NEPAL COLLEGE OF INFORMATION TECHNOLOGY

Balkumari, Lalitpur

Affiliated to Pokhara University

ASSIGNMENT FOR DATA COMMUNICATION

TUTORIAL 4

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Tutorial 4

1) Why burst error is more difficult to handle than single error? Explain why CRC is better than parity method of error detection.

→ A burst error is a series of consecutive bits in a data stream that are altered, whereas a single error affects only one bit.
Burst error are challenging to handle because:

(i) Multiple bit corruption
In a burst error, several bits are corrupted simultaneously, making it harder to detect and correct compared to a single bit error.

(ii) Error pattern complexity
Burst errors create more complex error patterns, requiring more sophisticated detection and correction methods.

(iii) Higher probability in real transmission
In practical communication systems, burst errors are more common du to noise, making them a frequent issue to address.

⇒ Cyclic Redundancy check (CRC) is more effective than the parity check method because:

(i) Higher accuracy
Parity can only detect odd numbers of bit errors, whereas CRC can detect multiple and burst errors.

(ii) Burst error detection
CRC is specifically designed to detect burst errors of a certain length, which makes it more suitable for real-world applications.

(iii) Mathematical foundation
CRC uses polynomial division, ensuring more robust and reliable error detection compared to the simple XOR used in parity checks.

(iv) Error correction capability
While parity checks only indicate that an error occurred, CRC provides more information about the error pattern, making it useful in error correction as well.

2) Explain different types of data compression techniques in data communication. Highlight its importance in communication.

→

Types are:

(i) Lossless compression
- No data is lost during compression.
- Examples * Run-length Encoding
  ↳ compresses repetitive data by storing repeated character followed by a count.
  Example: AAAA → A4

* Huffman coding
Assigns shorter binary codes to frequently occurring symbols and longer codes to rare symbols.

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Example: In a text file, the letter "e" may be assigned a shorter code than "Z" since "e" appears more frequently.

* Lempel-Ziv-~~Welch~~ Algo (LZ-Algorithm)
Identifies repeated patterns and stores them as dictionary entries. Commonly used in ZIP files and GIF images.

(ii) Lossy compression
Lossy compression permanently removes some data to achieve higher compression rates. The original data cannot be perfectly reconstructed, but the loss is usually imperceptible to users.

Techniques:
* JPEG (Joint Photographic Experts Group):
Used for images by reducing colors and details that are less noticeable to the human eye

* MP3 (MPEG Audio Layer-3):
Used for audio compression by removing sounds outside human hearing range.

* MPEG (Moving Picture Experts Group):
Used for video compression by reducing redundant frames and less important visual details

3) Why is flow control needed? Explain sliding window flow control algorithm in detail.

→

Flow control prevents the sender from overwhelming the receiver by ensuring data is sent at a rate the receiver can handle without it, buffer overflow and data loss may occur.

Sliding Window Flow Control Algorithm :→

The sliding window Algorithm ensures efficient, reliable transmission by managing how much data can be sent before receiving acknowledgements.

1. Window size : sender transmits a fixed number of frames(w) without waiting for individual ACKs.
2. Sliding Mechanism : Upon receiving an ACK, the window slides forward, allowing new frames to be sent.
3. Error Handling : If a frame or ACK is lost, only the missing frame is retransmitted, and the window halts until resolved.

Advantages :

- Efficient Bandwidth Use : Enables continuous transmission.
- Error Recovery : Retransmits only lost frames.
- Fair control : Matches sender speed with receiver capacity.

Q4) Compare asynchronous and synchronous data-link protocols.

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	Aspect	Asynchronous Protocol	Synchronous Protocol
1.	Definition	Data is transmitted one character at a time, with start and stop bits for synchronization.	Data is sent as continuous stream, with synchronization achieved using clock signals.
2.	synchronization	Achieved using start and stop bits for each character.	Achieved using a shared clock or specific synchronization sequences.
3.	Efficiency	Less efficient due to additional start and stop bits.	More efficient as no start/stop bits are used.
4.	Speed	slower due to character-by-character transmission.	Faster as data is transmitted in blocks or streams.
6.	Overhead	Higher overhead due to extra bits per character.	lower overhead as synchronization is maintained continuously.
7.	Error Detection	Basic error detection mechanisms, such as parity.	Advanced error detection and correction methods, like CRC.
8.	complenity	simple to implement and less expensive.	More complen and requires precise synchronization.
9.	Examples	serial communication (e.g. RS-232)	Ethernet, HDLC, and PPP.

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(Q5) What are the two types of sliding window ARQ error control? Explain Two Types: Go back - N - ARQ and selective ARQ.

→ Sliding window ARQ (Automatic Repeat Request) is a method of error control used in data communication protocols to ensure reliable transmission of data. The two types, differ in how they handle errors and retransmissions.

1. Go-Back-N ARQ

In Go-Back-N ARQ, the sender can transmit multiple frames without waiting for an acknowledgement (ACK) for each frame. However, if an error is detected or an ACK is not received for a specific frame, the sender retransmits that frame and all subsequent frames in the sequence, even if they were correctly received.

2. Selective ARQ

Selective ARQ improves efficiency by retransmitting only the erroneous frames. The sender maintains a record of unacknowledged or corrupted frames and retransmits them individually, instead of resending the entire sequence.

Comparison:

Feature	Go-Back-N ARQ	Selective
1. Retransmission	Entire sequence after error	Only erroneous frames
2. Efficiency	Lower due to redundant data	Higher, avoids redundancy
3. Complexity	Simpler to implement	More complex (requires buffer and tracking)

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Q6) How is data link error control from flow control? Explain.

→

Data link error control and flow control are distinct mechanisms in data communication, although both aim to ensure reliable data transmission.

1. Error control
- Purpose: Ensures the integrity and correctness of transmitted data by detecting and correcting errors caused by noise, interference or other issues during transmission.
- Mechanisms: Uses techniques like ARQ (Automatic Repeat Request) and FEC (Forward Error Correction)
- Focus: Reliability
- Example: Sliding window ARQ methods (Go-Back-N and selective ARQ) detect errors and retransmit corrupted frames

2. Flow control
- Purpose: Prevents the sender from overwhelming the receiver by managing the pace of data transmission.
- Mechanisms: Uses protocols like stop-and-wait and sliding window protocols to match the sender's rate with the receiver's processing capability.
- Focus: Efficiency and synchronization.
- Example: Sliding window protocol limits the number of unacknowledged frames in transit to maintain a manageable data flow.

Q7) Explain the advantages and disadvantages for stop and wait error control method and sliding window error control method.

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Stop-and-Wait Error control Method :

Advantages :-

1. Simplicity : Easy to implement as it requires minimal control logic and resources.
2. Error Recovery : Ensures that only one frame is in transit, making error detection and retransmission straightforward
3. Low Resource Usage : suitable for low-speed or low-volume data communication where bandwidth isn't a concern.

Disadvantages :

1. Inefficiency : Poor utilization of available bandwidth, as the sender waits for ACK before sending the next frame.
2. High latency : Increases transmission time, especially in high latency networks, as the sender remains idle while waiting for ACK.
3. Not scalable : Ineffective for high-speed networks or large data transfers, where multiple frames could be sent simultaneously.

sliding window Error control Method :

1. Advantages :
1. Efficient bandwidth utilization
2. Reduced Latency
3. Scalability
4. Flexibility

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Disadvantages:

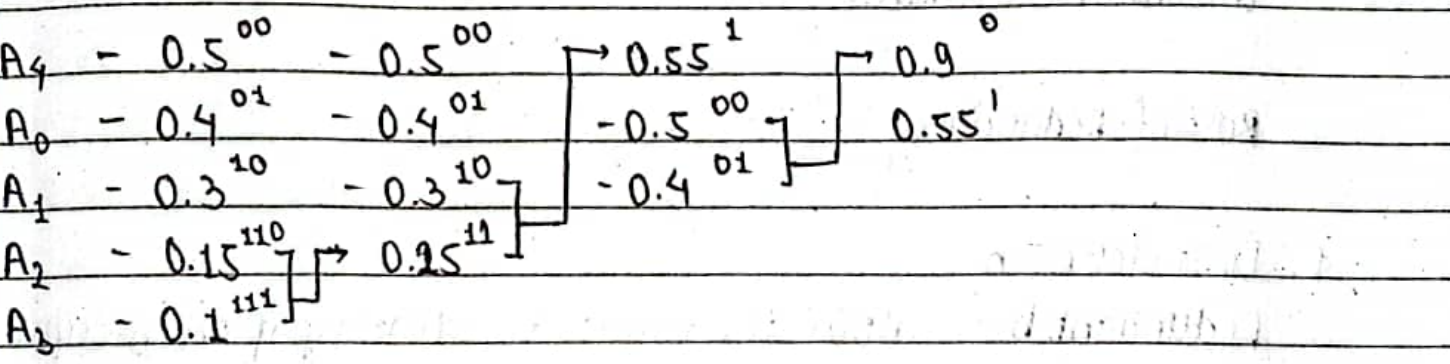
1. Complexity
2. Higher Resource Requirements
3. Error propagation (Go-Back-N)
4. Receiver Buffering (selective Repeat)

Q8) The source of information symbols $\{A_0, A_1, A_2, A_3 \text{ and } A_4\}$ have corresponding probabilities $\{0.4, 0.3, 0.15, 0.1 \text{ and } 0.5\}$. Encode the source symbols using Huffman coding scheme and calculate the corresponding efficiency.

Soln

Here, $P(A_0) = 0.4$, $P(A_1) = 0.3$, $P(A_2) = 0.15$, $P(A_3) = 0.1$, $P(A_4) = 0.5$

Arranging in descending order,



Here, we have re-ordered the ~~eg~~ probability in each step above, until we are left with 2-symbol source.

Now, we assign the value in each step. Lets assume higher probability as '0' and low as '1'.

With this convention, the source are encoded as shown in figure above.

Hence, huffman code for each symbol are:

$A_0 \rightarrow 01$
$A_1 \rightarrow 10$
$A_2 \rightarrow 110$
$A_3 \rightarrow 111$
$A_4 \rightarrow 00$

Q9) Discuss the concept of redundancy in error detection and correction. Define Hamming distance.

→

Redundancy refers to adding extra bits or information to the original data during transmission to detect and correct errors. These additional bits are not part of the actual data but serve as means to verify the integrity and correctness of the transmitted data.

Role of Redundancy:

1. Error detection
Redundant bits allow the receiver to identify if errors occurred during transmission. Techniques like parity checks and cyclic redundancy checks (CRC) use redundancy to detect errors.

2. Error correction
With more advanced redundancy (e.g. Hamming codes), errors can be not only detected, but corrected, without needing retransmission.

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3. Trade-off:
More redundancy increases error detection and correction capability but reduces transmission efficiency by increasing data size.

The Hamming distance is a measure of how different two binary strings of equal length are. It is defined as the number of positions at which the corresponding bits differ.

$$\text{Hamming Distance} = \sum_{i=1}^{n} (1 \text{ if } A[i] \neq B[i], \text{ else } 0)$$

where n is the length of strings.

Q10) Suppose a code has a Hamming distance $d_{min} = 4$. What is the error detection and correction capability of this scheme?

→

Given,
Minimum Hamming distance, $d_{min} = 4$

Error detection capability:

We know,

$$E_{detectable} = d_{min} - 1$$

so,

$$E_{detectable} = 4 - 1$$
$$= 3$$

so, the code can detect upto 3 errors.

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Error correction capability:

We have,

$$E_{correctable} = \left\lfloor \frac{d_{min} - 1}{2} \right\rfloor$$

so,

$$E_{correctable} = \left\lfloor \frac{4-1}{2} \right\rfloor = \left\lfloor \frac{3}{2} \right\rfloor = 1$$

so, the code can correct upto 1 error.

Q11) Encode "Phool ko ankhama phoolai sansara" using Huffman encoder and find the transmission efficiency.

soln

"Phool ko ankhama phoolai sansara" (32)

Lets calculate frequency for each character,

P → 1
h → 3
o → 5
l → 2
k → 2
a → 7
n → 2
m → 1
p → 1
i → 1
s → 2
(space) → 4
r → 1

Total frequency = 32.

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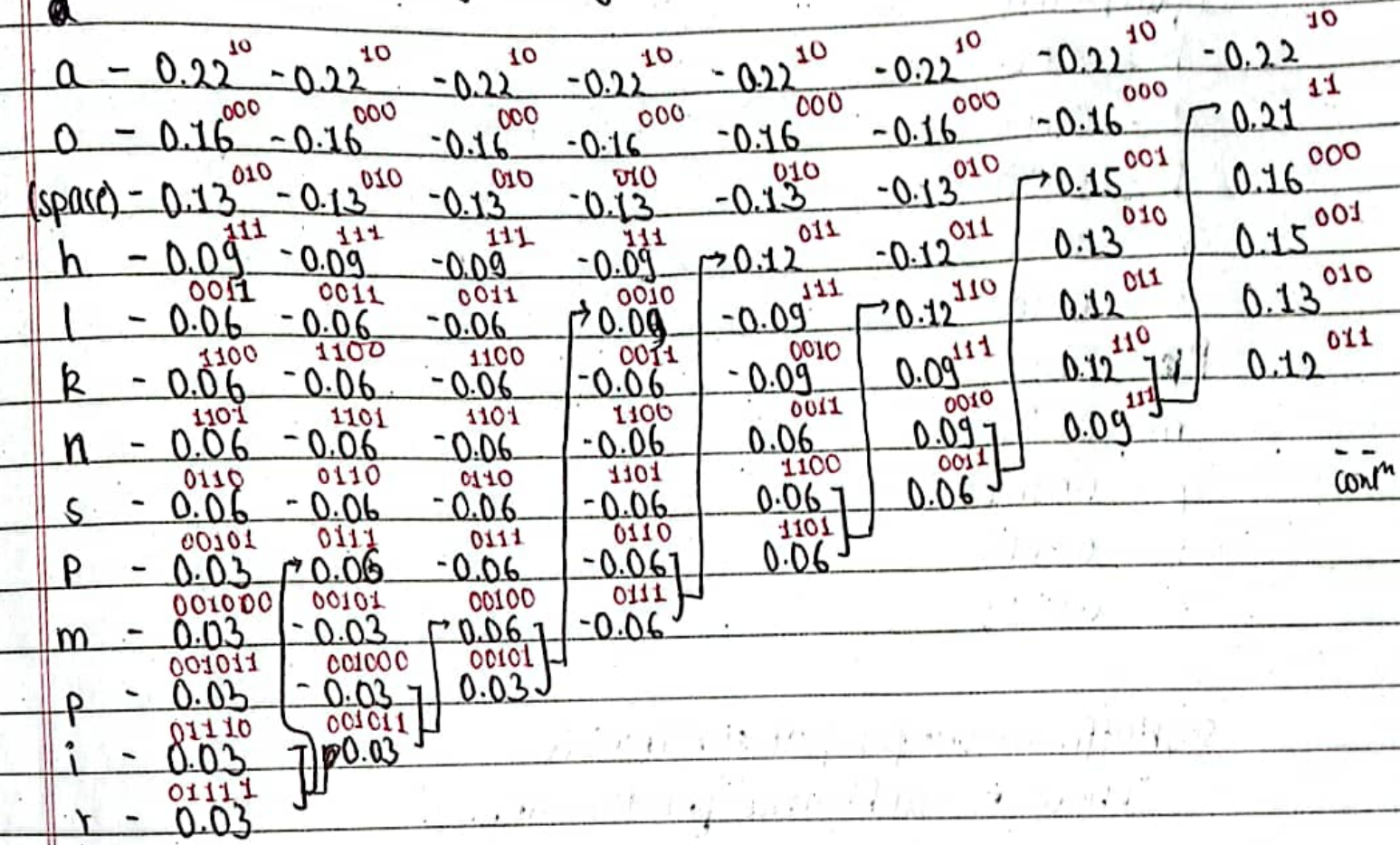
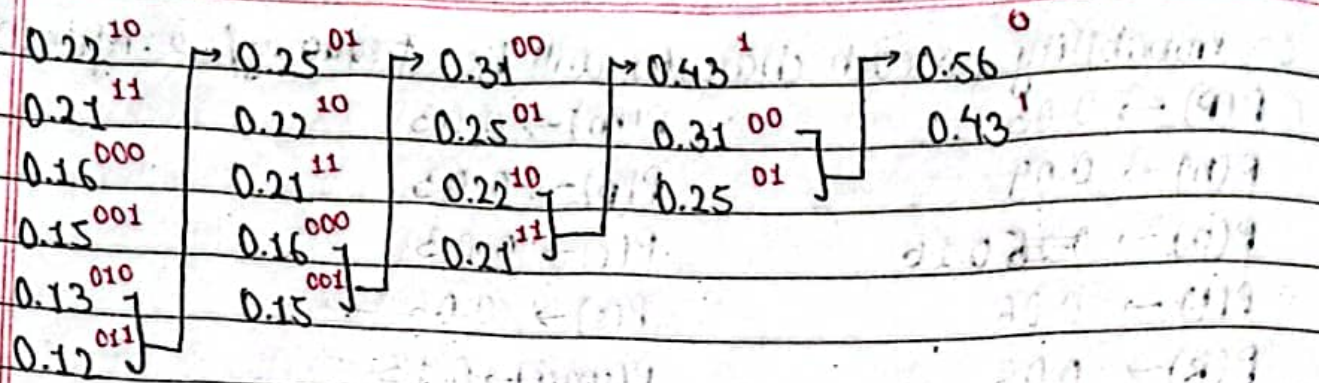
So, Probability for each character will be frequency/32. After computing,

P(P) → 0.03
P(h) → 0.09
P(o) → 0.16
P(l) → 0.06
P(k) → 0.06
P(a) → 0.22
P(n) → 0.06
P(m) → 0.03
P(p) → 0.03
P(i) → 0.03
P(s) → 0.06
P(space) → 0.13
P(r) → 0.03

Now, For Huffman coding, Arrangind in descending order along with probabilities,



Cont'



Hence, Huffman code for each character is as,

a - 10
o - 000
(space) - 010
h - 111
l - 0011
k - 1100
n - 1101
s - 0110
P - 00101
m - 001000
p - 001011
i - 01110
r - 01111

so, Huffman code for full statement is,
"Phool ko ankhama phoolai sansara"

00101 111 000 000 0011 010 1100 000 10 1101 1100 111 10 →

→ 001000 10 010 001011 111 000 000 0011 10 01110 010 →

→ 0110 10 1101 0110 10 01111 10