Maze Router

Peter Aziz - 900212368
Farida Bey - 900212071
Farida Elgharbawy - 900221087
Nour Tamer - 900213112

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Overview

This project implements a maze router using Lee's algorithm that supports multi-pin routing over two layers. The router finds paths between pins while avoiding obstacles, taking into account "wrong direction" moves and via (layer switch) costs.

Design & Implementation

Input Specification

- Input file defines:
  - Grid size (e.g., 10x10)
  - Obstacles (OBS(x, y))
  - Nets with pins: net1 (layer, x, y), (layer, x, y) ...
- Validated format and bounds before processing

Output Specification

- Routed net paths saved to output filen net1 (layer, x, y), (layer, x, y) ...
- Optional routing visualization as image (routing_visualization.png)

Design Specifications

- 2-Layer Grid
  - Represented as two separate 2D arrays: Layer 1 and Layer 2
- Allows for vertical (via) routing
- Pin Reordering
  - Pins within each net are reordered: source is chosen closest to grid edge
- Net Reordering
  - Nets are ordered by total Manhattan distance from smallest to largest
- Cost Modeling
  - Wrong-direction cost: penalty for moving in undesired direction (Layer 1 prefers horizontal; Layer 2 prefers vertical)
  - Via cost: penalty for switching layers

Examples & Tests

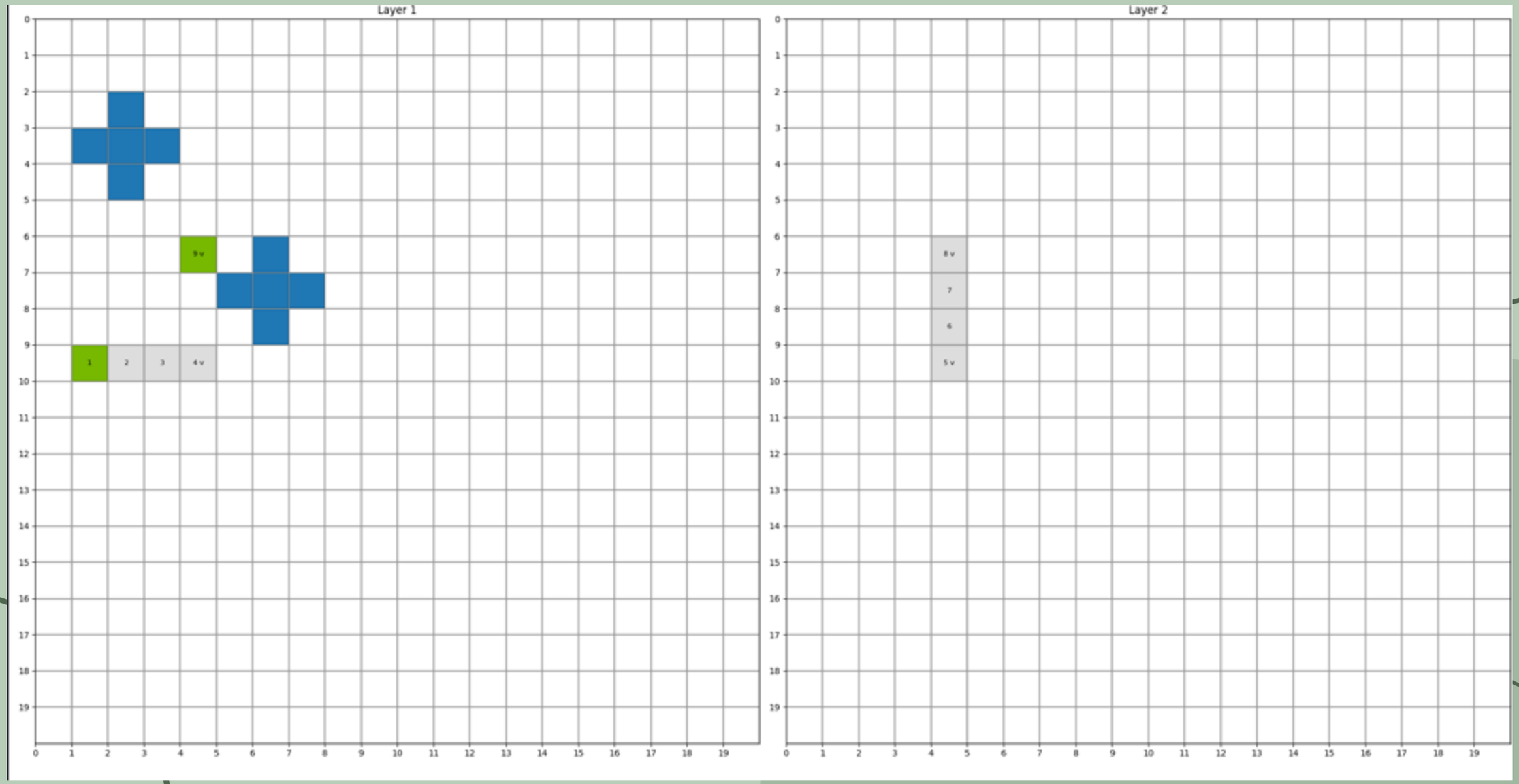
Input

```
5x5
OBS (1, 1)
OBS (1, 2)
OBS (1, 3)
OBS (2, 1)
OBS (2, 3)
OBS (3, 1)
OBS (3, 2)
OBS (3, 3)
net1 (1, 0, 0) (1, 4, 4)
```

Output

```
net1 (1, 1, 9) (1, 2, 9) (1, 3, 9) (1, 4, 9) (2, 4, 9) (2, 4, 8) (2, 4, 7) (2, 4, 6) (1, 4, 6)
```

Visualization



Examples & Tests

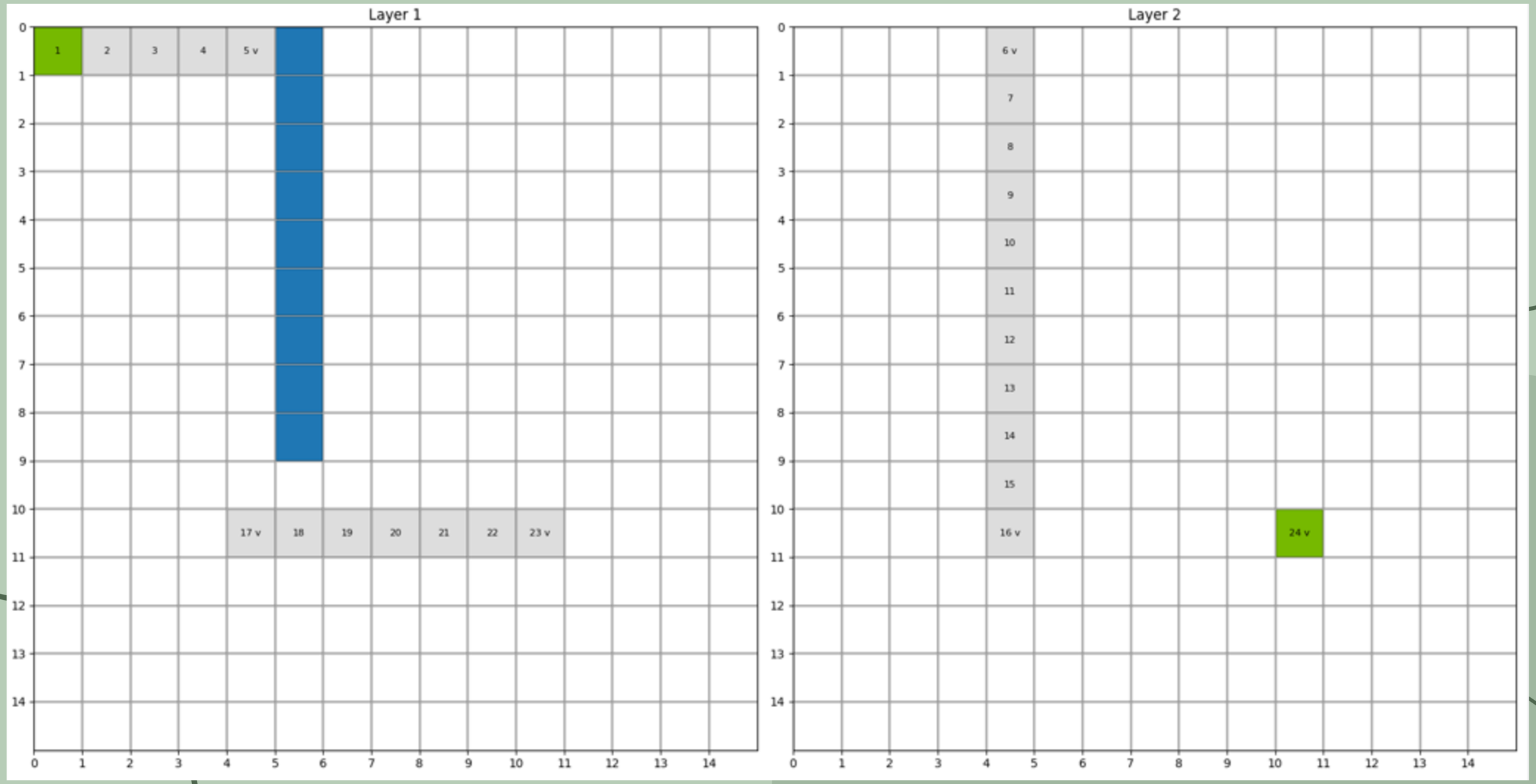
Input

```
5x5
OBS (1, 1)
OBS (1, 2)
OBS (1, 3)
OBS (2, 1)
OBS (2, 3)
OBS (3, 1)
OBS (3, 2)
OBS (3, 3)
net1 (1, 0, 0) (1, 4, 4)
```

Output

```
net1 (1, 0, 0) (1, 1, 0) (1, 2, 0) (1, 3, 0) (1, 4, 0) (2, 4, 0) (2, 4, 1) (2, 4, 2) (2, 4, 3)
(2, 4, 4) (2, 4, 5) (2, 4, 6) (2, 4, 7) (2, 4, 8) (2, 4, 9) (2, 4, 10) (1, 4, 10) (1, 5, 10) (1, 6, 10)
(1, 7, 10) (1, 8, 10) (1, 9, 10) (1, 10, 10) (2, 10, 10)
```

Visualization



Examples & Tests

Input

```
20x20
OBS (2, 1)
OBS (2, 2)
OBS (2, 3)
OBS (2, 4)
OBS (2, 5)
OBS (2, 6)
OBS (2, 7)
OBS (2, 8)
OBS (2, 9)
OBS (3, 1)
OBS (4, 1)
OBS (5, 1)
OBS (6, 2)
OBS (6, 3)
OBS (6, 4)
OBS (6, 5)
OBS (6, 6)
OBS (6, 7)
```

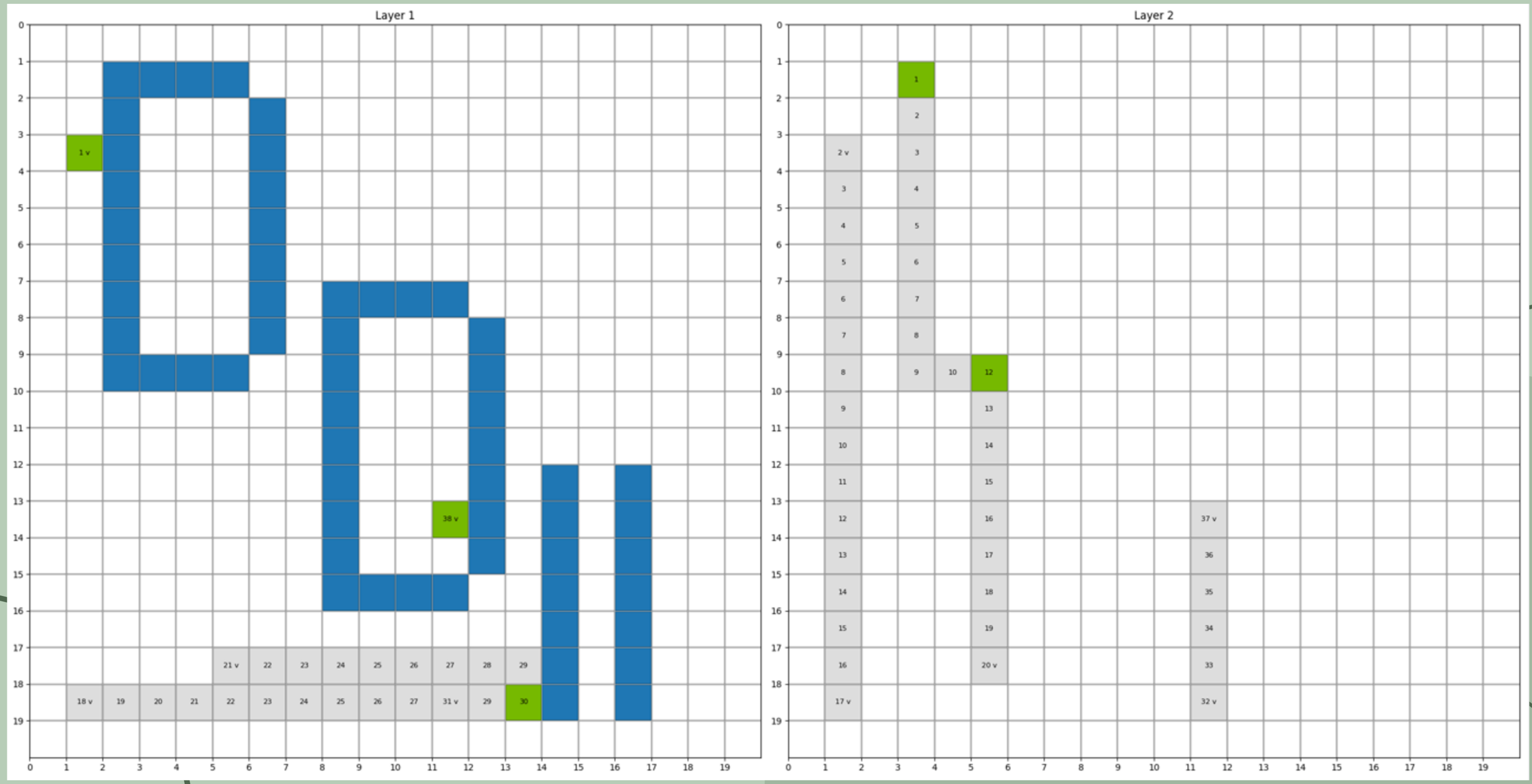
```
OBS (6, 8)
OBS (5, 9)
OBS (4, 9)
OBS (3, 9)
OBS (8, 7)
OBS (8, 8)
OBS (8, 9)
OBS (8, 10)
OBS (8, 11)
OBS (8, 12)
OBS (8, 13)
OBS (8, 14)
OBS (8, 15)
OBS (9, 7)
OBS (10, 7)
OBS (11, 7)
OBS (12, 8)
OBS (12, 9)
OBS (12, 10)
```

```
OBS (12, 11)
OBS (12, 12)
OBS (12, 13)
OBS (12, 14)
OBS (11, 15)
OBS (10, 15)
OBS (9, 15)
OBS (11, 15)
OBS (14, 12)
OBS (14, 13)
OBS (14, 14)
OBS (14, 15)
OBS (14, 16)
OBS (14, 17)
OBS (14, 18)
OBS (16, 12)
OBS (16, 13)
OBS (16, 14)
OBS (16, 15)
OBS (16, 16)
OBS (16, 17)
OBS (16, 18)
net1 (1,1,3) (1,11,13) (1,13,18)
net2 (2,3,1) (2,5,9) (1,13,18)
```

Output

```
net1 (1, 1, 3) (2, 1, 3) (2, 1, 4) (2, 1, 5) (2, 1, 6) (2, 1, 7) (2, 1, 8) (2, 1, 9) (2, 1, 10)
(2, 1, 11) (2, 1, 12) (2, 1, 13) (2, 1, 14) (2, 1, 15) (2, 1, 16) (2, 1, 17) (2, 1, 18) (1, 1, 18)
(1, 2, 18) (1, 3, 18) (1, 4, 18) (1, 5, 18) (1, 6, 18) (1, 7, 18) (1, 8, 18) (1, 9, 18) (1, 10, 18)
(1, 11, 18) (1, 12, 18) (1, 13, 18) (1, 11, 18) (2, 11, 18) (2, 11, 17) (2, 11, 16) (2, 11, 15)
(2, 11, 14) (2, 11, 13) (1, 11, 13)
net2 (2, 3, 1) (2, 3, 2) (2, 3, 3) (2, 3, 4) (2, 3, 5) (2, 3, 6) (2, 3, 7) (2, 3, 8) (2, 3, 9)
(2, 4, 9) (2, 5, 9) (2, 5, 9) (2, 5, 10) (2, 5, 11) (2, 5, 12) (2, 5, 13) (2, 5, 14) (2, 5, 15)
(2, 5, 16) (2, 5, 17) (1, 5, 17) (1, 6, 17) (1, 7, 17) (1, 8, 17) (1, 9, 17) (1, 10, 17) (1, 11, 17)
(1, 12, 17) (1, 13, 17) (1, 13, 18)
```

Visualization



Limitations

Layer Limitation:

- The router supports only two layers. Expanding to more layers would require modifications to grid initialization and routing logic.

Scalability:

- Large grid sizes may lead to increased computation time due to the exhaustive nature of the search.

Basic Visualization:

- The routing visualization is simple and may not capture complex routing details or overlaps.

Obstacles Initialization:

- Obstacles are automatically placed on Layer 1 only
- Cannot assign obstacles to Layer 2

Conclusions

- The project successfully implements a 2-layer Maze Router using Lee’s algorithm
- Supports via insertion and penalization for vias and wrong-way routing
- The router handles multiple nets, basic conflict resolution, and produces visually interpretable results
- Demonstrates key principles of grid-based routing, layer management, and minimal cost pathfinding
- Limitations such as layer constraints, scalability issues, and basic visualization highlight potential areas for future improvement

Thank you!