

Figure 2: First proposal based on Events in the Game of Thrones Visualization

startup, Knomos [2], whose aim is to develop fully featured tool for visualizing law.

2 RELATED WORK

Cross references between cases can be visualized as a network of citations. There are many popular ways to visualize network data but a unique solution must be found to achieve the results needed for this visualization. Many different visualization approaches were considered and helped to influence the final design.

2.1 Events in the Games of Thrones

The first example suggested by the Knomos team was the “Events in the Game of Thrones” visualization by Jerome Cukier [3]. This visualization uses an adapted form of the node-link idiom. Each link between one bubble node to another indicates a kill. The visualization is a very creative way to depict the interactions between Game of Thrones Characters, but it falls short as being useable as production level software. For example, there is no indication of who killed who (i.e. which direction) between nodes connected by lines. The visualization is also crowded with no labels on the bubbles, the user must hover over a node to determine the character’s name and then hover over the node that it links to, to determine who that character killed or was killed by.

2.2 Initial Project Proposal

The initial proposed modification would use a similar layout as above:

- Each node represents a case decision, clustered by jurisdiction (e.g. Supreme Court of Canada).
- The size of the node represents the frequency of

the case’s citations throughout other cases decisions.

- The color of each node signals the relative treatment of that case decision in other cases (e.g. Green = favourable, yellow = distinguished, red = overturned).
- The lines between nodes represent interactions (the citations) between case decisions.
- The time control scrollbar can be shifted to adjust the visualization, and stopped at a specific point in time.
- Content scope can be filtered by including or restricting the years or jurisdictions selected beneath the scrollbar.

In the original “Events in the Game of Thrones” visualization the nodes were grouped by families and kills mostly happened between one family to another. For judicial cases, citations are most likely to come from the same group (i.e. within BC Laws). It is highly likely that all cases could all pertain within one jurisdiction so grouping the cases this way with lines (citations) looping back to the same group would be difficult to distinguish. Additionally, for this project we are limiting our data to one jurisdiction so the depicted clustering will not work.

A character is usually killed only once, meaning there is only one link coming into it. For judicial citations, there is likely to be a many to many relationship. With the large clusters in the Game of Thrones visualization it is hard to see where the lines are coming in and out.

2.3 Node-Link Layout

The most common idiom for visualizing network data is the Node-Link Diagram. The Judicial case data would be very easy to adapt to this approach as each case could be thought of as a node and the citations can be thought of as links. The d3 Force-Directed Graph visualization [4] is a popular example employed by many. One glaring issue with this approach is that text label occlusion is likely due to the location and density of nodes, as well as link occlusion in large clusters. The force directed graph is already used by Knomos as well so it is useful to study different approaches.

2.4 Other Social Networks

Citation networks can be thought of as a type of social network. Adapting this to judicial cases, we could think of the primary case as the “ego”, and its children citations as “alters”. A recent paper, egoSlider [5], specifically focuses on viewing the changes of an ego’s network over time. The approach that they have taken would not lend itself well to judicial cases, however, because a case does not persist over time the same was a human does. Judicial cases have a single time-stamp so it would not make sense to analyze things like tie-strength.

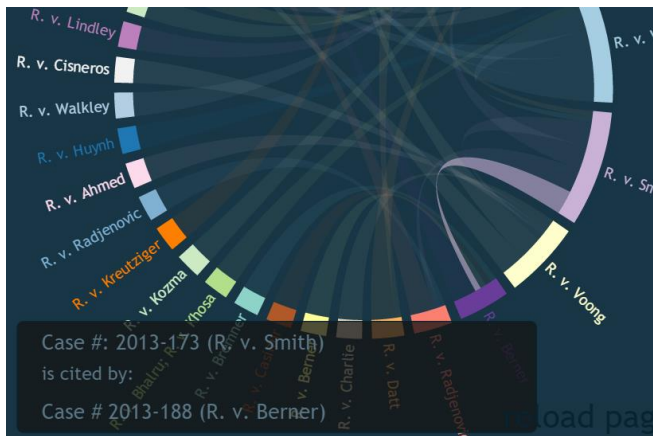


Figure 6: Hovering over an individual chord highlights that chord as well as brings up a window that displays more information.

be considered 2nd level cases. For the purpose of this visualization we are only recursively searching the primary case to a depth of 2 levels. More levels of recursion would extend the amount of time required to query the database and process the data. Additionally, the chord diagram has a limited number of chords that it can support before both the cognitive load becomes too high, and pixel resolution becomes an issue on standard monitors.

5.2 Building the Matrix

The input of the d3 Chord Diagram is a matrix. The value located at X_i, Y_i represents the flow between case i and itself. The value at position X_i, Y_j represents the flow from case i and case j , and the value at position at value represents the flow from case j to case i . These flows are represented as chord widths. For the purpose of this visualization the widths are being used to identify directionality in the form of a *cites vs cited by* relationship. A wider chord coming out of an arc indicates that the case is being *cited by* the case on the other side. So for a *cited by* position on our matrix (ie. X_i, Y_j) we use the value 4, and the arc on the other side of the chord is the *cites* position (i.e. X_j, Y_i) a value of 1 is chosen.

5.3 Slider

The package Dragdealer [14] (dragdealer.js) is used to implement the slider that determines the position on the timeline. Before we can display the slider we need to determine our timescale from the data. The nature of the data requires a non-linear timescale. It is possible that there could be one case in 1999 and 30 in 2012, for example.

Each case represents a single, unique point in time, ie. 2013-173 represents case #173 in 2013, so using individual cases is a logical choice for time steps. However, the problem with this is that we are visualizing pairs of cases rather than individual cases so the earliest case in our dataset will be *cited by* a case later in time. As we progress along the timeline the diagram will be filled with more cases with future dates. This is non-intuitive and also results in many

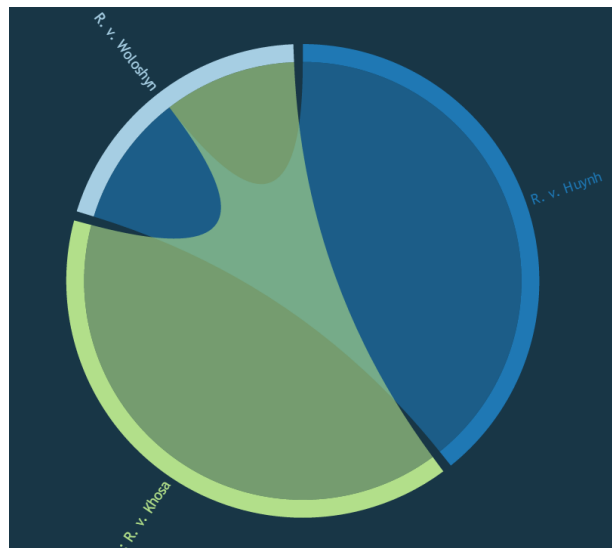


Figure 7: Chord diagram with only 3 cases on it.

slider movements where no new cases pop up on the diagram because they are already referenced by previous cases. To deter future cases showing up on the diagram we filter out cases that occur at a later date. The time steps are also restricted to cases which cite at least one other case to ensure that there is something to actually draw when the slider position is moved to that case. By the time the slider reaches the end of the timeline, all cases are on display on the diagram.

5.4 Animation

To allow the user to visually track the change in time the chords and arcs will animate between time steps. The implementation used is inspired by delimited.io [8] (interactive chord diagrams in d3). The scripts chordDirective.js and matrixFactory.js were borrowed from [8] with some modifications. Their code leverages the Angular javascript package (angular.js), however it is not absolutely necessary. Essentially, for each time step on the slider, a new matrix is being built from our timeline reduced dataset. When the slider is changed, new items are added (or removed) from the diagram. These items will be initialized to the default position and then their positions are interpolated to their final positions.

A Play/Stop Timeline button is included to allow the diagram to automatically animate from start to finish.

5.5 Other Views

Highlighting over a chord displays a tool tip with more information about the relationship between chords. For this relationship formatted text is used to display: *Case # (Case Title): is cited by: Case # (Case Title)* in a superimposed window (figure 6).

Another view in the center of the window displays the relationships between the case specified on the timeline slider and each of its citations. This is displayed as (figure

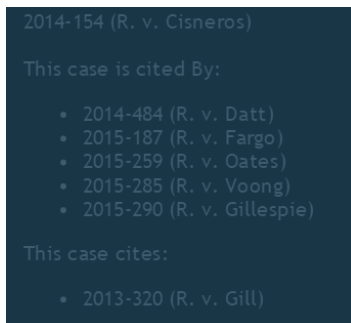


Figure 8: Centre window displaying detailed information about the current case on the timeline.

8):

Case # (Case Title)

This case cites:

- Case # (Case Title) for each case cited

This case is cited by:

- Case # (Case Title) for each case this case is cited by

This centre view is displayed by dynamically creating html objects in Javascript each time the slider moves and adding them to an html section.

5.6 Other Software

Foundation [15] was used for some of the CSS styling and paletteon [16] was used to help come up with a website colour scheme. Github is being used to host the website.

6 SOLUTION

6.1 Initial Attempts

A first attempt set the width of the chord to 1 on the *cited by* side and 0 on the *cites* side. Most of the 2nd degree cases are not cited by any other cases so they end up with an arc of 0 width causing their labels to be bunched together and occluded. A subsequent attempt (figure 3) set the width to 1 on each end. This reduced any text occlusion, however, it made it unclear what the relationship was between the two cases. Next a width of 2 on one end and a width of 1 on the other end was used to differentiate the relationship, but the difference was not easy enough to decipher with ease. A width of 4 for the case that is being cited vs a width of 1 for cases that the case cites made it much easier to differentiate between the two. This also has the effect of making the arc width wider for cases that are cited by many other cases increasing its importance, which is specifically useful for finding key cases.

6.2 User Opinions



Figure 9: View of a case that is cited by 3 cases (wide chords) and cites (thin chord with a different colour) only 1 other case.

From a development standpoint it is most useful to reference data by its unique identifier, in this case the combination of year and case # ie. 2013-173. These were initially used as the labels for each case on the chord diagram wheel. After speaking with 3 non-domain expert test subjects, it became clear that the visualization was not entirely intuitive. On consultation with a legal expert, the decision was made to display the case title (also known as a SOC) instead of the case number. For the tooltip view (figure 6) and the detailed view in the center (figure 8) both the Case Year - Number and Case title are displayed.

6.3 Final Result

Approaching the experts and non-experts alike the consensus is that the final result is much more intuitive. *R. v. Mansfield* resembles a case decision much more than 2013-173. Additionally having text in the tooltip view as well as the centre view that explicitly states *cites* and *cited by* relationships helps train the user if they are not already aware of the relationship from the Chord Diagram.

6.4 Use Case

As mentioned earlier, the aim of the visualization is to aid the user in finding key cases which are cited by many other cases. The first step would require them to enter a case of interest in the text field and initiate the search. The visualization starts by playing the timeline from the beginning. Oftentimes a key case can be one that happened many years ago and has been cited by many cases since then. In that situation the case will show up earlier on in the timeline, and *cited by* links will be added to it as the slider progresses. It will be clear to the user that a case who has many links added to it is important.

The user can stop the animation at any time, or wait until it finishes. For the most part it is easy to follow the links between two cases visually. There exists some occlusion of chords in the centre of the diagram due to overlapping, however, this is alleviated somewhat by having non fully opaque chords so that you can see which chords are passing through which. It is also generally easy to follow a chord based on its arc and trajectory, as well as its unique colour.

In the case that it is not easy enough to follow the links between cases, the user may simply highlight an arc to see

centric to that case. Given that it can take 20 seconds or longer for the diagram to load it did not seem as though it would be a great time saver over having to enter the case into the form and hitting search again.

7.5 Critique

After the first iteration with a static diagram with uniform width and poor colour choices (figure 3), it was not clear whether using a chord diagram was a good choice. It was hard to determine the relationship between cases, and the diagram was non-intuitive. However, after resolving many issues it has become clear that the chord diagram is a powerful tool for displaying information. Adding many new features to the visualization has also helped to make the tool more intuitive.

8 CONCLUSION

Legal research can be done more efficiently with a well-developed visual tool. The Judicial Case Law Citation Timeline visualization has shown that it can be used to effectively visualize a case law citation network, and help identify key cases. The slow process of reading through many documents is no longer necessary and can be replaced with tools that display all the information more effectively.

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