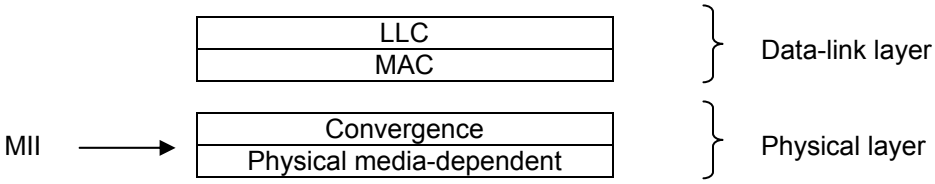
Vysokorýchlostné siete LAN

Najrozšírenejšie vysokorýchlostné LAN siete sú založené na technológiách 10Mbps Ethernet, resp. IEEE 802.3, pričom sú rozšírené siete o rýchlostiach 100Mbps a 1Gbps.

- fyzická vrstva je rozdelená na Convergence Sublayer a Physical media-dependent sublayer



MII - Medium independent interface

100 Mbps Ethernet (Fast Ethernet)

IEEE pracovalo na špecifikáciách vysokorýchlostného 100Mbps Ethernetu. Nedohodli sa však úplne na tom, či zachovajú pôvodnú MAC metódu – CSMA/CD alebo zadefinujú novú. Tak vznikli dve grupy a následne aj dve špecifikácie – 100BaseT a 100VG-AnyLAN.

100BaseT

Špecifikuje 100Mbps Ethernet na UTP a STP kabeláži štandardizované ako **802.3u**. MAC podvrstva zachováva kompatibilnú s MAC podvrstvou špecifikácie 802.3. Okrem MAC metódy zachováva aj formát a veľkosť rámca, error-detection mechanizmus. Podporuje dual speed, t.j. 10 a 100 Mbps použitím 100BaseT fast link pulses (FLPs). Convergence podvrstva kóduje dáta do 4-bitov pre MII a do MAC podvrstvy prepája carrier sense a colision detection signal generované z PMD podvrstvy. Podporuje dva typy signalizácie - 100BaseX a 4T+.

Signalizácia 100BaseX používa kódovanie 4B5B (výsledná baudová rýchlosť 125MBd), pre prácu jej postačujú dva páry vodičov ako pri 10Mbps. Toto kódovanie navyše umožnuje využiť zvyšné kódové slová na link control funkcie ($2^4 = 16$, $2^5 = 32$ => mám ešte 16 slov navyše). Je použitá pri **100BaseTX** a **100BaseFX** typoch médií.

Signalizácia 4T+ používa 1 pár vodičov na detekciu kolízie a ďalšie 3 na prenos údajov. Používa kódovanie 8B6T, teda osmicu bitov do šestíc ternárnych (trojúrovňových) symbolov. Baudová rýchlosť je potom 33MBd a umožňuje 100Mbps prenos na kabeláži UTP category 3. Pretože kódujeme osmice, je. Vzhľadom na kódovanie 8B6T máme $2^8 = 256$ vstupných slov a $3^6 = 729$ možných kódových slov. Táto redundancia sa využíva na synchronizáciu a DC-free. Je použitá pri **100BaseT4** type média, podporuje iba poloduplex.

Ešte existuje špecifikácia **100BaseT2**, ktorá umožňuje 100Mbps prenos na kabeláži UTP category 3 po dvoch pároch, pričom využíva kódovanie PAM5x5 (výsledná baudová rýchlosť 25MBd).

Hlavný rozdiel technológie 100BaseT oproti 10BaseT je okrem rýchlosti diameter siete. Jeho veľkosť je 205 metrov z čoho vyplýva maximálna vzdialenosť medzi HUBom a DTE cca 100 metrov. To je asi 10x menej ako pri 10Mbps. Táto redukcia je kvôli tomu, že stanica aj pri prenose najmenšieho rámca (64B) musí vedieť detekovať kolíziu. Pretože rýchlosť šírenia signálu je rovnaká, ale prenosová rýchlosť sa zvýšila 10x, tak bolo potrebné zmenšiť maximálnu vzdialenosť 10x.

Prostredníctvom tzv **Fast link pulses** táto technológia kontroluje integritu linky medzi HUBom a 100BaseT zariadením a podporuje tzv. 100BaseT Autonegotiation Option, pomocou ktorej umožňuje zariadeniu a HUBu vymieňať informácie o ich možnostiach, dohodnúť si prenosovú rýchlosť (10 alebo 100Mbps), prenosový mód (full-duplex alebo polo-duplex) a typ použitej signalizácie (pri staniciach 100BaseT4 a 100BaseTX).
FPLs sú spätne kompatibilné s 10BaseT normal-link pulses (NLPs), obsahujú však viac info ako NLP, ktoré sú používané pri opísanom autonegociačnom procese medi HUBom a zariadením na sieti.

Fast Ethernet devices that support auto-negotiation send fast link pulses (FLP) to the adjacent link station to negotiate the SPEED and MODE of the link. The FLP signals carry information necessary to negotiate the highest level of service available for the link. The priority for services includes 100BaseTX full-duplex as the highest priority, then 100BaseT4, 100BaseTX, 10BaseT Full-Duplex, and finally 10BaseT (which has the lowest priority).

Charakteristiky troch druhov 100BaseT sietí:

vyššie vrstvy		
LLC podvrstva		
802.3 MAC podvrstva		
100BaseTX UTP cat.5, STP Type1,2 2 páry segment ≤ 100m network diameter ≤ 200m	**100BaseFX** 62,5/125µm multimód 1 pár optických vlákien segment ≤ 400m network diameter ≤ 400m	**100BaseT4** UTP cat.3, 4, 5 4 páry segment ≤ 100m network diameter ≤ 200m

Figure 7-10 The 100BaseTX is limited to a link distance of 100 meters.

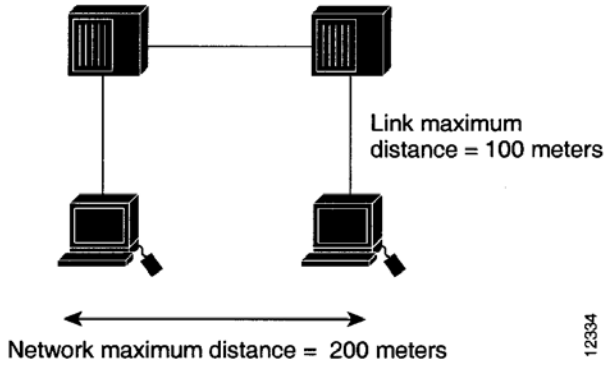
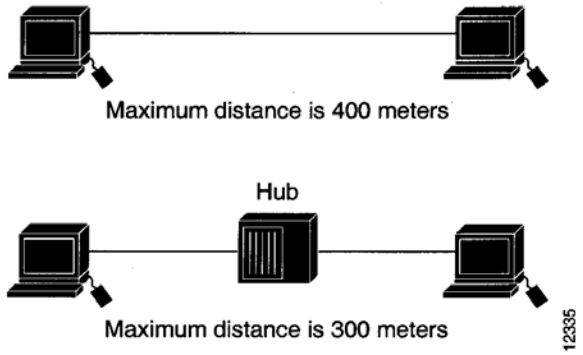


Figure 7-11 The 100BaseFX DTE-to-DTE limit is 400 meters.



100VG-AnyLAN

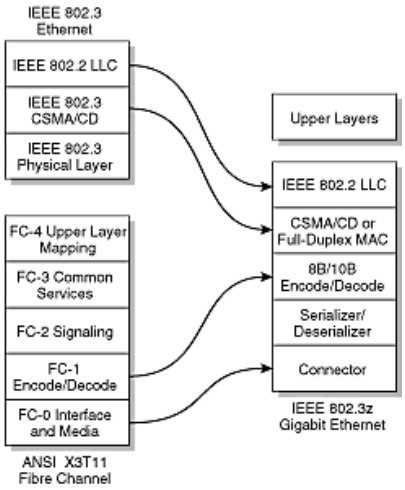
- špecifikácia pre 100Mbps Ethernet a Token Ring na štvorpárovom UTP
- MAC nie je kompatibilná s 802.3
- bola vyvinutáv v HP pre nové, time-sensitive aplikácie ako upgrade z Ethernetu a TokenRingu
- štandardizovaná ako 802.12
- podporuje rôzne druhy médií (4páry UTP cat3, 2 páry UTP cat4 alebo cat5, STP, Fiber optic)
- 100VG-AnyLAN HUBy sú v hierarchickej štruktúre
- používa demand-priority access method – eliminuje kolízie, môže byť viac zaťažený ako 100BaseT
- Demand Priority works like this: The hub directs all transmissions, acknowledging higher-priority packet requests before normal-priority requests. This effectively guarantees bandwidth to time-sensitive applications like voice, video, and multimedia applications.

Gigabitový Ethernet

standardized in June 1998
Je rozšírenie štandardu IEEE 802.3 na rýchlosť 1Gbps. Štandard IEEE 802.3z Gigabit Ethernet definuje Gigabitový Ethernet na optických médiách a na koaxiálnom kábli. Štandard 802.3ab definuje 1Gb Ethernet na kabeláži UTP. Podobne ako pri 100BaseT aj 1000Base-LX (SX, CX, T) umožňujú autonegociačnú option, a umožňujú dohodnúť full-duplex prenos na rýchlosti 1000 Mbps.

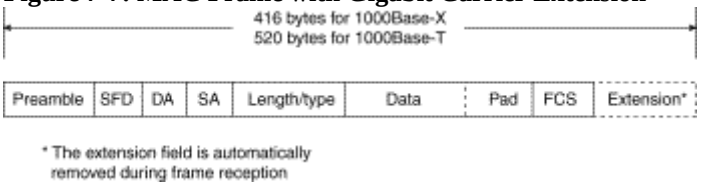
- zlúčením štandardov IEEE 802.3/Ethernet (LLC, prístupová metóda a frame format) a ANSI X3T11 Fibre Channel (médium, interface, encoding) vznikol štandard IEEE 802.3z Gigabit Ethernet. 802.3ab definuje 1Gb Ethernet na UTP
- bolo potrebných niekoľko zmien na fyizickom interface
- od data-link vrstvy je identický s Ethernetom

Leveraging these two technologies means that the standard can take advantage of the existing high-speed physical interface technology of FibreChannel while maintaining the IEEE 802.3 Ethernet frame format, backward compatibility for installed media, and use of full- or half-duplex carrier sense multiple access collision detect (CSMA/CD).



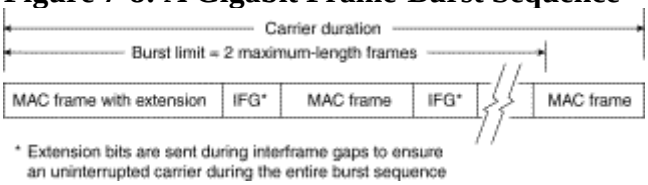
Samotná MAC podvrstva je podobná ako u Ethernetu a Fast Ethernetu (formát rámcov, prístupová metóda, network diameter). Umožňuje **half-duplex** prenos, kedy je použitá rovnaká CSMA/CD. Kvôli možnosti detekcie najkratšieho rámca sa musia pridať bity za rámec (carrier extention) s cieľom dodržať minimálnu dĺžku 520B pre 1000BaseT a 416B pre 1000Base-X. Navyše ako optional feature umožňuje frame bursting (stanica môže naraz vyslať celý burst rámcov). V každom prípade je half-duplex mód z hľadiska využitia kapacity veľmi neefektívny a preto sa prakticky ani nepoužíva.

Figure 7-7: MAC Frame with Gigabit Carrier Extension



Another change to the Ethernet CSMA/CD transmit specification was the addition of frame bursting for gigabit operation. Burst mode is a feature that allows a MAC to send a short sequence (a burst) of frames equal to approximately 5.4 maximum-length frames without having to relinquish control of the medium. The transmitting MAC fills each interframe interval with extension bits, as shown in Figure 7-8, so that other stations on the network will see that the network is busy and will not attempt transmission until after the burst is complete.

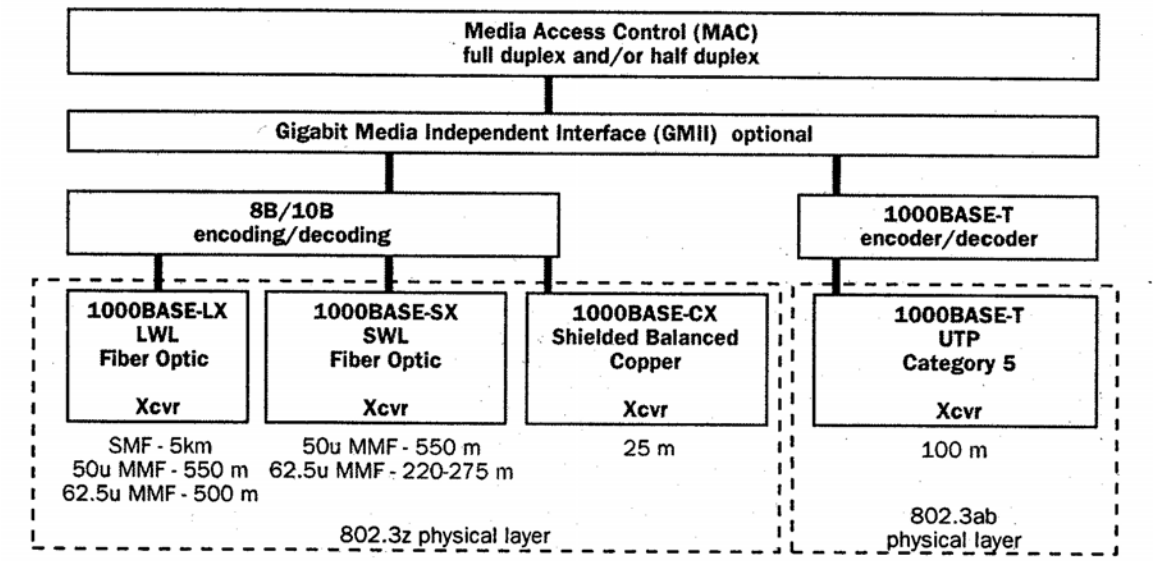
Figure 7-8: A Gigabit Frame-Burst Sequence



If the length of the first frame is less than the minimum frame length, an extension field is added to extend the frame length to the value indicated in Table 7-1. Subsequent frames in a frame-burst sequence do not need extension fields, and a frame burst may continue as long as the burst limit has not been reached. If the burst limit is reached after a frame transmission has begun, transmission is allowed to continue until that entire frame has been sent.

Používaný je hlavne **full-duplex** mód, určený pre point-to-point linky, typicky medzi dvomi switchmi, servermi a pod. Agregovaná kapacita dosahuje 2Gbps, pri použití zväzkov až 8Gbps. Full duplex prenos môže byť zriadený iba na point-to-point linkách, flow control metóda je definovaná štandardom 802.3x (tento štandard nie je použitý pri 100Mbps full-duplexe).

Jednotlivé vrstvy pri štandardoch Gigabitového Ethernetu vyzerajú nasledovne:

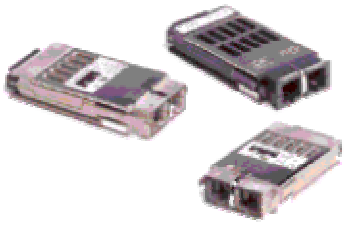


In order to obtain the 1000Mbps data bit rate across the UTP cable without breaking the FCC rules for emission, all 4 pairs of the cable are used. Hybrid circuits at each end of each pair are used to allow simultaneous transmission and reception of data (full-duplex) by separating the transmission signal from the receiving signal. Because some transmission signal still manages to couple itself to the receiving side there is an additional echo canceller built in, this is called a NEXT canceller. This system minimises the symbol rate.

Gigabit Ethernet Interface Carrier (GBIC)
Pretože existuje relatívne veľa špecifikácií fyzických prenosových médií pre Gigabitový Ethernet, bolo by nepraktické konštruovať zariadenia s interfejsami napevno zabudovanými. Preto bol definovaný tzv. *GBIC interface*, ktorý umožňuje použiť zásuvné moduly do zariadení (napr. Switch-ov).

A **GBIC** is a transceiver for gigabit ethernet. The name is an acronym for "gigabit interface converter". A GBIC measures 8.5 mm x 13.4 mm on its exposed edge and fits into a slot about 50 mm deep. By offering a standard, hot swappable electrical interface, one gigabit ethernet port can support the full range of physical media, from copper to 100 km single-mode fiber.

Cisco Gigabit Interface Converters]



3.1 Cisco 1000BASE-T GBIC

The Cisco 1000BASE-T GBIC (product number WS-G5483) connects a GBIC port to Category 5 wiring via a standard RJ-45 interface. The maximum Category 5 wiring distance is 328 feet (100 meters). For details, see the *Cisco 1000BASE-T Gigabit Interface Converter Data Sheet*.

3.2 Cisco 1000BASE-SX GBIC

The Cisco 1000BASE-SX GBIC (WS-G5484) operates on ordinary multimode fiber (MMF) optic link spans up to 1815 feet (550 m) long.

3.3 Cisco 1000BASE-LX/LH GBIC

The Cisco 1000BASE-LX/LH GBIC (WS-G5486) fully complies with the IEEE 802.3z 1000BASE-LX standard. However, its higher optical quality allows it to reach 6.2 miles (10 kilometers) over single-mode fiber (SMF), compared with the 3.1 miles (5 km) specified in the standard.

3.4 Cisco 1000BASE-ZX GBIC

The Cisco 1000BASE-ZX GBIC (WS-G5487) operates on ordinary single-mode fiber optic link spans up to 43.4 miles (70 km) long. Link spans of up to 62 miles (100 km) are possible using premium single-mode fiber or dispersion shifted single-mode fiber. The GBIC provides an optical link budget of 23 dB—the precise link span length will depend on multiple factors such as fiber quality, number of splices, and connectors.

When shorter distances of single-mode fiber are used, it might be necessary to insert an in-line optical attenuator in the link to avoid overloading the receiver:

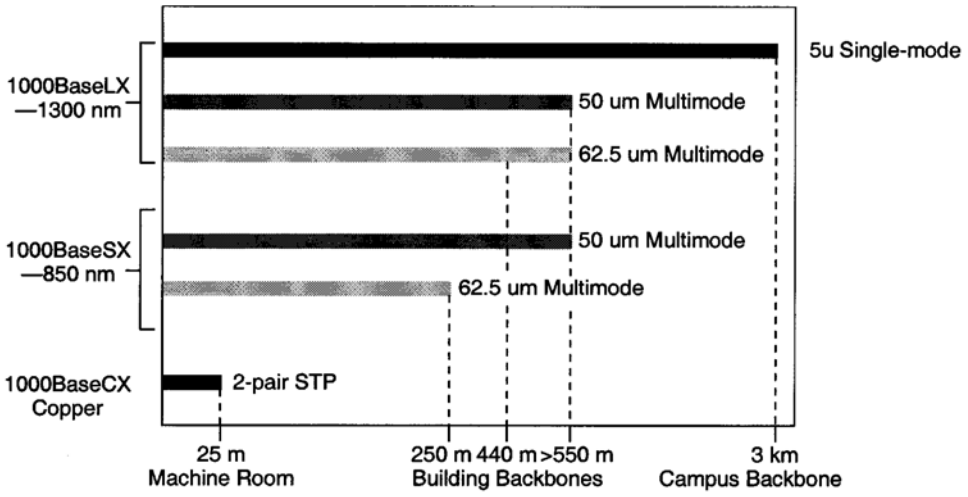
- A 5-dB or 10-dB inline optical attenuator should be inserted between the fiber-optic cable plant and the receiving port on the Cisco 1000BASE-ZX GBIC at each end of the link whenever the fiber-optic cable span is less than 15.5 miles (25 km).

Gigabit Ethernet prenosové médiá

optické mediá, koaxiál
- Physical media attachment (PMA) sublayer je zhodná s PMA pre Fiber Channel, iba rýchlosť signalizácie bola zvýšená z 1,062 gigabaud na 1,25 Gbaud
- 8B/10 encoding

twisted pair
- 1000Base-T – UTP
- kódovanie 5 level PAM – naraz kódujem 2 bity, 1 úroveň mám na FEC, pri 125Mbaud

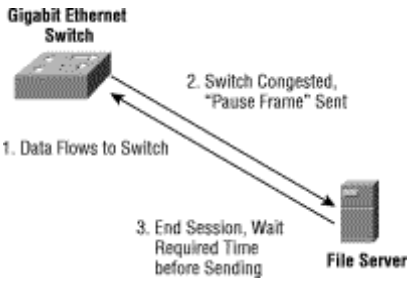
Figure 7-18 **The Gigabit Ethernet draft specifies these distance specifications for Gigabit Ethernet.**



IEEE 802.3x

The IEEE 802.3x committee is examining a method of flow control for full-duplex Ethernet. This mechanism is set up between the two stations on the point-to-point link. If the receiving station at the end becomes congested, it can send back a frame called a "pause frame" to the source at the opposite end of the connection, instructing that station to stop sending packets for a specific period of time. The sending station waits the requested time before sending more data. The receiving station can also send a frame back to the source with a time-to-wait of zero, instructing the source to begin sending data again. (See Figure 9.)

Figure 9: Operation of IEEE 802.3x Flow Control



This flow-control mechanism was developed to match the sending and receiving device throughput. For example, a server can transmit to a client at a rate of 3000 pps. The client, however, may not be able to accept packets at that rate because of CPU interrupts, excessive network broadcasts, or multitasking within the system. In this example, the client sends out a pause frame and requests that the server delay transmission for a certain period of time. This mechanism, though separate from the IEEE 802.3z work, complements Gigabit Ethernet by allowing gigabit devices to participate in this flow-control mechanism.

3.5 10 Gigabit Ethernet

The new 10 gigabit Ethernet standard encompasses seven different media types for LAN, MAN and WAN. It is currently specified by a supplementary standard, IEEE 802.3ae, and will be incorporated into a future revision of the IEEE 802.3 standard.

- 10GBASE-SR -- designed to support short distances over deployed multi-mode fiber cabling, it has a range of between 26 m and 82 m depending on cable type. It also supports 300 m operation over a new 2000 MHz.km multi-mode fiber.

- 10GBASE-LX4 -- uses wavelength division multiplexing to support ranges of between 240 m and 300 m over deployed multi-mode cabling. Also supports 10 km over single-mode fiber.

- 10GBASE-LR and 10GBASE-ER -- these standards support 10 km and 40 km respecively over single-mode fiber.

- 10GBASE-SW, 10GBASE-LW and 10GBASE-EW. These varieties use the WAN PHY, designed to interoperate with OC-192 / STM-64 SONET/SDH equipment. They correspond at the physical layer to 10GBASE-SR, 10GBASE-LR and 10GBASE-ER respectively, and hence use the same types of fiber and support the same distances. (There is no WAN PHY standard corresponding to 10GBASE-LX4.)

10 gigabit Ethernet is very new, and it remains to be seen which of the standards will gain commercial acceptance.