1 Ethernet

Ethernet is most common LAN type. There are different standards/speeds, such as 10Mbps, 100Mbps, and 1000Mbps, but most of them are quite similar, and backwards compatible (ie: devices running at 100Mbps, can still talk to 10Mbps ones).

1.1 Ethernet 10 Mbps

Well, the obvious thing about this network is that it operates at 10 Mbps—so for example, it takes 51.2 μs to transmit 512 bits.

Access method is CSMA/CD, that says there is a shared medium (not full-duplex). It also says that stations must follow some sort of a collision detection/avoidance strategy. In Ethernet 10, stations monitor the medium, once they detect that that it's free, they wait for interfame gap (IFG) period of time (time to send 96 bits, which for 10 Mbps network is 9.6 μs). The collision is sensed during the first 512 bits of transmission (this is the smallest transmission unit—so if collision didn't happen during that time, then it cannot happen—assuming all stations follow the same CSMA/CD scheme).

Ethernet does not provide any mechanism for acknowledgments; which have to be provided by higher layers.

Ethernet frames are:

1. Preamble, 7 bytes (56 bits). Alternating 1s and 0s. It's put in by the hardware layer. Used mostly for synchronization. The receiver knows to expect data after they see 56 bits of alternating 1s and 0s.

2. Start Frame Delimiter (SFD), 1 byte (8 bits). 10101011. Indicates the first frame that's not a preamble.

3. Destination Address (DA), 6 bytes. This is what is commonly known as a "MAC" address (or NIC address; basically one that is hard-coded into the network interface card—they're globally unique). If the first bit is a 0, then it's a unicast address, otherwise it's a multicast/broadcast address.

4. Source Address (SA), 6 bytes.

5. Length/type, 2 bytes. If less than 1518, then specifies length (1518 is maximum length of a frame). If more than 1536, specifies the type of the PDU that is encapsulated.

6. Data. This can be a minimum of 46 bytes, to a maximum of 1500 bytes.

7. CRC, 4 bytes.

The preamble and SFD aren't usually counted as part of the frame; they're used for synchronization—not actual data transmission.

Maximum length of the frame is 1518 bytes. 1500 max for data, and 18 for the frame (again, not counting preamble and SFD).

Minimum length of the frame is 64 bytes (512 bits). That's 18 bytes for frame header/footer, and 46 bytes for the data. If data is smaller than 46 bytes, then padding is added.

The 64 byte minimum isn't accidental. For proper functioning of CSMA/CD frames, the farthest parts of the network have to be able to sense the transmission before the transmission ends. If the frames could be arbitrarily short, the source could be done transmitting before farthest reaches of the network detect the transmission. Ie: There has to be a minimum limit.

There is also the notion of 'slot time', which is the time required for a signal to traverse from one end of the network to another, plus the time required to send the jam signal in case of collision. The slot time is the time needed to send 512 bits.

We can now calculate the maximum length of Ethernet 10Mbps network:

$$MaxLength = PropagationSpeed \times \frac{SlotTime}{2}$$

For Ethernet, propagation speed is generally 2/3rds of what the propagation is in air, or 2×10^8 m/s. So max length becomes:

$$MaxLength = (2 \times 10^8) \times (51.2 \times 10^{-6}/2) = 5120m$$

So the max length is 5120 meters.

1.2 Bridges

One way to expand a LAN is to use a bridge. On an Ethernet, all stations share the medium. If one station is sending, no other station could be sending. What a bridge does (besides for subdividing the network) is separate collision domains—basically you now have two separate mediums, that the bridge connects.

1.3 Switched Ethernet

This is like having a bridge for each station. The effect is that the medium is used by only one station, and in effect, it can forget about CSMA/CD schemes, and just use the medium. Which leads to...

1.4 Full Duplex Ethernet

The CAT-5 wire is capable of carrying a full-duplex connection both ways. Basically the sending and receiving can both happen at the same time on their own dedicated link (no CSMA/CD).

1.4.1 MAC Control

With the full-duplex scheme, there is no CSMA/CD. There needs to be another method to do flow control, error control, that doesn't depend on detecting collisions. The MAC Control layer periodically inserts frames to be sent; which contain flow control information—they are also received by that layer.

1.5 Fast Ethernet

Fast Ethernet operates at 100Mbps. For the most part, the scheme/protocol remains the same as the 10Mbps case, except now the maximum length of the network is shortened.

Maximum frame size is still kept 512 bits, which now arrive 10 times faster than they do in 10Mbps Ethernet, which the result being that the network must be 10 times smaller, or somewhere around 512 meters, which practical length being somewhere around 250 meters.

There is also a new "Auto Negotiation" feature, which allows Fast Ethernet (100Mbps) to talk to the regular Ethernet (10Mbps).

1.6 Gigabit Ethernet

The idea behind the whole 'Ethernet' scheme was to mostly keep it the same, and backwards compatible, for the most part. As with Fast Ethernet, there is an "Auto Negotiation" feature, which allows backwards compatibility with Fast Ethernet and Ethernet.

There are several modes. The traditional mode allows for CSMA/CD, etc. The frame size is also kept at 512 bits, which theoretically limits this network to 50 meters (and practically to about 25).

Since network length is dependent on the length of the frame, there's "Carrier Extension" that increases the minimum frame length to 512 bytes—which means the network can be around 200 meters (or 100 meters from station to hub).

The problem with carrier extension is that you're 'forced' to send 512 bytes, even if you don't have 512 bytes to send—basically you have to put in padding. If you have many small frames to send, there is a better scheme known as 'Frame Bursting'.

With 'Frame Bursting', once a station begins sending, and realizes that there are no collisions, it just continues to send frame after frame, without letting go of the medium. The whole big 'frame' (that encompasses the smaller frames) is limited to 8192 bytes—which means that stations cannot monopolize the medium.