A számítógépes hálózatok
Computer networks
Počítačové siete

Topológia / Topology

3

Network topology

Network Topology refers to layout of a network and how different nodes in a network are connected to each other and how they communicate.

Computer users log on to their networked computers without having to consider the sophisticated technology that enables them to use and share resources.

Differences Between Topologies

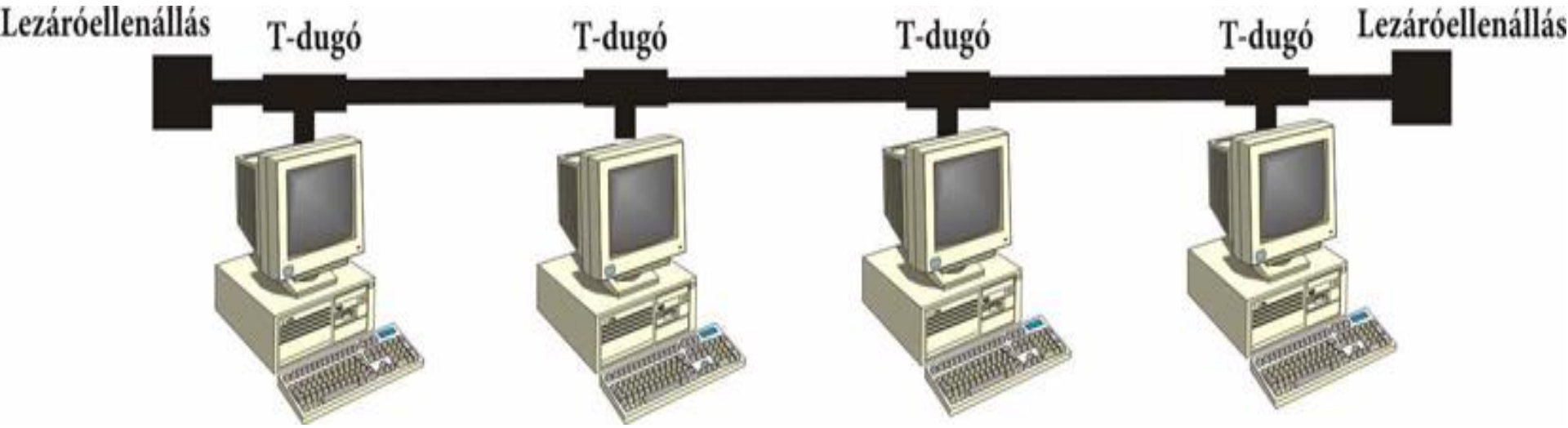
The structure of a computer network is known as the topology. Differences between topologies, such as in bus and ring networks, can have a significant impact on a network's performance and fault tolerance.

The most common

network topologies are:

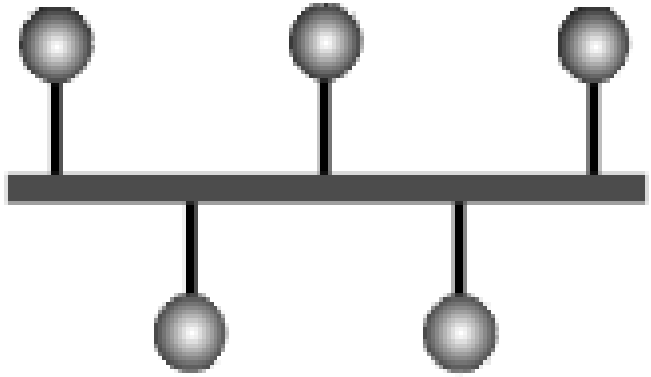
- Bus topology
- Star topology
- Ring topology
- Tree topology
- Mesh topology

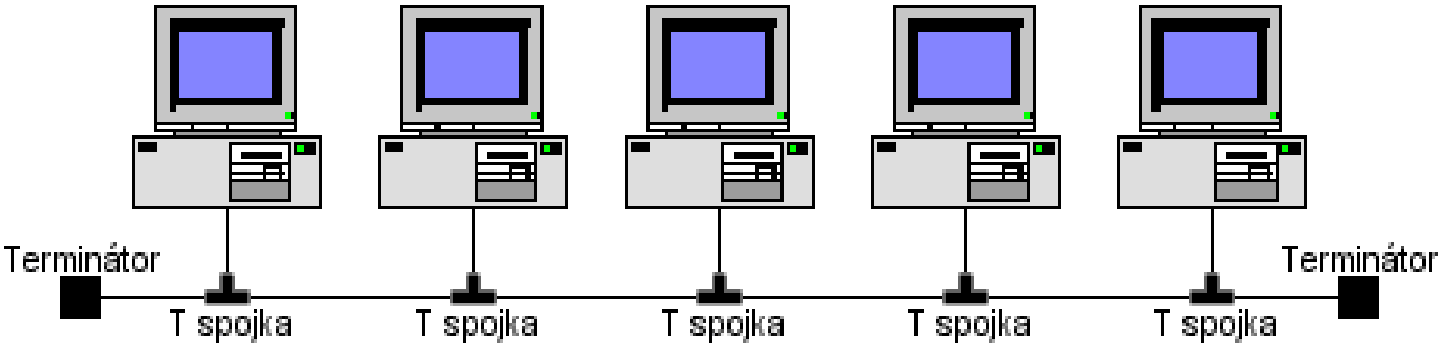
Sín (busz) topológia



Podľa fyzickej topológie 1

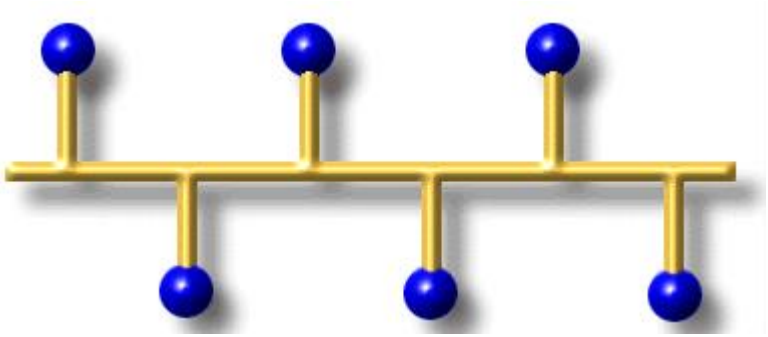
Zbernicová





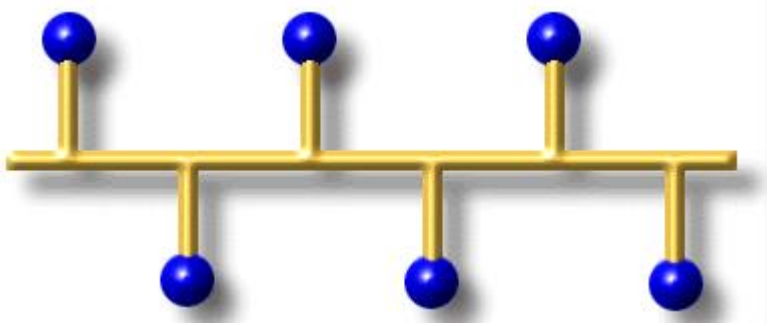
BNC terminátor

Zbernicová topológia



- Všetky uzly sú pripojené k jednému priamemu vedeniu a žiadne iné spojenie medzi nimi neexistuje.
- Výhody: všetky zariadenia sú navzájom prepojené a teda spolu komunikujú.
- Malá spotreba kábla a nízka cena kabeláže.
- Jednoduché pripojovanie ďalších zariadení.
- Je vhodná pre malé siete s nízkym počtom staníc

Zbernicová topológia



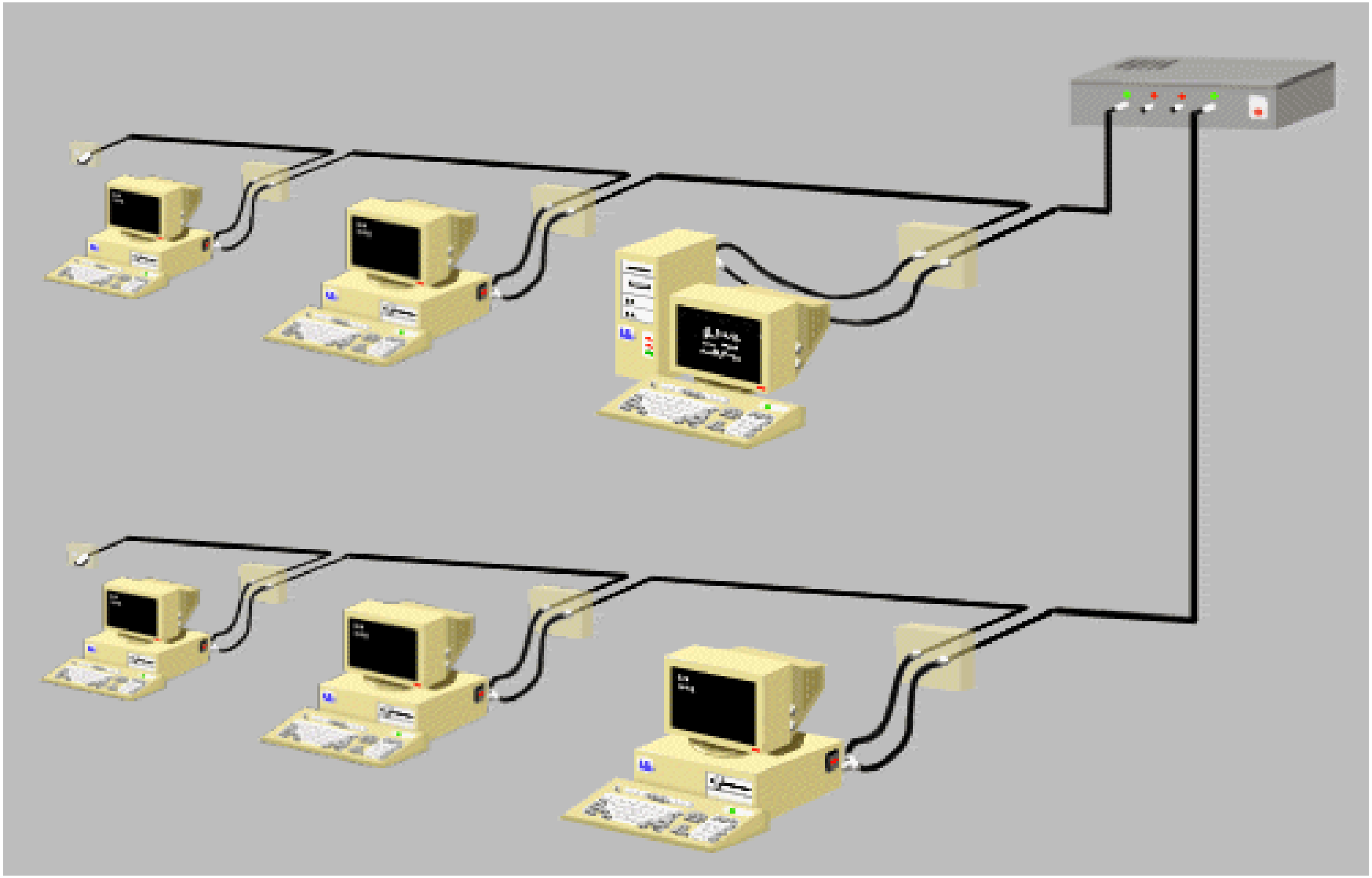
Nevýhody:

- porušený kábel (zlom) odpojí všetky zariadenia,
- malá prenosová rýchlosť,
- veľký počet spojov na kábli, potenciálny zdroj porúch a útlmu signálu,
- umožňuje pre všetky zariadenia vidieť všetky správy, zariadenie, pre ktoré je správa určená, ju prijme,
- obmedzená dĺžka kábla a počtu staníc,
- Pripájaním ďalších staníc sa znižuje rýchlosť siete,
- V jednom okamžiku možno poslať len jednu správu,

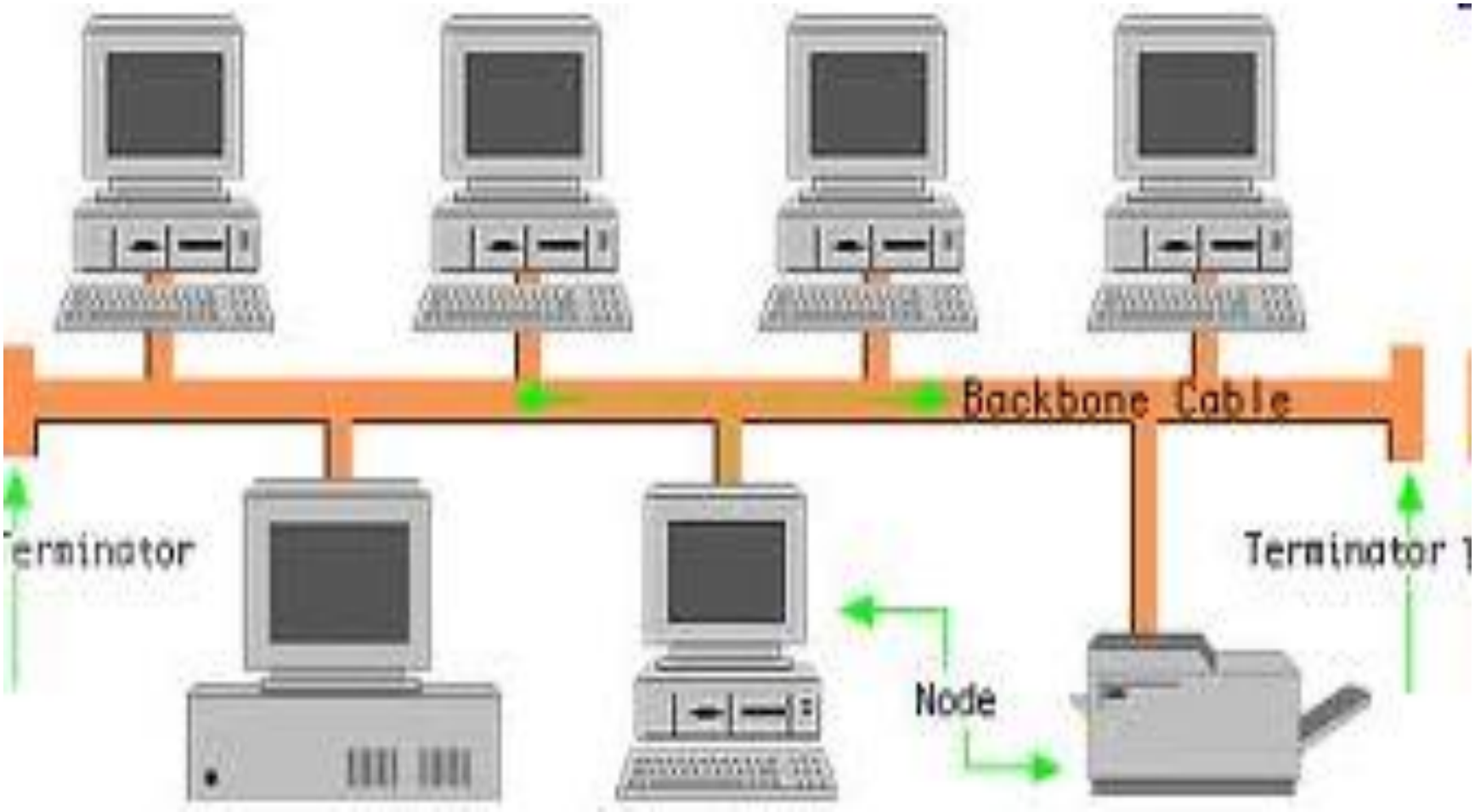
Bus Network

- Networks organized using the **bus topology** have a single cable that acts as the backbone for that network segment. Modern networks, using RJ-45, contain a hub that is connected to all devices in the segment. Devices can include workstations, printers and additional hubs, which can then become the start of an additional network segment.

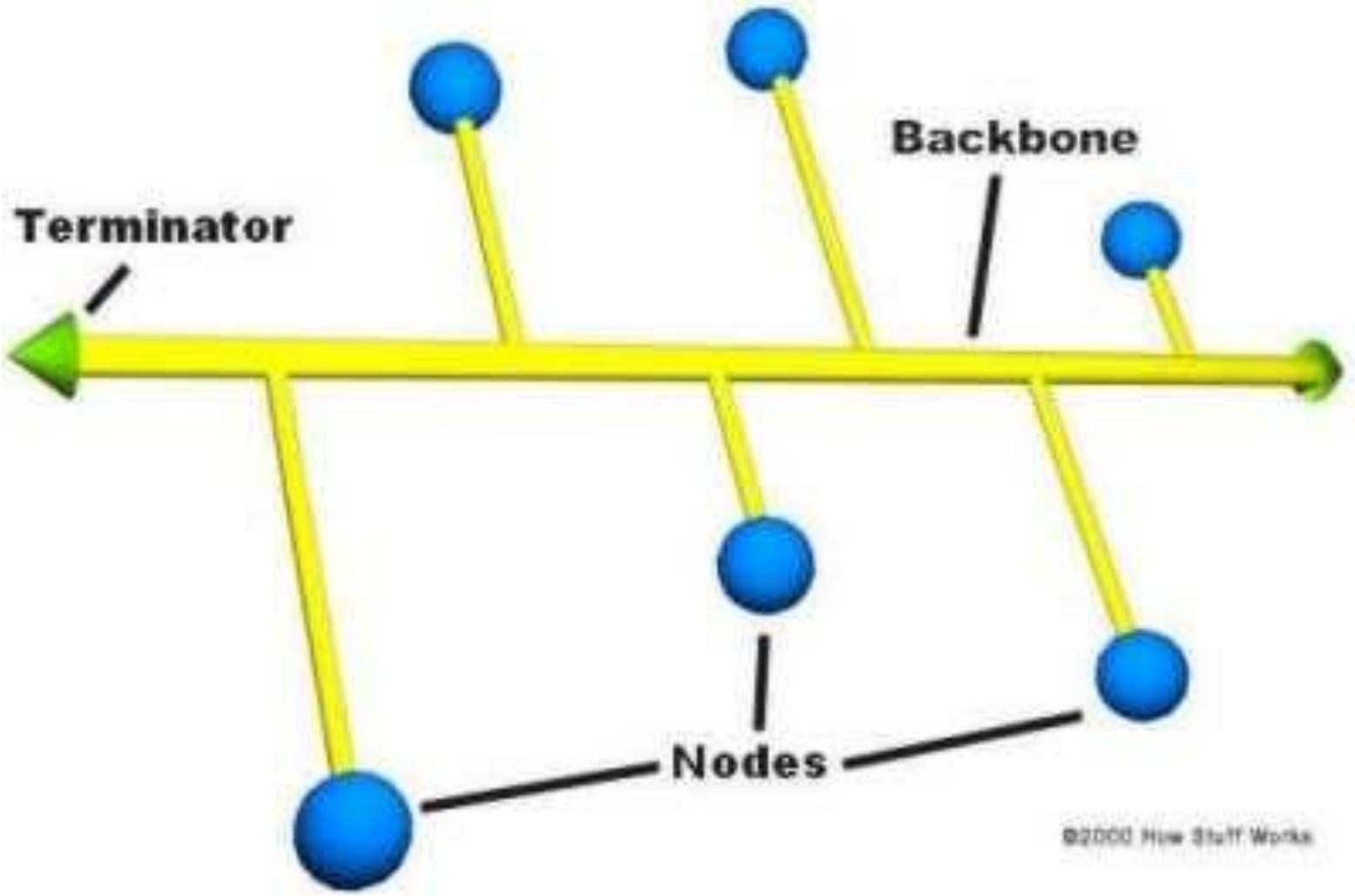
Sín / busz topológia



Bus network topology



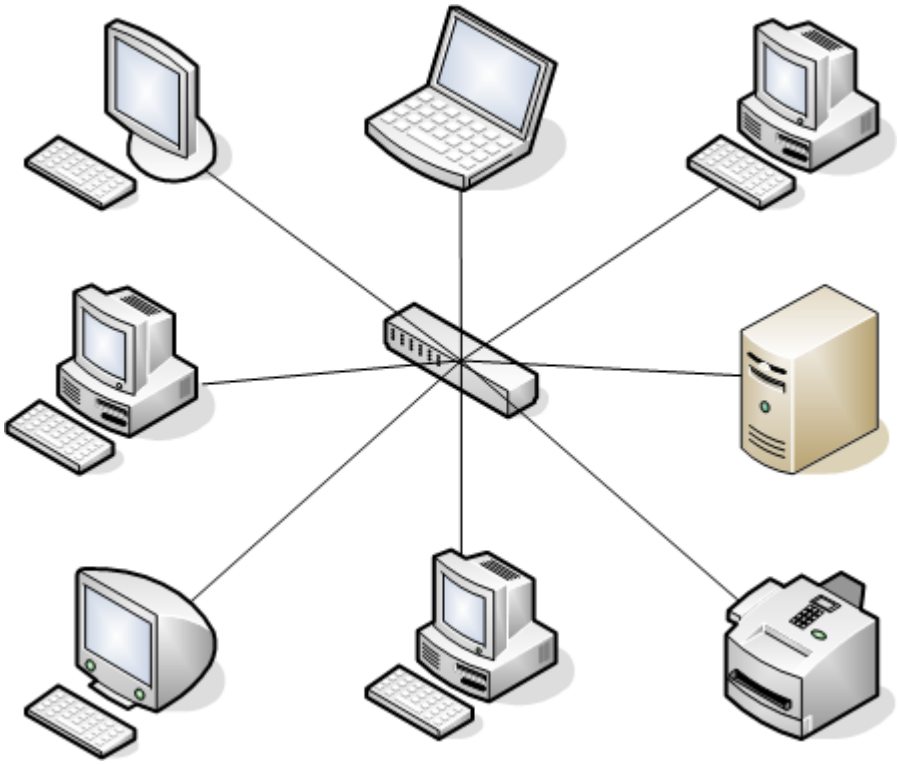
Bus network topology

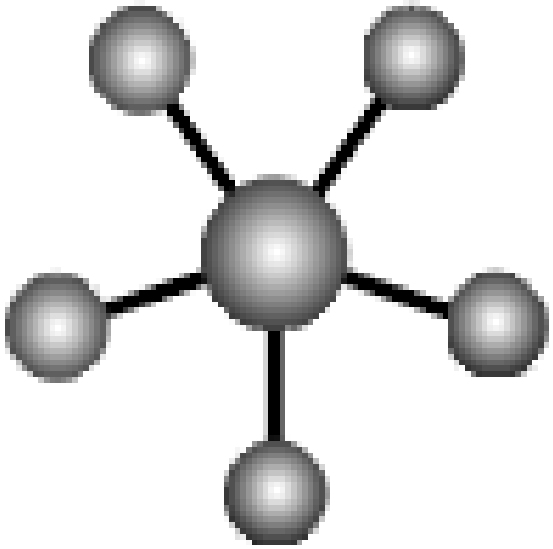


Bus network topology

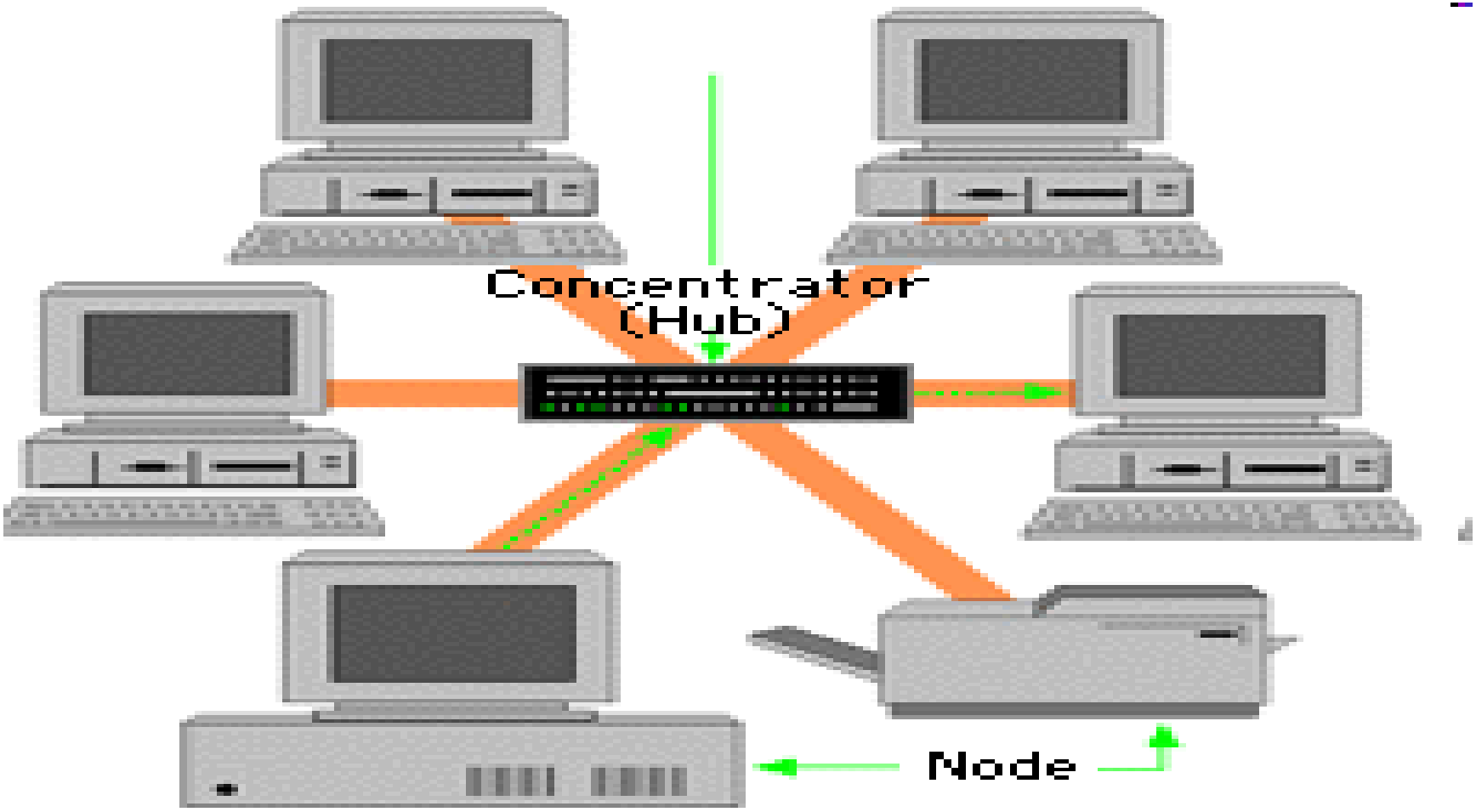
- Each node is **daisy-chained** (connected one right after the other) along the same backbone, similar to Christmas lights. Information sent from a node travels along the backbone until it reaches its destination node. Each end of a bus network must be **terminated** with a resistor to keep the signal that is sent by a node across the network from bouncing back when it reaches the end of the cable.

Star topology

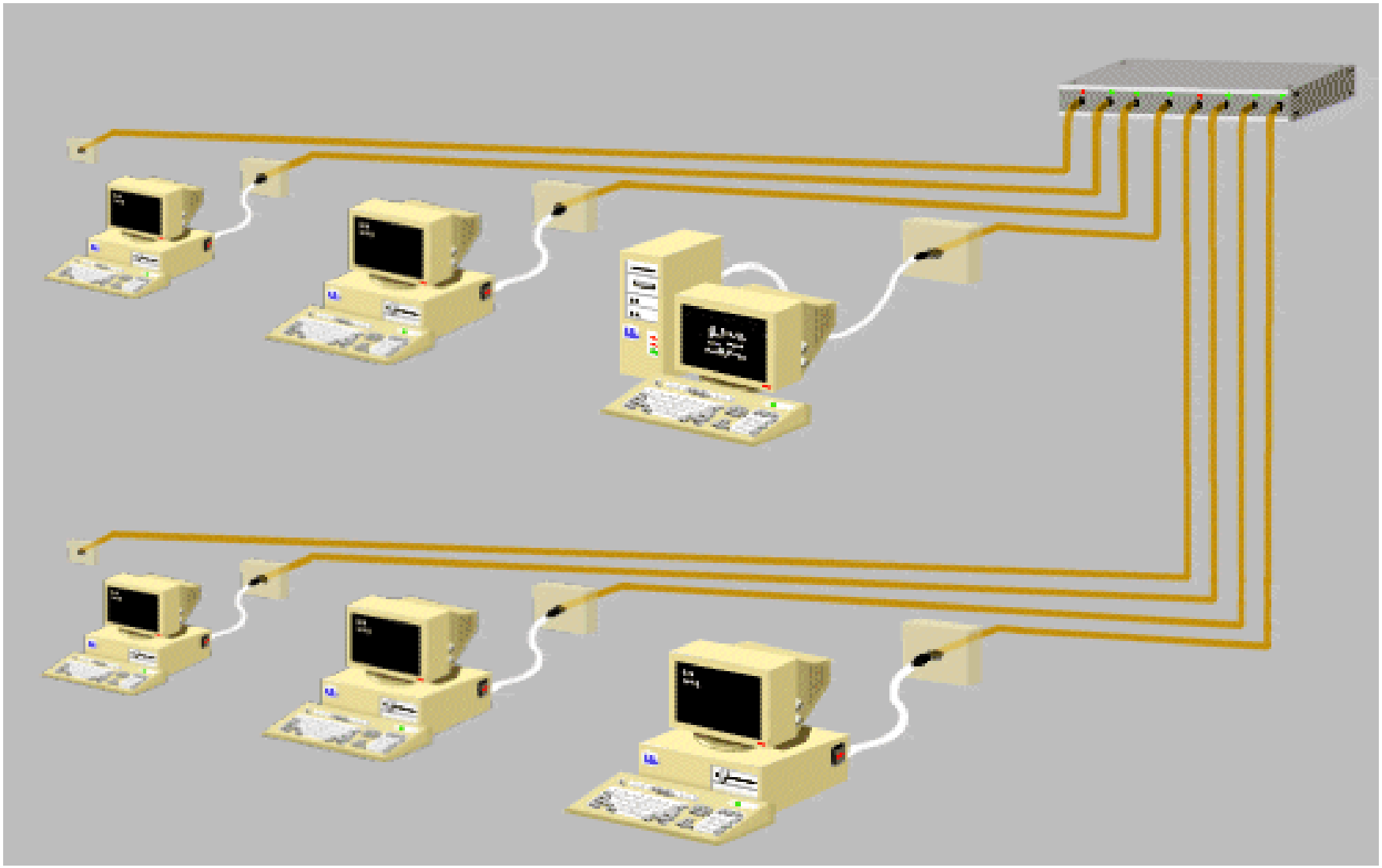




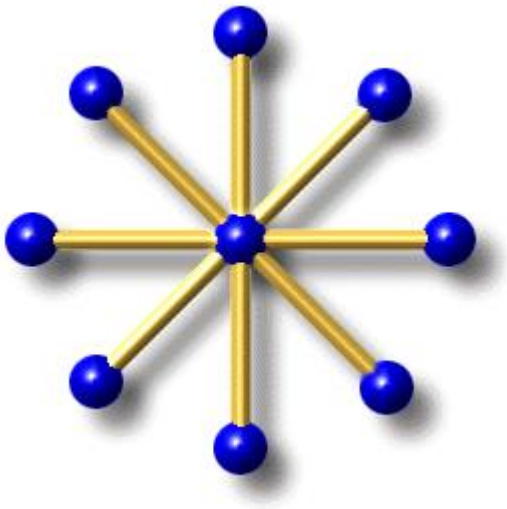
Star topology

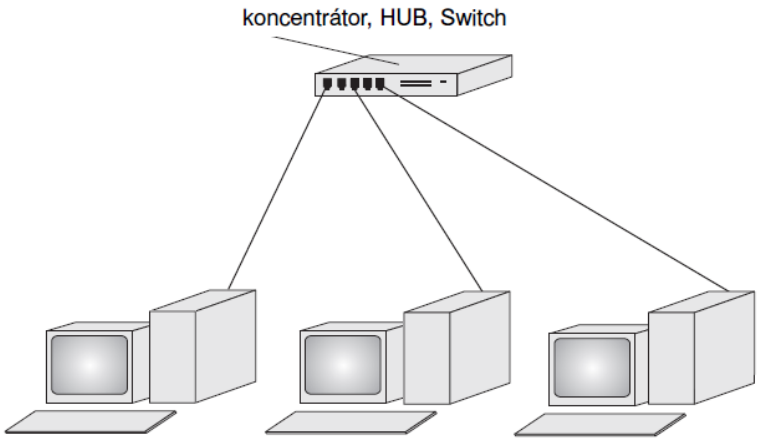


Csillag topológia



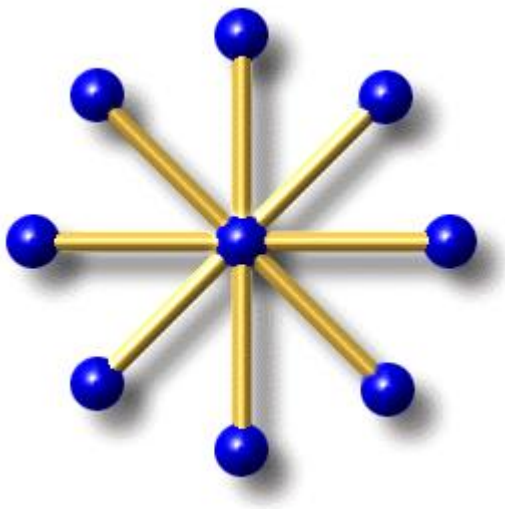
Hviezdicová topológia





- Hviezda má centrálny uzol, ku ktorému sa pripájajú všetky ostatné uzly, zvyčajne je to rozbočovač (hub) alebo prepínač (switch). Najrozšírenejšia topológia.
- Výhody: všetky prepojenia prechádzajú cez stred, čo umožňuje pohodlnú komunikáciu medzi zariadeniami.
- Nízka náchylnosť k chybe a jej jednoduchá detekcia,
- Medzi uzlami existuje len jedno spojenie,
- údajové pakety sú prenášané rýchle, pretože neputujú nepotrebnými uzlami

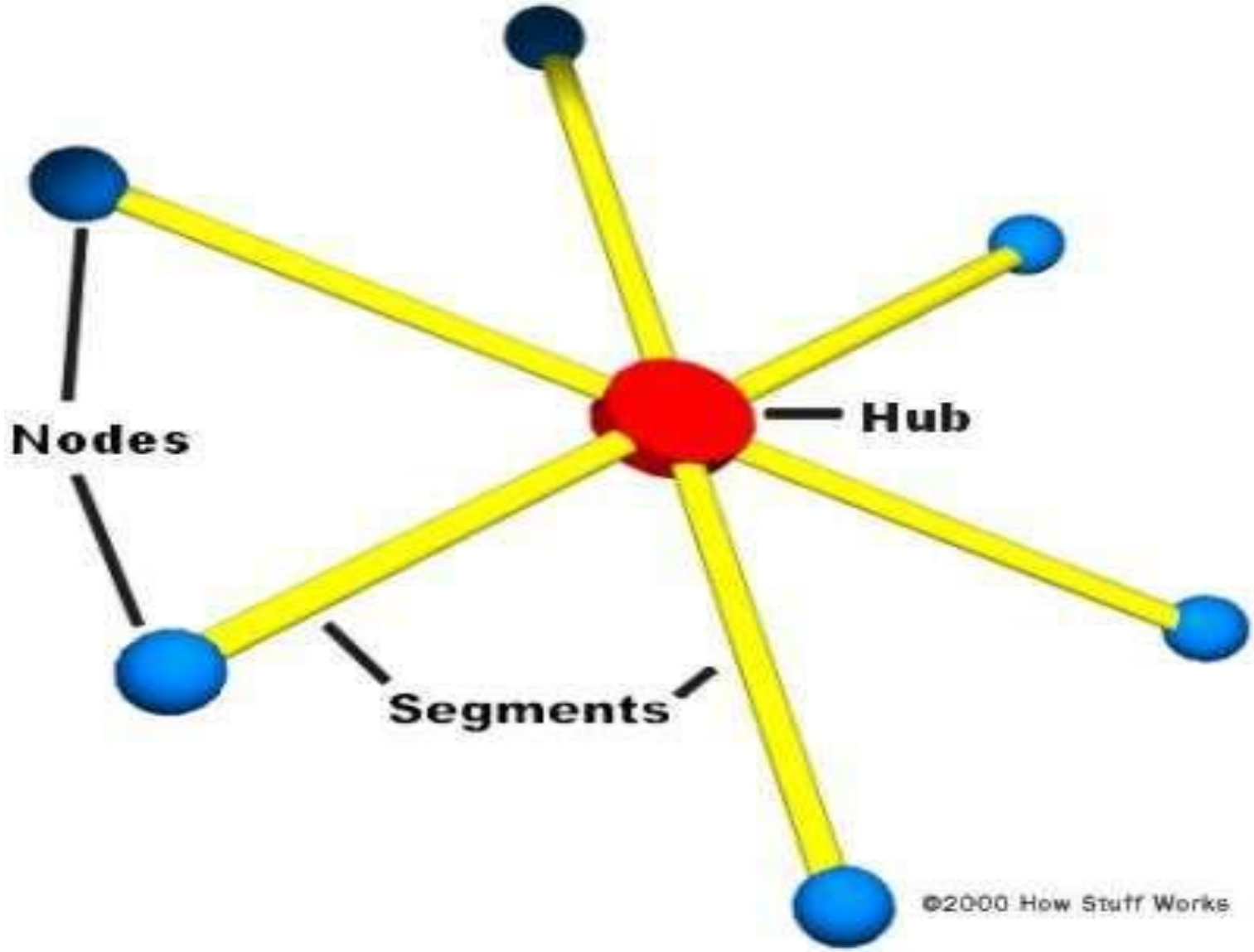
Hviezdicová topológia



Nevýhody:

- ak sa centrálny uzol pokazí, zruší sa celá sieť,
- Všetky informácie prechádzajú cez centrálne zariadenie – nevýhodné kvôli bezpečnosti,
- Každý uzol potrebuje spojenia na centrálny uzol – vyššie náklady,
- Potrebný dodatočný hardvér – centrálny uzol

Star network topology



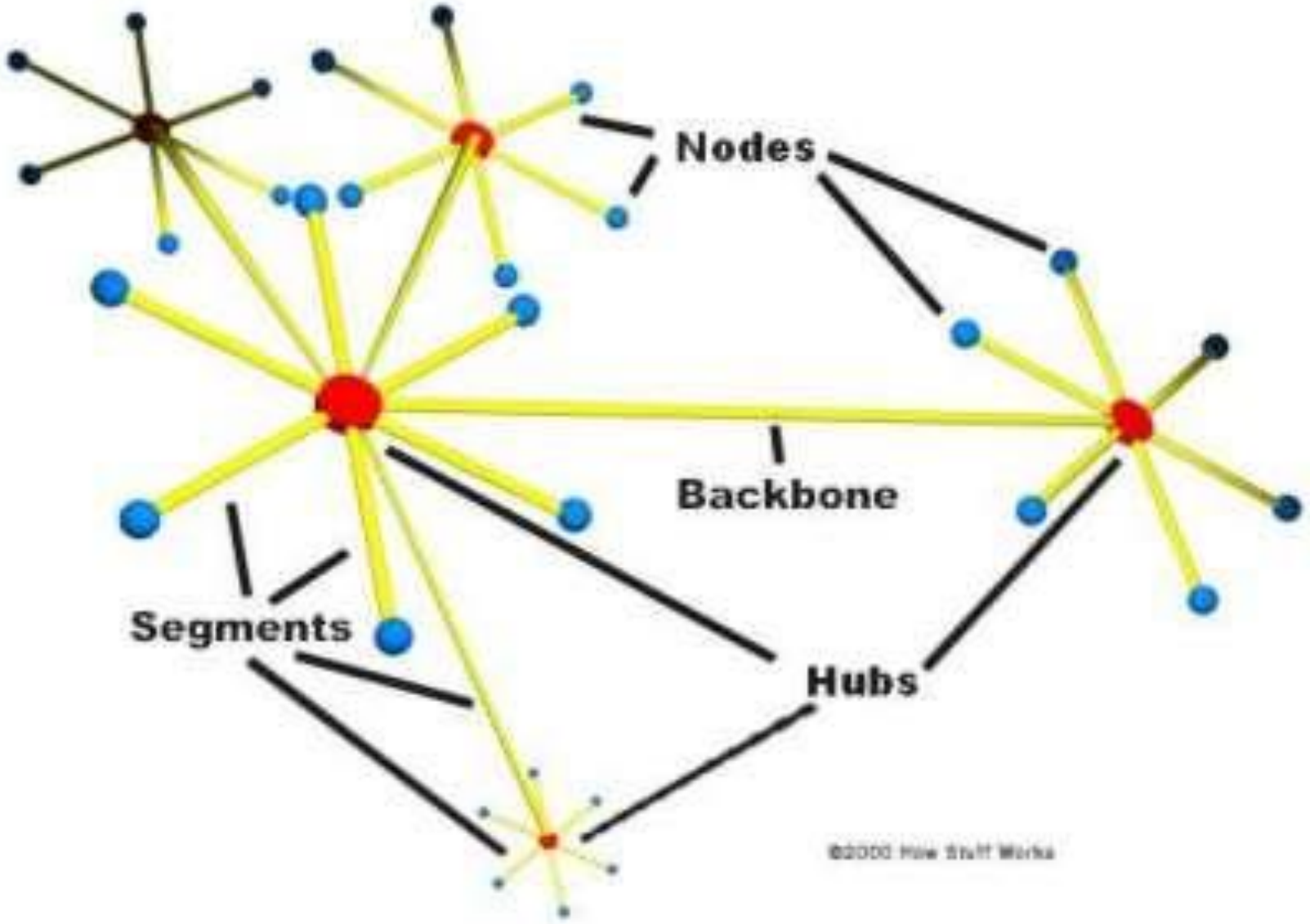
Star network topology

- In a star network, each node is connected to a central device called a **hub**. The hub takes a signal that comes from any node and passes it along to all other nodes in the network. A hub does not perform any type of filtering or routing of the data. It is simply a junction that joins all the different nodes together.

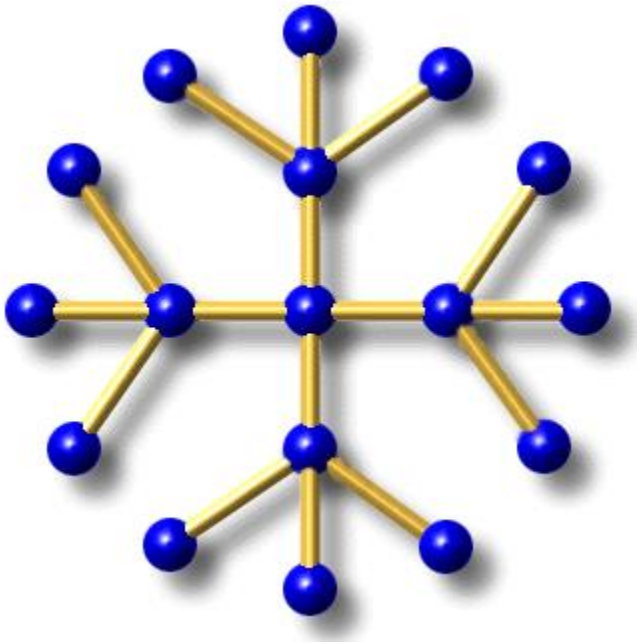
Star bus network

- Probably the most common network topology in use today, **star bus combines elements** of the star and bus topologies to create a versatile network environment. Nodes in particular areas are connected to hubs (creating stars), and the hubs are connected together along the network backbone (like a bus network). Quite often, stars are nested within stars.

A typical **star bus** network



Rozšírená hviezdica (extended star)



- Každý uzol je stredom ďalšej hviezdice
- Výhoda: kabeláž sa skracuje, limituje sa počet zariadení pripojených do jedného centra
- Je veľmi hierarchická, informácie zostávajú lokálne. (na tomto princípe pracujú telefónne siete)

Centrálny prvok hviezdicovej topológie

Hub, rozbočovač, koncentrátor

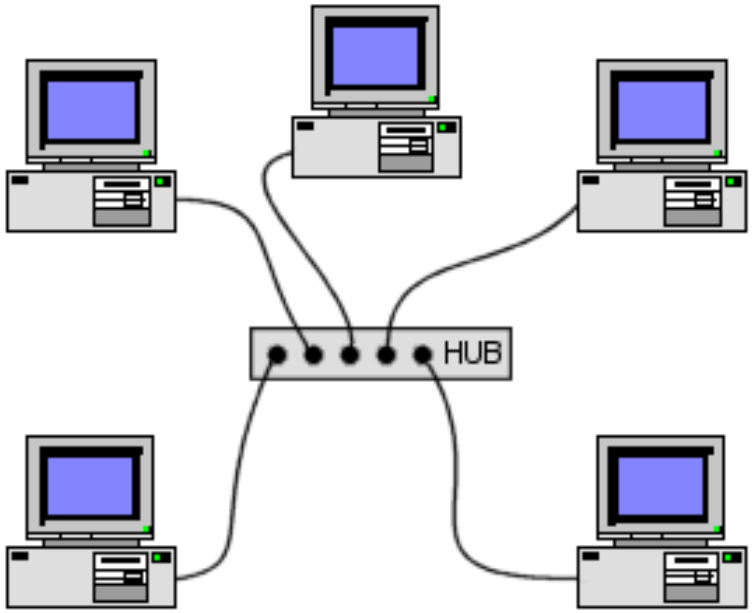
Switch, prepínač

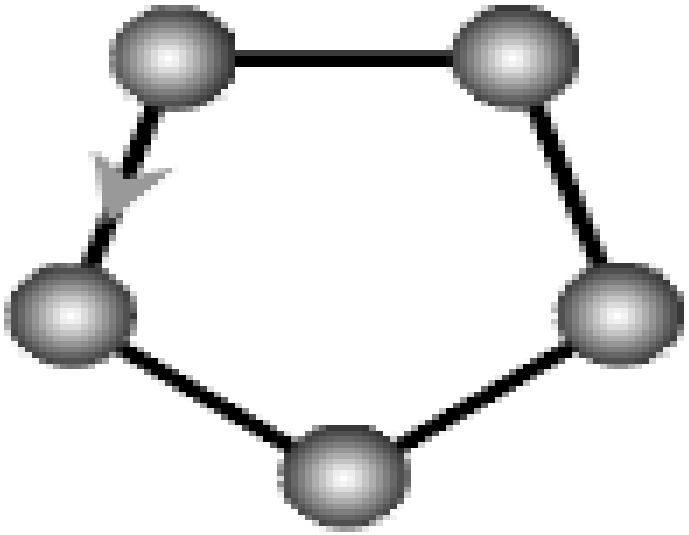
24 portový switch

Príklad 24-portového switchu

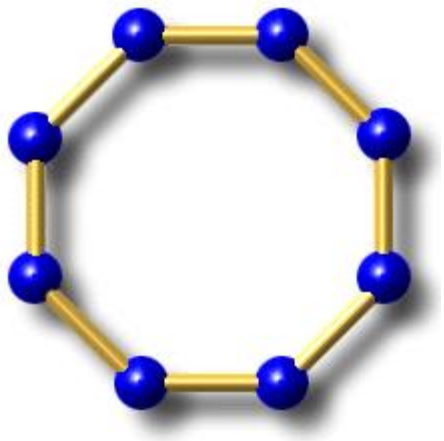
Ring topology

Kruhová (prstencová)





Kruhová topológia

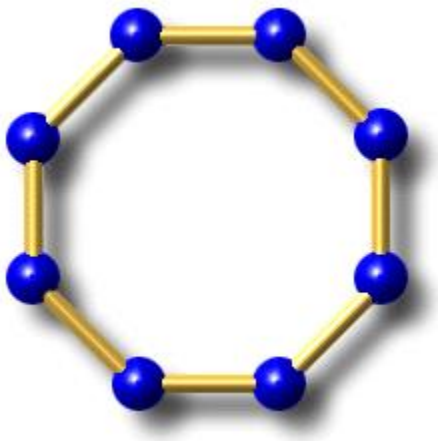


- Je to jednoduchý uzavretý kruh, v ktorom každý bod je spojený s dvomi susednými bodmi
- Postupné predávanie správ – „token“
- Správa sa šíri jedným smerom od jedného zariadenia k druhému a každé ho posiela ďalej k svojmu susedovi, až kým nedôjde k cieľovému počítaču

Ring topology

- A local-area network (LAN) whose topology is a ring. That is, all of the nodes are connected in a closed loop. Messages travel around the ring, with each node reading those messages addressed to it. One main **advantage** to a ring network is that it can span larger distances than other types of networks, such as bus networks, because each node regenerates messages as they pass through it.

Kruhová topológia



Výhody:

•Nevznikajú kolízie na sieti, pretože údaje putujú jedným smerom

•Realizácia siete vyjde na nízke náklady

•Nie je potreba ukončovať sieť terminátormi

Nevýhody:

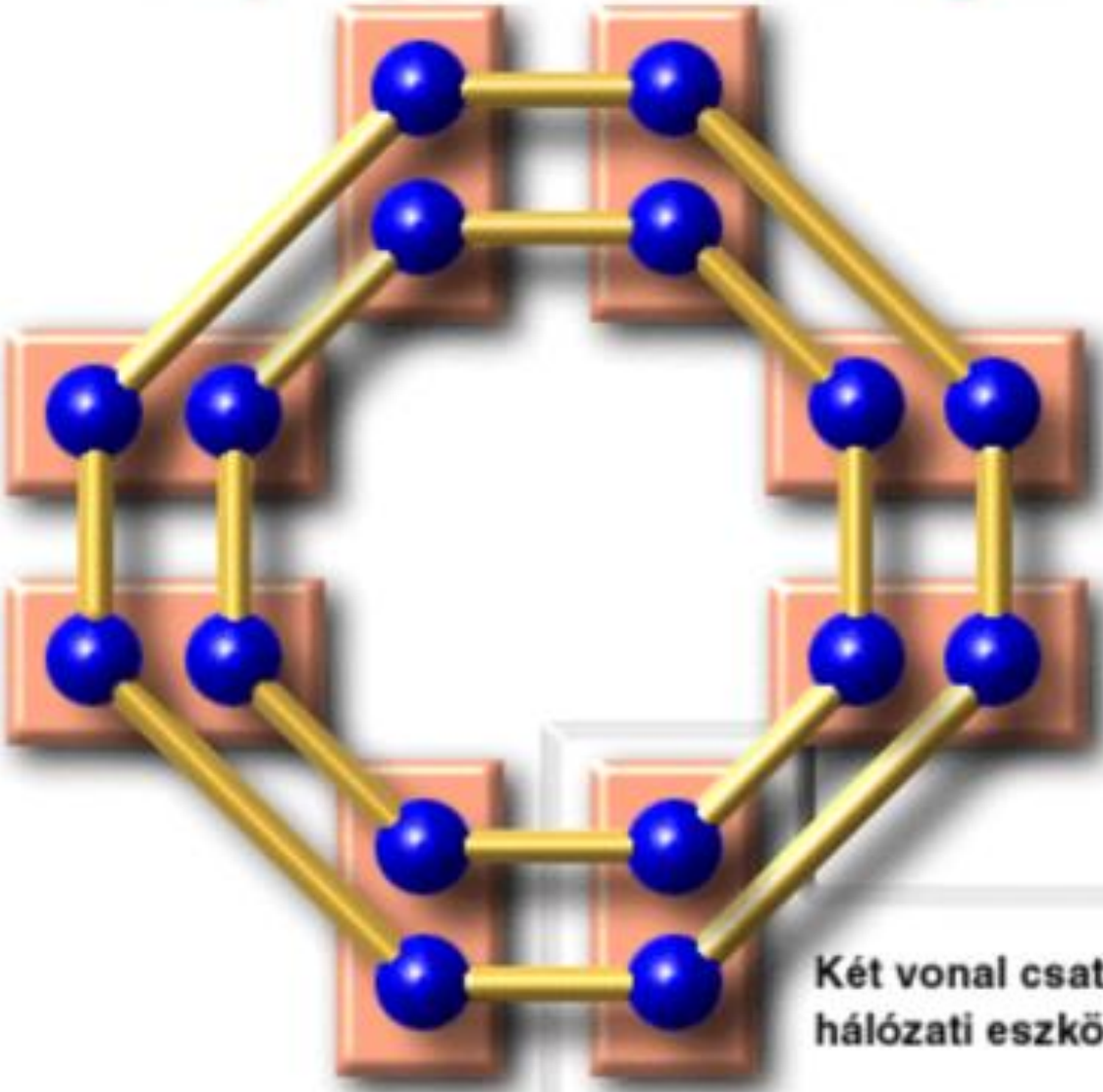
•Údaje prechádzajú všetkými stanicami, zdržuje sa prenos

•„zrútenie“ jedného uzla zapríčiňuje nefunkčnosť siete,

•Obtiažne sa identifikuje miesto poruchy,

•Pri inštalácii nového zariadenia sa odstavuje celá sieť

Duplagyűrűs topológia

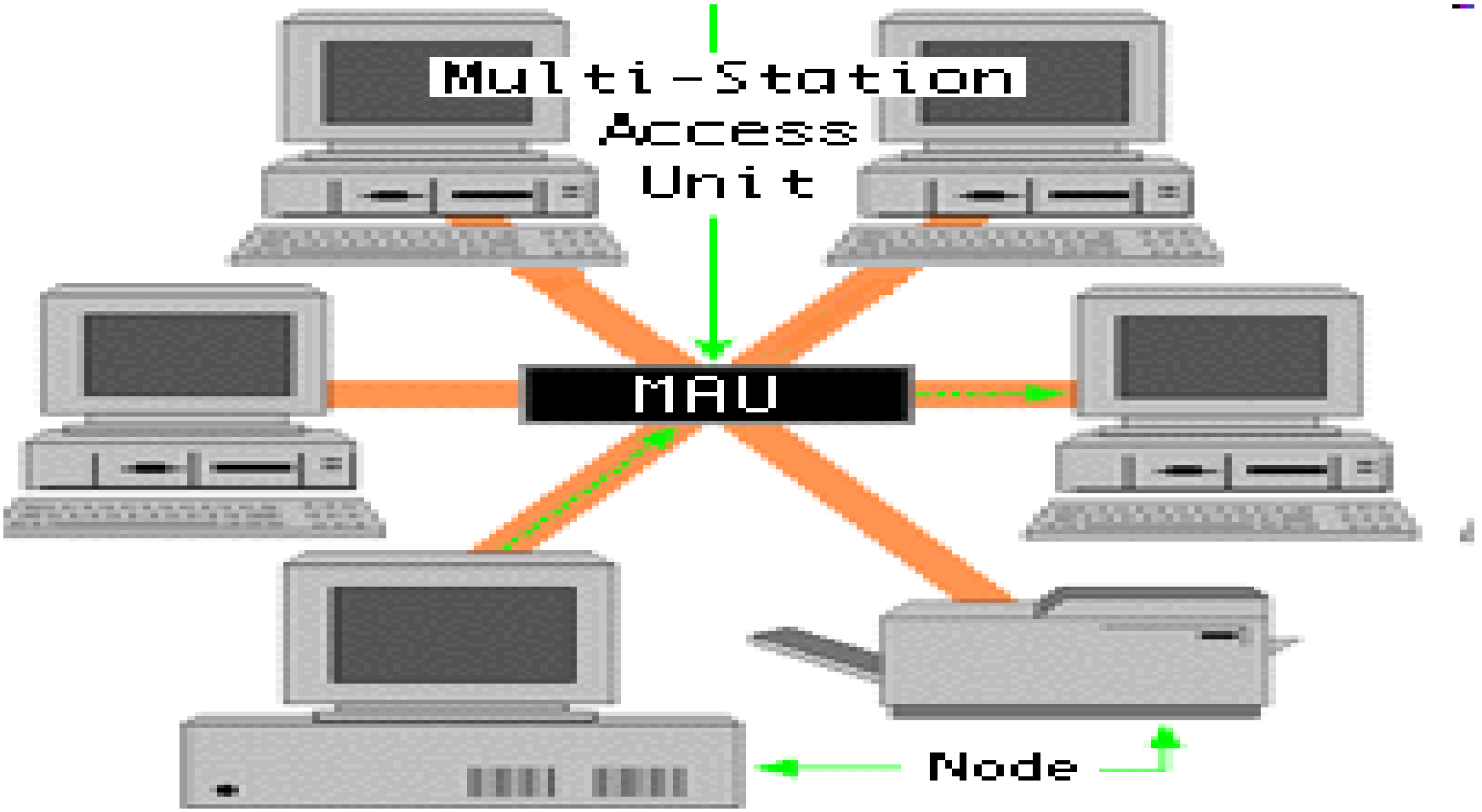


Két vonal csatlakozik minden hálózati eszközhöz

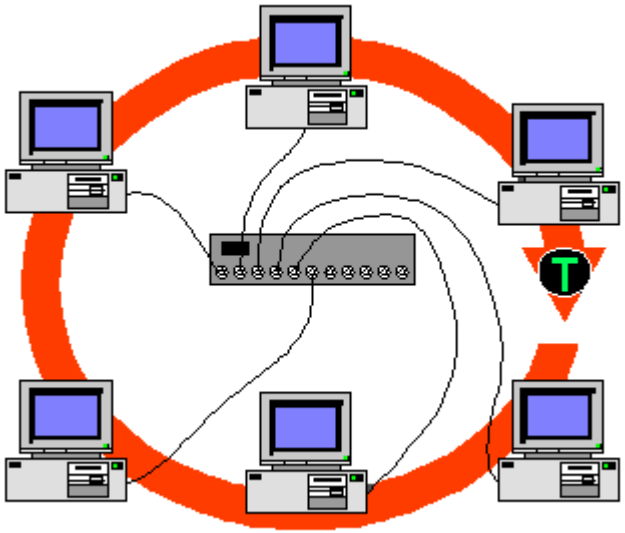
Ring Network

- Devices on a ring network connect to a central loop of cable via a network adapter and an MAU - Multistation Access Unit. Up to eight devices can be connected to each MAU. Like hubs in the bus topology, MAUs can be cascaded to expand the number of devices that can connect to the network.

A star-wired ring topology



Hviezdicovo – kruhová topológia



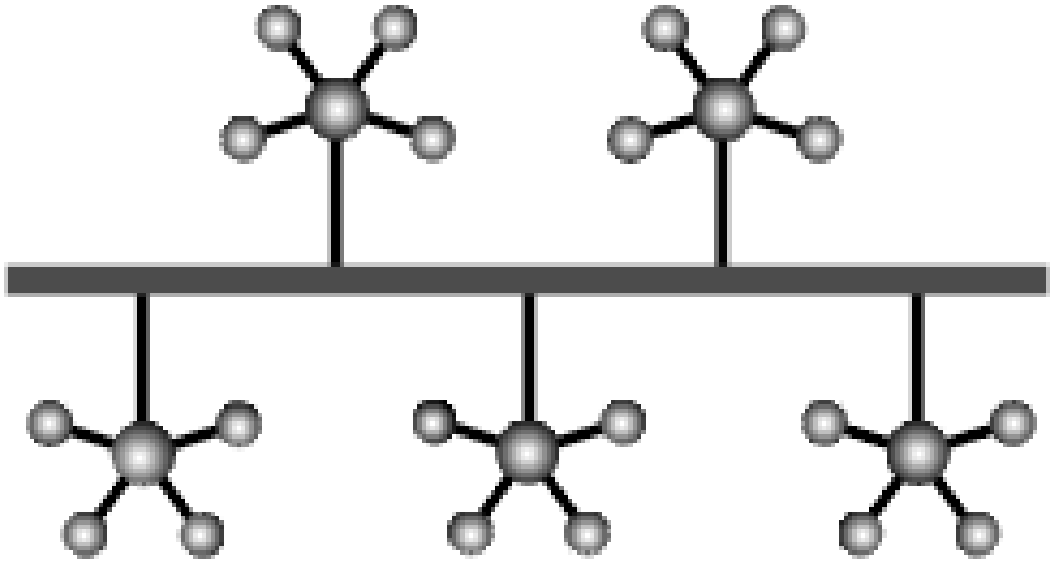
- Je tvorená kombináciou kruhovej a hviezdicovej topológie. **Fyzický hviezda**, informácie logický prechádzajú z jedného do druhého uzla - **kruh**. Z každého počítača vedie jeden kábel do MAU (Multistation Access Unit). Štandard IBM Token Ring (IEEE 802.5). Používa sa UTP, STP.

A star-wired ring topology

may appear (externally) to be the same as a star topology. Internally, the MAU (multistation access unit) of a star-wired ring contains wiring that allows information to pass from one device to another in a circle or ring. The Token Ring protocol uses a star-wired ring topology.

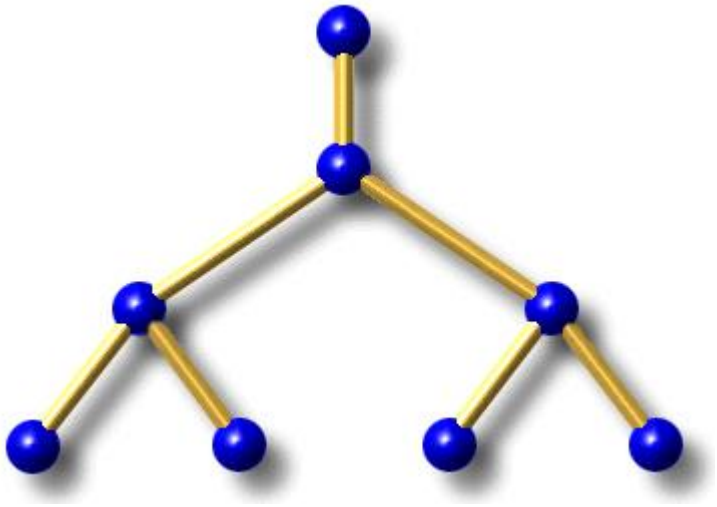
Podľa fyzickej topológie 4

- **Stromová (chrbticová – backbone)**



Stromová (binárna)

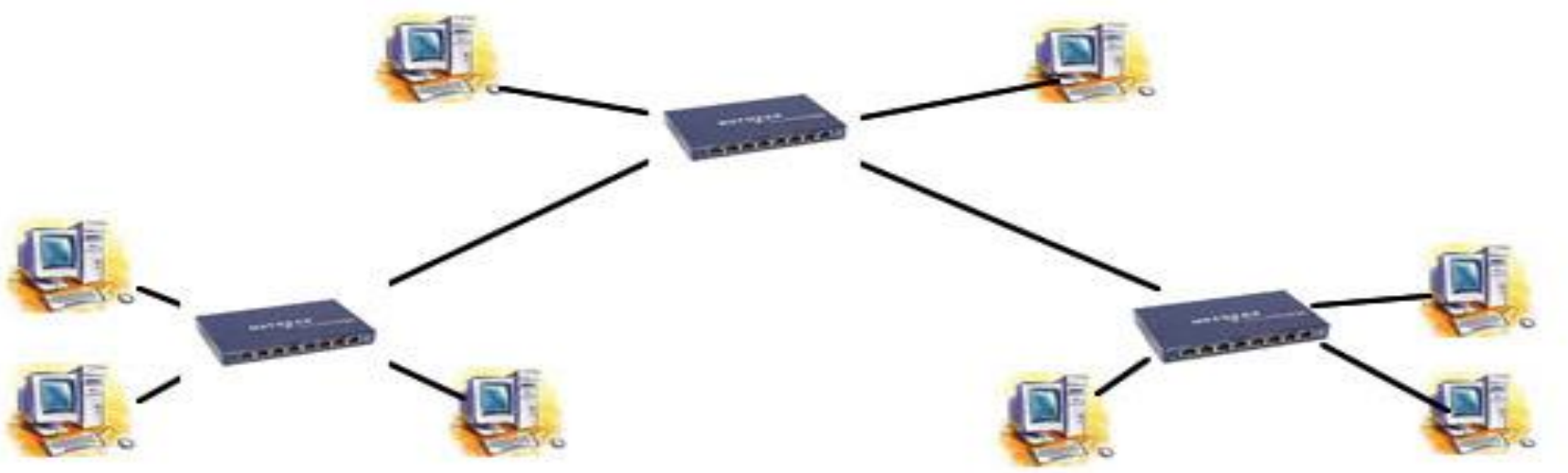
(niekedy označovaná ako hierarchická (tree)



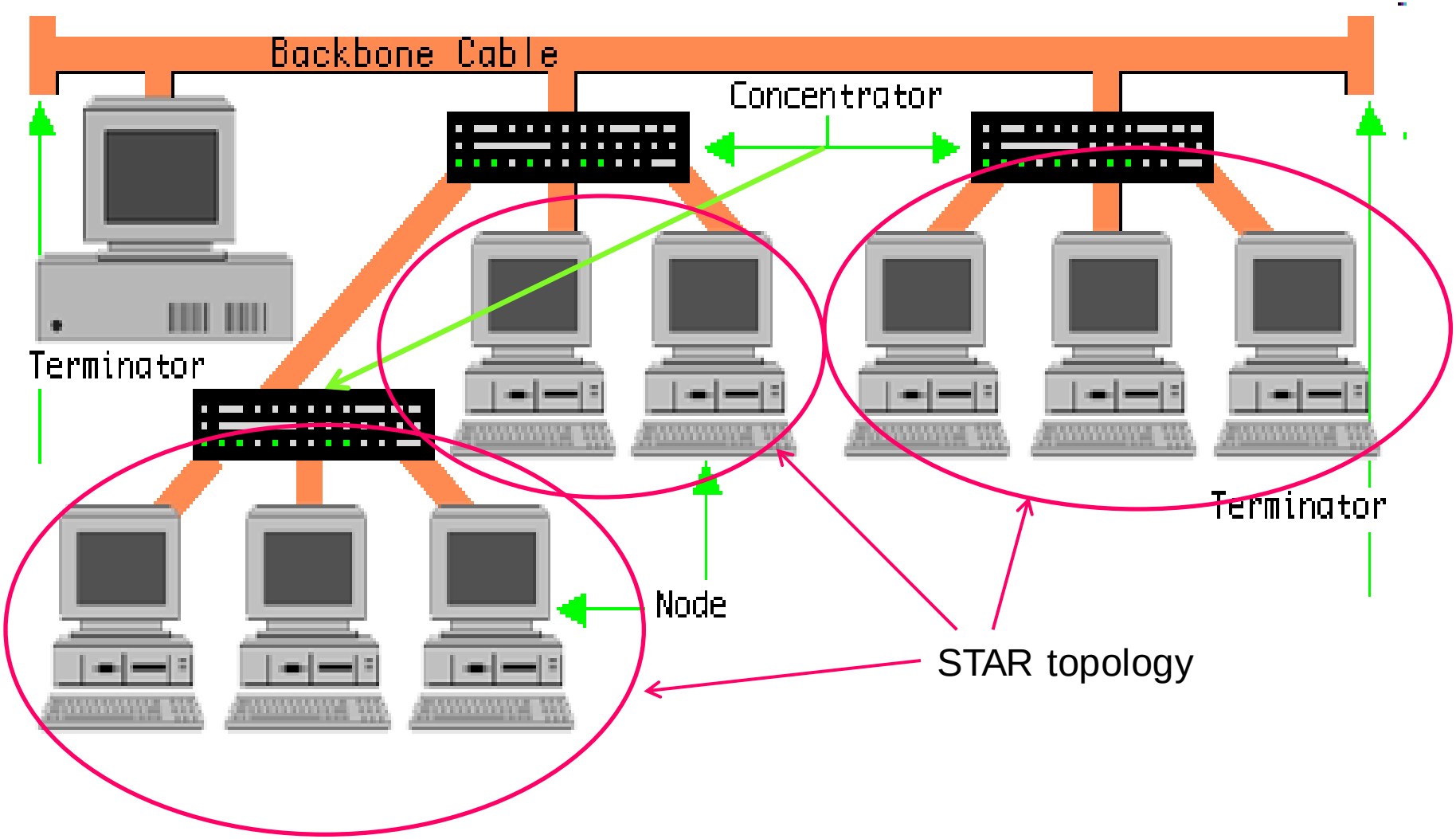
- Možno si ju predstaviť ako časť rozšírenej hviezdice, s kmeňom stromu, miesto centra
- Strom môže byť binárny, alebo backbone (chrbticový)
- Kmeň stromu je kábel, ktorý má niekoľko úrovní
- Tok informácií je hierarchický

Stromová topológia

- Stromová topológia zložená z niekoľkých hviezdicových topológií, ktoré sú vzájomne prepojené HUB-mi, alebo SWITCH-mi. Výhody a nevýhody ako u hviezdicovej topológií. Siete veľkých firiem (univerzít)



Tree topology



Tree topology

- A tree topology combines characteristics of linear bus and star topologies. It consists of groups of star-configured workstations connected to a linear bus backbone cable (See slide above). Tree topologies allow for the expansion of an existing network, and enable to configure a network to meet their needs.

Tree topology

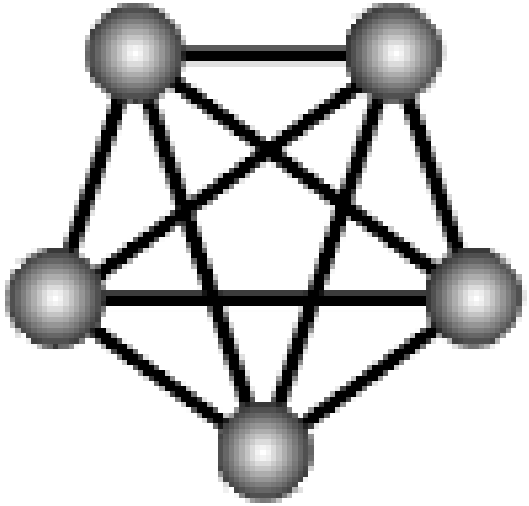
- This is a "hybrid" topology that combines characteristics of linear bus and star topologies. In a tree network, groups of star-configured networks are connected to a linear bus backbone cable.
- ***Main Advantage:*** A Tree topology is a good choice for large computer networks as the tree topology "divides" the whole network into parts that are more easily manageable.
- ***Main Disadvantage:*** The entire network depends on a central hub and a failure of the central hub can cripple the whole network.

Disadvantages of a Tree Topology

- Overall length of each segment is limited by the type of cabling used.
- If the backbone line breaks, the entire segment goes down.
- More difficult to configure and wire than other topologies.

Podľa fyzickej topológie 5

- **Úplná** **(Mesh, sieťová, pletivová, slučková, ...)**



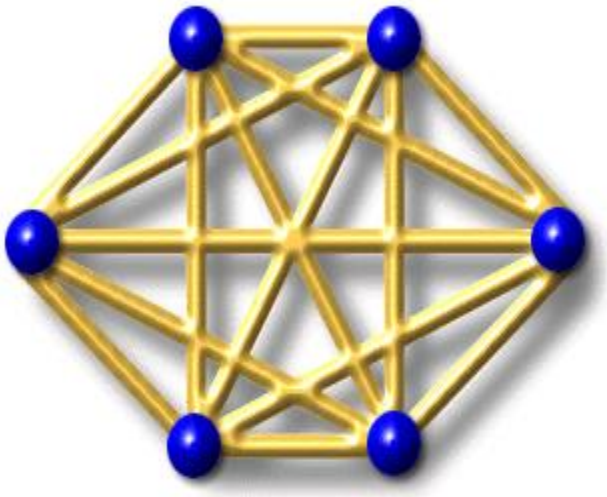
Mesh topology

- In a mesh network, devices are connected with many redundant interconnections between network nodes. In a true mesh topology every node has a connection to every other node in the network. There are two types of mesh topologies:
  - **Full mesh topology**
  - **Partial mesh topology**

Full mesh topology

- occurs when every node has a circuit connecting it to every other node in a network. Full mesh is very expensive to implement but yields the greatest amount of redundancy, so in the event that one of those nodes fails, network traffic can be directed to any of the other nodes.

Úplná sieť



- Všetky uzly sú vzájomne prepojené
- Výhody: z prepojenia vyplýva, že pri poruche niektorého z vedení sa sieť nenaruší
- Nevýhody: je použiteľná len pre malé siete
- Celkové správanie sa siete a tok informácií vo veľkej miere závisí od zariadení pripojených do siete

Advantages of Mesh topology

- Data can be transmitted from different devices simultaneously. This topology can withstand high traffic.
- Even if one of the components fails there is always an alternative present. So data transfer doesn’t get affected.
- Expansion and modification in topology can be done without disrupting other nodes.

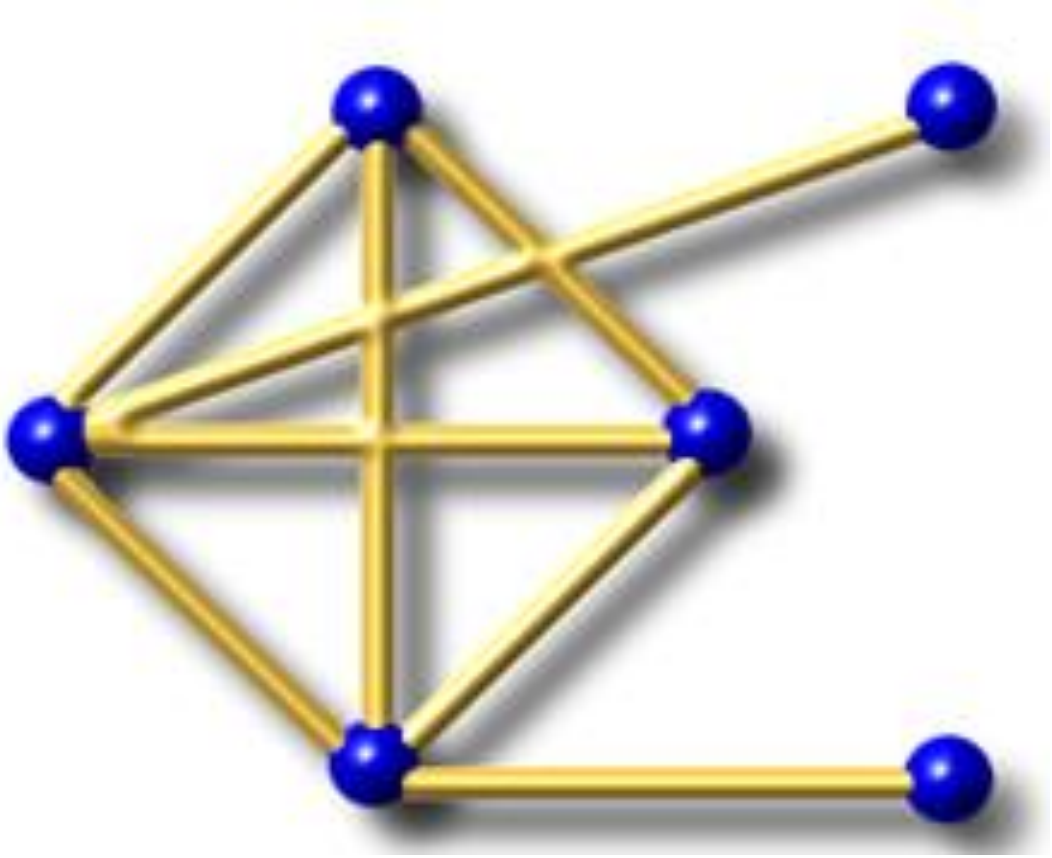
Disadvantages of Mesh topology

1) There are high chances of redundancy in many of the network connections.
2) Overall cost of this network is way too high as compared to other network topologies.
3) Set-up and maintenance of this topology is very difficult. Even administration of the network is tough.

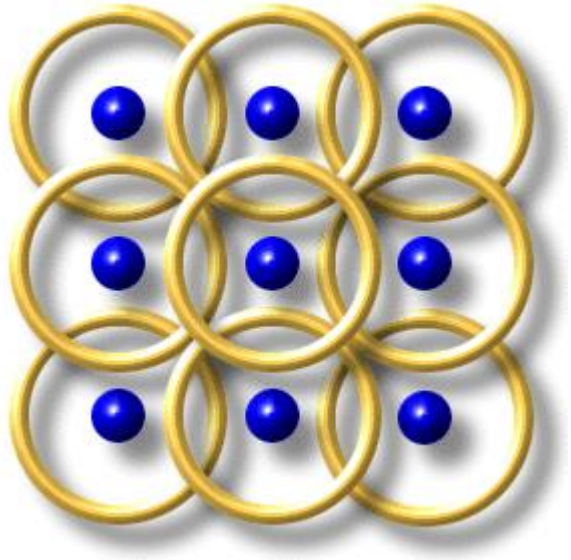
Partial mesh topology

is less expensive to implement and yields less redundancy than full mesh topology. With partial mesh, some nodes are organized in a full mesh scheme but others are only connected to one or two in the network. Partial mesh topology is commonly found in peripheral networks connected to a full meshed backbone

Szabálytalan / Részletes

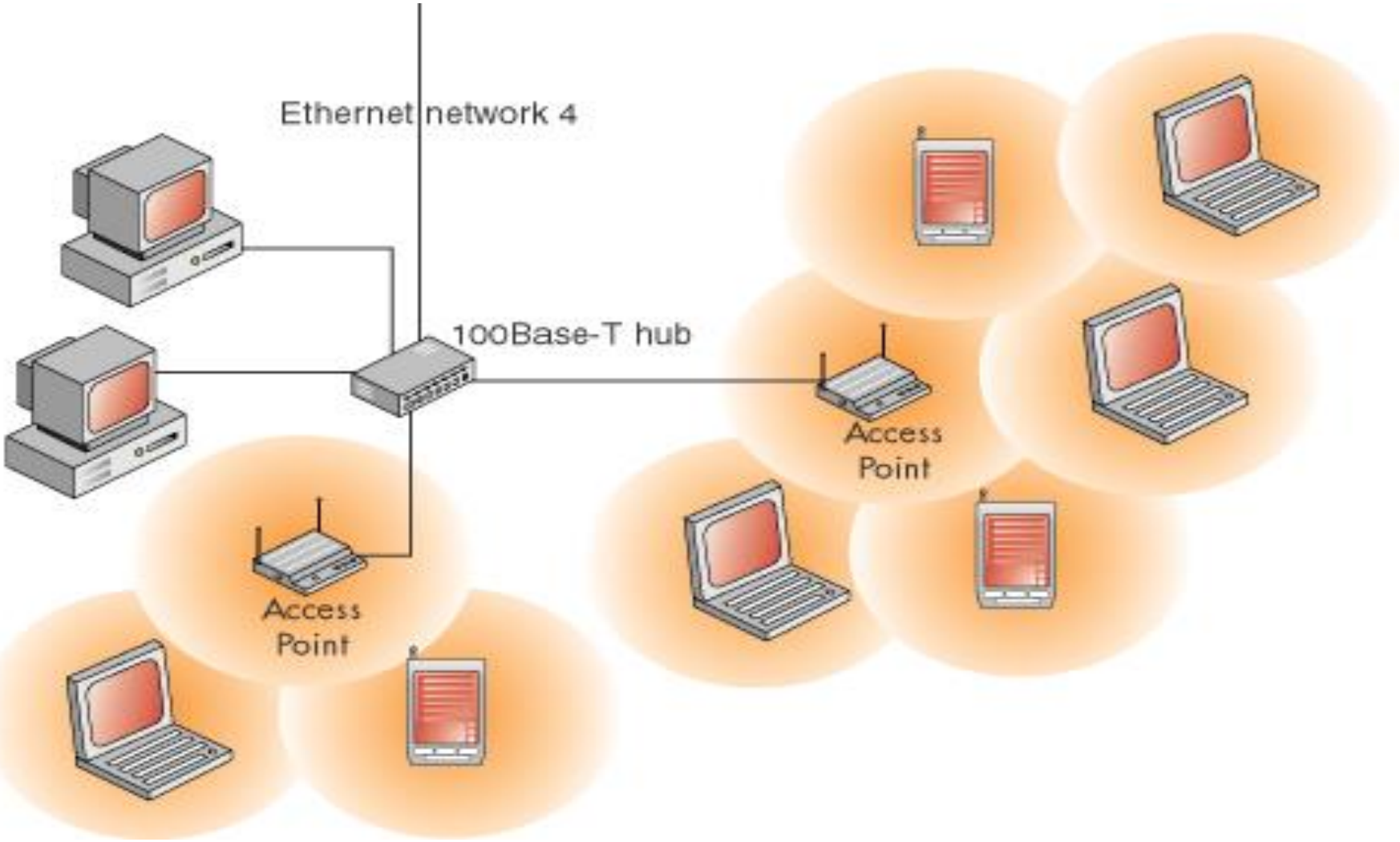


Celulárna (cellular)



- Táto topológia sa využíva pri bezdrôtovom spojení. (Informácie sa šíria pomocou elektromagnetických vĺn). Delí určitú geografickú oblasť na regióny tzv. bunky.
- Výhody: nepoužíva fyzické médium na prenos informácií
- Nevýhody: rušivé prvky v jednotlivých bunkách, nie je zaručená bezpečnosť údajov
- Komunikácia medzi jednotlivými uzlami je priama

Cellular

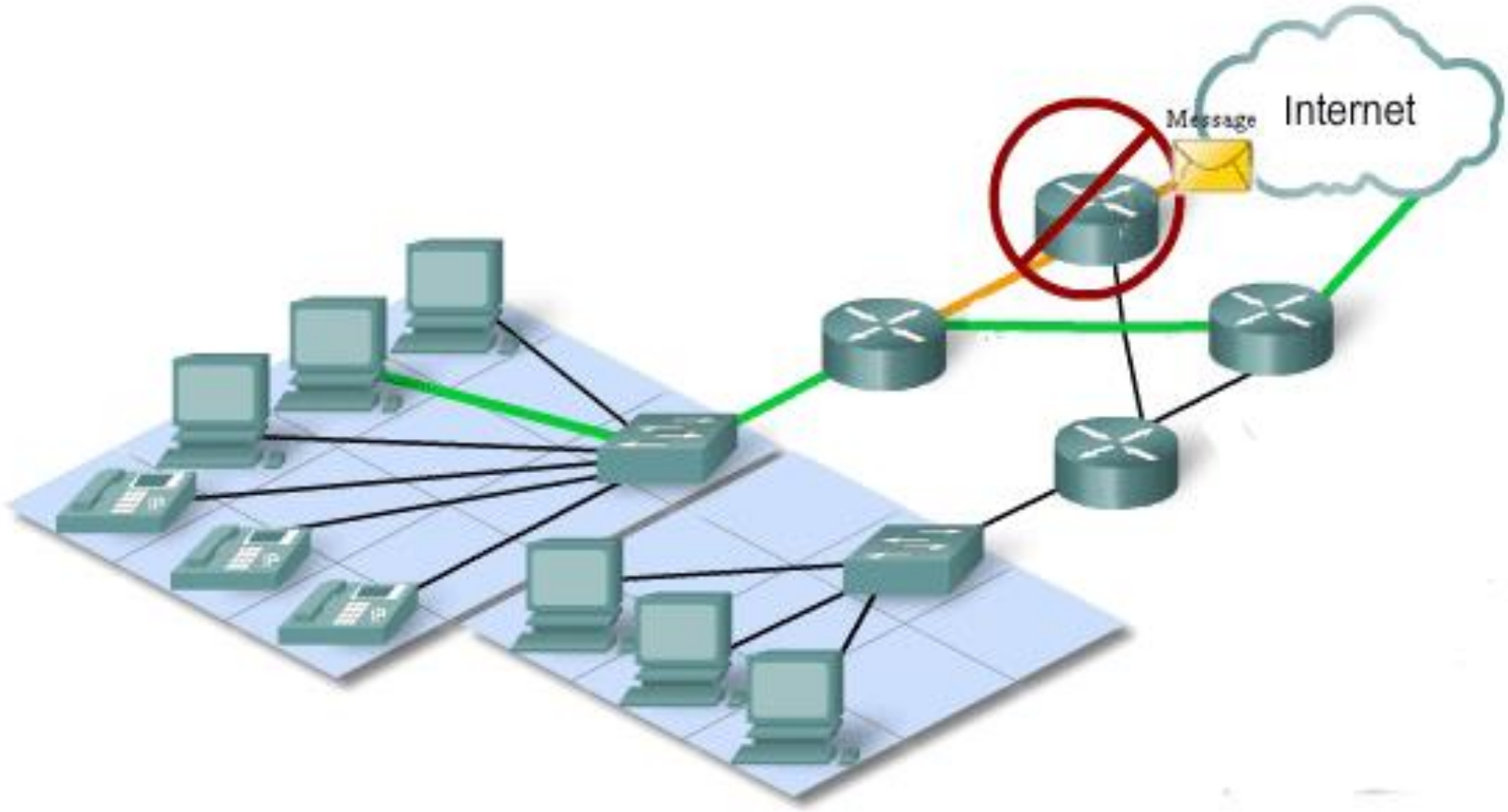


Podľa fyzickej topológie 6

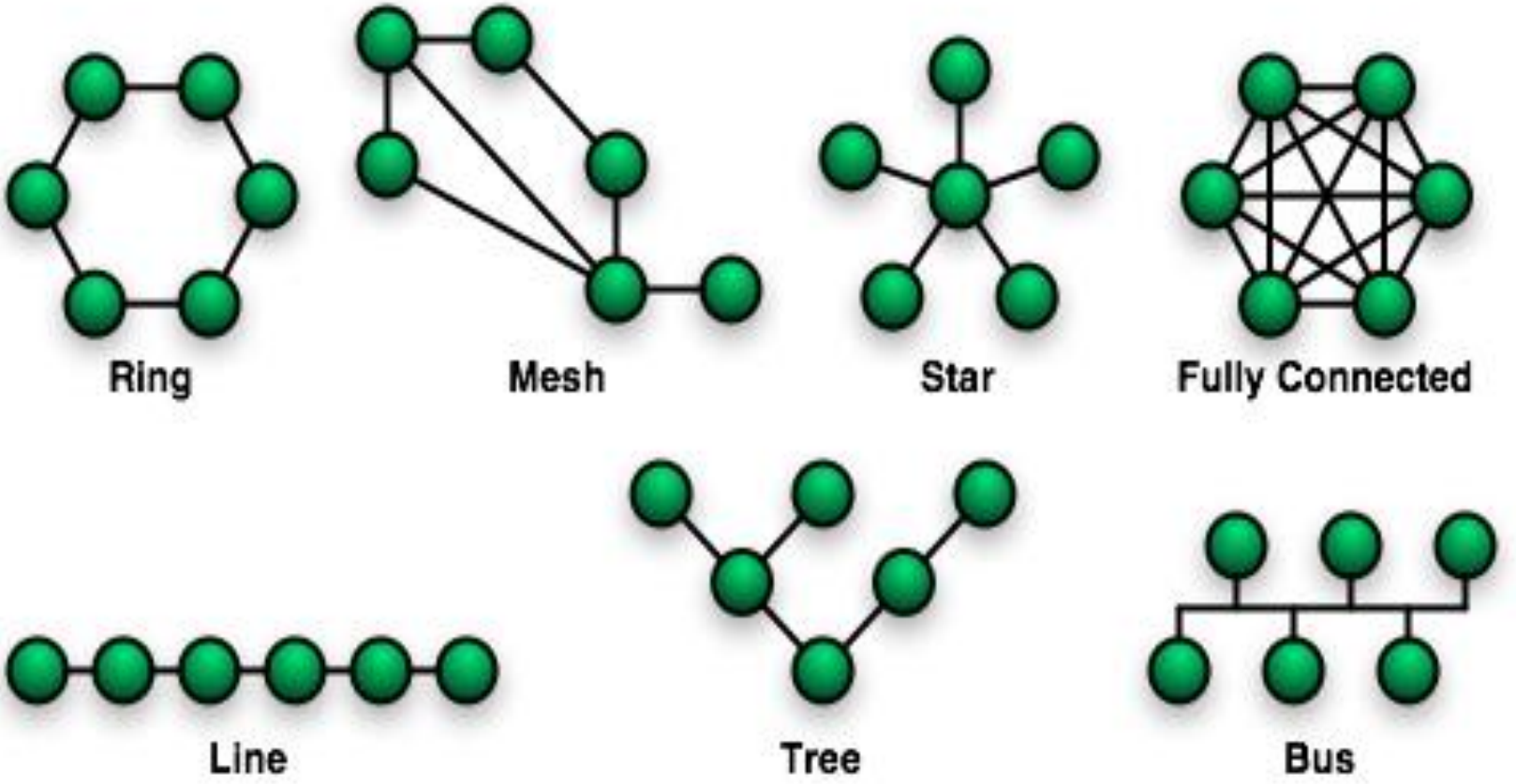
Chrbticová (backbone)

Chrbticové vedenie, ktorým sú prepojené ostatné segmenty siete. Komunikácia presahujúca jednotlivé segmenty idú týmto vedením. Prepája jednotlivé LAN s ľubovoľnou topológiou. Požaduje sa vysoká prenosová rýchlosť – Gb/s (Gbps)

Fault Tolerance



A különböző hálózati topológiák



Fyzická topológia - výhody / nevýhody

ZBERNICA (BUS) Jednoduchá, spoľahlivá; ľahko sa rozširuje; jednoduché pripájanie ďalších staníc do siete. Pri prerušení prenosového média kostry siete je sieť nefunkčná.

HVIEZDA (STAR) Ľahká modifikácia a pridávanie nových staníc siete. Ak zlyhá centrálny uzol, zlyhá celá sieť

KRUH (RING) Rovnocenný prístup pre všetky stanice siete. Sťažená inštalácie siete a obmedzený počet staníc v kruhu. Zlyhanie jednej stanice siete spôsobí nefunkčnosť celej siete.

STROM (TREE) Jednoduché rozširovanie siete. Pri výpadku centrálneho uzla je nefunkčný celý „pod strom“ siete

ÚPLNÁ (MESH) Veľmi spoľahlivá. Zle rozšírovateľná a nákladná

Considerations When Choosing a Topology:

- **Money**. A linear bus network may be the least expensive way to install a network; you do not have to purchase concentrators.
- **Length of cable needed**. The linear bus network uses shorter lengths of cable.
- **Future growth**. With a star topology, expanding a network is easily done by adding another concentrator.
- **Cable type**. The most common cable is un-shielded twisted pair (UTP), which is most often used with star topologies.

Podľa logickej topológie (1)

Unicast - „jednosmerové vysielanie“. Údaje sú posielané len z jedného uzla inému (jednému).

Multicast „viacsmerové vysielanie“. Údaje sa odošlú celej skupine len raz z počítača a tie sa podľa potreby v uzli kopírujú, pričom rozhodnutie o cieľoch je určený obsahom správy.

Podľa logickej topológie (2)

Broadcast „všesmerové vysielanie“. Údaje sa posielajú na všetky počítače v dosahu (obvykle sa jedná o lokálnu sieť).

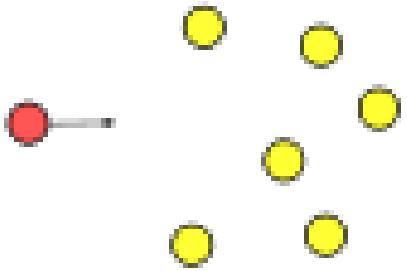
Token passing (odovzdávanie „tokenu“), posielať - vysielať údaje môže iba tá stanica, ktorá vlastní „token“.

Podľa logickej topológie (3)

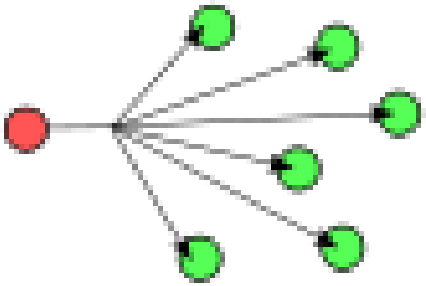
Anycast (výberové) –

správa odchádza z jedného uzla a je určená skupine uzlov, pričom ľubovoľný člen tejto skupiny je schopný správu prijať. Ako náhle je správa jednému uzlu doručená, komunikácia je ukončená.

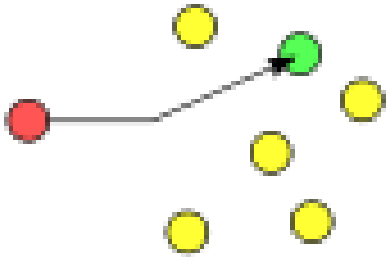
Podľa logickej topológie (4)



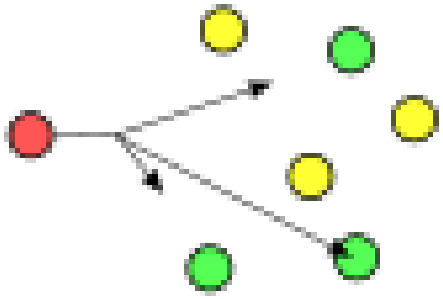
Routing schemes



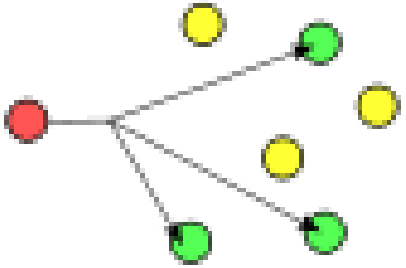
broadcast



unicast



anycast



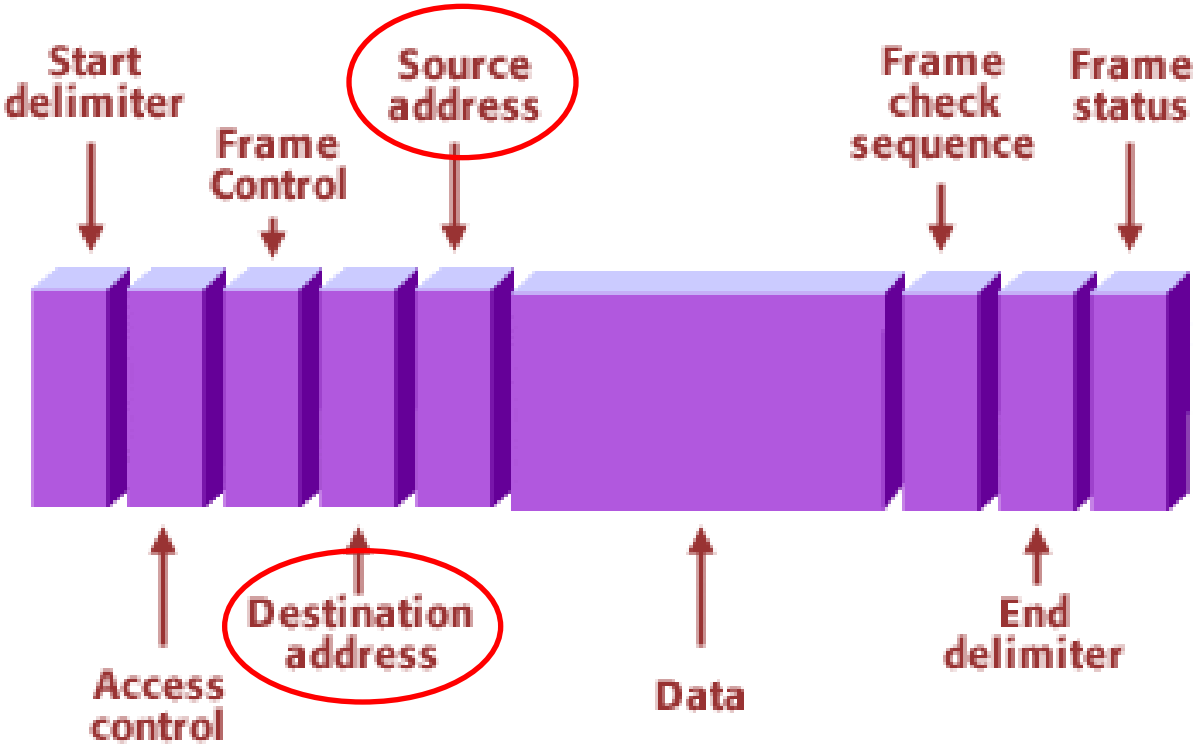
multicast

geocast

Vysielanie podľa MAC adresy

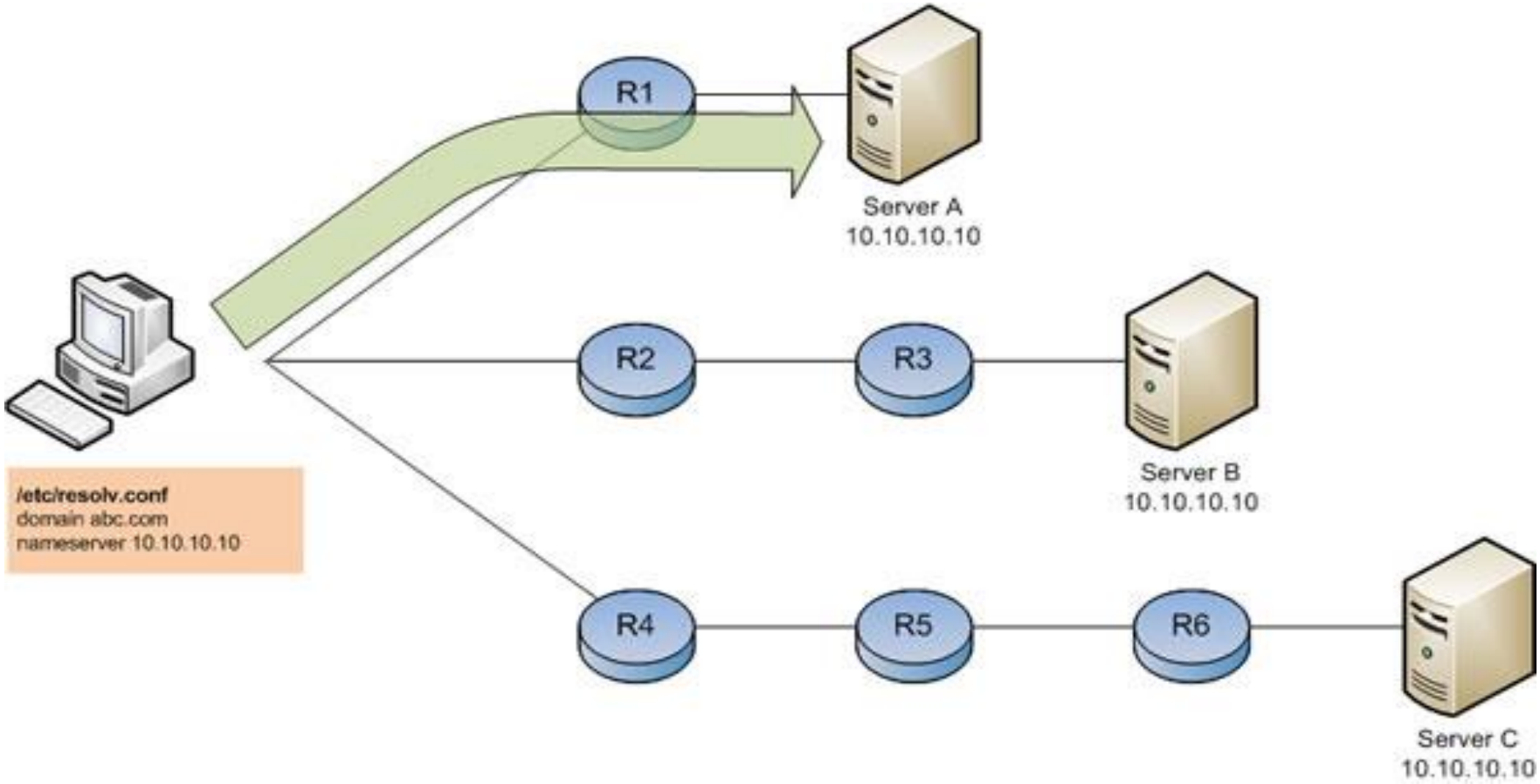
- V každom balíku dát (viď. ďalší slide „rámec“ - frame) sa nachádza adresa zdrojová (ktorá karta posiela) a cieľová adresa MAC (ktorej karte posiela). Podľa cieľovej MAC adresy môže byť prenos dát:
- UNICAST - karta (zdroj) posiela konkrétnej karte, napríklad 34:00:6e:b1:08:aa → e7:07:cc:6a:ba:30
- MULTICAST - karta (zdroj) posiela skupine kariet, napríklad 34:00:6e:b1:08:aa → ff:07:cc:6a:ba:30
- BROADCAST - karta (zdroj) posiela všetkým kartám, ktoré môžu správu prijať (sú v rovnakej sieti LAN), napríklad 34:00:6e:b1:08:aa → ff:ff:ff:ff:ff:ff

The data frame

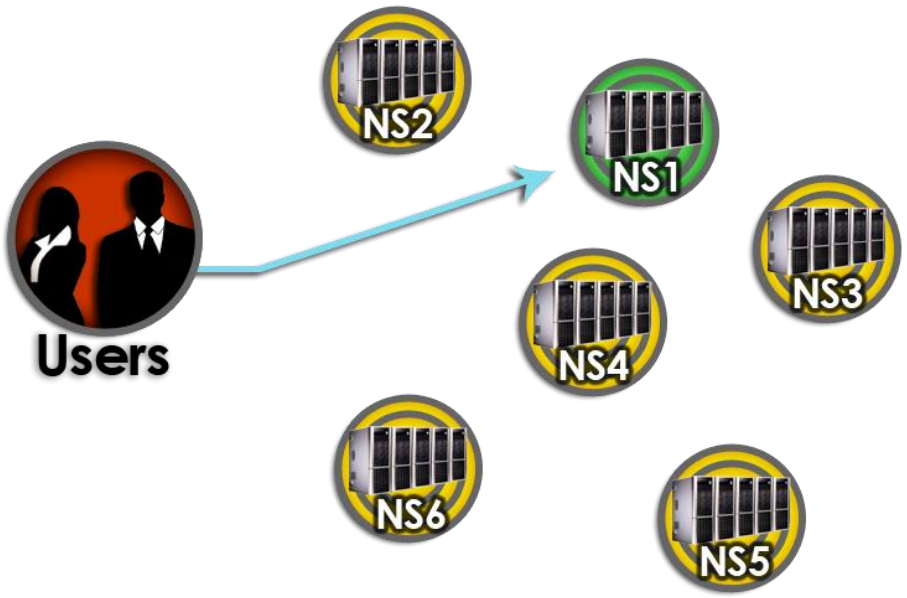


The data frame includes a number of headers. The data field varies in length but is commonly 4202 bytes.

The diagram below shows an example of Anycast DNS. A single DNS client workstation, configured with the Anycast DNS IP address of 10.10.10.10, is shown performing DNS resolution against its "closest" of three DNS name servers deployed using the same Anycast IP address.



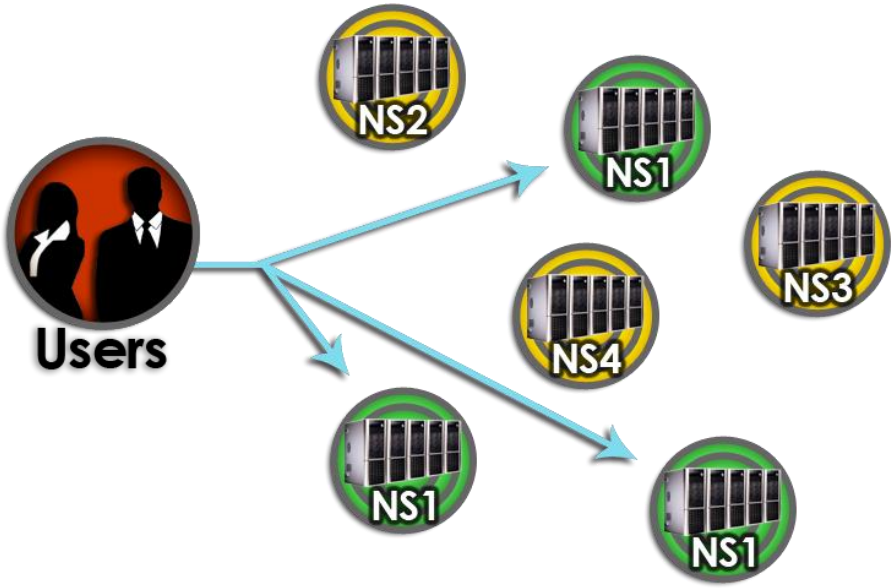
Unicast DNS vs. Anycast DNS



In Unicast DNS, there is a one-to-one association between network address and network end point: each destination address uniquely identifies a single receiver endpoint. So, if your Unicast DNS network had three name server records - ns1, ns2, and ns3 - each of those corresponds to exactly one name server.

As long as everything is working properly, your DNS will be fine. However, if one of those servers goes down for any reason, suddenly one of your name server records does not work, because that one server is down. So, you have ns1, ns2, and ns3 listed as your name servers, but due to a severe storm, ns3 has gone down. Now, 1/3 of your queries are going to be dropped because that server is no longer available on your network.

Unicast DNS vs. Anycast DNS



In Anycast DNS, there is a one-to-many association between network addresses and network endpoints: each destination address identifies a set of receiver endpoints, but only one of them is chosen at any given time to receive information from any given sender.

So, if your Anycast DNS network has three name server records - ns1, ns2, and ns3 - each of those corresponds to a group of name servers located in many different geographical regions. So, if one of the servers on the network goes down, it's ok, because there are several other servers that can respond for the same name server record.

Unicast DNS vs. Anycast DNS

- In addition, an Anycast DNS network will automatically route queries to the name server that is closest to the client geographically. So even though the servers listed for ns1 could be located in the US, Europe, and Asia, a client in China will only be getting responses from the name server in Asia rather than having their queries routed to several different continents. Clearly, **Anycast DNS is vastly superior to Unicast DNS in terms of reliability and speed.**

Közeg hozzáférési módszerek (CSMA/CD, Vezért jeles gyűrű)

- N számú független ADÓ osztozik egy kommunikációs csatornán,
- az állomásoknak van ütközés érzékelő mechanizmusa, (ütközés: két ADÓ ad egy időben)
- az állomások képesek a csatorna foglaltságát figyelni.

A közeg elérési módja (1)

- **Véletlen átvitel - vezérlés:** akkor a közeget elvileg bármelyik állomás használhatja, de a használat előtt meg kell győződnie arról, hogy a közeg más állomás által nem használt.
- **Osztott átvitel - vezérlés:** ebben az esetben egy időpontban mindig csak egy állomásnak van joga adatátvitelre, és ez a jog halad állomásról-állomásra.

A közeg elérési módja (2)

- **Központosított átvitel - vezérlés:** ilyenkor van egy kitüntetett állomás, amely vezérli a hálózatot, engedélyezi az állomásokat. A többi állomásnak figyelnie kell, hogy mikor kapnak engedélyt a közeg használatára.

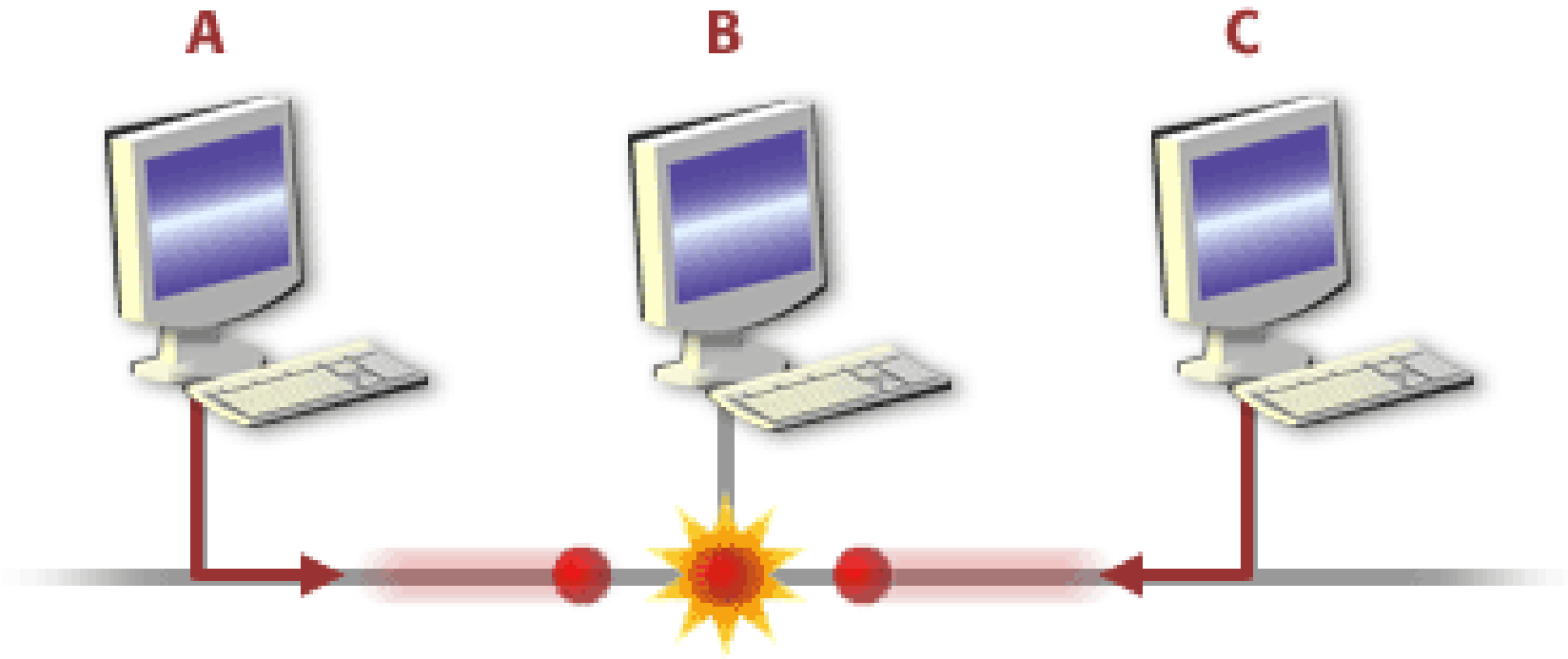
Prístupové metódy

- Prístup sieťových staníc ku káblu.
  - Zabezpečiť, aby do siete vždy vysielala v jednom okamžiku len jedna stanica
  - Súčasné vysielanie viacerými stanicami dochádza k znemožneniu prenosu
  - Prístupové metódy, rovnako ako topológia je podstatný znak sieťového štandardu

Access control method

- A network can consist of two or three computers, or several thousand. Regardless of the size, however, when multiple computers share a cable or airwave there is a chance that more than one computer will transmit at the same time. This can cause the transmissions to "collide," or interfere with one another. To prevent this, an *access control method* must be implemented.

The graphic below illustrates what happens when several computers linked on a linear bus network send out a data packet simultaneously.



Access methods can be classified as one of two types:

1. *Contention methods*: In these methods, the computers must contend, or compete, for use of the network cable or other media. Any computer can transmit at any time, so there is a chance for collisions of data packets if two transmit simultaneously.

Access methods can be classified as one of two types (cont.):

2. Non-contention methods: In these methods, computers must "wait their turn" to transmit. There is an orderly process for designating the computer that is allowed to transmit at a given time, so there is no chance of data packets colliding on the wire.

Access methods

- The access method used by Ethernet networks, Carrier Sense Multiple Access/Collision Detection (CSMA/CD), is a popular **contention** method of media access. Token passing, used by IBM's Token Ring networks, is a popular **non-contention** method.

Prístupové metódy (1)

- CSMA-CD (Carrier-sense Multiple Access with Collision Detection) – metóda náhodného prístupu (stochastická)
- Collision
  - In Ethernet, the result of two nodes that transmit simultaneously. The frames from each device impact and are damaged when they meet on the physical media.

Prístupové metódy (2)

- Token ring – špeciálny paket – token. Deterministická prístupová metóda.
- Token bus – ako „token ring“, ale nie je nutná kruhová fyzická topológia siete. Deterministická prístupová metóda.

CSMA-CD

- Stanica zistí, či nevysiela niektorá zo staníc v sieti
  - Ak nie, začne vysielať
  - Ak áno, nevysiela a čaká na ukončenie vysielania
- Ak súčasne začne vysielať niekoľko staníc, preruší sa vysielanie a pokračuje po náhodnom čase.

The characteristics of the CSMA/CD access method.

- The most common access method in use on LANs today is *CSMA/CD*, which stands for *Carrier-Sense Multiple Access/Collision Detection*. To understand what CSMA/CD is, let's break the name down into its three component parts:

CSMA/CD, part 1.

- Carrier-Sense: This means the NIC (or network interface card) on each computer on the network "listens" and senses whether there is traffic on the cable before sending.

CSMA/CD, part 2.

- Multiple Access: This means all computers have access to the cable at any given time (making this a contention method of access control).

CSMA/CD, part 3.

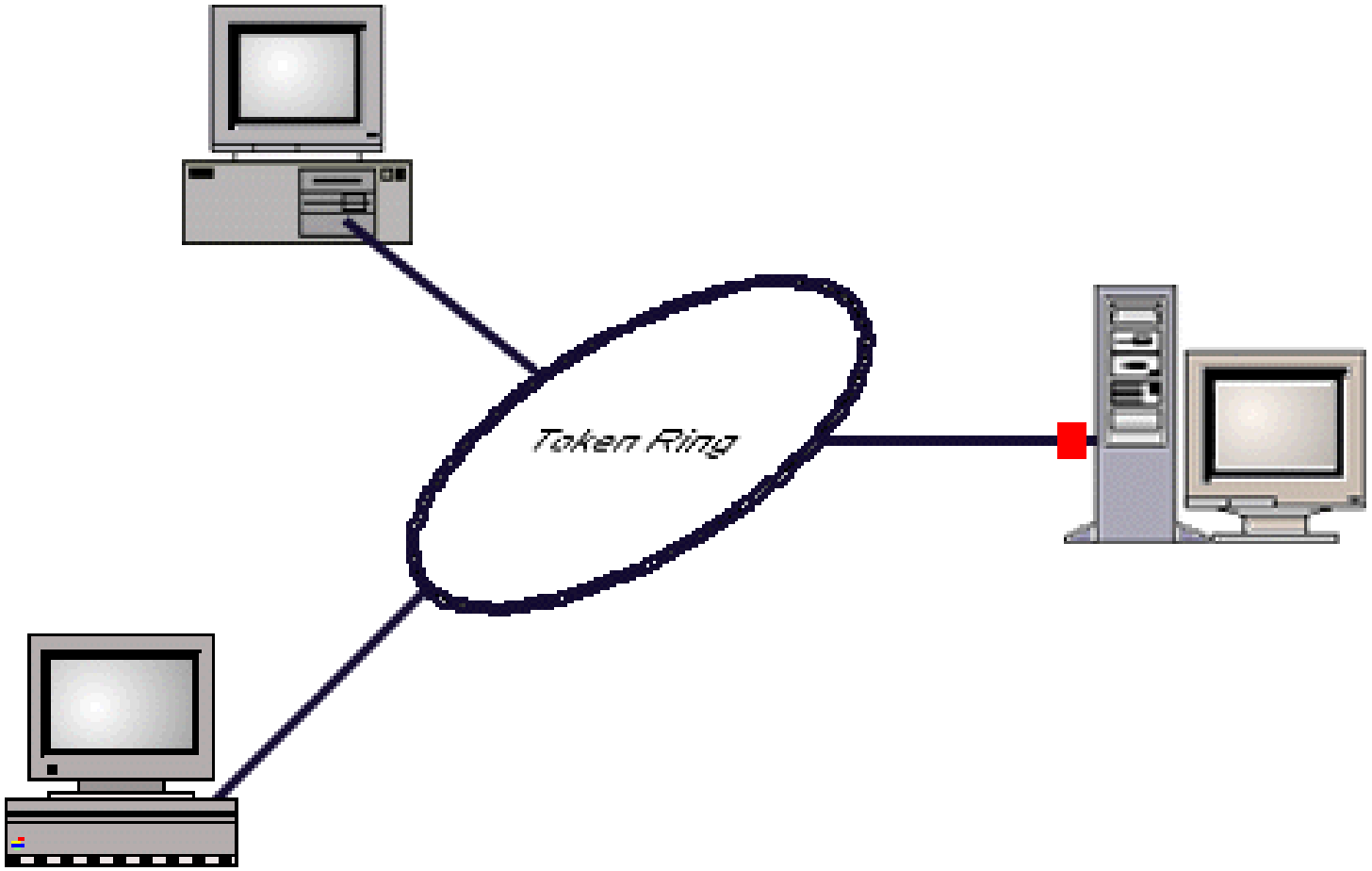
- Collision Detection: This means that *collisions* may occur, if two computers send data at exactly the same time--but the NICs of the sending computers will detect that a collision has occurred so they can re-send their data.

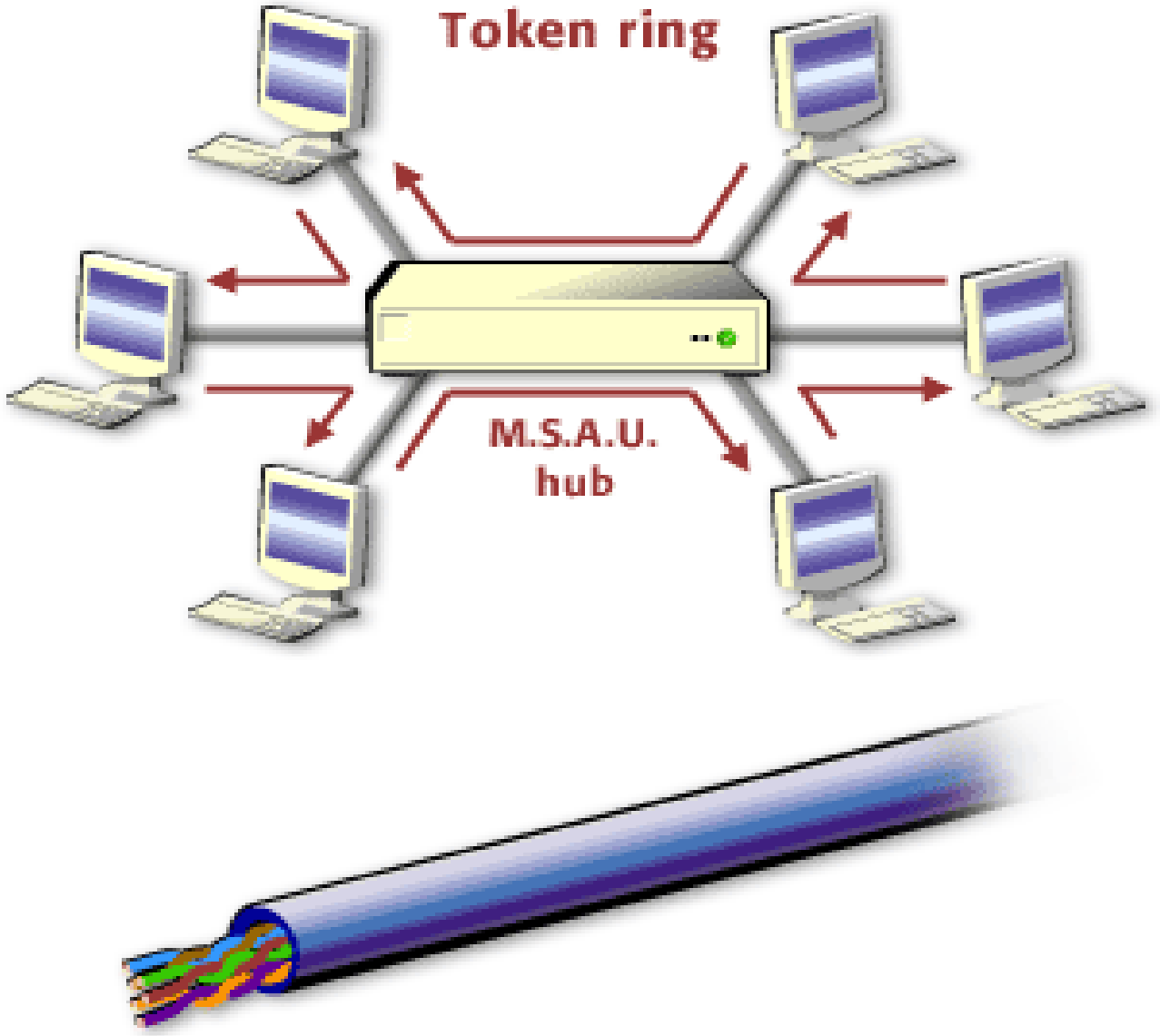
- http://thought1.org/nt100/module5/csma_cd_fb.sb.html
- http://thought1.org/nt100/module5/csma_ca_fb.sb.html

Token ring

- **Token ring** local area network (LAN) technology is a local area network protocol which resides at the data link layer (DLL) of the OSI model. It uses a special three-byte frame called a **token** that travels around the ring. Token-possession grants the possessor permission to transmit on the medium. Token ring frames travel completely around the loop.

Token passing





Multi-station Access Unit (MSAU)

The Token Ring

- architecture was developed by IBM in the 1980s. Specifications are defined in the IEEE 802.5 standard. IBM designed Token Ring to connect different computer types, including PCs and mainframes (using the Systems Network Architecture, or SNA, environment).

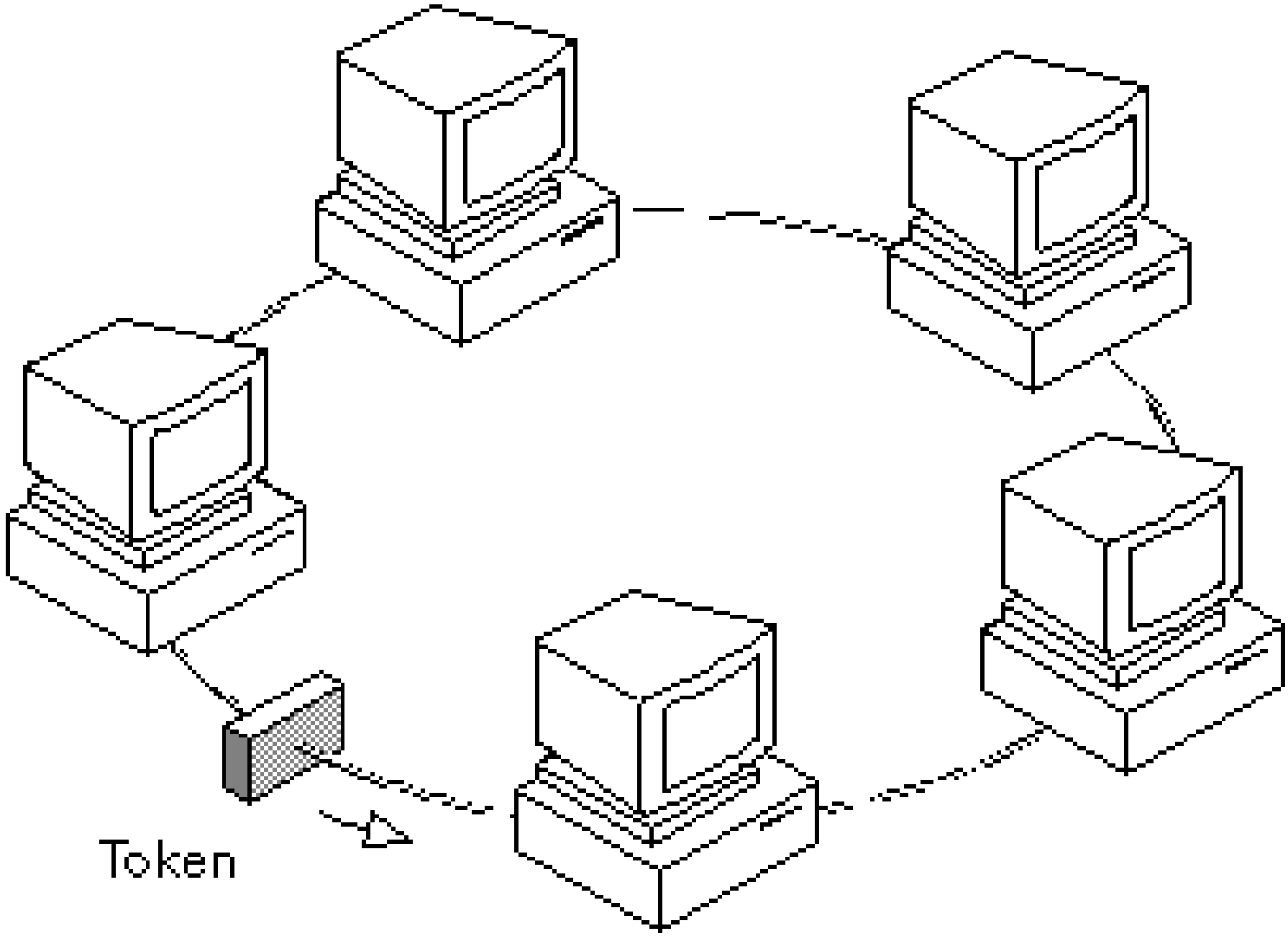
The token passing access method

- Token passing is a more orderly way for a network to conduct its business. A signal called a *token* goes from one computer to the next. In a Token Ring network, the token **goes around the ring**; in a token bus network, it goes down the line of the bus. If a computer has data to transmit, it must wait until the token reaches it; then that computer can capture the token and transmit data.

- http://thought1.org/nt100/module5/token_p_fb.sb.html

Token ring

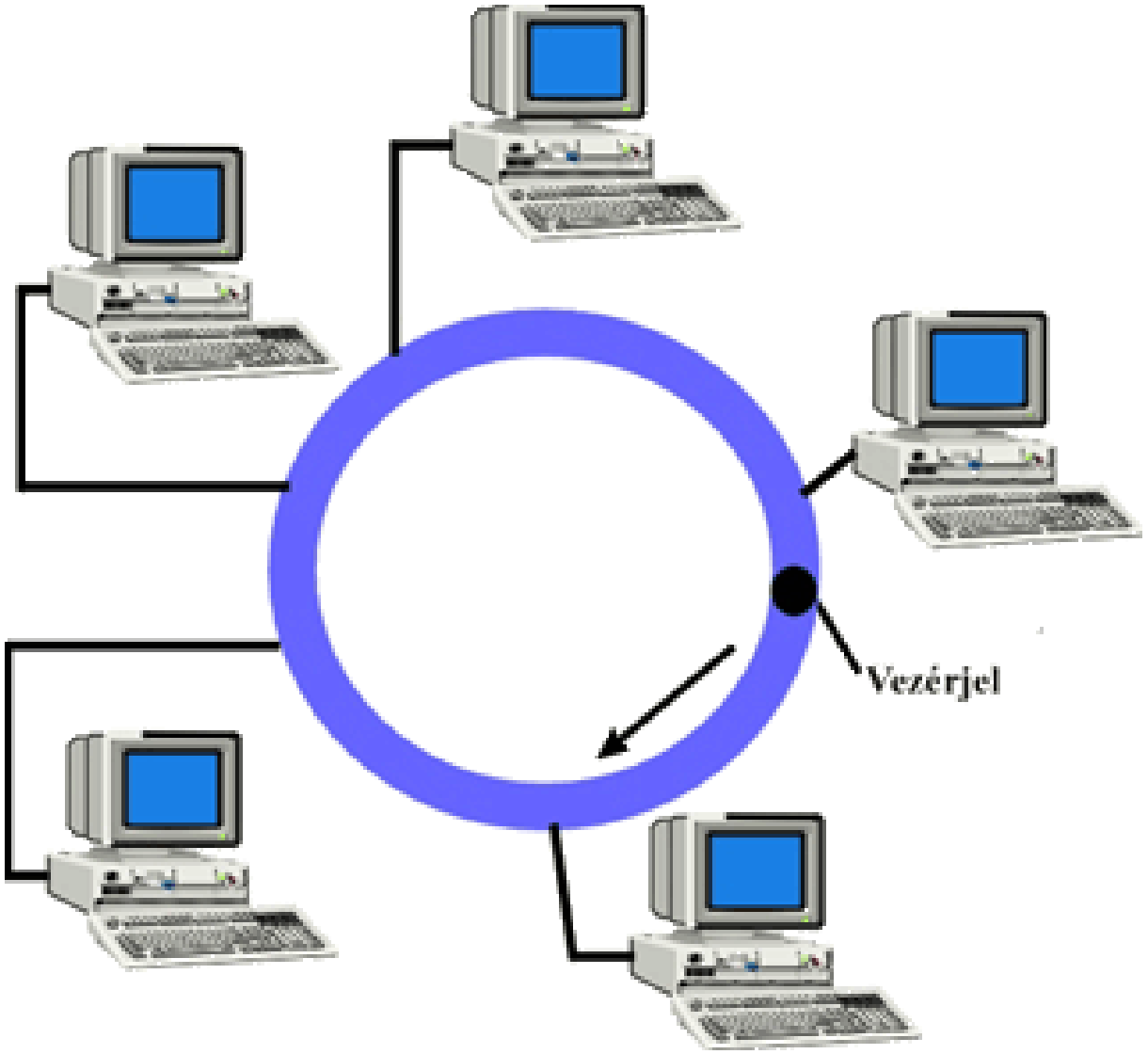
- Jednoduchý princíp – koluje paket „token“.
- Vysiela stanica, ktorá vlastní „token“.
- Token sa postupne odovzdáva po sieti
- Výhody: Odolnosť proti zahlteniu aj pri vysokom zaťažení siete.
- Nevýhody: zložitosť a nižšia rýchlosť (časť činnosti siete je venovaná obehu tokenu)


Token

„Beszélőpálca”

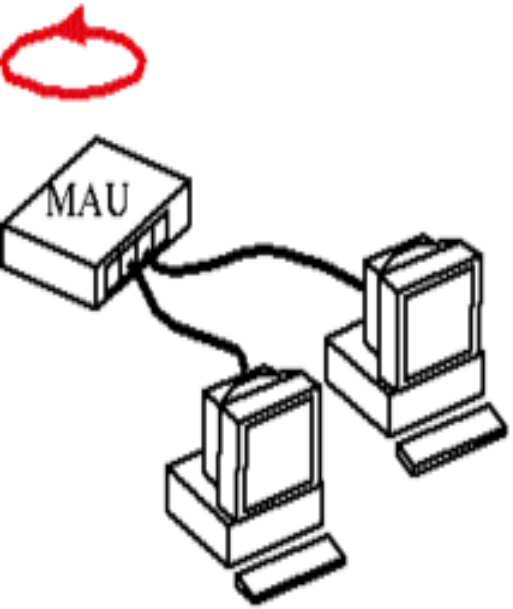
Token Ring

Vezérjeles gyűrű (Token Ring)

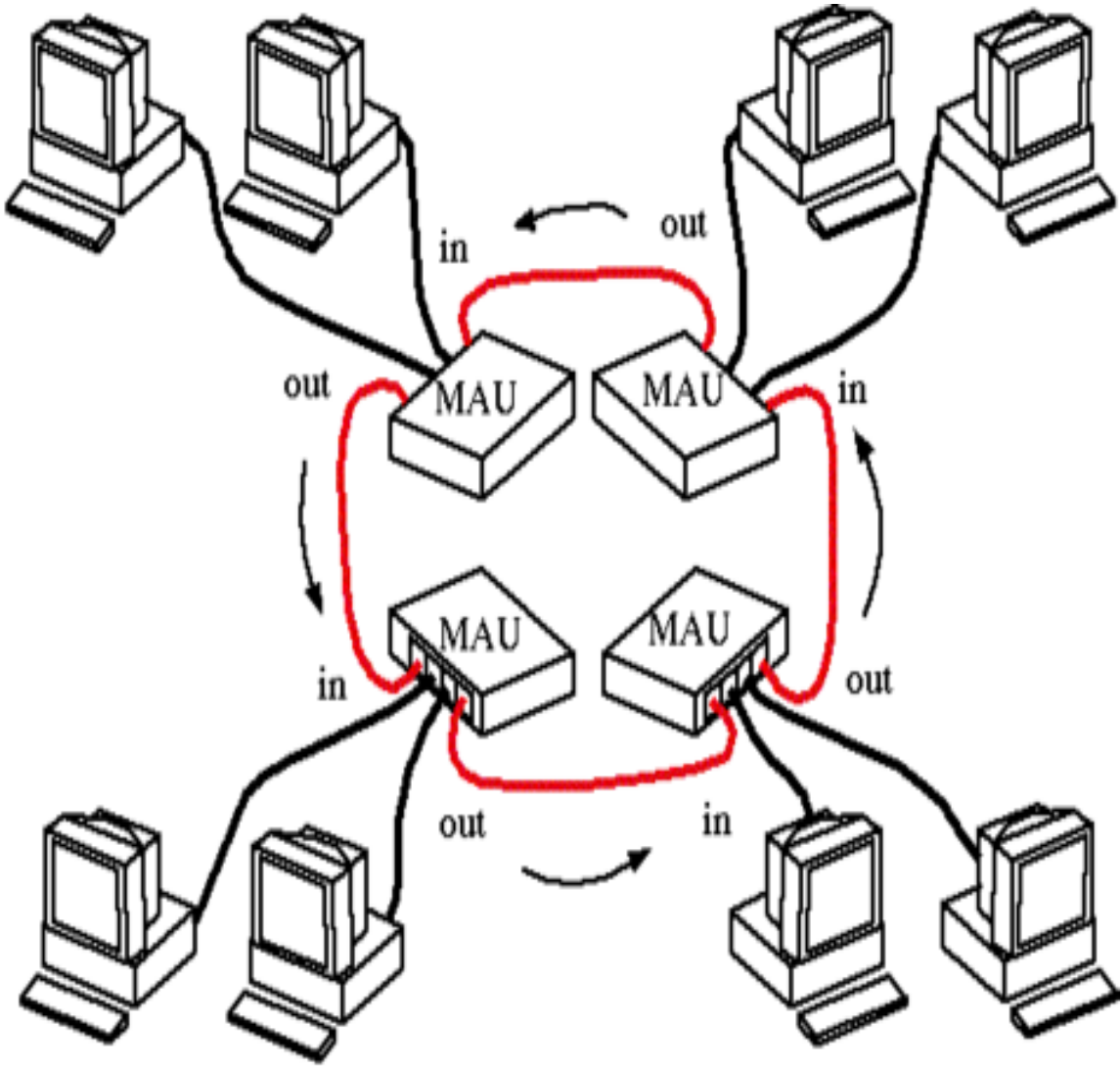


Token ring -

- the cables are connected from each computer to a type of hub called a *Multi-station Access Unit (MSAU)*. You will recall that Token Ring's topology consists physically as a star, but logically as a ring because inside the hub, the wiring is arranged in a ring. There can be multiple MSAUs on one ring; you must connect the "out" port on one MSAU to the "in" port on the next to maintain the ring configuration.

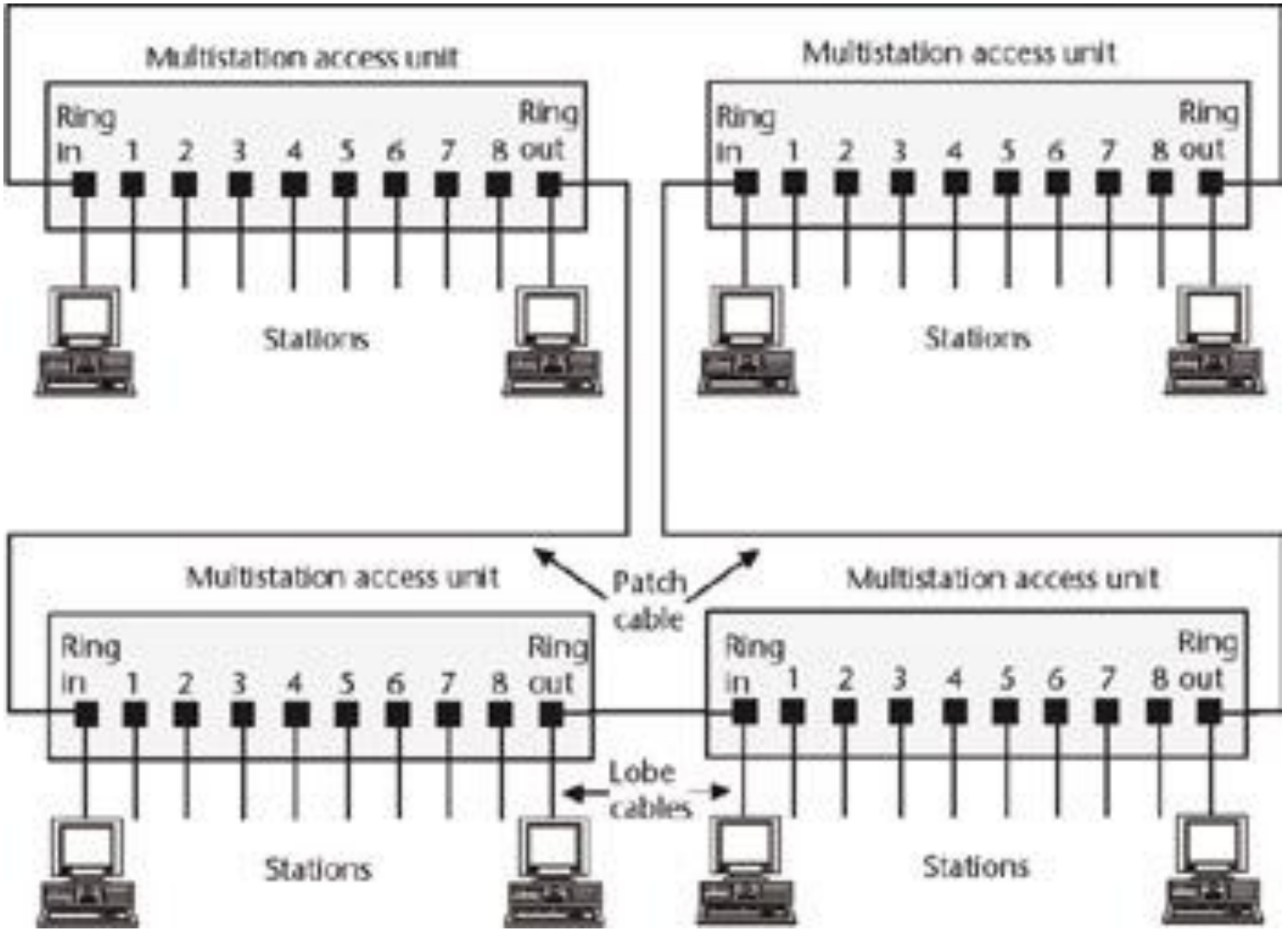


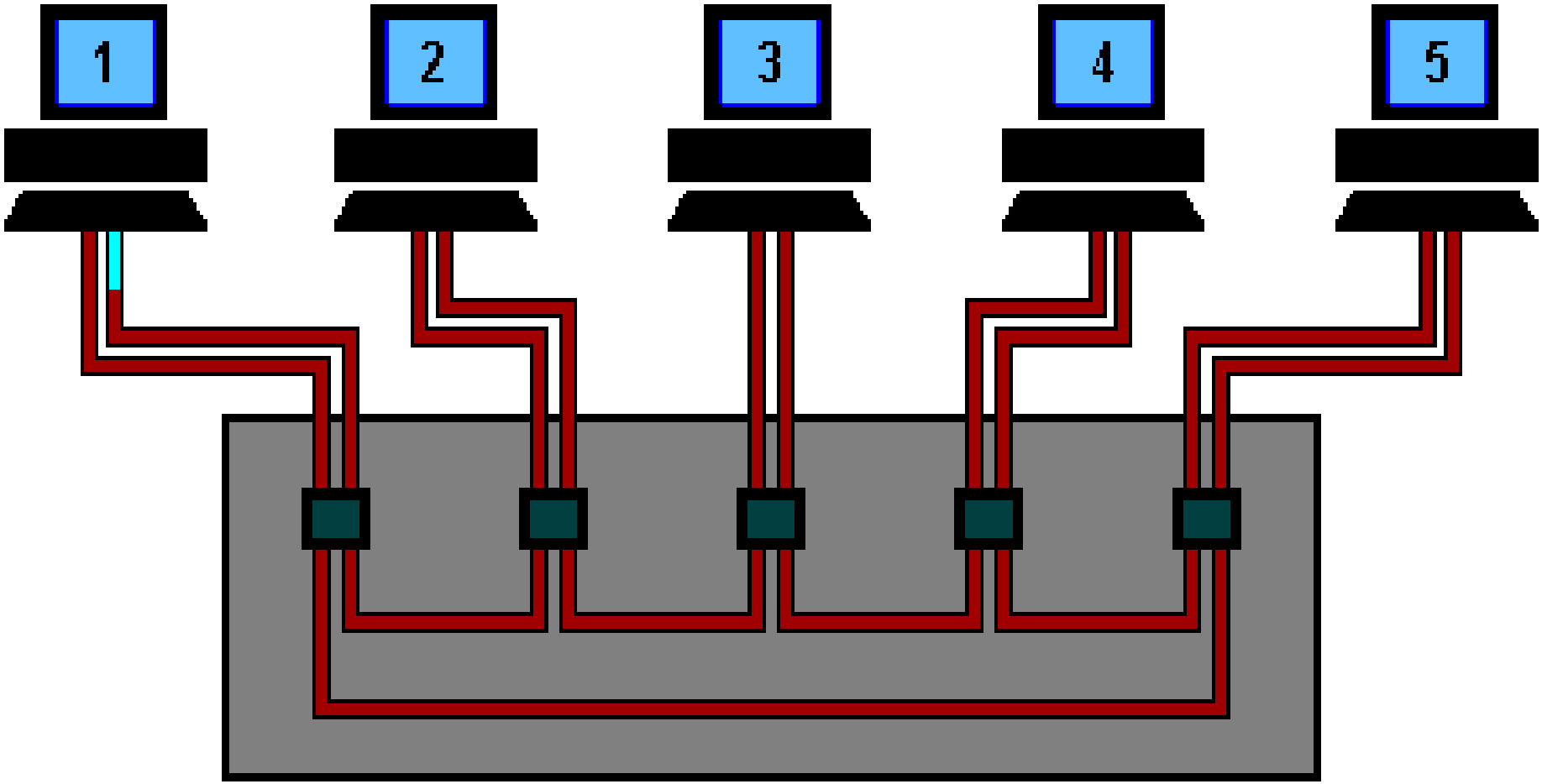
a)



b)

Token ring configured in a star topology through the use of MAUs.




1
2
3
4
5

Token Ring networks

- use the token passing access control method. Only one token can be active on the network at a given time. It circles the network until a computer that is ready to send data captures it. The token's direction of travel depends on which specifications you use. According to 802.5, the token should travel clockwise, but some IBM publications say it should travel counterclockwise.

Token Ring networks

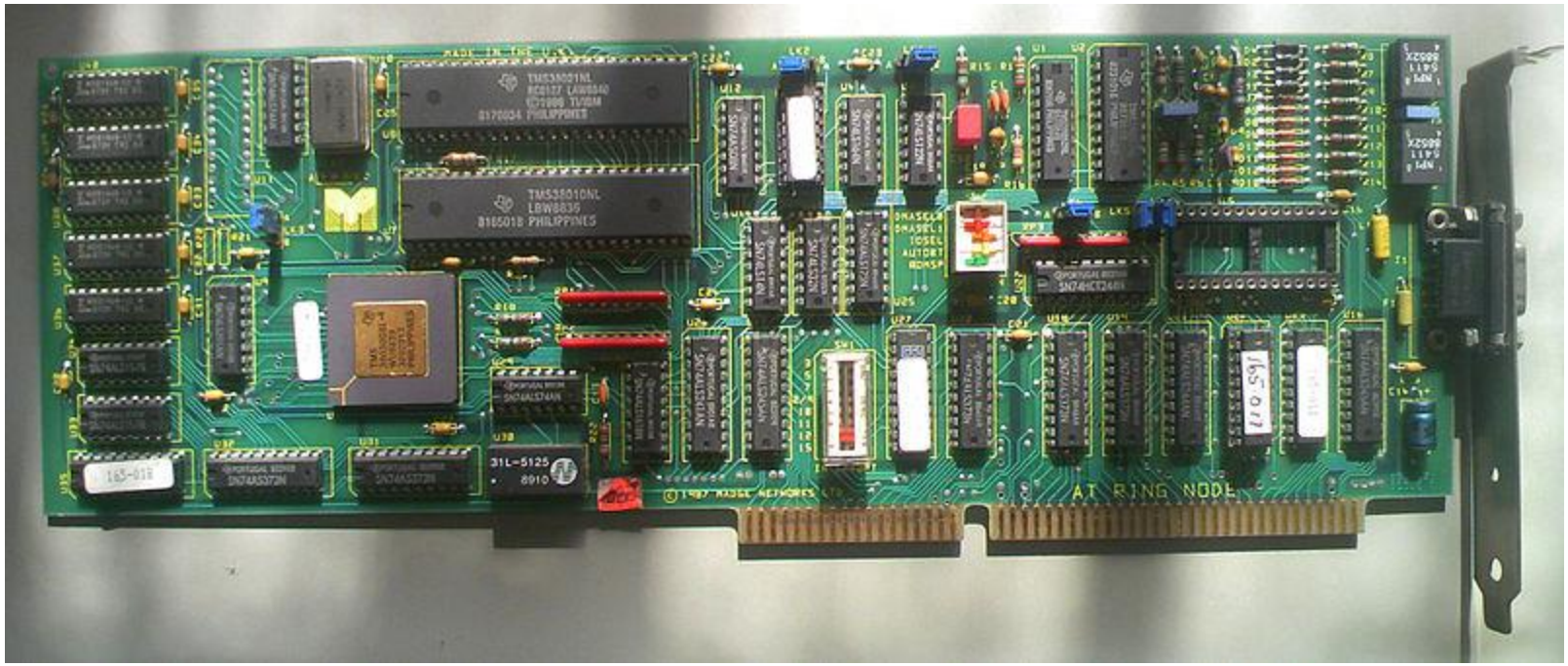
designate one computer to monitor network activity and ensure that frames get delivered correctly. This is the first computer that comes online on the network. The computer does this by sending a signal called a *beacon* at periodic intervals-a process called beaconing.

There are actually three types of Token Ring frames:

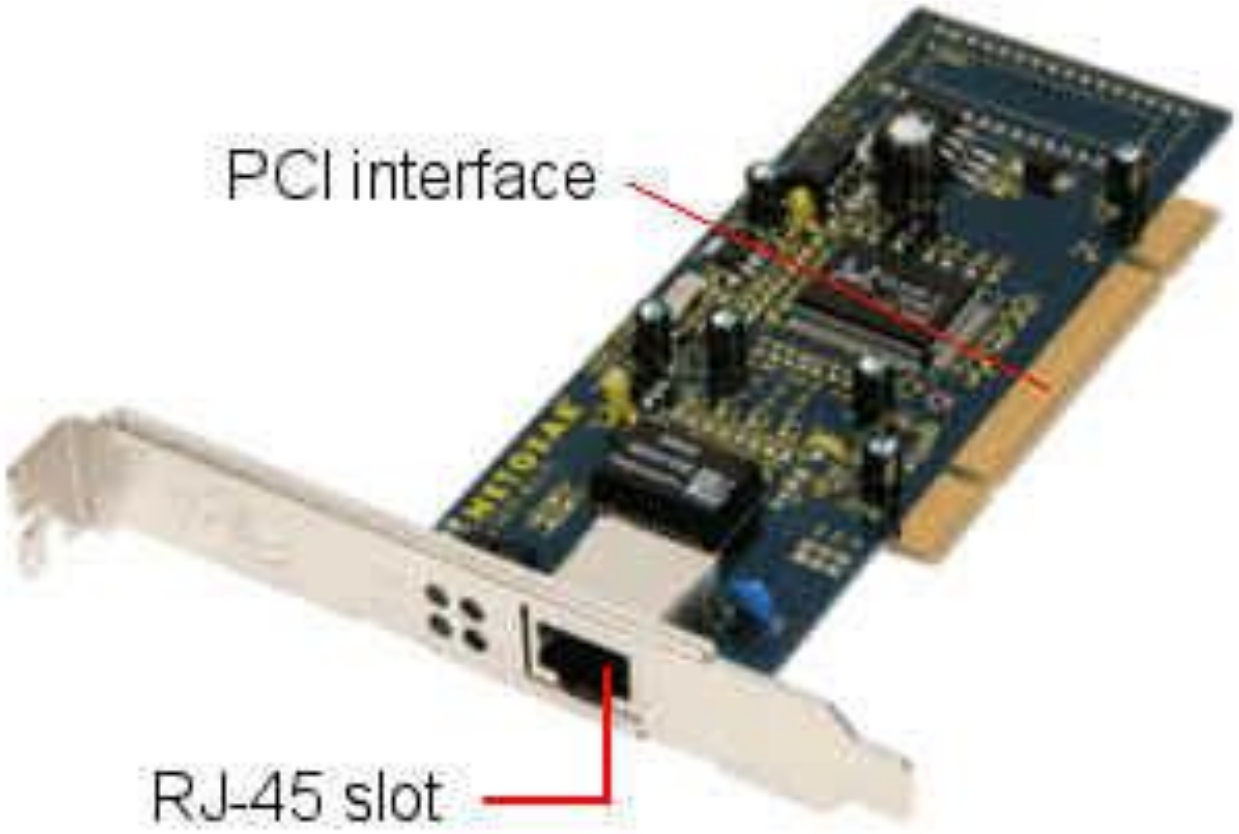
- Token frame
- Data frame (also called LLC frame)
- Management control frame (also called MAC frame)

- http://thought1.org/nt100/module6/token_ring_fb.sb.html

Madge 4/16Mbps Token Ring ISA NIC

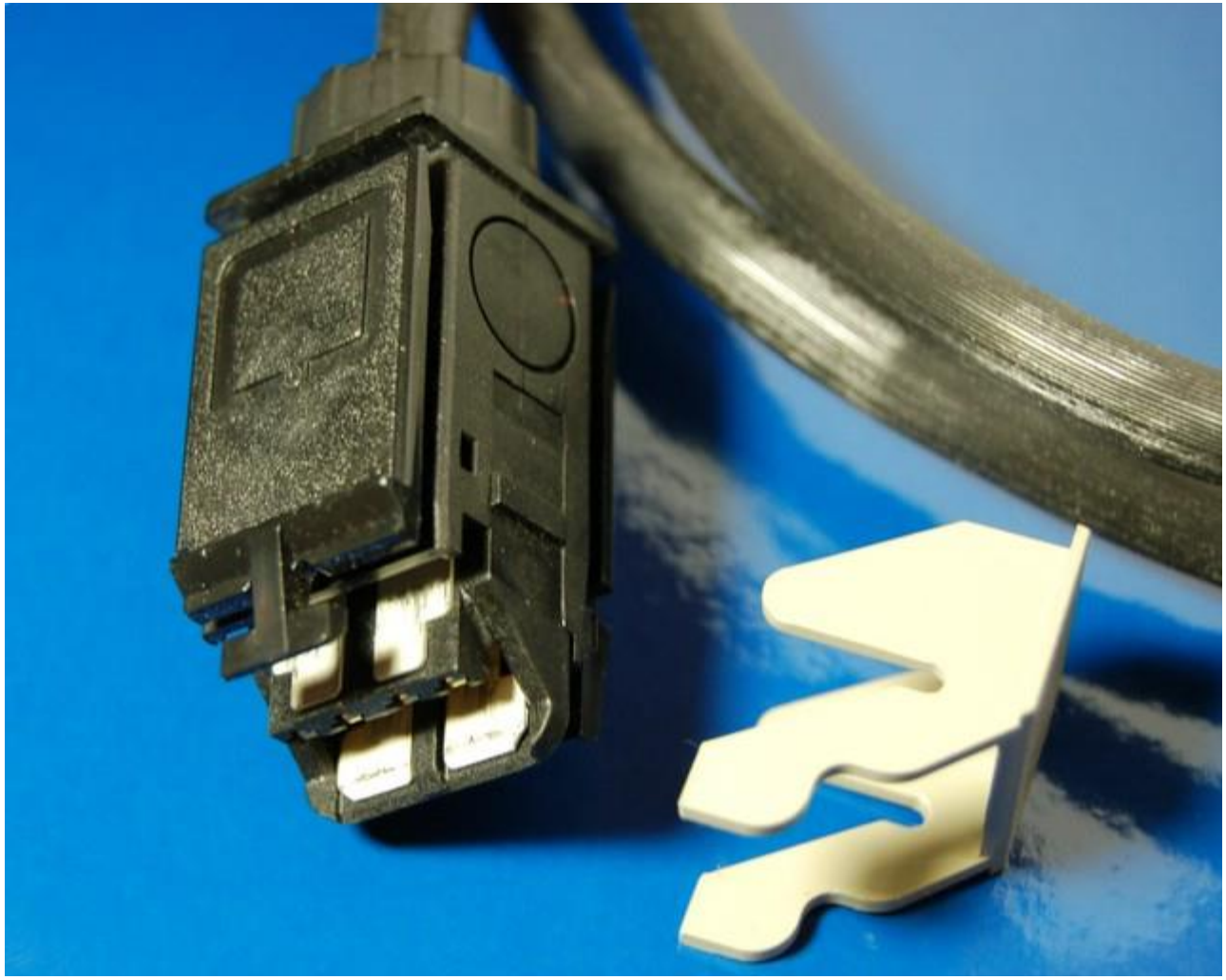


NIC



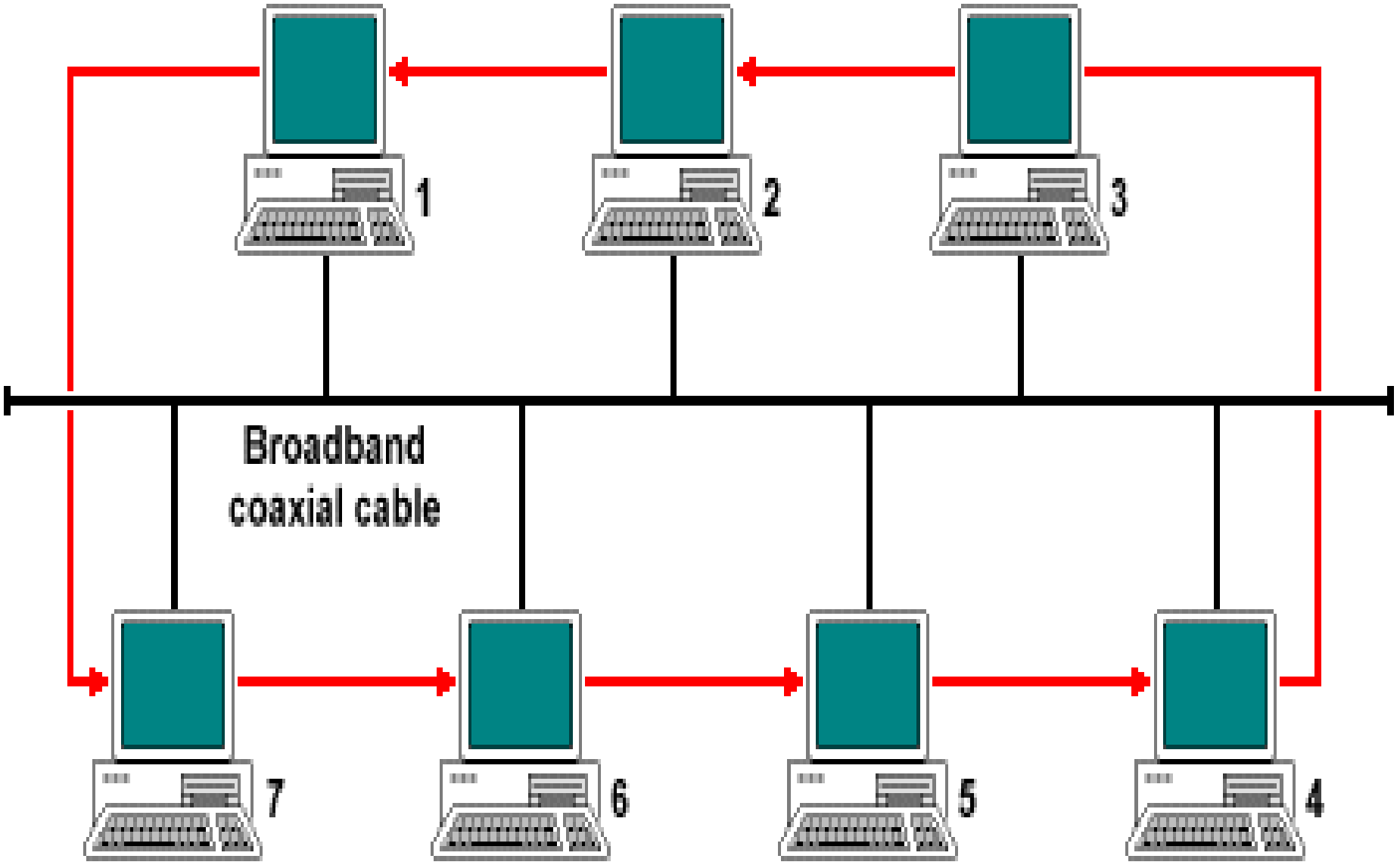
An IBM 8228 MAU

IBM hermaphroditic connector with locking clip

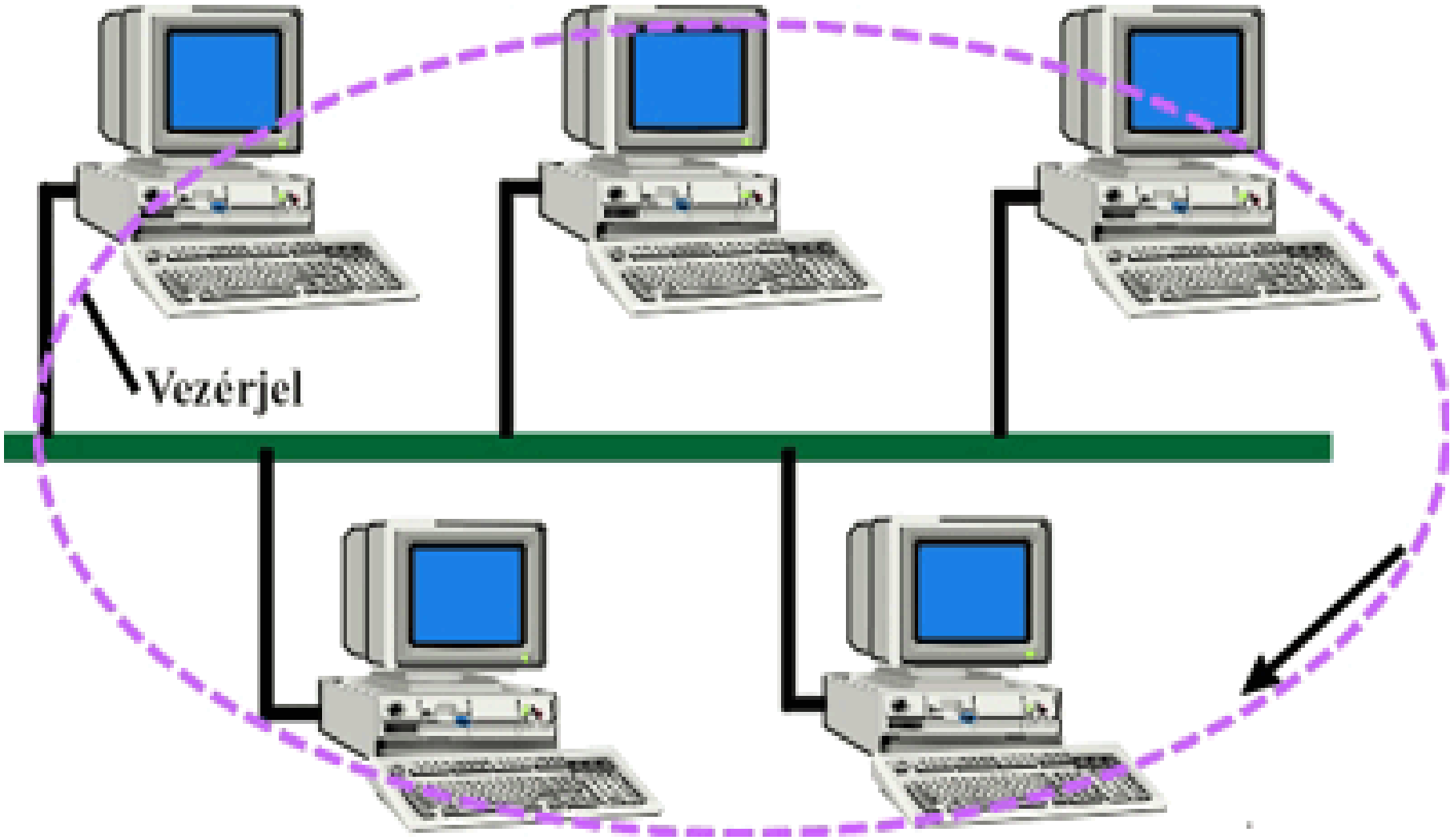


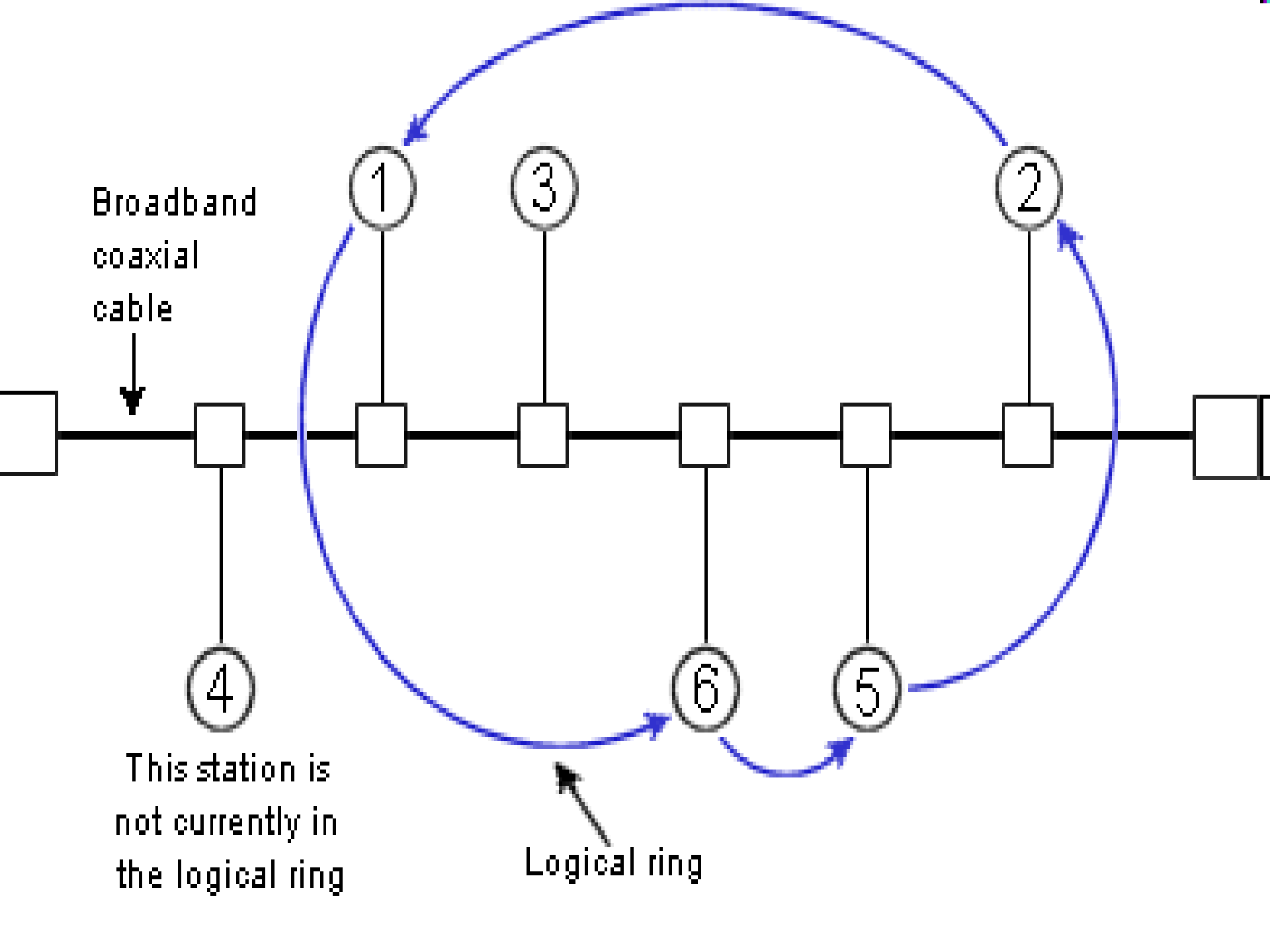
Token bus

- Každá stanica obdrží logickú adresu, vytvára sa „logický kruh“.
- Token sa podáva – koluje po logických adresách
- Nutnosť logickej adresácie staníc


1
2
3
Broadband
coaxial cable
7
6
5
4

Vezérjeles sín (Token Bus)

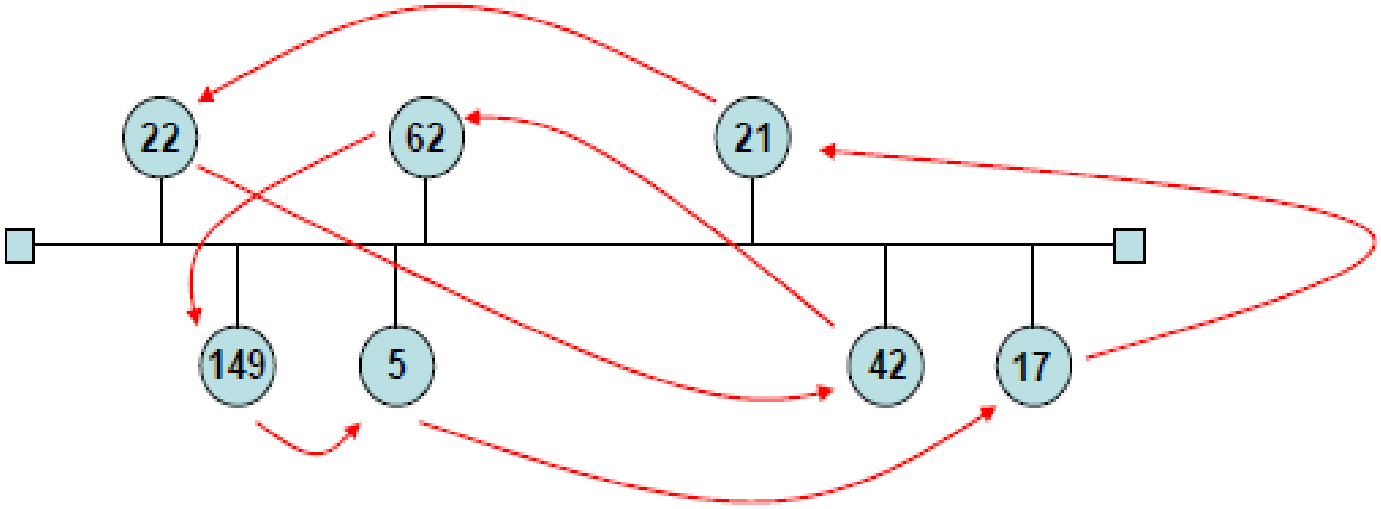



Broadband
coaxial
cable
1
3
2
4
6
5
This station is
not currently in
the logical ring
Logical ring

Token Bus

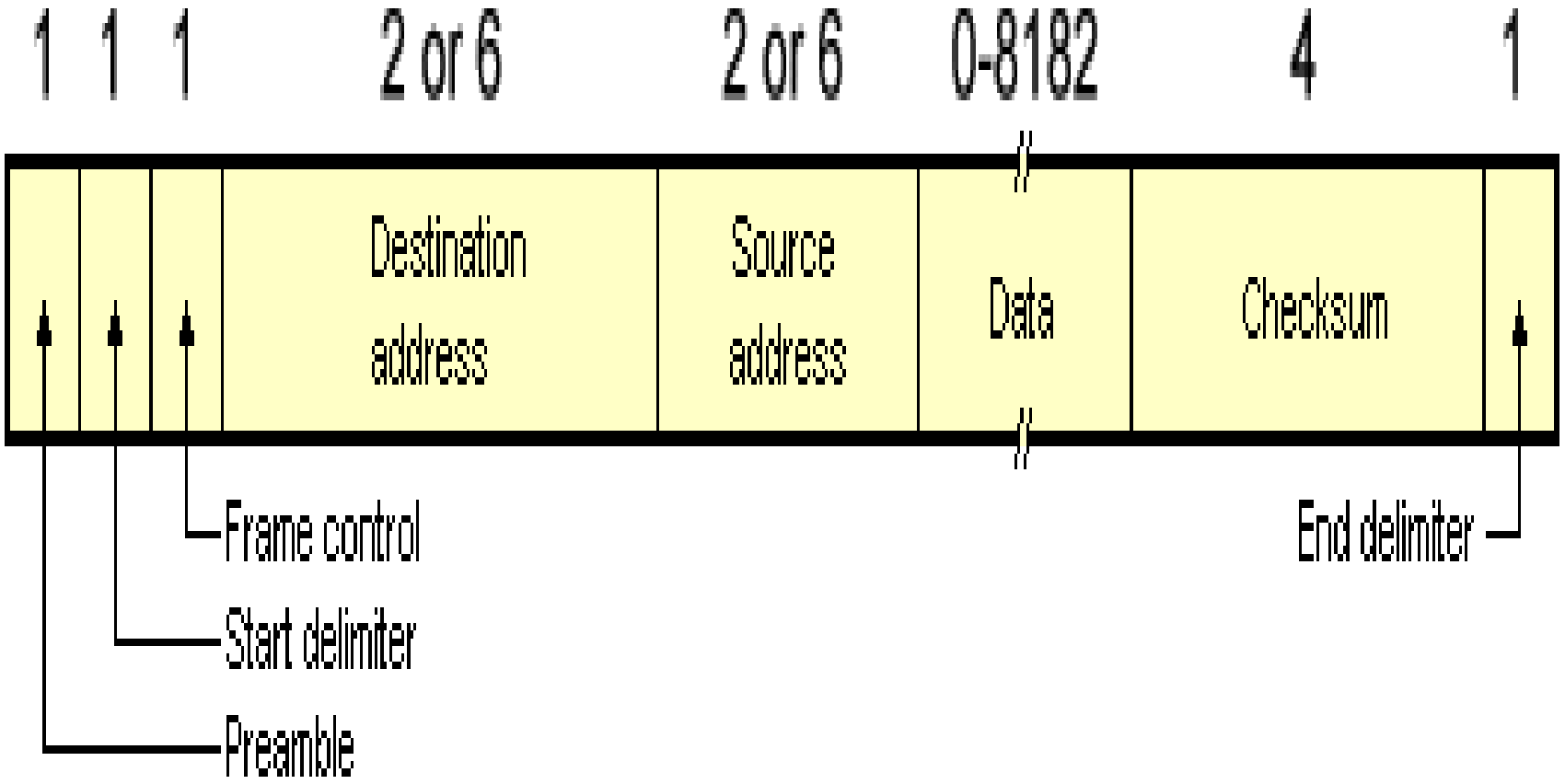
"Token"-procedure: Only someone who possesses a certain token (= bit sequence), may send.

- One example for a token network: IEEE 802.4 "Token Bus"
- All stations should be treated equally, i.e. they have to pass on the token cyclically
- For this: logical ordering of all stations to a ring
- In a bus topology, ordering is made regarding station addresses:

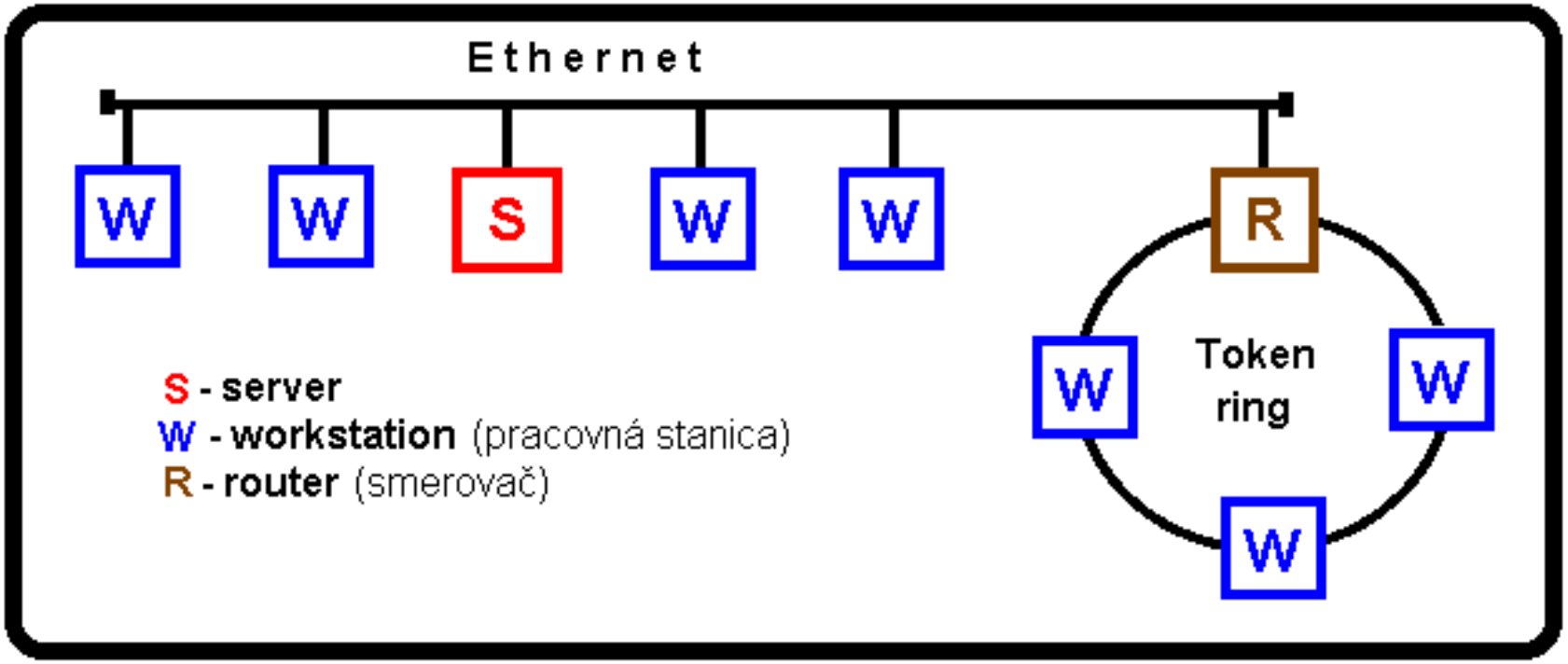


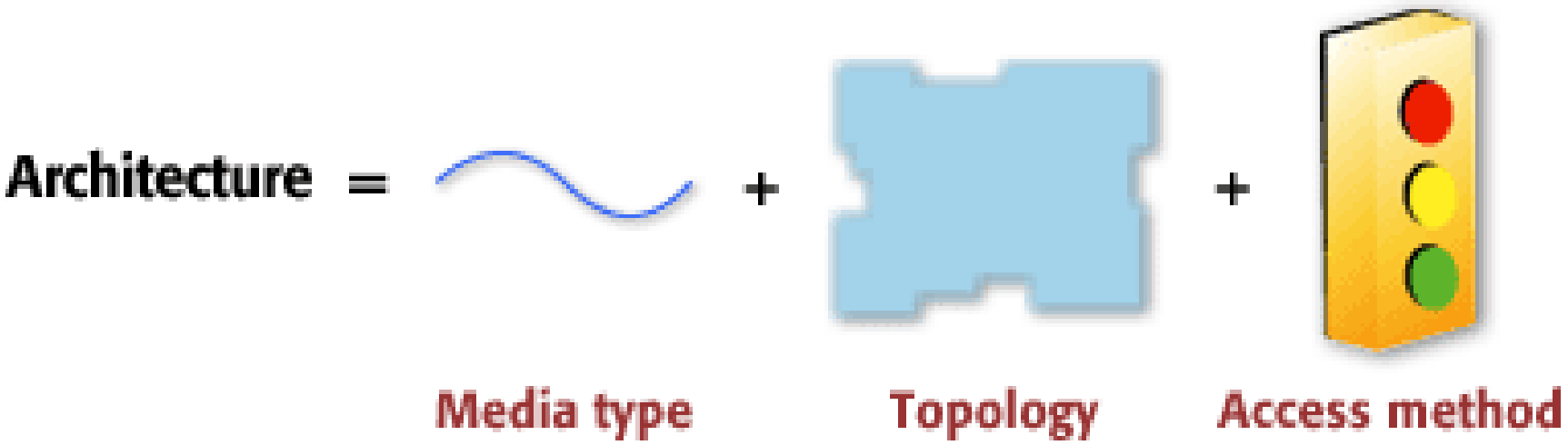
- Usage e.g. as a field bus (Feldbus in German) in industrial environments with a high degree of noise. Purpose: e.g. roboter control; a few masters, many slaves (they only listen). Data rate is not that important, but guarantees in response times are necessary (not possible with Ethernet).

The Token Bus frame format



Prepojenie sietí s rôznou topológiou



Obrázok: Prepojenie sieti s rôznou topológiou

Network architecture is a term that defines a particular network in terms of a combination of factors.