2019/20 ITP part 4

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Consider a backbone using the BGP/MPLS VPN solution; therefore, the IP packets are encapsulated with two MPLS labels. The MPLS packets are carried directly over Ethernet (no VLAN tag) and the line rate is 10Gb/s.

A file of size S is sent using UDP and the length of packets at IP level is L. The IP+UDP header length is 28 bytes. Each MPLS header is 4 bytes long, and the information about Ethernet Frames and Layer 1 Ethernet packets is shown in the figure below.

How many bytes needs to be considered at Layer 1 Ethernet level (i.e. including the Interpacket Gap – IPG) to transfer the file?

Evaluate the total transmission time of the file T_file [s], if the full capacity of the link is used for the file transfer.

Layer	Preamble	Start of frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interpacket gap
	7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	46-1500 octets	4 octets	12 octets
Layer 2 Ethernet frame			← 64–1522 octets →						
Layer 1 Ethernet packet & IPG	← 72–1530 octets →								← 12 octets →

S 400 MBytes
L 1200 bytes

Answer:

L_eth = Number of bytes at Layer 1 Ethernet level per packet

Preamble+SOF + MACdst+MACsrc+Ethertype+MPLS+MPLS+IP +FCS + Interpacket gap
7+ 1 + 6 + 6 + 2 + 4 + 4 + 1200 + 4 + 12
L_eth = 1246 [bytes]

NoP Number of packets
To evaluate the number of packets, we divide the file size by the number of bytes available in the UDP payload of each packet.
The capacity of the payload of each packet is L-28 = 1200-28= 1172 bytes

NoP = 400 * 1e6 / 1172 = 0.333333 * 1e6 = 341296 packets

Total number of bytes on the channel to transfer the file is
Tot_bytes = NoP * L_eth = 341296 * 1246 = 425254816 [bytes]

The total time to transmit the packet T_file can be evaluated as follow
T_file = Tot_bytes / Line rate = 425254816 [bytes] / C =
= 425254816 * 8 [bit] / 10Gb/s = 3,402,038,528 / 10e9 = 3402 / 10e3 =
= 0.3402 [s] = 340.2 [ms]

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A voice signal is sampled with a frequency F (khz) and converted to digital with a M bit converter. The digital stream is compressed with a coder. The coder produces a compressed packet every T ms and each compressed packet has a size of B bytes.
Evaluate the compression factor q (ratio between the original bit rate and compressed net bit rate).

Two compressed packets are inserted into an IP packet, adding the UDP and RTP headers. The IP, UDP and RTP headers are respectively 20, 8 and 12 bytes.

Evaluate the packetization delay.
Evaluate the bit rate at IP level R-IP.

If the maximum tolerable packetization delay is 25ms, how many compressed voice packets can be inserted into an IP packet?

T	15 ms
F	16Khz
M	16 bit
B	20 bytes

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Consider a stream of IP packets, which is controlled by a Two Rate Three Color Marker (trTCM), with parameters CIR, CBS, PIR, PBS.

An application needs to send a burst of S kbytes (at IP level) every T ms.
Evaluate the minimum CIR CIR_min [kB/s] to support the application so that all packets could be marked green (with a proper choice of CBS).

The application needs to complete the transmission of the burst after T1 ms. Evaluate the needed sending rate Rb [kB/s]

Assume that the bucket is full of tokens when the application start sending the first burst at rate Rb. Evaluate the CBS_min [kB] so that all packets can be marked green (with the evaluated CIR_min).

Using the evaluated CBS_min, if the application is sending the burst at a rate Rb/2, evaluate the tokens remaining in the bucket when the burst has been transmitted.

S	400 KB
PIR	16 MB/s
T	1200 ms
T1	150 ms

Answer:
The CIR_min so that all packets could be marked green corresponds to the overall average sending rate.

CIR_min = OverallAvg [B/s]

OverallAvg [B/s] = S/T = 400 KB / 1.2 s = 333.33 [KB/s]

To complete the transmission of the burst at rate Rb a time T1 :
S/Rb = T1
Rb [KB/s] = S / T1 = 400 / 0.15 = 2666.66 KB/s

Condition on Bucket empty at the end of the burst (starting from buffer full)
CBS_min / (Rb - CIR_min) = T1
CBS_min = T1 * (Rb – CIR_min) = 150 [ms] * (2666.66 – 333.33) =
= 0.150 [s] * 2333.33 [KB/s] = 350 KB

If the application is sending at a rate Rb/2 the bucket is decreasing at a rate
R_dec = (Rb/2 – CIR_min) = (1333.33 – 333,33) = 1000 KB/s

If the application is sending at a rate Rb/2 the new time to send the burst is:
T2 = S / (Rb/2) = 400 [k] / (1333.33) = 400 / 1333.33 = 0.3 [s]

The bucket level at time T2 will be

B(T2) = CBS_min – T2 * R_dec = 350 – 0.3 * 1000 = 350 -300 = 50 KB

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Consider an application that is sending IP packets, controlled by a Two Rate Three Color Marker (trTCM) with parameters CIR, CBS, PIR, PBS. The application is using a UDP connection. The length of IP+UDP headers is 28 bytes. The IP packet length is L=1500 bytes.
The application sends a block of data of size M1 = 1 MB (at IP level) at a rate Rb every T1=2 s.
In addition, the application sends a block of data of size M2 = 2 MB (at IP level) at a rate Rb every T2=6 s.

CBS 1MB
CIR 2 MB/s
PIR 20 MB/s
Rb 5 MB/s

The application does not adapt to the token bucket marker, so the packets that are out of the traffic profile (CIR, CBS) are marked yellow.

1) Evaluate if the CIR is larger than the average sending rate of the application.

At time T=0 the bucket is full, and the application starts sending the two blocks of data.

2) Evaluate the time Tb1 needed to send the block of data M1 and the time Tb2 needed to send the block of data M2 (each one at rate Rb).

3) Evaluate if all packets of the first two blocks of data are marked green. If not, evaluate how many bytes are marked yellow globally for the first block M1 and the first block M2.

4) Evaluate the bucket size when the application starts sending the second block of data of size M1 at time T=2 s.

5) Evaluate the CBS_min that allows to mark green the two initial blocks of data M1 and M2 (it is ok to write the equation that needs to be solved to find CBS_min).

Answer:

1) The average sending rate of the application is the sum of the sending rates of the two blocks of data

Avg_rate = M1/T1 + M2/T2 = 1/2 [MB/s] + 2/6 [MB/s] = 0.833 MB/s

2)
The time needed to send the two blocks of data:
Tb1 = M1/Rb = 1 / 5 = 0.2 [s]
Tb2 = M2/Rb = 2 / 5 = 0.4 [s]

3)
From 0 to Tb1 the bucket is emptying at a rate (2 Rb – CIR), starting from CBS

B(Tb1) = CBS – Tb1 (2Rb – CIR) = 1 MB – 0.2 (10 -1) = 1 – 1.8 = -0.8

The bucket level would be negative at Tb1, this is NOT possible. The bucket goes to zero before Tb1. It is not possible to mark all packets green.

Let us evaluate Te, the time at which the buffer becomes empty

$CBS - Te\,(2Rb - CIR) = 0$

$CBS = Te\,(2Rb - CIR)$

$Te = CBS / (2Rb - CIR) = 1\ MB / 9\ MB/s = 0.111\ [s]$

From 0 to Te all packets are marked green.

From Te to Tb1 a fraction CIR/2Rb of packets is marked green, a fraction (2Rb-CIR)/2Rb is marked yellow (both for block 1 and block 2)

From Tb1 to Tb2 a fraction CIR/Rb packets is marked green, a fraction of (Rb-CIR)/Rb is marked yellow (only for block 2 because transmission of block 1 ends at Tb1).

How many bytes are marked yellow (globally for the first block M1 and the first block M2)?

As mentioned above, for the block M1, from Te to Tb1 a fraction (2Rb-CIR)/2Rb is marked yellow. The total amount of bytes YM1 that are marked yellow for the first block M1

$YM1 = (Tb1-Te) * Rb * (2Rb-CIR)/2Rb = (Tb1-Te)\,(2Rb-CIR)/2 = (0.2-0.111)\,(10-2)/2 =$

$= 0.089\ [s] * 4\ [MB/s] = 0.356\ MB$

For the block M2 from Te to Tb1 a fraction (2Rb-CIR)/2Rb is marked yellow

$YM2\_beforeTb1 = (Tb1-Te) * Rb * (2Rb-CIR)/2Rb = YM1 = 0.356\ MB$

From Tb1 to Tb2 a fraction of (Rb-CIR)/Rb is marked yellow

$YM2\_afterTb1 = (Tb2-Tb1)*Rb * (Rb-CIR)/Rb = (Tb2-Tb1) * (Rb-CIR) = (0.2) * 3\ MB/s =$

$= 0.6\ MB$

The total amount of bytes YM2 that are marked yellow for the first block M2

$YM2 = YM2\_beforeTb1 + YM2\_afterTb1 = 0.356 + 0.6 = 0.956\ MB$

4) Evaluate the bucket size when the application starts sending the second block of data of size M1 at time T=2 s.

The first block of data of size M2 ends its transmission at Tb2=0.4 [s], in this moment the bucket level is 0. Then the bucket starts refilling at a rate CIR (= 2 MB/s).

The CBS is 2 MB. The time T_fill needed to fill the bucket is derived in this way

$CBS = T\_fill * CIR$

$T\_fill = CBS/CIR = 2\ MB / 2\ [MB/s] = 1\ s$

Therefore, the buffer will be fill at $Tb2+T\_fill = 0.4 + 1 = 1.4\ s$

The buffer will remain filled at full level until the application start sending the second block of data at time T = 2 s.

5) Evaluate the CBS_min that allows to mark green the two initial blocks of data M1 and M2 (it is ok to write the equation that needs to be solved to find CBS_min).

The buffer needs to be empty at Tb2 when the the block M2 ends.

Starting from a buffer or CBS_min, the buffer level at time Tb1 is

$B(Tb1) = CBS\_min – Tb1\ (2Rb - CIR)$

The buffer level at time Tb2 is

$B(Tb2)= B(Tb1) – (Tb2-Tb1)\ (Rb-CIR)$

If we want B(Tb2) to be 0 and we replace B(Tb1) with the above expression, we have:

$0 = CBS\_min – Tb1\ (2Rb - CIR) – (Tb2-Tb1)\ (Rb-CIR)$

$CBS\_min = Tb1\ (2Rb - CIR) + (Tb2-Tb1)\ (Rb-CIR)$