

FIRST GENERATION MOBILE CELLULAR TELEPHONE SYSTEMS

(Commercialized in Early 1980s)

ECE 525E – MOBILE COMMUNICATION SYSTEMS

Monday, February 24, 2025

ADVANCED MOBILE PHONE SYSTEM (AMPS)

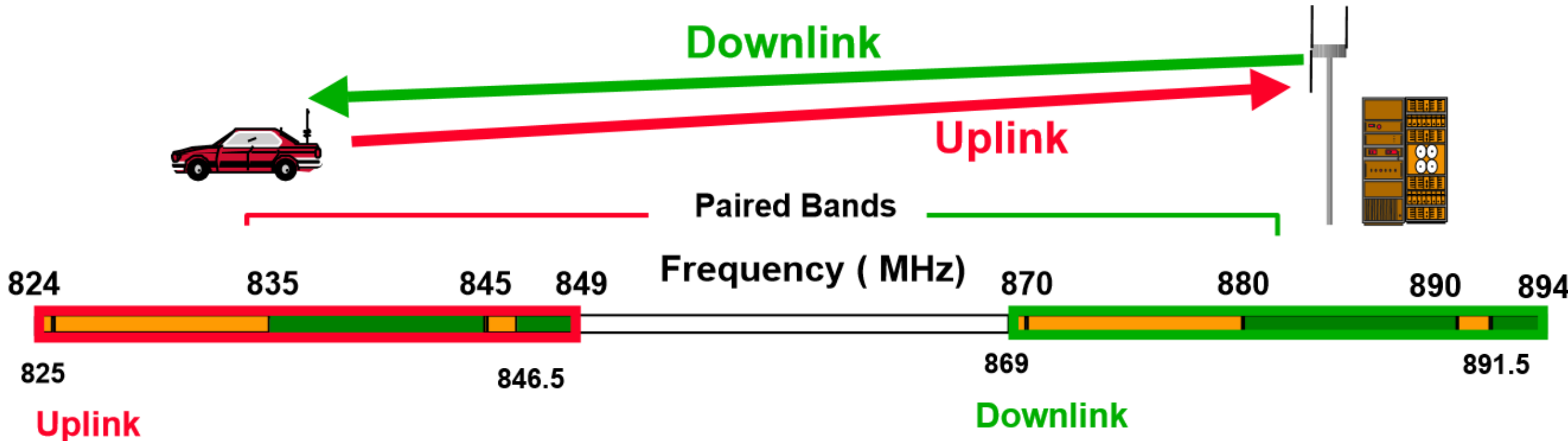
- **Advanced Mobile Phone System (AMPS)** was the first mobile cellular communication system.
- **Brief History:**
- **1958:** AT&T proposes AMPS
- **1971:** AMPS technical feasibility demonstrated
- **1979:** Network and marketing trial approved between American Telephone & Telegraph (AT&T) and Illinois Bell
- **1983:** Commercial AMPS service launched

AMPS FREQUENCY PLAN

1. Setting up a new wireless communication system requires negotiations with the communication regulators (CA, FCC, OFCOMM, ITU).
2. For AMPS, the regulator was the Federal Communications Commission (FCC) in the USA.
3. By 1980, USA was using the **Federal Communication Commission (FCC)** 1970 National Frequency Plan.
4. AMPS was allocated **70 MHz** in the frequency band **824 – 894 MHz** which was free at the time.
5. The allocation as as follows:
 - **Uplink 824-849 MHz**
 - **Downlink: 869-894 MHz**
6. 20 MHz ga, commonly referred to as duplex frequency, was left between uplink and downlink as a guard band.

AMPS FREQUENCY PLAN (2)

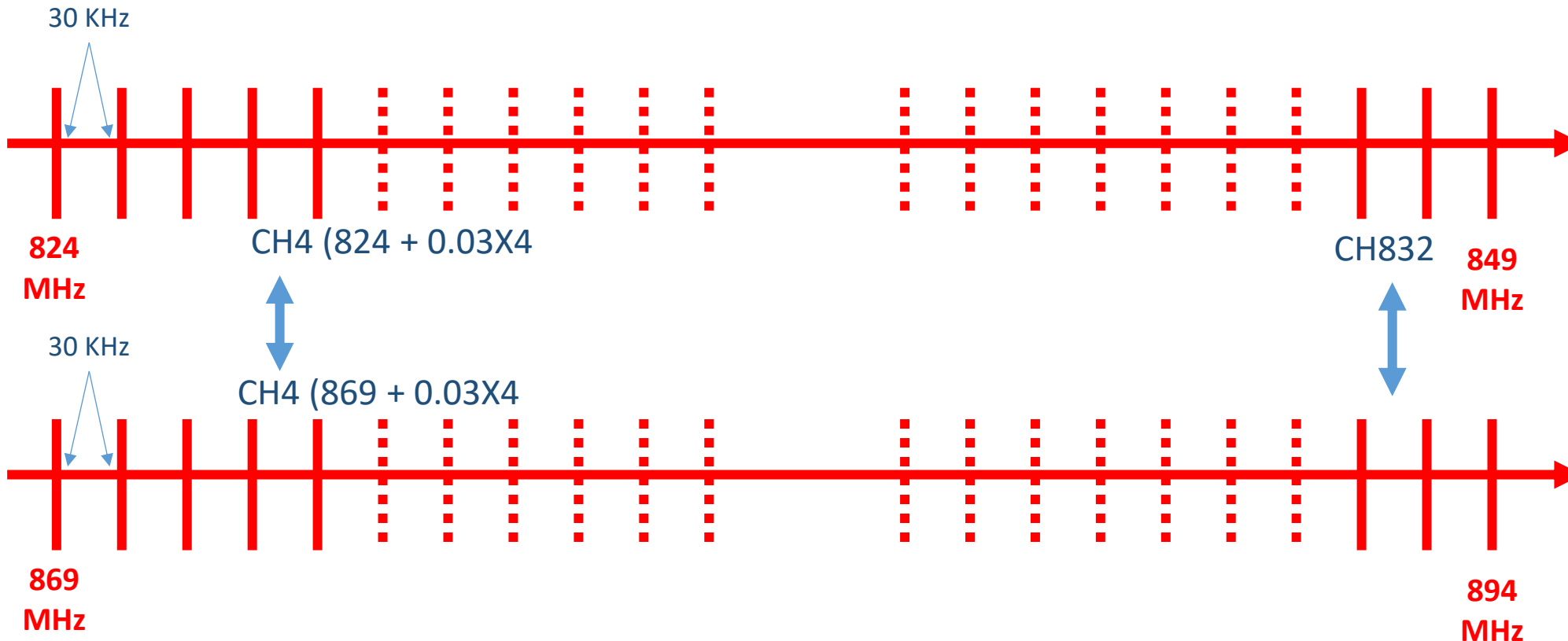
- AMPS provides full-duplex communications, i.e. two-way simultaneous conversation requires simultaneous voice paths in both directions.
- 25 MHz band of frequencies used for mobile transmission (uplink)
- 25 MHz band of frequencies used for cell site transmission (downlink)



AMPS MULTIPLE ACCESS SCHEME

- AMPS uses Frequency Division Multiple Access (FDMA).
- Each channel uses 30 KHz
- Total number of Channels, N, over the allocated frequency band is therefore

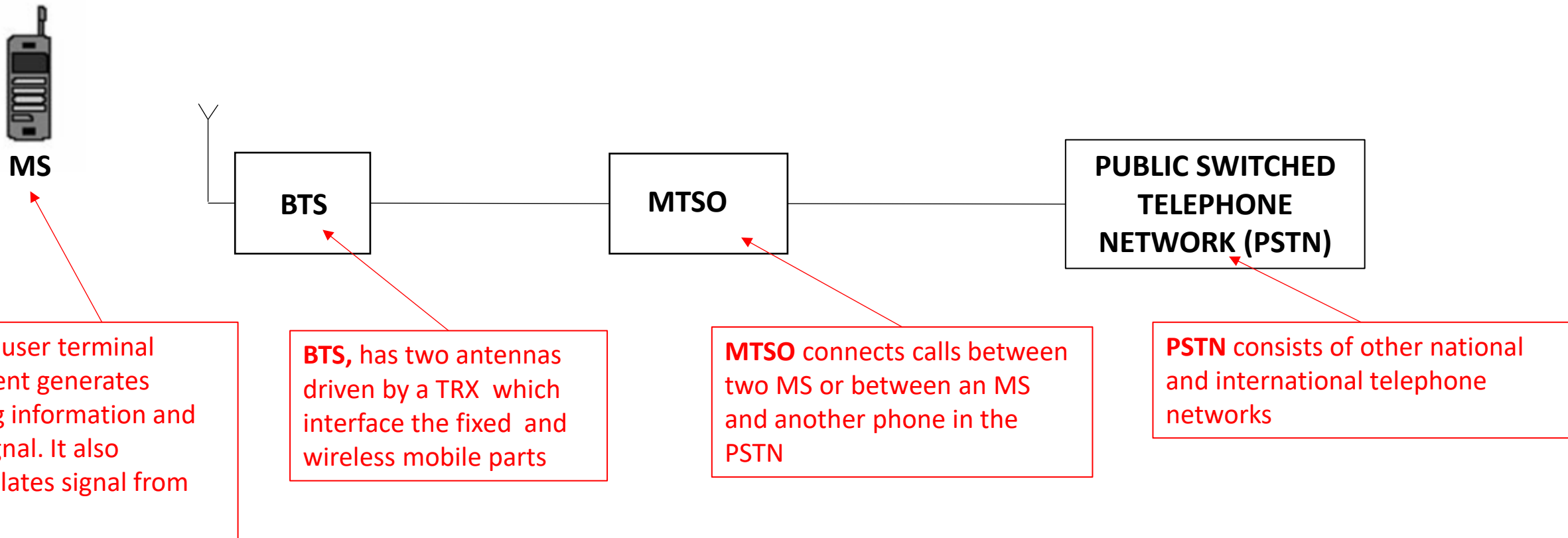
$$N = \frac{849-824}{0.03} = \frac{25}{0.03} = 833 \text{ channels}$$



AMPS ARCHITECTURE

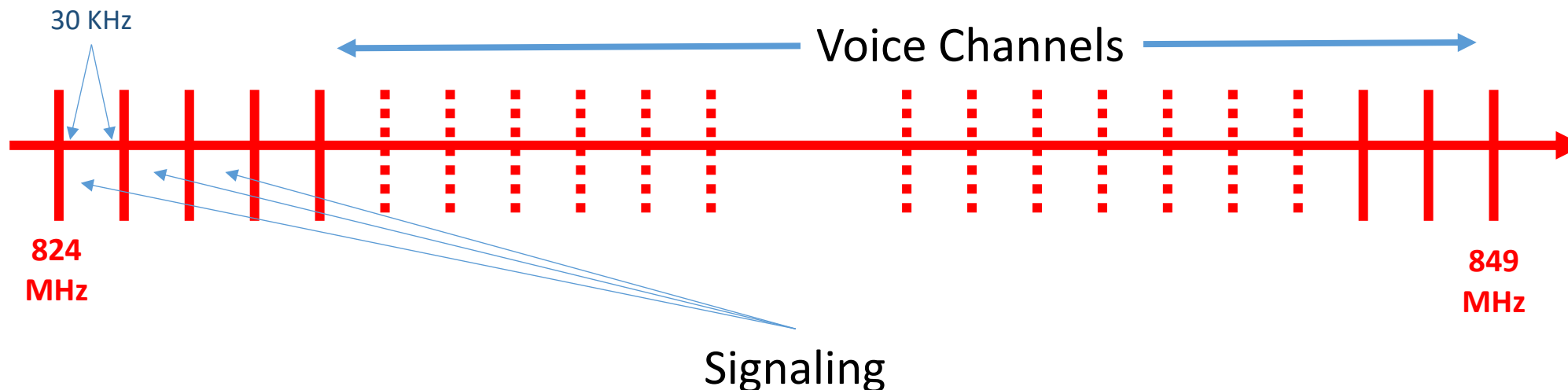
The key functional units in an AMPS network are:

- (a) Mobile Station (MS)
- (b) Base Transceiver Station (BTS)
- (c) Mobile Telecommunication Switching Office (MTSO)



MODULATION SCHEMES IN AMPS

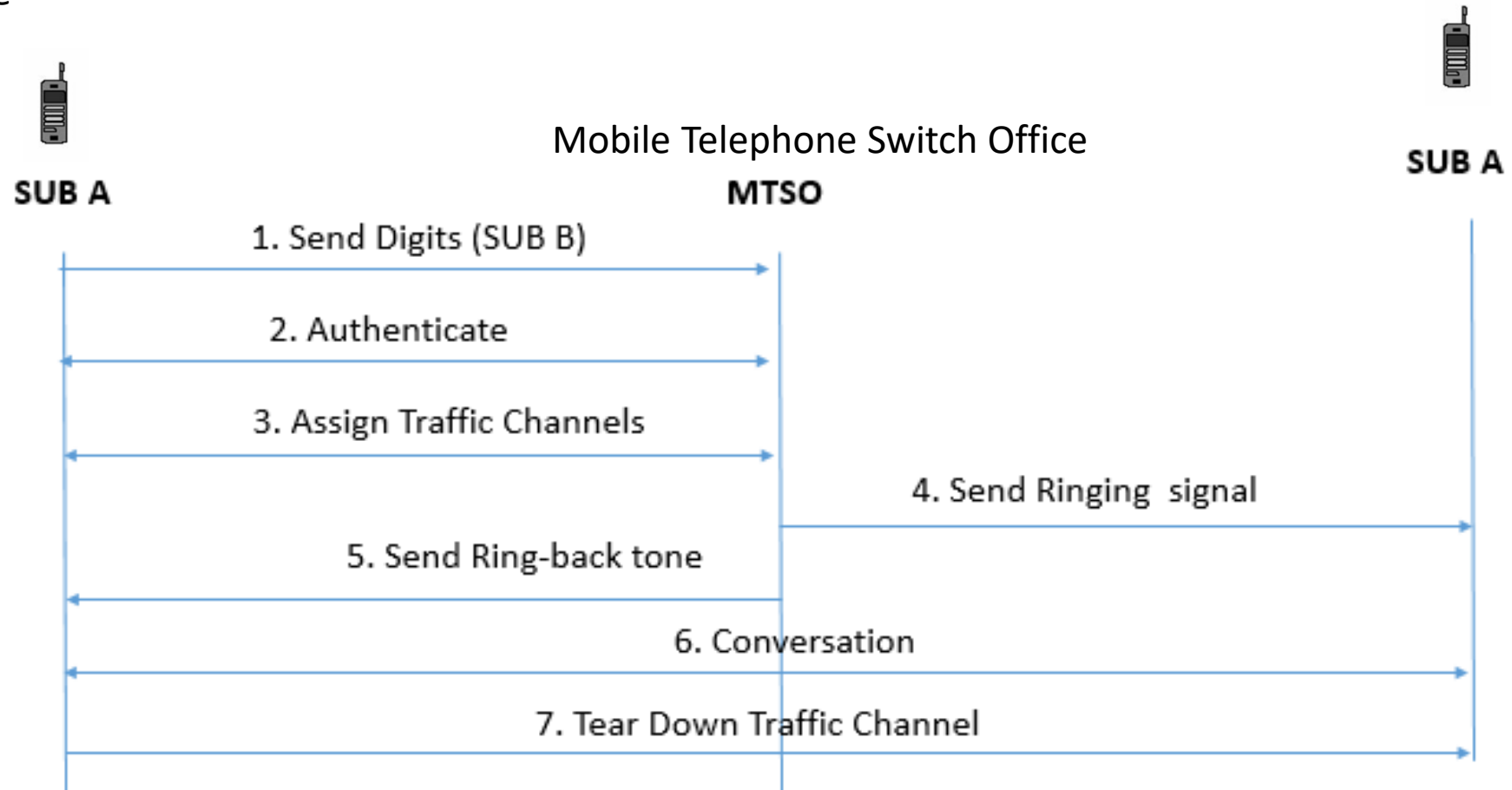
1. Voice traffic is modulated using FM modulation with peak deviation of 12 KHz.
2. Signaling is modulated using FSK modulation with peak deviation of about 8 KHz.
3. Specific channels are dedicated for carrying signaling (seizure, dialed digits and tear-down/disconnect)



AMPS CALL PROCEDURE

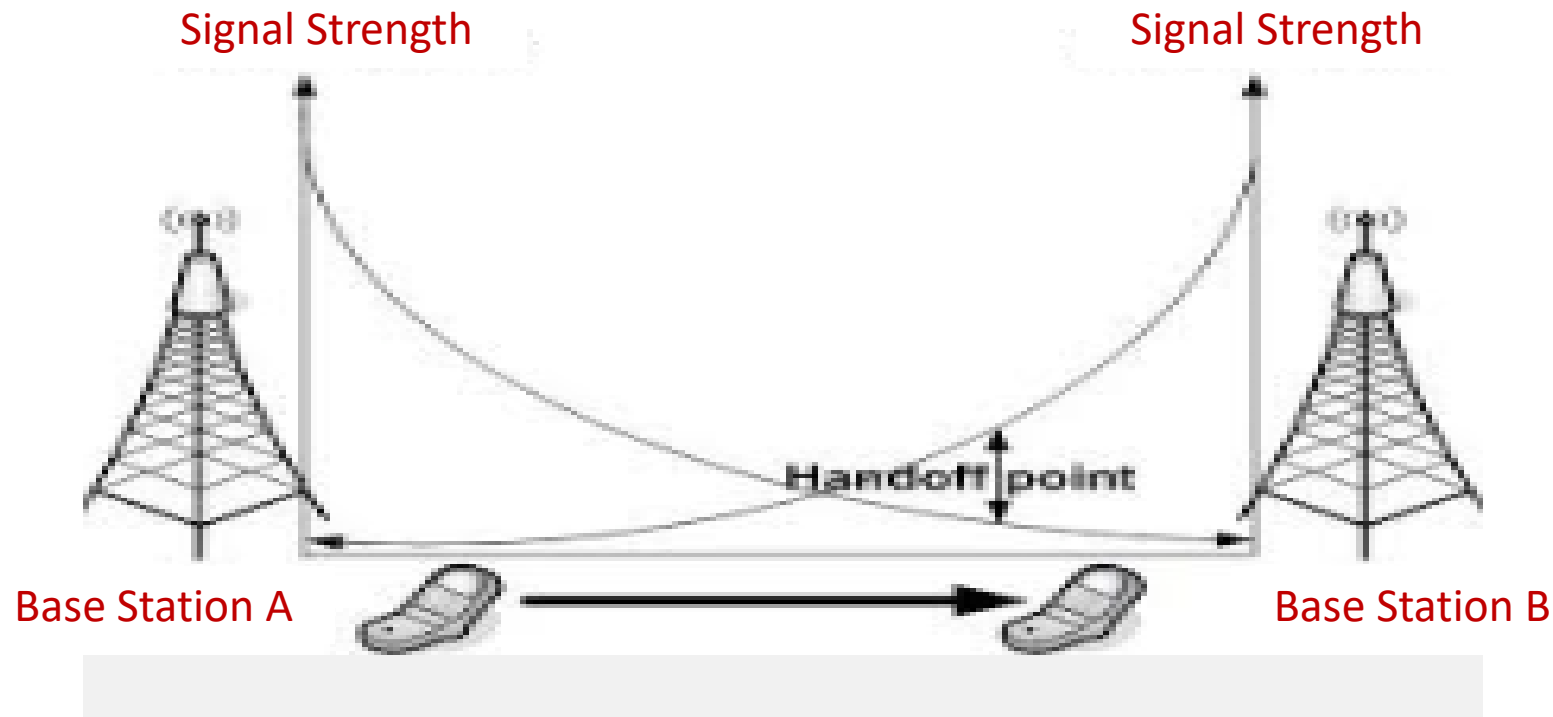
The AMPS call procedure is as shown below. It involves

1. Call set-up phase (call initiation, authentication and traffic channel assignment)
2. Sending call progress information (ringing/ringback tones)
3. Conversation phase
4. Tear-down phase



AMPS HAND-OFF PROCEDURE(1)

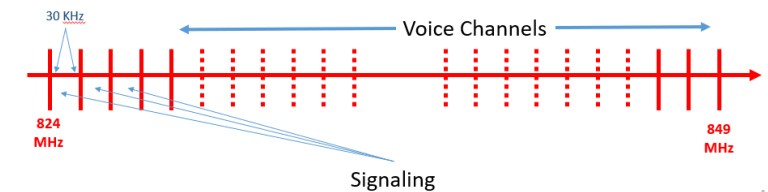
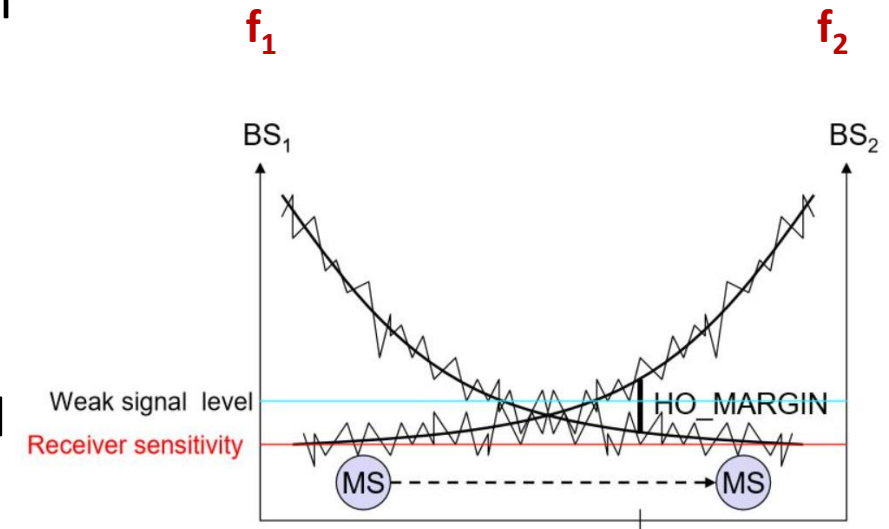
- Handoff refers to the process when a wireless network automatically switches a mobile call to an adjacent base station.



AMPS HAND-OFF PROCEDURE(2)

AMPS was designed to initiate hand-off as follows.

1. The home base station (BS_1) notices mobile station's (MSs) signal is weakening (when the received signal strength goes below a certain threshold value).
2. BS_1 sends a handoff measurement request message to its MTSO.
3. The MTSO requests neighbour base stations to report the mobile's signal strength.
4. The MTSO picks neighbour base station with highest received signal strength (RSS).
5. The MTSO instructs BS_1 and BS_2 to commence hand-off
6. BS_1 instructs the MS to turn off its transmission on channel f_1 and tune to new channel f_2 .
7. MS confirms it has tuned to f_2
8. BS_2 confirms to the MTSO that it has tuned to channel f_2
9. Conversation progresses on channel f_2



FIRST GEN CELLULAR SYSTEM - TACS

- **Total Access Communication System (TACS)** is a variant of Advanced Mobile Phone System (AMPS) which was announced as the choice for the first two UK national cellular systems in 1983.
- The main difference between TACS and AMPS are summarized below.

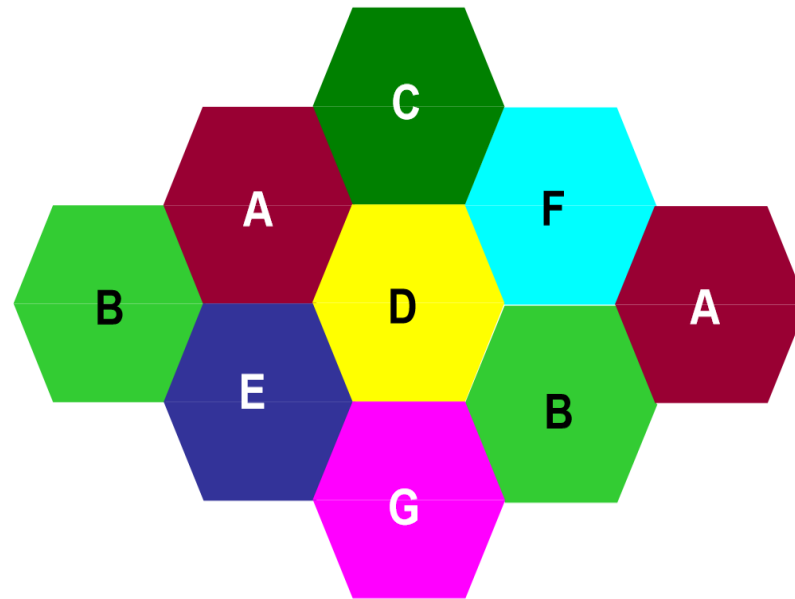
Feature	TACS	AMPS
Frequency band	900 MHz	800 MHz
Channel Spacing	25 kHz	30 kHz
Speech peak Freq Dev	9.5 kHz	12 kHz
Signalling FSK peak Freq Dev	6.4 kHz	8 kHz
Signalling rate	8 kbit/s	10 kbit/s

FIRST GEN CELLULAR SYSTEM - NMT

- **Nordic Mobile Telephone (NMT, NMT-450, and NMT-900)** is a first generation analog cell phone system.
- NMT was specified by Nordic telecommunications administrations (PTTs) and opened for service in 1981.
- Originally designed for and by Nordic countries (Finland, Sweden, Norway, Denmark) it was widely deployed around the world.
- NMT voice channel is transmitted with FM-modulation
- NMT signaling transfer speeds vary between 600 and 1,200 bits per second, using FFSK (Fast Frequency Shift Keying) modulation.

FREQUENCY REUSE

- Frequency reuse is the process of using the same radio frequencies on radio transmitter sites within a geographic area that are separated by sufficient distance.
- Analogue mobile systems were able to achieve national coverage through frequency reuse.



ASSIGNMENT 1

QUESTION ONE

Assume that you were a member of a project engineering team in the early 1990s charged with the planning for a new analogue cellular mobile communication system in Kenya. If the communication regulators allowed your team to use the frequency band 880 – 960 MHz. Discuss the following:

1. Choice of the channel bandwidth. Specifically discuss the lowest possible channel bandwidth and the effect of using a high channel bandwidth; (*Note: There was no GSM in the 1980s*)
2. Choice of the heights of the various telecommunication towers.
3. Portion of the allocated spectrum you are prepared to lose. Give three reasons why a portion of the spectrum must be lost.
4. Discuss how your proposed design addresses the following problems:
 - a) Call initiation, i.e authentication and transfer of dialed digits
 - b) Security, i.e ensuring that other mobile subscribers do not listen in.
 - c) Call tear-down.
5. Assume that one country, Kenya, requires the cellular system must cover an area of 580,367 km², how many cell sites are required to cover that area assuming that the population is uniformly distributed; and towers will be 30m high and the radius of the earth is 6470 Kms. State any assumptions you make.
6. What factors may make you to increase the number of base stations beyond the answer in question 4?
7. What resources are required to support handoff and how do they affect the traffic carried by the system meeting the requirements in question 4

ASSIGNMENT 1 (Continued)

QUESTION TWO

The Maps below shows the nationwide coverage of Safaricom in 2000 and 2012

1. Name and discuss the various network infrastructure components which must be procured and installed as part of network expansion.
2. As an engineer, discuss the key factors/data that you must have while planning mobile network expansion

