WAN (Wide Area Network)—A leased line connecting two LANs (Local Area Networks), usually at a distance from each other, e.g. a branch office and a main office. At each location, a router would connect the WAN link, ordered from a third-party to that LAN and route traffic between the two.

Leased Lines—(OSI layer-one) deliver bits in full duplex at a set (and paid for) rate between two locations over what appears to be a crossed-over serial cable between the two locations. How the telco (telephone company) or other provider accomplishes this is hidden from the user. Terminology includes:

Term	Description
Link / WAN Link	Generic term
Leased Circuit	Just a leased line. Telephone people like to call it a circuit
Serial Line / Link	There's only one wire pair in each direction, so the bits flow one after another
Point-to-Point Line / Link	Only two locations are connected, not multiple
T1	A specific leased line. Runs at 1.544 Mbps (24 x 64 Kbps digital telephones)
Private Line	Data isn't visible to other telco customers, unlike the open internet

CO (Central Office)—of the telco

CPE (Customer Premises Equipment)—Equipment that is physically at the customer (your) site.

CSU/DSU (Channel Service Unit / Data Service Unit)—Connects the router's serial output, probably from a WIC (WAN Interface Card), to the telco's wire. Like a modem, except that both sides are digital (modems add digital/analog conversion). If the CSU/DSU isn't part of the WIC card, then a short DTE serial cable will run from a serial WIC card to the CSU/DSU.

DTE (Data Terminal Equipment) Cable—Serial cable connecting router to the CSU/DSU. The CSU/DSU end of the cable has a male connector.

DCE (Data Communications Equipment)—Serial cable that can be combined with a DTE cable to produce a serial crossover cable between two routers. Has a female connector. The router with the DCE cable will need to produce a clock signal to make it work.

```
R(config-if)# clock rate 64000
```

Speeds Available—multiples of 64 Kbps until T1 (1.544 Mbps = 24 x 64K), then multiples of T1.

Layer 2 Protocols for Leased Lines:

- HDLC (High-level Data Link Control)
- PPP (Point-to-Point Protocol)

Encapsulation—at each router (OSI layer 3), the layer 2 encapsulation is stripped off (de-encapsulation) and a fresh L2 encapsulation is applied for the next hop. Thus, L2 addressing is specific to each hop, while the inner L3 addressing denotes the final destination and is good for the whole voyage.

HDLC

HDLC Frame Fields—since the line is point-to-point, the source and destination are implicit.

Field	Size (Bytes)	Description
Flag	1	Known bit pattern to announce a frame (like Ethernet preamble)
Address	1	Historical. (Destination) Telcos used to offer "multi-drop" lines; useless now
Control	1	Historical
Type	2	Non-standard Ciscoism—Tells what layer 3 protocol is encapsulated.
Data	Varies	
FCS	FCS	Error detection (Frame Check Sequence)

Ethernet WANs

Ethernet can be offered as a layer-2 service, compared to serial lines, which are L1.

1000BASE-LX is good for 5km cable lengths, and 1000BASE-ZX is good for 70km.

PoP (Point of Presence)—The service provider's equipment that is connected to the customer. Could even be CPE (Customer Premises Equipment), but is owned and controlled by the provider.

EoMPLS (Ethernet over MultiProtocol Label Switching)—point-to-point service that pretends to be an Ethernet fiber link. At the client sites, Ethernet is used for both L1 and L2. MAC addresses in the Ethernet headers correspond to the customer's routers at each end.

The Internet as a WAN

Traditionally, businesses would use a leased line to an ISP for their internet access. Consumers would use DSL or cable.

DSL (Digital Subscriber Line)—short distance (miles) over a single telephone pair. The customer site gets a modem, which connects to the customer's router.

DSLAM (DSL Access Multiplexer)—At the telco, terminates multiple customer DSL lines, splitting the voice from data.

Asymmetric Speeds—Download (to the home) can be faster than upload speed.

Cable Internet—just like DSL in the home, except uses a CATV (CAble TeleVision) modem.