Flickring Our World: An Approach for a Graph Based Exploration of the Flickr Community

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Abstract. When using the Web, one begins to understand and acknowledge the existence of the "other side of the mirror". The Internet has become a means of inter-relationship between its users, usually forming complex and emergent relationships, providing a handful of knowledge waiting to be extracted. In this paper, we present a tool that analyzes the Flickr community using semantic web technologies. It uses the FOAF ontology to present the result of the analysis as graphs based on the relations between the users of this community.

Keywords: Social Networks, Flickr, FOAF, Semantic Connections, Web 2.0, Semantic Web.

1 Introduction

The Web, as we know it today, is made of – and by – everything. By everything we mean *everything*: plain text, pictures, movies, and so on. However, one thing that is missing is meaning. Every one of these things has the meaning that we provide to them, but none has the underlying meaning that can be recognizable by machines, necessary in order to do some computation and reason about the single most powerful media mechanism known to men. The science of semantic web [1] has this role, to provide a means to compute web resources, providing them the semantics and the structures in order to use them in an intelligent fashion.

One of the main focus of this fairly new science is the contribution to the study of social sciences [2]. The communities that originate from the main web concentration points are very rich in semantic information, as they self organize themselves and their interests by using a tagging mechanism [24]. These virtual societies, by using tags, provide an adaptive taxonomy – the folksonomies [3] – that allows the emergence of social trends, by analyzing the movement and creation of clouds of information. These clouds, composed by terms exclusively created by users, provide a way to verify trends, relations and future directions of people, businesses, products, and so on, thus providing a way of analyzing the hidden features and relations of the web. Our work will focus on developing a tool that allows the analysis of such phenomenon regarding the Flickr environment.

Using Flickr [4] – the famous photo blogging site – as our base of information, we will make use of the API [5] provided by the site to compute users, the pictures they upload and, most of all, the tags they associate with each picture. This information will be structured using a specific ontology [6] named FOAF [7, 8, 9] – friend-of-a-friend –, used mostly on web analysis of societies, with the focus on connections between users. We will treat this information as RDF graphs [25] and try to make a simplified approach to the, so called, second generation clouds [10, 11], by presenting visual, interactive graphs representing the semantic landscape created by the users of the community.

In the present paper, we begin by introducing Flickr and its community, discussing about the concepts behind the creation and usage of the site. We will then make a brief introduction to social network analysis, referring the history of the field and its area of work, and exposing some key concepts behind a social analysis of a network. The following section will introduce our approach to the developing of the tool, by discussing the main structure, followed by the explanation of the algorithms using during the graph computation/creation. We will then expose some of the experimentations made, including its results and observations, and address some future work to be made related to this work. In the end, we round up some conclusions to the work performed and the results obtained.

2 The Flickr World

Developed by Ludicorp [12, 13], the Flickr project was an evolution of a project named Game Neverending [12, 13], a massive multiplayer online game developed in order to provide a platform for an enhanced real time online interaction, in the form of a role playing game based on social interaction. As the project was cancelled, its ideias and tools were used in order to build the Flickr website. Nowadays owned by Yahoo, Ludicorp developed what is now called one the first Web 2.0 applications [12] and, certainly, one of the most famous.

The Flickr website provides a way for people to, not only share their photos with the other users of the site, but also for these users to collaborate in the definition of the meaning of these photos, making use of the tagging phenomenon. As such, one can use Flickr to search for photos depicting a certain color, place or whatever other characteristics, by searching these tags. This tagging is one of the best examples of the use of folksonomies (although there are opposing opinions [14, 15] of this view regarding the Flickr context) , where the users define, evolve and adapt the taxonomy used for a determined context, instead of using a predetermined, fixed and static set of terms.

Although the Flickr website provides for the identification of the users (direct) relatedness, either by being able to (co)exist in each others contact lists or by belonging to the same group, this tagging mechanism may allow for a higher level connectivity assessment approach. Regarding the growing relevance of the Flickr website, and the also growing diversity and number of people participating both in sharing the photos and labeling them, we see the Flickr community as a good possible source of social network analysis.

3 Social Network Theory and the Web

Social science [18] is a thoroughly studied field, regarding what the humans do as specie. Focusing on scientific methods, based on psychology, sociology, and so on, the social sciences are aimed at studying and understanding the human behavior [18]. However, although the traditional view of social sciences focuses on the rational choices made by individuals, it does not regard the aspects of interrelation between those actors [16].

As such, a new field emerged in order to address this issue, named social network theory (or analysis). This field focuses mainly on the social context of the actors and the behavior of their relationships [16], identifying the underlying patterns on these relationships. There is actually a debate [16] whether the social network analysis should be an independent, self contained field or, on the other hand, a subset of social studies, a set of collection methods and studies in order to use in the study of social, human relations (centered on the individual). However, the complexity of the structures of these social networks may induce that it is, indeed, a whole new science [19], that although has its roots and some of its foundations in the traditional social sciences, tries to form its own theories regarding a complex concept.

Social network analysis (SNA) is based on the concept that there are determinable structures behind the formation of the network of agents and their relationships [17]. This concept has originated many theories regarding people and how they organize themselves in networks, being the most famous the “six degrees of separation” theory [20], with roots on the small world models [21].

The social networks field had three main influences [16]: sociometric analysis (graph theory models), mathematical analysis and the anthropology view on the structure of communities. During the 60’s and the 70’s, however, a Harvard congregation on these influences created the general field known as SNA.

SNA regards three main points of investigation [16]:

1) The total structure;
2) The subsets of a determined group;
3) The individuals (as “points”, “vertices” or “nodes”) that form the network;

In order to address these points, SNA also defines a set of concepts regarding the study of networks [16]:

- *Dyad*: Two actors how have a connection, meaning they have a relationship;
- *Clique*: A subset of actors within a network who have ties with all other actors between the subset;
- *Density*: The proportion of total available ties connecting actors;
- *Centralization*: The fraction of main actors within a network;
- *Reachability*: The number of ties connecting actors;
- *Connectedness*: The ability of the actors to reach one another reciprocally, that is, the ability to choose a relationship between both parties;

- *Asymmetry*: The ratio of reciprocal relationships – the mutual relationships – to total relationships within the network;
- *Balance*: The extent to which ties in the network are direct and reciprocated;

Regarding the study of individuals in the network, there are a few more concepts to consider [16]:

- *Centrality*: The degree to which an actor is in a central role in the network;
- *Homophily*: The degree to which similar actors in similar roles share information;
- *Isolate*: An actor with no ties to other actors;
- *Gatekeeper*: An actor who connects the network to outside influences;
- *Cutpoint*: An actor whose removal results in unconnected paths in the network;

3.1 The Web and its Dual Relation with SNA

The Internet boom has provided a very rich and diverse arena for the study of social networks. In fact, it was the development of the World Wide Web (WWW) that provided for a wider application of the field, accompanied by further developments on theories, models and concepts. The presence of logs, blogs, forums and registers of all kinds provide for very useful data to be used in SNA [17].

SNA has provided some interesting studies (and consequent results), using traditional methods and targets of study. The Internet has evolved this study and its scope one step further: the globalization of the population has provided for a much wider sense of connections, regarding aspects from preferences of music, food and films to ideologies and ways of living. In a sense, we can say we are in the presence of the *meta level* of social networks, where the localization of the agents no longer matter, due to the world virtualization of the WWW [23].

If, at first, there was an underlying fear of the eventually ephemeral Internet base connections, the appearance of Internet communities proved that the aforementioned relationship arena was strong, cohesive and robust, and, as such, ready and perfectly suited for the SNA field [22, 23]. The fact that online communities often change its paradigms (the *social trends* shifting) provides yet another dimension for this social analysis, as the networks *evolve* in time (and space, eventually). As such, SNA has another characteristic to study (evolution of online networks) and a playground to test and infer theories.

On the other hand, social network concepts became so famous that, nowadays, we have companies and businesses based solely on them, regarding networking sites such as Orkut, Flickr, MySpace, etc. [16].

4 Developing a Tool for Social Network Analysis in Flickr

In this section, we describe our work presenting several key points of the project, such as the ontology used, the architecture built and the algorithm and structures included for the generation of graphs. The goal is the development of a tool that allows for the modulation, parameterization and navigation on graph representations of the Flickr social networks.

4.1 Architecture

In order to build a tool for both constructing and analyze the graphs representing the connections between the Flickr users, we need to perform the task of data extraction from the Flickr database. After this preliminary step, we needed some way of constructing the models in order to apply the algorithms, and then a dynamic fashion on representing the graphs. As so, the application consists, mainly, on three different tiers, as represented on figure 1.

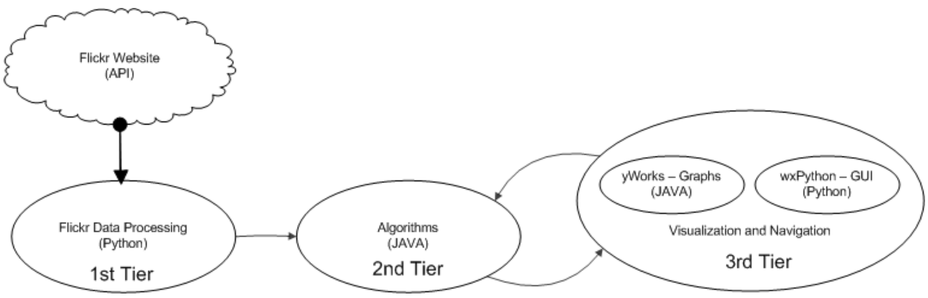

Figure 1: Overall architecture of the tool

The first tier (Flickr Data Processing) is responsible for querying the Flickr API service, while storing this data in a local MySQL database. The algorithms for implementing these queries are built using the Python language [31], and the focus is based mostly on the task of processing the XML data originated by the Flickr API upon a data request.

The second tier (Algorithms) is in charge of all data manipulation and algorithmic functions. This tier uses the data retrieved from the first tier for the construction and storing of RDF [25] graphs, which are then used for SPARQL [26] querying. These queries are built upon the needs of the data used in the main algorithms, responsible for performing the assessment of the relations between the Flickr users. Related to this tier is the creation of a virtual matrix representing all the connections between the Flickr users (stored in the local database). This structure will be used in the third tier. This second tier is implemented using a Java application, including the JENA [27] package in order to perform the RDF construction and querying.

The third tier (Visualization and Navigation) uses the previously mentioned virtual matrix to perform the mapping of the matrix to a visual graph. Using the YWorks

Java package [28], we (re)present the results derived from the implemented (and selected) algorithms to a graph of nodes representing the users. The layout is built in order to depict visually the connectivities between the Flickr users in the graph. This visualization is inserted in an interface allowing the user to define certain parameters of the presented graph. An example of a graph is shown in figure 2. This third tier comprises another visual element, allowing the algorithms to be selected, as previously mentioned. As the goal of this work is to build a tool for social graph analysis, we developed a Graphic User Interface (GUI), allowing the user to both choose from a different set of algorithms and insert the desired parameter values regarding the formulas used in the assessment of the relatedness of the Flickr users. This GUI is built using a Python graphic package, wxPython [29].

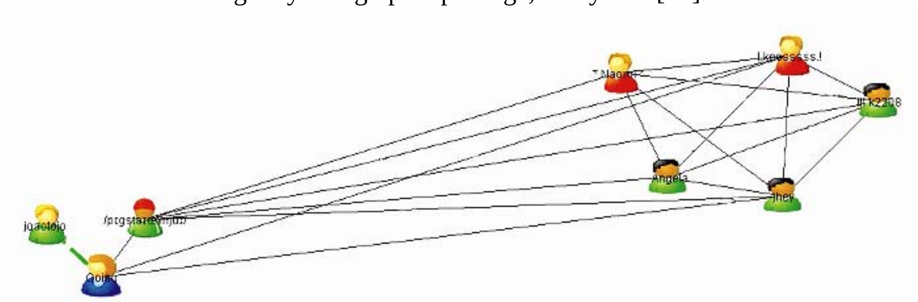

Figure 2: An example of a graph created with yWorks and a subset of Flickr data.

4.2 Ontology

In order to analyze the Flickr data, we use a base structure that can provide for the needs on asserting relationships between actors, which can be either persons or objects. Not only for that reason, but also because of principles of good engineering, the use of an ontology is an obvious choice. For that we used the FOAF [7] (friend-of-a-friend) ontology, because it provides not only defined structures for persons, activities and properties, but also the means of performing simple and direct connections between them and their related objects. This ontology enables the identification of relationships within groups of people and relations between people and resources (locations, films, photos), and people and their activities (blogging, tagging). FOAF ontology not only provides these direct assertions, but also lays the foundation for reasoning about some higher level relationships, not so clear at a first glance, such as the relation between actors based on the properties of their activities, or the objects they create.

It is with one of these higher level relationship identifications in mind (namely, the tagging relationship) that we use the FOAF ontology. However, in order to use the ontology within our project, we had to perform some modifications, for example, including specific terms related to our work and concerning the Flickr activities and properties.

As stated above, the use of FOAF ontology is considered to be important from a conceptual point of view.

Despite that, the technological perspective should not be forgotten as it provides the possibility to make direct reasoning with the Flickr data and prepares it for future applications in terms of scalability. The ontology used in the present work is depicted on figure 3.

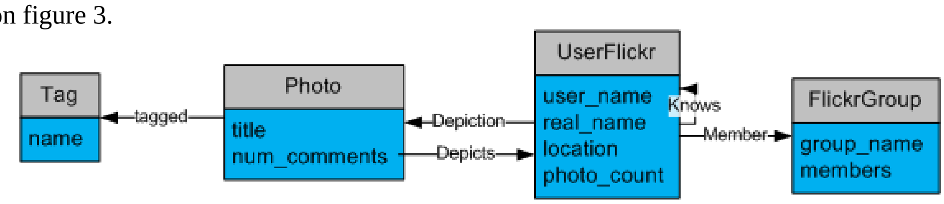

Figure 3: Part of the ontology used in the current work.

4.3 Algorithms for Asserting Connections on the Network Creation

We have used a formula to compute the proximity between users, which takes in consideration 3 factors:

4) If the users are contacts of each other;
5) If the users are in the same group;
6) The similarity asserted from the tags related to each of the users;

As so, the main formula is presented on formula 1.

$$con(u1,u2) = w1 * ContactS(u1,u2) + w2 * GroupS(u1,u2) + w3 * TagS(u1,u2) \quad (1)$$

With: ContactS = Similarity as a contact, GroupS = Similarity as in the same group, TagS = Similarity by tags and, preferentially, w1+w2+w3 = 1, in order to normalize values.

4.3.1 Contact Similarity

on the contact similarity is computed based on the user's contacts. However, this relation may not be bidirectional, as the user can have a contact that doesn't have the user as its own contact. As such, we specify this option as a parameter (p1), so it can be chosen how to deal with this relation. If p1 is true, the relation is assumed to be directional, otherwise it is assumed bidirectional. The following formulas, 2 and 3, represent, respectively, both these cases.

$$p1 = false \rightarrow \qquad contactS = u1has(u2) \quad (2)$$

$$p1 = true \rightarrow \qquad contactS = (u1has(u2) + u2has(u1))/2 \quad (3)$$

With: u1has(u2) = Verification if u1 has u2 on its contact list (equals 1) or not (equals 0) and u1has(u2) = (0;1).

4.3.2 Group Similarity

As a user can belong to several different groups, we've considered this value to represent a higher relation between users if the number of similar groups of the users is higher. So, the formula has in consideration not only the number of similar groups between the users, but also the amount of groups of the first user, as shown in formula 4.

$$groupS(u1,u2) = \frac{\sum similarGroups(u1,u2)}{\sum groups(u1)} \tag{4}$$

With: similarGroups(u1, u2) = Number of groups similar between u1 and u2, and groups(u1) = Number of total groups of u1.

4.3.3 Tag Similarity

Tag similarity is the most complex relation between the users, as it is the only one that is not directly retained when consulting the data. We could have used several approaches to tackle this issue: we have chosen, however, one that simplifies this relation by relating the tags associated with the photos of each user.

The algorithm runs each user list of tags present in her/his photos, comparing the values and counting the similar cases. We've also implemented a step deeper, by using the Flickr API function, which returns the related tags of a specific tag. We add this into the equation by, whenever a tag between two users does not relate, discovering the related tags (as "stated" by Flickr) and finding a relation between them. As this isn't a direct relation, and regarding the fact that Flickr already provides in its response for a classification of the most related, we infer a linearly descendant weight for each tag on the list of similar.

Two formulas were implemented for the direct relation between tags and one for the indirect relation. The weight of these two relations can be user defined.

For the direct tag similarity, we have formulas 5 (Record Semantic Proximity (RSP) [30]) and 6 (self named Empiric Semantic Proximity (ESP)).

$$tagS(u1,u2) = \frac{\sum similarTags(u1,u2)}{\sum tags(u1) + \sum tags(u2) - \sum similarTags(u1,u2)} \tag{5}$$

$$tagS(u1,u2) = \frac{\frac{\sum similarTags(u1,u2)}{\sum tags(u1)}}{\frac{1-\sum tags(u1) - \sum tags(u2)}{\sum tags(u1) + \sum tags(u2)}} \quad \textbf{(6)}$$

With: similarTags(u1, u2) = Number of equal tags in tag lists of user 1 and user 2, and tags(uX) = Number of total tags in tag list of user X.

The difference between RSP and ESP resides mostly on its concept. While RSP accounts for the similarity of both the users on a joint context, asserting it as a whole, ESP looks at this similarity from a “point of view” of u1, giving the tag relation a slight different meaning.

Regarding the indirect tag relationship, the value is computed according to the following steps:

1) For every tag “ tagU” from user1, if it’s not on user2 tag list, for every “tagY” in user2 tag list, get “tagY” list of similar tags (according to Flickr), checking if this list contains “tagU”;
2) If so, add to the counter the weight related to the position of the tag on the list. For example (assuming a base value of 0.8 and a threshold of values 0.01):
    a. [‘cat’:0.4, ‘dog’:0.2, ‘bird’:0.05, ‘meow’:0.025]
3) Divide the sum value obtained for the multiplication between the number of sub lists compared with and the maximum value of each sub list. See formula 7, for the given example.

$$indirectRelation = sum / (0.4 * nAnalyzed) \quad \textbf{(7)}$$

With: sum = All the “contributions” from the different sub lists. And nAnalyzed = the number of sub lists analyzed.

As a final result, both the direct and indirect tag relations are taken into account (if that is the desire of the user), regarding formula 8.

$$tagS = w1 * DirectSim(u1,u2) + w2 * IndirectSim(u1,u2) \quad \textbf{(8)}$$

With: DirectSim(u1, u2) = The value of the direct tag relations (formula 5 or 6), IndirectSim(u1, u2) = The value of indirect tag relation and, preferentially, w1+w2 = 1, in order to normalize values.

4.4 Adjacency Matrix

The result of the previous formulas is a value for each pair (UserX, UserY). The value of the pair (User1, User2) *may not be the same* as the value of the pair (User2, User1). For instance, if it is decided not to use the complete approach when asserting the users contact similarity, and User1 has User2 as a contact while the reverse is not true, then User1 will have a weight of 1 in that relationship, while User2 will have a weight of 0 in the same calculus. As the graphs to be constructed are spatially visualized, we had to, somehow, normalize this distances. As so, we opted for the following way: for each pair (of pairs) ((UserX, UserY), (UserY, UserX)), we assign the mean value, regarding, each sub pair. For example, let's say that con(User1, User2) = 0.83 and con(User2, User1) = 0.25. The assigned value for this (double) relation would be (0.83+0.25)/2 = 0.54.

In the end, the matrix will look like the one represented in table 1.

Table 1. The Adjacency Matrix

P1\P2	Person1	Person2	Person3	Person4	Person5	Person6	Person…
Person1	NA	0.54	0.67	0.04	0.08	0.34	…
Person2	0.54	NA	0.78	0.23	0.51	0.001	…
Person3	0.67	0.78	NA	0.02	0.045	0.43	…
Person4	0.04	0.23	0.02	NA	0.78	0.12	…
Person5	0.08	0.51	0.045	0.78	NA	0.28	…
Person6	0.34	0.001	0.43	0.12	0.28	NA	…
Person…	…	…	…	…	…	…	…

Note: "NA" means the value is "not assigned", as it wouldn't make sense to connect a person to itself.

5 Experimentations

In order to create a reasonable experience, where we could visually control and manage the data with ease, we've extracted around 200 Flickr users, chosen randomly, with their tags, contacts and photos. From that information, we created a set of graphs, modifying some of the parameters.

The base parameters, used in formula 1, are, respectively, 0.2, 0.2 and 0.6. This means that the contact relation has a weight of 0.2, the same for the group relation. The tag relation, the one we intend to perceive the most, has a weight of 0.6. Figures 4 and 5 depict the graphs obtained, with both the RSP formula and the ESP formula. The indirect relation from tags was not used in these computations.

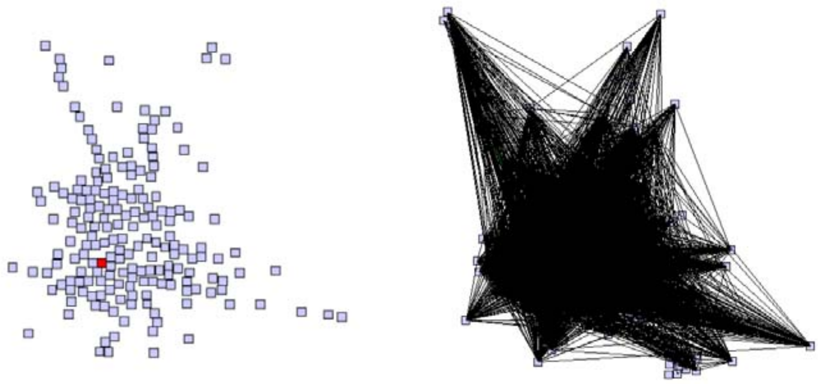

Figure 4: Graph generated with the RSP formula. Graph with the connections on the right and just the nodes on the left.

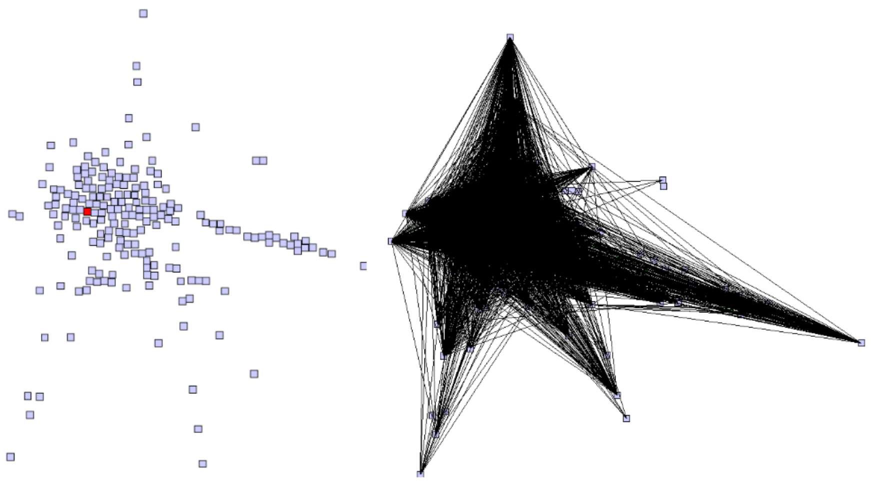

Figure 5: Graph generated with the ESP formula. Graph with the connections on the right and just the nodes on the left.

We varied the base parameters in order to use the values 1.0, 0.0 and 0.0, meaning that only the contact factor is represented in the graph. The resulting graph is shown in figure 6.

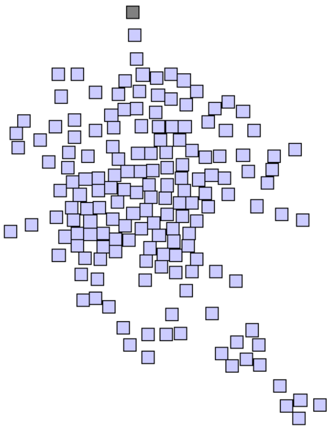

Figure 6: Graph generated by giving only significance to the contacts relation.

6 Observations

Regarding our experimentations, we can observe some relevant aspects:

- *Graph Modulation*: Both figures 4, 5, and 6 show that we can modify the topology of a graph representing the same data, by varying the parameters that construct that graph. This aspect allows graph modifications related to the aspects more relevant to the people analyzing the graphs. In the present case, one could prefer to study the dynamics of a network fully based on Flickr contact connections (figure 6), while, on the other hand, a study could be performed where all the variables are inserted into the graph construction (figures 4 and 5).

- *Visual properties*: If we observe the graphs on the previous section, we can easily identify a few characteristics of networks. In all the examples (figures 4, 5 and 6) we are able to visually identify sets of people grouped together, forming a subset of the network – *clusters* – we can also spot some subsets further away and separated from the others, forming some sort of *islands*; some of the persons are farther away from the main group of people, forming a set of individuals that we can call of *outliers*.

- *Graph navigation*: Another goal of the project was over the second generation view on this sort of graphs. In figure 7 is shown an example of navigability on the graph. By selecting a node in the graph, one can perform a sort of navigation by "travelling" through the neighbors of each node. When a node is selected, its directed connections will be highlighted giving a visual output of the "road". By performing this sort of navigation, we enhance the study of networks on the individual level [16], allowing the possible analysis of *individual's connections* and characteristics of a determined individual, either as a "real" person or as a role on the network.

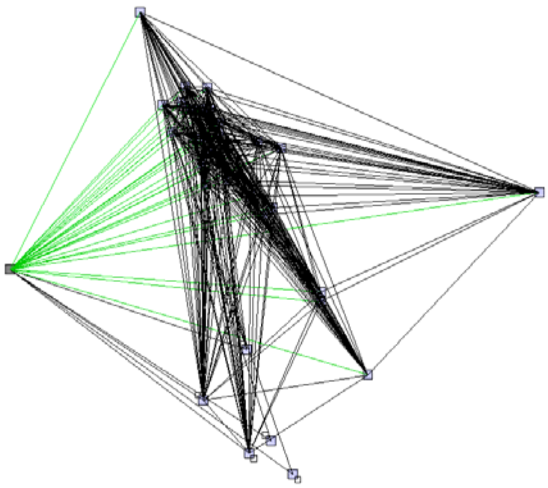

Figure 7: Example of navigability on the graph, while selection the leftmost node.

7 Future Work

The current work, presented in this article, was a first step towards an interactive tool for the science of SNA. The principal basis of the work is already implemented, with a project that allows for the creation and visualization of graphs representing social networks. However, and precisely because this work is a basis for future work, there are a few features that can be enhanced in the project.

One of the main augmentations of the work will be the inclusion of methods for explicit social network analysis, where we are able to withdraw statistics for inference on characteristics like density or reachability of the graph. On the other hand, the inclusion of different layers on the second generation aspect will allow for a concrete visualization of the proximity based on specific aspects. One example on the current work is the inclusion of tag clouds, where the location of the persons on the network is accompanied by a set of tags, representing the semantic landscape on another level. These two additions to the current work will allow for a deeper theoretical validation on the graphs constructed with the tool,

Regarding the construction of the graph, other elements can be included into the calculations of proximities. One can include another level of tagging, by considering the tags related by proximity (Flickr API provides this list), or by including metadata from the pictures (when the API provides methods for that goal). Other formulas can also be included, in order to experiment with different topologies.

As we validate the constructed graphs, trying larger sets of data may provide for richer network environments. We believe that the built tool will handle these larger sets of data without much effort, thus achieving a good level of scalability.

8 Conclusion

The work performed and described in this article provides a step further on the SNA. Using the basis of semantic web, we've developed a project that reveals as a core engine for an auxiliary tool for SNA. We've proved the creation of the graphs depending on the desired set of parameters is achieved. At the same time, the graph navigation is already possible, as the main work is already produced; the additional methods that allow for a specific analysis can be included in the tool.

Several questions also emerge from the produced work: what other elements from web 2.0 can be used along with the web semantics in order to produce valid results and conclusions? What metadata is valid, and what isn't? On the other hand, how can this SNA and its networks enhance the web 2.0 experience? Although the answers to questions of these sorts are not evident, the solution to them is to investigate and aid in the investigation of SNA in the context of the Internet. And tools as the one described in this work are a precious aid in this goal.

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