Social Fibers: Visualizing Personal Communication and Physical Location over Time

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Abstract

We envision a future where mobile device communiqué and geographic positional information will yield large data sets that can be interpreted for understanding social interaction, especially in small networks of people. People can get a better idea of the method and extent of conversation with individuals in their social circles, while understanding the effect of the physical proximity with others. We have created several novel visualizations assuming a future flooded with data regarding an individual's position over time. We use a *fiber* metaphor to show a person's movement and a *weave* metaphor to show the interaction of people according to position and communication method. Our concept visualizations are described along with scenarios that illustrate potential insights derived from these data portraits.

Keywords

Information visualization, global positioning systems, social visualization, space-time visualization

Introduction

This paper presents our concept of interpersonal communication and visualization tools for understanding the data that will soon be available regarding the position of people in the physical world. In the near future, mobile devices will provide users with the ability to receive location-based services. Assuming a global tracking technology (like GPS) is actively used and massive amounts of data are being collected about the movement of people and interpersonal communication (text messaging, email, and voice), what things can we learn about our social networks by visualizing the data over a period of time?

Imagine a mobile device that provides all the advanced services devices have today: voice, email, text messaging, web browser, etc. In addition, this future device knows exactly where you are in the physical world. Considering the Federal Communication Commission's mandate that all mobile phones are required to provide the precise location of 911 calls, it's not difficult to envision a new commercial market geared around location-based services [1]. People will be able to locate nearby amenities such as restaurants, taxi services, evening festivities around town, etc [2]. Furthermore, users will find novel ways to communicate with other subscribers. By exposing one's location information to other trusted subscribers, there will be opportunities for impromptu meetings and general awareness about the proximity of family, friends, and coworkers [3]. There is much to be discussed about these envisioned devices: they will require crafty user interfaces, high-tech infrastructures, and stringent privacy control. This paper assumes these issues will be addressed and focuses on the massive amounts of data that can potentially reveal interesting social patterns.

How will virtual communities support awareness and communication amongst the members of a group? A good social network visualization would help users understand each others spatial proximity, time-space patterns for scheduling, the emergence of movement patterns based their interests etc. The dataset of *location and time* for each person would provide a visual labyrinth of human movement patterns and social activities, especially if linked with additional information about the users, such as virtual communication (voice, email, text messaging).

The service might store information regarding the subscribers' age, gender, interests, and other preferences that would be made available to other subscribers (based on detailed privacy shells). The information can be used for searching the location of other users with common interests, finding people with similar interests or movement patterns, planning meeting times and places, learning about another subscriber's communication preferences based on physical location.

We are contributing a series of visualizations we call “Social Fibers” that will help people learn interesting things about their personal social networks assuming the envisioned services and technology described above. We intend for this to evoke interesting conversations regarding tracking technology, social networks, and privacy concerns. The visualizations are initial concepts that will likely evolve as the actual services and data logs come into fruition.

Methodology

Our process for exploring this space started with a curiosity about tracking technology. What if you could track every object and person over time? How would this be visualized? What sort of patterns would emerge? We brainstormed a very broad list of tasks and scenarios that spanned several domains. We narrowed our focus to the movement of people and the tasks that would benefit social connections. We created sketches for the interface and visualization tools, many of which are discussed in this paper. Global positioning system (GPS) data was simulated using a Java program that converts mouse positions to a specific time-space coordinate. This data was incorporated into a working prototype, developed in Macromedia Director, that demonstrates several insightful scenarios for socially motivated tasks.

Related Work

There have been a number of visualizations that address similar datasets of social interactions; many great examples are from the Social Media group at MIT (see figure 1). One example is the PeopleGarden, which represents online chat room communication using a flower garden metaphor [4]. The flowers show an individual's contribution to a chat room over time. The Chat Circles project also visualized chat room activity using circles to represent users. This project included a history visualization that shows how users interact chronologically [5]. Also related is the Loom visualization which visualizes Usenet discussion threads as a "weave of digital fabric" [6]. Our visualizations are very much inspired by this work.

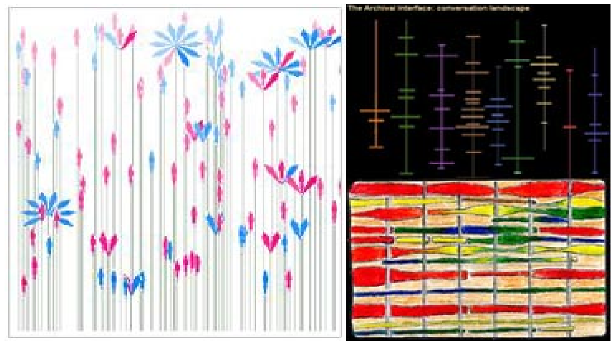

Figure 1: Social Visualizations by the Social Media group at MIT. Clockwise from left: PeopleGarden online community participation, Chat Circle messaging history, and Loom discussion threads.

There has also been some thinking regarding the use of GPS and other technology for mobile computing. Ashbrook, et.al., collected GPS data for a number of users for various periods of significant time (seven months, in one case) [7]. Their work focused on developing predictive models of user movement and machine learning techniques rather than visualizations. Our work emphasizes the human’s ability to evaluate the data and notice patterns in visual representations. Their work did reveal some interesting tasks that people might want to achieve from the data. It also provided us a baseline for the quantity and structure of the GPS data sets.

Our Concept: Social Fibers

Our system is designed around a metaphor of interwoven fibers or strands. Each person represents a fiber that shows their movement over time. Between each fiber are interconnections that represent virtual communication such as phone, email and text chat. Physical and virtual connections define our social interactions, and, when visualized together in this way, form an interweaving mesh of fibers metaphorical of other biological representations like DNA helixes. Figure 2 illustrates the basic concept, which is explained in further detail later in the paper. We assume that this information visualization will be viewed on a traditional desktop screen rather than a mobile device since most of the tasks we support involve viewing data over time at one’s leisure rather than immediate mobile tasks.

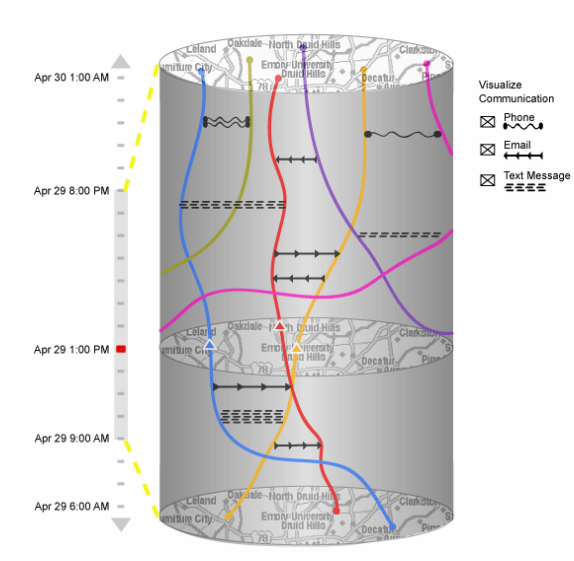

Figure 2: The "Social Fiber" concept. The 3D cylinder represents a 2D spatial map over a time period. Individuals' positions are marked with colored lines and other forms of communication are representing by black patterned lines.

Supported tasks

Our visualizations support specific socially motivated tasks that might be asked of the data sets we created. Such social tasks include: understanding the schedules of other people in your social group for the purpose of planning a meeting, viewing the current locations of friends for impromptu gatherings, and gaining insights about the patterns of others, such as identifying people who travel the same paths you do (to find new friends with similar schedules, lifestyles or interests) or recognizing other people's favorite spots (to discover new restaurants you might like). Supplementing this location data is data about virtual communications over time. A user might want to see where and how often virtual communication happens. The task in this case might be to identify an individual's preferred method of communication or determine the frequency of communication between pairs or among groups of people. A user may also notice communication anomalies, such as a break in otherwise frequent communication, or an especially long phone call. One may also identify communication "inefficiencies," such as excessively lengthy long-distance phone calls, and conclude that a change in communication patterns would be beneficial for financial or efficiency reasons.

Our system supports the visualization of a small group of friends, coworkers, family members, and others in the user's personal network. Although interesting, we do not intend to support visualizations of large numbers of people for more global tasks such as visualizing shopper traffic patterns in a mall or identifying popular spots for older people vs. young people in Atlanta. We also focus on small (rather than global) areas; we do not support visualization of the distribution of morbidly obese people in California. While our system does not support time/space visualizations for large areas or large numbers of people, it seems possible that some of the visualization techniques we employ could be useful for more global contexts.

Within this scale and context of city-size regions and small social groups, we designed a suite of complementary visualizations to support socially motivated tasks and built an interactive user interface that enables manipulation of the visualizations to facilitate understanding of the data.

System layout

Figure 3 shows a screenshot of the system layout, which contains an aerial map view and a 3D cylinder view on the right side. The visualization displayed on the right side is interchangeable; a user may choose to display one of several complementary visualizations. The system will be fully interactive and will support brushing among the various windows. For the remainder of this section we describe the visualizations and interactions we developed within the Social Fiber concept.

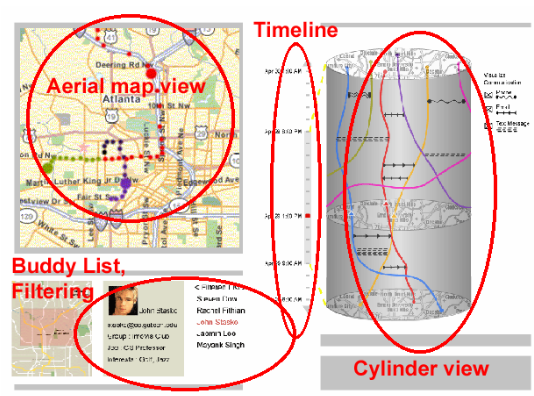

Figure 3: System layout

Aerial map view

Omnipresent and located at the top-left of the layout is the standard aerial map view. This view displays what a user would see if currently looking down from above at himself and others. Visualizations of people's movements are superimposed on a map of the area, which grounds locations in "real" space and provides clues about the scale of the space. Users may choose to display one of three visualizations available in the map view (points over time, line paths, and highlighted points), and may select to show data for any subset of "buddies." Users can pan the map to see different geographic areas, and zoom in and out on the map to get a closer look at the data points. We provide semantic zooming as follows: when the user is zoomed in, we show every street; when the user is zoomed out, we only show major roads. We provide different levels of detail including street view, neighborhood view, city view, state view, etc. Larger maps are rarely needed within the Social Fiber context as we focus primarily on local social interactions.

Points over time

Users may choose to view all recorded GPS locations between time x and time y (time x and y are selected and modified via the timeline slider discussed later). Users see a point on the map for each location, providing a sense of the buddy's path over time, as shown in Figure 4. Each buddy is associated with a color, and a buddy's points on the map are colored accordingly. We attempted to choose a set of colors that stand out from the colors in the map underlay and also are easily distinguishable from each other. Of course, this becomes a problem, particularly for users with color vision deficiencies, as the number of buddies grows and the number of distinct colors needed increases. We do not expect to encounter this problem in our system as it is designed only to support visualizations of a small number of people.

If desired, a user can choose to have the points for a buddy change in value from the original color to black (or white), with the level of "blackness" (or whiteness) corresponding to the timestamp of the point; the first (oldest) GPS location in the selected range (time x to time y) is shown in pure black (or white), and the last (most recent) GPS location in the range is shown in the "pure" version of the buddy's color. This assists the user in determining both the direction and speed of a buddy's movements.

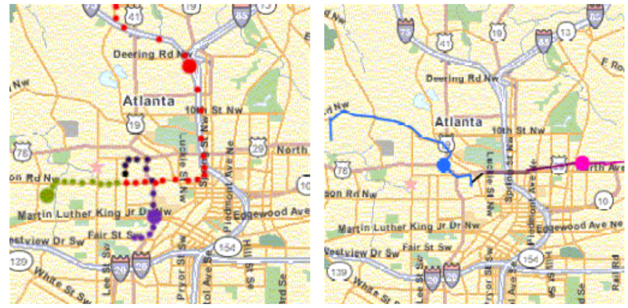

Figure 4: Points over time, line paths

Line paths

Users can also choose to display lines that connect successive GPS locations for a buddy, which approximate the buddy's path over time, seen in Figure 4. If desired, these lines can be colored from [black or white] to [buddy color], as described above. These lines may provide further information about the direction and speed of the buddy's movements.

Highlighted points

Via the timeline, users may select a moment in time to focus on (the "highlighted moment"). An icon (e.g. a small circle) on the map shows each buddy's location at the highlighted moment. When used in conjunction with the point path or line path views, this visualization shows a focus point in the context of the all movements between time x and y. In addition, users can move the highlight moment forward and back in time, via the timeline slider, in order to see an animation of buddies' movements.

Timeline

The timeline slider, shown in Figure 5, serves as the primary method for manipulating the visualizations. Users may select a highlight moment on the timeline by dragging the central slider (shown in red). If desired, this highlighted moment is depicted on the aerial map view with icons representing a people's locations at that moment. Moving the slider causes real-time animated changes in relevant visualizations. We implemented the timeline such that the top of the slider represents more recent time, as we felt this was most intuitive, but a user may

Figure 5: Timeline

certainly change this if he wishes. Users can select (or filter) a span of time for which to view data. In Figure 5, the user has chosen to view data recorded between 9AM and 8PM on April 29th. A user might view only the movements made in a single day or view the movements made over a week (perhaps to identify patterns). Eventually, this model breaks down as the time span selected increases in length while screen real estate remains constant, but we expect that users with socially-motivated questions and tasks will focus on short time segments. The timeline provides a view of the selected time span within the entire range of data available. Figure 5 shows that the available data extends beyond 1AM on the 30th and 6AM on the 29th.

Interchangeable visualizations

Displayed on the right side of the interface is a second visualization that complements the aerial map; users may cycle among a set of interchangeable visualizations. Each of these visualizations is designed to support a slightly different subset of tasks.

Cylinder view

The cylinder view provides a 3D visualization of people's movements over time. This essentially represents a stack of 2D maps that differ in time. The cylinder is semitransparent and helps the user to ground the locations of the data points in space and in relation to each other. For each buddy the user wishes to view, data points showing each recorded GPS location (within the time range specified on the timeline) are drawn inside the cylinder in the color associated with that buddy, as seen in Figure 6.

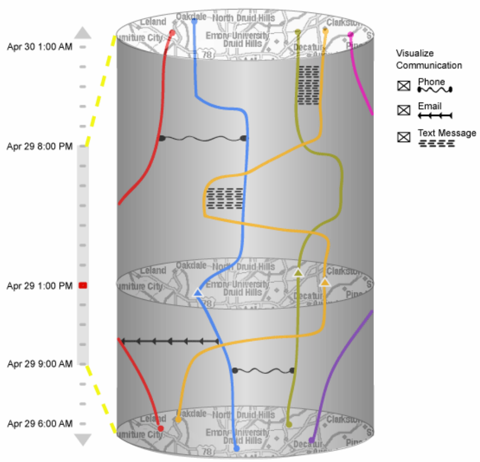

Figure 6: Another cylinder view

While the range of time displayed in the cylinder may change as the user manipulates the timeline, the cylinder is always the same size on the screen. Thus, the time scale changes according to changes in the timeline.

The cylinder contains a "highlight slice" (corresponding to the highlighted moment indicated on the timeline); a semitransparent map is superimposed on the slice and icons indicate where each individual "fiber" intersects with the plane of the slice. The user can move the highlighted slice in the cylinder forward and backward in time by dragging the central slider on the timeline or by interacting directly with the 3D model. As the user moves the time slider (or the slice itself), the position of the slice is updated in real-time. This interaction is useful for investigating a particular moment, or for visualizing animations, as dragging the highlight slice or timeline slider updates the aerial map as well. Users may choose to turn off the highlight slice if they wish to focus more on data over time rather than at one moment.

The cylinder is centered over some physical map area, as show with the semi-transparent circle of map projected on the slice, floor and roof of the cylinder, which grounds the space in a real location. A circle is superimposed on the aerial map to indicate the map area encompassed by the cylinder. A user can modify this area by dragging the circle on the aerial map. Changes to the map area of interest result in immediate updates to all relevant visualizations.

Because 3D worlds are sometimes difficult to navigate, we limit the user's ability to manipulate the 3D view. A user may only rotate the cylinder around its long axis. We think that the manipulation options provided will be sufficient for users to resolve occlusions and understand the locations of the data points in 3D. However, we realize that 3D visualizations are tricky and would need to perform user evaluations to determine whether our 3D cylinder view is successful in helping users understand locations in space over time.

We were initially hesitant to include 3D elements in our system because of the notorious difficulty of implementing 3D successfully in information visualization. However, we feel that the 3D cylinder view is critical to the certain tasks we intend to support. This view enables users to gain an understanding of patterns of movements in space over time, and compare movements and patterns of one person to those of another person. In addition, this visualization enables users to determine which people are close to each other at any moment, and the patterns in distances between/among people. In Figure 6, we see that Blair moved around a lot on the 29th, while John and Bruce were more stationary. Perhaps John and Bruce spend a long day at work, while Blair had the day off and gallivanted around town. Beth and Aaron were not near each other at any point on the 29th. This could suggest that they do not work together. (Knowing that Aaron and Beth do in fact work together, we may conclude that they both spent the day off campus.) It appears that John and Blair may have crossed paths three times (this could be confirmed either by rotating the cylinder or viewing these moments on the aerial map). Depending how much time they spent in close proximity (here it appears to be not that much time), we might conclude either that they just passed each other in the hall, or met very briefly, or that they spent a long lunch together. If the trajectories shown for April 29th represent a typical workday for Bruce, we would expect to see this pattern repeated five days a week if we changed the time span of the cylinder from one day to a week or two. Also, if the data were real, Beth and Blair's relationship would be reflected by their paths joining each other at night (and moving slightly further apart during the day since they work in the same place, but it in a large building rather than a house). We would also expect those people who work in the same building to be quite closely co-located in space, requiring significant zooming in to distinguish their individual locations within the building.

If desired, a user may choose to augment the cylinder view with visualizations of communications among the buddies depicted. Users may choose to view any subset of communication types. Figures 1 and 6 show phone, email, and text message communications.

This visualization may enable a user to gain insight about a buddy's communication habits, communication patterns between people, and relationships among buddies. We can see in Figure 6 that Blair and Bruce had a 2-hour text message conversation on the evening of April 29th, so are probably good friends. We also see that Blair communicated only by text message that day; perhaps he does not like talking to people on the phone. John used a variety of communication types within a single day, and communicated with more people than the others did. This may suggest that he is quite techno-savvy and popular! Figure 1 tells a different story. Here we see that Aaron and Blair communicate frequently (three times during the day), and that John, Aaron, and Blair appear to form a triad of people with frequent interwoven communications. (If the data were real, we would expect to see much more frequent communications between close buddies and coworkers, perhaps on the order of 50-100 communications per person, per day, and a much wider range in frequency of communications among people.) It appears that email is Aaron's preferred method of communication. We also see that most communications tend to be short-lived, and that using the phone is relatively unpopular, suggesting that these buddies prefer to keep communications among coworkers short and to the point. We also see that the frequency of communication among these coworkers is fairly constant throughout the day (this is rather unrealistic; real data would probably show a much higher frequency of communications among this group during the day rather than at night).

Person-centric distance plot

The person-centric distance plot shows the distances of buddies from a particular person (normally YOU) over time. The distance from the person of choice is represented on the horizontal axis, and time is represented on the vertical axis. Each of the other people is represented by a line (fiber), which moves closer or farther from the vertical axis corresponding to decreases or increases in the distance between the buddy and the person of choice over time. Unlike the cylinder view, this view only shows the spatial relationships between one person (the central person) and each of the other people; there is no way to determine the spatial relationship between two people other than the central one.

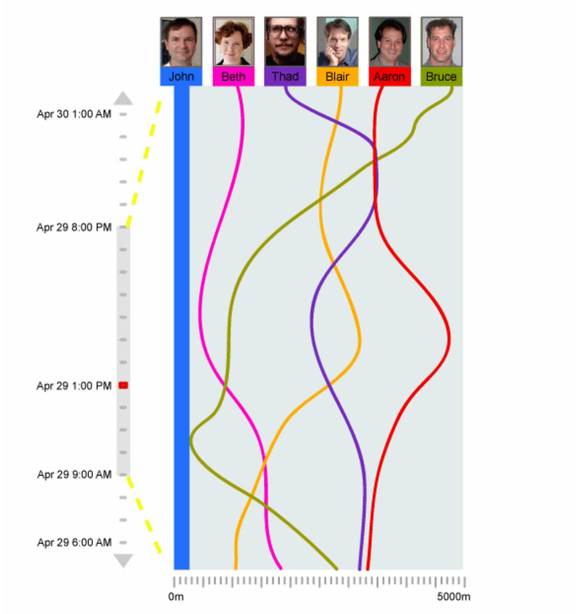

Figure 7: Person-centered distance plot

However, this view distills all of the information in the cylinder view to one dimension, and we may use this dimension to answer specific questions about the data that are more difficult to answer with the cylinder visualization. This graph shows patterns in the density of people in close proximity to you, and reveals which people you tend to spend a lot of time with. In Figure x it appears that John may have had lunch with Beth and dinner with Bruce on the 29th. For most of the day, John does not appear to spend much time in close proximity with the five coworkers shown on this graph (especially Aaron and Thad), perhaps reflecting the nature of his work relationships and a tendency toward reclusiveness. It appears on this graph that Thad and Aaron were together for a few hours late at night, but perhaps they were equidistant from John but not anywhere near each other. To examine the relationship between Aaron and Thad more closely, a user could change the central person from John to Thad.

Grid view

Another interchangeable visualization is the grid view. A table shows buddies along one axis and geographic or semantic (e.g. TSRB) locations on the other. Each section of the table is shaded according to how much time that person spends in that particular location. A user defines his own points of interest and the system determines the appropriate grayscale level to place in the grid. On can imagine enhancing both the cylinder space and maps with visualizations of these points of interest, which could provide added context to the visualization.

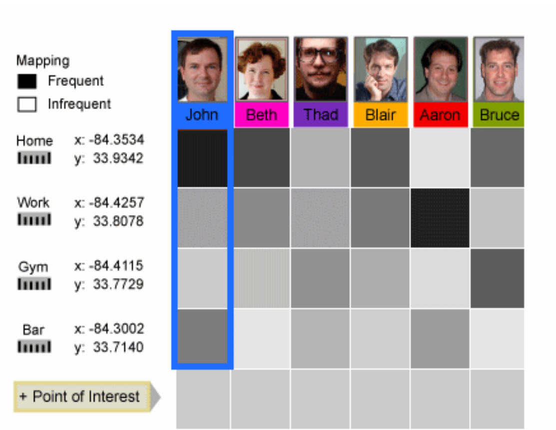

Figure 8: Grid view

This may enable a user to gain understanding of buddies' schedules and how they relate to his own, as well as popularity of semantic locations, such as restaurants, among his buddies. In Figure x, we see that John appears to spend a lot of time at home and a lot of time at the bar (and very little time at work). Beth spends a lot of time at home (perhaps suggesting she works out of home or is a stay-at-home parent), as does Blair. (Hopefully at least one of them works in order to support Grace!) Aaron spends a lot of time at work and very little at home, while Bruce spends a lot of time at home and at the gym; he is probably very fit and has a healthy home life.

Quantity view

This line graph shows changes in the value of a particular variable over time within the space enclosed by the cylinder. The user may choose from a variety of variables to visualize, including number of people in a space, number of people satisfying certain criteria (e.g. women between the ages of 20 and 30), level of activity (movement), etc. For example, if the space chosen is the downtown area, the illustration below shows the number of people and taxis downtown on the 29th.

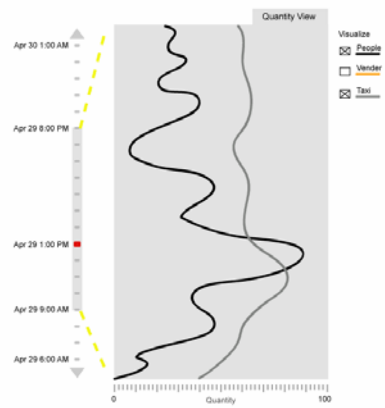

Figure 9: Quantity view

This visualization can assist users in answering questions about characteristics of locations of interest. For example, how many of my buddies frequent the downtown bars on the weekends (perhaps to determine whether that would be a good place to make an impromptu stop on a Saturday night)? At what point of the day are most of my lab members at the TSRB (to determine a good time to meet with them)? This graph would also be useful for highlighting anomalies in buddy density, such as those caused by a large party or GVU convocation. In Figure x we see that the number of people in the space peaks around lunchtime. This may suggest that many of the user's buddies like to eat lunch in the space being visualized. The number of taxis peaks slightly right before lunch, perhaps indicating that some people take taxis to lunch. It might be either easier (because they are more abundant) or harder (because more people are using them) to get a cab at this time. (A visualization of taxis' movements over time, along with their available/not available status may be useful for gaining a better understanding of taxi patterns and likelihood of finding one at a certain time of day and/or certain location.)

Buddy list, filtering

We provide a variety of methods by which users may choose which subset of buddies to visualize. Users may select or deselect them in a list, or within the visualizations themselves. They may also filter buddies by a variety of attributes. A user may choose to view only the young ladies in his social network in order to determine where he should hang out to pick up women, or may choose to view only his lab mates in order to get a clear view of patterns in their work schedules. Any changes (e.g. additions, deletions) made to the subset of buddies the user wishes to visualize is reflected immediately in all visualizations.

Conclusions

We developed a system centered around a metaphor of interwoven fibers reflecting the spatial and virtual interactions among people. We imagine that the visualizations we developed, currently designed to support tasks centered on a small personal network, could be expanded to support tasks in other contexts. Brainstorming revealed several potential groups for whom extensions of these visualizations of movements over time may be useful, including urban planners looking at the flow of individuals over time. Visualizations of objects rather than people may assist industrial engineers concerned with the flow of chickens on the plant floor or for shipping and handling companies to visualize their fleet of vehicles. The government may benefit from systems that visualize car traffic, or assist in tracking convicted criminals.

Acknowledgements

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