Network Security

Introduction to networks

Radboud University, The Netherlands

Spring 2019

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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  (phones and backbone infrastructure are (special) computers)

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- Synchronization of communication

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  netcat -lp 51966
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- What information (sequence of bits) goes through the cable?

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- 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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  - Specify network together with mask, e.g:
  - Example: 192.168.42.0/24

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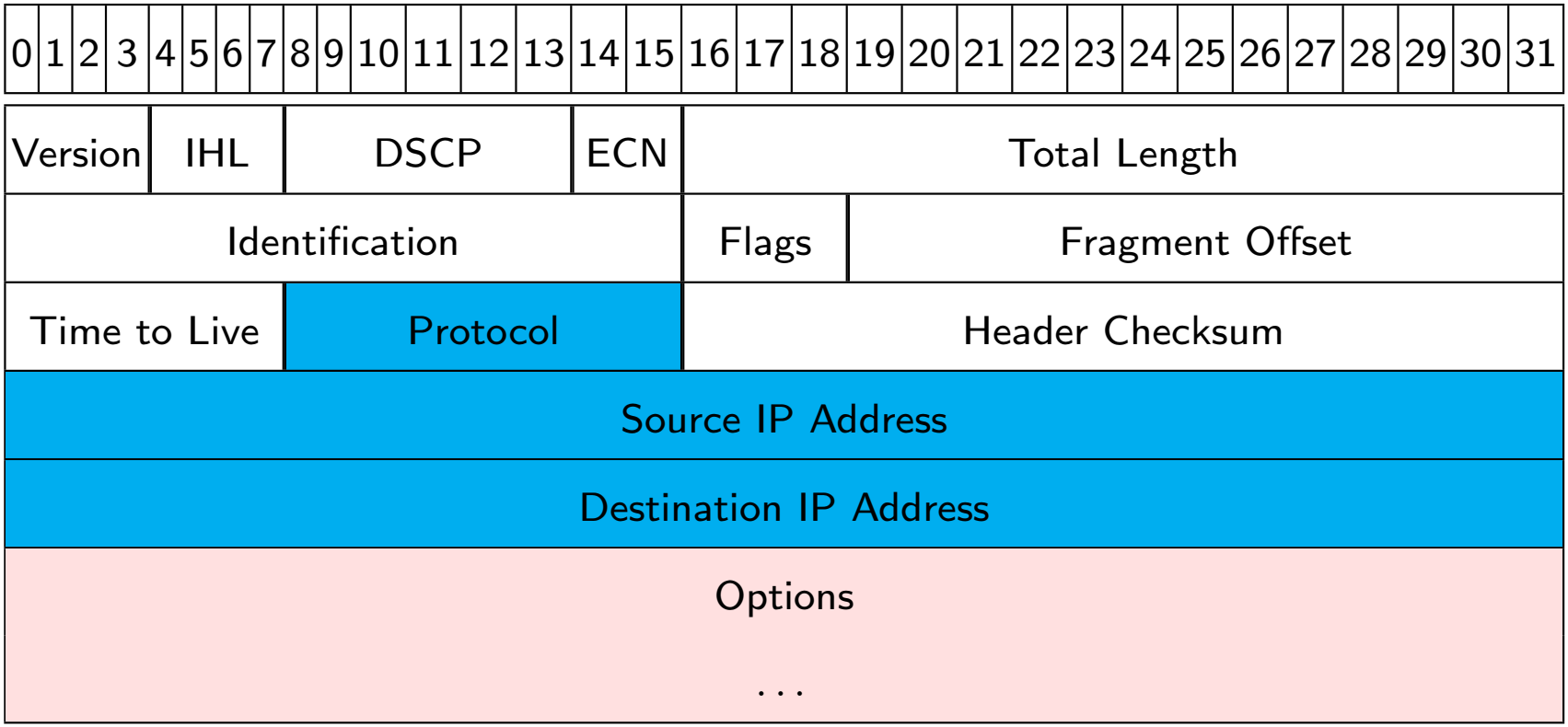
- 127.0.0.0/8: Loopback, important host: 127.0.0.1 (localhost)

Picture source: http://ars.userfriendly.org/cartoons/?id=20010523

The IP header



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

Getting to the right process: TCP

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- Solution: Transport Control Protocol (TCP)
- TCP introduces *port* numbers
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- TCP does *much* more than offering ports; e.g.:
  - Creates a *reliable* connection
  - Takes care of retransmissions
  - Congestion control

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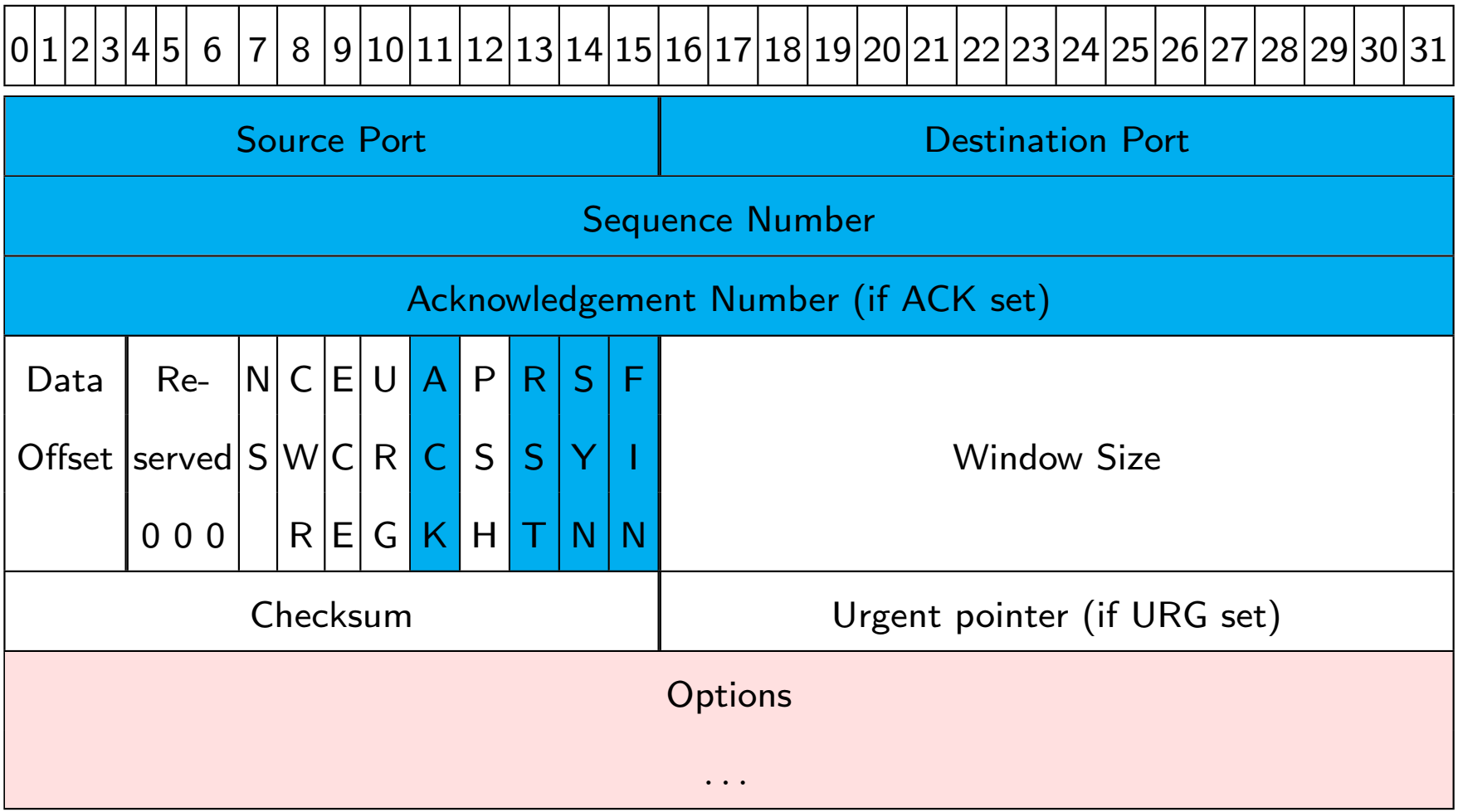

TCP sessions

- Before sending data, create TCP connection with three-way handshake:
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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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  - IP packet with source IP addr: 192.168.42.2 and dest. IP addr: 192.168.42.1
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- `tyrion` receives frame, opens it up, hands payload of TCP segment to the application listening on port 51966 (netcat)

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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: 50:7b:9d:f4:db:29
- `arya` sends all the bits of the Ethernet frame through the cable
- `tyrion` receives frame, opens it up, hands payload of TCP segment to the application listening on port 51966 (netcat)
- `tyrion` confirms receipt of the TCP segment (ACK)

Short recap: putting it together

- `tyrion`'s netcat "listens" on TCP port 51966
- `arya` looks up the IP address of `tyrion`: 192.168.42.1
- `arya` sends an ARP request (ARP who has 192.168.42.1) to the broadcast MAC address ff:ff:ff:ff:ff:ff
- `tyrion` answers with ARP reply 192.168.42.1 is at 50:7b:9d:f4:db:29
- `arya` establishes a TCP/IP connection to `tyrion` (TCP port 51966)
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- `tyrion` receives frame, opens it up, hands payload of TCP segment to the application listening on port 51966 (netcat)
- `tyrion` confirms receipt of the TCP segment (ACK)
- `arya` closes the session, `tyrion` closes the session

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  - **connect():** Connect to remote "listening" socket
  - **send():** Send data through connected socket
  - **recv():** Receive data from connected socket
  - **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 *link layer*:
  - Communication of directly connected nodes
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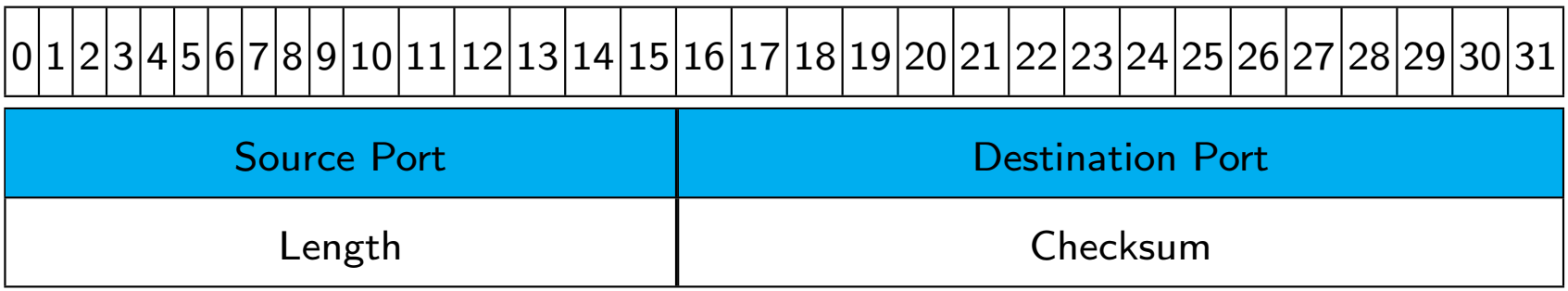
  - Most importantly: TCP, UDP
- The application layer:
  - Process-to-Process communication
  - Examples: HTTP, SSH, SMTP

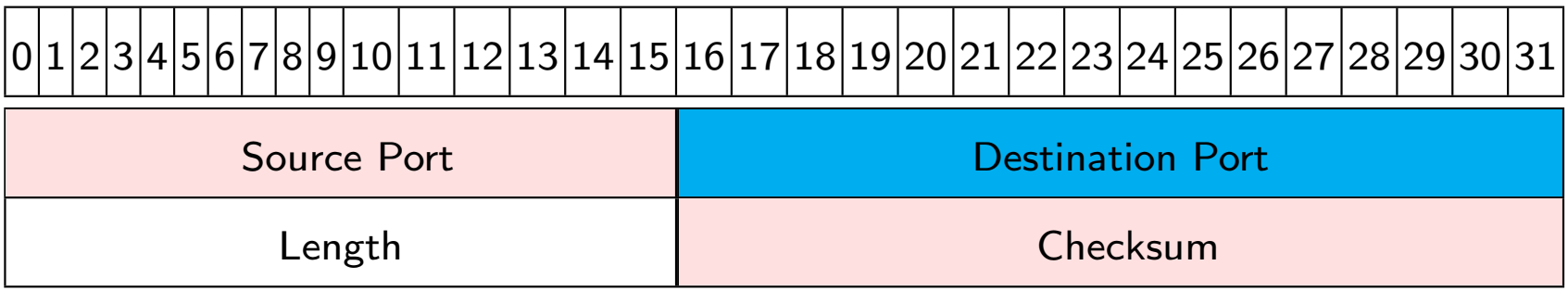
Lightweight communication: UDP

- For some messages you do not have to ensure that they arrive
- A TCP session for sending "Hi tyrion" 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



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