

## Master Course Computer Networks

### Homework 5

(submission until January 21 into INBOX located in front of 03.05.052)

**Note:** Subproblems marked by \* can be solved without preceding results.

### Middleboxes Processing of packets

Given a network protected by a stateful firewall with two network interfaces, an internal and an external one. The firewall operates between two zones: green (the internal one) and red (the external one). It should allow incoming packets that are related to an already established state, as well as incoming packets that match user-defined policies. If packets are not related to an established state and if no policy exists, packets should be dropped.

a)\* What means the termin *stateful* firewall?

b) Describe the operation for incoming packets of a stateful firewall using the Processing Model as presented in the lecture.

Figure 1 shows two variants of TCP hole punching.

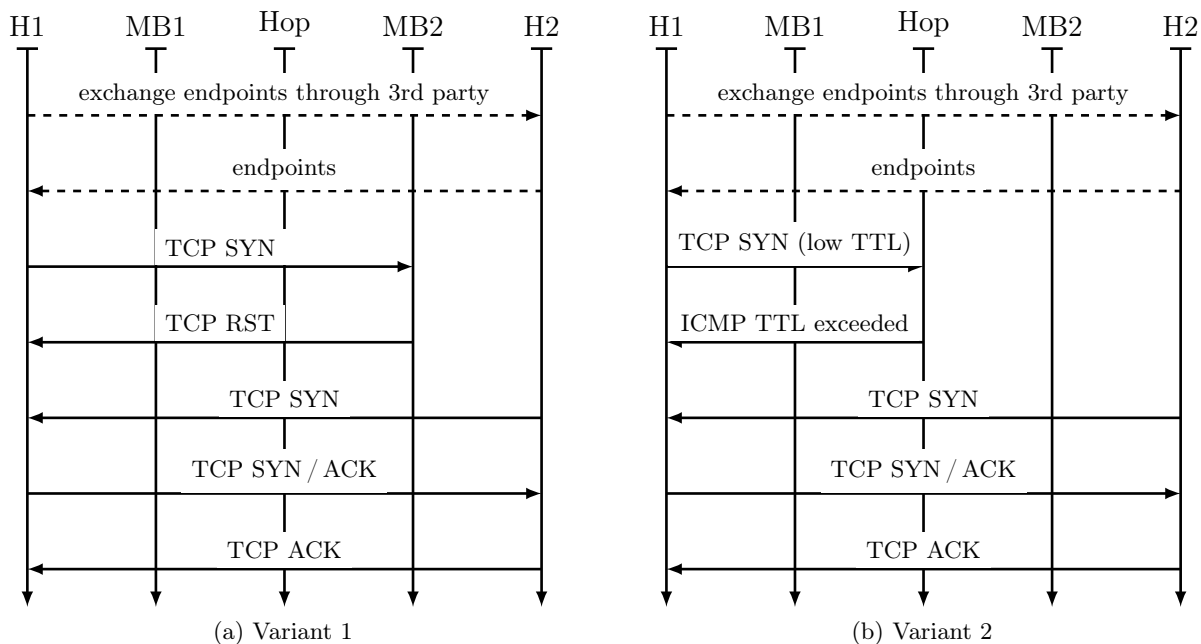


Figure 1: TCP hole punching, H = Host, MB = Middlebox.

c)\* Explain both variants and think of possible scenarios that might happen depending on the behavior of the middleboxes involved, e.g. packet 1 causes packet 2, which might or might not cause event  $x$ .

d)\* What are the general prerequisites for TCP hole punching?

**Note:** Please refer to the information model as presented in the lecture and follow the example for UDP hole punching when giving your answer.

## Delay in packet networks

Consider the wireless setup in Figure 2. Nodes  $i$  and  $j$  represent wireless computers like notebooks operating in ad-hoc mode, i. e., there is not access point. We assume that frames are sent at a constant rate  $r$ . However, due to media access control procedures there must be an average<sup>1</sup> idle time of  $\Delta t$  between any two frames. The MTU on the wireless link is denoted by  $l$  and the additional header information added by layers 2 and 1 is denoted by  $l_h$ . Further, the distance between  $i$  and  $j$  is given by  $d$  and the signal propagation of electromagnetic waves is approximately  $c$  (speed of light).

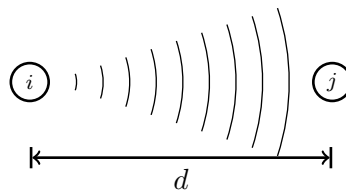


Figure 2: Sample network

a)\* Give a precise definition of MTU.

b) Derive the total time  $t$  it takes node  $i$  to transmit a *single* frame to node  $j$  (including headers, without the idle time  $\Delta t$ ).

c) The expression derived in (b) consists of two components. Discuss which of these terms primarily accounts for the transmission time.

From now on you may disregard the smaller term but remember the idle time  $\Delta t$  before each frame.

d) Derive the transmission time  $T$  of a data block of  $s$  Byte, which is fragmented into multiple frames if  $s$  exceeds the MTU.

e) Derive the effective average transmit rate  $r_{eff}$ , assuming that no collisions occur. (You do not have to consider acknowledgements that might be sent by  $j$ , just give a term for the transmit rate of  $i$ .)

Now assume  $\Delta t = 101.5 \mu s$ , which is an approximation for IEEE 802.11a/g networks. Further, consider the cooresponding gross data rates of  $r \in \{6, 12, 18, 24, 36, 54\}$  Mbit/s.

f) Use a CAS and plot  $r_{eff}$  depending on  $r$  and a series of meaningful values for  $l$  (for IEEE 802.11a  $l_{max}$  is somewhere around 2200 Byte,  $l_h = 34$  Byte is fine).

g) What is wrong with IEEE 802.11a/g? Suggest possible fixes (except for removing  $\Delta t$ ).

<sup>1</sup>The idle time contains a random component for collision avoidance. You don't have to care about that, just use the average here.