Vision, Modeling, and Visualization (2018)
F. Beck, C. Dachsbacher, and F. Sadlo (Eds.)

Supplementary Material for Clustering for Stacked Edge Splatting

M. Abdelaal[1], M. Hlawatsch[1], M. Burch[2], and D. Weiskopf[1]

[1]Visualization Research Center (VISUS), University of Stuttgart, Germany
[2]TU Eindhoven, Netherlands

Abstract

We present a time-scalable approach for visualizing dynamic graphs. By adopting bipartite graph layouts known from parallel edge splatting, individual graphs are horizontally stacked by drawing partial edges, leading to stacked edge splatting. This allows us to uncover the temporal patterns together with achieving the time-scalability. To preserve the graph structural information, we introduce the representative graph where edges are aggregated and drawn at full length. The representative graph is then placed on the top of the last graph in the (sub)sequence. This allows us to obtain detailed information about the partial edges by tracing them back to the representative graph. We apply sequential temporal clustering to obtain an overview of different temporal phases of the graph sequence together with the corresponding structure for each phase. We demonstrate the effectiveness of our approach by using real-world datasets.

CCS Concepts

• ***Human-centered computing*** $\rightarrow$ ***Information visualization; Visual analytics;***

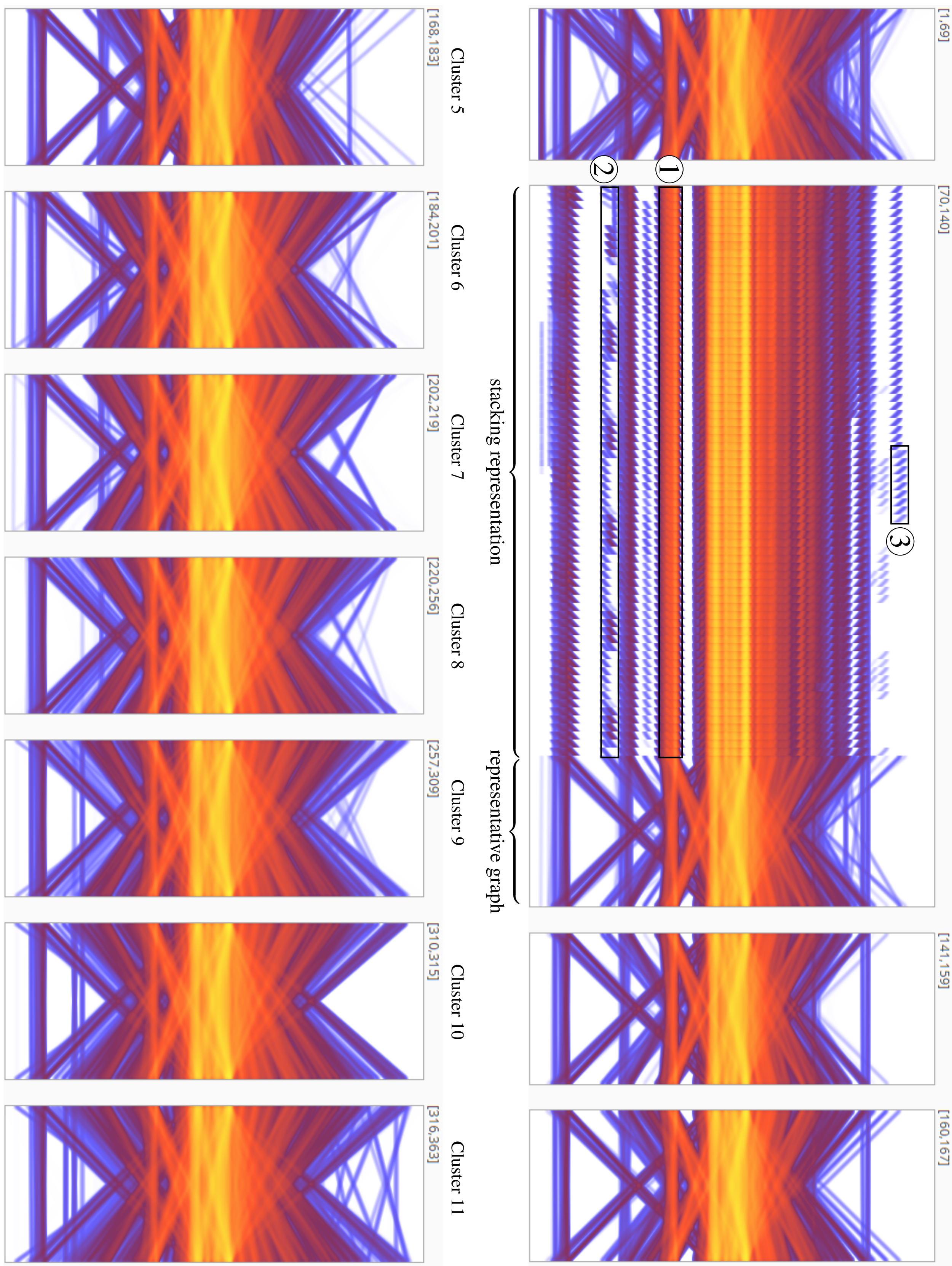
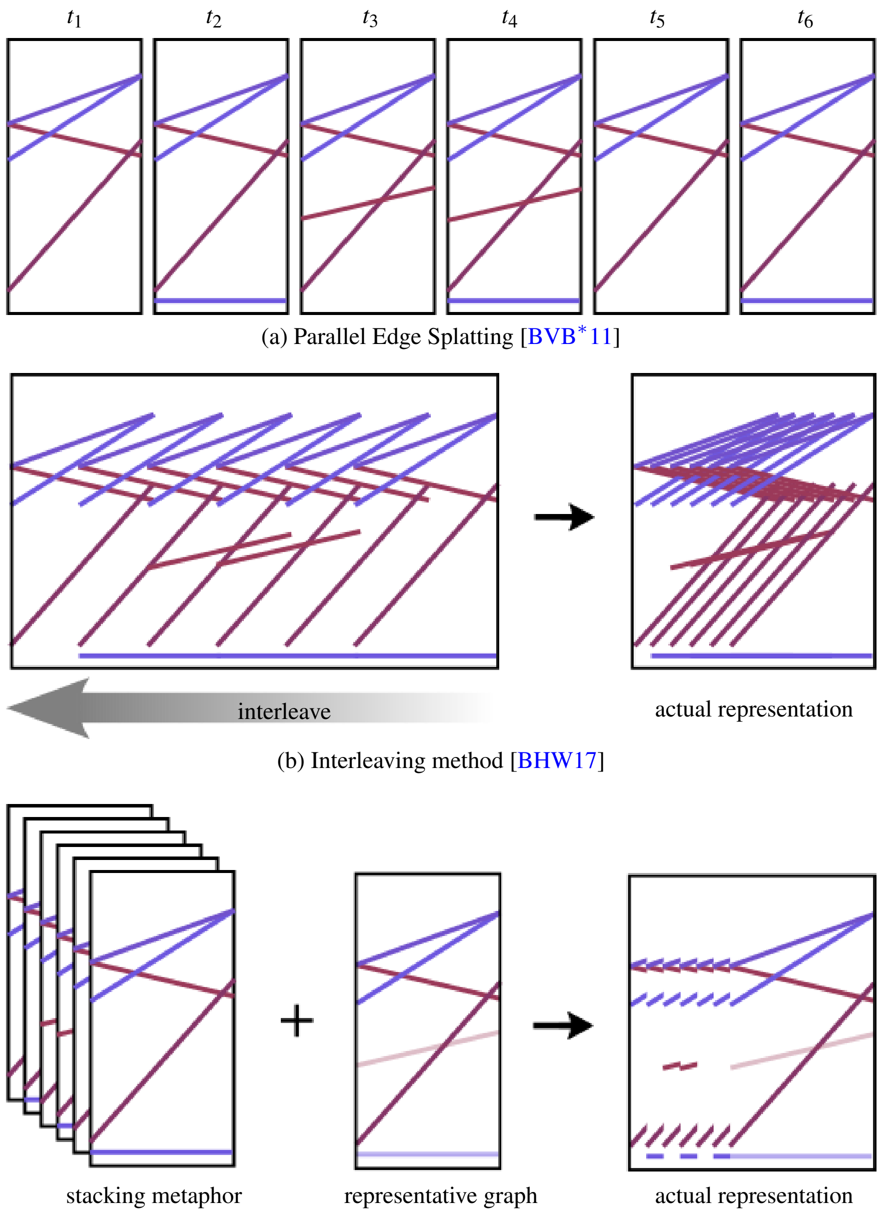


Figure 1: *A dynamic graph visualization depicting the US domestic flight dataset from October 1st, 1987, to December 31st, 2017. The data is aggregated on a per-month basis. It contains 402 vertices, which are the airports, 1,300,340 weighted edges, which are the flight connections and their frequencies, and 363 timepoints, which are given by the graphs per month. The dataset is sequentially clustered at a threshold of 1.1, resulting in 11 clusters. As annotated, the stacking representation allows us to identify several temporal patterns: (1) Stability, (2) Periodicity, and (3) Anomaly, while the clustering allows us to identify different temporal phases of the graph.*



(a) Parallel Edge Splatting [BVB*11]

(b) Interleaving method [BHW17]

(c) Our approach: stacked edge splatting

Figure 2: *Stacking bipartite graphs to obtain a time-scalable visualization. (a) Parallel edge splatting: bipartite graphs are drawn next to each other. (b) Interleaving method: bipartite graphs are interleaved. (c) Our approach: bipartite graphs are horizontally stacked by drawing partial edges.*

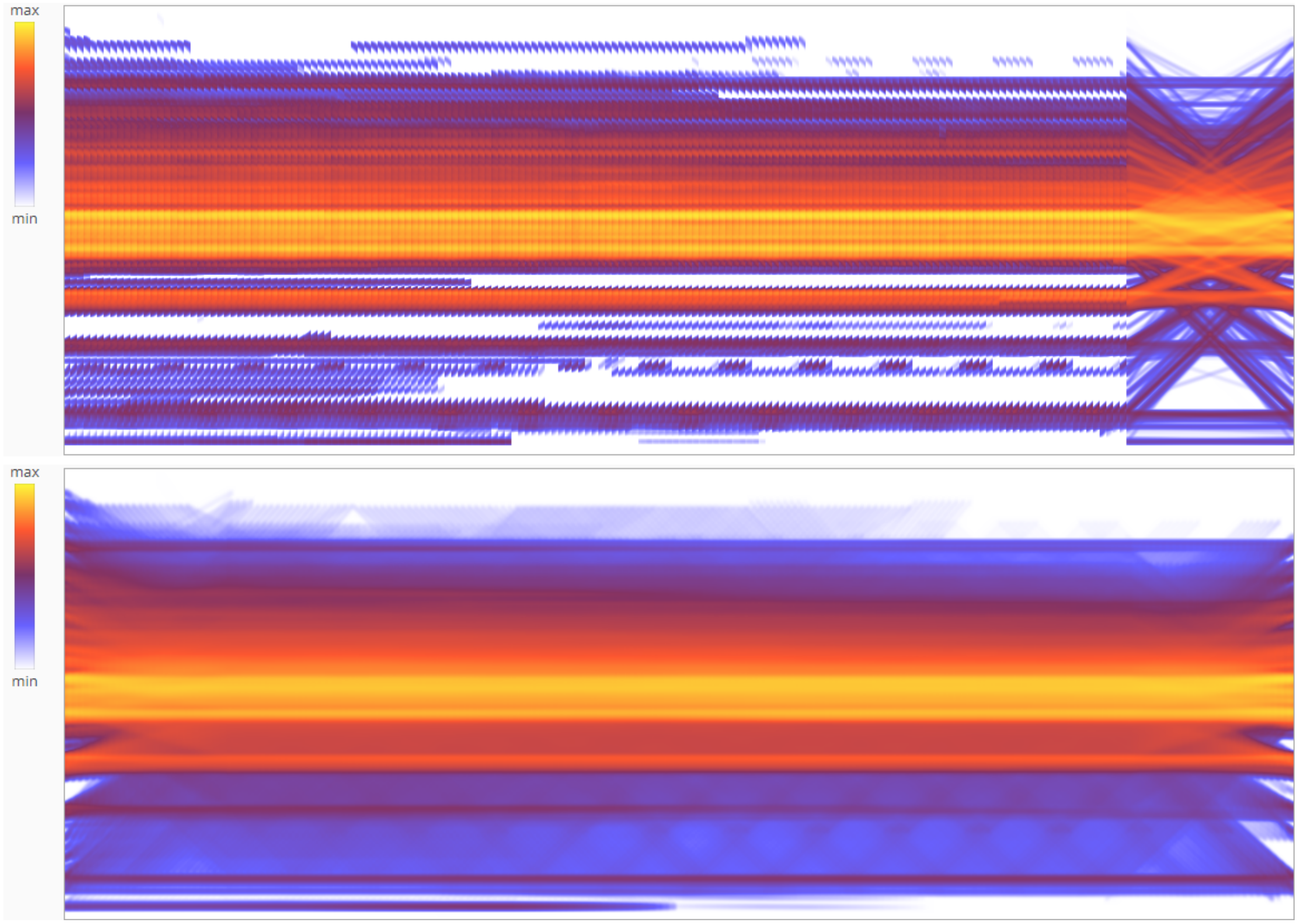
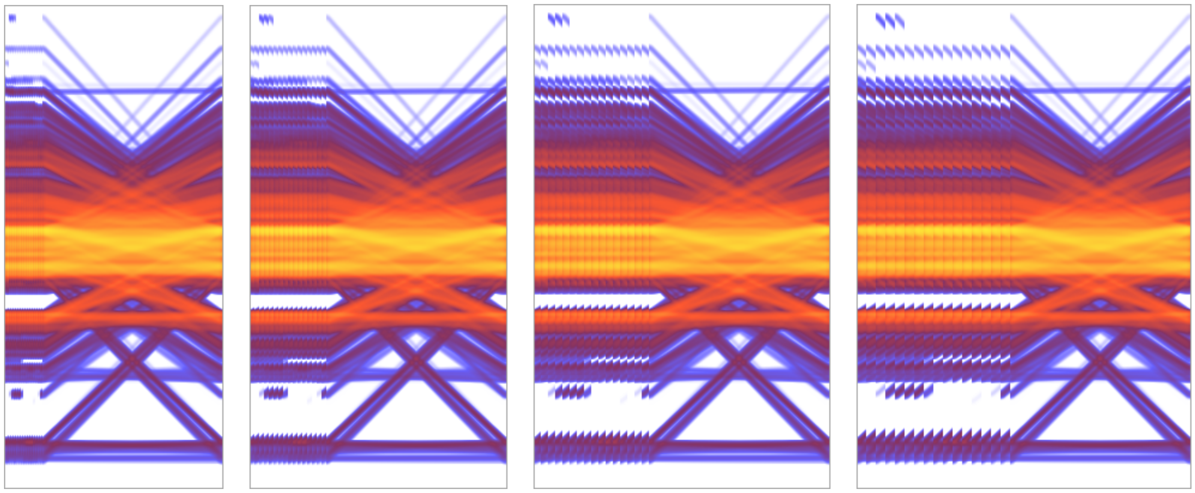


Figure 3: *First 159 timepoints of the flight dataset visualized using stacked edge splatting (top) and the interleaving method (bottom). Temporal patterns are more recognizable in the stacked edge splatting representation as a result of avoiding over-drawing problems caused by the interleaving method.*



(a) 1 pixel (b) 3 pixels (c) 5 pixels (d) 7 pixels

Figure 4: *Stacked edge splatting with different lengths of partial edges. Shorter partial edges result in a more compressed representation, whereas longer ones provide more edge information.*

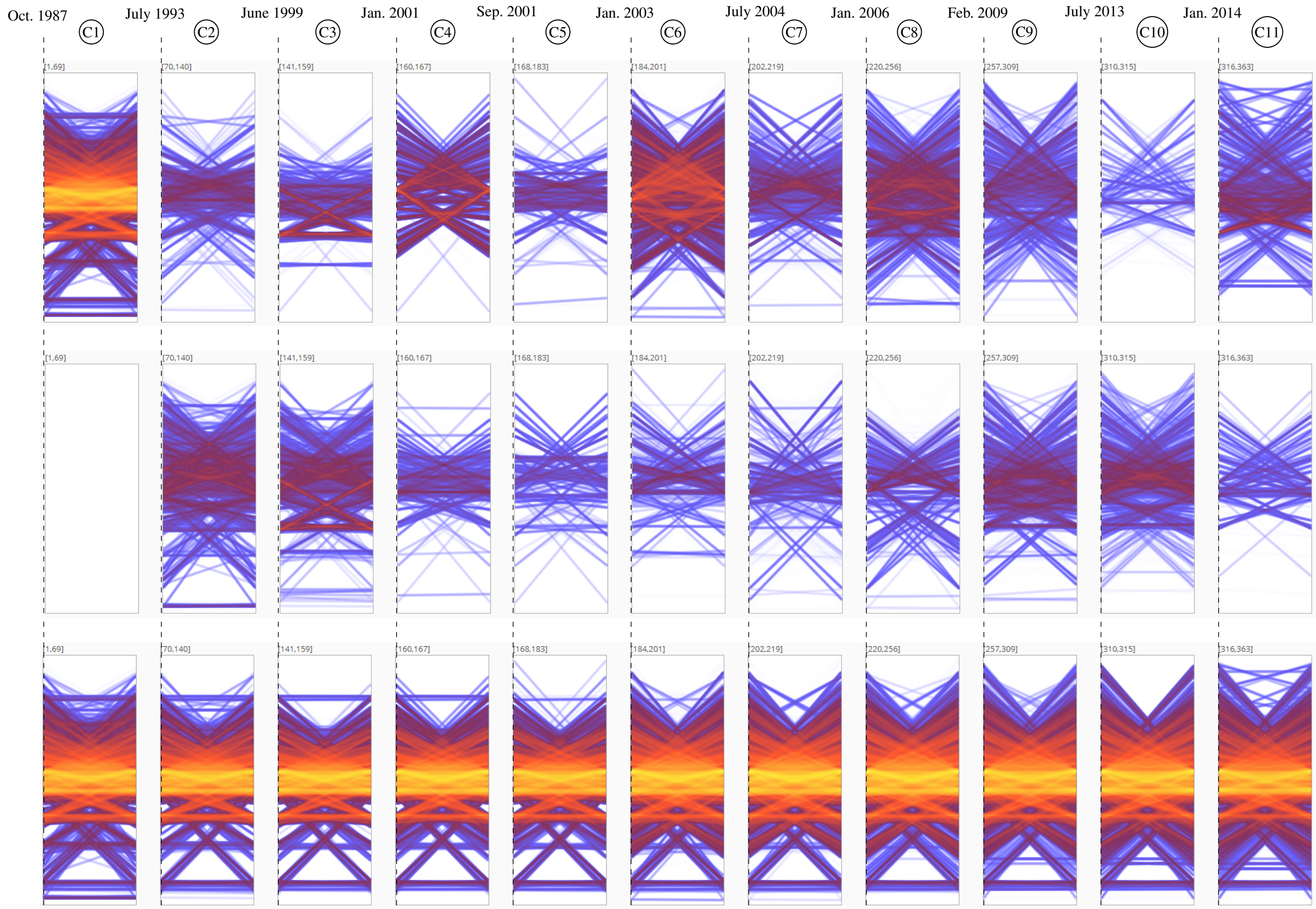


Figure 5: *Sequentially clustering the flight dataset at a threshold of 1.1, resulting in 11 clusters: (bottom) the clusters' representative graphs, (middle) links deleted by each cluster, (top) links added by each cluster. Each of the representative graphs at the bottom is a result of adding the links at the top to the previous representative graph, followed by subtracting links at the middle.*

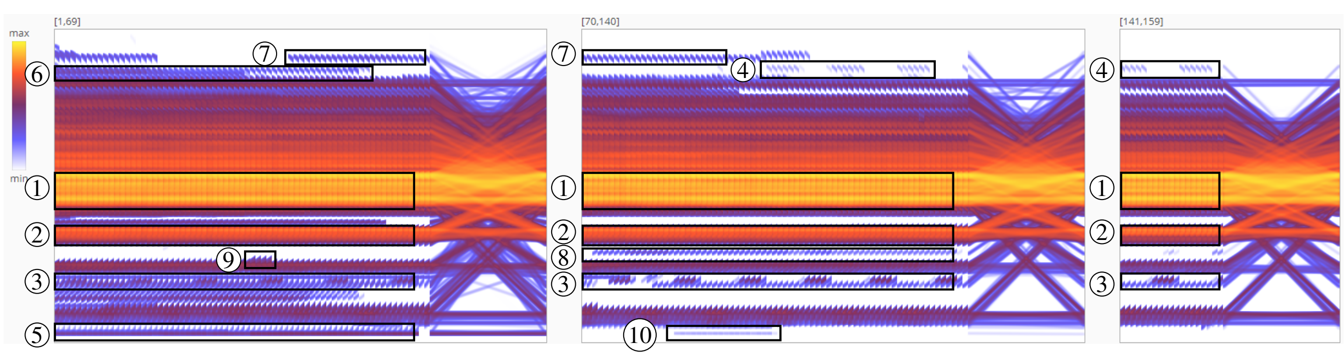


Figure 6: *The expanded view of the first three clusters of the flight dataset. The stacking representation allows us to identify several temporal patterns.*

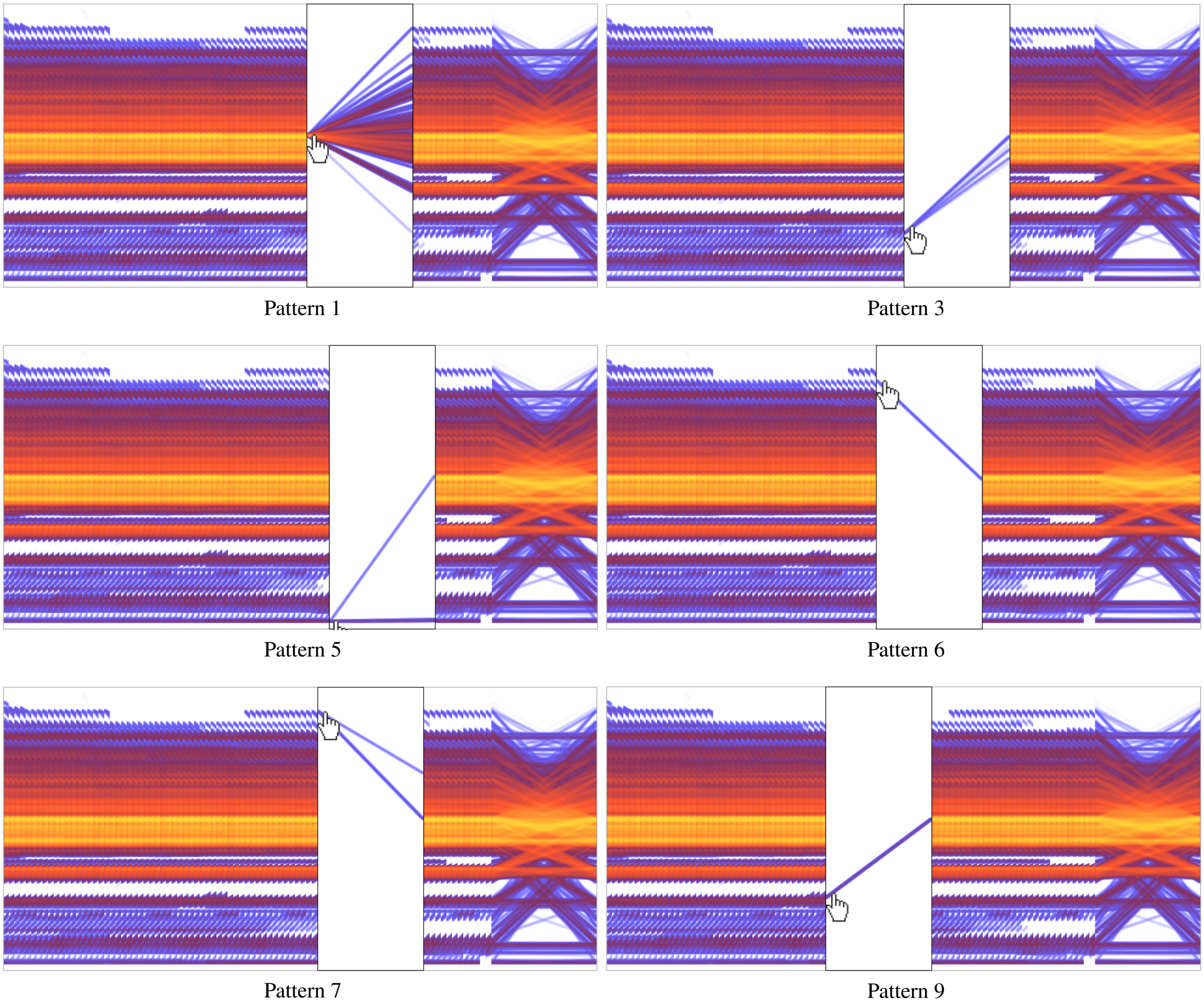


Figure 7: *The edge-highlighting interaction technique is used to view the source and destination vertices of the previously identified temporal patterns.*

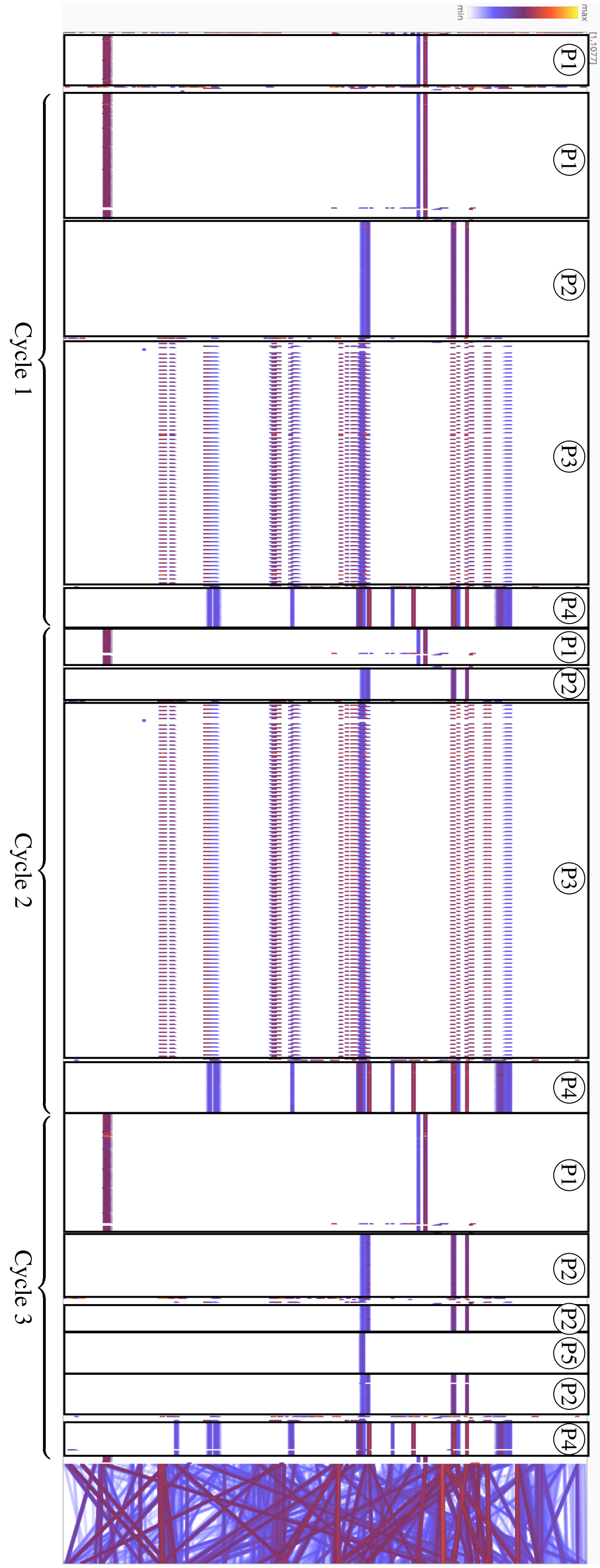


Figure 8: *Visualization of the software call graph dataset using our approach: Five different patterns can be identified along with the cyclic behavior starting from timepoint 47.*

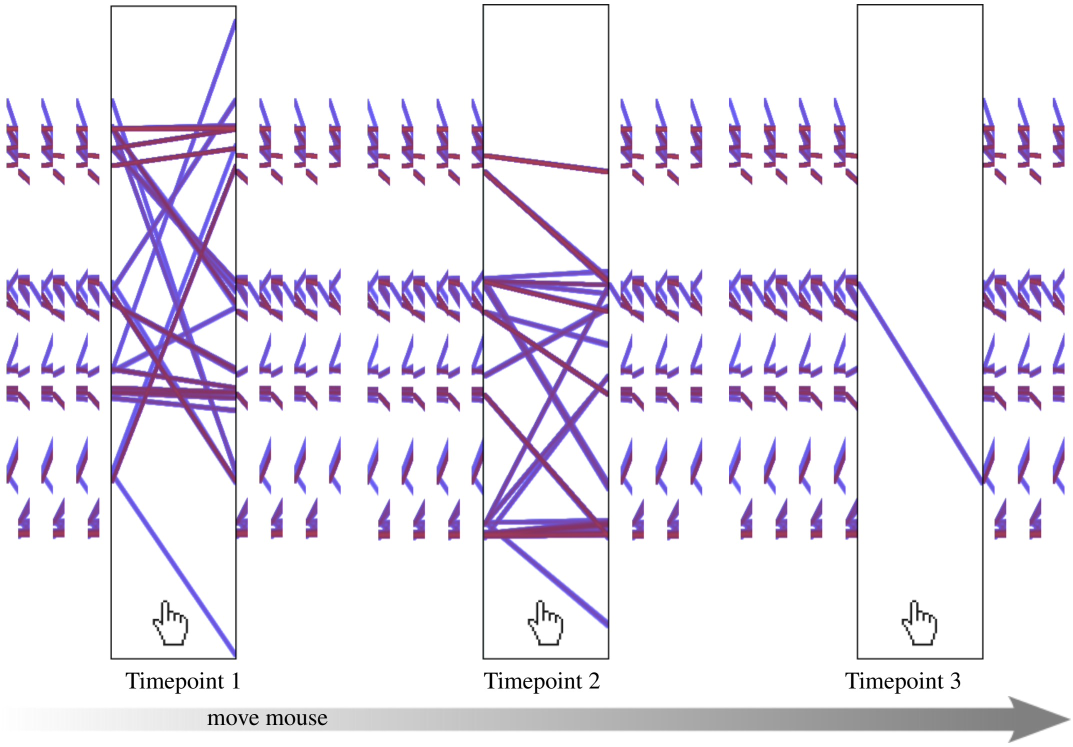


Figure 9: *Closeup segment of pattern P3 shows a dynamic behavior that keeps altering between three distinct timepoints. The mouse-hover interaction technique is used to expand the timepoints to the full width.*

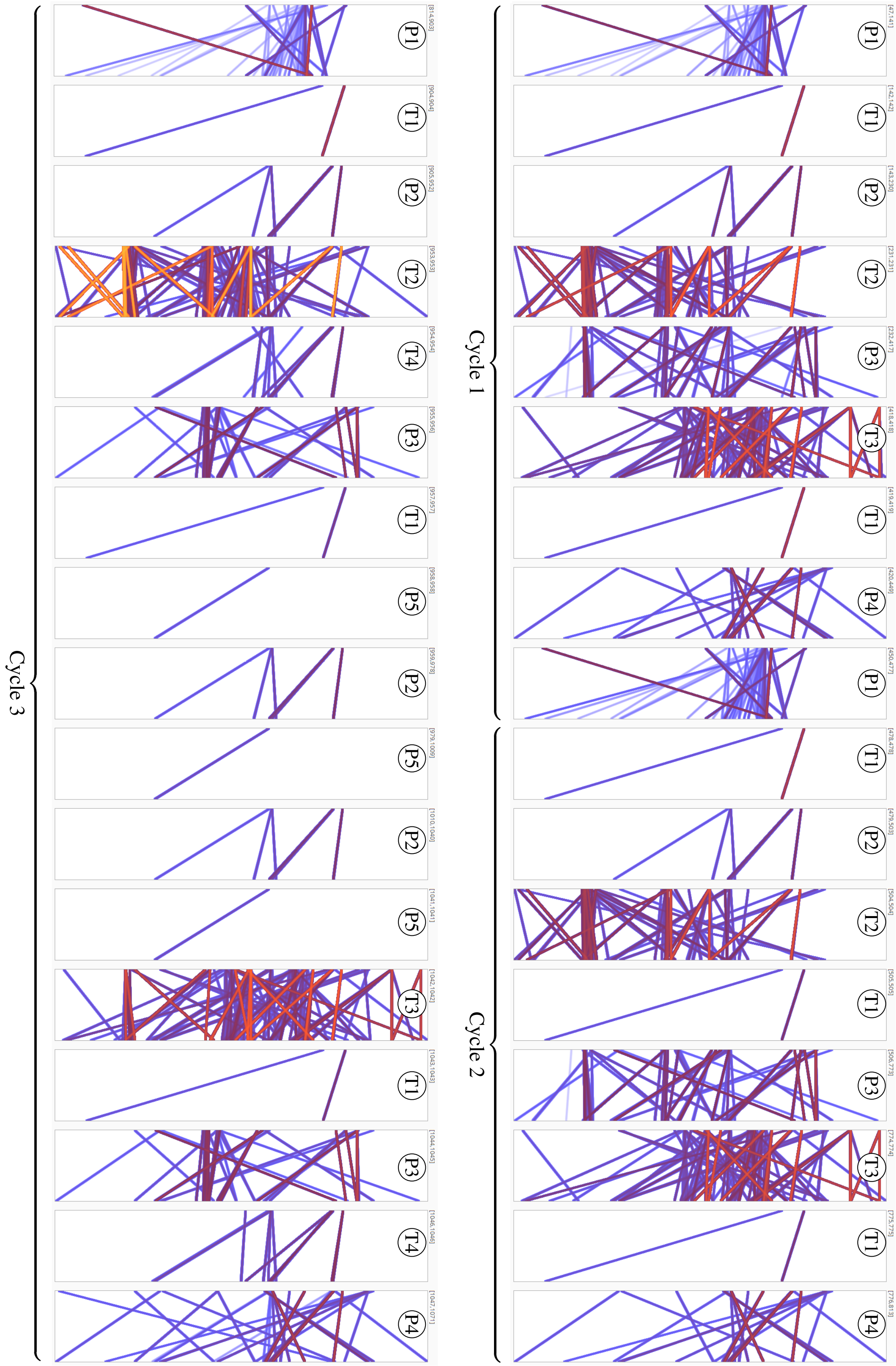


Figure 10: *The dynamic graph from the software system sequentially clustered so that timepoints that share the same temporal pattern belong to the same cluster. Each cluster is represented by the representative graph.*

References

[BHW17] BURCH M., HLAWATSCH M., WEISKOPF D.: Visualizing a sequence of a thousand graphs (or even more). *Computer Graphics Forum 36*, 3 (2017), 261–271. 3

[BVB*11] BURCH M., VEHLOW C., BECK F., DIEHL S., WEISKOPF D.: Parallel edge splatting for scalable dynamic graph visualization. *IEEE Transactions on Visualization and Computer Graphics 17*, 12 (2011), 2344–2353. 3