Folkview: A Multi-agent System Approach to Modeling Folksonomies

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Abstract. Folksonomies contain semantic information on data, and represent a meaningful mean for identifying similarities among users, resources and tags. Their strong potential is often reduced by the lack in social tagging systems of specialized functionalities for managing and modifying them, and of specific tools for generating customized and dynamic views on them.

The aim of this paper is to present Folkview, an innovative way to conceive a folksonomy in terms of a multi-agent system. Each element (tag, user, resource) become an active entity and the folksonomy transforms itself from a traditional passive container of data into a computational agent, provided of a set of procedural and distributed skills.

The agents actively collaborate in order to generate dynamic and customized views and supporting users in the updating, managing and modifying her personomy, and the same folksonomy.

Keywords: Folksonomy, Multi-agent system, Dynamic views, Authoring, Zz-structures.

1 Introduction

The collective participation is one of the most specificity of social tagging systems; users 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 of general methodologies for extracting semantic information (this topic is widely discussed in literature, see the survey [1,2]);
- the lack of customizable and dynamic workspaces in which users can *visualize personalized views* of the folksonomy or *apply personal changes*;
- the lack of specialized tools for involving user in the improvement of the folksonomy. The attention is essentially focused on sophisticated methodologies for automatically extracting similarities or recommendations. If a user

L. Ardissono and T. Kuflik (Eds.): UMAP 2011 Workshops, LNCS 7138, pp. 198–212, 2012.

notes some errors, imprecisions or semantic incongruences, the tagging system does not provide her with appropriate tools for simply transferring her knowledge to the system.

The increasing amount of information scattered across several social applications has strengthened the users' need of customization, manipulation and easy managing of her workspace.

In order to satisfy this exigence, the most of the traditional Web browsers themselves became to offer personal views, so-called *start pages* (see for example the iGoogle[1], NetVibes[2], or My Yahoo[3]. Some extensions of these examples are adaptive bookmarking systems such as PowerBookmarks [3], Siteseer [4] and WebTagger [5]. Few steps in this direction have been made by social tagging systems. They should deal with these compelling and open challenges, expanding their capabilities and enhancing the visualization and authoring functions, in order to simplify (a) the comprehension of the semantic relations of a folksonomy, (b) the navigation through the involved elements, and (c) the manipulation of existing relations among tags and resources.

The folksonomies are generated by the union of a set of personomies. Both are generally visualized as a tag cloud, although, as highligted also in [6], this kind of visualization is not sufficient as the sole means of navigation. Tag clouds are useful for discovering, for example, the number of bookmarks related to a chosen tag or the list of resources annotated with it. However they are not adaptive and not support the user in the generation of customized views, neither in the authoring process. 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* [7] and represented as a hyper graph or as a tri-partite graph [8,9]. 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 system called Folkview. It is flexible, modular, and scalable. In it a folksonomy is conceived in terms of a multi-agent system. Each element (tag, user, resource) become an active entity and the folksonomy transforms itself from a traditional passive container of data into a computational agent, provided of a set of procedural and distributed skills.

The agents actively collaborate in order to generate dynamic and customized views and supporting users in the updating, managing and modifying her personomy, and the same folksonomy.

The paper is organized as follows: in next Section 2 we discuss related work, in Section 3 we present the architecture of Folkview, organized in four layers:

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

storage, semantic, social, and presentation. An example accompanies the reading of this paper and the description of the multi-agent system. In Section 4, describe the collaboration activities among the agents when visualization and authoring functionalities are activated. Final considerations close the paper.

2 Related Work

Early *definitions* of folksonomy [10,11,12] 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 kinds 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 [13] where the authors propose the social application GroupMe!, defining an additional element, the group, which can be either 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 their personomy or to navigate through different and more effective visualizations.

As observed in the introduction section, a folksonomy is usually represented by a tripartite graph or network, but this leads to the 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 [14], 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 [15] 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.

So, a crucial issue regards the *navigability of a folksonomy*: typically a user has to browse through huge lists of potential interesting resources, beforearriving at the desired information.

In order to simplify the user navigation, in [16] the authors propose tag-resource taxonomies; differently from tag taxonomies, using this new approach the"users not only to quickly navigate to related concepts but also toresources from a tagging system". An alternative approach, applied in [17], and before in [18], is to extract from folksonomy hierarchical structures and to use them as background knowledge for supporting navigation and decentralized searches, and for evaluating navigational tasks in social tagging systems. These works are focused on the creation of taxonomies upon existing folksonomy in order to improve its navigability but the topic of personalization and authoring of a folksonomy is not investigated.

However, these researches are oriented to provide new ways to visualize a folksonomy or to improve its navigability, but they 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 [19] the authors use a customized cluster maps for visualizing both the overview and the detail of semantic relationships intrinsic in the folksonomy; in [20] 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.

Finally, although the folkosonmy are created for their intrinsic nature from a distributed and collaborative users' activity, few works have leveraged the advantages of the multi-agent systems paradigm for modeling social tagging system: one of these [21] share with us the importance of a multi-agent approach for improving collaborative tagging activities. In the following of this work, we describe our multi-agent approach and the reasons of our choices.

3 Folkview: The Formal Model

Traditionally, given three sets U, T and R respectively of users, tags and resources, a folksonomy is defined as the set of tag assignments (*tas*, for short) $(u_i, r_j, t_k) \in U \times T \times R$, each of them indicating that user u_i has tagged the resource r_j with the tag t_k.

Let consider an example of a simple folksonomy, where $|U| = 3$, $|T| = 6$, and $|R| = 5$, and the *tas*, listed in terms of three personomies, are defined as following:

- for the user u_1: (u_1, r_1, t_2), (u_1, r_1, t_3), (u_1, r_1, t_4), (u_1, r_1, t_5), (u_1, r_1, t_6), (u_1, r_2, t_1), (u_1, r_2, t_2), (u_1, r_3, t_3), (u_1, r_3, t_4), (u_1, r_4, t_3), (u_1, r_4, t_4), (u_1, r_4, t_6), (u_1, r_5, t_5), (u_1, r_5, t_6);
- for the user u_2: (u_2, r_1, t_1), (u_2, r_1, t_4), (u_2, r_1, t_5), (u_2, r_1, t_6), (u_2, r_2, t_1), (u_2, r_2, t_3), (u_2, r_3, t_4), (u_2, r_3, t_6), (u_2, r_4, t_1), (u_2, r_4, t_2), (u_2, r_4, t_3),(u_2, r_4, t_5), (u_2, r_5, t_4), (u_2, r_5, t_6);

[4] http://taggraph.com/

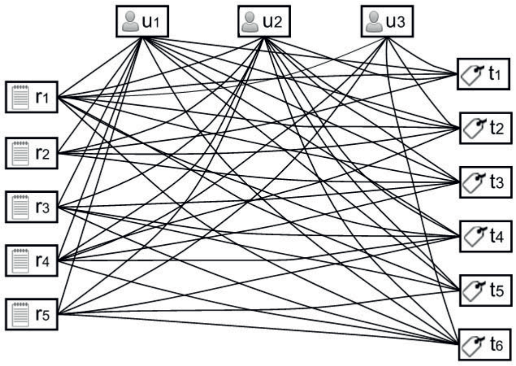

Fig. 1. The tripartite graph for the sample folksonomy

– for the user u_3: (u_3, r_1, t_1), (u_3, r_1, t_2), (u_3, r_2, t_2), (u_3, r_2, t_3), (u_3, r_3, t_3), (u_3, r_3, t_4), (u_3, r_3, t_6), (u_3, r_4, t_2), (u_3, r_4, t_5), (u_3, r_4, t_6), (u_3, r_5, t_4), (u_3, r_5, t_6).

A common graphical representation is the tripartite graph shown Figure 1.

This organization of data does not provide the user with simple keys to the reading. User profiles, functions, metrics or semantic relations among users, tags, resources, and *tas* are not intrinsic features of the folksonomy, and cannot be simply (neither visually) inferred by the tripartite graph (see Figure 1); they may be (or not) applied and elaborated by the system which hosts it. So, a classical definition of folksonomy is a set of static components; but several works [2] emphasize the role of a folksonomy for:

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

For this reason, we propose a new concept of folksonomy, conceived as a dynamic and semantic entity, organized as a universe of inherently autonomous computational sub-entities. Each of them interacts with each other by sending messages and reacting to external stimuli by executing predefined procedural skills. A dynamic folksonomy in Folkview is a multi-agent system. Figure 2 shows the main agent classes involved in the architecture.

We identify eight classes of agents: $User$, *Resource*, and Tag represent the storage layer, *Dimension* adds semantic relations on it; *Personomy* and $Folksonomy$ identify the social layer, and finally *Session* and $View$ the presentation layer.

Various authors [22,23,24] proposed different definitions of agents. In our setting an agent is defined by its local environment (the internal state) and by a discrete, finite set of procedural skills, that it uses for replying to the incoming requests generated by other agents. Graphically, we represent an agent class as

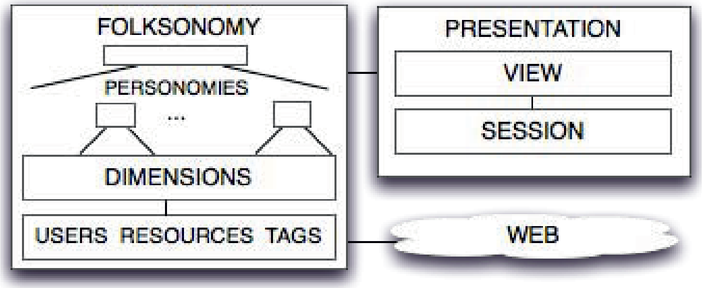

Fig. 2. Folksonomies in Folkview

a box containing the name of agent class, the set of local variables, and the set of methods (see next Table 1).

3.1 The Storage Layer

The three agent classes of the storage layer are shown in Table 1.

The *User Agent u* represents single user; it is uniquely identified by an *id*, and is associated to a set of keywords *meta*; it owns a *profile*, a set of *settings* and *preferences*, a *reputation* and a set of similar users, called *neighbors*. Finally it knows all the tags, resources and semantic connections (=dimension, see next semantic layer) belonging to the user. More in details, T^u and R^u are respectively the set of tags and resources used by u, while $T^u_{r_j}$ and $R^u_{t_k}$ are the set of tags (resp. resources) used by u on a specific resource r_j (on a specific tag t_k). $\mathcal{D}^u$ addresses the list of Dimension Agent belonging to the user, while $\mathcal{P}^u$ and $\mathcal{F}$ addresses the personomy of u and the folksonomy.

Each *User Agent u* is able to apply a set of methods, such as make aware other agents of an event or a change of internal state - *notify(agent-list, message)*, require an update - *update(agent-list,operation)*, and apply opportune metrics - *applyMetric(metric)*. The other two agents belonging to this layer are similar,

Table 1. The storage layer

User Agent u	*Tag Agent t*	*Resource Agent r*
id meta profile settings preferences reputation neighbors ... T^u R^u $T^u_{r_j}$ $R^u_{t_k}$ $\mathcal{D}^u$ $\mathcal{P}^u$ $\mathcal{F}$	id meta label reputation neighbors ... U^t R^t $U^t_{r_j}$ $R^t_{u_i}$ $\mathcal{D}^t$ $\mathcal{F}$	id meta url reputation neighbors ... U^r T^r $U^r_{t_k}$ $T^r_{u_i}$ $\mathcal{D}^r$ $\mathcal{F}$
notify(agent-list, message) update(agent-list,operation) applyMetric(metric) ...	notify(agent-list, message) update(agent-list,operation) applyMetric(metric) ...	notify(agent-list, message) update(agent-list,operation) applyMetric(metric) ...

as it is possible to argue by Table 1. All the instances of these three classes represent the atomic components of Folkview.

3.2 The Semantic Layer

The semantic layer is composed by the *Dimension* agents. A dimension is a semantic filter applied on the storage layer: it creates cluster of components, that share a semantic relation (a common meaning, an objective, an interpretation). A dimension can be represented as the union of labeled paths. The label expresses the semantic of the clusters identified. The dimension is main component of each personomy/folksonomy. *Dimension Agent* $\mathcal{D}$ is shown in Table 2.

Table 2. Dimension Agent

Dimension Agent $\mathcal{D}$
id meta label type components $\mathcal{F}$ ...
update(agent-list,operation) notify(agent-list,message) applyMetric(metric) ... . . .

It is described by an unique *id*, a set of keywords *meta*, a semantic *label*, a *type*, a list of *components*. We identify three main types of dimensions: *structural*, *computed*, and *user-generated*: the first one regroups all the information contained in a traditional personomy or folksonomy; the second one is automatically computed by the system applying specific metrics, or collapsing edges and applying weighted label to the new edge, or using ontologies. Indeed recent studies [25,26,27] have already addressed the extraction of ontologies from folksonomy, and their integration, for obtaining a dynamic representation or useful insights of the knowledge. Finally, the third typology of dimension is created directly by the user. We identify two typologies of components: atomic or composite. In the first case, *components* address a list of atomic (storage) agents, while in the second one, it addresses other dimension agents, generating more complex structures.

In order to avoid confusion among set of items and dimension agents, we use the following notation: we indicate with T_r^u, R_t^u, and U_t^r respectively the set of tags applied by user u to resource r the set of resources tagged by u with t, and finally the set of users that tagged r with t. Differently, we indicate with $\mathcal{T}_r^u$, $\mathcal{R}_t^u$, and $\mathcal{U}_t^r$ (we use a different font) respectively the **dimension agent** constituted by the set tags applied from user u con resource r, by the set of resources tagged by u with t, and finally by the set of users that tagged r with t.

For example, consider the personomy related to user u_1 and, in particular, the 14 triples containing u_1 as first component. They can be represented by five linear paths containing the tags applied by user u_1 respectively on resources $r_1, \ldots, r_5$, as shown in Figure 3 (left).

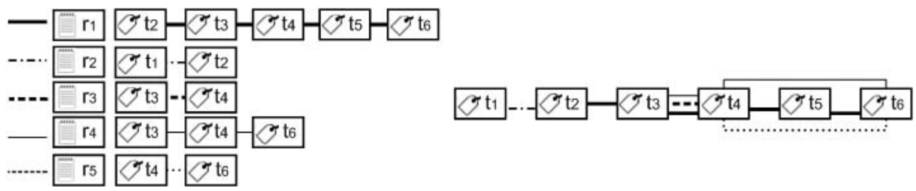

Fig. 3. Topological representation of the components of 5 dimensions (left) and the corresponding personomy view (right)

The five dimensions, on these five topological paths, are indicated respectively by $\mathcal{T}_{r_i}^{u_1}$, $i = 1, \ldots, 5$.

Figure 3 (right) collapses in a labeled multigraph the five paths/structural dimensions. They are created focusing the attention on tags, and generating relations with the other two components of the storage layer (users and resources). It is simple to argue that three classes of structural dimensions (focused on tags, resources and users) completely describe a static personomy/folksonomy.

An example of composite dimension is present in Figure 4 (next subsection 3.4). In this case, a structural dimension connects three users (u_1, u_2, and $u3$), but each user component is composite: in fact, it can be exploded in a set of structural dimensions, one for each user.

Finally, the methods associated to a *Dimension* agent allow it to manage semantic clusters, contacting sending requests, and making aware their components and the same folksonomy.

3.3 The Social Layer

The social layer is composed by *Personomy* and *Folksonomy* agents.

Folksnomy $\mathcal{F}$ is unique within the social tagging system; it knows all the $\mathcal{P}$ agents, and contact them for assigning tasks to them; on the other hand, also all the *Personomy* agents know $\mathcal{F}$ and contact it for receiving information or simplify the coordination with other agents.

The social layer is devoted to collaborate with the semantic and the storage layers in order to i) recommend tags and resources, ii) infer knowledge about the user profile, her preferences, needs or skills and iii) identify similar users, resources or tags.

Different types of metrics are evaluated by both $\mathcal{P}$ and $\mathcal{F}$ agents, in order to calculate, for instance the average time spent by user to do a specific task; similarities among users, tag and resources; semantic relations on resource contents.

Table 3 contains both the two agent classes. The *Personomy* agent manages the social activities of the user u, and knows her tags T^u, her tagged resources R^u, and dimensions $\mathcal{D}^u$. Each $\mathcal{P}$ is able to evaluate specific metrics $evalMetric(data, type)$ and strictly collaborate with other personomies. Each action is coordinated by $\mathcal{F}$. We may note that the social layer strictly interacts

Table 3. Personomy and Folksonomy Agents

Personomy Agent $\mathcal{P}$	*Folksonomy Agent* $\mathcal{F}$
id meta u T^u R^u $\mathcal{D}^u$ $\mathcal{F}$ ...	id meta personomies ...
update(item,operation) notify(message) getItem(id,type) evalMetric(data,type) ...	update($\mathcal{P}$,operation) notify(message) getPersonomy(id) evalMetric(data,type) ...

with the presentation layer; for this reason, $\mathcal{P}$ and $\mathcal{F}$ address both *Session S* and *View V* agents.

3.4 The Presentation Layer

The presentation layer manages the interaction of users with the system, elaborates views on data, supports the authoring process, traces the user sessions. It is composed by two agent classes, *Session* and *View* agents (see Table 4)..

Each session starts with *Session Agent*, instantiated on the specific *user*; it maintains the *history* of the interaction of the user with the system. A fundamental procedural skill is *evaluateRequest*: given a general list of agents and a specific operation the S evaluates it and interacts with the appropriate agents. There are several operations that $\mathcal{S}$ handles and dispatches:

- apply changes to the structural agents: merge two or more tags, add, modify, delete tags and/or resources, change user personal settings or profile;
- apply changes to the *Dimension* agents: add, modify, delete dimensions;
- select personalized views: interact with the *View Agent V*.

Session Agent knows the personomy $\mathcal{P}$ of user *user* that generates the request, the *Folksonomy Agent* $\mathcal{F}$ and, finally, V.

The *View Agent V* is contacted by specific session agents and provide for them specific views.

Example of *type* are linear, star, m-extended views, discussed more in details in next Section 4.

Table 4. Session and View agents

Session Agent S	*View Agent V*
id meta user history $\mathcal{P}$ $\mathcal{F}$ V ...	id label type session components ...
evalRequest(agent-list,operation) notify(message)...	update(item,operation) notify(message) visualize(...) ...

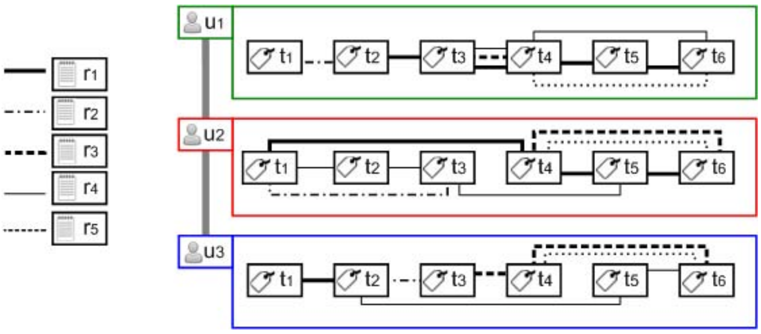

Fig. 4. A folksonomy view in Folkview

Here we would like to re-consider the folksonomy of Figure ??. In Folkview it can be drawn in a number of graphical representations more expressive than the tripartite graph of Figure 1. An example of complete view of the whole folksonomy is given in Figure 4 where the union of the personomies related to the three different users is shown.

This view provides a synthetic and semantic way to visualize a traditional folksonomy (compare it with Figure 1).

4 Visualization and Authoring

It is simple recognize in the labeled multigraph contained in the folksonomy view of Figure 4 the *zz-structures* [28]: 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 data, 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 types of contents, which are connected with links of the same color into linear sequences called *dimensions*. A single series of connected cells 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 [29], 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 [30], virtual museum tours [31,32] and so on.

In [33] the authors compare zz-structures with mSpaces and Polyarchies, generating a taxonomy from the graph theory point of view, whereas the work [34], 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 [28]. In next two subsections 4.1 and 4.2 we show and discuss how a Session Agent may interact with to the system in order to manage two different views (*H-view* and *m-extended star view*) and apply a *merge* of two tags into another one.

4.1 Dynamic Views

Suppose that the user u_1 selects a tag and requires to the system to visualize a two-dimensional view focused on it and on two specific resources. Let be the tag t_4, the two specific resources r_1 and r_4, and the chosen two-dimensional view a H-view.

This task is managed by the Session agent related to u_1, S^{u_1}: it requires from the personomy $\mathcal{P}^{u_1}$ to contact the user dimensions (where t_4 has been used for tagging the resources r_1 and r_4) in order to obtain from them their components. The sequence of collaboration is the following:

$S^{u_1} \rightarrow \mathcal{P}^{u_1} \rightarrow (T^{u_1}_{r_1}, \mathcal{T}^{u_1}_{r_4})$

The request is sent to $\mathcal{T}^{u_1}_{r_1}$ and $\mathcal{T}^{u_1}_{r_4}$ in multicast. As successive step, S^{u_1}, received the list of components (if the dimensions exist), sends to V^{u_1} the following request:

$S^{u_1} \rightarrow V^{u_1}$

evalRequest$(V^{u_1}, \mathit{visualize}(t_4, \mathit{h\text{-}view}, ((u_1, r_1)(t_2, t_3, t_4, t_5, t_6)), (u_1, r_4)(t_3, t_4, t_6)))$

In it, S^{u_1} specifies the focus node (t_4), the components (that are from $T^{u_1}_{r_1}$, $\{t_2, t_3, t_4, t_5, t_6)\}$ and from $\mathcal{T}^{u_1}_{r_4}$ $\{t_3, t_4, t_6\}$), and the type of visualization (h-view).

The result is the visualization shown in Figure 5 (left).

The presence of two black triangle symbols corresponds to the selection of the option (see the triangle used for the option *views*), and to the not selected option (see the other symbol, used for the other options): these triangles are associated to specific methods related to the Session agent, and represent the means to interact with the cell-agents. When selected, the session agent S^{u_1} asks

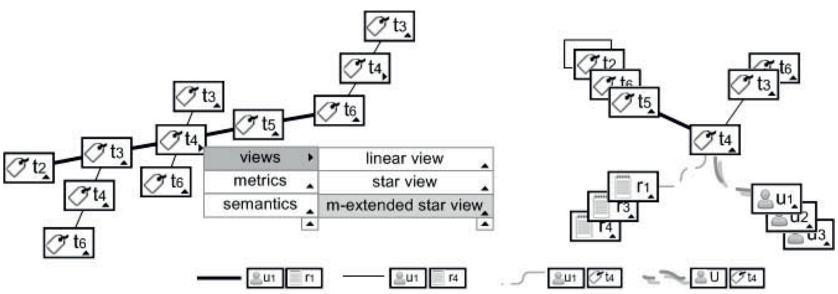

Fig. 5. A *H-view* (left) and a *m-extended star view* on t_4 (right)

and obtains, through the personomy agent $\mathcal{P}^{u_1}$, the set of methods that can be activated on it. In order to satisfy such a request, t_4 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 kinds of possible *views*. The other two categories of functions 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.

Following our example, the user selects the option *views* and then *m-extended star view*. The default value for m is 3, and indicates the maximum number of components visualizable for each different dimension.

The corresponding 3-extended star view is shown in Figure 5 (right). Compared to the H-view, the m-extended star view provides a deep insight of the various dimensions: in particular, we can note that the cell t_4 is connected to the following semantic paths (from the top-left corner in a clockwise direction):

- $T_{r_1}^{u_1}$, that it is the set of tags applied by u_1 on the resource r_1;
- $T_{r_4}^{u_1}$, that it is the set of tags applied by u_1 on the resource r_4;
- U_{t_4}, that it is the set of users that used t_4;
- $R_{t_4}^{u_1}$, that it is the set of resources tagged by u_1 with t_4.

Other features, not displayed in Figure 5, 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 then can be shared with the other users. While displaying dynamic views, the user will also be able to personalized her personal workspace, adding or removing dimensions, applying changes to her annotations and so on.

4.2 Authoring

Consider now the situation in which a user, navigating in her workspace, has used two different tags (following our example, t_2=*web2-0*, t_6=*socialWeb*) with the same meaning. Or, equivalently, consider the situation in which the system automatically infers that these two tags are different writings for the same concept, and recommends her to substitute any occurrence of one of them with the other (for example, *socialWeb*) or with a new more popular tag (for example, t'=*social-web*).

If the user accepts to update her tags, then Folkview will manage this task activating a collaborative set of agents. A more general description of this task is the following: the system must merge a set of l tags $t_k^{'}$ $(k = 1, ..., l)$ into one tag $t^{'}$. It could (or could not) be that $t'=t'_k$ for a given k.

It is conceptually equivalent to treat the l substitutions of t'_k with $t^{'}$ in a separate way.

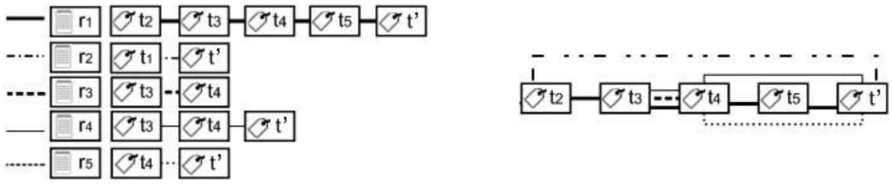

Fig. 6. New topological representation of the components of 5 dimensions (left) and the corresponding personomy view (right)

Also in this case, the operations start from the Session Agent S^u and proceed in cascading style for generating the merge: S^u contacts P^u for delegating it of the merging task. In its turn, P^u will contact in multicast all the dimensions that address t'_k, that it is the set $\mathcal{D}^u_{t'_k}$. Received from each of them the list of involved storage agents (t'_k and $R^u_{t'_k}$), P^u directly will contact them for updating. Finally a request of update will be sent to the folksonomy $\mathcal{F}$. We note that the merge of tags is an update local to the user workspace, but the same P^u, ended the task, will require to $\mathcal{F}$ to make aware (=notify, or recommend) the other users of the choice made by u.

In this way, the sequence of collaboration is:
$S^u \to P^u \to \mathcal{D}^u_{t'_k}$
$P^u \to (t'_k \ , R^u_{t'_k})$
$P^u \to \mathcal{F} \to \mathcal{P}^U$

Graphically, the topological representation of the personomy components shown in Figure 3 become that proposed in next Figure 6.

The tags t_2=*web2-0* and t_6=*socialWeb* have been merged in t'=*social-web*.

5 Conclusion and Future Work

In this paper we introduced Folkview, an innovative way to conceive a folksonomy in terms of a multi-agent approach; firstly, we described the formal model through a framework built on different layers, then we provided the description of dynamic views highlighting the interaction of the involved agents. By introducing this approach, we tackled the issue concerning the traditionally passive definition of a personomy, and highlighted the role of agents.

Folkview can be used in order to simply display customized views, to create personalized paths and to modify the semantic associations between tags and resources.

Up to now we have defined an extensible model and we have designed a simple prototype based on a public dataset taken from delicious. In the next future we intend to develop an extended prototype with a complete set of features, especially focusing our attention on semantic personalization and user customized paths. Moreover, we want to extend our tool in order to extract data from the most popular social tagging systems. We plan to validate our proposal defining a complete set of user tests based on specific tasks, to assess the impact and the effectiveness of the proposed approach.

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