André Arnold, Lutz Priese,
Roland Vollmar (editors):

Automata Theory: Distributed Models

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Tel.: +49-6871 - 2458
Fax: +49-6871 - 5942

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Bezugsadresse: Geschäftsstelle Schloß Dagstuhl
Informatik, Bau 36
Universität des Saarlandes
Postfach 1150
66041 Saarbrücken
Germany
Tel.: +49 -681 - 302 - 4396
Fax: +49 -681 - 302 - 4397

Report on the Dagstuhl-Seminar

"Automata Theory: Distributed Models"

11.01. - 15.01.93

Organizers: A. Arnold (Bordeaux), L. Priese (Koblenz), R. Vollmar (Karlsruhe)

This meeting was the third one in a series of automata theory seminars in January at Schloß Dagstuhl. Its specific theme was on "distributed models". To distinguish this meeting from others on semantics of parallelism or on distributed algorithms a concentration on the interplay of automata concepts and distributed computations was intended. Thus several researchs on the main interconnections, namely cellular automata, Petri-nets, and asynchronous automata and traces as their languages, have been invited. Nevertheless, also some lectures on further topics, such as tree-like automata, dataflow networks, domain-theoretic semantics for principles of distributed computations, etc., have been welcome.
The talks of Koiran, Mauri, Mazoyer, Umeo, Vollmar and Worsch covered the centre of cellular automata theory, while Thomas' talk on acceptors over graphs and pictures connected cellular automata with distributed automata over graphs and trees. Also Gruska contributed to automata over modified trees. The lectures of Best and Esparza came from the theory of Petri nets, Priese connected Petri nets and concurrent automata, whilst Starke presented a talk on applied Petri nets. Kwiatkowska started to research some important aspects of concurrent computations (liveness and fairness) with domain-theoretical methods. The talk of Burkhard on multi agents presented basical considerations for distributed models. The same holds for the talks of Arnold on transition systems and of Brzozowski on asynchronous networks. Rabinovitch dealt with dataflow networks. Asynchronous automata have been covered by Diekert, Muscholl, Pighizzini and Zielonka, and their languages, traces, by Badouel, Darondeau, Gastin, Petit and Rozoy.
Only one talk doesn't fit into this concept, namely Kleine Büning's lecture on a new combinatorial equation for trees. However, as this problem was solved in the evenings of our Dagstuhl seminar by Arnold and Kleine Büning in long discussions, we encouraged him to change his lecture into this actual stuff.
As it was one idea of the organizers to connect the main streams, cellular automata, Petri-nets, and asynchronous automata, the lectures had been mixed in order not to have a "trace-day", e.g. The following programme shows the chosen order and the abstracts are ordered as in this programme.
Thanks to Anca Muscholl, who organized this report.

The organizers

Programme

Monday, 11.1.93
W. Thomas (Kiel): Finite-State Acceptors over Graphs and Pictures
J.A. Brzozowski (Waterloo): Asynchronous Behaviors and Fundamental-Mode Realizations
T. Worsch (Karlsruhe): Poly-Finite Automata — a Generalization of One-Dimensional Cellular Spaces
L. Priese (Koblenz): On Very Simple Non-Simple Nets
H.-D. Burkhard (Berlin): Liveness and Fairness Properties in Multi-Agent Systems
P. Starke (Berlin): INA: Integrated Net Analyser
J. Gruska (Hamburg): Systolic Tree and Tree-like Automata

Tuesday, 12.1.93
A. Arnold (Bordeaux): Control and Observation of Transition Systems
A. Rabinovitch (El Paso, Texas): On Schematalogical Equivalence of Dataflow Networks
J. Mazoyer (Lyon): Moving Computing Areas on One-dimensional Cellular Automata
E. Badouel, P. Darondeau (Rennes): Regular Event Structures
E. Best (Hildesheim): Operational Semantics for the Box Algebra
J. Esparza (Hildesheim): Model Checking Using Net Unfoldings
G. Mauri (Milano): Complex Behaviour of Cellular Automata

Wednesday, 13.1.93
V. Diekert, A. Muscholl (Stuttgart): Deterministic Asynchronous Muller Automata
P. Koiran (Lyon): Computability and Complexity with Analog Machines
M. Kwiatkowska (Leicester): Towards a Domain-theoretic Logic for Liveness and Fairness

Thursday, 14.1.93
A. Muscholl (Stuttgart): Complexity Results on Automata over Infinite Traces
H. Umeo (Osaka): A Fault-Tolerant Scheme for Optimum-Time Firing Squad Synchronization
G. Pighizzini (Milano): Synthesis of Asynchronous Automata
P. Gastin, A. Petit (Paris): Recognizable Real Trace Languages and Büchi Asynchronous Cellular Automata
W. Zielonka (Bordeaux): Asynchronous Automata Behaviour and Open Problems

R. Vollmar (Karlsruhe): Some Remarks on the Complexity of Cellular Automata

Friday, 15.1.93
H. Kleine-Büning (Paderborn): On Some Properties of Trees
B. Rozoy (Paris): Star Problem in Trace Monoids: an overview and a small (limit ?) step

Finite-State Acceptors over Graphs and Pictures

Wolfgang Thomas
Universität Kiel

Two approaches to define finite-state acceptors over pictures (rectangular arrays of symbols from a given alphabet) are discussed and shown to be equivalent in expressive power:
(1) graph acceptors as introduced previously by the author (ICALP 1991), which accept a given graph by covering all its local neighbourhoods of fixed radius with "transitions", respecting extra "constraints" on the number of occurrences of transitions.
(2) tiling systems for pictures, introduced by Giammarresi and Restivo, which accept a picture by covering each 2×2-segment with a 2×2-tile from the system.
In both cases, the coverings have to match the underlying graph and additionally define a labelling of its vertices by "states".
The main result states that over pictures the acceptors in the sense of (1) and (2) have the same expressive power, which moreover coincides with that of existential monadic second-order logic.

(Joint work with D. Giammarresi, A. Restivo (Palerm) and S. Seibert (Kiel), supported by EBRA Working Group ASMICS.)

Asynchronous Behaviors and Fundamental-Mode Realizations

John Brzozowski
University of Waterloo

We study input-output behaviors suitable for describing asynchronous sequential circuits. A binary behavior has a finite number of binary inputs and outputs. It may be interpreted as a finite automaton in which the input alphabet has nonempty subsets of the set of all input and output variables as letters. Several useful properties of binary behaviors are considered. In particular, we study a class of "orderly" behaviors and define the concept of a realization of one behavior by another for this class. Next, a logic circuit is modeled as a directed graph, having an excitation function associated with each vertex. An analysis procedure is described for such a circuit; this procedure yields a binary behavior corresponding to the so-called fundamental-mode operation, in which circuit inputs are allowed to change only if the entire circuit is stable. We then define the concept of fundamental-mode realization of a binary behavior by a circuit.

(Joint work with C-J. Seger, Dep. of Comp. Sci., UBC, Vancouver, British Columbia, Canada V6T 1Z2, email: seger@cs.ubc.ca. This research was supported by the Information Technology Research Centre of Ontario, by the Natural Sciences and Engineering Research Council of Canada and by a fellowship from the Advanced Systems Institute.)

Poly-Finite Automata — A Generalization of One-Dimensional Cellular Spaces

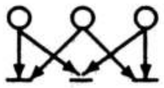
Thomas Worsch
Universität Karlsruhe

Algorithms for cellular spaces (CS) may have the same time and also the same space complexities, but nevertheless differ as far as the actual "computation activities" are concerned. A new model for computation is introduced called *poly-finite automata* (PFA). For it an additional complexity measure, the hardware complexity, can be defined, which allows some formal reasoning about the "degree of parallelism" of (cellular) algorithms. For the smallest and the largest meaningful hardware complexities PFA correspond directly to Turing machines with one head and cellular spaces respectively.
It is possible to prove a rather tight trade-off between time and hardware needed for the recognition of certain formal languages. Using combinatorial and diagonalization methods one can obtain uncountably infinite hierarchies of PFA complexity classes. Because of the relationship between CS and PFA, these results also give further insights into the structure of CS complexity classes.
One can also to generalize problems known from cellular spaces as for example the FSSP. Using an algorithm of Gerken it is possible to find a time optimal solution which needs only a linear overhead in hardware for the synchronization of arbitrary configurations.

On Very Simple Non-Simple Nets

Lutz Priese
Universität Koblenz-Landau

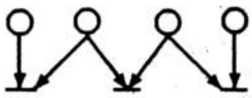
A Petri net $N = (P, E, \cdot)$ is called a *simple net* (SN) iff no event posesses more than one shared input place. It is well-known (Patil, 71), that no SN can simulate the 3-smoker-net, 3-S:



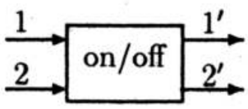
Here, "M simulates N" shall mean that

- $E_N \subseteq E_M$,
- Firesequences(N) = Firesequences(M)$|_{E_N}$,
- concurrent events in N (that are not "conflict connected") have to be concurrent in M, too,
- N is deadlock-free implies that M is deadlock-free.

Let $\mathcal{C}_1 \simeq \mathcal{C}_2$ denote that any net in $\mathcal{C}_1$ can be simulated by some net in $\mathcal{C}_2$, and vice-versa. A *modular net* over $N_1, \ldots, N_m$ consists of copies of the nets N_i, $1 \leq i \leq m$, that may be further connected to the rule, that only same arcs from some events to same places may be added. As a consequence, conflicts in a modular net have to be conflicts in the component-nets, N_i, and any modular net over SN is SN itself. Let MN($N_1, \ldots, N_k$) denote the class of modular nets over $N_1, \ldots, N_k$. It is known, that PN $\simeq$ MN(U), where U is the net

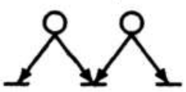
$U =$ 

Here we ask for nets simpler than U s.t. any PN can be simulated by modular nets over SN-components plus those nets. Of course, such candidates cannot be in SN themselves. Let 2-S denote the net represented as an automaton:



$$\begin{array}{c} 1, \text{on} \longrightarrow 1', \text{off} \\ 2, \text{on} \longrightarrow 2', \text{off} \\ \{1,2\}, \text{off} \longrightarrow \emptyset, \text{on} \end{array}$$

and NS the net



Now we can prove that any PN can be simulated by modular nets over SN plus 3-S (or: plus 2-S, or: plus NS). Moreover, in the case of NS livelocks have to be introduced in general, and in the case of 2-S a second token may reach some places. Thus there holds:
PN $\simeq$ MN(SN,3-S)

PN $\simeq$ MN(SN, 2-S), but
1-safe PN $\not\simeq$ 1-safe MN(SN, 2-S),
PN $\simeq$ MN(SN,NS), but
livelock-free PN $\not\simeq$ livelock-free MN(SN,NS).

Liveness and Fairness Properties in Multi-Agent Systems

Hans-Dieter Burkhard
Humboldt-Universität, Berlin

Problems of liveness and fairness are considered in multi-agent systems by means of abstract languages. Different approaches to define such properties for the agents and for a multi-agent system as a whole are discussed. It turns out that the properties of a multi-agent system need not correspond to separately definable properties of the agents (e.g. a community of fair agents need not to constitute a fair multi-agent system). In general, analysis and verification need the consideration of the whole system, and the agents have to be considered in the context of the system, too. The results are not unique, there are different results for deadlock freedom, liveness and fairness, respectively.

INA: Integrated Net Analyser

Peter Starke
Humboldt Universität, Berlin

The Integrated Net Analyser is a program to analyse various kinds of Petri nets with respect to properties such as liveness, boundedness, Deadlock-Trap-Property, etc. A reduction part helps to deal with nets of big size. The methods implemented allow to compute reachability graphs on the one hand and structural conditions on the other (such as coverings with invariants or with state-machine components). An expert system helps to choose only meaningful analysis steps and draws consequences of known properties.
The tool has been demonstrated.

Systolic Tree and Tree-like Automata

Jozef Gruska
Universität Hamburg

The research in the area of systolic automata has recently concentrated on the study of the power of various tree and tree-like networks of identical processors with one-directional, bottom-to-root, flow of data.
In the first part of the talk an overview of the main approaches, methods and results concerning systolic automata over trees and tree-like graphs was presented.
In the second part of the talk the recent results concerning the power of systolic automata over so called Y-trees were presented summarizing contributions of E. Fachini, M. Napoli, M. Parente, A. Maggiolo-Schettini, D. Sagniori and others. (Y-trees can be seen as being obtain form binary trees by adding various horizontal connections between neighbouring nodes without a common father.) Especially results concerning the power of nondeterminism, normal forms and dependencies of closure properties of the family of languages with respect to the structural properties of the corresponding Y-trees.

Control and Observation of Transition Systems

André Arnold
LaBRI, Université de Bordeaux I

Controllability and observability are two fundamental notions in Control Theory. Very roughly speaking, controllability is the posibility to put the system in any given state and observability is the posibility to know in which state the system is.
These notions are well-known for "continuous" systems. A few attempts were made to extend them to "discrete event" systems, i.e. transition systems. Such an attempt was made by Arnold and Nivat [1].
Another one, very promising, is due to W. M. Wonham [2,3,4], who obtains some unconventional results in Automata Theory.
We present the definitions and some of the results of Wonham, in the way they are formulated by A. Bergeron [5].

[1] A. Arnold, M. Nivat. Controlling behaviours of systems: some basic concepts and some applications. MFCS'80.
[2] P. J. G. Ramadge, W. M. Wonham. The control of discrete event systems. Proc. IEEE 77 (1989), 77-81.
[3] F. Lin, W. M. Wonham. On observability of discrete event systems. Information Sciences 44 (1988), 173-198.

[4] F. Lin, W. M. Wonham. Decentralized supervisory control of discrete event systems. Information Sciences 44 (1988), 199-224.
[5] A. Bergeron. (Report in preparation). LACIM, Université du Québec à Montréal.

On Schematalogical Equivalence of Dataflow Networks

Alexander Rabinovitch
University of Texas at El Paso

Dataflow is an important model of concurrency. We provide a simple characterization and a polynomial algorithm for schematalogical equivalence of dataflow networks.

Moving Computing Areas on One-dimensional Cellular Automata

Jacques Mazoyer
École Normale Supérieure de Lyon

We consider one-dimensional cellular automata as a parallel computational device. We consider that such a device computes functions on a finite alphabet. We choose to define inputs as to be injected on diagonal sites (namely, sites $\langle i, i \rangle$), and outputs to be obtained on the first cell.
We observe that computations can be viewed as moves of signals, any signal carrying an associated data. Some signals have an important semantical property: during evolution of a cellular automaton, they set up a grid (which is a twisted trellis automaton). If we define algorithms using moves of data and computation on associated data, such an algorithm does not depend on the basic grid (trellis automaton is the usual case); and if we put this algorithm on another grid, it will have the same behaviour. Such a grid is called a computational area. We investigate how to construct a computational area from another one, and an infinite family of computational areas. This allows us to simulate any recursive function with the following properties:

- moves of signals are independent of the associated data
- composition of functions is achieved in some parallel way
- we never need any synchronization process

- all necessary grids can be set up via a finite automaton.

Regular Event Structures

Eric Badouel   Philippe Darondeau
Université de Rennes

Winskel's Event Structures with binary conflicts and Stark's Trace Automata are in a strong correspondence: they both induce the Event Domains as their ordered sets of configurations. Through that correspondence, Event Structures or more precisely Event Domains may be viewed as unfolded Trace Automata. We define Regular Event Structures as Event Structures that may be associated with finite Trace Automata. We state a necessary and sufficient condition on Event Domains that ensures they correspond with Trace Automata on finite concurrent alphabets. We show the difficulties encountered for strengthening that condition into an independent characterization of Regular Event Structures.

Operational Semantics for the Box Algebra

Eike Best
Universität Hildesheim

The Box algebra has been developed to provide compositional semantics of high level programming contructs into a class of Petri nets with interfaces, called Petri Boxes. The Box algebra is based on Milner's CCS but distinguishes itself from CCS by being more general (allowing, for instance, non-tail-end-recursion) and by featuring an incremental multiway synchronisation device.
This lecture presents a structured operational semantics for the Box algebra. It is shown that the use of equations - which shall also be phrased formally as immediate-rewrite rules - in addition to action rules allows for a uniform theory consisting essentially of a single action rule, a set of context rules, and a set of equations. To axiomatise what is basically the Petri net transition rule we introduce an overbarring and underbarring technique which is closely related to the event systems of Boudol and Castellani. We provide both step sequence rules and partial order rules, and show their consistency (both mutually and with respect to their counterparts from net theory). For the partial order rules we use a modified variant of the proved transitions of Boudol/Castellani and Degano/Priami.

(Joint work with Javier Esparza and Maciej Koutny)

Model Checking Using Net Unfoldings

Javier Esparza
Universität Hildesheim

In (1), McMillan described a technique for deadlock detection based on net unfoldings. We extend its applicability to the properties of a temporal logic with a possibility operator. The algorithm is based on Linear programming. It compares favourably with other algorithms for the class of deterministic concurrent systems.

(1) K.L. McMillan: Using unfoldings to avoid the state explosion problem in the verification of asynchronous systems. Proceedings of the 4th Workshop on Computer Aided Verification, Montréal, pp. 164 - 174 (1992)

Complex Behaviour of Cellular Automata

Giancarlo Mauri
Università di Milano

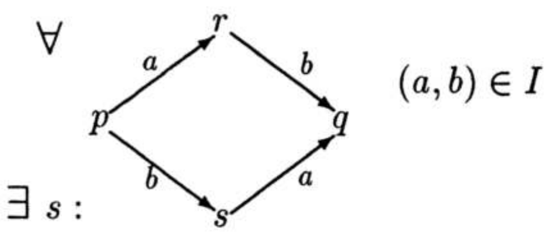
In this paper a class of boolean one-dimensional, Cellular Automata has been studied observing the behaviour of the automata when some parameters of the local function are changed. These automata are equivalent to a particular class of boolean Neural Networks and the change in the parameters corresponds to a change in the symmetricity of their connection matrix. The purpose was to analyse the different dynamics beginning with a symmetric weight matrix and moving towards an antisymmetric one. In this study we have observed simple dynamics in correspondence to the symmetric situation and more and more complex behaviours approaching the antisymmetrical case.

(Joint work with P. Flocchini, G. Braga and G. Cattaneo (Milano)).

Deterministic Asynchronous Muller Automata

Volker Diekert Anca Muscholl
Universität Stuttgart

We show the equivalence between the family of recognizable languages over infinite traces and the family of languages which are accepted by some asynchronous (cellular) Muller automaton. Thus, we give a proper generalization of McNaughton's Theorem from infinite words to infinite traces. Thereby we solve one of the main open problems in this field. As a special case we obtain that every word language which is closed w.r.t. some independence relation I can be accepted by some I-diamond deterministic Muller automaton.



(I-diamond property)

(To appear at STACS 93, Würzburg, work supported by ASMICS)

Computability and Complexity with Analog Machines

Pascal Koiran
École Normale Supérieure de Lyon

It has been known for a short time that a class of recurrent neural networks has universal computational abilities. These networks can be viewed as iterated piecewise-linear maps in a high-dimensional space. I explained why similar systems in dimension two are also capable of universal computations. On the contrary, it is necessary to resort to more complex systems (e.g., iterated piecewise-monotone maps) in order to retain this capability in dimension one.
If the computations are performed with infinite precision on arbitrary real numbers, like in the model of analog computation recently proposed by Hava Siegelmann and Eduardo Sontag, it is possible to compute all functions (even nonrecursive ones) in exponential time, and the class of polynomial-time computable functions is exactly P/poly.

Towards a Domain-theoretic Logic for Liveness and Fairness

Marta Kwiatkowska
University of Leicester, Imperial College London

Abramsky's "domain theory in logical form" considers a logical interpretation of SFP domains. It comprises: a (standard) metalanguage for denotational semantics; a (standard) interpretation of the metalanguage; a (new) logical interpretation as a "domain prelocale" (a weak second order axiomatic system, which is essentially a distributive lattice), and a statement of Stone duality between the two interpretations. The Stone duality allows to interpret logical formulas as the (Scott) compact-open subsets of the domain. We observe that this is very restrictive, as it does not allow for properties such as liveness and fairness, which correspond e.g. to general opens or G_δ sets, to be expressed. We therefore consider an extension of Abramsky's framework with minimal and maximal fixpoints. Following the work of Park [79], where it has been shown that fairmerge can be expressed as a suitable combination of the minimal and maximal fixpoints, but that either fixpoint on its own does not suffice, we propose to extend the domain prelocale with the minimal fixpoint μ, the maximal fixpoint ν, and allow their alternation. While the hierarchy of fixpoint formulas defining infinitary word languages terminates after two levels, the results of Niwinski [86] sugest that in general one should expect an infinite hierarchy.

Complexity Results on Automata over Infinite Traces

Anca Muscholl
Universität Stuttgart

Given a finite dependence alphabet (Σ, D), then an (in)finitary word language $L \subseteq \Sigma^\infty$ is called *closed* (w.r.t. (Σ, D)), if whenever $u, v \in \Sigma^\infty$ denote the same trace, then $u \in L$ if and only if $v \in L$.
Based on the classical notion of monoid automaton, we consider the corresponding automaton for traces. For finite traces, this yields automata with the I-diamond property.
In this talk we investigate the problem whether the language accepted by an I-diamond nondeterministic Büchi (resp., deterministic Muller) automaton is closed. The given characterizations lead to the following result: the closure problem in the Büchi case is PSPACE complete, whereby in the Muller case it is NLOG complete (w.r.t. the size of the automaton). This yields a weak blow-up result as a lower bound for determinization of Büchi I-diamond automata, in the

sense that the size of an equivalent deterministic Muller I-diamond automaton is at least exponential.

A Fault-Tolerant Scheme for Optimum-Time Firing Squad Synchronization

Hiroshi Umeo
Osaka Electro-Communication University, Japan

The famous firing squad synchronization problem [Mo64] is stated as follows: Given an array of n identical cellular automata, including a "general" at the left end which is activated at time $t = 0$, we want to design the automata so that at some future time all the cells will simultaneously and for the first time enter a special "firing" state. A lot of results have been developed. [Wa66] and [Ba67] have given an optimum-time firing squad synchronization algorithm, each having 16 and 8 states in each cell, respectively. Some researchers [RoFH73], [Ro77], and [Sz82] developed firing squad synchronization algorithms for two- and three-dimensional arrays, tree- and graph-structured networks. [Vo82] introduced a new measure called "number-of- state-changes of cellular automata" and showed that $\Omega(n \log n)$ state change was necessary for the synchronization. [Ma87] and [Ge87] explored the minimal-state optimum-time firing squad synchronization algorithm.
In this paper we consider this classical problem from an another view point of fault-tolerance. Several fault-tolerant nearly time-optimum firing squad synchronization algorithms are developed for one-dimensional cellular arrays. Main theorems are as follows:

[Theorem 1] Let A be an array with p faulty regions, where $n_i \geq m_i$, for any i, $1 \leq i \leq p$ and p be fixed integer. We can construct a fault-tolerant $(2n-2)$-step optimum-time firing squad synchronization algorithm for A.

[Theorem 2] Let A be an array with p faulty regions such that $n_i \geq m_i$ and $n_i + m_i \geq p - i$ for any i, $1 \leq i \leq p$ and p be any integer unknown to each cell. We can construct a fault-tolerant $(2n - 2 + p)$-step nearly optimum firing squad synchronization algorithm for A.

Synthesis of Asynchronous Automata

Giovanni Pighizzini
Università di Milano

We present a new Kleene-like characterization of the class of recognizable trace languages and we use it in order to state a modular synthesis algorithm for asynchronous automata.
While all known synthesis algorithms for asynchronous automata produce *determistic* automata of superexponential size, this new algorithm is useful to build *nondeterministic* asynchronous automata of polynomial size.

Recognizable Real Trace Languages and Büchi Asynchronous Cellular Automata

Paul Gastin — Université Paris 6
Antoine Petit — Université Paris-Sud

Real traces have been naturally defined as an extension of Mazurkiewicz traces in order to modelize non-terminating concurrent processes.
As in any monoid, recognizable languages describe the finite-state processes and form hence one of the basic family. We present a brief survey of existing characterizations of recognizable languages of real traces. We emphasize in particular on the automata characterizations. Given a recognizable real trace language, there exists only global construction of a Muller Asynchronous Cellular Automaton recognizing this language. On the contrary, a modular construction from particular c-rational expressions can be used to obtain (non-deterministic) Büchi Asynchronous Cellular Automata.
Finally, we propose some open problems and possible extensions in this area. We present in particular the problems which arise when one considers non-deterministic Büchi I-diamond automata.

Asynchronous Automata Behaviour and Open Problems

Wiesław Zielonka
Université de Bordeaux I

In the talk we present a general definition of asynchronous automata (the various types of asynchronous automata used up to now constitute a special narrow subcase of this general definition). We present open problems that arise in the general case where unidirectional communication is possible (in all previous models the communication was bidirectional). The equivalence between various classes of asynchronous automata is established. At the end we mention some problems concerning fairness in this model.

Some Remarks on the Complexity of Cellular Automata

Roland Vollmar
Universität Karlsruhe

A short survey of different types of complexities which may help to gain a better understanding of cellular automata is given:

- structural complexity
- dynamical complexity
- phenomenological complexity

In the first section well-known standardization results are quoted. This area is rather well elaborated but in most cases optimal results are missing.
Concerning the dynamical complexity even the languages recognizable in real time by (real space) cellular automata form a large class (which is not congruent with any other known class of languages). Therefore an additional complexity measure, state change complexity, is considered which generates some hierarchies.
In the eighties S. Wolfram started investigations, mainly statistical ones, to classify some of the simplest classes of cellular automata. Hints to the difficulties which arise are given and other approaches are sketched; some results of H. Rust obtained by analytical methods are presented.

Star Problem in Trace Monoids: an overview and a small (limit ?) step

Brigitte Rozoy
Université de Paris-Orsay

A trace monoid is the quotient of a free monoid by the congruence generated by some irreflexive and symmetric relation defined on the alphabet (which is the independence relation).

The families of recognizable (resp. rational) sets in a monoid are the families of languages recognized by finite automata (resp. closed under $\cdot, +, *$ and containing finite sets).
It happens that trace monoids are not closed under the star operation. Necessary or sufficient conditions are known for a recognizable language L to be such that L^* is recognizable.
We address the decidability of the star problem: let L be recognizable, is L^* recognizable?
We prove that this problem is decidable when the monoid is a direct product of free monoids $A^* \times \{b\}^*$. This result shows for the first time and contrary to possible intuition, that the star problem and the recognizability problem are of distinct nature.

(Joint work with E. Ochmanski (Warsaw), P. Gastin, A. Petit (Paris))

On the Average External Path Length of Trees

Hans Kleine Büning
Universität Paderborn

The average (external) path length of a tree is the sum over the length of all path from the root to a node (leaf) divided by the number of nodes (leafs). We show that for arbitrary trees the average external path length is less or equal twice the average path length.

Dagstuhl-Seminar 9302: List of Participants

André **Arnold**
Université Bordeaux I
Laboratoire Bordelais de
Recherche en Informatique
351 Cours de la Libération
F-33405 Talence Cedex
France
arnold@labri.greco.pog.fr
tel.: +33.56.84.60.94

Eric **Badouel**
Université de Rennes
IRISA
Campus de Beaulieu
Avenue du Général Leclerc
F-35042 Rennes Cedex
France
eric.badouel@irisa.fr

Eike **Best**
Universität Hildesheim
Institut für Informatik
Marienburger Platz 22
W-3200 Hildesheim
Germany
e.best@informatik.uni-hildesheim.de
tel.: +49-5121-883-741/0

Wilfried **Brauer**
TU München
Institut für Informatik
Postfach 202420
W-8000 München 2
Germany
brauer@informatik.tu-muenchen.de
tel.: +49-89-21 05-24 01/02/0/4/06

John **Brzozowski**
University of Waterloo
Department of Computer Science
Waterloo Ontario N2L 3G1
Canada
brzozo@watmath.uwaterloo.ca
tel.: +1-519-888-44 41

H. Dieter **Burkhard**
Humboldt Universität
Fachbereich Informatik
Clara-Zetkin-Str. 26
O-1086 Berlin
Germany
hdb@informatik.hu-berlin.de
tel.: +49-30-203-15-3 02

Philippe **Darondeau**
Université de Rennes
IRISA
Campus de Beaulieu
Avenue du Général Leclerc
F-35042 Rennes Cedex
France
darondeau@irisa.fr
tel.: (33) 99 84 72 80

Volker **Diekert**
Universität Stuttgart
Institut für Informatik
Breitwiesenstraße 20-22
W-7000 Stuttgart 80
Germany
diekert@informatik.uni-stuttgart.de
tel.: +49-711-78-16 3 29

Javier **Esparza**
Universität Hildesheim
Institut für Informatik
Samelsonplatz 1
W-3200 Hildesheim
Germany
esparza@informatik.uni-hildesheim.de
tel.: +49-5121-883-7 44

Paul **Gastin**
Université Paris VI
LITP
Institut Blaise Pascal
4 Place Jussieu
F-75252 Paris Cedex 05
France
gastin@litp.ibp.fr
tel.: +33-1-44.27.53.91

Jozef **Gruska**
Universität Hamburg
FB Informatik
Vogt-Kölln Str. 30
W-2000 Hamburg 54
gruska@informatik.uni-hamburg.de
tel.: +49-40-54715-2 42

Günter **Hotz**
Universität des Saarlandes
Fachbereich Informatik
Am Stadtwald 15
W-6600 Saarbrücken 11
hotz@cs.uni-sb.de
tel.: +49-681-302 2414

Hans **Kleine-Büning**
Universität-GHS-Paderborn
Fachbereich 17
Warburger Straße 100
W-4790 Paderborn
Germany
kbcsl@uni-paderborn.de
tel.: +49-5251-60-33 61

Pascal **Koiran**
Ecole Normale Superieure de Lyon
Laboratoire LIP/IMAG
46 allee d'Italie
F - 69364 Lyon Cedex 07
France
koiran@lip.ens-lyon.fr
tel.: +33-72 72 81 52

Marta **Kwiatkowska**
University of Leicester
Department of Mathematics and Computer Science
Leicester LE1 7RH
Great Britain
mzk@mcs.le.ac.uk
tel.: +44-533-52 36 03

Giancarlo **Mauri**
Universita di Milano
Dipartimento di Scienze dell'Informazione
Via Comelico 39
I-20135 Milano
Italy
gmauri@ghost.dsi.unimi.it
tel.: +39-2-55 00 62 29

Jaques **Mazoyer**
Ecole Normale Superieure de Lyon
Laboratoire LIP/IMAG
46 allee d'Italie
F - 69364 Lyon Cedex 07
France
mazoyer@frensl61.bitnet
tel.: +33.72.72.83.81

Anca **Muscholl**
Universität Stuttgart
Institut für Informatik
Breitwiesenstraße 20-22
W-7000 Stuttgart 80
Germany
muscholl@informatik.uni-stutgart.de
tel.: +49-711-7816 491

Maurice **Nivat**
Université Paris VII
LITP
Institut Blaise Pascal
2 Place Jussieu
F-75251 Paris Cedex 05
France
tcsmn@litp.ibp.fr
tel.: +33-1-44 27 68 45

Antoine **Petit**
Université Paris Sud
Laboratoire de Recherche en Informatique
Bât 490
F-91405 Orsay Cedex
France
petit@lri.lri.fr
tel.: +33-169.41.66.09

Giovanni **Pighizzini**
Universita di Milano
Dipartimento di Scienze dell'Informazione
Via Comelico 39
I-20135 Milano
Italy
pighizzi@imiucca.csi.unimi.it
tel.: +39-2-55-00 63 03

Lutz **Priese**
Universität Koblenz-Landau
Fachbereich Informatik
Rheinau 3-4
W-5400 Koblenz
Germany
priese@uni-koblenz.de
tel.: +49-261-9119-414 (432)

Alexander **Rabinovitch**
University of Texas at El Paso
Department of Computer Science
El Paso TX 79968
USA
alex@cs.ep.utexas.edu

Brigitte **Rozoy**
Université Paris Sud
Laboratoire de Recherche en Informatique
Bât 490
F-91405 Orsay Cedex
France
rozoy@lri.lri.fr
tel.: +33-1-69.41.66.09

Peter **Starke**
Humboldt Universität
Fachbereich Informatik
Clara-Zetkin-Str. 26
O-1086 Berlin
Germany
starke@informatik.hu-berlin.de
tel.: (030) 20315310

Wolfgang **Thomas**
Universität Kiel
Institut für Informatik
Olshausenstraße 40
W-2300 Kiel 1
Germany
wt@informatik.uni-kiel.dbp.de
tel.: +49-431-880-44 80

Hiroshi **Umeo**
Osaka Electro-Comm. University
Faculty of Engineering
Neyagawa-shi
Osaka 572
Japan
umeo@umeolab.osakac.ac.jp
tel.: +81-720-24-11 31

Roland **Vollmar**
Universität Karlsruhe
Lehrstuhl Informatik für Ingenieure
und Naturwissenschaftler
Am Fasanengarten 5
W-7500 Karlsruhe 1
Germany
vollmar@ira.uka.de
tel.: +49-721-608-43 12

Thomas **Worsch**
Universität Karlsruhe
Lehrstuhl Informatik für Ingenieure
und Naturwissenschaftler
Am Fasanengarten 5
W-7500 Karlsruhe
Germany
worsch@ira.uka.de
tel.: +49-721-608-43 11

Wieslaw **Zielonka**
Université Bordeaux I
Département d'Informatique
351 Cours de la Libération
F-33405 Talence Cedex
France
zielonka@geocub.greco-prog.fr
tel.: +33-56 84 69 08

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