Preface

With the rapid development of computer network and information technologies, especially the Internet and World Wide Web, university and college programs offered in distributed environments are alternative forms of education for those students who are best served by flexible location and time schedules. The situation in which distributed education is primarily used in selective situations to overcome problems of scale (not enough students in a single location) and rarity (a specialized subject not locally available) is being changed. There are three major upcoming trends:

- *Multimode Integration*. The boundary between information technology (IT) application in education and distance education will become blurred. Distinctions between different forms of educational telecommunications have fallen away. New wireless bandwidth services further help to blur the distinctions. Moreover, educators must help all learners become adept or at least get familiar with distributed interaction by using multiple technologies, for skills of information gathering from remote sources and of collaboration with dispersed team members are central to the future workplace as learning to perform structured tasks quickly was central to the industrial revolution.
- *Learner-Centered Environments*. With the advances in natural language processing, reusable learning objects, and agent technology, learners will simply talk to their computers, describe the desired learning goal, and piece together applications by sending intelligent agents to grab suitable learning objects from learning objects repositories around the globe, and insert into their own plug-and-play learning environments. Thus, instruction will be learner-centered, collaborative global learning, with learners engaged through technologies, and with teachers taking on the role of facilitators. Students will take increased responsibility for their own learning, defining their own learning agendas, using educational resources.

- *Service-Oriented Institutions*. The quality of services of distributed-learning institutions will become a key competitive advantage for e-learning institutions. The services include at least three levels: pedagogical services, learning services, and infrastructure.

Nevertheless, most of today's learning environments are focused mainly on infrastructure and neglect the personalized pedagogical services and learning services aspects of the institution. According to Jafari (2002):

> *Although new versions (of Course Management Systems, CMS for short) include easy-to-use Web authoring tools, most offer passive services. As a result, some instructors spend more time teaching a distance-learning course than teaching the same course in a classroom setting. This problem results mostly from the time-consuming operational nature of online courses. It is not unfair to call the typical CMS a "dumb software environment."…We need smart learning environments that offer personal services with capabilities to learn, reason, have autonomy, and be totally dynamic.*

Some of the challenges associated with distributed learning include inadequate end-user quality of service (QoS), inadequate materials, lack of interactivity, and shortcomings in learning paradigms (Vouk et al., 1999). For example, in most existing Web-based distributed-learning systems, course materials are arranged by the course authors in order to cover one or more topics and convert them in interactive linked HTML pages. The course materials are then placed online to make them downloadable or visible to the students. The students can use them only by following the path established. Besides, as the instructors and tutors are not always available online, the need for assistance and interactions between students is particularly salient. Research shows that in terms of course design, development, and maintenance, as the number of online learners increases, serious problems in balancing cost, quality, and efficiency in course development and maintenance emerge.

Interactivity is another key issue in distance education. Web-based educational platforms available on the market, such as WebCT, LearningSpace, Top Class, ToolBookII, or Web Course in a box, provide different Web-based educational environments, each with its specific features. Nevertheless, they all share some underlying common features, as the aim is the same for all: to deliver learning content through a Web environment. Students' interest in the learning process is drastically reduced when the level of interactivity is low.

To overcome these challenges or deficiencies in distributed learning, the authors of the chapters in this collection will discuss emerging technologies and develop models and tools to automate or semiautomate educational services.

Due to its inherently distributed nature, a distributed-learning environment can be supported and managed by a set of autonomously cooperating software agents that communicate intelligently with one another. They can interact with human users at the right time, with the right information. Much experimental research has shown that intelligent software agents, such as interface agents, information agents, and collaborative agents, have great potential to reduce information workload and to automatically perform many knowledge- and labor-intensive tasks for users. For example, these agents, with the functions of motivation, learning facilitation and collaboration, and so forth, serve as students' assistants, companions, and tutors. Implementing agent-supported distributed learning has become a strategy of many institutions striving for success in basic education, higher education, continuing education, and training. They have incorporated intelligent agents into a wide range of educational systems, from intelligent tutoring systems (ITSs) to computed-supported collaborative learning (CSCL) environments.

The agent-oriented approach has been used for solving the complexity of distributed-learning environments and enhancing the functionality of WBE systems.

The use of agents as an abstraction tool, or a metaphor, for the design and construction of systems provided the initial impetus for developments in the field. On the one hand, agents offered an appropriate way to consider complex systems with multiple distinct and independent components. On the other hand, they also enabled the aggregation of different functionalities that have previously been distinct (such as planning, learning, coordination, etc.) in a conceptually embodied and situated whole. Thus, these notions provide a set of technology areas that relate directly to these abstractions in the design and development of large systems, of individual agents, of ways in which agents may interact to support these concepts, and in the consideration of societal or macrolevel issues, such as organizations and their computational counterparts. Current efforts span diverse areas including agent-oriented software engineering, agent architecture, mobile agent systems, agent infrastructure, and electronic institutions (Luck et al., 2003).

Furthermore, in a distributed collaborative learning environment where users are geographically distributed and collaborate through a Web-based learning environment, an agent can *facilitate* collaboration processes, such as participation, coordination, teacher intervention, and group interaction.

Recently, several strands of research in artificial intelligence (AI), Web languages and technologies, and multiagent systems are being brought together and unified in exciting and interesting ways. This development makes Web-based distributed learning more practical and attractive by deploying agents supporting the users and computer programs of distributed-learning systems.

Multiple agent systems (MASs) improve the education system by making it viable in open knowledge domains, where ITSs were earlier applied with less success. Moreover, the MAS architectures have great potential to solve many of the current problems of (Web-based) distributed-learning systems. MAS can be used to adapt and personalize the distributed-learning environment by using machine learning tools and can simulate an expert when performing pedagogical tasks.

Challenges and Opportunities

At present, educational agents exist in academic and commercial laboratories but are not widely available in real-world applications. To make the move from the laboratories to real-world applications happen, we need to solve a number of technological issues for research and development:

First, if agent technologies are to be effective, software engineering issues need to be carefully considered:

- How can multiagent architectures designed for maximum effect?
- Can such architectures be used effectively to support and enhance existing work practices?
- What kinds of agents and MASs are effective?
- How can such systems be designed to successfully *complement* people's existing practices and preferences?
- On which conceptual design approach should the agents be based?
- How should we design the functionality and human-agent interaction in distributed-learning environments?
- How should we design an experimental study to assess the impact of pedagogical agents on these environments?

Second, we need to increase the quality of agent software to industrial standards and provide effective agent standards to allow open system development.

Third, in addition to standard language and interaction protocols, agent societies for distributed learning will require the ability to collectively evolve language and protocols specific to distributed-learning applications and to the agents involved.

Fourth, we need to have a greater understanding of how agents for distributed learning and educational resource information systems interact.

Fifth, we need Web standards that enable structural and semantic description of information access at a higher level.

Sixth, we need to create common ontologies, thesauri, and knowledge bases, formally describe information, and potentially have a reference architecture to support the higher-level services.

Seventh, we need to develop agents' ability to understand learners' and educators' requirements and to adapt to changes in distributed learning environments.

Finally, we need to ensure confidence and trust in agents. A user must have confidence that an agent or agent system, which represents them within an open system, will act effectively on his or her behalf—it must be at least as effective as the user would be in similar circumstances. Moreover, agents must be secure and tamper-proof and must not reveal private information inappropriately. Besides, if a user is to trust the outcome of an open agent system, the user must have confidence that agents representing other parties or organizations will behave within certain constraints.

Organization of This Book

This book reports on the most recent important advances in agent technologies for distributed learning. It is organized into 10 chapters. A brief description of each chapter is provided below.

Chapter 1 introduces the design and implementation of a multiagent system based on a human collaborative online learning environment (COLE). Silva de Azevedo (Paraná Federal Center for Technological Education, Brazil) and Scalabrin (Pontifical Catholic University of Paraná, Brazil) discuss the concept of human collaboration and the ways that project-based learning (PBL)

and portfolios can improve the social competencies of distributed learners. It presents the system analysis for agent systems (SAAS) method, a way for identifying services and agents.

Chapter 2 presents intelligent agents facilitating distributed collaborative learning. It covers agent design issues and implementation details. Chen and Wasson (University of Bergen, Norway) provide different support to users (including students and instructors). They have combined awareness information and advice, agent regulation, students' self-regulation, and instructor regulation. The performances of these agents have been evaluated in various scenarios, both in asynchronous and synchronous collaborative environments. They received positive feedback from students and instructors.

Chapter 3 explores the challenges, issues, and solutions associated with satisfying requirements for privacy and trust in agent-supported distributed learning (ADL). Korba et al. (National Research Council of Canada) discuss an often-ignored area—that of building trustworthy user interfaces for distributed-learning systems.

Chapter 4 by Yang (National Research Council of Canada) first addresses the issue of the importance of intelligence in MAS-based distributed-learning environments (DLEs). Then it stresses that there are three main intelligent competencies in MAS-based DLEs: intelligent decision-making support, coordination and collaboration of the agents in MAS, and student modeling for personalization and adaptation in learning systems. It also describes in detail how to apply relevant AI techniques, including the introduction of AI techniques, their state-of-the-art application in the e-learning domain. Finally, future trends in the research and development of intelligence for MAS-based DLEs are discussed.

In Chapter 5, Chen and Ding (University of Houston, USA) first discuss how agent technology can be used in an educational system and then focus on how knowledge management techniques play an important role in agent-based tutoring systems.

In Chapter 6, Ally (Athabasca University, Canada) provides information on how to design intelligent tutoring systems for distributed learning to cater to individual learner needs and style. He argues that intelligent tutoring systems must use the expertise that tutors use in a one-to-one teaching situation to build intelligent tutoring systems for distributed learning. Also, the appropriate psychological and educational theories must be used to build the domain module, student model, and pedagogical module.

In Chapter 7, Lin et al. (Athabasca University, Canada) discuss the concept of distributed-learning environments and the rationale for using intelligent software agents in such environments. Lin et al. propose a new approach to designing and developing adaptive distributed-learning environments by integrating Agent Technology and Web Services Technology.

In Chapter 8, Esmahi and Lin (Athabasca University, Canada) describe a multiagent system for delivering adaptive e-learning and provide a discussion on three issues related to personalization in e-learning: technology advancement and the shift in perception of the learning process, one-size-fits-all versus personalized services, and the adaptation process. Finally the authors provide an overview of most known implemented systems for adaptive e-learning, as well as a detailed description of the architecture and components of the proposed multiagent framework.

Chapter 9 by Lin (University of Houston–Downtown, USA) introduces the Gamma language as a formal language for the specification of agent systems. Through case studies of various agents for distributed learning, Lin demonstrates the feasibility and benefits of using Gamma as a specification language for multiagent systems, in light of how architectural design can be streamlined succinctly. A case study is also done in specifying a multiagent-based e-learning system for course material maintenance.

In Chapter 10, Shih et al. (Tamkang University, Taiwan) present the preliminary results of an ongoing distance-learning research project—developing a system based on virtual reality (VR) technology and agent technology, which enables online discussions via different real-time communication channels. The system has a generic interface, which includes five scenes of a virtual university, as well as a set of plug-and-play communication agent tools. An intelligent agent maintains each user. Shih et al. implemented a generic user interface as well as a state machine engine, which runs a specification language for the system.

Conclusions

This book provides readers with an overview of intelligent agents. Conceptual, strategic, pedagogical, and architectural issues related to agent and multiagent system design in distributed-learning environments are covered. Readers will learn about major issues in agents and multiagent systems re-

search in educational applications, such as knowledge representation and management, agent communication, privacy and trust, coordination, and cooperation. The reader will also learn about what roles agents play in distributed learning. By using case studies, the authors will address the important issues involving the design and implementation of agents for distributed learning.

This book is intended for researchers, designers, and developers who are interested in intelligent agents, multiagent systems, electronic learning, distributed learning, and educational systems (academic and industry).

Although there are some books that provide general introductions to distributed-learning technologies and multiple agent systems, no other book deals with all the topics listed here.

References

Jafari, A. (2001, July). Conceptualizing intelligent agents for teaching and learning. *International Conference on Intelligent Agents*, Las Vegas, Nevada, USA.

Luck, M., McBurney, P., & Preist, C. (2003, January). Agent technology: Enabling next generation computing: A roadmap for agent based computing, *AgentLink II*.