

Progress Report 03  
ConsRel, Fapesp Project 2004/14107-2  
Logical Consequence and Combinations of Logics  
— Fundamentals and Efficient Applications

Period: April 1st, 2007 to April 30th, 2008

Main Researcher: Walter Carnielli (CLE/IFCH-UNICAMP)

**Resumo**

This is the third report of CONSREL Project covering activities developed during the period from April 1st, 2007 to April 30th, 2008. As the initial proposal of this project was written in English, we believe it appropriate to present the corresponding progress reports in English as well. The first section contains a brief summary of this report in Portuguese.

**Sumário**

O Projeto CONSREL trata da investigação acerca das relações de consequência, enfocando diversas vertentes:

1. estudo da questão da expressividade das relações de consequência dentro de padrões específicos, tais como aspectos qualitativos versus quantitativos;
2. investigação das formas gerais de semânticas formais (isto é, semânticas formuladas com precisão matemática e para as quais se possa dispor de métodos ou técnicas de caráter formal, em particular algébrico ou categorial);
3. investigação dos métodos e técnicas de combinação (síntese) de sistemas lógicos ou de relações de consequência;
4. investigação dos métodos e técnicas de decomposição (análise) de sistemas lógicos.

O Projeto, em resumo, se constitui dos seguintes módulos:

- Módulo 1: Fundamentos de Combinação de Sistemas Lógicos (*Task 1: Fundamentals of Combining Logics*);
- Módulo 2: Aspectos Computacionais das Combinação de Sistemas Lógicos e Demonstração Automática de Teoremas (*Task 2: Computational Aspects of Combinations of Logics and Theorem Proving*);
- Módulo 3: Lógicas Quânticas e Algoritmos (*Task 3: Quantum Logics and Algorithms*).

Informações adicionais encontram-se disponíveis nas páginas do Projeto:  
<http://www.ime.usp.br/~consrel>

e

<http://consrel.incubadora.fapesp.br/portal/project-members>

Fazemos aqui uma breve descrição, quantitativa e qualitativa, a respeito dos principais resultados atingidos dentro de cada “Task” no período de 01/04/2007 até 30/04/2008. Para uma avaliação qualitativa deve-se consultar a Seção 2. Para uma descrição das atividades organizadas a partir dos membros componentes do Projeto deve-se consultar a Seção 3.

Dentro da **Task 1: Fundamentals of Combining Logics**, coordenada por Marcelo Coniglio, foram publicados ou submetidos 12 artigos completos e 10 resumos sobre tópicos relativos às diferentes linhas de pesquisa deste módulo. Além disso, foi aceita e publicada a versão revisada (seguindo sugestões dos pareceristas) do livro “Analysis and Synthesis of Logics”, escrito por W.A. Carnielli, M.E. Coniglio, D. Gabbay, P. Gouveia e C. Sernadas, que reflete alguns dos avanços do projeto relativos a esta Task.

Alguns dos trabalhos, como parte das tarefas específicas da Task, são devotados à investigação das questões básicas concernentes aos processos de combinação de lógicas e à definição de tradução entre lógicas. Outros artigos tratam de outros aspectos mais específicos das combinação entre lógicas, tais como a combinação de lógicas algebrizáveis e o desenvolvimento de quantificadores modulados.

Com relação à **Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**, coordenada por Marcelo Finger, foram elaborados 10 artigos, todos eles relevantes às linhas de pesquisa desta Task: aproximação de lógicas, provadores automáticos eficientes de teoremas e inferência sensível a recursos. Uma das características principais da pesquisa desenvolvida nesta Task foi, como em anos anteriores, a procura de aplicações, principalmente no contexto de robótica, através do desenvolvimento de jogos educativos baseados na noção prática de inferência. Vários trabalhos foram desenvolvidos nesta direção.

Finalmente, no que concerne à **Task 3: Quantum Logics and Algorithms**, coordenada por Walter Carnielli, um artigo foi publicado, outro pre-

parado e redigido e duas dissertações de mestrado com alguma relação com os temas da **Task 3** foram defendidas.

O artigo [AC07] foi publicado após ter sido apresentado e discutido no *UC'07- International Conference on Unconventional Computation*, organizado pela School of Computing, Queen's University, Kingston, Canadá, e pelo Centre for Discrete Mathematics and Theoretical Computer Science, The University of Auckland, Australia. Uma versão anterior do trabalho foi apresentada na “*Oficina ConsRel- CLE 30 anos*”, uma oficina de trabalhos organizada no CLE-UNICAMP em setembro de 2007, ver

[http://www.cle.unicamp.br/principal/CLE.30anos/oficina\\_consrel.php](http://www.cle.unicamp.br/principal/CLE.30anos/oficina_consrel.php)  
<http://seminarioslogica.blogspot.com/2007/09/programao-oficina-consrel-cle-30-anos.html>

Além disso, um extenso artigo foi finalizado e redigido, “*A Paraconsistent Approach to Quantum Computing*”, que está sendo submetido a publicação. Versões preliminares foram postadas nos “CLE e-Prints”:

[http://www.cle.unicamp.br/e-prints/vol\\_8,n\\_1,2008.html](http://www.cle.unicamp.br/e-prints/vol_8,n_1,2008.html)

e no sítio “arxiv” (<http://arxiv.org/abs/0802.0150>).

Continuam as investigações sobre o problema dos estados quânticos emaranhados através da perspectiva lógica (lógicas não-adjuntivas definidas através de operadores modais) e o estudo das possibilidades de se estender o Teorema de Cook para circuitos lógicos não-standard (definidos por meio de cálculos de polinômios com variáveis ocultas). Nesse sentido, um interessante progresso tem sido feito na direção de se obter métodos de prova e de decidibilidade de sistemas modais (mais notadamente, **S5**) através de cálculos de polinômios.

Na nossa avaliação o terceiro ano do Projeto foi, assim como os dois primeiros, muito produtivo em termos dos avanços substantivos alcançados, totalmente de acordo com os objetivos iniciais.

Continuando com a notação adotada nos relatórios anteriores, [Ref] denota que a referência [Ref] corresponde a uma publicação produzida pelos membros do Projeto durante o período.

## 1 Introduction

The third year of the CONSREL Project, analogously to the previous ones, has been a very productive period. A good amount of papers, as well as a research book, were published or submitted for publication; an improved version of the open source theorem prover developed by a member of the Project has been released; finally, one MSc and one PhD students have finished their theses in the context of the Project. Additionally, several graduate students will have their final defense happening in the coming year, within the lifetime of the Project.

Following a policy of saving paper, we decided from now on not to include printed material in the Scientific Reports. Most of the papers published within the context of the Project can be found at the Project webpages:

<http://www.ime.usp.br/~consrel>  
<http://consrel.incubadora.fapesp.br/portal/project-members>

The structure of this Report is as follows: The rest of this section recalls the Project's setting, describing its domain, goals and the structure in which the Project tasks were divided. Section 2 reports the achievements in each of the Project tasks. Section 3 details the personal contribution of each member to the Project's goals. Finally, Section 6 discusses work in progress, plotting the directions of the Project in its continuation. Using the same notation as in the previous report,  $\boxed{\text{[Ref]}}$  denotes that the reference [Ref] corresponds to a publication produced by Project members within the reported period .

## 1.1 The Project domain

The Project CONSREL deals with the topic of Logical Consequence and Combinations of Logics. This wide topic allows us to deal with many subjects, and we have chosen to concentrate on the following:

- The study of methods for combining logics. This encompasses the ways logics can be put together to generate more complex systems, as well as the ways a logic can be decomposed into simpler ones. The combination procedures can generate a single logic, as in the fibring or in the possible-translations approach, or the process can be asymptotic and generate a class of logics, as in the families of logics that approximate classical logic.
- The study of practical applications of combinations of logics, which covers the fields of theorem proving, AI, belief revision and the study of novel models of computation, such as quantum computation and quantum algorithms.

To cover this wide spectrum we face the problem of combining logics from the mathematical, computational, conceptual and philosophical points of view.

## 1.2 The Project goals

As we have stated in the Project proposal, the aims of this Project are directed towards the following aspects of combination of logics:

1. To study the fundamental issues of combining logics, covering the following points:
  - Specific methods for combining logics, such as *fusion*, *products* and *fibring*.

- Algebraic and categorial aspects of logic combinations, such as *Blok-Pigozzi algebraization*.
  - Formal semantics for logic combination, such as *possible-translations semantics* and *society semantics*.
2. The study of computational aspects of logical combination, addressing the following topics:
    - Approximations of classical logic and the development of approximate theorem provers.
    - Belief Revision and its relation with the notions of relevance generated by approximation processes.
    - Logics *with* uncertainty, as opposed to logics that reason *about* uncertainty. These logics of practical interest can be modeled as a combination of classical logics with probability theory or with fuzzy logics.
  3. The study of particular logics of interest resulting from combination of logics, namely:
    - Quantum Logics, which are connected to mathematical questions on Hilbert Spaces, Lie Algebras and Topology.
    - Quantum algorithms which, from the standpoint of combination mechanisms, can be seen as superpositions of classical models.

### 1.3 The Structure of the Project

To achieve the above mentioned goals, the Project is divided into three main tasks, each of which by its turn subdivided into several subtasks, as follows.

**Task 1: Fundamentals of Combining Logics**, coordinated by Marcelo Coniglio. Subtasks:

- Subtask 1.1: Combinations of Logics and their Applications
- Subtask 1.2: Splitting and Algebraizing Logics
- Subtask 1.3: Algebraic Semantics for Modal Logics
- Subtask 1.4: Algebraic and Categorial Aspects of Logical Consequence

**Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**, coordinated by Marcelo Finger. Subtasks:

- Subtask 2.1: Approximations of Classical Propositional Logic
- Subtask 2.2: Logics for Ontologies<sup>1</sup>

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<sup>1</sup>This Subtask replaces the Subtask “First-Order Approximate Inference”.

- Subtask 2.3: Resource Sensitive Inference
- Subtask 2.4: Automatizing Paraconsistent Inference

**Task 3: Quantum Logics and Algorithms**, coordinated by Walter Carnielli. Subtasks:

- Subtask 3.1: Quantum Computation and Quantum Logics
- Subtask 3.2: Polynomial Ring Proof Procedures
- Subtask 3.3: Paraconsistent Turing Machines

## 1.4 Human Resources of the Project

As it is usual in projects of wide range involving people from different institutions and from several levels and distinct backgrounds, there is a continuous adjustment in the human resources component of the Project:

- Luís Sbardellini (IME- USP) has left the project due to personal reasons.
- Adolfo Gustavo Serra Seca Neto is now professor at the Computer Science Department of the Universidade Estadual de Santa Catarina (UDESC).
- New Master students were incorporated into the Project:  
Pietro Kreiton Carolino, from IFCH- UNICAMP, with a grant from FAPESP; Mauricio S. C. Hernandez and Márcio Moretto Ribeiro, from IME-USP.

The updated group of researchers consists from now on of the following people:

### Project Coordinator

- Walter Carnielli (IFCH and CLE – UNICAMP)

### Task Coordinators

- Marcelo Coniglio (IFCH and CLE – UNICAMP)
- Marcelo Finger (DCC-IME-USP)

### Researchers

- Flavio Soares Correa da Silva (DCC-IME-USP)
- Itala D’Ottaviano (IFCH and CLE – UNICAMP)
- Hércules de Araujo Feitosa (MAT-UNESP-Bauru)
- Odilon Otávio Luciano (MAT-IME-USP)
- João Marcos (DIMAp/ CCET- UFRN)
- Hugo Mariano (MAT-IME-USP)

- Adolfo Gustavo Serra Seca Neto (DCC-UEDSC)
- Renata Wassermann(DCC-IME-USP)
- Angela Weiss (MAT-IME-USP)

#### **Post-Doc Members**

- Milton Augustinis de Castro (IFCH – UNICAMP)

#### **PhD Students**

- Juan Carlos Agudelo Agudelo (IFCH-UNICAMP) (name in publications: Juan Carlos Agudelo)
- Juliana Bueno (IFCH-UNICAMP) (name in publications: Juliana Bueno-Soler)
- Luiz Henrique da Cruz Silvestrini (IFCH- UNICAMP)
- Rodrigo de Alvarenga Freire (IFCH-UNICAMP)
- Carlos Hifume (IFCH-UNICAMP)
- Joselyto Riani (DCC-IME-USP)

#### **MSc Students**

- Anderson de Araujo (IFCH- UNICAMP)
- Samir Gorsky (IFCH- UNICAMP)
- Pietro Kreiton Carolino (IFCH- UNICAMP)
- Mauricio S. C. Hernandez (IME-USP)
- Newton Marques Peron (IFCH- UNICAMP)
- Márcio Moretto Ribeiro (IME-USP)
- Rodrigo Podiack (IFCH- UNICAMP)
- Guilherme Rabello (MAT-IME-USP)
- Teófilo de Sousa Reis (IFCH- UNICAMP)
- Leandro Suguitani (IFCH- UNICAMP)
- Rafael Rodrigues Testa (IFCH-UNICAMP)

#### **External Participants**

- Jean-Yves Béziau (Université de Neuchâtel, Switzerland)
- Carlos Caleiro (IST, Lisbon)
- Alexandre Costa-Leite (Université de Neuchâtel, Switzerland)
- Eduardo Fermé (Department of Mathematics and Engineering, Universidade da Madeira, Portugal)
- Dov Gabbay (King's College, London)
- Paulo Mateus (IST, Lisbon)

- João Rasga (IST, Lisbon)
- Amílcar Sernadas (IST, Lisbon)
- Cristina Sernadas (IST, Lisbon)
- Jorge Petrucio Viana (IM-UFF, Rio de Janeiro)

## 2 Report by Tasks

### Task 1: Fundamentals of Combining Logics

*Task coordinator: Marcelo Coniglio*

This task is mainly dedicated to the study and the development of a general theory of combination of logic systems, from a theoretical and conceptual point of view.

During the period under analysis a more than satisfactory amount of results were obtained in the scope of this Task. Most of the research topics proposed in the previous Research Report (“Future Work: Next Steps and Work in Progress”) were attained, as described below.

One of the main achievements of the team was the publication, under a revised form following the suggestions of the referees, of a book about combination of logics submitted in 2007, as informed in the previous Research Report. This book contains conceptual issues on the topic and covers the main techniques on combining logics, with a good amount of original contribution. This book involves two main researchers of the project, as well as other external members.

On the other hand, a satisfactory number of papers and communications were produced by the team members, some of them in collaboration with external project members and other researchers. Some of these papers were published or accepted for publication, others have been submitted for publication, and some have been released as electronic preprints, with the purpose of being submitted in the near future. Altogether, 12 complete articles and 10 communications concerning this task were produced during the period being evaluated.

Additionally, three Master dissertations and two PhD thesis are being elaborated by student members of the team attached to this task, one of them endowed with a grant from FAPESP.

The research developed in the reported period covered the four corresponding subtasks. In a similar way to the first years of the Project, the advancements can be classified into two main lines: the first line concerns to the study of general conceptual issues about combination and representation of logic systems. The second is about the analysis of specific techniques for composing and decomposing logic systems.

#### Subtask 1.1: Combinations of Logics and their Applications

One of the main achievements concerning this subtask was the publication of the book:

[CCGGS08] W.A. Carnielli, M.E. Coniglio, D. Gabbay, P. Gouveia, and C. Sernadas. **Analysis and Synthesis of Logics**. Applied Logic Series, Vol. 35, Springer, 2008.

The book, submitted in 2007 (as informed in the previous Report), was accepted for publication after a reviewing process, and the revised version was effectively published in March 2008. This book reflects the efforts of team members dedicated to the development of general techniques for composing and decomposing logics.

Along the same lines, an ample survey of the subject of combining logics, explaining the main techniques, historical perspective and main problems, was elaborated. The article was published in the prestigious Stanford Encyclopedia of Philosophy:

[CC07a] Walter Carnielli and Marcelo E. Coniglio. Combining Logics. In: The Stanford Encyclopedia of Philosophy, 2007. Ed.: E.N. Zalta.  
URL: <http://plato.stanford.edu/entries/logic-combining/>

As announced in the previous report, the possibility of obtaining ‘bridge principles’ (that is, interaction laws between connectives of logics being combined) and the philosophical significance of this phenomenon was investigated. This discussion relates the subject of combining logics with a well-known philosophical discussion, Hume’s ‘is-ought problem’. The results of this line of research were described in the article

[CC07b] Walter Carnielli and Marcelo E. Coniglio. Bridge principles and combined reasoning. In: **Logik, Begriffe, Prinzipien des Handelns** (Logic, Concepts, Principles of Action), pp. 32-48. Eds.: T. Müller and A. Newen. Mentis Verlag, Paderborn, 2007.

On the other hand, an improved version of an early preprint was published as the following article:

[C07b] Marcelo E. Coniglio. Recovering a logic from its fragments by meta-fibring. *Logica Universalis* 1, no. 2: 377-416, 2007.

The article above deals with fibring in a category of sequent calculi in which morphisms are based on a novel and stronger notion of translation between logics which preserves certain meta-properties of the given logics. Taken profit of this feature, a large class of logic systems can be recovered from its fragments.

On the other hand, the investigations on the subject of the general theory of translations between logics were continued during the period under evaluation.

Firstly, new interesting translations between logic systems represented basically by a set of formulas and a consequence operator were obtained. The main idea is to use this translations in order to establishing a general concept of

duality between logics and between other formal systems. The results obtained were published in the following paper, which is a revised version of an early preprint:

[DF07a] Itala M.L. D'Ottaviano and Hércules A. Feitosa. Deductive systems and translations. In **Perspectives on universal logic**. Eds.: J.-Y. Béziau and A. Costa Leite. Monza: Polimetrica International Scientific Publisher, 2007, p. 125-157.

Additionally, the possibility of translating intuitionistic logic into classical logic was analyzed in the communication above:

[DF07b] Itala M.L. D'Ottaviano and Hércules A. Feitosa. Is there a translation from intuitionistic into classical logic?. In: *2nd World Congress and School on Universal Logic - UNILOG'07*, 2007, Xi'an. Proceedings of the 2nd World Congress and School on Universal Logic. Xi'an, 2007, p. 81-82.

A survey on the subject of translations between logics was presented in

[CCD07] Walter Carnielli, Marcelo E. Coniglio and Itala M.L. D'Ottaviano. New dimensions on translations between logics. In: *2nd World Congress and School on Universal Logic - UNILOG'07*, 2007, Xi'an. Proceedings of the 2nd World Congress and School on Universal Logic. Xi'an, 2007, p. 44-54.

This subtask also devotes some efforts to the study of non-classical logics. In the period under evaluation some interesting results were obtained.

The Logics of Formal Inconsistency, LFIs, are paraconsistent logics which permit the internalization of the concepts of consistency and inconsistency inside the object language. In the chapter

[CCM07] W.A. Carnielli, M.E. Coniglio and J. Marcos. Logics of Formal Inconsistency. In: *Handbook of Philosophical Logic*, vol. 14, pp.15-107. Eds.: D. Gabbay; F. Guentner. Springer, 2007

semantical characterizations as well as tableaux systems adequate for several classes of LFIs were obtained. This ambitious project was initiated in 2004 and was finally published at the end of 2007 after a detailed and exhaustive revision taking into account the valuable criticism of the referees.

The decomposition of LFIs by means of Possible-Translation Semantics was also studied. Some new results are described in the paper below.

[M07] J. Marcos. Possible-translations semantics for some weak classically-based paraconsistent logics. *Journal of Applied Non-Classical Logics*, 18(1), pp. 7-28, 2008.  
<http://wslc.math.ist.utl.pt/ftp/pub/MarcosJ/04-M-PTS4swcbPL.pdf>

Still in the realm of LFIs, a new and promising research line was inaugurated, by considering the combination of certain LFIs with deontic operators, in order to analyze deontic paradoxes under a new perspective. The first results were described in the following technical reports:

[C07a] Marcelo E. Coniglio. Logics of deontic inconsistency. *CLE e-Prints*, vol. 7(4), 2007.

[C07c] Marcelo E. Coniglio. Logics of deontic inconsistency. In: *Volume of Abstracts of 13th International Congress of Logic, Methodology and Philosophy of Science*, Beijing, 2007, p. 90-91.

A master student of the team, Newton Peron, is currently working along this line of research. The first results obtained were described in the following communication:

[P07] Newton Peron. Lógicas da Inconsistência Formal aplicadas a Paradoxos Deônticos (*Logics of Formal Inconsistency applied to deontic paradoxes*, in Portuguese). *Annals of "V Principia International Symposium"*, 2007, Florianópolis, p. 127-128.

In a related line of research accomplished by a PhD student of the team, Juliana Bueno, more results on the combination of modal logics and LFIs were described in the communication below:

[B07] Juliana Bueno-Soler. Extensões modais das lógicas **mbC** e **Ci** (*Modal extensions of mbC and Ci*, in Portuguese). *Annals of "V Principia International Symposium"*, 2007, Florianópolis, p. 110.

Finally, another master student of the team, Rafael Testa, is working on argumentation theory applied to normative system. The studies involve an analysis and comparisons with the subject of Belief Change. Part of this analysis was described in the following communication:

[T07] Rafael Testa. Sobre a Lógica de Revisão de Crenças: a (não) similaridade entre os diferentes métodos para construir contrações de teorias (*On the logic of Belief Revision: the (non)similarity between the different methods for constructing contraction of theories*, in Portuguese). *Annals of "V Principia International Symposium"*, 2007, Florianópolis, p. 141.

On a more philosophical perspective, based on a direct argument from Gödel's First Incompleteness Theorem, it was discussed the impossibility of constructing a complete formal theory or a complete Turing machines' algorithm to the human capacity of recognition of first-order arithmetical truths and so of mathematical truths in general. This philosophical analysis was detailed in the article below.

[DT07] Itala M.L. D’Ottaviano and Ricardo Tassinari. “Cogito Ergo Sum Non Machina- About Gödel’s First Incompleteness Theorem and Turing Machines. *CLE e-Prints*, vol. 7(3), 2007.

Still concerning Gödel’s Incompleteness Theorem, Samuel Kripke presented a novel proof of this famous theorem during his visit to Campinas last year. A MSc student of the team is working on this proof, and the results already obtained were presented in the communication below.

[A07] Anderson de Araujo. Kripke’s proof of Gödel’s Incompleteness Theorem: A formalization by logical games. *Annals of “V Principia International Symposium”*, 2007, Florianópolis, p. 22.

### Subtask 1.2: Splitting and Algebraizing Logics

In the period under analysis, two submitted papers concerning this subtask were revised and finally published:

[FC07] Víctor L. Fernández and Marcelo E. Coniglio. Fibring in the Leibniz Hierarchy. *Logic Journal of the IGPL*, vol. 15, no. 5-6:475-501, 2007.

[BCC07] Juliana Bueno-Soler, Marcelo E. Coniglio and Walter A. Carnielli. Possible-translations algebraizability. In J.-Y. Béziau, D. Gabbay and W.A. Carnielli, editors, **Handbook of Paraconsistency**, Studies in Logic (Logic & Cognitive Systems), vol. 9, pp. 321-340. College Publications, 2007.

The first one deals with composition of algebraizable logics by fibring, while the second one departs from the dual point of view of decomposition of logics by algebraizable logics. Thus, a kind of algebraization for a logic through a possible-translations semantics whose factors are algebraizable can be obtained.

On the other hand, several new results concerning this subtask were obtained, and it is intended to submit one or two articles in the next months.

### Subtask 1.3: Algebraic Semantics for Modal Logics

The goal of this subtask is the study of abstract consequence operators and generalized (or modulated) quantifiers (such as ‘generally’, ‘rarely’, ‘most’, etc.), and their relationship to other logics, in particular, to modal logics. One aspect of the Project is to study algebraic semantics for such logics, as well as to develop applications to epistemology and philosophy of science.

There was a relevant advance concerning this task during the last year, and some articles were produced. The most relevant production within this line of research is listed below.

[FG07] Hércules A. Feitosa and Maria C. Cabrini Grácio. Sobre os quantificadores naturais: muitos, ..., quase sempre (*On the natural quantifiers: many, ..., almost always*, in Portuguese). Annals of “V Principia International Symposium”, 2007, Florianópolis, p. 77-78.

[SM07] Luiz H. da Cruz Silvestrini and Mariana Matulovic da Silva Fadel. Algumas Lógicas Moduladas em Sistemas de Tableaux (*Some modulated logics in tableaux systems*, in Portuguese). Annals of “V Principia International Symposium”, 2007, Florianópolis, p. 105-106.

[S07] Luiz H. da Cruz Silvestrini. Um sistema de tableaux analíticos para a lógica do plausível (*An analytic tableaux system for the logic of plausibility*, in Portuguese). *Revista Eletrônica de Informação e Cognição* (REIC), vol. 6, n. 2, 2007, pp. 57-71.

A comparative study between da Costa’s truth theory, first-order semantics for LFIs applied to inconsistent databases and modulated quantifiers is currently developed by a PhD member of the team, Luiz Henrique da Cruz Silvestrini. The main idea is to obtain new perspectives in the realm of epistemology and philosophy of science.

Under a different perspective, the well-known algebraic semantics for modal logics introduced by Lemmon and Scott in the “Lemmon Notes” was studied in the context of the modal logics G-infinite. The results obtained, part of a Master Dissertation of an student member of the team to be defended soon, were reported in the following communication:

[G07] Samir Gorski. Semântica algébrica para algumas lógicas modais (*Algebraic semantics for some modal logics*, in Portuguese). Annals of “V Principia International Symposium”, 2007, Florianópolis, p. 152-153.

#### **Subtask 1.4: Algebraic and Categorical Aspects of Logical Consequence**

This subtask was originally designated to obtain applications for the subject of combining logics by using tools from category theory, with emphasis in fibring and possible-translations semantics.

A line of research involving a generalization of Possible-Translation Semantics by using multifunctions announced in the previous report was continued. Some preliminary results were obtained by a MSc student of the team, Teófilo Reis, and were described in the communication below:

[R07] Teófilo Reis. Representação de lógicas por traduções possíveis: um formalismo de decomposição de lógicas (*Representation of logics*

*by possible-translations: a formalism for decomposing logics*, in Portuguese). Annals of “V Principia International Symposium”, 2007, Florianópolis, p. 165.

It is intended to submit a complete article soon, containing the main results of this line of research.

Tarski’s approach to first-order logic through algebras of relations was analyzed by a MSc student of the team as part of his dissertation. Some results were announced in the communication below.

[Su07] Leandro Suguitani. Álgebra de relações: uma abordagem Tarskiana da lógica de primeira ordem (*Algebras of relations: a Tarskian approach to first-order logic*, in Portuguese). Annals of “V Principia International Symposium”, 2007, Florianópolis, p. 102-02.

Still, several articles concerning this subtask are under elaboration, which are intended to be finished and submitted in the next months.

In particular, as announced in the previous Report, a joint research with Amílcar Sernada’s group from Lisbon, devoted to obtain a graph account of representation of logic systems and their combinations by fibring was continued. Under the perspective of this approach, signatures, semantics and derivations inside a logic can be represented by means of p-graphs, which are graphs having edges with multiple nodes as sources. At least one article along this research line is expected to be finished soon.

## **Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**

*Task coordinator: Marcelo Finger*

This task deals with the study of the computational and practical aspects of combination of logic systems.

This task has continued its progress in several in its ongoing subtasks. This progress is detailed below.

### **Subtask 2.1: Approximations of Classical Propositional Logic**

Several mature results have been reached in this area. We highlight the following advances.

- Approximations have been extended for a whole range of Modal Logics [RF08]. It has been shown that modal approximations involves *introspection approximation*, a dimension of approximation that is orthogonal to classical approximations.
- In the previous report, we have shown that approximation could be done by controlling the Cut inference rule, a method called *Cut and Pay*. This

work has been extended to the point of studying inference methods that instead of relying in cut-free deduction, actually compute the cut rule.

The paper presenting modal approximations is:

[RF08] Guilherme de Souza Rabello and Marcelo Finger. Approximations of modal logics: **K** and beyond. *Analys of Pure and Applied Logic*, 152(1–3):161–173, March 2008.

The paper showing that non-analytic cuts can be computed was presented in

[FG07] Marcelo Finger and Dov M. Gabbay. Equal Rights for the Cut: Computable Non-analytic Cuts in Cut-based Proofs. *Logic Journal of the Interest Group in Pure and Applied Logics*, 2007.

### Subtask 2.2: Logics for Ontologies

This task used to deal with first-order approximations, a line that was interrupted, as described in the previous report. This line has been replaced by the much more productive field of logic combination that support Ontologies and allows one to reason about ontology-based descriptions and their instantiations, with applications to the new field of web-semantics.

In particular, the process of revising ontology-based descriptions have been studied under the view-point of classical belief revision. This has produced the following article:

[RW08] Márcio Moretto Ribeiro and Renata Wassermann. Base revision for ontology debugging. *Journal of Logic and Computation*, 2008. Accepted for publication.

At least more two articles are being elaborated following this line of research, which will be submitted soon.

### Subtask 2.3: Resource Sensitive Inference

On this topic, several works related to robotics and use of inference in practical cases have been developed. Several applications have been developed for computer and educational games, and for knowledge management.

In the area of knowledge management, the following papers were produced:

[TCCdSNB08] Gustavo Salazar Torres, Ettore Colombo, Flavio Soares Correa da Silva, Christian Alberto Noriega Guerra, and Stefania Bandini. Design issues for knowledge artifacts. *Knowledge Based Systems (accepted)*, \*(\*):\* , 2008.

[CdSV07] Flavio Soares Correa da Silva and Wamberto Vasconcelos. Managing responsive environments with software agents. *Applied Artificial Intelligence*, 21(\*):469–488, 2007.

[CdSPH07] Flavio Soares Correa da Silva, Rogerio Panigassi, and Carlos Hulot. Learning management systems desiderata for competitive universities. *European Journal of Open, Distance and e-Learning*, 2007(\*):\*, 2007.

Finally, we had some application for computer and educational games.

[CBCdS07] Daniel Clua, Vivian Bertoni, and Flavio Soares Correa da Silva. Vida — jogo de simulação de vida e evolução (*Life – Simulation game of life and evolution*, in Portuguese). In *SBGames – Brazilian Symposium on Computer Games*, Brazil, 2007.

[VPCdS07b] Giuseppe Vizzari, Giorgio Pizzi, and Flavio Soares Correa da Silva. A framework for situated crowd behavior in virtual environments. In *SBGames – Brazilian Symposium on Computer Games*, Brazil, 2007.

[VPCdS07a] Giuseppe Vizzari, Giorgio Pizzi, and Flavio Soares Correa da Silva. A framework for interactive situated agents in virtual environments. In *Workshop – From Objects to Agents*, Italy, 2007.

#### Subtask 2.4: Automatizing Paraconsistent Inference

The work in this area has matured, leading to the successful PhD thesis by Adolfo Neto, which has generated the following publication.

[NF07] Adolfo G. S. S. Neto and Marcelo Finger. A KE tableau for a logic of formal inconsistency. In Nicola Olivetti and Camilla Schwind, editors, *Proceedings of TABLEAUX’07 position papers and Workshop on Agents, Logic and Theorem Proving*, volume LSIS.RR.2007.002, 2007.

Finally, continuing the research about the development of proof systems for da Costa’s paraconsistent logics, natural deduction systems for these hierarchies (including their first-order version) were obtained. This results were presented in the following communication:

[DC07] Itala M.L. D’Ottaviano and Milton A. de Castro. Natural deduction systems for da Costa’s hierarchies of paraconsistent logics  $C_n$  and  $C_n^*$ . In: *Volume of Abstracts of 13th International Congress of Logic, Methodology and Philosophy of Science*, Beijing, 2007, p. 74.

## Task 3: Quantum Logics and Algorithms

*Task coordinator: Walter Carnielli*

This task has the purpose of studying Quantum Logics and Quantum Computation, and their application to the modeling of quantum computation in a wide range.

### – Subtask 3.1: Quantum Computation and Quantum Logics

This task is dedicated to investigate the relationship between logic systems and computation models, with emphasis on quantum computation models. The intention within this task to investigate the role of distinct underlying logics in models of computation. An ongoing research goal in this task is the analysis of the role that quantum features play in the development of efficient quantum algorithms. The student Juan Carlos Agudelo Agudelo is now working under a Ph.D. FAPESP grant, and part of his research interests are related to the subtasks of this Task We are obtaining some encouraging results in all fronts of this Task:

### – Subtask 3.2: Polynomial Ring Proof Procedures

The “polynomial ring proof procedures” is a new and innovative approach to theorem proving and semantics in classical and non-classical logics, related to algebraization of logics and to applications to quantum gates in quantum computation. From proper conceptual perspective, it is also related to philosophical discussions on how and how much the foundations of computer science may depend upon logic (where the heritage of G. Boole and G. Leibniz in formalizing logic play a decisive role).

### – Subtask 3.3: Paraconsistent Turing Machines

The proposal within this subtask is to investigate the models of Paraconsistent Turing Machines proposed in previous steps of the Project to verify its connections with quantum computing. We are still studying the role of non-adjunctive logics and its (conjectured) relationship with entangled quantum states. Parallel to this problem, we are also studying extensions of polynomial ring proof procedures (cf. Subtask 3.2) with the aims of application in non-standard logic circuits. Some interesting results in this directions connected to new proof systems to the modal logic **S5** (within which such non-adjunctive logics can be defined) have been already obtained, and will submitted for publication in the next period.

## Research results and production

The following results have been as a consequence of the research efforts around the whole Task (and integrating all subtasks):

1. Detailed study of the polynomial ring calculus over finite fields with hidden variables, and the proposal of a paraconsistent circuit model.

2. Investigation on the relationship between paraconsistent circuit models and quantum circuits.

3. Analysis of some quantum algorithms in order to gain intuition on the distinctions between quantum and classical algorithms, namely: Dan Simon's algorithm to find function periods; Peter Shor's algorithm to factor integer numbers in polynomial time, and Grover's search algorithm.

The following items represent the results of the work developed within the present Task within the reported period:

1. The paper

[AC07] J.C. Agudelo and W.A. Carnielli. Unconventional Models of Computation through Non-Standard Logic Circuits

was accepted for presentation in the "UC'07- International Conference on Unconventional Computation" (Organized by the School of Computing, Queen's University, Kingston, Canada and the Centre for Discrete Mathematics and Theoretical Computer Science, The University of Auckland, Australia). Further references at <http://www.cs.queensu.ca/uc07>.

2. The same paper was also accepted (after two positive referee reports) to appear in the conference proceedings to be published in the Lecture Notes in Computer Science (LNCS), Springer-Verlag, 2007.

3. Participation in "Unconventional Computation 2007"

in August 2007 Juan Carlos Agudelo participated in the "Unconventional Computation 2007 (UC07)" an international congress held in Kingston, Ontario, Canada (<http://www.cs.queensu.ca/uc07/>). In this event, The talk "Unconventional Models of Computation Through Non-standard Logic Circuits", has been presented, showing a work coauthored by himself with Walter Carnielli, in which a generalization for classical logic circuits was proposed. Such a generalization is defined via the *polynomial ring calculus (PRC)* introduced by Walter Carnielli 2005. The **PRC** is a semantic approach adequate for a wide class of non-classical logics (including some logics with non-truth functional connectives), which basically consists in translating formulas into (total or partial) polynomial functions over finite fields and accomplishing deductions through polynomial operations. Certain *hidden variables* are used in the polynomials in order to capture the behavior of non-truth functional connectives. In order to generalize the model of classical (boolean) logic circuits, the concept of *L-circuit* has been defined, where *L* refers to a logic provided with **PRC**. In a *L-circuit*, input/output values are those of the field considered in the **PRC** and logic gates are considered as computing polynomials in accordance with the **PRC**. In this way the model of paraconsistent *mbC*-circuits is defined taking into account the paraconsistent logic *mbC*, and some similarities of this model with the model of quantum circuits are emphasized. Some potentialities of this model of computation in relation with computational

complexity are also investigated: hidden variables can be used to provide a kind of parallelism in the process of computation, which allow us to define (in principle) more efficient algorithms. The work has been published in *Lecture Notes in Computer Science*, an international vehicle with higher impact. The complete reference is [AC07].

4. Participation in the “*Oficina Cons-Rel- CLE 30 anos*”

A first version of the previously described work was also presented in the “*Oficina Cons-Rel- CLE 30 anos*”, a workshop organized by CLE in September 2007 (<http://seminarioslogica.blogspot.com/2007/09/programa-oficina-consrel-cle-30-anos.html>).

5. Elaboration of the paper “*A Paraconsistent Approach to Quantum Computing*”

A paper titled “*A Paraconsistent Approach to Quantum Computing*” was written and posted in

[http://www.cle.unicamp.br/e-prints/vol\\_8,n\\_1,2008.html](http://www.cle.unicamp.br/e-prints/vol_8,n_1,2008.html)

and

<http://arxiv.org/abs/0802.0150>.

At this moment, the paper is being submitted for publication in an international journal.

The paper initially defines a model of *paraconsistent Turing machines (ParTMs)* by using the logic  $LFI1^*$  in the constitution of the model. It is shown that, with ParTMs, some features of quantum computing can be simulated in a natural way. In particular, it is shown that the quantum algorithms solving the well-known Deutsch’s and Deutsch-Josza problems can be efficiently simulated by ParTMs. It is shown, as well, that this model does not allow a direct representation of quantum entangled states, an important feature of quantum computing. Such ideas were introduced before but the present paper shows some new results:

(1) ParTMs can be simulated in polynomial time by deterministic Turing machines;

(2) A new model of ParTMs, called *entangled paraconsistent Turing machines (EParTMs)*, has been developed.

EParTMs were defined following the same method used in the definition of ParTMs, but using a paraconsistent logic defined into the modal system **S5** instead of  $LFI1^*$ . This new model have the advantage of be able to directly represent entangled states. This feature, in conjunction with the use of inconsistent conditions on the instructions, allowed us to define a polynomial time (paraconsistent) algorithm to solve an NP-complete problem, In this way, we proved that EParTMs are really powerful. It is also shown that EParTMs can be viewed as quantum Turing machines allowing only uniform superposed states (i.e. superposed states with the same probability amplitude for all basis states in the superposition). However,

inconsistent conditions on instructions seem to be a more powerful way than quantum interference in order to take advantage of parallelism in the process of computation. We then propose a logic way to define a notion of ‘relative phase factor’ and ‘interference’ in EParTMs, in order to obtain a model with more similarity with quantum Turing machines.

### 3 Report by Members

We now expose, for each member of the Project, which were their main contributions to the Project.

#### Project Coordinator

- Walter Carnielli (IFCH and CLE – UNICAMP)

**Conference papers:** [CCD07].

**Book Chapters:** [CCM07, CC07b, BCC07, AC07].

**Encyclopedia entry:** [CCD07].

**Books:** [BCG07, CCGGS08].

**Student supervision:** (Ongoing) Juan Carlos Agudelo Agudelo (PhD), Rodrigo de Alvarenga Freire (PhD), Anderson de Araujo (MSc), Samir Gorsky (MSc), Rodrigo Podiack (MSc).

#### Talks, mini-courses and seminars:

- Talk in the “Colloque international sur les Attitudes et l’Action dans le Discours”, Trois Rivières, Canada, May, 2007:  
*Combinations of Logics: Paradoxes, Problems and Perspectives.*
- Plenary Talk in the “13th International Congress of Logic, Methodology and Philosophy of Science”, Beijing, China, August 9-15, 2007:  
*Many valued logic in algebraic form: roots of universal logic in the legacy of Boole and Leibniz.*
- Talk in the “2nd World Congress and School on Universal Logic (UNILOG’07)”, Xi’an, China, August 15-22, 2007:  
*Logics in polynomial format, logic autopoiesis and the laws of form.*
- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Logics in polynomial form: motivation and perspectives.*
- Talk in the “XIII Jornadas de Epistemología de las Ciencias Económicas”, Universidad de Buenos Aires, Argentina, October 4-5, 2007:  
*Cuantificadores modulados y votación en poblaciones infinitas.*

#### Prizes:

- Recipient of the “Prêmio Jabuti” (Jabuti Prize), for *Computabilidade, Funções Computáveis, Lógica e os Fundamentos da Matemática* (W.A. Carnielli and R.L. Epstein). Editora UNESP, São Paulo, Brazil, 2006.

### Task Coordinators

- Marcelo Coniglio (IFCH and CLE – UNICAMP)

**Journal papers:** [C07b, FC07].

**Conference papers:** [CCD07].

**Book Chapters:** [CCM07, CC07b, BCC07].

**Encyclopedia entry:** [CCD07].

**Books:** [CCGGS08].

**Conference abstracts:** [C07c].

**Preprints:** [C07a].

**Student supervision:** (Ongoing) Luiz Henrique Silvestrini (PhD), Newton Marques Peron (MSc), Teófilo de Sousa Reis (MSc), Rafael Rodrigues Testa (MSc), Tarcísio Genaro Rodrigues (MSc), Júlio Cesar Bueno de Andrade (MSc).

### Talks, mini-courses and seminars:

- Visit to the Center for Logic and Computation, Instituto Superior Técnico, Lisbon, June 2007, developing research activities. Seminar in the “Logic and Computation Seminar”:  
*Decomposing logics by possible-translations coverings.*
- Talk in the “13th International Congress of Logic, Methodology and Philosophy of Science”, Beijing, China, August 9-15, 2007:  
*Logic of Deontic Inconsistency.*
- Tutorial in the “2nd World Congress and School on Universal Logic (UNILOG’07)”, Xi’an, China, August 15-22, 2007:  
*Category Theory and Logic.*
- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*The art of combining logics.*
- Talk in the “XIII Jornadas de Epistemología de las Ciencias Económicas”, Universidad de Buenos Aires, Argentina, October 4-5, 2007:  
*(De) Construcción de sistemas lógicos a través de combinaciones.*
- Talk at “XI Colóquio Conesul de Filosofia das Ciências Formais”, Universidade Federal de Santa Maria, Brazil, November 14-18, 2007:

*Lógicas da inconsistência formal e negações paraconsistentes.*

- Marcelo Finger (IME – USP)

**Journal papers:** [FG07, RF08].

**Conference papers:** [NF07, FW08].

**Student supervision:** (Ongoing) Fábio Natanael Kepler (PhD), Maurício Hernandes Simões Camilo (MSc).

(Finished) Fernando Corrêa Lima (MSc), Danilo Conde (MSc).

**Courses and seminars:**

- King’s College Computing Seminars. *Computing Non-Analytic Cuts Using Algebraic Methods*, Kings College, London, June 2007.
- Seminário Brasileiro de Análise (SBA). *Teoria da Prova – Provas não Analíticas*, 2007.

**Prizes:**

- Recipient of the “Prêmio Jabuti” (Jabuti Prize), for *Lógica para Computação* (Flávio S. C. da Silva, Marcelo Finger e Ana C. V. de Melo.). Editora Thomson, Brazil, 2006.
- Supervisor of Eugênio Akihiro Nassu, nominee for the *Prêmio Santander de Empreendedorismo, Ciência e Inovação*, 2007.

**Researchers**

- Flavio Soares Correa da Silva (IME – USP)

**Journal papers:** [TCCdSNB08, CdSV07, CdSPH07].

**Conference papers:** [VPCdS07a, VPCdS07b, CBCdS07].

**Student supervision:** (Ongoing) Sirley Ambrosia Vitorio Oliveira (PhD), Archias Alves de Almeida Filho (PhD), Crhistian Alberto Noriega Guerra (PhD), Daniel Clua (MSc), Ary Fagundes Bressane Neto (MSc), Vivian Betoni (MSc), Fernando Bertolli Petroni (MSc), Omar Jardim Gaudio (MSc), Gustavo Torres (MSc). (Finished) Filipe Correa Lima da Silva (MSc), Igor Ribeiro Sucupira (MSc), Crhistian Alberto Noriega Guerra (MSc).

- Hércules de Araujo Feitosa (MAT-UNESP-Bauru)

- During the period under evaluation, Hércules Feitosa was at the Universidade Federal de Santa Catarina, UFSC, under a Post-Doc Position supervised by Prof. Décio Krause. The results of the research developed in this stage will we described in the next Report.

**Book Chapters:** [DF07a].

**Conference abstracts:** [FGr07, DF07b]

**Student supervision:** Maria Matulovic da Silva Fadel (MSc).

**Talks, mini-courses and seminars:**

- Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:

*Sobre os quantificadores naturais: muitos, ..., quase sempre.*

- João Marcos (UFRN, Natal)

**Journal papers:** [M07].

**Book Chapters:** [CCM07].

**Talks, mini-courses and seminars:**

- Invited speech at *Escola Regional de Computação Bahia Alagoas Sergipe (ERBASE 2008)*, Salvador, BA, Brazil, 14-18 April 2008:

*The foundations of computerized theorem proving.*

- Hugo Luiz Mariano (IME – USP)

- During the period under evaluation, Hugo Mariano was at the University Paris VII under a Post-Doc Position supervised by Prof. Max Dickmann. The results of the research developed in this stage will be described in the next Report.

- Itala D’Ottaviano (IFCH and CLE – UNICAMP)

**Conference papers:** [DC07].

**Conference abstracts:** [DF07b, DC07]

**Book chapters:** [DF07a].

**Preprints:** [DT07].

**Student supervision:** Juliana Bueno (PhD), Carlos Hifume (PhD), Mauro Scheer (PhD), Leandro Suguitani (MSc).

**Post-doc supervision:** Milton Agustini de Castro.

### Talks, mini-courses and seminars:

- Talk in the “International Conference on Residuated Structures: Algebra and Logic”, Universidad de Buenos Aires, Argentina, April 16-19, 2008:  
*Is there a translation from intuitionistic into classical logic?*
- Talk in the “First Joint International Meeting with the Sociedade Brasileira de Matemática and the American Mathematical Society”, 2008:  
*On the development of paraconsistent logic and da Costa’s work.*
- Talk in the “II Congreso Internacional Extraordinário de Filosofía - El Proyecto Humano y su Futuro: alternativas”, San Juan, Argentina, 2007:  
*Atualidad y prospectiva de las lógicas no clásicas.*
- Talk in the “13th International Congress of Logic, Methodology and Philosophy of Science”, Beijing, China, August 9-15, 2007:  
*Natural deduction systems for da Costas’s Hierarchies of Paraconsistent Logics  $C_n$  and  $C_n^*$ .*
- Talk in the “2nd World Congress and School on Universal Logic (UNILOG’07)”, Xi’an, China, August 15-22, 2007:  
*Is there a translation from intuitionistic into classical logics?*
- Tutorial in the “2nd World Congress and School on Universal Logic (UNILOG’07)”, Xi’an, China, August 15-22, 2007:  
*Translations between logics*
- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Is there a translation from intuitionistic logic into classical logic?*

- Adolfo Gustavo Serra Seca Neto (DCC – UDESC)

**Conference papers:** [NF07].

- Renata Wassermann (IME – USP)

**Journal papers:** [RW08].

**Conference papers:** [dSW07, FW08].

**Conference papers:** [RW08d, RW08c].

**Student supervision:** (Ongoing) Márcio Moretto Ribeiro (PhD), Rodrigo Rage Ferro (MSc). (Finished) Thiago Carvalho de Sousa [dS07] (MSc), André Casado Castaño [Cas08] (MSc).

### Post-Doc Students

- Milton Augustinis de Castro (IFCH – UNICAMP)

**Talks, mini-courses and seminars:**

- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Natural Deduction Systems for da Costa’s Hierarchies of Paraconsistent Logics  $C_n$  e  $C_n^*$ .*

## PhD Students

- Juan Carlos Agudelo Agudelo (IFCH-UNICAMP)

**Conference papers:** [AC07].

**Talks, mini-courses and seminars:**

- Talk in the “Sixth International Conference on Unconventional Computation (UC07)”, Kingston, Canada, August 13-17, 2007:  
*Unconventional Models of Computation Through Non-standard Logic Circuits.*
- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Unconventional Models of Computation Through Non-standard Logic Circuits.*

- Juliana Bueno (IFCH-UNICAMP)

**Book chapters:** [BCC07].

**Conference abstracts: Talks, mini-courses and seminars:**

- Seminar at Departamento de Ciência da Informação e Documentação, UnB, Brasília, 18/07/2007:  
*Polinômios como provas: a álgebra nas demonstrações lógicas.*
- Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Extensões modais das lógicas  $mbC$  e  $Ci$*
- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*The roots of possible-translations algebraization.*
- Seminar at CLE-UNICAMP, 12/12/2007:  
*Modalidades anódicas e catódicas.*

- Rodrigo de Alvarenga Freire (CLE-UNICAMP)

**Talks, mini-courses and seminars:**

- Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Observações sobre Teoria de Modelos e os fundamentos do pensamento matemático.*

## MSc Students

- Anderson de Araujo (IFCH- UNICAMP)  
**Conference abstracts:** [A07]  
**Talks, mini-courses and seminars:**
  - Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Kripke’s proof of Gödel’s Incompleteness Theorem: A formalization by logical games.*
  - Talk in the “Workshop Gödel: Logic and Time”, Rio de Janeiro, RJ, August 27-28, 2007:  
*What is the role of diagonalization in the proof of incompleteness theorems?*
- Mauricio S. C. Hernandez (IME – USP)  
MSc student under the supervision of Marcelo Finger, joined the project in 2007.  
**Talks, mini-courses and seminars:**
  - *Simpósio de Iniciação Científica e Pós-Graduação do IME-USP*, presenting the talk:  
*Lógica Modal: Uma abordagem natural*, 2007.
- Márcio Moretto Ribeiro (IME – USP)  
**Journal papers:** [RW08].  
**Submitted papers:** [RW08d, RW08c].
- Leandro Suguitani (IFCH- UNICAMP)  
**Conference abstracts:** [Su07]  
**Talks, mini-courses and seminars:**
  - Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Álgebra de relações: uma abordagem Tarskiana da lógica de primeira ordem.*
  - Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Tarski’s axiomatization of Relation Algebra.*
- Newton Marques Peron (IFCH- UNICAMP)  
**Conference abstracts:** [P07]  
**Talks, mini-courses and seminars:**
  - Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Lógicas da Inconsistência Formal aplicadas a Paradoxos Deônticos.*

- Pietro Kreiton Carolino (IFCH- UNICAMP)  
**Talks, mini-courses and seminars:**
  - Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Compacidade e Tabelas de Laver.*
  
- Rafael Rodrigues Testa (IFCH-UNICAMP)  
**Conference abstracts:** [T07]  
**Talks, mini-courses and seminars:**
  - Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Sobre a Lógica de Revisão de Crenças: a (não) similaridade entre os diferentes métodos para construir contrações de teorias.*
  
- Teófilo de Sousa Reis (IFCH- UNICAMP)  
**Conference abstracts:** [R07]  
**Talks, mini-courses and seminars:**
  - Talk in the “Oficina Cons-Rel- CLE 30 anos”, Campinas, SP, September 21-24, 2007:  
*Possible-Translations Coverings: a formalism of decomposition of logics.*
  - Talk in the “V Principia International Symposium”, Florianópolis, SC, August 6-9, 2007:  
*Representação de lógicas por traduções possíveis: um formalismo de decomposição de lógicas.*

#### External Participants

- Dov Gabbay (King’s College, London)  
**Books:** [CCGGS08].  
**Journal papers:** [FG07].
  
- Cristina Sernadas (IST, Lisbon)  
**Books:** [CCGGS08].

## 4 Academic events

During this period, a workshop was realized and the last organization details of an important international conference, to be celebrated after the period related in this Report, were accomplished.

#### 4.1 Oficina ConsRel-CLE 30 Anos / Workshop ConsRel-CLE 30 Years

On Friday, September 21 and Monday, September 24, 2007 was realized at the Center for Logic, Epistemology and the History of Science (CLE) of UNICAMP the *Workshop ConsRel-CLE 30 Years (Oficina ConsRel-CLE 30 Anos*, in Portuguese), organized by W. Carnielli. This workshop, defined to be part of the celebrations of the 30th anniversary of CLE, was a stimulating meeting of most of the researchers of ConsRel together with the important logician Daniele Mundici, from the Università degli Studi di Firenze, which was visiting CLE in September, 2007.

The event was a unique opportunity for the members of the project to exchange academic ideas, to present the state-of-the-art of their respective research within the project, as well as to plan future research and collaborations. Professor Mundici was a very critical attendant, giving valuable remarks and suggestions to the speakers, and additionally offered an interesting three-hours tutorial, “Many-valued reasoning: from foundations to applications”.

The complete programme of the event can be found at the following Web pages:

[http://www.cle.unicamp.br/principal/CLE\\_30anos/oficina\\_consrel.php](http://www.cle.unicamp.br/principal/CLE_30anos/oficina_consrel.php)

<http://seminarioslogica.blogspot.com/2007/09/programao-oficina-consrel-cle-30-anos.html>

#### 4.2 Organization details of CLE 30/ XV EBL / XIV SLALM

During the period under evaluation most of the organization details of the important international joint event “CLE 30/ XV EBL / XIV SLALM” were accomplished. The event is constituted by three joint conferences:

- CLE 30 - 30th Anniversary of the Centre for Logic, Epistemology and the History of Science, UNICAMP;
- XV EBL - 15th Brazilian Logic Conference; and
- XIV SLALM - 14th Latin-American Symposium on Mathematical Logic.

This event, held in Paraty, RJ, from May 11th to May 17th, 2007, joined the traditional meetings of the Brazilian Logic Society (SBL) and the Latin-American Conferences in logic plus the celebrations of the 30th anniversary of CLE. The conference was preceded by a “Logic School” held at UNICAMP, Campinas. All the activities connected to these events will be reported in the next Scientific Report.

### 5 Prizes and Public Reception

During the report period, two books written by project members have been awarded the “Prêmio Jabuti”, Brazil’s most prestigious literary award, conferred

by the CBL (Câmara Brasileira do Livro - Brazilian Book Chamber). The books are:

- *Lógica para Computação* (Flávio S. C. da Silva, Marcelo Finger e Ana C. V. de Melo.). Editora Thomson, Brazil, 2006.
- *Computabilidade, Funções Computáveis, Lógica e os Fundamentos da Matemática* (W.A. Carnielli and R.L. Epstein). Editora UNESP, São Paulo, Brazil, 2006.

From the viewpoint of the public reception of the work developed in the scope of the project, it is to be mentioned the article

[http://www.agencia.fapesp.br/boletim\\_dentro.php?id=8041](http://www.agencia.fapesp.br/boletim_dentro.php?id=8041)

published online by the *Boletim Agência FAPESP* in November 11th, 2007.

## 6 Future Work: Next Steps and Work in Progress

**Task 1: Fundamentals of Combining Logics**, coordinated by Marcelo Coniglio.

- Subtask 1.1: Combinations of Logics and their Applications.

With respect to this subtask, the main objectives to be attained were described in Subsection 2 above.

Concerning the new goals, we plan to continue the research about the generation of interactions between the connectives when combined. In particular, the paradigmatic case of the combination of conjunction with disjunction, in which the distributivity law automatically arises, will be studied with more details.

On the other hand, a conceptual paper about paraconsistency, in particular about Logics of Formal Inconsistency, in contrast with Graham Priest's "Dialetheism", is planned to be written.

- Subtask 1.2: Splitting and Algebraizing Logics.

We plan to write a paper concerning the dual hierarchies of paraconsistent logics  $P^n$  and paracomplete logics  $I^n$ , and their relations in the context of Blok-Pigozzi's notion of algebraizability.

- Subtask 1.3: Algebraic Semantics for Modal Logics.

We expect to continue our research on the quasi-truth theory. On the other hand, new concepts and applications of modulated quantifiers are expected to be developed. Specifically, the goal is to obtain applications to epistemology and philosophy of science of modulated quantifiers.

- Subtask 1.4: Algebraic and Categorical Aspects of Logical Consequence.

This subtask is mainly devoted to the use of tools from category theory for representation and combination of logics. We expect, on the one hand, to continue the development of a generalization of possible-translation semantics by using a wide notion of signature morphism based on multi-functions.

On the other hand, we intend to continue our studies concerning the presentation of logic systems based on the theory of p-graphs, that is, graphs with finite sequences of vertexes as source of the edges. The categorical fibring of such structures, as well as the completeness preservation by fibring will also be analyzed.

- **Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**, coordinated by Marcelo Finger.

- Subtask 2.1: Polynomial-Time Approximations of Classical Propositional Logic

Following the Cut and Paste developments, which started to control the development of proof search with the cut rule, we plan to study more detailed means of computing non-analytic cuts. The plans are to start studying two methods, namely computing cuts via abduction, and computing cuts via algebraic methods. Hopefully, these methods will be incorporated in existing theorem provers.

- Subtask 2.2: Logics for Ontologies

At least more two articles are being elaborated following this line of research, which will be submitted soon.

This sub-task was cancelled.

- Subtask 2.3: Resource Sensitive Inference

Recent developments in the application of AI techniques in multi-agent systems for the development of games motivate further investigations on that path. The aim continues to be the application of logics and AI techniques to the design of automated agents in computer games.

- Subtask 2.4: Automatizing Paraconsistent Inference

We hope to incorporate the development of the computation of non-analytic cuts to be developed in subtask 2.1 to many non-classical logics, including some paraconsistent ones.

- **Task 3: Quantum Logics and Algorithms**, coordinated by Walter Carnielli.

- Research connected to Cook's theorem of 1971 (which states that any NP-problem can be converted to the satisfiability problem in propositional classical logic in polynomial time) is still being developed. Cook's proof shows how to translate (in a constructive way)

a Turing machine into a set of propositional formulas in such a way that the machine outputs ‘1’ if, and only if, the collection of formulas is consistent. We are obtaining some first results similar to Cook’s theorem for paraconsistent Turing machines, which may confirm our running conjecture that paraconsistent circuits could efficiently solve Deutsch-Jozsa problem. Questions involving the proposals of ‘non-standard’ complexity measure for handling classes of unconventional models of computation have been postponed for the moment, in view of other results already obtained.

- Departing from some promising results on new proof methods based on Polynomial Ring Calculus for modal logics (in the moment, **S5**) obtained within the scope of **Subtask 3.2: Polynomial Ring Proof Procedures**. In this polynomial calculus decidability for **S5** can be checked within Kripke semantics containing just a single world, using non-truth functional valuations. The meaning and scope of what seems to us a nice discovery are being evaluated. We plan first of all to prepare a publication divulging such methods, and try to extend to other modal calculi. We believe that an analogous methods (involving perhaps a couple of worlds equipped with non-truth functional valuations)

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