Annual report 1992

Department of Software Technology
Annual Report 1992

0   Introduction

0.1   Staff Department of Software Technology, April 1, 1993

- AP1
  - J.W. de Bakker
  - J.J.M.M. Rutten
  - M. Bonsangue (Italian funds)
  - F. van Breugel (NFI)
  - D. Turi (SION)
  - H. Wiklicky (Austrian funds)

- AP2
  - F.W. Vaandrager
  - D.J.B. Bosscher
  - W.J. Fokkink
  - A.S. Klusener
  - H.P. Korver
  - J. Trescher (ERCIM fellow)
  - 0.5 transfer vacancy

- AP3
  - P. Klint
  - H. Bakker
  - A. van Deursen
  - T.B. Dinesh
  - J.J. Ganzevoort
  - J. Heering
  - J. Kamperman
  - E.A. van der Meulen
  - F. Tip

- H.R. Walters
- 0.5 transfer vacancy

- AP4
  - J.W. Klop
  - H.P. Barendregt (0.4)
  - C. Brovedani (Italian funds)
  - F. van Raamsdonk (SION)
  - M. Marchiori (Italian funds)
  - F.J. de Vries

- AP5a
  - K.R. Apt
  - S. Etalle (Italian funds)
  - M. Gabbrielli (Italian funds)
  - E. Marchiori
  - F. Teusink (SION)

- AP5b
  - D.J.N. van Eijck
  - G. Cepparello (Italian funds)
  - R.T.P. Fernando (NFI)
  - W. Meyer Viol (RUU)
  - V. Stebletsova (NFI)

- Secretary: M. Brune

0.2 International External Funding

Current EC-projects:

- ESPRIT, main programme: GIPE II, Compare (AP3)

- RACE: BOOST (AP2)

- ESPRIT, Basic Research Actions: Concur 2 (AP2), Confer (AP4), Compulog 2 (AP5a)

- ESPRIT, Working Groups: Semagraph (AP4)

- SCIENCE: Mask (AP1)

Awarded projects:

- HCM, Networks: Logical Foundations for Computer Science (AP1,4,5a) EXPRESS (AP2,4)

1 Semantics (AP1)

1.1 Staff

- Prof. dr. J.W. de Bakker, department head and group leader

- drs. M. Bonsangue, visitor

- ir. F. van Breugel, junior researcher (OIO), NFI/REX

- dr. J.J.M.M. Rutten, researcher

- drs. D. Turi, junior researcher (OIO), SION

1.2 Scientific Report

De Bakker continued his work on the preparation of an advanced textbook with the provisional title 'Control Flow Semantics'. This is a joint project with dr. E. de Vink (VUA). Together, they also revised a paper 'Rendez- vous with metric semantics', which is to appear in New Generation Computing. Jointly with Van Breugel, De Bakker moreover worked on the use of topological models in higher order control flow (2nd order assignment and 2nd order communication); recently developed techniques by Van Breugel and Rutten could be applied here. Together with dr. A. de Bruin (EUR), they made a study of the comparative semantics of linear arrays of communicating processes, as a means to study the UNIX fork and pipe commands. Jointly with Rutten, De Bakker edited a volume of selected papers of the Amsterdam Concurrency Group, representing ten years of work on concurrency semantics. Together with Apt, De Bakker and Rutten moreover prepared a collection of papers on the ESPRIT Basic Research Action Integration. In the context of the NFI-sponsored REX project, De Bakker, jointly with De Roever and Rozenberg, edited the proceedings of the REX91 meeting (LNCS 600, on Real-Time: Theory in Practice) and the REX92 meeting (LNCS 666, on Semantics: Foundations and Applications). Furthermore, the preparations for the final REX meeting (to be held in 1993, called 'A Decade of Concurrency - reflections and perspectives') were started. Finally, in a joint effort with Rutten and prof. P. Panangaden (McGill University, Montreal), a draft version of the thesis 'Fully Abstract Models for Concurrent Languages', by E. Horita of NTT, Tokyo, was extensively discussed.

Bonsangue. The first period of the year has been devoted to the study of literature. Later, together with Joost Kok of Utrecht University, we have studied an extension of the Dijkstra guarded command language to which recursion has been added in a fully compositional way. We have used a technique of transferring properties from one domain to another, which permits, also, to calculate fixed points in complete partial orders by iterations even for some non-monotonic functions (such as a backtrack operator used in our extension of the Dijkstra guarded command language). Furthermore, we have studied some relationships between the predicate transformers and the three standard powerdomains: the Hoare, the Smyth, and the Plotkin. At first we have studied these relationships for simple (flat) complete partial orders, suitable in input-output semantics. Later we have extended these relationships also to general complete partial orders, suitable in semantics for concurrency.

Van Breugel. Transition systems provided with a metric have been investigated. By means of

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the additional structure added by the metric, the finiteness conditions finitely branching and image finite could be generalized. The use of metric transition systems enabled us to model certain language constructs in an elementary way.

By means of metric transition systems we have already modelled some higher order programming constructs and we will continue this line of research. Furthermore, the above described research guided us towards a new process domain. To a certain extent, this new process domain has already been related to the already known process domains, but further study in this area is still needed.

Rutten and Turi have been working out and generalizing the final coalgebra semantic scheme as sketched in Peter Aczel's work. In this approach, semantics is defined as the unique mapping from a coalgebra into the final one. In [CS-R9241], the mathematical foundations of final semantics are studied. It is shown that solving domain equations in the three different categories of non-well-founded sets, metric spaces, and partial orders, always amounts to finding a final coalgebra for the functor involved in the domain equation. Also, a coalgebraic notion of bisimulation given by Aczel and Mendler has been generalized to partial orders. Furthermore, an interesting reformulation of the so-called anti-foundation axiom in terms of final coalgebras has been given, with as consequence a dramatic simplification of a crucial theorem in Aczel's book 'Non-well-founded sets', namely, the 'solution lemma'. In (Rutten 92), final coalgebras have been characterized in terms of a property called coinduction which is a useful proof technique. In (Turi 92), the final coalgebra scheme has been applied to obtain a domain-theoretic decription of linear ('trace') semantics for non-deterministic transition systems (making use of the tensor product as described by Hennessy and Plotkin). It is here remarkable that trace-equivalence has been obtained as an instance of the coalgebraic formulation of bisimulation.

(Rutten 92): A structural coinduction theorem.

(Turi 92): Tensor Product and Linear Final Semantics (preprint).

1.3 Organisation of Conferences, Workshops, Courses, etc

- REX92 Workshop on Semantics – Foundations and Applications

  From June 1-4 the REX92 meeting took place in Beekbergen, conference centre De Wipselberg. Directors of the meeting were J.W. de Bakker, W.P. de Roever and G. Rozenberg; the local organization was in the hands of J.W. de Bakker, M. Bruné, J.J.M.M. Rutten and F. Snijders. The Workshop was attended by 40 participants. The proceedings of the workshop will appear as Springer Lecture Notes in Computer Science 666.

- REX visiting professor

  Prof.dr. P. Panangaden (McGill University, Montreal) visited the CWI with support from the REX project, from 1 till 29 May. He presented the following 4 lectures.

  The Expressiveness of Indeterminate Dataflow Primitives

  A Domain Theoretic Model of a Higher-Order Process Calculus

  Semantic Foundations of Concurrent Constraint Programming

  Concurrent Constraint Programming: A Hyperdoctrinal View.

- SCIENCE-MASK

  The CWI is coordinator of the MASK project - devoted to Mathematical Structures in Concurrency Semantics. Partners in the project are the CWI, the univeristies Koblenz,

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Mannheim, Pisa and Udine, and INRIA/IRISA in Rennes. Action manager is dr. J.J.M.M. Rutten. The first workshop of MASK took place in Udine, see under 1.4.

- ACG – the Amsterdam Concurrency Group

  ACG is a – on average biweekly – seminar in which ongoing research on semantics is discussed by members and former members of AP1, and invited visitors. External participants are dr. E. de Vink (VUA), dr. J.N. Kok (RUU), dr. A. de Bruin (EUR), dr. F.S. de Boer (TUE) and dr. J.-M. Jacquet (Univ. Namen).

1.4 Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *Workshop Software Construction*, Dagstuhl, Germany, January 12–15: J.W. de Bakker (Semantics for concurrency with atomicity and action refinement).

- *Working Visit University of Oldenburg* (Prof. W. Dam and Prof. E. Olderog), Oldenburg, Germany, January 20–21: J.W. de Bakker (Semantics for concurrency with atomicity and action refinement).

- *Review ESPRIT BRA Demon*, Brussels, Belgium, January 30–31: J.W. de Bakker.

- *ESPRIT BRA Integration, final meeting*, Funchal, Portugal, February 15–18: J.W. de Bakker, F.S. de Boer (Semantics of concurrent constraint programming), J.-M. Jacquet, J.N. Kok, J.J.M.M. Rutten.

- *REX Workshop Semantics: Foundations and Applications*, Beekbergen, June 1–4: J.W. de Bakker, M. Bonsangue, F. van Breugel, J.J.M.M. Rutten (On the foundations of final semantics: metric spaces and partial orders), D. Turi (On the foundations of final semantics: non-standard sets).

- *International Conference on Logic Programming and Automated Reasoning*, St Petersburg, Russia, July 15–20: D. Turi (A two step semantics for logic programs with negation).

- *Working Visit Imperial College* (Prof. M. Smyth), London, UK, August 22–24: J.J.M.M. Rutten.

- *CONCUR '92*, Stony Brook, NY, USA, August 24–27: F. van Breugel.

- *Working Visit University of Torino* (Prof. M. Dezani-Ciancaglini), Torino, Italy, October 8–11, October 15–16: J.W. de Bakker (Series of ten lectures on Comparative control flow semantics).

- *First MASK Workshop*, Udine, Italy, October 12–14: J.W. de Bakker (Higher order control flow semantics), F. van Breugel, J.J.M.M. Rutten (Processes as terms: deriving compositional models from SOS), D. Turi (Observations as functors: (towards) final semantics for programming languages).

- *Workshop on Assertional Methods*, Amsterdam, November 17–18: M. Bonsangue (Semantics, orderings and recursion in the weakest precondition calculus).

- *REX Seminar*, CWI, Amsterdam, November 27: J.W. de Bakker (Topological models for higher order control flow), M. Bonsangue, F. van Breugel (Metric labelled transition systems: a tool for relating operational and denotational semantics), J.J.M.M. Rutten, D. Turi.

1.5 Memberships of Committees and Other Professional Activities

J.W. de Bakker:

- professor of Computer Science, Vrije Universiteit Amsterdam
- member Koninklijke Nederlandse Akademie van Wetenschappen
- member Academia Europaea
- editor Theoretical Computer Science
- editor Journal of Computer and Systems Sciences
- editor Fundamenta Informaticae
- consulting editor, Wiley Series in Parallel Computing
- editor Cambridge University Press Tracts in Theoretical Computer Science
- project leader ESPRIT Basic Research Action INTEGRATION (Integrating the Foundations of Functional, Logic and Object-Oriented Programming)
- project leader NFI project REX: Research and Education in Concurrent Systems
- director REX Workshop on Semantics: Foundations and Applications, Beekbergen, June 1-4
- director REX School/Symposium 'A Decade of Concurrency', June 1-4, 1993
- reviewer ESPRIT Basic Research Actions Cedisys and Demon
- chairman Scientific Advisory Board, Dutch Research Foundation for Computer Science (SION)
- board member Graduate School in Logic
- member IFIP Working Group 2.2 on Formal Description of Programming Concepts
- member panel Mathematics and Computing, EC Programme on Human Capital and Mobility
- member Ph.D. committee W. van der Hoek (VUA), A. Ponse (UvA)

J.J.M.M. Rutten:

- Coordinator SCIENCE project MASK (Mathematical Structures in the Semantics of Concurrency)
- Project leader SION project 'Non-well-founded sets and programming language semantics'

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1.6 Papers in Journals and Proceedings

1. P. America, J.J.M.M. Rutten. A layered semantics for a parallel object-oriented language. In *Formal Aspects of Computing.* 4:376–408, 1992.

2. F.S. de Boer, J.N. Kok, C. Palamidessi, J.J.M.M. Rutten. From failure to success: comparing a denotational and a declarative semantics for Horn Clause Logic. In *Theoretical Computer Science.* 101:239–263, 1992.

3. K. De Bosschere and J.-M. Jacquet. Comparative Semantics of μlog. In D. Etiemble and J.-C. Syre, editors, *Proceedings of the PARLE'92 Conference.* LNCS 605, pages 911–926. Springer-Verlag, 1992.

4. M. Gabrielli, G. Levi, D. Turi. A two step semantics for logic programs with negation. In A. Voronkov, editor, *Proceedings of the International Conference on Logic Programming and Automated Reasoning (St. Petersburg, July 15-20, 1992)*, LNAI 624, Springer-Verlag, 1992.

5. J.-M. Jacquet and L. Monteiro. Communicating Clauses: towards Synchronous Communication in Contextual Logic Programming. In K.R. Apt, editor, *Proceedings of the Joint International Conference and Symposium on Logic Programming*, MIT Press, pages 98-112, 1992.

6. J.J.M.M. Rutten, J.I. Zucker. A semantic approach to fairness. In *Fundamenta Informaticae.* 16: (1):1–38, 1992.

7. J.J.M.M. Rutten. Processes as terms: non-well-founded models for bisimulation. In *Mathematical Structures in Computer Science.* 2:257–275, 1992.

1.7 CWI Reports

1. CS-R9210, J.W. de Bakker, E.P. de Vink, Bisimulation semantics for concurrency with atomicity and action refinement.

2. CS-R9211, J.J.M.M. Rutten, Processes as terms: non-well-founded models for bisimulation.

3. CS-R9241, J.J.M.M. Rutten, D. Turi, On the foundations of final semantics: non-standard sets, metric spaces, partial orders.

4. CS-R9267, M. Bonsangue, J.N. Kok, Semantics, orderings and recursion in the weakest precondition calculus.

1.8 Other Publications

1. J.W. de Bakker, W.P. de Roever, G. Rozenberg (eds.). Proceedings REX Workshop on Real-Time: Theory in Practice, Springer, LNCS 600, 723 pp, 1992.

2. J.W. de Bakker, J.J.M.M. Rutten (eds.). Ten Years of Concurrency Semantics – selected papers of the Amsterdam Concurrency Group, World Scientific Publishers, 441 pp, 1992.

3. J.W. de Bakker, J.J.M.M. Rutten (eds.). Deliverables 1991-1992 and Final Report ESPRIT Basic Research Action Integration, March 1992.

1.9 Visitors

- D. Harel (Weizmann Institute, Israel), November 16-18, Workshop Assertional Methods.

- E. Horita (NTT Tokyo, Japan), May 18-29.

- M. Nivat (LITP, Paris, France), November 10.

- D. Nolte (University of Koblenz, Germany), April 8-10.

- P. Panangaden (McGill University, Canada), May 1-29.

- A. Pitts (Cambridge University, UK), November 27. REX Concurrency day.

- H. Wiklicky (Research Institute for AI, Vienna, Austria), September 18. Synthesis and Analysis of Artificial Neural Networks.

2 Concurrency and Real-Time Systems (AP2)

2.1 Staff

- Prof. dr. J.C.M. Baeten, group leader (0.2 fte), until April 1

- Drs. D.J.B. Bosscher, junior researcher (OIO), since November 1

- Drs. W.J. Fokkink, project member

- Drs. A.S. Klusener, project member

- Drs. H. Korver, project member

- Dr. A. Ponse, project member, until March 31; 0.3 fte subcontract UvA for RACE SPECS since April 1

- Dr. F.W. Vaandrager, group leader, since April 1

2.2 Scientific Report

Real-time. One of the main topics of research within AP2 is the development of formal models and verification techniques for real-time, distributed systems. Together with Prof. Nancy Lynch (MIT), Vaandrager worked on the journal version of the paper *Forward and backward simulations for timing based systems* (LNCS 600). This work presents a general automaton model for timing-based systems, and uses it as the context for developing a variety of simulation proof techniques for such systems. At the CONCUR conference, Lynch and Vaandrager advocated the use of timed trace inclusion as an implementation relation for timed systems. A general class of operations was identified that preserve trace inclusion. Within this class, a particular process algebra was singled out consisting of timed versions of known operations from untimed process algebras, extended with a timer operator to express timing constraints. Klusener and Fokkink continued their thesis work on real-time process algebra. Klusener investigated the notion of silent steps in real-time process algebra, and presented at the CONCUR conference a complete axiomatization of a timed variant of branching bisimulation semantics. Fokkink studied the question what regularity means in a real-time setting, and gave a complete axiomatization w.r.t. rooted branching bisimulation for

a particular notion of timed regularity. Together with R. Segala (MIT) research was started on mutual translations between real-time process algebras with integration and timed automata in the sense of Alur and Dill.

Structural Operational Semantics (SOS). Vaandrager continued his work on the general theory of SOS. The paper *Structured Operational Semantics and Bisimulation as a Congruence*, written jointly with J.F. Groote (RUU), was published in *I&C*. Together with B. Bloom (Cornell) and L. Aceto (University of Sussex), Vaandrager found an algorithm for deriving a complete axiomatizations of bisimulation equivalence starting from a very general type of SOS specification. In many cases the axiomatizations produced by the algorithm compare reasonably well with axiomatizations published in the literature. At the REX92 workshop, Vaandrager presented some expressiveness results for process algebras in a general setting of SOS. One of the motivations behind the work the general theory of SOS is that this can help to integrate the various process algebra verification tools that have been proposed by the partners in the CONCUR2 project. Doeko Bosscher has started to look at some theoretical questions that have to be solved to make the algorithm of Aceto, Bloom and Vaandrager practically useful in verification tools.

Processes and data. In June, Ponse defended his Ph.D. thesis on an extension of process algebra with abstract data types called μCRL. The language μCRL was developed by CWI in the context of the RACE project SPECS. The proof theory of μCRL is meant to formalize the interaction of processes and data, and prvides the means to prove properties about these in a precise way. The proof theory has been designed such that automatic proof checking is feasible. As a case study in the use of μCRL, Korver and Groote verified a simple version of Lamport's bakery protocol.

Case studies. During the year, AP2 was involved in a number of substantial case studies in the use of formal methods for specification and verification:

- In the context of the BOOST project, and in collaboration with Dutch PTT, Klusener, van Waveren (UvA) and Van Vijmen (UvA) gave a formal specification in the process algebra language PSF of a number of Service Independent Building Blocks that are described in the draft CCITT standard for Intelligent Networks.

- Together with J. van Wamel (UvA) and in cooperation with ORFIS International, Fokkink gave a specification of some interest products offered by banks in the process specification formalism PSF.

- Together with J.F. Groote (RUU), Bosscher and Vaandrager worked on the verification of a datalink protocol provided by Philips. The idea was to "attack" the protocol using three different formalisms: (1) In order to become familiar with process algebra, Doeko Bosscher analyzed the protocol using the CCS-based Edinburgh Concurrency Workbench Tool (CWB), one of the tools put forward within the BRA project CONCUR2; (2) Groote gave a verification using the process algebra μCRL; and (3) Vaandrager worked out a verification in the state based I/O automata model of Lynch and Tuttle. Comparison of these three verifications led to several interesting conclusions, which are currently being working out. Also, we are trying to address additional features of the protocol, notably "interrupts" and "real-time".

2.3   Organisation of Conferences, Workshops, Courses, etc

- PAM — the Process Algebra Meeting

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A weekly seminar on concurrency theory, with an emphasis on process algebra, coordinated by Klusener. Besides the members of AP2, the PAM is attended by members of the research groups of Prof. Bergstra (UvA/RUU), Prof. Baeten (currently at the TUE), and Prof. Ollongren (RUL). Besides presentation and discussion of ongoing research, also external speakers are invited.

2.4 Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *RACE SPECS Meeting*, Nice, France, Februari 18–20: W.J. Fokkink, H. Korver.

- *RACE BOOST Initial Meeting*, MARI, Newcastle-upon-Tyne, UK, Februari 25: A.S. Klusener.

- *RACE BOOST Consortium Meeting*, Berlin, Germany, April 27–29: F.W. Vaandrager.

- *Syposium Neurale Netwerken*, Rotterdam, May 13: W.J. Fokkink.

- *RACE BOOST, Working Visit to MARI*, Newcastle-upon-Tyne, May 21–22: H. Korver.

- *RACE SPECS Meeting*, Madrid, Spain, June 1–3: W.J. Fokkink, H. Korver.

- *REX Workshop "Semantics: Foundations and Applications"*, Beekbergen, June 1–4: F.W. Vaandrager (Expressiveness results for process algebras).

- *Working Visit Massachusetts Institute of Technology* (Prof. N.A. Lynch), Cambridge, MA, USA, June 15–19: F.W. Vaandrager.

- *Symposium on Logic in Computer Science*, June 22–25, Santa Cruz, CA, USA: F.W. Vaandrager.

- *Working Visit Stanford University* (Dr. R.J. van Glabbeek), Stanford, USA, June 26 – July 1: F.W. Vaandrager (Action transducers and timed automata).

- *RACE BOOST, Working Visit to Intecs Systemi*, Pisa, Italy, June 27–30: A.S. Klusener.

- *RACE BOOST Meeting*, Crete, Greece, July 6–9: A.S. Klusener, H. Korver.

- *Symposium on Logical Foundations of Computer Science (Logic at Tver)*, Sokol, Tver region, Russia, July 20–24: F.W. Vaandrager (Expressiveness results for process algebras, invited lecture).

- *CONCUR '92*, Stony Brook, NY, USA, August 24–27: A.S. Klusener (The silent step in time).

- *Working Visit University of Oxford* (Prof. J. Sanders), Oxford, UK, September 10-11: F.W. Vaandrager.

- *PDS-colloquium*, University of Utrecht, October 13: F.W. Vaandrager (Logics for branching bisimulation).

- *Workshop on Assertional Methods*, Amsterdam, November 17–18: D. Bosscher, W.J. Fokkink, A.S. Klusener, F.W. Vaandrager.

- *RACE BOOST Meeting*, Aveiro, Portugal, November 24–28: A.S. Klusener.

- *REX Seminar,* CWI, Amsterdam, November 27: F.W. Vaandrager (Turning SOS rules into equations).

- *Second RACE Telecommunications Software Engineering Symposium,* Essy-les-Moulineaux, France, November 19–20 : A. Ponse (μCRL: analysing processes with data).

- *RACE SPECS Meeting,* Nice, France, December 16–27: H. Korver.

- *Working Visit Università degli Studi di Roma "La Sapienza"* (Prof. De Nicola), Rome, Italy, December 17–22: F.W. Vaandrager (Action transducers and timed automata).

2.5 Memberships of Committees and Other Professional Activities

AP2:

- SPECS – Specification and Programming Environment for Communications Software, RACE project No. 1046. (1 March 1988 – 1 January 1993.)

- BOOST – Broadband Object-Oriented Service Technology, RACE project No. 2076. (1 August 1992 – 1 August 1995.)

- ATMOSPHERE – Advanced Systems Engineering Environments, ESPRIT project No. 2565. (1 March 1989 – 1 June 1992.)

- CONCUR – Theories of Concurrency: Unification and Extension. ESPRIT Basic Research Action No. 3006. (1 September 1989 – 31 March 1992.)

- CONCUR2 – Calculi and Algebras of Concurrency: Extensions, Tools and Applications. ESPRIT Basic Research Action No. 7166. (1 September 1992 – 1 September 1995.)

F.W. Vaandrager:

- Associate professor (Universitair Hoofddocent), University of Amsterdam.

- Moderator of CONCURRENCY email forum (`concurrency@cwi.nl`). Active forum focusing on concurrency theory, with a subscription list of more than 400, including about 25 subsidiary lists.

- Observer IFIP Working Group 2.2 on Formal Description of Programming Concepts

- Member Programme Committee Second International Symposium on Logical Foundations of Computer Science (Tver '92), Sokol, Tver region, Russia, July 20–24.

- Opponent at the public defense of Ph.D. thesis Alban Ponse, *Process Algebra with Data.* University of Amsterdam, June 9.

- Examiner Ph.D. thesis Karen Seidel, *Probabilistic Communicating Processes.* University of Oxford, UK, September 11.

- Referee Ph.D. thesis Rom Langerak, *Transformations and Semantics for LOTOS,* University of Twente, November 20.

2.6 Papers in Journals and Proceedings

1. L. Aceto, B. Bloom and F.W. Vaandrager. Turning SOS rules into equations (extended abstract). In *Proceedings 7th Annual Symposium on Logic in Computer Science*, Santa Cruz, California, pages 113–124. IEEE Computer Society Press, 1992.

2. J.C.M. Baeten and J.A. Bergstra. Process algebra with signals and conditions. In M. Broy, editor, *Programming and Mathematical Methods, Proceedings Summer School Marktoberdorf 1991*, pages 273–323. Springer-Verlag, 1992. NATO ASI Series F88.

3. J.C.M. Baeten and J.A. Bergstra. Discrete time process algebra (extended abstract). In W.R. Cleaveland, editor, *Proceedings CONCUR 92*, Stony Brook, New York. LNCS 630, pages 472–485. Springer-Verlag, 1992.

4. J.C.M. Baeten, J.A. Bergstra and S.A. Smolka. Axiomatizing probabilistic processes: ACP with generative probabilities (extended abstract). In W.R. Cleaveland, editor, *Proceedings CONCUR 92*, Stony Brook, New York. LNCS 630, pages 401–420. Springer-Verlag, 1992.

5. J.C.M. Baeten and J.A. Bergstra. The state operator in real time process algebra. In J.W. de Bakker, C. Huizing, W.-P de Roever, and G. Rozenberg, editors, *Proceedings of the REX Workshop "Real-Time: Theory in Practice"*. LNCS 600, pages 107–123. Springer-Verlag, 1992.

6. J.C.M. Baeten and J.A. Bergstra Asynchronous communication in real space process algebra. In L. Augustsson, P. Dybjer, B. Nordstrom, K.V.S. Prasad and B. von Sydow, editors, *Proceedings Workshop on Concurrency*, Bastad 1991. Report 63, Programming Methodology Group, Chalmers University 1992, pp. 56-75. Also in J. Vytopil, editor, *Proceedings Formal Techniques in Real-Time and Fault-Tolerant Systems*, Nijmegen 1992. LNCS 571, pages 473 - 492. Springer-Verlag 1991.

7. J.C.M. Baeten and F.W. Vaandrager. An algebra for process creation. *Acta Informatica*, 29(4):303–334, 1992.

8. J.F. Groote. A short proof of the decidability of bisimulation for normed BPA-processes. *Information Processing Letters*, 42:167–171, 1992.

9. J.F. Groote and F. Moller. Verification of parallel systems via decomposition. In W.R. Cleaveland, editor, *Proceedings CONCUR 92,* Stony Brook, NY, USA, LNCS 630, pages 62–76. Springer-Verlag, 1992.

10. J.F. Groote and F.W. Vaandrager. Structured operational semantics and bisimulation as a congruence. *Information and Computation*, 100(2):202–260, 1992.

11. A.S. Klusener. The silent step in time. In W.R. Cleaveland, editor, *Proceedings CONCUR 92*, Stony Brook, New York. LNCS 630, pages 421–435. Springer-Verlag, 1992.

12. A.S. Klusener. Completeness in real time process algebra. In J.W. de Bakker, C. Huizing, W.-P de Roever, and G. Rozenberg, editors, *Proceedings of the REX Workshop "Real-Time: Theory in Practice"*. LNCS 600, pages 325–352. Springer-Verlag, 1992.

13. N.A. Lynch and F.W. Vaandrager. Forward and backward simulations for timing-based systems. In J.W. de Bakker, C. Huizing, W.-P de Roever, and G. Rozenberg, editors, *Proceedings of the REX Workshop "Real-Time: Theory in Practice"*. LNCS 600, pages 397–446. Springer-Verlag, 1992.

14. F.W. Vaandrager and N.A. Lynch. Action transducers and timed automata. In W.R. Cleaveland, editor, *Proceedings CONCUR 92*, Stony Brook, New York. LNCS 630, pages 436–455. Springer-Verlag, 1992.

2.7 CWI Reports

1. CS-R9203, J.F. Groote, F. Moller, Verification of parallel systems via decomposition. January.

2. CS-R9207, A. Ponse, Computable processes and bisimulation equivalence. January.

3. CS-R9209, W.J. Fokkink, A simple specification language combining processes, time and data. February.

4. CS-R9218, L. Aceto, B. Bloom and F.W. Vaandrager. Turning SOS rules into equations. June.

5. CS-R9219, W.J. Fokkink, A.S. Klusener, Real time process algebra with prefixed integration. June.

6. CS-R9221, A.S. Klusener, The silent step in time. June.

7. CS-R9231, W.J. Fokkink, Regular processes with relative time and silent steps. July.

2.8 Other Publications

1. J.C.M. Baeten (ed.). Final Report ESPRIT Basic Research Action CONCUR, April 1992.

2. J.C.M. Baeten and J.A. Bergstra. Real space process algebra (revised version). Report P9206, Programming Research Group, University of Amsterdam, 1992. Also available as Report CSN 92/03, Dept. of Computer Science, Technical University Eindhoven, 1992.

3. J.C.M. Baeten and J.A. Bergstra. Discrete time process algebra. Report P9208, Programming Research Group, University of Amsterdam, 1992. Also available as Report CSN 92/06, Dept. of Computer Science, Technical University Eindhoven, 1992.

4. J.C.M. Baeten, J.A. Bergstra and S.A. Smolka. Axiomatizing probabilistic processes: ACP with generative probabilities. Report P9218, Programming Research Group, University of Amsterdam, 1992. Also available as Report CSN 92/19, Dept. of Computer Science, Technical University Eindhoven, 1992.

5. R. De Nicola and F.W. Vaandrager. Three logics for branching bisimulation. Rapporto di Ricerca SI-92/07, Dipartimento di Scienze dell'Informazione, Università degli Studi di Roma "La Sapienza", November 1992.

6. W.J. Fokkink and J.J. van Wamel. An Algebraic Specification of Interest Products. Confidential Report CR9201, Programming Research Group, University of Amsterdam, September 1992. (Only available with permission from ORFIS International, Huis ter Heide, The Netherlands.)

7. J.F. Groote and H. Korver. A correctness proof of the bakery protocol in μCRL. Technical Report Logic Group Preprint Series No. 80, Utrecht University, 1992.

8. A. Ponse, *Process Algebras with Data*. Ph.D. Thesis, University of Amsterdam, June 1992.

9. SPECS-SEMANTICS AND ANALYSIS. *Methods and Tools on CRL/MR*. Deliverable 46/SPE/WP5/DS/A/011/b1, RACE project 1046 (SPECS), December 1992. (With contributions of H. Korver.)

10. SPECS-SEMANTICS AND ANALYSIS. *Definition of CRL/MR for Implementation*. Deliverable 46/SPE/WP5/DS/A/022/b1, RACE project 1046 (SPECS), December 1992. (With contributions of A. Ponse.)

11. SPECS-SEMANTICS AND ANALYSIS. *Final Definition of CRL/MR*. Deliverable 46/SPE/WP5/DS/A/008/b1, RACE project 1046 (SPECS), December 1992. (With contributions of W.J. Fokkink.)

2.9 Visitors

- R. Diaconescu (Oxford University, UK), January 16, Logical Support for Modularisation.

- A. Jeffrey (University of Sussex), April 7–9.

- A. Skou (University of Aalborg), April 7.

- R. de Simone (INRIA Sophia-Antipolis), April 7.

- S. Peters (CSLI, Stanford, USA), June 13–16.

- J. Gustafson (IBM Zurich, Switserland), June 24–26.

- R. Segala (MIT), August 31 – September 7, A Process Algebraic view of I/O automata.

- R. De Nicola (Università degli Studi di Roma "La Sapienza"), September 27 – October 4, Observation Trees.

3 Extensible Programming Environments (AP3)

3.1 Staff

- Drs. H.C.M Bakker, project member, since January 16.

- Drs. A. van Deursen, junior researcher (OIO).

- Dr. S.M. Eker, project member, until July 1; ERCIM fellow.

- Drs. J. Ganzevoort, project member, since October 16.

- J. Heering, senior researcher.

- Drs. E.A. van der Meulen, project member.

- Prof. Dr. P. Klint, group leader.

- Dr. T.B. Dinesh, project member.

- Drs. J. Kamperman, project member.

- Dr. J. Rekers, project member, until August 1.

- Drs. F. Tip, project member.

- Dr. H.R. Walters, senior researcher.

3.2 Scientific Report

In 1992 AP3 continued its participation in three externally funded projects, namely,

- GIPE2 (Generation of Interactive Programming Environments - ESPRIT Project 2177) in co-operation with the University of Amsterdam, INRIA Sophia-Antipolis (the main contractor), the Bull Research Center in Sophia-Antipolis, the Telematics Laboratory of the Dutch PTT in Groningen, and the software companies SEMA.METRA and PLANET;

- COMPARE (Compiler Generation for Parallel Machines - ESPRIT Project 5399) in co-operation with the software company ACE (the main contractor), GMD Karlsruhe, de software companies Harlequin and Steria, INRIA Rocquencourt, and the University of Saarland;

- the NWO Computer Science Priority Program "Incremental Program Generation."

The group is involved in the design and implementation of the ASF+SDF system for interactive language development and incremental programming environment generation. The system is in an advanced stage of development, and is being evaluated in a LOTOS application by the Telematics Laboratory of the Dutch PTT in Groningen as part of the GIPE2 project. Apart from this, it is distributed to commercial and academic customers by the Connexité company in Sophia-Antipolis. Connexité is closely related to INRIA-Sophia Antipolis, which is the main contractor for GIPE2.

The ASF+SDF system supports the development and implementation of both programming and application languages. A language in the latter category is RPM, a language for describing interest products offered by banks. In co-operation with ORFIS International (Huis ter Heide), RPM was defined formally in the ASF+SDF system, and the resulting RPM environment was used to define a number of new products.

The GSE editor of the ASF+SDF system offers both text and syntax-directed editing. Rather than having to learn a new set of text edit commands, the user would prefer to continue using the text editor he is already familiar with. To this end, work was started on replacing the text edit mode of GSE with Epoch, a version of the widely used and powerful Emacs editor. An additional benefit of this integration is the fact that the documentation and help facilities of Epoch/Emacs, which are very convenient and were already used in a somewhat roundabout way, are integrated at the same time.

The ASF+SDF language has a first-order algebraic specification component ASF and a syntax definition component SDF. Experience with ASF has suggested a notion of higher-order algebraic specification based on polymorphic higher-order matching. Its advantages were illustrated in a small static semantics specification (report CS-R9254). At the same time, a less ambitious attempt is being made to simulate some higher-order features within the existing first-order framework.

As far as COMPARE is concerned, work was started on an ASF to C compiler intended as a more efficient alternative to the current Lisp implementation. The compiler was written in ASF and can

compile itself. The experiments performed with it so far have been very encouraging. The efficiency of the code generated by the compiler compares favorably with New Jersey ML, BimProlog, and C (New Jersey ML and C are high quality public domain implementations; BimProlog is a commercial implementation). This is ongoing work.

Research on origin tracking was continued. Origin tracking involves propagation of pointers to parts of the subject during term rewriting, the basic mechanism used by the ASF+SDF system. It can be used for error message generation, debugging, and animation of execution (report CS-R9230). Its possibilities were illustrated in a demonstration environment for the Clax language. The static semantics part of the Clax definition was written in an abstract interpretation style which combines very well with origin tracking (report CS-R9253).

A substantial amount of work was done on the design and implementation of the full Structure Definition Language (fSDL), which is a language for the definition of abstract syntax trees and graphs that will be used by all COMPARE partners. An algebraic specification of the translation of fSDL to C++ library calls is currently being written. It will be compiled to C by the above-mentioned ASF to C compiler.

The "Incremental Program Generation" project has concentrated on the transfer of existing attribute grammar technology for incremental type checking to an algebraic specification context. This relatively simple approach yields incremental type checking if the non-incremental algebraic specification of the static semantics is a so-called "conditional primitive recursive scheme." An implementation of this was integrated in the ASF+SDF system.

3.3   Organisation of Conferences, Workshops, Courses, etc

- Workshop on Programming Environments, Dagstuhl Castle, March 9–13. Organized by P. Klint, T. Reps, and G. Snelting.

3.4   Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *ESPRIT COMPARE Management Meeting*, Cambridge, UK, January 15–16: H.R. Walters.

- *Working Visit INRIA-Sophia Antipolis*, Sophia Antipolis, France, January 16–17: A. van Deursen, J. Rekers.

- *ESPRIT GIPE2 Management Meeting*, Sophia Antipolis, France, February 13: J. Heering, P. Klint.

- *IFIP Seminar on Formal Description of Programming Concepts*, Bombay, India, February 15–29: A. van Deursen (Generation of interactive programming environments).

- *Working Visit STERIA*, Paris, France, February 18: F. Tip.

- *Working Visit GMD-Karlsruhe*, Karlsruhe, BRD, March 8–10: T.B. Dinesh, H.R. Walters.

- *Workshop on Programming Environments*, Dagstuhl, BRD, March 9–13: P. Klint (Term rewriting as a unifying principle in the ASF+SDF meta-environment), E.A. van der Meulen (Fine-grain implementation of algebraic specifications), F. Tip (Origin tracking).

- *ESPRIT GIPE2 4th Annual Review Meeting*, Sophia Antipolis, France, March 9–10: J. Heering (Algebraic specifications—current work at CWI).

- *ESPRIT COMPARE Review Meeting*, Saarbrücken, BRD, March 17–18: P. Klint.

- *Typing Workshop at the Eiffel Conference*, Dortmund, BRD, April 3: T.B. Dinesh (Yet another proposal for making Eiffel type safe).

- *Working Visit University of Iowa* (Prof. A.C. Fleck), Iowa City, Iowa, USA, April 7 – May 10: T.B. Dinesh (Algebraic specification of object-oriented languages, Object-oriented programming: inheritance to adoption).

- *ESPRIT COMPARE Meeting*, Dagstuhl, BRD, May 19–22: J.F.Th. Kamperman.

- *ESPRIT COMPARE Management Meeting*, Versailles, France, July 8–9: P. Klint.

- *Workshop on the λPROLOG Programming Language*, University of Pennsylvania, Philadelphia, USA, July 31 – August 1: J. Heering (Implementing higher-order algebraic specifications).

- *ESPRIT COMPARE Meeting*, Dagstuhl, BRD, September 2–4: J.F.Th. Kamperman, H.R. Walters.

- *BENELOG '92*, Luxemburg, September 11: J. Heering (Implementing higher-order algebraic specifications).

- *Workshop on F-bounded quantification*, Cambridge, UK, September 15–17: T.B. Dinesh ("Selftype" can render derived classes inconsistent).

- *Working Visit Universities of Linköping and Lund*, Sweden, September 26 – October 1: E.A. van der Meulen, F. Tip (Course "Generation of Incremental Environments," The ASF+SDF meta environment).

- *Working Visit GMD-Karlsruhe*, BRD, October 1–2: J.F.Th. Kamperman, H.R. Walters.

- *ESPRIT COMPARE Review Meeting*, Paris, France, October 27–29: P. Klint, F. Tip (Demonstration of Clax).

- *ERCIM Workshop on Methods and Tools for Software Reuse*, Heraklion, Crete, October 29–30: T.B. Dinesh (Dynamic Semantics of KOOL).

- *Computing Science in The Netherlands (CSN92)*, Utrecht, November 4–5: A. van Deursen (Specification and generation of a λ-calculus environment).

- *Working Visit GMD-Frankfurt*, BRD, November 16: H.R. Walters.

- *WAM: Workshop on Assertional Methods*, Amsterdam, November 17–18: T.B. Dinesh.

3.5 Memberships of Committees and Other Professional Activities

P. Klint:

- Akademie voor informatica/Software Engineering School (member of the board).

- Software Engineering Research Centre (SERC) (member of the board).

- SION Scientific Advisory Board (member).

- SION Werkgemeenschap Programmatuur en Architectuur (chairman).

- Institute for Logic Language and Computation (ILLC) (member of the board).

- Ph.D. advisor J. Rekers, Parser generation for interactive environments University of Amsterdam, January 31.

- member Ph.D. committee Alban Ponse, Process algebras with data, University of Amsterdam, March 9.

- member Ph.D. committee Erik H. Baalbergen, The declarative operating system model, Free University, March 26.

- Ph.D. advisor T.B. Dinesh, Object-oriented programming: inheritance to adoption, University of Iowa, USA, May.

- member Ph.D. committee Chris Verhoef, Linear unary operators in process algebra, University of Amsterdam, June 1.

- member Ph.D. committee Edwin Paalvast, Programming for parallellism and compiling for efficiency, Technical University Delft, June 11.

- member Ph.D. committee Gert Veldhuijzen van Zanten, A formal model for code generation, Technical University Twente, September 24.

- member Ph.D. committee Ernst Lippe, Camera: support for distributed cooperative work, University of Utrecht, October 19.

- member Ph.D. committee Guus Schreiber, Pragmatics of the knowledge level, University of Amsterdam, October 28.

- Ph.D. advisor M.G.J. van den Brand, Pregmatic—A generator for incremental programming environments, Katholieke Universiteit Nijmegen, November 2.

- member Ph.D. committee M. Vilares Ferro, Efficient incremental parsing for context-free languages, University of Nice, November 13.

3.6 Papers in Journals and Proceedings

1. A. van Deursen. Specification and generation of a λ-calculus environment. In *Proceedings of Computer Science in the Netherlands (CSN92)*, SION, 1992, pages 14–26.

2. J. Heering. Implementing higher-order algebraic specifications. In D. Miller, editor, *Proceedings of the 1992 Workshop on the λPROLOG Programming Language*, Report MS-CIS-92-86, University of Pennsylvania, Philadelphia, 1992, pages 141–157.

3. J. Heering, P. Klint, and J. Rekers. Incremental generation of lexical scanners. *ACM Transactions on Programming Languages and Systems*, **14** (1992), pages 490–520.

3.7 CWI Reports

1. CS-R9223, S.M. Eker, A comparison of OBJ3 and ASF+SDF.

2. CS-R9224, S.M. Eker, Associative matching for linear terms.

3. CS-R9225, S.M. Eker, Verification of parameterised synchronous concurrent algorithms with OBJ3: The pixel architecture revisited.

4. CS-R9230, A. van Deursen, P. Klint, and F. Tip, Origin tracking.

5. CS-R9233, A. van Deursen, Specification and generation of a λ-calculus environment.

6. CS-R9253, T.B. Dinesh and F. Tip, Animators and error reporters for generated programming environments.

7. CS-R9254, J. Heering, Second-order algebraic specification of static semantics.

3.8   Other Publications

1. B. Arnold and A. van Deursen, Algebraic specification of a language defining interest rate products, CWI/ORFIS International, 1992. (Confidential document. Only available with permission from ORFIS International, Huis ter Heide, The Netherlands.)

2. D. Arnon, A. Atie, I. Attali, D. Austry, Y. Bertot, A. van Deursen, S. Dissoubray, P. Franchi, M.C. Giboulot, J. Heering, I. Jacobs, H. Joosten, P. Klint, J.W.C Koorn, T. Kuehne, A. Le Hors, M. Loyer, E.A. van der Meulen, V. Pascual, G. Popovitch, V. Prunet, J. Rekers, L. Rideau, C. Thies, F. Thomasset, V. Tijssen, G. Viland, A. Wammes, and J. Wester. Fourth Review Report ESPRIT Project 2177 (GIPE2), February 1992.

3. A. van Deursen, P. Klint, and F. Tip. Origin Tracking. Deliverable D 3.3/1, ESPRIT Project 5399 (COMPARE), October 1992.

4. T.B. Dinesh and F. Tip. A sophisticated interactive environment for Clax program development. Deliverable D 1.3.3/2, ESPRIT Project 5399 (COMPARE), October 1992.

5. T.B. Dinesh. *Object Oriented Programming—Inheritance to Adoption.* Ph.D. Thesis, Technical Report 92-02, University of Iowa, 1992.

6. P. Klint, ed. The ASF+SDF Meta-environment User's Guide. CWI, Amsterdam, 1992. Distributed with the ASF+SDF system.

7. P. Klint, T. Reps, and G. Snelting, Programming Environments, Report on an international workshop at Dagstuhl Castle, *SIGPLAN Notices*, **27** (11) (November 1992), pages 90–96.

8. J. Rekers. *Parser Generation for Interactive Environments.* Ph.D. Thesis, University of Amsterdam, 1992.

9. H.R. Walters and J.F.Th. Kamperman. A feasibility study in the formal definition of the DM, the IR and Cosy engines. Deliverable D 1.3.1/2, ESPRIT Project 5399 (COMPARE), February 1992.

3.9   Visitors

- B. Lang, INRIA-Rocquencourt, January 30, Garbage Collecting the World.

- B. Johansson, ASEA Brown Boveri, April 3, Development Support for Little Languages.

- P. Fritzson, Linköping University, April 13.

- J. Tanaka, Fujitsu Laboratories, April 29, A Logic Metaprogramming Language.

- P. Mosses, University of Aarhus, June 4–6, Action Semantics.

- N. Shahmehri, Linköping University, November 3 – December 14.

4 Algebraic and Syntactic Methods (AP4)

4.1 Staff

- Prof. dr. J.W. Klop, group leader

- Dr. F.J. de Vries, researcher

- Drs. F. van Raamsdonk, junior researcher (OIO), SION

- Drs. C. Brovedani, visitor, since April 15

- M. Marchiori, stagiaire, since November 1

4.2 Scientific Report

Jan Willem Klop. Together with H.P. Barendregt (KUN) and Y. Toyama (NTT Tokyo) he extensively revised the paper *Termination for direct sums of left-linear term rewriting systems* (CWI Report CS-R8923), which will appear in 1993 in JACM.

Jointly with Z. Ariola (University of Oregon) he worked on the subject of cyclic lambda graph rewriting, with the surprising result that there is no confluent notion of reduction for cyclic lambda graphs. This work has not yet led in 1992 to a report, but will in 1993. The study on the foundations of graph rewriting initiated for the ESPRIT Basic Research Action SEMAGRAPH— since September 1992 continuing as an ESPRIT Working Group— has been continued. The work is performed in close collaboration with De Vries, see there for details. In the context of ESPRIT Basic Research Action CONFER jointly with J.A. Bergstra (UVA) a study is initiated to formulate the π-calculus in the framework of ACP, thereby facilitating a term rewriting analysis (leading e.g. to an expansion theorem). This work is stimulating for the study of CRSs by Van Raamsdonk, as the version of π-calculus arrived at turns out to be a weakly orthogonal CRS.

With F. Vaandrager (AP2), F.S. de Boer (TUE), C. Palamidessi (Genova) and several other partners (also some non-European) a HCM (Human Capital and Mobility) network proposal was prepared and submitted, titled 'EXPRESS', aiming at systematically exploring expressivity issues for formal systems for communicating processes and corresponding languages. (In March 1993 this proposal was approved.)

Together with R. de Vrijer (VUA) a small project was started aiming to extend and prepare for publication an old unpublished note of J.W. Klop: *Extending Partial Combinatory Algebras.* Interest in this subject was rekindled by some recent references in the types community to the notion of partial combinatory algebra.

With H.P. Barendregt and M. Bezem the Festschrift for Dirk van Dalen was edited (appeared in March 1993). Jointly with De Vries and the SEMAGRAPH partners of the University of East Anglia, M.R. Sleep and J.R. Kennaway, a contribution for this Festschrift was prepared. (See the section on De Vries.)

With F. van Raamsdonk (AP4) and V. van Oostrom (VUA) a contribution for a Festschrift for Böhm was initiated. (See the section on Van Raamsdonk.)

Fer-Jan de Vries. In the context of the ESPRIT BRA/WG SEMAGRAPH and in close collaboration with Klop and the SEMAGRAPH partners from the University of East Anglia, M.R. Sleep and J.R. Kennaway, the study on the foundations of term graph rewriting has been continued. We have established a close correspondence between finitary cyclic term graph rewriting and a restricted form of infinitary term rewriting. Surprisingly, the correspondence breaks down for infinitary graph rewriting: infinitary term rewriting is more powerful than infinitary graph rewriting. Further we have investigated the connection between orthogonal term graph rewriting and event structures. For every normalisable term in an orthogonal term graph rewrite system a corresponding elementary event structure can be defined, the events being essentially the different redexes which must be reduced to reach the normal form. The paper on the transfinite Church-Rosser property for non-collapsing orthogonal term rewriting systems has been revised. Together with an introductory chapter the afore mentioned items will become four chapters in the book *Term Graph Rewriting: Theory and Practice* (M.R. Sleep, M.J. Plasmeijer and M.C. van Eekelen, editors, John Wiley & Sons Ltd, expected publication in April 1993). We also made a detailed study comparing the properties of a functional term rewrite system with its curried applicative version. E.g., a curried term rewrite system is strongly normalizing if the original functional term rewriting system is. A similar result holds for confluence provided the rewrite systems are left-linear. A report on this work has appeared in the Festschrift for Dirk van Dalen.

Finally, together with with Z. Ariola (University of Oregon) the five of us have started an investigation of notions of undefinedness in orthogonal term rewriting. This investigation was suspended, but will be resumed and expected to be finalised in 1993. Together with A. Ponse (UVA) and F.S. de Boer (TUE) De Vries organised the Workshop on Assertional Methods at CWI. Jointly with D. Pitt (Surrey) and D. Rydeheard (Manchester) initial preparations have been made for the international conference Category Theory in Computer Science to be held at CWI in 1993.

Femke van Raamsdonk. The work has been done in SION-project 612-316-606, Extensions of orthogonal rewrite systems, starting date January 1, 1992. As a first step a new and short proof was given of the fundamental theorem asserting that all orthogonal Combinatory Reduction Systems (CRSs) are confluent. This work was reported in CWI report CS-9234. Moreover, in this report an interesting characterisation was given of Aczel's notion of parallel reduction for CRSs, by means of 'superdevelopments', a generalisation of the classical lambda calculus concept of 'developments'. A condensed version of this report has been accepted for publication in the proceedings of RTA 93, Montreal. The investigation has been continued by an attempt to generalise the confluence property to the class of all weakly orthogonal CRSs. This is of relevance for a syntactic study of Milner's π-calculus, an important theme in the ESPRIT Basic Research Action CONFER in which AP4 is participating. Together with J.W. Klop and V. van Oostrom (VUA), an invited paper was prepared to appear in the forthcoming Festschrift for Corrado Böhm: Combinatory Reduction Systems - introduction and survey. A start was made with a comparison, in cooperation with V. van Oostrom (VUA), between CRSs and Nipkow's HRSs (Higher-order Rewrite Systems).

Claudia Brovedani. (Initially, a stay of half a year was envisaged; this has been extended and at present funding is sought for an extension to a Ph.D. investigation.) The first period of the stay has been devoted to the study of process algebra. Then the problem was taken up to specify and verify in process algebra a simple version of the Bakery Protocol. At present, the general version of this protocol is treated. Report about this work is expected in 1993.

Massimo Marchiori. Supervision of the research is in cooperation with Prof. Apt (AP5), who suggested to study the relation between Logic Programming and Term Rewriting Systems. The research so far has presented a class of logic programs that are fully equivalent to their transformation as TRSs, improving on previous work by Krishna Rao (guest of AP5 in 1991). Moreover various topics concerning this translation are investigated, including expressive power, unicity, and implementations.

4.3 Organisation of Conferences, Workshops, Courses, etc

- Workshop on Assertional Methods, CWI, November 17-18.
  The program and organising committee consisted of F.S. de Boer (TUE), A. Ponse (UVA) and F.J. de Vries. Invited lectures have been given by K.R. Apt (CWI, UVA), D.J.N. van Eijck (CWI, RUU), D. Harel (Weizmann Institute Israel), W.H. Hesselink (RUG), E.-R. Olderog (University of Oldenburg, Germany) and J. Zwiers (TUT). In addition eight other lectures were given. The workshop was attended by about 60 participants.

4.4 Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *Program Committee Meeting ICALP '92*, Vienna, Austria, January 31 - February 2: J.W. Klop.

- *ESPRIT Basic Research Action Integration, Final meeting*, Funchal, Madeira, 15-18 February: J.W. Klop.

- *Séminar: La Seconde Vie de la Logique Mathématique*, ENS, April 6-7: F.J. de Vries.

- *Ecole jeunes chercheurs du Greco de programmation*, Bordeaux, France, April 6–16: F. van Raamsdonk.

- *Program Committee Meeting ALP 92*, Nancy, France, April 12-14: J.W. Klop.

- *Term Rewrite Seminar*, Vrije Universiteit, Amsterdam, April 24: F. van Raamsdonk (confluence for combinatory reduction systems).

- *University of East Anglia, working visit*, Norwich, UK, May 25-29: F.J. de Vries (On comparing curried and uncurried term rewriting).

- *Term Rewrite Seminar*, Vrije Universiteit, Amsterdam, June 3: F.J. de Vries (On Applification).

- *CTRS*, Nancy, France, July 8-10: F.J. de Vries.

- *International Summer School, Program Design Calculi*, Marktoberdorf, Germany, July 28 - August 9: F. van Raamsdonk.

- *Working visit NTT Research Lab.* (Dr. Y. Toyama), Kyoto, Japan, September 29 - October 25: J.W. Klop (Infinitary Term Rewriting; Equational Graph Rewriting).

- *Working visit Hitachi Advanced Research Laboratories*, Hatoyama, Japan, October 10-18: F.J. de Vries (On the Preservation of Strong Normalisation by Currying).

- *Working visit Hitachi Advanced Research Laboratories*, Hatoyama, Japan, October 12-14: J.W. Klop (Combinatory Reduction systems and Strong Normalisation)

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- *Working visit NTT Research Lab.* (Dr. Y. Toyama), Kyoto, Japan, October 1-9: F.J. de Vries (On the Preservation of Confluence by Currying).

- *Italian Chapter of the EATCS*, L'Aquila, Italy, October 26-30: J.W. Klop (Invited talk: Combinatory Reduction Systems).

- *Working visit University of Genua* (Dr. C. Palamidessi), Genua, Italy, November 2-7: J.W. Klop (Combinatory Reduction Systems; Infinitary Rewriting and Graph Rewriting; Modularity in Term Rewriting).

- *Working visit University of Pisa* (Prof. U. Montanari), Pisa, Italy, November 5: J.W. Klop (Strong normalisation in orthogonal combinatory reduction systems).

- *Zuidelijk Interuniversitair Colloquium*, TUE, Eindhoven, November 3: F. van Raamsdonk (A general confluence theorem).

- *Seminar Computer Algebra* CWI, November 17: J.W. Klop (On Term Rewriting).

- *Working visit University of East Anglia* (Prof. M.R. Sleep and Dr. J.R. Kennaway), Norwich, UK, November 24-27: F.J. de Vries.

- *Peripatetic Seminar on Sheaves and Logic*, Cambridge, UK, November 28-29: F.J. de Vries.

4.5 Memberships of Committees and Other Professional Activities

AP4:

- Participation in ESPRIT Working Group SEMAGRAPH 6345

- Participation in ESPRIT Basic Research Action CONFER 6454

Jan Willem Klop:

- Professor in Computer Science at the Free University of Amsterdam.

- Member Curatorium of the 'bijzondere leerstoel Theor. Inf.' of Prof. J.-J.Ch. Meyer (VUA).

- Scientific Secretary of Werkgemeenschap Theoretische Informatica

- Editor of Nieuwsbrief van de Werkgemeenschap Theoretische Informatica

- Member Organizing Committee LICS conferences (Logic in Computer Science)

- Member Advisory Board of CMF (Caribean Mathematical Foundation)

- Member Program Committee of CSN 92 (Computer Science in the Netherlands)

- Member Program Committee of CAAP/TAPSOFT93

- Member Program Committee of ICALP92

- Member Program Committee of ALP92

- Member Program Committee of TLCA 93 (Typed Lambda Calculi and Applications)

- Member Ph.D Committee L. Maranget (promotor J.-J. Lévy), INRIA, Rocquencourt, Paris

- Member Ph.D Committee C. Verhoef (promotor J.A. Bergstra), UVA, Amsterdam

- Member Reading Committee at promotion of U. de Liguoro, promotor C. Bohm, University of Rome

Fer-Jan de Vries:

- Member Program and Organizing Committee of Workshop on Assertional Proof Techniques

- Member Program and Organizing Committee CTCS93 (Category theory in computer science)

4.6 Papers in Journals and Proceedings

1. F.S. de Boer, J.W. Klop, C. Palamidessi (1992), Asynchronous communication in process algebra (extended abstract). Proceedings LICS92, IEEE In *Proceedings 7th Annual Symposium on Logic in Computer Science*, Santa Cruz, California, 113–124. IEEE Computer Society Press, 1992.

2. J. van Eijck and F.J. de Vries (1992). A sound and complete calculus for update logic. Proceedings of the Eight Amsterdam Colloquium, ILLC, Amsterdam, 133–152.

3. J. van Eijck and F.J. de Vries (1992). Dynamic interpretation and Hoare deduction. Journal of Logic, Language, and Information, 1:1–44.

4. A. Middeldorp and E. Hamoen (1992). Counterexamples to Completeness Results for Basic Narrowing (Extended Abstract), Proceedings of the 3rd International Conference on Algebraic and Logic Programming, Pisa, LNCS 632, pp. 244-258.

4.7 CWI Reports

1. CS-R9204, J.R. Kennaway, J.W. Klop, M.R. Sleep, F.-J. de Vries, On the adequacy of graph rewriting for simulating term rewriting.

2. CS-R9205, J.R. Kennaway, On transfinite abstract reduction systems.

3. CS-R9206, F.S. de Boer, J.W. Klop, C. Palamidessi, Asynchronous communication in process algebra.

4. CS-R9234, F. van Raamsdonk, A simple proof of confluence for weakly orthogonal combinatory reduction systems.

4.8 Other Publications

1. J.C.M. Baeten, J.A. Bergstra, J.W. Klop (1992), Decidability of bisimulation equivalence for processes generating context-free languages, Report P9210, University of Amsterdam, Programming Research Group.

2. J.A. Bergstra, J.W. Klop (1992), A convergence theorem in process algebra, Ten Years of Concurrency Semantics, J.W. de Bakker, J.J.M.M. Rutten (eds.), World Scientific, Singapore.

3. J.W. Klop (1992), Chapter 1: Term rewriting systems. In: handbook of Logic in Computer Science, S. Abramsky, D. Gabbay, T. Maibaum (eds.), Volume 2, Oxford University Press, 116 pp.

4.9 Visitors

- Dr. Z. Ariola, University of Oregon, January 12–25 and August 1–September 15 (Graph Rewriting).

- Dr. J.R. Kennaway, University of East Anglia, Norwich, UK, January 13–February 29 (On transfinite abstract reduction systems), June 30–July 2 (Concepts of Undefinedness in Orthogonal Rewriting) and August 15–31 (Working visits SEMAGRAPH)

- Prof. dr. M.R. Sleep, University of East Anglia, Norwich, UK, January 16 and June 30–July 1 (Working visits SEMAGRAPH).

5 Logic and Language (AP5a)

5.1 Staff

- prof.dr. K.R. Apt, group leader, since March 1, 1987,

- dr. E. Marchiori, project member, since April 1, 1992,

- F. Teusink, Ph.D. Student (OIO), since April 1, 1992,

- S. Etalle, visitor, since November 1, 1992,

- M. Gabbrieli, visitor, since March 15, 1993.

5.2 Scientific Report

K.R. Apt worked with *A. Pellegrini*, a visitor from Padova University, on the subject of so-called occur-check which is omitted in most Prolog implementations for the efficiency reasons. A short version of their paper on this subject appeared in the Proceedings of the Fourth International Symposium on Programming Language Implementation and Logic Programming conference (PLILP 92) and the full version (available as Technical Report) was submitted for publication. In this work natural syntactic conditions were provided which allow the occur-check to be safely omitted. The established results apply to most well-known Prolog programs, including those that use difference-lists, and seem to explain why this omission does not lead in practice to any complications. These results were also applied to general logic programs, i.e. programs which use negative literals. Finally, a program transformation was proposed which transforms every program into a program for which only the calls to the built-in unification predicate need to be resolved by a unification algorithm with the occur-check.

Further, in a joint work with *H.C. Doets*, submitted for publication, a new, "top-down" definition of SLDNF-resolution was proposed which retains the spirit of the original definition but avoids the difficulties noted in the literature. This definition was compared with the "bottom-up" definition of Kunen.

Finally, in a joint work with *E. Marchiori*, a member of the project, and *C. Palamidessi*, a visitor from the University of Pisa, a framework was provided for studying Prolog programs with

various built-in's that include arithmetic operations, and such metalogical relations like *var* and *ground*. To this end a new, declarative semantics was proposed and completeness of the Prolog computation mechanism w.r.t. this semantics was proved. It was also shown that this semantics is fully abstract in an appropriate sense. Finally, a method for proving termination of Prolog programs with built-in's which uses this semantics was proposed. The method was shown to be modular and was illustrated by proving termination of a number of programs including the `unify` program of Sterling and Shapiro. A short version of this paper appeared in the Proceeding of the Conference on Algebraic and Logic Programming and the full version will appear in the Journal on Applicable Algebra in Engineering, Communication and Computing (AAECC).

E. Marchiori together with *L. Collussi*, her PhD supervisor from Padova University, additionally worked on the subject of unification. The paper on this subject appeared in the Proceeding of the Joint International Conference and Symposium on Logic Programming (JISCLP '92). Unification was studied as a predicate transformer. To this end a Dijkstra-style calculus was introduced and its completeness and termination was proved. The predicate language considered contains monotonic predicates together with some non-monotonic predicates like *var*, *¬ground*, *share* and *¬share*. This allows to use the calculus for the static analysis of run-time properties of Prolog programs.

Further, she studied run-time properties of general programs w.r.t. constructive negation, i.e. termination and properties of the form of the arguments of the literals selected during the execution. To this end SLD-CNF resolution was considered, i.e. resolution with constructive negation and arbitrary selection rule, and LD-CNF resolution, i.e. resolution with constructive negation and Prolog selection rule. It was shown that the class of programs which terminate for all ground goals for arbitrary (resp. Prolog) selection rule coincides with the so-called *acyclic* (resp. *acceptable*) programs, and that SLD-CNF (resp. LD-CNF) resolution is sound and complete w.r.t. Clark's semantics for bounded goals and acyclic (resp. acceptable) programs.

F. Teusink, who joined the project as OIO in April 92 devoted the first months of his work to the study of relations between logic programming and non-monotonic reasoning. His current work deals with the problem of characterizing an important class of models of general logic programs, called *stable models*, which were introduced by Gelfond and Lifschitz. These models allow us to establish an important connection between various approaches to non-monotonic reasoning.

S. Etalle, a visitor from University of Padova, continued his work on transformations of general programs with *A. Bossi* and *N. Cocco*, also from University of Padova. In their work they studied the problem which semantics of general logic programs are preserved under such natural program transformations, like replacement. Also, he started to work with *K.R. Apt* on the problem of identifying Prolog programs which can be executed with the unification algorithm replaced by iterating matching. Such a replacement can result in more efficient implementation of the programs.

5.3   Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *IFIP Seminar on "Formal Description of Programming Concepts"*, Bombay, India, February 21 –March 7: K.R. Apt (4 lectures on Program Verification, Reasoning about termination of Prolog programs, Non-monotonic reasoning and logic programming, From declarative progrmaming to Prolog, From Logic Programming to Prolog).

- *Eurocomp 92,* , The Hague, 6-7 May: K.R. Apt (From Declarative Programming to Prolog).

- *2nd Annual Meeting of Compulog Network,* , Rome, Italy, 11 - 12 May: K.R. Apt (Why the occur-check is not a problem).

- *Meeting of ESPRIT Basic Research Action 6810 (Compulog 2)* , Rome, Italy, 13 - 14 May: K.R. Apt

- *Colloquium Niet-monotoon redeneren* Free University, Amsterdam, 9 June: K.R. Apt (Implementation of Non-monotonic Reasoning using Logic Programming)

- *Fourth International School for Computer Science Researchers*, Acireale, Italy, 22–28 June : K.R. Apt (6 lectures on Correctness of Logic and Prolog programs).

- *Algebraic and Logic Programming, Third International Conference*, Volterra, Italy, 2–4 September: K.R. Apt, E. Marchiori, C. Palamidessi (A Theory of First-order Built-in's of Prolog).

- *Benelog '92*, Luxemburg, 11 September: K.R. Apt, F. Teusink

- *1992 Joint International Conference and Symposium on Logic Programming*, Washington, D.C., U.S.A., 9–13 November: K.R. Apt (Program Chair), C. Palamidessi (A Process Algebra of Concurrent Constraint Programming), E. Marchiori (A Predicate Transformer for Unification).

- *Meeting of ESPRIT Basic Research Action 6810 (Compulog 2)* , Rome, Italy, 17–19 December: K.R. Apt, E. Marchiori.

- *Workshop on Assertional Methods*, Amsterdam, November 17–18: K.R. Apt (Assertional Reasoning in Prolog), E. Marchiori (A Predicate Transformer for Unification), F. Teusink.

- *University of Padova* (host: Prof. A. Bossi), Padova, Italy, 18 November – 9 January 1993: K.R. Apt (A new definition of SLDNF-resolution; From Modes to Assertions via Types)

5.4 Memberships of Committees and Other Professional Activities

AP5a:

- member of the European Network in Computational Logic (initiated by the ESPRIT Basic Research Action "Compulog"), since 1991.

K.R. Apt:

- professor of Computer Science, University of Amsterdam, since 1981.

- editorial board, Science of Computer Programming, since 1981.

- editorial board, Information and Computation, since 1987.

- editorial board, Journal of Logic and Computation, since 1989.

- editorial board, Wiley/Teubner Series in Computer Science, since 1989.

- editorial board, Fundamenta Informaticae, since 1990.

- editorial board, Journal of Logic Programming, since 1991.

- editorial board, Mathematical Centre Tracts, since 1992.

- IFIP Working Group 2.2 (Formal Description of Programming Concepts), since 1981.

- Scientific Board of INRIA (Institut National de Recherche en Informatique et en Automatique), France, 1989 – 1992.

- Esprit Basic Research Action "Integration," 1989 – 1992.

- Scientific Commission for Computer Science of the Belgian National Fund for Scientific Research, since 1990.

- Executive Committee of the Association for Logic Programming, since 1991.

- lecturer at the UNESCO and IFIP Course "Formal Description of Programming Concepts," Bombay, India, February 1992.

- lecturer at the Fourth International School for Computer Science Researchers, Acireale, Italy, June 1992.

- lecturer at the Advanced School on 'Logic and Artificial Intelligence', Udine, Italy, September 1992.

- co-organizer of 4th BENELOG – 4th Benelux Meeting on Logic Programming and PROLOG, Luxembourg, September 1992.

- invited lecturer at the Computer Systems and Software Engineering Conference (CompEuro 92), The Hague, The Netherlands, May 1992.

- program committee chairman, Joint International Conference on Logic Programming (chairman), Washington, D.C, November 1992.

- coordinator of the Esprit Basic Research Action "Compulog 2", since 1992.

- member Ph.D. committee Chengzheng Sun, Case Studies in Parallel Processing, University of Amsterdam, March 3.

- member Ph.D. committee M. Morreau, Conditionals in Philosophy and Artificial Intelligence, University of Amsterdam, June 18.

- member Ph.D. committee Paul Veerkamp, On the Development of an Artifact and Design Description Languages, Free University of Amsterdam, September 15.

- member Ph.D committee, J. Rao, University of Austin, Texas, USA, December.

5.5 Papers in Journals and Proceedings

1. K. R. Apt and A. Pellegrini. Why the occur-check is not a problem. In M. Bruynooghe and M. Wirsing, editors, *Proceeding of the Fourth International Symposium on Programming Language Implementation and Logic Programming (PLILP 92)*, Lecture Notes in Computer Science, Berlin, 1992. Springer-Verlag.

2. K.R. Apt, E. Marchiori, and C. Palamidessi. A Theory of First-order Built-in's of Prolog. In *Proceedings Third International Conference on Algebraic and Logic Programming*, Volterra, Italy, pages 69–83, Springer-Verlag LNCS 632, 1992.

3. L. Colussi and E. Marchiori. A Predicate Transformer for Unification. In *Proceedings 1992 Joint International Conference and Symposium on Logic Programming*, Washington, D.C., U.S.A., pages 67–81. The MIT Press, 1992.

4. F. S. de Boer and C. Palamidessi. A Process Algebra of Concurrent Constraint Programming. In *Proceedings 1992 Joint International Conference and Symposium on Logic Programming*, Washington, D.C., U.S.A., pages 463–477, The MIT Press, 1992.

5.6 CWI Reports

1. CS-R9216, K.R. Apt, E. Marchiori, C. Palamidessi, A theory of first-order built-in's of Prolog. June.

2. CS-R9227, L. Colussi, E. Marchiori, A predicate transformer for unification. July.

3. CS-R9238, K. R. Apt and A. Pellegrini, Why the occur-check is not a problem. October.

4. CS-R9242, K.R. Apt, H.C. Doets, A new definition of SLDNF-resolution. November.

5. CS-R9245, E. Marchiori. Proving run-time properties of general programs w.r.t. constructive negation. November.

6. CS-R9246, K.R. Apt, E. Marchiori, C. Palamidessi, A declarative approach for first-order built-in's of Prolog. November.

5.7 Visitors

- N. Cocco, University of Padova, Italy, 15 May - 15 June, (Partial correctness of Prolog programs),

- F. Levi, University of Pisa, Italy, 1 May - 30 June,

- J. Minker, University of Maryland, USA, 16-19 October (Semantics of Disjunctive Deductive Databases),

- P. Sapiecha, University of Warsaw, 15 May - 30 June.

6 Logic and Language (AP5b)

6.1 Staff

- prof.dr. D.J.N. van Eijck, (sub)group leader, since Nov 1, 1989

- prof.dr. M. Moortgat, researcher, since Dec 1, 1990

- dr. T. Fernando, post-doc researcher, since July 15, 1991

- drs. W. Meyer Viol, Ph.D. Student (OIO), since Jan 1, 1991

- V. Stebletsova, Ph.D. Student (OIO), since Feb 1, 1992

6.2 Scientific Report

In 1992 the group as a whole was involved in the larger scale enterprise of pursueing the obvious parallel between information processing and imperative programming, by demonstrating that logical tools from theoretical computer science are relevant for the logic of information flow, and by applying ideas and techniques from natural language analysis to problems that are also addressed in computer science.

In this connection, Jan van Eijck showed in a joint paper with Fer-Jan de Vries which was published in the Journal of Logic, Language and Information that the perspective of Hoare logic can fruitfully be applied to the conceptual simplification of information flow logics. Van Eijck and De Vries analysed 'dynamic interpretation' in this way, using the example of dynamic predicate logic (Groenendijk and Stokhof).

A second part of this program, the analysis of 'dynamic inference' was carried out in a study of Veltman's update logic from the perspective of Hoare logic. Van Eijck and De Vries reported on this in the Proceedings of the *Amsterdam Colloquium*. Update logic is an example of a logical framework which takes the dynamics of drawing inferences into account by modelling information growth as discarding of possibilities. The paper shows how information logics like update logic can fruitfully be studied by linking their dynamic principles to static 'correctness descriptions'.

Jan van Eijck worked with Giovanna Cepparello (visiting from Scuola Normale in Pisa) on a system combining dynamic predicate logic and update logic. In a CWI report, they combine dynamic predicate logic and update logic in a dynamic version of modal predicate logic (DMPL). It is shown that this logic is eliminative at a global level and distributive at a local level. The logic is axiomatized in Quantified Dynamic Modal Logic. The axiomatization gives rise to a translation function from quantified dynamic modal logic to S5 modal predicate logic. This translation function can be used to derive the static truth conditions of DMPL meaning representations.

Jan van Eijck worked with Nissim Francez (visiting from The Technion, Haifa) on a procedural theory of verb phrase ellipsis, and with Nguyen Quoc Toan (visiting from the University of Hanoi) on a theory of concept formation.

Michael Moortgat worked on theorem proving for categorial grammars using Gabbay's Labelled Deductive Systems as a unifying framework, and reported on this in the Proceedings of the *Eighth Amsterdam Colloquium*. He also studied the connections between A. Joshi's Tree Adjoining Grammars and categorial grammar formalisms.

Tim Fernando continued his work on the logic of transition systems and the construction of transition systems from first-order models, and reported on this in Pisa, Bern, Berlin and Budapest. While the main emphasis of this work is on logical and foundational issues, some of the work has ramifications for NL semantics.

Wilfried Meyer Viol worked on a proof theoretical perspective for natural language analysis, based on Kit Fine's theory of arbitrary objects. Fine's ideas are used to motivate a new perspective on discourse representation theory.

Vera Stebletsova worked on the problem of relating the modal logic of process equivalences involving silent moves to fragments of first order logic. Joint work with Johan van Benthem (University of Amsterdam) and Jan van Eijck was started to study labelled transition systems from a modal logic viewpoint.

6.3 Organisation of Conferences, Workshops, Courses, etc

- NFI seminar Lambek Calculus, March–April, CWI (Jan van Eijck).

- Computational Linguistics in the Netherlands (CLIN) 1993, Tilburg October 30 (Jan van Eijck).

- NFI Parallels Colloquium, Amsterdam, monthly through the year (Jan van Eijck).

6.4 Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- *SNS (host: Dr. Uwe Moennich)*, Tuebingen, Germany, January 23 and 24, Jan van Eijck (Dynamic Interpretation in NL Analysis, Dynamic Interpretation and Presupposition)

- *DANDI Workshop on Computational Semantics*, Pitlochry, Scotland, March 7, Jan van Eijck (The Cutting Edge in Computational Semantics)

- *Imperial College*, London (hosts: D. Gabbay and R. Kempson), March 2–10, Wilfried Meyer Viol (Two talks on Discourse Representation Theory)

- *NFI Seminar Lambek Calculus*, CWI, Amsterdam, April 13, Michael Moortgat (Logics of structured resources)

- *Colloquium on Dynamic and Partial Logic*, Utrecht, March 17, Vera Stebletsova (Branching temporal logics with binary operators as a tool for verification of concurrent programs)

- *Colloquium Non-monotonic Reasoning*, Free University, Amsterdam, Wilfried Meyer Viol (Non-monotonic logic and arbitrary objects)

- *ERCIM workshop on Knowledge Representation*, Pisa, Italy, May 20–23, Jan van Eijck (Axiomatizing DPL with QDL), Tim Fernando (Transition Systems over First-order Models), Wilfried Meyer Viol (Partial Objects and Discourse Representation Theory)

- *Dipartimento di Filosofia, University of Pisa*, Pisa, Italy, May 25, Jan van Eijck (Dynamic Logic and Natural Language Interpretation)

- *Seminar in Logik und Informatik*, Bern, Switserland, June 10, Tim Fernando (Transitions between programs and processes)

- *TAG+ Workshop*, Institute for Research in Cognitive Science. University of Pennsylvania, June, Michael Moortgat (TAGs, types and labelled deduction)

- *4th Symposium on Logic and Language*, Budapest, Hungary, August 4–9, Jan van Eijck (Presupposition Failure and Error State Semantics) Tim Fernando (Dynamic semantics and the construction of first-order contexts)

- *Summer School for Logic, Language and Information*, Colchester, England, August 15–28, Wilfried Meyer Viol (Syntactic Discourse Representation Theory), Vera Stebletsova

- *JELIA 92*, Berlin, September 7–10, Tim Fernando (Transition systems and dynamic semantics)

- *Philips Natuurkundig Laboratorium*, Eindhoven, September 16, Jan van Eijck (Dynamic Logic and Natural Language Analysis)

- *Computer Science Logic 92*, Pisa, September 28 - October 2, Tim Fernando (Comparative transition system semantics)

- *Algemeen CWI Colloquium*, CWI, Amsterdam, October 16, Michael Moortgat (Categorial grammar and type theory)

- *ITK Colloquium*, Tilburg, November 5, Tim Fernando (Understanding and extending dynamic semantics)

- *Workshop on Assertional Methods*, Amsterdam, November 17–18, Jan van Eijck (Applications of Assertional Reasoning in Natural Language Analysis), Tim Fernando (About bisimulations)

- *CIS Seminar*, Munich, Germany, Tim Fernando (Understanding and extending dynamic semantics)

- *Opening Onderzoeksschool Logica*, Amsterdam, November 20, Michael Moortgat (Logic and Linguistics)

- *Seminar on Intensional Logic*, Amsterdam, December 4, Vera Stebletsova (A logical characterization of behavioural equivalences over concurrent processes)

- *Colloquium on Parallels between Natural Language and Programming Language Analysis*, December 15, Tim Fernando (Analyzing change through transition systems)

- *Logic at Work' Conference*, Amsterdam, December 19, Jan van Eijck (together with N. Francez), (Procedural Dynamic Semantics, Verb-Phrase Ellipsis, and Presupposition)

6.5 Memberships of Committees and Other Professional Activities

Jan van Eijck:

- member of the Programme Committee of *JELIA* 1992

- member of 'NWO Voorbereidingscommissie Prioriteitsprogramma Taal- en Spraaktechnologie', Spring 1992.

- member of the PhD committee of Joost Zwarts, Utrecht University, November 27

- member of the PhD committee of Hub Prüst, University of Amsterdam, December 3

6.6 Papers in Journals and Proceedings

1. J. van Eijck and R.C. Moore, Semantic Rules for English, In *The Core Language Engine*, H. Alshawi (ed.), MIT Press, Cambridge, Massachusetts, 1992, pp. 83–115.

2. J. van Eijck and H. Alshawi, Logical Forms, Semantic Rules for English, In *The Core Language Engine*, H. Alshawi (ed.), MIT Press, Cambridge, Massachusetts, 1992, pp. 11–39.

3. J. van Eijck and F.J. de Vries, A Sound and Complete Calculus for Update Logic, In *Proceedings of the Eighth Amsterdam Colloquium*, P. Dekker and M. Stokhof (eds.), ILLC, Amsterdam, 1992, pp. 133–152.

4. J. van Eijck and F.J. de Vries, Dynamic Interpretation and Hoare Deduction, *Journal of Logic, Language, and Information*, I, 1992, pp 1–44.

5. J. van Eijck, Axiomatizing Dynamic Predicate Logic with Quantified Dynamic Logic (Abstract), *ERCIM Workshop on Theoretical and Experimental Aspects of Knowledge Representation*, C. Meghini and F. Sebastiani (eds.), CNR, Pisa, 1992, pp. 125–137.

6. J. van Eijck and N. Francez, Procedural Semantics, Verb-Phrase Ellipsis, and Presupposition, *Proceedings APLOG conference, Amsterdam*, 1992.

7. T. Fernando, Transition systems and dynamic semantics, in *Logic and AI*, D. Pearce and G. Wagner, eds. (LNCS 633), Springer, Berlin, 1992, pp. 232-251.

8. T. Fernando, A primitive recursive set theory and AFA, , In *Computer Science Logic 91*, E. Börger et al, eds (LNCS 626), Springer, Berlin, 1992, pp 96-110.

9. W. Meyer Viol, Partial Objects and DRT, In *Proceedings of the Eighth Amsterdam Colloquium*, P. Dekker and M. Stokhof (eds.), ILLC, Amsterdam, 1992, pp. 381–402.

10. M. Moortgat, Labelled Deductive Systems for Categorial Theorem Proving, In *Proceedings of the Eighth Amsterdam Colloquium*, P. Dekker and M. Stokhof (eds.), ILLC, Amsterdam, 1992, pp. 403–423.

6.7 CWI Reports

1. CS-R9237 J. van Eijck and G. Cepparello, Dynamic Modal Predicate Logic, September.

2. CS-R9212 T. Fernando, Provably recursive programs, March.

3. CS-R9213 T. Fernando, A primitive recursive set theory and AFA, March.

4. CS-R9217 T. Fernando, Transition systems and dynamic semantcs, June.

5. CS-R9222 T. Fernando, Comparative transition systems semantics, July.

6.8 Other Publications

1. J. van Benthem and W. Meyer Viol, *Semantics of Programming*, preprint, University of Amsterdam.

2. J. van Eijck and W. Meyer Viol (eds.), *Papers from the Second CLIN Meeting (1991)*, Utrecht 1992 (OTS Working Papers)

3. T. Fernando, A primitive recursive set theory and AFA, CSL 92, To appear in *LNCS*. Springer, Berlin.

4. T. Fernando, Between programs and processes: absoluteness and open ended-ness, *University of Bern, tech report IAM-92-011*, July.

5. W. Meyer Viol, Discourse Representation Theory, In: *Papers from the Second CLIN Meeting (1991)*, J. van Eijck and W. Meyer Viol (eds.), Utrecht 1992 (OTS Working Papers)

6. M. Moortgat, Taal- en rekenkunde, In: *TA! Studentenblad Computationele Taalkunde*, 1, nr 1, pp. 55–77.

6.9 Visits to Conferences, Workshops, Colloquia, etc., Working Visits

- Dr. Dirk Roorda, University of Groningen, March 15 – May 15

- Prof. Stanley Peters, Stanford University, USA, June 13–16.

- Prof. Nissim Francez, The Technion, Haifa, Israel, July.

- Giovanna Cepparello, Scuola Normale Superiore, Pisa, Italy, October.

- Dr. Nguyen Quoc Toan, Univerisity of Hanoi, Vietnam, September – November.

- Alla Frolova, Institute for Logic and Cognitive Science, University of Moscow, November 15 – January 15.

- Olivier Bouchez and Olivier Istace, University of Namur, Belgium, September – December.