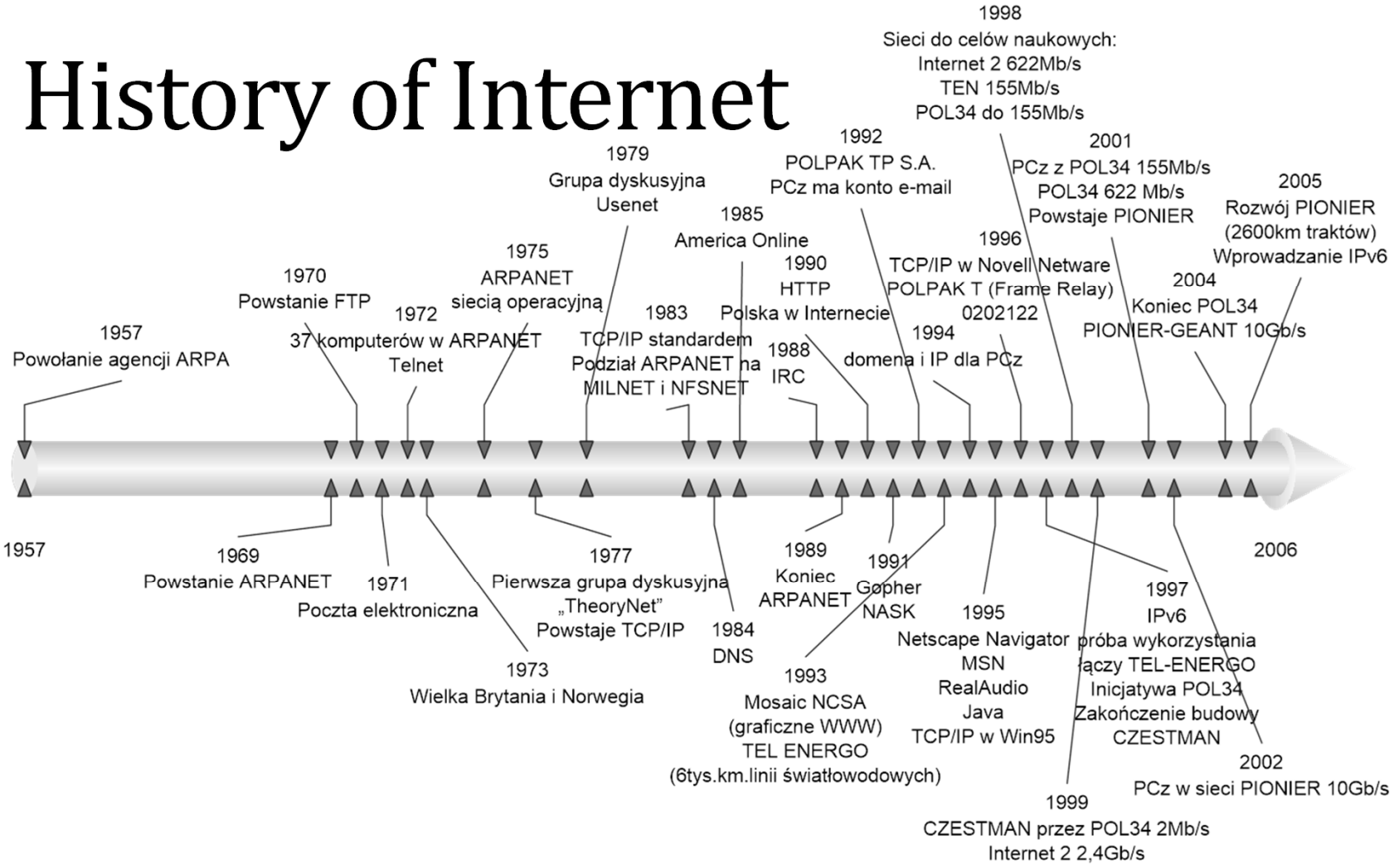
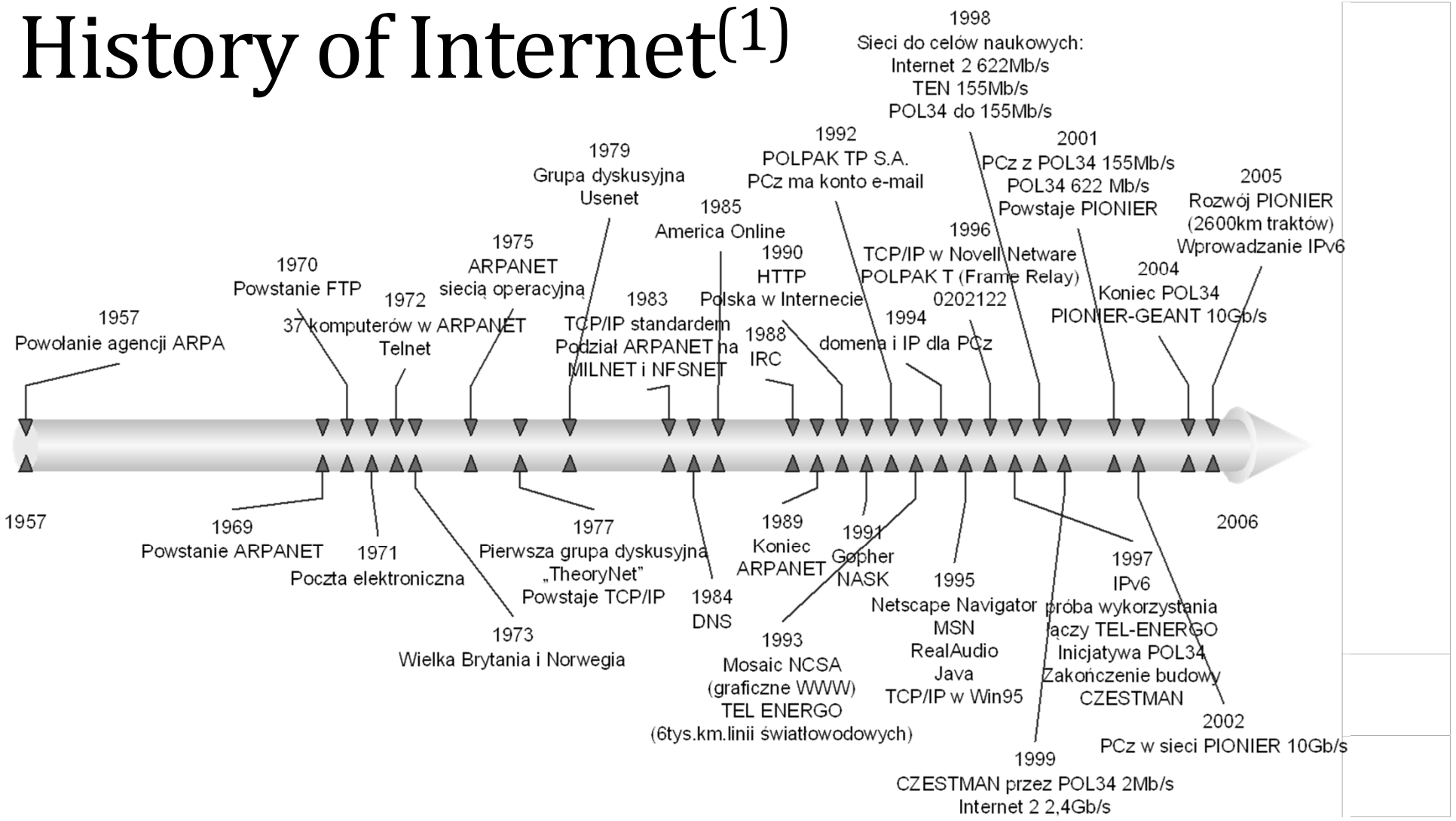
# Internet, TCP/IP

Foundations of computer networks

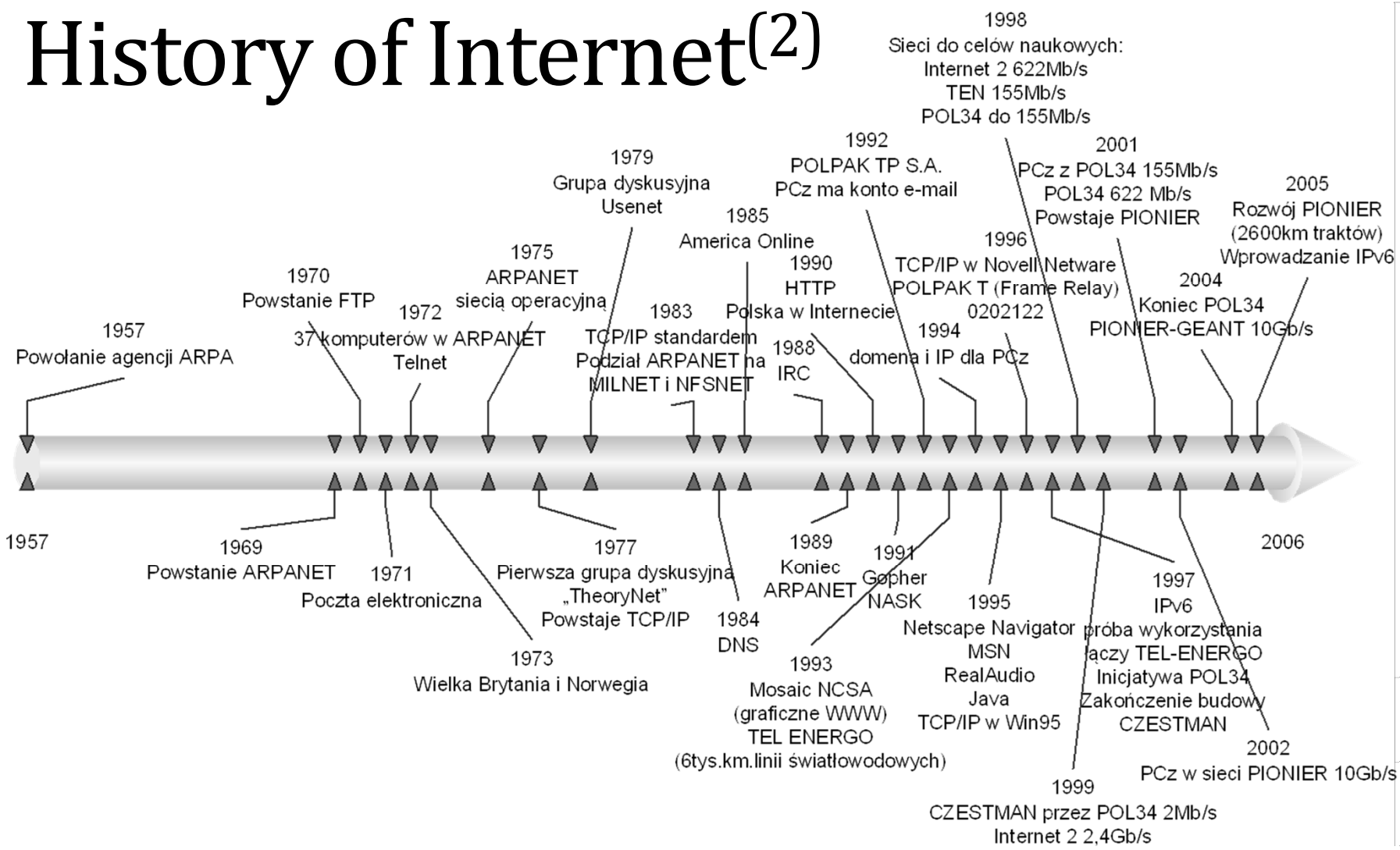
# History of Internet



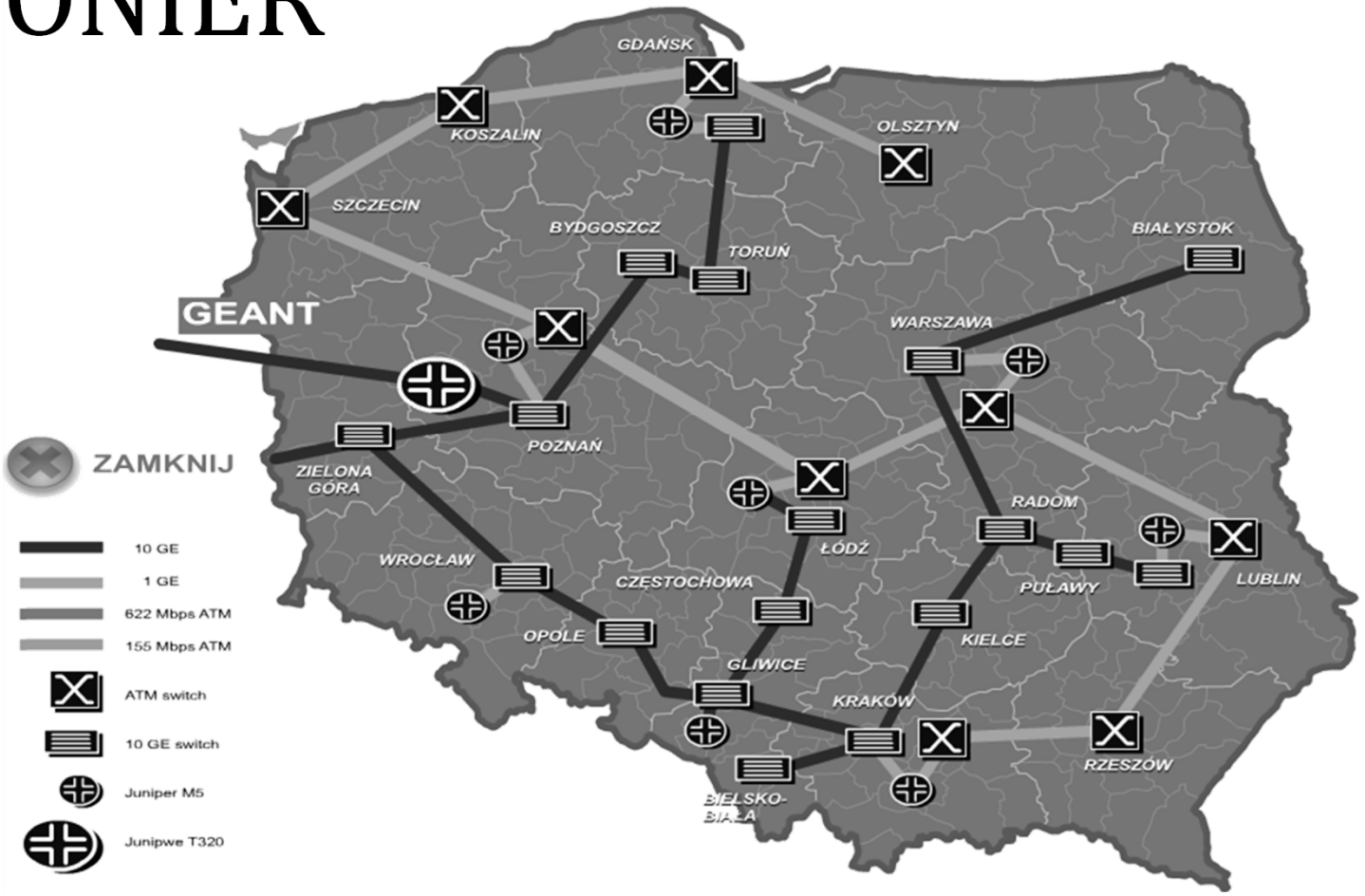
# History of Internet(1)



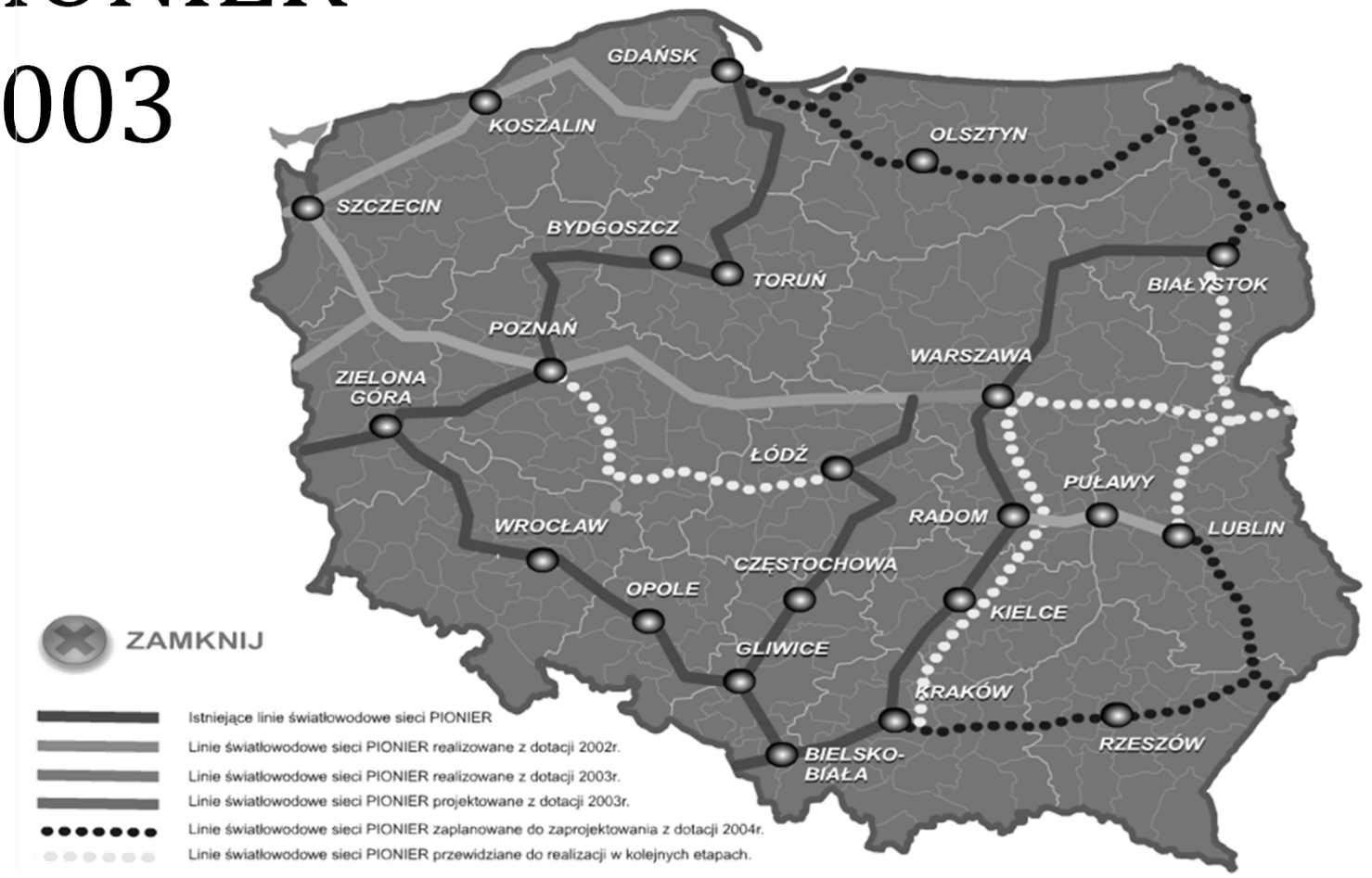
# History of Internet(2)



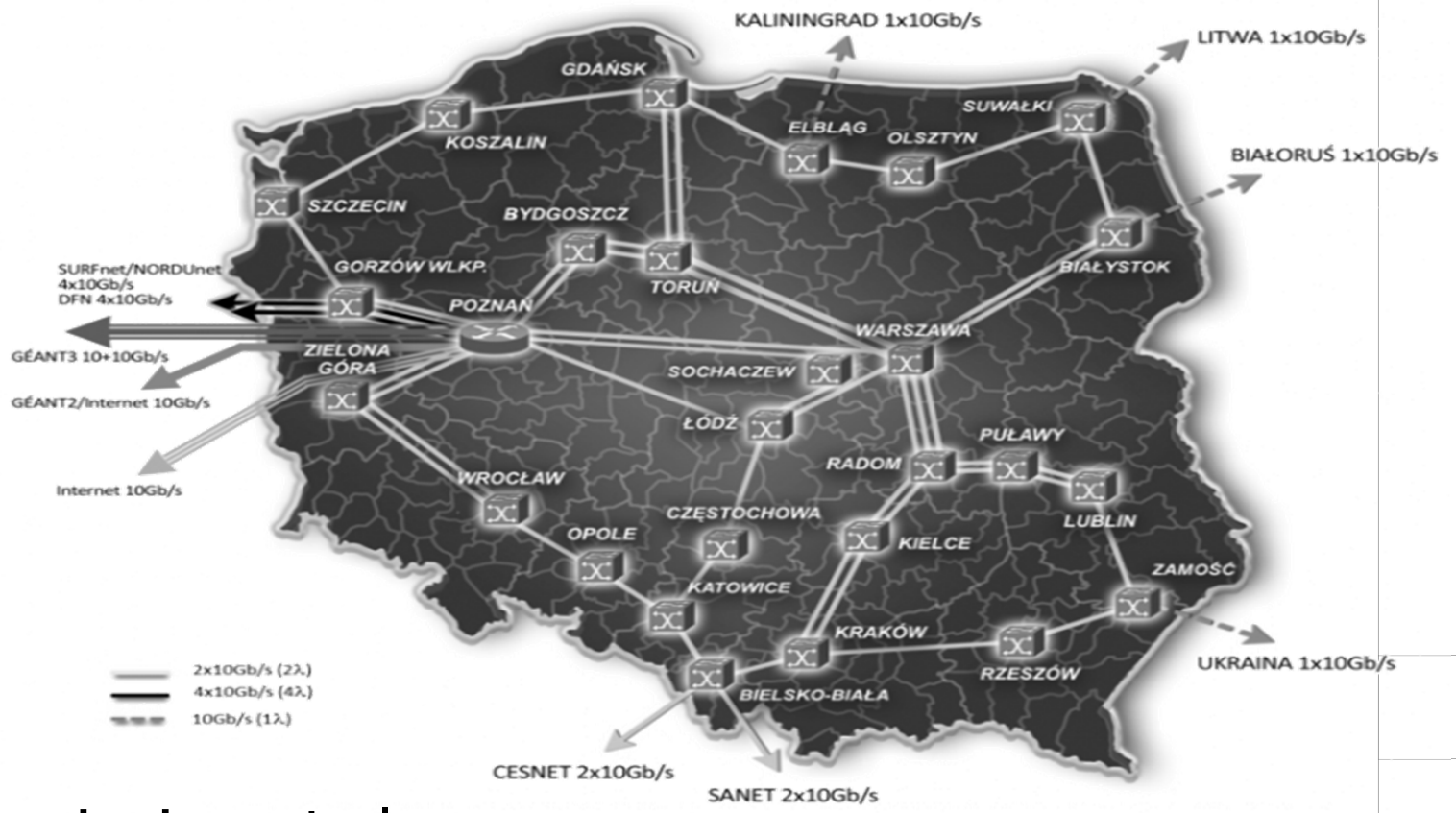
# PIONIER


GDAŃSK
KOSZALIN
OLSZTYN
SZCZECIN
BYDGOSZCZ
TORUŃ
BIAŁYSTOK
GEANT
WARSZAWA
POZNAŃ
ZIELONA GÓRA
RADOM
ŁÓDŹ
WROCŁAW
CZĘSTOCHOWA
PUŁAWY
LUBLIN
OPOLE
KIELCE
GLIWICE
KRAKÓW
RZESZÓW
BIELSKO-BIAŁA
ZAMKNIJ
10 GE
1 GE
622 Mbps ATM
155 Mbps ATM
ATM switch
10 GE switch
Juniper M5
Junipwe T320

# PIONIER 2003

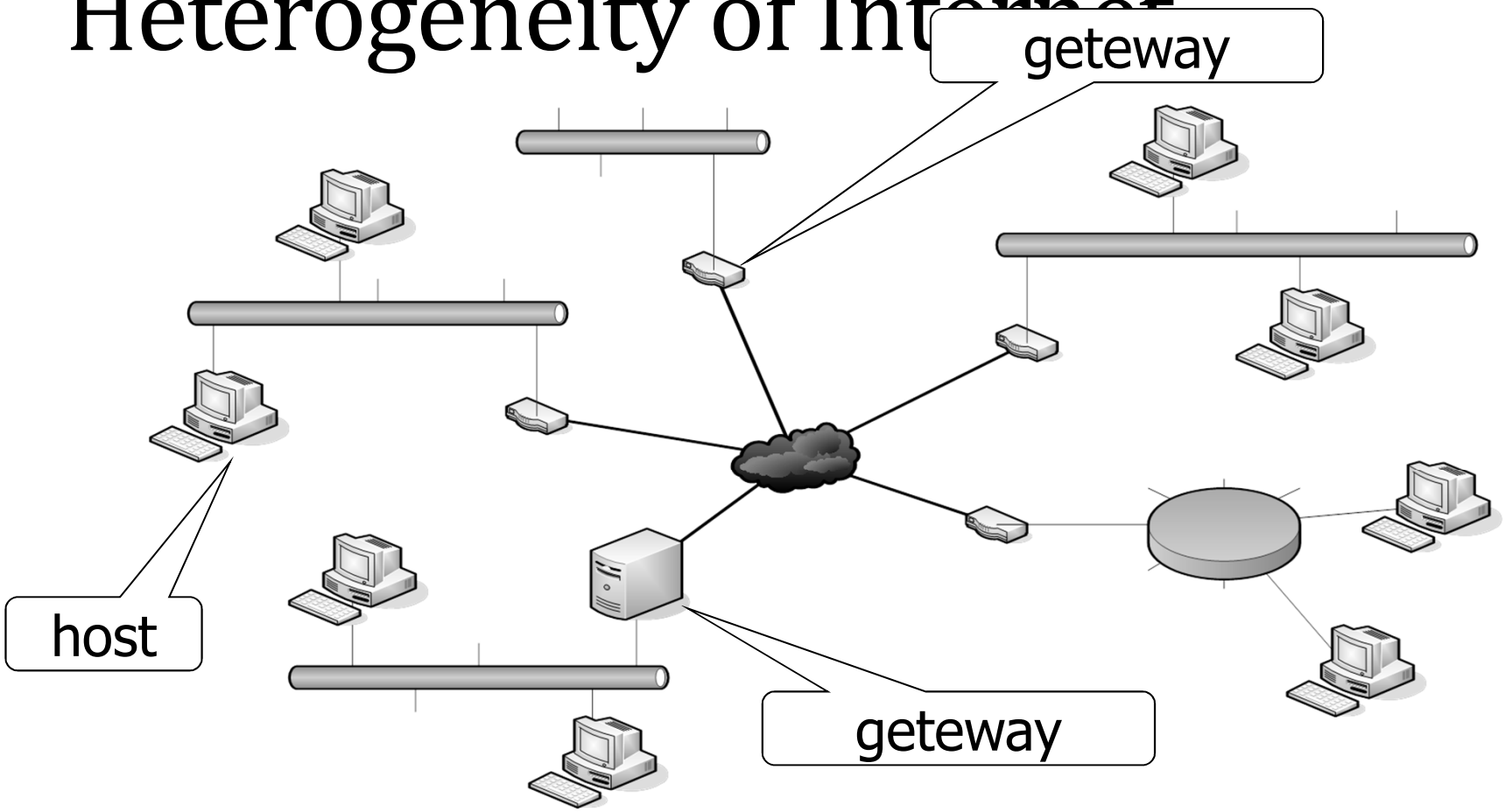


# PIONIER 2011

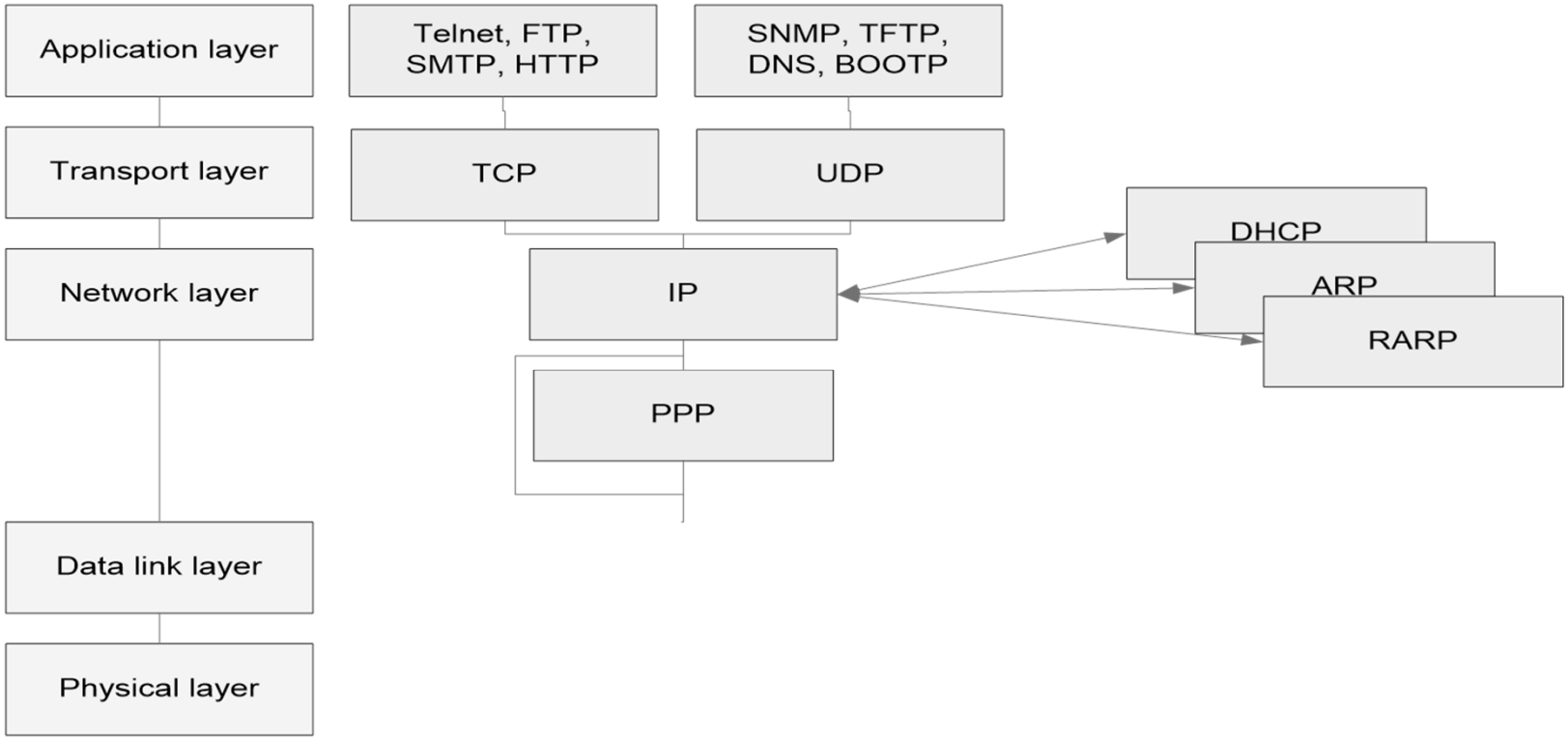



http://www.pionier.net.pl

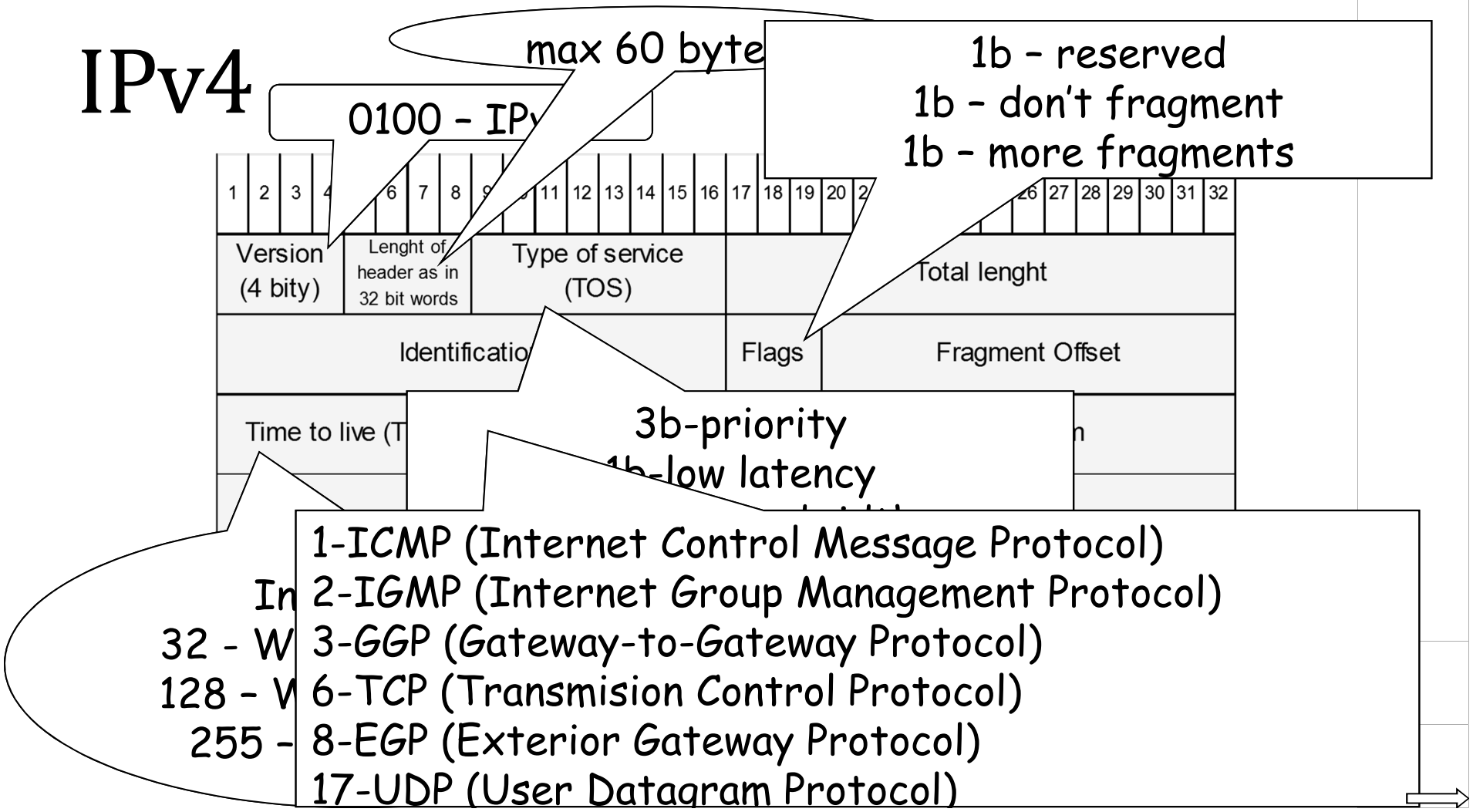
# Heterogeneity of Internet



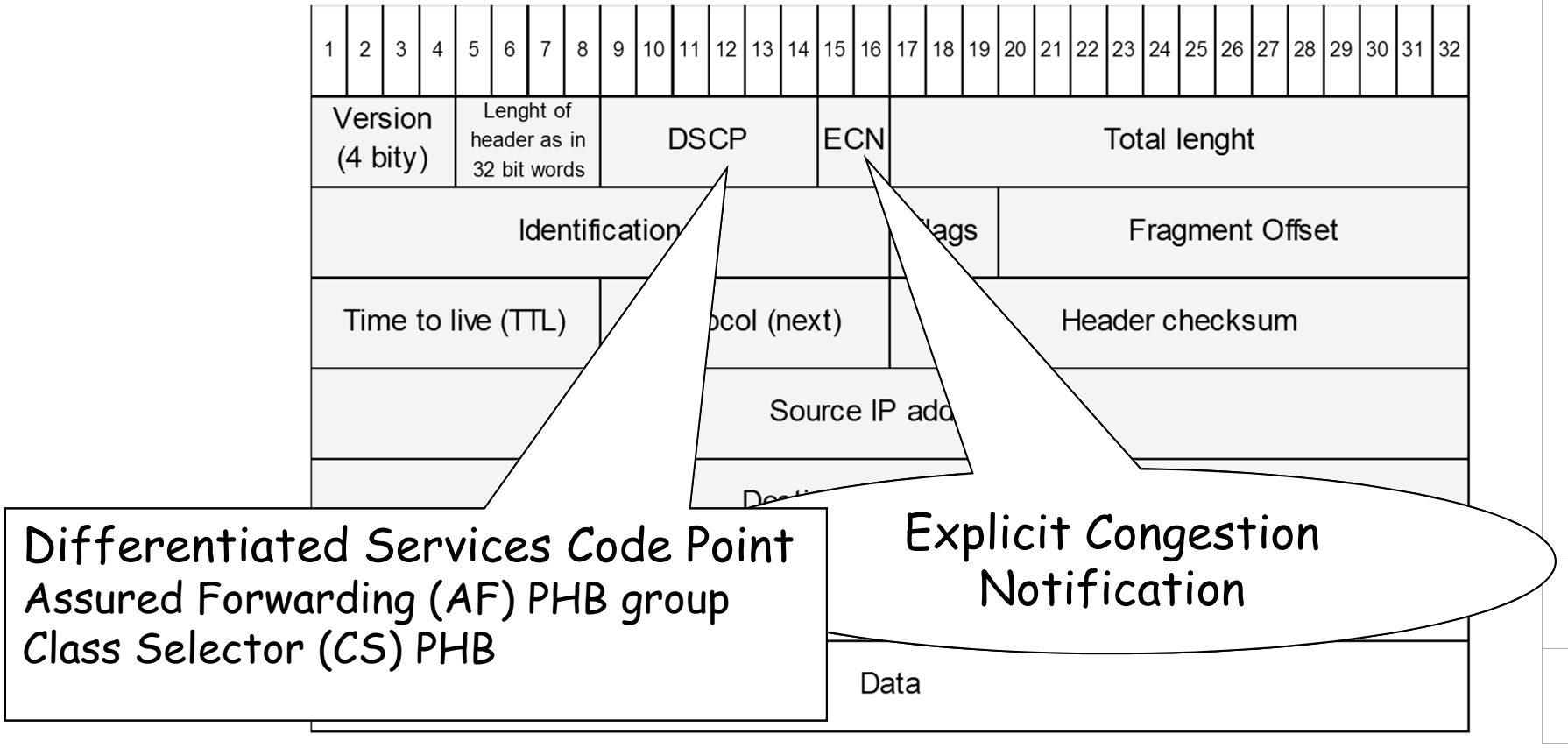
# TCP/IP stack

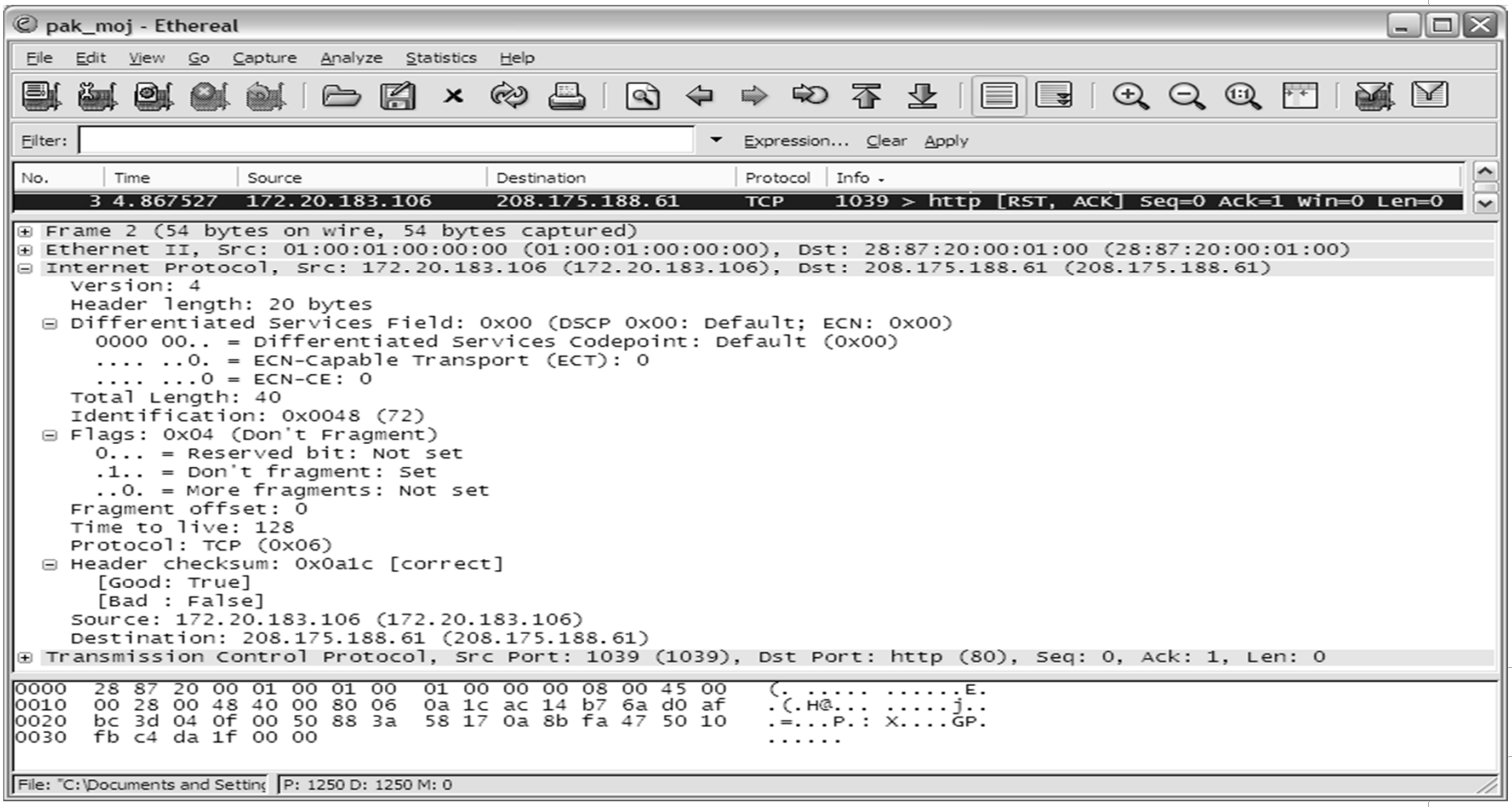

Application layer
Telnet, FTP, SMTP, HTTP
SNMP, TFTP, DNS, BOOTP
Transport layer
TCP
UDP
Network layer
IP
DHCP
ARP
RARP
PPP
Data link layer
Physical layer

# IPv4


max 60 byte
0100 - IPv
1b – reserved
1b – don't fragment
1b – more fragments
1 2 3 4 6 7 8 11 12 13 14 15 16 17 18 19 20 26 27 28 29 30 31 32
Version (4 bity)
Lenght of header as in 32 bit words
Type of service (TOS)
Total lenght
Identificatio
Flags
Fragment Offset
Time to live (T
3b-priority
1b-low latency
In
32 - W
128 - W
255 -
1-ICMP (Internet Control Message Protocol)
2-IGMP (Internet Group Management Protocol)
3-GGP (Gateway-to-Gateway Protocol)
6-TCP (Transmision Control Protocol)
8-EGP (Exterior Gateway Protocol)
17-UDP (User Datagram Protocol)

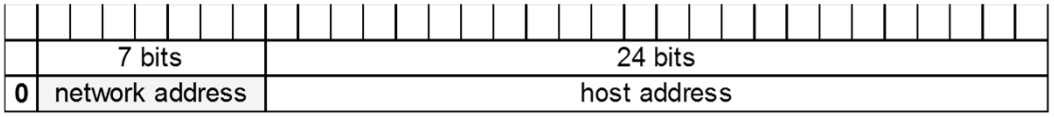
# TOS → DSCP+ECN


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 32
Version (4 bity)
Lenght of header as in 32 bit words
DSCP
ECN
Total lenght
Identification
Fragment Offset
Time to live (TTL)
Header checksum
Source IP add
Data
Differentiated Services Code Point
Assured Forwarding (AF) PHB group
Class Selector (CS) PHB
Explicit Congestion Notification

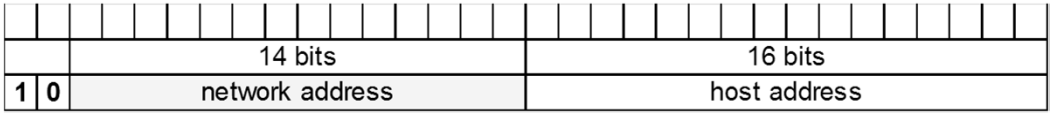

pak_moj - Ethereal
File Edit View Go Capture Analyze Statistics Help
Filter: Expression... Clear Apply
No. Time Source Destination Protocol Info
3 4.867527 172.20.183.106 208.175.188.61 TCP 1039 > http [RST, ACK] Seq=0 Ack=1 Win=0 Len=0
Frame 2 (54 bytes on wire, 54 bytes captured)
Ethernet II, Src: 01:00:01:00:00:00 (01:00:01:00:00:00), Dst: 28:87:20:00:01:00 (28:87:20:00:01:00)
Internet Protocol, Src: 172.20.183.106 (172.20.183.106), Dst: 208.175.188.61 (208.175.188.61)
Version: 4
Header length: 20 bytes
Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
0000 00.. = Differentiated Services Codepoint: Default (0x00)
.... ..0. = ECN-Capable Transport (ECT): 0
.... ...0 = ECN-CE: 0
Total Length: 40
Identification: 0x0048 (72)
Flags: 0x04 (Don't Fragment)
0... = Reserved bit: Not set
.1.. = Don't fragment: Set
..0. = More fragments: Not set
Fragment offset: 0
Time to live: 128
Protocol: TCP (0x06)
Header checksum: 0x0a1c [correct]
[Good: True]
[Bad : False]
Source: 172.20.183.106 (172.20.183.106)
Destination: 208.175.188.61 (208.175.188.61)
Transmission Control Protocol, Src Port: 1039 (1039), Dst Port: http (80), Seq: 0, Ack: 1, Len: 0
0000 28 87 20 00 01 00 01 00 01 00 00 00 08 00 45 00
0010 00 28 00 48 40 00 80 06 0a 1c ac 14 b7 6a d0 af
0020 bc 3d 04 0f 00 50 88 3a 58 17 0a 8b fa 47 50 10
0030 fb c4 da 1f 00 00
File: "C:\Documents and Setting
P: 1250 D: 1250 M: 0

# Classes of IP addresses

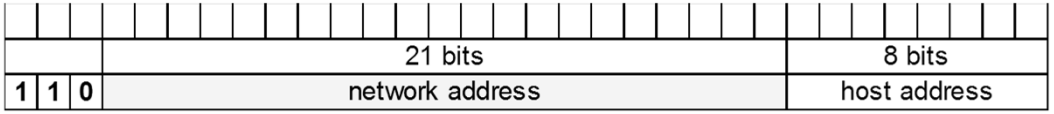
- Class A: 1.0.0.0 – 126.255.255.255




- Class B: 128.0.0.0 – 191.255.255.255

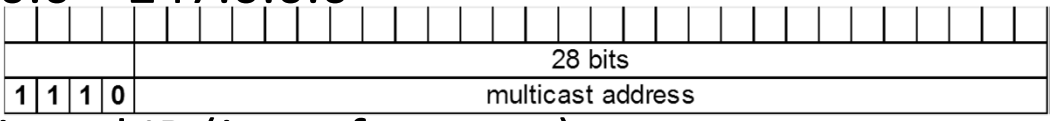



- Class C: 192.0.0.0 – 223.255.255.255

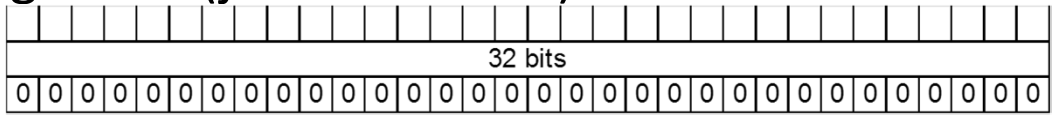


# Special IP addresses

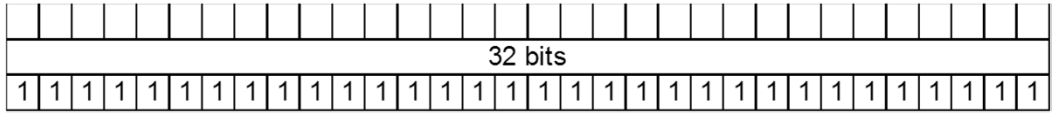
- Multicast: 224.0.0.0 – 247.0.0.0



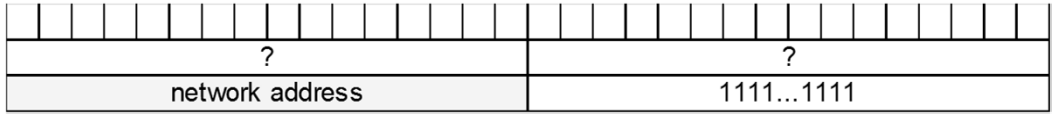

- Host without assigned IP (just after start)



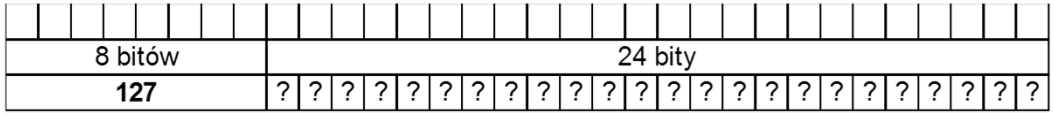

- Broadcast




- Direct broadcast




- Loop

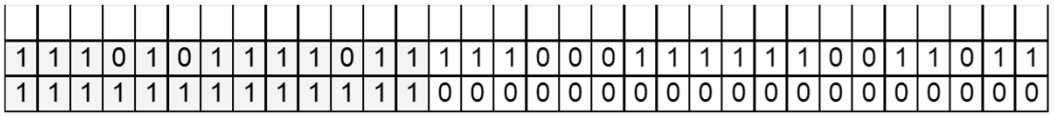


# Local IP addresses

- 10.0.0.0 – 10.255.255.255
- 172.16.0.0 – 172.31.255.255
- 192.168.0.0 – 192.168.255.255

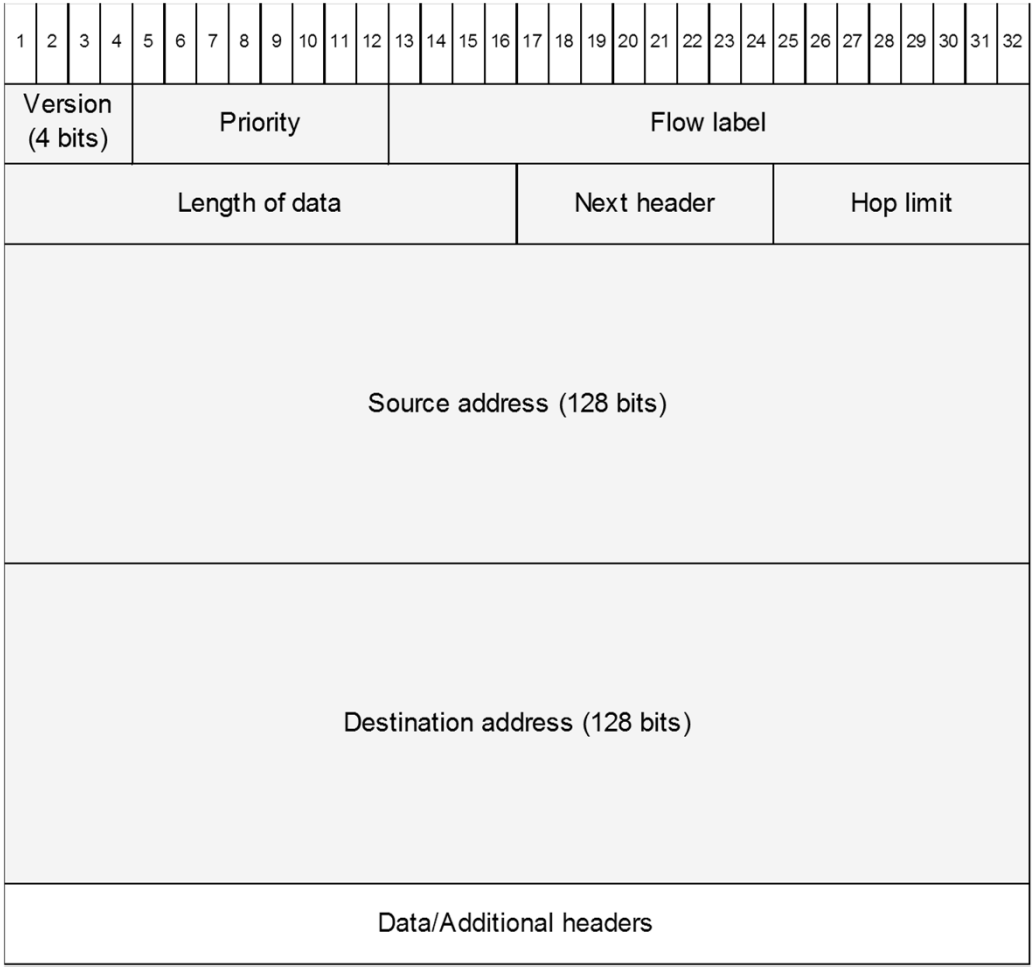
# Mask

- Mask
  - 255.248.0.0
  - 11111111.11111000.00000000.00000000

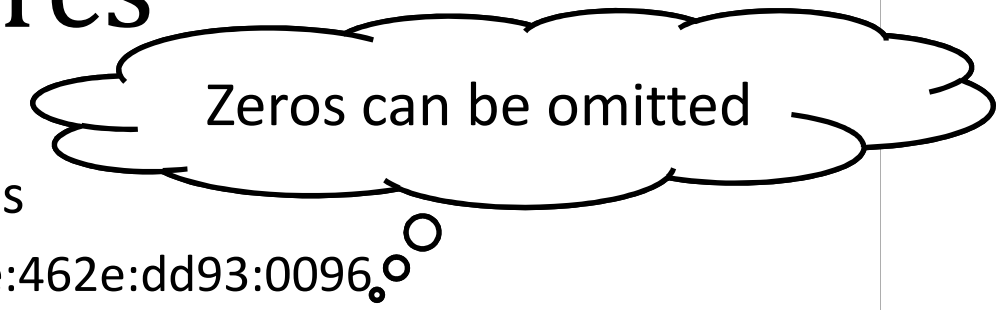



- Class A: 255.0.0.0
- Class B: 255.255.0.0
- Class C: 255.255.255.0

# IPv6

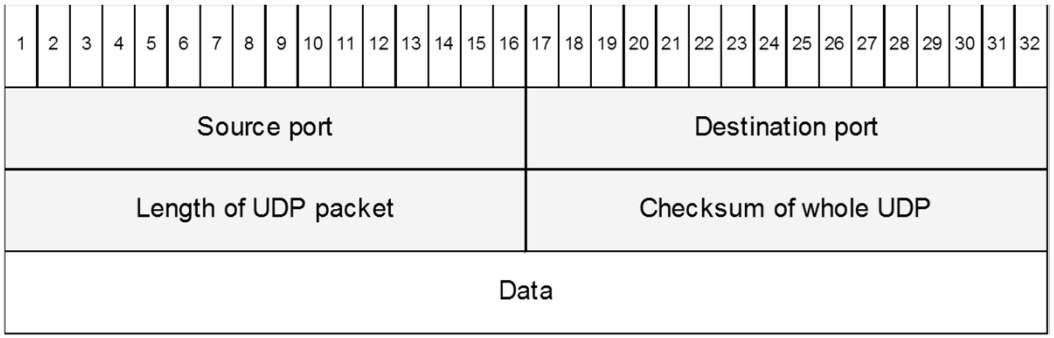

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Version (4 bits)
Priority
Flow label
Length of data
Next header
Hop limit
Source address (128 bits)
Destination address (128 bits)
Data/Additional headers

# Main IPv6 features

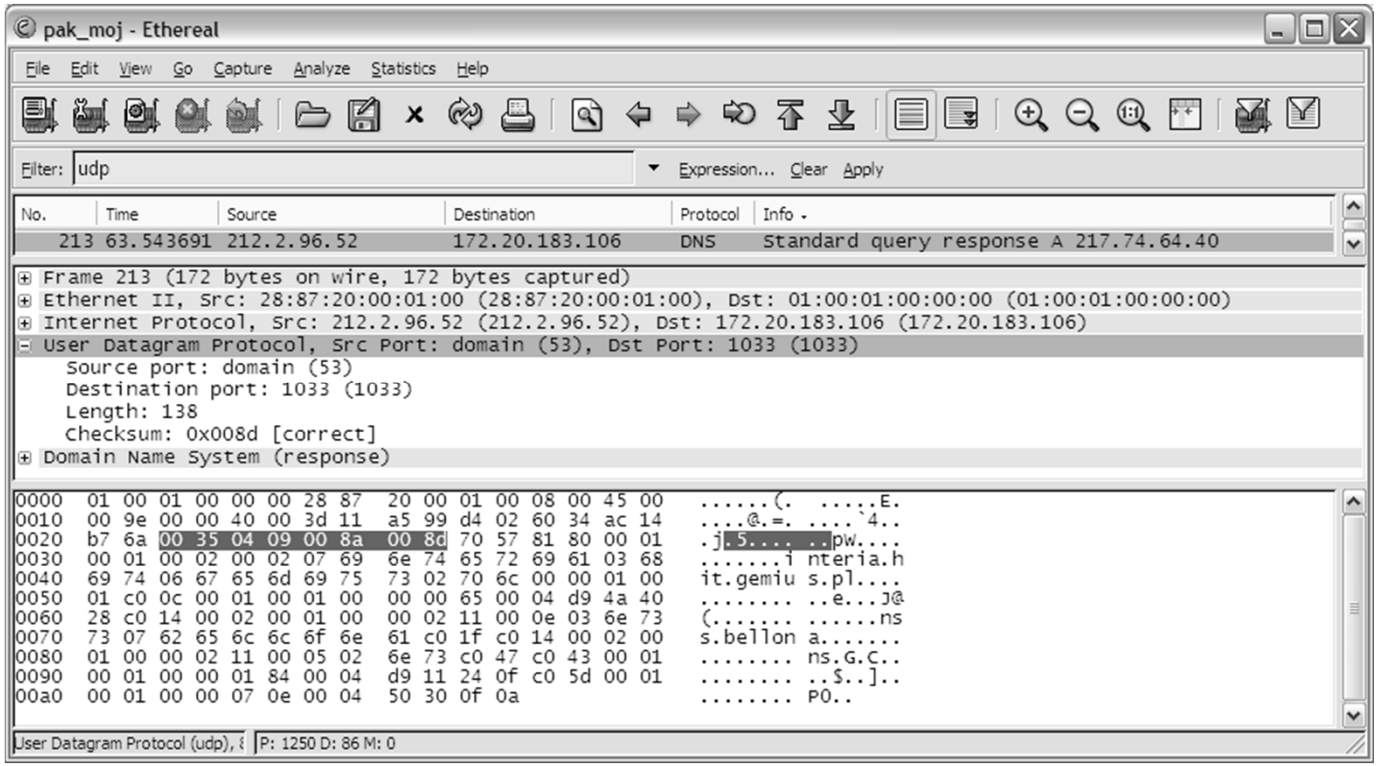



- Increased length of address
  - 1234:9876:aabb:76cd:ffee:462e:dd93:0096
  - theoretical amount of addresses $2^{128} \approx 3,4*10^{38}$
- Mandatory implementation of IPsec
- Identification for QoS (flow label)
- No fragmentation during transmission
- Address autoconfiguration based on MAC

# UDP

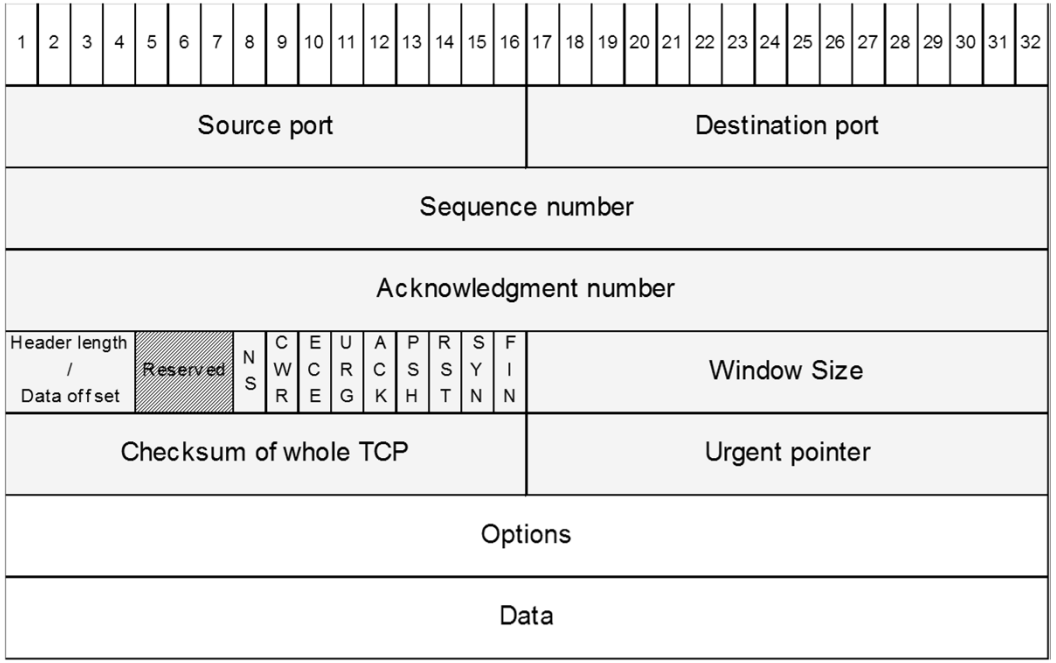

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Source port
Destination port
Length of UDP packet
Checksum of whole UDP
Data

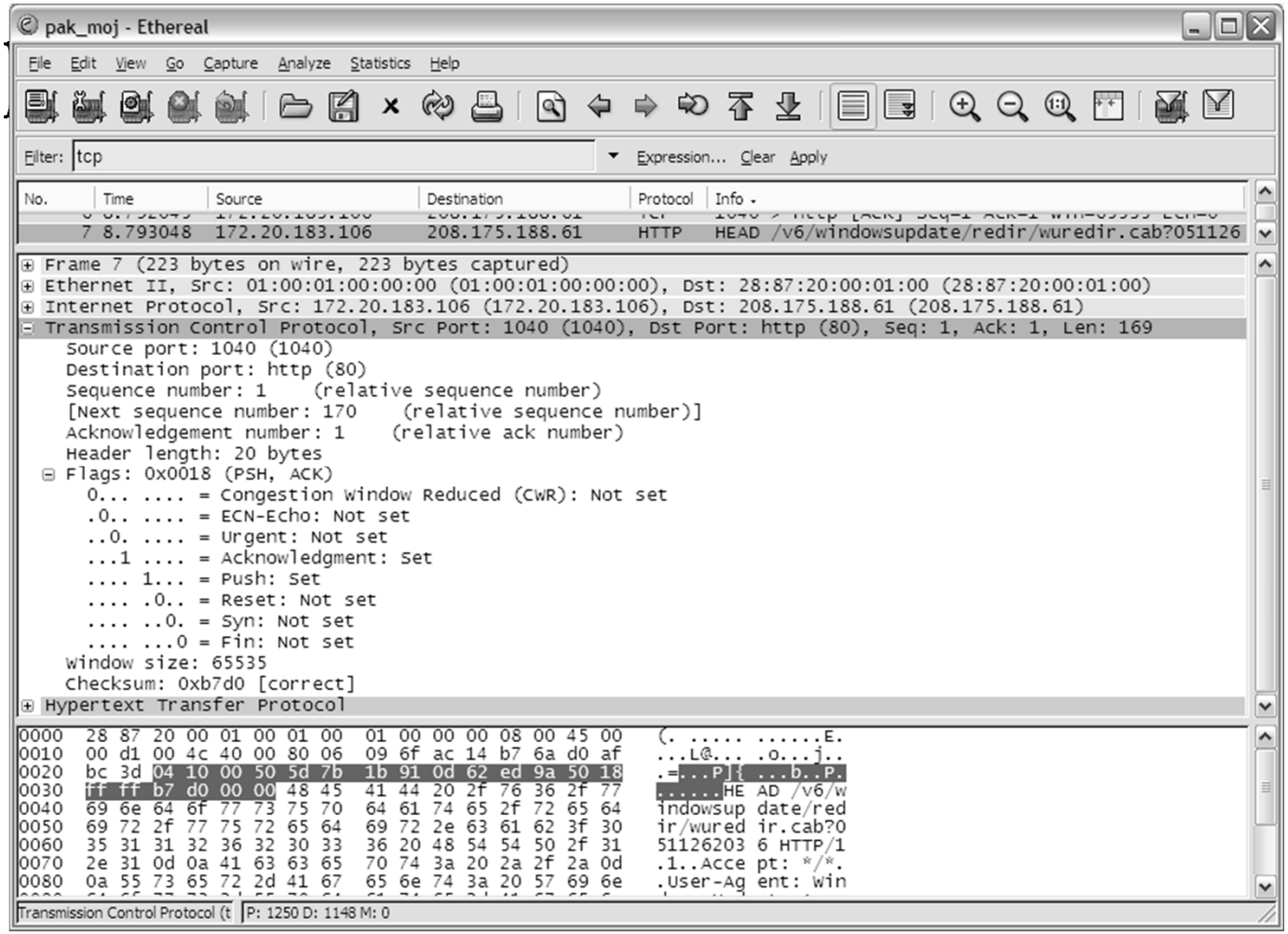
# Captured UDP header



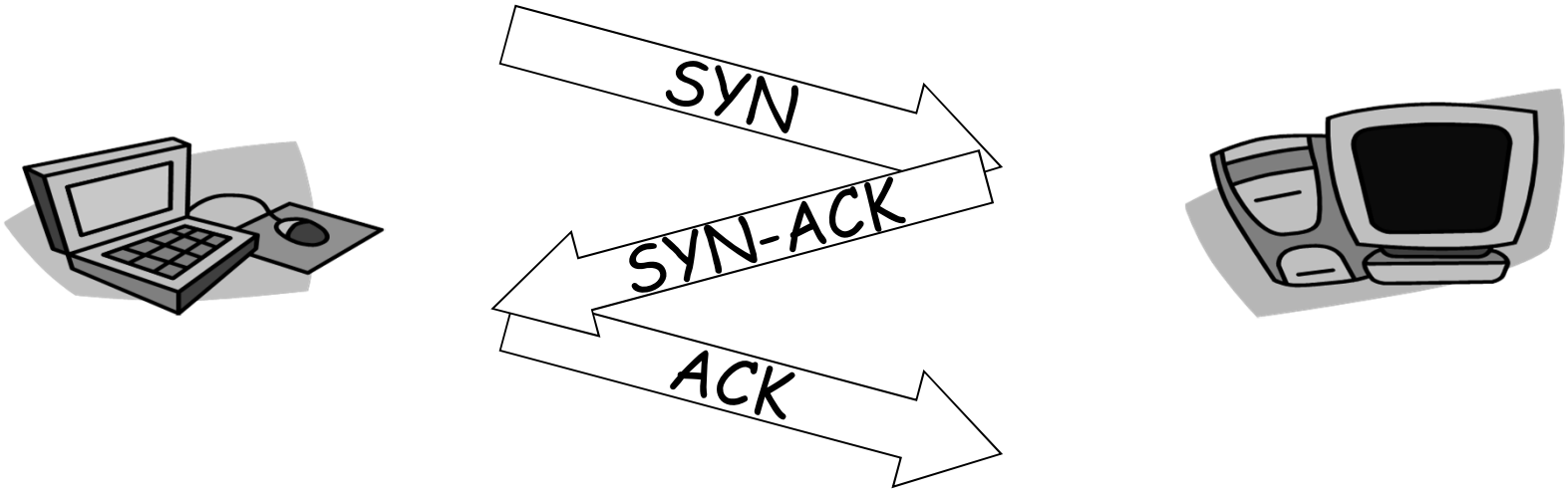
# TCP

Number of bytes

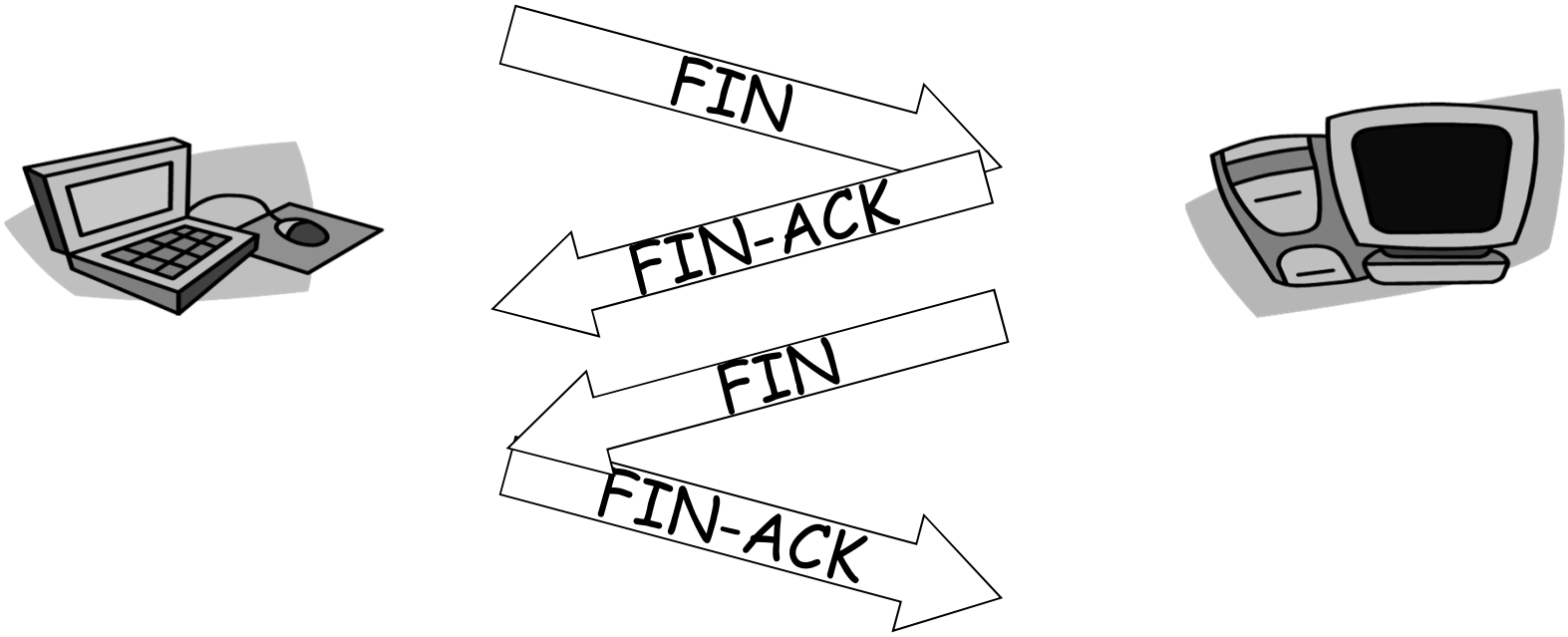



pak_moj - Ethereal
File Edit View Go Capture Analyze Statistics Help
Filter: tcp
Expression... Clear Apply
No. Time Source Destination Protocol Info
7 8.793048 172.20.183.106 208.175.188.61 HTTP HEAD /v6/windowsupdate/redir/wuredir.cab?051126
Frame 7 (223 bytes on wire, 223 bytes captured)
Ethernet II, Src: 01:00:01:00:00:00 (01:00:01:00:00:00), Dst: 28:87:20:00:01:00 (28:87:20:00:01:00)
Internet Protocol, Src: 172.20.183.106 (172.20.183.106), Dst: 208.175.188.61 (208.175.188.61)
Transmission Control Protocol, Src Port: 1040 (1040), Dst Port: http (80), Seq: 1, Ack: 1, Len: 169
Source port: 1040 (1040)
Destination port: http (80)
Sequence number: 1 (relative sequence number)
[Next sequence number: 170 (relative sequence number)]
Acknowledgement number: 1 (relative ack number)
Header length: 20 bytes
Flags: 0x0018 (PSH, ACK)
0... .... = Congestion Window Reduced (CWR): Not set
.0.. .... = ECN-Echo: Not set
..0. .... = Urgent: Not set
...1 .... = Acknowledgment: Set
.... 1... = Push: Set
.... .0.. = Reset: Not set
.... ..0. = Syn: Not set
.... ...0 = Fin: Not set
Window size: 65535
Checksum: 0xb7d0 [correct]
Hypertext Transfer Protocol
0000 28 87 20 00 01 00 01 00 01 00 00 00 08 00 45 00 (. ..... ......E.
0010 00 d1 00 4c 40 00 80 06 09 6f ac 14 b7 6a d0 af ...L@... .o...j..
0020 bc 3d 04 10 00 50 5d 7b 1b 91 0d 62 ed 9a 50 18 .=...P]{ ...b..P.
0030 ff ff b7 d0 00 00 48 45 41 44 20 2f 76 36 2f 77 ......HE AD /v6/w
0040 69 6e 64 6f 77 73 75 70 64 61 74 65 2f 72 65 64 indowsup date/red
0050 69 72 2f 77 75 72 65 64 69 72 2e 63 61 62 3f 30 ir/wured ir.cab?0
0060 35 31 31 32 36 32 30 33 36 20 48 54 54 50 2f 31 51126203 6 HTTP/1
0070 2e 31 0d 0a 41 63 63 65 70 74 3a 20 2a 2f 2a 0d .1..Acce pt: */*.
0080 0a 55 73 65 72 2d 41 67 65 6e 74 3a 20 57 69 6e .User-Ag ent: Win
Transmission Control Protocol (t
P: 1250 D: 1148 M: 0

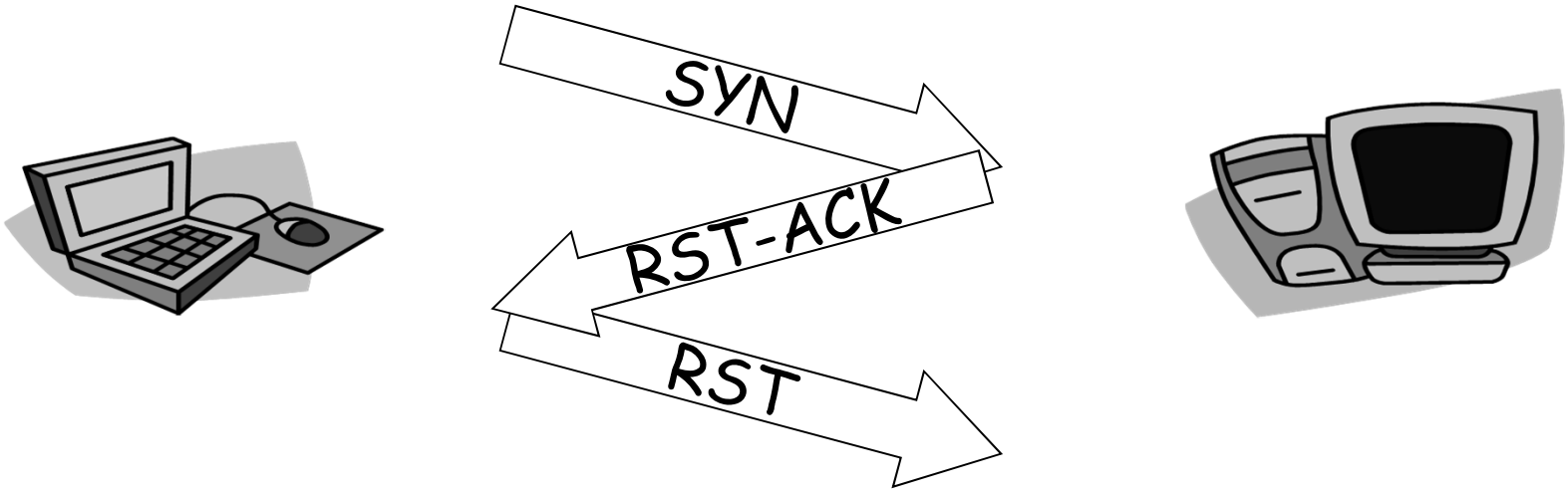
# Opening of TCP connection



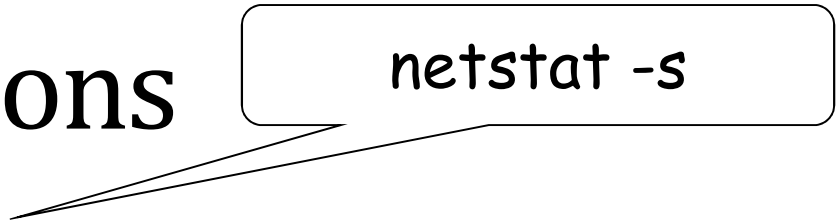
# Closing of TCP connection



# Opening TCP connection attempt – closed TCP port



# Retransmissions




- Major reasons
  - Lost TCP datagram or acknowledgment
  - Damaged frame (CRC error)
  - Data damaged by switch or router (TCP checksum error, without CRC error)
  - Full buffer on receiver site
  - Lost fragment IP datagram (in the case of fragmentation)
  - Late acknowledgment

# ARP, DNS i IP

- ARP
  - Who has the following address (gataway)? np. 192.168.1.1
  - Me 00-02-11-84-cd-aa.
- DNS
  - How is IP address of www.wp.pl? Gataway, send the request to pointed DNS server.
  - 212.77.100.101
- IP
  - Comunication with www.wp.pl

# pir

```
>arp -a
No ARP Ent

>ipconfig
Windows IP
Successful

>ping wp.p
Pinging wp
Reply from
Reply from
Reply from
Reply from

Ping stati
    Packet
Approximat
    Minimu
```