Chapter #10

Modeling the Interactions in Virtual Spaces Oriented to Collaborative Work

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1 INTRODUCTION

Collaborative work is based on communication and information exchange among individuals for developing a conceptual object (Conde *et al.* 2008, 2009). Systems of the CSCW (computer-supported cooperative work; Grudin, 1994) paradigm constitute an approach to facilitate group work processes mediated by information technology (Peiro *et al.* 1993).

Molina *et al.* (2009) propose three main lines of systems development related to the CSCW paradigm:

[a] Development *ad-hoc*, in which systems are built in a completely adapted way to the specific problem to which it is intended to support. This has been until now the usual trend in creating groupware systems.

[b] The use of programming toolkits, which provide a higher level of programming abstraction by using functions and API (Application Programming Interfaces).

[c] The development based on components that allows the construction of CSCW systems by using predefined building blocks. Such blocks can be reused and combined in different ways.

Moreover, Molina *et al.* (2009) indicate that another line of development is proposed on the basis of the development process in the conceptual modeling of the collaborative virtual environment. There are some proposals for conceptual modeling notational aspects of group work. Among these notations can be mentioned: (a) APM (Action Port Model) focused on modeling the workflows developed by groups (Carlsen 1997); (b) PROCLETS that proposes a notation for interaction processes associated with managing multiple workflows (van der Aalst *et al.* 2001); (c) AMENITIES, that proposes extensions of UML notation (COMO-UML) for groupware modeling with emphasis on the modeling of dynamical aspects (Garrido 2003); and (d) UML-G, also focused on the modeling of groupware but emphasizing on data modelling (Rubart and Dawabi 2002; 2004).

In this Chapter, we define the problem of modeling the interactions in a working group (Section 2), we propose an integrated modeling framework (Section 3) composed of formalisms: table category-concept-definition (Section 3.1), interaction cases and interaction group diagrams (Section 3.2), interaction procedures (Section 3.3), sequence diagram of group dynamics (Section 3.4), and development diagram of conceptual objects (Section 3.5); we present a concept proof of the introduced formalisms (Section 4); finally, we formulate conclusions and future research lines (Section 5).

2 DEFINITION OF THE PROBLEM

Several authors (Sosa *et al.* 2006; Giraldo *et al.* 2008; Molina *et al.* 2008; 2009) have pointed out the need to address—prior to CSCW system modelling—the modeling of aspects of group dynamics such as social interactions and responsibilities among individual. The current state of conceptual modelling work group is characterized by the following limitations:

[a] Lack of theoretical and computational models that allow to adequately specify the group activities mediated by information technology.

[b] Difficulties for addressing the integral modeling of interactive aspects among individuals and task aspects of group work.

[c] Lack of adequate conceptual specification artifacts for modeling collaborative tasks which have to be mediated by CSCW systems.

In the context of formalisms to develop the analysis and design of CSCW systems we can formulate the following research question: Is it possible to develop new modeling formalisms which complement the ones previously presented, in order to model interactions among group members and their social dynamics, which could be managed by CSCW systems?

3 PROPOSED SOLUTION

The proposed framework for analyzing and designing virtual spaces oriented to collaborative work is composed by the following modeling formalisms: table category-concept-definition (presented in Section 3.1), interaction cases and interaction group diagrams (presented in Section 3.2), interaction procedures (presented in Section 3.3), sequence diagram of group dynamics (presented in Section 3.4), and development diagram of Conceptual Objects (presented in Section 3.5).

3.1 *Proposed Formalism: table category-concept-definition*

In the context of formalisms for knowledge representation proposed by the Knowledge Engineering (Gomez *et al.* 1997; Garcia-Martinez & Britos 2004), Rodriguez *et al.* (2010) introduce the concept-category-definition (CCD) table to represent the factual knowledge of the conceptual model of group dynamics. The CCD table introduces the concepts to be used in other formalisms in lexicographic order, specifying the category and giving the concept definition. The formalism is captured in the form of a table as shown in Table 1.

Table1. Example of table category-concept-definition

Concept	Category	Definition
Concept 1	Category 1	Definition of Concept 1
Concept 2	Category 1	---
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Concept N	Category Q	Definition of Concept N

A concept can belong to any of the following categories: actor, object, or interaction. Actors are who bring to life the group dynamics. Objects are the entities receiving the exercise of the powers of the actor interactions. Interactions define processes the actors agree to perform on objects.

3.2 *Proposed formalism: interaction cases and interaction group diagrams*

The modeling of the interactions among actors is made by using two formalisms: [a] interaction cases and [b] interaction group diagrams. An interaction case captures interactions between two actors (see Figure 1). In particular, the reflection is a case of interaction of an actor with himself. An interaction group diagram provides, in an integrated way, interactions among all actors considered in the modeling process (see Figure 2).

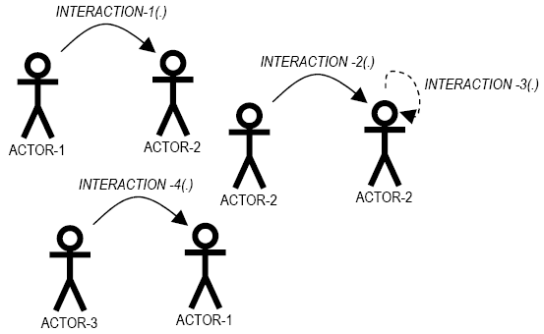

Figure 1. Examples of interaction cases

The notation proposed for interaction cases and interaction group diagrams is based on use cases and use case diagrams (Booch *et al.* 1998, Kendall & Kendall 2005). However, as a difference, object paradigm interactions between the actors and the system are not modeled, and interactions among actors are considered. The formalism proposed in this Chapter uses solid lines to model interactions among actors and dotted lines to model the reflections of an actor.

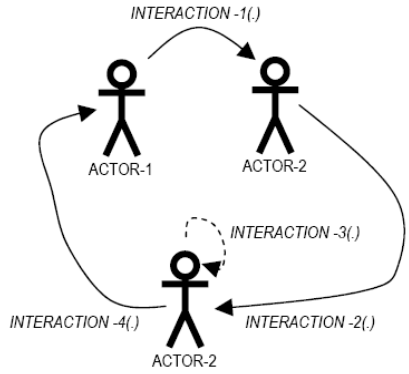

Figure 2. Example of interaction group diagrams

3.3 *Proposed formalism: interaction procedures*

Procedures describe the composition of interactions among the actors made for the development of an object. To express the procedures the actors can perform on the objects, we propose to use predicates of N-order (Cuena 1985; Naishtat 1986). Prefix notation and the used grammar are shown in Table 2.

Table 2. Grammar for expressing procedures

< ACTION >	::=	<Acción 1> | <Acción 2> | . . . | < Acción P >
< ACTOR >	::=	<Actor 1> | <Actor 2> | . . . | <Actor Q>
< OBJECT >	::=	<Objeto 1> | <Objeto 2> | . . . | <Objeto >
< PROCEDURE >	::=	<ACCION> "(" < ACTOR > "," <OBJETO> ")" | <ACCION> "(" <ACTOR> "," <PROCEDIMIENTO> ")"

The N-order predicate logic provides rich semantic for representing the procedures. For example the following ex-

pression: ACTION-T(ACTOR-S,ACTION-R(ACTOR-Q,OBJECT-P)) can be interpreted as "... the ACTOR-S applies the ACTION-T to what is the result of ACTOR-Q applies the ACTION-R to OBJECT-P ..."

3.4 *Proposed formalism: sequence diagram of group dynamics*

To express the group dynamics among the actors in the timeline imposed by the procedures of interaction, Rodriguez *et al.* (2010) and Rodriguez (2012) introduce the sequence diagram of group dynamics. Such diagrams are based on sequence diagrams (Booch *et al.* 1998; Kendall & Kendall 2005). A theoretical example of the CCD table is presented in Table 3 and a sequence diagram of group dynamics is presented in Figure 3.

Table 3. Concept-category-definition table corresponding to the theoretical example

Concept	Category	Definition
ACTOR-Q	Actor	The ACTOR-Q is ...
ACTOR-P	Actor	The ACTOR-P is ...
ACTOR-R	Actor	The ACTOR-R is ...
ACTION-S	Action	The ACTION-S is ...
ACTION-T	Action	The ACTION-T is ...
ACTION-R	Action	The ACTION-R is ...
OBJECT-P	Object	The OBJECT-P is ...

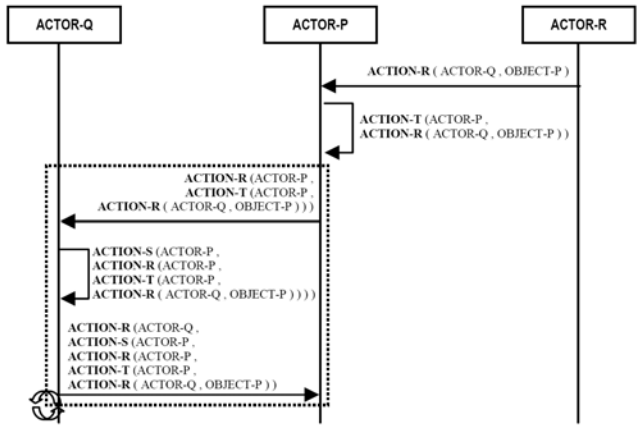

Figure 3. Sequence diagram of group dynamics corresponding to the theoretical example

3.5 *Proposed formalism: development diagram of conceptual objects*

Virtual spaces dedicated to collaborative work are intended to facilitate mediation among teams whose members are not physically contiguous, and have to develop a conceptual object (for example: research, project development, software, thesis plan, technical articles, and reports, among others). The modeling of interactions in virtual spaces dedicated to collaborative work should help to specify the interactions among the team members, and the developing work stages of the conceptual object that the collaborative working team is carrying on. The virtual space for collaborative work should satisfy requirements like keeping and documenting the different versions of the conceptual object to be developed by the collaborative working team; leaving a record of the evolution from the agreement between the members of the working team since the initial specifications of the conceptual object are gathered until its final stage development is reached. For modeling the object transformations we propose the formalism development diagram of conceptual objects. Such diagrams are based on Petri Nets (1962) and are digraphs with two types of nodes: the "conceptual objects" which will be denoted by circles and the "transformations" denoted by rectangles. The "transformation" represents the action should be performed to make evolve the "conceptual object" from a level of development into another. A theoretical example of a development diagram of conceptual objects is presented in Figure 4.

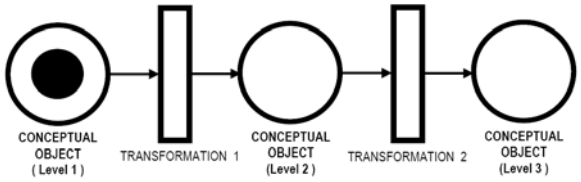

Figure 4. Theoretical example of the development diagram of conceptual objects

4 PROOF OF CONCEPT

As a way to illustrate the proposed formalism, we provide a proof of concept based on a case study from Rodriguez (2012). The situation described in the case study is based on developed interactions within a virtual space during the thesis plan review of a master degree student made by a PhD degree student (co-director of the master thesis) under supervision of a senior researcher (director of the master and doctoral thesis). The case "review of the master thesis plan" is described by the following paragraph:

> *"...Master degree student sends to the PhD degree student his previously developed thesis plan. PhD degree student reviews the plan and makes the corrections and comments he considers relevant, then send them to the master degree student. The later appropriates the corrections and comments to continue working on his master thesis plan. Once the PhD degree student believes that the version of the master thesis plan is correct, he forwards it to the senior researcher asking for his overseeing of the final version of the master thesis plan. Senior researcher oversees the corrections made by the PhD degree student. As a result of overseeing, he can send comments which may include observations about the correction made and/or to make further corrections to be introduced in master thesis plan. Upon receiving these comments, the PhD degree student appropriates these and forwards them to the master degree student for his ap-*

propriating also, allowing in this way the generation of new versions of the document ..."

In the case study we identify three actors, one object, and eight interactions. These elements are shown in the CCD table (see Table 4).

From the actors and interactions identified in Table CCD, interaction cases are presented in Figure 5. Cases of interaction are integrated in the group interaction diagram that is shown in Figure 6.

Table 4. CCD table for the case study "review of the master thesis plan"

Concept	Category	Definition
INCORPORATE	INTERACTION	Actor "A" incorporates the received information in the document and/or comments in it.
PhD STUDENT	ACTOR	Professional who has a master degree or academic equivalent and is making a career of doctoral degrees, scientific production of national importance, with a history of co-management of R&D, with expertise in co-management of in human resources training at level of master degree, specialization degree, and accreditation of being investigator category III or IV of the Argentine Ministry of Education.
SEND	INTERACTION	Actor "A" sends to actor "B" a document or information.
SEND COMMENTS	INTERACTION	Actor "A" sends Actor "B" the comments on the results of overseeing carried out; this may include observations about the correction made and/or further corrections to make.
SEND CORRECTION	INTERACTION	Actor" A" sends to actor "B" the result of the review and correction of the document with his observations.
SENIOR RESEARCHER	ACTOR	Professional with a PhD degree or academic equivalent, with scientific production of international importance, with background in project management of R & D, with background in human resources training at the doctoral level, master degree, and grade, and accreditation of being investigator category I or II of the Argentine Ministry of Education.
MASTER STUDENT	ACTOR	Professional with grade title and who is applying for a master's degree, with national scientific production, with a history of collaboration in the development of human resources at grade level, and accreditation of being investigator category IV or V of the Argentine Ministry of Education.
THESIS PLAN	OBJECT	Document referred to student's research project that is carrying out to earn a PhD, master, specialty or grade degree.
REVIEW	INTERACTION	The actor reviews the document and states his comments (in case needed) but without doing any correction.
REVIEW AND CORRECT	INTERACTION	The actor revises and corrects the document with indication of his comments and corrections (if it was necessary).
REQUEST OVERSEE	INTERACTION	Actor "A" asks to oversee of review/corrections on a document generated by a third actor. Overseeing will be made by actor "B".
OVERSEE	INTERACTION	Actor "A" oversees the reviews or corrections made by an actor "B" on a document that has been previously sent to him by a third actor.

The group dynamics that develops among actors within the timeline is expressed through the interaction group diagram that is shown in Figure 7. The conceptual object identified is "Master Thesis Plan" and the development diagram of conceptual objects is shown in Figure 8.

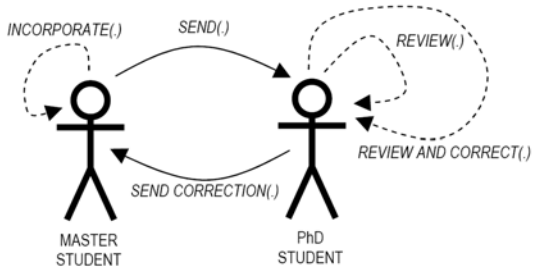

Figure 5.a. Interaction case between Master Student and PhD Student

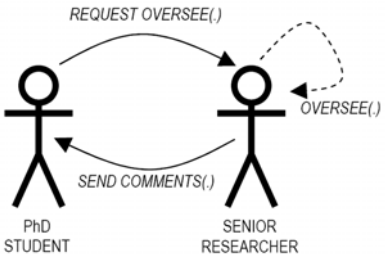

Figure 5.b. Interaction case between PhD Student and Senior Researcher

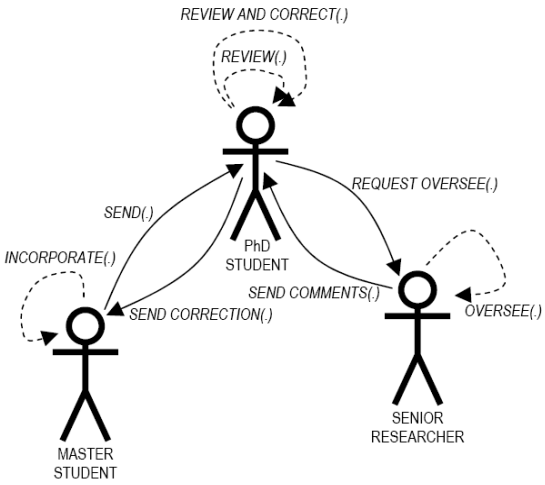

Figure 6. Group interaction diagram between Master Student, PhD Student, and Senior Researcher

5 CONCLUSIONS

Virtual spaces dedicated to collaborative work are emerging as a tool to integrate work teams whose members are not physically contiguous. The first experiences in Argentina in the use of such environments have emerged in universities and are linked to the collaboration of researchers from sever-

al countries in training human resources in research (Rodríguez 2012).

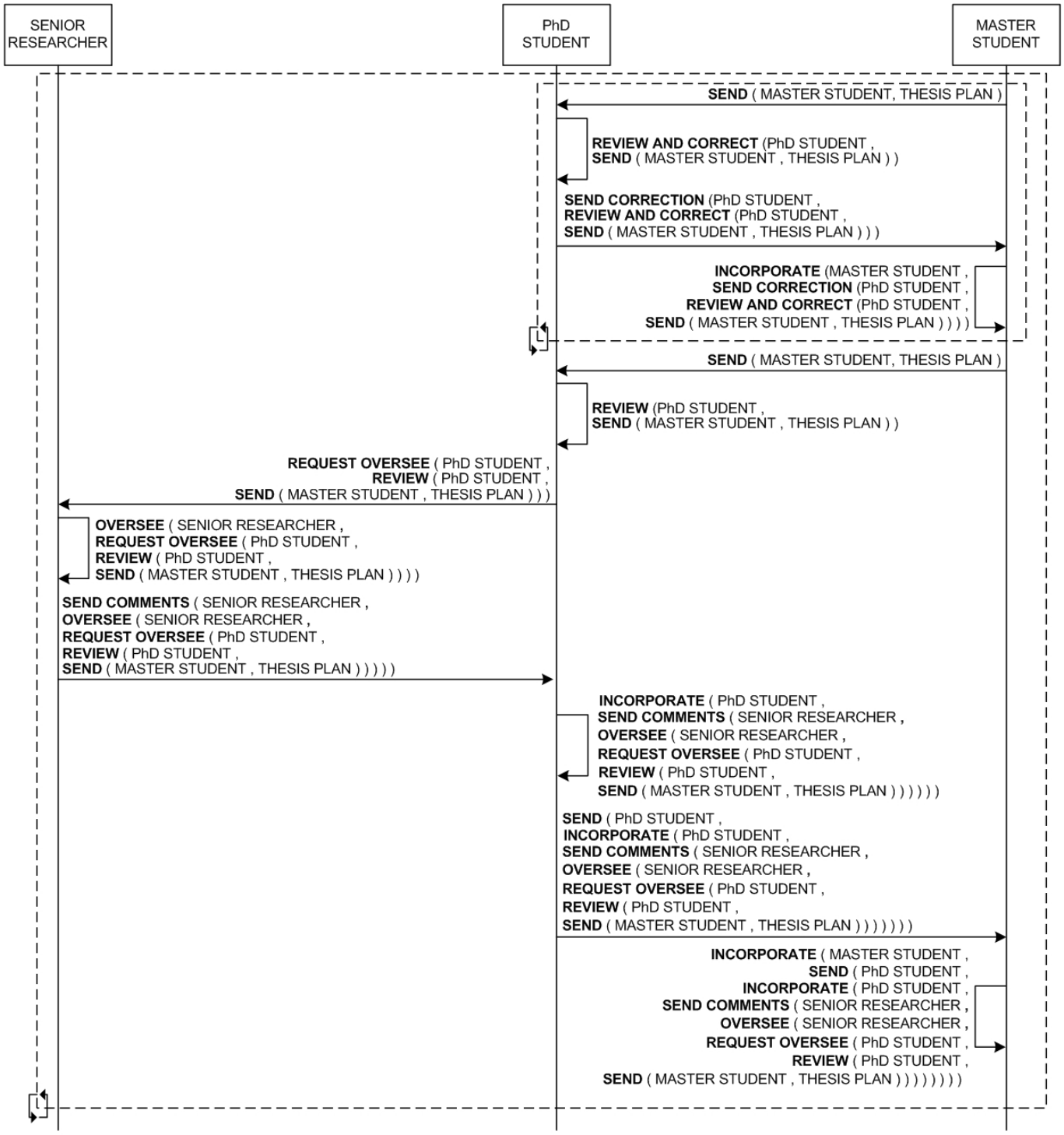

Figure 7. Interaction group diagram of case "Review of Master's Thesis Plan"

The virtual environments used have a low level of integration between its components and do not often have the functionality of asynchronous communication (online) among members of the workgroup. It is perhaps this feature which made evident the need for formalisms for modelling the interactions among members of the working group and the evolution of conceptual objects they create.

Given this context, in this paper we introduced the integrated formalisms: category-concept-definition table, interaction cases and interaction group diagrams, interaction procedures, sequence diagram of group dynamics, and development dia-

gram of conceptual objects. It has been shown the use of the presented formalisms through a test case taken from recent state-of-the-art review on the subject.

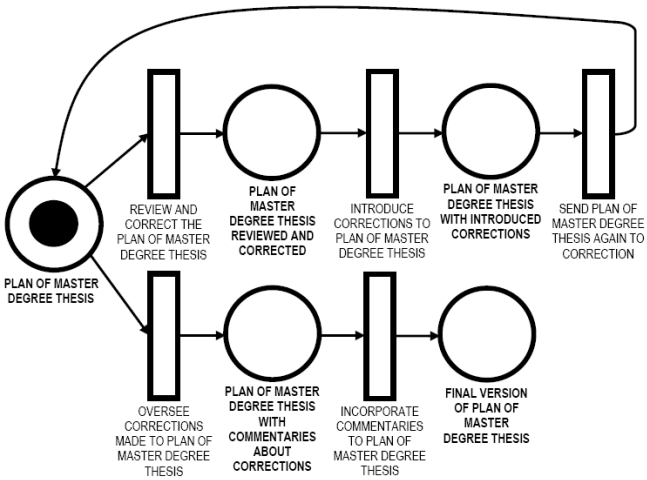

Figure 8. Development diagram of conceptual objects for the case "Review of Master's Thesis Plan".

As future line of research work, we are going to validate the generality of use of the modelling formalisms proposed in two domains: management of software development teams, and management of architectural design teams. In both cases, we plan to use members whom are not physically contiguous.

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