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Cognitive Informatics

(ICCI 2008)

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Edited by

Yingxu Wang

Du Zhang

Jean-Claude Latombe

Witold Kinsner

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Preface

Welcome to the *7th IEEE International Conference on Cognitive Informatics* (ICCI 2008)!

Cognitive Informatics (CI) is a cutting-edge and multidisciplinary research area that tackles the fundamental problems shared by modern informatics, computation, software engineering, AI, cybernetics, cognitive science, neuro-psychology, medical science, philosophy, linguistics, life sciences, and many others. CI is the trans-disciplinary study of cognitive and information sciences, which investigates the internal information processing mechanisms and processes of the natural intelligence – human brains and minds – and their engineering applications in computational intelligence.

The development and the cross fertilization among the aforementioned science and engineering disciplines have led to a whole range of extremely interesting new research areas. Following the first six successful conferences on Cognitive Informatics, ICCI'02 (Calgary, Canada), ICCI'03 (London, UK), ICCI'04 (Victoria, Canada), ICCI'05 (Irvine, USA), ICCI'06 (Beijing, China), and ICCI'07 (Lake Tahoe, USA), ICCI'08 focuses on the theme of *Cognitive Computers and Computational Intelligence*. The objectives of ICCI'08 are to draw attention of researchers, practitioners, and graduate students to the investigation of cognitive mechanisms and processes of human information processing, and to stimulate the international effort on cognitive informatics research and engineering applications. The ICCI'08 technical program encompasses 56 regular papers selected from 115 submissions from all over the world based on rigorous reviews by program committee members and external reviewers. The program is enriched by 4 keynotes from prestigious scientists.

The growing field of CI covers many areas as follows in natural intelligence, neural informatics, cognitive computing, computational intelligence, and their engineering applications:

*** Natural Intelligence ***

- Informatics models of the brain
- Cognitive processes of the brain
- Internal information processing mechanisms
- Theories of natural intelligence
- Intelligent foundations of computing
- Denotational mathematics for CI
- Abstraction and means
- Ergonomics
- Informatics laws of software
- Knowledge representation
- Models of knowledge and skills
- Language acquisition
- Cognitive complexity of software
- Distributed intelligence
- Computational intelligence
- Emotions/motivations/attitudes
- Perception and consciousness
- Hybrid (AI/NI) intelligence

*** Computational Intelligence ***

- Imperative vs. autonomous computing
- Reasoning and inferences
- Cognitive informatics foundations
- Robotics
- Informatics foundations of software eng.
- Fuzzy/rough sets/logic
- Knowledge engineering
- Pattern and signal recognitions
- Autonomic agent technologies
- Memory models
- Software agent systems
- Decision theories
- Problem solving theories
- Machine learning systems
- Distributed objects/granules
- Web contents cognition
- Nature of software
- Cognitive computers

*** Neural Informatics ***

- Neuroscience foundations of information processing
- Cognitive models of the brain
- Functional modes of the brain
- Neural models of memory
- Neural networks
- Neural computation
- Cognitive linguistics
- Neuropsychology
- Bioinformatics
- Biosignal processing
- Cognitive signal processing
- Gene analysis and expression
- Cognitive metrics
- Neural signal interpretation
- Visual information representation
- Visual information interpretation
- Sensational cognitive processes
- Human factors in systems

The ICCI'08 program as presented in the proceedings is the result of the great effort and contributions of many people. We would like to thank all authors who submitted interesting papers to ICCI'08. We acknowledge the professional work of the Program Committee, special session organizers, and external reviewers for their effective review and improvement of the quality of submitted papers. Our acknowledgement also goes to the invaluable sponsorships of IEEE Computer Society, The IEEE ICCI Steering Committee, IEEE Canada, and IEEE CS Press, Stanford University, as well as International Journal of Cognitive Informatics and Natural Intelligence (IJCINI) and International Journal of Software Science and Computational Intelligence (IJSSCI). We thank the keynote speakers for presenting their visions and insights on fostering this transdisciplinary area. We acknowledge the organizing committee members, particularly Liliana Rivera, Lisa Doyer, and all student volunteers who have helped to make the event a success.

Jean-Claude Latombe, Yingxu Wang, Witold Kinsner, and Du Zhang

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Strategies to recommend Groupware Tools According to Virtual Team Characteristics

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Abstract

The different communication technologies that appeared in the last decades made Global Software Development (GSD) projects a common way to develop software. However, the difficulties distance between sites causes in communication and information management are the main disadvantages of this kind of projects and therefore, an interesting field of research. Our proposal focuses on techniques from the field of cognitive psychology to define a new approach to groupware tools selection. In previous work we focused on defining preferences at the individual level. As a complement, this paper presents a set of strategies to find the best selection for a given group of people, taking into account the different combinations of cognitive profiles that can arise in a GSD project.

1. Introduction

Global Software Development (GSD) refers to the development of software in scenarios where stakeholders are distributed through many geographically distanced sites. This practice has surprisingly increased during the last decades [14], being today a common way to build large software. In fact, real projects regularly involve two or more sites in North America, Europe, Asia, or South America. Then, as a consequence of the dispersion, often face-to-face communication is not possible and stakeholders must communicate by means of especially designed technology, called groupware.

In such a scenario, our research is focused on the distributed requirement elicitation process. That is because most of the problems in the requirements elicitation process are based on communication [10, 19]; and, in addition, the lack of face-to-face interaction, the time difference between different sites and the cultural diversity of stakeholders [9] make the requirements definition process one of the most problematic in the GSD projects life cycle.

Even when Computer-Supported Cooperative Work (CSCW) is the research area that focuses on providing technology to enable communication, we found out in Cognitive Informatics a complementary point of view. Since part of Cognitive Informatics relates concepts from psychology to improve processes in engineering disciplines such as software engineering [8, 24], we took it as a starting point for our research.

In the scenario of our research, people are working collaboratively at various different geographic sites and communicate with each other using groupware tools. Considering that communication involves aspects of human processing mechanisms that are analyzed by the cognitive sciences, we focused on some techniques from the field of psychology, called Learning Style Models (LSMs), to select groupware tools and elicitation techniques according to the stakeholders' cognitive styles.

In previous papers we have presented a model based on fuzzy logic and focused on the definition of a simple strategy for the selection of requirement elicitation techniques [2]. Later, we focused on the selection of groupware tools, based on the stakeholders' cognitive aspects, and the definition of preference rules from a set of examples [4]. In this paper we analyze the different ways that virtual teams can be conformed, and we review our previous strategies and propose new ones, according to the different settings that can arise.

The rest of the paper is organized as follows: first we briefly introduce learning style models and some related works in computer sciences and software engineering.

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Later we explain how LSMs can be used to obtain a set of preference rules about groupware tools by means of a model based on fuzzy logic and fuzzy sets. Finally we present the different combination of cognitive profiles that can occur in a group and we propose a strategy to select the most suitable technology in each case.

2. What are LSMs?

LSMs or learning style models are techniques from the field of cognitive psychology that classify people according to a set of behavioural characteristics.

They are based on Jung's theory of psychological types, and are used to analyse and understand differences in human behaviour [21]. LSMs are instruments designed to measure human characteristics and explain differences between different people. Specifically, LSMs analyze the way people receive and process information, in order to improve the manner in which people learn a given task.

LSMs have been discussed in the context of analyzing relationships between instructors and students. So far, in informatics and computer sciences research, LSMs have been mainly used with educational purposes [5, 6, 22, 23, 25]). However, we propose to take advantage of this kind of model and adapt it to virtual teams that deal with distributed elicitation processes, since requirement elicitation is about learning the needs of the users [15]. On the other hand, users and clients also learn from analysts and developers (for instance, they learn how to use a software prototype, new vocabulary, etc.), we can say that stakeholders play the role of student or instructor depending upon the moment at which the requirement elicitation process they are carrying out takes place [20].

Previous related work in software engineering has used cognitive styles; for instance, in [17] cognitive styles are used as a mechanism for software inspection team construction proving that heterogeneous software inspection teams give a better performance than homogeneous ones (where heterogeneity is defined according to the participants' cognitive style). Even when our work uses the concept of cognitive styles to classify people too, we must differentiate our approach because we do not try to say which people seem to be more suitable to work together in a requirements elicitation process. On the contrary, we aim to give an already chosen group of people, a set of technologies that fit their characteristics from a cognitive point of view and improve their performance.

The LSM we have chosen for our methodology is the one proposed by Felder-Silverman (F-S) [13], which classifies people into four categories, each of them further decomposed into two subcategories as follows: Sensing / Intuitive; Visual / Verbal; Active / Reflective; Sequential / Global. A graphical view of categories and subcategories is shown in Figure 1.

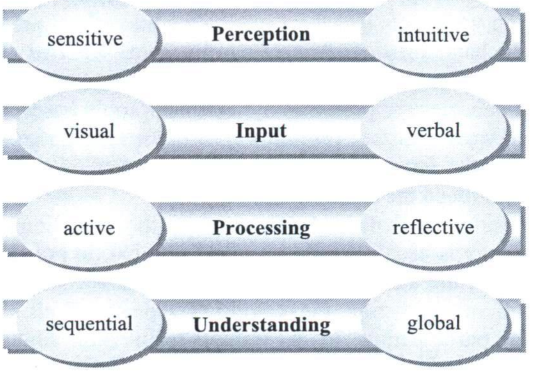

Figure 1: Felder and Silverman (F-S) categories and subcategories

Further detail about the characteristics of each subcategory can be found in [11, 12]

3. The Global Software Development scenario

As we mentioned before, the loss of communication richness is one of the most cited problems in GSD, which is the result of the lack of face-to-face interaction. Since stakeholders are distributed along two or more distant sites, they cannot meet regularly and interaction between them is restricted to virtual collaboration, by means of communication tools for groups, called groupware tools.

The most common groupware tools used during multi-site developments are e-mails, electronic discussion or forums, bulletin boards, shared whiteboards, document sharing, chat, instant messaging, audio-conferencing, and video-conferencing. [9, 18]. Each of them has different characteristics. For instance, they can be divided into *synchronous* (chat, instant messaging, audio or videoconference) and *asynchronous* (mail, forums, etc) depending upon whether the users have to work at the same time or not [17]. But also they can be divided according to the way they show the information: by means of images, figures, or diagrams (shared whiteboards, videoconferencing); or by using words (chat, instant messaging, e-mails, newsgroups, mailing lists, forums).

Effectiveness when using synchronous and/or asynchronous collaboration in distributed requirements elicitation process has been discussed, in a general way, without considering cognitive profiles [9, 18].

In order to relate stakeholders' cognitive characteristics and their preference when using technology, we interviewed some stakeholders [1] and we discovered that some of them admitted feeling more comfortable using synchronous tools, while others felt that such technology is too intrusive and preferred using asynchronous tools. Similarly, some people tend to prefer working with tools based on graphics while others prefer verbal characteristics. Analyzing the data, we had the evidence that people with strong preferences for the visual subcategory preferred synchronous tools based on written words (instant messenger) over the rest. Later we repeated the interviews with a wider number of people and we noticed the same tendencies [3].

Considering that in GSD projects the selection of technology is usually made by managers that do not take the rest of the stakeholders preferences into account, we focused on analyzing the cognitive aspects of all the people participating in a virtual team and finding strategies for technology selection that can fit most of the stakeholders' preferences in the group.

With such an aim we defined a process for technology selection that we present in the next section.

4. A process for defining preference rules

Our proposal for a process to define preference rules include a model for technology selection based on fuzzy logic and fuzzy sets which obtains rules from a set of representative examples in the manner of patterns of behaviour [1]. The patterns we looked for indicate the preferences of stakeholders in their daily use of groupware tools, according to their classification in the F-S model. In a similar way, we proposed finding a suitable set of elicitation techniques according to the preferences for each category of the F-S model [2].

The input variables of our fuzzy model are the four categories that correspond with the F-S model:

I = {Active-Reflective, Sensing-Intuitive, Visual-Verbal, Sequential-Global}

The domain (DDV) for each input variable has been defined by using the adverbs (and their corresponding abbreviations): Very (V), Moderately (M) and Slightly (S), which correspond respectively to strong, moderate and mild in the F-S model, but we have changed their names to avoid confusion with respect to the use of the first letter, as it is shown in Table 1.

Table 1: Definition domain for F-S categories

	V	M	S	S	M	V	
Active	VAc	MAc	SAc	SRe	MRe	VRe	Reflective
Sensitive	VSe	MSe	SSe	SIn	MIn	VIn	Intuitive
Visual	VVi	MVi	SVi	SVe	MVe	VVe	Verbal
Sequential	VSq	MSq	SSq	SGl	MGl	VGl	Global

Finally, the output variable of our fuzzy model represents the person's choice, for example, the groupware tool he or she prefers.

Once the model was defined, we codified the examples we had obtained in the previous surveys, and we applied the machine learning algorithm defined in [7], to find a finite set of fuzzy rules able to reproduce the input-output system's behaviour.

The result of the application of this machine-learning algorithm over the set of examples was a set of rules that we called "preference rules about groupware".

In a similar way we plan to get a set of "preference rules about requirements elicitation techniques", but this survey is not as easy as asking stakeholders preferences, since the selection or requirements elicitation techniques is also related to the project and the requirements that the analyst need to gather, as it is explained in [16].

The application of the preference rules, to a given virtual team, is as follows:

- Obtain the personal preferences of each person in the virtual team
- Obtain the preferred technology for each member
- Analyze the composition of the group, according to the cognitive characteristics of its members
- Apply the most suitable strategy to combine the preference rules according to the characteristics of the group.

Following we will explain the last two steps of the process.

5. Strategies for groupware selection

In the previous section we have explained how we got a set of preference rules about groupware. These rules represent the preference according to the cognitive style of people; however the rules can be used to know the suggested groupware for only one person. That means, for each person in the virtual team we will get a groupware tool that is the most suitable according to his or her cognitive style.

But it is not expected that the most suitable groupware tool be the same for all members of a team, thus we need to provide strategies to combine the results.

Let us suppose we have three stakeholders P1, P2 y P3, and we know their cognitive profile, according to the F-S model. Then, we introduce each cognitive profile in the rule system and we obtain a suitable groupware tool for each stakeholder. How many combinations are possible?

According to the F-S model definition, people with slight and moderate preferences can get accustom to different media easily; then if there are no strong preferences in the virtual team, we suggest selecting the groupware tool that appear more times as the most suitable. We can express this strategy; we have called S_1, as follows:

$$S_1 (\{g\}, GS_1, GS_2, ..., GS_n) \rightarrow g_i \in \{g\}$$

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

Figure 2 shows an example based on this strategy. As we can see from the figure, according to the preferences rules, Chat is the groupware recommended for P1 and P2, while Email is recommended for P3. Since all the stakeholders have slight and moderate preferences, the recommended groupware for the group is Chat, which has more adherents.

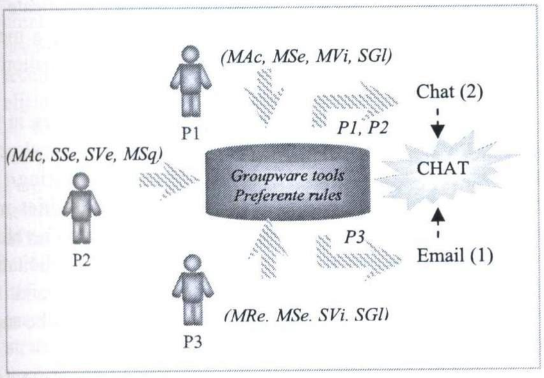

Figure 2: Strategy 1 represented for 3 stakeholders with slight and moderate preferences

As we explained, function S_1 is suitable for teams where there are no strong preferences. On the contrary, if some stakeholders' preferences are strong and the rest of the stakeholders are moderate or mild, the preferences that should be primarily considered are those of the first group of stakeholders. This is because people with strong preferences perform better when the technology is closer to the way they receive and process information [12]. Then, we differentiate the type of preferences and introduce the strategy S_2:

$$S_2 (\{g\}, (\{GS_1\}, ws_1), (\{GS_2\}, ws_2), ... ,(\{GS_n\}, ws_n)) \rightarrow g_i \in \{g\} \wedge g_i \in \{GS_j\} \wedge ws_j = \max(ws_1, ws_2, ..., ws_n)$$

where GS_i represents the groupware tool that fit 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 for this strategy is shown in Figure 3. As we can see from the figure, according to the preferences rules, Chat is the groupware recommended for P1 and P2, while Email is recommended for P3. Since P3 has strong preferences, the recommended groupware for the group is Email, in order to make this stakeholder feel more comfortable with the groupware and knowing that for the rest of the stakeholders using this groupware is not going to be difficult because they have slight and moderate preferences.

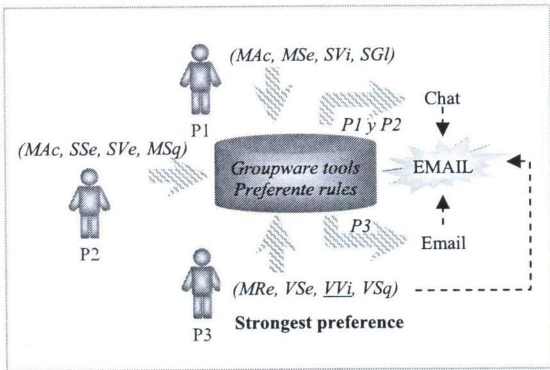

Figure 3: Strategy 2 represented for 3 stakeholders with strong preferences without conflict

Unfortunately, the strategy S_2 is not applicable when there are people with strong preference in the opposite sides of the same category (for instance, some people are strongly visual and other strongly verbal in the same team). In this case we say there is a *conflict* and we need to extend the strategy *S2* to solve it.

To define a strategy for technology selection for teams with conflicting preferences, we propose to improve the process by changing the machine-learning algorithm. To do so, we need an algorithm that for each rule returns a ranking of output variables, instead of only one. Then, when a conflict is detected, as we have a ranking for each person, we can look trough the ranking for those people with the strongest preferences. The groupware tool that is located higher for all of them will be the best choice for the team, even though it would not be the first choice for some, or even none of them. An example is shown in Figure 4. As we can see from the figure, since P1 and P3 have strong preferences in the opposite sides of the same category (Verbal-Visual), the recommended groupware for the group is chosen looking through the ranking from both stakeholders. Doing so, we found out that Chat is the best choice for both, even when it is in the second place in both rankings. As we explain previously, we do not take into account the preference rules for stakeholder P3 because we know that it is not going to be difficult for him to get accustom, since he has slight and moderate preferences.

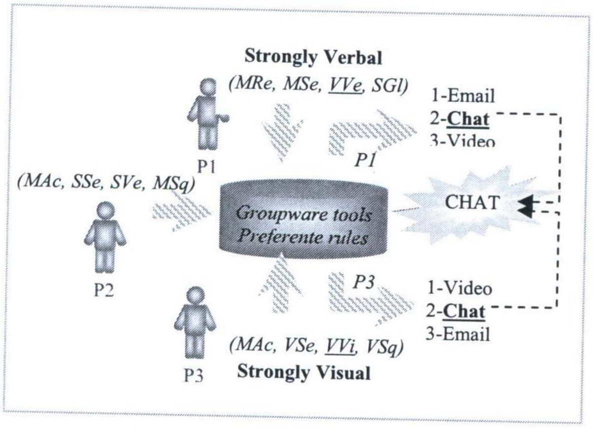

Figure 4: Strategy 3 represented for 3 stakeholders with strong preferences with conflict

This last strategy is currently under study, since we need to analyse the existing algorithms that fit the kind of result we need to implement.

To sum up, the strategy to be applied in each case depends on the cognitive profile of stakeholders, and the existence of strong preferences with or without conflicts. Figure 5 shows a graphical representation of this selection process.

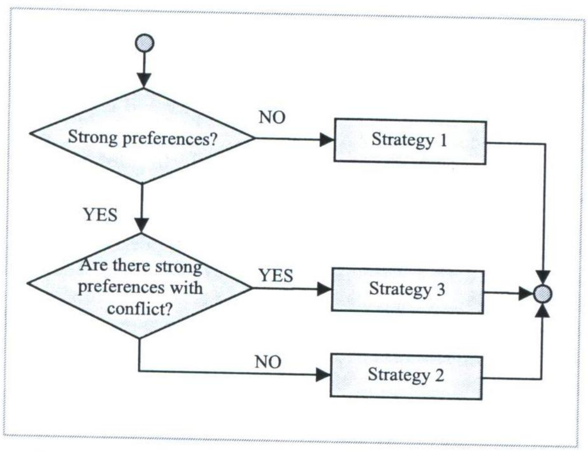

Figure 5: Analyzing the type of preferences in the virtual team

6. Discussion

This work is part of a wider proposal that aims recommending strategies to minimize the problems that commonly arise during the requirements elicitation process in GSD projects.

Since one of the most common problems is communication, we centred our attention on the technology used in GSD projects and realized that there are many related works that focused on groupware design, a few ones that analysed their suitability during software development process, but we did not find any related works that analyse groupware suitability considering stakeholders' cognitive characteristics.

According to the definition of the psychological types, people have patterns of behaviour that correspond to cognitive characteristics that are innate. For example, regarding learning style, people behave in different ways: some people like rational thinking, others like drawing and making analogies; and their performance depend on their own capability as well as the compatibility with the learning environment [13].

For example, if a person is strongly visual and the groupware tool used by the group is audio-conference, it is probable that his/her perception will be reduced, the focus of his/her attention will be lost, and as a result, the communication will be poor. The same would happen if a strongly verbal person is forced to communicate by means of diagrams and images and do not have a media that stimulate him/her way to perceive information as spoken words.

Considering the analogy between stakeholders in the requirements elicitation process and the student-instructor environment, as we explained before, making the environment closer to the stakeholders' capabilities may improve stakeholders "learning" performance. Therefore, communication during the requirements elicitation process is expected to be more successful and the obtained requirement specification is expected to be more precise.

In order to validate our proposal we have carried out an experiment in which 24 computer science post-graduate students from Argentina and Spain took part. The students were divided into eight teams, with three people in each, in which two Spanish people played the role of analysts and the other, from Argentina, played the role of client. After analyzing the students learning style model, applying the F-S test; we realized that in each team there were at least one strongly visual person and there where not strongly verbal people; then we applied the strategy 2 for groupware selection. The groupware chosen for the experiment were email, chat and audio-conference. The teams were randomly assigned to the treatments: half of them were told to use the best groupware tool according to our preference rules, while the rest were told to use a different groupware (less suitable). However, team members were not advised about which groupware tool was supposed to be the most suitable for their cognitive profiles. We gave people one week to contact each other as many times as they needed, and asked them to record every conversation they had. Seven days later we received a requirements specification for the proposed system. In addition, we asked the teams members to fill in a post-experiment questionnaire to obtain their opinion about the requirements elicitation process and the requirements specification they had written. Our current work focuses on the analysis of the data collected from the questionnaires, at the same time that requirement specifications obtained from the experiment are being analysed by several professors who teach software engineering topics. We expect these results will be useful to asses the influence of our selection strategy on the global requirements elicitation process.

7. Conclusions and future work

In GSD projects, stakeholders are distributed among many distanced sites and communicate through groupware tools, giving organizations the possibility of saving costs, specially hiring human resources at a lower rate.

Choosing the appropriate technology for communication becomes crucial in such environments, because if stakeholders feel comfortable with the technology they use, information gathered during elicitation is expected to be more accurate.

With such an aim, we have developed a methodology for requirements elicitation in distributed environments. Part of such a methodology involves groupware tools selection according to the learning styles of the members of the virtual team.

In this paper we present three different strategies we define to combine the preferences for all the team members, looking for the best solution for the group. The strategies are based on the detection of the strongest preferences and the possibility of conflicts about it.

An experiment to check the second strategy was performed where software engineering students from Spanish and Argentinean universities were involved. Our current work is centred on analyzing the data collected during such experiment. In future we plan replicating this experiment in other academic environment before applying it in an industrial scenario.

Acknowledgements

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