Check Point®
SOFTWARE TECHNOLOGIES LTD.

Workshop in Information Security

Building a Firewall within the Linux Kernel

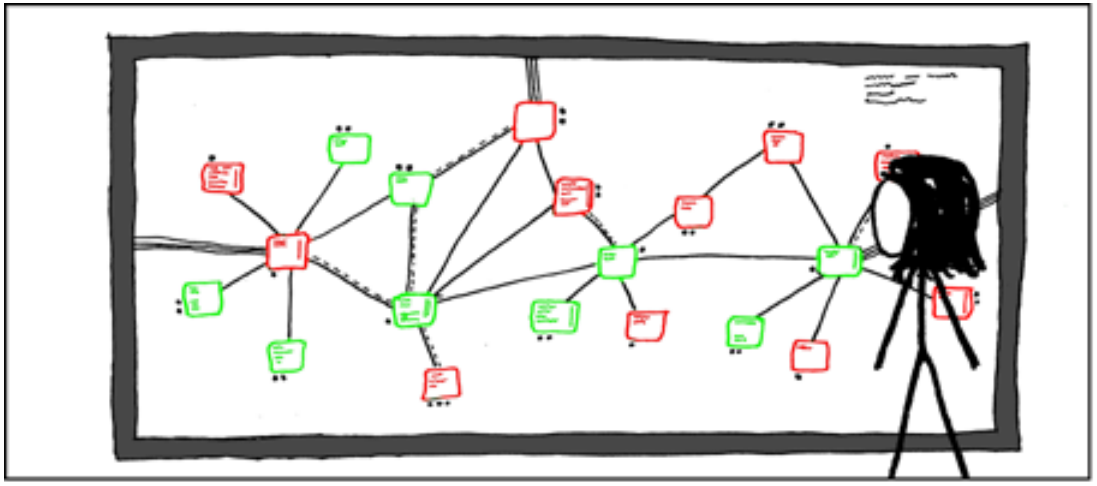
Virtualization, Networks & Communication.

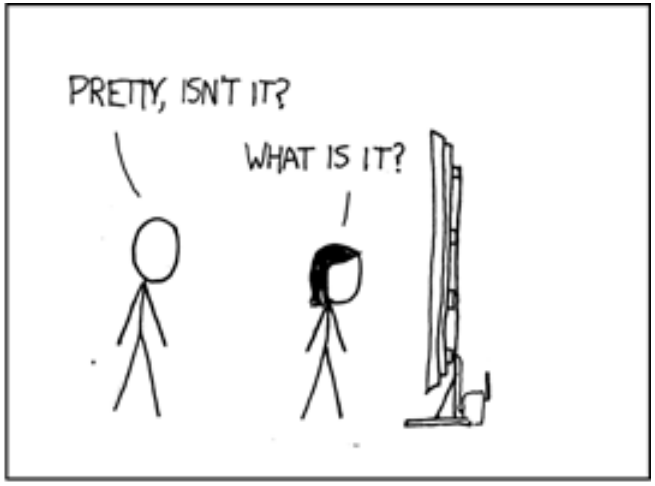
Lecturer: Eran Tromer

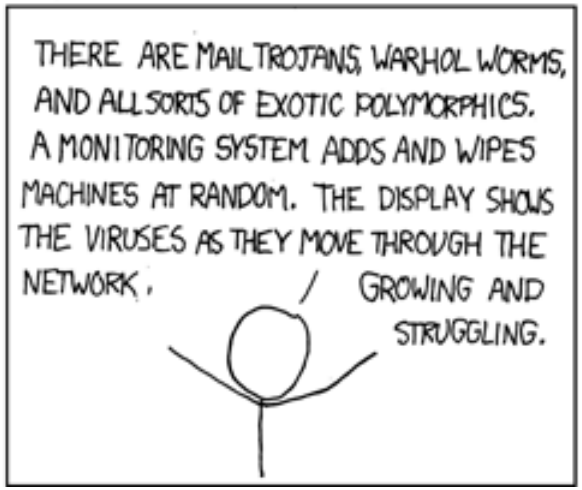
Teaching assistant: Ariel Haviv

Advisor: Assaf Harel

Network (http://xkcd.com/350/)







Virtual Networking

1. Virtual Machines & Networks
2. Network Tools
3. TCP/IP
4. Firewall Functionality

Virtual Networking

1. **Virtual Machines & Networks**
2. Network Tools
3. TCP/IP
4. Firewall Functionality

Virtual Machines - Basics

- Virtual Machine:
  - "completely isolated guest operating system installation within a normal host operating system“
- Host – the OS that is really installed on the physical machine.
- Guest – the OS that sits inside a folder in that machine, and `thinks’ it is installed on a physical machine.

Virtual Machines

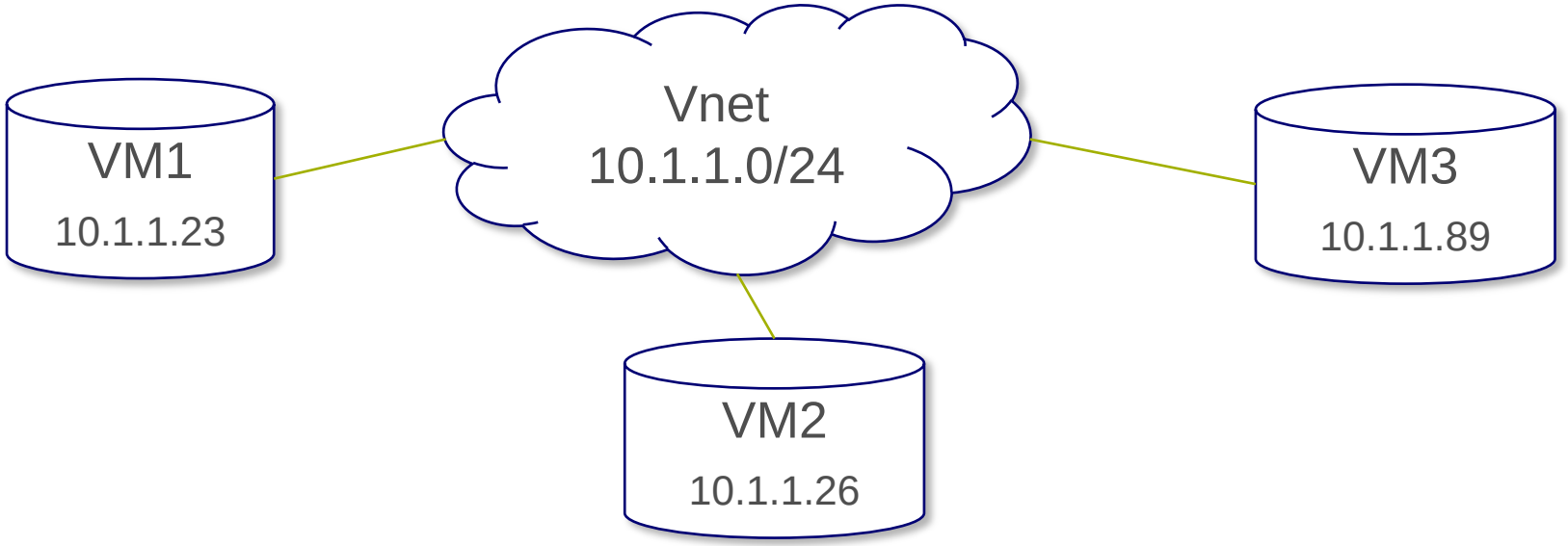
- The Host supplies virtualized hardware to the guest.
  - A hard-disk (really a few files on the host)
  - RAM (part of the host's RAM, with complex virtual memory algorithms)
  - IO (screen, keyboard, mouse, NIC)
  - Interrupts to/from the guest (like clock interrupts)
- NICs are connected either to the outer world, or to internal virtual networks.

IPv4 Networks

- In IPv4, every host has at least one name with the form: www.xxx.yyy.zzz
  - Each of these four fields ranged from 0 to 255 (1 byte).
- Networks have names too:
  - Left x bits are network name.
  - Right (32 – x) bits are zeroed.
- A network consists of several interconnected machines:
  - All have the same left x bits.
  - Each machine with rightmost (32 – x) bits unique.
- A router forwards traffic from one network to another.

Virtual Networks

- Virtual networks are the same as a physical network, but virtualized. The cables only exist in the memory of the host OS.
- We can create virtual clusters of VMs, by connecting all of their virtual NICs to the same virtual network.

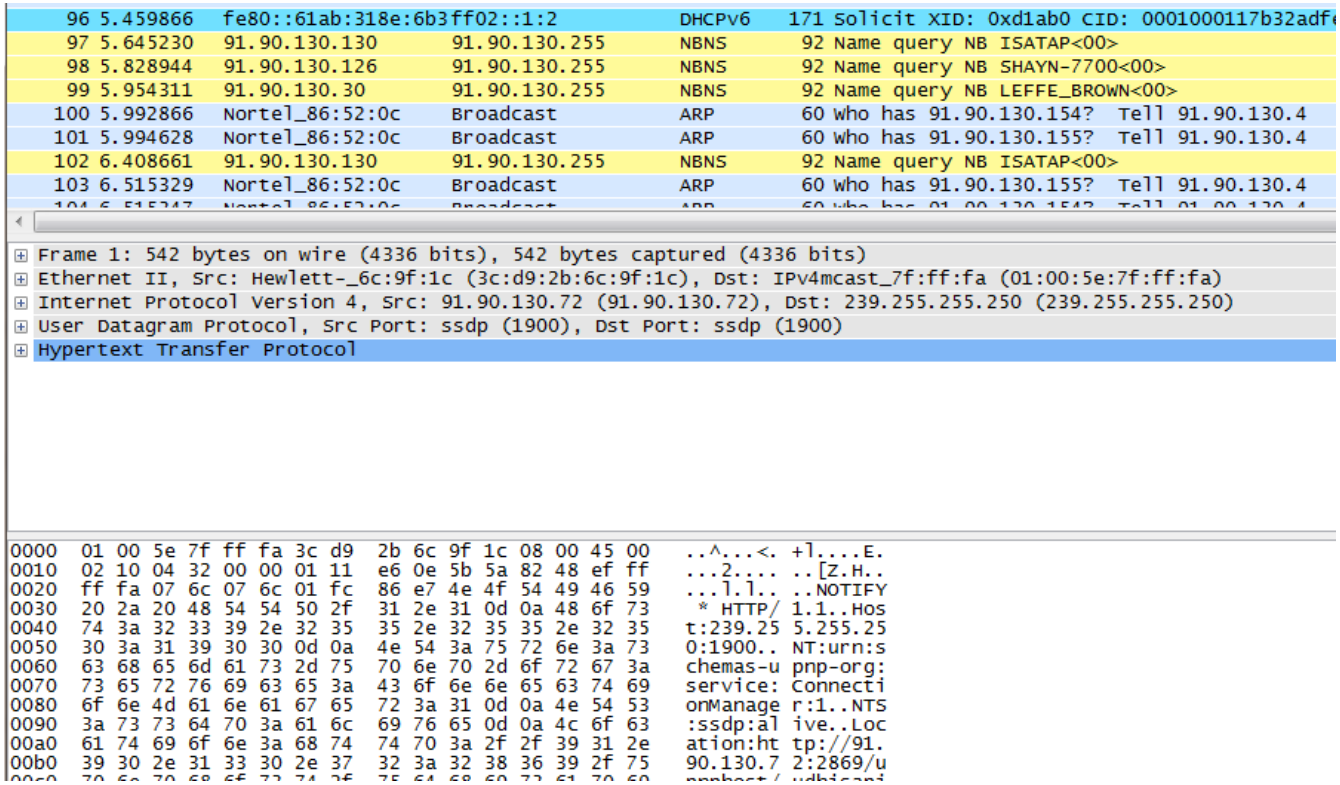


Virtual Networking

1. Virtual Machines & Networks
2. **Network Tools**
3. TCP/IP
4. Firewall Functionality

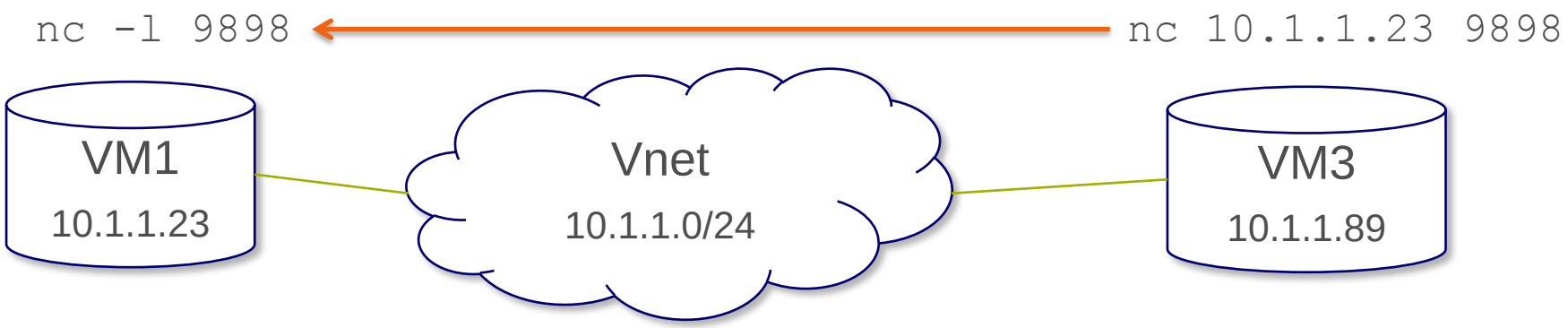
Network Monitor Tools

- Watch and record traffic: Wireshark.
- Inspects every packet – headers & data.



Generating traffic - netcat

- Use netcat on both ends. One listens on a port, one initiates the conversation.
- Then clear text (from stdin or a file) can be transferred both ways.
- Wireshark can record the traffic on each of these machines.



Generating traffic – hping3

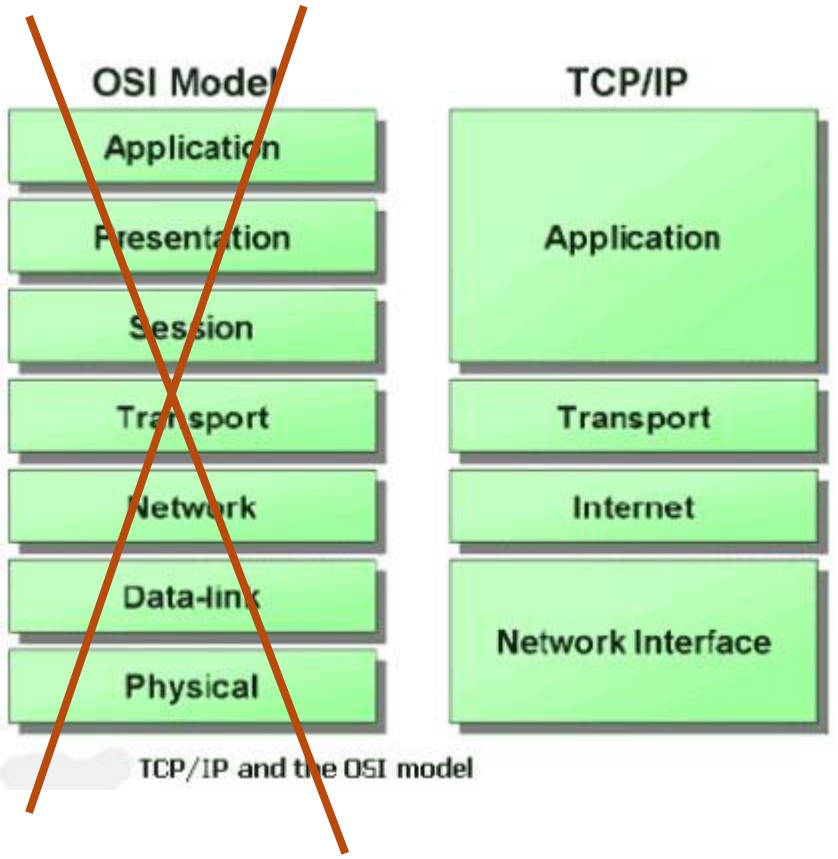
- Generates traffic in one direction.
- Doesn’t care if anyone listens on the other side.
- Can send packets in any protocol, and even raw packets.

Virtual Networking

1. Virtual Machines & Networks
2. Network Tools
3. **TCP/IP**
4. Firewall Functionality

OSI Model

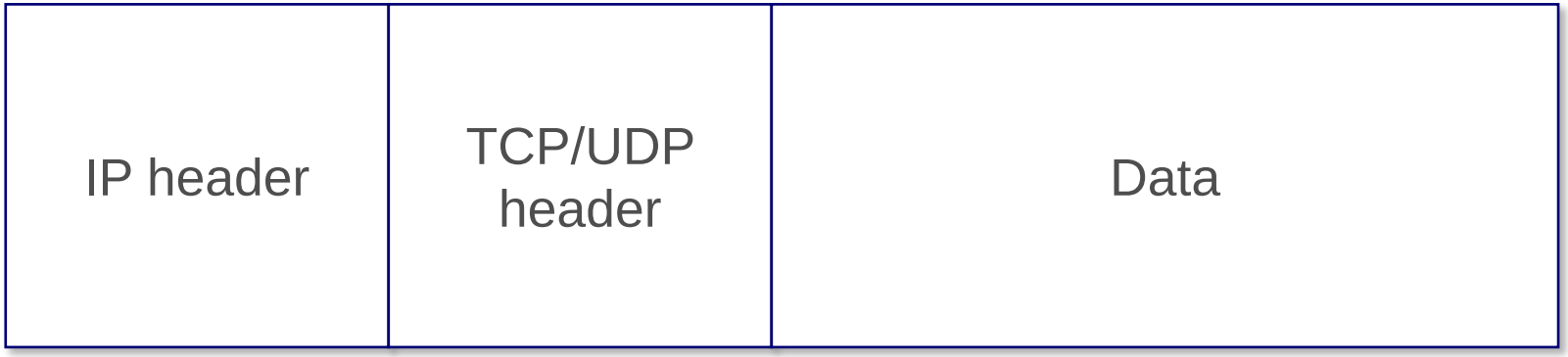
- A layer serves the layer above it and is served by the layer below it.
- Application – the actual content of the conversation.
- Transport – making sure the communication arrives to its destination, and in the right order.
- Network – makes sure two hosts on different networks can communicate.



TCP/IP and the OSI model

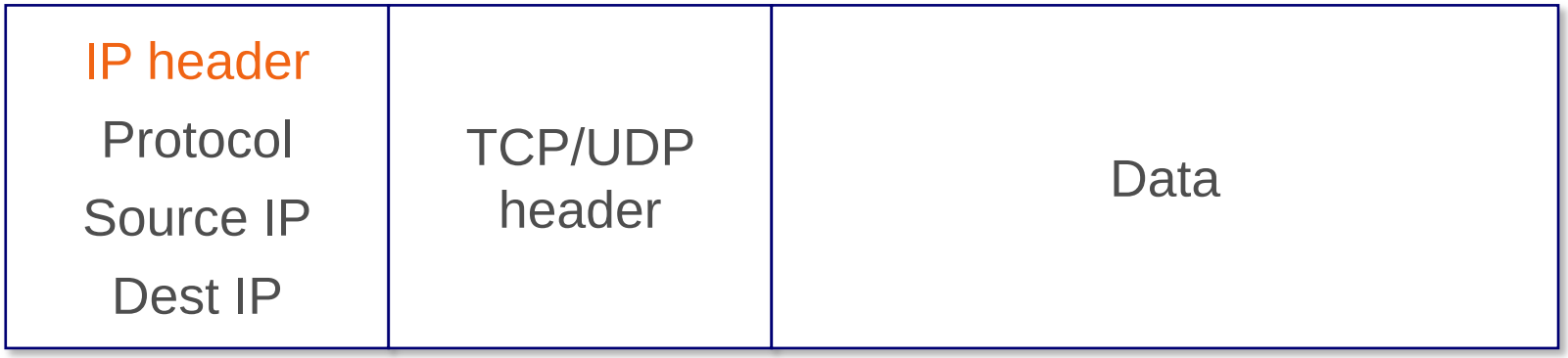
TCP/IP

- A protocol suite named after 2 very important components:
  - TCP – a very important protocol in the transport layer.
  - IP – a very important protocol in the network layer.
- Used everywhere. The standard of today's internet.
- A large portion of the chunks of data we will encounter will look like this:



TCP/IP - Network

- The IP header contains information like source and destination IP addresses, the protocol of the encapsulated transport header etc.
- IP allows one host in one network to connect to another host, on a different network.

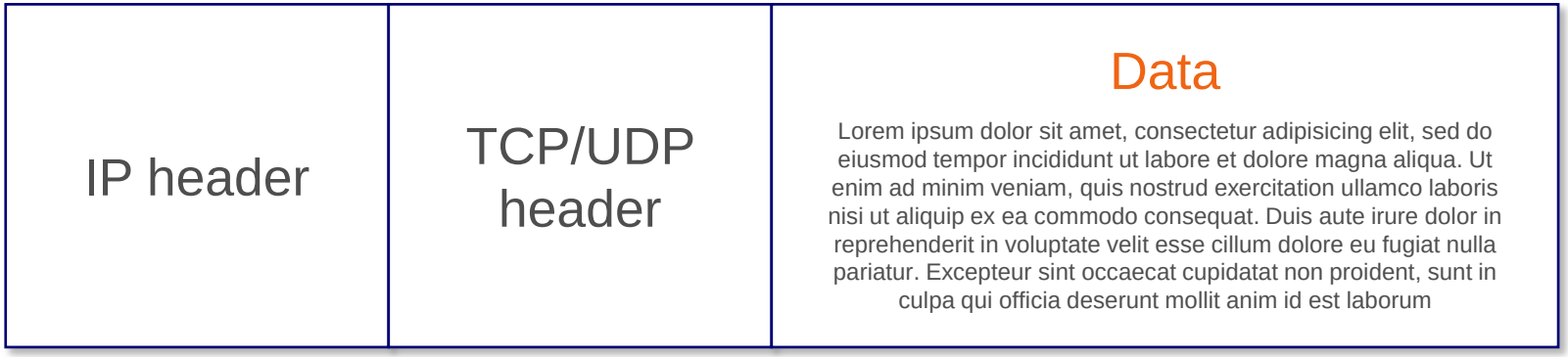


TCP/IP - Transport

- UDP header contains only source and destination ports, because it is a stateless protocol.
- TCP contain additional information:
  - Seq#, Ack#, 9 control bits, checksum, etc.
- The transport layer enables different applications on the host to communicate with the outer world, without disturbing each other.

TCP/IP - Payload

- The Data (called payload too), is the information passed between the two applications. It can be a web page, a file transferred through FTP, etc.



Virtual Networking

1. Virtual Machines & Networks
2. Network Tools
3. TCP/IP
4. **Firewall Functionality**

Example: TCP Handshake

- To initiate a TCP connections, we have a 3-way handshake:
  - SYN + seq(X)
    - “Hello, I’m here. I chose X.”
  - SYN + seq(Y) + ACK + ack(X+1)
    - “I heard your X. here’s your X+1. I’m here too, I chose Y.”
  - ACK + ack(Y+1)
    - “I heard your Y, here’s your Y+1.”
- Now a connection has been established.
- SYN, ACK, seq#, ack# are all fields in the TCP header.

Connection Tracking

- A firewall which tracks connections will:
  - Open a new connection table entry when inspecting a packet with SYN flag on. The sender is the client.
  - Update the entry when the SYN+ACK is replied. The host that replied is the server.
  - Update the entry to active connection when the ACK is sent. Usually set a long timeout to the entry.
  - Close the entry with:
    - FIN → FIN+ACK → ACK
    - RST
    - Timeout expired
- Stricter tracking includes also seq# and ack# enforcement.