3 Ethernet

Today the most common method for connecting networked devices is Ethernet, though many other protocols such as Token Ring and FDDI are used. Ethernet is essentially a bus communication method where all devices are connected to the same communication channel (though many modern implementations using hubs may blur this definition slightly)

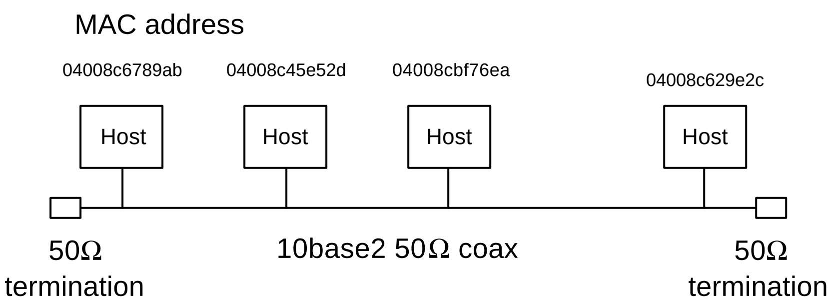


fig 2 MAC addresses on 10base2 Ethernet bus

The MAC address is a 6byte, 48 bit number that is unique to every Ethernet adapter manufactured, if a host wishes to send a data packet to another host it is addressed using the MAC address. The first three bytes of the MAC address are the 'vendor ID' and unique to the manufacturer, (04008c is NTL) and the last three bytes are the device ID, unique to that device made by a particular manufacturer.

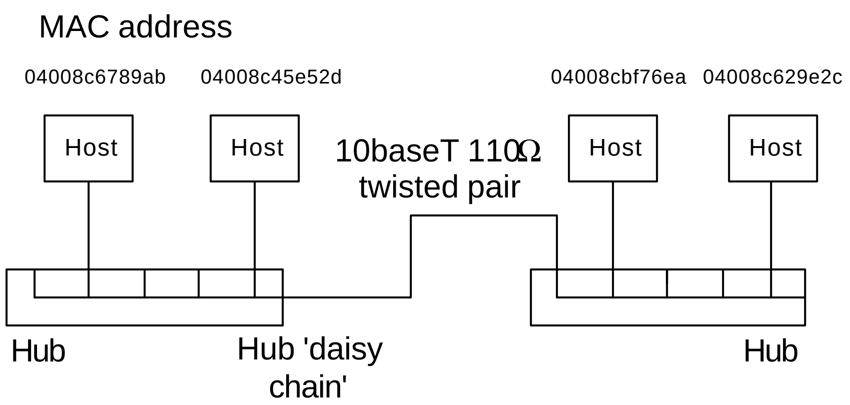


fig 3 MAC addresses on 10baseT UTP/hubEthernet bus

3.1.1 XXX Base T physical connection

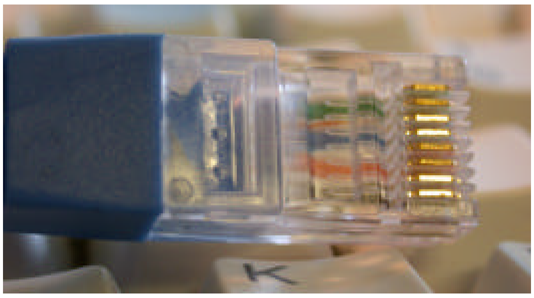


fig 4 RJ45 connector

There are a number of physical implementations of Ethernet, today the most common is 10baseT ‘ten base T’ (IEEE 802.3I), which is most commonly cabled using ‘UTP’, 110Ω unshielded twisted pair. 10 base T uses 8 pin RJ45 connectors using pairs 1-2 and 3-6 only, N.B. if wiring connectors great care needs to be taken to ensure that pins 3 and 6 use a twisted pair within the actual cable. One pair of the cable is used for transmit and one pair of the cable is used for receive.

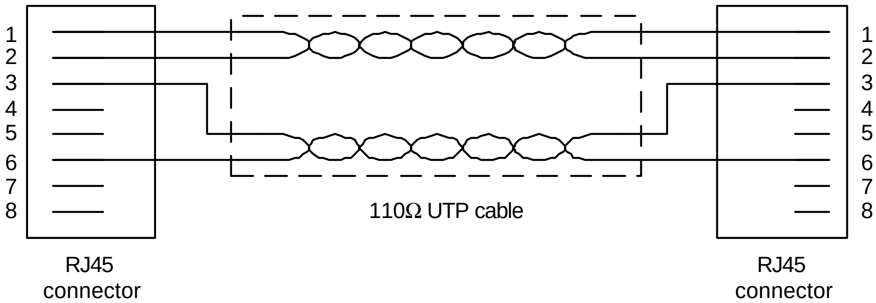
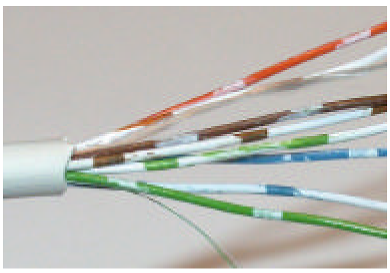


fig 5 cable connection details for 10baseT UTP Ethernet



Pin 1: White / orange stripe
Pin 2: Orange / white stripe
Pin 3: White / green stripe
Pin 4: Blue / white stripe
Pin 5: White / blue stripe
Pin 6: Green / white stripe
Pin 7: White / brown stripe
Pin 8: Brown / white stripe

fig 6 Wire colours for standard RJ45 cable

N.B. the nylon cord in the cable it can be used as an aid to stripping back the cable sleeveing.

3.1.2 XXX Base T Crossover cable

It is possible to interconnect a pair of hosts without using a hub, in which case a 'cross over' cable is used in which at one end the pairs 1-2 and 3-6 are swapped over. A crossover cable can also be used to interconnect hubs, though more normally a special 'daisy chain' output, which can use a normal 'straight' cable, is supplied on the hub for this purpose. Most commonly the maximum cable length for UTP is 100m, though this may vary according to cable type. 10baseT operates at a maximum bit rate of 10Mb/s, increasingly common today is 100baseT, which operates at 100Mb/s.

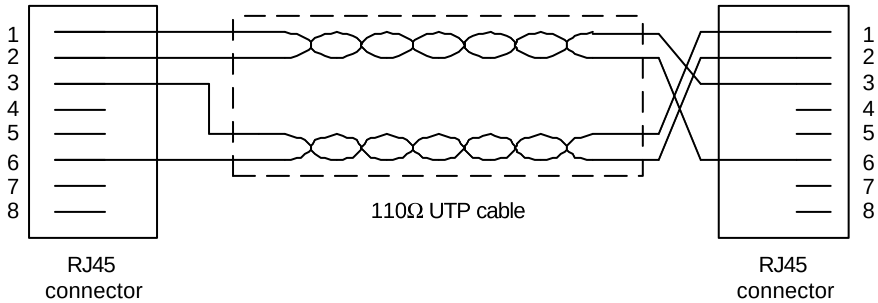


fig 7 Ethernet UTP 'crossover' cable

3.1.3 Other Ethernet physical implementations

Historically 10base2 'thin Ethernet' (IEEE 802.3b) and 10base5 'thick Ethernet' (IEEE 802.3) 50Ω co-axial cable Ethernet systems have been common. In thin Ethernet the hosts are simply 'Teed' into the coax cable using 'T-piece' connectors. With the thick Ethernet implementation a 'bee-sting' or 'vampire tap' connector is used to connect the host to the cable via an AUI (Attachment Unit Interface), see fig x. The maximum cable lengths are 185m (200 yards, 10base2) and 462.5m (500 yards, 10base5). 10base2 and 10base5 both operate at a maximum bit rate of 10Mb/s

fig 8 NIC with 10 base 5 and 10 base 2 connectors, with AUI for 10 base T

There are numerous other variations in Ethernet cabling systems including 10BaseF (IEEE 802.j) using a fibre optic connection, these will often be connected via appropriate AUIs.

3.2 Ethernet in Action

In an Ethernet system all the host devices are effectively connected to the same cable bus. None of the Ethernet hosts has any knowledge of when other hosts may wish to talk to the bus and clearly if two hosts attempt to put data on to the cable segment at the same time there will be conflict and data corruption. To overcome the cable contention problem Ethernet uses a system called CSMA/CD 'Carrier Sense Multiple Access / Collision Detection'.

CSMA / CD works as follows: CSMA, when a host wishes to talk to the Ethernet bus it first listens to the bus to check no other host is using the bus (the Carrier Sense), it then starts to send its Ethernet packet. If a second host decides to access the bus at the same time it too puts out its Ethernet packet and the two packets 'collide' on the bus. Two hosts transmitting to the bus simultaneously will cause an abnormal signal level (Collision Detect) which indicates to the two affected hosts that a collision has occurred, at this point both hosts 'back off', transmitting a 32 bit jamming signal onto the bus and then stop transmitting. After a random amount of time each of the affected hosts attempts to retransmit their packet, it is likely that the two random pauses will be different and the hosts are unlikely to collide a second time.

fig 9 Ethernet packet collision occurring at low utilisation

fig 10 High network bitrate,with no collisions

This collision activity is often indicated on a hub, typically by a red 'collision' indicator, and so long as there is not an excess of collisions there is not a problem with transmission. Normally a 'utilisation' indicator is provided on a hub and generally with an Ethernet segment that is simultaneously accessed by many hosts the maximum utilisation achievable is around 70%, though in a point to point implementation of Ethernet with a single host pair access levels approaching 100% are achievable.

3.3 The Ethernet Packet

A number of forms of Ethernet (more accurately IEEE 802.X) packet exist to support overlaying network technologies. The form of an IP Ethernet packet is as follows:

Length	**Content**
7	preamble
1	start frame delimiter
6	Destination address (MAC unicast/multicast/broadcast)
6	Source address (MAC)
2	Ethernet data type (length in the IEEE 802.3 protocol)
46-1500	IP (or other) Data
4	Frame check sequence

fig 11 Ethernet packet content and structure

The type field is used to indicate the protocol of the data being carried, e.g. 0800 IP, 0806 ARP, 8137 Novell IPX.

3.4 Connecting Ethernet cable segments

Clearly for most modern networks the UTP limitation of 100m maximum cable length is a severe limitation, to overcome these problems a number of solutions are possible.

3.4.1 Repeaters

Repeaters are essentially OSI physical layer devices that operate at the electrical (or optical) level and simply act to buffer and re-amplify the signal to be passed on to the next cable segment. Repeaters are unintelligent devices passing all packets between segments

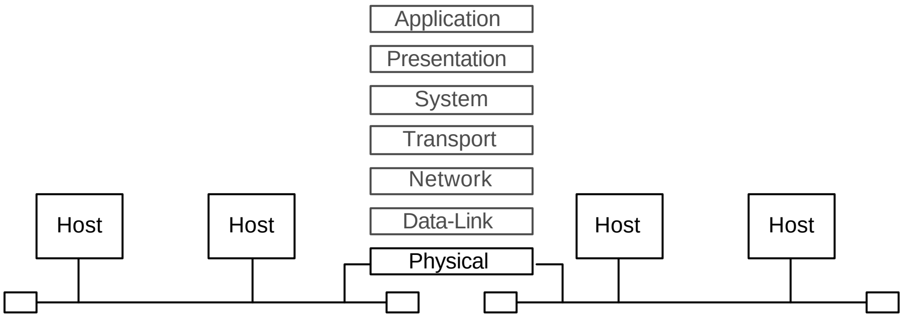


fig 12 Repeater linking Ethernet cable segments

3.4.2 Bridges / Switches

Bridges / Switches are are essentially OSI Data-Link layer devices that operate at the MAC address level.

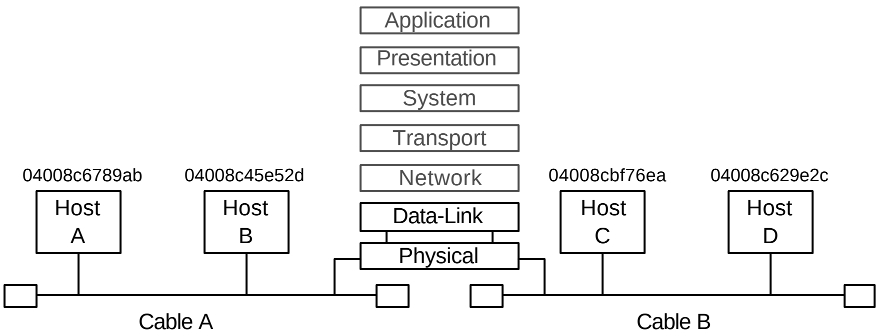


fig 13 Bridge linking Ethernet cable segments