MARCO ANTONIO M. ELEUTERIO

AMANDA:

A Computational Method for Mediating Asynchronous Group Discussions

Dissertation presented to the Graduate Program in Applied Computer Science (PPGIA) of the Pontifical Catholic University of Paraná (PUCPR) and to the Department of Computer Engineering of the Technology University of Compiègne (UTC) in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Directed by: Prof. Flávio Bortolozzi, PhD (PUCPR) and
Prof. Jean-Paul Barthès, PhD (UTC)

CURITIBA

September, 2002

ELEUTERIO, Marco Antonio M.
AMANDA: A Computational Method for Mediating Asynchronous Group Discussions.
Curitiba, 2002. 170 pages

Doctoral Thesis – Pontifical Catholic University of Paraná / Technology University of Compiègne

Keywords:
1. Computer-mediated communication 2. Argumentative discussions
3. Knowledge Representation 4. Online learning 5. Artificial Intelligence

Directed by: Prof. Flávio BORTOLOZZI (PUCPR)

Prof. Jean-Paul BARTHES (UTC)

Committee: Prof. Celso Alves KAESTNER (PUCPR)

Prof. Gilda Helena Bernardino de Campos (PUC-RIO)

Prof. Rosa Maria VICARI (UFRGS)

Prof. Monique GRANDBASTIEN (Nancy 1)

Claire BEYOU (Research Director, CEGOS)

I dedicate this thesis
to my dear son, André.

Acknowledgements

Many people have directly or indirectly taken part in this work, some of them providing technical guidance and others providing encouragement and emotional support. Firstly, I wish to thank the institutions that made this work possible: the Pontifical Catholic University of Paraná (PUCPR) for its financial and institutional support, the Technology University of Compiègne (UTC) for being our academic partner in France, Siemens Telecomunicações for its financial support and CEGOS for being our project partner in France.

I would like to thank my thesis advisors, Flávio Bortolozzi and Jean-Paul Barthès for their precious support along the work, for their guidance and mentoring. Thanks to Prof. Celso Kaestner for helping me debug AMANDA's formal models and for his suggestions on the content of the work. Many thanks to my colleagues at UTC (Milton Ramos, César Tacla and Fabrício Enembreck) who dragged me out of the lab once in a while. I am grateful to CEGOS people, especially Sandra Bellier, Annette Soulier, Agnès Wolf and Claire Beyou, with whom we had fruitful talks about AMANDA and who helped us develop the domain models and arranged for the experimental part of the thesis.

Special thanks to my parents, Antonio Carlos and Glecy, who have constantly encouraged me and who are always present in my thoughts.

My dearest thanks to my lovely wife Leila, who has been always on my side and who's always present in my heart. A very special thanks to my dear daughter Amanda and my dear son André, who have lived every moment of this work and who unconsciously made me see "it was just a thesis".

Table of contents

Chapter 1 Introduction 1
1.1 Motivation 1
1.2 Challenge 2
1.3 Our proposal 2
1.4 Contribution 3
1.5 Organization 3
1.6 Résumé 3
Chapter 2 Related research fields 6
2.1 Cognitive aspects of group interaction 6
2.1.1 The cognitive benefits of group communication 6
The Community of Inquiry model 8
The Critical Thinking model 9
Relation between AMANDA and the Critical Thinking and Community of Inquiry models 11
2.1.2 The knowledge creation theory 11
The notion of knowledge 12
Types of knowledge 12
Conversion between knowledge types – the SECI model 12
Providing a shared context for knowledge creation 13
Relation between AMANDA and the knowledge creation theory 15
2.2 Computer-mediated communication (CMC) 16
2.2.1 An overview of CMC 16
2.2.2 Delphi method 16
2.2.3 Forum systems 18
2.2.4 Relation between AMANDA and CMC 19
2.3 Argumentative discussions 20
2.3.1 The general notion of argumentation 20
2.3.2 Argumentation applied to dispute resolution 20
2.3.3 Argumentation applied to collaborative learning 21
2.3.4 Argumentation applied to Artificial Intelligence 23

The Simari-Loui model for argumentative discussions 24
2.3.5 Relation between AMANDA and the existing argumentation theories 25
2.4 Knowledge representation 27
2.4.1 What is knowledge representation? 27
2.4.2 Ontologies 28
What is an ontology? 28
What are ontologies used for? 30
2.4.3 Task models 31
The notion of task, subtask and methods 31
What are task models used for? 32
2.4.4 Relation between AMANDA and knowledge representation 33
2.5 Summary of the chapter 33
2.6 Résumé 34

Chapter 3 The AMANDA method 35
3.1 The underlying principles of AMANDA 36
3.2 The discussion models 38
3.2.1 The extended model for argumentative discussions 38
3.2.2 The static model 39
The notion of multi-issue, multiparty discussions 39
The proposed static model 40
3.2.3 The dynamic model for AMANDA discussions 42
3.3 Discussion mediation 44
3.3.1 The stages of a discussion in AMANDA 44
3.3.2 The advance of the discussion 46
Launching a discussion 47
Form Reception 48
Opening new discussion cycles 48
3.3.3 The Evaluation phase 49
Filtering 49
Extraction & Ordering 50
3.3.4 The assignment phase 54
The notion of discussion assignment 55
Coordination goals and assignment mechanisms 56

Assignment arbitration 63
3.4 Delivering the discussion to the participants 64
3.5 Measuring the progress of the discussion 65
3.6 Summary of the chapter 66
3.7 Résumé 67

Chapter 4 Knowledge representation and NL generation 68
4.1 Introduction 68
4.2 Knowledge representation in AMANDA 70
4.2.1 Ontologies in AMANDA 70
4.2.2 Task structures in AMANDA 73
4.2.3 The relation between task structure and ontology 75
4.3 Natural language generation 76
4.3.1 The principle of NL generation 76
4.3.2 The exploratory mechanisms 77
4.3.3 Sentence patterns 79
4.4 Summary of the chapter 81
4.5 Résumé 81

Chapter 5 The prototype software and results 82
5.1 AMANDA software 82
5.1.1 The Coordination module 83
The local interface 84
5.1.2 Delivering the discussion through the web-based interface 90
5.1.3 The KB module 91
Building ontologies 91
Building task structures 92
Linking the task structure to the ontology 94
5.1.4 The NL Generator 94
Implementation of the exploratory mechanisms. 94
Implementation of the sentence patterns 95
5.2 Experimental results 97
5.2.1 Test #1 97
Performance measures for test#1 98

Evaluation of test#1 98
Selected interactions from test#1 99
5.2.2 Test #2 101
Performance measures for test#2 102
Evaluation of test#2 102
Selected interactions from test#2 103
5.2.3 Test #3 105
Performance measures for test#3 106
Evaluation of test#3 107
Selected interactions from test#3 107
5.3 Simulating discussion scenarios 109
5.3.1 Discussion simulator 109
The agreement level 109
The participation level 110
The simulator interface 111
5.3.2 Discussion scenarios 112
Scenarios to be simulated 113
5.3.3 Simulation results 115
5.3.4 Analysis of simulation results 122
5.4 Summary of the chapter 124
5.5 Résumé 124
Chapter 6 Conclusion and future work 125

List of figures

Fig. 2.1: The Community of Inquiry model 9
Fig. 2.2: The Critical Thinking model 10
Fig. 2.3: Knowledge types and conversion modes, the SECI model 13
Fig. 2.4: Knowledge spiral 13
Fig. 2.5: Knowledge shared spaces and their conversion modes 14
Fig. 3.1: An example of discussion tree in AMANDA 41
Fig. 3.2: An example of discussion in the preparatory stage 45
Fig. 3.3: The advance of a discussion through the argumentation stage 46
Fig. 3.4: An overview of the AMANDA method 47
Fig. 3.5: Flowchart of the *New Cycle* procedure 49
Fig. 3.6: The Evaluation phase 49
Fig. 3.7: The RS parameter 51
Fig. 3.8: Local and transmitted support levels 53
Fig. 3.9: The assignment phase 56
Fig. 3.10: Coordination goals and assignment mechanisms 57
Fig. 3.11: An example of *Ext* assignment 58
Fig. 3.12: An example of `Reply` assignment 59
Fig. 3.13: An example of `Vld-Atck` assignment 60
Fig. 3.14: An example of `Buddy` assignment 62
Fig. 3.15: An example of `Spread` assignment 63
Fig. 3.16: The discussion schedule 64
Fig. 4.1: Example of domain ontology in AMANDA 72
Fig. 4.2: Example of task structure in AMANDA 74
Fig. 4.3: Relation between task structure and ontology 75
Fig. 4.4: Natural language generation 76
Fig. 4.5: General scheme for NL generation 77
Fig. 4.6: An example of sentence pattern for the *isa-dif* rule 79
Fig. 5.1: System overview 82
Fig. 5.2: Coordination functions 83
Fig. 5.3: The local interface 85
Fig. 5.4: Interface for creating a discussion 86

Fig. 5.5: Interface for launching the discussion 87
Fig. 5.6: A discussion after being launched 87
Fig. 5.7: New Cycle interface.. 89
Fig. 5.8: Web-based interface overview 90
Fig. 5.9: Discussion form as it appears on the user’s interface..................................... 91
Fig. 5.10: The KB interface – the ontology editor 92
Fig. 5.11: The KB interface – the task structure editor 93
Fig. 5.12: The NL Generator interface 95
Fig. 5.13: Example of discussion thread for test #1 100
Fig. 5.14: Example of discussion thread for test #2 104
Fig. 5.15: Discussion progress for test #3.. 107
Fig. 5.16: Example of discussion thread for test #3 108
Fig. 5.17: Discussion simulator interface 111
Fig. 5.18: Simulation results for ‘class 1’ scenarios... 116
Fig. 5.19: Simulation results for ‘class 2’ scenarios... 117
Fig. 5.20: Simulation results for ‘class 3’ scenarios... 118
Fig. 5.21: Simulation results for ‘class 4’ scenarios... 119
Fig. 5.22: Simulation results for ‘class 5’ scenarios... 120
Fig. 5.23: Simulation results for ‘class 6’ scenario (average scenario)....................... 121
Fig. 5.24: Simulation results for ‘class 7’ scenario 121
Fig. 5.25: Simulation results for ‘class 8’ scenario 121

List of tables

Tab. 4.1: Exploratory mechanisms and their interrogative purposes 78
Tab. 4.2: Sentence patterns 80
Tab. 5.1: General data for test #1 (Cegos-02-04-01).. 97
Tab. 5.2: Evaluation parameters and performance measures for test #1 98
Tab. 5.3: General data for test #2 (Cegos-22-07-01)... 101
Tab. 5.4: Evaluation parameters and performance measures for test #2 102
Tab. 5.5: General data for test #3 (SO-Abril-02) 105
Tab. 5.6: Evaluation parameters and performance measures for test #3 106
Tab. 5.7: Agreement levels 110
Tab. 5.8: Parameter values and ranges 113
Tab. 5.9: Discussion scenarios 114
Tab. 5.10: Classes of discussion scenarios 115

Abstract

This thesis is about computer-mediated communication. It describes AMANDA, a computational method for mediating asynchronous group discussions[1] among distant learners. The proposed method is intended to coordinate collective discussions and improve group communication with negligible or no human effort. The method consists of launching a set of issues for collective debate and involving the participants in successive discussion cycles. At each cycle, the answers and arguments provided by the participants are intentionally redistributed among the group. Throughout the discussion, specific mechanisms search for potential interactions that might improve the debate and propose new interactions among the group. In addition to the intelligent mediation of group discussions, AMANDA supports knowledge representation (domain ontologies and task structures) and generates natural language questions to be used as issues for the debate. This work also describes the software prototype that implements the method and the experimental results from applying AMANDA in actual training situations.

Résumé

Cette thèse traite de la communication assistée par ordinateur. Nous proposons AMANDA, une méthode algorithmique pour la médiation de discussions de groupe à distance destinée à l'articulation d'une discussion collective sans effort humain de coordination. La méthode consiste à lancer un ensemble de questions parmi un groupe de participants et ensuite à relancer leurs réponses et arguments en des cycles de discussions successifs. Tout au long de la discussion, des mécanismes intelligents identifient les interactions potentielles entre les participants du débat et proposent des nouvelles interactions entre eux. La discussion est structurée sous la forme d'un arbre de discussions, sur lequel la méthode réalise ses inférences. Nous proposons aussi la modélisation de la connaissance du domaine - à l'aide d'ontologies et de modèles de tâches - et une méthode de génération de questions en langage naturel à partir des modèles de domaine. La méthode « Amanda » a été implémentée et expérimentée dans des situations réelles de formation à distance.

---

[1] The "Computational Method for Mediating Asynchronous Group Discussions" is registered at the Brazilian National Institute of Industrial Property (INPI) and the World Intellectual Property Organization (WIPO) under the terms of the Patent Cooperation Treaty (PCT), patents required PI0201651-6 and PCT/BR03/00004 respectively.

Chapter 1

Introduction

The aim of this chapter is to provide an overview of the thesis by presenting the motivation and challenges that inspired the work, our proposal and its expected contributions and the overview of the thesis structure.

1.1 Motivation

Since the early 1970's, computers have been applied to facilitate communication among people. At the beginning, the severe technical constraints imposed by the available communication infrastructure and the high costs of computers kept it restricted to research laboratories. However, when computer networks became available in large scale, we were faced with a revolution in computer-based communication. Nowadays, the Internet allows people to communicate in various modes, either synchronously or asynchronously, using text, voice, images and real-time video. This provides the base for the formation of virtual communities for varying purposes, such as conferencing, information exchange, entertaining and collaborative learning. This work focuses on the use of computers to facilitate group communication for collaborative learning purposes. Our motivation is provide learning communities with an efficient way to collaboratively learn at distance.

1.2 Challenge

This work proposes an intelligent computational method to help distant people to better interact in learning environments by transcending the boundaries of the available systems and methodologies.

Today's available asynchronous computer-mediated communication (CMC) systems, such as forum systems, provide group communication by merely storing and organizing discussion data. The poor results from group interactions in distance learning and the considerable effort in mediating dispersed learners lead us to propose new alternatives for this type of system. Our challenge is to transcend the boundaries of current CMC systems by providing them with an intelligent behavior capable of improving the results of group learning.

1.3 Our proposal

Our proposal is to create an intelligent system for mediating group discussions based on domain models and argumentative structures. Domain models are used to generate natural language issues for group debate. Argumentative structures are intended to create a highly interactive dialoguing context for the discussants to debate over the proposed issues. The final objective is to improve the outcomes of group discussions through the articulation of knowledge among the group.

AMANDA, the proposed method, organizes discussions in argumentation trees, whose nodes reflect the discussion moves made by the discussants. It mediates the argumentative interaction by intentionally controlling the focus of the discussion in subsequent discussion rounds. The central issue in AMANDA is how to establish the focus of the discussion and upon which principles the discussion is advanced. At each discussion round, AMANDA evaluates structural parameters of the discussion and proposes new interactions among the discussants based on specific coordination goals. This repeats until the discussion cannot be advanced any further, i.e. when the evaluation of structural parameters finds satisfactory measures of participation and common agreement.

1.4 Contribution

The main scientific contribution expected from this work is a bridge between artificial intelligence and cognitive science applied to collaborative learning.

In the artificial intelligence domain, AMANDA contributes in two main aspects. Firstly, it provides reflections on the use of domain modeling (ontologies and task models) to generate natural language questions with the purpose of exploring a given domain of interest. Secondly, it proposes an extended model for argumentative discussions and a formal description of the coordination mechanisms.

In the cognitive science domain, AMANDA provides researchers with a framework for: (i) observing learners' behaviors in argumentative interactions; (ii) investigating the value of system-generated questions in comparison with tutor-generated questions and (iii) validating discussion coordination mechanisms.

1.5 Organization

The remaining chapters are organized as follows. Chapter II explores the related research fields: knowledge transfer, computer-mediated communication, argumentative discussions and knowledge representation. Chapter III presents the AMANDA method, including the extended model of argumentative discussions, the coordination principles, the formal description of the coordination mechanisms and their performance measures. Chapter IV discusses knowledge representation and natural language generation in AMANDA, more specifically the construction of ontologies and task structures and the use of such models to build interrogative sentences. Chapter V presents the prototype software and the results of applying AMANDA in actual distance training situations. Chapter VI concludes the work with a summary on the positive and negative aspects of the work and provides directions for future research.

1.6 Résumé

Depuis les années 70, l'ordinateur est utilisé pour faciliter la communication humaine. Au départ, à cause des difficultés imposées par le coût de l'infrastructure de communication et par les contraintes techniques, l'utilisation d'applications

informatiques se limita aux laboratoires de recherche. Au fur et à mesure que les moyens de communication se développèrent, notamment les réseaux de communication, les applications informatiques pour la communication humaine commencèrent à être de plus en plus exploitées. Aujourd'hui, l'Internet nous permet de communiquer en mode synchrone ou en mode asynchrone, en utilisant du texte, de la voix, des images et de la vidéo en temps réel. Sur cette base se sont formées des communautés virtuelles aux objectifs divers, y compris les conférences à distance, l'échange d'information et l'apprentissage collaboratif. Ce travail traite de l'utilisation des ordinateurs pour faciliter la communication de groupe dans le domaine de l'apprentissage de groupe. Notre motivation est de doter les communautés virtuelles d'apprentissage d'un moyen efficace de communication.

Ce travail décrit une méthode algorithmique intelligente pour améliorer l'interaction des apprenants dans des environnements d'apprentissage à distance qui représente une nouvelle frontière aux systèmes et méthodologies existants. Les résultats, souvent insatisfaisants, observés dans les environnements de discussion à distance, notamment dans les forums de discussions, nous ont encouragé à proposer une solution qui améliore l'interaction de groupe.

Nous proposons une méthode algorithmique capable d'animer une discussion de groupe à distance basée sur la notion d'argumentation et sur la représentation de la connaissance de domaine. L'argumentation est utilisée pour structurer la discussion sous la forme d'une « arbre de discussion » et pour créer une ambiance hautement interactive entre les participants. La représentation de la connaissance de domaine sert à produire les phrases interrogatives en langage naturel qui seront lancées comme des questions de débat. Le but principal de la méthode est de faire avancer la discussion de façon intentionnelle, en fonction de l'état actuel de la discussion et des objectifs d'interaction envisagés. La discussion avance en des cycles successifs, où les réponses et argumentations de chaque participant sont relancées pour être analysées collectivement. À chaque cycle de discussion, les mécanismes responsables pour la médiation de la discussion évaluent l'arbre de discussion et proposent des nouvelles interactions entre les participants. Le processus se répète jusqu'à ce que la discussion ne puisse plus progresser ou que le temps destiné à la discussion se termine.

La principale contribution scientifique de ce travail est la construction d'un lien entre l'Intelligence Artificielle et l'Apprentissage Collaboratif. Dans le domaine de l'Intelligence Artificielle, nous proposons la modélisation de connaissance de domaine pour la génération de questions en langage naturel et nous créons un nouveau formalisme de discussions argumentées. Dans le domaine de la science cognitive, ce travail (i) offre un cadre d'analyse de l'apprentissage basé sur l'argumentation, (ii) propose des bases d'expérimentation sur les questions synthétisées par le système et (iii) ouvre un nouveau champ de recherche sur la coordination automatique de discussions de groupe.

Chapter 2

Related research fields

The aim of this chapter is to present an overview of AMANDA related research fields. We will start by presenting the cognitive aspects of group interaction and the theory of knowledge creation as the base for introducing other research fields, such as computer-mediated communication, argumentative discussions, and knowledge representation.

2.1 Cognitive aspects of group interaction

The aim of this section is to explore the role of group interaction as a facilitator of the collaborative learning process. For this purpose, we investigate research works from the fields of cognitive science, education, computer-mediated communication and knowledge management, with special emphasis on group communication and its influence on learning.

2.1.1 The cognitive benefits of group communication

Extensive research has been done on the effects of group communication on learning, especially through asynchronous online environments. In such research, cognitive aspects, such as collaborative learning ([STA99], [KAY92], [MAS90], [HAR90], [HAR95]), constructivist learning [GAR93], critical thinking ([GAR00], [ARC01]) and cognitive presence [GAR01], as well as experimental results ([HEN96], [HIL94]), are investigated and evaluated.

According to Stacey [STA99], group communication among learning communities is the key factor to achieve collaborative learning, as demonstrated in a large-scale experiment among post-graduate students using on-line discussion spaces. This experiment showed that the process of communicating electronically facilitates the social construction of knowledge in the groups as they used group conferences as the central communication space.

Kaye [KAY92] considers group communication, especially computer-mediated discussions, appropriate for collaborative learning due to the possibility of reflective and thoughtful analysis and review of earlier contributions.

Mason [MAS90], considers group discussions as “a new paradigm in distance education that can provide enhanced opportunities for dialogue, debate and conversational learning and the potential for a sense of community with access to other student’s experiences and opinions”.

Harasim [HAR90] describes group communication as the greatest strength of online education for its ability in achieving the cognitive benefits of peer-to-peer interaction. In a later work [HAR95], he states that online discussions have become “the locus of rich and satisfying experiences in collaborative learning”. According to him, online discussions can be viewed as an interactive group knowledge building process in which learners actively construct knowledge by formulating ideas into words that are shared with and built on through the reactions and responses of others.

Garrison [GAR93] states that “group communication has the potential to change the nature of distance learning by creating mutual understanding among the learning community”. Garrison presents a cognitive constructivist approach to learning theory, where learners attempt to interpret, clarify and validate their understanding through sustained dialogue and negotiation.

In terms of evaluation, Henri [HEN96] advocates that on-line asynchronous communication can be more intense than face-to-face communication, due to the absence of social pressure and the greater freedom to express their views without struggling for the “right of audience”. According to Henri, this enables the participants of online discussions to “react to the *content* and not to the *author*”, yielding more reflective and effective communications.

The work by Hiltz [HIL94] shows that learning in asynchronous environment results in higher quality solutions due to the visibility of individual responses combined with in-depth reflection that can be achieved in asynchronous work.

Despite the difficulty in assessing the effects of group communication on learning, experiments reveal higher quality outcomes in groups that practice effective communication during the learning process, which does not mean however that effective communication usually occurs among the groups. In many cases, the "delayed" characteristic of online asynchronous discussions, associated to the effects of physical distance and the poor engagement of the group, may discourage people to communicate.

We now turn our attention to a more structured theory, which describes learning as a multi-dimension critical thinking process and clarifies how the cognitive benefits emerge from group interaction.

The Community of Inquiry model

Garrison et al. [GAR00] have proposed a conceptual framework – the *Community of Inquiry model* – which identifies the elements that are crucial prerequisites for a successful higher educational experience. The Community of Inquiry model assumes that learning occurs within the community through the interaction of three key elements: the *cognitive presence*, the *social presence*, and the *teaching presence* (see Fig. 2.1).

The first element – the *cognitive presence* – considered by the author as the most basic element for the success of higher education, is defined as "the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication". In practice, cognitive presence is observed by three main interactions: information exchange, concept integration and the application of new ideas.

The second element – the *social presence* – is defined as "the ability of learners to project their personal characteristics into the community of inquiry, thereby presenting themselves as real people". In practice, the social presence is observed by socio-emotional interactions, such as expressing emotions, humor, shared feelings/interests and appreciation. According to Garrison, the main role of the social presence is to support and facilitate the process of critical thinking carried on by the community of learners. Similar position is shared by Schamp [SCH91], who found that providing learning communities with opportunities for exchange of personal information reduces the feeling of social isolation and allows the participants to form individualized perceptions of each other.

The third element – the *teaching presence* – is defined as “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educational worthwhile learning outcomes”. In practice, the teaching presence (normally performed by a teacher or instructor) corresponds to the role of facilitating communication, such as selecting/initiating discussion topics, sharing personal meaning and focusing discussion.

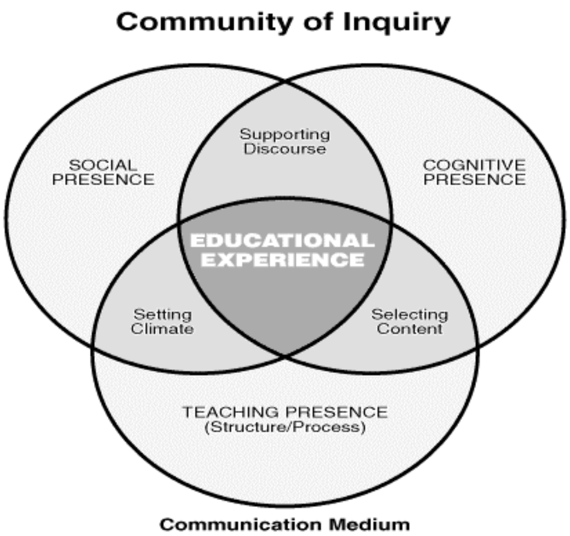


Fig. 2.1: The Community of Inquiry model

We now focus attention to the element of *cognitive presence* and how it emerges from group interaction. For this purpose, we take a closer look at Garrison’s work and inspect a more specific model which explains how knowledge emerges from group interaction and practice – the *Critical Thinking model*.

The Critical Thinking model

The element of cognitive presence in a computer-mediated discussion can be better understood in the context of a general model of critical thinking (or critical inquiry) [GAR00], based on the notion of practical inquiry [DEW33] and the original model proposed in [GAR91]. In this model, critical thinking is seen as “a multi-phased process associated to a triggering event, which is followed by perception, deliberation, conception and warranted action".

The general model of critical thinking assumes an iterative and reciprocal relationship between the personal world (individual reflection) and the shared world (group interaction). The model is structure in terms of two axes: the *practical axis*, i.e. the reflection on practice (action-deliberation) and the *conceptual axis*, i.e. the assimilation of information and construction of meaning (perception-conception), see figure below.

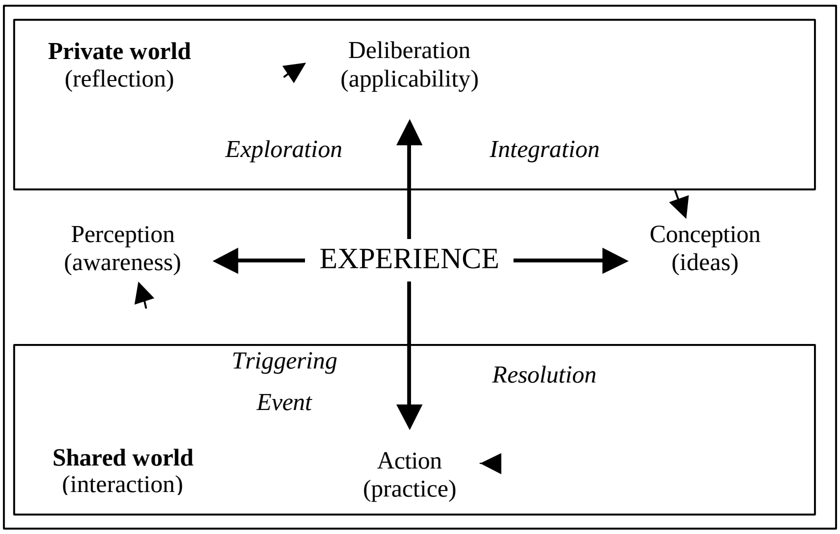


Fig. 2.2: The Critical Thinking model

The four quadrants of the model correspond to the categories of cognitive presence indicators. The first quadrant (triggering event) is the state of uncertainty/doubt resulting from an experience. The second quadrant (exploration) corresponds to the search for information, knowledge and alternatives that might help to make sense of the situation/problem. The third quadrant (integration) is the phase where the acquired information and knowledge is integrated into a coherent idea or concept. Finally, the fourth quadrant (resolution) corresponds to solving the issue/problem and applying the results back to the inquiry process.

In a learning community, critical inquiry benefits from group communication in all phases of the thinking process. In group discussions, the participants constantly shift between their individual personal worlds and the shared world. In their personal world, they reflect and elaborate concepts, while in the shared world they capture new ideas and experiences from their peers. The statements and new ideas shared among the group might cause reflection, uncertainty and disagreement, which moves people back to further discussion.

The conceptual framework of the Critical Thinking model and the experiments described in [GAR00] suggest that there is a direct relation between group communication and the cognitive outcomes of learning. This intuitively means that the richer is the communication among the learning community, the higher are the corresponding cognitive benefits.

Relation between AMANDA and the Critical Thinking and Community of Inquiry models

In what concerns the *Community of Inquiry* model, AMANDA acts as the element of *teaching presence*, by playing the role of a facilitator of group communication. In what concerns the *Critical Thinking* model, AMANDA works to enhance the cognitive presence of the discussants by facilitating the shift between exploration and the triggering events, i.e. by encouraging people to express their thoughts and reflect over their peer's opinions. In general terms, AMANDA is an "element of the medium" designed to improve group communication.

In this section, we investigated how group communication, especially computer-mediated discussions, can affect learning. From the learning viewpoint, researchers share the common position that group interaction provides substantial cognitive benefits. Similar position is shared by researchers from other fields, such as knowledge management, as presented in the next section.

2.1.2 The knowledge creation theory

This section is based on the work by Nonaka and Takeuchi [NON95]. In this work, they present the *knowledge creation theory*, a compilation of concepts and case studies which explain how new knowledge is created among individuals and organizations. In [NON98] and [NON99], Nonaka explores how individuals sharing a common context transfer new knowledge among them. The similarities between the knowledge creation theory and the learning process in collaborative learning environments [ELE99] justify a deeper inspection of Nonaka's ideas.

The notion of knowledge

In Nonaka's theory of knowledge creating process, knowledge is defined as "a dynamic human process of justifying personal belief toward the truth", with special focus on "justified" rather than "true" aspect of belief. According to Nonaka, knowledge is *dynamic*, since it is dynamically created in social interactions among individuals and organizations. Knowledge is *context-specific*, as it depends on particular time and space. Without being put into a context, it is just information, not knowledge. Knowledge is also *humanistic*, as it is essentially related to human action. It is the humanistic aspect, more specifically the interactional dimension, that guides Nonaka's work.

Types of knowledge

According to Nonaka, there are two types of knowledge: *explicit knowledge* and *implicit (tacit) knowledge*. Explicit knowledge is the *trace of knowledge*, i.e. every type of contextualized information expressed in a formal and systematic language, e.g. manuals, specifications, written procedures, spreadsheets and other types of tangible information. Implicit knowledge, on the other hand, resides within the individuals and is represented by subjective insights, intuitions, feelings etc. This type of knowledge is deeply rooted in action, procedures, commitment, values, or emotions and therefore is difficult to formalize and to communicate to others.

Both types of knowledge are essential to knowledge creation. In fact, according to Nonaka, knowledge is created through interactions between implicit and explicit knowledge, rather than implicit or explicit knowledge itself. The items below explore in deeper details the dynamic nature of knowledge.

Conversion between knowledge types – the SECI model

According to Nonaka, implicit and explicit knowledge can be converted into each other by means of the following conversion modes, see figure 2.3:

(i) *socialization*, which converts implicit knowledge among individuals;

(ii) *externalization*, which converts implicit knowledge into explicit knowledge;

(iii) *combination*, which converts existing explicit knowledge into more complex and systematic explicit knowledge and

(iv) *internalization*, which converts explicit knowledge into tacit knowledge.

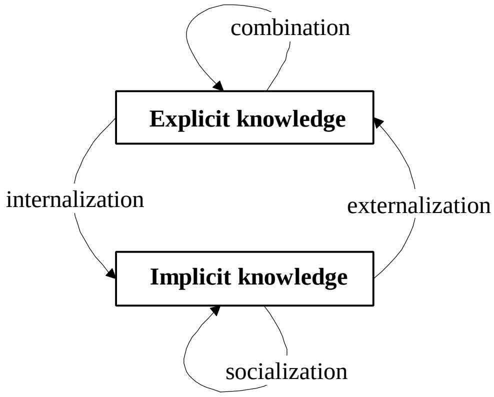


Fig. 2.3: Knowledge types and conversion modes, the SECI model

These four conversion modes, named the SECI model [NON99], are the key elements for knowledge creation. The shift among these four types of knowledge forms a spiral in which knowledge is "amplified" as individuals interact with each other, as shown in figure 2.4.

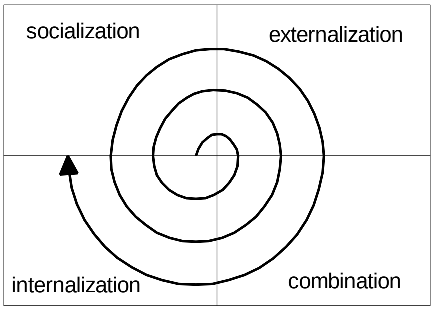


Fig. 2.4: Knowledge spiral

Providing a shared context for knowledge creation

Every knowledge transfer needs a context to occur. This can be a physical, virtual or mental space that offers a context in which the knowledge is shared, created and utilized. Each knowledge transfer space, named "Ba"[2] in Nonaka's work, is a shared context where a specific knowledge conversion takes place. Such spaces can be physical spaces like an office, a meeting room or a classroom, virtual spaces like a web-based learning environments or can be mental spaces like shared ideals.

---

2 "Ba" is a japanese word originally used by Nonaka to express the space in which interactions take place. In the rest of this section, we will use "space" instead.

According to Nonaka, there are four types of knowledge sharing spaces: *originating* space, *dialoguing* space, *systemizing* space and *exercising* space. Figure 2.5 shows the knowledge transfer spaces and their corresponding knowledge conversion processes.

Originating Space socialization	**Dialoguing Space** externalization
Exercising Space internalization	**Systemizing Space** combination

Fig. 2.5: Knowledge shared spaces and their conversion modes

The *originating* space is where individuals join together to exchange implicit knowledge, in the form of experiences, feelings, emotions and mental models. It is the space where *socialization* takes place and the individuals transcend the boundary between self and others.

The *dialoguing* space is where individuals' mental models are shared, converted into common terms and articulated into concepts. When individuals join together to collectively discuss an issue or solve a problem, for instance, they externalize their implicit knowledge (ideas, feelings, viewpoints) into words, sketches, diagrams and other forms of explicit knowledge. The dialoguing space is the context for *externalization*, where the implicit knowledge from each individual is articulated through collective dialogues and turned into new explicit knowledge.

The *systemizing* space offers a context for the *combination* of existing explicit knowledge into new forms of explicit knowledge. These new forms of knowledge can be, for instance, a summary report integrating data from different sources of information like databases, spreadsheets, graphics etc.

The *exercising* space is the context for *internalization*, where individuals convert explicit knowledge into implicit knowledge. Internalization occurs, for instance, when an individual interprets data from a spreadsheet. Interpretation in this case represents the conversion of an explicit knowledge (spreadsheet) in to the individual's implicit knowledge in the form of mental models and new ideas, etc.

Relation between AMANDA and the knowledge creation theory

In respect to Nonaka's theory, AMANDA is a self-regulating *dialoguing* space, where individuals externalize their viewpoints and articulate their ideas. AMANDA involves the participants in argumentative discussions, where the participants express their ideas and evaluate their peer's opinions through argumentation. When expressing their viewpoints, individuals *externalize* their implicit knowledge. When arguing over expressed opinions, they first *internalize* the explicit knowledge expressed by the group and then elaborate a more complex type of knowledge, the argumentation.

Having presented the fundamental concepts of the knowledge creation theory, with special emphasis on the dialoguing space and the externalization of implicit knowledge, we now investigate how computer systems can support group communication. For this purpose, we concentrate on computer-mediated communication (CMC) systems and their roles in implementing dialoguing spaces.

2.2 Computer-mediated communication (CMC)

This section aims at providing historical background and general concepts about computer-mediated communication systems (CMC).

2.2.1 An overview of CMC

Computer-mediated communication (CMC) is a research field which investigates the use of computers to facilitate group communication. The main interest is on asynchronous communication systems that mediate discussions among a group of individuals, such as computerized conferencing systems, forum systems, decision support tools and voting systems [TUR91].

In practice, a CMC system builds an appropriate structure for human communication process concerning a specific subject, with the objective of providing opportunity for a group to exhibit *collective intelligence* [LIN75].

To date, CMC systems have been utilized to support a variety of fields, such as project management, crisis management, planning and budgeting, collaborative learning, large-scale information exchange and decision support.

2.2.2 Delphi method

Historically, the first CMC system derived from a group decision-making method called Delphi method ([DAL63], [BRO68]). The Delphi method, originally developed in the 1950s, allows a group of individuals to collaboratively analyze and judge over a complex issue with the objective of improving the quality of a decision making. At first, each member of the group answers a questionnaire by providing comments regarding a particular set of issues. A facilitator compiles the comments and then distributes new questionnaires, so that the participants can compare their viewpoints to those of the group. Once this is done, the participants, having the benefit of the previous discussion, anonymously comment and vote on the issues. The facilitator collects the questionnaires and the process repeats until the group reaches consensus or stable disagreement.

Since its creation, the Delphi method was widely adopted as a means to mediate group discussions, either in paper-and-pencil and face-to-face environments, specially for predicting complex situations involving uncertainty and subjectivity. Typical application examples of the Delphi method are medical decisions, stock market predictions, military strategies and forecasts on potential breakthroughs in research fields.

In march 1970, the first experiment on computer-automated conference was conducted at the Office of Emergency Preparedness by Murray Turoff [TUR72]. The on-line conference was held during thirteen weeks and involved twenty individuals throughout the United States, who used teletype computer terminals connected to the telephone line to participate in a Delphi exercise.

In this experiment, a member of the conference was able to:

(i) enter discussion items of his own, i.e. proposals and arguments;

(ii) view discussion items entered by other members;

(iii) vote on proposals using scales for desirability and feasibility;

(iv) vote on arguments using dimensions of importance and validity and

(v) track votes on all discussion items.

Turoff's experiment showed that the computer contributes by reducing the delay in discussion rounds of Delphi exercises, although the participants have faced severe problems of reliability on the communication lines and the hardware itself.

With the technological improvements on computers and communication infrastructure, a large number of CMC systems were developed with enhanced features, such as EIES (Electronic Information Exchange System) [TUR77] allowing messages, conferences, document composition and an extensive activity monitor that provided data on system usage. Over 25 special-purpose sub-systems were developed on EIES over the period 1976-1987.

In the 1990s, CMC systems benefited from the Internet and the World Wide Web to provide users with an integrated environment to communicate within the group and with other information resources. As a result, CMC systems transcended the boundaries of specific decision-making applications to gain a wider dimension, by allowing people to communicate either synchronously and asynchronously through e-mail messages, on-line chats and forum systems. The combination of accessibility, low communication costs and standardized graphical interfaces have pushed CMC into new perspectives.

In the decision-making field, web-based CMC systems allowed for conducting large scale conferences. An example is the Open Meeting system [HUR96], a large scale public conference system that joined thousands of individuals geographically dispersed in the United States to discuss government issues. This experience, announced over mailing lists and bulletin boards for government workers, gathered over 4200 registrations and 1000 individuals actually attended the discussion threads [HUR98].

In the learning field, CMC systems have been extensively used as integral part of computer-supported collaborative learning (CSCL) environments. In many respects, CMC is a pivotal component in contemporary flexible learning systems [MAS97]. The Internet and the World Wide Web brought new possibilities for flexible learning and the formation of virtual learning communities provided with collaborative communication tools, such as closed-group messaging, on-line chatting and discussion forums.

2.2.3 Forum systems

From all communication tools in a learning environment, one is of our special interest for its asynchronous, structured and persistent nature – the *forum systems* [FAH01]. Forum systems are asynchronous communication spaces that allow a group of people to collectively discuss over a specific subject. In forum systems, questions (issues), answers and comments are linked together and organized in a hierarchical structure. To date, forum systems exist either as stand-alone tools, e.g. Allaire Forums, or integrated in distance learning environments.

Eureka [ELE00], a web-based distance learning environment developed at the Pontifical Catholic University of Paraná (PUC PR), allows for synchronous and asynchronous group communication. Eureka provides synchronous and asynchronous CMC tools like on-line chatting, messaging and discussion forums. The forum system in Eureka is a threaded structure composed of questions and comments. Threads can be easily closed and opened to visualize the topics of interest.

An example of a stand-alone CMC system is KOM2000, a forum system developed at the Stockholm University [PAL01]. It provides both synchronous (chat) and asynchronous (discussion forum and e-mail) communication tools. There are five types of discussions in KOM2000: *open*, *closed*, *restricted*, *moderated* (contributions are validated by a moderator) or *course* discussions (monitored and graded by the teacher).

The I-Help system [GRE01], developed at the University of Saskatchewan, is a web-based peer-help system that provides public and private discussion spaces to assist learners in problem-solving situations. The I-Help system is an example of large scale deployment of CMC in the learning field. [GRE01] reports experiments on public discussions available to 1600 students.

Although forums systems have been widely used to promote group communication in distance learning environments, we still face problems in getting satisfactory results from them ([FAH01], [GRE01]). The lack of motivation from the participants and the considerable effort required from the tutor/mediator to efficiently coordinate dispersed learners are among the key factors for the poor interaction observed in distance group discussions.

In the attempt to increase the participation and motivation among learners, researchers have proposed a higher degree of group interaction by focusing on *argumentative* discussions. Argumentative discussions, rather than *comment*-based discussions, tend to favor disagreements and reflections among the group and lead to improvements in learning, as shown in [BAK96].

The following section provides a more comprehensive insight on this matter, exploring argumentative discussions from various perspectives.

2.2.4 Relation between AMANDA and CMC

AMANDA is a special type of discussion-based CMC applied to collaborative learning. In what concerns the interactions among the discussants, AMANDA uses a method similar to Delphi to involve the participants in a collective debate through subsequent discussion rounds. The main difference is that the mediating role of the human facilitator in a Delphi exercise is entirely played by AMANDA. In AMANDA, the Delphi questionnaires are turned into discussion forms, which are produced by the system based on the intended interactions among the discussants.

AMANDA is an asynchronous discussion framework that organizes the discussion in a tree-like structure, and in this respect it resembles a forum system. However, we avoid this association because AMANDA is not a forum space, rather it is a mechanism that may run under a forum system to provide it with an autonomous mediating capability.

2.3 Argumentative discussions

This section provides concepts and formal background on argumentative discussions. We start by presenting the general notion of argumentation from different domains, such as pragmatics, discourse analysis, collaborative learning and artificial intelligence. Afterwards, we present a formal model of argumentation as the base for formalizing AMANDA framework.

2.3.1 The general notion of argumentation

Many definitions of argumentation exist in different research fields, from pragmatics and discourse analysis to education and dialectical logic. Regardless of the approach and formalism proposed by each field, we adopt the common notion of rational argumentation as *a process of making statements in order to support or refute an expressed opinion* [EEM84]. This general definition, however, is made more explicit when added with different perspectives from the various applications domains in which argumentation is explored. The sections below present the variations on definitions and concepts adopted by the different application fields.

2.3.2 Argumentation applied to dispute resolution

From the pragmatics point of view, i.e. concerning the purpose of the argumentation, Frans Eemeren and Rob Grootendorst [EEM84] define argumentation as *an attempt to convince a rational judge of the rightness of a particular standpoint in respect of the acceptability of an expressed opinion*. This definition has important assumptions about argumentation. Firstly, the *attempt to convince a rational judge* means that argumentation is a purposive act of promoting some kind of belief change on a rational judge. In addition, the *acceptability of an expressed opinion* suggests that there exists a proposition (or a set of propositions) to be accepted/refused by means of reasoning. This general definition clarifies the purposive nature of the argumentation, i.e. the perlocutionary aspect of it, but still casts doubts about how the *attempt to convince* is made.

A second definition, also proposed by Eemeren, is more specific in respect to the illocutionary aspect of argumentation. According to this definition, which is based on the speech act theory, the argumentation is *an illocutionary act complex composed of elementary illocutions, i.e. assertives, which in conjunction justify or refute an expressed opinion*. The above definition classifies argumentation as a type of speech act – the illocutionary speech act – and at the same type expresses the supportive/refuting relation of the argumentation in relation to the so called *expressed opinion*.

Classifying argumentation as an illocutionary act recalls other theories, such as Searle's speech act theory [SEA70]. According to Searle, an illocutionary act is a *purposive assertive* composed of a *propositional* content and an *essential* content. In the case of argumentation, the *propositional content* corresponds to the set of assertives made by the discussant and the *essential content* corresponds to the intention of justifying an expressed opinion (pro-argumentation) or refuting it (counter-argumentation).

In addition to the conceptualizations on arguments, Eemeren also explores the temporal stages of argumentation. He identifies four stages of an argumentative discussion: the *confrontation* stage, the *opening* stage, the *argumentation* stage and the *concluding* stage [EEM84]. In each stage, a specific interaction between the discussants takes place. In the confrontation stage, an opinion is advanced by one of the language users[3] and the dispute is identified. In the opening stage, the language users assume the roles of protagonists and antagonist. During the argumentation stage, both discussants exchange supporting and refuting argumentations in respect to the other's position. Finally, in the concluding stage, the dispute is resolved and the discussants collectively establish its outcome.

The next items provide insights on the use of argumentative discussions in the domains of collaborative learning and artificial intelligence.

2.3.3 Argumentation applied to collaborative learning

The objective of this section is to explore possible relations between argumentation and learning from the point of view of researchers on cognitive science. We explore new definitions of argumentation from the educational perspective and investigate empirical results from argumentative activities among students.

---

[3] The term *language users*, proposed by Franz van Eemeren, refers to the participants of a discussion in an the confrontation stage, when they have not yet assumed the roles of protagonists and antagonists.

We start by examining Goldman's definition [GOL76], in which *knowing something is the ability to eliminate other rival possibilities or believing that the chosen belief is more warranted than plausible rival beliefs*. Such a definition, cited by Baruch Schwarz in his work on construction of knowledge in argumentative activities [SCH01], suggests that knowing is an intra-subjective activity, a choice done by individuals. On the other hand, the plausibility of all alternatives is inter-subjective, being judged according to norms adopted by communities. This inter-subjective nature of the so called *plausible rival beliefs* reveals an evident relation between collaborative learning and argumentative discussions. A central means of constructing knowledge is reasoning, and the outcome of reasoning is an *argument*, a structure consisting of a conclusion and of a set of supporting reasons [SCH01]. The latter definition links reasoning and argumentation to the construction of knowledge.

Schwarz's empirical work demonstrated improvements in all measures of individual arguments along successive argumentative activities. Individual arguments became less one-sided and more compounded. In argumentative discussions, more reasons supporting alternative arguments were raised and these reasons became less vague or personal and more abstract.

This observation is in accordance with Michael Baker's notion of *conceptual association* (abstraction) [BAK96] as one of the discursive operations triggered by argumentative discussions, as presented below. The work by Matthieu Quignard and Michael Baker [QUI97] extended the classical notion of argumentation an *attempt to persuade listeners to accept the speaker's point of view* by considering it as essentially concerned with cognitive effects. According to Quignard and Baker, the classical theories on argumentation are not suitable to model cognitive aspects due to the fact that they are mainly concerned to the outcomes of the debate and do not contemplate cognitive aspects, such as beliefs and mental changes.

The empirical work by Michael Baker [BAK96] shows the positive cognitive effects of argumentation over students collaboratively solving a problem. In a later work [BAK98], Baker explored the functions of argumentation in collaborative problem-solving. According to this work, argumentation plays three major functions: it works as a *trigger for information search*, as a *filter of defective proposals* and as a *provider of interactive pressure to co-elaborate meanings*. Baker continued investigating the role of argumentation in learning [BAK99] and concluded that argumentative interactions can lead to *reconstruction* rather than explicitation of knowledge. According to this work, argumentative activities relate to cognition by promoting three types of discursive operations: *negotiation of meaning*, *conceptual dissociation* and *conceptual association*. The discursive operations referred by Baker is a transformation of meaning, understanding and concepts that is accomplished in and by discourse. *Negotiation of meaning* involves adjusting meanings in order to achieve mutual understanding, *conceptual dissociation* involves distinguishing concepts from each other and *conceptual association* involves subsuming concepts under more general ones.

Another empirical approach for argumentation is the work by Arja Veerman [VEE00]. In her work, she reports a study on collaborative learning through argumentation using synchronous and asynchronous computer-mediated communication (CMC) systems. According to Veerman, collaborative learning allows students to negotiate different perspectives by externalizing and negotiating them. Through argumentation, students can re- and co-construct knowledge in relationship with specific learning goals. Veerman's empirical interest is on the relation between argumentation and the production of constructive activities. For this purpose, Veerman classifies argumentation in two categories: the 'direct' forms of argumentation (challenges, counter-argumentation) and the 'indirect' forms of argumentation (information check). Her work demonstrated that students produced a higher degree of constructive activities by the indirect forms of argumentation than the direct forms. According to Veerman, this is explained by the fact that the students need well established conceptual knowledge before engaging in critical debates. These results may be used to re-design argumentative systems in order to intentionally promote more direct forms of argumentation.

2.3.4 Argumentation applied to Artificial Intelligence

In the AI domain, the notion of argumentation dates back to the early 80's, as described by Chesñevar et al. in [CHE00]. John Doyle's work on truth maintenance systems and decision making [DOY80] applies the notions of beliefs, justifications and defeasible reasoning to allow programs to reflect on and change previous inferences according to observed mistakes. Argument-based systems, however, gained force after the work by Donald Nute [Nut88] on "defeasible conditional logic". After this, research on argumentation in AI evolved as a result of several works, such as the general theory of warrant by Guillermo Simari [SIM89], the formal reconstruction of Rescher´s theory by Gerhard Brewka [BRE94] and the abstract assumption-based framework for default reasoning by A. Bondarenko [BON97].

Further research on argumentation and defeasible reasoning was done by Thomas Gordon, Nikos Karacapilidis and Dimitris Papadias, inspired in the issue-based information systems. In 1996, they proposed an argumentation based framework for defeasible and qualitative reasoning [KAR96], a model for multi-agent cooperation through argumentation.

In 1997, Gordon and Karacapilidis proposed the ZENO framework [GOR97], a formal model of argumentation conceived to be used in mediation systems with special support for argumentation and group decision-making. In 1998, the ZENO framework was extended to the HERMES platform ([KAR98a], [KAR98b]), a world-wide web implementation of an argumentation-based cooperative design system. In HERMES platform, the authors propose the use of case-based reasoning (CBR) techniques to estimate variations among discussants' opinions.

The Simari-Loui model for argumentative discussions

We present below the Simari-Loui model for argumentation, a set of conceptualizations upon which AMANDA framework will be proposed.

The Simari-Loui model, proposed by Guillermo Simari and Ronald Loui [SIM92] defines the knowledge of a discussant agent as a pair (K, ?). The set K represents *indefeasible* knowledge and ? is a set of *defeasible* rules of the form p ? q, used to represent that "p is the reason for q". The defeasible rules contained in ? are used to form the propositional content of the argumentation in relation to a given expressed opinion *h*. An argumentation <A, h> is a subset of ground instances of ? 's members for a given sentence *h.* Again, as in Eemeren's definitions, argumentation is defined as a sequence of statements (in this theory called *rules*) related to an expressed opinion (sentence *h*).

Later on, Simari extended his work by proposing an argumentative system - the MTDR framework [SIM94] – in which he proposes a broader structure for arguments, named *dialectical tree*. A dialectical tree for argumentation <A, h>, denoted by $?_{<A, h>}$ is defined as follows:

(i) a single node containing an argument $<A, h>$ with no defeaters is a *dialectical tree*;

(ii) if an argument $<A, h>$ has a set of defeaters $<A_1, h_1> \ldots <A_n, h_n>$ the dialectical tree $?_{<A, h>}$ is constructed by letting $<A, h>$ be the root node of the tree and by making this node the parent node of its defeaters;

(iii) any path $? = [<A_0, h_0>, <A_1, h_1>, \ldots <A_k, h_k>]$ in a dialectical tree ? is an *argumentation path*, i.e. an alternate sequence of arguments $<A, h>$ starting with the supporting argument $<A_0, h_0>$.

The Simari-Loui model and the corresponding concepts on argumentation, dialectical tree and argumentation path will be recalled in the next chapter to build an extended model for AMANDA's argumentative discussions.

2.3.5 Relation between AMANDA and the existing argumentation theories

We identify three main differences between the discussion framework adopted in AMANDA and those found in classical argumentation systems and theories.

Firstly, the existing argumentation theories normally consider argumentation as a two-party interaction, where one proponent and one opponent exchange arguments. Secondly, the classic argumentation theory defines an argument as a binary relation of support/refute in relation to a certain proposition, which eliminates the possibility of having partial agreements. Thirdly, the existing argumentation approaches focus on dispute resolution and their reasoning mechanisms are focused on the determination of the winner of the discussion.

In AMANDA, on the other hand, argumentation is applied to group discussions, what makes it a multiparty interaction, as in Karacapilidis's approach of group decision-making. This approach extends the dual-party (proponent-opponent) paradigm of previous argumentation theories.

In addition to the multiparty nature, AMANDA allows multiple issues to be discussed simultaneously, i.e. several dialectical trees co-exist simultaneously. Participants are also allowed to express *partial* agreements in relation to a peer's proposition, which extends the classical notion of a binary support/refute relation. Finally, the objective of argumentative discussions in AMANDA is neither dispute resolution nor decision making, rather is the mediation of group discussions for learning purposes. The latter difference changes our concept of reasoning over the discussion, when compared with the classical defeasible logical approach adopted by most researchers. In this respect, AMANDA'S reasoning mechanisms do not attempt neither to find the winner of the discussion nor the 'right' alternative for an issue. Rather, they are intended to provide purposive mediation for group discussions.

Another important feature of AMANDA is that the issues that initiate the debate can be generated from domain models. In order to provide background for this feature, we explore in the next section the research field of knowledge representation.

2.4 Knowledge representation

This section provides a brief investigation on knowledge representation (KR), with special emphasis on conceptual modeling (ontologies) and task representation.

2.4.1 What is knowledge representation?

Since the early days of Artificial Intelligence, researchers have proposed various types of representations to enable computers to use knowledge. However, a complete and unique knowledge representation does not exist. Each representation explicitly represents a given aspect of knowledge and hides others. The choice for an appropriate KR depends on how it is to be used by the computer. It is in this direction that Randall Davis et al. present their definition of knowledge representation [DAV93].

According to Davis, a knowledge representation can be defined in terms of five different roles it can play. It can be defined as:

- (i) a substitute for the thing itself that enables an entity to determine consequences by thinking rather than acting;
- (ii) a set of ontological commitments, i.e. the answer to the question "In what terms should I think about the world?";
- (iii) a fragmentary theory of intelligent reasoning;
- (iv) a medium for pragmatically efficient computation and
- (v) a medium of human expression.

From these five definitions of knowledge representation, we focus on two of them: KR as a set of *ontological commitments* and KR as a *medium of human expression*. These two definitions of knowledge representation are of special interest in this work for being highly related to the roles that KR plays in AMANDA.

The definition of a knowledge representation as a set of *ontological commitments* relates to nature of the "things of the world", i.e. to the concepts created by the man to refer to things that exist in the world. This is the essence of conceptual modeling and a also a key element for reflective learning. For this purpose, we focus on the notion of ontology and related types of representation.

On the other hand, the definition of a knowledge representation as a medium of human expression explores the representational role of a KR rather than the nature of the concepts. Human expression is built *upon* ontological commitments to express all sorts of ideas and facts about the world. In this work, we also concentrate on the representation of *human activities* and on the knowledge about *procedural tasks*. Therefore, we investigate *task models* and the possible ways to represent the relation between tasks, sub-tasks, methods and resources.

Ontologies and task models make up AMANDA's knowledge base. The following items present research that has been done on these two types of KR.

2.4.2 Ontologies

Before exploring the various definitions of ontology, we must distinguish the *philosophical* discipline of Ontology from the *engineering* discipline of ontology. In this work, we will use the same convention adopted in [GUA95], in which the capital letter "O" is used to distinguish the "Ontology" in philosophy from others.

What is an ontology?

Several definitions exist for ontology, according to the context in which it is applied. It seems contradictory that the ontology itself, intended to establish terminological consensus, is subject to so many different definitions. In fact, the different definitions on ontology found in the literature reflect different interpretations of the engineering aspect of it, which is finally rooted in the different application purposes of ontologies. In this section, we will present definitions proposed by various researchers in the KR field.

The work by Mizoguchi [MIZ98] compiles the following definitions on ontology:

(i) In philosophy, it means *theory of existence*. It tries to explain what exists in the world and how the world is configured by introducing a system of critical categories to account things and their intrinsic relations.

(ii) From the AI perspective, an ontology is an explicit specification of conceptualization [GRU94].

(iii) From the knowledge-base systems perspective, an ontology is a theory of concepts/vocabulary.

(iv) Thomas Gruber also defines ontologies as agreements about shared conceptualizations, reported in [USC96].

(v) From a compositional perspective, an ontology is composed of concepts with definitions, hierarchical organization (not mandatory), relations among them and formalizing axioms.

Another compilation of ontology definitions appears in a work by Nicola Guarino [GUA97]. According to this work, ontologies are defined as:

(i) a theory of what entities can exist in the mind of a knowledgeable agent [WIE93];

(ii) a taxonomy of concepts for a given task or domain that define the semantic interpretation of the knowledge [ALB93] and

(iii) an explicit partial specification of a conceptualization [SCH95].

John Sowa in his web page [SOW01] provides the following insightful definition on ontology. "The subject of ontology is the study of the categories of things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalog of the types of things that are assumed to exist in a domain of interest *D* from the perspective of a person who uses a language *L* for the purpose of talking about *D*. An uninterpreted logic, such as predicate calculus, conceptual graphs or KIF, is ontological neutral. It imposes no constraints on the subject matter or the way the subject may be characterized. By itself, logic says nothing about anything, but the combination of logic with an ontology provides a language that can express relationships about the entities in the domain of interest."

In the above definition, Sowa touches important issues on ontology. Firstly, he defines an ontology from the perspective of a *person* who *talks about something* using a certain *vocabulary* in a given *context* (domain). The term "perspective of a person" clearly identifies Sowa's inspiration from semiotics, as demonstrated in his recent work "Ontologies, Metadata and Semiotics" [SOW00]. He defines an ontology as a catalog of types of things, which can be translated by a *taxonomy of concepts*. Finally, he gives a sense to the ontology by considering it as a *provider of meaning* to other knowledge representations. In fact, this latter thought is in accordance with many researchers' opinion that ontologies are the "skeleton" upon which knowledge bases are constructed and that without an ontology knowledge bases are meaningless.

The common point of all above definitions, is that an ontology is a sort of *fundamental KR* rooted in philosophical issues and structured in a taxonomy that describes the nature of the concepts.

The degree of formalization and rigor on the construction of an ontology depends on its application. Some researchers concentrate on *axioms* as the key elements for ontology design, while others, such as Guarino and his theory of formal ontologies [GUA00], propose rigorous taxonomical approach for building "clean" and unambiguous ontologies. Sowa focuses on both axioms and taxonomy. He defines a formal ontology as a collection of concepts organized in a partial ordering by the type-subtype relation. He classifies formal ontologies in two types, depending on the way the subtypes are distinguished from their supertypes: an *axiomatized ontology* distinguishes subtypes by axioms and definitions stated in a formal language, such as logic or some computer-oriented notation that can be translated to logic; a *prototype-based ontology* distinguishes subtypes by a comparison with a typical member or *prototype* for each subtype. According to Sowa, large ontologies often use a mixture of definitional methods: formal axioms and definitions for formalizing terms in mathematics, physics, and engineering; and prototypes for describing plants, animals, and common household items.

What are ontologies used for?

The *raison d'être* of an ontology is to provide shared comprehension on a given domain, thereby eliminating differences, overlaps and mismatches in concepts, structures and terminology. In this respect, ontologies can unify different viewpoints and improve communication. The key purpose of an ontology is then to provide *common understanding* for those who wish to communicate. This common understanding can be used in many different ways, as exemplified below.

In the work of Thomas Gruber, common understanding is reflected in knowledge sharing and reuse [GRU92]. He believes that ontologies can make knowledge bases interoperate consistently and, hopefully, understand each other. Gruber's opinion is shared by Sowa, who states that "without ontologies, there is no hope of merging and integrating the ever expanding and multiplying databases and knowledge bases around the world". Wache et al. [WAC01] explore the role of ontologies to provide integration an interoperability to information sources. Kassel

[KAS97] reports the use of application ontologies to provide common understanding for medical expert systems. Aguado [AGU98] explores linguistic ontologies as a means of generating natural language text. Mizoguchi concentrates on the roles of ontologies in the learning field [MIZ00] and on the perspective that "ontologies can help people identify what they agree on and what they do not". The above examples make it clear that, regardless of the application domain, ontologies are useful whenever integration and common understating are required.

Having explored the conceptual and usage aspects of ontologies, we now concentrate on the second type of KR of interest – *task models*.

2.4.3 Task models

Much less controversial than ontology, task modeling investigates the representation of tasks and their decomposition into sub-tasks and methods.

One of the first researchers to investigate task modeling in the AI field was Chandrasekaran. In the late 70's, inspired by the work of the Stanford group on MYCIN[4] [BUC84] and diagnostic systems, he elaborated the first insights on generic tasks and task structures applied to problem solving for medical applications. To date, the work by Chandrasekaran ([CHA92], [CHA93]) is focused on modeling medical diagnosis domain knowledge using tasks and methods as mediating concepts.

The work by Keith Decker and Victor Lesser on GPGP[5] and TÆMS[6], see [DEC95a] and [DEC95b], is centered on task structures as models for building coordination algorithms applied to distributed agent environments.

The work by Mizoguchi [MIZ95] is based on the notion of task ontologies and the decomposition of expert knowledge to build general problem solving models.

The notion of task, subtask and methods

According to Chandrasekaran [CHA92], tasks are procedures that transform an initial problem state with certain features into a goal state with additional features. A

---

4 MYCIN is an expert (rule-based) system for selecting therapies for bacterial infections of the blood.

5 GPGP (Generalized Partial Global Planning) is a domain-independent framework proposed by Victor Lesser and Keith Decker for coordinating small teams of agents

6 TÆMS (Task Analysis, Environment Modeling and Simulation) is a framework for modeling and analyzing task-based environments.

complex task can be decomposed by subtasks in a tree-like structure called *task structure.*

The same interpretation of tasks and subtasks is shared by Decker & Lesser in TÆMS [DEC95a]. In TÆMS, tasks can be decomposed into subtasks, but the fundamental difference is that in TÆMS, task structures capture not only the task-subtask decomposition, but also the *dynamics* of a task-based environment and a rich (and open) set of *inter-relations* among tasks. Decker's approach is deeply rooted in the progress of tasks over time and the corresponding effects over the "quality" of the root task. The role of task structures in TÆMS is to provide a generic domain-independent model for simulating different task configurations and observing the effects of deploying distributed agents to execute them.

In Mizoguchi's approach [MIZ95], tasks and subtasks are represented by *task ontologies,* much in the same way that concepts and sub-concepts are represented by domain ontologies. The main difference is that Mizoguchi's task ontology also captures the role that objects play during the problem solving process.

In addition to the task-subtask decomposition, task structures also represent *alternative ways* of accomplishing a given task. For instance, the task of predicting the behavior of a device (T) can be accomplished by two ways: either by *simulation* (T_1) or by *physical manipulation and observation* (T_2). T_1 and T_2 are alternative ways of accomplishing T; in the task modeling field, they are called *methods* of T.

Methods are integral part of task structures. What differs from one approach to another is the way in which they are incorporated. In the work by Chandrasekaran, for example, *methods* are special nodes of the task structure. In Decker's approach, on the other hand, methods are represented by a special type of relation, named "quality accrual function OR". Roughly speaking, when two subtasks T_1 and T_2 are linked to an upper level task T by an accrual function OR, T is considered accomplished if T_1 *OR* T_2 are completed. This is the essentially the same as Chandrasekaran's notion of *method*.

What are task models used for?

Task models are used to explicitly represent how a task is executed. Task representation is typically used as a template for computer programs and for simulating the behavior of task environments. The latter application requires more sophisticated task models, generally dynamic and composed of several types of relations among tasks.

In the simplest form, however, task models should allow for expressing the decomposition of tasks into subtasks and distinguishing alternative ways of executing the tasks.

2.4.4 Relation between AMANDA and knowledge representation

In AMANDA, domain knowledge is represented by ontologies and task models that represent the *domain of discourse*. AMANDA uses domain models for generating natural language interrogative sentences to be used as issues for the discussion. From the relations found in the domain ontologies and task models and a set of sentence templates, AMANDA extracts questions for exploring the knowledge contained in the models. The objective of such questions is to lead the discussants to a reflection over the domain under discussion. Section 3.4 explores how KR and NL generation in further details.

2.5 Summary of the chapter

This chapter presents the main research fields related to AMANDA, namely knowledge transfer, computer-mediated communication, argumentative discussions and knowledge representation.

The theory of knowledge creation by Nonaka is presented in order to help us understand how knowledge is dynamically created as a result of interactions among individuals. This theory gives us the notion of knowledge transfer spaces, in which knowledge is converted and augmented. At the end, AMANDA is identified as a dialoguing space, in which group interaction is articulated to improve knowledge transfer.

The second topic – computer-mediated communication (CMC) – provides a historical view on the contribution of computer systems to group communication. Delphi, a group methodology which has many common points with AMANDA, is identified as the inspiring method of the first generation CMCs. Some examples of CMC applications in the decision-making and collaborative learning fields are given.

In the third topic – argumentative discussions – we present the notion of argumentation from the perspective of various research fields, such as dispute resolution, collaborative learning and artificial intelligence. We also present a formal model of argumentative discussion, which will be further used to build AMANDA's extended argumentation model.

Finally, in the forth research topic – knowledge representation – we present a general view on the field, with special interest on ontologies and task structures. Ontologies are defined as fundamental KR representations, while task structures are viewed as models to represent tasks, subtasks and methods. The ideas contained in this topic will be used to build AMANDA's knowledge base.

2.6 Résumé

Ce chapitre présente l'état de l'art des divers champs de recherche qui concernent ce travail. D'abord nous investiguons l'aspect cognitif lié à la communication de groupe, notamment le rôle des discussions collectives dans l'apprentissage ainsi que le domaine plus générique de la création de connaissance dans des groupes de travail. Deuxièmement nous analysons la communication assistée par ordinateur (CMC – « computer-mediated communication »), la méthode Delphi et des applications des systèmes CMC pour la prise de décisions et pour l'apprentissage collaboratif. Ensuite, nous examinons le concept d'argumentation sur ses multiples approches : la résolution de disputes, l'apprentissage collaboratif et l'intelligence artificielle. Finalement nous nous concentrons dans la représentation de la connaissance comme forme de modélisation de la connaissance de domaine du discours, surtout dans la structurations des concepts (ontologies) et dans la représentation de tâches (modèles de tâches).

Chapter 3

The AMANDA method

After a couple of years of development and use of our distance learning platform Eureka[7], we observed that distant learners and tutors tend to use this type of tool mainly as an *exploratory* tool rather than a *communication* tool. In general, Eureka is used to organized the learning material and to make it available in the file repository. Little use is made of its embedded communication tools. This means that an important learning principle – the *collaborative learning* – has not been satisfactorily practiced, despite all communication facilities offered by the platform.

We turn our attention to the communication resources generally available in distant learning environments. They can be synchronous, like on-line chats and videoconferences, or asynchronous, like e-mail and discussion forums. From these tools, the discussion forums are of special interest for us, due to its high potential as a collective dialoguing space and its asynchronous nature.

Discussion forums make it possible to conduct group discussion among distant learners with very few time and technology constraints. However, one major obstacle makes it fail - the mediating effort required by the tutor to motivate and articulate this type of discussion is frequently beyond his time availability. The origin of the problem, in our opinion, is that group discussions are not normally considered by the tutors as an integral part of their distance learning activities. They are generally used as just another communication tool for placing individual questions with very little emphasis on the collective nature of group discussions. Our aim is to propose a method that retrieves the real value of group discussions for effective distance learning by providing the discussion forum with some intelligent behavior.

Initially, we imagined a mechanism (like a software agent) that would motivate group discussions by silently "tapping into" the discussion forum in the search for semantic relations among the participants' contributions. This agent would animate the discussion without being noticed, possibly as a disturbing agent and even assuming a false identity within the group. It would apply text techniques to analyze the textual content of the discussion and a domain ontology to allow for semantic matching.

After some weeks of thoughts and scratches, we noticed that this agent could possibly be successful, but certainly not with the kind of discussion we normally had. It would require a discussion with a large amount of text, i.e. with a large number of interactions among the discussants, and this is just what we didn't have.

We then inverted the order of the solution by first finding a way to create highly interactive discussions and then possibly develop additional prospective mechanisms. In this new perspective, the emphasis of the work shifted from the textual content of the discussion towards a way of *creating interactions among the group*. And this is how AMANDA was born[8].

3.1 The underlying principles of AMANDA

AMANDA is a method for mediating multiple-issue asynchronous discussions among a group of distance learners. The objective of AMANDA is to help tutors achieve better results from group discussions and to improve knowledge transfer among the participants. It proposes an innovative way of conducting group debates, where the discussion mediation is entirely algorithmic. The main advantage of the proposed method is the possibility of carrying large discussions, for instance among tens or hundreds of participants, over several issues simultaneously, without the interference of a human mediator. In addition, the method provides a disciplined discussion, focused on the most polemical viewpoints and with an even participation of the group over the proposed issues.

---

[7] Eureka is a web-based distance learning platform developed at PUC PR in a partnership with Siemens S.A. It currently hosts hundreds of courses and features thousands of active users.

[8] AMANDA was developed under a partnership project between the Technology University of Compiègne (UTC) and CEGOS, a training and consultancy firm in Human Capital Development.

From a user's perspective, AMANDA mediates a discussion much in the same way as a human tutor would do it he/she had enough time to spend on it. It attempts to focus the discussion on the most relevant topics and assigns specific discussion tasks to the participants. The intended result from this coordination is a debate in which the participants articulate their knowledge as much as possible, given their time constraints and the effects of the distance.

From a technical perspective, AMANDA behaves as a sort of intelligent state machine, which advances the discussion based on (i) the current configuration of the discussion and (ii) a set of coordination rules.

The method consists of launching a set of issues for group debate and then redistributing the corresponding answers and argumentations among the participants to be analyzed and validated collectively along successive discussion cycles. At each discussion cycle, the method detects agreements and disagreements and proposes new interactions among the group so that the focus of the discussion is intentionally controlled and the debate progressively advances according to specific interaction objectives. New discussion cycles are successfully opened until the discussion cannot be advanced any further or until the discussion time expires. Internally, AMANDA organizes group discussions in a tree-like structure - called *discussion tree* – where the nodes represent individual peer-to-peer argumentative interactions. The participants interact in the discussion by means of discussion forms, containing questions to be answered, as well as answers and argumentations from other participants to be validated or refuted.

Another feature of the method is the generation of natural language questions from domain models (section 3.6). AMANDA provides a method for modeling the domain under discussion by building ontologies and task models. The relations between concepts in the ontology and tasks/sub-tasks in the task model are turned into interrogative sentences, which can be later selected by a human tutor to be used as issues for the discussion.

We now turn our attention back to the mediation of the discussion and explore the underlying structures and formal representations of AMANDA.

3.2 The discussion models

This section aims at presenting the formal background of AMANDA, including AMANDA's extended model of argumentative discussions and the dynamic model of discussion mediation.

Group discussions in AMANDA are structured as a collection of argumentative interactions among the participants. We developed the model for argumentative discussion in AMANDA as an extension of the Simari-Loui model, presented in the preceding chapter. Before presenting AMANDA model, we first recall the fundamental concepts from the Simari-Loui model, which defines an argumentative discussion as the following set of elements:

- (K, ?) represents the knowledge of a discussant agent, where K is the *indefeasible* knowledge and ? is a set of *defeasible* rules of the form p? q;
- an *argument* <A, *h*> is a subset of ground instances of ? 's members for a given sentence *h*, i.e. the rules in ? formulate the propositions that justify an argument in respect to an expressed opinion *h*;
- a *dialectical tree* for the argument <A, h>, denoted by $?_{<A, h>}$, is either a single node containing an argument <A, h> or an argument <A, h> with a set of defeaters $<A_1, h_1> \ldots <A_n, h_n>$;
- an *argumentation path* is any path $? = [<A_0, h_0>, <A_1, h_1>, \ldots <A_k, h_k>]$.

The above concepts can be summarized as follows: "A given discussant defeats an expressed opinion *h* by means of a set of arguments (*defeasible rules*). The argumentative process is organized in a *tree-like* structure, where the nodes represent the individual arguments proposed by the discussants".

Based on the above concepts, we present below our extended model for argumentative discussions.

3.2.1 The extended model for argumentative discussions

The extended model of argumentative discussions is the formal representation of AMANDA discussions. It extends the existing models in four main aspects:

- it expresses a discussion composed of multiple issues;
- it allows multiple participants to take part in the discussion;

- it allows discussants to express partial agreements/disagreements and
- it represents a discussion as it advances over time.

For the sake of comprehension, we will first present AMANDA's static (time-independent) model for argumentative discussions. Afterwards, we will extend the static model to build the corresponding dynamic (time-dependent) model, needed to represent coordination issues.

3.2.2 The static model

AMANDA framework extends the classical argumentative discussion theories by introducing the notion of *multi-issue and multiparty argumentative discussions*. This extension requires the development of new formal models and concepts.

The notion of multi-issue, multiparty discussions

By *multi-issue* we mean that more than one issue (question) can be simultaneously launched for debate. In structural terms, this means that AMANDA discussions are composed of a set of discussion trees, instead of a single dialectical tree as in Simari's theory. Each question launched for debate is, in fact, the root of a specific discussion tree.

By *multiparty* we mean that the discussion is not restricted to a pair of discussants (proponent-opponent), as in most classical argumentation approaches. Rather, it accepts an arbitrary number of discussants forming a *set of participants*. The multiparty characteristic of AMANDA adds new perspectives to apply argumentative discussion to the collaborative learning field. In fact, a substantial effort of AMANDA is devoted to articulating the set of participants in a collective debate.

In addition to the multi-issue, multiparty feature of AMANDA, the proposed model also addresses practical issues regarding argumentative interactions among learners. In distance text-based discussions, it's common to have viewpoints that are judged 'mostly correct', but which need complementary arguments to be fully justified. On the other hand, viewpoints might be judged 'mostly incorrect', but with a little bit of true in it. In order to allow a more flexible judgment over such propositions, argumentations in AMANDA can also express partial agreements/disagreements. Inspired on an informal methodology for mediating group discussions and brainstorms[9], we adopt four types of argumentation: two types of supporting argumentations (total and partial support) and two types of refuting argumentations (total and partial disagreement).

AMANDA framework also differs from the existing argumentation models by explicitly representing the domain of discourse by means of knowledge models. We use domain ontologies and domain task models to represent the subject under discussion. The knowledge models provide the framework with a degree of theory awareness [MIZ00] that can be helpful to provide additional mediating capabilities. The role of knowledge models in the AMANDA will be discussed later in this chapter.

The proposed static model

We may now define a *discussion structure* ? as a triple of the form ? = $<I, D, T>$, where $I = \{I_1, I_2 \dots I_n\}$ is the set of *participants* (discussants), $D = <O, M>$ is the *domain of discussion*, represented by the domain ontology O and the domain task model M and $T = \{T_1, T_2 \dots T_m\}$ is the set of *discussion trees*. Each discussion tree, denoted by $T_i = <q_i, A_i, G_i>$, is composed of a proposed issue q_i (the root element), a set of alternative answers $A_i = \{a_{<i,1>}, a_{<i,2>} \dots a_{<i,k>}\}$ over the proposed issue q_i and a set of argumentations $G_i = \{g_{<i,1>}, g_{<i,2>} \dots g_{<i,p>}\}$. We also define the set $Q = \{q_o, q_1 \dots q_m\}$ as the set of all issues of the discussion.

An *alternative answer* $a_{<i,j>}$? A_i is a triple of the type $<p, q_i, I_q>$, where p is the textual content of the answer given by I_q to issue q_i. The textual content p can be either a valid string of text p_v or an empty textual content $p_Ø$[10]. An alternative answer $a_{<i,j>}$, when represented in a tree structure, is called an ALT node.

An *argumentation* $g_{<i,j>}$ is a tuple of the type $<g, h_i, w, I_q>$, where g is the argument provided by I_q to argue over the sentence h_i with the intention w. The argument g can be either a valid string of text g_v or an empty textual argument $g_Ø$ (see

---

9 We adopt the 4-level argumentation proposed by the "Post-it" methodology, used for mediating group discussions and brainstorms, in which the participants place "post-its" on a white board to express their supporting/refuting reaction against a given position. Four different "post-its" are used to express total agreement, partial agreement, partial disagreement and total disagreement.

10 The empty textual content $p_Ø$ is any string that clearly identifies the propositional content as *empty*, e.g. the null string, the string "Type your answer here …", the string "I don't know" or any string of the same nature. In practice, $p_Ø$ is used to characterize "unanswered" or "just-created" nodes and to distinguish them from "answered" nodes.

note on $p_Ø$). The sentence h_i ? A_i ? G_i is either an alternative answer $a_{<i,j>}$? A_i or another argumentation $g_{<i,k>}$? G_i. The element *w* ? {++, +, -, --, $w_Ø$} is interpreted as the degree of support/refutation of the argumentation $g_{<i,j>}$ with respect to h, respectively interpreted as *total agreement*, *partial agreement*, *partial disagreement*, *total disagreement* and *no-intention*. An argumentation $g_{<i,j>}$, when represented in a tree structure, is called an ARG node. Depending on the intention w, ARG nodes can be of the following subtypes: ARG++, ARG+, ARG- and ARG-- and $ARG_Ø$.

Figure 3.1 illustrates a discussion ? on the domain D among a set I of participants. The discussion is made up of two issues q_1 and q_2, each one forming the root of the discussion trees T_1 and T_2. Issue q_1 has three alternative answers p_1, p_2 and p_3, respectively provided by I_2, I_3 and I_1. In T_1, for instance, the alternative answer p_1 is partially supported by the argument g_1 and partially refuted by g_2. The argument g_2 is fully attacked by g_5 and fully supported by g_6. In T_2, the alternative answer p_4 is fully refuted by the argument g_8 and partially refuted by g_9. The argument g_9 is partially supported by g_{10} and fully supported by g_{11}.

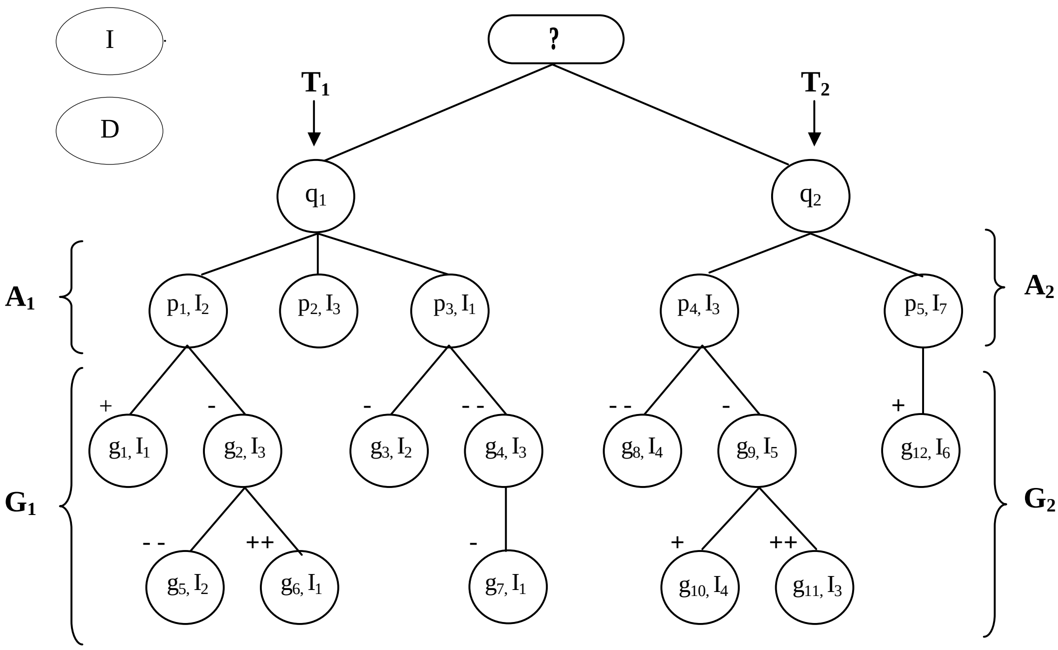


Fig. 3.1: An example of discussion tree in AMANDA

According to the proposed model, the above discussion tree is represented by the following expressions:

? ? ? = <I, D, T>, the discussion structure;

? ? I = $\{I_1 \ldots I_7\}$, the set of participants;

? ? T = $\{T_1, T_2\}$, the set of discussion trees;

? ? $T_1 = \langle q_1, A_1, G_1 \rangle$, discussion tree T_1;

? ? $A_1 = \{\langle p_1, q_1, I_2 \rangle, \langle p_2, q_1, I_3 \rangle, \langle p_3, q_1, I_1 \rangle\}$, the set of ALT nodes of T_1;

? ? $G_1 = \{\langle g_1, a_{<1,1>}, +, I_1 \rangle \ \ldots \langle g_7, g_{<1,4>}, -, I_1 \rangle\}$, the set of ARG nodes of T_1;

? ? $T_2 = \langle q_2, A_2, G_2 \rangle$, the discussion tree T_2;

? ? $A_2 = \{\langle p_4, q_2, I_3 \rangle, (\langle p_5, q_2, I_7 \rangle\}$, the set of ALT nodes of $T_{2;}$

? ? $G_2 = \{\langle g_8, a_{<2,1>}, --, I_4 \rangle \ldots \langle g_{12}, a_{<2,5>}, +, I_6 \rangle\}$, the set of ARG nodes of T_2.

We observe, however, that the proposed model is a static (time-independent) representation of a discussion. It is not capable of expressing the discussion over time, thus is not suitable to model discussions as processes neither is expressive enough to represent coordination issues. For this reason, we examine argumentative discussions in a temporal perspective and then propose the corresponding dynamic model.

3.2.3 The dynamic model for AMANDA discussions

In order to express the temporal changes that occur when a discussion advances over time, we propose to extend the static discussion model to a dynamic (time-dependent) model. Upon this dynamic model, we will be able to formulate the notion of discussion coordination.

Our first assumption is that the discussion advances in discrete time intervals called *discussion cycles*. The advance of the discussion is due to the aggregation of new nodes to the discussion tree, resulting from the discussion moves made by the discussants. In order to represent the progress of a discussion along the time, we propose the notion of *discussion configuration*. The n^{th} configuration of the discussion structure ?, denoted by $?^n$, is a "snapshot" of the discussion at cycle *n*. The dynamics of the discussion is represented by successive advances from $?^n$ to $?^{n+1}$.

The advance of the discussion from $?^{n}$ to $?^{n+1}$ is the result of two types of interactions among the discussants:

(i) the *externalization* of a viewpoint and

(ii) the *argumentation* over an expressed opinion.

The first act (externalization) corresponds to ‘answering a question’ and thus aggregates ALT nodes to the discussion tree. The second act (argumentation), corresponds to ‘reacting over a given viewpoint’ and thus aggregates ARG nodes to the discussion tree. From a structural point of view, these acts cause the discussion trees to expand either in breadth and/or depth, as a result of the new ALT and ARG nodes respectively. In the following paragraphs we present the formal approach for the discussion configuration and the explore in deeper details the advance of the discussion.

Let $?^{n}$ = <I, D, T^{n}> be the n^{th} configuration of the discussion structure. At each discussion cycle, the discussion trees (i.e. elements of T^{n}) are expanded with new nodes. Formally, the n^{th} configuration of the discussion structure $?^{n}$ = <I, D, T^{n}> is advanced to $?^{n+1}$ = <I, D, T^{n+1}> as a result of the expansion of each individual discussion tree by a set of new nodes $N^{n} = N_a^{n}\ ?\ \ N_g^{n}$, where N_a^{n} is the set of ‘new ALT nodes’ and N_g^{n} is the set of ‘new ARG nodes’. Each discussion tree T_i^{n+1}, is formed by the union of A_i^{n} and G_i^{n} and the new nodes N_a^{n} and N_g^{n} proposed for the new cycle *n+1*. Formally, T_i^{n+1} = <q_i, A_i^{n+1}, G_i^{n+1}>, where $A_i^{n+1} = A_i^{n}\ ?\ \ N_a^{n}$ and $G_i^{n+1} = G_i^{n}\ ?\ \ N_g^{n}$.

The advance from $?^{n}$ to $?^{n+1}$, however, is not accomplished in a single step. This is because the newly aggregated ALT and ARG nodes are initially empty nodes, i.e. nodes with empty propositional content $p_{Ø}$ and $g_{Ø}$ respectively. These new empty nodes will then be ‘worked on’ by the participants and their contents will be changed to ‘valid’ contents p_v and g_v. This leads us to define a ‘temporary’ discussion configuration $?^{n+1}_{Ø}$, which corresponds to $?^{n+1}$ before the participants work on the newly aggregated nodes. Once the participants have worked on the corresponding nodes, the discussion advances from $?^{n+1}_{Ø}$ to $?^{n+1}$ and the $(n+1)^{th}$ discussion cycle terminates.

The discussion advances until no more changes in the discussion trees can be produced, i.e. until the set $N^{n} = N_a^{n}\ ?\ \ N_g^{n}$ for all discussion trees T_i^{n} is empty.

The main issue to be explored at this point is the mechanism behind the progress of the discussion. Who, or what, generates the discussion configurations? Which is the origin of the new nodes that are aggregated to the discussion trees? How are they assigned to the corresponding participants? Upon which principles or intentions does the discussion advance? The answer lies in the *mediation principle* of the method, which is the subject of the following section.

3.3 Discussion mediation

This section presents the discussion mediation principles of AMANDA. We begin by first distinguishing the stages of an argumentative discussion and then we explore how the discussion is advanced along the time.

3.3.1 The stages of a discussion in AMANDA

From a dynamic perspective, AMANDA discussions are structured in *stages*, based on the proposition by Franz Eemeren presented in the preceding chapter. Argumentative discussions in AMANDA are divided in the following stages:

- *preparatory* stage (combination of Eemeren's confrontation and opening stage),
- *argumentation* stage and
- *concluding* stage.

The *preparatory* stage in AMANDA corresponds to all actions that precede a discussion, including (i) the specification of the *domain* of discussion; (ii) the specification of the group of *discussants*; (iii) the generation of the set of *issues* to be debated and (iv) the reception of the *answers* to the proposed issues.

Figure 3.2 shows a tree representation of a discussion in the preparatory stage. In this example, the proposed issues q_1, q_2 and q_3 are initially distributed among the participants I_1 … I_5. This results in the creation of five 'empty' ALT nodes (Alt-1 .. Alt-5) of the type $<p_? , q_i, I_j>$ assigned to I_1 .. I_5 respectively. When the participants answer the questions, the $p_?$ element of each ALT node is replaced by the corresponding 'valid' answer p_v.

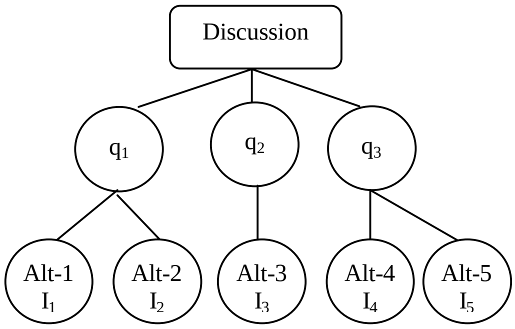


Fig. 3.2: An example of discussion in the preparatory stage

The association between the issue nodes q_i and the corresponding alternative answers Alt-j creates a set of viewpoints which enables the discussion to advance to the next stage – the *argumentation* stage.

The *argumentation* stage comprises subsequent discussion cycles, in which the participants argue over their peers' opinions. At each cycle, the discussion tree grows either in depth or breadth as a result of the argumentative moves taken by the participants. Figure 3.3 shows a discussion being advanced over time through the argumentation stage. In this figure, the dark nodes represent the interactions occurring at the corresponding cycle.

.

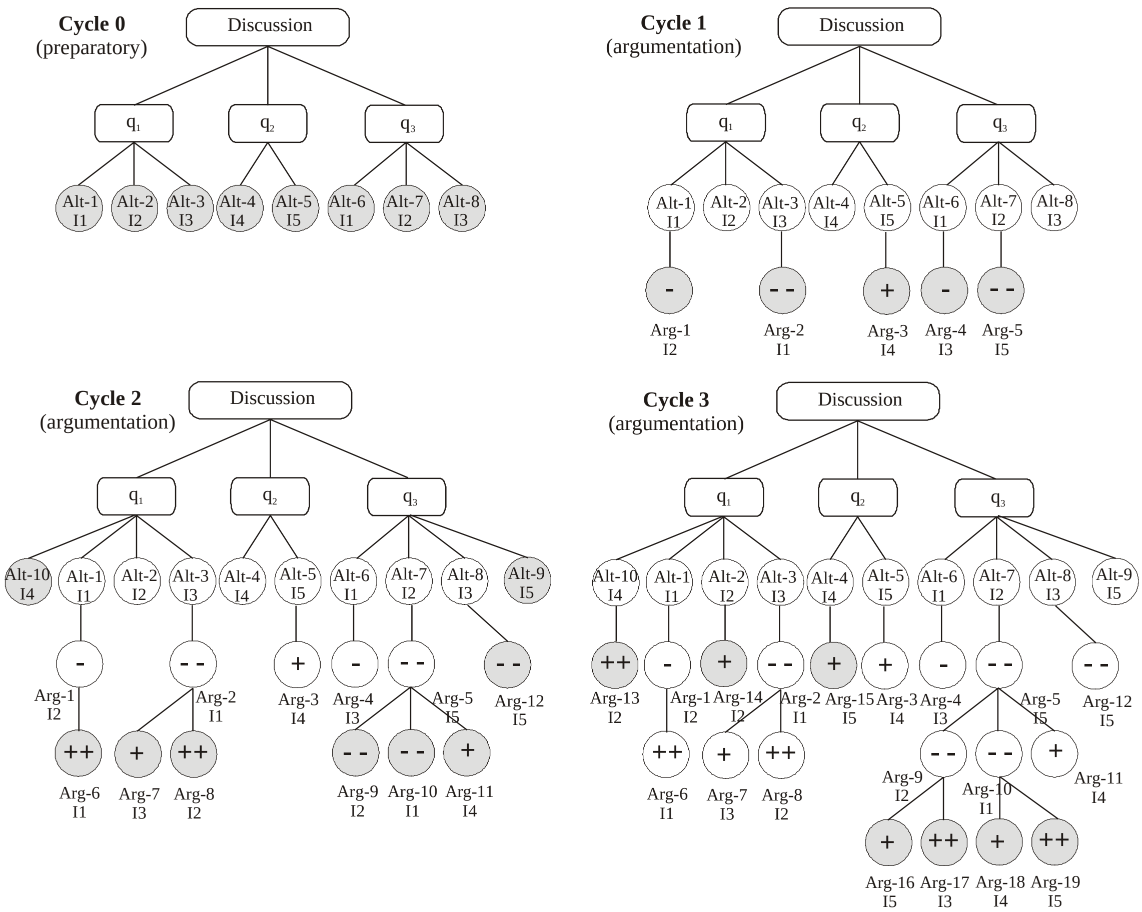


Fig. 3.3: The advance of a discussion through the argumentation stage

The *concluding* stage in AMANDA is reached when the discussion cannot be advanced any further. This occurs when (i) all participants have taken part of all issues and (ii) all disagreements and conflicts have been fully debated. The concluding stage of a discussion might never be reached, simply because collective agreement is not always possible. In fact, achieving the concluding state is not the aim of AMANDA, as opposed to the traditional dispute resolution methods.

3.3.2 The advance of the discussion

The discussion is advanced through the generation of successive discussion cycles, according to the stages shown in the preceding item. Initially, in the preparatory stage, the issues are distributed (launched) among the participants and the corresponding answers are collected from them. Afterwards, the discussion enters in the argumentation stage, where successive discussion cycles are opened until the discussion cannot be advanced any further[11]. The flowchart of figure 3.4 shows an overview of the method and the items below explore it in deeper details.

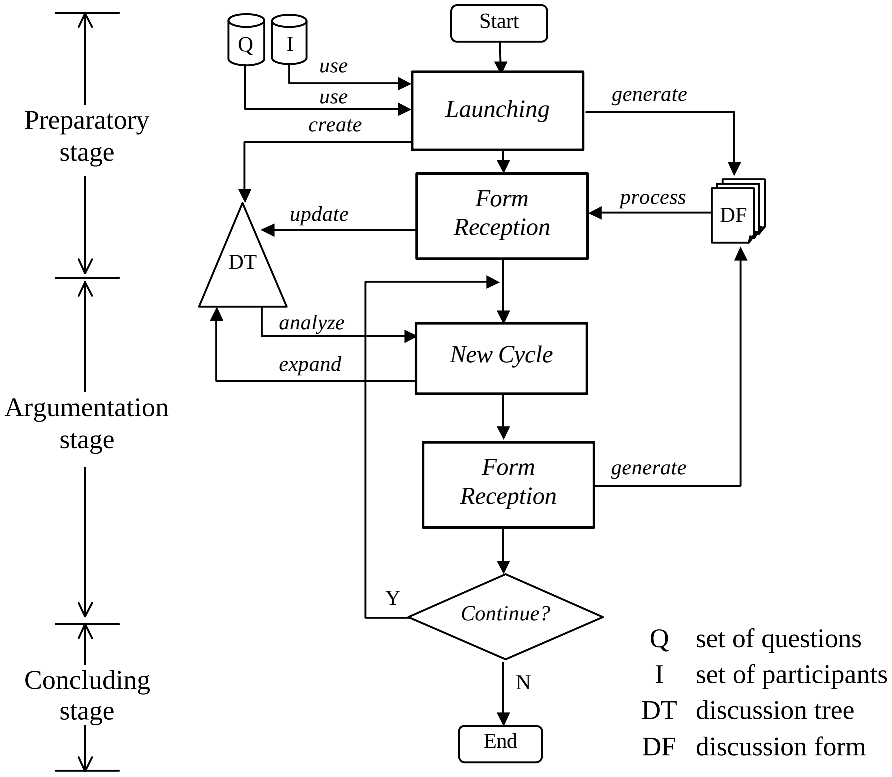


Fig. 3.4: An overview of the AMANDA method

Launching a discussion

The *Launching* procedure takes as input the set of issues Q, as well as the set of participants I, and executes an algorithm that assigns questions to participants so that: (i) the participants are assigned the same number of questions; (ii) the questions are evenly distributed among the participants and (iii) the number of questions per participant does not exceed the maximum workload WL_{max}[12]. For each resulting assignment (Q_i, I_j), an empty ALT node of the type <$p_{Ø}$, q_i, I_j> is created and linked to the discussion tree. In addition, the first generation of discussion forms is made available to the participants. A

[11] A discussion terminates either by the absence of potential interactions among the participants (i.e. fully consensual discussions) or by the expiry of the discussion period.

[12] The WL_{max} parameter determines the maximum workload per cycle, i.e. the highest number of items allowed in a participant's discussion form in a given discussion cycle.

discussion form for participant I_j is composed of all newly created nodes assigned to I_j, formatted in a way that they can be answered and sent back by the participant.

Form Reception

The *Form Reception* procedure receives the discussion forms from the participants, extracts their content and updates the discussion tree accordingly. Internally, this corresponds to filling the empty content $p_Ø/g_Ø$ of the pending ALT/ARG nodes with the corresponding valid answers/argumentations p_v/g_v contained in the discussion forms.

Once the preparatory stage is terminated, the discussion enters in the argumentation stage. As mentioned earlier, the role of AMANDA is to control the focus of a group discussion in a purposive manner. In practice, AMANDA analyzes the current discussion $?^n$, detects potential interactive situations and articulates the discussion by re-launching discussion nodes in the next discussion cycle. Re-launching a node N means creating child nodes for N and assigning them to specific participants, to whom is given the task of "working on" N by arguing over its propositional content.

Opening new discussion cycles

In AMANDA, the re-launch of nodes, and consequently the advance of the discussion, is performed by the *New Cycle* procedure. This procedure first evaluates the current nodes of the discussion $?^n$ (*Evaluation* phase) and then generates the next discussion configuration $?^{n+1}$ by creating new nodes and assigning them to specific participants (*Assignment* phase). Figure 3.5 shows a flowchart of the *New Cycle* procedure and the items below describe it in details.

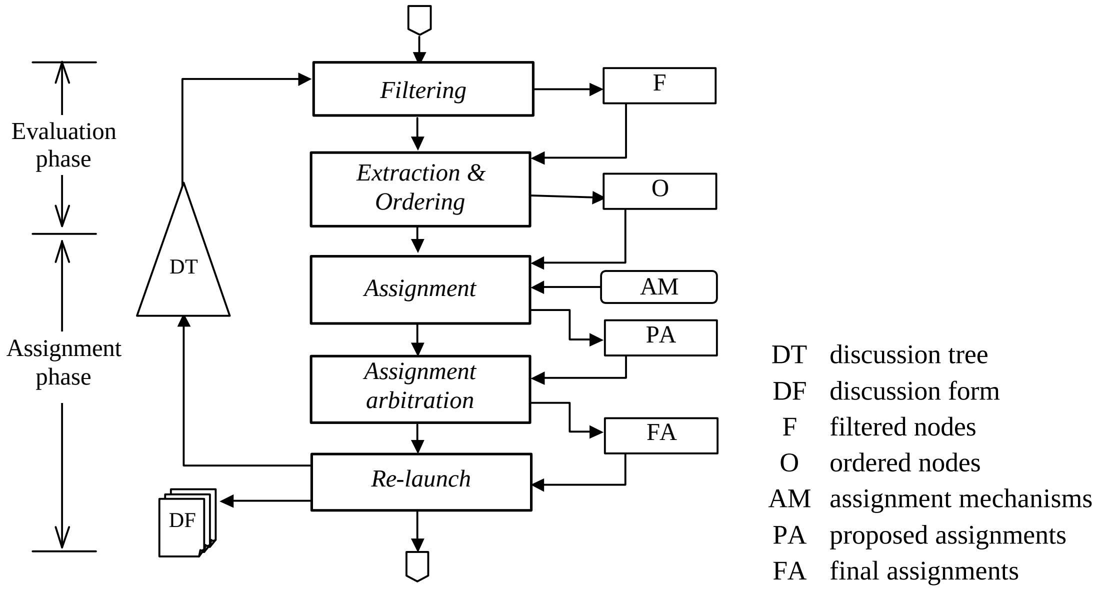


Fig. 3.5: Flowchart of the *New Cycle* procedure

3.3.3 The Evaluation phase

In the *Evaluation* phase, the nodes of the discussion tree are filtered and sorted according to their "importance" for the discussion. This is done by two functions: *Filtering* and *Extraction & Ordering*, as illustrated in figures 3.6 and 3.7.

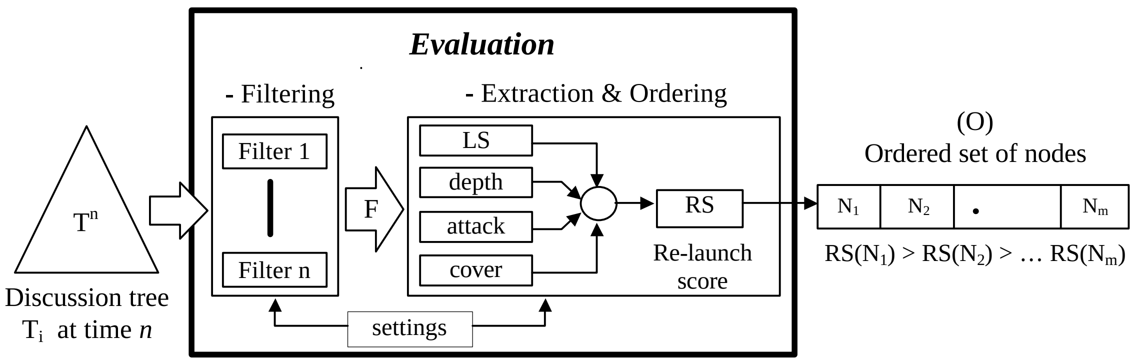


Fig. 3.6: The Evaluation phase

Filtering

This stage analyses all discussion trees T_i^n = <q_i, A_i, G_i> of the discussion and filters the nodes which are not worth re-launching, i.e. nodes with empty propositional content (unanswered nodes) and nodes belonging to depth levels above a certain threshold, and produces a set of "re-launchable" nodes (see F, Fig. 3.6).

To formally express the filtering function, let $p_?$ /$g_?$ be the empty content of an answer/argumentation respectively, let *depth*(N) be a function that returns the depth level of node N and let *max_depth* be the maximum depth level allowed for a re-launchable node. Let Q = {q_1, q_2 … q_m} be the set of issues of ? and A = {A_1 … A_m} and G = {G_1 … G_m} be the sets of ALT and ARG nodes for all issues of ?. The filtering stage is a function that takes as input a set N = Q ? A ? G composed of all nodes of the discussion and outputs a subset F, named *set of re-launchable* nodes and expressed by F = Q' ? A' ? G' where:

? ? Q' = Q,

? ? A' = {$a_{<i,j>} = <p, q_i, I_j>$ | p ? $p_?$? *depth*($a_{<i,j>}$) ? *max_depth*} and

? ? G' = {$g_{<i,j>} = <g, h_i, w, I_j>$ | g ? $g_?$? *depth*($g_{<i,j>}$) ? *max_depth*}.

Extraction & Ordering

The objective of this function is to assign a grade to each node in F. This function is responsible for extracting structural parameters from the re-launchable nodes in F and sorting the nodes according to their corresponding *re-launch priorities*. The re-launch priority of a node is expressed by the *re-launch score* (RS), which estimates the likelihood that a given node positively contributes to the discussion.

The RS parameter estimates the "quality" of a node in respect to the discussion. Although "quality" is a highly subjective concept, we adopt this term to denote the potential of a node to trigger further debate. "High quality nodes" in AMANDA are represented by controversial opinions, refuting argumentations and nodes insufficiently debated within the group. Our assumption is that the higher the RS of a node, the higher the contribution of this node to the collective debate.

The RS parameter is composed of the following sub-parameters, see figure 3.7:

(i) the *local support level* of the node, named LS(N),

(ii) the *depth level* of the node, named depth(N),

(iii) the *degree of support/attack* of the node, named attack(N) and

(iv) the percentage of *participants covered by this node*, named cover(N).

The final RS of a node is calculated as the weighted average among these four sub-parameters (Fig. 3.7). The RS value is used as the sorting parameter to produce an ordered list of nodes (see O, Fig. 3.5).

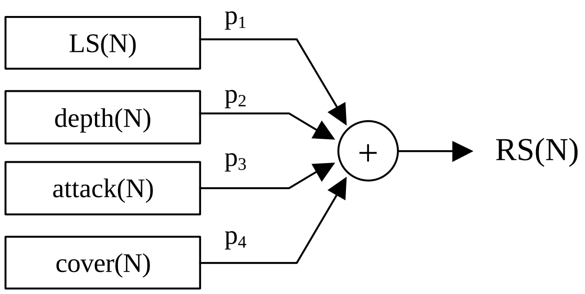


Fig. 3.7: The RS parameter

We must point out that the above assumptions are purely heuristic, based on our intuition and informal observations on discussion forums. We do not intend, at this point, to go any further than proposing a method to estimate the potential of a node in respect to the debate and to suggest an analytical approach for it. We believe, however, that empirical research on this matter might reveal improvements in this formulation and this we leave as an open challenge for future work.

? ? The LS parameter

The *local support* level of a node LS(N) represents the degree of consensus of a node with respect to its lower level sub-tree. LS(N) ranges from +1.0 to –1.0, indicating the highest and lowest support respectively. In practice, the LS parameter assigns higher re-launch priorities to nodes that exhibit lower support, with the objective of focusing the discussion on the most polemical positions rather than on common agreements.

The computation of the LS value is done by traversing the discussion tree from the leaves up to the root and assigning LS values to each ALT or ARG node. This causes the local support of a node to propagate upwards and affect all nodes that belong to its argumentation path ?. LS(N) is expressed by Eq. 3.1.

$$LS(N) = \begin{cases} \overset{n}{\underset{i=1}{?}} \ 1/n \ ? \ \ TS(child_i(N)) & \text{if } n > 0 \\ +1.0 & \text{if } n = 0 \end{cases}$$

where:
- TS is the transmitted support level (Eq. 3.2),
- $child_i$(N) returns the ith child node of N
- n is the number of child nodes of N.

Eq. 3.1: The local support level (LS)

As shown in Eq. 3.1, the local support level of a node is the average level of the *transmitted support* (TS) from all its direct descendant nodes. If the node has no direct child nodes (n = 0), as in the case of *leaf nodes*, the local support level is assigned the maximum value of +1.0. Otherwise, LS(N) depends on the TS of its child nodes, as detailed below.

The transmitted support of a node TS(N) expresses the node's intention to support/refute his parent node modulated by its own local support. The practical effect of TS(N) is to make a node N affect its parent node proportionally to its own degree of consensus, where LS(N) acts as a "damping" parameter that tends to reduce the support transmitted by N if it does not exhibit total support from its lower levels.

Each ARG node <g, h, w, I> transmits to its direct parent *h* a certain TS level. This level depends on the node's intention *w* ? {++, +, -, --} and on the LS level of the transmitting node itself (LS(N)). The nominal TS level that an ARG node <g, h, w, I> with *w* = ++/+/-/-- transmits to its parent *h* is respectively +1.0/+0.5/-0.5/-1.0. This nominal value, however, is modulated by LS(N), as shown in Eq. 3.2.

$$TS(N) = \begin{cases} +1.0 \ ? \ \ LS'(N) & \text{if } w = \text{"++"} \\ +0.5 \ ? \ \ LS'(N) & \text{if } w = \text{"+"} \\ -0.5 \ ? \ \ LS'(N) & \text{if } w = \text{"-"} \\ -1.0 \ ? \ \ LS'(N) & \text{if } w = \text{"--"} \end{cases}$$

Where LS'(N) = min(0, LS(N))

Eq. 3.2: The transmitted support level (TS)

We observe in this equation that the limitation imposed by LS'(N) = min(0, LS(N)) avoids nodes with LS<0 (negative supported nodes) to affect their parents' local support. In addition, it also avoids negative supported nodes to invert the polarity of its support/refute intention.

For example, a given ARG- node N_1 = <g, h, -, I> with LS(N_1) = +1.0 transmits to its direct parent *h* a support level TS(N_1) = -0.5. If, as the result of the advance of a discussion, LS(N_1) decreases to +0.5, the transmitted support TS(N_1) changes to -0.25 (see Fig. 3.8). This is intentional, because the refuting argument N_1 is being itself refuted, and this reduces its effect over the local support of its parent node *h*.

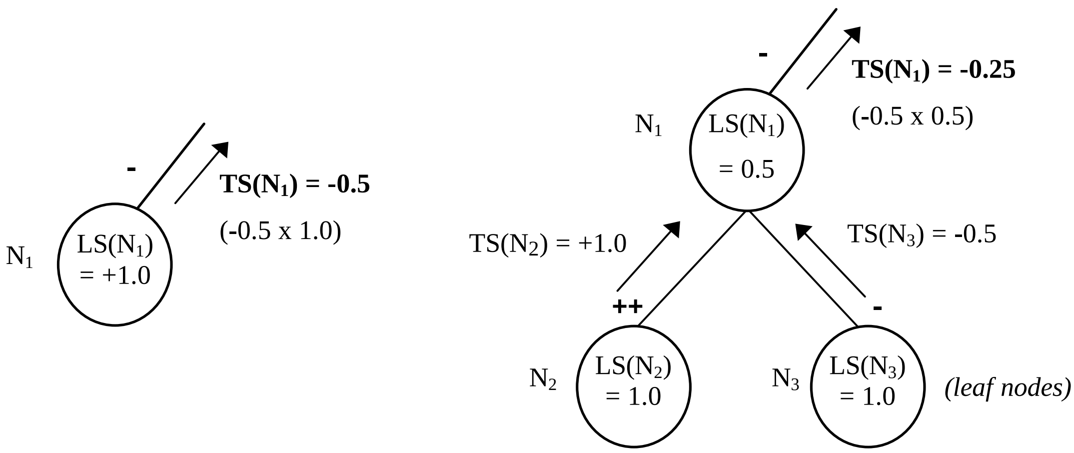


Fig. 3.8: Local and transmitted support levels

? ? **The *depth* parameter**

The depth parameter measures the distance between a node and its root node. It serves to assign higher re-launch priorities to nodes that occupy the uppermost positions in the discussion tree, i.e. nodes with low depth levels[13].

We define the depth level of a node N in respect to its argumentation tree T, denoted by *depth*(N), as the number of elements of its argumentation path ?, i.e. *depth*(N) = |?|, where T = <q, A, G> and N ? G ? A. In other words, the depth level of N represents the distance between N and the root of its discussion tree (the issue node q). In AMANDA, we normalize the depth parameter to fit it into the range from +1.0 (closest to root) to –1.0 (furthest from root).

? ? **The *attack* parameter**

The attack parameter measures the refuting intention of a node in relation to its direct parent. It serves to assign higher re-launch priorities to nodes that exhibit higher refuting intentions. This is done in order to increase the probability of a refuting node to be re-launched and thus validated within the group. This parameter ranges from –1.0 (ARG++ nodes) to +1.0 (ARG- - nodes).

? ? **The *cover* parameter**

The cover parameter measures the degree of participation of a given node with respect to the group. It serves to assign higher re-launch priorities to nodes with low participation within the group and thus evenly spread the participants over the discussion. The *cover* parameter is evaluated as a function of the number of different participants that appear as authors of its descending nodes and the total number of participants of the discussion. This parameter ranges from +1.0 to –1.0, where +1.0 is assigned to nodes that haven't been worked on by any participant and –1.0 is assigned to nodes that have been worked on by all the participants of the group.

3.3.4 The assignment phase

In the preceding section, we described the *Evaluation* phase, which selects and sorts the nodes of the discussion tree according to their re-launch priorities. It doesn't mean, however, that the "re-launchable" nodes will actually be re-launched in the next discussion cycle. A node will only be re-launched if there is a "reason" for it, i.e. if it produces a specific desirable peer-to-peer interaction. The *Assignment* phase is responsible for finding such interactions and deciding which nodes will be actually re-launched and which participant they will be assigned to.

In the *Assignment* phase, the set of "re-launchable" nodes is analyzed in the search for potential interactions that might advance the discussion. To handle this heuristic and multiple-criteria procedure, a set of independent *assignment mechanisms* is proposed in order to find coherent matching relations (assignments) between the set of nodes and the set of participants. Each AM applies specific assignment rules to find the most suitable participant to work on a given node of the discussion tree, see further

---

[13] Deep nodes often cause usability problems due to the fact that, when they are re-launched, the whole path of nodes up to the root must appear in the discussion form.

details later in this section. The assignment phase is crucial for the advance of a discussion, for it governs the interactions to take place among the discussants. The items below detail the notion of discussion assignment and the related mechanisms.

The notion of discussion assignment

As mentioned above, a discussion assignment is a matching between a given node of the discussion tree and a participant that should work on it. Formally, a discussion assignment ?, referred simply as *assignment*, is an association of the type (N_i, I_j) between a node N_i ? Q ? A ? G and a target participant I_j ? I. An assignment ? = (N_i, I_j), when incorporated in the discussion, causes N_i to be relaunched, i.e. a new child node N_i' to be created and assigned to I_j. For example, if N_i is an ALT node of the type $<p_v, q, I_k>$, the assignment (N_i, I_j), when incorporated in the discussion tree, creates an ARG node $N_i' = <g_Ø, N_i, w_Ø, I_j>$. The node N_i' is intended to make participant I_j express his opinion over the answer p_v given by I_k to question q.

Generically, an assignment ? = (N_i, I_j) is intended to make I_j contribute to the discussion by either expressing his opinion over the proposition contained in N_i (if N_i ? A ? G, i.e. an ALT or ARG node) or by giving an alternative answer to the proposed question (if N_i ? Q, i.e. an issue node). In either case, the opinion expressed by I_j becomes the propositional content of N_i', whose direct parent node is N_i. If N_i is an ALT or ARG node whose author is I_i, then the assignment ? = (N_i, I_j) results in the confrontation of ideas between I_i and I_j. If N_i is an issue node, then ? adds to the discussion a new alternative answer from the viewpoint of I_j.

To what concerns the progress of the discussion, an individual assignment ? corresponds to a single 'discussion move'. In fact, the discussion $?^n$ advances to $?^{n+1}$ as a result of a set ? of individual assignments ?. The aim of this section is to explore how AMANDA generates ? to purposively advance the discussion.

Figure 3.9 shows a block diagram of the assignment phase. The assignments are proposed by a set of independent *assignment mechanisms* {AM_1, AM_2 … AM_k}. Each AM_i proposes its own set of assignments $?_i$ = {$?_1$, $?_2$ … $?_{pi}$}. As shown in the figure, the sets of assignments $?_i$ from all mechanisms are combined to produce the set of final assignments FA.

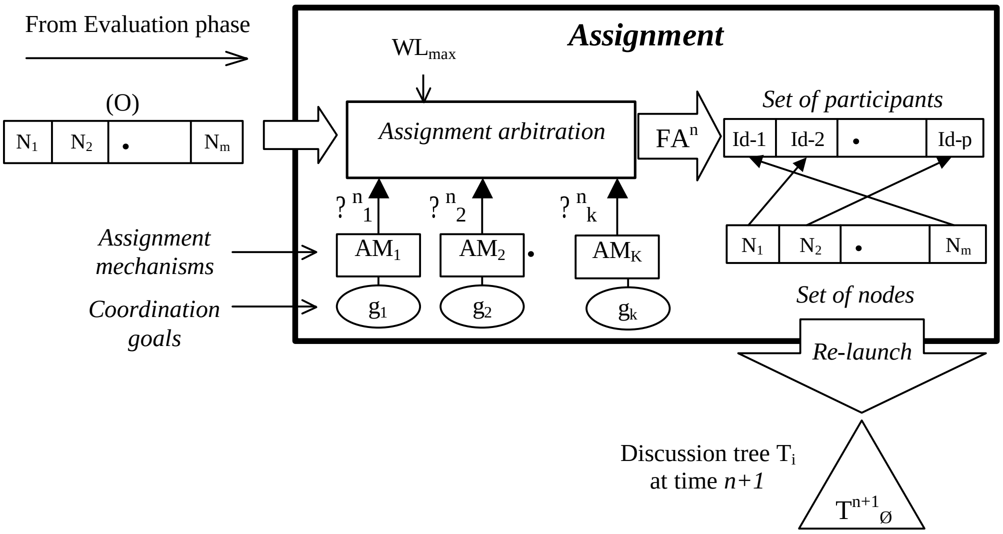


Fig. 3.9: The assignment phase

The core of the assignment phase is the goal-driven behavior of the assignment mechanisms, which is the subject of the following item.

Coordination goals and assignment mechanisms

We recall from earlier chapters that the discussants in an argumentative discussion are involved in two main activities: *externalization* and *argumentation*. In AMANDA, these two activities are turned into *coordination goals* and are used to propose group interactions.

The *externalization* goal is fully achieved when all the discussants have answered the whole set of questions. The externalization goal, implemented by the `Ext` assignment mechanism, is stated as follows: “all discussants should express their viewpoints over all proposed issues”.

The *argumentation* goal, on the other hand, is intended to detect specific interaction situations that might improve the collective debate and to articulate the discussants accordingly. The *argumentation goal* is stated as follows: “the discussants should be involved in as many argumentative interactions as possible, specially those with high probabilities of resulting in fruitful debate.”

We decompose the argumentation goal into the following sub-goals:

(i) providing participants with the right of response in the presence of refuting argumentations (*right-of-reply* sub-goal), implemented by the `Reply` mechanism;

(ii) validating controversial positions by the tutor/mediator (*validate-attack* sub-goal), implemented by the `Vld-Atck` mechanism;

(iii) making participants argue over answers concerned with questions that he/she had previously answered (*evaluate-buddy-answer* sub-goal), implemented by the `Buddy` mechanism and

(iv) assuring that the participants be evenly distributed over the discussion (*spread-over-tree* sub-goal), implemented by the `Spread` mechanism.

Figure 3.10 shows the taxonomy for coordination goals and the corresponding assignment mechanisms.

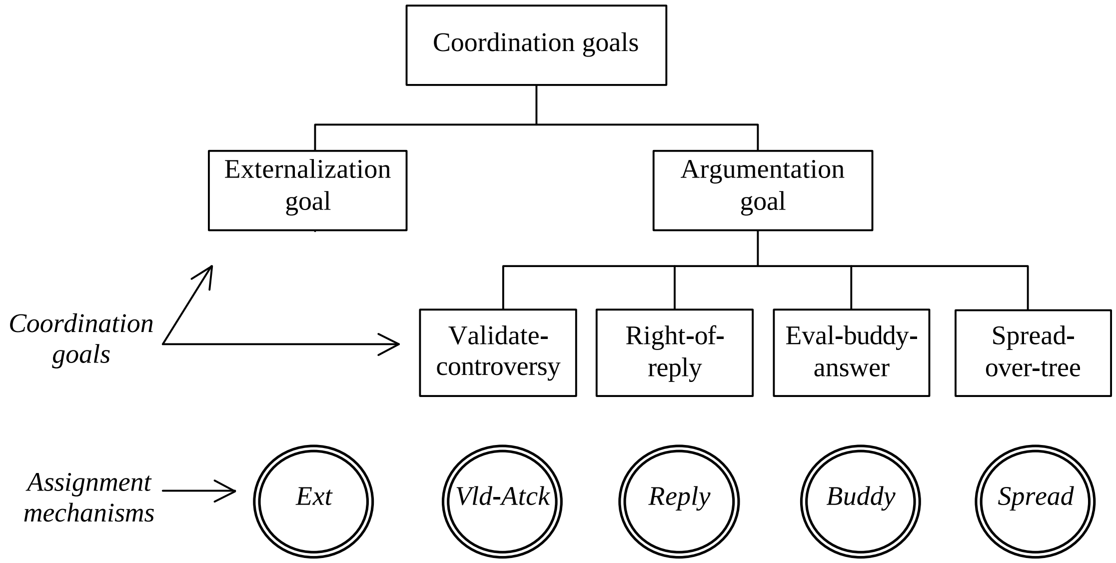


Fig. 3.10: Coordination goals and assignment mechanisms

Let $?^{n} = ?_{a}^{n} ? \ \ ?_{g}^{n}$ be the entire set of assignments proposed by all mechanisms for $?^{n+1}$, where $?_{a}^{n} ? \ \ \{(N_i, I_j) \mid N_i ? \ \ Q ? \ \ I_j ? \ \ I\}$ is the set of assignments proposed by `Ext` mechanism and $?_{g}^{n} = ?^{n}_{g(vld)} ? \ \ ?^{n}_{g(reply)} ? \ \ ?^{n}_{g(bud)} ? \ \ ?^{n}_{g(spread)} ? \ \ \{(N_i, I_j) \mid N_i ? \ \ A ? \ \ G ? \ \ I_j ? \ \ I\}$ is the set of assignments proposed by the mechanisms `Vld-Atck`, `Reply`, `Buddy` and `Spread` respectively.

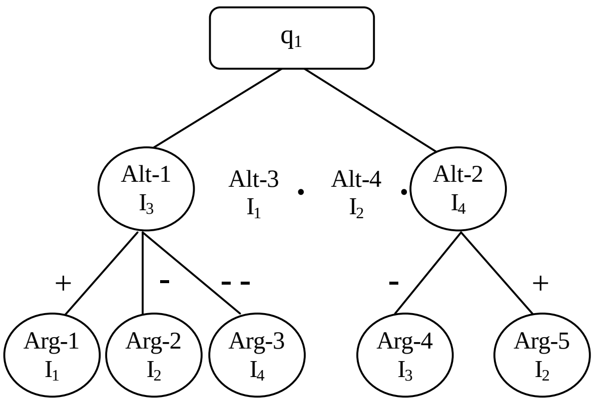
When integrated in the discussion, the assignments contained in $?^{n}$ result in the aggregation of new nodes represented by $N^n = N_a^n ? \ \ N_g^n$, where N_a^n is the set of ALT nodes of the type $\langle p_{\emptyset}, h, I\rangle$ produced by $?_{a}^{n}$ and N_g^n is the set of ARG nodes of the type $\langle g_{\emptyset}, h, w_{\emptyset}, I\rangle$ produced by $?_{g}^{n}$. We also define the following functions: *id*(N) that returns the identification of the author of a node N and *parent*(N) that returns the parent of node N.

? ? The *Ext* assignment mechanism

The objective of the `Ext` assignment mechanism is to assure that all discussants answer all proposed issues. For this purpose, `Ext` searches all issue nodes q_i of the discussion and creates one child node of q_i for each missing participant.

Formally, let $?^{n}_{i} = \{id(N) \mid N ? A_i^n\}$ be the set of all participants that have answered the issue q_i and $Q^n = \{q_1, q_2 \ldots q_m\}$ be the set of all issues of $?^n$. For each issue q_i, the `Ext` mechanism proposes a set of assignments E^n_i assigned to each missing participant, i.e. $E^n_i = \{(q_i, I_j) \mid I_j ? (I - ?_i^n)\}$. The set of assignments proposed by `Ext`, denoted by $?^n_a$, is expressed by $?^n_a = E^n_1 ? E^n_2 ? \ldots E^n_m$.

Figure 3.11 illustrates an `Ext` assignment. The participants I_1 and I_2 are detected as *missing participants* of q_1, i.e. members of $(I - ?_i)$. As a result, the `Ext` mechanism proposes the assignments (q_1, I_1) and (q_1, I_2) in order to collect the missing answers from I_1 and I_2. These two assignments are then integrated in the discussion by means of the nodes Alt-3 and Alt-4.



$I = \{I_1 \ldots I_4\}$
$?_1 = \{I_3, I_4\}$
$I - ?_1 = \{I_1, I_2\}$
$?_a = \{(q_1, I_1), (q_1, I_2)\}$
Alt-3 = <$p_Ø$, q_1, I_1>
Alt-4 = <$p_Ø$, q_1, I_2>

Fig. 3.11: An example of *Ext* assignment

? ? The `Reply` assignment mechanism

The objective of the `Reply` mechanism is to detect the existence of a counter-argument G that refutes a given position P, in every degree of intensity, and to assure the right of response to the proponent of P. Internally, `Reply` creates a child node to every non-supporting node (ARG+, ARG- or ARG--) and assigns the newly created nodes to the participants to which the non-supporting nodes refer.

Formally, let R^n = {g_1, g_2, … g_m} ? G^n be the set of non-supporting argumentation nodes of the discussion, i.e. R^n = {<g, h, w, I> | {<g, h, w, I> ? G^n ? *w* ? {+, `-`, `--`}}. For each non-supporting argumentation g_i = <g, h, w, I> ? R^n, `Reply` proposes an assignment $?^n_i$ = (g_i, I_j), where I_j = *id*(h). The set of new nodes proposed by `Reply`, denoted by $?^n_{g(reply)}$ is expressed by $?^n_{g(reply)}$ = $?^n_1$? $?^n_2$? … $?^n_m$. In practice, the assignments proposed by the `Reply` mechanism assure that the authors of all refuted positions, i.e. *id*(h), have the right of response to their corresponding refuting propositions g_i.

Figure below shows an example of a `Reply` assignment. The new nodes Arg-6, Arg-7 and Arg-8 are proposed in an attempt to give I_3 and I_8 the right of response.

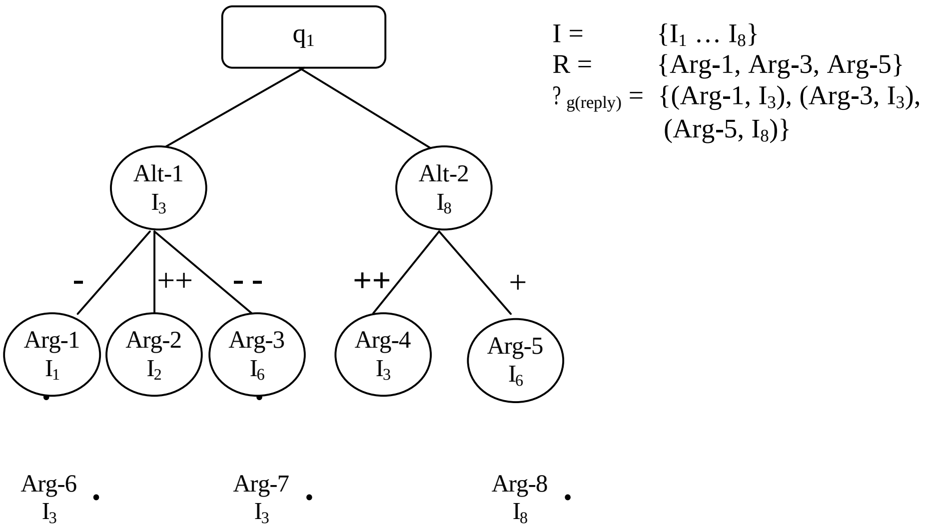


Fig. 3.12: An example of `Reply` assignment

? ? The `Vld-Atck` assignment mechanism

The objective of the `Vld-Atck` mechanism is to assure that every refuting argumentation, i.e. ARG`-` and ARG`--` nodes, is validated by a qualified participant, for instance a tutor or a mediator of the discussion. This is intended to focus the tutor's effort on disagreement situations, polemical positions and specific peer-to-peer disputes.

Formally, let R^n = {g_1, g_2, … g_m} ? G^n be the set of refuting ARG nodes of the discussion, i.e. R^n = {<g, h, w, I> | w ? {-, --} ? <g, h, w, I> ? G^n} and let T =

{I_1, … I_p} ? I be the set of tutors of ?. For every refuting node of the discussion, i.e. for every g_i ? R^n, `Vld-Atck` produces a set of assignments V^n_i = {(g_i, I_j) | I_j ? T}, where each assignment (g_i, I_j) is an attempt to make tutor I_j argue over the refuting argumentation g_i. Finally, the entire set of assignments proposed by `Vld-Atck`, denoted by $?^n_{g(vld)}$, is expressed by $?^n_{g(vld)}$ = V^n_1 ? V^n_2 ? … V^n_m.

Fig. below shows an example of a `Vld-Atck` assignment. The new nodes, dotted in the figure, are proposed in order to validate the refuting arguments Arg-1, Arg-3 and Arg-4 by the tutors of the discussion (I_3 and I_5).

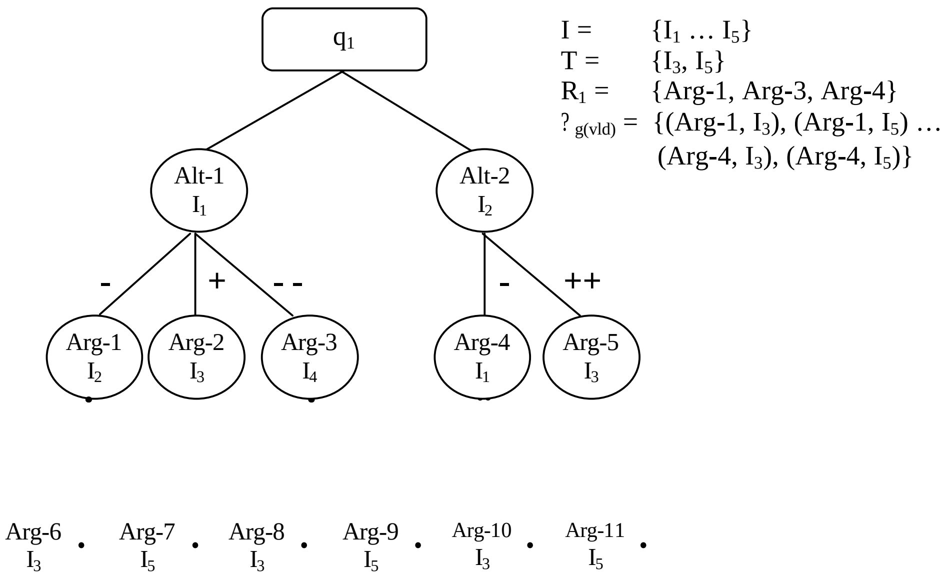


Fig. 3.13: An example of `Vld-Atck` assignment

In what concerns the role of the tutor in a discussion, the following situations may occur: (i) the tutor takes part in the discussion like any other participant; (ii) the tutor only validates refuting argumentations and (iii) the discussion has no tutors. As we will see in the next chapter, the "validate-only" role of the tutor is preferable in terms of discussion progress, because the tutor's effort is entirely focused on clarifying peer-to-peer disputes, rather than working on common agreements. In this aspect, the `Vld-Atck` mechanism plays a key role.

? ? The `Buddy` assignment mechanism

The objective of the *evaluate-buddy-answer* (`Buddy`) mechanism is to make participants evaluate answers to questions that they have already answered in preceding cycles. In practice, the `Buddy` mechanism searches for pairs of ALT nodes having the same parent issue (called *buddy* answers) and creates a pair of child ARG nodes with cross assignment.

For example, suppose that two participants I_1 and I_2 have answered the same issue q_1 with two different ALT nodes $a_1 = <p_1, q_1, I_1>$ and $a_2 = <p_2, q_1, I_2>$ respectively. In the following discussion cycle, the `Buddy` mechanism will attempt to make I_1 validate the answer given by I_2 and vice-versa. This is done by the following assignments $?_1 = (a_1, I_2)$ and $?_2 = (a_2, I_1)$.

Formally, we define the set $B^n = \{b_1, b_2, \ldots b_m\}$ of "buddy answers" of the discussion in $?^n$, i.e. $B^n = \{(x, y) \mid x, y ? A^n ? G^n ? \mathit{parent}(x) = \mathit{parent}(y) ? x ? y\}$. For each pair $b_i = (x, y) ? B^n$, the `Buddy` mechanism creates a set of assignments $P^n_i = \{?_x, ?_y\}$ where $?_x = (x, id(y))$ and $?_y = (y, id(x))$. We observe in $?_x$ and $?_y$ that the proponents of both answers x and y are interchanged, so that the proponent of x analyzes y and vice-versa. The entire set of assignments proposed by the `Buddy` mechanism, denoted by $?^n_{g(bud)}$, is expressed by $?^n_{g(bud)} = P^n_1 ? P^n_2 ? \ldots P^n_m$.

Figure below illustrates the `Buddy` assignment, where three pairs of buddy nodes are detected (b_1, b_2 and b_3) and for each pair of buddy nodes, two new nodes are created and cross-assigned.

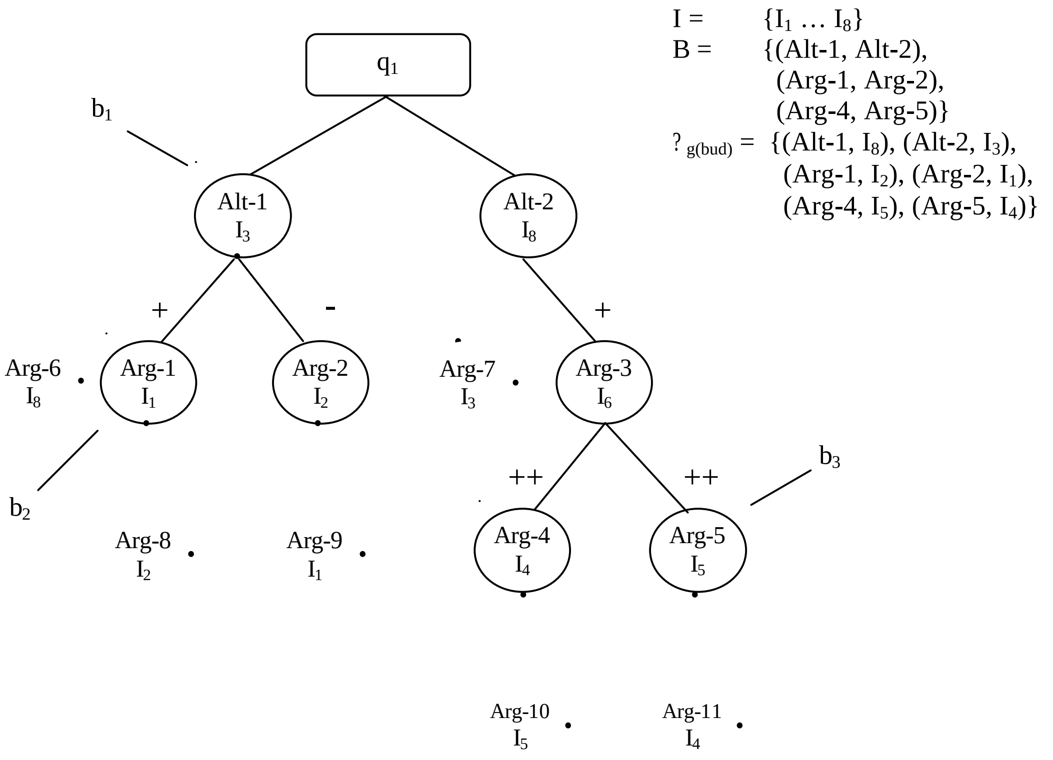


Fig. 3.14: An example of `Buddy` assignment

? ? The `Spread` assignment mechanism

The objective of the `Spread` mechanism is to distribute the participants evenly over the discussion. For all nodes of the discussion tree, the `Spread` mechanism verifies the existence of missing participants, i.e. participants that do not appear as authors of any of the descendants of the analyzed node. For all missing participants of a node N, the `Spread` mechanism creates child nodes of N and assigns them to all missing participants.

Formally, let A^n ? $G^n = \{a_1, a_2 \ldots a_p\}$ be the set of all ALT and ARG nodes in ?^{n} and ? $^n{}_i = \{I_1, I_2 \ldots I_k\}$ be the set of missing participants of a_i, i.e. the set of participants who do not appear as authors of any child node of g_i. Let M^n ? $\{m_1, m_2 \ldots m_q\}$ be the subset of all ALT and ARG nodes with missing participants, i.e. $M^n = \{m_i$ | m_i ? A^n ? G^n ? ? $^n{}_i$? ? }. For each node m_i ? M^n, `Spread` proposes a set of assignments $S^n{}_i = \{(m_i, I_j) \mid I_j$? ? $^n{}_i)$. The entire set of assignments proposed by `Spread`, denoted by ? $^n{}_{g(spread)}$, is expressed by ? $^n{}_{g(spread)} = S^n{}_1$? $S^n{}_2$? … $S^n{}_q$.

Figure below shows an example of `Spread` assignments. In this example, Arg-5 and Arg-6 are created in the attempt of making I_3 and I_1 participate in all propositions of the discussion.

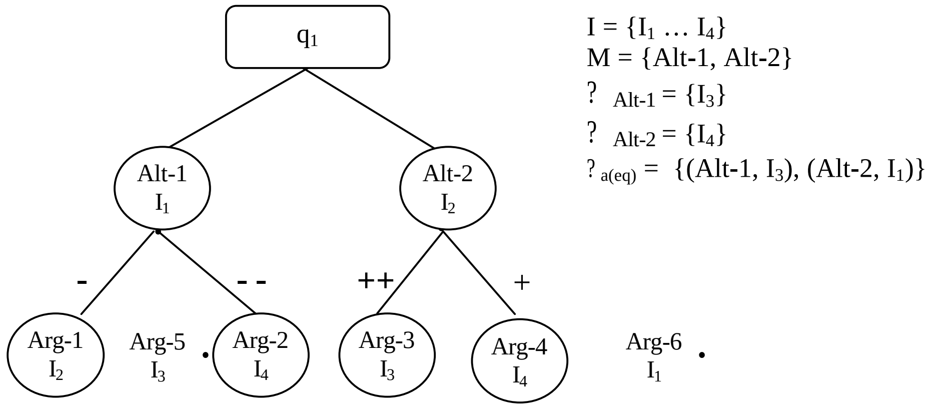


Fig. 3.15: An example of `Spread` assignment

Assignment arbitration

Not all the assignments proposed by the assignment mechanisms can be incorporated in the discussion. There are two main reasons for this: (i) the total number of nodes assigned to a given participant must respect the maximum workload per participant (WL_{max}) and (ii) we must avoid duplicate assignments from different assignment mechanisms.

This raises the additional problem of selecting the assignments that will be effectively assigned to a given participant. This means that the assignment mechanisms will compete for a chance to incorporate their assignments in the discussion. The *Assignment arbitration* procedure regulates this competition by assuring that: (i) the assignments are selected according to the re-launch priority of each node and (ii) all the assignment mechanisms have the same importance, i.e. for a given participant I_j, one assignment (N_i, I_j) from each mechanism is selected until the number of assignments reaches WL_{max}.

The output of the assignment arbitration is the “final list of assignments” (FA) containing the assignments that will actually be aggregated to the next discussion cycle.

Re-launch

In the *Re-launch* procedure (Fig. 3.5), each assignment (N, I) contained in FA is incorporated in the discussion, i.e. an empty node N’ is created as child node of N and N’ is assigned to the participant I. When all assignments have been incorporated, the discussion enters in the $(n+1)^{th}$ configuration, the new generation of discussion forms (DF) is produced and the method returns to the *Form Reception* procedure (Fig. 3.4).

3.4 Delivering the discussion to the participants

Up to now, we have explored how the coordination module advances the discussion through successive discussion cycles. We now explore how the discussion is “delivered” to the participants, i.e. how they provide their answers and arguments. As mentioned earlier, at every discussion cycle, each participant receives an individual *discussion task* composed of the ‘just-relaunched’ nodes assigned to this specific participant. The set of discussion tasks for all participants forms the *discussion schedule*.

Formally, let $I = \{I_1, I_2 \ldots I_n\}$ be the set of discussants and N^n be the set of new nodes for $?^{n+1}$. We define a discussion schedule for $?^{n+1}$, denoted by $?^{n+1} = \{?_1^{n+1}, ?_2^{n+1} \ldots ?_n^{n+1}\}$, as a set of individual assignments $?_i^{n+1} = (I_i, N_i^n)$, where $N_i^n = \{? \mid ? ? \; N^n \; ? \; id(?) = I_i\}$, $I_i \; ? \; I$ and $|N_i^n| = WL_{max}$.. In other words, a discussion schedule is a table where each line relates a specific discussant to all nodes assigned to him/her for the next discussion cycle, as illustrated in figure 3.16.

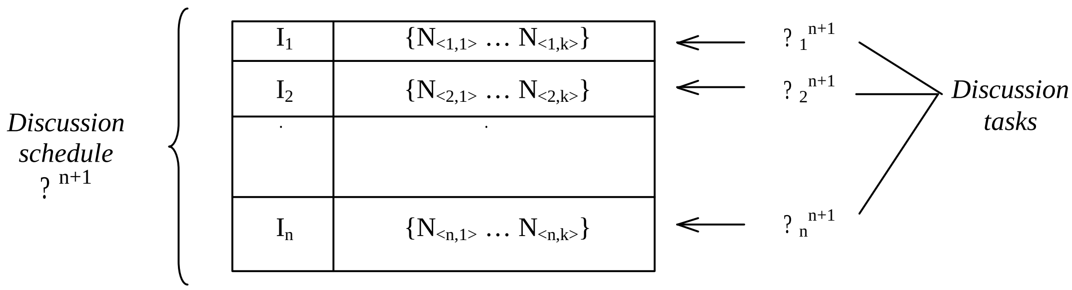


Fig. 3.16: The discussion schedule

In the web-based implementation of AMANDA, each line $?_i^{n+1}$ of the discussion schedule is converted into an individual HTML form, called *discussion form*. In the discussion form, the nodes $N_{<i,j>}$ are formatted in a way that they can be answered by the participant and received by the *Form Reception* procedure (see example in Appendix I).

3.5 Measuring the progress of the discussion

Up to now we have showed how AMANDA advances a discussion over time, but can we measure the progress of the discussion? Is it possible to evaluate how well the discussion is being mediated? In order to address these issues, we developed a method to quantify the progress of the discussion.

We define the progress of a discussion at cycle *n*, denoted as P^n, as a value that reflects the 'distance' between the current state of the discussion and its concluding state. P^n is expressed by a real number ranging from 0 to 1.0, where 0 means the beginning of the discussion and 1.0 means that the discussion is naturally terminated, i.e. it reached its final state due to the absence of new interactions. The value of P^n is defined as the ratio between the total number of interactions already achieved since the beginning of the discussion (up to cycle *n*) and the total number of interactions at its concluding stage. The number of interactions already achieved is, in fact, the number of ALT and ARG nodes that exist in $?^n$. The number of interactions at the concluding state can be estimated as the sum between the existing interactions and the number of assignments proposed by all assignment mechanisms for $?^{n+1}$.

Since the progress of the discussion is directly related to the interactions proposed by each assignment mechanism, we propose that P^n be calculated as the average value among the progress of each individual mechanism (P^n_{ext}, P^n_{vld}, P^n_{reply}, P^n_{buddy} and P^n_{spread}).

Generically, the progress of a given assignment mechanism AM_i is calculated as the ratio between the number of assignments already achieved by AM_i up to the current cycle and the total number of assignments that AM_i would have effectuated at the concluding state. Let n_p be the number of nodes of the current discussion configuration $?^n$ proposed by AM_i. Let n_i be the total number of assignments proposed by AM_i for $?^{n+1}$, i.e. the number of elements of $?^n_{AMi}$. The progress of AM_i is defined as $P^n_{AMi} = n_p / (n_p + n_i)$. The average progress of a discussion (P^n) is defined as the average among the progress of all assignment mechanisms.

We must observe that the assignment mechanisms behave differently along the discussion. The `Ext` mechanism, for example, may reach the final state in a few cycles, while the `Buddy` mechanism may advance quite slowly. Yet, the progress of the `Reply` and `Vld-Atck` mechanisms depend heavily on the agreement level of the discussion; in consensual discussions, they tend to converge more rapidly towards the final state. It must also be noted that the final state might never be reached, because refuting argumentations will always demand further cycles to be resolved and it is unpredictable whether common agreement will ever be achieved.

The proposed method for measuring the progress of a discussion is useful to observe the behavior of the assignment mechanisms and the related algorithms, as well as the effects of changing discussion parameters, such as WL_{max}, the number of questions and participants, the agreement level of the discussion and the 'validate-only' role of the tutor. These issues will be addressed in the next chapter, where the results of actual discussions will be investigated.

3.6 Summary of the chapter

In this chapter, we presented AMANDA, a method for mediating asynchronous discussions among distant learners. Throughout this chapter, we described the underlying structures of the discussion and the principles of discussion mediation.

Firstly we introduced the basic features of the method, its objectives, the internal discussion representation and the principles that govern the advance of a discussion. Then we formalized the underlying discussion structures, including the notion of multi-issue/multiparty argumentative discussions, the static model for the discussion tree and the dynamic model for the discussion mediation. Afterwards we developed the theory of discussion mediation by describing how discussion cycles are successively opened and how emerging interactions are proposed among the participants. Finally we showed how the discussion is delivered to the participants and proposed a method for measuring the progress of the discussion along the time by means of quantified parameters.

3.7 Résumé

Ce chapitre présente la méthode AMANDA pour la médiation de discussions de groupe à distance, ses structures internes et ses mécanismes de médiation. Premièrement les idées fondamentales sont décrites, y compris les objectifs de la méthode, la représentation interne de la discussion et les principes qui gouvernent le progrès de la discussion. Deuxièmement les modèles théoriques de la discussion sont présentés, c'est-à-dire la notion de discussion argumentée collectif sur des multiples questions, le modèle statique de l'arbre de discussion et le modèle dynamique qui décrivent la médiation de la discussion. Ensuite nous développons la théorie de médiation de la discussion, comprenant la description formelle des mécanismes intelligents responsables pour le déroulement temporel de la discussion. Finalement nous proposons une méthode pour mesurer le progrès temporel de la discussion à l'aide de paramètres quantifiables.

Chapter 4

Knowledge representation and NL generation

This chapter discusses the role of knowledge representation (KR) and natural language (NL) generation in AMANDA. In the KR section, we propose the use of domain models, such as ontologies and task structures, to describe the domain of discourse. In the NL generation section, the proposed models are used to produce 'theory-based' questions as issues for the discussion.

4.1 Introduction

Before going deeper on how ontologies and task models were implemented, we must clarify that, up to the current state of this work, domain modeling is NOT part of AMANDA's coordination mechanism, i.e. the proposed method was conceived to mediate group discussions without any knowledge about the domain of discourse. As we can observe in the description of chapter 3, the mediation algorithms take into consideration only "structural" aspects of the discussion tree, such as the type of link between two nodes, the relative distance between the nodes, the number of child nodes, etc. This domain-independence was somehow intentional, because domain modeling is not an easy task and the resulting system would not flexible enough if the method was domain-dependent. Then we decided not focus the mediation mechanism on domain models and keep the method domain-independent.

So one may think: "What is knowledge representation used for in AMANDA"? The answer lies in the early days of the AMANDA project and the conversations we held with our project partners from CEGOS. Our partners idealized a system that could replace the tutors as much as possible and make the best of the students' time. We came up with the idea of building ontologies that could be used both to represent the desired domain of study and possibly guide the discussion process. Our partners counter-argued saying that, in the context of their training courses, conceptual modeling wouldn't be enough, because most of their training was about "how to behave in a given situation" or "how to do things", rather than concept-based courses. So we came up with the additional idea of modeling the "tasks" of the domain of study, e.g. the task of "managing projects" in a project management course.

The next obvious question was: "How to relate ontologies and task models?". Based on our previous knowledge about task modeling and task ontologies, especially the works by Mizoguchi [MIZ95] and Decker [DEC95a], the following assumption came to mind: "we can build ontologies so that the concepts be the resources used by the tasks, or conversely the tasks/subtasks of the task model use the ontological concepts somehow". This established the missing relation between ontologies and task models and provided us with a consistent framework to represent either concepts and tasks in a single representation. It was clear, at this point that we could benefit from both ontologies and task models to build a broader type of knowledge representation – and that's the sense of domain modeling in the context of this work.

One question remained unanswered: "What could domain models be used for?". Ironically, we had the solution but not the problem, but this was the way we found a problem to solve. The "hidden" problem was that the tutors might not have enough time (and sometimes not even the required skill) to create thoughtful questions to produce good debates, but the system could get the job done. Domain models could be used as a source of knowledge and a natural language generator could produce the desired questions. This was how KR and NL generation found their place in AMANDA.

In order to put this in practice, we and our partners at CEGOS chose a "domain" to be modeled and used it as test-bed for our ideas. Among the various domains used by CEGOS in its training courses, we chose "Corporate training management", for which we had the highest amount or course material and the largest number of experts. Based on the course material provided by CEGOS and the interviews with the domain experts, we built the corresponding domain models and developed an NL generator, as described in the following sections.

4.2 Knowledge representation in AMANDA

In AMANDA, knowledge representation (KR) is used to describe the domain of discourse, i.e. the subject area of the discussions. The role of KR in AMANDA is very close to Mizoguchi's approach, presented in chapter 2, as *helping people to identify what they agree on and what they do not*. This approach is also closely related to the purpose of argumentative discussions. In fact, AMANDA links *domain modeling* and *common understanding* by means of *argumentative discussions*.

In the context of this work, domain models are used as the source of natural language generation, more specifically the generation of NL questions as issues for the discussion. The natural language (NL) generator uses the available domain models, along with linguistic patterns, to produce 'theory-based' interrogative sentences that explore the domain over several dimensions.

We propose the use of two types of knowledge models: *ontologies* and *task structures*. Ontologies provide us with a representation of the 'domain concepts', while task structures describe how a given 'domain task' is performed. The concepts and tasks concerned in these models share to the same domain of discourse *D*, to which the discussion ? = <I, D, T> refers.

For instance, if AMANDA is used to mediate a discussion on a given domain *D*, say 'Computer networks' (CN), then we may build a domain ontology ? *(CN)* and a task structure *TS(CN)* describing the concepts and tasks of the corresponding domain. The related domain concepts (e.g. *network_element*, *LAN*, *WAN*, *router*, *hub*, *protocol*, *twisted_pair_cable*, etc.) are organized in a 'Computer network ontology', while the domain tasks (e.g. "*Design a computer network*", "*Install a local area network*", "*Configure a network server*", etc.) are described in specific task structures.

The items below describe how ontologies and task structures are constructed in AMANDA.

4.2.1 Ontologies in AMANDA

As mentioned in chapter 2, ontologies are hierarchical structures that describe concepts and their interrelations. Depending on the intended application, ontologies can range from simple hierarchies of words to complex structures describing concepts by properties and formal axioms.

In AMANDA, ontologies are used to represent the "conceptual" part of the domain and, in the context of this work, they are used for terminological purposes only. This purely linguistic approach defines ontologies in AMANDA as '*a collection of terms linked together by means of taxonomical and compositional relations*'. In AMANDA, the concepts of the ontology can be related either by *taxonomical* (is-a) relations to express subsumptions or by *compositional* (part-of) relations to express part-whole relations, as illustrated in the sample ontology of Fig. 4.1[14].

According to the example below, the top-level concept 'Training Action' (C_1) is composed of three sub-concepts: 'Pedagogical Method' (C_2), 'Pedagogical Objective' (C_3) and 'Pedagogical Scenario' (C_4). This compositional relation is represented by the use of *part-of* links. Yet in the same ontology, the 'Pedagogical Method' (C_3) concept is decomposed into more specific subtypes by means of *is-a* relations, which gives rise to five different types of pedagogical methods (C_5 .. C_9). The 'Pedagogical Scenario' concept (C_4) is decomposed into parts and one of its parts ('Pedagogical Resource') is successively decomposed into subtypes by means of sequential *is-a* relations. The result is a hybrid hierarchy, which mixes taxonomical and compositional relations to express the intended interrelations between the concepts of the domain. We must note, however, that the structure shown in figure 4.1 is one of the several possible ways of organizing the concepts. In fact, ontologies are far from being rigid structures; they reflect the perspective of the ontology designer, who emphasizes certain concepts and hides others, depending on the application purpose of the ontology.

---

[14] The sample ontology of figure 4.1 is part of the 'RF Ontology' developed in conjunction with CEGOS as an attempt to model the domain of 'Professional Training Management'.

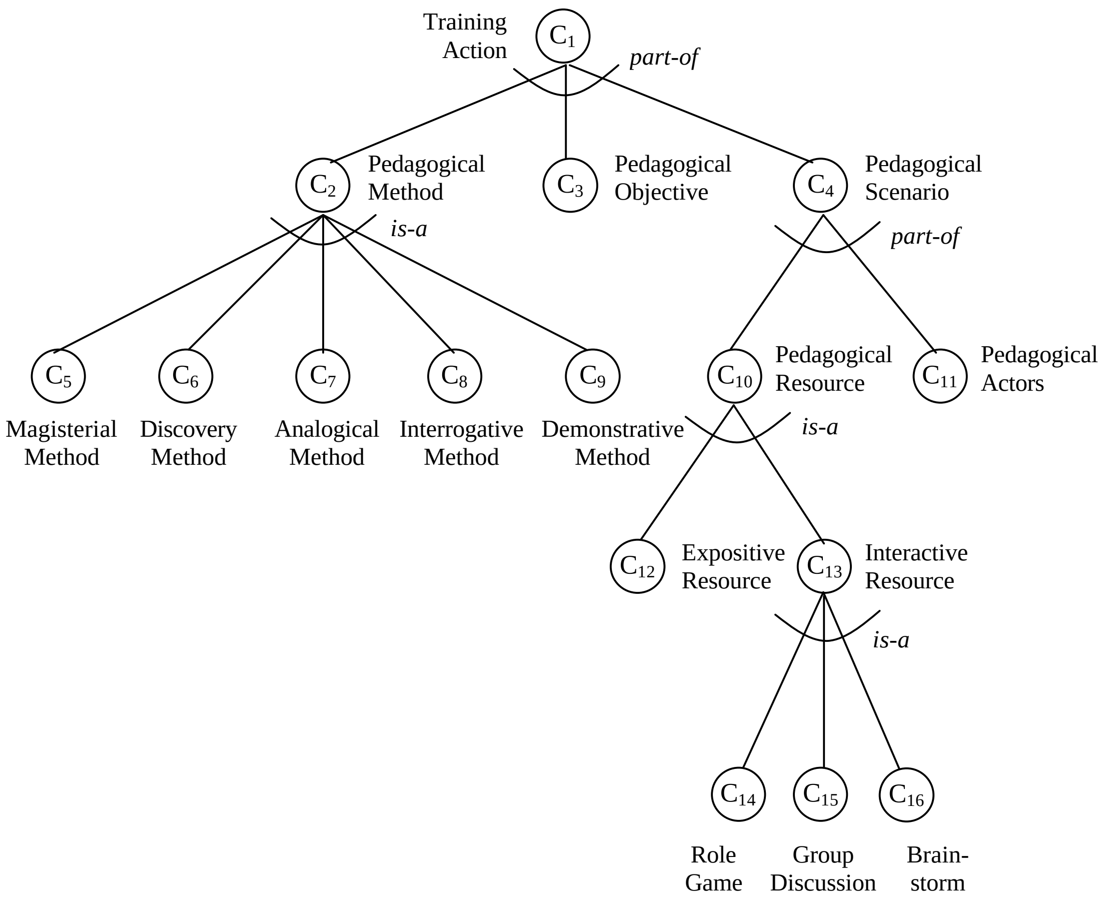


Fig. 4.1: Example of domain ontology in AMANDA

Formally, a domain ontology ? that belongs to a given domain *D*, denoted by ? (*D*), is represented by a root concept $c_r = \langle t, D, v \rangle$ and a set of sub-concepts $c_s = \langle t, c_p, r_o, v \rangle$, where ‘t’ is the textual expression that denotes the concept, ‘c_p’ is the parent concept of c, ‘r_o’ ? {*is-a*, *part-of*} is the relation between c and c_p and ‘v’ is a vector of the type [*gender*, *number*] containing linguistic parameters on t (required to build NL sentences[15]). According to this formalism, the sample ontology of figure 4.1 is represented by the following expressions:

[15] In order to integrate the textual expression *t* in a natural language sentence, some linguistic properties are required, such as the gender/number property of *t*. This ad-hoc information, however, is language-specific and might need to be redefined according to the target language.

C_1 = <*Training Action*, RF[16], [neutral, sing]>

C_2 = <*Pedagogical Method*, c_1, part-of, [neutral, sing]>

C_3 = <*Pedagogical Objective*, c_1, part-of, [neutral, sing]>

C_4 = <*Pedagogical Scenario*, c_1, part-of, [neutral, sing]>

C_5 = <*Magisterial Method*, c_3, is-a, [neutral, sing]>

C_6 = <*Discovery Method*, c_3, is-a, [neutral, sing]>

C_7 = <*Analogical Method*, c_3, is-a, [neutral, sing]>

C_8 = <*Interrogative Method*, c_3, is-a, [neutral, sing]>

C_9 = <*Demonstrative Method*, c_3, is-a, [neutral, sing]>

C_{10} = <*Pedagogical Resource*, c_4, part-of, [neutral, sing]>

C_{11} = <*Pedagogical Actors*, c_4, part-of, [male, plural]>

C_{12} = <*Expositive Resource*, c_{10}, is-a, [neutral, sing]>

C_{13} = <*Interactive Resource*, c_{10}, is-a, [neutral, sing]>

C_{14} = <*Role Game*, c_{13}, is-a, [neutral, sing]>

C_{15} = <*Group Discussion*, c_{13}, is-a, [neutral, sing]>

C_{16} = <*Brainstorm*, c_{13}, is-a, [neutral, sing]>

4.2.2 Task structures in AMANDA

Task structures are used in AMANDA to represent the "procedural" part of the domain of discourse, i.e. to represent how a given domain task is decomposed into subtasks and methods. We must clarify, at this point, that AMANDA uses task structures merely to describe domain tasks and generate natural language questions. Task structures are not part of the mediation method (as mentioned in the beginning of this chapter, we kept the method domain-independent).

Our proposed model for task structures is a simplified version[17] of TÆMS model [DEC95]. In AMANDA, a task structure TS is a tree composed of a root node (the most general task) and intermediate nodes (subtasks) linked together by *seq* and *type* relations. *Seq* relations are used to decompose a given task/subtask in a sequence of

---

[16] RF stands for "*Responsable Formation*", the French term for "Training Manager". RF is the domain of discourse chosen as test case for the development of the domain models at CEGOS.

[17] In this work, we use only the formal model proposed in TÆMS and not its coordination mechanisms.

subtasks, while *type* relations allow defining different ways (methods) of accomplishing a given task. Figure 4.2 shows an example of task structure in AMANDA[18].

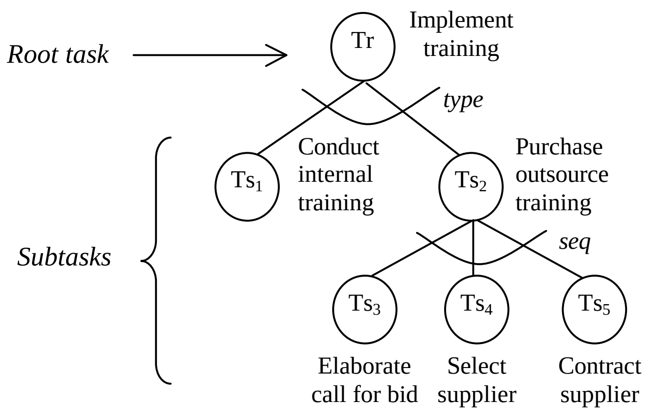


Fig. 4.2: Example of task structure in AMANDA

According to the sample TS of figure 4.2, the root task 'Implement training' (Tr) can be done either by 'Conducting internal training' (Ts_1) or by 'Purchasing outsource training' (Ts_2). The task 'Purchase outsource training', on its turn, is achieved by performing three sequential subtasks: 'Elaborate call for bid' (Ts_3), 'Select supplier' (Ts_4) and 'Contract supplier' (Ts_5).

Formally, a task structure TS that belongs to a domain *D*, denoted by TS(*D*), is represented by a root task Tr = <t, *D*> and a set of subtasks Ts = <t, Tp, r_t>, where 't' is the textual expression that denotes the task/subtask, *D* is the corresponding domain of discourse, Tp is the parent task of a given subtask Ts and r_t ? {*seq*, *type*} is the relation between Ts and Tp.

According to this formalism, the task structure of figure 4.2 is expressed by:

Tr = <*Implement training*, RF>

Ts_1 = <*Conduct internal training*, Tr, type>

Ts_2 = <*Purchase outsource training*, Tr, type>

Ts_3 = <*Elaborate call for bif*, Ts_2, seq>

Ts_4 = <*Select supplier*, Ts_2, seq>

Ts_5 = <*Contract supplier*, Ts_2, seq>

---

[18] The complete task structure will be presented in the next chapter.

4.2.3 The relation between task structure and ontology

Conceptually, as stated in [MIZ95], tasks structures and domain ontologies are related by the fact that the concepts required, manipulated or produced by the tasks can be explicitly represented in the corresponding domain ontology.

In Decker's TÆMS framework [DEC95], this relation is made explicit by the use of a special type of relation (*resource link*) relating tasks and input/output resources. In TÆMS, resources are not organized in ontologies, rather they are represented by special nodes in the task structure.

In AMANDA, we adopt nearly the same approach, except that (i) the resources used by the tasks of TS(*D*) are explicitly defined in a domain ontology *O*(*D*) and (ii) tasks and resources can also be related by a 'mental resource' relation in addition to the input/output resource relations of Decker's approach.

The relations between task structure and ontology proposed in AMANDA are:

? ? the *input-resource* relation, that associates a given task/subtask to a particular concept used as 'input' resource, for instance a 'report on training requirements' used as input for the 'Elaborate a training plan' task;

? ? the *output-resource* relation, that associates a given task to a particular concept used as 'output' resource, for instance a 'Pedagogical scenario' produced by the 'Conceive the pedagogical scenario' task and

? ? the *implicit-knowledge* relation, that associates a given task to a particular 'mental concept' whose knowledge is required to perform the task, for instance the knowledge on the 'enterprise investment policy' required to the 'Elaborate the training budget' task.

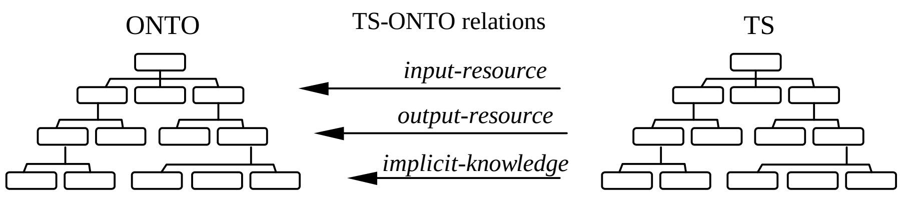


Fig. 4.3: Relation between task structure and ontology

The TS-ONTO relations provide us with a richer representation of the domain of discourse and with additional possibilities to generate NL questions out of the domain models, as detailed in the next section.

4.3 Natural language generation

The nature of the questions launched for group discussion is crucial for a successful debate, for they act as "triggering events" of group interaction (see the Critical Thinking model [GAR00] described in section 2.1.1). Thoughtful and non-trivial questions normally result in incomplete or incorrect answers, which in turn triggers group reaction and feeds back the discussion.

In AMANDA, discussion questions can be automatically generated out of domain models. The relations, concepts and tasks retrieved from the models are turned into NL questions with the aid of linguistic patterns, as shown in figure 4.4. The resulting questions explore the domain of discourse *D* along several dimensions, according to the relations inferred from the available models *O*(*D*) and TS(*D*).

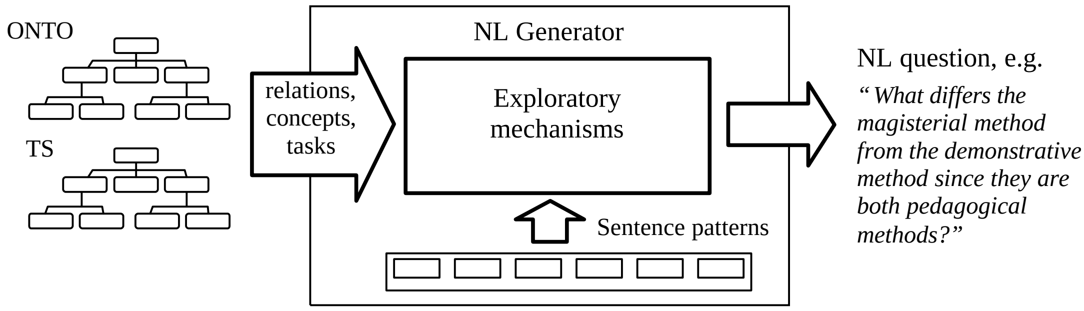


Fig. 4.4: Natural language generation

4.3.1 The principle of NL generation

The principle of NL generation is to associate a particular type of relation (e.g. *is-a*, *part-of*, *seq*, etc.) to a given *class of question*. For instance, if two concepts c_1 and c_2 are linked to the same parent concept c_0 by means of an *is-a* relation, i.e. if c_1 and c_2 are different types of c_0, we may explore the fact that "if two distinct concepts belong to the same category, there must be an *identity criteria* that distinguishes them". We can then create a specific 'exploratory mechanism' that maps the <*is-a*, c_0, c_1, c_2> relation to a particular type of question by means of a given *sentence pattern*, such as “What distinguishes <c_1> from <c_2> since both are <c_o>?”. The final NL sentence is obtained by replacing the concept tags <c_0>, <c_1> and <c_2> by the corresponding textual expressions extracted from the ontology.

Analogously, we can create one exploratory mechanism for each type of relation, in order to explore the domain models along several dimensions, as detailed in the following item.

4.3.2 The exploratory mechanisms

The exploratory mechanisms (EMs) are algorithms that extract the relations, concepts and tasks from the domain models, select the appropriate sentence pattern and generate the corresponding NL sentences (see Fig. 4.5). For this purpose, each EM searches the respective model (ONTO, TS) for a given type of relation and selects the sentence pattern from a set of available ‘equivalent patterns’. At each generation, the EM randomly chooses among the available patterns to provide the final set of questions with some linguistic diversity.

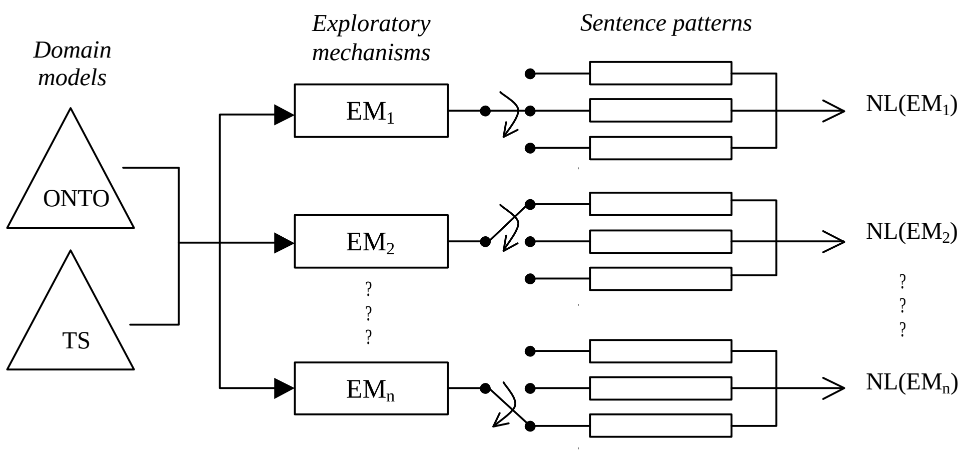


Fig. 4.5: General scheme for NL generation

In AMANDA, we propose seven different EMs[19], each one handling a specific type of relation. Each type of relation has a particular interrogative purpose, which determines the sentence pattern to be applied.

Table 4.1 summarizes the exploratory mechanisms and their respective relations and interrogative purposes and table 4.2 shows the corresponding sentence patterns.

EM	Relation	Model	Interrogative purpose
isa-dif	is-a	ONTO	The difference between two types of the same concept.
part-of-role	part-of	ONTO	The role that a given component plays in its whole.
mt-seq-prio	seq	TS	The priority/order of execution between pairs of sequential subtasks.
mt-seq-role	seq	TS	The role of a subtask in its upper level task.
mt-type-dif	type	TS	The difference between two methods of a task.
lien-mt-onto	input-resource output-resource impl-knowledge	TS, ONTO	The relation between a task and its corresponding input/output/mental resources.
concept-use	individual concept	ONTO	The use of a concept.

Tab. 4.1: Exploratory mechanisms and their interrogative purposes

In what concerns the ontological *is-a* and *part-of* relations, two exploratory mechanisms are defined: (i) *isa-dif*, which investigates the identification criteria that distinguishes one concept from another and (ii) *part-of-role*, which investigates the fact that "if a given concept is divided into parts, each part plays a specific role in its whole".

In what concerns the task-related *seq* and *type* relations, three exploratory mechanisms are defined: (i) *mt-seq-prio*, which interrogates about the execution order of a given subtask in respect to the other subtasks sharing the same parent task; (ii) *mt-seq-role*, which interrogates about the role that a given subtask plays in the parent (more general) task and (iii) *mt-type-dif*, which explores the fact that "if there is more than one way of accomplishing a task, we may investigate the advantages and disadvantages of performing it one or another way".

[19] The objective here is neither to provide an exhaustive list of mechanisms nor to investigate all possible ways of exploring a given domain. We limit ourselves to find out how far we can go with NL generation in this context.

The TS-ONTO relations are handled by the *lien-mt-onto* mechanism, which explores how a given task uses the related concept(s) defined as input/output/mental resource(s). We also define the *concept-use* mechanism that explores the role that a given concept plays in its domain. This mechanism produces general and open questions about the purpose of existence of a given concept.

4.3.3 Sentence patterns

A *sentence pattern* is a sequence of fixed and variable text segments, which defines the final form of the sentence. The final sentences are produced by replacing the variable text segments of the corresponding sentence pattern with the textual expressions retrieved from the ontology and the task structure.

For example, the sentence "*What distinguishes the magisterial method from the demonstrative method, since both are types of pedagogical methods?*", produced by the exploratory mechanism *isa-dif*, is derived from the sample ontology shown in figure 4.1 and the following sentence pattern:

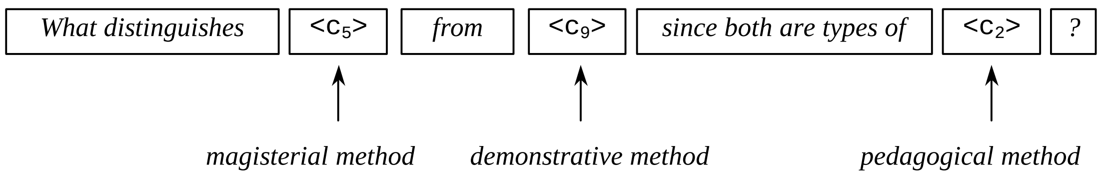


Fig. 4.6: An example of sentence pattern for the *isa-dif* rule

In the above example, the replacements $<c_5>$ = "interrogative method"; $<c_9>$ = "demonstrative method" and $<c_2>$ = "pedagogical method" are extracted directly from the ontology. We recall, from the preceding section, that a concept is a 4-tuple of the type $c = <t, c_r, r_o, v>$, where 't' is the textual expression that replaces 'c' in the pattern. The information stored in vector 'v', e.g. male/female and plural/singular properties, are ad-hoc language-specific information that allows us to adapt the textual expression 't' in the final sentence.

In order to avoid the repetition of a given pattern in successive NL generations, we propose that the pattern to be applied be chosen out of a set of 'equivalent' patterns. Equivalent patterns are sentence patterns with the same interrogative purpose but with different formulations or styles.

For example, the sentence pattern of figure 4.6 ("What differs $<c_5>$ from $<c_9>$ since they are both types of $<c_2>$?") could have the following equivalent patterns:

? ?"$<c_5>$ and $<c_9>$ are different types of $<c_2>$, so what is the difference between them?" and

? ?"How can we distinguish $<c_5>$ from $<c_9>$ if both are types of $<c_2>$?".

In fact, the larger the set of equivalent patterns, the more diverse the final set of questions. Table 4.2 shows the sentence patterns used by each exploratory mechanism.

EM	Sentence patterns
isa-dif	? ? What distinguishes $<c_1>$ and $<c_2>$ if they are both types of $<c_3>$? ? ? In which situation should we use $<c_1>$ instead of $<c_2>$? ? ? How can we distinguish $<c_1>$ from $<c_2>$? ? ? $<c_1>$ and $<c_2>$ are two types of $<c_3>$, so what is the difference between them?
part-of-role	? ? What is the role of $<c_2>$ as a component of $<c_1>$? ? ? In your opinion, is $<c_2>$ an indispensable component of $<c_1>$? Why? ? ? Could we replace $<c_1>$ by another concept? ? ? How can we increase the efficiency of $<c_2>$ in the context of $<c_1>$?
mt-seq-prio	? ? Can we establish a priority between $<t_2>$ and $<t_3>$ for $<t_1>$? ? ? Is there a specific order of execution between $<t_2>$ and $<t_3>$ for $<t_1>$?
mt-seq-role	? ? What is the role of $<t_2>$ in the task of $<t_1>$? ? ? Why $<t_2>$ for $<t_1>$? ? ? Do you consider that we must $<t_2>$ for $<t_1>$? ? ? Could we $<t_2>$ without $<t_1>$? ? ? Do we have to $<t_2>$ for $<t_1>$? Justify.
mt-type-dif	? ? What is the difference between $<t_2>$ and $<t_3>$ for $<t_1>$? ? ? What is the advantage between $<t_2>$ and $<t_3>$ for $<t_1>$? ? ? $<t_2>$ and $<t_3>$ are two methods for $<t_1>$. So what is the difference between them? ? ? How can we choose between $<t_2>$ and $<t_3>$ for $<t_1>$?
lien-mt-onto	? ? Which are the input resources needed for $<t_1>$? ? ? Which are the output resources produced by $<t_1>$? ? ? What do we need to know to $<t_1>$? ? ? Can we $<t_1>$ without knowing about $<c_1>$? ? ? How can the knowledge about $<c_1>$ be used to $<t_1>$? ? ? What is the relation between $<c_1>$ and $<t_1>$?
concept-use	? ? What is $<c_1>$ used for? ? ? In which situations do we use $<c_1>$? ? ? How can we define $<c_1>$?

Tab. 4.2: Sentence patterns

The proposed method for NL generation was implemented and validated in actual situations. We carried out discussions in which the questions were entirely generated by AMANDA, with significantly positive results from NL generation and domain modeling. The sentence patterns proved to be a simple and effective way of generating sentences and the use of several ‘equivalent’ patterns provided the intended linguistic diversity for the final set of questions. The results of NL generation and the details of the tests will be discussed in the next chapter.

4.4 Summary of the chapter

In this chapter, we explored how knowledge models and NL generation are used in AMANDA. Firstly, we proposed the use of ontologies and task structures to represent the domain of discourse and showed how domain concepts and tasks would be organized in these models. Afterwards, we developed a method for generating natural language questions from the available models. In the proposed method, the relations, concepts and tasks retrieved from the models are turned into interrogative sentences by means of sentence patterns. Throughout this chapter, we illustrated the domain models and NL sentences with real examples taken from field tests carried out at CEGOS.

4.5 Résumé

Ce chapitre traite de la représentation de la connaissance et de la génération de langage naturel dans le cadre d’AMANDA. Premièrement nous proposons l’utilisation d’ontologies et de modèles de tâches pour représenter le domaine de discours. Ensuite nous développons une méthode de génération de questions en langage naturel à partir des modèles de domaine. Cette méthode utilise les relations, les concepts et les tâches récupérés des modèles, ainsi qu’un ensemble de « patterns » de questions, pour fabriquer des phrases interrogatives qui seront lancées comme des questions de débat. Les exemples de modélisation et de génération de langage naturel ont été retirés des expérimentations réelles menées à la CEGOS.

Chapter 5

The prototype software and results

The aim of this chapter is to present the software implementation of AMANDA, including the discussion mediation, domain modeling and natural language generation, as well our experience from applying AMANDA in actual training situations. We also present the 'discussion simulator', developed to validate AMANDA in a broader range of situations and thus extend the available results from the field tests.

5.1 AMANDA software

This section presents the software system that implements AMANDA. It is composed of three blocks: the Coordination Module, the KB Module and NL Generator. Figure 5.1 shows the block diagram of the system and the items below describe the corresponding modules and interfaces.

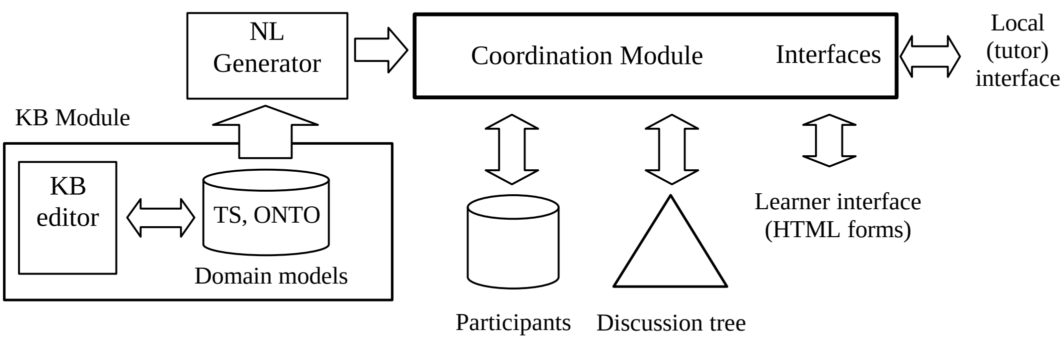


Fig. 5.1: System overview

Almost the entire system (approximately 98% of all functions), including the coordination module, the KB editor, the NL generator and the tutor interface, was developed in Common LISP. The data manipulated by the system, i.e. discussion trees, list of participants, domain models and sentence patterns, is stored directly as LISP statements in text files. As the files are read, the data structures are created and loaded into memory by the LISP 'read' function. This solution replaces the use of relational databases and satisfies the research (non-commercial) application of the system.

The learner interface, which is responsible for dynamically building and delivering the discussion forms through the Internet, was developed in PHP/HTML.

5.1.1 The Coordination module

The coordination module is the heart of the system. It implements the overall discussion control, which involves launching a discussion and conducting it over time by opening successive discussion cycles, as described in chapter 3 and illustrated in the flowchart of figure 3.4.

The coordination module performs a large number of functions, which are organized in groups, as illustrated in figure 5.2.

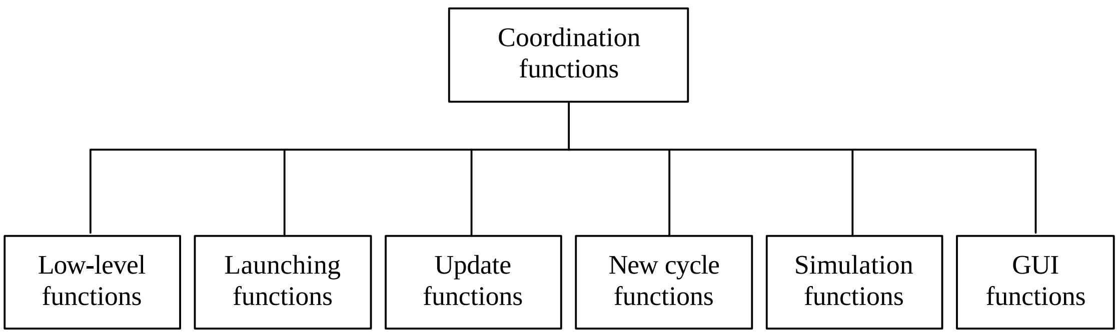


Fig. 5.2: Coordination functions

The *Low-level* functions are responsible for the low-level manipulation of the data (discussion tree and list of participants), such as adding/deleting/editing nodes, retrieving node parameters, saving and loading data from disk and managing the list of participants.

The *Launching* functions perform all actions required to launch a discussion, i.e. to distribute the issues among the participants and to build the initial configuration of the discussion tree. The interface for launching a discussion is shown in figure 5.5.

The *Update* functions implement the reception of discussion forms and the update of the discussion tree. This involves gathering all pending answer files from the participants and updating the corresponding nodes of the discussion tree.

The *New cycle* functions are the core of the coordination module. They are responsible for the advance of the discussion, through the opening of new discussion cycles. The ‘new cycle’ functions implement the ‘New cycle’ procedure detailed in the flowchart of figure 3.5, which includes the evaluation of the discussion tree and the implementation of the assignment mechanisms. The New Cycle interface is shown in figure 5.7.

The *Simulation* functions implement the ‘discussion simulator’, developed in this work to create discussion scenarios and simulate a discussion over time (see section 5.3 for further details). Simulation is useful to observe the behavior of the system in various situations, from small to very large discussions, as well as to evaluate the effects of the discussion-related parameters on the progress of the discussion. The possibility of creating and simulating discussion scenarios allows us to validate AMANDA in situations other than those available in the field tests.

The *GUI* functions are responsible for building and handling the local (tutor) interface (Fig. 5.3) and activating the internal functions in response to the users’ actions (see details below).

The local interface

The local interface is used by the tutor/mediator to follow up the discussion through graphical viewers and to act on the discussion by means of control buttons. It allows creating and managing discussions, as well as opening discussion cycles and observing system behavior.

Figure below illustrates the local interface loaded with a sample discussion. The items below describe the actions that can be performed on it.

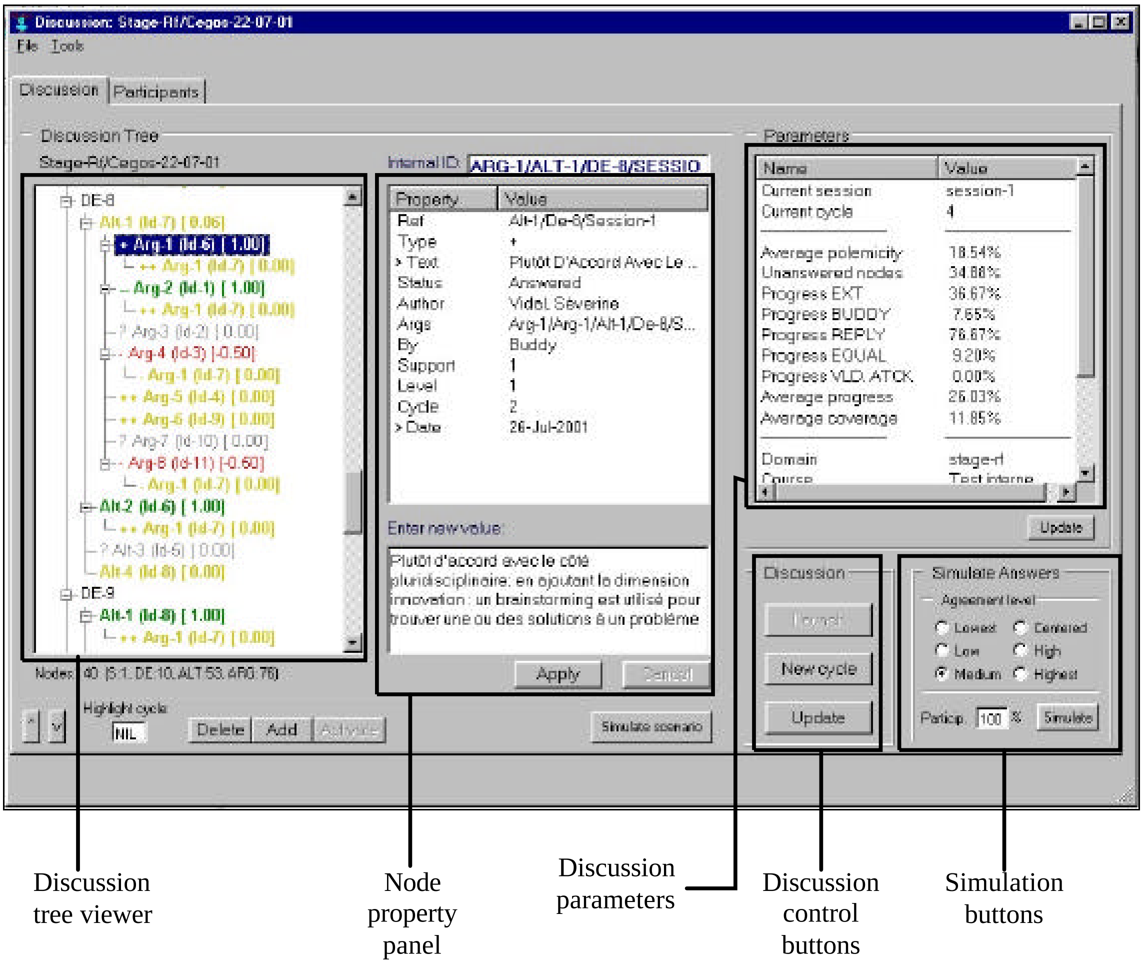


Fig. 5.3: The local interface

? ? **Creating a discussion**

From the local interface, a ‘New discussion’ dialog is opened (Fig. 5.4), which allows creating a new discussion and specify the corresponding parameters.

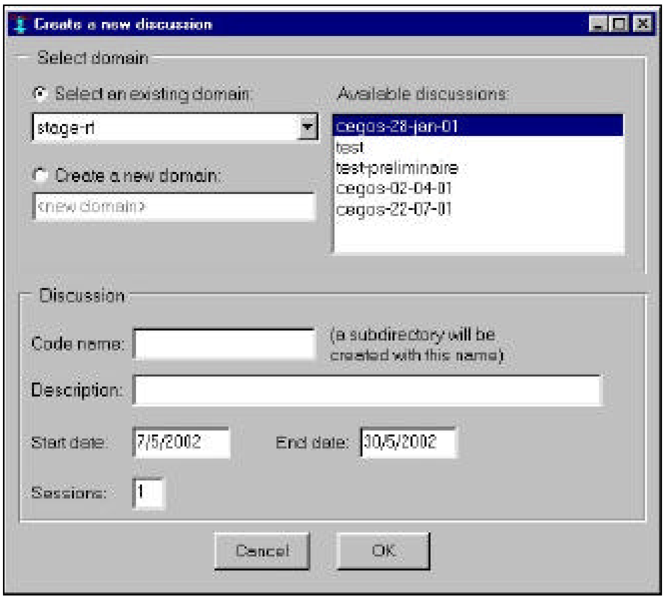


Fig. 5.4: Interface for creating a discussion

After creating a new discussion, the system builds the initial configuration of the discussion tree and creates an empty list of participants. The user should then add the desired questions and the corresponding participants so that the discussion can be launched.

? ? **Launching a discussion**

When the discussion is prepared, i.e. the issue nodes are added and the list of participants is complete, we may launch the discussion by using the 'Launch' button on the local interface. This opens a dialog window showing the issues (DEs) to be distributed and the participants (IDs) assigned to each question.

Figure 5.5 shows a discussion composed of 6 issues (DE-1 to DE-6) being launched among a set of 12 participants (ID-1 to ID-12).

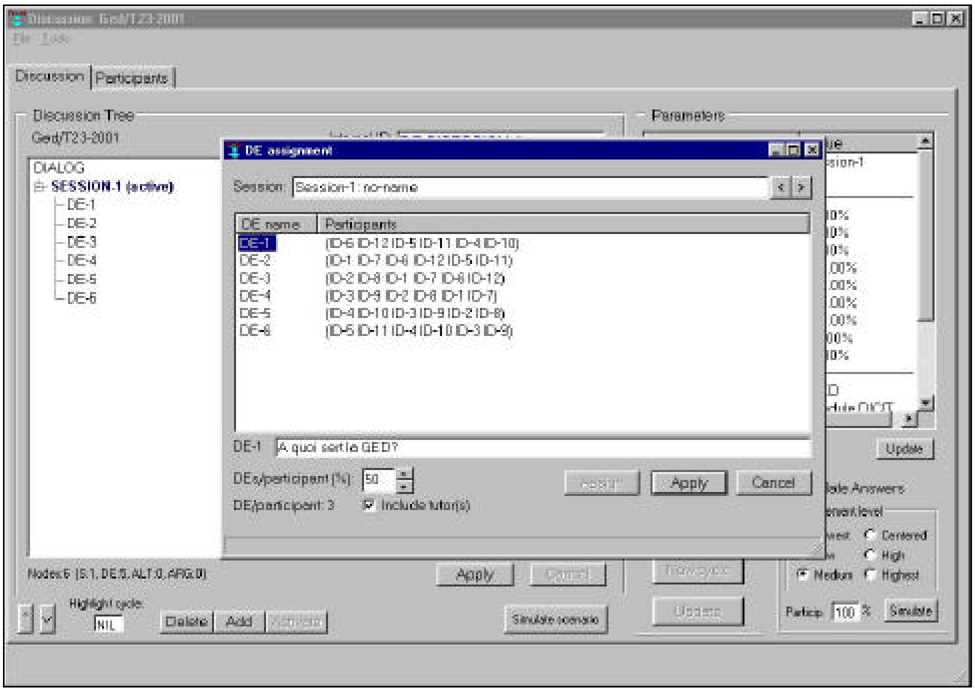


Fig. 5.5: Interface for launching the discussion

Once the discussion is launched, the questions are distributed and assigned to the participants. In what concerns the discussion tree, this corresponds to the aggregation of new ‘empty’ ALT nodes under the respective issue nodes, as shown in figure 5.6.

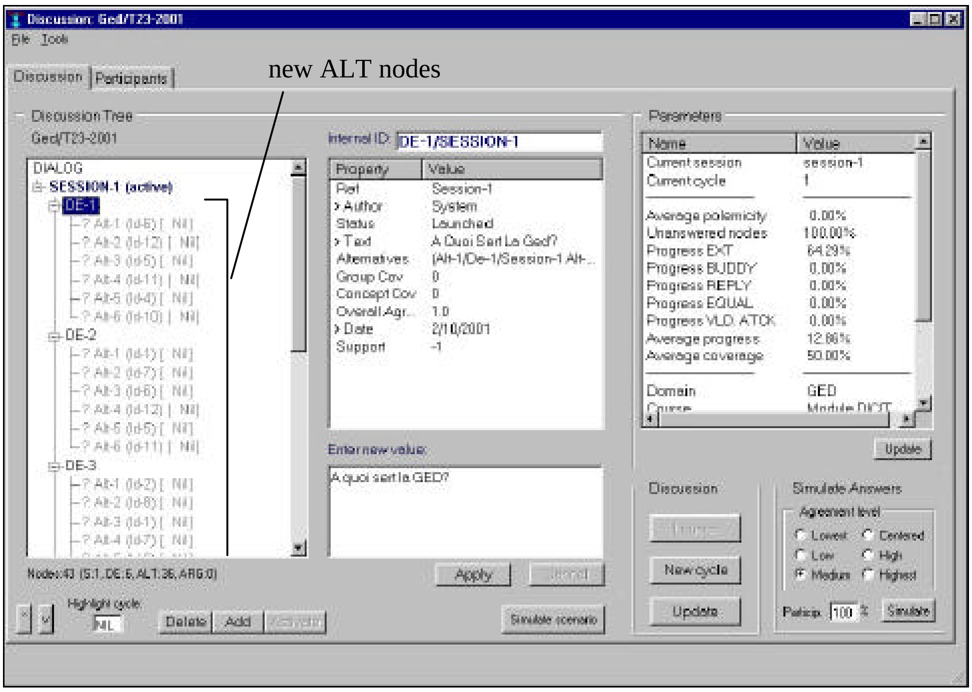


Fig. 5.6: A discussion after being launched

? ? **Delivering the discussion**

As soon as the new nodes are added to the discussion tree, the system makes available the corresponding HTML discussion forms, through which the participants will answer the assigned questions and send them back to the system. Once the discussion forms are returned, the discussion tree is updated accordingly, as detailed below.

? ? **Updating the discussion**[20]

Updating the discussion corresponds to reading the pending answers from the participants and filling the empty nodes with the corresponding content extracted from the discussion forms. This is done with the 'Update' button on the local interface, which implements the *DF reception* procedure shown in figure 3.4. After updating the discussion, a new discussion cycle may be opened, as described below.

? ? **Opening a new discussion cycle**[21]

The 'New cycle' button on the local interface is used to open a new discussion cycle, according to the flowchart of figure 3.5. When the 'New cycle' button is activated, the system performs both the 'Filtering' and the 'Extraction & Ordering' procedures and displays the 'New cycle' interface (see Fig. 5.7).

Through the 'New Cycle' interface, we may follow up the opening of a new discussion cycle, which includes:

? ? viewing the re-launchable nodes (sorted according to the RS parameter);

? ? adjusting the new cycle parameters;

? ? triggering each assignment mechanism individually;

? ? viewing the assignments proposed by each assignment mechanism;

? ? executing the assignment arbitration and

? ? finally re-launching the new discussion cycle.

---

[20] In order to eliminate the need for human interference, the update of the discussion should be automatically triggered at each discussion cycle. In our implementation, however, we do it manually through a control button on the local interface.

[21] Although the system is capable of opening discussion cycles without human interference, the New Cycle interface is useful for research purposes. It allows us to observe the system, specially how the assignment mechanisms behave when proposing new assignments, and also to manually adjust the discussion parameters.

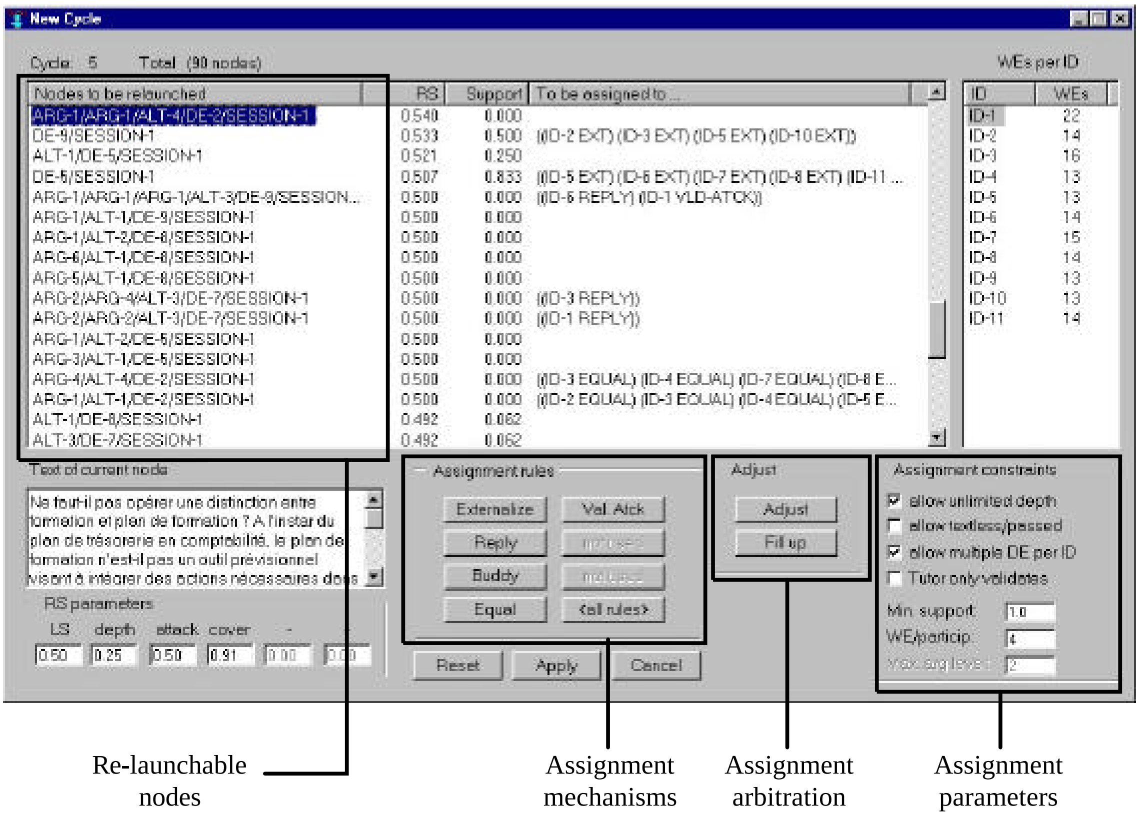


Fig. 5.7: New Cycle interface

The ‘Nodes to be relaunched’ column shows the list of nodes that were filtered and sorted according to the RS (relaunch score) parameter. These nodes correspond to the ‘O list’ of the ‘New cycle’ flowchart of figure 3.5.

The ‘To be assigned to …’ column shows the proposed assignments (elements of the ‘PA list’) generated by each assignment mechanism.

The ‘Assignment rules’ panel contains the buttons corresponding to the assignment mechanisms, which can be triggered individually. The ‘Adjust’ button implements the assignment arbitration, which limits the number of assignments per participant to the WL_{max} parameter (WE/particip.).

The ‘WEs per ID’ panel shows the participants (IDs) and the corresponding number of proposed assignments. Note that this number will be cut off to WL_{max} (in this case 4) whenever the ‘Adjust’ button is activated.

The ‘Assignment constraints’ panel allows us to set parameters for the filtering and assignment arbitration procedures.

The ‘Reset’ button clears the assignments so that we can repeat it with different parameters. The ‘Apply’ button incorporates the assignments to the discussion, which effectively opens the new discussion cycle and adds the new nodes to the discussion tree.

5.1.2 Delivering the discussion through the web-based interface

The web-based interface is the communication channel that allows the participants to interact with the system and take part of the discussion. The interaction between AMANDA and the participants occurs via the exchange of discussion forms in HTML format (see example in Appendix I). Figure 5.8 presents the block diagram of the web-based interface, showing how the discussion forms are generated and received by the system.

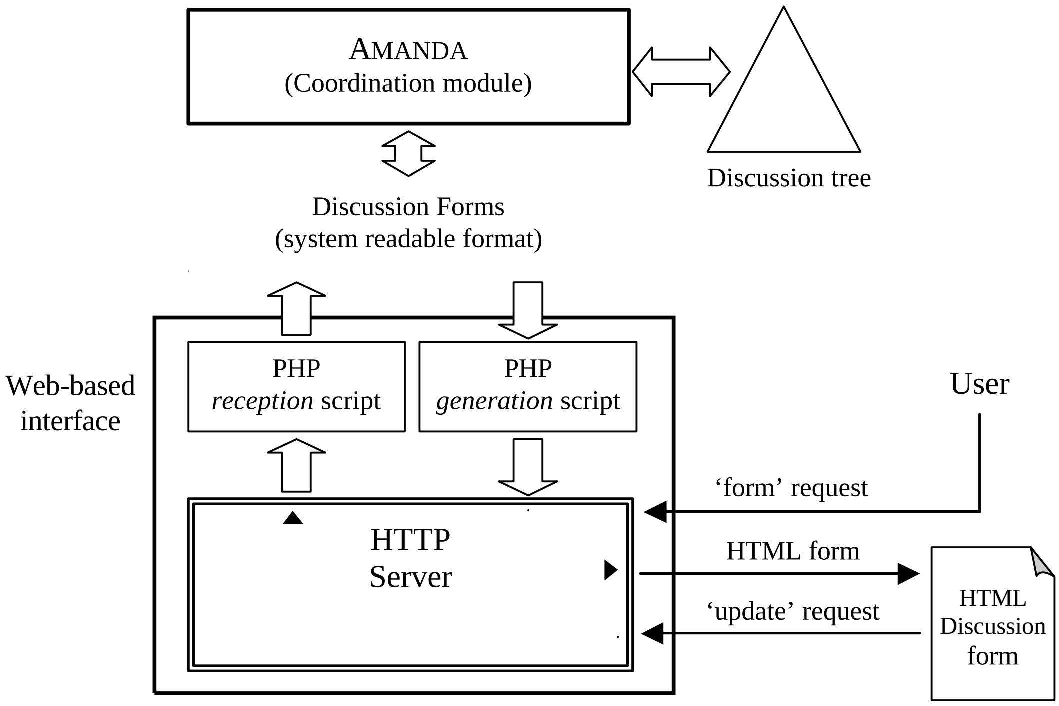


Fig. 5.8: Web-based interface overview

At each discussion cycle, AMANDA notifies the participants that a new discussion form is available at a specific URL. This URL is, in fact, an *http* request that commands the HTTP server to generate the corresponding discussion form in HTML format ('form' request). The 'form' request contains the identification of the participant as well as the corresponding discussion cycle. Upon receiving a 'form' request from the user, the HTTP server activates the *generation* script that dynamically builds the corresponding discussion form in HTML format and delivers it to the user. Figure 5.9 shows the discussion form as it appears to the user.

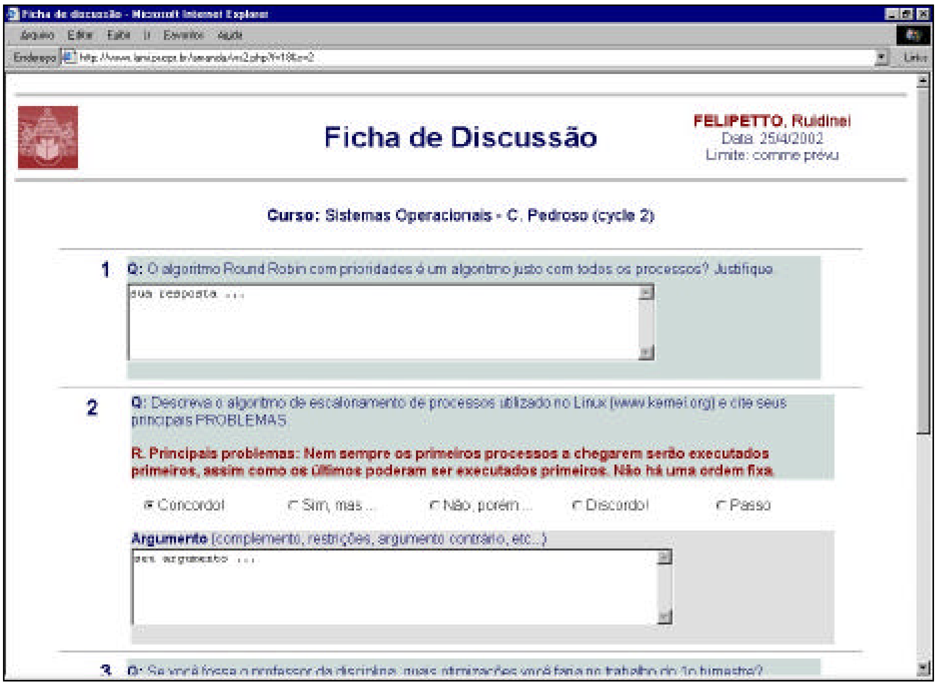


Fig. 5.9: Discussion form as it appears on the user's interface

After filling up the discussion form, the participant sends it back to the HTTP server ('update' request). Upon receiving the discussion form, the server activates the *reception* script that extracts the content (answers and argumentations) from the form and converts it into the system-readable format, so that it can be processed by AMANDA.

5.1.3 The KB module

The KB module is responsible for managing the domain models. This includes the creation of a given domain and the corresponding ontologies and task structures. The KB module interface allows us to build ontologies and task structures by adding concepts, tasks and relations, according to the description of the domain models given in section 4.1. Figures 5.10 and 5.11 illustrate the KB interface, respectively showing the ontology and the task structure editors.

Building ontologies

In AMANDA, ontologies are built by creating concepts and specifying their corresponding properties. The allowed properties of a concept are:

? ? the textual 'label' that corresponds to the name of the concept;

? ? the concept ‘type’ (root, is-a, part-of) specifying the relation that bounds it to the parent concept (if any);

? ? the list of ‘is-a’ and ‘part-of’ sub-concepts;

? ? the list of synonymous (alternative labels) for the concept and

? ? the linguistic properties (gender/number), which correspond to the information contained in vector ‘v’ (see item 4.1.1).

Figure below shows the ontology editor with the ‘RF’ ontology[22] loaded. The left-hand panel shows the ontology tree and the right-hand panel shows the properties of the currently selected concept.

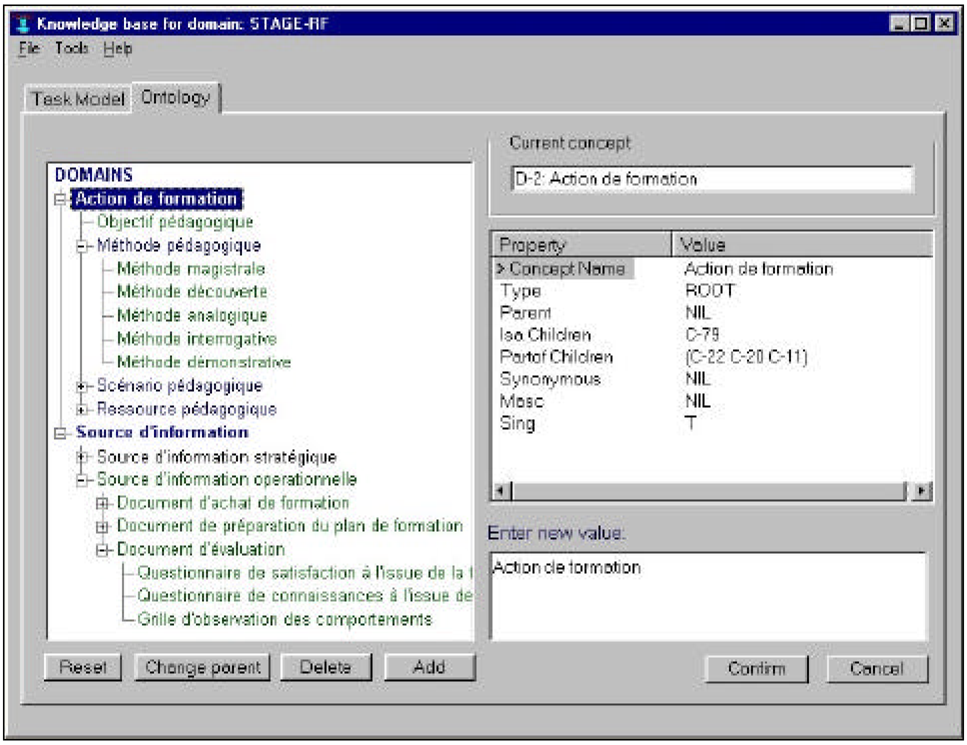


Fig. 5.10: The KB interface – the ontology editor

Building task structures

Task structures are built by adding tasks and subtasks and specifying their corresponding properties. The allowed properties of a task/subtask are:

? ? the textual ‘label’ that identifies the task (task name);

[22] The ‘RF’ ontology describes the concepts involved in the domain of ‘corporate training management’. It was developed from the training material provided by Cegos and used in validation tests.

? ? the task 'type '(root, seq, type) identifying the relation that bounds it to the upper level task (if any);

? ? the name of the upper level (parent) task;

? ? the depth 'level' of a task (level = 0 corresponds to the root task);

? ? the list of 'input-resource' concepts;

? ? the list of 'output-resource' concepts;

? ? the list of 'implicit-knowledge-resource' concepts;

? ? the list of SEQ sub-tasks and

? ? the list of TYPE sub-tasks.

Figure below shows the task structure editor with the 'RF' task structure[23] loaded. The left-hand panel shows the task structure tree and the right-hand panel shows the properties of the currently selected task.

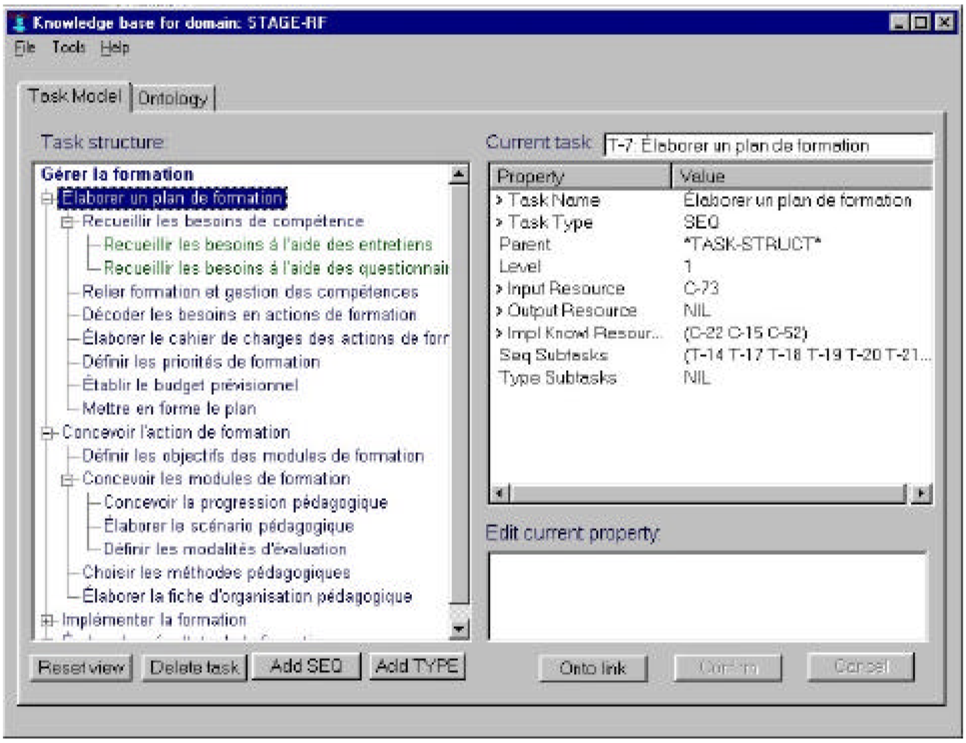


Fig. 5.11: The KB interface – the task structure editor

---

[23] The 'RF' task structure describes the task of 'managing corporate training'. It was developed from the training material provided by Cegos and used in validation tests.

Linking the task structure to the ontology

The KB module allows to link a given task of the task structure to a particular concept of the ontology. This is done by the 'Onto link' button shown in figure 5.11. By clicking on this button, we may choose any concept from the ontology to be used as 'input', 'output' or 'implicit' knowledge' resource for the currently selected task (see item 4.1.3 for more details on this type of link).

5.1.4 The NL Generator

The NL Generator implements the method of producing natural language questions out of the domain models, described in section 4.2. The NL Generator implements the exploratory mechanisms and sentence patterns of the proposed method, presented in tables 4.1 and 4.2

Implementation of the exploratory mechanisms.

The exploratory mechanisms were implemented as LISP functions that perform the following standard procedure:

(i) Open the corresponding model (ONTO or TS) and search for all relations of the specified type, e.g. *is-a*, *part-of*, *seq*, *type*, etc.;

For each occurrence of the specified relation:

(ii) Retrieve the labels of the corresponding concepts/tasks;

(iii) Randomly select a sentence pattern out of a set of equivalent patterns;

(iv) Build a 'raw sentence' by replacing the tags of the pattern by the corresponding labels and

(v) Modify the final sentence so that it conforms to the gender/number properties of the labels and to other language-specific requirements.

The output of the NL generator is a list of natural language questions that covers the domain of discourse. Figure 5.12 illustrates the NL Generator interface and the resulting questions for the 'RF' domain. On the left-hand side of this interface are the generated questions and on the right-hand side we may enable/disable each exploratory mechanism.

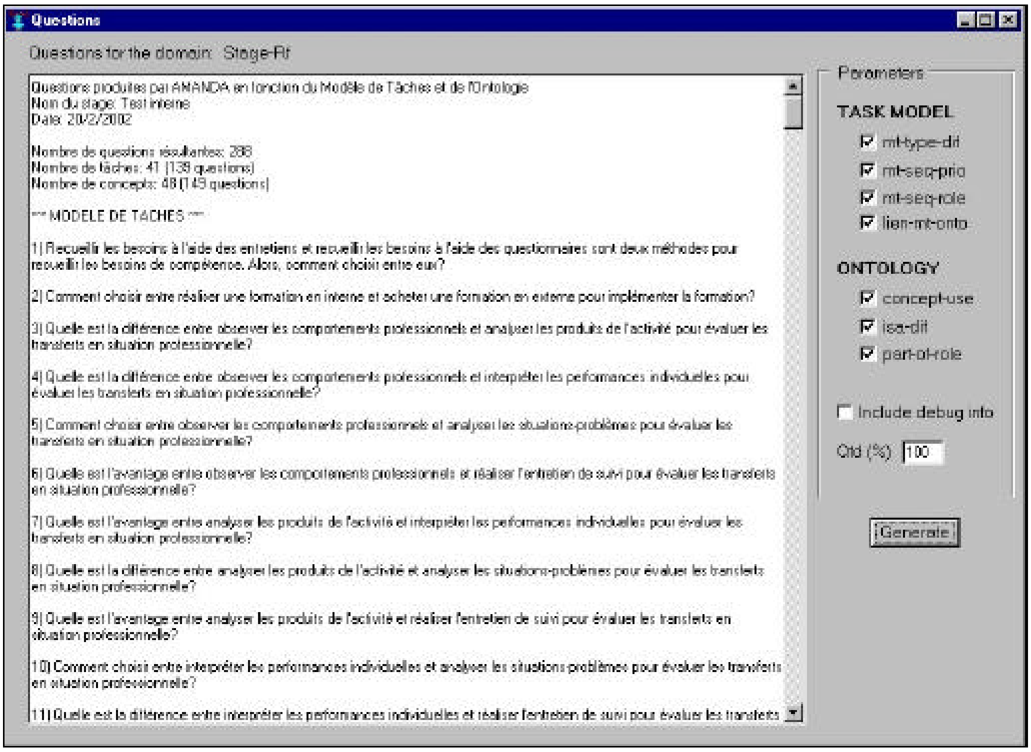


Fig. 5.12: The NL Generator interface

In the above example, the NL Generator produced 288 questions out of 41 tasks from the task structure and 48 concepts from the ontology. The complete list of sentences corresponding to this example is shown in Appendix II.

As we can see, the final list of questions can be exhaustive. In order to decrease the number of generated questions and thus reduce the overload of manually selecting the desired ones[24], the interface allows to specify a percentage of questions to be output ('Qtd' parameter).

For debugging and validation purposes, the interface provides the 'Include debug info' check box, which allows us to view/hide details on the concepts/tasks and the specific sentence patterns applied to each question.

Implementation of the sentence patterns

In our implementation, the sentence patterns <SP_i> of a given mechanism <mech> are defined in a list of the type (<mech>, <SP_1>, <SP_2> … <SP_n>). Each sentence pattern <SP_i> is a list of segments of two types: 'fixed strings' and 'tags'. In

---

[24] The current implementation of the NL Generator does not provide any automatic tool for the evaluation and selection of the generated questions; up to now this must be done manually.

order to generate the final NL sentence, the mechanism randomly selects a pattern <SP_i> to be applied and replaces the tags contained in the pattern by the corresponding labels retrieved from the domain model.

Following is an example of sentence patterns for the *mt-type-dif* mechanism[25], as it was implemented in AMANDA. The sentence patterns for the *mt-type-dif* mechanism are defined as follows:

```
(list 'mt-type-dif
   '("Quelle est la différence entre " 2 " et " 3 " pour " 1"?")
   '("Quelle est l'avantage entre " 2 " et " 3 " pour " 1"?")
   '(2 " et " 3 " sont deux méthodes pour " 1". Alors, comment choisir entre elles?")
   '("Comment choisir entre " 2 " et " 3 " pour " 1"?"))
```

An example of a sentence produced by *mt-type-dif* is:

```
« Observer les comportements professionnels et analyser les
produits de l'activité sont deux méthodes pour évaluer les
transferts en situation professionnelle. Alors, comment choisir
entre elles? »
```

In the above sentence, the *mt-type-dif* mechanism applied the 3rd sentence pattern and the following labels retrieved from the task structure:

? ? T_1 = « Évaluer les transferts en situation professionnelle »;

? ? T_2 = « Observer les comportements professionnels » and

? ? T_3 = « Analyser les produits de l'activité ».

Using the 4th sentence pattern with the same labels would result in the following sentence:

```
« Comment choisir entre observer les comportements professionnels
et analyser les produits de l'activité pour évaluer les transferts
en situation professionnelle? »
```

As we can see, AMANDA provides us with a simple and effective way of defining sentence patterns and producing varying styles of questions. Adding an equivalent pattern is as easy as adding a string in a text file. However, if we wish to generate sentences in other languages, we must change the language-specific code in order to include the adaptations required for the target language.

---

[25] We recall that the objective of the *mt-type-dif* mechanism is to explore the difference between two different methods (tags '2' and '3') of a given task (tag '1').

5.2 Experimental results

This section presents the experimental results obtained from applying AMANDA to actual training situations. We will analyze and discuss three main tests, two of them carried out in France and the third one in Brazil. The tests in France and in Brazil involved different types of students and different domains. The French participants were mostly professionals taking part of a short-term course offered by CEGOS on 'Managing corporate training', while the Brazilian participants were Computer Engineering graduate students taking part of a one-semester course on 'Operating Systems'.

5.2.1 Test #1

The first test was carried out at CEGOS (France) in April, 2001 and involved 14 participants discussing over 11 issues along 5 discussion cycles. The table below shows the general data for the test and the original questions used as issues for the discussion.

Discussion name: Cegos-02-04-01	Domain : Responsable formation (RF)
Start date: 03/04/2001	End date: 09/04/2001
Number of questions: 11 (tutor-generated)	Number of participants: 14
Number of cycles: 5	WL_{max}: 4
Questions:	
Q-1	La connaissance de la typologie de l'entreprise dans laquelle il évolue permet au RF de positionner la fonction formation comme soit: un outil de régulation sociale, une action de motivation -compensation, un vecteur de gestion des compétences, ou un véritable investissement. Dans quelle mesure le positionnement est-il définitif ? Quels sont les facteurs susceptibles de faire évoluer ce positionnement ?
Q-2	Quels sont les liens entre les missions allouées à la fonction formation et les autres activités de la gestion qualitative des ressources humaines ? Dans quelle mesure, la connaissance et l'intervention dans ces autres domaines, permet-elle au RF d'évoluer dans sa fonction ?
Q-3	Quels sont les éléments à prendre en compte dans l'élaboration du plan de formation ? Dans quelle mesure faut-il intégrer les avis des partenaires sociaux et les besoins individuels des salariés ?
Q-4	Afin d'identifier les objectifs globaux de l'entreprise, quelles sont les informations que le Responsable de formation doit rechercher auprès de la Direction Générale?
Q-5	Citez les grandes logiques d'élaboration du plan de formation.
Q-6	Dans le cadre du recueil des besoins, à quelle situation l'entretien exploratoire d'analyse de la demande de formation s'avère comme l'outil le plus adapté ?
Q-7	Comment peut-on définir la notion de compétence ?
Q-8	Précisez quels sont les acteurs, ou groupes d'acteurs impliqués dans l'élaboration du plan de formation et les enjeux ou attentes liés à la formation, pour chacun d'entre eux .
Q-9	Selon vous, comment peut-on définir au mieux les conditions de réussite et les outils de mesure des résultats d'une action de formation ?
Q-10	Quelles sont les conditions de réussite de l'entretien exploratoire d'analyse de la demande de formation?
Q-11	De quelle façon, le responsable de formation peut-il agir pour oeuvrer au développement des compétences individuelles et collectives ?

Tab. 5.1: General data for test #1 (Cegos-02-04-01)

Performance measures for test#1

Table below shows the evaluation parameters and the performance measures[26] after the end of the discussion.

Total number of nodes	257
Percentage of unanswered nodes	43.67%
Average coverage	8.87%
Average polemicity	12.89%
Progress EXT	80.85%
Progress REPLY	73.33%
Progesss BUDDY	7.01%
Progress VLD-ATCK[27]	n/a
Progress SPREAD	6.25%
Average progress	41.86%

Tab. 5.2: Evaluation parameters and performance measures for test #1

As we can see from the table, the discussion tree has reached 257 nodes and 43.67% of the nodes remained unanswered (participation level = 56.33%). Each node of the tree covered, in average, 8.87% of the participants and the percentage of refuting nodes was 12.89% (average polemicity).

The EXT mechanism reached a progress measure of 80.85%, meaning that 19.15% of answers to direct questions (ALT nodes) were not assigned by the system. The REPLY progress indicates that the system managed to assure the right of response to 73.33% of the refuted positions. The progress of the BUDDY mechanism means that only 7.01% of the positions were cross-analyzed and the progress of the SPREAD mechanism indicates that only 6.25% of the overall discussion was fully covered by all participants. In average, the discussion reached a progress measure of 41.86%.

Evaluation of test#1

The progress measures shown in table 5.2 reveal that the discussion was fairly well conducted, when compared to other tests and simulations, as we will see later in

---

[26] The performance measures reflect how close a given assignment mechanism is from the concluding stage, see section 3.5 for more details.

[27] In this test the VLD-ATCK mechanism had not been yet implemented

this chapter. The apparent low progress rates achieved by BUDDY and SPREAD were expected, given the large number of proposed assignments from these mechanisms and the comparatively lower number of items allowed in a discussion form (WL_{max}).

This test the very first attempt to put AMANDA in practice. During the test, we needed to adjust the system 'on the fly', in response to the observations made at each discussion cycle. Among these adjustments, was the addition of specific constraint rules to the assignment arbitration algorithm in order to avoid certain 'undesirable' assignments, such as participants receiving their own answers to analyze.

This test also revealed the lack of a specific assignment mechanism to validate refuting argumentations. We noticed that most of the interest of the discussion was focused on disagreements, rather than on common positions, and that refuting positions were not sufficiently taken into consideration in further discussion cycles. This lead us to develop the VLD-ATCK mechanism, which is focused on re-launching refuting nodes to the group and, in particular, to the tutor (see results in test #3).

Although this test was not long enough to reveal long-term effects, it was useful to test and adjust the coordination algorithms and to see the behavior of the participants.

Selected interactions from test#1

In order to observe and analyze the interactions that occurred through this test, we selected question Q-7 ("How can we define competence?") to follow up a small part of this discussion. Figure 5.13 shows the selected part of the discussion tree, as it appears on the local interface. Our special interest, in this example, is the discussion thread originated by the answer 'Alt-5' (inside the dotted rectangle in figure 5.13). In order to analyze this thread in deeper details, we show the original textual content of each node of this thread, as well as the assignment mechanisms responsible for each interaction.

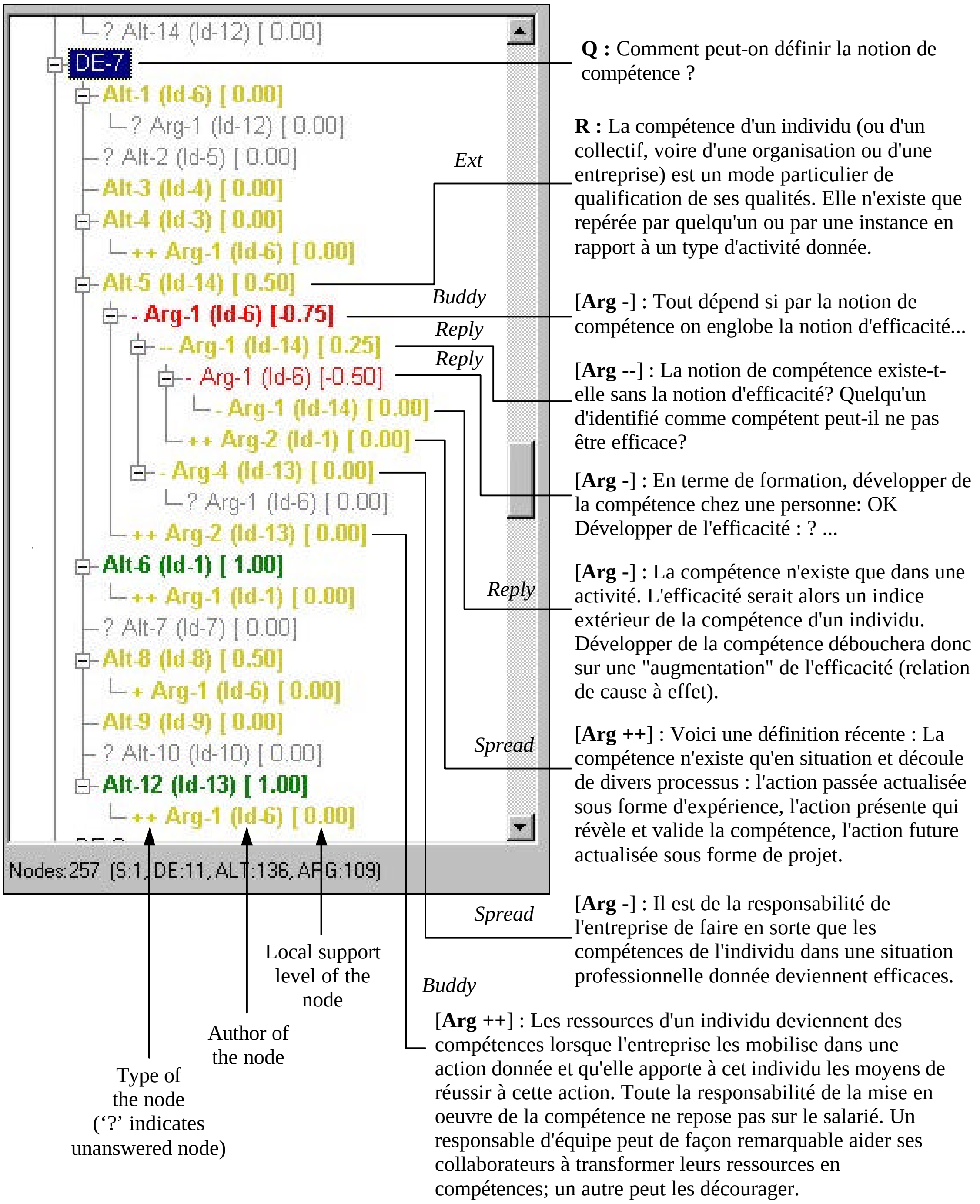


Fig. 5.13: Example of discussion thread for test #1

We observe in this example that answer ‘Alt-5’ gave rise to a threaded discussion mediated by the *Reply*, *Buddy* and *Spread* mechanisms. The *Reply* mechanism successively attempted to assure the right of response either to Id-14 and Id-6, resulting in the growth of the thread in depth. On the other hand, the *Buddy* and the

Spread mechanisms attempted to involve other participants in the discussion (Id-1 and Id-13), expanding the thread in breadth.

By carefully observing the selected thread, we see that answer 'Alt-5' (provided by Id-14) was partially refuted by Id-6, but was fully supported by Id-13. However, the successive counter-arguments provided by Id-6 to refute Id-14 don't seem very convincing, because they were refuted either by Id-13 and Id-1. Consequently, the 'local support level' of the nodes provided by Id-14 are positive (+0.5, +0.25 and 0.0), while those provided by Id-6 are negative (-0.75 and –0.5). This indicates that, as far as the discussion advanced, Id-14's ideas are collectively more acceptable than those of Id-6.

5.2.2 Test #2

The second test was carried out at CEGOS in July, 2001. This test involved 11 participants discussing over 10 issues along 4 discussion cycles. The most important innovation here is that the questions were generated by the NL Generator, instead of being typed by the tutor as in test#1. Another change is that WL_{max} was set to 3, instead of 4. Table below shows the general data for test#2 and the (system-generated) questions used as issues for the discussion.

Discussion name: Cegos-22-07-01	Domain : Responsable formation (RF)
Start date: 22/07/2001	End date: 31/07/2001
Number of questions: 10 (system-generated)	Number of participants: 11
Number of cycles: 4	WL_{max}: 3
Questions:	
Q-1	Pourrait-on gérer la formation sans évaluer les résultats de la formation? Pourquoi?
Q-2	Pourquoi relier formation et gestion des compétences pour élaborer un plan de formation?
Q-3	Quelle est la différence entre un cahier des charges de formation et un questionnaire de recueil des besoins qui sont deux types de document de préparation du plan de formation?
Q-4	Quel est le lien entre une action de formation et la méthode pédagogique?
Q-5	Considérez-vous qu'on doit impérativement concevoir la progression pédagogique pour concevoir les modules de formation? Pourquoi?
Q-6	Faut-il évaluer la satisfaction client pour évaluer les résultats de la formation? Justifiez.
Q-7	Pourrait-on acheter une formation en externe sans rédiger un appel d'offre? Pourquoi?
Q-8	Quelle situation favorise l'utilisation d'un brainstorming par rapport à un jeu de rôle en tant que ressources pédagogiques?
Q-9	Une méthode interrogative et une méthode démonstrative sont deux types de méthode pédagogique. Alors, quelle est la différence entre les deux?
Q-10	Comment définir un référentiel compétences ?

Tab. 5.3: General data for test #2 (Cegos-22-07-01)

Performance measures for test#2

Table below shows the evaluation parameters and the performance measures after the end of the discussion.

Total number of nodes	140
Percentage of unanswered nodes	34.88%
Average coverage	11.85%
Average polemicity	18.54%
Progress EXT	36.67%
Progress REPLY	76.67%
Progesss BUDDY	7.65%
Progress VLD-ATCK	n/a
Progress SPREAD	9.20%
Average progress	32.55%

Tab. 5.4: Evaluation parameters and performance measures for test #2

The discussion tree has reached 140 nodes and 34.88% of the nodes remained unanswered. In average, each node of the tree covered 11.85% of the participants and the percentage of refuting nodes (average polemicity) was 18.54%.

The EXT mechanism advanced 36.67%, which means that the system did not do a good job on collecting answers from the participants. On the other hand, 76.67% of the refuted positions were given the right of response (Progress REPLY). Respectively 7.65% and 9.20% of the BUDDY and SPREAD assignments were incorporated in the discussion. The discussion average progress reached 32.55%

Evaluation of test#2

From the above data, we observe that the discussion carried out in test#2 was shorter, more participative and slightly more polemical than that of test#1. The low performance of the EXT mechanism (only 36.67% of progress) is justified by the fact that, in this test, we had only 4 discussion cycles and the maximum workload (WL_{max}) was set to ‘3’, instead of 4, as in test#1. In general, the lower the WL_{max}, the slower the discussion advances.

The REPLY, BUDDY and SPREAD mechanisms reached about the same progress rates than in test#1. The REPLY progress of 76.67% indicates that most of the refuted positions were argued by their original authors. As in test#1, the BUDDY and SPREAD progress measures remained under 10%, which is again explained by the fact that the number of assignments proposed by these mechanisms accumulates at each discussion cycle and cannot be absorbed by the limited and constant value of WL_{max}.

However, the most important contribution of this test is that the questions of the discussion were not defined by the tutor, as in test#1. Rather, they were produced by the NL Generator out of the available domain models. The results show that system-generated questions can be even more effective than those produced by a human tutor. Although this issue is far beyond the objectives of the present work, we have reasons to believe that system-generated questions can be more objective and thus more suitable for group discussions, specially when the domain models are well constructed. We observed for instance that, when an ontology is carefully constructed, i.e. with well defined categories and intermediate concepts, the questions produced by the NL Generator can be significantly reflective. On the other hand, if the ontology mixes concepts of different natures under the same parent concept, the resulting questions are frequently nonsense.

This test allowed us to observe a discussion fully originated by system-generated questions. The item below shows an excerpt of such a discussion.

Selected interactions from test#2

In order to observe and analyze the interactions that occurred through this test, we selected question Q-9 ("What is the difference between the interrogative and the demonstrative pedagogical methods?") to follow up a small part of this discussion. Figure 5.14 shows the discussion tree for question 9 (DE-9), as it appears on the local interface. Our special interest, in this example, is the discussion thread originated by the answer 'Alt-2' (inside the dotted rectangle in figure 5.14). In order to analyze this thread in deeper details, we show the original textual content of each node of this thread, as well as the assignment mechanisms responsible for each interaction.

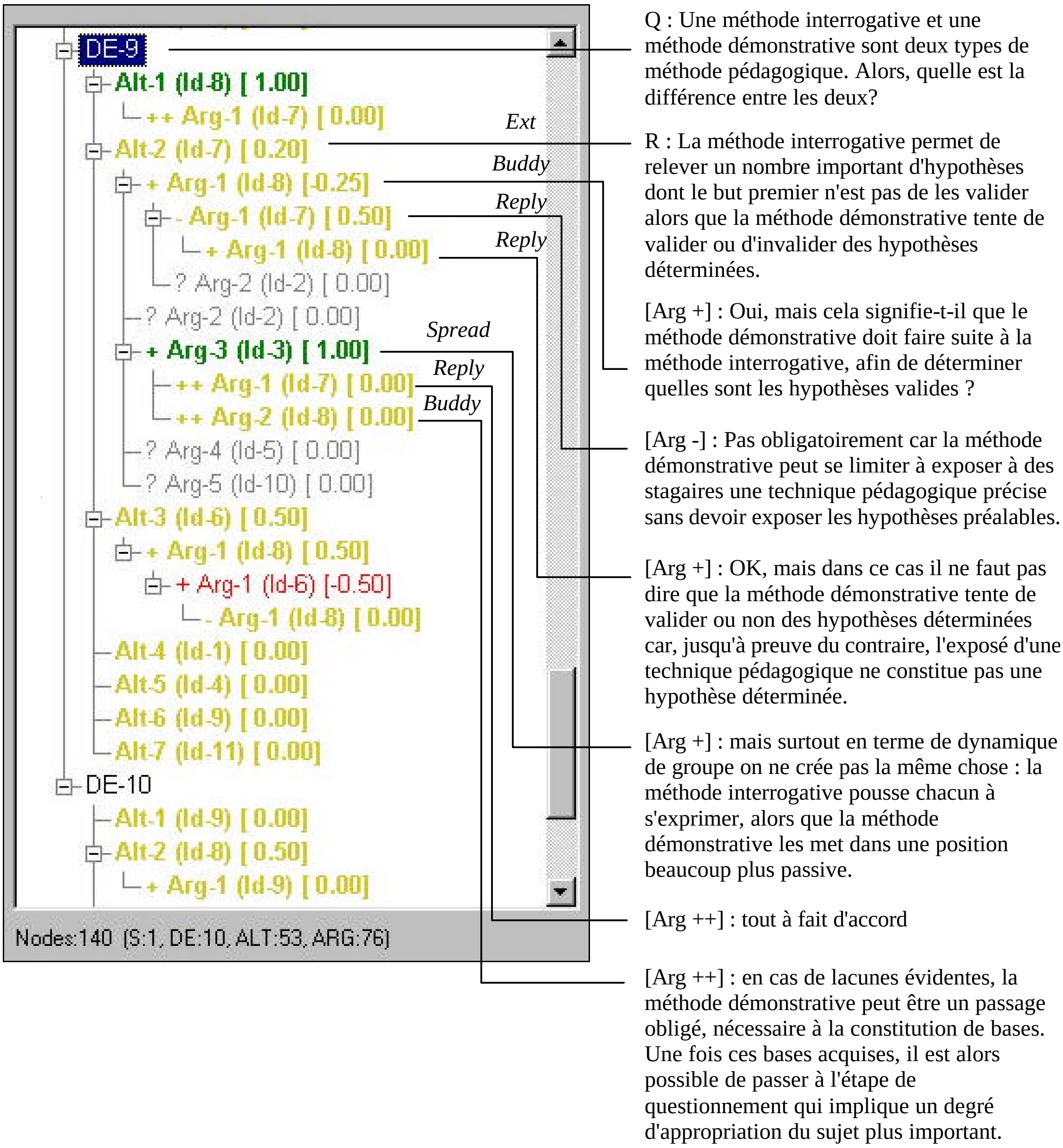


Fig. 5.14: Example of discussion thread for test #2

As in the case of test#1, we observe that the mechanisms *Buddy*, *Reply* and *Spread* worked together to mediate the above discussion thread.

Initially, the answer ‘Alt-2’ provided by Id-7 was not fully supported by Id-8. This disagreement originates successive argumentation moves between Id-7 and Id-8, with progressive clarifications that tend to a common understanding between the two parties. Meanwhile, a third participant (Id-3) joins this discussion (assigned by the *Spread* mechanism) and adds a remark (Arg+) on answer ‘Alt-2’. After this, the system does a very good job on calling up Id-7 and Id-8 to analyze Id-3’s remark. Id-7 was assigned by the *Reply* mechanism, because he was partially refuted by Id-3, while Id-8 was assigned by the *Buddy* mechanism for having participated in the same issue.

5.2.3 Test #3

The third test was carried out at PUC PR in April-May, 2002. This test involved 20 participants discussing over 9 issues along 9 discussion cycles. The most important innovations of this test were: (i) the longer period of discussion (9 cycles in one month); (ii) and the profile of the participants (graduate students instead of professionals); (iii) the addition of the VLD-ATCK mechanism and (iv) a more detailed trace of the progress measures (at each cycle, instead of at the end of the discussion). As in test#1, the questions for this test were created by the tutor.

Table below shows the general data for test#3 and the (tutor-generated) questions used as issues for the discussion.

Discussion name: SO-Abril-02	Domain : Operating Systems
Start date: 16/04/2002	End date: 17/05/2002
Number of questions: 9 (tutor-generated)	Number of participants: 20
Number of cycles: 9	WL_{max}: variable (4-5)
Questions:	
Q-1	Qual a influência do tamanho do QUANTUM no desempenho de um Sistema Operacional?
Q-2	O algoritmo Round Robin com prioridades é um algoritmo justo com todos os processos? Justifique.
Q-3	Pode-se utilizar o algoritmo Round Robin com prioridades em uma sistema que atende processos em tempo real? Como?
Q-4	O algoritmo de escalonamento de processos do Windows NT é bom ou ruim? Por quê?
Q-5	Descreva o algoritmo de escalonamento de processos utilizado no Linux (www.kernel.org) e cite suas principais VANTAGENS.
Q-6	Descreva o algoritmo de escalonamento de processos utilizado no Linux (www.kernel.org) e cite seus principais PROBLEMAS.
Q-7	O desenvolvimento do simulador melhorou o seu conhecimento? Por quê?
Q-8	Se você fosse o professor da disciplina, quais otimizações você faria no trabalho do 1o bimestre?
Q-9	O semáforo resolve definitivamente o problema da exclusão mútua? Justifique?

Tab. 5.5: General data for test #3 (SO-Abril-02)

Performance measures for test#3

Table below shows the evaluation parameters and the performance measures at each discussion cycle.

Cycle > Parameter	1	2	3	4	5	6	7	8	9
Number of nodes	86	166	246	326	406	481	562	656	756
Percentage of unanswered nodes	7.01%	8.97%	9.75%	12.97%	14.65%	17.20%	20.83%	35.30%	28.55%
Average coverage	8.18%	9.18%	7.76%	7.60%	7.54%	7.53%	7.68%	7.71%	7.67%
Average polemicity	0.00%	8.58%	8.38%	12.44%	15.78%	26.93%	27.34%	25.67%	25.05%
Progress EXT	44.44%	63.64%	69.52%	95.45%	97.16%	97.73%	97.73%	97.73%	100.0%
Progress REPLY	0.00%	0.00%	27.78%	61.90%	50.00%	62.71%	64.71%	67.89%	73.13%
Progesss BUDDY	0.00%	1.35%	2.73%	3.04%	2.96%	3.36%	4.38%	5.02%	6.06%
Progress VLD-ATCK	0.00%	0.00%	14.29%	28.57%	28.57%	30.43%	32.43%	33.33%	33.33%
Progress SPREAD	0.00%	1.17%	2.26%	2.99%	3.31%	4.92%	4.66%	6.63%	7.56%
Average progress	8.89%	13.23%	23.32%	38.39%	36.40%	39.83%	40.78%	42.12%	43.56%

Tab. 5.6: Evaluation parameters and performance measures for test #3

The discussion tree has reached 756 nodes after nine discussion cycles, with a growth rate of approximately 80 nodes per cycle. The percentage of unanswered nodes grew from 7.01% to 28.55%, showing high concentration in the last two cycles. The average coverage remained stable around 8%. The average polemicity increased from 8.58% to 25.05%, mostly concentrated at the end of the discussion.

The EXT mechanism started with a progress measure of 44.44% and advanced up to 97.73% in the 6^{th} cycle, when it became stable for three consecutive cycles before reaching 100% at the end of the discussion. This is explained by the fact that, during cycles 6, 7 and 8 the 'tutor-only-validates'[28] parameter was set to TRUE, which stopped the system from assigning Alt-nodes to the tutor, and consequently avoided the EXT mechanism to reach 100%.

The REPLY mechanism reached a progress measure of 73.13%, which means that most of the refuted positions were given the right of response. The progress of the

[28] We recall that the 'tutor-only-validates' parameter, when set to TRUE, makes the system assign only refuting ARG nodes to the tutor.

BUDDY and the SPREAD mechanisms remained under 10%, as in previous tests. The VLD-ATCK mechanism reached 33.33% of progress, meaning that the tutor was assigned 1/3 of all refuting nodes to validate. The discussion average progress reached 43.53%.

Figure 5.15 shows the graphical representation of the progress measures along the discussion cycles (C_1 to C_9).

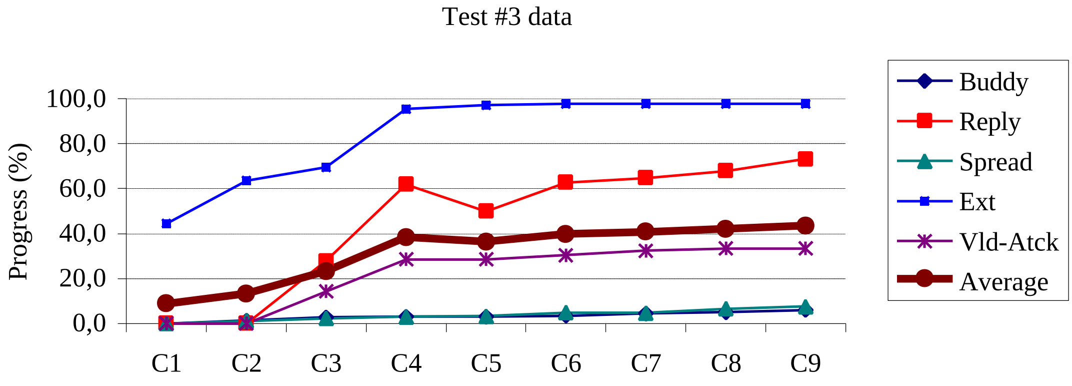


Fig. 5.15: Discussion progress for test #3

Evaluation of test#3

From the above data, we observe that the discussion carried out in test#3 was longer and more polemical than the first two tests. We observe that the discussion became more polemical after the 4^{th} cycle, which is indicated by a higher density of refuting arguments. The low performance of the BUDDY and SPREAD mechanisms was again expected, as mentioned in the preceding tests. The VLD-ATCK mechanism, which was first implemented in this test, assigned around 30% of the refuting argumentations for group validation. In general, this test confirmed the progress measures and general parameters observed in the first two experiments.

Selected interactions from test#3

In order to observe and analyze the interactions that occurred through this test, we selected question Q-1 ("How does the size of the QUANTUM affect the performance of an Operating System?") to follow up a small part of this discussion. Figure 5.16 shows the discussion tree for question 1 (DE-1), as it appears on the local interface. Our special interest, in this case, are the discussion threads originated by the answers ‘Alt-3’ and ‘Alt-5’ (marked by the dotted rectangles in figure 5.16). In order to analyze this thread in deeper details, we show the original textual content of each node of these threads, as well as the assignment mechanisms responsible for each interaction.

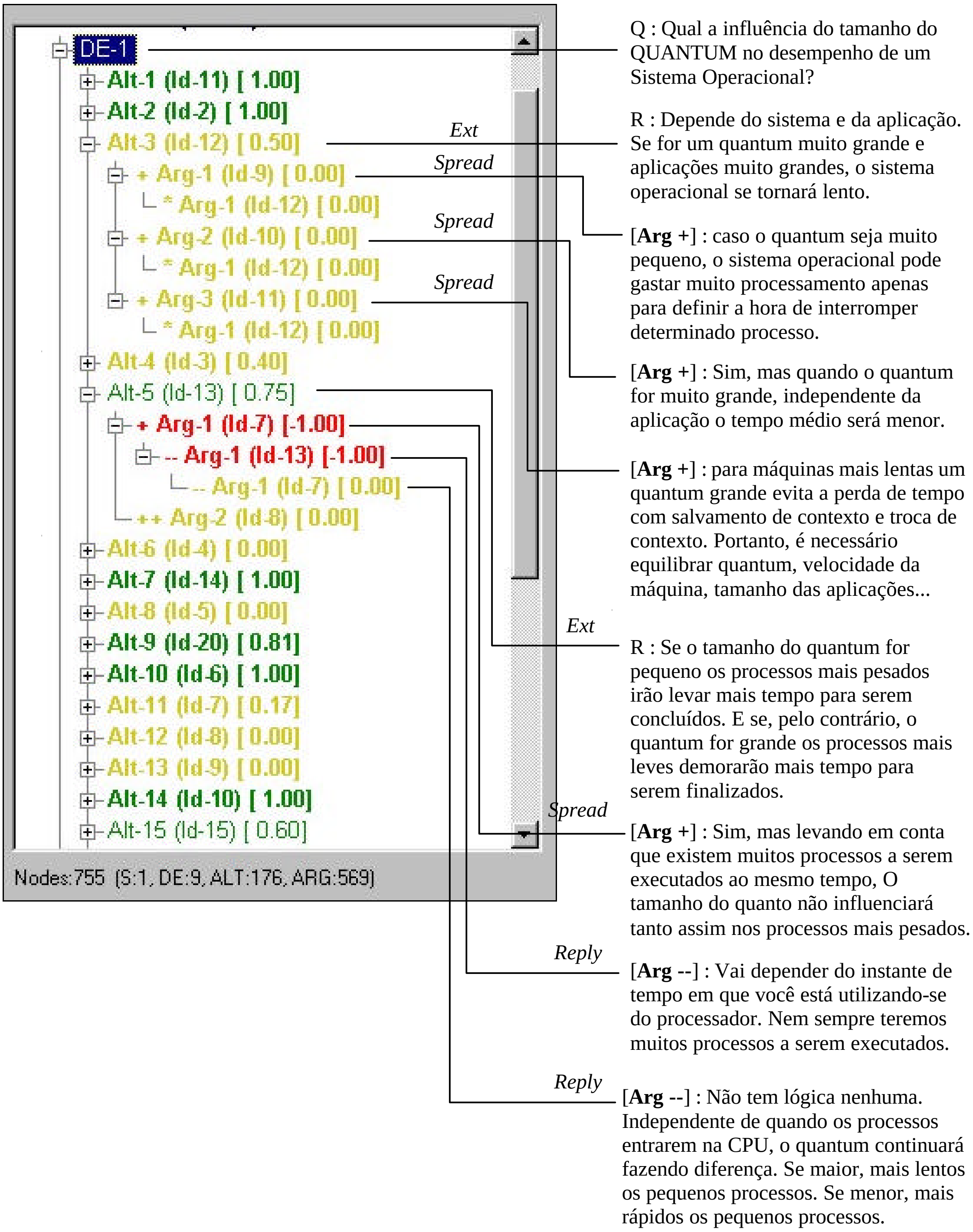


Fig. 5.16: Example of discussion thread for test #3

In the first thread, originated by 'Alt-3', the answer provided by Id-12 was not fully supported by participants Id-9, Id-10 and Id-11. As Id-12 didn't argue against any of the comments from the three participants, the system decided not to expand the thread any further.

On the other hand, the second thread, originated by 'Alt-5', is more polemical, since no agreement seems to be possible between the positions from Id-13 and Id-7. In this case, as in the two previous tests, the Reply mechanism was again responsible for attempting to solve disagreements.

5.3 Simulating discussion scenarios

The need for data to observe the behavior of AMANDA in different situations and the practical difficulties in carrying out large number of discussions with real students, lead us to consider a way of simulating a discussion. This simulation should generate a discussion as if it were produced by real students and to provide data to analyze the outcomes of the discussion is a wide range of situations. This section describes the discussion simulator presenta the corresponding results.

5.3.1 Discussion simulator

The discussion simulator is a software that creates and simulates discussions, from simple two-party discussions to complex discussions involving a large number of participants and issues. A discussion is simulated by setting a number of 'discussion parameters' (e.g. the number of participants/issues, the maximum workload, the agreement level, etc.) and running the simulator along a number of discussion cycles.

Internally, the simulator creates a discussion from the specified parameters and generates 'simulated answers' along the desired number of cycles. At each discussion cycle, the answers are simulated according to the specified agreement level and the assignment mechanisms are applied to open new discussion cycles.

The agreement level

The agreement level is a parameter used by the simulator to produce discussions with varying degrees of consensus. Based on this parameter, the simulator determines the distribution of supporting and refuting nodes (Arg++, Arg+, Arg- and Arg-- nodes), as shown in table 5.7 and explained in the paragraph below.

Agreement level	ARG++	ARG+	ARG-	ARG--
HIGHEST	100%	0%	0%	0%
HIGH	40%	30%	20%	10%
MEDIUM	25%	25%	25%	25%
CENTERED	0%	50%	50%	0%
LOW	10%	20%	30%	40%
LOWEST	0%	0%	0%	100%

Tab. 5.7: Agreement levels

When the agreement level is set to HIGHEST, the simulator produces 100% of fully supporting (Arg++) nodes, i.e. it simulates 'the highest possible consensual discussion'. When set to HIGH, 70% of the nodes are supporting (Arg++ and Arg+) and 30% are refuting (Arg- and Arg--) nodes, which corresponds to a 'mostly consensual' discussion. The MEDIUM agreement level simulates a discussion where supporting and refuting argumentations are equally distributed. The CENTERED agreement level excludes radical positions (Arg++ and Arg--) and distributes the nodes equally among Arg+ and Arg- nodes. The LOW agreement level simulates a 'mostly polemical' discussion by assigning 30% of supporting nodes and 70% of refuting nodes. Finally, the LOWEST agreement level corresponds to 100% of fully refuting nodes, which simulates 'the highest possible polemical discussion'.

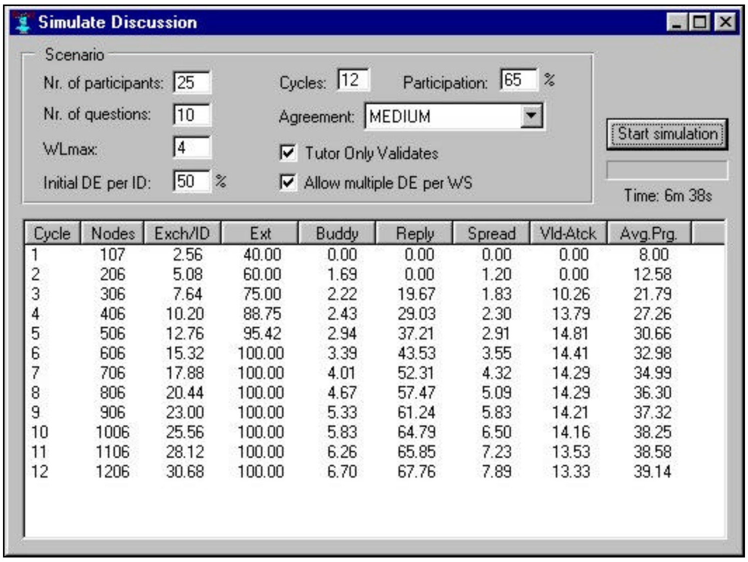
The participation level

The participation level is a parameter used by the simulator to produce discussions with varying degrees of participation. Based on this parameter, the simulator determines the percentage of 'answered' and 'unanswered' nodes. For instance, a participation level of 75% makes the simulator randomly choose 25% of the simulated nodes and marked them as 'unanswered'.

The simulator interface

The simulator interface (Fig. 5.17) allows creating a discussion and simulating it along the desired number of cycles. The parameters for creating a discussion are:

- the number of participants;
- the number of questions;
- the workload per participant (WL_{max});
- the agreement level of the group (highest, high, medium, low, lowest);
- the participation level (0 - 100%);
- the 'tutor-only-validate' parameter (TOV) and
- the 'allow multiple DE per WS' parameter (Multiple DE)[29].



Cycle	Nodes	Exch/ID	Ext	Buddy	Reply	Spread	Vld-Atck	Avg.Prg.
1	107	2.56	40.00	0.00	0.00	0.00	0.00	8.00
2	206	5.08	60.00	1.69	0.00	1.20	0.00	12.58
3	306	7.64	75.00	2.22	19.67	1.83	10.26	21.79
4	406	10.20	88.75	2.43	29.03	2.30	13.79	27.26
5	506	12.76	95.42	2.94	37.21	2.91	14.81	30.66
6	606	15.32	100.00	3.39	43.53	3.55	14.41	32.98
7	706	17.88	100.00	4.01	52.31	4.32	14.29	34.99
8	806	20.44	100.00	4.67	57.47	5.09	14.29	36.30
9	906	23.00	100.00	5.33	61.24	5.83	14.21	37.32
10	1006	25.56	100.00	5.83	64.79	6.50	14.16	38.25
11	1106	28.12	100.00	6.26	65.85	7.23	13.53	38.58
12	1206	30.68	100.00	6.70	67.76	7.89	13.33	39.14

Fig. 5.17: Discussion simulator interface

When the simulation is started, the simulator reads the specified parameters, builds the corresponding discussion structure and starts generating discussion cycles according to the agreement and participation levels. At each cycle, the simulator outputs the following information:

- the total number of nodes of the discussion tree;
- the average number of exchanges per participant (Exch/Id);
- the progress measures for each assignment mechanism and
- the average progress of the discussion.

The simulated discussion of figure 5.17 is composed of 10 questions among 25 participants along 12 cycles. In this example, the agreement level is set to 'medium', the participation level is set to 65% and WL_{max} = 4. Yet, the 'tutor-only-validates' parameter is set to TRUE, as well as the 'allow multiple DE per WS'.

The simulator shows that, at the end of the 12th cycle, the discussion tree reached 1206 nodes, with an average of 30.68 interactions per participant. The assignment mechanisms achieved 100%, 6.70%, 67.76%, 7.89 and 13.33% of progress for Ext, Buddy, Reply, Spread and Vld-Atck respectively. The average progress of the discussion was 39.14%.

5.3.2 Discussion scenarios

In order to simulate discussions in different contexts, we create the notions of 'generic discussion' and 'discussion scenario'. A generic discussion is a vector composed of the discussion parameters, while a discussion scenario is an instance of a generic discussion, created by assigning specific values to the parameters. By changing the discussion parameters, we obtain a different scenario and consequently a different discussion context.

Different scenarios produce different outcomes from the discussion. For instance, high polemical discussions, i.e. with low agreement levels, will be mediated differently than high consensual ones and will consequently yield in different progress measures for the assignment mechanisms. It is reasonable to think, for example, that consensual discussions will result in higher progress measures than polemical ones. Analogously, a discussion among a large set of participants should take longer to achieve the same progress measures than a discussion among fewer participants. The purpose of creating different discussion scenarios is to observe the effects of the discussion parameters over the progress measures and hopefully establish their optimal values.

---

[29] When the 'Multiple DE' parameter is set to TRUE, the system allows multiple arguments of the same question (DE) to appear in a given discussion form. Otherwise, the discussion forms will only contain arguments from different questions.

Scenarios to be simulated

Our aim here is to establish the boundaries of the simulation by specifying a finite and comprehensive set of discussion scenarios to be simulated. To do this, we assign to each discussion parameter five possible values, which correspond to the following ranges (*minimum*, *low*, *medium*, *high* and *maximum*). Then we create a set of scenarios where the parameters are limited to these values. For example, the 'number of participants' parameter will assume five different values, for example: 4 (minimum), 15 (low), 30 (medium), 65 (high) and 100 (maximum). This means that, for every discussion scenario, the "number of participants" will fall into one of the above values.

The values used to represent each of the five ranges were chosen so as to reflect the 'normal' conditions in distance learning. For instance, in practice, it's unlikely that we carry a discussion with more than 100 students or that we launch more than 20 issues to be simultaneously discussed. This does not mean, however, that the simulator cannot handle a wider range of values, or that AMANDA cannot accommodate more than 100 participants; it only means that we will use these values to limit the simulation results presented in this work.

Table 5.8 shows the discussion parameters with their respective ranges and values, where each cell corresponds to a specific discussion scenario (S_1 to S_{23}).

Parameters	Value range				
	Minimum	Low	Medium	High	Maximum
Number of participants	4 [S_1]	15 [S_6]	30 [S_{11}]	65 [S_{12}]	100 [S_{17}]
Number of questions	1 [S_2]	5 [S_7]	10 [S_{11}]	15 [S_{13}]	20 [S_{18}]
WL_{max}	2 [S_3]	3 [S_8]	4 [S_{11}]	6 [S_{14}]	10 [S_{19}]
Agreement level	Lowest [S_4]	Low [S_9]	Medium [S_{11}]	High [S_{15}]	Highest [S_{20}]
Participation level	20% [S_5]	40% [S_{10}]	60% [S_{11}]	80% [S_{16}]	100% [S_{21}]
Tutor only validates (TOV)	True	-	True	-	False [S_{22}]
Multiple DE	True	-	True	-	False [S_{23}]

Tab. 5.8: Parameter values and ranges

A given scenario S_i is built by taking the corresponding parameter value from the cell where it appears, e.g. 'number of participants = 4 for S_1', and assuming the 'medium' value (gray column) for all remaining parameters. For instance, S_6 is parameterized as follows: 15 participants, 10 questions, WLmax = 4, agreement = ‘medium’, participation = 60%, TOV = TRUE and Multiple DE = TRUE.

The middle column corresponds to S_{11} (the ‘average scenario’), i.e. the one with all parameters set to ‘medium’. All other scenarios deviate from S_{11} in exactly one parameter, which allows us to easily observe the effects of a given parameter and compare it to the ‘average scenario’.

Table 5.9 lists all the discussion scenarios and the corresponding parameter values. The gray cells indicate which parameter deviates from the ‘medium’ value for each scenario.

Scenario	Nr. participants	Nr. questions	WL_{max}	Agreem. Level	Participation level	TOV	Multiple DE
S_1	4	10	4	Medium	60%	True	True
S_2	30	1	4	Medium	60%	True	True
S_3	30	10	2	Medium	60%	True	True
S_4	30	10	4	Lowest	60%	True	True
S_5	30	10	4	Medium	20%	True	True
S_6	15	10	4	Medium	60%	True	True
S_7	30	5	4	Medium	60%	True	True
S_8	30	10	3	Medium	60%	True	True
S_9	30	10	4	Low	60%	True	True
S_{10}	30	10	4	Medium	40%	True	True
S_{11} *	30	10	4	Medium	60%	True	True
S_{12}	65	10	4	Medium	60%	True	True
S_{13}	30	15	4	Medium	60%	True	True
S_{14}	30	10	6	Medium	60%	True	True
S_{15}	30	10	4	High	60%	True	True
S_{16}	30	10	4	Medium	80%	True	True
S_{17}	100	10	4	Medium	60%	True	True
S_{18}	30	20	4	Medium	60%	True	True
S_{19}	30	10	10	Medium	60%	True	True
S_{20}	30	10	4	Highest	60%	True	True
S_{21}	30	10	4	Medium	100%	True	True
S_{22}	30	10	4	Medium	60%	False	True
S_{23}	30	10	4	Medium	60%	True	False

* the ‘average scenario’

Tab. 5.9: Discussion scenarios

5.3.3 Simulation results

This item presents the simulation results for each of the 23 discussion scenarios. To facilitate the interpretation of the results, we divide the scenarios into eight distinct classes, see table 5.10.

Class	Scenarios	Parameter deviating from 'medium'
Class 1	$\{S_1, S_6, S_{12}, S_{17}\}$	number of participants
Class 2	$\{S_2, S_7, S_{13}, S_{18}\}$	number of questions
Class 3	$\{S_3, S_8, S_{14}, S_{19}\}$	workload per participant (WL_{max})
Class 4	$\{S_4, S_9, S_{15}, S_{20}\}$	agreement level
Class 5	$\{S_5, S_{10}, S_{16}, S_{21}\}$	participation level
Class 6	$\{S_{11}\}$	none (all parameters have 'medium' values)
Class 7	$\{S_{22}\}$	TOV (tutor-only-validates)
Class 8	$\{S_{23}\}$	Multiple DE

Tab. 5.10: Classes of discussion scenarios

A class of scenarios is composed of all scenarios which deviate from the 'average scenario' by the same parameter. For example, class 1 is made up of all scenarios which deviate by the 'number of participants', while class 2 joins all scenarios which deviate by the 'number of questions'. This allows us to directly observe how a given parameter, say the 'number of participants', affects the progress of the discussion when it ranges from the minimum to the maximum values.

In order to observe the progress of the discussion in different situations, we simulated each of the 23 scenarios of table 5.9 and collected the progress measures for the assignment mechanisms along 10 discussion cycles. We grouped the results according to the classes of scenarios, so as to observe how the isolated parameters affect the discussion. The results of the simulation are shown in the graphics below.

Simulation results for ‘class 1’ scenarios

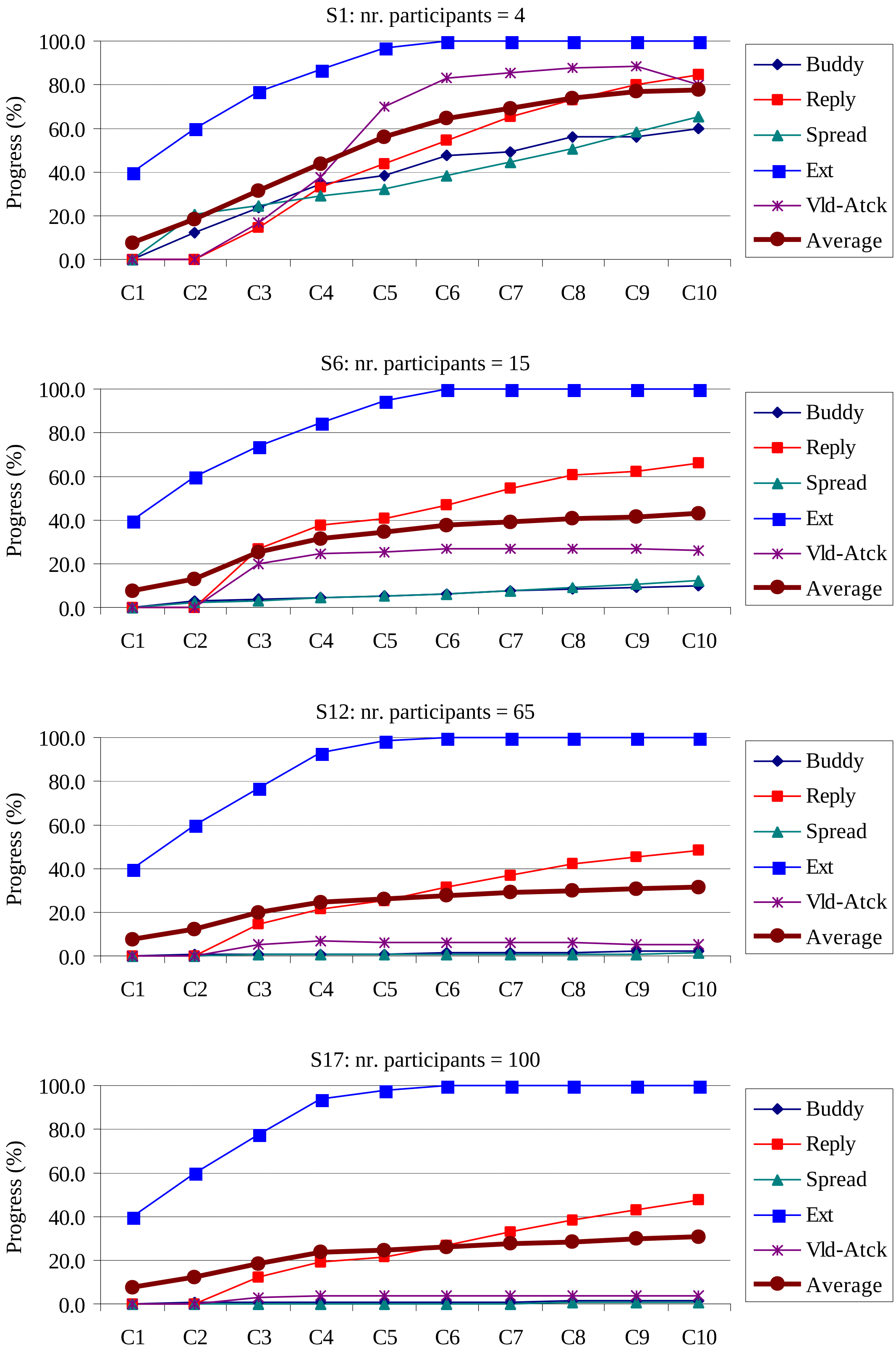


Fig. 5.18: Simulation results for ‘class 1’ scenarios

Simulation results for ‘class 2’ scenarios

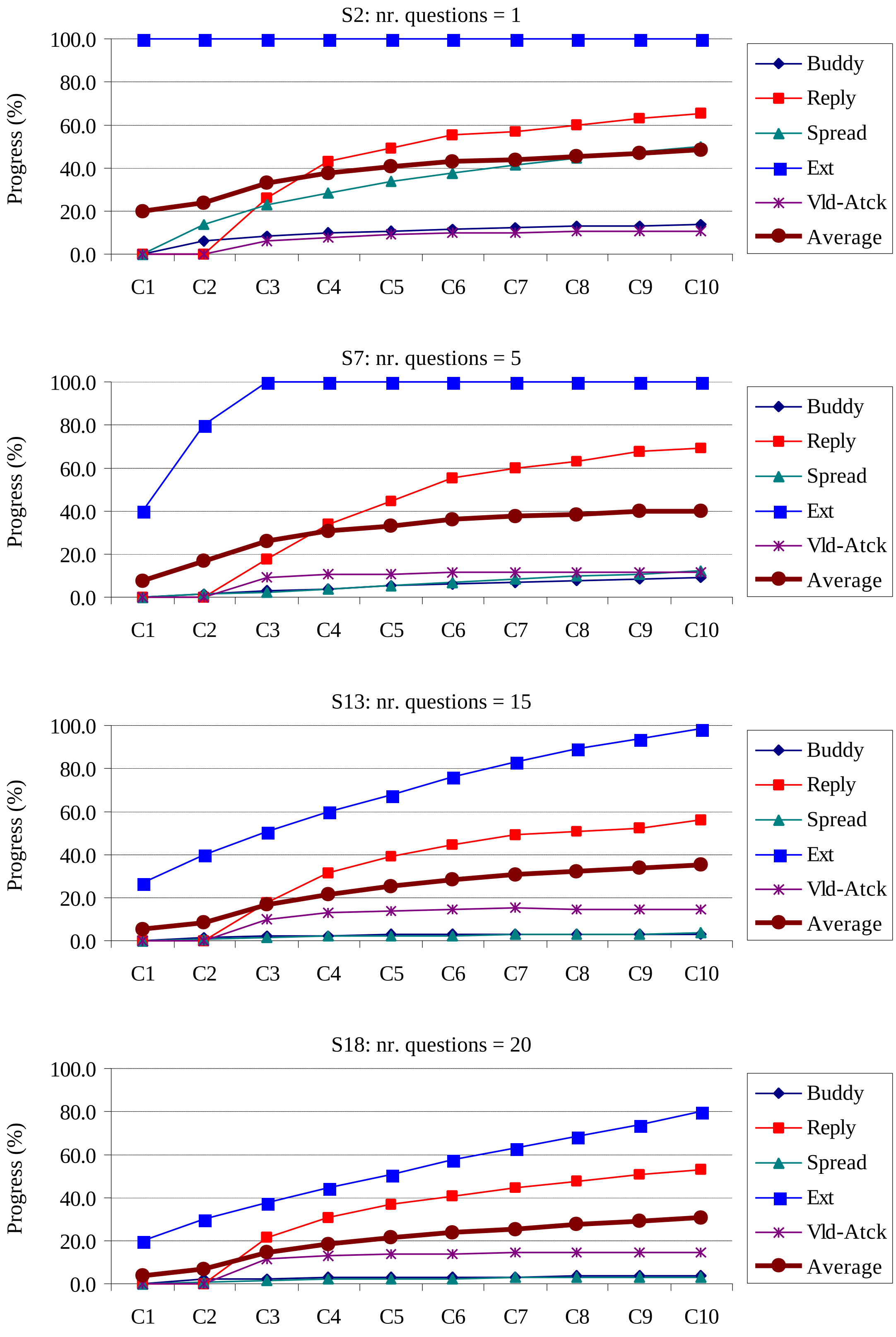


Fig. 5.19: Simulation results for ‘class 2’ scenarios

Simulation results for ‘class 3’ scenarios

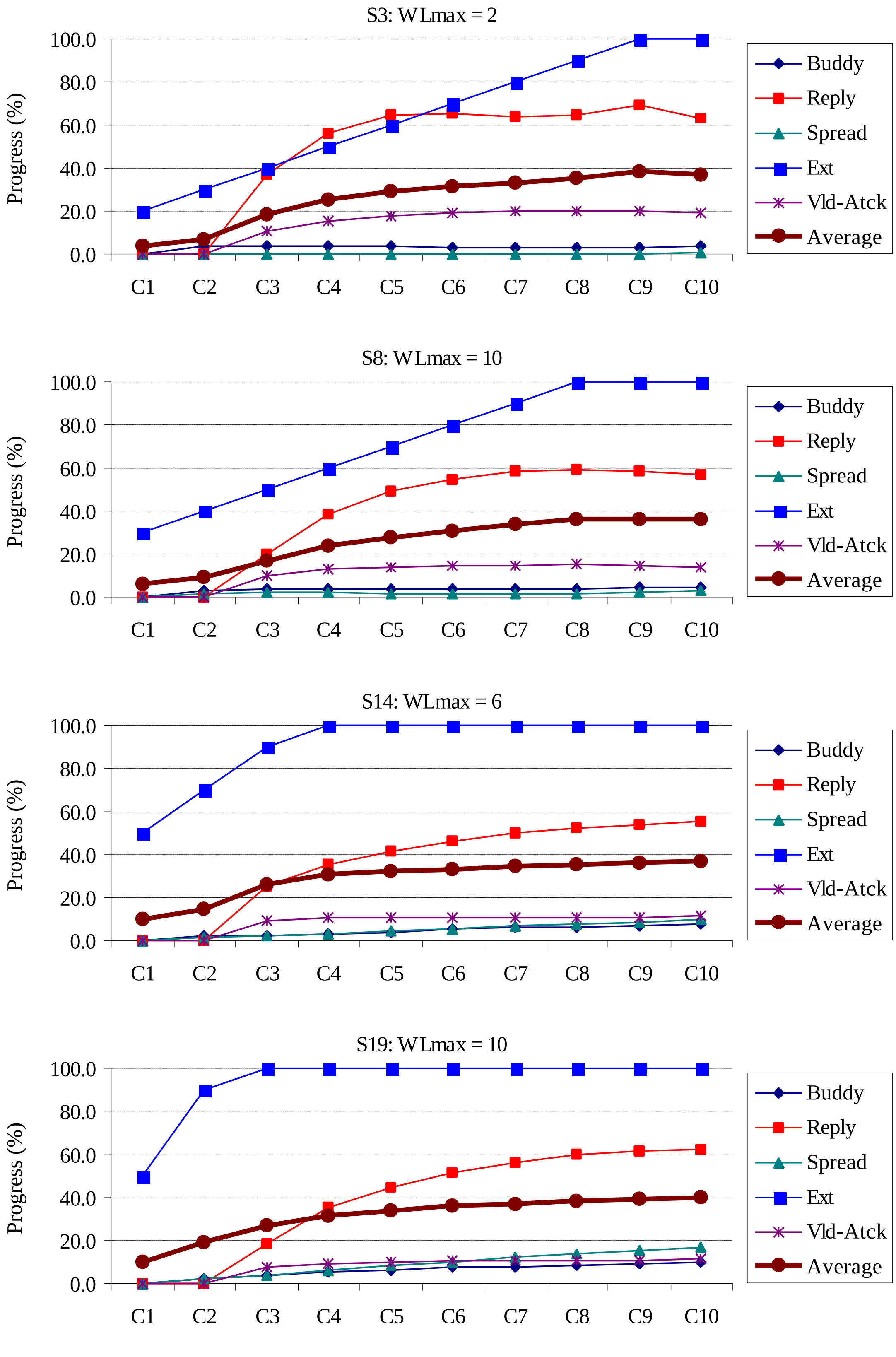


Fig. 5.20: Simulation results for ‘class 3’ scenarios

Simulation results for 'class 4' scenarios

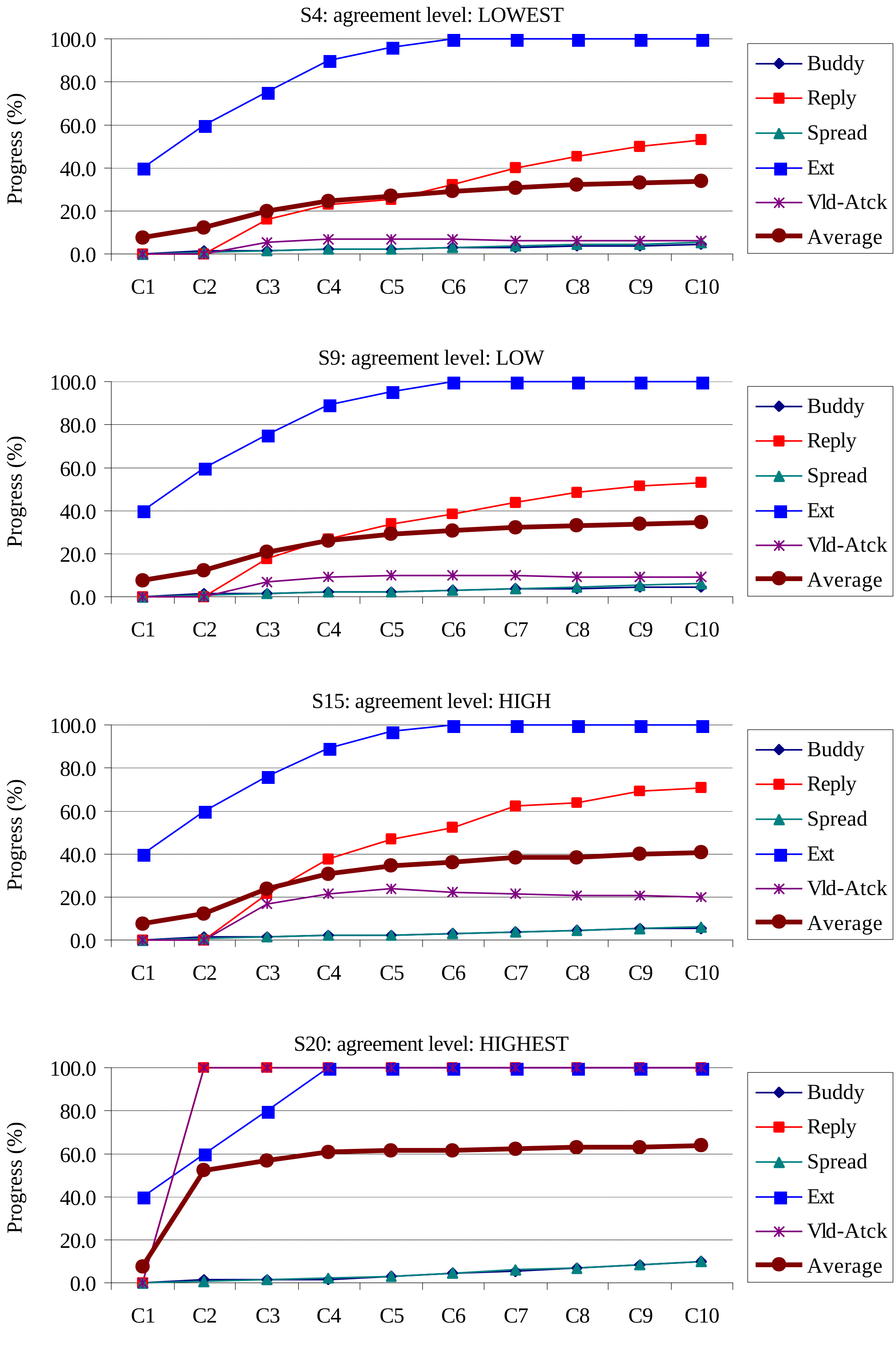


Fig. 5.21: Simulation results for 'class 4' scenarios

Simulation results for ‘class 5’ scenarios

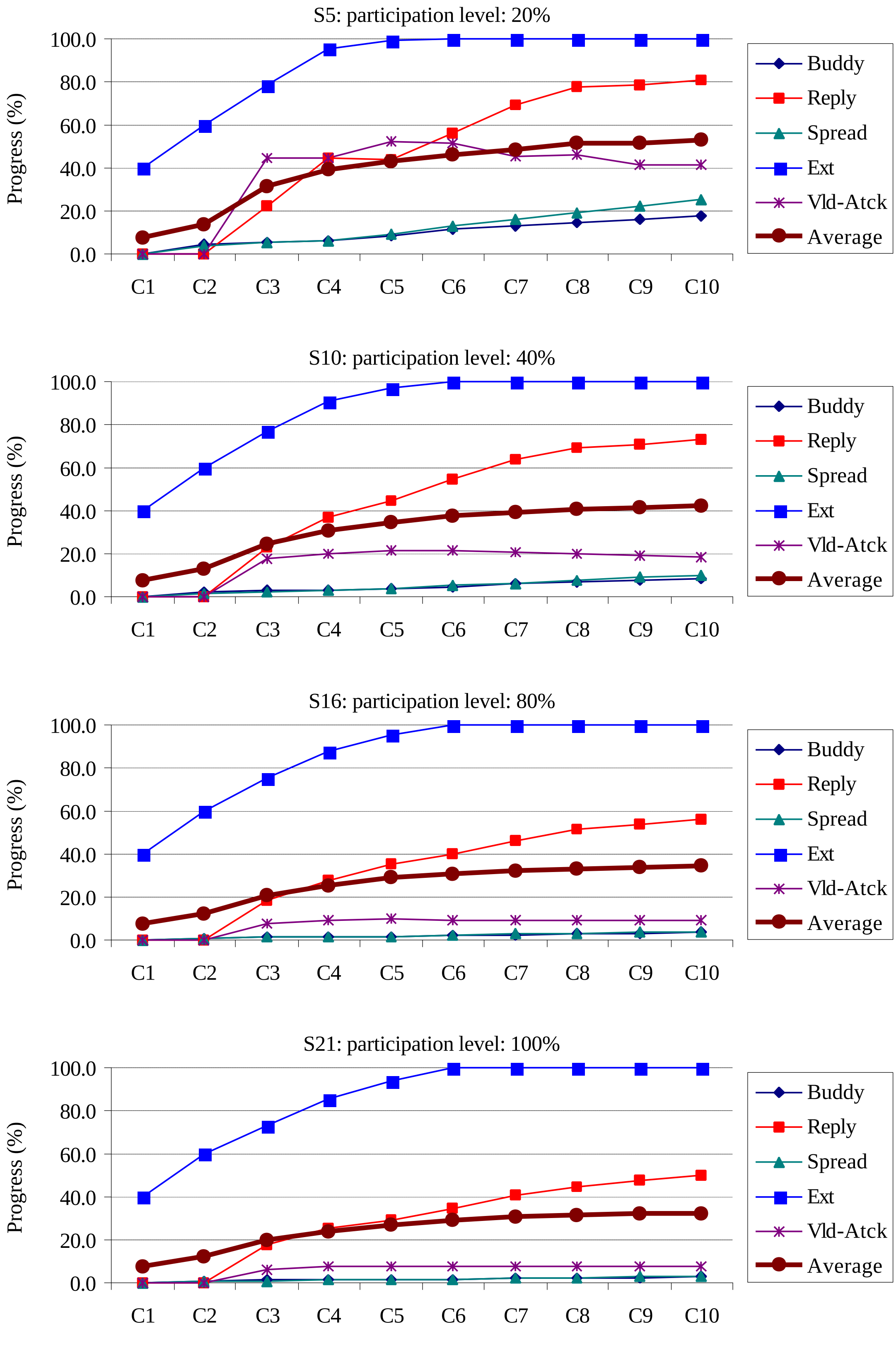


Fig. 5.22: Simulation results for ‘class 5’ scenarios

Simulation results for 'class 6' scenario (average scenario)

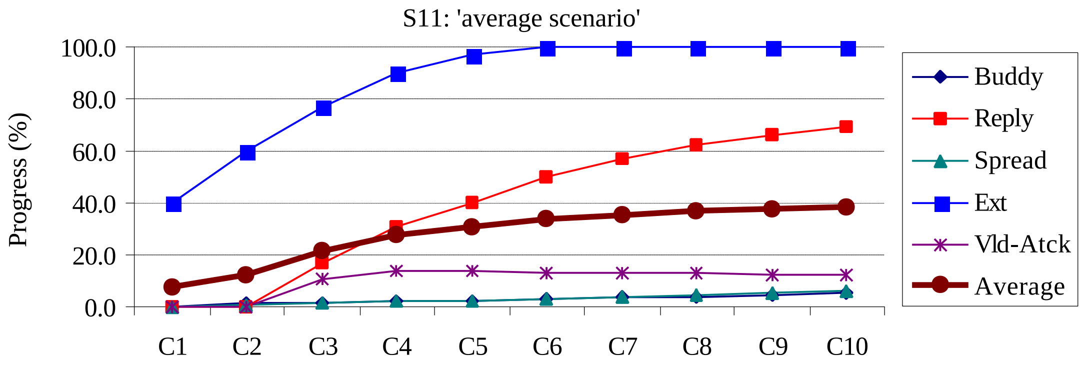


Fig. 5.23: Simulation results for 'class 6' scenario (average scenario)

Simulation results for 'class 7' scenario

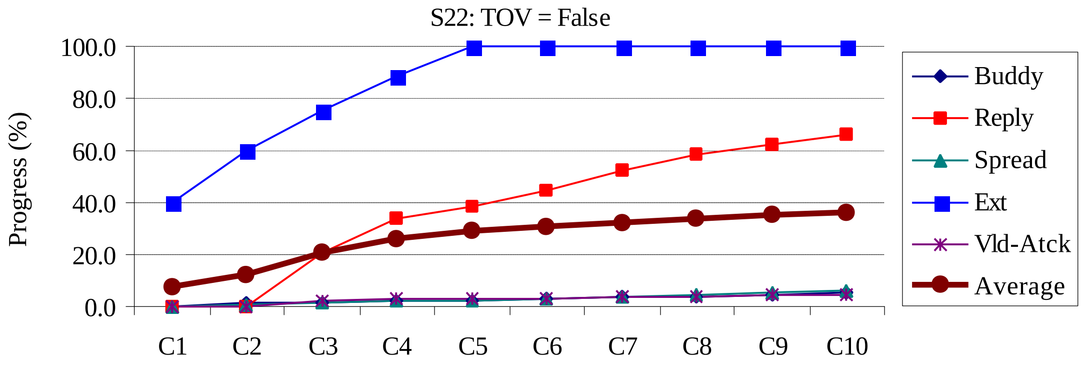


Fig. 5.24: Simulation results for 'class 7' scenario

Simulation results for 'class 8' scenario

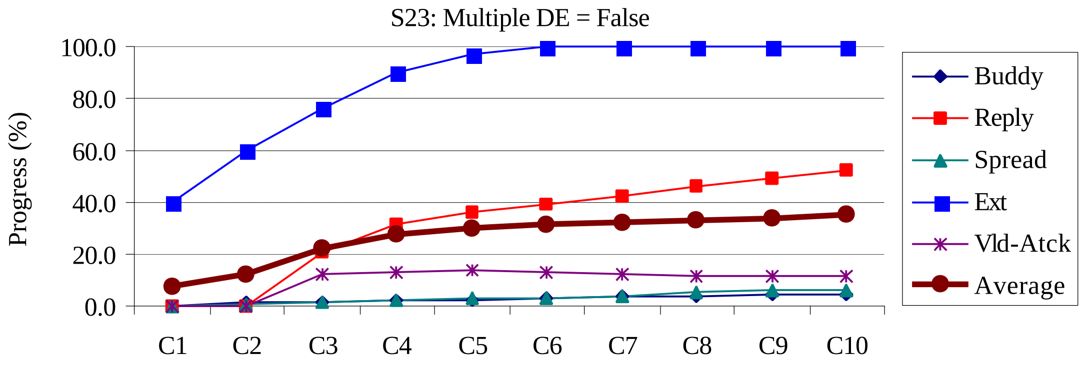


Fig. 5.25: Simulation results for 'class 8' scenario

5.3.4 Analysis of simulation results

We now analyze the effects of each discussion parameter over the progress measures, by observing the resulting progress curves for each discussion scenario (figures 5.18 to 5.25). For a closer analysis, Appendix III shows the simulation results in numbers.

The *number of participants* (see class 1 scenarios in figure 5.18) affects the discussion by reducing the average progress. This reduction is due to a lower performance of nearly all assignment mechanisms, especially the VLD-ATCK mechanism. For instance, when the number of participants increase from 4 to 15 (scenarios S_1 and S_6), the VLD-ATCK progress reduces from 80% to 23% and the average progress reduces from 78% to 43%. This is explained by the fact that the tutor cannot handle the increasing number of refuting argumentations resulting from the larger number of participants. In scenarios S_{12} and S_{17}, where the number of participants is set to 65 and 100 respectively, this effect is less visible, because the low progress of VLD-ATCK (under 10%) is masked by the comparatively high progress of EXT and REPLY.

The *number of questions* (see class 2 scenarios in figure 5.19) affects the discussion measures by reducing the progress of the EXT mechanism. This is expected, since a discussion with a large number of questions takes longer to cover all issues. We observe in scenarios S_{13} and S_{18} that, after 10 discussion cycles, the EXT mechanism did not even reach 100%. The negative effects caused by a large the number of questions could be compensated by increasing the workload (WL_{max}) or extending the discussion over a larger number of cycles.

The *maximum workload* WL_{max} (see class 3 scenarios in figure 5.20) improves the progress of the EXT mechanism, but reduces the progress of the REPLY and VLD-ATCK mechanisms. The increased EXT performance is explained by the fact that higher WL_{max} values make the questions be covered more quickly by the participants. However, after EXT has reached 100%, WL_{max} has no significant effects on the discussion progress. We must note, on the other hand, that high WL_{max} values adds more contributions to the discussion, which increases the number of exchanges per participant, but does not necessarily help the discussion do advance quicker.

The *agreement level* (see class 4 scenarios in figure 5.21) affects the discussion by influencing over the progress measures of the REPLY and VLD-ATCK mechanisms. As expected, higher agreement levels yield in higher performances of the REPLY and VLD-ATCK mechanisms, and consequently improves the average progress of the discussion. In fully consensual discussions (agreement level = HIGHEST), the average progress is 64%, while in fully polemical discussions (agreement level = LOWEST), the average progress falls to 33.80%.

The *participation level* (see class 5 scenarios in figure 5.22) affects the discussion by reducing the performances of the REPLY and VLD-ATCK mechanisms. The higher the participation level, the lower the average progress. This is explained by the fact that higher participation levels produce more ‘valid’ nodes and consequently more refutations. The increasing number of refuting nodes cannot be absorbed by the REPLY and VLD-ATCK mechanisms due to the constant WL_{max}, which results in lower average progress measures. In fact, the effects of the participation level are similar to the effects of the number of participants.

The *tutor-only-validates* (TOV) parameter (see class 7 scenario in figure 5.24) drastically affects the performance of the VLD-ATCK. When TOV = TRUE, i.e. the tutor only validates refuting argumentations, the progress of the VLD-ATCK mechanism is 12.55%. When TOV is set to FALSE, i.e. the tutor behaves as an ordinary discussant, the VLD-ATCK progress falls to 4.63%. This was expected, since when TOV = TRUE the tutor is focused on resolving disputes. However, the increased performance of the VLD-ATCK mechanism does not significantly improve the average discussion progress.

Finally, the *Multiple DE* parameter (see class 8 scenario in figure 5.25) affects the discussion by slightly reducing the performance of the REPLY mechanism. In fact, when Multiple DE = FALSE, the REPLY progress is slowed down by the fact that the system never assigns more than one node from the same issue in a given discussion form. The REPLY progress is affected because disagreements concentrated in a given issue will take longer to be resolved.

5.4 Summary of the chapter

In this chapter, we presented the implementation of the AMANDA method and the results obtained from applying the system to actual training situations. We presented the Coordination module of AMANDA, the corresponding user interfaces and examples of group discussions. We also described the implementation of the KB module and the NL Generator with examples of domain models and system-generated sentences. Afterwards, we analyzed real cases of group discussion and observed the behavior of the system in specific interactions. At the end, we proposed a method for tracing and validating the system in various situations, by simulating discussion scenarios and graphically observing the progress of the discussion.

5.5 Résumé

Ce chapitre décrit l'implémentation d'AMANDA et présente les résultats obtenus dans des situations réelles de formation. Nous présentons le module de coordination, les interfaces d'utilisateur et des exemples de discussions de groupe. Nous y décrivons les modules responsables pour la modélisation de domaine (module KB) et pour la génération de questions (module « NL Generator »). Ensuite nous analysons des cas réels de discussion et nous observons le comportement du système dans des situations de discussion spécifiques. Finalement, nous proposons une méthode de validation, comprenant un simulateur de discussions qui permet d'observer le comportement du système dans une ample gamme de scénarios de discussions et d'enregistrer pour chaque scénario le progrès de la discussion.

Chapter 6

Conclusion and future work

In this work, we described AMANDA, a computational method for mediating asynchronous group discussions in distance learning environments. This method, based on argumentation and domain representation, was conceived as an aid to the coordination of collective discussions. AMANDA was developed to improve the outcomes of group discussions in distance learning courses, as an alternative for the traditional discussion forums. Although the target application is distance learning, AMANDA can also be applied as a "knowledge management" tool for enterprises and research groups. In fact, AMANDA is concerned with the interaction among distant people towards the discussion over a given domain.

The experiments reveal that AMANDA makes it possible to conduct group discussions among distant learners with negligible or no effort from the tutor. In our experiments, we observed that AMANDA may improve the motivation of the students and turn group discussions into disciplined activities. In addition, other motivational elements appear in the course of the discussion, such as participants receiving 'personal' discussion forms to work on and being challenged to argue over conflicting positions from their peers. The *ready-to-do* nature of the discussion forms and the way they are delivered through the Internet reduce the time that the participants need to spend on the discussion.

Another relevant achievement of this work is the generation of natural language questions out of domain models. We have indications that, when domain models are well constructed, the resulting questions can be even more suitable for discussion than those produced by human tutors. However, this and other educational issues demand further research to be certified and are out of the scope of this work.

AMANDA was developed in a modular architecture, which allows for expansion without significant change in code. This is particularly true for the assignment mechanisms, which are totally independent and have their own mediation objectives. In fact, many of the improvements that we can foresee for AMANDA are related to the assignment mechanisms.

Future research on AMANDA may follow a number of possible directions. In what concerns the mediation method itself, i.e. the coordination module, we believe that improvements in the mediation strategy may be proposed and tested, which includes the design of new assignment mechanisms and more flexible arbitration methods. In order to improve the mediation strategy, one of the possible directions is the use of text techniques, such as ontology-based matching, to find semantic relations among participants' postings and consequently create new peer-to-peer interactions. In addition, machine learning techniques could also be applied to allow AMANDA *learn from previous discussions* and use the acquired knowledge to improve its mediation strategy. Another suggested improvement is the use of data mining techniques for knowledge discovery purposes, such as detecting unattended interaction patterns, since the discussions normally produce a large amount of structured data (typically hundreds or thousands of nodes).

Another relevant research lies on the exploitation and analysis of the post-discussion results. Our experiments have shown that discussions may become very large and produce a substantial amount of textual contributions (around 800 postings, as in test#3). This brings another difficulty – that of exploring/analyzing the content of the postings and selecting the most relevant interactions to focus on. It is feasible to think of mechanisms that would explore the discussion tree and grade the discussion threads and postings according to a "parameter of interest". For instance, we may be interested on the most polemical threads and postings, or alternatively on the most consensual ones. We may also need to evaluate the participants according to their overall contribution to the discussion based on a set of "performance parameters". This research requires a deeper understanding of how people communicate in group discussions and how the "cognitive presence" [GAR01] of each participant can be measured.

In what concerns domain modeling and natural language generation, we may suggest that further research be done in order to extend the ideas contained in this work to a broader dimension. This includes a deeper inspection on the extent to which domain models can be explored in educational environments [MIZ00]. In this context, some research questions can be raised, such as: “Can we use domain models to validate students’ postings (text understanding)?” or “Is the proposed model, based on ontologies and task structures, suitable to address the needs of group discussions in every domain?”. These and other related questions may result in new models and extended applications of domain modeling. Contributions from the fields of education and cognitive science are crucial to establish stronger links between the available types of knowledge representation and the way they can be explored to achieve better learning.

Although many improvements and alternative techniques may be suggested, we believe that only a broader application of AMANDA for different types of participants and domains, as well as a careful inspection of the corresponding educational outcomes, could indicate the right way to go. In what concerns the cognitive effects on the students, it is known that group discussions yield better learning ([BAK96], {VEE00], [STA99], [KAY92], [MAS90], [HAR90], [HEN96]), but further work is required to evaluate the actual contribution of AMANDA as an effective learning tool.

Résumé

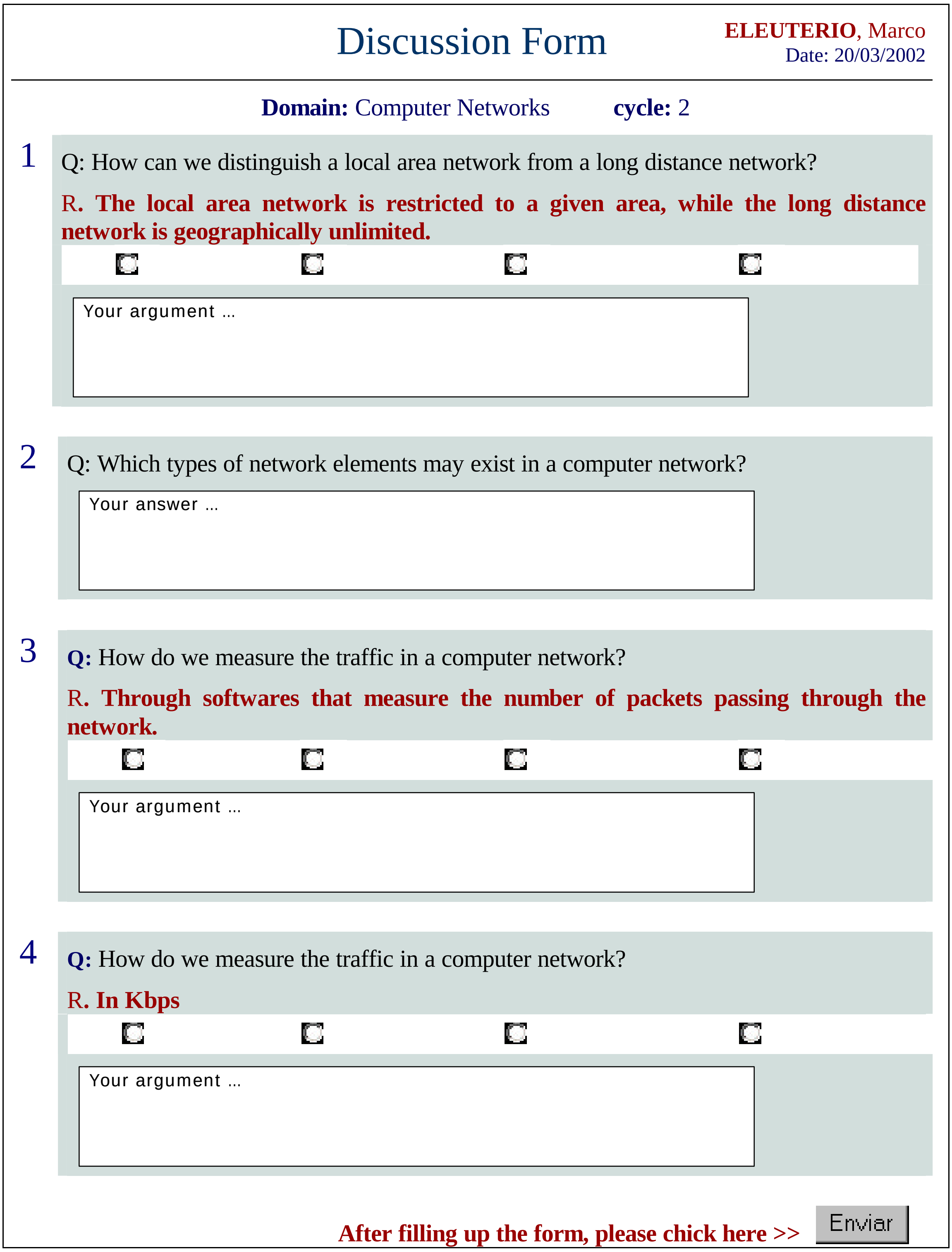
Dans ce travail nous décrivons Amanda, une méthode algorithmique pour la médiation de discussions de groupe à distance. Cette méthode, basée sur la notion d’argumentation et la représentation de la connaissance, a été conçue pour améliorer le niveau d’interaction entre les participants d’une séance de discussion à distance. Les expérimentations révèlent que la méthode proposée est capable d’animer une discussion de groupe sans l’intervention humaine de médiation et que la modélisation de la connaissance de domaine, à l’aide d’ontologies et de modèles de tâches, peut produire des questions en langage naturel comparables à celles produites par un formateur humain.

Dans le futur, nous proposons le traitement du corpus de la discussion pour améliorer le mécanisme de médiation. Ce traitement pourra utiliser les ontologies pour

trouver des liens sémantiques entre les réponses et les argumentations des participants. Nous envisageons aussi l’utilisation d’algorithmes de traitement de texte pour générer une synthèse de la discussion pour une meilleure exploitation des résultats et le développement d’une méthode pour évaluer le niveau de participation des apprenants.

Toutefois, des études éducationnelles plus approfondis sur AMANDA sont indispensables pour guider les travaux de recherche à venir et pour évaluer le rôle de cette méthode comme outil d’apprentissage de groupe.

Appendix I: Discussion form



Discussion Form

ELEUTERIO, Marco
Date: 20/03/2002

Domain: Computer Networks **cycle:** 2

1 Q: How can we distinguish a local area network from a long distance network?

R. **The local area network is restricted to a given area, while the long distance network is geographically unlimited.**

Your argument ...

2 Q: Which types of network elements may exist in a computer network?

Your answer ...

3 **Q:** How do we measure the traffic in a computer network?

R. **Through softwares that measure the number of packets passing through the network.**

Your argument ...

4 **Q:** How do we measure the traffic in a computer network?

R. **In Kbps**

Your argument ...

After filling up the form, please chick here >> Enviar

A 1: An example of discussion form for cycle 2

Appendix II: Results from NL generation

The following is the complete listing of NL sentences produced by the NL Generator with the domain models and sentence patterns available.

Questions produites par AMANDA en fonction du Modèle de Tâches et de l'Ontologie
Nom du stage: not-loaded
Date: 13/5/2002

Nombre de questions résultantes: 288
Nombre de tâches: 41 (139 questions)
Nombre de concepts: 48 (149 questions)

*** MODELE DE TACHES ***

1) Recueillir les besoins à l'aide des entretiens et recueillir les besoins à l'aide des questionnaires sont deux méthodes pour recueillir les besoins de compétence. Alors, comment choisir entre elles?

2) Quelle est l'avantage entre réaliser une formation en interne et acheter une formation en externe pour implémenter la formation?

3) Observer les comportements professionnels et analyser les produits de l'activité sont deux méthodes pour évaluer les transferts en situation professionnelle. Alors, comment choisir entre elles?

4) Quelle est la différence entre observer les comportements professionnels et interpréter les performances individuelles pour évaluer les transferts en situation professionnelle?

5) Observer les comportements professionnels et analyser les situations-problèmes sont deux méthodes pour évaluer les transferts en situation professionnelle. Alors, comment choisir entre elles?

6) Observer les comportements professionnels et réaliser l'entretien de suivi sont deux méthodes pour évaluer les transferts en situation professionnelle. Alors, comment choisir entre elles?

7) Comment choisir entre analyser les produits de l'activité et interpréter les performances individuelles pour évaluer les transferts en situation professionnelle?

8) Comment choisir entre analyser les produits de l'activité et analyser les situations-problèmes pour évaluer les transferts en situation professionnelle?

9) Quelle est l'avantage entre analyser les produits de l'activité et réaliser l'entretien de suivi pour évaluer les transferts en situation professionnelle?

10) Comment choisir entre interpréter les performances individuelles et analyser les situations-problèmes pour évaluer les transferts en situation professionnelle?

11) Comment choisir entre interpréter les performances individuelles et réaliser l'entretien de suivi pour évaluer les transferts en situation professionnelle?

12) Quelle est l'avantage entre analyser les situations-problèmes et réaliser l'entretien de suivi pour évaluer les transferts en situation professionnelle?

13) Y-a-t-il une ordre spécifique entre élaborer un plan de formation et concevoir l'action de formation pour gérer la formation?

14) Peut-on établir une priorité entre élaborer un plan de formation et implémenter la formation pour gérer la formation?

15) Y-a-t-il une ordre spécifique entre élaborer un plan de formation et évaluer les résultats de la formation pour gérer la formation?

16) Y-a-t-il une ordre spécifique entre concevoir l'action de formation et implémenter la formation pour gérer la formation?

17) Y-a-t-il une ordre spécifique entre concevoir l'action de formation et évaluer les résultats de la formation pour gérer la formation?

18) Peut-on établir une priorité entre implémenter la formation et évaluer les résultats de la formation pour gérer la formation?

19) Peut-on établir une priorité entre recueillir les besoins de compétence et relier formation et gestion des compétences pour élaborer un plan de formation?

20) Y-a-t-il une ordre spécifique entre recueillir les besoins de compétence et décoder les besoins en actions de formation pour élaborer un plan de formation?

21) Peut-on établir une priorité entre recueillir les besoins de compétence et élaborer le cahier de charges des actions de formation pour élaborer un plan de formation?

22) Y-a-t-il une ordre spécifique entre recueillir les besoins de compétence et définir les priorités de formation pour élaborer un plan de formation?

23) Peut-on établir une priorité entre recueillir les besoins de compétence et établir le budget prévisionnel pour élaborer un plan de formation?

24) Y-a-t-il une ordre spécifique entre recueillir les besoins de compétence et mettre en forme le plan pour élaborer un plan de formation?

25) Y-a-t-il une ordre spécifique entre relier formation et gestion des compétences et décoder les besoins en actions de formation pour élaborer un plan de formation?

26) Y-a-t-il une ordre spécifique entre relier formation et gestion des compétences et élaborer le cahier de charges des actions de formation pour élaborer un plan de formation?

27) Y-a-t-il une ordre spécifique entre relier formation et gestion des compétences et définir les priorités de formation pour élaborer un plan de formation?

28) Peut-on établir une priorité entre relier formation et gestion des compétences et établir le budget prévisionnel pour élaborer un plan de formation?

29) Y-a-t-il une ordre spécifique entre relier formation et gestion des compétences et mettre en forme le plan pour élaborer un plan de formation?

30) Peut-on établir une priorité entre décoder les besoins en actions de formation et élaborer le cahier de charges des actions de formation pour élaborer un plan de formation?

31) Y-a-t-il une ordre spécifique entre décoder les besoins en actions de formation et définir les priorités de formation pour élaborer un plan de formation?

32) Peut-on établir une priorité entre décoder les besoins en actions de formation et établir le budget prévisionnel pour élaborer un plan de formation?

33) Peut-on établir une priorité entre décoder les besoins en actions de formation et mettre en forme le plan pour élaborer un plan de formation?

34) Peut-on établir une priorité entre élaborer le cahier de charges des actions de formation et définir les priorités de formation pour élaborer un plan de formation?

35) Peut-on établir une priorité entre élaborer le cahier de charges des actions de formation et établir le budget prévisionnel pour élaborer un plan de formation?

36) Peut-on établir une priorité entre élaborer le cahier de charges des actions de formation et mettre en forme le plan pour élaborer un plan de formation?

37) Peut-on établir une priorité entre définir les priorités de formation et établir le budget prévisionnel pour élaborer un plan de formation?

38) Y-a-t-il une ordre spécifique entre définir les priorités de formation et mettre en forme le plan pour élaborer un plan de formation?

39) Peut-on établir une priorité entre établir le budget prévisionnel et mettre en forme le plan pour élaborer un plan de formation?

40) Y-a-t-il une ordre spécifique entre définir les objectifs des modules de formation et concevoir les modules de formation pour concevoir l'action de formation?

41) Y-a-t-il une ordre spécifique entre définir les objectifs des modules de formation et choisir les méthodes pédagogiques pour concevoir l'action de formation?

42) Y-a-t-il une ordre spécifique entre définir les objectifs des modules de formation et élaborer la fiche d'organisation pédagogique pour concevoir l'action de formation?

43) Peut-on établir une priorité entre concevoir les modules de formation et choisir les méthodes pédagogiques pour concevoir l'action de formation?

44) Peut-on établir une priorité entre concevoir les modules de formation et élaborer la fiche d'organisation pédagogique pour concevoir l'action de formation?

45) Peut-on établir une priorité entre choisir les méthodes pédagogiques et élaborer la fiche d'organisation pédagogique pour concevoir l'action de formation?

46) Y-a-t-il une ordre spécifique entre concevoir la progression pédagogique et élaborer le scénario pédagogique pour concevoir les modules de formation?

47) Y-a-t-il une ordre spécifique entre concevoir la progression pédagogique et définir les modalités d'évaluation pour concevoir les modules de formation?

48) Peut-on établir une priorité entre élaborer le scénario pédagogique et définir les modalités d'évaluation pour concevoir les modules de formation?

49) Y-a-t-il une ordre spécifique entre rédiger un appel d'offre et sélectionner le prestataire pour acheter une formation en externe?

50) Y-a-t-il une ordre spécifique entre rédiger une lettre d'appel d'offre et rédiger un cahier de charge de consultation pour rédiger un appel d'offre?

51) Peut-on établir une priorité entre réaliser la présélection des prestataires et réaliser l'entretien et la négociation pour sélectionner le prestataire?

52) Peut-on établir une priorité entre évaluer la satisfaction client et évaluer les acquis pour évaluer les résultats de la formation?

53) Y-a-t-il une ordre spécifique entre évaluer la satisfaction client et évaluer les transferts en situation professionnelle pour évaluer les résultats de la formation?

54) Peut-on établir une priorité entre évaluer la satisfaction client et évaluer les effets pour l'entreprise pour évaluer les résultats de la formation?

55) Peut-on établir une priorité entre évaluer les acquis et évaluer les transferts en situation professionnelle pour évaluer les résultats de la formation?

56) Peut-on établir une priorité entre évaluer les acquis et évaluer les effets pour l'entreprise pour évaluer les résultats de la formation?

57) Peut-on établir une priorité entre évaluer les transferts en situation professionnelle et évaluer les effets pour l'entreprise pour évaluer les résultats de la formation?

58) Peut-on établir une priorité entre évaluer les paramètres d'exploitation de l'entreprise et évaluer les effets socio-organisationnels pour évaluer les effets pour l'entreprise?

59) Y-a-t-il une ordre spécifique entre évaluer les paramètres d'exploitation de l'entreprise et évaluer le changement culturel pour évaluer les effets pour l'entreprise?

60) Y-a-t-il une ordre spécifique entre évaluer les effets socio-organisationnels et évaluer le changement culturel pour évaluer les effets pour l'entreprise?

61) Faut-il élaborer un plan de formation pour gérer la formation? Justifiez.

62) Pourrait-on gérer la formation sans concevoir l'action de formation? Pourquoi?

63) Pourquoi implémenter la formation pour gérer la formation?

64) Considérez-vous qu'on doit impérativement évaluer les résultats de la formation pour gérer la formation? Pourquoi?

65) Considérez-vous qu'on doit impérativement recueillir les besoins de compétence pour élaborer un plan de formation? Pourquoi?

66) Pourquoi relier formation et gestion des compétences pour élaborer un plan de formation?

67) Pourrait-on élaborer un plan de formation sans décoder les besoins en actions de formation? Pourquoi?

68) Considérez-vous qu'on doit impérativement élaborer le cahier de charges des actions de formation pour élaborer un plan de formation? Pourquoi?

69) Considérez-vous qu'on doit impérativement définir les priorités de formation pour élaborer un plan de formation? Pourquoi?

70) Pourquoi établir le budget prévisionnel pour élaborer un plan de formation?

71) Considérez-vous qu'on doit impérativement mettre en forme le plan pour élaborer un plan de formation? Pourquoi?

72) Faut-il définir les objectifs des modules de formation pour concevoir l'action de formation? Justifiez.

73) Considérez-vous qu'on doit impérativement concevoir les modules de formation pour concevoir l'action de formation? Pourquoi?

74) Considérez-vous qu'on doit impérativement choisir les méthodes pédagogiques pour concevoir l'action de formation? Pourquoi?

75) Pourquoi élaborer la fiche d'organisation pédagogique pour concevoir l'action de formation?

76) Faut-il concevoir la progression pédagogique pour concevoir les modules de formation? Justifiez.

77) Pourrait-on concevoir les modules de formation sans élaborer le scénario pédagogique? Pourquoi?

78) Pourquoi définir les modalités d'évaluation pour concevoir les modules de formation?

79) Pourrait-on acheter une formation en externe sans rédiger un appel d'offre? Pourquoi?

80) Pourquoi sélectionner le prestataire pour acheter une formation en externe?

81) Pourrait-on rédiger un appel d'offre sans rédiger une lettre d'appel d'offre? Pourquoi?

82) Pourquoi rédiger un cahier de charge de consultation pour rédiger un appel d'offre?

83) Faut-il réaliser la présélection des prestataires pour sélectionner le prestataire? Justifiez.

84) Pourquoi réaliser l'entretien et la négociation pour sélectionner le prestataire?

85) Considérez-vous qu'on doit impérativement évaluer la satisfaction client pour évaluer les résultats de la formation? Pourquoi?

86) Pourrait-on évaluer les résultats de la formation sans évaluer les acquis? Pourquoi?

87) Considérez-vous qu'on doit impérativement évaluer les transferts en situation professionnelle pour évaluer les résultats de la formation? Pourquoi?

88) Pourquoi évaluer les effets pour l'entreprise pour évaluer les résultats de la formation?

89) Pourquoi évaluer les paramètres d'exploitation de l'entreprise pour évaluer les effets pour l'entreprise?

90) Pourquoi évaluer les effets socio-organisationnels pour évaluer les effets pour l'entreprise?

91) Faut-il évaluer le changement culturel pour évaluer les effets pour l'entreprise? Justifiez.

92) Pour bien gérer la formation quelles sont les ressources nécessaires?

93) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant élaborer un plan de formation?

94) On dit qu'il faut maîtriser la méthode pédagogique pour bien élaborer un plan de formation, mais pourquoi?

95) Quelle est l'importance de maîtriser la politique de formation pour bien élaborer un plan de formation?

96) On dit qu'il faut maîtriser la politique de l'entreprise pour bien élaborer un plan de formation, mais pourquoi?

97) Peut-on penser à élaborer un plan de formation sans utiliser un guide d'élaboration du plan de formation?

98) Qu'est-ce qu'on doit prendre en compte avant recueillir les besoins de compétence?

99) Pour bien recueillir les besoins à l'aide des entretiens quelles sont les ressources nécessaires?

100) Recueillir les besoins à l'aide des questionnaires demande quelles ressources?

101) Pourquoi utiliser un questionnaire de recueil des besoins pour recueillir les besoins à l'aide des questionnaires?

102) Pour bien relier formation et gestion des compétences quelles sont les ressources nécessaires?

103) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant décoder les besoins en actions de formation?

104) Quelle est l'importance d'utiliser un questionnaire de recueil des besoins pour décoder les besoins en actions de formation?

105) Pour bien élaborer le cahier de charges des actions de formation quelles sont les ressources nécessaires?

106) Est-ce que la tâche d'élaborer le cahier de charges des actions de formation doit forcement générer un cahier des charges de formation ?

107) Définir les priorités de formation demande quelles ressources?

108) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant établir le budget prévisionnel?

109) Quels sont les éléments dont on a besoin pour mettre en forme le plan?

110) Concevoir l'action de formation demande quelles ressources?

111) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant définir les objectifs des modules de formation?

112) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant concevoir les modules de formation?

113) Pour bien concevoir la progression pédagogique quelles sont les ressources nécessaires?

114) Élaborer le scénario pédagogique demande quelles ressources?

115) Qu'est-ce qu'on doit prendre en compte avant définir les modalités d'évaluation?

116) Pour bien choisir les méthodes pédagogiques quelles sont les ressources nécessaires?

117) Qu'est-ce qu'on doit prendre en compte avant élaborer la fiche d'organisation pédagogique?

118) Qu'est-ce qu'on doit prendre en compte avant implémenter la formation?

119) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant réaliser une formation en interne?

120) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant acheter une formation en externe?

121) Rédiger un appel d'offre demande quelles ressources?

122) Pour bien rédiger une lettre d'appel d'offre quelles sont les ressources nécessaires?

123) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant rédiger un cahier de charge de consultation?

124) Pour bien sélectionner le prestataire quelles sont les ressources nécessaires?

125) Qu'est-ce qu'on doit prendre en compte avant réaliser la présélection des prestataires?

126) Quels sont les éléments dont on a besoin pour réaliser l'entretien et la négociation?

127) Quels sont les éléments dont on a besoin pour évaluer les résultats de la formation?

128) Qu'est-ce qu'on doit prendre en compte avant évaluer la satisfaction client?

129) Pour bien évaluer les acquis quelles sont les ressources nécessaires?

130) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant évaluer les transferts en situation professionnelle?

131) Qu'est-ce qu'on doit avoir comme ressource d'entrée avant observer les comportements professionnels?

132) Pour bien analyser les produits de l'activité quelles sont les ressources nécessaires?

133) Qu'est-ce qu'on doit prendre en compte avant interpréter les performances individuelles?

134) Analyser les situations-problèmes demande quelles ressources?

135) Quels sont les éléments dont on a besoin pour réaliser l'entretien de suivi?

136) Évaluer les effets pour l'entreprise demande quelles ressources?

137) Évaluer les paramètres d'exploitation de l'entreprise demande quelles ressources?

138) Qu'est-ce qu'on doit prendre en compte avant évaluer les effets socio-organisationnels?

139) Pour bien évaluer le changement culturel quelles sont les ressources nécessaires?

*** ONTOLOGIE ***

140) A quoi sert une action de formation?

141) Dans quels contextes se fait nécessaire un objectif pédagogique ?

142) Comment définir une méthode pédagogique ?

143) A quoi sert une méthode magistrale?

144) Comment définir une méthode découverte ?

145) Une méthode analogique se définit comment?

146) Comment définir une méthode interrogative ?

147) Une méthode démonstrative se définit comment?

148) Comment définir un scénario pédagogique ?

149) Un modèle de document d'organisation pédagogique s'utilise dans quelles situations?

150) A quoi sert un guide animateur?

151) Quelle situation demande l'emploi d'une ressource pédagogique ?

152) Quelle situation demande l'emploi d'une ressource pédagogique ?

153) Quelle situation demande l'emploi d'une étude de cas ?

154) Un brainstorming se définit comment?

155) Un jeu de rôle s'utilise dans quelles situations?

156) Un cassette audio s'utilise dans quelles situations?

157) A quoi sert un cassette vidéo?

158) Quelle situation demande l'emploi d'une télévision ?

159) Comment définir un jeu pédagogique ?

160) Dans quels contextes se fait nécessaire une radio ?

161) Un didacticiel s'utilise dans quelles situations?

162) Une source d'information s'utilise dans quelles situations?

163) Comment définir une source d'information stratégique ?

164) Dans quels contextes se fait nécessaire une politique de l'entreprise ?

165) Quelle situation demande l'emploi d'une politique des ressources humaines ?

166) Dans quels contextes se fait nécessaire une politique de formation ?

167) A quoi sert une source d'information opérationnelle?

168) Comment définir un document d'achat de formation ?

169) Dans quels contextes se fait nécessaire une analyse des contraintes internes et externes ?

170) Un bâtir un argumentaire se définit comment?

171) A quoi sert une grille de négociation?

172) A quoi sert une interprétation des prix?

173) A quoi sert un la grille et les critères de sélection?

174) Un maîtriser le déroulement de la négociation s'utilise dans quelles situations?

175) Dans quels contextes se fait nécessaire un méthode d'analyse des réponses des prestataires ?

176) Une document de préparation du plan de formation se définit comment?

177) A quoi sert un cahier des charges de formation?

178) A quoi sert un cahier des charges de consultation?

179) A quoi sert un questionnaire de recueil des besoins?

180) Comment définir un guide de rédaction des questionnaires ?

181) Quelle situation demande l'emploi d'un guide de conduite des entretiens ?

182) A quoi sert un guide d'élaboration du plan de formation?

183) Une grille de définition des priorités s'utilise dans quelles situations?

184) A quoi sert une document d'évaluation?

185) Comment définir un questionnaire de satisfaction à l'issue de la formation ?

186) Un questionnaire de connaissances à l'issue de la formation se définit comment?

187) Dans quels contextes se fait nécessaire une grille d'observation des comportements ?

188) Comment différencier une méthode magistrale d'une méthode découverte ?

189) Quelle situation demande ou favorise l'utilisation d'une méthode magistrale par rapport à une méthode analogique, vu qu'ils sont deux types de méthode pédagogique?

190) Quelle situation demande ou favorise l'utilisation d'une méthode magistrale par rapport à une méthode interrogative, vu qu'ils sont deux types de méthode pédagogique?

191) Quelle est la différence entre une méthode magistrale et une méthode démonstrative, vu qu'ils sont deux types de méthode pédagogique?

192) Quelle est la différence entre une méthode découverte et une méthode analogique, vu qu'ils sont deux types de méthode pédagogique?

193) Quelle est la différence entre une méthode découverte et une méthode interrogative, vu qu'ils sont deux types de méthode pédagogique?

194) Comment différencier une méthode découverte d'une méthode démonstrative ?

195) Quelle est la différence entre une méthode analogique et une méthode interrogative, vu qu'ils sont deux types de méthode pédagogique?

196) Quelle est la différence entre une méthode analogique et une méthode démonstrative, vu qu'ils sont deux types de méthode pédagogique?

197) Une méthode interrogative et une méthode démonstrative sont deux types de méthode pédagogique. Alors, quelle est la différence entre eux?

198) Quelle est la différence entre une étude de cas et un brainstorming, vu qu'ils sont deux types de ressource pédagogique?

199) Comment différencier une étude de cas d'un jeu de rôle ?

200) Quelle est la différence entre une étude de cas et un cassette audio, vu qu'ils sont deux types de ressource pédagogique?

201) Comment différencier une étude de cas d'un cassette vidéo ?

202) Une étude de cas et une télévision sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

203) Quelle est la différence entre une étude de cas et un jeu pédagogique, vu qu'ils sont deux types de ressource pédagogique?

204) Une étude de cas et une radio sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

205) Quelle situation demande ou favorise l'utilisation d'une étude de cas par rapport à un didacticiel, vu qu'ils sont deux types de ressource pédagogique?

206) Un brainstorming et un jeu de rôle sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

207) Un brainstorming et un cassette audio sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

208) Quelle situation demande ou favorise l'utilisation d'un brainstorming par rapport à un cassette vidéo, vu qu'ils sont deux types de ressource pédagogique?

209) Quelle situation demande ou favorise l'utilisation d'un brainstorming par rapport à une télévision, vu qu'ils sont deux types de ressource pédagogique?

210) Quelle situation demande ou favorise l'utilisation d'un brainstorming par rapport à un jeu pédagogique, vu qu'ils sont deux types de ressource pédagogique?

211) Quelle situation demande ou favorise l'utilisation d'un brainstorming par rapport à une radio, vu qu'ils sont deux types de ressource pédagogique?

212) Comment peut-on établir la différence entre un brainstorming et un didacticiel par rapport à leur utilisation, vu que ce sont deux types de ressource pédagogique?

213) Quelle est la différence entre un jeu de rôle et un cassette audio, vu qu'ils sont deux types de ressource pédagogique?

214) Comment différencier un jeu de rôle d'un cassette vidéo ?

215) Quelle est la différence entre un jeu de rôle et une télévision, vu qu'ils sont deux types de ressource pédagogique?

216) Un jeu de rôle et un jeu pédagogique sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

217) Comment différencier un jeu de rôle d'une radio ?

218) Quelle est la différence entre un jeu de rôle et un didacticiel, vu qu'ils sont deux types de ressource pédagogique?

219) Un cassette audio et un cassette vidéo sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

220) Comment peut-on établir la différence entre un cassette audio et une télévision par rapport à leur utilisation, vu que ce sont deux types de ressource pédagogique?

221) Quelle situation demande ou favorise l'utilisation d'un cassette audio par rapport à un jeu pédagogique, vu qu'ils sont deux types de ressource pédagogique?

222) Quelle situation demande ou favorise l'utilisation d'un cassette audio par rapport à une radio, vu qu'ils sont deux types de ressource pédagogique?

223) Comment différencier un cassette audio d'un didacticiel ?

224) Un cassette vidéo et une télévision sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

225) Quelle est la différence entre un cassette vidéo et un jeu pédagogique, vu qu'ils sont deux types de ressource pédagogique?

226) Un cassette vidéo et une radio sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

227) Quelle situation demande ou favorise l'utilisation d'un cassette vidéo par rapport à un didacticiel, vu qu'ils sont deux types de ressource pédagogique?

228) Comment différencier une télévision d'un jeu pédagogique ?

229) Quelle est la différence entre une télévision et une radio, vu qu'ils sont deux types de ressource pédagogique?

230) Quelle est la différence entre une télévision et un didacticiel, vu qu'ils sont deux types de ressource pédagogique?

231) Un jeu pédagogique et une radio sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

232) Comment peut-on établir la différence entre un jeu pédagogique et un didacticiel par rapport à leur utilisation, vu que ce sont deux types de ressource pédagogique?

233) Une radio et un didacticiel sont deux types de ressource pédagogique. Alors, quelle est la différence entre eux?

234) Comment peut-on établir la différence entre une source d'information stratégique et une source d'information opérationnelle par rapport à leur utilisation, vu que ce sont deux types de source d'information?

235) Quelle situation demande ou favorise l'utilisation d'une politique de l'entreprise par rapport à une politique des ressources humaines, vu qu'ils sont deux types de source d'information stratégique?

236) Comment différencier une politique de l'entreprise d'une politique de formation ?

237) Quelle situation demande ou favorise l'utilisation d'une politique des ressources humaines par rapport à une politique de formation, vu qu'ils sont deux types de source d'information stratégique?

238) Quelle est la différence entre un document d'achat de formation et une document de préparation du plan de formation, vu qu'ils sont deux types de source d'information opérationnelle?

239) Quelle situation demande ou favorise l'utilisation d'un document d'achat de formation par rapport à une document d'évaluation, vu qu'ils sont deux types de source d'information opérationnelle?

240) Comment différencier une document de préparation du plan de formation d'une document d'évaluation ?

241) Quelle est la différence entre une analyse des contraintes internes et externes et un bâtir un argumentaire, vu qu'ils sont deux types de document d'achat de formation?

242) Comment différencier une analyse des contraintes internes et externes d'une grille de négociation ?

243) Comment différencier une analyse des contraintes internes et externes d'une interprétation des prix ?

244) Quelle situation demande ou favorise l'utilisation d'une analyse des contraintes internes et externes par rapport à un la grille et les critères de sélection, vu qu'ils sont deux types de document d'achat de formation?

245) Une analyse des contraintes internes et externes et un maîtriser le déroulement de la négociation sont deux types de document d'achat de formation. Alors, quelle est la différence entre eux?

246) Comment différencier une analyse des contraintes internes et externes d'un méthode d'analyse des réponses des prestataires ?

247) Quelle situation demande ou favorise l'utilisation d'un bâtir un argumentaire par rapport à une grille de négociation, vu qu'ils sont deux types de document d'achat de formation?

248) Quelle est la différence entre un bâtir un argumentaire et une interprétation des prix, vu qu'ils sont deux types de document d'achat de formation?

249) Quelle situation demande ou favorise l'utilisation d'un bâtir un argumentaire par rapport à un la grille et les critères de sélection, vu qu'ils sont deux types de document d'achat de formation?

250) Quelle est la différence entre un bâtir un argumentaire et un maîtriser le déroulement de la négociation, vu qu'ils sont deux types de document d'achat de formation?

251) Quelle est la différence entre un bâtir un argumentaire et un méthode d'analyse des réponses des prestataires, vu qu'ils sont deux types de document d'achat de formation?

252) Comment peut-on établir la différence entre une grille de négociation et une interprétation des prix par rapport à leur utilisation, vu que ce sont deux types de document d'achat de formation?

253) Comment différencier une grille de négociation d'un la grille et les critères de sélection ?

254) Comment peut-on établir la différence entre une grille de négociation et un maîtriser le déroulement de la négociation par rapport à leur utilisation, vu que ce sont deux types de document d'achat de formation?

255) Comment peut-on établir la différence entre une grille de négociation et un méthode d'analyse des réponses des prestataires par rapport à leur utilisation, vu que ce sont deux types de document d'achat de formation?

256) Quelle situation demande ou favorise l'utilisation d'une interprétation des prix par rapport à un la grille et les critères de sélection, vu qu'ils sont deux types de document d'achat de formation?

257) Une interprétation des prix et un maîtriser le déroulement de la négociation sont deux types de document d'achat de formation. Alors, quelle est la différence entre eux?

258) Quelle est la différence entre une interprétation des prix et un méthode d'analyse des réponses des prestataires, vu qu'ils sont deux types de document d'achat de formation?

259) Comment différencier un la grille et les critères de sélection d'un maîtriser le déroulement de la négociation?

260) Un la grille et les critères de sélection et un méthode d'analyse des réponses des prestataires sont deux types de document d'achat de formation. Alors, quelle est la différence entre eux?

261) Un maîtriser le déroulement de la négociation et un méthode d'analyse des réponses des prestataires sont deux types de document d'achat de formation. Alors, quelle est la différence entre eux?

262) Comment peut-on établir la différence entre un cahier des charges de formation et un cahier des charges de consultation par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

263) Comment peut-on établir la différence entre un cahier des charges de formation et un questionnaire de recueil des besoins par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

264) Un cahier des charges de formation et un guide de rédaction des questionnaires sont deux types de document de préparation du plan de formation. Alors, quelle est la différence entre eux?

265) Comment différencier un cahier des charges de formation d'un guide de conduite des entretiens ?

266) Quelle situation demande ou favorise l'utilisation d'un cahier des charges de formation par rapport à un guide d'élaboration du plan de formation, vu qu'ils sont deux types de document de préparation du plan de formation?

267) Quelle est la différence entre un cahier des charges de formation et une grille de définition des priorités, vu qu'ils sont deux types de document de préparation du plan de formation?

268) Quelle situation demande ou favorise l'utilisation d'un cahier des charges de consultation par rapport à un questionnaire de recueil des besoins, vu qu'ils sont deux types de document de préparation du plan de formation?

269) Comment différencier un cahier des charges de consultation d'un guide de rédaction des questionnaires ?

270) Quelle situation demande ou favorise l'utilisation d'un cahier des charges de consultation par rapport à un guide de conduite des entretiens, vu qu'ils sont deux types de document de préparation du plan de formation?

271) Quelle est la différence entre un cahier des charges de consultation et un guide d'élaboration du plan de formation, vu qu'ils sont deux types de document de préparation du plan de formation?

272) Comment peut-on établir la différence entre un cahier des charges de consultation et une grille de définition des priorités par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

273) Un questionnaire de recueil des besoins et un guide de rédaction des questionnaires sont deux types de document de préparation du plan de formation. Alors, quelle est la différence entre eux?

274) Comment peut-on établir la différence entre un questionnaire de recueil des besoins et un guide de conduite des entretiens par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

275) Comment peut-on établir la différence entre un questionnaire de recueil des besoins et un guide d'élaboration du plan de formation par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

276) Quelle situation demande ou favorise l'utilisation d'un questionnaire de recueil des besoins par rapport à une grille de définition des priorités, vu qu'ils sont deux types de document de préparation du plan de formation?

277) Quelle est la différence entre un guide de rédaction des questionnaires et un guide de conduite des entretiens, vu qu'ils sont deux types de document de préparation du plan de formation?

278) Comment différencier un guide de rédaction des questionnaires d'un guide d'élaboration du plan de formation ?

279) Un guide de rédaction des questionnaires et une grille de définition des priorités sont deux types de document de préparation du plan de formation. Alors, quelle est la différence entre eux?

280) Comment peut-on établir la différence entre un guide de conduite des entretiens et un guide d'élaboration du plan de formation par rapport à leur utilisation, vu que ce sont deux types de document de préparation du plan de formation?

281) Quelle situation demande ou favorise l'utilisation d'un guide de conduite des entretiens par rapport à une grille de définition des priorités, vu qu'ils sont deux types de document de préparation du plan de formation?

282) Quelle situation demande ou favorise l'utilisation d'un guide d'élaboration du plan de formation par rapport à une grille de définition des priorités, vu qu'ils sont deux types de document de préparation du plan de formation?

283) Quelle situation demande ou favorise l'utilisation d'un questionnaire de satisfaction à l'issue de la formation par rapport à un questionnaire de connaissances à l'issue de la formation, vu qu'ils sont deux types de document d'évaluation?

284) Quelle situation demande ou favorise l'utilisation d'un questionnaire de satisfaction à l'issue de la formation par rapport à une grille d'observation des comportements, vu qu'ils sont deux types de document d'évaluation?

285) Comment peut-on établir la différence entre un questionnaire de connaissances à l'issue de la formation et une grille d'observation des comportements par rapport à leur utilisation, vu que ce sont deux types de document d'évaluation?

286) Quelle est le rôle de la méthode pédagogique tant que composant d'une action de formation?

287) Considérez-vous que le scénario pédagogique est un élément indispensable d'une action de formation? Pourquoi?

288) Considérez-vous que le modèle de document d'organisation pédagogique est un élément indispensable d'un scénario pédagogique? Pourquoi?

Appendix III:

Numerical results from simulation

Simulation data Scenario: S1

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	12.5	24.0	34.5	38.2	47.4	48.9	56.3	56.1	60.3
Reply	0.0	0.0	14.3	33.3	43.8	55.0	65.4	73.3	80.0	84.6
Spread	0.0	20.8	24.3	28.9	32.0	38.8	44.9	51.0	58.3	65.3
Ext	40.0	60.0	76.7	86.7	96.7	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	16.7	37.5	70.0	83.3	85.7	87.5	88.2	80.0
Average	**8.0**	**18.7**	**31.2**	**44.2**	**56.1**	**64.9**	**69.0**	**73.6**	**76.5**	**78.1**

Simulation data Scenario: S2

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	6.2	8.6	10.0	11.1	11.7	12.2	12.8	13.1	13.6
Reply	0.0	0.0	26.4	43.0	49.5	55.5	56.7	60.2	63.0	65.3
Spread	0.0	14.1	22.7	28.5	33.6	37.7	41.7	44.9	47.7	50.4
Ext	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	6.0	7.9	8.9	9.7	10.1	10.6	10.9	11.2
Average	**20.0**	**24.1**	**32.7**	**37.9**	**40.6**	**42.9**	**44.1**	**45.7**	**47.0**	**48.1**

Simulation data Scenario: S3

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	4.2	4.1	3.8	3.5	3.4	3.4	3.2	3.0	3.5
Reply	0.0	0.0	37.0	56.1	64.8	65.2	63.9	64.3	69.1	62.8
Spread	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Ext	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	100.0
Vld-Atck	0.0	0.0	11.1	15.4	17.7	19.5	20.0	20.0	20.3	19.3
Average	**4.0**	**6.8**	**18.5**	**25.1**	**29.2**	**31.6**	**33.5**	**35.5**	**38.5**	**37.2**

Simulation data Scenario: S4

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.5	1.9	2.0	2.5	2.8	3.3	3.7	4.1	4.5
Reply	0.0	0.0	16.1	22.8	25.4	32.1	39.8	45.5	50.0	53.0
Spread	0.0	1.0	1.6	2.0	2.6	3.1	3.7	4.3	4.9	5.4
Ext	40.0	60.0	75.5	90.0	95.9	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	5.3	6.6	6.7	6.6	6.5	6.4	6.2	6.2
Average	**8.0**	**12.5**	**20.1**	**24.7**	**26.6**	**28.9**	**30.7**	**32.0**	**33.0**	**33.8**

Simulation data Scenario: S5

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	4.6	5.7	6.0	8.8	11.2	13.1	14.9	16.2	17.8
Reply	0.0	0.0	22.2	44.8	44.2	56.5	69.5	77.6	78.3	80.6
Spread	0.0	3.5	5.2	6.1	9.5	12.9	16.1	19.2	22.5	25.3
Ext	40.0	60.0	78.6	95.5	99.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	44.4	44.4	52.2	51.6	45.5	46.2	41.8	41.6
Average	**8.0**	**13.6**	**31.2**	**39.4**	**42.7**	**46.4**	**48.8**	**51.6**	**51.7**	**53.0**

Simulation data Scenario: S6

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	3.0	4.2	5.0	5.5	6.3	7.3	8.6	9.6	10.3
Reply	0.0	0.0	27.3	37.5	40.5	47.1	55.0	60.4	62.4	66.0
Spread	0.0	2.3	3.4	4.4	5.3	6.3	7.7	9.2	10.6	12.0
Ext	40.0	60.0	73.6	85.0	95.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	20.0	24.2	25.5	27.1	26.7	27.0	26.9	26.2
Average	**8.0**	**13.1**	**25.7**	**31.2**	**34.4**	**37.4**	**39.3**	**41.0**	**41.9**	**42.9**

Simulation data Scenario: S7

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.7	2.8	4.2	5.3	6.2	7.0	7.7	8.3	8.9
Reply	0.0	0.0	17.7	34.2	44.6	55.5	60.0	62.8	67.5	69.2
Spread	0.0	1.6	2.5	4.1	5.7	7.0	8.4	9.7	11.0	12.2
Ext	40.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	9.3	10.5	10.8	11.4	11.4	11.3	11.5	11.5
Average	**8.0**	**16.7**	**26.4**	**30.6**	**33.3**	**36.0**	**37.4**	**38.3**	**39.7**	**40.3**

Simulation data Scenario: S8

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	3.0	3.8	4.0	4.0	4.0	3.9	3.8	4.4	4.8
Reply	0.0	0.0	20.0	38.3	49.1	54.7	58.8	59.5	58.8	57.3
Spread	0.0	1.6	2.0	2.0	1.9	1.8	1.8	1.8	2.4	3.0
Ext	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	10.3	13.3	13.6	14.5	14.7	15.1	14.4	14.0
Average	**6.0**	**8.9**	**17.2**	**23.5**	**27.7**	**31.0**	**33.8**	**36.0**	**36.0**	**35.8**

Simulation data Scenario: S9

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.4	1.9	2.1	2.5	3.0	3.6	4.1	4.6	4.9
Reply	0.0	0.0	17.8	27.1	33.9	38.2	43.6	48.3	51.7	53.3
Spread	0.0	1.0	1.6	2.0	2.6	3.2	3.9	4.5	5.2	5.8
Ext	40.0	60.0	75.5	89.0	95.5	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	7.1	9.3	9.7	9.6	9.6	9.3	9.1	9.0
Average	**8.0**	**12.5**	**20.8**	**25.9**	**28.9**	**30.8**	**32.1**	**33.3**	**34.1**	**34.6**

Simulation data Scenario: S10

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	2.3	2.9	3.2	4.0	4.8	5.9	6.8	7.6	8.3
Reply	0.0	0.0	23.3	37.1	44.3	55.0	63.5	69.3	70.5	73.4
Spread	0.0	1.6	2.4	3.1	4.1	5.2	6.4	7.5	8.9	10.1
Ext	40.0	60.0	76.6	91.0	97.2	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	17.4	20.0	21.8	21.9	20.6	19.8	19.2	18.6
Average	**8.0**	**12.8**	**24.5**	**30.9**	**34.3**	**37.4**	**39.3**	**40.7**	**41.2**	**42.1**

Simulation data Scenario: S11

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.5	1.9	2.1	2.6	3.0	3.6	4.2	4.7	5.2
Reply	0.0	0.0	17.0	30.5	40.2	49.7	57.1	62.4	66.3	69.4
Spread	0.0	1.1	1.6	2.0	2.6	3.2	3.9	4.6	5.2	5.9
Ext	40.0	60.0	76.6	90.0	96.9	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	11.1	13.6	13.5	13.0	12.7	12.7	12.6	12.6
Average	**8.0**	**12.5**	**21.6**	**27.6**	**31.1**	**33.8**	**35.5**	**36.8**	**37.8**	**38.6**

Simulation data Scenario: S12

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	0.6	0.8	0.8	1.1	1.3	1.6	1.8	2.0	2.1
Reply	0.0	0.0	14.8	21.7	25.5	31.2	37.0	42.0	45.7	48.1
Spread	0.0	0.3	0.4	0.4	0.7	0.8	0.8	0.9	1.1	1.3
Ext	40.0	60.0	77.0	93.4	98.3	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	5.3	6.8	6.4	6.2	6.1	5.9	5.7	5.6
Average	**8.0**	**12.2**	**19.7**	**24.6**	**26.4**	**27.9**	**29.1**	**30.1**	**30.9**	**31.4**

Simulation data Scenario: S13

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.7	2.3	2.6	2.8	3.0	3.0	3.2	3.3	3.5
Reply	0.0	0.0	18.0	31.3	39.0	44.4	49.0	51.0	52.6	56.4
Spread	0.0	1.0	1.6	2.0	2.3	2.6	2.8	3.1	3.4	3.6
Ext	26.7	40.0	50.8	59.8	67.8	75.9	83.2	89.4	94.0	98.2
Vld-Atck	0.0	0.0	10.3	12.9	13.8	14.8	15.3	14.9	14.8	14.9
Average	**5.3**	**8.5**	**16.6**	**21.7**	**25.1**	**28.1**	**30.7**	**32.3**	**33.6**	**35.3**

Simulation data Scenario: S14

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	2.2	2.5	3.2	4.2	5.1	5.9	6.5	7.1	7.7
Reply	0.0	0.0	25.2	35.6	41.4	45.9	49.8	52.3	54.0	55.4
Spread	0.0	1.8	2.3	2.9	4.2	5.4	6.6	7.8	8.8	10.0
Ext	50.0	70.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	9.2	11.1	10.8	10.8	10.6	10.8	11.1	11.2
Average	**10.0**	**14.8**	**25.9**	**30.6**	**32.1**	**33.4**	**34.6**	**35.5**	**36.2**	**36.9**

Simulation data Scenario: S15

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.4	1.9	2.1	2.6	3.2	3.9	4.6	5.1	5.7
Reply	0.0	0.0	21.6	37.4	46.6	52.3	62.6	64.2	69.4	71.1
Spread	0.0	1.0	1.6	2.0	2.5	3.1	3.8	4.6	5.3	6.1
Ext	40.0	60.0	76.2	89.3	96.9	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	16.7	21.6	23.5	22.5	21.7	20.7	21.1	20.3
Average	**8.0**	**12.5**	**23.6**	**30.5**	**34.4**	**36.2**	**38.4**	**38.8**	**40.2**	**40.6**

Simulation data Scenario: S16

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.1	1.5	1.7	1.9	2.2	2.6	3.0	3.4	3.7
Reply	0.0	0.0	18.2	27.9	35.1	40.2	46.3	51.4	54.2	55.9
Spread	0.0	0.8	1.2	1.5	1.9	2.3	2.7	3.2	3.7	4.2
Ext	40.0	60.0	75.2	87.6	95.5	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	7.6	9.3	9.8	9.5	9.4	9.3	9.3	9.2
Average	**8.0**	**12.4**	**20.7**	**25.6**	**28.8**	**30.8**	**32.2**	**33.4**	**34.1**	**34.6**

Simulation data Scenario: S17

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	0.4	0.5	0.5	0.7	0.9	1.0	1.2	1.3	1.5
Reply	0.0	0.0	12.1	19.2	21.7	26.6	33.2	38.2	43.0	48.1
Spread	0.0	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.5
Ext	40.0	60.0	77.6	94.0	98.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	2.9	3.8	3.9	3.7	3.6	3.6	3.6	3.5
Average	**8.0**	**12.1**	**18.7**	**23.6**	**24.9**	**26.3**	**27.6**	**28.7**	**29.7**	**30.7**

Simulation data Scenario: S18

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	2.1	2.7	3.1	3.2	3.4	3.4	3.6	3.6	3.6
Reply	0.0	0.0	21.3	30.4	37.1	40.8	45.0	48.1	51.0	52.9
Spread	0.0	1.0	1.6	2.0	2.4	2.6	2.9	3.0	3.2	3.4
Ext	20.0	30.0	37.8	44.7	51.0	57.4	63.1	68.6	74.1	79.7
Vld-Atck	0.0	0.0	11.4	13.1	14.0	14.0	14.3	14.6	14.7	15.0
Average	**4.0**	**6.6**	**15.0**	**18.6**	**21.5**	**23.6**	**25.7**	**27.6**	**29.3**	**30.9**

Simulation data Scenario: S19

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	2.1	3.7	5.2	6.4	7.3	8.0	8.7	9.2	9.7
Reply	0.0	0.0	18.5	35.4	45.0	51.3	56.0	59.8	61.6	62.5
Spread	0.0	2.2	4.2	6.3	8.3	10.2	12.0	13.8	15.5	17.2
Ext	50.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	7.6	9.4	10.2	10.5	10.5	10.8	11.0	11.2
Average	**10.0**	**18.8**	**26.8**	**31.2**	**34.0**	**35.9**	**37.3**	**38.6**	**39.4**	**40.1**

Simulation data Scenario: S20

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.5	1.8	1.8	3.1	4.4	5.7	7.1	8.5	9.9
Reply	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Spread	0.0	1.1	1.6	2.0	3.2	4.6	5.9	7.3	8.7	10.2
Ext	40.0	60.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average	**8.0**	**52.5**	**56.7**	**60.8**	**61.3**	**61.8**	**62.3**	**62.9**	**63.4**	**64.0**

Simulation data Scenario: S21

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	0.9	1.2	1.4	1.6	1.7	2.0	2.3	2.6	2.8
Reply	0.0	0.0	17.9	25.2	29.5	34.6	40.7	44.6	47.6	49.7
Spread	0.0	0.6	1.0	1.3	1.5	1.8	2.1	2.5	2.8	3.2
Ext	40.0	60.0	73.5	85.2	94.1	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	6.2	7.7	8.0	8.0	7.7	7.6	7.5	7.4
Average	**8.0**	**12.3**	**19.9**	**24.1**	**26.9**	**29.2**	**30.5**	**31.4**	**32.1**	**32.6**

Simulation data Scenario: S22

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.3	1.8	2.1	2.5	3.0	3.6	4.1	4.5	5.0
Reply	0.0	0.0	20.7	33.7	38.4	44.9	52.1	58.3	62.5	66.3
Spread	0.0	1.0	1.5	2.0	2.6	3.2	3.9	4.5	5.2	5.8
Ext	40.0	60.0	75.7	88.7	99.7	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	2.4	3.2	3.3	3.3	3.8	4.2	4.4	4.6
Average	**8.0**	**12.5**	**20.4**	**25.9**	**29.3**	**30.9**	**32.7**	**34.2**	**35.3**	**36.3**

Simulation data Scenario: S23

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Buddy	0.0	1.5	1.8	2.0	2.5	2.9	3.5	3.9	4.4	4.8
Reply	0.0	0.0	21.1	31.3	36.2	39.1	42.7	46.3	48.9	52.3
Spread	0.0	1.1	1.7	2.1	2.7	3.4	4.2	5.1	5.8	6.5
Ext	40.0	60.0	75.9	89.7	96.6	100.0	100.0	100.0	100.0	100.0
Vld-Atck	0.0	0.0	12.5	13.3	13.5	13.0	12.5	11.9	11.7	11.5
Average	**8.0**	**12.5**	**22.6**	**27.7**	**30.3**	**31.7**	**32.6**	**33.4**	**34.1**	**35.0**

References

[AGU98] AGUADO, G. et al. *ONTOGENERATION: Reusing domain and linguistic ontologies for Spanish text generation*. Workshop on ontologies and problem-solving methods. ECAI'98, Brighton, United Kingdom, August, 1998.

[ALB93] ALBERTS, L. K. *YMIR: an Ontology for Engineering Design*. University of Twente, 1993.

[ARC01] ARCHER, W., GARRISON, D. R., ANDERSON, T., & ROURKE, L. *A Framework for Analyzing Critical Thinking in Computer Conferences*. Proceedings of the EURO-CSCL'01, Maastricht, 2001.

[BAK96] BAKER, M. *Argumentation et co-construction des connaissances*. Interaction et Cognition, vol 1 (2-3), p 157-191, L'Harmattan, Paris, 1996.

[BAK98] BAKER, M. *The function of argumentation dialogue in cooperative problem-solving*. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C.A. Willard (Eds), Proceedings of the 4th International Conference on Argumentation (ISSA'98). Amsterdam, p. 27-33. Amsterdam: SIC SAT Publications, 1998.

[BAK99] BAKER, M. *Argumentation and Constructive Interaction*. In G. Rijlaarsdam & E. Espéret (Series Eds.) & Pierre Coirier and Jerry Andriessen (Vol. Eds.) Studies in Writing: Vol. 5. Foundations of Argumentative Text Processing , p. 179 – 202. Amsterdam. University of Amsterdam Press, 1999.

[BON97] BONDARENKO, A. et al. *An abstract, argumentation-theoretic approach to default reasoning*. Artificial Intelligence 93, p. 63-101, 1997.

[BRE94] BREWKA, G. *A reconstruction of Rescher's theory of formal disputation based on default logic*. Proceedings of the 11th European Conference on Artificial Intelligence, p. 366-370, 1994.

[BRO68] BROWN, B. *Delphi Method: A Methodology Used for Elicitation of Opinions of Experts*. Santa Monica, CA. Rand Corp., 1968

[BUC84] BUCHANAN B. G. and SHORTLIFFE E. H. *Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project*. Addison-Wesley, Reading, MA, 1984.

[CHA92] CHANDRASEKARAN, B., JOHNSON T. and SMITH, J. *Task-Structure Analysis for knowledge Modeling*. Communications of the ACM (CACM 35) n. 9, 1992, p. 124-137.

[CHA93] CHANDRASEKARAN, B. and JOHNSON T., *Generic Tasks And Task Structures: History, Critique and New Directions*. Second Generation Expert Systems, eds., J.M. David, J.P. Krivine, and R. Simmons, Springer-Verlag, 1993, p. 239-280.

[CHE00] CHESÑEVAR, C., MAGUITMAN, A AND LOUI, R. *Logical Models of Argument*. ACM Computing Surveys, volume 32 number 4, p. 337-383. December, 2000.

[DAL63] DALKEY, N. and HELMER, O. *An Experimental Application of the Delphi Method to the Use of Experts*. Management Science n. 9, 1963, p. 458-467.

[DAV93] DAVIS, R., SHROBE, H. and SZOLOVITS, P. What is knowledge representation? AI Magazine, 14(1), 1993, p. 17-33.

[DEC95a] DECKER, K. *Environment Centered Analysis and Design of Coordination Mechanisms*. Ph.D. thesis. University of Massachusetts, Amherst, 1995.

[DEC95b] DECKER, V. and LESSER, V. *Designing a family of coordination algorithms*. In Proceedings of the First International Conference on Multi-Agent Systems, San Francisco, AAAI Press, June 1995.

[DEW33] DEWEY, J. *How we think*. Boston: D.C. Health, 1933

[DOY80] DOYLE, J. *A Model for Deliberation, Action and Introspection*. Ph.D. Thesis, Massachusetts Institute of Technology (MIT), 1980.

[EEM84] EEMEREN, F. VAN, GROOTENDORST R. *Speech acts in argumentative discussions: a theoretical model for the analysis of discussions directed towards solving conflicts of opinion*. Foris Publications, 1984.

[ELE00] ELEUTERIO, M., EBERSPÄCHER, H., JAMUR, J. *Using a web-based learning environment for distance courses*. Paper submitted to the IEEE Transactions on Education, 2000.

[ELE02] ELEUTERIO, M., BARTHES, J., BORTOLOZZI, F. *Mediating collective discussions using an intelligent argumentation-based framework*. Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA'02), Denver, Colorado, 2002.

[ELE99] ELEUTERIO, M. and EBERSPACHER, H. *A Knowledge Management Approach to Virtual Learning Environments*; International Workshop on Virtual Education (WISE'99), 1999.

[FAH01] FAHRAEUS, E. *Collaborative Learning through Forum Systems – Problems and Opportunities*. European Computer-Supported Collaborative Learning (EURO-CSCL 2001). Maastricht, the Netherlands, 2001.

[GAR00] GARRISON, D. R., ANDERSON, T., & ARCHER, W. *Critical thinking in a text-based environment: Computer conferencing in higher education*. Internet and Higher Education, 11(2), 1-14, 2000.

[GAR01] GARRISON, D. R., ANDERSON, T., & ARCHER, W. *Critical thinking, cognitive presence, and computer conferencing in distance education*. American Journal of Distance Education, 15(1), 2001.

[GAR91] GARRISON, D. R. *Critical thinking and adult education: A conceptual model for developing critical thinking in adult learners*. International Journal of Lifelong Education, 10(4), pp. 287-303, 1991.

[GAR93] GARRISON, D. R. *A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions*. Distance Education, 14(2), pp. 199-211, 1993.

[GOL76] GOLDMAN A. Discrimination and perceptual knowledge. Journal of philosophy, LXXIII (20), 1976, p. 771-791.

[GOR97] GORDON, T., KARACAPILIDIS, N. *The Zeno Argumentation Framework*. Proceedings of the Sixth International Conference on Artificial Intelligence and Law, ACM Press, New York, p 10-18, 1997

[GRE01] GREER, J. et al. Lessons Learned in Deploying a Multi-Agent Learning Support System: The I-Help Experience. Artificial Intelligence in Education. J. D. Moore et al. (Eds.). IOS Press, 2001, p. 410-421.

[GRU92] GRUBER, T. R. *A Translation Approach to Portable Ontology Specifications*, knowledge Acquisition, 1993.

[GRU94] GRUBER, T. R. *Toward Principles for the Design of Ontologies Used for Knowledge Sharing*, IJHCS, 43(5/6), 1994, p. 907-928.

[GUA00] GUARINO, N. and WELTY, C. 2000. *A Formal Ontology of Properties*. In R. Dieng and O. Corby (eds.), Knowledge Engineering and Knowledge Management: Methods, Models and Tools. 12th International Conference, EKAW2000. Springer Verlag, 2000, p. 97-112.

[GUA95] GUARINO, N. and GIARETTA, P. *Ontologies and knowledge bases towards a terminological clarification*. Proceedings of KB&KS'95, 1995, p. 25-32.

[GUA95] GUARINO, N. *Formal Ontology, Conceptual Analysis and Knowledge Representation*. International Journal of Human and Computer Studies, 43(5/6), 1995, p. 625-640.

[GUA97] GUARINO, N. *Understanding, Building, and Using Ontologies*: *A Commentary to "Using Explicit Ontologies in KBS Development", by van Heijst, Schreiber and Wielinga*. International Journal of Human and Computer Studies 46, 1997, p. 293-310.

[HAR90] HARASIM, L. M. (Ed.). *Online education: Perspectives on a new environment*. New York: Prager, 1990.

[HAR95] HARASIM, L. M., HILTZ, S. & TUROFF, M. *Learning networks: A field guide to teaching and learning online*. Cambridge, MA: MIT Press, 1995.

[HEN96] HENRI, F. & RIGAULT, C. *Collaborative distance education and computer conferencing*. In T. Liao (Ed.) Advanced educational technology: research issues and future potential, pp. 45-76. Springer-Verlag, 1996.

[HIL94] HILTZ, S. R. *The virtual classroom: learning without limits via computer networks*. Ablex Publishing Corporation, 1994.

[HUR96] HURWITZ, R., MALLERY, J. *The Open Meeting: A Web-based System for Conferencing and Collaboration*. Proceedings of the Fourth International Conference on the World Wide Web. Boston, 1996, p. 19-36.

[HUR98] HURWITZ, R., MALLERY, J. *Managing Large Scale On-line Discussions: Secrets of the Open Meeting*. Community computing and support systems: social interaction in network communities. Toru Ishida (Ed.), Springer-Verlag Berlin Heidelberg, 1998, p. 155-169.

[KAR96] KARACAPILIDIS, N., PAPADIAS, D. AND GORDON, T. *An Argumentation Based Framework for Defeasible and Qualitative Reasoning*. Proceedings of the 13th Brazilian Symposium on Artificial Intelligence (SBIA'96), p. 1-10. Curitiba, Brazil, October 1996.

[KAR98a] KARACAPILIDIS, N., PAPADIAS, D. *A computational approach for argumentative discourse in multi-agent decision making environments*. AI Communications vol. 11, 1998 p. 21-33. IO Press, 1998.

[KAR98b] KARACAPILIDIS N., PAPADIAS D. *Hermes: Supporting Argumentative Discourse in Multi-Agent Decision Making*. Proceedings of the AAAI-98, p. 827-832, Madison, WI, 1998.

[KAS97] KASSEL G., KRIM G. *Une expérience de réutilisation d'une ontologie*. Rapport interne 97/64, HEUDIASYC, Université de Technologie de Compiègne.

[KAY92] KAYE, A. R. *Learning together apart*. In A. R. Kaye (Ed.), Collaborative Learning through computer conferencing, pp. 1-24. London: Springer-Verlag, 1992.

[LIN75] LINSTONE, H. and TUROFF, M. *The Delphi Method: Techniques and Applications*. Addison-Wesley, Reading, Mass., 1975.

[MAS90] MASON, R. & KAYE, A. R. *Towards a new paradigm for distance education*. In L. M. Harasim (Ed.), On-line Education: Perspectives on a new environment, pp. 279-288. New York: Praeger, 1990.

[MAS97] MASON, J. and HART, G. *Effective Use of Asynchronous Virtual Learning Communities. Proceedings from Virtual Communities*. The University of Sydney, 1997.

[MIZ00] MIZOGUCHI, R. and BOURDEAU, J. *Using ontological engineering to overcome common AI-ED problems*. International Journal of Artificial Intelligence in Education, vol. 11, 2000.

[MIZ95] MIZOGUCHI, R. et al. Task ontology for reuse of problem solving knowledge. Proceedings of the 2nd International Conference on Very Large Scale Knowledge Bases, Tnschede, The Netherlands, 1995, p. 46-59.

[MIZ98] MIZOGUCHI, R. *A step towards ontological engineering*. Proceedings of the 12th National Conference on AI of JSAI, 1998, p. 24-31.

[NON95] NONAKA, I. and TAKEUCHI, H.; *The Knowledge-Creating Company*; Oxford University Press Inc., 1995.

[NON98] NONAKA, I. and KONNO, N.; *The Concept of Ba: Building a Foundation for Knowledge Creation*; California Management Review, vol.40 p. 40-58, 1998.

[NON99] NONAKA, I., TOYAMA, R. and KONNO, N.; SECI, *Ba, and Leadership: A Unified Model of Dynamic Knowledge Creation* (Draft) - to be published in D.J. Teece and I. Nonaka (Eds), Knowledge and the Firm, Oxford University Press, forthcoming.

[NOY97] NOY, N. and HAFNER, C. *The State of Art in Ontology Design: A Survey and Comparative Review.* AI Magazine, n^{o} 3, vol 18, Fall 1977, p. 53-74.

[NUT88] NUTE, D. *Defeasible Reasoning*. Aspects of Artificial Intelligence, p. 251-288. Kluwer Academic Publishers. Norwell, MA., 1988.

[PAL01] PALME, J. KOM2000: *Advanced, distributed forum software*. This document is available at http://cmc.dsv.su.se/kom/kom-summary.html and was first published in September 1998 by Jacob Palme.

[QUI97] QUIGNARD, M. and BAKER, M. *Modeling Argumentation and Belief Revision in Agent Interactions*. Proceedings of the 2nd European Conference on Cognitive Science (ECCS'97), p. 85-90. Manchester, UK, 1997.

[SCH01] SCHWARZ, B, NEUMAN, Y., GIL, J. and ILYA M. *Construction of knowledge in argumentative activities*. Proceedings of the European Conference on Computer-Supported Collaborative Learning, Maastricht, The Netherlands, 2001.

[SCH91] SCHAMP, S. *Mechanomorphism in perception on computer communication partners*. Computers in Human Behavior, 7(3), pp. 147-161, 1991.

[SCH95] SCHEIBER, G., WIELINGA, B., and JANSWEIJER, W. *The KAKTUS View on the 'O' Word*. In Proceedings of IJCAI95, Workshop on Basic Ontological Issues in Knowledge Sharing. Montreal, Canada, 1995.

[SEA70] SEARLE, J. R. *Speech Acts; An Essay in the Philosophy of Language*. Cambridge University Press (2nd ed.), 1970.

[SIM89] SIMARI, G. R. *A Mathematical Treatment of Defeasible Reasoning and its Implementation*. Ph.D. Thesis, Washington University, 1989.

[SOW00] SOWA, J. F. *Ontologies, Metadata and Semiotics*. 8th International Conference on Conceptual Structures Logical, Linguistic, and Computational Issues, ICCS'2000, August 2000, Darmstadt, Germany.

[SOW01] SOWA, J. F. John Sowa's website at http://www.jfsowa.com, last accessed in February, 2002.

[STA99] STACEY, E. *Collaborative Learning in an Online Environment*. Journal of Distance Education/Revue de l'enseignement à distance, vol. 14.2, 1999.

[TUR72] TUROFF, M. *Delphi Conferencing: Computer-based conferencing with anonymity*. Journal of Technological Forecasting and Social Change (3:2), 1972, p. 159-204.

[TUR77] TUROFF, M., WHITESCARVER, J. and HILTZ, S. R. *The Human-machine interface in a computerized conferencing environment*. In Proceedings of the IEEE Systems, Man and Cybernetics Annual Conference, 1977, p. 145-157.

[TUR91] TUROFF, M. *Computer-Mediated Communication Requirements for Group Support*. Journal of Organizational Computing, vol. 1, 1991, p. 85-113.

[USC96] USCHOLD, M. and GRUNINGER, M. *Ontologies: Principles, Methods and Applications*. The Knowledge Engineering Review, 1996.

[VEE00] VEERMAN, A. *Computer-supported collaborative learning through argumentation*. Ph.D. Thesis, University of Utrecht, Netherland, 2000.

[WAC01] WACHE H. et al. *Ontology-based Integration of Information - A Survey of Existing Approaches*. Proceedings of IJCAI-01 Workshop: Ontologies and Information Sharing, Seattle, WA, 2001, pp. 108-117.

[WIE93] WIELINGA, B. J. and SCHREIBER, A. T. *Reusable and sharable knowledge bases: a European perspective*. In Proceedings of Proceedings of First International Conference on Building and Sharing of Very Large-Scaled Knowledge Bases. Tokyo, Japan Information Processing Development Center, 1993.