Overview on agent application to support collaborative learning interaction

Erlin, Yusof Norazah, Abdul Rahman Azizah

(Faculty of Computer Science and Information System, University of Technology Malaysia, Skudai 81310, Malaysia)

Abstract: Collaborative learning involves students working together to aid their learning and is considered an effective method to implement learning goal. However, it involves complicated processes such as have inconvenient assistance to manage the increasing demand for information and support extension of interaction and how to activate collaboration interaction and communication between different types of interactions. A collaborative learning model based on agent can improve learning effectiveness and give good impact to learning process. This paper discusses the definition, classification and roles of agent to support collaborative learning interaction in E-learning. It overviews the rapidly use of agents to support collaborative learning and describes the types of interaction and communication tools to enhance interaction between all participants. We identify three types of major agents used in collaborative learning interaction; interface agent, information and internet agent, and collaborative agent.

Key words: agent; collaborative learning; interaction

1. Introduction

With the rapid expansion of communication and information technologies, working together in groups can be done effectively at a distance and at any time. Collaborative learning is a learning strategy where several learners interact with each other in order to achieve their common goals (Yacine, L. & Tahar, B., 2007). Other researcher has argued that learners learn better when they learn together and foster creative thinking as members in a group generated new ideas, strategies, and solutions more frequently than working individually (Johnson, D. & Johnson, R., 1999). Moreover, online collaborative learning is regarded as an effective method for improving practical and highly advanced problem solving abilities and is being partly applied in the areas of action learning in companies, and of project-based learning and inquiry-based learning in schools (Bielaczyc, K. & Collins, A., 1999; Johnson, D. & Johnson, R., 1986).

However, numerous studies show collaboration is more difficult in e-learning environments. These studies cite such components as physical separation, reduced sense of community, disconnectedness, isolation, distraction, and lack of personal attention as contributors to lack of success in various virtual programs (Kerka, S, 1996; Stonebraker, P. W. & Hazeltine, J. E., 2004).

Erlin, Ph.D. student at the Faculty of Computer Science and Information Systems, University of Technology Malaysia; research fields: E-learning, social network analysis, computational model and e-learning agent.

Yusof Norazah, associate professor, Ph.D., Faculty of Computer Science and Information Systems, University of Technology Malaysia; research fields: adaptive hypermedia learning system, intelligent system, software engineering and E-learning.

Abdul Rahman Azizah, Ph.D., head of Information Systems Department, Faculty of Computer Science and Information Systems, University of Technology Malaysia; research fields: information systems management, knowledge management, service quality management, information architecture and E-learning.

Furthermore, the presence of an agent in a collaborative learning is essential since the agent is a crucial part of the learning design process and now constitutes powerful tools that are utilized in most applications. Most of current collaborative learning systems integrate an agent to improve performance of learning. Generally, this agent supports in synchronous and asynchronous environment. Research has shown that the main features of agents (as well as the modularity, the adaptability and the autonomy) can make them good tools for supporting collaborative learning systems (Yacine, L. & Tahar, B., 2007).

The rest of the paper is organized as follows. In section 2 we briefly introduce agent in collaborative learning. Section 3 firstly provides the types of interaction in collaborative learning and then types of communication that support interaction in cluster of agent. Section 4 gives the concluding remarks.

2. Agent in collaborative learning

The concept of agents in software engineering is not new, but it has begun to develop quickly and be successful in recent years. In this section, we examine the definition, classification and roles of an agent in collaborative learning.

2.1 Definition of an agent

Agents cannot be easily defined, as seen by the numerous definitions cited by several researchers (Franklin, S. & Graesser, A., 1996). In general, an agent is regarded as a function or software program that, when requested to do an action, understands the intention of the request and performs the action under the agent's own independent judgment (LIN, F., Esmahi, L. & Poon, L., 2005). Beside that, there are some common properties that most definitions include. Agents are autonomous which means that they act independently of any other entity. Agents are also interactive or communicative; they can send and receive messages with other agents. Agents also exist in some environment that they can sense and they act upon that environment. Agents can also exhibit other properties such as adaptability, reactivity, proactivity, mobility, responsivity and rationality (Wooldridge, M. J. & Jennings, N. R., 1995). Shoham (1997) stated additional properties by continuously; agent would be able to learn from its experience (Shoham, Y., 1997).

In educational situation, the autonomy of an agent means the ability to perform independently a task assigned to the agent by a person or other software. The autonomous feature of agents reduces users' burdens of learning activities, teaching activities, management activities, and so on (LIN F., Esmahi, L. & Poon, L., 2005). Hence, it is impossible for educators to manage the large volume of information generated from learners' interaction (CHEN P. & DING W., 2005). Agents can process a huge amount of data, make direct interventions in the process, and interact with other agents for carrying out tasks. Thus, they can help users concentrate on the contents that they are studying (Suh, H. J. & Lee, S. W., 2006).

Furthermore, agents promote interaction between a human and computer for the delivery of information, and interaction among human users for high-level achievements. Another advantage of agents in education is that they can provide a learning environment customized to individuals a unified learning environment that integrate between local and remote resources, and a mechanism for users to concentrate on knowledge provided by the agents (CHEN P. & DING W., 2005).

2.2 Classification of an agent

Agent can be classified by the type of the agent, by the technology used to implement the agent, or by the application domain itself. Nwana (1996) proposes seven categories, as shown in Figure 1, of agents as follows: (1)

collaborative agent have to negotiate in order to reach mutually acceptable agreements on some matters, general characteristics of these agents include autonomy, social ability, responsiveness and proactiveness; (2) interface agent is a personal assistant who is collaborating with the user in the same work environment; (3) mobile agent their ability to move around some network; (4) information and internet agent perform the role of managing, manipulating or collating information from many distributed sources; essentially, they help manage the vast amount of information in wide area networks like the internet; (5) reactive agent shows a reaction or response to the user, which should not wait to be told what to do next; (6) hybrid agent refer to those whose constitution is a combination of two or more agent philosophies within a singular agent; (7) heterogeneous agent system contain one or more hybrid agents which belong to two or more different agent classes (Nwana, H. S., 1996).

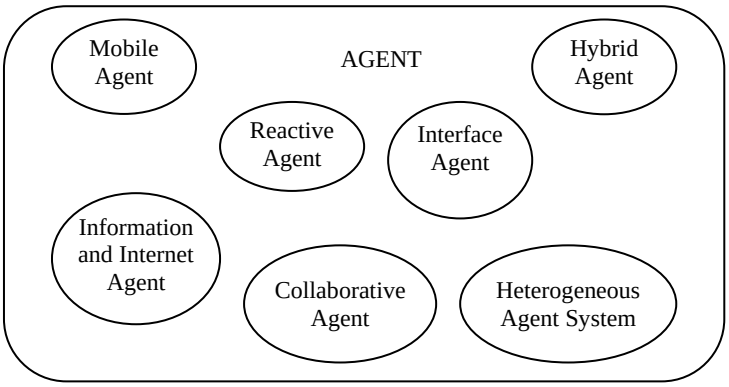

Figure 1 Classification of agents

2.3 Roles of an agent

The collaborative learning will be populated by a variety of autonomous agents that it can play many roles, hence personal assistants or knowbots. Agent roles are defined by four attributes: responsibilities, permissions, activities, and protocols (Wooldridge, M. J., Jennings, N. R. & Kinny, D., 2000). Roles signify the behaviors of an agent. The behavior of an agent is one of the most difficult aspects to model using current class diagrams. In addition to roles, agents can also belong to groups. Agents can belong to one or more groups and have one or more roles within each group because an agent's group and role designations are dynamic.

Many researchers suggested three methods of supporting collaborative learning. The first method involves quantifying the learners' joint work activities in a graph or other means and presenting the results to participating learners so that the learners can understand their collaborative acts. The second method involves monitoring and modeling all interactions among the learners and presenting differences between the ideal state and the current state. The third method involves analyzing the state of collaborative learning and providing advice for effective collaboration (Soller, A., Jermann, P., Muhlenbrock, M. & Martinez, A., 2004).

The common roles of agents that support collaborative learning are as follows: (1) monitoring the collaborative learning process; (2) giving feedback and guidance to activate interaction and collaboration among participants; (3) giving information on the current state of a learner's interaction in the collaborative learning process; and (4) giving advice on the learning process according to the process and strategy of collaborative learning by comparing the current and ideal states (Soller, A., Jermann, P., Muhlenbrock, M. & Martinez, A., 2004; Hmelo, S. C., 2002).

Nowadays, there are a number of agents and their functions have been designed specially for support collaborative learning by many authors as shown in Table 1. Each of them possesses its own view on the agent.

The main idea consists to say that there is not a standardization concerning the components of a system, or the affected role to each agent in the system. The architecture of the system and the role given to each agent depend on both the type of application and the global functionalities of the system. Based on classification of agents by Nwana, we identified clustering of each agent.

Table 1 Example of agent in support collaborative learning

Author	Name of agent	Function of agent	Type of communication	Clustering of agent
Hee-Jeon Suh & Seung-Wook Lee (2006)	Monitoring agent	Collects, analyzes, and processes information on learners' collaborative learning activities and stores it in a workplace. In particular, the monitoring agent tracks the process of learners' collaborative activities according to the form defined by the workplace reference model and stores this information in a temporary workplace.	Asynchronous: • Discussion boards • Email	Information and internet agent
	Facilitator agent	Analyzes the data in the workplace database that was collected by the monitoring agent, automatically produces learning advice and alarm messages and statistically analyzes collaborative learning.		Collaborative agent
Khaing Moe San, et al. (2005)	Mobile agent as a personal agent	To assist the student and the human tutor.	Synchronous and asynchronous: • Chat; • Email	Mobile agent
	An artificial tutor agent	Partially tries to replace the human during student interaction.		Interface agent
	Information agent	Takes the responsibility to control database and knowledge access.		Information and internet agent
	Question agent	To prepare the question and evaluate the answer.		Information and internet agent
Lafifi Yacine & Bensebaa Tahar (2007)	Assistant agent of learner	It proposes to the learner an interface which makes the learning task easier for learner.	Asynchronous and synchronous: • Forum (public forum, group forum and subject forum); • Email; • Chat	Interface agent
	Tutor agent	To present the pedagogical objectives to the learner according to his/her final profile and his/her current knowledge state.		Interface agent
	Collaborative agent	Takes into account the collaboration process between learners as well as the associated problems.		Collaborative agent
	Assessment agent	To measure the learner's knowledge level by proposing to him/her a set of exercise from various models and difficulties.		Information and internet agent
	Assistant agent of the teacher	It proposes to the teacher an interface in order to assist him/her in the creation of the concepts and the exercise of the subject to be taught.		Interface agent
	Mediator agent of the teacher	It facilitates the communication between the teacher and the learners or between teachers themselves.		Interface agent
LIU Zhi, JIN Hai & FANG Zhao-lin (2006)	Student agent	A kind of learner assistants to support the learner to acquire the resources and services.	Synchronous and asynchronous: • Discussion group	Interface agent
	Teacher agent	Act as an agent for teacher, specially, when the teacher is offline. It could record the questions from learners or forward the problem to other teachers. It also can give the learners a guide according to his background or his learning track.		Interface agent
	Instructor agent	Takes an important role in the ELMS. It could support learning process, manage virtual collaborative group, response the requirement from users, and so on.		Interface agent
	Manager agent	Several instructor agents and a manager agent compose a main container to manage the whole virtual collaborative group.		Interface agent
K. Robert Lai & Chung Hsien-lan (2005)	Assessment agent	Agent can reach a mutually acceptable agreement to overcome the subjective judgment and the unfair assessment. To negotiate the assessment of students and to achieve an agreement.	Asynchronous	Collaborative agent

From clustering, we can observe that the agents appeared in a collaborative learning typically can have a

great variance in physical attributes, and have different inherent functionalities. However, the most popular agents used in collaborative learning are collaborative agent, interface agent, and information and internet agent. Therefore, it is necessary to set some guideline for this multitude of agents, which have to interact in a collaborative learning and communicate with each other, and orient them towards the group-learning goal.

3. Collaborative learning interaction

In collaborative learning, interaction plays an important role in the educational process and context. In addition, interactivity or interaction is fundamental to creation of the learning communities, and other influential educational who focus on the critical role of community in learning (Lipman, M., 1991; Wenger, E., 2001).

3.1 Type of interaction in collaborative learning

Definition of interaction as "reciprocal events that require at least two objects and two actions (Wagner, E. D., 1994). Interactions occur when these objects and events mutually influence one another". Michael Moore (1989) first discussed the three most common forms of interaction in distance education: student-student, student-teacher, and student-content (Moore, M. G., 1989). As shown in Table 2, this list was expanded to be six types of interaction that include teacher-teacher, teacher-content, and content-content interaction (Anderson, T. & Garrison, D. R., 1998).

Table 2 Six types of interaction (Anderson & Garrison, 1998)

Types of Interaction	Descriptions
Student-student interaction	Modern constructive learning design stresses the value of peer to peer interaction. Peer interaction is critical to development of communities of learning that allow learners to develop interpersonal skill, and to investigate tacit knowledge shared by community members as well as a formal curriculum of studies.
Student-teacher interaction	Student-teacher interaction is supported in online learning in a large number of varieties and format that include asynchronous and synchronous communication using text, audio, and video.
Student-content interaction	The web support more passive forms of student-content interaction, and also provides a host of new opportunities, including online computer-assisted tutorials, and the development of interactive content that responds to student behavior and attributes.
Teacher-teacher interaction	It creates the opportunity for professional development and support that sustains teachers through communities of like-minded colleagues. These interactions also encourage teacher to take advantage of knowledge growth and discovery in their own subject and within the scholarly community of teachers.
Teacher-content interaction	It focuses on the creation of content and learning activities by teachers. It allows teachers continuously to monitor and update the content resources and activities that they create for student learning.
Content-content interaction	It is a newly developing mode of educational interaction in which content is programmed to interact with other automated information sources, so as to refresh it self constantly, and to acquire new capabilities.

The recent emergence of collaborative learning modeling languages allows educators to describe, in a language accessible on the web, not only the content but also the activities and context or environment of learning experiences (Koper, R., 2001). Together these capabilities afforded by the semantic web allow us to envision an e-learning environment that is rich with student-student, student-content, and student-teacher interactions that are

affordable, reusable, and facilitated by active agents as shown in Figure 2.

As the agents are autonomous, the interactions are usually fairly sophisticated—involving cooperation, coordination and negotiation. Many researchers have argued that student agents will be used for intelligent searching of relevant content, and as secretaries for booking and arranging for collaborative meetings, for reminding students of deadlines, and for negotiating with the agents of other students for assistance, collaboration, or socialization, and making collaborative learning effective in any time or any place context (Thaiupathump, C., Bourne, J. & Campbell, J., 1999; Shaw, E., Johnson, W. L. & Ganeshan, R., 1999). Teacher agents will be used to provide remedial tuition, and to assist with record keeping, with monitoring student progress, and even with marking and responding to student communications. Content itself can be augmented with agents that control rights to its use, automatically update and refresh it, repair and protect content, and track the means by which the content is used by students (Anderson, T., 2003).

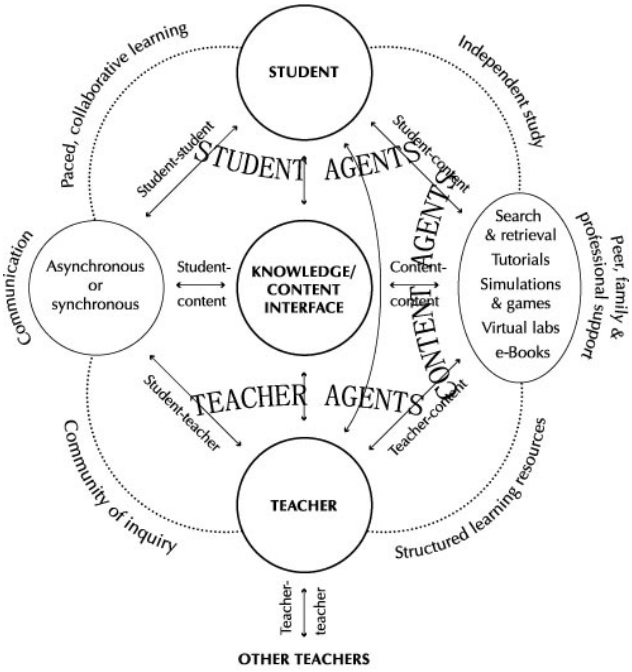

Figure 2 Educational interaction on the semantic web (Anderson, 2003)

The model illustrates the two major human actors, learners and teachers, and their interactions with each other and with content. Learners can of course interact directly with content that they find in multiple formats, and especially on the web; however, many choose to have their learning sequenced, directed, and evaluated with the assistance of a teacher. This interaction can take place within a community of inquiry, using a variety of net-based synchronous and asynchronous activities.

3.2 Relationship of communication, interaction and agent cluster

Collaborative learning can be either asynchronous (communications are sent and received at different times) or synchronous (communications are sent and received at virtually the same times). Asynchronous communication tools include e-mail, mailing list, discussion board, calendar, survey and pools, and newsgroup. Synchronous communication tools include chat, whiteboard, instant messaging, and audio-video conference. In both asynchronous and synchronous communications, students not only learn from their instructor, who provides content expertise and feedback during ongoing learning, but also from each other's comments and feedback.

In addition, to analyze the available communication tools and their utilization in various types of interaction and relationship with cluster of agent in collaborative learning, we observe a group of communication tools that support each type of interaction as shown in Table 3. Interaction between learners and teachers, and their interaction with content are available in synchronous and asynchronous communication.

Furthermore, these interactions will be supported by interface agent, information and internet agent, and collaborative agent working on behalf of all participants. Moreover, as learners, instructors and administrators when observing and using agent technology in their own jobs, they will likely find increasing acceptance in e-learning (Bonk, C. J., 2004).

Table 3 Clustering of agent and communications tools based on types of interaction

Types of interaction	Type of communications	Communications tools	Agent cluster
Student-student interaction	Synchronous	chat, instant messaging, audio conference, whiteboard	Interface agent; Information and internet agent; Collaborative agent
	Asynchronous	email, mailing list, discussion forum, newsgroup	
Student-teacher interaction	Synchronous	audio-video conference, whiteboard	Interface agent; Information and internet agent; Collaborative agent
	Asynchronous	email, mailing list, discussion forum, newsgroup, calendar, survey and pools	
Student-content interaction	Synchronous	online quizzes, exams and homework	Information and internet agent
	Asynchronous	upload, download, calendar, e-book	
Teacher-teacher interaction	Synchronous	chat, instant messaging, audio-video conference, whiteboard	Interface agent; Information and internet agent; Collaborative agent
	Asynchronous	email, mailing list, discussion forum, newsgroup	
Teacher-content interaction	Synchronous	online quizzes, exams and homework	Information and internet agent
	Asynchronous	upload, download, calendar, e-book	

3.3 Discussion

Agent application has been used in collaborative learning for some time, and a number of agents have been designed specially for collaborative learning purposes. In these systems, agents can play different roles: tutor, facilitator, monitoring, assessment and information, and they can facilitate collaboration processes such as coordination, teacher intervention and group interaction. However, there is no standardization concerning the components of a system, or the affected role to each agent in the system. It is necessary to make classification of agent by characterizing agents along certain dimension. Therefore, more complete and systemic analysis is needed for understanding role of agents.

In addition, communication tools are used in collaborative learning to enhance interaction between all participants. These interactions will be supported by interface agent, information and internet agent, and

collaborative agent working on behalf of all participants. It's a challenge to explore the application agent for collaborative learning in a multiplatform environment.

4. Conclusions and further work

In collaborative learning systems, students can participate at any time and communicate with their instructors, classmates and administrator using tools such as e-mail, chat, audio video conference, bulletin boards, etc. However, in the context of collaborative learning, it is usually difficult for students to be aware of others' activities and for instructors to overview the process and regulate the collaboration. This paper shows various agents and how they support interaction between students, teachers and contents in collaborative learning. Future work might discuss about computational model of collaborative learning interaction that the agents compute statistically, detect possible problems, and give advice both synchronously and asynchronously to the students and instructors.

We expect that the agent will overcome some of the problems faced by existing collaborative learning systems. Hence, it may contribute to improve the achievement and satisfaction of online collaborative learning.

References:

Anderson, T. & Garrison, D. R. (1998). Learning in a networked world: New roles and responsibilities. In: C.Gibson. (Ed.), *Distance learners in higher education*. Madison, WI: Atwood Publishing, 7-112.

Anderson, T. (2003). Toward a theory of online learning // *Theory and Practice of Online Learning.* Retrieved from http://cde.athabascau.ca/online_book/ch2.html.

Bonk, C., J. (2004). The perfect E-Strom: Emerging technology, enormous learner demand, enhanced pedagogy and erased budgets. Part 1: Strom #1 and #2. *The Observatory on Borderless Higher Education.*

Bielaczyc, K. & Collins, A. (1999). Learning communities in classrooms: A reconceptualization of educational practice. In: C. M. Reigeluth. (Ed.). *Instructional-design theories and models (vol. II): A new paradigm of instructional theory.* Mahwah, NJ: Lawrence Erlbaum, 269-292.

CHEN P. & DING W. (2005). Knowledge management for agent-based tutoring system. In: LIN F. O. (Ed.). *Designing distributed learning environments with intelligent software agents.* Hersey: ISP, 146-161.

Franklin, S. & Graesser, A. (1996). Is it an agent, or just a program? A taxonomy for autonomous agents. *Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages*, Spring-Verlag.

Hmelo, S., C. (2002). Collaborative ways of knowing: Issues in facilitation. *Proc. Computer Supported Collaborative Learning (CSCL) Conf*, 199-208.

Johnson, D. & Johnson, R. (1999). *Cooperation and competition: Theory and research.* Edina MN: Interaction Book Company.

Johnson, D. & Johnson, R. (1986). Computer-assisted cooperative learning. *Educational Technology*, *25*(1), 12-18.

Kerka, S. (1996). *Distance learning, the internet, and the world wide web*. (ERIC Document Reproduction Service No. ED 395 214). The Ohio State University, Columbus, OH.

Koper, R. (2001). *Modelling units of study from a pedgagogical perspective: The pedagogical meta-model behind EML*. Retrieved April 26, 2004, the Open University of the Netherlands, from http://eml.ou.nl/introduction/docs/ped-metamodel.pdf.

Lipman, M. (1991). *Thinking in education*. Cambridge: Cambridge University Press.

LIN F., Esmahi, L. & Poon, L. (2005). Integrating Agents and Web Services into Adaptive Distributed Learning Environments. In: LIN F. O. (Ed.). *Designing distributed learning environments with intelligent software agents*. Hersey: ISP, 184-217.

Moore, M., G. (1989). Three types of interaction. *The American Journal of Distance Education*, *3*(2), 1-6.

Nwana, H., S. (1996). Software agents: An overview. *Knowledge Engineering Review*, *11*(3), 1-40.

Stonebraker, P., W. & Hazeltine, J., E. (2004). Virtual learning effectiveness: An examination of the process. *The Learning Organization*, *11*(3), 209-215.

Shoham, Y. (1997). An overview of agent-oriented programming. In: J. M. Bradshaw. (Ed.). *Software agents*. Menlo Park, Calif.: AAAI Press.

Suh, H. J. & Lee, S. W. (2006). Collaborative learning agent for promoting group interaction. *ETRI Journal, 28*(4), 461-474.

Soller, A., Jermann, P., Muhlenbrock, M. & Martinez, A. (2004). Designing computational models of collaborative learning interaction. *Proc. ITS 2004 Workshop*, 5-12.

Shaw, E., Johnson, W. L. & Ganeshan, R. (1999). Pedagogical agents on the Web. *Proceedings of the Third International Conference on Autonomous Agents*. Retrieved April 26, 2004, from http://www.isi.edu/isd/ADE/papers/agents99/agents99.htm.

Thaiupathump, C., Bourne, J. & Campbell, J. (1999). Intelligent agents for online learning. *Journal of Asynchronous Learning Networks*, *3*(2). Retrieved May 17, 2004, from http://www.sloan-c.org/publications/jaln/v3n2/pdf/v3n2_choon.pdf.

Wooldridge, M. J., Jennings, N. R. & Kinny, D. (2000). The gaia methodology for agent-oriented analysis and design. *Autonomous Agents and Multi-Agent Systems*, (3), 285-312.

Wenger, E. (2001). *Supporting communities of practice: A survey of community-orientated technologies* (1.3 ed.). (Shareware). Retrieved April 26, 2004, from http://www.ewenger.com/tech.

Wagner, E., D. (1994). In support of a functional definition of interaction. *The American Journal of Distance Education*, *8*(2), 6-26.

Yacine, L. & Tahar, B. (2007). Learner's assessment in a collaborative learning system. *Asian Journal of Information Technology*, *6*(2), 145-153.

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