Multimedia Internet

1.Exercise – TDM

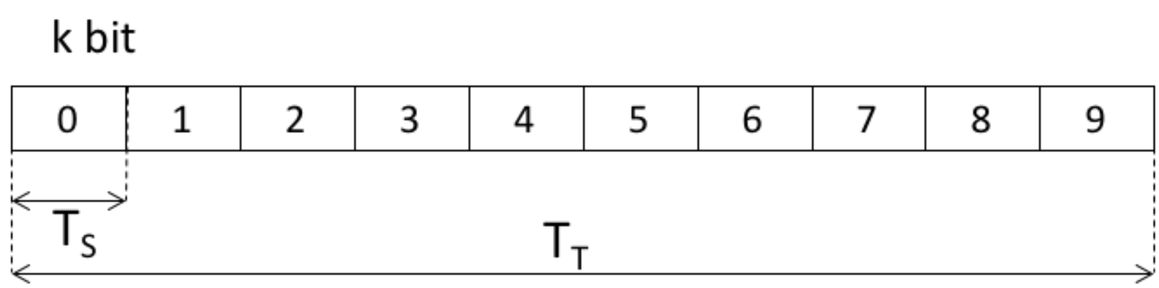
A TDM multiplexing system has a frame of N = 10 slots; k = 128 [bit] are transmitted in each slot. If the system is used to multiplex 10 channels, each at V = 64 [kbit/s], calculate the transmission rate W of the multiplex, the duration (T_T) of the multiplex frame and the duration of the slot (T_S).

Solution

The multiplexing system must have enough speed (rate) to support all the N flows; therefore, very simply:

$W = V \cdot N = 64$ [kbit/s] $\cdot$ 10 = 640 kbit/s

The duration of the frame can be calculated by imposing that if you assign a slot per frame to a flow, the equivalent rate of the channel thus defined is equal to the input rate of tributary flow V.



T_T = k/V= 128 $[bit]$ / 64 $\cdot$ 10^3[bit/s] =2 $[ms]$

The <u>slot duration</u> is defined as the time necessary for transmitting al the bits that compose the slot, k, at a speed equal to W; hence:

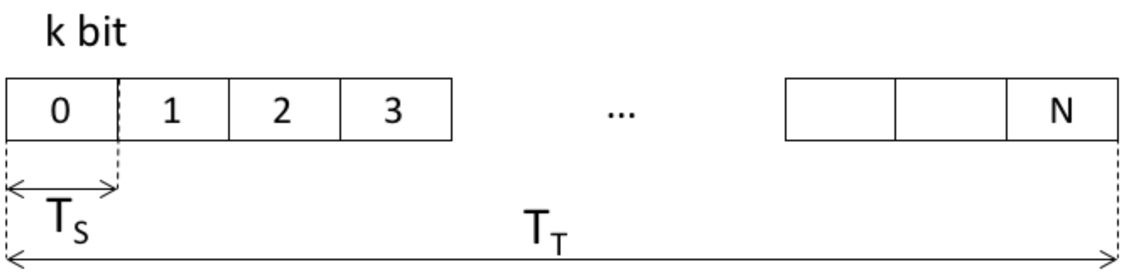
T_S = k/W= 128 $[bit]$ / 640 $\cdot$ 10^3[bit/s] = 200 $[\mu s]$

2.Exercise – TDM

A TDM multiplexing system has a multiplex rate of W = 2.048 [Mbit/s] and k = 8 [bits] per slot. Assuming the transmission rate of each channel is equal to V = 64 [kbit/s], calculate the (maximum) number of supported tributary channels, N, the frame length (duration) T_T, and the length (duration) of the slot T_S.

Solution

The Multiplexing system has an overall rate W and must support tributary flows with rate V. The maximum number of tributary flows that can be supported is therefore:



N= W/V = 2048 [kbit/s] / 64 [kbit/s] =32

The frame duration can be computed by imposing that if we assign one slot per frame to a tributary flow, the equivalent rate of the channel thus defined is equal to the ingress rate of tributary flow, V.

$T_T = k/V = 8\ [bit] / 64 \cdot 10^3 [\text{bit/s}] = 125 [\mu s]$

The slot duration can be computed as the frame duration divided by the number of slots per frame, hence with the time necessary to send k bits at a speed W; hence:

$T_S = T_T / N = k/W = 125[\mu s] / 32 \cong 3{,}90[\mu s]$

3.Exercise –TDM

A time division multiplexing system is characterized by a degree of interlacing k = 8 [bit] and must serve input flows (tributaries) with rate r = 128 [kbit/s]. Find the minimum duration of the multiplexing frame, T_T. Knowing then that the single slot in the multiplexing frame has a duration T_s = 3.125 [microseconds], find the transmission rate downstream of the multiplexer, W, and the maximum number of input flows that can be served, N.

Solution

The duration of the frame can be found by imposing: $r = k/T_T$; hence, we have: T_T = 62.5 [microseconds].

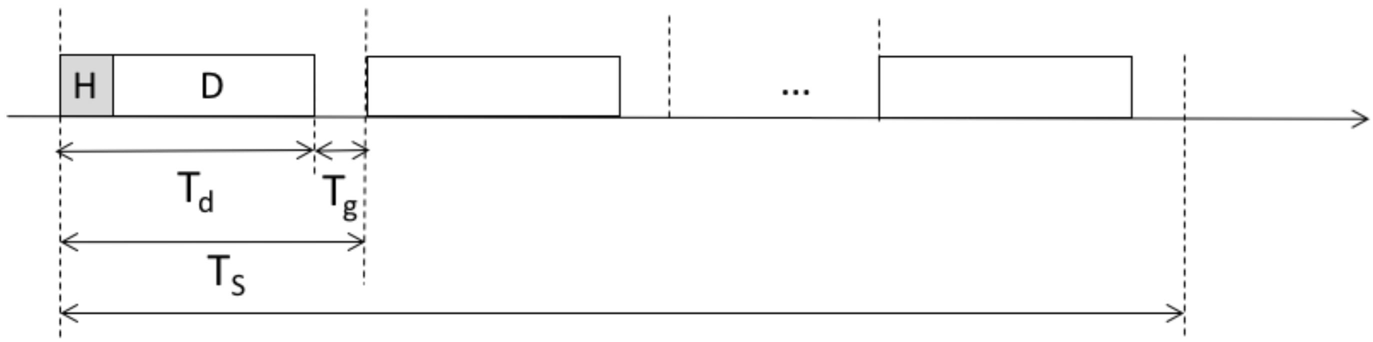
The rate W is defined as: $W = k/T_s$ = 2.56 [Mbit/s]. The maximum number of tributaries is equal to the overall multiplexer rate divided by the rate of the single tributary: N = W/r = 20.

4.Exercise - TDMA

A TDMA multiple access system uses N = 10 time slots, a guard time T_g = 200 [μs], data packets consisting of a data field of size D = 180 [bit] and a header of size H = 20 [bit] , and a T_T frame time of 10 [ms].

Calculate the carrier speed (multiplex) W and the net speed (for transmitting *data*) V of each channel.

Solution



The size of each slot (expressed in bits) is equal to:

$k = H + D = 200\ [bit]$

The slot duration is given by the frame duration divided by the number of slots in the frame:

$T_S = T_T$ / N =10/10 = 1$[ms]$

The transmission time of the *data* part in the slot is given by the slot duration minus the guard time:

$T_d = T_S - T_g = 0{,}8\ [ms]$

The speed of the multiplexed flow is given by the size (in bits) of the data part of the slot divided by the time necessary to send it:

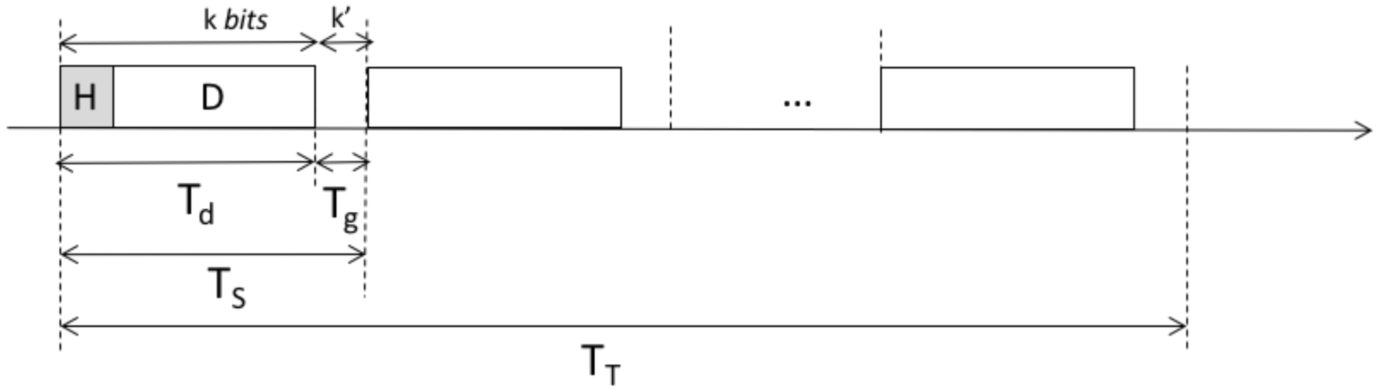
W =k/ T_d= 200 bit /0.8 ms = 250 kbit/s

The net speed of the channel defined as "one slot per frame" is equal to the amount of information sent into the slot divided by the duration of the frame

V = D/ T_T = 180 bit / 10 ms = 18 kbit/s

5.Exercise - TDMA

The TDMA multiple access system of the GSM cellular system uses N = 8 time slots, a guard time equal to k' = 8.25 bit times, data packets consisting of D = 114 [bit] of data, and H = 34 [bit] of overhead, and a frame time T_T of 4.615 [ms]. Calculate the multiplex speed W and the net speed (data) V of each channel.



Solution

The number of *overhead* and data bits contained in a slot is equal to:

$k = H + D = 148\ bit$

The overall number of bits (*overhead* + data + guard) is:

$k_{TOT} = k + k' = 156{,}25[bit]$

The duration of a single slot is equal to the frame duration divided by the number of slots:

$T_S = T_T / N = 4{,}615[ms] / 8 = 577[\mu s]$

The carrier speed can be calculated by observing that k_{tot} bits must be transmitted in a slot time, therefore:

$W = k_{TOT} / T_S = 156{,}25[bit] / 577[\mu s] = 270{,}8$ [kbit/s]

The corresponding net speed of the channel defined as "one slot per frame" is:

$V = D / T_T = 114[bit] / 4{,}615$ [ms] = 24,70 [kbit/s]

Note that in the calculation we considered 114 [bits] in the numerator (without the guard bits) because this is the "space" that can be used to "host" information (data).

6. Exercise TDMA

A time division centralized multiple access system (TDMA) is characterized by a frame with slot of duration T_S = 10 [μs], with a minimum guard time T_G = 2 [μs]. The system serves 8 users and has a transmission rate of the multiplexed signal equal to C = 1 [Mbit/s]. We ask to:

1) indicate the number of bits of each tributary transmitted in each slot, n

2) indicate the maximum possible rate for each incoming tributary flow, r

Solution

1) $n = (10\ \mu s - 2 \mu s)$* 1 Mbit/s = 8 $[bit]$
2) The frame duration (T_T) is equal to the slot duration (T_S)

multiplied for the number of slots (8 users = 8 slots). Hence, $T_T = 8*T_S = (8*10\ \mu s) = 80\ \mu s$.
The maximum possible transmission rate for each flow is hence given by the number of bits transmitted in a slot (8 bits, see point 1)) divided by the *frame* duration T_T.
r = 8 bit / (8*10 μs) = 100 [$kbit/s$]

7.Exercise – Random Multiple Access

Consider a network based on the ALOHA access protocol, with a very large number of stations (tending to infinity). The duration of the transmitted frames is equal to T = 1 unit of time. Let us assume that the traffic on the channel (that is, the average number of transmissions in time T) is equal to 1,649 = $\sqrt{e}$ times the number of frames successfully transmitted.

a) Calculate the *throughput* of the network.

b) Then calculate the network throughput in the same conditions, in the same network but using the *Slotted ALOHA* access protocol.

Solution

a) The expression throughput S as a function of traffic on channel G for the ALOHA protocol is: $S = G e^{-2G}$ from which it follows: $G / S = e^{2G}$

From the data of the problem we have: G / S = 1,649, (in fact "the number of frames successfully transmitted" represents S, while the average number of transmissions G). Hence we can get the value of G = 1⁄4 (in fact it turns out: $e^{1/2} = e^{2G}$), and finally:

S = G / (sqrt(e)) = (1/4)/(1.649) = **0.1516**

Or also: $S = G e^{-2G} = 0.1516$

b) The expression of the *throughput S* as a function of the traffic on the channel *G* for the Slotted ALOHA protocol is: $S = G\ e^{-G}$ from which it follows: $G / S = e^{G}$

From the data of our problem we have: $G / S = 1{,}649$. Hence we can determine the value of **G = 1⁄2** (hence it results: $e^{1/2} = e^{G}$), and finally:

$S = G / (sqrt(e)) = (1/2)/(1.649) =$ **0.303**

Or also: $S= G\ e^{-G}=$ **0.303**