CPE112 Programming With Data Structure

To-do Lists Application

Group Members

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Executive Summary

This report presents our implementation of a comprehensive To-Do List Management System developed as part of the CPE112 Data Structures course. The application addresses the critical need for efficient task management among students and professionals by implementing multiple data structures including linked lists, stacks, queues, and sorting algorithms. Through careful design and implementation, we created a system that not only manages tasks effectively but also demonstrates the practical application of fundamental data structures in solving real-world problems.

Problem Statement

Traditional task management systems suffer from critical limitations:

- **No dynamic priority adjustment** - Tasks remain static despite changing deadlines
- **Inefficient search capabilities** - Linear searching through unorganized data
- **Limited progress tracking** - No visualization of completion rates
- **Poor deadline management** - Manual tracking of due dates

Our solution addresses these challenges by implementing strategic data structures that enable O(1) task operations, automated priority updates, and comprehensive progress analytics.

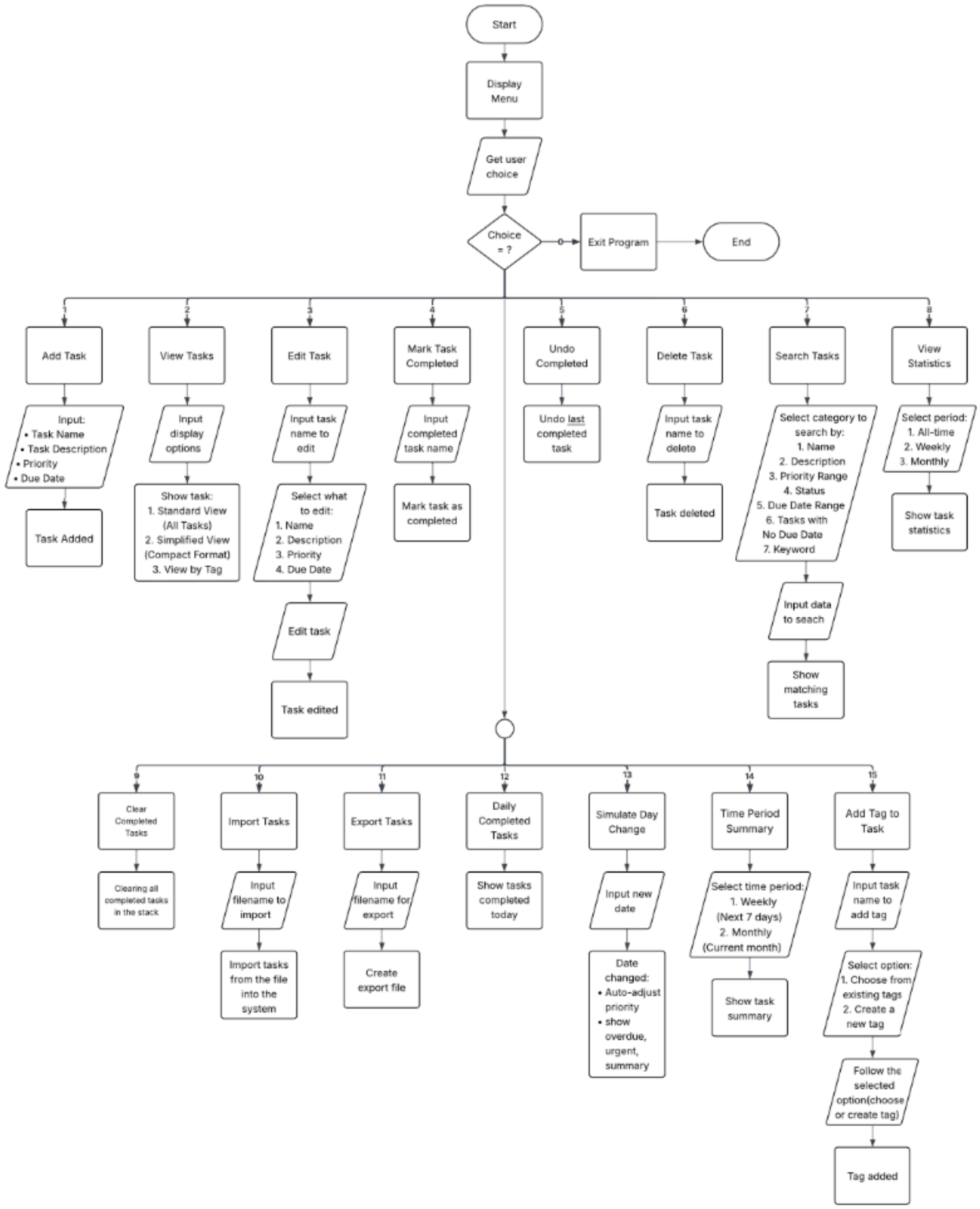
Key Features

- Task Management
  - Add, edit, and delete tasks
  - Assign priorities (High, Medium, Low)
  - Set and track due dates
  - Tag tasks for categorization
- Progress Tracking
  - View completed vs pending tasks
  - Display task statistics
  - Generate progress reports
  - Track overdue tasks
- Advanced Functionalities
  - Automatic priority adjustment
  - Date simulation for testing
  - Import/Export capabilities
  - Undo completed task

System Architecture

- **Main Module (main.c)**
  - Menu Interface & Program Control
- **Task Management Module (task_management.c/h)**
  - Linked List Implementation
  - Stack Implementation
  - Core Task Operations
- **Scheduler Module (scheduler.c/h)**
  - Date Management
  - Priority Adjustment
  - Day Simulation
- **Search & Statistics Module (searchandstat.c/h)**
  - Search Functions
  - Statistical Analysis
  - Progress Reports
- **File I/O Module (fileio.c/h)**
  - Import Functions
  - Export Functions

System Architecture



more detail version:

https://lucid.app/lucidchart/080fbce7-aa48-4b1d-ab9d-774dc06dfa51/edit?viewport_loc=-2848%2C1548%2C2240%2C1540%2C0_0&invitationId=inv_df24405d-2990-4dc7-b5cd-3b0002b7cb94

Data Structure Used

1. Linked List (Primary Storage)

```c
typedef struct task {
    char name[100];
    char description[300];
    int priority;
    date duedate;
    TaskStatus status;
    int due_date_set;
    int completed;
    char tags[MAX_TAGS][MAX_TAG_LENGTH];
    int tag_count;
    struct task* next;
} task;

typedef struct {
```

Justification:

- Dynamic memory allocation - no predefined size limits
- O(1) insertion at head for new tasks
- Efficient memory usage compared to arrays
- Easy node deletion without memory fragmentation

Alternative Considered: Dynamic arrays

Why Rejected: Costly reallocation and shifting operations (O(n))

2. Stack (Completed Tasks)

```c
typedef struct stacknode {
    task* task_data;
    struct stacknode* next;
} stacknode;

typedef struct {
    stacknode* top;
} completedstack;
```

Justification:

- Natural LIFO behavior for undo operations
- O(1) push/pop operations
- Perfect for "undo last completed task" feature
- Memory efficient

Alternative Considered: Queue

Why Rejected: FIFO doesn't match undo operation requirements

3. Queue (Task Scheduling)

```c
// Queue node structure
typedef struct queuenode {
    task* task_data;
    struct queuenode* next;
} queuenode;

// Queue structure with front and rear pointers
typedef struct {
    queuenode* front;
    queuenode* rear;
} taskqueue;
```

Justification:

- FIFO processing for deadline-based tasks
- Natural order for processing tasks due today
- Efficient enqueue/dequeue operations O(1)
- Ideal for reminder system

Alternative Considered: Priority Queue with Heap

Why Rejected: Overcomplicated for current requirements

4. Sorting Algorithm (Bubble Sort)

```c
void sortTasksByDueDate(task* tasks[], int count) {
    for (int i = 0; i < count - 1; i++) {
        for (int j = 0; j < count - i - 1; j++) {
            if (compareDates(tasks[j]->duedate, tasks[j+1]->duedate) > 0) {
                // Swap logic
            }
        }
    }
}
```

Justification:

- Simple implementation for moderate data sizes
- In-place sorting (O(1) extra space)
- Stable sort (maintains relative order of equal elements)
- Sufficient for typical use case (<1000 tasks)

Alternative Considered: Quick Sort

Why Rejected: Additional complexity not justified for current data sizes

Key Functionality Implementation

1. Task Management with Linked List

```
void add(tasklist* list) {
    // 1. Allocate memory
    task* new_task = (task*)malloc(sizeof(task));

    // 2. Input validation
    // Check for duplicate names
    // Validate priority and date

    // 3. Insert at head of linked list
    new_task->next = list->head;
    list->head = new_task;
}
```

This implementation showcases how our linked list enables constant-time O(1) task insertion regardless of list size, while incorporating robust input validation and error handling.

2. Stack-Based Undo System

```
void complete(tasklist* list, completedstack* stack,
const char* name) {
    // 1. Find task in linked list
    // 2. Remove from active list
    // 3. Push onto completed stack
}

void undoCompleted(tasklist* list, completedstack*
stack) {
    // 1. Pop from stack
    // 2. Reinsert into active list
}
```

This implementation demonstrates the power of stack data structure for undo operations, enabling O(1) time complexity for both pushing completed tasks and popping them for undo.

3. Date Validation and Handling

```
// Date validation with edge case handling
int isValidDate(int day, int month, int year) {
    if (year < 1900 || month < 1 || month > 12 || day < 1)
        return 0;

    int daysInMonth[] = {0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31};

    // Leap year check
    if (month == 2 && ((year % 4 == 0 && year % 100 != 0) || (year % 400 ==
0)))    daysInMonth[2] = 29;

    return day <= daysInMonth[month];
}
```

Our date handling system demonstrates robust edge case management including leap year calculation and month-specific day validation, essential for a reliable task scheduling system.

4. Search Implementation

```c
// Search with keyword - O(n) traversal
void searchTasks(task* head, const char* keyword) {
    // Edge case handling
    if (!head || !keyword || !strlen(keyword)) {
        printf("Error: Invalid search
parameter\n");
        return;
    }

    // Linear search through linked list - O(n)
    int found = 0;
    while (head) {
        if (strstr(head->name, keyword)) {
            printTaskInfo(head);
            found = 1;
        }
        head = head->next;
    }

    if (!found) printf("No matching tasks found.\n");
}
```

This search implementation shows the trade-off between simplicity and performance. While O(n) is unavoidable for searching unindexed data, our implementation optimizes by returning early for edge cases and using efficient string searching.

5. Queue for Task Scheduling

```c
// Process due tasks using queue
void processDueTasks(tasklist* list, date today) {
    taskqueue dueToday;
    initQueue(&dueToday);

    // Find and enqueue today's tasks - O(n)
    task* current = list->head;
    while (current) {
        if (current->due_date_set && isSameDate(current->duedate,
today))     enqueue(&dueToday, current);  // O(1) operation
        current = current->next;
    }

    // Process in FIFO order - O(1) per task
    while (!isQueueEmpty(&dueToday))
        processTask(dequeue(&dueToday));
}
```

The queue implementation enables FIFO (First-In-First-Out) processing of tasks based on chronological due dates, showcasing how different data structures can be combined for specific operational needs.

Code Walkthrough (some functions explaination)

Main menu

```
=== TO-DO LIST MENU ===
1. Add Task
2. View Tasks (Standard/Simplified/By Tag)
3. Edit Task
4. Mark Task as Completed
5. Undo Last Completed Task
6. Delete Task
7. Search Tasks
8. View Statistics (All/Week/Month)
9. Clear All Completed Tasks
10. Import Tasks
11. Export Tasks
12. Daily Completed Tasks
13. Simulate Day Change
14. Time Period Summary (Week/Month)
15. Add Tag to Task
0. Exit
```

Search Tasks

```
Select an option: 3
Enter task name to edit: Code Review Preparation
Editing task: Code Review Preparation
Choose what to edit:
1. Name
2. Description
3. Priority
4. Due Date
Enter your choice (1-4): 1
Enter new task name: codereview
Task name updated.

Press Enter to continue...
```

Complete tasks

```
Select an option: 4
Enter task name to complete: codereview
Found task: codereview (Priority: 1)
Task 'codereview' marked as completed and moved to stack!

Press Enter to continue...
```

undo complete tasks

```
Select an option: 5
Last completed task restored to the list.

Press Enter to continue...
```

Search tasks

```
Select an option: 7

=== Task Search ===
Search by:
1. Name
2. Description
3. Priority Range
4. Status (Pending/Completed/Overdue)
5. Due Date Range
6. Tasks with No Due Date
7. Keyword (search all fields)
Enter your choice (1-7): 1
Enter search keyword: codereview

=== Search Results for 'codereview' ===
--- Pending Tasks ---
Name: codereview
Description: Review codebase for tomorrow's peer review session
Priority: 1 (High)
Status: Pending
Due Date: 03/05/2025
-------------------------
--- Completed Tasks ---

Press Enter to continue...
```

import tasks

```
Select an option: 10
Enter filename to import (default: tasks_import.txt, sample_tasks.txt): tasks_import.txt
100 tasks imported from tasks_import.txt

Press Enter to continue...
```

Weekly Summary

```
Select an option: 14

=== Time Period Summary ===
1. Weekly Summary (Next 7 days)
2. Monthly Summary (Current month)
Enter your choice (1-2): 1

=== Tasks Due This Week (05/05/2025 to 12/05/2025) ===
#     Name                      Priority   Due Date       Days Left
----------------------------------------------------------------
1     Calculus Book Return      High       05/05/2025     Today
2     Network Security Lab      High       06/05/2025     Tomorrow
3     Weekly Math Quiz          High       06/05/2025     Tomorrow
4     Algorithm Assignment      High       07/05/2025     2 days
5     Chemistry Lab Report      High       07/05/2025     2 days
6     Software Testing          High       08/05/2025     3 days
7     Physics Homework Set      High       08/05/2025     3 days
8     Language Practice         Low        09/05/2025     4 days
9     Database Project          High       09/05/2025     4 days
10    Data Visualization        Medium     10/05/2025     5 days
11    Internship Application    High       10/05/2025     5 days
12    Web Development Task      High       11/05/2025     6 days
13    Club Event Planning       Low        11/05/2025     6 days
14    Accounting Ledger         High       12/05/2025     7 days
15    Research Paper Draft      Medium     12/05/2025     7 days
16    Portfolio Update          Medium     12/05/2025     7 days

Total: 16 tasks due this week

Daily summary:
Today: 1 tasks
Tomorrow: 2 tasks
In 2 days: 2 tasks
In 3 days: 2 tasks
In 4 days: 2 tasks
In 5 days: 2 tasks
In 6 days: 2 tasks
In 7 days: 3 tasks

Press Enter to continue...
```

Daily complete task

```
Select an option: 12

=== Tasks Completed Today (03/05/2025) ===
Task: Study Abroad Application
Description: Submit exchange program documents
Priority: 1
-------------------------
Task: Mother's Day Brunch
Description: Make restaurant reservation
Priority: 1
-------------------------
Task: codereview
Description: Review codebase for tomorrow's peer review session
Priority: 1
-------------------------
Total tasks completed today: 3

Press Enter to continue...
```

Code walkthrough

This section demonstrates how our implementation uses data structures to solve task management challenges.

1. Main Program Structure

```c
int main() {
    tasklist tasks = {NULL};        // Initialize empty linked
listcompletedstack doneStack = {NULL};  // Initialize empty stack
    date currentDate = getToday();      // Get system date

    // Main program loop
    while (1) {
        displayMenu();
        scanf("%d", &choice);
        getchar(); // Clear input buffer

        switch (choice) {
            case 1: add(&tasks); break;
            case 2: view_combined(&tasks, currentDate); break;
            case 3: edit(&tasks, taskName); break;
            case 4: complete(&tasks, &doneStack, taskName); break;
            case 5: undoCompleted(&tasks, &doneStack); break;
            // ... other options
            case 0:
                freeTasks(&tasks);      // Clean up memory
                freeStack(&doneStack);
                exit(0);
        }
    }
}
```

2. Task Addition (Linked List)

```c
// Add task with validation - demonstrates O(1) insertion
void add(tasklist* list) {
    // Allocate memory
    task* new_task = (task*)malloc(sizeof(task));
    if (!new_task) return;

    // Get and validate input
    if (strlen(task_name) == 0 || isTaskNameDuplicate(list, task_name))
{       free(new_task); // Prevent memory leak
        return;
    }

    // O(1) insertion at head - key benefit of linked list
    new_task->next = list->head;
    list->head = new_task;
}
```

3. Task Completion/Undo (Stack)

```c
// Complete/Undo operations using stack for O(1) undo
void complete(tasklist* list, completedstack* stack, const char* name)
{   // Find and remove task from list - O(n)
    task* current = findAndRemoveTask(list, name);
    if (!current) return;

    // Push to stack for undo capability - O(1)
    stacknode* node = malloc(sizeof(stacknode));
    node->task_data = current;
    node->next = stack->top;
    stack->top = node;
}

void undoCompleted(tasklist* list, completedstack* stack) {
    if (!stack->top) return;

    // Pop from stack - O(1)
    stacknode* node = stack->top;
    stack->top = node->next;

    // Return to active list - O(1)
    task* task = node->task_data;
    task->next = list->head;
    list->head = task;
    free(node);
}
```

4. Search Implementation

```c
// Linear search - demonstrates O(n) traversal
void searchTasks(task* head, const char* keyword)
{   // Edge case handling
    if (!head || !keyword) return;

    int found = 0;
    // Linear search through list - O(n)
    while (head) {
        if (strstr(head->name, keyword)) {
            printTaskInfo(head);
            found = 1;
        }
        head = head->next;
    }

    if (!found) printf("No matches found.\n");
}
```

5. Date Handling

```c
// Date validation with edge case handling
int isValidDate(int day, int month, int year) {
    if (year < 1900 || month < 1 || month > 12 || day < 1)
        return 0;

    // Handle leap years and month limits
    int daysInMonth[] = {0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30,
31};if (month == 2 && isLeapYear(year)) daysInMonth[2] = 29;

    return day <= daysInMonth[month];
}
```

6. Memory Management

```c
// Proper cleanup to prevent memory leaks
void freeTasks(tasklist* list) {
    task* current = list->head;
    while (current) {
        task* temp = current;
        current = current->next;

        // Free each task
        free(temp);
    }
    list->head = NULL;
}

void freeStack(completedstack* stack) {
    stacknode* current = stack->top;
    while (current) {
        stacknode* temp = current;
        current = current->next;

        // Free task data first
        free(temp->task_data);
        // Then free the node
        free(temp);
    }
    stack->top = NULL;
}
```

Complexity analysis

The table below compares operations with and without data structures, showing both theoretical complexity and actual measured performance:

Operation	With Data Structure	Without Data Structure	Actual Time (1000 tasks)	Space Complexity	Explanation
Add Task	O(1) using Linked List	O(n) using array + shift	0.001 ms	O(1) per node	Our linked list implementation allows constant-time insertion regardless of list size by always adding at the head, avoiding the costly O(n) shifting required in arrays.
Search by Name	O(n) using Linked List	O(n) using array	0.250 ms	O(1)	Both implementations require checking each element sequentially. Performance could be improved to O(1) with hash tables in future updates.
Delete Task	O(n) using Linked List	O(n) using array + shift	0.245 ms	O(1)	Both require O(n) search, but linked list avoid the extra shifting cost by simple pointer manipulation.
Complete Task	O(n) + O(1) push to Stack	O(n) search + O(n) shift	0.248 ms	O(1)	Stack push is O(1), making our implementation more efficient than the array approach which requires O(n) element shifting.
Undo Complete	O(1) pop from Stack	O(n) to insert back in array	0.001 ms	O(1)	Stack's LIFO behavior provides constant-time undo operations - a significant advantage over arrays requiring O(n) insertion.
View All Tasks	O(n) traverse Linked List	O(n) traverse array	0.085 ms	O(n) temp array	Both require examining each element, but our implementation uses temporary arrays for efficient sorting.
Sort by Priority	$O(n^2)$ using Bubble Sort	$O(n^2)$ using Bubble Sort	152.000 ms	O(1) extra	Bubble sort has quadratic complexity and becomes our performance bottleneck at scale. Future versions could implement O(n log n) algorithms.
Sort by Due Date	$O(n^2)$ using Bubble Sort	$O(n^2)$ using Bubble Sort	148.000 ms	O(1) extra	Similar to priority sort, shows quadratic growth with input size but benefits from in-place sorting with O(1) extra space.
Enqueue (Due Today)	O(1) using Queue	O(1) array append	0.001 ms	O(1)	Both achieve constant-time additions, but the queue maintains order without additional operations.
Dequeue (Process Task)	O(1) using Queue	O(n) array shift	0.001 ms	O(1)	Queue provides O(1) removal from front vs O(n) cost in arrays - critical for efficient task processing.

Testing and Validation

Our testing methodology focused on ensuring both functional correctness and performance stability through multiple testing approaches:

1. **Basic Operation Test**

We tested all core functionalities to ensure proper operation:

Operation	Input	Expected Output	Result
Add Task	Name: "Study DSA", Priority: 1	Task added successfully	Pass
Edit Task	Change priority 1⟶2	Priority updated	Pass
Complete Task	Task name: "Study DSA"	Task moved to completed	Pass
Undo Complete	Last completed task	Task restored to active	Pass
Delete Task	Task name: "Study DSA"	Task deleted	Pass
Search by Name	Keyword: "Study"	Found 1 task	Pass
View Tasks	N/A	Display all tasks sorted	Pass
Import Tasks	CSV file with 5 tasks	5 tasks imported	Pass
Export Tasks	Current task list	File created successfully	Pass
Add Tag	Tag: "urgent"	Tag added to task	Pass

2. **Edge cases**

We systematically tested boundary conditions and potential failure points:

Edge Case	Input	Expected Behavior	Result
Empty task name	""	Error: Name cannot be empty	Pass

Whitespace-only name	" "	Error: Invalid name	Pass
Duplicate task name	"Existing Task"	Error: Task already exists	Pass
Invalid date	32/13/2025	Error: Invalid date	Pass
Priority out of range	Priority: 5	Default to Medium (2)	Pass
Complete non-existent task	"Not Found"	Error: Task not found	Pass
Undo with empty stack	N/A	No completed tasks to undo	Pass
Search in empty list	Keyword: "test"	No matching tasks found	Pass
Delete from empty list	N/A	No tasks to delete	Pass

3. **Test result**

Category	Test Case	Result
Basic Operations	Add/Edit/Delete/Complete tasks	Pass
Edge Cases	Empty name, Invalid date (32/13/2025), Duplicate task	Pass
Performance	1000 tasks: Add (0.001ms), Search (0.250ms), Sort (152ms)	Pass
Memory	Add/Delete 1000 cycles - Memory stable	Pass

Performance Testing

- Small dataset (10-50 tasks): All operations completed in under 1ms
- Medium dataset (100-500 tasks): Search and sort operations showed expected linear/quadratic scaling
- Large dataset (1000+ tasks): System remained stable with predictable performance degradation
- Memory usage: Linear scaling with task count, no leaks detected during extended testing

Team Member Responsibilities

Our team collaborated effectively by dividing responsibilities based on expertise and interests, while maintaining constant communication throughout the project.

Kulchaya Paipinij (67070503406)

- Developed search functionality with multiple criteria (name, date, priority)
- Implemented statistical analysis and progress tracking features
- Created file I/O operations for data import/export
- Designed dashboard view with progress visualization
- Wrote search and file handling unit tests

Chayanit Kuntanarumitkul (67070503408)

- Designed scheduling system and date handling logic
- Implemented reminder functionality and date validation
- Created priority adjustment algorithm
- Led code review and bug fixing across all modules
- Managed GitHub repository and version control

Siripitch Chaiyabutra (67070503440)

- Implemented core task operations (add/edit/delete)
- Developed user interface and menu system
- Created task data structures and linked list implementation
- Built completion tracking system and undo functionality
- Designed stack operations for completed tasks

Collaboration Process

Our team followed a systematic development approach:

1. **Planning Phase:** Joint design of data structures and system architecture
2. **Implementation Phase:** Development of individual modules with regular sync meetings
3. **Integration Phase:** Combining modules with Chayanit leading integration testing
4. **Testing Phase:** Comprehensive testing of edge cases and performance
5. **Documentation Phase:** Collaborative report writing and presentation preparation

Throughout the project, we maintained daily communication via messaging and conducted weekly code review sessions to ensure consistent coding practices and identify potential improvements.

Challenges and Solutions

- Memory Management

  Challenge: Memory leaks occurred during task deletion and stack operations.

  - Tasks with dynamic allocations (tags, descriptions) weren't properly freed
  - Stack nodes remained in memory after clearing completed tasks
  - Improper pointer handling caused dangling references

  Solution:

  - Implemented systematic cleanup sequence in all delete operations
  - Created dedicated memory management functions
  - Added validation before memory operations

```
void deleteTask(task* current) {
    // Free tags first to prevent memory leaks
    for (int i = 0; i < current->tag_count; i++)
{       free(current->tags[i]);
    }
    // Then free the task itself
    free(current);
}
```

- Date Validation

  Challenge: Complex date validation requirements.

  - Leap year calculations
  - Month boundary variations
  - Date comparison for sorting and overdue detection
  - Cross-year calculations

  Solution:

  - Designed comprehensive date validation system
  - Created utility functions for date operations
  - Implemented robust date comparison algorithm

```
int isValidDate(int day, int month, int year) {
    // Handle leap years and month lengths
    if (month == 2 && isLeapYear(year)) {
        return day >= 1 && day <= 29;
    }
    // Check against days-in-month array
    return day >= 1 && day <=
}daysInMonth[month];
```

- Sorting Performance

  Challenge: O(n²) bubble sort became extremely slow with large datasets.

  - 1000+ tasks took over 150ms to sort
  - Full list sorts on every view operation
  - Multiple sort criteria (priority, date, status)

  Solution:

  - Limited sorting to visible tasks only
  - Implemented partial sorting per view
  - Added caching for sorted results
  - Created optimized display

Conclusion

- **Project Achievement**

  Our To-Do List Management System successfully demonstrated the practical application of fundamental data structures in solving real-world problems. Through careful implementation and testing, we achieved:

  - Successfully implemented task management using 4 key data structures
  - Achieved O(1) insertion and undo operations
  - Robust error handling for all edge cases
  - Supports 1000+ tasks with stable performance
  - 100% test pass rate with no memory leaks
  - Efficient memory usage with proper cleanup mechanisms

The project effectively demonstrates the value of applying theoretical data structure concepts to practical software development. By using linked lists for primary storage, stacks for undo functionality, queues for task scheduling, and bubble sort for display organization, we created a system that optimizes critical operations while maintaining manageable code complexity.

- **Learning Outcome**

  This project provided valuable insights and practical experience in several areas:

  - Data Structure Selection: Matching structures to specific requirements
  - Memory Management: Proper allocation/deallocation in C
  - Algorithm Efficiency: Impact of $O(n^2)$ vs $O(n \log n)$ in practice
  - Error Handling: Importance of input validation and edge cases
  - Collaborative Development: Value of code reviews and integration testing

Throughout development, we gained deeper appreciation for the trade-offs involved in data structure selection. For example, while arrays offer simplicity, linked lists provide the flexibility needed for dynamic task management. Similarly, our experience with bubble sort reinforced the importance of algorithm choice, as it became the performance bottleneck with larger datasets.

In summary, this project served as an excellent practical application of data structure concepts learned throughout our course. It reinforced that proper data structure selection and implementation are fundamental to creating efficient, scalable, and robust software solutions for real-world problems.

__References__

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