A Social Validation of Collaborative Annotations on Digital Documents

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ABSTRACT

In this paper, we present the annotation purposes for a personal as well as for a collective use. In the context of digital documents, annotation systems allow not only to annotate passages but also to comment or reply to annotations within discussion threads (similar feature than forum's one). Thus, readers can express their points of view, debate and even reach a consensus about annotated passages in the context of the documents. Moreover, thanks to this reply feature, people can respond to annotations for criticizing them. Therefore, a reader can explore the thread for evaluating the main annotation reliability according to the reactions of previous readers. As this mental work could be painful in the presence of numerous replies and answer levels, we describe, in this paper, an algorithm that computes annotations reliability. Annotation reliability relies on a synthesis of comments given for this annotation. It can be considered as a social validation of the annotation content. By using this reliability calculation, annotation systems can highlight the most reliable annotations, for instance. This visual adaptation can relieve readers from mentally identifying trustworthy annotations. Consequently, this leads to decreasing their cognitive overload.

KEYWORDS
annotation system, social validation of annotation, point of view synthesis, annotation types, discussion thread, TafAnnote.

1   INTRODUCTION

Annotating paper documents is a common activity in everyday life, it enables the combination of the act of reading with critical thinking. Such a process is called "active reading" by Adler and Van Doren (1972). Nowadays, documents tend to be drawn up with word processing software. Therefore, they are exchanged and read on their electronic form. However, the need for annotating these digital documents still exists. Due to the growth of digital documents principally on the Web, the transposition of annotations from paper to digital documents is a key issue. C. Marshall (1998) underlines that many people prefer buying annotated book rather than brand new ones because annotations are bringing some gain to the original content cf. law books for instance.

Annotating digital resources seems to be useful in many cases. Therefore, let's consider an annotation system used by numerous users that annotate documents heavily. As the number of annotations increases, exploiting them becomes more and more difficult. Moreover, each annotation potentially generates a debate in the form of a discussion thread. However, the reader must mentally evaluate each annotation reliability to determine its trustworthiness. This implies a cognitive overload for the reader that is distracted from its main task: **reading**. Although, such an excess of mental effort should be reduced at all costs (O'Hara & Sellen, 1997). That is the reason why we propose to automatically measure the validity of annotations thanks to their informational content and the debates they sparked off. Our aim is to help the user to identify annotations that have been validated by

subsequent annotators. To do this, we wondered about the way a reader can judge the reliability of each annotation. Indeed, even if an annotator's expertise is given, it is difficult to judge an annotation. As a solution, we propose a social approach mainly based on the analysis of the discussion thread to detect the reliability of each annotation. We call this approach a social evaluation of the annotations reliability. The aim of this approach is to offer readers a qualitative value associated to each annotation. Thanks to this, they can evaluate the annotation reliability without reading the associated discussion thread as a whole. Then, they can choose to consider it or not. This issue is essential when dealing with collaborative environments.

The importance of such annotations reliability computing can be seen in different contexts that are:

- − Decisional Systems; such as datawarehouses which allow analysts to aggregate huge amounts of data in a single multidimensional table. Indeed, these experts read and interpret information presented in these tables. As analyses gain in complexity, a single expert may not carry them out. Thus, since many analysts work on the same analysis, an individual can comment and explain his conclusions to others in the context of the multidimensional table. Thanks to these annotations and to the discussion threads associated with annotations, decisional systems can exploit analysts' expertise in order to build an "expertise memory" which can be used in other multidimensional table analyses.
- − Web Context; enabling readers to annotate Web pages may bring these pages a valuable information. Each other can express its feedback and questions, formulate corrections, etc. For instance, authors may use annotations reliability to decide which modifications of their Web pages are most relevant.
- − Digital Libraries; nowadays, documents tend to be created and exchanged in their electronic form. More and more libraries are digitalized original paper-made documents. Many librarians are needed to deal with such a task. They can annotate documents and/or discuss them in order to identify the most important passages which are representatives of the content or to elicit the document structure. Annotations reliability could be used, in this context, to adapt and improve the indexation process.
- − Industrial Context; annotating technical documentation allows users to express their feedback on documents. For instance, let's consider documents explaining the ways a pilot can handle an engine failure. Pilots, thanks to an annotation system, could annotate and discuss the checklist to identify some mistakes or malfunctions. Such annotations reliability can be used to pinpoint mistakes in these documents that have been socially validated by most pilots.

In order to present the way the social validation of an annotation is computed, the paper is organized as follows: in the second section, we detail the concept of annotation and its realization within software called annotation systems. The third section describes the social validation algorithm that computes annotations reliability. We present in the fourth section the implantation of the validation algorithm in an annotation system called *TafAnnote*. Finally, the fifth section makes a conclusion and introduces perspectives of future work.

2   FROM PAPER TO DIGITAL ANNOTATIONS

Annotations are defined as *"information or additional marks formulated on a document for enhancing it with brief and useful explanations. Annotating allows the user to keep tracks of its feedback [...]."* in (Evrard & Virbel, 1996). In fact, annotating is an essential activity for the paper reader's task (Marshall, 1998). That is the reason why paper annotations have been transposed onto digital documents. Thanks to an annotation system, users now can view and create annotations on digital documents.

We consider in the following the aim of using digital annotations for a personal and a collective use:

- − For personal use, annotations help understanding. They enable people to personalize the document contents by reformulating it in their own verbal representations. Furthermore, people can identify and mark passages dealing with the same subject. Later, an annotator can quickly remind a document by glancing at the marked passages.
- − For collective use, annotations are shared among users. This sharing can be restricted to specific groups of users. Collective annotations give authors the opportunity to improve the

quality of their publications by correcting mistakes pointed out by annotators. Considering the Web context, feedback expressed by readers could improve Web site pertinence, for instance. Readers also benefit from consulting other's annotations, as they are not only constrained to the author's point of view anymore: they can access previous readers' opinions. Furthermore, a reader may contribute to document drafting simply by annotating it cf. the collaborative drafting of (Pédauque, 2005). Finally, people can react to an annotation by replying to it. Replies and questions about an annotation are organized as a discussion thread (similar feature to forum organization). Thanks to this latter feature, readers can exchange points of view, correct each other's annotation or add an example or a reference to any incomplete annotations.

Many systems have been developed to enable people to use digital annotations. We present in TAB. 1 a comparison of twenty annotation systems according to their type (Commercial or Research system), the information they store about annotators and the types available for characterizing digital annotations. Moreover, in a collaborative point of view, we consider each system's ability to share annotations and its discussion threads support.

Year	Application name	Reference	Type	Information about the annotator	Available types for describing an annotation	Annotation share	Discussion thread feature
1993	Microsoft Word	(Microsoft Word)	C	name	no	public: belongs to the document	no
1994	ComMentor	(Röscheisen et al, 1994) (Heck et al, 1999)	R	profile, name, email, personal web page, photograph	no	private, group or public	yes
1995	Futplex	(Heck et al, 1999)	R	login, name	no	public, group	yes
1995	CoNote	(Davis & Huttenlocher, 1994) (Heck et al, 1999)	R	name	no	private, read or write (one or both) access	yes
1995	Hypernews	(LaLiberte & Braveman, 1995)	R	name, email, personal web page	{Angry, Sad, Smile, Agree, Disagree, Yes, No, Ok, Idea, New idea, Maybe, Note, Question, Warning}	public	yes
1997	JotBot	(Vasudevan & Palmer, 1999)	R	name	restrain answers to "Yes" or "No"	public	yes
1998	CritLink	(Heck et al, 1999)	R	name, email	{Query, Comment, Support, Issue}	public	no
1999	Annotator (Annotation technology)	(Ovsiannikov et al, 1998) (Heck et al, 1999)	R	login	no	private, group or public	yes
1999	HyperPass	(Heck & Luebke, 1999)	R	name, email	no	private, group or public	yes
1999	Pharos	(Bouthors & Dedieu, 1999)	R	profile, rating	no	private, group or public	no
1999	Third Voice Annotation System	(Heck et al, 1999)	C	login, email	no	private, group or public	no
2000	iMarkup	(iMarkup, 2000)	C	no	A single user-defined type	private, shared via email	no
2000	Microsoft Office Web discussions	(Bernheim Brush, 2002)	C	name, surname	no	public	yes
2000	Yawas (MSIE version)	(Denoue, 2000)	R	no	no	private, shared via email	no
2001	Amaya	(Koivunen & Swick, 2001)	R	login	{Advice, Change, Comment, Example, Explanation, Question, SeeAlso}	private or public	yes

2001	WebAnn (Common Annotation Framework)	(Bargeron et al, 2001)	R	name	no: "not necessary"	private or public	yes
2002	Annotation System for Semantic Web	(Venkatasubramani & Raman, 2002)	R	login	Amaya 7 ones + {Correction}	private or public	yes
2003	Annozilla	(Mozdev, 2003)	C	email	Amaya 7 ones	private or public	yes
2004	PDF Annotator	(GRAHL software, 2004)	C	no	no	private	no
2005	Yawas for Firefox	(Denoue, 2005)	R	no	no	private, shared via email	no

TAB. 1 – *Comparison of several annotation systems.*

Thanks to this study, we have identified systems that associate a single type with an annotation e.g. *Amaya*[1]. Therefore, if an annotator expresses both a question and an example in a single annotation, he must choose a single type, as they are exclusive. It seems that this is too restrictive for concrete situations. Annotators should be able to describe their comments with any combination of types. Moreover, the types proposed by most of the systems we studied only allow to describe the comment; they do not inform subsequent readers about the annotator's opinion. For instance, types such as "I agree" and "I disagree" would help readers while they manage to extract the annotator's point of view from the comment.

In a more collaborative way, we can identify many systems that support a discussion thread feature. This is interesting because it indicates that such systems believe in collaborative improvement of documents. Indeed, such systems do not only purely provide an annotation feature but they also enable readers to reply to an annotated passage. Furthermore, this study underlines that annotations are commonly aimed at readers. Unfortunately, most annotation systems do not consider exploiting annotations content for additional usage. For instance, *Yawas* exploits annotations content to categorize annotated documents which makes the indexation process more accurate (Denoue 2000).

Thanks to these observations, we propose a social validation of annotations based on the measure of their contents reliability. This measure is detailed in next section.

3   SOCIAL VALIDATION OF COLLABORATIVE ANNOTATIONS

We describe in this section the conceptual model of a collaborative annotation as well as a detailed approach used for validating annotation content.

3.1   Conceptual model of a collaborative annotation

An annotation is defined by the pair (*OI*, *SI*) where *OI* is an objective information set and *SI* is a subjective information set. In the following sections, we present the characteristics of an annotation in terms of objective (annotator, anchoring point, etc.) and subjective (textual content, etc.) information.

3.1.1   Objective information

For each annotation, *OI* contains data defined by the system in terms of the annotation's:
   − **Identification**: a unique identifier and the identifier of its ancestor in the discussion thread.
   − **Creator**: the identity (name and surname) and the email address of the annotator.
   − **Creation time** that helps to organize the discussion thread chronologically.
   − **Anchoring point** that precisely localizes the annotated passage within the document.

3.1.2   Subjective information

In addition to objective information, an annotation is made up of more subjective information *SI* that can be omitted by annotators i.e. *SI* is optional. This subjective information contains the annotation's:
   − **Content** formulated by the annotator.
   − **Visibility** that can be private, public or restricted to some groups of users.

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[1] The Amaya editor/browser is the first implementation of the *Annotea* project cf. http://www.w3.org/Amaya.

− **Creator expertise** given through a scale ranging from "neophyte" to "expert". We introduced this information because people generally give more importance to an expert's opinion than a novice's one (Marshall, 1998).
− **Reference list** that allows people citing external resources.
− **Different types** chosen by the annotator. We have extracted from literature some types that we have grouped into three categories, as shown in TAB. 2. The first row contains the name of the category : the "judgment" class represents an evaluation of the annotated passage, the "comment" class describes the content of the annotator's comment and the "opinion" class represents the user's agreement towards what he comments. The second row gives the name of the type. Finally, the third one contains icons we use in the following sections when we refer to a particular type (we opted for icons introduced with the *Hypernews* system for their expressiveness).

judgment (exclusives)		comment			opinion (exclusives)	
positive	negative	correction	question	example	confirm	refute
👍	👎	⚠	❓	💡	✔	✘

TAB. 2 – *Collaborative annotation types grouped into three classes.*

In order to relieve users of exploring the discussion thread for evaluating the trustworthiness of a collaborative annotation, we propose an algorithm that computes its reliability. The reliability corresponds to a social confirmation or refutation of the annotation content. Let's consider a "correction" typed annotation associated to any document passage; if another reader believes that this annotation is wrong, the initial annotated passage should not be considered as wrong as said in the annotation. With this aim in view, we consider an annotation content, its author's expertise and the discussion it has sparked off. We describe in the following sections how we actually infer reliability from annotations.

3.2 Agreement of a collaborative annotation

We associate an "agreement" value to each annotation according to its type(s). This value is positive (*resp.* negative) if the annotator agrees (*resp.* disagrees) with what he annotates or what he replies to. The "agreement" value depends on:

− First, we consider the annotation "confirm" value given by the function *confirm*(*a*) (applied to an annotation *a*). It is based on the study of the annotation types combination: FIG. 1 shows their relatives values.
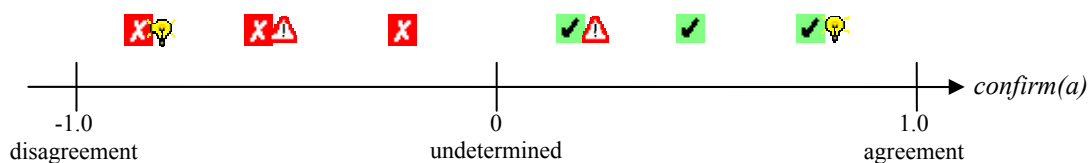

FIG. 1 – *Computing "agreement" value from opinion and comment types.*

− Second, we increase the "agreement" value considering the annotator's involvement in terms of commenting (cf. EQU. 1) and referencing resources (cf. EQU. 2). Ranges of the functions are given under their names e.g. [0.0 ; 1.0]. These equations reflect the fact that we consider the presence of a comment or references to other documents for increasing the "agreement" value. Indeed, an annotation containing a comment that refines the used type is more relevant than an uncommented one.

$$comment(a) = \begin{cases} 0.0 & if \; \|a.comment\| = 0 \\ 1.0 & else \end{cases}$$
$$\scriptstyle [0.0\,;1.0]$$

EQU. 1 – *Comment function based on the length of the annotation comment.*

$$references(a) = \frac{|a.references|}{\forall x \in Annotations \quad \max(|x.references|) + 1}$$
$$\scriptstyle [0.0\,;1.0[$$

EQU. 2 – *References function based on the number of references.*

Finally we compute the "agreement" value of an annotation *a* thanks to the three previous functions (cf. EQU. 3). The α and β parameters allow to adjust the weight of the two last functions.

$$agreement(a) = \frac{confirm(a) \times (1 + \alpha \cdot comment(a)) \times (1 + \beta \cdot references(a))}{(1 + \alpha) \times (1 + \beta)} \quad where \quad \begin{array}{l} \alpha \in [0.0\,;1.0] \\ \beta \in [0.0\,;1.0] \end{array}$$
$$\scriptstyle [-1.0\,;1.0]$$

EQU. 3 – *Agreement function depending on confirm, comment and references functions.*

This "agreement" value is based on intrinsic characteristics of the annotation without considering its position in the discussion thread. To this, a specific recursive process is realized to adjust the annotation "agreement" value according to its replies. We present this process in the following section.

3.3   Social reliability of a collaborative annotation

In this section, we present the information extraction from an annotation replies (structured into a discussion thread). Therefore, we compute the social reliability of an annotation considering not only its "agreement" value but also the information based on people's contributions (hence the "social" adjective). In other words, the social reliability considers the agreement of the annotation itself and a synthesis of its replies agreements. The more the annotation content is confirmed in the discussion thread, the more the initial judgment is high ($\rightarrow 1$ or $\rightarrow -1$). On the contrary, the more the annotation is infirmed in the discussion thread, the more the initial judgment is wrong ($\rightarrow 0$). We identified in TAB. 3 four cases to take into account for moderating or increasing the parent annotation reliability according to its replies reliabilities:

	case 1	**case 2**	**case 3**	**case 4**
Annotation (parent)	✔ confirm	✔ confirm	✘ refute	✘ refute
Replies	✔ confirm	✘ refute	✔ confirm	✘ refute
Parent reliability	reliability → 1	reliability → 0	reliability → − 1	reliability → 0

TAB. 3 – *Adjustment of an annotation reliability according to its replies reliabilities.*

In concrete terms, EQU. 4 computes the reliability of an annotation *a*. If *a* is the root (*a.ancestor* = λ) of a an empty discussion thread (|*a.replies*| = 0) then *reliability(a)* = 0 which means that *a* is neither confirmed nor refuted. Otherwise, *a* reliability is computed according to its "agreement" value and a "synthesis" of its replies. The *synthesis* function returns a negative value when the replies globally refute the parent annotation and a positive one otherwise. Finally, the γ parameter allows to adjust the impact of the discussion thread on the measure of the reliability.

$$reliability(a) = \begin{cases} 0 & if \; a.ancestor = \lambda \wedge |a.replies| = 0 \\ \\ \dfrac{agreement(a) \times (1 + \gamma \cdot synthesis(a))}{2} & where \; \gamma \in \,]0.0\,;1.0] \quad else \end{cases}$$
$$\scriptstyle [-1.0\,;1.0]$$

EQU. 4 – *Reliability function depending on agreement and synthesis functions.*

The *synthesis* function is important because it takes into account the replies as a whole (cf. EQU. 5). We propose a function that is based on a weighted mean giving a prominent role to annotations qualified with a greater expertise (the *expertise* function range being strictly positive). We also

increase the value of the synthesis considering the number of replies: the more an annotation has replies, the more is its reliability relevant.

$$synthesis(a)_{[-1.0;1.0]} = \begin{cases} \dfrac{1}{\gamma} & if \ |a.replies| = 0 \\[2em] \dfrac{\sum\limits_{i=1}^{|a.replies|} reliability(a.replies[i]) \times expertise(a.replies[i])}{\sum\limits_{i=1}^{|a.replies|} expertise(a.replies[i])} \times \left[1 + \ln\left(1 + \dfrac{|a.replies|}{maxNbReplies(1+lvl(a))}\right) - \ln(2) \right] & else \end{cases}$$

EQU. 5 – *The synthesis function that computes the global reliability of an annotation replies.*

In the above equation *a.replies* represents an array containing all the replies associated to the annotation *a*. The *lvl* function returns the level of the annotation *a* in the discussion thread (the root annotation having a level of 0). Finally, the function *maxNbReplies* applied to an argument *l* returns the maximum number of replies at the lth level of the tree corresponding to the discussion thread.

If an annotation *a* belongs to the discussion thread and doesn't have any reply, its reliability corresponds to the agreement value: $|a.replies| = 0 \Rightarrow reliability(a) = agreement(a)$. On the contrary, if *a* has got replies, the "synthesis" value relies on the weighted mean of their reliability (*A*) multiplied by an expression (*B*) increasing with the number of replies. Actually, *B* takes into account the maximum number of replies existing for the same level than the level of *a*. For instance, if *a* (level *l*) has *n* replies and if the maximum number of replies for the annotations at the lth level is *N* then $B = 1 + \ln(1 + n / N) - \ln(2)$. Note that the upper bound of *B* is reached when $n = N \Rightarrow B = 1$. Therefore, $B \in [\ln(\mathbf{e} \times (N + 1) / (2 \times N)) ; 1]$, we use a natural logarithm for reducing differences between little and large values of *N*. As $B \leq 1$, it cannot increase the value of *A*.

The value of the *reliability* function is useful for validating an annotation according to the *agreement* and *synthesis* functions. Indeed, $|reliability(a)| \rightarrow 1$ points out an annotation that contains replies agreeing to it. According to the sign of the reliability value *r*, we can conclude that people validate a "confirm" typed (*resp.* "refute" typed) annotation $r \rightarrow 1$ (*resp.* $r \rightarrow -1$).

To show how this reliability can be taken into account in an annotation system, we present in the following section the implementation of this approach into an annotation system called *TafAnnote*.

4 THE TAFANNOTE ANNOTATION SYSTEM

This section introduces the *TafAnnote* annotation system, which is used to measure the collaborative annotations social reliability. Concretely, *TafAnnote* is a plug-in toolbar for the Mozilla Firefox Web browser and allows to annotate Web documents in HTML format. Particularly, it aims to:

- Improve the interactivity of the annotation system in order to encourage users' active participation. Indeed, they can discuss in the context of documents within discussion threads. In order to encourage users to reply to annotations, our system displays the number of answers an annotation has already sparked off. We show in FIG. 2 a typical discussion thread where asterisks represent expertise and circled numbers indicate the number of replies e.g. ❷.
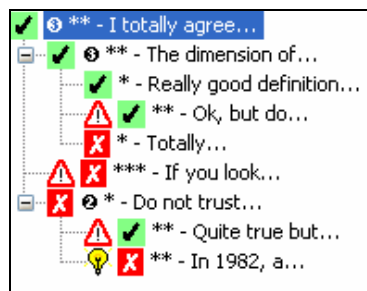
FIG. 2 – *A typical discussion thread in TafAnnote.*

- Reduce users' cognitive overload while they read an annotated electronic document. New annotations for the current user are displayed with a specific pictogram so that the reader doesn't have to remember the ones he has already read. Moreover, when a user creates an annotation, he has to indicate his expertise level. This helps future readers to estimate and moderate their trust in annotations. Finally, we took back types introduced by the *Annotea* project (Kahan et al., 2001). However, instead of associating only one type with an annotation, we propose to describe it with one or many types so that an annotation can be seen according to its facets. The *TafAnnote* system allows annotators to associate many types to the same annotation; to our knowledge, that is not possible with annotation systems of TAB. 1. Thanks to these annotation types, our system measures an annotation reliability as shown above.

- Improve the way annotations are displayed so that readers obtain more information without requiring more effort from them. For instance, contrary to *Amaya* that represents an annotation within its document simply with the icon , we display in *TafAnnote* the range of the annotation, a metaphoric preview of its contents using annotation types icons and the number of replies it sparked off. If the user wants to know more about it, a tooltip popup displays the author's identity, the title he gave to the annotation and the beginning of the comment (as the reader hovers over the annotation).

The recapitulative table TAB. 4 presents *TafAnnote* according to the same evaluation criteria as TAB. 1.

Year	Application name	Reference	Type	Information about the annotator	Available types for describing an annotation	Annotation share	Discussion thread support
2005	TafAnnote	(Cabanac, 2005)	R	login, name, surname, email, personal web page	{Comment, Reference, Positive judgment, Negative judgment, Correction, Question, Example, Confirm, Refute}	private or public	yes

TAB. 4 – *The TafAnnote system characteristics.*

TafAnnote supports discussion threads where the original annotation and its replies are typed (cf. FIG. 2). Therefore, in order to evaluate an annotation reliability, a reader can consult both its author's expertise level given at the creation and the opinion types of the replies, if provided. For a reader, this work is harder and harder to achieve as the discussion thread contains numerous levels of replies. Thanks to the social reliability algorithm that we have detailed in section 3, we can adapt the visual presentation of annotations: we emphasize validated annotations whereas we minimize equivocal others. Actually, we modify the size of opinion class icons (cf. TAB. 2) according to a linear adjustment. We use the *VisualOpinionIconSize*(*a*) function returning the size of the opinion icon according to $|reliability(a)| \in [0 ; 1]$ and *maxOpinionIconSize* (resp. *minOpinionIconSize*) which is the maximum (*resp.* minimum) opinion icon's size. Therefore, validated annotations are clearly visible (cf. FIG. 3).

$$VisualOpinionIconSize_{[minOpinionIconSize \, ; \, maxOpinionIconSize]}(a) = (maxOpinionIconSize - minOpinionIconSize) \times |reliability(a)| + minOpinionIconSize$$

EQU. 6 – *Size of an annotation opinion icon according to the annotation reliability.*

The annotations reliability calculation has been implemented into an Oracle PL/SQL package running on the *TafAnnote* annotation server, on server side. It is invoked every time the *TafAnnote* client embedded in Mozilla Firefox retrieves annotations associated with a given document.
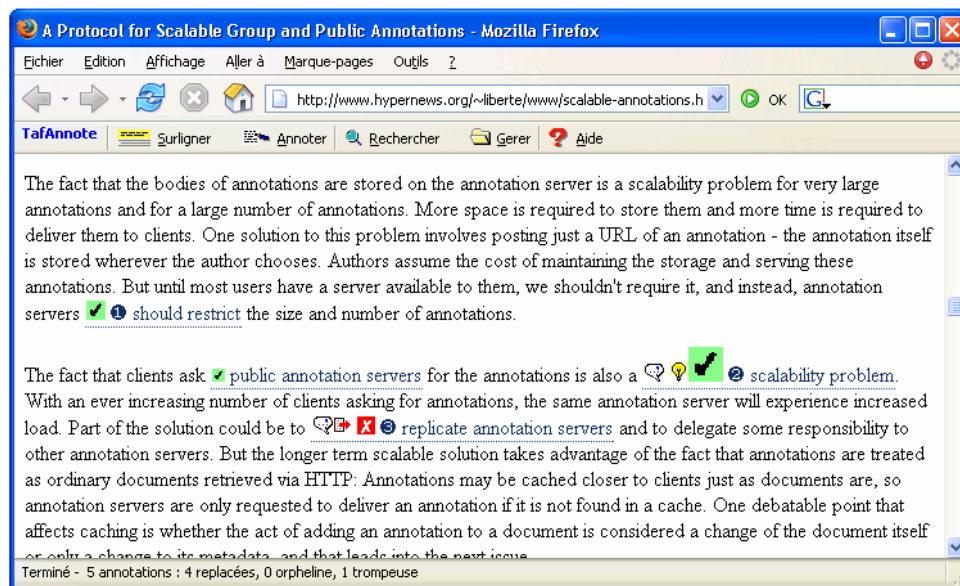
FIG. 3 – *Adapted visualization of an annotated Web page in TafAnnote.*

5   CONCLUSION AND PERSPECTIVES

In this paper we propose a way to compute an annotation reliability. This reliability measure modifies the impact of the annotation contents on the annotated passage. It relies on a conceptual model of collaborative annotations that introduces some specific types and discussion threads support. The reliability measure takes into account the way other readers confirm or infirm annotations.

An implementation of the reliability measure is provided through the *TafAnnote* annotation system. Such a system can exploit the gain given by the annotation contents associated to any comment, i.e. any reply.

In terms of perspectives, we have to evaluate this approach through a concrete application. Furthermore, we have identified evolutions for such a system; we can apply natural language processing techniques to annotations contents in order to deduce "opinion" types. Moreover, we can study how validated annotations, i.e. reliable ones, can improve an indexation process. Another perspective is to study the impact of such an annotation system in automatic document summarization.

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