Interactive Visualization of a News Clips Network
A Journalistic Research and Knowledge Discovery Tool

José Devezas and Álvaro Figueira
CRACS/INESC TEC, Faculdade de Ciências, Universidade do Porto
Rua do Campo Alegre, 1021/1055, 4169-007 Porto, Portugal
{jld, arf}@dcc.fc.up.pt

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Abstract: Interactive visualization systems are powerful tools in the task of exploring and understanding data. We describe two implementations of this approach, where a multidimensional network of news clips is depicted by taking advantage of its community structure. The first implementation is a multiresolution map of news clips that uses topic detection both at the clip level and at the community level, in order to assign labels to the nodes in each resolution. The second implementation is a traditional force-directed network visualization with several additional interactive aspects that provide a rich user experience for knowledge discovery. We describe a common use case for the visualization systems as a journalistic research and knowledge discovery tool. Both systems illustrate the links between news clips, induced by the co-occurrence of named entities, as well as several metadata fields based on the information contained within each node.

1 INTRODUCTION

Interactively exploring data through visualization enables the users to improve their understanding of the provided information. They gain knowledge by "connecting the dots", establishing mental relationships between the individual pieces of data in an intuitive manner. Visualization can be used as a tool during the research process, but it may as well become the end product of an information system.

Breadcrumbs (Figueira et al., 2009) is a social network based on the relations established by collections of text fragments taken from online news. This intelligent information system can be used to collect and store fragments of text from online sources in a Personal Digital Library. These fragments, usually gathered from online news sites, are then semantically organized, based on several latent features found in the text, tags and comments assigned by the users.

We present two interactive visualization systems based on a multidimensional network of news clips from the Breadcrumbs platform. In this network, nodes represent news clips, while edges were created between every two clips that mentioned the same entity (e.g. two clips are connected if they both mention "United Kingdom"). Three classes of entities (Places, People, and Dates) were used to establish the three distinct network dimensions, resulting in three types of edges: Who, Where, and When.

Our goal was to create an interface for the user to explore the already available information in a user-friendly and insightful manner. We largely took advantage of the community structure of the news clips network — identified by the Breadcrumbs system using methodologies such as the Louvain method (Blondel et al., 2008) or Tang's multidimensional integration methods (Tang et al., 2011) — not only to visually define coherent groups of nodes by using different colors, but also to support the discovery of labels capable of illustrating the main topics of the news clips. The developed systems consisted of:

1. A multiresolution visualization based on *gvmap* (Gansner et al., 2010), a tool to generate static illustrations of graphs as maps and an integrating part of GraphViz (Ellson et al., 2002).
2. A force-directed visualization (Fruchterman and Reingold, 1991) developed using the data-driven approach of *d3.js* (Bostock et al., 2011), a JavaScript library for the manipulation of documents, that allows the production of dynamic and interactive visualizations using technologies such as SVG, HTML and CSS.

This paper is organized as follows. In Section 2, we characterize the news clips network depicted in the visualizations. In Section 3, we present our goal and describe the two visualization systems, detailing the techniques used to create them. In Section 4, we propose a use case of the developed systems as a journalistic research and knowledge discovery tool. In Section 5, we present some final observations, including the main challenges encountered during the development phase, as well as the future contributions regarding this work.

2 NEWS CLIPS NETWORK

The network of news clips we used for the visualizations comprises 94 nodes with 166 edges connecting them. Out of these, 17 edges belong to the dimension *Who*, 106 to the dimension *Where*, and 43 to the dimension *When*. To store the network, we used the GraphML format (Brandes et al., 2002), saving several attributes alongside each node and edge:

Nodes

clipID A unique identifier for the news clip.

date The date when the news clip was collected.

url The online news source from where the clip was gathered.

text A text fragment collected from an online news source.

community The membership identifier, uniquely representing the community the node belongs to, according to the Louvain method.

Edges

weight An integer number representing the number of times an entity co-occurs in a pair of news clips.

dimension One of the three dimensions: *Who*, *Where*, and *When*.

class One of the many classes contained within each dimension (e.g. *dbpedia-owl:Scientist*).

uri A unique resource identifier for the named entity.

3 VISUALIZATION SYSTEMS

In this section, we present our goal and describe the main features of the developed visualization systems, explaining how some of the metadata content was used to define visual attributes, including the node label and color.

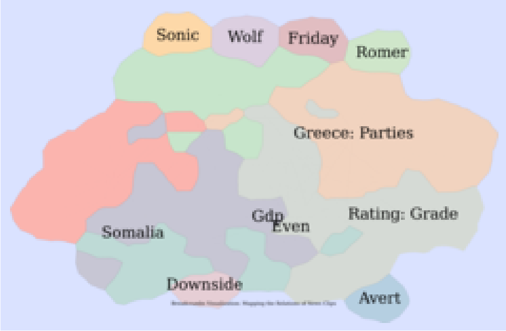


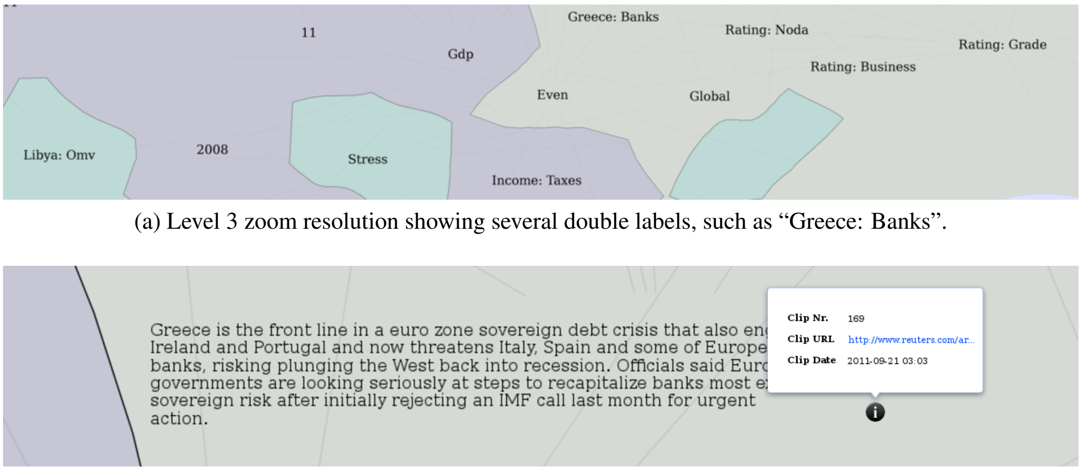
Figure 1: Lowest resolution zoom level for the network map visualization.

3.1 Mapping the Relationships of News Clips

Our intention was to conceive a system capable of providing the user with an environment that would facilitate the exploration of the connected data, including the previously identified grouping relationships, available in the network of news clips.

Given the *gvmap* tool was only capable of generating static map images for a single network and in order to introduce an additional interactivity layer capable of providing semantic zoom, we used OpenLayers (Hazzard, 2011) to define a multiresolution visualization based on several different map images, independently generated for each resolution. To achieve this, we started by converting the GraphML file representing the news clips network into a *dot* file (Koutsofios and North, 1991), the native format supported by GraphViz. A *dot* file describes a graph that can be directly converted into a high resolution image. The visualization of these large files is a computationally intensive task that can be highly simplified by creating several smaller tiles, which can then be dynamically loaded and rendered by OpenLayers.

Algorithm 1 illustrates the steps taken to generate the tile images for each resolution of the map visualization. We used the *text* attribute as the node's label and, during the conversion process, we also introduced a new attribute with the PageRank (Brin and Page, 1998) of each node, computed through the JUNG library (O'Madadhain et al., 2003) from within the Breadcrumbs system. We used GraphViz's *sfdp* to calculate the positions of the nodes based on a force-directed algorithm. The result of this process was then passed to *gvmap*, which identified the clusters and defined the borders of the "countries" in our map, resulting in a *dot* file that could be directly plotted with GraphViz to generate an image representing the largest resolution of our visualization.



Greece is the front line in a euro zone sovereign debt crisis that also en
Ireland and Portugal and now threatens Italy, Spain and some of Europe
banks, risking plunging the West back into recession. Officials said Euro
governments are looking seriously at steps to recapitalize banks most e
sovereign risk after initially rejecting an IMF call last month for urgent
action.

Clip Nr. 169
Clip URL http://www.reuters.com/ar...
Clip Date 2011-09-21 03:03

(a) Level 3 zoom resolution showing several double labels, such as "Greece: Banks".

(b) Maximum zoom resolution showing the text for the "Greece: Banks" news clip along with its information tooltip.

Figure 3: Partial views of the multiresolution map for the news clips network.

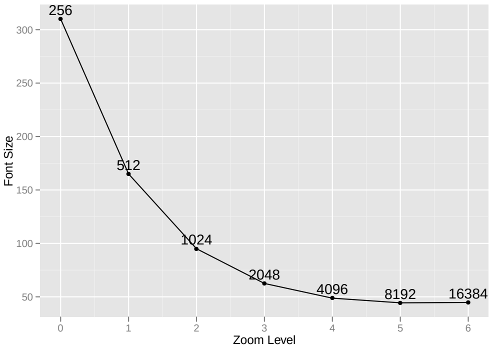


Figure 2: Evolving font size for progressively larger zoom levels and resolutions.

In order to obtain semantically coherent map plots for each resolution, we parsed the resulting *dot* file, clearing the existing labels, so that a larger font could be used and a smaller, descriptive label could replace the clip's text, without the need to recalculate the layout. Using the PageRank attribute allowed us to to identify the most central nodes in the network, which often correspond to visually central nodes as well, using them to position the new labels. We generated n image files, where images 0 to $n-1$ represented progressively larger resolution zoom levels of the visualization. A larger number of labels were successively added to the most central nodes as the resolution increased, while the font size decreased. Figure 2 depicts the function used to calculate the font size, so that each image, corresponding to a squared map, could be resized to its final side measure — for example, at zoom level 2, the font size would be 95 points, for an image displayed in 1024 pixels. Image n simply represented the largest resolution of the map visualization, with the clip's text as the label.

Figure 1 shows image 0 of the resulting visualization, corresponding to the lowest resolution possible. As we can see, only a few labels are shown. These coincide with the most central node in each community. Labels were sometimes defined using two words, which was, for instance, the case of "Greece: Parties". This double label was defined by combining a community label ("Greece") with a clip label ("Parties"). To compute the community label returned by the *getCommunityLabel* function, we aggregated the text of the community's news clips as a single document, calculating the TF-IDF (Salton and Buckley, 1988) of its terms, after removing stop words. Ranking the terms from highest to lowest TF-IDF gave us the label, or labels, of the community. We repeated this process for the news clips, using the text of each clip as the document, thus acquiring a second label from the *getVertexLabel* function.

Given the multiresolution map should have a semantic zoom behavior, it was important to maintain an inter-resolution coherence, specifically regarding the transition to the highest zoom level, where the map changed from displaying a set of labels to displaying a set of text fragments from news clips. Accordingly, we only assigned a community label to a node whenever the text in the corresponding news clip contained that same label. Otherwise we search for the next community label, according to the TF-IDF ranking, until we found a matching label — this was done within the *getCommunityLabel* function. In the particular case when the community label and the clip label were equal, or when none of the possible com-

Algorithm 1 Pseudocode for the generation of the multiresolution network map.

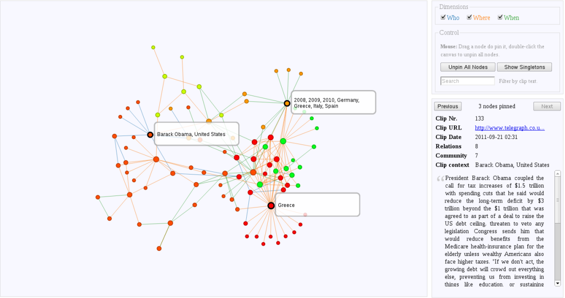
```
Input: News clips network $G_{max(levels)}$ in dot format.
Output: Set of tiled images for each resolution.
  $tileSide \leftarrow 256$
  $G_{base} \leftarrow gvmap(sfdp(G_{max(levels)}))$
  for all $V \in G_{base}$ do
    $V.label \leftarrow None$
    $V.pageRank \leftarrow computePageRank(V)$
  end for
  for all $n \in levels \setminus max(levels)$ do
    $nrLabels \leftarrow 2 \times (n+1)$
    $fontSize \leftarrow \frac{300}{2^n} + 5 \times (n+1) + 5$
    $G_n \leftarrow G_{base}$
    for all $V \in G_n$ decreasingly ordered by PageRank
          $\wedge$ while $labelCounter < nrLabels$ do
      $V.fontSize \leftarrow fontSize$
      $communityLabel \leftarrow$
            $getCommunityLabel(V.community, V.text)$
      $vertexLabel \leftarrow getVertexLabel(V)$
      $label \leftarrow concat(communityLabel,\ vertexLabel)$
      if $communityLabel = nodeLabel$
            $\vee \neg V.text.contains(communityLabel)$ then
        $V.label \leftarrow vertexLabel$
      end if
      $increment(labelCounter)$
    end for
    $image \leftarrow createImage(G_n)$
    $side \leftarrow 2^n \times tileSide$
    $resize(image,\ width \leftarrow side,\ height \leftarrow side)$
    $createTiles(image,\ tileSide)$
  end for
```

munity labels were contained in the clip text, we simply used the clip label.

Figure 3 depicts the zooming behavior that our network map provides. In Figure 3a we can see labels such as "Greece: Banks", "Income: Taxes", or simply "Stress", as well as "Rating: Grade" or "Rating: Business". Zooming to the maximum resolution for the node labeled "Greece: Banks" shows the corresponding clip text depicted in Figure 3b. Next to the text fragment, there is an information icon that can be pressed to display a tooltip containing relevant metadata for the corresponding news clip, including its identification number and date of clipping, as well as a link to the news website where the text was collected from, along with a set of user-assigned tags.

3.2 Multidimensional Network of News Clips

Although zooming is an interesting interactive behavior, our aim was to provide a more dynamic and even more interactive tool that would allow the user to explore every aspect of the news clips network, including the metadata that supported the discovery of the multidimensional relationships. Thus, based on the same network data, we used *d3.js* to create the visualization depicted in Figures 4, 5 and 6. The users can hover through a node to see its identified named entities, as well as its metadata in the sidebar. Additionally, users can pin nodes by dragging them, which allows them to navigate through the metadata of these nodes by pressing "Previous" and "Next". This way they can for instance examine the semantics provided by the different communities, which are mapped as colors. As we can see from Figure 5, the user can also enable and disable each dimension. This visually translates into the removal of the edges of the same type as the toggled dimension, disconnecting the corresponding pairs of nodes and actively updating the force system until it stabilizes. Figure 5a shows the *Where* dimension disabled, with all the disconnected nodes hovering around the main network component. Figure 5b illustrates the same behavior, now with the singleton nodes hidden for a cleaner interface.


Barack Obama, United States
2008, 2009, 2010, Germany, Greece, Italy, Spain
Greece
Dimensions
Control
Unpin All Nodes
Show Singletons
Search
Previous
Next

☑ Who ☑ Where ☑ When

Mouse: Drag a node do pin it, double-click the canvas to unpin all nodes.

Filter by clip text.

3 nodes pinned

Clip Nr.	133
Clip URL	http://www.telegraph.co.u...
Clip Date	2011-09-21 02:31
Relations	8
Community	7
Clip context	Barack Obama, United States

"President Barack Obama coupled the call for tax increases of $1.5 trillion with spending cuts that he said would reduce the long-term deficit by $3 trillion beyond the $1 trillion that was agreed to as part of a deal to raise the US debt ceiling. threaten to veto any legislation Congress sends him that would reduce benefits from the Medicare health-insurance plan for the elderly unless wealthy Americans also face higher taxes. "If we don't act, the growing debt will crowd out everything else, preventing us from investing in things like education. or sustaining

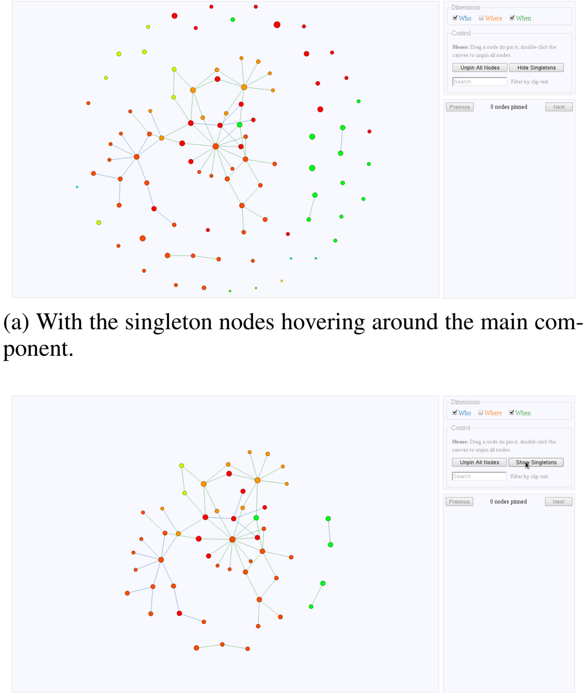
Figure 4: Interactive visualization for a multidimensional network of news clips, with three pinned nodes.

Finally, users can also apply a node filter based on the news clip's text, allowing them to find nodes for specific topics. Figure 6 shows an example filtering, where the word "greece" is used to find news clips about the country. Visually, any node that doesn't contain any reference to the word "greece" is faded out, so that the users can find the nodes about the topic they searched.

4 VISUALIZATION-BASED JOURNALISTIC RESEARCH

We describe a possible use case of the developed visualization systems, in a journalistic environment, as a news research and knowledge discovery tool, using the underlying socially based collection of news clips, provided by the Breadcrumbs platform.

Our visualization tools are specially useful when-

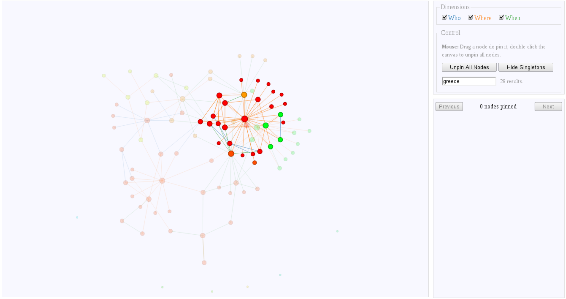


Mouse: Drag a node do pin it, double-click the canvas to unpin all nodes.

(a) With the singleton nodes hovering around the main component.

(b) With the singleton nodes hidden.

Figure 5: Interactive visualization for a multidimensional network of news clips, with the *Where* dimension disabled.



Mouse: Drag a node do pin it, double-click the canvas to unpin all nodes.

Figure 6: Interactive visualization for a multidimensional network of news clips, with a filter for "greece".

ever a journalist wishes to research the public's opinions and interests on either current or past reported events. Given the folksonomic character of the explored data set, a journalist should be able to explore the news through the reader's point of view, reaching the original news article from the fragments of text that the users collected. Next, we present an example of a typical usage pattern of our visualization systems in the process of interactively organizing information and discovering hidden relations.

To better understand the available information, a journalist might use the multiresolution map visualization tool. This provides an overview of the network, enabling the journalist to immediately become familiar with the global topics which the users are reading about. The semantic aggregation of news clips provided by the colored communities should help identify the different groups of related topics, as well as the boundaries where topics transition to new subjects. Zooming into a higher resolution should provide further topical information, making it progressively clearer to the journalist what were the topics in the center of the user's attention. Finally, the journalist might access the highest resolution zoom level, being able to read the news clips at the source of the displayed topics, as well as access some of the news clip's metadata, such as the news source location, the date of clipping, or the user-assigned tags. Nevertheless, the overview provided by the map visualization tool might not be sufficiently insightful. To continue the research, the journalist might use the multidimensional network visualization tool.

The multidimensional network contains relational knowledge about the entities present in news clips, including people, places and dates. These three dimensions are at the core of any news article, and help provide an answer to three of the five questions in the "Five Ws" journalistic maxim: Who, Where, When, What and Why. When using this visualization system, the journalist might start by discovering which nodes are in the center of each community (depicted using different colors). A simple mouse hover on a node with a high number of connections should be a good starting point. Whenever an interesting node is found, a journalist can pin that node, consult its metadata, and continue researching and pinning as many nodes as desired (see Figure 4). Pinned nodes, corresponding to single news clips, have a label where the identified entities are displayed, allowing the journalist to understand the focus of readers when collecting news clips. For instance, whenever a group of news clips containing several entities are connected to each other for coreferencing a single entity, such as "Barack Obama", the journalist might decide to explore the related news clips in the same community, knowing that the public is interested on that person. The system has two additional features that can help the journalist filter the displayed nodes and edges. Whenever the researcher is, for example, interested in discovering news clips connections solely based on people and dates, the *Where* dimension can be disabled and the singleton nodes hidden, providing a filtered view of the network (see Figure 5). On the other hand, the journalist can directly search for news clips, by using a text filter that highlights all nodes corresponding to the news clips that match the input string. This type of behavior is depicted in Figure 6, where a filter for "greece" was applied to the multidimensional network visualization, therefore allowing the researcher to find news clips about Greece.

These visualization tools can be used to complement a journalist's research by taking advantage of a knowledge base created by the readers, thus bringing the producer closer to the consumer's interests.

5 CONCLUSIONS AND FUTURE WORK

We developed two interactive visualization systems for a multidimensional network of news clips. Our implementations enabled users to explore the relationships between news clips, based on the co-occurrence of named entities and the community structure of the network, empowering them with a set of tools to explore the relational data present in news clips. The biggest challenge for the interactive map visualization was the identification of descriptive node labels, as well as their positioning. This happened because the tool we used to generate the set of images for the multiresolution visualization didn't take into account the different label lengths to define a common layout across zoom levels. We solved this problem by positioning the labels for lower resolutions in the most central nodes, according to the PageRank, as well as by selecting the appropriate font size for the various zoom levels.

The multiresolution map visualization was effective in producing a clear illustration of the network's nodes and clusters, however it didn't provide by itself a very rich interaction to the user apart from a semantic zooming behavior and the consultation of news clips metadata. Using the layout properties to influence the behavior of other web components would require further implementation as the tool only provided the means to generate a simple static map in the format of an image. On the other hand, with the visualization of the multidimensional network of news clips, developed using a data-driven approach, we were able to develop several web components that enabled the user to organize and filter the nodes, as well as to visually toggle any of the available edge dimensions. This allowed the users to interactively explore several aspects of the data that would otherwise be difficult to interpret, resulting in a tool that can be used in journalist research.

As future work, we would like to improve on the existing network map visualization, specially in regards to the method of community and news clip topic discovery, when computing the pair of node labels. We would also like to evaluate the developed visualization systems based on human input, assessing user experience and usability, with a focus on the journalistic community.

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