Report on exercise #3

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The proposed solution for the exercise makes use of three types of data structures:

- SHARED_VARS: it is used to hold data that is common to all threads, including:
  - The synchronization variables: two CRITICAL_SECTIONs called meL2R and meR2L and a HANDLE, used for storing an event, called busy;
  - The shared variables for inter-thread communication: two integers called nL2R and nR2L.
- THREAD_DATA: it is passed as a data structure to a first-level thread (the ones created by the main function), and it holds the three integer values of parameters arrival time (timeA), traversal time (timeT) and numbers of cars that have to traverse the bridge (carsNumber), plus a pointer to the SHARED_VARS structure;
- CAR_THREAD_DATA: it is passed as a data structure to a second-level thread (the ones representing cars), and it holds an identifier (DWORD id), the traversal time parameter (DWORD timeT) and a pointer to the SHARED_VARS structure.

The main thread, after having checked the number of parameters, converts them into integer by means of the generic _ttoi() function, storing the result in the appropriate fields of two THREAD_DATA structures, called tdL2R and tdR2L. Then, it proceeds to create the synchronization variables inside its local SHARED_VARS structure (two critical sections and an event are used for the purpose of the exercise). After that, it proceeds to create two threads, the first one executing the LeftToRightThread() function and receiving as argument the tdL2R structure and the other executing the RightToLeftThread() function and receiving as argument the tdR2L structure. The main finally proceeds to wait for all threads to complete, close their handles and destroy the synchronization objects.

The two first-level threads perform similar actions, the only difference being the function that is used to create the car threads. In particular:

- They initialize the random seed of the rand() function by using their thread identifier;
- They allocate two vectors, the first one (of type LPHANDLE) to store the handles of the created car threads and the second one (of type LPCAR_THREAD_DATA) to store the data structures to be passed to each of them, checking the correctness of the allocation;
- They loop for carsNumber times; at each iteration:
  - They sleep, waiting for a car to arrive, for a random number of seconds between 0 and timeA, by means of the Sleep() system call;
  - They set the parameters in the structure to be passed to the new car thread;
  - They create a new car thread by means of CreateThread(), checking the correctness of the operation, making them execute one of the two functions CarLeftToRightThread() and CarRightToLeftThread() and passing the prepared structure.
- After the loop is completed, they join all the created threads via WaitForMultipleObjects(), close the handles of the created threads and release the allocated memory.

Each car thread performs similar actions, implementing the single-lane tunnel protocol; they can be divided in three distinct sections:

- Access protocol: protected inside a critical section that makes it run in mutual exclusion with all the other car threads travelling in the same direction, the car thread increments one of the two shared variables nL2R or nR2L, counting the number of cars travelling in each direction; if the count is one (no other car is travelling in its direction), then the car has to wait on the busy event until the bridge becomes free for traversal, otherwise it can simply proceed to traverse the bridge;
- Bridge traversal: the car thread sleeps for timeT seconds, simulating the traversal of the bridge;
- Release protocol: protected inside a critical section that makes it run in mutual exclusion with all the other car threads travelling in the same direction, the car thread decrements one of the two shared variables nL2R or nR2L; if the count is zero (it is the last car travelling in its direction), then the car can set the busy event to signal that the bridge is free for traversal.