Interactive Visualization of Time-Dependent Bipartite Graphs

Yahya Jabary*   Manuela Waldner†

TU Wien, Austria

ABSTRACT

This paper explores novel techniques for visualizing temporal bigraphs, with a specific focus on the "Media Transparency Database Austria". Established in 2012 by Austrian law, this dataset records quarterly advertising expenditures of governmental organizations across various media outlets. Our study aims to develop an effective, interactive visualization that allows users to explore patterns, trends and anomalies.

We survey state-of-the-art approaches for visualizing dynamic graphs, including animated node-link diagrams, timeline-based representations and hybrid techniques. Building on these methods, we propose a novel interactive visualization that combines temporal bigraph representations. Our design aims to provide both clear overviews and detailed analysis capabilities, allowing users to explore the evolution of advertising expenditures over time and the relationships between public entities and media outlets. We discuss potential evaluation strategies for assessing the effectiveness of our visualization and outline expected outcomes. This work contributes to the field of dynamic graph visualization while demonstrating its practical application in government transparency and policy analysis.

Index Terms: Interactive Visualization, Temporal Graphs, Bipartite Graphs, Media Transparency, Public Policy, Government Spending

1 INTRODUCTION

Effective visualization of temporal graphs can reveal valuable insights such as patterns, trends, and anomalies that might otherwise remain hidden in raw data. This allows researchers, analysts, and decision-makers to quickly grasp evolving relationships, identify critical points of change, and make data-driven decisions.

In the context of global warming, multi-temporal scale visualizations of carbon emissions data can provide valuable insights for decision-makers, as demonstrated by Ma et al. [5]. In logistics, these visualizations can help optimize supply chain operations and identify inefficiencies [12] [7]. For social networks, they can illuminate user interactions and information spread. In public policy, temporal graph visualizations can aid in tracking disease spread, monitoring resource allocation and analyzing policy impacts [1]. These examples demonstrate how temporal graph visualizations compress temporal network data into intuitive representations. And as the volume and complexity of temporal data continue to grow across various domains, the development and application of effective visualization techniques for temporal graphs will likely become increasingly important.

As a practical example this paper explores various techniques for interactive visualization of time-dependent and bipartite graphs, using the "Media Transparency Database Austria" [4].

Time-dependent graphs or temporal graphs are structures that evolve over time, with nodes and edges changing as time progresses. These graphs are crucial for representing dynamic systems and processes that unfold chronologically. They allow us to observe patterns, trends, and changes in relationships between entities over

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*e-mail:yahya.jabary@tuwien.ac.at
†e-mail:manuela.waldner@tuwien.ac.at

different time periods [11]. One specific type of temporal graph that has gained prominence is the bipartite graph. **Bipartite** graphs or bigraphs consist of two distinct sets of nodes, with connections only existing between nodes from different sets, but not within the same set. If the two subsets have equal cardinality (balanced bigraph) and each node in one subset is connected to every node in the other subset, the graph is called a complete bigraph [2]. These graphs are particularly useful for modeling relationships between two different types of entities, such as public authorities and their advertising expenditures. Due to their scale and complexity, time-dependent and bipartite graphs can be challenging to visualize effectively. To make sense of the "Media Transparency Database Austria", which contains thousands of entries over multiple years, we need to design scalable and **interactive visualizations** that allow users to explore the data, for example, by filtering, zooming, and selecting specific time periods or entities.

The "Media Transparency Database Austria" [4] or **MT dataset** for short is a public repository that records the advertising expenses of public authorities in Austria. This database serves as a tool for transparency (based on the Austrian § 34 Transparenzdatenbankgesetz 2012 TDBG), allowing citizens and researchers to track how public funds are spent on advertising across various media outlets. It provides a rich dataset that can be represented as both a time-dependent and bipartite graph structure. By visualizing this data – although not the focus of this paper – we can gain insights into how public authorities allocate advertising budgets, which media outlets receive the most / least funding, how both the political and media landscapes evolve over time and mutually influence each other. This information can be used to evaluate the effectiveness of public advertising campaigns, identify potential biases and inform public policy decisions.

This paper aims to combine state-of-the-art techniques and approaches for designing interactive visualizations of time-dependent and bipartite graphs to propose a final design for the MT dataset. We will focus on clear, uncluttered overviews while maximizing information content and propose a design that allows users to interact with the data intuitively. Additionally, we will consider how our proposed visualization could be evaluated and what results we expect to achieve.

2 RELATED WORK

In this section, we will explore existing solutions for visualizing time-dependent and bipartite graphs, focusing on their strengths, weaknesses and suitability for the MT dataset.

Jüttner et al. - Media Transparency   Jüttner et al. [3] present an interactive visualization approach specifically designed for the MT dataset that directly addresses our unique challenges. They describe a visualization approach in which different aspects of the data are simultaneously presented through interactive and inter-linked sub-visualizations, called views. These multiple views work in concert, all showing different aspects of the same data and being updated in sync when users interact with any of them. This is commonly referred to as a "multiple coordinated views" or *"coordinated multiple views" (CMV)* [6] visualization and aligns well with the popular design principle of "Eyes beat memory" by Tamara Munzner. This principle suggests that users can more effectively

understand data when they can see it, rather than having to remember it from a previous view. Their visualization concept provides both broad overviews (i.e. overall spending patterns) and detailed insights (i.e. drill down into specific actors or time periods). It consists of elements, including an overview bar chart, an alphabetically ordered, searchable list of actors, a tree-like graph displaying connections between selected actors and detailed bar charts showing quarterly spending and media-specific expenses.

This ability to interactively filter data, search for specific actors, and update charts based on user selections is a great strength of their approach. It allows users to explore the data in a non-linear fashion, focusing on specific aspects of the data that interest them.

However, the approach also has some limitations. The authors acknowledge performance issues especially on startup as their web-based `d3.js` implementation doesn't scale well with the given dataset size. This could potentially hinder user experience, especially for users with slower internet connections or less powerful devices. Additionally, the lack of advanced features like brushing, zooming, and direct comparison tools for actors and time spans, as mentioned by the authors, represents a missed opportunity for more sophisticated data analysis.

In conclusion while Jüttner et al.'s approach provides a solid foundation through its coordinated multiple views design, it doesn't leverage the temporal and bipartite nature of the data to its full potential.

Related Student Projects After some research, we found that Jüttner et al.'s work was part of a student project at the University of Vienna in 2016 WS [8] before being published in 2017. This context is important to note as it suggests that other students might have also worked on similar projects during that time. By modifying the URL suffix of the original project, we were able to find several other student projects from the same year that also explored the MT dataset [9] [10], each with unique approaches and interesting insights.

3 VISUAL ENCODING AND INTERACTION DESIGN

4 IMPLEMENTATION

5 EVALUATION

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