Agent-based Social Assessment of Shared Resources*

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Abstract. Prior to the access to decentralized resources like web services and shared files in peer-to-peer networks, the user needs to be provided with accurate information about these resources. While some of them can be specified impartially, other descriptions might be biased by individual preferences or subjective utility, for example quality ratings or content synopsizes. Unfortunately, such assessments of distributed resources usually either solely reflect the requirements, opinion and preferences of the resource providers or single users, or they consist of plain, often overgeneralized ratings obtained from voting-based recommender systems. In contrast to these approaches, we propose an agent-based framework for the distributed assignment and social weighting of rich, multidimensional and possibly *inconsistent* resource descriptions obtained from the conflicting opinions of communicating agents, which compete in the assertion of individual resource assessments.

Keywords: Open Systems, Peer-to-Peer Computing, Semantic Web, Multidimensional Rating, Collaborative Filtering

1 Introduction

In the context of resource sharing in large, open and heterogenous peer-to-peer networks like Gnutella, eDonkey or KaZaA, and public internet resources like web sites and web services, a well-known problem is constituted through the notorious lack of reliable, impartial descriptions (especially ratings) of such resources. If a resource description (RD) is available, in most cases the description is provided by the original resource provider, which makes it in general as useless as any other kind of advertisement. In contrast, recommendation systems [1] based on the evaluation of access statistics, voting or resource content analysis try to ascertain the “objective” value of resources. E.g., collaborative filtering recommendation systems provide filtering criteria for site classification, which classify the rated object in terms of “appropriate/inappropriate” or “interesting/uninteresting”, based on the assumed interests of a more or less homogenous group of users with a common profile, or on implicitly majority voting algorithms like Google’s *PageRank* [2]. As a supplement or as a competing approach, content-based filtering recommendation systems try to analyze the content of documents (usually by means of keyword counting) and compare these results with the interest profiles of the potential users [3]. The main drawback of such filtering systems is their limitation to

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one-dimensional descriptions (amounting to “$like/dislike$”) grounded in the presumed predilections of predefined or computationally demarcated interest groups. This approach does not provide much help for the process of interest forming, which should in fact *precede* any filtering. Likewise, *trust networks* like PeopleNet [4] don’t help much in case there is no trust yet regarding a specific rater, topic or object. Another problem is the apparent black-box character of many (commercial) recommendation methods, which on the one hand provides some protection against manipulation, but on the other hand seriously restricts their trustability. Balanced descriptions (i.e. the weighting of the opinions of multiple users and groups) which are in addition reliable and unrestricted can currently only be provided by humans, for example journalists and experts, or through discussion forums (e.g., newsgroups and threaded message boards like *Slashdot* [5]). Another disadvantage of this kind of approach is the absence of a machine readable encoding of the results, which makes it almost impossible for information agents like web spiders to analyze such descriptions. Although the Semantic Web effort addresses the problem of missing machine-understandability of web site descriptions, it currently focusses primarily on the specification of languages and tools for the syntactical representation of semantics and ontologies, not on the process of information gathering and rating itself, and it is just beginning to take into consideration phenomena like social RD impact [6], conflicting opinions, information biasing by commercial interests, and inconsistent or intentionally incorrect information. In contrast to traditional approaches, our goal is to provide a framework for the emergence of so-called *social resource descriptions* (social RDs) with the following properties:

Recognition of controversies A high amount of RDs are subjectively biased quality judgements with a high conflict potential. Competitive descriptions, represented by software agents, shall *enable* such controversies, and social resource descriptions shall make them *explicit* and available to information agents.

Pro-active opinion representation The competitive descriptions which contribute to social descriptions are no single “passive” statements like votes for an opinion poll, but shall instead continuously be represented by social agents which support them actively in a dynamic social process, e.g. by means of argumentation or conflicting behavior.

Complexity and hybridity Due to the size, the heterogeneity and the openness of the world wide web and public peer-to-peer networks, the agent-supported description of resources is a highly complex task. Socially obtained descriptions increase the complexity of hybrid information-rich environments because they make human sociality “behind” the technical infrastructure visible. Nevertheless, to overcome the idea of a web consisting of unrelated (or only syntactically related) information pieces, the enabling of computational social structures is inalienable in our opinion.

Unveiling of social intentions Even an individual description does not only assert the rated resource, but makes an implicit statement about the actor that is responsible for the description [6].

2 Architecture

As an approach to the described issues, we outline a multiagent system consisting of the following components. For lack of space, we cannot go into technical details.

1. Self-interested *description agents* which are able to deliberatively describe resources in accordance with the opinions, criteria and interests of their clients, and to represent their individual descriptions in a discourse with other description agents[1]. They act either as representatives for existing RDs (therefore in some sense the pro-active "incarnations" of RDF documents), or of peer agents, user communities, source creators (e.g., web sites owners or media providers), or private and public organizations. Every description agent supports a certain opinion and announces, asserts and probably defends it in an open discussion *forum* which is assigned to the rated resource (usually a web site) or a peer-to-peer client (e.g., a file sharing application). These forums are public whiteboards, on which the agents put their messages addressed to other agents and receive responses - very much like people do in newsgroups and message boards. Every forum has its own description vocabulary which could be assembled by the agents themselves via some ontology negotiation technique.
2. A technical instance (*Social Resource Description System* (SRDS)) for the technical facilitation of description agents communication and for the derivation of social RDs from these communication. It is a software component which observes the forums and continuously derives from the forum communication so-called *social expectation structures* [7, 8]. These structures are distilled to social RDs. Together with the rated web page, the descriptions are presented to the user (e.g. to the web surfer through a special HTML frame within the browser window or via some user agent), and to information agents, for example the web spiders of internet search machines like Google or Altavista. The description agents will also obtain these information, since such knowledge is considered to be important for the agents to let them intentionally avoid or achieve conflicting or collaborative behavior in respect to other agents and social norms, and to find appropriate allies and opponents.

3 Social resource descriptions

In terms of the RDF standard (the XML-based *Resource Description Framework* [9], a successor of the internet rating language PICS [10]), the description of a certain (web) resource is a finite set of statements (*elementary resource descriptions*) together with a description vocabulary. Each statement describes the properties of the respective resource (which can be virtually any kind of object like web site attributes, documents or web services, but also other statements) by means of meta data, according to a vocabulary of property types or classes (sometimes called an "ontology" or "schema"). Technically, such an elementary resource description is defined as a proposition of the form $(resource, propertyType, value)$, in which $resource$ denotes an object with an unique identifier (i.e., a Uniform Resource Identifier (URI) or a locator

[1] *Voting* is considered to be a simple kind of such discourse participation.

like $ed2k : //|file|filename.mp3$). $propertyType$ is the described attribute of the resource (an element of the given description vocabulary), and $value$ is its assigned value. Elementary RDs can be expressed through a formal description language, for example RDF or DAML/OIL [11]. A simple example for a description with boolean property type is
($\texttt{www.SomeCompany.com}, MinorOrientation, True$). $value$ can also be a resource by itself, and thus the description vocabulary can form a hierarchy of (meta-) property types (e.g., $Author$ and $Trustability$ in
$\{\texttt{www.somesite.com}, Author, John), (John, Trustability, high)\}$.
Social RDs are based on *expectations* regarding social agent behavior and derived from graphical *expectation networks* [7, 8][2]. They are sets of expectations regarding the anticipated utterance of elementary RDs in a certain discourse context, inductively learned by the SRDS from the observation of agent communications. Each element of a social resource description is the expectation of a certain *reply* to a question regarding the *agreement* with an elementary RD, directed to agents (or, in a generalized way, to social agent *roles*) which currently participate in the observed forum. The calculation of social RDs regarding resource properties from expectations regarding communications makes use of the fact that an elementary RD is equivalent to a set of meta descriptions, i.e. "descriptions of descriptions" with a common property type "$Assent$": From a multidimensional description $(resource, propertyType, value)$ as in RDF we can generate meta-descriptions in the form of $(propertyType = value, Assent, degree\ of\ assent)$, where the first element of this tuple is the content (logical proposition) of an assertive speech act, the second element denotes the property type corresponding to the speech act performative "$Assert$"[3]. The omitted resource $resource$ is provided implicitly through the forum topic. The social amount of agreement or dissent, respectively, can then simply be measured as the probability that a certain RD agent (or a role subsuming a set of agents) utters the message "$Actor_1 \rightarrowtail Actor_2 :' Assert(propertyType = value)'$". E.g., a SRDS query regarding the assessment of the SomeCompany site by a set of agents A would look like ($\texttt{www.SomeCompany.com}, MinorOrientation, ?x$) (where $?x$ is an existentially quantified variable with instances v_i), which could be transformed into the speech acts "$B \rightarrowtail A :' Query(MinorOrientation = ?v)'$ or "$B \rightarrowtail A :' Request(Assert(MinorOrientation = v_i))'$.
The social RD is then simply a set of expectabilities (the expectation *strengths*, denoted as probabilities in a range of 0 to 1) of the potential reactions to such a request, together with attributes for expectation *normativity* and *deviancy*[4]. E.g., the resulting values for answers asserting
($\texttt{www.SomeCompany.com}, MinorOrientation, True(= v_1)$) could be
$strength = 0.9, normativity = 0.7, deviancy = 0.01$

[2] Note that *trust* is a special kind of such social expectation.

[3] or what ever performative the respective communication agent language provides to signal consent.

[4] Informally, *normativity* = long-term stability of social expectations, in a range from 0 to 1, and *deviancy* = difference between a highly normative, long-term expectation and the actual probability of the respective speech act occurrence obtained from short-term observations. Please see [8, 7] for details.

and $strength = 0.1$, $normativity = 0.7$, $deviancy = 0.01$ for
(www.SomeCompany.com, $MinorOrientation, False(= v_2)$)[5] (i.e., these agents assert in a quite normative way that SomeCompany is highly minor-oriented).
We denote (unconditioned) social RDs as sets of terms having the form
$Actor : (resource, propertyType, (value, expectability, normativity, deviancy))$, where $Actor$ can denote an agent or a social role.
The query results are obtained from the expectation network, either directly if the expectation network already contains expectations for the respective
$Query/Request(...) \rightarrow Assert/Agree/Deny(...)$ speech act trajectories, or by means of an SRDS query on the forum directed to the RD agents. In the latter case, the query introduces the required expectation network paths, and then the SRDS observes the subsequent agent communications to obtain expectabilities which reflect the agent opinions along these paths. Besides this example, expectation networks allow for the obtainment of a large variety of other kinds of social RDs, e.g.:

- *Single agent RD*, obtained from
  "$B \rightarrowtail SingleAgent :' Query(PropertyType = ?v)'$" $\rightarrow$
  "$SingleAgent \rightarrowtail B :' Assert(PropertyType = v_i)'$"
- *Social role RD*[6], obtained from
  '$B \rightarrowtail Role :' Query(PropertyType = ?v)'$" $\rightarrow$
  "$Role \rightarrowtail B :' Assert(PropertyType = v_i)'$"
- *Public RD* (provided that the substitution list for role All contains every agent within the forum), obtained from
  '$B \rightarrowtail All :' Query(PropertyType = ?v)'$" $\rightarrow$
  "$All \rightarrowtail B :' Assert(PropertyType = v_i)'$"
- *Conditioned social RD*, obtained from
  Prefix $\rightsquigarrow$ "$B \rightarrowtail A :' Query(PropertyType = ?v)'$" $\rightarrow$
  "$A \rightarrowtail B :' Assert(PropertyType = v_i)'$"
  Here, "*Prefix* $\rightsquigarrow$" denotes a sequence of messages (or message templates) which has to precede the Query/Answer pattern. For example, an agent might commit himself to a certain RD that has been requested from another agent only if the other agent agrees with a certain RD by himself (behavioral *reciprocity* of self-interested agents).
  Since an expectation network can model virtually any kind of interaction pattern, *Prefix* could denote highly complex conditions, e.g. auctions for the selling of web site ratings for the purpose of commercial advertising (i.e., the agents commit themselves to agree with the opinion of the auction winner).

3.1 Embedding social resource descriptions within RDF documents

To provide a machine-readable format for (simple) social RDs taking the form
$\{Actor : (resource, propertyType, (value, expectability, normativity, deviancy))\}$, it seems reasonable to extend a well-established XML-based RD language like the RDF.

[5] Uttered using a "$Deny$" performative, for example.
[6] Although social roles usually group similarly behaving agents, in our formal framework [7], a single role can generalize different inconsistent opinions.

This can basically be done by means of a replacement of the description parts of statements with lists of probabilistically annotated propositions. The description vocabulary for the following example is implicitly given as an XML namespace “V” , provided by some fictitious rating organization “description.org”, and through a “Social Resource Description Rating Meta Language“ namespace called SRDML:

```
   <rdf:Description about='http://www.SomeCompany.com'
    xmlns:s='http://description.org/schema'>
        <V:MinorOrientation>
                <SRDML:disjunctive>
                        <SRDML:boolean strength=0.9 normativity=0.7 deviancy=0
                                agent='Entertainment industry'>True</SRDML:boolean>
                        <SRDML:boolean strength=0.1 normativity=0.7 deviancy=0
                                agent='Entertainment industry'>False</SRDML:boolean>
                        <SRDML:boolean strength=0.3 normativity=0.7 deviancy=0.6
                                agent='User community 6'>True</SRDML:boolean>
                        <SRDML:boolean strength=0.7 normativity=0.7 deviancy=0.6
                                agent='User community 6'>False</SRDML:boolean>
                </SRDML:disjunctive>
        </V:MinorOrientation>
</rdf:Description>
```

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