

Cyclic Redundancy Check

Course Title: Computer Networks



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Lecture Outline



1. Cyclic redundancy check



Cyclic Redundancy Check

Introduction

- ❖ What if the transmitted bits get altered on the way?

- Is there any technique to detect the error?

Yes, using Cyclic Redundancy Check (CRC)

❑ CRC

- In CRC, some redundant bits are sent in addition to the message bits.
- The purpose of the redundant bits is to facilitate detecting error.
- *The redundant bits are called frame check sequence (FCS)*

How is FCS generated?



Cyclic Redundancy Check

Introduction....

- Strength of the CRC depends on the number of redundant bits (that is, FCS length)
- Longer FCS length results in better accuracy in detecting error

Required two sequence

- *Message sequence, M*
 - The desired data to be sent
 - Can be of any length
- *Pattern sequence, P*
 - Known to both sender and receiver
 - If we want to use K bits FCS, we need a pattern bit sequence, P , of length $K+1$ bits.



Cyclic Redundancy Check

Generation of FCS

1. Decide how many FCS bits, K , you are going to use.
2. Append K zeros at the end of the message bits to generate $M+K$ bits long sequence S .
3. Select a $K+1$ bits long pattern sequence, P .
4. Divide the sequence S by the pattern sequence P to find the K bits of the remainder, R .
5. Remove the appended zeros from S and append the calculated remainder R .
Thus, the N bits message bits and K bits remainder constitutes the transmitting sequence, T .



Cyclic Redundancy Check

Error detection at the receiver

1. At the destination, the received sequence, T' , is divided by the same pattern sequence, P .
2. If at this step there is no remainder, the data unit is assumed to be correct and is therefore accepted.
3. A remainder indicates that the data unit has been damaged on the way and therefore must be rejected.



Cyclic Redundancy Check

Example 1

- Generate FCS if the message polynomial and generator polynomial are $X^3 + X^2 + 1$ And $X^3 + X + 1$, respectively.

Let $M(x)$ be the **message polynomial**

Let $P(x)$ be the **generator polynomial/Pattern sequence**

$$\text{Let } P(x) = X^3 + X + 1 \rightarrow 1011$$

$$\text{Let } M(x) = X^3 + X^2 + 1 \rightarrow 1101$$

1. Consider the case where $M=1101$ and $P=1011$.

2. Since P consists of 4 bits, append $K=3$ bits zeros (000) at the end of M , $S=1101000$

3. Divide S by P to get 3 bits remainder.



Cyclic Redundancy Check

Example 1

$$\begin{array}{r}
 P \longrightarrow 1011 \quad | \quad \begin{array}{r} 1111 \\ 1101000 \\ 1011 \\ \hline 1100 \end{array} \quad S \\
 \text{At sender} \quad | \quad \begin{array}{r} 1011 \\ 1110 \\ 1011 \\ \hline 1010 \\ 1011 \\ \hline 001 \end{array} \quad R
 \end{array}$$

The diagram illustrates the generation of a Cyclic Redundancy Check (CRC) for a message. On the left, the polynomial $P = 1011$ is shown with an arrow pointing to the right. This is followed by a vertical bar, then the dividend 1101000 , which is divided by P . The quotient is 1111 and the remainder is 1011 . Below this, the remainder 1011 is shown above a horizontal line, followed by the divisor 1011 and the remainder 1100 below it. An arrow points from the remainder 1011 to the quotient 1111 . The word "S" is placed to the right of the quotient.

On the right, the word "At sender" is written above a series of operations. The first row shows the divisor 1011 above the dividend 1110 , with a remainder 110 below. The second row shows the divisor 1011 above the dividend 1011 , with a remainder 1010 below. The third row shows the divisor 1011 above the dividend 1010 , with a remainder 1011 below. The fourth row shows the divisor 1011 above the dividend 1011 , with a remainder 001 below. An arrow points from the remainder 1011 to the remainder 1010 . The word "R" is placed to the right of the remainder 001 .



Cyclic Redundancy Check

Example 1

$$\begin{array}{r} 1011 \quad | \quad 1101001 \\ \underline{1011} \\ \hline 1100 \\ \underline{1011} \\ \hline 1110 \\ \underline{1011} \\ \hline 1011 \\ \underline{1011} \\ \hline 0000 \end{array}$$

At
Receiver

Since the remainder is zero, there is no error in the received sequence



Cyclic Redundancy Check

Example 1

What if any bit gets altered in the channel?

Suppose that the second bit (red) has altered from 1 to 0.

$$\begin{array}{r} 1011 \overline{\Big|} & 1 \textcolor{red}{0} 0 1 0 0 1 \\ & 1 0 1 1 \\ \hline & 1 0 0 0 \\ & 1 0 1 1 \\ \hline & 1 1 1 \end{array}$$

The nonzero remainder indicates an erroneous reception.

The frame will not be acknowledged.

The sender will resend the frame.



Cyclic Redundancy Check

Example 2

- Message $M = 1010001101$
- Pattern $P = 110101$
- Length of $P=6$
- Append $K=6-1=5$ zeros at the end of M
- $S=1010001101\textcolor{red}{00000}$
- Now divide S by P to find 5 bits remainder [1].



Cyclic Redundancy Check

Example 2

$$\begin{array}{r}
 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \\
 \xrightarrow{P \rightarrow} & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
 & 1 & 1 & 0 & 1 & 0 & 1 & & & & & & & & & & & \\
 \hline
 & 1 & 1 & 1 & 0 & 1 & 1 & & & & & & & & & & \\
 & 1 & 1 & 0 & 1 & 0 & 1 & & & & & & & & & & \\
 \hline
 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & & & & & & & & & \\
 & 1 & 1 & 0 & 1 & 0 & 1 & & & & & & & & & & \\
 \hline
 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & & & & & & & & & \\
 & 1 & 1 & 0 & 1 & 0 & 1 & & & & & & & & & & \\
 \hline
 & 1 & 0 & 1 & 1 & 0 & 0 & & & & & & & & & & \\
 & 1 & 1 & 0 & 1 & 0 & 1 & & & & & & & & & & \\
 \hline
 & 1 & 1 & 0 & 0 & 1 & 0 & & & & & & & & & & \\
 & 0 & 1 & 1 & 1 & 0 & 0 & & & & & & & & & & \\
 \end{array}$$

- Transmitted sequence, $T=1010001101\textcolor{red}{01110}$
- At the receiving end, T is divided by P to see if the remainder is zero. The zero remainder indicates error free reception.



Cyclic Redundancy Check

Example 1

$$\begin{array}{r} P \rightarrow 1 \ 1 \ 0 \ 1 \ 0 \ 1 \end{array} \begin{array}{r} 1 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 1 \ 0 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 1 \ 1 \ 0 \ 1 \ 1 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 1 \ 1 \ 0 \ 1 \ 0 \ 0 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 1 \ 1 \ 1 \ 1 \ 0 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 0 \ 1 \ 1 \ 1 \ 1 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \\ \hline 0 \end{array}$$

Because there is no remainder, it is assumed that there have been no errors.



Homework

1. Detect whether the received sequence 101110101 is error free if the pattern sequence is 1010.



References

- [1] W. Stallings, *Data and Computer Communication*, 10th ed., Pearson Education, Inc., 2014, USA, pp. 194 - 196.
- [2] B. Sklar, *Digital Communications*, 2nd ed., Prentice Hall. 2017, USA, pp. 328 - 345.



Recommended Books

1. **Data Communications and Networking**, *B. A. Forouzan*, McGraw-Hill, Inc., Fourth Edition, 2007, USA.
2. **Computer Networking: A Top-Down Approach**, *J. F. Kurose, K. W. Ross*, Pearson Education, Inc., Sixth Edition, USA.
3. **Official Cert Guide CCNA 200-301 , vol. 1**, *W. Odom*, Cisco Press, First Edition, 2019, USA.
4. **CCNA Routing and Switching**, *T. Lammle*, John Wiley & Sons, Second Edition, 2016, USA.
5. **TCP/IP Protocol Suite**, *B. A. Forouzan*, McGraw-Hill, Inc., Fourth Edition, 2009, USA.
6. **Data and Computer Communication**, *W. Stallings*, Pearson Education, Inc., Tenth Edition, 2013, USA.