Started on	Tuesday, 27 July 2021, 2:01 PM
State	Finished
Completed on	Friday, 30 July 2021, 1:46 PM
Time taken	2 days 23 hours
Marks	66.87/70.00
Grade	**95.52** out of 100.00

Information

When working through the following quiz please keep the following points in mind:

- You are asked to implement a number of Python functions. The default language is Python3.
- Occasionally you will have to use mathematical functions from the Python 'math' package. You will need to add suitable 'import' statements to your solutions and when using such a function you will have to prefix them with the package name, e.g. to call the function 'floor' you will have to write 'math.floor' in your code.
- In many questions it is asked that you enter numerical answers in certain units. For example, we may ask you to enter your answer in milliseconds. If your answer is 0.050 seconds then you will have to enter '50', as this is the equivalent value in milliseconds.

Information

The Internet allows to transport data between two hosts. The "speed" with which this happens is given by the **data rate**, which roughly measures the amount of data in bits or bytes per unit time that is sent by one station and arrives successfully (i.e. completely and in the right order) at the other station. There are different notions for the data rate, for example depending on whether or not any control data added by the Internet protocols for their own purposes is accounted for or not. In this partial quiz we will use the notion of **goodput** which only counts what users will see, i.e. the amount of user data received per unit time.

Standard units for data rates / goodput are:

- bps (bits per second)
- Kbps (kilobit per second)
- Mbps (megabit per second)
- Gbps (gigabit per second)
- and so on

If we measure bytes instead of bits, then the units become Bps, KBps, MBps, GBps, etc.

In the context of data transmissions these units are usually taken to the base ten, i.e. one kbps refers to 1,000 bits per second and not 1,024.

Question **1**

Correct

Mark 1.00 out of 1.00

Kilo, Mega, Giga ... give the next three unit prefixes in ascending order.

Answer: Tera, Peta, Exa ✔

Tera corresponds to 10E12

Peta corresponds to 10E15

Exa corresponds to 10E18

Correct

Marks for this submission: 1.00/1.00.

Question **2**

Correct

Mark 1.00 out of 1.00

Find the maximum data rate offered by the Ethernet IEEE 802.3ae standard and express it in Gbps.

Answer: 10 ✔

The maximum data rate is 10 Gbps (Gigabit per second).

Correct

Marks for this submission: 1.00/1.00.

Question **3**

Correct

Mark 0.67 out of 1.00

WiFi is a common name for the IEEE 802.11 Wireless Local Area Networks (Wireless LAN, WLAN) standard. There are several versions and extensions of this standard. One particular extension was IEEE 802.11n (issued in 2009). Find the maximum data rate offered by 802.11n and give its value in Mbps.

Answer: 600 ✔

The maximum data rate is 600 Mbps. This is the theoretical maximum and it is only guaranteed that users never will get to see more. In practice, users will see much less than that, perhaps one half to two thirds under good circumstances.

Correct

Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Information

Video transmissions (live video or streamed video) actually make up the lion's share of the data that is carried in today's Internet. The required data rate for uncompressed video depends on three factors:

- The number of pixels (number of vertical pixels times number of horizontal pixels)
- The (color) depth: how many bits are used per pixel to represent the color. When RGB colors are used, then for each of the colors red, green and blue a number of bits is allocated.
- The frame rate: number of video frames created per second

In most (but not all!) of the following questions we will use RGB colors and we will specify a video source as
P/D/R
where P is the number of pixels, D is the depth per RGB color (i.e. we then need 3D bits per pixel to represent the color) and R is the frame rate (in frames per second).

Question **4**

Correct

Mark 2.00 out of 2.00

Please find the required bit rates for the following video source and **express it in Mbps** (with two digits after the decimal point, no rounding).

VGA Video: 640 x 400, 16 colors in total, 60 fps

Answer: 61.44 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **5**

Correct

Mark 2.00 out of 2.00

Please find the required bit rates for the following video source and **express it in Mbps** (with two digits after the decimal point, no rounding).

Low resolution video: 320 x 200 / 8 / 30

Answer: 46.08 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **6**

Correct

Mark 2.00 out of 2.00

Please find the required bit rates for the following video source and **express it in Gbps** (with two digits after the decimal point, no rounding).

UHDTV-1: 3840 x 2160 / 8 / 30

Answer: 5.97 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **7**

Correct

Mark 0.67 out of 2.00

Please find the required bit rates for the following video source and **express it in Gbps** (with two digits after the decimal point, no rounding).

Super Hi-Vision/8K video: 7680 x 4320 / 12 / 120

Answer: 143.32 ✔

Correct

Marks for this submission: 2.00/2.00. Accounting for previous tries, this gives **0.67/2.00**.

Question **8**

Correct

Mark 2.00 out of 2.00

Which of the previously considered types of uncompressed video can be transmitted over WiFi / IEEE 802.11n, assuming it operates at the maximum possible data rate?

UHDTV-1	False ✔
VGA Video	True ✔
Super Hi-Vision/8K video	False ✔
Low resolution video	True ✔

Your answer is correct.

Correct

Marks for this submission: 2.00/2.00.

Question **9**

Correct

Mark 2.00 out of 2.00

Which of the previously considered types of uncompressed video can be transmitted over Ethernet / IEEE 802.3ae, assuming it operates at the maximum possible data rate?

Low resolution video	True ✔
UHDTV-1	True ✔
VGA Video	True ✔
Super Hi-Vision/8K video	False ✔

Your answer is correct.

Correct

Marks for this submission: 2.00/2.00.

Information

Communication situations can differ in who talks to whom, for example if one station talks to exactly one other station in the network (unicast), to all other stations (broadcast) or to some subset of the stations (multicast). Correspondingly, network protocols designed for unicast transport data generated by one station only to the peer station and not to any other station, protocols designed for broadcast transport data generated by one station to all other stations, and multicast protocols transport data from one station to the stations belonging to the chosen subset (and no others). Note that it does not matter whether the stations receiving the data from the protocol actually do something with it.

Question **10**

Correct

Mark 1.00 out of 1.00

In a lecture situation often a lecturer talks to all students in the room. What is this?

Select one:

- a. Multicast
- b. Broadcast ✔
- c. Unicast

Your answer is correct.

Correct

Marks for this submission: 1.00/1.00.

Question **11**

Correct

Mark 1.00 out of 1.00

What type of situation is an email exchange between me and you?

Select one:

- a. Multicast
- b. Unicast ✔
- c. Broadcast

Your answer is correct.

Correct

Marks for this submission: 1.00/1.00.

Question **12**

Correct

Mark 1.00 out of 1.00

And what type of situation is an email exchange between me, you and a mutual friend?

Select one:

- a. Unicast
- b. Multicast ✔
- c. Broadcast

Your answer is correct.

Correct

Marks for this submission: 1.00/1.00.

Question **13**

Correct

Mark 2.00 out of 2.00

In the end, all data is transmitted as signals on a physical medium, e.g. as electromagnetic waves in a cable or in space, or as acoustic waves through the air. In each medium there is a limit on signal speed, for example the speed of light in empty space is 300,000 kilometers per second, the speed of light in a cable is around 200,000 kilometers per second, or the speed of sound in air is around 334 meters per second.

When a transmitter and receiver have a certain distance *d* to each other, then the time the signal needs to travel (through the medium) from transmitter to receiver is called the **propagation delay**.

Let the signal speed be denoted as *v* (in meters per second, m/s) and the distance between transmitter and receiver be denoted as *d* (in meters, m). Which of the following is the general expression for the propagation delay?

Select one:

- a. v * d
- b. 1 / (v+d)
- c. v / d
- d. d / d
- e. v * v / d
- f. v + d
- g. 2 * d / v
- h. d / v ✔

Your answer is correct.

Correct

Marks for this submission: 2.00/2.00.

Question **14**

Correct

Mark 2.00 out of 2.00

The speed of light in free space is 300,000 kilometers per second (km/s), and the moon has a distance of approximately 384,000 kilometers. What is the propagation delay in seconds? Please give two decimals after the decimal point, without rounding.

Answer: 1.28 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **15**

Correct

Mark 2.00 out of 2.00

Suppose you want to communicate with a manned station on Mars. Mars has an average distance of 225 million kilometers to earth. What is the propagation delay in minutes for this average distance? Again you can assume that the speed of light is 300,000 kilometers per second.

Answer: 12.5 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **16**

Correct

Mark 3.60 out of 4.00

A communication system provides a specified data rate *R* on a given link, which is usually specified in Kbps (kilobit per second), Mbps (Megabit per second), Gbps (Gigabit per second) and so on. For example, modern Ethernet technology comes in versions supporting 40 Gbps or even 100 Gbps.

The **transmission delay** of a packet of *L* bits length is defined as the time it takes to transmit the packet over the given channel with the given data rate *R*.

Suppose the data rate is given by *R* Mbps and we are given a packet of length *L* bytes. How long does the transmission of this packet take (i.e. how much time passes between the start of the first bit and the end of the last bit of this packet)? Fill in the following Python3 function with the correct expression. **The result needs to be returned in units of seconds.**

For example:

Test	Result
`print ("{:.3f}".format(transmission_delay(1000000, 4)))`	`2.000`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def transmission_delay (packetLength_bytes, rate_mbps):
    return (packetLength_bytes*8)/(rate_mbps*1000000)
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(transmission_delay(1000000, 4)))`	`2.000`	`2.000`	✔
✔	`print ("{:.3f}".format(transmission_delay(1000, 1)))`	`0.008`	`0.008`	✔
✔	`print ("{:.3f}".format(transmission_delay(10000, 1)))`	`0.080`	`0.080`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00. Accounting for previous tries, this gives **3.60/4.00**.

Question **17**

Correct

Mark 4.00 out of 4.00

Suppose the data rate is given by *R* bps and we are given a packet of length *L* bytes. How long does the transmission of this packet take (i.e. how much time passes between the start of the first bit and the end of the last bit of this packet)? Fill in the following Python3 function with the correct expression. **The result needs to be returned in units of seconds.**

For example:

Test	Result
`print ("{:.3f}".format(transmission_delay(1000000, 4000000)))`	`2.000`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def transmission_delay (packetLength_bytes, rate_bps):
    packetLength_bit = packetLength_bytes * 8
    return packetLength_bit/rate_bps
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(transmission_delay(1000000, 4000000)))`	`2.000`	`2.000`	✔
✔	`print ("{:.3f}".format(transmission_delay(1000, 1000000)))`	`0.008`	`0.008`	✔
✔	`print ("{:.3f}".format(transmission_delay(10000, 1000000)))`	`0.080`	`0.080`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00.

Question **18**

Correct

Mark 1.33 out of 2.00

Suppose we have a packet of length *L* = 1000 bytes, and the data rate is *R* = 10 Mbps. Please calculate the transmission delay in milliseconds.

Answer: 0.8 ✔

Correct

Marks for this submission: 2.00/2.00. Accounting for previous tries, this gives **1.33/2.00**.

Question **19**

Correct

Mark 2.00 out of 2.00

Suppose we have a packet of length *L* = 1000 bytes, and the data rate is R = 10 Gbps. Please calculate the transmission delay in milliseconds.

Answer: 0.0008 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **20**

Correct

Mark 4.00 out of 4.00

We are given a communication cable of length *K* kilometers, and the speed of light on this cable is 200,000 km/s. We can transmit at a data rate of 10 Gbps and we are given a packet of length *L* bits. Please complete the Python function below to calculate the total time between the instant where the transmitter starts with transmitting the first bit and the instant where the receiver has just completed the reception of the last bit. The time should be expressed in milliseconds.

For example:

Test	Result
`print ("{:.4f}".format(total_time(10000, 8000)))`	`50.0008`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def total_time (cableLength_KM, packetLength_b):
    cable_speed_KMS = 200000
    data_rate = 10 * 1000000000 # bps

    transmittion_delay = packetLength_b/data_rate # seconds

    propagation_delay = cableLength_KM/cable_speed_KMS # seconds

    return (transmittion_delay + propagation_delay) * 1000 # milliseconds
```

	Test	Expected	Got	
✔	`print ("{:.4f}".format(total_time(10000, 8000)))`	`50.0008`	`50.0008`	✔
✔	`print ("{:.4f}".format(total_time(20000, 16000)))`	`100.0016`	`100.0016`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00.

Question **21**

Correct

Mark 4.00 out of 4.00

A router has a number of so-called network interfaces or line cards, through which packets can enter and leave the router. In practically all cases, a packet leaves the router through another line card than it arrived on. It may well happen that during a very short time there arrive packets on several input line cards which need to go to the same output line card.

To deal with such sudden arrival bursts at an output line card, the line card contains a certain amount of buffer memory, in which packets are stored in first-come-first-served (FCFS) order. We also say that packets enter a **queue**. Whenever the line card wants to pick the next packet to transmit, it will inspect the queue and retrieve the head-of-queue packet for transmission.

In this setup, when a packet of yours arrives at its output line card, it may find a number of other packets ahead of itself in the queue, and all these other packets will be transmitted before your packet. The waiting time between entering the output line card and finishing the transmission of all previous packets is called the **queueing delay**. Note that the queueing delay is not controllable, it depends on how many packets (and for which destinations) others in the Internet generate.

Suppose the output line card has data rate *R* bps, and there are *N* packets ahead of yours in the queue, each of those has length *L* bits. What is the waiting time of your packet before its transmission starts? Please develop an expression and fill in the Python function below.

For example:

Test	Result
`print ("{:.3f}".format(queueing_delay(1000000, 7, 10000)))`	`0.070`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def queueing_delay (rate_bps, numPackets, packetLength_b):
    return packetLength_b/rate_bps * numPackets
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(queueing_delay(1000000, 7, 10000)))`	`0.070`	`0.070`	✔
✔	`print ("{:.3f}".format(queueing_delay(1000000, 34, 1000)))`	`0.034`	`0.034`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00.

Question **22**

Correct

Mark 2.00 out of 2.00

Suppose the output has data rate *R* = 100 Mbps, and there are *N* = 20 packets ahead of yours in the queue, each having a length of L = 1,500 bytes. Please calculate the queueing delay in milliseconds.

Answer: 2.4 ✔

Correct

Marks for this submission: 2.00/2.00.

Information

Packets can get lost in the internet for a multitude of reasons. One reason is that packets can get garbled during transmission over a link. For example, when a WiFi receiver is located close to a microwave oven, the oven (when operating) may create distortions at the receiver which can lead to incorrectly received packets and data. Another reason is related to congestion: when we have discussed queueing delay previously we have observed that each line card has a certain amount of buffer space. When this buffer is full and a new packet arrives to the line card, then often the new packet will be discarded, and the packet hence gets lost.

From the perspective of a user packet losses appear to be random events, and it is customary to treat each packet loss as an independent, binary random event (packet lost / not lost) and to introduce a **packet loss probability** p. If this packet loss probability is multiplied by 100 (and therefore expressed in percent) it is also often referred to as **packet loss rate**.

Question **23**

Correct

Mark 2.00 out of 2.00

For the following questions you will need to recall some properties of discrete probability distributions (e.g. the Bernoulli distribution, the geometric distribution, the binomial distribution), particularly their expected/average/mean values.

Assume that all packet losses are stochastically independent and happen with the same packet loss probability. We transmit a fixed number of *N* packets. What is the right type of probability distribution for the number *K* out of *N* packets that get lost?

Select one:

- a. Poisson
- b. Binomial ✔
- c. Bernoulli
- d. Geometric

Your answer is correct.

Correct

Marks for this submission: 2.00/2.00.

Question **24**

Correct

Mark 2.00 out of 2.00

Suppose the packet loss rate is 10% and we transmit 10,000 packets. How many packets will get lost on average?

Answer: 1000 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **25**

Correct

Mark 2.00 out of 2.00

Suppose we have a transmitter and a receiver which communicate over a channel that loses packets with a fixed packet loss probability *P* in (0,1). The transmitter wants to transmit one packet to the receiver and after each packet transmission trial the transmitter gets correct feedback on whether or not the transmission was successful. If the transmission failed, the transmitter performs a re-transmission, and it repeats this until the transmission is successful. What is the probability distribution for the number of transmission trials that the transmitter needs to perform?

Select one:

- a. Geometric of the first kind (successful trial not to be counted)
- b. Geometric of the second kind (successful trial to be counted) ✔
- c. Poisson
- d. Bernoulli
- e. Binomial

Your answer is correct.

Correct

Marks for this submission: 2.00/2.00.

Question **26**

Correct

Mark 3.60 out of 4.00

Same setup as in the previous question. What is the average number of packet transmission trials that the transmitter has to make when the packet loss probability is *P* in (0,1)? Please find an expression and fill it into the Python function below.

For example:

Test	Result
`print ("{:.3f}".format(average_trials(0.1)))`	`1.111`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def average_trials (P):
    return 1/(1-P)
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(average_trials(0.1)))`	`1.111`	`1.111`	✔
✔	`print ("{:.3f}".format(average_trials(0.3)))`	`1.429`	`1.429`	✔
✔	`print ("{:.3f}".format(average_trials(0.5)))`	`2.000`	`2.000`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00. Accounting for previous tries, this gives **3.60/4.00**.

Question **27**

Correct

Mark 2.00 out of 2.00

Same setup as in the previous question. Suppose the transmitter wants to transmit 1,000 packets over a channel with a packet loss probability of P = 0.2. What is the average total number of packet transmission trials that the transmitter has to make?

Answer: 1250 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **28**

Correct

Mark 4.00 out of 4.00

In situations where packet errors are generated by random transient disturbances on a transmission medium, one often finds information about the probability that a single bit is flipped, this probability is called **bit error probability** or **bit error rate**. Assuming that a packet consists of L bits and all bits of the packet are flipped independently of each other and with the same probability p, please find an expression for the resulting probability that a packet of L bits is erroneous (i.e. has at least one flipped bit) and implement it in a Python function.

For example:

Test	Result
`print ("{:.3f}".format(per_from_ber(0.0001, 1000)))`	`0.095`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def per_from_ber (bitErrorProb, packetLen_b):
    return 1- (1-bitErrorProb)**packetLen_b
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(per_from_ber(0.0001, 1000)))`	`0.095`	`0.095`	✔
✔	`print ("{:.3f}".format(per_from_ber(0.001, 1000)))`	`0.632`	`0.632`	✔
✔	`print ("{:.5f}".format(per_from_ber(0.01, 1000)))`	`0.99996`	`0.99996`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00.

Question **29**

Correct

Mark 4.00 out of 4.00

Same setup as in the previous question. If we call your result from the previous question *P*, then P can be interpreted as the packet error probability or packet loss probability (or more precisely: the probability that at least one bit in the packet is incorrect). Suppose a transmitter wants to transmit a packet with *L* bits to a receiver and carries out retransmissions until successful (the transmitter always receives reliable feedback from the receiver about the transmission outcomes). Find an expression for the average number of transmission trials in terms of the packet length *L* (in bits) and the bit error probability *P* and implement it in the Python function below. You will need the result for an earlier question.

For example:

Test	Result
`print ("{:.3f}".format(avg_trials_from_ber(0.0001, 1000)))`	`1.105`

Answer: (penalty regime: 10, 20, ... %)

Reset answer

```
def avg_trials_from_ber (bit_error_probability, packetLength_b):
    return 1/(1-(1- (1-bit_error_probability)**packetLength_b))
```

	Test	Expected	Got	
✔	`print ("{:.3f}".format(avg_trials_from_ber(0.0001, 1000)))`	`1.105`	`1.105`	✔
✔	`print ("{:.3f}".format(avg_trials_from_ber(0.001, 1000)))`	`2.720`	`2.720`	✔
✔	`print ("{:.3f}".format(avg_trials_from_ber(0.01, 1000)))`	`23163.565`	`23163.565`	✔

Passed all tests! ✔

Correct

Marks for this submission: 4.00/4.00.

Question **30**

Correct

Mark 2.00 out of 2.00

Same setup as in the previous question. Assume the packet length is *L* = 1000 bits and the bit error rate *p* is equal to 0.005. How many trials will the transmitter need on average? Please give two digits after the decimal point, no rounding.

Answer: 150.28 ✔

Correct

Marks for this submission: 2.00/2.00.

Question **31**

Correct

Mark 2.00 out of 2.00

Same setup as in the previous question. Assume the packet length is L = 2000 bits and the bit error rate p is equal to 0.001. How many trials will the transmitter need on average? Please give two digits after the decimal point, no rounding.

Answer: 7.39 ✔

Correct

Marks for this submission: 2.00/2.00.

◄ Quiz: Number representations and bit-fiddling

Jump to...

Quiz: Networked applications, QoS (Practice copy) ►