Computer Networks

Exercise Session 12

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General Schedule

All exercises will follow this general schedule

- Identify potential understanding problems
  → Ask your questions
  → Recap of the lecture
- Address the understanding problems
  → Answer your questions
  → Repeat certain topics
- Walk through the exercises/solutions → Some hints and guidance
  → Work time or presentation of results

TCP

You have seen . . .

- the functioning and segment structure of TCP
- how flow control works in TCP
- what congestion control is
- which enhancements for TCP exist
- how a TCP connection is implemented with sockets
- what SYN Flood DOS attack is

UDP

You have seen . . .

- the functioning and segment structure of UDP
- that UDP is much simpler compared to TCP and allows for best-effort communication
- how a UDP server and client is implemented with sockets

Other Protocols

You have seen . . .

- SCTP as another connection-oriented transport layer protocol
- DCCP to be used for real-time applications
- QUIC as the newest relevant transport layer protocol to deal with shortcomings of TCP for web traffic

Domain Name System

You have seen . . .

- DNS as an essential protocol to translate between IP addresses and domain names
- the hierarchical namespace for domain names
- that every FQDN is part of a tree
- that this tree is composed below the root servers
- what a resource record is and which type it can have

Remote Shells

You have seen . . .

- Telnet and rlogin/rsh as simple examples for remote access to a host over the Internet
- that the Telnet client may serve as a debugging tool
- how SSH represents very popular and secure alternative for remote access
- that SSH can be used to tunnel traffic through

HTTP

You have seen ...

- HTTP as the basis for the WWW
- that HTTP messages are composed of a header and a body
- different types of HTTP methods and status codes
- how an HTTP request can look like
- the differences from HTTP/1.0 to HTTP/3

Email

You have seen . . .

- what a MUA and a MTA are
- that an every email consists of an envelope, a header, and a body
- SMTP, POP, and IMAP as the central protocols for email exchange
- how email suffers from various issues like Spam or Phishing
- more modern protocols and extensions to email to improve the security of the system
- how a SMTP communication looks like

More Protocols

You have seen . . .

- MQTT as a very relevant pub-sub protocol for IoT applications
- Signal as a secure protocol for instant messaging
- CoAP as a lightweight alternative to HTTP for constrained-node networks

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   Introducing a new transport layer protocol on Internet scale is difficult. CoAP is designed to enable end-to-end connection between hosts in the Internet and *things*. Integrating a new transport layer implementation in all clients is difficult.

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   - Requests:

     Confirmable – Expects an acknowledgement
     Non-confirmable – Does not expect an acknowledgement
   - Responses:

     Acknowledgement – Acknowledges a confirmable message
     Reset – Indicates that it had received a message but could not process it

Exercise 2: TCP and UDP

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   - *UDP*
     - *Connectionless Transport Layer protocol. Transmissions take place without previous connection establishment.*
     - *More simple protocol in contrast to the connection-oriented TCP. Only responsible for addressing of the segments. Does not secure the data transmission.*
     - *The receiver does not acknowledge transmissions at the sender. Segments can get lost during transmission.*
   - *TCP*
     - *Connection-oriented Transport Layer protocol.*
     - *Makes connections via IP reliable in a way that is desired or simply necessary for many applications.*
     - *Guarantees that segments reach their destination completely and the correct order. Lost or unacknowledged TCP segments are requested by the receiver at the sender.*

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   Sockets are the platform-independent, standardized interface between the implementation of the transport layer protocols in the OS and the applications.

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   The receiver notifies the sender about free storage capacity in the receive window not before 25% of the reception buffer is free or a segment size of size MSS can be received.

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    The linear growth phase after a configures threshold has exceeded.

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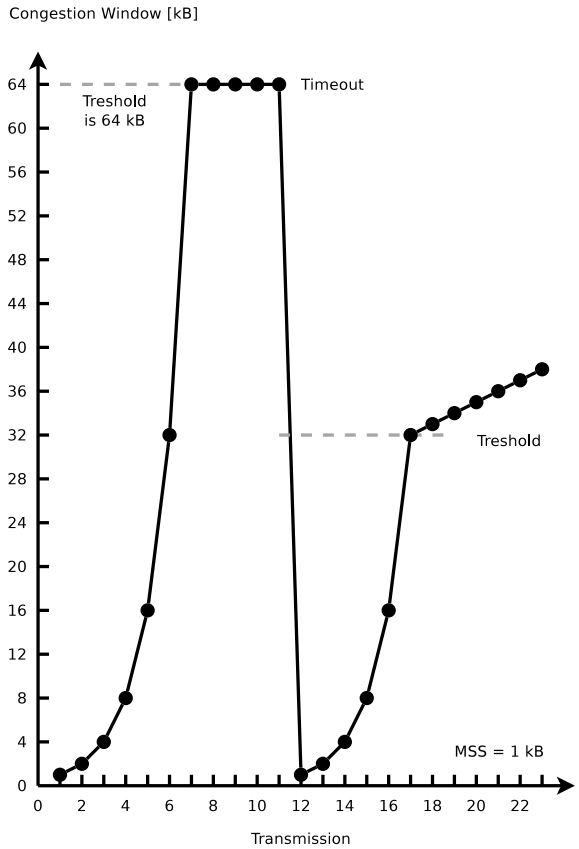
13 Mark in the figure both the slow-start phase and the congestion avoidance phase.



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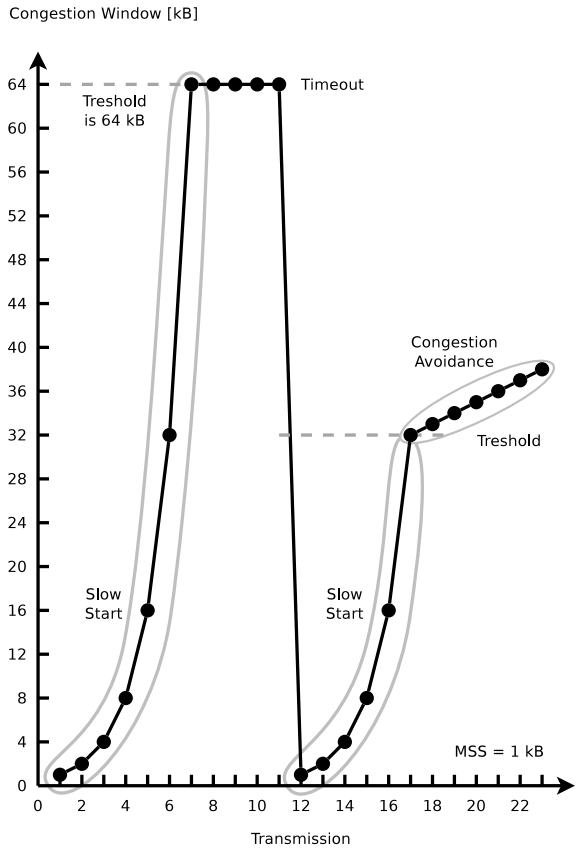

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15 Describe what fast recovery is.

The slow-start phase after three duplicate ACKs arrived is avoided. If three duplicate ACKs arrive, the congestion window is set directly on the threshold value.

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16 The concept of TCP congestion control is called **AIMD** (= Additive Increase / Multiplicative Decrease). **Describe the reason** for the aggressive reduction and conservative increase of the congestion window.

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16 The concept of TCP congestion control is called **AIMD** (= Additive Increase / Multiplicative Decrease). **Describe the reason** for the aggressive reduction and conservative increase of the congestion window.

The consequences of a congestion window which is too large in size are worse than for a window which is too small. If the window is too small in size, available bandwidth remains unused. If the window is too large in size, segments will get lost and must be transmitted again. This increases the congestion of the network even more! The congestion state must be left as fast as possible. Therefore, the size of the congestion window is reduced significantly.

Exercise 2: TCP and UDP

17 Describe the functioning of a Denial-of-Service attack via **SYN flood**.

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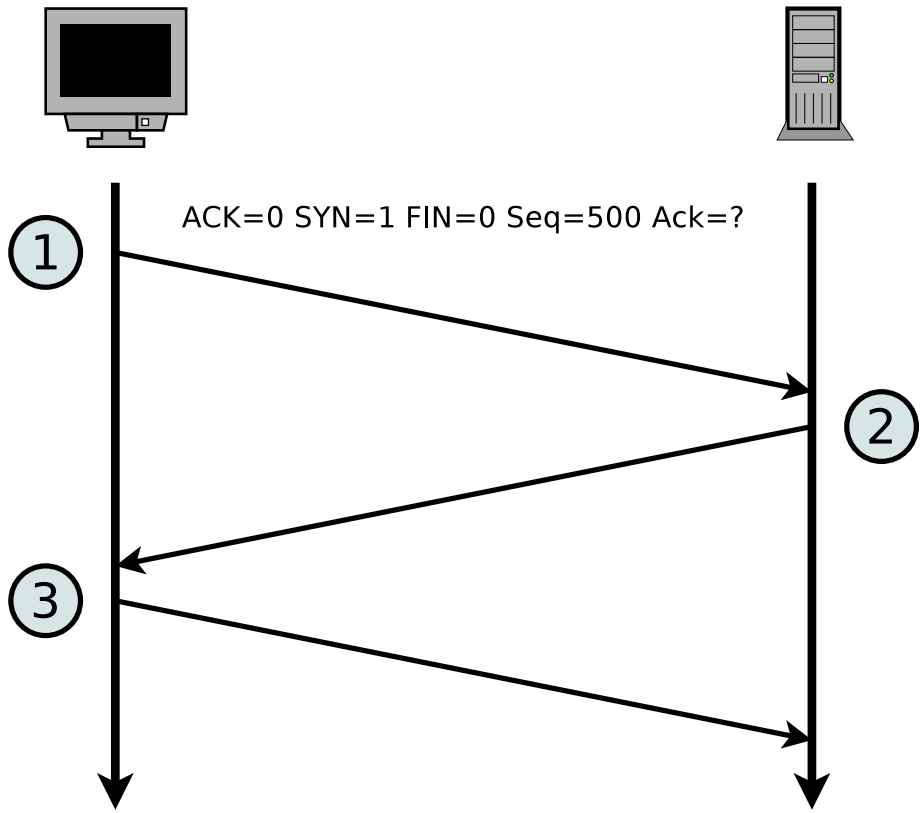
17 Describe the functioning of a Denial-of-Service attack via **SYN flood**.

A client sends many connection requests (*SYN*), but does not respond to the acknowledgments (*SYN ACK*) of the server via *ACK*. The server waits some time for the acknowledgment of the clients because the delay of the confirmation could be caused by a network issue. During this period, the address of the client and the status of incomplete connection are stored in the memory of the network stack. By flooding the server with connection requests, the table which stores the TCP connections in the network stack is completely filled. This causes the server to become unable to establish new connections. The memory consumption at the server may become this large that the main memory gets completely filled and the server crashes.

Exercise 3: TCP Connections

1. The diagram shows the establishment of a TCP connection. Complete the information in the table for TCP messages 2 and 3 according to TCP messages 1.



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2					1000	
3						

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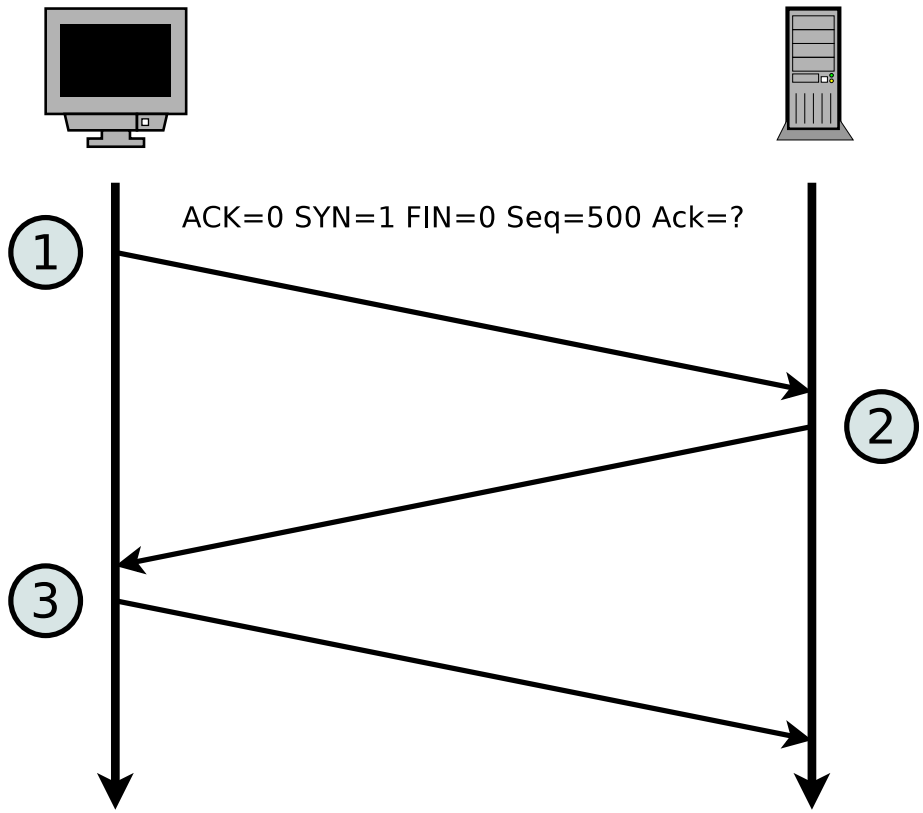

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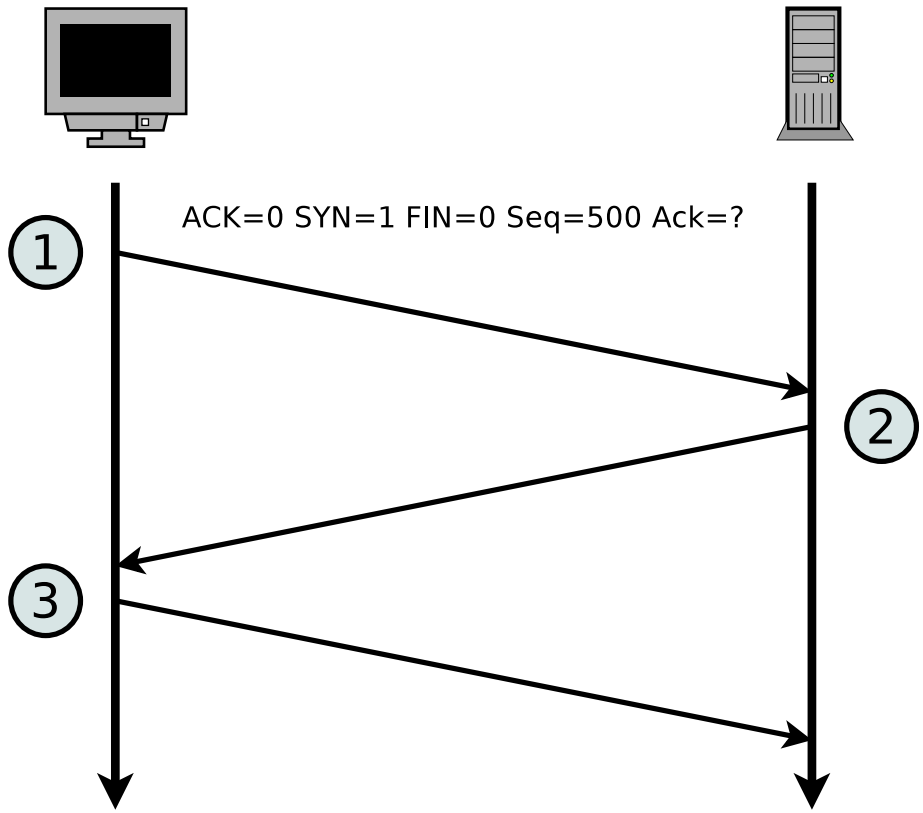

Message	ACK	SYN	FIN	Payload length	Seq number	ACK number
1	0	1	0	0	500	0
2	1	1	0	0	1000	501
3	1	0	0	0	501	1001

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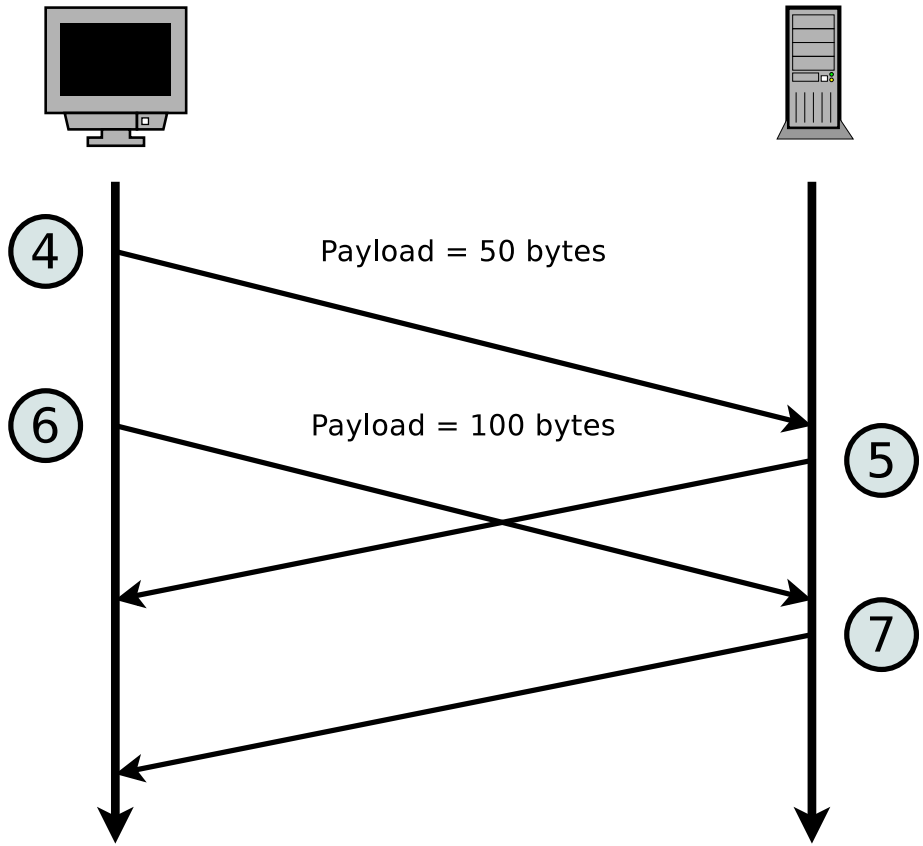
2 The diagram shows an excerpt of the transmission phase of a TCP connection. Complete the table.



Message	ACK	SYN	FIN	Payload length	Seq number	ACK number
4	0			50	501	1001
5	1			0		
6	0			100		
7	1			0		

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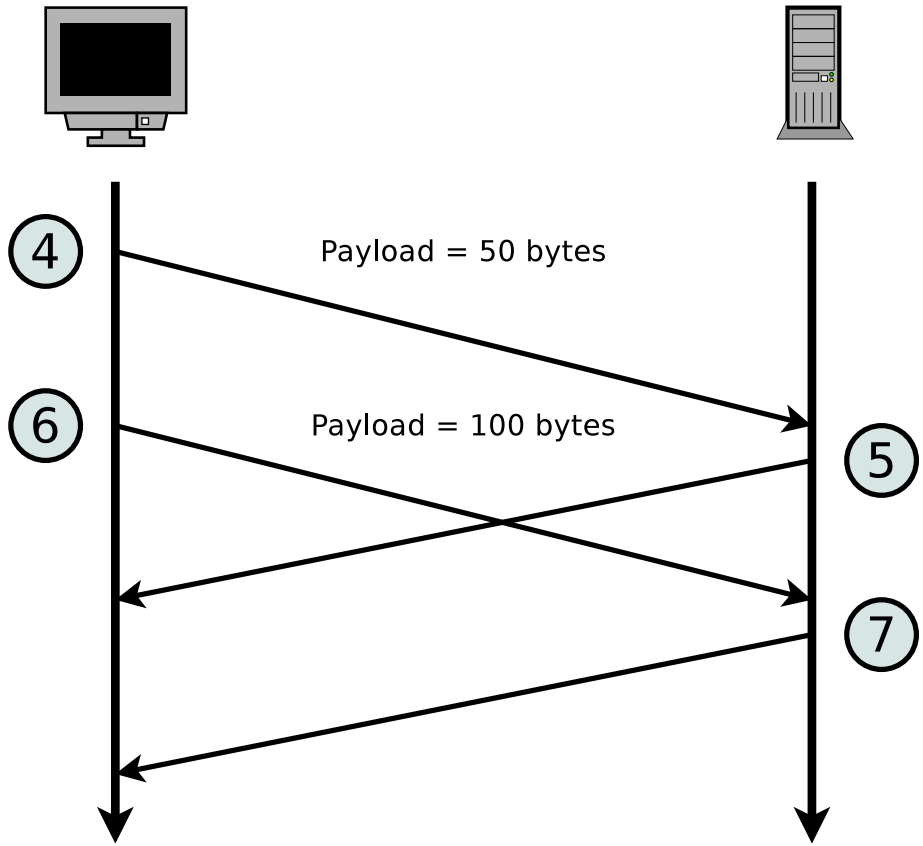

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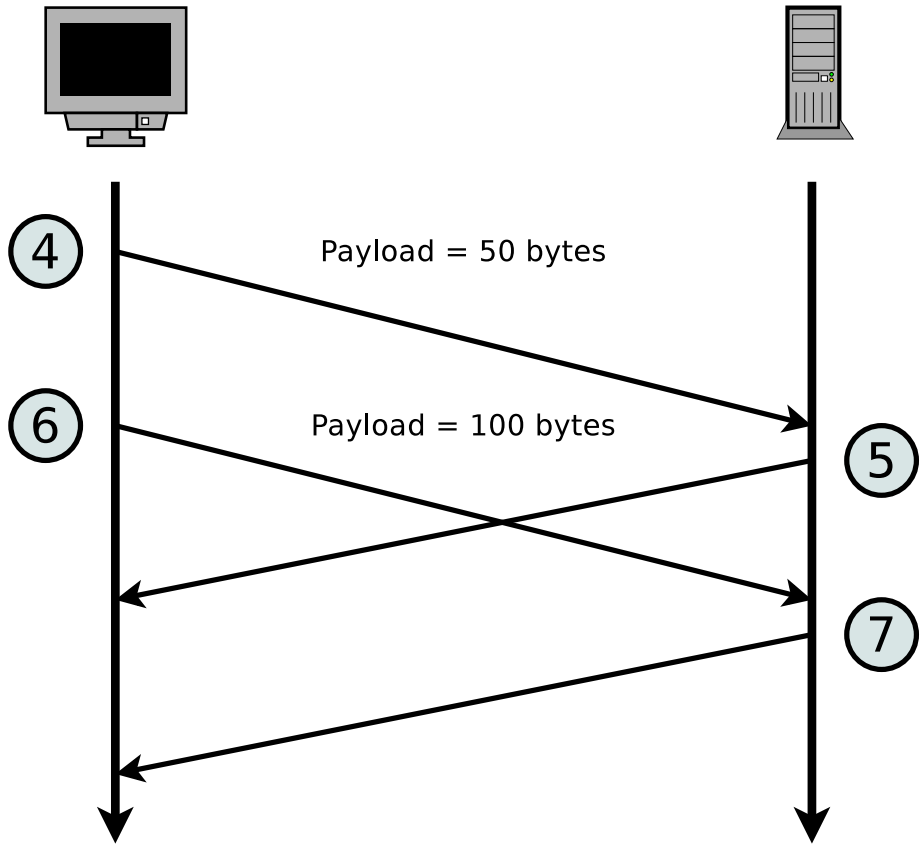

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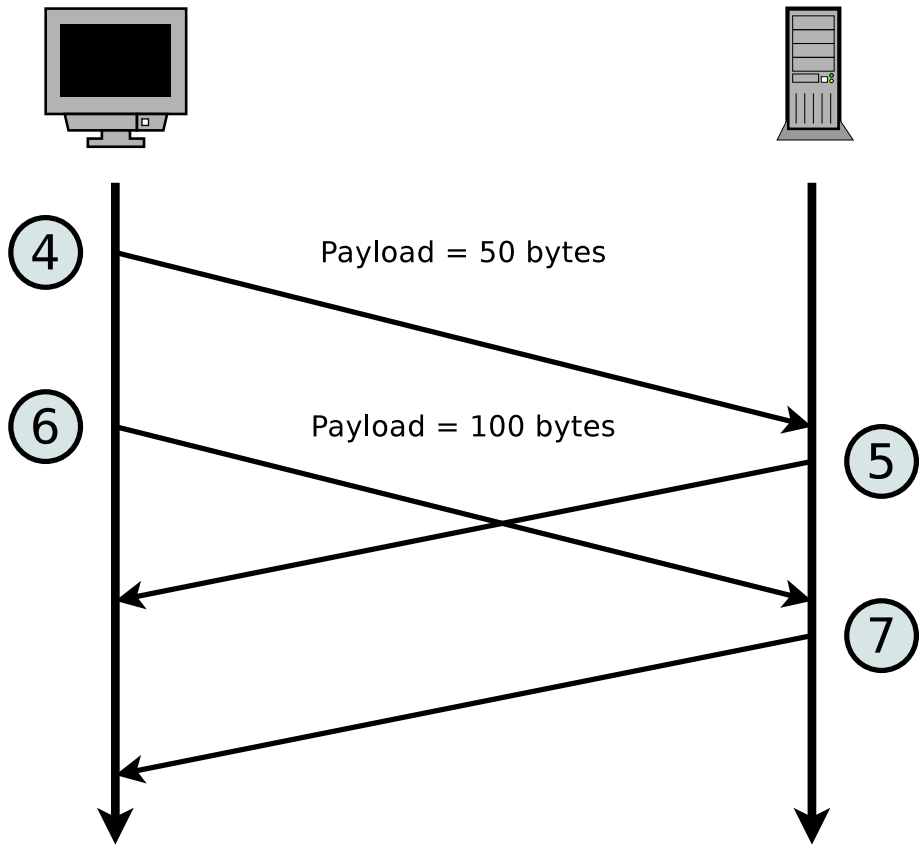

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5	1	0	0	0	1001	551
6	0	0	0	100	551	1001
7	1	0	0	0	1001	651

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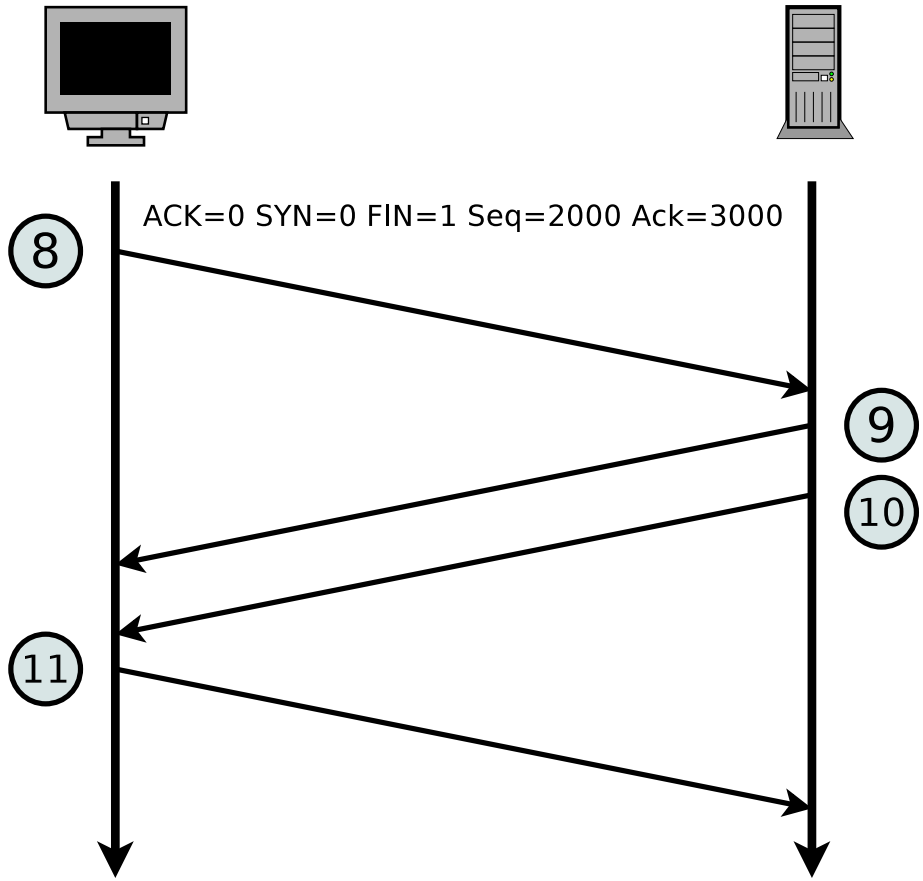
3 The diagram shows the termination of a TCP connection. Complete the table.



Message	ACK	SYN	FIN	Payload length	Seq number	ACK number
8	0	0	1	0	2000	3000
9				0		
10				0		
11				0		

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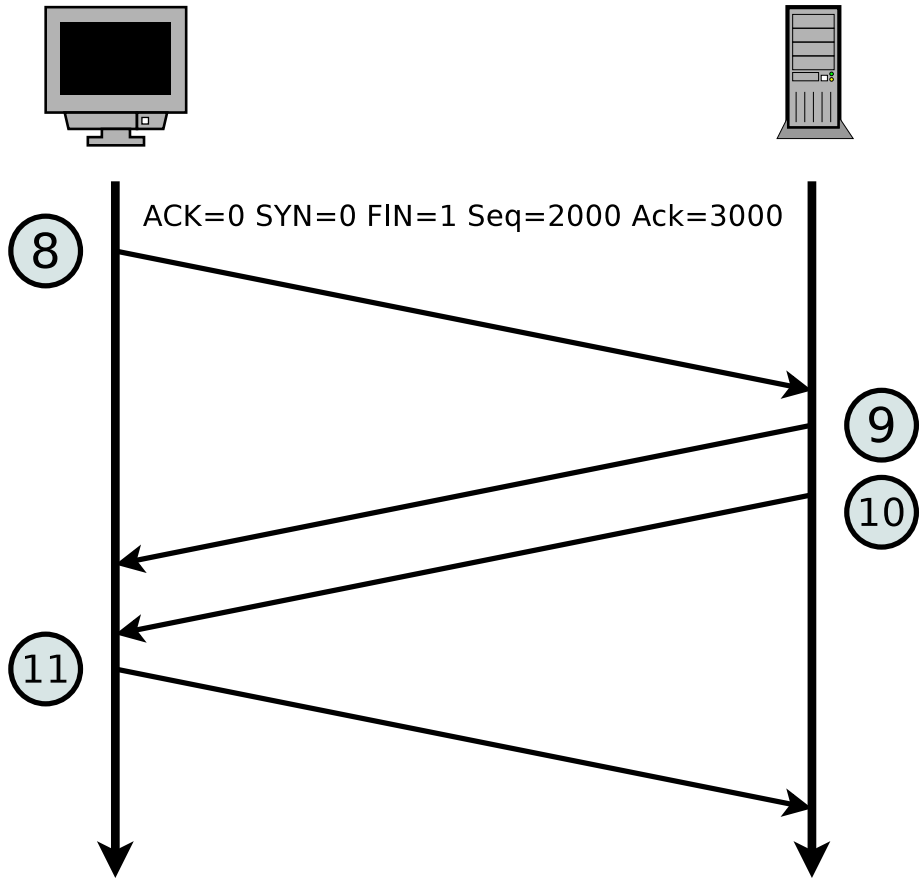

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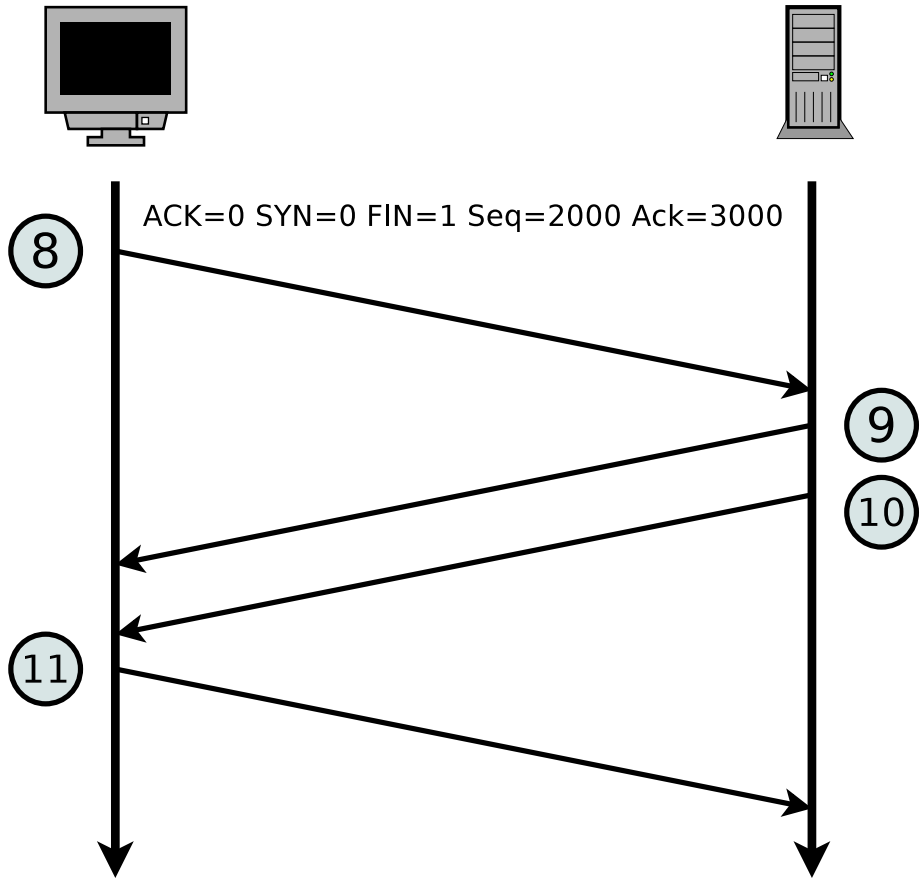

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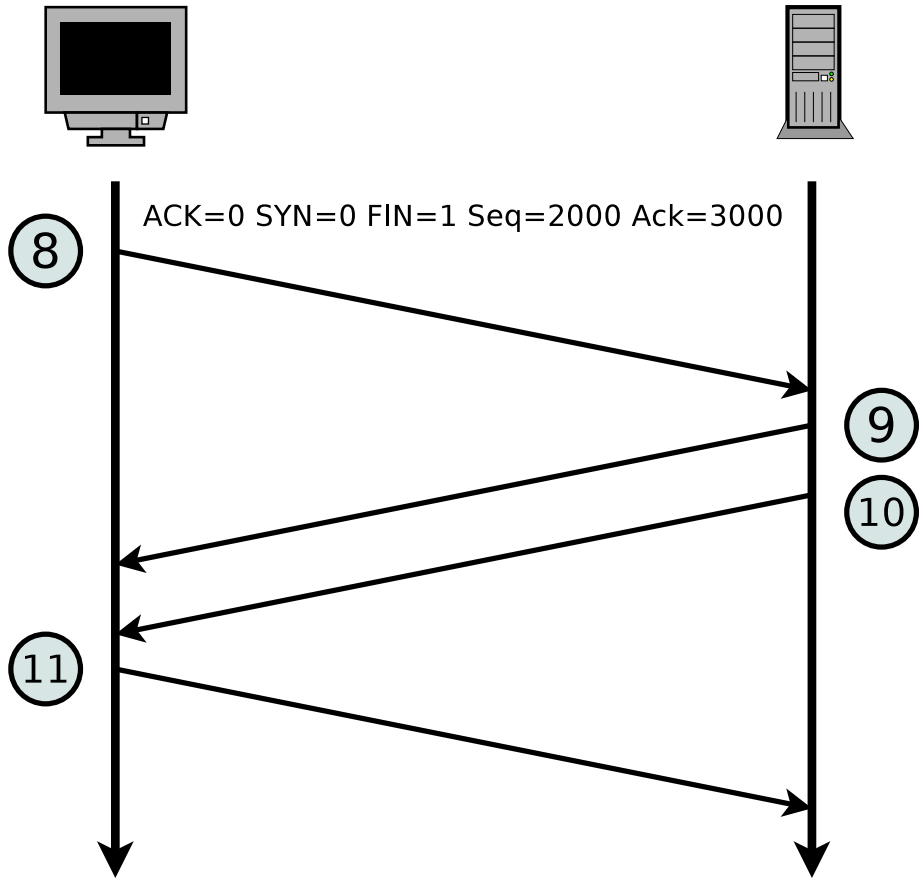

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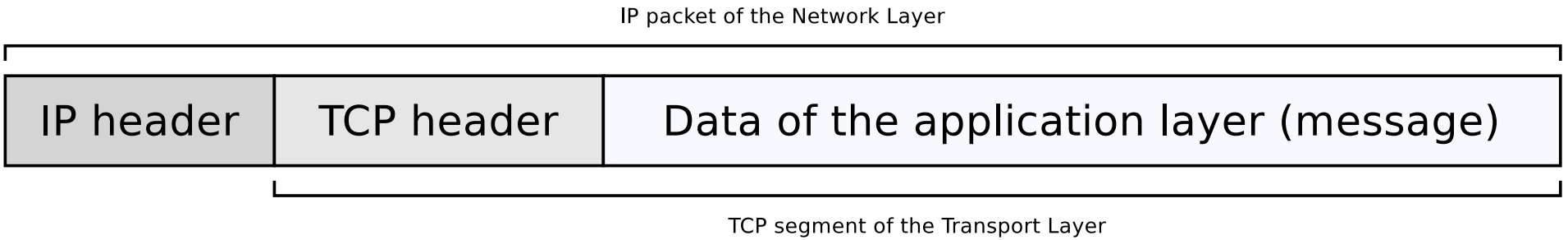
   The higher the bandwidth-delay product, the more data is *stored* in the line. The more data is stored in the line, the longer a sender has to wait for an acknowledgement. The longer a sender has to wait for an ACK, the lower the efficiency.

Exercise 5: Header and Payload

An application generates 40 bytes payload which is first packed into a single TCP segment, and then packed into a single IP packet. What is the percentage of header data in the IP packet and what is the percentage of application generated payload?



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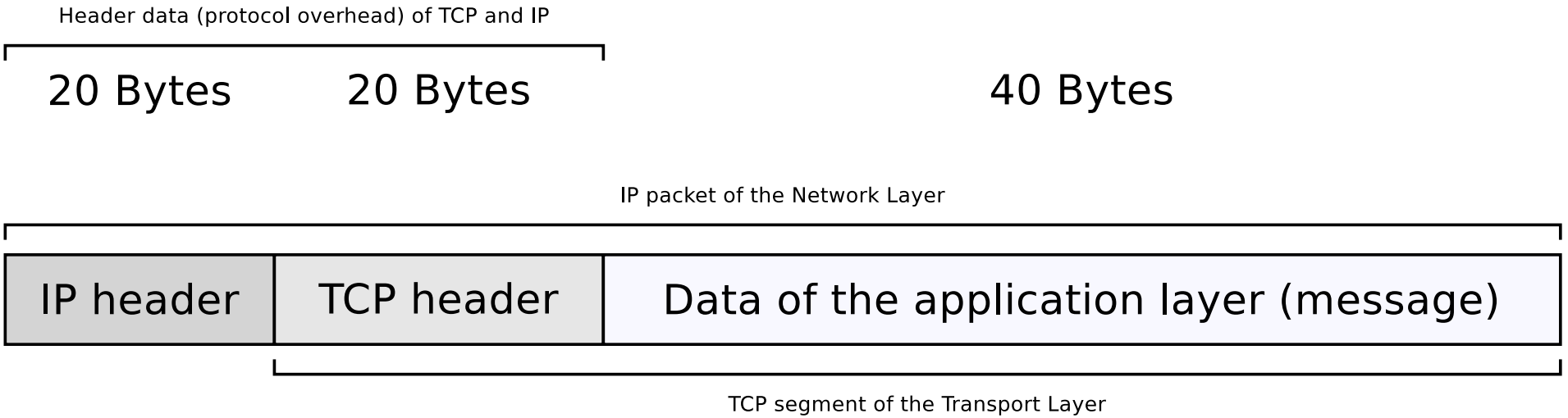

TCP header = usually 20 bytes
IP header = usually 20 bytes
$\Longrightarrow$ the IP packet contains usually 40 bytes (= 50%) header data.

Exercise 6: Domain Name System

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   The problem usually does not occur. DNS names must be shorter than 256 bytes. The standard requires this. Thus, all DNS names fit in a single minimum-length packet. In other cases (for other RR types) TCP can be used.

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Exercise 7: Networking Applications

1. Describe which protocols are involved when you boot up your computer, open a web browser, go to the `https://webmail.frankfurt-university.de`, login, and send an email to `oliver.hahm@fb2.fra-uas.de`.

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   At boot time DHCP (over UDP, IPv4, and Ethernet/WLAN) or SLAAC (over IPv6) may be used to obtain an IP address

   Accessing the webmail page Uses HTTP over TCP, IP and layer 2

   Login to the mailserver Uses HTTP POST and IMAP (again over TCP/IP and layer 2)

   Send a mail Uses HTTP POST (and maybe PUT) plus SMTP (again over TCP/IP and layer 2)

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   SMTP is used to between MTAs and for sending mails from the MUA. IMAP and POP can be used to retrieve mails from the server.

Exercise 8: Do some research

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2. The original congestion control algorithm in TCP was called Tahoe. Many other algorithms were introduced over the last decades. Name two of them that can be used without any knowledge about the TCP implementation on the receiver side and two that requires information about the receiver's TCP implementation.

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   Vegas and CUBIC require no changes at the receiver side. TFRC and MaxNet require modifications on the receiver side as well.

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   A SMTP should only accept mails that it can deliver locally or forward (*relay*) mails from an authenticated and authorized user. If a mail server relays all mails of any user it its called an *open relay* and can be exploited to send spam mails.