Annual progress report ALAPEDES

Contract ERB–FMRX–CT 96–0074

Period: October 01, 1998 – September 30, 1999

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0.0 Guidance

0.1 The network

ALAPEDES is the acronym for ALgebraic Approach to Performance Evaluation of Discrete Event Systems. The theory of discrete event systems deals with dynamical systems that are *event-driven* as opposed to *time-driven*; usually their state variables take on only discrete values. Several approaches exist to study discrete event systems; of these the "logical" approach, where the *ordering* of the events is of interest, and the "timed" approach, where the *timing* of the events is also of interest for the mainstreams form the research within ALAPEDES. In both streams the structure of algebraic systems plays a dominant rôle.

In ALAPEDES eight partners from four different countries work together in ten strongly interrelated subprojects, to develop new theory, applications and software tools within the algebraic approach to discrete event systems. ALAPEDES is a network in the framework of the TMR programme, European Commission, Directorate General XII, network contract no. ERB–FMRX–CT 96–0074.

0.2 The report

This report describes the activities of the network ALAPEDES during the third year of its official existence (the commencement date was October 1, 1996). The report is written to inform the European Union on the progress of the ALAPEDES network, but equally serves as an information source on ALAPEDES for the network partners (and maybe for interested outsiders as well).

The report consists of five parts. This first (*Section 0*) serves as an introduction to it; included are the acronyms of the partners and a list of the subprojects.

Section 1 describes the progress of the ALAPEDES network against the objectives set out in the work programme. It gives the scientific results (1.1) per subproject, relating them, whenever possible, to the text in the first annual report, gives scientific highlights (1.2) for the general reader, reports on networking and coordination activities undertaken (1.3), introduces the researchers funded by the network (1.4), gives information about contacts with industry (1.5), and lists difficulties experienced with environmental constraints (1.6).

Section 2 gives factual information on the network activities. The scientific specialities of the partners are listed (2.1), according to the codes that the European Union uses, the research staff involved is listed (2.2), introducing the researchers funded by the network (2.3), presents publications that have emerged or will emerge from the network activities (2.4) and acknowledges secondments between partners (2.5).

Section 3 stresses the collaboration within the ALAPEDES network. In it a list of joint publications is given (3.1) and a description of the way contacts and coordination were sustained (3.2).

The report has five appendices. *Appendix A* tries to list the names of all researchers involved in ALAPEDES in one way or another. *Appendix B* gives an extensive list of publications. *Appendix C* gives additional information about the network, that is not explicitly required according to the reporting guidelines. Furthermore, one finds in *Appendix D* the programme of the ALAPEDES workshop held in Paris (France), and in *Appendix E* the programme of the ALAPEDES mid-term review meeting, also in Paris.

0.3 Legend

0.3.1 Partners

The ALAPEDES network consists of eight partners (one of which comprises two locations). They are frequently referred to, in which the following acronyms are utilized.

TUD – Technische Universiteit Delft, Delft, Nederland;
scientific teamleader: G.J. Olsder; g.j.olsder@math.tudelft.nl

ARMINES – Association pour la Recherche et le Développement des Méthodes et Processus Industriels, École Nationale Supérieure des Mines de Paris (ENSMP), Fontainebleau, France;
scientific teamleader: G. Cohen; guy.cohen@mail.enpc.fr

INRIA – Institut National de Recherche en Informatique et en Automatique) has two research teams involved in ALAPEDES:

INRIA - Sophia Antipolis (near Nice), France;
scientific teamleader: F. Baccelli; francois.baccelli@inria.fr

INRIA - Rocquencourt (near Paris), France;
scientific teamleader: J.-P. Quadrat; jean-pierre.quadrat@inria.fr

KUL – Katholieke Universiteit Leuven, Leuven, België;
scientific teamleader: B. De Moor; bart.demoor@esat.kuleuven.ac.be

HP – Hewlett Packard Limited, Basic Research Institute in the Mathematical Sciences (BRIMS), Bristol, United Kingdom;
scientific teamleader: J.H.C. Gunawardena; jhcg@hplb.hpl.hp.com

LIAFA (formerly **LITP**) – Université Paris VII, Laboratoire d'Informatique Algorithmique: Fondements et Applications, Paris, France;
scientific teamleaders: J. Mairesse; mairesse@liafa.jusiieu.fr and D. Krob; krob@liafa.jussieu.fr

RUG – Rijksuniversiteit Groningen, Groningen, Nederland;
scientific teamleader: R. Smedinga; rein@cs.rug.nl

ULG – Université de Liège, Liège, Belgique;
scientific teamleader: V. Blondel; vblondel@ulg.ac.be

Recently two scientists-in-charge moved to another employer. See § 1.6 for further details.

0.3.2 Subprojects

The ALAPEDES network is structured into ten closely related subprojects. As for instance noticed at the mid-term review meeting, the split up of the research according to these ten subprojects has not always been very strict. We prefer, however, to keep reporting according to this structure as much as possible. Whenever practicable activities and accomplishments in the sequel will be brought in relation with these subprojects; for ease of reference they are summarized below (the text utilizes the accompanying codes).

Cross-Fertilisation on The Theoretical Level

T-1   Representation problems
T-2   Stability problems
T-3   Optimisation problems
T-4   Control of automata
T-5   Large systems problems

Applications

A-1   Transportation systems
A-2   Manufacturing systems
A-3   Communication networks

Software

S-1   Investigation and critical analysis of existing software
S-2   Development of new software

0.3.3   Glossary

In the report the term (Alapedes) *partner* is used for the organizations that were listed in
§ 0.3.1; students preparing their graduation are called *undergraduates*, graduated students
working for a doctoral degree are referred to as *postgraduate*s, researchers having a doctoral
degree are called *postdocs*; the term Alapedes *researcher* is reserved for those (mostly
postdocs) who are paid by the network funds, and Alapedes *member* applies to researchers
working for some Alapedes partner, but paid from other funds.

1 Progress

Probably the highlight of the third year of ALAPEDES' existence was the ALAPEDES convention held at the prestigious 'École Normale Supérieure' in Paris. It was organized in conjunction with the 'journées thématiques algèbres tropicales'. A joint booklet was published with most of the lectures given. The joint activities took place during March 29 till 31. On the last day, the mid-term review meeting was held.

The ALAPEDES community was very pleased to learn that its project was jugded well (letter by Bernard (project officer European Commission) of June 16, 1999) and that the continuation for the third and fourth year had been granted. One point of concern was the low number of postdoc months filled in during the first two years. In order to be able to improve this situation, we asked for an extension of the contract with one year and this has been approved by the European Commission (letter of Nilsson (European Commission) of July 26, 1999). Fortunately, now at the end of the third year, the situation has been improved somewhat: some postdocs left the project, but many more entered.

The long-standing "Kanta-problem" (see previous annual reports and §1.3.1) has finally been resolved satisfactorily (letter by Nilsson (European Commission) to Bosma (TUD) of September 17, 1999).

The next (after the one in Paris) ALAPEDES convention will take place in Delft, on October 1 and 2, 1999. We will report on this most recent convention in the next (fourth) annual report.

1.1 Scientific results

The description of the scientific results is structured according to the ten subprojects. Activities which belong to more than one subproject, have been mentioned under one of them and a reference from the other subproject(s) to that description is given. Frequently names are mentioned; names with an ALAPEDES connection appear in Appendix A where more particulars, such as home institution and the rôle in ALAPEDES can be found. Next to these descriptions, there is a separate one (§ 1.1.11) on milestones. Cross-references with the previous annual progress report, when appropriate, are sometimes given.

1.1.1 T-1

De Schutter (formerly KUL, now TUD) and Olsder (TUD) submitted a paper on the minimal state space realization problem in the (max, +)-algebra. The paper provides an overview on existing results and on open problems. Complexity of algorithms is also discussed.

Publications within ALAPEDES which are relevant to this part of the subproject are [169, 168].

The work initiated in the past few years by Cohen (ARMINES), Gaubert and Quadrat (INRIA - Rocquencourt) about the geometry of idempotent semimodules has been continued. The projector on semimodules has been studied previously, with applications to aggregation and minimal realization of event graphs. In these studies, a subclass of semimodules called "regular" appeared to play an important rôle: indeed, it proved possible to find another semimodule, "transverse" to the former, while the projector on the regular semimodule, parallel to the transverse semimodule, is a well-defined *linear* operator.

This year, this study has been pursued by trying to classify the semimodules in relation with the standard theory of modules. The semigroup properties of the first operation induce a asymmetry between kernel and image that we are trying to investigate. This asymmetry prevents the immediate adaptation of the standard machinery of homology; the right tools to make substantial advances remain to be discovered.

Publications within ALAPEDES which are relevant to this part of the subproject are [55, 56].

Due to changes in the project staff, the research on T-1 has been discontinued at KUL. Instead, the research effort at KUL now primarily focuses on topic A-1 (see §1.1.6) with a special emphasis on traffic control and traffic modelling.

The different possible semantics of Timed Petri nets have been investigated recently by Haar and Gaujal. This work will be presented shortly.

As a continuation, Haar, Kaiser and Simonot have established several theoretical correspondences between Time and Timed Petri Nets and several types of timed automata (using bi-simulation). This work is submitted for publication.

A publication within ALAPEDES which is relevant to this part of the subproject is [119].

Portier and Blondel (ULG) have used a connection between the minimal realization problem for discrete event systems and automata to show that the minimal realization problem is NP-hard. This means that, unless $\mathsf{P} = \mathsf{NP}$, the problem does not admit a polynomial solution. These results answer a long-standing question in the field. Similar connections between automata and positive systems are now being investigated.

Publications within ALAPEDES which are relevant to this part of the subproject are [181, 182, 183].

1.1.2 T-2

Soto Y Koelemeijer (TUD) and Heidergott are about to finish a paper on the transient behaviour of $(\max, +)$-systems. They show that the difference between maximum cycle mean and the one but largest cycle mean indeed (as common sense suggests) is a crucial parameter.

Olsder, Roos and Van Egmond (TUD) came up with a new, efficient, algorithm to calculate the eigenvalue and eigenvector of a $(\max, +)$-system. It makes use of the Floyd-Warshall procedure; the eigenvalue problem is considered as a problem of maximal circulation. The results have been published recently.

Attention has been paid by Van der Woude and Subiono (TUD) to $(\max, +)$-systems, bipartite $(\min, \max, +)$-systems and and general $(\min, \max, +)$-systems. Especially, the existence and computation of the eigenvalue of such systems have been investigated. For this a notion of irreducibility for bipartite and general $(\min, \max, +)$-systems has been developed.

Publications within ALAPEDES which are relevant to this part of the subproject are [205, 193].

The work about the eigensystem of monotonous homogeneous systems initiated by Gaubert and Gunawardena has been continued this year.

Work by Baccelli, Mairesse and Borovkov on T-5, that is also relevant for this subproject, has been described in §1.1.5.

1.1.3 T-3

The purpose of this task is the optimization of discrete event systems: troughput optimization, optimization of time spent in a system, resource optimization, and schedule optimization, with applications to manufacturing systems, transportation systems or design of circuits.

One first has to make a distinction between different classes of discrete event systems: event graphs vs. more general Petri nets, and deterministic vs. stochastic systems.

An application of known results about optimization of general (and, up to now, deterministic) Petri nets for the design of traffic light controllers in a city has been initiated. This work will be described in the §1.1.6.

The optimal scheduling of event graphs has been formulated in terms of heaps of pieces. The results have been published this year by Gaubert (INRIA) and Mairesse (LIAFA). The optimal schedule in the case of two pieces has been found by Mairesse and Vuillon (LIAFA) last year. A new proof has been found this year by Sparrow (Cambridge / HP).

Publications within ALAPEDES which are relevant to this part of the subproject are [114, 113, 116, 163].

For stochastic sytems, the work of the network may be decomposed in two parts: stochastic iteration approach, and to obtain analytic results for Lyapunov exponents.

The stochastic iteration approach allows the optimization of some parameters of a discrete event system as soon as one is able to simulate it. It has been studied before mainly by Heidergott (TUD) who made some progress in the computation of the weak derivatives of some random $(\max, +)$-matrices.

New formulae have been obtained this year by Ayhan (Georgia Institute of Technology) and Baccelli (INRIA - Sophia Antipolis) for the waiting time in a $(\max, +)$-linear system with Poisson input. See also § 1.1.11).

The quest for some explicit formulae of the throughput of a discrete event system in which some parameters appear explicitly is useful in order to optimize such systems. A great deal of progress has been made at INRIA - Sophia Antipolis on the computation of Lyapunov exponents for stochastic systems. Baccelli and Hong obtained an explicit series expansion for the Lyapunov exponent of a perturbed $(\max, +)$-system, which in some sense generalizes the previous computation of the derivative of a $(\max, +)$-stochastic linear system. The corresponding paper is accepted for publication.

A publication within ALAPEDES which is relevant to this part of the subproject is [21].

In another paper, which is also accepted for publication, the same authors gave sufficient conditions for such series expansions to be convergent. Here they use some extensions of ideas of Ruelle and Peres, initially used for products of random matrices in the conventional algebra, to iterates of non-expansive random maps. One can deduce simple conditions from this, based on large deviations, allowing one to derive a region of parameters where analyticity is granted for the expansions in question.

A publication within ALAPEDES which is relevant to this part of the subproject is [112].

Recently, Hong (INRIA - Sophia Antipolis) and Gaubert (INRIA - Rocquencourt) also found new representations of Lyapunov exponents for stochastic $(\max, +)$-systems, using automata theory. Their work was presented at a conference. A survey on all this will be presented by Hong at another conference, and will be included in the proceedings of this latter conference.

Joint work is also initiated at INRIA - Sophia Antipolis with Schmidt and Schlegel of Universität Ulm, on stochastic $(\max, +)$-systems with sub-exponential distribution functions.

Baccelli gave a plenary lecture on stochastic $(\max, +)$-systems at the 10$^{\text{th}}$ applied probability conference.

Using a new version of integer convexity called multimodularity, Gaujal, Altman and Hordijk have derived several results concerning the optimal control of $(\max, +)$-linear systems. The work on open loop admission control and that on optimal routing will appear in the literature. Finally, the general methodology has been recently accepted also.

A publication within ALAPEDES which is relevant to this part of the subproject is [7].

As for close loop control, results on the monotonicity property of the optimal control will be presented in a workshop.

In a joint effort by LIAFA and INRIA - Rocquencourt, Gaubert and Mairesse have continued their work on heaps of pieces. The problems adressed are of the following type: what is the density of an infinite heap of pieces, if one lets pieces fall down randomly, or if one selects

pieces to maximize the density? Several techniques have been used. First, a completed "non-linear automaton" is introduced, which essentially fills incrementally all the gaps that can be filled in a heap without changing its asymptotic height. Using this construction, when the pieces have integer valued shapes, and when any two pieces overlap, the asymptotic behaviour can be explicitly computed. Second, a construction, partly based on Cartier-Foata normal forms of traces, is proposed, which allows to compute the optimal case behaviour, assuming only that the pieces have integer valued shapes.

A publication within ALAPEDES which is relevant to this part of the subproject is [116].

1.1.4   T-4

Klimann (LIAFA) has been working on an adaptation of the (A, B)-invariance problem in the framework of languages and formal series. The idea is to find new tools to solve this problem and to adapt these new tools to solve the (A, B)-invariance problem on modules — a problem which appears naturally in control theory, but is unsolved yet. The solution to this problem, in the framework of languages and formal series, is described in the doctoral thesis [152] of Klimann which was defended in April, 1999. For more details, the reader is referred to § 1.3.5.

Publications within ALAPEDES which are relevant to this part of the subproject are [153, 154].

1.1.5   T-5

The purpose of this task is the study of large scale discrete event systems. Two main endeavours have been exerted this year.

Fall and Quadrat continued their investigations about $(\min, +)$-product forms. In this work, the link between geodesic computations on a regular mesh and flow problems has been established. Some particular flow problems can be solved explicitly, which gives explicit formulae for the length of geodesics, analogous to the product form of Jacksonian systems of queues with service times that are independent of the state. This year, a generalization of these earlier results has been obtained in the case, when the length of the admissible displacement depends on the state in a manner analogous to the standard dependence of the service time on the state of Jacksonian systems of queues. A publication is in preparation. Martin studied the asymptotics of large queueing systems composed of blocking queues in series.

Baccelli, Mairesse and Borovkov (Novosibirsk University) have been working on infinite tandem queueing networks. They consider an infinite tandem queueing system, consisting of $\cdot/GI/1$ stations with independent, identically distributed service times. Such a model can be viewed as a stochastic $(\max, +)$-system in infinite dimension. Several ergodic results are obtained for the model. There are interesting links with percolation theory, and in particular hydrodynamic limits for certain infinite percolation models. The corresponding paper has been accepted for publication. This work is also relevant to subproject T-2.

A closely related problem is the one of existence of fixed points for a single server station. Mairesse has been working on this problem with Prabhakar from Stanford University.

Publications within ALAPEDES which are relevant to this part of the subproject are [14, 161].

1.1.6   A-1

At TUD, Subiono has entered his last (fourth) year. He got some recent results on the reallocation of trains on the Dutch railway system such as to give all circuits about the same cycle means. Van Egmond introduced a so-called M-matrix by means of which he can calculate the propagation of delays easily. This M-matrix has other properties useful for applications.

Preliminary contacts with the Netherlands air carrier KLM did not lead to a continuation.

The group at the KUL is currently working on modelling and control of highway traffic. The

developed traffic models aim at tracking and predicting the traffic situation on the studied highway. Two main types of models are studied: microscopic and macroscopic models. In a microscopic model, the different cars on the highway are modelled individually. Every vehicle has its own parameters, such as its origin, destination and desired speed. In a macroscopic model aggregated variables are used such as: the car, flows (the number of cars passing per minute), the average speed of the cars and the traffic density (number of cars per kilometer) on the highway.

Another topic of research is the estimation of dynamic origin–destination (OD) matrices. These OD-matrices contain the (time dependent) traffic flows from every possible origin in the network to every possible destination. The OD-matrices are estimated based on measurements from sensors along the highways and from historical data. Most current traffic simulation packages use OD-matrices as input for the traffic situation. Egido Arteaga (KUL) conducted a literature search, and some new ideas have been produced on how to reconstruct the paths followed by cars. These ideas amount, basically, to dynamically adjusting the trajectories of the cars during a traffic simulation, trying to match as well as possible the input/output data, and iterate until a satisfactory solution has been found. A 'toy model' has been proposed to test these ideas, but it has not been implemented yet.

Ramp metering is being studied as one possible traffic control measure for highways. With ramp metering, the number of cars that is allowed to enter the highway is limited in order to prevent congestion. Egido Arteaga continues research, started originally by De Schutter and Bellemans. He studies different ramp metering controllers, making a trade-off between the traffic smoothness on the main line and the length of the queue at the on-ramp. The traffic model used has been simplified, and the simulation software has been improved both in efficiency and robustness. The high computational costs involved in these problems forms a serious obstacle yet and require serious improvements in the optimization tasks for real time applications.

Cohen (ARMINES), Gaubert, Mancinelli, Quadrat and Rofman (INRIA - Rocquencourt) have started investigations on the design of a plan to control the traffic lights in Bahia Blanca (Argentina). A model based on previous work of Olsder and Van Egmond (TUD) has been embarked on. First, an extension of this former work to more general Petri nets has been proposed. Based on this modelling, a decomposition between flow problems and green wave problems is provided. For regular towns and a uniform speed in the town, a simple solution (in terms of cycle times, and phase lags) can be otained. The average speed for realistic cycle lengths seems too slow, however. An improvement can be obtained by favouring some streets. The optimal choice of the fast streets remains to be considered. A preliminary internal report on this work is available.

A publication within ALAPEDES which is relevant to this part of the subproject is [54].

The use of techniques developed in discrete event systems to analyse real-time problems have been initiated by Baccelli, Gaujal and Simon for a real-time operating system used in robots, called ORCCAD.

A publication within ALAPEDES which is relevant to this part of the subproject is [17].

As for the use of these techniques for communication networks, Gaujal and Navet have designed a traffic shaping technique that preserves real-time constraints and improves the response times of the other messages. This work will appear in the literature.

A publication within ALAPEDES which is relevant to this part of the subproject is [125]

1.1.7 A-2

As for the application to manufacturing systems, some preliminary contact with the French car manufacturer Renault has been achieved. This preliminary discussion shows the necessity of proposing tools for the fast evaluation of the design. Current simulation tools are often

to heavy for the initial design. The evaluation of the interest of $(\max, +)$-transfer function concepts is being considered, but has not been undertaken yet.

A preliminary toolbox for the evaluation and design of manufacturing systems has been started on at INRIA - Rocquencourt. It is based on the $(\max, +)$-toolbox already developed in recent years within the SCILAB package (at École des Mines and INRIA). The available functionalities have been demonstrated during the mid-term review meeting in Paris. They are still in development. Some possible links between ERS (by Jean-Marie at INRIA - Sophia Antipolis) and SCILAB have been discussed, but are still to be further developed. With the tools that are available in ERS and SCILAB, it is possible now to efficiently evaluate the performance of flowshops. The resource optimization of flowshops has still to be implemented, but this does not present any major difficulty. The optimization of scheduling remains the main difficult problem.

1.1.8 A-3

The thesis of Bonald, which was supported by France Telecom, has been prepared at École Polytechnique, and defended in October, 1999. In this thesis, Bonald studied TCP type congestion control in communication networks using some perturbations of $(\max, +)$-linear systems. Bonald joined France Telecom recently.

The main progress was made this year in connection with performance analysis of telecommunications protocols using combinatorial methods. In relationship with Dornstetter (head of Nortel Networks research and development departement) and Thibon (Université de Marne-la-Vallée), Krob (LIAFA) discovered a purely combinatorial method for solving a complicated performance analysis problem arising in the domain of mobile communications protocols. This solution is now implemented as one of the main routines of software used by Nortel.

A publication within ALAPEDES which is relevant to this part of the subproject is [91].

1.1.9 S-1

The subproject S-1 (investigation and critical analysis of existing software) was completed during the first year of the network.

1.1.10 S-2

The development of the $(\max, +)$-toolbox has been continued, albeit somewhat slowly, after M$^{\text{c}}$ Gettrick left the ALAPEDES network rather unexpectedly, and because he has not yet been replaced by another postdoc working more or less full time on this demanding task. Almost all manipulations of standard linear systems have a $(\max, +)$-counterpart now. It remains to produce the documentation and to test the toolbox with the forthcoming next version of SCILAB to consider when a first version of the toolbox is available for distribution. This will be achieved hopefully quickly when Lotito will join INRIA - Rocquencourt very soon now. The main functionalities of this piece of software were demonstrated during the mid-term review meeting in Paris.

The main piece of work that remains to be done is to add facilities to manipulate $(\max, +)$-transfer functions. Up to now, linear systems are manipulated only in their state space form, with very limiting simplifications, compared to what can be expected from transfer function computations.

Links between ERS and SCILAB have been embarked on and a production toolbox has been set up (see § 1.1.7).

Several suggestions by Gaubert and Mairesse were implemented in the software package SEMIGROUPE (Pin, LIAFA), in particular to handle semigroups of matrices over $(\max, +)$-semirings.

1.1.11 Milestones

A NSF grant between INRIA and Georgia Institute of Technology starts this fall. This grant bears on stochastic discrete event systems. The results obtained within ALAPEDES were instrumental for the acceptance of this grant. Within this framework, new formulas were derived by Ayhan (of Georgia Institute of Technology) and Baccelli (INRIA - Sophia Antipolis) for the joint Laplace transform of two or more waiting times in a $(\max, +)$-linear system with Poisson input. See also § 1.1.3.

After the successful spring school on $(\max, +)$-algebra, held in Noirmoutier (France) in May, 1998 (see the second annual progress report, appendix G), the editors of the scientific journal *Theoretical Computer Science* (TCS), suggested to prepare a special issue of TCS on $(\max, +)$-algebra. The co-editors for this special issue are Gaubert (INRIA - Rocquencourt), Loiseau (Ircyn), Mairesse and Pin (LIAFA). Of these four, only is not a member of the ALAPEDES project. For the issue 17 papers were submitted, covering a large spectrum of the field (ranging from formal languages and control to applications). Among them, about a quarter is submitted by ALAPEDES partners. The selection process is still going on, but about 12 papers are expected to be published in this special issue.

1.2 Scientific highlights

Though no definition of "scientific highlight" will be given, the following results are definitely worth mentioning under this heading:

- insight in the complexity of minimal realization problems (Portier, Blondel);
- optimal scheduling through the heaps of pieces approach (Gaubert, Mairesse);
- series expansions for the calculation of Lyapunov coefficients (Baccelli, Hong); and
- weak derivative approach within the stochastic $(\max, +)$-algebra setting (Heidergott).

Also worth mentioning are:

- The concept of the M-matrix (maximal delays not causing a further propagation) (Van Egmond);
- Further progress in traffic light control (Gaubert, Mancinelli, Quadrat).

1.3 Networking and coordination

1.3.1 General coordination

E-mail   Day-to-day contact between ALAPEDES members within different partners is established by electronic mail. The medium is used evenly for scientific purposes (spreading knowledge and tools) and for coordination (preparation of meetings, reporting, information exchange).

Vacancies   Vacancies are a point of concern, though the situation has been improved somewhat recently. It turns out to be difficult to find qualified candidates for all positions available. Attracting qualified postdocs is apparently a more general problem and the European Commission now also allows the exchange of postgraduates. Sofar, such an exchange did not occur within ALAPEDES.

The coordinator played little rôle in the search for postdocs to fill in the positions available in the network. In most cases the network partners advertised their own positions specifically. The issue of coordination in the quest for suitable candidates for vacant positions for ALAPEDES researchers is treated in § 1.4.1.

Formal contacts   Through the network coordinator (TUD) several questions were asked to the European Commission via its project officer. They concerned refunding of travelling costs outside Europe, the organization of the mid-term review by the European Commission, and the procedures with respect to relocation of ALAPEDES members, with repercussions to the resposibilities of the ALAPEDES partners concerned.

The preparation of the mid-term review report and meeting and contacts on the mid-term review assessment with the project officer (Christane Bernard) and the expert reviewer (Christos Nikolaou) augmented the organizational burden for the coordinator.

On March 31, 1999 a (more informal) meeting was intercalated during the mid-term review meeting to discuss the "Kanta issue", that has to do with the refusal by the EC to pay for a researcher (Matthias Kanta at LIAFA), that surpassed the age of 35 before employment, and could hence not be regarded as a young researcher. The discussion did not lead to a direct result, but the ALAPEDES community felt really relieved after a letter was received by the end September, in which the European Commission as yet gave its approval for the payment of the more experienced researcher.

Sponsoring   The meeting in Paris — from March 29 till March 31, 1999 — was organized together with the Tropical Days committee; it was cofinanced by ALAPEDES.

1.3.2   Management committee

The management committee met once: on March 30, 1999 in Paris. Progress within the subprojects, possibilities for joint publications, vacancies for ALAPEDES researchers and homebase exchanges for the postdocs were discussed, and plans were set out for the period to come. Furthermore, the mid-term review report was approved and the mid-term review meeting has been prepared. Minutes of such meetings are available for internal use.

The mid-term review meeting was being held on March 31, 1999 in Paris, with the management committee and all ALAPEDES researchers present. During it all aspects of the functioning of the network, its deliverables and the postdocs were reviewed, leading to the conclusion that — grossly speaking — the network functions very satisfactorily, the only serious point of concern being the number of ALAPEDES postdocs that the network could attract. The network sollicited for an extension to the contract for another year.

1.3.3   Plenary meeting

The mid-term review meeting — to be held obligatorily between halfway and two thirds of the network contract — formed a good occasion to organize a plenary meeting ('convention'); because of officiency both the convention and the meeting were adhered to a tropical algebra meeting, that was planned in Paris. The combined event took place from March 29 till 31, 1999, and attracted many ALAPEDES members, but also many French researchers from the somewhat wider area that the tropical algebra meetings cover.

The combined event was rather successfull, also because it stimulated contacts between scientists and postdocs (of which four were new) within the network, and with others in France. The programme of the tropical days and the ALAPEDES convention can be found in Appendix D.

1.3.4   Subproject meetings

Many meetings have taken place. An overview of most of them can be found in Appendix C, while details on some specific ones have been included in further appendices. In the sequel two others are summarized. Beyond those, several other opportunities for the teams to meet each other were being exploited.

Reading group   A reading and working group involving people from LIAFA, INRIA and ENS was created. The study concentrated on two books: *Probability measures on semigroups* by G. Högnäs and A. Mukherjea, and *Performance Guarantees in Communication Networks* by C.S. Chang. The group met once every two weeks on average. Lectures were given on the various domains involved (semigroups, Markov chains, networks) by Baccelli (INRIA-ENS), Choffrut (LIAFA), Hong (INRIA-ENS), Mairesse (LIAFA), Martin (INRIA-ENS) and Pin (LIAFA).

Invitation of Vincent Blondel to LIAFA   ¿From mid-April to mid-May, 1999, Blondel was invited professor at LIAFA. During his stay he has had several meetings with Mairesse and Mantaci (LIAFA) and with Gaubert (INRIA - Rocquencourt) and Baccelli (INRIA - Sophia Antipolis). Some of these discussions were related to T-4.

1.3.5   Further networking

Internet   At the address `http://www.cs.rug.nl/~rein/alapedes/alapedes.html` ALAPEDES presents itself on Internet. The pages contain the research objectives, approach and work plan, schedules and milestones, a list of participants, an overview of meetings and an advertisement for postdocs and postgraduates. Furthermore, the body of the previous annual progress reports is available there. A brochure aiming at a general public is included as well.

The function of the ALAPEDES pages is to provide factual data on the ALAPEDES network. It is not meant to attract otherwise not interested visitors, and is held sobre. There have been some complaints about the ALAPEDES web page. It is our intention to improve the information regarding our project and Smedinga (RUG) is willing to add and to update. It is not our intention, however, to improve the layout in the sense of a flashy layout with bright colours, etcetera, due to lack of time.

Conferences   ALAPEDES members meet each other frequently at conferences outside the network.The 10$^{\text{th}}$ Applied Probability Conference in Ulm, during July, 1999, was such an occasion. Heidergott (TUD), Hong, Gaujal, Baccelli and Martin (INRIA - Sophia Antipolis) met there.

The special session on open problems organized by Blondel (ULG), during the Conference on Decision and Control, held in Tampa (USA), in December, 1998, was a good opportunity for several members of the network to exchange information and present their results to the international community.

Blondel organized the third workshop on systems and dynamics at the Université de Liège, Belgium, which had "the dynamical of switching" as its central topic.

Theses   Several instances of co-supervised theses foster networking within ALAPEDES. In April 1999, Klimann (LIAFA) defended his thesis (see also § 1.1.4). There were four ALAPEDES scientists among the members of the defense committee: Blondel (ULG), Gaubert (INRIA - Rocquencourt), Mairesse (LIAFA) and Pin (LIAFA). Pin acted as co-director of the thesis, together with Weil (Université de Bordeaux). Other members of the thesis committee were Gaubert (INRIA - Rocquencourt) and Pin (LIAFA). Blondel supported Mairesse to supervise Mantaci's work.

1.4   Researchers

1.4.1   Publication of vacant positions

Vacancies related to the ALAPEDES project have been published or made known via several webpages, including `http://www.cs.rug.nl/~rein/alapedes/alapedes.html` (those

of the network) and CORDIS, and via the use of electronic letters, of which the E-LETTER on Systems, Control, and Signal Processing, the NA Digest and the ELA List deserve to be mentioned. Furthermore informal networks and accidental contacts are being used to sollicit potential candidates on an individual basis.

Several candidates for ALAPEDES postdoc positions have been interviewed at ULG. Among them, Natacha Portier has accepted a position at ULG and Ioannis Michos has eventually accepted a position at LIAFA. The network proved much more successful in attracting new postdocs. Also, Sabrina Mantaci started at LIAFA, and INRIA - Sophia Antipolis even welcomed two new postdocs, James Martin and Stefan Haar. KUL also has a new postdoc around, Santiago Egido Arteaga. At HP Cormac Walsh — being already known to the network since the Waterford convention in 1997 — is the new postdoc, while RUG was pleased with Ahmed Al-Falou, who started just before the end of the reporting period.

Even though some of these postdocs left the network again (§ 1.4.3), the number of ALAPEDES researchers and the total research effort by this category, raised substantially, which gives rise to positive expectations as to the deliverables in terms of manmonths.

1.4.2 Dissemination of applications

Applications were sollicited specifically for vacancies the partners in the network have. Information on relevant candidates for open positions within other associated contractors was communicated throughout the network.

The network has the intention to reallocate postdocs at least once during the duration of the network (thus after one or two years) over the ALAPEDES partners. Because of difficulties in solliciting (see § 1.6) and in tying postdocs with a temporary position to the network this intention has merely been concretized once: Katirtzoglou left HP and joined TUD.

Also, Stefan Haar is planning to relocate, but only within INRIA: from November 1, 1999 he will join INRIA-ENS. Further, several ALAPEDES researchers (Lifsches, Heidergott, Portier, Mantaci) left the network for a position, that is not being financed from the network budget. Several of these postdocs stay in close contact with ALAPEDES, however.

1.4.3 Researchers paid from the network

A list of ALAPEDES researchers can be found in § 2.3 and in Appendix A, where also a table of all other researchers involved in ALAPEDES can be found.

Integration ALAPEDES researchers partly enter the network with a background that differs from the ALAPEDES theme. Integration in the network is quite successful. This is partly due to the local scientific environment, where they can usually participate in projects that the institutes where they are employed are involved in, but a good part also by the cooperation between the partners, of which Appendix C gives a good impression, and by meetings such as that in Paris (see § 1.3.3 and Appendix D).

Matthias Kanta Matthias Kanta obtained his doctoral degree from the University of Wisconsin-Milwaukee, where he investigated projective geometry and non-commutative algebra. He joined LIAFA as per November 15, 1996 till the end of his contract, on November 15, 1997. His contract could not be extended, because teh European Commission did not accept payment of his salary from the ALAPEDES funds. Now that the "Kanta problem" has been solved, this third annual progress report seems to be the right occasion to do him justice, by presenting below some information on his contribution to the network activities.

Computing with rational series with multiplicities in the tropical semiring is not obvious: there is indeed no possible equality test due to the undecidability of the equality problem in this context. The only single case where one can work in full generality is the case of one

letter series. One can very easily prove that all classical decidability problems are decidable in this last case. However, it is not totally obvious to obtain efficient algorithms that achieve these theoretical results (essentially due to the lack of good notions of normal form). The purpose of the contribution by Matthias Kanta is to present algorithmic solutions that allow to compute in the context considered here.

Eleni Katirtzoglou   Eleni Katirtzoglou spent most of her time at HP studying basic topics of control theory. Her interest on the subject was the result of the contacts she had with other ALAPEDES researchers who are experts in this area. She realized that some knowledge of this topic will allow her to understand better the research of my collegues. Also during her last months in HP she gave lectures at third year students of the University of Bristol, on control theory, at an introductory level. Her contract with HP was extended: she stayed till January 31, 1999.

Eleni Katirtzoglou joined TUD as per February 22, 1999, after having left HP three months earlier. Thus she changed "homebase" (which is a feature mentioned in the work programme). The interest of this step lies mainly in stimulating further coherence within the network as a whole. Her contract in Delft will end August 22, 2000.

She got in touch with Metz and Sabot. Some of the tools, used by them in the existence of diffusions on fractals, are Hilbert's projective metric and operators which are defined on a cone of Dirichlet forms, and are homogeneous and monotonic. Sabot gave criteria for the existence of fixed points of such an operator. Several discussions with Metz and Sabot led to the insight that Sabot's operator has crucial similarities with the D-A-D functions Katirtzoglou is studying and convinced her that her approach to solve the problem of the existence and calculation of the cycle time vector for topical functions is the right one for at least a big and important class of such functions. This approach suggests the approximation of the dynamical behaviour of a certain topical function, by using projections of the function on appropriately chosen faces of the positive cone.

Due to her transition from Bristol to Delft and some related problems, she did not make as much progress as expected.

Bernd Heidergott   Bernd Heidergott studied Taylor series expansions for $(\max, +)$-linear systems. He has begun writing a joint paper with Felisa Vázquez–Abad, University of Montreal, Canada, and one with Nikolai Krivulin, St. Petersburg University, Russia. He left ALAPEDES as per August 1, 1999 in order to join Eurandom in Eindhoven.

vacancy ARMINES   As Cohen, the scientist-in-charge of ARMINES left ARMINES September 1, 1999, the vacancy for an ALAPEDES postdoc position at ARMINES still exists. This matter will be left over till the responsibilities and representation of ARMINES within the network have been resolved; this was not yet the case on October 1, 1999.

Natacha Portier   Natacha Portier entered the network on November 1, 1998. She worked at ULG on the complexity of the minimal realization problem (see § 1.1.1). She left ALAPEDES per September 1, 1999 for a tenured position in Lyon.

James Martin   James Martin entered INRIA - Sophia Antipolis per November 1, 1998; his contract will end on January 1, 2001. He studies Jackson networks, more in particular the asymptotics of large queueing systems composed of blocking queues in series.

Sabrina Mantaci   Sabrina Mantaci joined the project as a postdoc on January 8, 1999. She resigned from her ALAPEDES contract as per September 30, 1999, in order to accept a position as ATER (teaching assistant) at the Université de Paris VII, within LIAFA. She will continue to do research, to work on discrete event systems and to participate to the

ALAPEDES events, however.

Her research experiences before beginning as a ALAPEDES postdoc were in the field of combinatorics on words and language theory. More in detail, the research she developed, first for her doctoral thesis in Palermo (Italy), and then in Turku (Finland) as a postdoc, was devoted to the generalization from the word case to the k-ary tree case of notions, properties and results of combinatorial theory of words.

Her first period at LIAFA has been devoted to get acquainted with the background and the problems in the domain of $(\max, +)$-algebra and discrete event systems. At the present moment she is investigating, in collaboration with two members of the ALAPEDES group (Mairesse (LIAFA) and Blondel from ULG) the following question: is it possible to connect the problem of weighted tree automata with the study of linear structures in the $(\max, +)$-algebra? Sabrina Mantaci also actively participated to the reading group, that was mentioned in § 1.3.4.

Stefan Haar   Stefan Haar entered the ALAPEDES network by joining INRIA - Sophia Antipolis as per February 1, 1999. He is currently investigating different possible semantics of Timed Petri nets, in close cooperation with Gaujal. This work will be presented shortly. ¿From November 1, 1999 Stefan will work at INRIA-ENS.

Santiago Egido Arteaga   Santiago Egido Arteaga obtained his doctoral degree in applied mathematics at the University of Maryland, College Park for work on nonlinear and parallel algorithms for finite element discretizations of the incompressible Navier- Stokes equations. He is also interested in some areas of discrete mathematics, including integer factorization and the $3n + 1$ problem. Per July 1, 1999 he joined KUL, attracted by the problem of traffic simulation and control. He is currently working on the subjects of origin-destination matrices estimation and optimal ramp metering. His contract lasts till December 31, 1999, but probably will be extended.

Cormac Walsh   Cormac Walsh joined HP on July 1, 1999 and will stay there for two years. He is currently investigating topical operators on finite-dimensional cones with the intention of finding sufficient conditions for the existence of a fixed point.

Ioannis Michos   Ioannis Michos holds a doctoral degree in algebra from UMIST, Manchester. His topic was free Lie algebras and, in particular, their structure as modules for finite groups over a field of positive characteristic or the ring of integers. ¿From July 2, 1999, he is working at LIAFA with Mairesse and Krob, on free partially commutative (trace) monoids. In particular, he is trying to obtain the generating function (in 2 variables) of the number of traces of given length n and given Cartier-Foata height m. This is an enumeration problem stemming from the Cartier-Foata decomposition of trace monoids, having many connections with spectral graph theory. Furthermore, Ioannis works on non-commutative symmetric functions and free Lie algebras.

Ioannis Michos has joined the LIAFA team of the ALAPEDES network on July 2, 1999. His contract officialy finishes on June 30, 2000 with the possibility of an extension.

His scientific background is in algebra and combinatorics: free Lie algebras and representation theory (integral and modular) of finite groups, free monoids, formal (rational and algebraic) power series and free partially commutative structures.

Since the pioneering work of Cartier-Foata and Mazurkiewicz the theory of trace (free partially commutative) monoids has been an active research area which is close to the classical theory of free monoids and models concurrency and task resource systems. Ioannis Michos focuses on the notion of the *height* of a trace, that is the number of factors (cliques) in its Cartier-Foata normal form. This terminology comes from the theory of *heaps* of pieces. In

the language of task resource models, the height represents the *makespan* or execution time of a given schedule.

More precisely the problem of enumerating all possible traces of given Cartier-Foata height m (and length n) is of interest. Problems like this lie in the domain of *spectral* graph theory, namely graph theory utilizing linear algebraic methods.

The emphasis of this contribution lies in subprojects T-3, T-4 and A-2, A-3. A publication within ALAPEDES of this work is currently in preparation.

A publication by Ioannis Michos is in preparation ([164]).

Ahmed Al-Falou   Ahmed Al-Falou entered the network as per September 16, 1999. His contract will last till October 1, 2000. He plans to work at RUG on hybrid systems, and in cooperation with LIAFA.

1.5 Interactions with industry

HP, as industry, is one of the associated contractors within the network. The HP group involved is theoretically inclined.

The ALAPEDES community at TUD has continued its collaboration within the project "Seamless Multimodal Mobility" reported upon in the previous annual report. Through this project official contacts with the Dutch railway companies exist (meeting frequency: three times a year).

See § 1.1.7 for a discussion of contacts with the French car manufacturer Renault.

Many contacts and collaborations (especially through two doctoral theses) continue to be made with the research and development departement of Nortel Networks (see also § 1.1.8). The main direction of research presently followed is performance analysis of equalization related protocols.

Two joint articles with Dornstetter (Nortel Matra) have been written (see [89, 91]).

1.6 Difficulties encountered

The scientific teamleaders of two partners (hence, of two associate contractors) moved to another employer recently. It was not fully clear to us if the ALAPEDES contract could be transferred from the old to the new employers. The answer apparently is "yes", but the two transfers (if the parties concerned wish such a transfer) have not yet been fully realized. The procedure is that old and new employer must agree on a transfer, after which all associate contractors have to approve such a transfer in writing.

Blondel moved from the Université de Liège (ULG) to Université Catholique de Louvain (UCL), as per October 1, 1999). It seems that the parties concerned are in favour of such a transfer and that all documents will be signed shortly.

Cohen moved from École Nationale des Mines de Paris (location: Fontainebleau) (ARMINES) to École Nationale des Ponts et Chaussées (ENPC), as per September 1, 1999. The situation is less clear here. The parties are in the process of negotiating a transfer. It is hoped that a decision will be made soon. The network coordinator has written two letters to ARMINES in this respect.

Though KUL is officially represented by its scientific teamleader, De Moor, it was De Schutter who did this representation in practice (due to many other obligations of De Moor). Now that De Schutter has moved to Delft, it is not clear who will be the contact-person in practice (Motmans fulfilled this rôle up to now, but he also has many other duties, and he is not scientifically involved). Also, there has been a shift in research interests; see § 1.1.1.

The second annual report, including the financial statements, was sent in October 31, 1998

and was approved by the European Commission by letter of January 6, 1999. It was stated that the payments related to the third year would arrive shortly in Delft, but they arrived not before April. Why such a delay? It should be noted that the arrival of the payments in Delft was mentioned to the network coordinator only after he inquired about this; this caused another delay unfortunately.

2   Factual information

2.1   Scientific speciality

All ALAPEDES partners are involved via a mathematics department; most of them have an information sciences department as well. Consequently, most mathematical subjects and many information sciences subjects are covered.

The following table presents the specialities of the partners that are most relevant for the ALAPEDES network expressed in the discipline classification codes for the mathematics, information and engineering sciences, issued and utilized by the European Union offices. As the list contains only a few broad subject categories the table does however not convey much detail. The disciplines which are referred to in the forthcoming tables are summarized in a second part.

partner	*discipline codes*		
TUD	M-99	M-53	I-22
ARMINES	M-53	M-99	M-51
INRIA	M-41	M-53	I-26
KUL	M-53	M-49	I-22
HP	M-43	M-54	I-26
LIAFA	M-46	M-48	M-41
RUG	M-48	M-51	M-53
ULG	M-53	M-48	

code	*description*
	mathematics and information sciences
M-41	Statistics and Probability
M-42	Algebra and Number Theory
M-43	Geometry and Topology
M-45	Applied Mathematics and Mathematical Physics
M-46	Discrete Mathematics and Computational Mathematics
M-48	Algorithms and Complexity
M-49	Signals, Speech and Image Processing
M-51	Information Systems, Software Development and Databases
M-53	Systems Control, Modelling and Neural Networks
M-54	Parallel and Distributed Computing, Computer Architecture
M-99	Other Mathematics and Information Sciences
	engineering sciences
I-22	Transport Engineering
I-26	Telecommunications

Table 1: Specialities by partner.

2.2   Research staff

A list of all researchers within the ALAPEDES context can be found in Appendix A. It contains the teamleaders (scientists-in-charge) and further permanent research staff, ALAPEDES researchers, postgraduates employed with ALAPEDES partners, who study a subject in connection with the ALAPEDES field, undergraduates having contributed to the research within ALAPEDES and administrative staff involved. The table is not supposed to be exhaustive.

The research effort (in manmonths) spent to ALAPEDES by the different partners is estimated below; it is sorted out according to the source of payment (from ALAPEDES funds or not, respectively) and gives figures per partner.

partner	manmonths			total
TUD	17	35	0	52
ARMINES	0	6	0	6
INRIA	19	56	0	75
KUL	3	6	0	9
HP	7	12	0	19
LIAFA	18	7	2	25
RUG	6	1	0	7
ULG	11	1	0	12
ALAPEDES	81	124	+ 2	205

Legend: in the table the first column indicates the partner, the second column gives the number of manmonths paid by the European Commission, the third column the same, but invested by the partners themselves, the fourth column applies to undergraduate students, and the fifth column gives totals (leaving out undergraduate students).

Table 2: Research effort by partner and by category.

2.3   Researchers financed

In table 3 all ALAPEDES researchers have been listed; their nationality, date of birth, begin and prognosed end of their (present or past) appointment, the partner they are working at, and the specialities are given. See also Appendix A. For the meaning of the codes used for the specialities the reader is referred to the information in § 2.1. All ALAPEDES researchers fall in the postdoc category.

Note that end dates of appointments are unsure as they are subject to: 1) internal regulations within the partners (the contract may initially not extend beyond one year of duration), 2) the possibility that further funding (outside ALAPEDES, however) may be found, 3) the possibility that ALAPEDES researchers may want to leave earlier to fulfill a permanent position (this has occurred already thrice) and 4) the reallocation between partners that is strived at (ALAPEDES researchers are encouraged to change their "homebase" within the network).

Now that the Kanta issue has become solved, Matthias Kanta should have been included in the list of ALAPEDES researchers in the previous annual reports. Because the latter is impractical, (incomplete) data about his contribution are scattered in this annual progress report, and subsumed in the tables in this section, as if this work was being done during the reporting period.

2.4   Publications

2.4.1   Publications by ALAPEDES researchers

Publications by ALAPEDES researchers are listed in table 4. The table refers to the list of publications in Appendix B.

2.4.2   Publications by other ALAPEDES members

Publications by other members of the network are incorporated in Appendix B.

name	nationality	birth	appointment	partner	specialities
Remco de Vries	NL	640328	961101 – 980831	KUL	M-53, M-41
Stéphane Perennes	F	681206	961115 – 970930	TUD	M-99
Matthias Kanta	D	571004	961115 – 971115	LIAFA	M-43, M-42
Eleni Katirtzoglou	GR	651016	961125 – 981125	HP	M-99
Eleni Katirtzoglou	GR	651016	990222 – 000822	TUD	M-99
Michael McGettrick	IRL	641103	970101 – 980531	ARMINES	M-51
Bernd Heidergott	D	630430	970401 – 990731	TUD	M-41
Sam Lifshes	ISR	630411	970801 – 990401	RUG	M-47, M-53, M-99
Natacha Portier	F	711009	981101 – 990901	ULG	M-47
James Martin	GB	730124	981101 – 010001	INRIA	M-53
Sabrina Mantaci	I	680323	990108 – 991001	LIAFA	M-47, M-99
Stefan Haar	D	650814	990201 – 010301	INRIA	M-41, M-53
Santiago Egido Arteaga	E	670518	990701 – 991231	KUL	M-45, M-54, M-44
Cormac Walsh	IRL		990701 – 010630	HP	
Ioannis Michos	GR	690331	990621 – 000831	LIAFA	M-42
Ahmed Al-Falou	D	680119	990916 – 001001	RUG	M-46, M-53, M-99

Table 3: Researchers financed within Alapedes.

Remco de Vries	[]
	[68, 198, 70, 69, 147, 200, 199]
Stéphane Perennes	[102, 104, 148, 170, 172, 171, 173]
Matthias Kanta	[]
Eleni Katirtzoglou	[150, 151]
Michael McGettrick	[49, 175, 176]
Bernd Heidergott	[94, 95, 96, 155]
	[135, 133, 134, 132, 141, 144, 143, 142, 139, 138, 136, 140, 147, 137, 145, 146]
Sam Lifshes	[157]
Natacha Portier	[178, 180, 179, 181, 183, **?**]
James Martin	[]
Sabrina Mantaci	[]
Stefan Haar	[119]
Santiago Egido Arteaga	[]
Cormac Walsh	[]
Ioannis Michos	[164]
Ahmed Al-Falou	[]

Remark: publications that were mentioned in the previous Alapedes annual
progress report are type-set in a smaller typeface on a separate line.

Table 4: Publications by researchers financed within Alapedes.

2.5   Secondments

Within ALAPEDES there has been one secondment in which expertise between institutes was mediated by a detachment lasting for a period longer than two weeks: Blondel (ULG) stayed from April 19, 1999 through May 14, 1999, at LIAFA. There he worked together with Mantaci and Mairesse (LIAFA).

3   Joint work

3.1   Joint publications

Joint papers — defined as publications in which authors from at least two ALAPEDES part-
ners have contributed — are [14, 29, 61, 57, 54, 116, 114, 118, 121, 130, 202]. Publications
in this category, that were mentioned in the previous ALAPEDES annual progress report are:
[15, 13, 50, 55, 56, 62, 60, 68, 110, 109, 113, 117, 126, 159, 160, 201, 187, 186, 188, 51, 49, 59, 58,
66, 67, 70, 69, 111, 115, 147, 169, 168, 176]. They have been included in the publication list of
Appendix B.

3.2   Collaboration

Many mutual visits have been paid by ALAPEDES members. In Appendix C an overview
of such visits is attempted, that probably stayed incomplete. Furthermore, in § 1.3.4 some
extra information has been included on some of these contacts.

3.3   Conference visits by ALAPEDES-members

3.3.1   Paris convention

The plenary meeting in Paris brought together nearly all ALAPEDES members. Many of them
presented (part) of their achievements since the convention near Cagliari, either during the
preceding Tropical Algebra day or during the ALAPEDES convention. Appendix D contains
the programme. More information on the presentations are available upon request.

3.3.2   Other conferences and workshops

Appendix C contains an overview of visits by ALAPEDES members to other conferences,
workshops and courses, that are related to ALAPEDES. Probably the overview is incomplete.

3.3.3   External collaboration by ALAPEDES-members

A 30 hour course called "Semi-anillos en matematica aplicada" has been given by Quadrat
(INRIA‑Rocquencourt) at the university of Rosario (Argentina) in November, 1998. The
material of this course will be published in Spanish by the Rosario University). It is currently
available through the web and from Quadrat's home page. Mancinelli came per March 1, 1999
from this university for a postoc position at INRIA‑Rocquencourt to work on applications
of $(\max, +)$ to transportation systems.

Next year (in April, 2000), another course on $(\max, +)$ algebra and Petri nets will be given
by Cohen (ARMINES) at the same University of Rosario.

Cohen (ARMINES) served as a referee for the thesis of Cottenceau in Angers. The thesis
([63]) has as a subject the control of discrete event systems in relation with timed event
graphs on dioids.

Although De Schutter has officially moved from KUL to TUD (not forming part of the AL-
APEDES team there, however), frequent (weekly) contacts between him and the ALAPEDES
members at KUL are organized. Of course, De Schutter has many contacts with the TUD
team as well.

During a visit of (Massachusetts Institute of Technology), the traffic research at KUL was
presented. This resulted in a stay of two months for a researcher (Bellemans) of KUL at
the Laboratory of Information and Decision Systems (LIDS) where research is conducted on
modelling of congested airports.

Mairesse (LIAFA) and Baccelli (INRIA‑Sophia Antipolis) continued the collaboration with
Foss (Novosibirsk), who visited LIAFA and INRIA-ENS for one month. New results on
generalized Jackson networks were obtained during this visit. See also § 1.1.5).

A   Research effort

The next tables give the research effort by ALAPEDES researchers, and the same for other AL-
APEDES members, arranged into the categories 'teamleaders', 'permanent staff', 'postdocs',
'postgraduates', 'undergraduates' and 'administrative staff'.

The share column contains percentages that apply tothe intersection withthe period reported
on. Involvement planned in remaining years may be incomplete.

In the second table several estimations had to be reverted to. In two cases (with respect yto
Bart De Schutter and Guy Cohen, respectively), the second table includes an involvement
by an ALAPEDES member that left one of the partners in the network.

name	nationality	period concerned	share	partner
ALAPEDES **researchers**				
Remco de Vries	NL	961101 – 980831		KUL
Stéphane Perennes	F	961115 – 970930		TUD
Matthias Kanta	D	961115 – 971115	50 %	LIAFA
Eleni Katirtzoglou	GR	961125 – 990131	100 %	HP
Eleni Katirtzoglou	GR	990222 – 000822	100 %	TUD
Michael McGettrick	IRL	970101 – 980531		ARMINES
Bernd Heidergott	D	970401 – 990731	100 %	TUD
Shmuel Lifsches	ISR	970801 – 990401	100 %	RUG
Natacha Portier	F	981101 – 990831	100 %	ULG
James Martin	GB	981101 – 010001	100 %	INRIA - SA
estimate Sabrina Mantaci	I	990108 – 991001	100 %	LIAFA
Stefan Haar	D	990201 – 010301	100 %	INRIA - SA
Santiago Egido Arteaga	E	990701 – 991231	100 %	KUL
Cormac Walsh	IRL	990701 – 010630	100 %	HP
Ioannis Michos	GR	990702 – 000630	100 %	LIAFA
Ahmed Al-Falou	D	990916 – 001001	100 %	RUG

Table 5: Research effort by ALAPEDES researchers.

name	period involved	share	partner
scientific teamleaders			
Geert Jan Olsder	961001 –	15 %	TUD
Guy Cohen	961001 –	50 %	ARMINES
François Baccelli	961001 –	50 %	INRIA - SA
Jean-Pierre Quadrat	961001 –	50 %	INRIA-Rocq
Bart de Moor	961001 –	5 %	KUL
old Jeremy Gunawardena	961001 –	10 %	HP
estimate Daniel Krob	961001 –	20 %	LIAFA
Jean Mairesse	961001 –	50 %	LIAFA
Rein Smedinga	961001 –	5 %	RUG
estimate Vincent Blondel	961001 –	10 %	ULG
permanent research staff			
Jacob van der Woude	961001 –	25 %	TUD
Alain Jean-Marie	961001 –	40 %	INRIA - SA
Bruno Gaujal	961001 –	40 %	INRIA - SA
Stéphane Gaubert	961001 –	100 %	INRIA-Rocq
Marianne Akian	961001 –	100 %	INRIA-Rocq
Edmundo Rofman	–	10 %	INRIA-Rocq
Bart De Schutter	981001 –	5 %	TUD
estimate Colin Sparrow	961001 –	10 %	HP
old P. Gastin	961001 –	10 %	LIAFA
Jean Éric Pin	961001 –	10 %	LIAFA
C. Choffrut	961001 –	10 %	LIAFA
M. Morvan	961001 –	10 %	LIAFA
postdocs			
Andrew Burbanks	980701 –	80 %	HP
Elina Mancinelli	990301 –	100 %	INRIA-Rocq
postgraduates			
Subiono	961001 – 000001	100 %	TUD
Robert Jan van Egmond	970901 – 010901	70 %	TUD
old Gerardo Soto Y Koelemeijer	980515 –	100 %	TUD
Hong Dohy	–	25 %	INRIA - SA
Tom Bellemans	–	50 %	KUL
Laurent Vuillon	970801 –	10 %	LIAFA
old			
undergraduates			
Ines Klimann	970801 – 9904...	30 %	LIAFA
administrative staff			
Niek Tholen	961001 –	25 %	TUD
Bart Motmans	961001 –	5 %	KUL

Table 6: Research effort by other ALAPEDES members.

B   Publications

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C   Contacts

The next table gives a summary of mutual visits by ALAPEDES members. Only such contacts are mentioned that did not take place at one in the meetings in § 1.3 (see there). Also, Cohen visited INRIA - Rocquencourt once a week, the whole year long for interaction with Gaubert and Quadrat. Baccelli and Mairesse have met regularly at LIAFA.

name			from	till	destination	objective
1998						
Bruno Gaujal		I	–10 /	–10	INRIA-Rocq	
1999						
Eleni Katirtzoglou	T-2	I	– /	27–03	HP	collaboration
Jeremy Gunawardena	T-2	C	31–03 /	02–04	Paris, TUD	
Eleni Katirtzoglou	T-2	I	21–06 /	27–06	HP	collaboration
Stéphane Gaubert	T-2	I	08–07 /	21–07	HP	collaboration
Stéphane Gaubert	T-2	I	21–07 /	23–07	Cambridge	collaboration
Eleni Katirtzoglou	T-2	IO	26–09 /	28–09	HP	mini-workshop
convention						
management committee	***	M	30–03 /	30–03	Paris	formal meeting
several members	***	M	31–03 /	31–03	Paris	mid-term review
Vincent Blondel	T-4	COI	19–04 /	14–05	LIAFA	invited professor
Stéphane Gaubert		C	–07 /	–07	Bristol	

Legend: in the tables in this appendix the following codes are used:

*** in the subproject column signal the whole project;
in the third column activities undertaken are signalled:
N = network presentation, S = subproject presentation, O = own work presentation, M = meeting, C = consultation, I = informal contact, A = attend, F = formal function.

Remark: this table is not expected to be complete.

The next table gives some information about visitors from outside to partners of the ALAPEDES network, having a strong relation with its subject. The information is bound to be incomplete.

name			from	till	destination	origin
1999						
Mike Keane	T-2	IC	27–02 /	11–03	HP	
Sjoerd Verduyn Lunel	T-2	IC	27–02 /	05–03	HP	Amsterdam
Eric Feron	A-1	OC	20–05 /	22–05	KUL	MIT (USA)
S. Foss	T-5	C	– /	–	LIAFA, INRIA	Novosibirsk
Glolubkov	T-5	SC	01–09 /	31–10	LIAFA	Moskwa

The next table gives some information about visits to scientists outside the network by partners of ALAPEDES, bearing a strong relation with its subject. The information is only given schematically, and hence is incomplete. More information can be obtained from the visiting scientists.

C CONTACTS

name			from	till	destination	objective
1998						
Vincent Blondel	FC		07–12 / 10–12		Univ. Lyon	thesis jury
Vincent Blondel	I		14–12 / 15–12		New York	Overton, Oustry
1999						
Vincent Blondel	FC		18–01 / 19–01		ENS Lyon	thesis jury
Vincent Blondel	C		17–05 / 17–05		Harvard Un.	Brockett
Vincent Blondel	C		18–05 / 22–05		MIT, Cambr.	Tsitsiklis

The next table gives a summary of visits by ALAPEDES members to conferences, workshops and courses. More information on meetings of the working group on tropical algebra, can be found in § 1.3.4, and in Appendix D (on Internet at `http://amadeus.inria.fr/TROPICAL/`), respectively. More details on presentations by ALAPEDES members are available upon request.

name			from	till	destination	objective
1998						
Bernd Heidergott	T-3	O	21–10 / 21–10		Delft	SSOR Colloq.
Bruno Gaujal			–11 / –11		Oberwolfach	Stoch. Processes
Daniel Krob		C	16–12 / 17–12		Barcelona	
Bruno Gaujal			16–12 / 18–12		Tampa Bay	IEEE CDC
Bart De Schutter	A-1,T-1	O	16–12 / 18–12		Tampa Bay	IEEE CDC
Vincent Blondel		FO	16–12 / 18–12		Tampa Bay	IEEE CDC
1999						
Bernd Heidergott	T-3	O	24–02 / 24–02		Amsterdam	Queueing Colloq.
Jacob van der Woude	T-2	O	03–03 / 05–03		Houthalen	Benelux Meeting
Tom Bellemans	A-1		03–03 / 05–03		Houthalen	Benelux Meeting
Jean Mairesse		O	22–03 / 26–03		Bordeaux	Jeunes Chercheurs
Sabrina Mantaci		O	22–03 / 26–03		Bordeaux	Jeunes Chercheurs
Vincent Blondel		O	01–04 / 01–04		Univ. Lille	seminar
Tom Bellemans	A-1		19–04 / 25–04		Gent	Flanders Technology
Eleni Katirtzoglou			20–05 / 23–05		USA	
Jean-Éric Pin		O	17–06 / 23–06		Braga	Int. Conf. Semig.
Vincent Blondel		A	06–07 / 09–07		Aachen	DLT '99
Sabrina Mantaci		O	06–07 / 09–07		Aachen	DLT '99
several members	***	O	26–07 / 28–07		Ulm	INFORMS
Subiono	T-2	O	27–07 / 29–07		Yogyakarta	SEAMS
Jean-Éric Pin		O	–08 / –08		Vasszécsény	AFL '99
Jean Mairesse		O	07–09 / 10–09		Zaragoza	PNPN '99
Sabrina Mantaci		A	21–09 / 22–09		Rouen	Words
Stefan Haar		A	–09 / –09		Warszawa	workshop CS&P

Legend: in the destination column the acronym of the network partner, and name and place of conference etc. participated in is mentioned; *** in the subproject column signal the whole project.

D   Tropical day and Paris convention

Réunion commune au groupe de travail

ALGÈBRES TROPICALES ...

et applications aux systèmes à événements discrets et à la commande optimale

(GdR "ALP" et "Automatique")

et au Réseau EC-TMR

ALAPEDES

(The ALgebraic Approach to Performance Evaluation of Discrete Event Systems)

Du Lundi 29 au Mercredi 31 Mars 1999

– Salle Dussane, ENS 45 rue d'Ulm, Paris (les lundi et mardi)

– Salle de Conférence, 46 rue d'Ulm, Paris (le mercredi).

Toiles: `http://amadeus.inria.fr/TROPICAL/`
`http://www.cs.rug.nl/ rein/alapedes/`

Organisateurs: Stéphane Gaubert — Jean-Jacques Loiseau (GdT Tropical)
`Stephane.Gaubert@inria.fr, loiseau@lan.ec-nantes.fr`
Geert-Jan Olsder — Niek Tholen (ALAPEDES)
`G.J.Olsder@math.tudelft.nl, N.Tholen@math.tudelft.nl`

Lundi 29 Mars

9h00	Accueil des participants	
9h30	Claude Dellacherie	Théorie du potentiel lmentaire non linéaire
11h00	Pause	
11h30	Gérard Duchamp	Un critère de rationalité provenant de la géométrie non-commutative
12h30	Déjeuner	
14h30	Christian Commault	Commande des systèmes structurés: approche graphique
16h00	Pause	
16h30	Stéphane Gaubert et Jean-Jacques Loiseau	Un bilan de trois ans d'activité tropicale
18h00	Table ronde	
19h00	Cocktail	

Mardi 30 Mars, matin

9h00	Thomas Bonald	Effet du trafic transverse sur les performances de TCP
10h00	Marc Artzrouni	Distances projectives, coefficients d'ergodicité, et processus iteratifs linéaires et "pseudo-linéaires" dans le cone positif de R^n
11h00	Pause	
11h30	Vassili Kolokoltsov	Deterministic approach to option pricing theotry
12h30	Déjeuner	

Exposés scientifiques du réseau ALAPEDES

Mardi 30 Mars, après midi

14h00	Alain Jean-Marie	New bounds for Lyapounov exponents of stochastic $(\max, +)$-matrices
14h25	Bruno Gaujal	Analysis of preemptive periodic real time systems
14h50	Robert Jan van Egmond	Railway capacity assessment — an algebraic approach
15h15	Jacob van der Woude	Conditions for the structural existence of an eigenvalue of a bipartite $(\min, \max, +)$-system
15h40	Jean-Pierre Quadrat	$(\max, +)$-Objects in SCILAB and application to evaluation and optimisation of production systems
16h00	Pause	
16h25	Stefan Haar	Choosing a Semantics for Petri Nets
16h50	Sabrina Mantaci	Tree codes and the defect theorems for trees
17h15	James Martin	Fast Jackson Networks

Mercredi 31 Mars, matin

9h00	Natacha Portier	The minimal realization problem in $(\max, +)$-algebra is NP-hard
9h25	Sam Lifsches	Hybrid Systems and Monadic Logic
9h50	Eleni Katirtzoglou	*Titre non parvenue*
10h15	Bernd Heidergott	The Maclaurin Series for $(\max, +)$-Lyapunov Exponents — The Bernouilli Case

Cette réunion scientifique, ouverte à tous, sera suivie par une réunion d'évaluation, cette fois ci non-publique, avec les experts de la Commission Europeenne.

E   Mid-term review

Programme of mid-term review session

Tuesday 30 March, 1999

14:00–16:00   presentations by ALAPEDES members
> Alain Jean-Marie
> Bruno Gaujal
> Robert Jan van Egmond
> Jacob van der Woude
> Jean-Pierre Quadrat

16:00–17:35   presentations by young researchers
(introduction to the research activities of the researchers paid from funds of the European Commission)
> Stefan Haar
> Sabrina Mantaci
> James Martin

Wednesday 31 March, 1999

09:00–10:40   presentations by young researchers
(introduction to the research activities of the researchers paid from funds of the European Commission)
> Natacha Portier
> Sam Lifsches
> Eleni Katirtzoglou
> Bernd Heidergott

11:00–11:10   introduction
(introduction by the representative(s) of the European Commission on their rôle and the purpose of the meeting)

11:10–11:40   coordinator's report
(Geert Jan Olsder will present the network: importance of the subject, objectives, approach, results, internal and external collaboration, training of the postdocs, finance)

11:40–12:50   tour de table
(presentation by subproject leaders on the contribution of the subproject to the overall goals, followed by an overview by teamleaders on the contribution of their teams to the different subprojects; also the issues of training and collaboration may be taken up)

13:00–14:00   lunch break

14:00–15:00   young researchers' reports
(the postdocs currently being employed introduce themselves, their work and their experiences in the network)

15:00–18:00   open discussion
(discussion on strengths and weaknesses, organisation, joint research, training aspects, and what else will come up)