



Frame Relay



M4, CCNA4, v5

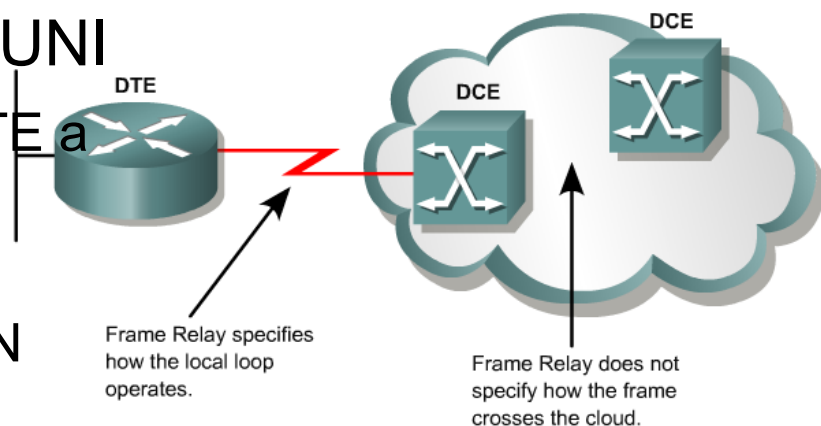
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Čo je Frame Relay?

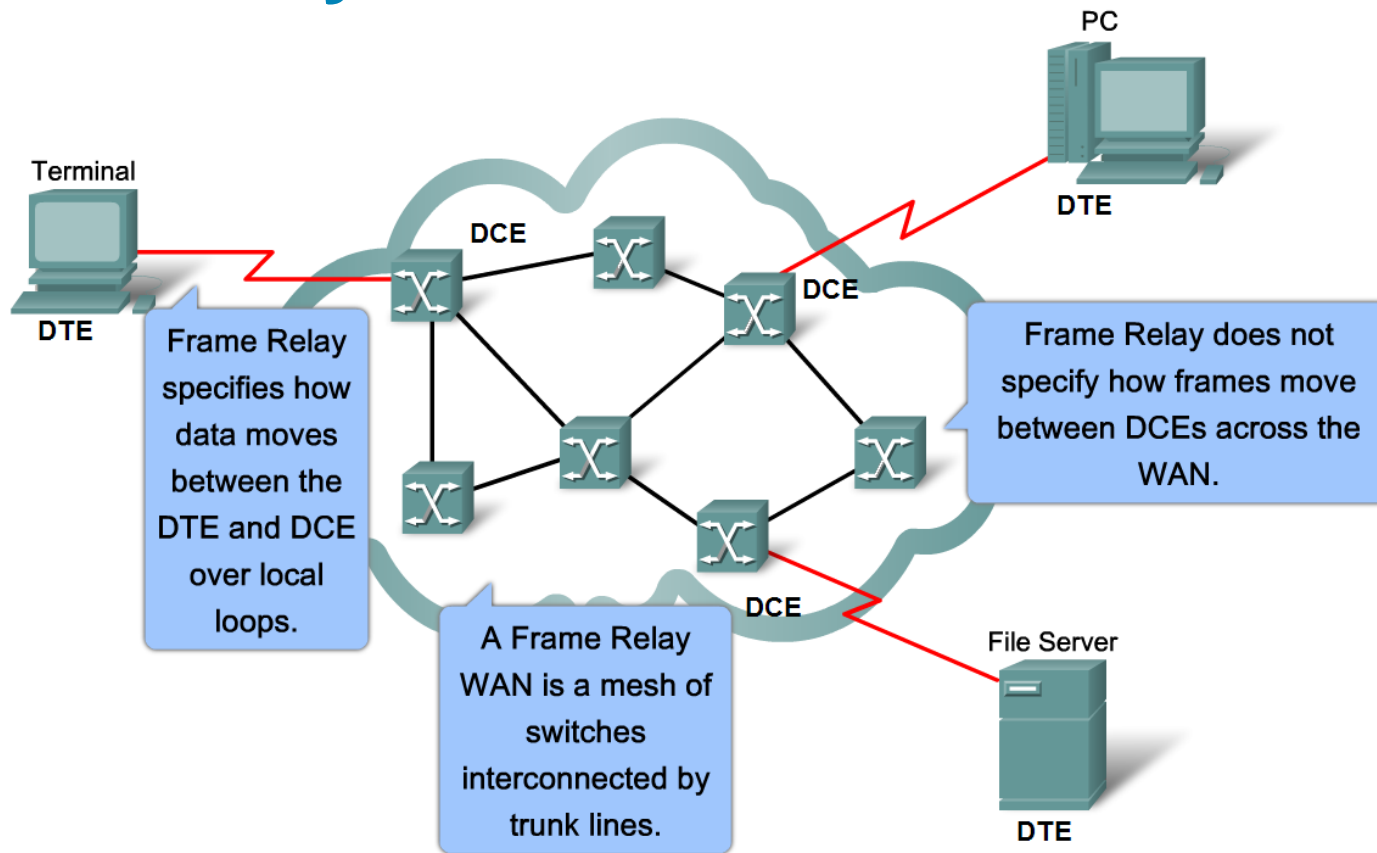
- F.R. je najpoužívanejšia WAN technológia vo svete
 - Pôvodne myslená ako náhrada X.25 protokolu (dáta cez analog. tel. linky) jednoduchším a rýchlejším protokolom
 - Ponúka vzdialený prepojení LAN cez WAN sieť
- Definuje rozhranie medzi používateľom a verejnou sieťou (FR mračnom), tzv. UNI
 - Definuje zapuzdrenie rámcov medzi DTE a DCE
 - Počítala pôvodne s ISDN, alebo leased line
 - Nedefinuje prenos rámcov v rámci WAN provider siete



FR vlastnosti

- FR je paketová technológia
 - Založená na Packet switching prepínaní
 - Pôvodne plánovaná ako dátové rozšírenie ISDN
 - Veľkosť rámcov do 4096 bajtov, typicky 1600B
- Pracuje na ISO OSI L2
- Predpokladá nízku poruchovosť prenosových liniek (digitálny prenos)
 - Žiadny mechanizmus riadenia chýb rámcov pri prenose (retransmisia poškodených pri prenose)
 - Detekcia chýb a opravy sú ponechané na protokoly vyšších vrstiev (TCP) koncov
 - Neobsahuje mechanizmus riadenia toku
 - Obsahuje mechanizmus riadenia zahltenia siete (drop)
- Je spojoovo orientovaná
 - Medzi používateľmi prepojenými FR existuje virtuálne spojenie
 - Max teoreticky je 1024 na linku
- Ponúka rýchlosti od 64 kbps do približne 45 Mbps
 - Bandwidth je prideľovaný podľa požiadavky (štatistický MUX)
 - Typicky záujem zákazníkov je 1Mbps or 2Mbps
- Najčastejšie nasadenie
 - Bursty prevádzka
 - Prepojenie odľahlých LAN, prístup do Internetu a pod.

Frame Relay WAN



Frame Relay poskytuje:

- prístup do siete
- doručenie rámcov v poradí,
- zabezpečenie chybovosti rámcov Cyclic Redundancy Check

FR – prepojenie – Virtual Connection

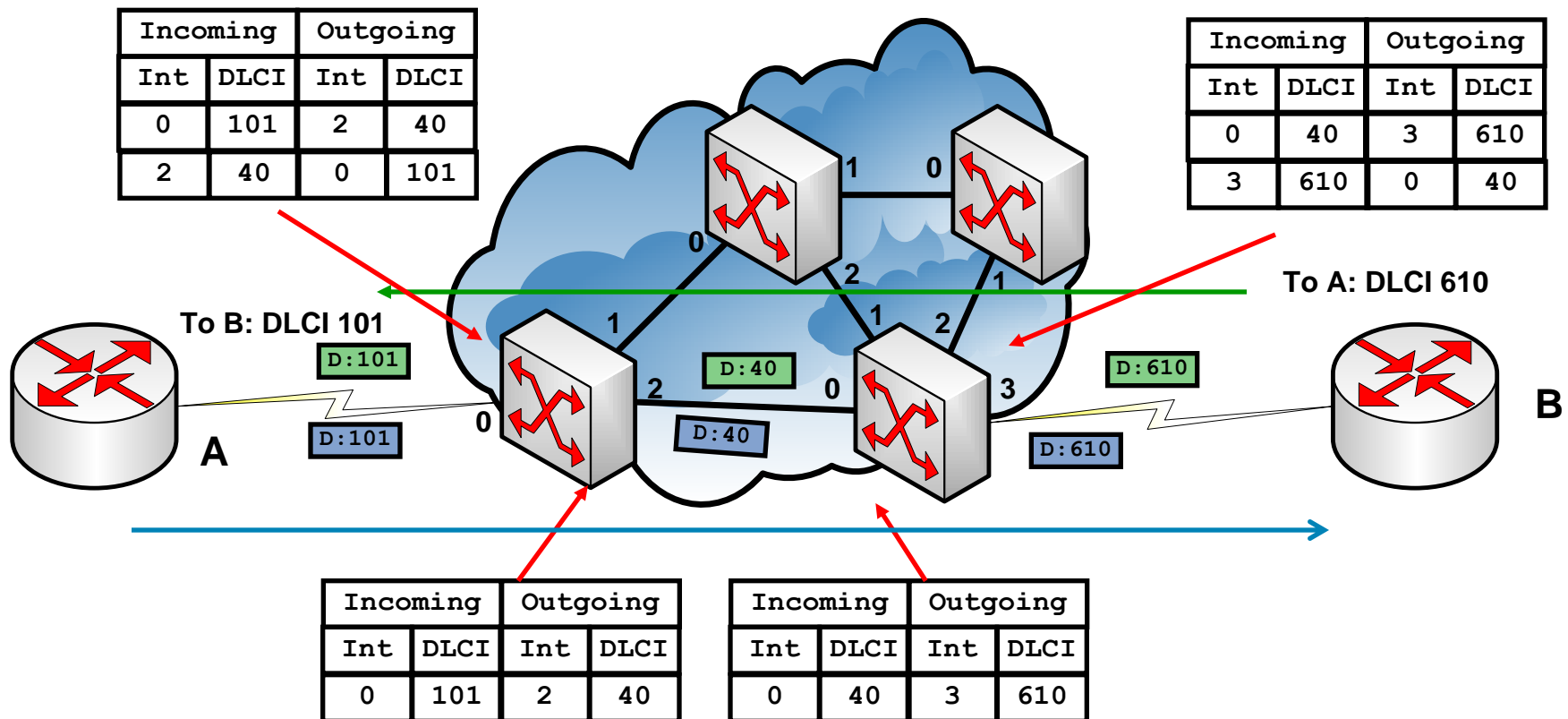
- Prepojenie zákazníkov

- Virtuálne okruhy (logické spojenie)

- PVC – Permanent Virtual Circuit
 - SVC – Switched Virtual Circuit
 - Zostavené signalizáciou CALL SETUP, DATA TRANSFER, IDLE, CALL TERMINATION

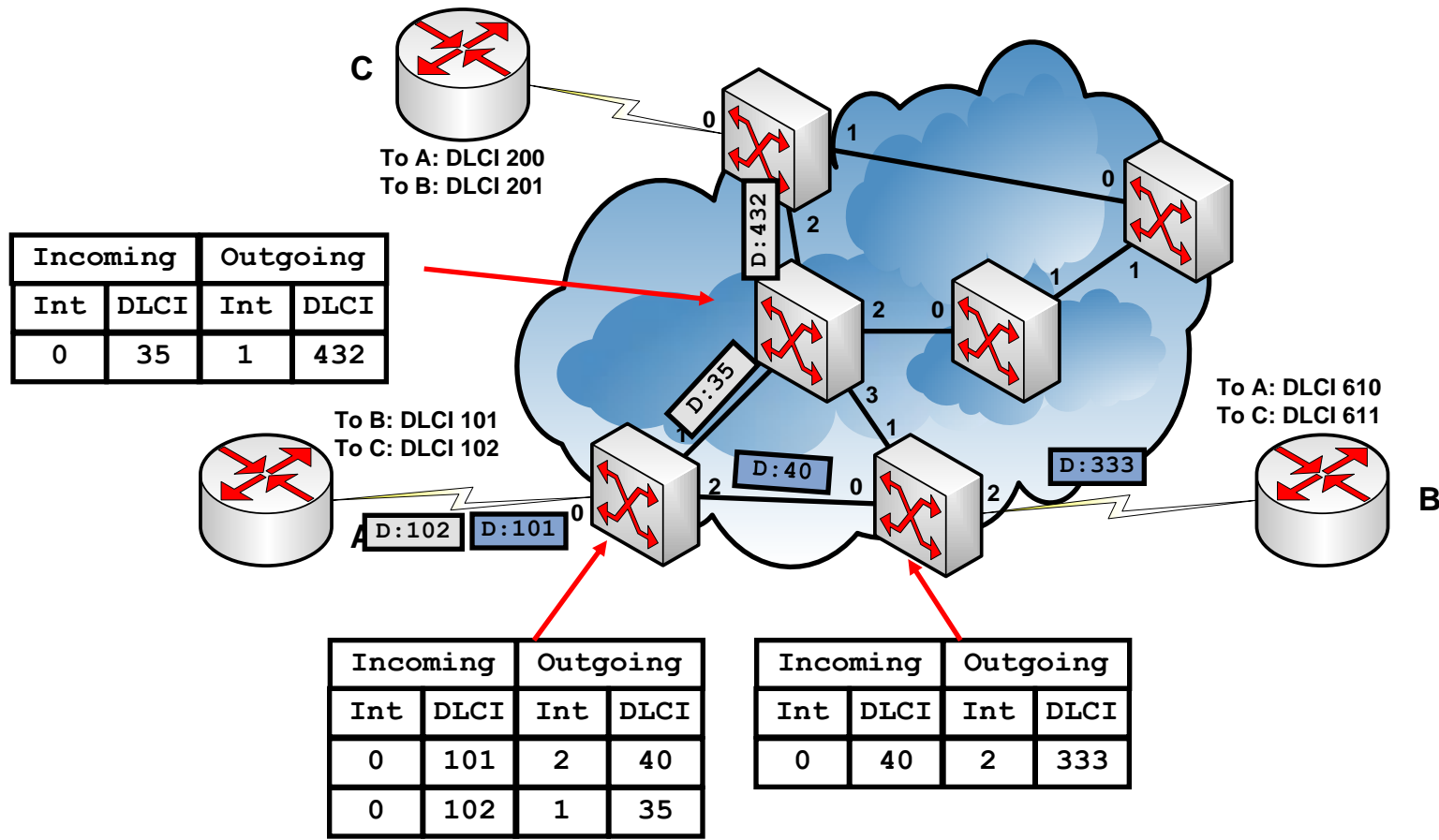
- Identifikátor VC

- DLCI – Digital Line Connection Identifier
 - Len lokálny význam medzi dvomi FR zariadeniami
 - Pri PVC pridelený providerom

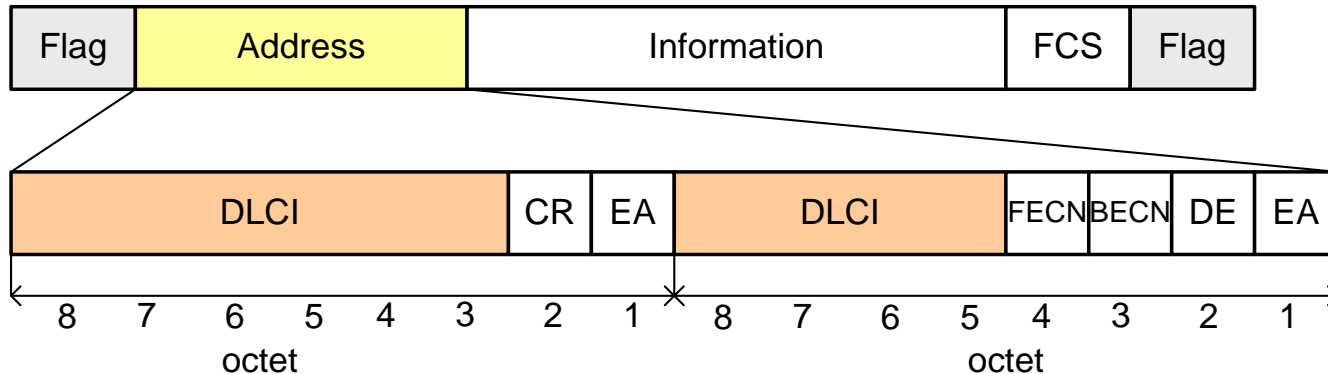


FR – prepojenie zákazníkov - VC

- Multiplexovanie PVC cez prístupovú linku
 - Zdieľanie riešené cez štatistický multiplex
 - Odlíšenie PVC cez DLCI



FR rámec



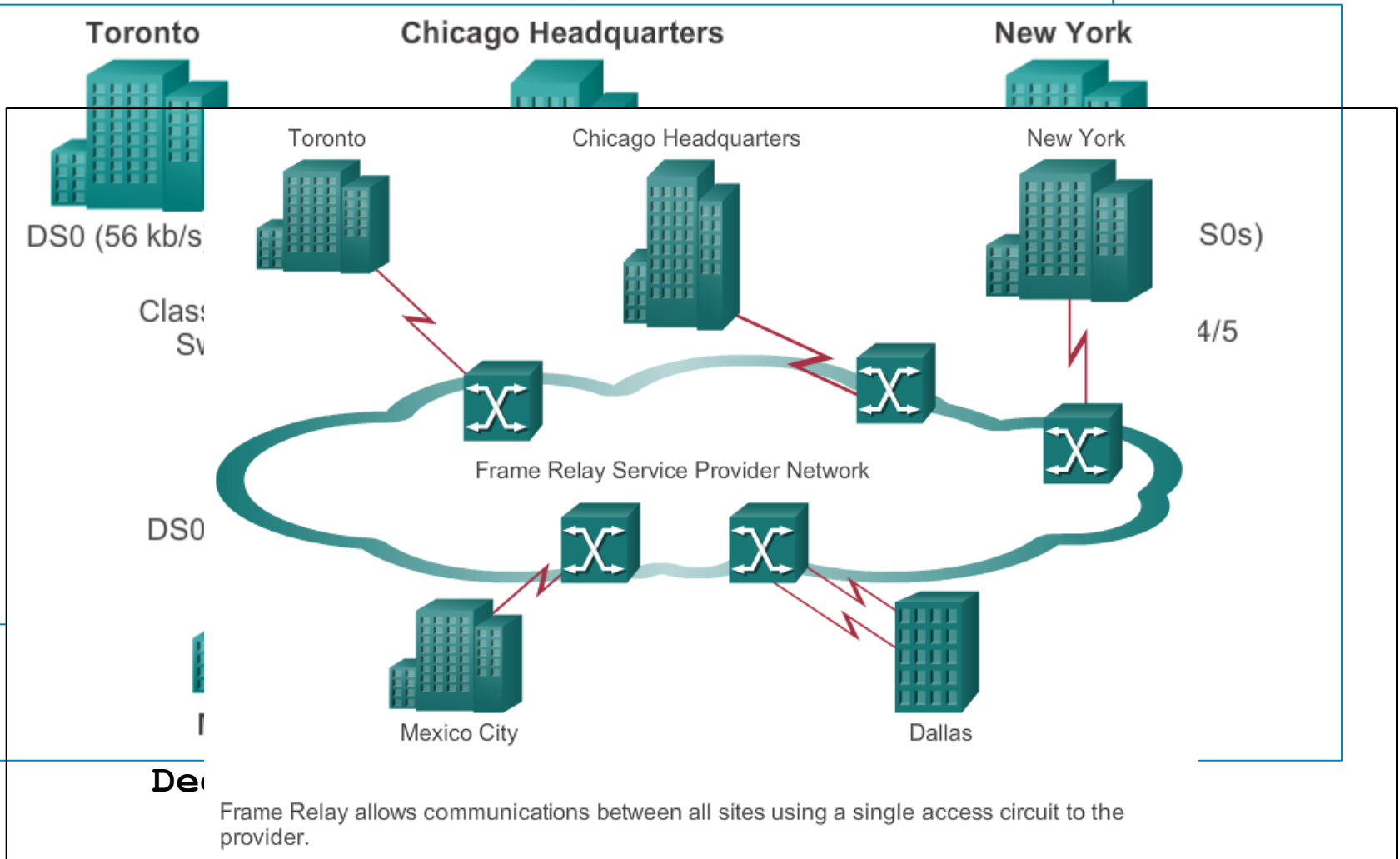
- Flag – 01111110
 - Značka začiatku a konca rámca (1 byte: 01111110)
- Address: 2B
 - DLCI - 10-bit DLCI
 - C/R – command/respond
 - E/A - Extended Address indicator
 - „1“ v rámci nie je ďalší adresný oktet
 - FR môže mať až 4 adresné oktety
 - Riadenie zahltenia
 - FECN: Forward Explicit Congestion Notification
 - BECN: Backward Explicit Congestion Notification
 - DE - Discard Eligibility
- Information: data
- FCS
 - Frame Check Sum, CRC, 2B

Dva druhy rámcov

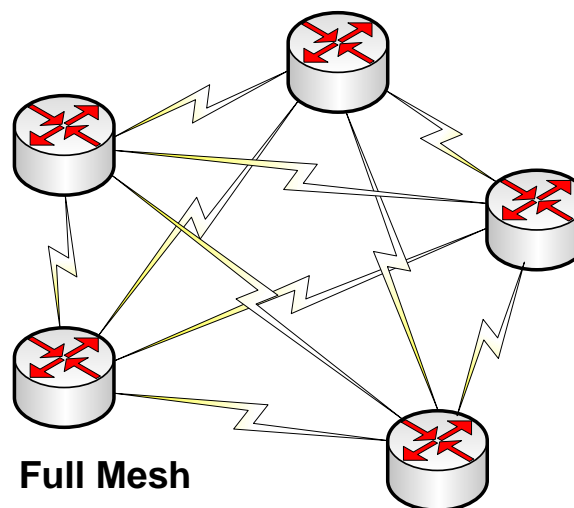
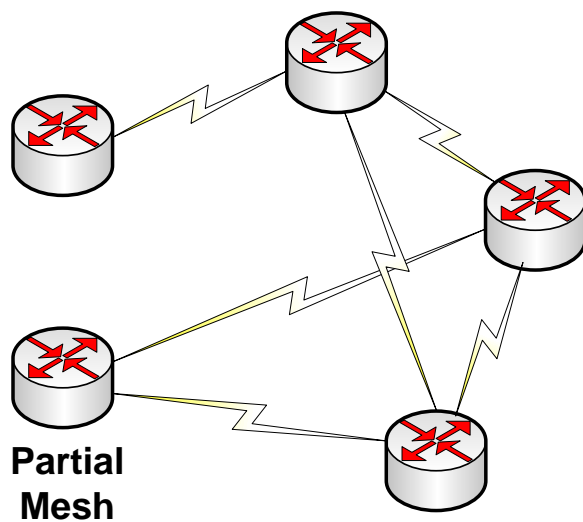
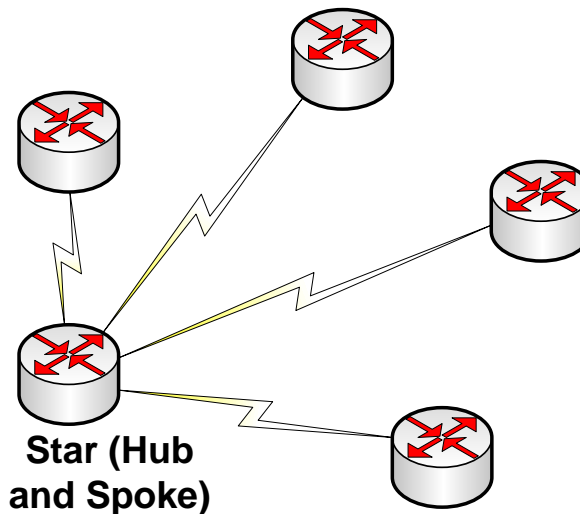
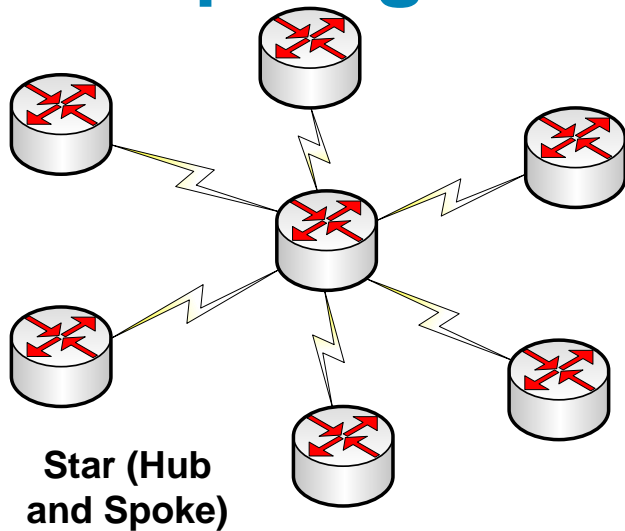
- Cisco: hlavička 4B
- IETF: hlavička 2B

Výhody FR

SPAN Engineering Company
Corporate Bandwidth Requirements



FR topológie – logická topológia



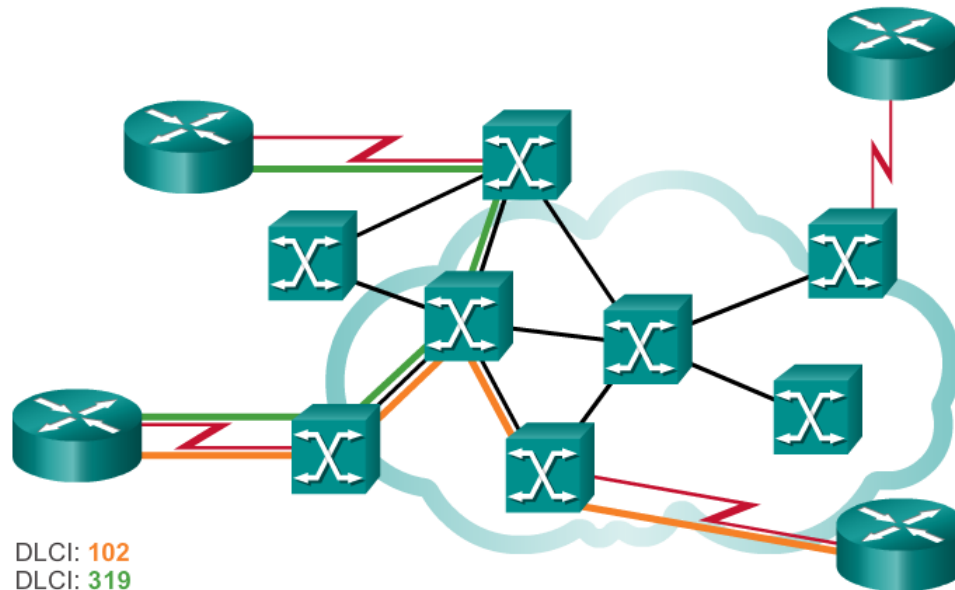


Mapovanie L3 na L2 adries



Mapovanie IP adries na FR adresy (DLCI)

- Ak chce smerovač komunikovať s iným smerovačom cez FR
 - podobne ako IP cez ethernet má ARP
 - musí vedieť mapovanie L3 IP adresy suseda do lokálneho VC kanálu - jeho DLCI (L2 adresa)



Mapovanie IP adres na FR adresy (DLCI)

- Realizácia

- Dynamicky

- inARP (inverse ARP)

- Smerovač zistí IP adresu suseda z DLCI adresy VC
 - Smerovač posiela cez všetky svoje VC inARP správy
 - Z odpovedí vytvára tabuľku mapovaná L3 IP na L2 DLCI

- LMI (Local Management Interface)

- Statické mapovanie

- Manuálne zadáme aké IP adresy mapovať do akého DLCI VC

- Použitie:

- ak smerovač na druhej strane FR mračna nepodporuje inARP
 - Pri topológii Hub and Spoke, kde smerovače nie sú priamo susedia

Mapovanie IP adries na FR adresy (DLCI)

```
R1# show frame-relay map  
Serial0/0/1 (up): ip 10.1.1.2 dlci 102(0x66,0x1860), static,  
                broadcast,  
                CISCO, status defined, active  
R1#
```

```
R1(config)# interface serial 0/0/1  
R1(config-if)# ip address 10.1.1.1 255.255.255.0  
R1(config-if)# encapsulation frame-relay  
R1(config-if)# no frame-relay inverse-arp  
R1(config-if)# frame-relay map ip 10.1.1.2 102 broadcast  
cisco  
R1(config-if)# no shutdown  
R1(config-if)#  
*Mar 31 18:57:38.994: %LINK-3-UPDOWN: Interface Serial0/0/1,  
changed state to up  
R1(config-if)#
```

LMI (Local Management Interface)

- Signálny štandard medzi DTE a Frame Relay prepínačom (DCE)
 - Doplnený do FR neskôr
 - Slúži na dynamické získavanie informácií o stave siete
- Funkcie poskytované LMI
 - Keepalive mechanizmus
 - Zisťuje stav spojenia medzi DCE a DTE
 - Posielanie dotazov každých 10s
 - Ak nedostanem odpoveď, spojenie je down
 - Používa aj inArp na mapovanie DLCI a IP
- LMI rozšírenia
 - Stavový mechanizmus
 - Aké VC sú k dispozícii
 - Multicast komunikácia pripojených
 - Priradenie globálneho významu pre DLCI
 - Ináč je defaultne lokálne (per hop sa mení)
 - Jednoduché riadenie toku
- Info o LMI **show frame-relay lmi**

LMI

- LMI definuje správy na komunikáciu medzi DTE a DCE
- Líšia sa implementácie LMI (druhy)
 - Cisco
 - Ansi
 - ANSI standard T1.617 Annex D
 - Q933a
 - ITU standard Q933 Annex A
- Podľa druhu LMI sa mení využitie niektorých DLCI (max1024)
- Konfigurácia LMI, ak je potrebná
 - frame-relay lmi-type [cisco | ansi | q933a]**
- Konfiguračne musí byť rovnaký typ na oboch stranách spojenia
 - t.j. DTE smerovač a FR prepínač
 - od Cisco IOS v11.2 je druh LMI zistený automaticky



Riešenia FR pripojenia



Spôsoby poskytnutia FR prístupu

- **Viaceré spôsoby realizácie pripojenia a spoplatnenia**

- **Access rate or port speed**

- Provider poskytne prístupovú linku (prenajatý okruh) do POP, ktorej kapacita je dedikovaná zákazníkovi na pripojenie k FR
 - Typicky 56 kb/s, T1 (1.536 Mb/s), or Fractional T1 (násobok 56 kb/s or 64 kb/s).
 - Port speeds má nastavený clock na strane providera
 - Platba za linku podľa rýchlosti, rýchlejšie = drahšie

- **PVC s Committed Information Rate (CIR)**

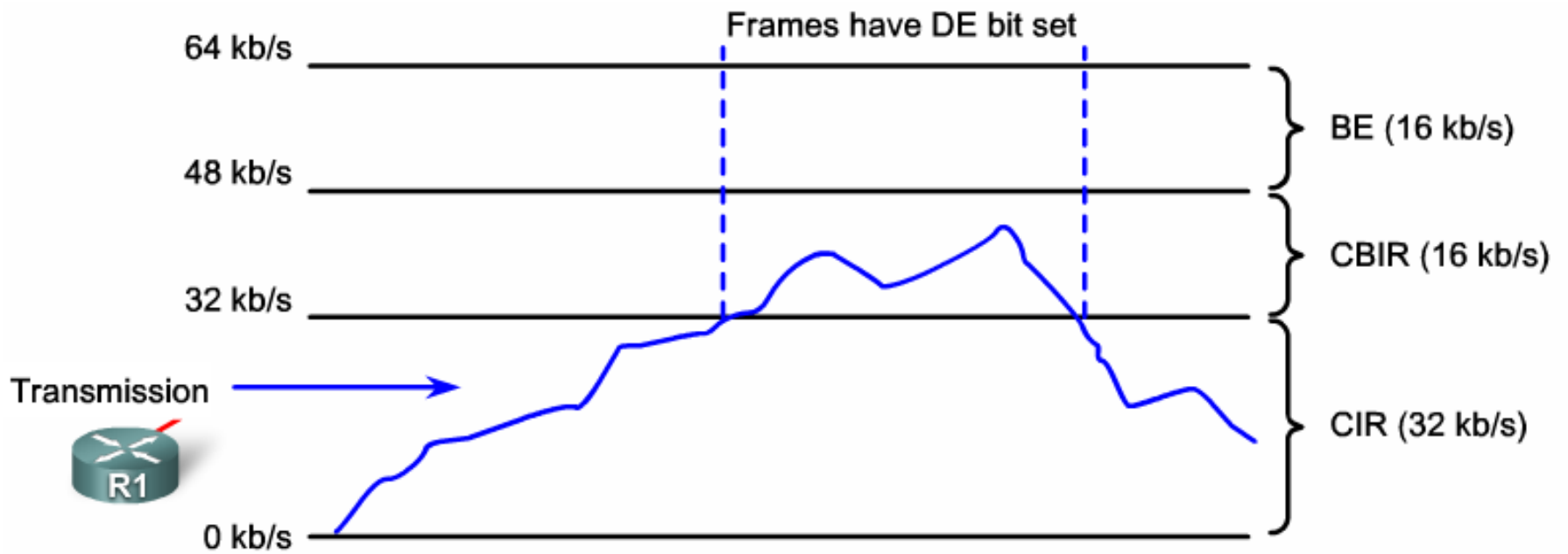
- Vhodné pri Multiplexácií (prepojenie viac pobočiek)
 - Zákazník si dohodne parametre pre každý PVC s providerom, ktoré budú dodržiavané
 - Prenajatá prístupová linka, musí byť rýchlejšia aby dokázala obslúžiť všetky PVC pri multiplexovaní
 - Príklad: ak multiplexujeme 15 64 kbps PVCs, rýchlosť linky musí byť 960kbps (T1)

FR Oversubscription

- Oversubscription
 - Provider predá často väčšiu kapacitu ako fyzická rýchlosť linky
 - Málokedy pri data komunikácii idú všetci zákazníci naplno v rovnakom čase

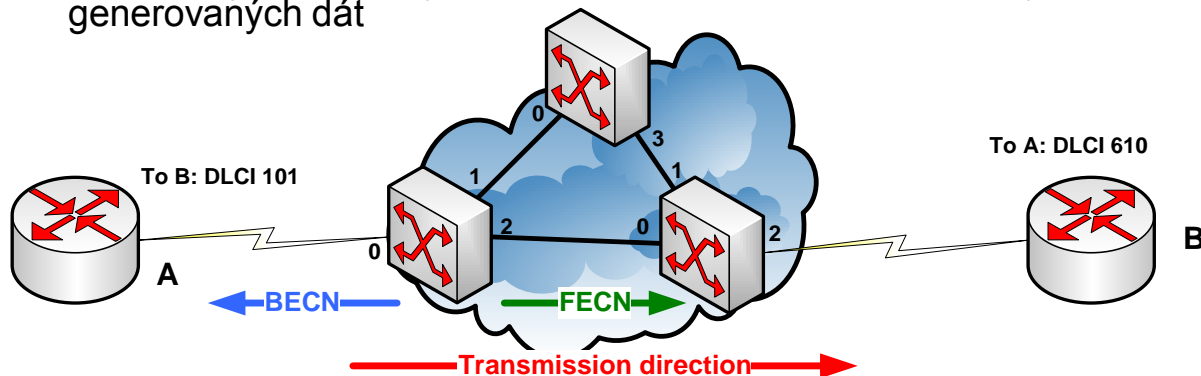
Parametre PVC

- Garantované parametre priepustnosti
 - CIR: Committed Information Rate
 - Garantovaná rýchlosť, počíta sa cez T_c
 - B_C : Committed Burst Size
 - max. počet bitov prenesených počas jednotky času T_c (v rámci CIR)
 - $B_C = T_C * CIR$
- Rozšírené parametre priepustnosti
 - Umožňuje zákazníkovi preniesť určité množstvo dát v špičke navyše nad CIR negarantovane
 - Committed Burst Information Rate (CBIR)
 - Maximálna priepustnosť dostupná zákazníkovi, CIR plus B_e .
 - EIR: Extended (Excess) Information Rate
 - Typicky je EIR nastavená na rýchlosť rozhrania.
 - B_E : Extended (Excess) Burst Size
 - max. počet bitov nad B_C , ktoré je sieť schopná preniesť v danom T_c , takéto rámce sú označené DE (Discard Eligible)
 - Rámce takto označené sieť preniesie ak má kapacitu, ak nemá okamžite ich dropne
 - $B_E = T_C * EIR$
 - Rámce nad CIR plus B_E sú pri zahltení hneď dropnuté
- T_C : Measurement Interval



Riadenie toku a zahltenia

- FR nemá explicitné metódy riadenia toku
 - FR sieť používateľa len informuje o zahltení v sieti (Congestion Avoidance)
- Riadenie zahltenia
 - FR prepínače dropnú pakety zo zahltených zásobníkov
- Informácia o zahltení cez hlavičku:
 - **FECN**
 - Forward Explicit Congestion Notification
 - Informácia prijímateľovi toku, aby informoval komunikačného partnera (odosielateľa), aby znížil množstvo generovaných dát.
 - **BECN**
 - Backward Explicit Congestion Notification
 - BECN bit je nastavený za účelom informovania stanice aby znížila množstvo generovaných dát



Frame Relay (v porovnaní s prenajatými okruhmi)

- Pre firmy s viac pobočkami ponúka výhody
 - Jednoduchosť
 - Jednoduchosť technológie, konfigurácie
 - Flexibilita
 - Väčšia priepustnosť, spoľahlivosť ako prenajaté okruhy
 - Cena
 - Menej zariadení, jednoduchšia implementácia, menej zložitý, platba len za CIR nie za celú linku

Frame Relay (v porovnaní s prenajatými okruhmi)

- Nevýhody

- Pozn. mnoho závisí na kontrakte s providerom
- Nie je vhodný pre časovo citlivé aplikácie
 - VoIP, video
- Negarantuje doručenie rámcov



Konfigurácia FR



Konfigurácia FR – nevyhnutné úkony

- Nastavenie enkapsulácie

```
! Nastavenie enkapsulácie  
Switch(config)#int serial 0/0/0  
Switch(config-if)#encapsulation frame-relay
```

- Konfigurácia dynamického alebo statického mapovania
 - Defaultne je spustené LMI, ktoré využíva inArp
 - Vypnutie LMI – **no keepalive**
 - Vypnutie inARP - **no frame-relay inverse-arp**



Základná konfigurácia,
LMI a inARP
podporované



Základné príkazy

```
! Specifikacia rozhrania
Router(config)# interface serial0

! Zadefinovane enkapsulacie
Router(config-if)# encapsulation frame-relay [cisco | ietf]

!zadefinovanie BW pre smerovaci protokol
Router(config-if)# bandwidth value-in-kbps

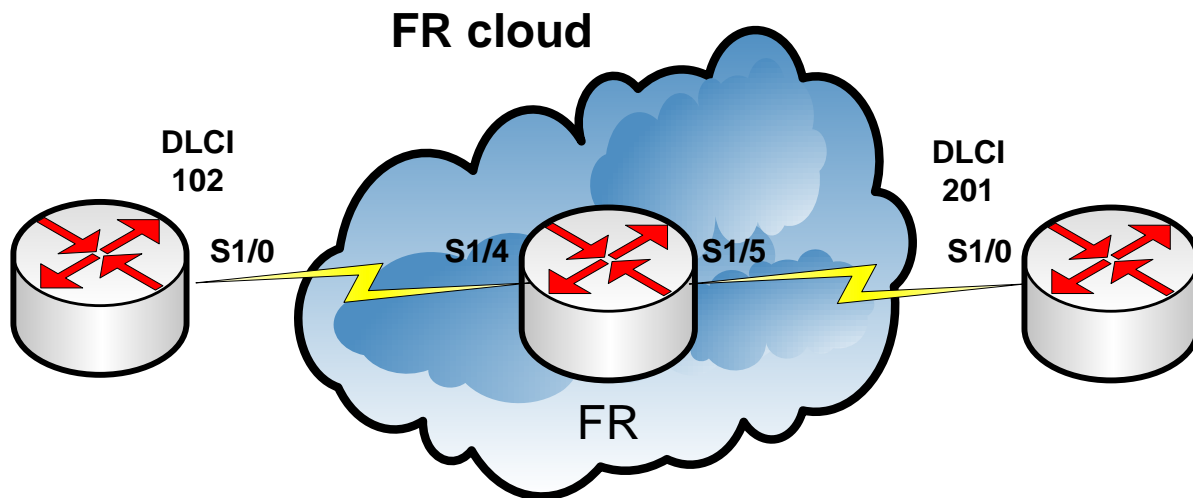
!popis rozhrania
Router(config-if)# description text

!volitelne, od 12.1 autosence
!Zadefinovanie LMI a druhu LMI
Router(config-if)# frame-relay lmi-type [ansi | cisco | q933a]

! Staticke mapovanie IP na DLCI
Router(config-if)# frame-relay map <protocol> <address> <DLCI> [broadcast]

! Nastavenie lokalneho DLCI
Router(config-if)# frame-relay interface-dlci DLCI_num
```

Konfigurácia smerovačov – DTE konce



Incoming int	DLCI	Outgoing int	DLCI
S1/4	102	S1/5	201
S1/5	201	S1/4	102

```
Lavy(config)#interface Serial1/0
Lavy(config-if)# ip address 1.0.0.1 255.255.255.252
Lavy(config-if)# encapsulation frame-relay
Lavy(config-if)#no shut
```

```
Pravy(config)#interface Serial1/0
Pravy(config-if)# ip address 1.0.0.2 255.255.255.252
Pravy(config-if)# encapsulation frame-relay
Pravy(config-if)#no shut
```

Overenie konfigurácie – DTE smerovač

```
Lavy#sh int s 1/0
Serial1/0 is up, line protocol is up
  Hardware is M4T
  Internet address is 1.0.0.1/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, crc 16, loopback not set
  Keepalive set (10 sec)
  Restart-Delay is 0 secs
  LMI enq sent 92, LMI stat recvd 92, LMI upd recvd 0, DTE LMI up
  LMI enq recvd 0, LMI stat sent 0, LMI upd sent 0
  LMI DLCI 1023 LMI type is CISCO frame relay DTE
  Broadcast queue 0/64, broadcasts sent/dropped 1/0, interface broadcasts 0
  Last input 00:00:07, output 00:00:07, output hang never
  Last clearing of "show interface" counters 00:15:27
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/0 (size/max total/threshold/drops)
    Conversations 0/1/256 (active/max active/max total)
    Reserved Conversations 0/0 (allocated/max allocated)
    Available Bandwidth 1158 kilobits/sec
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    99 packets input, 1928 bytes, 0 no buffer
```

Overenie konfigurácie – DTE smerovač

```
Lavy#sh frame-relay map
```

```
Serial1/0 (up): ip 1.0.0.2 dlci 102(0x66,0x1860), dynamic,  
                broadcast,, status defined, active
```

```
Lavy#sh frame-relay pvc
```

```
PVC Statistics for interface Serial1/0 (Frame Relay DTE)
```

	Active	Inactive	Deleted	Static
Local	1	0	0	0
Switched	0	0	0	0
Unused	0	0	0	0

```
DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1/0
```

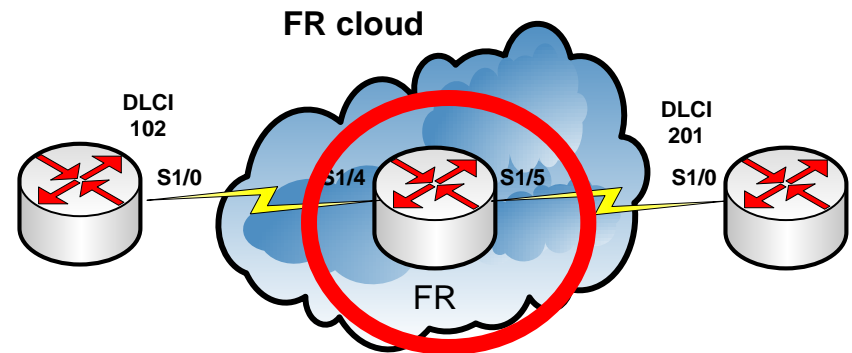
```
input pkts 15          output pkts 18          in bytes 1210  
out bytes 1662         dropped pkts 0          in pkts dropped 0  
out pkts dropped 0     out bytes dropped 0  
in FECN pkts 0         in BECN pkts 0         out FECN pkts 0  
out BECN pkts 0        in DE pkts 0           out DE pkts 0  
out bcast pkts 3       out bcast bytes 102  
5 minute input rate 0 bits/sec, 0 packets/sec  
5 minute output rate 0 bits/sec, 0 packets/sec  
pvc create time 00:38:46, last time pvc status changed 00:37:46
```

Konfigurácia smerovača ako FR prepínač (DCE)

```
!konfiguracia FR prepinania  
FR(config)#frame-relay switching
```

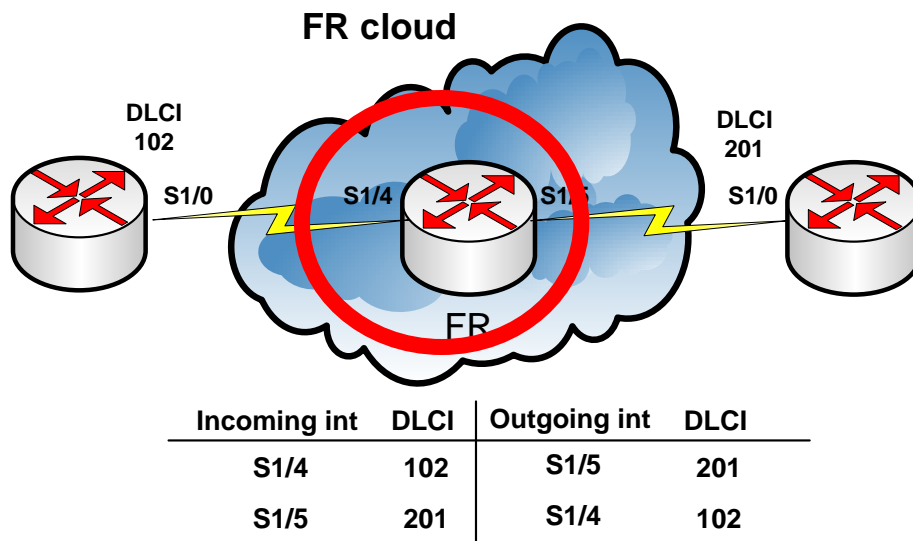
```
! Konfigurácia rozhraní  
FR(config)#int s1/4  
FR(config-if)#encapsulation frame-relay  
FR(config-if)#frame-relay intf-type dce  
FR(config-if)#clock rate 64000  
FR(config-if)#no shut  
FR(config-if)#int s 1/5  
FR(config-if)#encapsulation frame-relay  
FR(config-if)#frame-relay intf-type dce  
FR(config-if)#clock rate 64000  
FR(config-if)#no shut
```

```
!Konfigurácia FR prepinacej mapy  
FR(config)#int s 1/4  
FR(config-if)#frame-relay route 102 int s 1/5 201  
FR(config-if)#int s 1/5  
FR(config-if)#frame-relay route 201 interface s1/4 102
```



Incoming int	DLCI	Outgoing int	DLCI
S1/4	102	S1/5	201
S1/5	201	S1/4	102

Overenie FR prepínacej mapy

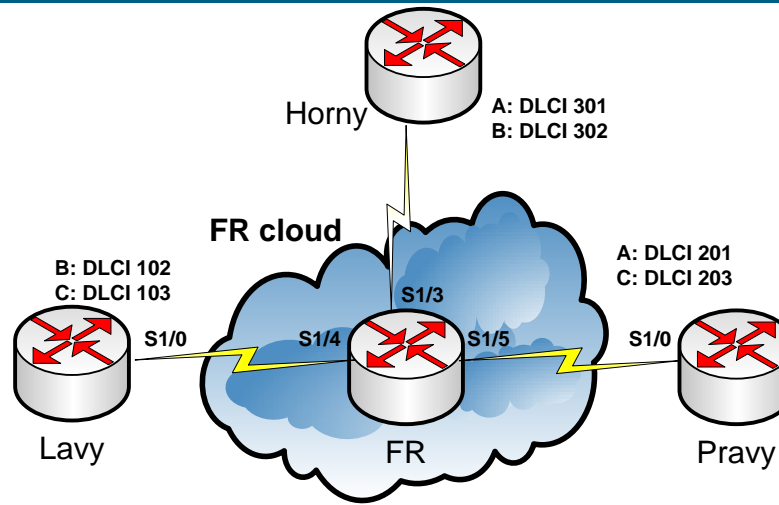


```
FR#sh frame-relay route
```

Input Intf	Input Dlci	Output Intf	Output Dlci	Status
Serial1/4	102	Serial1/5	201	active
Serial1/5	201	Serial1/4	102	active

Príklad 2

– Full mesh



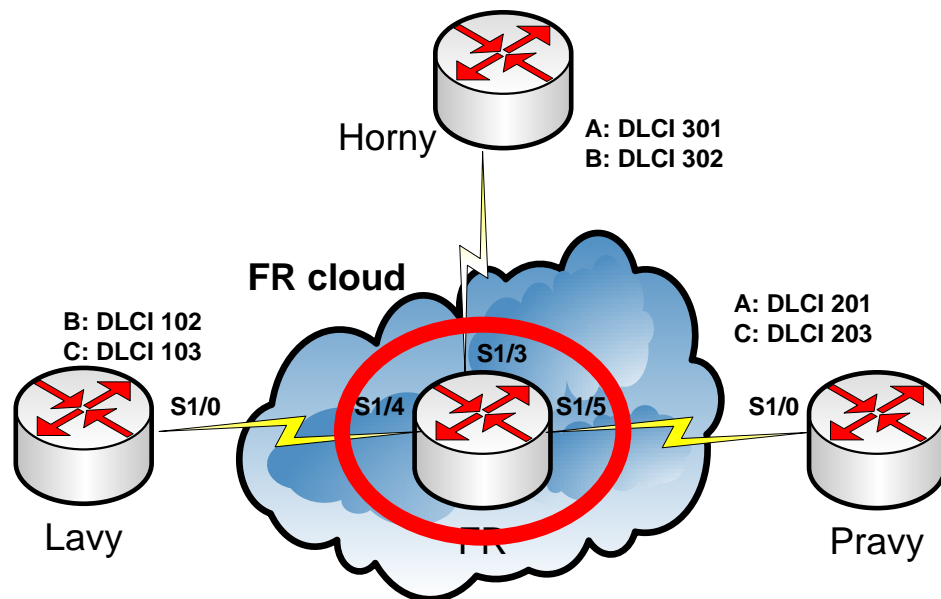
Incoming int	DLCI	Outgoing int	DLCI
S1/4	103	S1/3	301
S1/4	102	S1/5	201
S1/5	201	S1/4	102
S1/5	203	S1/3	302
S1/3	301	S1/4	103
S1/3	302	S1/5	203

```
Lavy(config)#interface Serial1/0
Lavy(config-if)# ip address 1.0.0.1 255.255.255.0
Lavy(config-if)# encapsulation frame-relay
Lavy(config-if)#no shut
```

```
Pravy(config)#interface Serial1/0
Pravy(config-if)# ip address 1.0.0.2 255.255.255.0
Pravy(config-if)# encapsulation frame-relay
Pravy(config-if)#no shut
```

```
Horny(config)#interface Serial1/0
Horny(config-if)# ip address 1.0.0.3 255.255.255.0
Horny(config-if)# encapsulation frame-relay
Horny(config-if)#no shut
```

Overenie prepínacej mapy



Incoming int	DLCI	Outgoing int	DLCI
S1/4	103	S1/3	301
S1/4	102	S1/5	201
S1/5	201	S1/4	102
S1/5	203	S1/3	302
S1/3	301	S1/4	103
S1/3	302	S1/5	203

```
FR#sh frame-relay route
```

Input Intf	Input Dlci	Output Intf	Output Dlci	Status
Serial1/3	301	Serial1/4	103	active
Serial1/3	302	Serial1/5	203	active
Serial1/4	102	Serial1/5	201	active
Serial1/4	103	Serial1/3	301	active
Serial1/5	201	Serial1/4	102	active
Serial1/5	203	Serial1/3	302	active

Overenie konfigurácie – DTE smerovač

```
Lavy# sh frame-relay map
Serial1/0 (up): ip 1.0.0.2 dlci 102(0x66,0x1860), dynamic,
                broadcast,, status defined, active
Serial1/0 (up): ip 1.0.0.3 dlci 103(0x67,0x1870), dynamic,
                broadcast,, status defined, active
```

```
Lavy# sh frame-relay pvc
PVC Statistics for interface Serial1/0 (Frame Relay DTE)

      Active      Inactive      Deleted      Static
Local          2           0           0           0
Switched       0           0           0           0
Unused         0           0           0           0

DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1/0
  input pkts 15          output pkts 18          in bytes 1210
  out bytes 1662         dropped pkts 0          in pkts dropped 0
  out pkts dropped 0     out bytes dropped 0
  in FECN pkts 0        in BECN pkts 0         out FECN pkts 0
  out BECN pkts 0       in DE pkts 0           out DE pkts 0
  out bcast pkts 3      out bcast bytes 102
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:38:46, last time pvc status changed 00:37:46

DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1/0

  input pkts 6          output pkts 6          in bytes 554
  out bytes 554         dropped pkts 0          in pkts dropped 0
  out pkts dropped 0     out bytes dropped 0
  in FECN pkts 0        in BECN pkts 0         out FECN pkts 0
  out BECN pkts 0       in DE pkts 0           out DE pkts 0
  out bcast pkts 1      out bcast bytes 34
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:12:44, last time pvc status changed 00:07:04
```

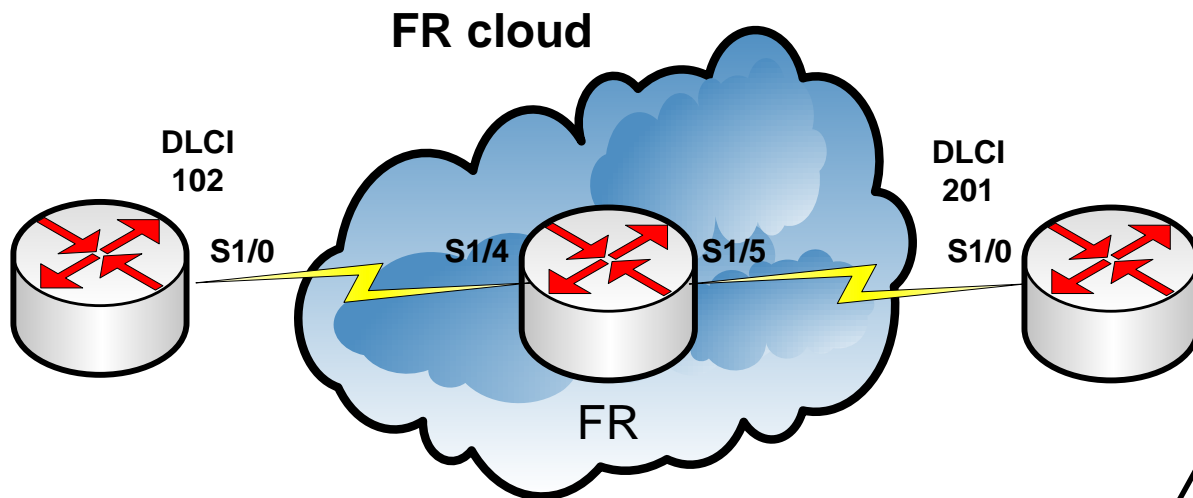


Konfigurácia statickej FR mapy



Vykonávame v prípade nedostupnosti inARP

Konfigurácia smerovačov – DTE konce



Incoming int	DLCI	Outgoing int	DLCI
S1/4	102	S1/5	201
S1/5	201	S1/4	102

Simulujeme
nedostupnosť
inARP tak, že
ho vypneme

```
Lavy(config)#interface Serial1/0
Lavy(config)#ip address 1.0.0.1 255.255.255.252
Lavy(config)#encapsulation frame-relay
Lavy(config)#no frame-relay inverse-arp
Lavy(config)#no shut
```

```
Pravy(config)#interface Serial1/0
Pravy(config)#ip address 1.0.0.2 255.255.255.252
Pravy(config)#encapsulation frame-relay
Pravy(config)#no frame-relay inverse-arp
Pravy(config)#no shut
```

Overenie konfigurácie – DTE smerovač

```
Lavy#ping 1.0.0.2
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.2, timeout is 2 seconds:
```

```
.....
```

```
Success rate is 0 percent (0/5)
```

```
Lavy#sh frame-relay map
```

```
Lavy#
```

InARP je vypnutý, nemám ako zistiť adresu suseda

Konfigurácia statickej mapy

```
Router(config-if)# frame-relay map protocol protocol-address dlci [broadcast]
```

Pridáme mapovanie IP na DLCI do oboch DTE smerovačov

```
Lavy(config)#interface Serial1/0  
Lavy(config)#frame-relay map ip 1.0.0.2 102 broadcast  
Lavy(config)#no shut
```

```
Pravy(config)#interface Serial1/0  
Pravy(config)#frame-relay map ip 1.0.0.1 201 broadcast  
Pravy(config)#no shut
```

Overenie mapovania

```
Lavy#sh frame-relay map  
Serial1/0 (up): ip 1.0.0.2 dlci 102(0x66,0x1860), static,  
                broadcast,  
                CISCO, status defined, active
```

Overenie dostupnosti

```
Lavy#ping 1.0.0.2  
Type escape sequence to abort.  
Sending 5, 100-byte ICMP Echos to 1.0.0.2, timeout is 2 seconds:  
!!!!  
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/20/40 ms
```

Voľba Broadcast

```
Lavy(config)#interface Serial1/0  
Lavy(config)#frame-relay map ip 1.0.0.2 102 broadcast  
Lavy(config)#no shut
```

- FR je NBMA sieť a nepodporuje zasielanie broadcastov (aj mcastov) cez PVC
 - Niektoré smerovacie protokoly to k činnosti vyžadujú (RIP, EIGRP, OSPF)
 - Voľba **broadcast** aktivuje zasielanie bcast a mcast paketov cez PVC

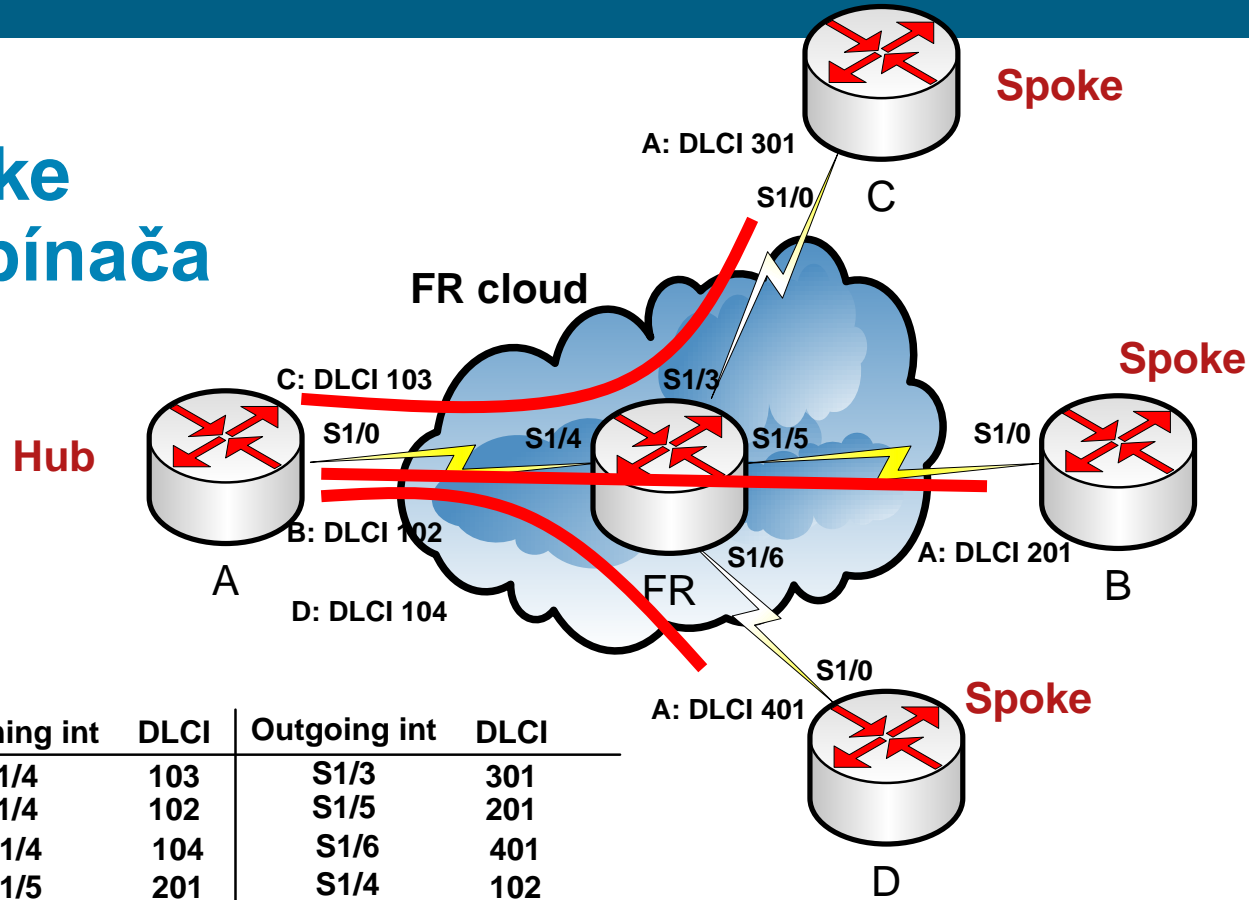


Pokročilejšie techniky FR



Príklad 3

- Hub and spoke
- konf. FR prepínača



Incoming int	DLCI	Outgoing int	DLCI
S1/4	103	S1/3	301
S1/4	102	S1/5	201
S1/4	104	S1/6	401
S1/5	201	S1/4	102
S1/3	301	S1/4	103
S1/6	401	S1/4	104

FR#sh frame-relay route

Input Intf	Input Dlci	Output Intf	Output Dlci	Status
Serial1/3	301	Serial1/4	103	inactive
Serial1/4	102	Serial1/5	201	inactive
Serial1/4	103	Serial1/3	301	inactive
Serial1/4	104	Serial1/6	401	inactive
Serial1/5	201	Serial1/4	102	inactive
Serial1/6	401	Serial1/4	104	inactive

Príklad 3 - Hub and spoke - konf. Spoke smerovačov

```
A(config-if)#int s 1/0
A(config-if)#encapsulation frame-relay
A(config-if)#ip add 1.0.0.1 255.255.255.0
A(config-if)#no shut
```

```
B(config)#int s 1/0
B(config-if)#encapsulation frame-relay
B(config-if)#ip add 1.0.0.2 255.255.255.0
B(config-if)#no shut
```

```
C(config)#int s 1/0
C(config-if)#encapsulation frame-relay
C(config-if)#ip add 1.0.0.3 255.255.255.0
C(config-if)#no shut
```

```
D(config)#int s 1/0
D(config-if)#encap fram
D(config-if)#ip add 1.0.0.4 255.255.255.0
D(config-if)#no shut
```

Akú konektivitu budeme mať?

```
A#ping 1.0.0.2
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.2, timeout is 2 seconds:
```

```
!!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/16/44 ms
```

```
A#ping 1.0.0.3
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.3, timeout is 2 seconds:
```

```
!!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/16/36 ms
```

```
A#ping 1.0.0.4
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.4, timeout is 2 seconds:
```

```
!!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/15/40 ms
```

```
B#ping 1.0.0.1
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.1, timeout is 2 seconds:
```

```
!!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/40/72 ms
```

```
B#ping 1.0.0.3
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.3, timeout is 2 seconds:
```

```
.....
```

```
Success rate is 0 percent (0/5)
```

```
B#ping 1.0.0.4
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 1.0.0.4, timeout is 2 seconds:
```

```
.....
```

```
Success rate is 0 percent (0/5)
```

Hub

- Konektivita
s každým
spoke

Spoke

- Konektivita
len s Hub s
inými spoke
nie je

- Každý
spoke

Kde je problém?

```
A#sh frame-relay map
Serial1/0 (up): ip 1.0.0.2 dlci 102(0x66,0x1860), dynamic,
                broadcast,, status defined, active
Serial1/0 (up): ip 1.0.0.3 dlci 103(0x67,0x1870), dynamic,
                broadcast,, status defined, active
Serial1/0 (up): ip 1.0.0.4 dlci 104(0x68,0x1880), dynamic,
                broadcast,, status defined, active
```

```
B#sh frame-relay map
Serial1/0 (up): ip 1.0.0.1 dlci 201(0xC9,0x3090), dynamic,
                broadcast,, status defined, active
```

```
C#sh frame-relay map
Serial1/0 (up): ip 1.0.0.1 dlci 301(0x12D,0x48D0), dynamic,
                broadcast,, status defined, active
```

```
D#sh frame-relay map
Serial1/0 (up): ip 1.0.0.1 dlci 401(0x191,0x6410), dynamic,
                broadcast,, status defined, active
```

- InARP poskytne mapovanie IP na DLCI medzi susedmi
- Spoke smerovače nie sú susedia
 - Nemám mapovanie ich IP na DLCI

Riešenie – pridať statické mapovanie na spoke smerovače

```
B(config)#int s 1/0  
B(config-if)#frame-relay map ip 1.0.0.3 201 broadcast  
B(config-if)#frame-relay map ip 1.0.0.4 201 broadcast
```

```
C(config)#int s 1/0  
C(config-if)#frame-relay map ip 1.0.0.2 301 broadcast  
C(config-if)#frame-relay map ip 1.0.0.4 301 broadcast
```

```
D(config)#int s 1/0  
D(config-if)#frame-relay map ip 1.0.0.2 401 broadcast  
D(config-if)#frame-relay map ip 1.0.0.3 401 broadcast
```

Overenie – spoke smerovač B

```
B#sh frame-relay map
Serial1/0 (up): ip 1.0.0.1 dlci 201(0xC9,0x3090), dynamic,
                broadcast,, status defined, active
Serial1/0 (up): ip 1.0.0.3 dlci 201(0xC9,0x3090), static,
                broadcast,
                CISCO, status defined, active
Serial1/0 (up): ip 1.0.0.4 dlci 201(0xC9,0x3090), static,
                broadcast,
                CISCO, status defined, active
```

```
B#ping 1.0.0.1
```

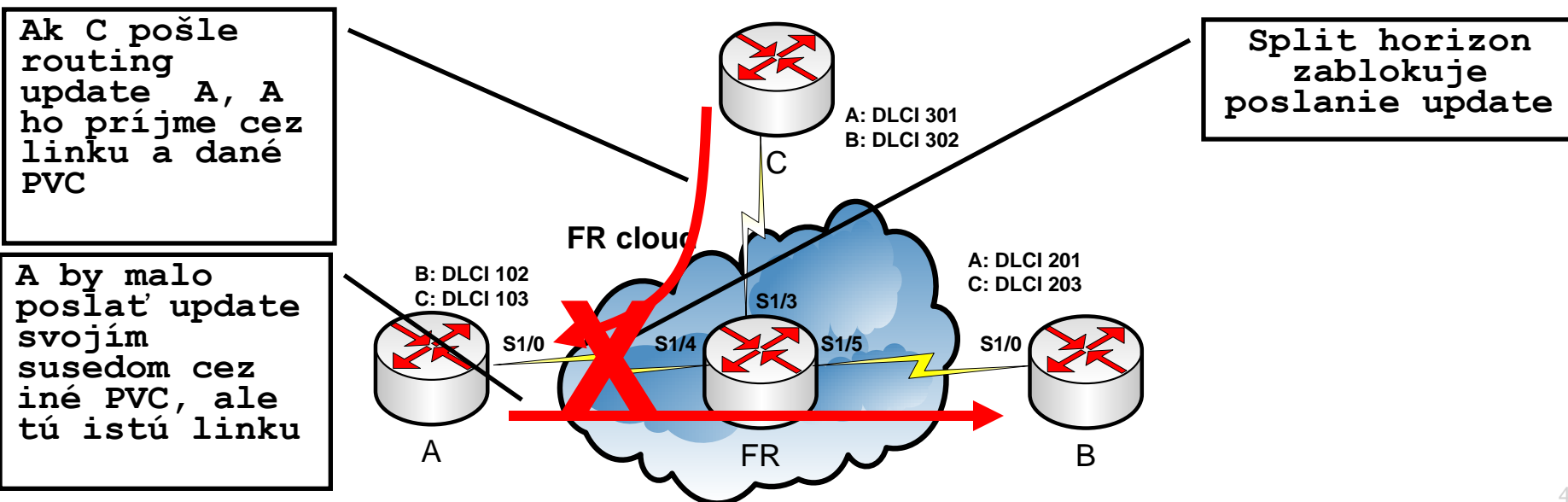
```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.0.0.1, timeout is 2 seconds:
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/26/64 ms
B#ping 1.0.0.3
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.0.0.3, timeout is 2 seconds:
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/32/48 ms
B#ping 1.0.0.4
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.0.0.4, timeout is 2 seconds:
!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/30/92 ms
```

FR problémy s dostupnosťou

- FR je NBMA sieť
- Pri nasadení smerovacích protokolov, ktoré pracujú so Split Horizon
 - Môžeme nad FR mať problémy s dostupnosťou (Hub and Spoke topo.).
 - SPLIT zabraňuje posielanie informácií o danej sieti naučených z daného smeru späť cez to isté rozhranie



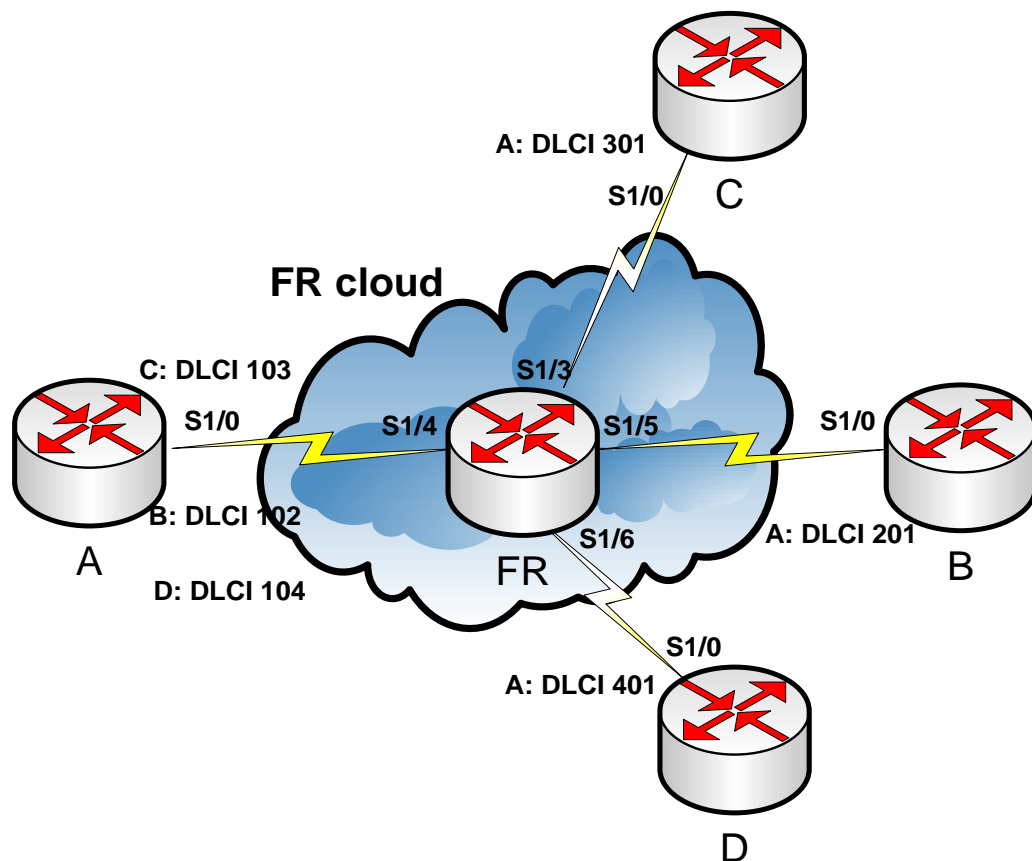
Riešenie split horizon problému

- Vypnutie split horizon na rozhraní
 - Podporuje len IP protokol
 - IPX a Apple nie
 - Pre RIP je split-horizon automaticky vypnutý
- Iné riešenie
 - Rozdeliť fyzické rozhrania na viac subrozhraní
 - Subrozhrania môžu byť typu
 - **Point-to-point**
 - split hotizon rieší
 - **Point-to-multipoint**
 - split hotizon nerieší

Topo z príkladu 3

- Pridáme LAN siete na každý smerovač a zapneme RIP

- A:
 - LAN 10.0.0.0/8
 - fa 0/0: 10.0.0.1
- B:
 - LAN 20.0.0.0/8
 - fa 0/0: 20.0.0.1
- C:
 - LAN 30.0.0.0/8
 - fa 0/0: 30.0.0.1
- D:
 - LAN 40.0.0.0/8
 - fa 0/0: 40.0.0.1



RIP nad FR

```
B#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF
       inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external
       type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 -
       IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-
       user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

    1.0.0.0/24 is subnetted, 1 subnets
C       1.0.0.0 is directly connected, Serial1/0
C    20.0.0.0/8 is directly connected, FastEthernet0/0
R    40.0.0.0/8 [120/1] via 1.0.0.1, 00:00:12, Serial1/0
R    10.0.0.0/8 [120/1] via 1.0.0.1, 00:00:20, Serial1/0
R    30.0.0.0/8 [120/1] via 1.0.0.1, 00:00:20, Serial1/0
```

Routing frčí lebo RIP ma def. Vypnuté split horizon

ELGRP nad FR

```
A#sh ip route
1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C    1.0.0.0/24 is directly connected, Serial1/0
D    1.0.0.0/8 is a summary, 00:02:33, Null0
D    20.0.0.0/8 [90/2172416] via 1.0.0.2, 00:02:12, Serial1/0
D    40.0.0.0/8 [90/2172416] via 1.0.0.4, 00:00:36, Serial1/0
C    10.0.0.0/8 is directly connected, FastEthernet0/0
D    30.0.0.0/8 [90/2172416] via 1.0.0.3, 00:01:41, Serial1/0
```

Hub - Vypada to OK

```
B#sh ip route
1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C    1.0.0.0/24 is directly connected, Serial1/0
D    1.0.0.0/8 is a summary, 00:05:58, Null0
C    20.0.0.0/8 is directly connected, FastEthernet0/0
D    10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:05:10, Serial1/0
```

Spoke – problém, siete chýbajú

```
C#sh ip route
1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C    1.0.0.0/24 is directly connected, Serial1/0
D    1.0.0.0/8 is a summary, 00:05:56, Null0
D    10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:05:31, Serial1/0
C    30.0.0.0/8 is directly connected, FastEthernet0/0
```

Spoke – problém, siete chýbajú

```
D#sh ip route
1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C    1.0.0.0/24 is directly connected, Serial1/0
D    1.0.0.0/8 is a summary, 00:04:59, Null0
C    40.0.0.0/8 is directly connected, FastEthernet0/0
D    10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:05:04, Serial1/0
```

Spoke – problém, siete chýbajú

EIGRP riešenie – zákaz split horizon na spoke smerovači

```
Router(config-if)#no ip split-horizon eigrp AS
```

```
A(config-if)#no ip split-horizon eigrp 1
```

EIGRP nad FR – route tab. je kompletná

```
B#sh ip route
      1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       1.0.0.0/24 is directly connected, Serial1/0
D       1.0.0.0/8 is a summary, 00:10:15, Null0
C      20.0.0.0/8 is directly connected, FastEthernet0/0
D      40.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:05, Serial1/0
D      10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:00:05, Serial1/0
D      30.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:05, Serial1/0
```

```
C#sh ip route
      1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       1.0.0.0/24 is directly connected, Serial1/0
D       1.0.0.0/8 is a summary, 00:09:49, Null0
D      20.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:39, Serial1/0
D      40.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:39, Serial1/0
D      10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:00:39, Serial1/0
C      30.0.0.0/8 is directly connected, FastEthernet0/0
```

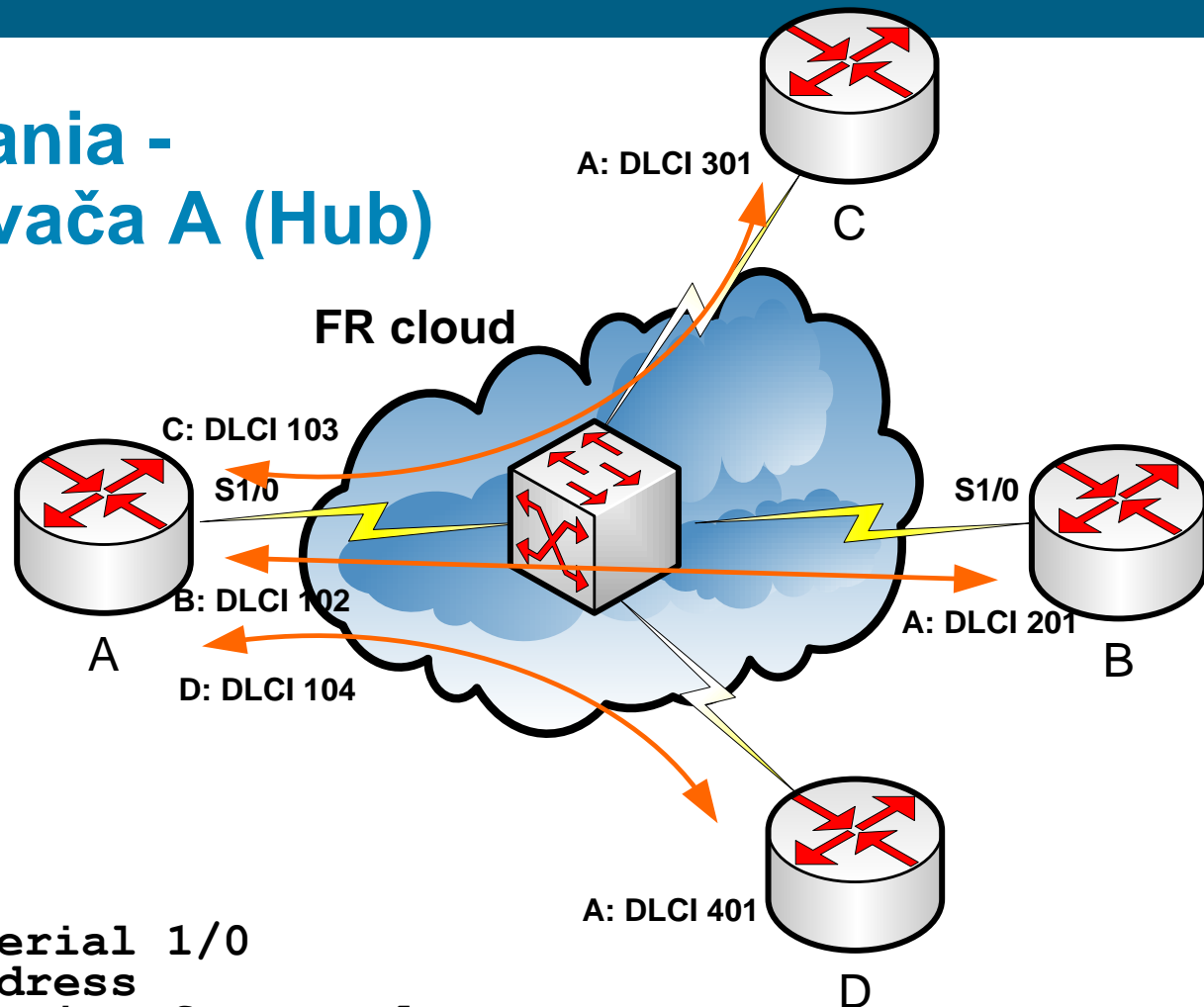
```
D#sh ip route
      1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       1.0.0.0/24 is directly connected, Serial1/0
D       1.0.0.0/8 is a summary, 00:08:44, Null0
D      20.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:59, Serial1/0
C      40.0.0.0/8 is directly connected, FastEthernet0/0
D      10.0.0.0/8 [90/2172416] via 1.0.0.1, 00:00:59, Serial1/0
D      30.0.0.0/8 [90/2684416] via 1.0.0.1, 00:00:59, Serial1/0
```



Riešenie cez subinterfaces



FR subrozhrania - Konf. Smerovača A (Hub)

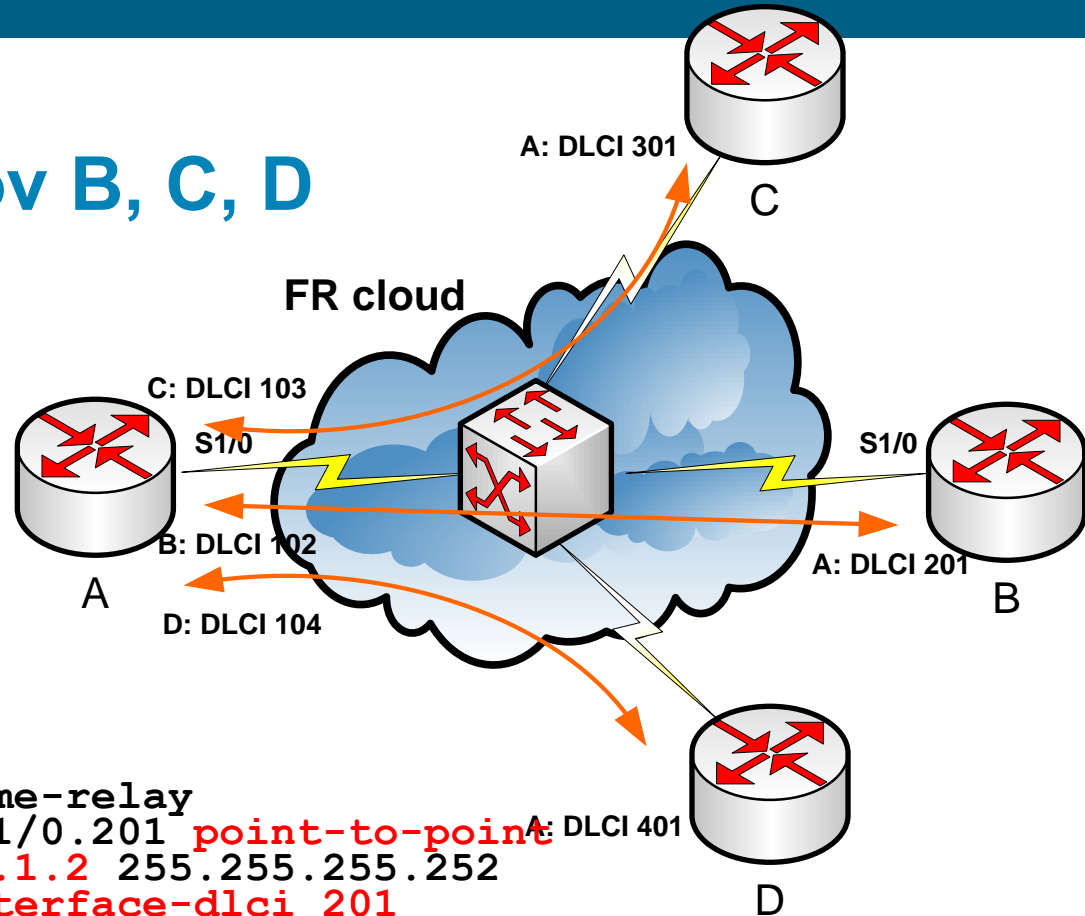


```
A(config)# interface serial 1/0
A(config-if)# no ip address
A(config-if)# encapsulation frame-relay
A(config-if)# interface serial 1/0.102 point-to-point
A(config-subif)# frame-relay interface-dlci 102
A(config-subif)# ip add 192.168.1.1 255.255.255.252
A(config-subif)# interface serial 1/0.103 point-to-point
A(config-subif)# frame-relay interface-dlci 103
A(config-subif)# ip add 192.168.2.1 255.255.255.252
A(config-subif)# interface serial0.104 point-to-point
A(config-subif)# frame-relay interface-dlci 104
A(config-subif)# ip add 192.168.3.1 255.255.255.252
```


FR subrozhrania

Konf. smerovačov B, C, D

(Spoke)



```
B(config)# interface serial 1/0
B(config-if)# no ip address
B(config-if)# encapsulation frame-relay
B(config-if)# interface serial 1/0.201 point-to-point
B(config-subif)# ip add 192.168.1.2 255.255.255.252
B(config-subif)# frame-relay interface-dlci 201
```

```
C(config)# interface serial 1/0
C(config-if)# no ip address
C(config-if)# encapsulation frame-relay
C(config-if)# interface serial 1/0.301 point-to-point
C(config-subif)# ip add 192.168.2.2 255.255.255.252
C(config-subif)# frame-relay interface-dlci 301
```

```
D(config)# interface serial 1/0
D(config-if)# no ip address
D(config-if)# encapsulation frame-relay
D(config-if)# interface serial 1/0.401 point-to-point
D(config-subif)# ip add 192.168.3.2 255.255.255.252
D(config-subif)# frame-relay interface-dlci 401
```



Overenie a diagnostika FR



Príkazy

! Info o enkaps a stave rozhrania

```
sh interface serial 0/0
```

! Zobrazí FR mapovanie IP a DLCI - InARP

```
sh frame-relay map
```

! Zobrazí FR mapovanie IP a DLCI

```
sh frame-relay map
```

! Zobrazí info o PVC

```
sh frame-relay pvc
```

Príkazy

! Info o type a stavu LMI, DTE, DCE type

A#sh frame-relay lmi

```
LMI Statistics for interface Serial1/0 (Frame Relay DTE) LMI TYPE = CISCO
Invalid Unnumbered info 0          Invalid Prot Disc 0
Invalid dummy Call Ref 0           Invalid Msg Type 0
Invalid Status Message 0           Invalid Lock Shift 0
Invalid Information ID 0            Invalid Report IE Len 0
Invalid Report Request 0            Invalid Keep IE Len 0
Num Status Enq. Sent 421            Num Status msgs Rcvd 412
Num Update Status Rcvd 0            Num Status Timeouts 9
Last Full Status Req 00:00:38       Last Full Status Rcvd 00:00:38
```

! Info o PVC

A#sh frame-relay pvc

PVC Statistics for interface Serial1/0 (Frame Relay DTE)

	Active	Inactive	Deleted	Static
Local	3	0	0	0
Switched	0	0	0	0
Unused	0	0	0	0

DLCI = **102**, DLCI USAGE = LOCAL, PVC STATUS = **ACTIVE**, INTERFACE = Serial1/0

```
input pkts 202          output pkts 109          in bytes 15070
out bytes 8748          dropped pkts 0          in pkts dropped 0
out pkts dropped 0      out bytes dropped 0
in FECN pkts 0          in BECN pkts 0          out FECN pkts 0
out BECN pkts 0          in DE pkts 0           out DE pkts 0
out bcast pkts 62       out bcast bytes 4438
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
pvc create time 01:10:02, last time pvc status changed 01:06:52
```

DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1/0

.....

Príkazy

! Info o konketnom PVC

A#sh frame-relay pvc ?

```
interface
<16-1022>   DLCI
|           Output modifiers
<cr>
```

A#sh frame-relay pvc 103

PVC Statistics for interface Serial1/0 (Frame Relay DTE)

DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1/0

```
input pkts 188          output pkts 107          in bytes 14288
out bytes 8500          dropped pkts 0          in pkts
dropped 0
out pkts dropped 0      out bytes dropped 0
in FECN pkts 0          in BECN pkts 0          out FECN pkts
0
out BECN pkts 0          in DE pkts 0          out DE pkts 0
out bcast pkts 64      out bcast bytes 4566
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
pvc create time 01:12:01, last time pvc status changed 01:06:21
```

Príkazy

```
!debug udalosti
```

```
A# debug frame-relay lmi
```

```
Frame Relay LMI debugging is on
```

```
Displaying all Frame Relay LMI data
```

```
A#
```

```
*Mar 1 01:29:54.823: Serial1/0(out): StEnq, myseq 186, yourseen 185, DTE up
```

```
*Mar 1 01:29:54.823: datagramstart = 0x2DB0D74, datagramsize = 13
```

```
*Mar 1 01:29:54.827: FR encap = 0xFCF10309
```

```
*Mar 1 01:29:54.827: 00 75 01 01 01 03 02 BA B9
```

```
*Mar 1 01:29:54.827:
```

```
*Mar 1 01:29:54.839: Serial1/0(in): Status, myseq 186, pak size 13
```

```
*Mar 1 01:29:54.839: RT IE 1, length 1, type 1
```

```
*Mar 1 01:29:54.839: KA IE 3, length 2, yourseq 186, myseq 186
```

```
*Mar 1 01:30:04.823: Serial1/0(out): StEnq, myseq 187, yourseen 186, DTE up
```

```
*Mar 1 01:30:04.823: datagramstart = 0x2DB1274, datagramsize = 13
```

```
*Mar 1 01:30:04.823: FR encap = 0xFCF10309
```

```
*Mar 1 01:30:04.827: 00 75 01 01 01 03 02 BB BA
```

```
*Mar 1 01:30:04.827:
```

```
*Mar 1 01:30:04.839: Serial1/0(in): Status, myseq 187, pak size 13
```

```
*Mar 1 01:30:04.839: RT IE 1, length 1, type 1
```

```
*Mar 1 01:30:04.839: KA IE 3, length 2, yourseq 187, myseq 187
```

```
A#undebug all
```

```
All possible debugging has been turned off
```

Ďalšie zdroje

- Cisco FR tutorial
 - http://docwiki.cisco.com/wiki/Frame_Relay

ĎAKUJEM