Name	**Vorname**
Studiengang (Hauptfach)	**Fachrichtung (Nebenfach)**
Matrikelnummer	**Unterschrift der Kandidatin/des Kandidaten**

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TECHNISCHE UNIVERSITÄT MÜNCHEN

Fakultät für Informatik

☐ **Midterm-Klausur**
☒ **Final-Klausur**

☐ **Semestralklausur**
☐ **Diplom-Vorprüfung**
☐ **Bachelor-Prüfung**
☐ .....

☐ **Einwilligung zur Notenbekanntgabe per E-Mail / Internet**

Prüfungsfach: Master Course: Computer Networks

Prüfer: Prof. Dr.-Ing. Georg Carle **Datum: February 16, 2013**

Hörsaal: ..... **Reihe:** ..... **Platz:** .....

Nur von der Aufsicht auszufüllen:

Hörsaal verlassen **von ..... : .....** **bis ..... : .....**

Vorzeitig abgegeben **um ..... : .....**

Besondere Bemerkungen:

Endterm

Master Course: Computer Networks

Prof. Dr.-Ing. Georg Carle
Chair for Network Architectures and Services
Department of Computer Science
Technische Universität München

Saturday, February 16, 2013
9:00 a.m. – 10:00 a.m.

- This exam consists of **15 pages** and a total of **4 problems** as well as an **additional handout** which contains a reference of protocol headers. Please make sure that you got a complete copy of all documents.
- Write your name and matriculation number in the header of **every** page.
- Do neither write with red / green colors nor use pencils.
- The total amount of credits is 50.
- This exam is **closed book**, i. e., lecture notes, homework, cheat sheets, pocket calculators etc. are **not** allowed.
- Turn off your mobile phones and put them into your bag.
- Problems marked by * can be solved without knowledge of previous results.
- **Results are only rated if your approach is reproducible**. If not instructed otherwise, state a reason for all your answers.

Problem 1 Protocol dissemination (8 credits)

8

Consider the hexdump (network byte order) given in Table 1. It shows an IEEE 802.3 FastEthernet frame (preamble and checksum are stripped). In the following we will disseminate this frame step by step. The additional handout accompanying the exam might be helpful.

Byte	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0000	00	25	90	57	1f	dc	28	37	37	02	32	41	86	dd	60	00
0010	00	00	00	23	11	40	20	01	4c	a0	20	01	00	11	5d	92
0020	47	55	86	2e	34	65	20	01	4c	a0	20	01	00	17	00	00
0030	00	00	00	00	01	97	d8	ad	00	35	00	23	fa	1b	08	7f
0040	01	00	00	01	00	00	00	00	00	00	06	67	6f	6f	67	6c
0050	65	02	64	65	00	00	01	00	01							

Table 1: Hexdump (network byte order) of an IEEE 802.11 FastEthernet frame, preamble and checksum are stripped.

a)* Explain the difference between host and network byte order.

1

b) Which network layer protocol is being used (give a reason)?

1

c) Which transport layer protocol is being used (give a reason)?

1

d) What kind of payload does the frame carry (give a reason)?

1

1

e) What is the protocol identified in (d) being used for?

Assume that the frame given in Table 1 is going to be transmitted through an MPLS network. The MPLS header is depicted in Figure 1.1.

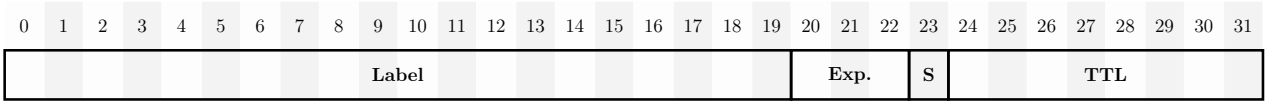


Figure 1.1: MPLS header (offset in bit)

1

f)* At which point of the frame is the MPLS header inserted?

1

g)* Explain what the label field is used for.

1

h)* What is the advantage of using MPLS?

Problem 2 Traceroute and IP alias resolution (15 credits)

/ 15

This problem covers the well-known tool `traceroute` and techniques to resolve IP aliases.

a)* Briefly describe how `traceroute` works. / 2

b)* Optionally `traceroute` may use TCP instead of UDP or ICMP. State two advantages / disadvantages. / 1

c)* In practice, paths between two nodes on the Internet are often asymmetric, i. e., the path from some node A to B is different from the reverse path. Give two possible reasons for this phenomenon. / 2

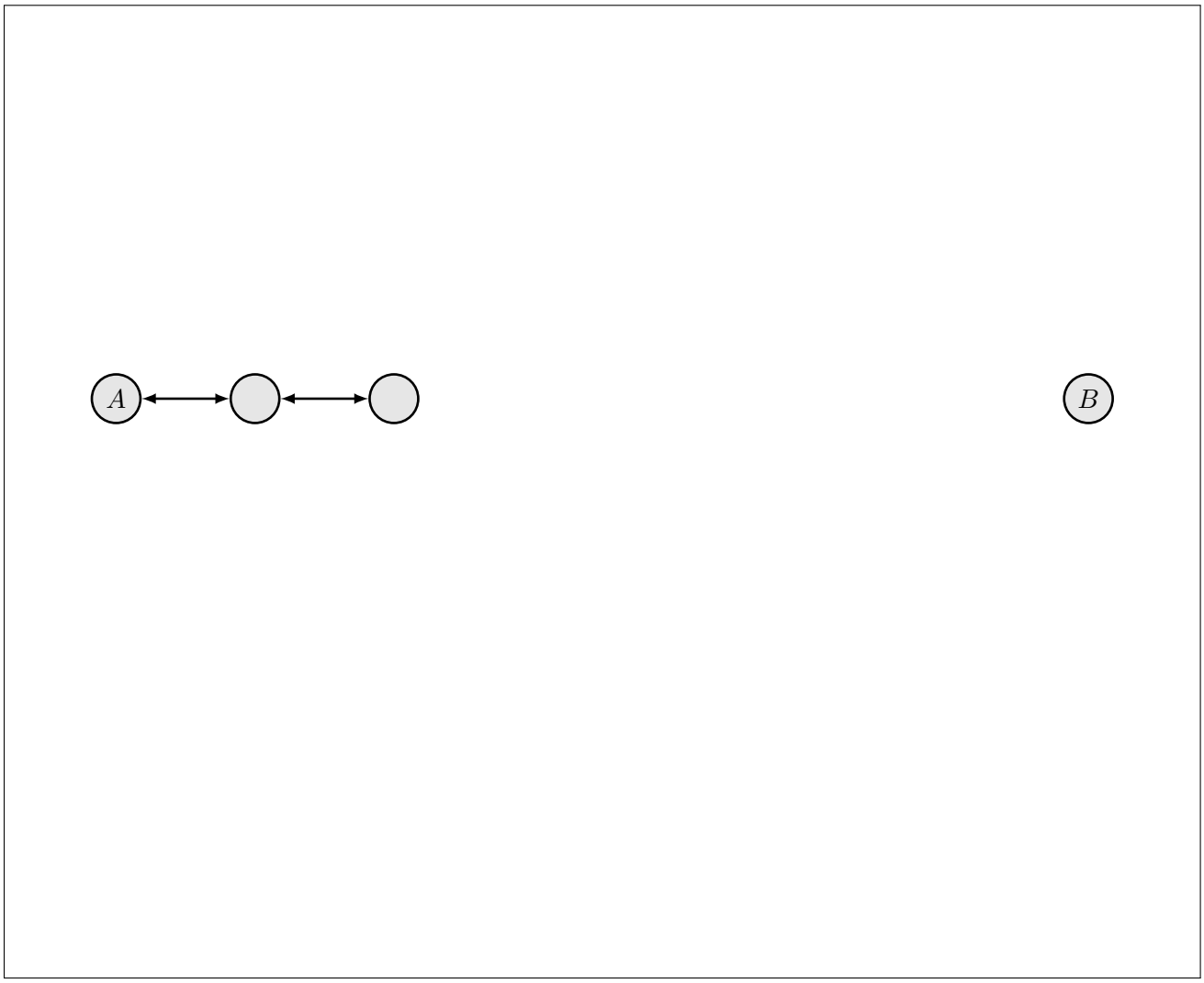
Table 2 lists a the output of `traceroute` issued from from two nodes A and B to each other.

Hop	$A \rightarrow B$	$A \leftarrow B$
1	85.214.1.25	46.4.173.33
2	85.214.0.168	213.239.224.1, 213.239.224.65
3	85.214.0.71	213.239.240.150
4	80.81.192.164	80.81.192.110
5	213.239.240.240	85.214.0.70
6	213.239.224.8, 213.239.224.104	85.214.0.169
7	213.239.199.116	85.214.236.18

Table 2: Output from `traceroute` executed on A and B, respectively.

3

d)* Based on the output listed in Table 2, derive a likely network topology by completing the Figure below.
Note: You do not have to write down every single IP address, but make sure we are able to map your graph to Table 2.



Based on a more or less reasonable assumption, you probably assigned two or more different IP addresses to the same node in (d).

e) Select one of those nodes from (d) and give a reason, why you think this node has more than one IP address. /1

Given the initial assumption, we want to verify that two IP addresses are indeed aliases for the same node. As we have seen in the homework, there are quite a few different approaches.

f)* Briefly describe how absolute values of IP identifiers can be used to detect IP aliases. /2

g) Describe two problems when using IP identifiers. /2

h) Why may it be helpful to use the difference between consecutive IP identifiers? /2

14

Problem 3 IP addressing, NAT, and SCTP (14 credits)

In this problem we consider IP addressing, NAT, and SCTP in the network depicted in Figure 3.1. The private network on the left hand side is connected via a NAT-enabled router to a public network. Router SP1 acts as SOCKS4a proxy for HTTP connections. SP1 and SP2 use a proprietary HTTP-over-SCTP implementation (similar to what we did in the project), i. e., incoming HTTP messages on SP1 are sent as part of an SCTP association to SP2 which decapsulates the HTTP messages and forwards them to the webserver and vice versa. You may assume that all links shown in Figure 3.1 are FastEthernet segments.

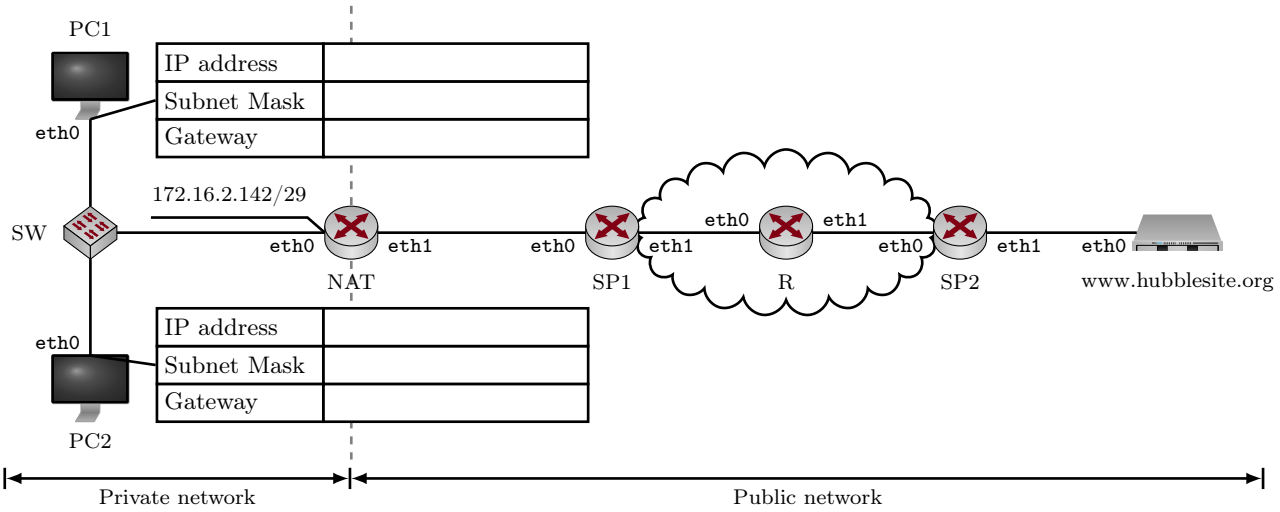


Figure 3.1: Network topology

In the following, we will first assign addresses to the private network and consider some fundamental problems. Afterwards, you are asked to state the contents of specific protocol headers at different points in the network.

1

a)* Based on the local address of the NAT router, derive the network and broadcast address of the private network.

1

b) Assign meaningful IP addresses, subnet masks, and default gateways to both PC1 and PC2. Write the configuration directly into Figure 3.1.

1

c)* Why do we need a NAT-enabled router in this setup?

d)* Briefly describe at least two advantages of SCTP over TCP.

/ 1

e)* What may be a problem if the local PCs would try to directly establish an SCTP connection to SP2?

/ 1

f)* Assuming that the restrictions considered in (e) do not apply, what is the advantage of exchanging the positions of SP1 and the NAT?

/ 1

Figure 3.2 is a larger copy of our network. We assume that PC1 tries to establish an HTTP session to the webserver www.hubblesite.org via its SOCKS4a proxy SP1. The message shown in Figure 3.2 may be the HTTP request sent by the client.

The next problem asks you to state the contents of specific header fields at three different points in the network. You may abbreviate MAC and IP addresses of individual devices using the naming convention `<device>.<interface>.<layer>`, e.g. `NAT.eth1.MAC` means the MAC address on interface eth1 of the NAT router while `NAT.eth1.IP` denotes the IP address on that interface.

g) Fill out the header fields in the three boxes shown in Figure 3.2. If the content of a field is not uniquely defined, make a **meaningful** choice. Abbreviate MAC and IP addresses as stated above!

/ 8

Comments:

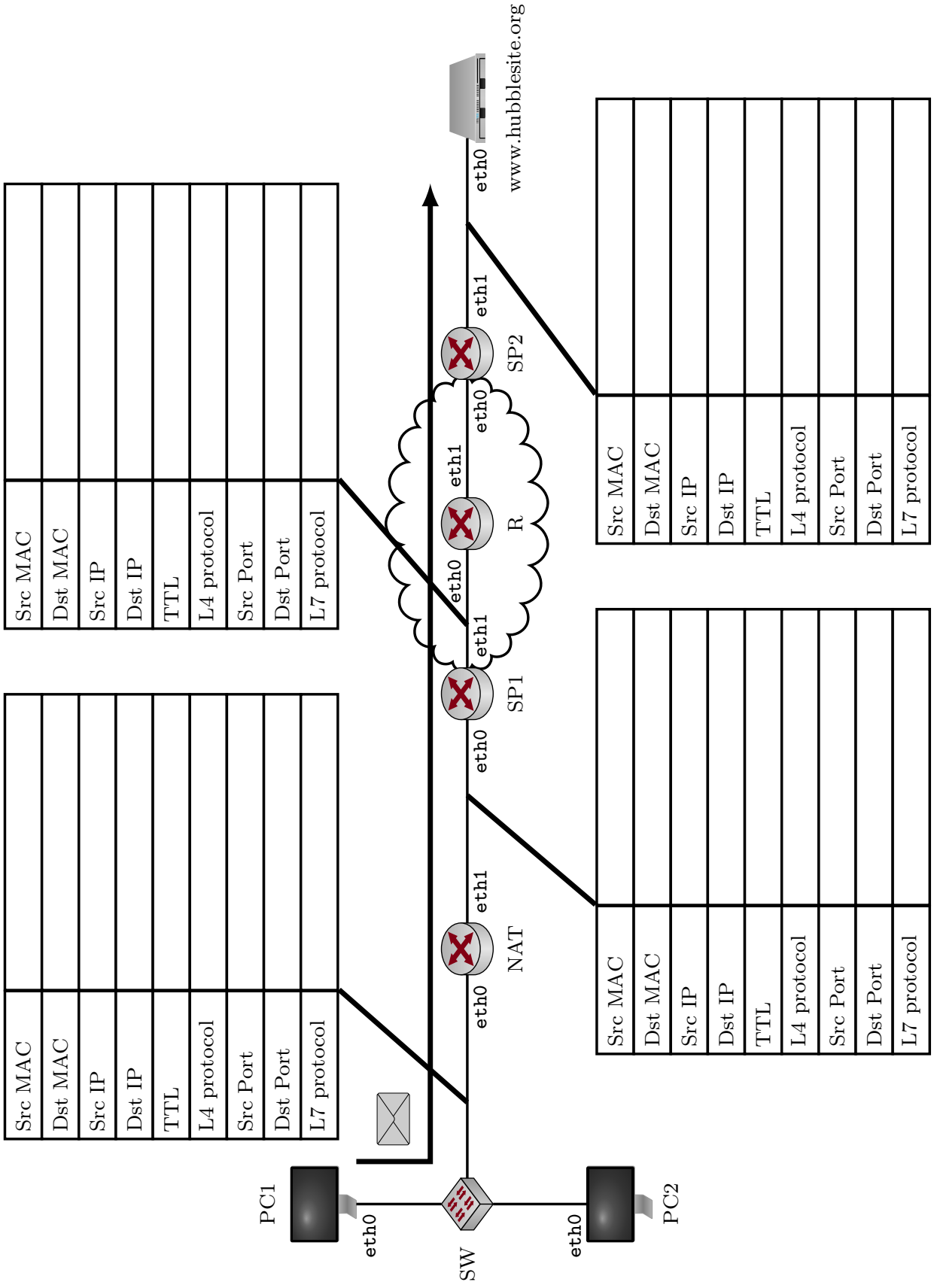


Figure 3.2: Preprint for subprblem (g)

Problem 4 TCP congestion control (13 credits)

13

In this problem we consider the congestion control mechanism of TCP. We denote the size of TCP's sender window by $w[n]$ given in multiples of the MSS and depending on discrete time steps n given in multiples of the RTT. We assume that $w[n]$ depends on the current value of the congestion window only, i. e., the receiver window is larger than the maximum value W of the sender window.

a)* What is the purpose of congestion control?

1

b)* What is the receiver window used for?

1

Assume that a new TCP connection has just been established at time index $n = 0$. We consider the ideal case where no segment loss occurs until the sender window reaches its maximum value, i. e., $w[n] = W$. For simplicity, we assume that W is a power of two. When the maximum value is reached, we assume that **a single segment** is lost and timely retransmitted by the sender. This leads to the time-discrete development of $w[n]$ depicted in Figure 4.1.

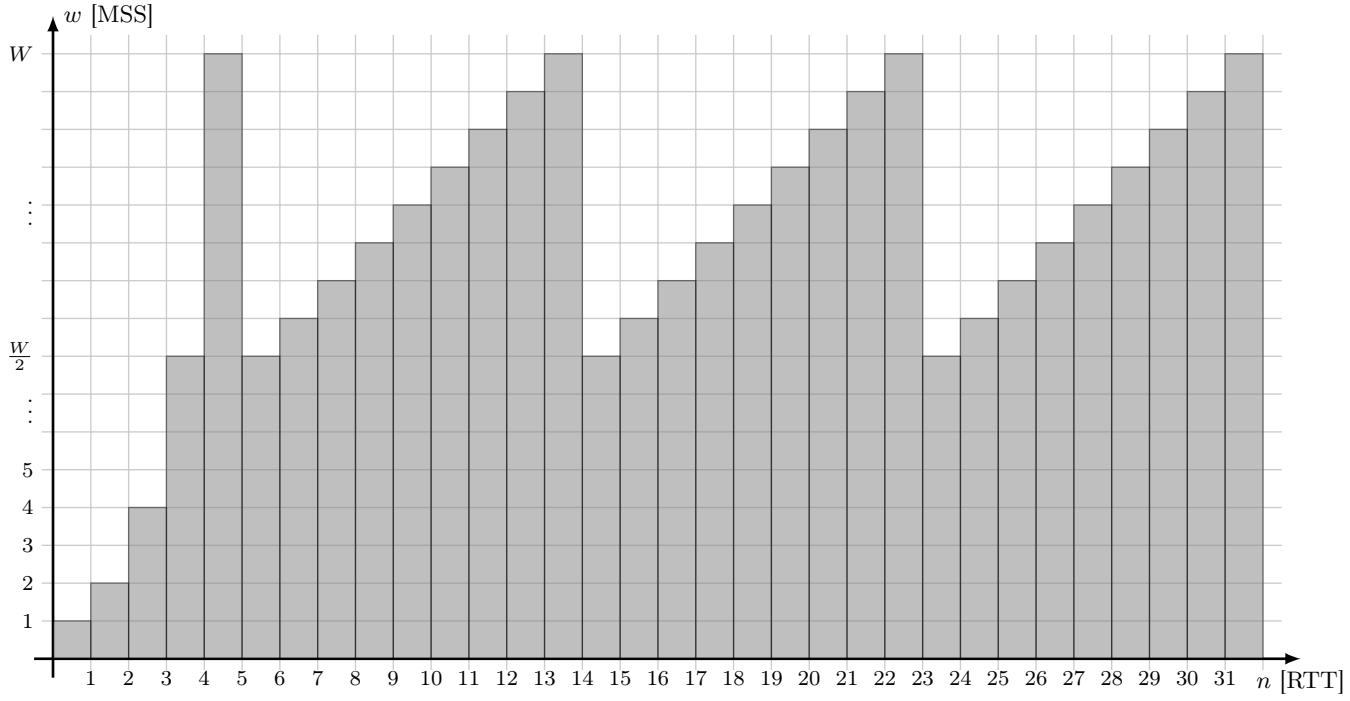


Figure 4.1: Development of the TCP sender window over time.

1

c)* Mark and name the different phases of TCP's congestion control in Figure 4.1.

The average number of segments during the first phase of congestion control is given by

$$N_\alpha = 2W - 1. \tag{1}$$

2

d)* Prove Equation (1).

The average number of segments during the second phase is given by

$$N_\beta = \frac{3}{8}W^2 + \frac{3}{4}W. \tag{2}$$

3

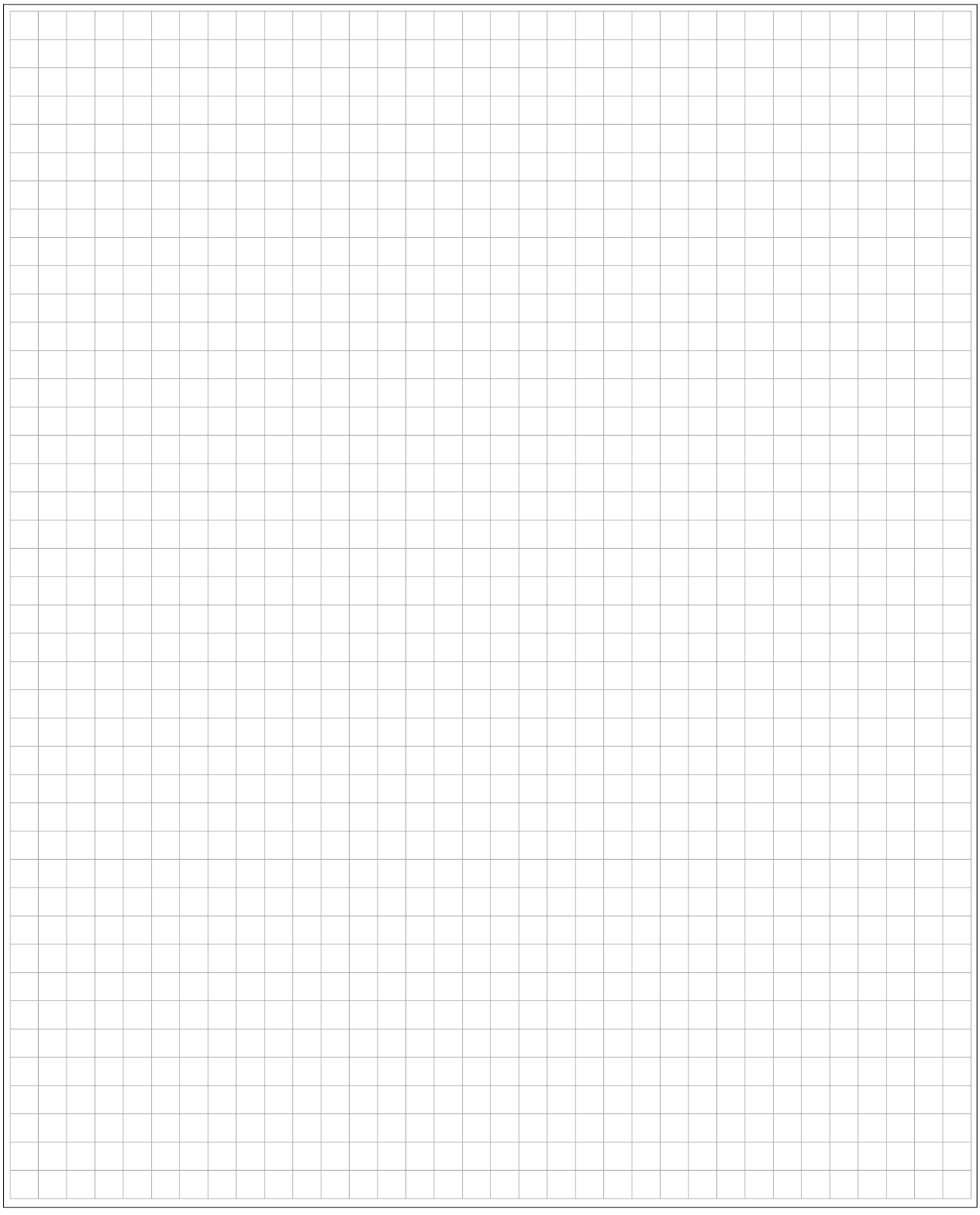
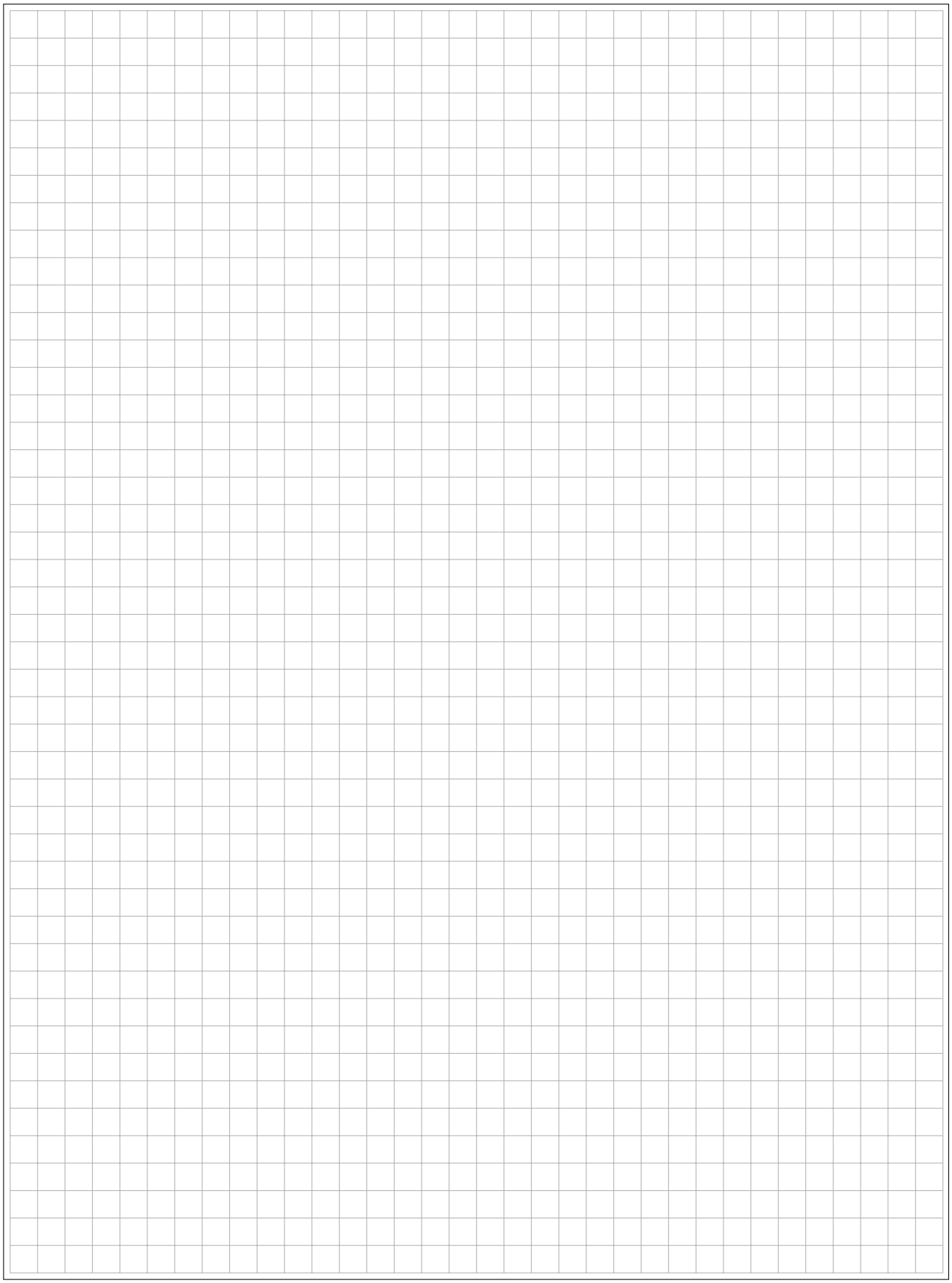
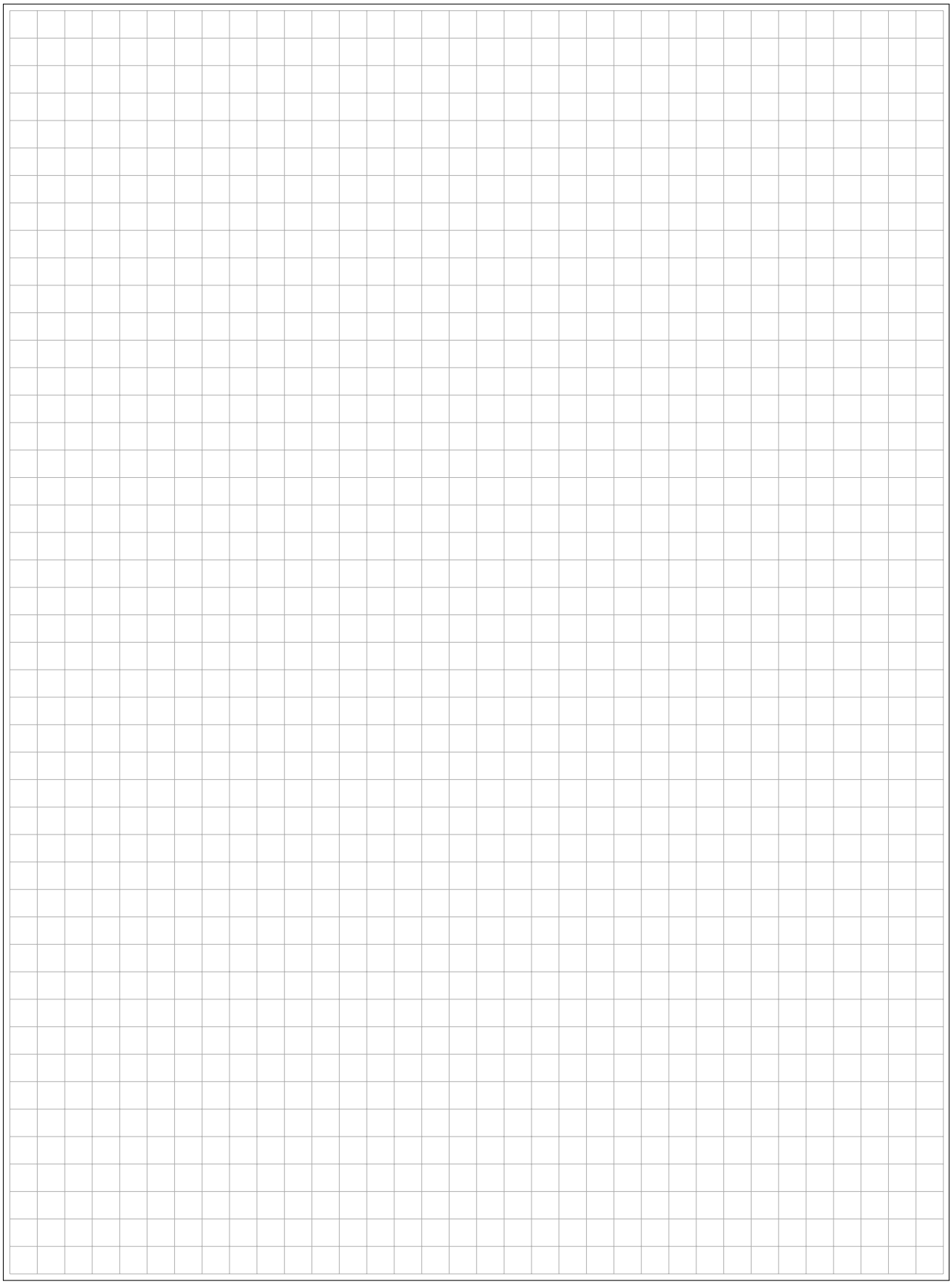
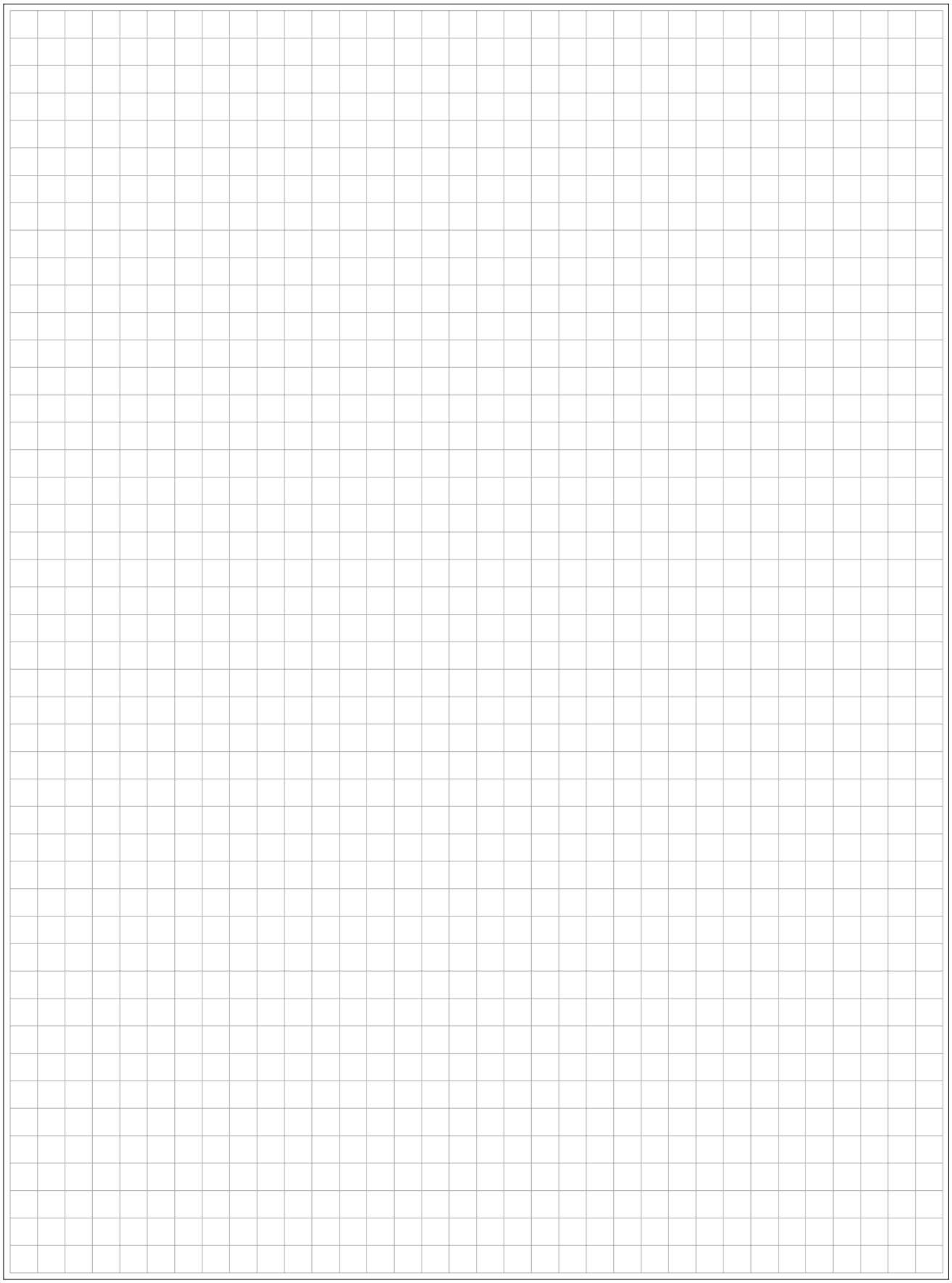
e)* Prove Equation (2).

Assume that there is chance of $\epsilon = \frac{1}{9}$ that the sender fails to retransmit a lost segment in time. The fails are assumed to be statistically independent. This causes a timeout at the receiver and thus restarts the congestion control algorithm (we assume that the congestion threshold is also reset).

f)* Derive the expected number N of segments between two restarts of the congestion control mechanism. Simplify the result. 1

g) Determine the expected time T between two restarts in dependency of W and RTT for $\epsilon = \frac{1}{9}$. 2

Assume a RTT of $\frac{1}{11}$ s, a maximum window size of $W = 16$ MSS, and a maximum segment size of 1400 Byte.

h) Determine the expected transmit rate r in MB/s. 2

Additional space for solutions – plaese clearly indicate to which problem your notes belong and strike invalid solutions.