Semester Final Solutions

Lecture 9

Origin42 Final

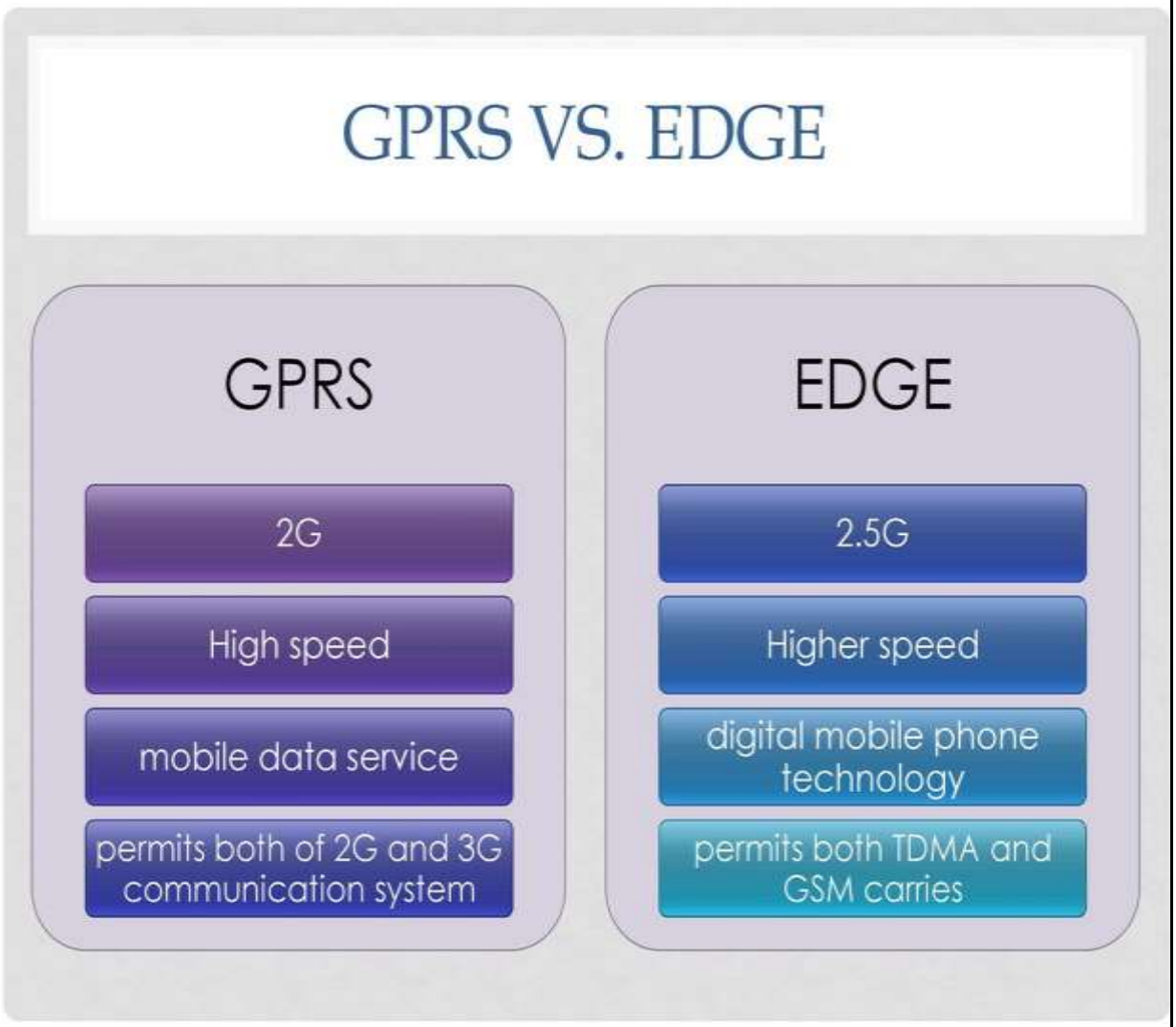
4. a. Write short note on following topics [4]
i) 3G vs 4G
ii) GPRS vs EDGE
iii) HLR vs VLR

Solution:

i. 3G vs 4G:

Technology	3G	4G
Frequency band	1.8 - 2.5GHz	2 - 8GHz
Bandwidth	5-20MHz	15-200MHz
Data rate	Up to 2Mbps	100Mbps moving - 1Gbps stationary
Core Network	Wide area concept: Circuit and Packet switching	Broadband, IP based Packet Switching
Technologies	W-CDMA, CDMA-2000	OFDMA, MC-CDMA

ii. GPRS vs EDGE:



iii. HLR vs VLR: Both are part of GSM network architecture.

- Home location register (HLR) database stores information about each subscriber and updates the information in HLR as soon as the subscriber leaves its current local area.
- Visitor location register (VLR) database maintains information about subscribers that are currently physically in the region covered by the switching center.

4. b. Describe GSM transmission technique and show that GSM connection can provide a data transmission speed of up to 270.8 Kbps. [5]

Solution:

GSM Data Rate

Time slot width

114 traffic bits + 42.25 control bits = 156.25 bits

Frame width

8 time slots per frame × 156.25 bits per slot = 1,250 bits per frame

Multiframe width

26 frames × 1,250 bits per frame = 32,500 bits per multiframe

Total transmission rate

32,500 bits per multiframe / 120 ms = 270.833 kbps

4. c. If we consider the trailing bits, stealing bits, guard bits, and training bits in a GSM frame as overhead, and the rest of the bits as data, then what is the percentage overhead in a GSM frame? What is the duration of a bit in GSM? If a user is allocated one time slot per frame, what is the delay between successive transmissions in successive frames? [5]

Solution: O24

GSM frame has 8 timeslot. Each time slot is as follows:
Trailing-Voice-Stealing-Training-Voice-Stealing-Trailing-Guard:-
3-57-1-26-57-1-3-8.25 = 156.25 bits
So, percentage of overhead = ((156.25 - 114) / 156.25) * 100 % = 27.04%

We know, system sends 216.66 frames/sec
Total frame width = 156.25 * 8 = 1250 bits/frame
Total transmission rate = 216.66 * 1250 = 270.83 Kb/sec
So, duration of a bit = 1 / 270.83 = 3.69 micro-sec

Time duration of each frame = 1250 / 270.83 = 4.62 mili-sec
So, a user have to wait 4.62 mili-sec

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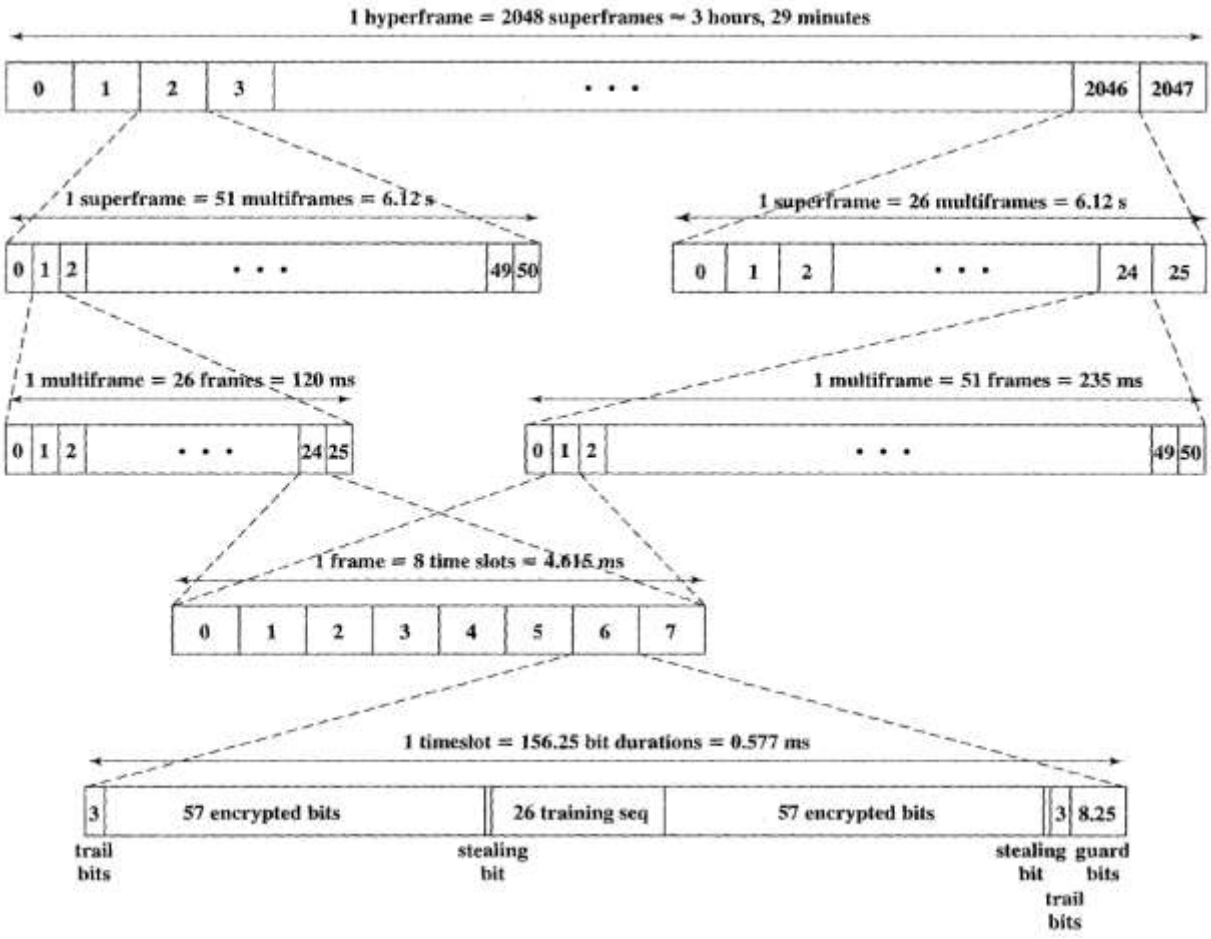
5. a. Describe the GSM frame hierarchy (hyperframe, superframe, multiframe and frame) with a diagram and calculate the time slot width, frame width, multiframe width, total transmission rate and user traffic rate with the help of frame format. [5]

Solution:



GSM Data Rate

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Total transmission rate

32,500 bits per multiframe / 120 ms = 270.833 kbps

User traffic rate

Traffic in 24 frames — frames 12 and 25 carry no traffic

$$\left(\frac{2 \times 57 \text{ bits}}{\text{time slot}} \times \frac{24 \text{ time slots}}{\text{multiframe}}\right) \Big/ \frac{120 \text{ ms}}{\text{multiframe}} = 22.8 \text{ kbps}$$

5. b. Explain the steps how speech is encoded and transmitted over the radio channel in GSM. [5]

Solution: 024

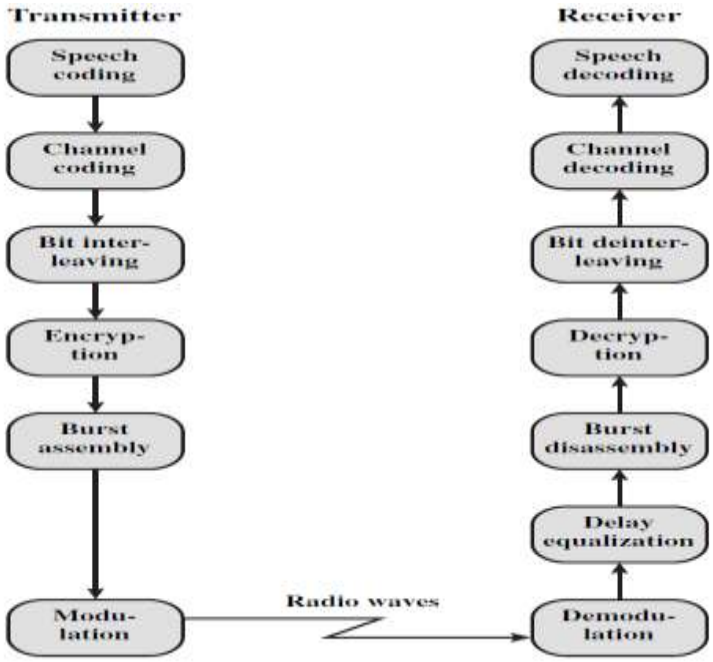

Figure 10.16 GSM Speech Signal Processing

Speech Coding: The speech signal is compressed using an algorithm known as Regular Pulse Excited—Linear Predictive Coder (RPE-LPC). In essence, data from previous samples are used to predict the current sample. Each sample is then encoded to consist of bits representing the coefficients of the linear combination of previous samples plus an encoded form of the difference between the predicted and actual sample.

Channel Coding: GSM speech frames are divided in three different classes according to their function and importance. From the point of view of the quality of the speech produced by this encoding, the bits in the 260-bit block can be divided into three classes:

- Class Ia: 50 bits, most sensitive to bit errors
- Class Ib: 132 bits, moderately sensitive to bit errors
- Class II: 78 bits, least sensitive to bit errors

Interleaving: To further protect against the burst errors common to the radio interface, each sample is interleaved. Each 456 bit block is then divided into eight blocks each containing 57 bits. The first four blocks will be placed in the even bit positions of the first four bursts. The last four blocks will be placed in the odd bit positions of the next four bursts.

Encryption: It is used to protect signaling and data. This process is done using 3 algorithms:

- A3 algorithm for authentication
- A5 algorithm for encryption
- A8 algorithm for key generation

Modulation: The modulation chosen for the GSM system is the Gaussian Minimum Shift Keying (GMSK).

5. c. Write short note on following different generation technology: [4]
i) GPRS
ii) EDGE
iii) HSDPA

Solution:
i) GPRS

2.5G – GPRS (General Packet Radio Service)

- GPRS is a packet-switching-based data service for GSM.
- Purpose is to provide increased data rates on existing 2G GSM network.
- GPRS supports the world's leading packet-based Internet communication protocols: Internet protocol (IP) and X.25.
- One to eight time slots can be allocated to a user, or several active users can share a single time slot.
- Theoretically, a GPRS connection can provide a data transmission speed of up to 171.2Kbps if all eight time slots are used.

ii) EDGE

2.75 – EDGE (Enhanced Data rates for GSM Evolution)

- GSM EDGE cellular technology is an evolutionary upgrade to the existing GSM / GPRS networks, and can be implemented as a software upgrade to existing GSM / GPRS networks.
- EDGE is capable of offering data rates of 384 kbps and theoretically up to 473.6 kbps.
- **Use of 8PSK modulation:**
  - In order to achieve the higher data rates within GSM EDGE, the modulation format was changed from GMSK to 8PSK.
  - This provided a significant advantage in being able to convey 3 bits per symbol, thereby increasing the maximum data rate.
  - Several new coding schemes are introduced that offer net bit rates per time slot of up to 59.2 Kbps. If a subscriber has all the eight time slots of a carrier, the maximal theoretical data rate with EDGE is then

$$59.2 \text{ Kbps} \times 8 \text{ time slots} = 473.6 \text{ Kbps}.$$

iii) HSDPA

- 3.5G – HSDPA (High-Speed Downlink Packet Access):
  - Provides a smooth evolutionary path for UMTS-based 3G networks allowing for higher data transfer speeds.
  - HSDPA is a packet-based data service in W-CDMA downlink with data transmission up to 8-10 Mbits over a 5MHz bandwidth in WCDMA downlink.
  - Implementations includes Adaptive Modulation and Coding (AMC), Multiple-Input Multiple-Output (MIMO), Hybrid Automatic Request (HARQ), fast cell search, and advanced receiver design.

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4. a. Briefly explain the channel coding procedure used in the GSM system. [5]

Solution: O24

Channel Coding

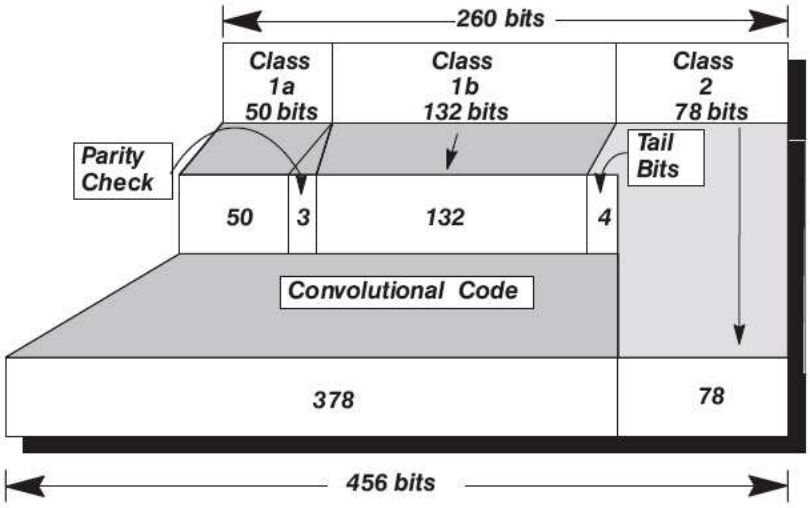
GSM speech frames are divided in three different classes according to their function and importance:

1. Class Ia: 50 bits, most sensitive to bit errors
2. Class Ib: 132 bits, moderately sensitive to bit errors
3. Class II: 78 bits, least sensitive to bit errors

The different classes are coded differently.

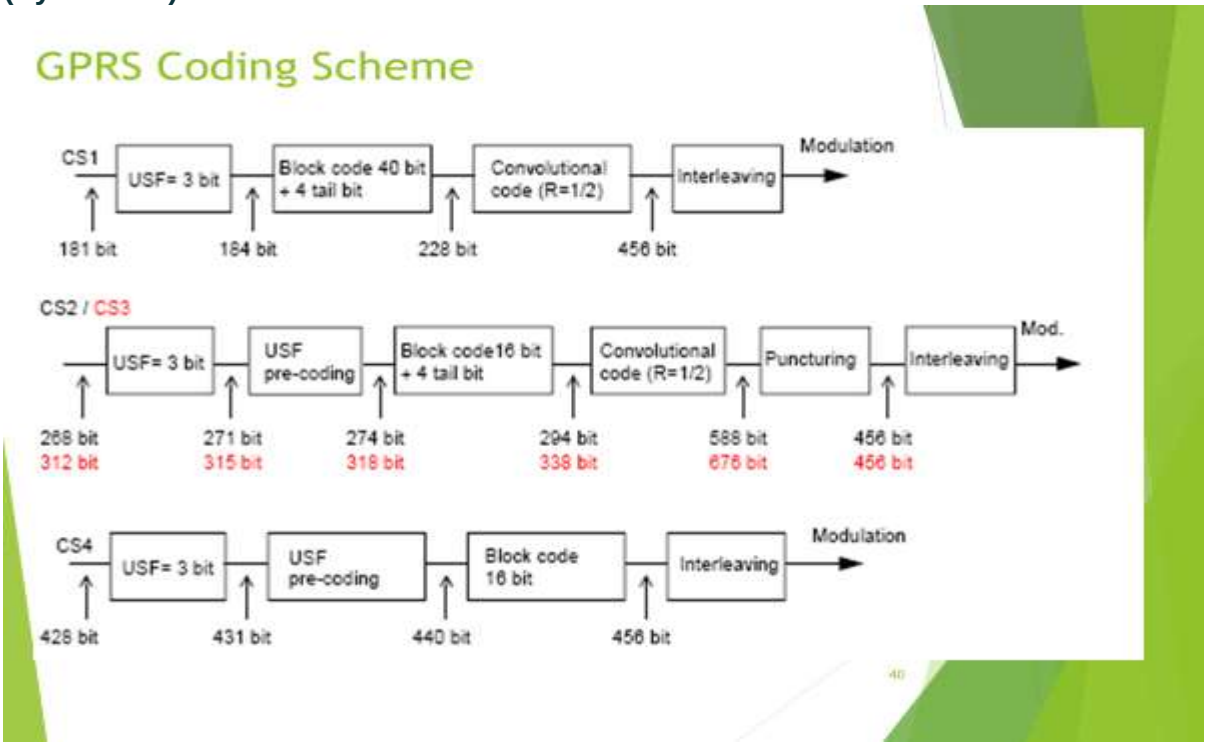
The first 50 bits are protected by a 3-bit cyclic redundancy check (CRC) error detection code. These 53 bits plus the 132 class 1b bits, plus a 4-bit tail sequence, are then protected by a convolutional (2, 1, 5) error correcting code, resulting in 189 X 2 = 378 bits.

The remaining 78 bits are unprotected and appended to the protected bits to produce a block of 456 bits.



4. b. Describe GPRS coding scheme and show that GPRS connection can provide a data transmission speed of up to 171.2 Kbps. [5]

Solution:
(By Wasi 34)



GPRS Coding Scheme

	Duration of radio block	Net number of bits	Preco-ded USF	BCS	Tail bits	Number of coded bits	Punc-tured bits	Net data rate
CS-1	20 ms	181	3	40	4	456	0	9,05 kbit/s
CS-2	20 ms	268	6	16	4	588	132	13,4 kbit/s
CS-3	20 ms	312	6	16	4	676	220	15,6 kbit/s
CS-4	20 ms	428	12	16	0	456	0	21,4 kbit/s

For CS-4, Net data rate = Net number of bits / Duration of radio block
= 428 / 20 ms
= 21.4 kbps

Total time slots = 8
Maximal data rate = 8*21.4 = 171.2 Kbps per user

GPRS offers a number of coding schemes with different levels of error detection and correction. These are given labels CS-1 to CS-4:
CS-1: It is used in scenarios when interference levels are high or signal levels are low.
CS-2: is a less reliable coding scheme and used for better channel.
CS-3: is an even less reliable coding scheme and used for more reliable channel than CS-2.
CS-4: is an unreliable coding scheme and used in when interference levels are low or signal levels are high.

4. c. GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bits and data is transmitted over a channel at 270.833 kbps. Find
(i) time duration of a bit, [4]
(ii) time duration of a TDMA frame
(iii) control data rate, and
(iv) user traffic rate.

Solution: O24
GSM frame has 8 timeslot. Each time slot contains 156.25 bits and data is transmitted over a channel at 270.833 kbps.

a. Time duration of a bit = 1 / 270.833K = 3.69 micro-sec

b. Time duration of a time slot = 156.25 * 3.69 = 577 micro-sec
So, time duration of a TDMA frame = 577 * 8 = 4.616 mili-sec

c. We know, system sends 216.66 frames/sec.
GSM frame has 8 timeslot. Each time slot is as follows:
Trailing-Voice-Stealing-Training-Voice-Stealing-Trailing-Guard:-
3-57-1-26-57-1-3-8.25 = 156.25 bits

Here control data in one time slot = 3 + 1 + 26 + 1 + 3 + 8.25 = 42.25 bits
So, control data rate = 216.66 * 42.25 * 8 = 73.66 Kbps

d. Here traffic data in one time slot = 57 + 57 = 114 bits
So, traffic data rate = 216.66 * 114 * 8 = 197.59 Kbps