

Homework 3 – Project Description in the textbook

A. Program Design and Additional or Modified Requirements: the requirements described in **Homework #3, Tasks I & II** must be followed in addition to what is defined in the textbook. If it is *not the same* as what is described in the textbook, please follow the description/requirements in **Homework #3, Tasks I & II**.

B. Project Description in Textbook: This programming project is the **Project 1** defined in **pages P-27 through P-29 at the end of Chapter 4 (Threads & Concurrency) in Textbook (10/E)**. Please read the textbook for details.

Programming Projects

Project 1—Sudoku Solution Validator

A **Sudoku** puzzle uses a 9×9 grid in which each column and row, as well as each of the nine 3×3 subgrids, must contain all of the digits $1 \cdots 9$. Figure 4.26 presents an example of a valid Sudoku puzzle. This project consists of designing a multithreaded application that determines whether the solution to a Sudoku puzzle is valid.

6	2	4	5	3	9	1	8	7
5	1	9	7	2	8	6	3	4
8	3	7	6	1	4	2	9	5
1	4	3	8	6	5	7	2	9
9	5	8	2	4	7	3	6	1
7	6	2	3	9	1	4	5	8
3	7	1	9	5	6	8	4	2
4	9	6	1	8	2	5	7	3
2	8	5	4	7	3	9	1	6

Figure 4.26 Solution to a 9×9 Sudoku puzzle.

There are several different ways of multithreading this application. One suggested strategy is to create threads that check the following criteria:

- A thread to check that each column contains the digits 1 through 9
- A thread to check that each row contains the digits 1 through 9
- Nine threads to check that each of the 3×3 subgrids contains the digits 1 through 9

This would result in a total of eleven separate threads for validating a Sudoku puzzle. However, you are welcome to create even more threads for this project. For example, rather than creating one thread that checks all nine columns, you could create nine separate threads and have each of them check one column.

I. Passing Parameters to Each Thread

The parent thread will create the worker threads, passing each worker the location that it must check in the Sudoku grid. This step will require passing several parameters to each thread. The easiest approach is to create a data structure using a struct. For example, a structure to pass the row and column where a thread must begin validating would appear as follows:

```
/* structure for passing data to threads */
typedef struct
{
    int row;
    int column;
} parameters;
```

Both Pthreads and Windows programs will create worker threads using a strategy similar to that shown below:

```
parameters *data = (parameters *) malloc(sizeof(parameters));
data->row = 1;
data->column = 1;
/* Now create the thread passing it data as a parameter */
```

The data pointer will be passed to either the `pthread create()` (Pthreads) function or the `CreateThread()` (Windows) function, which in turn will pass it as a parameter to the function that is to run as a separate thread.

II. Returning Results to the Parent Thread

Each worker thread is assigned the task of determining the validity of a particular region of the Sudoku puzzle. Once a worker has performed this check, it must pass its results back to the parent. One good way to handle this is to create an array of integer values that is visible to each thread. The i_{th} index in this array corresponds to the i_{th} worker thread. If a worker sets its corresponding value to 1, it is indicating that its region of the Sudoku puzzle is valid. A value of 0 indicates otherwise. When all worker threads have completed, the parent thread checks each entry in the result array to determine if the Sudoku puzzle is valid.