Test Cases:

Test Case 1:

- **Input:**

  10, 10, 5, 10
  OBS(0, 4, 4)
  net1 (0, 2, 2) (0, 8, 8)
  net2 (0, 1, 1) (0, 3, 3) (0, 6, 6)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
       Pin 1: Layer=0, X=2, Y=2
       Pin 2: Layer=0, X=8, Y=8
--------------------------------------------------
2     net2
       Pin 1: Layer=0, X=1, Y=1
       Pin 2: Layer=0, X=3, Y=3
       Pin 3: Layer=0, X=6, Y=6
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
  Path 1: [(0, 2, 2), (0, 3, 2), (0, 4, 2), (0, 5, 2), (0, 6, 2), (0, 7, 2), (0, 8,
2), (1, 8, 2), (1, 8, 3), (1, 8, 4), (1, 8, 5), (1, 8, 6), (1, 8, 7), (1, 8, 8), (0,
8, 8)]
  Length for Path 1: 15
  Cost for Path 1: 34
  ******
 Total Wire Length for 'net1': 15
 Total Cost for 'net1': 34
--------------------------------------------------
Net 'net2':
--------------------------------------------------
  Path 1: [(0, 1, 1), (0, 1, 2), (0, 1, 3), (0, 2, 3), (0, 3, 3)]
  Length for Path 1: 5
  Cost for Path 1: 14
  ******
  Path 2: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 6, 4), (0, 6, 5), (0, 6,
6)]
  Length for Path 2: 7
  Cost for Path 2: 21
  ******
```

Total Wire Length for 'net2': 12
 Total Cost for 'net2': 35

Summary
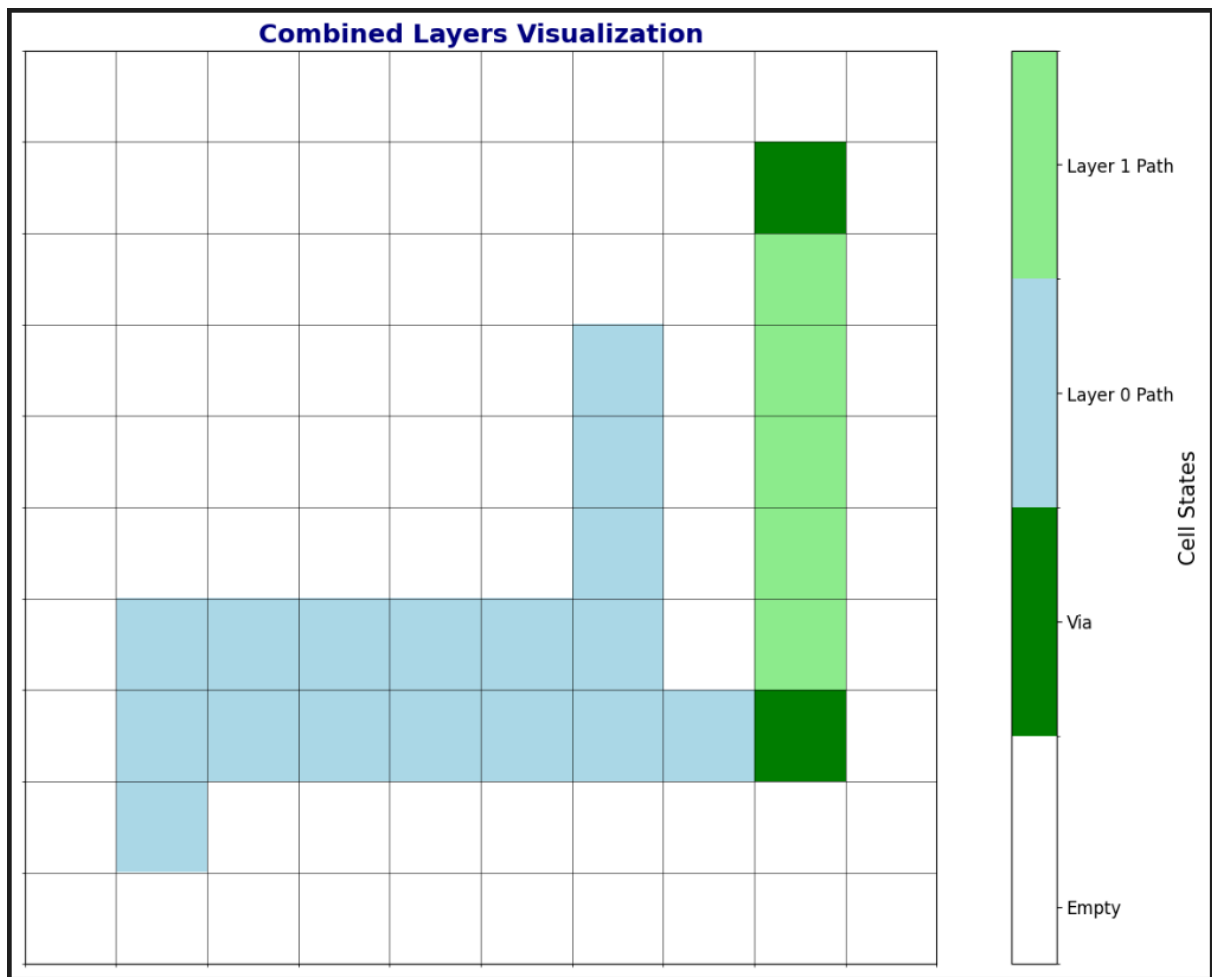===
Longest Route Length: 15
Net with Longest Route: 'net1'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 27
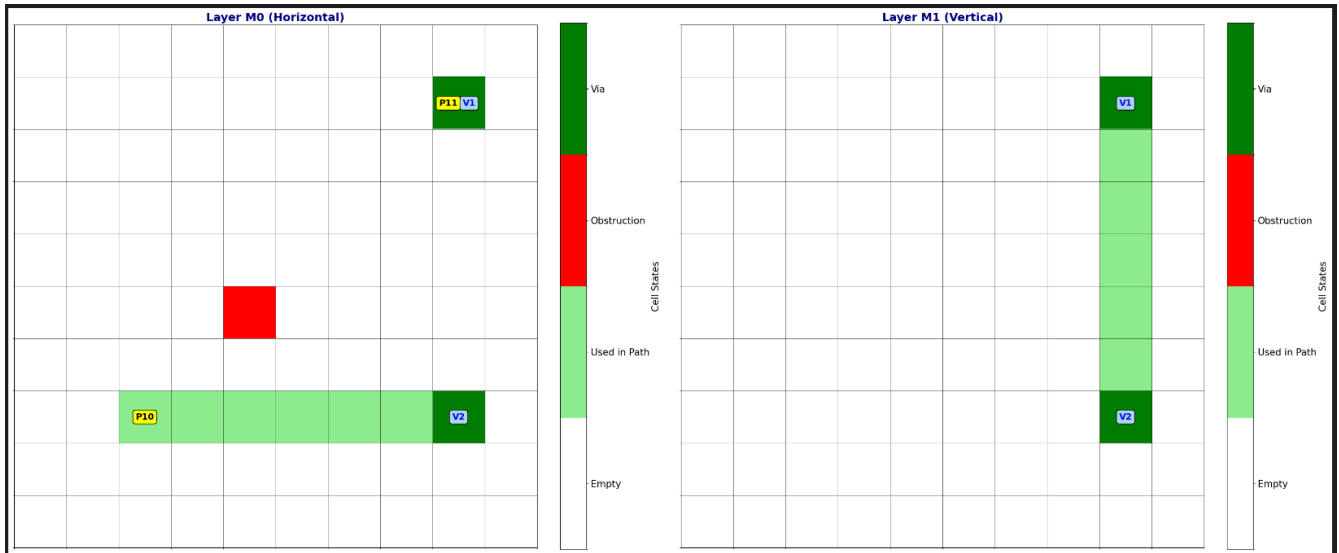Total cost of the routing is: 69
===

Combined Layers Visualization
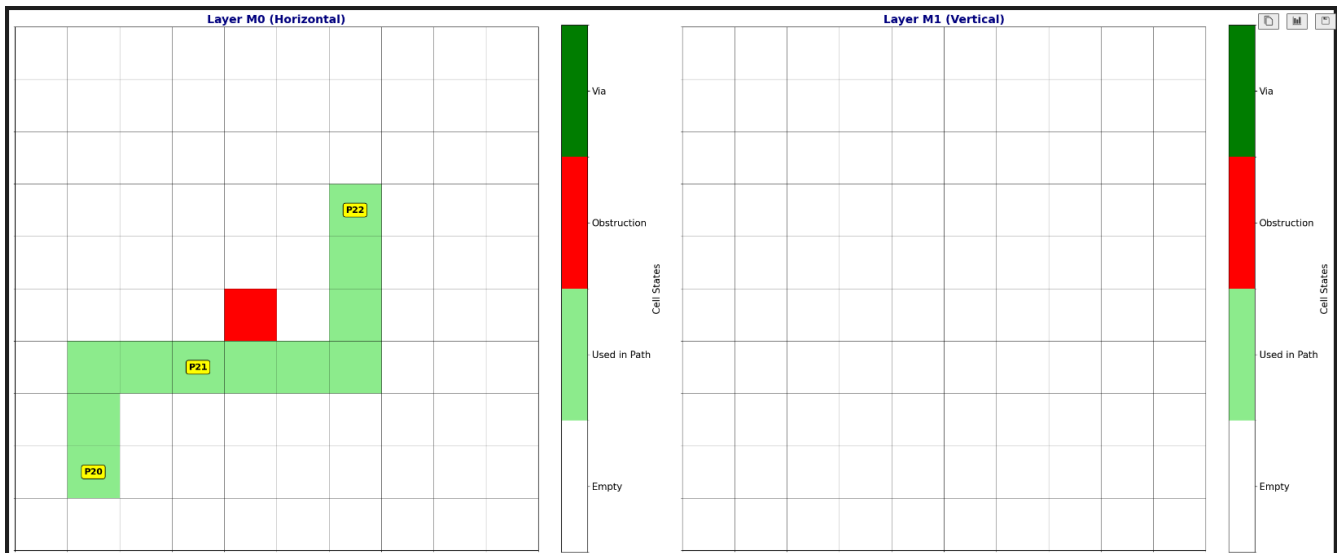
Figure 1: net1

Figure 2: net2

- **Tracing:**

  ⇒ **Net:** `net1`

  ▸ **Path 0** begins at (`0, 2, 2`) in Layer M0 and travels horizontally along the x-axis (columns) while maintaining the same row (`z = 2`) up to (`0, 8, 2`). It then uses a via to transition from Layer M0 to Layer M1 at (`0, 8, 2`). From (`1, 8, 2`), the path continues vertically along the z-axis (rows) through (`1, 8, 3`) to (`1, 8, 8`). Finally, it transitions back to Layer M0 via another via at (`1, 8, 8`) and terminates at (`0, 8, 8`).

  ⇒ **Net:** `net2`

  ▸ **Path 0** begins at (`0, 1, 1`) in Layer M0 and traverses vertically through the z-axis (rows), moving from (`0, 1, 1`) to (`0, 3, 3`). It follows a clear vertical path in Layer M0, avoiding obstruction.

  ▸ **Path 1** starts at (`0, 3, 3`) in Layer M0 and moves horizontally along the x-axis (columns) while staying on row z = 3. At (`0, 6, 3`), it begins to traverse vertically through rows z = 4 to z = 6. The path terminates at (`0, 6, 6`) after completing a clear vertical traversal in Layer M0.
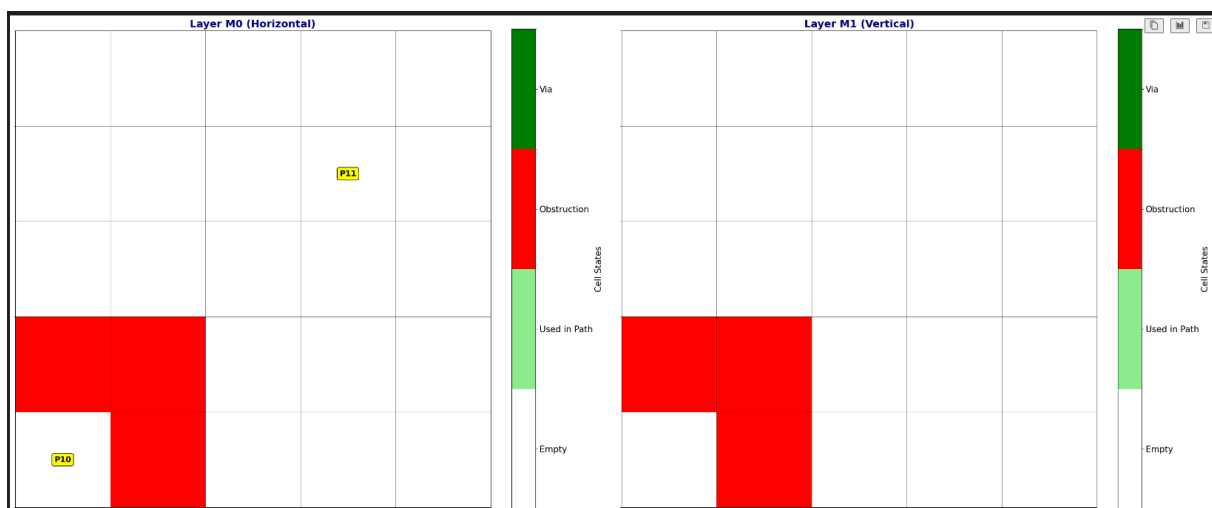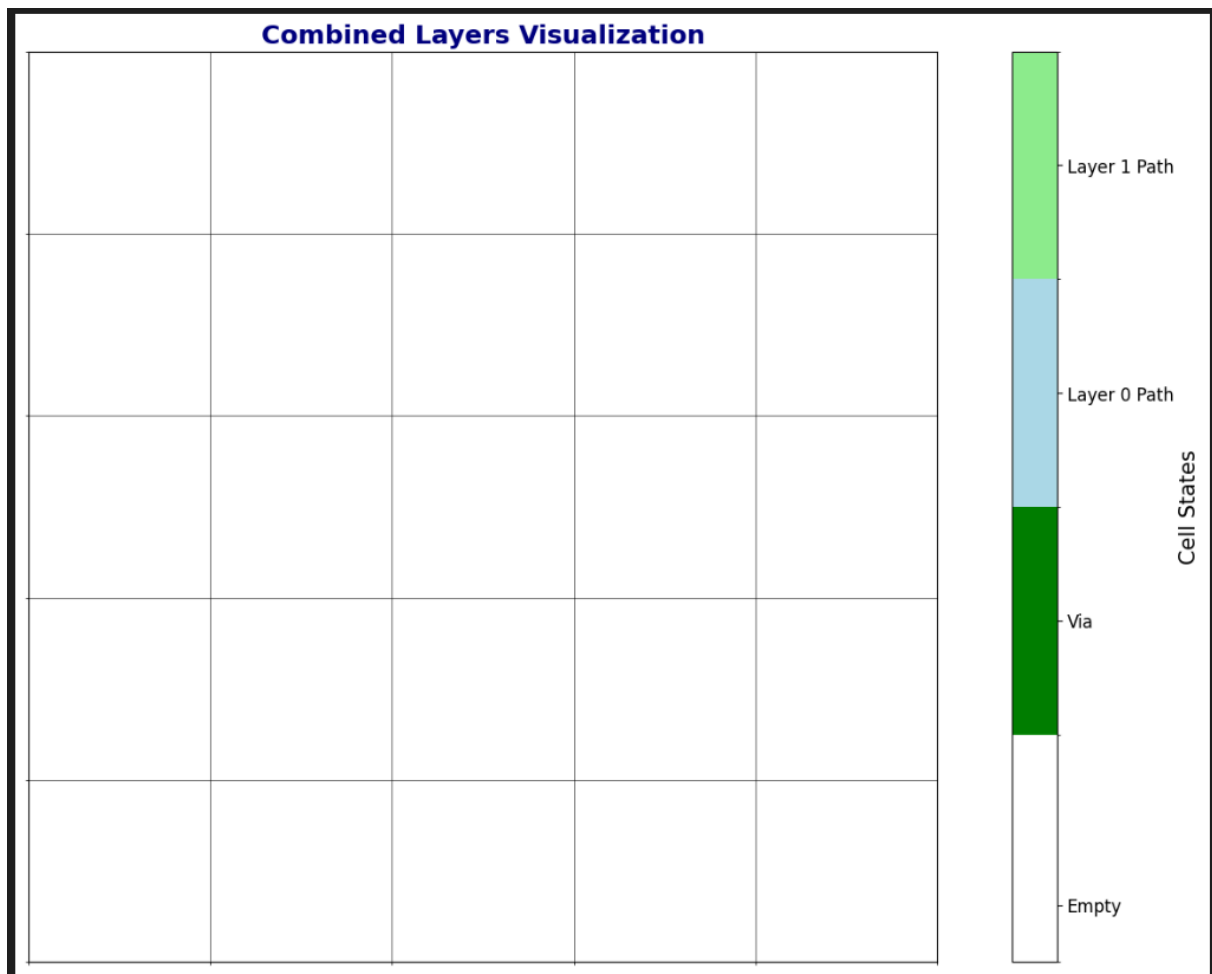
Test Case 2:

- **Input:**

  5, 5, 10, 10
  OBS (0, 1, 1)
  OBS (0, 0, 1)
  OBS (0, 1, 0)
  OBS (1, 1, 1)
  OBS (1, 0, 1)
  OBS (1, 1, 0)
  net1 (0, 0, 0) (0, 3, 3)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
       Pin 1: Layer=0, X=0, Y=0
       Pin 2: Layer=0, X=3, Y=3
--------------------------------------------------
==================================================
Error: Unable to find a path for net 'net1'.
==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
 Total Wire Length for 'net1': 0
 Total Cost for 'net1': 0
--------------------------------------------------

Summary
==================================================
Longest Route Length: 0
Net with Longest Route: ''
Path Number of Longest Route: 0
Total Wire Length Across All Nets: 0
Total cost of the routing is: 0
==================================================
```

Combined Layers Visualization

Layer M0 (Horizontal) Layer M1 (Vertical)

- **Tracing:**

  ⇒ **Net:** net1

  There are no paths available to reach the target because it's surrounded by obstacles.

Test Case 3:

- **Input:**

  5, 5, 10, 5
  OBS (0, 1, 1)
  OBS (0, 0, 1)
  OBS (0, 1, 0)
  OBS (1, 1, 1)
  OBS (1, 0, 1)
  OBS (1, 1, 0)
  net1 (0, 0, 0) (0, 3, 3)
  net2 (0, 2, 0) (0, 4, 2) (1, 0, 4)

- **Output:**

```
=================================================
Ordered Nets with Pin Details
=================================================
Order Net Name  Pin Details (Layer, X, Y)
-------------------------------------------------
1     net2
       Pin 1: Layer=0, X=2, Y=0
       Pin 2: Layer=0, X=4, Y=2
       Pin 3: Layer=1, X=0, Y=4
-------------------------------------------------
2     net1
       Pin 1: Layer=0, X=0, Y=0
       Pin 2: Layer=0, X=3, Y=3
-------------------------------------------------
=================================================
Error: Unable to find a path for net 'net1'.
=================================================
Routed Nets Summary
=================================================
Net 'net2':
-------------------------------------------------
  Path 1: [(0, 2, 0), (0, 3, 0), (0, 4, 0), (1, 4, 0), (1, 4, 1), (1, 4, 2), (0, 4,
2)]
  Length for Path 1: 7
  Cost for Path 1: 16
  ******
  Path 2: [(0, 2, 0), (1, 2, 0), (1, 2, 1), (1, 2, 2), (1, 2, 3), (1, 2, 4), (1, 1,
4), (1, 0, 4)]
  Length for Path 2: 8
  Cost for Path 2: 32
  ******
 Total Wire Length for 'net2': 15
 Total Cost for 'net2': 48
-------------------------------------------------
Net 'net1':
-------------------------------------------------
 Total Wire Length for 'net1': 0
 Total Cost for 'net1': 0
```

Summary
==
Longest Route Length: 8
Net with Longest Route: 'net2'
Path Number of Longest Route: 2
Total Wire Length Across All Nets: 15
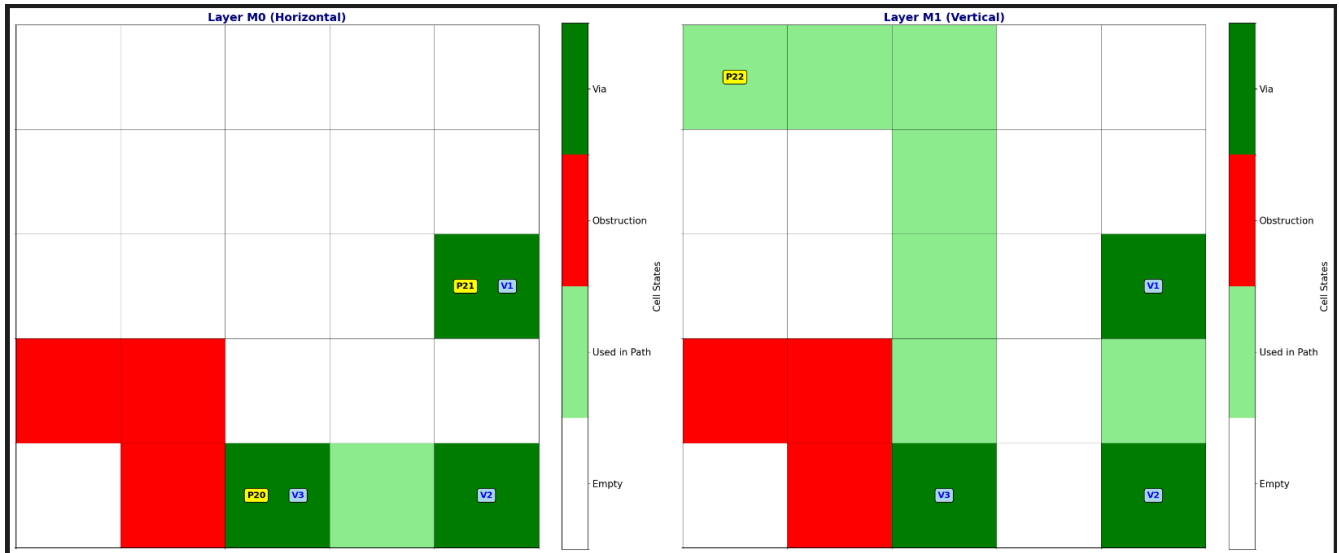Total cost of the routing is: 48
==

Combined Layers Visualization

Cell States

- Layer 1 Path
- Layer 0 Path
- Via
- Empty
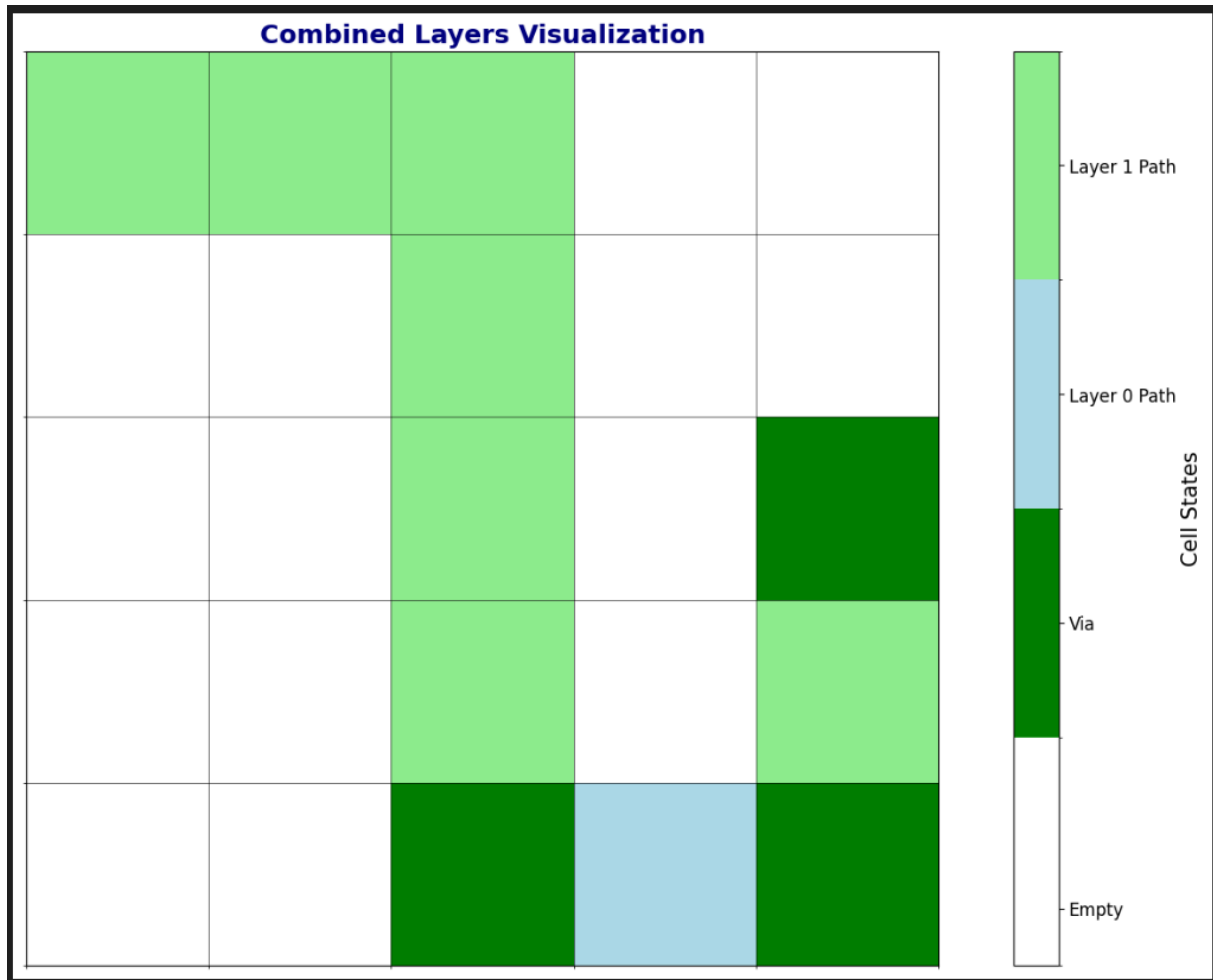
Figure 3: net2

- **Tracing:**

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (0, 2, 0) in Layer M0 and moves horizontally along the x-axis (columns) while maintaining the same row (z = 0) up to (0, 4, 0). At (0, 4, 0), it uses a via to transition to Layer M1. From (1, 4, 0), the path continues vertically along the y-axis (rows), moving through (1, 4, 1) to (1, 4, 2). It then transitions back to Layer M0 via another via at (1, 4, 2) and terminates at (0, 4, 2).

  ‣ **Path 2** starts at (0, 2, 0) in Layer M0 and transitions to Layer M1 via a via at (0, 2, 0). From (1, 2, 0), the path moves vertically along the y-axis (rows), traveling through (1, 2, 1) to (1, 2, 4). At (1, 2, 4), the path changes direction and moves horizontally along the x-axis (columns) to (1, 0, 4), where it terminates.

  ⇒ **Net:** net1

  ‣ No valid path was found for net1. The net could not be routed due to obstructions or other constraints.

Test Case 4:

- **Input:**

  5, 5, 5, 20
  OBS (0, 3, 0)
  OBS (0, 3, 1)
  OBS (0, 3, 2)
  OBS (0, 3, 3)
  OBS (0, 3, 4)
  OBS (1, 0, 3)
  OBS (1, 1, 3)
  OBS (1, 2, 3)
  OBS (1, 3, 3)
  OBS (1, 4, 3)
  net1 (0, 0, 0) (0, 4, 4)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
        Pin 1: Layer=0, X=0, Y=0
        Pin 2: Layer=0, X=4, Y=4
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (1, 2, 0), (1, 3, 0), (1, 4, 0), (1, 4,
1), (1, 4, 2), (0, 4, 2), (0, 4, 3), (0, 4, 4)]
  Length for Path 1: 11
  Cost for Path 1: 70
  ******
 Total Wire Length for 'net1': 11
 Total Cost for 'net1': 70
--------------------------------------------------

Summary
==================================================
Longest Route Length: 11
Net with Longest Route: 'net1'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 11
Total cost of the routing is: 70
==================================================
```
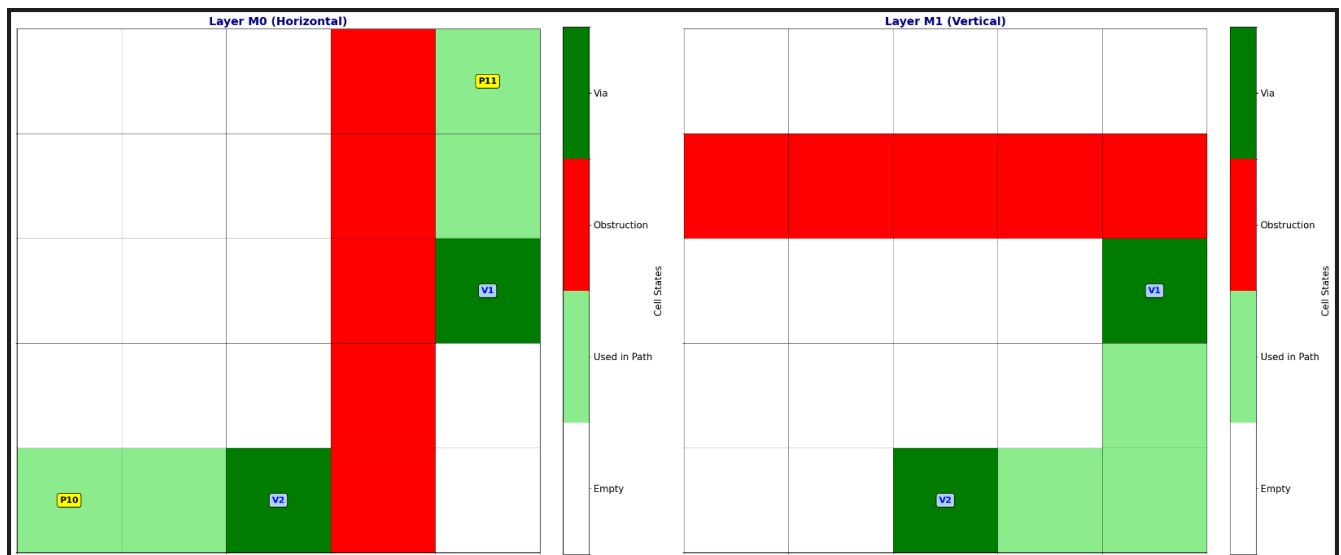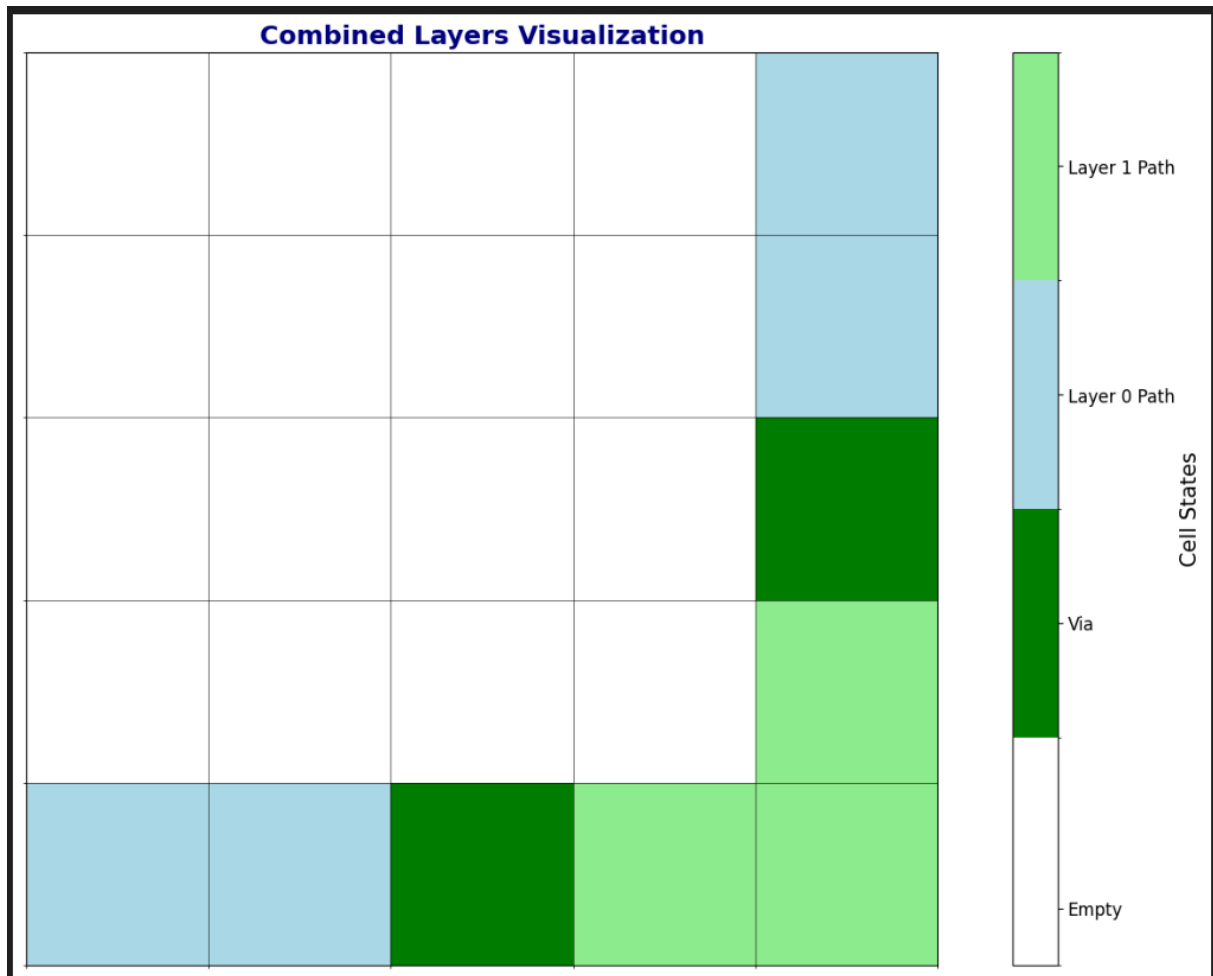
Figure 4: net1

- **Tracing:**

  ⇒ **Net**: `net1`

  ‣ **Path 0** begins at `(0, 0, 0)` in Layer M0 and travels horizontally along the x-axis (columns) while maintaining the same row (z = 0) up to `(0, 2, 0)`. It then uses a via to transition from Layer M0 to Layer M1 at `(0, 2, 0)`. From `(1, 2, 0)`, the path continues horizontally along the

x-axis (columns), moving from `(1, 2, 0)` to `(1, 4, 0)`. At (1, 4, 0), the path changes direction and begins to traverse vertically along the y-axis (rows), moving from `(1, 4, 0)` to `(1, 4, 2)`. It then transitions back to Layer M0 via another via at `(1, 4, 2)`. Finally, the path continues horizontally along the x-axis (columns) in Layer M0, moving from `(0, 4, 2)` to `(0, 4, 4)`, where it terminates.

Test Case 5:

- **Input:**

  11, 11, 5, 2
  OBS (0, 5, 5)
  net1 (0, 1, 1) (0, 3, 3) (0, 7, 7) (1, 9, 9)
  net2 (0, 2, 3) (1, 6, 7) (0, 10, 9)
  net3 (0, 1, 2) (1, 4, 7) (0, 8, 8)

- **Output:**

```
=================================================
Ordered Nets with Pin Details
=================================================
Order Net Name  Pin Details (Layer, X, Y)
-------------------------------------------------
1     net1
        Pin 1: Layer=0, X=1, Y=1
        Pin 2: Layer=0, X=3, Y=3
        Pin 3: Layer=0, X=7, Y=7
        Pin 4: Layer=1, X=9, Y=9
-------------------------------------------------
2     net2
        Pin 1: Layer=0, X=2, Y=3
        Pin 2: Layer=1, X=6, Y=7
        Pin 3: Layer=0, X=10, Y=9
-------------------------------------------------
3     net3
        Pin 1: Layer=0, X=1, Y=2
        Pin 2: Layer=1, X=4, Y=7
        Pin 3: Layer=0, X=8, Y=8
-------------------------------------------------
=================================================
=================================================
Routed Nets Summary
=================================================
Net 'net1':
-------------------------------------------------
  Path 1: [(0, 1, 1), (0, 2, 1), (0, 3, 1), (1, 3, 1), (1, 3, 2), (1, 3, 3), (0, 3,
3)]
  Length for Path 1: 7
  Cost for Path 1: 10
  ******
  Path 2: [(1, 3, 3), (1, 3, 4), (1, 3, 5), (1, 3, 6), (1, 3, 7), (0, 3, 7), (0, 4,
7), (0, 5, 7), (0, 6, 7), (0, 7, 7)]
  Length for Path 2: 10
  Cost for Path 2: 11
  ******
  Path 3: [(0, 7, 7), (0, 8, 7), (0, 9, 7), (1, 9, 7), (1, 9, 8), (1, 9, 9)]
  Length for Path 3: 6
  Cost for Path 3: 7
  ******
 Total Wire Length for 'net1': 23
 Total Cost for 'net1': 28
-------------------------------------------------
```

Net 'net2':

  Path 1: [(0, 2, 3), (0, 2, 4), (0, 3, 4), (0, 4, 4), (0, 5, 4), (0, 6, 4), (1, 6, 4), (1, 6, 5), (1, 6, 6), (1, 6, 7)]
  Length for Path 1: 10
  Cost for Path 1: 16
  ******
  Path 2: [(1, 6, 7), (1, 6, 8), (1, 6, 9), (0, 6, 9), (0, 7, 9), (0, 8, 9), (0, 9, 9), (0, 10, 9)]
  Length for Path 2: 8
  Cost for Path 2: 9
  ******
 Total Wire Length for 'net2': 18
 Total Cost for 'net2': 25

Net 'net3':

  Path 1: [(0, 1, 2), (0, 2, 2), (0, 3, 2), (0, 4, 2), (1, 4, 2), (1, 4, 3), (1, 4, 4), (1, 4, 5), (1, 4, 6), (1, 4, 7)]
  Length for Path 1: 10
  Cost for Path 1: 11
  ******
  Path 2: [(1, 4, 7), (1, 4, 8), (0, 4, 8), (0, 5, 8), (0, 6, 8), (0, 7, 8), (0, 8, 8)]
  Length for Path 2: 7
  Cost for Path 2: 8
  ******
 Total Wire Length for 'net3': 17
 Total Cost for 'net3': 19

Summary
==
Longest Route Length: 10
Net with Longest Route: 'net1'
Path Number of Longest Route: 2
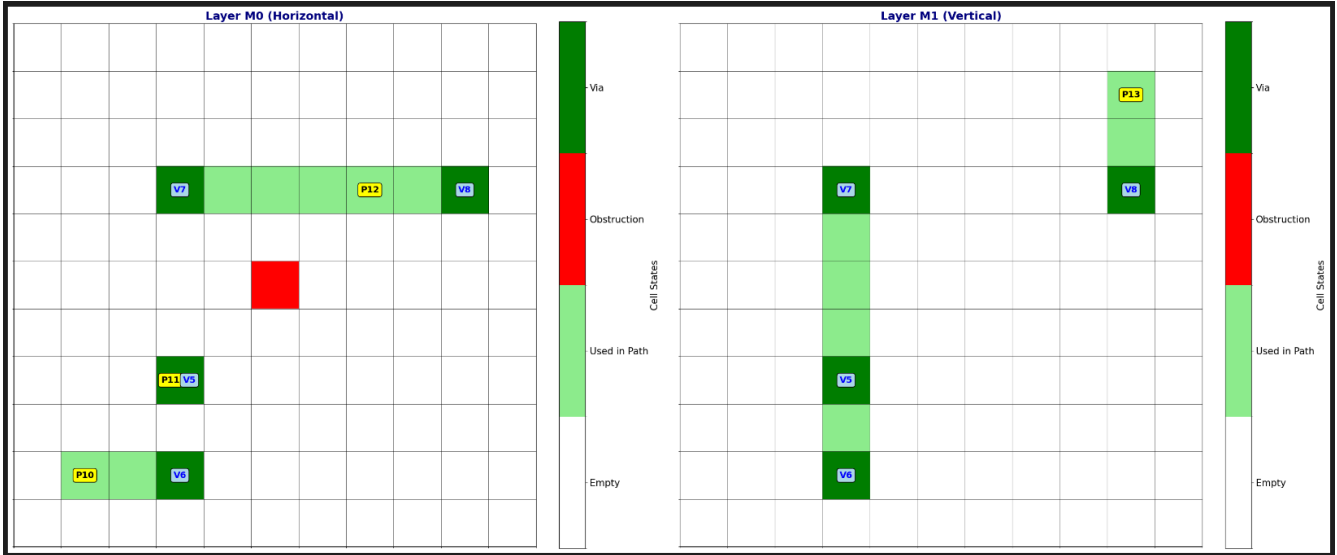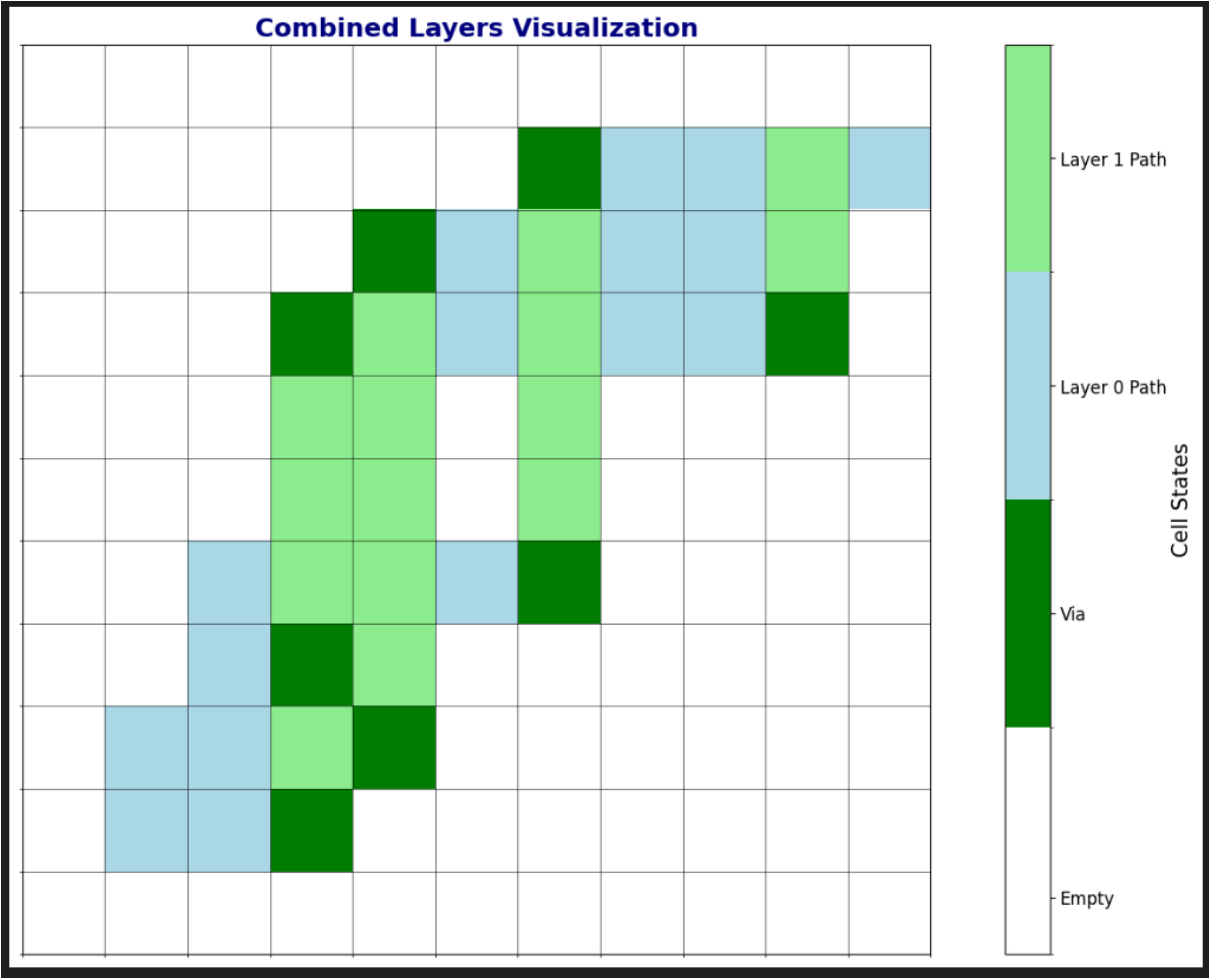Total Wire Length Across All Nets: 58
Total cost of the routing is: 72
==
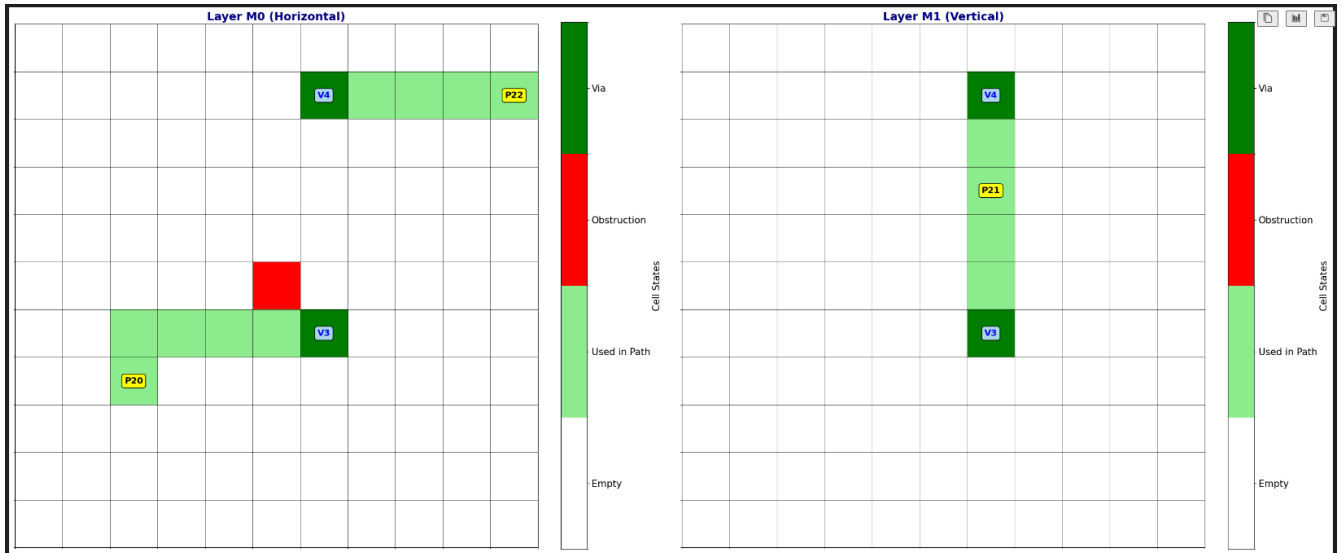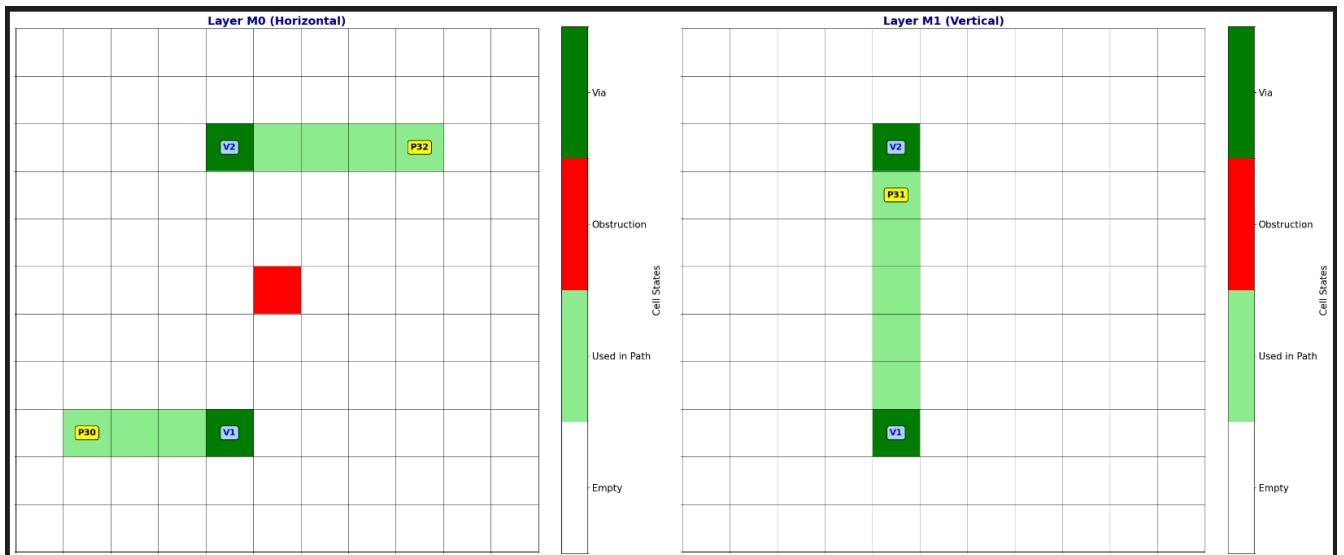
Figure 5: net1

Figure 6: net2

Figure 7: net3

- **Tracing:**

  ⇒ **Net:** net3

  ‣ **Path 0** begins at (0, 1, 2) in Layer M0 and moves horizontally along the x-axis (columns) while maintaining the same row (z = 2) up to (0, 4, 2). At (0, 4, 2), it uses a via to transition from Layer M0 to Layer M1. From (1, 4, 2), the path continues vertically along the y-axis (rows), moving through (1, 4, 3) to (1, 4, 7), where it terminates.

  ‣ **Path 1** starts at (1, 4, 7) in Layer M1 and continues vertically along the y-axis (rows) through (1, 4, 8). It then transitions back to Layer M0 via a via at (1, 4, 8). From (0, 4, 8), the path moves horizontally along the x-axis (columns), traveling through (0, 5, 8) to (0, 8, 8), where it terminates.

  ⇒ **Net:** net2

  ‣ **Path 0** begins at (0, 2, 3) in Layer M0 and moves horizontally along the x-axis (columns) while maintaining the same row (z = 3) up to (0, 6, 4). At (0, 6, 4), it transitions to Layer

M1 via a via and continues vertically along the y-axis (rows) through (1, 6, 5) to (1, 6, 7), where it terminates.

▸ **Path 1** starts at (1, 6, 7) in Layer M1 and continues vertically along the y-axis (rows) through (1, 6, 9). It then transitions back to Layer M0 via a via at (1, 6, 9). From (0, 6, 9), the path moves horizontally along the x-axis (columns) through (0, 7, 9) to (0, 10, 9), where it terminates.

⇒ **Net:** net1

▸ **Path 0** begins at (0, 1, 1) in Layer M0 and travels horizontally along the x-axis (columns), maintaining the same row (z = 1) up to (0, 3, 1). At (0, 3, 1), it uses a via to transition to Layer M1. From (1, 3, 1), the path continues vertically along the y-axis (rows) through (1, 3, 2) to (1, 3, 3). It then transitions back to Layer M0 via another via at (1, 3, 3) and terminates at (0, 3, 3).

▸ **Path 1** starts at (1, 3, 3) in Layer M1 and continues vertically along the y-axis (rows), moving through (1, 3, 4) to (1, 3, 7). At (1, 3, 7), it transitions back to Layer M0 via a via. From (0, 3, 7), the path moves horizontally along the x-axis (columns) through (0, 4, 7) to (0, 7, 7), where it terminates.

▸ **Path 2** begins at (0, 7, 7) in Layer M0 and continues horizontally along the x-axis (columns) through (0, 8, 7) to (0, 9, 7). At (0, 9, 7), it uses a via to transition to Layer M1. From (1, 9, 7), the path moves vertically along the y-axis (rows) through (1, 9, 8) to (1, 9, 9), where it terminates.

Test Case 6: (Without Bonus)

- **Input:**

  15, 15, 10, 5
  OBS (0, 4, 4)
  OBS (0, 5, 5)
  OBS (1, 6, 6)
  OBS (0, 7, 7)
  OBS (1, 10, 10)
  net1 (0, 0, 0) (0, 3, 3) (1, 9, 9)
  net2 (0, 1, 2) (1, 5, 6) (0, 11, 11)
  net3 (0, 2, 1) (0, 4, 5) (1, 8, 8) (0, 13, 13)
  net4 (1, 0, 5) (1, 4, 10) (0, 10, 12)
  net5 (0, 3, 3) (1, 9, 4) (0, 14, 14)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
        Pin 1: Layer=0, X=0, Y=0
        Pin 2: Layer=0, X=3, Y=3
        Pin 3: Layer=1, X=9, Y=9
--------------------------------------------------
2     net2
        Pin 1: Layer=0, X=1, Y=2
        Pin 2: Layer=1, X=5, Y=6
        Pin 3: Layer=0, X=11, Y=11
--------------------------------------------------
3     net3
        Pin 1: Layer=0, X=2, Y=1
        Pin 2: Layer=0, X=4, Y=5
        Pin 3: Layer=1, X=8, Y=8
        Pin 4: Layer=0, X=13, Y=13
--------------------------------------------------
4     net4
        Pin 1: Layer=1, X=0, Y=5
        Pin 2: Layer=1, X=4, Y=10
        Pin 3: Layer=0, X=10, Y=12
--------------------------------------------------
5     net5
        Pin 1: Layer=0, X=3, Y=3
        Pin 2: Layer=1, X=9, Y=4
        Pin 3: Layer=0, X=14, Y=14
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net1':
```

  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (0, 3, 0), (1, 3, 0), (1, 3, 1), (1, 3, 2), (1, 3, 3), (0, 3, 3)]
  Length for Path 1: 9
  Cost for Path 1: 18
  ******
  Path 2: [(1, 3, 3), (1, 3, 4), (1, 3, 5), (1, 3, 6), (1, 3, 7), (1, 3, 8), (1, 3, 9), (0, 3, 9), (0, 4, 9), (0, 5, 9), (0, 6, 9), (0, 7, 9), (0, 8, 9), (0, 9, 9), (1, 9, 9)]
  Length for Path 2: 15
  Cost for Path 2: 24
  ******
 Total Wire Length for 'net1': 24
 Total Cost for 'net1': 42

Net 'net2':

  Path 1: [(0, 1, 2), (0, 2, 2), (0, 3, 2), (0, 4, 2), (0, 5, 2), (1, 5, 2), (1, 5, 3), (1, 5, 4), (1, 5, 5), (1, 5, 6)]
  Length for Path 1: 10
  Cost for Path 1: 14
  ******
  Path 2: [(1, 5, 6), (1, 5, 7), (1, 5, 8), (1, 5, 9), (1, 5, 10), (1, 5, 11), (0, 5, 11), (0, 6, 11), (0, 7, 11), (0, 8, 11), (0, 9, 11), (0, 10, 11), (0, 11, 11)]
  Length for Path 2: 13
  Cost for Path 2: 17
  ******
 Total Wire Length for 'net2': 23
 Total Cost for 'net2': 31

Net 'net3':

  Path 1: [(0, 2, 1), (0, 3, 1), (0, 4, 1), (1, 4, 1), (1, 4, 2), (1, 4, 3), (1, 4, 4), (1, 4, 5), (0, 4, 5)]
  Length for Path 1: 9
  Cost for Path 1: 18
  ******
  Path 2: [(1, 4, 5), (1, 4, 6), (1, 4, 7), (1, 4, 8), (0, 4, 8), (0, 5, 8), (0, 6, 8), (0, 7, 8), (0, 8, 8), (1, 8, 8)]
  Length for Path 2: 10
  Cost for Path 2: 19
  ******
  Path 3: [(1, 8, 8), (1, 8, 9), (1, 8, 10), (1, 8, 11), (1, 8, 12), (1, 8, 13), (0, 8, 13), (0, 9, 13), (0, 10, 13), (0, 11, 13), (0, 12, 13), (0, 13, 13)]
  Length for Path 3: 12
  Cost for Path 3: 16
  ******
 Total Wire Length for 'net3': 31
 Total Cost for 'net3': 53

Net 'net4':

  Path 1: [(1, 0, 5), (1, 0, 6), (1, 0, 7), (1, 0, 8), (1, 0, 9), (1, 0, 10), (0, 0, 10), (0, 1, 10), (0, 2, 10), (0, 3, 10), (0, 4, 10), (1, 4, 10)]
  Length for Path 1: 12
  Cost for Path 1: 21

```
    ******
  Path 2: [(1, 4, 10), (1, 4, 11), (1, 4, 12), (0, 4, 12), (0, 5, 12), (0, 6, 12),
(0, 7, 12), (0, 8, 12), (0, 9, 12), (0, 10, 12)]
  Length for Path 2: 10
  Cost for Path 2: 14
    ******
 Total Wire Length for 'net4': 22
 Total Cost for 'net4': 35
----------------------------------------------------
Net 'net5':
----------------------------------------------------
  Path 1: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 7, 3), (0, 8, 3), (0, 9,
3), (1, 9, 3), (1, 9, 4)]
  Length for Path 1: 9
  Cost for Path 1: 13
    ******
  Path 2: [(1, 9, 4), (1, 10, 4), (1, 11, 4), (1, 11, 5), (1, 11, 6), (1, 11, 7), (1,
11, 8), (1, 11, 9), (1, 11, 10), (1, 11, 11), (1, 11, 12), (1, 11, 13), (1, 11, 14),
(0, 11, 14), (0, 12, 14), (0, 13, 14), (0, 14, 14)]
  Length for Path 2: 17
  Cost for Path 2: 41
    ******
 Total Wire Length for 'net5': 26
 Total Cost for 'net5': 54
----------------------------------------------------

Summary
====================================================
Longest Route Length: 17
Net with Longest Route: 'net5'
Path Number of Longest Route: 2
Total Wire Length Across All Nets: 126
Total cost of the routing is: 215
====================================================
```
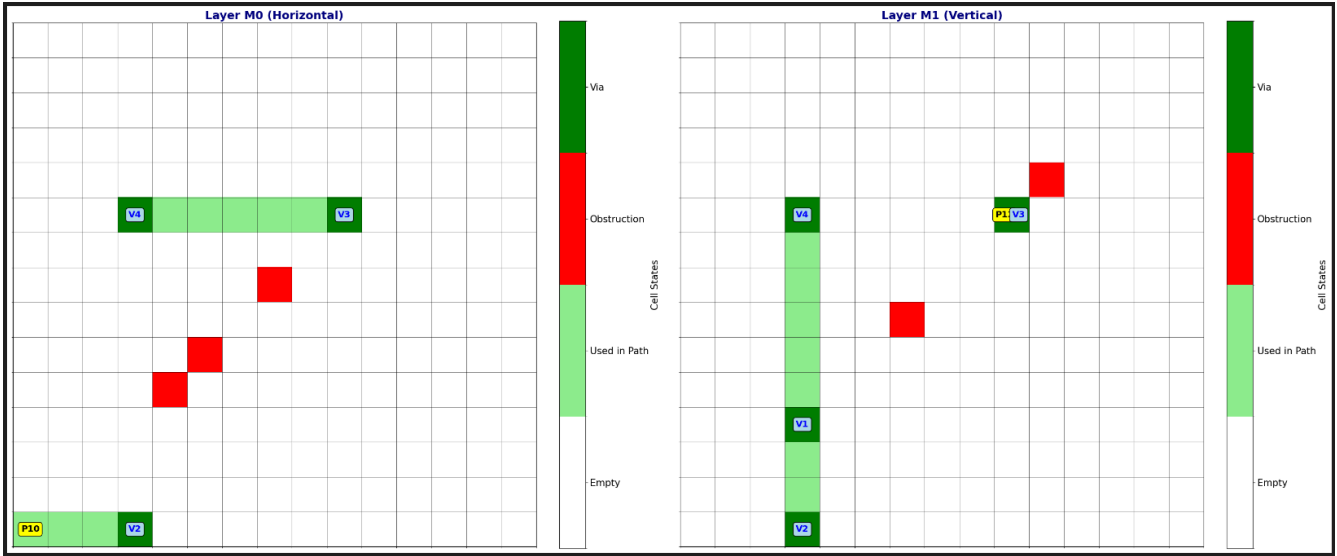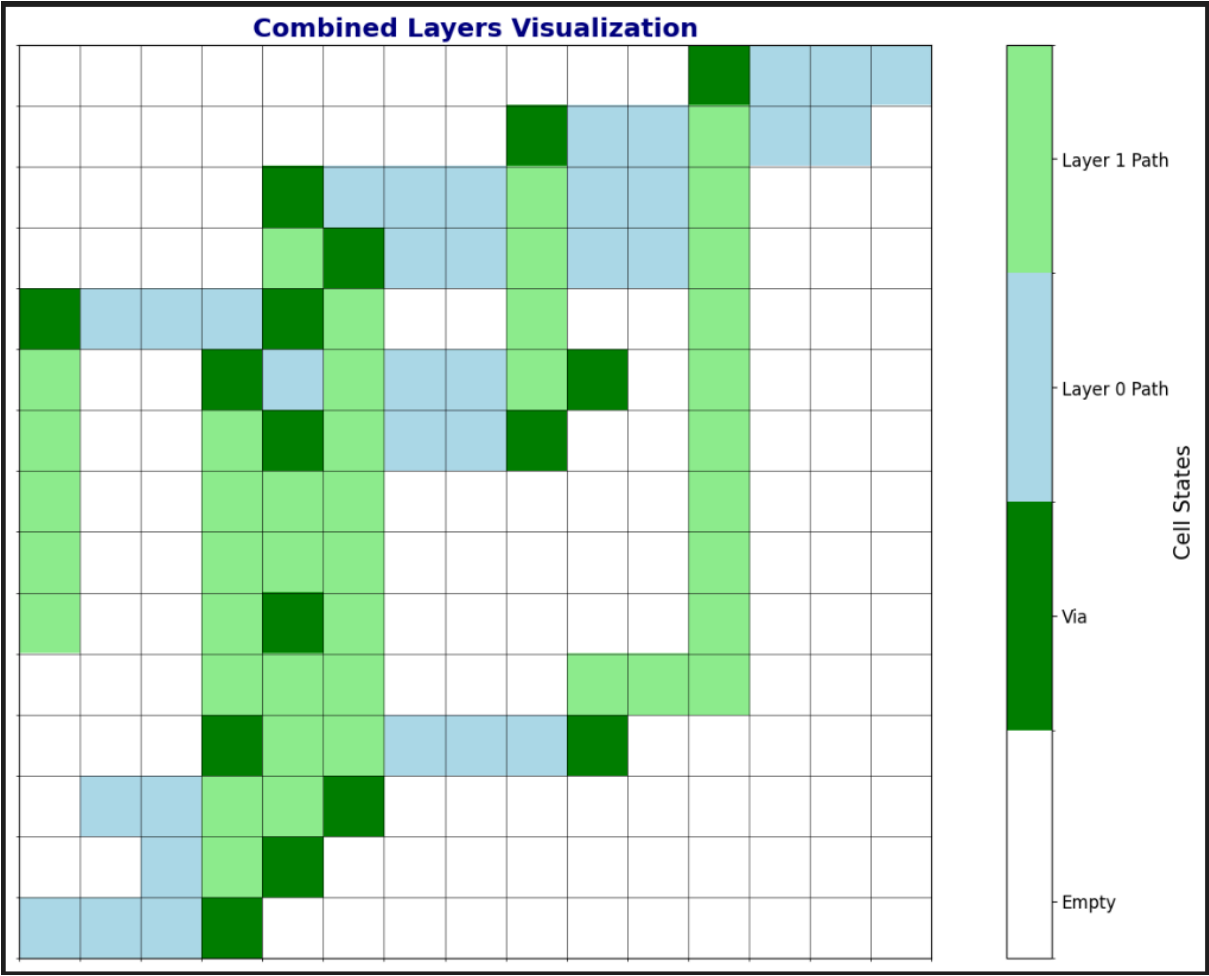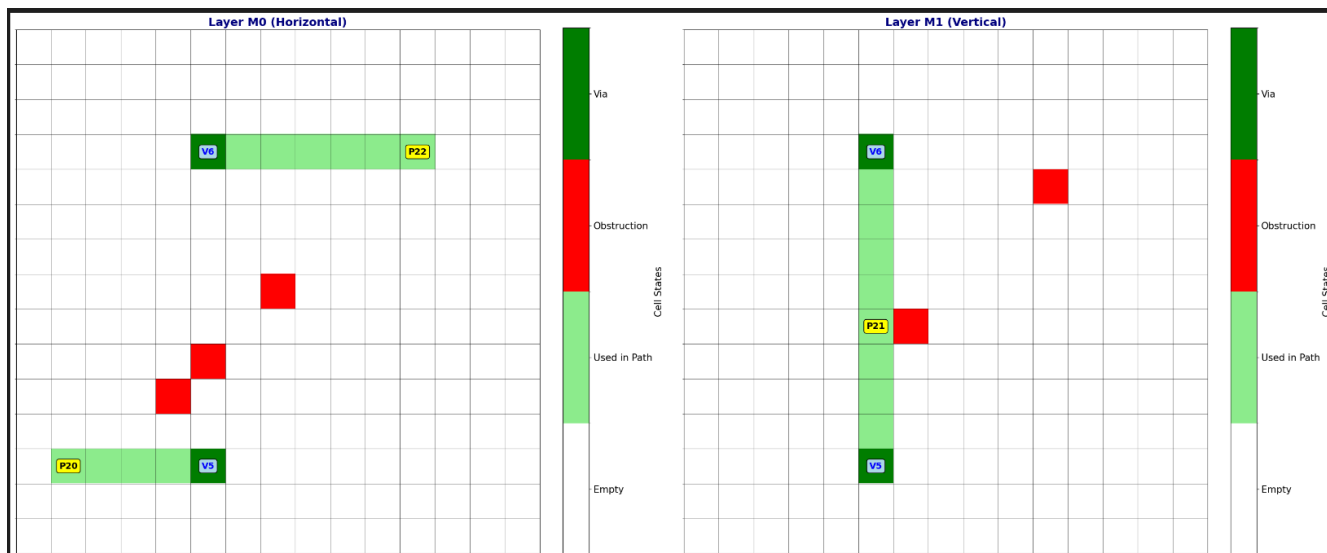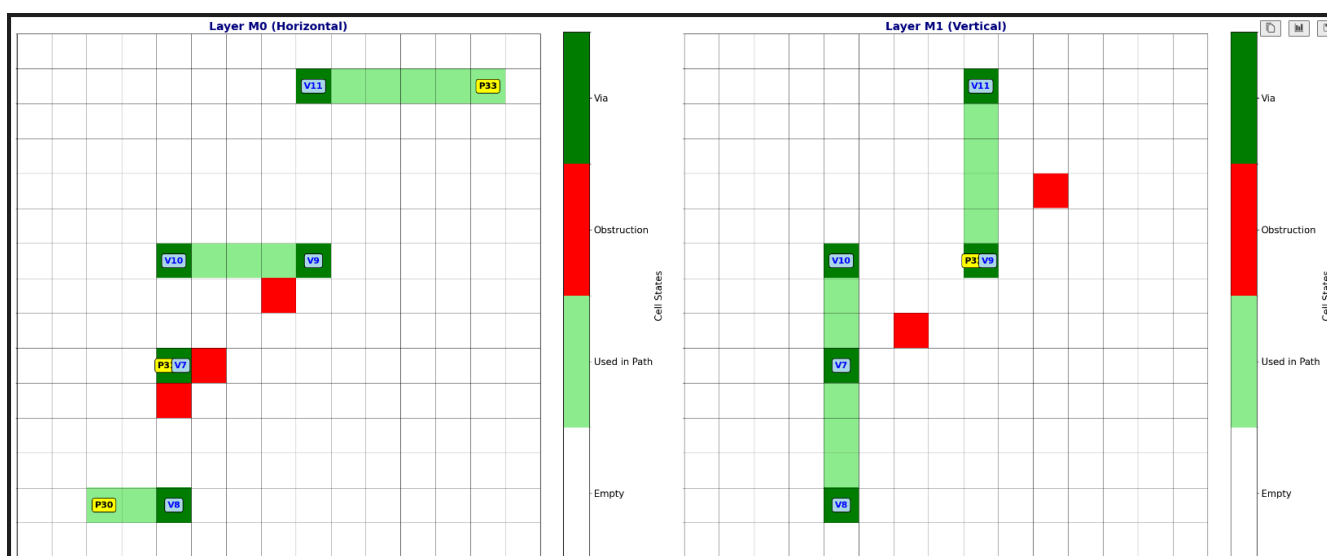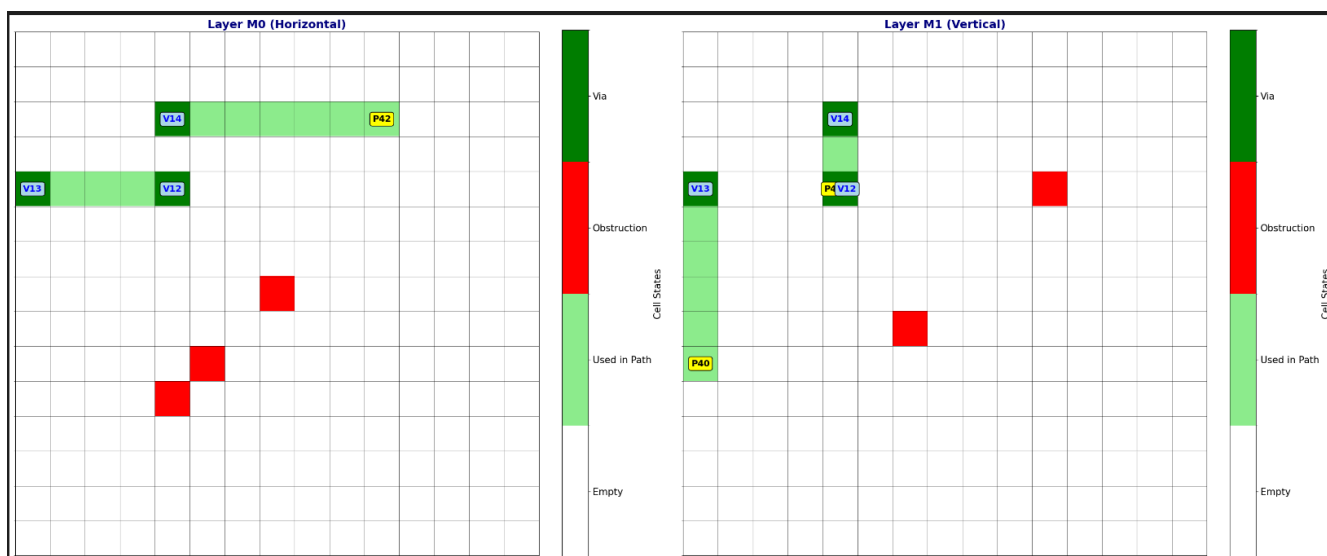
Figure 8: net1
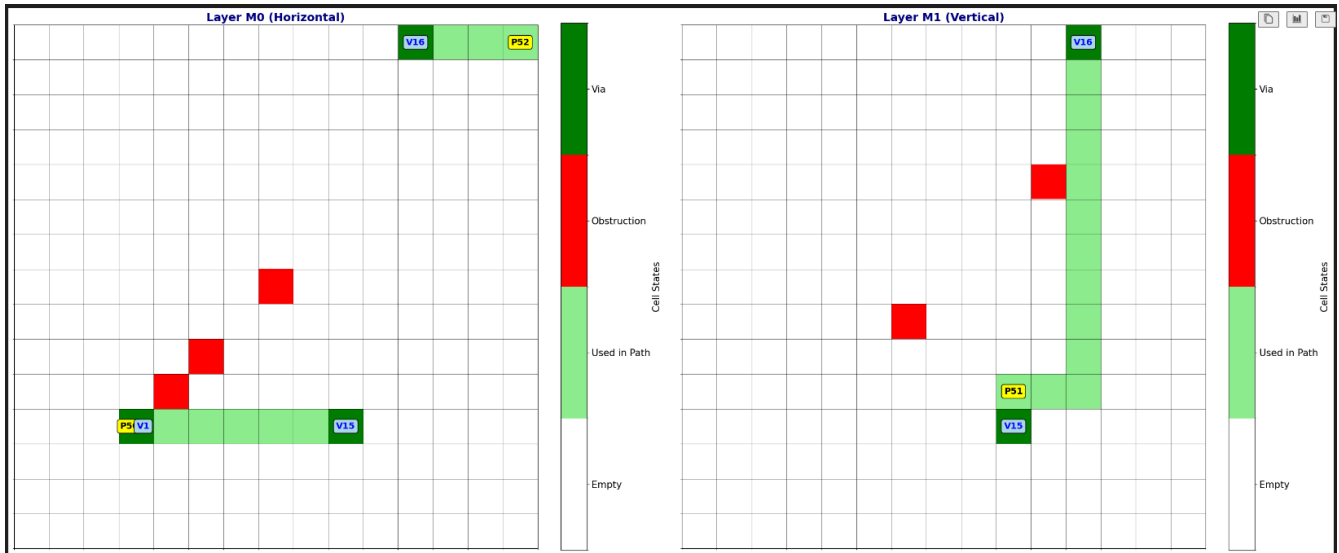
Figure 9: net2

Figure 10: net3

Figure 11: net4

Figure 12: net5

- **Tracing:**

  ⇒ **Net:** net1

  ‣ **Path 1** begins at (0, 0, 0) in Layer M0 and moves horizontally along the x-axis (columns) while maintaining the same row (z = 0) up to (0, 3, 0). At (0, 3, 0), it uses a via to transition to Layer M1. From (1, 3, 0), the path continues vertically along the y-axis (rows) through (1, 3, 1) to (1, 3, 3). Finally, it transitions back to Layer M0 via another via at (1, 3, 3) and terminates at (0, 3, 3).

  ‣ **Path 2** starts at (1, 3, 3) in Layer M1 and continues vertically along the y-axis (rows), traveling through (1, 3, 4) to (1, 3, 9). At (1, 3, 9), it transitions back to Layer M0 via a via. From (0, 3, 9), the path moves horizontally along the x-axis (columns) through (0, 4, 9) to (0, 9, 9). It then transitions to Layer M1 via a via at (0, 9, 9) and terminates at (1, 9, 9).

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (0, 1, 2) in Layer M0 and travels horizontally along the x-axis (columns) while maintaining the same row (z = 2) up to (0, 5, 2). At (0, 5, 2), it uses a via to transition to Layer M1. From (1, 5, 2), the path continues vertically along the y-axis (rows), traveling through (1, 5, 3) to (1, 5, 6), where it terminates.

  ‣ **Path 2** starts at (1, 5, 6) in Layer M1 and continues vertically along the y-axis (rows) through (1, 5, 7) to (1, 5, 11). At (1, 5, 11), it transitions back to Layer M0 via a via. From (0, 5, 11), the path moves horizontally along the x-axis (columns) through (0, 6, 11) to (0, 11, 11), where it terminates.

  ⇒ **Net:** net3

  ‣ **Path 1** begins at (0, 2, 1) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 1) up to (0, 4, 1). At (0, 4, 1), it transitions to Layer M1 via a via and continues vertically along the y-axis (rows) through (1, 4, 2) to (1, 4, 5). Finally, it transitions back to Layer M0 via another via at (1, 4, 5) and terminates at (0, 4, 5).

  ‣ **Path 2** starts at (1, 4, 5) in Layer M1 and continues vertically along the y-axis (rows) through (1, 4, 6) to (1, 4, 8). It then transitions back to Layer M0 via a via at (1, 4, 8). From (0, 4, 8), the path moves horizontally along the x-axis (columns) through (0, 5, 8) to (1, 8, 8), where it terminates.

- **Path 3** starts at (1, 8, 8) in Layer M1 and continues vertically along the y-axis (rows) through (1, 8, 9) to (1, 8, 13). At (1, 8, 13), it transitions back to Layer M0 via a via. From (0, 8, 13), the path moves horizontally along the x-axis (columns) through (0, 9, 13) to (0, 13, 13), where it terminates.

⇒ **Net:** net4

- **Path 1** begins at (1, 0, 5) in Layer M1 and continues vertically along the y-axis (rows) through (1, 0, 6) to (1, 0, 10). At (1, 0, 10), it transitions back to Layer M0 via a via. From (0, 0, 10), the path moves horizontally along the x-axis (columns) through (0, 1, 10) to (1, 4, 10), where it terminates.

- **Path 2** starts at (1, 4, 10) in Layer M1 and continues vertically along the y-axis (rows) through (1, 4, 11) to (1, 4, 12). At (1, 4, 12), it transitions back to Layer M0 via a via. From (0, 4, 12), the path moves horizontally along the x-axis (columns) through (0, 5, 12) to (0, 10, 12), where it terminates.

⇒ **Net:** net5

- **Path 1** begins at (0, 3, 3) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 3) up to (0, 9, 3). At (0, 9, 3), it transitions to Layer M1 via a via and terminates at (1, 9, 4).

- **Path 2** starts at (1, 9, 4) in Layer M1 and continues vertically along the y-axis (rows) through (1, 10, 4) to (1, 11, 14). At (1, 11, 14), it transitions back to Layer M0 via a via. From (0, 11, 14), the path moves horizontally along the x-axis (columns) through (0, 12, 14) to (0, 14, 14), where it terminates.

Test Case 7: (Without Bonus)

- **Input:**

  14, 14, 10, 1000
  OBS (0, 7, 7)
  net1 (1, 0, 9) (1, 4, 13)
  net2 (1, 1, 12) (1, 4, 8)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
       Pin 1: Layer=1, X=0, Y=9
       Pin 2: Layer=1, X=4, Y=13
--------------------------------------------------
2     net2
       Pin 1: Layer=1, X=1, Y=12
       Pin 2: Layer=1, X=4, Y=8
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
  Path 1: [(1, 0, 9), (1, 1, 9), (1, 2, 9), (1, 3, 9), (1, 4, 9), (1, 4, 10), (1, 4,
11), (1, 4, 12), (1, 4, 13)]
  Length for Path 1: 9
  Cost for Path 1: 48
  ******
 Total Wire Length for 'net1': 9
 Total Cost for 'net1': 48
--------------------------------------------------
Net 'net2':
--------------------------------------------------
  Path 1: [(1, 1, 12), (1, 1, 11), (1, 1, 10), (0, 1, 10), (0, 2, 10), (0, 3, 10),
(0, 4, 10), (0, 4, 9), (0, 4, 8), (1, 4, 8)]
  Length for Path 1: 10
  Cost for Path 1: 2049
  ******
 Total Wire Length for 'net2': 10
 Total Cost for 'net2': 2049
--------------------------------------------------

Summary
==================================================
Longest Route Length: 10
Net with Longest Route: 'net2'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 19
Total cost of the routing is: 2097
==================================================
```
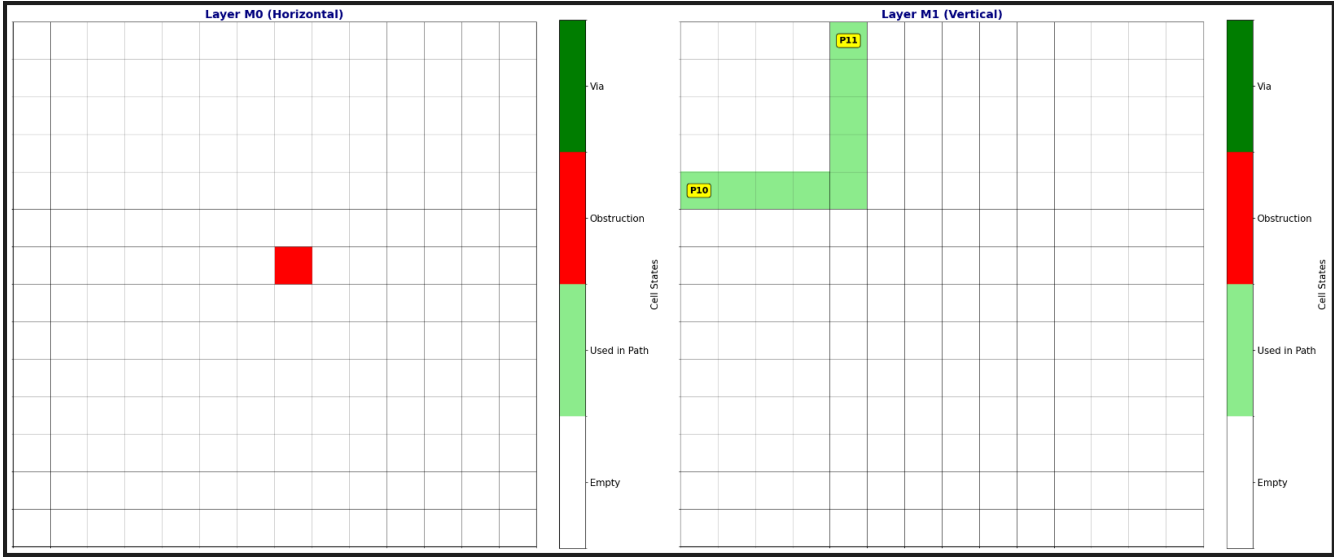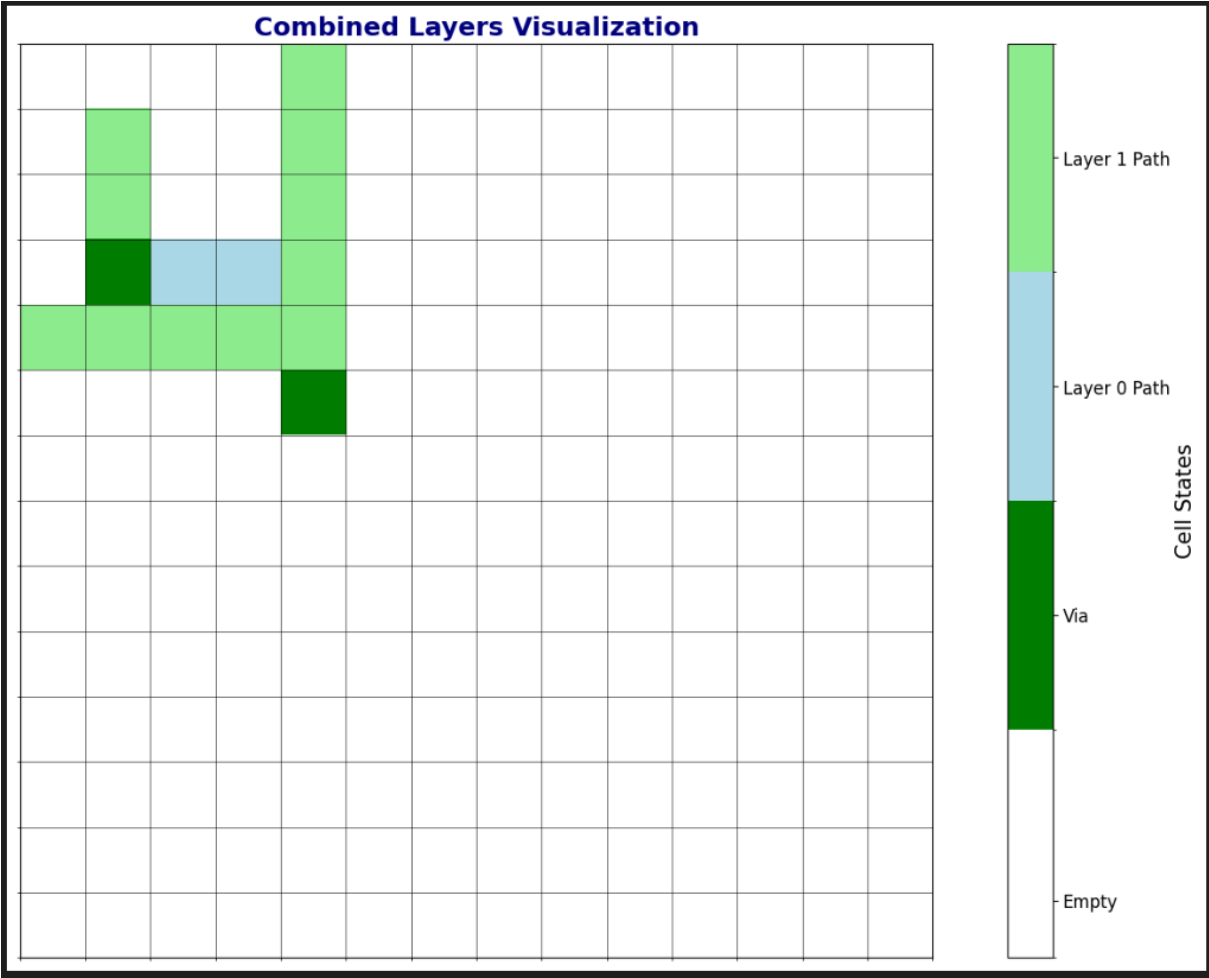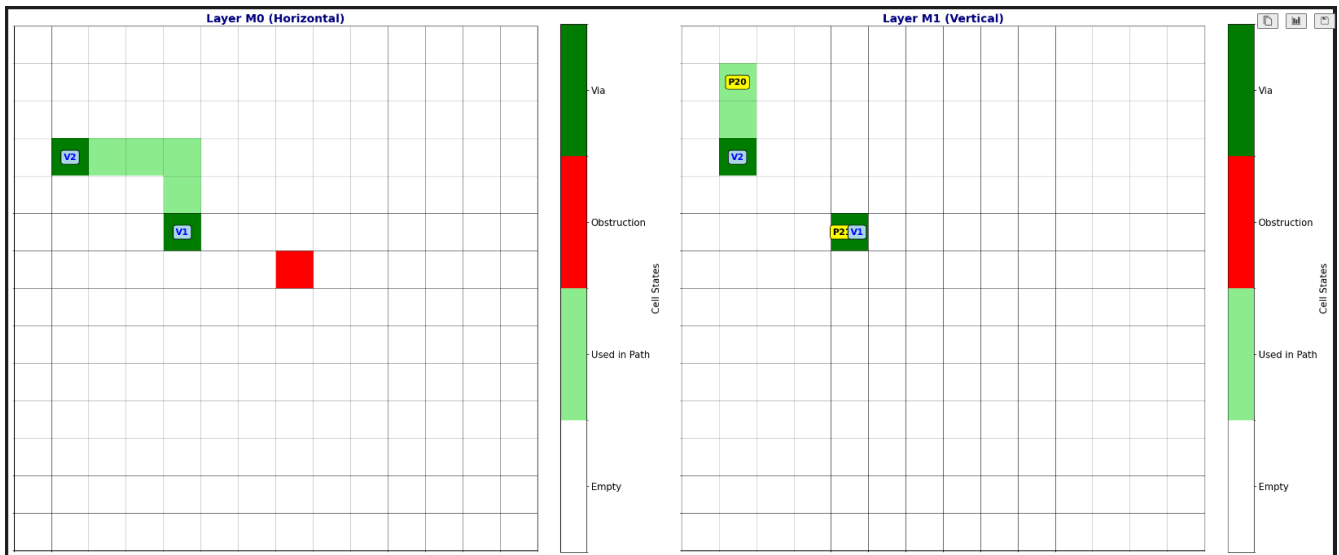
Figure 13: net1

Figure 14: net2

- **Tracing:**

  ⇒ **Net:** net1

  ‣ **Path 1** begins at (1, 0, 9) in Layer M1 and travels vertically along the y-axis (rows), moving from (1, 0, 9) to (1, 4, 9). At (1, 4, 9), the path changes direction and continues horizontally along the x-axis (columns) while maintaining the same row (z = 9), moving through (1, 4, 10) to (1, 4, 13), where it terminates.

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (1, 1, 12) in Layer M1 and travels vertically along the y-axis (rows), moving from (1, 1, 12) to (1, 1, 10). At (1, 1, 10), it transitions to Layer M0 via a via. From (0, 1, 10), the path moves horizontally along the x-axis (columns), traveling through (0, 2, 10) to (0, 4, 10). At (0, 4, 10), the path changes direction and continues vertically along the y-axis (rows), moving from (0, 4, 10) to (0, 4, 8). Finally, it transitions back to Layer M1 via a via at (0, 4, 8) and terminates at (1, 4, 8).

Test Case 8:

- **Input:**

  20, 20, 10, 5
  OBS (0, 5, 5)
  OBS (0, 5, 6)
  OBS (0, 6, 5)
  OBS (1, 10, 10)
  OBS (1, 10, 11)
  OBS (1, 11, 10)
  net1 (0, 0, 0) (0, 7, 7) (1, 15, 15)
  net2 (0, 3, 3) (1, 10, 9) (0, 19, 19)
  net3 (1, 2, 2) (0, 8, 8) (1, 18, 18)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
       Pin 1: Layer=0, X=0, Y=0
       Pin 2: Layer=0, X=7, Y=7
       Pin 3: Layer=1, X=15, Y=15
--------------------------------------------------
2     net2
       Pin 1: Layer=0, X=3, Y=3
       Pin 2: Layer=1, X=10, Y=9
       Pin 3: Layer=0, X=19, Y=19
--------------------------------------------------
3     net3
       Pin 1: Layer=1, X=2, Y=2
       Pin 2: Layer=0, X=8, Y=8
       Pin 3: Layer=1, X=18, Y=18
--------------------------------------------------
==================================================

==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (0, 3, 0), (0, 4, 0), (0, 5, 0), (0, 6,
0), (0, 7, 0), (1, 7, 0), (1, 7, 1), (1, 7, 2), (1, 7, 3), (1, 7, 4), (1, 7, 5), (1,
7, 6), (1, 7, 7), (0, 7, 7)]
  Length for Path 1: 17
  Cost for Path 1: 26
  ******
  Path 2: [(0, 7, 7), (0, 8, 7), (0, 9, 7), (0, 10, 7), (0, 11, 7), (0, 12, 7), (0,
13, 7), (0, 14, 7), (0, 15, 7), (1, 15, 7), (1, 15, 8), (1, 15, 9), (1, 15, 10), (1,
15, 11), (1, 15, 12), (1, 15, 13), (1, 15, 14), (1, 15, 15)]
  Length for Path 2: 18
  Cost for Path 2: 22
  ******
 Total Wire Length for 'net1': 35
```

Total Cost for 'net1': 48

Net 'net2':

  Path 1: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 7, 3), (0, 8, 3), (0, 9,
3), (0, 10, 3), (1, 10, 3), (1, 10, 4), (1, 10, 5), (1, 10, 6), (1, 10, 7), (1, 10,
8), (1, 10, 9)]
  Length for Path 1: 15
  Cost for Path 1: 19
  ******
  Path 2: [(1, 10, 9), (1, 11, 9), (1, 12, 9), (1, 12, 10), (1, 12, 11), (1, 12, 12),
(1, 12, 13), (1, 12, 14), (1, 12, 15), (1, 12, 16), (1, 12, 17), (1, 12, 18), (1, 12,
19), (0, 12, 19), (0, 13, 19), (0, 14, 19), (0, 15, 19), (0, 16, 19), (0, 17, 19),
(0, 18, 19), (0, 19, 19)]
  Length for Path 2: 21
  Cost for Path 2: 45
  ******
 Total Wire Length for 'net2': 36
 Total Cost for 'net2': 64

Net 'net3':

  Path 1: [(1, 2, 2), (1, 2, 3), (1, 2, 4), (1, 2, 5), (1, 2, 6), (1, 2, 7), (1, 2,
8), (0, 2, 8), (0, 3, 8), (0, 4, 8), (0, 5, 8), (0, 6, 8), (0, 7, 8), (0, 8, 8)]
  Length for Path 1: 14
  Cost for Path 1: 18
  ******
  Path 2: [(0, 8, 8), (0, 9, 8), (0, 10, 8), (0, 11, 8), (0, 12, 8), (0, 13, 8), (0,
14, 8), (0, 15, 8), (0, 16, 8), (0, 17, 8), (0, 18, 8), (1, 18, 8), (1, 18, 9), (1,
18, 10), (1, 18, 11), (1, 18, 12), (1, 18, 13), (1, 18, 14), (1, 18, 15), (1, 18,
16), (1, 18, 17), (1, 18, 18)]
  Length for Path 2: 22
  Cost for Path 2: 26
  ******
 Total Wire Length for 'net3': 36
 Total Cost for 'net3': 44

Summary
==
Longest Route Length: 22
Net with Longest Route: 'net3'
Path Number of Longest Route: 2
Total Wire Length Across All Nets: 107
Total cost of the routing is: 156
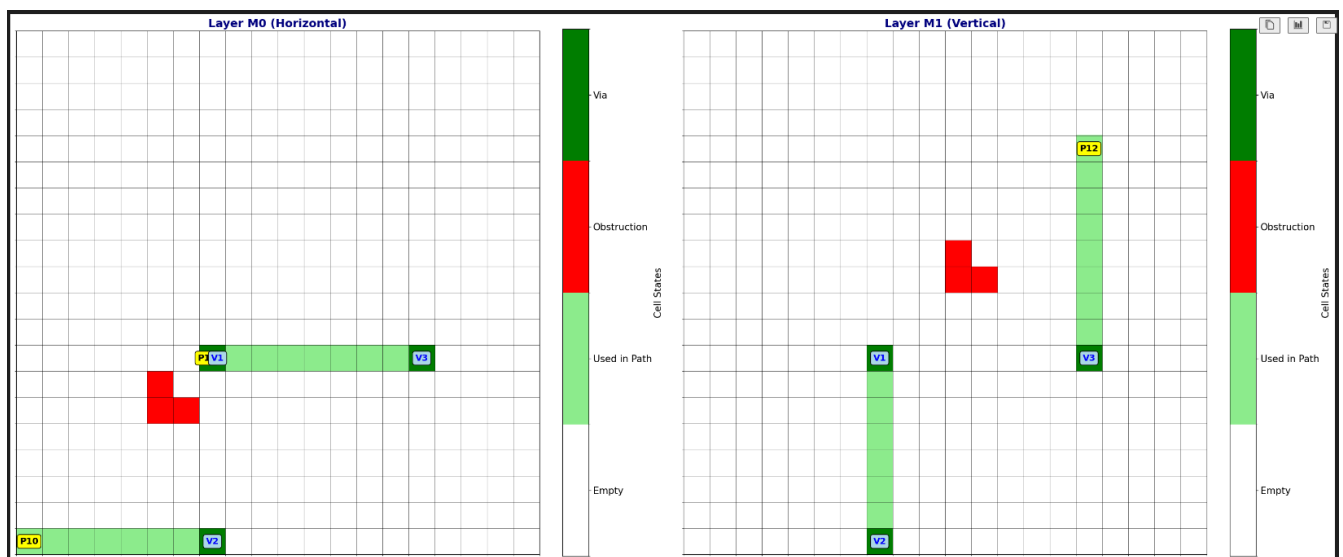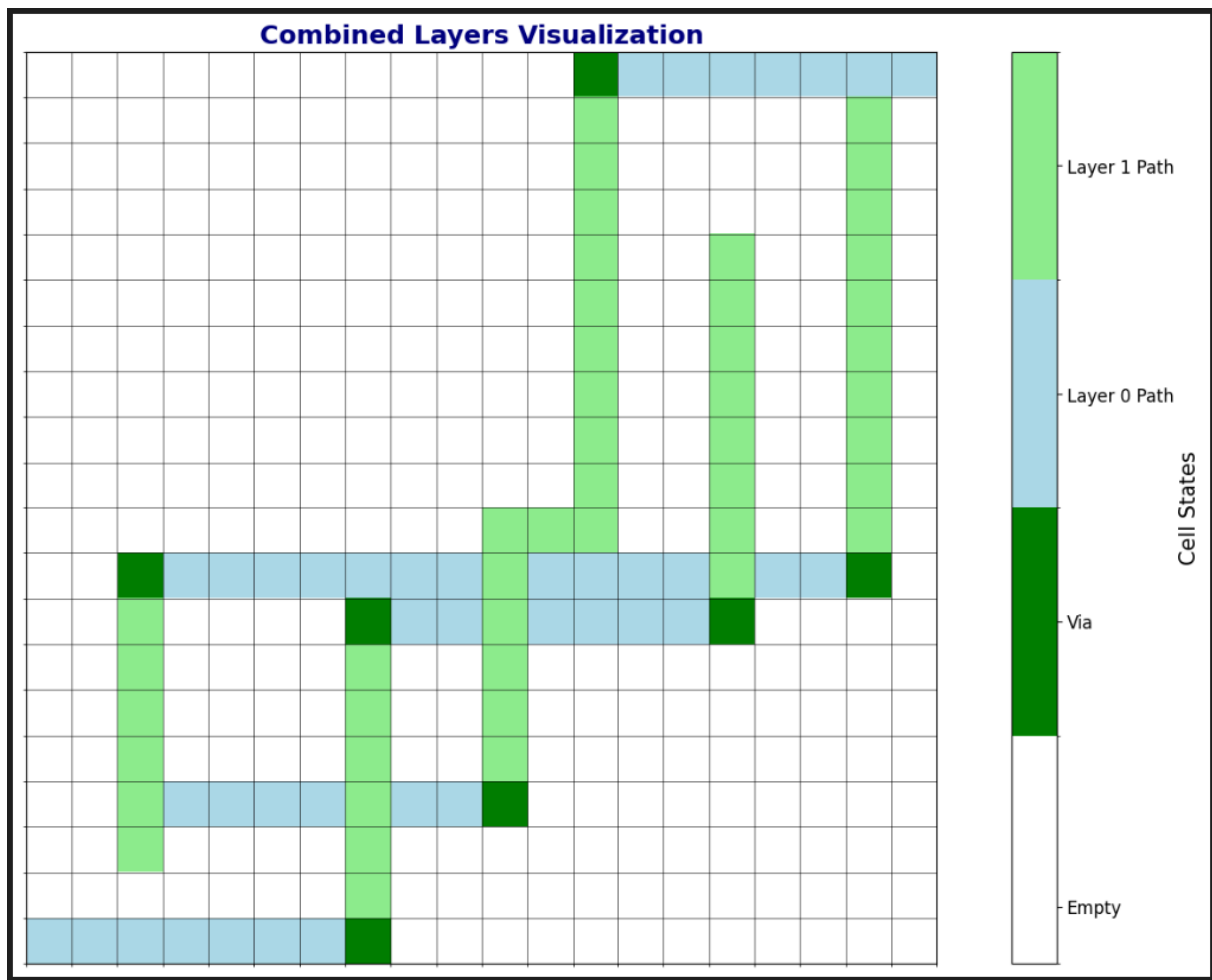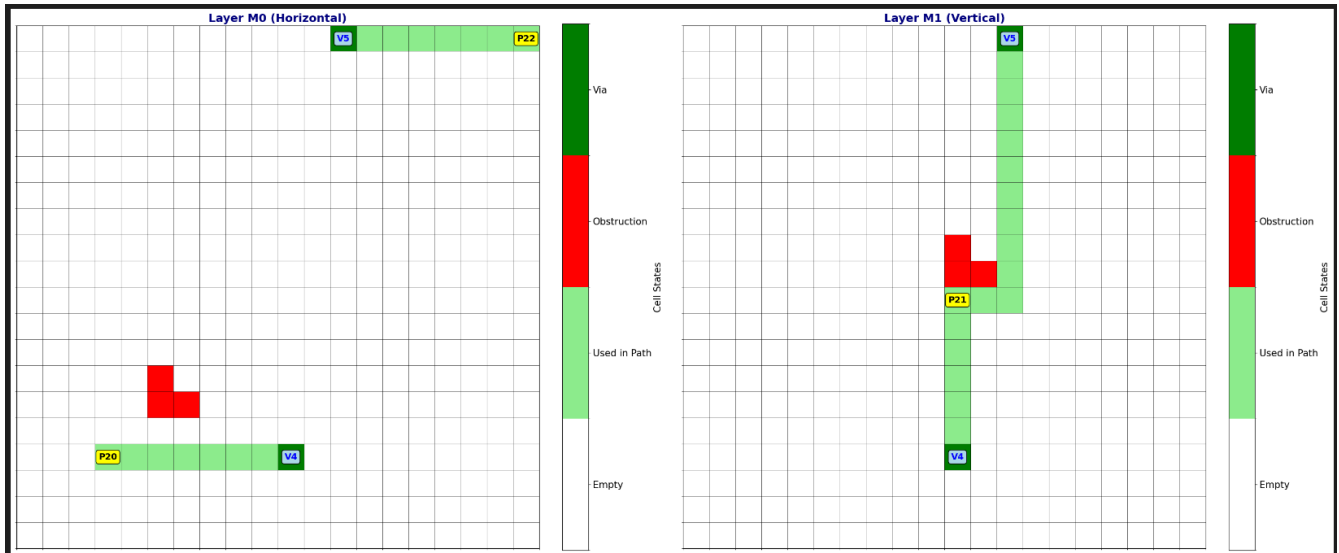==
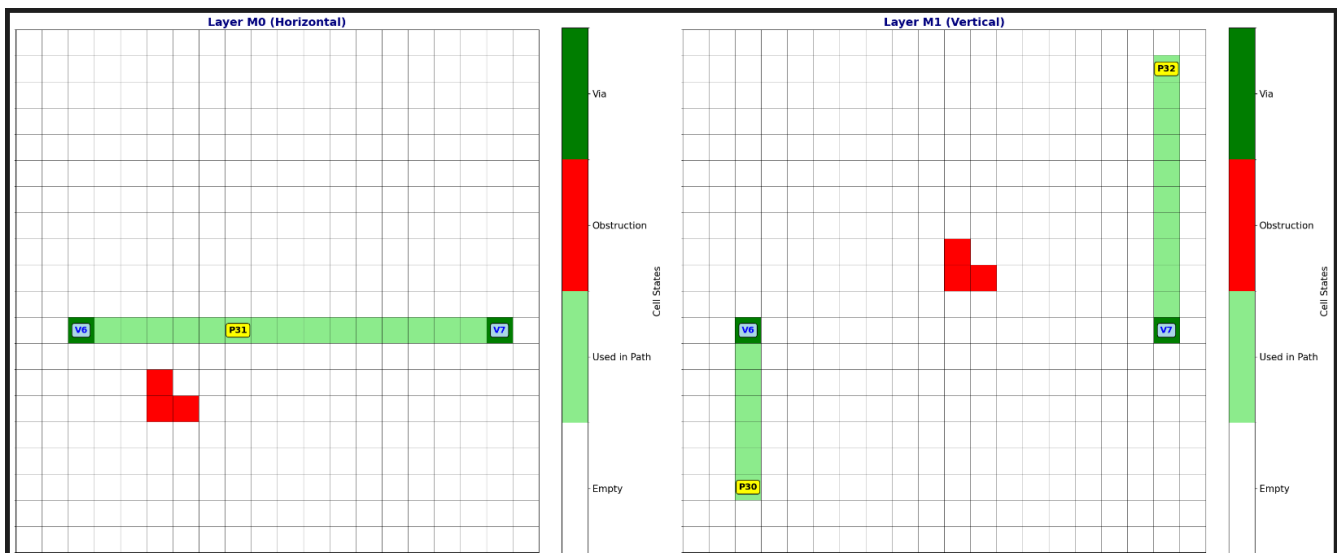
Figure 15: net1

Figure 16: net2

Figure 17: net3

- **Tracing:**

  ⇒ **Net:** net1

  ▸ **Path 1** begins at (0, 0, 0) in Layer M0 and travels horizontally along the x-axis (columns) while maintaining the same row (z = 0) through (0, 7, 0). At (0, 7, 0), it transitions to Layer M1 via a via. From (1, 7, 0), the path continues vertically along the y-axis (rows), moving through (1, 7, 1) to (1, 7, 7). Finally, it transitions back to Layer M0 via another via at (1, 7, 7) and terminates at (0, 7, 7).

  ▸ **Path 2** starts at (0, 7, 7) in Layer M0 and moves horizontally along the x-axis (columns), traveling through (0, 8, 7) to (0, 15, 7). At (0, 15, 7), it transitions to Layer M1 via a via. From (1, 15, 7), the path continues vertically along the y-axis (rows), moving through (1, 15, 8) to (1, 15, 15), where it terminates.

  ⇒ **Net:** net2

  ▸ **Path 1** begins at (0, 3, 3) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 3) through (0, 10, 3). At (0, 10, 3), it transitions to Layer M1 via a

via. From (1, 10, 3), the path continues vertically along the y-axis (rows), moving through (1, 10, 4) to (1, 10, 9), where it terminates.

- **Path 2** starts at (1, 10, 9) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 10, 9) to (1, 12, 19). At (1, 12, 19), it transitions back to Layer M0 via a via. From (0, 12, 19), the path moves horizontally along the x-axis (columns), traveling through (0, 13, 19) to (0, 19, 19), where it terminates.

⇒ **Net:** net3

- **Path 1** begins at (1, 2, 2) in Layer M1 and moves vertically along the y-axis (rows), traveling through (1, 2, 3) to (1, 2, 8). At (1, 2, 8), it transitions to Layer M0 via a via. From (0, 2, 8), the path moves horizontally along the x-axis (columns), traveling through (0, 3, 8) to (0, 8, 8), where it terminates.

- **Path 2** starts at (0, 8, 8) in Layer M0 and moves horizontally along the x-axis (columns), traveling through (0, 9, 8) to (0, 18, 8). At (0, 18, 8), it transitions to Layer M1 via a via. From (1, 18, 8), the path continues vertically along the y-axis (rows), traveling through (1, 18, 9) to (1, 18, 18), where it terminates.

Test Case 9: (Without Bonus)

- **Input:**

  25, 25, 20, 10
  OBS (0, 10, 10)
  OBS (0, 10, 11)
  OBS (1, 15, 15)
  OBS (1, 15, 16)
  OBS (0, 20, 20)
  net1 (0, 0, 0) (0, 12, 12) (1, 24, 24)
  net2 (1, 5, 5) (0, 18, 18) (1, 24, 5)
  net3 (0, 3, 3) (1, 10, 9) (0, 20, 20)
  net4 (1, 2, 2) (0, 5, 5) (1, 10, 10)

- **Output:**

```
Error: Net 'net3' contains an obstruction at (0, 20, 20) and this point will be
removed.
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net1
        Pin 1: Layer=0, X=0, Y=0
        Pin 2: Layer=0, X=12, Y=12
        Pin 3: Layer=1, X=24, Y=24
--------------------------------------------------
2     net2
        Pin 1: Layer=1, X=5, Y=5
        Pin 2: Layer=0, X=18, Y=18
        Pin 3: Layer=1, X=24, Y=5
--------------------------------------------------
3     net3
        Pin 1: Layer=0, X=3, Y=3
        Pin 2: Layer=1, X=10, Y=9
--------------------------------------------------
4     net4
        Pin 1: Layer=1, X=2, Y=2
        Pin 2: Layer=0, X=5, Y=5
        Pin 3: Layer=1, X=10, Y=10
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net1':
--------------------------------------------------
  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (0, 3, 0), (0, 4, 0), (0, 5, 0), (0, 6,
0), (0, 7, 0), (0, 8, 0), (0, 9, 0), (0, 10, 0), (0, 11, 0), (0, 12, 0), (1, 12, 0),
(1, 12, 1), (1, 12, 2), (1, 12, 3), (1, 12, 4), (1, 12, 5), (1, 12, 6), (1, 12, 7),
(1, 12, 8), (1, 12, 9), (1, 12, 10), (1, 12, 11), (1, 12, 12), (0, 12, 12)]
  Length for Path 1: 27
  Cost for Path 1: 46
  ******
```

Path 2: [(0, 12, 12), (0, 13, 12), (0, 14, 12), (0, 15, 12), (0, 16, 12), (0, 17, 12), (0, 18, 12), (0, 19, 12), (0, 20, 12), (0, 21, 12), (0, 22, 12), (0, 23, 12), (0, 24, 12), (1, 24, 12), (1, 24, 13), (1, 24, 14), (1, 24, 15), (1, 24, 16), (1, 24, 17), (1, 24, 18), (1, 24, 19), (1, 24, 20), (1, 24, 21), (1, 24, 22), (1, 24, 23), (1, 24, 24)]
  Length for Path 2: 26
  Cost for Path 2: 35
  ******
 Total Wire Length for 'net1': 53
 Total Cost for 'net1': 81

Net 'net2':

  Path 1: [(1, 5, 5), (1, 6, 5), (0, 6, 5), (0, 7, 5), (0, 8, 5), (0, 9, 5), (0, 10, 5), (0, 11, 5), (0, 12, 5), (0, 13, 5), (0, 14, 5), (0, 15, 5), (0, 16, 5), (0, 17, 5), (0, 18, 5), (0, 19, 5), (0, 20, 5), (0, 21, 5), (0, 22, 5), (0, 23, 5), (0, 24, 5), (1, 24, 5)]
  Length for Path 1: 22
  Cost for Path 1: 61
  ******
  Path 2: [(0, 18, 5), (1, 18, 5), (1, 18, 6), (1, 18, 7), (1, 18, 8), (1, 18, 9), (1, 18, 10), (1, 18, 11), (1, 18, 12), (1, 18, 13), (1, 18, 14), (1, 18, 15), (1, 18, 16), (1, 18, 17), (1, 18, 18), (0, 18, 18)]
  Length for Path 2: 16
  Cost for Path 2: 35
  ******
 Total Wire Length for 'net2': 38
 Total Cost for 'net2': 96

Net 'net3':

  Path 1: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 7, 3), (0, 8, 3), (0, 9, 3), (0, 10, 3), (1, 10, 3), (1, 10, 4), (1, 10, 5), (1, 10, 6), (1, 10, 7), (1, 10, 8), (1, 10, 9)]
  Length for Path 1: 15
  Cost for Path 1: 24
  ******
 Total Wire Length for 'net3': 15
 Total Cost for 'net3': 24

Net 'net4':

  Path 1: [(1, 2, 2), (1, 2, 3), (1, 2, 4), (1, 2, 5), (0, 2, 5), (0, 3, 5), (0, 4, 5), (0, 5, 5)]
  Length for Path 1: 8
  Cost for Path 1: 17
  ******
  Path 2: [(0, 5, 5), (0, 5, 6), (0, 6, 6), (0, 7, 6), (0, 8, 6), (0, 9, 6), (1, 9, 6), (1, 9, 7), (1, 9, 8), (1, 9, 9), (1, 9, 10), (1, 10, 10)]
  Length for Path 2: 12
  Cost for Path 2: 61
  ******
 Total Wire Length for 'net4': 20
 Total Cost for 'net4': 78

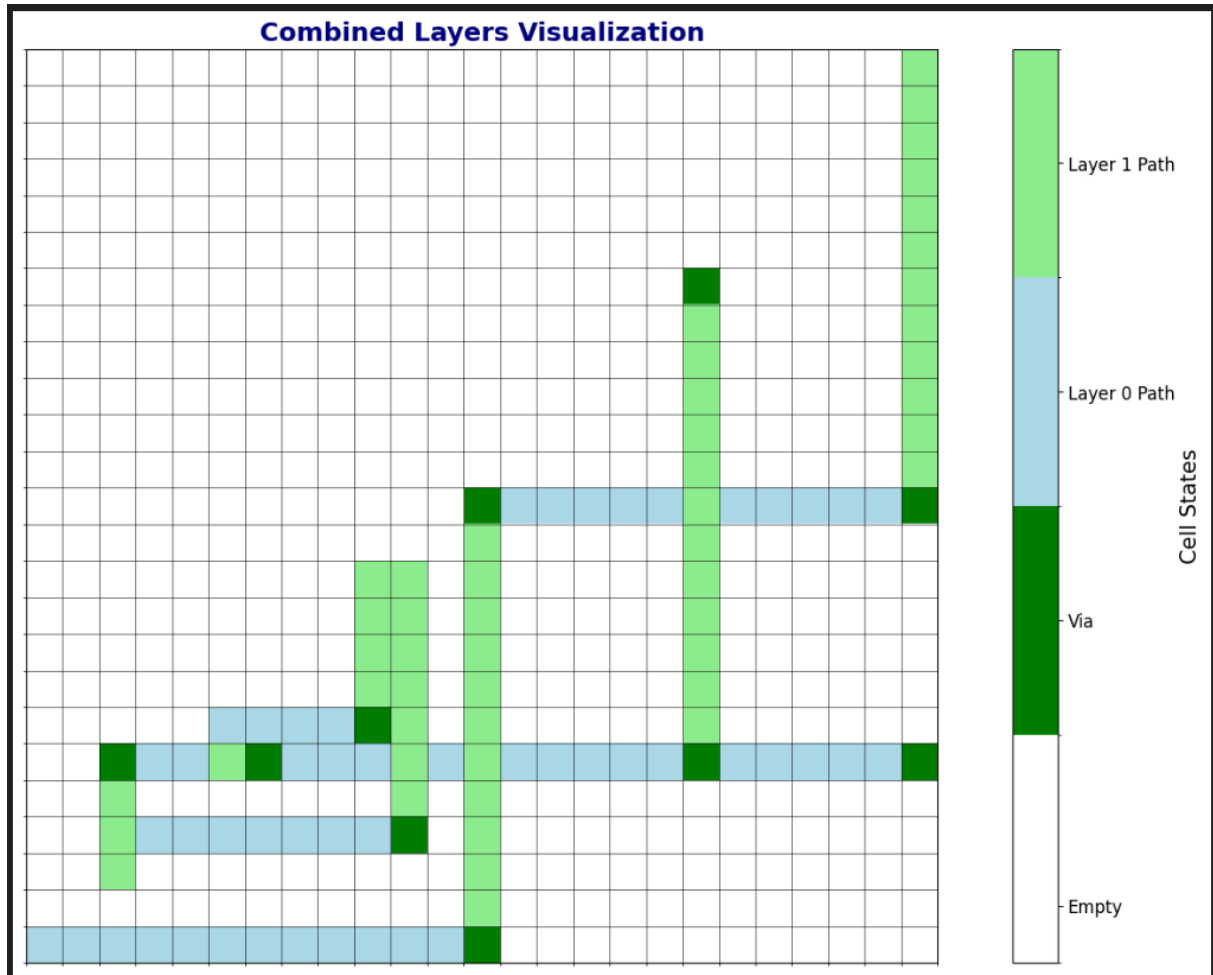Summary

===
Longest Route Length: 27
Net with Longest Route: 'net1'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 126
Total cost of the routing is: 279
===

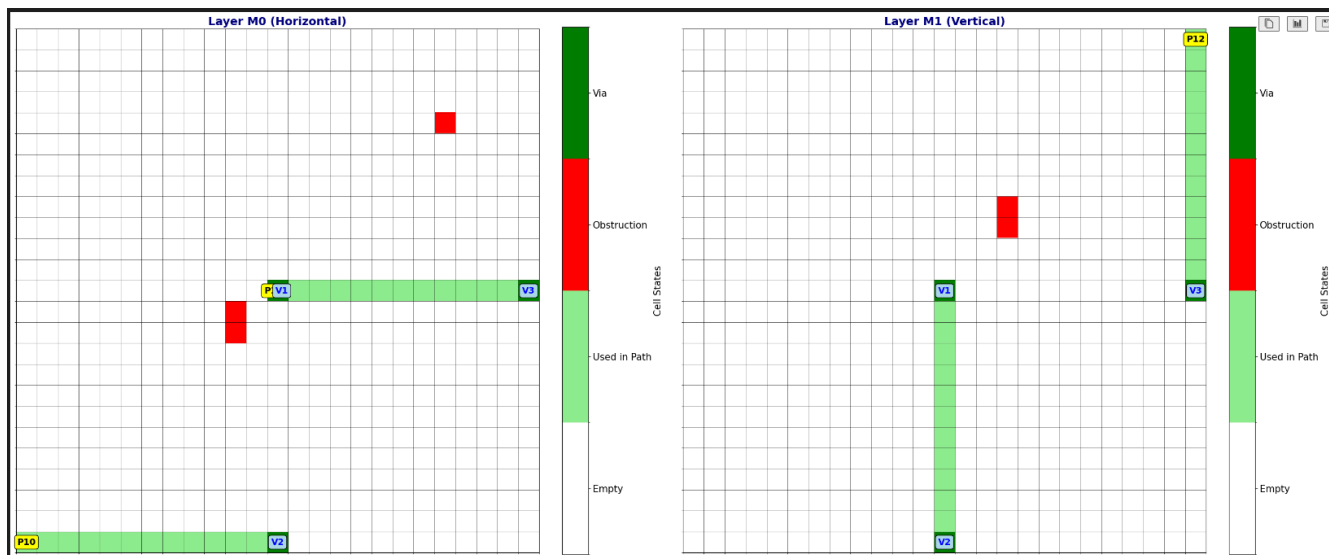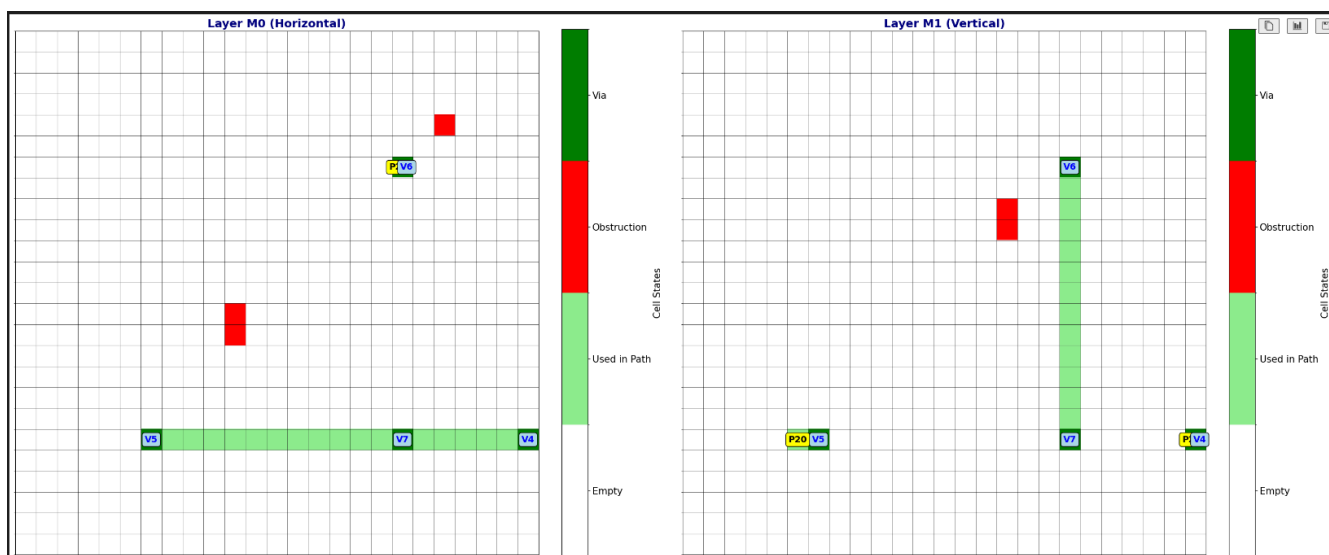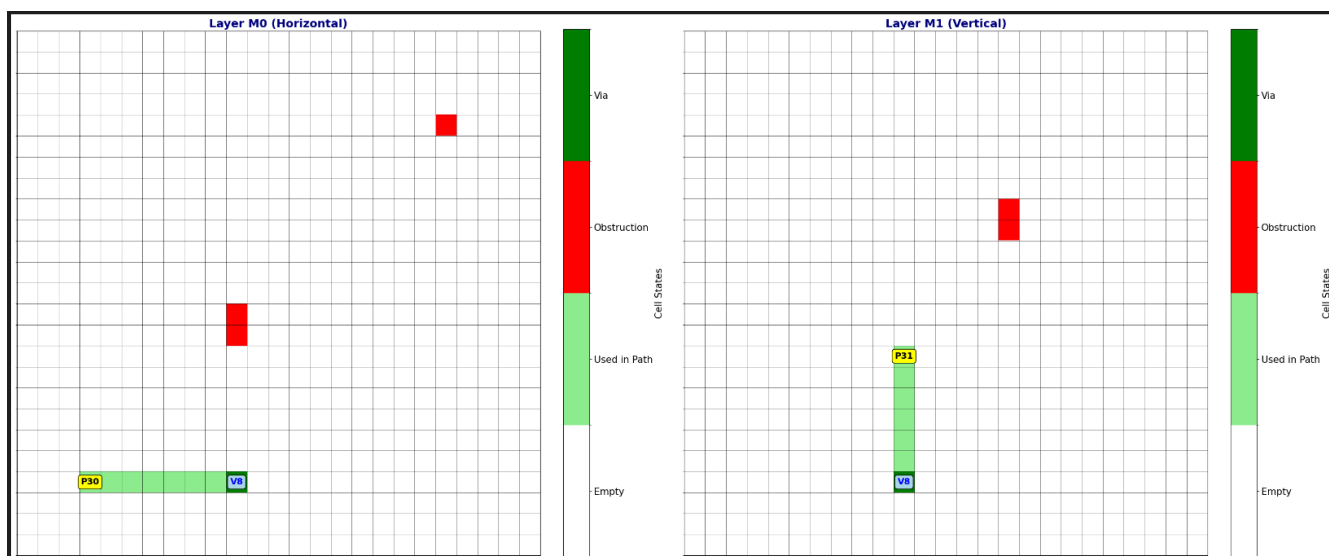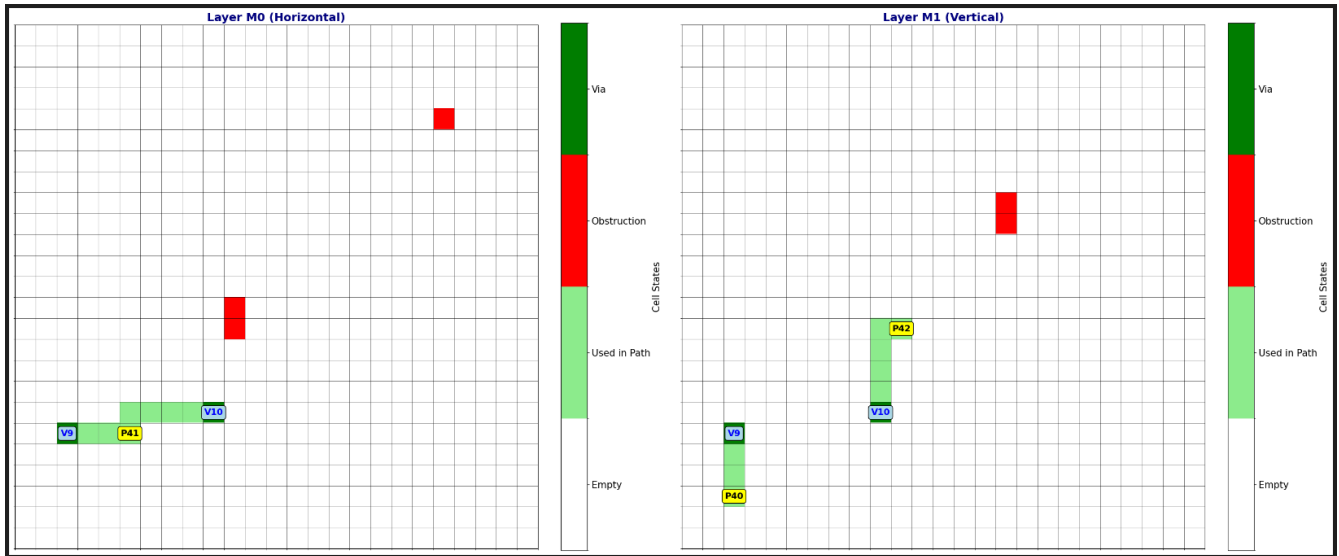Combined Layers Visualization

Figure 18: net1

Figure 19: net2

Figure 20: net3

Figure 21: net4

- **Tracing:**

  ⇒ **Net:** net1

  ‣ **Path 1** begins at (0, 0, 0) in Layer M0 and travels horizontally along the x-axis (columns) while maintaining the same row (z = 0) up to (0, 12, 0). At (0, 12, 0), it uses a via to transition to Layer M1. From (1, 12, 0), the path continues vertically along the y-axis (rows), moving from (1, 12, 0) to (1, 12, 12). Finally, it transitions back to Layer M0 via another via at (1, 12, 12) and terminates at (0, 12, 12).

  ‣ **Path 2** starts at (0, 12, 12) in Layer M0 and travels horizontally along the x-axis (columns) through (0, 13, 12) to (0, 24, 12). At (0, 24, 12), it transitions to Layer M1 via a via and continues vertically along the y-axis (rows), moving from (1, 24, 12) to (1, 24, 24), where it terminates.

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (1, 5, 5) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 5, 5) to (1, 6, 5). At (1, 6, 5), it transitions to Layer M0 via a via. From (0, 6, 5), the path continues horizontally along the x-axis (columns), moving through (0, 7, 5) to (0, 24, 5). At (0, 24, 5), it transitions back to Layer M1 via another via and terminates at (1, 24, 5).

  ‣ **Path 2** starts at (0, 18, 5) in Layer M0 and transitions to Layer M1 via a via. From (1, 18, 5), the path continues vertically along the y-axis (rows), traveling from (1, 18, 5) to (1, 18, 18). Finally, it transitions back to Layer M0 via another via at (1, 18, 18) and terminates at (0, 18, 18).

  ⇒ **Net:** net3

  ‣ **Path 1** begins at (0, 3, 3) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 3) up to (0, 10, 3). At (0, 10, 3), it uses a via to transition to Layer M1. From (1, 10, 3), the path continues vertically along the y-axis (rows), traveling from (1, 10, 3) to (1, 10, 9), where it terminates.

  ⇒ **Net:** net4

  ‣ **Path 1** begins at (1, 2, 2) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 2, 2) to (1, 2, 5). At (1, 2, 5), it transitions to Layer M0 via a via. From (0, 2, 5), the path moves horizontally along the x-axis (columns), traveling through (0, 3, 5) to (0, 5, 5), where it terminates.

- **Path 2** starts at (0, 5, 5) in Layer M0 and moves horizontally along the x-axis (columns) while maintaining the same row (z = 5) through (0, 6, 6) to (0, 9, 6). At (0, 9, 6), it transitions to Layer M1 via a via and continues vertically along the y-axis (rows), traveling from (1, 9, 6) to (1, 10, 10), where it terminates.

Test Case 10: (With Bonus)

- **Input:**

  25, 25, 20, 10
  OBS (0, 10, 10)
  OBS (0, 10, 11)
  OBS (1, 15, 15)
  OBS (1, 15, 16)
  OBS (0, 20, 20)
  net1 (0, 0, 0) (0, 12, 12) (1, 24, 24)
  net2 (1, 5, 5) (0, 18, 18) (1, 24, 5)
  net3 (0, 3, 3) (1, 10, 9) (0, 20, 20)
  net4 (1, 2, 2) (0, 5, 5) (1, 10, 10)

- **Output:**

```
Error: Net 'net3' contains an obstruction at (0, 20, 20) and this point will be
removed.
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net3
        Pin 1: Layer=0, X=3, Y=3
        Pin 2: Layer=1, X=10, Y=9
--------------------------------------------------
2     net4
        Pin 1: Layer=1, X=2, Y=2
        Pin 2: Layer=0, X=5, Y=5
        Pin 3: Layer=1, X=10, Y=10
--------------------------------------------------
3     net2
        Pin 1: Layer=1, X=5, Y=5
        Pin 2: Layer=0, X=18, Y=18
        Pin 3: Layer=1, X=24, Y=5
--------------------------------------------------
4     net1
        Pin 1: Layer=0, X=0, Y=0
        Pin 2: Layer=0, X=12, Y=12
        Pin 3: Layer=1, X=24, Y=24
--------------------------------------------------
==================================================

==================================================
Routed Nets Summary
==================================================
Net 'net3':
--------------------------------------------------
  Path 1: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 7, 3), (0, 8, 3), (0, 9,
3), (0, 10, 3), (1, 10, 3), (1, 10, 4), (1, 10, 5), (1, 10, 6), (1, 10, 7), (1, 10,
8), (1, 10, 9)]
  Length for Path 1: 15
  Cost for Path 1: 24
  ******
 Total Wire Length for 'net3': 15
```

Total Cost for 'net3': 24

Net 'net4':

  Path 1: [(1, 2, 2), (1, 2, 3), (1, 2, 4), (1, 2, 5), (0, 2, 5), (0, 3, 5), (0, 4, 5), (0, 5, 5)]
  Length for Path 1: 8
  Cost for Path 1: 17
  ******
  Path 2: [(0, 5, 5), (0, 6, 5), (0, 7, 5), (0, 8, 5), (0, 9, 5), (1, 9, 5), (1, 9, 6), (1, 9, 7), (1, 9, 8), (1, 9, 9), (1, 9, 10), (1, 10, 10)]
  Length for Path 2: 12
  Cost for Path 2: 41
  ******
 Total Wire Length for 'net4': 20
 Total Cost for 'net4': 58

Net 'net2':

  Path 1: [(1, 5, 5), (1, 5, 6), (0, 5, 6), (0, 6, 6), (0, 7, 6), (0, 8, 6), (0, 9, 6), (0, 10, 6), (0, 11, 6), (0, 12, 6), (0, 13, 6), (0, 14, 6), (0, 15, 6), (0, 16, 6), (0, 17, 6), (0, 18, 6), (1, 18, 6), (1, 18, 7), (1, 18, 8), (1, 18, 9), (1, 18, 10), (1, 18, 11), (1, 18, 12), (1, 18, 13), (1, 18, 14), (1, 18, 15), (1, 18, 16), (1, 18, 17), (1, 18, 18), (0, 18, 18)]
  Length for Path 1: 30
  Cost for Path 1: 59
  ******
  Path 2: [(0, 18, 6), (0, 19, 6), (0, 20, 6), (0, 21, 6), (0, 22, 6), (0, 23, 6), (0, 24, 6), (0, 24, 5), (1, 24, 5)]
  Length for Path 2: 9
  Cost for Path 2: 38
  ******
 Total Wire Length for 'net2': 39
 Total Cost for 'net2': 97

Net 'net1':

  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (0, 3, 0), (0, 4, 0), (0, 5, 0), (0, 6, 0), (0, 7, 0), (0, 8, 0), (0, 9, 0), (0, 10, 0), (0, 11, 0), (0, 12, 0), (1, 12, 0), (1, 12, 1), (1, 12, 2), (1, 12, 3), (1, 12, 4), (1, 12, 5), (1, 12, 6), (1, 12, 7), (1, 12, 8), (1, 12, 9), (1, 12, 10), (1, 12, 11), (1, 12, 12), (0, 12, 12)]
  Length for Path 1: 27
  Cost for Path 1: 46
  ******
  Path 2: [(0, 12, 12), (0, 13, 12), (0, 14, 12), (0, 15, 12), (0, 16, 12), (0, 17, 12), (0, 18, 12), (0, 19, 12), (0, 20, 12), (0, 21, 12), (0, 22, 12), (0, 23, 12), (0, 24, 12), (1, 24, 12), (1, 24, 13), (1, 24, 14), (1, 24, 15), (1, 24, 16), (1, 24, 17), (1, 24, 18), (1, 24, 19), (1, 24, 20), (1, 24, 21), (1, 24, 22), (1, 24, 23), (1, 24, 24)]
  Length for Path 2: 26
  Cost for Path 2: 35
  ******
 Total Wire Length for 'net1': 53
 Total Cost for 'net1': 81

Summary

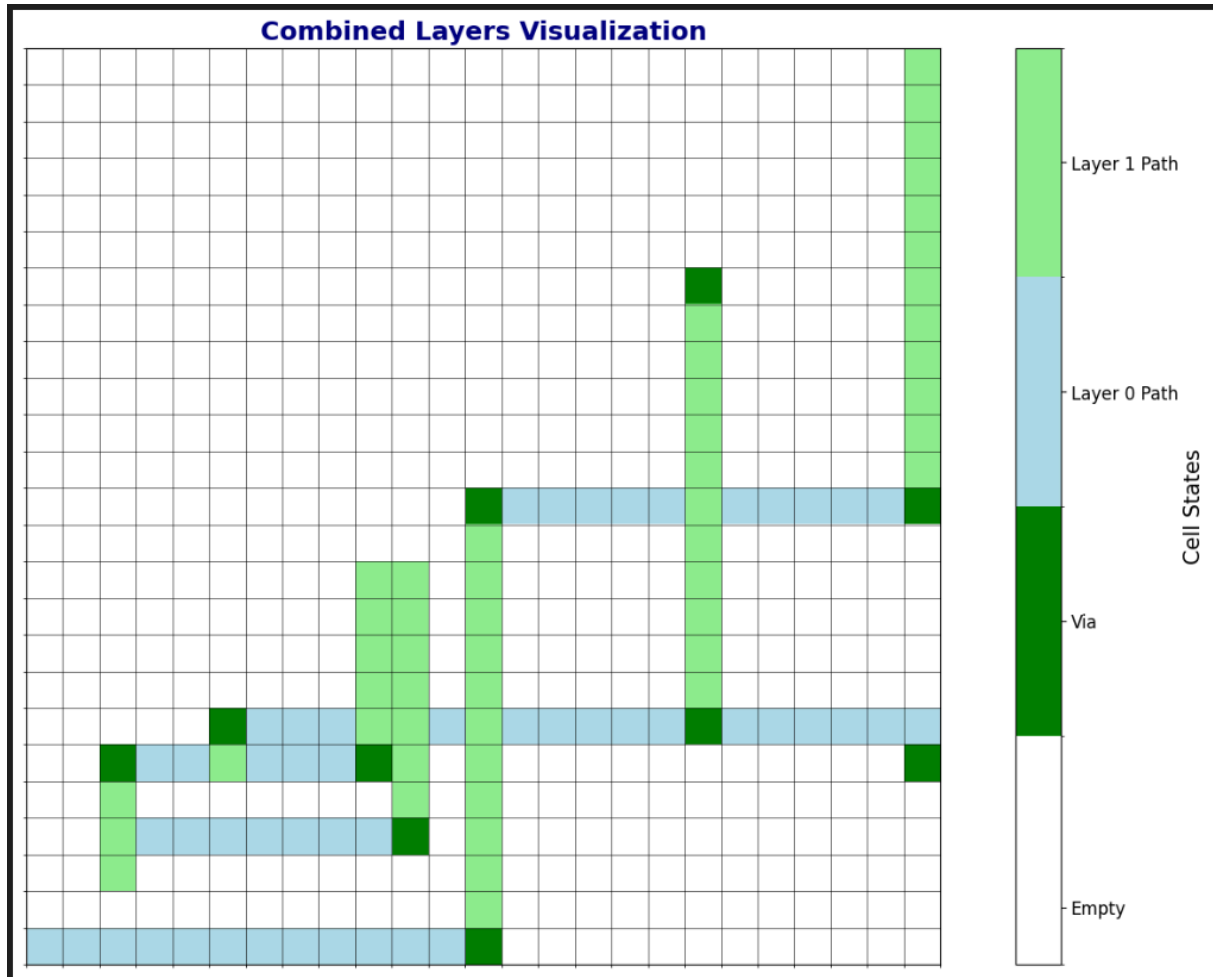==
Longest Route Length: 30
Net with Longest Route: 'net2'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 127
Total cost of the routing is: 260
==
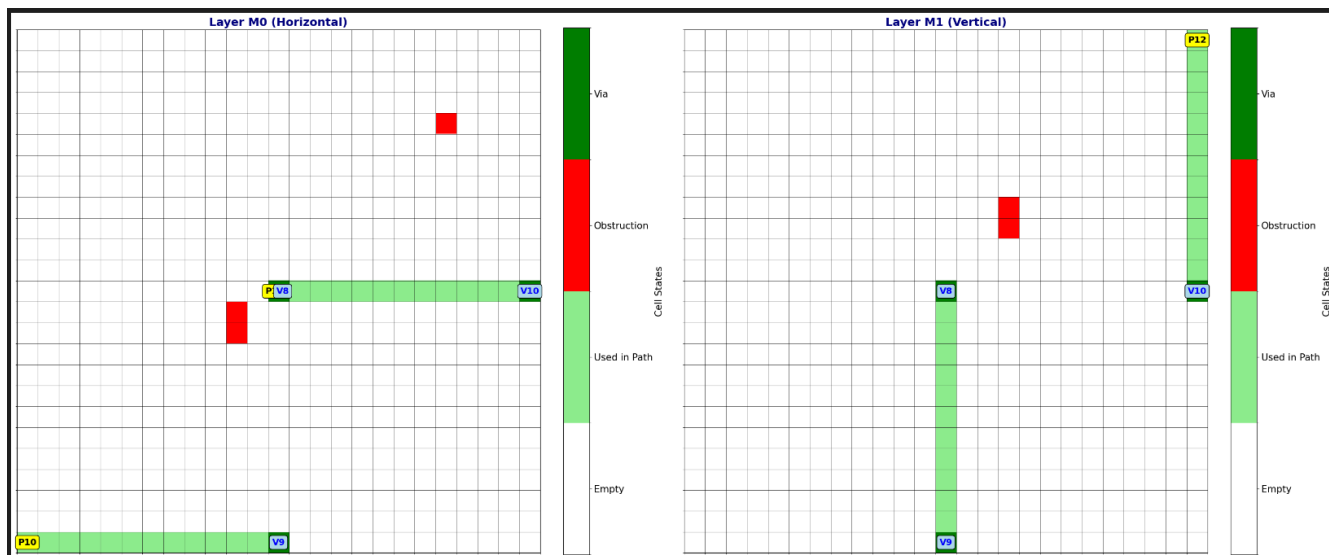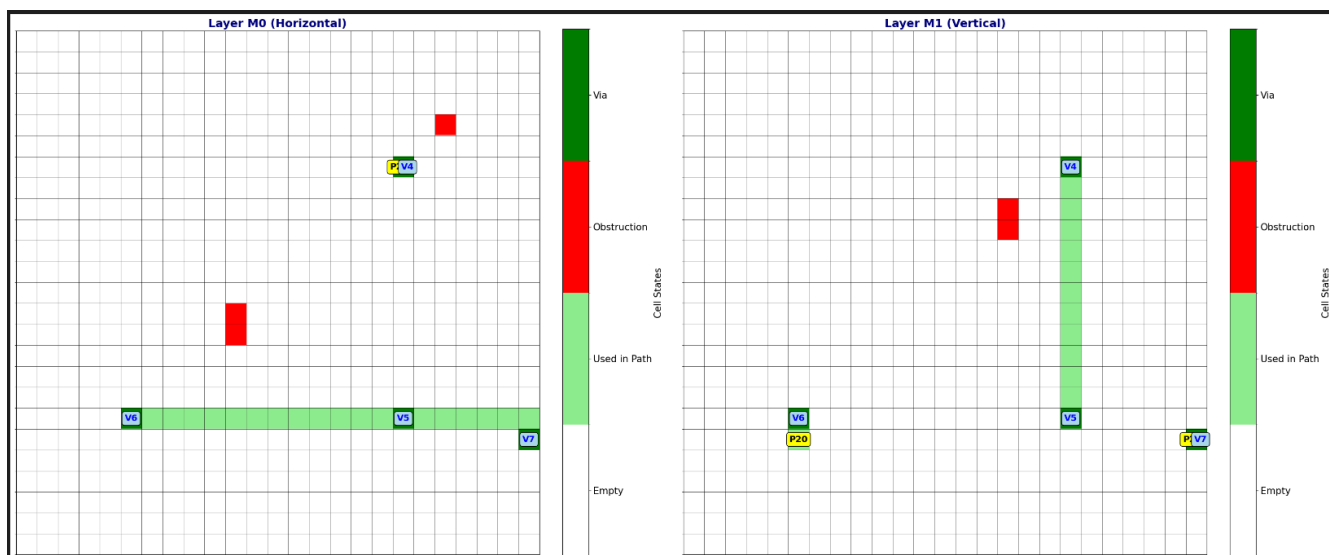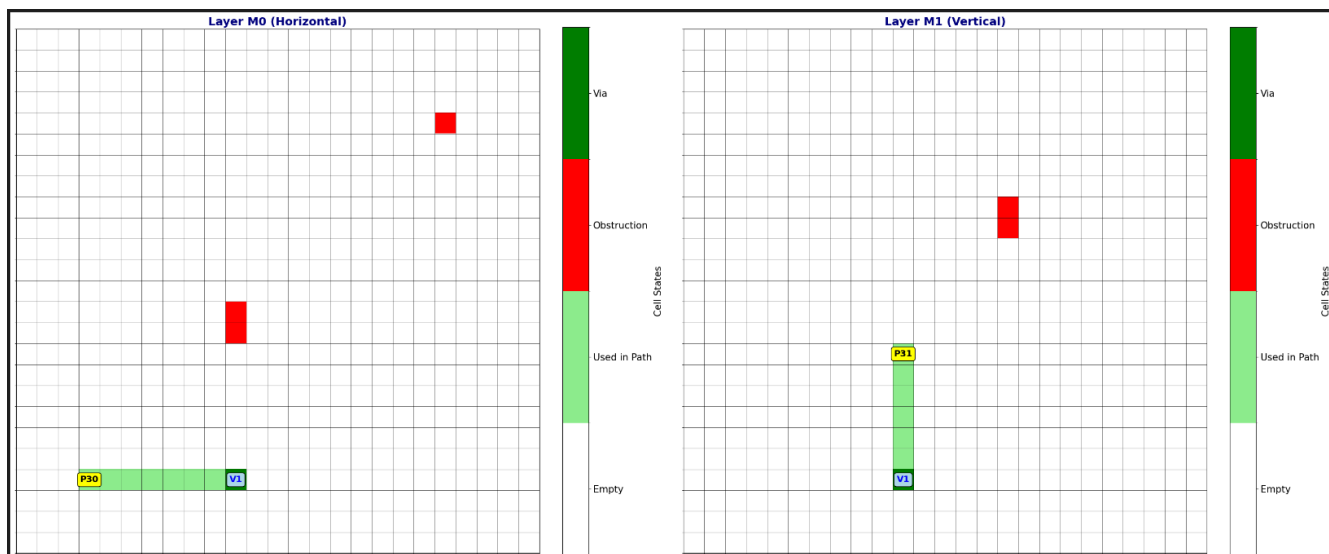
Combined Layers Visualization

Figure 22: net1

Figure 23: net2

Figure 24: net3
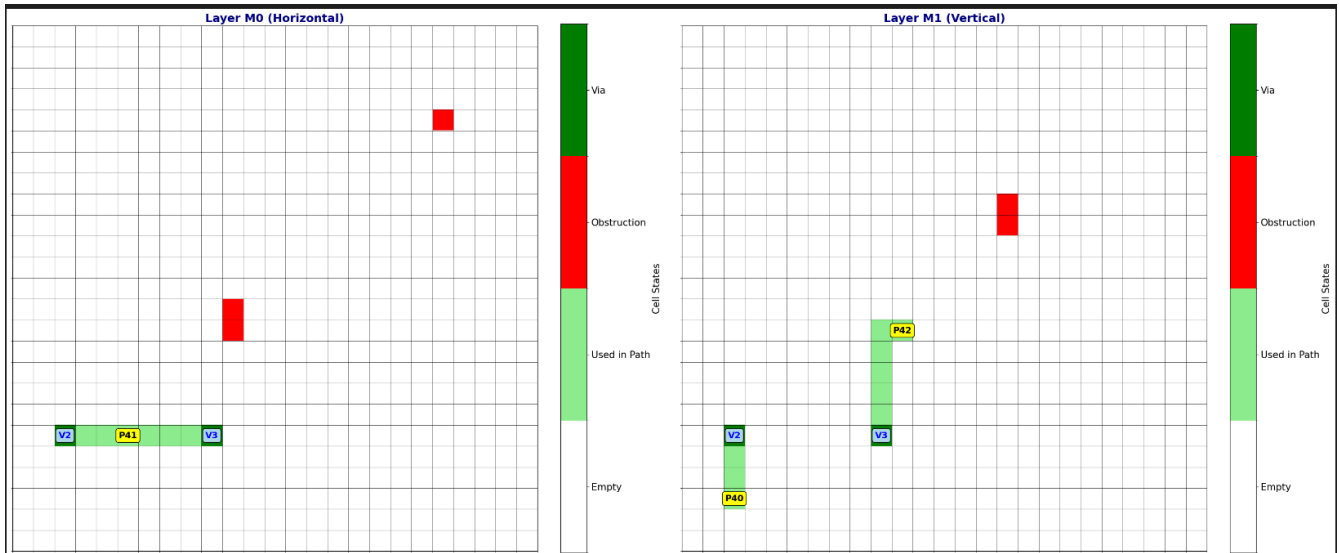
Figure 25: net4

- **Tracing:**

  ⇒ **Net:** net3

  ‣ **Path 1** begins at (0, 3, 3) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 3) up to (0, 10, 3). At (0, 10, 3), it uses a via to transition to Layer M1. From (1, 10, 3), the path continues vertically along the y-axis (rows), moving through (1, 10, 4) to (1, 10, 9), where it terminates.

  ⇒ **Net:** net4

  ‣ **Path 1** begins at (1, 2, 2) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 2, 2) to (1, 2, 5). At (1, 2, 5), it transitions to Layer M0 via a via. From (0, 2, 5), the path moves horizontally along the x-axis (columns), traveling through (0, 3, 5) to (0, 5, 5), where it terminates.

  ‣ **Path 2** starts at (0, 5, 5) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 5) through (0, 9, 5). At (0, 9, 5), it transitions to Layer M1 via a via and continues vertically along the y-axis (rows), moving from (1, 9, 5) to (1, 10, 10), where it terminates.

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (1, 5, 5) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 5, 5) to (1, 5, 6). At (1, 5, 6), it transitions to Layer M0 via a via. From (0, 5, 6), the path moves horizontally along the x-axis (columns), traveling through (0, 6, 6) to (0, 18, 6). At (0, 18, 6), it transitions back to Layer M1 via a via and continues vertically along the y-axis (rows) through (1, 18, 7) to (1, 18, 18). Finally, it transitions back to Layer M0 via another via at (1, 18, 18) and terminates at (0, 18, 18).

  ‣ **Path 2** starts at (0, 18, 6) in Layer M0 and continues horizontally along the x-axis (columns), traveling from (0, 18, 6) to (0, 24, 6). At (0, 24, 6), it moves vertically along the y-axis (rows) through (0, 24, 5). Finally, it transitions to Layer M1 via a via at (0, 24, 5) and terminates at (1, 24, 5).

  ⇒ **Net:** net1

- **Path 1** begins at (0, 0, 0) in Layer M0 and moves horizontally along the x-axis (columns), maintaining the same row (z = 0) through (0, 12, 0). At (0, 12, 0), it transitions to Layer M1 via a via. From (1, 12, 0), the path continues vertically along the y-axis (rows), traveling from (1, 12, 0) to (1, 12, 12). Finally, it transitions back to Layer M0 via another via at (1, 12, 12) and terminates at (0, 12, 12).

- **Path 2** starts at (0, 12, 12) in Layer M0 and moves horizontally along the x-axis (columns), traveling from (0, 12, 12) to (0, 24, 12). At (0, 24, 12), it transitions to Layer M1 via a via. From (1, 24, 12), the path continues vertically along the y-axis (rows), traveling from (1, 24, 12) to (1, 24, 24), where it terminates.

Test Case 11: (With Bonus)

- **Input:**

      14, 14, 10, 1000
      OBS (0, 7, 7)
      net1 (1, 0, 9) (1, 4, 13)
      net2 (1, 1, 12) (1, 4, 8)

- **Output:**

```
==================================================
Ordered Nets with Pin Details
==================================================
Order Net Name  Pin Details (Layer, X, Y)
--------------------------------------------------
1     net2
       Pin 1: Layer=1, X=1, Y=12
       Pin 2: Layer=1, X=4, Y=8
--------------------------------------------------
2     net1
       Pin 1: Layer=1, X=0, Y=9
       Pin 2: Layer=1, X=4, Y=13
--------------------------------------------------
==================================================
==================================================
Routed Nets Summary
==================================================
Net 'net2':
--------------------------------------------------
  Path 1: [(1, 1, 12), (1, 2, 12), (1, 3, 12), (1, 4, 12), (1, 4, 11), (1, 4, 10),
(1, 4, 9), (1, 4, 8)]
  Length for Path 1: 8
  Cost for Path 1: 77
  ******
 Total Wire Length for 'net2': 8
 Total Cost for 'net2': 77
--------------------------------------------------
Net 'net1':
--------------------------------------------------
  Path 1: [(1, 0, 9), (1, 0, 10), (1, 0, 11), (1, 0, 12), (1, 0, 13), (1, 1, 13), (1,
2, 13), (1, 3, 13), (1, 4, 13)]
  Length for Path 1: 9
  Cost for Path 1: 48
  ******
 Total Wire Length for 'net1': 9
 Total Cost for 'net1': 48
--------------------------------------------------

Summary
==================================================
Longest Route Length: 9
Net with Longest Route: 'net1'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 17
Total cost of the routing is: 125
==================================================
```
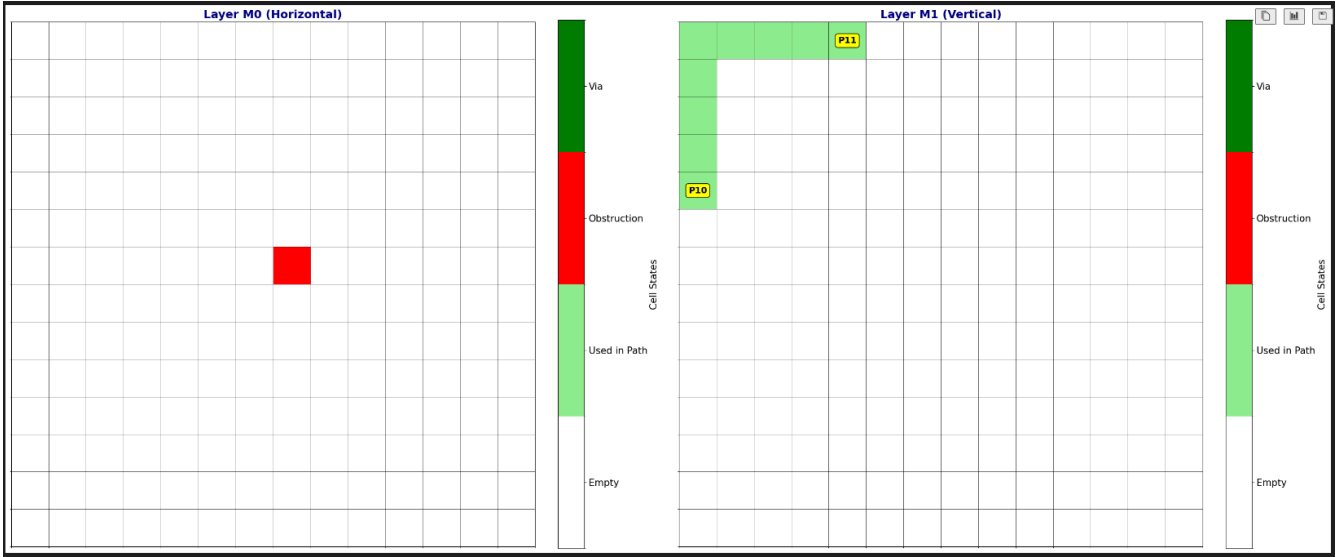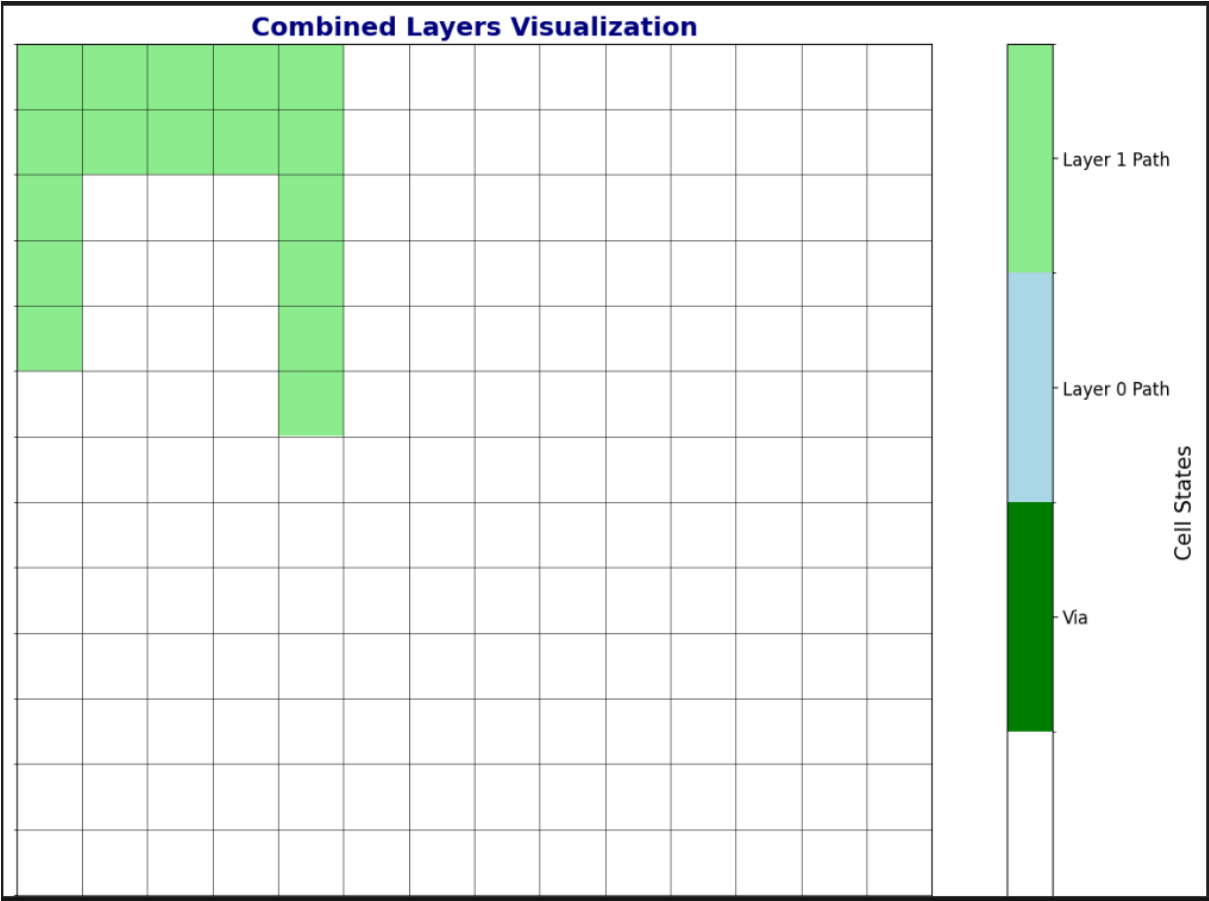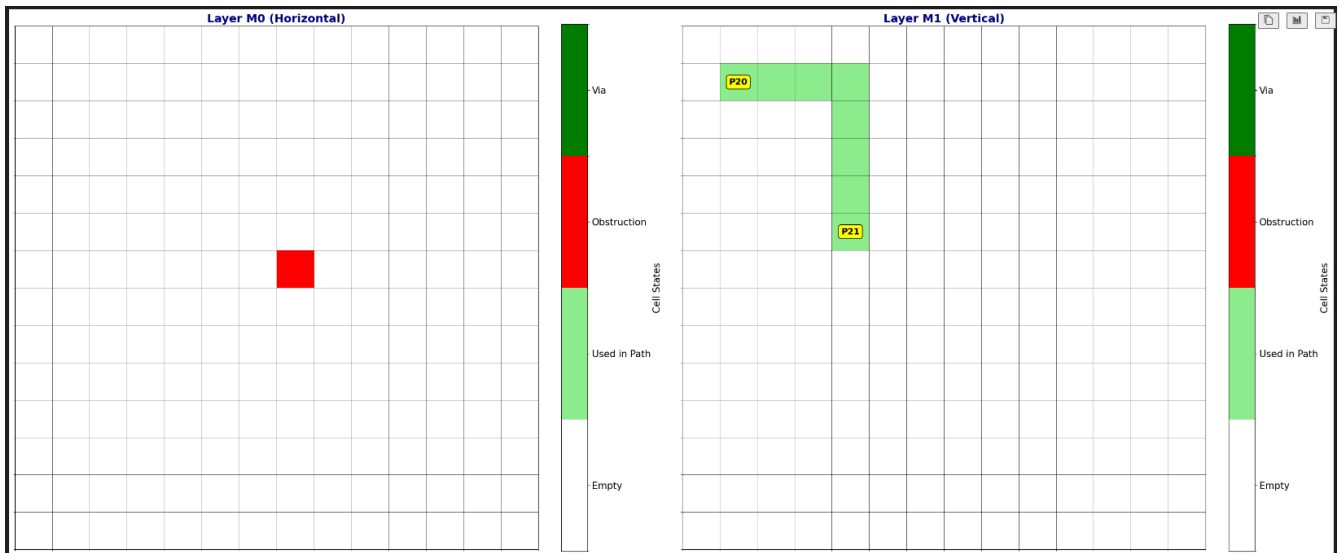
Figure 26: net1

Figure 27: net2

- **Tracing:**

  ⇒ **Net:** net2

  ‣ **Path 1** begins at (1, 1, 12) in Layer M1 and moves vertically along the y-axis (rows), traveling through (1, 2, 12) to (1, 4, 12). At (1, 4, 12), the path changes direction and moves horizontally along the x-axis (columns), traveling through (1, 4, 11) to (1, 4, 8), where it terminates.

  ⇒ **Net:** net1

  ‣ **Path 1** begins at (1, 0, 9) in Layer M1 and moves horizontally along the x-axis (columns), traveling through (1, 0, 10) to (1, 0, 13). At (1, 0, 13), the path changes direction and moves vertically along the y-axis (rows), traveling through (1, 1, 13) to (1, 4, 13), where it terminates.

Test Case 12: (With Bonus)

- **Input:**

  15, 15, 10, 5
  OBS (0, 4, 4)
  OBS (0, 5, 5)
  OBS (1, 6, 6)
  OBS (0, 7, 7)
  OBS (1, 10, 10)
  net1 (0, 0, 0) (0, 3, 3) (1, 9, 9)
  net2 (0, 1, 2) (1, 5, 6) (0, 11, 11)
  net3 (0, 2, 1) (0, 4, 5) (1, 8, 8) (0, 13, 13)
  net4 (1, 0, 5) (1, 4, 10) (0, 10, 12)
  net5 (0, 3, 3) (1, 9, 4) (0, 14, 14)

- **Output:**

```
===================================================
Ordered Nets with Pin Details
===================================================
Order Net Name  Pin Details (Layer, X, Y)
---------------------------------------------------
1      net4
        Pin 1: Layer=1, X=0, Y=5
        Pin 2: Layer=1, X=4, Y=10
        Pin 3: Layer=0, X=10, Y=12
---------------------------------------------------
2      net5
        Pin 1: Layer=0, X=3, Y=3
        Pin 2: Layer=1, X=9, Y=4
        Pin 3: Layer=0, X=14, Y=14
---------------------------------------------------
3      net1
        Pin 1: Layer=0, X=0, Y=0
        Pin 2: Layer=0, X=3, Y=3
        Pin 3: Layer=1, X=9, Y=9
---------------------------------------------------
4      net2
        Pin 1: Layer=0, X=1, Y=2
        Pin 2: Layer=1, X=5, Y=6
        Pin 3: Layer=0, X=11, Y=11
---------------------------------------------------
5      net3
        Pin 1: Layer=0, X=2, Y=1
        Pin 2: Layer=0, X=4, Y=5
        Pin 3: Layer=1, X=8, Y=8
        Pin 4: Layer=0, X=13, Y=13
---------------------------------------------------
===================================================
Error: Unable to find a path for net 'net1'.
===================================================
Routed Nets Summary
===================================================
```

Net 'net4':

  Path 1: [(1, 0, 5), (1, 0, 6), (1, 0, 7), (1, 0, 8), (1, 0, 9), (1, 0, 10), (0, 0, 10), (0, 1, 10), (0, 2, 10), (0, 3, 10), (0, 4, 10), (1, 4, 10)]

  Length for Path 1: 12

  Cost for Path 1: 21

  ******

  Path 2: [(1, 4, 10), (1, 4, 11), (1, 4, 12), (0, 4, 12), (0, 5, 12), (0, 6, 12), (0, 7, 12), (0, 8, 12), (0, 9, 12), (0, 10, 12)]

  Length for Path 2: 10

  Cost for Path 2: 14

  ******

 Total Wire Length for 'net4': 22

 Total Cost for 'net4': 35

Net 'net5':

  Path 1: [(0, 3, 3), (0, 4, 3), (0, 5, 3), (0, 6, 3), (0, 7, 3), (0, 8, 3), (0, 9, 3), (1, 9, 3), (1, 9, 4)]

  Length for Path 1: 9

  Cost for Path 1: 13

  ******

  Path 2: [(1, 9, 4), (1, 10, 4), (1, 11, 4), (1, 11, 5), (1, 11, 6), (1, 11, 7), (1, 11, 8), (1, 11, 9), (1, 11, 10), (1, 11, 11), (1, 11, 12), (1, 11, 13), (1, 11, 14), (0, 11, 14), (0, 12, 14), (0, 13, 14), (0, 14, 14)]

  Length for Path 2: 17

  Cost for Path 2: 41

  ******

 Total Wire Length for 'net5': 26

 Total Cost for 'net5': 54

Net 'net1':

  Path 1: [(0, 0, 0), (0, 1, 0), (0, 2, 0), (0, 3, 0), (1, 3, 0), (1, 3, 1), (1, 3, 2), (1, 3, 3), (1, 3, 4), (1, 3, 5), (1, 3, 6), (1, 3, 7), (1, 3, 8), (1, 3, 9), (0, 3, 9), (0, 4, 9), (0, 5, 9), (0, 6, 9), (0, 7, 9), (0, 8, 9), (0, 9, 9), (1, 9, 9)]

  Length for Path 1: 22

  Cost for Path 1: 36

  ******

 Total Wire Length for 'net1': 22

 Total Cost for 'net1': 36

Net 'net2':

  Path 1: [(0, 1, 2), (0, 2, 2), (0, 3, 2), (0, 4, 2), (0, 5, 2), (1, 5, 2), (1, 5, 3), (1, 5, 4), (1, 5, 5), (1, 5, 6)]

  Length for Path 1: 10

  Cost for Path 1: 14

  ******

  Path 2: [(1, 5, 6), (1, 5, 7), (1, 5, 8), (1, 5, 9), (1, 5, 10), (1, 5, 11), (0, 5, 11), (0, 6, 11), (0, 7, 11), (0, 8, 11), (0, 9, 11), (0, 10, 11), (0, 11, 11)]

  Length for Path 2: 13

  Cost for Path 2: 17

  ******

 Total Wire Length for 'net2': 23

 Total Cost for 'net2': 31

```
--------------------------------------------------
Net 'net3':
--------------------------------------------------
  Path 1: [(0, 2, 1), (0, 3, 1), (0, 4, 1), (1, 4, 1), (1, 4, 2), (1, 4, 3), (1, 4,
4), (1, 4, 5), (0, 4, 5)]
  Length for Path 1: 9
  Cost for Path 1: 18
  ******
  Path 2: [(1, 4, 5), (1, 4, 6), (1, 4, 7), (1, 4, 8), (0, 4, 8), (0, 5, 8), (0, 6,
8), (0, 7, 8), (0, 8, 8), (1, 8, 8)]
  Length for Path 2: 10
  Cost for Path 2: 19
  ******
  Path 3: [(1, 8, 8), (1, 8, 9), (1, 8, 10), (1, 8, 11), (1, 8, 12), (1, 8, 13), (0,
8, 13), (0, 9, 13), (0, 10, 13), (0, 11, 13), (0, 12, 13), (0, 13, 13)]
  Length for Path 3: 12
  Cost for Path 3: 16
  ******
 Total Wire Length for 'net3': 31
 Total Cost for 'net3': 53
--------------------------------------------------

Summary
==================================================
Longest Route Length: 22
Net with Longest Route: 'net1'
Path Number of Longest Route: 1
Total Wire Length Across All Nets: 124
Total cost of the routing is: 209
==================================================
```
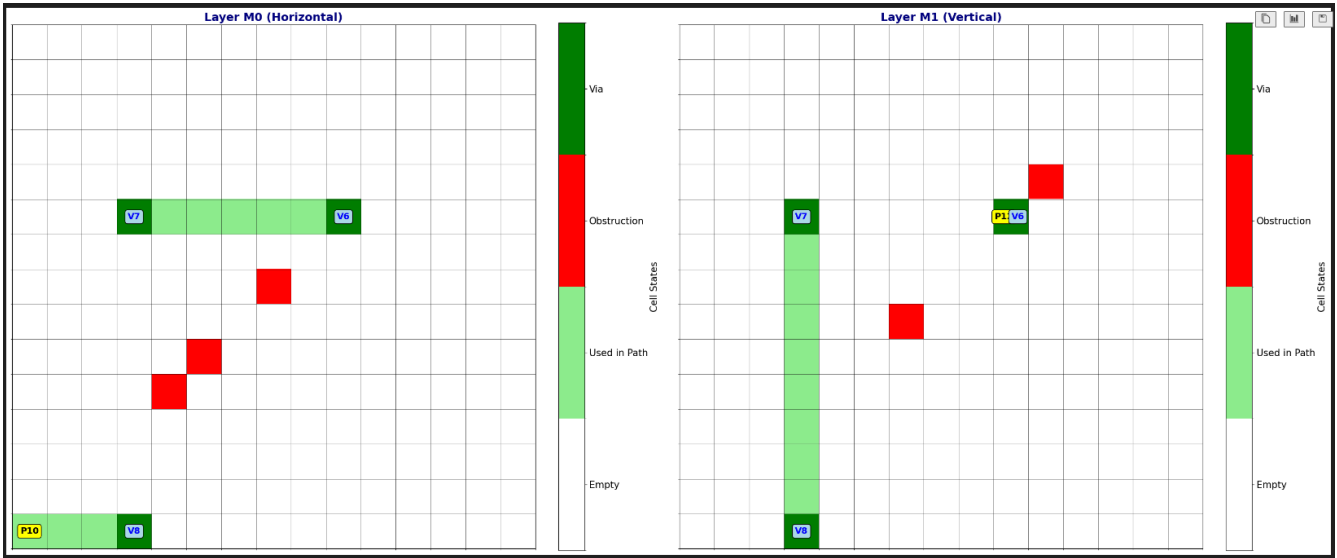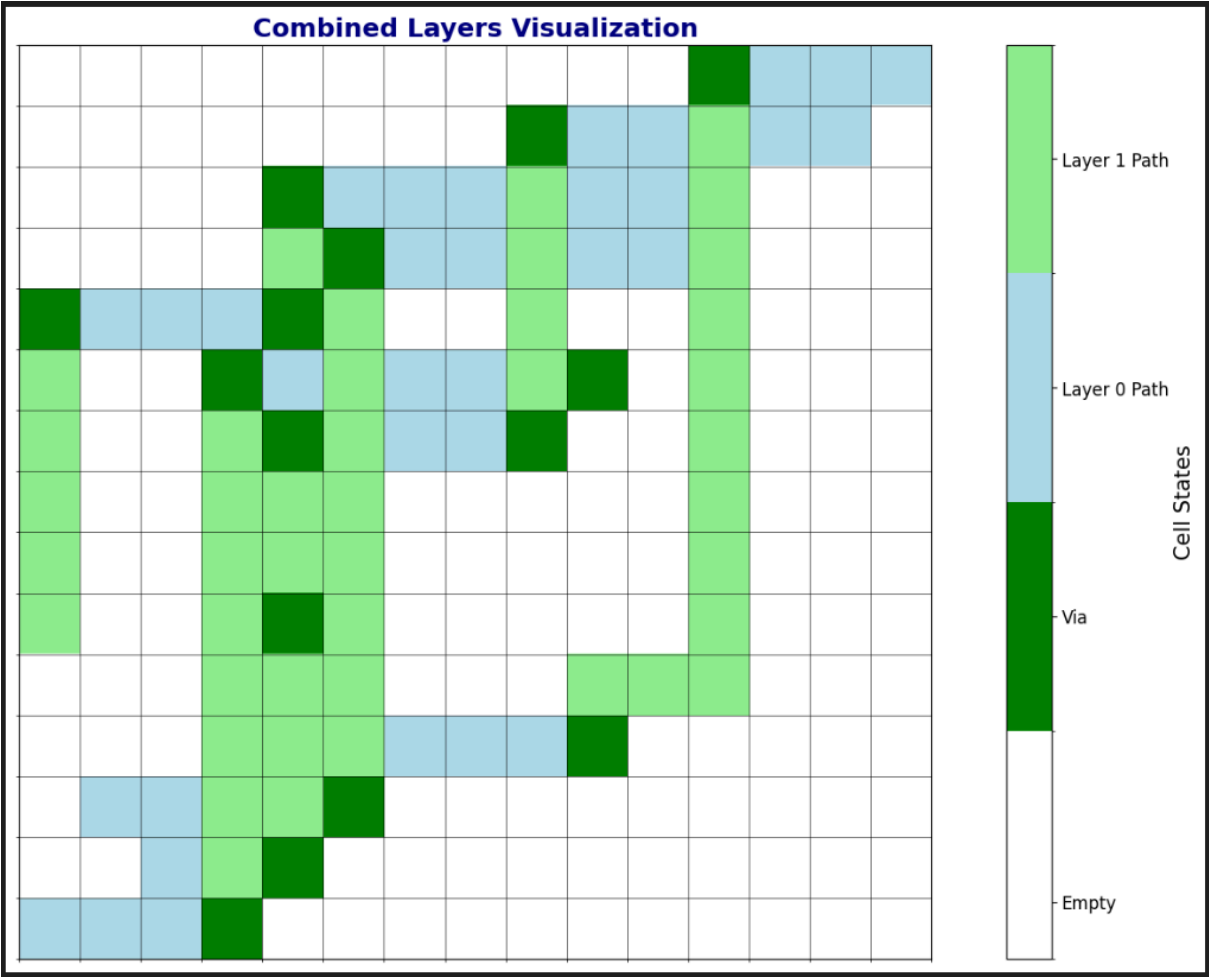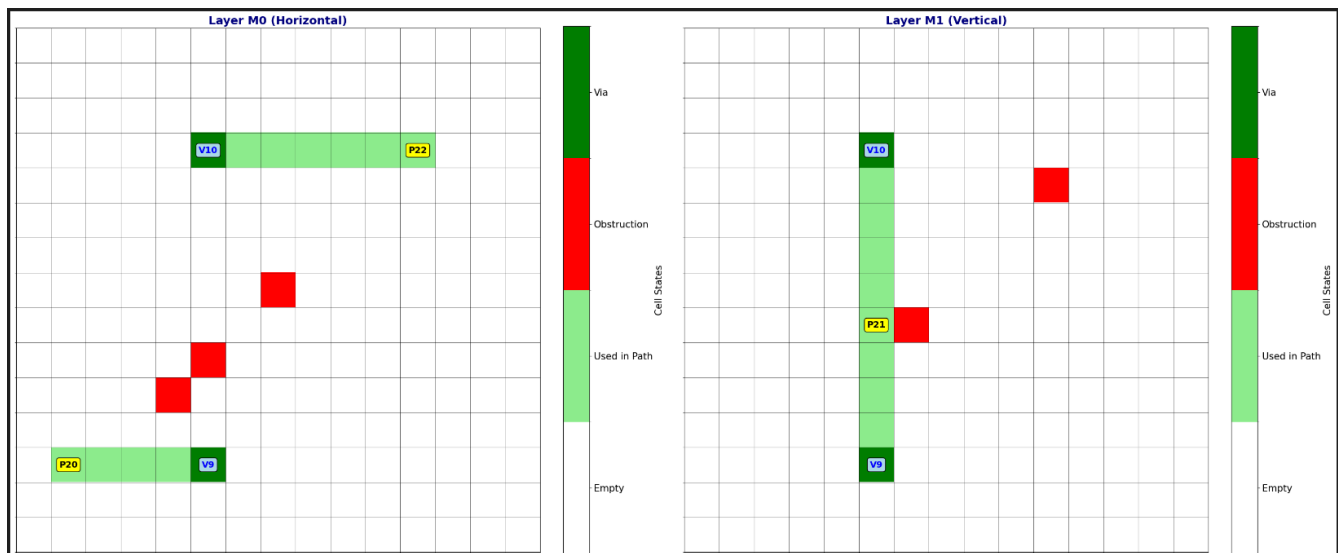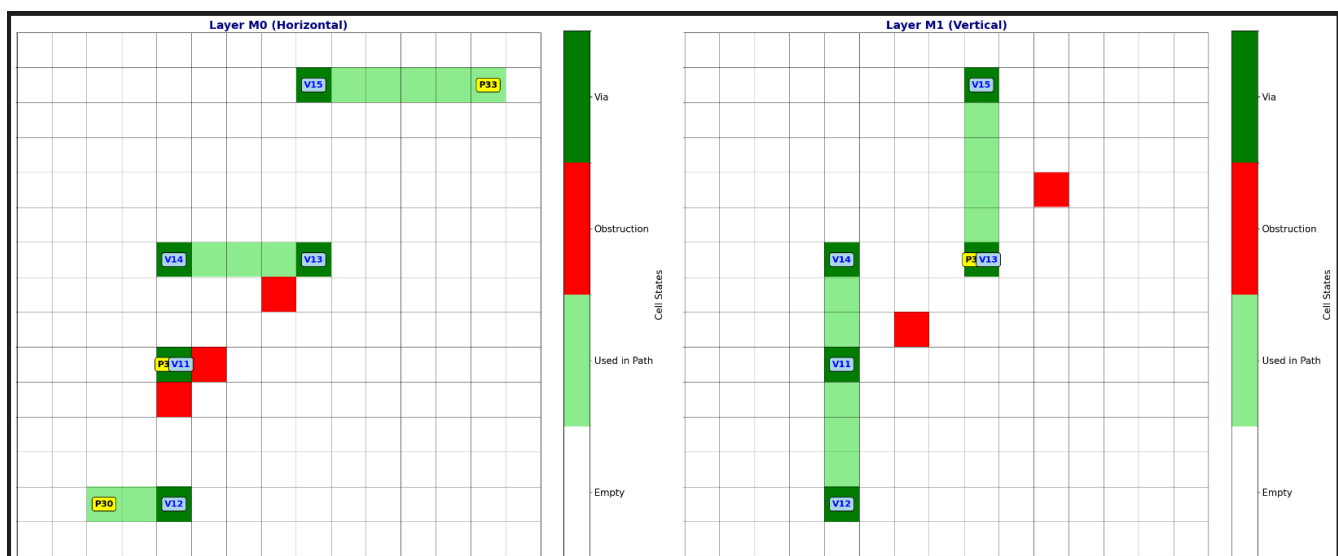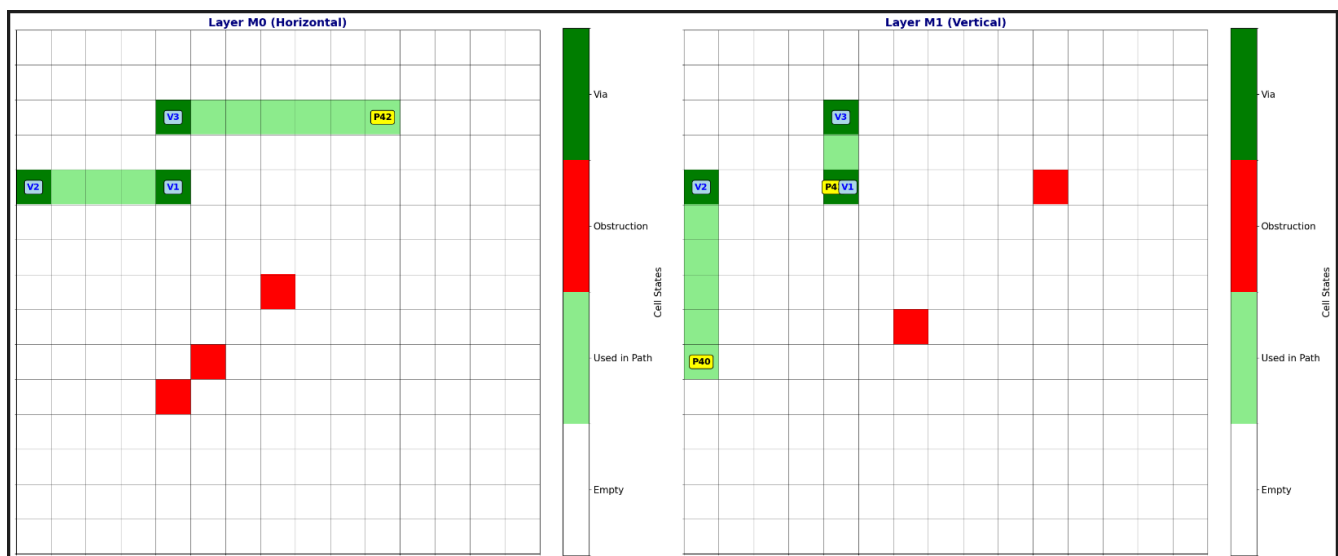
Figure 28: net1

Figure 29: net2

Figure 30: net3

Figure 31: net4

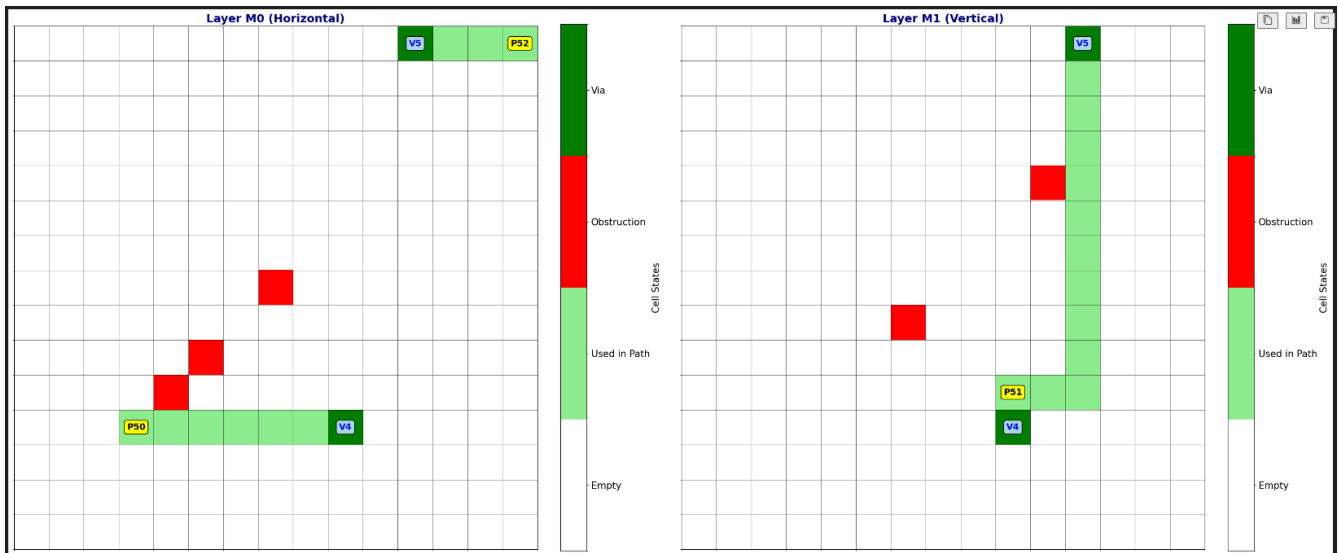Figure 32: net5

- **Tracing:**

⇒ **Net:** net4

‣ **Path 1** begins at (1, 0, 5) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 0, 5) to (1, 4, 5). At (1, 4, 5), it transitions to Layer M0 via a via. From (0, 4, 5), the path moves horizontally along the x-axis (columns), traveling through (0, 5, 5) to (0, 10, 5). Finally, it transitions back to Layer M1 via another via at (0, 10, 5) and terminates at (1, 10, 10).

‣ **Path 2** starts at (1, 4, 10) in Layer M1 and moves vertically along the y-axis (rows), traveling from (1, 4, 10) to (0, 4, 12) where it transitions back to Layer M0 via a via. From (0, 4, 12), the path moves horizontally along the x-axis (columns) through (0, 5, 12) to (0, 10, 12) where it terminates.

⇒ **Net:** net5

‣ **Path 1** begins at (0, 3, 3) in Layer M0 and moves horizontally along the x-axis (columns), traveling from (0, 3, 3) to (0, 9, 3). At (0, 9, 3), it transitions to Layer M1 via a via and continues to (1, 9, 4), where it terminates.

‣ **Path 2** starts at (1, 9, 4) in Layer M1 and moves vertically along the y-axis (rows) through (1, 9, 5) to (1, 11, 5). At (1, 11, 5), it transitions back to Layer M0 via a via. From (0, 11, 14), the path moves horizontally along the x-axis (columns) through (0, 12, 14) to (0, 14, 14), where it terminates.

⇒ **Net:** net1

‣ **Path 1** begins at (0, 0, 0) in Layer M0 and moves horizontally along the x-axis (columns), traveling from (0, 0, 0) to (0, 12, 0).At (0, 12, 0), it transitions to Layer M1 via a via. From (1, 12, 0), the path continues vertically along the y-axis (rows), traveling from (1, 12, 0) to (1, 12, 9), where it terminates.

⇒ **Net:** net2

‣ **Path 1** begins at (0, 1, 2) in Layer M0 and travels vertically along the y-axis (rows), moving through (0, 3, 2) to (0, 5, 2). At (0, 5, 2), it transitions to Layer M1 via a via. From (1, 5, 2), the

path continues vertically along the y-axis (rows), moving from (1, 5, 2) to (1, 5, 6), where it terminates.

▸ **Path 2** starts at (1, 5, 6) in Layer M1 and moves vertically along the y-axis (rows), traveling through (1, 5, 7) to (1, 5, 12) where it transitions to Layer M0 via a via at (0, 5, 12). From (0, 5, 12), the path moves horizontally along the x-axis (columns) through (0, 12, 12) where it terminates.

⇒ **Net:** net3

▸ **Path 1** begins at (0, 2, 1) in Layer M0 and moves horizontally along the x-axis (columns), traveling from (0, 2, 1) to (1, 2, 5). At (1, 4, 5), the path moves vertically to layer 0