

# MELOSCOPE

a self-reflection app for **MeLo**  
The Meaningful Location Project

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## ABSTRACT

The purpose of this final project was to create visualizations that would provide users of a location-based tagging service (MeLo) a meaningful way to reflect on their location history. Our project is a self-reflection module that uses APIs made available by MeLo to access a particular user's data and visualize the data based on parameters set by the users. Our goals for this project were twofold:

- To allow users to quickly notice patterns in their location history.
- To allow users to define goals to be achieved and quickly track their progress in achieving those goals.

While there have been many visualizations on location information, most of these have been based mainly on geography. They normally consist of heat maps or shapes and colors overlaid on maps. While these are interesting visualizations, they do not allow us to leverage the personal aspects of place that MeLo provides.

We iterated through two revisions of prototypes with 9 potential users before implementing the visualizations. We developed 3 unique visualizations for the final implementation: a map-based path visualization, a stacked graph visualization and a goals achieved visualization. These were then tested again on the end users and refined based on their feedback.

Tools used for this project include the Google App engine, Google Maps API, Javascript, Protovis, Python and PHP.

## INTRODUCTION

Technology has advanced to the point where we are able to report or trace where we are at any given moment. This is typically done through ubiquitous mobile devices that have GPS modules built in. Location information basically consists of latitude and longitude coordinates and a time stamp that pinpoint an exact location in the world at a particular moment. The problem with this coordinate based system is that the coordinate position numbers do not really make sense to the common person. Most people describe locations with names or with personal perceptions of what that place means to them. For example, a Starbucks coffee shop might be called 'work' by one person, 'coffee shop' by someone else and 'first date' by another.

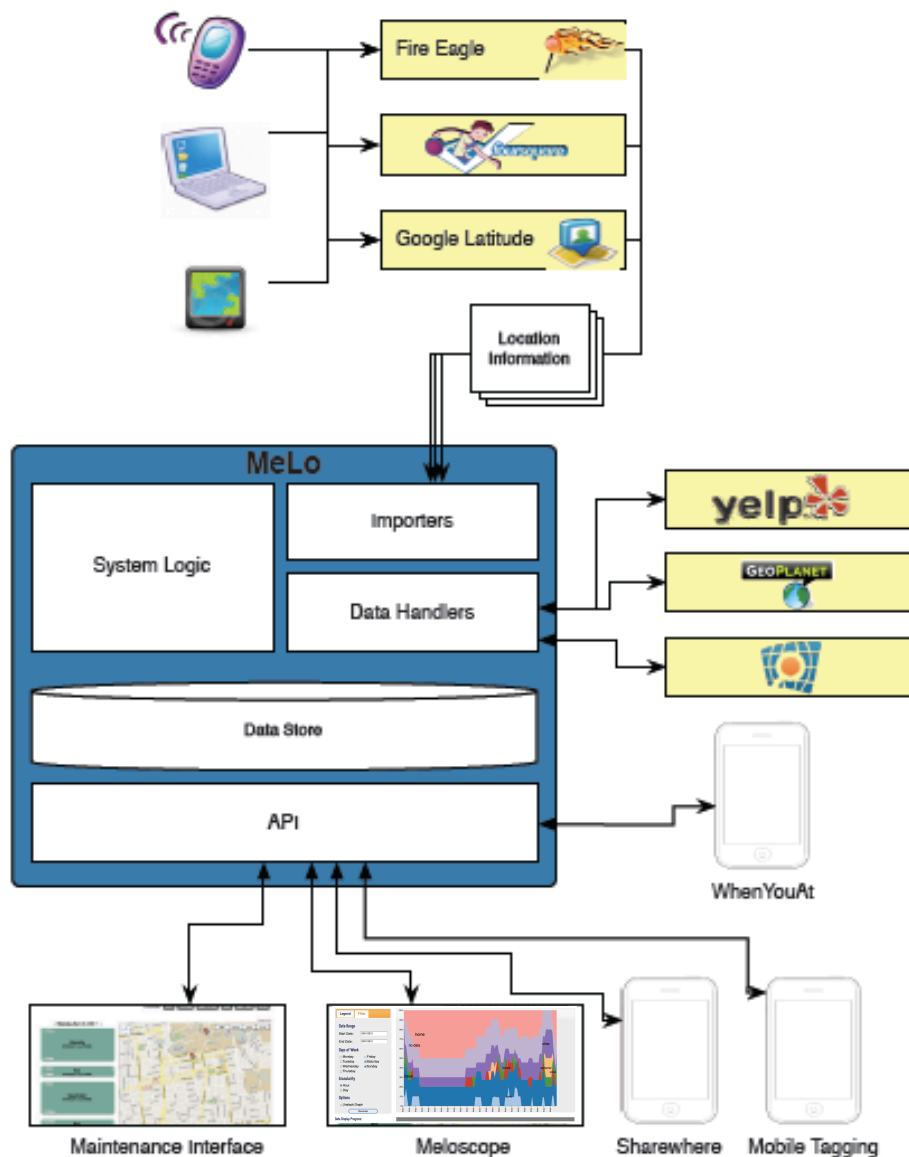


Figure 1 The MeLo Ecosystem



MeLo is a second year MIMS final project developed by Nick Doty, Ryan Greenberg, Mohit Gupta, Karen Joy Nomorosa and Stephanie Pakrul. This project implements a platform that allows users to name and tag locations based on their personal preferences. Geographic location information is imported by MeLo using popular location tracking services such as Yahoo! FireEagle and FourSquare. A tagging interface is implemented to facilitate the adding of tagging to locations. MeLo also provides suggestions for tags based on historical entries as well as categories and ontologies imported from services such as Yelp and FourSquare. All the data gathered by MeLo is accessible via APIs. As proof of concept, the MeLo team members have come up with several modules to be built on top of the API as in Figure 1.

The purpose of this information visualization final project is to implement a self-reflection application using MeLo's API. The application, or meloscope as it is named, should allow users to view their location history data in a way that would provide more meaning for them than if the data was presented in a table or text form. It is our hope that by using meloscope, users will be able to notice behavioral trends in their location history. Observing these behavioral trends might bring about beneficial changes in their daily activities that are reflected in their location history. For example, a user might notice that while travelling, he spends too much time in the hotel and not enough time sightseeing. Two visualizations have been created for this purpose of more easily getting insights from: a map-based paths visualization and a stacked graph visualization.

On the other hand, meloscope will also help users keep track of specific goals that they intend to achieve. For example, a user might want to at least 5 hours a week on socializing. Based on the data collected by MeLo, the Self Reflection Module will be able to provide information on how successful they were in achieving those goals. A separate visualization was created for this purpose.

## **SCOPE OF THE PROJECT**

The project is an independent application using MeLo's API. It assumes the following:

1. MeLo takes care of collecting user information through whatever external source, aggregates the information and combines them to create groupings that refer to a particular place, instead of passing along exact location points. The information that MeLo passes on to meloscope includes:
  - a. Start Time of the user's duration in the location
  - b. End Time of the user's duration in the location

- c. Latitude and Longitude of a point in the location (for mapping purposes)
  - d. Personal annotations on the location
  - e. Name of the place
2. meloscope will not have access to raw data coming from users, only the processed data coming from MeLo
  3. All maintenance, including tagging, modification, and removing of erroneous information for stays and locations is done in MeLo. meloscope main goal is to visualize the information already in MeLo, and will perform only read processes and no writes to the data.

The scope of meloscope is to create a self-reflection application using MeLo's API. To meet this goal, a server-side application is constructed to collect information from MeLo. At the same time, a front-end web-based client is also created to generate visualizations using the information.

## DESIGN PHASE

In summary, meloscope followed a user-centric, iterative approach, iterating through several user interviews and prototypes before implementation (Figure 2).

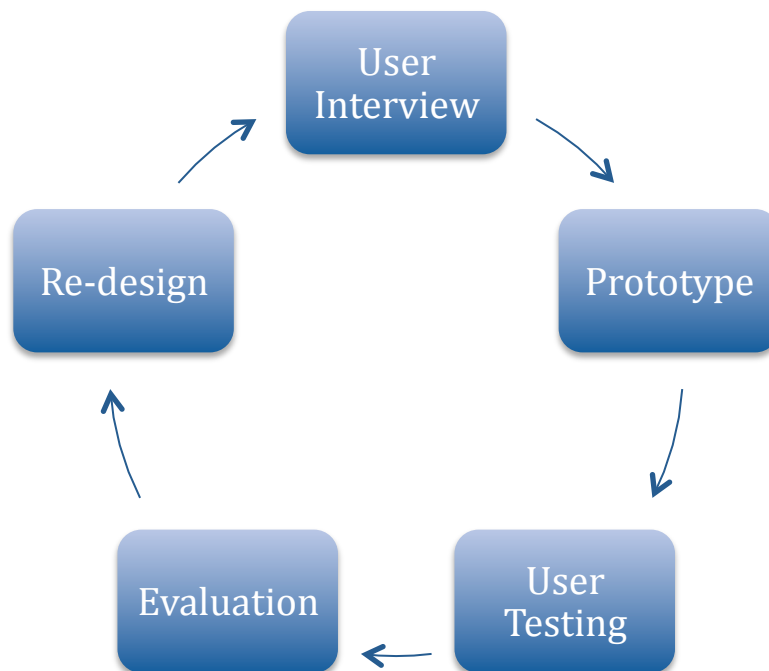


Figure 2. Iterative Design

## INITIAL USER INTERVIEWS

From the beginning, we decided to engage with our end users to understand their needs and to ensure that the solution provided by the application addresses their needs. Initial interviews were conducted with 9 people. These interviews were conducted to help us understand current user behavior regarding location history as well as the basic features that need to be implemented in meloscope.

Some of the questions asked include:

- What are the tools you currently use to help you remember where you have been or what you were doing in the past?
- Can you tell us of any specific examples where you had to look through your location history?
- What details do you think would be important to show when your location history is presented to you?
- When you start thinking about your personal history, what goals do you usually have? What questions do you normally ask yourself?
- How do you think you'd be able to use your location history information?

The answers obtained from our initial round of interviews were very insightful. Some of our key findings include:

- Users think that seeing the location history of others might be useful but are wary of sharing their own location history with others.
- Users currently do not have a particular tool that they use to reflect on their location history consistently. The coping mechanism for this varied from user to user, with most of them using a calendar program (such as Google Calendar) to make note of their locations and tools such as FourSquare to get geographic locations for those locations. Therefore, most reflections occur in a very ad-hoc manner, such as while taking a shower, or sending emails to family.
- Users oftentimes have very specific questions that they want answered, such as "what is that place I went to that time when this friend was visiting?", exhibiting a combination of location, time, activity, and companions.
- Users wanted to see deviations from normal behavior. Most indicated that they lead very boring lives -- from school to home and back -- and would like to see ways by which special events or locations out of the norm can easily be seen.
- Some users wanted to see what routes they've taken from one place to another and to compare the efficiency of those paths or routes.
- Some users wanted to see how their daily activities reflected in their location history matched up with personal goals.

## INITIAL PROTOTYPES

From the beginning, we decided to engage with our end users to understand their

After interviewing the users, we generalized the results into 5 main points that summarize what the users want:

- Comparing their own history with others
- Specifics about WHAT they've done, WHERE they've been and WHO they were with
- Easily spotting outliers or deviance from the norm
- Being able to see different paths or routes taken from one location to another
- Easily compare actual versus goals in terms of time allotted to a particular activity

Our next step in the design process was a brainstorming session based on user feedback and our goals for this project. Because we were using a particular platform, there were some limitations as to the type and amount of information we could get, namely:

- MeLo offers a privacy framework that allows the user control of the level of information he or she is willing to share. For instance, a contact may choose to only share his location at the city level (i.e. sharing that he is in "Berkeley"), while some can choose not to show any geographic information at all and stick to categories of place (i.e. sharing that he is "at a coffee shop"). MeLo, still being in an alpha phase and therefore a limited user set, does not have an API for aggregated user information either. These different levels of information, privacy concerns, as well as a lacking API for aggregated user information made it impossible to fulfill an interesting use case for the application -- comparing a person's history with an aggregate group, or with specific contacts.
- MeLo likewise has not implemented an algorithm to determine routes and paths. At this point, locations that people are at when they are 'in transit' are considered specific locations. What users have done to cope with this is to label or tag these as 'in transit' or as 'bus', 'bart' or whatever mode of transportation they are using.

Taking these limitations into consideration, the team underwent a brainstorming session to develop ideas on how to visualize the information that we did have. Figure 3 shows the output of this brainstorming session. We decided to take multiple approaches to our solution and obtaining user feedback on them before implementing the ones that were preferred by the end users.

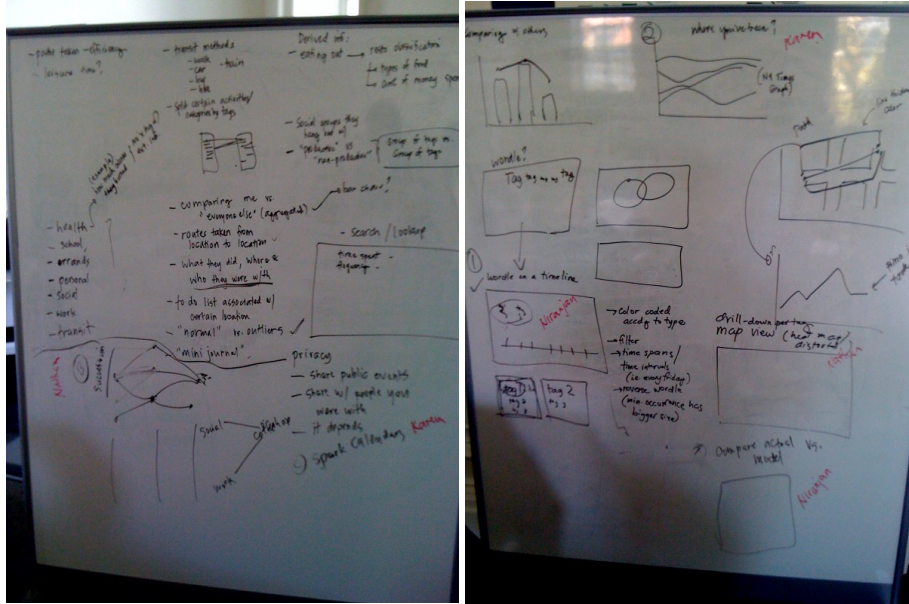


Figure 3. Brainstorming Session for Initial Prototypes

## Map-based paths

The map-based paths prototype was designed to allow users to not only see their location history but also the paths linking the various places in their location history. This information is overlaid on top of a map. Different colors are used for different locations and the opacity of the color reflects the amount of time spent at that particular location. Paths between locations are colored to match the color of the path's destination, thus allowing the user to know the start and end points of paths. Figure 4 shows an initial prototype of this visualization.



Figure 4. Initial Prototype for Map-based Path Visualization

## Path

This visualization employs the same features as the map-based paths visualization but removes the maps. By doing so, the visualization changes the user's focus from the locations to the paths taken between locations. Users are also able to filter paths by location. In the example in Figure 5, the visualization shows a path pattern of home-school-(all paths)-home. The thickness of the line shows how often the user takes the path from one location to another. Thus, users can quickly get a summary of what their normal routine looks like, as well as see outliers (in this case, the user does not normally do personal things after school).

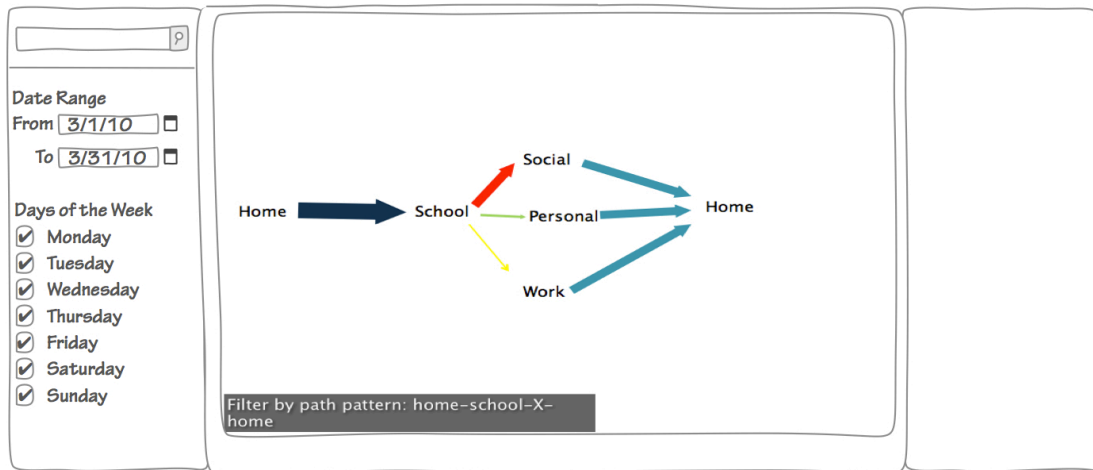


Figure 5. Initial Prototype for Path Visualization

## Wordle

This visualization (Figure 6) attempts to leverage the frequency of the tag words used and display them in a Wordle-like fashion. Frequency of tags are reflected by their size and the tags are ordered from most frequent to least.

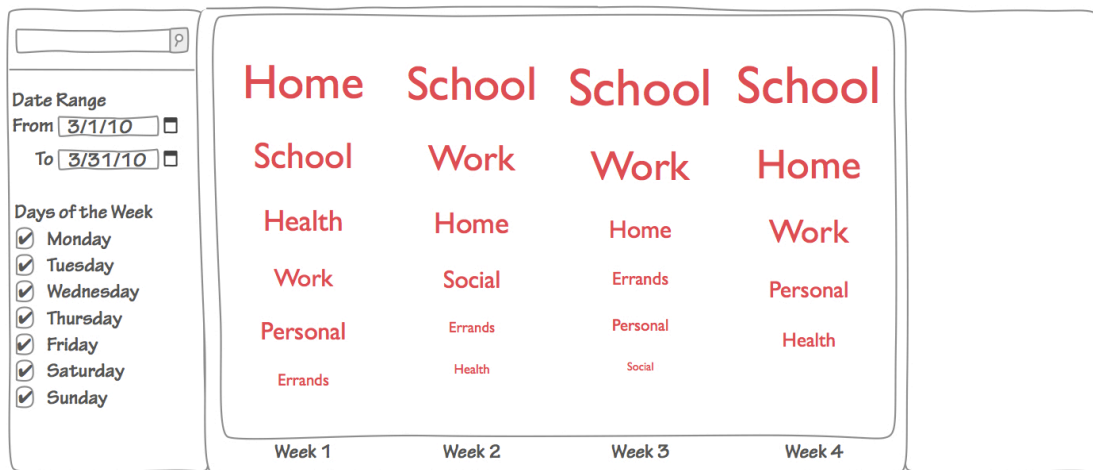


Figure 6. Initial Prototype for Wordle Visualization



## NY Times-Inspired Stacked Line Chart

The New York Time's visualization on how people spend their day gave us inspiration for this visualization. By assuming that we have location history data for entire days, this visualization takes the data for different categories and visualizes them in user-defined time spans. The y-axis is a scale of 0% to 100% and the x-axis is the time granularity in hours. Figure 7 shows the main overview of this visualization.

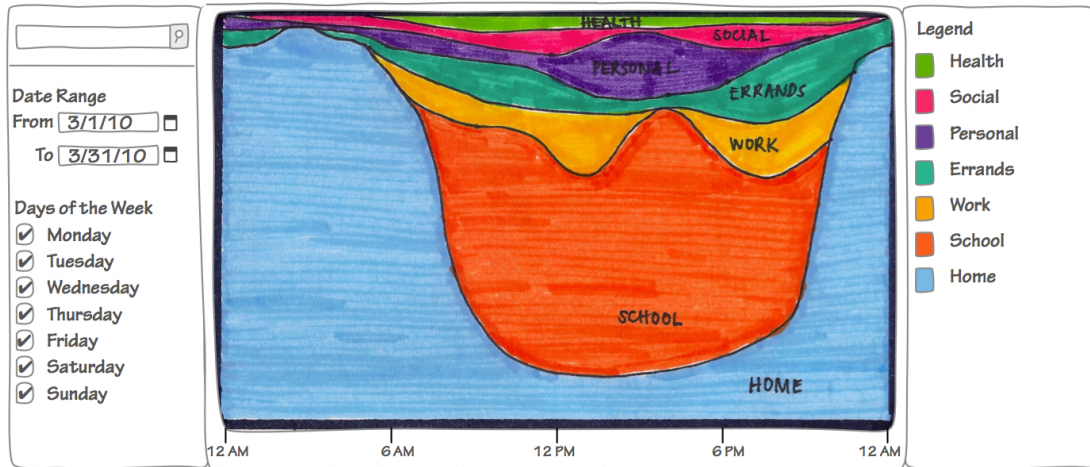


Figure 7. Initial Prototype of the Stacked Line Chart Visualization

A user can also also visualize data from particular categories to see how elements in that category contribute to their location history. An example of this is shown in Figure 8.

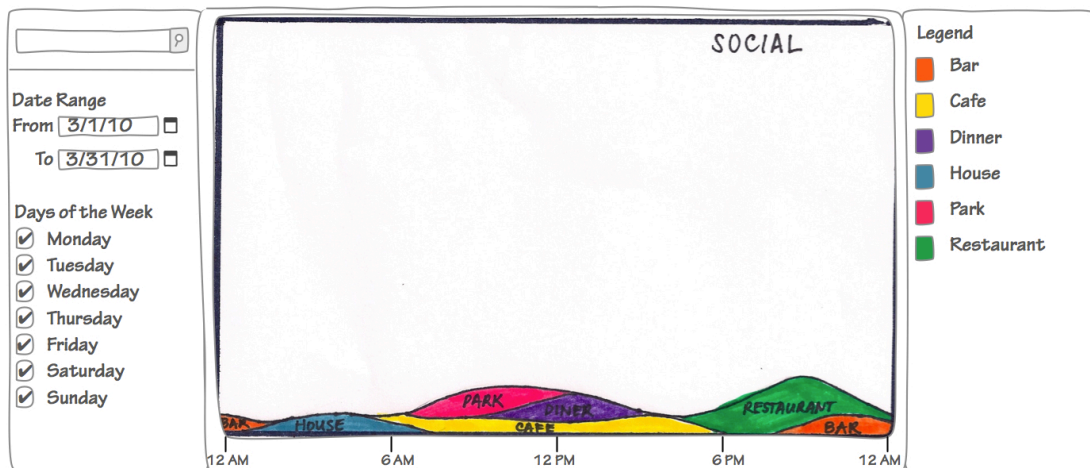


Figure 8. Drilling down to the details of a specific category

## Calendar View

This visualization attempts to provide users with meaningful information about their location history using calendars. This visualization was developed because people are used to viewing events in a calendar format. A day is divided into 3 parts and a bar is drawn in a day's box depending on the time of the day spent of each category. For example, if someone was at home for only the first third of the day, then the box for that day would be lined with a bar at the top of the box. Figure 9 shows an overview of the different categories using the calendar view. With this view, users can easily show outliers in their normal routine, and quickly discern when those activities or events happened.

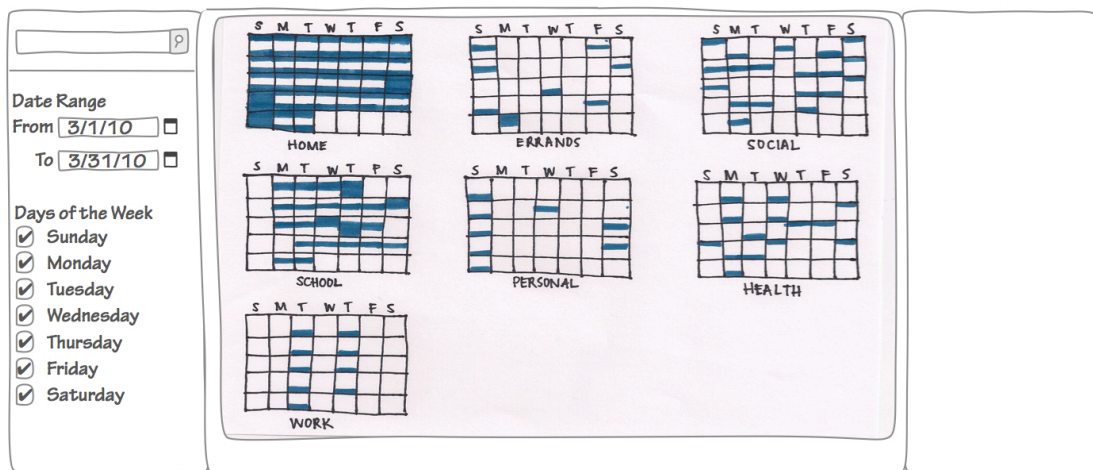


Figure 9. Initial Prototype of the calendar view visualization. This shows the overall time spent.

As with the stacked graph visualization, a user can click on particular categories to obtain detailed information. This is depicted in Figure 10.

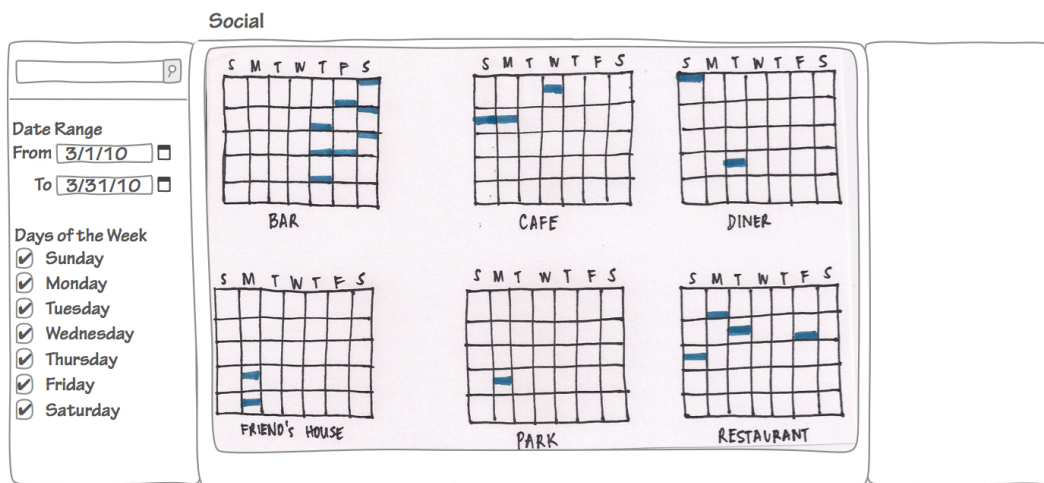


Figure 10. Showing calendars for a specific category.



Should a user choose to obtain data for more than a month, the visualization can combine the data for particular categories into one calendar as in Figure 11.

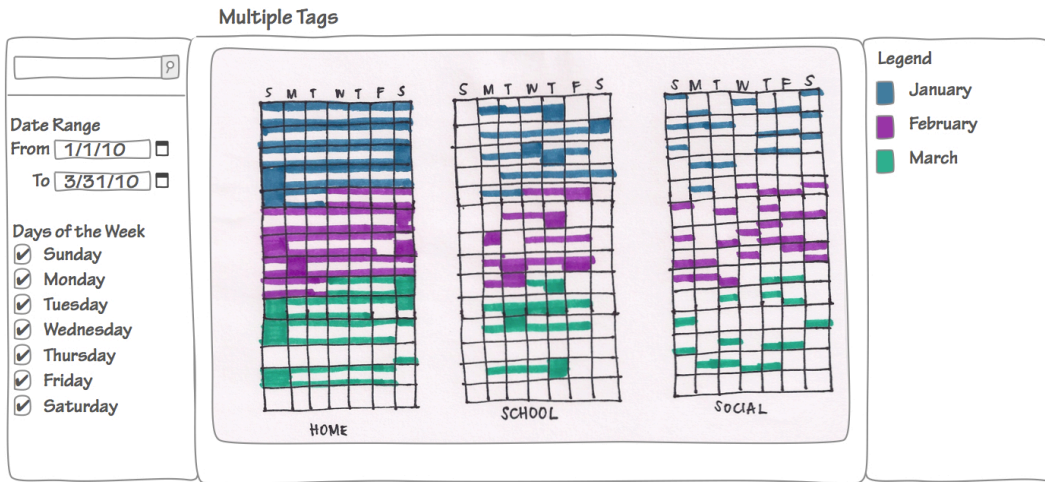


Figure 11. Showing multiple months

## Goals

Figure 12 shows the goals based visualization. Each goal is depicted by a floating balloon that progresses along the x-axis. Goals are also organized from top to bottom based on the number of hours dedicated to that particular goal. In this example, the most amount of hours were dedicated towards school and the least towards health.

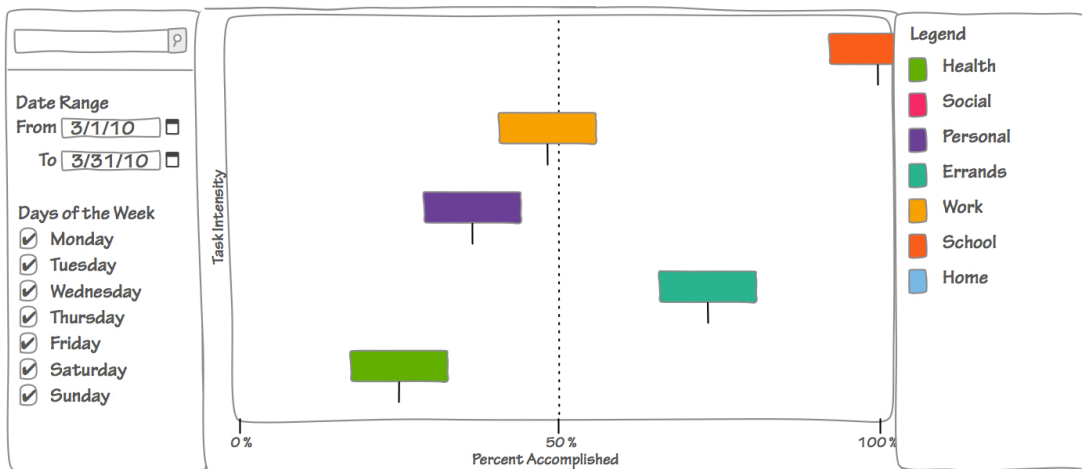


Figure 12. Goals-based Visualization

## REFINED PROTOTYPES

We presented the initial prototypes to our users and invited them to think aloud as they stepped through the different visualizations. Their feedback suggested that the most useful visualizations are the map-based path visualization, the stacked-graph visualization and the goals visualization. Below we present revised prototypes of these visualizations based on our user feedback.

The main user interface of the prototypes was refined to save space and reduce clutter. The filters and legends were put into user-switchable tabs, with the realization that once information has been filtered, there would be no need for the filters again until a new dataset is requested.

### Map-based paths

Key findings from our user feedback on the map based path visualization include the following:

- The satellite view of the map was too distracting and was hard to analyze. It took some effort for the users to recognize that the map was actually centered on the UC Berkeley campus.
- Hovering over particular locations should bring up more information about the user's history in that location.
- Opacity as an indicator of location history intensity was in a map with many colors and overlays. Instead, size was used to differentiate intensity.

Figure 13 shows an example of this refined prototype.

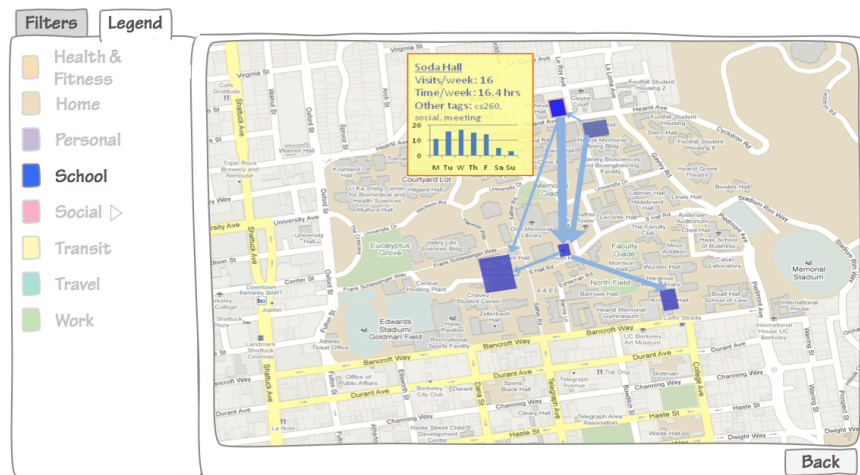


Figure 13. Refined prototype of the maps visualization

## Stacked Line Chart

Key findings from our user feedback on the stacked line visualization include the following:

- The time granularity should be user-customizable. This was implemented using a slider as in the lower left corner of Figure 14.
- The visualization should zoom in on clicked categories. This was implemented by changing the y-axis to fit the percent of time taken for that particular category as depicted in Figure 15.
- Users found it difficult to calculate the amount of time spent on categories when they were stacked. To account for this, we implemented an unstack feature, as depicted in Figure 16.

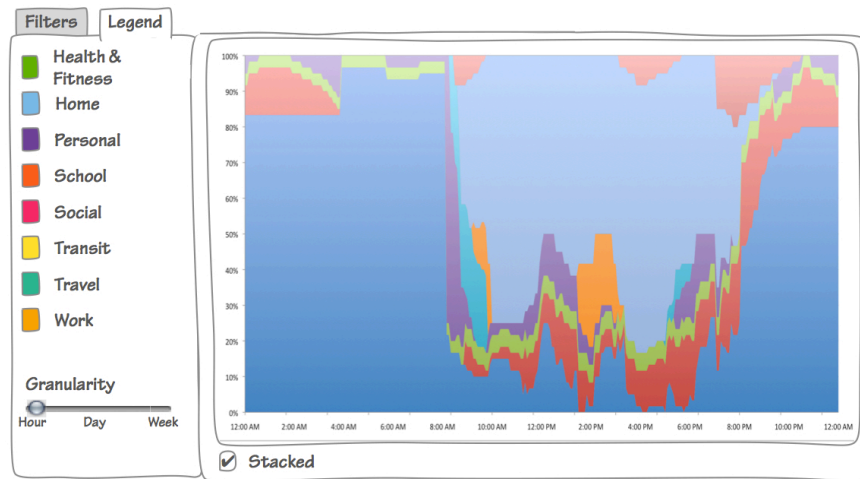


Figure 14 Revised prototype of the stacked line based visualization.

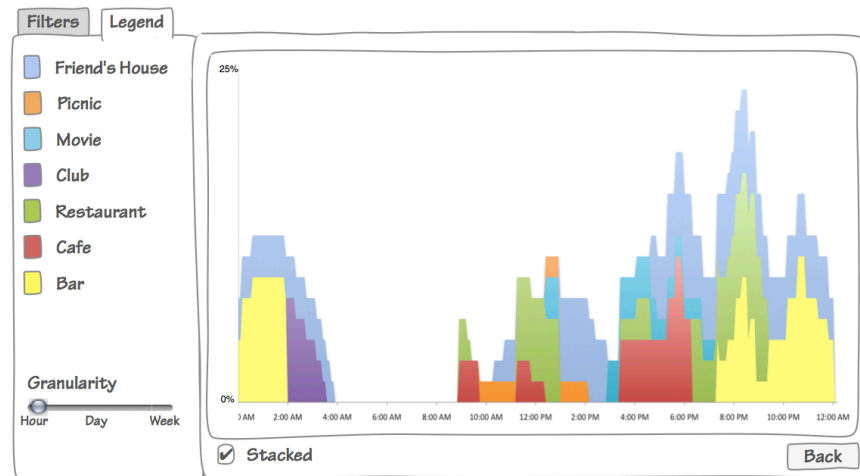


Figure 15. Revised prototype of drill-down screen for a particular category.

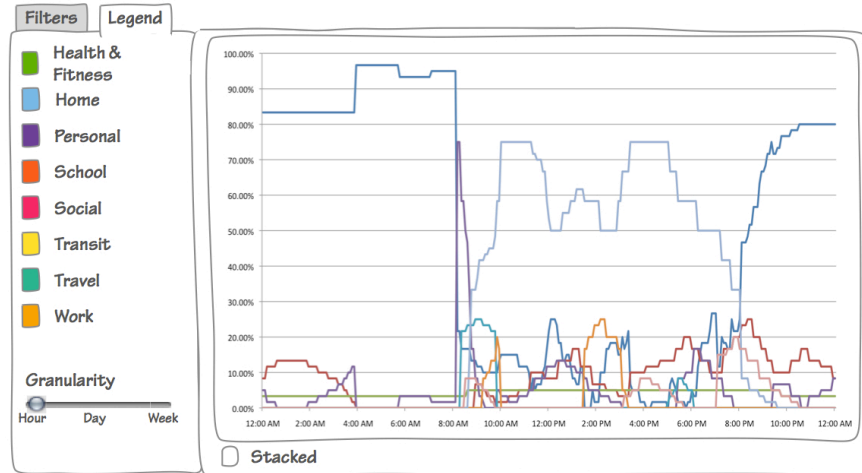


Figure 16. Revised prototype of the unstacked view for the line graph

## Goals

Key findings from our user feedback on the goals visualization include the following:

- The goals should be reflected using progress bars and not balloons. One user commented that she should be rewarded with more colors as she progresses in achieving her goals.
- Text in the bars should quickly indicate the total hours achieved per goal as in Figure 17.
- The user should have the option to compare their goals achieved between weeks to see their progress in achieving goals over time as depicted in Figure 18.

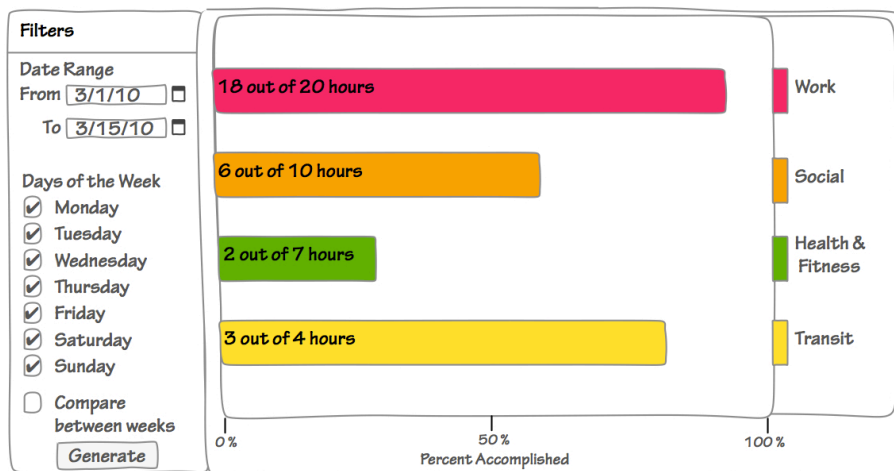


Figure 17. Revised prototype of the goals visualization

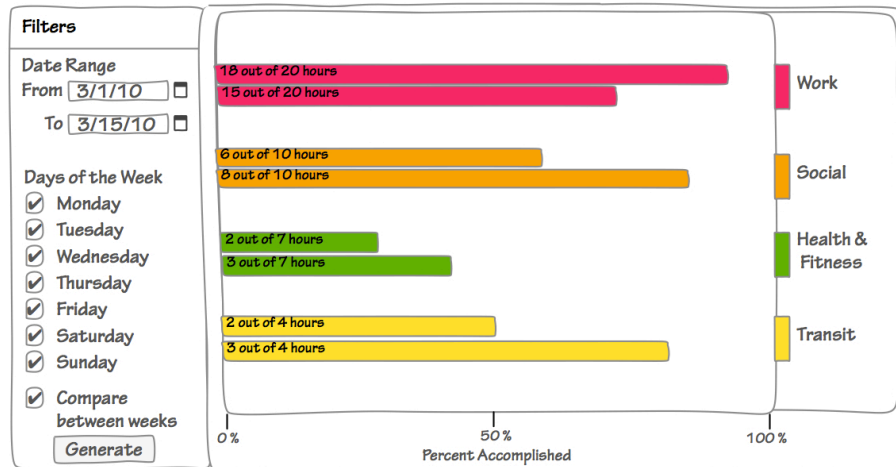


Figure 18. Revised prototype of comparing by week

## IMPLEMENTATION PHASE

After several rounds of user interviews and initial user testing, we implemented a higher-fidelity prototype. The different components of the implementation is illustrated in Figure 19.

A back-end server and datastore communicates with MeLo to get location history. Once location history is collected, server-side scripts compare these against user-configured categories and goals in meloscope and comes up with a cleaned version of the dataset linked with the user preferences. The meloscope back-end also does the management of user accounts and tokens to access MeLo. The back-end performs multi-threaded queries to MeLo to speed up the querying process. Location information is cached for one hour to accommodate other visualizations that the user may want to generate, and then deleted from the repository to protect user privacy. Google App Engine and Python was used to create this back-end.

Once the location information has been processed, it is then sent to a client-side application that formats this information even further to fit the formats needed for the different visualizations. So as to limit the number of queries done to the back-end, an object is created containing the location information, and is kept in memory while the user is on the page. No cookies are saved containing location information to protect user privacy, and so when the user navigates away from the page, he would have to requery and reload his data from the server. Maintaining this object also implies that once a data set has been queried from the meloscope for a certain date range, it would not need to be requeryed when the user moves to a different visualization. The front-end is developed with HTML, CSS, Javascript and JQuery.

The goals visualization and the stacked bar graph visualization was created using Protovis. The maps visualization was implemented using the Google Maps APIv2.

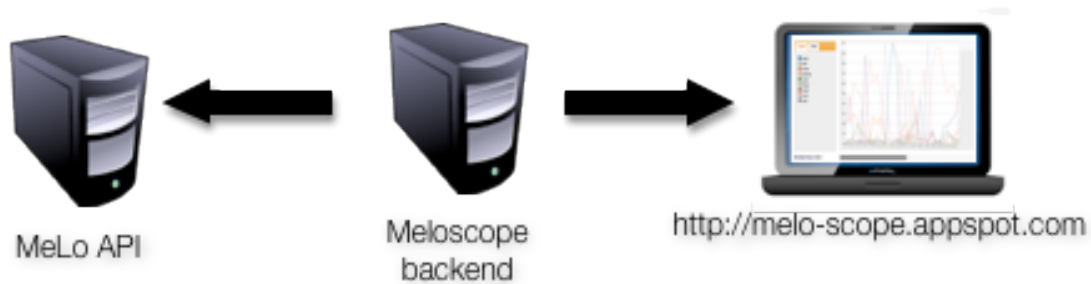


Figure 19. meloscope components

## USER SETUP INTERFACE

As discussed, users are allowed to set up their personal categories in meloscope. This allows the users the flexibility to determine what categorizations make the most meaning to them. They then add associated tags to the categories. These associated tags are what they would use to annotate their locations in MeLo. Figure 20 shows a sample of the screen where this is done.

The figure shows a priority column, and this means that if there are several conflicting tags (i.e. a location is both tagged coffee shop, which the user has associated with social, and meeting, which the user has associated with work), it will be classified according to the category with the higher priority. The associated tags, aside from classifying it according to a main category, are also used to show the more detailed view of a particular category when clicked on in the maps or stacked line visualizations.

The team has set up a default set of main categories based on user interviews, including: "home", "school", "work", "personal", "transit", "social", "fitness".

Another screen in the settings tab allows the user to set up his goals. This is done by specifying a tag to associate with the goal. All time spent a specific location that is annotated with this tag will be counted towards the goal. The user specifies an amount (in hours) and a unit of time to track it against (per Day, per Week or per Month). A week starts on Sunday. Figure 21 shows a screenshot of this settings page.

Priority	Category	Associated Tags	Add Tag
0	travel	travel x airport x airplane x museum x sightseeing x plaza x	add new tag add tag x
1	work	work x office x job x career x meeting x boss x presentation x	add new tag add tag x
2	school	school x study x meeting x project x class x	add new tag add tag x
3	personal	church x buy x visit x errands x	add new tag add tag x
4	social	social x party x bar x restaurant x eat x drink x club x friend x cafe x coffee shop x birthday x dance x karaoke x park x	add new tag add tag x
5	fitness	fitness x gym x sports x doctor x diet x	add new tag add tag x
6	transit	transit x bus x train x car x walk x airplane x ship x ferry x bike x motorcycle x bart x	add new tag add tag x
7	home	home x	add new tag add tag x
			add new tag add tag +

Figure 20. User setup of categories

Tag	Goal Amount	Unit
gym	4.0	hours per Week Set x
school	8.0	hours per Day Set x
social	5.0	hours per Week Set x
		hours per Day Set +

Figure 21. User setup of goals

## MAP VISUALIZATION INTERFACE

Our first visualization (Figure 22) was a map-based visualization of paths - circles indicating locations and arrows between locations indicating paths. By mousing over a particular location or path, more information is brought up on time spent, number of trips, and other tags associated with the path or location. Locations are color-coded according to categorical tags, and vary in size based on time spent.

This visualization facilitates the viewing of spacial relationships between locations in the user's history, as well as temporal relationships between locations (via incoming and outgoing paths from each location).



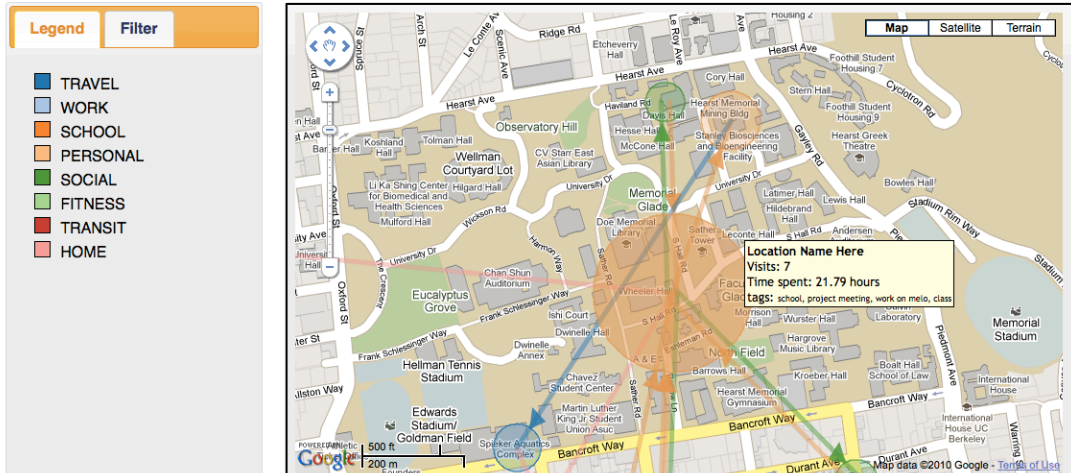


Figure 22. Map Visualization. Hovering reveals more information.

## LINE GRAPH VISUALIZATION INTERFACE

The line graph interface shows a user's patterns on an hourly and daily basis. The hourly basis (Figure 23) takes a sample every 10 minutes and checks where a person is at that time for every data point in the date range. The resulting visualization gives the user a summary of what his normal day looks like from midnight to midnight. For instance, a person can see that he is normally at home at 1am, but the visualization may show that in some circumstances, the user was out in a social capacity or travelling at that time. In this sense, users can quickly single out patterns of behavior as well as variances in that behavior.

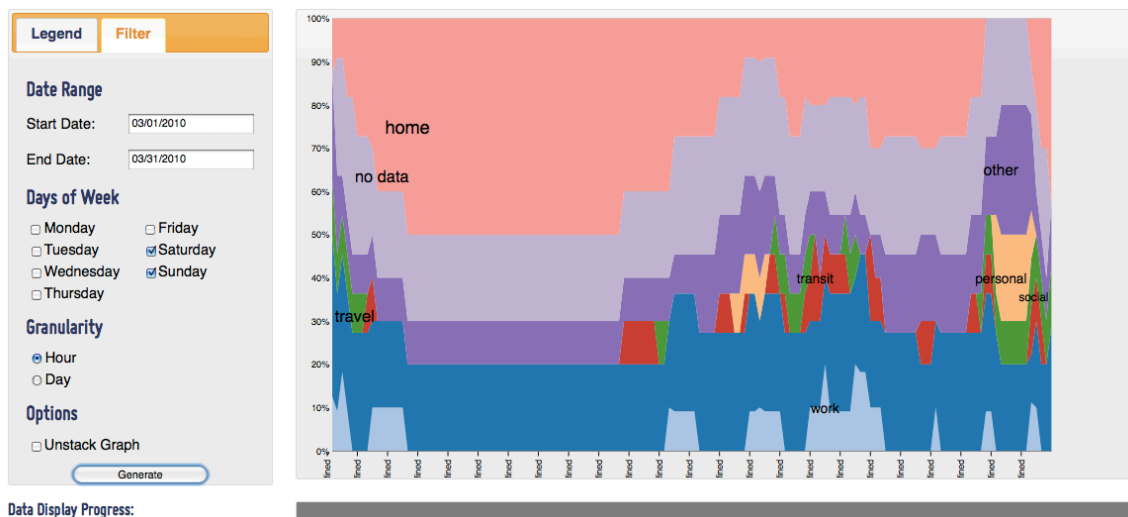


Figure 23. Hourly view of data

If users want to compare between days, they can switch the graph to a daily view (Figure 24), which looks at their location history within a day and breaks it down to



their defined categories. For instance, a person can see that within a day, he has spent x amount of time at work, y amount at home, and z amount in social activities. He can then compare this easily with some other day.

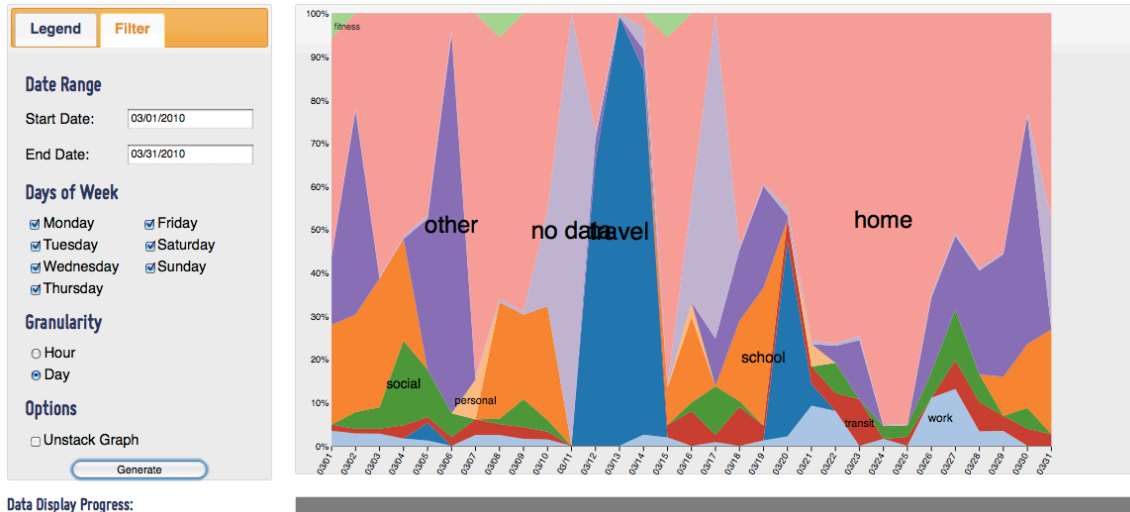


Figure 24. Daily view of data

In each of these views, users can click on a particular category and get a breakdown of the sub-categories under it (based on how they tagged it in MeLo). Figure 25 shows a breakdown of the travel category, and the user can quickly see what he has been spending the most time on while travelling.

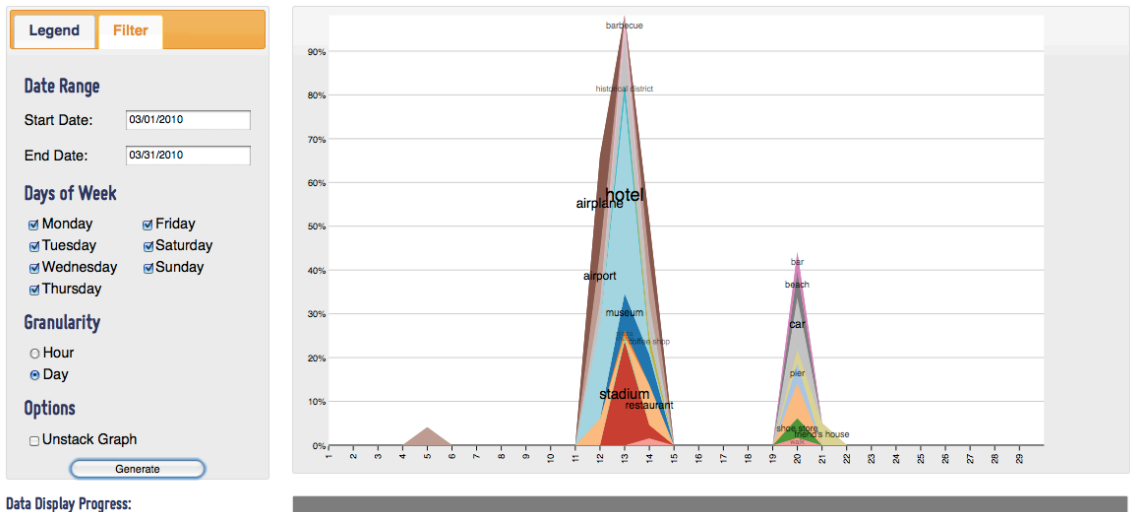


Figure 25. Breakdown of travel category

Users can also choose to filter by day, so as to compare data between days. For instance, if users just want to see a summary of their weekend activities, they can

quickly unclick the days of the week, and just leave Saturday and Sunday. This filters down the data to Saturday and Sunday data points, so users can quickly see what they have been spending their time on during these days.

When users would like to compare the time they've spent between activities / locations, instead of summaries between days, they can also choose to unstack the graph (Figure 26). This effectively creates a traditional line graph with 0 as the base, allowing easier comparisons between one category and the other.

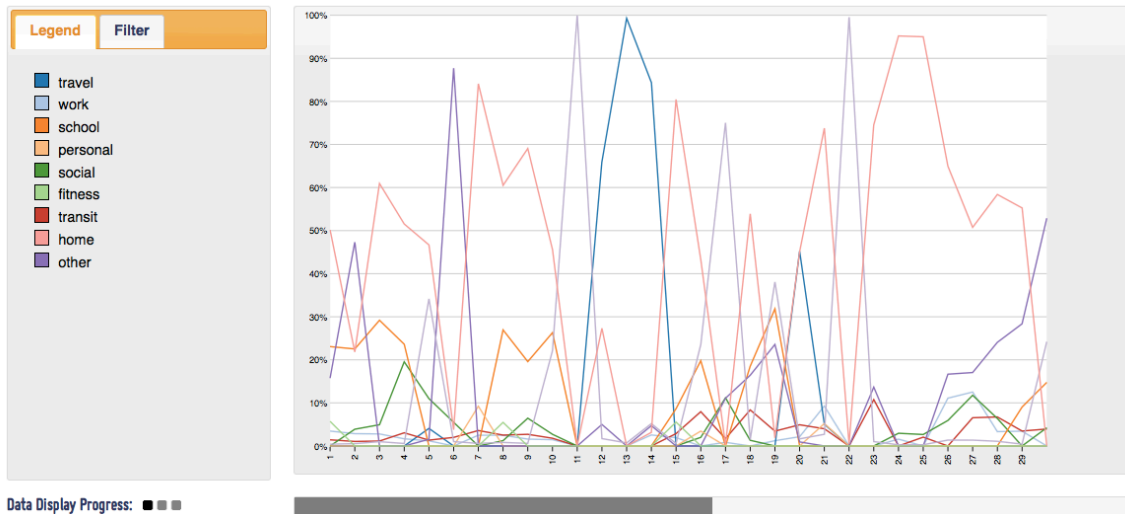


Figure 26. Unstacked line graph

## GOALS VISUALIZATION INTERFACE

The goals visualization (Figure 27) aims to let the user easily see how much time they've spent on a certain activity (associated with a location) versus how much time they have planned or set for themselves. It shows a traditional bar graph arranged horizontally. A line is placed on the 100% goal for the user to see how far away he is from reaching his or her set goal. A user can exceed this 100% line if he has spent more time than he intended on a specific category.

When looking at huge periods of time, users can also break the graph down into weekly periods (Figure 28). This also enables the user to see how he has been meeting his goals on a week-by-week basis, showing if he is improving or not in terms of this.

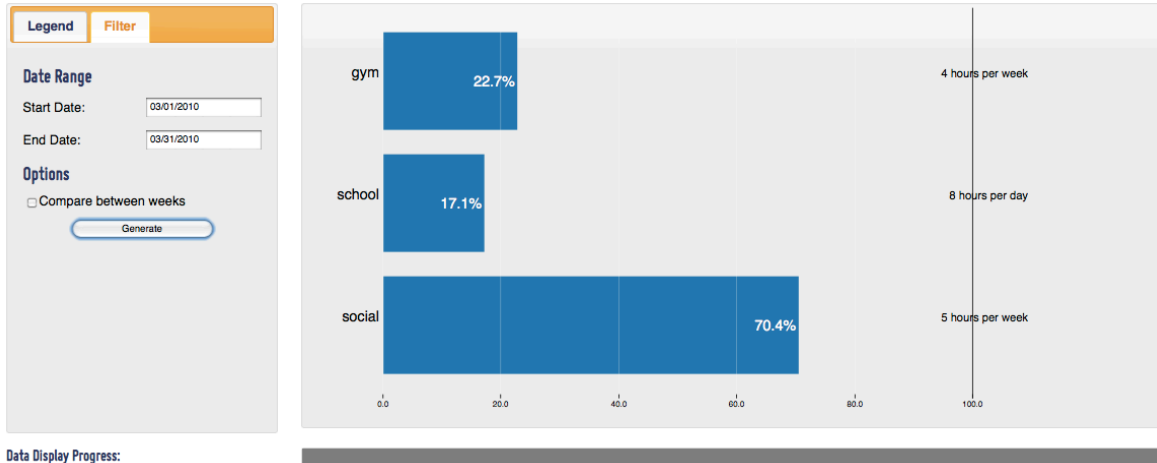


Figure 27. Goals visualization

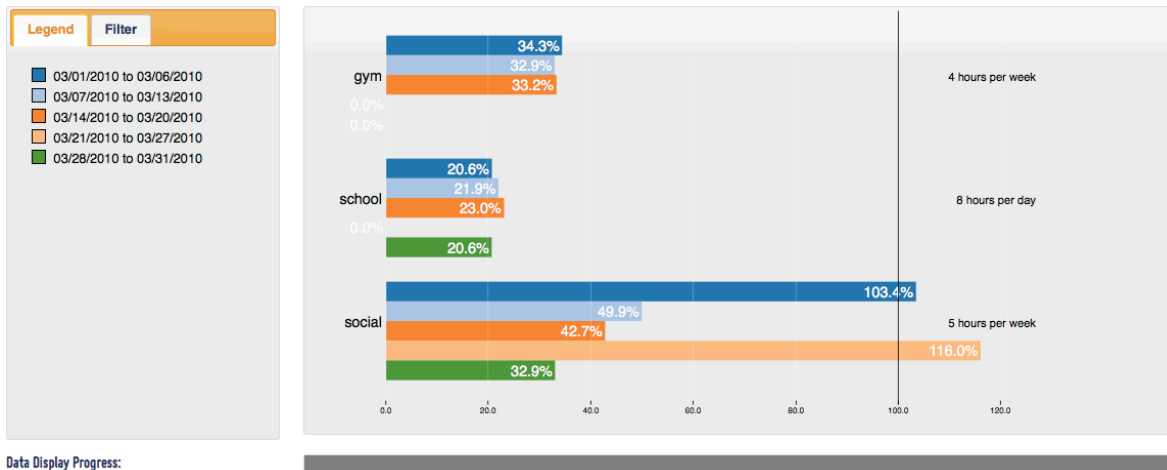


Figure 28. Comparing goals between weeks

## USER TESTING AND FEEDBACK

After the partial implementation of meloscope, it was again exposed to users in order to gather more user feedback about what other functionalities and features would be helpful. Most of the comments revolved around more interactive features. Some comments echoed the original suggestions in earlier interviews, but which we weren't able to implement. The feedback summary include:

### Maps Viz

- Map background is still too distracting, especially since circles are semi-transparent. Might be good to lighten the map even more.

- Clicking on circles or paths should do something -- either filter it according to locations with the same category, or filtering it to locations that succeed that location in a path or pattern.
- Colors are sometimes hard to discern, especially when zooming out.
- Hard to see places of activity when map is zoomed out to see across states or countries. Perhaps data can be aggregated to a geographic level when it is this high up?

### *Line-Area Viz*

- Highlighting the area that is being hovered on, such that you can quickly see which category you want to drill down on.
- Filtering based on the legend instead of directly on the graph. It is somewhat difficult to choose those occupying a smaller area.
- Being able to access actual data when a sub-category is clicked (i.e. seeing all of the times I went to a bar when I click on 'social' and then 'bar' in the graph).
- Tooltips that would give more information about a point in the graph.
- Thicker lines in the unstacked bar graph. A better way also to distinguish which category a particular line refers to.
- Maybe a better way of organizing the information (it is currently alphabetical), like placing the locations that I spent the most time on in the bottom.

### *Goals Viz*

- Would be nice to see absolute values beside percentages. Knowing that I am 20% shy of my goal doesn't inform me how much more time I need to spend on an activity / location

### *General Comments*

- A progress indicator would be helpful to see if all data has been loaded and the visualization is complete, or if more time is needed.
- Filtering mechanism was great, but would like some pre-set lengths of time, like 'weekends', 'vacation', etc. that the user can set up, instead of having to always click and unclick multiple checkboxes.
- Switching between legend and filter can be a bit tedious after successive uses. Maybe the filter can be placed at the bottom, where it is out of the way of the viz but at the same time not consume so much space?
- It would be nice to be able to set the default visualization that pops up after loading (right now it is set to map).
- It would be nice to be able to control what the sub-categories to be shown are, based on the different types of tags available in MeLo (i.e. name of place, category of place, activity or description).
- Filtering based on time range would also be really helpful. For instance, it would be more interesting to focus on my activities after work, since I know

that I'm mostly in the office from 8-5pm. Being able to focus on 5pm onwards would be more interesting.

Some of these improvements have been implemented, including:

- Progress indicator showing how much data has been loaded
- Hovering in line graph
- Filtering / drilling down to detail using the legend
- Tooltips for unstacked line graph
- Increased opacity in maps graph for more vivid color

## FUTURE WORK AND CONCLUSION

The three visualizations just show a sampling of what can be done with this type of personalized user information. Through our user interviews, we were overwhelmed with many different suggestions on how to visualize this information. Most of them were for very specific use cases, but were very interesting nonetheless. They include:

- Mashing up with some other services such as Yelp or Blipy. This could give visualizations on how much you are spending money and where (i.e. you are spending most of your time AND money in social activities, or you are spending way too much on restaurants -- as can be computed by the \$ ratings on Yelp, or you are spending way too much time in places that other people don't think are very good -- as can be computed by the stars rating on Yelp);
- A visualization on how efficient that different paths or routes you take are, based on the average time you get from one place to another;
- A visualization on how many calories you've burned based on the activity tag in MeLo;
- A visualization showing where you are the most productive based on file information from the laptop mashed up with where you were at the time the file saving / modifying / creating occurred.

Because meloscope is part of a bigger final project, the plan is to incorporate further improvements to the user interface based on the feedback given by users.

The team set out to leverage the personal perception of place that MeLo allows its users to annotate their location history with. Through a user-centric, iterative process, the meloscope team was able to come up with three useful visualizations: a map-based visualization, a stacked-line visualization and a bar graph based showing actual time vs. goals. User feedback has shown that these are helpful in synthesizing hundreds of data points in a way that is easy for them to understand.