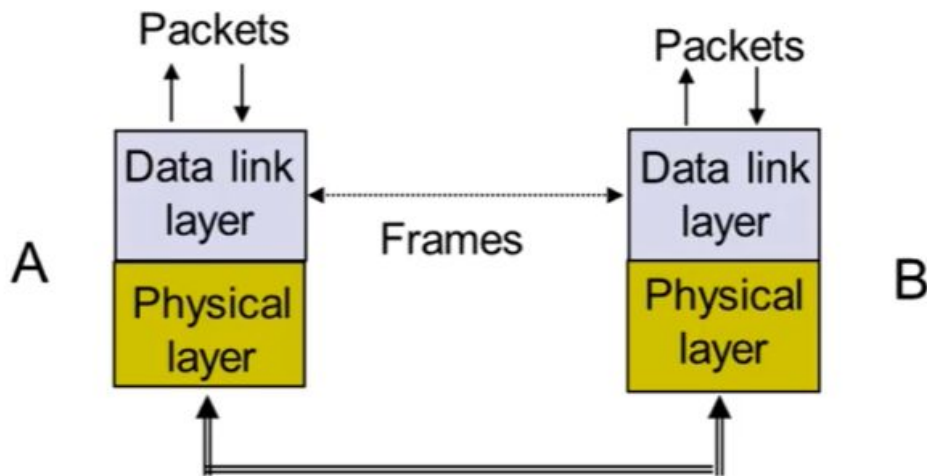


MAC Address
MAC地址

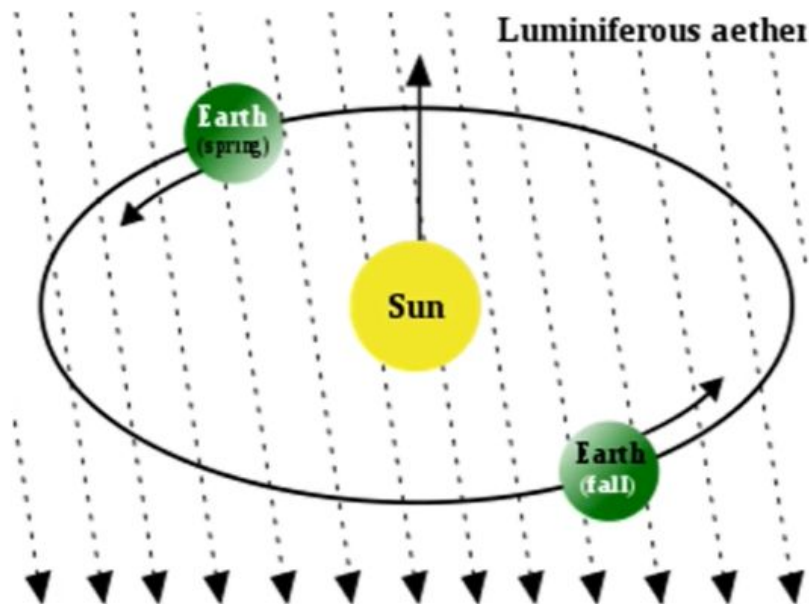
Data link Layer Protocol 数据链路层协议



- Ethernet
- PPP
- HDLC
- IEEE 802.11 (Wi-Fi)
- Token Ring

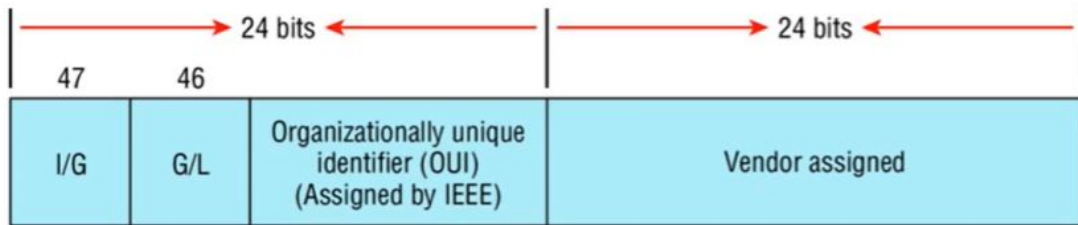
Ethernet 以太网

- The new protocol is medium independent, the physical medium (ie., a cable) carries bits to all stations 这个协议是独立于介质的，即物理介质(电缆)将比特传送到所有站
- Ether, or Luminiferous Ether, was once thought to propagate electromagnetic waves through space. It was proposed by the greek philosopher Aritstotle. 以太，或发光的以太，曾经被认为是通过空间传播电磁波。它是由希腊哲学家 亚里士多德(Aritstotle)提出的。



Ethernet Addressing 以太网寻址

- Ethernet at the Data Link layer is responsible for Ethernet addressing, commonly referred to as MAC or hardware addressing. It's used to find hosts on a local network. 数据链路层的以太网负责以太网寻址, 通常称为MAC或硬件寻址。它用于在本地网络上查找主机。
- It uses the Media Access Control (MAC) address burned into each and every Ethernet network interface card (NIC). 它使用媒体访问控制地址, 而媒体访问控制(MAC)地址已烧录进每个以太网网络接口卡(NIC)。
- The MAC, or hardware, address is a 48-bit (6-byte) address written in a hexadecimal format. MAC地址或硬件地址是以十六进制格式记录的48比特地址(6字节)。



Example: 0000.0c12.3456



- The organisationally unique identifier (OUI) is assigned by the IEEE to an organisation that's supposedly unique to each and every adapter an organisation manufactures. IEEE会将“组织唯一标识符(OUI)”分配给某一组织, OUI对于每一个组织制造的每个适配器都是唯一的。
- Individual/Group (I/G) bit. When it has a value of 0, we can assume that the address is the MAC address of a device. When it's a 1, we can assume that the address represents either a broadcast or multicast address in Ethernet. 个人/组(I / G)位。当其值为0时, 我们可以假定该地址是设备的MAC地址。如果为1, 我们可以假设该地址代表以太网中的广播或多播地址。
- Global/Local bit (G/L) bit. When set to 0, this bit represents a globally administered address, as assigned by the IEEE, but when it's a 1, it represents a locally governed and administered address. 全局/本地位(G / L)位。设置为0时, 该位代表IEEE分配的全局管理地址, 但是当它为1时, 则代表本地管理和地址。

MAC Address MAC地址

Command Prompt

```
C:\Users\Aseem>ipconfig /all
```

Windows IP Configuration

```
Host Name . . . . . : AseemVostro
Primary Dns Suffix . . . . . :
Node Type . . . . . : Hybrid
IP Routing Enabled. . . . . : No
WINS Proxy Enabled. . . . . : No
DNS Suffix Search List. . . . . : fios-router.home
```

Ethernet adapter Ethernet:

```
Connection-specific DNS Suffix . : fios-router.home
Description . . . . . : Realtek PCIe GBE Family Controller
Physical Address. . . . . : 64-00-6A-02-2F-0E
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
Link-local IPv6 Address . . . . . : fe80::257e:9cae:15eb:1922%10(Preferred)
IPv4 Address. . . . . : 192.168.1.233(Preferred)
Subnet Mask . . . . . : 255.255.255.0
Lease Obtained. . . . . : Wednesday, October 11, 2017 9:31:56 PM
Lease Expires . . . . . : Wednesday, October 18, 2017 9:31:56 AM
Default Gateway . . . . . : 192.168.1.1
```

MAC Address Finder

MAC address or vendor:

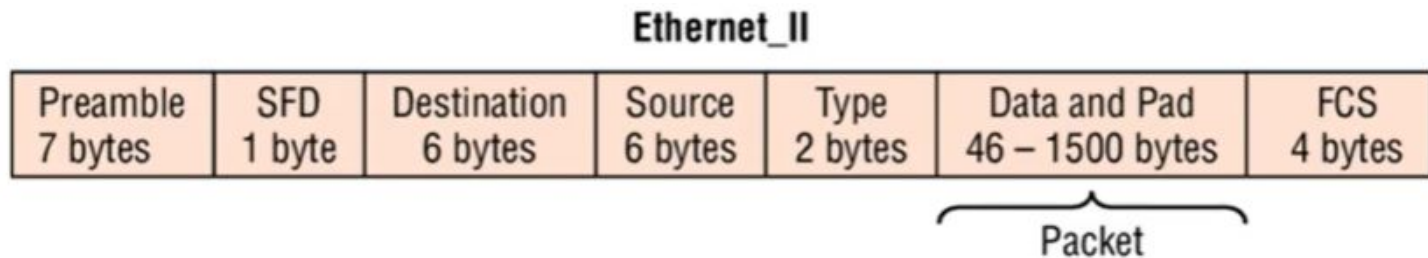
Enter first 6 characters or full MAC address. Or search by Vendor name, e.g. cisco or apple

Database updated - October 29, 2017

Search results for "64006A"

MAC	Vendor
64006A	Dell Inc.

Ethernet Frame Format 以太网格式

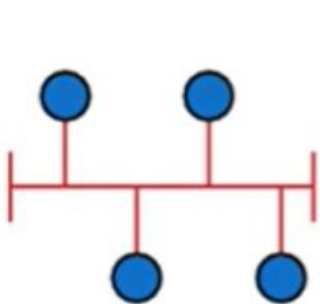


- Type: Ethernet_II frame uses a Type field to identify the Network layer protocol 类型
:Ethernet_II帧使用“类型”字段来标识网络层协议
 - 0x0800 IPv4
 - 0x0842 Wake-on-LAN 中文多译为“网络唤醒”、“远程唤醒”技术
 - 0x86DD IPv6
 - 0x8906 FCoE (Fibre Channel over Ethernet) 以太网光纤通道标准
- FCE: is a field at the end of the frame that's used to store the cyclic redundancy check (CRC) answer. The CRC is a mathematical algorithm that's run when each frame is built based on the data in the frame. When a receiving host receives the frame and runs the CRC, the answer should be the same. If not, the frame is discarded, assuming errors have occurred. FCE: 是帧末尾的字段, 用于存储循环冗余校验(CRC)答案。CRC是一种数学算法, 会在构建每个框架时根据框架中的数据来运行。当接收主机接收到该帧, 并运行CRC时, 答案应该相同。如果不是, 则假定此时已发生错误, 从而丢弃该帧。

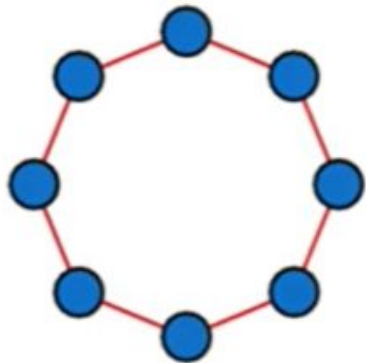
Physical Layer 物理层

Physical Topology 物理拓扑

- Physical layout of devices and cabling. 设备和电缆的物理布局。



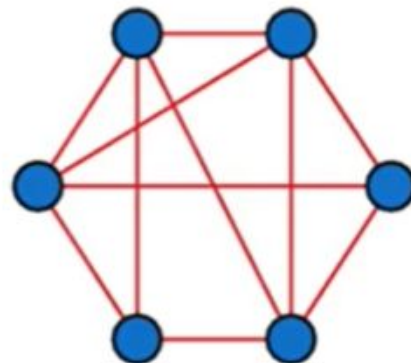
Bus Topology
总线拓扑



Ring Topology
环状拓扑



Star Topology
星型拓扑



Mesh Topology
网状拓扑

Network Cabling 网络线缆

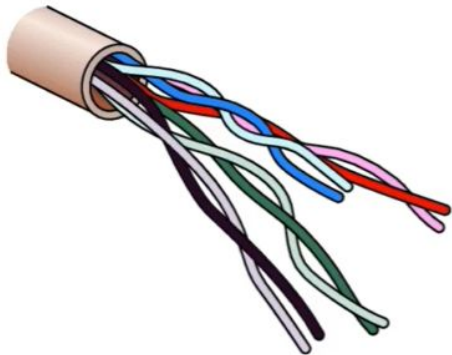
- Coaxial Cables 同轴线
- Twisted Pair Cables 双绞线
 - UTP
 - STP
- Fibre Optics 光纤
- USB Cables USB线
- Serial and Parallel Cables 串行&并行线



Ethernet Cabling 以太网线缆

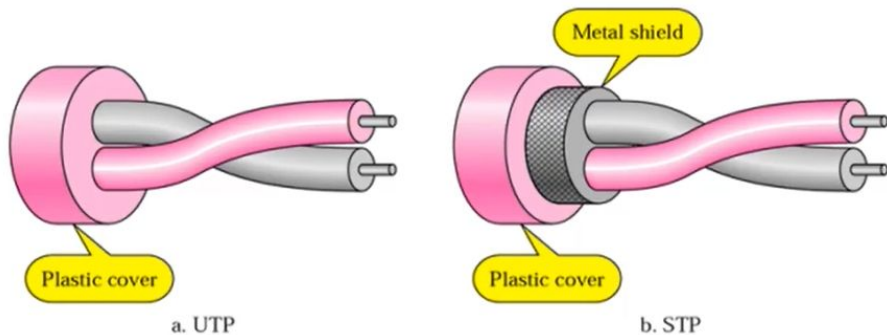


- Ethernet protocol can run on Copper or Fibre Optic cable 以太网协议可以在铜缆或光纤电缆上运行
- Ethernet cable most likely refer to Twisted Pair Copper cable 以太网电缆最有可能是指双绞铜线



Twisted Pair Cable 双绞线

- Twisted pair 双绞线
 - Twisted pair eventually emerged during the 1990s as the leading cabling standard for Ethernet, starting with 10 Mbps
- Unshielded Twisted Pair (UTP) 非屏蔽双绞线
 - have no protection against external interference 没有抵抗外部干扰的保护措施
- Shielded Twisted Pair (STP) 屏蔽双绞线
 - have additional shielding material that is used to cancel any external interference 具有用于消除任何外部干扰的附加屏蔽材料



Modern Ethernet cables use UTP wiring due to its lower cost, while STP cabling can be found in some other types of networks such as Fibre Distributed Data Interface (FDDI) 现代以太网电缆由于成本较低的原因多使用UTP布线, 而STP布线可在某些其他类型的网络中找到, 例如光纤分布式数据接口(FDDI)

UTP Categories

- Choose correct cable and network interface 选择正确的电缆和网络接口

UTP Categories - Copper Cable

UPT CATEGORY	DATA RATE	MAX. LENGTH	CABLE TYPE	APPLICATION
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Ring & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10 Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10 Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

UTP Connector UTP连接器

- Jack & Plug 插孔和插头



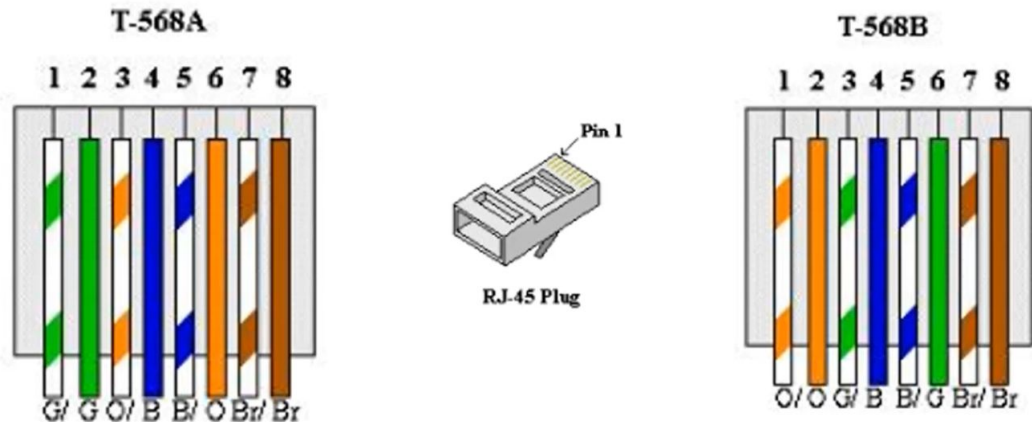
RJ45 Plug



RJ45 Jack

RJ-45 wiring standards: T568A and T568B

- T568A (also called EIA)
- T568B (also called AT&T and 258A) - most widely chosen 被使用最广泛

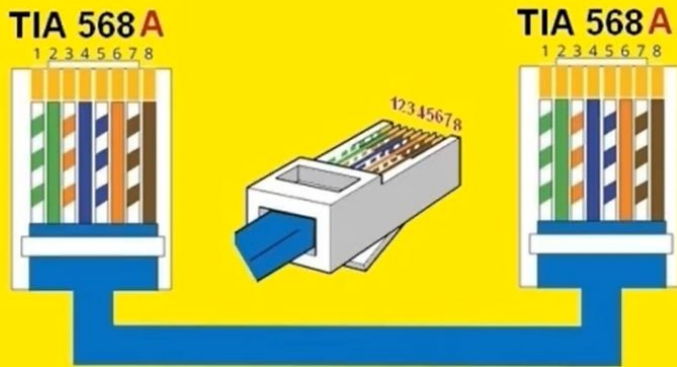


T568A and T568B are the two colour codes used for wiring eight-position RJ45 modular plugs. The only difference between the two colour codes is that the orange and green pairs are interchanged. T568A和T568B是用于连接八位RJ45模块化插头的两种颜色编码。两种颜色编码之间的唯一区别是橙色和绿色对互换了。

Straight-Through Cable 直连线

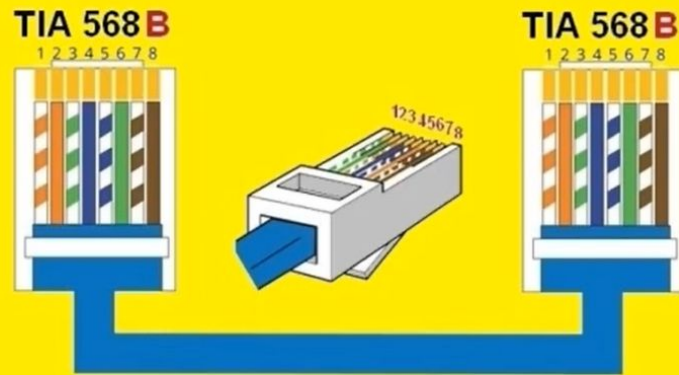
- Host to Switch 主机到交换机
- Router to Switch 路由器到交换机
- Host to Router 主机到路由器

Straight cable TIA 568 A



WiringDiagram21.com

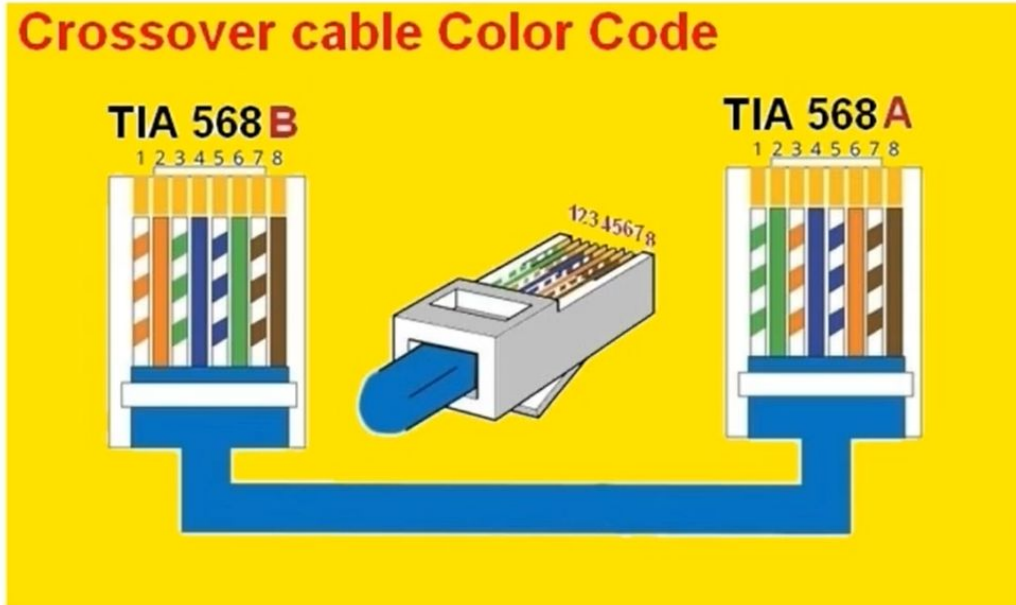
Straight Cable Color code TIA 568B



WiringDiagram21.com

Crossover Cable 交叉线

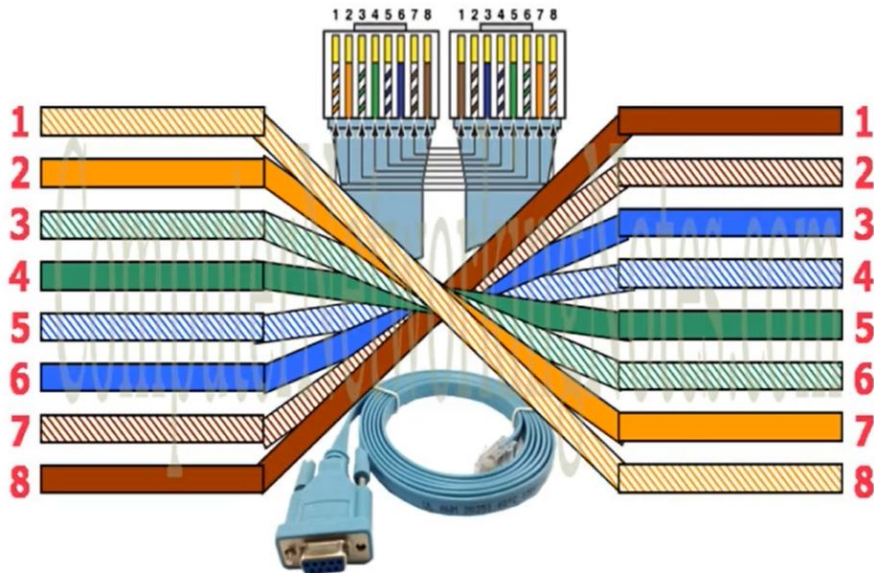
- Host to Host 主机到主机
- Switch to Switch 交换机到交换机
- Router to Router 路由器到路由器



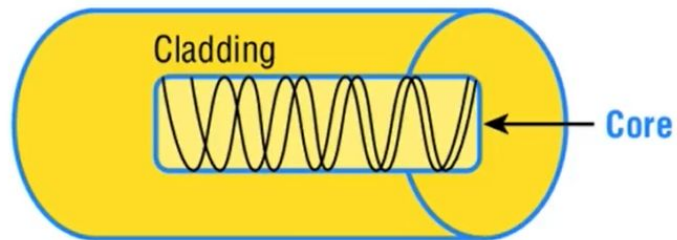
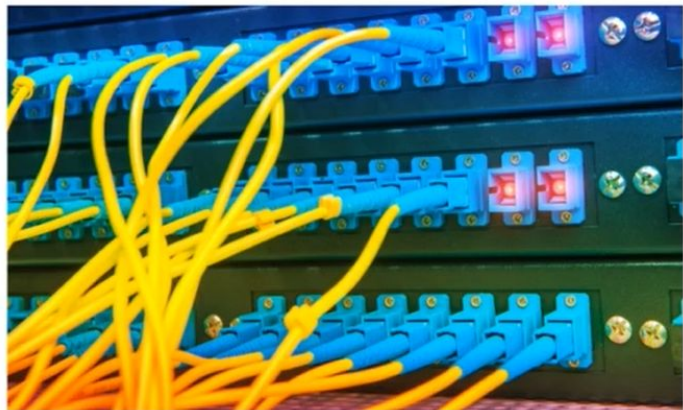
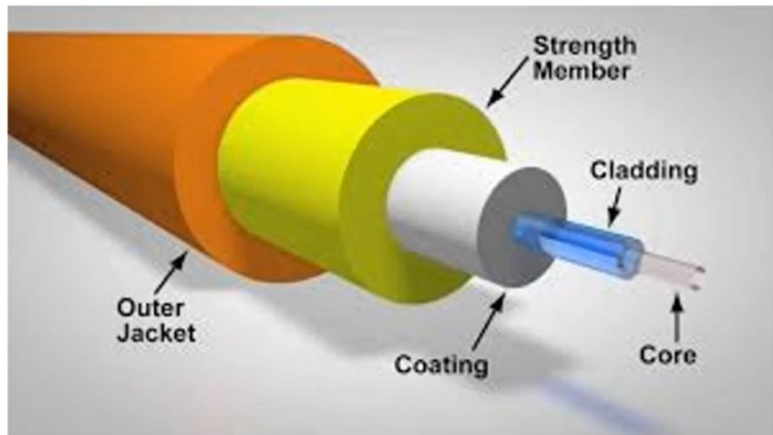
Automatic Medium-Dependent Interface Crossover (Auto-MDIX): 自动介质相关接口切换 (Auto-MDIX) :
You can use straight through to connect same devices as well as different devices and same hold true to cross over cable 您可以使用直通来连接相同的设备以及不同的设备, 并且同样适用于交叉电缆

Rolled Cable 翻转电缆

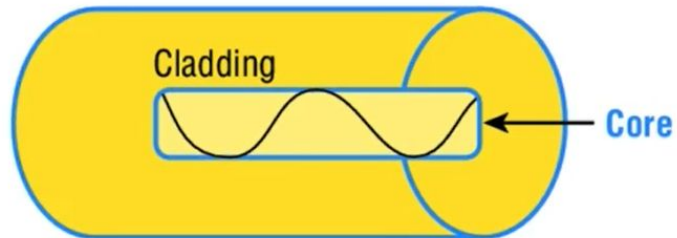
- Although rolled cable isn't used to connect any Ethernet connections together, you can use a rolled Ethernet cable to connect a host RS232 interface to a router console serial communication (COM) port 尽管不使用翻转电缆进行任何的以太网连接, 但是您可以使用绞线将主机RS232接口连接到路由器控制台串行通信 (COM) 端口
- Cut the end off on one side of a straight-through cable, turn it over, and put it back on with a new connector 切断直通电缆一侧的一端, 将其翻转, 然后使用新的连接器重新装回



Fibre Optic 光纤



Multimode fiber



Single-mode fiber

Single-mode is more expensive, has a tighter cladding, and can go much farther distances than multimode. 单模的价格更高，覆层更紧密，并且比多模的距离更远。

OM (Optical Multimode) 光学多模

- ISO/IEC 11801 standard includes the prefix “OM” ISO / IEC 11801标准里有“ OM”这个前缀
- OM1 cable typically comes with an orange jacket and has a core size of 62.5 micrometers(μm). It can support 10 Gigabit Ethernet at lengths up to 33 meters. It is most commonly used for 100 Megabit Ethernet applications. OM1电缆通常带有橙色护套, 芯线尺寸为62.5微米(μm)。它可以支持10 Gb以太网, 最长可达33米。它最常用于100兆以太网应用。
- OM2 also has a suggested jacket color of orange. Its core size is 50 μm instead of 62.5 μm . It supports 10 Gigabit Ethernet at lengths up to 82 meters but is more commonly used for 1 Gigabit Ethernet applications. OM2的建议外套颜色也为橙色。其核心尺寸为50 μm , 而不是62.5 μm 。它支持长度达82米的10 Gb以太网, 但更常用于1 Gb以太网应用。
- Both OM1 and OM2 work well with LED based equipment that can send hundreds of modes of light down the cable. OM1和OM2都可以与基于LED的设备一起使用, 该设备可以沿电缆发送数百种模式的光。
- OM3 has a suggested jacket color of aqua. Like OM2, its core size is 50 μm , but the cable is optimized for laser based equipment that uses fewer modes of light. As a result of this optimization, it is capable of running 10 Gigabit Ethernet at lengths up to 300 meters. Since its inception, production techniques have improved the overall capabilities of OM3 to enable its use with 40 Gigabit and 100 Gigabit Ethernet up to 100 meters. 10 Gigabit Ethernet is its most common use. OM3的建议外套颜色为水蓝色。与OM2一样, 其芯尺寸为50 μm , 但该电缆针对使用较少光模的基于激光的设备进行了优化。作为优化的结果, 它能够运行长达300米的10 Gb以太网。自成立以来, 生产技术提高了OM3的整体性能, 使得它能用于40Gb和100Gb以太网, 最长达100米。10Gb以太网是其最广泛的使用。
- OM4 also has a suggested jacket color of aqua. It is a further improvement to OM3. It too uses a 50 μm core but it supports 10 Gigabit Ethernet at lengths up to 550 meters and it supports 100 Gigabit Ethernet at lengths up to 150 meters. OM4也是使用建议的水蓝色的外套颜色。它是对OM3的进一步改进。它也使用了50 μm 的内核, 但是它支持10Gb以太网(最长550米), 并且支持100Gb以太网(最长150米)。

多模光纤 OM

Fiber Type	1000BASE-SX (distance/loss)	10GBASE-SR (distance/loss)	40/100GBASE-SR4 (distance/loss)
OM1	275 m / 2.6 dB	33 m 2.4 dB	Not specified
OM2	550 m / 3.56 dB	82 m / 2.3 dB	Not specified
OM3	Not specified	300 m / 2.6 dB	100 m / 1.9 dB
OM4	Not specified	400 m / 2.9 dB	150 m / 1.5 dB
OM5	Not specified	400 m / 2.9 dB	150 m / 1.5 dB

Fiber Connector

- There are about 70 different connectors for fiber. 光纤有大约70种不同的连接器。



SC and LC



SC Connector



LC Connector

Name	Mating Cycles	Ferrule Size	Typical Insertion Loss(dB)	IEC Specification	Cost	Ease of use	Application Features
SC	1000	Ø 2.5mm Ceramic	0.25 - 0.5	61754-4	\$\$	●●●●●	Mainstream, Reliable, Fast deployment, Field fit
LC	500	Ø 1.25mm Ceramic	0.25 - 0.5	61754-20	\$\$	●●●●○	High density, Cost effective, Field fit

SFP Transceiver SFP收发器



- The small form-factor pluggable (SFP) is a compact, hot-pluggable optical module transceiver 小型可插拔(SFP)是一款紧凑的可热插拔光模块收发器
 - SFP for 1 Gbit/s
 - SFP+ for 10 Gbit/s
 - 1000BASE-T for RJ-45
 - etc

Transceiver Code 收发器编码

- SR stands for Short Reach (10GBase-SR) SR代表短距离(10GBase-SR)
 - Almost always multi-mode 几乎总是多模
 - OM3 and OM4 formats can push that into the hundreds of meters for a single cable OM3和OM4格式, 可达数百米
- LR stands for Long Reach (10GBase-LR) LR代表长距离(10GBase-LR)
 - Either multi-mode or single-mode 多模或单模
 - Long-range communications, such as wiring buildings together on a large campus or even setting up a Metro Area Network(MAN) 远程通信, 例如在大型校园中将建筑物布线在一起, 甚至建立城域网(MAN)
- LRM stands for Long Reach Multimode (10GBase-LRM) LRM代表远程多模(10GBase-LRM)
 - used for long-distance multi-point mode of connection 用于长距离多点连接模式
 - Support distance up to 220 over multi-mode fiber and use 1310nm lasers 在多模光纤上支持的最大距离为220, 并使用1310nm激光器
- ER stands for Extended Reach (10GBase-ER) ER代表延伸范围(10GBase-ER)
 - Support distance up to 40km over single mode fiber and use 1550nm lasers 在单模光纤上支持的距离可达40km, 并使用1550nm激光器
- ZR also stands for Extended Reach (10GBase-ZR) ZR也代表延伸范围(10GBase-ZR)
 - Transmit 10G data rate and 80km distance over single mode fiber and use 1550nm lasers 通过单模光纤传输10G数据速率和80km距离, 并使用1550nm激光器
- BX stands for Single Fiber Bi-Directional (GLC-BX-10U/D) BX代表单光纤双向(GLC-BX-10U / D)
 - Transmit and receive data to/from interconnected equipment through a single optical fiber 通过单根光纤向/从互连设备发送/接收数据
- Minimum cabling distance for -SR, -LRM, -LR, -ER modules is 2m, according to the IEEE 802.3ae 根据IEEE 802.3ae, -SR, -LRM, -LR, -ER模块的最小布线距离为2m

Simplex vs Half Duplex vs Full Duplex 单工vs半双工vs全双工

- Simplex 单工

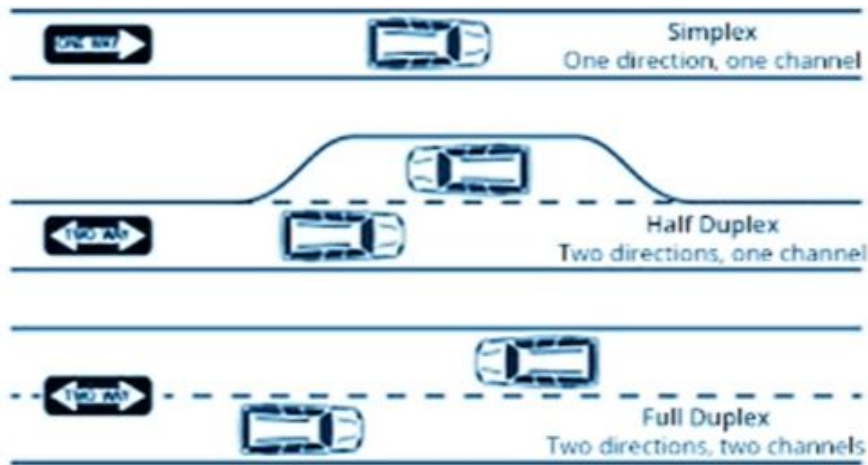
- Signals can flow in only one direction at a time 信号一次只能沿一个方向流动
- One end is the transmitter, while the other is the receiver and that is not reversible. 一端是发送器, 另一端是接收器, 并且不可逆。

- Half Duplex 半双工

- Data can be transmitted in both directions on a signal carrier but not simultaneously. 数据可以在信号载体上双向传输, 但不能同时传输。
- One end is the transmitter, while the other end is the receiver and may be reversible. 一端是发送器, 另一端是接收器, 并且可能是可逆的。

- Full Duplex 全双工

- Full duplex is two-way communication achieved over a physical link that has the ability to communicate in both directions simultaneously. 全双工是通过物理链路实现的双向通信, 该链路具有双向同步通信的能力。



Simplex&Duplex Fiber Optic Cables 单工和双工光纤电缆

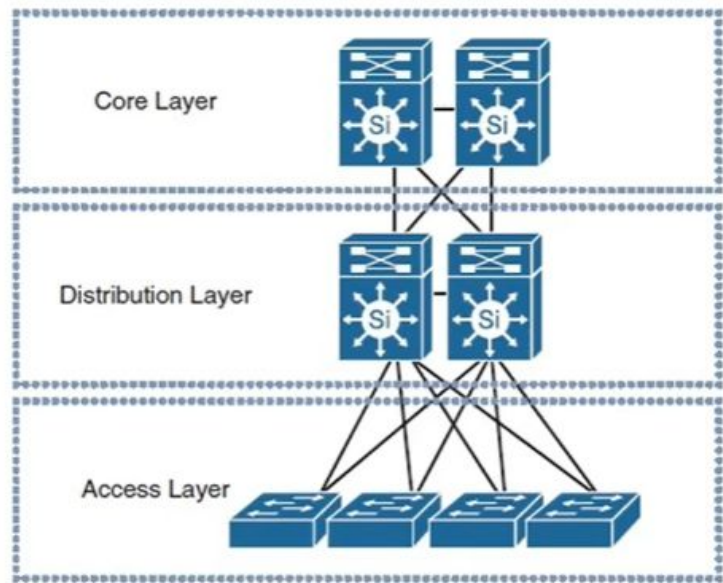


Network Architecture - LAN

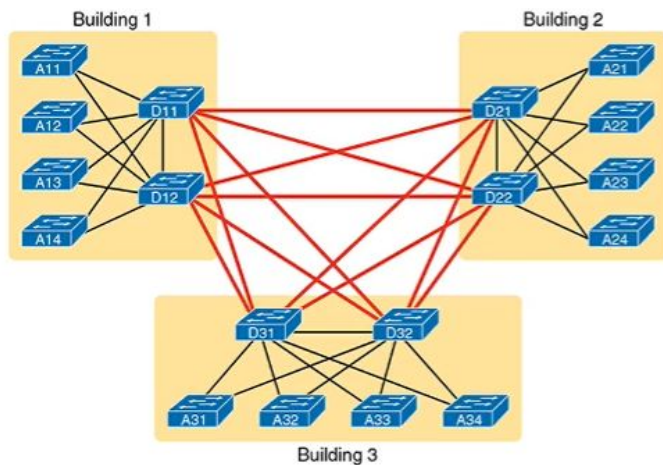
网络架构 - 局域网

Core 核心层, Distribution 汇聚层(Aggregation) & Access 接入层

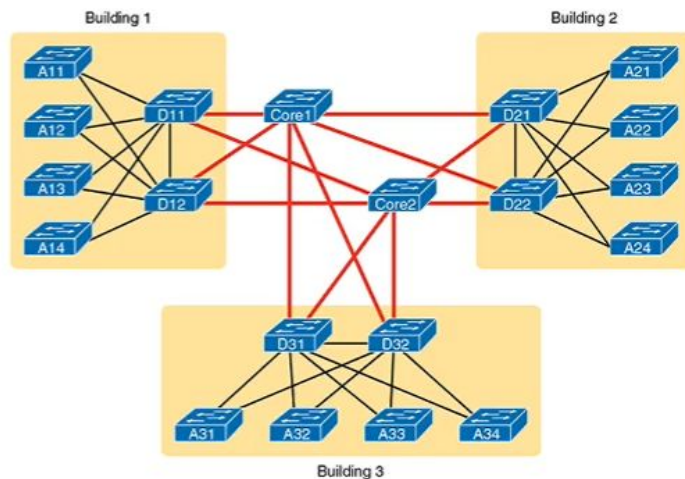
- **Core:** Aggregates distribution switches in very large campus LANs, providing very high forwarding rates for the larger volume of traffic due to the size of the network. 核心层: 在非常大的园区LAN中汇聚交换机, 由于网络的规模, 可以为大量流量提供很高的转发速率。
- **Distribution:** Provides an aggregation point for access switches, providing connectivity to the rest of the devices in the LAN, forwarding frames between switches, but not connecting directly to end-user devices. 汇聚层: 为接入交换机提供汇聚点, 提供与LAN中其余设备的连接, 在交换机之间转发帧, 但不直接连接到最终用户设备。
- **Access:** Provides a connection point (access) for end-user devices. Does not forward frames between two other access switches under normal circumstances. 接入层: 为最终用户设备提供连接点(访问)。通常情况下, 不会在其他两个交换机之间转发帧。



Three-Tier Campus Design (Core) 3层的园区架构



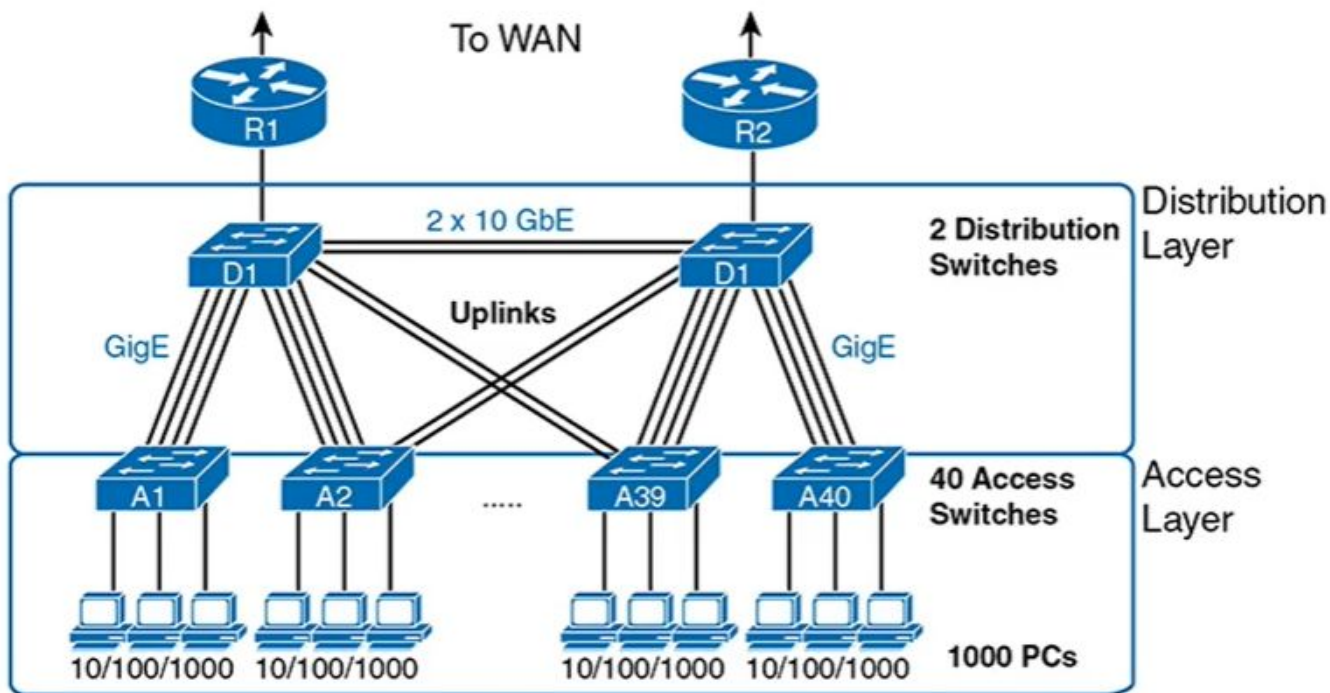
Without Core Layer



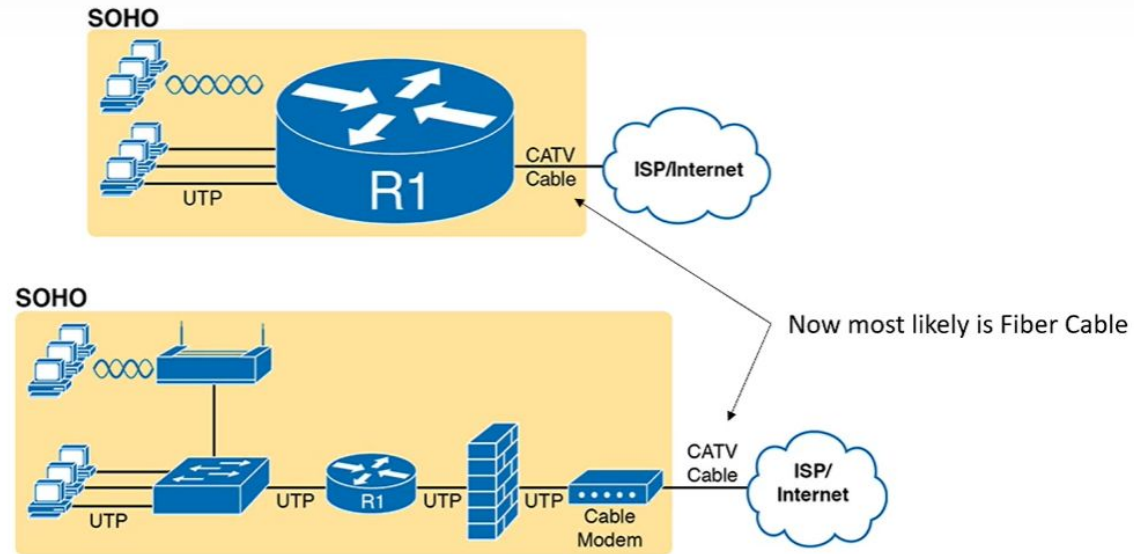
With Core Layer

- A full mesh would consume 15 links 全冗余实现需要15个连接
 - $N(N-1) / 2$
- 30 switch ports - two per link 每条线缆占用2个交换机的端口

Two-Tier Campus Design (Collapsed Core) 2层的园区架构



Small Office / Home Office (SOHO)



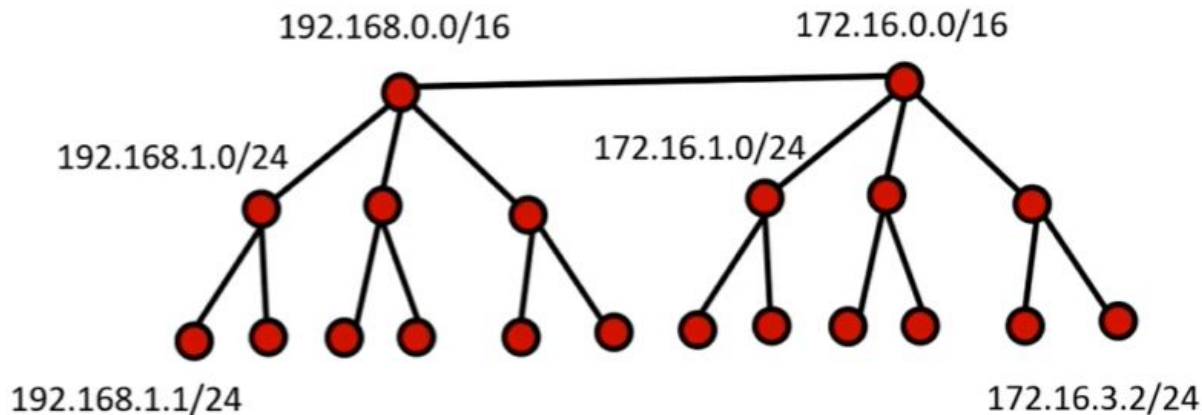
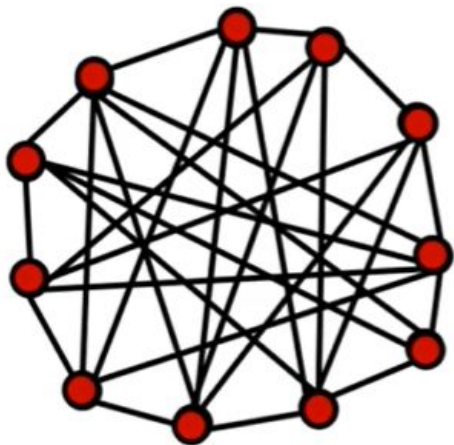
CATV = Cable Television (use Coaxial Cable for data transmission)

IP Address

IP地址

Hierarchical IP Addressing 分层IP寻址

- MAC address is flat or non-hierarchical scheme. **MAC地址是平的或非分层方案。**
- If every address were unique, all routers on the internet would need to store the address of each and every machine on the internet. **如果每个地址都是唯一的，则Internet上的所有路由器都需要存储Internet上每台计算机的地址。**
- The solution to this problem is to use a two- or three-level hierarchical addressing scheme that is structured by network and host. **解决此问题的方法是使用由网络和主机构成的两级或三级分层寻址方案。**



IP Address Class

- IP address consists of 32 bits of information. IP地址包含32位信息。
 - 172.16.30.56 (10101100.00010000.00011110.001110000)
- IP Address = Network Address + Node (Host) Address IP地址=网络地址+节点(主机)地址
 - uniquely identifies, each network 唯一地标识每个网络
 - uniquely identifies, each machine on a network 唯一地标识网络上的每台计算机
- The designers of the Internet decided to create classes of networks based on network size. 互联网的设计者决定根据网络大小来创建不同的网络类别。

	8 bits	8 bits	8 bits	8 bits
Class A:	Network	Host	Host	Host
Class B:	Network	Network	Host	Host
Class C:	Network	Network	Network	Host
Class D:	Multicast			
Class E:	Research			

Identify the Class

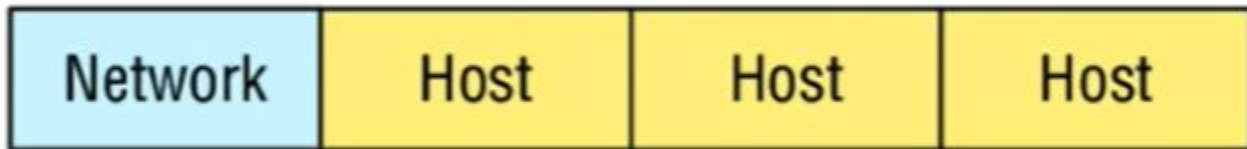
- How does a router know the IP belongs to which class? - through **Leading Bit** (below in red) 路由器如何知道IP属于哪一类？ -通过前面几位(下方红色的)

Class	Range	First Octet	Remark
A	1.0.0.1 to 126.255.255.254	0 0000000 = 0* 0 1111111 = 127*	0 reserved for special purpose 127 reserved for loopback IP
B	128.1.0.1 to 191.255.255.254	10 000000 = 128 10 111111 = 191	
C	192.0.1.1 to 223.255.254.254	110 00000 = 192 110 11111 = 223	
D (Multicast)		1110 0000 = 224 1110 1111 = 239	
E (Research)		1111 0000 = 240 1111 1111 = 255*	255 reserved for broadcast

Class A

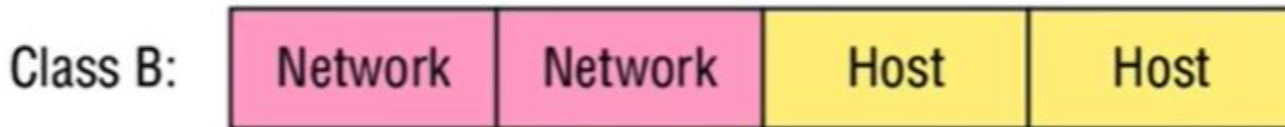
- The maximum number of Class A networks that can be created is 128 ($2^7 = 128$) - why not 2^8 ? 最多可以创建128个A类网段($2^7 = 128$))-为什么不是 2^8 个?
 - 8 bits in first Octet 前八个比特是网络位
 - 1 bit in first Octet been used as Leading Bit 这8个比特中的第一个比特被用作前导位
 - 7 (8-1) bits available for you to create network segment 剩下7位用来创建网段
- The maximum number of hosts in Class A network is 2147483648 (because $128 * (2^{24} - 2)$) A类网络中的最大主机数为2147483648(因为 $128 * (2^{24} - 2)$)
 - There are 128 networks in Class A 网络段中有128个网络
 - Each network has 2^{24} IP address, the 1st IP represent the subnet itself, the last IP represent broadcast 每个网络段有 2^{24} 个ip地址, 其中第一个ip地址代表这个子网本身, 最后一个ip代表着广播
 - Each network has $2^{24} - 2$ IP available for Host 每个网络都有 $2^{24} - 2$ IP可用于主机

Class A:



Class B

- The maximum number of Class B networks that can be created is 16384 ($2^{14} = 16384$) 可以创建的B类网络的最大数量为16384 ($2^{14} = 16384$)
- The maximum number of hosts in Class B network is 1073709056 ($16384 * (2^{16} - 2)$) B类网络中的最大主机数量为1073709056 ($16384 * (2^{16} - 2)$)



Class C

- The maximum number of Class C networks that can be created is 2097152 ($2^{21} = 2097152$) 可以创建的C类网络的最大数量为2097152 ($2^{21} = 2097152$)
- The maximum number of hosts in Class C network is 532676608 ($2097152 * (2^8 - 2)$) C类网络中的最大主机数为532676608 ($2097152 * (2^8 - 2)$)



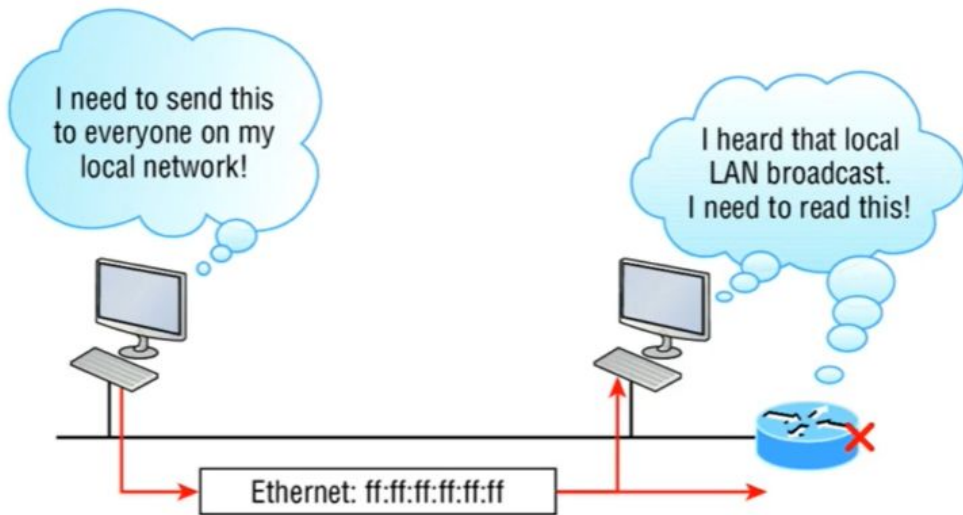
Private IP Address 私有ip地址 (RFC 1918)

- Not routable through the Internet 不在互联网上进行路由

Address Class	Reserved Address Space
Class A	10.0.0.0 through 10.255.255.255
Class B	172.16.0.0 through 172.31.255.255
Class C	192.168.0.0 through 192.168.255.255

Layer 2 Broadcast 2层广播

- ff:ff:ff:ff:ff:ff
- Only go out on a LAN 仅在局域网内
- Every network interface card (NIC) will receive and read the frame 每一个网卡都会接收和读取帧



No.	Time	Source	Destination	Protocol	Length	Info
...	2019-04-28 15:48:52.974123	Microsoft_3e:c2:0d	Broadcast	ARP		42 Who has 192.168.0.11? Tell 192.168.0.12
...	2019-04-28 15:48:53.039668	38:53:9c:8e:72:10	Microsoft_3e:c2:0d	ARP		42 192.168.0.11 is at 38:53:9c:8e:72:10
...	2019-04-28 15:48:53.039758	192.168.0.12	192.168.0.11	ICMP		74 Echo (ping) request id=0x0001, seq=7/1792, ttl=128 (reply in 58)
...	2019-04-28 15:48:53.045429	192.168.0.11	192.168.0.12	ICMP		74 Echo (ping) reply id=0x0001, seq=7/1792, ttl=64 (request in 57)
...	2019-04-28 15:48:53.982457	192.168.0.12	192.168.0.11	ICMP		74 Echo (ping) request id=0x0001, seq=8/2048, ttl=128 (reply in 65)
...	2019-04-28 15:48:54.069344	192.168.0.11	192.168.0.12	ICMP		74 Echo (ping) reply id=0x0001, seq=8/2048, ttl=64 (request in 64)
...	2019-04-28 15:48:54.992264	192.168.0.12	192.168.0.11	ICMP		74 Echo (ping) request id=0x0001, seq=9/2304, ttl=128 (reply in 72)
...	2019-04-28 15:48:55.086390					
...	2019-04-28 15:48:55.998636					
...	2019-04-28 15:48:56.004360					

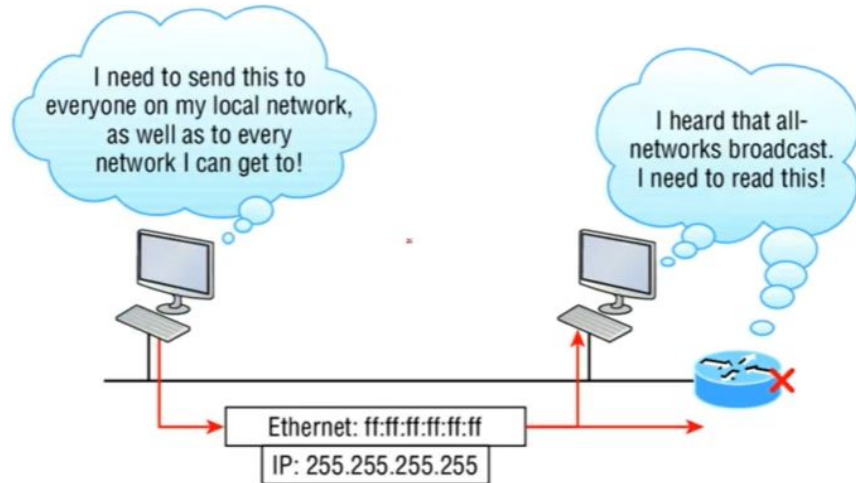
Wireshark - Packet 55 - wireshark_pcapng_27265DF1-6031-4160-A051-7567B09FAE77_20190428154820.p03748	
> Frame 55: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0	
> Ethernet II, Src: Microsoft_3e:c2:0d (98:5f:d3:3e:c2:0d), Dst: Broadcast (ff:ff:ff:ff:ff:ff)	
> Address Resolution Protocol (request)	
Hardware type: Ethernet (1)	
Protocol type: IPv4 (0x0800)	
Hardware size: 6	
Protocol size: 4	
Opcode: request (1)	
Sender MAC address: Microsoft_3e:c2:0d (98:5f:d3:3e:c2:0d)	
Sender IP address: 192.168.0.12	
Target MAC address: 00:00:00:00:00:00 (00:00:00:00:00:00)	
Target IP address: 192.168.0.11	

0000	ff ff ff ff ff 98 5f d3 3e c2 0d 08 06 00 01>.....
0010	08 00 06 04 00 01 98 5f d3 3e c2 0d c0 a8 00 0c>.....
0020	00 00 00 00 00 00 c0 a8 00 0b

arp协议是通过广播的方式获得目标ip的mac地址

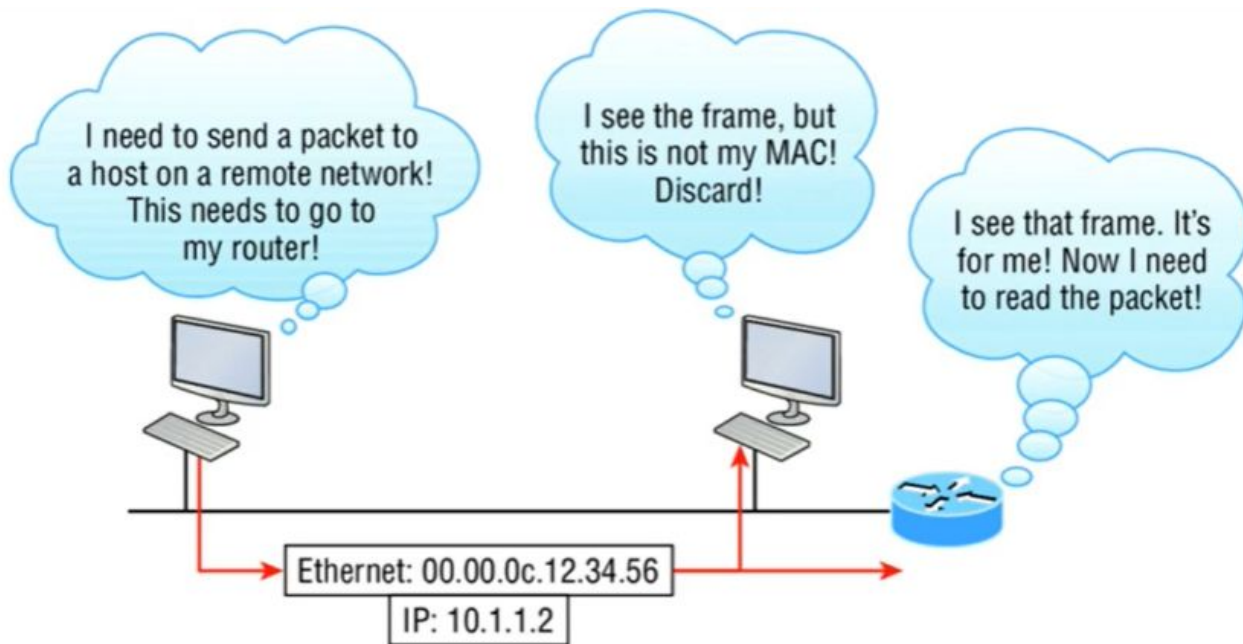
Layer 3 Broadcast 3层广播

- All host bits on - 10.255.255.255, 172.16.255.255, 192.168.1.255, 255.255.255.255 每一个网段的最后一个地址是广播地址
- All hosts on the LAN will get this broadcast on their NIC 局域网上的所有主机都将在其网卡上收到此广播



Unicast 单播

- It's used for directing packets to a specific host 用于将数据包定向发送到特定主机



Multicast 组播

- Multicast does allow point-to-multipoint communication. 多播允许点对多点通信。
- Multicast works by sending messages or data to IP multicast group addresses. 组播工作方式是将消息或数据发送到IP组播组地址。

