DSOC: Decision Support for Organizational Change

Rob Barwell and Eric Spero

Fig. 1. Version 3 of DSOC. Columns: Demand (left) and Supply (right). Rows: Organizational (top), Process (middle) and Redundancy (bottom).

Abstract— DSOC is a novel way to visualize the complex problem of organizational change by allowing the user to quickly see where gaps exist in an organization, understand the gaps that exist, and help the user determine how they might fill the gaps. This is supported by using email within an organization to model the flow from one employee to another. This representation provide the most current and concrete representation of the organization and allows the user to make better decisions when faced with organizational change.

Index Terms—Organizational change, decision-making, information visualization

1 Introduction

The rise of the 'gig economy' [1,2] has forced society through a massive transition in the past two decades with people transitioning between jobs with greater frequency. Historically, a person would obtain a job from high school or university and stay with a specific company until they retire. This resulted in organizations that had minimal change, which could be easily managed. Modern organizations are forced to adapt with the shift to the gig economy and other non-traditional employment models.

An organization is a social network [3] of individuals engaged in complex *interlocking contingencies* [4]: individuals in an organization are tightly interconnected, where the behaviour of one both depends on, and has subsequent consequences for the behaviour of others [4]. This feature of organizations means that the results of changes to its social structure—say, by adding or removing an individual—can be difficult to understand. Change is disruptive, and care must be taken to minimize any negative side-effects. The challenge of minimizing organizational disruption as a result of personnel change depends critically on understanding the effects of that change. In the gig economy, this challenge, and the need for tools that support it, is even greater.

Say a bit about emails here?

During the course of development, as a result of our conversations with others and our own observations, we noticed that the problem of organizational change boils down to a problem of *demand and supply*. When an individual leaves or is removed from an organization, this

• *Rob Barwell and Eric Spero are with Carleton University. E-mail: rob.barwell/eric.spero@carleton.ca.*

creates a need (i.e. a gap, a *demand*) which must be addressed by the manager. To do so, the manager will have to inspect their internal pool of resources (i.e. their *supply*) and assign new duties/responsibilities to one or more people.

An individual's function within an organization can be viewed using different lenses. For example, employees can be viewed in terms of their position in the hierarchical structure of the organization, the processes they participate in, and their process- and organizational-agnostic social ties. When dealing with an organizational change issue, the manager be considering each of these views (and perhaps others not mentioned) on both sides of the demand and supply issue mentioned above.

We proposed DSOC (Decision Support for Organizational Change), a visual analytics dashboard to help managers respond to organizational change in a way that minimizes disruption to the organization. A screenshot of our functional prototype is shown in Figure 1. When using DSOC, managers are shows a number of visualizations that each help managers grapple with a part of the complex demand and supply problem. Visualizations are organized into two columns: demand and supply, and as many rows corresponding to the views of an employee that a manager is interested in. We implement demand and supply visualizations for three views: *organizational*, *process*, and *redundancy*, which correspond to the three example views mentioned in the example above.

In this paper, we discuss . . . in Section 2, . . . in Section 3 . . . in Section 4 . . . in Section 5 . . . in Section 6 . . . in Section 7

2 Literature Review

Need for a review of the literature in this area. Relevant concepts, similar works, etc.

2.1 Information visualization and cognition

We aim to address this problem through *information visualization*. Visualizations support thought by reducing the gap between the data, and the users' *mental model* of the data [5]. A mental model is an internal representation of how something in the world works [6, 7]. Wherever there is distance between the presentation of the data and our understanding of the data, mental work must be done so that understanding is possible. This type of mental work does not bring us closer to solving domain goals, but rather is a sort of unfortunate precursor for the really important work, and therefore should be avoided wherever possible [8]. Fortunately, the physical environment can be used to store information, which allows us to 'off-load' mental work onto the environment [9]. Visualizations are essentially one way of effectively leveraging this property of the environment to aid thought.

The development of our visualization started with defining a methodology to help guide the design process. We reviewed a number of papers in the area of evaluation of information visualization. We found this area of research to be less concrete then other topics we had studied before. The Challenge of Information Visualization Evaluation [10] paper we reviewed helped us to clarify our evaluation criteria and approach by validating our desire to present our design and findings to various user groups throughout the design process. The Empirical Studies in Information Visualization: Seven Scenarios paper [11] paper supported our desire to have an iterative approach similar agile software development. The approach presented in the paper was Pre-design, design, prototype, deployment, and re-design. This approach would also line up with using different user groups through the process.

3 Design

3.1 Background

3.1.1 Methodology

Our design was informed by consultation with three user groups. These groups are:

A. **Government Department**. Members of a large department at the Government of Canada who address organizational change issues in their work.

B. **Academia**. Students and a professor at Carleton University.

C. **Private Company**. Users at a private multi-national company who discovered our research during the design process.

We made the real-world viability of our design a top priority. As such, we felt it was important to show our design to people from a number of different backgrounds to help ensure that our design was comprehensible to a wide variety of potential users, and that our visualizations effectively communicated the underlying data and helped support the task at hand. Our initial design underwent two major revisions in response to feedback received from members of these groups.

After implementing Version 1 (V1) of our prototype we presented it to Group A. Group A provided the key insight that the problem we were addressing was problem of demand and supply across multiple views. The design concept behind V2—a major redesign—came directly from our interactions with Group A. V2 was then shown to V3, who pointed out a number of issues with specific visualizations. This group provided creative ways of helping support the needs identified by Group A. V3 was then shown to all groups, where no major issues with our implementation were identified.

3.1.2 Problem Space

After implementing our original design and going through several subsequent iterations, the way in which we framed the core problem we were trying to address also changed. We loosely followed Pirolli and Card's sensemaking loop [12]: we started with a question, eventually leading to a hypothesis, and then through a validation process, leading us back to a new formulation of the question.

The problem as we originally conceived it was simply how to help managers fill empty positions in the gig economy era, which has high employee overturn. Managers rely on organizational models like organizational charts to help with this task, which are representations of the structure and function of an organization. Organizational charts are not ideal tools for this task as they are quickly out of date in the gig economy, and they provide a limited view of a person's role in an organization. We set out to offer a new solution leveraging the power of graphical user interfaces and information visualization.

As we developed our design, we found it useful to break our original definition of the problem into sub-problems. Each sub-problem imposed their own demands on the interface, which was obscured in the original definition. We eventually recast the original problem into three research questions:

1. "How do we support decision makers to minimize negative side-effects from organizational change?"
2. "How do we value a person in the organization?"
3. "How do we provide options to users to address vacancies within an organization?"

From the point of view of the manager, these questions take the following form:

1. "Where is the gap that results from an individual leaving the organization?"
2. "How big is the gap?"
3. "What can I do about the gap?"

3.1.3 Option Space

Using a refined problem description we started to focus on how we would address these statements. Using the work done by Ware on Visual Thinking Algorithms [13, Chapter 11] we decided to enumerate the steps a user would do manually to solve the problem statements and determine where visualization could help offload cognitive processes.

During our walkthrough of V1 with Group A, we presented V1 of the interface and asked users to imagine using the software to solve the original problem. Group A immediately sub-divided the problem into the three sub-problems mentioned in Section 3.1.2, and explored it

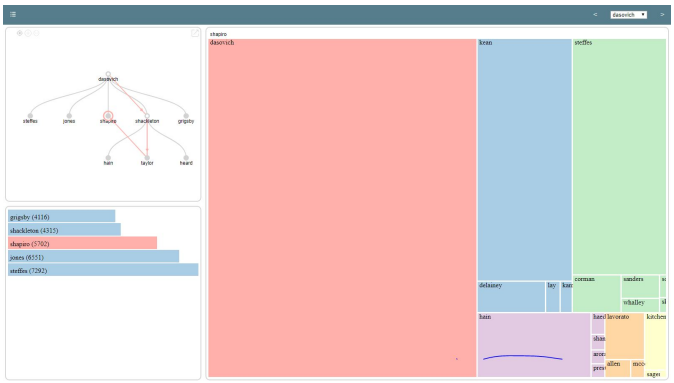

Fig. 2. Version 1.

from different perspectives or views. Group A expressed that it would be helpful if the interface could model all of the different views. The different views are summarized below:

Organizational This places an employee in the traditional hierarchical organizational structure. Commonly this is represented by a tree where the employee is a node and an edge is the link between nodes.

Process This places an employee as part of a process where they receive information, process information, and output information to the next stage of the process. Users typically used flow charts and other process diagrams to represent this view.

Redundancy During the walk through we noticed it was most common to address the vacancy by re-distributing the workload within the group, however the users occasionally tried to find people that did similar tasks as replacement.

3.1.4 Data

During the exploration of the problem space we needed to identify what data we were going to present to the user with the visualization. Building upon previous work from our colleague on information flow within an organization **Can we say a sentence or two about this previous work?**, we decided to use emails. The majority of communication within a modern organization is through email or instant messaging. We thought that analyzing email data would allow us to build an accurate and up to date model of how information flows through an organization.

Using emails as the basis of our data model was well-received by Group A because it addressed some shortcomings with the traditional organizational chart model, which is typically out of date and does not capture all of the contributions an employee makes to an organization.

The data model requires enrichment through the addition of value models. One value model would be required to help the manager find out "How big is the gap?" and another value model would be required to help the manager find out "What can I do about the gap?". We use rudimentary value models as the primary focus of this paper is the problem of how to visualize the data, and not the data itself.

Gap Size By modeling each employee as a node, the emails between nodes would represent an edge with a weight of 1.

Gap Options One option to address the gap could be redistributing the work to a 'similar' employee. The value model we used to compare the similarity of two employees is 'overlap' in terms (a) number of emails sent, and (b) who the emails are sent to.

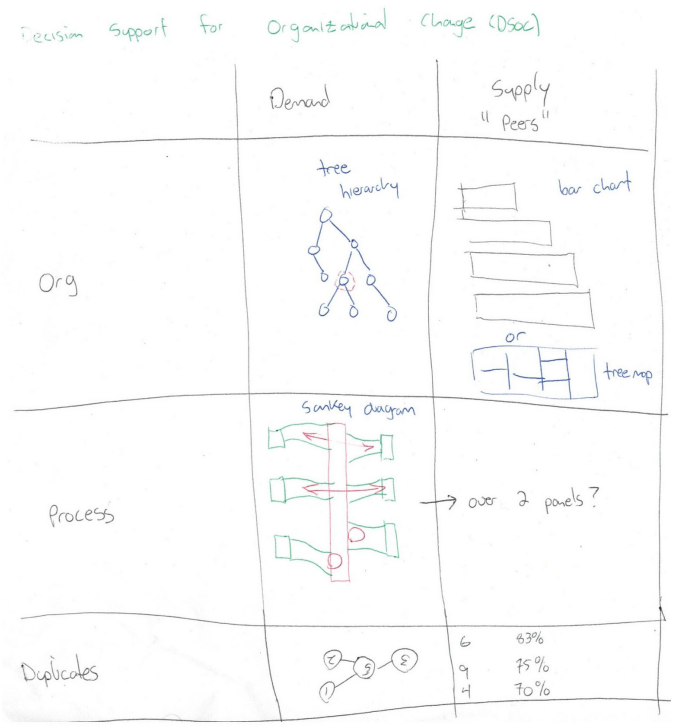

Fig. 3. UI design sketch drawn after initial meeting with Group 1. Shows the grid pattern and several of the visualizations used in the final version.

3.2 Evolution of Design

Our made incremental refinements to our design in response to feedback obtained from the users in the groups mentioned in Section 3.1.1. Our design went through three major versions:

V1 The initial design by the authors that focused on the organization and communication problem.

V2 Overhauled layout and introduced grid layout. Added the process and redundancy views.

V3 Refined the process and redundancy views to better align with the users' mental model and how they interact with the visualization.

Our greatest challenge was creating a functional and comprehensible layout that also conveyed the complex intricacies of organizational change.

3.3 Layout

3.3.1 Structure

The original, design shown in Figure 2, had viewing panes to try and convey the organizational perspective of information flow and the process perspective. It attempted to do this using the standard organizational tree for organizational structure and a tree map to show the volume of communication between a selected individual and their communication links.

This view presented many challenges for users as they found it difficult to understand what the visualization was trying to communicate. There seemed to be a severe incompatibility between this design and Group A's mental model of the problem of organizational change. For Group A, the problem at hand boiled down to a problem of *supply* and *demand* (these were the words they used most frequently during this conversation), yet these concepts were not straightforwardly represented in our design. This observation called for a major redesign of the structure, where starting in V2 (Figure 4) we would build the notion of supply and demand into our structure. The first stage in this redesign is captured in the sketch in Figure 3.

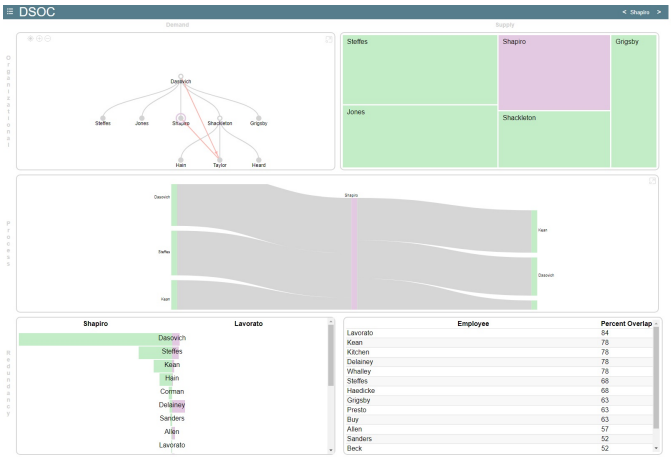

Fig. 4. Version 2

The new design featured a grid layout of 2 columns × N rows. Visualizations that focus on the *demand* aspect of the problem are placed in the left column, and visualizations focusing on the *supply* aspect are placed in the right column. By visualizing both the supply and demand aspects of the problem next to each other, managers can simultaneously see the gaps left by an individual's absence, and also ways to fill those gaps.

The grid layout redesign seemed to resonate better with all groups. This allowed all groups to focus on the individual views within the visualizations versus focusing on the layout.

Allowing each row to represent a different view of the problem space enables the flexibility to include different views in the future as more users trials of the system are conducted.

3.3.2 Navigation

Complimentary to the structure of the layout is how the user will navigate the layout. Our goal was to provide the user with the freedom to explore the problem however they choose. This required the support of a brushing scatter plot concept where the interactions within an individual sub view are reflected in the other sub views to ensure the user is always viewing the problem from a single data point through a number of lens. As the user explored the problem it was also important to have a way for them to keep track of the problem space they have already explored. This was a salient point that we found during the literature review with the quote "Information exploration is inherently a process with many steps, so keeping the history of actions and allowing users to retrace their steps is important" [14]. This quote accurate describes how our users would interact with the system. This was included by providing the user the option to display history as direction arrows or simply coloring the nodes in the organizational chart. The user can then navigate the history using the navigation bar at the top of the screen.

3.4 Organizational

The organizational demand and supply view were the most consistent between version 1 and 3. The demand view was modeled as a classical organizational tree structure as this paradigm was most aligned with the users current mental model of the problem. During the design phase we uncovered a number of issues that we needed to address.

Actions Some organizational trees can be large and we need to provide the user with the ability to zoom in and out of the tree, expand a node with children and select a node. In version 1 we decided to use a single click to expand a node and select a node with one action and double click would zoom in and out of the tree. Users in Group A found this confusing since opening the children of a node would also cause the node to be visited. This was refined in version 2 where a single click selected a node, the double click would zoom in and out, and a right mouse click would open a node with children.

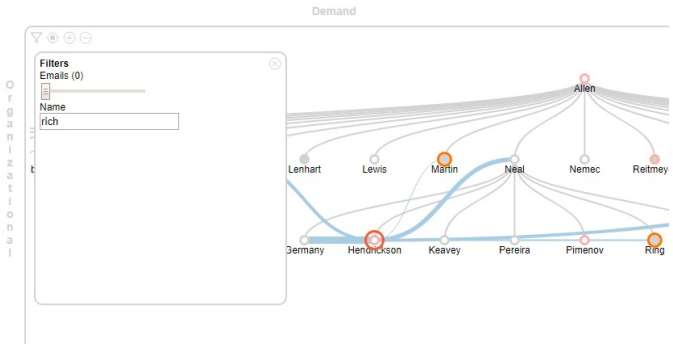

Fig. 5. Node Selection

Highlight During the initial design of version 1 we needed to come up with a creative solution to visualize the various states a node could have. This includes: being selected, having children, being visited, and being filtered. We originally experimented with glyphs and other icons, however this resulted in a visualization that was too "busy". We settled on using concentric circles of different colors as shown in Figure 3 to denote various states of a node. A node with children has a filled in circle. A node that the user has visited appears in red. A node that is filter is orange. And a node that is selected appears red. We recognized the issue this might present for color blind people and also chose to vary the size of circle around the nodes to account for this.

Navigation Navigating large trees can present challenges for some users. This was addressed by providing a real time filter where the user adjusts the filter parameters which are quickly reflected by circles appearing and disappearing around nodes in the tree that match the filter criteria. Additionally the organization demand panel can be expand to fill the whole window to help the user navigate the entire tree. Additional short cuts are provided at the top of the frame to center on the current selected node, expand all nodes, or collapse all nodes.

Comparison Version 1 of the design provide a feature that allowed the user to hover over a node and display the nodes they communicated with using a blue line. This was further refined based on discussions with Group B to incorporate a weight. This would then allow the user to see the overlap of where the employee is within the organization and which other employees they communicate with and how much. This is denoted by the blue line in figure 3.

The original organizational supply view was a horizontal bar chart as shown on the left side of figure 1. In version 2 we experimented with changing this to a tree map as we wanted to show the relative size of each employee in a group compared to the others. The space filling method [15] as discussed in Ben Shneiderman original treemap paper was appealing since we did not know how large a group might be. After discussion with Group B we decided treemaps were not appropriate since there were no levels to drill down to or group by. It was also noted by Group A that a bar chart might be better for a comparison view point. When the user clicks on any of the bars it will re-orient all views to select the employee. The final vertical bar chart is shown in figure 4.

3.5 Process

The process demand and supply view went through the most significant change between versions. In version 1 a treemap was used to model the communication flow between the selected employee and those they communicate with. This approach was great a showing the relative comparison of communication from the view of an employee, however Group A noted that this didn't really show flow of information and made it hard to determine what information started or ended with the selected employee. Group A's suggestion was to investigate using a Sankey diagram. In version 2 we added a Sankey diagram, however this version presented a number of challenges for Group B. The unbalanced flow connections led the group to believe there was some sort

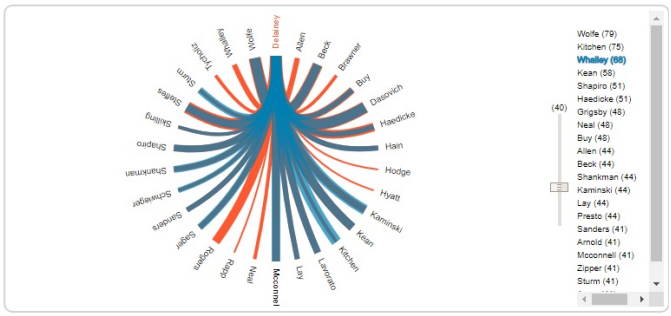

Fig. 6. Palm Tree

of knowledge in the way it flowed from left to right which was simply a function of the layout algorithm and not used to communicate any information. Additionally some communication links were large and made the visualization hard to interpret. It was further compounded by users not being lined up on the left and right of the diagram. Based on this feedback a complete redesign of the diagram was required. Version 3 significantly changed the layout from version 2. We scaled the links to make them easier to differentiate on the screen, color was added to denote links that either started or ended with the selected employee, and most significantly we lined up the communication flow so if a user was an incoming and outgoing communication flow they would appear at the same location on both the left and right hand side of the screen. The unique nature of the Sankey diagram allows it to both show demand and supply. This concept will be further discussed in the evaluation and discussion section.

3.6 Redundancy

The redundancy view was introduced in version 2 after discussions with Group A. They thought it would be a "neat" idea to show similar people within an organization as a potential supply source to solve the identified gap. Version 2 included a simple implementation where a back to back bar chart was used to help the user determine if the supply lined up with the demand and a table allowed the user to select the best supply based on the value model discussed in the previous section. Group B had some challenges with the supply part of the design as a table wasn't how users typically compared two options. This led us to investigate a number of options including hierarchical edge bundling and chord diagrams to try and show the overlap between two selections. The chord diagram presented challenges since the selected employee would fill the entire circle making it hard to differentiate between the different paths. The hierarchical edge bundling had the challenge of not showing the relative size of each connection. This was over come by merging the two concepts to create the palm tree diagram. This diagram allows the user to hover over the list of recommended users which was the table in version 2 and see the comparison. This is shown in figure 5. The slider also allows the user to adjust the cut off of the list in real time to try and narrow the scope of comparison without discounting employees that might have poor overlap with other employees. This approach seemed to resonate well with all user groups in version 3 as it was flexible to an employee with many connections and provided instantaneous feedback to the user.

4 Implementation

Each version of the design was implemented using MySQL, PHP, HTML, CSS, and Javascript using the D3 library. A number of visualization systems were contemplated, however D3 was chosen due to its maturity level and flexibility to visualize our designs.

4.1 Data

Email (SMTP) header information was used to implement the value model discussed in the previous sections. Alternative value models later in the paper.

To demonstrate our value model we chose the popular Enron email data set. This data set was originally made public during the Federal Energy Regulatory Commission investigation. It contains the emails of approximately 150 users in the Eron organization. Most of these users are senior managers. This particular data set has been studied a number of times primarily with a focus in social networking and natural language processing. This paper will use this data set to illustrate our visualization to support the flow of information through an organization.

In addition to the email boxes of users we also required an organizational chart to represent what the organization thinks is the structure of their employees. Unfortunately, during our research we were unable to obtain an organizational chart. This is a well documented problem with the data set which has limited research against it for lack of verification. Since our research is primarily focused on the visualization and not the under laying data we decided to use the organizational chart reverse engineered by a group from the University of Amsterdam [16]. Based on our research this is one of the more accurate papers to model the organization from a standard organizational structure vice a social networking structure.

4.1.1 Data Preparation

The Enron data set was obtained from Carniege Mellon University. It was processed using a Python script to parse all the SMTP header information from a given email. This was then stored in a MySQL database for further processing by the application. SMTP information was chosen since it contained all the information required to construct the nodes and edges within the graph.

4.2 Organizational

The organizational view was straight forward to implement using the hierarchical tree and bar chart components of D3. Custom path generation was required to connect nodes when a user hover over them to denote the email and not organizational connections as shown by the blue lines in figure 3. This was accomplished by binding the database node id to the D3 object id. This facilitated the selection of individual nodes in the tree to determine their x and y position to draw a path between. This process was also used for the history link paths as shown in figures 1 and 2. The only design choice that arose during implementation was what to do when two nodes are connected, but one node isn't visible. In this case we decided to connect it the visible node to the closest parent of the hidden node.

4.3 Process

The process view was the most complex to implement. It required a custom layout generator. The generator takes a list of all nodes and edges for a current view. It then splits the edges into incoming and outgoing. After iterating through the edges to determine if the incoming or outgoing edge is greater it then conducts a layout which utilizes the full space allocation. Nodes are also logarithmically scaled to reduce overlap and make the visualization easier to use.

4.4 Redundancy

The redundancy view was the most challenging to implement since it had a number of custom visualization components. A custom bar chart was required to display the back to back bars in the redundancy demand view since D3 only had a standard bar chart. However, a number of D3 features that create bar charts were utilized to create the back to back bar chart. The most challenging feature to create was the palm tree in the redundancy supply panel. This required a custom layout that would place the selected employee in a circle with all the people they communicate with. Then additional layers were required on top to position the compared employee in place of the selected employee. This also required a custom data structure to communicate this information from the server to the D3 engine.

4.5 Other Implementation Choices

Colour A single colour scheme was implemented to ensure consistency across all views. This provides consistency for the user

where all the nodes are the same color regardless of view and the selectednode is easily identifiable.

Layout The layout was implemented using CSS grids that allow for the screen to be divided into frames. This facilitated the layout of allowing 2 rows within the window at any point in time.

Labels Labels were added to reduce confusion of the new demand/supply layout in version 2. Users found this very helpful to understand the problem space.

5 Evaluation and Discussion

5.1 Overview

Evaluation of the design was done at a number of points during the development. The final design was primarily utilized to provide direction on future work and understand how organizations might use the final product. During the development we explained our design using a use case which helped focus users to how we intended the system to be used.

5.2 Use Case Walk Through

The original problem was how to address empty positions in the organization. This could be from employees switching jobs, they could be on temporary leave of absences, or the could be seconded to other positions. The result of this is the manager needs to determine what gap is left by the employee and how to fill it. Taking a hypothetical situation where you have a manager named Eric who has a gap left when his employee Rob quit. He now needs to go through the process to address the 3 problem statements we enumerated in the first section.

"Where is the gap?" Gaps left when an employee leaves are not restricted to the employees organizational group, but could effect other groups as well. Job descriptions are typically a poor reflect of an employees job as they are only updated when an employee leaves. This means Eric in our example needs to look at the organizational side of the problem and the process side of the problem.

"How big is the gap?" When gaps are found the manager needs to know are they small such as a person just needs to sign an approval form, or are they big such as the person who is responsible for producing a yearly financial report.

"What can I do about the gap?" This problem is the most complex as it require the manager to evaluate first if they are filling the gap and then what resources do they have available to them to fill the gap.

5.2.1 Finding the Gap

Our visualization helps Eric with each of these questions. First he can identify the gap by using the organizational demand tree shown in Figure 4. By navigating and filtering the tree Eric can start to understand if Rob managed any employees under him or maybe he was more senior and larger parts of the tree will be without leadership. The tree can also be used to quickly determine which parts of the organization might be effected most by hovering over Rob and looking where the largest blue lines connect to. Understanding where the gap is can also be viewed from the process view where Eric can determine which email connections start or stop with Rob. This typically denotes starts and ends of processes that would be high priority to back fill. Additionally the process diagram can provide Eric an overview of the stronger communicate links Rob had which might also need to be addressed as Rob may have been a significant part of an individual process.

5.2.2 Size of the Gap

During the exploration process in finding the gap, Eric has already started to understand the size of the problem by the weight of the lines either in the organization or process demand chart.

5.2.3 Filling the Gap

Eric can now use the supply side of the application to see how he might fill the gap he identify. This could come from a redistribution of workload within the group. The organizational supply bar chart can quickly show Eric the relative contribution of Rob to the group and potentially identify other people in the group that may be under utilized. The process chart can be used to determine if Rob is even required in some processes. This could result in system efficiencies by remove Rob from the process and simply having people on the left side connect directly with people on the right side. Lastly, Eric can try and find other employees in the organization that provide a similar role to Rob and see if they have spare capacity to take over some of the workload. This is done by hovering over names on the right side of the palm tree and trying to find one that aligns the best. This can be studied in further detail using the redundancy demand view.

5.2.4 Result

The result of this process is Eric having a better understanding of the gap created when Rob left the position and possible sources of workload redistribution to people within the organizational group, others in the process, or other employees in the organization that provide a similar role. In a real world scenario Eric would most likely fill the gap with one or more of the identified supply sources. This is why our tool was design as decision support and not decision making since a human is still required to weigh the pros and cons of these options.

5.3 Organizational Models

Our discussions with Group 3 solidified our understand of the power of our concept. When Group 3 saw the final design they immediate connected how it cold help their organization solve the problem given to them by their management to flatten their organizational chart. Having the different views that our application presented allowed Group 3 to revise their concept of using a hierarchy to model their organization and start thinking about using processes instead. The new model that was discussed involves removing the hierarchical nature of an organization and replace it with the concept of employees that have skills and contribute to processes. This would result in the organization only needing 2 or 3 levels to manage the allocation of resources and deal with conflicts when they arise. The concept of a traditional project manager would be extended and modified to create a process manager. The process manager would be responsible for identifying the skills required to accomplish their process. A resource manager would then provide an employee with those skills for the time identified by the process manager. This would have the effect of providing the organization with the flexibility to recruit specific skills vice generic positions that may or may not require that skill depending on the job. The concept is further extended to employee renumeration where it could be adapted to pay based on skill or proficiency of a skill. Therefore employees with more skills or deeper knowledge of skill would be remunerated at a higher rate.

6 Future Work

During the design and development of the visualization we discovered many areas that required further thought and research. Some of these areas were identified by us and others came from the groups that supported our research.

6.1 Value Model

All groups were quick to understand the visualization we were demonstrating and wanted to focus their time and discussions around the value model aspect of the problem vice the visualization.

The weight of each edge in the value model needs to be adjusted. For example this could include a new value based on whether the user is in the from, to, bcc, or cc field. It could also explore the content within the email through natural language processing to reduce the weight of trivial emails that do not contribute value to the business.

The value model around redundancy could also be adjusted to account for volume or frequency of emails to help the user find another employee in the organization with appropriate overlap.

6.2 Performance

The current data is housed in a relational database which is not optimized for graph sets. To increase the performance of the application it might be better aligned with a noSQL database or other non-traditional database engine.

6.3 Data

The Enron data set was used to demonstrate the current visualization, however it contains gaps within the organizational tree and only a limited set of email data. Further work would be required to validate our approach using a more fulsome and realistic data set.

6.4 Views

The current layout was developed to allow extension to the application with new views into the problem. An interesting topic was generated during one of our discussions to refocus the problem from an internal redistribution of resources and also include the ability to obtain external resources to fill the gap. This would include a new view to identify the skill sets that are most common in the emails of an employee and help the user understand what types of skills would be required from an external hire.

6.5 Documentation

As the user explores the data set it would be helpful for the application to capture the notes or thoughts of the user as the look at the problem space. This might involve adding a sticky note type feature to each node that could then be used in a collaborative environment to allow multiple users to generate a solution [13].

7 Conclusions

We found during our research there was a lot of excitement about this topic and there are a number of different pieces of follow on work that we can use in the future.

8 Acknowledgments

We would like to thank our colleague Mr Brad Mazurek for the initial idea of modeling information flow in an organization with SMTP headers. Also we would like to thank the various user groups and academics for helping to shape our design.

References

[1] V. De Stefano, "The rise of the just-in-time workforce: On-demand work, crowdwork, and labor protection in the gig-economy," *Comp. Lab. L. & Pol'y J.*, vol. 37, p. 471, 2015.

[2] G. Friedman, "Workers without employers: shadow corporations and the rise of the gig economy," *Review of Keynesian Economics*, vol. 2, no. 2, pp. 171–188, 2014.

[3] J. Scott, "Social network analysis," *Sociology*, vol. 22, no. 1, pp. 109–127, 1988.

[4] S. S. Glenn and M. E. Malott, "Complexity and selection: Implications for organizational change," *Behavior and Social Issues*, vol. 13, no. 2, pp. 89–106, 2006.

[5] J. S. Yi, Y. ah Kang, J. T. Stasko, J. A. Jacko *et al.*, "Toward a deeper understanding of the role of interaction in information visualization," *IEEE Transactions on Visualization & Computer Graphics*, no. 6, 2007.

[6] N. Staggers and A. F. Norcio, "Mental models: concepts for human-computer interaction research," *International Journal of Man-Machine Studies*, vol. 38, no. 4, pp. 587–605, 1993.

[7] D. A. Norman, "Some observations on mental models," in *Mental models*. Psychology Press, 2014, pp. 15–22.

[8] F. Paas, A. Renkl, and J. Sweller, "Cognitive load theory and instructional design: Recent developments," *Educational psychologist*, vol. 38, no. 1, pp. 1–4, 2003.

[9] M. Wilson, "Six views of embodied cognition," *Psychonomic bulletin & review*, vol. 9, no. 4, pp. 625–636, 2002.

[10] C. Plaisant, "The challenge of information visualization evaluation," *IEEE Proc. of AVI*, 2004.

[11] H. Lam, E. Bertini, P. Isenberg, C. Plaisant, and S. Carpendale, "Empirical studies in information visualization: Seven scenarios," *IEEE transactions on visualization and computer graphics*, vol. 18, no. 9, pp. 1520–1536, 2012.

[12] P. Pirolli and S. Card, "The sensemaking process and leverage points for analyst technology as identified through cognitive task analysis," in *Proceedings of international conference on intelligence analysis*, vol. 5. McLean, VA, USA, 2005, pp. 2–4.

[13] C. Ware, *Information visualization: perception for design*. Elsevier, 2012.

[14] A. Figueiras, "Towards the understanding of interaction in information visualization," *2015 19th International Conference on Information Visualization*, pp. 140–147, 2015.

[15] B. Shneiderman, "Tree visualization with tree-maps: 2-d space-filling approach," *ACM Transactions on graphics (TOG)*, vol. 11, no. 1, pp. 92–99, 1992.

[16] R. Rowe, G. Creamer, S. Hershkop, and S. J. Stolfo, "Automated social hierarchy detection through email network analysis," in *Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis*. ACM, 2007, pp. 109–117.