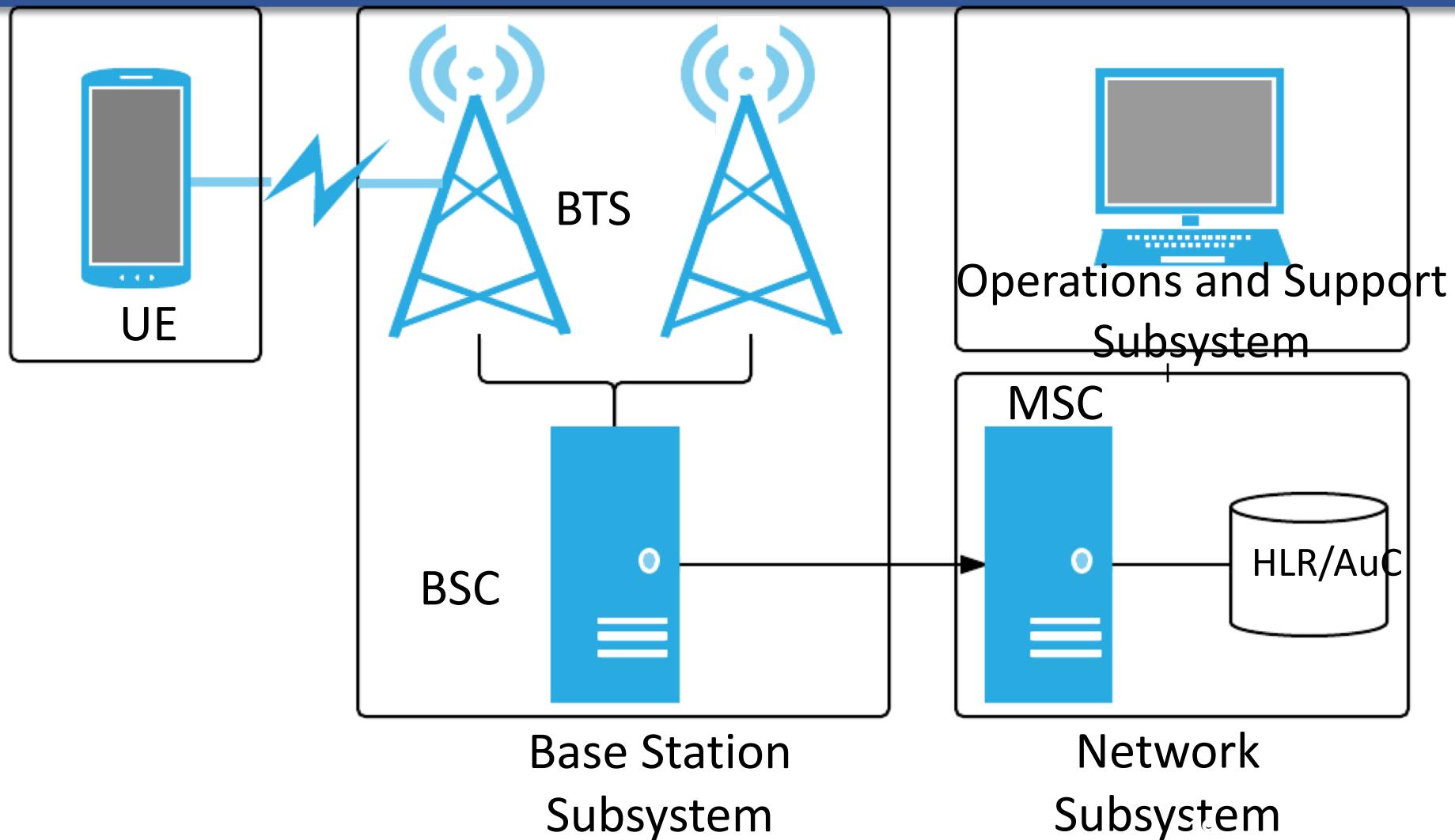


IP-based Internet

Inter-Generation Technologies

- CS networks need to be able to connect with PS networks and other distinct cellular networks
 - The internet is a good example of PS network
- GPRS (General packet radio service)
 - 2.5G packet switched technology
- EDGE (Enhanced Data Rates for GSM Evolution)
 - 2.75G packet switched technology
- HSPA (High Speed Packet Access)
 - 3.5/3.75 packet switched data technology
 - There were a few quick iterations on this technology, thus “variants”

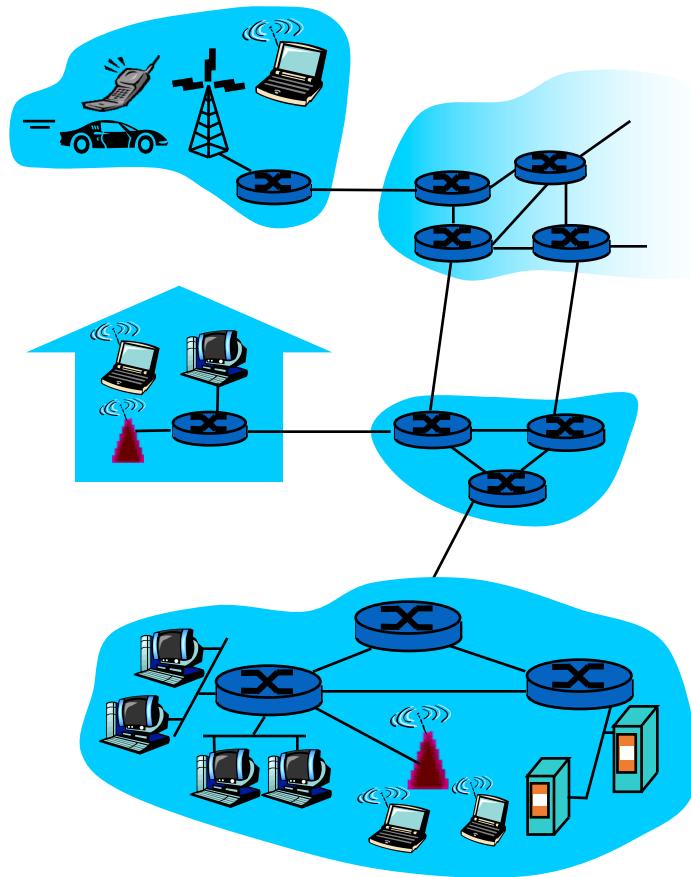
2G Network Architecture (GSM)



2G Based on Circuit Switching (CS)

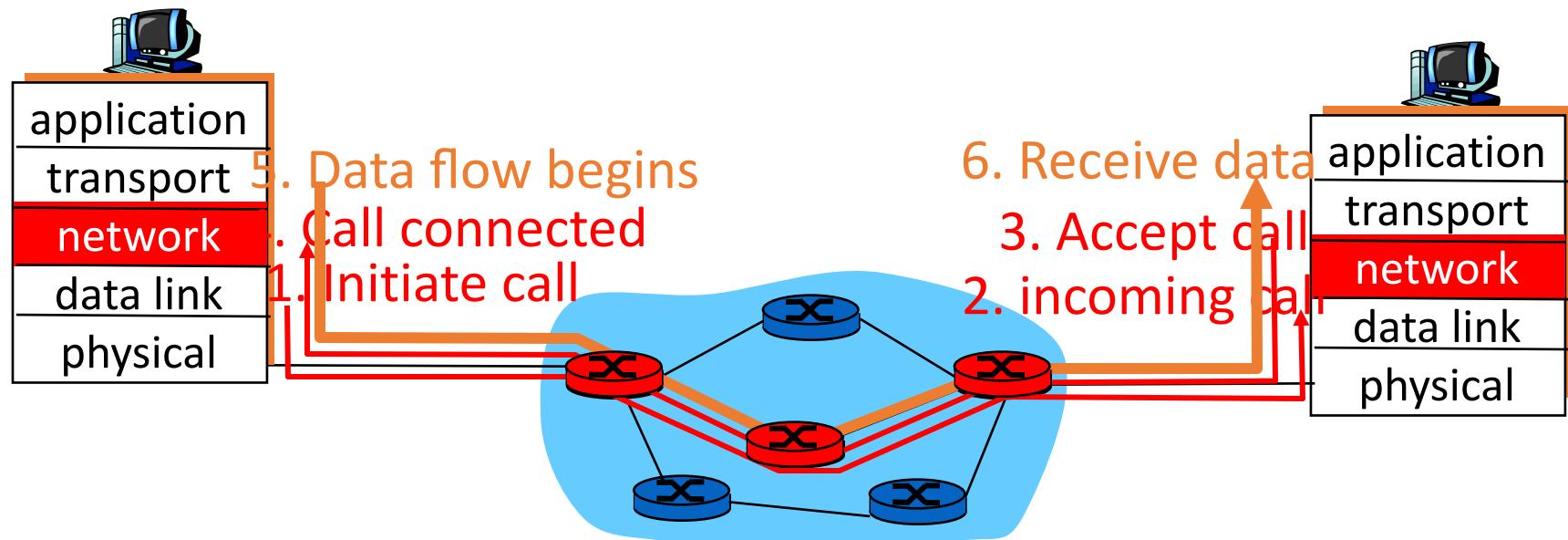
End-to-End
resources
reserved for
“call”

- link bandwidth, switch capacity
- dedicated resources: no sharing
- circuit-like (guaranteed) performance
- call setup required

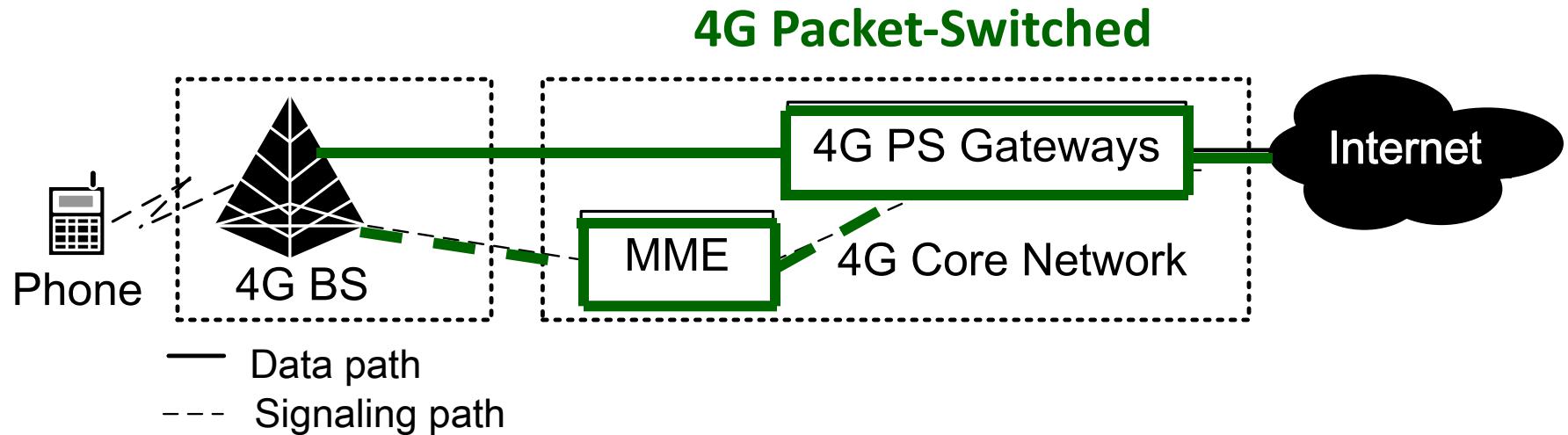


CS Signaling

- used to setup, maintain teardown VC
- used in 2G, as well as in 3G
- not used in today's Internet

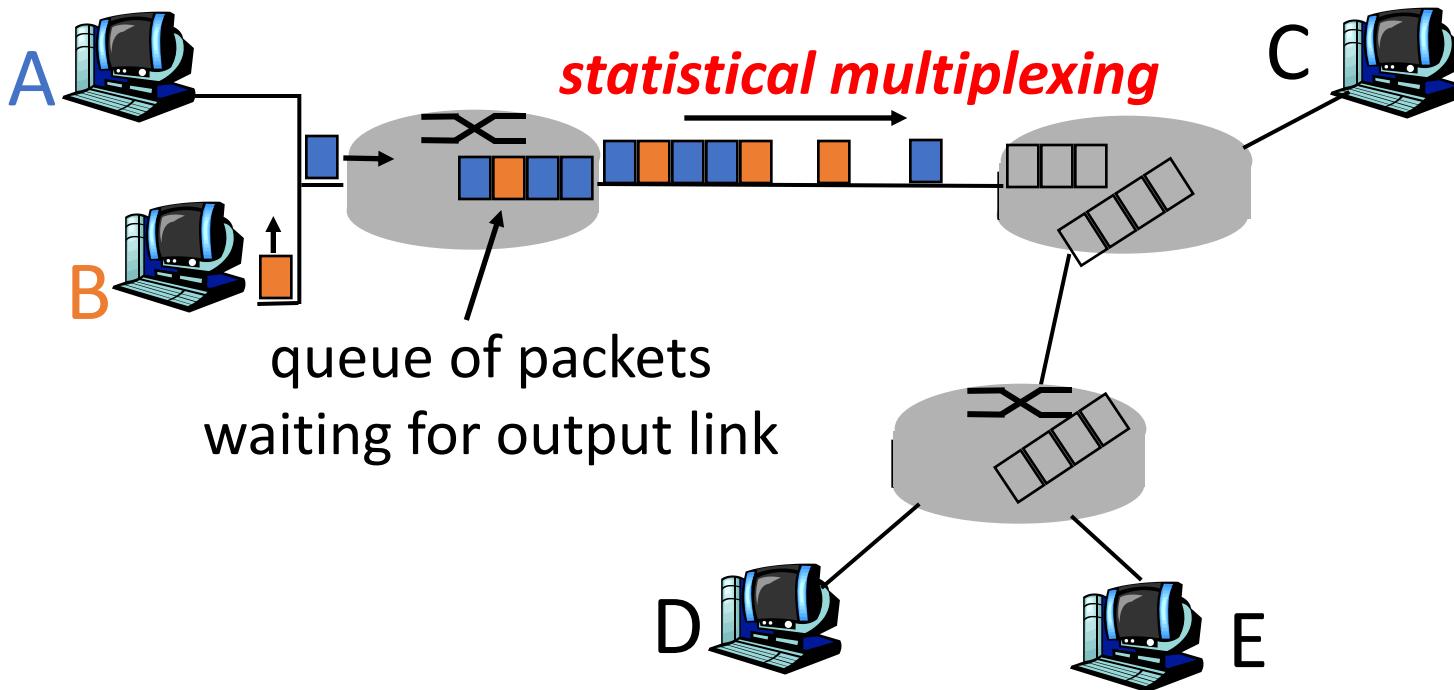


4G Network Architecture (LTE)



MME: Mobility Management Entity
BS: Base Station (4G: eNodeB)

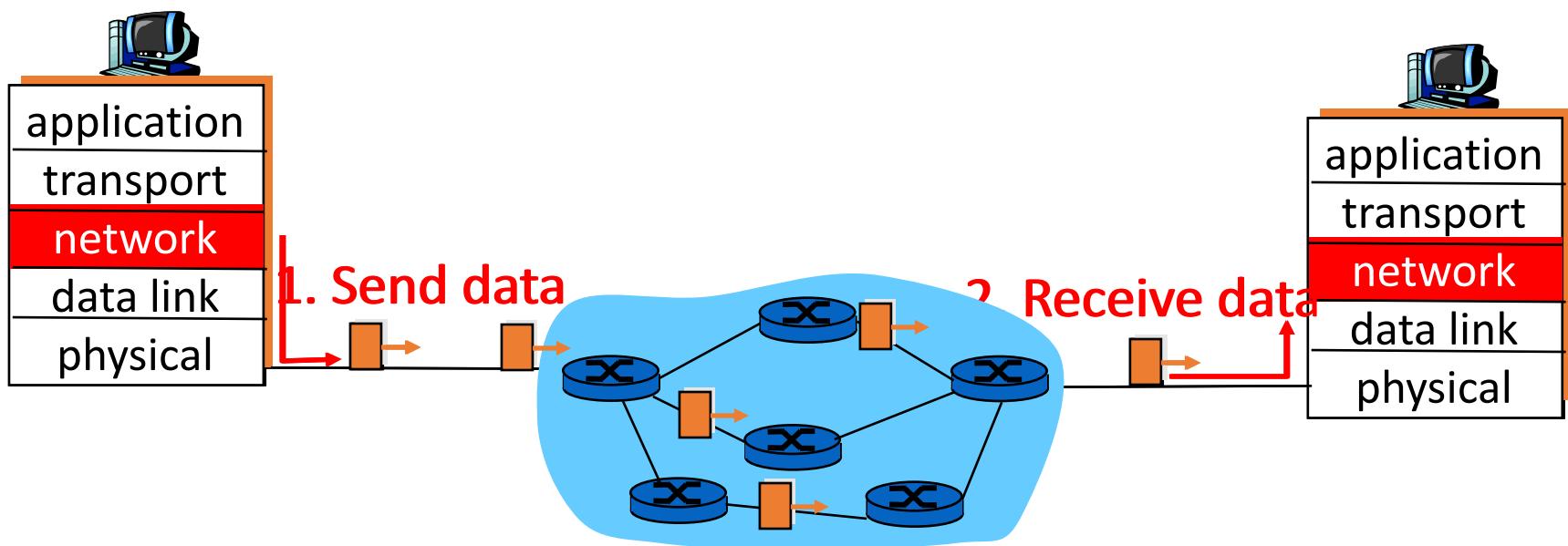
Packet Switching (PS)



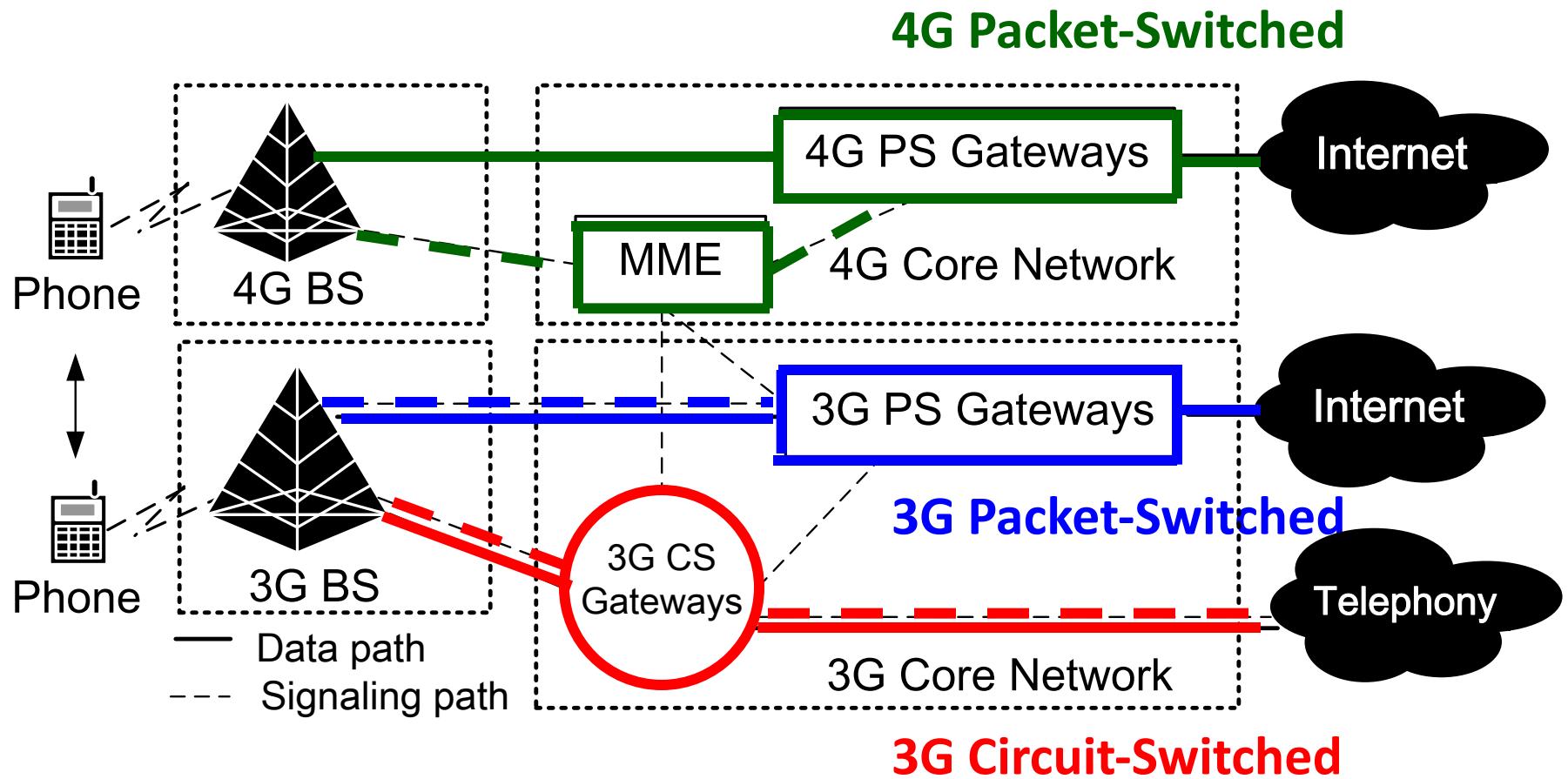
- Sequence of A & B packets does not have fixed pattern, bandwidth shared on demand → statistical multiplexing
- Store-and-forward at intermediate routers
- Used by the Internet

PS Signaling

- no call setup at network layer
- routers: no state about end-to-end connections
 - no network-level concept of “connection”
- packets forwarded using destination host address
 - packets btw same source-dest pair may take different paths



3G/4G Network Architecture



Operations

Two main planes in operation in parallel:

- **Data plane (also called User plane)**: content delivery
- **Control plane**: signaling functions

There is an additional plane that works with the above two planes:

- **Management plane**: configurations, monitoring

Illustration of Data and Control Planes

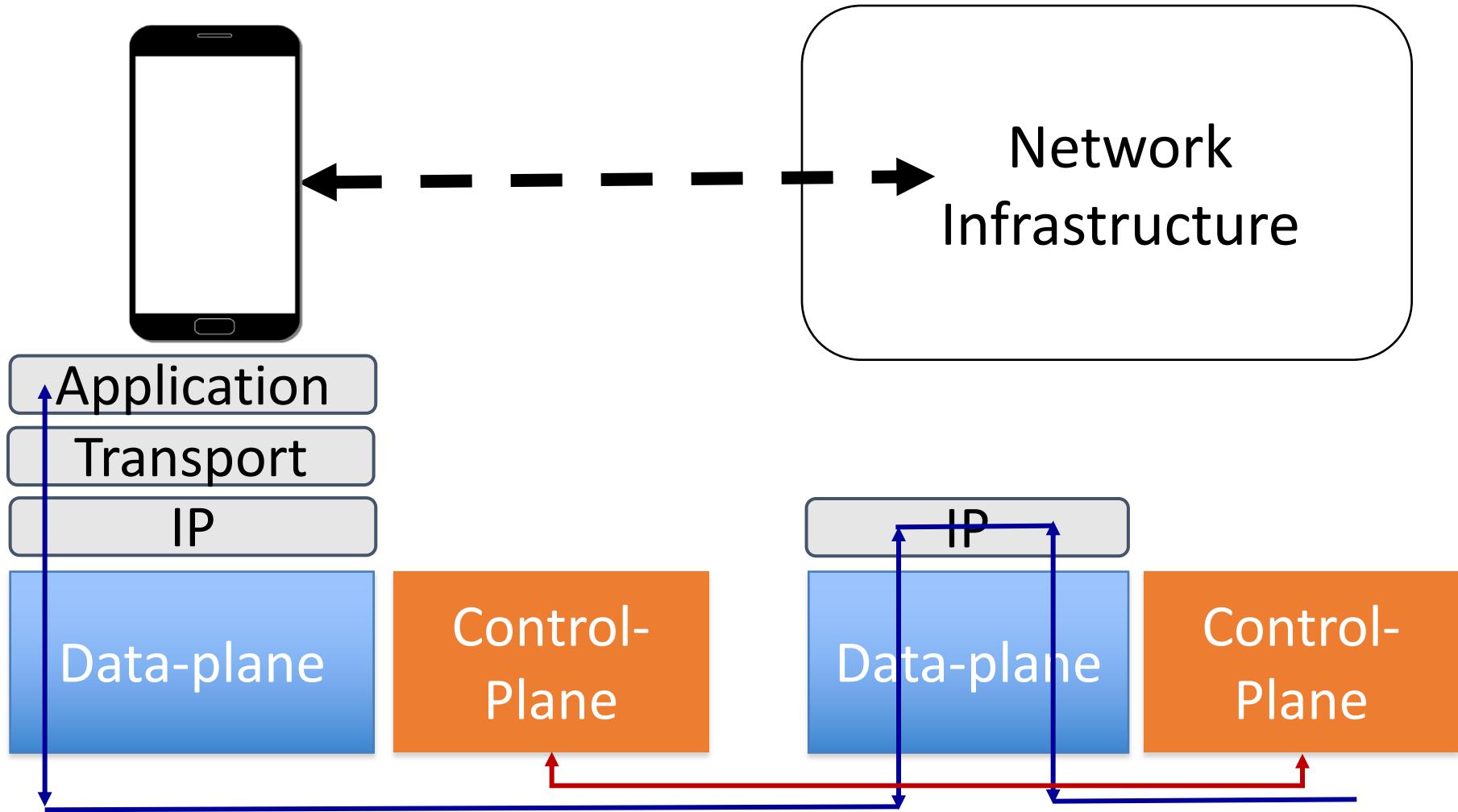
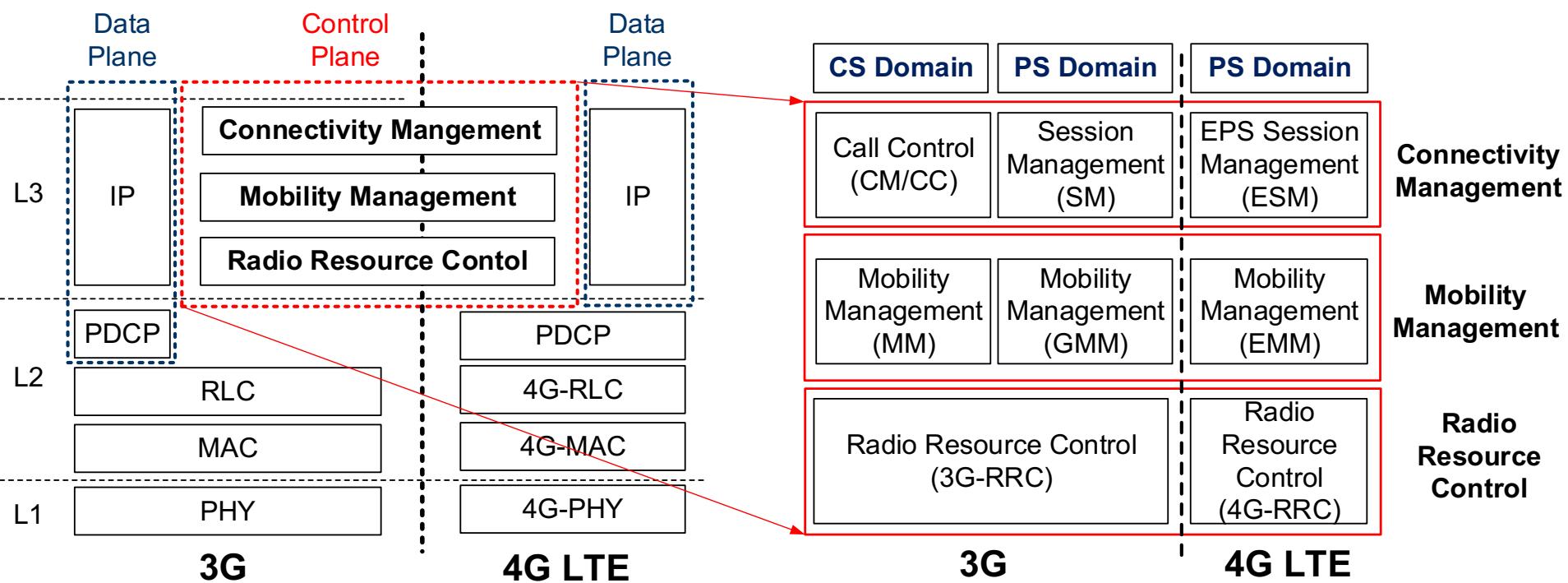


Illustration of Data and Control Planes



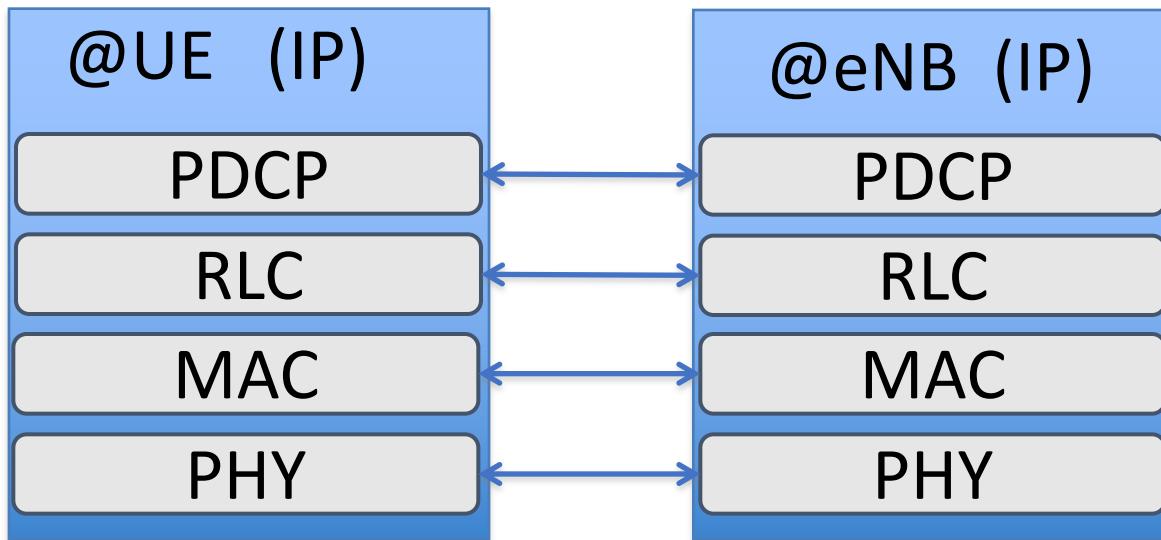
EPS: Evolved Packet System

PDCP: Packet Data Convergence Protocol

RLC: Radio Link Control

MAC: Medium Access Control

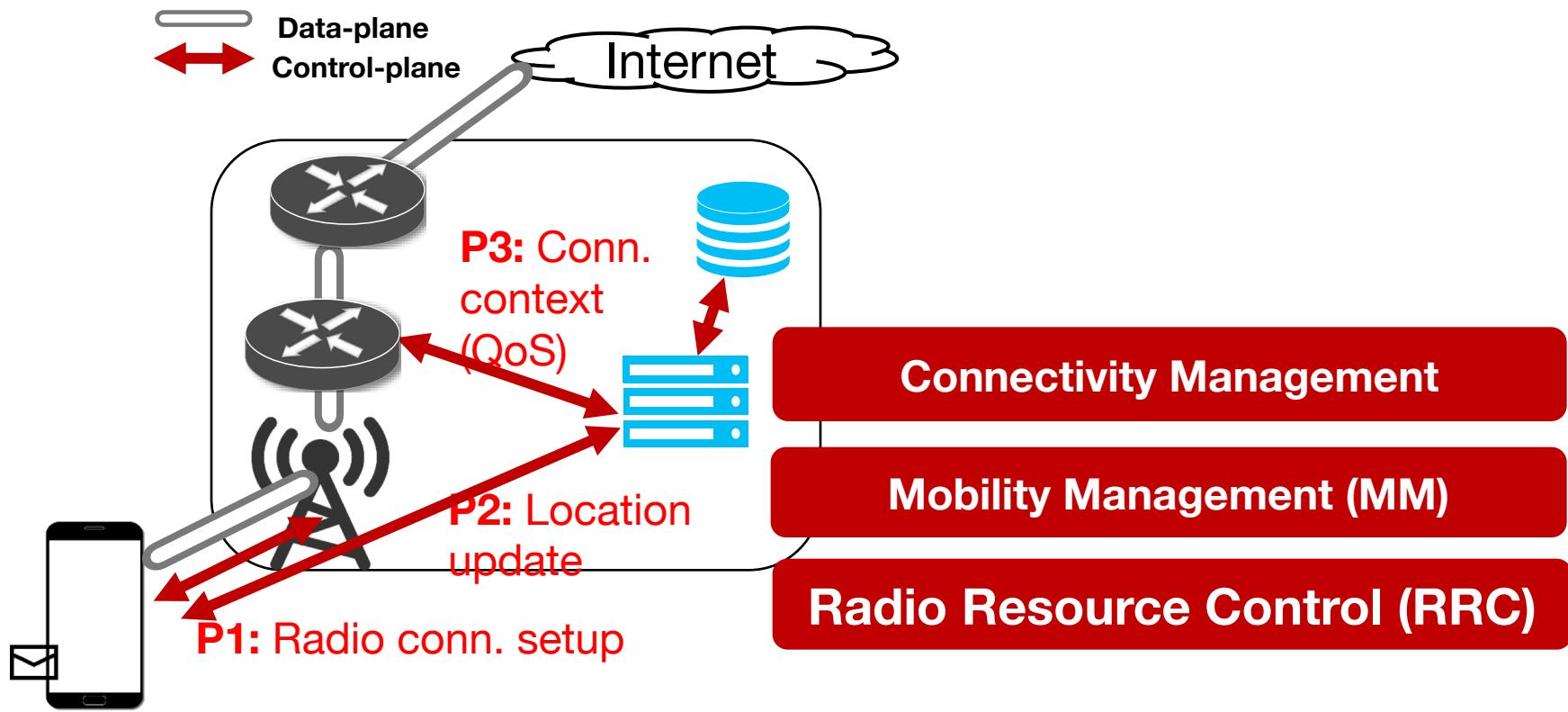
Data-Plane Protocols: IP + lower layers



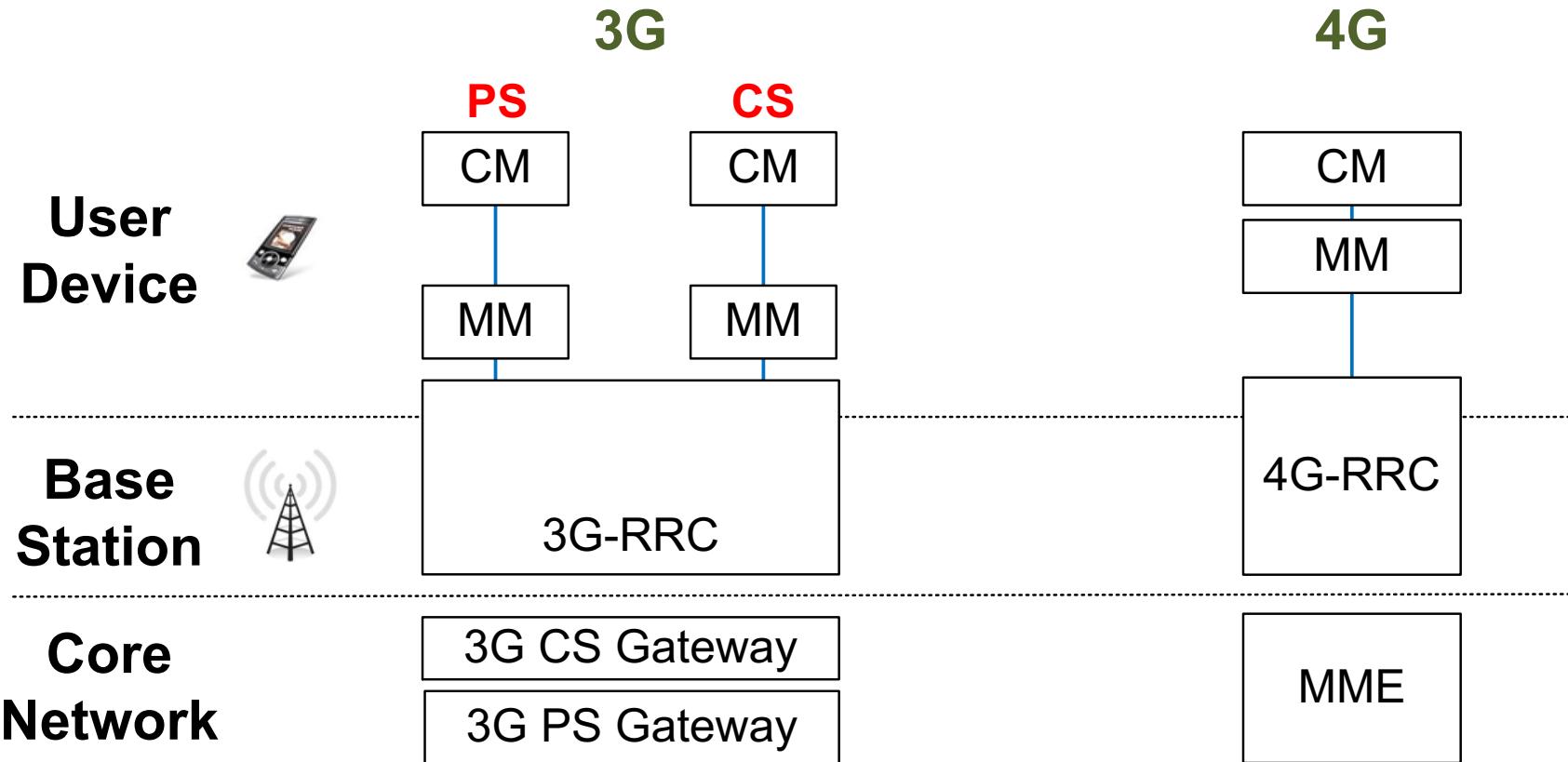
- **Packet Data Convergence Protocol (PDCP)** – header compression, radio encryption
- **Radio Link Control (RLC)** – Readies packets to be transferred over the air interface
- **Medium Access Control (MAC)** – Multiplexing, QoS

Control-Plane Protocols

- Control utilities: mobile network specific
 - Different from Internet counterparts

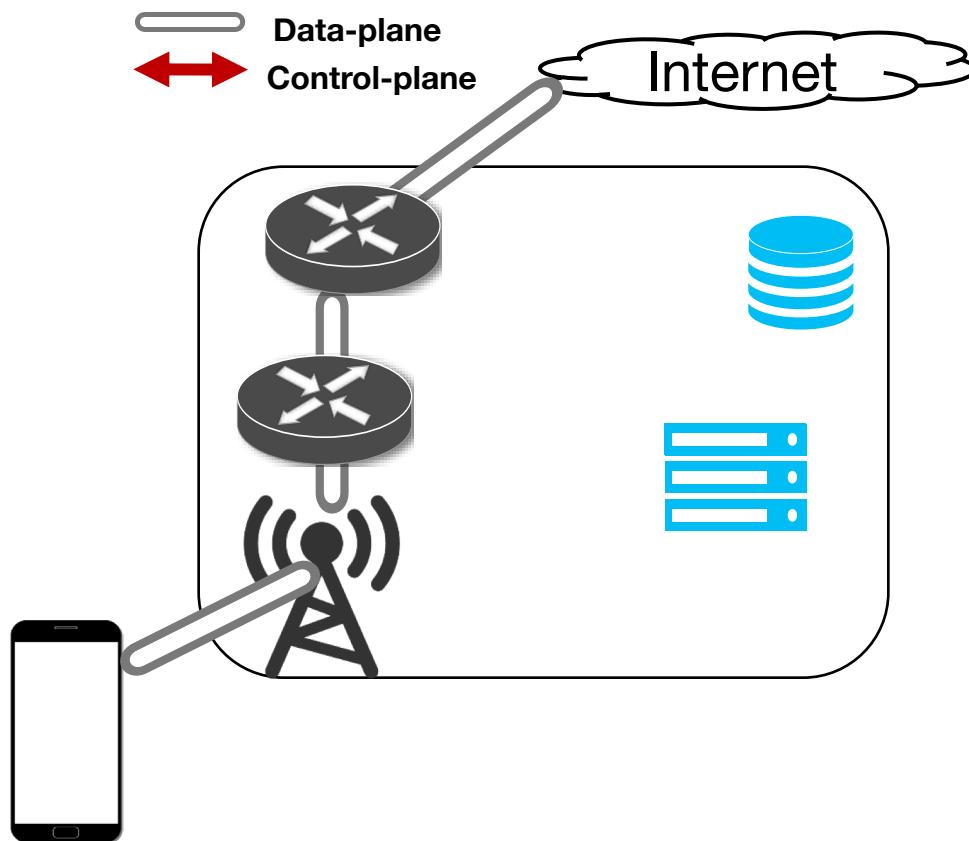


Distributed Operations: Device, base station, core networks

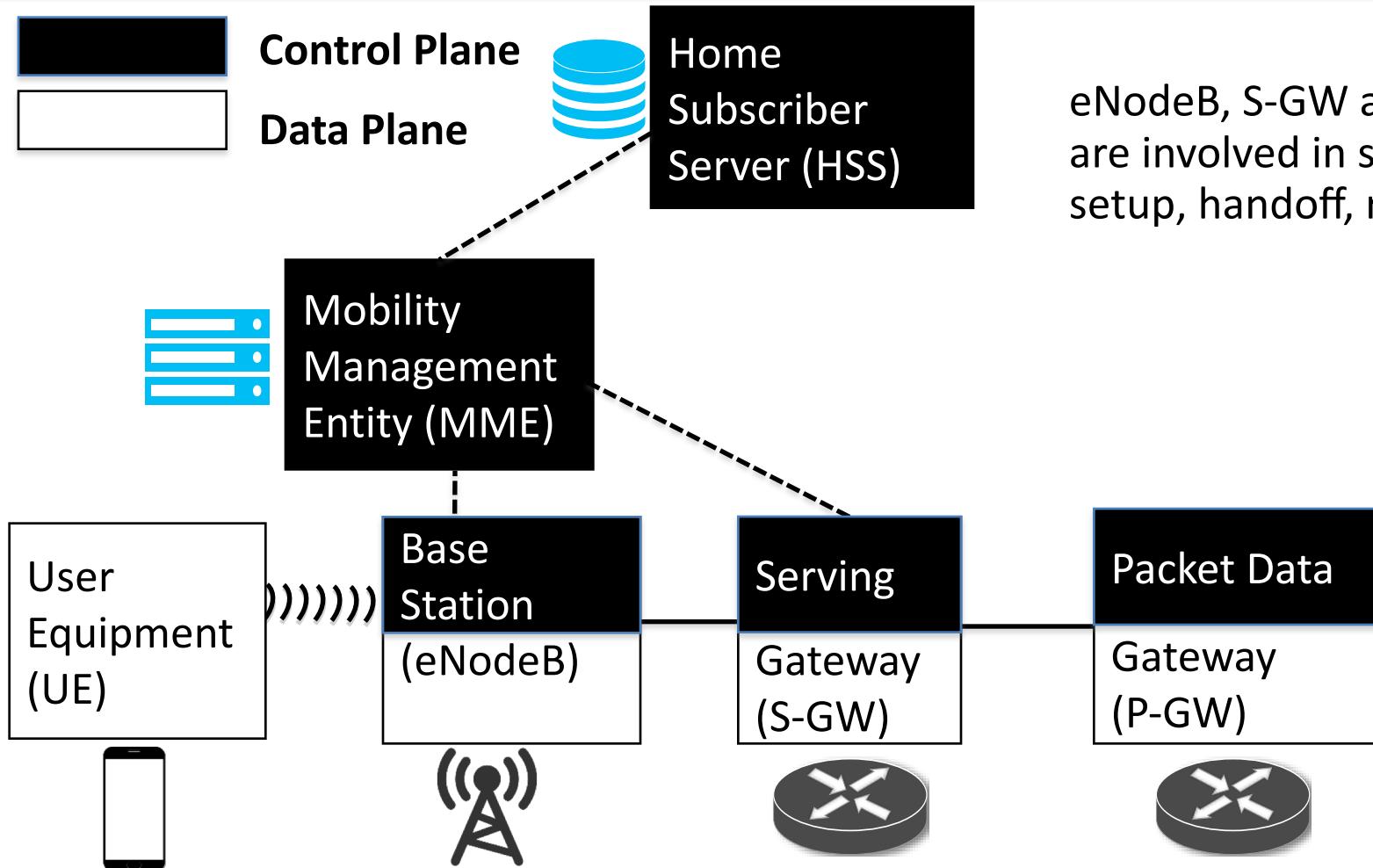


Put Them Together

- Setting up data service in 4G



Data and Control Planes in LTE



Setting Up Data Service in 4G

