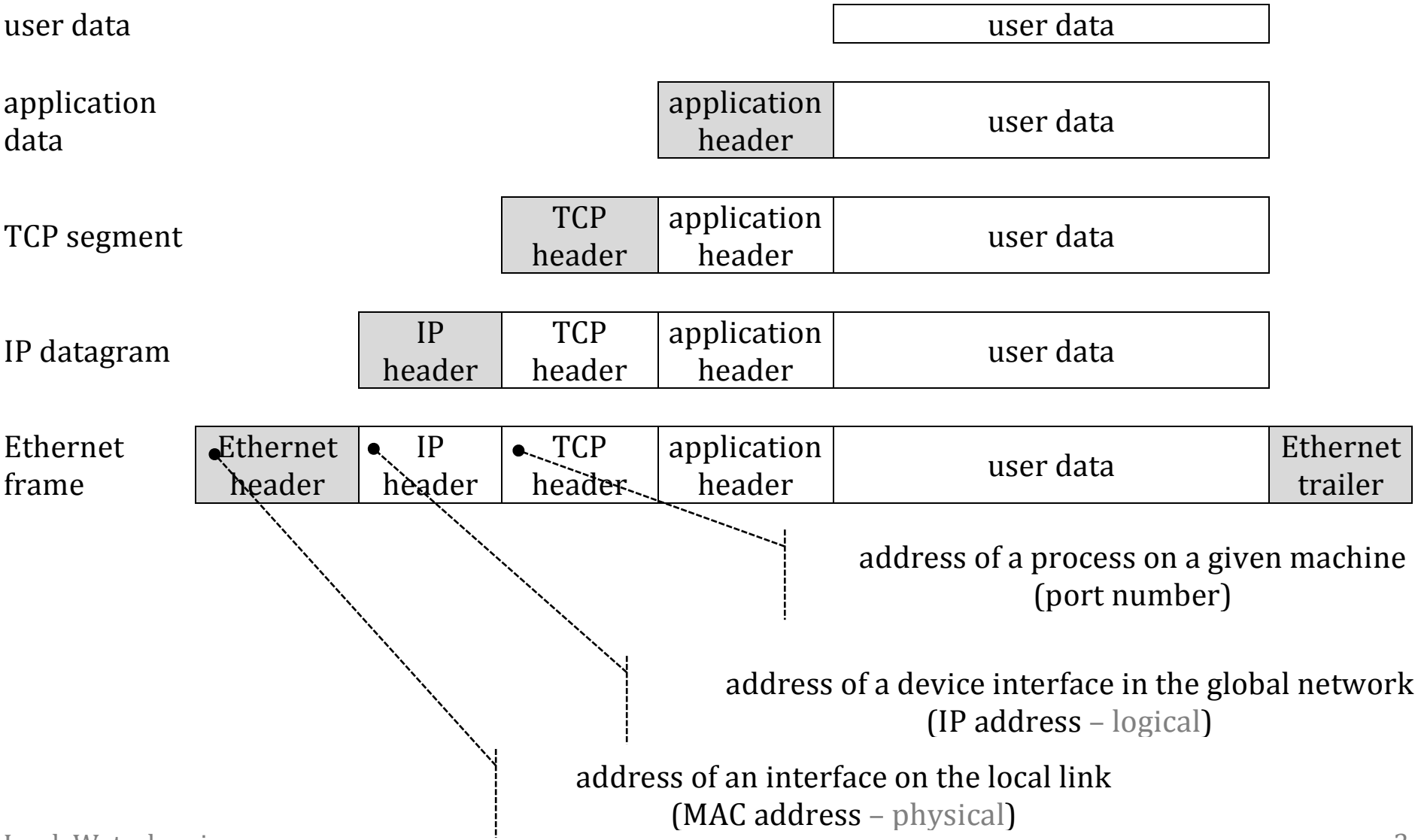
Computer Networks

Lecture on
Addressing – MAC, EUI, IPv4, IPv6, port numbers, URL

Plan of This Lecture

- Encapsulation of packet headers
- 2nd layer addresses – IEEE 802 addresses
- 3rd layer addresses – Internet addresses
- 4th layer addresses – port numbers
- Web addresses – Uniform Resource Locators (URLs)

Encapsulation of Packet Headers



Address Notations – Examples

		Numerical		Symbolic
Transport	address	25, 80	/etc/services	SMTP, HTTP
Network	type of payload	6, 17	/etc/protocols	TCP, UDP
	address	139.159.208.110 2607:f8b0:4000:813::200e	→ DNS ← RevDNS	www.qzhu.edu.cn ipv6.google.com
	ARP ↓ ↑ RARP or ICMPv6			
Data Link	type of payload	0x0800, 0x86DD		IPv4, IPv6
	address	00-20-AF-9A-10-E1		

2nd Layer Addresses – IEEE 802 Addresses

MAC-48 (Medium Access Control address, 48-bits length)

- Was defined to distinguish hardware interfaces
- IEEE considers the term as obsolete

EUI-48 (Extended Unique Identifier, 48-bits length)

- Indistinguishable from MAC-48
- Was defined to distinguish hardware or software instances
  – not necessarily a network address
- Users still use the name MAC-48
- Used by: Ethernet, WiFi, Bluetooth, ATM, Token Ring, SCSI, FDDI, Fibre Channel, most other IEEE 802 networks

EUI-64 (64-bits length)

- Used by: FireWire, 802.15.4 PAN, ZigBee

MAC address

2-byte format

- for simple devices working in local isolated networks
- address is assigned by network administrator

6-byte format

- for general usage
- address
  - is assigned by interface manufacturer
    - 3-byte Organizational Unique Identifier (OUI)
    - 3-byte Network Interface Card (NIC)
  - can be cloned by administrator
  - can by assigned by administrator

    bit1: U/L =0 => universal, =1 => local
- unicast, multicast and broadcast

  bit0: I/G =0 => individual, =1 => group

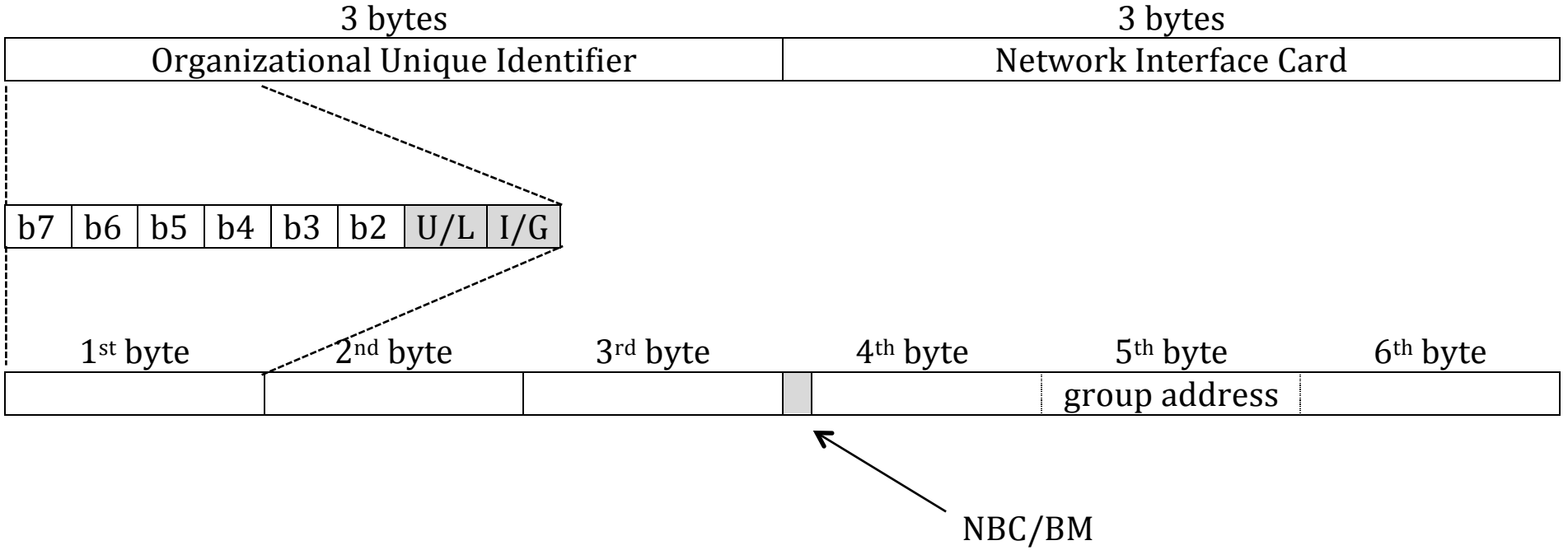
  NBC/BM bit24: =0 => Natural Binary Code, =1 => bit mask

  FF-FF-FF-FF-FF-FF – broadcast

  00-00-00-00-00-00 – NULL or uninitialized value

IEEE defined logical format of addresses

- physical structure (transferred order of bits and bytes) is not the same in different networks
  e.g. MSB first in Ethernet, Ring LSB first in Token



EUI-64

64 bit identifier

Organizational Unique Identifier lengths:

- 24, 28 and 36 bits, so the organisations have 40, 36, and 28 bits for numbering

00-00-00-00-00-00-00-00 – NULL or uninitialized value

FF-FF-FF-FF-FF-FF-FF-FF – broadcast

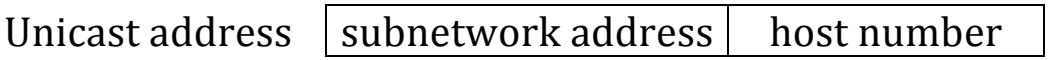
Address translation is deprecated, historically it was:

MAC-48 → EUI-64: OUI + 0xFFFF + NIC

EUI-48 → EUI-64: OUI + 0xFFFE + NIC

3rd Layer Addresses – Internet Addresses

	IPv4	IPv6
Length	32 bits	128 bits
Notation	decimal, e.g.: 139.159.208.110	hexadecimal, e.g.: 2607:f8b0:4000:813::200e :: is a shortcut for string of 0s
Type	unicast, multicast, broadcast in subnets special (e.g. loopback)	unicast, multicast, anycast no broadcast special (e.g. loopback) IPv4 mapped
Range	global and private	global, unique-local (private), link-local
Subnetwork addressing	class-full classless	classless



Several IP addresses can be assigned to one interface!

IPv4 Addresses

Class	First Octet	Leading Bits	Network Address	Host Index
			address (effective) #bits	*#bits*
A	0-127	0…	8 (7)	24
B	128-191	10…	16 (14)	16
C	192-223	110…	24 (21)	8
D	224-239	1110…	multicast	
E	240-255	11110…	reserved	

e.g. 127.0.0.1 is a loopback address

Host index = 0 – unknown source address or default destination
Host index = all 1s – broadcast inside the subnetwork

Number of hosts = $2^H - 2$ H – number of index bits
Number of networks = $2^N - 2$ N – number of effective bits

Dotted decimal notation e.g. 192.168.16.4 → 11000000 10100000 00001000 00000010

Private address pools

1	class A network:	10.0.0.0/8
16	class B networks:	172.16.0.0/12
256	class C networks:	192.168.0.0/16

Automatic Private IP Addressing (APIPA) 169.254.0.0/16

– for configuration of link-local addresses in IPv4

Prefixes, VLSM, CIDR

Prefix notation

194.29.168.0 255.255.255.0 = 194.29.168.0/24

11111111.11111111.11111111.00000000

10.2.3.4 255.255.255.252 = 10.2.3.4/30

11111111.11111111.11111111.11111100

Variable Length Subnet Mask

#ISP level 1	…	# organization	# host

Subnetwork address = 0 – unknown source address or default destination

Subnetwork address = all 1s – broadcast inside the subnetworks

Classless Inter-Domain Routing

- Routers can aggregate routing records for subnets reachable form the same output
- Routers have to store IP addresses and subnet masks

Subnetwork Mask

IP address: 11000101.11001010.11101001.01010100

197 . 202 . 233 . 84

Subnet mask 11111111.11111111.11111111.11000000

255 . 255 . 255 . 192

Subnet address IP address AND mask

11000101.11001010.11101001.01000000

197 . 202 . 233 . 64

Host Index IP address AND (NOT subnetwork mask)

00000000.00000000.00000000.00010100

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IPv6 Addresses

- Optimistically around 4,000 trillions of addresses per 1 m^2 of the earth (considering different types of allocations)
- Most pessimistically, at least 1,564 addresses per 1 m^2 of the earth
- Hexadecimal notation

  e.g. 2001:0DB8:AC10:FE01:: *:: – indicates omitted zeroes*

  2a00:1450:401b:804::200e

  2001:0db8::0001 = 2001:db8::1 *leading zeroes can be omitted too*

Hierarchy of IPv6 addressing

# Regional Internet Registry	#ISP level 1	# ISP level 2	#ISP level N	#organi zation	#locali zation	# host
		64 bits				64 bits

Anycast addresses

- Selected from the unicast address space
- Assigned to more than one interface / nodes

Domain Names

- Symbolic representation of IP addresses
- Hierarchical structure
- Can reflect:
  - geographical dependences
    e.g. www.ztm.waw.pl bip.warszawa.pl
  - organizational dependences
    e.g. www.ii.pw.edu.pl
- Can use national characters
  e.g.: .中国 кц.рф
- One domain name can be attributed to many IP addresses
- One IP address can have many domain names

4th Layer Addresses – Port Numbers

Port identifies a process, participating in a communication

It is a 16-bit natural number

3 scopes

- Permanent ports – used by server processes
  - Well-known services (<1024)
    - defined by Internet Assigned Numbers Authority
    - system processes
  - Registered ports (1024 ÷ 49151)
    - assigned by IANA
    - can be used without superuser privileges
- Private or ephemeral (dynamic) ports (49152 ÷ 65535)
  - used for private or customized services, for temporary purposes
  - used by client processes – automatic allocation of ephemeral ports

Web Address – Uniform Resource Locator

Is a reference to a web resource

Is a specific type of Uniform Resource Identifier (URI)

Often URI and URL are used interchangeably

URI = scheme:[//authority]path[?query][#fragment]

Popular schemes: http, https, ftp, mailto, file, data, irc

authority = [userinfo@]host[:port]

Examples:

http://en.qzhu.edu.cn/list.jsp?urltype=tree.TreeTempUrl&wbtreeid=1069

https://john.doe@www.example.com:123/forum/questions/?tag=networking&order=newest#top

https://en.wikipedia.org/wiki/URL#Syntax

http://[::FFFF:129.144.52.38]:80/index.html

hkp:// 192.0.2.16:80/

sftp://wytrebowicz@ www.example.com/ftpdir

file:///path/resource.txt <-- *It is not a web address*

Summary

- Encapsulation of packet headers
- 2nd layer addresses – IEEE 802 addresses
  - MAC addresses
  - Extended Unique Identifiers
- 3rd layer addresses – Internet addresses
  - IPv4 addresses
  - IPv6 addresses
  - Domain Names
- 4th layer addresses – port numbers
- Web addresses – Uniform Resource Locators (URLs)

Exercises

See content of the following files:

- /etc/services (see: man services)
- /etc/protocols (see: man protocols)
- /etc/hosts (see: man hosts)

Run in a terminal window the following commands:

- ifconfig (ipconfig on a MS Windows OS; or the newer ip addr list on Linux)
  and figure out the output (see: man ifconfig)
- host www.ii.pw.edu.pl (similar commands: dig, nslookup)
- host www.qzhu.edu.cn
- host -t AAAA en.wikipedia.org
- wget http://staff.ii.pw.edu.pl/~jwt/4you.html

Check the manufacturer name of the network interface of your computer. Use the MAC Address Lookup tool: https://www.macvendorlookup.com

Questions

1. What is the difference between multicast and anycast addressing?
2. Give an example of anycast address usage?
3. What is the structure of the MAC-48 address?
4. What is the difference between MAC-48 and EUI-48 addresses?
5. Describe the types of addresses defined by IEEE (2^{nd} layer addresses).
6. What is the host number pointed by the IPv4 address 197.202.233.64/24?
7. What is the host number pointed by the IPv4 address 197.202.32.64/16?
8. What is the meaning of the 197.202.255.255/16 IPv4 address in the subnet?
9. What is the meaning of the 0.0.0.0 IPv4 address in a subnet?
10. What is the meaning of the 255.255.255.255 IPv4 address in a subnet?
11. What for can we use the 127.0.0.1 address?
12. How many hosts can we address in the subnet 192.168.6.00/9?
13. How many IP addresses can be bind to a domain name?
14. How many domain names can be attributed to an IP address?
15. What for is the port number field in the TCP header?
16. What are permanent and ephemeral port numbers?
17. Characterize the addressing in the Internet (distinguish addresses related to 2^{nd}, 3^{rd}, and 4^{th} OSI layers).
18. Describe the structure of URL.