Laboratory assignment

Component 4

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Problem definition and MAS specification for SP2 (doc)

1 Problem Definition

This project addresses the challenge of distributed traffic management through a multi-agent system where each vehicle is represented by an autonomous agent. In urban environments with increasing traffic density, centralized traffic management systems often struggle to adapt to rapidly changing conditions. Our solution implements a distributed pathfinding approach where vehicle agents communicate directly with each other to share information about obstacles, traffic conditions, and route availability.

Agents exchange real-time data about road blockages, congestion levels, and unexpected events, allowing each agent to dynamically adjust its pathfinding algorithm based on collective intelligence. This distributed approach enables more responsive traffic flow optimization compared to traditional centralized systems, as decision-making occurs locally but with globally shared information.

2 High-Level MAS Specification

2.1 System Architecture

The multi-agent system utilizes a decentralized architecture with peer-to-peer communication between vehicle agents. The system operates within a simulated urban road network with configurable road segments, intersections, and potential obstacles. Each vehicle agent maintains a local knowledge base that is continuously updated through communication with nearby agents.

2.2 Core Capabilities

The system implements four key capabilities:

1. Distributed obstacle detection and reporting
2. Dynamic path recalculation based on shared information
3. Traffic flow optimization through collaborative routing
4. Emergent traffic pattern formation without centralized control

3 Inputs and Outputs

3.1 System Inputs

Input	Description
Road Network	Graph representation of the road system with nodes (intersections) and edges (road segments)
Traffic Conditions	Initial traffic density and flow rates for road segments
Vehicle Parameters	Starting locations, destinations, and movement capabilities
Obstacle Events	Scheduled or random events that block roads or reduce capacity

3.2 System Outputs

Output	Description
Route Solutions	Paths selected by each vehicle agent
System Performance	Overall metrics including average travel time, congestion levels, and system throughput
Information Spread	Analysis of how quickly obstacle information propagates through the system
Emergent Patterns	Identification of cooperative behaviors that emerge without explicit programming

4 Types of Agents

4.1 Vehicle Agents

The primary agent type representing individual vehicles navigating through the network. Each vehicle agent has unique origin-destination pairs and can communicate with nearby agents.

4.2 Monitor Agents

Observer agents that track system-wide metrics without directly participating in pathfinding. These agents collect data for performance evaluation.

4.3 Infrastructure Agents

Optional extension representing fixed infrastructure elements like traffic lights or road sensors that can communicate with vehicle agents.

5 Agent Specifications

5.1 Vehicle Agent

Inputs: Current location, destination, local map, messages from other agents
Internal State: Known obstacles, traffic conditions, planned route
Outputs: Movement decisions, information broadcasts
Task: Navigate to destination efficiently while sharing and utilizing collective information

5.2 Monitor Agent

Inputs: System state observations, performance metrics
Internal State: Historical performance data, statistical models
Outputs: System analysis reports
Task: Evaluate overall system efficiency and information propagation patterns

5.3 Infrastructure Agent

Inputs: Local traffic observations
Internal State: Local traffic history, scheduled operations
Outputs: Status broadcasts to nearby vehicle agents
Task: Provide fixed reference points for information dissemination

6 Agent Communications

6.1 Communication Model

The system implements a hybrid communication model combining:

1. Direct message passing between agents
2. Selective information forwarding for important updates
3. Information persistence with time decay for reliability

6.2 Message Types

Message Type	Content	Purpose
Obstacle Alert	Location, type, severity, timestamp	Inform about road blockages
Traffic Update	Road segment, congestion level, velocity	Share traffic conditions
Route Intention	Planned path segments, estimated arrival	Coordinate future movements
Request Info	Location area, information type	Query for specific information

6.3 Communication Protocol

Agents communicate asynchronously with no guaranteed delivery. Information reliability is established through:

1. Timestamping all shared information
2. Confidence ratings based on information source and age
3. Prioritization of high-impact information (major obstacles)
4. Confirmation mechanisms for critical updates

Messages between agents have limited propagation distance to prevent network congestion while ensuring relevant information reaches affected vehicles.