Paper Number(s): **E4.03**
AS5
SO10
ISE4.3

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE
UNIVERSITY OF LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2002

MSc and EEE/ISE PART IV: M.Eng. and ACGI

MOBILE RADIO COMMUNICATION

Wednesday, 8 May 10:00 am

There are FOUR questions on this paper.

Answer THREE questions.

Time allowed: 3:00 hours

Corrected Copy

Examiners responsible:

First Marker(s): Gurcan,M.K.

Second Marker(s): Ward,D.B.

Special instructions for invigilator: None

Information for candidates : None.

1. a) Assume that a signal-to-noise ratio of 15 dB is required for the satisfactory down-link channel performance of a cellular system that has 6 co-channel cells in the first tier. What is the frequency re-use factor and cluster size that should be used for maximum capacity if the path loss is due to the inverse fourth power loss? [2]

b) A mobile is located 5 km away from a base station and uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The E field at 1 km from the transmitter is measured to be 10^{-3} V/m. The carrier frequency used for the system is 900 MHz.

i) Find the length and the effective area, A_e, of the receiving antenna. [2]

ii) Find the received power at the mobile using a 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5 m above ground. [3]

c) Using Figure 1.1, compute the diffraction loss for the three cases shown in Figure 1.2. For all the cases assume that $\lambda = 1/3$ m, $d_1 = 1$ km, $d_2 = 1$ km. Also assume that the obstacle height for each case is

i) $h = 25$ m, [2]

ii) $h = 0$ m, [1]

iii) $h = -25$ m. [1]

For each of these cases, identify the Fresnel zone within which the tip of the obstruction lies. [1]

d) Consider a transmitter which radiates a sinusoidal carrier frequency of 1850 MHz. For a vehicle moving at 60 mph, compute the received carrier frequency if the mobile is moving $\mp 26.82\ ms^{-1}$

conversion to ms^{-1} announced 10:40 in Rm 406/7

i) directly towards the transmitter, [2]

ii) directly away from the transmitter, [1]

iii) in a direction which is perpendicular to the direction of arrival of the transmitted signal. [1]

e) Find the average fade duration for a threshold level $R_0 = 0.707$ when the Doppler frequency is 20 Hz. Assume that for a binary digital modulation with data rate of 50 bps, a bit error occurs whenever any portion of a bit encounters a fade for which $R_0 < 0.1$. Calculate the average number of bit errors. [4]

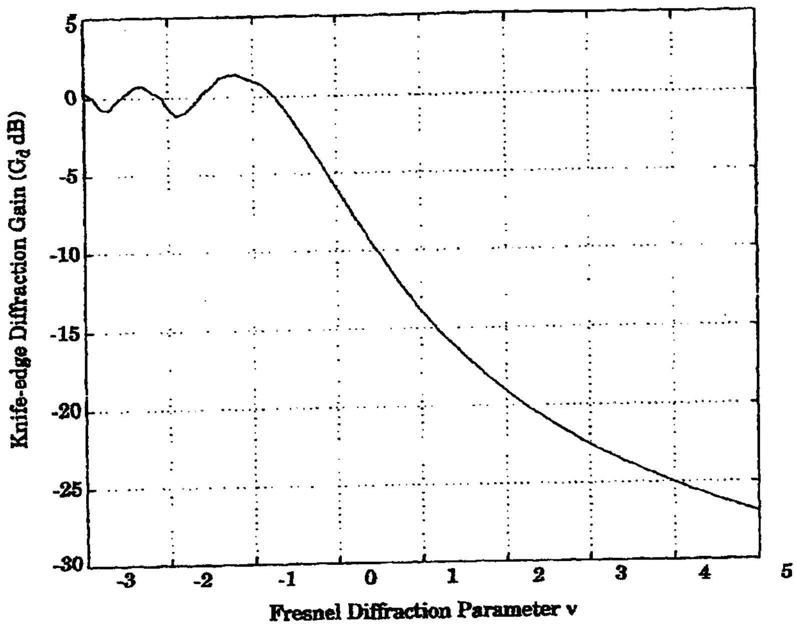

Figure 1.1 Diffraction loss diagram

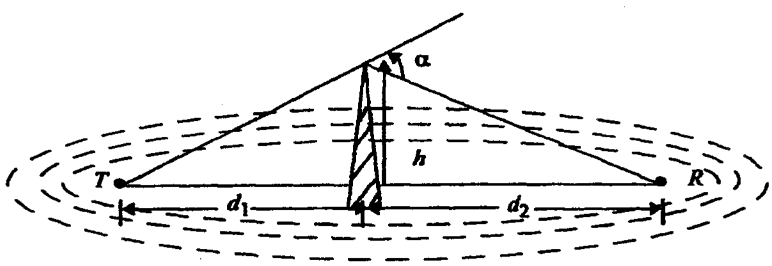

Figure 1.2, case 1.

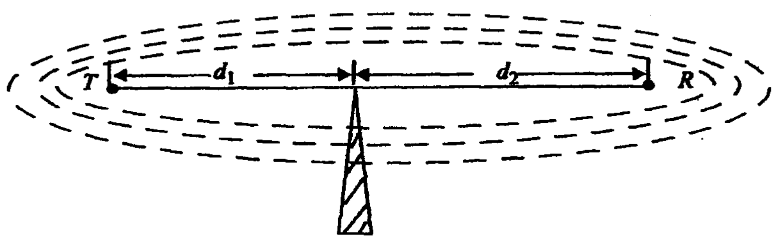

Figure 1.2, case 2.

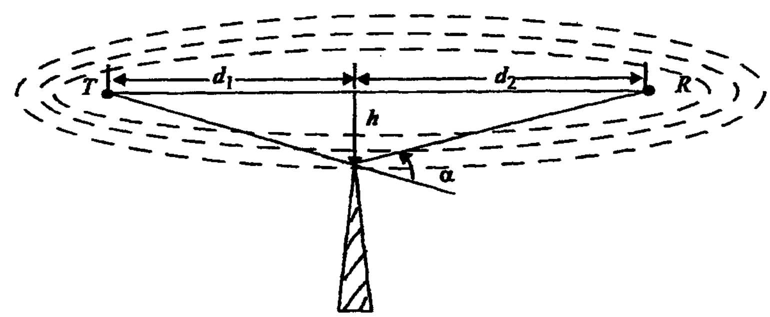

Figure 1.2, Case 3.

2. a) In a mobile radio data transmission system, each cell radius is designed to be 500 metres. The calls originating from the users in each radio cell divide into four groups. Average bit rates for the four groups are: 10, 12.5, 17.5 and 20 kbit/s. Packets are of equal size of 1250 bits. There are 40741 mobile users in an area of 2 km^2 and 90 percent of the mobile users are active during any period of one hour.

i) What is the call arrival rate, λ, per second ? [2]

ii) What is the average number of packets an active user transmits over an hour period? [1]

b) The call arrival process described in part a) identifies the call arrivals for a deferred-first transmission Aloha system. The packets are transmitted over a link with data rate of 200 kbs. The number of backlogged users is $n_k = 30$ and the re-transmission probability is $q_r = 1/30$. Compute

i) the offered load, g, for the system and the corresponding throughput [2]

ii) the call arrival rate, λ_T, per slot [1]

iii) the drift, dn, for the real number of backlogged users. [2]

c) The joint drift equation $dj = dn - g\,ds$ is used to stabilise the Aloha system given in part b). In the joint drift equation, the term ds is the estimated drift equation for the estimated number of backlogged users with the control parameters $(u_0,\ u_1,\ u_c)$. If $u_1 = u_c = 0.4$

i) find the control parameter u_0 which will provide a unique settling point at $g = 1$ [3]

ii) calculate the estimated drift (ds), the real drift (dn) and also the joint drift (dj) at the offered load value of $g = 2$. [3]

d) For a deferred-first transmission Aloha system

i) state three criteria that can be used to stabilise the system using the joint drift equation [2]

ii) find the limiting values of $dj(G)$ for $G = 0$ and $G = \infty$ [2]

iii) describe how the roots of $dj = 0$ are used to determine the settling points for the Aloha system. [2]

3. a) Assume a mobile travelling at a velocity of 10 m/s receives two multipath components at a carrier frequency of 1000 MHz. The first component is assumed to arrive at $\tau = 0$ with an initial phase of zero degrees and a power of -70 dBm (which is equal to 100 pW). The second component is 3 dB weaker than the first component and is assumed to arrive at $\tau = 1$ μs with the initial phase of zero degrees. The mobile moves directly towards the direction of arrival of the first component and directly away from the direction of arrival of the second component. For a narrow band system, consider the observation interval $0 \le t \le 0.5\,\mu$s and

   i) compute the instantaneous power at the times 0μs, 0.1μs, 0.2μs, 0.3μs, 0.4μs, 0.5μs [2]

   ii) calculate the average power received over the observation interval [2]

   iii) compare average narrowband and wideband received powers over the interval. [2]

b) Assume that in a small scale propagation measurement system, the time between samples is equal to $T_c/2$, where T_c is the coherence time. Determine the sampling interval required to make the measurements when it is assumed that consecutive samples are highly correlated in time.

   i) How many samples will be required over 10 m travel distance if $f = 1900$ MHz and $v = 50$ m/s? [2]

   ii) How long would it take to make these measurements assuming they could be made in real time from a moving vehicle? [2]

   iii) What is the Doppler spread B_D for the channel? [1]

c) A minimum-mean-square-error decision-feedback-equaliser has the mean square error between the desired and equalised signals as follows [4]

$$\varepsilon^2 \approx \frac{1.3\,(N+1)}{1+\left(Nh_0^2+(N-1)h_1^2+(N-2)h_2^2\right)X_R}$$

where X_R is the signal-to-noise-ratio (SNR) at the input of the equaliser and the feed-forward filter is of length N+1. The channel impulse response coefficients are specified by $\mathbf{H} = [h_0 \quad h_1 \quad h_2]^T$. Find the equaliser gain for large values of X_R.

d) In connection with the Global Systems Mobile (GSM) radio system, explain

   i) the framing structure for the traffic channels [3]

   ii) how the network switching subsystem is organized. [2]

4) a) In connection with the transitional 2.5 G radio systems, explain how the HSCSD, EDGE and GPRS systems will be used to provide a smooth transition from the 2G to 3G systems. [4]

For the 3G wideband radio system, describe

b) the uplink transmission, paying particular attention to

- i) the uplink dedicated channels DPCCH and DPDCH [2]
- ii) the uplink multiplexing over the DPDCH channel. [2]

c) the system architecture, paying particular attention to

- i) the user equipment [1]
- ii) the UTRAN system [1]
- iii) the core network. [1]

d) the UMTS interfaces, paying particular attention to

- i) the Cu interface [1]
- ii) the Uu interface [1]
- iii) the Iu interface [1]
- iv) the Iur interface [1]
- v) the Iub interface. [1]

e) the UMTS traffic classes, paying particular attention to

- i) the conversational class [1]
- ii) the streaming class [1]
- iii) the interactive class [1]
- iv) the background class. [1]

1-a Using

$Q = \frac{D}{R} = \sqrt{3N}$

$N = i^2 + ij + j^2$
using integer values for i and j we identify that N takes the following values
$N = 1, 3, 7, 12, 13$

N	Q
3	3
7	4.58
12	6
13	6.24

$SNR = \frac{1}{6}\left(\frac{D}{R}\right)^4 = \frac{(\sqrt{3N})^4}{6} = \frac{9N^2}{6} = \frac{3N^2}{2} = \frac{3 \times 49}{2} = 75.3$

$= 18.66\,dB$

Since this SNR is greater than minimum required SNR of 15 dB, cluster size of N=7 can be used

1-b i) T-R separation is 5 km
E field at a distance of 1 km $= 10^{-3}$ V/m.
Frequency of operation, f = 900 MHz.

$\lambda = \frac{c}{f} = \frac{3\times10^8}{900\times10^6} = 0.333\,m$

length of the antenna

$L = \frac{\lambda}{4} = \frac{0.333}{4} = 0.0833\,m = 8.33\,cm$

ii) Gain of the antenna $G = \frac{4\pi A_e}{\lambda^2} = 2.55\,dB = 1.8$

Examinations : Mobile radio Communication
MODEL ANSWER and MARKING SCHEME
First Examiner: Dr. M. Gurcan — Paper Code E4.03, AS5, SO10, ISE4.3
Second Marker : Dr. D. Ward

Question labels in left margin — Marks allocations in right margin

$A_e = \frac{G \cdot \lambda^2}{4\pi} = \frac{1.8 \times (0.333)^2}{4 \times \pi} = 0.0159$

Since $d \gg \sqrt{h_t h_r}$, the electric field is given by

$E_R(d) \approx \frac{2E_0 d_0}{d} \frac{2\pi h_t h_r}{\lambda d} \approx \frac{k}{d^2}$ V/m

$= \frac{2\times10^{-3} \times 1 \times 10^3}{5\times10^3}\left[\frac{2\times\pi\times50\times1.5}{0.333\times5\times10^3}\right]$

$= 113.1\times10^{-6}$ V/m

The received power at a distance d can be obtained using

$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2} = \frac{|E|^2}{2\times120\pi} A_e$

$= \frac{(113.1\times10^{-6})^2}{2\times377} \times 0.0159$

$= 2.695\times10^{-13}$ W

$\boxed{P_r(d) = 2.695\times10^{-13}\,W}$

$\lambda = 1/3$

$d_1 = 1$ km

$d_2 = 1$ km

i.) • using

$$V = h\sqrt{\frac{2(d_1+d_2)}{\lambda d_1 d_2}} = 25\sqrt{\frac{2(1000+1000)}{1/3 \times 1000 \times 1000}} = 2.74$$

From figure 1, the loss is obtained to be 22 dB.

The path length difference between the direct and diffracted rays is given by

$$\Delta = \frac{h^2}{2}\frac{(d_1+d_2)}{d_1 d_2} = \frac{25^2 \times (1000+1000)}{2 \times 1000 \times 1000} = 0.625\text{m}$$

To find the Fresnel zone in which the tip obstruction lies we need to compute n which satisfies the relation $\Delta = n\lambda/2$. For $\lambda = 1/3$m and $\Delta = 0.625$ m we obtain

$$n = \frac{2\Delta}{\lambda} = \frac{2 \times 0.625}{0.3333} = 3.75$$

Therefore the tip of the obstruction completely blocks the first three Fresnel zones.

ii. $h = 0$

Therefore the Fresnel parameter $V = 0$

From figure 1, the diffraction loss is obtained as 6dB.

For this case, since $h = 0$, we have $\Delta = 0$, and the tip of the obstruction lies in the middle of the first Fresnel zone.

iii. $h = -25$

using $v = h\sqrt{\frac{2(d_1+d_2)}{\lambda \cdot d_1 d_2}} = -2.74$

From Figure 1, the diffraction loss is as approximately equal to 1dB.

Since the absolute value of the height h, is the same as part (a), the excess path length Δ and hence n will also be the same. The tip of the obstruction blocks the first three Fresnel zones, the diffraction losses are negligible, since the obstruction is below the line of sight.

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$f_c = 1850$ MHz

wavelength $\lambda = \dfrac{c}{f_c} = \dfrac{3\times10^8}{1850\times10^6} = 0.162$ m

Vehicle speed, $v = 60$ mph $= 26.82$ m/s

i.) The vehicle is moving directly towards transmitter. The Doppler shift is positive and the received frequency is given by

$$f = f_c + f_c = 1850\times10^6 + \frac{26.82}{0.162} = 1850.00016 \text{ MHz}$$

ii) The vehicle is moving directly away from the transmitter.

The Doppler shift is negative. The received frequency is given by

$$f = f_c - f_d = 1850\times10^6 - \frac{26.82}{0.162} = 1849.999834 \text{ MHz}$$

iii) The vehicle is moving perpendicular to the angle of arrival of the transmitted signal.

In this case $\theta = 90^\circ$, $\cos\theta = 0$ and there is no Doppler shift.

The received signal frequency is the same as the transmitted frequency of 1850 MHz.

The average fade duration can be obtained from

$$\bar{\tau} = \frac{\exp(\rho^2)-1}{\rho f_m \sqrt{2\pi}} = \frac{\exp(0.707)^2-1}{0.707 \times 20 \times \sqrt{2\pi}}$$

$$= 18.3 \text{ ms}$$

For a data rate of 50 ms, the bit period is 20 ms. Since average fade duration is less than the bit period, for the given data rate the signal undergoes fast Rayleigh fading.

Using $\rho = 0.1$ and the fading duration equation,

$$\bar{\tau} = \frac{\exp(\rho^2)-1}{\rho f_m \sqrt{2\pi}} = \frac{\exp(0.1^2)-1}{0.1 \times 20 \times \sqrt{2\pi}} = 0.002 \text{s}$$

The number of level crossings for $\rho = 0.1$

$$N_R = \sqrt{2\pi} f_m \rho \exp(-\rho^2) = 4.96 \text{ crossings/s}$$

A bit error is assumed to occur whenever a portion of a bit encounters a fade, and since average fade duration spans only a fraction of a bit duration, the total number of bits in error is 5 per second, resulting in a bit error $= \frac{5}{50} = 0.1$

a-) Total data rate $= [10+12.5+17.5+20] \times 10^3 = 60 \times 10^3$ bps

Number of packets per second $= \frac{60 \times 10^3}{1250} = 48$ packets/s

Over an hour we have $= 48 \times 3600 = 172800$ packets.

Total number of active users in the cell is

$$\frac{40741 \times \pi \times (0.5)^2 \times 0.9}{2} = 14400 \text{ users}$$

Number of packets per user $= \frac{172800}{14400} = 12$ packets/hour.

b-) Packet rate for the link $= \frac{200 \times 10^3}{1250} = 160$ packets/s.

Call arrival rate

ii) $$\lambda_T = \frac{48}{160} = 0.3 \text{ packets/slot.}$$

i) $g = n \cdot q_r = 1$ packet/s.

$S(g=1) = g\exp(-g) = \exp(-1) = 0.368$.

iii) $d_n = \lambda_T - g\exp(-g) = 0.3 - 0.368 = 0.068$

i) $dJ = 0 = dn - g\,ds$

$= \lambda - g\exp(-g) - g\left[u_0\exp(-g) + u_1 g\exp(-g) + u_0(1 - \exp(-g) - g\exp(-g))\right]$

$= 0.3 - \exp(-1) - \left[u_0\exp(-1) + 0.4\exp(-1) + 0.4(1 - \exp(-1) - \exp(-1))\right]$

$u_0 = \exp(1)\left[0.3 - \exp(-1) + 0.4\exp(-1) - 0.4\right]$

$= -0.6 - 0.1\exp(1) = -0.8718$

$\boxed{u_0 = -0,8718}$

ii) $ds = u_0 \cdot \exp(-g) + u_1\, g\exp(-g) + u_c(1 - g\exp(-g) - \exp(-g))$

$= -0.8718 \times \exp(-2) + 0.4 \times 2 \times \exp(-2) + 0.4(1 - \exp(-2) - 2\times\exp(-2))]$

$= 0.2279$

$dn = 0.3 - 2.\exp(-g) = 0.0293$

$dJ = dn - g.ds = 0.0293 - 2 \times 0.2279$

$= -0.4265$

i) $dJ = dn - g\,ds$

When $dJ = 0$ the system settles at that point. Stability criteria

$dJ = 0$ for $g = 1$

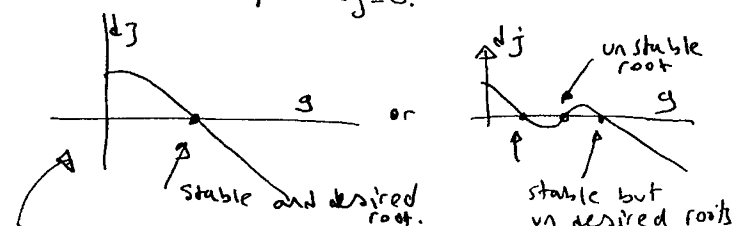
$dJ > 0$ for $g < 1$

$dJ <$ for $g > 1$.

ii) $dJ = \lambda$ for $g \to 0$

$dJ = -\infty$ for $g \to \infty$

iii) as $dJ = \lambda$ for $g = 0$ and $dJ < 0$ for $g \to \infty$ there must be at least 1 and at most 3 roots for $dJ = 0$.



We want one root $dJ(g=1) = 0$.

i) Given $v = 10$ m/s, the time interval of 0.1 s corresponds to spatial intervals of 1 m. The carrier frequency is given to be 1000 MHz, hence the wavelength of the signal is

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{1000\times10^6} = 0.3 \text{ m}$$

The narrow band instantaneous power can be computed using

$$|r(t)|^2 = \left|\sum_{i=0}^{N-1} a_i \exp(j\theta_i(t,\tau))\right|^2$$

Note that -70 dBM = 100 pw. At time $t=0$, the phases of both multipath components are 0°, hence the instantaneous power is equal to

$$|r(t)|^2 = \left|\sqrt{100\text{pw}} \times \exp(0) + \sqrt{50\text{ pw}} \times \exp(0)\right|^2 = 291 \text{ pw}$$

Now, as the mobile moves, the phase of the two multipath components changes in opposite directions. At $t=0.1$s, the phase of the two multipath components changes in opposite directions. At $t=0.1$ s, the phase of the first component is

$$\theta_i = \frac{2\pi d}{\lambda} = \frac{2\pi v t}{\lambda} = \frac{2\pi \times 10\ (m/s) \times 0.1\ s}{0.3\ m} = 20.94 \text{ rad}$$

$$\theta_i = 20.94 \text{ rad} = 2.09 \text{ rad} = 120^\circ$$

Since the mobile moves towards the direction of arrival of the first component, and away from the direction of arrival of the second component, θ_1 is positive and θ_2 is negative.

Therefore, at $t = 0.1$ s, $\theta_1 = 120^\circ$, and $\theta_2 = -120^\circ$, and the instantaneous power is equal to

$$|r(t)|^2 = \left|\sum_{i=0}^{N-1} a_i \exp(j\theta_i(t,\tau))\right|^2$$

$$= \left|\sqrt{100\text{pW}} \times \exp(j\,120^\circ) + \sqrt{50\text{pw}} \times \exp(-j\,120^\circ)\right|^2$$

$$= 78.2 \text{ pW}$$

Similarly, at $t=0.2$ s, $\theta_2 = 240^\circ$, and $\theta_2 = -240^\circ$, and the instantaneous power is equal to

$$|r(t)|^2 = \left|\sum_{i=0}^{N-1} a_i \exp(j\,\theta_i(t,\tau))\right|^2$$

$$= \left|\sqrt{100\text{pw}} \times \exp(j240^\circ) + \sqrt{50\text{pw}} \times \exp(-j240^\circ)\right|^2$$

$$= 81.5 \text{ pW}$$

Similarly, at $t=0.3\,s$, $\theta_1 = 360^\circ = 0^\circ$ and $\theta_2 = -360^\circ = 0^\circ$ and the instantaneous power is equal to

$$|r(t)|^2 = \left|\sum_{i=0}^{N-1} a_i \exp(j\,\theta_i(t,\tau))\right|^2$$

$$= \left|\sqrt{100pw} \times \exp(j0) + \sqrt{50pw} \times \exp(-j0)\right| = 291pw$$

It follows that at $t=0.4\,s$, $|r(t)|^2 = 78.2pw$ and at $t=0.5\,s$, $|r(t)|^2 = 81.5\,pw$

ii) The average narrowband received power is equal to

$$\frac{2\times 291 + 2\times 78.2 + 2\times 81.5}{6} = 150.233\,pw$$

iii) The wideband power is given by

$$E\left(P_{w,B}\right) = \sum_{i=0}^{N-1} \overline{a}_i^{\,2} = 100pw + 50pw = 150pw$$

As can be seen, the narrowband and wideband received power are virtually identical.

i) As $T_s = \frac{T_c}{2}$, and we use the smalest value of T_c

$$T_c = \frac{9}{16\pi f_m} = \frac{9\lambda}{16\pi v} = \frac{9c}{16\pi v f_c}$$

$$= \frac{9\times 3\times 10^8}{16\times 3.14\times 50\times 1900\times 10^6}$$

$T_c = 565\,\mu s$.

Taking time samples at less than half T_c at $282.5\,\mu s$, corresponds to a spatial interval of

$$\Delta x = \frac{v\,T_c}{2} = \frac{50\times 565\,\mu s}{2} = 0.014125\,m$$

$$= 1.41\,cm.$$

Therefore, the number of samples required over a 10 m travel distance is

$$N_x = \frac{10}{\Delta x} = \frac{10}{0.014125} = 708 \text{ samples}$$

ii) Time taken to make this measurement is equal to $\frac{10\,m}{50\,m/s} = 0.2\,s$.

The Doppler spread is

$$B_D = f_m = \frac{v f_c}{c} = \frac{50\times 1900\times 10^6}{3\times 10^8} = 316.66\,Hz.$$

$$\varepsilon^2 = \frac{(N+1)\,a}{1+\left[N h_0^2 + (N-1)h_1^2 + (N-2)h_2^2\right] X_R} = \frac{(N+1)a}{1+bX_R}$$

$$X_A = \frac{1}{\varepsilon^2} - 1 = \frac{1+bX_R}{(N+1)a} - 1$$

For large values of X_R ignore 1's

$$X_A = \frac{b\,X_R}{(N+1)\,a} \simeq \frac{1}{a}\left(\frac{N}{N+1}h_0^2 + \frac{N-1}{N+1}h_1^2 + \frac{N-2}{N+1}h_2^2\right) X_R$$

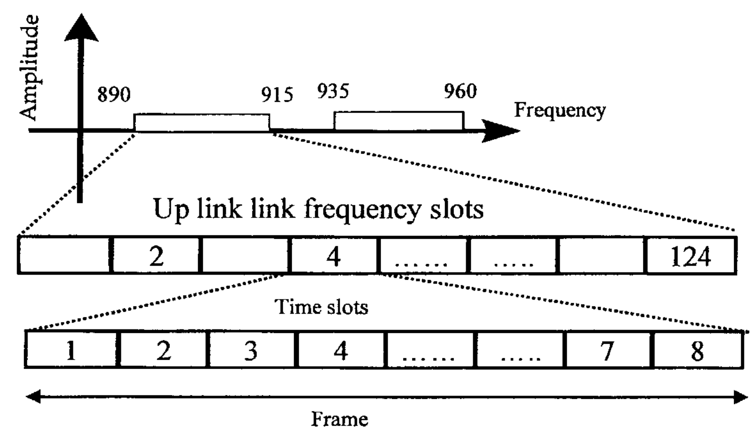
$$c = \frac{1}{a}\left(\frac{N}{N+1}h_0^2 + \frac{N-1}{N+1}h_1^2 + \frac{N-2}{N+1}h_2\right)$$

—///—

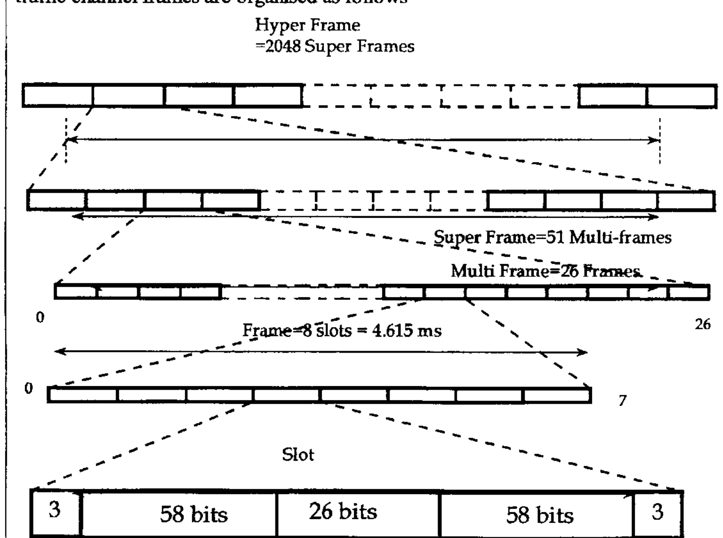
$a = 1.3$

$$c = \frac{1}{1.3}\left(\frac{N}{N+1}h_0^2 + \frac{N-1}{N+1}h_1^2 + \frac{N-2}{N+1}h_2\right.$$

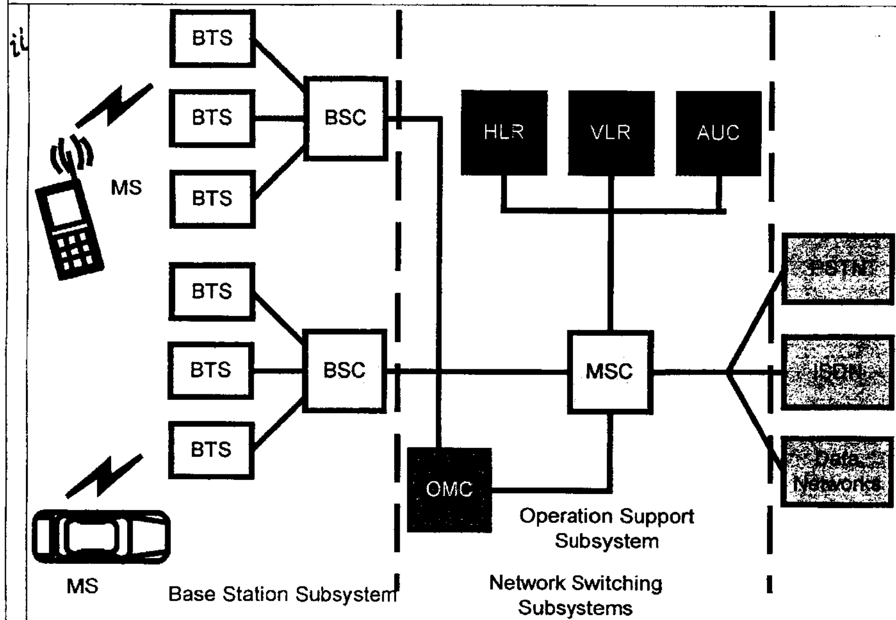
i-) The physical channels are organised as follows



traffic channel frames are organised as follows



ii)



i)

HSCSD

HSCSD, High Speed circuit switched data is a circuit switched technique that allows a single mobile subscriber to use consecutive user time slots in the GSM standard. Instead of limiting each user to only one specific time slot in the GSM TDMA standard HSCSD will allow individual data users to commandeer consecutive time slots in order to obtain higher speed data access on the GSM network. HSCSD relaxes the error control coding algorithms originally specified in the GSM standard for data transmissions and increases the available application data rate 14.400 bps as compared to the original 9600 bps in the GSM specifications. By using up to four consecutive time slots, HSCSD is able to provide a raw transmission rate up to 57.6 kbps to individual users.

GPRS

General Packet Radio Service is a packet based data network, which is well suited for non-real time Internet usage, including retrieval of email, faxes, and asymmetric web browsing where the users downloads much more data than it uploads on the Internet. Unlike HSCSD, which dedicates circuit switched channels to specific users, GPRS supports multi-user network sharing of individual radio channels ~~and~~ to specific users, GPRS supports many more users than HSCSD, but in a bursty manner. Similar to the cellular American system, GPRS retains the original modulation formats specified in the original 2G TDMA standards, but uses a completely redifined air interface in order to better handle packet data access. GPRS subscriber units are automatically instructed to tune to dedicated GPRS radio channels and particular time slots for "always on" access to the network.

When all eight time slots of a GSM radio channel are dedicated to GPRS, an individual user is able to achieve as much as 171.2 kbps. Applications are required to provide their own error correction schemes as part of the carried data payload in GPRS.

EDGE

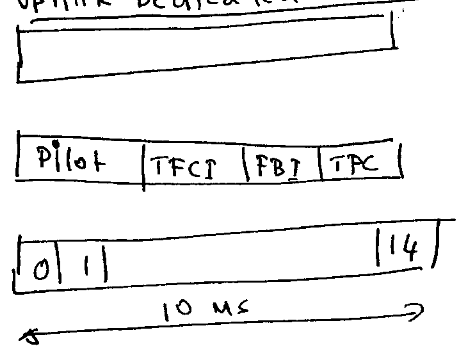
EDGE (Ehanced Data Rates for GSM Evolution) introduces a new digital Modulation format 8-PSK which is used in addition to GSM's standard GMSK modulation

EDGE allows nine different air interface formats known as multiple modulation ~~add~~ coding schemes (MCS), with varying degrees of error control protection. Each MCS state may use either GMSK (low data rate) or 8-PSK (high data rate) modulation for network access depending on the instantaneous demands of the network and operating conditions. Because of the higher data rates and relaxed error control covering in many of the selectable air interface formats, the coverage range is smaller ~~than~~ in EDGE than in HSDRC or GPRS.

In EDGE packets are transmitted first with maximum error protection and maximum data rate throughput, and then subsequent packets are transmitted with less error protection. Then subsequent packets are transmitted with less error protection and less throughput, until the link has an unacceptable outage or delay. Rapid feedback between the base station and subcriber unit then restores the previous acceptable air interface.

i) The uplink multiplexing -

Uplink Dedicated channel



uplink dedicated channel structure

The uplink channel uses I/Q multiplexing for user data and physical layer control information. The physical layer information including data is carried by Dedicated Physical Control Channel (DPDCH) with a fixed spreading factor of 256. The higher layer information, including user data, is carried on one or more Dedicated Physical Data channels (DPDCH) with a possible spread factor ranging from 256 down to 4.

The uplink transmission may consist of one or more dedicated physical channels

DPDCH with a variable spreading factor

DPDCH data rate may vary on a frame-by-frame basis. Typically with a variable rate service the DPDCH data rate is informed on the DPDCH. The DPCCH is transmitted continuously and rate information is sent with Transport Format Combination Indicator (TFCI), The DPCCH information on the data rate on the current DPDCH frame. If TFCI is not decoded correctly, the whole data frame is lost. The reliability of TFCI is higher than the reliability of the user data detection on the DPDCH.

The uplink DPCCH uses a slot structure with 15 slots over the 10 ms radio frame. This results in a slot duration of 2560 chips or 666 μs. This is rather close to the GSM burst duration of 577 μs. Each slot has four fields to be used for pilot bits, TFCI, Transmission Power Control (TPC) bits and Feedback Information (FBI)

The pilot bits are used for the channel estimation in the receiver, and the TPC bits carry the power control commands for the downlink power control. The FBI bits are used when closed loop transmission diversity is used in the down link. The use of FBI bits is covered as part of physical channel procedures. The system uses either open loop or closed loop transmit diversities.

In the closed loop diversity scheme, the base station uses two antennas. The FBI channel is used to send feedback commands to control phase adjustments that are expected to maximize power received by the terminal.

In mode 2, the amplitude is adjusted in addition ~~the~~ to the phase adjustment.

ii) Uplink Multiplexing

In the uplink direction the services are multiplexed dynamically so that the data stream is continuous with the exception of zero rate. The symbols on the DPDCH are sent with equal power level

for all services. This means in practice that the service coding and channel multiplexing ~~is~~ needs in some cases to adjust the relative symbol rates for different services in order to balance the power level requirements for the channel symbols.

The rate matching function in the multiplexing chain can be used for such quality balancing operations between services on a single DPDCH. For the uplink DPDCH there do not exist fixed positions for different services but the frame is filled according to the outcome of the rate matching and interleaving operations.

After receiving a transport block from higher layers, the first operation CRC attachment. After the CRC attachment the transport blocks are either concentrated together or segmented to different coding blocks. The channel coding is performed on the coding blocks after the concentration or segmentation operation. After channel

Coding the radio frame equalisation is performed to ensure that data can be divided into equal sized blocks when transmitted over more than a single 10 ms radio frame.

The first or second interleaving is used when the delay budget allows more than 10 ms of interleaving.

Rate matching is then used to match the number of bits to be transmitted to the number available on a single frame.

The higher layers provide a semi-static parameter, the rate matching attribute, to control the relative matching between different transport channels. Different transport channels are multiplexed together by the transport channel multiplexing operation. This is a serial multiplexing. This multiplexing simply divides the data evenly on the available spreading codes.

ii

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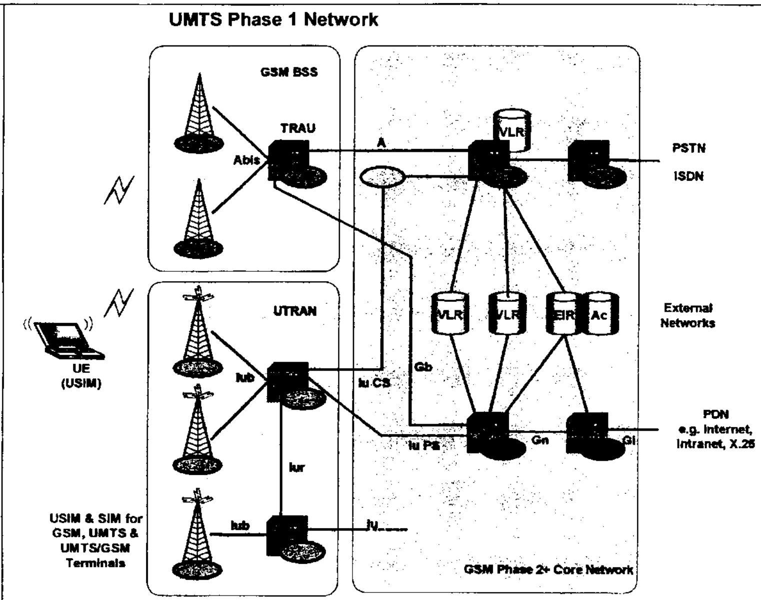
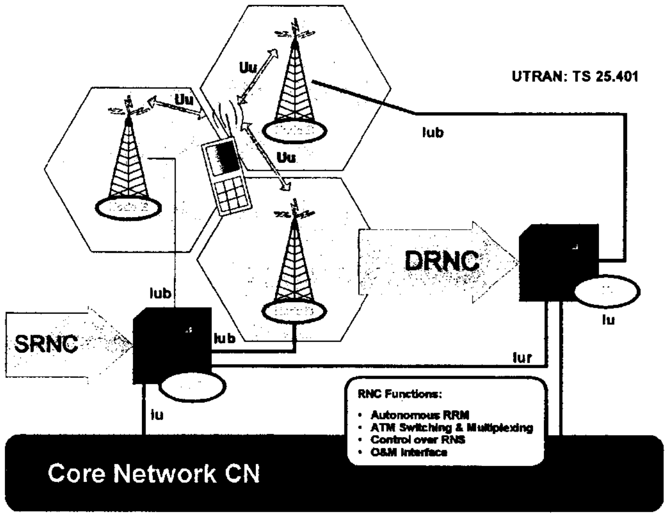
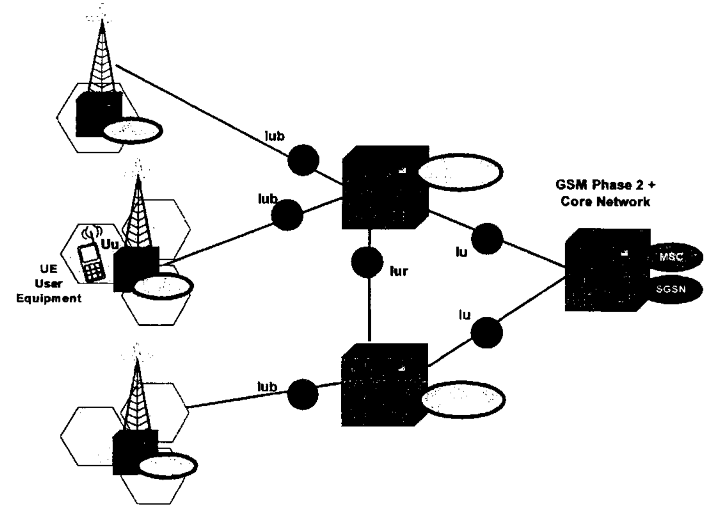


RNC Functions



UMTS Phase 1: UTRAN



4-d

•**Cu Interface.** This is the electrical interface between the VSIM smartcard and the ME. The interface follows a standard format for smartcards.

•***Uu* Interface**. This is the WCDMA radio interface. The *Uu* is the interface through which the UE accesses the fixed part of the system, and is therefore probably the most important open interface in UMTS.

•**Iu Interface.** This connects *UTRAN* to the CN. Similarly to the corresponding interfaces in GSM.

•**Iur Interface.** The open Iur interface allows soft handover between RNCs from different manufacturers

•**Iub Interface**. The Iub connects a Node Band an RNC. *UMTS* is the first commercial mobile telephony system where the Controller-Base Station interface is standardised as a fully open interface.

4e-i

The conversational class

The best-known application of this class is speech service over circuit-switched bearers.

With Internet and multimedia, a number of new applications will require this type, for I example voice over IP and video telephony.

This is the only type of the four where the required characteristics are strictly imposed by human perception

The end-to-end delay is low and the traffic is symmetric or nearly symmetric.

The maximum end-to-end delay is given by the human perception of video and audio conversation the end-to-end delay has to be less than 400 ms.

ii)

The Streaming Class

Multimedia streaming is a technique for transferring data such that it can be processed as a steady and continuous stream.

With the growth of the Internet because most users do not have fast enough access to I download large multimedia files quickly.

With streaming, the client browser or plug-in can start displaying the data before the entire file has been transmitted. For streaming to work, the client side receiving the data must be able to collect the data and send it as a steady stream to the application that is processing the data and converting it to sound or pictures

Streaming applications are very asymmetric and therefore typically withstand more delay than more symmetric conversational services. They tolerate more jitter in transmission. Jitter can be easily smoothed out by buffering

iv)

Background Class

Data traffic of applications such as e-mail delivery, SMS, downloading of databases and reception of measurement records can be delivered background since such applications do not require immediate action.

The delay may be seconds, tens or seconds or even minutes.

Background traffic is one of the classical data communication schemes that is broadly characterised by the fact that the destination is not expecting the data within a certain time.

It is thus more or less insensitive to delivery time

Data to be transmitted has to be received error free.

The electronic postcard is one example of new applications that are gradually becoming more and more common.

iii Interactive Class

Interactive class is used when the end-user, either a machine or a human, is on line requesting data from remote equipment.

Examples of human interaction with the remote equipment are

–Web browsing,

–database retrieval, and

–server access

Examples of machine interaction with remote equipment are

–polling for measurement records and

–automatic database enquiries (tele-machines).