Visualizing and Managing Folksonomies

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Abstract. Social tagging represents an innovative and powerful mechanism introduced by social Web: it shifts the task of classifying resources from a reduced set of knowledge engineers to the wide set of Web users. Tags generate folksonomies; in the current popular social tagging systems (such as delicious or Bibsonomy), they are difficult to manage, modify, and visualize in dynamic and personalized ways.
The aim of this paper is to describe Folkview, an innovative way to conceive a folksonomy in terms of a multi-agent system. Folkview is able to support specific modular tools for personalizing customized and dynamic visualization features allowing users to simply update, manage and modify a folksonomy.

Key Words: Folksonomy, Formal model, Multi-agent system, Personalized views, Authoring

1 Introduction

Social tagging systems are characterized by the active participation and interaction of users, which upload, share and freely annotate with labels, known as *tags*, a huge amount of resources, explicitly inducing on them personal classifications. Although these systems are widely used and personal annotations represent a democratic, powerful and easy way of classifying resources, they suffer from different issues:

- The lack and the exigence of general methodologies for extracting semantic information (this topic is widely discussed in literature, see the survey [1]);
- the lack and the exigence of personalized and dynamic workspaces in which users can *visualize personalized views* of the folksonomy or *apply personal changes*.

The creation of personalized views, which may display a limited, well defined and personalized sub-portion of an entire hyperspace is something that has already been considered in different settings. To implement this strategy, most of traditional Web browsers become to offer personalized views, so-called *start pages* such as, e.g. NetVibes[1], My Yahoo[2] and iGoogle[3]. Some extensions to

[1] http://www.netvibes.com/it
[2] http://my.yahoo.com/
[3] http://www.google.it/ig

these examples are adaptive bookmarking systems such as PowerBookmarks [2], Siteseer [3] and WebTagger [4].

These applications highlight that a crucial task for the developers of nowadays Web application is how to model and create specific tools for providing personalized views to the users. All the types of social tagging systems should deal with these compelling and open challenges, expanding their capabilities and enhancing possible multiple visualizations, in order to achieve (a) a more effective comprehension of the semantic relations of a folksonomy, (b) a more useful navigation through the involved elements, and (c) the manipulation of the existing relations among tags and resources according to the user needs.

The folksonomies (and the personomies) are generally visualized as a tag cloud: in spite of this, the work [5] states that this kind of visualization is not sufficient as the sole means of navigation. Let we consider for instance the Figure 1, where is shown a portion of workspace offered by delicious, the popular social bookmarking application.

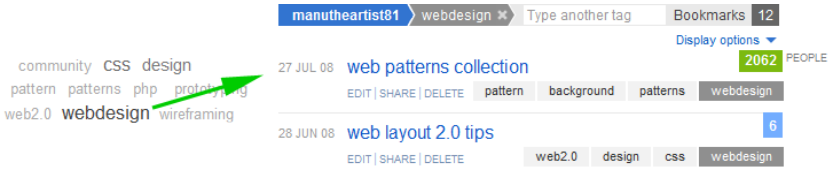

Figure 1. A sample view taken from delicious

The user navigates her tag cloud (shown on the left); when she selects a specific tag ("Webdesign", in our case), the number of bookmarks related to the chosen tag and the list of resources annotated with it are shown. The navigation may continue by clicking on each resource, tag or user, but

- the tag cloud is not adaptive;
- personalized views cannot be created;
- it is not possible to simply modify the personomy, or the personal view of the folksonomy (for example, renaming a tag for a set of resource or merging two or more tags on a unique label).

These limitations are partially ascribable to the static nature attributed in literature to a folksonomy; in fact, it has been defined in terms of finite sets of *users*, *resources* and *tags* [6] and represented as a hyper graph or as a tripartite graph [7, 8]. These definitions do not consider the dynamic aspects, like the personalization and the authoring, as intrinsic features of a folksonomy, although they are. In fact, the role and the importance of a folksonomy are not in the trivial, passive storage and visualization of data, but in the semantics contained in it, in the identification of user features, habits, needs, and in the possibility of inferring recommendations.

The main aim of this work is to propose a novel, distributed, modular system called Folkview, whereby a folksonomy is conceived dynamically through the use of multiple agents. These agents will be capable of

- managing the structural and semantic properties;
- cooperating for obtaining common objectives;
- offering personalized and dynamic views.

The paper is organized as follows: in next Section 2 we discuss related work, in Section 3 we present the formal, multi agent-based model at the basis of Folkview, while, in Section 4, we discuss its dynamic features with respect to authoring and personalized views. Finally, final considerations end the paper.

2 Related Work

Early definitions of folksonomy [9–11] are related to the user activity of annotating resources with metadata for her own individual aims, and/or for sharing them in a community. In these definitions, only three kind of entities (users, resources and tags) and the relations among them, called *tas* (tag assignments), are considered, instead of any dynamic aspect of visualization and manipulation. An extended definition of the previous ones is given in [12] where the authors propose the social application GroupMe!, defining an additional element, the group, which can be both a resource or a group. Even if some interesting relations are highlighted in this application, like the relation between tags assigned to different resources of the same group, users are not allowed either to directly manipulate her personomy or to navigate through different and more effective visualizations.
As observed in the introduction paragraph, a folksonomy is usually represented by a tripartite graph or network, but this leads to another issue related to the complexity of the nature of the graph itself. Various researches have dealt with this problem, projecting a folksonomy on simplified structures. For example, in [13], the tri-partite network is first projected on a bipartite network, then on a unipartite one, thanks to the correlations between two nodes of the same kind. In a recent work [14] the authors, starting from the edge-colored multigraph of users, tags, and resources, propose some simplified definitions that maintain some of its properties. Thanks to this mechanism, the information extraction process becomes easier and simplifies the application of a modular and extensible methodology applied for discovering synonyms, homonyms and hierarchical relationships amongst sets of tags. However, these researches are oriented to provide a different and intuitive way to visualize a folksonomy, but do not discuss about possible simple modifications of them. For example, at the best of our knowledge, there are not dynamic authoring tools that allow the user to globally change the tag labeled in a certain way within her personomy. The same social tagging applications, such as Bibsonomy, delicious or Flickr, suffer from similar limitations.

A few research projects have addressed some of them: in [15] the authors use a customized cluster maps for visualizing both the overview and the detail of semantic relationships intrinsic in the folksonomy; in [16] the authors use information visualization techniques to discover implicit relationships between users, tags and bookmarks and offer end-users different ways to discover content and information that would not have been found through explicit searches.

Another project is TagGraph[4], a folksonomy navigator which visualizes the relationships between Flickr tags. User may enter a Flickr username or a tag, and the graph sets out drawing itself automatically; after this early step, she may navigate through related tags or among related images, but could not manipulate her personomy.

The mentioned projects are by all means interesting attempts of interactive visualizations of folksonomies; nevertheless they do not provide neither personalized views nor effective dynamic changes according to the user needs or preferences.

3 Folkview: the formal model

Traditionally, given the sets U, T and R respectively of users, tags and resources, a folksonomy is defined as the set of tag assignments (tags, for short) $(u_i, r_j, t_k) \in U \times T \times R$, where $i = 1, \ldots, |U|; j = 1, \ldots, |T|; k = 1, \ldots, |R|$, each of them indicating that user u_i has tagged the resource r_j with t_k. User profiles, functions, metrics or semantic relations among users, tags, resources and tas are not intrinsic properties of the folksonomy, but may be (or not) applied by the system which hosts the folksonomy. We indicate this traditional concept of folksonomy as static folksonomy F. In order to define a F, we identify three classes of sets:

- $T_{u_i,r_j} \in T$ is the set of tags used by u_i on r_j;
- $R_{u_i,t_k} \in R$ is the set of resources tagged by u_i with t_k;
- U_{t_k,r_j} is the set of users that tagged r_j with t_k.

Each set represents a structural component of the folksonomy, and we call it *structural* ; the tags are grouped associating to them a semantic label for identifying their meaning in that dimension. A graphical example of 6 sets of tags is given in Figure 2, on the left.

The first three linear paths contain the resources tagged by user u_1, using respectively t_1, t_2 and t_3. So, the labels associated with them are respectively u_1, t_1, u_1, t_2 and u_1, t_3.

Definition 1. *A structural dimension is a labeled path*

$$D_{u_i,r_j} = (V, E, \lambda)$$

where $V = T_{u_i,r_j}$ *is the set of vertices,* E *is the set of edges,* $\lambda(e) = (u_i, r_j)\ \forall e \in E$ *is an edge labeling, and* $degree(t_k) = 0, 1, 2\ \forall t_k \in T_{u_i,r_j}$. *In particular,* $degree(t_k) = 0, 1, 2$ *only if* $|T_{u_i,r_j}| = 1$.

[4] http://taggraph.com/

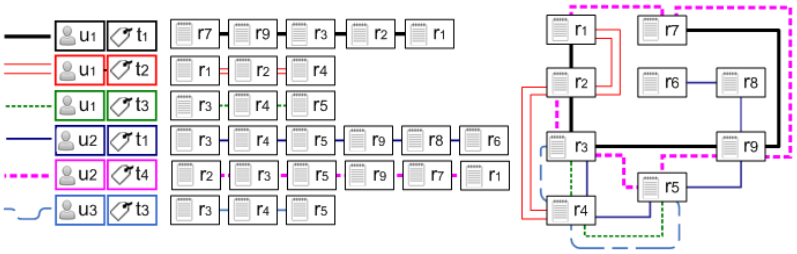

Figure 2. 6 structural dimensions (left) and the correspondingfolksonomy (right)

Analogously we define D_{u_i,t_k} (resp. D_{t_k,r_j}) as the labeled path constituted by the set of resources R_{u_i,t_k}, labeled with t_k by the user u_i (resp. by the set of users U_{t_k,r_j}, that assigned the tag t_k to the resource r_j).

Definition 2. *A static folksonomy F is a labeled multigraph given by the union of three families of structural dimensions.*

$$F = \bigcup_{i,k} D_{u_i,r_j} \cup \bigcup_{i,j} D_{u_i,t_k} \cup \bigcup_{j,k} D_{t_k,r_j}$$

where $u_i \in U$, $r_j \in R$ and $t_k \in T$.

An example of F is shown in Figure 2 (right); it is based on the six dimensions visualized on the left.

The previous definition is restrictive for a folksonomy: several works [1] emphasize the role of a folksonomy for

- supporting tag suggestions, or recommendations;
- inferring knowledge about the user profile, her habits, preferences, and skills;
- for identifying similar users, resources or tags.

In summary, folksonomies add semantics on the data. For this reason, we propose a new concept of folksonomy, conceived as a dynamic entity, organized as an universe of inherently autonomous computational sub-entities, which interact with each other by sending messages and reacting to external stimuli by executing some predefined procedural skills. Various authors have proposed different definitions of agents. In our setting an agent is formally defined as follows.

Definition 3. *An agent $A = (Ts, En, Re, Ac)$ is a quadruple where*

- *Ts represents its* **topological structure***;*
- *$En = \{\eta_1, \eta_2, \ldots\}$ defines its local* **environment***;*
- *$Re = \{\rho_1, \rho_2, \ldots\}$ is the finite set of incoming* **requests***;*
- *$Ac = \{\alpha_1, \alpha_2, \ldots\}$ is the discrete, finite set of possible* **actions***.*

Ts and *En* represent the passive part of the agent, while *Re* and *Ac* its active part.

Finally, we can introduce the definition of the dimension $\mathcal{D}_{u_i,r_j}$ based on the structural dimension D_{u_i,r_j}.

Definition 4. *A dimension* $\mathcal{D} = (Ts, En, Re, Ac)$ *is an agent where*

- $Ts = D_{u_i,r_j}$;
- $En = \{u_i, r_j, t_1, \ldots, t_n\}$;
- $Re = \{\emptyset\}$, *initially;*
- $Ac = \{add\text{-}tag, delete\text{-}tag, modify\text{-}tag, \ldots\}$

Analogously, we can define new classes of agent dimensions, not only for structural dimensions. New dimensions can be created directly from the user, or computed by the system applying specific metrics, or generated applying ontological models; each dimension can contain other dimensions; each dimension associates a semantics to the set of grouped entities.

Definition 5. *A folksonomy* F *is a multi-agent system formally described as a labeled multigraph of agent entities, organized in semantic contexts, called dimensions.*

$$\mathcal{F} = \bigcup_{i=1}^{n} \mathcal{D}^i$$

All in a folksonomy is a computational agent, equipped with a set of *local variables*, that define its internal state, and a modular and extensible set of *procedural skills*. So, for example, each user is represented in a folksonomy by an user agent: it knows the resources tagged by the user, and the used tags; but it also contains and manages the user profile, and it is able to calculate specific local metrics for her, such as the average number of tags applied on a single resource, the average time spent on a resource, the tagging date, etc. They can further communicate with the other agents present in the personomy and in the folksonomy, such as the tag agents, or the resource agents, or the same dimension agents.

Some semantic connections may be inferred by $\mathcal{F}$, applying opportune metrics, for example a similarity function for identifying neighbors tags, users or resources, or ontological relations.

4 Personalized views and authoring

It is simple recognize in the labeled multigraph contained in the definition of $\mathcal{F}$ the *zz-structures* [17]: they are non-hierarchical, minimalist, scalable structure for storing, linking and manipulating different kind of data. From these structures, we inherit many strengths, such as their intrinsic capability to preserve contextual interconnections among different information, thanks to their particular properties.

The peculiarity of such structures derives from the relation among their component elements: data is stored into *cells*, that may contain very different type of contents, which are connected with links of the same color into linear sequences called *dimensions*. A single series of connected cell among one dimension is called *rank*, while the starting and the ending cells of a rank are called *headcell* and *tailcell*. There is also a restriction according to which for any dimension, each cell can connect almost two other cells following the direction of the dimension.

As discussed in literature [18], zz-structures are used with success in many applications, implemented for different platforms, and due to their flexibility and adaptivity, they have been successful used in several fields, such as bioinformatic, electronic music, e-learning [19], virtual museum tours [20, 21] and so on.

In [22] the authors compare zz-structures with mSpaces and Polyarchies, generating a taxonomy from the graph theory point of view, whereas the work [23], defining a formal model for zz-structure conceived as multigraph graph, proposes different visualizations and a set of navigational information (e.g. such as the distance between the visited cells). Zz-structures can be visualized in different customizable visualizations called *views*, such as H-view, I-view, star-view, m-extended star view, and also *view spaces*, as canvases, projection spaces, presentational fields and viewing tanks [17].

In Figure 3 (left) we show a *H-view*, on two dimensions, $\mathcal{D}_{u_2,t_4}$ and $\mathcal{D}_{u_2,t_1}$, extracted from the folksonomy shown in Figure 2.

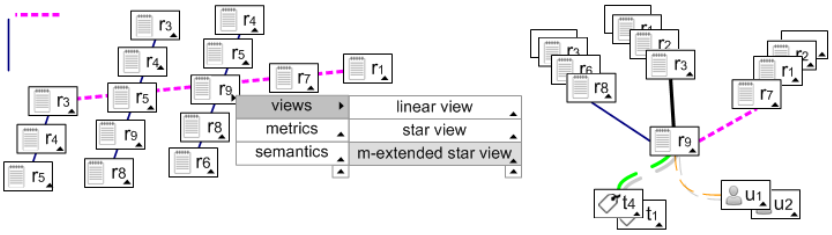

Figure 3. A *H-view* (left) with menu on $r9$; a *5-extended star view on* $r9$ (right)

We note the presence of a black triangle symbol, in two positions, corresponding to selected/not selected: these triangles are associated to scripts related to the session agent of the current visualization, and represent the mean to interact with the cell-agent. When selected, the session agent asks to the chosen resource (r_9, in our example) the set of actions Ac that can be activated on it. In order to satisfy this request, r_9 sends a multicast message to all the dimensions in which it is included, and a run-time created contextual menu, organized in three meta-categories (views, metrics and semantics) is shown. The first category is concerning the different kind of possible views while the other two categories of functions offered by the menu, are related to the computation of an extensible set of *metrics*, and to the application of opportune *semantic relations and ontologies* in order to generate, for example, specific recommendations on content, tag and user.

In our example, the user selects the menu item *views* and then, from its sub-menu, the menu item *m-extended star view* (where $m = 3$). The related 5-extended star view is displayed in Figure 3 (right): we can note that the cell r_9 is connected to the following:

– three labeled edges related to the dimensions $\mathcal{D}_{u_1,t_1}$, $\mathcal{D}_{u_2,t_1}$ $\mathcal{D}_{u_2,t_4}$;

– one labeled edge related to the dimension $\mathcal{D}_{u_i,r_j}$, i.e. the tags (t_4 and t_1) which other users applied on the same resource r_9;
– one labeled edge concerning the dimension $\mathcal{D}_{t_k,r_j}$, i.e. the users (u_1 and u_2) which annotated the resource r_9 with the same tag.

Comparing the two visualizations, it is clear that the *3-extended star view* provides a deep insight of all the dimensions connected to a given focus cell.

Other features, not displayed in Figure 3, regard the possibility to dynamically change, at local or global level, the features of each agent, simply clicking directly on the visualized item and applying modifications. To this extent we can highlight that due to the agent-based technology the folksonomy grows and changes according to the user contributes, and can be shared with the other users.

5 Conclusion and future work

In this paper we have proposed an innovative way to conceive a folksonomy in terms of a multi-agent system, first defining a formal model and then showing Folkview. Such system can be used to simply display personalized user views, to create personalized and adaptive paths for users and to modify the associations between tags and resources.

Up to now we have built a partial, but modular and extensible, prototype, based on a public dataset taken from delicious, and that implements the structural aspects of the considered folksonomy, adding main existing metrics functions, and using both server-side and client technology.

As future work we want to extend the prototype to all the main functionality we discussed, focusing our attention on a semantic personalization. In particular, we plan to make user tests to assess the impact and the effectiveness of the proposed tool, comparing particular user-tasks on our proposal system than what already exists as social tagging system. Furthermore, although we started with a specific dataset, we intend to extend our tool in order to extract data from a large number of social tagging systems.

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