Trust and Provenance
You Can't Have One Without The Other

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Abstract. On the social web content is no longer generated by a small number of established authorities but by a huge number of mostly anonymous users. On the semantic web new content is created by combining existing information from different sources on the fly. In both cases trust is of fundamental importance. Is the user providing new content trustworthy? How trustworthy is information inferred from such content? Trust ratings are one approach to define a measure for user reputation. Provenance in turn, provides meta information about the creation and processing of content. It answers questions such as who created the original source, under which conditions, and how it was further manipulated before being published. Provenance makes trust ratings transparent, i.e., reproducible. On the semantic web trust and provenance are on the top of the so-called semantic web layer cake and hence necessary parts of its infrastructure. In contrast, while trust ratings are popular on the social web, provenance plays a minor role so far. In this paper we use a simple example to demonstrate why this is questionable and how the absence of provenance may render trust ratings useless.

Key words: Trust, Provenance, Social Web

1 Introduction and Motivation

In his recognized book *The 48 Laws of Power* Robert Greene [1] investigates the keys to power based on historical figures and anecdotes. His second law states *Never put too Much Trust in Friends, Learn how to use Enemies.* While the law does not imply that friends are not trustworthy at all, it points out that trust does neither rely on friendship nor on morality. It is a prediction of reliance, a bet [2], from the past behavior of an agent to its future behavior [3]. On the social web, trust is usually defined with respect to similarity. If two users have similar profiles, e.g., have used similar tags for similar bookmarks in the past, they are likely to agree in the future [4, 5]. However, as pointed out in recent work by Goldbeck [6], overall similarity is too coarse to capture all effects of trust. To make trust applicable to large scale social networks, it is assumed to be transitive and asymmetric [7]. Nevertheless, the propagation of trust within networks is still controversially discussed. Bishr and colleagues [8, 9] investigate the spatial characteristics of trust arguing for a geographic distance weighted notion of trust.

Social bookmarking systems are one of the most prominent applications on the social web. *Delicious.com* is one of the first and most popular social bookmarking systems. It offers two main functions. Registered user can add new bookmarks to their account. Each bookmark consists of a title, a link, optional tags, and an optional note. All users, registered or not, can search the bookmarks by keyword, or browse them by tag or user. Users can mark each other as *fans* (called *friends* on other platforms) and thereby create networks of bookmarks. One key assumption underlying social bookmarking is that it provides more accurate results than purely algorithm-based search engines (see also [10] for combinations of both approaches). Gräfe and colleagues investigated this assumption [11] and came up with a seven theses framework for future research. Theses five and six state:

Thesis 5. *Compared to algorithm-based search engines, social bookmarking systems are far less prone to manipulations. This results in a greater Precision of search inquires.* [11, p. 7]

Thesis 6. *Users perceive the search results of social bookmarking systems as more trustworthy than those of algorithm-based search engines.* [11, p. 7]

In this paper we assume that thesis 6 holds. This is also supported by literature, e.g., on customer reviews and feedback in e-commerce systems [12, 13, 14]. In contrast, we will argue that thesis 5 does not hold. Consequently, users may perceive social bookmarking systems as less prone to manipulations while they are not. If this is the case, (data) provenance [15] becomes a central issue on the social web. This has also been recognized by the semantic web community [16, 17]. Trust and provenance are essential part of the so-called semantic web layer cake [18, 19, 20]. Provenance provides meta information about the creation and processing of content. Simplifying, one can distinguish between where-provenance, why-provenance, and how-provenance [15, 18]: *Where* does the data come from, *why* is it shown as result (for a specific query), and *how* were these results produced? Within this work, we focus on a social web oriented notion of provenance. As working definition, we reduce provenance to why-provenance and state:

Provenance is any additional information that allows the user of a social web system to understand why particular results are displayed.

In this work, we argue that the absence of provenance may render trust ratings useless. To do so, we will demonstrate how to manipulate the results from the social bookmarking systems delicious.com. This manipulation will not involve any kind of hacking but just the API provided by delicious.com[1] and the notion of trust used by delicious.com. As the manipulation is simply based on user-generated content, i.e., the key force driving the social web, it can probably not be avoided as such. In this work, we do not focus on developing a

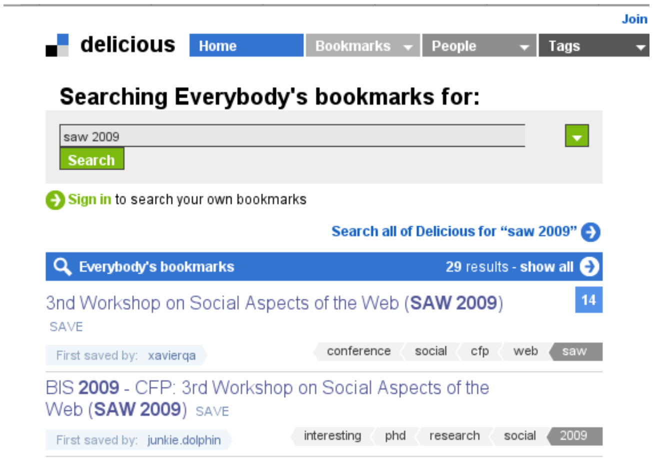
[1] http://delicious.com/help/tools

theory of provenance but on provenance-aware interface design. We will show that the implementation of a provenance strategy does not necessary involves a computational measure of provenance but (at least in the case of delicious.com) can be boiled down to some fundamental interface design decisions. In case of delicious.com it even boils down to a single term – *everybody*.

The remaining paper is structured as follows: First, we demonstrate why a computational theory of trust alone cannot replace provenance. Second, we argue why social bookmarking systems as delicious.com cannot replace trust by provenance – and hence need both. Finally, we summarize the presented approach and suggest directions of future work. To ensure that this paper does not do any harm to existing data at delicious.com, we will use information about a single workshop as target (the workshop was part of the delicious.com data set before and, for the fun of it, lists trust as one of its topics). Many other examples including the webpage of the author's department are available online. Changes that had an impact on the services offered by delicious.com were removed after testing.

2 Trust Without Provenance

As depicted in figure 1, delicious.com users can search everybody's bookmarks by keyword or tag. The results consist of the title assigned to a resource, i.e., a URL, the number of users which have bookmarked this resource, a number of common tags used for bookmarking, and the name of the user who first saved this bookmark[2].



Searching Everybody's bookmarks for:

saw 2009

Sign in to search your own bookmarks

Search all of Delicious for "saw 2009"

3nd Workshop on Social Aspects of the Web (**SAW 2009**) 14

First saved by: xavierqa — conference social cfp web saw

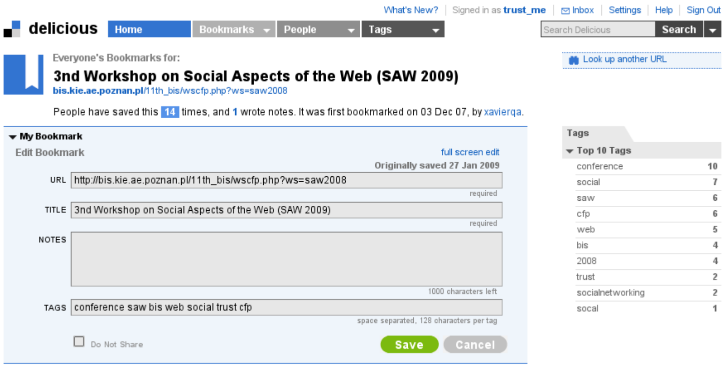
BIS **2009** - CFP: 3rd Workshop on Social Aspects of the Web (**SAW 2009**)

First saved by: junkie.dolphin — interesting phd research social 2009

Fig. 1. Searching for *saw 2009* at delicious.com.

[2] Users can choose between three levels of detail provided by delicious.com, the most detailed view also displays the URL as such.

The screenshot shows the first two bookmarks (out of six) resulting from a user's query for *saw 2009*. While the first bookmark was saved by 14 users, the other bookmarks cannot be summarized to one record by delicious.com because each of them refers to a slightly different URL (a common problem known from classical search engines)[3]. While these bookmarks refer to the 3^{rd} *Workshop on Social Aspects of the Web (SAW 2009)*, the first one in fact links to the webpage of the 2^{nd} workshop held in 2008. This is for the following reason. The bookmark was first created by the user *xavierqa* in 2008 and also saved by several other users. The original title assigned by these users therefore also refers to the SAW workshop held in 2008. To demonstrate the need for provenance, we have created a set of trustworthy users, and thereby were able to rename the title of the bookmark to refer to SAW 2009. Consequently, if users are searching for the SAW 2009 workshop they will probably click on this link and will end up at the old SAW 2008 webpage. We could have chosen any title to be displayed. For instance, one could also rename the bookmark to *SAW 2009 was canceled*[4].



Everyone's Bookmarks for:

3nd Workshop on Social Aspects of the Web (SAW 2009)

bis.kie.ae.poznan.pl/11th_bis/wscfp.php?ws=saw2008

People have saved this 14 times, and 1 wrote notes. It was first bookmarked on 03 Dec 07, by xavierqa.

Originally saved 27 Jan 2009

URL: http://bis.kie.ae.poznan.pl/11th_bis/wscfp.php?ws=saw2008 (required)

TITLE: 3nd Workshop on Social Aspects of the Web (SAW 2009) (required)

NOTES: (1000 characters left)

TAGS: conference saw bis web social trust cfp (space separated, 128 characters per tag)

☐ Do Not Share

Tags — Top 10 Tags

conference	10
social	7
saw	6
cfp	6
web	5
bis	4
2008	4
trust	2
socialnetworking	2
socal	1

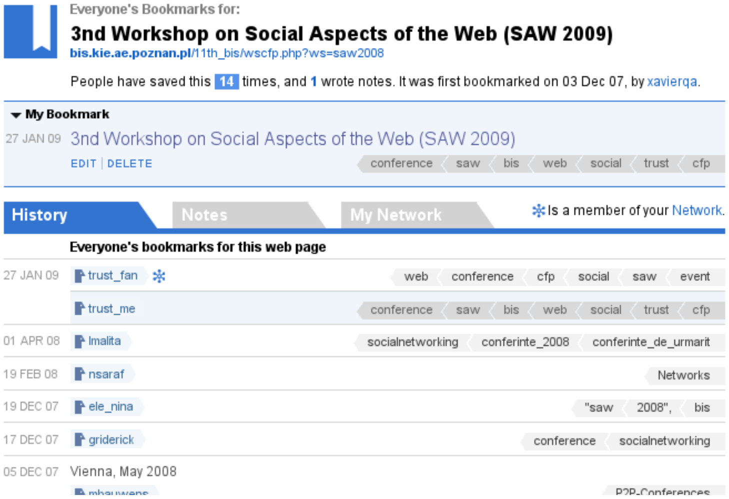
Fig. 2. Changing the title of the bookmark for the SAW 2008 workshop.

Note that we have not created a new bookmark but were able to change the title of an existing record saved by several users before. These users still see the title they have assigned. In contrast, users who have not bookmarked this URL before will see the manipulated title. As depicted in figure 1 and 2, instead of pointing out that a single user has assigned this specific name to the URL, the web interfaces states *Everyone's Bookmarks for*. In figure 2, you can also see that the bookmark in fact refers to the 2008 workshop. Delicious.com also provides a more detailed history page, showing when users have saved the bookmark. While this page displays the tags assigned by each user, it does not

[3] This is also the reason why we use the 2008 web page to demonstrate our approach.

[4] To demonstrate this, we have temporarily renamed the website of the authors home department from *Institut für Geoinformatik, Uni Münster* to *Institut für Geoinformatik (ifgi) with bad reputation!* The screenshot is available at `http://ifgi.uni-muenster.de/~janowicz/saw09/ifgi_reputation.png`.

display which title they have selected but again refers to a single title using the misleading *Everyone's Bookmarks for* phrase (see figure 3).



Everyone's Bookmarks for:

3nd Workshop on Social Aspects of the Web (SAW 2009)

bis.kie.ae.poznan.pl/11th_bis/wscfp.php?ws=saw2008

People have saved this 14 times, and 1 wrote notes. It was first bookmarked on 03 Dec 07, by xavierqa.

My Bookmark

27 JAN 09 3nd Workshop on Social Aspects of the Web (SAW 2009)

conference saw bis web social trust cfp

Is a member of your Network.

Everyone's bookmarks for this web page

27 JAN 09	trust_fan	web conference cfp social saw event
	trust_me	conference saw bis web social trust cfp
01 APR 08	lmalita	socialnetworking conferinte_2008 conferinte_de_urmarit
19 FEB 08	nsaraf	Networks
19 DEC 07	ele_nina	"saw 2008", bis
17 DEC 07	griderick	conference socialnetworking
05 DEC 07	Vienna, May 2008 mbauwens	P2P-Conferences

Fig. 3. The history page for the SAW 2008 bookmark.

The demonstrated shortcoming in the delicious.com bookmarking system involves trust and provenance. Out of several possible titles for a given bookmark the manipulated was chosen to be displayed as everyone's title. Without any detailed knowledge about the implementation of trust used by delicious.com, first experiments with several bookmarks and accounts show:

- If different titles are assigned to the same URL, the title of the most trustworthy user is chosen as most representative[5]. Trustworthiness seems to depend on the number of bookmarks saved by the user, the used tags, and the user's fan network.

- If several users have agreed on the same title (e.g., the one given by the HTML $<$ *title* $>$-tag of the bookmarked URL). Additional accounts may become necessary to make the manipulation work. The frequency of same titles seems to be more relevant than the trustworthiness of a single user.

To create trustworthy users we have registered several new accounts at delicious.com. Next, we have created a small java applications (less than 100 lines of code) to aggregate bookmarks. The application uses the delicious.com API in combination with the dapper data mapper[6], and the delicious-java-api from sourceforge[7]. It extracts about 200 popular tags from www.delicious.com/tag/

[5] This has also been confirmed by delicious.com by email.
[6] http://www.dapper.net/
[7] http://delicious-java.sourceforge.net/

and then uses the delicious API setcount-parameter to get 100 bookmarks for each of these tags. These bookmarks do not only contain the single tag used for the query but all tags assigned by the last user. Dapper was used to automatically extract the bookmarks to XML (which could also be done using the delicious.com RSS feeds) and to act as proxy. Due to restrictions from the delicious.com API, the extraction of about 20.000 bookmarks takes several hours. Using dapper as proxy prevents us from being blocked by the delicious.com API. The application could be extended in several ways , e.g., to use the most popular tags per bookmark. However, this turns out not to be necessary. After running the application, the first account (called *trust_me*) had accumulated nearly 20.000 bookmarks with about 11.000 unique tags. To learn about the delicious.com trust model, other accounts were created with slightly different versions of the application and had also accumulated several thousand bookmarks and tags. The *trust_me* account was used to rename the titles as described above. If one user was not sufficient, the other accounts were used in addition.

It is clear that social bookmarking systems have to make a decision on how to select a representative title for a bookmark. Choosing a trust model seems to be a natural approach. Moreover, the decision to rely on the frequency of same titles in the first place makes the system robust against attacks of single users. The reason why the delicious.com approach fails lies in the absence of provenance. The misleading usage of the term *everybody* strongly suggests that all users have assigned the title to this URL. Three simple changes to the web interface could prevent confusion and allow a searching user to judge whether the displayed title is appropriate. This corresponds to the definition of provenance introduced before.

- The term *everybody* should either be replaced by *many* (or *most*), or the name of the most trustworthy user. This would make users aware of the naming heterogeneity.

- The titles assigned by each user should be visible in the history page in the same way as the tags and notes. This would allow users to judge whether changes are substantial or not.

- If users have changed any tag, note, or title the time stamp displayed on the history page should also change. This way, users could immediately see whether changes were made recently and by how many users. So far, the history page only lists the date on which the bookmarked was saved first.

Summarizing, one could derive the following provenance-aware user interface design law.

If information is not directly taken from the primary source (e.g. the < title >-tag of the web page) the user interface has to provide meta date about how it was extracted from the social network.

Fortunately, the tagging functionality offered by delicious.com shows how this law can successfully be implemented. As depicted in figure 1, the search interface lists the most relevant tags for the SAW bookmark. It is possible to inject manipulated tags here. However, in contrast to the titles the history page lists the tags assigned per user (see figure 3).

One could argue that the presented manipulation only works for bookmarks saved by a few users, i.e., it does not scale. We believe that this is only partially true. The only protection against automatic account creation used by delicious.com is a single Captcha. Most of these Captchas are known to be vulnerable [21]. Several web services offer online Captcha breaking. Other solutions, such as Melissa[8], rely on social engineering to break Captchas. During our experiments, we found spam bookmarks listed at www.delicious.com/recent/ which supports our assumption. Finally, it is known from attacks on social networks that humans tend to use weak passwords. One could misuse existing accounts instead of creating new. As changes are not shown on the delicious.com history page, one would not recognize if suddenly the title of a bookmark gets changed by many users.

3 Provenance Without Trust

The focus of our work is to demonstrate why trust cannot replace provenance. Nevertheless, the delicious.com example also shows why we still need a notion of trust on the social web. Leaving the fact aside that social bookmarking as such is based on trusting human users, two further reasons are worth mentioning.

As explained with respect to figure 1, the grouping of similar URLs is a common challenge for search engines. Google, Yahoo, and Microsoft recently agreed on a specific *canonical* attribute for links to overcome this kind of problems. Social bookmarking systems face a similar but more difficult situation. As long as data provenance is provided, grouping similar bookmarks by the record of a trustworthy user is a valid approach. Moreover, in many cases the title cannot be directly extracted from the primary source. For instance, users can also bookmark pictures. The < *title* >-tag may be missing, misleading or to generic. Using just provenance would not allow to preselect relevant titles. In case of tags, if no criteria for the relevance of tags would be defined (and frequency can be a simplistic trust measure), one would have to display all the dozens of tags assigned to a URL.

Consequently, provenance alone could not be used to solve these problems. On the social web trust is used to infer, filter, and summarize information. These functions are essential to develop usable interfaces. In contrast, provenance allows the user to understand how the displayed information was inferred, filtered, or summarized – it makes trust ratings transparent to the user.

[8] http://news.bbc.co.uk/1/hi/technology/7067962.stm

4 Conclusions and Future Work

In this work we have demonstrated how a simple manipulation can render trust ratings useless if no data provenance is provided. This manipulation does not require any kind of hacking, but just the core functionality provided by a typical social web API – in this case the one of delicious.com. Instead of introducing new theories of trust or provenance, we focused on the interface design. We demonstrated how simple changes can improve transparency – even one word can make a difference. In case of delicious.com, the information required to establish provenance (e.g., time stamps and titles per user) is already available. In terms of thesis 5 introduced above, it is trust and provenance which makes social bookmarking systems less prone to manipulation than purely algorithm-based search engines. While every trust model is potentially vulnerable, trust offers core functionalities for social bookmarking systems. Provenance in turn allows users to critically analyze derived content (and trust ratings).

The ongoing evolution of social networks will require more complex trust models (especially if openID will succeed). In the near future we may face various attacks on social networks based on trust (and missing provenance). Similarly to botnets, we will probably see networks of either pseudo accounts or hacked accounts. Such networks could be used for spamming but also driven by political motivations such as opinion-making. With the increasing power of APIs offered by social web systems, and services such as dapper.net, large parts of today's botnets infrastructure could be transferred to the social web (also replacing IRC as communication channel).

During our experiment, we also found many time-sensitive tags. This raises the question of maintenance on the social web in general. For instance, *obama* is one of the top5 tags for http://www.whitehouse.gov/. It has been assigned more often than *usa* or *president*. Will users change such tags on the long term?

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