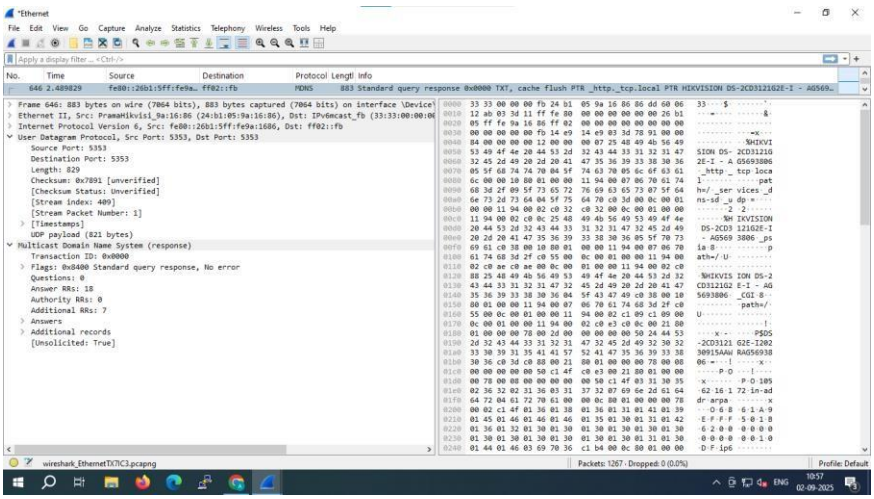


Result

Wireshark was successfully used to capture and analyze network traffic. The process of protocol encapsulation and the structure of packet headers at different layers were observed and understood.

EXP:06	**Error Correction at Data Link Layer**

Aim

To write a program to implement error detection and correction using the **Hamming Code** concept.

Algorithm / Procedure

1. **Determine** the number of redundant (parity) bits required for the given data size.
2. **Calculate** the positions of the parity bits (powers of 2).
3. **Implement** the Hamming Code generation algorithm:
   - Place data bits and parity bits in their respective positions.
   - Calculate the value of each parity bit based on the data bits it covers.
4. **Implement** the error detection and correction algorithm:
   - Receive the transmitted codeword.
   - Recalculate the parity bits.
   - Calculate the syndrome (error position) by combining the recalculated parity bits.
   - If the syndrome is non-zero, flip the bit at the error position.

5. **Test** the program with a data stream, introducing a single-bit error to verify the correction feature.

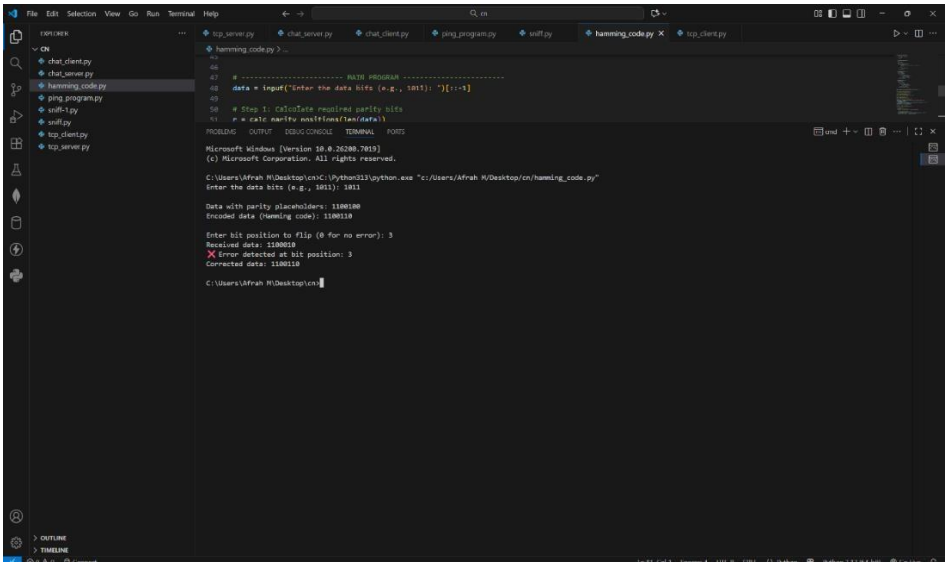
Code:

```
def calc_parity_positions(m):
    r = 0
    while (2**r) < (m + r + 1):
        r += 1
    return r


def insert_parity_bits(data, r):
    j = 0
    k = 1
    m = len(data)
    res = ''
    for i in range(1, m + r + 1):
        if i == 2**j:
            res += '0'  # parity bits start as 0 instead of 'P'
            j += 1
        else:
            res += data[-1 * k]
            k += 1
    return res[::-1]


def calc_parity_bits(arr, r):
    n = len(arr)
    arr = list(arr)
    for i in range(r):
```

```
        val = 0
        for j in range(1, n + 1):
            if j & (2**i) == (2**i):
                val ^= int(arr[-1 * j])
        arr[-1 * (2**i)] = str(val)
    return ''.join(arr)

def detect_error(arr, r):
    n = len(arr)
    res = 0
    for i in range(r):
        val = 0
        for j in range(1, n + 1):
            if j & (2**i) == (2**i):
                val ^= int(arr[-1 * j])
        res += val * (10**i)
    return int(str(res)[::-1], 2)

# ------------------------ MAIN PROGRAM ------------------------
data = input("Enter the data bits (e.g., 1011): ")[::-1]

# Step 1: Calculate required parity bits
r = calc_parity_positions(len(data))

# Step 2: Insert parity bits into data
arr = insert_parity_bits(data, r)
print("\nData with parity placeholders:", arr)
```

```
# Step 3: Calculate parity bits
arr = calc_parity_bits(arr, r)
print("Encoded data (Hamming code):", arr)

# Step 4: Introduce an error (optional)
error_index = int(input("\nEnter bit position to flip (0 for no error): "))
arr_with_error = list(arr)
if error_index != 0:
    arr_with_error[-error_index] = '1' if arr_with_error[-error_index] == '0' else '0'
arr_with_error = ''.join(arr_with_error)
print("Received data:", arr_with_error)

# Step 5: Detect error position
error_pos = detect_error(arr_with_error, r)

if error_pos == 0:
    print("No error detected.")
else:
    print(f"Error detected at bit position: {error_pos}")

    # Step 6: Correct the error
    arr_corrected = list(arr_with_error)
    arr_corrected[-error_pos] = '1' if arr_corrected[-error_pos] == '0' else '0'
    print("Corrected data:", ''.join(arr_corrected))
```

Output:



Result

A program to implement the Hamming Code was successfully written. The program demonstrated the ability to detect and correct a single-bit error in the transmitted data stream.

EXP:07	**Flow control at Data Link Layer**

Aim

To write a program to implement flow control at the data link layer using the **Sliding Window Protocol** and simulate the flow of frames from one node to another.

Algorithm / Procedure

1. **Define** the window size for the sender and receiver.
2. **Implement** the sender logic:
   - Maintain a sending window of sequence numbers.
   - Send frames within the window limit.
   - Start a timer for each unacknowledged frame.
3. **Implement** the receiver logic:
   - Maintain a receiving window.
   - Accept frames in order and send cumulative acknowledgments (ACKs).
   - Discard out-of-order frames (or buffer, depending on the specific protocol variant).