

¹ The Keçeci Layout: A Deterministic, Order-Preserving Visualization Algorithm for Structured Systems

³ Mehmet Keçeci  ¹

⁴ 1 Independent Researcher, Türkiye

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⁵ Summary

⁶ Graph visualization is a cornerstone of network analysis, yet traditional algorithms often prioritize topological representation over the preservation of inherent node order. This can obscure sequential or procedural information critical in many scientific and structural analyses. This ⁷ paper introduces the *Keçeci Layout*, a deterministic, order-preserving graph layout algorithm ⁸ designed to arrange nodes in a structured zigzag pattern. This method provides a clear, ⁹ predictable, and structurally informative visualization for systems where the sequence of ¹⁰ nodes is meaningful. The layout is implemented in the open-source `kececelayout` Python ¹¹ package, which offers seamless interoperability with major graph analysis libraries, including ¹² NetworkX, igraph, rustworkx, Networkkit, and Graphillion. `kececelayout` is open source, ¹³ licensed under the MIT license, and the source code is available on GitHub at <https://github.com/WhiteSymmetry/kececelayout>. The version of the software described in this paper is ¹⁴ archived on Zenodo ([Keçeci, 2025g](#)). We detail the algorithm's methodology, showcase its ¹⁵ implementation, and discuss its applications as a cross-disciplinary framework for structural ¹⁶ analysis. The deterministic nature of the layout ensures that any given graph will always be ¹⁷ rendered identically, facilitating reproducible research and comparative analysis.
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²¹ Statement of Need

²² The visualization of complex networks is fundamental to understanding their structure, function, ²³ and underlying patterns. Algorithms such as force-directed layouts ([Fruchterman & Reingold, 1991](#)) are highly effective at revealing topological features like clusters and central nodes. ²⁴ However, they achieve this by optimizing node positions to minimize edge crossings and ²⁵ regularize edge lengths, a process that inherently disregards any pre-existing order among the ²⁶ nodes.
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²⁸ To address this gap, the Keçeci Layout was developed as a structural approach for interdisciplinary ²⁹ scientific analysis ([Keçeci, 2025m, 2025n, 2025o](#)). It is a deterministic algorithm that ³⁰ explicitly preserves the order of nodes, arranging them in a predictable zigzag pattern ([Keçeci, 2025d, 2025f](#)). This approach moves beyond purely topological representations to provide a ³¹ "structural thinking" framework, enabling clearer insight into ordered systems ([Keçeci, 2025c](#)). ³² As described by Keçeci ([2025l](#)), this paper describes the core principles of the Keçeci Layout, ³³ details its implementation, and highlights its utility in cross-disciplinary contexts.
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³⁵ The Keçeci Layout Algorithm

³⁶ The Keçeci Layout is fundamentally a sequential algorithm that places nodes one by one ³⁷ according to their given order. Its defining characteristic is the combination of linear progression ³⁸ along a primary axis and an alternating, expanding offset along a secondary axis. This generates

³⁹ the distinctive zigzag shape (Keçeci, 2025d). The algorithm is deterministic: for a given list of
⁴⁰ nodes and a fixed set of parameters, the resulting layout is always identical (Keçeci, 2025b).

⁴¹ Algorithmic Principles

⁴² The position of each node is determined by its index in the sorted node list. Let $N =$
⁴³ $(n_0, n_1, \dots, n_{k-1})$ be the ordered sequence of k nodes. For each node n_i at index i , its
⁴⁴ coordinates (x_i, y_i) are calculated based on four key parameters:

- ⁴⁵ ■ **primary_direction**: Defines the main axis of progression. It can be vertical ('top-down',
⁴⁶ 'bottom-up') or horizontal ('left-to-right', 'right-to-left').
- ⁴⁷ ■ **primary_spacing**: The constant distance separating consecutive nodes along the primary
⁴⁸ axis.
- ⁴⁹ ■ **secondary_spacing**: The base unit of distance for the offset along the secondary axis.
- ⁵⁰ ■ **secondary_start**: Defines the direction of the first offset on the secondary axis (e.g.,
⁵¹ 'right' or 'left' for a vertical primary axis).

⁵² The core logic for a 'top-down' primary direction is as follows:

- ⁵³ 1. **Primary Coordinate Calculation**: The primary coordinate (in this case, y) is determined
⁵⁴ by the node's index i .

$$y_i = -i \times \text{primary_spacing}$$

- ⁵⁵ 2. **Secondary Coordinate Calculation**: The secondary coordinate (x) is calculated based on
⁵⁶ an alternating and growing offset. The magnitude of the offset for node n_i is proportional
⁵⁷ to $\lceil i/2 \rceil$, and its direction depends on whether i is odd or even.

$$\text{side} = \begin{cases} 1 & \text{if } i \text{ is odd} \\ -1 & \text{if } i \text{ is even} \end{cases}$$

$$x_i = \text{start_direction} \times \lceil i/2 \rceil \times \text{side} \times \text{secondary_spacing}$$

⁵⁸ The node at index $i = 0$ is placed at the origin of the secondary axis ($x_0 = 0$).

⁵⁹ This deterministic procedure ensures that nodes are arranged sequentially, making it easy to trace
⁶⁰ paths and understand flow while effectively utilizing two-dimensional space to avoid overlap.
⁶¹ The graph-theoretic underpinnings of this structured approach facilitate cross-disciplinary
⁶² inquiry by providing a common visual language (Keçeci, 2025a).

⁶⁴ Implementation: The kec Cecilayout Package

⁶⁵ The Keçeci Layout algorithm is implemented and distributed as an open-source Python package
⁶⁶ named kec Cecilayout. The package is designed for ease of use and seamless integration with
⁶⁷ the scientific Python ecosystem.

⁶⁸ Availability and Installation

⁶⁹ The package is available on both the Python Package Index (PyPI) and Anaconda, and its
⁷⁰ source code is hosted on GitHub. It can be installed using standard package managers:

⁷¹ Using pip:

```
pip install kec Cecilayout
```

⁷² Using conda (from the 'bilgi' channel):

```
conda install -c bilgi kec Cecilayout
```

⁷³ Relevant resources, including the source code and data sets, are publicly available (Keçeci,
⁷⁴ 2025j, 2025g, 2025h, 2025i, 2025k).

75 Interoperability and Usage

76 A key design goal of the kecceilayout package is to provide a unified interface for various
77 graph libraries. The main function, kecceilayout.kecceci_layout(), automatically detects
78 the input graph type and returns a position dictionary in the format expected by that library.
79 This promotes a cross-disciplinary graphical framework by allowing researchers to use the same
80 visualization logic regardless of their preferred analysis tool (Keçeci, 2025).

81 Supported libraries include:

- 82 ■ **NetworkX**: The most popular graph analysis library in the Python data science community.
- 83 ■ **igraph**: A high-performance library widely used in academic research.
- 84 ■ **rustworkx**: A fast, thread-safe graph library written in Rust, often used in performance-critical applications.
- 85 ■ **Networkkit**: A library focused on high-performance analysis of large-scale networks.
- 86 ■ **Graphillion**: A specialized library for very large sets of graphs.

88 The following example demonstrates how to apply the Keçeci Layout to a simple NetworkX
89 path graph and visualize it with Matplotlib.

```
import networkx as nx
import kecceilayout as kl
import matplotlib.pyplot as plt

# 1. Generate a graph (e.g., a path graph with 25 nodes)
G = nx.path_graph(25)

# 2. Compute the node positions using Keçeci Layout
# The node order is preserved (0, 1, 2, ...)
pos = kl.kecceci_layout(G, primary_spacing=1.5, secondary_spacing=0.8)

# 3. Visualize the graph
plt.figure(figsize=(8, 10))
nx.draw(
    G,
    pos=pos,
    with_labels=True,
    node_color='skyblue',
    node_size=500,
    font_size=8,
    edge_color='gray'
)
plt.title("Keçeci Layout Applied to a Path Graph (n=25)")
plt.axis('equal') # Ensure aspect ratio is not distorted
plt.show()
```

Keçeci Layout Applied to a Path Graph (n=25)



Figure 1: An example visualization of a path graph using the Keçeci Layout. The nodes are ordered sequentially from top to bottom, with their positions determined by the deterministic zigzag algorithm. This preserves the inherent one-dimensional structure of the path.

Applications and Use Cases

The primary strength of the Keçeci Layout is its ability to visualize systems “when nodes have an order” (Keçeci, 2025p). Its application is particularly relevant in fields where sequential data is modeled as a graph.

- **Workflow and Process Visualization:** Representing business processes, experimental workflows (Keçeci, 2025d, 2025b), or CI/CD pipelines where the sequence of steps is paramount. The layout clearly shows the progression from start to finish.

- 97 ▪ **Narrative and Structural Analysis:** Analyzing the structure of stories, legal arguments, or
- 98 scientific papers where nodes represent events, sections, or concepts in a specific order.
- 99 ▪ **Time-Series and Event Logs:** Visualizing sequences of events from logs or time-series
- 100 data, where the temporal order must be maintained.
- 101 ▪ **Comparative Structural Analysis:** As a standardized graphical framework, it allows for
- 102 the visual comparison of different ordered systems, fostering interdisciplinary insights
- 103 ([Keçeci, 2025m, 2025n](#)).

104 By providing a stable and structured visual representation, the layout encourages a “structural
 105 thinking” approach, where the focus shifts from complex topological entanglements to the
 106 clear, sequential architecture of the system being studied ([Keçeci, 2025c, 2025e](#)).

107 Conclusion

108 The Keçeci Layout provides a much-needed alternative to traditional graph drawing algorithms
 109 for the visualization of ordered systems. Its deterministic, zigzag-based approach ensures that
 110 the inherent sequence of nodes is not only preserved but becomes the primary organizing
 111 principle of the visualization. This results in clear, predictable, and structurally informative
 112 diagrams that are easy to interpret.

113 The implementation of this algorithm in the user-friendly and interoperable `kececilayout`
 114 Python package makes it an accessible tool for a wide range of researchers and practitioners. By
 115 offering seamless support for dominant graph libraries, it serves as a robust, cross-disciplinary
 116 framework for structural analysis. Ultimately, the Keçeci Layout champions the idea that for
 117 many systems, visualization should go beyond topology to faithfully represent structure and
 118 order ([Keçeci, 2025b](#)).

119 Future Work

120 Future work will focus on extending the layout’s principles to three dimensions and developing
 121 adaptive spacing strategies for graphs with highly variable node density or connectivity.

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