General

This type of network was developed by Xerox. It was eventually standardized as the IEEE802.3 based on the Ethernet DIX standard (DIX= Digital, Intel, Xerox). The IEEE802.3 describes all ethernet based networks; both 10, 100 and 1000 Mbps networks. This means they have a lot in common and are easilly connectable to eachother. Between two different 10 Mbps standards a repeater with two different interfaces is enough and the same goes for two different 100 Mbps standards. However to connect a 100 Mbps network to a 10 Mbps you need a bridge. This discribes the difference. The difference between the different 10 Mbps standards is situated on Layer 1 of the OSI reference model, where the difference between 10 and 100 Mbps is situated on the MAC-layer which is part of Layer 2 of the OSI reference model.

Detailed Description

According to the OSI layers an ethernet network looks like this:

2	Data Link	LLC or LLC + SNAP
		MAC
1	Physical	Interface + PHY

LLC

For SNAP and IEEE802.2 (LLC) see the corresponding documents.

MAC: IEEE802.3 CSMA/CD

The complete ethernet networking family is based on the CSMA/CD protocol. CSMA/CD stands for Carrier Sense Multiple Access with Collision Detetection, which means that a station that has something to send listens for a carrier (if someone is already sending something) if not it sends its data. At the moment multiple stations can decide to send their data, since they all heard no carrier, this is the multiple access. After sending the station keeps on listening to the carrier and when they detect that another station started sending too, collision detection, it backs off, waits a random time and starts the whole procedure from scratch.

The timing involved for sending and receiving is different for 10 and 100 Mbps ethernet:

	10 Mbps	100 Mbps	1000 Mbps
Bit Time	100 ns	10 ns	1 ns
Interpacket gap	96 bit times or 9.6 µs	96 bit times or 0.96µs	96 bit times or 0.096µs

The Data-link-Frame

[META]

Interface and PHY

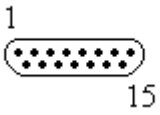
PHY is an abbreviation for the tranceiver. A tranceiver can be a separate device or it can be integrated on the network card or on the motherboard of the PC. It is on this layer that the real difference between the different standards start. Therefore they all have their own document to describe them.

10 Mbps Ethernet (IEEE802.3a-t clauses 1 to 20)

General

The PHY is the actual tranceiver which can be a separate device or it can be integrated on the

network card. The tranceiver interface is called AUI (Attachment Unit Interface). When a network card doesn't contain the interface there will be a Sub-D15 female connector. On the cable will be a tranceiver with an male connector. This means that an AUI-cable will ALWAYS be male-female.

	Male	Female
SubD15 (AUI)		

AUI pinning specification			
Pin	**Signal**	**Pin**	**Signal**
1	Control In Circuit Shield	9	Control In Circuit B
2	Control In Circuit A	10	Data Out Circuit B
3	Data Out Circuit Shield	11	Data Out Circuit Shield
4	Data In Circuit Shield	12	Data In Circuit B
5	Data In Circuit A	13	Voltage Plus
6	Voltage Common	14	Voltage Shield
7	Control Out Circuit A	15	Control Out Circuit B
8	Control Out Circuit Shield		

The difference between the different 10 Mbps topologies is in the PHY part. This section connects directly to the cable and is responsible for everything that is medium depended like: line encoding, transmission voltages, SQE, etc.

With AUI there are two ways power can be provided to the units. You eighter have a positive or negative polarity.

Positive polarity:
Pin 13 (to shell), +11 V to +13 V; Pin 6 (to shell), about 0.05 V

Negative polarity:
Pin 13 (to shell), about 0.5 V; Pin 6 (to shell), -11 to -16 V

Do not mix units with different polarities!

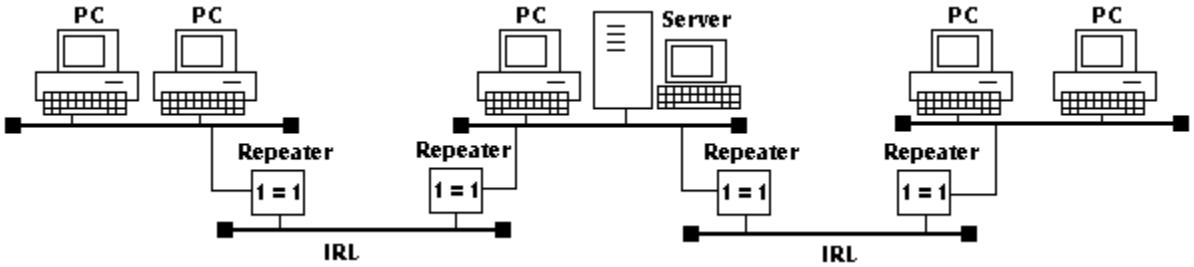
SQE
The Signal Quality Error signal is also called 'heartbeat' and is a kind of keepalive notification between the transceiver and the ethernet device. SQE can be ON or OFF between a transceiver and a workstation or file server. It MUST be set OFF between a transceiver and a Repeater.

10Base-5 (Thick Ethernet)

10Base-5 Quick Overview	
IEEE-spec	802.3
Max. speed	10 Mbps

Cable	Standard Ethernet Coax Cable
Connectors	N-type
Terminators	50 ohm
Max. length of a segment	500m/1640ft
Max. number of taps per segment	100
Max. number of stations per network	1024
Min. distance between taps	2.5m/8.3ft
Max. length of tranceiver cable	50m/164ft
Max. number of repeaters	4
Topology	Bus

Maximum Topology

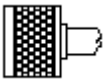


10Base-5 is a bus topology. A thick coaxial cable runs through the building and stations are attached to this cable by tranceivers. An closer look on cabling can be found below.

The maximum amount of repeaters in a network is four. Since a segment may be up to 500 meters the total network length can be 2500 meter. There is little catch in this because 2 of the total of 5 segments may not be occupied. This doesn't matter for the length, but it does for the way you position your computers. The 2 non-occupied segments are only ment for extending the network and are called IRLs (Inter Repeater Links). For larger distances you need fiber optic repeaters or bridges or routers.

Cabling

10Base-5 uses standard coaxial cable, the cable is about 1cm thick and yellow (normal cable) or orange (plenum cable) coloured. The connector type used is N-type.

	Male	Female	Side
N-Type			

A segment can be one cable length with only two N-type connectors at the far ends, or it can be composed of several pre-terminated cables. The two last N-type connectors on the cable need to have a 50 ohm terminator installed. One of the terminaters should be grounded. A segment is defined as all the cable between two terminators.

Devices are attached to the segment (or backbone cable) by means of transceivers. A transceiver can be intrusive (N-type) or non-intrusive (vampire type). A transceiver always has a Sub-D15 male AUI (Attachment Unit Interface) connector. An IEEE802.3 10Base-5 compatible device has a female Sub-D15 female AUI (Attachment Unit Interface) connector that normally connects to a tranceiver by means of a tranceiver cable (also called AUI or drop cable). The transceiver cable is ALWAYS a male-female cable.

Tranceivers and Fan-Out Units

A vampire or non-intrusive transceiver is connected to the coax cable by opening up the jacket and shielding, drilling a hole in the insulation and inserting a 'centre probe' in the hole. Two 'braid picks' connect to the braided shielding and the centre probe connects the core of the cable to the transceiver body. An intrusive transceiver has N-type connectors and connects to cable runs terminated with N-type connectors. A tranceiver can have the possibility to send out SQEs. This is a kind of keep alive message to notify to the attached station that everything is still allright.

One tranceiver tap can support multiple devices but will still count as only one of the 100 taps. A unit that makes it possible to connect multiple devices to one tap is called a Fan-Out Unit. A Fan-Out Unit usually has one ethernet device port (female) and 2, 4 or 8 ethernet transceiver ports (male). A transceiver cable connects the female AUI connector of the Fan-out unit to the male AUI connector of the tranceiver on the segment. Transceiver cables are also used to connect the ethernet devices to the transceiver ports on the Fan-Out Unit.

Notes on 10Base-5

With AUI there are two ways power can be provided to the units. You eighter have a positive or negative polarity.

Positive polarity:
Pin 13 (to shell), +11 V to +13 V; Pin 6 (to shell), about 0.05 V

Negative polarity:
Pin 13 (to shell), about 0.5 V; Pin 6 (to shell), -11 to -16 V

Do not mix units with different polarities!

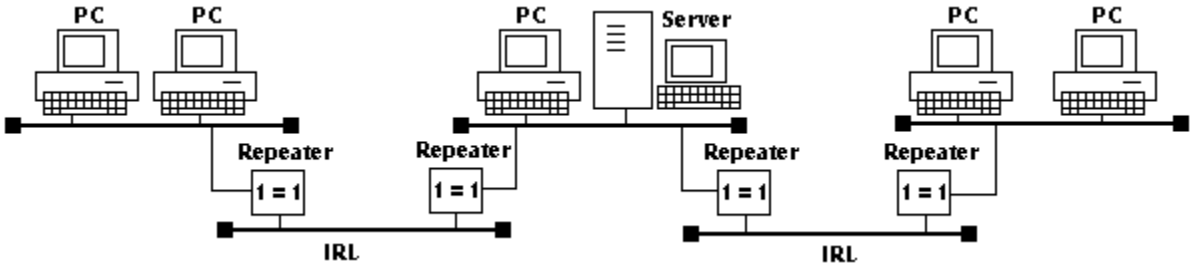
You cannot adapt to Thin Ethernet by using BNC-to-N-type adapters. You need a Thick/Thin Repeater or Media-Converter. In some networks with very short segments, using a BNC-to-N-type adapter appears to work. However, problems will occur when extending the segments or when adding new workstations or file servers. At first glance it looks that the problems are caused by the segment-extension or by the added network stations. Troubleshooting such a network will take a lot of time looking at the wrong causes.

10BASE-2 (Thin Ethernet)

10BASE-2 Quick Overview	
IEEE-norm	802.3
Maximum speed	10 Mbps
Cable	RG58
Connectors	BNC

Terminators	50 ohm
Max. length of a segment	185m/607ft
Max. number of taps per segment	30
Max. amount of stations per network	1024
Min. distance between taps	0.5m/1.65ft
Max. number of repeaters	4
Topology	Bus

Maximum Topology

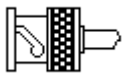


10Base-2 is a bus topology. The cable runs from computer to computer, like a daisy-chain. All devices are connected to the cable through a T-connector. The tranceiver is on the ethernet card in the device. This means that no cable is allowed between the T-connector and the device.

A complete 10BASE-2 network (one collision domain) may consist of five segments interconnected by four repeaters. Only three of those five segments may have network devices connected to them (populated). The other two segments function as Inter Repeater Links (IRLs) and their only function is to extend the network. This allows for a maximum of 925m/3035ft (5x185m) of network cable if you stick to 10Base-2 cable. For larger distances you need 10Base-5 or fiber optic repeaters or bridges or routers.

Cabling

Thin Ethernet is also called Cheapernet. Thin Ethernet uses RG58 coaxial cable and BNC connectors.

	Male	Female	Side
BNC			

An IEEE802.3 10Base-2 compatible device has a female BNC connector that connects to the coax cable by means of a FMF BNC T-connector. The T-connector connects directly to the device. It is not allowed to have any length of cable between the BNC T-connector and the device. The two last BNC T-connectors need to have a 50 ohm terminator installed on the un-used (open) side. One of the terminaters should be grounded. A segment is defined as all the cable plus T-connectors between two terminators.

Notes on 10BASE-2

- When measuring with an ohmmeter between the center and shell of the male connector of a BNC T-connector you should read 25 Ohm. This equals the resistance of the two 50 Ohm terminators in parallel. When measuring with the ohmmeter on one end of the cable where the terminator is unscrewed, you should measure 50 ohm. This equals the 50 Ohm terminator at the other end.

- RG58 PVC cable is 5 mm in diameter, a plenum cable is a little thicker.

- You cannot adapt to Thicknet cable by using BNC-to-N-type adapters. You need a Thick/Thin Repeater or Media-Converter. In some networks with very short segments, using a BNC-to-N-type adapter appears to work. However, problems will occur when extending the segments or when adding new workstations or file servers. At first glance it looks that the problems are caused by the segment-extension or by the added network stations. Troubleshooting such a network will take a lot of time looking at the wrong causes.

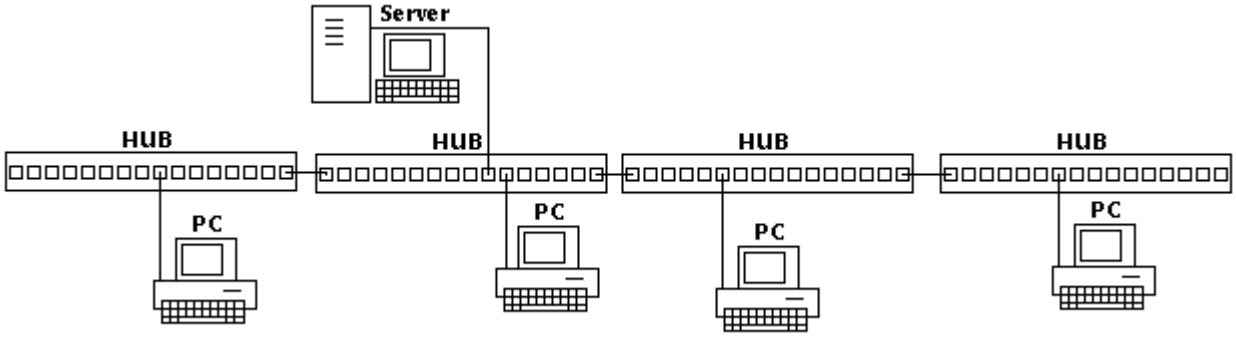
- One BNC tap can support multiple devices but will still count as only one of the 30 taps. For example you can use one BNC T-connector to connect a BNC Multi-Port Repeater.

- The maximum length of a Thin Ethernet segment is 185m according to the specs. In practice you may run into trouble with shorter lengths of cable. Due to the influence of the environment and due to different cable types (although they're all RG58) and due to less than perfect connector-to-cable connections you will loose segment length.

10BASE-T

10Base-T Quick Overview	
IEEE-spec	802.3
Wire speed	10 Mbps
Cable type	UTP CAT 3, 4 and 5
Connector type	RJ45
Used pins	1 & 2, 3 & 6
Max. length of a segment	100m/328ft
Max. number of taps per segment	2
Max. amount of stations per network	1024
Max. amount of repeaters	4
Topology	Star

Maximum Topology

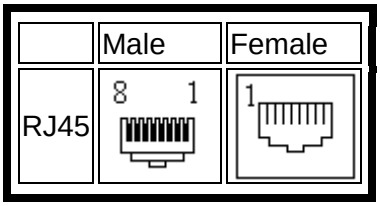


A segment is defined as the cable between the hub and a workstation. According to the EIA/TIA this length has a maximum of 100m separated in: 5m from HUB to patchpanel, 90 meters from patchpanel to wall outlet, and 5 meters from wall outlet to the workstation.

A complete 10Base-T network (one collision domain) may consist of 4 repeaters between the two far most workstations. Meaning the maximum length of a 10Base-T Network can be 500m/1500ft. To exceed this maximum you need Fiber Optic Repeaters or Bridges or Routers.

Cabling

10Base-T uses Category 3, 4 or 5 UTP cable and RJ45 connectors.



Any IEEE802.3 10Base-T compatible device has a female RJ45 connector that normally connects to a hub or concentrator using UTP cable. The cabling is more or less a DTE/DCE situation. The workstation is a DTE and the HUB is a DCE. Connecting a workstation to an HUB requires a straight cable. Connecting two hubs or two workstations togather requires a crossed cable. 10Base-T only uses 4 wires. In general the cable that is installed will be an 8-wire cable. The pins 4, 5, 7 and 8 are simply not used.

RJ45 pinning	
Pin	Signal
1	Transmit (positive)
2	Transmit (negative)
3	Receive (positive)
6	Receive (negative)
Straight cable	Crossed cable
1 - 1	1 - 3
2 - 2	2 - 6
3 - 3	3 - 1
6 - 6	6 - 2

HUBs and Repeaters

Repeaters in a 10Base-T network can have 2 or more ports. The most common word for those repeaters with more than two ports that act as the center of the network is HUB. HUBs may be connected to each other. There are three ways to do this:

1. The HUBs are stackable, this means that a stacked HUB counts as one repeater in the network.
2. Through un uplink port. This way a straight cable (1:1) can be used
3. Connecting two station ports with a crossed cable.

Error Detection

A collision within a 10Base-T network is detected by the simultaneous occurance of signals on the transmit and receive pairs.

Link Integrity Test

By checking the receive signals a HUB monitors if a link is working correctly. On idle networks HUBs send a link test signal to one-another to verify the link integrity.

If a HUB has a link test LED this makes it easier to monitor if the link is working allright. If the link is allright (LEDs on both sides have to be lit) you know your cable wiring is correct, but it doesn't say anything about the quality of the cabling.

Notes on 10Base-T

The used UTP cable varies between 0,404mm and 0,643mm diameter.

A common mistake with 10Base-T is the use of flat satin cable instead of twisted pair cable (flat satin is the kind of cable you use for your telephone cabling). The flat satin cable is NOT twisted. This results in excessive signal crosstalk which causes phantom collisions.

You cannot adapt 10Base-2 to 10Base-T by using a balun. Baluns always use two-wire UTP. 10Base-T uses 4-wire UTP. The only way you can use a 10Base-2 balun is in pairs. A pair of baluns and a length of two-wire UTP cable replaces a length of thin coax cable. That is why you cannot use a balun to convert between 10Base-2 and 10Base-T. You need a Repeater or Media-Converter.

The smallest network possible is two stations connected by a cross cable.

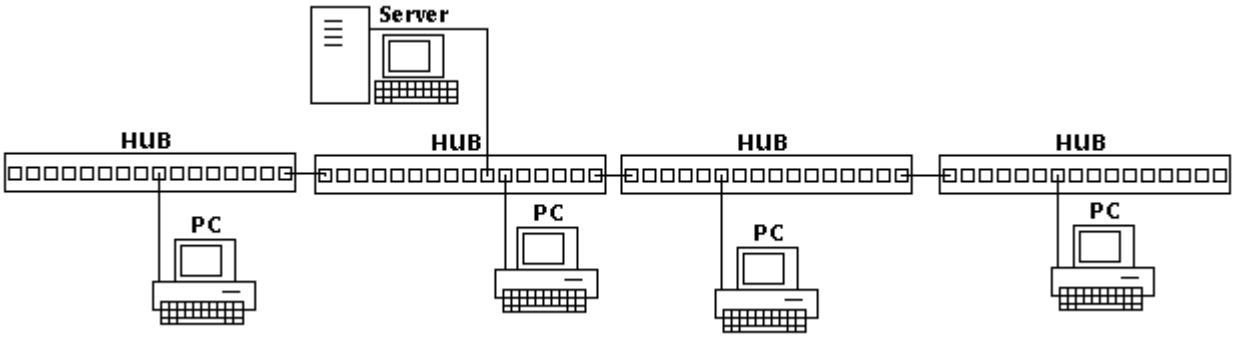
It is not advisable to use the non-used wires (4, 5, 7, 8) for other kinds of datacommunication like telehone, etc. The telephone signals can cause errors on the LAN connections. And even ruin your HUBs.

10BASE-F, (Fiber Ethernet)

10Base-F Quick Overview	
IEEE-spec	802.3
Max. speed	10 Mbps
Cable	50, 62.5, or 100 µm (62.5 µm most common)
Connectors	dual ST or dual SMA 905
Max. length of a segment	up to 2 km, depending on link budget
Max. number of taps per segment	2

Max. amount of stations per network	1024
Max. amount of repeaters	4
Topology	Star

Maximum Topology

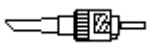
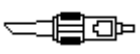
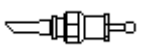
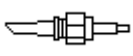


Between any pair of devices in a 10Base-F-only network (one collision domain) you can have a maximum of four repeaters. This means that five fiber point-to-point segments are connected by four repeaters. Populated or non-populated segments is not an issue here. Only when you start mixing 10Base-2, 10Base-5 and 10Base-F that becomes important.

Repeaters can be two-port or multi-port (usually 4 or 8).

Cabling

10Base-F uses two strands of optical fiber. In general multi-mode fiber of 62.5 µm diameter. The connectors used are most of the time ST, SC or SMA905/906.

	Male	Female	Side
ST			
SC			
SMA905			
SMA906			

10Base-F is a star topology and not a bus like Thin and Thick ethernet. A device can have a fiber port or an AUI port. A fiber port has two connectors, one for transmit and one for receive. A device with an AUI port can be connected to a fiber network by using a Fiber Optic Transceiver.

Notes on 10Base-F
100 Mbps Ethernet
General

According to the OSI layers an ethernet network looks like this:

OSI Layer 1	DTE	Repeater
	Reconciliation	
	MII	Baseband Repeater Unit
	PCS	PCS and PMA
	PMA	PMA
	PMD	
	AUTONEG	
	The Physical Medium	

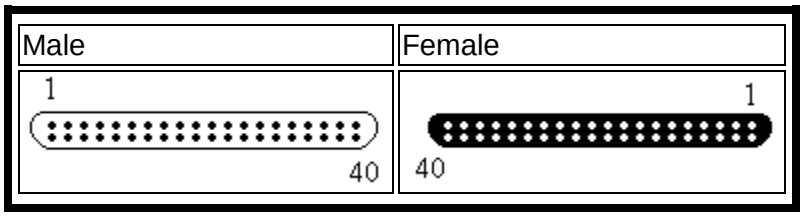
From the MII down to the physical medium is part of the PHY (tranceiver). The PHY may be integrated on the network card or it may be a separate device.

Reconciliation

This sub-layer translates the MAC terminology into MII terminology. It is a transparent, functionless sub-layer. Signals just pass through.

MII

The Media Independend Interface is the connection between the MAC layer and the PHY. It has the same function as the AUI connector in 10Base networks. The connector is, when the tranceiver is not integrated on the circuit board, a MII40 connector, which actually is 40 pin Sub-D connector.



Pin	Function	Pin	Function
1	+5 Vdc/ 3.3 Vdc	21	+5 Vdc/ +3.3 Vdc
2	MDIO	22	Ground
3	MDC	23	Ground
4	Rx Data	24	Ground
5	Rx Data	25	Ground
6	Rx Data	26	Ground
7	Rx Data	27	Ground
8	Rx Data Valid	28	Ground
9	Rx Clock	29	Ground
10	Rx Error	30	Ground

11	Tx Error	31	Ground
12	Tx Clock	32	Ground
13	Tx Enable	33	Ground
14	Tx Data	34	Ground
15	Tx Data	35	Ground
16	Tx Data	36	Ground
17	Tx Data	37	Ground
18	Collision	38	Ground
19	Carrier Sense	39	Ground
20	+5 Vdc/ +3.3 Vdc	40	+5 Vdc/ +3.3 Vdc

The data path is 4 bits wide (one nibble) and operates at 25 MHz, which leads to the throughput of 4 x 25 = 100 Mbps.

There are several options on the MII for different functions:

- There is the different clock speed for 10/100 Mbps selection. For 100 Mbps the clock speed is 25 MHz and for 10 Mbps it is 2.5 MHz.
- If a PHY (tranceiver) supports full-duplex transmission, it can be enabled on the MII
- Also a lot of management features are possibly set on this level. If you want to know more about those read the IEEE 802.3u specifications.
- With MII there are two ways power can be provided to the units. You eighter have +5V or +3.3V power. The latest one is for use with notebooks. Do not mix units with different voltages!
- The maximum cable length between the MII and the actual tranceiver is 0.5 meter.

PHY

The difference between the different 100 Mbps topologies is in the PHY part. This section connects directly to the cable and is responsible for everything that is medium depended like: line encoding, transmission voltages, etc.

The different physical media standards:

- 100Base-Tx
- 100Base-T4
- 100Base-Fx

Repeaters

Repeaters are devices that extend the signal to reach more length or to send out the signal to more devices. The later one are multiport repeaters, which are more commonly known as HUBs. In this repeater description we will use the term repeater for every repeaters.

100base repeaters can facilitate all the different 100base ethernet standards, but they don't need to. It can even be that there is an option to buy additional tranceivers to provide for the right connection to a medium. Connecting different ports (e.g. T4 and Tx) is not possible unless at least one of the repeaters is capable of translating the other ones signal.

If a maximum link length of 100 meters/ 328 feet is maintained the maximum amount of repeaters is two. With a maximum inter-repeater link of 5 meters/ 15 feet. Ofcourse shortening the link to the end stations makes it possible to extend the inter-repeater link, as long as the maximum distance does not exceed the 205 meter/ 615 feet. To extend this length switches or bridges are needed. With Fast-Ethernet there are defined two types of repeaters, which are called Class I and Class II.

The difference between them lies in the timing delay. A Class I repeater is slower than a Class II repeater. As a result there may be only one Class I repeater and two Class II repeaters in an 100Base collision domain.

The Reason for a Class I and II Repeater

The reason for a Class I repeater doesn't seem obvious, but there is a reason. The translation between 100Base-T4 and 100Base-Tx or Fx takes more time than translation between 100Base-Tx and 100Base-Fx. The tranceiver of the Tx and Fx standards look very much alike and therefor translation is easy. Where the tranceiver of T4 differs a lot from the other two.

A repeater with a T4 and another 100Base interface will almost certainly be a Class I repeater. Another reason for Class I repeaters is that they might facilitate some additional features, which can not be implemented in a Class II repeater because of the tight timing delay that restricts a Class II repeater. An example of an additional feature is: stacking.

100BASE-Tx

100Base-Tx Quick Overview	
IEEE-spec	802.3u
Wire speed	100 Mbps
Cable type	UTP CAT 5
Connector type	RJ45
Used pins	1 & 2, 3 & 6
Max. length of a segment	100m/328ft
Max. number of taps per segment	2
Max. amount of stations per network	1024
Max. amount of repeaters	2
Topology	Star

How it fits into OSI-Layer 1

OSI Layer 1	DTE	Repeater
	Reconciliation	
	MII	Baseband Repeater Unit
	PCS	PCS and PMA
	PMA	PMA
	PMD	

	AUTONEG
	MDI
	The Physical Medium

PHY
The combination of the PCS to MDI is called a Tx tranceiver. PHY is a weird abbreviation for Physical Layer Entity. The actual tranceiver is based on the FDDI standard (X3T9.5).

PCS
The Physical Coding Sub-layer is as the name implies responsible for the encoding and decoding of the signals so they can be understood by the lower or upper layers. The coding scheme used is a 4B5B coding, which means that every nibble received from the MAC sub-layer is coded in to a 5 bit symbol.

Tx uses after the coding a MLT-3 signaling, which is a three-level signal. In the MLT-3 a change of level is marked as a logical one and a non-change is a logical zero. The data rate per pair is 100 Mbps. The transition rate on each pair is 5/4 of that rate, or 125 MHz.

Responsiblities:
- Data encoding
- Error checking
- Collision detection

PMA
The Physical Medium Attachement is responsible for all the analog functions like transmit wave-shaping and receive data discrimination.

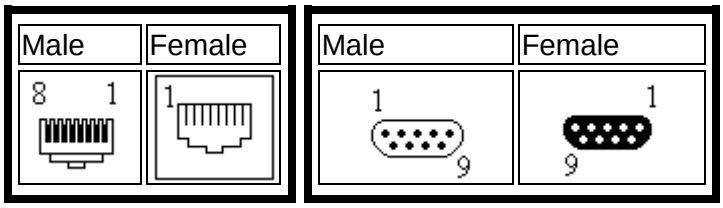
Responsiblities:
- Link monitor
- Carrier detect
- Far end fault

PMD
The Physical Medium Dependend sub-layer for Tx is borrowed from the FDDI standard (ANSI X3.263 TP-PMD, Revision 2.2: 1 March 1995). It is not a 100% copy, but it comes close.

Responsiblities:
- Analog functions
- Clock recovery
- Bit coding
- Scrambling (Tx)

AUTONEG
Auto-Negotiation (also called NWAY) is a setting which can be turned on only on UTP networks (not STP). When turned on it provides the posibility of autodetecting the far ends capabilities. This way it can detect a 10 Mbps card and make connectivity possible with the 10/100 Mbps card.

MDI
The Media Dependend Interface for Tx is the RJ45 connector for UTP or the Sub-D9 for STP.

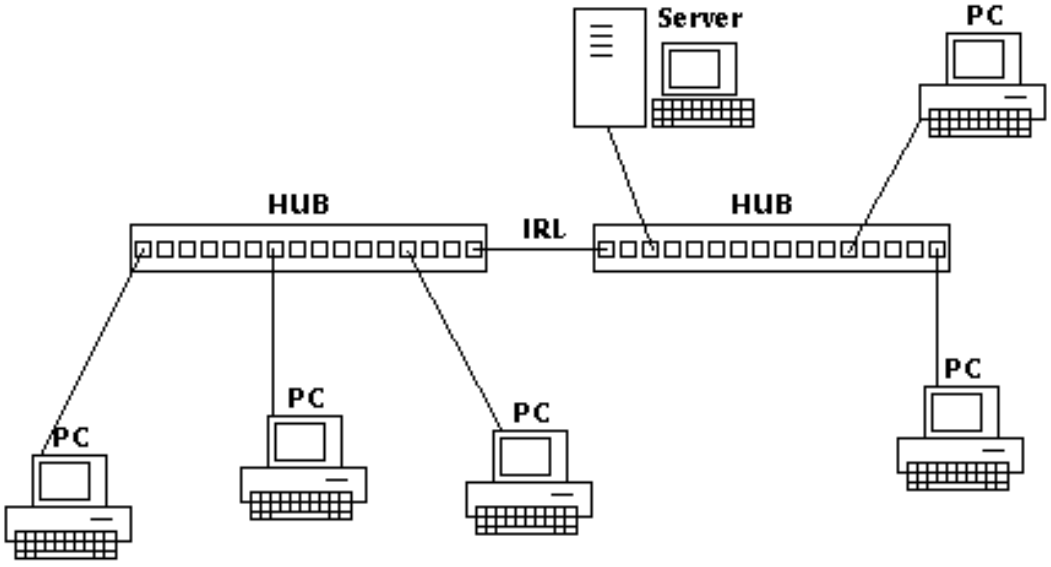


Pin	Signal
1	TX+
2	TX-
3	RX+
4	
5	
6	RX-
7	
8	

Pin	Signal
1	RX+
2	
3	
4	
5	TX+
6	RX-
7	
8	
9	RX-
Shield	Chassis

The Medium

Tx networks transmit their data over 4-wire (2 pair) Unshielded Twisted Pair or Shielded Twisted Pair. This can only be Cat. 5 (for UTP) or Type 1 (for STP) cabling with a maximum distance of 100 meter. The entire collision domain may be 200 meters. Adding repeaters will not get you greater distances, adding fiber repeaters will get you a little more distance between two end stations. Adding bridges (switches) or routers is the only real way you can extend your network over larger distances.



100BASE-T4

100Base-T4 Quick Overview	
IEEE-spec	802.3u
Wire speed	100 Mbps
Cable type	UTP CAT 3 or better
Connector type	RJ45
Used pins	1 & 2, 3 & 6, 4 & 5, 7 & 8
Max. length of a segment	100m/328ft
Max. number of taps per segment	2
Max. amount of stations per network	1024 D
Max. amount of repeaters	2
Topology	Star

How it fits into OSI-Layer 1

OSI Layer 1	DTE	Repeater
	Reconciliation	
	MII	Baseband Repeater Unit
	PCS	PCS and PMA
	PMA	PMA
	MDI	
	The Physical Medium	

PHY

The combination of the PCS and PMA, and the MDI, is called a T4 tranceiver. PHY is a weird abbreviation for Physical Layer Entity.

PCS

As the name Physical Coding Sub-layer implies, this layer is responsible for the coding and decoding of the data.

The PCS receives nibbles from the MII and froms them into octets (2 nibbles). An 8B6T coding is used on these octets, which makes sure that every octet is coded into a group of six three level symbols, which makes it possible to code more that one bit into a clock cycle. Now the symbols are send in a round robin-fashion to de three transmit pairs. Since there are three transmit and receive pairs the speed per pair 33.33333 Mbps. The transistion rate is 3/4 of that rate or 25 MHz.

Responsiblities:

- Data encoding
- Error checking
- Collision detection

PMA

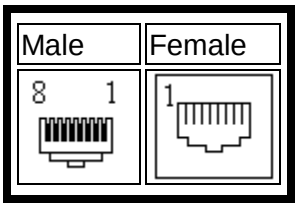
The Physical Medium Attachement is responsible for all the analog functions like transmit wave-shaping and receive data discrimination.

Responsiblities:

- Link integrity
- Carrier detect
- Pair skew alignment
- Clock recovery

MDI

The Media Dependend Interface for T4 is the RJ45 connector.

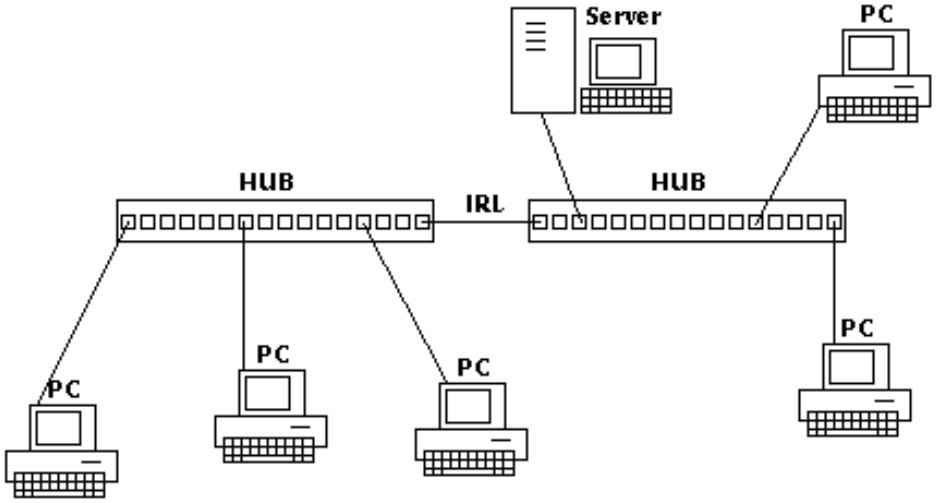


Pin	Signal
1	TX_D1+
2	TX_D1-
3	RX_D2+
4	BI_D3+
5	BI_D3-
6	RX_D2-
7	BI_D4+
8	BI_D4-

There is one dedicated transmit and one receive pair and two bidirectional pairs, which can be used for transmit and receive.

The Medium

T4 networks transmit their data over 8-wire (4 pair) Unshielded Twisted Pair. This may be Cat. 3 or better cabling with a maximum distance of 100 meter. The entire collision domain may be 200 meters. Adding repeaters will not get you greater distances, even if you use fiber repeaters the largest distance between two end stations will be 200 meters. Adding bridges (switches) or routers is the only way you can extend your network over larger distances.



100BASE-Fx

100Base-Fx Quick Overview	
IEEE-spec	802.3u
Wire speed	100 Mbps
Cable type	Fiber
Connector type	Various
Max. length of a segment half-duplex	412m/1300ft
Max. length of a segment full-duplex	2000m/6600ft
Max. number of taps per segment	2
Max. amount of stations per network	1024
Max. amount of repeaters	2
Topology	Star

How it fits into OSI-Layer 1

OSI Layer 1	DTE	Repeater
	Reconciliation	
	MII	Baseband Repeater Unit
	PCS	PCS and PMA
	PMA	PMA
	PMD	
	AUTONEG	
	MDI	
	The Physical Medium	

PHY
The combination of the PCS to MDI is called a Fx tranceiver. PHY is a weird abbreviation for Physical Layer Entity. The actual tranceiver is based on the FDDI standard (X3T9.5).

PCS
The Physical Coding Sub-layer is as the name implies responsible for the encoding and decoding of the signals so they can be understood by the lower or upper layers. The coding scheme used is a 4B5B coding, which means that every nibble received from the MAC sub-layer is coded in to a 5 bit symbol.

Fx uses after the coding a NRZI signaling, which is a two-level signal. According to NRZI a logical one is a change of state and a logical zero is not. The reason for a less complex signaling scheme in the Fx standard is due to the fact that fiber is not receptable to noise. The data rate per strain is 100 Mbps. The transition rate on each strain is 5/4 of that rate, or 125 MHz.

Responsiblities:
- Data encoding
- Error checking
- Collision detection

PMA
The Physical Medium Attachement is responsible for all the analog functions like transmit wave-shaping and receive data discrimination.

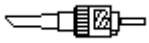
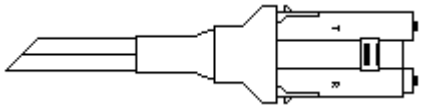
Responsiblities:
- Link monitor
- Carrier detect
- Far end fault

PMD
The Physical Medium Dependend sub-layer for Fx is borrowed from the FDDI standard. The actual tranceiver is based on the FDDI standard ISO 9314-3: 1990.

Responsiblities:
- Analog functions
- Clock recovery
- Bit coding
- Scrambling (Tx)

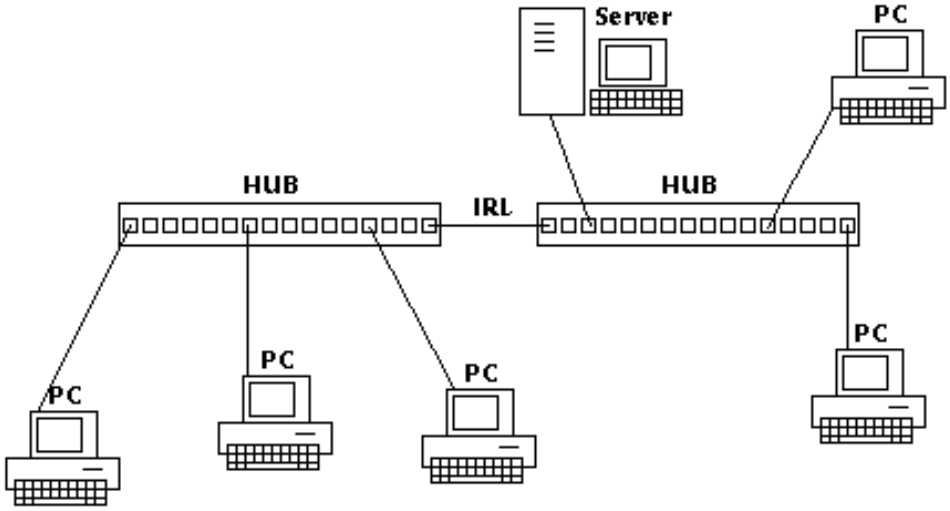
AUTONEG
Auto-Negotiation (also called NWAY) is a setting which can be turned on. When turned on it provides the posibility of autodetecting the far ends capabilities. This way it can detect a 10 Mbps card and make connectivity possible between the 10/100 Mbps card and the 10 Mbps card.

MDI
The Media Dependend Interface for Fx is not just one connector. It can be transported over various connetors.

	Male	Female	Side
ST			
SC			
SMA905			
SMA906			
FDDI			

The Medium

Fx networks transmit their data over 2 strands of fiber. This might be single mode or multimode. The actual design was for 62.5/125 µm multimode fiber and a wavelength of 1300 nm. Single mode fiber is NOT part of the standard. There for an exact estimate of the distance is not given, but distances of 20 km/ 660000 feet should be possible.



1000 Mbps Ethernet

Introduction

In July 1996 the IEEE802.3 formed the 802.3z task force responsible for the development of a Gigabit Ethernet standard. In March 1997 a split was made resulting in the original IEEE802.3z task force and a IEEE802.3ab task force.

The IEEE802.3z standard will result in a standard (around March of 1998) that deals with the MAC-layer specifications and the physical-layer specifications for fiber (1000BASE-SX and 1000BASE-LX) and a short copper cable run (1000BASE-CX).

The IEEE802.3ab standard only handles the compatibility with the already installed cabling (UTP CAT5) with cable runs of up to 100 mtr (according to the EIA/TIA 586-A spec). This standard will be finished near the end of 1998 and is only a physical-layer specification called 1000BASE-T.

A rough overview of Gigabit Ethernet and OSI would look like this:

2	MAC	MAC (Full Duplex/ Half Duplex)			
			GMII		
1	PHY	1000BASE-X Encode/Decode			1000BASE-T Encode/Decode
		1000BASE-SX	1000BASE-LX	1000BASE-CX	1000BASE-T

This document will describe the MAC-layer and the GMII. At the end of this document you will find links to the IEEE802.3z and IEEE802.3ab PHY-layer pages.

MAC

Some enhancements had to made to the CSMA/CD protocol to maintain a 200 meter collision domain when using gigabit speeds.

The carrier time and Ethernet slot time needed to be extended from their original 64 bytes to 512 bytes. Packets larger then 512 bytes will not be extended, but packets shorter then 512 bytes will use the extended time. To prevent the performance lost in networks with a large amount of small packets a new concept is added called packet bursting. This allows devices to send bursts of small packets to fully utilize the bandwidth.

Note: Full-duplex connections are NOT subject to these changes.

Reconciliation

The reconciliation sub-layer is actually a transparent interface between the MAC sub-layer and the PHY.

GMII

The Gigabit Media Independent Interface connects the reconciliation sub-layer to the PHY. It includes a 8-bit data bus which operates at 125 MHz. It also has clock signals, carrier indicators and error conditions. At the time of writing this document this is all the information that we have.

The different physical connections:

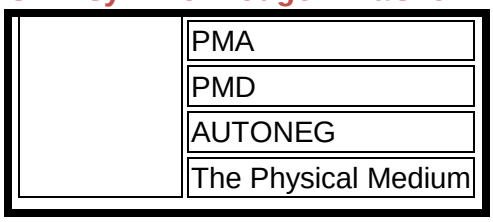
- 1 GBits Ethernet for Short haul fiber- 1000Base-SX
- 1 GBits Ethernet for Long haul fiber- 1000Base-LX
- 1 GBits Ethernet for Short copper links- 1000Base-CX
- 1 GBits Ethernet for Horizontal copper- 1000Base-T

Notes on Gigabit Ethernet

A new repeater is being defined by some vendors and is called a buffered distributor. This box is a full-duplex, multi-port repeater, which may buffer some frames before forwarding.

IEEE802.3ab
How it fits into OSI-Layer 1

OSI Layer 1	GMII
	PCS



From the GMII down to the physical medium is part of the PHY (tranceiver). The PHY may be integrated on the network card or it may be a separate device.

PCS
The PCS for horizontal copper (1000Base-T) is not yet defined.

PMA
[META]

PMD
Horizontal copper (100 meter) over Cat. 5 UTP cable is not yet defined.
STANDARD EXPECTED IN 1999