

MREŽNI SLOJ

Predmet: Aktivni mrežni uređaji

Predavač: dr Dušan Stefanović

Informacije o predmetu

Студијски програм: MKT

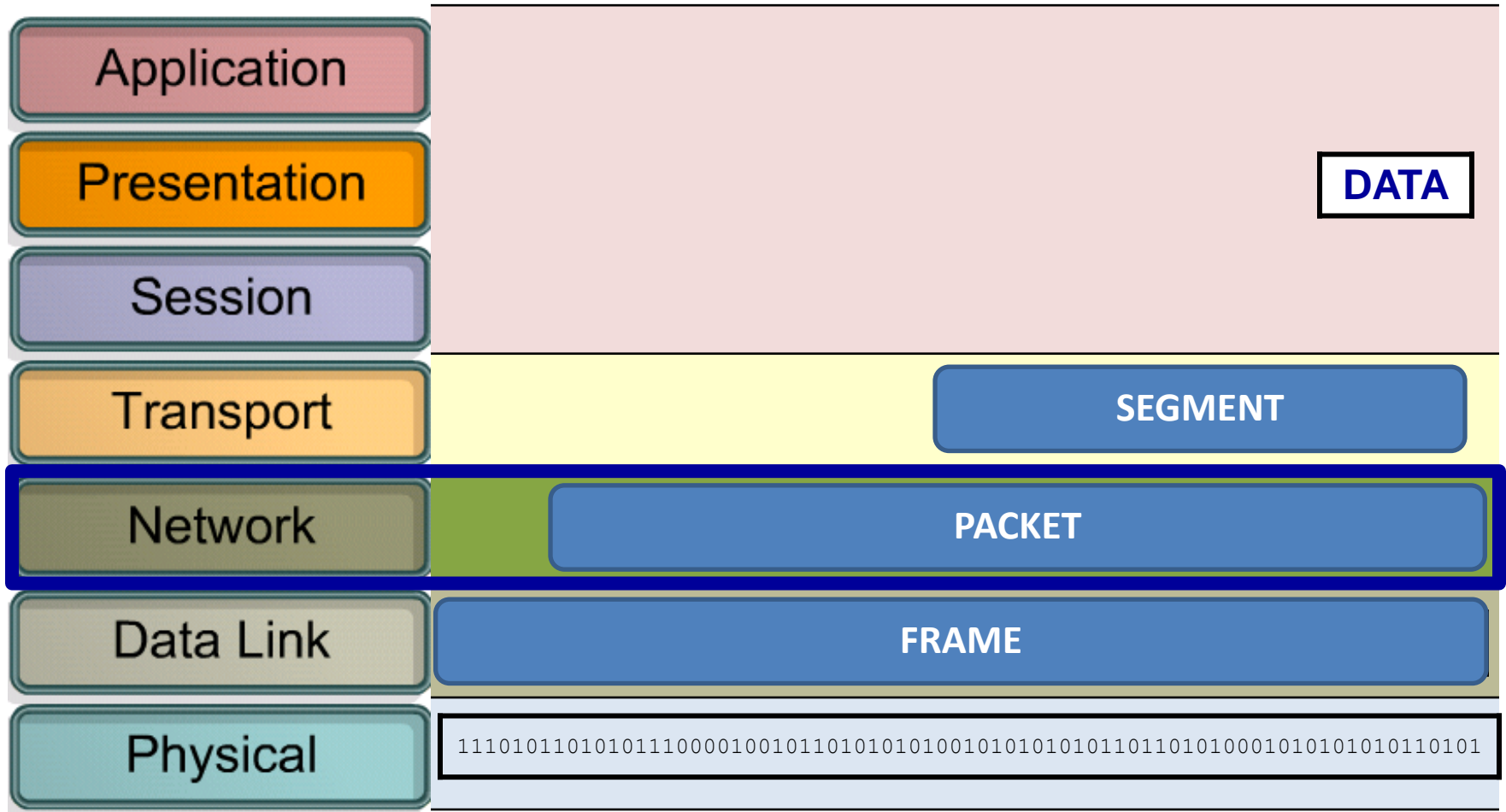
Статус предмета: Obavezni

Семестар: I

Број часова: 3 + 2 + 0

Број ЕСПБ: 6

ENKAPSULACIJA



FUNKCIJA MREŽNOG SLOJA

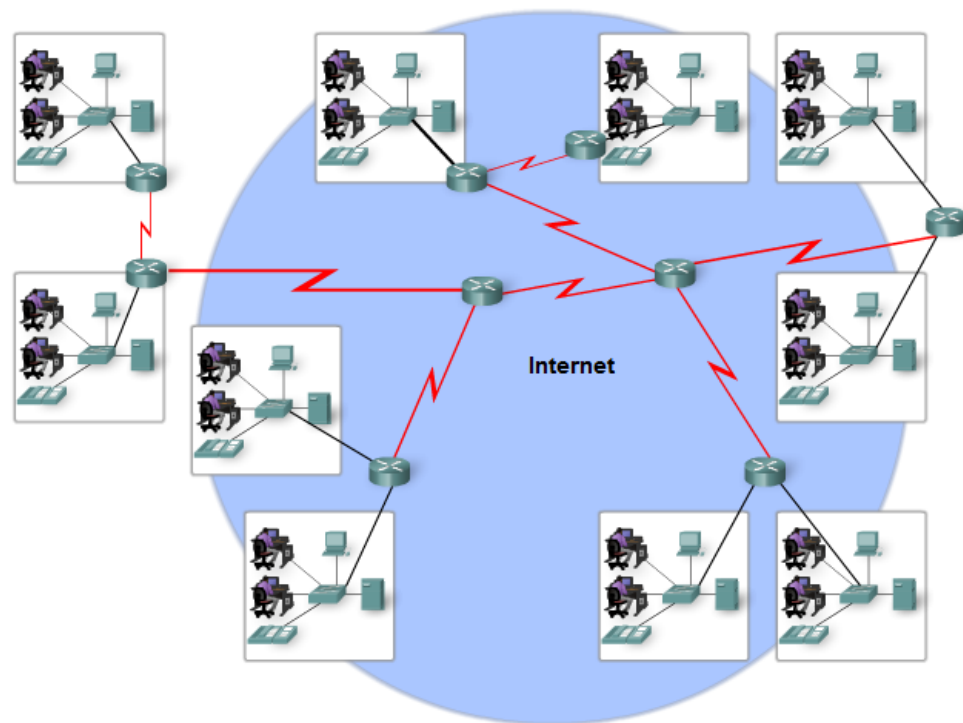
Mrežni sloj obavlja četiri osnovna procesa:

Adresiranje krajnjih uređaja

Enkapsulacija

Rutiranje

De-enkapsulacija



PROTOKOLI MREŽNOG SLOJA

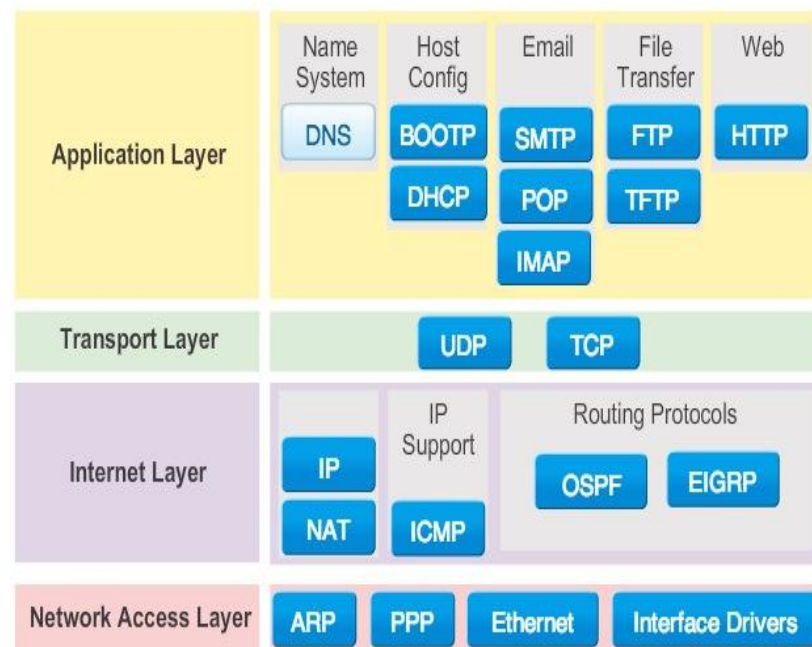
Standardni Network Layer Protokoli

- Internet Protocol version 4 (IPv4)
- Internet Protocol version 6 (IPv6)

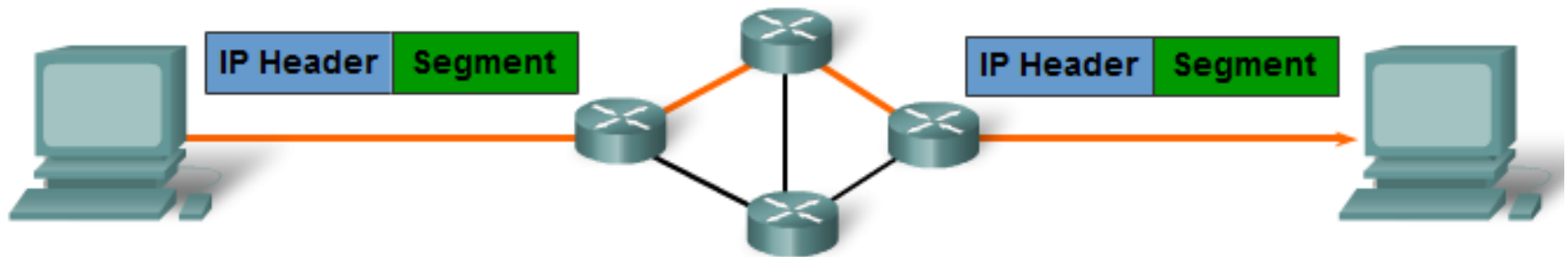
Zastareli Network Layer Protokoli

- Novell Internetwork Packet Exchange (IPX)
- AppleTalk
- Connectionless Network Service (CLNS/DECNet)

TCP/IP Protocol Suite and Communication Process



KARAKTERISTIKE IPv4 PROTOKOLA



Connectionless (Bezkonekcionni servis):

Ne uspostavlja konekciju pre nego što krene sa razmenom podataka

Best effort delivery:

Ne garantuje isporuku paketa.

Media independent:

Transparentan (nezavistan) je od prenosnog medijuma

BEZKONEKCIONI SERVIS



Letter

IZVOR NE ZNA

Da li je odrediše aktivno

Da li je poruka stgla

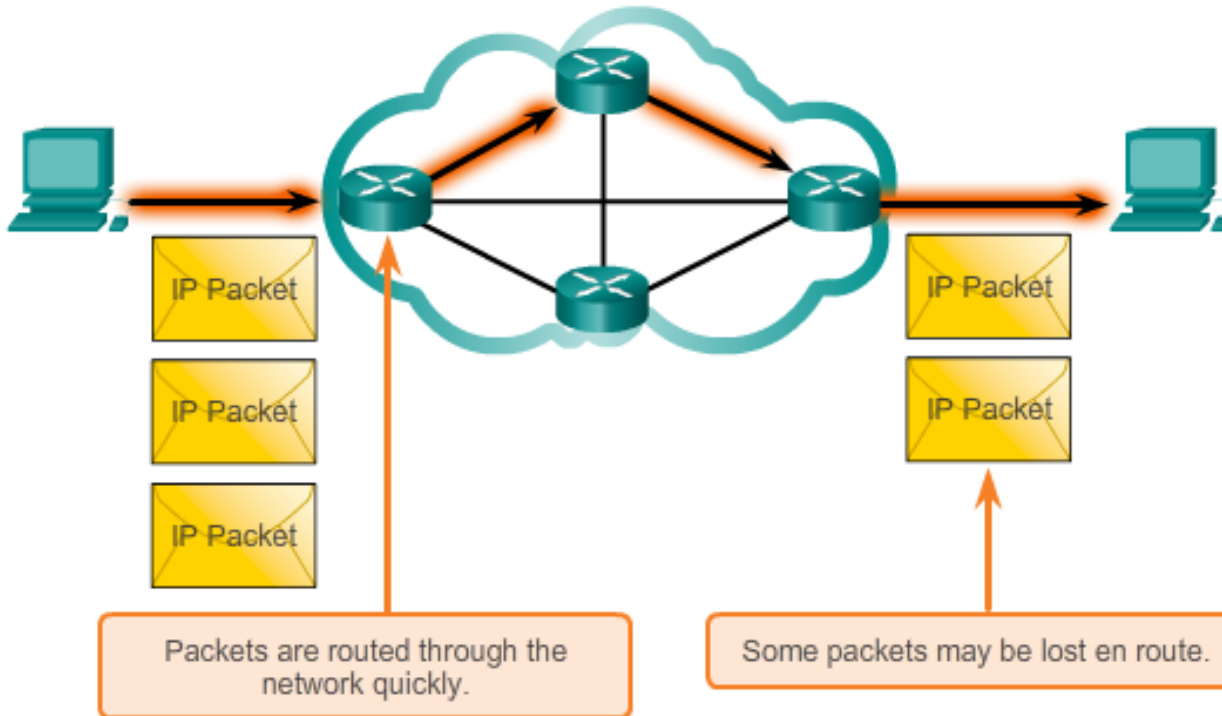
Da li odredište može da pročita poruku

ODREDIŠTE NE ZNA

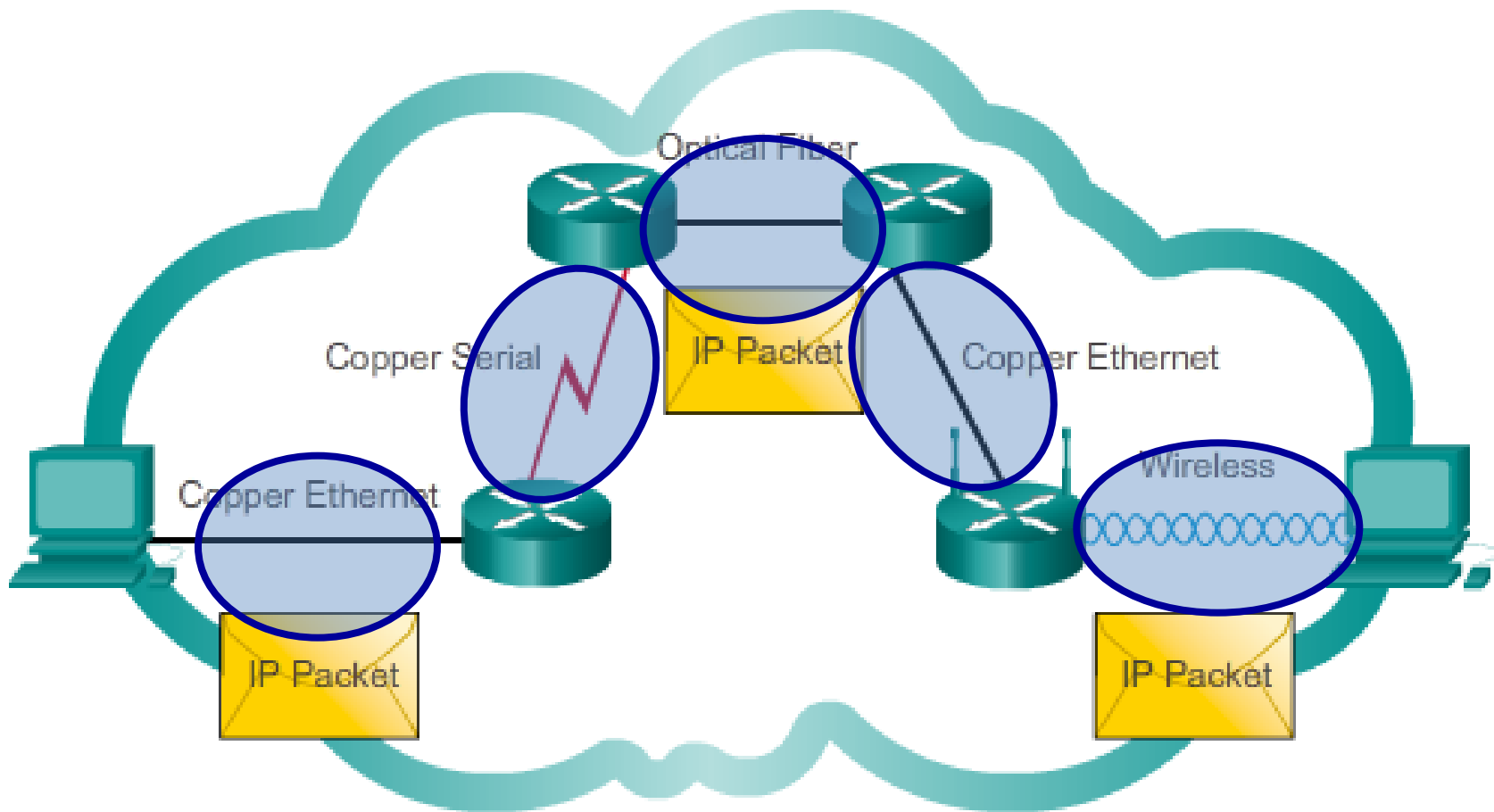
Kada će poruka stići

BEST EFFORT DELIVERY

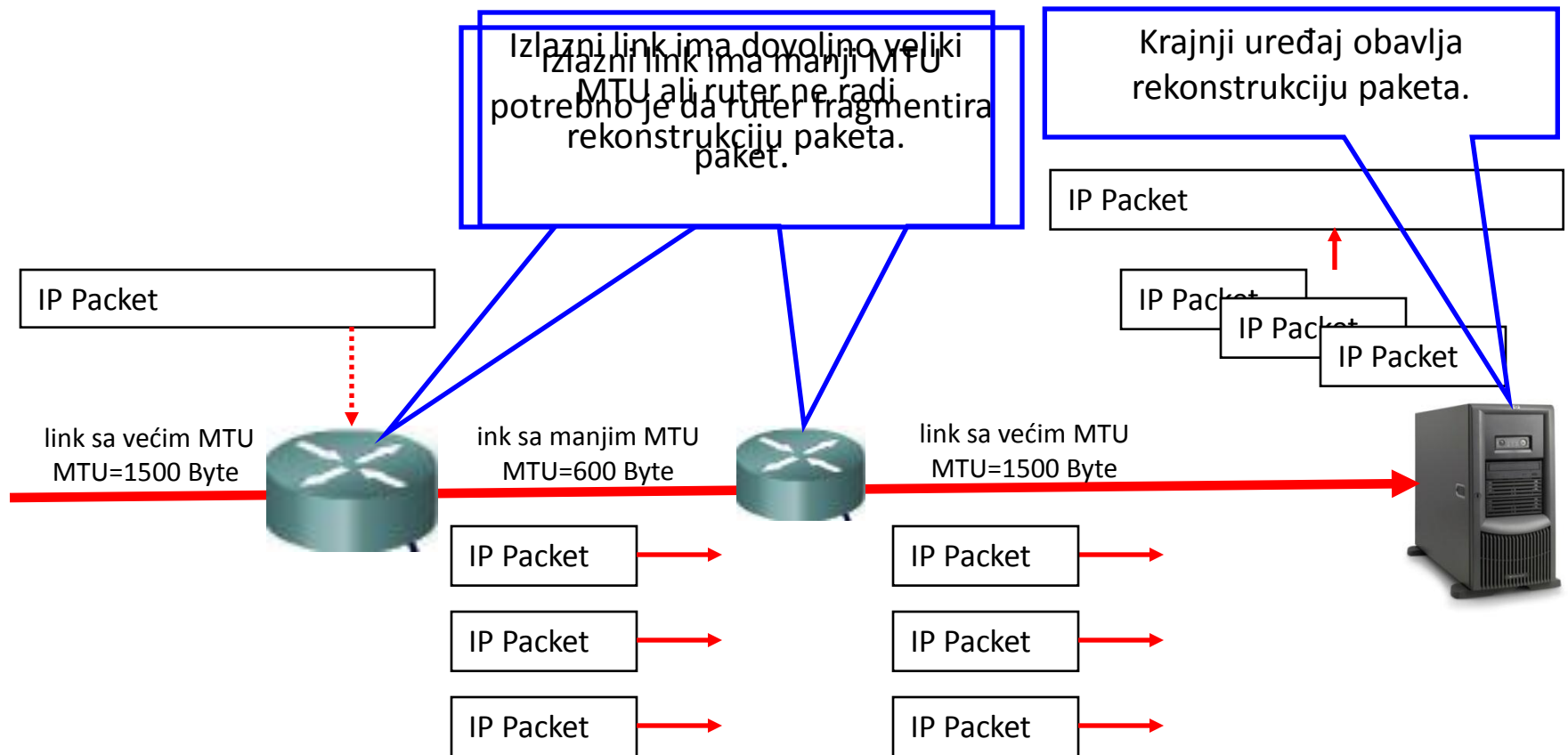
- Nepouzdan prenos, IP ne garantuje da će svi poslani paketi stići do odredišta.
- Drugi protokoli se bave praćenjem paketa i njihovom isporukom (TCP)
- Zadatak IP-a je što manji header i efikasno rutiranje



IPV4 – NE ZAVISI OD PRENOSNOG MEDIJUMA

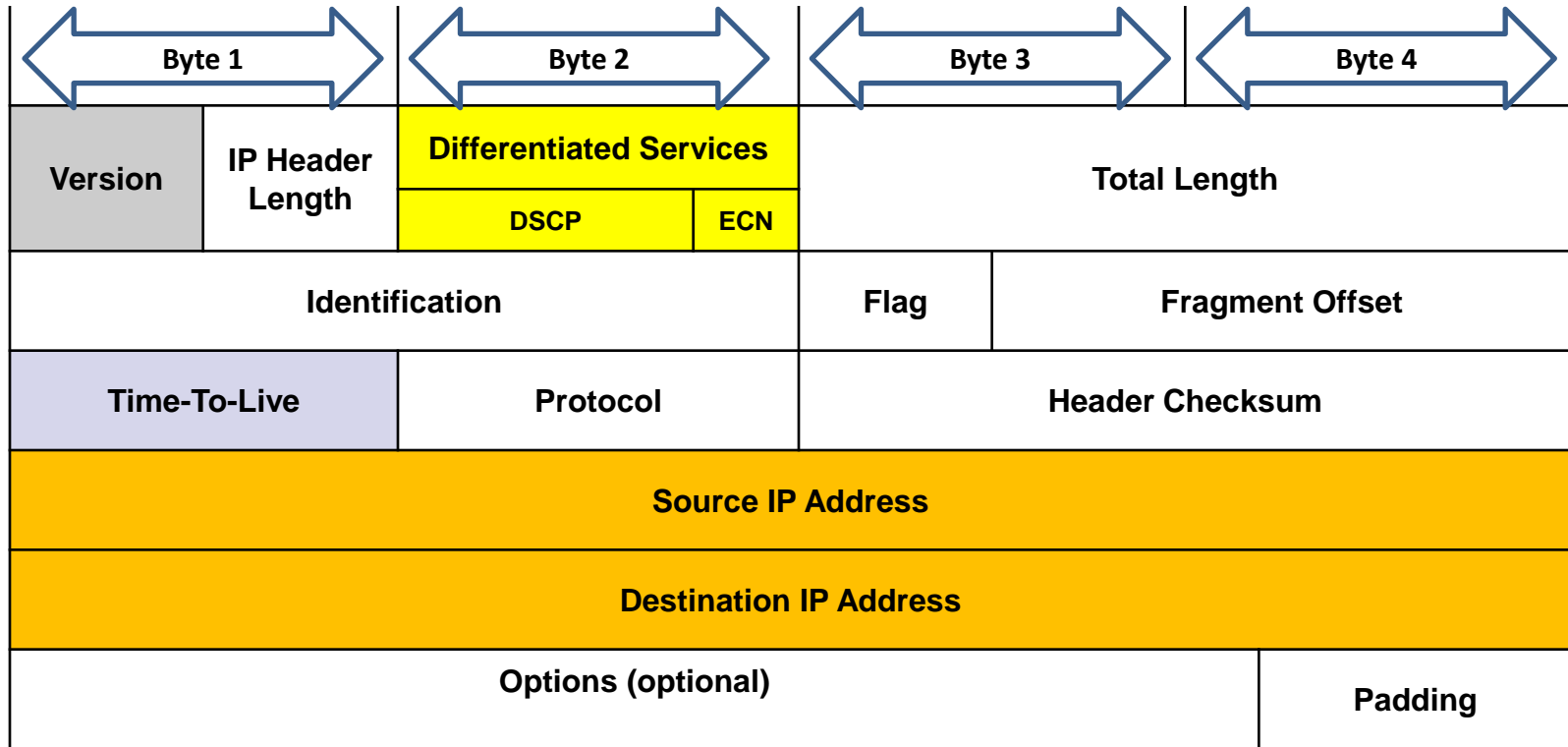


Maximum Transmission Unit (MTU)



- Fragmentacija unosi dodatno kašnjenje i iskorišćenje CPU-a.
- *Fragment Offset* polje u IPv4 verziji identifikuje redosled fragmenata

IPv4 ZAGLAVLJE



IPv4 ZAGLAVLJE U WIRESHARK-U

Microsoft: \Device\NPF_{7BB3C130-30C5-4419-B79E-C0868085ABED} [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	fe80::b1ee:c4ae:a11ff02::c	ff02::c	SSDP	208	M-SEARCH * HTTP/1.1
2	0.30588900	192.168.1.109	192.168.1.1	TCP	66	56081 > http [SYN] Seq=0 win=8192 Len=0 MSS=1260 WS=4 SACK_P
3	0.30723400	192.168.1.109	192.168.1.1	TCP	66	56082 > http [SYN] Seq=0 win=8192 Len=0 MSS=1260 WS=4 SACK_P
4	0.31007200	192.168.1.1	192.168.1.109	TCP	66	http > 56081 [SYN, ACK] Seq=0 Ack=1 win=5840 Len=0 MSS=1460
5	0.31018800	192.168.1.109	192.168.1.1	TCP	54	56081 > http [ACK] Seq=1 Ack=1 win=66780 Len=0
6	0.31092800	192.168.1.1	192.168.1.109	TCP	66	http > 56082 [SYN, ACK] Seq=0 Ack=1 win=5840 Len=0 MSS=1460
7	0.31103000	192.168.1.109	192.168.1.1	TCP	54	56082 > http [ACK] Seq=1 Ack=1 win=66780 Len=0
8	0.35044400	192.168.1.109	192.168.1.1	HTTP	425	GET / HTTP/1.1

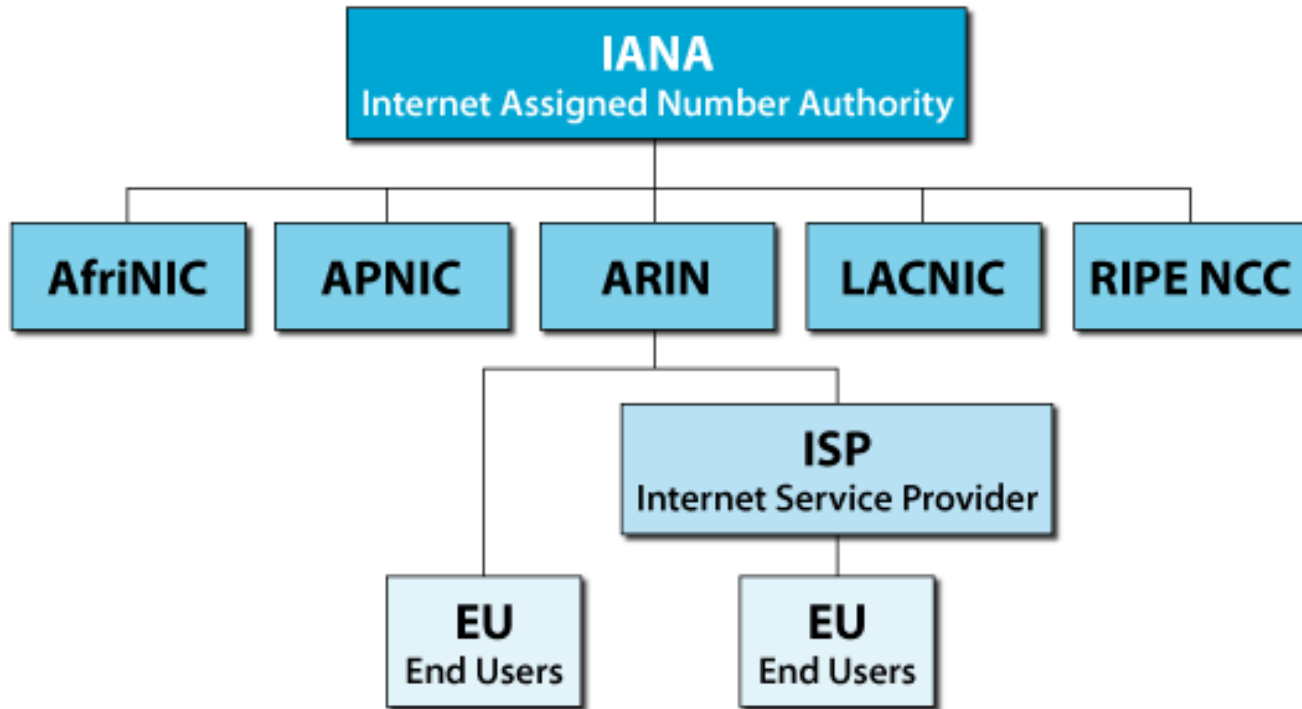
Frame 2: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0

- Ethernet II, Src: IntelCor_45:5d:c4 (24:77:03:45:5d:c4), Dst: cisco-Li_a0:d1:be (00:18:39:a0:d1:be)
- Internet Protocol Version 4, Src: 192.168.1.109 (192.168.1.109), Dst: 192.168.1.1 (192.168.1.1)**
 - Version: 4
 - Header length: 20 bytes
 - Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
 - Total Length: 52
 - Identification: 0x31fc (12796)
 - Flags: 0x02 (Don't Fragment)
 - Fragment offset: 0
 - Time to live: 128
 - Protocol: TCP (6)
 - Header checksum: 0x4509 [correct]
 - Source: 192.168.1.109 (192.168.1.109)
 - Destination: 192.168.1.1 (192.168.1.1)
 - [Source GeoIP: Unknown]
 - [Destination GeoIP: Unknown]
- Transmission Control Protocol, Src Port: 56081 (56081), Dst Port: http (80), Seq: 0, Len: 0**

```
0000  00 18 39 a0 d1 be 24 77 03 45 5d c4 08 00 45 00  ..9...$w .E]...E.
0010  00 34 31 fc 40 00 80 06 45 09 c0 a8 01 6d c0 a8  .41.@... E....m..
0020  01 01 db 11 00 50 a0 cc 44 95 00 00 00 00 80 02  ...P.. D.....
0030  20 00 0b 5c 00 00 02 04 04 ec 01 03 03 02 01 01  ..\.....
0040  04 02  ..
```

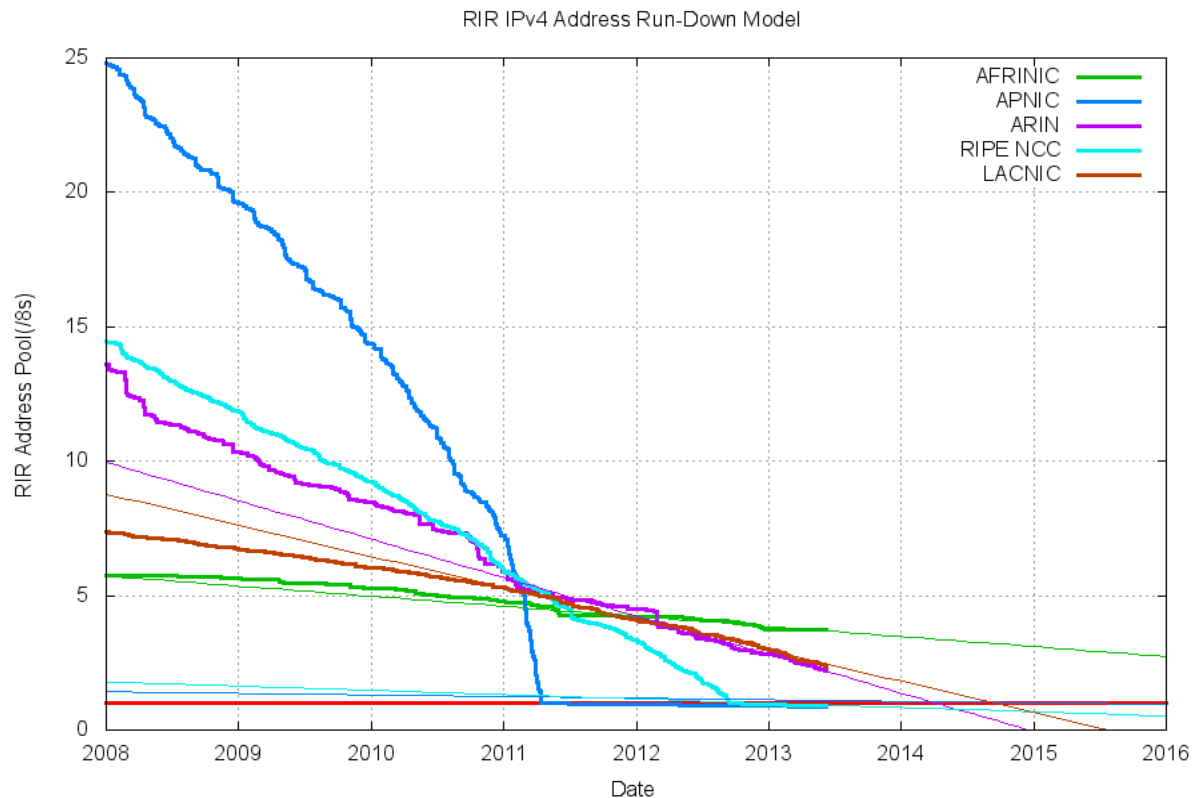
Internet Protocol Version 4 (ip), 20 bytes | Packets: 16 Displayed: 16 Marked: 0 Dropped: 0 | Profile: Default

IPv4 OGRANIČENJA



- IPv4 adresiranje utiče na tri osnovna problema
 - Nedostatak IPv4 adresa
 - Ogromne ruting tabele na Internetu
 - Problem sa end-to-end konektivnošću

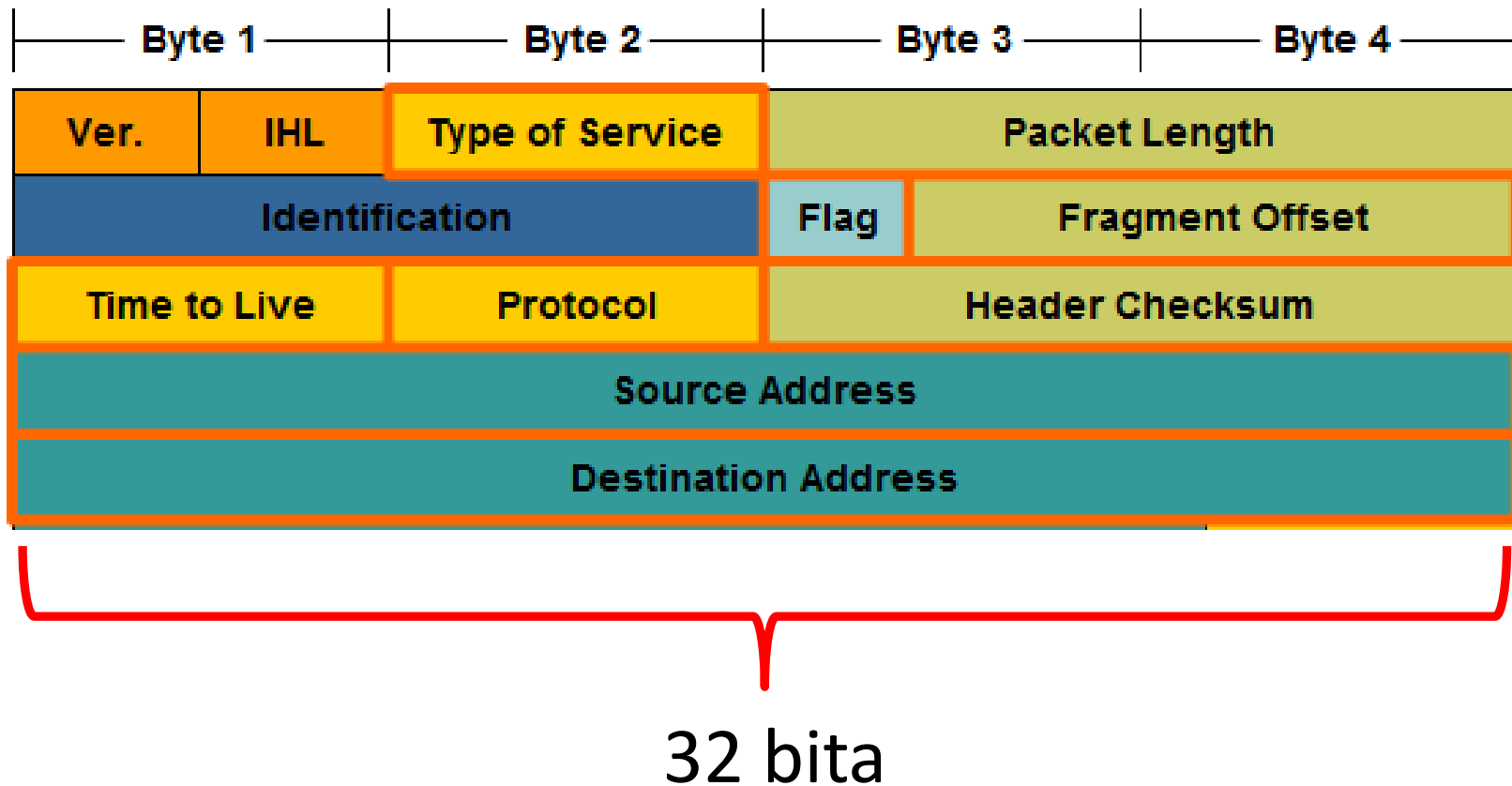
TROŠENJE IPv4 ADRESA



- IPv4 ima ograničen broj slobodnih javnih IPv4 adresa.
- Iako postoji 4 milijarde IPv4 adresa, porastom IP uređaja od kojih je većina uvek uključena dovelo je do nedostatka IPv4 adresa

IPv4 Adresse

IPv4 ZAGLAVLJE



IPV4 ADRESE

- IPv4 Adresa sastoji se iz 32 bita

1010100111000111010001011000100

10101001 11000111 01000101 10001001

- Predstavlja se formatu koji je razdvojen tačkom (dotted decimal notation) da bi se vrednost od jednog bajta(octet) predstavila u dekadnom formatu

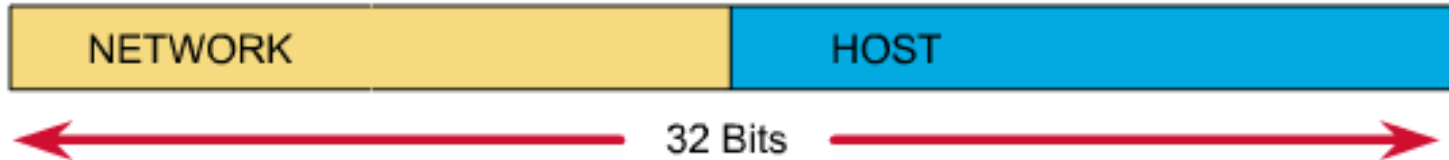
10101001 11000111 01000101 10001001

169 . 199 . 69 . 137

IPV4 ADRESA

IPv4 adresa sastoji se iz dva dela:

- mrežnog dela (identifikuje mrežu)
- host dela (identifikuje host)



- Subnet maska određuje granicu između mrežnog i host dela

VRSTE IPV4 ADRESA

Mrežna adresa
sadrži sve nule u
host delu IP adrese

Network Address

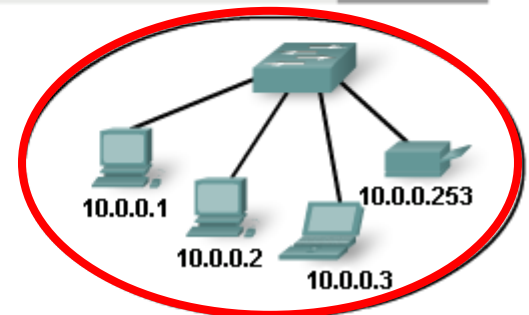
Broadcast Address

Host Address

Roll over to learn more.

Subnet Mask: 255.255.255.0

Network			Host
10	0	0	0
00001010	00000000	00000000	00000000
10	0	0	255
00001010	00000000	00000000	11111111
10	0	0	1
00001010	00000000	00000000	00000001



- **Network adresa** – Ova adresa identifikuje mrežu
- Broadcast adresa – Specijalna adresa za slanje poruke svim uređajima u mreži
- Host adresa – Adrese koje se zadaju računarima u mreži

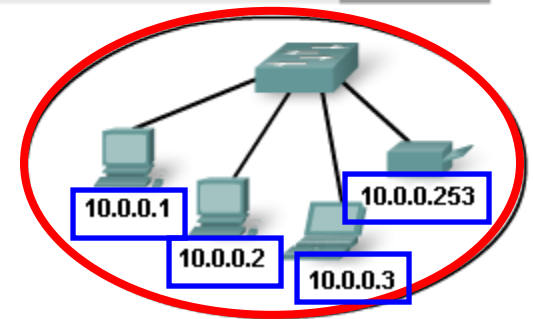
VRSTE IPv4 ADRESA

Broadcast adresa sadrži sve jedinice u host delu IP adrese

	Network			Host
Network Address	10	0	0	0
	00001010	00000000	00000000	00000000
Broadcast Address	10	0	0	255
	00001010	00000000	00000000	11111111
Host Address	10	0	0	1
	00001010	00000000	00000000	00000001

Roll over to learn more.

Subnet Mask: 255.255.255.0



- Network adresa – Ova adresa identifikuje mrežu
- **Broadcast adresa** – Specijalna adresa za slanje poruke svim uređajima u mreži
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VRSTE IPV4 ADRESA

Host adresa

sadrži sve kombinacije sem sve jedinice ili sve nule

Network Address

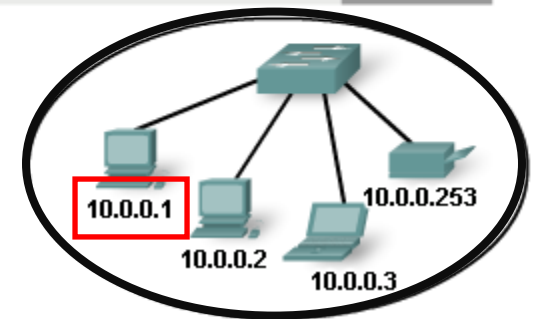
Broadcast Address

Host Address

Roll over to learn more.

Subnet Mask: 255.255.255.0

Network			Host
10	0	0	0
00001010	00000000	00000000	00000000
10	0	0	255
00001010	00000000	00000000	11111111
10	0	0	1
00001010	00000000	00000000	00000001



- Network adresa – Ova adresa identifikuje mrežu
- Broadcast adresa – Specijalna adresa za slanje poruke svim uređajima u mreži
- **Host adresa** – Adrese koje se zadaju računarima u mreži

PODELA IPV4 ADRESE NA HOST I NETWORK DEO

Razdvaja:

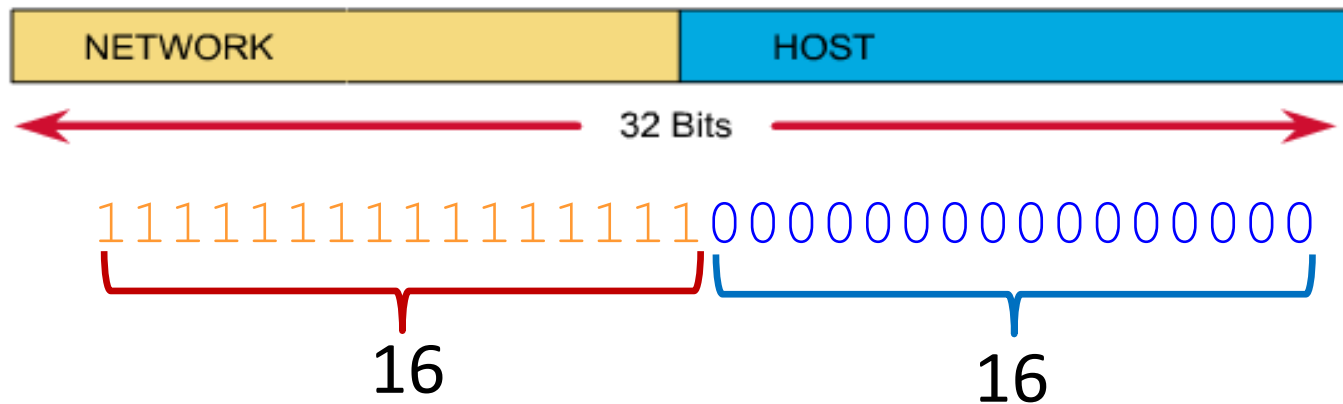
Network deo i Host deo

32 bita

“1” identifikuju Network deo

“0” identifikuju Host deo

SUBNET MASKA



Dotted decimal: 255. 255. 0 . 0

Slash notacija: /16

ODREĐIVANJE MREŽNE ADRESE

Network Adresa: 192.168.1.0

Subnet Maska: 255.255.255.0

Network IP Adresa binarna prezentacija:

network	host
11000000.10101000.00000001	00000000

Subnet Mask binarna prezentacija:

11111111.11111111.11111111	00000000
-----------------------------------	-----------------

Prefix Length: /24

192.168.1.0

Network Host

ZADATAK

Mrežna Adresa

Subnet Mask

172.0.0.0

255.0.0.0

172.16.0.0

255.255.0.0

192.168.1.0

255.255.255.0

192.168.0.0

255.255.0.0

192.168.0.0

255.255.255.0

10.1.1.0

/24

10.2.0.0

/16

10.0.0.0

/16

REŠENJE

Mrežna Adresa

172.0.0.0

172.16.0.0

192.168.1.0

192.168.0.0

192.168.0.0

10.1.1.0

10.2.0.0

10.0.0.0

Subnet Mask

255.0.0.0

255.255.0.0

255.255.255.0

255.255.0.0

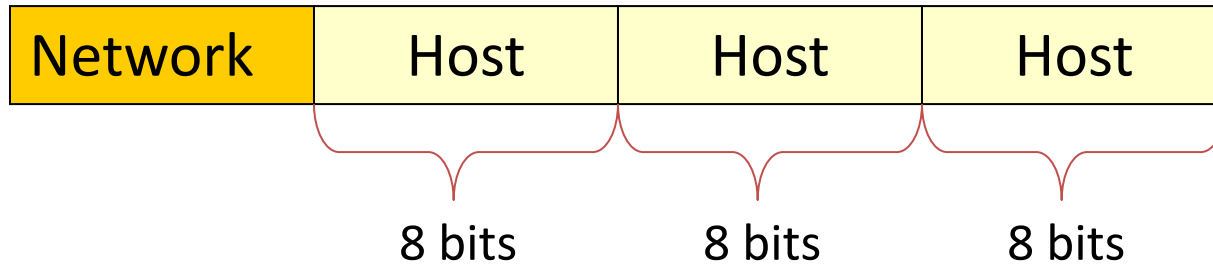
255.255.255.0

/24

/16

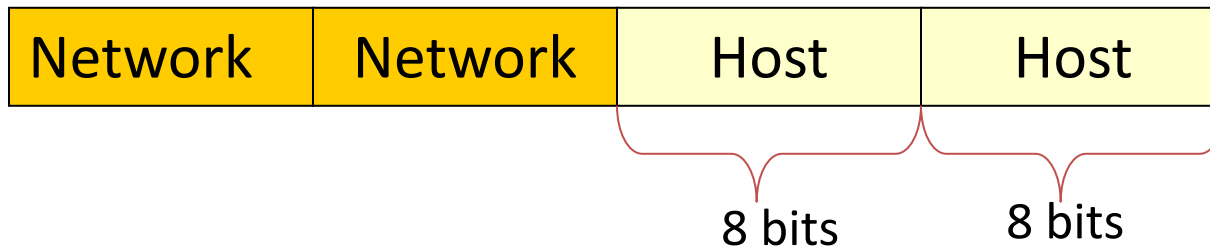
/16

SUBNET: 255.0.0.0 (/8)



24 bita je rezervisano za HOST, može se adresirati 2^{24} . To je ukupno 16,777,216 hosta!

SUBNET: 255.255.0.0 (/16)



16 bita je rezervisano za HOST, može se adresirati 2^{16} . To je ukupno 65,536 hosta!

ODREĐIVANJE HOST ADRESA

<u>Network Address</u>	<u>Subnet Mask</u>	<u>Broadcast Address</u>
172.0.0.0	255.0.0.0	172.255.255.255
172.0.0.1 - 172.255.255.254		
172.16.0.0	255.255.0.0	172.16.255.255
172.16.0.1 - 172.16.255.254		
192.168.1.0	255.255.255.0	192.168.1.255
192.168.1.1 - 192.168.1.254		
192.168.0.0	255.255.0.0	192.168.255.255
192.168.0.1 - 192.168.255.254		
192.168.0.0	255.255.255.0	192.168.0.255
192.168.0.1 - 192.168.0.254		

SUBNET MASKA: GRANICE UNUTAR OKTETA

- Subnet maska ne mora da bude na granicama okteta

Network Adresa

172.1.16.0 → 10101100.00000001.00010000.00000000

Subnet Mask

255.255.240.0 → 11111111.11111111.11110000.00000000

SUBNET MASKA: GRANICE UNUTAR OKTETA

PRIMER 1

192.168.1.0	11000000.10101000.00000001.00000000
255.255.255.224	11111111.11111111.11111111.11100000

192.168.1.1	11000000.10101000.00000001.00000001
192.168.1.2	11000000.10101000.00000001.00000010
...	
192.168.1.29	11000000.10101000.00000001.00011101
192.168.1.30	11000000.10101000.00000001.00011110

192.168.1.31	11000000.10101000.00000001.00011111
(broadcast)	

Ukupan broj hosta: $2^5 - 2 = 32 - 2 = 30$ hosta

SUBNET MASKA: GRANICE UNUTAR OKTETA

PRIMER 2

172.1.16.0	10101100.00000001.00010000.00000000
------------	-------------------------------------

255.255.240.0	11111111.11111111.11110000.00000000
---------------	-------------------------------------

172.1.16.1	10101100.00000001.00010000.00000001
------------	-------------------------------------

...

172.1.31.254	10101100.00000001.00011111.11111110
--------------	-------------------------------------

172.1.31.255	10101100.00000001.00011111.11111111
--------------	-------------------------------------

(broadcast)

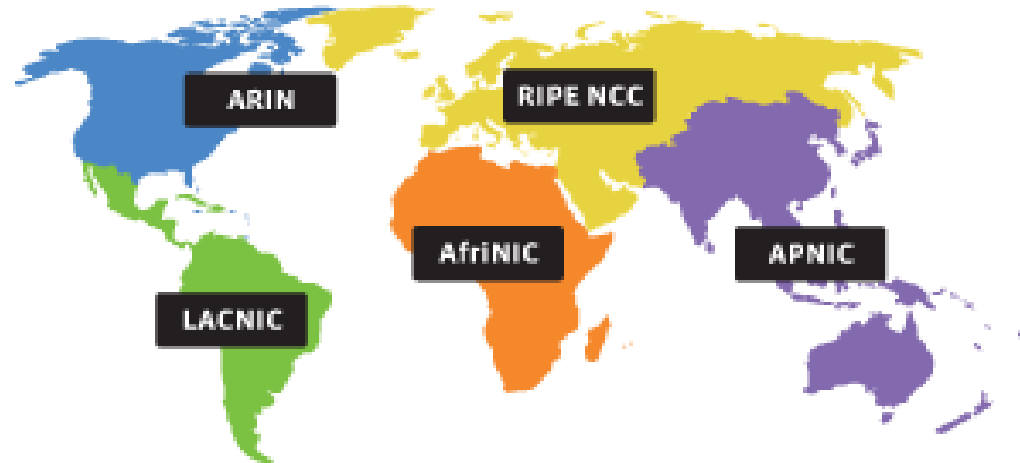
Ukupan broj hosta: $2^{12} - 2 = 4,096 - 2 = 4,094$ hosta

ORGANIZACIJA ZADUŽENA ZA DODELU IP ADRESA



- **Internet Assigned Numbers Authority (IANA)**
(<http://www.iana.net>) upravlja IP adresnim opsegom
- Adresni opseg je dodeljen RIR-ovima radi lakšeg upravljanja adresama

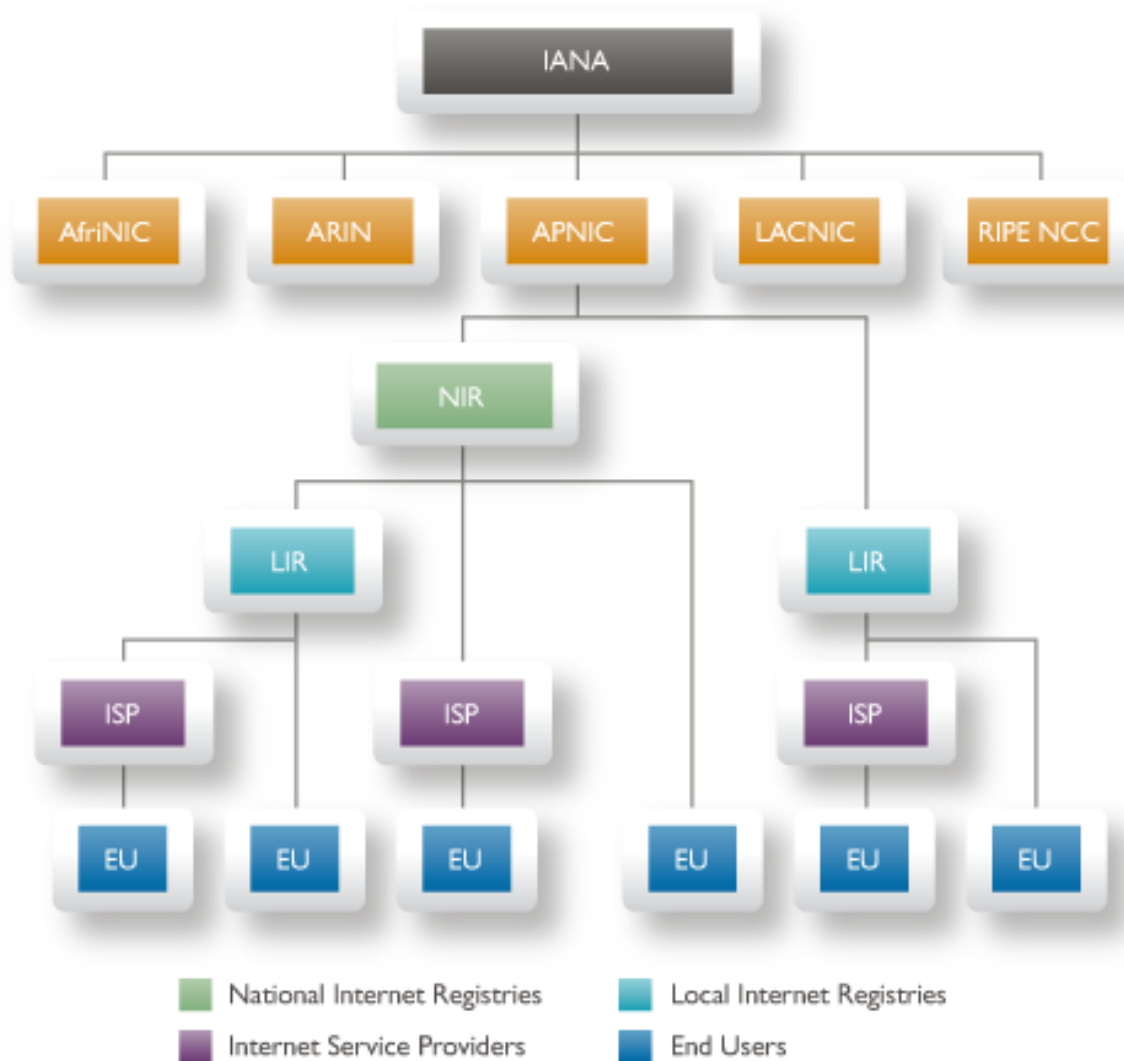
RIR (Regional Internet Registry)



SVET JE PODELJEN NA 5 REGIONA (RIR-A)

- **AfrINIC** (African Network Information Centre) – **AFRIKA** <http://www.afrinic.net>
- **APNIC** (Asia Pacific Network Information Centre) - **Azia/Pacifik Region** <http://www.apnic.net>
- **ARIN** (American Registry for Internet Numbers) – **Severna Amerika** <http://www.arin.net>
- **LACNIC** (Regional Latin-American and Caribbean IP Address Registry) – Južna Amerika i Karibska ostrva <http://www.lacnic.net>
- **RIPE NCC** (Reseaux IP Europeans) - Evropa, Srednji Istok i Centralna Azia <http://www.ripe.net>

HIJARARHIJA DISTRIBUCIJA IP ADRESA



SPECIJALNE IPv4 ADRESE

- **Default Route**

- 0.0.0.0

- **Loopback Adresa**

- Adresa koja usmerava saobraćaj ka host-u koji je i generisao saobraćaj.
 - 127.0.0.0 - 127.255.255.255

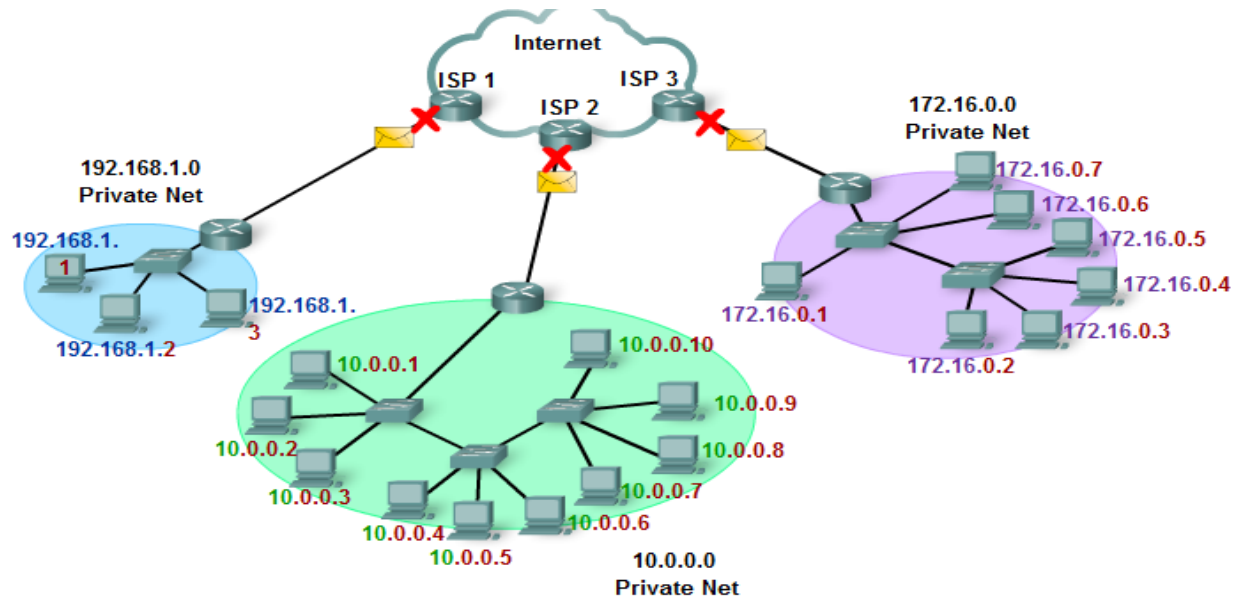
- **Link-Local Adresa**

- 169.254.0.0 - 169.254.255.255 (169.254.0.0 /16)
 - Automatski se zadaju host-u od strane OS-a kada host ne može da dobije regularnu IP adresu.

- **TEST-NET Adresa**

- 192.0.2.0 to 192.0.2.255 (192.0.2.0 /24)
 - Namenjene su učenju.
 - Ove adrese se koriste u dokumentaciji i primerima.

PRIVATNE IP ADRESE



RFC 1918

- 10.0.0.0 to 10.255.255.255 (10.0.0.0 /8)
- 172.16.0.0 to 172.31.255.255 (172.16.0.0 /12)
- 192.168.0.0 to 192.168.255.255 (192.168.0.0 /16)

Ove adrese nisu rutabilne na Internetu

- koriste se u kombinaciji sa NAT/PAT servisom

SUBNET MASKA i AND OPERACIJA

- Subnet maska se koristi da se u IP adresi odvoji mrežni deo od host dela.
- Subnet maska host-u govori kojoj mreži pripada.
- **VRLO JE VAŽNO DA HOST ZNA KOJOJ MREŽI PRIPADA.**
 - da li da frejm šalje u svojoj mreži?
 - da li da frejm šalje u drugoj mreži?

AND OPERACIJA

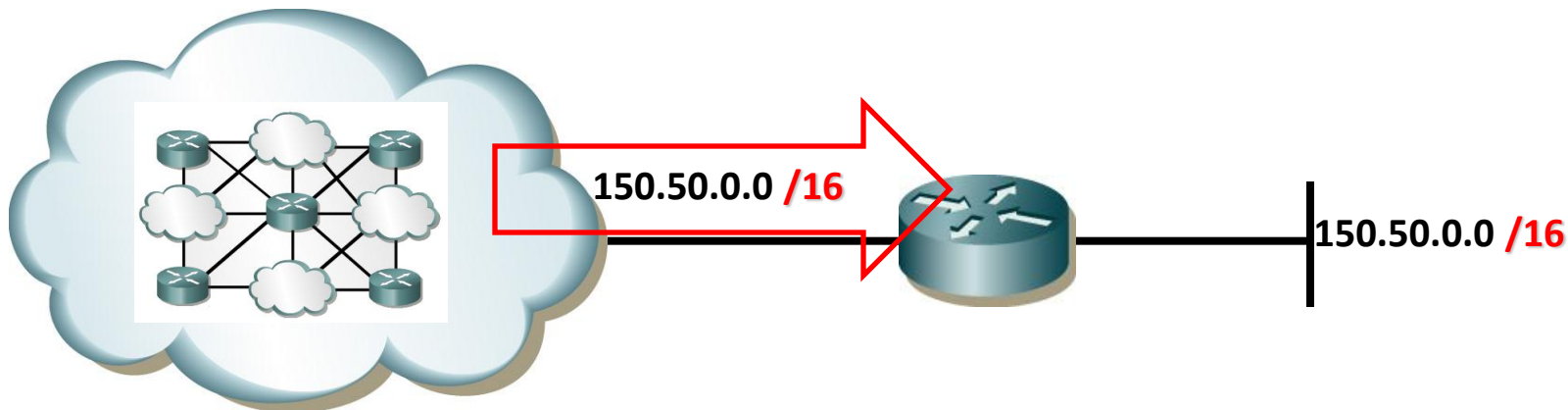
	Network	Host
Host IP: 172.16.33.10	10101100.00010000	.00100001.00001010
Mask: 255.255.0.0	11111111.11111111	.00000000.00000000

Net Add: 172.16.0.0	10101100.00010000	.00000000.00000000

SUBNET MASKA i AND OPERACIJA

	Network	Host
Host IP: 172.1.17.9	10101100.00000001.00010001.00001001	
Mask: 255.255.240.0	11111111.11111111.11110000.00000000	
	-----	-----
Net Add: 172.1.16.0	10101100.00000001.00010000.00000000	

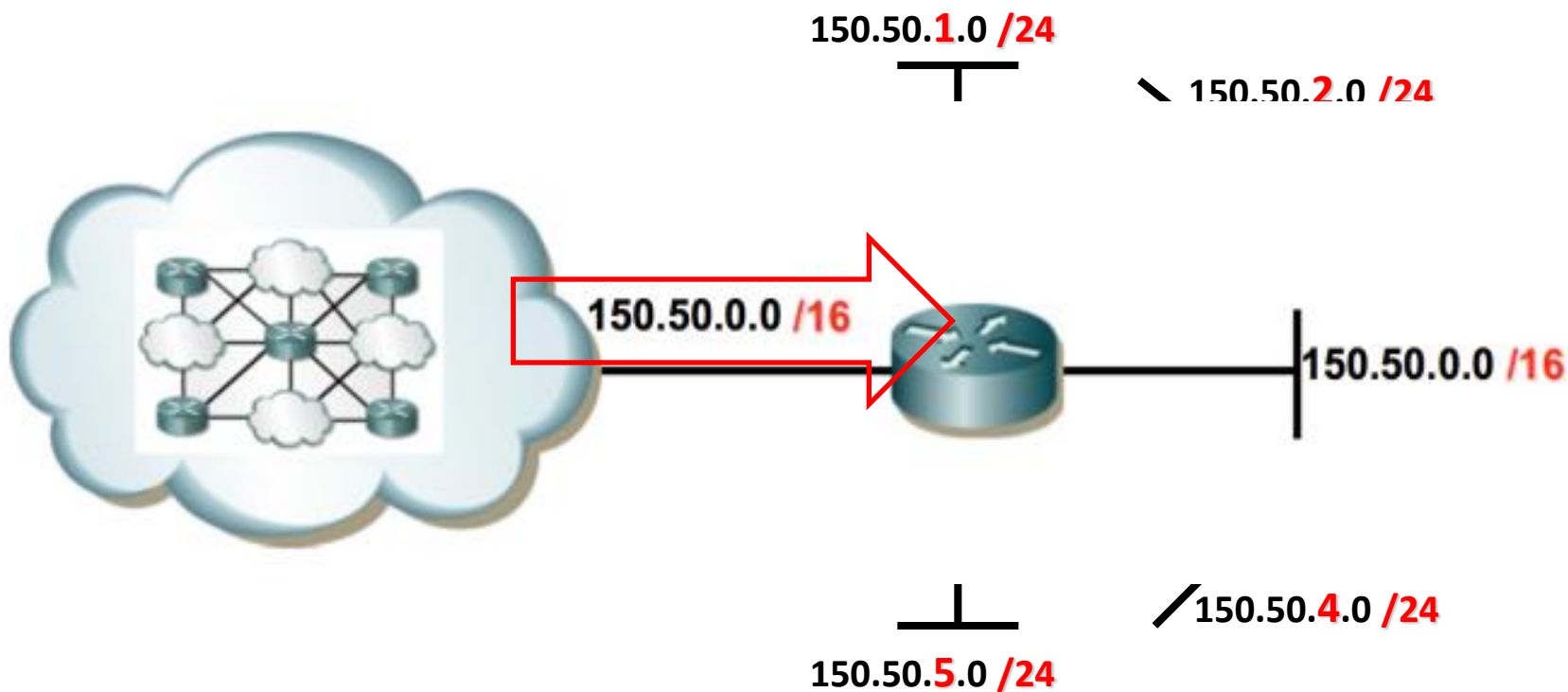
VELIKE IP MREŽE



- U velikim mrežama, *flat* mreža izaziva veliki broj problema
 - Ogroman broadcast saobraćaj (e.g., DHCP, ARP) u jednoj IP mreži.
 - Bezbednost i upravljanje strukturom same organizacije (help desk, finansije, wireless, proizvodnja,...)
- Mreža sa maskom /16 može da podrži do 65,534 hosta
 - Ne postoji potreba za tolikim brojem uređaja u jednoj IP mreži

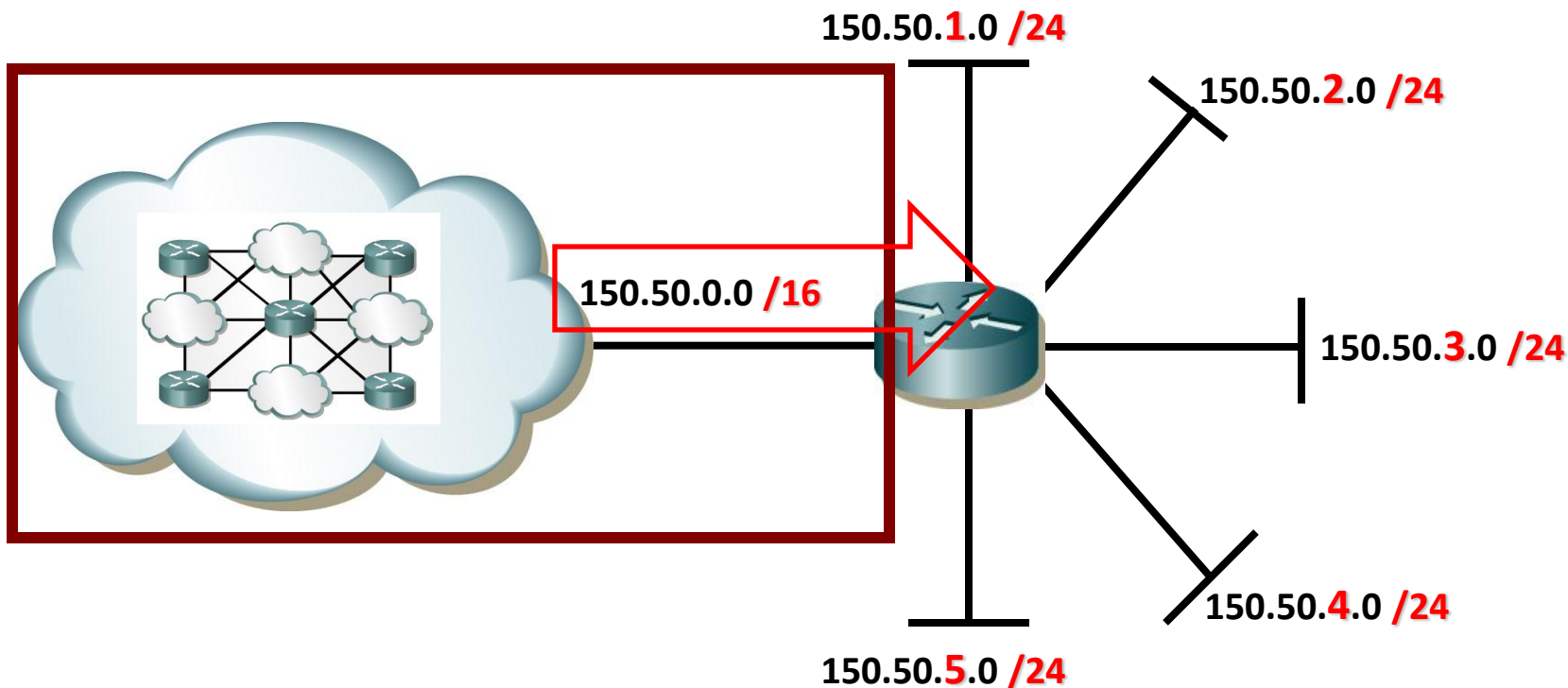
PODMREŽE (SUBNETING)

- Velike mreže se segmentiraju u manje podmreže koje se zovu “[Subnets](#)”.



PODMREŽE (SUBNETS)

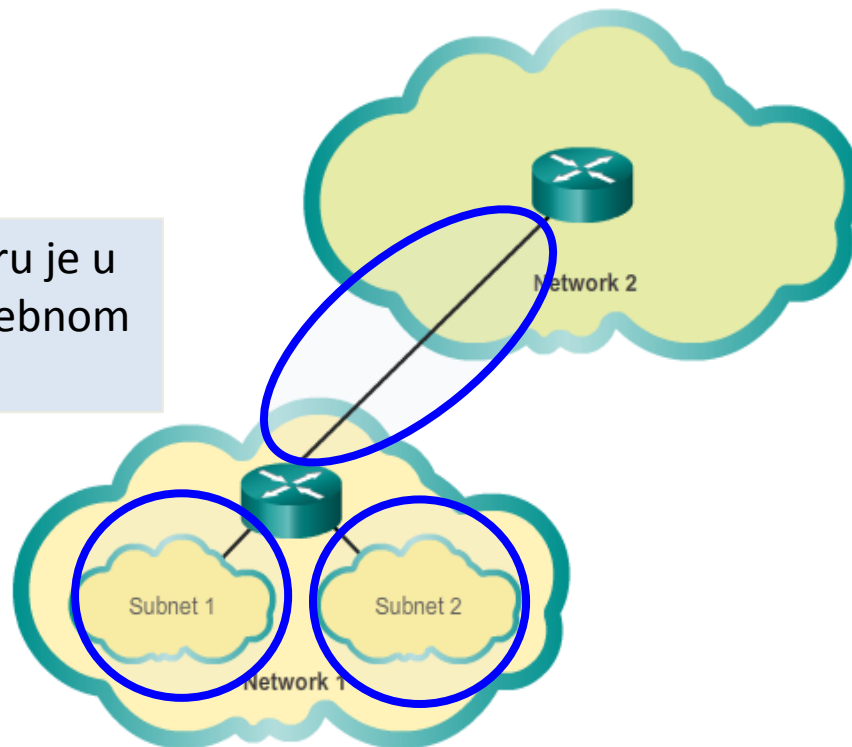
- Podmrežavanje ne utiče kako spoljni svet vidi našu mrežu već obezbeđuje dodatnu strukturu unutar organizacije.



KOMUNIKACIJA IZMEĐU PODMREŽA

- Ruter je neophodan za komunikaciju između podmreža.
 - Svaki interfejs na ruteru je u različitoj mreži.
 - IP uređaji u mreži koriste interfejs rutera kao svoj default gateway.

Svaki interfejs na ruteru je u različitoj mreži i u posebnom broadcast domenu.



DIZAJNIRANJE ADRESNE ŠEME

Razmotriti adresni plan na osnovu:

Broja hosta po pod mreži

Kako će hostu biti zadana adresa (dinamički ili statički)

Definišite standarde za dodelu IP adresa unutar pod mreže:

Ruterima se dodeljuju prve validne IP adrese iz opsega

Štampačima, serverima se dodeljuju statičke IP adrese

Korisnicima obično dinamičke IP adrese

PODMREŽE (SUBNETS)

Za kreiranje podmreža pozajmljujemo bite iz HOST dela mrežne adrese

Za mrežu 192.168.1.0/24 ako pozajmimo samo jedan bit iz HOST dela možemo kreirati dve podmreže

	← Network portion →			← Host portion →	
Address	192.	168.	1.	0000	0000
Mask	255.	255.	255.	1000	0000

	← Network portion →			← Host portion →	
Net 0	192.	168.	1.	0000	0000
Mask	255.	255.	255.	1000	0000

	← Network portion →			← Host portion →	
Net 1	192.	168.	1.	1000	0000
Mask	255.	255.	255.	1000	0000

ODREĐIVANJE MREŽNE I BROADCAST ADRESE

- Network adresa:

- Sve 0 u host delu adrese.

1st Network Adresa

192.	168.	1.	0	← Host portion →
				000 0000
192.	168.	1.	0	

2nd Network Adresa

192.	168.	1.	1	← Host portion →
				000 0000
192.	168.	1.	128	

- Broadcast adresa:

- Sve 1 u host delu adrese.

Broadcast Adresa

192.	168.	1.	0	← Host portion →
				111 1111
192.	168.	1.	127	

Broadcast Adresa

192.	168.	1.	1	← Host portion →
				111 1111
192.	168.	1.	255	

ODREĐIVANJE HOST ADRESA

- Prva host adresa:

1st Host Adresa

192.	168.	1.	0	← Host portion → 000 0001
192.	168.	1.	1	

2nd Host Adresa

192.	168.	1.	1	← Host portion → 000 0001
192.	168.	1.	129	

- Zadnja Host adresa:

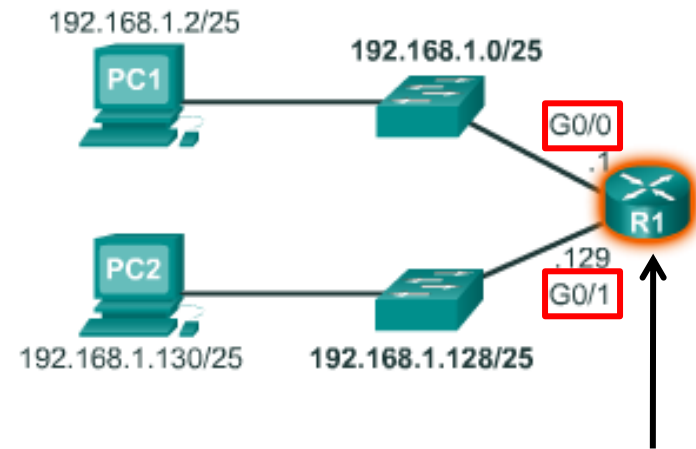
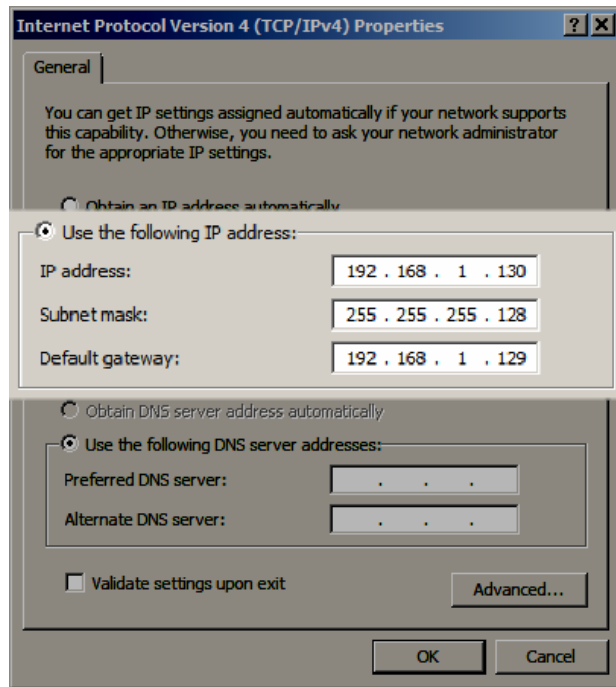
Broadcast Adresa

192.	168.	1.	0	← Host portion → 111 1110
192.	168.	1.	126	

Broadcast Adresa

192.	168.	1.	1	← Host portion → 111 1110
192.	168.	1.	254	

KONFIGURACIJA UREĐAJA



```
R1(config)#  
R1(config)# interface gigabitethernet 0/0  
R1(config-if)# ip address 192.168.1.1 255.255.255.128  
R1(config-if)# no shutdown  
R1(config-if)# exit  
R1(config)#  
R1(config)# interface gigabitethernet 0/1  
R1(config-if)# ip address 192.168.1.129  
255.255.255.128  
R1(config-if)# no shutdown  
R1(config-if)# exit  
R1(config)#
```

PODMREŽAVANJE

- Za svaki pozajmljeni bit broj podmreža se udvostručava
- Primer:
 - **1000 0000**: za 1 pozajmljen bit , 2 podmreže mogu se formirati.
 - **1100 0000**: za 2 pozajmljena bita , 4 podmreže mogu se formirati
 - **1110 0000**: za 3 pozajmljena bita , 8 podmreže mogu se formirati
 - **1111 0000**: za 4 pozajmljena bita , 16 podmreže mogu se formirati
 - **1111 1000**: za 5 pozajmljena bita , 32 podmreže mogu se formirati
 - **1111 1100**: za 6 pozajmljena bita , 64 podmreže mogu se formirati
- Za svaku podmrežu javlja se manji broj adresa koji je dostupan hostovima.

ZADATAK

Formirati maksimalan broj pod mreža tako da svaka pod mreža može da adresira do 50 IP uređaja.

Od provajdera ste dobili mrežnu adresu 192.168.1.0/24

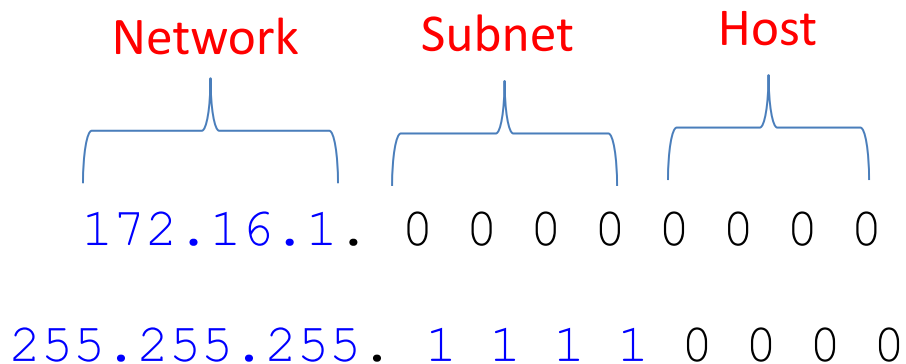
```
IP: 192.168.1. 0 0 0 0 0 0 0 0
SM: 255.255.255. 1 1 0 0 0 0 0 0
192.168.1. 0 0 0 0 0 0 0 0 192.168.1.0/26
192.168.1. 0 1 0 0 0 0 0 0 192.168.1.64/26
192.168.1. 1 0 0 0 0 0 0 0 192.168.1.128/26
192.168.1. 1 1 0 0 0 0 0 0 192.168.1.192/26
```

- Broj hosta po pod mreži: 6 bita, 64-2 hosta, 64 IP adrese, 62 su upotrebljive
- Broj pod mreža: 2 bita ili 4 pod mreža

ZADATAK 1

- Želimo da iz mreže 172.16.1.0/24 kreiramo što više podmreža sa po 12 hosta po podmreži
- Nova Subnet Maska: **255.255.255.240 (/28)**
 - Broj hosta po podmreži: 4 bita, 16-2 hosta, **14 hosta**
 - Broj podmreža: 4 bita ili **16 podmreža**

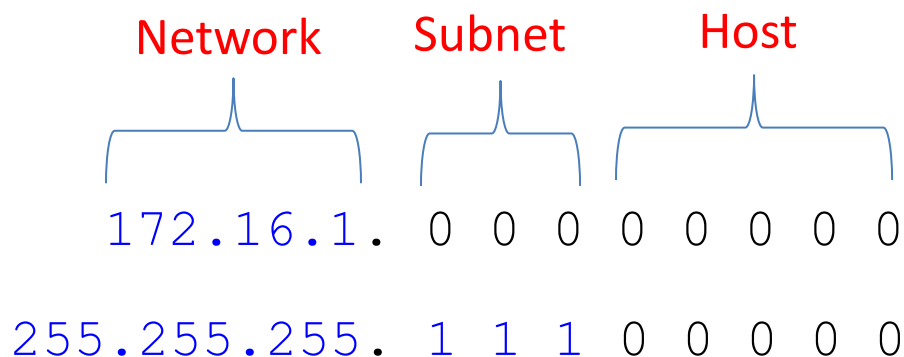
FLSM (FIX LENGTH SUBNET MASK)



ZADATAK 2

- Želimo da iz mreže 172.16.1.0/24 kreiramo 6 podmreža sa što više hosta po podmreži
- Nova Subnet Maska: **255.255.255.224 (/27)**
 - Broj hosta po podmreži: 5 bita, 32-2 hosta, **30 hosta**
 - Broj podmreža: 3 bita ili **8 podmreža**

FLSM (FIX LENGTH SUBNET MASK)



SUBNET KALKULATOR

The screenshot shows a web browser window with the URL www.subnet-calculator.com/subnet.php?net_class=C. The page title is "ip subnet calculator". The main content area is titled "Subnet Calculator" and contains several input fields and a "Calculate" button. The inputs are: Network Class (A, B, C, D), First Octet Range (192 - 223), IP Address (192.168.0.1), Hex IP Address (C0.A8.00.01), Subnet Mask (255.255.255.0), Wildcard Mask (0.0.0.255), Subnet Bits (0), Mask Bits (24), Maximum Subnets (1), Hosts per Subnet (254), Host Address Range (192.168.0.1 - 192.168.0.254), Subnet ID (192.168.0.0), Broadcast Address (192.168.0.255), and Subnet Bitmap (110nnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh). Below the inputs, there is a section titled "IP Subnet Calculator" with a description: "The IP Subnet Mask Calculator enables subnet network calculations using network class, IP address, subnet mask, subnet bits, mask bits, maximum required IP subnets and maximum required hosts per subnet." It also includes a note about the calculator's capabilities and a disclaimer: "Note: These online network calculators may be used totally free of charge provided their use is from this url (www.subnet-calculator.com)." There are also links for "Subnets", "CIDR", "Wildcard", "Feedback", "AdChoices", "Calculator", "IP Address", "IP Subnet", and "Subnet Mask".

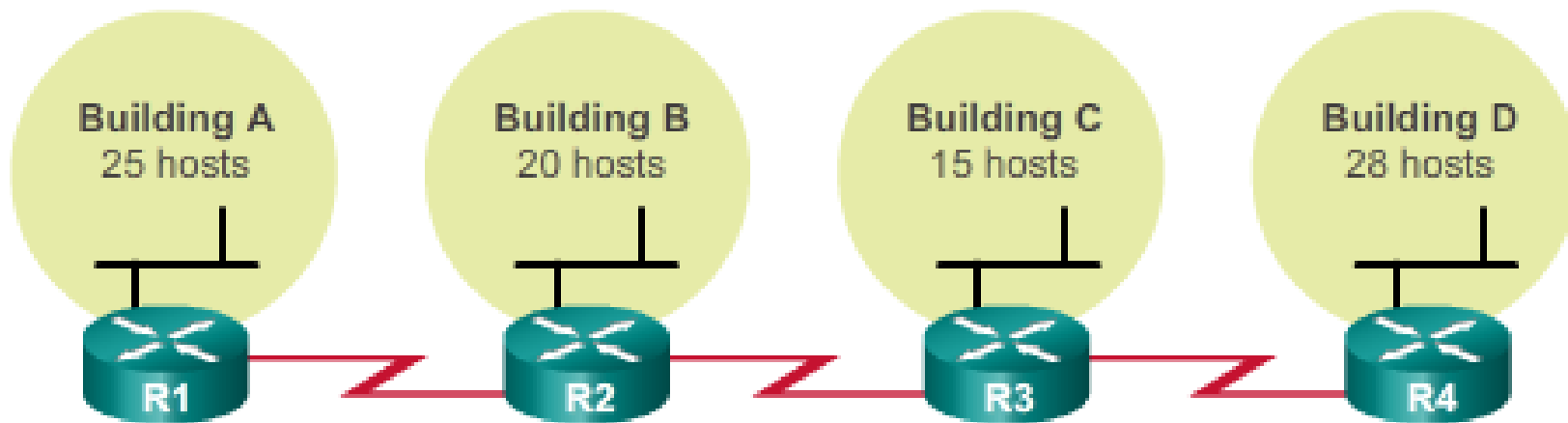
The screenshot shows a desktop application window titled "Advanced Subnet Calculator". The interface includes a menu bar (File, Edit, Tools, Skins, Help) and a "SOLARWINDS" logo. The main area has tabs for "Address Details", "Classful Subnet Calculator", "CIDR Calculator", and "Subnet Addresses". The "Classful Subnet Calculator" tab is active, showing input fields for IP Address (192.168.10.0), Subnet Mask (255.255.255.192), Mask Bits (26), Number of Subnets (4), Host Bits (6), and Hosts per Subnet (62). A "Generate Subnets" button is present. Below these fields, the "Subnet Bit Mask" is displayed as 110nnnnn.nnnnnnnn.nnnnnnnn.sshhhhhh. A table below shows the resulting subnets:

Subnet	Mask	Inverse Mask	Subnet Size	Host Range	Broadcast
192.168.10.0	255.255.255.192	0.0.0.63	62	192.168.10.1 to 192.168.10.62	192.168.10.63
192.168.10.64	255.255.255.192	0.0.0.63	62	192.168.10.65 to 192.168.10.126	192.168.10.127
192.168.10.128	255.255.255.192	0.0.0.63	62	192.168.10.129 to 192.168.10.190	192.168.10.191
192.168.10.192	255.255.255.192	0.0.0.63	62	192.168.10.193 to 192.168.10.254	192.168.10.255

There are also "Copy Details" and "Copy Subnets" buttons on the right side of the interface.

VLSM ŠEMA ADRESIRANJA

- Do sada svaka podmreža je bila iste veličine sa istim brojem hostova.
 - U praksi je retka situacija da svaka podmreža ima potrebu za istim brojem host-ova
 - VLSM omogućava znatno bolje **iskorišćenje adresnog opsega** i efikasniju sumarizaciju



- Na slici koliko podmreža je potrebno formirati?
 - 7 podmreža različite veličine.

ZADATAK 2

Building A: $2^x - 2 \geq 25 \Rightarrow 2^x \geq 27 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32-5)$

Building B: $2^x - 2 \geq 20 \Rightarrow 2^x \geq 22 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32-5)$

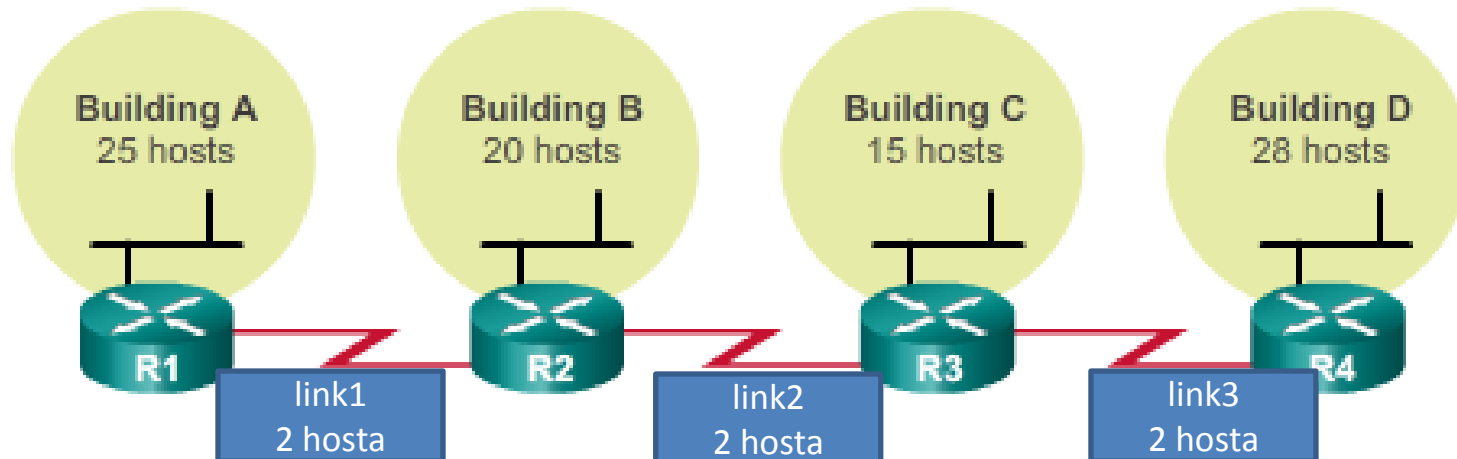
Building C: $2^x - 2 \geq 15 \Rightarrow 2^x \geq 17 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32-5)$

Building D: $2^x - 2 \geq 28 \Rightarrow 2^x \geq 30 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32-5)$

Link 1 : $2^x - 2 \geq 2 \Rightarrow 2^x \geq 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32-2)$

Link 2 : $2^x - 2 \geq 2 \Rightarrow 2^x \geq 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32-2)$

Link 3 : $2^x - 2 \geq 2 \Rightarrow 2^x \geq 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32-2)$



VLSM ŠEMA ADRESIRANJA

Building A: $2^x - 2 >= 25 \Rightarrow 2^x >= 27 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32 - 5)$

Building B: $2^x - 2 >= 20 \Rightarrow 2^x >= 22 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32 - 5)$

Building C: $2^x - 2 >= 15 \Rightarrow 2^x >= 17 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32 - 5)$

Building D: $2^x - 2 >= 28 \Rightarrow 2^x >= 30 \Rightarrow x = 5$ bita (host) $\Rightarrow 2^5 = 32 \Rightarrow SM = 27 (32 - 5)$

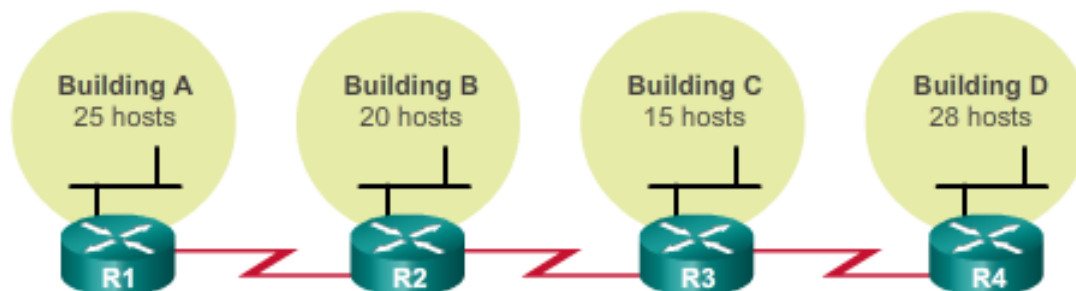
Link 1: $2^x - 2 >= 2 \Rightarrow 2^x >= 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32 - 2)$

Link 2: $2^x - 2 >= 2 \Rightarrow 2^x >= 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32 - 2)$

Link 3: $2^x - 2 >= 2 \Rightarrow 2^x >= 4 \Rightarrow x = 2$ bita (host) $\Rightarrow 2^2 = 4 \Rightarrow SM = 30 (32 - 2)$

$32 + 32 + 32 + 32 + 4 + 4 + 4 = 140$ IP adresa

$2^x > 140 \Rightarrow x = 8$ bita $\Rightarrow SM = 24$ (dodeljuje ISP)



VLSM ŠEMA ADRESIRANJA

ISP MREŽNA ADRESA: 212.1.1.0 /24

Building A: SM= 27 Building B: SM= 27 Building C: SM= 27 Building D: SM= 27
Link 1 : SM= 30 Link 2 : SM= 30 Link 3 : SM= 30

NA: 212.1.1.0 /27

VA: 212.1.1.1-212.1.1.30

BA: 212.1.1.31

NA: 212.1.1.32 /27

VA: 212.1.1.33-212.1.1.62

BA: 212.1.1.63 /

NA: 212.1.1.64 /27

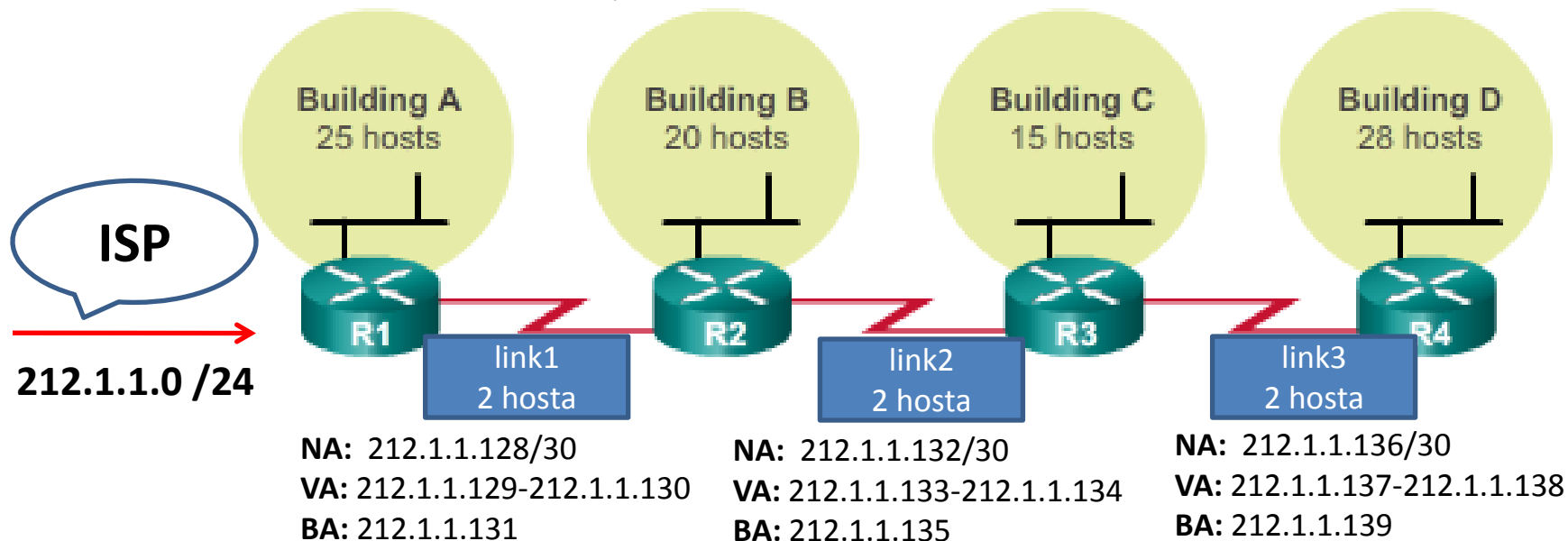
VA: 212.1.1.65-212.1.1.94

BA: 212.1.1.95

NA: 212.1.1.96 /27

VA: 212.1.1.97-212.1.1.126

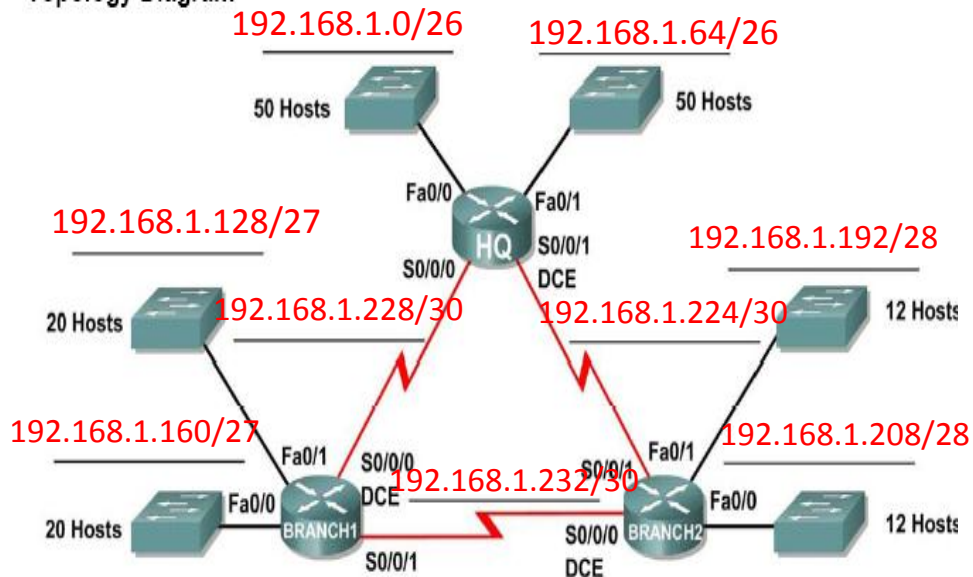
BA: 212.1.1.127



DIZAJN VLSM ŠEME ADRESIRANJA

Na osnovu dobijene mrežne IP adrese 192.168.1.0/24 kreirati adresnu šemu na osnovu slike

Topology Diagram



Device	Interface	IP Address	Subnet Mask
HQ	Fa0/0	192.168.1.1	255.255.255.192
	Fa0/1	192.168.1.65	255.255.255.192
	S0/0/0	192.168.1.229	255.255.255.252
	S0/0/1	192.168.1.225	255.255.255.252
Branch1	Fa0/0	192.168.1.161	255.255.255.224
	Fa0/1	192.168.1.129	255.255.255.224
	S0/0/0	192.168.1.230	255.255.255.252
	S0/0/1	192.168.1.232	255.255.255.252
Branch2	Fa0/0	192.168.1.193	255.255.255.240
	Fa0/1	192.168.1.209	255.255.255.240
	S0/0/0	192.168.1.234	255.255.255.252
	S0/0/1	192.168.1.226	255.255.255.252

MODELI ADRESIRANJA

- 1981, RFC 791 je IPv4 32-bitnu adresu podelio u tri različite klase
 - Klasa A koristi 8 bita za identifikaciju mreže,
 - Klasa B koristi 16 bita,
 - Klasa C koristi 24 bita.
 - Ovakav format je poznat kao **classful IP addressing** (klasna šema adresiranja).
- IP adrese su se vrlo brzo trošile
- Internet Engineering Task Force (IETF) predstavila je **Classless Inter-Domain Routing (CIDR)** metodu adresiranja
 - CIDR koristi Variable Length Subnet Masking (VLSM) koja pomaže u boljem iskorišćenju IPv4 adresnog prostora

BEZKLASNO ADRESIRANJE

- **CIDR i VLSM** su omogućile da ISP svojim klijentima dodeljuje mreže van klasnih granica.
- ISP je mogao da dodeli jednom klijentu deo adresa klasne mreže a drugom klijentudrugi deo adresa iste klasne mreže
- Tehnike koje su produžileživotni vek IPv4 su:
 - **VLSM & CIDR** notation (1993, RFC 1519)
 - **Network Address Translation** (1994, RFC 1631)
 - **Private Addressing** (1996, RFC 1918)

KLASNO ADRESIRANJE

Class	High Order Bits	Start	End
Class A	0	0.0.0.0	127.255.255.255
Class B	10	128.0.0.0	191.255.255.255
Class C	110	192.0.0.0	223.255.255.255
Multicast	1110	224.0.0.0	239.255.255.255
Experimental	1111	240.0.0.0	255.255.255.255

	1st Octet	2st Octet	3st Octet	4st Octet	<u>Subnet Mask</u>
Class A	Network	Host	Host	Host	255.0.0.0 or /8
Class B	Network	Network	Host	Host	255.255.0.0 or /16
Class C	Network	Network	Network	Host	255.255.255.0 or /24

Number of Networks and Hosts per Network for Each Class

Address class	First Octet Range	Number of Possible Networks	Number of Host per Networks
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

VEŽBA

1. 192.168.1.3 Klasa _____ Default Mask: _____
Network: _____ Broadcast: _____
Hosts: _____ do _____

2. 1.12.100.31 Klasa _____ Default Mask: _____
Network: _____ Broadcast: _____
Hosts: _____ do _____

3. 172.30.77.5 Klasa _____ Default Mask: _____
Network: _____ Broadcast: _____
Hosts: _____ do _____

REŠENJE

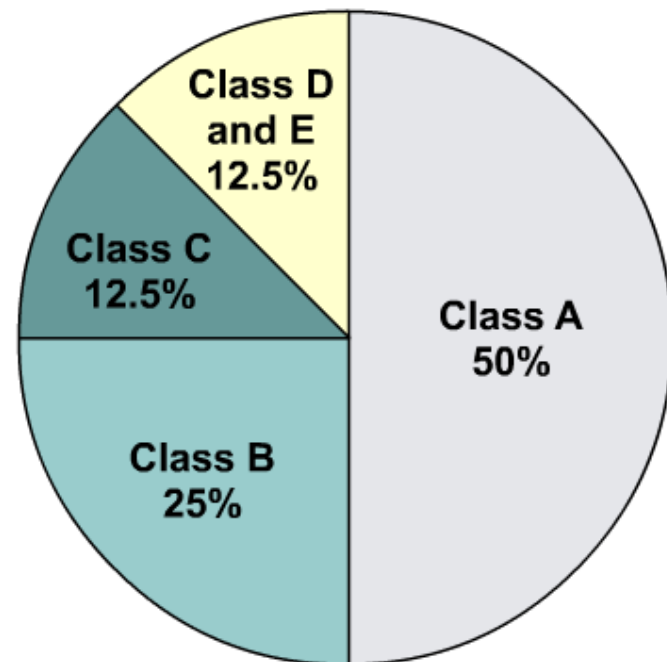
1. 192.168.1.3 Klasa C Default Mask: 255.255.255.0
Network: 192.168.1.0 Broadcast: 192.168.1.255
Hosts: 192.168.1.1 do 192.168.1.254

2. 1.12.100.31 Klasa A Default Mask: 255.0.0.0
Network: 1.0.0.0 Broadcast: 1.255.255.255
Hosts: 1.0.0.1 do 1.255.255.254

3. 172.30.77.5 Klasa B Default Mask: 255.255.0.0
Network: 172.30.0.0 Broadcast: 172.30.255.255
Hosts: 172.30.0.1 do 172.30.255.254

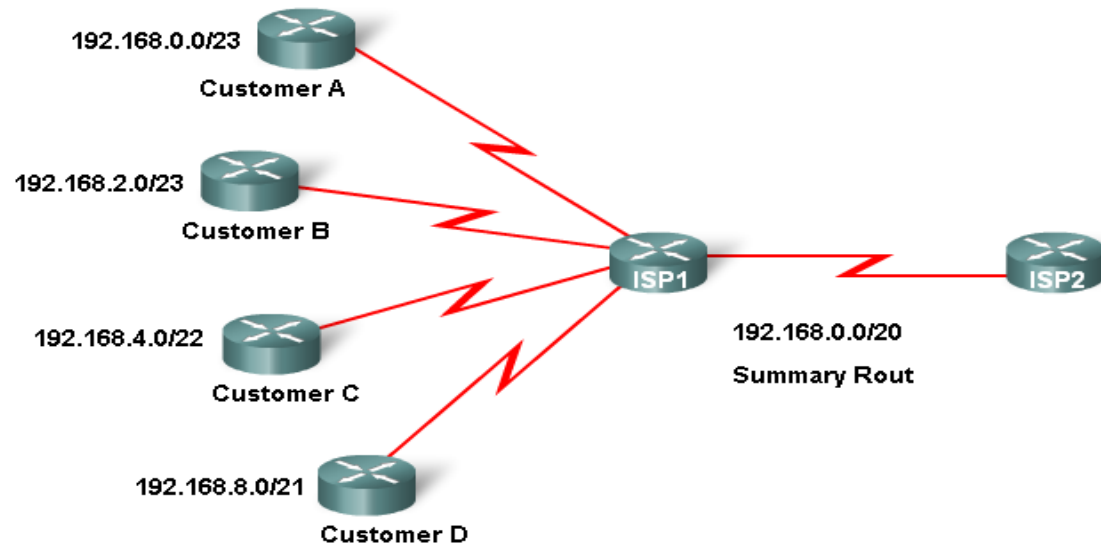
KLASNO ADRESIRANJE

- Na osnovu klasnog adresiranja javilo se nesrazmerno trošenje adresa koje je bilo prisutno na početku razvoja Interneta kada su kompanije dobijale adrese klase A.
- Neke kompanije i državne organizacije i dalje koriste adrese klase A.
 - General Electric poseduje 3.0.0.0/8,
 - Apple Computer poseduje 17.0.0.0/8,
 - U.S. Postal Service poseduje 56.0.0.0/8
- Neravnomerna raspodela IP adresa dovela je do ubrzanog trošenja IP adresa i ogromnih ruting tabela
- Klasa A sadrži 50% IP adresa sa svega 126 mreža



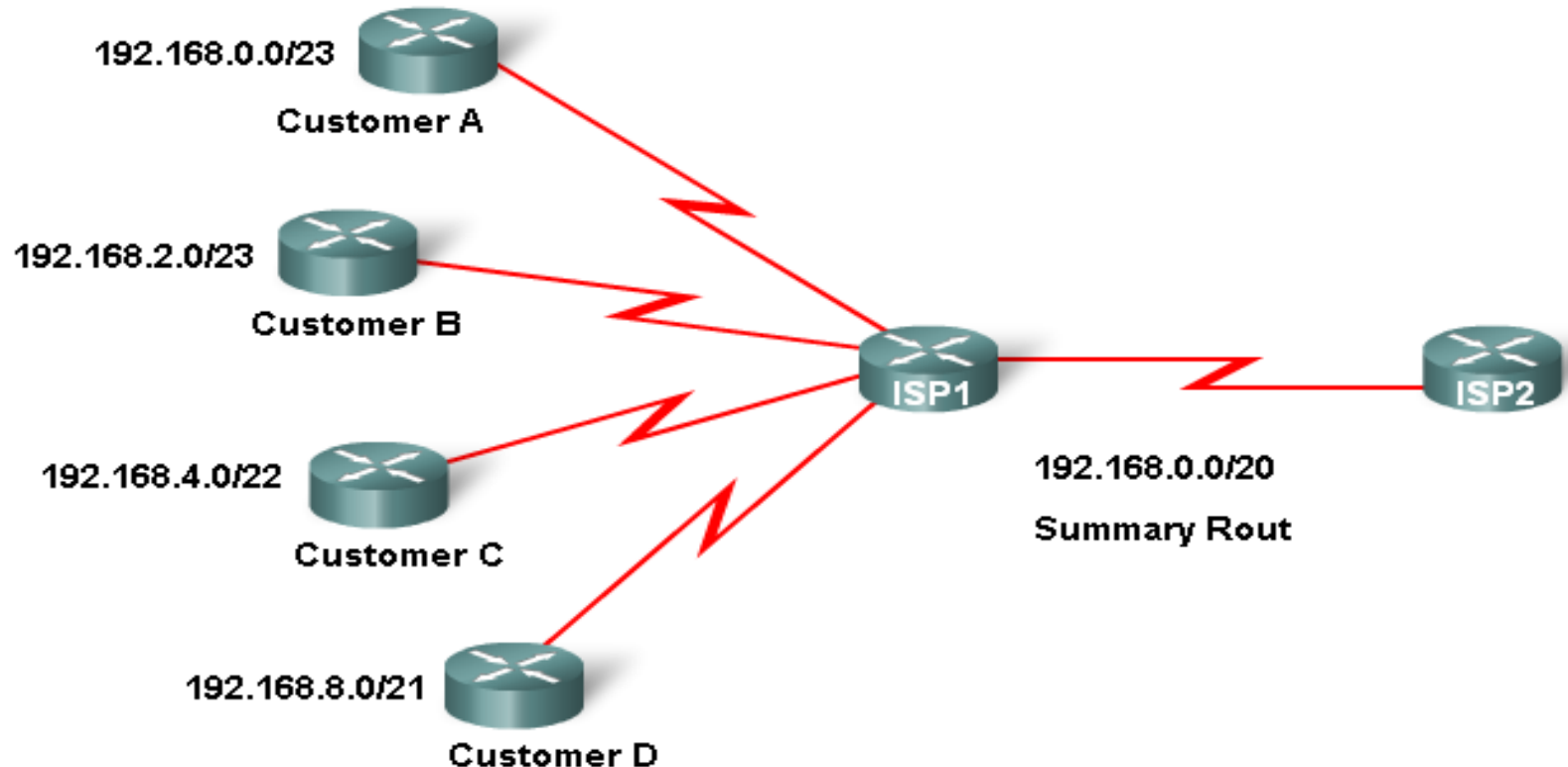
SUMARIZACIJA

- CIDR omogućava da više mreža budu sumarizovane u jednu ili nekoliko manjih mreža
- Sumarizacija se ostvaruje pozajmljivanjem bita iz mrežnog dela
- Sumarizacija je značajno pomogla u smanjivanju veličine ruting tabele
 - brže pretraživanje ruting tabele
 - manje zauzeće memorije



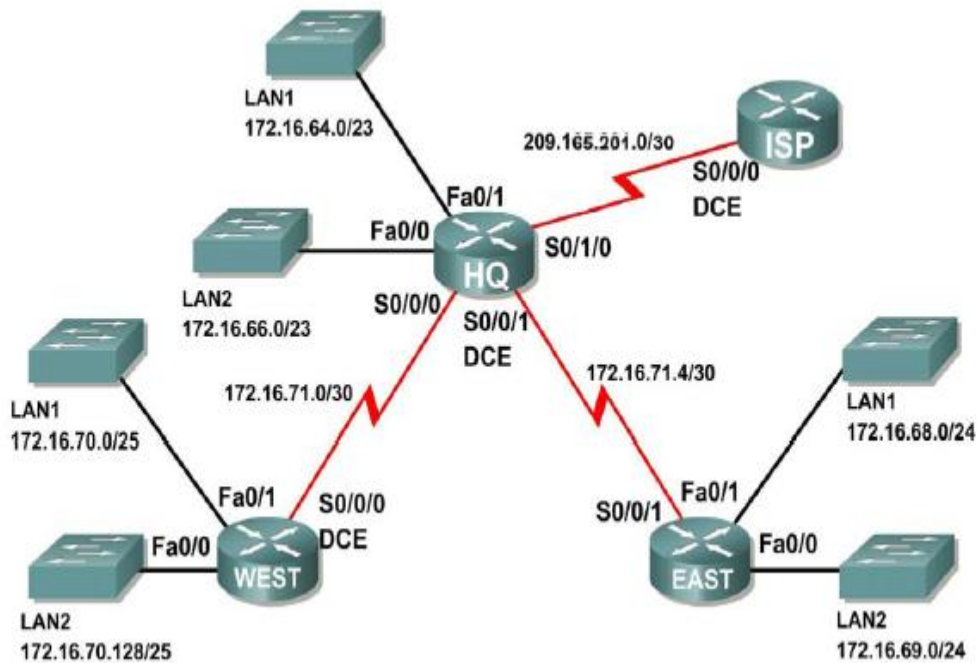
SUPERNET MREŽA

Ukoliko sumarizovana mreža ima manji prefiks (subnet mask) od clasfull mreža koje se sumarizuju reč je o **supernet mreži**



ZADATAK

KREIRATI SUMARIZOVANU RUTU KA ISP-U



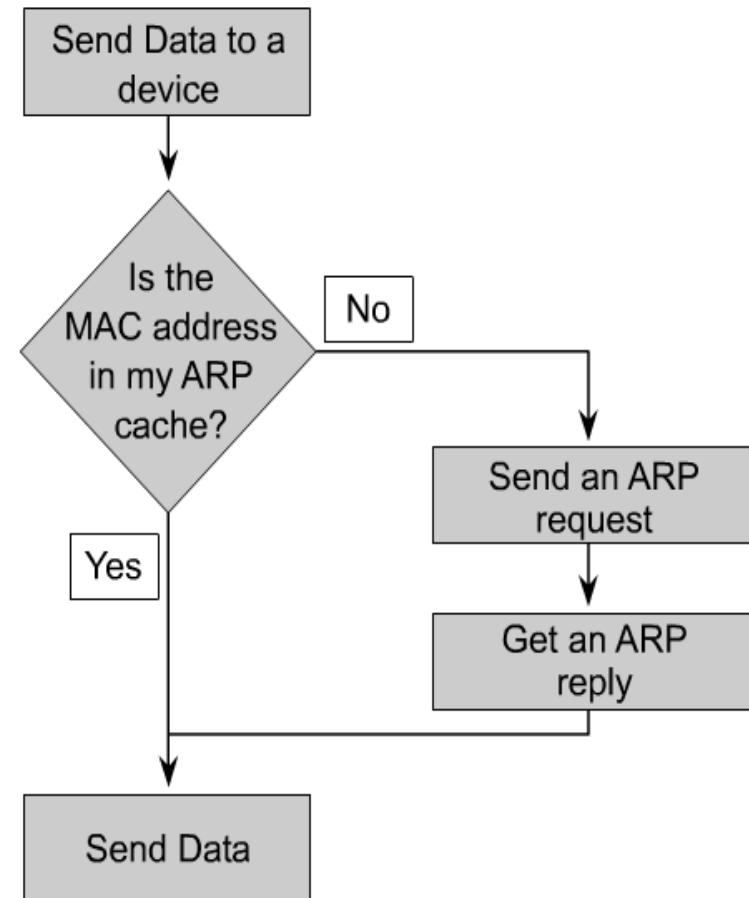
Addressing Table

Subnet	Network Address
HQ LAN1	172.16.64.0/23
HQ LAN2	172.16.66.0/23
EAST LAN1	172.16.68.0/24
EAST LAN2	172.16.69.0/24
WEST LAN1	172.16.70.0/25
WEST LAN2	172.16.70.128/25
Link from HQ to EAST	172.16.71.4/30
Link from HQ to WEST	172.16.71.0/30
Link from HQ to ISP	209.165.201.0/30

ADDRESS RESOLUTION PROTOCOL (ARP)

Princip rada ARP-a:

1. Razrešava MAC adrese na osnovu IP adrese
2. Čuva ARP informacije u ARP tabeli (ARP keš)



ARP KEŠ TABELA

```
C:\WINDOWS\system32\cmd.exe
C:\Documents and Settings\bvachon\Desktop>arp -a
Interface: 192.168.11.69 --- 0x3
Internet Address      Physical Address      Type
192.168.11.1         00-07-b4-00-0b-01    dynamic
192.168.11.5         00-10-83-06-8b-eb    dynamic
C:\Documents and Settings\bvachon\Desktop>arp -d
C:\Documents and Settings\bvachon\Desktop>arp -a
No ARP Entries Found
C:\Documents and Settings\bvachon\Desktop>
```

PRIMER RADA ARP PROTOKOLA

```
C:\Users\Dusan> arp -a
```

```
Interface: 192.168.11.13 --- 0xb
```

Internet Address	Physical Address	Type
192.168.11.1	00-07-b4-00-0b-01	dynamic

```
C:\Users\Dusan>
```

```
C:\Users\Dusan> ping 192.168.11.5
```

```
Pinging 192.168.11.5 with 32 bytes of data:
```

```
Reply from 192.168.11.5: bytes=32 time=1ms TTL=64
```

```
Reply from 192.168.11.5: bytes=32 time<1ms TTL=64
```

```
Reply from 192.168.11.5: bytes=32 time=1ms TTL=64
```

```
Reply from 192.168.11.5: bytes=32 time<1ms TTL=64
```

```
Ping statistics for 192.168.11.5:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

```
Approximate round trip times in milli-seconds:
```

```
    Minimum = 0ms, Maximum = 1ms, Average = 0ms
```

Start Wireshark

Stop Wireshark

ARP REQUEST PORUKA (PODACI U FREJMU)

ARP-ping.pcapng [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	a4:1f:72:73:01:3d	Broadcast	ARP	42	who has 192.168.11.5? Tell 192.168.11.13
2	0.00090800	Hewlett_7c:5c:cd	a4:1f:72:73:01:3d	ARP	60	192.168.11.5 is at 2c:41:38:7c:5c:cd
3	0.00092500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=30/7680, ttl=128
4	0.00169300	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=30/7680, ttl=64
5	1.00132200	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=31/7936, ttl=128
6	1.00217400	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=31/7936, ttl=64
7	3.00437500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=33/8448, ttl=128
8	3.00524000	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=33/8448, ttl=64

Frame 1: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0

- Ethernet II, Src: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
 - Destination: Broadcast (ff:ff:ff:ff:ff:ff)
 - Source: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Type: ARP (0x0806)
- Address Resolution Protocol (request)

ARP REQUEST PORUKA (PAYLOAD PODACI)

The image shows a Wireshark capture of an ARP request packet. The packet list pane shows 8 packets, with the first packet being an ARP request. The packet details pane shows the structure of the ARP request, including the hardware and protocol types, sizes, opcode, and sender and target MAC and IP addresses. The ARP request payload is highlighted with a red box.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	a4:1f:72:73:01:3d	Broadcast	ARP	42	who has 192.168.11.5? Tell 192.168.11.13
2	0.00090800	Hewlett-7c:5c:cd	a4:1f:72:73:01:3d	ARP	60	192.168.11.5 is at 2c:41:38:7c:5c:cd
3	0.00092500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=30/7680, ttl=128
4	0.00169300	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=30/7680, ttl=64
5	1.00132200	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=31/7936, ttl=128
6	1.00217400	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=31/7936, ttl=64
7	3.00437500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=33/8448, ttl=128
8	3.00524000	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=33/8448, ttl=64

Frame 1: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0

- Ethernet II, Src: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
 - Destination: Broadcast (ff:ff:ff:ff:ff:ff)
 - Source: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Type: ARP (0x0806)
- Address Resolution Protocol (request)
 - Hardware type: Ethernet (1)
 - Protocol type: IP (0x0800)
 - Hardware size: 6
 - Protocol size: 4
 - Opcode: request (1)
 - Sender MAC address: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Sender IP address: 192.168.11.13 (192.168.11.13)
 - Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
 - Target IP address: 192.168.11.5 (192.168.11.5)

ARP REPLY

ARP-ping.pcapng [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	a4:1f:72:73:01:3d	Broadcast	ARP	42	who has 192.168.11.5? Tell 192.168.11.13
2	0.00090800	Hewlett-_7c:5c:cd	a4:1f:72:73:01:3d	ARP	60	192.168.11.5 is at 2c:41:38:7c:5c:cd
3	0.00092500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=30/7680, ttl=128
4	0.00169300	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=30/7680, ttl=64
5	1.00132200	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=31/7936, ttl=128
6	1.00217400	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=31/7936, ttl=64
7	3.00437500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=33/8448, ttl=128
8	3.00524000	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=33/8448, ttl=64

Frame 2: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0

- Ethernet II, Src: Hewlett-_7c:5c:cd (2c:41:38:7c:5c:cd), Dst: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Destination: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Source: Hewlett-_7c:5c:cd (2c:41:38:7c:5c:cd)
 - Type: ARP (0x0806)
 - padding: 00
- Address Resolution Protocol (reply)
 - Hardware type: Ethernet (1)
 - Protocol type: IP (0x0800)
 - Hardware size: 6
 - Protocol size: 4
 - Opcode: reply (2)
 - Sender MAC address: Hewlett-_7c:5c:cd (2c:41:38:7c:5c:cd)
 - Sender IP address: 192.168.11.5 (192.168.11.5)
 - Target MAC address: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Target IP address: 192.168.11.13 (192.168.11.13)

SLANJE ICMP PORUKE

The image shows a Wireshark capture window titled "ARP-ping.pcapng [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]". The interface includes a menu bar (File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Tools, Internals, Help), a toolbar with various icons, and a filter field. The main display area shows a list of network packets. Packet 3 is selected, and its details are shown in the bottom pane.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	a4:1f:72:73:01:3d	Broadcast	ARP	42	who has 192.168.11.5? Tell 192.168.11.13
2	0.00090800	Hewlett-_7c:5c:cd	a4:1f:72:73:01:3d	ARP	60	192.168.11.5 is at 2c:41:38:7c:5c:cd
3	0.00092500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=30/7680, ttl=128
4	0.00169300	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=30/7680, ttl=64
5	1.00132200	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=31/7936, ttl=128
6	1.00217400	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=31/7936, ttl=64
7	3.00437500	192.168.11.13	192.168.11.5	ICMP	74	Echo (ping) request id=0x0001, seq=33/8448, ttl=128
8	3.00524000	192.168.11.5	192.168.11.13	ICMP	74	Echo (ping) reply id=0x0001, seq=33/8448, ttl=64

Frame 3: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0

- Ethernet II, Src: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d), Dst: Hewlett-_7c:5c:cd (2c:41:38:7c:5c:cd)
 - Destination: Hewlett-_7c:5c:cd (2c:41:38:7c:5c:cd)
 - Source: a4:1f:72:73:01:3d (a4:1f:72:73:01:3d)
 - Type: IP (0x0800)
- Internet Protocol Version 4, Src: 192.168.11.13 (192.168.11.13), Dst: 192.168.11.5 (192.168.11.5)
- Internet Control Message Protocol

PRIKAZ ARP KEŠ TABELE

```
C:\Users\Dusan> arp -a
```

```
Interface: 192.168.11.13 --- 0xb
```

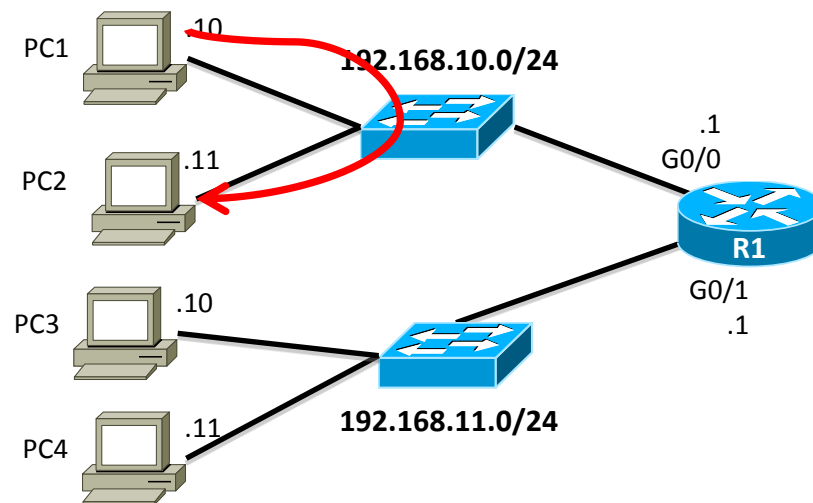
Internet Address	Physical Address	Type
192.168.11.1	00-07-b4-00-0b-01	dynamic
192.168.11.5	2c-41-38-7c-5c-cd	dynamic

```
C:\Users\Bob>
```

KOMUNIKACIJA HOSTA U ISTOJ MREŽI

PC1 (192.168.10.10 /24) šalje paket PC2 (192.168.10.11 /24)

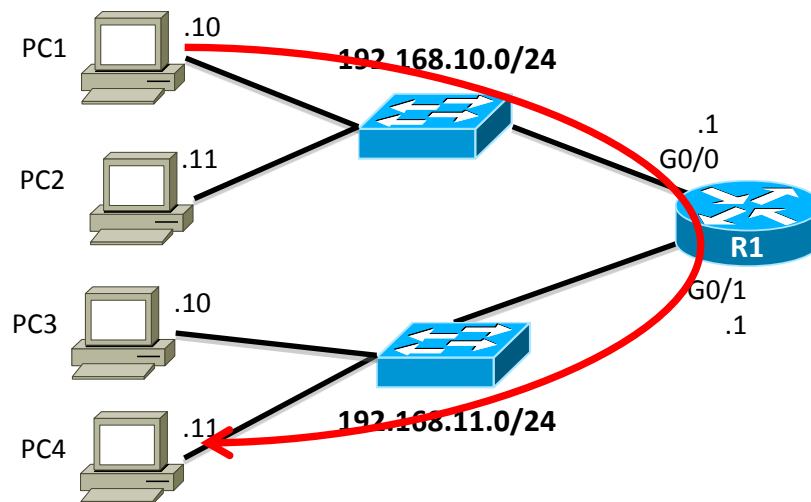
- Pošto se oba hosta nalaze u istoj mreži (192.168.10.x /24) usluga mrežnog prolaza (default gateway) nije potrebna



KOMUNIKACIJA HOSTA U RAZLIČITOJ MREŽI

PC1 (192.168.10.10 /24) šalje paket PC4 (192.168.11.11 /24)

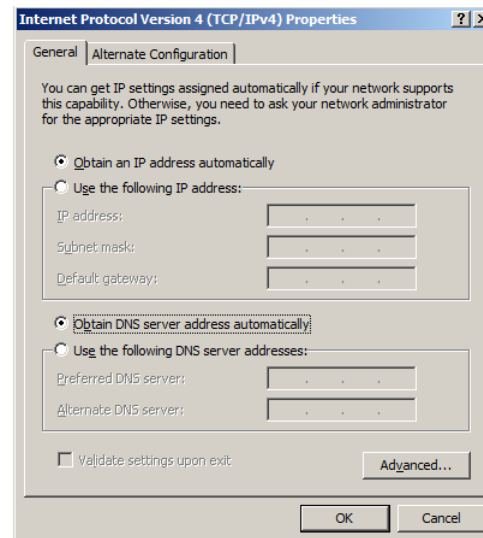
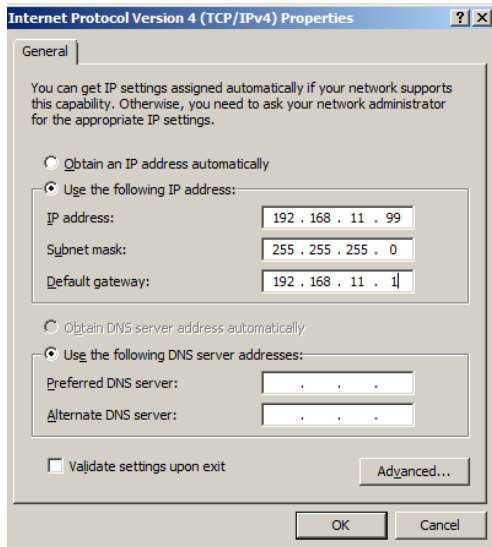
- Pošto se nalaze u različitim mrežama (192.168.10.x /24 i 192.168.11.x /24) zahteva se usluga mrežnog prolaza.



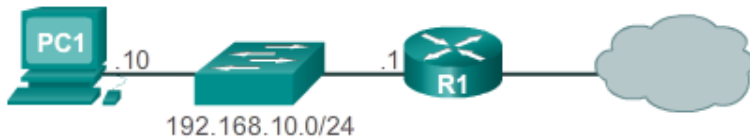
MREŽNI PROLAZ (DEFAULT GATEWAY)

```
C:\Users\Admin>ipconfig
Windows IP Configuration
Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix  . : cisco.com
    Link-local IPv6 Address . . . . . : fe80::b572:c6c:f983:cad%11
    IPv4 Address. . . . . : 192.168.11.99
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.11.1
```



RUTING TABELA NA HOSTU



Lista dostupnih mreža na hostu

Lista subnet maski

Lista adresa preko kojih se dolazi do tih mreža. Destinacija koja je direktno dostupna označava se "On-link".

Lista adresa na fizičkom interfejsu preko koga se šalju paketi

Cena do odredišnih mreža

```
C:\Users\PC1> netstat -r
```

<Output omitted>

IPv4 Route Table

=====

Active Routes:

Network	Destination	Netmask	Gateway	Interface	Metric
	0.0.0.0	0.0.0.0	192.168.10.1	192.168.10.10	25
	127.0.0.0	255.0.0.0	On-link	127.0.0.1	306
	127.0.0.1	255.255.255.255	On-link	127.0.0.1	306
	127.255.255.255	255.255.255.255	On-link	127.0.0.1	306
	192.168.10.0	255.255.255.0	On-link	192.168.10.10	281
	192.168.10.10	255.255.255.255	On-link	192.168.10.10	281
	192.168.10.255	255.255.255.255	On-link	192.168.10.10	281
	224.0.0.0	240.0.0.0	On-link	127.0.0.1	306
	224.0.0.0	240.0.0.0	On-link	192.168.10.10	281
	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
	255.255.255.255	255.255.255.255	On-link	192.168.10.10	281

=====

RUTING TABELA NA HOSTU



0.0.0.0

- Default ruta i njoj se prosleđuju paketi namenjeni drugim mrežama.
- Default gateway je 192.168.10.1 (R1)

127.0.0.0 – 127.255.255.255

- Ove adrese odnose se na lokalnu konekciju i obezbeđuju servise lokalnom hostu

192.168.10.0 - 192.168.10.255

- Adrese se odnose na host i lokalnu mrežu
- 192.168.10.0 – Ruta do lokalne mreže.
- 192.168.10.10 – Adresa lokalnog hosta.
- 192.168.10.255 – Broadcast adresa.

224.0.0.0

- Specijalne multicast adrese

```
C:\Users\PC1> netstat -r
```

```
<Output omitted>
```

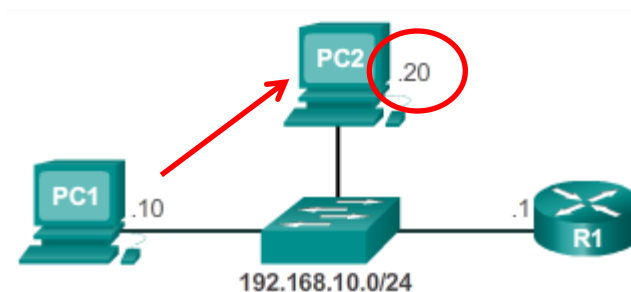
```
IPv4 Route Table
```

```
=====
```

```
Active Routes:
```

Network	Destination	Netmask	Gateway	Interface	Metric
	0.0.0.0	0.0.0.0	192.168.10.1	192.168.10.10	25
	127.0.0.0	255.0.0.0	On-link	127.0.0.1	306
	127.0.0.1	255.255.255.255	On-link	127.0.0.1	306
	127.255.255.255	255.255.255.255	On-link	127.0.0.1	306
	192.168.10.0	255.255.255.0	On-link	192.168.10.10	281
	192.168.10.10	255.255.255.255	On-link	192.168.10.10	281
	192.168.10.255	255.255.255.255	On-link	192.168.10.10	281
	224.0.0.0	240.0.0.0	On-link	127.0.0.1	306
	224.0.0.0	240.0.0.0	On-link	192.168.10.10	281
	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
	255.255.255.255	255.255.255.255	On-link	192.168.10.10	281

KOMUNIKACIJA PC1 i PC2



```
C:\Users\PC1> netstat -r
```

```
<Output omitted>
```

```
IPv4 Route Table
```

```
=====
```

```
Active Routes:
```

Network	Destination	Netmask	Gateway	Interface	Metric
	0.0.0.0	0.0.0.0	192.168.10.1	192.168.10.10	25
127.0.0.0	255.0.0.0	255.0.0.0	On-link	127.0.0.1	306
127.0.0.1	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
127.255.255.255	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
192.168.10.0	255.255.255.0	255.255.255.0	On-link	192.168.10.10	281
192.168.10.10	255.255.255.255	255.255.255.255	On link	192.168.10.10	281
192.168.10.255	255.255.255.255	255.255.255.255	On link	192.168.10.10	281
224.0.0.0	240.0.0.0	240.0.0.0	On-link	127.0.0.1	306
224.0.0.0	240.0.0.0	240.0.0.0	On-link	192.168.10.10	281
255.255.255.255	255.255.255.255	255.255.255.255	On link	127.0.0.1	306
255.255.255.255	255.255.255.255	255.255.255.255	On link	192.168.10.10	281

```
=====
```

KOMUNIKACIJA

PC1 SA ADRESOM 10.10.10.10



```
C:\Users\PC1> netstat -r
```

```
<Output omitted>
```

```
IPv4 Route Table
```

```
=====
```

```
Active Routes:
```

Network	Destination	Netmask	Gateway	Interface	Metric
	0.0.0.0	0.0.0.0	192.168.10.1	192.168.10.10	25
127.0.0.0	255.0.0.0	255.0.0.0	On-link	127.0.0.1	306
127.0.0.1	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
127.255.255.255	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
192.168.10.0	255.255.255.0	255.255.255.0	On-link	192.168.10.10	281
192.168.10.10	255.255.255.255	255.255.255.255	On-link	192.168.10.10	281
192.168.10.255	255.255.255.255	255.255.255.255	On-link	192.168.10.10	281
224.0.0.0	240.0.0.0	240.0.0.0	On-link	127.0.0.1	306
224.0.0.0	240.0.0.0	240.0.0.0	On-link	192.168.10.10	281
255.255.255.255	255.255.255.255	255.255.255.255	On-link	127.0.0.1	306
255.255.255.255	255.255.255.255	255.255.255.255	On-link	192.168.10.10	281

```
=====
```


ZADATAK

Refer to the exhibit. All of the routers in the network are configured with the ip subnet-zero command. Which network addresses should be used for Link A and Network A? (Choose two)

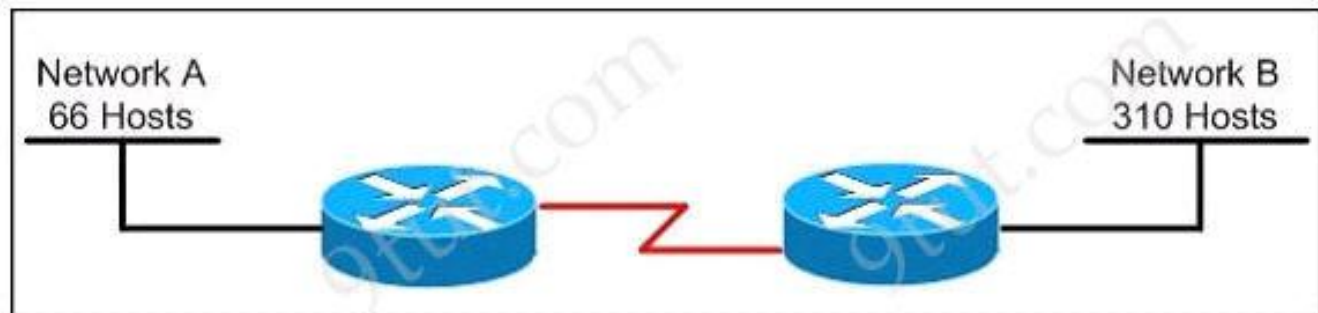


- A. Network A – 172.16.3.48/26
- B. Network A – 172.16.3.128/25
- C. Network A – 172.16.3.192/26
- D. Link A – 172.16.3.0/30
- E. Link A – 172.16.3.40/30
- F. Link A – 172.16.3.112/3

Odgovor B,D

ZADATAK

Refer to the exhibit. Which subnet mask will place all hosts on Network B in the same subnet with the least amount of wasted addresses?



- A. 255.255.255.0
- B. 255.255.254.0**
- C. 255.255.252.0
- D. 255.255.248.0

Odgovor B

ZADATAK

An administrator must assign static IP addresses to the servers in a network. For network 192.168.20.24/29, the router is assigned the first usable host address while the sales server is given the last usable host address. Which of the following should be entered into the IP properties box for the sales server?

A. IP address: 192.168.20.14
Subnet Mask: 255.255.255.248
Default Gateway: 192.168.20.9

B. IP address: 192.168.20.254
Subnet Mask: 255.255.255.0
Default Gateway: 192.168.20.1

C. IP address: 192.168.20.30
Subnet Mask: 255.255.255.248
Default Gateway: 192.168.20.25

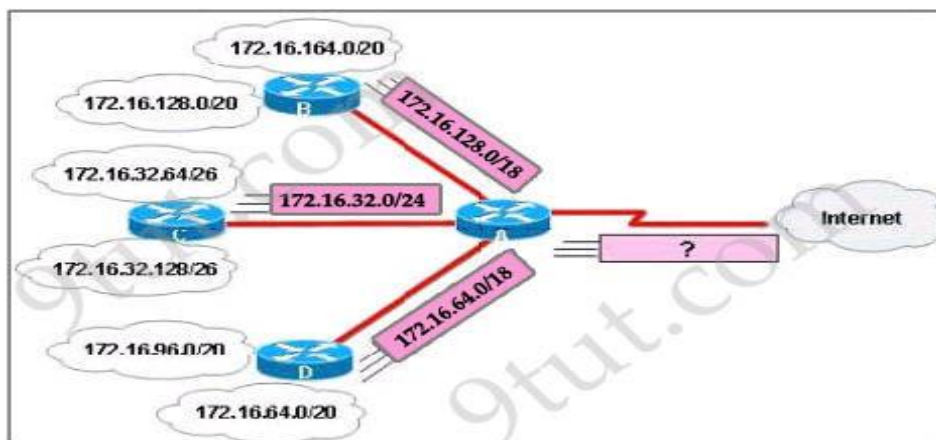
D. IP address: 192.168.20.30
Subnet Mask: 255.255.255.240
Default Gateway: 192.168.20.17

E. IP address: 192.168.20.30
Subnet Mask: 255.255.255.240
Default Gateway: 192.168.20.25

Odgovor C

ZADATAK

Refer to the exhibit. In this VLSM addressing scheme, what summary address would be sent from router A?



A. 172.16.0.0/16

B. 172.16.0.0/20

C. 172.16.0.0/24

D. 172.32.0.0/16

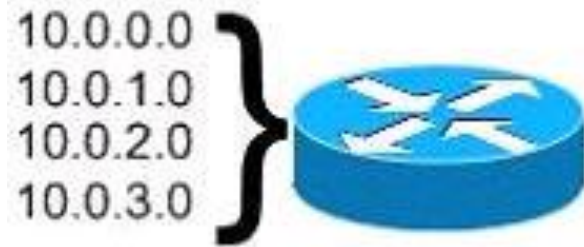
E. 172.32.0.0/17

F. 172.64.0.0/16

Odgovor A

ZADATAK

Refer to the exhibit. What is the most appropriate summarization for these routes?



- A. 10.0.0.0/21
- B. 10.0.0.0/22**
- C. 10.0.0.0/23
- D. 10.0.0.0/24

Odgovor B