Networks

By Miroshnichenko Denis

There are just my notes that I wrote down while studying computer networks. I am not responsible for the correctness of this information.

Topology of networkings

Topology of networks - configuration of graph:

Vertex - nodes of net (PC and net software)

Ribs - comminication between nodes (physical and informatical)

Physical topology = is connection devices in net (how devices connect to each other to build the net)

Logical topology = is rules of signal distribution in net

TOPOLOGY = schema of union devices in net

Basics of organisation of computer networks

Service - describe what functions implements level (what level does)

Interface - collection primitive operations, which lower level provides higher level (how to get access to service level)

Protocol - rules and agreements, using for communication level N one computer with (how level does do it) level N another computer

Model OSI

Host 1

Application level (network process to application)

Presentation level (data representation and enctyption)

Session level (interhost communication)

Transport (E2E connections and reliability)

Network (path determination and IP(logical addressing))

Data link (MAC and LLC (Physical addressing))

Physical (signals and binary transmissions)

1) Physical - transmission of bytes per channel connection. Not interesting in data.

Goal: how to represent bytes of information by signals, transmitted by environment.

2) Data Link - define start and end of byte stream. Define mistakes. Physical addressing.

3) Network level - union networks, built by foundation different techologies

Goals:

1) Create composite network (agree some differences between networks)

2) Addressing

3) Define route to shipment batches in composite network

4) Transport - maintain data flow between proccesses between hosts

Provide more reliability than network level

Direct communication between THIS level:

HOST_1 (Transport level) ↔ HOST_2 (Transport level)

5) Session level - create session of communication

6) Represent level - provide agreement in syntax and semantic transmitted data (presenting symbols, formats digit)

Encrypt and decrypt data

Example: TLS/SSL

7) Application level - useful for user programs (html pages, twitter, vk, emails)

Physical level

Goal: transmit flow of bytes per environment. Not interesting in data content, just represent bytes in signals

Transmission unit: Bytes

Environment of transmission:

1) Copper cables (wired)

2) Optical cables (wired)

3) Radiowaves (wireless)

Data Link level

Goal:

- Transmit messages per channel connection (frame).
- Define start and end of byte stream
- Define mistakes and correct it
- Multiple access to channel connection:

  1) Addressing

  2) Coordinated access to channel

Two sublevels:

1) Control logical channel (LLC)

2) Control access to environment (MAC)

Technology:

1) Ethernet, WI-FI

2) Token Ring, FDDI ...

Ethernet - is the most popular in current time networking technology of wire connection

Is located in physical and data link levels

Format of frame in Ethernet

```
-------------------------------------
6 bytes = address of consumer       |
6 bytes = adress of publisher       |  Title
2 bytes = type (IPv4, IPv6, ARP)    |
-------------------------------------
46-1500 bytes = data          |
-------------------------------------
4 bytes = conrol sum                | End
-------------------------------------
```

MAC addresses

- Is used in data link level

Format 6 hex digits:

Example: **1C-75-08-D2-49-45**

types of mac addresses:

1. **Unicast**
2. **Multicast** (first byte = 01)
3. **Broadcast** (all bytes = 1 : FF-FF-FF-FF-FF-FF)

should be unique

Mac addresses can be define by:

1. Automatic production network adapter
2. Manually (Administrator)

Commutators. Ethernet

1. Classical Ethernet (probably collision (avoid by CSMA/CD method))
2. Commutating Ethernet (withoud common environment, not collision, uses switches (commutators))

Connection : point-to-point

- Концентратор (hub)
- Коммутатор (switch)

Hub - uses topology of common bus. Physical level

Switch - full connected topology. Data Link level

Table of swiches:

```
Port of switch     MAC-address
    1      1C-75-08-D2-49-45
    2      00-02-B3-A7-49-D1
.... ..      ...
```

Bridge - uses for avoid collision in large environment by dividing one large by two smaller (with own table switch)

```
Example

 h1  h2                h3      h4   h5
 |   |                 |       |    |
---------[bridge] ------------------------
```

VLAN

VLAN - virtual local area network

Technology of dividing common net on some logical nets, isolated from each other

Osi level: Data link level (swiches)

Advantages of isolation:

1. Security
2. Load balancing
3. Destrict broadcast traffic

in switch table add one column: VLAN (1,2,3....)

Wi-Fi

OSI levels: Physical(6 standarts IEEE 802.11) and Data Link(Method CSMA/CA, protocol MACA)

Before sending frames computers checks carrier frequency that no one did not send frames at the time

Format frames Wi-Fi

4 MAC-address in frame

- DA - destination address
- SA - source address
- TA - transmitted address (device that transmit data in wireless environment)
- RA - receiver address (device that receives data from wireless environment)

Services Wi-Fi

In Ethernet Service (only one): transmission data

In Wi-Fi services:

1. Assosiation (connection to environment)
2. Authentication
3. Transmission data
4. Encrypt

Network level

Union networks based on different technologies (ethernet, wi-fi, 3g, 4g, 5g, etc)

Why we need this level?

- Different technologies in data link level
- Scalability

In data link level there are switches and it has switch table

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In global net switch table must has all mac-addresses ⇒

a lot of memory, and after that if switch table does not have mac-address it sends to all hosts ⇒

a lot of time to do it ⇒

Network level do it the best

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Scalability in Network level:

Aggregation of addresses:

1. Works with groups of addresses
2. Groups addresses - network

The batch was throw away if the network level can not define where should it be sent

Goals:

1. Internetworking
2. Routing
3. Provide quality of service

This level provides routers which connects in one or more nets with diffrent IPs

Protocols:

1. IP
2. ARP
3. DHCP

IP address

Structure:

1. Number subnet: most significant bits
2. Number host: least significant bits

Example:

1. IP: 213.180.193.3 / 24
2. Number subnet: 213.180.193.0
3. Number host: 3 (0.0.0.3)

Subnet mask - define where ip-address number net and where number host

Lenght: 32 bits

Zeroes: number host

Units: number subnet

```
      number subnet        number host
ip = [11010101.10110100.11000001].[0000011]

subnet mask = [11111111.11111111.11111111].[00000000]

More complex example:

213.180.193.3 / 20

IP:              11010101.10110100.11000001.00000011
subnet mask:    [11111111.11111111.1111][0000.00000000]
subnet:          11010101.10110100.11000000.00000000
subnet(10 view):         213.180.192.0
host (10 view):             0.0.1.3
```

How to define subnet address and host address:

1. Subnet mask
2. classes ip-addresses (obsolete)

Types of ip addresses:

1. unicast
2. multicast
3. broadcast

Broadcast ip address has the same part of subnet but in number of bits in host all units

Example:

IP: 213.180.193.3/24

Broadcast: 213.180.193.255

Special IP-addresses:

Can not use all zeroes and units in host bits because:

1. **All zeroes:** 213.180.193.0 - subnet (number subnet)
2. **All units:** 213.180.193.255 - broadcast address

And one unit can be preserved by router(gateway):

- 213.180.193.1

0.0.0.0 - current host (subnet)

255.255.255.255 - all host in current subnet

127.0.0.0/8 - loopback (127.0.0.1 - localhost)

Routing

Network level uses fragmentation for sending data

Routing - searching delivery route of batch between networks through transit nodes(routers)

Default router is router which send batches in unknown networks

```
Designation:

  1) 0.0.0.0, mask 0.0.0.0
  2) default

Destinaion  Gateway      Genmask    Metric    Iface
 0.0.0.0   172.19.132.64   0.0.0.0      0        wlan0
```

Fragmentation in IP

Fragmentation - is partitioning of batch in a smaller parts for transmission through the net with minimal MTU (maximum transmission unit)

Control protocols

DHCP - dynamic protocol configuration of hosts

Define automatically ip on computers in network

ARP - address resolution protocol

ARP - help to define MAC-address by IP-address

DHCP

DHCP - dynamic protocol configuration of hosts

Define automatically ip on computers in network

DHCP - has table of ip-addresses to avoid collision

ARP

ARP - address resolution protocol

ARP - help to define MAC-address by IP-address

ARP can know about MAC-addresses only in current network (router restrict arp messages through it)

ICMP

Goals:

1. Notify about errors on network level
2. Testing about perfomance of network

Utils: ping (cli command)

Transport level

Transport data between proccesses on the hosts (we should know package and corresponding application)

Transport level uses ports for routing

[192.168.1.3]:[80]

Protocols:

1. TCP
2. UDP

Interface:

1) Sockets

UDP

1. No connections
2. No guarantees to delivery
3. No guarantees to proper order

IP and UDP has no improvements for reliability of delivering messages (but we can indicates ports)

Use cases:

- DNS

TCP

Relible trasporting data

Guarantees:

1. Delivery messages
2. Save order of messages

TCP uses connection

TCP Connection

Process of dataflow in TCP:

1. Establish connection
2. Transmit data
3. Despose connection

TCP has duplex connection

Establish connection steps:

1. SYN
2. SYN + ACK(prev SYN acknowledge it)
3. ACK

Sockets

Sockets - de-factor standart of interfaces in transport layer

This is ip address and port

Protocols, interfaces and services

Service - describe features layer implements

Interface = collection of primitive operations, which available in upper layers

Protocols - agreements, which using to connection layer N with layer N another computer

Service - abstract description what we want to do in this layer

Services transport layer TCP/IP:

1. TCP (reliable transmit)
2. UDP (fast and unreliable transmit)

Interface - collection of operations to access this service

Interfaces transport layer:

1. Socket (one interface of socket can access to 2 types (TCP | UDP))

IPv6

Network level

16 bytes instead of 4 bytes (IPv4)

Additional goals to invent:

- Simplify protocol for speed boost of routers
- Maintain security

Additional headers:

- routing parameters
- receiver parameters
- routing
- fragmentation
- authentication (IP Authentication Header, RFC 2402)
- encryption (IP Encapsulating Security Payload, RFC 2406)

Format IP-addresses:

- IPv4: 77.88.02.01
- IPv6: 2a02:06b8:0892:ad61:59a2:3149:c73a:662a

max number in IPv6: ffff

Terminology IPv6:

- prefix IPv6
- Adress of interface
- Length of prefix

Example prefix IPv6:

- [2a02:06b8:0892:ad61]:59a2:3149:c73a:662a/64

first 64 bits is address of network

Types of IPv6:

- unicast
- multicast
- anycast

NPD

Discover neighbors

Goals:

- Discover address router and prefix IPv6
- Replacement for ARP in IPv6 format
- Router redirect
- Healthchecking nodes in network
- Define conflict in IP addresses

NDP extends ICMP:

- New types of messages
- Net format packages for each type

Routing

Routing - is finding route to deliver package between networks through transitive nodes

- statis
- dynamic

Protocols:

- RIP
- OSPF

Hierarchical routing

Policy:

- Service 'Transit'
- Service 'Peer'

Routing protocols:

- Inner: RIP, OSPF
- Outer: BGP

WebSockets

HTTP: Request/Response model

WebSockets: Bidirectional persistent connection

Steps:
- Establish connection (opening handshake)
- Broadcast traffic

Data transfers by frames:
- Headers have binary format
- Low overheads

Also can supports fragmentation