ASSIGNMENT REPORT

Algorithm and Design and Problem

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CONTENTS

DELIVERABLES

DATA STRUCTURE

Employee:

- employeeID
- firstName
- surname
- line

Certification

- employeeID
- earnedCertID

A) FLOWCHART OF COMBINE AND SORT PROCESS

Time complexity analysis:

O(N Log N)

FUNCTION: PROCESSTEAMS():

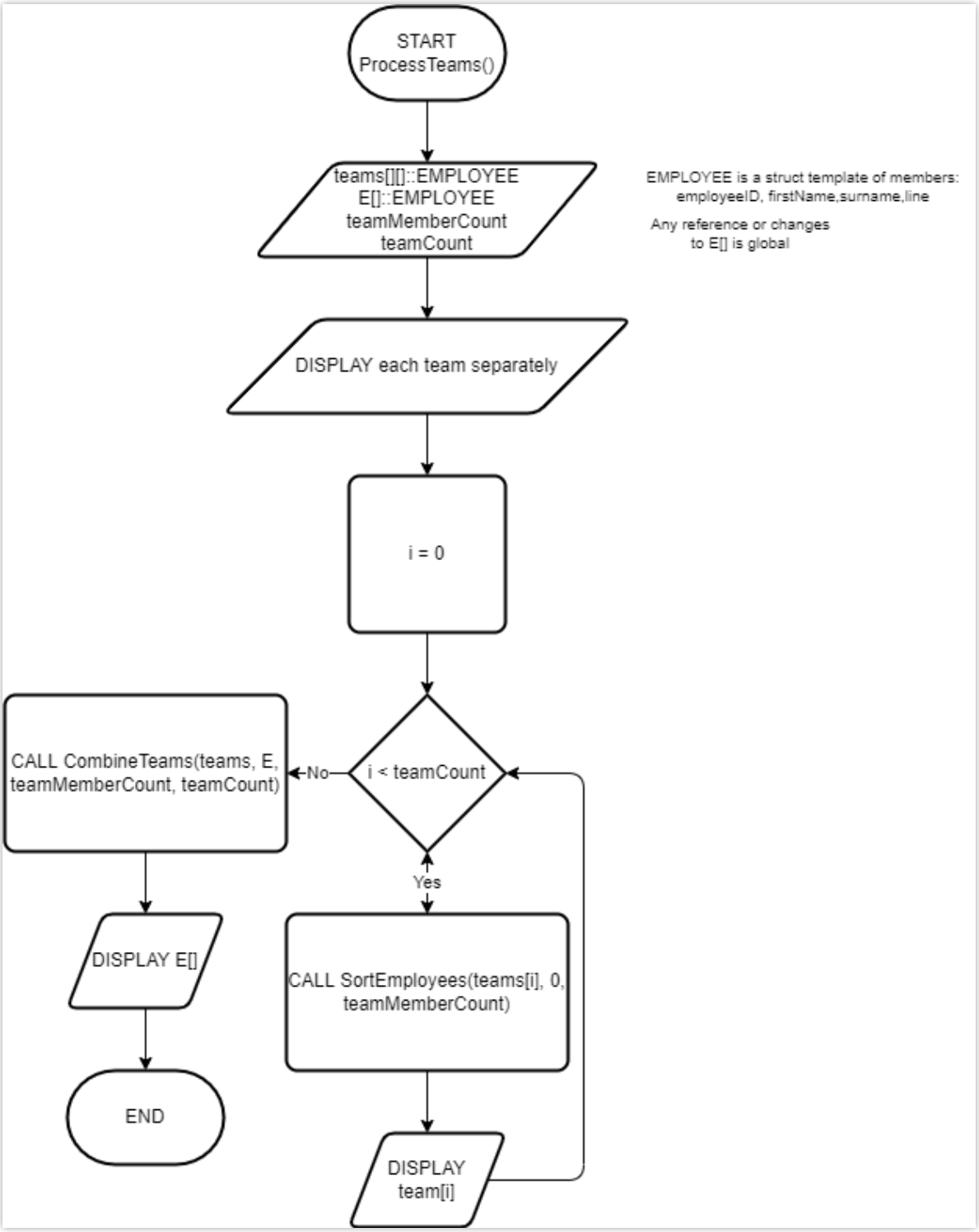
Time Complexity: O(n log n) + O(n) -> n

Merge sort: O(n log n)

Combine teams: O(n)

There were two efficiency requirements to meet:
The first requirements were to improve the efficiency of the merge sort by reducing the leaves within the call stack. This is done by stopping the recursive splitting of the array when the sub array size is less than 5. When the array size reaches 5, a modified insertion sort is used to sort the array. Then the algorithm merges the sub arrays back up to the full array.

The second requirement were to improve the efficiency of the elementary sort which was used to improve the merge sort. The elementary sort we used was insertion sort and in insertion sort, it searches for a spot in the sorted array to insert the key value to be placed where it is smaller than the value above it. This is done using insertion sort where it searches for the spot where the value is supposed to be and returns the index of it. Then the indexes higher than the index the key is supposed to be is shifted up to make room to insert the key.

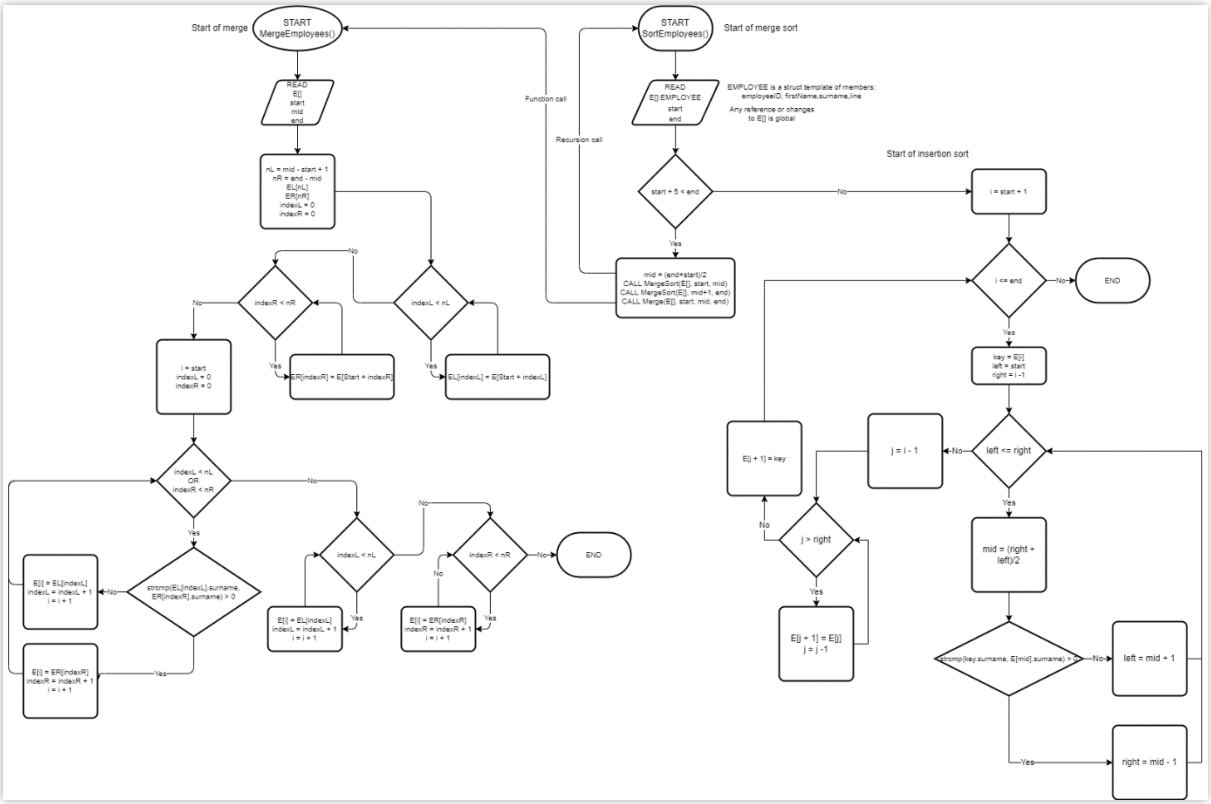

START
ProcessTeams()
teams[][]::EMPLOYEE
E[]::EMPLOYEE
teamMemberCount
teamCount
EMPLOYEE is a struct template of members:
employeeID, firstName,surname,line
Any reference or changes
to E[] is global
DISPLAY each team separately
i = 0
i < teamCount
No
Yes
CALL CombineTeams(teams, E,
teamMemberCount, teamCount)
DISPLAY E[]
END
CALL SortEmployees(teams[i], 0,
teamMemberCount)
DISPLAY
team[i]

FUNCTION: SORTEMPLOYEES():

Time Complexity: O(Log n) x O(n) -> O(N Log N)

At the divide part: O(Log n)

At conquer part nested within divide: O(n)



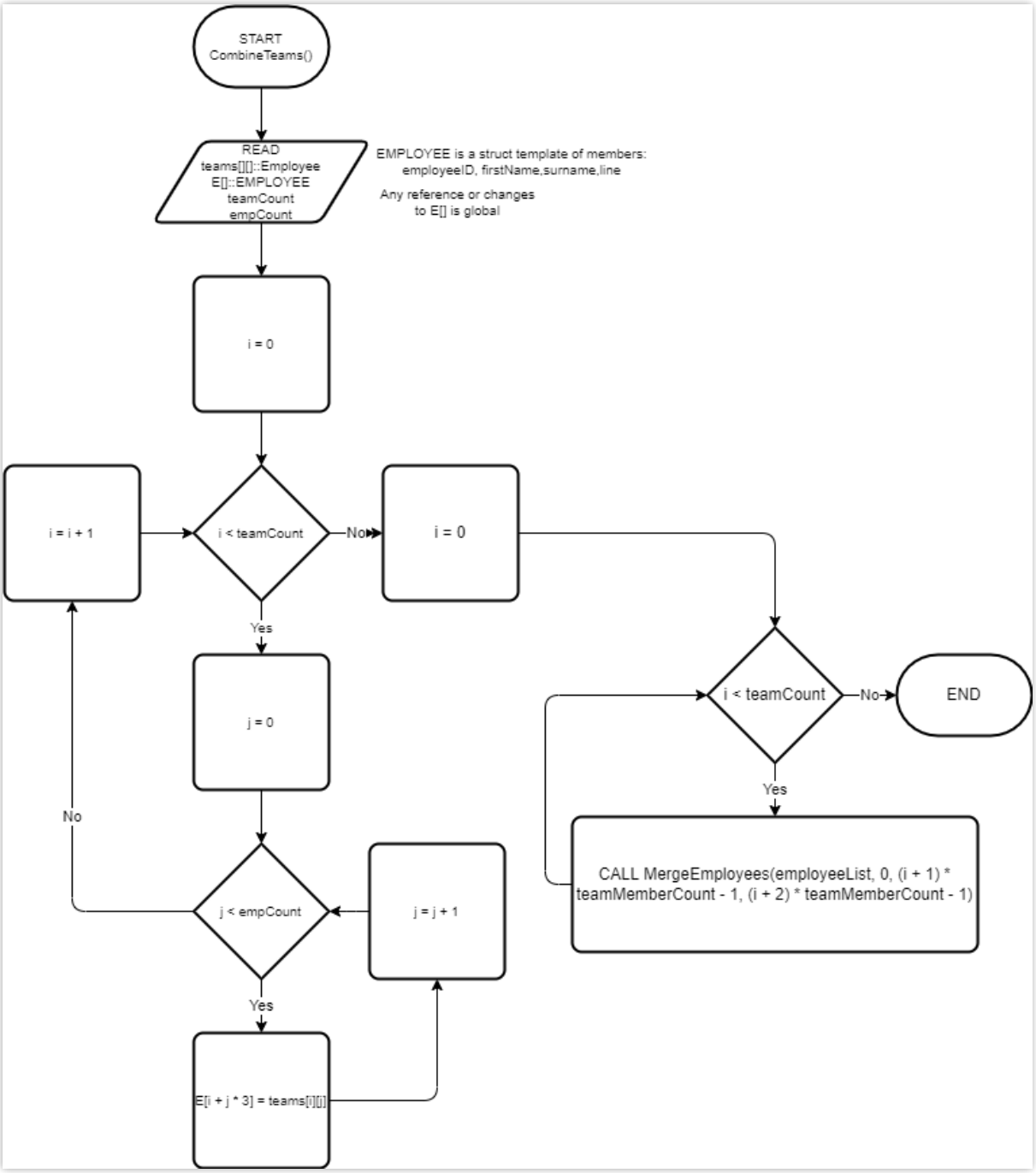
FUNCTION: COMBINETEAMS():

Time complexity: O(n)

There is two for loops however, no nested for loops

MergeEmployees() function is O(n) however the loop it is contained in does not fully nest the whole data.

Merging the employees is done by individually adding each team to the full list of employees while keeping the list sorted by surnames.



B) PSEUDOCODE FOR EMPLOYEES CERTIFIED TO WORK ON ALL LINES

Time complexity: O(n^2)

Depth of 2 nested for loop gives us O(n^2). First loop loops through all certs, second loops through each employee.

To find an employee the function uses linear search to find a certification for all 3 lines, if it encounters a certification for all 3 lines then it uses linear search to find the associated employeeID to the certification in the employee list.

```
// Struct Templates:
STRUCT EMPLOYEE{employeeID, firstName, surname, line}
STRUCT CERTIFICATION{employeeID, certificationID}

// Searches certifications for full certs where earnedCertID has a value of 7 and prints the
employee's name
// Params: employeeList[]::Struct EMPLOYEE{employeeeID, firstName, surname, line} - array of employees
//         certList[]::Struct CERTIFICATION{employeeID, certificationID} - array of certifications to
search
//         employeeCount - number of employees
//         certCount - number of certifications
FUNCTION PrintFullCerts(employeeList[] AS STRUCT Employees, certList[] AS STRUCT Certifications,
employeeCount, certCount)
    // Search for full certs

    PRINT "Employee ID, First Name, Surname, Line" // Row headers
    FOR i FROM 0 TO certCount
        IF certList[i].certificationID EQUALS 7
            // Search for employee with matching employeeID and print details
            FOR j FROM 0 TO employeeCount
                IF employeeList[j].employeeID EQUALS certList[i].employeeID
                    PRINT employee details at index[]
                    BREAK
                ELSE IF j EQUALS employeeCount - 1
                        PRINT "N/A"
                END IF
            END FOR
        END IF
    END FOR
END FUNCTION
```

C) PSEUDOCODE FOR SEARCHING BY SURNAMES

Time complexity: O(Log N)

Binary search splits array in half to find the solution which gives us O(Log N)

The search employee by surname algorithm is a binary search algorithm which searches an array sorted by surname, the algorithm returns the index of where the employee is which then can be used to print the employee, otherwise it tells the user there is no such employee.

```
// Struct Templates
STRUCT EMPLOYEE{employeeID, firstName, surname, line}

// Prompts user for surname to search then searches employee list for employees with that surname
using binary search and prints the employee's details
// Params: employeeList[]::Struct EMPLOYEE{employeeeID, firstName, surname, line} - array of employees
//         employeeCount - number of employees
FUNCTION GetEmployeeBySurname(employeeList[], count)
    DECLARE surname
    DECLARE index
    // Prompt user for surname
    DO
        PROMPT "Enter surname: "
        ASSIGN surname TO INPUT
        IF SURNAME EQUALS ""
            PRINT "Surname cannot be blank"
        END IF
    WHILE SURNAME EQUALS ""

    // Search for employee
    ASSIGN index TO CALL SearchEmployeeBySurname(employeeList, count, surname)
    IF index EQUALS -1
        PRINT "Employee not found"
    ELSE
        PRINT "Employee found: "
        PRINT Employee details at employeeList[index]
    END IF
END

// Uses binary search to find the person
// Employee array must be sorted by surname
// Params: employees[]::Struct Employee{employeeID, firstName, surname, line} - array of employees
//         key - surname to search for
//         start - start index of array
//         end - end index of array
// Returns: index of employee matching the surname else -1 if not found
FUNCTION SearchBySurname(employeeList[], key, start, end)
    IF end GREATER-OR-EQUAL start
        // Recursive case
        DECLARE mid TO (start + end) / 2
        IF employeeList[mid].surname EQUALS key
            RETURN mid
        END IF

        IF employeeList[mid].surname GREATER key
            RETURN CALL SearchBySurname(employeeList, key, start, mid - 1)
        ELSE
            RETURN CALL SearchBySurname(employeeList, key, mid + 1, end)
        END IF
    END IF

    // Base case
    RETURN -1
END FUNCTION
```

CODE FOR EACH FLOWCHART AND PSEUDOCODE ABOVE IN C

A) COMBINE AND SORT PROCESS CODE

function: ProcessTeams()

```c
// Option 1: a) Sorts and combines teams
// Prints individual teams then sorts the teams individually
// Then combines the teams into one sorted array
// Params: *teams[] - array of teams to sort and combine
//         employeeList[] - array of employees which will contain the combined sorted teams
//         teamMemberCount - number of members in each team
//         teamCount - number of teams
void ProcessTeams(EMPLOYEE *teams[], EMPLOYEE *employeeList, int teamMemberCount, int teamCount)
{

    // Display each team separately
    printf("\nDisplaying teams...\n");
    for (int i = 0; i < teamCount; i++)
    {
        printf("Team %d:\n", i + 1);
        PrintEmployeeList(teams[i], teamMemberCount);
    }

    PromptContinue();
    PrintSoftDivider();

    // Sort each team using merge sort
    printf("\nSorting teams...\n");
    for (int i = 0; i < teamCount; i++)
    {
        SortEmployees(teams[i], 0, teamMemberCount - 1);
    }
    // Display each team separately
    for (int i = 0; i < teamCount; i++)
    {
        printf("Team %d:\n", i + 1);
        PrintEmployeeList(teams[i], teamMemberCount);
    }

    PromptContinue();
    PrintSoftDivider();

    // Combine teams to employeeList and display
    printf("\nCombining teams...\n");
    CombineTeams(teams, employeeList, teamMemberCount, teamCount);
    printf("\nCombined teams list:\n");
    PrintEmployeeList(employeeList, teamCount * teamMemberCount);
}
```

Function: SortEmployees()

```c
// Modified merge sort with insertion srot sorts employees in a array by surname
// Base case is reached when array size is less than 5 then insertion sort is used
// Params: employeeList[] - array of employees to sort
//         start - starting index of array
//         end - ending index of array
void SortEmployees(EMPLOYEE *employeeList, int start, int end)
{
    // Base case when start and end are the same
    if (start + 5 < end)
    {
        // Recursive case
        int mid = start + (end - start) / 2;
        SortEmployees(employeeList, start, mid);
        SortEmployees(employeeList, mid + 1, end);
        MergeEmployees(employeeList, start, mid, end);
    }
    else
    {
        // Base case
```

```
        // Insertion sort
        for (int i = start + 1; i <= end; i++)
        {
                        EMPLOYEE key = employeeList[i];
            // Binary search can be used here to find the correct index for insertion to reduce
comparisons
            // incremental binary search
            int left = start;
            int right = i - 1;
            int j;
            while (left <= right)
            {
                int mid = left + (right - left) / 2;
                if (strcmp(key.surname, employeeList[mid].surname) < 0)
                {
                    right = mid - 1;
                }
                else
                {
                    left = mid + 1;
                }
            }
            // Shift elements to the right to make room for insertion
            for (j = i - 1; j > right; j--)
            {
                employeeList[j + 1] = employeeList[j];
            }
            employeeList[j + 1] = key;
        }
    }
}
```

Function: MergeEmployees()

```
// Merges two sorted subarray into one sorted array
// Params: employeeList[] - array of employees to sort
//         start - starting index of first subarray
//         mid - ending index of first subarray
//         end - ending index of second subarray
void MergeEmployees(EMPLOYEE *employeeList, int start, int mid, int end)
{
    // Create two temp arrays
    int nL = mid - start + 1;
    int nR = end - mid;
    EMPLOYEE *tempL = (EMPLOYEE *)malloc(sizeof(EMPLOYEE) * nL);
    EMPLOYEE *tempR = (EMPLOYEE *)malloc(sizeof(EMPLOYEE) * nR);

    // Copy elements from original array to temp arrays
    for (int i = 0; i < nL; i++)
    {
        tempL[i] = employeeList[start + i];
    }
    for (int i = 0; i < nR; i++)
    {
        tempR[i] = employeeList[mid + 1 + i];
    }

    // Merge temp arrays into original array
    int i = start, j = 0, k = 0;
    while (j < nL && k < nR)
    {
        if (strcmp(tempL[j].surname, tempR[k].surname) < 0)
        {
            employeeList[i++] = tempL[j++];
        }
        else
        {
            employeeList[i++] = tempR[k++];
        }
    }

    // Copy remaining elements from temp arrays
    while (j < nL)
    {
        employeeList[i++] = tempL[j++];
    }
    while (k < nR)
    {
        employeeList[i++] = tempR[k++];
    }

    // Free temp arrays
    free(tempL);
    free(tempR);
}
```

Function: CombineEmployees()

```
// Combine sorted teams into one sorted array
// Params: *teams[] - array of teams to combine
//         employeeList[] - array of employees
//         teamMemberCount - number of members in each team
//         teamCount - number of teams
void CombineTeams(EMPLOYEE *teams[], EMPLOYEE *employeeList, int teamMemberCount, int teamCount)
{
    int combinedSize = teamCount * teamMemberCount;
    // Concatenate teams into one array
    for (int i = 0; i < teamCount; i++)
    {
        for (int j = 0; j < teamMemberCount; j++)
        {
            employeeList[i * teamMemberCount + j] = teams[i][j];
        }
    }
    // Merge employeeList
    for (int i = 0; i < teamCount - 1; i++)
    {
        MergeEmployees(employeeList, 0, (i + 1) * teamMemberCount - 1, (i + 2) * teamMemberCount - 1);
    }
}
```

B) CERTIFIED TO WORK ON ALL LINES CODE

Function: PrintFullCerts()

```
// Option 2: b) Searches certifications for full certs where earnedCertID has a value of 7 and prints
the employee's name
// Params: employeeList[] - array of employees
//         certList[] - array of certifications to search
//         employeeCount - number of employees
//         certCount - number of certifications
void PrintFullCerts(EMPLOYEE employeeList[], CERTIFICATION certList[], int employeeCount, int
certCount)
{
    // Search for full certs
    printf("\nSearching for employees with full certifications...\n");

    printf("%-11s  %-12s  %-12s  %-4s\n", "Employee ID", "First Name", "Surname", "Line");
    for (int i = 0; i < certCount; i++)
    {
        // For each full cert, find the employee linked to it and print their details
        if (certList[i].earnedCertID == 7)
        {
            for (int j = 0; j < employeeCount; j++)
            {
                if (employeeList[j].employeeID == certList[i].employeeID)
                {
                    printf("%11d  %-12s  %-12s  %-4d\n", employeeList[j].employeeID,
employeeList[j].firstName, employeeList[j].surname, employeeList[j].line);
                    break;
                }
                else if (j == employeeCount - 1)
                {
                    printf("%11d  %-12s  %-12s\n", certList[i].employeeID, "Unknown", "Unknown");
                }
            }
        }
    }
    printf("\n");
}
```

C) SEARCHING BY SURNAMES CODE

Function: getEmployeeBySurname()

```
// Option 3: c) Prompts user for surname to search then searches employee list for employees with that surname using binary search and prints the employee's details
// Params: employeeList[] - array of employees
//         employeeCount - number of employees
void GetEmployeeBySurname(EMPLOYEE employeeList[], int count)
{
    // Prompt user for surname
    STRING30 surname;
    int index;
    do
    {
        printf("\nEnter surname (case sensitive max 29):\n> ");
        scanf("%29s", surname);
        if (strcmp(surname, "") == 0)
        {
            printf("\nSurname cannot be blank.\n");
        }
    } while (strcmp(surname, "") == 0);

    index = SearchBySurname(employeeList, surname, 0, count - 1);
    if (index == -1)
    {
        printf("\nNo employees found with surname '%s'.\n", surname);
    }
    else
    {
        printf("\nEmployee found:\n");
        printf("EmployeeID: %d\n", employeeList[index].employeeID);
        printf("First Name: %s\n", employeeList[index].firstName);
        printf("Surname:    %s\n", employeeList[index].surname);
        printf("Line:       %d\n", employeeList[index].line);
    }
    printf("\n");
}
```

Function: SearchBySurname()

```
// Search employee list by surname
// Params: employeeList[] - array of employees to search
//         key - surname to search for
//         start - starting index of array
//         end - ending index of array
// Returns: index of employee if found, -1 if not found
int SearchBySurname(EMPLOYEE *employeeList, STRING30 key, int start, int end)
{
    if (end >= start)
    {
        int mid = start + (end - start) / 2;
        if (strcmp(employeeList[mid].surname, key) == 0) return mid;

        if (strcmp(employeeList[mid].surname, key) > 0)
        {
            return SearchBySurname(employeeList, key, start, mid - 1);
        }
        else
        {
            return SearchBySurname(employeeList, key, mid + 1, end);
        }
    }

    return -1;
}
```

SOURCE CODE

```
/*
    Algorithms and Design and Problems Assignment - assignment
    Program contains details of 4 teams of employees and their details and line certifications
    Data structure:
        4 arrays represent 4 teams of 4 employees::
            Each employee contains details: employee id, first name, surname and line
        A separate array contains the line certifications of each employee
            The line certifications consists of: employee id, line certification
                The line certification has 3 bits:
                    Bit 0 (+1): Line 1
                    Bit 1 (+2): Line 2
                    Bit 2 (+4): Line 3

    Functions
        (a). Sorts each team by surname using merge sort then combines the 4 teams of employees into
one array
            Display each team separately
            Sort each team with merge sort
            Merge the 4 teams into one array
            Display full list of employees
        (b). Prints a list of employees certified for all 3 lines
            Create list of full certs (earnedCertID = 7)
        (c). Search employees by surname

    Data:
        Teams:
            Cols:
                employeeID,firstName,surname,line
            Team 1:
                8,Hanae,Mejia,1
                3,Evan,Underwood,1
                7,Jenette,David,3
                1,Quin,Knight,2
                4,Gannon,Mueller,3
                19,Merrill,Gilmore,2
            Team 2:
                14,Shellie,Soto,1
                23,Carson,Ayala,1
                5,Orla,Wyatt,1
                11,Neville,Berg,1
                10,Macy,Cotton,2
                6,Emi,Stafford,0
            Team 3:
                20,Austin,William,1
                2,Dana,Stephenson,0
                22,Amery,Bridges,1
                18,Mollie,Hester,1
                24,Brent,Molina,2
                15,Bradley,Ortiz,0
            Team 4:
                17,Maia,Mccullough,3
                16,India,Calhoun,2
                12,Nathaniel,Solis,3
                13,Drake,Leach,1
                9,May,Bowers,1
                21,Maxine,Marquez,2

        Certifications:
            Cols:
                employeeID,earnedCertID
            Employees:
                8,3
                3,7
                7,4
                1,5
                4,5
                19,5
                14,3
                23,7
                5,0
                11,1
```

```
                10,4
                6,3
                20,2
                2,2
                22,5
                18,2
                24,7
                15,2
                17,2
                16,7
                12,4
                13,0
                9,6
                21,1

    Author: Adrian Thomas Capacite
    Date: 13 / 04 / 2022
*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#define TEAM_MEMBER_COUNT 6     // Number of employees in each team
#define TEAM_COUNT 4    // Number of teams
#define CERT_COUNT 24   // Number of certs
#define PrintCentered(f, str, width) printf("%*s" f, (int)((width - strlen(str)) / 2), "", str)
#define PrintDivider() printf("\n================================================================\n")
#define PrintSoftDivider() printf("\n----------------------------------------------------------------
\n")
#define PromptContinue() printf("Press enter to continue..."); while(getchar() != '\n'); // Prompt
user to continue

/* Struct templates */
typedef char STRING30[30];
typedef struct EMPLOYEE
{
    int employeeID;
    STRING30 firstName;
    STRING30 surname;
    int line;
} EMPLOYEE;
typedef struct CERTIFICATION
{
    int employeeID;
    int earnedCertID;
} CERTIFICATION;

/* Function prototypes */
// Utility functions
void PrintEmployeeList(EMPLOYEE [], int);
void SortEmployees(EMPLOYEE [], int, int);
void MergeEmployees(EMPLOYEE [], int, int, int);
void CombineTeams(EMPLOYEE *[], EMPLOYEE [], int, int);
int SearchBySurname(EMPLOYEE [], STRING30, int, int);

// Option functions
void ProcessTeams(EMPLOYEE *[], EMPLOYEE [], int, int);
void PrintFullCerts(EMPLOYEE [], CERTIFICATION [], int, int);
void GetEmployeeBySurname(EMPLOYEE [], int);

/* Global varables prefix: g_ */
// 4 Teams of 6 employees
EMPLOYEE g_team1[TEAM_MEMBER_COUNT] = {
    {8, "Hanae", "Mejia", 1},
    {3, "Evan", "Underwood", 1},
    {7, "Jenette", "David", 3},
    {1, "Quin", "Knight", 2},
    {4, "Gannon", "Mueller", 3},
    {19, "Merrill", "Gilmore", 2}
};
EMPLOYEE g_team2[TEAM_MEMBER_COUNT] = {
    {14, "Shellie", "Soto", 1},
    {23, "Carson", "Ayala", 1},
    {5, "Orla", "Wyatt", 1},
    {11, "Neville", "Berg", 1},
```

```
    {10, "Macy", "Cotton", 2},
    {6, "Emi", "Stafford", 0}
};
EMPLOYEE g_team3[TEAM_MEMBER_COUNT] = {
    {20, "Austin", "William", 1},
    {2, "Dana", "Stephenson", 0},
    {22, "Amery", "Bridges", 1},
    {18, "Mollie", "Hester", 1},
    {24, "Brent", "Molina", 2},
    {15, "Bradley", "Ortiz", 0}
};
EMPLOYEE g_team4[TEAM_MEMBER_COUNT] = {
    {17, "Maia", "Mccullough", 3},
    {16, "India", "Calhoun", 2},
    {12, "Nathaniel", "Solis", 3},
    {13, "Drake", "Leach", 1},
    {9, "May", "Bowers", 1},
    {21, "Maxine", "Marquez", 2}
};

// Certifications
CERTIFICATION g_certifications[CERT_COUNT] = {
    {8, 3},
    {3, 7},
    {7, 4},
    {1, 5},
    {4, 5},
    {19, 5},
    {14, 3},
    {23, 7},
    {5, 0},
    {11, 1},
    {10, 4},
    {6, 3},
    {20, 2},
    {2, 2},
    {22, 5},
    {18, 2},
    {24, 7},
    {15, 2},
    {17, 2},
    {16, 7},
    {12, 4},
    {13, 0},
    {9, 6},
    {21, 1}
};

EMPLOYEE g_teamsCombined[TEAM_COUNT * TEAM_MEMBER_COUNT];

int main()
{

    int userInput;
    int sortBySurname = 0;
    int employeeCount = TEAM_MEMBER_COUNT * TEAM_COUNT;

    // Program title
    printf("\n---------------==================================---------------\n\n");
    PrintCentered("%s\n", "---- Employee Certification Program ----", 64);
    printf("\n---------------==========================================---------------\n");

    // Program loop - stops when user enters 4
    while (userInput != 4)
    {
        // Print menu prompt
        printf("\n");
        PrintDivider();
        PrintCentered("%s\n\n", "---- Main Menu ----", 64);
        printf(
            "(1) Sort Teams by Surname then combine teams\n"
            "(2) Print employees certified for all lines\n"
            "(3) Search for employee by surname\n"
            "(4) Exit\n"
```

```
        "> "
    );
    userInput = 0;
    scanf("%d", &userInput);
    while(getchar() != '\n');

    // Switch on user input
    switch (userInput)
    {
        case 1: // Part a)
        {
            printf("Running sort and combine routine...\n");
            PrintDivider();

            // Create array of teams
            EMPLOYEE *teams[TEAM_COUNT] = {g_team1, g_team2, g_team3, g_team4};
            // Print, sort, and combine teams then print combined teams
            ProcessTeams(teams, g_teamsCombined, TEAM_MEMBER_COUNT, TEAM_COUNT);

            sortBySurname = 1;
            PromptContinue();
            break;
        }
        case 2: // Part b)
        {
            // Check if teams have been sorted, option 1 must be run first
            if (sortBySurname == 0)
            {
                printf("Please run option 1 first.\n");
                PromptContinue();
                break;
            }

            printf("Running full cert search routine...\n");
            PrintDivider();

            // Print all employees with all certifications
            PrintFullCerts(g_teamsCombined, g_certifications, employeeCount, CERT_COUNT);

            PromptContinue();
            break;
        }
        case 3: // Part c)
        {
            // Check if teams have been sorted, option 1 must be run first
            if(sortBySurname == 0)
            {
                printf("Please run option 1 first.\n");
                PromptContinue();
                break;
            }

            printf("Running search by surname routine...\n");
            PrintDivider();

            // Search for employee by surname
            GetEmployeeBySurname(g_teamsCombined, employeeCount);

            PromptContinue();
            break;
        }
        case 4:
        {
            // Exit program
            printf("\nExiting program...\n");
            break;
        }
        default:
        {
            // Invalid input
            printf("\n\aInvalid input. Please try again.\n");
            break;
        }
    }
```

```
    }
}

// Utility functions
// Prints details of each employees in a array
// Params: employeeList[] - list of employees to print
//         count - number of employees in array
void PrintEmployeeList(EMPLOYEE employeeList[], int size)
{
    // Print employee list
    printf("%-11s  %-12s  %-12s  %-4s\n", "Employee ID", "First Name", "Surname", "Line");
    for (int i = 0; i < size; i++)
    {
        printf("%11d  %-12s  %-12s  %4d\n", employeeList[i].employeeID, employeeList[i].firstName,
employeeList[i].surname, employeeList[i].line);
    }
    printf("\n");
}

// Modified merge sort with insertion srot sorts employees in a array by surname
// Base case is reached when array size is less than 5 then insertion sort is used
// Params: employeeList[] - array of employees to sort
//         start - starting index of array
//         end - ending index of array
void SortEmployees(EMPLOYEE employeeList[], int start, int end)
{
    // Base case when start and end are the same
    if (start + 5 < end)
    {
        // Recursive case
        int mid = start + (end - start) / 2;
        SortEmployees(employeeList, start, mid);
        SortEmployees(employeeList, mid + 1, end);
        MergeEmployees(employeeList, start, mid, end);
    }
    else
    {
        // Base case
        // Insertion sort
        for (int i = start + 1; i <= end; i++)
        {
            EMPLOYEE key = employeeList[i];
            // Binary search can be used here to find the correct index for insertion to reduce
comparisons
            // incremental binary search
            int left = start;
            int right = i - 1;
            int j;
            while (left <= right)
            {
                int mid = left + (right - left) / 2;
                if (strcmp(key.surname, employeeList[mid].surname) < 0)
                {
                    right = mid - 1;
                }
                else
                {
                    left = mid + 1;
                }
            }
            // Shift elements to the right to make room for insertion
            for (j = i - 1; j > right; j--)
            {
                employeeList[j + 1] = employeeList[j];
            }
            employeeList[j + 1] = key;
        }
    }
}

// Merges two sorted subarray into one sorted array
// Params: employeeList[] - array of employees to sort
//         start - starting index of first subarray
//         mid - ending index of first subarray
```

```
//         end - ending index of second subarray
void MergeEmployees(EMPLOYEE employeeList[], int start, int mid, int end)
{
    // Create two temp arrays
    int nL = mid - start + 1;
    int nR = end - mid;
    EMPLOYEE *tempL = (EMPLOYEE *)malloc(sizeof(EMPLOYEE) * nL);
    EMPLOYEE *tempR = (EMPLOYEE *)malloc(sizeof(EMPLOYEE) * nR);

    // Copy elements from original array to temp arrays
    for (int i = 0; i < nL; i++)
    {
        tempL[i] = employeeList[start + i];
    }
    for (int i = 0; i < nR; i++)
    {
        tempR[i] = employeeList[mid + 1 + i];
    }

    // Merge temp arrays into original array
    int i = start, j = 0, k = 0;
    while (j < nL && k < nR)
    {
        if (strcmp(tempL[j].surname, tempR[k].surname) < 0)
        {
            employeeList[i++] = tempL[j++];
        }
        else
        {
            employeeList[i++] = tempR[k++];
        }
    }

    // Copy remaining elements from temp arrays
    while (j < nL)
    {
        employeeList[i++] = tempL[j++];
    }
    while (k < nR)
    {
        employeeList[i++] = tempR[k++];
    }

    // Free temp arrays
    free(tempL);
    free(tempR);
}

// Combine sorted teams into one sorted array
// Params: *teams[] - array of teams to combine
//         employeeList[] - array of employees
//         teamMemberCount - number of members in each team
//         teamCount - number of teams
void CombineTeams(EMPLOYEE *teams[], EMPLOYEE employeeList[], int teamMemberCount, int teamCount)
{
    int combinedSize = teamCount * teamMemberCount;
    // Concatenate teams into one array
    for (int i = 0; i < teamCount; i++)
    {
        for (int j = 0; j < teamMemberCount; j++)
        {
            employeeList[i * teamMemberCount + j] = teams[i][j];
        }
    }
    // Merge employeeList
    for (int i = 0; i < teamCount - 1; i++)
    {
        MergeEmployees(employeeList, 0, (i + 1) * teamMemberCount - 1, (i + 2) * teamMemberCount - 1);
    }
}

// Search employee list by surname
// Params: employeeList[] - array of employees to search
//         key - surname to search for
```

```
//          start - starting index of array
//          end - ending index of array
// Returns: index of employee if found, -1 if not found
int SearchBySurname(EMPLOYEE employeeList[], STRING30 key, int start, int end)
{
    if (end >= start)
    {
        int mid = start + (end - start) / 2;
        if (strcmp(employeeList[mid].surname, key) == 0) return mid;

        if (strcmp(employeeList[mid].surname, key) > 0)
        {
            return SearchBySurname(employeeList, key, start, mid - 1);
        }
        else
        {
            return SearchBySurname(employeeList, key, mid + 1, end);
        }
    }

    return -1;
}

// Option functions

// Option 1: a) Sorts and combines teams
// Prints individual teams then sorts the teams individually
// Then combines the teams into one sorted array
// Params: *teams[] - array of teams to sort and combine
//          employeeList[] - array of employees which will contain the combined sorted teams
//          teamMemberCount - number of members in each team
//          teamCount - number of teams
void ProcessTeams(EMPLOYEE *teams[], EMPLOYEE employeeList[], int teamMemberCount, int teamCount)
{

    // Display each team separately
    printf("\nDisplaying teams...\n");
    for (int i = 0; i < teamCount; i++)
    {
        printf("Team %d:\n", i + 1);
        PrintEmployeeList(teams[i], teamMemberCount);
    }

    PromptContinue();
    PrintSoftDivider();

    // Sort each team using merge sort
    printf("\nSorting teams...\n");
    for (int i = 0; i < teamCount; i++)
    {
        SortEmployees(teams[i], 0, teamMemberCount - 1);
    }
    // Display each team separately
    for (int i = 0; i < teamCount; i++)
    {
        printf("Team %d:\n", i + 1);
        PrintEmployeeList(teams[i], teamMemberCount);
    }

    PromptContinue();
    PrintSoftDivider();

    // Combine teams to employeeList and display
    printf("\nCombining teams...\n");
    CombineTeams(teams, employeeList, teamMemberCount, teamCount);
    printf("\nCombined teams list:\n");
    PrintEmployeeList(employeeList, teamCount * teamMemberCount);
}

// Option 2: b) Searches certifications for full certs where earnedCertID has a value of 7 and prints
the employee's name
// Params: employeeList[] - array of employees
//          certList[] - array of certifications to search
//          employeeCount - number of employees
```

```
//          certCount - number of certifications
void PrintFullCerts(EMPLOYEE employeeList[], CERTIFICATION certList[], int employeeCount, int
certCount)
{
    // Search for full certs
    printf("\nSearching for employees with full certifications...\n");

    printf("%-11s  %-12s  %-12s  %-4s\n", "Employee ID", "First Name", "Surname", "Line");
    for (int i = 0; i < certCount; i++)
    {
        // For each full cert, find the employee linked to it and print their details
        if (certList[i].earnedCertID == 7)
        {
            for (int j = 0; j < employeeCount; j++)
            {
                if (employeeList[j].employeeID == certList[i].employeeID)
                {
                    printf("%11d  %-12s  %-12s  %-4d\n", employeeList[j].employeeID,
employeeList[j].firstName, employeeList[j].surname, employeeList[j].line);
                    break;
                }
                else if (j == employeeCount - 1)
                {
                    printf("%11d  %-12s  %-12s\n", certList[i].employeeID, "Unknown", "Unknown");
                }
            }
        }
    }
    printf("\n");
}

// Option 3: c) Prompts user for surname to search then searches employee list for employees with that
surname using binary search and prints the employee's details
// Params: employeeList[] - array of employees
//          employeeCount - number of employees
void GetEmployeeBySurname(EMPLOYEE employeeList[], int count)
{
    // Prompt user for surname
    STRING30 surname;
    int index;
    do
    {
        printf("\nEnter surname (case sensitive max 29):\n> ");
        scanf("%29s", surname);
        if (strcmp(surname, "") == 0)
        {
            printf("\nSurname cannot be blank.\n");
        }
    } while (strcmp(surname, "") == 0);

    index = SearchBySurname(employeeList, surname, 0, count - 1);
    if (index == -1)
    {
        printf("\nNo employees found with surname '%s'.\n", surname);
    }
    else
    {
        printf("\nEmployee found:\n");
        printf("EmployeeID: %d\n", employeeList[index].employeeID);
        printf("First Name: %s\n", employeeList[index].firstName);
        printf("Surname:    %s\n", employeeList[index].surname);
        printf("Line:       %d\n", employeeList[index].line);
    }
    printf("\n");
}
```