Simulation Layout Editor

User Manual

Version 2.0

A visual editor for creating discrete event simulation layouts with support for manufacturing systems, AGV routing, and process modeling.

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Contents

Chapter 1

Introduction

1.1 Overview

The **Simulation Layout Editor** is a visual design tool for creating discrete event simulation layouts. It provides an intuitive interface for designing manufacturing floors, production lines, warehouse systems, and other process-oriented environments.

1.1.1 Key Features

- **Visual Layout Design** – Drag-and-drop placement of simulation elements

- **Multiple Node Types** – Sources, sinks, machines, buffers, workstations, and more

- **Path Routing** – Single and double lane paths with direct or Manhattan routing

- **Simulation Parameters** – Configure process times, capacities, and distributions

- **Validation** – Automatic detection of layout issues

- **JSON Export** – Standard format for simulation engine consumption

- **Icon Library** – 40+ industrial vector icons

1.1.2 System Requirements

Component	Requirement
Operating System	Windows 10/11 (64-bit)
Runtime	.NET 8.0 Desktop Runtime
Memory	4 GB RAM minimum
Display	1280 × 720 minimum resolution

Table 1.1: System requirements

1.2 Installation

1.2.1 Prerequisites

Ensure the .NET 8.0 Desktop Runtime is installed. Download from:

https://dotnet.microsoft.com/download/dotnet/8.0

1.2.2   Running the Application

1. Extract the `LayoutEditor.zip` archive

2. Navigate to the extracted folder

3. Run `dotnet build` to compile

4. Run `dotnet run` to start the application

Alternatively, if you have a compiled executable:

1. Double-click `LayoutEditor.exe`

Chapter 2

User Interface

2.1 Main Window Layout

The application window is divided into several functional areas:

```
+----------------------------------------------------------------+
|  Menu Bar                                                      |
+----------------------------------------------------------------+
|  Toolbar (File, Edit, Tools, Zoom, Validation)                |
+-----------+----------------------------------+---------------+
|           |                                  |               |
|  Toolbox  |                                  |  Properties   |
|  & Layers |            Canvas Area           |    Panel      |
|           |                                  |               |
|  - Nodes  |      [Grid and Layout Elements]  |  - Basic Info |
|  - Layers |                                  |  - Position   |
|  - Elements|                       [Minimap] |  - Simulation |
|           |                                  |               |
+-----------+----------------------------------+---------------+
|  Status Bar (Mode, Coordinates, Units, Counts)                |
+----------------------------------------------------------------+
```
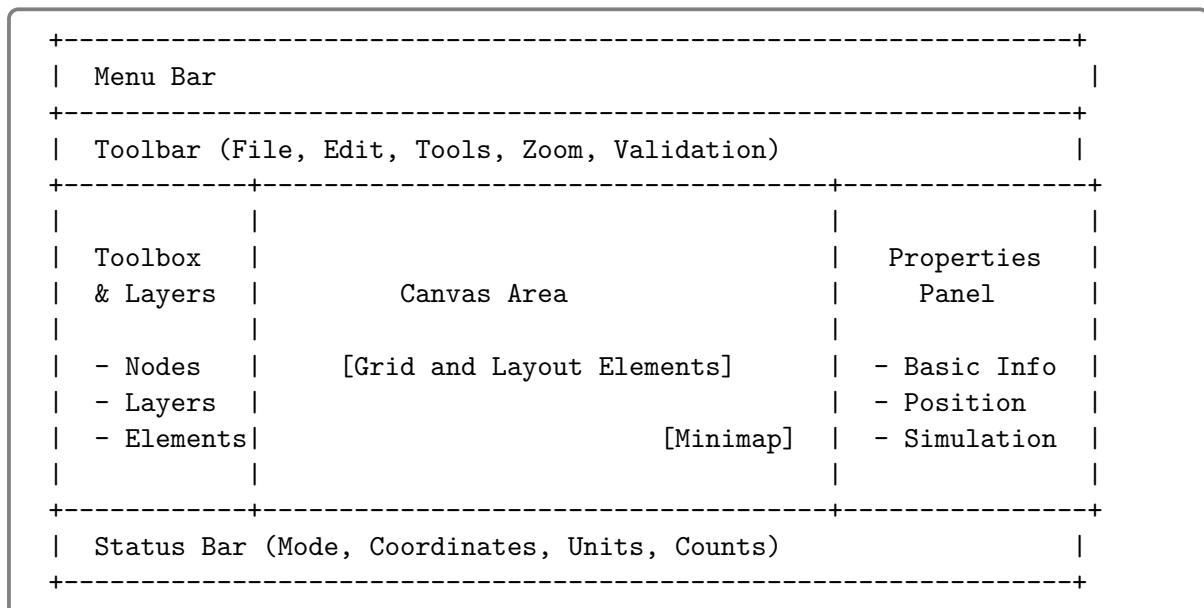
Figure 2.1: Main window layout

2.2 Menu Bar

2.2.1 File Menu

Command	Shortcut	Description
New	`Ctrl+N`	Create a new empty layout
Open	`Ctrl+O`	Open an existing layout file
Save	`Ctrl+S`	Save current layout
Save As	–	Save with a new filename
Import Background	–	Load a floor plan image
Import DXF	–	Import CAD drawing (future)

Command	Shortcut	Description
Export for Simulation	–	Export simulation-ready JSON
Export as Image	–	Save canvas as image (future)
Exit	–	Close application

Table 2.1: File menu commands

2.2.2 Edit Menu

Command	Shortcut	Description
Undo	`Ctrl+Z`	Undo last action (50 levels)
Redo	`Ctrl+Y`	Redo undone action
Cut	`Ctrl+X`	Cut selected elements
Copy	`Ctrl+C`	Copy selected elements
Paste	`Ctrl+V`	Paste elements
Delete	`Delete`	Delete selected elements
Select All	`Ctrl+A`	Select all nodes
Group	`Ctrl+G`	Group selected nodes
Ungroup	`Ctrl+Shift+G`	Ungroup selection

Table 2.2: Edit menu commands

2.2.3 View Menu

Command	Shortcut	Description
Zoom In	`Ctrl++`	Increase zoom level
Zoom Out	`Ctrl+-`	Decrease zoom level
Zoom to Fit	`Ctrl+0`	Fit all content in view
Reset Zoom	–	Return to 100% zoom
Show Grid	–	Toggle grid visibility
Show Rulers	–	Toggle ruler visibility
Show Minimap	–	Toggle minimap overlay
Show Labels	–	Toggle node labels
Snap to Grid	–	Toggle grid snapping
Show Alignment Guides	–	Toggle alignment guides

Table 2.3: View menu commands

2.3 Toolbar

The toolbar provides quick access to common operations:

2.4 Left Panel: Toolbox & Layers

2.4.1 Node Toolbox

The toolbox contains all available node types organized by category:

Icon	Name	Function
▌	New	Create new layout
▐	Open	Open existing file
▤	Save	Save current file
↺	Undo	Undo last action
↻	Redo	Redo action
↖	Select	Selection mode (default)
✋	Pan	Pan/scroll mode
→	Path	Draw path mode
■	Zone	Draw zone mode
▬	Zoom Out	Decrease zoom
✚	Zoom In	Increase zoom
✔	Validate	Run validation

Table 2.4: Toolbar buttons

Sources & Sinks

- **Source** – Entry point for entities into the system

- **Sink/Exit** – Exit point where entities leave the system

Processing

- **Machine** – Processing station with configurable process time

- **Workstation** – Manual or semi-automated work area

- **Inspection** – Quality control checkpoint

Buffers & Storage

- **Buffer (FIFO)** – First-in-first-out queue

- **Storage/Rack** – General storage area

Transport

- **Conveyor** – Material transport line

- **Junction** – Path intersection point

- **AGV Station** – Automated guided vehicle stop

2.4.2   Layers Panel

Control visibility of different element types:

- **Background** – Floor plan or reference image

- **Corridors** – AGV/transport corridors

- **Zones** – Restricted or special areas

- **Paths** – Connection lines between nodes

- **Nodes** – All simulation elements

- **Labels** – Node names and identifiers

2.4.3   Elements List

Displays all nodes and paths in the current layout. Click an item to select it on the canvas.

2.5   Right Panel: Properties

The properties panel shows details of the selected element.

2.5.1   Node Properties

Basic Information

- **ID** – Unique identifier (read-only)

- **Type** – Node type (source, machine, etc.)

- **Name** – Descriptive name

- **Label** – Short label shown on canvas

Position & Size

- **X, Y** – Canvas coordinates

- **Width, Height** – Node dimensions

- **Rotation** – Rotation angle in degrees

Visual

- **Icon** – Visual representation

- **Color** – Node color (hex format)

- **Label Position** – Bottom, Top, Left, Right, Center

Simulation Parameters

Parameters vary by node type. See Chapter 5 for details.

2.5.2   Path Properties

- **From/To** – Connected nodes

- **Path Type** – Single or Double lane

- **Routing Mode** – Direct, Manhattan, or Corridor

- **Transport Type** – Conveyor, AGV, Manual, Crane

- **Speed** – Transport speed

- **Capacity** – Maximum entities on path

2.6   Canvas Area

The central canvas is where you design your layout.

2.6.1   Navigation

Action	How To
Pan	Hold `Space` and drag, or use Pan tool
Zoom In/Out	`Ctrl` + Mouse Wheel
Zoom to Fit	`Ctrl+0` or toolbar button

Table 2.5: Canvas navigation

2.6.2   Grid and Snapping

- Grid lines help align elements

- When "Snap to Grid" is enabled, elements align to grid intersections

- Default grid size is 20 pixels

2.6.3   Minimap

The minimap in the bottom-right corner shows an overview of the entire layout. The blue rectangle indicates the current viewport.

2.7   Status Bar

The status bar displays:

- **Status** – Current operation or message

- **Mode** – Active tool (Select, Pan, Path, etc.)

- **Coordinates** – Mouse position in current units

- **Units** – Current measurement unit (meters, feet, pixels)

- **Counts** – Number of nodes and paths

- **File** – Current filename and save status

Chapter 3

Working with Nodes

3.1 Adding Nodes

There are several ways to add nodes to the canvas:

3.1.1 Method 1: Toolbox Button

1. Click a node type button in the left toolbox

2. The node appears at the center of the visible canvas

3. Drag to reposition as needed

3.1.2 Method 2: Right-Click Menu

1. Right-click on the canvas at the desired location

2. Select `Add Node Here` from the context menu

3. Choose the node type from the submenu

> **♀ Tip**
>
> Using the right-click method places the node exactly where you click, saving time on positioning.

3.2 Selecting Nodes

Action	Result
Click node	Select single node (deselects others)
`Ctrl` + Click	Toggle node in selection
`Shift` + Click	Add node to selection
`Ctrl+A`	Select all nodes
Click empty space	Deselect all

Table 3.1: Selection methods

Selected nodes display a blue glow effect and thicker borders.

3.3 Moving Nodes

1. Select one or more nodes

2. Click and drag any selected node

3. All selected nodes move together

4. Release to place

> **ⓘ Note**
>
> When "Snap to Grid" is enabled, nodes automatically align to grid points while dragging.

3.4 Editing Node Properties

1. Select a single node

2. View properties in the right panel

3. Edit values directly in the text fields

4. Changes apply immediately

3.5 Duplicating Nodes

1. Select one or more nodes

2. Right-click and select `Duplicate`

3. Copies appear offset from originals

4. New nodes are automatically selected

3.6 Deleting Nodes

1. Select nodes to delete

2. Press `Delete` or use `Edit > Delete`

> **⚠ Warning**
>
> Deleting a node also deletes all paths connected to it.

3.7 Aligning Multiple Nodes

When multiple nodes are selected, alignment tools appear in the properties panel:

- **Align Left** – Align to leftmost node

- **Align Top** – Align to topmost node

- **Distribute Horizontally** – Equal horizontal spacing

- **Distribute Vertically** – Equal vertical spacing

Chapter 4

Working with Paths

4.1   Path Concepts

Paths represent material flow or entity movement between nodes. Each path has:

- A **source node** (where entities come from)
- A **destination node** (where entities go)
- Optional **waypoints** for custom routing
- **Visual properties** (color, thickness, style)
- **Simulation properties** (speed, capacity, transport type)

4.2   Path Types

4.2.1   Single Lane

Standard unidirectional path. Drawn as a single line with an arrow indicating direction.

4.2.2   Double Lane

Higher-capacity path rendered as two parallel lines. Useful for:

- High-throughput connections
- Bidirectional transport (visual indication)
- Multi-lane conveyors

4.3   Routing Modes

4.3.1   Direct Routing

Straight line from source to destination. Best for:

- Short connections
- Adjacent nodes
- Simple layouts

4.3.2 Manhattan Routing

Paths use only horizontal and vertical segments (90° turns). Best for:

- Grid-based layouts

- Conveyor systems

- Clean, organized appearance

4.4 Creating Paths

4.4.1 Method 1: Path Tool

1. Select the Path tool from the toolbar (or press `P`)

2. Click the source node

3. (Optional) `Ctrl` + Click to add waypoints

4. Click the destination node

4.4.2 Method 2: Right-Click Menu

1. Right-click on the source node

2. Select `Start Path From Here`

3. Right-click on the destination node

4. Select `End Path Here`

4.4.3 Setting Path Options Before Drawing

Before creating a path, set options in the toolbar:

- **Path Type** dropdown – Single or Double

- **Manhattan** checkbox – Enable orthogonal routing

4.5 Adding Waypoints

Waypoints allow custom path routing:

1. Start path drawing (click source node)

2. Hold `Ctrl` and click to add waypoint

3. Add additional waypoints as needed

4. Click destination node to complete

> **♀ Tip**
>
> Waypoints are useful for routing paths around obstacles or through specific corridors.

4.6   Editing Paths

1. Click on a path line to select it (or use Elements list)

2. Edit properties in the right panel

3. Changes to From/To reconnect the path to different nodes

4.7   Deleting Paths

1. Select the path

2. Press `Delete` or click [Delete Path] in properties panel

Chapter 5

Simulation Parameters

5.1 Overview

Each node type has specific simulation parameters that control behavior during simulation execution.

5.2 Statistical Distributions

Many parameters use statistical distributions to model variability:

Distribution	Parameters	Use Case
Constant	Value	Fixed times
Exponential	Mean (μ)	Random arrivals
Normal	Mean (μ), Std Dev (σ)	Natural variation
Uniform	Min, Max	Equal probability range
Triangular	Min, Mode, Max	Estimated ranges
Weibull	Shape (k), Scale (λ)	Failure modeling

Table 5.1: Available statistical distributions

5.3 Node-Specific Parameters

5.3.1 Source Nodes

Parameter	Description
Interarrival Time	Time between entity arrivals (distribution)
Entity Type	Type/class of generated entities
Batch Size	Number of entities per arrival
Max Arrivals	Limit on total arrivals (optional)

Table 5.2: Source node parameters

> **ⓘ Note**
>
> For an arrival rate of λ entities per hour, set the interarrival time to an exponential distribution with mean $\mu = 60/\lambda$ minutes.

5.3.2 Machine & Workstation Nodes

Parameter	Description
Servers	Number of parallel processing units
Capacity	Maximum entities that can be processed simultaneously
Process Time	Time to process one entity (distribution)
Setup Time	Time between different entity types (optional)
MTBF	Mean Time Between Failures (hours)
MTTR	Mean Time To Repair (minutes)

Table 5.3: Machine/Workstation parameters

5.3.3 Buffer & Storage Nodes

Parameter	Description
Capacity	Maximum number of entities
Initial Level	Entities present at simulation start
Queue Discipline	FIFO, LIFO, or Priority
Blocking Mode	Behavior when full

Table 5.4: Buffer/Storage parameters

5.3.4 Inspection Nodes

Parameter	Description
Servers	Number of inspection stations
Process Time	Inspection duration (distribution)

Table 5.5: Inspection node parameters

5.3.5 Sink Nodes

5.4 Path Parameters

Parameter	Description
Collect Statistics	Enable/disable output statistics collection

Table 5.6: Sink node parameters

Parameter	Description
Transport Type	Conveyor, AGV, Manual, or Crane
Speed	Transport velocity (units per time)
Capacity	Maximum entities on path simultaneously
Distance	Path length (auto-calculated or manual)
Lanes	Number of parallel lanes
Bidirectional	Allow two-way travel

Table 5.7: Path simulation parameters

Chapter 6

Validation

6.1 Overview

The validation system checks your layout for potential issues before simulation. Run validation via:

- `Validate > Validate Layout`

- Toolbar validate button

- Keyboard shortcut `F5`

6.2 Validation Rules

6.2.1 Error-Level Issues

Errors indicate problems that will likely cause simulation failures:

Code	Description
ZERO_SERVERS	Machine has 0 servers configured
ZERO_CAPACITY	Buffer has 0 capacity
MISSING_PROCESS_TIME	Machine lacks process time distribution
MISSING_INTERARRIVAL	Source lacks interarrival time
INVALID_DISTRIBUTION	Distribution parameters are invalid
UNREACHABLE_SINK	No path exists from any source to sink

Table 6.1: Error-level validation issues

6.2.2 Warning-Level Issues

Warnings indicate potential problems or unusual configurations:

6.3 Interpreting Results

The validation status appears in the toolbar:

- ✔ Valid – No issues found

- ⚠ X errors, Y warnings – Issues detected

Click the validation button to see a detailed report of all issues.

Code	Description
DISCONNECTED_NODE	Node has no incoming or outgoing paths
ORPHAN_SOURCE	Source has no outgoing paths
ORPHAN_SINK	Sink has no incoming paths
NO_SOURCES	Layout has no source nodes
NO_SINKS	Layout has no sink nodes
OVERLAPPING_NODES	Two nodes visually overlap
PATH_CROSSES_RESTRICTED	Path goes through restricted zone

Table 6.2: Warning-level validation issues

Chapter 7

File Operations

7.1 File Format

Layouts are saved as JSON files with the `.json` extension. The format includes:

- Metadata (name, author, units)
- Canvas settings
- Templates
- All nodes with visual and simulation properties
- All paths with routing and transport settings
- Zones and groups
- Display preferences

7.2 Saving Layouts

7.2.1 Save

`Ctrl+S` saves to the current file. If no file exists, prompts for filename.

7.2.2 Save As

Creates a new file with a different name, leaving the original unchanged.

7.3 Opening Layouts

`Ctrl+O` opens a file browser to select an existing layout file.

> ⚠ **Warning**
>
> Opening a file replaces the current layout. Save your work first if needed.

7.4 Exporting for Simulation

`File > Export for Simulation` creates a streamlined JSON file containing only simulation-relevant data (removes visual properties for smaller file size).

7.5   Importing Background Images

1. `File > Import Background`

2. Select an image file (PNG, JPG, BMP)

3. Adjust opacity in canvas settings

4. Use as reference for node placement

> **♀ Tip**
>
> Set background opacity to 20-30% for best visibility while still seeing your layout elements.

Chapter 8

Keyboard Shortcuts

8.1 Quick Reference

Shortcut	Action
File Operations	
`Ctrl+N`	New layout
`Ctrl+O`	Open layout
`Ctrl+S`	Save layout
Edit Operations	
`Ctrl+Z`	Undo
`Ctrl+Y`	Redo
`Ctrl+X`	Cut
`Ctrl+C`	Copy
`Ctrl+V`	Paste
`Delete`	Delete selected
`Ctrl+A`	Select all
`Ctrl+G`	Group selected
`Ctrl+Shift+G`	Ungroup
View Operations	
`Ctrl+Scroll`	Zoom in/out
`Ctrl+0`	Zoom to fit
`Space+Drag`	Pan canvas
Tools	
`Escape`	Cancel current operation
`F5`	Validate layout
Path Drawing	
`Ctrl+Click`	Add waypoint (in path mode)
Selection	
`Ctrl+Click`	Toggle selection
`Shift+Click`	Add to selection

Table 8.1: Keyboard shortcuts

Chapter 9

Best Practices

9.1 Layout Design Tips

1. **Start with sources and sinks** – Define entry and exit points first

2. **Work left-to-right** – Typical flow direction aids readability

3. **Use consistent spacing** – Enable grid snapping for alignment

4. **Group related elements** – Use the Group feature for logical sections

5. **Label clearly** – Use descriptive names for all elements

6. **Validate often** – Check for issues during design, not just at the end

9.2 Naming Conventions

Element	Suggested Format
Sources	"Raw Material Input", "Part Arrival"
Machines	"CNC Mill 1", "Drill Press A"
Buffers	"WIP Buffer", "Input Queue"
Workstations	"Assembly Station 1", "Packing"
Sinks	"Shipping", "Finished Goods Exit"

Table 9.1: Naming conventions

9.3 Performance Considerations

- Large layouts (100+ nodes) may experience slower rendering

- Disable minimap for very large layouts if needed

- Use layers to hide elements you're not currently editing

- Save frequently during extended editing sessions

Chapter 10

Troubleshooting

10.1 Common Issues

10.1.1 Application Won't Start

- Ensure .NET 8.0 Desktop Runtime is installed
- Check Windows Event Viewer for error messages
- Try running from command line to see error output

10.1.2 Cannot Save File

- Verify write permissions for the target folder
- Check if file is open in another application
- Ensure sufficient disk space

10.1.3 Nodes Not Visible

- Check if "Nodes" layer is enabled in Layers panel
- Zoom out to see if nodes are outside visible area
- Use "Zoom to Fit" (`Ctrl+0`)

10.1.4 Paths Not Connecting Properly

- Ensure you're clicking on the node, not empty space
- Check that both nodes exist and aren't deleted
- Verify "Paths" layer is visible

10.2 Getting Help

For additional support:

- Check `Help > User Guide`
- View `Help > Keyboard Shortcuts`
- Contact your simulation team administrator

Appendix A

JSON Schema Reference

A.1 Root Structure

Listing A.1: Root JSON structure

```
1  {
2    "version": "2.0",
3    "metadata": { ... },
4    "canvas": { ... },
5    "templates": [ ... ],
6    "corridors": [ ... ],
7    "nodes": [ ... ],
8    "paths": [ ... ],
9    "zones": [ ... ],
10   "groups": [ ... ],
11   "display": { ... },
12   "validation": { ... }
13 }
```

A.2 Node Object

Listing A.2: Node JSON structure

```
1  {
2    "id": "mach_001",
3    "type": "machine",
4    "name": "CNC Mill 1",
5    "label": "M1",
6    "visual": {
7      "x": 350,
8      "y": 250,
9      "width": 80,
10     "height": 60,
11     "rotation": 0,
12     "icon": "cnc_mill",
13     "color": "#4A90D9",
14     "labelPosition": "bottom",
15     "labelVisible": true
16   },
17   "simulation": {
18     "servers": 1,
19     "capacity": 1,
```

```json
20      "processTime": {
21        "distribution": "triangular",
22        "min": 8.0,
23        "mode": 10.0,
24        "max": 15.0,
25        "unit": "minutes"
26      },
27      "mtbf": 480,
28      "mttr": 30
29    }
30  }
```

A.3   Path Object

Listing A.3: Path JSON structure

```json
1  {
2    "id": "path_001",
3    "from": "src_001",
4    "to": "buf_001",
5    "pathType": "single",
6    "routingMode": "direct",
7    "visual": {
8      "color": "#888888",
9      "thickness": 2,
10     "style": "solid",
11     "arrowSize": 8,
12     "laneSpacing": 6,
13     "waypoints": []
14   },
15   "simulation": {
16     "transportType": "conveyor",
17     "speed": 1.0,
18     "capacity": 10,
19     "lanes": 1,
20     "bidirectional": false
21   }
22 }
```

Appendix B

Icon Reference

B.1 Available Icons

Category	Icon Key	Description
Sources	source_arrow	Arrow indicating entry
	source_funnel	Funnel shape
	source_truck	Truck/delivery icon
Sinks	exit_flag	Finish flag
	exit_door	Door/exit
	exit_arrow	Arrow indicating exit
Machines	machine_generic	Generic machine
	cnc_mill	CNC milling machine
	cnc_lathe	CNC lathe
	robot_arm	Robotic arm
	press	Press machine
	drill	Drill press
Buffers	buffer_fifo	FIFO queue
	buffer_lifo	LIFO stack
	buffer_rack	Storage rack
	buffer_pallet	Pallet storage
Stations	workstation	General workstation
	assembly	Assembly station
	inspection	Inspection point
Transport	conveyor	Conveyor belt
	agv	Automated guided vehicle
	junction	Path junction

Table B.1: Available icons by category

Document History

Version	Date	Changes
2.0	January 2025	Initial release of v2.0 user manual