Computer Networks and Distributed Systems

Datalink-protocol framing and Ethernet

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Ancillary documentation:

- Check out these lecture presentations:
  - Pres. #1: http://paloalto.unileon.es/cn/lect/Ch2-MAIN-v5.0-CN-2022-Section-1.pdf
  - Pres. #2: http://paloalto.unileon.es/cn/lect/Ch2-MAIN-v5.0-CN-2022-Section-2.pdf
  - Pres. #3: http://paloalto.unileon.es/cn/lect/Ch2-2023-Section3.pdf

Topics outline:

- Bit-oriented and byte-oriented protocols
- Framing: BiSync, HDLC, PPP
- Ethernet System, CSMA/CD and Exponential Backoff
- Scalability of Ethernet (Binomial dist.)

Exercises

1. What is the essential difference between a bit-oriented protocol and a byte-oriented one? State the difference in a precise manner.

   Bit-oriented protocols accept payloads of any size, whereas byte-oriented protocols require payloads to be byte-aligned, *i.e.,* their size should be a multiple of 1 byte or 8 bits.

2. HDLC is bit-oriented protocol that uses the following sentinel whose name is *flag:* 01111110. The flag marks the start of a new HDLC frame and is also used to mark the end a the frame, much in the style of the quotation mark used for the start and the end of constant string in the C language. Ethernet is also a bit-oriented protocol since it allows a payload of any size, not necessarily a multiple of 8 (One byte). Let's recall the structure of an Ethernet frame (Consult slide no. 64 in the presentation mentioned above):

   [Preamble] [Dest MAC] [Src MAC] [Ethertype] [PAYLOAD] [CRC]

   The preamble is a 64-bit pattern much like HDLC's flag, but longer; the preamble is the Ethernet's sentinel that marks the start of a new frame.

   a. What field in the Ethernet frame constitutes the sentinel marking its end?
   Ethernet, today, constitutes a varied group of subnetwork-layer technologies, all

of them honor the basic datalink frame structure, however, a vast amount of phy (Physical-layer) transceivers are available. For the time being, we will limit ourselves to the original Ethernet which start-of-frame sentinel is the physical-layer preamble: 64-bit pattern 1010…1011. The original Ethernet system specifies no particular end-of-frame sentinel.

b. If you can't identify the end of frame sentinel in the Ethernet frame, can you speculate how the receiver discovers the end of the received frame?
It's the absence of carrier signal after transmission of the last bit of the CRC field that implicitly indicates end-of-frame.

3. Explain the transparency mechanism at use in the HDLC protocol

(No solution provided. This question is intended for your working out)

4. One of the stations that comprise an HDLC point-to-point link wishes to transmit the bit-string 10111011011111010101 0 to the station on the other end. Explain what the transmitter sends on the line and what the receiver's behavior is.

(No solution provided. This question is intended for your working out. You may want to check other similar exercises at paloalto.unileon.es/cn)

5. Explain the transparency mechanism at use in the BiSync protocol

(No solution provided. This question is intended for your working out. You may want to check with the textbook by prof. Peterson and Bruce Davie: Computer Networks).)

6. One of the stations that comprise a BiSync link wishes to send the following Byte-string (Each bracket space contains a Byte): [H][E] [L] [L] [O][ETX][!][SYN]. Explain what the transmitter sends on the line and the receiver's behavior is.

(No solution provided. This question is intended for your working out. You may want to check other similar exercises at paloalto.unileon.es/cn)

For all the following questions, assume an original Ethernet System network (Shared media Ethernet)

7. Explain the responsibilities of the Transceiver and the NIC in the Ethernet technology. Which one is responsible for computing Ethernet's CRC-32?

The transceiver, when transmitting, it translates binary symbols into electrical waveforms, when receiving it translates waveforms into binary symbols. The transceiver's responsibilities lay into the physical layer, among them, it contains electronics for computing the CRC.

The NIC, which implements the services of the Datalink layer, is responsible for building a new frame every time an upper layer protocol requests the transmission of a data unit: including the MAC addresses and the correct ethertype. When a new frame has been received by the transceiver, the NIC will deencapsulate its payload and convey it to the correct upper layer protocol.

8. What does Shared Link mean in the context of the Ethernet system? Then, what does Switched Ethernet mean?

In the original Ethernet System, the stations (Hosts or end nodes) were directly connected to a coaxial cable shared by all, thus, the bits transmitted by a station were inevitably received by all stations. Logically, only the station whose address is included in the frame's destination address field, deencapsulates the frame's contents and has it properly demultiplexed to the upper layer protocol number contained in the frame's ethertype.

A few years after its inception, the Ethernet System evolved into the Switched Ethernet in which stations are connected to a store-and-forward device named lan switch which has each received unicast frame copied to the destination station's port which has the benefit of keeping the communication private to sender and receiver.

9. Do the two forms of Ethernet mentioned above correspond to the multiplexing technique known as *Statistical Multiplexing?* Justify your response.

(No solution provided)

10. What is the Rtt of a maximally shared-medium Ethernet (2500m)?

The Rtt of a maximally-configured Ethernet is 51,2µs, which is known as *slot time.* The slot time has a great significance in the Ethernet System because it determines the minimum frame length that guarantees a proper functioning of the access control algorithm (CSMA/CD).

11. The transmission speed of the original Ethernet system is 10Mbps. Calculate how many bits fit the Rtt of a maximally-configured Ethernet.

Assume two stations, A and B are connected on the extreme points of an Ethernet segment of maximum allowed length, 2.5Km. Rtt is the time it takes for one bit to propagate from A to B plus the time it takes the response bit to propagate from B to A. We assume it takes zero seconds for B to generate the response bit. Basically, Rtt depends on the distance between A and B and the light speed in the physical transmission medium, in our case, a typical 50Ohm coaxial 10BASE5 cable. (For a review of Rtt and related concepts, consult textbook ch.1 and the solved exercises documents in paloalto.unileon.es/cn).

How many bits can be transmitted in a time T using the transmission speed of Ethernet, 10Mbps? We computed this on the board: 10Mbps = $10 \cdot 10^6$ b/s then we multiply this transmission rate by the time, in this case the time being Rtt:

Number of bits that fit into the Rtt = $10 \cdot 10^6$ b/s $\cdot$ 51,2µs = $10 \cdot 10^6$ b/s $\cdot$ 51,2 10^{-6}s = $10 \cdot 51{,}2$ b = 512 b

In conclusion, 512 bits fit the slot time (The Rtt of a maximally-configured Ethernet)

12. Assume a number of hosts (H1, H2,…) are connected to an original Ethernet; host H1 transmits a frame and wishes to prevent other hosts from receiving the frame. Is this possible? Make some suggestion.

In the original Ethernet system, the stations are all connected to the same coaxial cable, therefore, if the cable is of the maximum length allowed (2.5Km), then, every electrical signal driven by a station, will, necessarily be received by all the other peer stations. Any single station's physical layer receives each frame driven onto the cable and selects whether or not to hand the frame to the datalink protocol on the basis of the received frame's Destination MAC field being equal to the receiving adapter's MAC address.

Normally, a station's NIC is configured to reject all the frames sent to other stations, but, in principle, if a station wishes to receive and process all the frames, it can do so with the sender having no capability to avoid it whatsoever. In fact, network analyzers like Wireshark configure NICs in a mode known as *promiscuous mode*, in which the adapter will hand all the traffic to the datalink, so that it will eventually reach the Wireshark application.

13. What topology is implemented by the network based on coaxial cable used in 10BASE-2 and 10BASE-5? What is the topology used in 10BASE-T? What's is the acronym that represents the access protocol in the three cases?

By convention, the network topology resulting from the shared medium Ethernets, 10BASE2 and 10BASE5 is known as the *bus topology*. The 10BASE-T Ethernet implements the *star topology*. These three Ethernet technologies use the same access protocol: CSMA/CD, since the three are *shared-medium* Ethernets; in the first two cases, the shared medium is the coaxial cable and, in the third case, the shared medium is made up of the hub's electronics which behaves as a repeater/regenerator of electrical signals.

14. Ethernet's datalink frame structure is explained in slide no. 64, then, what's the minimum size of the payload field that honors that complies with Ethernet's *minimum frame size*? In other words, considering the other fields's sizes except the preamble, what's the resulting **minimum size of the Ethernet frame**? Is there also a maximum Ethernet frame's size?

The original Ethernet system prescribes a minimum frame size of 512 bits, this allows a correct operation of the CSMA/CD access protocol. Let's calculate the contribution of each frame's field to the **minimum** payload size:

We assume the typical parameters of a half-duplex Ethernet bus having the maximum length of 2500m (Transmission speed is 10 Mbps and the Rtt corresponding to the max length of 2500 m has been measured to be 51,2µs).

Correct operation of the CSMA/CD access protocol entails that the transmitter initiating the transmission of a fresh frame keep transmitting *at least* while the Rtt lasts, that is 51,2 µs. It's fitting that we translate that time (The round trip time, Rtt) to the number of bits that the transmitter should transmit in every frame transmission, at least. In other words, how many bits can be transmitted while the Rtt lasts right after initiating a new frame transmission?

$51{,}2\ \mu s \cdot 10\ Mbps = 51{,}2 \cdot 10^{-6}\ s \cdot 10 \cdot 10^{6}\ \frac{b}{s} = 512\ b$

Min frame length is 512 b = 512 bit · 1 bit/8 Byte = 64 Byte is the minimum frame size

Fields of an Ethernet frame:
- Dest MAC + Src MAC = 6 Byte + 6 Byte = 12 Byte
- Ethertype = 2 Byte
- CRC = 4 Byte
- We'll not include the 64-bit preamble in this calculation for providing an additional error margin
- The size of all the fields except the payload yields:
  12 Byte + 2 Byte + 4 Byte = 18 Byte
- Since the minimum frame's size is 64 Byte, the resulting minimum payload is:
  64 Byte – 18 Byte = **46 Byte**, or 46 Byte · 8 bit/1 Byte = **368 bit.**

Every Ethernet frame must contain at least 368 bit in its payload and, if the upper layer protocol requesting transmission is submitting a payload less than 368 bits, then, the transmitter should ***pad*** it with bits 0 until the desired size is reached. A question comes to mind immediately, how does the receiver find out the actual payload size of a received payload? We leave this question for you to resolve.

The Ethernet also system specifies a ***maximum payload*** size of 1500 Byte, so that no station monopolize the transmission medium.

15. Does there exist an Ethernet MAC address that represents all the hosts belonging to one network? What's the bit pattern of that special MAC address? What's its name?

> The broadcast MAC address is, by convention, the all-1 MAC address = 0xff ff ff ff ff ff. The broadcast MAC address represents all the stations connected to the LAN; when a transmitted Ethernet frame contains the broadcast MAC address in its Destination MAC field, then, all stations must hand it to the upper layer protocols.

16. What's the sentinel that marks the *end of frame* in the Ethernet system?

> Ethernet's end of frame is implicitly derived by a receiver when the medium becomes idle after receiving a frame. The Ethernet frame contains no length field, by contrast, the IEEE 802.3 frame does contain a length field. Both, Ethernet and 802.3 are implemented by NICs of present day.

17. Host H1 in an Ethernet has a number of frames to transmit. Assume no other hosts on the same network want to transmit for the time being, only H1 wants to transmit a frame now, therefore no carrier will be present in the medium when H1 checks CS (Carrier Sense). After H1 finishes transmitting the first of the backlog of frames it wishes to transmit the second frame: How long after the first is finished? (Skim slide no. 113).

> When host H1 finishes transmission of frame no. 1, it must sense the medium again (*CS*, *Carrier Sense*) and find it idle (*No carrier*) for at least IFG seconds (9,6μs), therefore, frame no. 2 will be transmitted later than 9,6μs after frame 1 finished transmission.

18. The 32-bit Jamming Sequence sent by a host when it determines that a collision took place is a fixed bit pattern? Discuss this.

> (No solution provided)

19. Why does the Ethernet system specify that minimum frame length is 512 bits? Consider the number of bits that fit the Rtt that you calculated above (Skim slides 120:123).

> The Rtt of the maximally-configured Ethernet is 51,2μs, known as *slot time* and 512 bits fit into it. Recall, that this is the Rtt resulting when the communicating stations are located at the cable's farthest points, *i.e.,* we are considering the worst case Rtt. Being located so far away, when station S1 and S2 more or less simultaneously monitor CS for initiating a new transmission, they can become aware that no carrier is present, then, after IFG seconds they will start transmitting. Both signal wavefronts move against each other and somewhere in the midst of the cable a collision will occur, which will arrive at station S1 and at station S2. In general, in the worst case, H1 will have to transmit at least 512 bits (The number of bits that fit into the *slot time*) if it wants to know whether the frame underwent a collision and , if that is the case, then proceed accordingly by attempting transmission again.

20. In slide #12 in Pres#3 (See the docs. Section above), observe the behavior of node D, which detects a collision earlier than node B. When the collision's wavefront arrives at D (Marked as "collision detect/abort time") it makes sure a collision is taking place: recall D (a transmitter) *continuously* monitors the average signal power as it transmits, it convinces itself that a collision is taking place since the power associated with the yellow/red wavefront is much higher than that of the red wavefront (Its own transmitted wavefront). What does D do after the "collision detect/abort time"? Indicate where in the diagram is D's Jamming Sequence sent.

D sends a Jamming Sequence after detecting the collision, and will attempt a new transmission of the involved frame at a *randomly distributed* time according to the *exponential backoff algorithm.*

21. An institution has a maximally configured original Ethernet whose length is 2500m and needs to extend it to 3000m. Calculate the minimum Ethernet frame length that allows the access algorithm (CSMA/CD) to function correctly.

Since 51.2 s is the Rtt corresponding to the 2500m length, we can compute the Rtt' corresponding to 3000m, then, again calculate, as we did above, the number of bits that fit into Rtt'

22. Explain the collision timing diagram in slides #12 and #13. Provide a substantial explanation that allows to check whether the idea you have about collisions is correct. Here, we are seeking your writing about collisions, whether it is an accurate, or simply an approximate explanation.

(No solution provided. This question is intended for your working out)

23. Following the indications in Pres. #3, slide #19 and #20, compute the scalability of a shared-medium Ethernet comprised of 200 hosts such that the measured network utilization offered by each is about p = 0,001.

(No solution provided. This question is intended for your working out)

24. Explain why a switched Ethernet, in general, offers much better aggregated throughput than a shared Ethernet, containing both the same number of hosts?

(No solution provided. This question is intended for your working out)