Direct Link Networks

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BSc - Computer Network Principles & App’s

Based on Chapter 2, Peterson & Davie, Computer Networks: A Systems Approach

Areas for Discussion

- Problems
  - Physically Connecting Hosts
  - 5 Additional Problems
- Encoding (Section 2.2)
- Framing (Section 2.3)

Problems Addressed

In order to successfully exchange data between nodes the following problems need to be addressed:

1 Connect two/more nodes with a suitable medium

2 Encode bits onto wire/optical fibre

3 Framing
  - Delineate the sequence of bits transmitted over a link

4 Error Detection
  - Detect the corruption of data due to noise, crosstalk, interference, etc; …

Problems Addressed

5 Reliable Delivery
  - Make a link appear reliable at higher levels even though it may be less than 100% reliable at the lower levels

6 Media Access Control
  - Obtaining access to shared media such as
    - Ethernet
    - FDDI

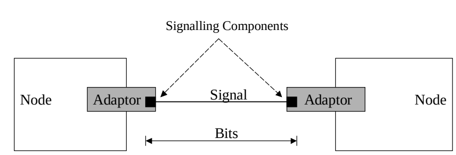
Note that these functions are generally implemented in a *network adapter*. The adapter is in turn controlled by a device driver running on the node

Encoding

NRZ, NRZI, Manchester, 4B/5B

Point to Point Link

(Fig 2.5 P&D)



Signals travel between signalling components; bits flow between adaptors

Point to Point Link

- Physical Layer
  - Deals with the representation of data on a physical link
- Link Layer
  - Deals with the transmission of data or frames across an end-to-end link
  - Link layer protocols therefore run over a single end-to-end link

2.2 Physical Layer Encoding

Concerned with the representation of data on the physical link between two nodes

1 NRZ (Non-Return to Zero)

A fancy name for the obvious encoding scheme

However the long strings of zeros or ones that can be generated by this scheme may cause problems:

- Difficult to distinguish from the absence of a message
- Baseline wander
- Clock synchronisation (clock recovery process)
  - note that the receiver has to derive its clock from the senders signal

2.2 Physical Layer Encoding

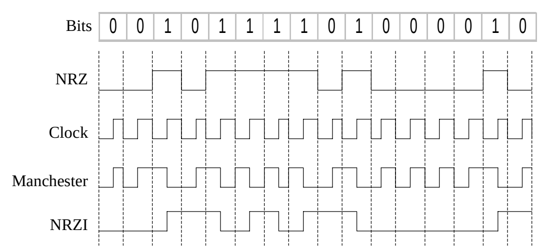
2 NRZI (Non-Return to Zero Inverted)

'One' encoded as a transition and 'zero' encoded as the absence of a transition

- solves the problem of consecutive ones
- no help with a string of zeros

Different Encoding Strategies

(Fig 2.7 P&D)



2.2 Physical Layer Encoding

3 Manchester Encoding

Exclusive-OR of the NRZ encoding and the clock giving at least one transition per bit

A rising transition in the middle of a cell represents a '0', a falling transition a '1'

- Doubles the signal transition rate/baud rate
- the baud rate is therefore twice the bit rate

2.2 Physical Layer Encoding

4 4B/5B Encoding

Each nibble of data is translated into a 5-bit code. The resulting code is then transmitted using NRZI.

Each code has a maximum of one leading zero and two trailing zeros

- maximum of 3 zeros (why 3?)
- coding 80% efficient, versus 50% for Manchester code

Note that about half of the unused codes can be used for various control purposes (line idle, dead, etc; …) without violating the rule regarding consecutive zeros

4B/5B Encoding Table

4 – Bit Data Symbol	5 – Bit Code
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

(Table 2.5 P&D)

Framing

2.3 Framing - The Link Layer

While the physical links transfer bits, we want our network adapters to transfer blocks of data, called *frames* at this level.

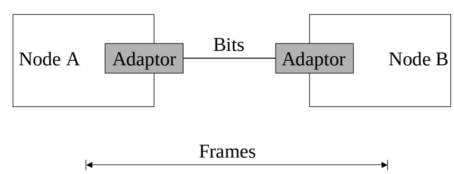
The problem is to determine where a frame begins and ends

There are several approaches to the framing problem:

- Bit-Orientated Protocols versus Byte-Orientated Protocols
- Sentinel Approach versus Counting Approach
- Clock based framing (Sonet)

2.3 Framing - The Link Layer

(Fig 2.8 P&D)



Bits flow between adaptors, Frames between hosts

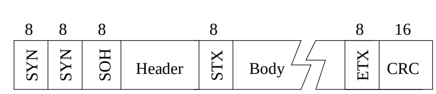
Byte - Orientated Protocols

1. Sentinel Approach

BISYNC – Binary Synchronous Communication

Developed by IBM in the late 60's

(Fig 2.9)



The BISYNC Frame Format

1. Sentinel Approach

- The beginning of a frame is denoted by a special SYN (synchronisation) character
  - Character allows the receivers clock to synchronise with the transmitters clock
- SOH character indicates start of header
- Data portion is contained between two special sentinel characters (STX & ETX)
- CRC characters used to detect errors

1. Sentinel Approach - Problems

- Corrupt sentinel char will cause framing error over two frames
- ETX may occur in data portion;
  - In this case DLE ETX is transmitted
  - DLE in turn is rendered as DLE DLE
- This approach is called **character stuffing**

1. Sentinel Approach

Point to Point Protocol

- A more recent example of the sentinel approach

(Fig 2.10)

8	8	8	16		16	8
Flag	Address	Control	Protocol	Payload	Checksum	Flag

The PPP Frame Format

1. Sentinel Approach

Point to Point Protocol

8	8	8	16		16	8
Flag	Address	Control	Protocol	Payload	Checksum	Flag

The PPP Frame Format

Flag:	start-of-text char
Protocol field:	used for de-multiplexing
Payload:	default is 1500
Checksum:	2 bytes by default

1. Sentinel Approach

Point to Point Protocol

- PPP format
  - Unusual in that several of the field sizes are negotiated
- LCP – Link Control Protocol
  - Used to set up field sizes
- Protocol Field
  - Used to distinguish PPP from LCP messages

2. Byte Counting Approach

DDCMP

- Digital Data Communication Message Protocol

(Fig 2.11)

8	8	8	14	42		16
SYN	SYN	Class	Count	Header	Body	CRC

The DDCMP Frame Format

2. Byte Counting Approach

DDCMP

- The beginning of the frame is still denoted by a special SYN (synchronisation) char
- COUNT specifies how many bytes are contained in the body of the frame
- CRC bytes are used to detect errors

Problem

- If the COUNT field is corrupted then two adjacent frames may be lost

Bit - Orientated Protocols

HDLC

HDLC – High Level Data Link Control Protocol

(Fig 2.12)

8	16		16	8
Beginning Sequence	Header	Body	CRC	Ending Sequence

- Beginning and end of a frame is marked with bit sequence 01111110
- Bit stuffing employed

HDLC – Bit Stuffing

- In the body of a message if 5 consecutive ones occur then an additional zero is inserted after the ‘5 consecutive ones’ by the sender
- The additional zeros are removed automatically by the receiver

Side Effect of Bit Stuffing

- The size of the frame is a function of how often bit stuffing is required rather than on the amount of data being transmitted
- The same problem occurs with character stuffing

Clock Based Framing (Sonet)

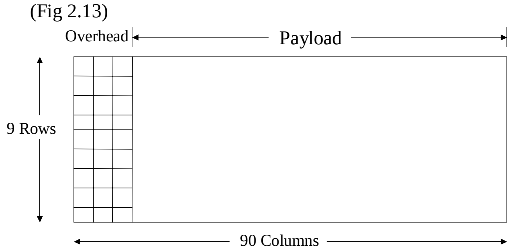
SONET: Clock Based Framing

- “defines how telephone companies transmit data over optical networks”
- Closely related to ATM (See Chapter 3)
  - Addresses framing and encoding
  - Allows multiplexing of several low-speed links onto one high-speed link

SONET: Clock Based Framing

810 byte Sonet STS –1 Frame

(Fig 2.13)



SONET: Notes

Framing

- First two bytes in each frame contain a synch pattern
- Note pattern is not unique to those two positions
  - No bit stuffing
  - No escape characters
- Receiver must detect a synch pattern that repeats every 810 bytes, but that can also occur elsewhere

SONET: Notes

Encoding

- Overhead bytes are coded using NRZ
- Payload bytes are also scrambled
  - XOR'd with a 127 bit pattern
  - Idea is to ensure frequent transitions
  - Avoid strings of ones and zeros
  - Helps clock synchronisation

Review Question

What is the probability that the pattern occurs in the wrong place and that as a result we get mis-synchronisation?

SONET Multiplexing

- A given Sonet link runs at one of a finite set of rates:

STS-1	51.84 Mbps
STS-3	155. 52 Mbps (Note: 3 times STS-1)
…	… … (Note: corrects book error of 155.25)
STS-48	2488.32 Mbps

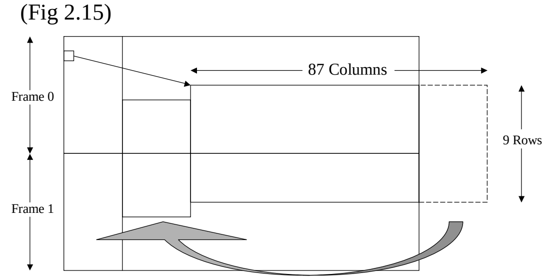
- An STS-N frame can be regarded as a single channel with a given bit rate or as N multiplexed ST-1 channels
- In the case of multiplexed channels, the bits from each channel are interleaved
  - In this case each Sonet frame is still transmitted in 125 micro-seconds

SONET Frames – Out Of Phase

- In practice each ST-1 frame does not hold a complete frame of data
- Instead data frames can be divided between two frames
- A pointer in the overhead bytes indicates the start of each data frame
- "payload may float across frame boundaries"

SONET Frames – Out Of Phase

(Fig 2.15)



Reliable Transmission

- In this section we are interested in the reliable transmission of frames over unreliable links
- We will use the *Sliding Window Algorithm* to achieve reliable transmission
- First we consider why errors occur and how they can be detected
- Based on sections 2.4 & 2.5 of Chapter 2, Peterson and Davie “Computer Networks: A Systems Approach”

Summary

- Problems
  - Physically Connecting Hosts
  - 5 Additional Problems
- Encoding (Section 2.2)
- Framing (Section 2.3)