

## Value engineering ten gigabit Ethernet

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Ten gigabit Ethernet standards cover a range of technologies that will cover distances from a metre to 40 km. With ten gigabit technology the transmission speed of choice for the next few years (until 40 and 100 gigabits/sec hits the streets) picking the right technology for the application is essential to value engineer the solution. Incorrect choices will mean that at worst the installation won't work: more likely is that a user will massively overspend to achieve an outcome that could have been realised at much lower cost.

Ten gigabit Ethernet is covered under four principal standards

- IEEE 802.3ae – 10GBASE-FX 2002
- IEEE 802.3ak – 10GBASE-CX4 2004
- IEEE 802.3an – 10GBASE-T 2006
- IEEE 802.3aq – 10GBASE-LRM 2006

And three proposed standards

10GBASE-KR/KX4- IEEE802.3ap (2007) (Ethernet backplane) Supports operation over a single lane across 2 connectors over copper traces for links consistent with lengths up to at least 1m

IEEE 802.3av (2009) EPON, Ethernet Passive Optical Network. Supports subscriber access networks using point to multipoint topologies on optical fibre

Recently several manufacturers have introduced 80 km-range ER interfaces under the name 10GBASE-ZR. This is not specified within the IEEE 802.3ae standard and manufacturers have created their own specifications based upon the 80 km PHY described in the OC-192/STM-64 SDH/SONET specifications. IEEE 802.3ak – 10GBASE-CX4 (2004). This is a screened cable solution (also known as Infiniband) that supports 10 gigabit Ethernet connection up to 15 m. Some claim this is the cheapest method of interconnection (up to 15 m).

IEEE 802.3an – 10GBASE-T (2006). This is ten gigabit over twisted pair copper cabling. The Standard calls for 100 m transmission over screened Cat 6 cable, Cat 7 cable and a new range of cables called Augmented Category 6, or Cat6<sub>A</sub> or Class E<sub>A</sub>. A new range of cable standards will come out later this year or early 2008 to fully define what this Cat6<sub>A</sub> cable looks like.

The IEEE802.3an Standard also expects that transmission up to 55 m should be possible over existing Cat unshielded (UTP) installations. This has yet to be proven and another standard, TSB 155, which gives a test method to see if your existing cable is ten gigabit compatible, expects that a distance of up to 37 m may be more realistic.

TSB 155 and the other forthcoming Cat6A Standards give a range of mitigation techniques, such as physically separating all your cables, that may be needed in order to make 10GBASE-T work over Cat 6 UTP.

A debate currently exists within the industry as to whether unscreened cables can ever support the 500 MHz (UHF) bandwidth of 10GBASE-T without causing unacceptable levels of interference between cables.

IEEE 802.3ae – 10GBASE-FX (2002). This range of standards describes a number of optical fibre interfaces that would take the transmission distance from a few tens of metres to over 40 km.

IEEE 802.3ae is also known as 10GBASE-xyz, where;

- x represents the wavelength of operation
  - = S short wave, 850 nm
  - = L long wave, 1300 nm
  - = E extra long wave, 1550 nm
- y represents the technology used
  - = W (WAN using SONET ST-192 encoding)
  - = R (LAN using serial encoding)
  - = X (LAN using CWDM (Coarse Wavelength Division Multiplexing))
- z = the number of CWDM channels, if used (currently four)

GBASE-SR is often of the most interest in the LAN and data centre environment as it uses the lowest cost VCSEL (Vertical Cavity Surface Emitting Laser) interface. Its transmission distance on the four multimode fibres most often encountered is;

| Fibre               | Distance |
|---------------------|----------|
| <b>OM1 62.5/125</b> | 33 m     |
| <b>OM2 50/125</b>   | 82 m     |
| <b>OM3 50/125</b>   | 300 m    |
| <b>OM3+ 50/125</b>  | 550 m    |

OM3 is the fibre designed to go hand-in-hand with ten gigabit LANs. OM3+ is an enhanced performance fibre with a higher bandwidth that is not mentioned in the standards but is marketed by all the major fibre manufacturers (under various brand names).

10GBASE-LX4 is a Course Wavelength Division Multiplexing technique that manages a distance of 300 m over old multimode fibre by sending four 2.5 gigabit data streams over four different wavelength, or colours, of light. That capability comes at a significant cost however.

10GBASE-LW can send the signal up to 10 km over singlemode fibre. 10GBASE-ER can send the signal up to 40 km by utilising the long wavelength 1550 nm band. Both the LW and EW interface use an expensive telecommunications grade singlemode laser interface and would be very expensive if used over short distances.

IEEE 802.3aq – 10GBASE-LRM (2006). A more recent addition is the LRM standard which endeavours to also use old multimode fibre (up to 220 m) but in a simpler method compared to 10GBASE-LX4. It uses a singlemode laser (and is thus still very expensive) plus a special offset patchcord to launch the laser light off-centre and thus avoiding the differential mode delay issues associated with old multimode fibre.

### Cost engineering

- Up to 100 m. The lowest installed cost is likely to come from the copper 10GBASE-T interface and cabling. One must be aware though of potential impracticalities when trying to achieve this with unscreened cable. There is also the running cost issue of the higher power consumption, (and heat generation of a 10GBASE-T chip). The approximate extra electricity cost is £2 per copper 10GBASE-T link per year in excess of the running costs when using fibre, e.g. 5000 links = £10k per year extra electricity plus a potential extra £10k year air conditioning.
- Up to 300 m. For a new installation a combination of OM3 optical fibre and 10GBASE-SR is the lowest cost combination. If it is required to use an existing old fibre then the 10GBASE-LRM can be used up to 220 mm and 10GBASE-LX4 can be used up to 300 m. It must be stressed however that the latter two are expensive equipment options and are not suited to new installations where it makes sense to install the latest and most appropriate fibre.
- Up to 550 m. Although not included in the Standards, the use of OM3+ fibre up to 550m, with the low cost 10GBASE-SR interface is still cheaper than migrating to singlemode.
- Beyond 550 m. Singlemode fibre interfaces will have to be used.

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