ETHERNET DESIGN RULES

A Technical News Article from Boston Technology

TECHNICAL BRIEF #1 PART ONE

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Standard Ethernet (10BaseT)

The following design rules on length of cable segment, node placement and hardware usage should be strictly observed.

Length of the Cable Segment

It is important to maintain the overall Ethernet requirements as far as length of the cable is concerned. Each segment has a particular maximum length allowable. For example, 10Base2 allows 185m, (200 yd) maximum length. The recommended maximum length is 80% of this figure. Some manufacturers advise that you can disregard this limit with their equipment. This can be a risky strategy and should be carefully considered.

System	Maximum	Recommended
10Base5	500 m (1640 feet)	400 m (1310 feet)
10Base2	185 m (600 feet)	150 m (500 feet)
10BaseT	100 m (330 feet)	80 m (260 feet)
1Base5	500 m (1640 feet)	400 m (1310 feet)

Table 1 - Ethernet Cable Segment Lengths

Maximum Transceiver Cable Length

In 10Base5 systems the maximum length of the transceiver cables is 500m (1640 feet) but it should be noted that this only applies to specified IEEE 802.3 compliant cables. Other AUI cables using ribbon or office grade cables can only be used for short distances (less than 12.5 m/41 feet) so check the manufacturer specifications for these!

Maximum Transmission Path

The maximum transmission path is made of five segments connected by four repeaters. The total number of segments can be made up of a maximum of three coax segments containing station nodes and two link segments, having no intermediate nodes.

This is summarised as the 5-4-3-2 rule.

5 segments 4 repeaters 3 coax segments 2 link segments	OR	5 segments 4 repeaters 3 link segments 2 coax segments

Table 2 - The 5-4-3-2 Rule

Node Placement Rules

Connection of the transceiver media access units (MAU) to the cable causes signal reflections due to their bridging impedance. Placement of the MAUs must therefore be controlled to ensure that reflections from them do not significantly add in phase. In 10Base5 systems the MAUs are spaced at multiples of 2.5 m (8.2 feet), coinciding with the cable markings. In 10Base2 systems the minimum MAU spacing is 0.5 m (1.6 feet).

It is important to verify that all paths between any two nodes on the network meet the above transmission rules.

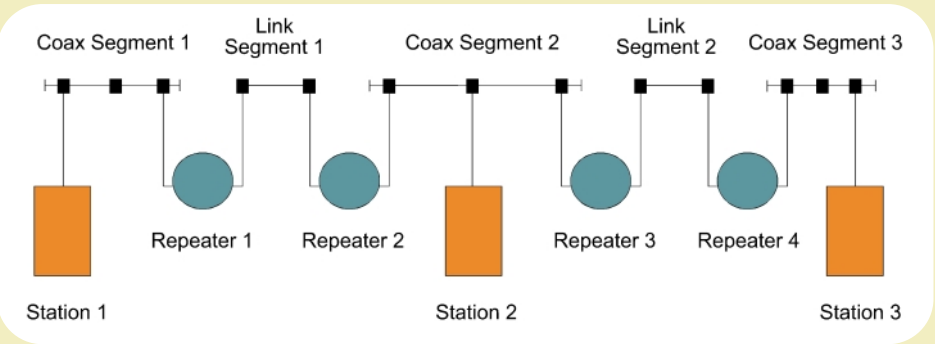

Figure 1 - Maximum Transmission Path

Note that the maximum sized network of four repeaters supported by IEEE.802.3 can be susceptible to timing problems. The maximum configuration is limited by propagation delay. In addition, the link segments are not restricted to coax, they can be fully functional fibre optic link segments. Note that with fibre segments the collision domain must not be exceeded. Ensure maximum round trip delay does not exceed 51.2 microseconds.

Maximum Network Size

10Base5= 2800 m (9200 feet) node to node
(5 x 500 m / 1640 feet) segments + 4 repeater cables + 2 AUI)

10Base2= 925 m (3034 feet) node to node
(5 x 185 m / 600 feet) segments)

10BaseT = 100 m (330 feet) node to hub

Repeater Rules

Repeaters are connected to transceivers that count as one node on the segments.
Fibre-optic repeaters are available giving up to 3000m links at 10 Mbps.

Cable System Grounding

Grounding has safety and noise connotations. IEEE 802.3 states that the shield conductor of each coaxial cable shall make electrical contact with an effective earth reference at one point only. The single point earth reference for an Ethernet system is usually located at one of the terminators.

Round Trip Delay Time

The maximum round trip propagation delay is 51.2 μs because of the minimum frame size of 64 bytes (512 bits) - determined by adding the propagation delays in all of the electronic components and cables that make up the longest signal path and then doubling this figure to obtain the round trip delay time.

CONT. ON THE BACK

CONT. FROM THE FRONT

Fast Ethernet (100BaseT)

UTP Cabling Distances 100BaseTX/T4

Maximum distance between UTP hub and desktop NIC is 100 metres, made up as follows:

- 5 metres from hub to patch panel
- 90 metres horizontal cabling from patch panel to office punch down block or wall socket
- 5 metres from punch-down block or wall socket to desktop NIC

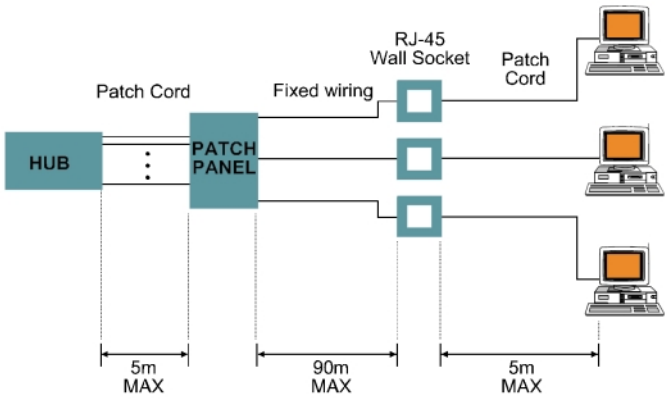

Figure 2 - UTP Cabling Distances

Fibre Optic Cable Distances 100BaseFX

The following maximum cable distances are in accordance with the 100BaseT bit budget:

- Node to Hub: maximum distance of multimode cable (62.5/125) is 160 metres (for connections using a single Class II repeater)
- Node to Switch: maximum multimode cable distance is 210 metres
- Switch to Switch: maximum distance of multimode cable for a backbone connection between two 100BaseFX switch ports is 412 metres
- Switch to Switch Full-duplex: maximum distance of multimode cable for a full-duplex connection between two 100BaseFX switch ports is 2000 metres

Note:
The IEEE has not included the use of single mode fibre in the 802.3u standard. However numerous vendors have products available enabling switch-to-switch distances of up to 10 to 20 km (6 to 12 miles) using single mode fibre.

100BaseT Repeater Rules

The cable distance and the number of repeaters, which can be used in a 100BaseT collision domain, depends on the delay in the cable and the time delay in the repeaters and NIC delays. The maximum round-trip delay for 100BaseT systems is the time to transmit 64 bytes or 512 bits and equals 5.12 ms. A frame has to go from the transmitter to the most remote node then back to the transmitter for collision detection within this round trip time. Therefore the one-way time delay will be half this.

The maximum sized collision domain can then be determined by the following calculation:

Repeater Delays + Cable Delays + NIC Delays + Safety Factor (5 bits minimum) < 2.56 ms

Note:
If the desired distance is too great it is possible to create a new collision domain by using a switch instead of a repeater.

Most 100BaseT repeaters are stackable, which means multiple units can be placed on top of one another and connected together by means of a fast back plane bus; such connections do not count as a repeater hop and make the ensemble function as a single repeater.

Component	Maximum Delay (µs)
Fast Ethernet NIC	0.25
Fast Ethernet Switch Port	0.25
Class I Repeater	0.70
Class II Repeater	0.46
UTP Cable (per 100 m/330 ft))	0.55
Multimode Fibre (per 100 m/330 ft)	0.50

Table 3 - Maximum One-Way Fast Ethernet Component Delays

The table on the left gives typical maximum one-way delays for various components. Repeater and NIC delays for your specific components can be obtained from the manufacturer.

Sample Calculation

Is it possible to connect two Fast Ethernet nodes together using two Class II repeaters connected by 50 m fibre? One node is connected to the first repeater with 50 m UTP while the other has a 100 m fibre connection.

The total one-way delay of 2.445 ms is within the required interval (2.56 ms) and allows at least 5 bits safety factor, so this connection is permissible.

NIC	0.250 µs
50 m (165 ft) UTP	0.275 µs
Repeater Class II	0.460 µs
50 m (165 ft) fibre	0.250 µs
Repeater Class II	0.460 µs
100 m (330 ft) fibre	0.500 µs
NIC	0.250 µs
Total Delay	**2.445 µs**

Calculation: Using the time delays in Table 3

Gigabit Ethernet (1000BaseT)

The discussion of Gigabit Ethernet and 802.3 standards is continued on our website: