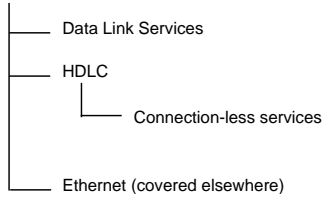


# Data Link Protocols



- Framing PDUs
- Addressing Destination
- Error Detection / Error Recovery
- Link Management

# Components of a DL

- Hardware
- Frame Format
- Protocol
- Buffer Memory
- Event Timers

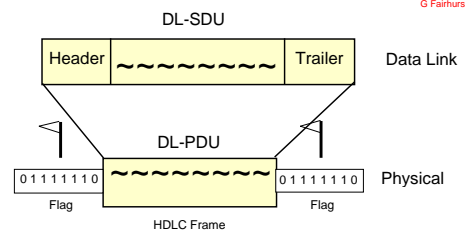
# High Level Data Link Control Protocol

- Definitions and Modes
- HDLC framing
- Connection-less services
- Throughput

# HDLC DATA LINK

# HDLC Framing

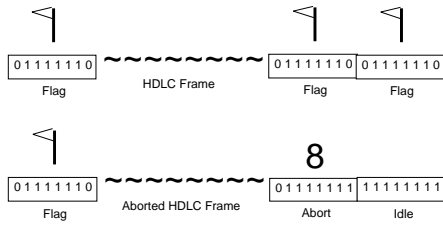
- Flags
- 0-bit insertion
- Cyclic Redundancy Check



Need to provide: Frame Delineation  
Data Transparency  
Error Control

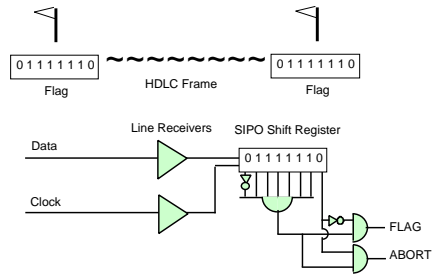
## HDLC Frame Delineation

G Fairhurst (c) 1998



## HDLC Flag Detection

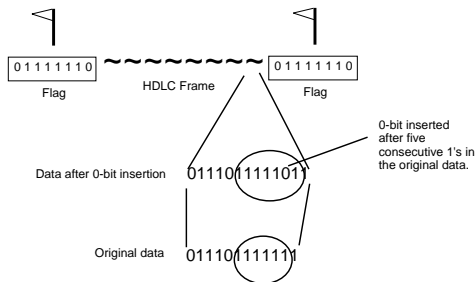
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N.B. Real implementation uses a Finite State Machine (FSM)

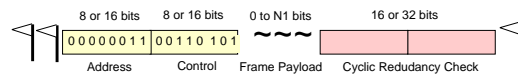
## HDLC 0-Bit Insertion

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## HDLC Frame Structure

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$N1$  = maximum number of bytes in the frame payload  
Typical values: 128 B, 576 B, 1500B, etc

## HDLC CRC

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Why is a CRC needed?

To verify correctness of data  
What happens if we don't check?

How can data become corrupted?

Noise  
Interference  
Errors in network components  
Faulty cabling  
Cosmic rays ???

## CRC Generator Polynomials

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$$\text{CRC-16} = x^{16} + x^{12} + x^5 + x$$

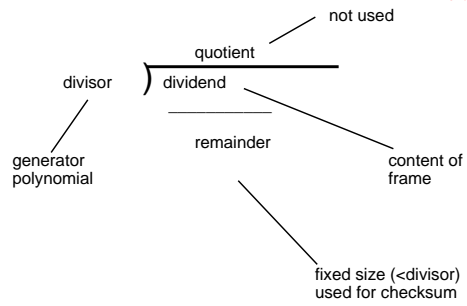
$$\text{CRC-CCITT} = x^{16} + x^{12} + x^5 + 1$$

$$\text{CRC-32} = x^{32} + x^{26} + x^{16} + x^{12} + x^{11} + x^{10} + x^5 + x^4 + x^2 + x + 1$$

## Cyclical Redundancy Check

Properties of a CRC-16	Synchronous Block/Frame Protocols Implemented in Hardware
1-bit error	100% Detected
2-bit errors	100% Detected
Odd errors	100% Detected
Burst errors < 16 bits	100% Detected
Burst errors exactly 17 bits	99.9969% Detected
All other error bursts	99.9984 % Detected

## Cyclical Redundancy Check



## CRC - Why Modulo 2 Division?

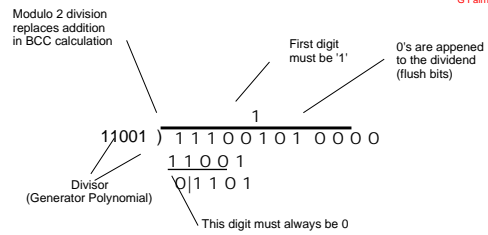
Because the hardware solution is simple!!!!

Truth Table for Modulo-2 Division (XOR)

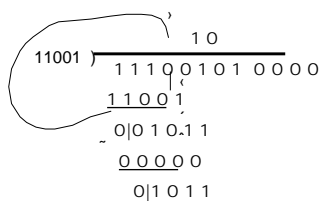
0	0	=	0
0	1	=	1
1	0	=	1
1	1	=	0

CRC calculations ignore the carry

## CRC Example (1)

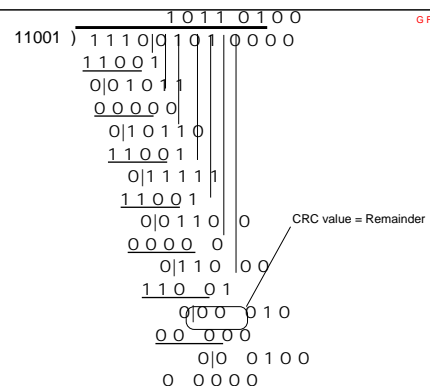


## CRC Example (2)



- < Bring next digit of dividend down
- > Copy msb of value to quotient
- ~ Insert 0 (if quotient 0) or divisor (if quotient 1)
- ^ Calculate XOR sum
- ~ Discard msb of value (always 0)

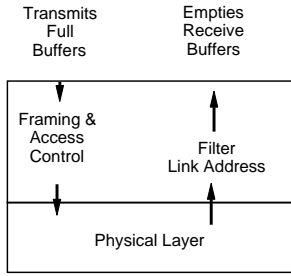
## CRC Example (3)





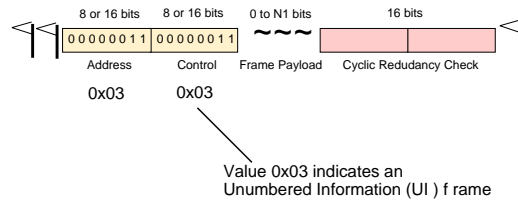
## Basic Connection-Less Service

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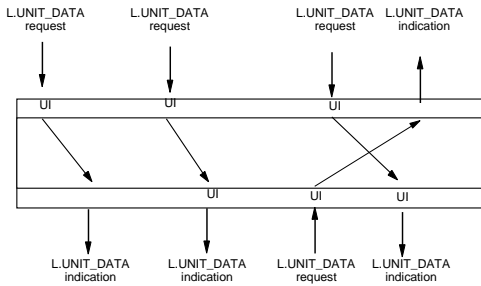
## UI Frame Format

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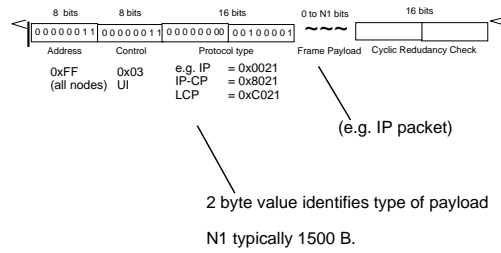
## HDLC Connectionless Service

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## Point-to-Point Protocol (PPP)

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RFC 1134, 1989

## Self - Help THINGS TO THINK ABOUT (1)

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Do you know:

How the data link receiver finds the start of:

- (a) An Ethernet Frame
- (b) An HDLC Frame

How the receiver finds the end of:

- (a) An Ethernet Frame
- (b) An HDLC Frame

??

What is a Best Effort Service?

## HDLC Performance

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