Fitting Three Dimensional Virtual Worlds into CSCW

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***Abstract*—Three dimensional virtual worlds (3DVW) have experienced a large growth in number of users, and are being used for collaboration activities. In parallel, the research field of Computer Supported Cooperative Work (CSCW) has developed taxonomies to classify systems that support collaboration. However, the CSCW perspective presents a bias towards traditional user interface paradigms, whose affordances are quite distinct from those of 3DVW, which include features such as the spatial environment, embodiment, and their dynamics. These are features which are regarded as significant factors in the research field of Presence, and yet, in our opinion, are not well appreciated from the perspective of CSCW analysis. Because of this, we question of the ability of CSCW taxonomies to properly describe the collaboration characteristics of 3DVW. By "properly", we mean to say that 3DVW bring to fore collaboration characteristics that are in fact distinctive of them as collaboration tools, impacting collaboration in ways that are seldom found in usual groupware, and yet CSCW taxonomies do not distinguish them. We posit that these features should be contemplated in CSCW taxonomies and their usefulness taken into account in the development of future systems that aim to support collaboration.**

Keywords—Three dimensional virtual worlds; Computer Supported Cooperative Work; Collaboration; Communication; Non-verbal communication; Presence.

I. Introduction

Computer-based virtual worlds (VW) are nowadays typically understood as virtual spaces inhabited by virtual characters, representing users or synthetic agents. Castronova [1] defines VW, from a social sciences perspective, as a system that has three key features: interactivity between people and the virtual environment; simulation of physical laws similar to the real world; and persistence, that is, the virtual world exists even if no one is using it, and it remembers the location of things and avatars. Morgado et.al [2] clarifies Castronova's requirements by stating that the key defining aspect of VW is that users interact with the system via manifestations of their personas inside the world, an avatar-mediated interaction that both affects the world and is affected by it. Current 3D Virtual Worlds (3DVW) are VW where multiple users interact in a common three-dimensional graphical environment. 3DVW typically present to the users a world that is easy to grasp, a world that can be interpreted by leveraging the intuitive understanding of the physical world to which we are used to. These understandable and immersive environments, empowered with technological facilities for communication, content building, and sharing of artifacts, among other affordances, can enhance collaboration [3]. Good examples of 3DVW used to support collaboration, for work activities, games, or social interaction, are World of Warcraft, and Second Life [4][5].

The detailed analysis of cooperation affordances of 3DVW has, for the most part, been given little attention by the research corpus on Computer Supported Cooperative Work (CSCW), a scientific field of study that aims to inform the design of computer systems to support cooperative work [6], focusing on activities such as planning, coordinating, monitoring, communicating, and establishing rules [7][8]. Groupware systems are a typical example of the object of study of CSCW. There are several taxonomies in the field of CSCW which were developed to classify the variety of tools created, along with their purposes and features, but a doubt may arises in knowing whether these taxonomies are well suited to classify 3DVW meaningfully. This is because typical Groupware tools possess either traditional command-based interfaces or, in more modern systems, GUIs based on the desktop or Web metaphors, with icons, links, windows or panes, and so forth, which hardly match the immersive environment of a 3DVW. 3DVW recreate instead, a virtual space, allowing users to enter that world with a virtual self (an avatar) and interact with the world in different ways than traditional Groupware tools. To test this concept, in this paper we assess the ability of one of the taxonomies of CSCW to classify 3DVW, demonstrating its shortcomings. We hope with this work to demonstrate the weakness of current CSCW taxonomies to adequately describe 3DVW, highlighting their distinctive characteristics and contributing to a better understanding of their weaknesses and strengths in collaboration activities.

In the next section, we present our research questions and methodology. In the third section we present CSCW theory. In the fourth section, Presence and its relation to 3DVW is presented. In the fifth, collaboration features of 3DVW are analyzed to extract their distinctive characteristics. In the sixth section we classify two common and widely used 3DVW under the representative CSCW taxonomy, and in the final section we present our conclusions.

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II. Research Questions and Methodology

We aim to verify the ability of CSCW theory to acknowledge the particular features of 3DVW for collaboration, by submitting 3DVW to CSCW theory classifications under a taxonomy. This objective is tackled through two research questions (RQ):

RQ1: Which are the distinctive collaboration characteristics of 3DVW?

RQ2: Can CSCW taxonomies highlight those characteristics?

To answer the first question, we present a compilation of distinctive characteristics produced by analysis of several cases of collaboration using 3DVW in these areas. There are in fact, many studies of collaboration in 3DVW, but the majority of them do not relate collaboration characteristics with the actual technological features that support them. Thus, for our purpose, we selected studies concerned precisely with that relationship, which has reduced considerably the set of references. To accomplish this, we used the search engine scholar.google.pt, with the following search terms (without quotes, i.e., searching for any arrangement of these words in the results): “types of collaboration” 3D virtual worlds”, “types of cooperation” 3D virtual worlds, “forms of collaboration” 3D virtual worlds, and “forms of cooperation” 3D virtual worlds”. We obtained more than 200 articles. From these, we selected 42 works by reading their titles and abstracts to confirm the subject treated. Finally, 17 of those we actually used to answer the first question, because they related collaboration features with technological features. Other references used, were obtained and their relevance confirmed by us in previous work [19][26]. For the second question, we employed a recent and comprehensive taxonomy of CSCW [19], in order to verify if this taxonomy can accommodate the compiled distinctive characteristics of 3DVW. The case for the selection of this taxonomy is made further ahead in next section.

III. CSCW Taxonomies

CSCW and its associated concept, groupware, focus on collaboration between people towards common goals, when supported by software [9]. Earlier approaches to group work were accomplished by [10],[11] and [12]. Based on these, in 1984 a taxonomy was proposed by [13], that classified group work using task dimensions (planning, creativity, intellective, decision-making, cognitive conflict, mixed-motive, contest, and performance), which are divided by four quadrants (generate, choose, negotiate, and execute). The dimensions time, distance and group were added later on [14], leading to the time/space matrix [15]. Several other taxonomies were proposed, such as the 3C model [16], taxonomies intended for developers [21], Okada’s hierarchical taxonomy [18], etc. A more detailed study about CSCW and Groupware taxonomies can be found in [19].

In a previous work involving the authors of the current paper [19], a model was proposed embodying the most important perspectives in the field of CSCW, based on a systematic taxonomy review starting in 1984, at the dawn of the CSCW field, using the number of citations as main criteria for selection. This model encompasses the important aspects of the most previous taxonomies, and includes a socio-technical perspective, thus being an adequate representation of all the other models for the analysis conducted herein. Interaction and social aspects provided by 3DVW are important for our study because several authors support that social interaction in 3DVW enhance collaboration. We demonstrate the validity of this claim with a few exemplar cases. Firstly, we consider that control over bodily appearance can impact cultural and societal perceptions, and consequently affect the development of trust, important for aspects such as team building – a factor which was identified by [20] as impacting collaboration in project management. Secondly, we consider that roles and authority emerge both from verbal and nonverbal clues, based on the fact that it is usual in 3DVW, such as Second Life or Active Worlds, that users establish their own rules and [21]. Thirdly, the very existence of a shared 3D space and avatar-based social interaction are considered important interaction features for decision-making and planning [20], as is the ability to simulate scenarios [22], including the establishment of rules and available roles. Lastly, Distance Learning, where several authors have pointed out the relevance of 3DVW-specific features: 3D-building activities, immersion, and avatar-based socialization [22][23] – here, “avatar-based socialization” includes interaction and control over the 3D environment, and “immersion” is a concept connected to capturing users’ attention by the system [24]. By environment we refer to the psychological effect created by characteristics such as ambient sounds and music, light, colors, theme, etc. The collaboration characteristics of 3DVW are held under an environment that is at least partly user controlled. Thus, a desired environment can be created by manipulating physical characteristics in order to influence the mood and humor of the users. This is believed to help users to socialize [20].

The model chosen, at the firs level, includes the 3C model, [16] with communication, cooperation and coordination; the Time/Space category, related to synchronism/asynchronism and dispersion or not of group members; and Awareness of group activities, which bounds collaboration [19]. The domains at the Application level contain a detailed classification scheme of core functionalities. This scheme includes four capabilities that are the most fundamental features of CSCW systems: jointly authored pages (conversation tools, polling tools, group dynamics, and shared editors), streaming technologies (desktop/application sharing, audio conferencing, and video

TABLE I. Holistic model of CSCW and Groupware taxonomies (adapted from [19])

<table>
<tr><th colspan="6">3C Model</th><th colspan="6">Time/Space</th><th rowspan="6">Awareness</th></tr>
<tr><th colspan="12">Application level</th></tr>
<tr><td colspan="3">Regulation</td><td colspan="5">Groupware application properties</td><td colspan="4">GDSS elements</td></tr>
<tr><th colspan="12">Group work</th></tr>
<tr><td colspan="3">Group characteristics</td><td colspan="3">Group tasks</td><td colspan="3">Situation factors</td><td colspan="3">Individual characteristics</td></tr>
<tr><td colspan="6">Interaction-outcomes variables</td><td colspan="3">Processes</td><td colspan="3">Results</td></tr>
<tr><td colspan="4">Classes of criteria</td><td colspan="4">Meta-criteria</td><td colspan="5">Other dimensions</td></tr>
</table>

conferencing), information access tools (shared file repositories, social tagging systems, search engines, and syndication tools), and aggregated systems. Adding to these functionalities, there are also message systems, information sharing technologies, Group Decision Support Systems (GDSS), project management software, virtual workspaces, electronic meeting rooms, process or event management systems, chat/instant messaging, notification systems, group calendars, collaboration laboratories, bulletin boards, data mining tools, e-mail, workflow systems, intelligent agents, etc. Regulation is a subcategory of the application level, and is related to features that enable collaboration in shared environments, and definition of work rules to ensure the accomplishment of group goals [25]. Regulation has several dimensions such as: arenas (location); actors (roles, places, and positions); tools (regulative or not); roles (thematic or causal); rules (constraints, norms, or work rules); types of interaction; interactive scenarios; and objects (means of communication and product of collaboration). The groupware application properties is a subcategory that refers to functional properties of collaboration tools such as: architecture, functional and quality properties, group processes support, collaboration interface (portal, devices, or physical workspace), relationships (collection, list, tree, and graph), core functionality, content (text, links, graphic, or data-stream), supported actions (receive, add, associate, edit, move, delete, or judge), identifiability, access controls, alert mechanisms, intelligent software components, awareness indicators, and platform. Finally, the GDSS elements subcategory includes hardware, software, and people support tools. This model is presented in Table 1. It presents blocks in layers, each containing a set of domains. The granularity or detail of the classification diminishes from top to the bottom of the table.

There are many CSCW and Groupware taxonomies, but there is a lack of taxonomies that address the socio-technical perspective related to the interaction of people belonging to a group. The set of domains and the detail of the Application level is the one adequate to use for classification of 3DVW and Groupware tools in this work, because it identifies the main topologies of groupware systems [19], that is, at this level the features of the applications are identified, therefore we will use it to compare features of 3DVW with those of groupware.

IV. PRESENCE AND COLLABORATION CHARACTERISTICS OF 3DVW

Presence is believed to influence positively collaboration on 3DVW because helps users to understand better the virtual world and thus, contributes to an easier and more intuitive use of it [26]. Because of this, we also consider the concept of Presence for this study. While mostly ignored by the CSCW field, Presence has its own body of literature and theory, and it is seen by several authors as important for collaboration in 3DVW [23][27]. A related concept with Presence is the ability of an application to detect users online. Also known as presence awareness, this feature is common to instant messaging systems, and refers to the possibility of users to know who is on line and, probably, available for interaction [28][29]. This facility is believed to support social presence [28][30]. Social presence is the feeling of communicating with other people or intelligence, and is one of the five dimensions of Presence [31]. In this work we refer to the wither view of Presence, that is, the psychological illusion felt by the user, that happens when the user is unable to recognize the mediation of technology in the creation of the experience [31]. In 3DVW, Presence is strongly influenced by the environment, the avatar, and features like gestures, sounds or customization [32].

According to Presence theory, non-verbal communication is related to features such as proximity, orientation, eye contact, eye gaze, and embodiment (the use of an avatar), and is important both to perceive Presence and to communicate [33][34]. Non-verbal communication can also improve group awareness [33], and collaborative tasks in general [35]. Table 2 presents the collaboration features of 3DVW and their relation to Presence theory. Highlighted by a thicker line, are the features common to both. The table is divided into two major columns. The non-verbal communication column encompasses: the physical space, including objects and artifacts (such as scripts, or images, textures, etc.); the environment (ambient sounds and music, light and colors, and theme); and the avatar (physical appearance, gestures and behavior, and sounds). The verbal communication column has the conversation features of voice, chat, and instant messaging.

TABLE II. Collaboration features of 3DVW and Presence

Non-verbal communication		**Verbal communication**
Physical space	***Avatar***	***Conversation***
Objects	Physical appearance	Voice
Artifacts	Gestures and behavior	Chat
Environment	Sounds	Instant messaging
Presence		

By one side, non-verbal communication features are hardly achieved with typical Groupware tools possessing traditional command-based, telephony-based interfaces, with icons, links, windows, etc, but easily found on 3DVW. By the other side, Presence, with its own body of literature and theory well established, is accepted has a relevant influence for collaboration on 3DVW, and remarks the importance for collaboration of the non-verbal communication features. Because of the above facts, we can affirm that Presence reinforces the importance of those features for collaboration on 3DVW, and helps to distinguish 3DVW of other tools that can be used for collaboration.

V. DISTINCTIVE COLLABORATION CHARACTERISTICS OF 3DVW

There are several examples of 3DVW used for collaboration: in education, training, and distance learning [3] [23][27]; in business decision making and planning [20][22], and in project management [3][20]. In this chapter we intent to retrieve the most distinctive features of collaboration that 3DVW have.

Besides text, audio and video, gestures and emotions are features for communication in 3DVW, based on the avatar [3] [5]. Also the possibility to touch, move and alter objects permits feedback and the expression of intentions in a non-verbal way. Further, the control over avatar appearance and behavior brings somatic communication and social symbolisms like culture, ethnicity, and religion [20]. Other non-verbal cues are present by employing positioning in the shared physical, both for avatars and objects, i.e., proximity, visual groupings (e.g., using gestalt theory), and orientation. Thus, the features of 3DVW for communication are those of verbal and non-verbal communication: in verbal, voice, chat and IM; and non-verbal, the features related to the avatar (appearance, gestures, sounds, focus and nimbus, etc), and those related to objects.

In 3DVW the communication is held in similar way to the real world, where order must be achieved by the users, not forced by the technology. That is, users establish rules and distribute roles between themselves, and the observation of those is not responsibility of the technology [3][36]. Rules, roles and authority can be established by verbal means, but in 3DVW can also be established by non-verbal clues, which is a fact on several well known 3DVW like Second Life or Active Worlds [21]. Non-verbal cues are also important for cooperation and cooperation because of the ability to visually perceive artifacts as belonging to different users [3] contributing for the observation of the rules established, namely by allowing the group members to touch or edit just the objects they are permitted to. So, coordination and cooperation are based on the establishment of rules and roles, which use features of both, verbal or non-verbal communication.

The existence of a shared 3D space and avatars are considered important interaction features [20]. The physical space also enhances the sharing of artifacts, interaction and awareness [37] . By this, it can be established that the physical space supports interaction, sharing, and awareness; the environment and embodiment support interaction and awareness; and aura, focus and nimbus support awareness [5].

Several of these features are common to typical Groupware tools, such as text, audio and video, awareness and interaction, rules for cooperation, and some degree of visual/iconic gestures and emotion expression. In fact, in audio or video conferencing it is possible to use some non-verbal communication. Also the time/space dimension can be related to the virtual physical space of 3DVW. So, these aspects are not themselves entirely new contributions of virtual worlds, and therefore their analysis hold the potential to impact non-virtual world CSCW technologies as well. Nevertheless, the features mentioned are modified by 3DVW or found only in them, via the provision of virtual physical space and avatars, adding new possibilities of communication, awareness, and interaction. The importance of these characteristics (virtual physical space, environment, and avatars) is transversal to all the collaboration cases we studied, and so, we consider them the distinctive ones of 3DVW for collaboration. These features and their relationship to the other collaboration features are presented in figure 1, highlighted by a thicker line.

VI. Fitting 3DVW into CSCW Taxonomies

In this section, the ability of CSCW taxonomies to adequately classify 3DVW will be put to test. Then, the comparison will be held with two perspectives: we will compare the characteristics of 3DVW to those covered by the CSCW taxonomy of [19], and we will also highlight the characteristics of 3DVW that are not covered by this CSCW taxonomy. With this analysis we can obtain the current perspective of 3DVW according to CSCW theory.

In the category of jointly authored pages, most of 3DVW (such as Second Life or Active Worlds) possess conversation tools (chat and instant messaging), and group dynamics (roles). In the category of streaming technologies they have audio conference (voice), environment audio and video streaming. In Information access tools they have a shared repository (the virtual world), social tagging systems (alerts), and search engines. At least these two 3DVW can cover all categories of the taxonomy, but in sub-categories they lack as a default, shared editors, polling tools, desktop/application sharing, video conferencing, and syndication tools. However, a usual facility in 3DVW is for users to be able to create, edit, or acquire personal objects for customizing personas or spaces, and share them, which can be seen as a form of shared edition. At least Second Life, end-user facilities include scripting, which has been used to create a huge diversity of tools including pooling tools and syndication tools. Other virtual worlds have also seen such tools produced by professional developers, and made available to its users, such as OpenWonderland and vAcademia. Despite the fact that there are no references to non-verbal communication functionalities in this or other CSCW taxonomies, 3DVW nevertheless possess most of the core functionalities important to CSCW. We need to cross these with the distinctive characteristics of 3DVW to establish the ability of CSCW theory to encompass them adequately. According to the chosen taxonomy, the perspective on collaboration requirements looks at four vectors: communication, coordination, cooperation and awareness – each implying important requirements that have to be fulfilled by cooperation systems. To support communication, software tools have to feature conversation in one-to-one, one-to-many or many-to-many topologies (conversation, audio/video conference, shared file repository). For coordination, the tools must have time and resource management, and shared artifacts (group dynamics, polling tools, and aggregated systems, i.e. specifically developed for each application). For cooperation, messaging systems and development/sharing of documents (conversation and desktop/application sharing) are required. And for awareness, the tools should have warning mechanisms and means of tracking or know the work of each group member (social tagging systems, search engines, and syndication tools). At this level at least, there are no references to non-verbal communication, or anything directly related to physical space: that is, such aspects can be fit within these categories, but become obscured. Thus, they are not given due relevance by this CSCW taxonomy.

To visualize the relation between collaboration concepts, we present in figure 1 all the features related to collaboration and their relations based on both CSCW's and distinctive features of 3DVW [19][26].We find that non-verbal communication features of 3DVW are lumped together in this CSCW taxonomy within the same category as audio/video conferencing, and that the virtual 3D space, as well as the 3D environment, are related entirely to the time/space dimension– but as seen above, the virtual 3D space and environment in 3DVW are part of communication also. This visualization enables us to understand how all the features relate to achieve collaboration in 3DVW, and how they fit within the taxonomy. The arrows represent the relations between them all. The features and arrows in thicker lines are those considered most relevant to Presence theory, as explained above, and match those lacking in CSCW taxonomy.

VII. Final Remarks

In this paper we analyzed the ability of CSCW to properly classify 3DVW under a holistic taxonomy. We started by identifying some features of 3DVW from the literature that are found to be relevant for collaboration, and emphasized that novel communication features, in particular non-verbal ones, as most relevant. We established that features like conversation or audio/video conferencing are contemplated in the holistic taxonomy, but that non-verbal communication features are not, despite the possibility of being accommodated by it, but implying a high level of granularity: at more detailed levels, it is obvious the lack of reference to features like gestures or embodiment, which is revealing of failure to properly describe 3DVW collaboration affordances. Since the employed taxonomy is a holistic one, encompassing most of the older taxonomies, it is reasonable to admit that this failure to describe 3DVW properly is characteristic of CSCW taxonomies. Also, it is an indication that more attention should be given by the CSCW community to the use of 3DVW for collaboration.

CSCW has studied the needs of users working together, in order to support the development of computer systems to support their needs. Most systems use the graphic interface that we all are used to, based on icons, windows, buttons, etc. And these solutions are probably adequate for most cases, but different approaches exist, 3DVW being the one under our scope. 3DVW software also has buttons, icons, and functionalities similar to those used in groupware, but it also has something that enables a different relation between user and system, and between users. That is the encompassing of the activity within a virtual world which includes personas of users as virtual selves (avatars), a world created artificially that opens new possibilities of support for collaboration between people. In the future, these possibilities shall be investigated, particularly the use of an avatar, of gestures, sounds, and other visual characteristics. The aim of such an investigation will be to establish how these characteristics affect the key concepts of CSCW. CSCW identified key concepts of collaboration: communication, coordination and cooperation (3C Model); sharing and interaction (Time/Space); and awareness. CSCW also supported these concepts at the application level by establishing mechanisms of rules and roles, verbal communication, shared repositories, triggers and warnings, etc. All these, we have seen, are used by most 3DVW too. But 3DVW bring a new perspective to time and space, with impact in other concepts, especially in communication.

As expressed earlier, embodiment, gestures, expressions, the environment, and the 3D space have significant impacts in collaboration, by the enhancement of communication, contributing to the awareness of the group, and also by promoting the sharing of artifacts, socialization of the users, and team building. These collaboration-relevant characteristics of 3DVW should therefore be seen as relevant under the theoretical models of the CSCW community. Hence, they should be taken into account in the future developments of these models. We posit that, without this improvement to current CSCW models, they will fail to adequately support the development of 3D-based embodied systems to support collaboration. These distinctive features of 3DVW are

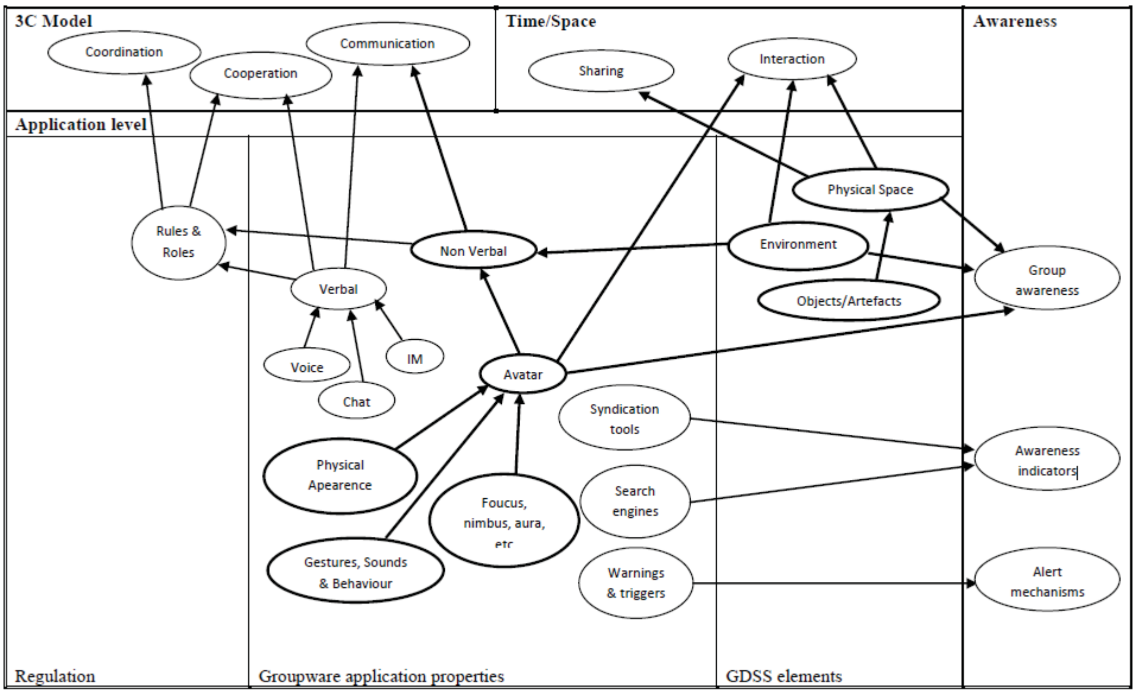

Fig. 1. Collaboration features of 3DVW and their classification.

coincident to those considered most important to the creation of the feeling of presence, under Presence theory. Thus, we believe that presence should be added to an even more encompassing CSCW taxonomy. This could be achieved by including Presence concepts in some dimensions, such as Presence awareness. Or, it could be achieved perhaps, as a new dimension. This new dimension could be called Presence, sub-divided into Physical space and Embodiment witch, in turn, would be divided into more detailed features, such as Avatar.

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