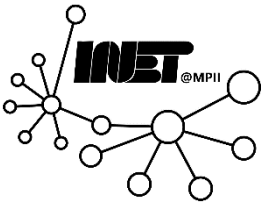
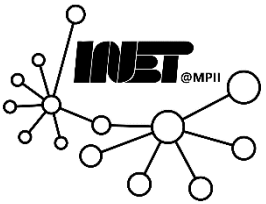
Homework 9

Multimedia & VoIP, Datacenter, SDN



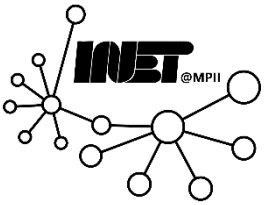
Homework Overview

- Multimedia Applications & VoIP
- Datacenter Networks
- Software Defined Network (SDN)



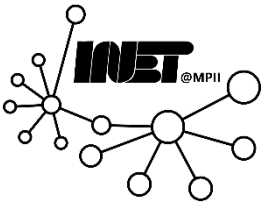
Question 1: Multimedia Applications

Please provide a short answer for the questions below.



Question 1 (a)

Multimedia applications can be classified into three categories. Name and briefly describe each category in 2-3 sentences. State how much they have tolerance to delay, jitter, and packet loss.



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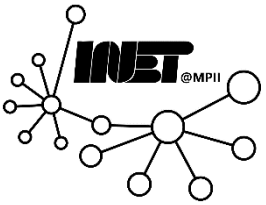
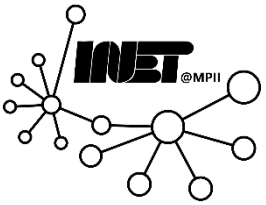


Question 1 (a)

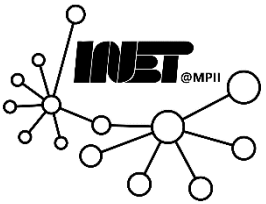
Streaming Stored Audio and Video



Question 1 (a)

Streaming Stored Audio and Video

- prerecorded video/audio
- placed on the server
- requested on demand by the users



Question 1 (a)

Streaming Stored Audio and Video

- prerecorded video/audio
- placed on the server
- requested on demand by the users
- not sensitive to Delay / jitter / packet loss

Question 1 (a)

Conversational Voice- and Video-over-IP

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- real-time
- similar to the traditional circuit-switched telephone service

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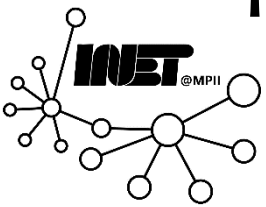
- sensitive to delay and jitter
- occasional loss only causes occasional glitches in audio/video playback



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- similar to traditional broadcast radio/television
- a live radio/television transmission to the users

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- a live radio/television transmission to the users
- sensitive to delay and jitter
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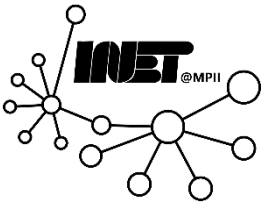
Question 1 (b)

What is the client playout delay? Explain how it can affect the users' experience in two ways.



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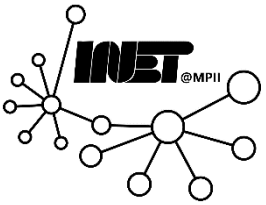
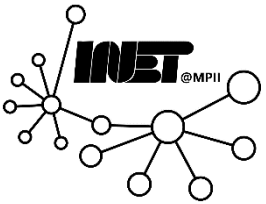


Question 1 (b)

What is the client playout delay? Explain how it can affect the users' experience in two ways.

Answers:

A certain amount of time which client buffered the received data till it renders and plays it.



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Too large: users experience a large delay at any new start

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What is the client playout delay? Explain how it can affect the users' experience in two ways.

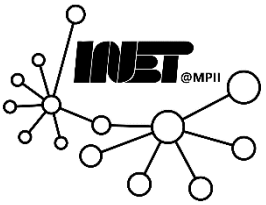
Answers:

Too large: users experience a large delay at any new start

Too small: users might experience multiple refreshing (lags) during rendering.

Question 1 (c)

What is the motivation behind using FEC instead of transport/application layer reliability in VoIP traffic?



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- Reliable delivery of frames is of **little use if retransmissions take too long** to keep the conversation going

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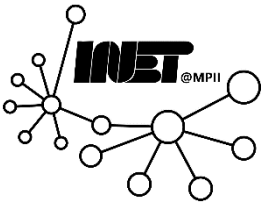
What is the motivation behind using FEC instead of transport/application layer reliability in VoIP traffic?

Answers:

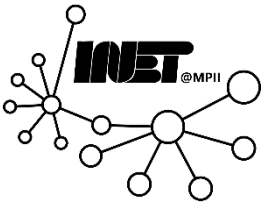
- Reliable delivery of frames is of **little use if retransmissions take too long** to keep the conversation going
- FEC-like mechanisms which **provide recovery without retransmission** appear to be better-suited

Questions?



Question 2(a): Video Streaming

Why are video frames categorized into three types (I-Frames, P-Frames, and B-Frames)?



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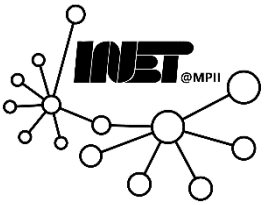


Question 2(a): Video Streaming

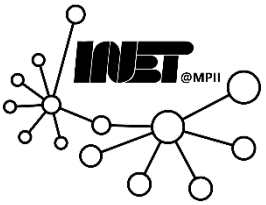
Why are video frames categorized into three types (I-Frames, P-Frames, and B-Frames)?

Answer:

Video is a flow of frames, in order to compress the data of a video we can divide frames into three categories as I,P and B frame.

Question 2(b): Video Streaming

What is the difference between these three types of frames?



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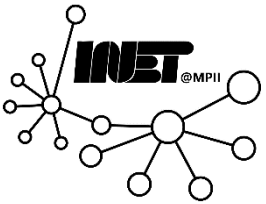
Answers:

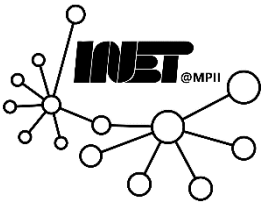
I frames are the most important ones that do not rely on any other frame they are sent periodically.

P frames are predicted frames. These frames contain the changes from proceeding I-frames.

B frames are bidirectional frame, these frames are relative to the past and future I/P frame.



Questions?



Question 3: Hands-on lab for VoIP

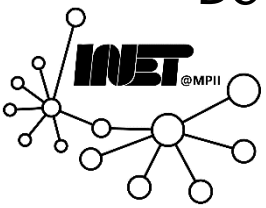
You need Wireshark1 traffic analyzer and a real traffic trace (.pcap files) in order to solve following questions. Do not use any other tools.

In this assignment we set up a lab with a PBX2 and two clients. Clients (Bob and Alice) are able to use VoIP service and PBX is the service provider.

Wireshark provides a set of analysis tools for VoIP traffic, most of them are in the statistics and telephony menus in the main window of the Wireshark. Familiarize yourself with these tools, you will need them to solve all of the following questions.

Important note: Your answers must include description for your reasoning and how did you reach to the answers. In cases you use display filters for a question, provide a snapshot of your filter in your answer sheet.

The VoIP lab topology is as Figure 1. We have traces from two vantage points. One is on Bob side which is the Bob.pcap3 file and the other one is the PBX.pcap3.



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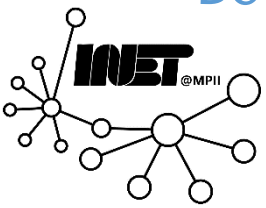

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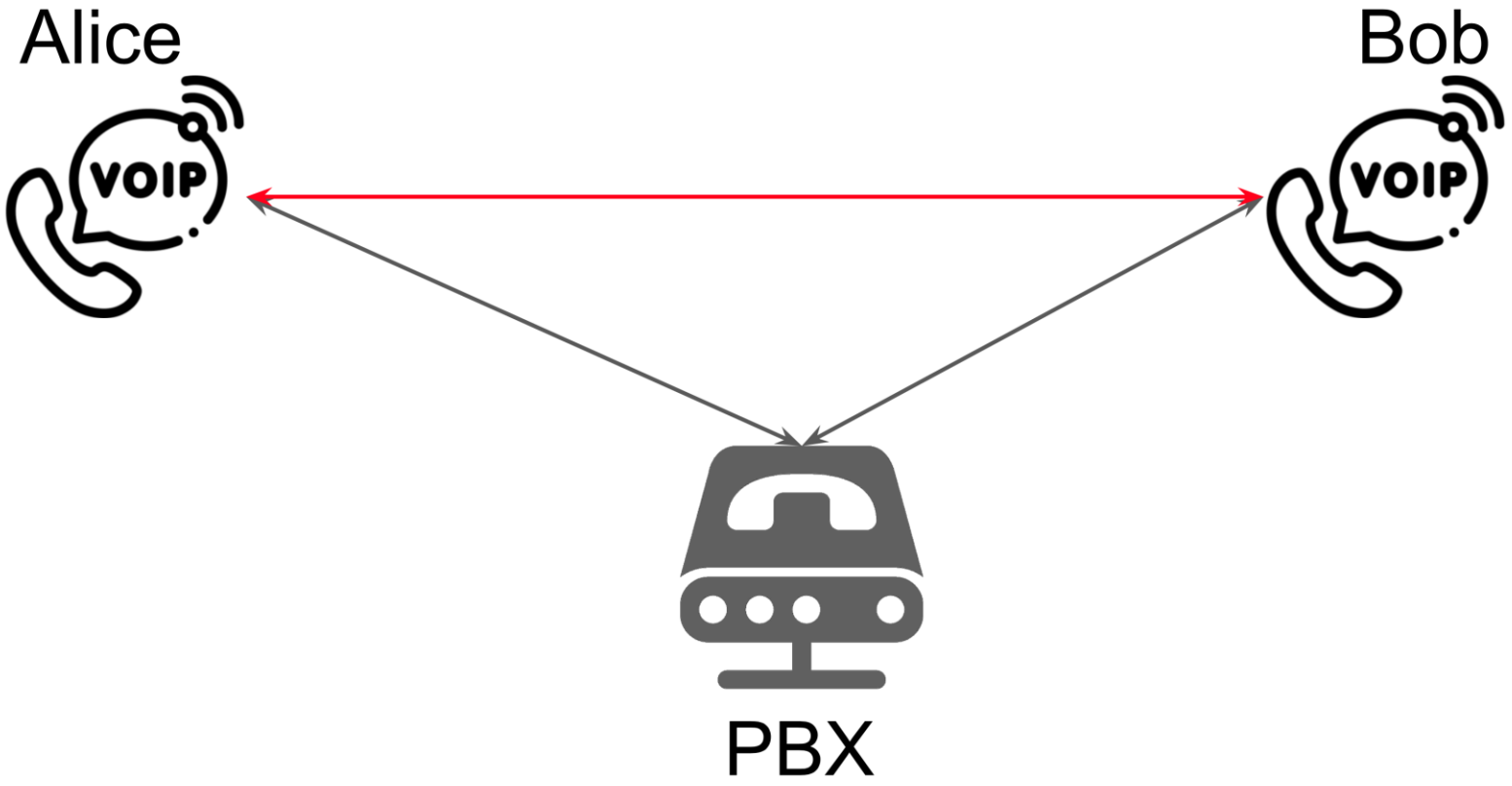

Figure 1: VoIP lab topology.

Question 3 (a)

Based on trace and wireshark analysis fill Table 1 and put a summary on how you identified which IP belongs to which node: (use PBX.pcap file)

	PBX	Alice	Bob
IP Address			

Table 1: IP Addresses

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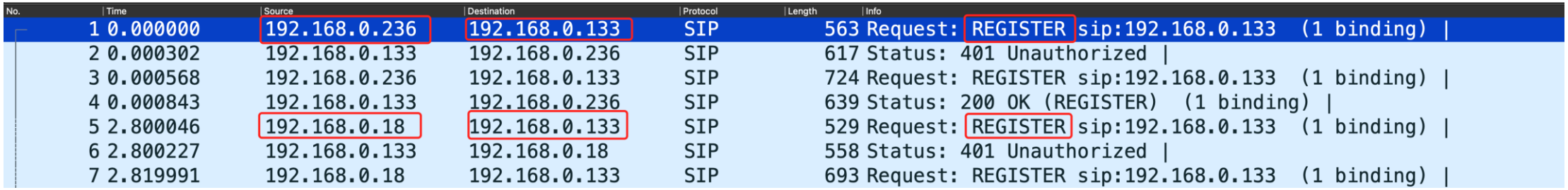
Question 3 (a)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.236	192.168.0.133	SIP	563	Request: REGISTER sip:192.168.0.133 (1 binding) |
2	0.000302	192.168.0.133	192.168.0.236	SIP	617	Status: 401 Unauthorized |
3	0.000568	192.168.0.236	192.168.0.133	SIP	724	Request: REGISTER sip:192.168.0.133 (1 binding) |
4	0.000843	192.168.0.133	192.168.0.236	SIP	639	Status: 200 OK (REGISTER) (1 binding) |
5	2.800046	192.168.0.18	192.168.0.133	SIP	529	Request: REGISTER sip:192.168.0.133 (1 binding) |
6	2.800227	192.168.0.133	192.168.0.18	SIP	558	Status: 401 Unauthorized |
7	2.819991	192.168.0.18	192.168.0.133	SIP	693	Request: REGISTER sip:192.168.0.133 (1 binding) |

For the 1st packet:

```
Internet Protocol Version 4, Src: 192.168.0.236, Dst: 192.168.0.133
User Datagram Protocol, Src Port: 51028, Dst Port: 5060
Session Initiation Protocol (REGISTER)
› Request-Line: REGISTER sip:192.168.0.133 SIP/2.0
⌄ Message Header
  › Via: SIP/2.0/UDP 192.168.0.236:51028;rport;branch=z9hG4bKPjdf56f9bccf1b409
    Max-Forwards: 70
  › From: <sip:alice@192.168.0.133>;tag=141594470f0048689de668a682f67042
  › To: <sip:alice@192.168.0.133>
    Call-ID: 0ad934a3d32d452bbb70b412bee5f040
    [Generated Call-ID: 0ad934a3d32d452bbb70b412bee5f040]
  › CSeq: 35068 REGISTER
    User-Agent: MicroSIP/3.20.5
  › Contact: <sip:alice@192.168.0.236:51028;ob>
```

Question 3 (a)



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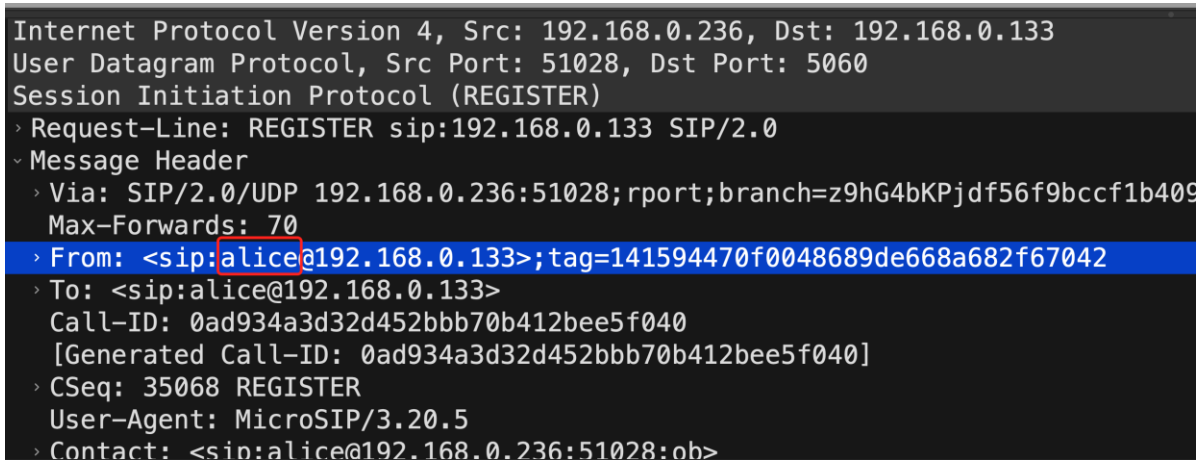

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User Datagram Protocol, Src Port: 51028, Dst Port: 5060
Session Initiation Protocol (REGISTER)
› Request-Line: REGISTER sip:192.168.0.133 SIP/2.0
⌄ Message Header
  › Via: SIP/2.0/UDP 192.168.0.236:51028;rport;branch=z9hG4bKPjdf56f9bccf1b409
    Max-Forwards: 70
  › From: <sip:alice@192.168.0.133>;tag=141594470f0048689de668a682f67042
  › To: <sip:alice@192.168.0.133>
    Call-ID: 0ad934a3d32d452bbb70b412bee5f040
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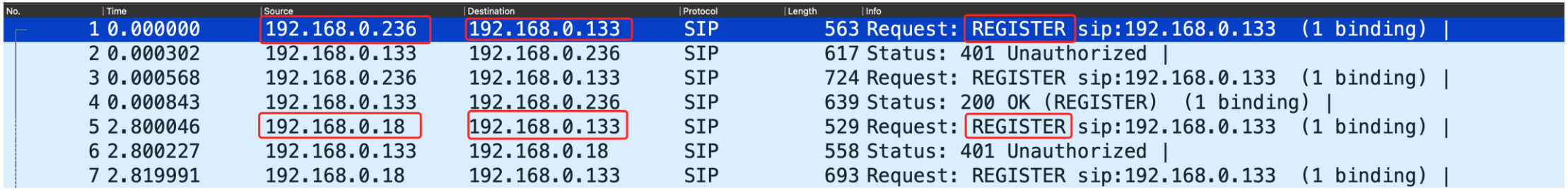
For the 5th packet:

```
› Internet Protocol Version 4, Src: 192.168.0.18, Dst: 192.168.0.133
› User Datagram Protocol, Src Port: 5060, Dst Port: 5060
⌄ Session Initiation Protocol (REGISTER)
  › Request-Line: REGISTER sip:192.168.0.133 SIP/2.0
  ⌄ Message Header
    › Via: SIP/2.0/UDP 192.168.0.18;branch=z9hG4bK232cc8c1-82cca759
    › From: sip:bob@192.168.0.133;tag=f961d7f7-10a453ee
    › To: sip:bob@192.168.0.133
      Call-ID: 8a75dc04-d11a3a9e-a6c70db1-820eaeb4
      [Generated Call-ID: 8a75dc04-d11a3a9e-a6c70db1-820eaeb4]
    › CSeq: 278 REGISTER
    › Contact: <sip:bob@192.168.0.18;x-reg=E6C9F60392C33CD9>;expires=600
      Content-Length: 0
      Expires: 600
      User-Agent: Sipnetic/1.0.37 Android
      Supported: path
```

Question 3 (a)



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7	2.819991	192.168.0.18	192.168.0.133	SIP	693	Request: REGISTER sip:192.168.0.133 (1 binding) |

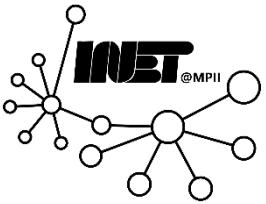
Answers:

	PBX	Alice	Bob
IP Address	192.168.0.133	192.168.0.236	192.168.0.18

IP Addresses

Question 3 (b)

Why do Alice and Bob send register requests twice? What is the difference between them? (use PBX.pcap file)



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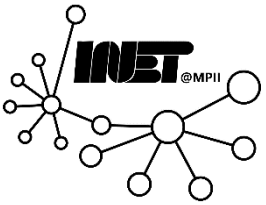

Question 3 (b)

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Answers:

The first register is replied by 401 Unauthorized from the server side, this packet contains WWW-Authenticate header.

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Why do Alice and Bob send register requests twice? What is the difference between them? (use PBX.pcap file)

Answers:

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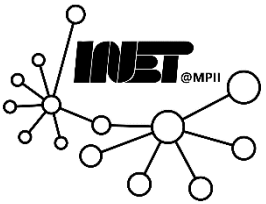
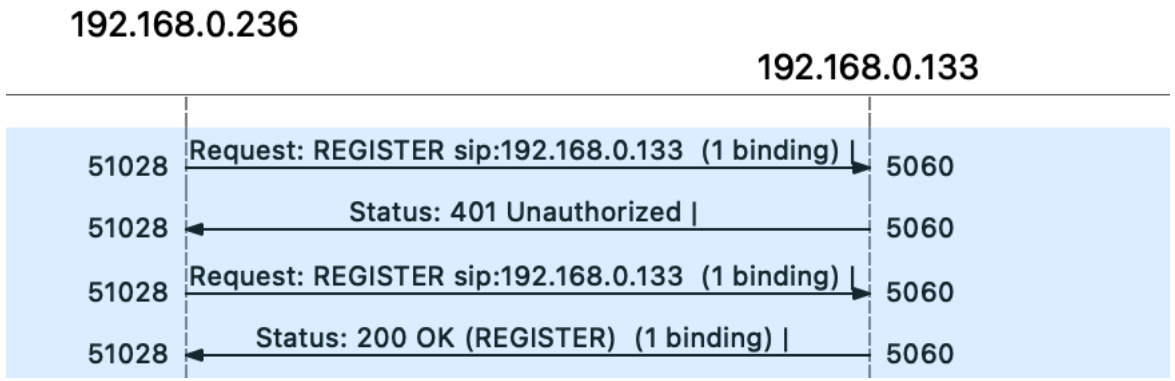
By this header, in the second register, by this header the user can decide about encryption method of its communications password.



Question 3 (b)

Why do Alice and Bob send register requests twice? What is the difference between them? (use PBX.pcap file)

To make the following graph: Statistics - >Flow Graph

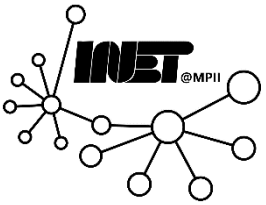


Question 3 (c)

How many calls do you see in this trace and how did you detect them? Fill Table 2 for each call, where did you find this information?(use PBX.pcap file)

Call Reference	Caller (Name - Number 700x)	Calee (Name - Number 700x)	Who hangs up the call	Duration (seconds)

Table 2: Calls list



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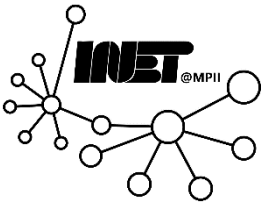

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Apply the filter "sip.Method == "BYE"

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No.	Time	Source	Destination	Protocol	Length	Info
210	68.336003	192.168.0.18	192.168.0.133	SIP	551	Request: BYE sip:7001@192.168.0.133:5060 |
215	68.337916	192.168.0.133	192.168.0.236	SIP	500	Request: BYE sip:alice@192.168.0.236:51028;ob |
646	185.498786	192.168.0.236	192.168.0.133	SIP	420	Request: BYE sip:7002@192.168.0.133:5060 |
652	185.520100	192.168.0.133	192.168.0.18	SIP	509	Request: BYE sip:bob@192.168.0.18;x-reg=E6C9F60392C33CD9 |
1115	264.641059	192.168.0.18	192.168.0.133	SIP	551	Request: BYE sip:7001@192.168.0.133:5060 |
1120	264.643473	192.168.0.133	192.168.0.236	SIP	500	Request: BYE sip:alice@192.168.0.236:50366;ob |

Question 3 (c)

How many calls do you see in this trace and how did you detect them? Fill Table 2 for each call, where did you find this information?(use PBX.pcap file)

Telephony -> VoIP Calls

Start Time	Stop Time	Initial Speaker	From	To	Protocol	Duration	Packets	State	Comments
27.250257	68.336352	192.168.0.18	sip:bob@192.168.0.133	sip:7001@192.168.0.133	SIP	00:00:41	12	COMPLETED	INVITE 401 200
27.293800	68.338184	192.168.0.133	"bob" <sip:7002@192.168.0.133>	<sip:alice@192.168.0.236:51028;ob>	SIP	00:00:41	13	COMPLETED	INVITE 200 200 200
141.472914	185.499258	192.168.0.236	<sip:alice@192.168.0.133>	<sip:7002@192.168.0.133>	SIP	00:00:44	12	COMPLETED	INVITE 401 200
141.477552	185.538902	192.168.0.133	"alice" <sip:7001@192.168.0.133>	<sip:bob@192.168.0.18;x-reg=E6C9F60392C33CD9>	SIP	00:00:44	12	COMPLETED	INVITE 200 200 200
223.073683	264.641276	192.168.0.18	sip:bob@192.168.0.133	sip:7001@192.168.0.133	SIP	00:00:41	12	COMPLETED	INVITE 401 200
223.118813	264.643698	192.168.0.133	"bob" <sip:7002@192.168.0.133>	<sip:alice@192.168.0.236:50366;ob>	SIP	00:00:41	13	COMPLETED	INVITE 200 200 200

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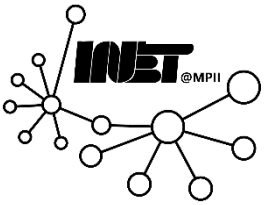
How many calls do you see in this trace and how did you detect them? Fill Table 2 for each call, where did you find this information?(use PBX.pcap file)

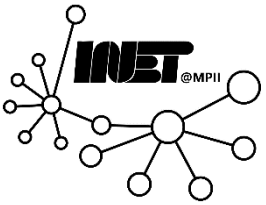
Answers:

Call Reference	Caller (Name - Number 700x)	Calee	Who hangs the call	Duration (s)
1	Bob 7002	Alice 7001	Bob	41
2	Alice 7001	Bob 7002	Alice	44
3	Bob 7002	Alice 7001	Bob	41

Calls list



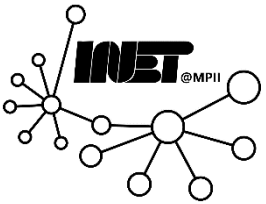
Questions?



Question 4: Datacenter

A new Datacenter topology design, Jellyfish, is to construct a random graph as its topology at the top-of-rack (ToR) switch layer, as Figure 2a. Each ToR switch has some number k of ports, of which it uses r to connect to other ToR switches, and uses the remaining k-r ports for servers.

In this question, we assume there are two data centers with the same number of equipment (switches and servers). One uses Fat tree topology and the other one uses Jellyfish topology.



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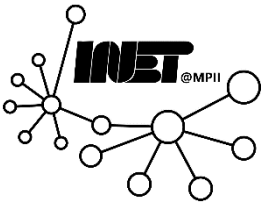

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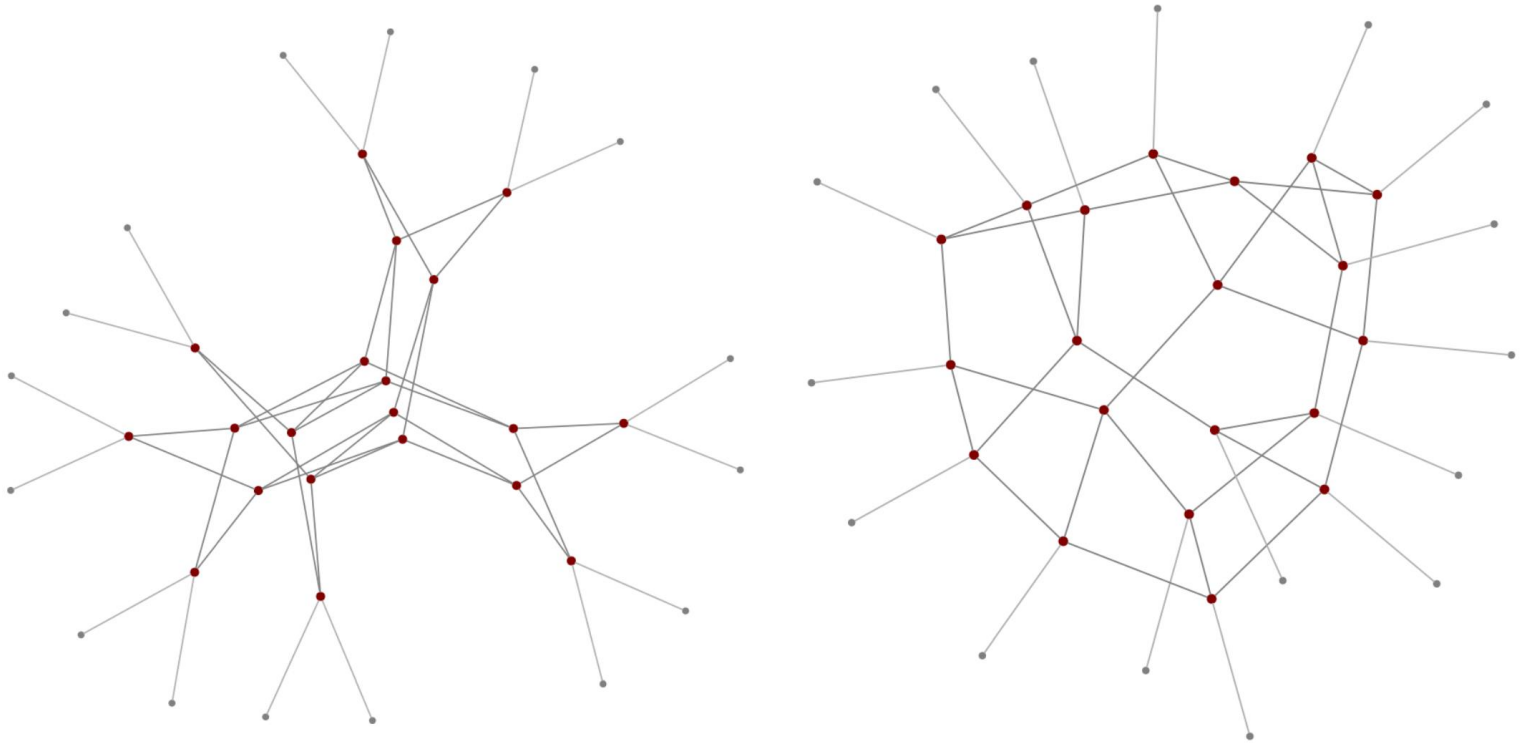

Fat tree topology

Jellyfish topology

Figure 2: Datacenter topologies

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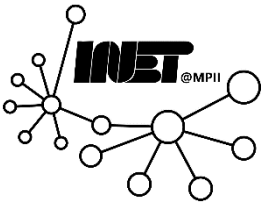

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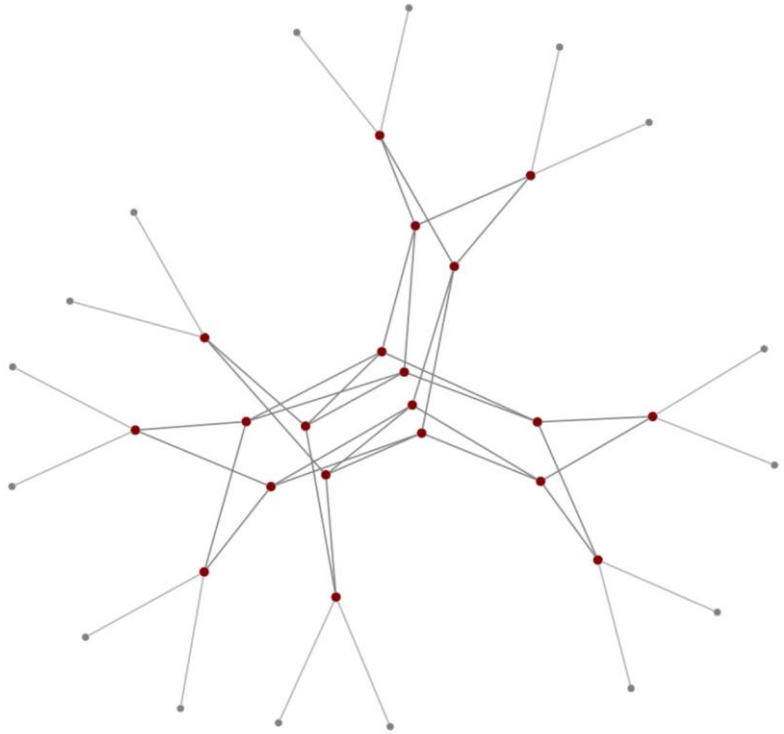

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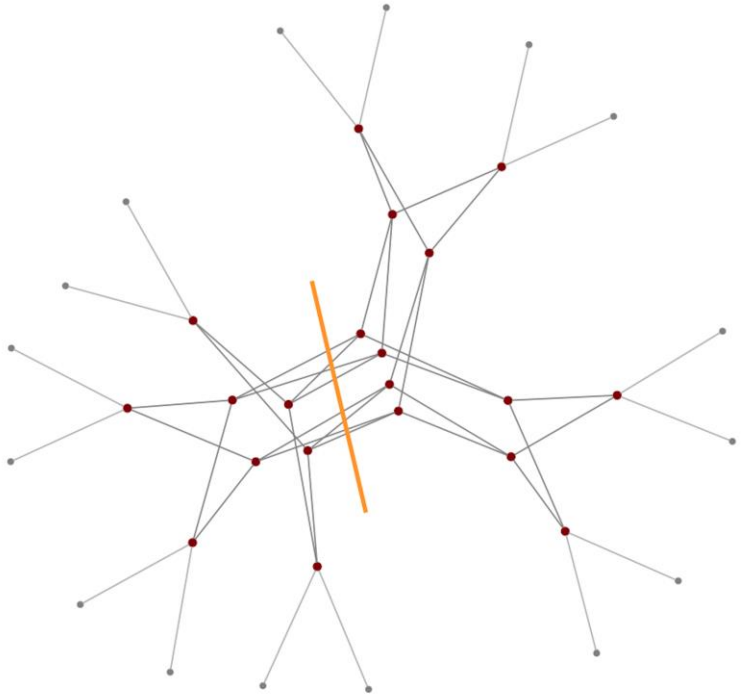

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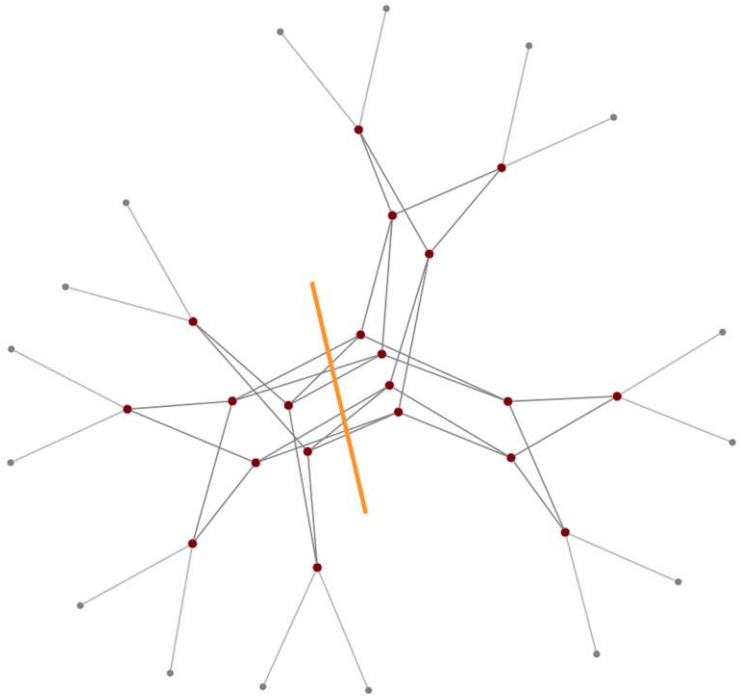
Fat tree bisection width: 8



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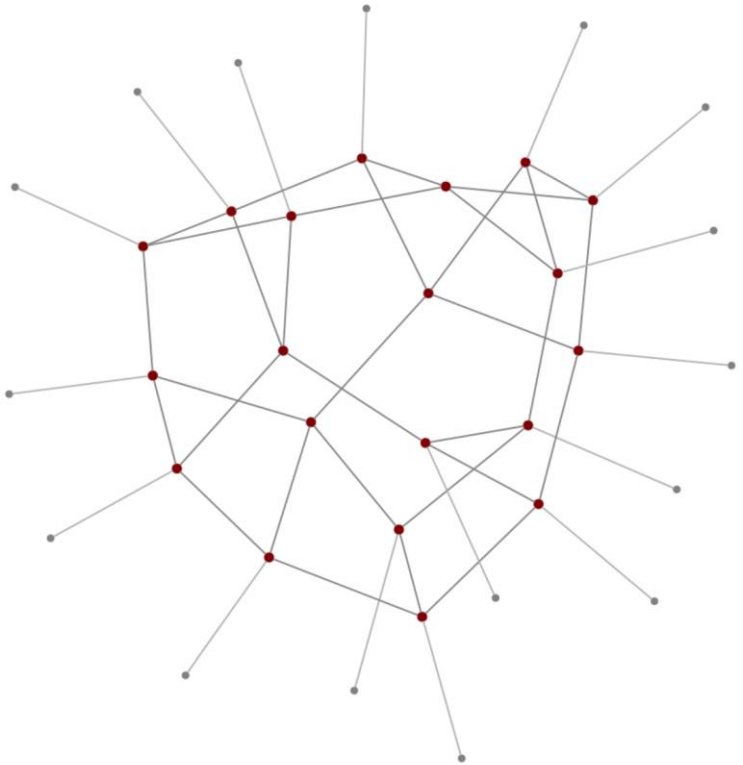

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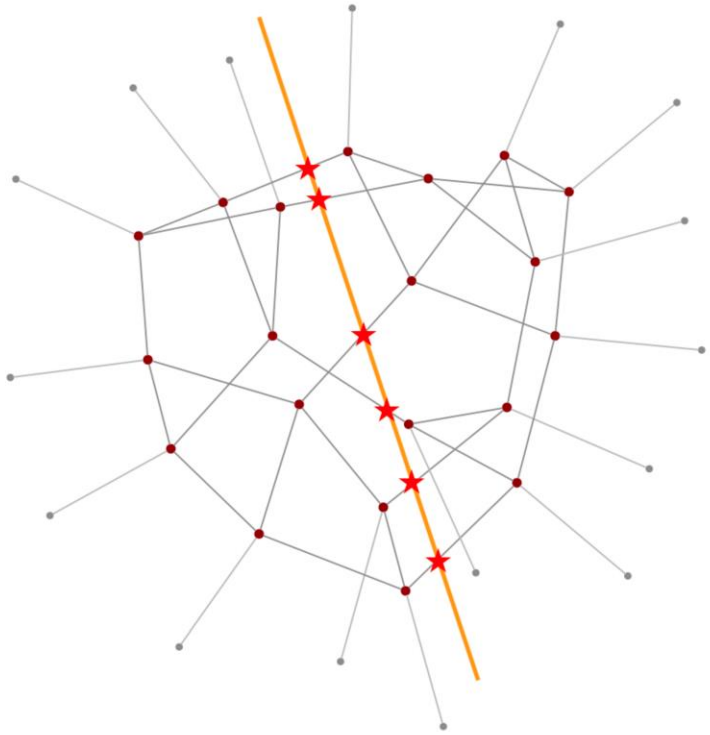

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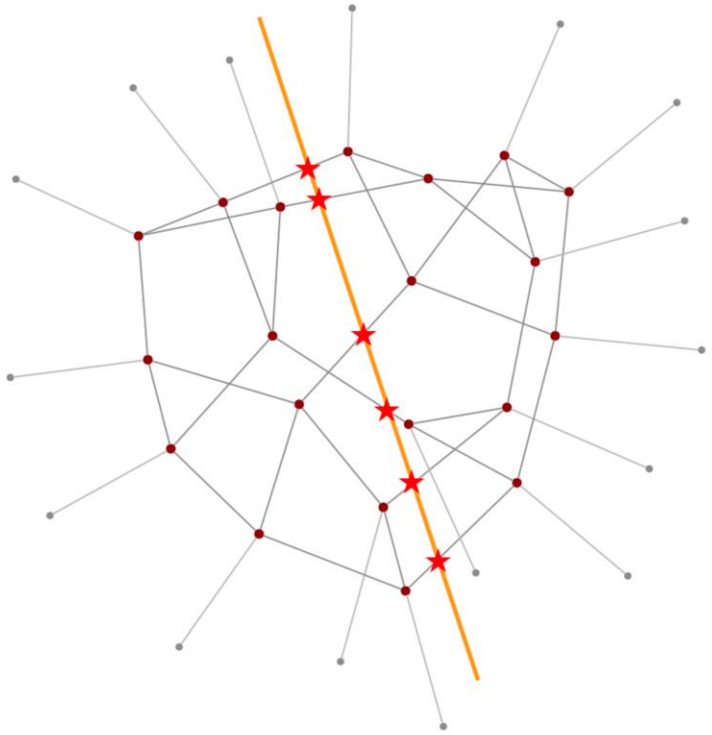

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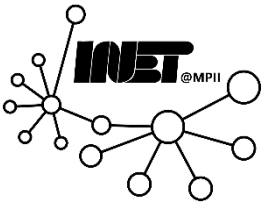
Question 4 (b)

In your opinion, which data center cost more in cabling? Please explain your answer taking into account complexity, maintenance and cable cost.



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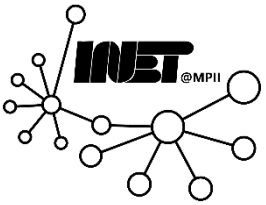

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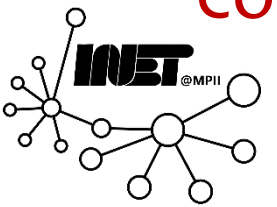
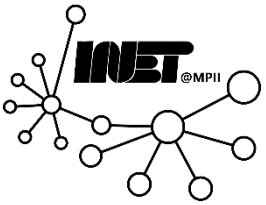
- Jellyfish has higher cable cost. It needs longer cable / more options of cables length because switches are not necessarily connected to switches nearby.



Question 4 (c)

In the random graph, there are usually more than one link between two nodes. But equal-cost multipath routing (ECMP) protocol doesn't work well in the Jellyfish datacenter. Why? What other problems may occur if we simply deploy current routing algorithms to the Jellyfish datacenter?



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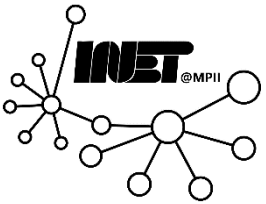
- Most traffic between two nodes would go with the shortest path which leads to traffic unbalance.
- Paths with different costs (hops) may cause packet reordering.



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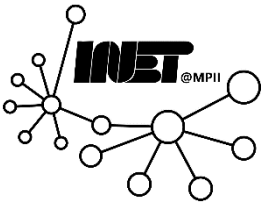
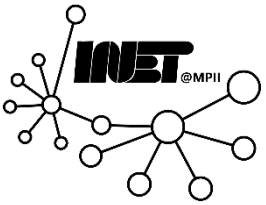


Question 5 (a): SDN

What are the advantages of SDN compared to closed equipment?



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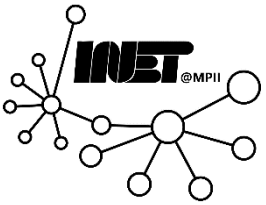

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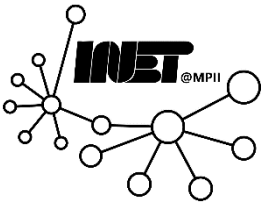

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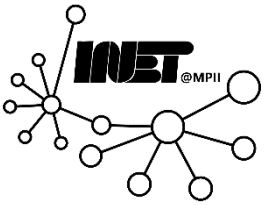

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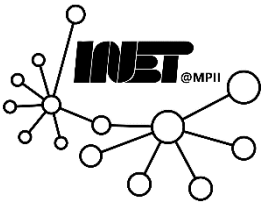

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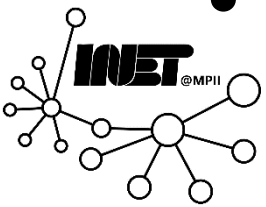

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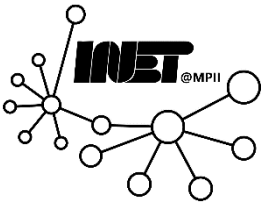

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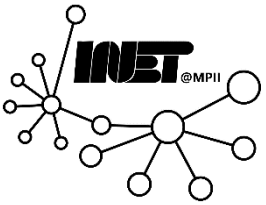

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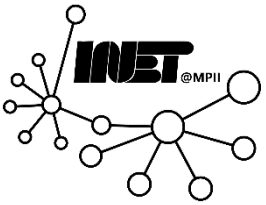
Answers:

- Data plane: packet streaming (e.g. forward, filter, buffer, mark, rate-limit, and measure packets).
- Control plane: track topology changes, compute routes, install forwarding rules

Question 5 (c): SDN

In 2049, we ran out of IPv6 addresses because robots learned how to replicate themselves. However, a genius invented IPv8, for which an address has 256 bits and the processing algorithm takes a new field, “INET”, as input. If you were a network architect in the future world, which SDN technologies we learned in Data Network lectures would you choose to implement IPv8 protocol? Why would you choose it over the other?



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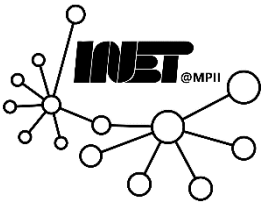

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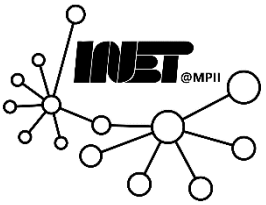

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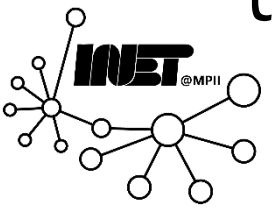
- IPv8 needs a new processing algorithm than the current IP processing algorithm. With P4, programmers can define new processing algorithms but OpenFlow only supports existing actions and there are only limited number of them.



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