Week 4 – Data Link Layer Contd

Internet Technologies
COMP90007

Error Correcting Codes Key Points

- *More efficient in noisy transmission* media e.g., wireless
- A challenge is that *the error can be in the check bits as well*
- Strict *assumption on a specific number of errors* occurring in transmission

Error Detecting Codes

- More efficient in some transmission media – e.g. where low error rates occur- e.g., **high quality copper**

A Common Basic Method:

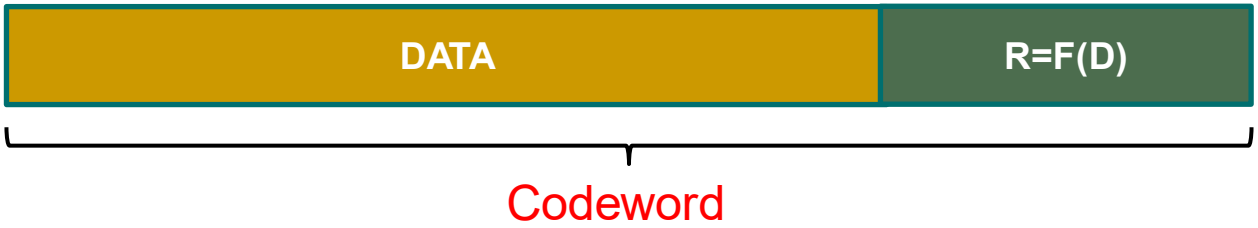
- ***Parity*** (1 bit): (Hamming distance=2)

Realistic Methods:

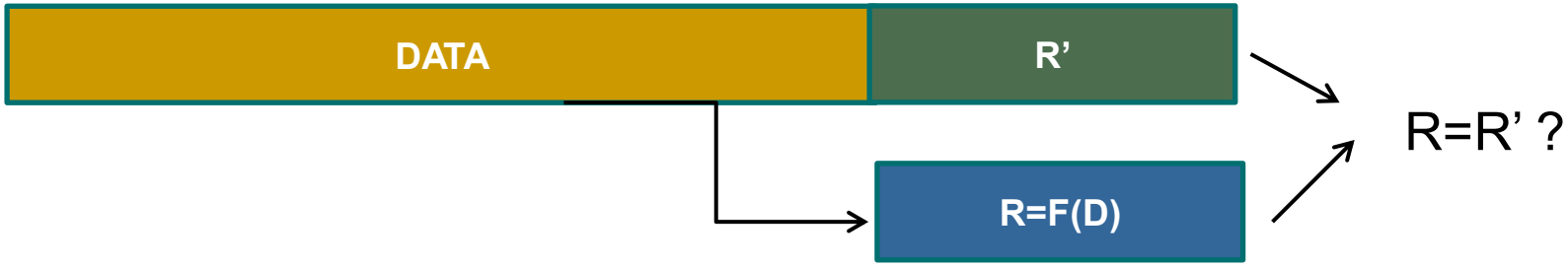
- ***Checksum*** (16 bit)
- ***Cyclical Redundancy Check*** (Standard 32 bit CRC)

How it works?

- Sender calculates R check bits using a function of data bits:



- Receiver: Receive the codeword and calculates the same function on the data and match the results with received data check bits:



Parity Bit

10001110 is your data and you count the number of 1s

You get = 100011100 (For even parity)

100011101 (For odd parity) and then transfer…

Check the transferred data for errors on arrival and you can catch:

(Recall: Hamming distance is 2 for Parity Bit…)

2 = #errors + 1 can be detected and
2 = 2 x #errors + 1 can be corrected

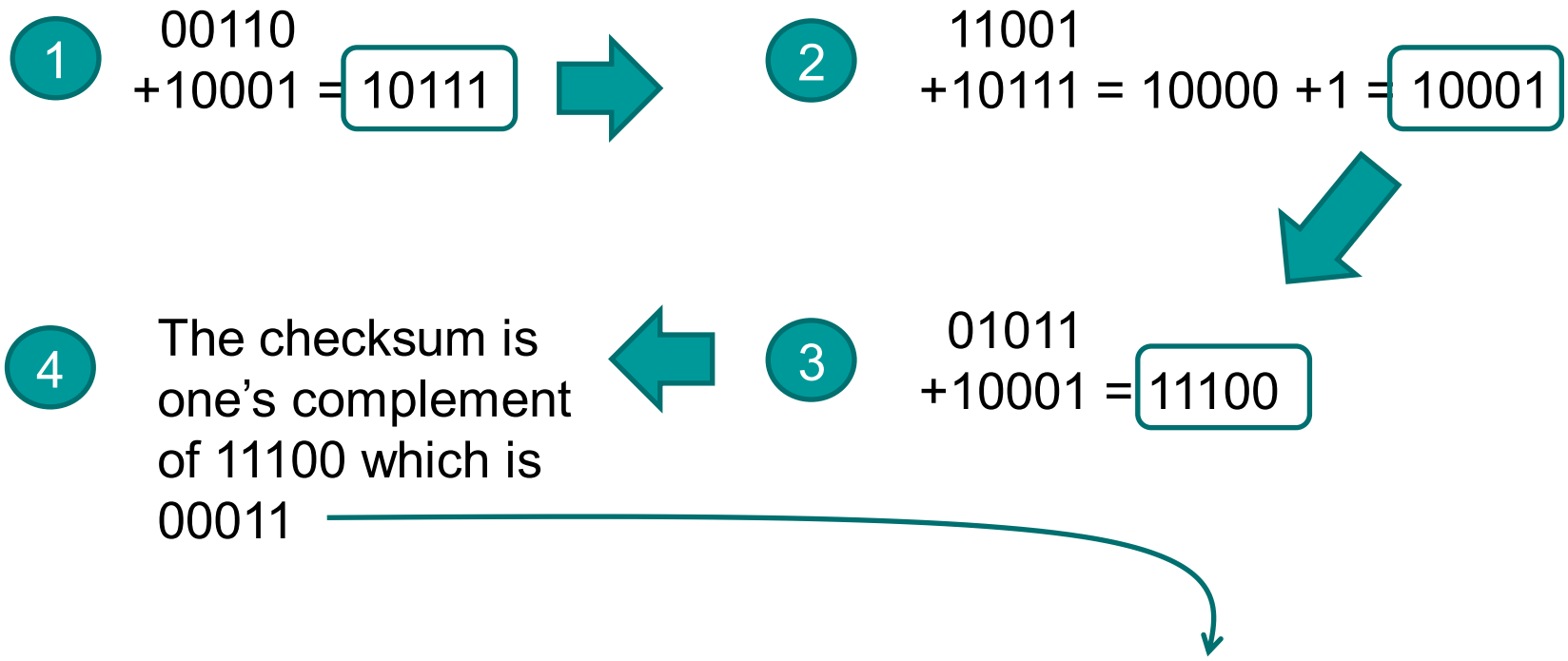
2 – 1 = **1 error bit can be detected** and
(2 – 1) / 2 = ½ not even 1 bit error can be corrected

Checksum

- There are different variations of checksum
- Internet version Checksum (16-bit word): Sum modulo 2^{16} and adding any overflow of high order bits back into low-order bits

Example of Checksum

Calculating checksum where words are 5 bits for data 00110 10001 11001 01011



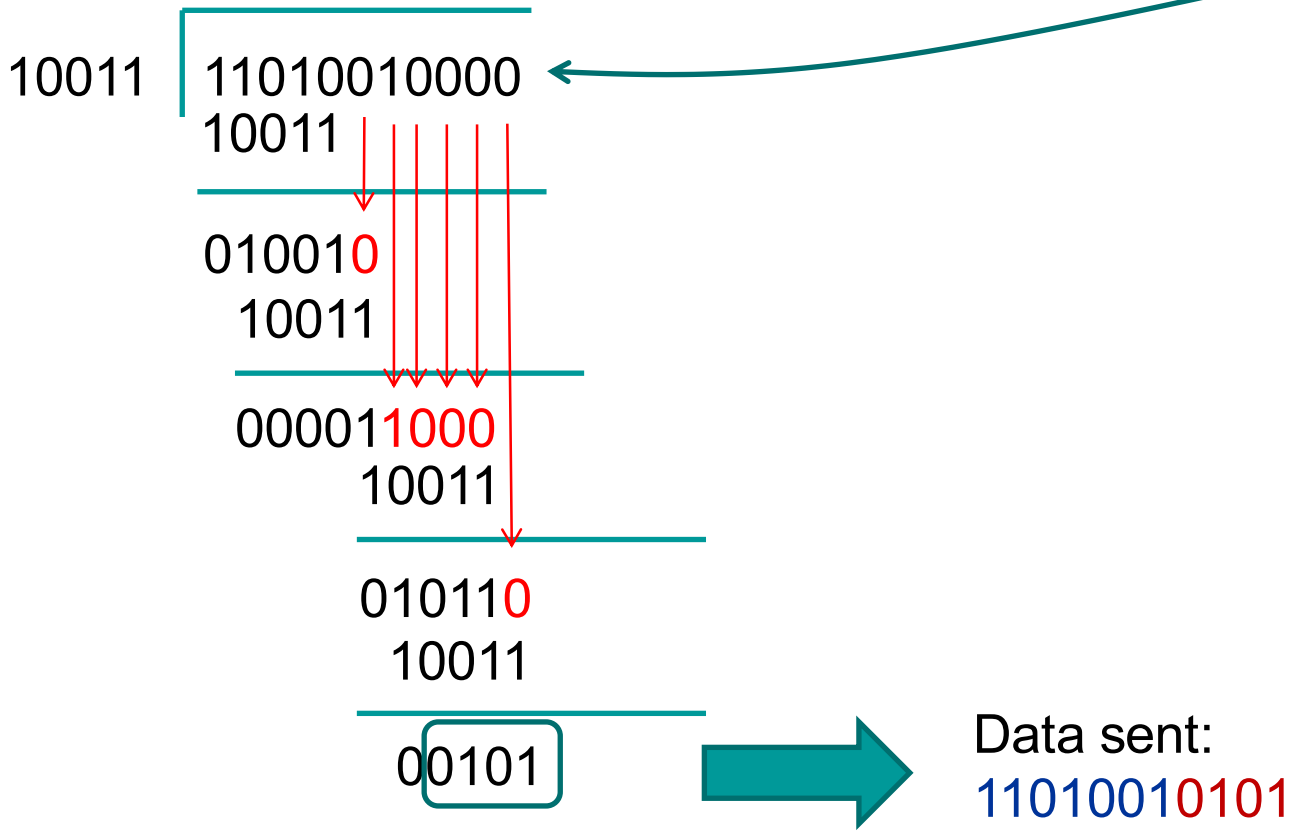
Cyclic Redundancy Check

- Based on a generator polynomial G(x)
  - Eg. $G(x) = x^4+x+1$ (10011)
  - Let *r* be the degree of *G*(*x*) (r=4). Append *r* zero bits to the low-order end of the frame so it now contains *m* + *r* bits and corresponds to the polynomial $x^rM(x)$.
  - Divide the bit string corresponding to *G*(*x*) into the bit string corresponding to $x^rM(x)$, using modulo 2 division.
  - Subtract the remainder (which is always *r* or fewer bits) from the bit string corresponding to $x^rM(x)$ using modulo 2 subtraction. The result is the frame to be transmitted. Call its polynomial *T*(*x*).

Example

Data: 1101001 and G(x) = x^4+x+1 (10011)

5 bits polynomial and add 4 bits as the checksum at the end, so add 0000



Data Transmission

- So far we discussed how to send single messages and now we will look at a series of messages
- A service to send messages should have:
  - Reliability AND
  - *Flow Control*

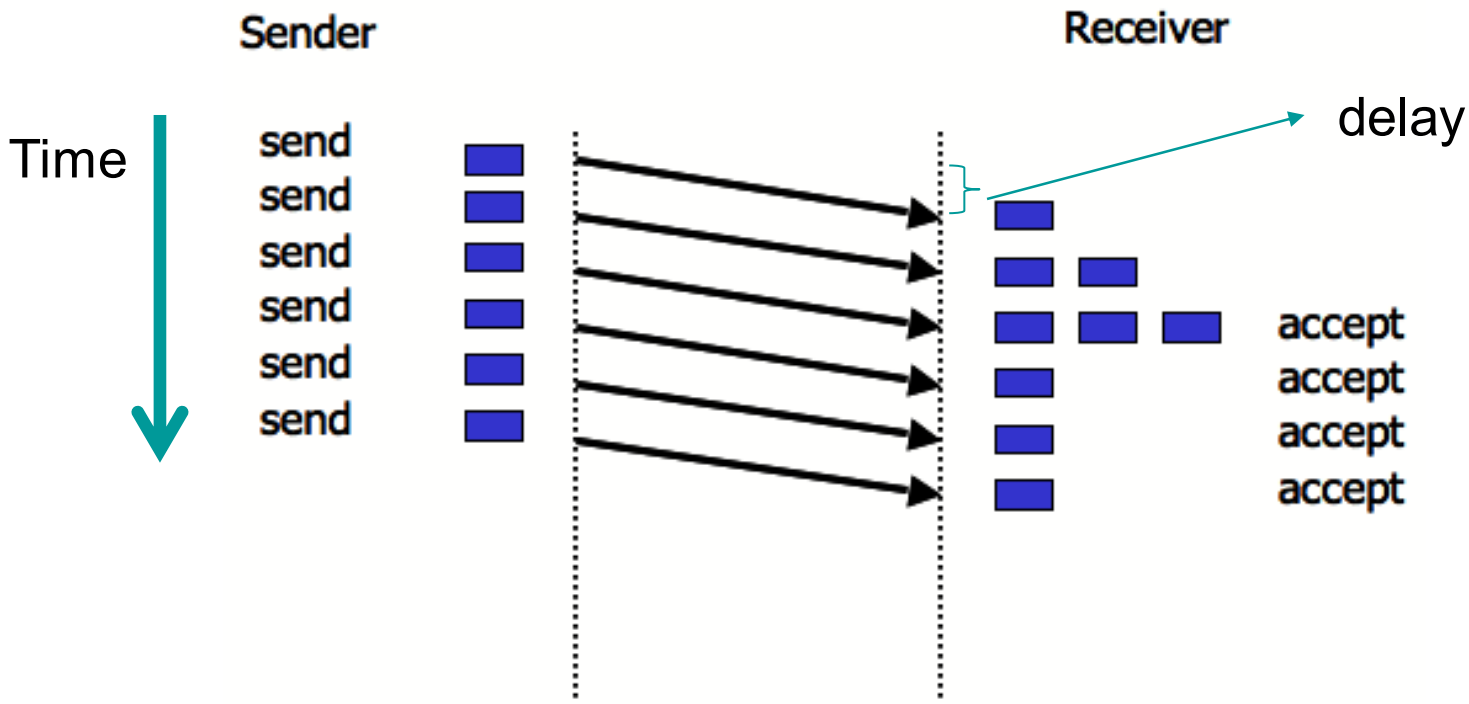
Reliability

- Each layer need to make sure the service provided to other layers is reliable
- Retransmission with error detection is a way of ensuring reliability
- Error correction is another way but has its shortcomings

Flow Control

- The fast senders vs slow receivers problem requires a solution
- Principles to control when sender can send next frame
  - Feedback based flow control is usually used in Data Link layer
  - Rate based flow control

A Very Simple Protocol



Acknowledged transmission

(think: fast sender / slow receiver)

Data transmitted in one direction

Time is relatively important, buffer space constrained