GlovoJS: A BDI-based Solution for Autonomous Parcel Delivery

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Outline

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2. System Architecture
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4. Performance Optimization
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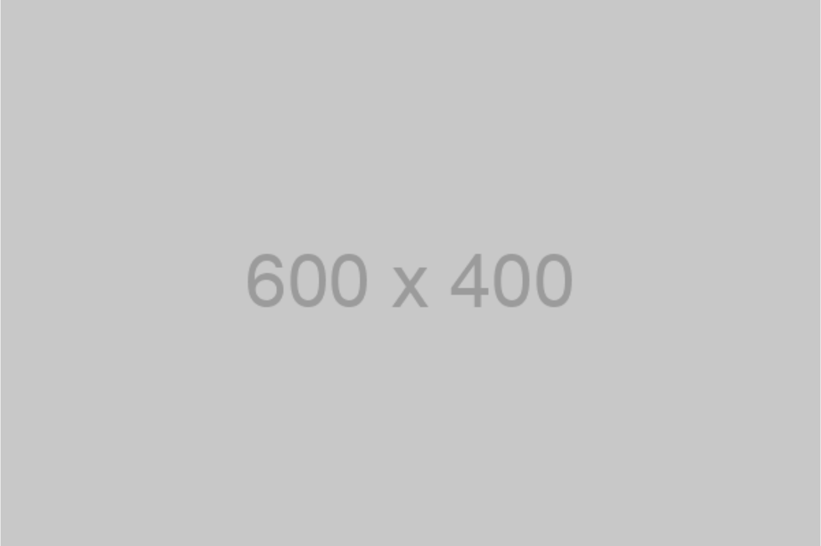
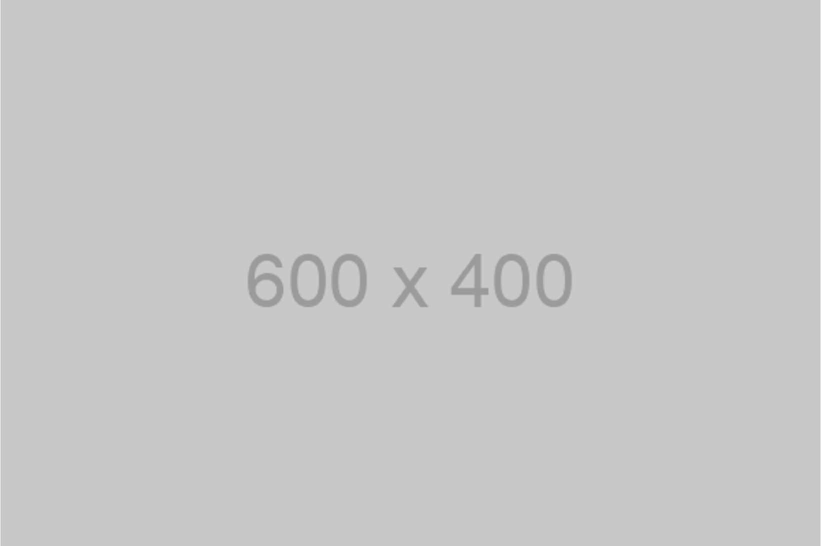
Introduction to Deliveroo.js

- 2D grid-based parcel delivery game
- Agents compete to achieve highest score
- Key features:
    - Dynamic parcel spawning
    - Decaying parcel values
    - Multiple agents
    - Delivery zones



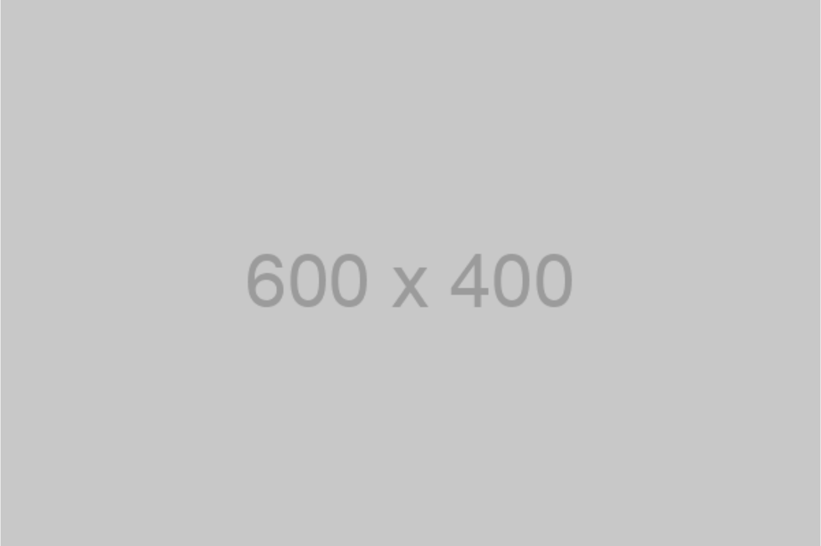
System Architecture

- Modular design for scalability and maintainability
- Key components:
  - Agent
  - Rider
  - Brain (Genetic Algorithm)
  - Field
  - Dashboard



BDI Architecture

- Beliefs: Agent's knowledge of the environment
- Desires: Goals (maximize score)
- Intentions: Generated plans



PDDL Integration

- Core component for pathfinding and planning
- Dynamic generation of PDDL domain and problem descriptions
- Parallel solving for multiple pathfinding problems
- Alternative to traditional pathfinding algorithms

Algorithms: Path Planning

- Breadth-First Search (BFS)
  - Optimal for unweighted graphs
  - Simple implementation
  - Memory efficient
  - Adaptable to dynamic obstacles

Algorithms: Decision Making

- Genetic Algorithm for plan optimization
- Key features:
  - Graph representation of environment
  - Multi-crossover operation
  - Adaptive planning
  - Scalability
  - Long-term optimization

Genetic Algorithm: Key Steps

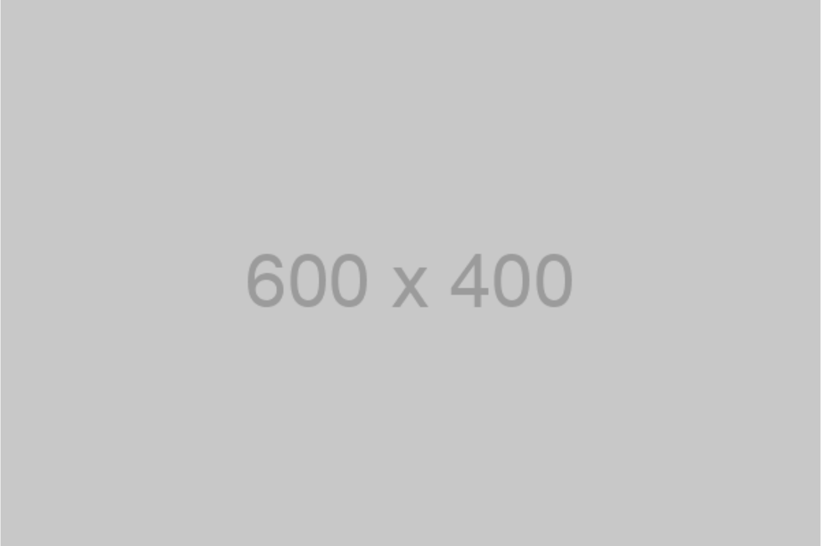
1. Initialize population
2. Evaluate fitness
3. Select parents
4. Perform crossover and mutation
5. Create new generation
6. Repeat until termination condition

Multi-Agent Coordination

- Centralized approach using external "Brain"
- Global state consideration for optimal planning
- Efficient use of PDDL solver
- Linear complexity increase with number of agents
- Constraint: No two plans can contain the same parcel

Performance Optimization: Parallelization

- Bundling multiple pathfinding requests
- Challenges:
    - One unreachable goal invalidates entire problem
    - Exponential complexity growth with goals
- Solution: Chunking large problems



Performance Optimization: Caching

- Storing precomputed paths
- Cache key: concatenation of locations and blocked tiles
- Bidirectional path storage
- Significant performance improvement, especially with PDDL
- "Boost" mode for precomputing paths

Evaluation and Results

- Performance metrics:
  - Dashboard for real-time visualization
  - Analytics for resource usage
  - Enhanced logs for debugging
- Benchmarking scenarios:
  - Single-agent
  - Multi-agent

Benchmarking Results

- Single-agent scenario:
  - BFS agent outperformed PDDL agents
  - BOOSTPDDL showed improvements over ALLPDDL
- Multi-agent scenario:
  - BFS agent still performed best
  - PDDL agents struggled in larger, sparser maps

Challenges and Solutions

1. Local Planner Overhead
    - Solution: Bundling multiple planning queries
2. PDDL Goal Specification Limitations
    - Solution: Fallback mechanism for unachievable goals
3. Large Response Payload Processing
    - Partial offset of gains from reduced call frequency
4. Performance Limitations of Local Solver
    - Remained a bottleneck for real-time decision-making

Future Improvements

1. Solver efficiency
    - Reduce overhead in PDDL solver calls
2. Robust e2e communication protocols
    - Implement end-to-end encryption for agent communication
3. Game-specific strategies
    - Develop advanced tactics for multi-agent coordination

Conclusions

- Successful combination of genetic algorithms, BDI architecture, and PDDL
- Effective multi-agent coordination and path planning
- Areas for improvement:
    - Computational efficiency in dynamic environments
    - Advanced planning strategies
    - Integration of PDDL-based problem solving

Thank You!

Questions?