Application White Paper
Ethernet and E1

Introduction

The methods of transmission used in Ethernet and in E1 systems are very dissimilar. The greatest difference is that Ethernet works on a broadcast medium in a multi-point to multi-point environment while E1 works as a point-to-point (end-to-end) bit-stream with fixed bandwidth and low latency.

Ethernet

Ethernet is a family of frame-based computer networking technologies for local area networks (LANs). Ethernet defines a number of wiring and signaling standards for the Physical Layer of the OSI networking model as well as a common addressing format and Media Access Control at the Data Link Layer.

Ethernet was originally based on the idea of computers communicating over a shared coaxial cable acting as a broadcast transmission medium. The methods used show some similarities to radio systems, although there are fundamental differences, such as the fact that it is much easier to detect collisions in a cable broadcast system than a radio broadcast. The common cable providing the communication channel was likened to the ether and it was from this reference that the name "Ethernet" was derived.

Ethernet is standardized as IEEE 802.3. The combination of the twisted pair versions of Ethernet for connecting end systems to the network, along with the fiber optic versions for site backbones, is the most widespread wired LAN technology in use today.

G.703 E1

The E1 standards form part of the Plesiochronous Digital Hierarchy (PDH) where groups of E1 circuits may be bundled onto higher capacity E3 links between telephone exchanges or countries. This allows a network operator to provide a private end-to-end E1 circuit between customers in different countries that share single high capacity links in between.

In practice, only E1 (30 circuit) and E3 (480 circuit) versions are used. Physically E1 is transmitted as 32 timeslots and E3 as 512 timeslots. However, in E1 one timeslot is used for framing and typically one is allocated for signaling call setup and tear down. Unlike Internet data services, E-carrier systems permanently allocate capacity for a voice call for its entire duration. This ensures high call quality because the transmission arrives with the same short delay (latency) and capacity at all times.

G.703 is an ITU recommendation which originally described voice over digital networks, associated with the PCM standard. Voice to digital conversion according to PCM requires a bandwidth of 64 kbps (+/- 100 ppm), resulting in the basic unit for G.703 (E0). By multiplication, this results in e.g. T1 (1544 kbps) and E1 (2048 kbps). Modern networks are working with voice and data and so does G.703.

G.703 recommendation is the electrical and functional description. Other characteristics are described in other G-standards. Some major definitions include G.704 for Framing, G.706 for CRC-4 procedure and G.732 for Fault handling.

G.703 can be transported over balanced (120 ohm TP) and unbalanced (dual 75 ohm coax) wires. The balanced version with a speed of 64kbps, is split in three different ways of transmission: co-directional (4-wire), central-directional (6/8 wire) and contra-directional (8-wire).

Mixed E1 and Ethernet Applications

When one understands the extreme differences between Ethernet and E1, it is plain to see that using the term "converter" indicates a lack of knowledge in this application area. The mix of applications falls into one of two camps:
A. Ethernet over E1
B. E1 over Ethernet

Important: To be specific for the application and required equipment, we must use this transport terminology.

Ethernet over E1

When we speak of Ethernet over E1, we include LAN extension applications (LAN to LAN) using E1 or multiple E1s as a transport system between the two LANs.

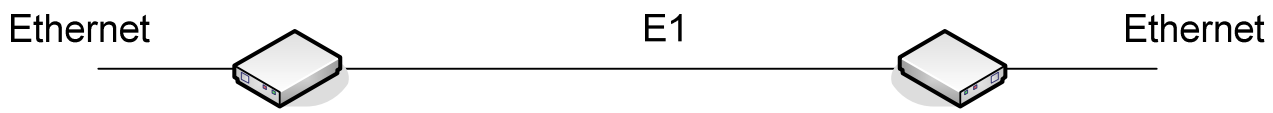

Figure 1. Ethernet over Single E1

E1 provides a serial bit stream as a transmission medium. In order to carry Ethernet packets over this serial bit stream, they must first be "encapsulated" or wrapped in a bit stream transport protocol. These protocols include PPP (Point-to-Point Protocol), FR (Frame Relay), and HDLC (High-level Data Link Control). Another wrapper, specific to Cisco routers, is a modified header HDLC which we refer to as "Cisco HDLC" or "cHDLC".

The Ethernet encapsulation takes place at L2 (Data Link). Bridges will use only this layer of encapsulation. Only Ethernet LANs with IP addresses in the same subnet can be connected with bridges. If the subnets are different then a Router is required. Routers work at the TCP/IP layer (L3 or Network Layer).

Products for Ethernet over E1.
EOE1 – Uses Unframed E1 only and provides bridging with standard HDLC encapsulation.
EOE1A – Same as EOE1 but additionally with web management and SNMP (Simple Network Management Protocol) support.
ETU01 – A stand alone DSU/CSU supports Unframed/Framed E1 and modular interface** (see below)
ETU01A – Same as ETU01 but additionally with LCD and Console management. SNMP option.
FRM220A-E1/ET100 – This is a card based Ethernet bridge solution for the FRM220A series.

** ETU/TTU Interface modules for Ethernet.
Bridging: **ET10/100** interface supports bridging with HDLC encapsulation.
Routing: **ET100R** interface is an embedded Router that supports PPP, HDLC and cHDLC encapsulations

Ethernet over multiple E1s

When multiple E1 signals are "bundled" to form a single transport, we refer to it as an "**Inverse Multiplexer**".

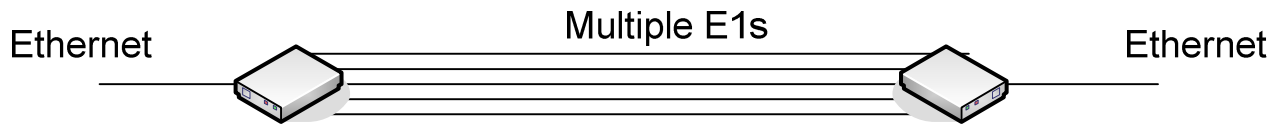

Figure 2. Ethernet over Multiple E1s

Each E1 circuit can carry 2048Kbps data rate. However, to successfully multiplex the E1s into a single coherent data path requires some framing overhead. Typically this overhead results in a throughput loss of 64kbps per E1. Throughput available is calculated as nx1984kbps, where n equals the number of E1 circuits.

Here again, the bit stream pipe requires a WAN protocol in order to encapsulate the Ethernet packets for transportation over the E1 bit stream. Typically this is GFP or General Framing Procedure.

Products for Ethernet over multiple E1s.
FRM220A-5E1/ET100 – This card based solution for the FRM220A series carries Ethernet by bridging over 1~5 E1 circuits (1984k~9920k). The card can be placed in single-slot, 2-slot, 4-slot or 20-slot chassis.
FRM220A-8E1/ET100 – This card based solution for the FRM220A series carries Ethernet by bridging over 1~8 E1 circuits (1984k~15.87M). The card can be placed in single-slot, 2-slot, 4-slot or 20-slot chassis.
FRM220A-16E1/ET100 – This double wide card based solution for the FRM220A series carries Ethernet by bridging over 1~16 E1 circuits (1984k~31.74M). The card can be placed in single-slot, 2-slot, 4-slot or 20-slot chassis.

E1 over Ethernet

This application is the exact opposite of the previous Ethernet over E1. When we say "E1 over Ethernet" we are also referring to the terms "TDMoIP" and "IP Multiplexer" or "IP Mux". TDMoIP is Time Division Multiplexing over Internet Protocol. TDM refers to E1, which uses framing to provide channels by dividing the entire E1 frame into 32 timeslots. The IP Multiplexer carries one or more E1 circuits over an IP network.

Figure 3. E1 transported over IP or Ethernet

The IP Mux performs point-to-point emulation of an E1 or T1/J1 circuit by converting unframed bit stream data into packets and transmitting them over a packet network. A second IP Mux receives the packets and converts the payload back into a bit stream. The result is a low-cost connection that is not dependent on a leased line. The circuit emulation uses a dynamic jitter buffer and accurate clock recovery to deliver measurable performance even over the variability of the packet network.

Products for E1 over Ethernet.
IPM-1SE – Single E1/T1/J1 over IP network IP MUX
IPM-4SE – One to four E1/T1 over IP network IP MUX
TDMUX**-**16 is 16 E1/T1 over IP network IP MUX

Conclusion:

Ethernet over E1 and E1 over Ethernet are vastly different application. It is important to understand the difference between both, to choose the right equipment and realize that specific equipment is required for each application. There is no "one" equipment that can do both IP Multiplexing and Inverse Multiplexing.

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