Smart Parking System

Multithreading Implementation

- **Vehicle Representation:**
  Each vehicle is represented as an asynchronous task. The implementation relies on the built-in .NET ThreadPool, which eliminates the need for manually creating or destroying threads. When a vehicle is waiting (for example, to enter, exit, or find a parking spot), the thread is released back to the pool, ensuring efficient utilization of system resources.
- **Concurrency Control:**
  No manual locks (lock) are used. Instead, shared resources are protected by thread-safe data structures such as ConcurrentQueue (for managing available parking spaces) and ConcurrentDictionary (for managing active sessions). Additionally, counters for free and occupied parking spots are updated safely using atomic operations (e.g., Interlocked.Increment), preventing race conditions on shared variables.

Parking Functions

Locks are not required for functions that operate on a specific parking spot. The system design guarantees that only one thread can interact with a given spot at any given time.

- **How it Works:**
  The ConcurrentQueue ensures that each thread is assigned a unique parking spot, preventing multiple threads from handling the same spot simultaneously.

Handling Waiting Vehicles

- **Assumption:** A vehicle may need to wait.
- **Current Behavior:** When a vehicle arrives at a full parking lot, it waits until a spot becomes available. If no spot opens, it remains waiting indefinitely.
- **Potential Improvements:**
  - Add a **timeout** for waiting. If a vehicle waits too long, it can give up and leave.
  - Redirect vehicles to an **alternative parking lot** when the current lot is full.
- **Decision:** For now, the implementation is kept simple, and these enhancements are marked as future improvements.

Future Enhancements

- **Alternative Parking Search:** A mechanism to locate a nearby parking lot if the current one is full.
- **Priority Queue:** Support for special vehicles (e.g., disabled, VIP).
- **Reservation System:** Allow users to reserve parking spaces in advance.
