

MILADY (Matrix+Linear Diagram): Visual Exploration and Edition of Multivariate Graphs for Computer Networks Management

Mathieu Guglielmino¹, Francesco Bronzino², Arnaud Sallaberry^{3,4}, Sebastien Monnet¹

¹ Université de Savoie Mont-Blanc, LISTIC, France

² ENS de Lyon, France

³ LIRMM, Université de Montpellier, CNRS, France

⁴ AMIS, Université Paul-Valéry Montpellier 3, France

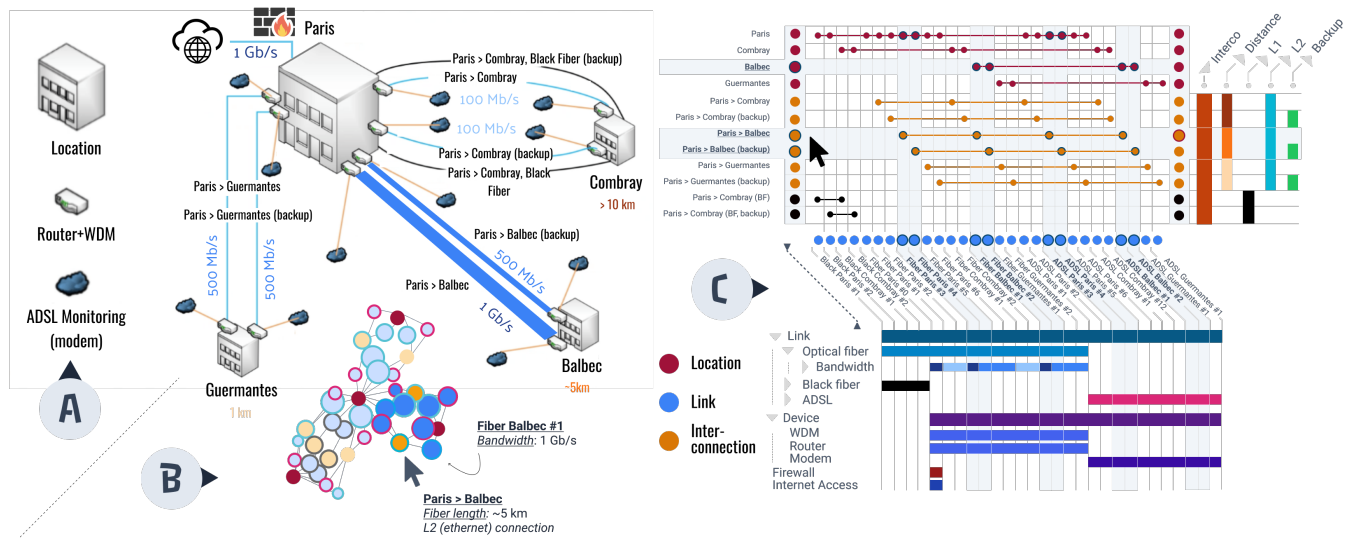


Figure 1: A customer topology with secured Internet access on a central location in Paris. (A) A schematic drawn by the sales department of a medium-sized network operator. (B) A tri-partite graph that encodes the network topology as a node-edge diagram. Surface represents bandwidth and border color attributes. (C) MILADY: Displays both structure (adjacency matrix, top) and node attributes (linear diagram, bottom) concurrently. All three representations highlight the same connection between Paris and Balbec (and backup). A parallel optical path backs up each connection, with an additional black fiber backup between Paris and Combray.

Abstract

This poster introduces MILADY (Matrix+Linear Diagram), a visual method for exploring and editing multivariate graphs from a computer networks perspective. Existing methods usually require multiple views, but our integrated approach enables users to visualize and edit both aspects with drag gestures and in a single view. We demonstrate the usefulness of our method for computer networks management.

1. Introduction

Designing computer network topologies can be a tedious and error-prone task. Network architects create detailed network diagrams, that are helpful for efficiently configuring, and installing equipment such as routers, switches, and firewalls. Some attempts to cre-

ate a standard abstraction model for network topologies have been proposed using the entity-attribute-relationship model which leads to multivariate graphs [?]. However, visualizing and editing such graphs remains a challenge.

In this poster, we propose MILADY, a visual approach for explor-

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ing and editing multivariate graphs. In particular, our interface provides editing functionalities based on natural drag-and-drop gestures allowing users to both update the structure given the attributes (SgA), or the attributes given the structure (AgS) [?]. We illustrate the relevance of this visualization for complex and large scale computer networks management.

2. Task Analysis and Workflow

Network architects often leverage static node-link diagrams when designing a network topology (see Figure 1A). However, while these images are well-suited for presentation purposes, they are not well suited as input for automation processes. We identified four requirements that must be matched to effectively tackle the tasks of users of these network representations, *i.e.*, network operators, business managers, *etc.* First, users have to understand both the structure and the attributes of the network [R1—INTEGRATE] and be able to edit them [R2—EDIT]. Second, they need to choose the level of abstraction and detail [R3—MULTISCALE] relevant to their expertise and needs. Finally, users often rely on "building blocks", used as design patterns, to deploy new topologies [R4—BUILDING BLOCKS].

To meet these requirements and allowing a rich data representation, we first adopt a multivariate tri-partite graph modeling approach, with nodes that might be either physical locations, links, or interconnections (see Figure 1B). Then, we propose a visual representation of this graph that leverages a matrix-based layout for the structure, and linear diagrams for the attributes (see Figure 1C). This visualization offers advantages over traditional node-link diagrams, which are often limited in their ability to represent structure and attributes concurrently.

3. Overall Visual Design

Our visual approach is made of two components:

MATRIX REPRESENTATION FOR GRAPH STRUCTURE. In our tri-partite approach, links are displayed in columns (blue dots), while locations (red) and interconnections (orange) in rows. The intersections of the adjacency matrix represent edges between these nodes (red and orange dots). This method is inspired by PAOH [?] and allows to tackle typical edges edition issues [?].

LINEAR DIAGRAMS FOR GRAPH ATTRIBUTES. Linear diagrams are a way of visualizing sets and their intersections using straight line segments. They can be superior to other set visualization techniques, such as Euler and Venn diagrams.

Hierarchical attributes can be collapsed [R3—MULTISCALE]. Hovering and selecting (see Figure 1C), filtering, and ordering of both the edges and attributes may be used to group nodes and tackle SgA or AgS tasks [R1—INTEGRATE].

4. Edition Interactions

Edit interactions are based on drag gestures (see Figure 2). Horizontal and vertical node selections are used to edit the structure and attributes concurrently [R1—INTEGRATE], [R2—EDIT]. Selections can be duplicated to enable [R4—BUILDING BLOCKS].

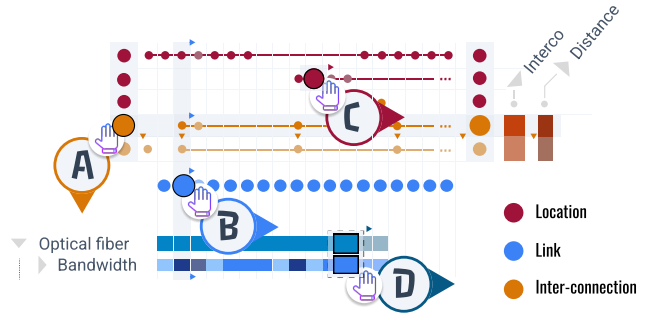


Figure 2: Edition in MILADY on filtered data from Figure 1. (A, B) Select & Drag for node duplication (with edges and/or attributes). (C) Edge duplication to neighbor nodes. (D) Attributes edition.

5. Case Study: Real-world Network Operator Topology

To demonstrate our approach, we use a real-world customer topology with four locations and 12 devices, modeled using 40 nodes, including eight interconnections, and 28 links (see Figure 1C). While topologies can scale to hundreds, or even thousands, of devices [?], we begin with a smaller example to illustrate our approach. The user would create and connect each node individually, specifying attributes to reflect their characteristics. Making a mistake during this process could result in significant setbacks and delay the production phase.

Let us assume the user wants to add a fourth location. Since this topology is highly symmetrical, the user needs to identify the branch she wants as a building block. Entities can be inspected for their relations or attributes, so even nodes which may slightly differ are easily identified and corrected if necessary. Because edges and nodes can be selected individually or in group, reordering and selection can be used to duplicate any pattern around a center, as is the case here.

6. Conclusion and Future Work

We presented MILADY (Matrix+Linear Diagram), a method to visualize and edit concurrently, and in an integrated view, the structure and attributes of a multivariate graph. Our approach includes intuitive drag gestures that can be used for the duplication of complex patterns. Even if this work is grounded in network management, we plan to validate the technique on a more general graph editing taxonomy. Additionally, operators store numerous customer topologies, which can serve as a foundation for recommending attributes. We plan to explore this further with graph querying and frequent item-sets mining.

7. Acknowledgments

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