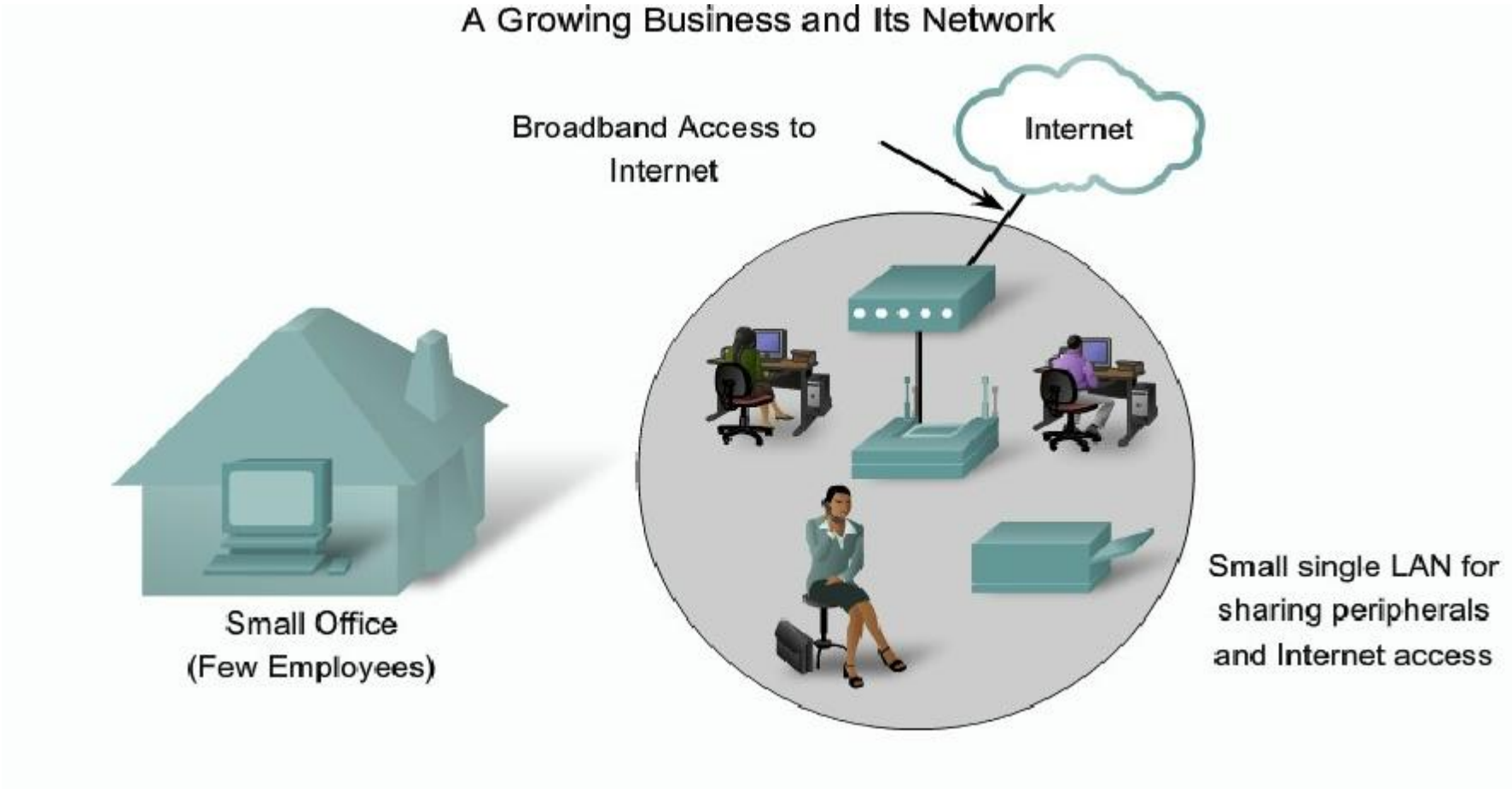
Úvod do WAN, PPP protokol

CCNA Exploration Semester 4 – Kapitola 1, 2

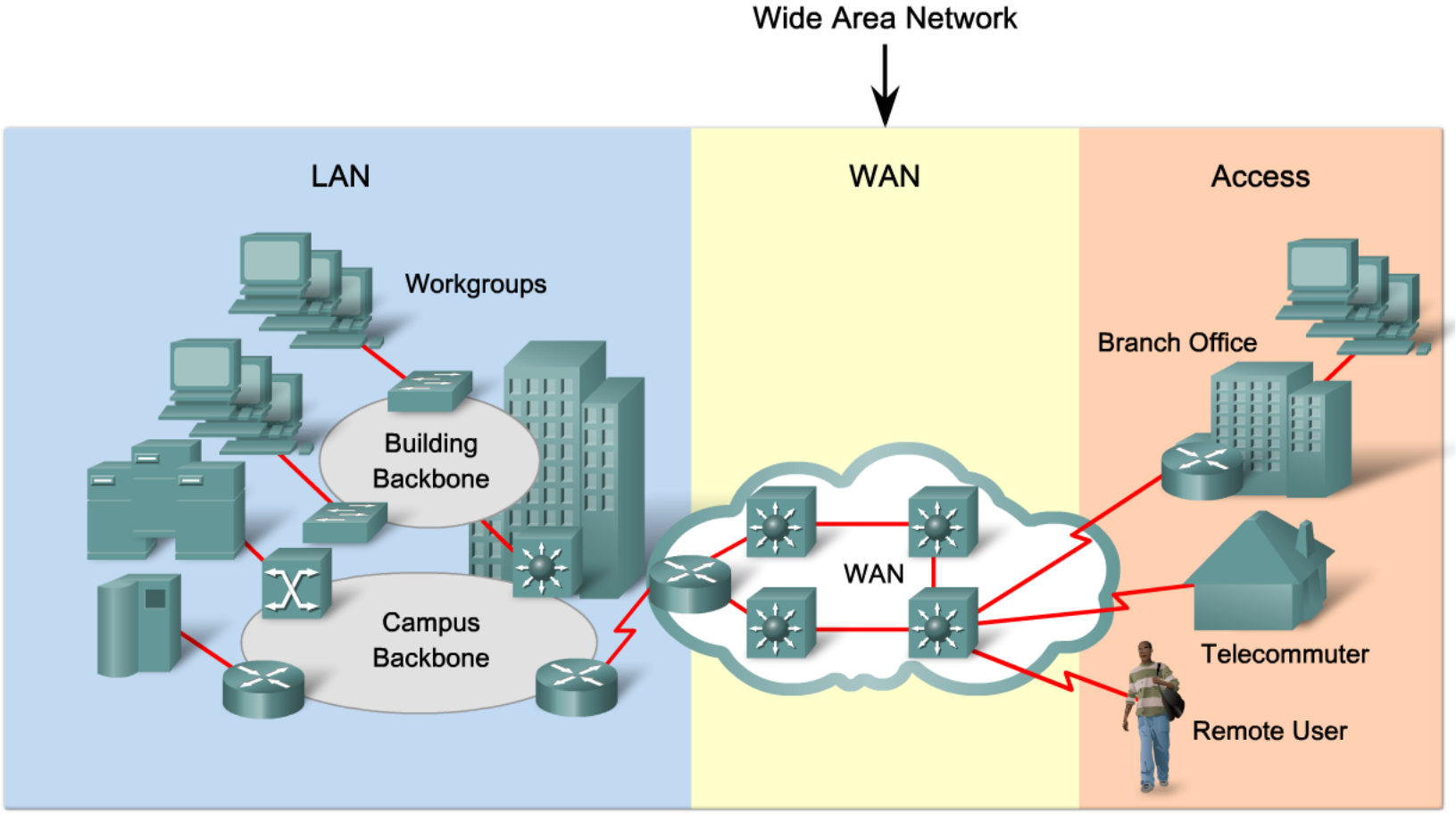
Poskytovanie integrovaných služieb pre podniky

Firma a jej siete - Prečo potrebujeme WAN?

- Ako firmy rastú, menia sa aj ich požiadavky na sieť a jej služby



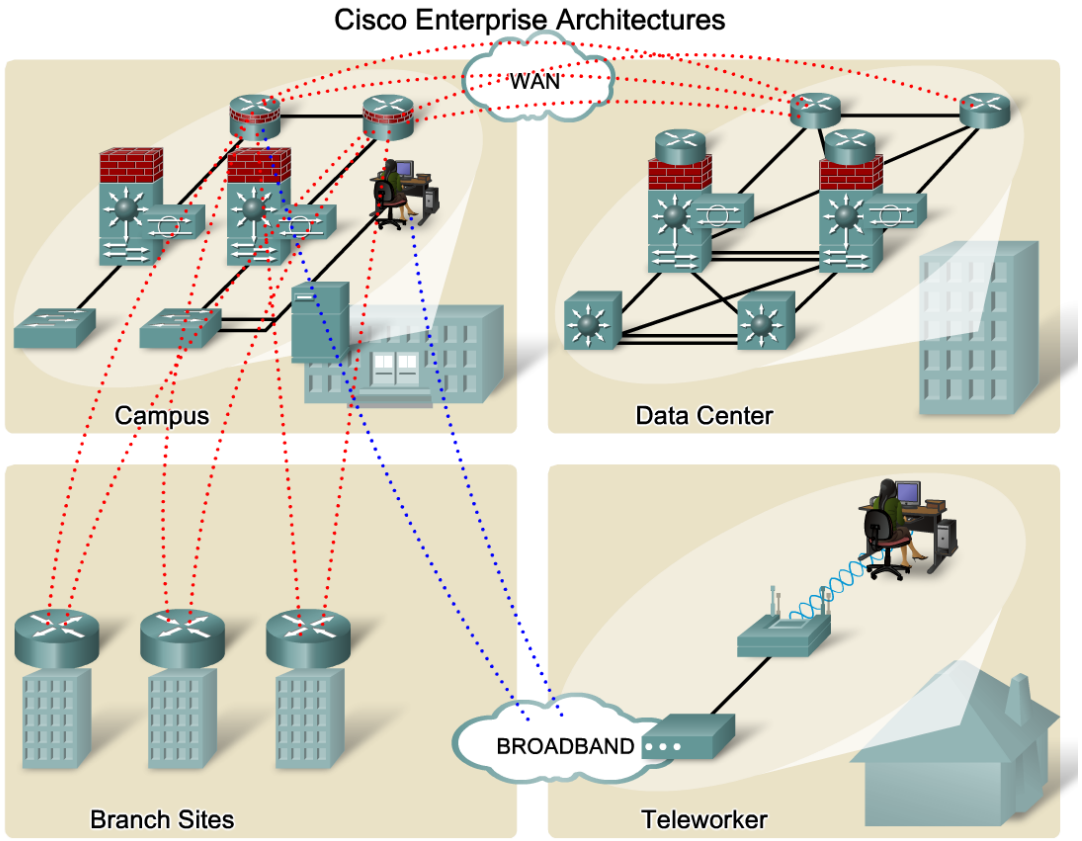
Prečo potrebujeme WAN?



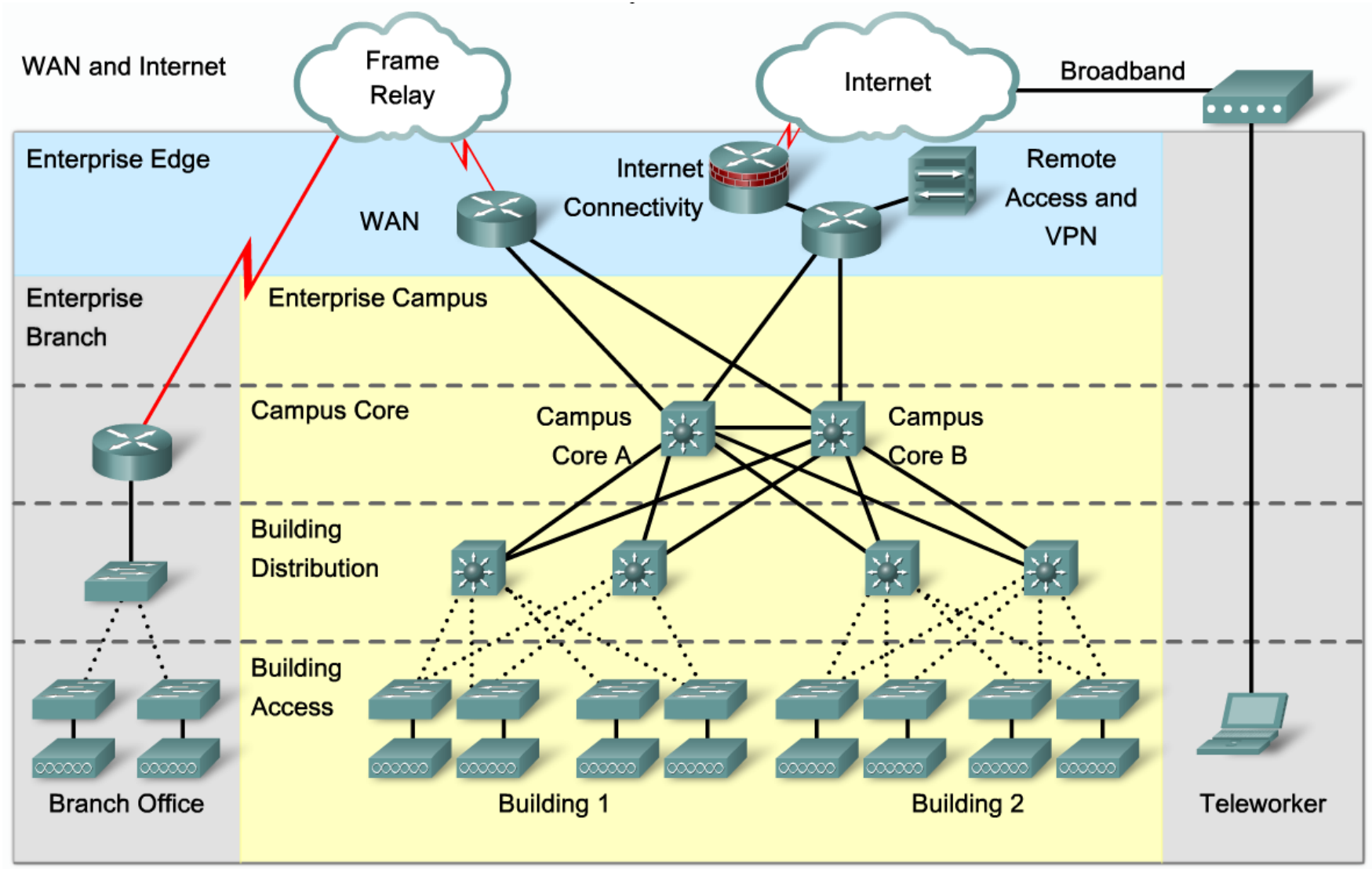
- LAN poskytuje vysokú rýchlosť a cenovo efektívne riešenie -> ale obmedzená na geograficky malé územie -> prepájanie medzi nimi = WAN (Wide Area Network)
- Typicky poskytovazé telco alebo service poskytovateľmi

Podniková sieťová architekútra

- Rozdielný biznis potrebuje rozdielne siete
  - Enterpise Composite Network Model (Cisco Enterprise Architectures)
    - Modulárna
    - Prispôsobená rôznym nárokom a veľkosti firemného nasadenia
  - Skladá za modulov (podľa nasadenia)
    - **Enterprise Campus Architecture**
    - **Enterprise Branch Architecture**
    - **Enterprise Data Center Architecture**
    - **Enterprise Teleworker Architecture**

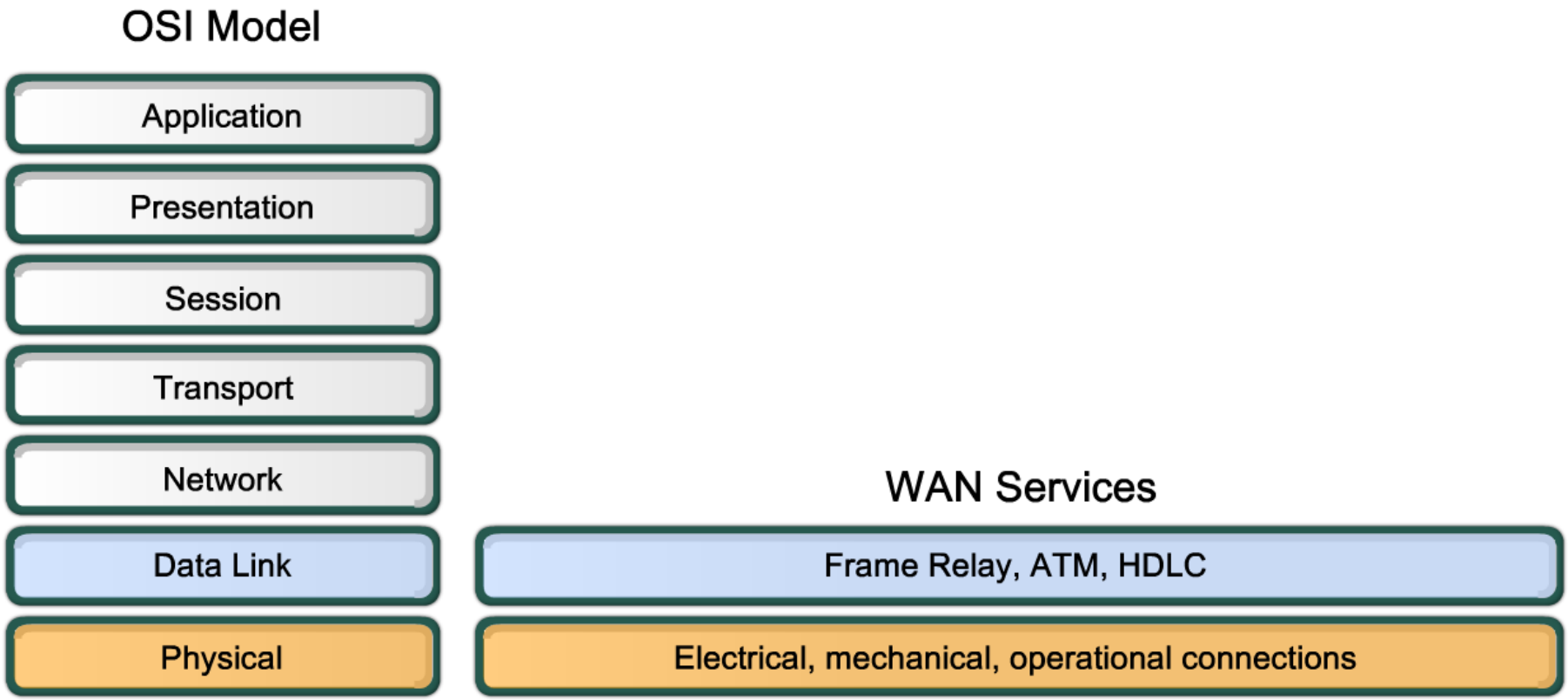


Podniková Architektúra – Príklad topológie



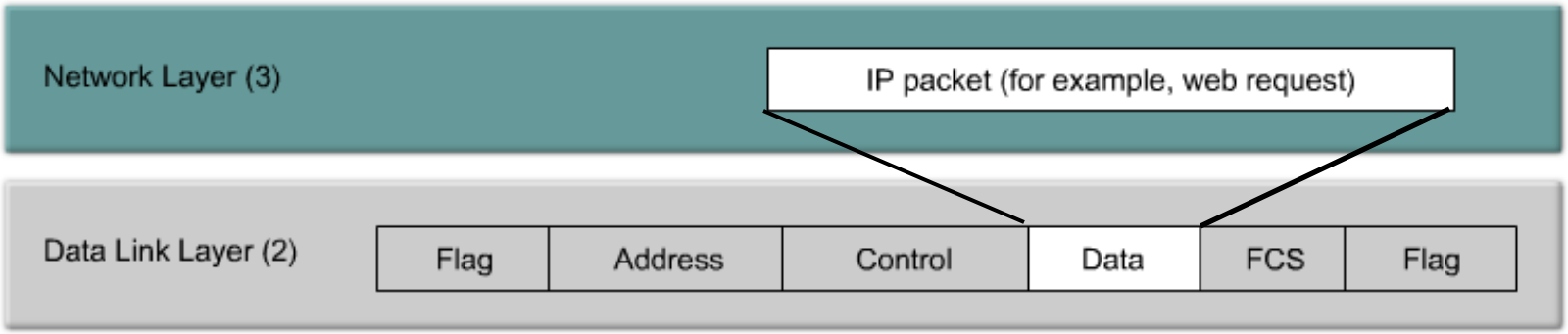
Technológie WAN sietí

WAN na ISO OSI

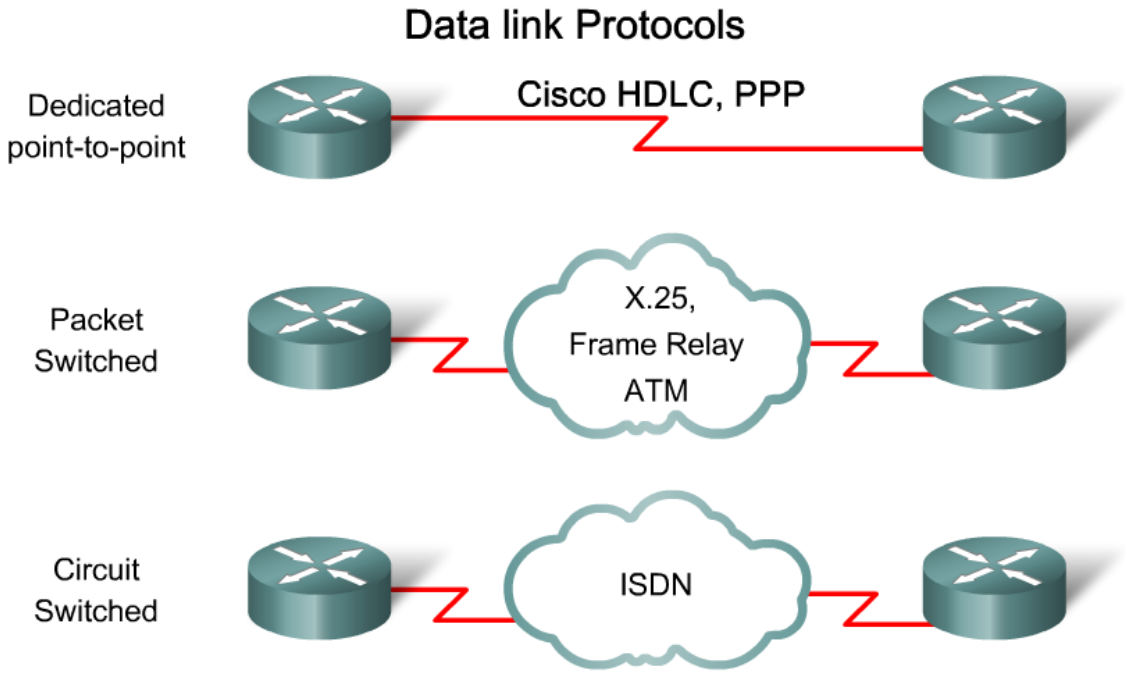


WAN sú definované a pracujú ma L1 a L2.

L3 -> L2 enkapsulácia

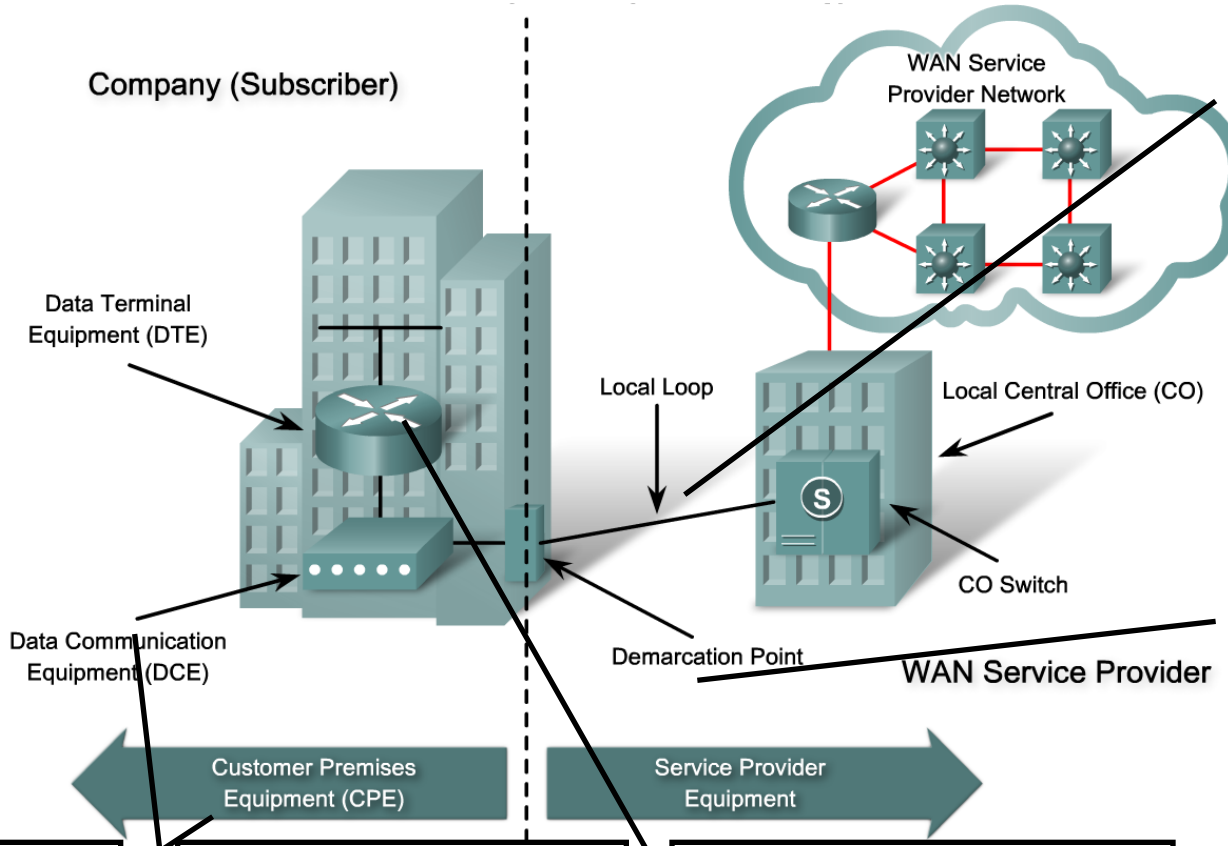


WAN Data Link Layer štandardy a typy sietí (L2)



Protocol	Usage
Link Access Procedure Balanced (LAPB)	X.25
Link Access Procedure D Channel (LAPD)	ISDN D channel
Link Access Procedure Frame (LAPF)	Frame Relay
High-Level Data Link Control (HDLC)	Cisco default
Point-to-Point Protocol (PPP)	Serial WAN switched connections

Terminológia WAN fyzickej vrstvy



Local loop

- last mile
- technológia, ktorou sa pripájam na providera

Demarcation point

- Miesto kde oddeľujem zákaznícke zariadenia od zariadení telco providera
- tu končí zodpovednosť providera
- pripájam sa na Local loop

Customer Premises Equipment (CPE)

- zariadenia umiestnené u zákazníka
  - Vlastné alebo prenajaté
- mimo zodpovednosť providera

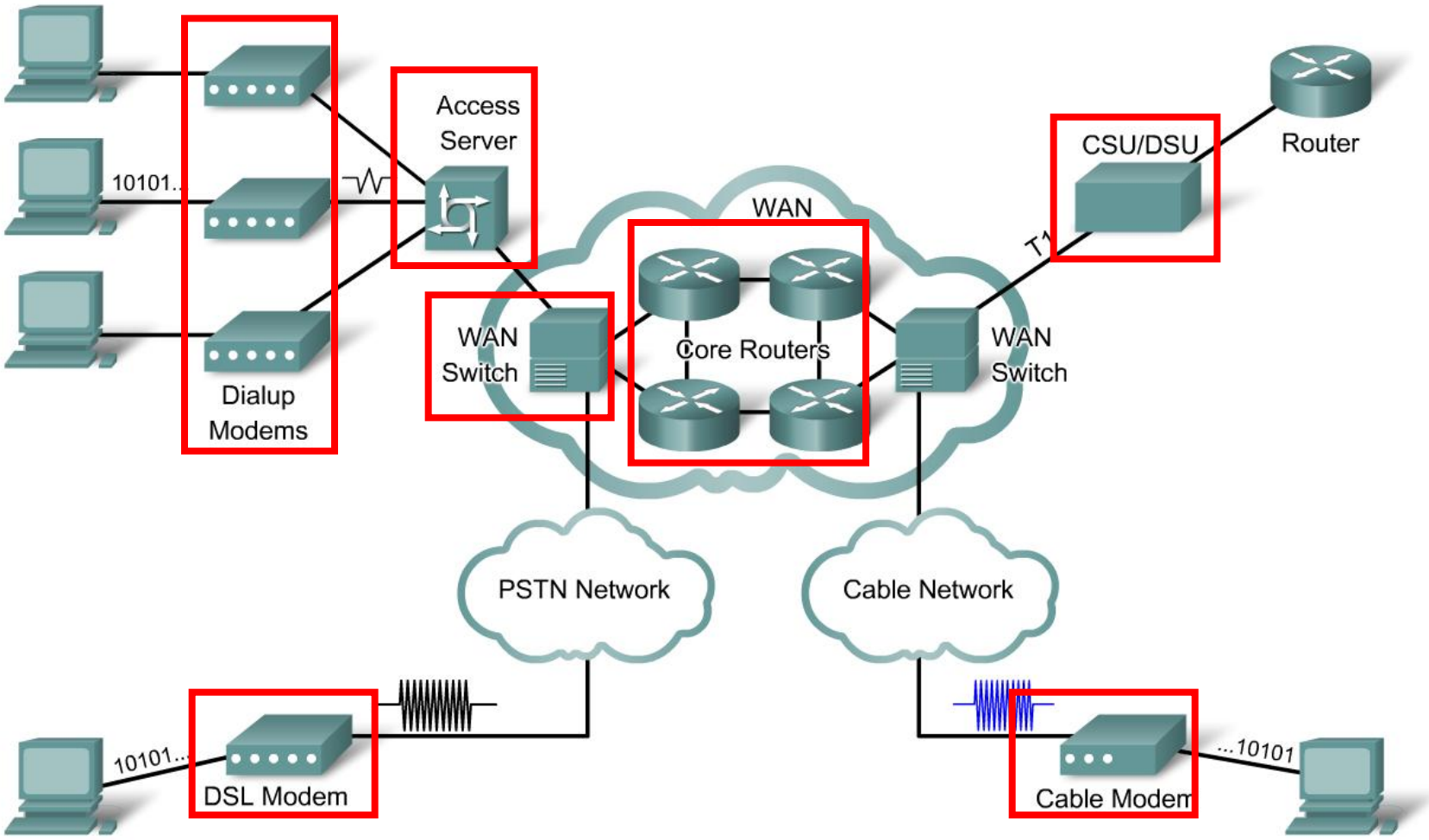
Data Communications Equipment (DCE)

- or data circuit-terminating equipment (DCE)
  - Modem, CSU
- pripravuje používateľské dáta na prenos vhodný na prenos cez WAN

Data Terminal Equipment (DTE)

- Zákaznícke zariadenie
  - router, terminal, computer, printer
- doručuje dáta zo zákazníkovej siete
- Pripája sa na local loop cez DCE

WAN zariadenia



- CSU/DSU – Channel Service Unit/Data service Unit (WAN modemy, napr. T1/E1)
- DSU konvertuje LAN dáta do formy vhodnej pre WAN prenos (T1 TDM)

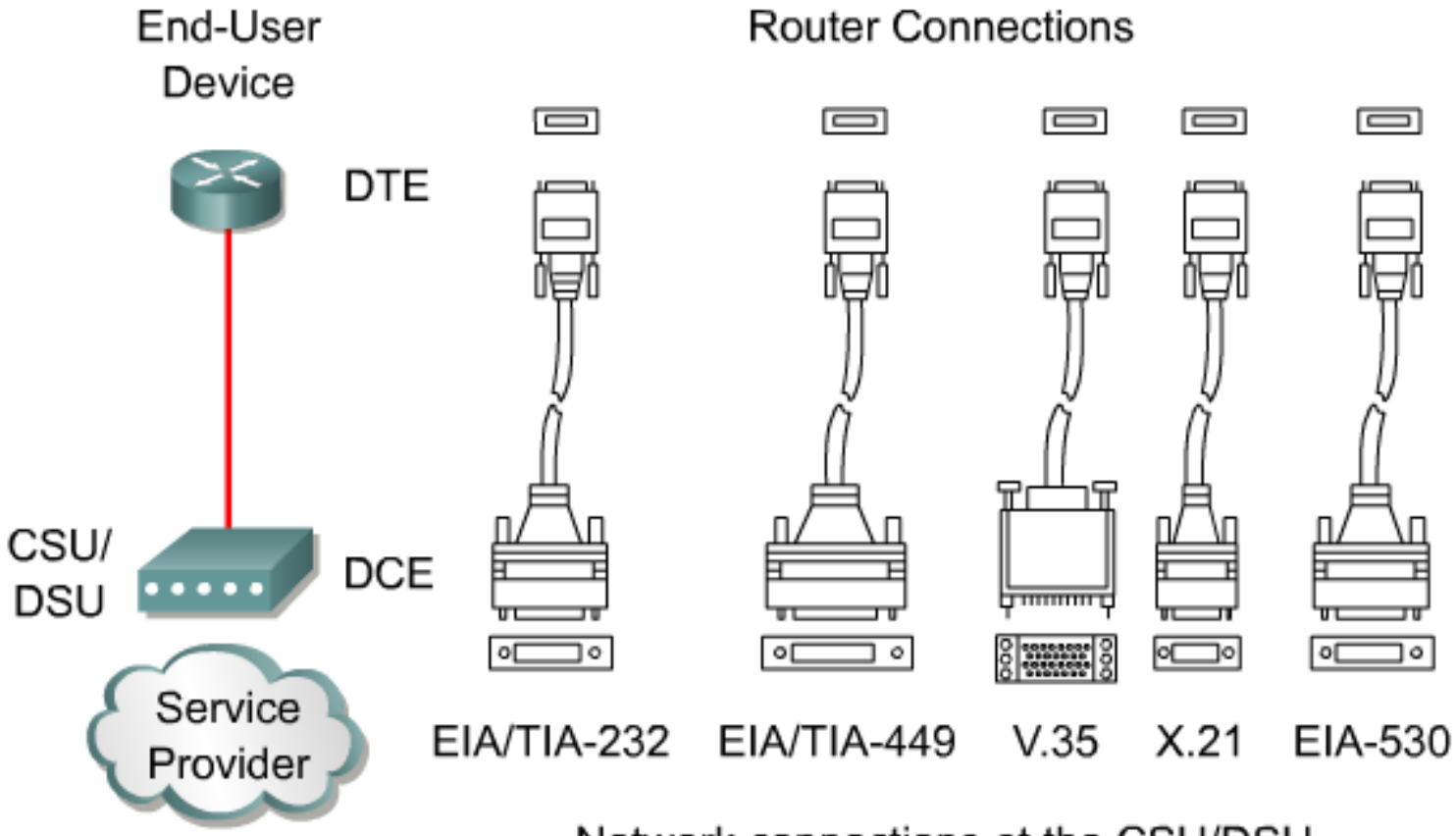
Štandardy L1 vrstvy (medzi DCE a DTE)

- Tvorené:
  - International Organization for Standardization (ISO)
  - Electronics Industry Association (EIA)
  - International Telecommunication Union - Telecommunications Standardization Sector (ITU-T)
- L1 štandardy definujú:
  - **Mechanical/physical**
    - Počet pinov a typ konektoru
  - **Electrical**
    - Definuje napäťové úrovne (0 a 1)
  - **Functional**
    - Špecifikuje funkcie, ktoré sú vykonávané pri manažovaní linky
  - **Procedural**
    - Špecifikuje sekvencie udalostí potrebných pri prenose dát

Štandardy L1 vrstvy (medzi DCE a DTE)

- EIA/TIA-232
  - This protocol allows signal speeds of up to 64 kb/s on a 25-pin D-connector over short distances. It was formerly known as RS-232. The ITU-T V.24 specification is effectively the same.
- EIA/TIA-449/530
  - This protocol is a faster (up to 2 Mb/s) version of EIA/TIA-232. It uses a 36-pin D-connector and is capable of longer cable runs. There are several versions. This standard is also known as RS422 and RS-423.
- EIA/TIA-612/613
  - This standard describes the High-Speed Serial Interface (HSSI) protocol, which provides access to services up to 52 Mb/s on a 60-pin D-connector.
- V.35
  - This is the ITU-T standard for synchronous communications between a network access device and a packet network. Originally specified to support data rates of 48 kb/s, it now supports speeds of up to 2.048 Mb/s using a 34-pin rectangular connector.
- X.21
  - This protocol is an ITU-T standard for synchronous digital communications. It uses a 15-pin D-connector.

Konektory sériových WAN médií

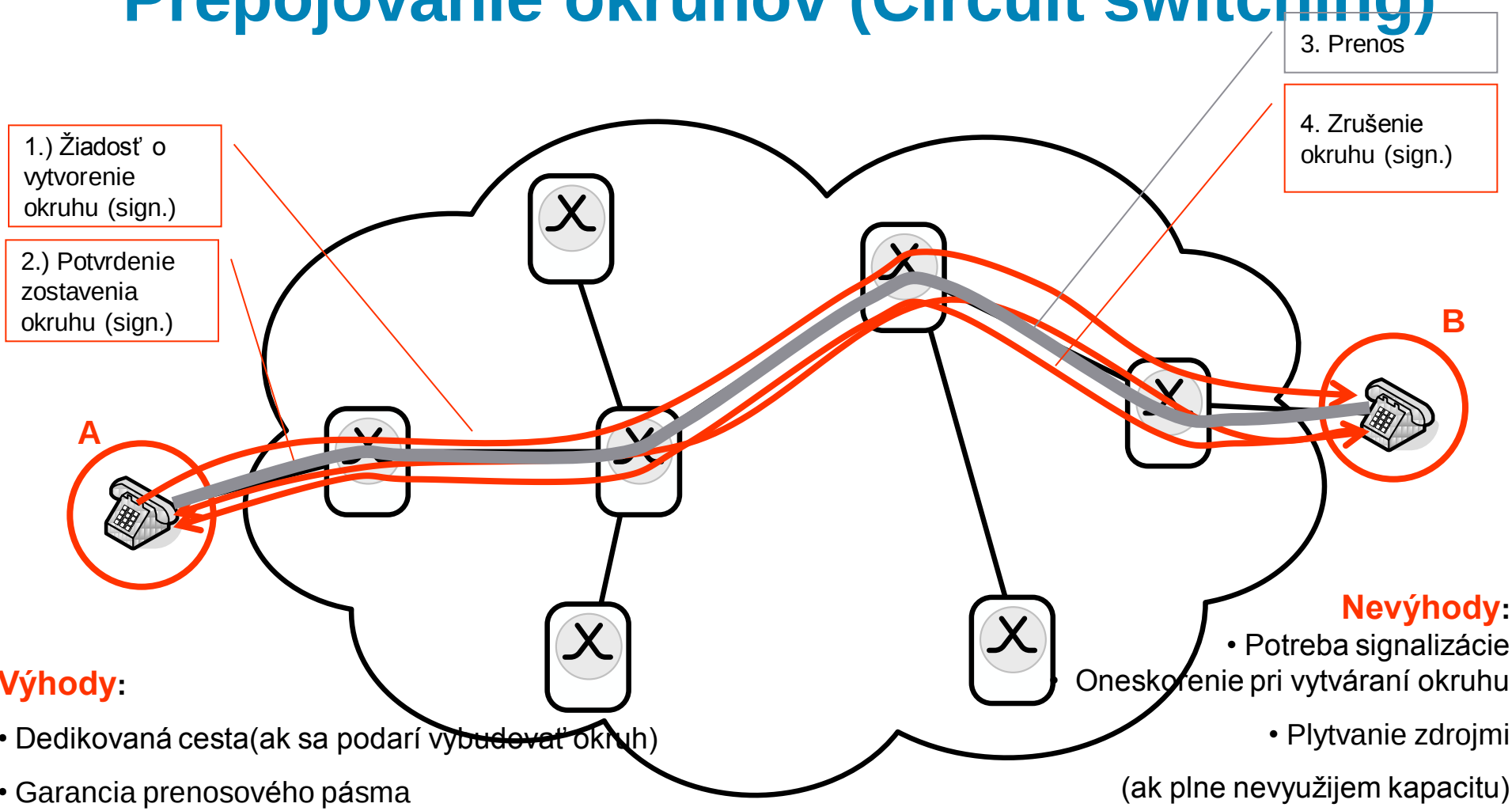


Network connections at the CSU/DSU

- CSU/DSU poskytuje voči DTE rozhrania ako V.35 alebo RS-232

WAN prepojovacie systémy

Prepojovanie okruhov (Circuit switching)



Výhody:

- Dedikovaná cesta(ak sa podarí vybudovať okruh)
- Garancia prenosového pásma
- Garancia QoS
- Rýchlosť systému při prenose

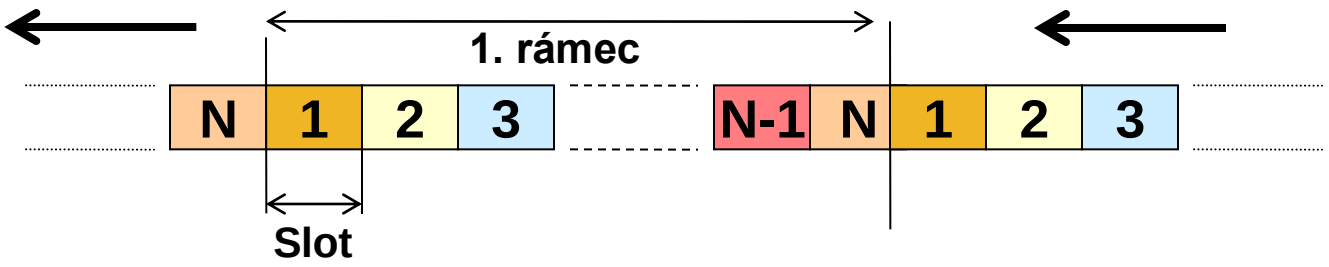
Nevýhody:

- Potreba signalizácie
- Oneskorenie pri vytváraní okruhu
- Plytvanie zdrojmi

(ak plne nevyužijem kapacitu)

- Raz zarezervované zdroje kým sa neuvoľnia nie je možné použiť

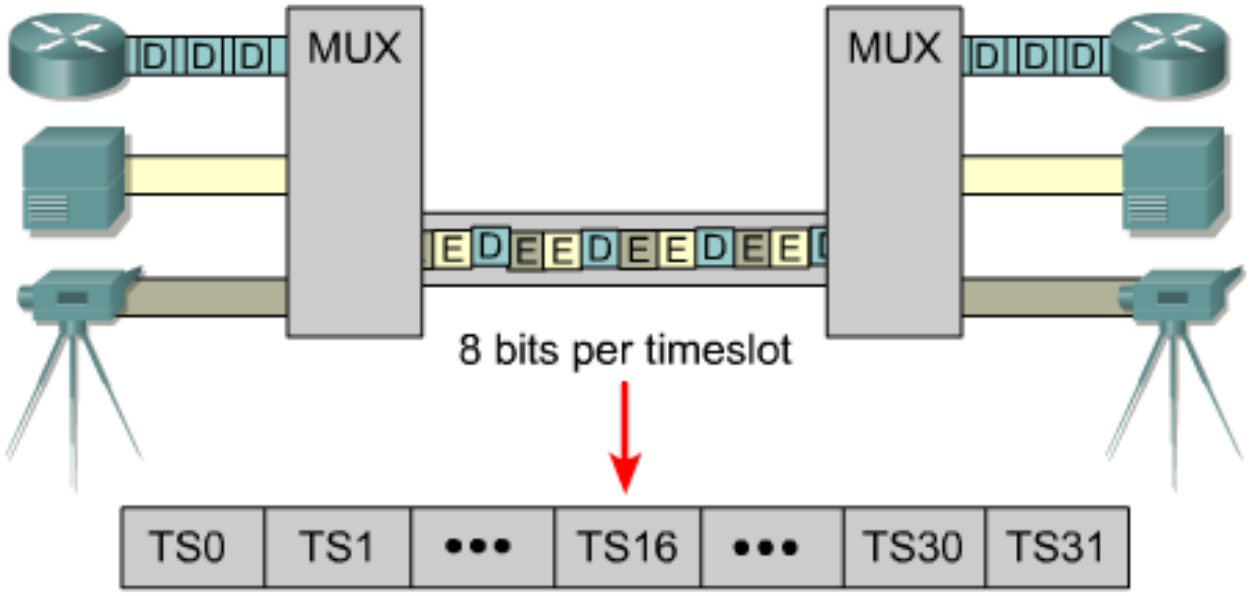
Synchrónny prenos



- Prenosová cesta sa rozdelí na tzv. **časové sloty**
- Pozícia slotu je presne určená v čase, obsah rovnomerne obsadzovaný pomocou synchrónneho časového multiplexovania
- Používané napr. v telefónnej sieti

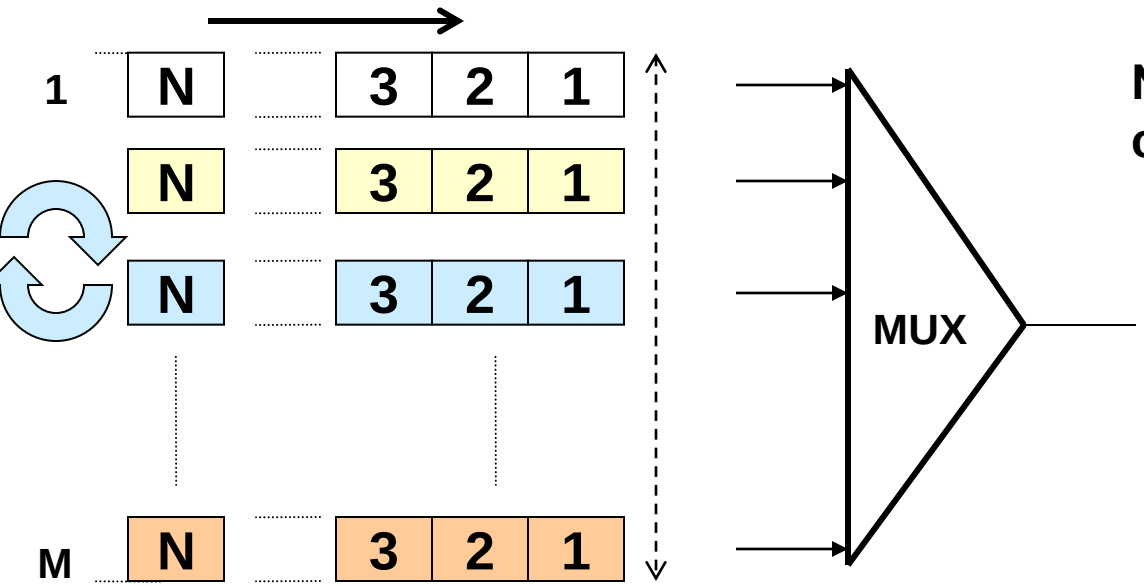
- **Výhody**
  - Jeden slot pridelený jednému komunikujúcemu
  - Získam garanciu prenosovej šírky pásma
  - Prenášajú sa len „užitočné dáta“
- **Nevýhody**
  - Plytvanie prenosovými prostriedkami (ak nemám konšt. gener. dáta)
  - Pre dátové siete nie veľmi vhodné

Time-Division Multiplexing



- Timeslots are always present even if data is not available for sending.
- Bandwidth is statically allocated to the application.
- Protocol independent (HDLC, PPP).

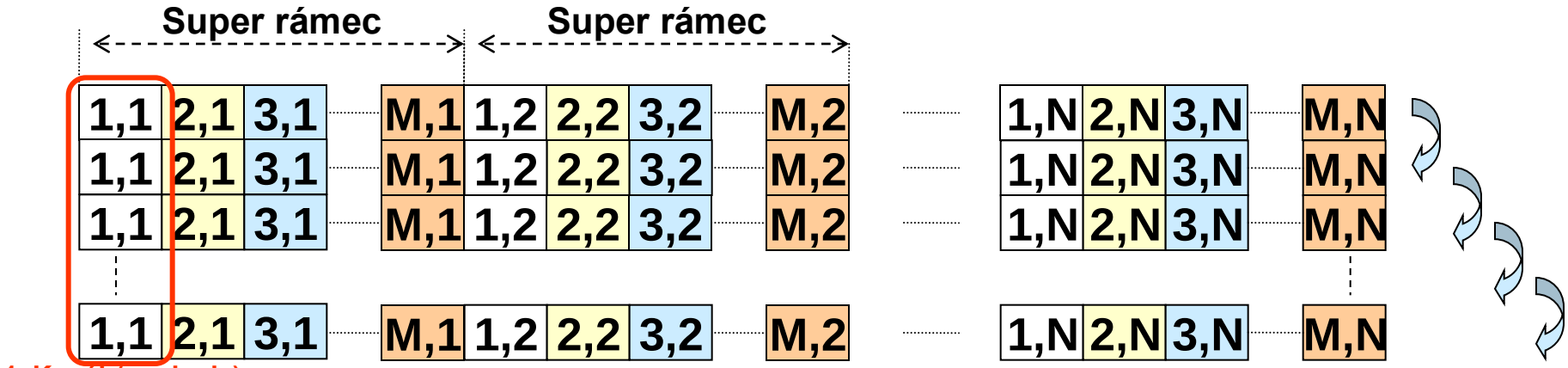
Super rámce



Napr. prenosový digitálny okruh E1:

32 PCM kanálov o rýchlosti 64kb/s

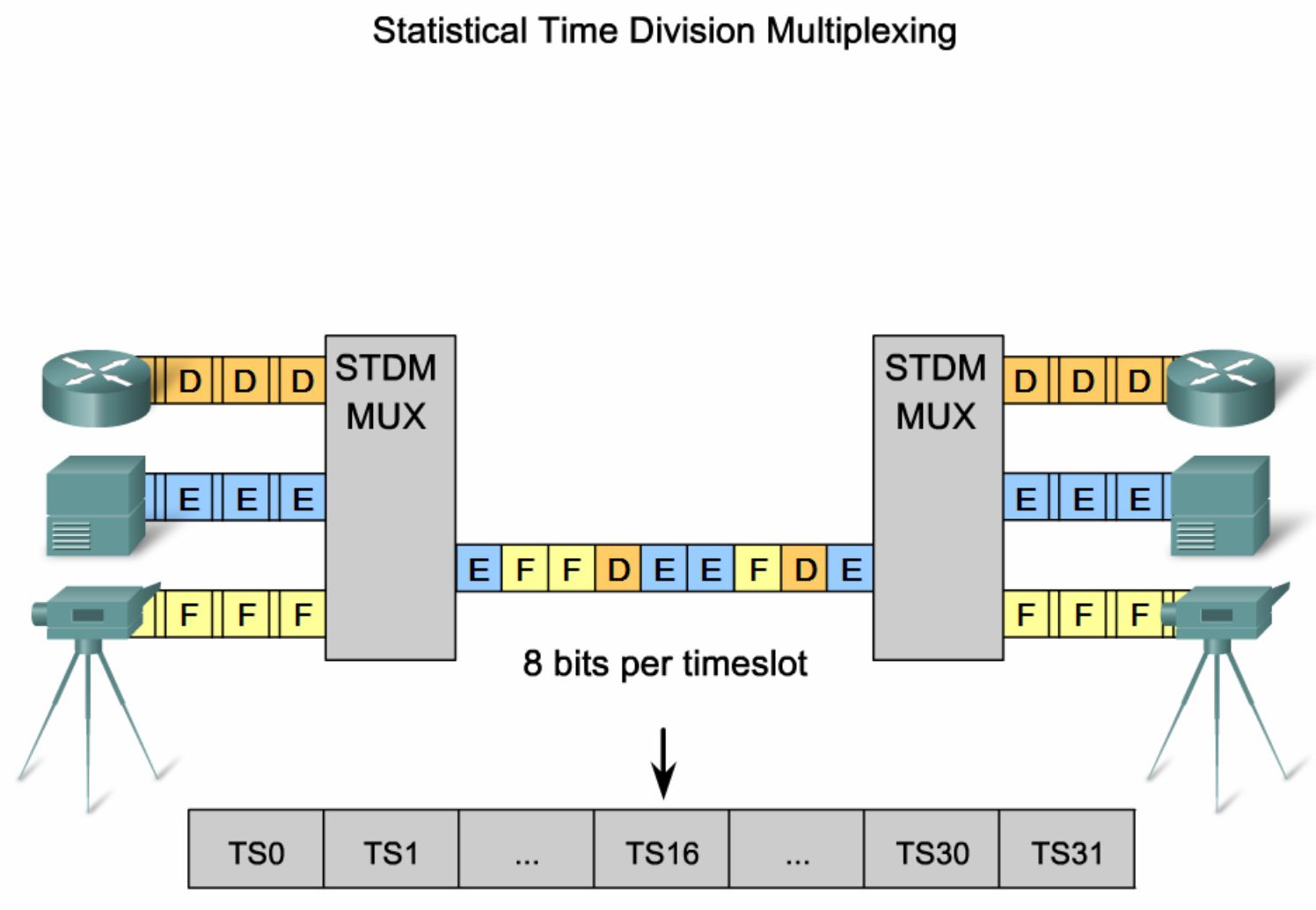
Výsledná rýchlosť: 2,048Mb/s



1. Kanál (spojenie)

64kbps

Štatisticky MUX



Prepojovanie paketov (Packet switching)

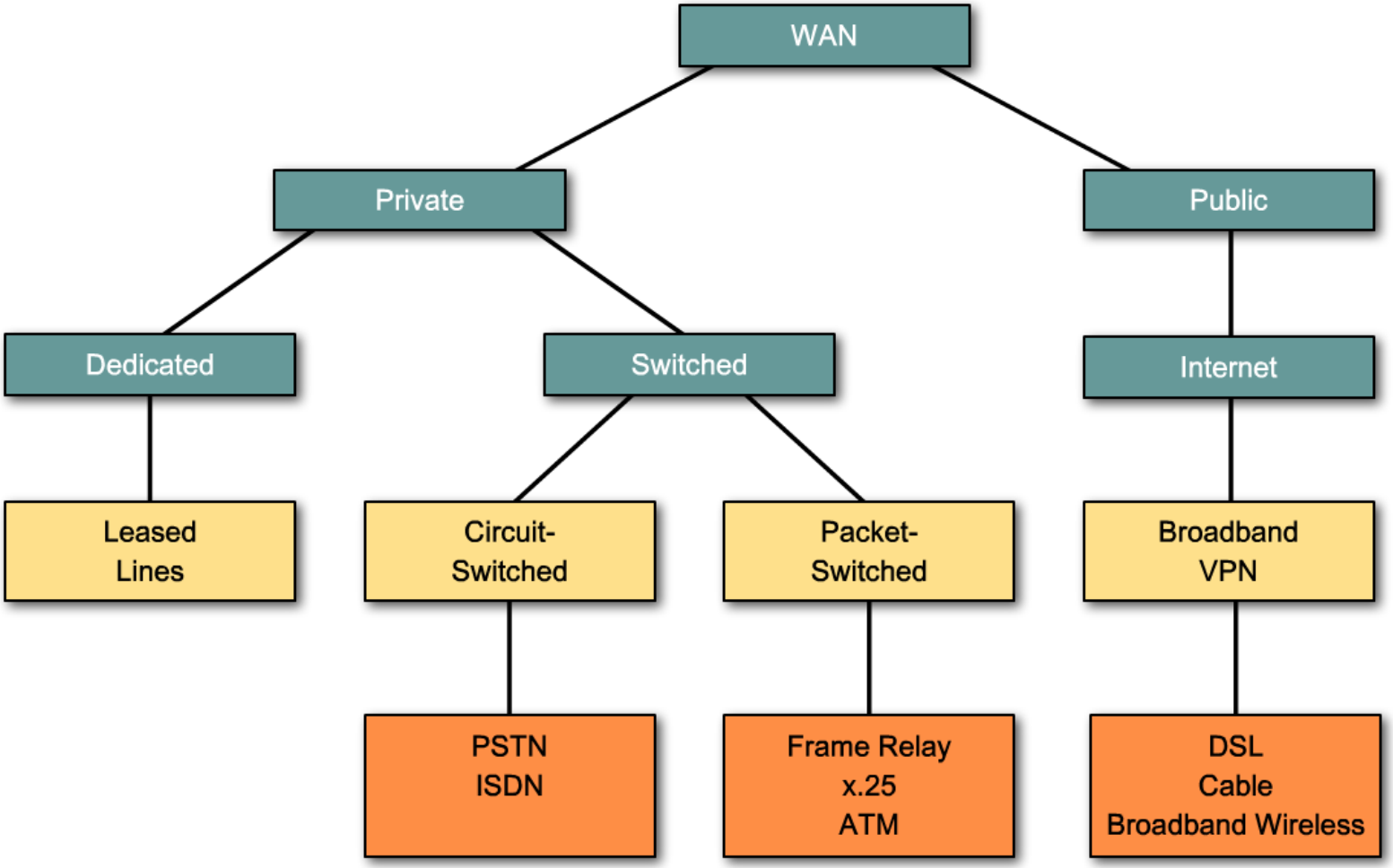
- Dáta delené a smerované ako nezávislé dátové bloky
  - Potrebujú doplňujúce informácie => prenos „neužitočných dát
- V každom uzle siete vykonané smerovacie rozhodnutie
  - Vznik oneskorenia
- Nie je garancia prenosového pásma
- Realizácia:
  - **Connectionless**
    - nie je garancia QoS parametrov (oneskorenie, straty a pod)
    - Príklad: IP
  - **Connection oriented**
    - potrebný admin. zásah alebo potreba signalizácie [SVC],
    - resp. podpora protokolov s “handshake” mechanizmami [TCP])
    - Príklad: X.25, FR, ATM, VPN

Paketový prenos

- Na prenos informácie dátové bloky (pakety) **premenlivej dĺžky**
- Každý paket
  - Nezávislý => Potrebujem dodať doplnkové info potrebné k prenosu paketu => **Hlavička**
- V sieti:
  - Žiadne garancie, nie sú vytvárané kanály
  - Prístup k prenosovým prostriedkom kedy je potrebné
    - Nemusím čakať na „slot“
  - Každý paket spracovávaný samostatne na základe údajov v hlavičke
    - Pakety môžu prísť poprehadzované
    - Dáta sa môžu stratiť
- **Nevýhody:**
  - Prenášam „neužitočné informácie“ (hlavička), potrebné na činnosť siete - protokolu
  - Negarantované prenosové pásmo, zaťaženie každého prenosového uzla
- **Výhody:**
  - Efektívne a ekonomické využitie prenosového pásma
    - Dáta sú prenášané len vtedy, keď sú nejaké určené k prenosu

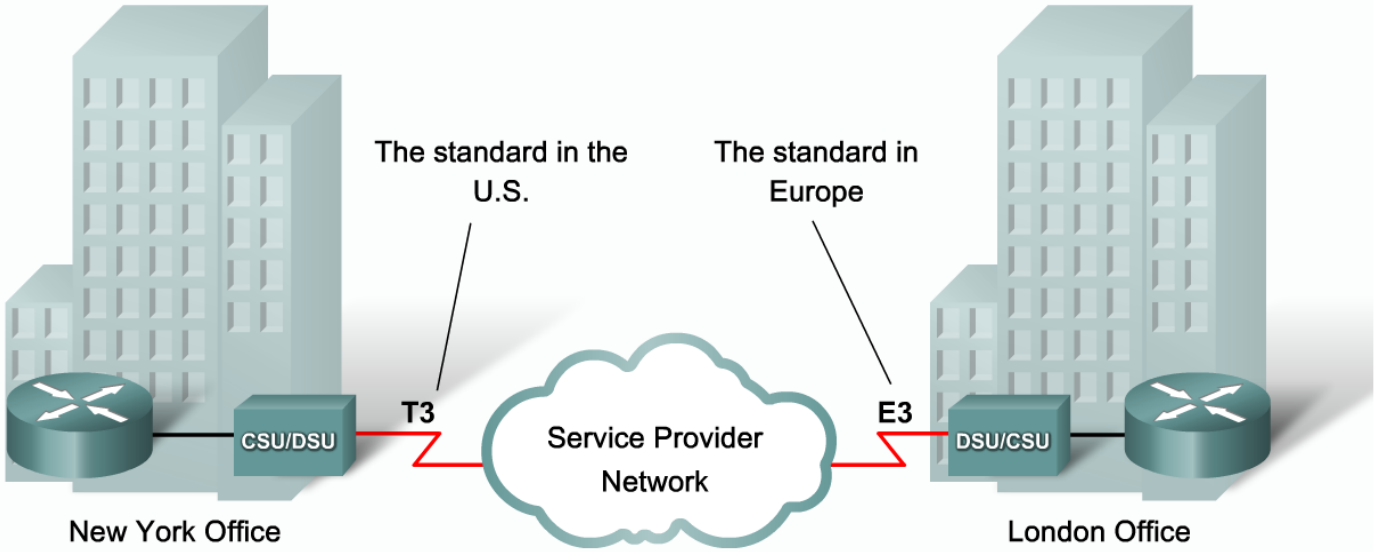
Spôsoby riešenia WAN a prístupu do WAN

Spôsoby riešenia WAN a prístupu do WAN



Leased line (Prenajaté okruhy)

- Point–to–point linka
- permanentná dedikovaná kapacita
  - kapacita nie je zdieľaná
  - dobré parametre oneskorenia a chvenia
- cena od rýchlosti
- Realizácia ako T1/E1, SONET, SDH/PDH

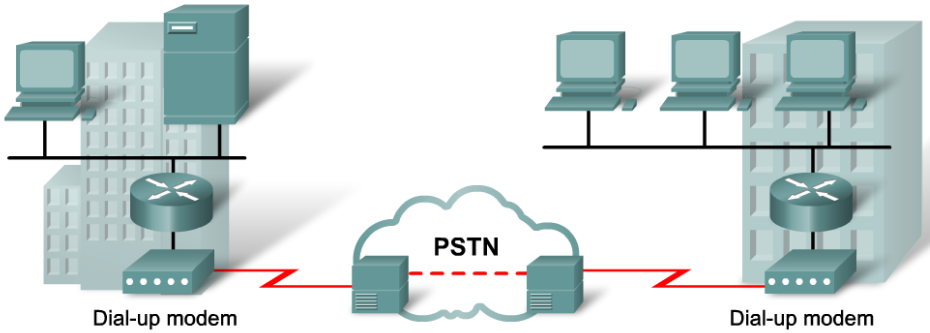


Line Type	Bit Rate Capacity
56	56 kb/s
64	64 kb/s
T1	1.544 Mb/s
E1	2.048 Mb/s
J1	2.048 Mb/s
E3	34.064 Mb/s
T3	44.736 Mb/s
OC-1	51.84 Mb/s
OC-3	155.54 Mb/s

Line Type	Bit Rate Capacity
OC-9	466.56 Mb/s
OC-12	622.08 Mb/s
OC-18	933.12 Mb/s
OC-24	1244.16 Mb/s
OC-36	1866.24 Mb/s
OC-48	2488.32 Mb/s
OC-96	4976.64 Mb/s
OC-192	9953.28 Mb/s
OC-768	39813.12 Mb/s

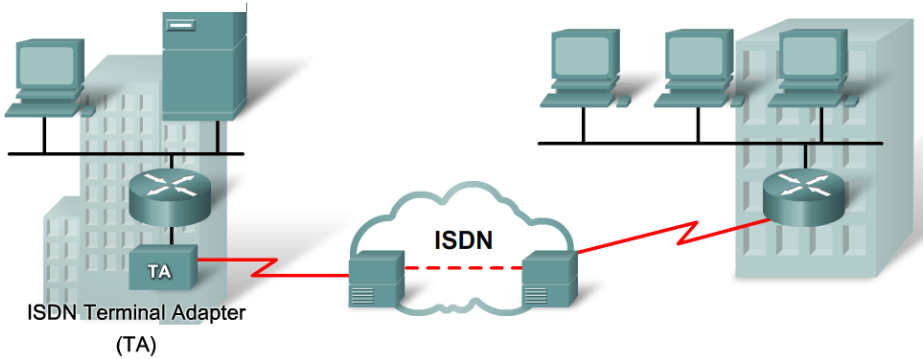
Circuit switching options (Prepojovanie okruhov)

Analog Dialup

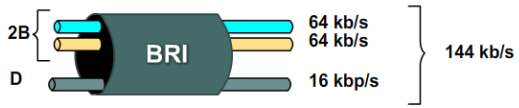


- Vyžaduje modemy a na druhej strane modemové servery
- Výhody:
  - Jednoduchosť, dostupnosť, nízka cena implementácie, rovnaké podmienky na linke (oneskorenie, jitter)
- Nevýhody:
  - Nízka rýchlosť, dlhý čas zostavenia spojenia

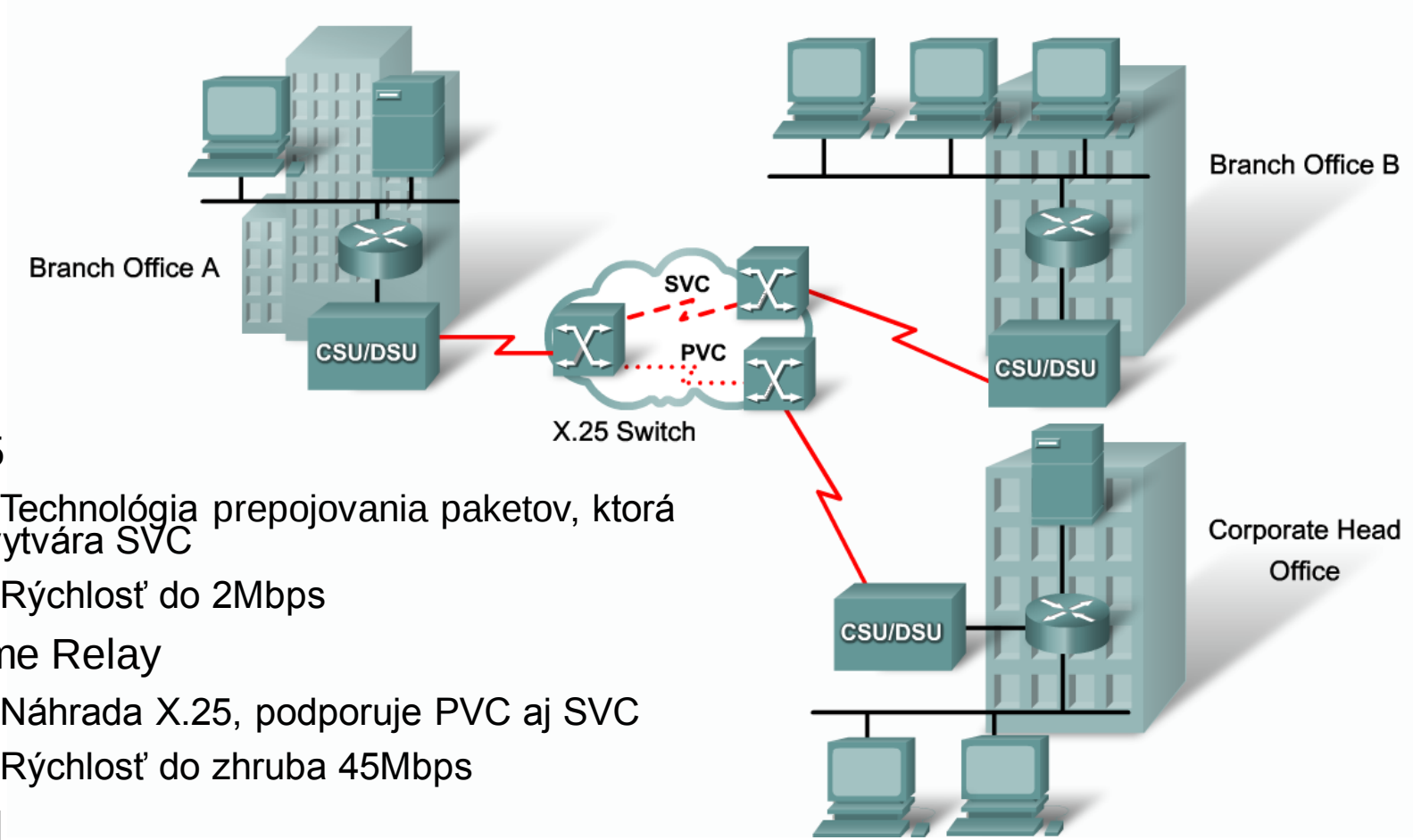
ISDN



- Integrovaná sieť digitálnych služieb (ISDN)
  - BRI prístup (2B+D)
  - PRI prístup (30B+2D)
- Vyššia kapacita, krátky čas zostavenia spojenia, dedikovaná kapacita
- Používa TDM
- Používaná často ako backup primárnej linky
  - Dial on Demand Routing DDR)



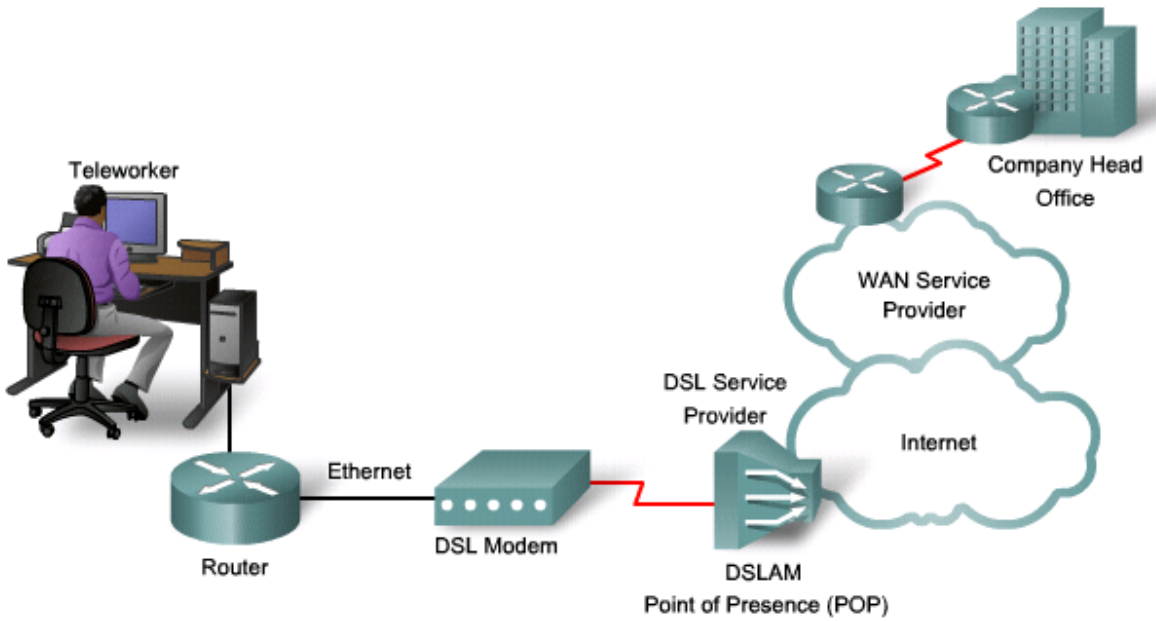
Packet switching options (Prepojovanie paketov)



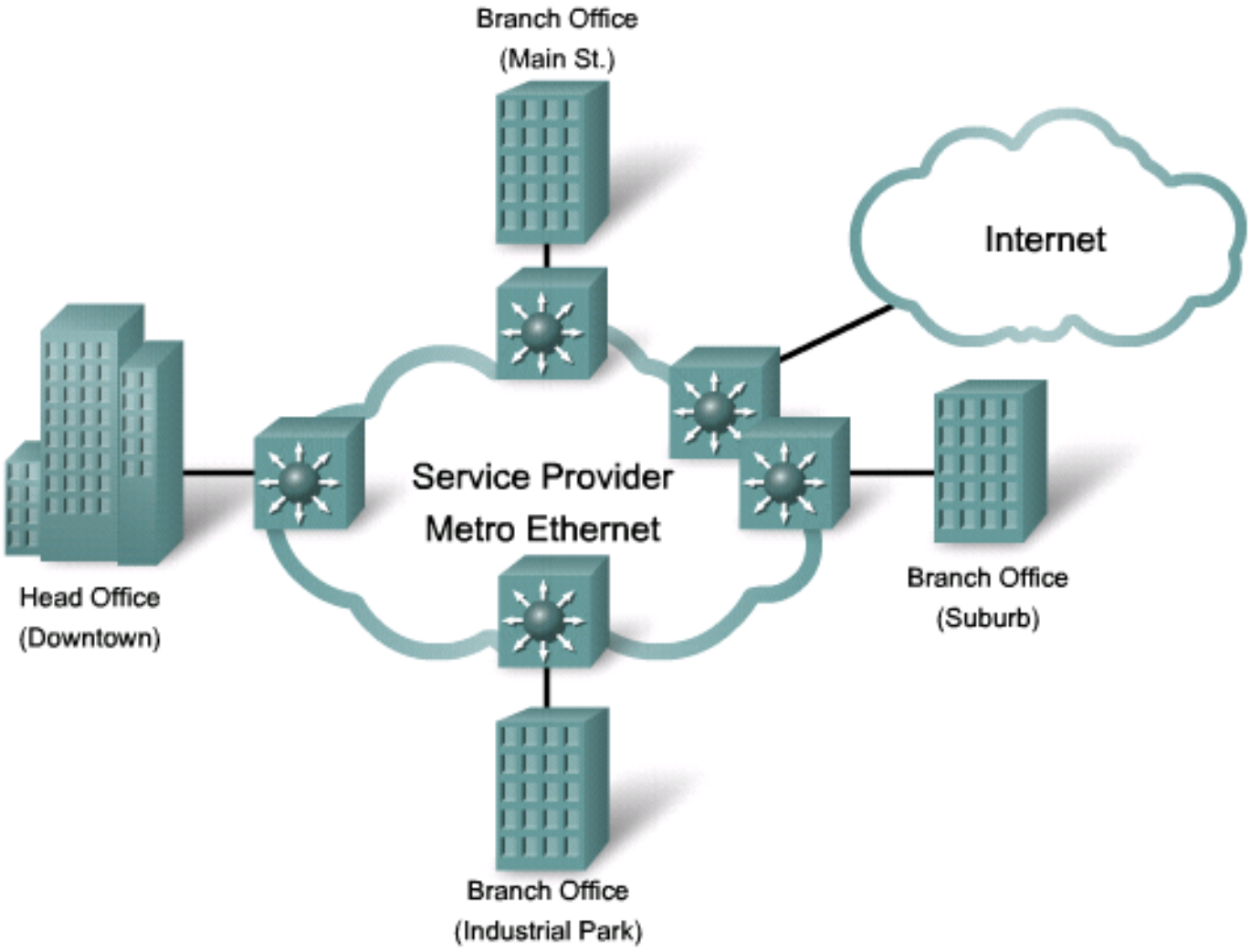
- X.25
  - Technológia prepojovania paketov, ktorá vytvára SVC
  - Rýchlosť do 2Mbps
- Frame Relay
  - Náhrada X.25, podporuje PVC aj SVC
  - Rýchlosť do zhruba 45Mbps
- ATM
  - Bývala „nádej“ telco sveta na ideálnu sieť. Technológiu
  - Rýchlosť do 13.21 Gbps (OC-255)

Broadband Services (Širokopásmové služby)

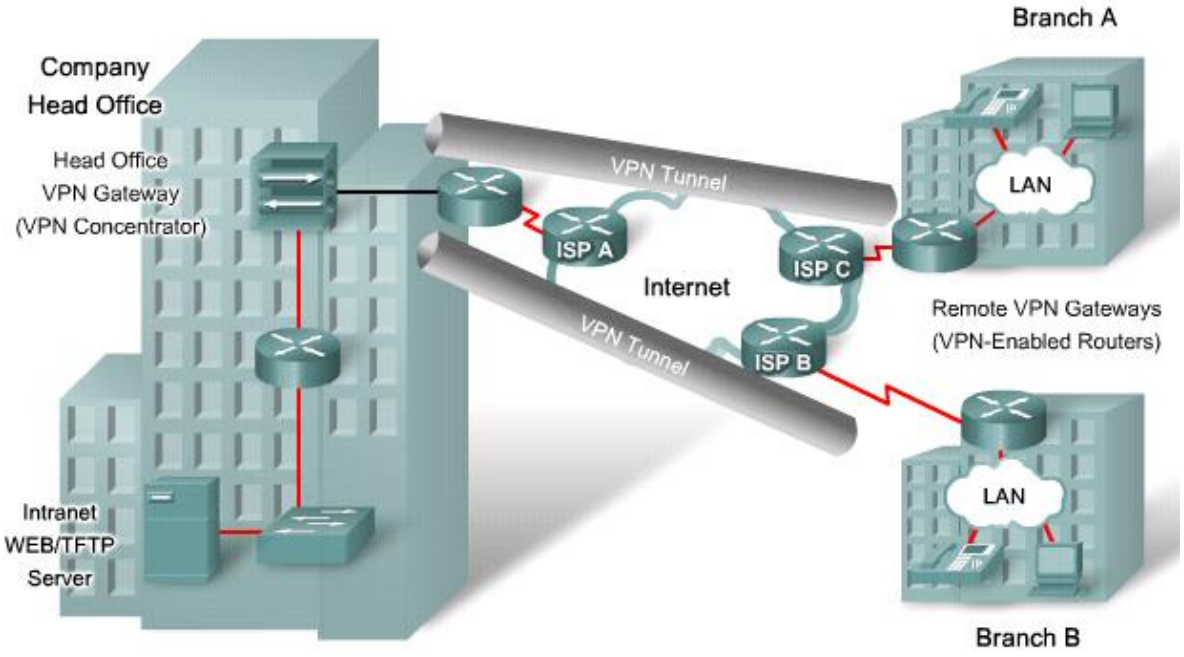
- xDSL
  - Veľmi populárna širokopásmová technológia
  - Prevádzka po tel.dvojlinke
  - Do 8Mbps
  - Viac štandardov
- Cable
  - Coax média
  - Populárna pri TV kábel poskytovateľov
- Wireless
  - WiMax
    - Bezdrôtová prístupová technol
    - Do 72Mbps
- Optika
  - FTTx, PON
- Mobile
  - UMTS, CDMA



Metro Ethernet



VPN



Výhody VPN:

- šetrenie nákladov
  - Teleworking, mobilita, využitie Internetu na bezpečný prístup do korporátnej siete
- Bezpečnosť
  - Vysoká úroveň zabezpečenia komunikácie
- Škálovateľnosť
  - Jednoduché riadenie pridávania používateľov

2 typy VPN prístupu:

- Site-to-site VPNs
- Remote-access

Faktory na zváženie pri výbere WAN technológie

Option	Description	Advantages	Disadvantages	Sample protocols used
Leased line	Point-to-Point connection between two computers or Local Area Networks (LANs).	Most secure	Expensive	PPP, HDLC, SDLC, HNAS
Circuit switching	A dedicated circuit path is created between endpoints. Best example is dialup connections.	Less expensive	Call setup	PPP, ISDN
Packet switching	Devices transport packets via a shared single point-to-point or point-to-multipoint link across a carrier interwork. Variable length packets are transmitted over permanent virtual circuits (PVCs) or switched virtual circuits.(SVCs)		Shared media across link	X.25, Frame Relay

Faktory na zváženie pri výbere WAN technológie

Option	Description	Advantages	Disadvantages	Sample protocols used
Cell relay	Similar to packet switching, but uses fixed length cells instead of variable length packets. Data is divided into fixed-length cells and then transported across virtual ciruits	best for simulated use of voice and data	Overhead can be considerable.	ATM
Internet	Connectionless packet switching using the Internet as the WAN infrastructure, uses network addressing to deliver packets. Because of security issues, VPN technology must be used.	Least expensive Globally available	Least secure	VPN, DSL, Cable-Modem, Wireless

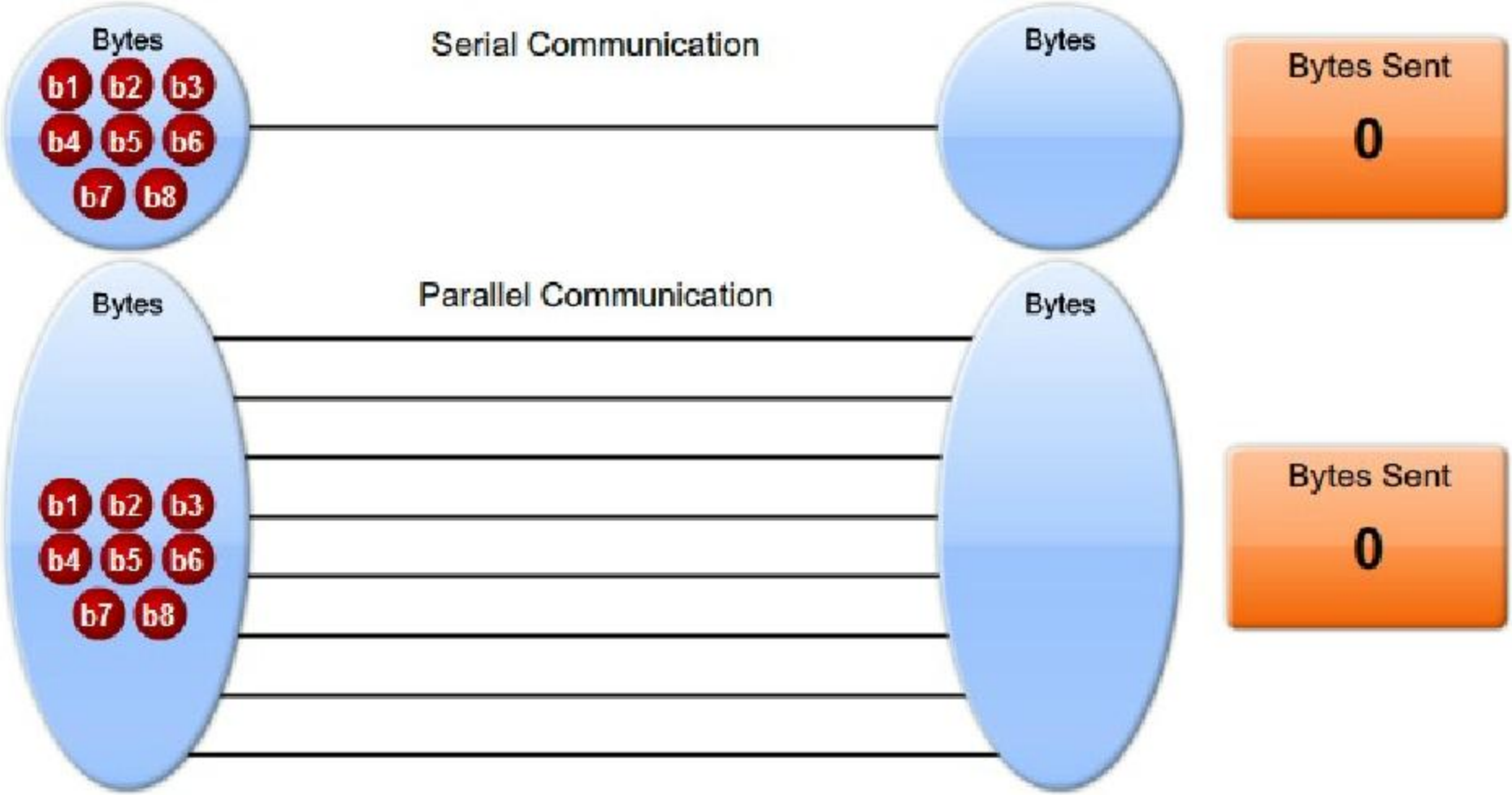
HDLC a Point-to-Point protokol (PPP) - WAN

Semester 4, Modul 2

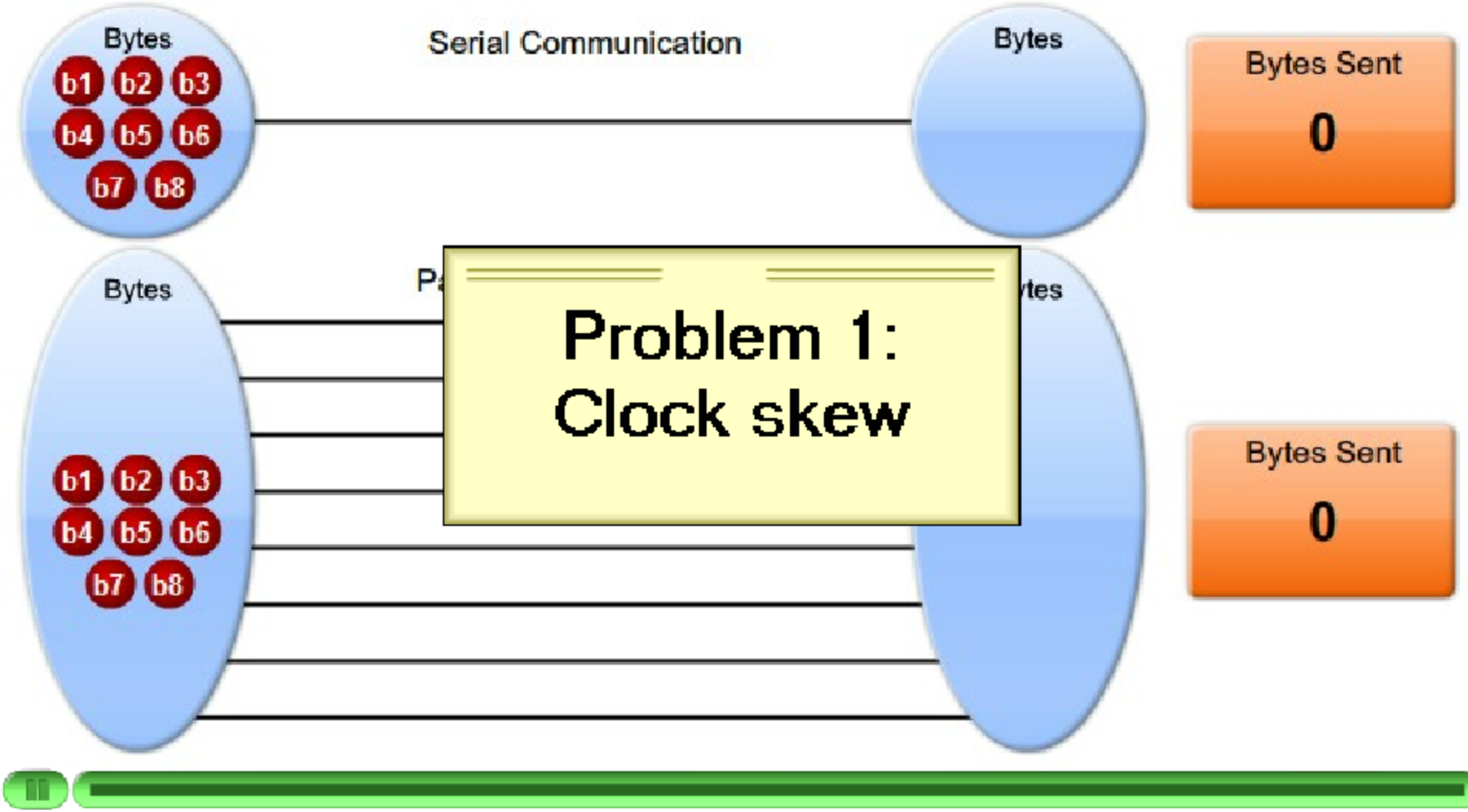
Obsah

- HDLC
- Serial Point-to-Point linky
- PPP
- PPP authentication
  - PAP
  - CHAP
- Configuring PPP

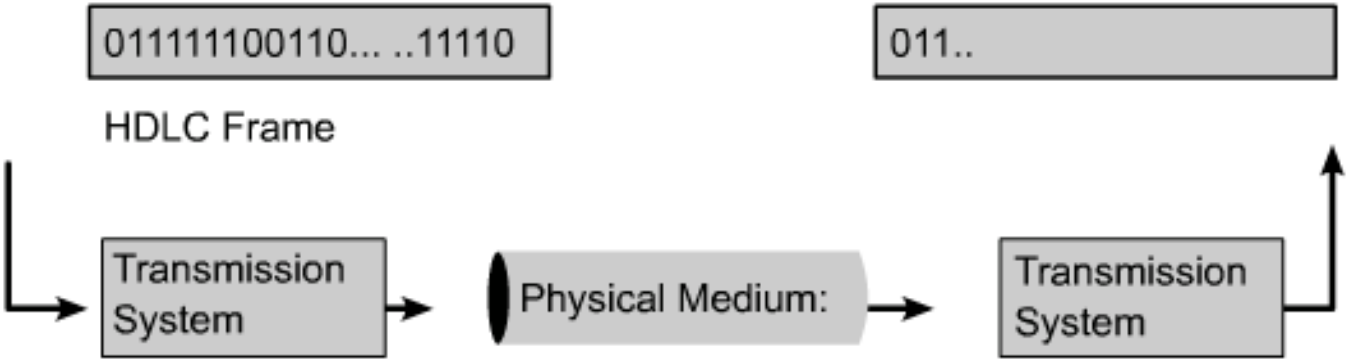
Sériová vs. Paralélna komunikácia



Sériová vs. Paralélna komunikácia - Problémy

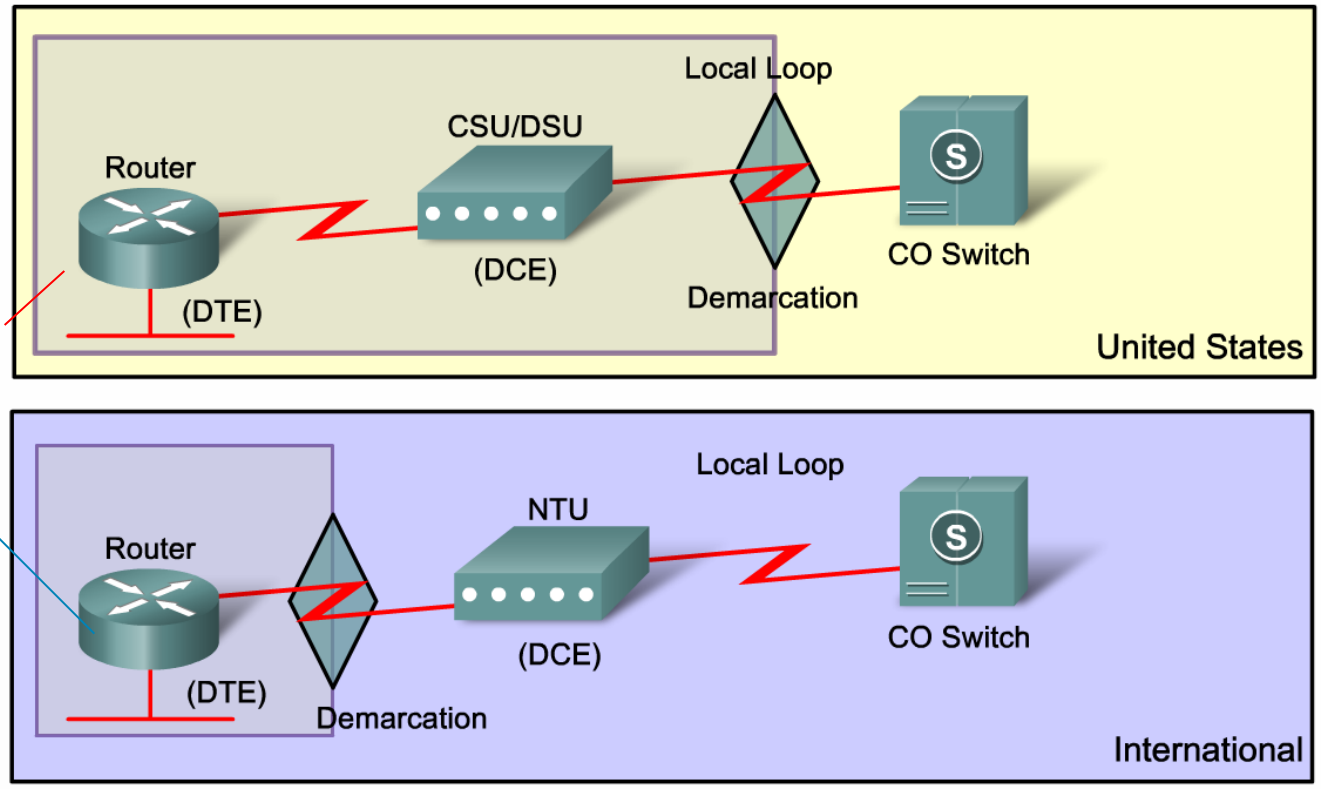


WAN komunikácia – typicky sériová komunikácia



- Typicky WAN používa sériovú komunikáciu, nie paralélnu
  - Lacnejšie média, odpadá problém so synchronizáciou
  - Médium má dlhší dosah, nakoľko odpadá CrossTalk
- Príklady
  - RS-232, RS/422/423, V.35, HSSI

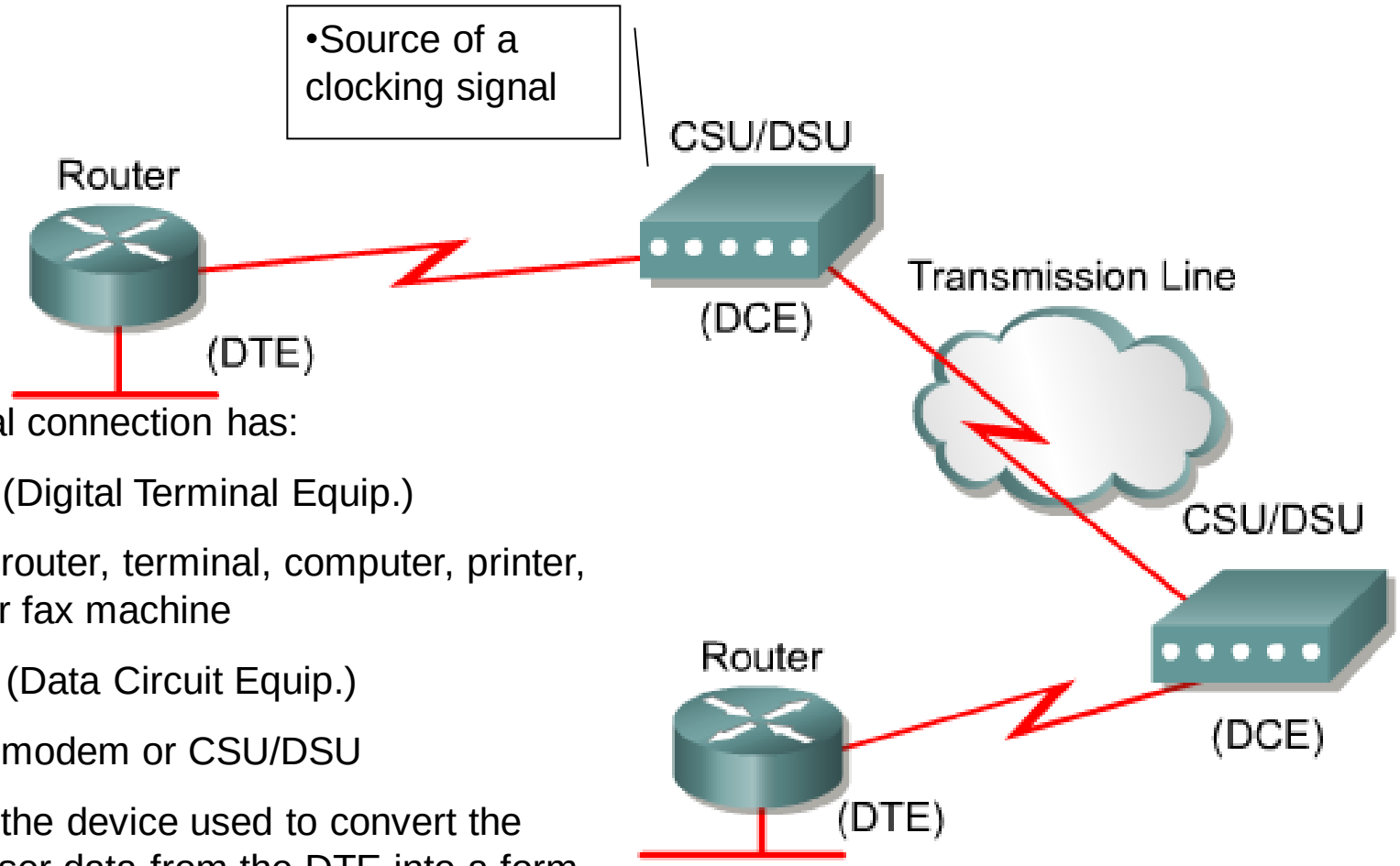
Demarcation Point (Demarc)



CPE (Customer Premises Equipment)

Bod v sieti v ktorom končí zodpovednosť poskytovateľa služby.

DTE-DCE

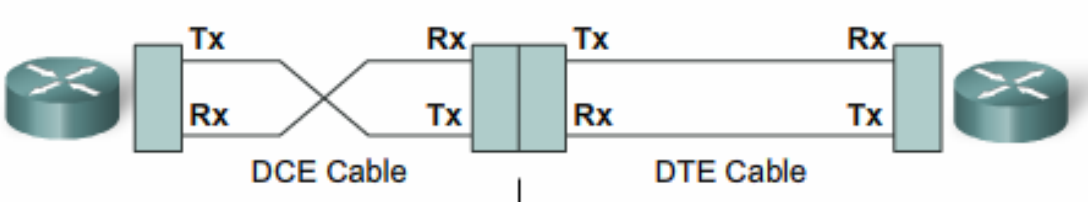


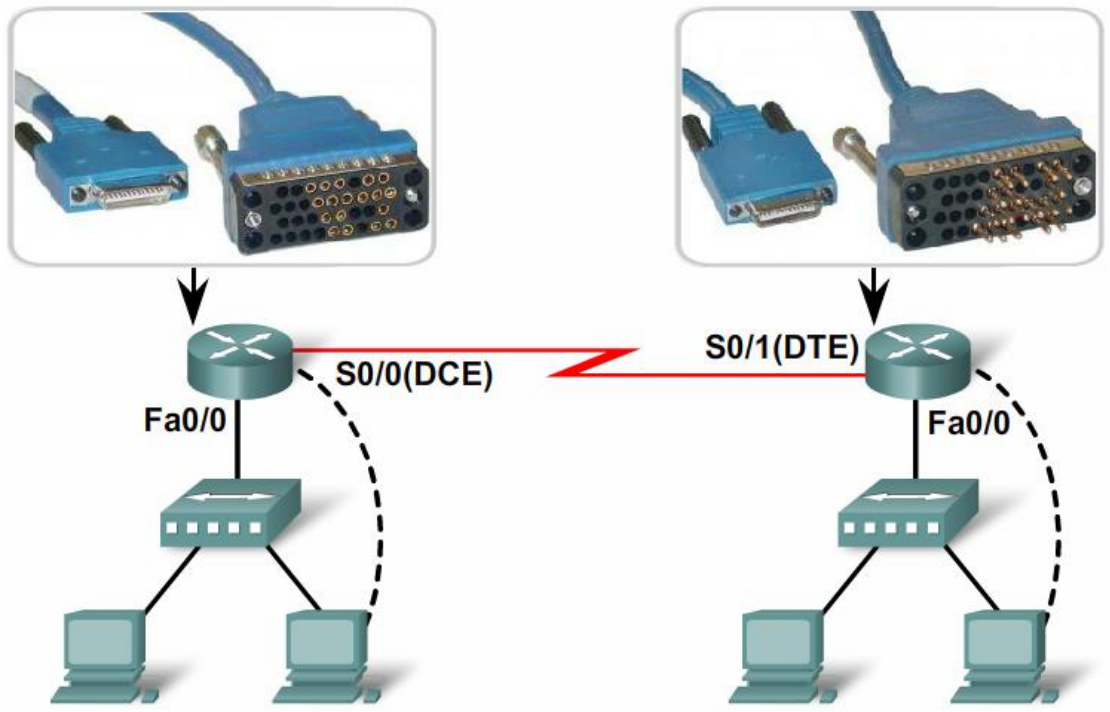
A serial connection has:

- DTE (Digital Terminal Equip.)
  - router, terminal, computer, printer, or fax machine
- DCE (Data Circuit Equip.)
  - modem or CSU/DSU
  - the device used to convert the user data from the DTE into a form acceptable to the WAN service provider transmission link.

DTE a DCE – zapojenie v labe (back to back)

Null modem





DTE-DCE

- Synchrónne sériové linky musia mať clock
  - Zvyčajne poskytuje DCE zariadenie
- Ak prepápájam dve DTE zariadenia (napr. routre v labe) cez synchrónne rozhranie
  - Jeden musí byť zdrojom hodin. taktu
  - Default je router DTE zariadenie
  - Musím zmeniť konfiguráciou na DCE
    - Podľa typu pripojeného kábla
    - `Clock-rate 64000`

High Level Data Link (HDLC) protokol

L2 komunikácia cez sériové linky

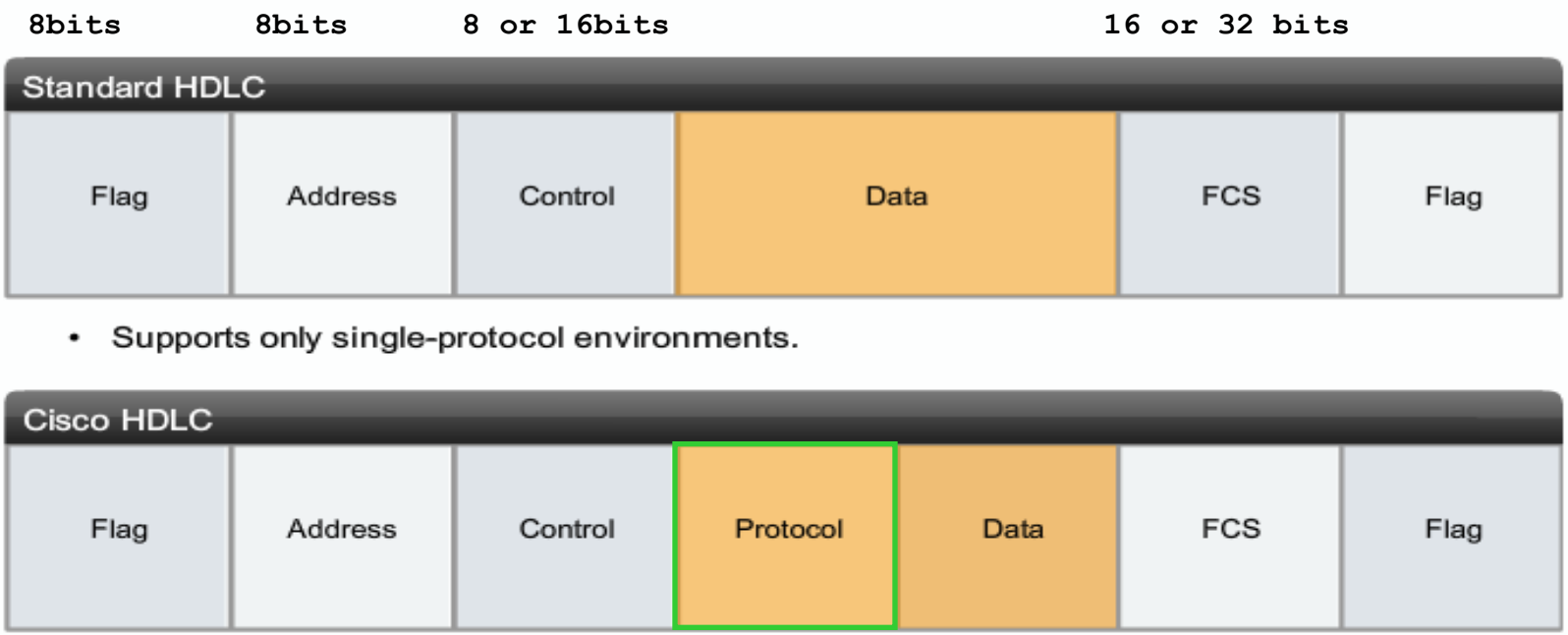
- Bolo vyvinutých viacero protokolov
  - HDLC, PPP, SLIP, FR, apod.
- **High-level data link control** (HDLC) protokol
  - Definovaný ISO 9 (ISO3239)
  - Bitovo orientovaný data link protokol
  - Point-to-point protokol
    - Bezchybový
  - Full duplex
  - Definuje ako enkapsulovať dáta na synchrónnych seriových linkách
    - Využíva L1Clocking
  - Umožňuje riadenie toku (flow control) cez potvrdzovanie a systém Okna

HDLC verzie

- ***Standard HDLC*** (ISO štandard)
  - Nepodporuje prenos viacerých L3 protokolov cez L2 linku
    - Nemá spôsob ako by príjemcovi naznačil, čo je nesené v HDLC rámci
- ***Cisco HDLC*** (cHDLC)
  - Proprietárna Cisco verzia HDLC.
  - Rámec nesie proprietárne pole 'type' alebo tiež tzv. protocol pole.
    - Pole umožňuje prenášať dáta viacerých L3 protokolov cez tú istp L2 linku.
  - cHDCL je spúšťaná ako default enkapsulácia na sériových rozhraniach.

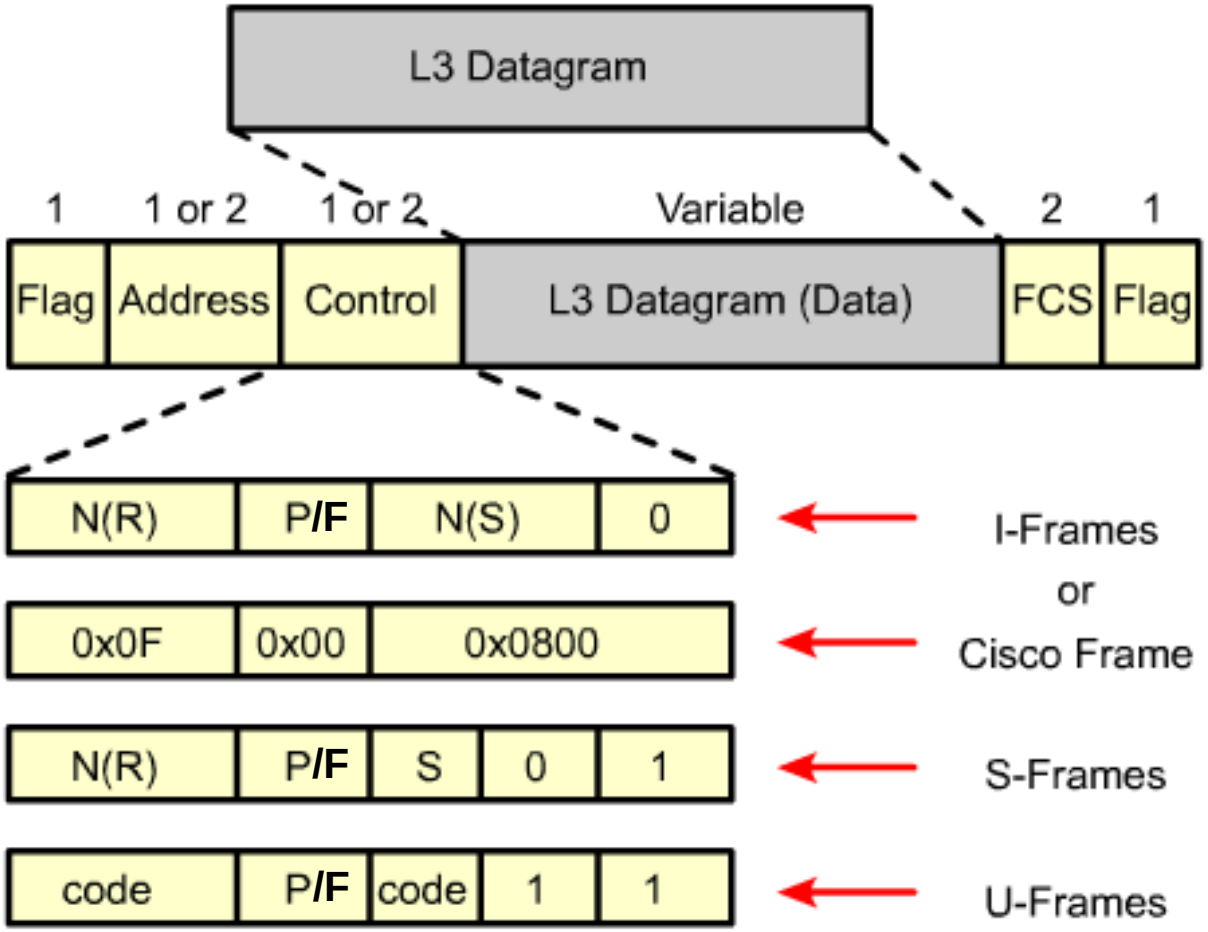
HDLC verzie – formát rámca

Standard and Cisco HLDC Frame Format




```
Opening Flag, 8 bits [01111110], [7E Hex]
Address, 8 bits [ môže byť viac]
Control, 8 bits, or 16 bits
Data [Payload], Variabilná dĺžka
CRC, 16 bits, or 32 bits
Closing Flag, 8 bits [01111110], [7E hex]
```

HDLC Typy rámcov



- **Information frames (I-frames)** – Carry the data to be transmitted for the station. Additional flow and error control data may be carried on an I-frame.
- **Supervisory frames (S-frames)** – provide error and flow control information. An S-frame can request and suspend transmission, report on status, and acknowledge receipt of I-frames (if no piggybacking).
- **Unnumbered frames (U-frames)** – Provide supplemental link control functions such as connection setup. The code field identifies the U-frame type.

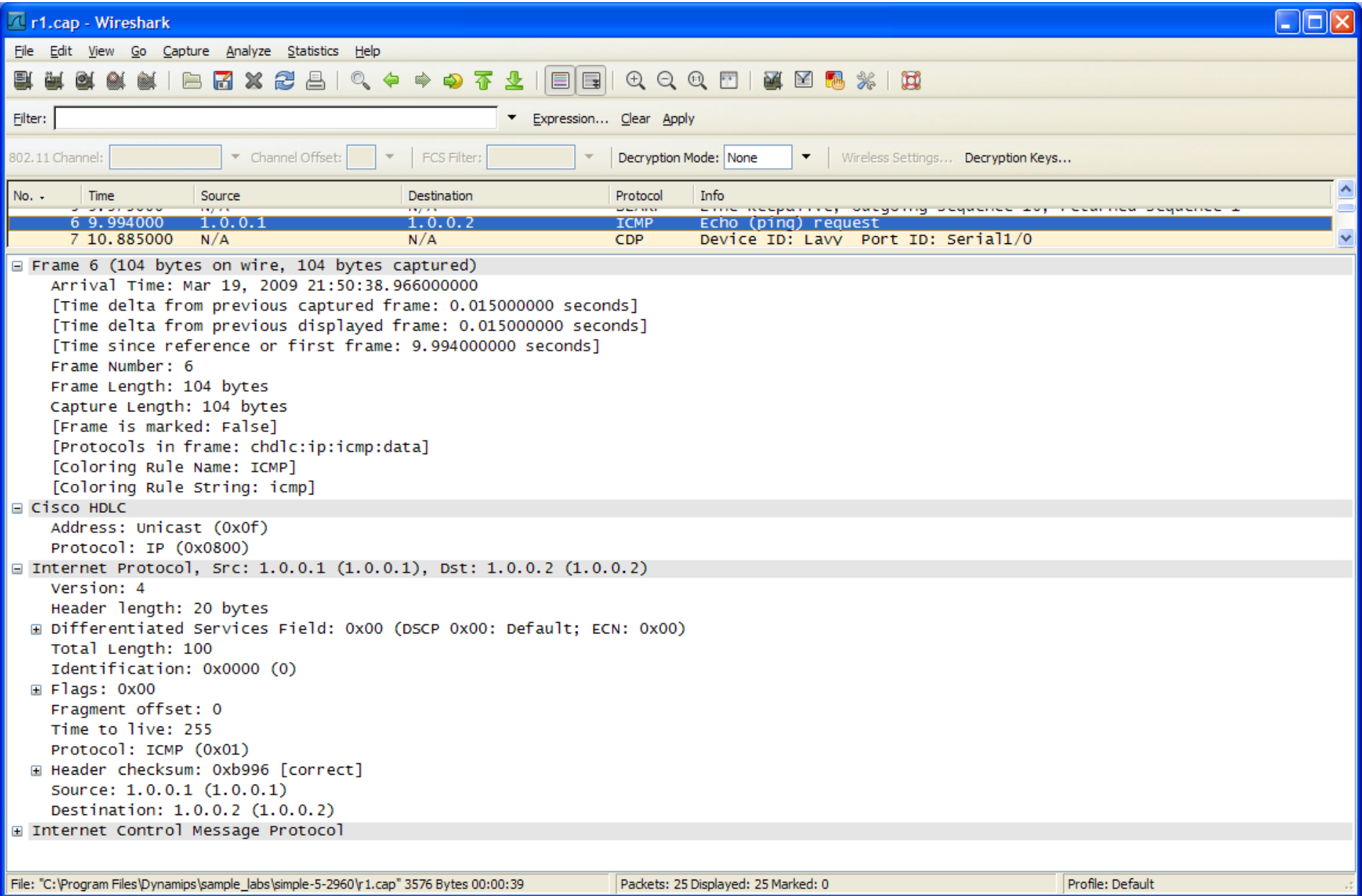
N(R) – receive seq. Numb.

N(S) – send seq. Numb.

Poll/Final

0x00 – 2 bit – indicate S messages (RR-Receive Ready, RNR-Receive Not Ready, REJ-Reject, SREJ-Selective Reject)

Wireshark sniff



Konfigurácia HDLC enkapsulácie

```
Router(config-if)#encapsulation hdlc
```

- cHDLC je defaultná WAN schéma na sériových rozhraniach

Diagnostika sériového rozhrania

```
Router#sh interfaces serial 0/0
Serial0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 1.1.1.1/8
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:01, output 00:00:01, output hang never
  Last clearing of "show interface" counters never
  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
     13 packets input, 1488 bytes, 0 no buffer
     Received 13 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     19 packets output, 2508 bytes, 0 underruns
     0 output errors, 0 collisions, 4 interface resets
     0 unknown protocol drops
```

Diagnostika sériového rozhrania

```
Router#sh controllers serial 0/0
Interface Serial0/0
Hardware is PowerQUICC MPC860
DCE 530, clock rate 64000
idb at 0x82561E58, driver data structure at 0x82569574
SCC Registers:
General [GSMR]=0x2:0x00000030, Protocol-specific [PSMR]=0x8
Events [SCCE]=0x0000, Mask [SCCM]=0x001F, Status [SCCS]=0x00
Transmit on Demand [TODR]=0x0, Data Sync [DSR]=0x0
Interrupt Registers:
Config [CICR]=0x00367F80, Pending [CIPR]=0x00000000
Mask   [CIMR]=0x40204000, In-srv  [CISR]=0x00000000
Command register [CR]=0x0
Port A [PADIR]=0x0000, [PAPAR]=0x0000
       [PAODR]=0x0000, [PADAT]=0x0000
Port B [PBDIR]=0x00000, [PBPAR]=0x00000
       [PBODR]=0x00000, [PBDAT]=0x28400
Port C [PCDIR]=0x000, [PCPAR]=0x000
       [PCSO]=0x000,  [PCDAT]=0x000, [PCINT]=0x000
Receive Ring
        rmd(680126B0): status 9000 length 60C address 376DCA4
        rmd(680126B8): status 9000 length 60C address 376D624
        rmd(680126C0): status 9000 length 60C address 376CFA4
        rmd(680126C8): status 9000 length 60C address 376C924
```

Diagnostika sériového rozhrania

```
Router#sh ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
Serial0/0                  1.1.1.1         YES manual up                    up
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/1                  unassigned      YES unset  administratively down down
```

Diagnostika sériového rozhrania

- Možné stavy rozhraní:
  - Serial *x* is down, line protocol is down.
  - Serial *x* is up, line protocol is down.
  - Serial *x* is up, line protocol is up (looped).
  - Serial *x* is up, line protocol is down (disabled).
  - Serial *x* is administratively down, line protocol is down.

show interface serial

Serial x is administratively down, line protocol is down	The router configuration includes the **shutdown** interface configuration command. A duplicate IP address exists.	1. Check the router configuration for the **shutdown** command. 2. Use the **no shutdown** interface configuration command to remove the **shutdown** command. 3. Verify that there are no identical IP addresses using the **show running-config** privileged exec command or the **show interfaces** exec command. 4. If there are duplicate addresses, resolve the conflict by changing one of the IP addresses.

show interface serial

Status Line	Possible Condition	Problem / Solution
Serial x is up, line protocol is up	This is the proper status line condition.	No action is required.
Serial x is down, line protocol is down (DTE mode)	The router is not sensing a CD signal, which means the CD is not active. A WAN carrier service provider problem has occurred, which means the line is down or is not connected to CSU/DSU. Cabling is faulty or incorrect. Hardware failure has occurred (CSU/DSU).	1. Check the LEDs on the CSU/DSU to see whether the CD is active, or insert a breakout box on the line to check for the CD signal. 2. Verify that the proper cable and interface are being used by looking at the hardware installation documentation. 3. Insert a breakout box and check all control leads. 4. Contact the leased-line or other carrier service to see whether there is a problem. 5. Swap faulty parts. 6. If faulty router hardware is suspected, change the serial line to another port. If the connection comes up, the previously connected interface has a problem.

show interface serial

Status Line	Possible Condition	Problem / Solution
Serial x is up, line protocol is down (DTE mode)	A local or remote router is misconfigured. Keepalives are not being sent by the remote router. A leased-line or other carrier service problem has occurred, which means a noisy line or misconfigured or failed switch. A timing problem has occurred on the cable, which means serial clock transmit external (SCTE) is not set on CSU/DSU. SCTE is designed to compensate for clock phase shift on long cables. When the DCE device uses SCTE instead of its internal clock to sample data from the DTE, it is better able to sample the data without error even if there is a phase shift in the cable. A local or remote CSU/DSU has failed. Router hardware, which could be either local or remote, has failed.	1. Put the modem, CSU, or DSU in local loopback mode and use the **`show interfaces serial`** command to determine whether the line protocol comes up. If the line protocol comes up, a WAN carrier service provider problem or a failed remote router is the likely problem. 2. If the problem appears to be on the remote end, repeat Step 1 on the remote modem, CSU, or DSU. 3. Verify all cabling. Make certain that the cable is attached to the correct interface, the correct CSU/DSU, and the correct WAN carrier service provider network termination point. Use the **`show controllers`** exec command to determine which cable is attached to which interface. 4. Enable the debug **`serial interface`** exec command. 5. If the line protocol does not come up in local loopback mode, and if the output of the **`debug serial interface`** exec command shows that the keepalive counter is not incrementing, a router hardware problem is likely. Swap the router interface hardware. 6. If the line protocol comes up and the keepalive counter increments, the problem is not in the local router. 7. If faulty router hardware is suspected, change the serial line to an unused port. If the connection comes up, the previously connected interface has a problem.

show interface serial

Status Line	Possible Condition	Problem / Solution
Serial x is up, line protocol is down (DCE mode)	The clockrate interface configuration command is missing. The DTE device does not support or is not set up for SCTE mode (terminal timing). The remote CSU or DSU has failed.	1. Add the **clockrate** interface configuration command on the serial interface. Syntax: **clockrate** *bps* Syntax Description:bps - Desired clock rate in bits per second: 1200, 2400, 4800, 9600, 19200, 38400, 56000, 64000, 72000, 125000, 148000, 250000, 500000, 800000, 1000000, 1300000, 2000000, 4000000, or 8000000 2. If the problem appears to be on the remote end, repeat Step 1 on the remote modem, CSU, or DSU. 3. Verify that the correct cable is being used. 4. If the line protocol is still down, there is a possible hardware failure or cabling problem. Insert a breakout box and observe leads. 5. Replace faulty parts as necessary.

show interface serial

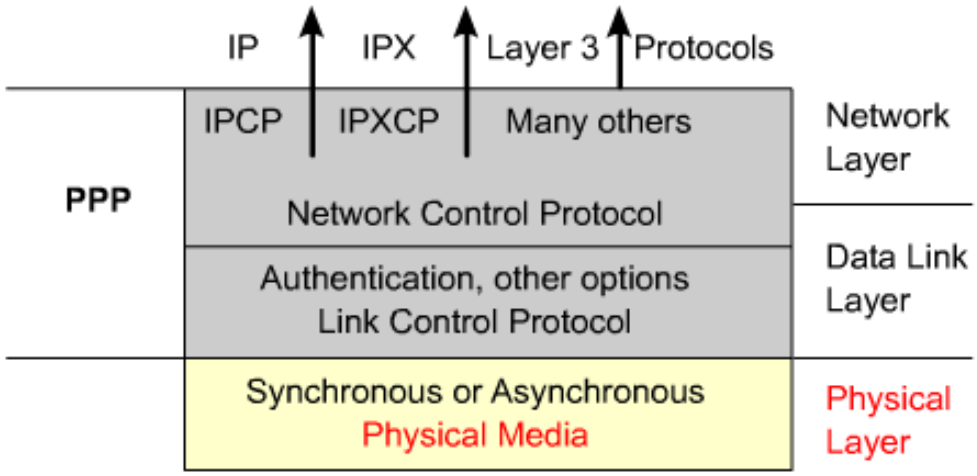
Status Line	Possible Condition	Problem / Solution
Serial x is up, line protocol is up (looped)	A loop exists in the circuit. The sequence number in the keepalive packet changes to a random number when a loop is initially detected. If the same random number is returned over the link, a loop exists.	1. Use the **show running-config** privileged exec command to look for any **loopback** interface configuration command entries. 2. If there is a **loopback** interface configuration command entry, use the **no loopback** interface configuration command to remove the loop. 3. If there is no **loopback** interface configuration command, examine the CSU/DSU to determine whether they are configured in manual loopback mode. If they are, disable manual loopback. 4. After disabling loopback mode on the CSU/DSU, reset the CSU/DSU, and inspect the line status. If the line protocol comes up, no other action is needed. 5. If upon inspection, that the CSU or DSU cannot be manually set, then contact the leased-line or other carrier service for line troubleshooting assistance.
Serial x is up, line protocol is down (disabled)	A high error rate has occurred due to a WAN service provider problem. A CSU or DSU hardware problem has occurred. Router hardware (interface) is bad.	1. Troubleshoot the line with a serial analyzer and breakout box. Look for toggling CTS and DSR signals. 2. Loop CSU/DSU (DTE loop). If the problem continues, it is likely that there is a hardware problem. If the problem does not continue, it is likely that there is a WAN service provider problem. 3. Swap out bad hardware as required (CSU, DSU, switch, local or remote router).

PPP protokol

PPP

- Štandardizovaná schéma pre sériovu synchrónnu aj asynchrónnu komunikáciu (RFC1661, 1662)
  - Vhodné do mixovaného prostredia
    - Rôzne smerovače
- PPP komponenty:
  - **HDLC**
    - Definuje enkapsuláciu datagramov cez ppp linku
  - **Link Control Protocol (LCP)**
    - Založenie, konfigurácia, testovanie a ukončenie spojenia
  - **Network Control Protocols (NCPs)**
    - Založenie a konfigurácia L3 protokolov cez ppp linku
      - Internet Protocol Control Protocol, Appletalk Control Protocol, Novell IPX Control Protocol, Cisco Systems Control Protocol, SNA Control Protocol, and Compression Control Protocol.

PPP vrstvená architektúra – fyzická vrstva

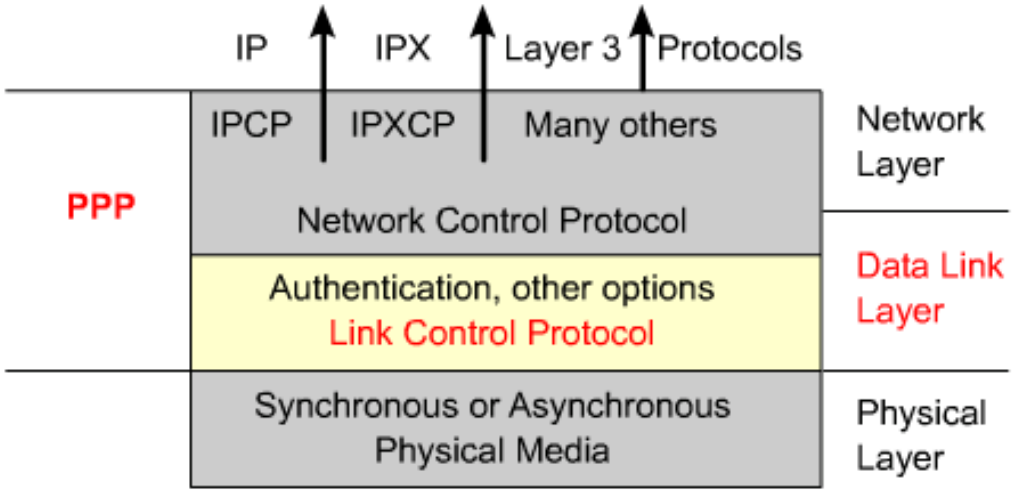


With its lower-level functions, PPP can use:

- Synchronous physical media
- Asynchronous physical media like those that use basic telephone service for modem dialup connections.

- PPP pracuje cez:
  - Asynchronous serial
    - Dialup
  - Synchronous serial
    - SONET/SDH
  - High-Speed Serial Interface (HSSI)
  - DSL
    - PPPoE, PPPoA
  - Integrated Services Digital Network (ISDN)

PPP vrstvená architektúra – L2 - LCP



- PPP offers a rich set of services that control setting up a data link.
- These services are options in LCP and are primarily negotiation and checking frames to implement the point-to-point controls an administrator specifies for the call.

- LCP
  - Je umiestnený v stacku nad L1 vrstvou
  - Používa sa na založenie, konfiguráciu a testovanie spojenia cez linku

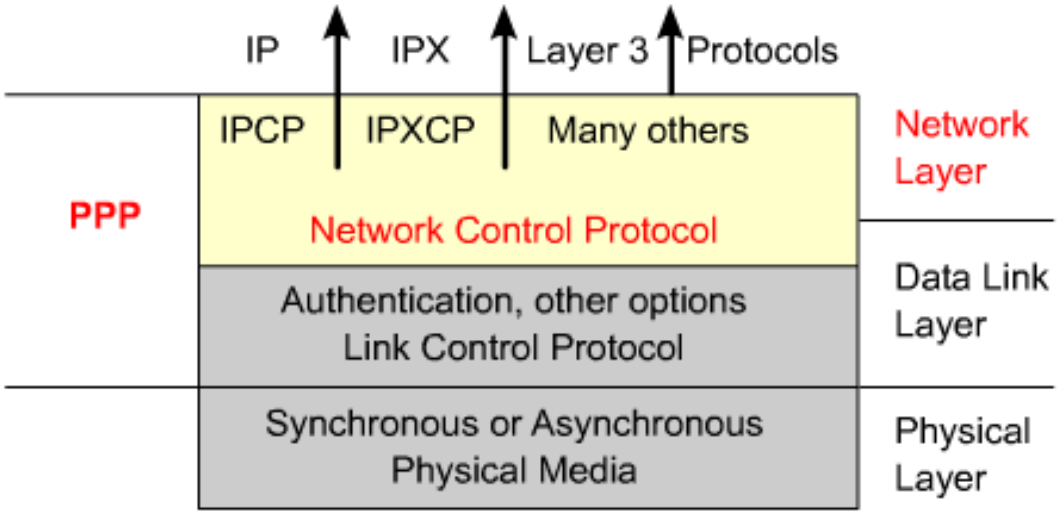
PPP vrstvená architektúra - LCP

- LCP functions
  - **Authentication**
    - Password Authentication Protocol (PAP)
    - Challenge Handshake Authentication Protocol (CHAP).
  - **Compression**
    - increase the effective throughput on PPP connections The protocol decompresses the frame at its destination.
    - Two compression protocols available on Cisco routers:
      - Stacker
      - Predictor.
  - **Error detection**
    - Allow to identify fault conditions. The Quality and Magic Number options help ensure a reliable, loop-free data link.
  - **Multilink**
  - **PPP Callback**
    - Cisco router can act as a callback client or as a callback server.
    - The client makes the initial call, requests that it be called back, and terminates its initial call.
    - The callback router answers the initial call and makes the return call to the client based on its configuration statements.

PPP vrstvená architektúra - LCP

- Iné funkcie LCP
  - Dohoduje veľkosť rámcov
  - Deteguje všeobecné konfiguračné chyby
  - Ukončuje linku
  - Určuje kedy linka pracuje správne a kedy s chybovosťou

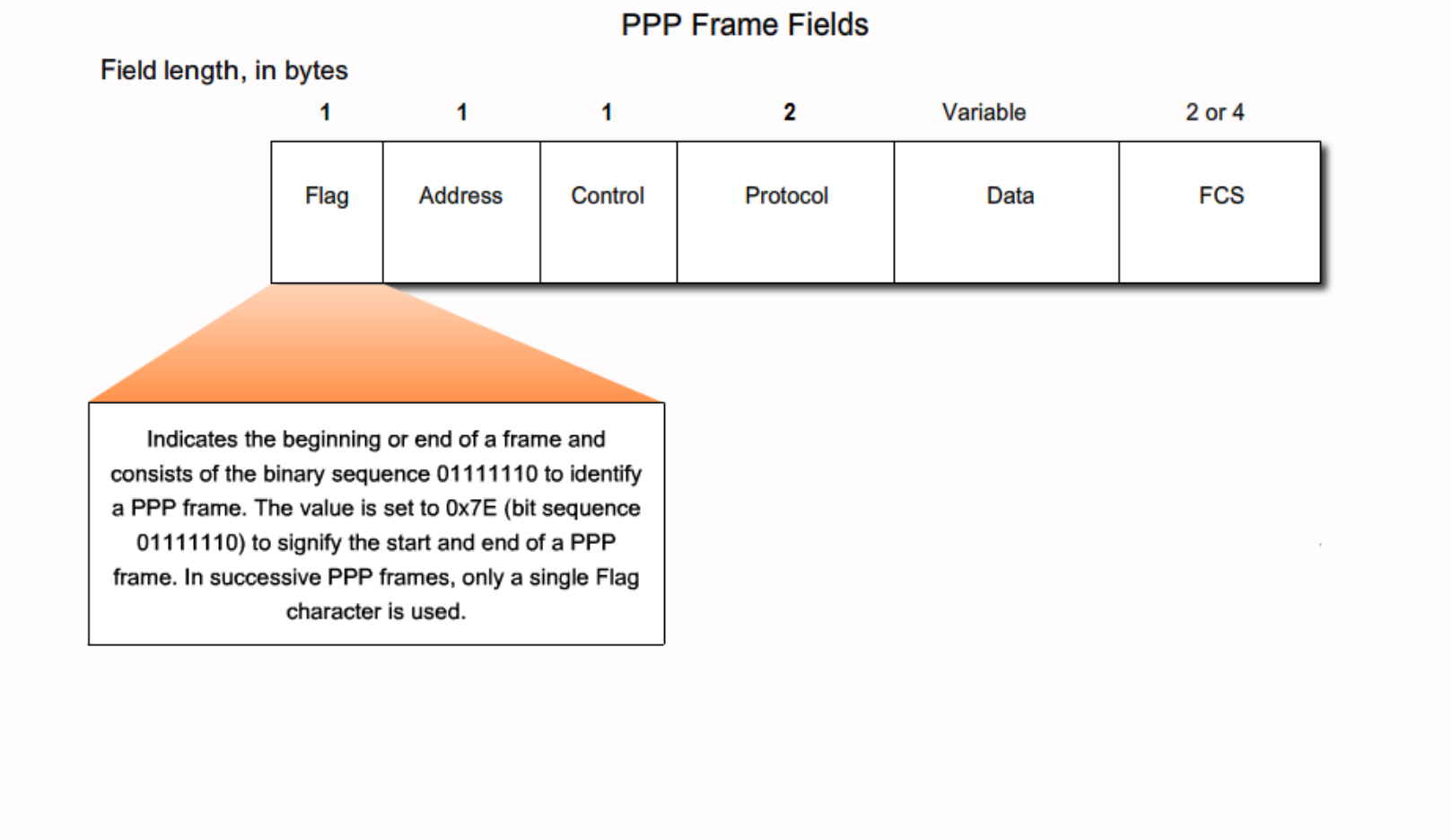
PPP vrstvená architektúra - NCP



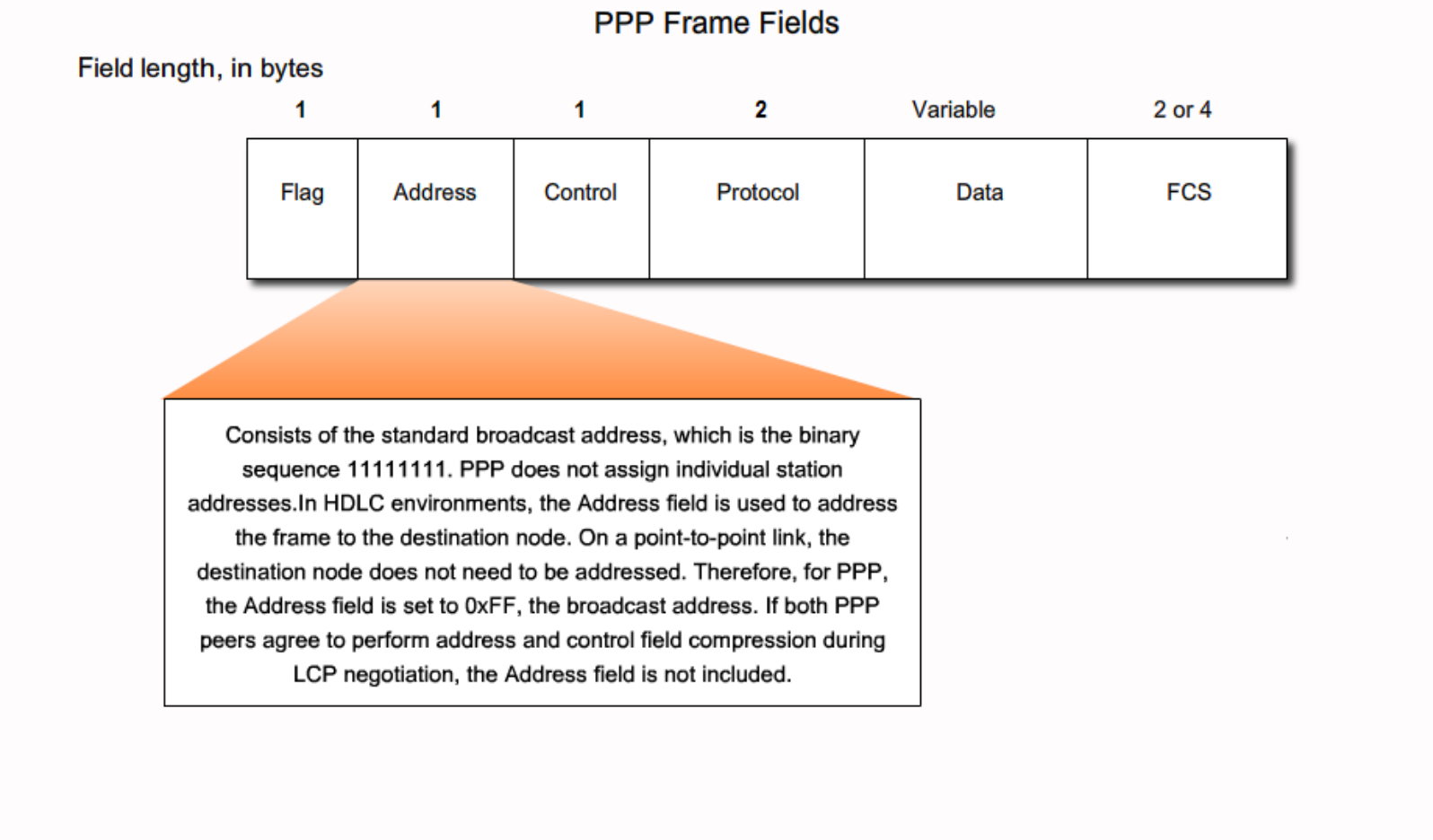
- With its higher-level functions, PPP carries packets from several network-layer protocols in NCPs.
- These are functional fields containing standardized codes to indicate the network-layer protocol type that PPP encapsulates.

- Umožňuje prenos viacerých L3 protokolov cez L2 WAN PPP linku

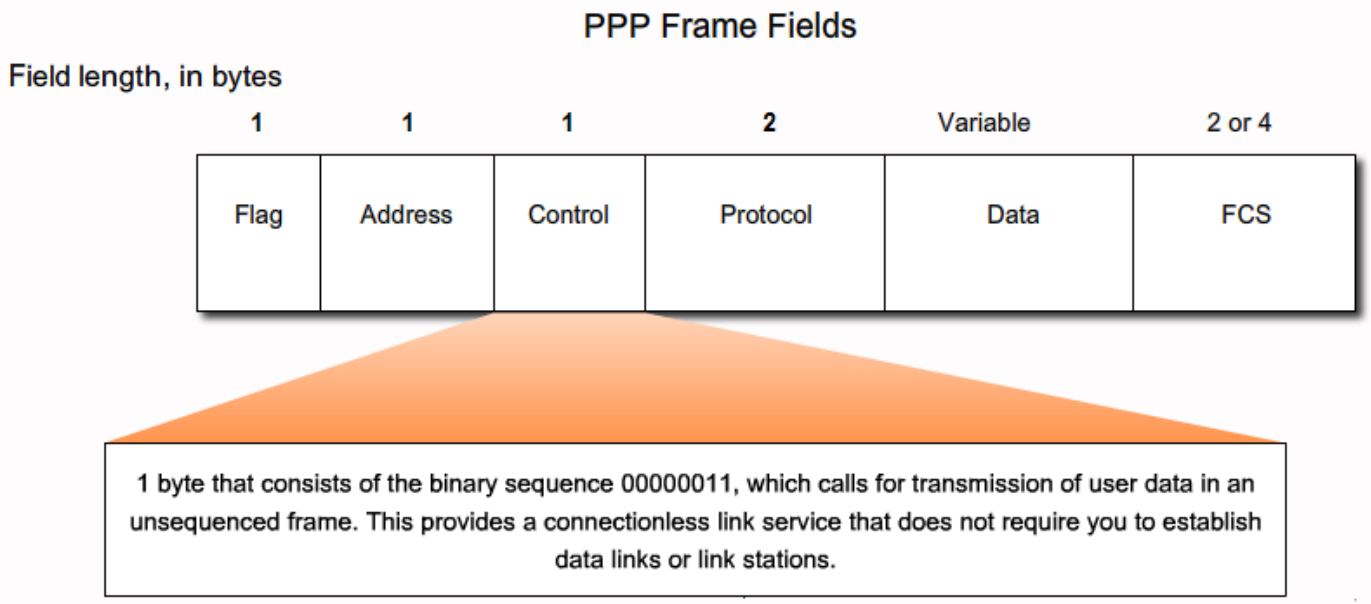
PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
Indicates the beginning or end of a frame and consists of the binary sequence 01111110 to identify a PPP frame. The value is set to 0x7E (bit sequence 01111110) to signify the start and end of a PPP frame. In successive PPP frames, only a single Flag character is used.

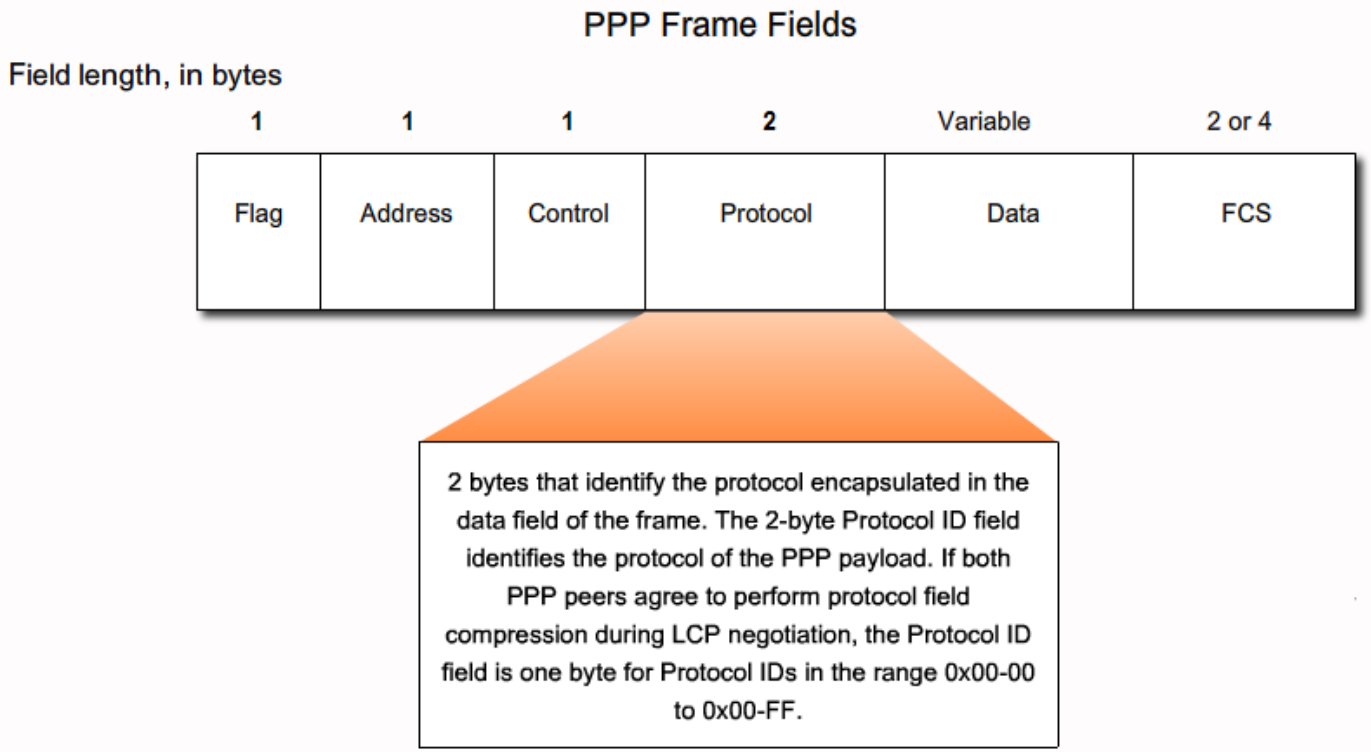
PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
Consists of the standard broadcast address, which is the binary sequence 11111111. PPP does not assign individual station addresses.In HDLC environments, the Address field is used to address the frame to the destination node. On a point-to-point link, the destination node does not need to be addressed. Therefore, for PPP, the Address field is set to 0xFF, the broadcast address. If both PPP peers agree to perform address and control field compression during LCP negotiation, the Address field is not included.

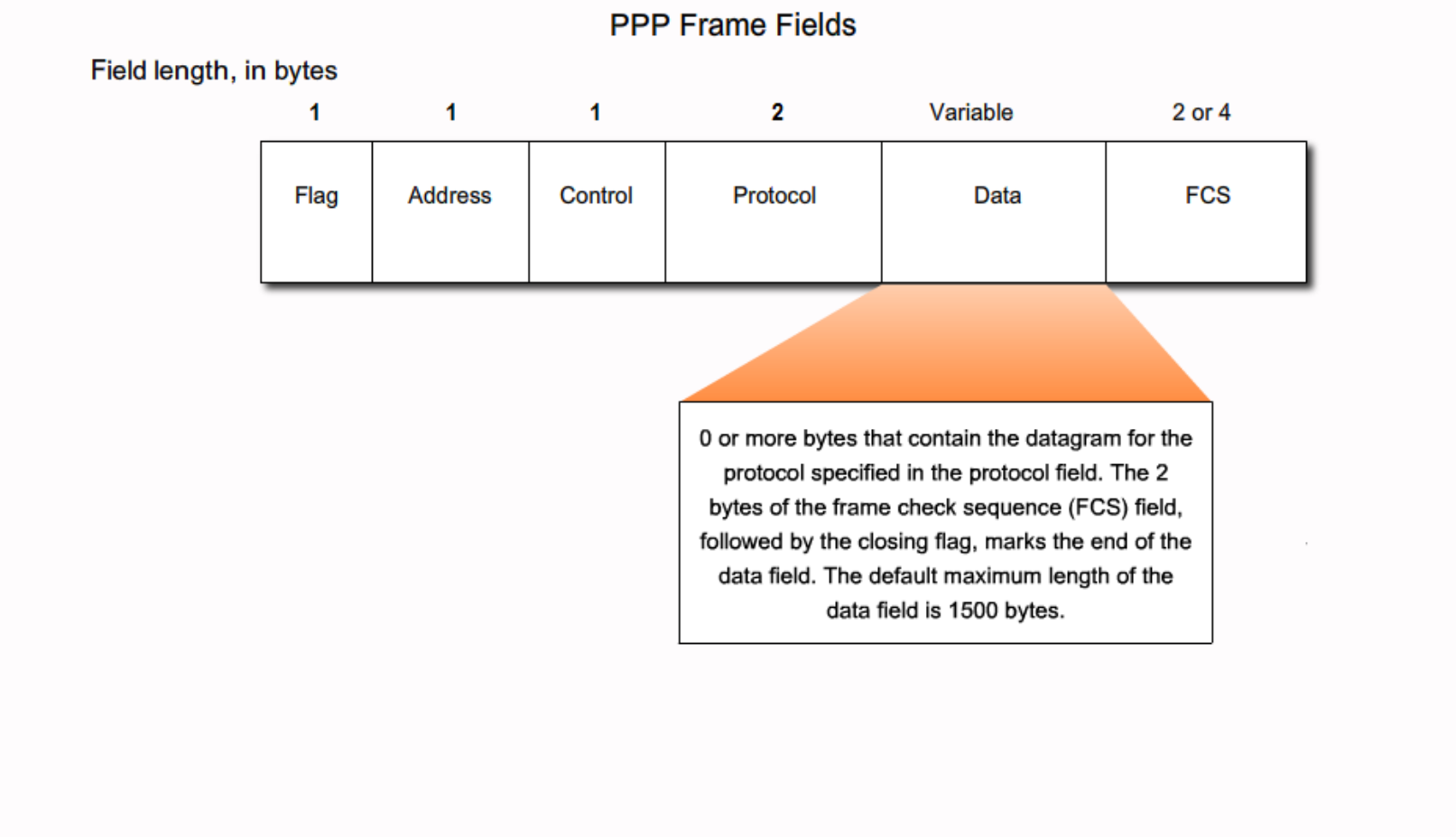
PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
1 byte that consists of the binary sequence 00000011, which calls for transmission of user data in an unsequenced frame. This provides a connectionless link service that does not require you to establish data links or link stations.

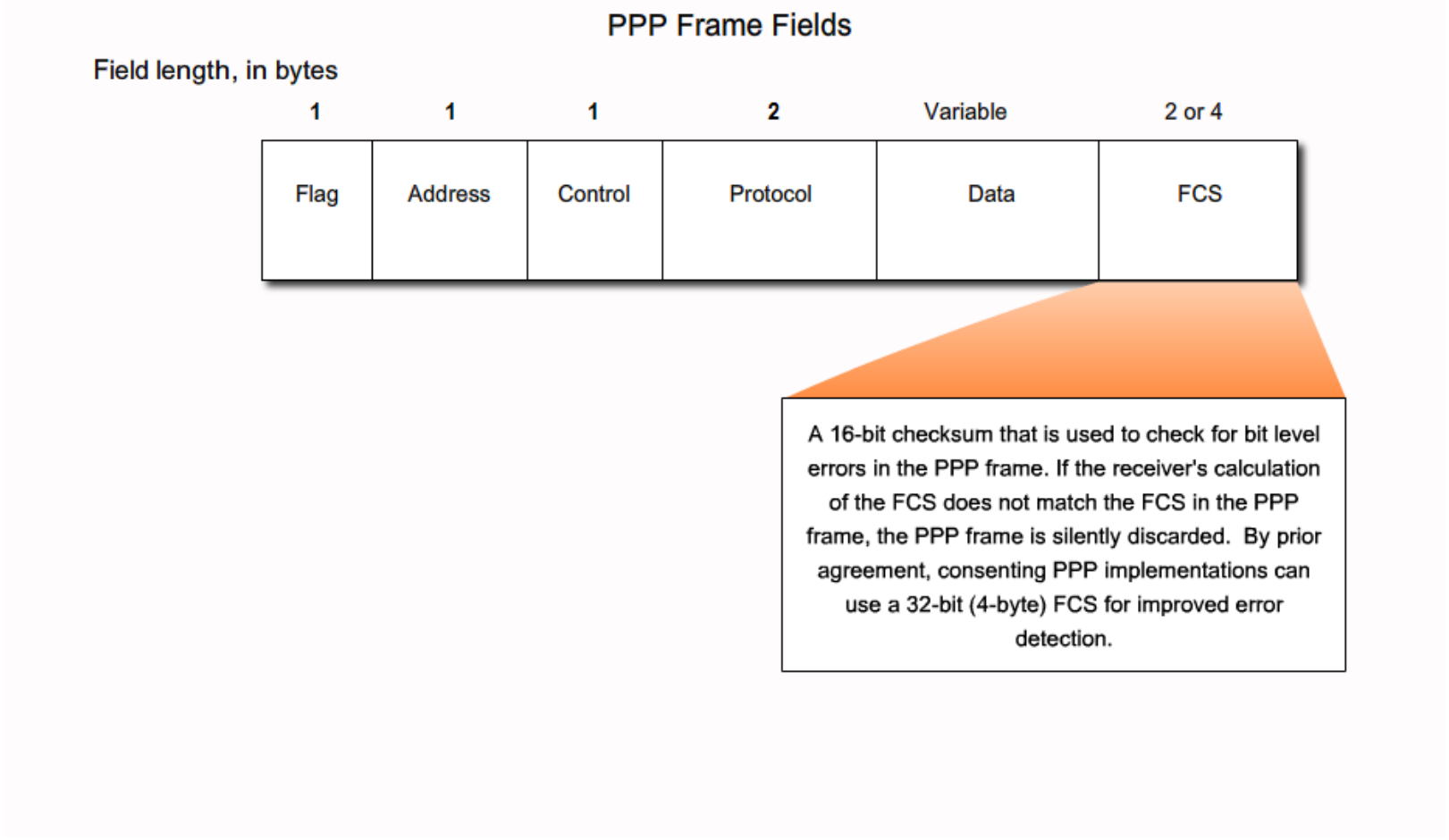
PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
2 bytes that identify the protocol encapsulated in the data field of the frame. The 2-byte Protocol ID field identifies the protocol of the PPP payload. If both PPP peers agree to perform protocol field compression during LCP negotiation, the Protocol ID field is one byte for Protocol IDs in the range 0x00-00 to 0x00-FF.

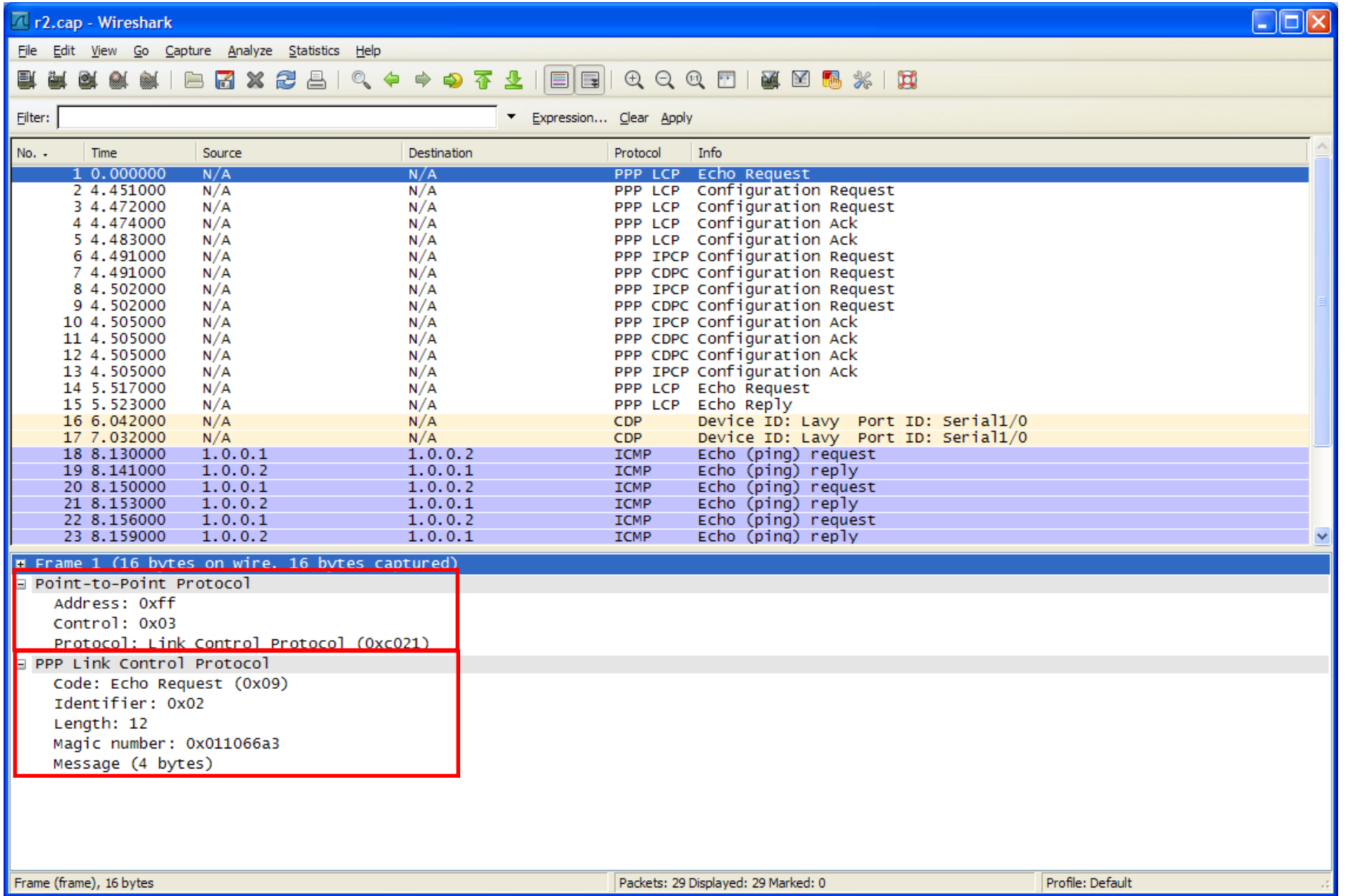
PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
0 or more bytes that contain the datagram for the protocol specified in the protocol field. The 2 bytes of the frame check sequence (FCS) field, followed by the closing flag, marks the end of the data field. The default maximum length of the data field is 1500 bytes.

PPP frame


PPP Frame Fields
Field length, in bytes
1
1
1
2
Variable
2 or 4
Flag
Address
Control
Protocol
Data
FCS
A 16-bit checksum that is used to check for bit level errors in the PPP frame. If the receiver's calculation of the FCS does not match the FCS in the PPP frame, the PPP frame is silently discarded. By prior agreement, consenting PPP implementations can use a 32-bit (4-byte) FCS for improved error detection.

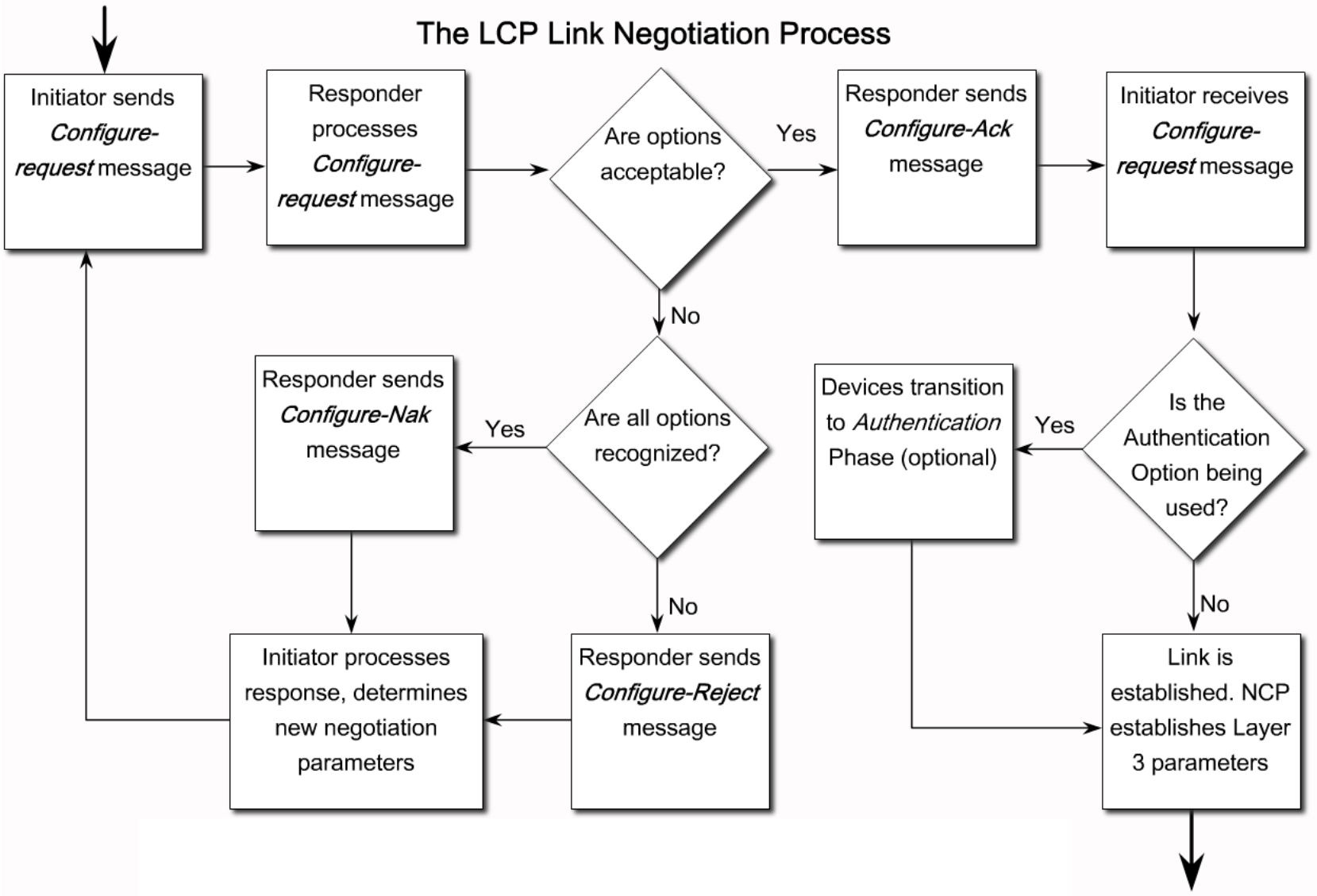
PPP frame - wireshark



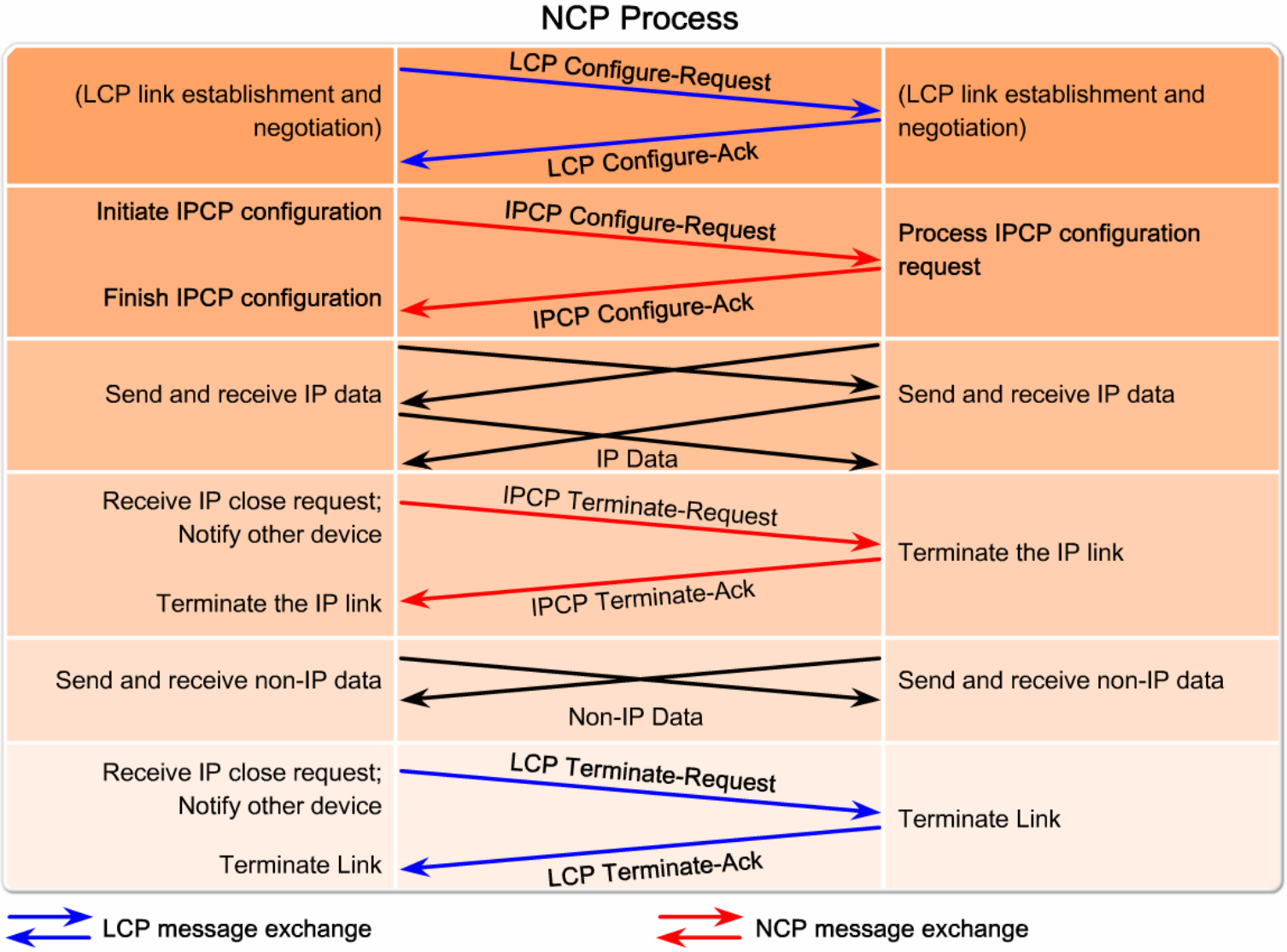
Establishing a PPP Session - Phases

- The three PPP session establishment phases are:
  - **Link-establishment phase**
    - LCP is used to configure and test the data link.
    - LCP frames contain a configuration option which allows devices to negotiate the use of options such as the maximum transmission unit (MTU), compression of certain PPP fields, and the link-authentication protocol.
    - This phase is complete when a configuration acknowledgment frame has been sent and received.
  - **Link quality determination (optional) and Authentication phase (optional)**
    - It takes place before the network layer protocol phase is entered.
    - Optionaly link-quality determination test is made.
    - The link is tested to determine whether the link quality is good enough to bring up network layer protocols.
  - **Network layer protocol phase**
    - NCP is used to choose and configure one or more network layer protocols, such as IP, IPX, etc.

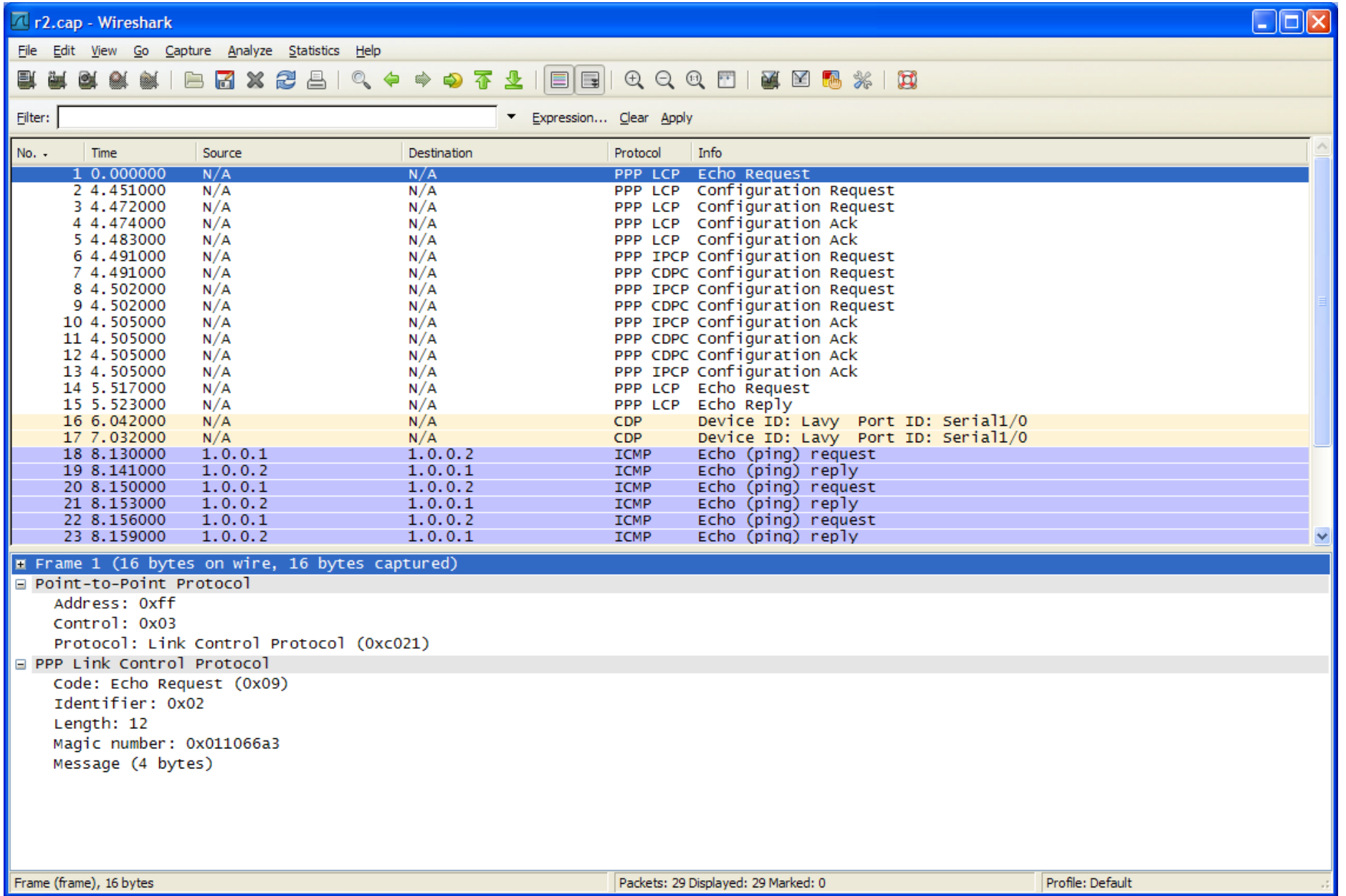
LCP Operation



NCP Operation – IP protokol

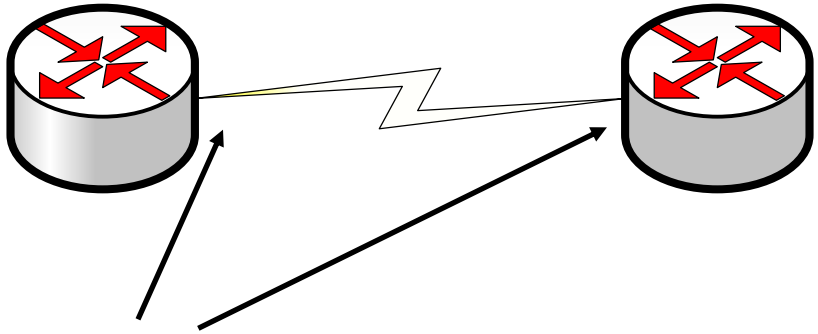


Wireshark – založenie spojenia



PPP konfigurácia

Spustenie PPP



```
Router(config-if)#encapsulation ppp
```

```
Router#sh int s 1/0
Serial1/0 is up, line protocol is up
  Hardware is M4T
  Internet address is 1.1.1.1/8
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Open: IPCP, CDPCP, crc 16, loopback not set
  Keepalive set (10 sec)
  Restart-Delay is 0 secs
```

```
Router#sh ip int brief
Interface                  IP-Address      OK? Method Status
   Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial1/0                  1.1.1.1         YES manual up                    up
```

Ďalšie konfiguračné možnosti PPP

- Kompresia

```
Router(config-if)#compress ?
  lzs         lzs compression type
  mppc        MPPC compression type
  predictor   predictor compression type
  stac        stac compression algorithm
```

- Kvalita

```
Router(config-if)#ppp quality ?
  <0-100>  Minimum percent of traffic successful
  reject   Reject Link Quality Monitoring negotiation
```

- Load balance

```
Router(config-if)#ppp multilink ?
  endpoint    Configure the local Endpoint Discriminator
  group       Put interface in a multilink bundle
  mrru        Configure multilink MRRU values
  multiclass  Configure support for Multiclass Multilink
  queue       Specify link queuing parameters
```

Overenie a diagnostika

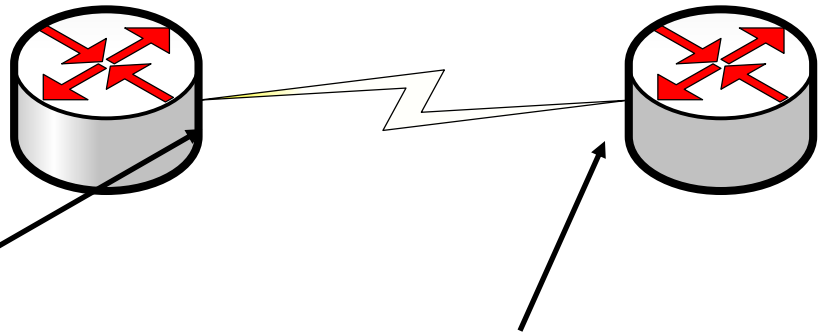
```
Router#show interface

Router#show interface serial

Router#debug ppp ?
  authentication  CHAP and PAP authentication
  bap             BAP protocol transactions
  cbcp            Callback Control Protocol negotiation
  elog            PPP ELOGs
  error           Protocol errors and error statistics
  forwarding      PPP layer 2 forwarding
  mppe            MPPE Events
  multilink       Multilink activity
  negotiation     Protocol parameter negotiation
  packet          Low-level PPP packet dump

Router#undebug all
```

Overenie PPP – linka OK

```
Router#debug ppp packet
PPP packet display debugging is on
Router#
*Mar  1 01:28:47.975: Se1/0 LCP: O ECHOREQ [Open] id 2 len 12 magic 0x006CEBBF
*Mar  1 01:28:48.003: Se1/0 LCP-FS: I ECHOREP [Open] id 2 len 12 magic 0x016CEB4A
*Mar  1 01:28:48.003: Se1/0 LCP-FS: Received id 2, sent id 2, line up
*Mar  1 01:28:52.067: Se1/0 LCP-FS: I ECHOREQ [Open] id 2 len 12 magic 0x016CEB4A
*Mar  1 01:28:52.067: Se1/0 LCP-FS: O ECHOREP [Open] id 2 len 12 magic 0x006CEBBF
*Mar  1 01:28:58.215: Se1/0 LCP: O ECHOREQ [Open] id 3 len 12 magic 0x006CEBBF
*Mar  1 01:28:58.227: Se1/0 LCP-FS: I ECHOREP [Open] id 3 len 12 magic 0x016CEB4A
*Mar  1 01:28:58.227: Se1/0 LCP-FS: Received id 3, sent id 3, line up
*Mar  1 01:29:02.287: Se1/0 LCP-FS: I ECHOREQ [Open] id 3 len 12 magic 0x016CEB4A
*Mar  1 01:29:02.287: Se1/0 LCP-FS: O ECHOREP [Open] id 3 len 12 magic 0x006CEBBF
```

```
Lavy#debug ppp negotiation
PPP protocol negotiation debugging is on
*Mar  1 03:22:41.579: Se1/0 PPP: Phase is ESTABLISHING
*Mar  1 03:22:41.579: Se1/0 LCP: O CONFREQ [Open] id 59 len 10
*Mar  1 03:22:41.579: Se1/0 LCP:    MagicNumber 0x00D57203 (0x050600D57203)
*Mar  1 03:22:41.587: Se1/0 LCP: I CONFACK [REQsent] id 59 len 10
*Mar  1 03:22:41.587: Se1/0 LCP:    MagicNumber 0x00D57203 (0x050600D57203)
*Mar  1 03:22:41.587: Se1/0 LCP: I CONFREQ [ACKrcvd] id 221 len 18
*Mar  1 03:22:41.587: Se1/0 LCP:    MagicNumber 0x01D571FE (0x050601D571FE)
*Mar  1 03:22:41.587: Se1/0 LCP:    EndpointDisc 1 Pravy (0x1308015072617679)
*Mar  1 03:22:41.587: Se1/0 LCP: O CONFACK [ACKrcvd] id 221 len 18
*Mar  1 03:22:41.587: Se1/0 LCP:    MagicNumber 0x01D571FE (0x050601D571FE)
*Mar  1 03:22:41.587: Se1/0 LCP:    EndpointDisc 1 Pravy (0x1308015072617679)
*Mar  1 03:22:41.587: Se1/0 LCP: State is Open
*Mar  1 03:22:41.591: Se1/0 PPP: Phase is FORWARDING, Attempting Forward
*Mar  1 03:22:41.591: Se1/0 PPP: Phase is ESTABLISHING, Finish LCP
*Mar  1 03:22:41.591: Se1/0 PPP: Phase is UP
*Mar  1 03:22:41.591: Se1/0 IPCP: O CONFREQ [Closed] id 1 len 10
*Mar  1 03:22:41.595: Se1/0 IPCP:    Address 1.1.1.1 (0x030601010101)
*Mar  1 03:22:41.595: Se1/0 CDPCP: O CONFREQ [Closed] id 1 len 4
*Mar  1 03:22:41.595: Se1/0 PPP: Process pending ncp packets
*Mar  1 03:22:41.595: Se1/0 CDPCP: I CONFREQ [REQsent] id 1 len 4
*Mar  1 03:22:41.595: Se1/0 CDPCP: O CONFACK [REQsent] id 1 len 4
*Mar  1 03:22:41.595: Se1/0 IPCP: I CONFREQ [REQsent] id 1 len 10
*Mar  1 03:22:41.595: Se1/0 IPCP:    Address 1.1.1.2 (0x030601010102)
*Mar  1 03:22:41.595: Se1/0 IPCP: O CONFACK [REQsent] id 1 len 10
*Mar  1 03:22:41.595: Se1/0 IPCP:    Address 1.1.1.2 (0x030601010102)
*Mar  1 03:22:41.603: Se1/0 IPCP: I CONFACK [ACKsent] id 1 len 10
*Mar  1 03:22:41.607: Se1/0 IPCP:    Address 1.1.1.1 (0x030601010101)
*Mar  1 03:22:41.607: Se1/0 IPCP: State is Open
*Mar  1 03:22:41.611: Se1/0 CDPCP: I CONFACK [ACKsent] id 1 len 4
*Mar  1 03:22:41.611: Se1/0 CDPCP: State is Open
*Mar  1 03:22:41.627: Se1/0 IPCP: Install route to 1.1.1.2
```

Overenie PPP - Príklad 1



```
Router(config-if)#encapsulation ppp
```

Ostane default cHDLC

```
Router#sh int s 1/0
Serial1/0 is up, line protocol is down
  Hardware is M4T
  Internet address is 1.1.1.1/8
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Open: IPCP, CDPCP, crc 16, loopback not set
  Keepalive set (10 sec)
  Restart-Delay is 0 secs
```

```
Router#sh ip int brief
Interface                  IP-Address      OK? Method Status
   Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial1/0                  1.1.1.1         YES manual up                    down
```

Overenie PPP - Príklad 1

```
Router#debug ppp packet
*Mar  1 01:15:13.815: Se1/0 PPP: O pkt type 0x0207, datagramsize 324
*Mar  1 01:15:13.827: Se1/0 PPP: I pkt type 0x008F, datagramsize 324 link[illegal]
*Mar  1 01:15:13.827: Se1/0 UNKNOWN(0x008F): Non-NCP packet, discarding
*Mar  1 01:15:15.847: Se1/0 LCP: O ECHOREQ [Open] id 19 len 12 magic 0x0035EB56
*Mar  1 01:15:15.847: Se1/0 LCP: echo_cnt 2, sent id 19, line up
*Mar  1 01:15:18.979: Se1/0 PPP: I pkt type 0x008F, datagramsize 24 link[illegal]
*Mar  1 01:15:18.979: Se1/0 UNKNOWN(0x008F): Non-NCP packet, discarding
*Mar  1 01:15:26.087: Se1/0 LCP: O ECHOREQ [Open] id 20 len 12 magic 0x0035EB56
*Mar  1 01:15:26.087: Se1/0 LCP: echo_cnt 3, sent id 20, line up
*Mar  1 01:15:28.983: Se1/0 PPP: I pkt type 0x008F, datagramsize 24 link[illegal]
*Mar  1 01:15:28.983: Se1/0 UNKNOWN(0x008F): Non-NCP packet, discarding
*Mar  1 01:15:29.983: Se1/0 PPP: I pkt type 0x008F, datagramsize 18 link[illegal]
*Mar  1 01:15:29.983: Se1/0 UNKNOWN(0x008F): Non-NCP packet, discarding
```

Overenie PPP - Príklad 1

```
Router#debug ppp negotiation
PPP protocol negotiation debugging is on
*Mar  1 01:17:39.171: Se1/0 LCP: Timeout: State Listen
*Mar  1 01:17:39.175: Se1/0 LCP: O CONFREQ [Listen] id 164 len 10
*Mar  1 01:17:39.179: Se1/0 LCP:    MagicNumber 0x0062F739 (0x05060062F739)
*Mar  1 01:17:41.187: Se1/0 LCP: Timeout: State REQsent
*Mar  1 01:17:41.191: Se1/0 LCP: O CONFREQ [REQsent] id 165 len 10
*Mar  1 01:17:41.191: Se1/0 LCP:    MagicNumber 0x0062F739 (0x05060062F739)
*Mar  1 01:17:43.203: Se1/0 LCP: Timeout: State REQsent
*Mar  1 01:17:43.207: Se1/0 LCP: O CONFREQ [REQsent] id 166 len 10
*Mar  1 01:17:43.207: Se1/0 LCP:    MagicNumber 0x0062F739 (0x05060062F739)
*Mar  1 01:17:45.219: Se1/0 LCP: Timeout: State REQsent
*Mar  1 01:17:45.219: Se1/0 LCP: O CONFREQ [REQsent] id 167 len 10
*Mar  1 01:17:45.219: Se1/0 LCP:    MagicNumber 0x0062F739 (0x05060062F739)
*Mar  1 01:17:47.235: Se1/0 LCP: Timeout: State REQsent
*Mar  1 01:17:47.239: Se1/0 LCP: O CONFREQ [REQsent] id 168 len 10
*Mar  1 01:17:47.239: Se1/0 LCP:    MagicNumber 0x0062F739 (0x05060062F739)
*Mar  1 01:17:49.251: Se1/0 LCP: Timeout: State REQsent
```

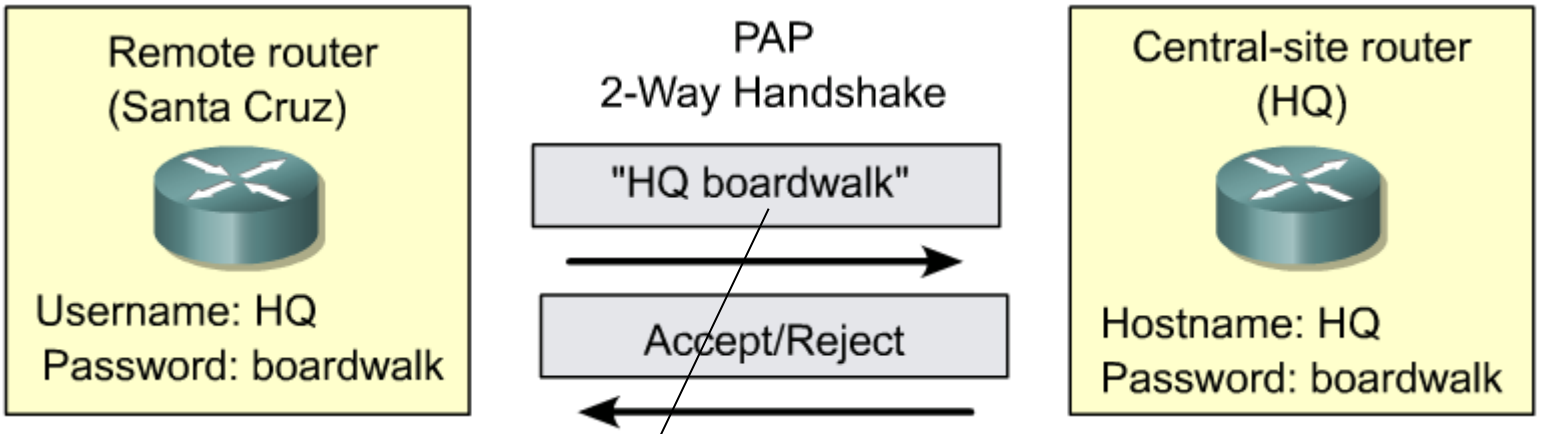
we're talking ppp, but the other end doesn't.

PPP autentifikácia

Autentifikácia v PPP

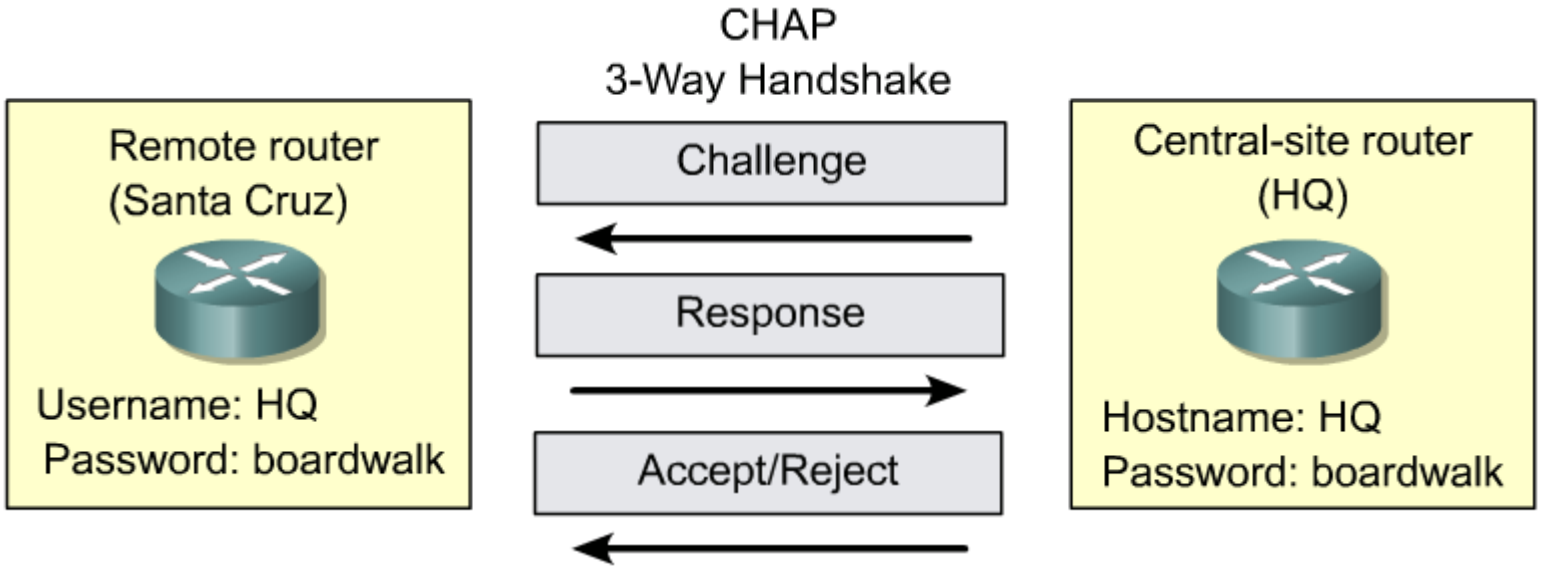
- Password Authentication Protocol (PAP)
- Challenge Handshake Authentication Protocol (CHAP)

Password Authentication Protocol (PAP)



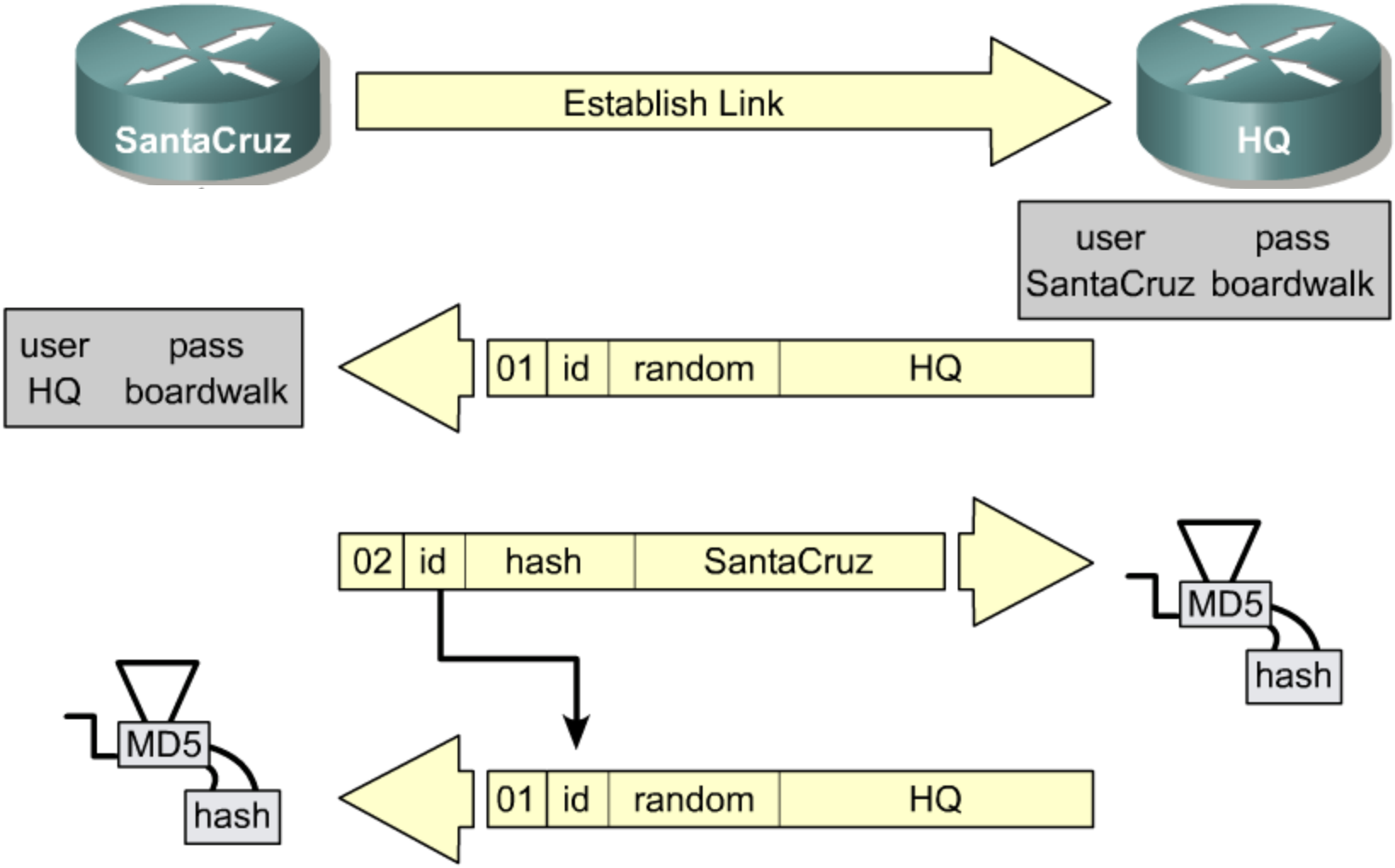
- Heslo posielané ako text
- Opakovane posielané až kým druhá strana nepotvrdí = **PROBLÉM (trial-and-error attacks)**

Challenge Handshake Authentication Protocol (CHAP)



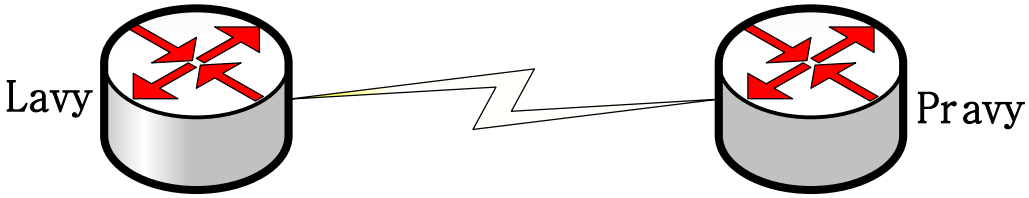
- CHAP poskytuje ochranu voči „playback“ útokom
  - používa náhodný challenge mechanizmus
- Heslo nie je posielané
  - je zdieľané medzi autentifikujúcimi smerovačmi

Autentifikačný proces v CHAP



Konfigurácia autentifikácie

PAP autentifikácia




```
Pravy(config)#username Lavy password heslo
Pravy(config)#int serial 1/0
Pravy(config-if)#encapsulation ppp
Pravy(config-if)#ppp authentication pap
```

```
Lavy(config)#int s 1/0
Lavy(config-if)#encapsulation ppp
Lavy(config-if)#ppp pap sent-username Lavy password heslo
```

Pozn. Rozhrania musia mať samozrejme IP adresy a byť aktívne

Overenie PPP PAP autentifikácie

```
Lavy#debug ppp authentication
*Mar  1 02:20:15.299: %LINK-3-UPDOWN: Interface Serial1/0, changed state
   to up
*Mar  1 02:20:15.307: Se1/0 PPP: Using default call direction
*Mar  1 02:20:15.311: Se1/0 PPP: Treating connection as a dedicated line
*Mar  1 02:20:15.315: Se1/0 PPP: Session handle[21000005] Session id[9]
*Mar  1 02:20:15.315: Se1/0 PPP: Authorization required
*Mar  1 02:20:15.343: Se1/0 PPP: No authorization without authentication
*Mar  1 02:20:15.343: Se1/0 PAP: Using hostname from interface PAP
*Mar  1 02:20:15.343: Se1/0 PAP: Using password from interface PAP
*Mar  1 02:20:15.343: Se1/0 PAP: O AUTH-REQ id 2 len 15 from "Lavy"
*Mar  1 02:20:15.351: Se1/0 PAP: I AUTH-ACK id 2 len 5
*Mar  1 02:20:16.351: %LINEPROTO-5-UPDOWN: Line protocol on Interface
   Serial1/0, change to up
```

Chybná autentifikácia – zlé heslo

```
Lavy#debug ppp authentication
Lavy(config)#conf t
Lavy(config)#int s 1/0
Lavy(config-if)#pap sent-username Lavy password ine_heslo
Lavy(config-if)#shut
Lavy(config-if)#no shut
*Mar  1 02:51:28.027: Se1/0 PPP: Authorization required
*Mar  1 02:51:28.055: Se1/0 PPP: No authorization without authentication
*Mar  1 02:51:28.055: Se1/0 PAP: Using hostname from interface PAP
*Mar  1 02:51:28.059: Se1/0 PAP: Using password from interface PAP
*Mar  1 02:51:28.059: Se1/0 PAP: O AUTH-REQ id 9 len 19 from "lavy"
*Mar  1 02:51:28.087: Se1/0 PAP: I AUTH-NAK id 9 len 26 msg is "Authentication
   failed"
```

PAP autentifikácia - obojsmerná


```
Pravy(config)#username Lavy password heslo_2
Pravy(config)#int serial 1/0
Pravy(config-if)#encapsulation ppp
Pravy(config-if)#ppp authentication pap
Pravy(config-if)#ppp pap sent-username Pravy password heslo_1
```

```
Lavy(config)#username Pravy password heslo_1
Lavy(config)#int serial 1/0
Lavy(config-if)#encapsulation ppp
Lavy(config-if)#ppp authentication pap
Lavy(config-if)#ppp pap sent-username Lavy password heslo_2
```

Pozn. Heslo musí byť zhodné na oboch stranách

CHAP autentifikácia - jednosmerná


```
Pravy(config)#username Lavy password heslo
Pravy(config)#int serial 1/0
Pravy(config-if)#encapsulation ppp
Pravy(config-if)#ppp authentication chap
```

```
Lavy(config)#username Pravy password heslo
Lavy(config)#int serial 1/0
Lavy(config-if)#encapsulation ppp
```

Pozn. Heslo musí byť zhodné na oboch stranách

Databázy musia byť naoboch stranách

Overenie PPP CHAP autentifikácie

```
Lavy#debug ppp authentication
Lavy(config)#
*Mar  1 03:04:05.971: Se1/0 PPP: Authorization required
*Mar  1 03:04:05.987: Se1/0 PPP: No authorization without authentication
*Mar  1 03:04:06.011: Se1/0 CHAP: I CHALLENGE id 1 len 26 from "Pravy"
*Mar  1 03:04:06.027: Se1/0 CHAP: Using hostname from unknown source
*Mar  1 03:04:06.027: Se1/0 CHAP: Using password from AAA
*Mar  1 03:04:06.031: Se1/0 CHAP: O RESPONSE id 1 len 25 from "Lavy"
*Mar  1 03:04:06.051: Se1/0 CHAP: I SUCCESS id 1 len 4

Lavy(config)#do sh ip int brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial1/0                  1.1.1.1         YES manual up                    up
Serial1/1                  unassigned      YES unset  administratively down down
Serial1/2                  unassigned      YES unset  administratively down down
Serial1/3                  unassigned      YES unset  administratively down down
```

CHAP – neexistuje meno v DB

```
Pravy(config)#username Lavy password heslo
Pravy(config)#int serial 1/0
Pravy(config-if)#encapsulation ppp
Pravy(config-if)#ppp authentication chap
```

```
Lavy#debug ppp auth
PPP authentication debugging is on
Lavy(config)#username Iny_router password heslo
Lavy(config)#int serial 1/0
Lavy(config-if)#encapsulation ppp
Lavy#

*Mar  1 03:34:21.303: Se1/0 PPP: Authorization required
*Mar  1 03:34:21.303: Se1/0 PPP: No authorization without authentication
*Mar  1 03:34:19.303: Se1/0 CHAP: I CHALLENGE id 3 len 26 from "Pravy"
*Mar  1 03:34:19.303: Se1/0 CHAP: Unable to authenticate for peer
*Mar  1 03:34:21.315: Se1/0 PPP: Authorization required
*Mar  1 03:34:21.375: Se1/0 PPP: No authorization without authentication
```

Autentifikácie PAP a CHAP môžeme kombinovať

```
! LEN CHAP
Pravy(config-if)#ppp authentication chap

! LEN PAP
Pravy(config-if)#ppp authentication pap

! VYKONAJ OBE PAP PRVY, POTOM CHAP
Pravy(config-if)#ppp authentication pap chap

! VYKONAJ OBE CHAP PRVY, POTOM PAP
Pravy(config-if)#ppp authentication chap pap
```