LOGIC SYSTEMS LABORATORY

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STRATEGIC ACTIVITY REPORT

1995 - 2001

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Strategic Activity Report 1995-2001

Logic Systems Laboratory (LSL)

(Final Version as of October 1, 2001)

1. Research Vision and Strategy

1.1 Fields of Research

The **Logic Systems Laboratory** (LSL) conducts research along two primary lines: (1) bio-inspired systems, and (2) development and analysis of innovative hardware architectures, including new microprocessor architectures and custom processors based on reconfigurable logic.

The first line of research aims at developing novel **bio-inspired computing machines**. The inspiration is drawn from three levels of organization, observed in nature: the *phylogenetic level* concerns the temporal evolution of the genetic programs within individuals and species, the *ontogenetic level* concerns the developmental process of a single multicellular organism, and the *epigenetic level* concerns the learning processes during an individual organism's lifetime (e.g., in the nervous system and the immune system). Each of the above three levels corresponds to a research axis in our Laboratory. Phylogeny leads to evolutionary computation, and from there to evolving machines, the first prototype of which, dubbed *Firefly* is worldwide unique. Ontogeny forms the basis of the *Embryonics* project, which aims at designing multicellular automata whose embryonic development imitates the biological processes of cellular division and differentiation. Finally, epigenesis leads us to the development of novel types of artificial neural networks whose synaptic weights, as well as topological connections, are programmable.

The second line of research is concerned with the **development and analysis of computer hardware**. Our studies are mainly based on the latest innovations in the domain of programmable hardware, most notably *Field-Programmable Gate Arrays*, or FPGAs. An FPGA is a set of logic components associated with a network of programmable connections. We use off-the-shelf FPGAs to realize several types of digital systems, and in particular dedicated processors (watch processors, GENSTORM - a custom computer for bio-molecular sequence comparison and pattern matching, etc.) and reconfigurable processors (RENCO - a reconfigurable network computer).

In its search for new principles of organization and development of logic systems, our Laboratory has been able to rely upon solid theoretical competence in both formal logic and cellular automata theory.

1.2 Unsolved Problems and Research Strategy

Within the domain of bio-inspired computing machines, our research is developing along all of the three axes: phylogenetic (P), ontogenetic (O), and epigenetic (E). On the phylogenetic axis, we aim to further develop and generalize *Firefly*, the first prototype of an intrinsically-evolving machine, that is, a hardware device capable of evolving in real time. For the ontogenetic machines, we want to move from the parallel configuration of all the cells of a multicellular artificial organism to a purely sequential growth, in conformance with the historical project of von Neumann's self-replicating automaton and with the most recent findings in the study of embryology. Finally, on the epigenetic axis, we wish to embed into a multicellular ontogenetic machine the capabilities of learning (artificial neural networks) and of self-test (*immunotronics* = immune electronics). The ensemble of these research efforts aims at the realization of a completely novel electronic substrate, the *reconfigurable computing tissue*, combining programmable logic systems (FPGAs), input units (touch screen), and output units (display). Such a substrate will have to be capable of implementing the P (phylogenetic), O (ontogenetic), and E (epigenetic) levels: the age of *POEtic machines* will be born.

1.3 Positioning among Competing Groups and Estimated Position at a World-Wide Level

According to an evaluation performed by the American magazine *Business Week*, published on June 23rd, 1997, our Laboratory is in third place in the world for research in the domain "bio-inspiration, artificial life, and genetic algorithms", after the *Santa Fe Institute* (1st place) and *Stanford University* (2nd place). This high ranking is a consequence of the effort devoted to the *full hardware realization of novel bio-inspired computing machines*, as opposed to the software simulations used by most of our competitors (essentially in the UK, the US, and Japan). Our Laboratory remains the founder and world leader of the domain of *Embryonics* (embryonic electronics).

1.4 Future Perspectives

Our strategy relies strongly on the similarities between molecular biology and digital electronics, both based on a discrete language, written using a four-letter alphabet for biology (the four bases A, C, G, T of DNA) and a two-letter one for electronics (the binary language). While today the conception and the realization of our machines exploit standard silicon-based semiconductors, we are already developing architectures that could be adapted to tomorrow's technologies, and notably to nanotechnologies (carbon nanotubes, for example).

As a consequence, we are eager to participate in the future interdisciplinary Centres that are being created at the EPFL, of which one will be dedicated to bio-inspired systems, and another to advanced digital systems (Centre for Advanced Digital Systems).

2. Research Achievements

References [L…] and [P…] refer to books, respectively to publications, described in Section 5.3, references [Patent…] refer to patents, described in Section 5.4, while references [Th…] refer to theses described in Section 5.5.

2.1 Embryonics = Embryonic Electronics

- Creation of the concept of Embryonics (embryonic electronics) and realization of a first family of fine-grained artificial cells (MUXTREE, for *tree of multiplexers*) capable of self-repair and self-replication [L28] [P243] [Patent 1] [Patent 2] [Patent 3].
- Development and realization of a second family of coarse-grained artificial cells (MICTREE, for *tree of micro-instructions*) capable of self-repair and self-replication [P173].
- Realization of the first multicellular embryonic automaton implementing a specialized Turing machine (a parenthesis checker) capable of self-repair and self-replication [P229]. See also: G. Taubes, After 50 Years, Self-Replicating Silicon, *Science*, Vol. 277, 26 September 1997, p. 1936.
- Development and realization of the first multicellular embryonic architecture capable of self-repair and self-replication, based on artificial cells themselves decomposed into artificial molecules [P303] [Th11].
- Realization of the first multicellular embryonic automaton implementing a universal Turing machine capable of self-repair and self-replication [P311] [Th17].

2.2 Cellular Automata

- Development of the first cellular automaton embedding a self-replicating loop capable of finite computation (example of the LSL acronym) [P154].
- Development of the first cellular automaton embedding a self-replicating loop capable of universal computation (universal Turing machine) [P190].
- Co-evolution of cellular automata, development and realization of *Firefly*, the first intrinsically-evolving machine [L26] [P212].
- Development of the first cellular automaton embedding externally-controllable self-replicating loops, implemented on the intelligent wall *BioWall* [PECAL].

2.3 POE Model for Bio-Inspiration

- Creation of the POE (phylogeny, ontogeny, epigenesis) model as a general paradigm for the conception of bio-inspired computing machines [P214].

2.4 Artificial Neural Networks

- Realization of the first artificial neural network inspired by the historic concepts of A. Turing [LSpringer] [P332].

2.5 Reconfigurable Computing Tissue

- Conception and realization of the first reconfigurable computing tissue, the intelligent wall *BioWall* [P335] [Patent4].

3. Research Valorization

The general concept of *Embryonics* is covered by a series of generic patents (Switzerland, Europe, USA), aimed at protecting our interests in the context of the long-term realization of very complex integrated circuits capable of on-line self-repair and self-replication [Patent1] [Patent2] [Patent3].

We hope to obtain shorter-term benefits from the concept of *reconfigurable computing tissue*, today embodied by two major applications: an intelligent wall (*BioWall*) and a giant self-repairing watch (*BioWatch*). A Swiss patent has already been deposed and we are committed to exploiting all possible industrial opportunities, including a possible start-up [P329] [Patent4].

Moreover, we have deposed in Switzerland the following trademarks:

·	MUXTREE	(multiplexers tree),	1.11.1995	(No 435 787);
·	BIODULE	(biological logidule),	1.11.1995	(No 436 403);
·	BIOWATCH	(biological watch),	11.01.1996	(No 442 789);
·	MICTREE	(micro-instructions tree),	16.6.1997	(No 443 281);
·	BIOWALL	(biological wall),	deposed in May, 2001.	

4. Teaching Strategy and Achievements

4.1 Current Challenges

Teaching digital hardware design is subject to a double challenge:

- the extremely rapid expansion of scientific and technical knowledge in the domain of computer science, and
- the considerable increase in the number of students in a branch that has evolved from a specialization in 1969 (directed exclusively to the students of the Electrical Engineering Department in the 2nd cycle) to a basic course, taught by the LSL in the 1st cycle to all of the students of the Computer Science, Communication Systems, Electrical Engineering, Mechanical Engineering, and Micro-Engineering Departments.

The constraints of the curriculum naturally limit the duration of the courses proposed by our Laboratory. As a consequence, increasing the efficiency of the teaching becomes a necessity, in order to be able to transmit a growing amount of theoretical and practical knowledge in a limited time.

4.2 Meeting the Challenge

Our *pedagogical approach* has been steadily evolving through the years. Among the main steps of this evolution we will mention:

- The beginning, with conventional “ex cathedra” courses.

- The introduction of laboratory sessions, with conventional electronic material (experimental breadboards).
- The development of a completely novel experimental platform, the *logidules*. A logidule is, essentially, a plastic cube containing a simple digital integrated circuit (logic gates, memories, etc.). Logidules can then be joined to realize digital systems of unlimited complexity. The logidule can thus be seen as a LEGO for hardware design.
- The introduction of the basic concept of *integrated course/laboratory*. In this concept, the laboratory becomes an integral part of the course, allowing the student to round out the theoretical notions with practical know-how.
- The introduction of the basic concept of *firmware (*or *co-design)*, defined as the art and the technique of hardware-software transformations. This concept, based on the notion of algorithm and realized using the universal notation of the binary decision tree, allows the main concepts of hardware (switching theory) and software (microprogramming) to be taught as a single subject [P124].
- The introduction of complex logidules, the *microdules*, built around an 8-bit wide universal bus, allowing the student to easily realize the complex systems associated with micro-programmed processors.
- The introduction of the *personal computer* and of a standardized connection between the computer and the logidules or microdules.
- The introduction of the *biodules*, a family of high-complexity logidules, implementing the artificial cells and molecules of the Embryonics project.

The *subject matter* of our teaching has also evolved, through the successive introduction of the following courses:

- *Systèmes logiques*, since 1969 (Electrical Engineering, Mathematics, Mechanical Engineering, Physics, Micro-Engineering, Computer Science, and Communication Systems Departments, as well as University of Lausanne).
- *Machines séquentielles*, since 1972 (Electrical Engineering, Mathematics, and Computer Science Departments).
- *Calculatrices digitales*, since 1969 (Electrical Engineering, Physics, and Mathematics Departments).
- *Systèmes digitaux*, since 1979 (Electrical Engineering and Computer Science Departments).
- *Systèmes formels*, since 1983 (Mathematics and Computer Science Departments).
- *Théorie des automates*, since 1984 (Computer Science Department).
- *Systèmes microprogrammés*, since 1985 (Computer Science, Electrical Engineering, Mathematics, and Micro-Engineering Departments).
- *Conception des processeurs,* since 1985 (Computer Science and Communication Systems Departments).
- *Informatique du temps réel*, since 1986 (Mechanical Engineering Department).
- *Logique élémentaire*, since 1988 (Computer Science Department).
- *Systèmes numériques*, since 1990 (Micro-Engineering Department).
- *Laboratoire de matériel informatique*, since 1991 (Computer Science Department).
- *Réseaux cellulaires*, since 1994 (Computer Science and Physics Departments).
- *Systèmes et programmation génétiques*, since 1996 (Computer Science Department).
- *Automates et calculabilité*, since 1996 (Computer Science Department).
- *Architecture des ordinateurs*, since 1997 (Computer Science and Communication Systems Departments).
- *Conception avancée de systèmes numériques*, since 1997 (Computer Science and Communication Systems Departments).
- *Circuits complexes*, since 1998 (Computer Science Department).
- *Bio-Inspired Systems and Computing*, since 2000 (Pre-Doctoral School of the Computer Science Department).

4.3 LSL Teaching Charges

From a quantitative standpoint, the total teaching charge of the LSL can be resumed as follows:

- From 1988 to 1992, the teaching charge of the LSL was evaluated with the old EPFL formula, showing that our Laboratory has always been the most heavily charged unit in the Computer Science Department. The ratio between the most heavily charged Laboratory (the LSL) and the least heavily charged one reached, for the 1989-1990 academic year, a value of 9,25!
- For the 1993-1994 academic year, the charge evaluation, using the new EPFL formula, still places the LSL in first place (heaviest charge). The above-mentioned ratio fell to 3,15.
- For the 2001-2002 academic year, the LSL is in first place in the Computer Science Department, with a charge index, computed with the Department’s formula, of 49’793. Considering that the total charge of the Department is 251’400, the LSL handles **19,8% of the total charge of the Department**, with a personnel (Confederation positions) equal to **9,6% of the total personnel of the Department**.

In conclusion, the contribution of the LSL to teaching has been and remains the heaviest in the entire Department.

4.4 Measuring the Quality of Teaching

All the members of the LSL have repeatedly been subject to evaluations, with the goal of increasing the quality of their teaching.

As examples, we will mention here the results of four recent evaluations:

- *Conception de processeurs* (Computer Science Department, Winter 1999-2000). The score for each question is above-average. This course is the best (highest score) for the semester both for the practical laboratories and for the general interest of the subject.
- *Systèmes logiques* (Electrical Engineering Department, Winter 1999-2000). The course is the best (highest score) of the semester.
- *Systèmes et programmation génétiques* (Computer Science Department, Summer 2000). The score for each question is above-average. This course is the best (highest score) for the semester for the general interest of the subject.
- *Systèmes microprogrammés* (Electrical Engineering Department, Summer 2000). The course is the second best (second highest score) of all the courses of the semester.

4.5 Impact Outside the EPFL

In addition to the education of our students, which remains our primary mission, a series of derived products have been put at the disposal of a large number of external users, thus extending the reputation and influence of out Institute well beyond its natural frontiers. We will mention, notably:

- The publication of a series of books of high technical and typographic quality, published essentially by the Presses polytechniques et universitaires romandes (PPUR) in Switzerland and by Dunod-Bordas or by the Collection technique et scientifique des télécommunications (CNET-ENST) in France [L3] [L5] [L14] [L15] [L16] [L17] [L27] [L28].
- An english version of two of these books has been published by Artech House [L11] and by Chapman & Hall [L20].

- The publication of several laboratory manuals and of a catalog of logidules.
- The technology transfer of logidules and microdules to the industry: the SYPROLEC company, in Geneva, assures the production and the diffusion of this material, which equips several professional schools, the CSEM in Neuchâtel, the University of Fribourg (Computer Science Laboratory), the Integrated Systems Laboratory of the EPFZ (prof. W. Fichtner), and the Ecole supérieure d'ingénieurs en électrotechnique et électronique (Paris).

5. Achievements

5.1 Public Research Contracts

See annexe at the end of this report.

5.2 Contract Activities

See annexe at the end of this report.

5.3 Important Books and Publications

For those who might be interested in consulting the complete list of our publications, please go to the following Web address http://lslwww.epfl.ch and click on "Publications". You will find an exhaustive list of our books (since 1992), our papers (since 1991), our technical reports (since 1995), and the completed theses (since 1994).

For the period under evaluation (1995-2001), our Laboratory has published 189 papers, 3 patents, 8 theses, and 5 books.

As for the complete list of our publications (refereed papers, proceedings, theses, books, patents, and others) published from 1996 to 2001, see annexe at the end of this report.

Books

[L3] D. Mange, Analyse et synthèse des systèmes logiques, vol. V du Traité d'électricité, Lausanne, PPUR, 1985, coédition en français par Dunod (1981).

[L5] J. Zahnd, Machines séquentielles, vol. XI du Traité d'électricité, St-Saphorin, Georgi, 1980.

[L11] D. Mange, Analysis and Synthesis of Logic Systems, Norwood, MA, Artech House, 1986.

[L14] A. Stauffer, Systèmes numériques câblés et microprogrammés, Lausanne, PPUR, 1989.

[L15] D. Mange, Systèmes microprogrammés: une introduction au magiciel, Lausanne, PPUR, 1990, coédition française dans la Collection technique et scientifique des télécommunications sous l'égide du Centre national d'études des télécommunications (CNET) et de l'Ecole nationale supérieure des télécommunications (ENST).

[L16] C. Piguet, A. Stauffer, J. Zahnd, Conception des circuits ASIC numériques CMOS, Paris, Dunod Bordas, 1990.

[L17] C. Piguet, A. Stauffer, Synthèse de circuits ASIC, Paris, Dunod Bordas, 1990.

[L20] D. Mange, Microprogrammed Systems: An Introduction to Firmare Theory, London, Chapman & Hall, 1992.

[L26] M. Sipper, Evolution of Parallel Cellular Machines, The Cellular Programming Approach, Springer-Verlag, Berlin, 1997.

[L27] J. Zahnd, Logique élémentaire, Cours de base pour informaticiens, Presses polytechniques et universitaires romandes, Lausanne, 1998.

[L28] D. Mange, M. Tomassini (eds), Bio-Inspired Computing Machines, Presses polytechniques et universitaires romandes, Lausanne, 1998.

[LSpringer] C. Teuscher, Turing's Connectionism. An Investigation of Neural Network Architectures. Discrete Mathematics and Theoretical Computer Science, Springer-Verlag, London, September 2001 (to appear).

Publications

[P124] D. Mange, Teaching Firmware as a Bridge Between Hardware and Software, *IEEE Transactions on Education*, Vol. 36, No 1, February 1993, pp. 152-157.

[P154] G. Tempesti, A New Self-Reproducing Cellular Automaton Capable of Construction and Computation, *Advances in Artificial Life*, 3rd European Conference on Artificial Life, Granada, Spain, June 4-6, 1995, *Lecture Notes in Artificial Intelligence*, 929, Springer Verlag, Berlin, 1995, pp. 555-563.

[P173] D. Mange, M. Goeke, D. Madon, A. Stauffer, G. Tempesti, S. Durand, Embryonics, A New Family of Coarse-Grained Field-Programmable Gate Array with Self-Repair and Self-Reproducing Properties, *Towards Evolvable Hardware*, Springer-Verlag, Berlin, 1996, pp.197-220.

[P182] A. Pérez-Uribe, E. Sanchez, FPGA Implementation of an Adaptable-Size Neural Network, *Artificial Neural Networks, ICANN '96*, Springer, Berlin, 1996, pp. 383-388.

[P190] J.-Y. Perrier, M. Sipper, J. Zahnd, Toward a viable, self-reproducing universal computer, *Physica D 97*, 1996, pp. 335-352.

[P196] M. Capcarrère, M. Sipper, M. Tomassini, Two-state, $r = 1$ Cellular Automaton that Classifies Density, *Physical Review Letters*, Vol. 77, No 24, 1996, pp. 4969-4971.

[P212] M. Goeke, M. Sipper, D. Mange, A. Stauffer, E. Sanchez, M. Tomassini, Online Autonomous Evolware. In T. Higuchi, M. Iwata and W. Liu, editors, *Evolvable Systems: From Biology to Hardware*, volume 1259 of *Lecture Notes in Computer Science*, pp. 96-106. Springer-Verlag, Berlin, 1997.

[P214] M. Sipper, E. Sanchez, D. Mange, M. Tomassini, A. Pérez-Uribe, A. Stauffer, A Phylogenetic, Ontogenetic, and Epigenetic View of Bio-Inspired Hardware Systems, *IEEE Transactions on Evolutionary Computation*, Vol. 1, No 1, April 1997, pp. 83-97.

[P224] G. Tempesti, D. Mange, A. Stauffer, A robust multiplexer-based FPGA inspired by biological systems, *Journal of Systems Architecture (The EUROMICRO Journal)* , Vol. 43, No 10, September 1997, pp. 719-733.

[P229] D. Mange, D. Madon, A. Stauffer, G. Tempesti, Von Neumann revisited: A Turing machine with self-repair and self-reproduction properties, *Robotics and Autonomous Systems*, Vol. 22, No 1, 1997, pp. 35-58.

[P231] M. Sipper, D. Mange, A. Stauffer, Ontogenetic Hardware, *BioSystems*, Vol. 44, No 3, 1997, pp. 193-207.

[P243] D. Mange, E. Sanchez, A. Stauffer, G. Tempesti, P. Marchal, C. Piguet, Embryonics, A New Methodology for Designing Field-Programmable Gate Arrays with Self-Repair and Self-Replicating Properties, *IEEE Transactions on VLSI Systems*, Vol. 6, No 3, September 1998, pp. 387-399.

[P260] G. Tempesti, D. Mange, A. Stauffer, Self-Replicating and Self-Repairing Multicellular Automata, *Artificial Life*, Vol. 4, No 3, Summer 1998, pp. 259-282.

[P264] M. Sipper, D. Mange, E. Sanchez, Quo Vadis Evolvable Hardware? *Communications of the ACM*, Vol. 42, No 4, April 1999, pp. 50-56.

[P277] E. Sanchez, M. Sipper, J.-O. Haenni, J.-L. Beuchat, A. Stauffer, A. Perez-Uribe, Static and Dynamic Configurable Systems, *IEEE Transactions on Computers*, Vol. 48, No 6, June 1999, pp. 556-564.

[P303] D. Mange, M. Sipper, A. Stauffer, G. Tempesti, Toward Robust Integrated Circuits: The Embryonics Approach, *Proceedings of the IEEE*, Vol. 88, No 4, April 2000, pp. 516-541 (*Invited Paper*).

[P311] H. F. Restrepo, D. Mange, M. Sipper, A Self-Replicating Universal Turing Machine: From von Neumann's Dream to New Embryonic Circuits. In M. A. Bedau & al. (Eds.), *Proceedings of the Seventh International Conference on Artificial Life, Artificial Life VII*, pp. 3-12. The MIT Press, Cambridge, 2000.

[P317] J.-L. Beuchat, J.-O. Haenni, Von Neumann's 29-State Cellular Automaton: A Hardware Implementation, *IEEE Transactions on Education*, Vol. 43, No 3, August 2000, pp. 300-308.

[P320] M. Tomassini, M. Sipper, M. Perrenoud, On the Generation of High-Quality Random Numbers by Two-Dimensional Cellular Automata, *IEEE Transactions on Computers*, Vol. 49, No 10, October 2000, pp. 1146-1151.

[P329] *BioWall, un tissu électronique qui palpite comme une peau*, Laboratoire de systèmes logiques EPFL, avril 2001.

[P332] C. Teuscher, E. Sanchez, A Revival of Turing's Forgotten Connectionist Ideas: Exploring Unorganized Machines. In R. M. French and J. P. Sougné (Eds), *Connectionist Models of Learning, Development and Evolution, Perspectives in Neural Computing*, pp. 153-162. Springer-Verlag, London, 2001.

[P335] A. Stauffer, D. Mange, G. Tempesti, C. Teuscher, BioWatch: A Giant Electronic Bio-Inspired Watch, *Proceedings, The Third NASA/DoD Workshop on Evolvable Hardware*, pp. 185-192. IEEE Computer Society, Los Alamitos, 2001.

[P338] M. Sipper, J. A. Reggi, Go Forth and Replicate, *Scientific American*, Vol. 265, No 2, August 2001, pp. 34-43.

[PECAL] A. Stauffer, M. Sipper, Externally Controllable and Destructible Self-Replicating Loops. *6th European Conference on Artificial Life*, Prague, September 10-14, 2001 (*to appear*).

[PIEEE] C. A. Pena, M. Sipper, Fuzzy CoCo: A cooperative-coevolutionary approach to fuzzy modeling, *IEEE Transactions on Fuzzy Systems*, 2001 (*to appear*).

5.4 Patent Applications and Issued Patents

[Patent 1] D. Mange, P. Marchal, C. Piguet, E. Sanchez, *Système électronique organisé en réseau matriciel de cellules* (demandeur: CSEM, Centre suisse d'électronique et de microtechnique S.A.), 1994, brevet déposé dans 17 pays européens (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LI, LU, MC, NL, PT, SE).

[Patent 2] D. Mange, P. Marchal, C. Piguet, E. Sanchez, *Electronic System Organised as an Array of Cells*, United States Patent No 5,508,636, April 16, 1996.

[Patent 3] D. Mange, P. Marchal, C. Piguet, E. Sanchez, *Circuit électronique organisé en réseau matriciel de cellules*, brevet suisse No CH 688 425, 15 septembre 1997.

[Patent 4] D. Mange, A. Stauffer, G. Tempesti, C. Teuscher, *Dispositif électronique à affichage électro-optique commandé par des circuits logiques programmables*, brevet européen No 01201221.7, 29 mars 2001.

5.5 Completed and On-Going PhD Theses

Completed Theses

[Th10] C. Iseli, SPYDER: a Reconfigurable Processor Development System, Thesis No 1476, 1996.

[Th11] G. Tempesti, A Self-Repairing Multiplexer-Based FPGA Inspired by Biological Processes, Thesis No 1827, EPFL, Lausanne, 1998.

[Th12] E. Mosanya, A Reconfigurable Processor for Biomolecular Sequence Processing, Thesis No 1910, EPFL, Lausanne, 1998.

[Th13] A. Pérez Uribe, Structure-Adaptable Digital Neural Networks, Thesis No 2052, EPFL, Lausanne, 1999.

[Th14] J.-M. Puiatti, Instruction-Level Parallelism for Low-power Embedded Processors, Thesis No 2110, EPFL, Lausanne, 2000.

[Th15] D. Madon, Processeur RISC Multitâche, Thèse No 2159, EPFL, Lausanne, 2000.

[Th16] J.-L. Beuchat, Etude et conception d'opérateurs arithmétiques optimisés pour circuits programmables, Thèse No 2426, EPFL, Lausanne, 2001.

[Th17] H. F. Restrepo, Implementation of a Self-Replicating Universal Turing Machine, Thesis No 2457, EPFL, Lausanne, 2001.

On-Going PhD Theses

[Th18] J.-O. Haenni, Benefits of EPIC Architectures for Multimedia Applications.

[Th19] M. Capcarrère, Evolution of Ontogenetic Cellular Systems for Problem Solving.

[Th20] C. A. Pena, An Evolutionary-Fuzzy Approach to Modeling and Problem Solving.

[Th21] C. Teuscher, Bio-Inspired Hardware and Computing Machines: Going Beyond Traditional Computation.

[Th22] E. Petraglio, Bio-Inspired Improvements of a Cell Matrix Circuit.

[Th23] R. Hoffmann, Processeur à haut degré de parallèlisme basé sur des composantes sérielles.

[Th24] Y. Thoma, Evolutive Hardware for Reinforcement Learning.

5.6 List of Awards

M. Sipper
Subvention as a professeur boursier of the Fonds national suisse de la recherche scientifique, 2001-2005.

R. Hoffmann
Prix Steria Informatic, 2000.

D. Mange
"Les 100 qui font bouger la Suisse", *L'express international,* No 2571, 12-18 octobre 2000.

C. Teuscher
Prix Fondation Edwin Annaheim, 2000.
Prix Jean Landry, 2000.
Prix de la Société suisse des Informaticiens, 2000.
Prix ABB 2000 dans les domaines de l'informatique, de l'automatique et des télécommunications.

M. Sipper
Prix 1999 of the International Latsis Fondation.

J.-L. Beuchat
Prix universitaire de la Société académique du Valais, 1998.

J. Zahnd, C. Piguet
Best poster award, "Signal-Transition Graph-based Design of Speed-Independent CMOS Circuits", ESSCIRC '98, The Hague, 22-24 September, 1998.

D. Mange
Honorary visiting professor, The University of York (GB), 20 November 1998.

D. Mange, M. Sipper
Subvention of 50'000.- for the LATSIS Conference 1998 (ICES '98).

D. Mange, M. Sipper
Guest researcher of the State Key Laboratory of Software Engineering, Wuhan University (China), 1997.

E. Bruchez
Prix SISR, 1997.

J.-L. Beuchat
Prix SISR, 1997.

J.-L. Beuchat
Prix Annaheim, 1997.

J.-O. Haenni
Prix Dommer, 1997.

J.-L. Beuchat
Prix NCR: 1er prix (The golden mouse), 1997.

5.7 Member of Conference Program and Organization Committees

Conference Program

M. Sipper (Program Committee)
6th International Conference on Parallel Problem Solving From Nature (PPSN VI), France, 2000.

M. Sipper (Program Committee)
Genetic and Evolutionary Computation Conference (GECCO 2000), Las Vegas, 2000.

M. Sipper (Steering Committee)
D. Mange, A. Perez-Uribe, E. Sanchez, M. Sipper, A. Stauffer (Program Committee)
3th International Conference on Evolvable Systems: From Biology to Hardware (ICES 2000), Edinburgh, April 17-19, 2000.

D. Mange, E. Sanchez, M. Sipper (Program Committee)
The 2nd NASA/DoD Workshop on Evolvable Hardware, Palo Alto (CA, USA), July 13-15, 2000.

M. Sipper (Program Committee)
The 7th International Conference on the Simulation and Synthesis of Living Systems (Artificial Life VII), Portland (OR, USA), August 1-6, 2000.

M. Sipper (Program Committee)
Evolution artificielle 2001 (EA '01), France, 2001.

M. Sipper (Program Committee)
Genetic and Evolutionary Computation Conference (GECCO 2001), San Francisco, July 7-11, 2001.

D. Mange, E. Sanchez, M. Sipper (Program Committee)
The 3rd NASA/DoD Workshop on Evolvable Hardware, Long Beach (CA, USA), July 12-14, 2001.

E. Sanchez (Chairman)
International Congress on Computational Intelligence, Medellin, Colombia, August 2-4, 2001.

H. F. Restrepo, M. Sipper, C. A. Pena (Program Committee)
International Congress on Computational Intelligence, Medellin, Colombia, August 2-4, 2001.

D. Mange (Program Co-Chair)
The 4th International Conference on Evolvable Systems: From Biology to Hardware (ICES 2001), Tokyo, October 3-5, 2001.

M. Sipper (Program Committee)
5th European Conference on Genetic Programming (EuroGP 2002), Ireland, 2002.

E. Sanchez (Steering Committee)
Rapid Systems Prototyping (RSP 2002), Germany, 2002.

C. Teuscher (Chairman)
5th International Workshop on Information Processing in Cells and Tissues (IPCAT 2003), Lausanne, 2003.

Editorial Boards

D. Mange (Advisory Board)
E. Sanchez (Associate Editor)
M. Sipper (Editorial Board)
Genetic Programming and Evolvable Machines, Kluwer Academic Publishers, Norwell (MA, USA).

M. Sipper (Associate Editor)
IEEE Transactions on Evolutionary Computation, IEEE, New York.

M. Sipper (Council of Authors)
International Society for Genetic and Evolutionary Computation, ISREC.

Other Committees

D. Mange

- Assemblée constituante du Canton de Vaud, membre (1999 - 2000).
- Communauté d'intérêts pour les transports publics, section Vaud (CITRAP VAUD), membre du comité (1992 -).
- Conseil d'administration du Tramway du sud-ouest lausannois (TSOL), membre, (2001 -).
- Comité stratégique, 150^{e} anniversaire de l'EPFL, membre (2001 -).
- Comité du prix de la Fondation Annaheim (1996 -).

E. Sanchez

- Advanced Learning and Research Institute (ALARI), Universita della Svizzera italiana (Lugano), Steering Committee (1999-2001), Faculty Member (1999 -).
- Comité du prix de la Fondation Annaheim (1996 -).

D. Mange

Lausanne, the 1st of October, 2001

Annexe: Section 5.1 (Public Research Contracts)
Section 5.2 (Contract Activities),
Section 5.3 (List of Publications),

Annexe

5.1 Public Research Contracts

European Projects

Lab	From	To	No	Title
LSL	15.2.1996	14.2.1997	OFES 95-0758	Evonet Network of Excellence in Evolutionary Computing
LSL	1.9.01.2001	31.8.2004	IST-2000-28027	Reconfigurable POEtic Tissue

CTI / Swiss Federal Office for Professional Education and Technology

Lab	From	To	No	Title
LSL	1.7.1998	31.5.1999	CTI 3955.1	Reconfigurable cryptographic coprocessor
LSL	1.6.1999	31.5.2000	CTI4470 IKTS	Reconfigurable cryptographic coprocessor
LSL	1.7.2001	31.12.2002	CTI 5311.IKTS	VLIW processor with serial architecture

FN/ Swiss National Science Foundation

Lab	From	To	No	Title
LSL	1.7.1994	30.6.1995	20-39391.93	Biologiciel: Pseudo-biological synthesis of logic systems on cellular architectures
LSL	1.7.1994	30.6.1995	20-39391.93/2	Biologiciel: Pseudo-biological synthesis of logic systems on cellular architectures
LSL	1.7.1995	30.6.1997	20-42270.94	Biologiciel: Pseudo-biological synthesis of logic systems on cellular architectures
LSL	1.7.1995	30.7.1997	20-42380.94	Abstract analyses of polymorphic functional languages
LSL	1.7.1995	30.7.1997	20-42380.94/2	Abstract analyses of polymorphic functional languages
LSL	1.4.1996	31.3.1997	21-45630.95	Cellular Programming: Programming massively parallel cellular machines by means of co-evolution
LSL	1.1.1998	30.6.1999	20-493375.96	Embryonics: conception of bio-inspired multi-cellular automata capable of self-reproduction and self-repair
LSL	1.4.1997	31.3.1999	20-49349.96	Cellular Programming: Programming massively parallel cellular machines by means of co-evolution
LSL	14.1.1999	26.6.2000	83BC-055130	A. Tyrrell grant
LSL	1.9.1998	31.3.1999	21-53412.98	International conference on evolutionary systems
LSL	1.10.1998	30.9.2000	21-54113.98	Implementation of self-repairing and self-replicating processors in a universal cellular structure
LSL	1.4.1999	31.3.2002	20-55597.98	Cellular Programming: Programming massively parallel cellular machines by means of co-evolution
LSL	1.4.2001	31.3.2003	20-63711.00	Implementation of self-repairing and self-replicating processors in a universal cellular structure
LSL	1.4.2001	31.3.2005	620-62734	National Science Foundation Assistant Professor (provided)

5.2 Contract Activities

Lab	From	To	No	Title
LSL	1994	2001	Fondation Edwin Annaheim	Bio-informatics interest group
LSL	1995	1995	Projet UNI-EPFL (en collaboration avec l'Institut LUDWIG)	Dedicated algorithms and machines for the alignment of bio-molecular sequences
LSL	1995	1995	BOBST	Agreement of training (second year)
LSL	1995	1995	EM-Marin	Realization of an environment for the development of the MICROPUS processor
LSL	1995	1995	MICROSWISS	Conception through description languages
LSL	15.8.1995	25.4.1996	Prof. Christian Piguet CSEM Neuchâtel	Development of the CoolRisc processor
LSL	1.4.1996	30.9.1996	Prof. Christian Piguet CSEM Neuchâtel	Development of the CoolRisc processor
LSL	1996	1998	Prof. Pierre Marchal CSEM Neuchâtel	Structure-adaptable neural networks
LSL	1996	1998	Prof. Christian Piguet CSEM Neuchâtel	CoolRisc-based superscalar/VLIW processor
LSL	1997	1998	Fondation LATSIS	ICES '98 conference
LSL	1.5.1997	31.1.2000	M. Pascal Nussbaum CSEM Neuchâtel	FPPA programming tools

Contract Activities (continued)

Lab	From	To	No	Title
LSL	1998	2000	Fondation Werner Steiger	Network-configurable processor (RENCO)
LSL	1998	2001	Dr T. Higuchi, Electrotechnical Laboratory, Tsukuba, Japan - Real World Computing Partnership (Tokyo)	Fault-tolerant FPGA architecture
LSL	1999	2001	Fondation Leenaards No 479	Embryonics
LSL	1999	2001	Sponsored Research Agreement Hewlett Packard-EPFL -projet LSL-P2	Benefits of EPIC Architectures for Multimedia Applications
LSL	1999	2001	Villa Reuge, Ste-Croix	BioWall and BioWatch
LSL	2001		B. Hochet Réserve stratégique HES-SO (Ecole d'ingénieurs du Canton de Vaud)	Asynchronous digital systems

5.9.200