

Network Security

Introduction to networks

Radboud University Nijmegen, The Netherlands



Autumn 2014

What is a (computer) network

Definition

A *computer network* is two or more computers that are connected, so that information can be transmitted between them.

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- ▶ The phone network?

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(many connected independent components (“computers”))
- ▶ The phone network? **Yes**
(phones and backbone infrastructure are (special) computers)

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- ▶ Session initialization and termination
- ▶ Synchronization of communication

A simple example: netcat

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netcat -lp 51966
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- ▶ How does arya know that information should go through the cable? Does it actually go through the cable?
- ▶ What information (sequence of bits) goes through the cable?

The lowest level: Ethernet

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- ▶ *MAC address*: 48 bit “physical address”
- ▶ MAC stands for “media access control”
- ▶ Specified in IEEE 802, not only used by Ethernet
- ▶ Ethernet ensures that bits are correctly transmitted
 - ▶ Transmit data in *frames*
 - ▶ Detect and recover from collisions
 - ▶ Ethernet uses a 32-bit checksum

The Ethernet frame

Preamble	Start of Delimiter	Destination MAC address	Source MAC address	802.1Q tag (optional)	Ethertype or Length	Payload	Frame check sequence (32-bit CRC)	Interpacket gap
7 Bytes	1 Byte	6 Bytes	6 Bytes	(4 Bytes)	2 Bytes	46–1500 Bytes (42–1500 Bytes)	4 Bytes	12 Bytes

- ▶ Most interesting for us: MAC addresses (and payload)
- ▶ Minimal payload size is 46 bytes (without 802.1Q tag) or 42 bytes (with 802.1Q tag)
- ▶ Gigabit Ethernet defines *Jumbo Frames* with payload >1500 bytes

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- ▶ For the moment, only consider IPv4:
 - ▶ 32-bit addresses (typically written in *dotted decimal*)
 - ▶ *Hostnames*, such as `tyrion` or `arya` are aliases for such an IP address
 - ▶ Multiple mechanisms to map hostnames to IP addresses, easiest one: `/etc/hosts`

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- ▶ Entry in `/etc/hosts` on `arya`:

```
192.168.42.1      tyrion
```

IP networks and addresses

- ▶ IP addresses have a *network part* and a *host part*
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 - ▶ Specify network together with mask, e.g:
 - ▶ Example: 192.168.42.0/24

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Some special IP address ranges

- ▶ 10.0.0.0/8: Private network (not reachable from the Internet)
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- ▶ 127.0.0.0/8: Loopback, important host: 127.0.0.1 (localhost)

USER FRIENDLY by Illiad



MIRANDA: YOU GUYS ARE SO LAME,
I BET YOU CAN'T EVEN KNOCK
ME OFF THE 'NET.

BUNG13: OH YEAH? WE'LL FIX YOU.
DOOF: YOU'RE TOAST!
W4NK3R: WHAT'S YOUR IP ADDRESS?



MIRANDA: 127.0.0.1
COME GET SOME.

BUNG13: *DISCONNECTED*
DOOF: *DISCONNECTED*
W4NK3R: *DISCONNECTED*



The IP header

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Version	IHL	DSCP			ECN		Total Length																								
Identification					Flags		Fragment Offset																								
Time to Live		Protocol			Header Checksum																										
Source IP Address																															
Destination IP Address																															
Options ...																															

Address mapping from IP to MAC: ARP

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- ▶ arya remembers this information in the *ARP cache*

Getting to the right process: TCP

- ▶ Need to be able to distinguish bits that shall go to netcat and bits that go to, e.g, my browser
- ▶ Solution: Transport Control Protocol (TCP)
- ▶ TCP introduces *port* numbers
- ▶ An end-to-end connection is characterized by
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- ▶ Low ports can typically only be opened (used by an application) with root rights
- ▶ TCP does *much* more than offering ports; e.g:
 - ▶ Creates a *reliable* connection
 - ▶ Takes care of retransmissions
 - ▶ Congestion control

The TCP header

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Source Port																Destination Port															
Sequence Number																															
Acknowledgement Number (if ACK set)																															
Data Offset	Re-served	N	C	E	U	A	P	R	S	F	Window Size																				
	0 0 0	S	W	C	R	C	S	S	Y	I																					
		R	E	G	K	H	T	N	N																						
Checksum																Urgent pointer (if URG set)															
Options																															
...																															

TCP sessions

- ▶ Before sending data, create TCP connection with three-way handshake:
 - ▶ Client sends SYN, $SEQ=X$
 - ▶ Server answers with SYN, ACK, $SEQ=Y$, $ACK=X + 1$
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- ▶ Termination of a connection uses a 4-way handshake:
 - ▶ Each side terminates independently (through a FIN)
 - ▶ Each side acknowledges the FIN of the other side

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- ▶ arya sends "Hi tyrion" through the established TCP connection
 - ▶ TCP segment with destination port 51966
 - ▶ IP packet with source IP addr: 192.168.42.2 and dest. IP addr: 192.168.42.1
 - ▶ Ethernet frame with source MAC addr: 00:1e:68:b8:c7:eb, and dest. MAC addr: 28:d2:44:54:88:02

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 - ▶ **close()**: Close the connection, release resources allocated to socket

“netcat” client in Python

```
#!/usr/bin/env python

import socket

host = 'tyrion'
port = 51966
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect((host,port))
s.send('Hi tyrion\n')
s.close()
```

“netcat -l” in Python

```
#!/usr/bin/env python

import socket

host = ''
port = 51966
backlog = 5
bufsize = 1024

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((host,port))
s.listen(backlog)

client, address = s.accept()
data = client.recv(bufsize)
if data:
    print data
    client.close()
```

The Internet protocol suite

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- ▶ The application layer:
 - ▶ Process-to-Process communication
 - ▶ Examples: HTTP, SSH, SMTP

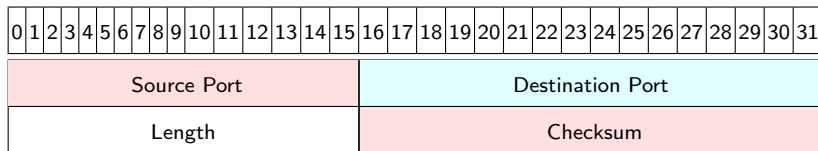
Lightweight communication: UDP

- ▶ For some messages you do not have to ensure that they arrive
- ▶ A TCP session for sending “Hi tyron” is like cracking nuts with a sledgehammer
- ▶ Solution: User Datagram Protocol (UDP):
 - ▶ No session initialization
 - ▶ No session termination
 - ▶ No acknowledgements
 - ▶ No guaranteed transmission
- ▶ “Send your data and hope for the best”

The UDP header

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Source Port																Destination Port															
Length																Checksum															

The UDP header



- ▶ The Source Port and the Checksum are even optional

Control messages: ICMP

- ▶ ICMP stands for Internet Control Message Protocol
- ▶ Provides diagnostics and control on the internet layer
- ▶ ICMP messages are in the IP payload (protocol number 1)
- ▶ Most important ICMP messages:
 - ▶ Echo request and Echo reply (“ping”)
 - ▶ Destination unreachable
 - ▶ Redirect message
 - ▶ Source quench