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Capsim Application Note

Simulation of the Physical Layer of IEEE 803.3 CSMA/CD (Ethernet)

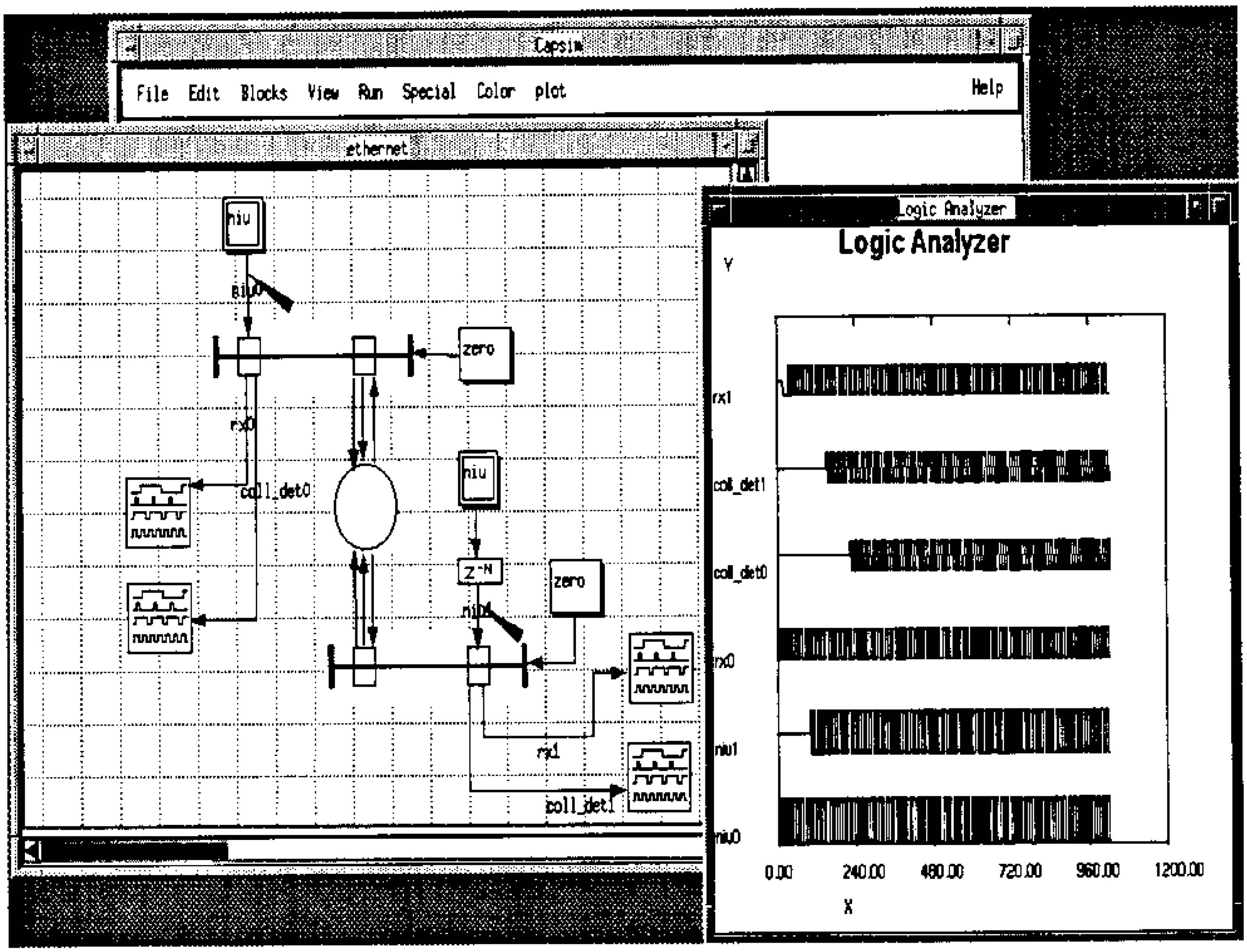

Figure 1. Simulation of a two segment Ethernet LAN

Introduction

The simulation of the physical layer of the IEEE 803.3 CSMA/CD Local Area Network is both a challange and a necessary requirement in the design of these networks. For example, in the standard, the slot time is defined to be larger than the sum of the physical layer round-trip propagation time (twice the time it takes for a signal to travel from one end of the medium to the other) and the MAC (Medium Access Control) layer jam time. In turn, the slot time is used to determine the minimum MAC frame length. Obviously, the determination of the slot time for various network configurations requires the accurate simulation of the physical layer. This includes the modeling of transmission line effects,

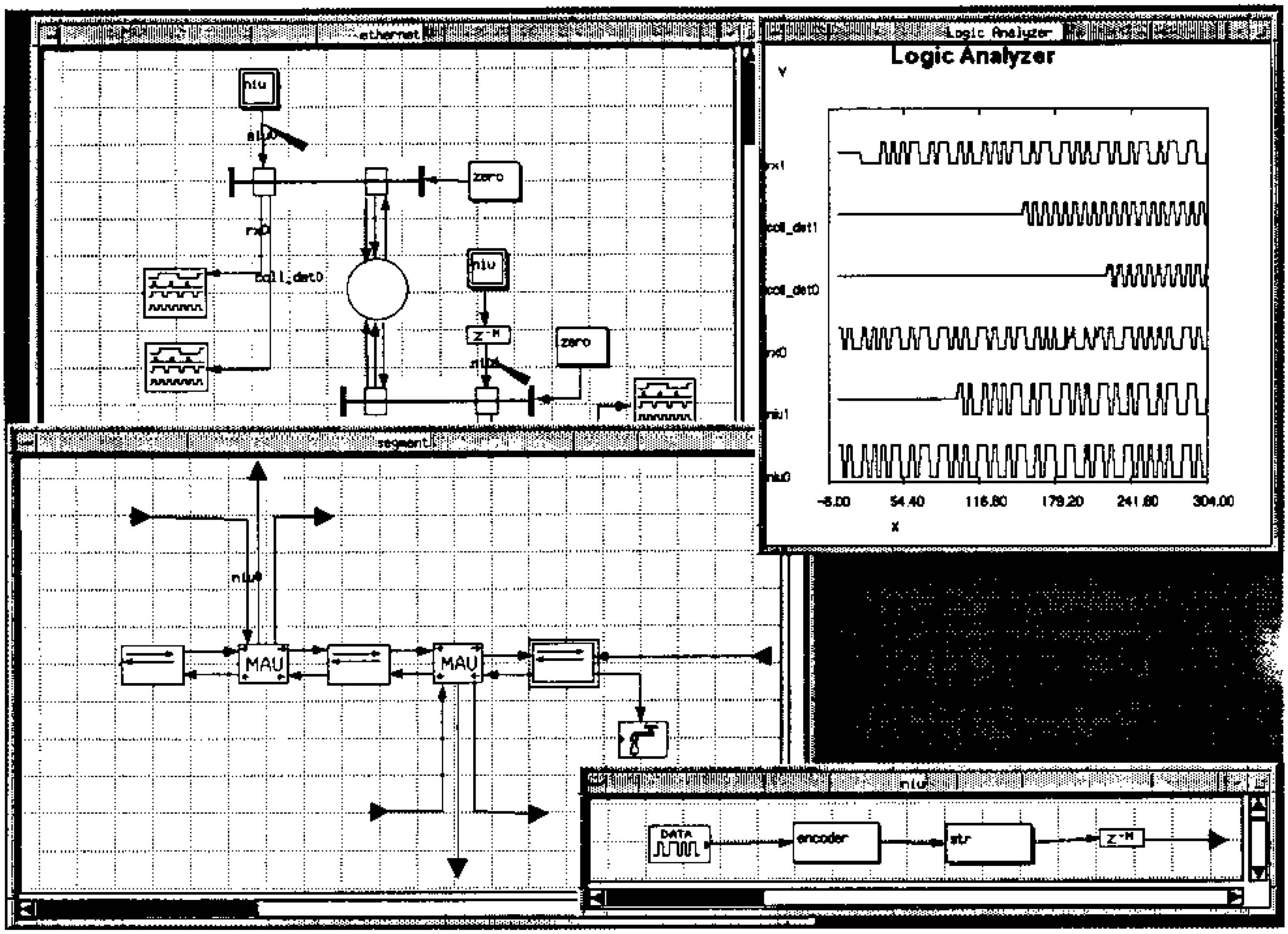

Figure 2. Segment and NIU galaxies

the effects of taps, and various medium such as coax or twisted pair. In addition the jam time also depends on other details of the physical layer.

This application note illustrates the simulation of a shared bus topology. Other topologies can easily be simulated using the concepts illustrated in this note.

Simulation of an Ethernet LAN

In Fig. 1, we show the Capsim simulation of an Ethernet network consisting of two segments connected through a repeater. A network interface unit (NIU) transmits data through the network. The NIU on the other segment, also transmits data but after a delay. The delay between the transmissions of the NIU's is such that a collision occures. Usually the NIU will listen to the line and only transmit if it does not sense a carrier. However, due to the propagation time through the network, the other NIU may have sent a frame and, in the meantime, the NIU on the other segment also sends a frame assuming that the medium is free. Hence, a collision occurs.

When a collision occurs, the Medium Attachment Unit (MAU) circuitry must detect the collision and report it to the MAC. In fact the MAU must do the following:

Transmit signals on the medium.
Receive signals from the medium.
Recognize the presence of a signal on the medium.
Recognize a collision.

In Fig.1, the collision of the frames and the generation of a collision detect and receive signal by the MAU are illustrated using the *Logic Analyzer* facility in Capsim. The logic analyzer can be used

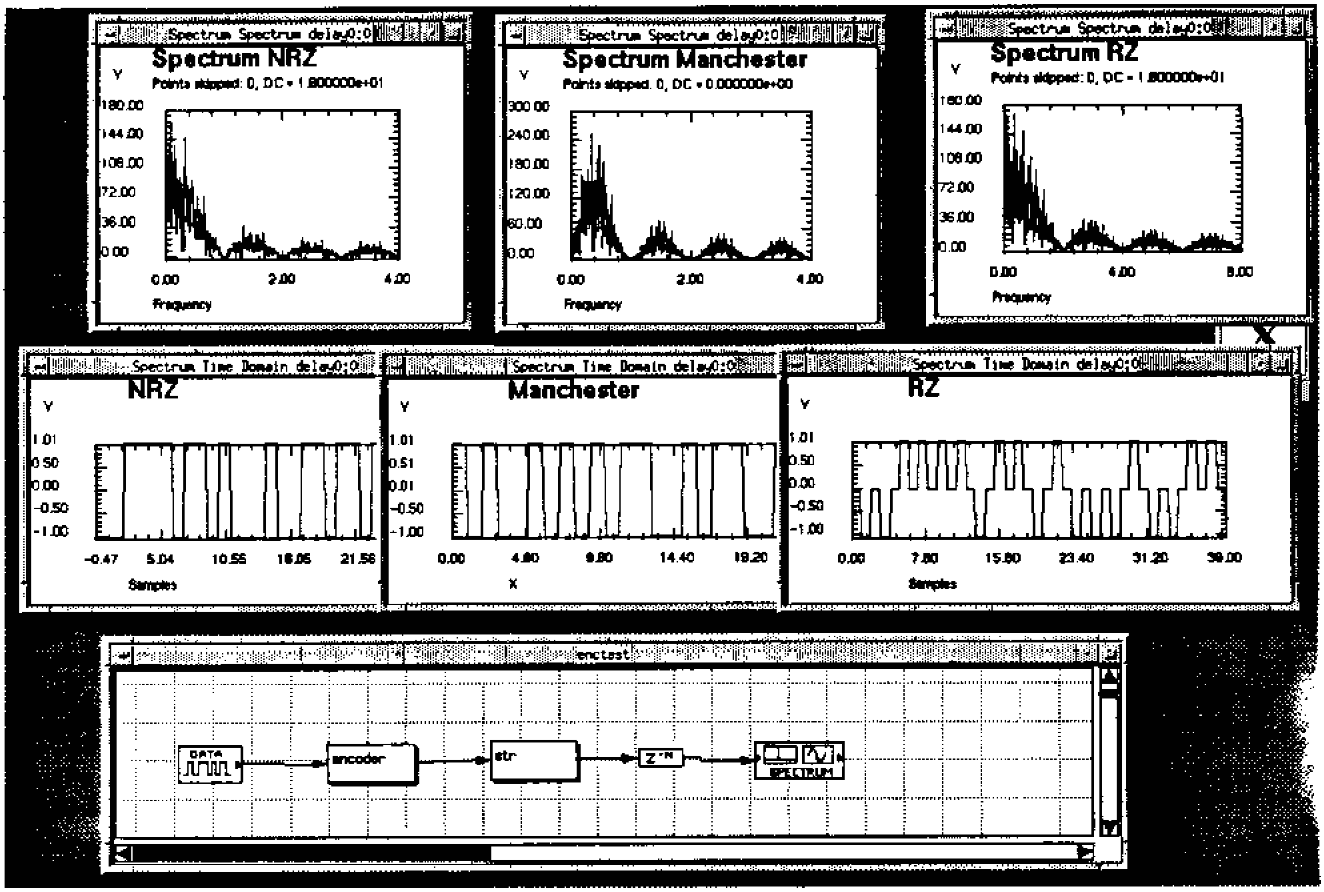

Figure 3. Encoding formats

as an individual block or as a probe (see Fig. 1).

In the simulation, there is feedback between the segments through the repeater and within the segments themselves. In Fig. 2, the details of the segment and the NIU are shown. In fact the segment is a galaxy (or macro block) and consists of six stars or blocks. The segment, in this case, models the transmission medium through two way blocks that intoduce delay. These stars are indicated by the two way arrows. Note that one of these blocks is a termination and, hence, the input signal is reflected back. This is powerful feature in Capsim. That is, stars can have a different number of lines (buffers) connected to them and adjust their functionality accordingly. This is an illustration of the auto fan-in and fan-out feature in Capsim. If four connections are made then the signals propagate through the star (in both cases a delay specified by a parameter is introduced).

The MAU is an individual star and attaches to the medium as shown. It implements the detection of a collision and the generation of the collision detect tone. In addition, it handles all the voltage levels and generates the receive signal. It also places the transmit signal onto the medium.

The NIU is a galaxy. It consists of a random binary data generator, an encoder that encodes the logical True and False values into a Manchester code. It includes the *stretch* star that increases the sampling rate in order to model an analog signal. The delay block is used to control the transmit time. In the figure, the beginning sequence in the logic analyzer has been zoomed in to show details of the collision process.

Capsim allows the use of accurate and detailed modeling of the transmission medium. It can be Coax, twisted pair, or other medium. The number of taps, length, and placement of the MAU on the line can be specified. An appropriate network specifying the transmission line network is generated and modelled. This is a major feature of Capsim in which the simulation can progress form a delay line model to the actual transmission line and circuit level simulation.

A full simulation of Ethernet requires the NIU to respond to the recieved signal and the collision detect to control retransmissions and so forth. Also, the NIU will include frame assembly and the complete CSMA/CD protocol.

The encoder star can encode the binary data into various formats including Manchester, return to zero, 2B1Q, and partial response. Fig. 3 illustrates the encoded signals and their spectrums obtained from the topology. In this case, the parameter on the encoder was changed for each simulation to change the encoding format.

Summary

From the foregoing, it is clear that Capsim can handle complex hierarchical simulations with multiple feedback and multi-rate sampling. It can provide the bases for the high level design of the physical and link layer of a local area network. It can model the system with varying degrees of accuracy down to the transmission line level. This application note provides the framework for the implementation of a detailed simulation of the physical layer of the IEEE 803.3 CSMA/CD standard.

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