Collaborative Activity ISC-CAN-65
between the Canada and the European Union

EUCALYPTUS-2

A European/Canadian LOTOS Protocol Tool Set

Periodic Progress Report — 1995

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1 Introduction

This is the technical report for the EUCALYPTUS-2 project in 1995. It is organized as follows:

- Section 2 presents the main facts about the management of the EUCALYPTUS-2 project.
- The next sections 3, 4 and 5 report about the technical activities carried out in EUCALYPTUS-2. These sections reflect the decomposition in tasks provided by the workplan attached to the Contract:
  - Task 1: Application of the EUCALYPTUS toolset to large-size, industrial case studies
  - Task 2: Improvement of the EUCALYPTUS tools
  - Task 3: Contribution to the standardization work on Extended-LOTOS
- Section 6 summarizes the efforts done to disseminate the results of EUCALYPTUS-1 and the preliminary results of EUCALYPTUS-2.
- Finally, Section 7 draws our main conclusions for EUCALYPTUS-2.

2 Management report

Management and administration are carried out by Grenoble, with a deliberate attempt to avoid excessive administrative overhead, that would slow down the research and development activity.

Communication between the EUCALYPTUS partners is largely done using electronic mail. A FTP server, located in Liège, is used as a common repository for storing the last releases of the EUCALYPTUS tools and reports.

2.1 Participants

The first year of the EUCALYPTUS-2 project involved the following participants:

For Grenoble: At INRIA / VERIMAG, five researchers have contributed to the EUCALYPTUS-2 project:

- Dr. Hubert Garavel: project management, improvement of the CÆSAR and BCG tools, and contribution to the development of E-LOTOS
- Dr. Alain Kerbrat: improvement of the ALDÉBARAN tool
- Radu Mateescu: improvement of the BCG and XTL tools

- Dr. Laurent Mounier: improvement of the ALDÉBARAN tool
- Mihaela Sighireanu: contribution to the definition of E-LOTOS

For Liège: At University of Liège, six researchers have contributed to the EUCALYPTUS project:

- Pr. André Danthine: project management
- Dr. Guy Leduc: project management, contribution to the definition of E-LOTOS
- Charles Pecheur: improvement of APERO and the graphical user interface, contribution to the definition of E-LOTOS
- Luc Léonard: contribution to the definition of E-LOTOS
- France Bierbaum: writing of the user manual of the user interface
- Clarence Filsfils: management of the EUCALYPTUS server

For Ottawa: The Ottawa participation in EUCALYPTUS is supported by the Telecommunications Research Institute of Ontario (TRIO). The following researchers have contributed to EUCALYPTUS:

- Pr. Luigi Logrippo: project management
- Jacques Sincennes: improvement of the tools
- Patrick Bihan-Faou: application of EUCALYPTUS tools to develop and validate an ATM example
- Jalel Kamoun: application of tools to develop and validate Intelligent Network specifications
- Bernard Stepien: contributions to the definition of E-LOTOS, use of tools to seek solutions to the Feature Interaction problem in telephony
- Randy Tuok: application of tools to develop and validate Mobile Telephony specifications, also to demonstrate generation and validation of use cases.

For Montréal: The Montréal participation in EUCALYPTUS was originally supported by the Hewlett-Packard/NSERC/CITI Industrial Research Chair on Communications Protocols at the University of Montréal of which Gregor v. Bochmann is the chairholder. This support was approved by the steering committee of the chair in March 1993. Since November 1994, the Montréal participation is supported by Bochmann's NSERC research grant. The following researchers have contributed to EUCALYPTUS:

- Pr. Gregor v. Bochmann: project management
- Pr. Rachida Dssouli: collaboration
- Daniel Ouimet: supervision
- Omar Bellal: improvement of the TETRA tool

2.2 The joint Grenoble-Ottawa action

The goals of the EUCALYPTUS-2 project, as described in the Technical Annex of the EUCALYPTUS-2 contract, imply some significant work in terms of software development and maintenance. Unfortunately, the European side of EUCALYPTUS-2 provides no manpower for these tasks.

Part of this effort has been supported by EUCALYPTUS partners on their own budgets. However, as this is not sufficient to achieve the aforementioned goals, other solutions had to be found.

For this reason, Grenoble and Ottawa have decided to intensify their cooperation by launching a joint action. This joint action involves the exchange of three 3rd-year students of the ENSIMAG[1] engineering school:

- Xavier Etchevers,
- Jean-Michel Frume,
- and Mark Jorgensen

This joint action aims at improving the integration of Grenoble's and Ottawa's tools within the EUCALYPTUS toolset (see Section 4.3 for technical details).

The three engineering students have started to work on this project in November 1995. They will work in Grenoble until March 1996, then will go to Canada and spend three months in Ottawa to complete their project.

2.3 Co-operation with additional partners

Two research teams, not directly involved in the EUCALYPTUS-2 consortium, have expressed interest in the project and proposed to integrate their own tools in the EUCALYPTUS toolset:

- The research group of Pr. Ana Cavalli (INT, Evry, France), which developed the TESTGEN tool for generating test sequences from Labelled Transition Systems.
- The research project PAMPA of IRISA (Rennes, France) — especially Claude Jard and Thierry Jéron — which developed the VISCOPE tool for 3-dimensional display of Labelled Transition Systems (see Figure 1 for an example).

[1] Ecole Nationale Supérieure d'Informatique et de Mathématiques Appliqués de Grenoble

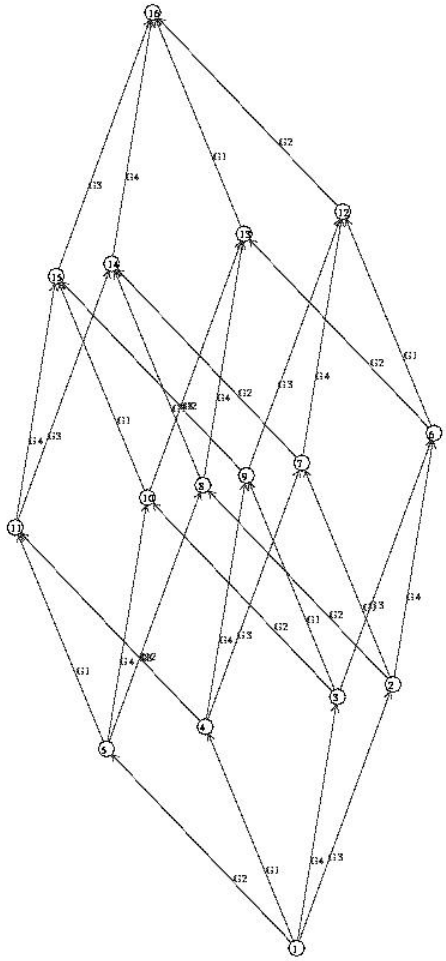

Figure 1: The VISCOPE tool

2.4 Meetings

Since the beginning of the EUCALYPTUS-2 project, two meetings were held:

- the first one in Ottawa (July 25, 1995),
- and the second one in Liège (December, 20, 1995).

In order to optimize travel expenses, these two EUCALYPTUS-2 meetings have been combined with ISO meetings devoted to the standardization of the E-LOTOS language. We expect to maintain this policy in the future.

2.5 Reports

[EUCA/GR/11] H. Garavel, *Minutes of the* EUCALYPTUS-*2 meeting – Ottawa, July 25, 1995*. 4 pages.

[EUCA/GR/12] EUCALYPTUS-2: Periodic Progress Report — 1995. 19 pages.

3 Application of the EUCALYPTUS toolset to large-size, industrial case studies (Task 1)

It should be clearly understood that the purpose of EUCALYPTUS-1 and EUCALYPTUS-2 is not to study formal methods for their mathematical perfection only, nor to develop software as a side academic activity.

All EUCALYPTUS-2 partners are involved in industrial projects. They have to demonstrate that using the LOTOS language and the EUCALYPTUS tools can bring significant improvements to real-life developments.

We give here a list of such projects. As EUCALYPTUS-2 provides no manpower, these projects are (strictly speaking) different from EUCALYPTUS-2. However, all these projects are related to EUCALYPTUS-2 since they use LOTOS and the EUCALYPTUS tools:

1. Grenoble has used the EUCALYPTUS tools to study the correctness of the LOTOS descriptions of CCR[2] Service and Protocol, two descriptions which are currently standardized within ISO (ISO standard 9804 and 9805). In these large LOTOS descriptions (1,400 and 3,000 lines), several errors have been found and reported to the Editor.

2. Similarly, Grenoble has applied the EUCALYPTUS tools to the OSI-TP[3] Protocol, a data-base protocol, currently under revision (ISO standard 8326). We found 11 errors in this large description (15,400 lines), which have been officially reported to ISO through AFNOR, the French standardization Institute.

3. Grenoble is currently involved in a close co-operation with Bull for the formal verification of Bull's hardware algorithms. In 1995, the EUCALYPTUS tools were successfully applied to the study of the bus arbiter used in Bull's multi-processor workstations. The bus arbiter was formally described in LOTOS and its correctness was established using the EUCALYPTUS tools.

   Bull plans to continue this co-operation in 1996. The EUCALYPTUS tools will be applied to the analysis of the cache memory algorithm of PegaKid (PegaKid is the name of Bull's new parallel architecture based on PowerPC processors).

[2] Concurrency, Commitment and Recovery

[3] Transaction Processing

4. Grenoble has also used the EUCALYPTUS tools to verify the correctness of the COOP-SCAN environment. This environment is a platform for the development of co-operative, synchronous applications; it was developed in Bull-Imag (a joint academic/industrial research unit in Grenoble). Also, Bull-Imag has used the EUCALYPTUS tools to validate three groupware protocols for failure recovery in groups allowing dynamic connections and disconnections.

5. Liège is currently using the EUCALYPTUS tools to develop a formal Description in LOTOS of the ODP[4] Trader. The EUCALYPTUS toolset is used to validate the specification. Liège is also using LOTOS (with appropriate time extensions) to model the behaviour of the ODP Binding Object.

6. Liège is involved in the ACTS project number 051 ("OKAPI") dealing with security, cryptography and authentication in computer networks. This project will start in January 1996 and end in December 1997. In this project, Liège will specify a Trusted Third Party (TTP) protocol in LOTOS. This protocol provides security in client-server exchanges. It involves three parties: Users' Access Control Units, Video on Demand Service Providers and a TTP. Liège will use the EUCALYPTUS toolset to verify the correctness of this protocol.

7. Ottawa has a good experience in applying LOTOS to software development in telecommunications. Ottawa is involved in several industrial projects related to telecommunications, many of which involve Canadian telecommunication industries. The EUCALYPTUS tools are used to validate the LOTOS descriptions which have been elaborated in these projects. They are also used to derive execution scenarios and test cases from the formal descriptions. These projects are:

    - Mobile telephony: a complete, "high-level" specification of the protocols of the mobile telephony GSM standard was developed in LOTOS by using the EUCALYPTUS tools. Also a similar specification was developed for the MAP protocol, one of the lower-level protocols within GSM. In this project Ottawa demonstrated how the tools can be used to generate use cases and test cases from the specification. Also it was shown how these tools can be used in a software design process based on use cases. More general work in this direction was also done with Ray Buhr, D. Amyot and F. Bordeleau within the context of a design methodology called "use case maps".
    - Asynchronous Transfer Mode (ATM): the EUCALYPTUS toolset was used in order to develop a specification of Q.931 signaling. It was shown that the specification satisfies certain user requirements specified in temporal logic.
    - Intelligent Network: the EUCALYPTUS toolset was used to create an abstract, executable model of Intelligent Network feature creation facilities, at the Distributed Functional Plane level.

[4] Open Distributed Systems

- Feature interaction: the EUCALYPTUS toolset was used to demonstrate possible solutions of the Feature Interaction problem, based on Goal-Oriented execution.

All these projects are positively contributing to the dynamics of the EUCALYPTUS-2 cooperation. Many of them have led to publications in international conferences (see Section 6.1).

Besides these industrial projects, the EUCALYPTUS tools have been used for teaching purpose in many Universities (see Section 6.4).

4 Improvement of the EUCALYPTUS tools (Task 2)

4.1 Tool improvement

The overall architecture of the EUCALYPTUS toolset is depicted on Figure 2. Since the beginning of EUCALYPTUS-2 (January 1995), the partners have improved their tools.

- In 1995, Grenoble has released several new versions of its CADP[5] tools. The latest version "Z-q" provides significant improvements, when compared to the version "Z-c" which was demonstrated in December 1995, during the final review of the EUCALYPTUS-1 project. It integrates new tools and new functionalities:
  - The CÆSAR and CÆSAR.ADT compilers integrate a garbage collection mechanism for abstract data types, which allows larger descriptions to be processed.
  - The CÆSAR and CÆSAR.ADT compilers have been enhanced to provide support (at least partially) for parameterized types. By doing so, we have found an error in the LOTOS standard. We have reported this error to ISO, and the possibility of issuing a Technical Corrigendum for the LOTOS standard is currently being discussed.
  - The size of the C code generated by CÆSAR for large LOTOS descriptions has been significantly reduced.
  - A new verification tool, named EVALUATOR, has been added. This tool allows formulas of the branching-time μ-calculus to be evaluated on-the-fly on LOTOS programs.
  - Grenoble has added a new tool, named BCG_EDIT. This tool is an interactive, graphical editor, which allows the modification of the PostScript representation of Labelled Transition Systems generated by the BCG_DRAW tool. A picture of BCG_EDIT is shown on Figure 3.
  - Grenoble has continued the development of the XTL compiler. XTL[6] is a meta-language for specifying algorithms for temporal logics evaluation. In 1995, a first

[5] CÆSAR/ALDÉBARAN Development Package
[6] eXecutable Temporal Logic

prototype of the XTL compiler has been achieved. It is not distributed yet, but has been used successfully for several student projects.

  - Finally, since January 1995, Grenoble has started to adapt the CADP tools to Sun's new operating system Solaris 2.*. This difficult evolution is now completed. In the future, it should be easier to port the CADP tools to other platforms (Hewlett-Packard, Bull, etc.), since provisions for multi-architecture support have been taken.

- Liège has maintained and improved its APERO tool developed in EUCALYPTUS-1. The current version of APERO is only available for Sparc stations running SunOS 4.1.*. However, Liège foresees no problem in porting APERO since APERO is written in ML and it is likely that ML compilers for Solaris 2.* are available.

- Ottawa has improved the XELUDO tools. A random walk functionality was added and the Goal-Oriented Execution tool for full LOTOS has been improved.

4.2 Graphical user interface improvement

The development of the Graphical User Interface (GUI) developed in EUCALYPTUS-1 has progressed in 1995. Several new versions have been elaborated (versions 0.998, 0.9991, 0.9992, 0.9993, 0.9994). In addition to bug fixes, the main improvements have been the following ones:

- Liège has written a User Manual for the EUCALYPTUS toolset.

- Grenoble has written an Installation Manual for the EUCALYPTUS toolset.

- The GUI has been modified to integrate the VISCOPE and TESTGEN tools (see Section 2.3). This work was done by Grenoble, in collaboration with INT and IRISA.

- A demonstration example (the Plain Old Telephony System) has been added.

- The GUI has been ported under Solaris 2.* operating system.

4.3 The Grenoble-Ottawa joint action

In the framework of EUCALYPTUS-2, we have also started a specific action to improve the EUCALYPTUS toolset. As mentioned in Section 2.2, this joint action will involve the exchange of three engineering students between Grenoble and Ottawa. This joint action has the following objectives:

1. It aims at improving the "common trace format" used by many EUCALYPTUS tools. This format allows execution sequences to be generated by some tools and replayed by

other tools. The current version of the format, developed in EUCALYPTUS-1, will be enriched with new constructs, such as regular expressions, to enhance its expressiveness.

2. The existing tools will be enhanced to support the new version of the common trace format. For some tools (such as ALDÉBARAN, CÆSAR and OPEN/CÆSAR), the modifications will be easy. However some other tools based on goal-oriented execution (such as Ottawa's GOAL tool and Grenoble's EXHIBITOR) will have to be largely rewritten. The expected benefits of the new trace format are twofold:

   - First, the pattern language currently used for goal-oriented execution will be significantly improved by the use of regular expressions.
   - Second, the integration of Grenoble's and Ottawa's tools will be enhanced. In particular, this will allow two-ways communications (it will be possible to replay, using Ottawa's tools, an execution sequence generated with Grenoble's tools) whereas, currently, the communications is only one-way.

3. Finally, the joint action plans to rewrite entirely the GUI. The current versions of the GUI is based on the XTPANEL tool, an interface generator developed at Stanford University. In 1995, we faced difficulties with XTPANEL, as its authors have left Stanford. Although XTPANEL is still maintained by one of its authors, it is not sure that this will continue in the future. Moreover, we had problems when trying to port XTPANEL to new machines and operating systems.

   Therefore, we plan to rewrite entirely the GUI using the TCL/TK toolkit, another interface generator, more powerful and more popular than XTPANEL.

5 Contribution to the standardization work on Extended-LOTOS (Task 3)

In the framework of EUCALYPTUS-2, Grenoble, Liège, and Ottawa are actively contributing to revision of the LOTOS standard that is currently in progress within ISO (ISO/IEC JTC1/SC21/WG7 New Work Item on "Extended LOTOS").

This standardization project aims at enhancing LOTOS with new features suitable for the new generations of communication protocols and distributed systems. The EUCALYPTUS-2 project helps in pursuing this long-term effort, initiated during the EUCALYPTUS-1 project (1993–1994).

In 1995, the EUCALYPTUS partners have attended three ISO meetings:

- the first one in Paris (6th-8th of February 1995),
- the second one in Ottawa (20th–26th of July 1995),
- the third one in Liège (18th-21th of December 1995).

They have provided significant contributions for these meetings, as illustrated by the following list of inputs documents (numbered [PARi], [OTTj] and [LGk] for the Paris, Ottawa, and Liège meetings respectively):

- [PAR2]: *Generalized Termination, Enabling and Disabling* (Spanish and Canadian experts)
- [OTT2]: *An ET-LOTOS Description of an ODP Binding Object* (Belgian experts)
- [OTT3]: *Belgian Comments on ISO/IEC JTCS1/SC21/WG7 N1001* (Belgian experts)
- [OTT4]: *Towards a proposal for Datatypes in* E-LOTOS (Belgian and UK experts)
- [OTT6]: *French-Romanian Proposal for a Correct Flattening of* LOTOS *Parameterized Types* (French and Romanian experts)
- [OTT7]: *Contribution to the Design of Datatypes in* E-LOTOS (French experts)
- [LG1]: *Defect report regarding IS8807 (*LOTOS*) and Proposal for a Correct Flattening of* LOTOS *Parameterized Types* (French and Romanian experts)
- [LG2]: *Application of the proposed* E-LOTOS *Datatype Language to the Description of OSI and ODP Standards* (French and Romanian experts)
- [LG3]: *French-Romanian Comments regarding some Proposed Features for* E-LOTOS *Data Types* (French and Romanian experts)
- [LG4]: *A Proposal for the Datatype Part of* E-LOTOS *Applicable to the Formal Description of OSI and ODP Standards* (French and Romanian experts)
- [LG5]: *A Wish List for the Behaviour Part of* LOTOS (French experts)
- [LG8]: *Compositional Specification of ODP Binding Objects* (Belgian and French experts)
- [LG11]: *Specifying the Suspend-Resume Behaviour with Time in* LOTOS (Canadian experts)
- [LG12]: *The Suspend-Resume Operator Application to Action Interrupts* (Canadian experts)

As a consequence, an important part of the output documents elaborated during these two ISO meetings originates (at least partially) from the EUCALYPTUS-1 and EUCALYPTUS-2 projects. This is the case of five sections in the last available document (output document of the Ottawa meeting, referenced ISO/IEC JTC1/SC21 N10108):

- Annex A: *Toward a Proposal for Datatypes in* E-LOTOS (Belgian, French, Romanian and UK experts)

- Annex B, Proposal 2: *Typed Gates* (French experts)
- Annex C: *Time Extended* LOTOS (Belgian and Spanish experts)
- Annex F, Part 1: *Generalized termination, Enabling and Disabling* (Canadian and Spanish experts)
- Annex F, Part 2: *Six Improvements to the Process Part of* LOTOS (French experts)

Moreover, part of this work on E-LOTOS has led to international publications (see Section 6.1).

6 Dissemination of results

6.1 Publications

The EUCALYPTUS project has a good international visibility, as indicated by the list of our most recent publications and theses:

[ABBL95] D. Amyot, F. Bordeleau, R. J. A. Buhr, L. Logrippo. *Formal support for design techniques: A Timethreads-LOTOS approach.* In Proceedings of the 8th International Conference on Formal Description Techniques FORTE'95, Montreal, Canada, October 17-19, 1995.

[Fac95] Mohammed Faci, *Detecting Feature Interactions in Telecommunications Systems Designs.* PhD Thesis, University of Ottawa, 1995.

[FNLL96] A. Février, E. Najm, G. Leduc, L. Léonard, *Compositional Specification of ODP Binding Objects.* To appear in: Information Network and Data Communication, Chapman & Hall, London (1996).

[Gar95] H. Garavel, *On the Introduction of Gate Typing in E-LOTOS.* In P. Dembinski and M. Sredniawa, eds., Proceedings of the 15th IFIP International Workshop on Protocol Specification, Testing and Verification (Warsaw, Poland), June 1995.

[GM96] H. Garavel and L. Mounier, *Computer-Aided Design and Verification of some Distributed Leader Election Algorithms.* To appear in Science of Computer Programming, Special Issue on Formal Methods, 1996.

[Haj95] Mazen Haj-Hussein, *Guided Search Technique for LOTOS.* PhD Thesis, University of Ottawa, 1995.

[Kam96] Kamoun J. *Formal Specification and Feature Interaction Detection in the Intelligent Network.* Master Thesis, University of Ottawa, 1996.

[KB95a] Khendek, F. and Bochmann, G. v., *Merging behavior specifications*, in Journal of Formal Methods in System Design, Vol. 6, No. 3, pp. 259-293, June 1995.

[KB95b] Khoumsi, A. and Bochmann, G. v., *Protocol synthesis using basic LOTOS and global variables*, in International Conference on Network Protocols (ICNP) 1995.

[KHB96] Kant, C., Higashino, T. and Bochmann, G. v., *Deriving protocol specifications from service specifications written in LOTOS*, to be published in Distributed Computing.

[Led95] G. Leduc, *Failure-based congruences, unfair divergences and new testing theory.* Protocol Specification, Testing and Verification, XIV, Chapman & Hall, London (1995), 252-267.

[LL95] L. Léonard, G. Leduc, *An Extended LOTOS for the Design of Real-Time Systems.* Invited talk, Workshop on Design and Analysis of Real-Time Systems, Brussels, Belgium, 9–10 November 1995

[LL96] L. Léonard, G. Leduc, *An introduction to ET-LOTOS for the description of time-sensitive systems*, To appear in: Computer Networks and ISDN Systems.

[SL95a] Stepien, B., and Logrippo, L. *Representing and Verifying Intentions in Telephony Features Using Abstract Data Types.* In: Cheng, K.E., and Ohta, T. (Eds.) Feature Interactions in Telecommunications, III (1995). IOS Press, 141-155.

[SL95b] Stepien, B., and Logrippo, L. *Feature Interaction Detection Using Backward Reasoning with LOTOS.* In: S. Vuong (ed.) Protocol Specification, Testing, and Verification, XIV (Proc. of the 14th International Symposium on Protocol Specification, Testing, and Verification, organized by IFIP WG 6.1, Vancouver), 1995, pp. 71-86.

[TPB95] Tan, Q. M., Petrenko, A. and Bochmann, G. v., *Modeling Basic LOTOS by FSMs for Conformance Testing*, Proceedings of the 15th International Symposium on Protocol Specification, Testing and Verification (PSTV 15), Poland, June 1995, pp.137–152.

[Tuo96] Tuok, R. *Modelling and Generation of Scenarios for a Mobile Telephony System in LOTOS.* Master Thesis, University of Ottawa, 1996.

[UvdS95] Ural, H. and van der Schoot, H., *Data flow oriented test selection for LOTOS*, in Computer Networks and ISDN Systems , vol. 27(7), pp. 1111-1136, May 1995.

6.2 Toolset distribution

During the EUCALYPTUS-2 meeting in Ottawa, the partners have agreed upon a common distribution policy for the EUCALYPTUStools:

- The EUCALYPTUS Graphical User Interface will be placed on an anonymous FTP server to be publicly available (with appropriate statements indicating authorship and

sponsorship).

- Each partner will be responsible for the distribution and licensing of his own tools.

Within EUCALYPTUS, the distribution of Grenoble's tools has progressed in 1995. Currently, more than 120 sites are licensed to use the CADP tools.

6.3 Toolset demonstration

The EUCALYPTUS tools have been presented and demonstrated in several international conferences, including:

- CFIP'95: Colloque Francophone sur l'Ingénierie des Protocoles (Rennes, France, May 1995).
- PARADIS'95: 2nd Summer School on Parallel and Distributed Systems (Sinaia, Romania, August 1995).
- IWPTS'95: International Wokshop on Protocol and Test Systems (Evry, France, September 1995).
- Rencontres Inria-industrie (Paris, France, September 1995)
- FORTE'95: 8th International Conference on Formal Description Techniques (Montréal, October 1995).
- COST'247: 6th Management Committee Meeting (Budapest, Hungary, October 1995)
- COST'247: 7th Management Committee Meeting (Madrid, Spain, February 1996)

6.4 Academic use of the toolset

The EUCALYPTUS tools are heavily used in academic laboratory exercises, mostly to explain the principles of protocol engineering, formal specification and verification. We list here some examples about which we have precise information (but there are many other uses about which we have less information):

- At the University of Montréal, the the EUCALYPTUS toolset is used in the course "Sujets avancés en télé-informatique".
- At the University Joseph Fourier of Grenoble, the EUCALYPTUS toolset is used in the course "Verification and Performance Evaluation of Distributed Systems".

- At ENSIMAG[7], the EUCALYPTUS toolset is used in the courses "Real-Time" and "Specification and Verification of Protocols".
- At the University of Liège, the EUCALYPTUS toolset is used in the courses "Protocoles de réseaux d'ordinateurs" and "Ingénierie des systèmes informatiques répartis" where students apply it to medium-size case-studies (e.g. ATM switch, Token Ring);
- At ENST[8], the EUCALYPTUS toolset is used in the course "Specification and Verification of Protocols".

6.5 Internet and World-Wide Web

Following the recommendations made by the experts at the end of the final EUCALYPTUS-1 reviews meeting, Grenoble and Ottawa have created World-Wide Web pages describing the CADP and XELUDO tools. The references of these pages are:

```
ftp://ftp.imag.fr/imag/SPECTRE/LOTOS/cadp.html
```

and:

```
http://www.csi.uottawa.ca/~lotos
```

Ottawa has also prepared a World-Wide Web page describing the features of the EUCALYPTUS toolset:

```
http://www.csi.uottawa.ca/~lotos/Euca
```

Liège has prepared another World-Wide Web page for EUCALYPTUS:

```
http://www-run.montefiore.ulg.ac.be/projects/EUCALYPTUS.html
```

Also, an overview paper on EUCALYPTUS would be highly desirable. It is suggested that Grenoble prepares a draft of such a paper, to be discussed and enriched by the other partners.

In 1996, special efforts will be undertaken to merge these pages into a unique one, which will provide on-line access to the EUCALYPTUS reports and, also, to the EUCALYPTUS toolset itself.

7 Conclusions and perspectives

In this Report, we have presented the achievements of the EUCALYPTUS-2 project. Significant progress has taken place in the three tasks of the project (see Sections 3, 4 and 5). An important effort for dissemination has taken place (see Sections 6).

[7] Ecole Nationale Supérieure d'Informatique et de Mathématiques Appliquées de Grenoble
[8] Ecole Nationale Supérieure des Télécommunications (Paris)

The scientific cooperation between Canadian and European partners is going well. In addition to the collaborative work performed during the EUCALYPTUS-2 meetings and using electronic mail, we have launched new forms of cooperation, involving the exchange of engineering-school students between Grenoble and Ottawa (see Section 2.2).

Obviously, all the work described in this Report could not have be accomplished in the framework of EUCALYPTUS-2 only, due to the fact that the European part of EUCALYPTUS-2 provides no manpower and only covers travel expenses. In particular, Task 1 ("Application of the EUCALYPTUS toolset to large-size, industrial case studies") and Task 2 ("Improvement of the EUCALYPTUS tools") could not have been performed without both the existence of national sources of fundings for research and the existence of industrial contracts.

However, we believe that EUCALYPTUS-2 is playing an essential role in coordinating the on-going activities undertaken by the Canadian and European partners. If we only consider the activities specifically funded by EUCALYPTUS-2, we observe that the project is very useful and successful in three areas:

- EUCALYPTUS-2 allows the work undertaken in the EUCALYPTUS-1 project (1993–1994) to be pursued, especially with respect to the integration of Canadian and European tools.
- EUCALYPTUS-2 plays a central part in the definition of the Extended-LOTOSlanguage. The EUCALYPTUS-2 partners are actively contributing to the on-going standardization effort undertaken within ISO (see Section 5).
- EUCALYPTUS-2 achieves a good visibility, through scientific publications and tool demonstrations in international conferences. For instance, we are pleased to mention that two research groups have decided to integrate their own tools within the EUCALYPTUS toolset (see Section 2.3). Also, we start to see an industrial uptake of our ideas, for instance in our cooperation with large companies, such as Bull, Bell Northern Research, etc.

In 1996, we plan to continue EUCALYPTUS-2 in these directions. For 1997, we would like to apply for an extension of the project, since we are convinced that formal methods are a long-term goal, which requires a long-term support. During the 80's and early 90's, large amounts of money have been invested in formal methods, often for short-term projects (3 years) with large consortiums (a dozen of partners). However, only a few of these projects have survived. We believe that a more effective approach would consist in funding smaller, selective consortiums on a longer period, in order to ensure proper scientific work and industrial uptake.

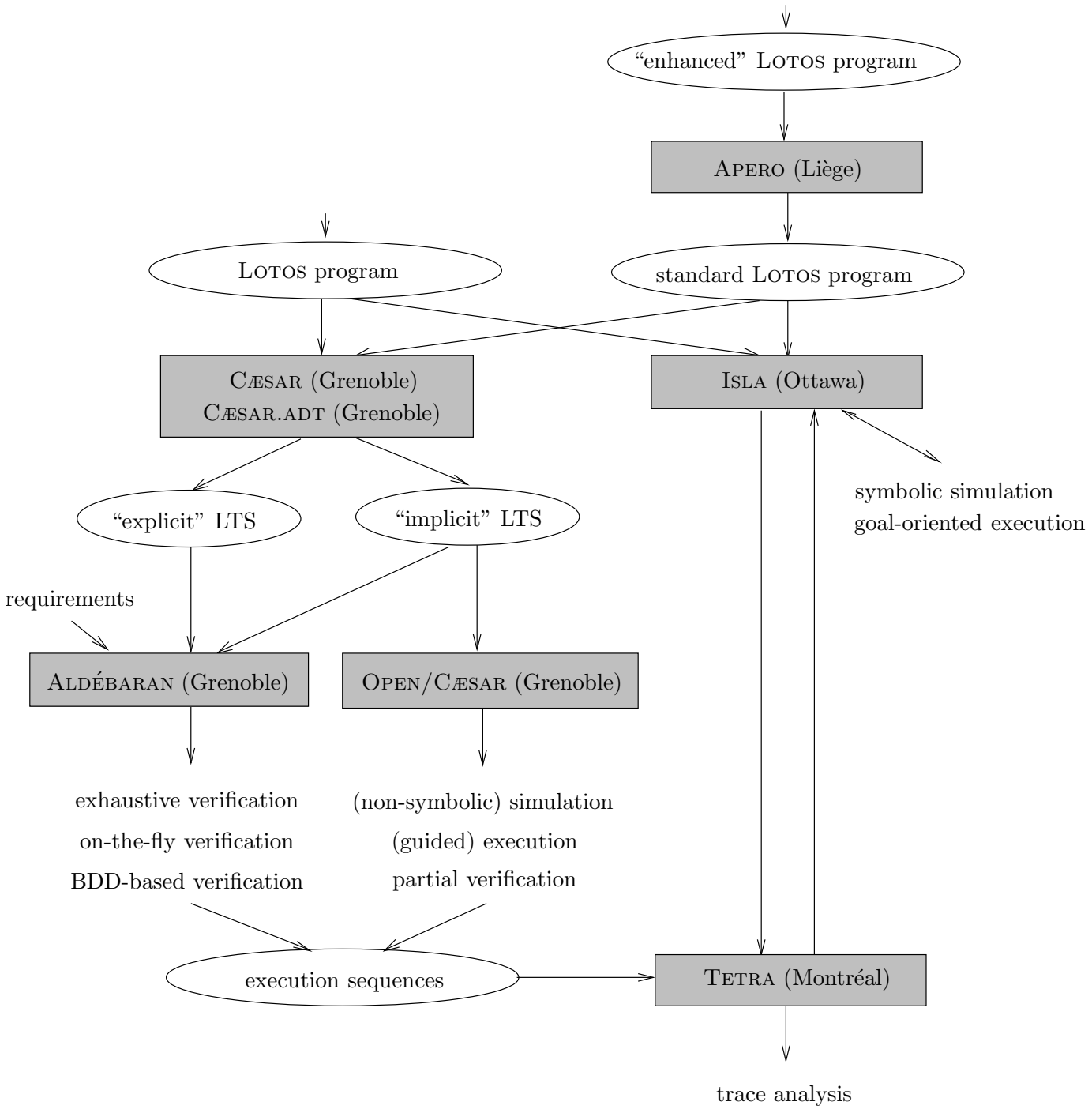

Figure 2: Architecture of the EUCALYPTUS toolset

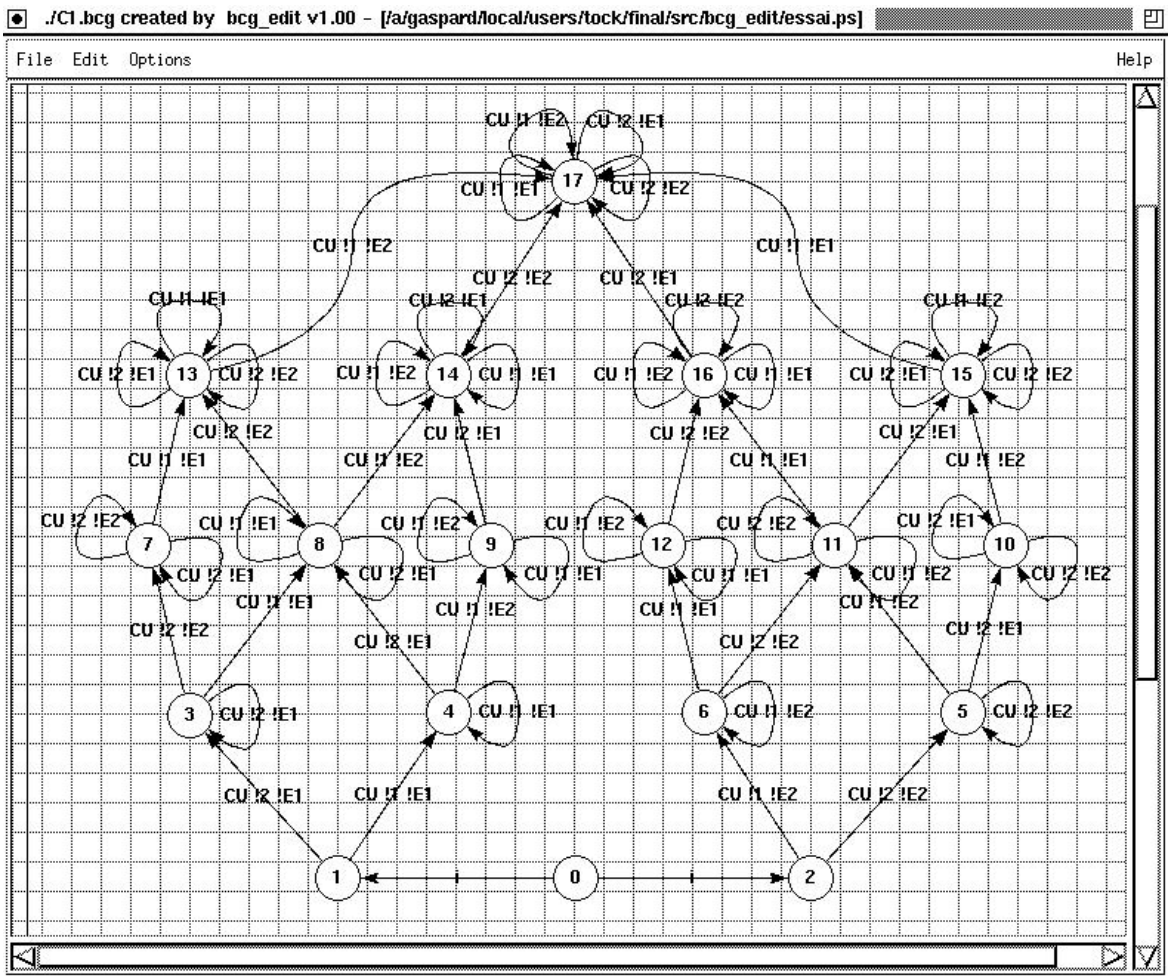

Figure 3: The BCG_EDIT tool