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BAHIA

# Redes de Computadores

Ramon Fontes

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# Ementa

Introdução à redes. Conceitos básicos de redes. Meios físicos para redes. Cabeamento de redes locais e WANS. Conceitos básicos de Ethernet. Tecnologias Ethernet. Comutação Ethernet. Conjunto de protocolos TCP/IP e endereçamento IP. Conceitos básicos de roteamento e de sub-redes. Camada de transporte TCP/IP e de aplicação. Comunicação sem fio. Introdução à segurança de redes.

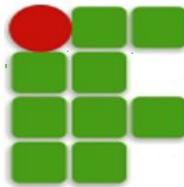
**Carga horária:** 72 horas

# Competências e habilidades

- Identificar os principais conceitos envolvidos numa rede de computadores, suas várias aplicações e configurações possíveis, as tecnologias mais utilizadas e também apresentar os padrões e protocolos de comunicação mais importantes.

# Bibliografia

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# REDES DE COMPUTADORES I

Conceitos

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# Conceitos

Conjunto de computadores autônomos interconectados

- Troca de informações
- Compartilhamento de Recursos

# Tipos de Redes

O tipo de rede, praticamente, define os meios de comunicação e os periféricos que utilizaremos para montagem da rede.

Os tipos de redes estão divididos em:

- LAN – Rede Local
- MAN – Rede Metropolitana
- WAN – Rede de Grande Alcance.

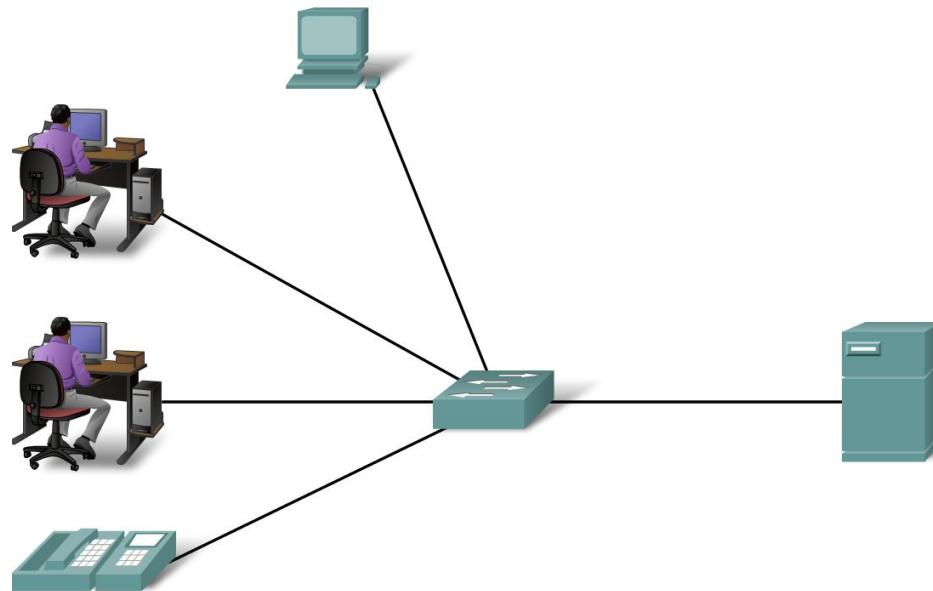
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## LAN – Rede Local

A rede local é utilizada para realizar a conexão entre um grupo de computadores com a finalidade de trocar informações entre eles.

A denominação local vem por esse tipo de rede ser normalmente montada para cobrir um alcance de no máximo 10 Km.

# LAN – Rede Local



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# LAN – Rede Local

Uma rede local normalmente é composta por:

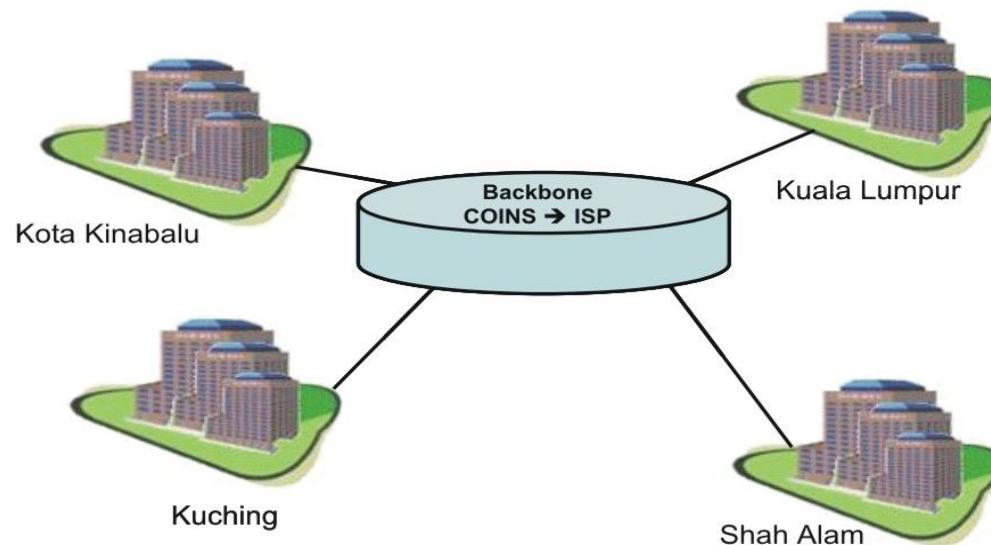
- Servidores
- Estações
- Sistemas operacionais de rede
- Dispositivo de rede
- Protocolo de comunicação

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# MAN – Rede Metropolitana

- As redes metropolitanas são redes de alcance médio. Esse tipo de rede é utilizado para fazer a interligação de diferentes LANs dentro da mesma cidade.
- Ela é comum em empresas e instituições que têm várias delegações e departamentos espalhados pela cidade e precisam estar interligados em uma única rede.

# MAN – Rede Metropolitana

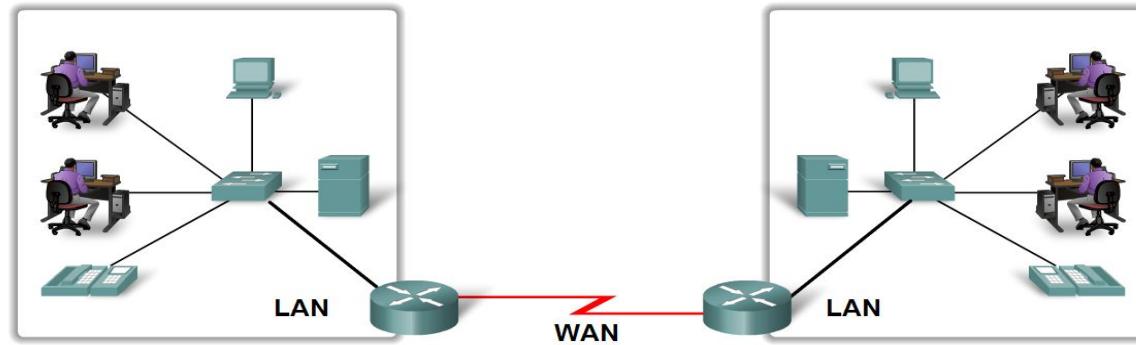


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## WAN – Rede de Longa distância

- Esse tipo de rede é utilizado para comunicação entre diferentes pontos. Podemos dizer que uma empresa que possui filiais e franquias, em diferentes cidades do estado ou país, necessita se comunicar, então utilizamos esse tipo de rede para fazer a comunicação entre elas.

# WAN – Rede de Longa distância

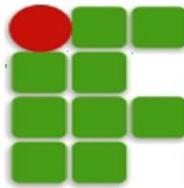


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# Meios de Comunicação

Os meios de comunicação são a forma como os computadores irão se comunicar na rede.

Podemos citar como meios de comunicação a linha telefônica, cabos, rádio, satélite, etc.



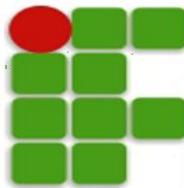
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# REDES DE COMPUTADORES I

**Topologias de Redes**

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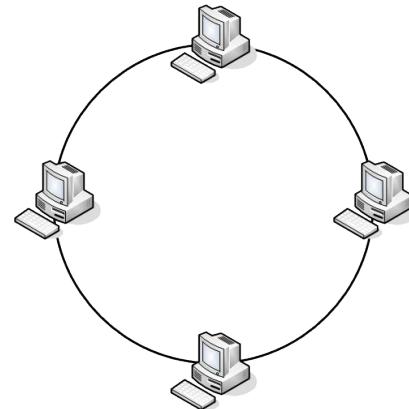
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# Topologia em Anel

Uma rede em anel é conhecida pelo seu formato de um circuito fechado. Essa rede trabalha com os computadores ligados em série.



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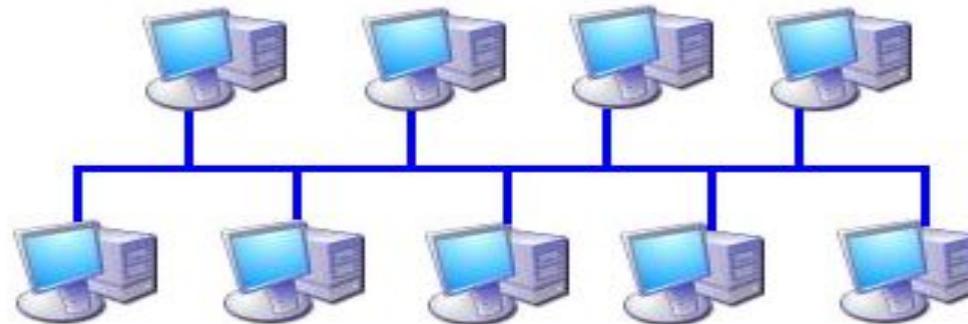
## Topologia em Barras

Esse tipo de topologia foi um dos mais utilizados durante alguns anos.

A grande vantagem desse tipo de topologia é o custo de instalação que se torna barato. Mas a grande desvantagem é que quanto maior o número de computadores na rede, mais lenta ela fica, e, quando um cabo desconecta ou falha, a rede para em determinados pontos.

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# Topologia em Barras



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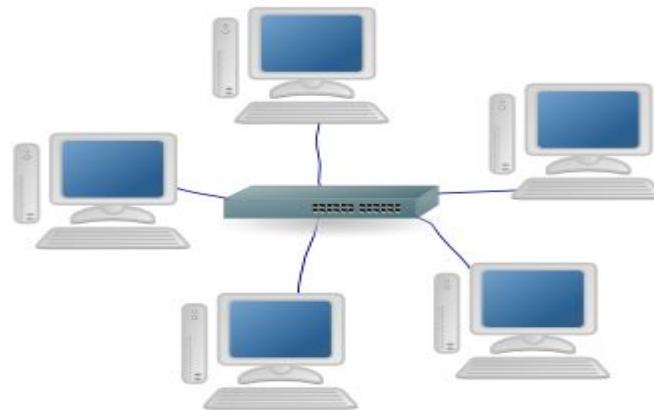
## Topologia em Estrela

Essa topologia é a mais utilizada hoje em dia, todas as estações são conectadas por um concentrador principal.

A grande vantagem é que cada estação se comunica diretamente com o nó central e facilita a manutenção da rede.

A grande desvantagem é que a montagem dessa topologia gera um custo alto, porque cada máquina utiliza um cabo.

# Topologia em Estrela



# Topologia Ponto a Ponto

É o tipo de topologia utilizada para ligação de dois pontos de redes diretamente.

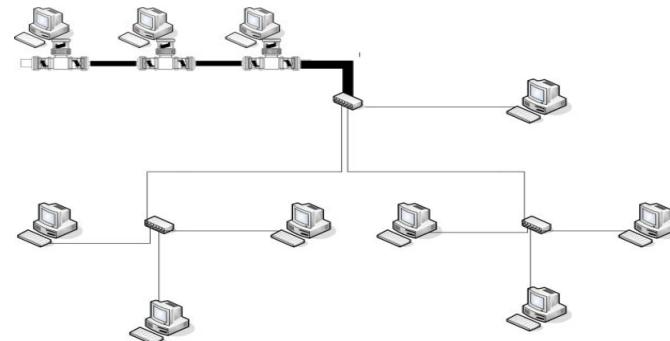
Normalmente esse tipo é utilizado em residências e pequenas empresas para ligar dois computadores.

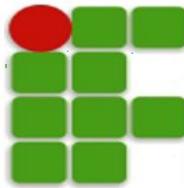


# Estruturas Mistas

Esse tipo de estrutura ocorre quando em uma rede existem vários tipos de topologia interligadas.

Um exemplo é a topologia em barra interligada com a topologia em estrela.





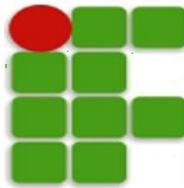
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# REDES DE COMPUTADORES I

Dispositivos de Redes

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# HUB

Os hubs são os dispositivos mais utilizados para a montagem de uma rede com topologia em estrela. A sua principal função é realizar a conexão entre os equipamentos que compõem a rede.

# HUB



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# SWITCH

Os switches são bem parecidos com os hubs, a sua função também é conectar as estações de trabalho com a rede. Mas a diferença entre ele e o Hub, é que os switches são inteligentes e oferecem vários recursos dependendo do modelo do equipamento.

# SWITCH



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# BRIDGE

São conhecidos como Pontes e são responsáveis em conectar várias LANs.

Imagine uma grande empresa onde dois departamentos diferentes possui as suas LANs e eles precisam ser conectados.

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# BRIDGE



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# ROTEADORES

O roteador tem como função fazer a comunicação entre diferentes redes de computadores.

Hoje podemos encontrar diversos modelos de roteadores, os mais comuns são os ADSL, Wireless, etc.

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# ROTEADORES



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# REPETIDORES

Os repetidores são utilizados quando a distância entre dois pontos são superiores ao recomendado de acordo com o tipo de cabo utilizado. Para resolver esse problema são colocados repetidores a determinadas distâncias para amplificar o sinal e enviar novamente até chegar ao destino.

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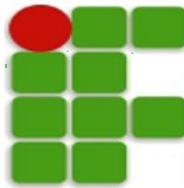
# REPETIDORES



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# Prática

## Hub x Switch



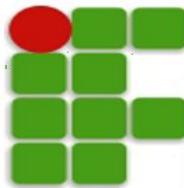
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# REDES DE COMPUTADORES I

Transmissão de Informações

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# Media

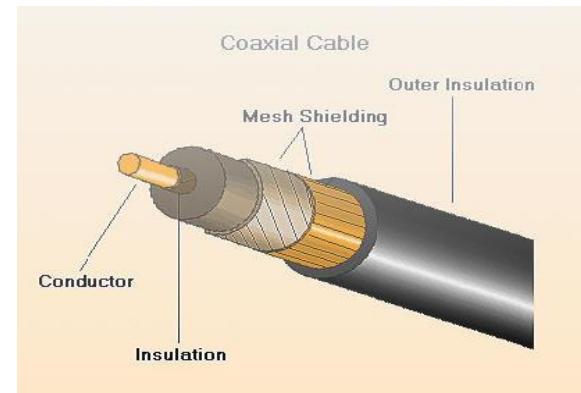
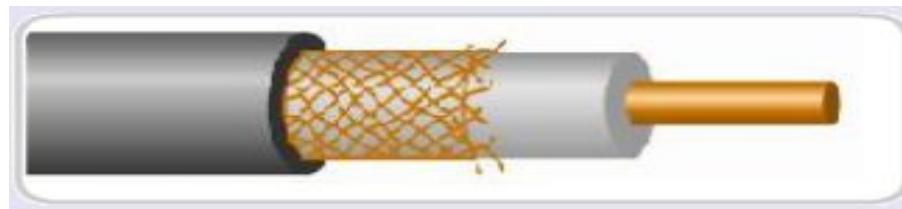
- Copper cable (twisted pair and coaxial)
- Fibre optic cable
- Wireless

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# CABO COAXIAL

O cabo coaxial é um tipo utilizado para enviar sinais elétricos. Ele é constituído por um fio de cobre revestido por um material isolante e uma blindagem revestindo esse material também. A grande vantagem desse cabo é que ele pode transmitir frequências elevadas e para longas distâncias.

# CABO COAXIAL



# Connectors for coaxial cable



# Coaxial cable

- Good for high frequency radio/video signals
- Used for antennas/aerials
- Used for cable TV and Internet connections, often now combined with fibre optic.
- Formerly used in Ethernet LANs – died out as UTP was cheaper and gave higher speeds

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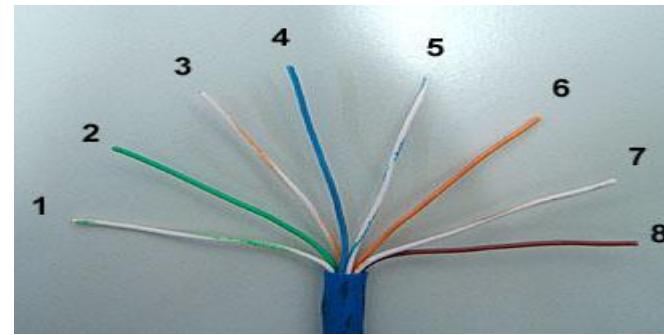
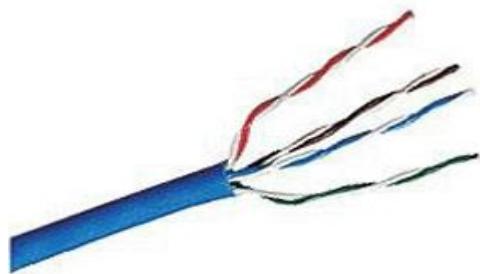
## CABO DE PAR TRANÇADO

Esse tipo de cabo possui dois condutores enrolados ao redor dos outros para anular a interferência eletromagnética.

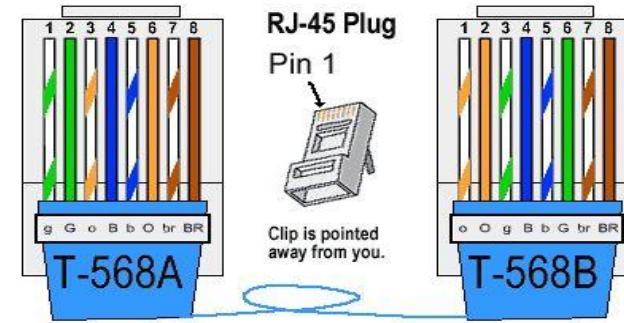
A grande vantagem de utilizar esse cabo é a facilidade de implantação e instalação da rede.

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# CABO DE PAR TRANÇADO



# CABO DE PAR TRANÇADO

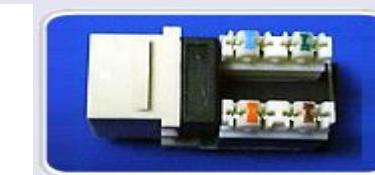
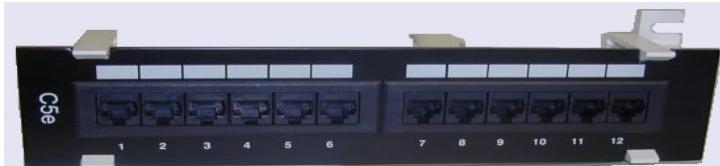
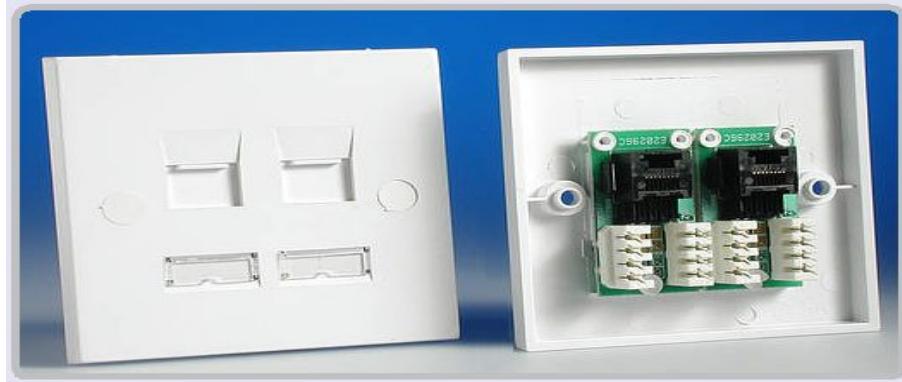


# RJ45 connectors

Plugs on patch  
cables  
(crimped)

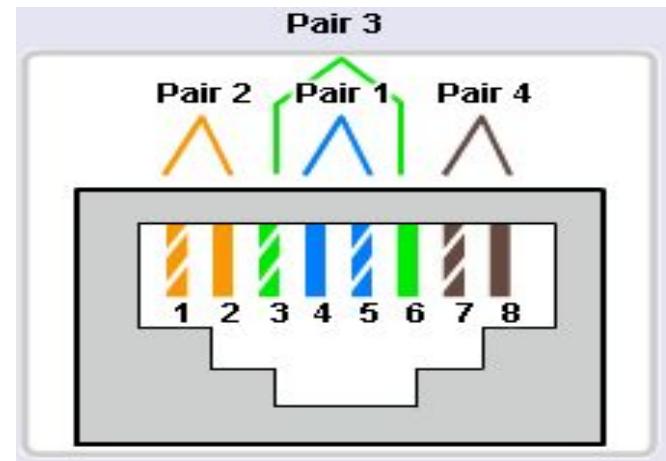


Sockets to terminate  
installed cabling  
(punch down)



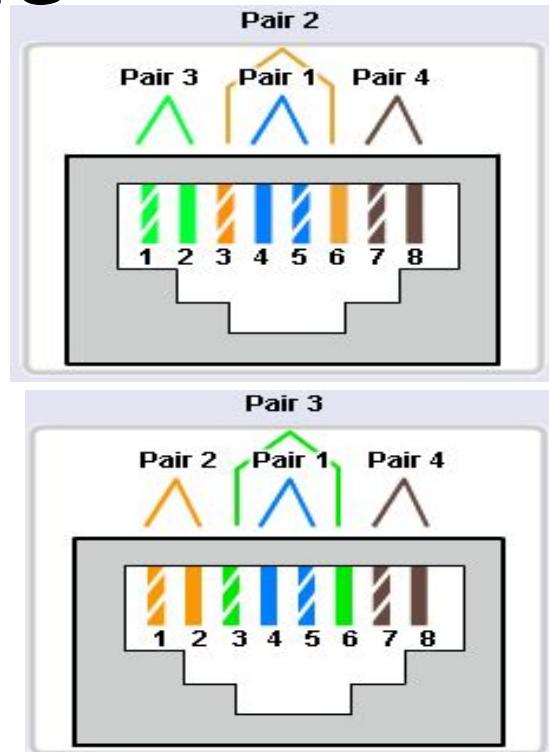
# Straight through cable

- Both ends the same
- Connect PC to switch or hub
- Connect router to switch or hub
- Installed cabling is straight through



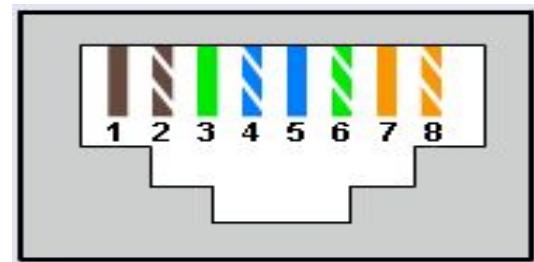
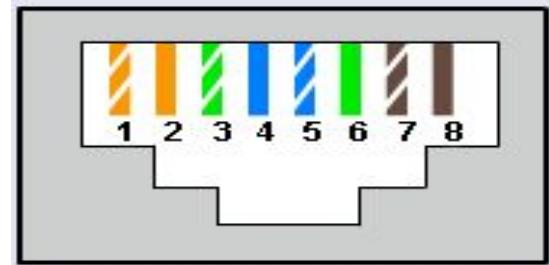
# Crossover cable

- Wire 1 swaps with 3
- Wire 2 swaps with 6
- Connect similar devices to each other
- Connect PC direct to router

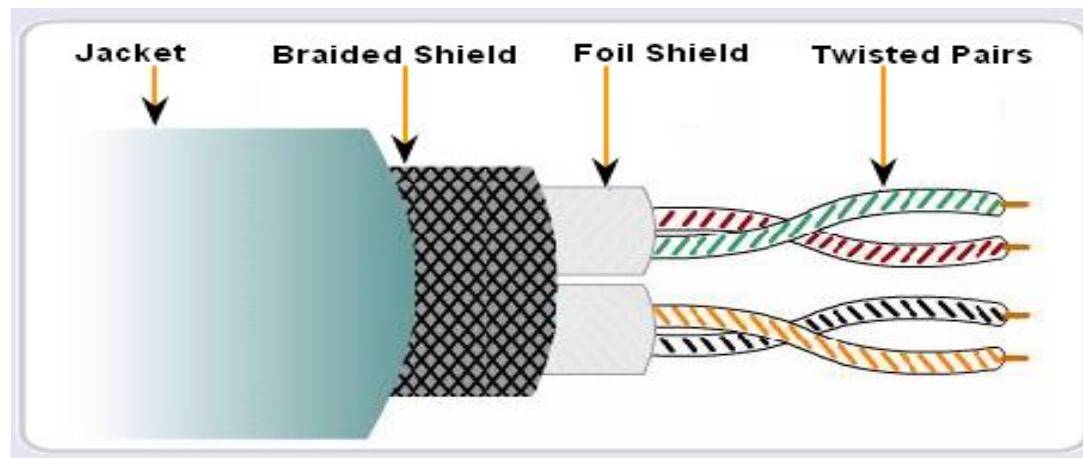


# Rollover cable

- Cisco proprietary
- Wire order completely reversed
- Console connection from PC serial port to router – to configure router
- Special cable or RJ45 to D9 adaptor.



# SHIELDED TWISTED PAIR (STP)



# Noise

- Electrical signals on copper cable are subject to interference (noise)
- Electromagnetic (EMI) from device such as fluorescent lights, electric motors
- Radio Frequency (RFI) from radio transmissions
- Crosstalk from other wires in the same cable or nearly cables

# Avoiding noise problems

- Metal shielding round cables
- Twisting of wire pairs gives cancelling effect
- Avoiding routing copper cable through areas liable to produce noise
- Careful termination – putting connectors on cables correctly

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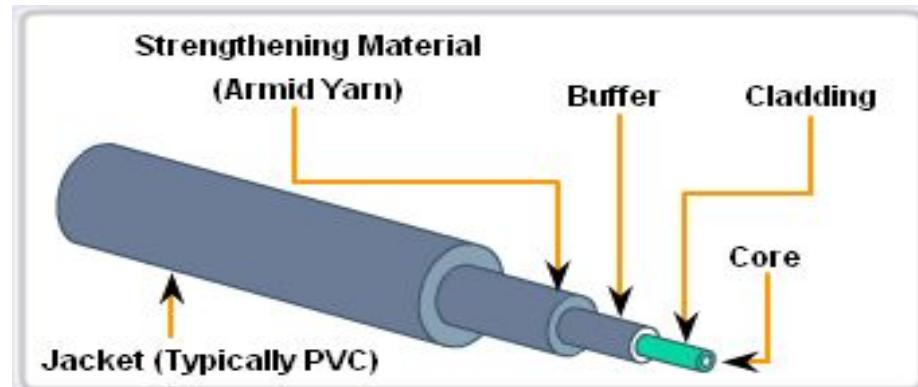
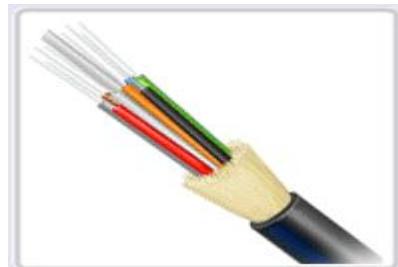
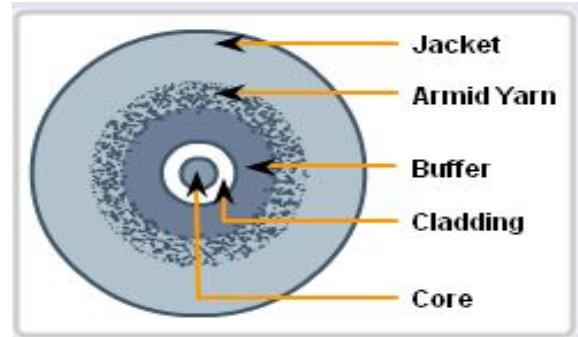
# FIBRAS ÓPTICAS

A fibra óptica é um filamento feito de vidro ou material polimérico, com capacidade de transferir sinais de luz por ele. A transmissão é feita por um sinal de luz codificado dentro do domínio de frequência a uma velocidade de 10 a 15 MHz.

As transmissões podem ser feitas por LED ou Laser semicondutor.

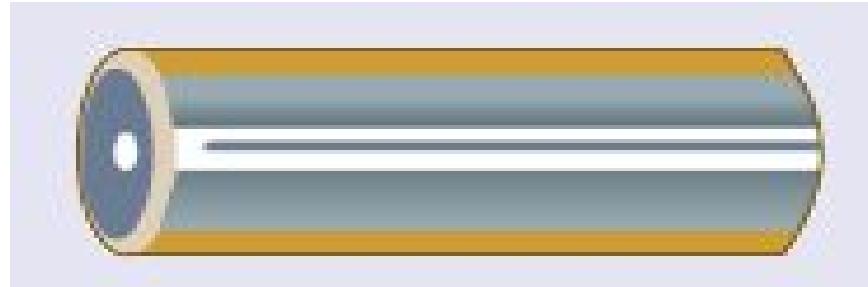
# Fibre optic cable

- Transmits flashes of light
- No RFI/EMI noise problem
- Several fibres in cable
- Paired for full duplex



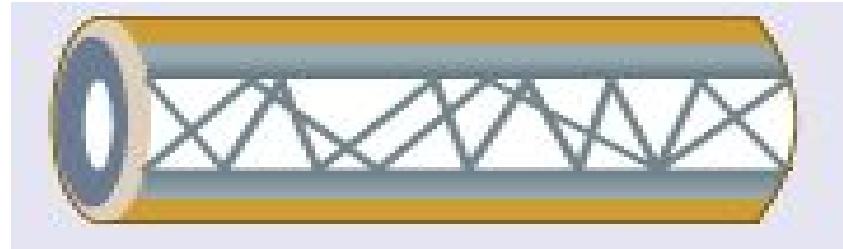
# Single mode fibre optic

- Glass core 8 – 10 micrometres diameter
- Laser light source produces single ray of light
- Distances up to 100km
- Photodiodes to convert light back to electrical signals



# Multimode fibre optic

- Glass core 50 – 60 micrometres diameter
- LED light source produces many rays of light at different angles, travel at different speeds
- Distances up to 2km, limited by dispersion
- Photodiode receptors
- Cheaper than single mode



# Fibre optic connectors



Straight tip (ST) connector  
single mode



Subscriber connector (SC)  
multimode



Single mode lucent connector



Multimode lucent connector



Duplex multimode lucent connector (LC)

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# CABOS UTP E FIBRAS ÓTICAS

<b>UTP copper</b>	<b>Fibre optic</b>
Max 100 m length	100km or 2km
Noise problems	No noise problems
Within building only	Within/between buildings
Cheaper	More expensive
Easier to install	Harder to install

# Testing cables



Fluke NetTool for twisted pair  
cables



Optical Time Domain Reflectometer (OTDR) for  
fibre optic cables

# Wireless

- Electromagnetic signals at radio and microwave frequencies
- No cost of installing cables
- Hosts free to move around



Wireless access point



Wireless adaptor



# Wireless problems

- Interference from other wireless communications, cordless phones, fluorescent lights, microwave ovens...
- Building materials can block signals.
- Security is a major issue.

# Wireless networks

- IEEE 802.11 - Wi-Fi for wireless LANs. Uses CSMA/CA contention based media access
- IEEE 802.15 - Bluetooth connects paired devices over 1 -100m.
- IEEE 802.16 - WiMAX for wireless broadband access.
- Global System for Mobile Communications (GSM) - for mobile cellular phone networks.

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# TIPO DE TRANSMISSÃO DE DADOS

A transmissão de dados é baseada no conceito em que um indivíduo ou entidade envia uma determinada informação (Transmissor - TX) a um outro indivíduo ou entidade que irá receber a informação enviada (Receptor – RX).

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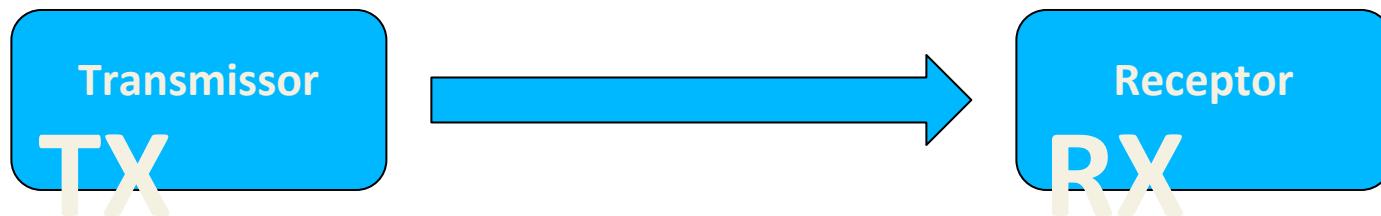
## SIMPLEX

Esse tipo de transmissão é feito em um sistema unidirecional, em que uma das unidades apenas transmite e a outra apenas recebe.

Podemos citar o controle remoto e a televisão como exemplo de transmissão simplex.

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# SIMPLEX



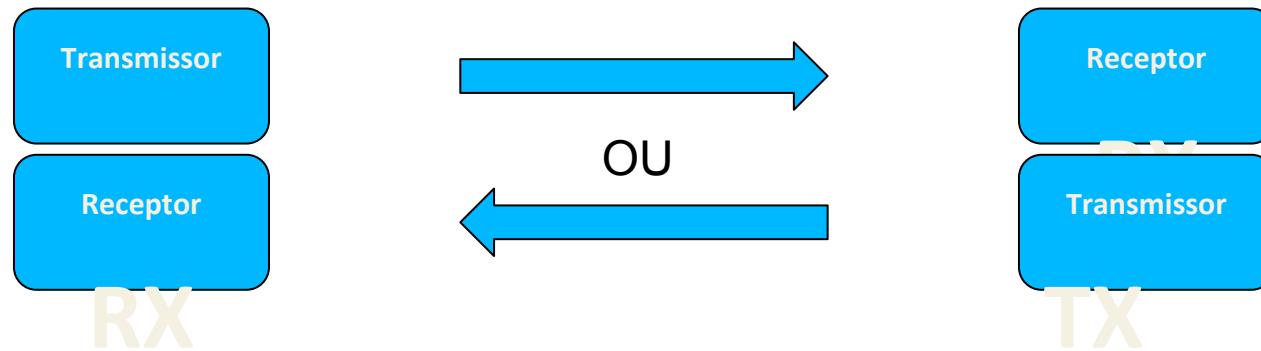
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## HALF DUPLEX

Esse tipo de transmissão é bidirecional, ou seja, os elementos TX/RX alternam-se em funções do sentido de envio da informação.

Isso ocorre porque os elementos utilizam uma mesma linha de dados.

# HALF DUPLEX

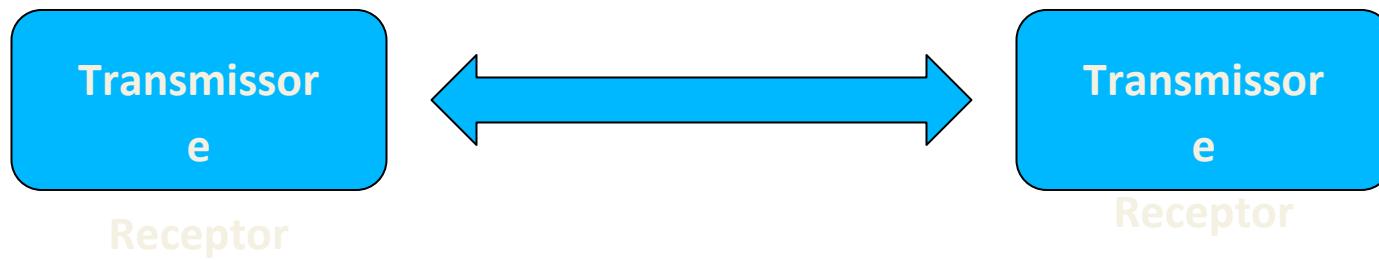


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## FULL DUPLEX

Esse é o melhor tipo de transmissão e é bidirecional. Cada elemento pode transmitir e receber informações ao mesmo tempo.

# FULL DUPLEX



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# PADRÕES DE TRANSMISSÃO

Os padrões de transmissão são fundamentais para definir a forma na qual os dados serão transmitidos e assim o tipo e velocidade de transmissão de acordo com o padrão escolhido.

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# ETHERNET

É o padrão de transmissão mais utilizado hoje nas redes atuais. Esse padrão possui três velocidades de transmissões:

10 Ethernet – Velocidade de até 10 Mbps;

Fast Ethernet – Velocidade de até 100 Mbps;

Gigabit Ethernet – Velocidade de até 1 Gbps.

**Terabytes!!**

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# TOKEN RING

Este padrão de transmissão foi muito utilizado antigamente.

Este padrão trabalha em forma circular para determinar qual estação tem permissão de que todas as estações da rede tenham chance de transmitir os dados.

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## IEEE 802.11 (WI-FI)

Padrão conhecido por transmitir os dados utilizando uma rede sem fio. Ele foi dividido em vários formatos, como exemplo vejamos:

*802.11a – opera em 5 GHz;*

*802.11b – opera em 2.4 GHz;*

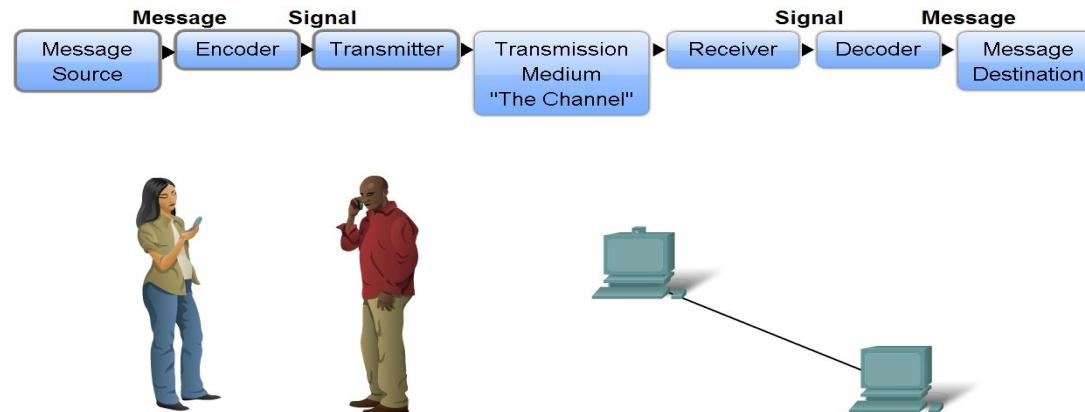
*802.11n/g/ac*

# 802.11 Wi-Fi

- LAN wireless protocol
- Fragile environment – lots of interference, risk of lost frames, contention.
- Every transmission needs to be acknowledged.
- No acknowledgement – re-send frame.

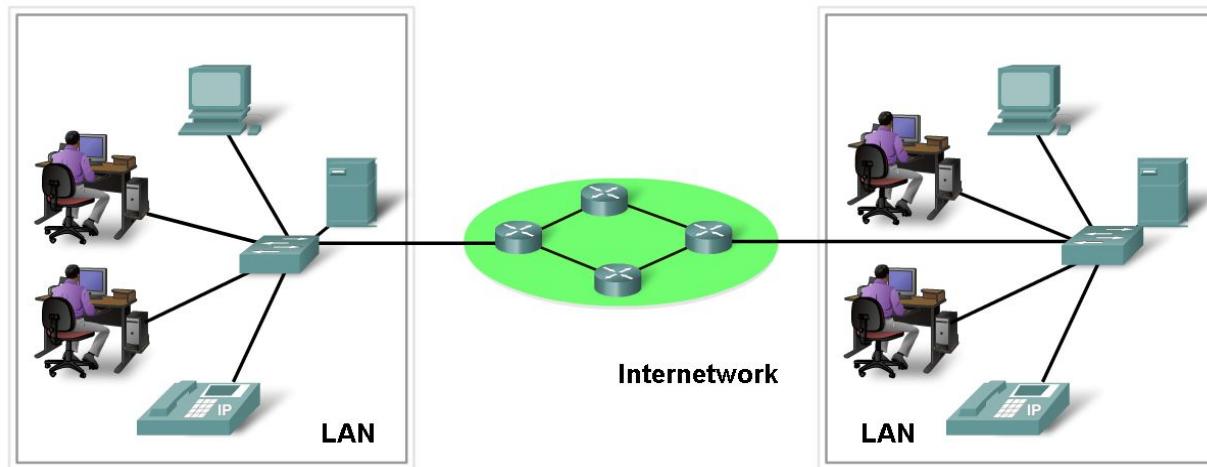
# Estrutura da Rede

- Elementos de comunicação
  - origem da mensagem
  - o canal
  - destino da mensagem



# Estrutura da Rede

- Componentes de Rede
  - hardware
  - software



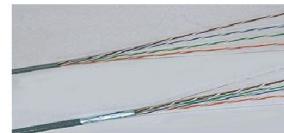
# Estrutura da Rede

- Mídias de Rede
  - representa o canal por onde as mensagens são trafegadas

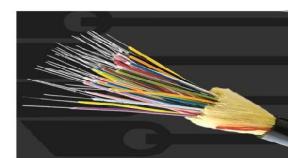


**Network Media**

**Copper**



**Fiber Optics**



**Wireless**



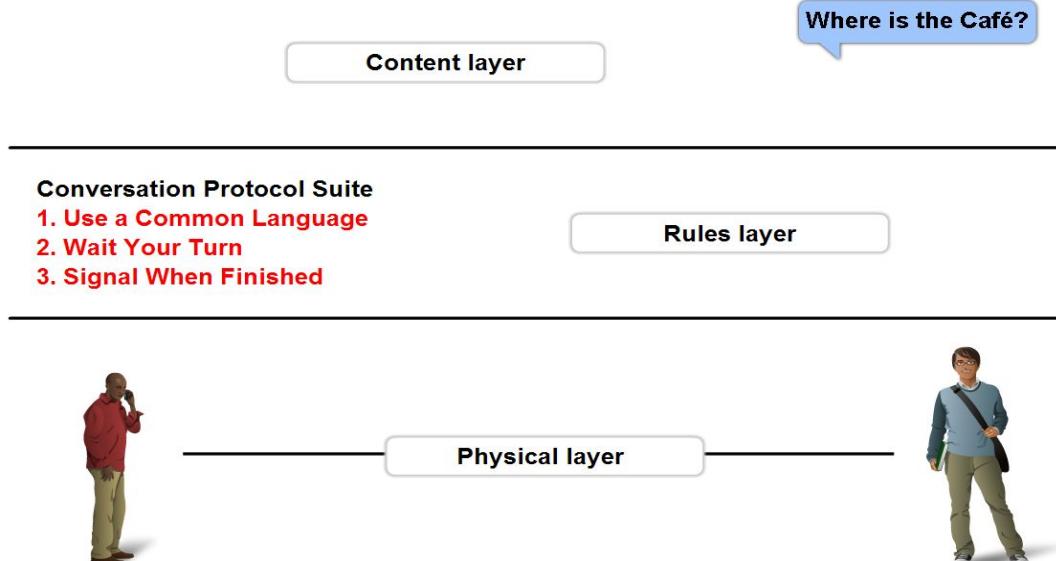
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# PROTOCOLOS DE REDES

Os protocolos são os principais responsáveis em organizar a forma como as informações serão trocadas na rede. Eles ditam as regras e todas as máquinas na rede precisam utilizar o mesmo protocolo, caso contrário elas não poderão trocar informações com protocolos diferentes.

# Função dos Protocolos de Comunicação em uma Rede

- Os protocolos são utilizados para facilitar a comunicação em uma rede. Ele quem determina as regras!



# Função dos Protocolos de Comunicação em uma Rede

- Protocolos de Rede
  - Utilizados para permitir que os dispositivos possam se comunicar com sucesso.

Protocols provide:

The format or structure of the message

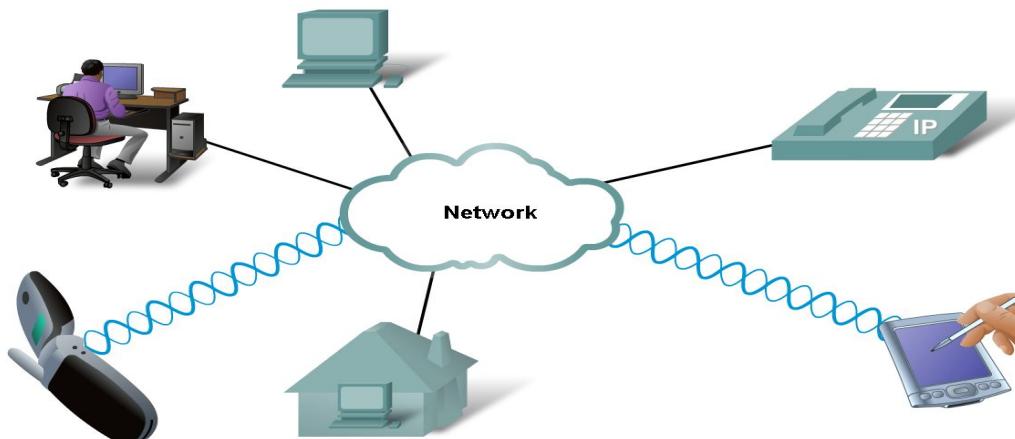
The process by which networking devices share information about pathways to other networks

How and when error and system messages are passed between devices

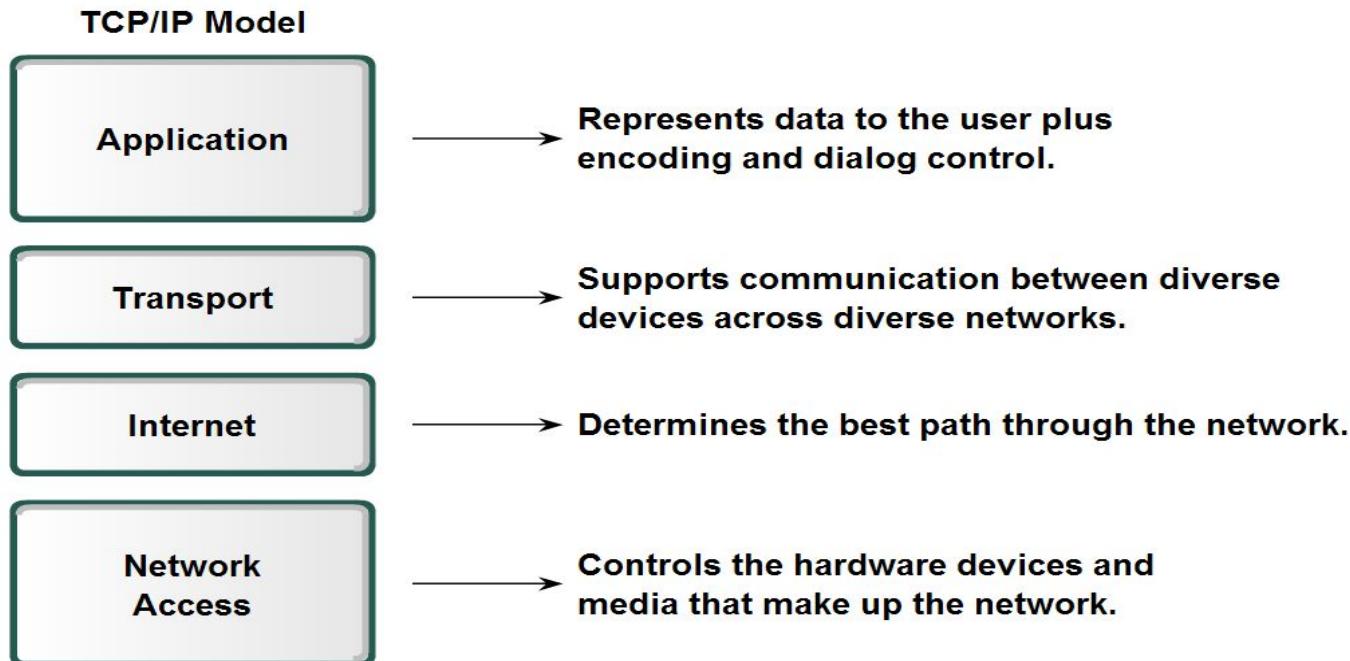
The setting up and termination of data transfer sessions

# Função dos Protocolos de Comunicação em uma Rede

- Technology independent Protocols
  - Vários tipos de dispositivos podem se comunicar utilizando os mesmos protocolos.

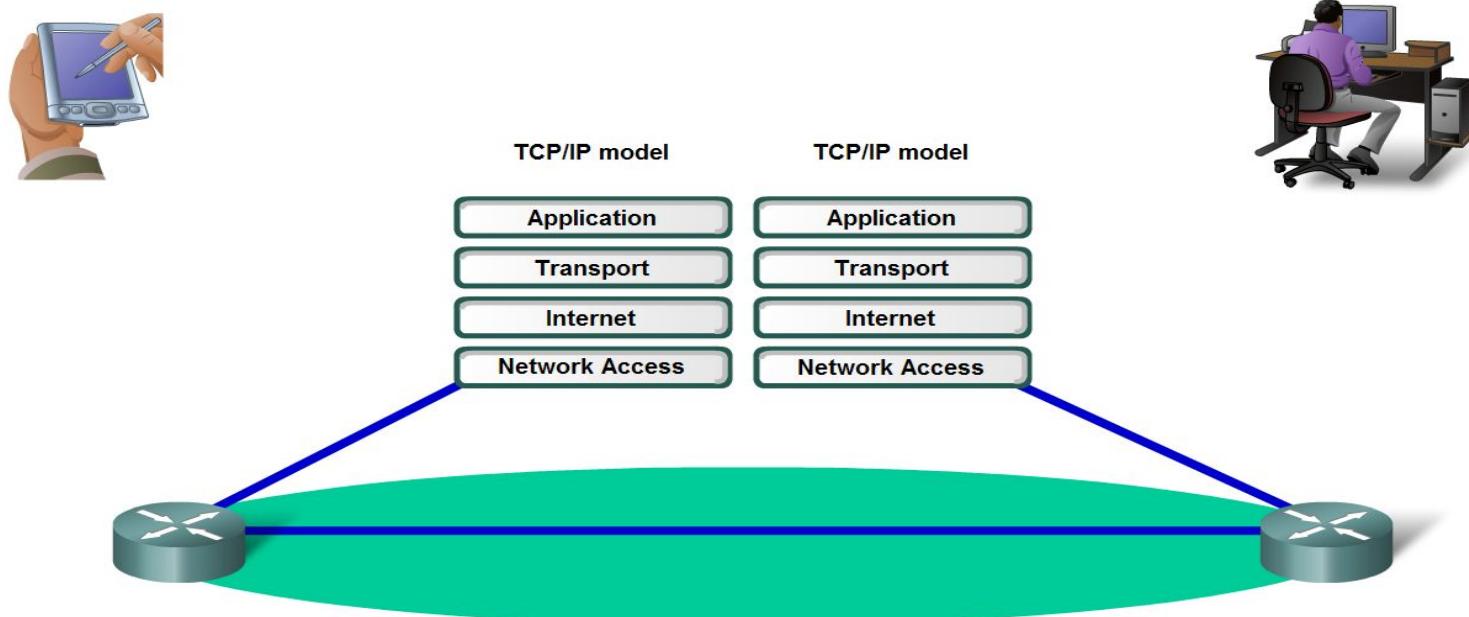


# Modelo TCP/IP



# Modelo TCP/IP

- Processo de comunicação

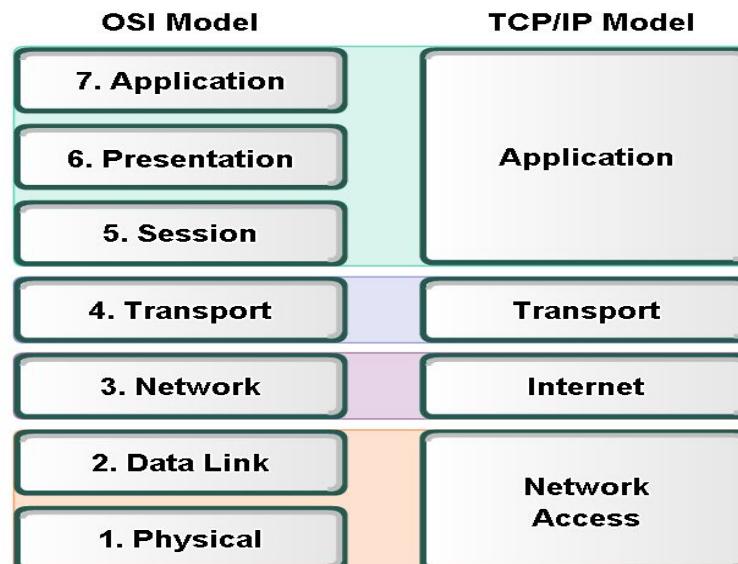


# Modelo OSI

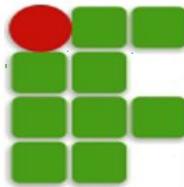


# Camadas TCP/IP e OSI

- Comparação entre os modelos



The key parallels are in the Transport and Network layers.



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# REDES DE COMPUTADORES I

## CAMADA FÍSICA

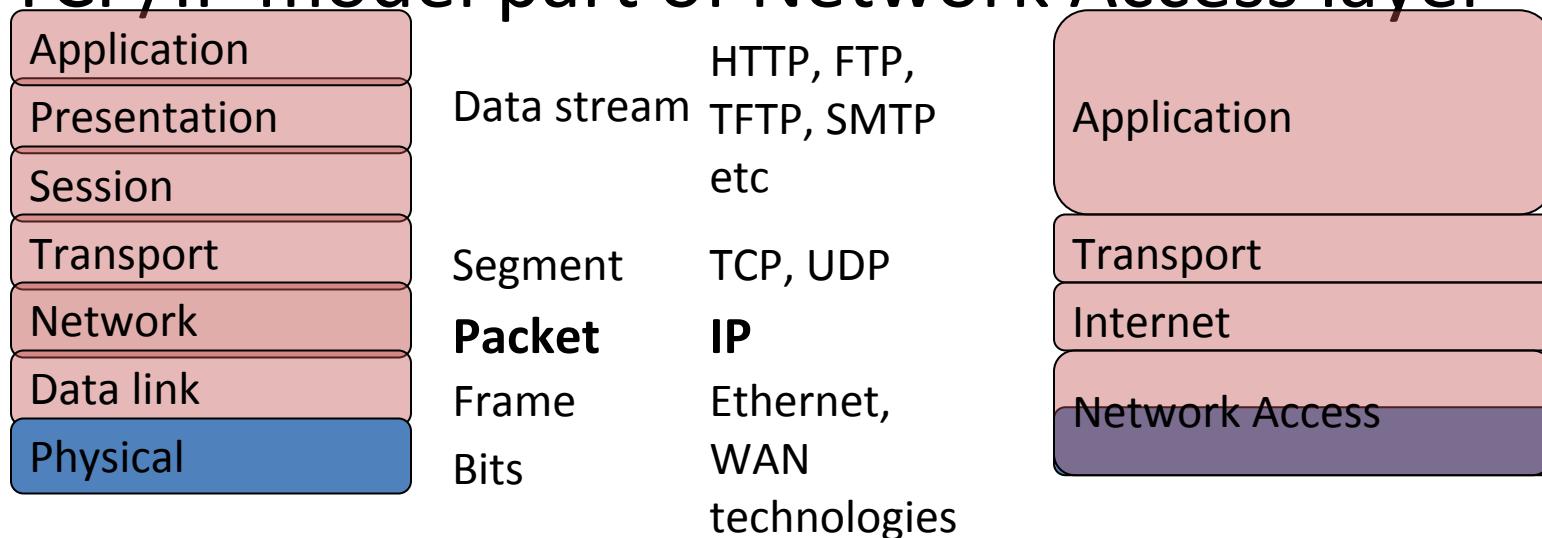
Ramon Fontes

@ramonfontes



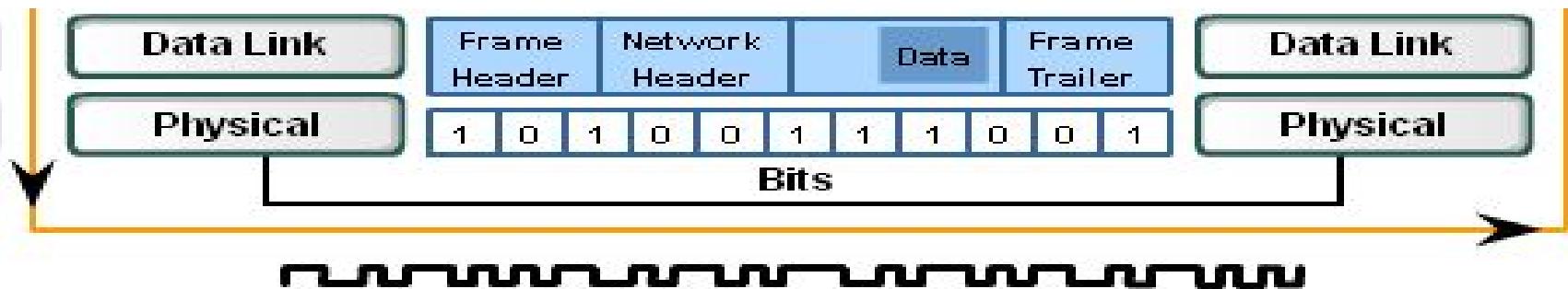
# OSI Physical layer

- OSI model layer 1
- TCP/IP model part of Network Access layer



# Physical layer tasks

- Takes frame from data link layer
- Sees the frame as bits – no structure
- Encodes the bits as signals to go on the



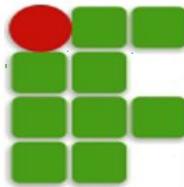
# Physical layer standards define:

- Physical and electrical properties of the media
- Mechanical properties (materials, dimensions, pinouts) of the connectors and NICs
- Bit representation by the signals (encoding)
- Definition of control information signals

# Physical layer standards

Set by engineering institutions

- The International Organization for Standardization (ISO)
- The Institute of Electrical and Electronics Engineers (IEEE)
- The American National Standards Institute (ANSI)
- The International Telecommunication Union (ITU)
- The Electronics Industry Alliance/ Telecommunications Industry Association (EIA/TIA)



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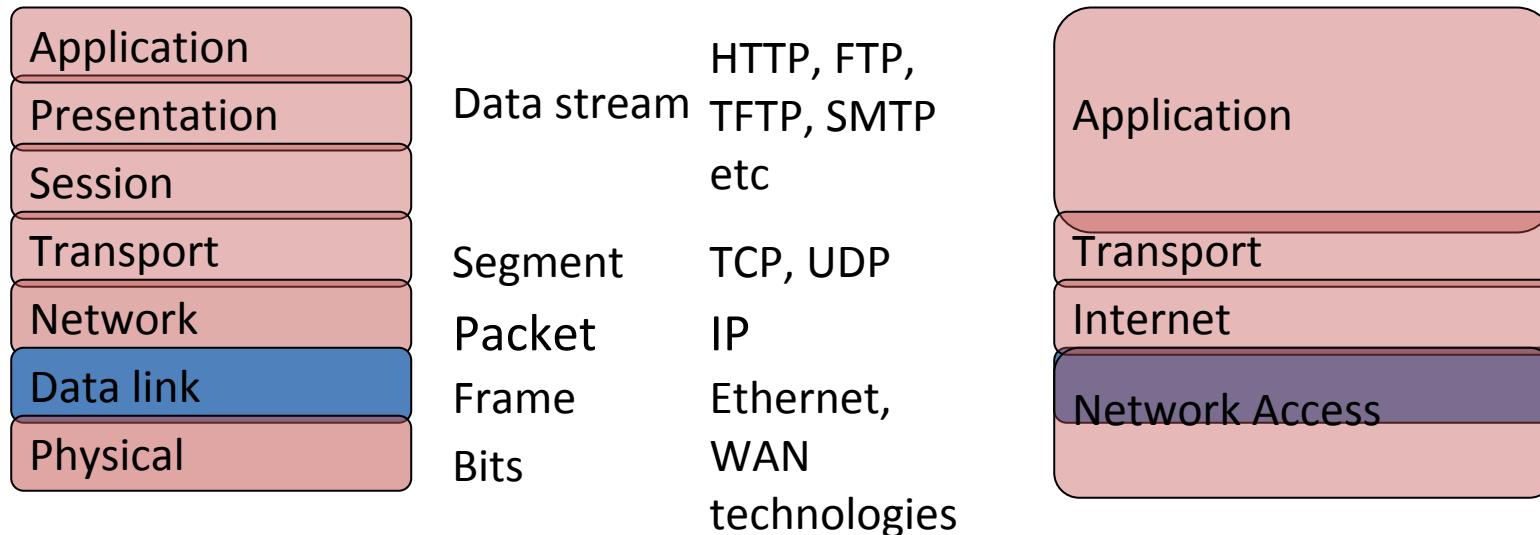
## CAMADA DE ENLACE

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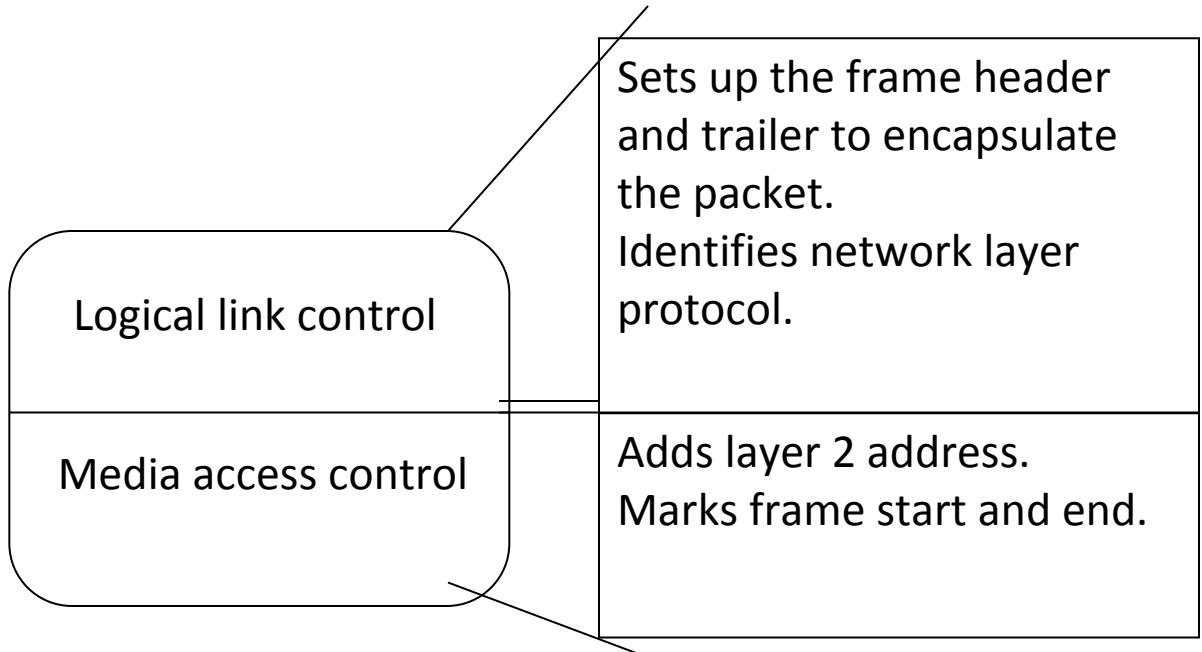
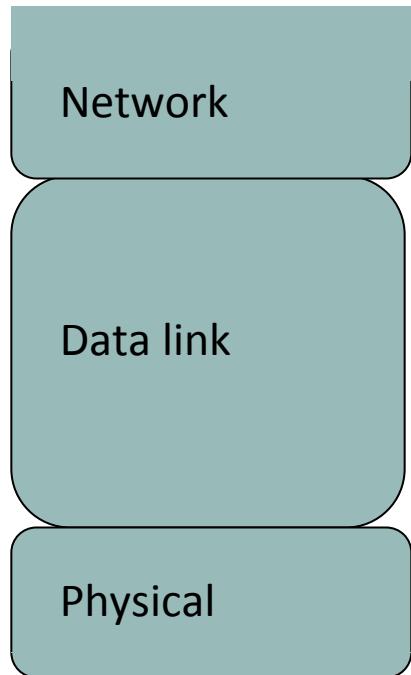
# Camada de acesso



# Funções da camada de acesso

- Encapsulam pacotes adicionando frames e trailer com endereçamento apropriado.
- Controle de acesso ao meio.

# Subcamadas



# Standards

Institute of Electrical and Electronics Engineers

- IEEE 802.2 Logical link control
- IEEE 802.3 Ethernet
- IEEE 802.5 Token ring
- IEEE 802.11 Wi-fi

International Telecommunication Union (ITU)

- Various WAN standards: HDLC, ISDN, Frame relay

# Variation on contention based

- Traditional Ethernet uses CSMA/CD (collision detection): collisions are allowed and detected, frames sent again.
- Wi-fi uses CSMA/CA (collision avoidance): when the medium is clear, host sends signal to say it is about to use the medium. It then sends.

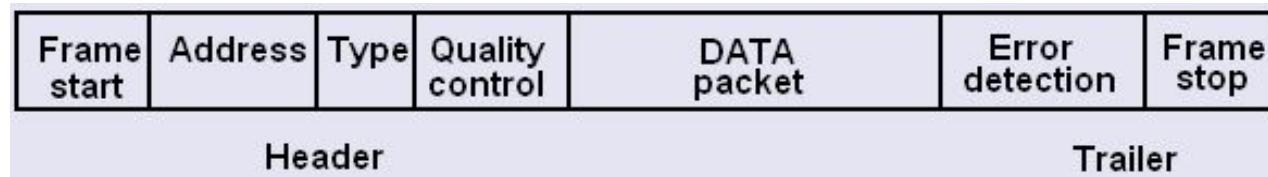
# Different environments

- Fragile environment e.g. satellite link – frames are likely to be lost – need large overhead of control mechanisms to make sure data arrives.
- Protected environment e.g. modern LAN – frames not often lost – do not need such elaborate control mechanisms
- Therefore need different layer 2 protocols



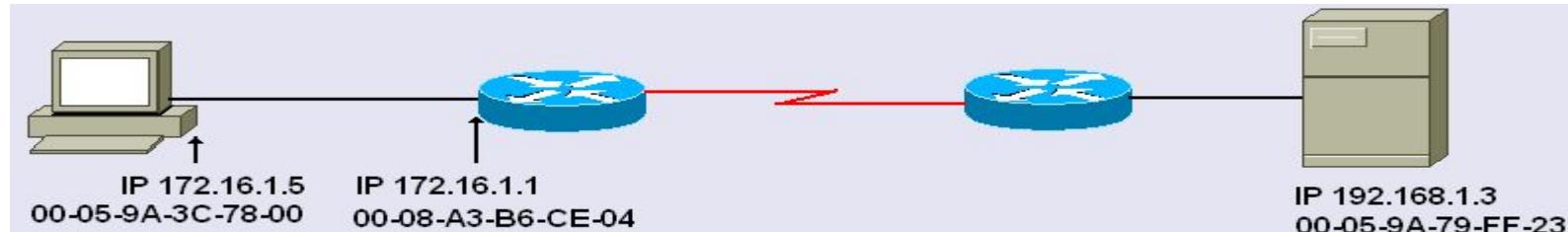
# Layer 2 frame format

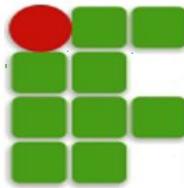
- All protocols have the same general form but there are variations.



# End to end

- PC sends packet to server
- Packet header has PC IP address and source and server IP address as destination.
- Frame header has PC MAC address as source and





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# REDES DE COMPUTADORES I

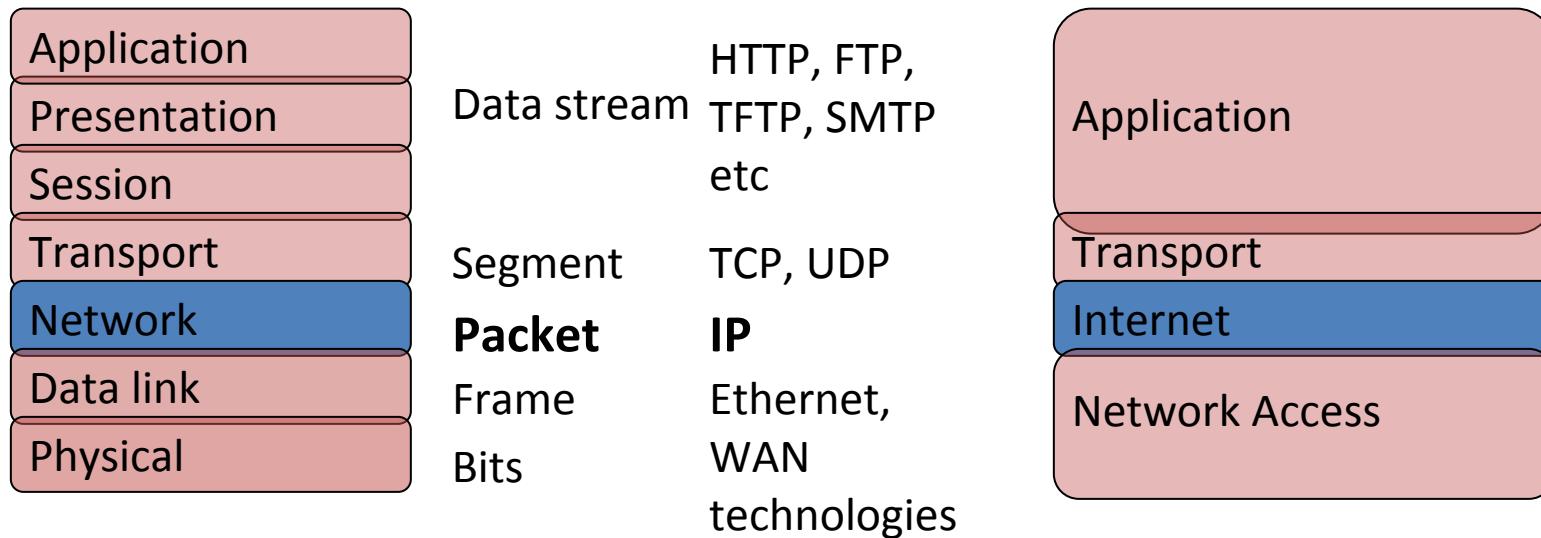
## CAMADA DE REDE

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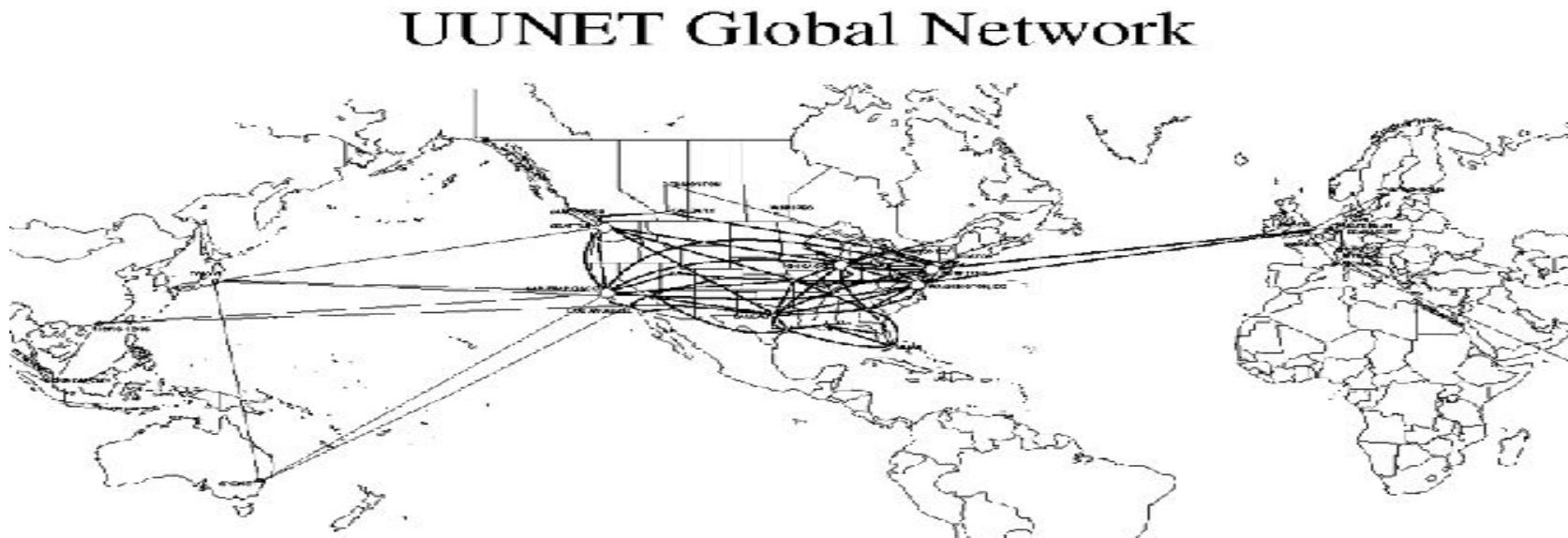
# Camada de Rede



# Camada de Rede

- IP version 4 – O protocolo roteável mais comum da camada 3.
- Divide hosts em grupo.
- Envia os pacotes através das rotas.
- Define como as rotas são conhecidas.
- Endereçamento IP.

# Objetivo da camada 3



# Protocolo de camada 3

Um protocolo de camada 3 como o IPv4 deve:

- Prover o esquema de endereçamento para identificar redes e hosts.
- Encapsula segmentos de camada 4 dentro de pacotes e inclui endereços.
- Encaminha os pacotes
- Desencapsula pacotes entregam para o segmento de camada 4.

# Protocolos da camada de Rede

- Internet Protocol version 4 (IPv4) – Mais comum
- Internet Protocol version 6 (IPv6) – destinado a substituir o IPv4
- Novell Internetwork Packet Exchange (IPX)
- AppleTalk
- Connectionless Network Service (CLNS/DECNet)

# Características do IP

- Desenhado com baixo overhead para melhor desempenho.
- Não orientado a conexão
- Best effort. Não garante entrega.
- Independente da mídia, mas necessita conhecer o tamanho máximo do pacote.

# Encapsulamento – Camada de Rede

Segment from transport layer



Packet header added to make IP packet



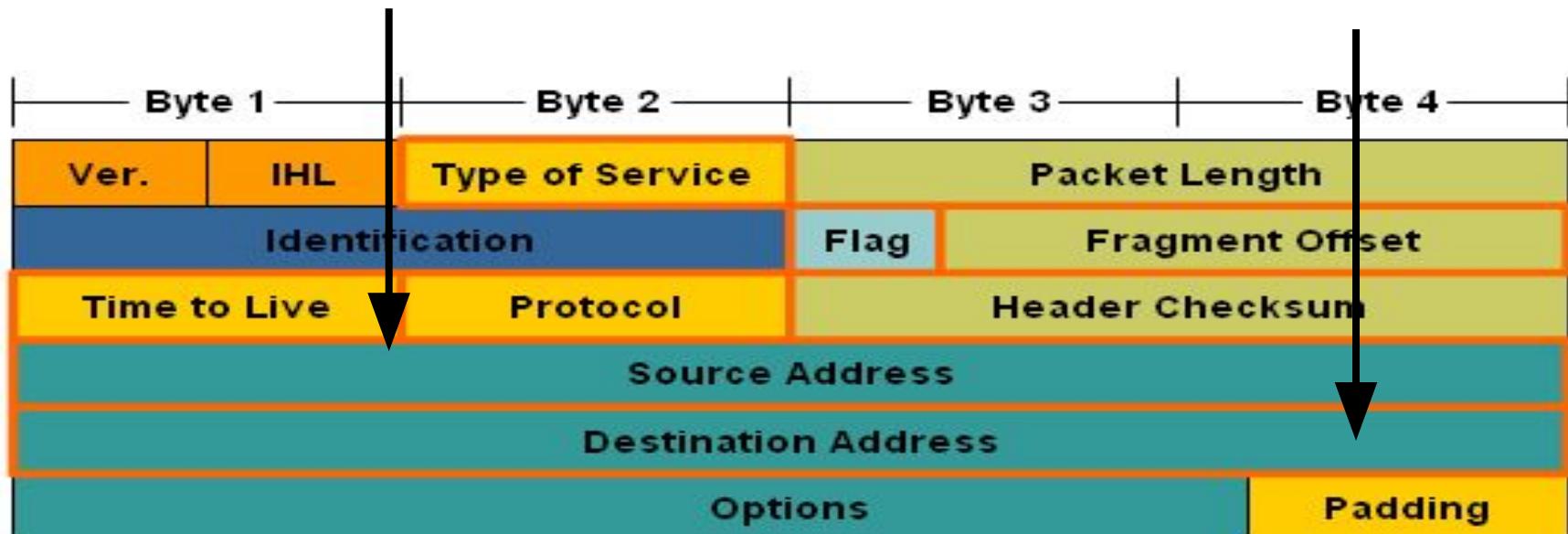
Sent to data link layer for further  
encapsulation into frame



# IPv4 - Cabeçalho Pacote

IP address of source host, needed so reply can be sent.

IP address of destination host, needed so routers can find route.

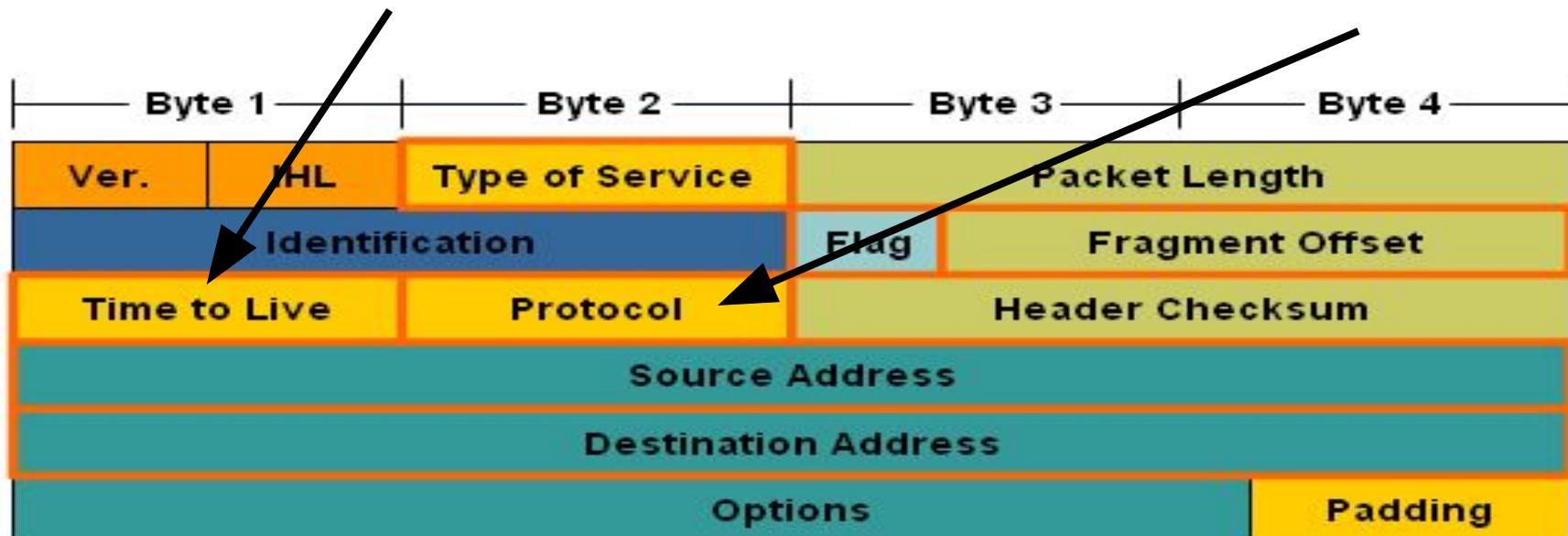


# IPv4 - Cabeçalho Pacote

Reduced by 1 at each router.

Packet dropped if it goes to 0.

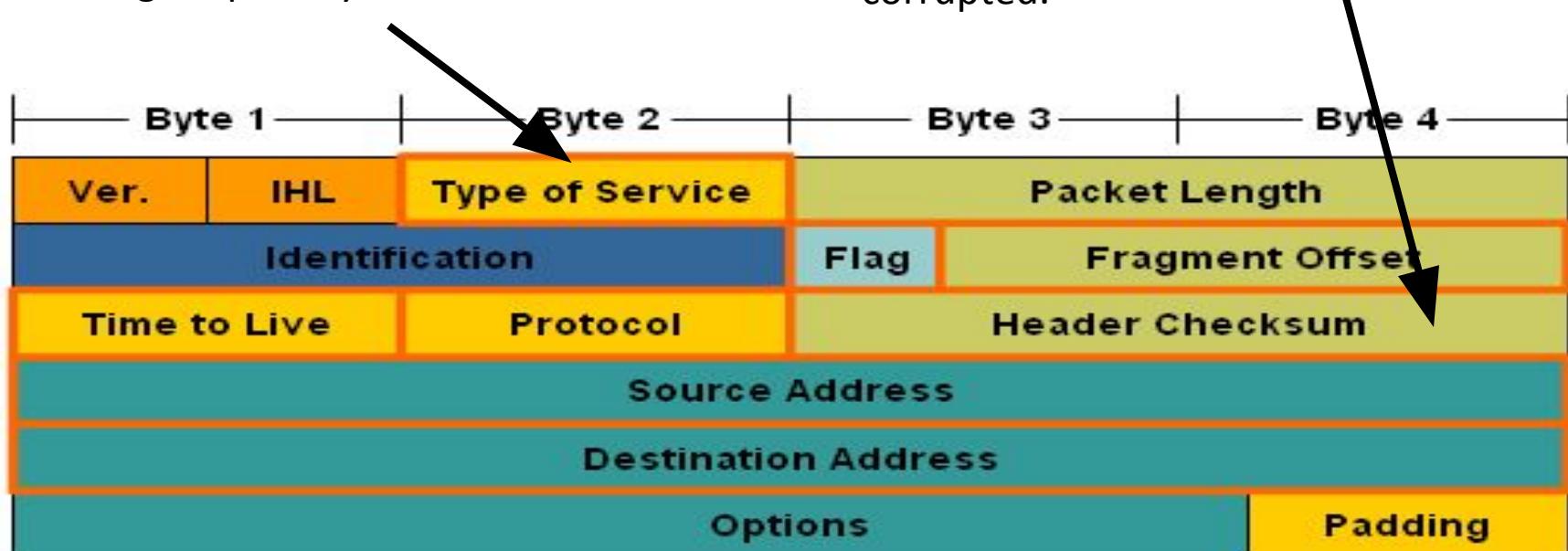
TCP or UDP used in Transport layer.



# IPv4 - Cabeçalho Pacote

Priority for QoS. E.g. voice data has higher priority than e-mail.

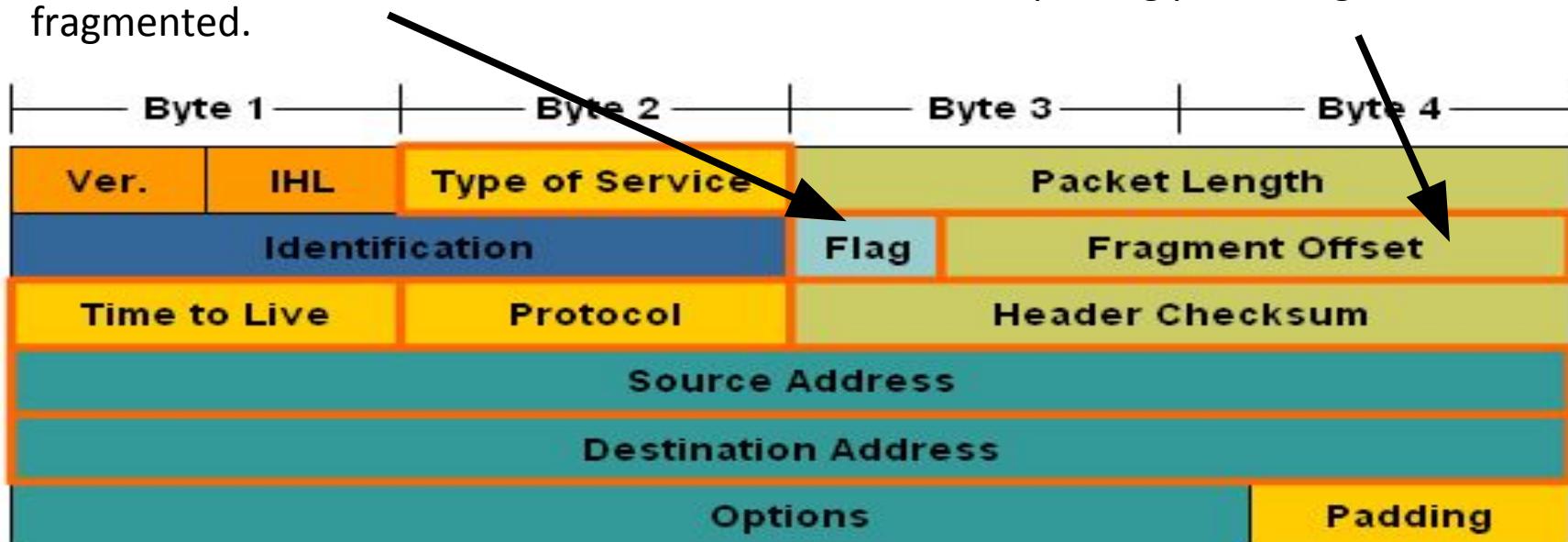
For checking if header has been corrupted.



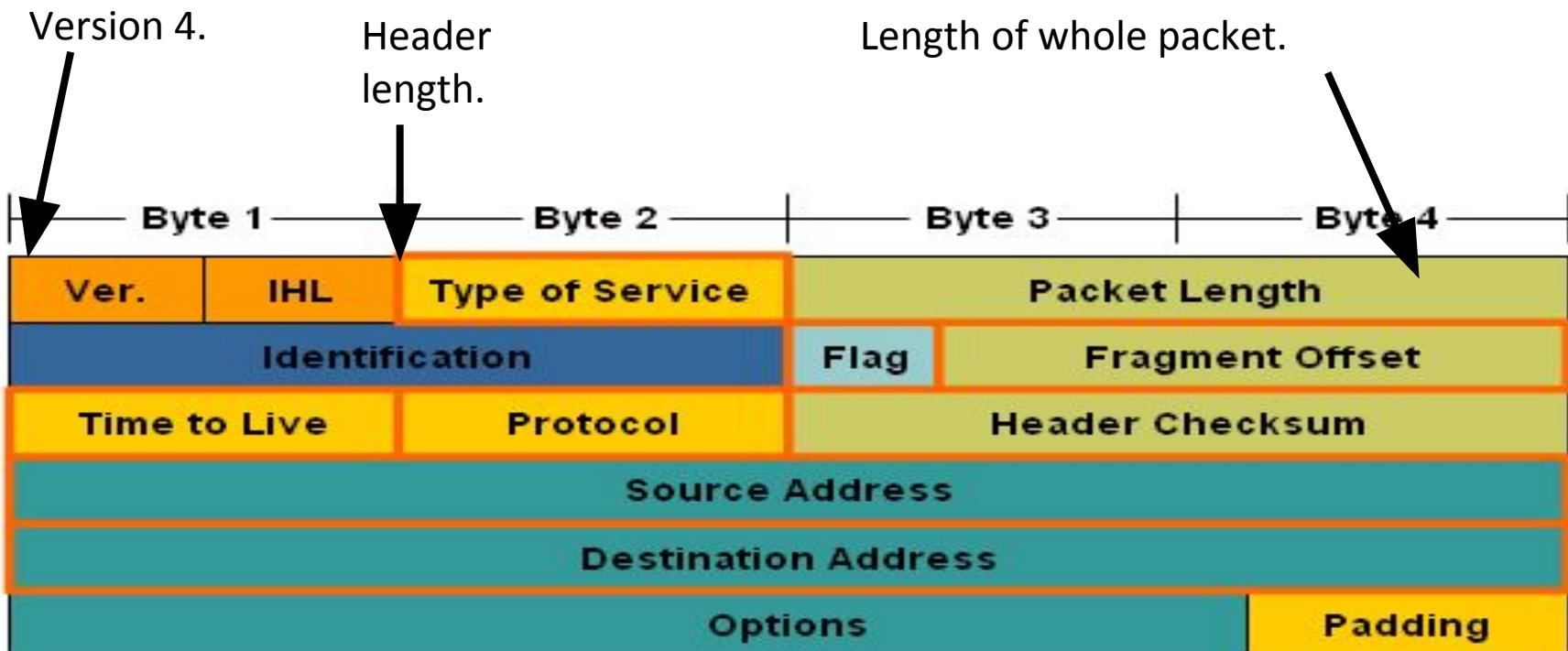
# IPv4 - Cabeçalho Pacote

Shows if packet has been fragmented or must not be fragmented.

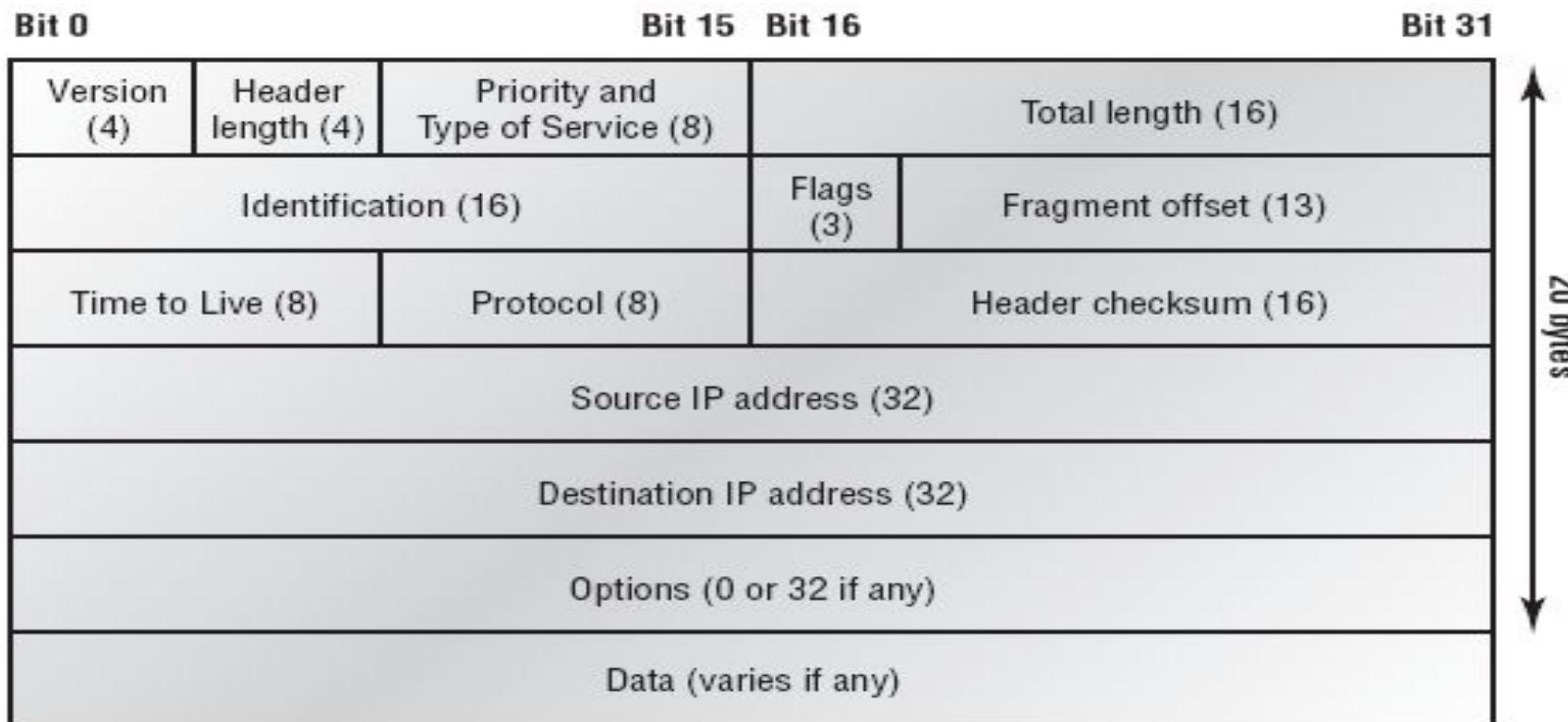
If router has to split a packet, this gives order for putting pieces together.



# IPv4 - Cabeçalho Pacote



# Cabeçalho - IP

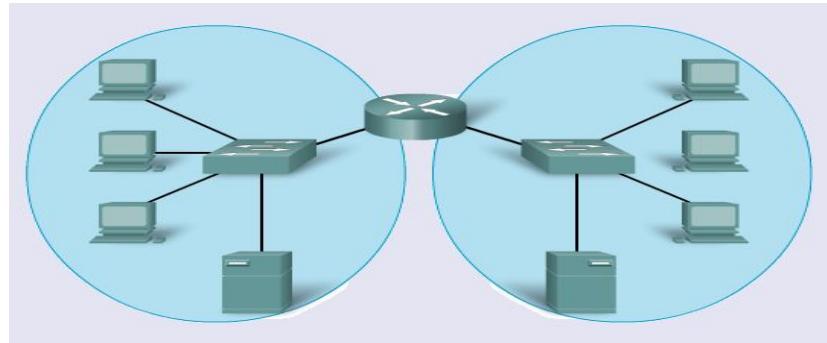


# Divisão de Redes

- Geográfica – Diferentes lugares
- Propósito – Quais softwares e recursos são utilizados?
- Propriedade – Diferentes companhias ou departamentos em uma companhia, requisitos de segurança, etc.

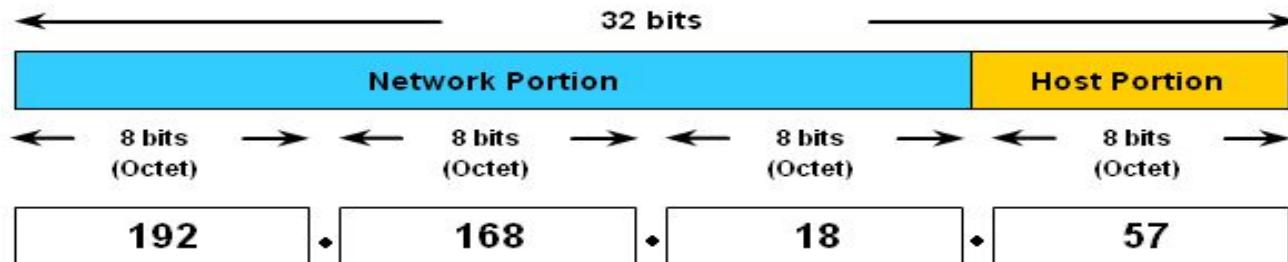
# Utilizando um Roteador

- Limits broadcasts
- Can provide security
- Addressing scheme based on networks - hierarchical



# Endereço IPv4

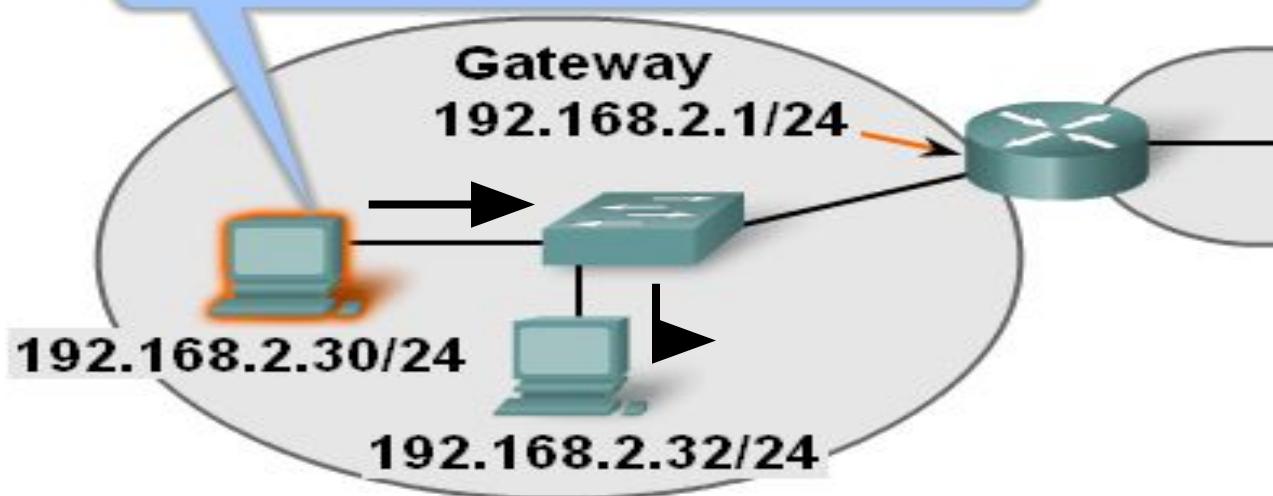
- 32 bits in four 8-bit octets, written in decimal
- Network part then host part
- Here network part (prefix) is 24 bits /24
- Length of network part can vary.



# Message to same network

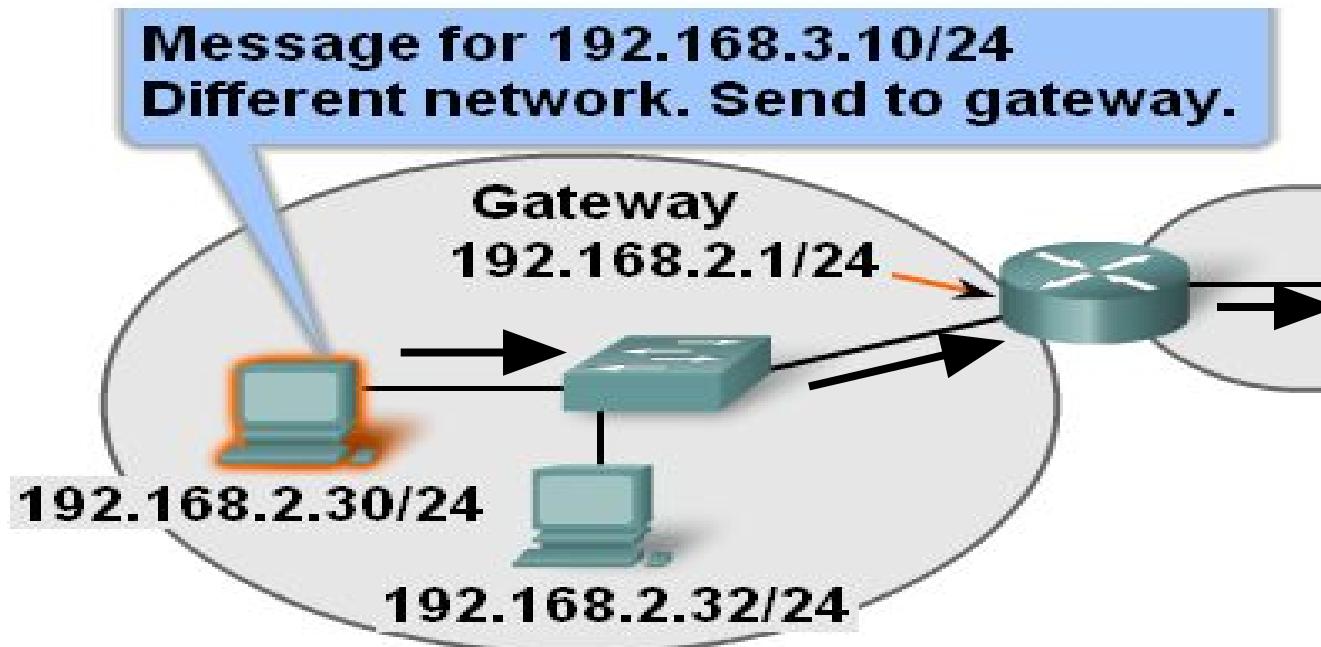
**Network 192.168.2.0/24**

**Message for 192.168.2.32  
Same network. Send it direct.**



# Message to different network

Network 192.168.2.0/24



# Default gateway

- Cada PC é configurado com um endereço IP e um default gateway.
- O default gateway é o endereço IP da porta de um roteador na mesma rede que um PC.
- Cada porta do roteador têm que estar em redes diferentes.

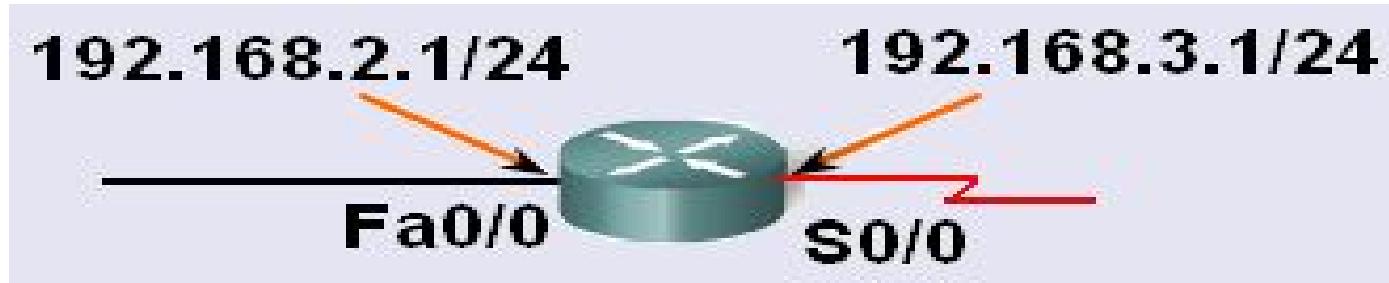
# Saltos

- Um pacote pode passar por diversos roteadores em seu caminho.
- Cada roteador que um pacote passa em sua jornada é chamado de saltos.
- Cada roteador toma as decisões de encaminhamento com base no endereçamento IP e cabeçalhos dos pacotes.

# Tabela de roteamento e encaminhamento

- Cada roteador tem uma tabela de roteamento. Este possui uma lista de redes conhecidas e os melhores caminhos para o próximo salto.
- O roteador analisa o endereço IP do pacote e decide para onde encaminhá-lo. Se a rede é conhecida o pacote é enviado, caso contrário o pacote é descartado.

# Diretamente conectado



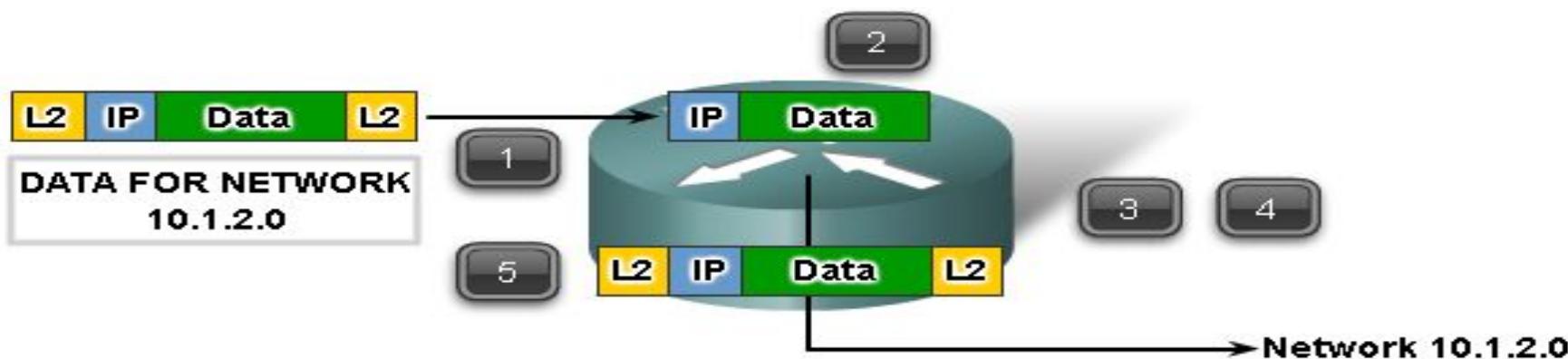
The networks of the router's own interfaces go into the routing table.

- C **192.168.2.0/24 is directly connected, FastEthernet 0/0**
- C **192.168.3.0/24 is directly connected, Serial 0/0**

# Outras Redes

- As rotas para outras redes podem ser configuradas por um roteador (static routes)
- Ou podem ser aprendidas através de protocolos de roteamento (dynamic routes)
- O roteador pode ter uma rota default.

# Aprendizado das Rotas



1. The router removes the Layer 2 encapsulation
2. Router extracts the destination IP address
3. Router checks the routing table for a match
4. Network 10.1.2.0 is found in the routing table
5. Router re-encapsulates the packet
6. Packet is sent to Network 10.1.2.0



# Protocolos de Roteamento

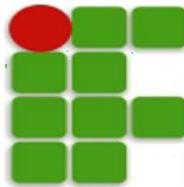
- Os roteadores aprendem as rotas e inserem elas em sua tabela de roteamento.
- O protocolo de roteamento define as regras para a troca de informações.
- As rotas são aprendidas dinamicamente.

# Static routes

- Entered by administrator
- Time consuming, different for each router
- Must be updated if routes change
- Little processing
- No bandwidth used
- Gives nothing away

# Dynamic routes

- Learned from other routers
- Start the protocol then it runs by itself
- Automatically updates when routes change
- More processing
- Uses bandwidth
- Gives away information



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# REDES DE COMPUTADORES I

## ENDEREÇAMENTO IP

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# Binary and decimal

- Convert to 8-bit binary
- 248
- 187
- 89
- Convert to decimal
- 00110100
- 01010101
- 11001111

# 248 to binary

128	64	32	16	8	4	2	1
1	1	1	1	1	0	0	0

$$\begin{array}{r} 248 \\ -128 \\ \hline 120 \end{array} \quad \begin{array}{r} 120 \\ -64 \\ \hline 56 \end{array} \quad \begin{array}{r} 56 \\ -32 \\ \hline 24 \end{array} \quad \begin{array}{r} 24 \\ -16 \\ \hline 8 \end{array}$$

# 187 to binary

128	64	32	16	8	4	2	1
1	0	1	1	1	0	1	1

$$\begin{array}{r} 187 \\ -128 \\ \hline 59 \end{array} \quad \begin{array}{r} 59 \\ -32 \\ \hline 27 \end{array} \quad \begin{array}{r} 27 \\ -16 \\ \hline 11 \end{array} \quad \begin{array}{r} 11 \\ -8 \\ \hline 3 \end{array} \quad \begin{array}{r} 3 \\ -2 \\ \hline 1 \end{array}$$

# 89 to binary

128	64	32	16	8	4	2	1
0	1	0	1	1	0	0	1

$$\begin{array}{r} 89 \\ -64 \\ \hline 25 \end{array} \quad \begin{array}{r} 25 \\ -16 \\ \hline 9 \end{array} \quad \begin{array}{r} 9 \\ -8 \\ \hline 1 \end{array}$$

# 00110100 to decimal

128	64	32	16	8	4	2	1
0	0	1	1	0	1	0	0
		32	16		4		

$$\begin{array}{r} 32 + 16 + \\ \hline 52 \end{array} \qquad \qquad \qquad \boxed{52}$$

# 01010101 to decimal

128	64	32	16	8	4	2	1
0	1	0	1	0	1	0	1
	64		16		4		1

$$\begin{array}{r} 64 + 16 + \\ 4 \\ + 1 \\ \hline 85 \end{array}$$

**85**

# 11001111 to decimal

128	64	32	16	8	4	2	1
1	1	0	0	1	1	1	1
128	64			8	4	2	1

$$\begin{array}{r} 128 \\ + 64 + \\ 8 \\ + 4 \\ \hline + 2 \\ + 1 \\ 207 \end{array}$$

# Binary and decimal

- Convert to 8-bit binary

- 248            11111000

- 187            10111011

- 89            01011001

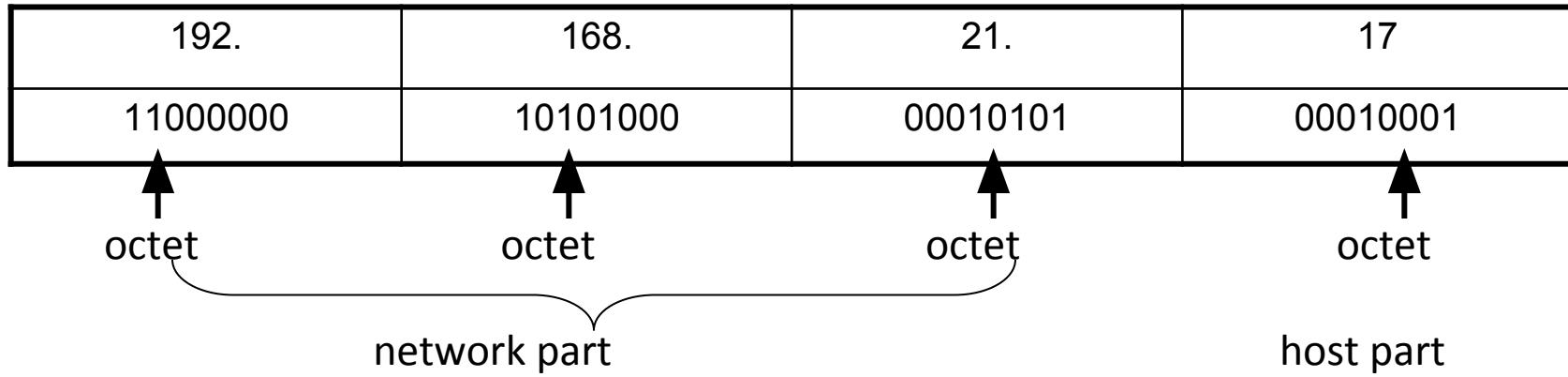
- Convert to decimal

- 00110100       52

- 01010101       85

- 11001111      227

# IPv4 address



Prefix /24 Subnet mask:

255.	255.	255.	0
11111111	11111111	11111111	00000000

# Find the network address

192.	168.	21.	17
11000000	10101000	00010101	00010001

In a network address, all the host bits are 0.

192.	168.	21.	0
11000000	10101000	00010101	00000000

The router needs to do this for every packet.

# Logical AND

192.	168.	21.	17
11000000	10101000	00010101	00010001

255.	255.	255.	0
11111111	11111111	11111111	00000000

192.	168.	21.	0
11000000	10101000	00010101	00000000

Do a logical AND at each position

# Find the broadcast address

192.	168.	21.	17
11000000	10101000	00010101	00010001

In a broadcast address, all the host bits are 1.

192.	168.	21.	255
11000000	10101000	00010101	11111111

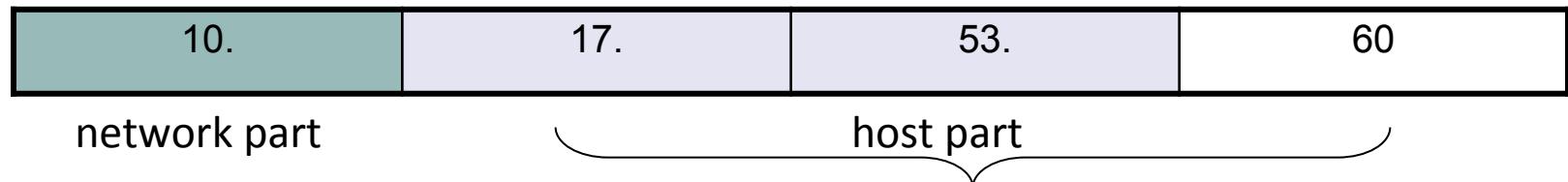
The broadcast is the last address in the network.

# 3 tipos de endereços

- Cada rede tem:
  - Endereço de Rede
  - Endereço de Broadcast
  - Endereço de Host

# Endereçamento Classfull

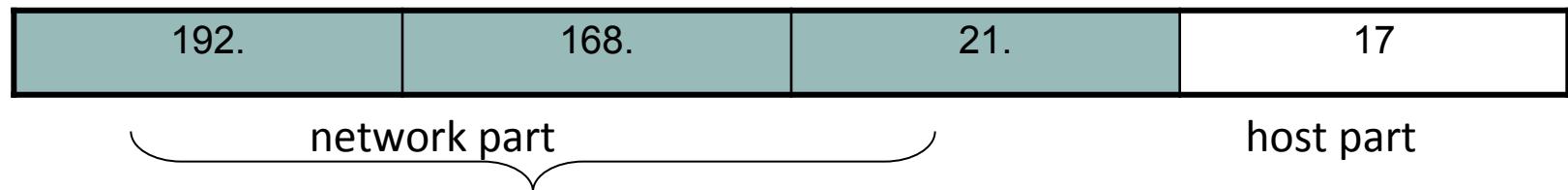
A



B



C



# Endereçamento Classfull

- Fácil de trabalhar, mas causa desperdício
- Roteadores e hosts ainda assumem máscaras default
- Class A /8 255.0.0.0
- Class B /16 255.255.0.0
- Class C /24 255.255.255.0

# Endereçamento Classless

- Qualquer prefixo pode ser utilizado
- Nós (e dispositivos) precisam conhecer o prefixo
- Mais flexível e causa menos desperdício

# Classless addressing /16

- 172.16.0.0/16 mask 255.255.0.0
- Broadcast address 172.16.255.255

172.	16.	0.	0
10101100	00010000	00000000	00000000

- Hosts 172.16.0.1 to 172.16.255.254
- 65534 host addresses

# Classless addressing /24

- 172.16.0.0/24 mask 255.255.255.0
- Broadcast address 172.16.0.255

172.	16.	0.	0
10101100	00010000	00000000	00000000

- Hosts 172.16.0.1 to 172.16.0.254
- 254 host addresses

# Classless addressing /22

- 172.16.0.0/22 mask 255.255.252.0
- Broadcast address 172.16.3.255

172.	16.	0.	0
10101100	00010000	00000000	00000000

- Hosts 172.16.0.1 to 172.16.3.254
- 1022 host addresses

# Classless addressing /26

- 172.16.0.0/22 mask 255.255.255.192
- Broadcast address 172.16.0.63

172.	16.	0.	0
10101100	00010000	00000000	00000000

- Hosts 172.16.0.1 to 172.16.0.62
- 62 host addresses

# Classless addressing /28

- 172.16.0.0/28 mask 255.255.255.240
- Broadcast address 172.16.0.15

172.	16.	0.	0
10101100	00010000	00000000	00000000

- Hosts 172.16.0.1 to 172.16.0.14
- 14 host addresses

# Calculating addresses

- A host has IP address 192.168.1.70/24
- What is the subnet mask?
- What is the network address?
- What is the broadcast address?
- What is the range of host addresses in the network?

# 192.168.1.70/24 – fill in the table

	Last octet binary	Last octet decimal	Full
Host			
Subnet mask			
Network			
Broadcast			
First host			
Last host			

# 192.168.1.70/24

	Last octet binary	Last octet decimal	Full
Host	01000110	70	192.168.1.70
Subnet mask	00000000	0	255.255.255.0
Network	00000000	0	192.168.1.0
Broadcast	11111111	255	192.168.1.255
First host	00000001	1	192.168.1.1
Last host	11111110	254	192.168.1.254

# Calculating addresses

- A host has IP address 192.168.1.70/26
- What is the subnet mask?
- What is the network address?
- What is the broadcast address?
- What is the range of host addresses in the network?

# 192.168.1.70/26 fill in the table

	Last octet binary	Last octet decimal	Full
Host			
Subnet mask			
Network			
Broadcast			
First host			
Last host			

# 192.168.1.70/26

	Last octet binary	Last octet decimal	Full
Host	01000110	70	192.168.1.70
Subnet mask	11000000	192	255.255.255.192
Network	01000000	64	192.168.1.64
Broadcast	01111111	127	192.168.1.127
First host	01000001	65	192.168.1.65
Last host	01111110	126	192.168.1.126

# Calculating addresses

- A host has IP address 192.168.1.70/28
- What is the subnet mask?
- What is the network address?
- What is the broadcast address?
- What is the range of host addresses in the network?

# 192.168.1.70/28 fill in the table

	Last octet binary	Last octet decimal	Full
Host			
Subnet mask			
Network			
Broadcast			
First host			
Last host			

# 192.168.1.70/28

	Last octet binary	Last octet decimal	Full
Host	01000110	70	192.168.1.70
Subnet mask	11110000	240	255.255.255.240
Network	01000000	64	192.168.1.64
Broadcast	01001111	79	192.168.1.79
First host	01000001	65	192.168.1.65
Last host	01001110	78	192.168.1.78

# Unicast, Multicast, Broadcast

- Unicast – a message addressed to one host
- Broadcast – a message addressed to all hosts on a network. Uses network's broadcast address or 255.255.255.255 locally
- Multicast – a message addressed to a group of hosts. Uses an address starting 224 - 239

# Endereços IP Privados

- Acesso irrestrito em redes privadas e não é roteável na internet.
- 10.0.0.0 – 10.255.255.255 (10.0.0.0/8)
- 172.16.0.0 – 172.31.255.255 (172.16.0.0/20)
- 192.168.0.0 – 192.168.255.255 (192.168.0.0/24)

# Endereços IP Públícos

- Roteável pela Internet
- Mantido pela IANA
- Designado para registros regionais e depois para ISPs
- O seu uso é estritamente controlado e não são permitidos endereços duplicados

# Endereços Especiais

- 0.0.0.0 “all addresses” in default route. Hosts cannot be given addresses starting 0.
- 127.0.0.1 is loopback. Hosts cannot be given addresses starting 127.
- 240.0.0.0 and higher – reserved for experimental purposes.
- 169.254.0.0 - 169.254.255.255 local only
- 192.0.2.0 to 192.0.2.255 for teaching

# Network address translation (NAT)

- Um grande número de hosts em uma rede utilizam endereços IPs privados para se comunicarem.
- Os ISPs alocam um ou poucos endereços públicos.
- O NAT permite que hosts compartilhem o endereço público quando querem utilizar a Internet

# Endereçando hosts

- Static addressing – address is configured by an administrator
- Servers, printers, routers, switches need static addresses
- Dynamic addressing – address is allocated automatically by DHCP by leasing addresses from a pool
- Dynamic addressing is best for workstations

# Blocks of addresses

Use	Address range	Summary
Network address	192.168.1.0	192.168.1.0/25
User hosts	192.168.1.1-127	
Servers	192.168.1.128 - 191	192.168.1.128/26
Peripherals	192.168.1.192 - 223	192.168.1.192/27
Network devices	192.168.1.224 - 253	192.168.1.224/27
Router	192.168.1.254	
Broadcast	192.168.1.255	

# Subnetting 192.168.1.0/24

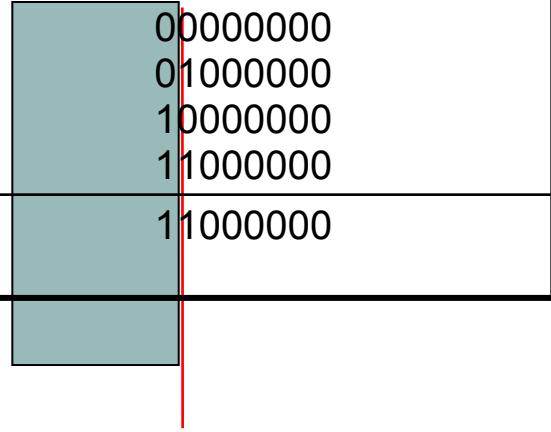
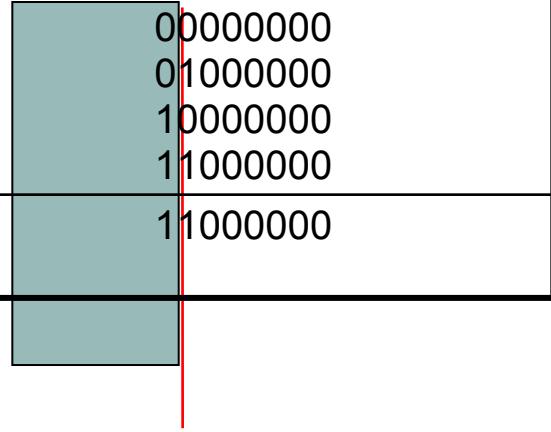
Last octet binary		
Address	192.168.1.0	00000000
Subnet mask	255.255.255.0	00000000

Borrow 1 bit from host part, give it to network part, /25

Addresses	192.168.1.0 192.168.1.128		00000000 10000000
Subnet mask	255.255.255.128		10000000

# Subnetting 192.168.1.0/24

Borrow 2 bits from host part, give to network part, /26

Addresses	192.168.1.0 192.168.1.64 192.168.1.128 192.168.1.192	 00000000 01000000 10000000 11000000
Subnet mask	255.255.255.192	 11000000

# Subnetting 192.168.1.0/24

Borrow 3 bits from host part, give to network part, /27

Addresses	192.168.1.0 192.168.1.32 192.168.1.64 192.168.1.96 192.168.1.128 192.168.1.160 192.168.1.192 192.168.1.224	00000000 00100000 01000000 01100000 10000000 10100000 11000000 11100000
Subnet mask	255.255.255.224	11100000

# Subnetting 192.168.1.0/24

Borrow 4 bits from host part, give to network part, /28

192.168.1.0	192.168.1.128	00000000	10000000
192.168.1.16	192.168.1.144	00010000	10010000
192.168.1.32	192.168.1.160	00100000	10100000
192.168.1.48	192.168.1.176	00110000	10110000
192.168.1.64	192.168.1.192	01000000	11000000
192.168.1.80	192.168.1.208	01010000	11010000
192.168.1.96	192.168.1.224	01100000	11100000
192.168.1.112	192.168.1.240	01110000	11110000
Subnet mask 255.255.255.240	11110000		

And so on...

# Subnetting 192.168.1.0/24

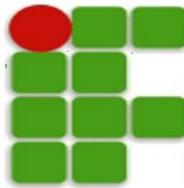
- Cada vez que você “toma emprestado” um bit, você:
  - Dobra o número de subredes
  - Reduz pela metade o número de subredes
- Cada subrede possui um endereço de rede, de broadcast e tudo que estiver entre esses endereços são endereços de host.

# Ping e traceroute

- O Ping envia uma mensagem ICMP. Se tudo ocorrer bem, o destino responde. Se não, o roteador pode responder dizendo que o destino está unreachable ou o ping pode dar timeout.
- Traceroute envia uma série de mensagens para cada roteador ao longo do caminho. Com isso, você ter o endereço de todos os roteadores.

# IPv6

- Development started in 1990s because of concerns about IPv4 addresses running out
- A whole new protocol suite – not just layer 3
- Uses 128-bit hierarchical addressing, written using hexadecimal
- Simpler header
- Integrated security – authentication, privacy
- Quality of service mechanisms



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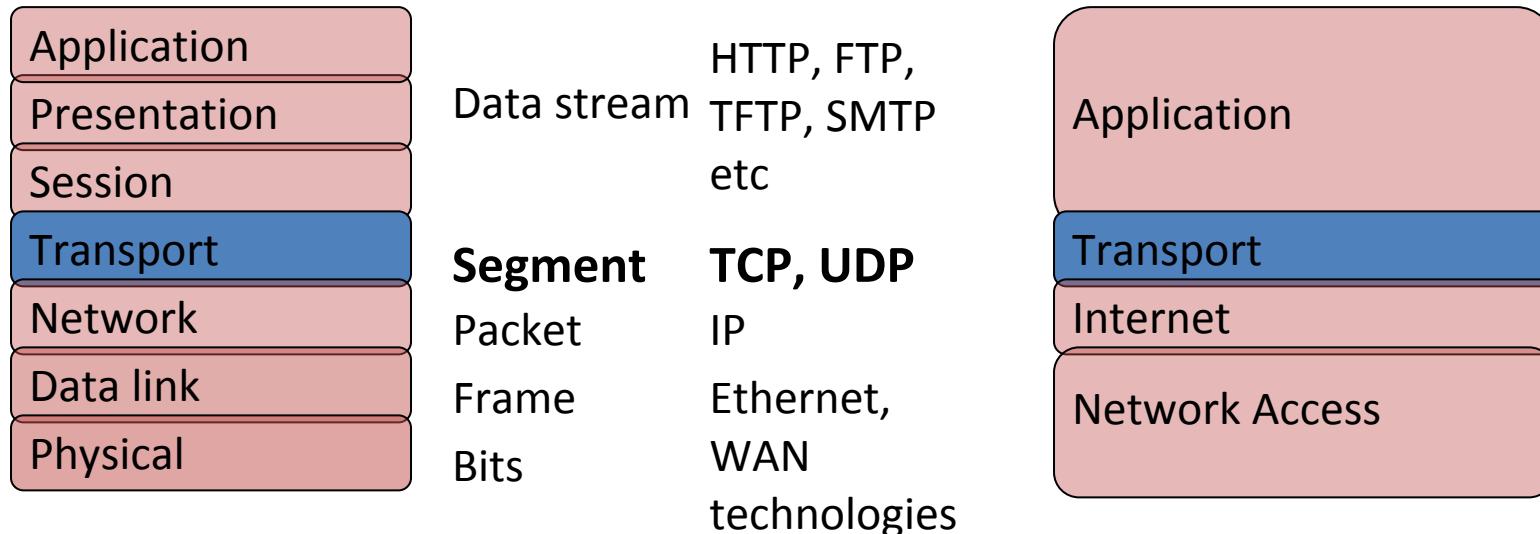
## CAMADA DE TRANSPORTE

Ramon Fontes

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# Camada de Transporte

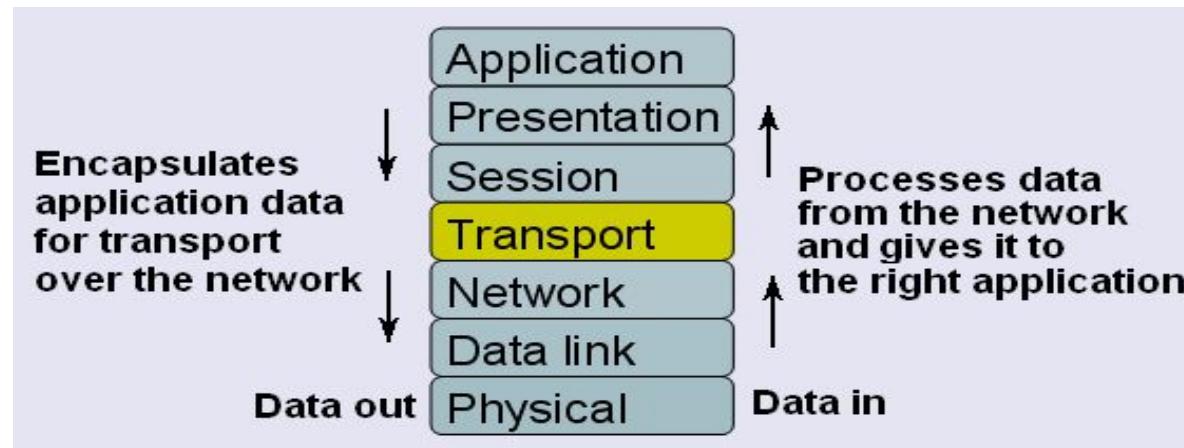


# Camada de Transporte

- TCP: Transport Control Protocol
- UDP: User Datagram Protocol

# Camada de Transporte - Objetivos

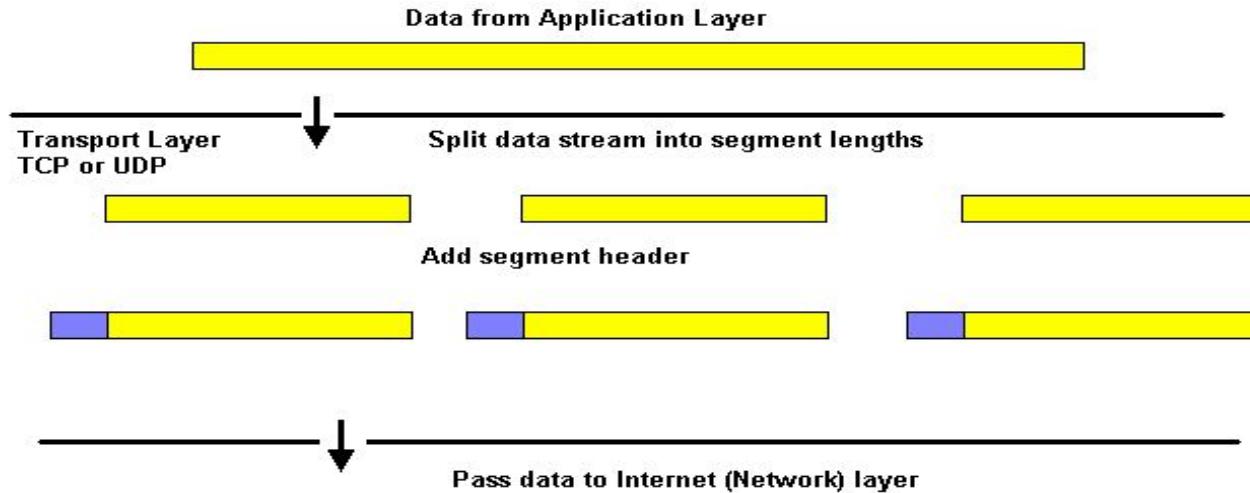
Responsável pela entrega fim-a-fim



# Camada de Transporte

- Permite que múltiplas aplicações em dispositivos diferentes envie informações através da rede de forma simultânea.
- Provê entrega confiável checando se os dados enviados foram recebidos pelo receptor.

# Camada de Transporte



# TCP

- A conexão é configurada antes do envio dos dados.
- Chega se os segmentos foram recebidos pelo receptor e reenvia caso necessário.
- Segmentos são organizados em ordem.
- Faz a checagem da velocidade de transmissão (Flow Control!).
- Mas... Custa tempo e recursos.

# UDP

- Não orientado a conexão. Não faz nenhuma verificação de erros.
- Não checa se os dados foram recebidos pelo receptor.
- Não organiza as informações.
- “Best effort”.
- Pouco overhead.
- Utilizado para VoIP, streaming video, DNS, TFTP

# Porquê dois protocolos de Transporte?

- Some applications need their data to be complete with no errors or gaps and they can accept a slight delay to ensure **Reliable**.  
They use TCP.

- Some applications can accept occasional errors or gaps in the data but they can't accept any delay.

They use UDP.



**Reliable**



**Fast**

# TCP and UDP headers

**TCP Segment**

Bit (0)	Bit (15) Bit (16)	Bit (31)
Source Port (16)	Destination Port (16)	
Sequence Number (32)		
Acknowledgement Number (32)		
Header Length (4) Reserved (6) Code Bits (6)	Window (16)	
Checksum (16)	Urgent (16)	
Options (0 or 32 if any)		
APPLICATION LAYER DATA (Size varies)		

↑  
20 Bytes  
↓

**UDP Datagram**

Bit (0)	Bit (15) Bit (16)	Bit (31)
Source Port (16)	Destination Port (16)	
Length (16)	Checksum (16)	
APPLICATION LAYER DATA (Size varies)		

↑  
8 Bytes  
↓

# Números de Porta

- Utilizado pelo TCP e UDP como forma de endereçamento.
- Identifica aplicações e conversação.
- Aplicações comuns possuem portas padrão:

80 for HTTP      110 for POP3 mail

20/21 for FTP    23 for Telnet

# Números de Porta

TCP Segment			
Source Port	49152	Destination Port	80

Client PC uses port 49152.

Chosen at random.

Remembers this to identify application and conversation.

Client PC uses port 80.

Identifies HTTP as application.

Requesting a web page.

Port + IP address = socket. E.g. 192.168.2.12:80

# Números de Porta

- The Internet Assigned Numbers Authority (IANA) assigns port numbers.
- Well Known Ports (0 to 1023) - Reserved for common services and applications such as HTTP, FTP, Telnet, POP3, SMTP.
- Registered Ports (1024 to 49151) - Assigned to user processes or applications. Can be dynamically selected by a client as its source port.
- Dynamic or Private or Ephemeral Ports (49152 to 65535) – Can be assigned dynamically to client applications when initiating a connection.

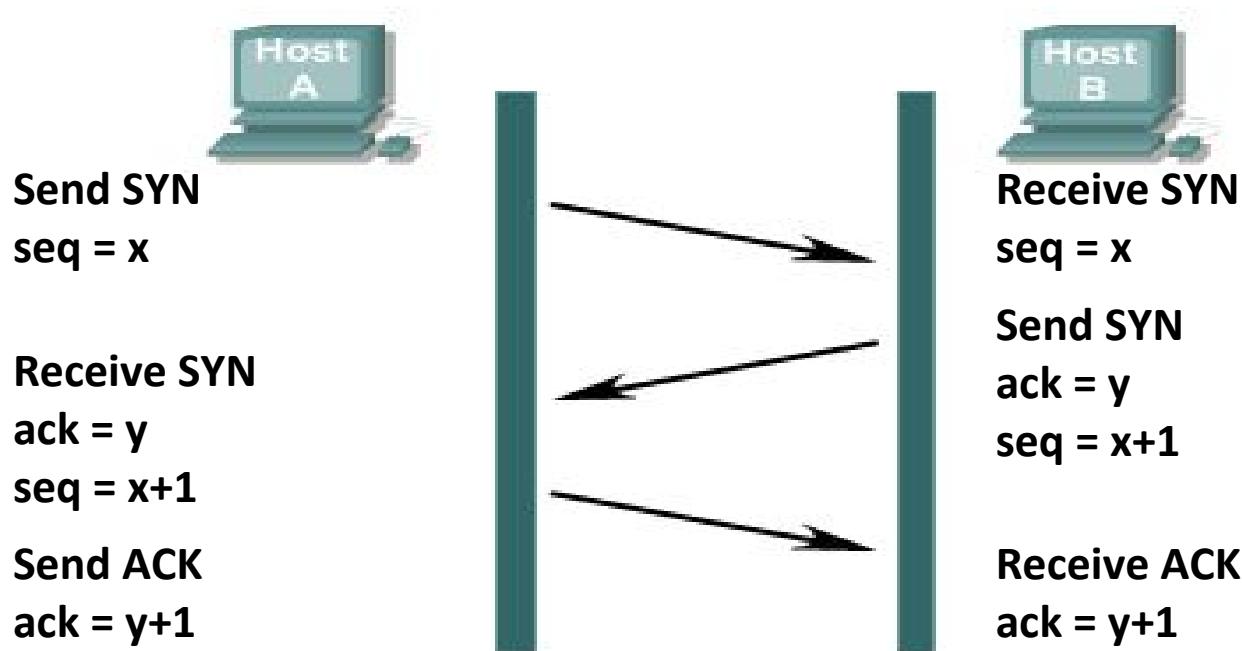
# Netstat

Active connections			
Proto	Local Address	Foreign Address	State
TCP	MyPC:1518	www.google.co.uk:http	ESTABLISHED
TCP	MyPC:1525	www.cisco.com:http	ESTABLISHED

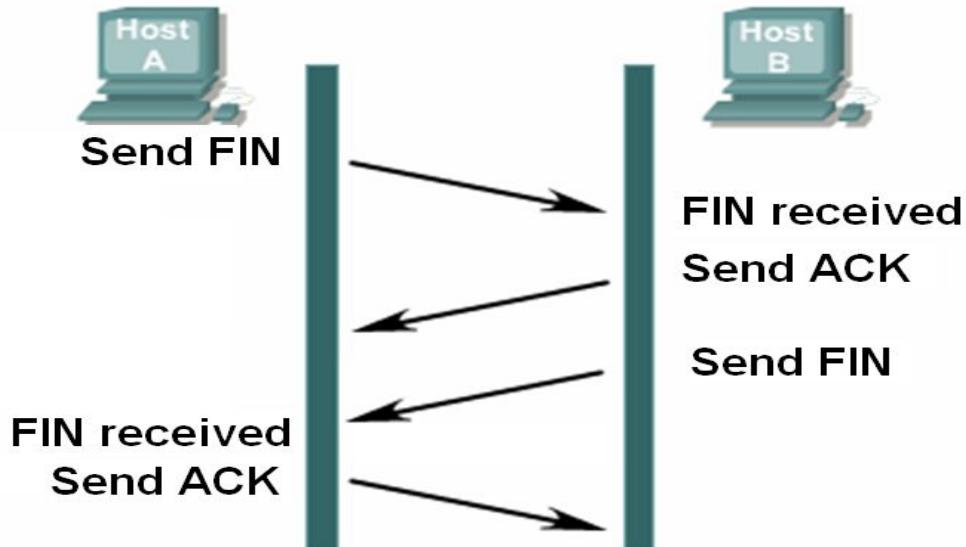
Protocol; endereço local e número de porta; endereço externo e número de porta.

Conexões inesperadas podem representar algum problema!

# Handshake triplo

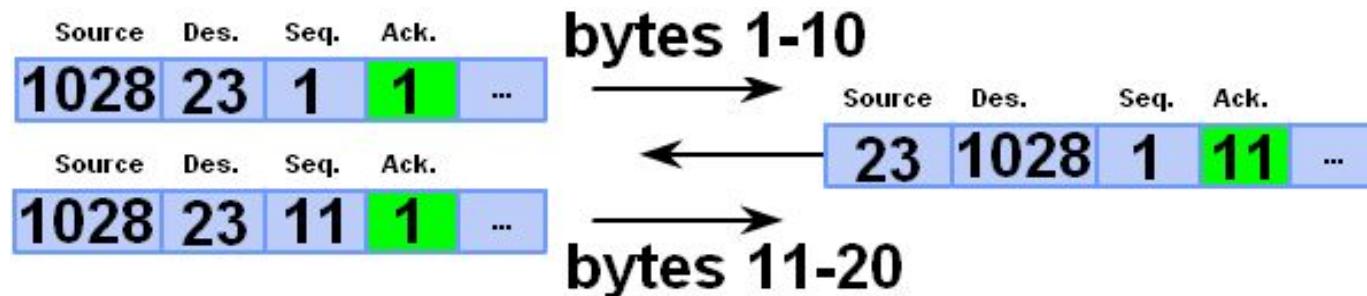


# Finalizando a conexão



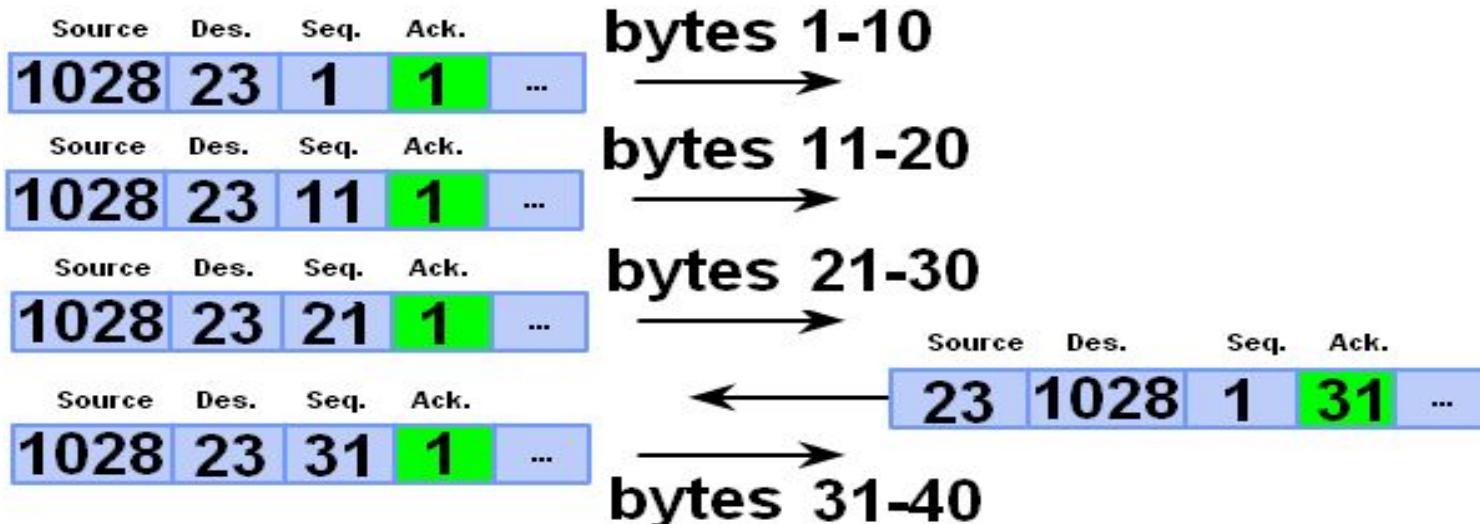
# Confirmação de Recebimento

- TCP checa se os dados foram recebidos;
- Os hosts enviam uma confirmação entregando o número de sequência.



# Tamanho da Janela

- Controla quantos bytes são enviados antes do recebimento de confirmação.



# Lost segments

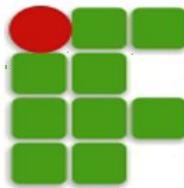
- Send bytes 1 to 2999
- Receive 1 to 2999, send ACK 3000
- Send bytes 3000 to 4999
- Receive 3000 to 3999, send ACK 4000  
(bytes 4000 to 4999 were lost)
- Send bytes 4000 to 5999
- Lost segments are re-sent.
- If no ACK – send them all again

# Controle de fluxo

- O tamanho da janela é acordado durante o handshake triplo.
- Se o tamanho da janela for grande demais e o receptor perder dados (buffer overflow), ele pode diminuir o tamanho da janela.
- Se estiver tudo “Ok”, o receptor irá incrementar o tamanho da janela.

# Comparação entre TCP e UDP

- TCP e UDP utilizam números de porta
- TCP configura uma conexão
- TCP utiliza controle de fluxo
- TCP pode enviar segmentos na ordem correta
- UDP tem menos overhead. Logo, é mais rápido.



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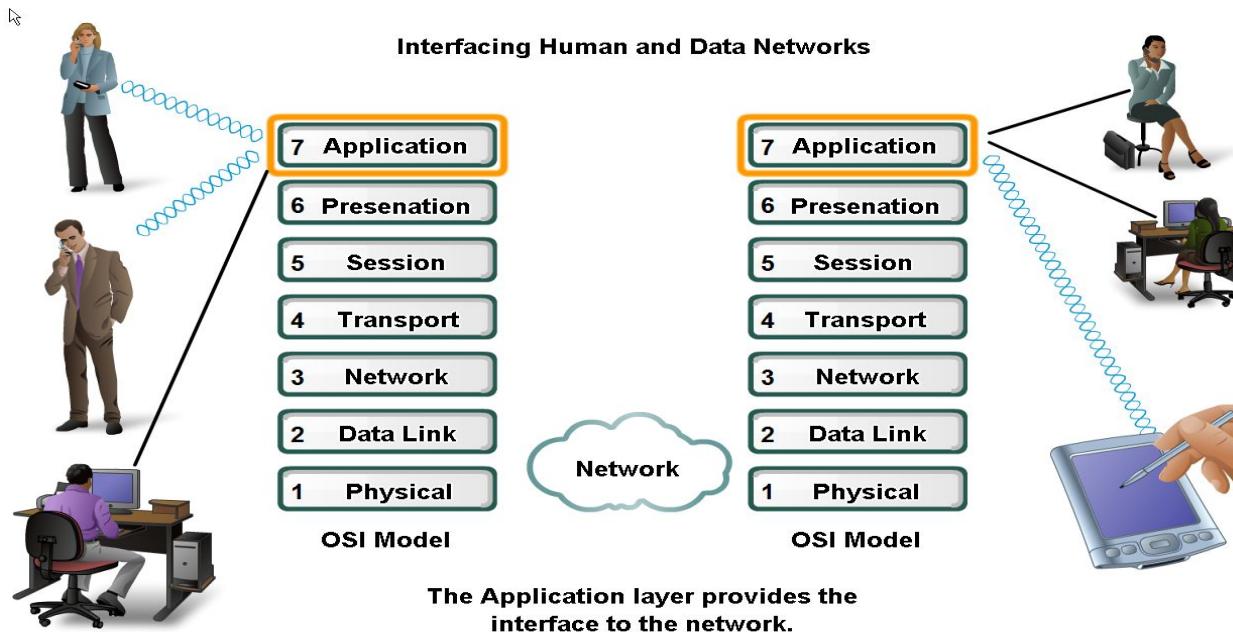
## CAMADA DE APLICAÇÃO

Ramon Fontes

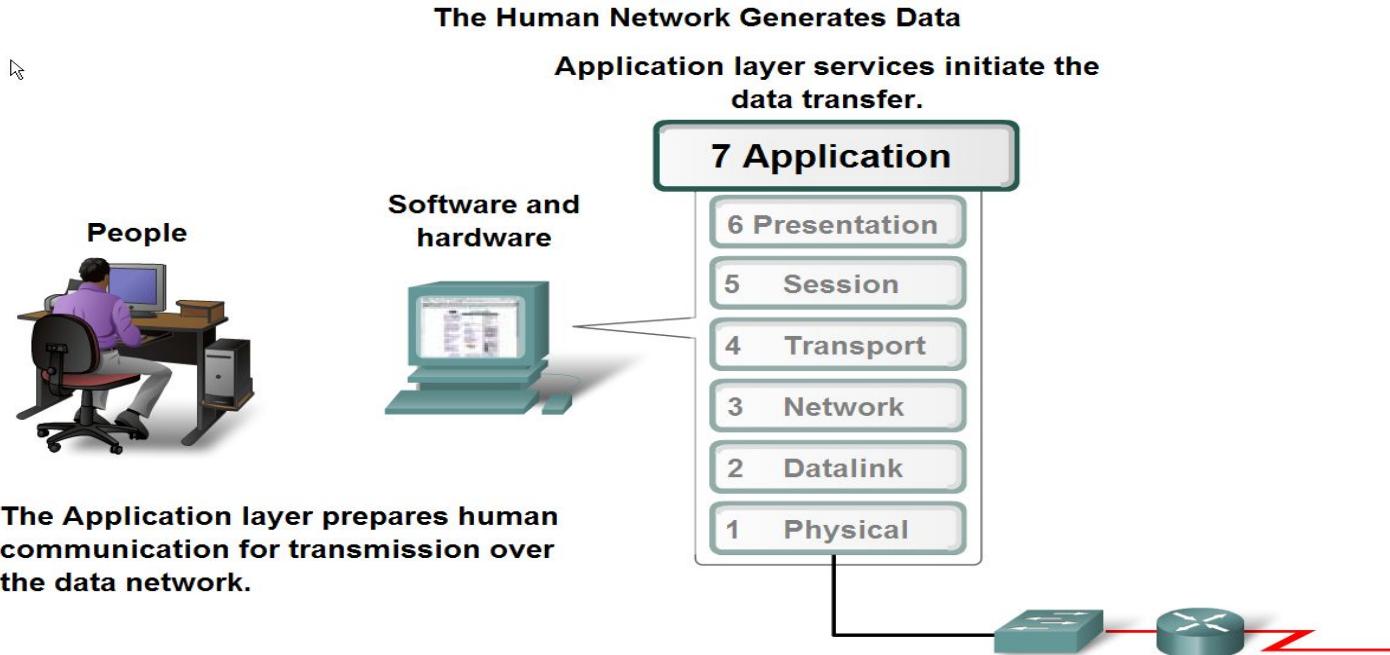
[ramonfontes.com](http://ramonfontes.com)

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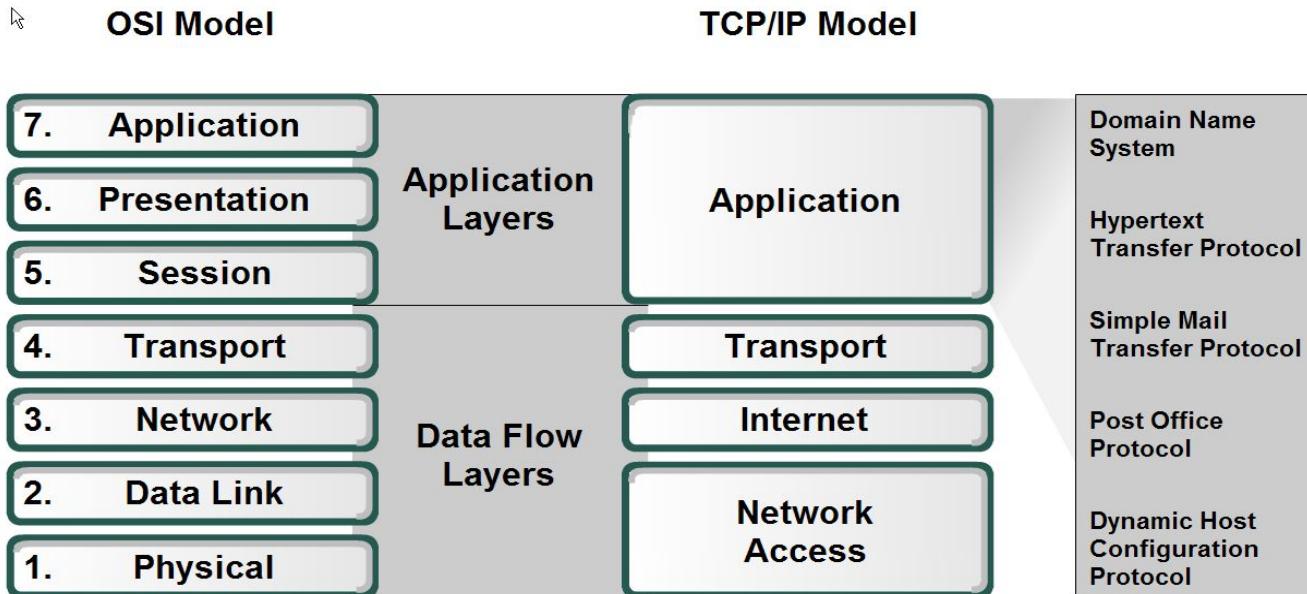
# Camada de Aplicação



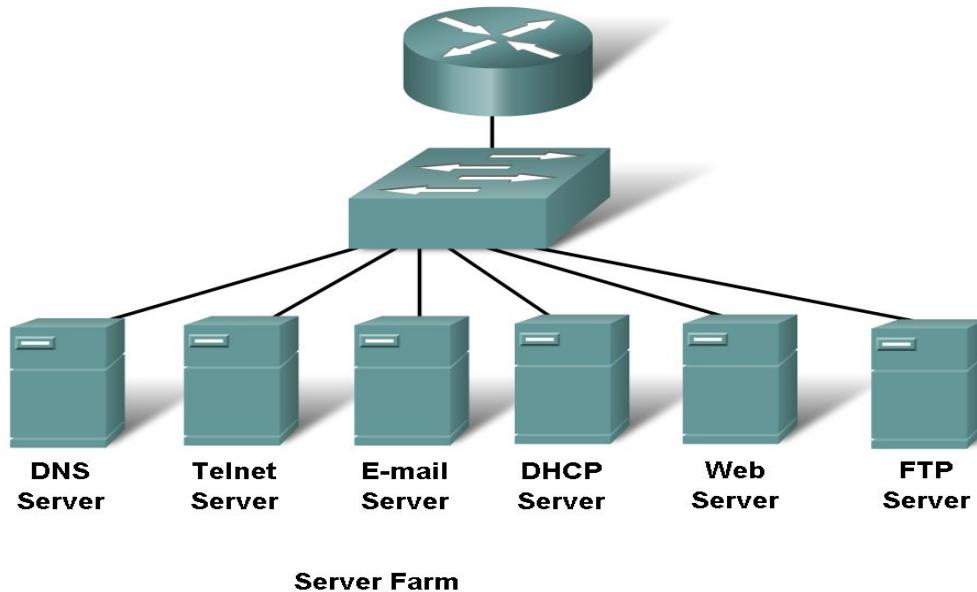
# Camada de Aplicação



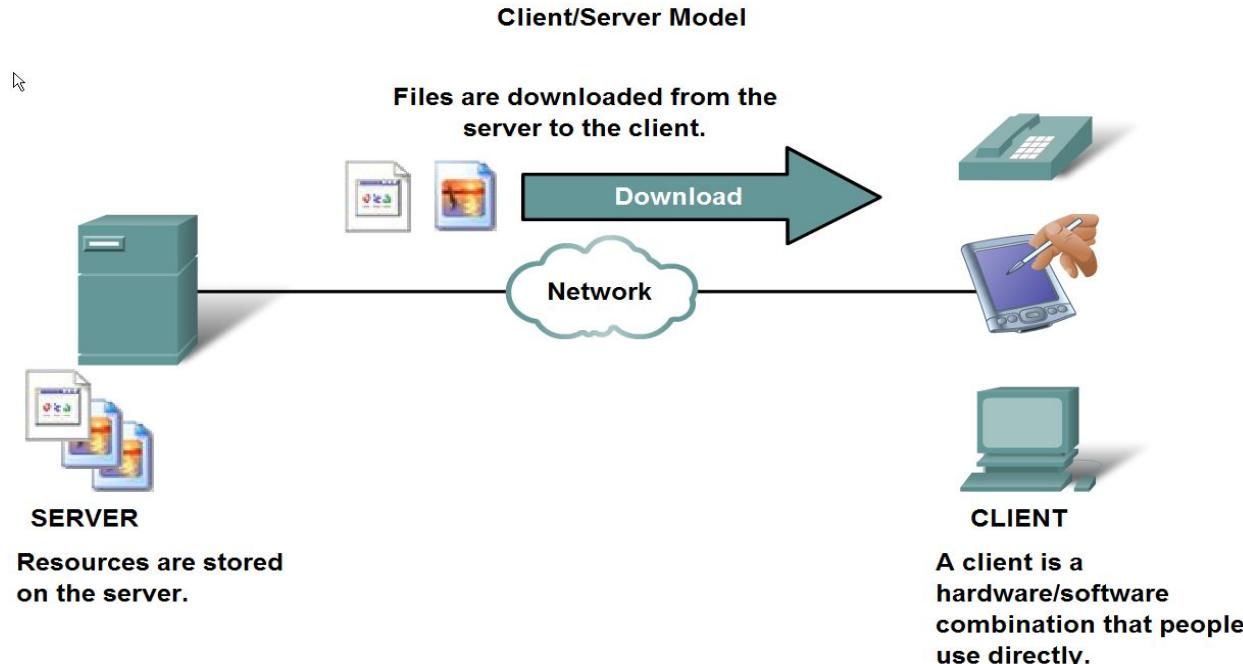
# Camada de Aplicação



# Camada de Aplicação

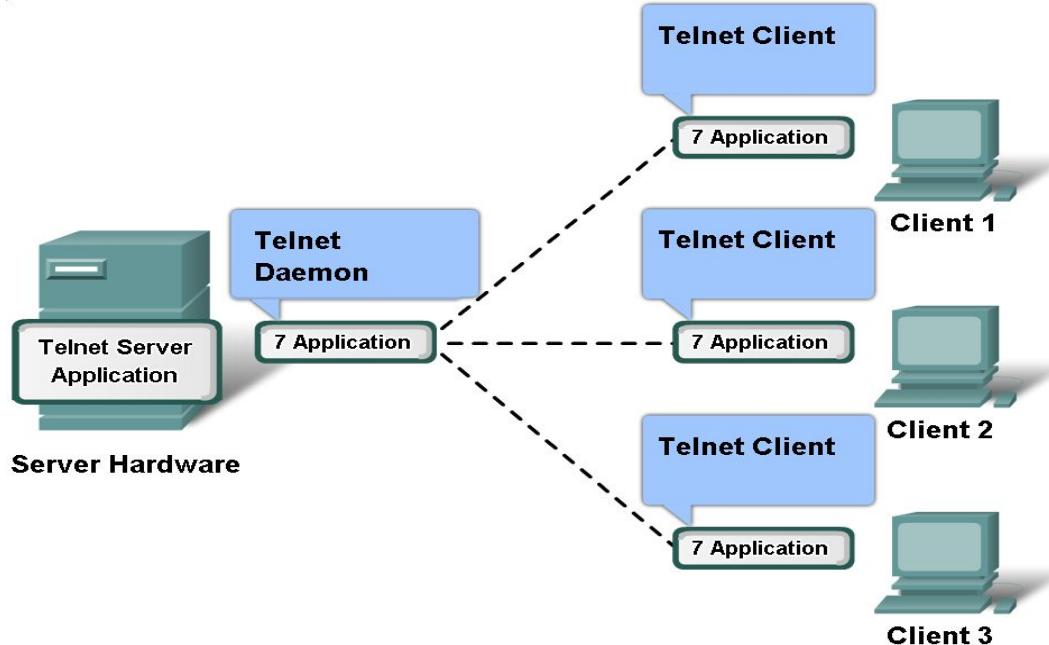


# Camada de Aplicação

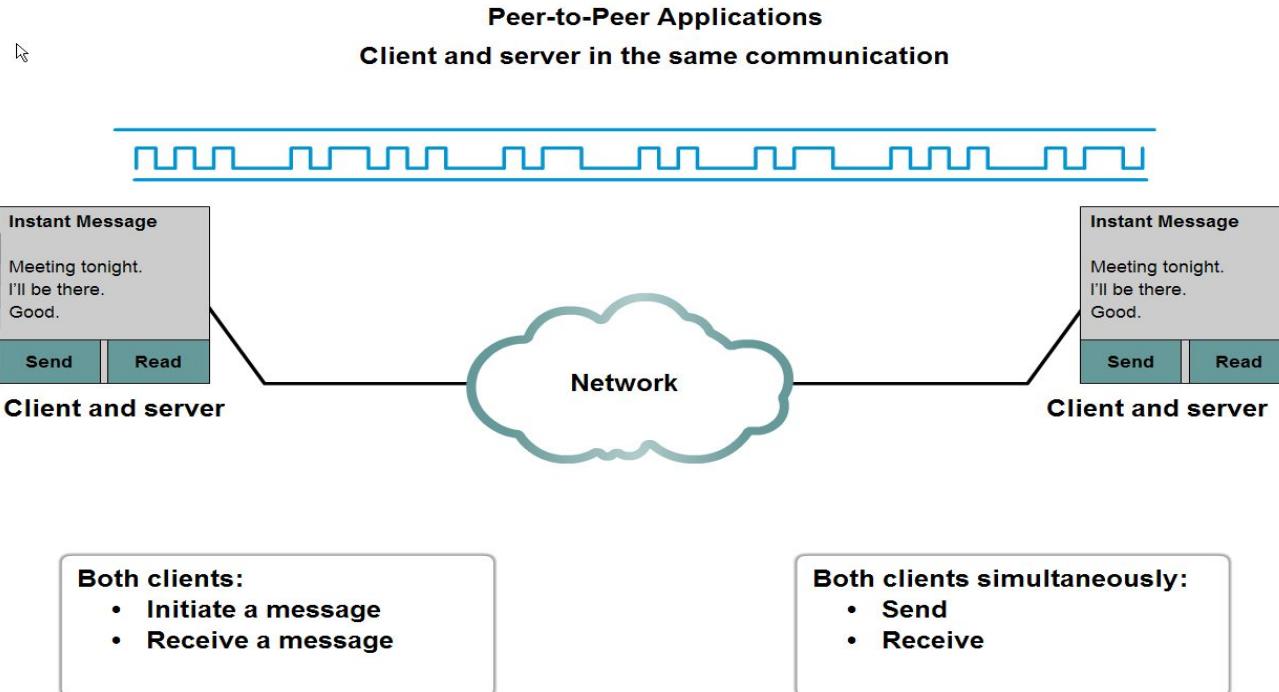


# Camada de Aplicação

**Server processes may support multiple clients.**

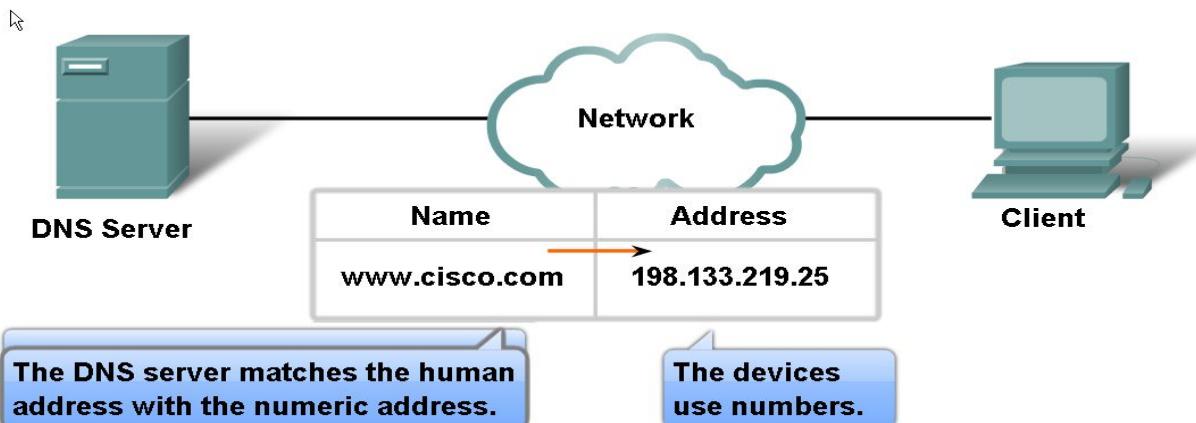


# Camada de Aplicação



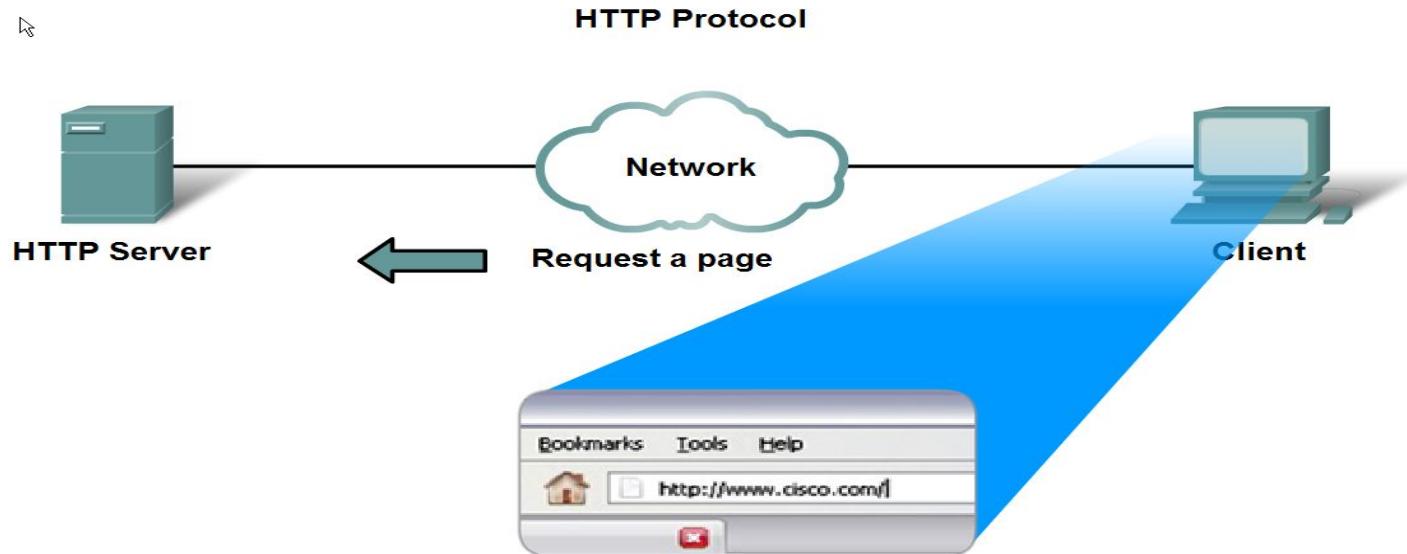
# Camada de Aplicação

## Resolving DNS Addresses

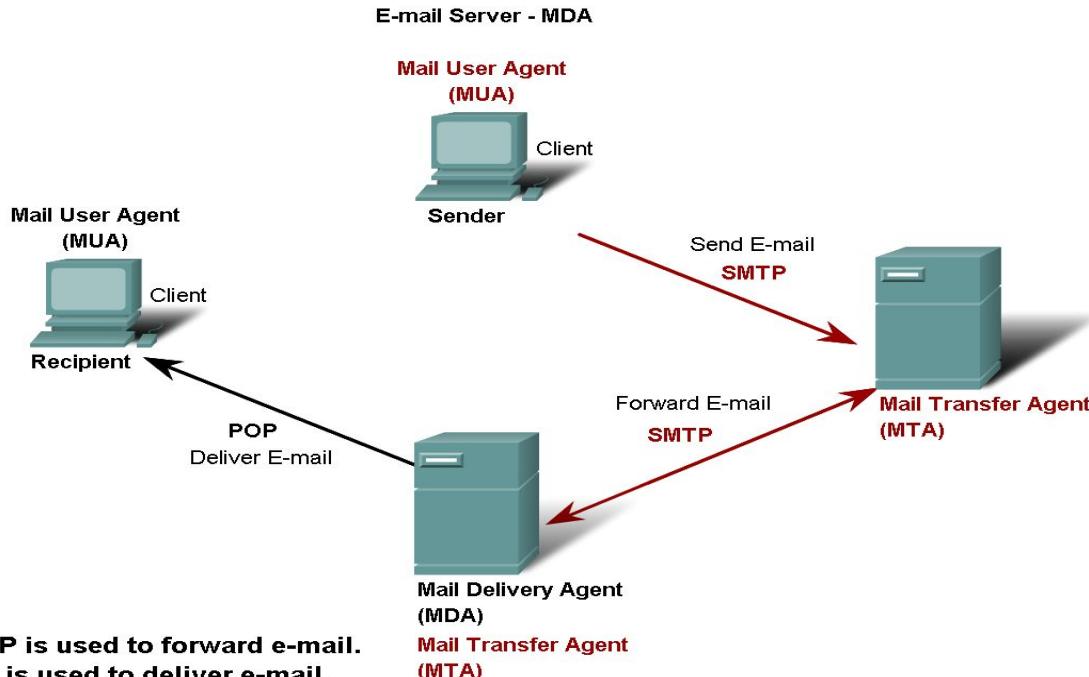


# Camada de Aplicação

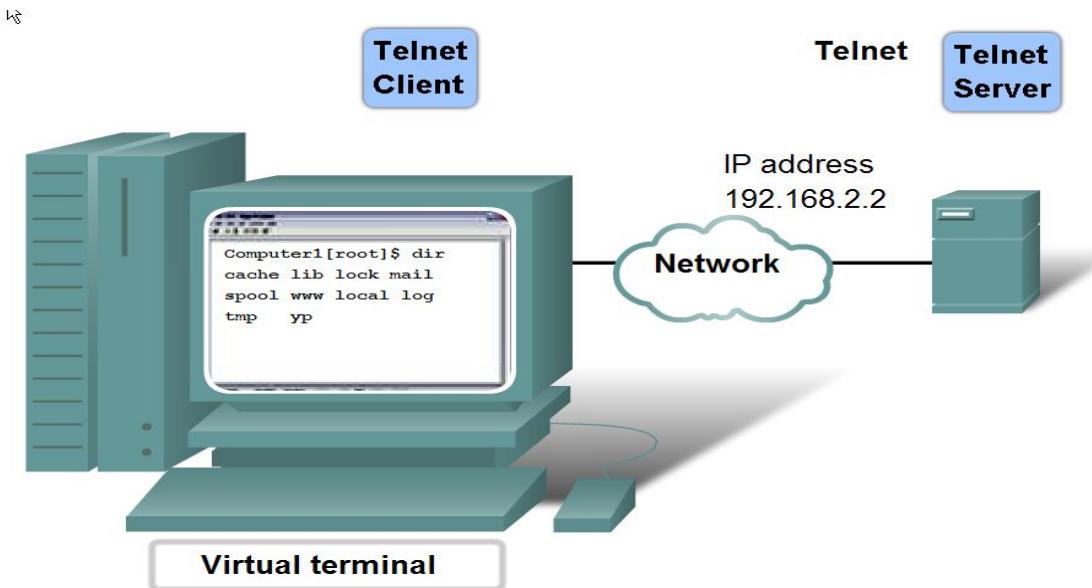
- Describe the features of the HTTP protocol and how this protocol supports the delivery of web pages to the client



# Camada de Aplicação

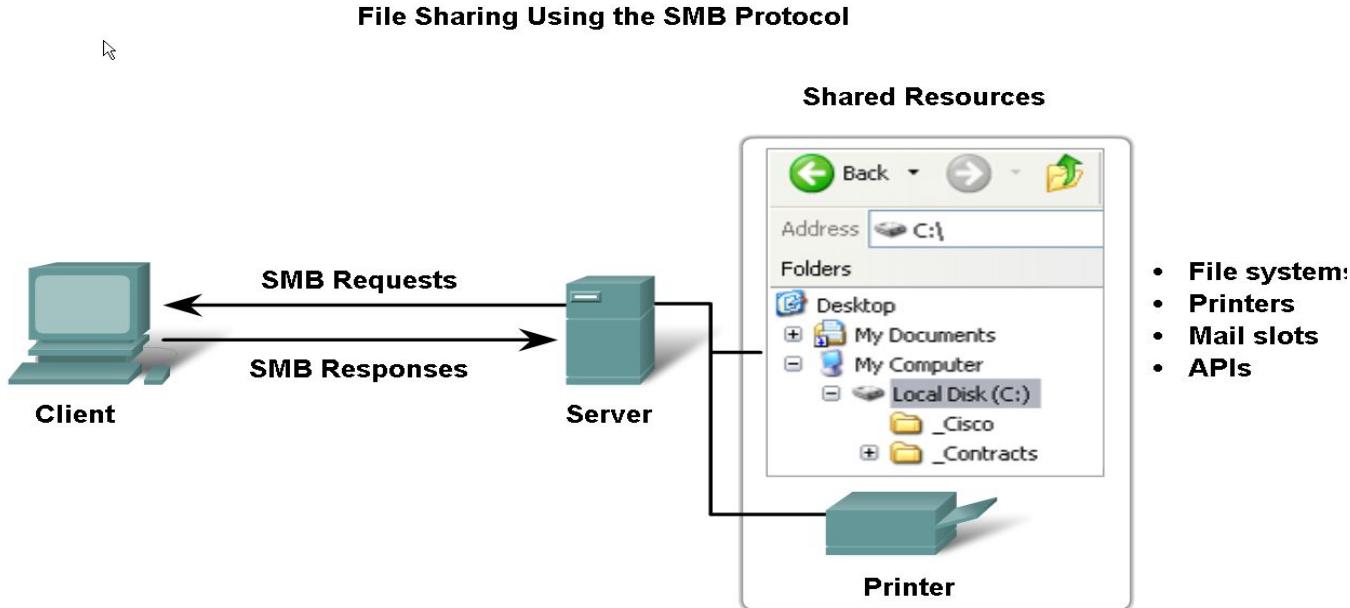


# Camada de Aplicação

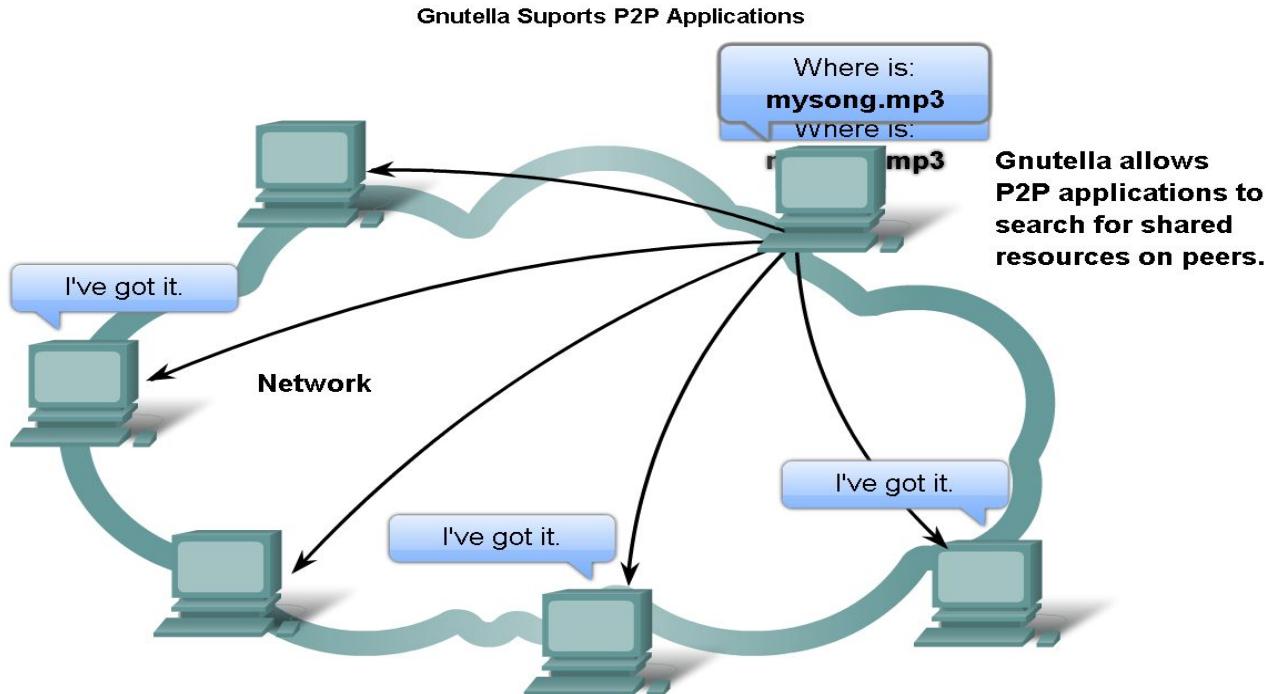


**Telnet provides a way to use a computer, connected via the network, to access a network device as if the keyboard and monitor were directly connected to the device.**

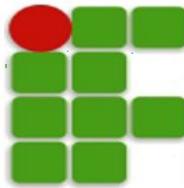
# Camada de Aplicação



# Camada de Aplicação



# BACKUP



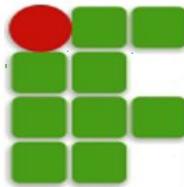
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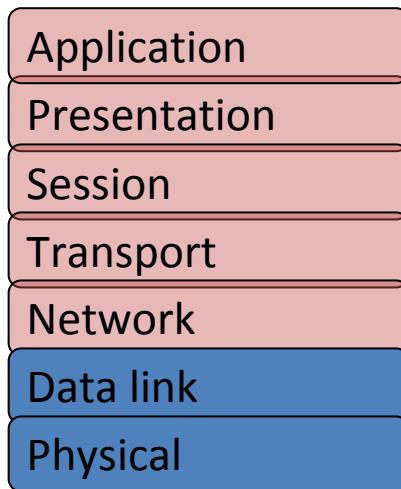
## ETHERNET

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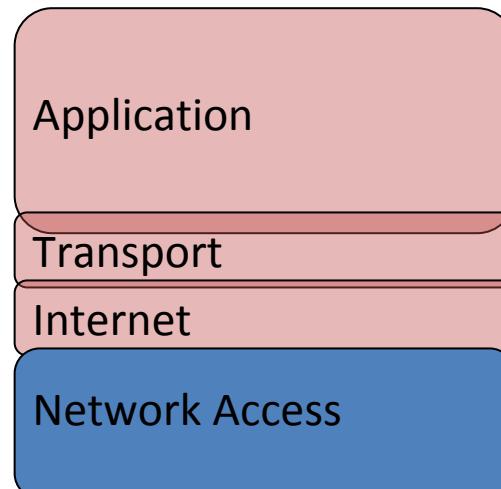
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# Ethernet



Ethernet



# Ethernet

- Tecnologia LAN mais comum
- Diferentes mídias (cabos, fibras ópticas)
- Diferentes larguras de banda (10, 100Mbps, Gbps, +)

# Ethernet history

- First LAN was Ethernet, designed at Xerox
- 1980 Ethernet standard published by DIX (Digital, Intel, Xerox)
- 1985 IEEE modified Ethernet standard and published as 802.3



# Sublayers

- Logical Link control sublayer links to upper layers, is independent of equipment.
- Media Access Control sublayer provides addressing, frame format, error detection, CSMA/CD.
- Physical layer handles bits, puts signals on the medium, detects signals.



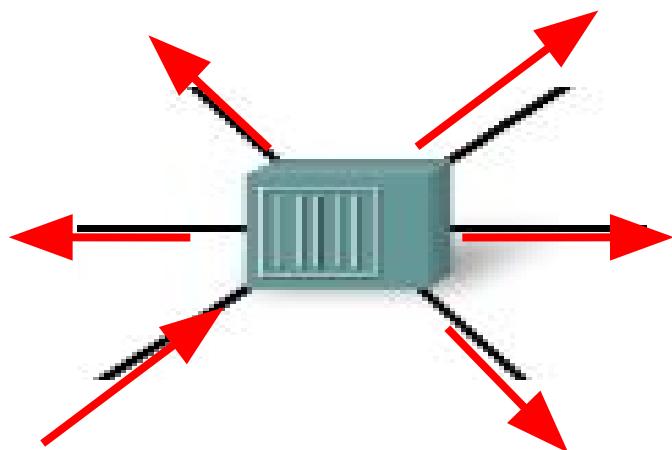
# Advantages of Ethernet

- Simplicity and ease of maintenance
- Ability to incorporate new technologies (e.g. fibre optic, higher bandwidths)
- Reliability
- Low cost of installation and upgrade

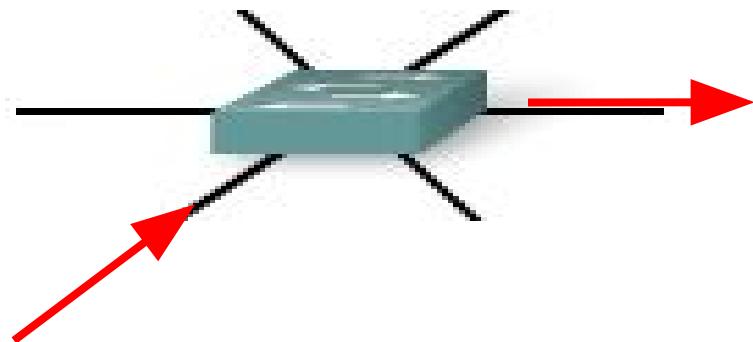
# Hubs and switches

- “Legacy Ethernet”, 10Base5, 10Base2 or 10BaseT with hubs is designed to work with collisions, when devices transmit at the same time. Collisions are managed by CSMA/CD.
- Performance is poor if there is a lot of traffic and therefore a lot of collisions.
- Collisions can be avoided by using switches and full duplex operation.

# Hubs and switches



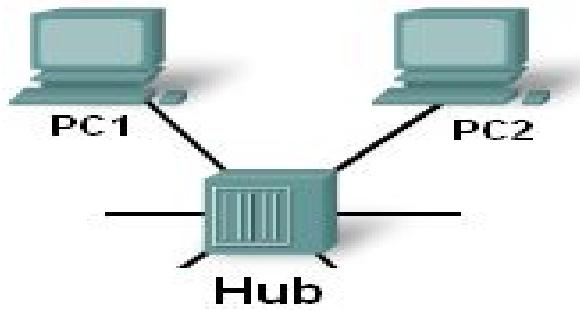
Hub forwards frames through all ports except incoming port.



Switch forwards frames only to the destination once the address is known.

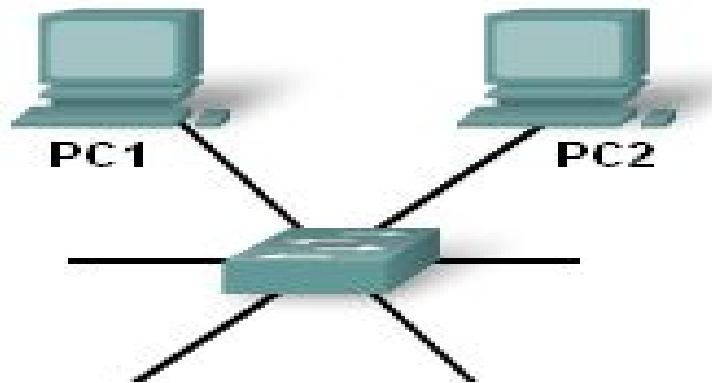
# Half duplex

- One-way traffic. Necessary on a shared medium.
- If PC1 is transmitting but also detects incoming signals then there is a collision.



# Full duplex

- Two way traffic
- PC can transmit and receive at the same time
- Not on shared medium – must have dedicated link from switch
- No collisions



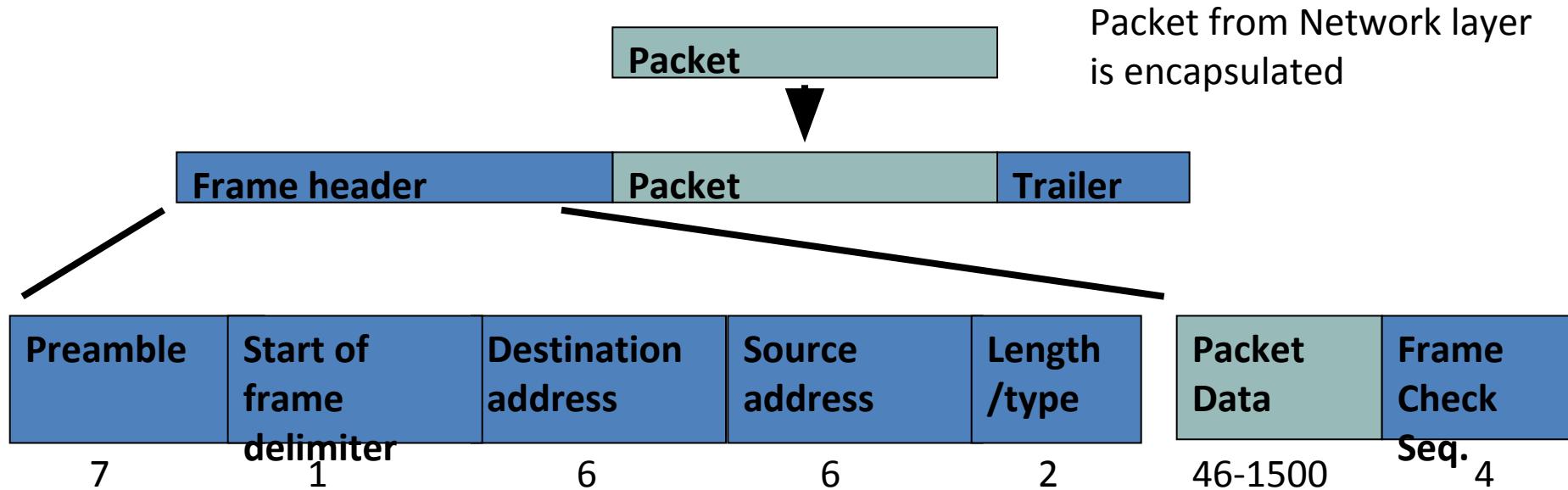
# Fast Ethernet, Gigabit Ethernet

- Along with the move to switches came higher bandwidth: 100 Mbps or Fast Ethernet.
- Later came 1000 Mbps, Gigabit Ethernet.
- Gigabit Ethernet requires fully switched and full duplex operation. Collisions are no longer defined and cannot be managed.

# LAN, MAN, WAN

- Ethernet was developed for local area networks confined to a single building or group of buildings on one site.
- Using fibre optics and Gigabit speeds, Ethernet can be used for Metropolitan Area Networks – throughout a town or city.
- Ethernet can even be used over larger areas so the distinction between LAN and WAN is no longer clear.

# Ethernet Frame



Field size in bytes. Preamble and SFD are not counted in frame size. Frame is 64-1518 (later 1522) bytes.

# Frame fields

- Preamble and start of frame delimiter: act as a wake-up call, help synchronisation, show where frame starts.
- Destination Address: MAC address of destination, 6 bytes hold 12 hex digits.
- Source Address: MAC address of sender, 6 bytes hold 12 hex digits.

# Frame fields

- Length/type field: DIX used this for type, the original IEEE 802.3 standard used it for length. The later IEEE standard allows it to be used for either.
- A value less than 0x0600 hex (1536 decimal) is length. A greater value is the type, a code showing which higher layer protocol is in use.

# Frame fields

- Data field: This contains the layer 3 protocol data unit, usually an IP packet.
- If the packet is less than 46 bytes then the field length is made up to 46 bytes with a “pad”.
- The frame trailer contains the Frame Check Sequence field, used for the cyclic redundancy check to detect corrupt frames.

# Ethernet MAC address

- A unique identification for a device (or NIC).
- Burned into the ROM but copied to RAM.
- First 3 bytes identify the manufacturer  
(Organizationally Unique Identifier)
- A device reads the destination MAC address to see if it should process the frame.
- A switch reads the destination MAC address to see where it should forward the frame.

# Writing a MAC address

- The 12 hex digits are written in different ways
- 00-05-9A-3C-78-00
- 00:05:9A:3C:78:00
- 0005.9A3C.7800
- This is the same address
- 00-05-9A is the manufacturer's ID assigned by IEEE
- 3C-78-00 is assigned by the manufacturer

# Different addresses

- MAC addresses are used to identify devices within a network. They are layer 2 addresses in the frame header.
- IP addresses are used to pass data between networks. They are layer 3 addresses in the packet header. They identify the network as well as the device.

# On a long journey...

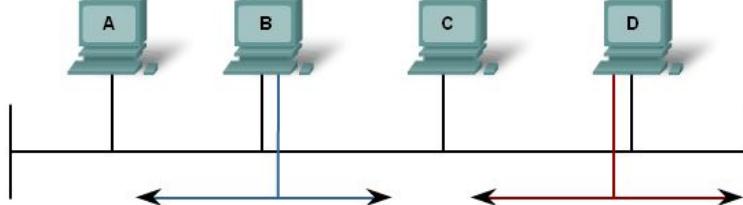
- The packet header with IP addresses is created by the source host and stays the same throughout the journey.
- The frame header is stripped off and replaced by each router, so the MAC addresses are different for every step of the journey. If parts of the journey are not over Ethernet then there will be a different addressing system – not MAC.

# Unicast, multicast, broadcast

- Unicast: a message sent to one particular host. It must contain the destination host's IP address and MAC address.
- Broadcast: message for all hosts on a network.  
“Host” part of IP address is all binary 1s. E.g.  
**192.168.1.255** MAC address is all binary 1s,  
FF:FF:FF:FF:FF in hex.
- Multicast: message for a group of devices.  
IP address 224.0.0.0 to 239.255.255.255

# Collisions

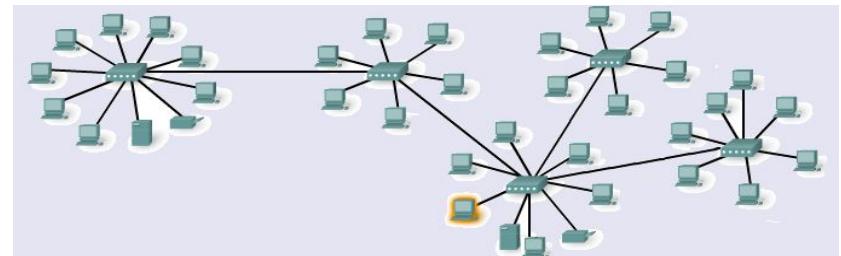
- Ethernet originally used shared coaxial cable.
- If hosts transmit at the same time, there is a collision.
- Later networks used hubs and UTP cable but the medium is still shared and collisions occur.



# Hubs and Collision Domains

- Collision domain – area where collisions occur.
- Add more hubs and PCs – collision domain gets bigger, more traffic, more collisions.
- Hosts connected by hubs share bandwidth.

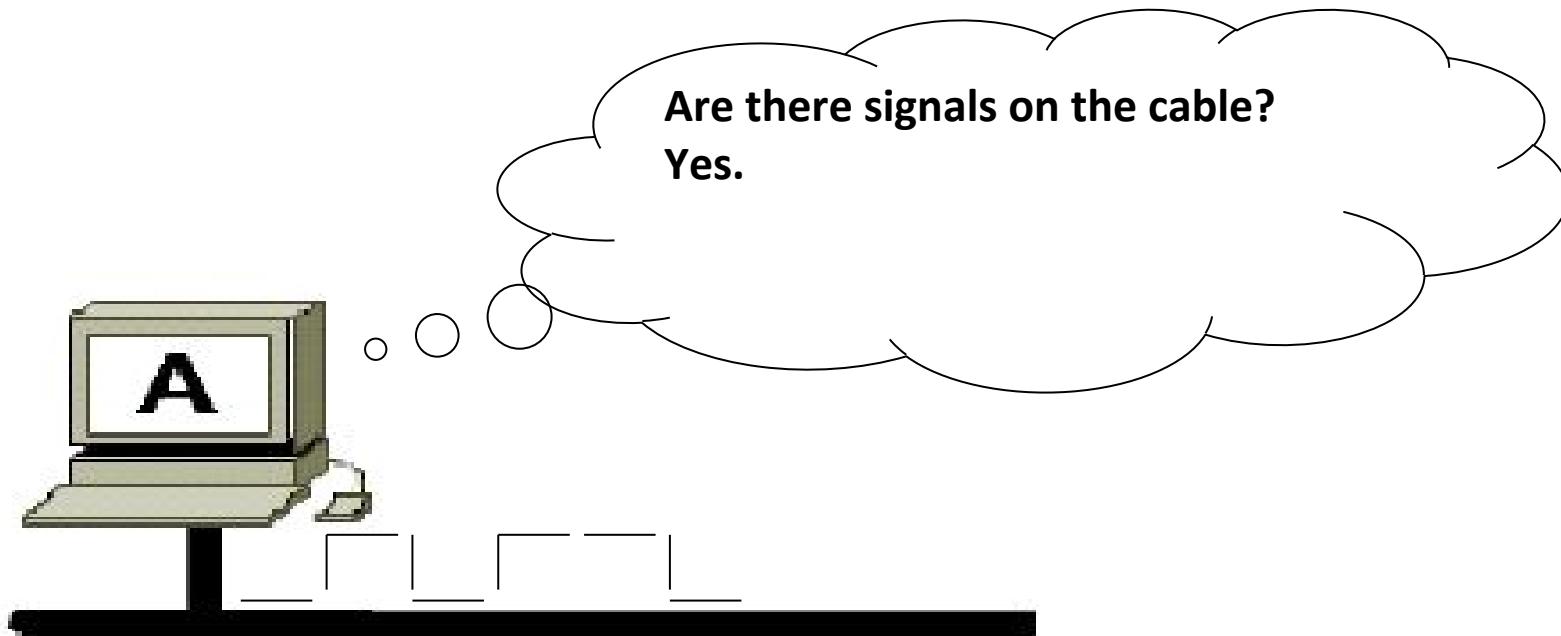
- Only one PC can send



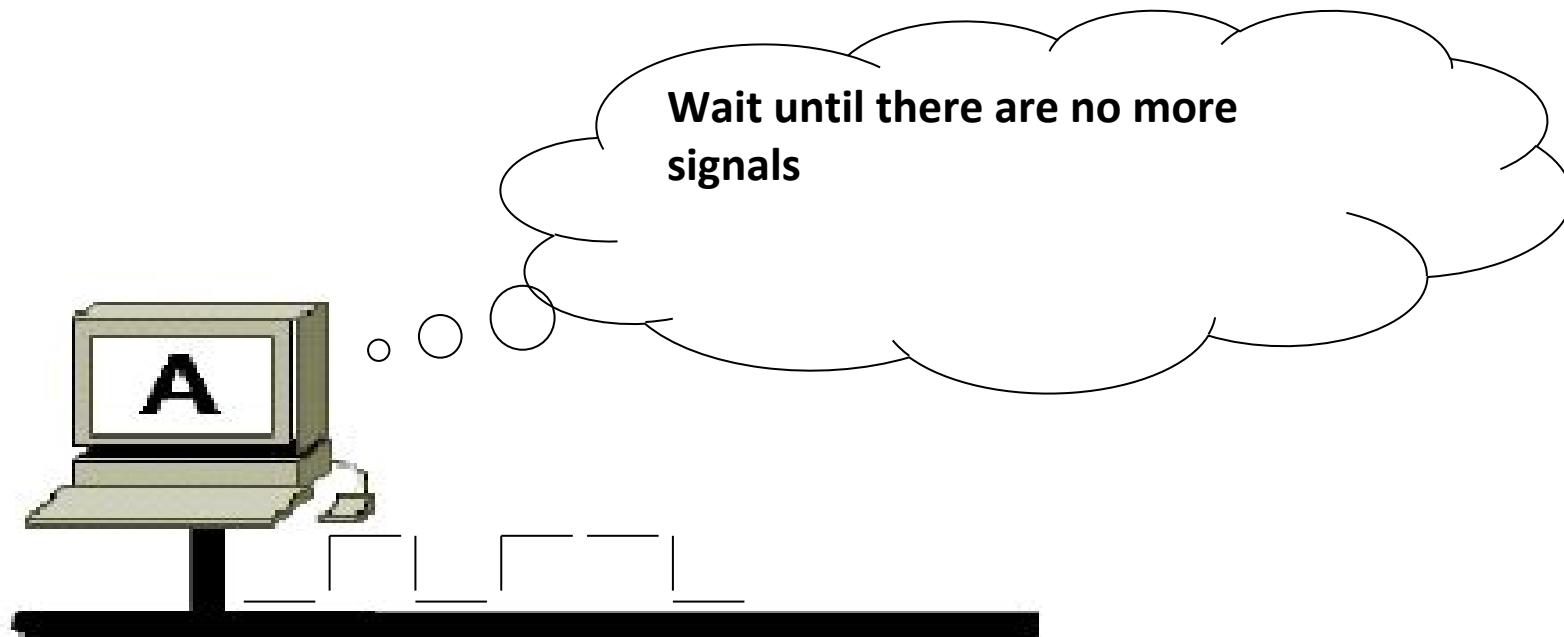
# CSMA/CD

- **Carrier Sense:** ‘Listen’ to see if there are signals on the cable
- **Multiple Access:** Hosts share the same cable and all have access to it
- **Collision Detection:** Detect and manage any collisions of signals when they occur
- This is the ‘first come, first served’ method of letting hosts put signals on the medium

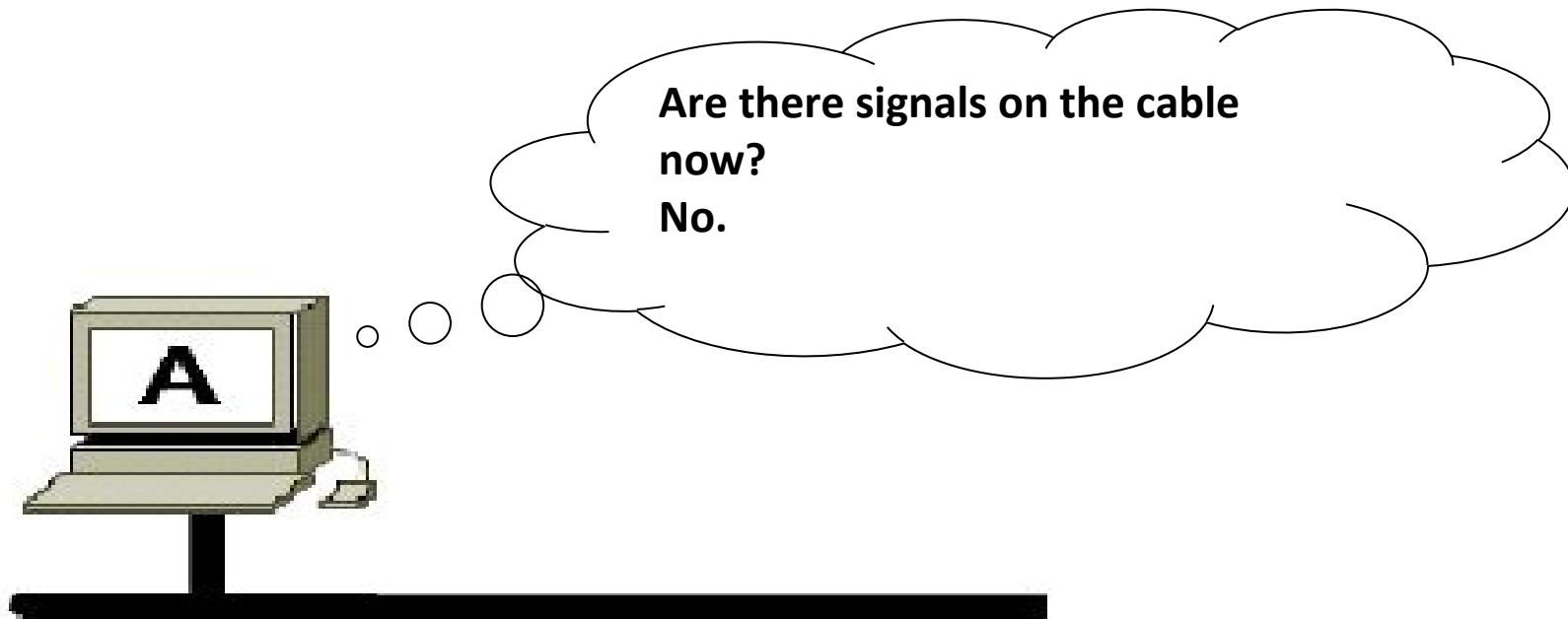
# Listen for signals



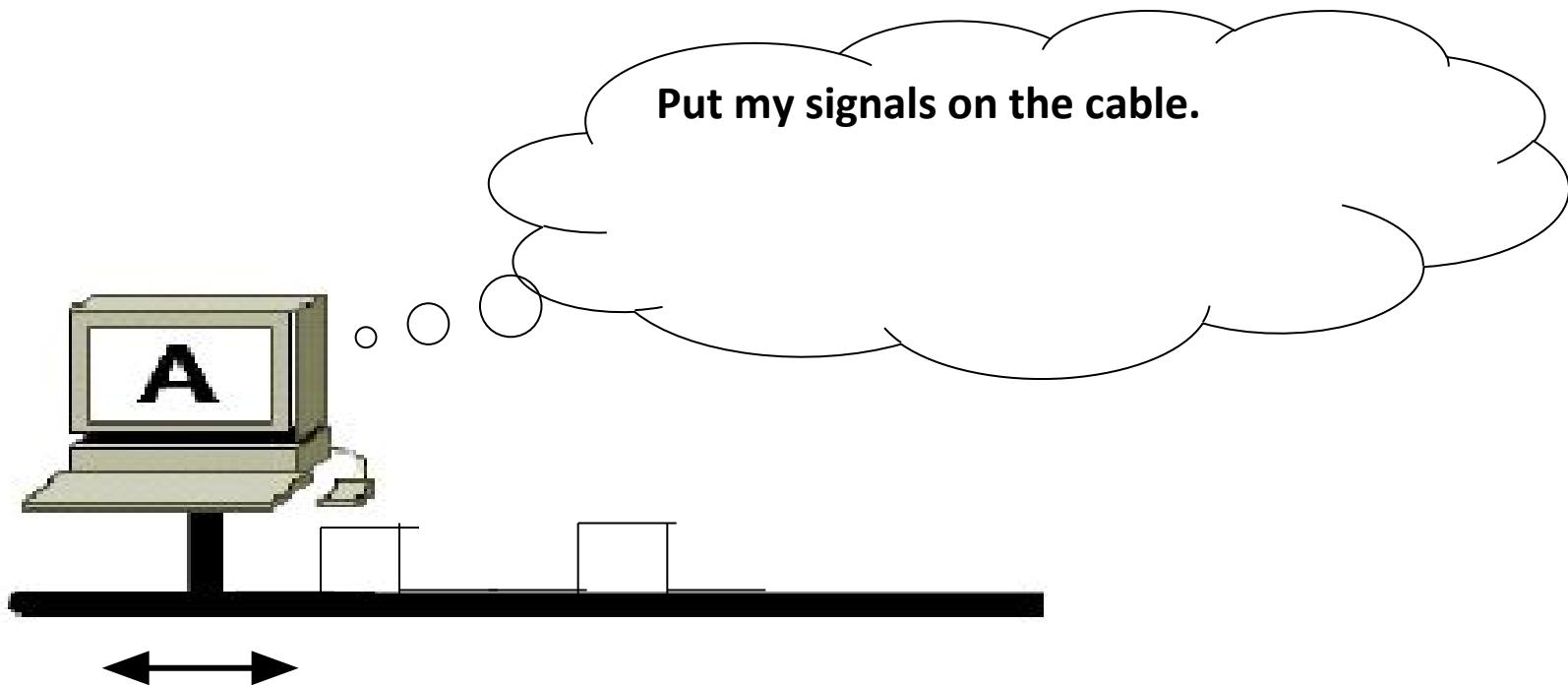
# Wait if there are signals



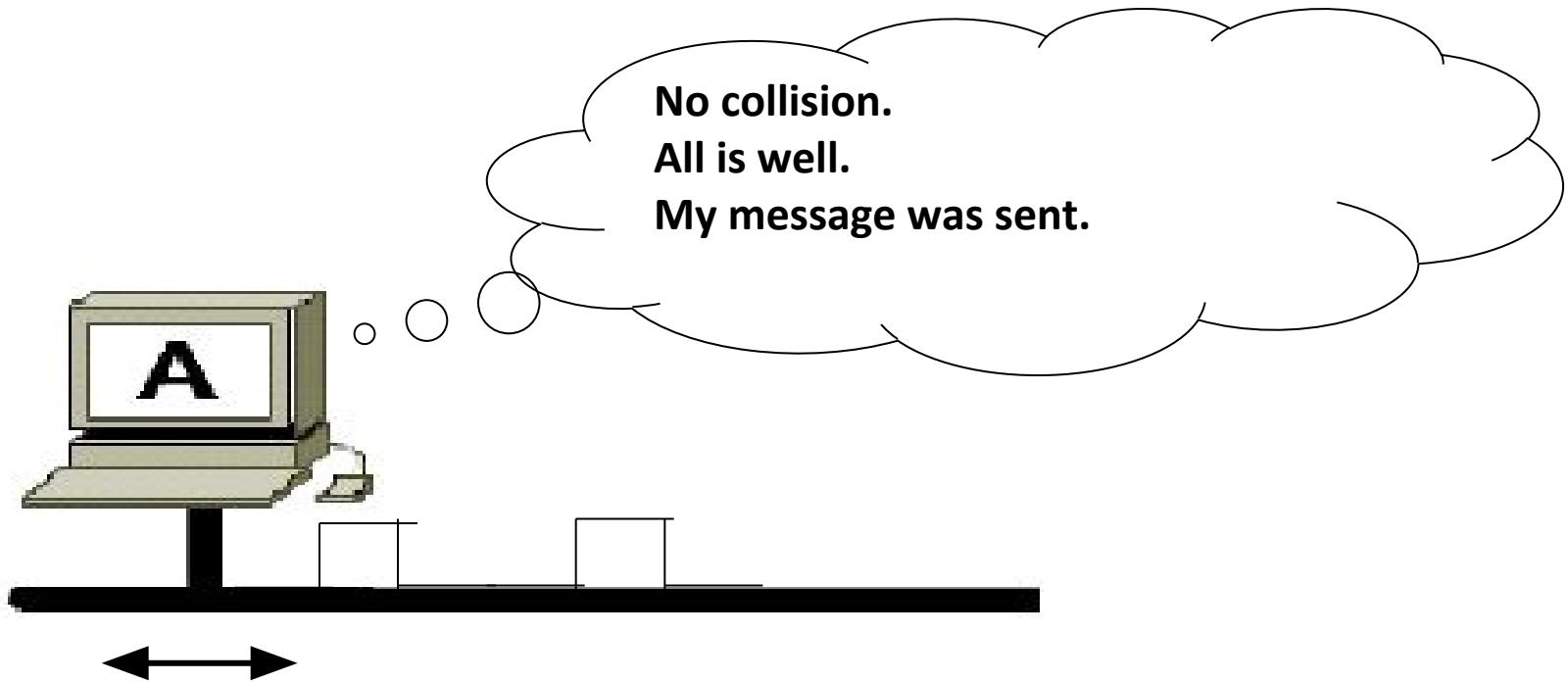
# Listen for signals



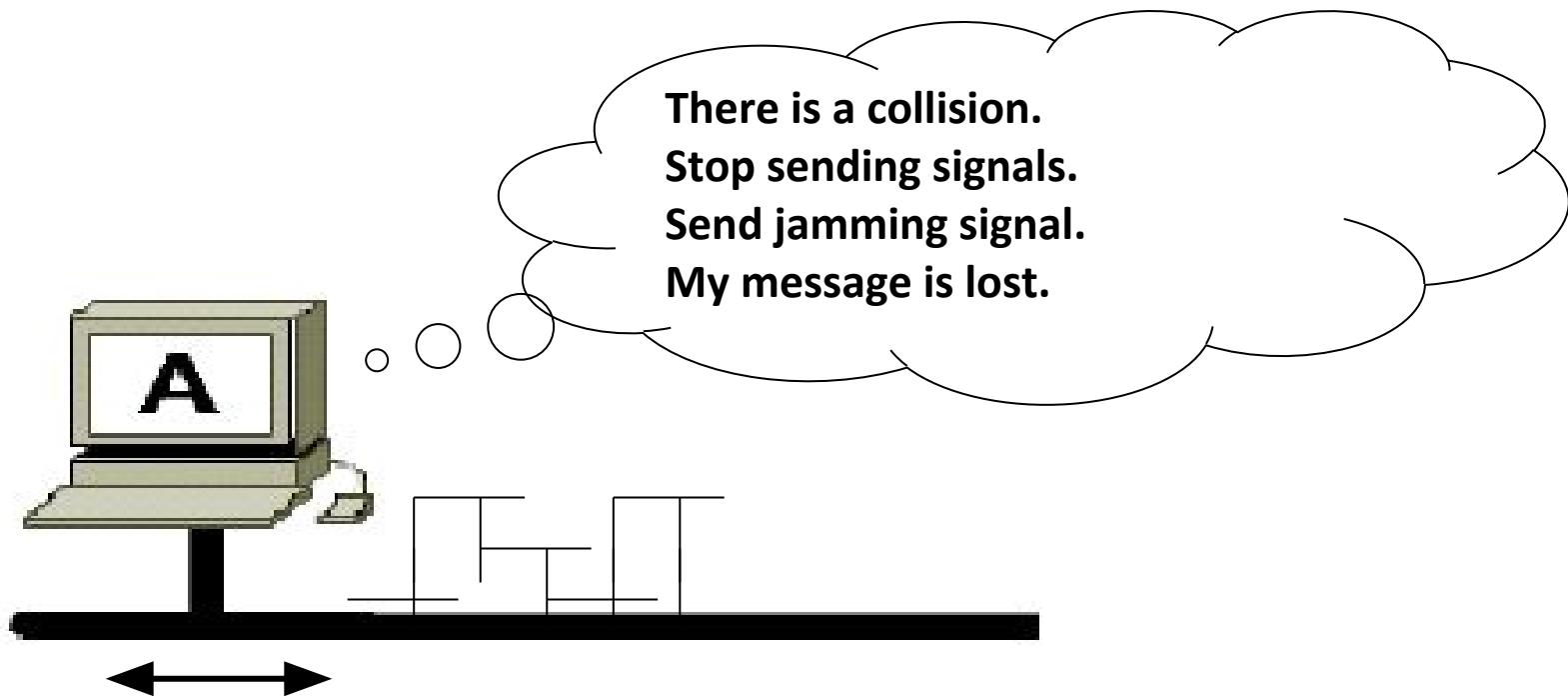
# Put signals on cable



# Listen for collisions: no



# Listen for collisions: yes

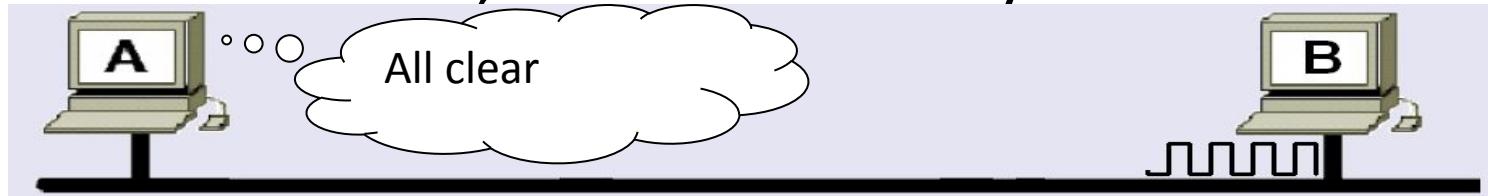


# Listen again



# CSMA/CD

- Collisions happen if a host transmits when there is a signal on the cable but the host does not yet know about it.
- Latency is the time a signal takes to travel to the far end of a cable. The longer the cable and the more intermediate devices, the more latency.



# CSMA/CD

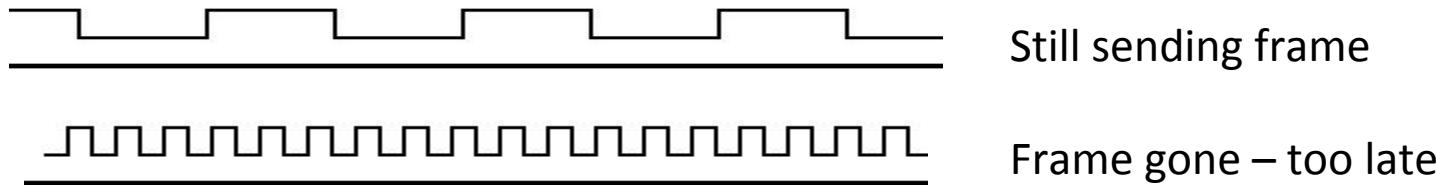
- If a host detects a collision while it is sending the first 64 bits of a frame then CSMA/CD works and the frame will get resent later.
- If the host has sent 64 bits and then detects a collision, it is too late. It will not resend.
- Latency must be small enough so that all collisions are detected in time.
- This limits cable length and the number of intermediate devices.

# Definitions

- Latency or propagation delay: the time it takes for a signal to pass from source to destination.
- Bit time: the time it takes for a device to put one bit on the cable. (Or for the receiving device to read it.)
- Slot time: the time for a signal to travel to the far end of the largest allowed network and return.

# Different bandwidths

- Change from 10 Mbps to 100 Mbps
- The sender puts the bits on the cable 10 times as fast, but they still travel at the same speed along the cable.
- Collision detected at the same time as before.



# So... for CSMA/CD to work

- The greater the bandwidth, the closer a collision must be in order to detect it in time.
- The greater the bandwidth, the shorter the possible cable length from one end of the collision domain to the other.
- 10 Mbps can have reasonable lengths.
- 100 Mbps can just manage 100 metres.
- 1 Gbps needs special arrangements
- 10 Gbps – not a chance. Can't do collisions.

# Get rid of collisions

- Replace all hubs with switches.
- Each device has a private cable and gets the full bandwidth.
- Use full duplex on each link.
- No collisions.
- Can use higher bandwidths.

# Legacy Ethernet

- 10 Base-T – 10 Mbps, uses UTP cables  
Transmits on wires 1/2, Receives on 3/6  
Uses Manchester encoding.
- 10 Base-2 and 10 Base-5 used coaxial cable. They are obsolete and are no longer recognised by the standards.

# Fast Ethernet

- 100 Base-TX – 100 Mbps, uses UTP cables  
Transmits on wires 1/2, Receives on 3/6  
Uses 4B/5B encoding
- 100 Base-FX – 100 Mbps, uses multimode fibre optic cables.

# Gigabit Ethernet

- 1000 base-T – 1Gbps uses UTP cables. Uses all 4 wire pairs, transmitting and receiving at the same time on the same wire.  
Complex encoding and detection system.
- 1000 Base-SX – uses multimode fibre, shorter wavelength.
- 1000 Base-LX – uses single or multimode fibre, longer wavelength.

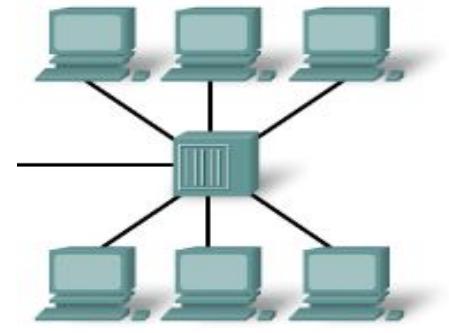
# 10 Gbps Ethernet

- Still evolving
- Potential for operating over longer distances – MANs and WANs
- Still uses same basic frame format as other Ethernet versions.
- Higher bandwidths are planned.

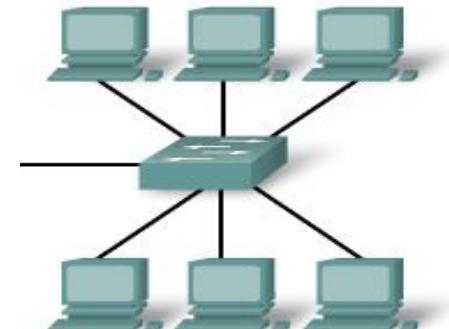
# Hub and Switch

- Shared medium
  - Shared bandwidth
  - Collisions
- 
- Point to point links
  - Dedicated bandwidth
  - Use full duplex – no collisions

Hub



Switch



# Switching table

- Switch builds a switching table matching its port numbers to the MAC addresses of devices connected to them.
- When a frame arrives, it reads the destination MAC address, looks it up in the table, finds the right port and forwards the frame.

SWITCHING TABLE	
PORT	MAC ADDRESS
1	0A
3	0B
6	0C
9	0D

# Flooding

- If the switch does not find the destination address in its table then it floods the frame through all ports except the incoming port.
- Broadcast messages are flooded.

# Learning addresses

- The switch learns addresses by looking at the source MAC address of an incoming frame.
- It then matches the address to the port where the frame came in and puts the information in its table.
- Entries are time stamped and removed from the table when the time runs out.
- They can be refreshed when another frame comes in from the same host.

# ARP table

- A host wants to send a message.
- It knows the destination IP address and puts it in the packet header.
- It looks in its ARP table and finds the corresponding MAC address.
- It puts the MAC address in the frame header.

# Address resolution protocol

- A host wants to send a message.
- It knows the destination IP address.
- The destination MAC address is not in its ARP table.
- Host broadcasts “Calling 192.168.1.7, what is your MAC address?”
- 192.168.1.7 replies “My MAC address is...”
- Host sends message and updates ARP table.