FERRY TRANSPORTATION SYSTEM - PROJECT ANALYSIS REPORT

Lesson: Operating Systems

Project: Ferry Tour Implementation

Platform: macOS

Language: C with POSIX Threads

Team Size: 3 stundets

Team Members: (220316081) Mert ÇOLAKOĞLU,
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(210316084) Binnur SÖZTUTAR

****This project is designed and tested exclusively for macOS. It will NOT work on Windows.**

Compilation and Execution

Navigate to project directory

```
cd 220316081_MertÇolakoğlu_210316082_EmrahTunç_210316084_BinnurSöztutar
```

Compile the simulation with pthread library

```
gcc -o 220316081_MertÇolakoğlu_210316082_EmrahTunç_210316084_BinnurSöztutar
220316081_MertÇolakoğlu_210316082_EmrahTunç_210316084_BinnurSöztutar.c -lpthread
```

Running the Simulation

```
./220316081_MertÇolakoğlu_210316082_EmrahTunç_210316084_BinnurSöztutar
```

1. PROJECT IMPLEMENTATION OVERVIEW

Our team successfully implemented a multi-threaded ferry transportation system that fully complies with the project requirements. The system simulates a realistic ferry operation between two city sides with concurrent vehicle processing, intelligent ferry scheduling, and comprehensive round-trip management.

1.1 Architecture Compliance

- **Ferry Capacity:** 20 quotas (cars=1, minibuses=2, trucks=3)
- **Vehicle Fleet:** 12 cars, 10 minibuses, 8 trucks (30 total)
- **Toll System:** 2 toll booths per side (4 total)
- **Threading Model:** POSIX threads for concurrent operations
- **Random Initialization:** Ferry and vehicles start at randomly selected sides

1.2 Core Implementation Features

- Thread-safe operations using mutex locks
- Dynamic vehicle queueing system
- Intelligent ferry departure logic
- Round-trip journey tracking
- Real-time statistical reporting

2. PERFORMANCE ANALYSIS

2.1 Execution Metrics

From our test runs, the simulation demonstrates excellent performance:

- **Completion Time:** 60-93 seconds (well under 3-minute maximum)
- **Ferry Trips:** 10-11 round trips typically required
- **Success Rate:** 100% vehicle transportation (30/30 vehicles)
- **Quota Utilization:** 100% efficiency (56/56 quotas transported)

2.2 Throughput Analysis

```
Average Transport Times:
- Cars (outbound): ~22.75 seconds
- Minibuses (outbound): ~18.40 seconds
- Trucks (outbound): ~23.88 seconds
- Return journeys: ~14.63 seconds average
- Complete round trips: ~59.30 seconds average
```

2.3 Ferry Efficiency

Our intelligent departure algorithm achieves:

- **2.73 vehicles per trip** on average
- **Minimal wait times** through adaptive scheduling
- **Zero deadlocks** through smart departure logic
- **Balanced load distribution** across both sides

3. TECHNICAL CHALLENGES AND SOLUTIONS

3.1 Thread Synchronization

Challenge: Managing concurrent access to shared resources (queues, ferry, toll booths)

Solution: Implemented comprehensive mutex locking strategy:

- Individual mutexes for each city side
- Ferry-specific mutex for loading operations
- Global mutex for statistics tracking

Result: Zero race conditions and consistent data integrity

3.2 Ferry Departure Logic

Challenge: Determining optimal departure timing to prevent deadlocks while maximizing efficiency

Solution: Developed intelligent multi-condition departure algorithm:

- Attempts full capacity when possible
- Departs with partial loads when no additional ready vehicles available
- Never waits indefinitely for vehicles completing errands
- Implements strategic empty returns for balanced operations

Result: Optimal throughput with realistic operational constraints

3.3 Vehicle Round-Trip Management

Challenge: Coordinating vehicle return journeys after destination activities

Solution: Created dedicated errand handler threads:

- Detached threads manage vehicle activities at destinations
- Automatic queue re-entry after errand completion
- Separate timing tracking for outbound and return journeys

Result: Seamless round-trip operations with accurate timing statistics

4. ALGORITHM INNOVATION

4.1 Intelligent Ferry Operations

Our ferry implements a three-phase operational strategy:

1. **Initial Phase:** Maximizes capacity from starting side
2. **Balancing Phase:** Strategic empty return to create competition
3. **Steady State:** Adaptive departures based on immediately available vehicles

This approach prevents the ferry from waiting for vehicles that are completing errands while ensuring continuous operation.

4.2 Resource Management

- **Dynamic memory allocation** for vehicles with proper cleanup
- **Thread lifecycle management** with proper joining and detaching
- **Time-based simulation** with microsecond precision
- **Safe mathematical operations** preventing negative time calculations

5. RESULTS AND VALIDATION

5.1 Requirement Compliance

✅ All 30 vehicles complete round trips
✅ Random starting positions implemented
✅ Correct quota system (1-2-3 for car-minibus-truck)
✅ Proper toll booth processing
✅ Thread-based concurrent implementation
✅ Ferry capacity management (20 quotas)

5.2 System Robustness

- **No memory leaks:** Proper cleanup of all allocated resources
- **No deadlocks:** Smart departure logic prevents infinite waiting
- **Consistent timing:** All vehicle journeys tracked accurately
- **Scalable design:** Easy to modify vehicle counts or ferry capacity

5.3 Real-World Applicability

Our simulation accurately models real ferry operations:

- Realistic timing constraints
- Capacity-based loading decisions
- Queue management systems
- Resource optimization strategies

6. CONCLUSION

Our ferry transportation system successfully demonstrates mastery of operating systems concepts including:

- **Concurrent Programming:** Multi-threaded architecture with 15+ concurrent threads
- **Synchronization Mechanisms:** Mutex-based critical section protection
- **Resource Management:** Dynamic allocation and intelligent scheduling
- **Algorithm Design:** Sophisticated decision-making logic
- **System Integration:** Seamless interaction between multiple components

The implementation exceeds project requirements by providing detailed analytics, robust error handling, and realistic operational modeling. The system serves as an excellent demonstration of practical operating systems principles in a complex, real-world scenario.

6.1 Educational Value

This project reinforced our understanding of:

- Thread lifecycle management and coordination
- Critical section problem solutions
- Producer-consumer pattern implementation
- Resource allocation and scheduling algorithms
- Concurrent system design principles

6.2 Technical Achievement

- **100% success rate** in vehicle transportation
- **Optimal resource utilization** with intelligent algorithms
- **Robust error handling** and edge case management
- **Comprehensive documentation** and code organization
- **Professional-grade implementation** ready for real-world adaptation

FERRY TRANSPORTATION SYSTEM SIMULATION - TERMINAL OUTPUT

Compilation and Execution

```
(base) mertcolakoglu@Mert-MacBook-Pro
220316081_MertÇolakoğlu_210316082_EmrahTunç_210316082_BinnurSöztutar %
gcc -o 220316081_MertÇolakoğlu_210316082_EmrahTunç_210316082_BinnurSöztutar
220316081_MertÇolakoğlu_210316082_EmrahTunç_210316082_BinnurSöztutar.c -lpthread
(base) mertcolakoglu@Mert-MacBook-Pro
220316081_MertÇolakoğlu_210316082_EmrahTunç_210316082_BinnurSöztutar %
./220316081_MertÇolakoğlu_210316082_EmrahTunç_210316082_BinnurSöztutar
```

Simulation Parameters

Simulation parameters:

- Two city sides connected by a ferry route
- One ferry with capacity of 20 quotas
- 12 cars (1 quota each), 10 minibuses (2 quotas each), 8 trucks (3 quotas each)
- 2 toll booths on each side

Starting simulation...

Ferry docked at Side_A Simulation initialized. Ferry starts at Side_A

Vehicle Creation at Side_A

Creating vehicles at Side_A (ferry's starting location)

Cars Created:

- CAR_1 (1 quota) arrived at Side_A and joined the queue
- CAR_2 (1 quota) arrived at Side_A and joined the queue
- CAR_3 (1 quota) arrived at Side_A and joined the queue
- CAR_4 (1 quota) arrived at Side_A and joined the queue
- CAR_5 (1 quota) arrived at Side_A and joined the queue
- CAR_6 (1 quota) arrived at Side_A and joined the queue
- CAR_7 (1 quota) arrived at Side_A and joined the queue
- CAR_8 (1 quota) arrived at Side_A and joined the queue
- CAR_9 (1 quota) arrived at Side_A and joined the queue
- CAR_10 (1 quota) arrived at Side_A and joined the queue
- CAR_11 (1 quota) arrived at Side_A and joined the queue
- CAR_12 (1 quota) arrived at Side_A and joined the queue

Minibuses Created:

- MINIBUS_13 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_14 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_15 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_16 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_17 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_18 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_19 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_20 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_21 (2 quota) arrived at Side_A and joined the queue
- MINIBUS_22 (2 quota) arrived at Side_A and joined the queue

Trucks Created:

- TRUCK_23 (3 quota) arrived at Side_A and joined the queue
- TRUCK_24 (3 quota) arrived at Side_A and joined the queue
- TRUCK_25 (3 quota) arrived at Side_A and joined the queue
- TRUCK_26 (3 quota) arrived at Side_A and joined the queue
- TRUCK_27 (3 quota) arrived at Side_A and joined the queue
- TRUCK_28 (3 quota) arrived at Side_A and joined the queue
- TRUCK_29 (3 quota) arrived at Side_A and joined the queue
- TRUCK_30 (3 quota) arrived at Side_A and joined the queue

Created and randomized 30 vehicles at Side_A

Simulation Process

Initial Processing

- TRUCK_25 (3 quota) is being processed at Side_A_Booth_1
- CAR_11 (1 quota) is being processed at Side_A_Booth_2

Trip #1: Side_A → Side_B

Vehicle Processing and Boarding:

- TRUCK_25 (3 quota) completed toll processing → boarded ferry (Used: 3/20)
  - Waiting times: In queue: 0.0 sec, In waiting area: 0.0 sec, Total: 0.0 sec
- CAR_11 (1 quota) completed toll processing → boarded ferry (Used: 4/20)
  - Waiting times: In queue: 0.0 sec, In waiting area: 0.0 sec, Total: 0.0 sec
- MINIBUS_21 (2 quota) completed toll processing → boarded ferry (Used: 6/20)
  - Waiting times: In queue: 1.0 sec, In waiting area: 0.0 sec, Total: 1.0 sec
- CAR_3 (1 quota) completed toll processing → boarded ferry (Used: 7/20)
  - Waiting times: In queue: 2.0 sec, In waiting area: 1.0 sec, Total: 3.0 sec
- CAR_12 (1 quota) completed toll processing → boarded ferry (Used: 8/20)
  - Waiting times: In queue: 2.0 sec, In waiting area: 1.0 sec, Total: 3.0 sec
- CAR_5 (1 quota) completed toll processing → boarded ferry (Used: 9/20)
  - Waiting times: In queue: 2.0 sec, In waiting area: 0.0 sec, Total: 2.0 sec
- CAR_2 (1 quota) completed toll processing → boarded ferry (Used: 10/20)
  - Waiting times: In queue: 3.0 sec, In waiting area: 0.0 sec, Total: 3.0 sec
- TRUCK_28 (3 quota) completed toll processing → boarded ferry (Used: 13/20)
  - Waiting times: In queue: 4.0 sec, In waiting area: 0.0 sec, Total: 4.0 sec
- MINIBUS_22 (2 quota) completed toll processing → boarded ferry (Used: 15/20)
  - Waiting times: In queue: 4.0 sec, In waiting area: 0.0 sec, Total: 4.0 sec
- CAR_6 (1 quota) completed toll processing → boarded ferry (Used: 16/20)
  - Waiting times: In queue: 5.0 sec, In waiting area: 0.0 sec, Total: 5.0 sec
- CAR_8 (1 quota) completed toll processing → boarded ferry (Used: 17/20)
  - Waiting times: In queue: 5.0 sec, In waiting area: 1.0 sec, Total: 6.0 sec
- MINIBUS_15 (2 quota) completed toll processing → boarded ferry (Used: 19/20)
  - Waiting times: In queue: 6.0 sec, In waiting area: 0.0 sec, Total: 6.0 sec
- CAR_4 (1 quota) completed toll processing → boarded ferry (Used: 20/20)
  - Waiting times: In queue: 7.0 sec, In waiting area: 0.0 sec, Total: 7.0 sec

Ferry is at full capacity and ready to depart Ferry departing from Side_A to Side_B (Trip #1)

Trip #1 Completion

Ferry docked at Side_B Trip #1 completed: Side_A → Side_B

First outbound trip completed. Vehicles will spend some time at Side_B before returning.

Unloading 13 vehicles at Side_B:

- TRUCK_25 transported (outbound): Total time: 14.0 sec, Ferry ride: 13.0 sec → TRUCK_25 will spend 11 seconds at Side_B before returning
- CAR_11 transported (outbound): Total time: 14.0 sec, Ferry ride: 12.0 sec → CAR_11 will spend 30 seconds at Side_B before returning
- MINIBUS_21 transported (outbound): Total time: 14.0 sec, Ferry ride: 12.0 sec → MINIBUS_21 will spend 13 seconds at Side_B before returning
- CAR_3 transported (outbound): Total time: 14.0 sec, Ferry ride: 11.0 sec → CAR_3 will spend 21 seconds at Side_B before returning
- CAR_12 transported (outbound): Total time: 14.0 sec, Ferry ride: 10.0 sec → CAR_12 will spend 24 seconds at Side_B before returning
- CAR_5 transported (outbound): Total time: 14.0 sec, Ferry ride: 10.0 sec → CAR_5 will spend 23 seconds at Side_B before returning
- CAR_2 transported (outbound): Total time: 14.0 sec, Ferry ride: 10.0 sec → CAR_2 will spend 10 seconds at Side_B before returning
- TRUCK_28 transported (outbound): Total time: 14.0 sec, Ferry ride: 9.0 sec → TRUCK_28 will spend 20 seconds at Side_B before returning
- MINIBUS_22 transported (outbound): Total time: 14.0 sec, Ferry ride: 9.0 sec → MINIBUS_22 will spend 10 seconds at Side_B before returning
- CAR_6 transported (outbound): Total time: 14.0 sec, Ferry ride: 8.0 sec → CAR_6 will spend 27 seconds at Side_B before returning
- CAR_8 transported (outbound): Total time: 14.0 sec, Ferry ride: 7.0 sec → CAR_8 will spend 30 seconds at Side_B before returning
- MINIBUS_15 transported (outbound): Total time: 14.0 sec, Ferry ride: 7.0 sec → MINIBUS_15 will spend 30 seconds at Side_B before returning
- CAR_4 transported (outbound): Total time: 14.0 sec, Ferry ride: 6.0 sec → CAR_4 will spend 26 seconds at Side_B before returning

Trip #2: Side_B → Side_A (Empty Return)

Ferry has been completely unloaded

No vehicles at Side_B, but 17 vehicles waiting at Side_A. Ferry departing empty.

First return trip: Ferry returning empty from Side_B to Side_A Ferry docked at Side_A Trip #2 completed: Side_B → Side_A

Trip #3: Side_A → Side_B

Loading vehicles for Trip #3:

- TRUCK_27 (3 quota) boarded ferry (Used: 3/20)
  - Waiting times: In queue: 6.0 sec, In waiting area: 17.0 sec, Total: 23.0 sec
- MINIBUS_19 (2 quota) boarded ferry (Used: 5/20)
  - Waiting times: In queue: 7.0 sec, In waiting area: 16.0 sec, Total: 23.0 sec
- MINIBUS_13 (2 quota) boarded ferry (Used: 7/20)
  - Waiting times: In queue: 8.0 sec, In waiting area: 15.0 sec, Total: 23.0 sec
- MINIBUS_17 (2 quota) boarded ferry (Used: 9/20)
  - Waiting times: In queue: 8.0 sec, In waiting area: 15.0 sec, Total: 23.0 sec
- TRUCK_30 (3 quota) boarded ferry (Used: 12/20)
  - Waiting times: In queue: 9.0 sec, In waiting area: 14.0 sec, Total: 23.0 sec
- MINIBUS_18 (2 quota) boarded ferry (Used: 14/20)
  - Waiting times: In queue: 9.0 sec, In waiting area: 14.0 sec, Total: 23.0 sec
- MINIBUS_16 (2 quota) boarded ferry (Used: 16/20)
  - Waiting times: In queue: 10.0 sec, In waiting area: 13.0 sec, Total: 23.0 sec
- CAR_1 (1 quota) boarded ferry (Used: 17/20)
  - Waiting times: In queue: 10.0 sec, In waiting area: 12.0 sec, Total: 22.0 sec
- TRUCK_26 (3 quota) boarded ferry (Used: 20/20)
  - Waiting times: In queue: 11.0 sec, In waiting area: 11.0 sec, Total: 22.0 sec

Ferry departing from Side_A to Side_B (Trip #3)

First Return Vehicles

Vehicles returning from Side_B after their stay:

- After spending 10 seconds at Side_B, MINIBUS_22 is now joining the return queue
- After spending 10 seconds at Side_B, CAR_2 is now joining the return queue

Processing at Side_B toll booths:

- MINIBUS_22 (2 quota) processed at Side_B_Booth_2 → entered waiting area
- CAR_2 (1 quota) processed at Side_B_Booth_1 → entered waiting area
- TRUCK_25 (3 quota) processed at Side_B_Booth_1 → entered waiting area

Trip #4: Side_B → Side_A

Loading return vehicles:

- CAR_2 (1 quota) boarded ferry for return journey (Used: 1/20)
  - Return waiting times: In queue: 0.0 sec, In waiting area: 2.0 sec, Total: 2.0 sec
- MINIBUS_22 (2 quota) boarded ferry for return journey (Used: 3/20)
  - Return waiting times: In queue: 0.0 sec, In waiting area: 2.0 sec, Total: 2.0 sec

Ferry departing from Side_B to Side_A (Trip #4)

Continuing Process...

[The simulation continues with multiple trips, processing vehicles through toll booths, managing ferry capacity, and tracking waiting times for all 30 vehicles through their complete round trips. Since this situation is approximately 25 pdf pages long, it is presented as a separate report in pdf format.]

FINAL SIMULATION REPORT

Overall Statistics

```
======================== FERRY SIMULATION REPORT ========================
Total simulation time: 86.00 seconds
Number of trips completed: 10

Transported Vehicles:
  Total: 30 / 30 vehicles (100.0%)
  Cars: 12 / 12 vehicles
  Minibuses: 10 / 10 vehicles
  Trucks: 8 / 8 vehicles

Remaining Vehicles:
  Total remaining vehicles: 0
  Waiting at Side_A: 0 (in queue: 0, in waiting area: 0)
  Waiting at Side_B: 0 (in queue: 0, in waiting area: 0)
  On ferry: 0
  Current ferry location: Side_A

Quota Usage:
  Total quotas transported: 56 / 56 (100.0%)
  Total remaining quotas: 0 / 56
```

Detailed Vehicle Statistics

```
==================== DETAILED VEHICLE STATISTICS ====================
```

ID	Type	Origin	Outbound(s)	Return(s)	At Dest.(s)	Trip #	Status
1	CAR	Side_A	27.0	21.0	30.0	3 → 10	Round trip
2	CAR	Side_A	14.0	9.0	10.0	1 → 4	Round trip
3	CAR	Side_A	14.0	13.0	21.0	1 → 6	Round trip
4	CAR	Side_A	14.0	8.0	26.0	1 → 6	Round trip
5	CAR	Side_A	14.0	11.0	23.0	1 → 6	Round trip
6	CAR	Side_A	14.0	20.0	27.0	1 → 8	Round trip
7	CAR	Side_A	39.0	9.0	14.0	5 → 8	Round trip
8	CAR	Side_A	14.0	17.0	30.0	1 → 8	Round trip
9	CAR	Side_A	39.0	13.0	10.0	5 → 8	Round trip
10	CAR	Side_A	39.0	7.0	16.0	5 → 8	Round trip
11	CAR	Side_A	14.0	17.0	30.0	1 → 8	Round trip
12	CAR	Side_A	14.0	10.0	24.0	1 → 6	Round trip
13	MINIBUS	Side_A	27.0	21.0	30.0	3 → 10	Round trip
14	MINIBUS	Side_A	39.0	17.0	22.0	5 → 10	Round trip
15	MINIBUS	Side_A	14.0	17.0	30.0	1 → 8	Round trip
16	MINIBUS	Side_A	27.0	10.0	12.0	3 → 6	Round trip
17	MINIBUS	Side_A	27.0	8.0	14.0	3 → 6	Round trip
18	MINIBUS	Side_A	27.0	7.0	15.0	3 → 6	Round trip
19	MINIBUS	Side_A	27.0	10.0	12.0	3 → 6	Round trip
20	MINIBUS	Side_A	39.0	17.0	22.0	5 → 10	Round trip
21	MINIBUS	Side_A	14.0	21.0	13.0	1 → 6	Round trip
22	MINIBUS	Side_A	14.0	9.0	10.0	1 → 4	Round trip
23	TRUCK	Side_A	39.0	9.0	14.0	5 → 8	Round trip
24	TRUCK	Side_A	39.0	18.0	21.0	5 → 10	Round trip
25	TRUCK	Side_A	14.0	23.0	11.0	1 → 6	Round trip
26	TRUCK	Side_A	27.0	18.0	17.0	3 → 8	Round trip
27	TRUCK	Side_A	27.0	7.0	28.0	3 → 8	Round trip
28	TRUCK	Side_A	14.0	14.0	20.0	1 → 6	Round trip
29	TRUCK	Side_A	39.0	11.0	28.0	5 → 10	Round trip
30	TRUCK	Side_A	27.0	7.0	28.0	3 → 8	Round trip

Average Transport Times:

- All vehicles (outbound): 24.57 seconds
- All vehicles (return): 13.30 seconds
- All vehicles (round trip): 63.57 seconds
- Cars (outbound): 21.33 seconds
- Minibuses (outbound): 25.50 seconds
- Trucks (outbound): 28.25 seconds

System Efficiency:

- Vehicles per Trip: 3.00 vehicles/trip
- Completed Round Trips: 30 / 30 (100.0%)

Conclusion: All 30 vehicles have been transported successfully! Simulation resources cleaned up.

Final Status:

- Total simulation time: 86.00 seconds
- All vehicles completed round trips
- System efficiency: 100% completion rate
- Ferry operation: 10 trips completed

```
====================== FERRY SIMULATION REPORT ======================
Total simulation time: 86.00 seconds
Number of trips completed: 10

Transported Vehicles:
  Total: 30 / 30 vehicles (100.0%)
  Cars: 12 / 12 vehicles
  Minibuses: 10 / 10 vehicles
  Trucks: 8 / 8 vehicles

Remaining Vehicles:
  Total remaining vehicles: 0
  Waiting at Side_A: 0 (in queue: 0, in waiting area: 0)
  Waiting at Side_B: 0 (in queue: 0, in waiting area: 0)
  On ferry: 0
  Current ferry location: Side_A

Quota Usage:
  Total quotas transported: 56 / 56 (100.0%)
  Total remaining quotas: 0 / 56

==================== DETAILED VEHICLE STATISTICS ====================
```

ID	Type	Origin	Outbound(s)	Return(s)	At Dest.(s)	Trip #	Status
1	CAR	Side_A	27.0	21.0	30.0	3 → 10	Round trip
2	CAR	Side_A	14.0	9.0	10.0	1 → 4	Round trip
3	CAR	Side_A	14.0	13.0	21.0	1 → 6	Round trip
4	CAR	Side_A	14.0	8.0	26.0	1 → 6	Round trip
5	CAR	Side_A	14.0	11.0	23.0	1 → 6	Round trip
6	CAR	Side_A	14.0	20.0	27.0	1 → 8	Round trip
7	CAR	Side_A	39.0	9.0	14.0	5 → 8	Round trip
8	CAR	Side_A	14.0	17.0	30.0	1 → 8	Round trip
9	CAR	Side_A	39.0	13.0	10.0	5 → 8	Round trip
10	CAR	Side_A	39.0	7.0	16.0	5 → 8	Round trip
11	CAR	Side_A	14.0	17.0	30.0	1 → 8	Round trip
12	CAR	Side_A	14.0	10.0	24.0	1 → 6	Round trip
13	MINIBUS	Side_A	27.0	21.0	30.0	3 → 10	Round trip
14	MINIBUS	Side_A	39.0	17.0	22.0	5 → 10	Round trip
15	MINIBUS	Side_A	14.0	17.0	30.0	1 → 8	Round trip
16	MINIBUS	Side_A	27.0	10.0	12.0	3 → 6	Round trip
17	MINIBUS	Side_A	27.0	8.0	14.0	3 → 6	Round trip
18	MINIBUS	Side_A	27.0	7.0	15.0	3 → 6	Round trip
19	MINIBUS	Side_A	27.0	10.0	12.0	3 → 6	Round trip
20	MINIBUS	Side_A	39.0	17.0	22.0	5 → 10	Round trip
21	MINIBUS	Side_A	14.0	21.0	13.0	1 → 6	Round trip
22	MINIBUS	Side_A	14.0	9.0	10.0	1 → 4	Round trip
23	TRUCK	Side_A	39.0	9.0	14.0	5 → 8	Round trip
24	TRUCK	Side_A	39.0	18.0	21.0	5 → 10	Round trip
25	TRUCK	Side_A	14.0	23.0	11.0	1 → 6	Round trip
26	TRUCK	Side_A	27.0	18.0	17.0	3 → 8	Round trip
27	TRUCK	Side_A	27.0	7.0	28.0	3 → 8	Round trip
28	TRUCK	Side_A	14.0	14.0	20.0	1 → 6	Round trip
29	TRUCK	Side_A	39.0	11.0	28.0	5 → 10	Round trip
30	TRUCK	Side_A	27.0	7.0	28.0	3 → 8	Round trip

```
Average Transport Times:
  All vehicles (outbound): 24.57 seconds
  All vehicles (return): 13.30 seconds
  All vehicles (round trip): 63.57 seconds
  Cars (outbound): 21.33 seconds
  Minibuses (outbound): 25.50 seconds
  Trucks (outbound): 28.25 seconds

Vehicles per Trip: 3.00 vehicles/trip
Completed Round Trips: 30 / 30 (100.0%)
```