Visualizing Paul Revere's other ride as a multiplex network

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Abstract

Paul Revere's night ride is an important tale in the story of the American Revolution. The case has been well studied and documented in the field of Sociology. These analyses [9, 7] refer to the social network as a multiplex network (a network with links of different types). Inspired by these works, we propose in this paper a Visual Analytics investigation of the social scientists' findings using *Detangler*, a framework designed to handle multiplex networks.

Index Terms: Human-centred computing [Visualization]: Visual Analytics—Social Networks

1 Introduction

Understanding and explaining the structure and reasons that tie a group together has been the focus of many social scientists. They often face the co-analysis of social networks and groups sometimes with different families of ties. The visualization community often proposes to support this task with the exploratory visual analysis of their network.

The analysis of Paul Revere's night ride [5] regroups relationships between early American freedom fighters before the Lexington and Concord battles. It has been documented with style by social scientist Healy in a popular blog entry [9] and refers to a more in depth analysis proposed by Han [7]. The point of view of the authors directly addresses the issue of "multiplexed" relationships, *i.e.* networks with links of different types. Healy and Han have both used social network analysis to understand and describe the content of the data, highlighting Paul Revere and others' particular roles in establishing the groups "macro"-structure. However, no actual visualization approach has been brought to this very interesting use case.

We propose in this poster to apply multiplex network analysis to Paul Revere's ride through our prototype, *Detangler*. After quickly overviewing existing work and introducing *Detangler*'s capabilities and the data itself, we will bring Healy's and Kan's analysis of Paul Revere's midnight ride into our visual approach.

2 Related work

Since this poster focuses on an application case of multiplex network visual analytics, this section most specifically concerns the visualization of multiplex networks, alternatively *heterogeneous* [1], and *multimodal* [6], rather than of affiliation and bipartite networks. Some previous work on multiplex network visualization are very straightforward, with Schreurs et al. [11] distinguishing types of links through color coding, or De Domenico et al. [4] with 3D planes views of the network. These approaches neither scale nor provide interaction support for the group cohesion analysis task. Other previous systems focus on the task of comparison between multiplex networks but do not support group cohesion analysis ([1]). Recent work also show very promising leads on investigating the group cohesion, such as Ghani et al. [6], but the topological features of the network are not shown. Most recently, Van den Elzen's awarded paper [12] brings both structural and multivariate analysis on demand, useful to investigate groups (although it is not applied to multiplex networks).

3 Detangler

Detangler tackles the visualization of multiplex networks at the data abstraction level by introducing a *catalyst network*, a network in which a single node (a *catalyst*) corresponds to an entire visual layer with many links in the full multiplex network. This data abstraction allow us to take advantage of different multiplex network measures introduced in [10]. They support the exploration of a multiplex network by providing indications on how catalysts distribute over the multiplex network's edges, with the advantage of being computable on-the-fly for any subset.

These analytical tools allow *Detangler* to coordinate the visual exploration of a multiplex network. It proposes by default the presentation of two node-link diagrams.The first one presents the network of *substrates*, which is a "monoplex" projection of the multiplex network (same nodes and simple links), and the second one is the network of *catalysts* as in [10] (here, the social groups).

Figure 1: The multiplex social network of Paul Revere. The dashboard present 4 linked views of this dataset. We select Paul Revere by his high *degree* and *centrality* value, in the bottom right view. It shows on the top right view that he belongs to five of the seven societies, highlighted with red outlines. In the top left view Paul Revere is selected in red, and hovered so we can observe his direct neighborhood (in green).

In addition, we propose other traditional views (scatter plots and bar charts) derived from any of these views. An asymmetric linked highlighting between catalysts and substrates enables brushing of the visualization. Another interaction, a *leapfrog*, allows to loop between catalysts and substrates for further investigation.

Detangler is built on top of Tulip [2] and D3 [3] integrated in a jquery-ui web interface. It benefits from all Tulip's layouts and measure algorithms, and from all the flexibility offered by D3 in terms of interaction. The prototype is available at `http://detangler.labri.fr:31497`.

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4 Paul Revere's midnight ride

Paul Revere's ride data provided in Fisher's work [5] presents an affiliation network of the American independence movement. The data is a matrix of 334 affiliations of 254 people across 7 social groups. The people are the freedom fighters, and the social groups all played an important role in organizing and defending against the British army.

In his stylish note [9], Healy introduces different observations of the affiliation data. He first pin-points the interest to study both people and groups at once, constructing both networks. The two networks are indeed presented side-by-side and can be brushed at will. He also highlights the importance of *multiplexed* links in the people-people network (people connected by at least 2 groups). Our multiplex network follow this idea and links the different people by a common participation in at least two social groups. This leads to 49/917 nodes and multiplex edges as opposed to the 254/10724 when considering all affiliations. It interestingly modifies the distribution of edges among groups: the *Tea Party* had 32% of links and now 12% after subsetting, the *North Caucus* 29% now 33%, the *London Ennemies* 22% now 32%, the St Andrew's Lodge 14% now 2%,and the *Boston Committee* jumps from 3% to 15%.

Healy uses different network centralities to isolate actors showing a notable behavior in joining people across the groups. They are *P. Revere*, *T. Urann*, *E. Proctor*, *J. Warren*, *J. Hoffins*, *C. William*, *S. Peck* and *N. Barber*. We propose here to plot all the "people" nodes on a *degree* $\times$ *betweenness centrality* scatter-plot linked highlighted view (Fig. 1). We can roughly identify 4 dominent profiles in this degree $\times$ centrality space: *P. Revere*; *S. Adams*, *B. Clarke*, and *J. Hancock*; J. Warren; and N. Barber, *C. Williams*, and *J. Coffins*. Interestingly, *T. Urann, E. Proctor*, and *S. Peck* do not seem to play a significative role here.

Han's *other ride of Paul Revere* is much more formal [7]. Interested by the underlying structure of this historic social network, he brings along an in-depth knowledge of the people and societies, putting forward the important role of other players coming along with *Revere* and specially *Warren*. Although he does not consider exactly the same dataset, he particularly highlights there position as *"singularly instrumental"* in there *"highly multiplex"* network. He argues both qualitatively and quantitatively, that they are structurally equivalent and vector of cohesion in the network.

To check this structural equivalence, we can select *Revere* (Fig. 1) and *Warren* and observe that they share 4 groups. Leapfrogging from *all* these groups we can observe that only *Revere* and *Warren* are in this very situation. Leapfrogging from *each* of the groups individually returns the whole network, confirming their structural role. Having participated to the *T. Party* gives actually to Revere a slight advantage: it brings him closer to the *Loyal Nine* (the less connected community).

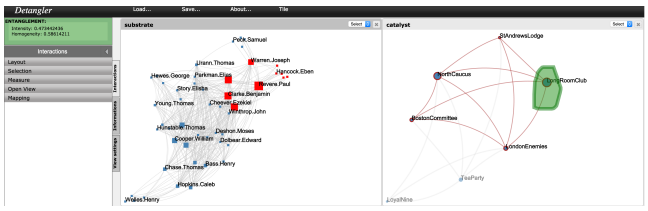

Figure 2: Leapfrogging consists of two steps in one manipulation: we first make a selection (here *The Long Room Club* on the right view), that highlight the corresponding people (in red on the left view), and then find the other clubs to which these people are affiliated (outlined on the right). Metrics [10] are also computed on-the-fly, and mapped to the catalyst nodes size.

Han also point out the important role of the organizational infrastructure for example the *L. R. Club*, being a smaller but well implanted society, involving important actors. The catalyst nodes size (Fig. 2) help us understand how the different groups intertwine over the people. In the case of the *L. R. Club*, when we *leapfrog* from its members back to the other societies, we can see how strongly it intertwines with the *N. Caucus*, and spreads over the other communities (see Fig. 2). With the same manipulation, we can highlight that the *B. Committee*, the *N. Caucus*, and the *St. A. Lodge*, appear fairly independent. The *L. Nine* are very involved with the *L. Ennemies*, and the *T. Party* with the *N. Caucus*.

Additionally, Han presents the dataset as a "loose alliance of groups" in which Revere and Warren played a role of coordinators. Our analysis would put some perspective here. Even if Revere is the only one belonging to 5 of the 7 groups, there is a tighter group of 11 other actors participating in 4 groups each. If we take the subgraph they compose, we can see that all groups except the *St. A. Lodge* are reached. Out of the *L. Ennemies*, links with the *Lodge* are limited. Only *S. Peck* and *T. Urann*, bring an additional link with the *T. Party*, and Revere and Warren play a very important role in bringing this group close to all others.

5 Conclusion

In conclusion, visualizing the Paul Revere's multiplex network with Detangler has put perspective to Han and Healy's analysis. Of course, this very brief and light analysis can only be better completed by a live demo, and we also invite interested readers to try it on Detangler's website. Multiplex networks analysis seems a promising lead, in which we will continue focusing efforts. As a conclusion, and to support our future work, we cannot resist quoting Healy: *"imagine what might be possible if we were but able to collect information on very many more people, and also synthesize information from different kinds of ties between people!"*.

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