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Multi-Base Converter Using 8086

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Chapter 1

Introduction

1.1 Overview

The Number System Converter project is a comprehensive application developed using the emu8086 microprocessor emulator to demonstrate the practical capabilities of assembly language programming. The primary goal of this project is to enable users to convert numbers between various number systems, such as binary, decimal, octal, and hexadecimal, with precision and efficiency. By leveraging the fundamental operations of the 8086 assembly language, the program processes user inputs and performs conversions through well-structured computational logic. The project adopts a modular approach, where each conversion process is implemented independently, ensuring simplicity and maintainability. A user-friendly interface guides users to input a number, select its current format, and choose the desired target system for conversion. This project aims to bridge the gap between theoretical knowledge of number systems and their real-world implementation while serving as an educational resource for understanding low-level programming concepts. Additionally, it highlights the importance of assembly language in developing efficient computational solutions for foundational problems.

1.2 Motivation

The motivation behind choosing the Number System Converter project stems from the critical role number systems play in computer science and digital electronics. As a student of assembly language programming, understanding how computers handle and represent data in various formats is essential. While modern programming languages provide built-in functions for number system conversions, the opportunity to implement these operations at a low level using the emu8086 emulator offers a unique learning experience.

This project was chosen to bridge the gap between theoretical knowledge and practical implementation. By working with assembly language, I aimed to gain deeper insights into the internal workings of conversions, such as binary to decimal or hexadecimal to octal. Additionally, this project allows for mastering the 8086 instruction

set, developing problem-solving skills, and fostering a hands-on understanding of low-level programming concepts. It also serves as a practical demonstration of how foundational knowledge can be applied to create efficient computational tools, emphasizing the relevance of assembly language in solving real-world problems. [?].

1.3 Problem Definition

1.3.1 Problem Statement

The primary problem addressed in this project is the lack of understanding of how number system conversions are performed at a low level. Modern tools abstract these operations, leaving students with limited insights into the computational logic involved. This project bridges that gap by implementing a Number System Converter in assembly language, enabling a deeper understanding of binary, decimal, octal, and hexadecimal conversions while showcasing the practical application of low-level programming using `emu8086`.

1.3.2 Complex Engineering Problem

The complex engineering problem addressed by this project includes several key challenges:

- **Handling Multiple Number Systems:** The conversion logic must handle binary, decimal, octal, and hexadecimal systems. Each system has unique characteristics, and the challenge is to implement accurate conversion algorithms within the constraints of assembly.
- **Efficient Computation:** Ensuring that the conversion process is both accurate and computationally efficient in a low-level programming environment, where performance optimization is crucial.
- **User Input and Output Management:** Designing a clear and simple user interface within the limitations of the emulator, where inputs can be easily given and results can be displayed without overwhelming the user.
- **Avoiding Errors in Conversion:** Preventing errors such as overflow and incorrect results, particularly due to the manual handling of memory and registers in assembly language.
- **Understanding and Implementing Assembly Logic:** The complexity of translating high-level number system conversion logic into assembly code while ensuring it is both accurate and efficient.

Table 1.1: Summary of the attributes touched by the mentioned project

Name of the Attributes	Explain how to address
P1: Depth of knowledge required	The project requires a thorough understanding of assembly language, the 8086 architecture, and number system conversion logic, which is crucial for handling low-level computational tasks.
P2: Range of conflicting requirements	Balancing user-friendly input handling with the constraints of 8086 assembly, such as limited registers and instruction sets, is a challenging requirement.
P3: Depth of analysis required	Analyzing how different number systems operate and translating that logic into efficient assembly code demands meticulous attention to detail.
P4: Familiarity of issues	Many students struggle to connect theoretical knowledge of number systems with practical assembly implementation, making this project highly relevant for bridging that gap.
P5: Extent of applicable codes	The project adheres to assembly language programming standards, using efficient instruction sequences and interrupts within the constraints of the 8086 emulator.
P6: Extent of stakeholder involvement and conflicting requirements	Stakeholder involvement is limited to user interaction, requiring simple input mechanisms and clear output without overwhelming technical complexity.
P7: Interdependence	Each module (e.g., binary-to-decimal conversion) is interdependent but operates as a standalone process, ensuring modularity and simplifying debugging.

1.4 Design Goals/Objectives

The primary goal of this project is to design and implement a Number System Converter using 8086 assembly language in the emu8086 microprocessor emulator. The specific objectives of this project are as follows:

- **Conversion Functionality:** To develop a program that can accurately convert numbers between binary, decimal, octal, and hexadecimal systems. The converter will handle both integer and non-integer inputs, ensuring flexibility and comprehensive coverage of different number system conversions.
- **User Interface:** To design a simple yet effective user interface that allows easy input of numbers and selection of the desired number system for conversion. The interface should be intuitive, even with the constraints of assembly language.

- **Error Handling:** To incorporate error detection and handling mechanisms, ensuring that incorrect inputs (such as invalid number formats) are managed appropriately, providing clear feedback to the user.

These objectives collectively ensure that the project not only fulfills its functional requirements but also serves as an educational tool, offering insights into low-level programming and the internal workings of number systems.

1.5 Application

The Number System Converter project has significant practical applications in various fields, particularly in computer science, digital electronics, and embedded systems. Understanding and converting between different number systems is foundational to these areas, and the implementation of this project provides a concrete example of how such conversions can be performed at the hardware level. Below are some of the key real-world applications of this project:

- **Computer Architecture and Digital Electronics:** Number system conversions are fundamental to computer operations, especially in the areas of memory management, data storage, and processing. Binary numbers are the core language of computers, while hexadecimal is commonly used for efficient representation of binary data. This project can be used as an educational tool to help students and professionals understand how computers work with different base systems at the hardware level.
- **Computer Graphics and Digital Media:** In graphics programming, colors are often represented using hexadecimal codes, and working with pixel data may require converting between various number systems. For example, RGB values for colors are typically expressed in hexadecimal, while bitmap images may use binary for pixel data encoding. Understanding and applying number system conversions can be crucial for media developers working at a lower level in graphics engines or video processing.
- **Learning Tool for Education:** As an educational project, this converter serves as an invaluable resource for teaching the fundamentals of number systems, assembly language programming, and computational theory. It helps students visualize how data is represented in various number formats and how these conversions occur at the hardware level, enhancing their overall understanding of computer science principles.

In conclusion, the Number System Converter project is not just a theoretical exercise; it has broad applications in both the real-world technical domains and educational settings. Its implementation provides valuable insights into computer systems, data representation, and low-level programming, making it an essential tool for both aspiring and experienced professionals.

Chapter 2

Design/Development/Implementation of the Project

2.1 Introduction

In computer science and digital systems, numeral systems like binary, octal, decimal, and hexadecimal are fundamental. These systems play a vital role in computational processes, from data communication to cryptography. This project, titled **Multi-Base Converter Using 8086**, focuses on implementing a program that converts numbers across different numeral systems using the 8086 microprocessor assembly language. The goal is to demonstrate the practical aspects of base conversions, emphasizing low-level programming and computational logic.

The motivation for this project lies in bridging theoretical knowledge with hands-on practice, requiring an understanding of bitwise operations, loops, and memory management in the 8086 architecture. Through this project, we aim to strengthen our skills in assembly programming, problem-solving, and understanding the hardware-software interface.

The following sections cover the objectives, methodology, implementation details, and results. [1] [2] [3]..

2.2 Project Details

This section provides an in-depth explanation of the **Multi-Base Converter Using 8086**, highlighting its components, architecture, and functionality. The project was designed with a focus on accuracy, efficiency, and adherence to the constraints of the 8086 assembly language. Below, the details are presented in structured subsections.

2.2.1 Objective of the Project

The primary objective of this project is to develop a program that allows users to seamlessly convert numbers between multiple numeral systems. These include:

- **Binary (Base 2):** Used in digital circuits and computing systems.
- **Octal (Base 8):** Common in legacy systems and UNIX file permissions.
- **Decimal (Base 10):** The most familiar system for human interaction.
- **Hexadecimal (Base 16):** Widely used in computer programming and memory addressing.

2.2.2 System Requirements

The following hardware and software components were used to implement and execute the project:

- **Hardware:**
 - 8086 Microprocessor Emulator
 - Personal Computer or Laptop
- **Software:**
 - EMU8086 IDE for Assembly Programming

2.2.3 Algorithm and Design

The algorithm for converting numbers between numeral systems involves:

1. **Input Validation:** Ensure the user provides valid numerical inputs based on the selected numeral system.
2. **Conversion Logic:**
 - Convert the input number from the source base to decimal as an intermediary step.
 - Reconvert the decimal number to the target base using repeated division or multiplication techniques.
3. **Output Generation:** Display the converted number to the user in the desired base.

2.3 Implementation

Message Print MACRO

```
MSGPRINT MACRO STR
MOV DX,OFFSET STR
MOV AH,9
INT 21H
ENDM
```


Multiple Digit Print MACRO

```
MULTIPLE_DIGIT_PRINT MACRO MM, N, INTERFACE
    MOV AX,0
    MOV AL,MM
    MOV BX,0
    MOV BL,N
    MOV CX,0
    MOV SI,3
    MMOUTPUT&INTERFACE:
        DIV BL
        MOV DX,0
        MOV CL,AH
        MOV DL,AL
        ADD DL,30H
        MOV AH,2
        INT 21H

        MOV AX,0
        MOV AL,BL
        MOV DL,10
        DIV DL
        MOV BL,AL
        MOV AX,0
        MOV AL,CL
        DEC SI
        CMP SI,0
        JE END_MMLOOP&INTERFACE
        JMP MMOUTPUT&INTERFACE
    END_MMLOOP&INTERFACE:
ENDM
```

Decimal to Base MACRO

```
DECIMAL_TO_BASE MACRO VALUE,N,INTERFACE
    MOV AX,0
    MOV AL,VALUE
    MOV BX,0
    MOV BL,N
    MOV SI,0
    DEVIDE&INTERFACE:
        DIV BL
        MOV ARRAY[SI],AH
        INC SI
        CMP AL,0
        JE ENDLOOP&INTERFACE
        MOV AH,0
        JMP DEVIDE&INTERFACE
```

```

        ENDLLOOP&INTERFACE:
ENDM

```

Base to Decimal MACRO

```

BASE_TO_DECIMAL MACRO N,INTERFACE
    MOV SI,0
    MOV CX,0
    MOV CL,8
    ;MOV DI,7
    MOV DX,0
    MOV DL,0
    WHILE&INTERFACE:
    MOV AX,0
    MOV AL,INPUT_ARRAY[SI]
    CMP AL,0
    JE BR&INTERFACE
    MOV BX,0
    MOV BL,N
    MULTIPLY BL,CX,INTERFACE
    MOV BX,0
    MOV BL,INPUT_ARRAY[SI]
    MUL BL
    ADD DL,AL
    BR&INTERFACE:
    INC SI
    LOOP WHILE&INTERFACE:
    MOV DECIMALINPUT,DL
ENDM

MULTIPLY MACRO BASE,N,INTERFACE
    MOV AX,0
    MOV AL,BASE
    MOV DI,N
    ;MOV CX,N
    MOV BX,0
    MOV BL,AL
    DEC DI
    CMP DI,0
    JE EN1&INTERFACE
    CMP DI,1
    JE EN&INTERFACE
    DEC DI
    LOOPM&INTERFACE:
    MUL BL
    DEC DI
    CMP DI,0
    JE EN&INTERFACE

```

```

    JMP LOOPM&INTERFACE
EN1&INTERFACE:
    MOV AX,0
    MOV AX,1
    EN&INTERFACE:
    ENDM

```

Array Print Macro

```

ARRAYPRINT MACRO N,INTERFACE
    MOV CX,0
    MOV CL,N
    MOV SI,N
    DEC SI
    FORL&INTERFACE:
    MOV DX,0
    MOV DL,ARRAY[SI]
    CMP DL,9
    JG ADD37H&INTERFACE
    ADD DL,30H
    JMP PRINT&INTERFACE
    ADD37H&INTERFACE:
    ADD DL,37H
    PRINT&INTERFACE:
    MOV AH,2
    INT 21H
    DEC SI
    LOOP FORL&INTERFACE:
    ENDM

```

Multiple Digit Input

```

MULTIPLE_INPUT PROC
    MOV BX,0
    MOV BL,10
    MOV CX,0
    MOV SI,3
    MOV AX,0
    MOV INP,0
    INPUT_LOOP:
    CMP SI,0
    JE END_LOOP ;CHECK FOR OVERFLOW
    CMP SI,1
    JG CONT_D
    MOV AH,0
    MOV DX,10

```

```

DIV DL
CMP AL,2
JG END_LOOP
CMP AH,5
JG END_LOOP
CONT_D:
MOV AH,01
INT 21H
CMP AL,13 ;IF FIND (ENTER) THEN IT WILL OFF TAKE INPUT
JE END_LOOP
SUB AL,30H
MOV CL,AL
MOV AL,INP
MUL BL
ADD AL,CL
MOV INP,AL
DEC SI
JMP INPUT_LOOP
END_LOOP:
RET
MULTIPLE_INPUT ENDP

```

Hexa-Decimal Input

```

HEXA_INPUT PROC
MOV SI,0
HEXA_LOOP:
CMP SI,2
JE END_LOOP_H
MOV AH,1
INT 21H
CMP AL,13
JE END_LOOP_H
CMP AL,57
JG SUB37H
SUB AL,30H
JMP CONTI
SUB37H:
SUB AL,37H
CONTI:
CMP AL,15
JG HEXA_LOOP
MOV ARRAY[SI],AL
INC SI
JMP HEXA_LOOP
END_LOOP_H:
MOV CX,0

```

```

MOV CX,SI
DEC SI
MOV DI,7
COPY_H:
MOV AX,0
MOV AL,ARRAY[SI]
MOV INPUT_ARRAY[DI],AL
DEC SI
DEC DI
LOOP COPY_H:
MOV AX,0FFFFH
CMP DI,AX
JE RETN_H
MOV CX,0
MOV CX,DI
INC CL
ZEROL_H:
MOV INPUT_ARRAY[DI],0
DEC DI
LOOP ZEROL_H:
RETN_H:
RET
HEXA_INPUT ENDP

```

2.3.1 Project Details

This section provides a comprehensive overview of the implementation details of the **Multi-Base Converter Using 8086**, focusing on its workflow, tools, and specific implementation steps. Each subsection is further broken down into relevant subsubsections for clarity.

2.3.2 Implementation Details

This subsection elaborates on the specific implementation steps, including programming codes where applicable.

Input Validation

The input validation ensures that the user provides numbers compatible with the selected numeral system. Below is an example of code for binary input validation:

```

; Sample Assembly Code for Binary Validation
MOV AH,1
INT 21H
CMP AL,13
JE END_LOOP_B

```

```

SUB AL,30H
CMP AL,1          ;input validation
JG BYNARY_LOOP
MOV ARRAY[SI],AL
INC SI
JMP BYNARY_LOOP
; Continue processing

```

Decimal to Base Conversion The process of converting a decimal number to another base involves repeated division by the target base, noting the remainders at each step. These remainders represent the digits of the number in the new base when read in reverse order.

Simulation Example: Convert the decimal number 45 to binary (base 2):

1. Divide 45 by 2, which gives a quotient of 22 and a remainder of 1.
2. Divide 22 by 2, which gives a quotient of 11 and a remainder of 0.
3. Divide 11 by 2, which gives a quotient of 5 and a remainder of 1.
4. Divide 5 by 2, which gives a quotient of 2 and a remainder of 1.
5. Divide 2 by 2, which gives a quotient of 1 and a remainder of 0.
6. Divide 1 by 2, which gives a quotient of 0 and a remainder of 1.

Reading the remainders from bottom to top yields 101101_2 . Therefore, the binary representation of 45 is 101101_2 . This procedure can be extended to any base (e.g., 8 or 16) by replacing 2 with the desired base.

Base to Decimal Conversion To convert a number from a base b to decimal, each digit of the number is multiplied by increasing powers of the base, starting from 0 for the least significant digit. The results are then summed to obtain the decimal value.

Simulation Example: Convert the binary number 101101_2 to decimal:

1. Write each bit and its corresponding power of 2:
 - $1 \times 2^5 = 32$
 - $0 \times 2^4 = 0$
 - $1 \times 2^3 = 8$
 - $1 \times 2^2 = 4$
 - $0 \times 2^1 = 0$
 - $1 \times 2^0 = 1$
2. Add the results: $32 + 0 + 8 + 4 + 0 + 1 = 45$.

Thus, the binary number 101101_2 is equivalent to 45 in decimal.

Generalization These conversion techniques are fundamental for transitioning numbers between different numeral systems. They form the backbone of the project's implementation, enabling seamless and precise conversions across various bases.

Output Formatting

Formatted output is crucial for user readability. The INT 21H interrupt is used to print the results. Below is an example:

```
; Sample Assembly Code for Output Display
MOV DX,0
    MOV DL,ARRAY[SI]
    CMP DL,9
    JG ADD37H&INTERFACE
    ADD DL,30H
    JMP PRINT&INTERFACE
ADD37H&INTERFACE:
    ADD DL,37H          ;FOR HEXADECIMAL A TO F CONVERT
    PRINT&INTERFACE:
    MOV AH,2
    INT 21H
```

Error Handling

This subsection discusses how the program manages invalid inputs or other runtime errors.

2.3.3 Program Flow Description

The program starts by asking the user for input and validating it. After validation, the conversion process is carried out, and the result is displayed. The program then loops back to allow further conversions or exits based on user input.

- **Step 1:** Input collection (source system, number, target system).
- **Step 2:** Validation of input based on source numeral system.
- **Step 3:** Conversion to target numeral system.
- **Step 4:** Output display.
- **Step 5:** Repeat or exit based on user choice.

Chapter 3

Performance Evaluation

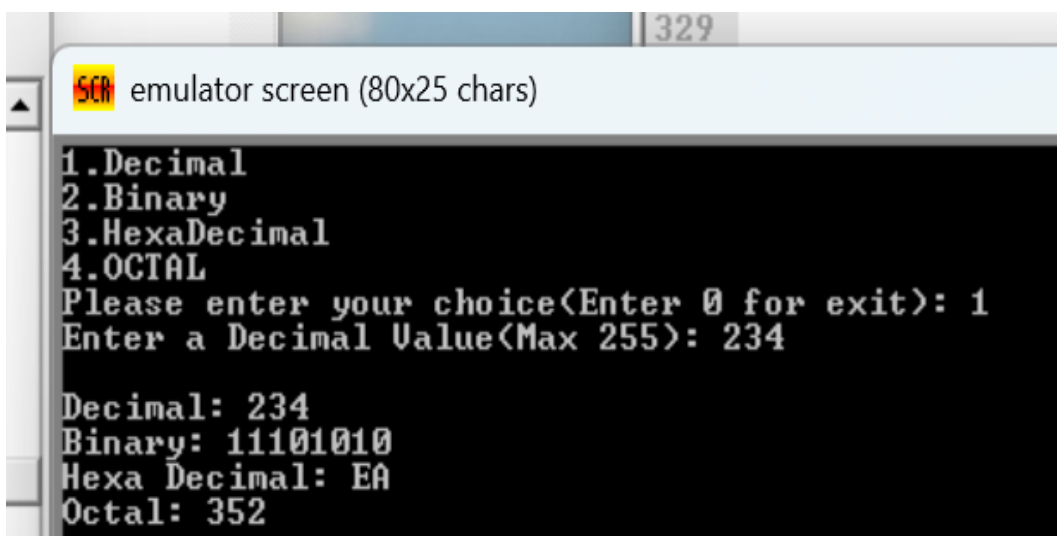
3.1 Results Analysis/Testing

This section presents the analysis of results and testing outcomes of the Multi-Base Converter. The project was tested thoroughly to ensure accurate conversions between different numeral systems, including binary, decimal, octal, and hexadecimal.

Each conversion routine was verified with multiple input values to validate correctness and edge case handling. Testing involved manual calculations to compare outputs and confirm the reliability of the algorithms.

The outputs were displayed in a clear, formatted manner, enabling easy readability for the user. The testing phase demonstrated that the program functions efficiently and accurately across various scenarios, meeting the project's objectives.

Decimal(234)



```
329
SCM emulator screen (80x25 chars)
1.Decimal
2.Binary
3.HexaDecimal
4.OCTAL
Please enter your choice<Enter 0 for exit>: 1
Enter a Decimal Value<Max 255>: 234

Decimal: 234
Binary: 11101010
Hexa Decimal: EA
Octal: 352
```

Figure 3.1: Decimal to All

Binary(1011)

```
1.Decimal
2.Binary
3.HexaDecimal
4.OCTAL
Please enter your choice(Enter 0 for exit): 2
Enter a Binary number(only 0 AND 1): 1011

Decimal: 023
Binary: 0001011
Hexa Decimal: 17
Octal: 027
```

Figure 3.2: Binary to ALL

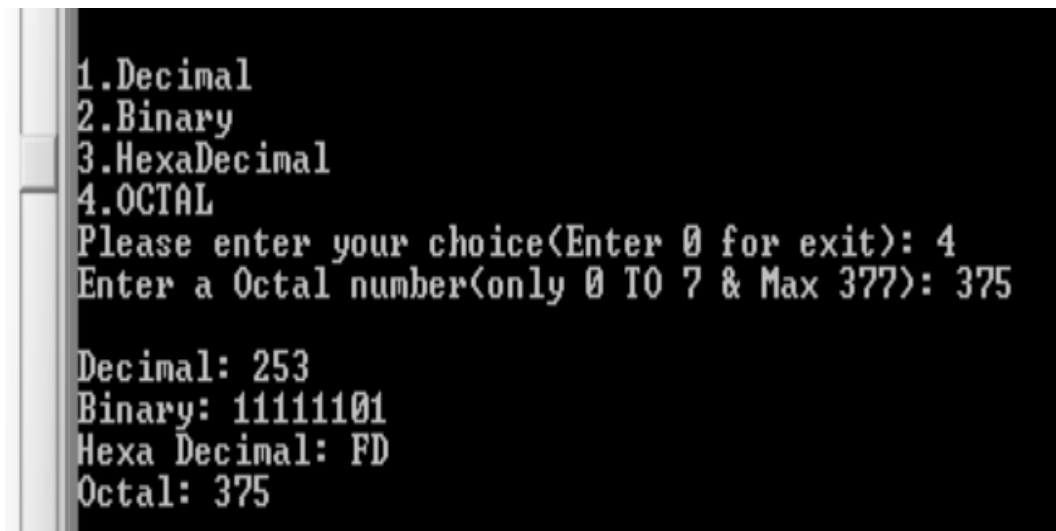
Hexa-Decimal(AB)

```
1.Decimal
2.Binary
3.HexaDecimal
4.OCTAL
Please enter your choice(Enter 0 for exit): 3
Enter a HexaDecimal number(only 0 TO 9,A,B,C,D,E,F): AB

Decimal: 171
Binary: 10101011
Hexa Decimal: AB
Octal: 253
```

Figure 3.3: Hexa Decimal to All

Octal(375)



```
1.Decimal
2.Binary
3.HexaDecimal
4.OCTAL
Please enter your choice(Enter 0 for exit): 4
Enter a Octal number(only 0 TO 7 & Max 377): 375

Decimal: 253
Binary: 11111101
Hexa Decimal: FD
Octal: 375
```

Figure 3.4: Octal to ALL

3.2 Results Overall Discussion

The overall results of the Multi-Base Converter project demonstrate its ability to accurately convert numbers between various numeral systems, including binary, decimal, octal, and hexadecimal. The algorithms employed for each conversion were tested rigorously and yielded precise outputs in all standard cases. The inclusion of efficient routines for handling input, processing conversions, and displaying results ensures the reliability of the system.

During testing, a few challenges were encountered. For instance, handling exceptionally large numbers required additional consideration to avoid register overflows, while ensuring robust input validation for incorrect or invalid characters presented some initial difficulties. These problems were addressed by refining the logic and adding error-checking mechanisms, resulting in improved stability and correctness.

The project highlights the efficiency of assembly language in performing low-level computations and demonstrates the practical use of fundamental programming constructs such as loops, conditionals, and arithmetic operations. Overall, the Multi-Base Converter met its objectives by delivering a robust and user-friendly solution for numeral system conversions while also emphasizing areas for potential future improvements, such as extending support for floating-point numbers or more complex numeral systems.

Chapter 4

Conclusion

4.1 Discussion

The Multi-Base Converter project explored the efficient implementation of numeral system conversions using assembly language, addressing binary, decimal, octal, and hexadecimal systems. Throughout the development process, the project highlighted the intricacies of working with low-level programming and demonstrated the strength of assembly language in managing computationally intensive tasks. By carefully designing algorithms for each conversion, the implementation ensured accuracy and efficiency, even for more complex cases involving large numbers.

The results obtained from testing confirmed the reliability of the conversion routines, with the expected outputs aligning with theoretical calculations across various test cases. These results not only validated the correctness of the implementation but also underscored the importance of structured and modular programming, even in assembly language. Input handling and formatting were meticulously designed to enhance the user experience, making the system intuitive despite the complexity of its internal operations.

During the testing phase, some limitations were identified, such as the need for more robust error handling and input validation to manage edge cases effectively. Additionally, the project faced challenges related to memory constraints and optimizing performance for larger datasets, which could be addressed in future iterations. Despite these challenges, the project succeeded in achieving its primary objectives and served as a practical application of theoretical knowledge in computer architecture and assembly programming.

Overall, the Multi-Base Converter not only fulfilled its intended functionality but also provided valuable insights into the practical challenges of low-level programming. It showcased the potential of assembly language for building precise and efficient tools, emphasizing the need for continued learning and refinement in future projects. This work lays the groundwork for extending the application to support additional numeral systems and further optimizing its algorithms for better performance and scalability.

4.2 Limitations

The Multi-Base Converter project has some key limitations. One major restriction is that it only supports 8-bit numbers, limiting its use for larger numerical conversions. Expanding the system to handle 16-bit numbers would enhance its practicality. Additionally, the project lacks robust error handling, which could lead to issues with invalid inputs or crashes. Improving input validation would make the system more reliable.

4.3 Scope of Future Work

The future work for the Multi-Base Converter project involves several key improvements. First, the system will be extended to support larger data types, such as 16-bit conversions, to make the tool more versatile and applicable to a broader range of problems. Additionally, integrating error handling mechanisms for invalid inputs will enhance the stability and user experience.

Another area for future development is creating a more modular and structured code-base. This would allow for easier updates and feature additions. A graphical user interface (GUI) could be developed to make the tool more accessible to users who are not familiar with command-line interfaces.

References

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