

# Analyzing and Evaluating the Main Factors that Challenge Global Software Development

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**Abstract:** Global Software Development (GSD) projects are characterized by the fact that work is distributed throughout many geographically distanced sites. Software engineering activities in such scenarios face various challenges. Although interpersonal communication is crucial if a common understanding with regard to the system under construction is to be achieved, time separation, cultural diversity and economical factors make it impossible for face-to-face meetings to take place. In this paper, we introduce a basis for analyzing those aspects that might cause communication problems in GSD environments and suggest some strategies to reduce misunderstandings among stakeholders, with the aim of improving distributed projects.

## 1. INTRODUCTION

Global Software Development (GSD) projects take place in an environment in which stakeholders are dispersed throughout many distanced sites across the limits of a country. GSD can be implemented by means of off-shoring (relocating the process in another country but as a part of the same organization) or offshore outsourcing (hiring an external organization to perform certain activities in a different country to that in which the software is actually developed).

Industry has rapidly adopted these practices owing to their many economical advantages [1], such as the possibility of saving costs by locating software development in countries where salaries are lower. However, geographical dispersion over multiple sites also has a negative effect upon the team's performance [2, 3]. One of the most important challenges that GSD must confront in this respect is the lack of face-to-face interaction, in addition to other factors such as cultural diversity and time separation, which are also worthy of consideration.

As communication is a well-known challenge during any requirements elicitation process [4], we consider that communication in GSD projects must be specially analyzed, and a methodology for requirements elicitation in distributed scenarios must be defined.

In order to define such a methodology, we have analyzed the requirements elicitation methodologies for co-located projects and adapted the different phases to a distributed environment, proposing strategies to minimize the most common problems that affect communication. In this paper we analyze these factors and propose a way in which to evaluate them, along with a series of strategies to minimize

the problems that they may cause in communication. Bearing this in mind, the remainder of this paper is organized as follows: in Section 2 we discuss the main problems facing GSD projects and, in Section 3, we propose forms with which to collect related information and a list of guidelines to evaluate it. Based on this evaluation, Section 4 proposes certain strategies which can be used to minimize the problems caused by such factors. Moreover, we present the preliminary results of a controlled experiment in which some of the proposed strategies have been applied. Conclusions and future work are addressed in the last section.

## 2. IDENTIFYING THE FACTORS THAT INTRODUCE PROBLEMS IN GSD

Most works concerning GSD mention inadequate communication as a key problem for requirements engineering activities [2, 3], which is mainly caused by the loss of communication richness as a consequence of the lack of face-to-face interaction. Other problems also challenge communication and are related to the fact that stakeholders are distributed throughout different countries. The first of these problems is the *time difference* which signifies that timetables do not overlap or overlap for only a short period. Certain delays in the project may therefore occur as a result of a lack of synchronous collaboration [2]. *Time separation* also refers to the problem of a lack of timetable overlap. However, time separation does not only consider time difference but also cultural issues such as different working hours, lunch breaks, weekend or holidays times [5]. *Cultural diversity* is another problem when team members are distributed in different countries, since these countries tend to have diverse religions, languages, and customs [2, 6]. Finally, *knowledge management* in GSD projects becomes more difficult in distributed settings since there is a huge amount of information from multiple sources that needs to be appropriately shared among all the stakeholders [2].

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**Table 1. Relationship Between Factors and Problems in GSD**

	Inadequate Communication	Time Separation	Cultural Diversity	Knowledge Management
Timetable overlap	√	√		
Language difference	√		√	√
Cultural difference	√		√	
Stakeholders' cognitive characteristics	√			

**Table 2. Linguistic Tags Defined for Each Factor**

Factor	Linguistic Tags
Time overlap	low, medium, high
Knowledge about a common language	low, low-intermediate, medium, high-intermediate, high
Cultural difference	low, medium, high
Stakeholders' cognitive characteristics	type 1, type 2, type 3

Bearing such problems in mind, we shall attempt to identify certain factors that are related to them with the aim of defining strategies with which to minimize the problems they cause, as will be explained in the following two sections.

After studying the main problems detected in GSD projects, we searched for related factors that could be evaluated and used as a guide to suggest strategies to minimize such problems.

The factors chosen for evaluation are: working timetable overlap, language difference, cultural difference and stakeholders' cognitive characteristics. Their relationship with the main problems in GSD is shown in Table 1, and can be summarized as follows:

- **Timetable overlap** is related both to the time difference between sites and to cultural issues such as habits. It affects communication since it is related to the possibility (or otherwise) of synchronous interaction.
- **Language difference** affects both communication and knowledge management because of the importance of a common vocabulary.
- **Cultural difference** is a natural consequence of cultural diversity. The existence of an indicator regarding cultural difference allows us to discover whether or not it is necessary to implement a strategy to minimize the problems caused by cultural diversity.
- **Stakeholders' cognitive aspects** refer to the way in which people behave according to their innate characteristics. This behaviour influences the way in which people interact with the world, and particularly their communication with other stakeholders.

Obtaining an indicator with regard to each one of these factors will allow us to define when strategies to minimize

the problems related to them are necessary. We therefore need a means of obtaining a value for each factor from a set of easy-to-remember linguistic tags, thus providing us with the possibility of reusing our functions in other projects by adjusting the various parameters. The tags we have defined for each factor are shown in Table 2. The following step will be to define a method to obtain a value for each factor.

### 3. OBTAINING A VALUE FOR EACH FACTOR

In this section we shall explain how a value for the different linguistic tags can be obtained for each factor presented in the previous section.

#### 3.1. Timetable Overlap Evaluation

If we consider that a virtual team is the minimal group of people that must interact during the software requirements elicitation process, then, we propose the evaluation of how much time they share in order to be able to interact synchronously. To do so, we propose using a form in which each stakeholder's timetable is converted into Greenwich Mean Time (GMT), and calculating the overlap between all the stakeholders' timetables.

As an example, let us consider three stakeholders (S1, S2, S3), where S1 and S2 are in Spain and S3 is in Argentina. Spanish time is +1 and Argentinean Time is -4, according to GMT. If we then consider each person's normal timetable: S1's is from 8.00 to 16.00 (which would be 7.00 to 15.00 in GMT), S2's is from 10.00 to 18.00 (9.00 to 17.00 GMT), and S3's is from 8.00 to 16.00 (12.00 to 20.00 GMT). This information is placed in Form 6 (as is shown in Fig. 1) and the overlap is calculated. In this example, the total overlap is, therefore, 4 hours, which is 50% of the total time.

Form 6: Timetable overlap																								
	Greenwich Mean Time																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
S1's name																								
S2's name																								
S3's name																								
Overlap																								

Fig. (1). Timetable overlap evaluation.

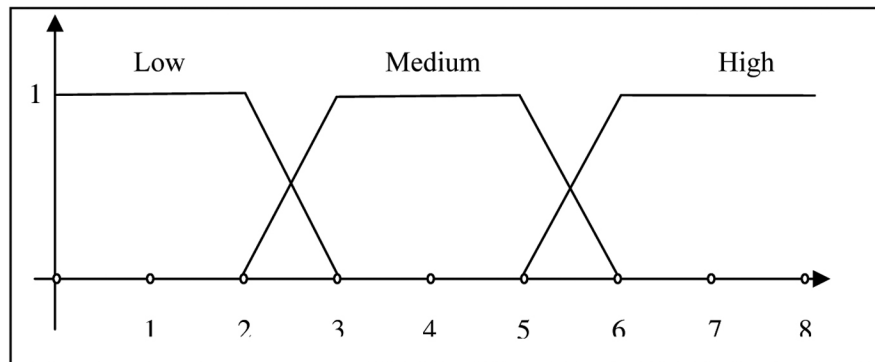


Fig. (2). Fuzzy function for the timetable overlap variable.

In order to obtain the tags “low”, “medium”, and “high” for the overlap factor, we propose the following formulas for a working day of  $n$  hours:

- $(n+1)/3$  is the lowest limit for the “medium” tag
- $n-(n+1)/3$  is the highest limit for the “medium” tag
- The highest limit for the “low” tag:  $((n+1)/3)-1$
- The lowest limit for the “high” tag:  $(n-(n+1)/3)+1$

The results for the aforementioned example are shown in Fig. (2).

### 3.2. Language Difference Evaluation

Language difference is a common factor in global environments as a consequence of the interaction among people from different countries. After analyzing the probable scenarios, we have identified three cases:

- *Same language*: For example, in a project involving organizations from Spain and Argentina the language is the same (Spanish) but differences in pronunciation, intonation, use of different words for the same concept or, on the contrary, the same word for different concepts, may cause misunderstandings and confusing situations.
- *Different language (native language for one of the sites)*: For example, in a project involving people from Spain and USA, the languages will be completely different. Since English is widely dispersed throughout the world as a second language, it will probably be chosen as the common language.

- *Different language (non native language for none of the sites)*: For example, in a project involving people from Spain and The Philippines, their languages will be completely different. Again, as English is widely dispersed throughout the world as a second language, it will be probably chosen as the common language. The difference this case and the previous case is that, as English is the second language for the people on both sites, the stakeholders share a similar difficulty when dealing with the foreign language, which will supposedly generate more empathy.

In this case, rather than using a scale to evaluate the language difference, we have preferred to use a scale that evaluates the degree of knowledge of a common language. In this scale the “High” tag is the best choice (which means that there is almost no language difference), followed by High-Intermediate, Intermediate, Low-Intermediate and Low. We therefore propose a form (shown in Fig. 3) with which to gather the information related to knowledge about a given language, and propose a scale to classify this difference. We propose filling in a form for each language that could be considered as a possible common language and analyzing which of these obtains the highest mark according to the tags we have previously defined.

### 3.3. Cultural Diference Evaluation

Culture is defined as a set of key values, norms and beliefs that are shared between members of a society, and can be described in terms of a series of dimensions [7]. The Hofstede model is that which is most widely used to analyze

Form 7: Degree of knowledge of a common language		
Possible common language	Language: .....	
Choose the options closest to your virtual team	<input type="radio"/> All the stakeholders are from the same country <input type="radio"/> Stakeholders do not share the mother language but they have a high level of knowledge of the chosen common language.	High
	<input type="radio"/> Stakeholders share the mother language but they are from different countries. <input type="radio"/> Stakeholders do not share the mother language but they have a high-intermediate level of knowledge of the chosen common language.	High-Intermediate
	<input type="radio"/> Stakeholders do not share the mother language but they have at least an intermediate level of knowledge of the chosen common language.	Intermediate
	<input type="radio"/> Stakeholders do not share the mother language but they have at least a low-intermediate level of knowledge of the chosen common language.	Low-Intermediate
	<input type="radio"/> Stakeholders do not share the mother language and all of them have a low level of knowledge of the chosen common language.	Low

Fig. (3). Language difference evaluation form.

cultural differences in GSD projects [6, 8], and can be applied to many situations, such as analysing behaviour between bosses and employees, the way in which people privilege individualism or collectivism, etc [9]. The five dimensions for the Hofstede model are:

- **Power Distance Index (PDI):** the degree of equality, or inequality, between people in the country's society.
- **Individualism (IDV):** the degree to which the society reinforces individual or collective achievement and interpersonal relationships.
- **Uncertainty Avoidance Index (UAI):** the level of tolerance for uncertainty and ambiguity within the society - i.e. unstructured situations.
- **Masculinity (MAS):** the degree to which the society reinforces, or does not reinforce, the traditional masculine work role model of male achievement, control, and power
- **Long-Term Orientation (LTO):** the degree to which the society embraces, or does not embrace, long-term devotion to traditional, forward thinking values

The values for the first four dimensions were defined by means of surveys in 53 different countries, while the fifth dimension was defined by means of surveys in 23 countries. Table 3 shows the values for some of these countries [9].

In order to obtain a value for cultural difference between two countries in a scale (low, medium, high), we propose the following formula,  $D_{A,B}$  for the cultural distance between countries A and B, which is calculated as:

$$D_{A,B} = \sum_{i=1}^5 d_{i(A,B)}$$

where:

- $i$  is a dimensions (1: PDI, 2: IDV, 3:UAI, 4:MAS, 5:LTO)
- $v_i$  is a value for the  $i$ -th dimension for a given country
- and  $d_i(A,B)$  is the distance for the  $i$ -th dimension, calculated

$$\text{as } |v_i(A) - v_i(B)|$$

For example, based on the values for Argentina and Spain obtained from Table 3, we can calculate the cultural difference between both countries,  $D_{\text{Argentina,Spain}}$ , as follows:

Argentina	49	46	86	56
Spain	57	51	86	42
Cultural difference	8	5	0	14

$$D_{\text{Argentina,Spain}} = (8+5+0+14) = 27$$

By applying this formula to each pair of countries, we have obtained an indicator for the cultural difference between them. In Table 4 we show the values calculated for the countries presented in Table 3. The symbol “-” was used to mark the cells that correspond to the same country. The table is symmetric since  $D_{A,B} = D_{B,A}$ , since the formula uses the absolute value to calculate the difference for each dimension, and addition is commutative. Finally, we marked with an “\*” the cells that it is not possible to calculate because the values known for both countries do not match (for example, for Argentina we know the first four dimensions and for China we know only the fifth one, so calculation is not possible).

Table 3. Hofstede’s Model Values for Certain Countries

Country	PDI	IDV	UAI	MAS	LTO
Argentina	49	46	56	86	
Australia	36	90	61	51	31
Austria	11	55	79	70	
Belgium	65	75	54	94	
Brazil	69	38	49	76	65
Canada	39	80	52	48	23
Chile	63	23	28	86	
China					118
Spain	57	51	42	86	

Table 4. Cultural Differences for Countries in Table 3

	Argentina	Australia	Austria	Belgium	Brazil	Canada	Chile	China	Spain
Argentina	-	97	86	55	45	86	65	*	27
Australia	97	-	97	94	156	33	162	87	114
Austria	86	97	-	123	111	102	151	*	103
Belgium	55	94	123	-	64	79	88	*	52
Brazil	45	156	111	64	-	145	52	53	42
Canada	86	33	102	79	145	-	143	95	95
Chile	65	162	151	88	52	143	-	*	48
China	*	87	*	*	53	95	*	-	*
Spain	27	114	103	52	42	95	48	*	-

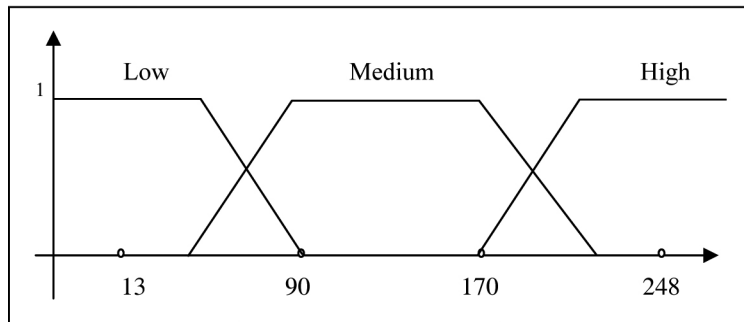


Fig. (4). Fuzzy function for cultural difference variable.

Finally, based on the indicators for cultural difference for all the pairs of countries, we define the values for the linguistic tags for cultural difference considering the lowest difference between two countries ( $D_{min} = 13$ ; which correspond to West Africa and Indonesia), and the highest difference between two countries ( $D_{max} = 248$ ; which correspond to Sweden and Japan). In doing so, we divided the distance between  $D_{min}$  and  $D_{max}$  into similar parts and defined the values for the “low”, “medium”, and “high” tags, and the corresponding fuzzy function, as is shown in Fig. (4). In our example of Argentina and Spain, since the cultural difference indicator is 27, we can talk about a “low” cultural difference.

### 3.4. Stakeholders Cognitive Characteristics Evaluation

In order to discover more about stakeholders, we have analyzed certain instruments from the field of cognitive psychology designed to measure human characteristics and to explain differences between people [10]. We have specifically chosen a learning style model, called Felder-Silverman (F-S) [11], which analyses the way in which people receive and process information, with the aim of making the environment in which they work closer to their cognitive profile. Stakeholders’ F-S learning styles are obtained by means of a test that catalogues their preferences in four categories (perception, input, processing, and understanding) as slight,

moderate and strong between two opposite subcategories. For instance, in the “input” category, people are catalogued as being verbal or visual on the scale (slight, moderate, strong). If people are verbal then they prefer to perceive information by means of spoken words, while visual people prefer graphics. The form used to gather the test results is similar to that shown in Fig. (5).

In order to define the types of virtual teams regarding the stakeholders’ learning style, we focus on the strongest preferences (values -11, -9, 9, and 11). For example, in the case shown in Fig. (5), the stakeholder is strongly active and strongly intuitive.

The information gathered regarding the virtual team members’ cognitive profile is summarized in Form 8 (Fig. 6).

Since when preferences are stronger people may have difficulty in learning in an environment that does not support their preference [12], we decided to classify teams according to the occurrence of strong preferences, as follows:

- **Type 1:** There are no strong preferences in the team.
- **Type 2:** There are strong preferences but not on the opposite sides of the same category. For instance: if there are strongly visual people in the team, and there are no strongly verbal people, communication should be based

	Strong		Moderate		Slight			Moderate		Strong		
	-11	-9	-7	-5	-3	-1	1	3	5	7	9	11
Active		√										Reflexive
Sensitive											√	Intuitive
Visual						√						Verbal
Sequential			√									Global

Fig. (5). Analyzing cognitive styles with F-S test.

Form: Defining the Virtual Team type				
Calculate the number of stakeholders with <b>strong preferences</b> for each subcategory and fill in the middle columns	Strongly ACTIVE (-11,-9)	Nº	Nº	Strongly REFLEXIVE (11,9)
	Strongly SENSITIVE (-11,-9)			Strongly INTUITIVE (11,9)
	Strongly VISUAL (-11,-9)			Strongly VERBAL (11,9)
	Strongly SEQUENTIAL (-11,-9)			Strongly GLOBAL (11,9)
Verify each row and choose the question whose answer is "YES". The team type is in the right-hand column	Have all cells been filled with zeros?	<input type="radio"/> <b>Type 1</b> (non-strong preferences group)		
	Are there one or more non-zero cells and are their adjacent cells (in the same row) always zero?	<input type="radio"/> <b>Type 2</b> (strong preferences without conflict group)		
	Are there one or more non-zero cells and is one of their adjacent cells (in the same row) also non-zero?	<input type="radio"/> <b>Type 3</b> (strong preferences with conflict group)		

Fig. (6). Virtual team evaluation regarding stakeholders' cognitive characteristics.

on diagrams and written words, since this will increase the involvement of visual people, and those people with slight and moderate preferences will not experience difficulties in becoming accustomed to them.

- **Type 3:** If there are strong preferences on the opposite sides of the same category, then there is a conflict of preferences. For example, if there are one or more strongly visual people, and also some strongly verbal people, communication should support both kinds of styles, as we shall discuss later.

The rationale behind our decisions is supported by research results in the field. In the following sections we shall analyze the possible strategies to be used by a given virtual team, once all these factors have been evaluated.

#### 4. DEFINING STRATEGIES TO MINIMIZE GSD PROBLEMS

Once values for time overlap, cultural difference, language difference and team type regarding cognitive aspects have been obtained (as was previously explained), we recommend three main strategies to minimize the problems caused by such factors. These strategies focus on:

- A. How to minimize problems related to high and intermediate degrees of cultural and language diversity, by means of training in the cultural differences that may appear.
- B. How to minimize problems related to high and intermediate degrees of language diversity, by means of ontologies as a communication facilitator.

- C. How to minimize problems related to communication by means of the study of the cognitive nature of people and the characteristics of their environment.

These strategies are analyzed in the following sections.

##### 4.1. Strategy A: Training in Cultural Differences

With regard to cultural difference, the main problems are related to people's behaviour. For instance, USA ranks high in individualism, while collectivism is a common characteristic of the Latin culture [9], so interaction between these countries may be problematic, leading Latin people to believe that Americans are not compromised with the group [13] or Americans to believe that Latin people spend too much time building up unnecessary social relationships. Since this kind of misunderstanding about behaviour may be source of frustration for team members, we propose a first strategy, called A, which focuses on learning about the other cultures:

Cultural differences cannot be avoided, but stakeholders can learn about the differences between the other culture and their own. Being trained in cultural diversity is crucial if stakeholders are to be both aware of normal behaviour in other cultures and conscious of their own behaviour, especially in aspects that may be offensive or misunderstood. In order to minimize this kind of problems, we have classified the strategies used as follows:

- Literature review, seminars, courses, etc.
- Cultural mediation: taking advantage of people who have visited the other site before – and therefore know about cus-

toms and normal behaviour related to the foreign culture – who will become a reference for communication with people at the other site. These people are called mediators, bridge-heads [14] or liaison personnel [15].

- Virtual mentoring: based on simulation and virtual actors. This may be an interesting way of motivating stakeholders in foreign language training and cultural familiarization [16].

#### 4.2. Strategy B: Using Ontologies as Communication Facilitators

In addition to cultural diversity, GSD projects must also deal with language differences. Language difference may occur on a wide variety of levels, depending upon whether or not stakeholders share the same mother language. When people do not share the same native language, the language chosen for interaction is usually English, and a clear understanding of domain concepts and relationships is crucial. However, when people share the native language, if they come from different countries, idiomatic differences may also be a challenge for communication. For instance, people from Argentina and Spain share Spanish as their native language, but pronunciation may differ, and many words may have different meanings. Since it is crucial to have a common understanding of the system domain during the requirements elicitation process, our strategy to minimize the idiomatic differences is that of using ontologies to help communication.

When stakeholders are not from the same country of origin, even if they share the same mother language, misunderstandings may arise as a result of the fact that some words have more than one meaning, or different words refer to the same concept, etc. Sharing a common vocabulary, especially that which refers to the domain components, is crucial, and we propose a domain ontology to help build said language. In addition, ontologies play a natural role in supporting knowledge management, which is of great importance during requirements elicitation, in which a considerable amount of data is collected from many different sources. Ontologies therefore make it possible to clarify the structure of knowledge and allow a clear specification of the concepts and the terms used to represent them [17].

#### 4.3. Strategies C: Selection of Suitable Technology

Finally, but of no less importance, we have considered the fact that people in GSD projects apply requirements elicitation techniques by means of groupware tools. Therefore, in order to improve people's communication, we have focused on analyzing how technology selection can influence people's performance. Based on such analysis we propose a third strategy: "Selection of suitable technology according to the environment's characteristics"

Two types of technology are used during requirements elicitation: groupware and requirements elicitation techniques. By analysing the factors measured, we aim to choose the most suitable technology according to the characteristics of the virtual team.

Various factors are involved in the selection of technology. The first is time overlap. In this case, it is obvious that when time overlap is low synchronous interaction will be

difficult, so we recommend using asynchronous groupware tools and avoiding requirements elicitation techniques based on synchronous interaction (such as brainstorming). Furthermore, when the stakeholders' mother language is not the same, and the degree of knowledge of a common language is intermediate or less, we propose restricting communication to asynchronous tools, in order to give people the opportunity to read and write with greater care.

Finally, we propose using knowledge about the stakeholders' cognitive characteristics for technology selection. As was explained previously, one of the factors that it is possible to discover in a virtual team is the cognitive characteristics that are innate to people and are related to the way in which people perceive information and understand it. Since communication in GSD projects takes place by means of groupware tools and requirements elicitation techniques, we have proposed a model to obtain preference rules at the individual level [18] along with strategies to combine the technology according to the type of virtual team (type 1, 2, or 3), which depends on the occurrences of people with cognitive strong preferences in the given virtual team [19]. Such strategies can be summarized as follows:

- **Strategy C1 for Type 1 Groups** (groups with non-strong preferences), is expressed as:

$$C1(\{g\}, GS1, GS2, \dots, GS_n) \rightarrow g_i \in \{g\}$$

where  $GS_i$  represents the groupware tool that fits the  $i$ -th stakeholder's preferences (which have been defined by mechanisms based on fuzzy logic and fuzzy sets), and  $g_i \in \{g\}$  is the tool that appears most frequently.

Fig. (7) shows an example based on this strategy. As this figure shows, according to the preference rules, Chat is the groupware tool recommended for P1 and P2, while Email is recommended for P3. Since all the stakeholders have slight and moderate preferences, the recommended groupware tool for the group is Chat, which has more adherents.

- **Strategy C2 for Type 2 Groups** (groups with strong preferences without conflict), is:

$$C2(\{g\}, (\{GS_1\}, ws_1), (\{GS_2\}, ws_2), \dots, (\{GS_n\}, ws_n)) \rightarrow g_i \in \{g\} \wedge g_i \in \{GS_j\} \\ \wedge ws_j = \max(ws_1, ws_2, \dots, ws_n)$$

where  $GS_i$  represents the groupware tool that fits the  $i$ -th stakeholder's preferences and  $ws_i$  is the weight –meaning how strong the preferences are—, and the resulting  $g_i$  is a tool that is appropriate for the stakeholder whose personal preferences are the strongest.

An example of this strategy is shown in Fig. (8).

As this figure shows, according to the preference rules, Chat is the groupware tool recommended for P1 and P2, while Email is recommended for P3. Since P3 has the strongest preferences, the recommended groupware tool for the group is Email, in order to make this stakeholder feel more comfortable with the groupware and knowing that the remaining stakeholders using this groupware will not experience difficulties since they have slight and moderate preferences.

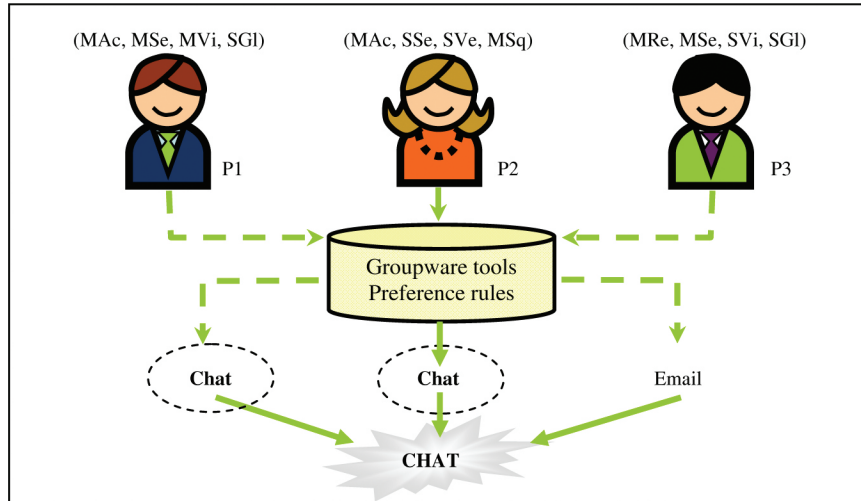


Fig. (7). Strategy C1 represented for 3 stakeholders with slight and moderate preferences (Type 1 Group).

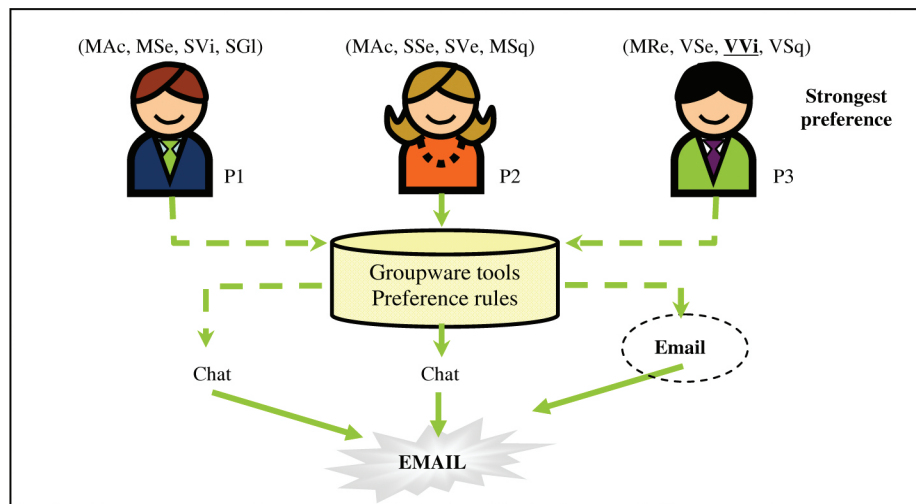


Fig. (8). Strategy C2 represented for 3 stakeholders with strong preferences without conflict (Type 2 Group).

- **Strategy C3 for Type 3 Groups** (groups with strong preferences with conflict), improves the process by using a different machine-learning algorithm. By doing so, we aim to develop an algorithm that, for each rule, returns a ranking of output variables, rather than only one. Therefore, when a conflict is detected, as we have a ranking for each person, we can browse through the ranking for those people with the strongest preferences, and the tool that is located in the highest position for all of them will be the best choice for the team, although it would not be the first choice for some, or even any of them.

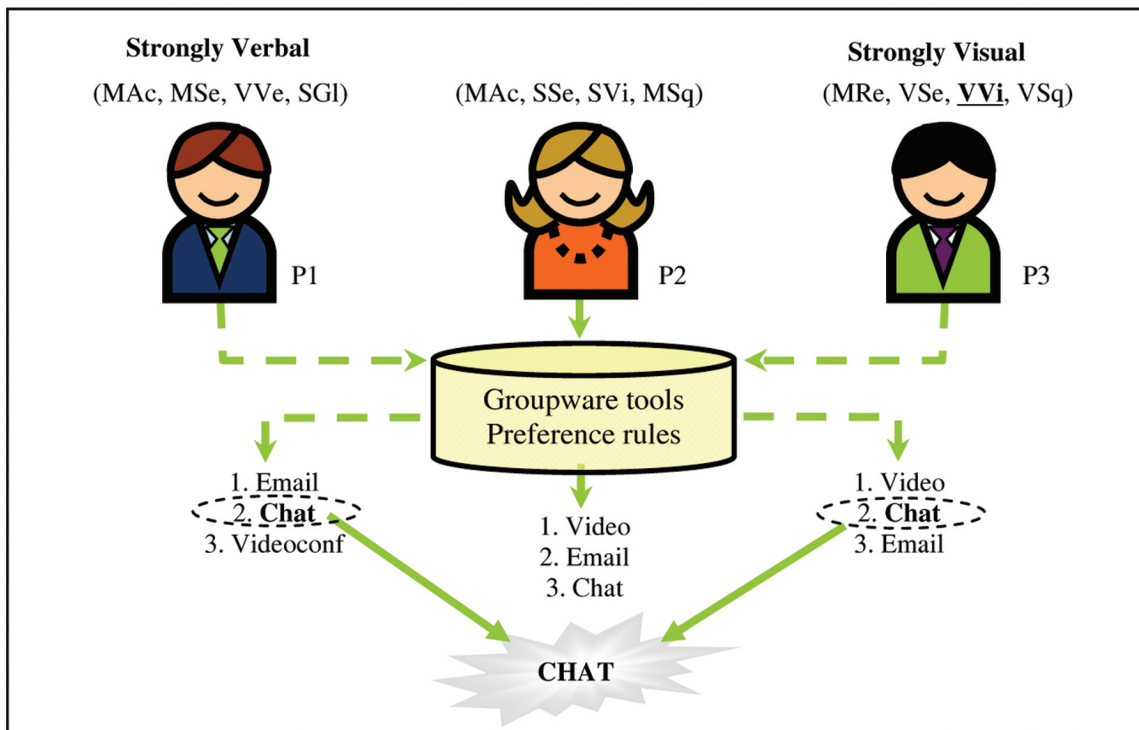
An example is shown in Fig. (9). As this figure shows, since P1 and P3 have strong preferences on the opposite sides of the same category (Verbal-Visual), the recommended groupware for the group is chosen by looking

through the ranking from both stakeholders. In doing so, we find that Chat is the best choice for both, despite the fact that it is in the second place in both rankings. As was explained previously, we do not take into account the preference rules for stakeholder P2 because we know that s/he will not experience difficulties in getting accustomed to it, since s/he has slight and moderate preferences.

Table 5 summarises the strategies suggested for a combination of factors. Only the table for the “low” cultural difference is shown owing to space limitations, but rows for the “medium” and “high” values, can be added by simply filling in the strategy A column with a “©” character.

In order to abbreviate the technology selection strategy names in Table 5, we have used the terms C1, C2, and C3 for strategies according to the group type, and we have similarly called the technology selection strategy based on asynchro-





**Fig. (9).** Strategy C3 represented for 3 stakeholders with strong preferences with conflict (Type 3 Group).

nous interaction C4, which is related to wide time separation or low knowledge of the common language.

In order to illustrate the use of this table with an example, let us consider the case analyzed in a controlled experiment recently carried out. In this experiment we had at our disposal 24 computer science students and teachers from Spanish and Argentinean universities. The cultural difference (as was explained in the formula in Section 3.3) was 27, and the value for this factor was “Low”. Virtual teams were made up of 2 Spanish students and 1 Argentinean teacher and their time overlap was that used in the example in section 3.1, so, the value for this factor was “Medium”. Finally, as we had sufficient people with strong preferences for the visual subcategory, we formed similar Type 2 groups (one or more people with strong preference without conflict). Table 5 shows (highlighted in light blue) the strategies suggested to minimize communication problems in our experiment where: first, strategy B is chosen, which recommends using a domain ontology to minimize misunderstandings due to language diversity; and second, strategy C2 is chosen, since a groupware technology strategy for Type 2 Groups was required.

The preliminary results of this experiment indicate that stakeholder perception with regard to communication appears to be better in those groups that applied the C2 strategy. As can be seen in Fig. (10), the preliminary analysis of data collected by means of the post-experiment questionnaire shows that, with regard to the stakeholders' satisfaction with communication during the experiment, all the people that participated in those groups applying the C2 strategy ranked their satisfaction as “very good” or “good”, most of them considering it to be “very good”. On the contrary, in groups

that did not apply the C2 strategy, most people ranked their satisfaction as simply “good” and some people also ranked their satisfaction as “indifferent”, which did not occur in the first group.

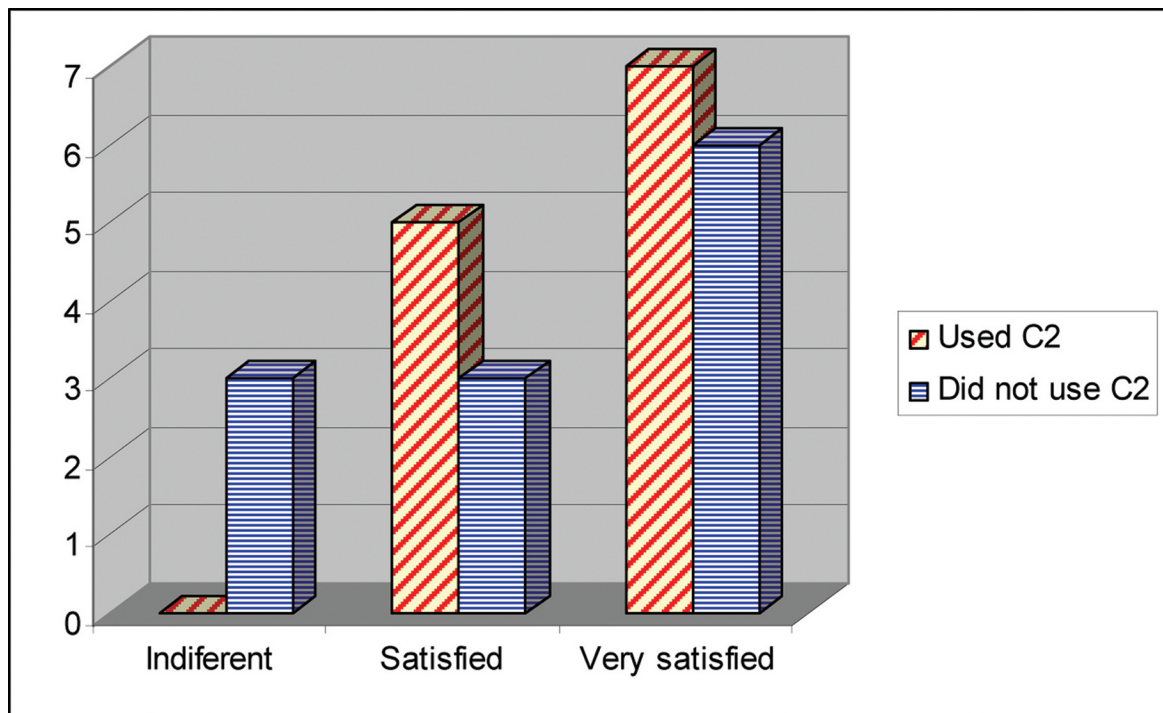
As improvements in communication are expected to be related to improvements in requirements quality, we have asked a group of software engineering teachers to analyze the requirements specifications written during our experiment. We are currently analyzing this data.

## 5. CONCLUSIONS

GSD has been widely adopted in software development organizations owing to the advantages that it represents in minimizing costs. However, the cultural diversity and the time difference present in this kind of projects, challenge the team performance, especially in software engineering activities in which communication is crucial for a common understanding of the problem.

In order to minimize such problems, we have proposed a method with which to evaluate the factors that are related to GSD challenges and we propose a set of strategies that can be used in each case. Our current work is focused on analyzing the results of a controlled experiment that was carried out to test performance when using domain ontologies and groupware technology selection in groups with strong preferences without conflict (type 2 group). Preliminary results indicate that the groups that used the most suitable groupware tools, according to our selection strategy C2 for type 2 groups, felt more comfortable with communication than those groups that did not use them. Nevertheless more experiments should be performed if these results are to be more conclusive.





**Fig. (10).** Stakeholders' satisfaction with communication in groups that applied strategy C2 and groups that did not.

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#### REFERENCES

- [1] W. Lloyd, M. B. Rosson, and J. Arthur, "Effectiveness of elicitation techniques in distributed requirements engineering," In: *10th Anniversary IEEE Joint International Conference on Requirements Engineering, RE'02*, Essen, Germany, pp. 311-318, 2002.
- [2] D. Damian, and D. Zowghi, "The impact of stakeholders geographical distribution on managing requirements in a multi-site organization," In: *IEEE Joint International Conference on Requirements Engineering, RE'02*, Essen, Germany, pp. 319-328, 2002.
- [3] R. Prikładnicki, J. Audy, and R. Evaristo, "Global software development in practice lessons learned," *Softw. Process Improv. Pract., Wiley InterSci.*, vol. 8, no. 4, pp. 267-281, October/December 2003.
- [4] A. Al-Rawas, and S. Easterbrook, "Communication problems in requirements engineering: a field study," In: *First Westminster Conference on Professional Awareness in Software Engineering*, London, pp. 47-60, 1996.
- [5] J. A. Espinosa, and E. Carmel, "The impact of time separation on coordination in global software teams: a conceptual foundation," *Softw. Process Improv. Pract., Wiley InterSci.*, vol. 8, no. 4, pp. 249-266, October/December 2003.
- [6] E. MacGregor, Y. Hsieh, and P. Kruchten, "Cultural patterns in software process mishaps: incidents in global projects," *ACM SIG-SOFT Softw. Eng. Notes*, vol. 30, no. 4, pp. 1-5, July 2005.
- [7] I. Nataatmadja, and L. E. Dyson, "The Role of Information and Communication Technology," In: *Information Resources Management*, W. K. Law, Ed.: IDEA Group, pp. 283-304, 2007.
- [8] R. W. Egan, M. Tremaine, and J. Fjermestad, "Cultural differences in temporal perceptions and its application to running efficient global software teams," In: *ICGSE 2006, IEEE International Conference on Global Software Engineering*, 2006.
- [9] G. Hofstede, *Cultures and Organizations, Software of the Mind: Intercultural Cooperation and its Importance for Survival*, McGraw-Hill, New York: 1996.
- [10] J. Miller, and Z. Yin, "A cognitive-based mechanism for constructing software inspection teams," *IEEE Trans. Softw. Eng.*, vol. 30, no. 11, pp. 811-825, November 2004.
- [11] R. Felder, and L. Silverman, "Learning and Teaching Styles in Engineering Education," *Eng. Educ.*, vol. 78, no. 7, pp. 674-681, April 1988 (and author preface written in 2002).
- [12] R. Felder, and J. Spurlin, "Applications, Reliability and Validity of the Index of Learning Styles," *Int. J. Eng. Educ.*, vol. 21, no. 1, pp. 103-112, February 2005.
- [13] J. Audy, R. Evaristo, and M. B. Watson-Manheim, "Distributed analysis the last frontier?," In: *37th Annual Hawaii International Conference on Systems Sciences (HICSS)*, Big Island, Hawaii, pp. CD-ROM, 2004.
- [14] E. Carmel, R. D. Whitaker, and J. E. George, "PD And Joint Application Design: A Transatlantic Comparison," *Commun. ACM, Special issue on graphical user interfaces: the next generation*, vol. 36, no. 6, pp. 40-48, June 1993.
- [15] J. D. Herbsleb, and R. E. Grinter, "Splitting the Organization and Integrating the Code: Conway's Law Revisited," In: *21th International Conference on Software Engineering (ICSE'99)*, New York, pp. 85-95, 1999.
- [16] E. M. Sims, "Reusable, lifelike virtual humans for mentoring and role-playing," *Comput. Educ.*, vol. 49, no. 1, pp. 75-92, August 2007.
- [17] B. Chandrasekaran, J. R. Josephson, and V. Benjamins, "Ontology of Tasks and Methods," In: *KAW'98*, Alberta, Canada, 1998.

- [18] G. Aranda, A. Vizcaíno, A. Cechich, and M. Piattini, "A cognitive-based approach to improve distributed requirement elicitation processes," In: *4th IEEE International Conference on Cognitive Informatics (ICCI'05)*, Irvine, USA, pp. 322-330, 2005.
- [19] G. Aranda, A. Vizcaíno, A. Cechich, M. Piattini, and J. J. Castro-Schez, "Cognitive-based rules as a means to select suitable groupware tools," In: *5th IEEE International Conference on Cognitive Informatics (ICCI'06)*, Beijing, China, pp. 418-423, 2006.

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