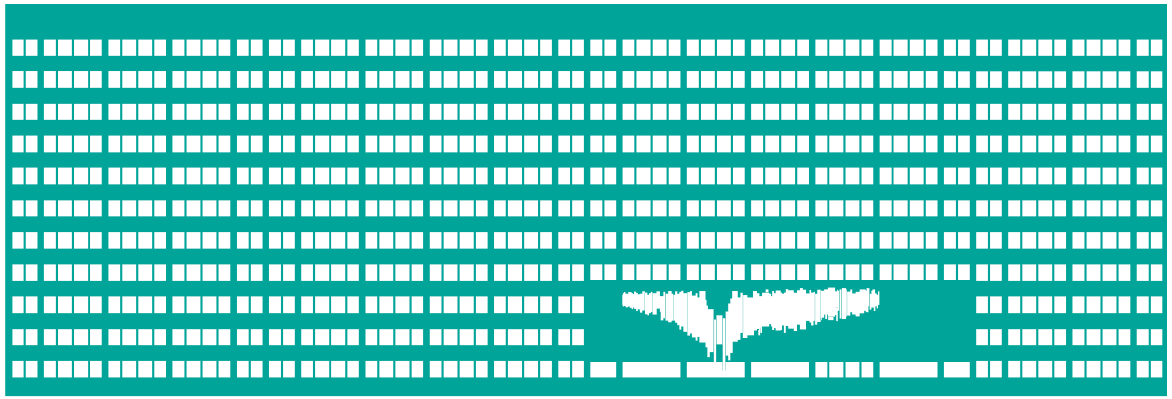
VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE | DEPARTMENT OF COMPUTER SCIENCE

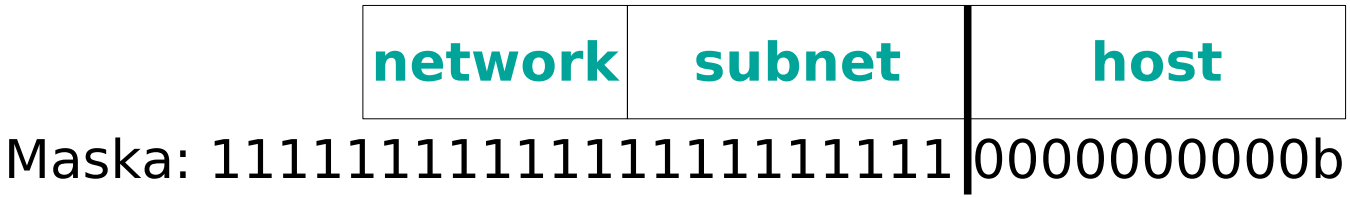
VLSM
Static routing



Computer networks
Seminar 5

IP address (network and host part)

- Address classes (legacy with exception of class D) – identified by first three bits
- Subnet mask – determines how the IP address is divided into network and host parts
  - Decimal notation, for example. 255.255.255.240
  - /<*bits for network*> for example /28
- Reserved addresses – not allowed to assign:
  - There are only 0 bits or 1 bits in host part of the IP address: only 0b – network address, only 1b – broadcast (exception /31 point-to-point link)
- Router interface also requires one „host“ IP address



Special IP addresses

- Any from IP addresses of local station (see bind())
  0.0.0.0
- Universal broadcast (multiaddress)
  255.255.255.255
- Private network ranges (not propagated to Internet)
  10.0.0.0/8
  172.16.0.0/16 – 172.31.0.0/16
  192.168.0.0/16
  100.64.0.0/10 (CGN)
- Local loop
  127.0.0.1

Special IP addresses

- Link-local address
  169.254.0.0/16
- Reserved addresses (not allowed to assign to the hosts)
  - **Network address**
    - In host part only 0 bits
  - **Broadcast**
    - In host part only 1 bits
  - Note: Subnet mask says if it is reserved address or not, for example 10.0.0.224/24 vs. 10.0.0.224/27

Assigned prefix (CIDR)

- Today you get prefix instead of classful address (and soon nothing), for example:
  100.75.50.64/28 (255.255.255.240)
- Bits intended for host address can be further divided between subnet and host addresses.

- Required maximum length of the prefix can be count as:
  32 - (bits_for_subnets + bits_for_hosts)

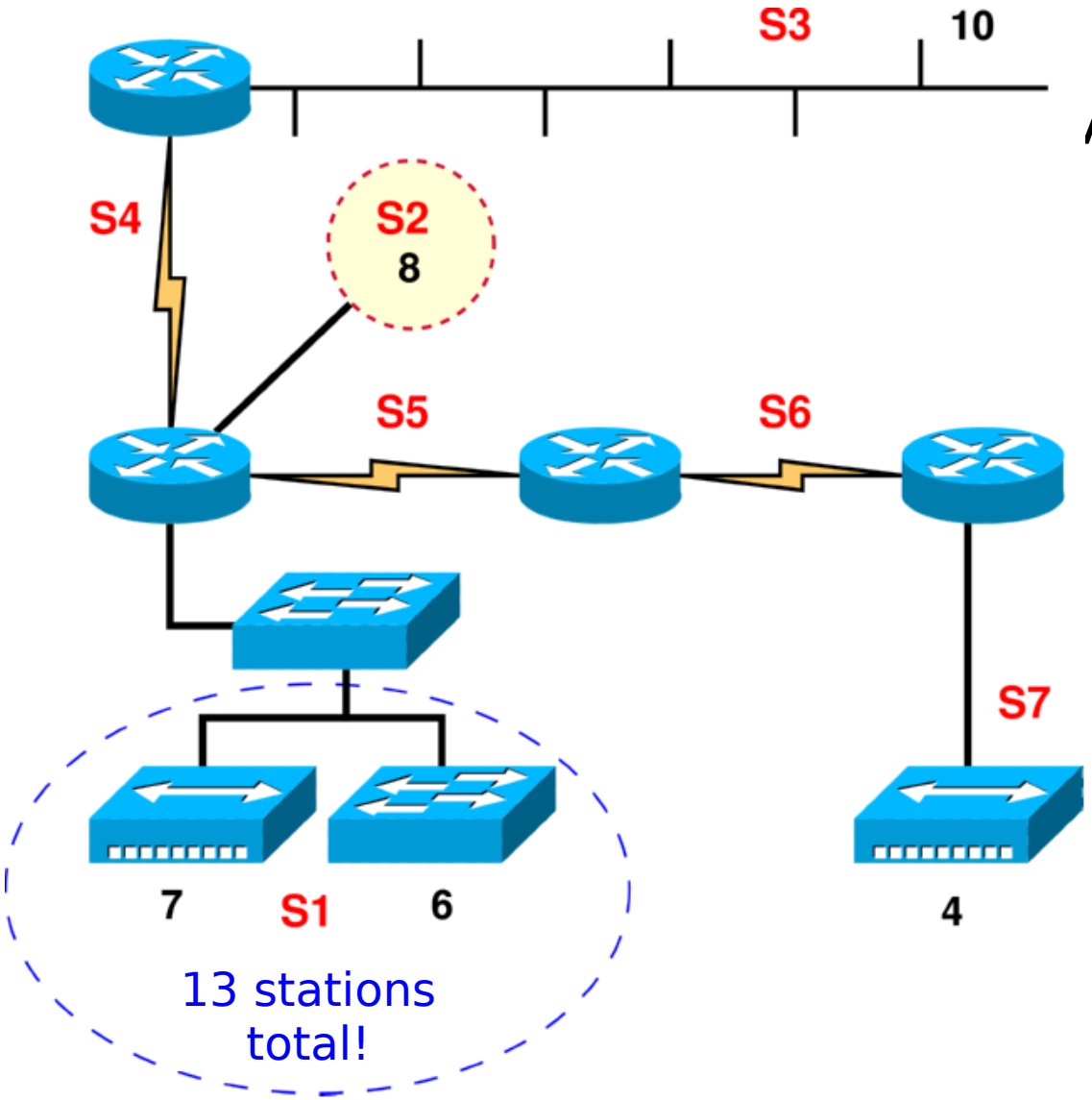
Maximum numbers of hosts and subnets

hosts + router interfaces	segments	next power of 2	bits required
-	2	2	1
2	4	4	2
6	8	8	3
14	16	16	4
30	32	32	5
62	64	64	6
126	128	128	7
254	256	256	8
510	512	512	9

WAN address plan

1. We determine the mask same for all subnets or different masks for single segments as necessary (VLSM)
2. We determine subnet addresses for all segments
3. We assign the address to router interfaces (including point-to-point links) and to all stations
4. Write down broadcast address of all subnets

Subnetting (i)



Assigned:
100.75.50.0/24

Subnetting (i)

- Prefix 100.50.40.0/24
- We start with the biggest subnet (S1) using VLSM
  - 13 stations + 1 router interface
  - 14 + 2 (reserved) (<= 2^4) (4 bits for addresses)
  - We assign the smallest possible prefix to network S1 (0000 XXXX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15

Subnetting (ii)

- We continue with the second biggest subnet (S3)
  - 10 stations + 1 router interface
  - 11 + 2 (reserved) (<= 2^4) (4 bits for addresses)
  - We assign prefix for S3 subnet (0001 XXXX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31

Subnetting (iii)

- Continuing with next subnet (S2)
  - 8 stations + 1 interface
  - 9 + 2 (reserved) (<= 2^4) (4 bits for addresses)
  - We assign next prefix to S2 subnet (0010 XXXX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31
S2	100.75.50. 0010XXXX	100.75.50.32/28	100.75.50.33 - 100.75.50.46	100.75.50.47

Subnetting (iv)

- Continuing with next segment (S7)
  - 4 stations + 1 interface
  - 5 + 2 (reserved) (<= 2^3) (3 bits for addresses)
  - We assign next prefix to S7 subnet (00110XXX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31
S2	100.75.50. 0010XXXX	100.75.50.32/28	100.75.50.33 - 100.75.50.46	100.75.50.47
S7	100.75.50. 00110XXX	100.75.50.48/29	100.75.50.49- 100.75.50.54	100.75.50.55

- Subnet (S4)
  - 2 interfaces
  - 2 + 2 (reserved) (<= 2^2) (2 bits for addresses)
  - We assign next prefix to S4 subnet (0011 1XXX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31
S2	100.75.50. 0010XXXX	100.75.50.32/28	100.75.50.33 - 100.75.50.46	100.75.50.47
S7	100.75.50. 00110XXX	100.75.50.48/29	100.75.50.49- 100.75.50.54	100.75.50.55
S4	100.75.50. 001110XX	100.75.50.56/30	100.75.50.57- 100.75.50.58	100.75.50.59

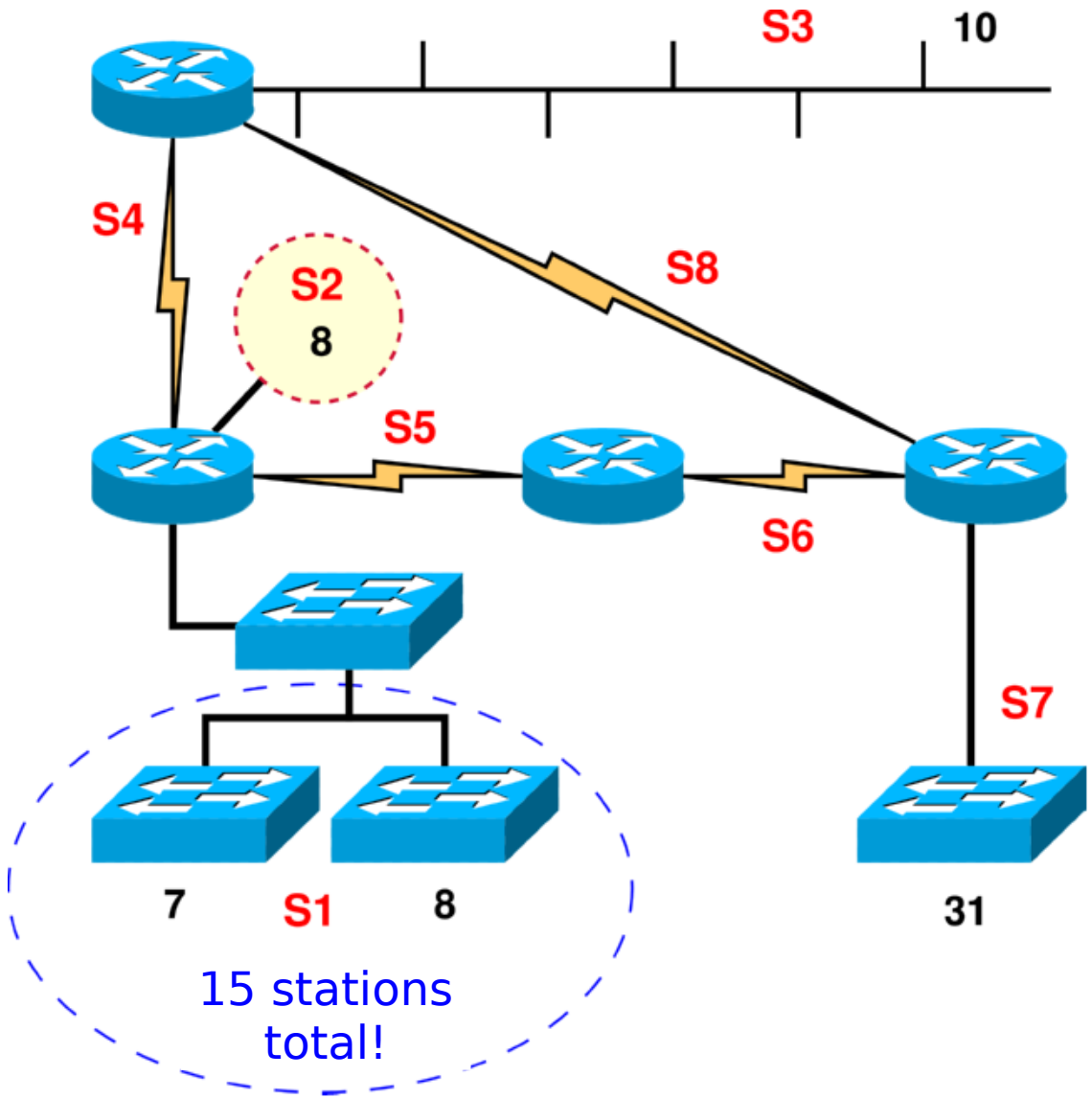
- Subnet (S5)
  - 2 interfaces
  - 2 + 2 (reserved) (<= 2^2) (2 bits for addresses)
  - We assign next prefix to S5 subnet (0011 11XX)

Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31
S2	100.75.50. 0010XXXX	100.75.50.32/28	100.75.50.33 - 100.75.50.46	100.75.50.47
S7	100.75.50. 00110XXX	100.75.50.48/29	100.75.50.49- 100.75.50.54	100.75.50.55
S4	100.75.50. 001110XX	100.75.50.56/30	100.75.50.57- 100.75.50.58	100.75.50.59
S5	100.75.50 001111XX	100.75.50.60/30	100.75.50.61- 100.75.50.62	100.75.50.63

- Subnet (S6)
  - 2 + 2 (reserved) (<= 2^2) (2 bits for addresses)
  - We assign next prefix to S6 subnet (0100 00XX)

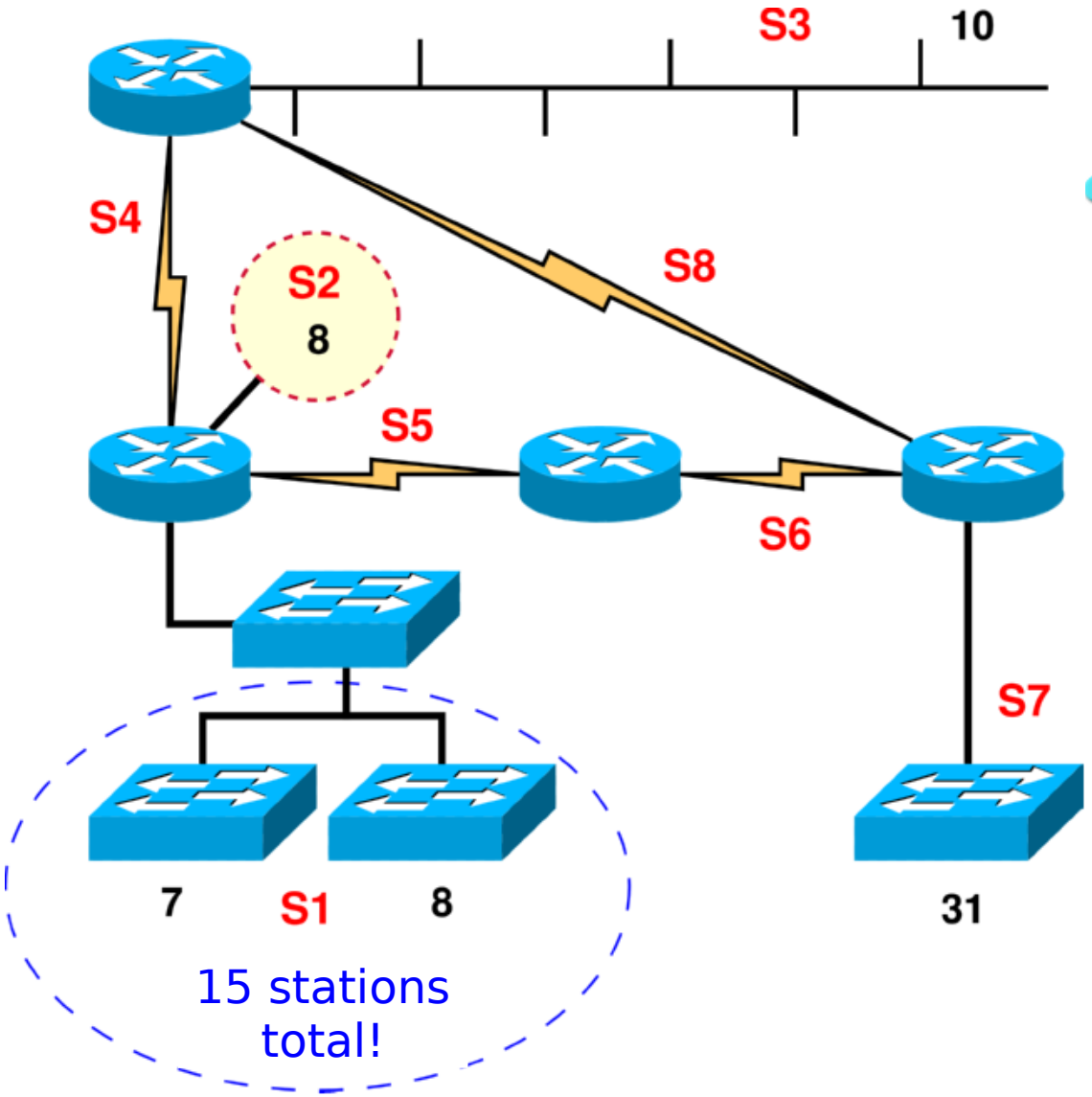
Segment	Prefix	Subnet	Usable addresses	Broadcast
S1	100.75.50. 0000XXXX	100.75.50.0/28	100.75.50.1- 100.75.50.14	100.75.50.15
S3	100.75.50. 0001XXXX	100.75.50.16/28	100.75.50.17- 100.75.50.30	100.75.50.31
S2	100.75.50. 0010XXXX	100.75.50.32/28	100.75.50.33 - 100.75.50.46	100.75.50.47
S7	100.75.50. 00110XXX	100.75.50.48/29	100.75.50.49- 100.75.50.54	100.75.50.55
S4	100.75.50. 001110XX	100.75.50.56/30	100.75.50.57- 100.75.50.58	100.75.50.59
S5	100.75.50 001111XX	100.75.50.60/30	100.75.50.61- 100.75.50.62	100.75.50.63
S6	100.75.50. 010000XX	100.75.50.64/30	100.75.50.65- 100.75.50.66	100.75.50.67

Subnetting (iii)



- More stations have been added to the network from example 2, also backup line S8 has been added
- Hubs have been replaced by switches (VLANs are not used)

Subnetting (iii)



- Segment S7 has now 31 + 2 (<= 2^6)
  (6 bits for addresses)
  .00XXXXXX

Segment	Prefix	Subnet	Usable addresses	Broadcast
S7	100.75.50. 00XXXXXX	100.75.50.0/26	100.75.50.1- 100.75.50.62	100.75.50.63
S1	100.75.50. 010XXXXX	100.75.50.64/27	100.75.50.65- 100.75.50.94	100.75.50.95
S3	100.75.50. 0110XXXX	100.75.50.96/28	100.75.50.97 - 100.75.50.110	100.75.50.111
S2	100.75.50. 0111XXXX	100.75.50.112/28	100.75.50.113- 100.75.50.126	100.75.50.127
S8	100.75.50. 100000XX	100.75.50.128/30	100.75.50.129- 100.75.50.130	100.75.50.131
S4	100.75.50. 100001XX	100.75.50.132/30	100.75.50.133- 100.75.50.134	100.75.50.135
S5	100.75.50. 100010XX	100.75.50.136/30	100.75.50.137- 100.75.50.138	100.75.50.139
S6	100.75.50. 100011XX	100.75.50.140/30	100.75.50.141- 100.75.50.142	100.75.50.143

Static routing

- Router interface settings
  - `(config)# interface <type> <port number>`
    - ***type*** – serial, GigabitEthernet, FastEthernet, vlan, ...
    - ***port number*** – various on different routers , for example: 0, 1, 0/0, 0/1, 1/0, 1/1, 0/1/0, ...
  - `(config-if)# ip address <address> <mask>`
  - `(config-if)# clock rate <speed-bps>`
    - only DCE on serial link
  - `(config-if)# no shutdown`
- PC default gateway settings
  - `route add default gw <gateway>`

Switched module in routers

The module provides more (typically 4 or 8) Ethernet switched ports (fast or gig. Ethernet)

- We need to use VLANs to configure these ports
  - (config)# **interface** gi0/1/0
  - (config-if)# **switchport mode access**
  - (config-if)# **switchport access vlan** 123
  - (config-if)# **no shutdown**
- The created virtual interfaces for VLANs are then configured as normal interfaces
  - (config)# **interface vlan** 123
  - (config-if)# **ip address** ...
- We can check the interfaces in normal way:
  - # **show ip interface brief**
  - # **show interface vlan** 123

Static routing

- Static route (configuration mode)
  - `(config)# ip route <network> <mask> <gateway>`
    - ***network*** – address of network to be added to the routing table
    - ***mask*** – decimal mask
    - ***gateway*** – ip address of next router on the way
  - Network address of default route is **0.0.0.0/0**

- Routing table entries (privileged mode)
  - `# show ip route [<network>]`

- To see the configuration of the device
  - `# show running-config`

Static routing - assignment

1. Interconnect 3 routers into the triangle topology
2. Connect PC to each router
3. Set the IP addresses acording to the topology plan
   (Don't forget to set default gateway on PC)
4. Set static routes to the networks which are not directly connected
5. Test the connectivity (Ping all IP addresses in the topology plan)

Static routing