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Project-Team Calligramme

Linear Logic, Proof Nets and Categorial Grammars

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Theme : Audio, Speech, and Language Processing

Activity Report

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2. Overall Objectives

2.1. Overall Objectives

Project-team Calligramme's aim is the development of tools and methods that stem from proof theory, and in particular, linear logic, in the area of computational linguistics. Two fields of application are emphasized: the modelling of the syntax and semantics of natural languages.

3. Scientific Foundations

3.1. Introduction

Project-team Calligramme's research is conducted at the juncture of mathematical logic and computer science. The scientific domains that base our investigations are proof theory and the λ-calculus, more specifically linear logic. This latter theory, the brainchild of Jean-Yves Girard [26], results from a finer analysis of the part played by structural rules in Gentzen's sequent calculus [24]. These rules, traditionally considered as secondary, specify that the sequences of formulas that appear in sequents can be treated as (multi) sets. In the case of intuitionistic logic, there are three of them:

$$\frac{\Gamma \vdash C}{\Gamma, A \vdash C}\ \text{(Weakening)} \qquad \frac{\Gamma, A, A \vdash C}{\Gamma, A \vdash C}\ \text{(Contraction)} \qquad \frac{\Gamma, A, B, \Delta \vdash C}{\Gamma, B, A, \Delta \vdash C}\ \text{(Exchange)}$$

These rules have an important logical weight: the weakening rule embodies the fact that some hypotheses may be dropped during a derivation; in a similar fashion the contraction rule specifies that any hypothesis can be used an unlimited number of times; as for the exchange rule, it stipulates that no order of priority holds between hypotheses. Thus, the presence of the structural rules in the ordinary sequent calculus strongly conditions the properties of the logic that results. For example, in the Gentzen-style formulations of classical or intuitionistic logic, the contraction rule by itself entails the undecidability of the predicate calculus. In the same manner, the use of the weakening and contraction rules in the right half of the sequent in classical logic is responsible for the latter's non-constructive aspects.

According to this analysis, linear logic can be understood as a system that conciliates the constructivist aspect of intuitionistic logic and the symmetry of classical logic. As in intuitionistic logic, the constructive character comes from the banning of the weakening and contraction rules in the right part of the sequent. But simultaneously, in order to preserve symmetry in the system, the same rules are also rejected in the other half.

	Propositional linear logic			
	Rudimentary linear logic			
	Negation	Multiplicatives	Additives	Exponentials
Negation	$A^\perp$			
Conjunction		$A \otimes B$	$A \& B$	
Disjunction		$A ⅋ B$	$A \oplus B$	
Implication		$A \multimap B$		
Constants		$\mathbf{1}, \perp$	$\top, \mathbf{0}$	
Modalities				!A, ?A

The resulting system, called *rudimentary linear logic*, presents many interesting properties. It is endowed with four logical connectors (two conjunctions and two disjunctions) and the four constants that are their corresponding units. It is completely symmetrical, although constructive, and equipped with an involutive negation. As a consequence, rules similar to De Morgan's law hold in it.

In rudimentary linear logic, any hypothesis must be used once and only once during a derivation. This property, that allows linear logic to be considered as a resource calculus, is due, as we have seen, to the rejection of structural rules. But their total absence also implies that rudimentary linear logic is a much weaker system than intuitionistic or classical logic. Therefore, in order to restore its strength, it is necessary to augment the system with operators that recover the logical power of the weakening and contraction rules. This is done via two modalities that give tightly controlled access to the structural rules. Thus, linear logic does not question the usefulness of the structural rules, but instead, emphasizes their logical importance. In fact, it rejects them as epitheoretical rules [23] to incorporate them as logical rules that are embodied in new connectors. This original idea is what gives linear logic all its subtlety and power.

The finer decomposition that linear logic brings to traditional logic has another consequence: the Exchange rule, which so far has been left as is, is now in a quite different position, being the only one of the traditional structural rules that is left. A natural extension of Girard's original program is to investigate its meaning, in other words, to see what happens to the rest of the logic when Exchange is tampered with. Two standard algebraic laws are contained in it: commutativity and associativity. Relaxing these rules entails looking for non-commutative, and non-associative, variants of linear logic; there are now several examples of these. The natural outcome of this proliferation is a questioning of the nature of the structure that binds formulas together in a sequent: what is the natural general replacement of the notion of (multi) set, as applied to logic? Such questions are important for Calligramme and are addressed, for example, in [38].

The activities of project-team Calligramme are organized around three research actions:

- Proof nets, sequent calculus and typed λ-calculi.
- Grammatical formalisms.
- Implicit complexity of computations.

The first one of these is essentially theoretical, the other two, presenting both a theoretical and an applied character, are our privileged fields of application.

3.2. Proof Nets, Sequent Calculus and Typed Lambda Calculi

The aim of this action is the development of the theoretical tools that we use in our other research actions. We are interested, in particular, in the notion of formal proof itself, as much from a syntactical point of view (sequential derivations, proof nets, λ-terms), as from a semantical point of view.

Proof nets are graphical representations (in the sense of graph theory) of proofs in linear logic. Their role is very similar to lambda terms for more traditional logics; as a matter of fact there are several back-and-forth translations that relate several classes of lambda terms with classes of proof nets. In addition to their strong geometric character, another difference between proof nets and lambda terms is that the proof net structure of a proof of formula T can be considered as a structure which is *added* to T, as a coupling between the atomic formula nodes of the usual syntactic tree graph of T. Since not all couplings correspond to proofs of T, there is a need to distinguish the ones that do actually correspond to proofs; this is called a *correctness criterion*.

The discovery of new correctness criteria remains an important research problem, as much for Girard's original linear logic as for the field of non-commutative logics. Some criteria are better adapted to some applications than others. In particular, in the case of automatic proof search, correctness criteria can be used as invariants during the inductive process of proof construction.

The theory of proof nets also presents a dynamic character: cut elimination. This embodies a notion of normalization (or evaluation) akin to β-reduction in the λ-calculus.

As we said above, until the invention of proof nets, the principal tool for representing proofs in constructive logics was the λ-calculus. This is due to the Curry-Howard isomorphism, which establishes a correspondence between natural deduction systems for intuitionistic logics and typed λ-calculi.

Although the Curry-Howard isomorphism owes its existence to the functional character of intuitionistic logic, it can be extended to fragments of classical logic. It turns out that some constructions that one meets in functional progamming languages, such as control operators, can presently only be explained by the use of deduction rules that are related to proof by contradiction [27].

This extension of the Curry-Howard isomorphism to classical logic and its applications has a perennial place as research field in the project.

3.3. Categorial Grammars

Lambek's syntactic calculus, which plays a central part in the theory of categorial grammars, can be seen *a posteriori* as a fragment of linear logic. As a matter of fact it introduces a mathematical framework that enables extensions of Lambek's original calculus as well as extensions of categorial grammars in general. The aim of this work is the development of a model, in the sense of computational linguistics, which is more flexible and efficient than the presently existing categorial models.

The relevance of linear logic for natural language processing is due to the notion of resource sensitivity. A language (natural or formal) can indeed be interpreted as a system of resources. For example a sentence like *The man that Mary saw Peter slept* is incorrect because it violates an underlying principle of natural languages, according to which verbal valencies must be realized once and only once. Categorial grammars formalize this idea by specifying that a verb such as *saw* is a resource which will give a sentence S in the presence of a nominal subject phrase, NP, and only one direct object NP. This gives rise to the following type assignment:

Mary, Peter:	NP
saw	$(NP \setminus S)/NP$

where the slash ($/$) (resp. the backslash ($\setminus$)) are interpreted as fraction pairings that simplify to the right (resp. to the left). However we notice very soon that this simplification scheme, which is the basis of Bar-Hillel grammars [22], is not sufficient.

Lambek solves this problem by suggesting the interpretation of slashes and backslashes as implicative connectors [29], [30]. Then not only do they obey the *modus ponens* law which turns out to be Bar-Hillel's simplification scheme

$$\frac{\Gamma \vdash A \quad \Delta \vdash A \backslash B}{\Gamma, \Delta \vdash B} \text{ (modus ponens)} \qquad \frac{\Gamma \vdash B/A \quad \Delta \vdash A}{\Gamma, \Delta \vdash B} \text{ (modus ponens)}$$

but also the introduction rules:

$$\frac{A, \Gamma \vdash B}{\Gamma \vdash A \backslash B} \ \backslash\text{-intro} \qquad \frac{\Gamma, A \vdash B}{\Gamma \vdash B/A} \ /\text{-intro}$$

The Lambek calculus does have its own limitations. Among other things it cannot treat syntactical phenomena like medial extraction and crossed dependencies. Thus the question arises: how can we extend the Lambek calculus to treat these and related problems? This is where linear logic comes into play, by offering an adequate mathematical framework for attacking this question. In particular proof nets appear as the best adapted approach to syntactical structure in the categorial framework.

Proof nets offer a geometrical interpretation of proof construction. Premises are represented by proof net fragments with inputs and outputs which respectively model needed and offered resources. These fragments must then be combined by pairing inputs and outputs according to their types. This process can also be interpreted in a model-theoretical fashion where fragments are regarded as descriptions for certain classes of models: the intuitionistic multiplicative fragment of linear logic can be interpreted on directed acyclic graphs, while for the implicative fragment, trees suffice [31].

This perspective shift from proof theory to model theory remains founded on the notion of resource sensitivity (e.g., in the form of polarities and their neutralization) but affords us the freedom to interpret these ideas in richer classes of models and leads to the formalism of Interaction Grammars. For example:

- Where previously we only considered simple categories with polarities, we can now consider complex categories with polarized features.
- We can also adopt more expressive tree description languages that allow us to speak about dominance and precedence relations between nodes. In this fashion, we espouse and generalize the monotonic version of Tree Adjoining Grammars (TAG) as proposed by Vijay-Shanker [36].
- Contrary to TAG where tree fragments can only be inserted, Interaction Grammars admit models where the interpretations of description fragments may overlap.

4. Application Domains

4.1. Modelling the Syntax and Semantics of Natural Languages

4.1.1. Abstract Categorial Grammars

Abstract Categorial Grammars (ACGs) are a new categorial formalism based on Girard's linear logic. This formalism, which sticks to the spirit of current type-logical grammars, offers the following features:

- Any ACG generates two languages, an abstract language and an object language. The abstract language may be thought as a set of abstract grammatical structures, and the object language as the sets of concrete forms generated from these abstract structures. Consequently, one has a direct control on the parse structures of the grammar.
- The languages generated by the ACGs are sets of linear λ-terms. This may be seen as a generalization of both string-languages and tree-languages.
- ACGs are based on a small set of mathematical primitives that combine via simple composition rules. Consequently, the ACG framework is rather flexible.

Abstract categorial grammars are not intended as yet another grammatical formalism that would compete with other established formalisms. It should rather be seen as the kernel of a grammatical framework in which other existing grammatical models may be encoded.

4.1.2. Interaction Grammars

Interaction Grammars (IGs) are a grammatical formalism based on the notion of polarity. Polarities express the resource sensitivity of natural languages by modelling the distinction between saturated and unsaturated syntactic structures. Syntactic composition is represented as a chemical reaction guided by the saturation of polarities. It is expressed in a model-theoretic framework where grammars are constraint systems using the notion of tree description and parsing appears as a process of building tree description models satisfying criteria of saturation and minimality.

The formalism of IGs stems from a reformulation of proof nets of Intuitionistic Linear Logic (which have very specific properties) in a model-theoretical framework [34] and it was at first designed for modelling the syntax of natural languages [33].

Even if the model of the syntax can be plugged with various representations of the semantics of natural languages, it can be also adapted to the semantics [35]: tree descriptions are replaced with DAG descriptions and semantic composition is driven by a similar operation of cancellation between polarized semantic features; the synchronization between the syntactic and the semantic levels is realized in a flexible way by a partial function that maps syntactic nodes to semantic nodes.

4.1.3. Grammatical and lexical resources for French

The relevance of new linguistic formalisms needs to be proved by experiments on real corpora. Parsing real corpora requires large scale grammars and lexicons. There is a crucial lack of such resources for French and all researchers committed in natural language processing (NLP) projects for French based on different formalisms are confronted with the same problem. Now, building large scale grammars and lexicons for French demands a lot of time and human resources and it is crucial to overcome the multiplicity of existing formalisms by developing common and reusable tools and data. This is the sense of two directions of research:

1. The modular organization of formal grammars in a hierarchy of classes allows the expression of linguistic generalizations and it makes their development and their maintenance on a large scale possible. To be used in NLP applications such modular grammars have to be compiled into operational grammars. By comparison with the area of programming languages, we write source grammars in a language with a high abstraction level and then we compile them automatically to object grammars, directly usable by NLP applications.

   Considering the multiplicity of linguistic formalisms, it would be interesting to express the various source grammars that can be written in different formalisms, in a common abstract language and to compile them with the same tool associated to this language. XMG is a first experiment in this direction: for the moment, it allows the edition and the compilation of source grammars for TAGs and IGs. Moreover, we can hope that the use of a common language of syntactic description with a high level of abstraction makes easier the reusability of some parts of grammars from one formalism to another.

2. With the same preoccupation of reusability, it is important to develop syntactic and semantic lexicons which contain only purely linguistic information and which are independent of the different existing grammatical formalisms. Now, a mechanism must be foreseen to combine these lexicons with the grammars built in the various formalisms. A convenient way of doing this is to design the entries of such lexicons in the form of feature structures and to associate also feature structures with the elementary constructions of the grammars. Then, their anchoring in the lexicons is realized by unification of the two kinds of feature structures. The construction of a syntactic and a semantic lexicon for French can be envisaged either by acquisition from corpora or by re-use of existing lexical information.

5. Software

5.1. Leopar

Participants: Bruno Guillaume [correspondant], Guy Perrier, Guillaume Bonfante [CARTE team], Sylvain Pogodalla, Jonathan Marchand.

5.1.1. Software description

LEOPAR is a parser for natural languages which is based on the formalism of Interaction Grammars [32]. It uses a parsing principle, called "electrostatic parsing" which consists in neutralizing opposite polarities. A positive polarity corresponds to an available linguistic feature and a negative one to an expected feature.

Parsing a sentence with an Interaction Grammar consists in first selecting a lexical entry for each of its words. A lexical entry is an underspecified syntactic tree, a tree description in other words. Then, all selected tree descriptions are combined by partial superposition guided by the aim of neutralizing polarities: two opposite polarities are neutralized by merging their support nodes. Parsing succeeds if the process ends with a minimal and neutral tree. As IGs are based on polarities and under-specified trees, LEOPAR uses some specific and non-trivial data-structures and algorithms.

The electrostatic principle has been intensively considered in LEOPAR. The theoretical problem of parsing IGs is NP-complete; the nondeterminism usually associated to NP-completeness is present at two levels: when a description for each word is selected from the lexicon, and when a choice of which nodes to merge is made. Polarities have shown their efficiency in pruning the search tree for the following two steps:

- In the first step (tagging the words of the sentence with tree descriptions), we forget the structure of descriptions, and only keep the bag of their features. In this case, parsing inside the formalism is greatly simplified because composition rules reduce to the neutralization of a negative feature-value pair $f \longleftarrow v$ by a dual positive feature-value pair $f \longrightarrow v$. As a consequence, parsing reduces to a counting of positive and negative polarities present in the selected tagging for every pair (f, v): every positive occurrence counts for +1 and every negative occurrence for –1, the sum must be 0.
- In the second step (node-merging phase), polarities are used to cut off parsing branches when their trees contain too many non neutral polarities.

5.1.2. Current state of the implementation

LEOPAR is presented at http://leopar.loria.fr. It is also a public project on the InriaGforge platform. http://gforge.inria.fr/projects/leopar/. It is freely available under the CECILL License (http://www.cecill.info).

The main features of current software are:

- automatic parsing of a sentence or a set of sentences,
- interactive parsing (the user chooses the couple of nodes to merge),
- visualization of grammars produced by XMG or of sets of description trees associated to some word in the linguistic resources,
- a graphical interface (using GTK) which is useful for debugging grammars.

The main changes this year:

- New algorithms for lexical desambiguisation are implemented.
- A dependency representation is available for each solution.
- A web-based interface for online parsing.

LEOPAR was presented at the ATALA workshop about parsing system for French [16]

5.2. ACG support system

Participants: Sylvain Pogodalla [correspondant], Philippe de Groote, Sylvain Salvati [SIGNES team].

The new and rewritten version of the ACG development toolkit prototype was first released in October 2008. Other released have been made before the ESSLLI 2009 course on ACG. The toolkit focuses on providing facilities to develop grammars. A parsing algorithm based on [28]'s methods is being implemented for second-order ACGs. Users are mainly members of the INRIA associate team "Lambda & Grammars" (see section 6.2.1) and the NWO network "A Global Network for Lambda Grammars and Abstract Categorial Grammars" (see section 7.2.1). It is available at http://acg.gforge.inria.fr with a CeCILL license.

6. New Results

6.1. Proof Nets, Sequent Calculus and Typed Lambda Calculi

Participants: Paola Bruscoli, Alessio Guglielmi, Robert Hein, François Lamarche, Novak Novakovi'c.

6.1.1. Denotational Semantics for Classical Logic

In [10] François Lamarche and Novak Novaković construct two denotational interpretations of proofs in classical propositional logic, which are based on posets and special relations between them, once called “comparisons” by Lambek. In the first interpretation types are modeled by iterated products of the integers $\mathbb{Z}$. The computations are simple and it is easy to extract simple invariants and relate them to proof nets. But this interpretation suffers from the fact that it has too many maps, due to the great number of order-preserving permutations of $\mathbb{Z}$. The second interpretations is based instead on the natural numbers $\mathbb{N}$, whose absence of non-trivial order-automorphism solves the problems associated with the previous model, but where computations are much more involved. The paper concludes by asking if the simplicity of the invariants of the first model might be due to the fact that it obeys the equations of a Frobenius algebra. Subsequent research by the second author has concluded that not only is it the case, but that those invariants are actually topological ones, having to do in particular with numbers of loops in the atomic flow presentation of a proof (see below).

6.1.2. Atomic Flows

Atomic flows are an important geometric invariant of classical propositional proofs in deep inference. They are a generalization of the set of links of a proof net, but contain in addition the information associated with (co)contraction and (co)weakening. In [5] Tom Gundersen first presents a new deep inference formalism, more flexible than the Calculus of Structures, which he calls the Functorial Calculus. He then describes atomic flows, shows how they can be used to define a hierarchy of normal forms for proofs, and then uses flows as blueprints to attain these normal forms by surgery on Functorial Calculus proofs, while providing complexity analyses. These proof rewriting methods have a novel aspect, quite different from what is usually seen with normalization in the sequent calculus, the lambda calculus or proof nets. Quasipolynomial complexity has been achieved for a particular normalization methodology, and it is strongly hoped that one can go even lower.

6.1.3. Deep Inference Systems for Linear Logic

In [21] Lutz Straßburger and Alessio Guglielmi expose the first part of the new normalisation theory of a mixed commutative/non-commutative linear logic with modalities. System NEL is the mixed commutative/non-commutative linear logic BV augmented with linear logic's exponentials, or, equivalently, it is MELL augmented with the non-commutative self-dual connective seq. System NEL is Turing-complete, it is able to directly express process algebra sequential composition and it faithfully models causal quantum evolution. In this paper, the authors show a basic compositionality property of NEL, which they call decomposition. This result leads to a cut-elimination theorem, which is proved in the next paper of this series. To control the induction measure for the theorem, the authors rely on a novel technique that extracts from NEL proofs the structure of exponentials, into what they call !-?-Flow-Graphs.

In [19] Alessio Guglielmi and Lutz Straßburger expose the second part of the new normalisation theory of a mixed commutative/non-commutative linear logic with modalities. In this paper, the authors show cut elimination for NEL, based on a property that they call splitting. NEL is presented in the calculus of structures, which is a deep-inference formalism, because no Gentzen formalism can express it analytically. The splitting theorem shows how and to what extent we can recover a sequent-like structure in NEL proofs. Together with the decomposition theorem, proved in the previous paper of the series, this immediately leads to a cut-elimination theorem for NEL.

6.1.4. Complexity of Deep Inference

In [6] Paola Bruscoli and Alessio Guglielmi obtain two results about the proof complexity of deep inference: 1) deep-inference proof systems are as powerful as Frege ones, even when both are extended with the Tseitin extension rule or with the substitution rule; 2) there are analytic deep-inference proof systems that exhibit an exponential speed-up over analytic Gentzen proof systems that they polynomially simulate.

In [18] Paola Bruscoli, Alessio Guglielmi, Tom Gundersen and Michel Parigot show a surprising result about the normalisation theory of propositional logic. In 2008, Jeřábek showed that analytic propositional-logic deep-inference proofs can be constructed in quasipolynomial time from nonanalytic proofs. In this work, the authors improve on that as follows: 1) they significantly simplify the technique; 2) their normalisation procedure is direct, i.e., it is internal to deep inference.

6.2. Categorial Grammars

Participants: Philippe de Groote, Guy Perrier, Sylvain Pogodalla, Florent Pompigne, Bruno Guillaume, Maxime Amblard, Jonathan Marchand.

6.2.1. Abstract Categorial Grammars

In the last three years, it was shown how to encode various grammatical formalisms into ACG. Along this line of research, Philippe de Groote, Sylvain Pogodalla and Carl Pollard have studied the relation between ACG and Convergent Grammars (CVG, a grammatical formalism proposed by Carl Pollard). In particular, they focused on extraction and scope ambiguities. This study has resulted in a modeling of the CVG architecture into ACG [13].

Using an extented type system of ACG (including dependent products), Florent Pompigne proposed a modeling of overt and overt movements in French, focusing on the constraints against extraction [12].

Sai Qian developed, for his master thesis, an ACG fragment of an english grammar for semantic modeling including simple negation, proper name, and scope ambiguity treatments.

6.2.2. Interaction Grammars

Jonathan Marchand, Bruno Guillaume and Guy Perrier have proposed a method to extract dependency structures from phrase-structure level parsing with Interaction Grammars [14]. Interaction Grammars are a formalism which expresses interactions among words using a polarity system. Syntactical composition is led by the saturation of polarities. Interactions take place between constituents, but as grammars are lexicalized, these interactions can be translated at the level of words. Dependency relations are extracted from the parsing process: every dependency is the consequence of a polarity saturation. The dependency relations we obtain can be seen as a refinement of the usual dependency tree. Generally speaking, this work sheds new light on links between phrase structure and dependency parsing.

Guillaume Bonfante, Bruno Guillaume and Mathieu Morey have proposed a new method to perform lexical disambiguation in lexicalized grammatical formalisms. It deals with the order constraints on words. Actually, the soundness of the method is due to an invariant property of the parsing of an Interaction Grammar. One of the strong point of the method is that this invariant can be computed statically from the grammar. This work for Interaciton Grammars was presented in July in [15]. A more complete version of this work which can be applied to other grammatical frameworks and which refers to a more abstract notion of dependency constraints between words was presented in October in the IWPT conference [8]

6.2.3. Categorial Minimalist Grammars

Categorial Minimalist Grammars (CMG) is a framework which implement a syntax semantic interface for NPL with the generative theory. They are based on commutative and non-commutative relations inside the sentence. Maxime Amblard defined new rules for the treatment of VP analysis to give account of phases of Generative theory. This works are based on the fact that VP hypothesis must be used with non-commutative relations in order to control the structure of the VP. He include the non-commutative product of Partially Commutative Intuitionistic Multiplicative Linear Logic (PCIMLL) to the definition of MCG. This allow to define phase island for scope representations at the semantic level (negation, quantification,...).

6.2.4. Semantic analysis

Guy Perrier, Mathieu Morey and Maxime Amblard [17] have designed a general two-step algorithm which transforms a graph expressing the semantic dependencies between the words of an utterance into logic formulae representing the different semantic interpretations of the utterance. The algorithm focuses on the scopal elements of the utterance, i.e. quantifiers and scopal predicates. First, the scope of every scopal element is computed as a subgraph of the whole graph, given an order on these elements. Second, we use these scopes with their order to build a logic formula incrementally from the most internal to the most external scopal elements.

Mathieu Morey is working on a calculus to compute semantics from deep syntactic dependency graphs, which can be obtained from a syntactic analysis performed in Interaction Grammars.

Philippe de Groote has pusrsued the line of research initiated in [37], and has defined a higher-order type-theoretic dynamic logic which conservative over usual classical logic. Together with Ekaterina Lebedeva, he has applied the same approach to model presupposition projection, using an exception handling mechanism to model accomodation. These works have been presented in several workshops, in particular during the CAULDmeetings.

In the same spirit, Sylvain Pogodalla and Nicholas Asher (IRIT, Toulouse) proposed an account for building the semantic representation of modal subordination in a type-theoretical setting (submitted). This joint work is part of the CAULD (see 7.1.4) ARC.

Maxime Amblard work on scope ambiguities of natural language and the implementation of the Davidsonian theory of *events* in de Groote's type theoretic dynamic logic. The use of *event* to linked the different parts of a semantic representation question computational semantic: the usual functional application has two effects: one which unify variables and the other which place the different predicates in the logical representation. This properties allow to capture ambiguities of natural language.

Sai Qian and Maxime Amblard studied an extension of DRT with external features to resolve pronoun anaphoras with Binding Theory. This study is the starting point for the definition of the structure of accessible discourse referent in type theoretic dynamic logic.

6.3. Development of linguistic resources

Participants: Guy Perrier, Bruno Guillaume.

6.3.1. Development of a French interaction grammar

Guy has enriched and improved the French interaction grammar on the following points:

1. He has built a relatively complete grammar for extraction phenomena[11]: relative, interrogative and cleft clauses.
2. He has documented all modules of the grammar with illustrative sentences. The grammar is accompanied with about 400 grammatical and 100 ungrammatical sentences, which can be also used as a test suite.
3. He has integrated the concept of syntactic dependency in the grammar in a systematically way, so that it is possible to produce parses of sentences in the form of dependency graphs between words.

6.3.2. Development of an Interaction Grammar for Persian

During his first year of master, Masood Ghayoomi, under the supervision of Bruno Guillaume, has begined to develop an interaction grammar for the Persian language. He focus on a modelization of the construction of Persian noun and adjectival phrases. The proposed grammar was implemented with the XMG Metagrammar compiler. A small test suite was built and tested with the LEOPAR parser. The experimental results show that we could parse the phrases successfully, even the most complex ones which have various constructions in them. This work was presented in [9].

7. Other Grants and Activities

7.1. National Actions

7.1.1. Agence Nationale de la Recherche (ANR) Infer

This three-year "programme blanc" project on the theoretical and applicative development of deep inference began in December 2006. Two Inria-Lorraine teams, Calligramme and Paréo, are involved in it, along with teams at INRIA-Futurs and the PPS lab (Université Paris VII). The head of the project is Lutz Straßburger (Parsifal, INRIA-Futurs), and the local co-ordinator is François Lamarche. One meeting was held at the Loria on June 18th.

Webpage: http://www.lix.polytechnique.fr/~lutz/orgs/infer.html

7.1.2. Agence Nationale de la Recherche (ANR) Prelude

Calligramme is involved in the ANR-Blanc action PRELUDE http://prevert.upmf-grenoble.fr/~alecomte/PRELUDE.htm. This action is starting and aims at giving a theory of pragmatics based on ludics [25] and continuations [37]. The partner teams are: Structures Formelles de la Langue[1](co-ordinator), Institut Mathématique de Luminy[2], the Signes INRIA project[3] and Calligramme.

7.1.3. Chaire d'Excellence ANR Démosthène

The Chaire d'Excellence is a new ANR program that offers two-year fellowships that are specifically targeted at high-level scientists from outside of France. Alessio Guglielmi, then at the University of Bath (UK) won one of these fellowships in 2008, and he is now at the Loria collaborating with François Lamarche, who is the local co-ordinator of the Chaire. The research program centers on the new geometric invariants obtainable from deep inference, their algebric formulation and the new complexity measures that they give rise to. Out of about a hundred applicants, only 15 fellowships were attributed for the whole of France. Paola Bruscoli also benefits from that fellowship as research assistant.

7.1.4. INRIA ARC CAUlD

The INRIA ARC "Construction Automatique de représentations Logiques du Discours" (CAULD)[4] is a two-year project that started in 2009. It aims at studying the representation of the discourse (rather than the sentence) in:

1. developping a formalism inspired by functionnal programming methods and checking its adequacy to linguistic theories for discourse, with a special focus on anaphora;
2. reconsider these linguistic theories for discourse and the models they propose inside this well-defined computational framework.

[1] UMR 7023, Paris 8, http://recherche.univ-paris8.fr/red_fich_equ.php?OrgaNum=48
[2] CNRS, http://iml.univ-mrs.fr/
[3] http://signes.labri.fr/
[4] http://www.loria.fr/~pogodall/cauld

This pluridisciplinary project involves people from computer science, logic and formal linguistics.

- people from the Calligramme team (coordinator)
- people from the Logic, Interaction, Language, and Compuation team (LILaC, IRIT) [5]
- people from the "Laboratoire de Linguistique Formelle" (LLF) [6]
- people from the SIGNES INRIA team[7]

7.1.5. INRIA ARC REDO

The two-year INRIA Action de Recherche Collaborative REDO began in early 2009 and involves INRIA project-teams Parsifal (INRIA Saclay – Ile de France), Calligramme and Pareo, as well as several reseachers and students at the University of Bath. The local members are Paola Bruscoli, Alessio Guglielmi, Yves Guiraud (Pareo), Robert Hein, François Lamarche and Novak Novaković. The scientific objectives are the redesign of syntactic formalisms with proof search as the specific application. Two meetings were held in 2009, one at the Laboratoire d'Informatique de l'École Polytechnique (LIX) on 26–27, and one at the Loria, November 16–18.

7.2. International Actions

7.2.1. NWO

The Calligramme project belongs to the network entitled "A Global Network for Lambda Grammars and Abstract Categorial Grammars"[8]. The other partners of this network are: the NII, Japan, the Technion, Israel, and Tilburg University, Netherlands (co-ordinator of this network). It started in 2007 for a three years period. It is supported at 80% by the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO, national agency for science of the Netherlands).

7.3. Visits and invitation of researchers

- Alessio Guglielmi from the University of Bath is spending the second year of a two-year ANR "Chaire d'Excellence" invited Professorship in Calligramme as François Lamarche's guest. Only 15 Chaires d'Excellence were given in the whole of France out of a hundred applicants from all over the world.
- François Lamarche spent ten days at the Department of Mathematics, McGill University, June 18–28.
- Paola Bruscoli visited the Department of Computer Science at the University of Bath, March 24.
- Lutz Straßburger from INRIA project-team Parsifal visited Calligramme, April 9–14.
- Michel Parigot from the PPS laboratory, Paris, visited Calligramme twice, June 23–24 and August 13-14.
- Bruno Woltzenlogel Paleo from TU Wien visited Callgramme, August 1–3.
- Sylvain Salvati visited Calligramme from October 26th to 30th.
- Sylvain Pogodalla visited Christian Retoré (SIGNES INRIA team), Oct 12–16.
- Nicholas Asher visited Calligramme, Oct 20–23.

8. Dissemination

8.1. Activism within the scientific community

[5] http://www.irit.fr/recherches/LILAC/
[6] http://www.llf.cnrs.fr/
[7] http://signes.labri.fr/
[8] http://www.nwo.nl/projecten.nsf/pages/2300136194?opendocument

- Philippe de Groote is member of the editorial board of the journal *Higher-Order and Symbolic Computation*. He is member of the ESSLLI standing committee, and the Formal Grammar conference series standing committee.
- Philippe de Groote was member of the program committees of GoTAl and FG'09.
- Philippe de Groote was president of the INRIA-Bordeaux CR1/CR2 hiring committee.
- Alessio Guglielmi was invited to write a portrait of Giorgio Levi for his Festschrift, published in Theoretical Computer Science [7]
- Guy Perrier is member of the editorial board of the journal *Traitement Automatique des Langues*.
- Guy Perrier was member of the program committee of the workshop *What French parsing systems ?* , which was held in Paris October 10th 2009.
- Guy Perrier is member of the program committee of the international conference IceTAl, which will be held in Reykjavik (Iceland) August 16th to 18th, 2010.
- François Lamarche was External Examiner for the thesis of Tom Gundersen, University of Bath, November 10.
- Sylvain Pogodalla is member of the editorial board of the journal *Traitement Automatique des Langues*.
- Sylvain Pogodalla was part of the scientific committee of MOL 11 (Bielefeld, 2009) and of the Parsing with Categorial Grammars workshop (ESSLLI, Bordeaux, 2009) and reviewers for the Journal of Logic, Language, Information and Computation (JoLLI).
- Sylvain Pogodalla was part of the hiring committee of the INRIA/ENSEIRB chaire d'excellence.
- Sylvain Pogodalla is head of the Commission de Développement Technologique for the INRIA Nancy–Grand Est centre.
- Sylvain Pogodalla organized a workshop on “Logical Methods for Discourse”, Nancy, December 14-15.
- Maxime Amblard is vice-treasurer of the Association pour le Traitement Automatique des Langues (ATALA).
- Maxime Amblard is member of the Association *Opération Postes* which works on diffusion of public scientific position in France.
- Maxime Amblard was part of the organization committees of the 50 years of ATALA (june 2009) and ESSLLI09 (July 2009).
- Maxime Amblard was chair of the thesis defense of Pierre Hankach, *Génération automatique par satisfaction de contraintes*, Université Paris Diderot, Paris 7, June 3.

8.2. Teaching

- Philippe de Groote is teaching, with Gérard Huet, the course "Structures Informatiques et Logiques pour la Modélisation Linguistique" of the *Master Parisien de Recherche en Informatique*.
- Philippe de Groote is teaching the course "Computational Sementics" of the Nancy computer science master, specialization "Traitement Automatique des Langues".
- Philippe de Groote and Sylvain Salvati gave a course at ESSLLI 2009, Bordeaux, on “Introduction to Abstract Categorial Grammars: Foundations and main properties.”.
- Sylvain Pogodalla and Makoto Kanazawa gave a course at ESSLLI 2009, Bordeaux, on “Advances in Abstract Categorial Grammars: Language theory and linguistic modeling”.
- Maxime Amblard, Sylvain Pogodalla attended ESSLLI 2009, Bordeaux.
- Maxime Amblard is the head of the master *Sciences Cognitives et Applications* (SCA) for the university of Nancy 2.

- Guy Perrier is the local coordinator of the Erasmus Mundus Master program *Language and Communication Technologies* for the university of Nancy 2.
- Guy Perrier is teaching the courses *tools and algorithms for NLP*, *initiation to NLP* and *programming for NLP* in the specialization *Traitement Automatique des Langues* of the Master in cognitive science of Nancy 2.
- Bruno Guillaume is teaching the course ”Grammatical formalisms” of the Nancy computer science master, specialization ”Traitement Automatique des Langues”.
- Novak Novaković is teaching the course "Creation an Design of Web Pages" for the students of bachelor program SUP'EST at ICN Business School in Nancy.
- Maxime Amblard is teaching the courses *Discourse and Dialogue* and *programming for NLP* (english version) in the master SCA, specialization *Traitement Automatique des Langues*. He is also teaching in the *Licence Informatique et Science Cognitives* the courses *a first step to NLP*, *Modeling knowledge*, *Algorithms*.

8.3. Academic Supervision

- Philippe de Groote is supervising the thesis works of Sarah Maarek and Ekaterina Lebedeva.
- Philippe de Groote and Sylvain Pogodalla are supervising thesis work of Florent Pompigne.
- Alessio Guglielmi is supervising the thesis of Tom Gundersen (student at the University of Bath).
- François Lamarche is supervising the thesis work of Robert Hein (defense planned in early 2010) and Novak Novakovic (defense in early 2011).
- Guy Perrier and Bruno Guillaume are co-supervising the thesis work of Jonathan Marchand.
- Guy Perrier is supervising the thesis work of Mathieu Morey.
- Guy Perrier has supervised the master thesis of Sana Grati.
- Maxime Amblard has supervised the master thesis of Sai Qian.
- Maxime Amblard is supervising the thesis works of Sai Qian.

8.4. Participation to colloquia, seminars, invitations

- Philippe de Groote, Florent Pompigne and Sylvain Pogodalla visited the SIGNES INRIA team March 9–13. They participated to the 7th workshop on Lambda Calculus and Formal Grammars.
- Philippe de Groote and Sylvain Pogodalla gave a talk [13] at the international Workshop on Language, Logic, Information and Computation (WoLLIC 2009, Tokyo, June 21-24.
- Sylvain Pogodalla attended the Journées ARC et ADT, Bordeaux, Sep 29–Oct 1.
- Alessio Guglielmi, François Lamarche, Robert Hein, Novak Novaković and Tom Gundersen attended the first REDO (Redesigning Logical Syntax) meeting at the Laboratoire d'Informatique d'école Polytechnique (LIX), Paris, May 26-29. Alessio Guglielmi, François Lamarche and Novak Novaković gave talks.
- François Lamarche was invited speaker at the “Modéles, logique et catégories à plus grandes dimensions: un hommage aux travaux de Mihaly Makkai” conference, at the Centre de Recherches Mathématiques, Montreal, June 18-20.
- François Lamarche, Robert Hein and Novak Novaković attended the Topology, Algebra and Categories in Logic conference (TACL 2009) in Amsterdam, July 7-11, 2009. Franoȩis Lamarche chaired a session.
- François Lamarche and Novak Novaković attended the Structures and Deduction 2009 workshop (SD 09) in Bordeaux, July 20-24, 2009. François Lamarche was invited speaker, while Novak Novaković contributed with a talk.

- Alessio Guglielmi was invited speaker at the Tableaux 2009 workshop “Gentzen Systems and Beyond”.
- Paola Bruscoli, Alessio Guglielmi, Tom Gundersen, François Lamarche, Robert Hein and Novak Novaković attended the the second REDO (Redesigning Logical Syntax) meeting November 16-18, LORIA, Nancy. Alessio Guglielmi and Novak Novaković gave talks.
- François Lamarche, Robert Hein, Novak Novaković attended the Workshop on Computer Algebra Methods and Commutativity of Algebraic Diagrams (CAM-CAD) in Toulouse, 16–17 October 2009. François Lamarche gave a talk.
- Bruno Guillaume, Mathieu Morey attended the European Summer School in Language, Logic and Information (ESSLLI 2009) in Bordeaux and Mathieu Morey gave a talk [15] at the Workshop on Parsing with Categorial Grammars.
- Bruno Guillaume, Jonathan Marchand, Mathieu Morey attended Interntioanl Conference on Parsing Technologies in Paris and Mathieu Morey gave a talk [8].
- Bruno Guillaume, Jonathan Marchand and Guy Perrier attended to the ATAL Workshop “What French parsing systems ?” and Jonathan Marchand gave a talk [16].
- Guy Perrier attended the conference RANLP 2009 in Borovets, Bulgaria, September 14th to 16th 2009, and gave a talk [11].

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