# Improving the Navigability of Tagging Systems with Hierarchically Constructed Resource Lists: A Comparative Study

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**Abstract.** *This paper presents the first practical results of a novel resource list generation algorithm based on a hierarchical network model which demonstrably improves the navigability of tagging systems. In particular, the results of a formal experiment show that the new algorithm is able to create tag networks which are significantly more navigable than the one generated by the currently most widely used resource list generation - the reverse chronological sorting resource list generation algorithm.*

**Keywords.** Tagging systems, tags, resource list algorithms, navigation

## 1. Introduction and Related Work

With the emergence of modern Web 2.0 hypertext systems such as Delicious, CiteUlike, Bibsonomy, LastFM or Flickr, tags have emerged as an interesting alternative to traditional forms of hypertext navigation and browsing. Tagging systems allow the user to use a free-form vocabulary to annotate resources with so-called tags [2, 6]. This is either done for semantic reasons (for example, to enrich information items with additional metadata), conversational reasons (for example, for social signaling) [1] or for organizational reasons (for example, to categorize information) [5]. Regardless of why people tag [8], tags are typically visualized as so-called tag clouds [1]. Basically, tag clouds are a selection of tags related to a particular resource. Upon clicking on a tag in the tag cloud, a list of resources related to the tag is presented to the user. Thus, tags provide users a simple third orthogonal form of navigation within a collection of resources.

In previous work [3], it was shown that navigability of tagging systems leaves much to be desired. In particular it was found out that the most popular resource list generation approach used these days in tagging systems generates tag networks structures which are per se unnavigable [3]. The issue is this: Tagging systems such as Delicious, CiteUlike, Bibsonomy, LastFM or Flickr for instance implement resource list generation approaches that generate for each click on a particular tag in the system the same tag-specific resource list typically reverse-chronologically sorted. Is the resource list limited to a certain factor k, due to interface space restrictions, then the tag cloud network is fragmented into isolated network clusters, which renders the tag network unnavigable from a network-theoretical point of view [3]!

However, in [3] an approach was suggested to overcome this issue by applying a simple greedy resource selection strategy. The “trick” is to select, for every click on a particular tag in the tag cloud, the k related resources at random. In common tag cloud construction algorithms, for every tag click the same result list is generated. This simple idea leads to the effect that the tag network becomes connected (even for small values of k) and in theory navigable again. But, as also shown in [3], this simple strategy does not lead to tag networks with are “good” or even “efficiently” navigable. Hence, more sophisticated strategies were investigated to generate also efficiently navigable tagging systems. Recently, it was found that we can create efficiently navigable tag networks if a hierarchical network model [3, 12] is applied to select the k resources in the resource list. Put simple, the idea is to place the resources of the tagging system within a hierarchical taxonomy and to use this taxonomy to generate a probability density function to generate a

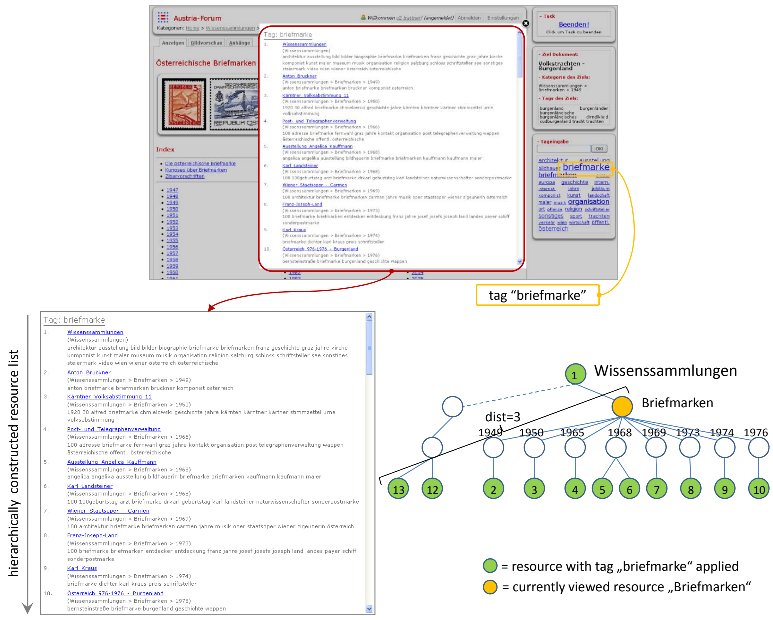



**Figure 1: Example of a hierarchically constructed resource list in a system called Austria-Forum [12] with corresponding resource taxonomy.**

k-limited resource list. In theory, if the resource taxonomy is balanced and provides a constant branching factor b, this hierarchical resource list generation approach leads to tag networks which are "efficiently" navigable [4]. In [12] a decentralized search approach was introduced to simulate tag driven navigation. In short, the simulations were able to demonstrate that the hierarchical resource list generation algorithm produced tag networks which are significantly more navigable than the networks of a tagging system generated by the reverse-chronologically sorting resource list generation algorithm. However, these results can only be approximate, as long as there is no research into how people really navigate in a tagging system. Hence, a formal experiment was conducted to validate these results also empirically.

Thus, this paper presents the results of a formal experiment conducting the navigability of a novel "hierarchical" resource list generation approach. The results of the experiment show: The hierarchical resource list generation approach creates tag networks structures which are significantly more navigable than the tag networks generated by currently most commonly used resource list generation algorithm - the reverse chronological sorting resource list generation algorithm.

The paper is structured as follows: In Section 2 the resource list generation algorithms as they were used and compared in the experiment are presented. In Section 3 the experiment is described. Section 4 presents the results of the experiment. Finally, Section 5 concludes the paper and shortly discusses future work in the area.

## 2. The Resource List Generation Algorithms

The following section will shortly describe the two resource list generation algorithms as they were used and compared in the experiment.

### 2.1. The Hierarchical Resource List Generation Algorithm

The hierarchical resource list generation algorithm is a novel approach for resource list generation in a tagging system. To put it simple, the algorithm generates a probability density function that is based on the tagging systems resource taxonomy to select the resources for the k-limited resource lists with the intention to form a tag network that is efficiently navigable. The idea for this algorithm was originally derived from work made by J. Kleinberg [4] who has investigated structural clues of small world networks. Kleinberg showed [4] that if the nodes of a network can be organized into a hierarchy, then such a hierarchy provides a probability distribution for connecting the nodes in the network. The resulting network is efficiently navigable. However, in detail the approach works as follows: For each click on a tag $t(r)$, where r is a resource in the tagging system, the algorithm returns a k-limited resource list where the resources $r(t(r))_i$ in the resource list are selected randomly according to a probability density function $p$ that is calculated from a given resource taxonomy $T$. $p$ is calculated as $p(dist(r(t(r)),r(t(r))_i)) = e^{-dist(r(t(r)),r(t(r))_i)}$. The distance $dist(r(t),r(t)_i)$ is calculated as $dist(r(t),r(t)i) = h(r(t)) + h(r(t)_i) - 2h(r(t),r(t)_i)$, where $h(r(t))$, $h(r(t)_i)$ are the heights of $r(t)$ and $r(t)_i$ in a given resource taxonomy $T$ and where $h(r(t),r(t)_i)$ is the height of the least common ancestor of $r(t)$ and $r(t)_i$ in the resource taxonomy $T$ [12] (cf. Figure 1).

In Figure 1 an illustrate example of a hierarchically constructed resource list within a tagging system called Austria-Forum [11] is presented. The example shows a resource list for the tag “briefmarke” and the resource “Briefmarken” in Austria-Forum system. Note the green nodes in the resource taxonomy – they reflect the resources within Austria-Forum having the tag “briefmarke” applied. The orange node presents the currently viewed resource “Briefmarken”.

## 2.2. The Reverse Chronologically Sorting Resource List Generation Algorithm

The reverse chronologically sorting resource list generation algorithm is the approach typically found in current tagging system such as Delicious, CiteUlike, Bibsonomy, LastFM or Flickr. Basically, the algorithm generates and returns a k-limited resource list for each click on a tag t in a tagging system. The resources are sorted in reverse chronological order. Contrary to the hierarchical resource list generation approach, the resource lists are statically calculated, i.e. for each tag t in the tagging system the same resource list is presented to the user. With the hierarchical resource list generation approach for each click on a tag $t(r)$ (specific to a certain resource r in the tagging system) a different resource list is generated, or in other words, the resource lists of the hierarchical resource list generation algorithm are specific to a certain tag and resource in a tagging system!

# 3. The Experiment

In this section we describe the experiment as it was conducted from November 8 to 12, 2010 at Graz University of Technology, Austria.

## 3.1. Participants

All in all, 24 participants were invited to join the experiment, 16 of them male and 8 of them female. The median age of the users was 33 years, ranging from 22 to 56. All participants were experienced computer (on average 46 hours per week) and Internet users (on average 19 hours per week). 12 of them were experienced with the test system. Hence, in order to get valid results, they were split up into two groups, i.e. six of them were assigned to evaluate the chronologically sorting resource list generation approach and six of them were assigned to evaluate the hierarchical resource list generation algorithm.

## 3.2. Test System

As test system for the experiment a large online encyclopedia called Austria-Forum [11] was chosen. Basically, Austria-Forum is a large online encyclopedia similar to Wikipedia providing the user around 180,000 resources related to Austria. Like Wikipedia, Austria-Forum structures articles into a taxonomy and provides an integrated tagging system [10, 11], which allows users to assign tags to resources and to navigate to related resources via tag clouds. As of October 16, 2010 the Austria-Forum tagging dataset contains 97,908 tag assignments, 13,314 tags and 19,430 resources.


**Figure 2: Example of tag based navigation in Austria-Forum system.**

## 3.2. Preliminaries

To prepare for the experiment, the latest (October 16, 2010) tagging dataset was downloaded from the Austria-Forum live system and two different tag networks were generated:

- **Network H (Hierarchical):** This tag network was generated with the hierarchical resource list generation algorithm introduced in Section 2.1. As input taxonomy to generate the tag network, the human crafted resource taxonomy of the Austria-Forum system was used.
- **Network C (Chronological):** This tag network was generated with the chronologically sorting resource list generation algorithm presented in Section 2.2.

Note, the tag networks were pre-calculated, since each participant of the experiment should be able to evaluate under the exact same conditions. The tag networks were also used in [12] to measure the navigability of the networks by simulations.

Then, 10 resource pairs (start and target resources) present in both tag networks were selected uniform at random. The resource pairs were selected such that the targets were reachable in a minimum number of one, two, three, four and five steps (one step = two clicks, one for opening the resource list and for moving on to the next resource). The maximum of five steps was chosen since it was calculated that almost all resources were reachable in a minimum of five steps in both networks. The different step (path) lengths were selected to ensure that participants would have to navigate via a certain number of intermediate resources to reach their designated target resource. Finally, ten online tasks, one for each resource pair, were designed and directly implemented into the Austria-Forum system (see Figure 3).

## 3.4. Procedure

In order to measure the performance of the both algorithms, a between-groups (independent measures) design was used for the experiment. All 24 participants were given the exact same 10 tasks (one for each pre-calculated resource pair). Users were asked to surf with different tag networks generated by different resource list generation algorithm (see Section 3.3). 12 users had to navigate in the pre-calculated tag Network H and 12 users had to navigate in the pre-calculated tag Network C. For each task (= one resource pair, start and target resource), the users were asked to reach the given target resource as fast as possible, using exclusively tags and the corresponding resource lists for navigation. For each task, participants were given a maximum of three minutes to reach the given target resource (this was found to be an appropriate upper limit during the pilot test phase). If the target was reached before the three-minute limit or if the user could not find the target after the time has elapsed, the user was asked to click the Cancel "Beenden" button and continue with the next task. In Figure 3 on the left side the actual test bed as it was implemented into Austria-Forum is presented. As shown, the name of the target resource "Ihr Ziel Dokument - Sie suchen nach:" and the category "in Kategorie" was indicated before each new task. By clicking on the "Klick um Test zu beginnen!" link, a new browser window was opened and the user was placed at the start resource. By clicking on the "Weiter zur

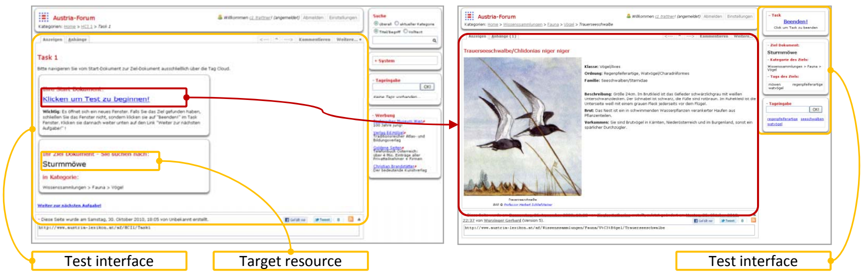



**Figure 3: Test bed (on the left hand side) and sample resource embedded in the test interface (on the right hand side).**

nächsten Aufgabe!" link the user is referred to the next task.

In Figure 3 on the right side the start resource of the first task embedded in the test environment is shown. The test interface provides a "Beenden!" link to cancel the task, a widget providing the user with target resource information "Ziel Dokument", category information of the target resource "Kategorie des Zieles" and the tag cloud of the currently viewed resource. By clicking on a tag (in this example "briefmarke") in the tag cloud, a new window is opened. By clicking on a link in the resource list, the user could move on to that resource.

## 4. Results

To compare the two tag cloud construction algorithms with each other the success rate was measured[1].

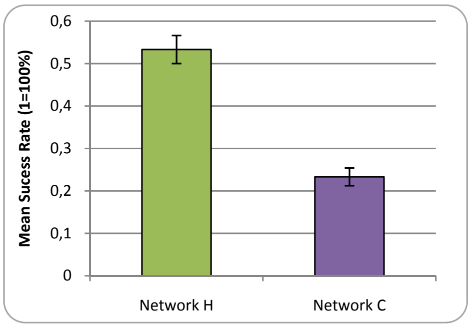
In Figure 4 (a), the average success rate for the both tag Networks H and C are presented. As shown, the user's success rate over all tasks with tag Network H is significantly higher ($p < 0.05$) than with tag Network C. More precisely, the experiment showed that the mean success rate per user for Network C is 23.3% while the mean success rate per user for Network H is 53.3%. In other words, a user was more than twice as likely to be able to find a target in tag network that has implemented a hierarchical resource list generation algorithm than a tag network that has been generated with a chronologically sorting resource list generation algorithm. These results confirm the erlier results from [12]. For exact the same tag networks and resource pairs, simulations show an overall success rate for Network C of 20% and for Network H of 50%.

Figure 4 (b) shows the mean success rate for each individual task. For all tasks with path length > 1, tag Network H performed on average better than tag Network C. Significant differences were found for Tasks 5, 9, and 10. It was observed that the low success rates for Tasks 3, 6, 7, and 8 were due the high branching factors in the resource taxonomy for the target resources used for these tasks. In latest research [13], we have focused on that issue and found a simple and promising way to automatically construct resource taxonomies from tagging data with fixed branching factors. First simulations show that the overall success rate to navigate the tag network could be increased to 98%.

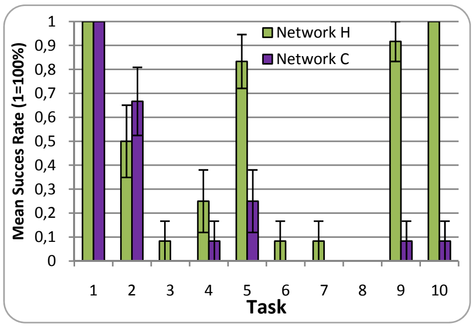
## 5. Conclusions and Future Work

This paper presented the first practical results of a novel resource list generation approach for tagging systems based on a hierarchical network model. The results of a formal experiment showed: The novel and hierarchical resource list generation algorithm creates tag networks which significantly more navigable than the tag network constructed by the currently most popular resource list generation approach in tagging systems - the reverse chronological sorting resource list generation algorithm. Future work will include further investigations towards the improvement of the navigability of tagging systems and research regarding automatic construction of resource taxonomies from tagging data.

[1]The number of clicks or time to reach the target resources was not evaluated since it was observed the success rates for navigating Network C were significantly lower than for Network H.




(a) Mean success rate over all tasks per user.




(b) Mean success rate per task.

**Figure 4: Mean success rates.**

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