A Social Network to Increase Collaboration and Coordination in Distributed Teams

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Abstract. Trust is one of the key factors involved in determining the success or failure of any project. However, achieving and maintaining trust in distributed projects when team members are geographically, temporally and culturally distant from each other is a considerable challenge. In this paper, we present Trusty, a tool designed to help develop trust in Virtual Teams. The tool is explained by using a schema of trustworthiness, and an indication of how the tool supports some features of these schema in order to foster the development of trust is therefore provided. Users have also evaluated the tool, and the results of this evaluation are presented here.

Keywords. Global software development, trustworthiness, virtual teams.

1 Introduction

The last few decades have witnessed a steady, irreversible trend towards the globalisation of business. Economic forces are relentlessly turning national markets into global markets and spawning new forms of competition and cooperation that reach across national boundaries. This change is having a profound impact on not only marketing and distribution, but also the way in which products are conceived, designed, constructed, tested, and delivered to customers [1].

Companies are therefore expanding globally, and are distributing their teams around the world by a variety of means such as acquisitions, partnerships, and outsourcing. As globalisation becomes more prevalent, many companies are evolving their approach and practices, and thus perhaps demonstrating the maturity of the distributed model. It is the age of Virtual Teams (VTs), in which members use technology to interact with one another across geographic, organisational, and other boundaries [2]. VTs can be composed of the best individuals for the task regardless of their physical or organisational location, thus enhancing the quality of decisions [3]. Furthermore, in order to attract and retain employees, and knowledge workers in particular, organisations are increasingly offering their employees remote working options [4]. Overall, VTs provide an effective structural mechanism with which to handle the increased travel, time, coordination, and costs associated with bringing together geographically, temporally, and functionally dispersed employees to work on a common task. Over the last decade, researchers have sought to understand the benefits and costs associated with VTs. Given this, there is now a burgeoning amount of literature on VTs that spans multiple disciplines [5].

Nevertheless, various challenges appear in VTs, one of which is a lack of trust that leads to other important consequences such as "poor socialisation and socio-cultural fit, absence of

conflict handling and lack of cognitive-based trust, increasing monitoring, inconsistency in work practices and both a decrease and unpredictability in communication" [6, 7]. Lack of trust can thus cause a decrease in productivity, quality and information exchange.

It is, however, difficult to build and foster trust by using an application, since the conditions associated with distribution are very demanding owing to the fact that most of the traditional sources of trust do not exist in networked conditions. Consequently, trust in networks may emerge occasionally, but maintaining and fostering it is particularly challenging [7-11].

Our awareness of this problem led us to study how this lack of trust could be avoided or decreased. Social Networking Sites (SNS), may be one alternative that can be used for this purpose, since they have the capacity to permit members of a virtual group to share experiences, exchange information and present themselves in real-time [10]. These features of SNS encouraged us to develop a tool based on the idea of a social network that helps to build trust among VT users. This tool is called Trusty.

The Trusty tool was therefore designed with the purpose of facilitating the fostering of trust among team members. The functionality of "Trusty" has consequently been aligned and presented according to the schema of trustworthiness proposed by [11]. Furthermore, in this paper we present the results of the mechanisms and information elements of Trusty as regards their trustworthiness, which were tested by 100 developers from 5 different cities in Mexico.

2 Background

In the literature, the term "trust" acquires various meanings according the context in which it appears. Trust is generally defined as a "positive characteristic leading to desirable behavior and outcomes". According to [12], it is therefore possible to find different types of trust, which are:

i) Personal or impersonal, including cognitive trust, which refers to beliefs about others' competence and reliability. This can lead individuals to engage in less self-protective actions and be more likely to take risks. This

type also includes affective trust, which refers to what arises from emotional ties among group members that reflect beliefs about reciprocated care and concerns.

ii) Swift or fragile. Swift trust occurs when people obtain trust from previous settings in the present. This emerges in a work context and in a limited history of working together, diverse member skills, etc. Fragile trust is a positive trust that is vulnerable to opportunistic defections. It generally develops early in a team's life cycle [13].

iii) Positive or Negative. Even when positive trust is desirable, negative trust and distrust may emerge. Negative cognitive trust occurs when a trustor believes that a trustee will not fulfil commitments and does not have the necessary competencies and skills to make an effective contribution. Mistrust may therefore stem from the unknown and can change to positive trust if expectations are met or exceeded.

Trust building is important, but more important is the initial trust building, because it is a process in which the trustee's trustworthiness is evaluated and expectations are negotiated [14], such that if the expectations about a trustee are not clear and well set out from the beginning, subsequent efforts to achieve or maintain trust will be useless [13].

3 Schema of Trustworthiness

All of the above has led different researchers to make efforts to develop and maintain trust during virtual teamwork [4, 15-17] in which they have identified that external signals (reputation, roles, rules), and intrinsic factors (predisposition to trust), determine initial swift trust. Moreover, assessments of benevolence and the continued assessment of integrity determine trust during the final stages of work, signifying that external signals (reputation, roles and rules), and intrinsic factors (predisposition to trust), determine initial swift trust. An appreciation of ability and integrity (cognitive trust), also enables trust to be established when a team first begins to work together. Benevolence (affective trust) ,and the continued assessment of integrity similarly determine trust in the later stages [13].

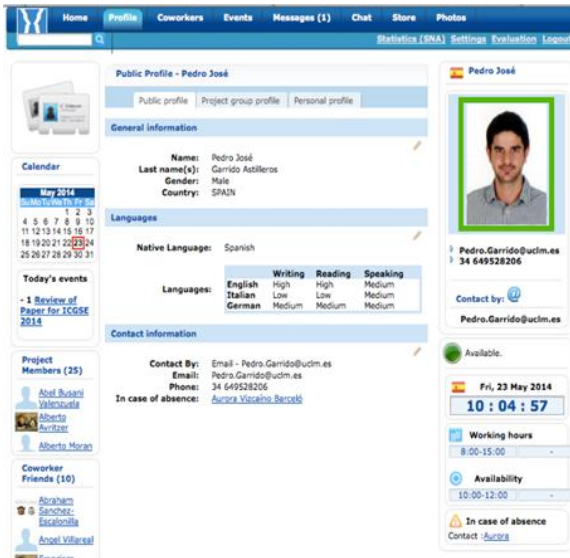**Fig. 1.** Model for the schema of trustworthiness proposed in [11]

Fig. 2. Trusty tool view

Fig. 3. Public profile information provided by trusty

The features of trust described previously are used by the authors of [11], to propose a method with which to improve the creation of interpersonal trust in a virtual team, the type of trust in which we are interested for this study.

The proposal from the aforementioned study will be used to show how the Trusty tool fosters interpersonal trust in VTs. The schema of trustworthiness, which has five main categories as is shown in Figure 1, is summarised in the following section.

4 Fostering Trust with Trusty

Trusty is a tool which was designed with the goal of fostering trust in VT's (see Figure 2). Trusty was developed to have the following main capabilities:

- To provide useful information about co-workers, focusing on easing the communication among team members.

- To provide mechanisms through which to share informal information in order to increase the friendship among members and, consequently, the team's spirit of trust.

- To provide mechanisms to support communication by means of a set of groupware tools.

- To provide mechanisms to support knowledge sharing.

- To provide mechanisms to support coordination by means of event creation and sharing.

- To provide reports on and statistical analyses of the social network supported by the tool in order to help project leaders to obtain feedback about members' interactions.

We have taken the schema of trustworthiness proposed by [11], as a reference model to explain how Trusty tool fosters trust during teamwork.

In this section we therefore describe how reliability can be perceived by a Trustor as regards the information elements that impact on the categories proposed in the schema of trustworthiness.

4.1 Communality

The first category that [11] considers important in order to foster trust is communality, which refers to the personal characteristics that the trustor has in common with the trustee. This can be any shared characteristic, like a similar goal that they wish to achieve, shared language use, common identity characteristics or shared values.

Trusty attempts to foster Communality by providing different types of information stated in three profiles: a public profile, a project group profile and a personal profile (see Figure 3A). These allow trustees to discover any characteristics that they may have in common with a particular trustee.

The *public profile* shows general information about stakeholders (trustee). It is therefore visible to all the people in the organisation in order to provide information that will allow them, for instance, to communicate with each other. The information shown in this profile is considered to be common (gender, nationality, native language and level of knowledge of foreign languages).

We considered that it was necessary to show information regarding gender (see Figure 3A) because some people feel more comfortable interacting with people of the same gender, or vice versa and sometimes it is difficult to know whether you are interacting with a man or a woman just by their name. A mistake of this nature may be offensive or embarrassing [18].

Furthermore, the language is very important for communality, since it can be a key factor (see Figure 3B). This is because the language will be the communication system that will allow the stakeholders to communicate and exchange their ideas [19-21].

It is thus important to know a trustee's level of knowledge of languages because the common language among stakeholders could increase the trust needed to start an interaction [22]. The objective of the *project profile* is to share information about those members who are working on the same project, which might make communication and coordination easier (see Figure 4).

Project Gropup Profile - Pedro José

| Public profile | Project group profile | Personal profile |

General information
Project information

	Project	Role	Date joined
	PFC_001_GSD	**Project Manager**	2010-02-27
	Astra_Project GSD	A **Programmer**	2010-02-02
	Evaluation_project	**Programmer**	2011-06-14
	Evaluation_project4	**Programmer**	2010-07-14
	Evaluation_project3	**Programmer**	2010-07-14

Work schedule B
Technical Information

C	**Technologies:**	web technologies, ajax,
	Programming Languages:	java, c , c#, python, php
	Others:	Expert in software design patterns

Work place information

D	**Continent:**	Europe
	Work Country:	SPAIN
	City:	Ciudad Real
	Company:	UCLM
	Time Zone:	Europe/Madrid

Fig. 4. Project group profile information provided by trusty

Personal Profile - Pedro José

| Public profile | Project group profile | Personal profile |

General information
Contact information
Cultural information

A	**Culture:**	Spanish Culture
	About my culture:	I have been living in Norway for one year. And I have visited many times Italy, because a lot friends of me are living there.

Status information
Work Experience
Studies
Interests

B	**Hobbies:**	Read and sports.
	Activities:	Browsing the Internet, comment on blogs and forums, and extreme sports.
	Interests:	Healthy living and sport.
	Cities Visited:	London, Oslo, Bergen, Milan, Trento, Padova, Bari, Napoles, Venecia, Gdansk, Copenhagen, Porto, Lisboa,...
	Favorite Music:	Jazz Fusion, Rock Pop, Flamenco
	Favorite TVShows:	quiz show, nature documentaries, Lost, Dexter
	Favorite Movies:	Godfather, Pulp Fiction, Braveheart.
	Favorite Books:	The Boy in the Striped Pyjamas.

Fig. 5. Personal profile information provided by trusty

This profile includes all the information in the public profile and also appends (see Figure 4A) project-related information such as the name of the project on which a person is working or has worked, their role in the project, current activities, forthcoming events (see Figure 4B), etc. Information concerning people skills (see Figure 4C) and place of work (see Figure 4D) can also be included. This information helps to locate where the other person is, as communicating with a colleague without knowing where that person is located may sometimes make one feel uncomfortable [23].

This information allows the trustor to discover features that s/he may have in common with the trustee, signifying that using information related to the type of project, role and knowledge can help to generate more willingness to interact [24].

The *personal profile* helps to share more private aspects, which is critical when attempting to foster trust. For instance, the culture a person is from may allow trust to be fostered among partners because culture plays a key role in the context of VTs [25], since it is clearly reasonable to believe that if you know more about a person, you might have more criteria to decide whether that person is trustworthy. Moreover, according to [26], how well people know each other has an impact on team spirit. This profile gives people the opportunity to share more information about themselves and to provide a channel for informal communication in VTs, with the objective of increasing mutual knowledge and helping to build trust [23]. The personal profile (see Figure 5) includes other data items that are specifically related to the person in order to encourage interpersonal interaction. This profile is only visible to people that have been previously accepted as "friends". The importance of understanding cultural differences and the relevance this can have in the successful completion of projects should not be underestimated [25], since a trustor could feel more comfortable starting an interaction with a trustee from the same or a similar culture (see Figure 5A) [27]. In contrast, the interest information (see Figure 5B) provides data concerning personal preferences, such as hobbies, activities, etc. So, unlike other (social networks) tools, the personal profile of Trusty is oriented to establish a formal communication, and do it as smoothly as possible,

among the team members providing information such as culture, hobbies, personal interests, etc.; one of the reasons for adding this type of information elements is for users to find their personal interest characteristics with their colleagues, to facilitate the starting of communication and to form their working community.

Trusty additionally includes the information element "contact by" which allows a trustee to indicate the means by which media s/he prefers to be contacted (see Figure 2). That is, when a trustor identifies that a possible trustee has chosen the same means of communication, this could encourage the trustor to contact him/her since they could interact by the same means in a comfortable manner.

4.2 Ability

In order to foster trust, it is important to know a trustee's capabilities, determined by knowledge, skills and competences, which enable tasks to be performed within a specific domain.

The project group profile provides two sections in which abilities are shown: Information about the trustee's roles and the project in which s/he is involved (Figure 6A) and type of experience with technology use (Figure 6B). The personal profile also provides more data about skills and knowledge [28], such as previous work experience (Figure 6C) and academic studies (Figure 6D). This information will allow the trustor to perceive a trustee's capabilities in a rapid and explicit manner. This kind of information could be useful when assigning tasks, and more so when these tasks are critical to a project [29].

4.3 Benevolence

This category refers to the perceived level of courtesy and positive attitude a trustee displays towards the trustor. It includes the extent to which a person seems: willing to help, available, sharing, to have faith in intentions, receptive, kind, open, caring and committed. Controlling benevolence in a tool can be a challenge.

However, we explain how we believe that the different features of Trusty could help a trustor to detect the positive attitude towards collaboration

that a particular person has (willingness to help, availability and sharing).

One important characteristic of Trusty is the existence of a mechanism that detects *availability* for contact [24], identifying the best moment at which to initiate communication with other users based on their personal preferences. To do this, user profiles in Trusty show information about the user's working hours, the time at his/her site, and the most important aspects of his/her current status regarding availability, his/her preferred time to be contacted, etc. It should be highlighted that users provide some of this information when they define their profiles (see Figure 7).

Trusty includes a mechanism that helps to choose the best moment at which to initiate communication with another user based on people's personal preferences.

To do this, each person provides, and his/her profile shows, information about their working hours, their current status regarding availability (see right-hand side of Trusty screens in Figure 2), the time people prefer to be contacted, etc. In addition, it has been shown that interruptions have a negative impact on task completion time [14, 30], decision-making [31, 32], and people's emotional states [33]. Interruptions may also result in prospective memory failure [30, 34], which refers to the fact that an individual may have a problem remembering what s/he has to do as regards a planned task (or in this case, the interrupted task). Moreover, in order to make this information clearer for the users, Trusty represents the user's status with a colour code similar to that of CWS [35]. This colour code is guided by the selective availability criteria [36], such as "*I am available only to people who are related to the task I am dealing with now and am not available to other people*".

Trusty does this by using different colours on the photo frame in the panel on the right of the screen in order to indicate whether or not it is an appropriate moment to start a synchronous interaction with the other person. There are five possible colours (blue, green, yellow, orange and red). The colour code for the photo frame, taking into account the setting of the current status and the time at the site with regard to the hours at which that person prefers to be contacted.

Fig. 6. Ability to view information using trusty

Fig. 7. Availability view

Fig. 8. Statistics (SNA) view

Table 1. Trusty versus continuous coordination tools

Tools	Communality	Ability			Benevolence								Internalized norms						Accountability			
	Knowledge	Competence	Skills	Willingness to help	Availability	Sharing	Faith in intentions	Receptively	Friendliness	Openness	Caring	Commitment	Integrity	Discretion	Honestly	Fairness	Loyalty	Reliability	Consistency	Self-confidence	Persistence	Responsibility
Palantir												X										X
Workspace Activity Viewer		X										X										
Ariadne					X																	X
World View	X	X			X																	
Trusty	X	X	X	X	X	X	X	X			X	X										X

Table 2. Trusty versus enterprise social networks

Tools	Communality	Ability			Benevolence								Internalized norms						Accountability			
	Knowledge	Competence	Skills	Willingness to help	Availability	Sharing	Faith in intentions	Receptively	Friendliness	Openness	Caring	Commitment	Integrity	Discretion	Honestly	Fairness	Loyalty	Reliability	Consistency	Self-confidence	Persistence	Responsibility
Yammer	X				X	X																
Zyncro	X					X						X										
Kudos		X																				
Facebook	X					X																
Twitter						X																
LinkedIn	X	X																				
IBM SB	X					X						X										
Trusty	X	X	X	X	X	X	X	X			X	X										X

Another of the capabilities that we wished to include in the design of Trusty was that of obtaining information about the usage of the tool by team members. This information may, for example, be useful in detecting that a particular person is undergoing message overload or the lack of interaction between certain team members. The algorithm that makes this possible is based on SNA [37]. The information is shown as a graph on which nodes represent Trusty users (see Figure 8C). This statistical mechanism is accessible to project managers and system administrators. The tool can be used to analyse various aspects of interaction on the social network, including message traffic, event publication, wall usage, profile visits, and knowledge repository usage (see Figure 8A). We therefore believe that this tool helps to increase positive leadership, team spirit and enthusiasm because it helps, for instance, to detect a particular worker's overload or whether there is a person who might have communication problems since s/he does not use any communication mechanisms (see Figure 8B). It is also possible to discover benevolence by analysing which people are contacted most often and whether or not they respond. This allows a trustor to "infer" whether the trustee is an open, kind or receptive person.

For instance, in Figure 8C we can see that there are several isolated nodes (Pablo, Jaime Alberto and Francisco), and this may be a sign of a problem, since as all these people are working on the same project it is logical to believe that all of them have to use some type of communication. When the project manager detects this situation by looking at the graph, s/he should attempt to find out why this situation has occurred. It might be that these people are on holiday at that time, and it is not therefore a problem. However, it could be a problem if these people do not communicate because they are shy or have problems understanding the messages, etc. In contrast, the node tagged as "Ana Lourdes" shows a lot of interaction with several members, and the project manager could therefore attempt to find out whether this person is overloaded or is an expert in a topic and is helping other teams' members.

Social Networks Analysis (SNA) [38], permits us to infer that a trustee has the characteristic of openness by viewing the items shared and the interest taken as regards interacting, even if s/he constantly responds to requests to interact [39]. The trustor can also infer whether a trustee is committed [40] and is interested in what is happening around the trustor, i.e. whether the trustee constantly participates on the trustor' wall. Moreover, when a trustee provides his/her availability schedule, a commitment indicator is shown.

According to literature, SNS is a good method with which to build trust in virtual teams. Furthermore, SNA can be used to obtain different information about team members, which might help to predict or detect possible problems in virtual teams, such as people who are isolated or overloaded, or a lack of communication among those that work in coupling tasks.

4.4 Internalised Norms

This category refers to the intrinsic moral norms a trustee uses to guard his/her actions. These differ from benevolence in that they are directed towards others in general, rather than toward a specific trustor. This includes the extent to which a person seems to have: integrity, discretion, honesty, fairness and loyalty [11].

The internalised norms are not potentiated with the tool, as we believe that they are very particular aspects of people's personalities. They have not therefore been considered when designing Trusty. However, Language Analysis regarding how a trustee uses the chat and walls could serve to infer some people's values. This language issue is not, however, within the scope of Trusty.

4.5 Accountability

This is the last category of the schema (see Figure 1) and refers to the degree to which a person is liable and accountable for his/her acts and meets the expectations of another person. It includes the extent to which a person seems to be: reliable, consistent, self- confident, persistent and responsible.

Trusty provides a list per project showing in which projects the trustor is involved. The items of information obtained from this list are project name, date joined, role, start date and completion of the project (responsibility). This kind of information makes it possible to know the workloads that teamwork members have accepted [41], and a trustor can therefore consult this information in order to see what responsibilities a person has and whether that person tends to meet deadlines.

5 Differences between this Social Application and Others

Several applications can support trust building in VT's. Table 1 shows a comparison between "Trusty" and various other continuous coordination tools. This comparison was performed according to how this tool fulfils the schema of trustworthiness proposed by [11]. A brief description of these tools is presented as follows:

− Palantír [42]: This application fosters benevolence towards the other team members, since it is possible to know which member has edited a module (commitment) and whether the task was completed (responsibility).

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Table 3. Factors and internal consistency

#	ITEMS	Factors				
		1	2	3	4	5
1	The information that Trusty distributes forms part of my work activities.	.657				
2	The information that Trusty shows is in accordance with my communication needs at work.	.723				
3	Trusty's information elements could help me to resolve any doubts I may have about my colleagues' experience.	.537				
4	Trusty shows different information profiles that could help me to identify a colleague with similar interests to my own.	.445				
5	The Trusty Project Group Profile shows information about a colleague's software development skills		.682			
6	I would be prepared to use Trusty to obtain information about my colleagues' expertise		.737			
7	Trusty allows me to analyse a colleague's level of interactions with the work group		.521			
8	Trusty provides information about colleagues in a clear way		.731			
9	A colleague's availability mechanism is appropriate as regards determining the best moment at which to contact me			.574		
10	The mechanism used to determine the best moment at which to contact a colleague is appropriate.			.551		
11	The assistance that I receive from the colour code in order to determine a colleague's state of availability is easy to understand.			.674		
12	Using Trusty to communicate with my colleagues is appropriate and useful.			.671		
13	The information provided about a colleague is sufficient for me to be able to contact him/her.			.678		
14	I shall recommend Trusty to my colleagues.				.538	
15	If anyone asks me about the Trusty system, I shall recommend it to them.				.496	
16	I shall encourage my colleagues to use the different services provided by Trusty.				.686	
17	If my organisation adopts Trusty, I shall use it to communicate with my colleagues				.574	
18	The personal information included in Trusty does not have a negative effect on me.				.727	
19	When using Trusty, it is easy to navigate and discover all that I need to know about my colleagues.				.459	
20	All the information provided by Trusty is supported in the software development work activities.				.438	
21	The image projected as regards the information provided by Trusty is one of integrity and good values to communicate with colleagues					.635
22	I can be sure that the use of my personal information will be managed with discretion and not made public, but will only be used by the organisation.					.607
23	The information provided by Trusty is truthful and verifiable.					.640
24	The information in Trusty can keep me informed about a colleague's workload.					.553
25	I consider that I could become skilled in the use of Trusty in a short amount of time.					.551
26	Trusty is able to provide me with information about a colleague's project commitments.					.552
27	I consider that the information that Trusty distributes is consistent with the communication among colleagues in Software Development					.690

Accumulated variance =56.87
Cronbach's Alpha = 0.917

– Workspace Activity Viewer [43]: This application helps to create more accurate expectations (commitment), since it illustrates each member's prior performance (competence).

– Ariadne [30]: This application permits team members to monitor themselves (availability). It also provides an interactive analysis, which permits the project manager to adjust team members' tasks (responsibility).

– World View [30]: It uses intuitive visualisations to explain the team members' status by identifying relevant tasks (competence), irrelevant tasks (communality), and dependences (commitment).

As the results in Table 1 show, Trusty is the most complete application as regards fulfilling the schema of trustworthiness.

On the other hand, in Table 2 is shown a comparison between Trusty and social networks. It is important to highlight that the social networks selected have been promoted for use in companies. A description of these social networks is presented as follows:

– Yammer [44]: This social network includes microblogging, private chats, shared workspaces (availability) and document exchange (sharing).

– Zyncro [32]: This social network was designed to allow employees to recognize each other, which promotes engagement (commitment) with the enterprise.

– Kudos [45]: It is a microblogging application, which includes an employee recognition program and a corporate social network designed to engage the enterprise team with enhanced communication, collaboration, appreciation, recognition, and rewards (competence).

– Facebook [46]: The main features are sharing and communication among contacts considered as "friends" (sharing). This utility also permanently shows its members' public profiles (communality), signifying that it is possible to access personal data.

– Twitter [47]: Users can describe an actual situation or discuss a specific topic (sharing).

These comments can be followed by users, thus allowing them to keep up to date with their topics of interest.

– LinkedIn [48]: It is thus possible to contact professional colleagues or old schoolmates. This network also makes it possible to become known in the professional field in order to find a job (communality).

– IBM Social Business (SB) [49]: This Social Business can help an organization extend customer relationships, generate new ideas faster (sharing), identify expertise (communally) and enable a more effective workforce (commitment).

– Table 2 shows Trusty as the social network that provides the most features to help develop trust. The fact that the SNS Analysis is included provides it with an important competitiveness and advantage over the other social networks, as important information can be obtained from these analyses. The differences shown in this section, with respect to Trusty's characteristics against other tools, were possible to determine by means of the factors of the Rusman Schema, since its factors helped us to make an analysis centered on the characteristics of Trustworthiness. With this it was possible to identify the shortcomings of the tools in terms of these factors and from there it could be possible to propose more suitable designs for the promotion of Trustworthiness among different users of an organization or virtual community.

6 Evaluation

The objective of this evaluation was to perceive the trustworthiness of Trusty by analysing users' opinions with regard to the performance of its mechanisms and services.

6.1 Design of the Study

A scenario was therefore designed whose objective was to test all the Trusty options, signifying that the users had to carry out all the activities indicated in the scenario. In order to test the trustworthiness of the application, we designed

a questionnaire on the basis of the schema of trustworthiness proposed by [11].

The decision was made to first carry out a pilot evaluation in order to test whether the scenario was as complete as possible (all the main functionalities were dealt with) and that the questionnaire was easy to understand. Two experts in Software Development created the activities and answered the questionnaire. They detected various limitations in the tool when it was used with Mac and they also suggested the addition of more activities in the evaluation scenario. Trusty was therefore improved and the proposed activities were added.

6.2 Subjects

The participants were 100 workers from different companies in five different Mexican cities. All of them were participating or had participated in Software projects. Their average age was 32 years old, and they all had at least three (3) years of experience in Software Development. All of them had Bachelor's degrees (BSc) in computer science or similar and eight (8) had Master's degrees (MSc) in computer science. They had different roles, i.e. there were 10 project managers, 2 testers, 25 programmers, 30 analysts, and one researcher. The remaining 33 respondents had played several roles, including programmer, analyst, tester or project manager. Each person was a member of a different software development enterprise in different geographical locations and they carried out the evaluation activities in their own workplaces.

6.3 Materials

This section describes the different materials used:

Scenario Document: This document described a set of scenarios for the fifteen activities that users have to perform in order to try out all the basic features of the tool.

Questionnaire regarding the tool: The questionnaire used to measure trustworthiness contained 27 questions quantified using a Likert scale of 1 (strongly disagree) to 5 (strongly agree). The average time needed to respond to the questionnaire was 15 minutes. Before responding

to the questionnaire the participants were asked to state their years of experience in software development, their age, highest qualifications and the role they played in the organisation. This questionnaires was designed by using the schema of trustworthiness proposed by [11] to create an initial set of 50 questions to which the aforementioned people would respond. This preliminary format then was presented to a group of experts (psychologists and software engineers) in order for them to evaluate it. The analysis carried out allowed us to select the 32 questions contained in the first version of the trustworthiness questionnaire.

The concurrent validity of the questionnaire was obtained by means of contrasted groups obtained using the t test for independent samples, with the aim of identifying the questions that would show which participants had obtained a low mark as regards their perception of trustworthiness, and which had obtained high marks. We discovered that the total number of questions had p values of less than 0.05, i.e. all of them were discriminatory and were sensitive as regards identifying low and high marks. We next developed a frequency analysis of the questions in order to eliminate those that were most biased and had an asymmetric distribution, thus reducing the number of questions in the questionnaire to 27, which were then subjected to an exploratory factorial analysis using orthogonal rotation techniques in which the saturation point was 0.40.

This initially showed seven factors, five of which contained three or more questions. Those factors containing less than three questions were eliminated, leaving us with five factors. This factorial structure of 27 questions proved to be the most psychometrically appropriate and consistent, and was as follows:

- Factor 1: Communality (4 items).
- Factor 2: Ability (4 items).
- Factor 3: Benevolence (5 items).
- Factor 4: Internalized norms (7 items).
- Factor 5: Accountability (7 items).

The five factors, along with their respective questions, accumulated variance and Cronbach's alpha are shown in Table 3.

Table 4. Communality results

ITEMS	Mean (std dev.)
1. The information that Trusty distributes forms a part of my work activities.	3.72 (0.780)
2. The information that Trusty shows is in accordance with my communication needs at work.	3.67 (0.753)
3. Trusty's information elements could help me to resolve any doubts I may have about my colleagues' expertise.	3.66 (0.879)
4. Trusty shows different information profiles that could help me to identify a colleague with characteristics that are similar to my own.	3.76 (0.698)
Total	**3.70 (0.046)**

Table 5. Ability results

ITEMS	Mean (std dev.)
5. The Trusty Project Group profile shows information about a colleague's software development skills.	3.10 (0.870)
6. I would be prepared to use Trusty to obtain information about a colleagues' expertise.	2.74 (1.088)
7. Trusty allows me to analyse a colleague's level of interactions with the work group.	3.68 (0.634)
8. Trusty provides information about colleagues in a clear way.	3.68 (0.764)
Total	**3.30 (0.463)**

Table 6. Benevolence results

ITEMS	Mean (std dev.)
9. A colleague's availability mechanism is appropriate as regards determining the best moment at which to contact me.	3.80 (0.620)
10. The mechanism used to determine the best moment at which to contact a colleague is appropriate.	3.60 (0.696)
11. The assistance that I receive from the colour code in order to determine a colleague's state of availability is easy to understand.	3.84 (0.581)
12. Using Trusty to communicate with my colleagues is appropriate and useful.	3.86 (0.697)
13. The information provided about a colleague is sufficient for me to be able to contact him/her.	3.57 (0.807)
Total	**3.73 (0.138)**

The questionnaire as a whole obtained an internal consistence of α=0.917.

6.4 Procedure

Three activities were necessary for this evaluation, which were:

i) Initial Meeting. The participants were introduced to the study and were provided with the Trusty tool and its user manual.
ii) Trusty Activities. They were asked to perform the following activities with the tool, and they had one week to carry out the tasks:

- Update their general information.
- Update the profile of a project group.
- Update their personal profile.
- Perform searches to locate a user ("Thomas").
- Locate the partners in the projects in which they were also involved, and identify their nationalities.
- Locate and identify friends' hobbies.
- Post a message.
- See next month's events and their rates.
- See posts.
- Create a message.
- Send a Chat message.
- Use the Private Message chat application.
- See the files in the "Documentation" repository.
- Consult the amount of interactions in a user profile.
- Create a repository and upload a file

iii) On-exit survey. Finally, we asked the participants to fill in a questionnaire evaluating the trustworthiness of the System.

6.5 Limitations

The experiment described in this section and the methods used in order to evaluate it might have several weaknesses. The influence that these weaknesses may have had on the results is explained as follows: A) The results are focused on the participants' opinions and we do not therefore know whether being exposed to the system changed their perception of the technology. These results are restricted to a group of developers who work in geographic locations in Mexico, and it will therefore be difficult to replicate the results. B) Finally, this study is an exploratory work whose reach is focused on the trustworthiness of the use of Trusty in Software Development work environments.

6.6 Results and Discussion

The evaluation of Trusty was performed in collaboration with enterprises working in Global Software Development (GSD). The objective of this evaluation was to perceive the trustworthiness of Trusty by analysing users' opinions as regards the performance of its mechanisms and services. A scenario was therefore designed whose objective was to test all the options of Trusty, signifying that the users had to carry out all the activities indicated in the scenario, after which we analysed the participants' responses to the questions. The questionnaire was quantified using a Likert scale of 1 (strongly disagree) to 5 (strongly agree).

In the case of testing **Trusty's Communality**, the mean communality score that users gave to Trusty was 3.70 (s.d.= 0.046), as is shown in Table 5. We should state that the developers considered that the information distributed by Trusty is appropriate for DSD activities (mean = 3.72; s.d.= 0.780) and that they also considered that Trusty provides useful information with which to identify a colleague's characteristics.

However, although Trusty provides communality with adequate support, the mean obtained would have been higher if more detailed information elements that would enable the trustor to identify personal characteristics that s/he has in common with the trustee had been provided (e.g. types of projects on which they have participated or a link to their personal network.

In the case of testing **Trusty's Ability**, the mean Ability score that users gave to Trusty was 3.30 (s.d.= 0.463), as is shown in Table 5. According to the scale in the questionnaire, the developers considered that the information provided by Trusty is insufficient. This is evident if we observe the mean score obtained by Item 6, which was evaluated with a low mark (mean =2.74;

Table 7. Internalized norms results

ITEMS	Mean (std dev.)
14. I shall recommend Trusty to my colleagues.	3.90 (0.732)
15. If anyone asks me about the Trusty system, I shall recommend it to them.	4.00 (0.804)
16. I shall encourage my colleagues to use the different services provided by Trusty.	3.71 (0.902)
17. If my organisation adopts Trusty, I shall use it to communicate with my colleagues.	3.41 (0.889)
18. The personal information included in Trusty does not have a negative effect on me.	3.56 (0.935)
19. When using Trusty, it is easy to navigate and discover all that I need to know about my colleagues.	3.94 (0.694)
20. All the information provided by Trusty is supported in the software development work activities.	4.07 (0.590)
Total	**3.80 (0.245)**

Table 8. Accountability results

ITEMS	Mean (std dev.)
21. The image projected as regards the information provided by Trusty is one of integrity and good values to communicate with colleagues.	3.89 (0.665)
22. I can be sure that the use of my personal information will be managed with discretion and not made public, but will only be used by the organisation.	3.69 (0.748)
23. The information provided by Trusty is truthful and verifiable.	3.62 (0.838)
24. The information provided by Trusty can keep me informed about a colleague's workload.	3.66 (0.728)
25. I consider that I could become skilled in the use of Trusty in a short amount of time.	3.58 (0.755)
26. Trusty is able to provide me with information about a colleague's project commitments.	3.27 (1.004)
27. I consider that the information that Trusty distributes is consistent with the communication among colleagues in Software Development.	3.90 (0.732)
Total	**3.66 (0.213)**

s.d.=1.088), since the participants considered that they were not given sufficient information about their colleagues' skills. What is more, the information provided about the Project Group profile was not sufficient as regards their colleagues' development skills or capabilities.

In the case of testing **Trusty's Benevolence,** the mean benevolence score that users gave to Trusty was 3.73 (s.d.= 0.138), as is shown in Table 6. The participants considered that Trusty provides elements that allow them to perceive their colleagues' level of availability and willingness to

help, as is evidenced by Item 12 (mean 3.86; s.d.=0.697). In this case they perceive that the information provided by Trusty is useful for them as regards contacting their colleagues at appropriate moments. We should also mention that, with regard to Item 11, they found that the colour code provided by Trusty in order to identify a colleague's availability is easy to use and understand (mean=3.84; s.d.=0.581).

In the case of testing **Trusty's Internalised norms**, the mean Internalised norms score that users gave to Trusty was 3.80 (s.d.= 0.245), as is shown in Table 7. The participants considered that Trusty tool promotes activities in the Software Development work environment (mean=4.07; s.d.=0.590). They were also of the opinion that Trusty helped them to find information about their colleagues (mean=3.94; s.d.=0.694), thus promoting communication by means of different services (mean=3.71; s.d.=0.902), and signifying that they would recommend the tool to their colleagues (mean=4.00; 0.804). In general, the participants considered that Trusty provides information with which to find colleagues and that this information is used only to support work activities.

In the case of testing **Trusty's Accountability**, the mean Accountability score that users gave to Trusty was 3.66 (s.d.= 0.213), as is shown in Table 8. Trusty tool was considered to promote integrity and good values with the aim of communicating with colleagues (mean=3.89; s.d.=0.665), whilst respecting the discretion of the organisation of the information (mean=3.69; s.d.= 0.748). However, despite being a tool with which to exchange personal and professional information, Trusty was not considered sufficient as regards providing information about a colleague's forthcoming engagements (mean=3.27; s.d.=1.004).

The results obtained from the questionnaire do indicate that Trusty provides a suitable level of trustworthiness among software developers. However, an important adjustment should be made to it as regards Ability, since the mean scores obtained for the responses tended towards the neutral part of the scale (mean=3.30/5). In the case of the remaining dimensions, the participants tended to agree that the tool was useful, although Trusty should be adjusted in order to facilitate trustworthiness towards colleagues in an organisation, and it will therefore be necessary to include information elements or mechanisms that will enable trustworthiness towards colleagues to be enriched.

7 Conclusions and Future Work

In this paper we have described some of the challenges of VTs. Lack of trust is one of the challenges that also affects communication, coordination and control. In order to decrease these problems, we have developed Trusty, a tool that has been designed to help to develop trust among team members and also to make communication, coordination, and control easier. Trusty has been explained by following the schema of trustworthiness proposed by [11], and showing how Trusty covers most of the features included in this schema.

Moreover, Trusty was tested by means of an evaluation at different software companies whose team members worked with geographically distributed co-workers. The results obtained have provided us with some insights into how Trusty was perceived by workers as regards its trustworthiness. These results provide evidence that users tend to agree that Trusty fosters elements related to Communality, Benevolence, Internalized norms and Accountability but that the information about Ability is not sufficient. It will be necessary to continue working on these aspects as there is still room for improvement.

Trustworthiness was measured by creating a questionnaire based on the schema of [11], which obtained a high internal consistency (α=0.917), and we therefore consider that the questionnaire is both reliable and valid for the purposes of this measurement. This questionnaire can be used to measure the level of confidence fomented in the work group via the use of communication and/or coordination tools, using the information elements that are distributed with colleagues' contextual, personal and professional information as a starting point.

The results obtained have provided us with information that will allow us to identify those elements of the Rusman schema used in Trusty that were perceived to be the weakest. In this case, Ability was perceived to be the lowest, and we are

therefore contemplating a modified version of Trusty that will permit access to more detailed information as regards the information elements that Trusty currently provides, such that if the trustor requires more information about a trustee's skills, it will be possible to obtain it.

To conclude, we would like to state that Trusty could be used by any company or organisation whose teams are distributed throughout the world owing to a variety of collaboration strategies such as acquisitions, partnerships, and outsourcing. We believe that the tool will be very useful, principally in the first steps of collaboration during which people do not know each other and communication and collaboration among team members is important.

Trusty could also be useful in academic settings, since there is a strong tendency to collaborate on projects with people from other countries. When preparing a European project, it is advisable to create a multinational consortium in which not all the researchers have previous experience of working together, and Trusty could be a perfect means to start this collaboration and to help to develop trust and team spirit. Moreover, Trusty could help researchers to discover which person is the most suitable to ask for help when performing a particular task.

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