ALAPEDES

THE ALGEBRAIC APPROACH TO PERFORMANCE EVALUATION OF DISCRETE EVENT SYSTEMS

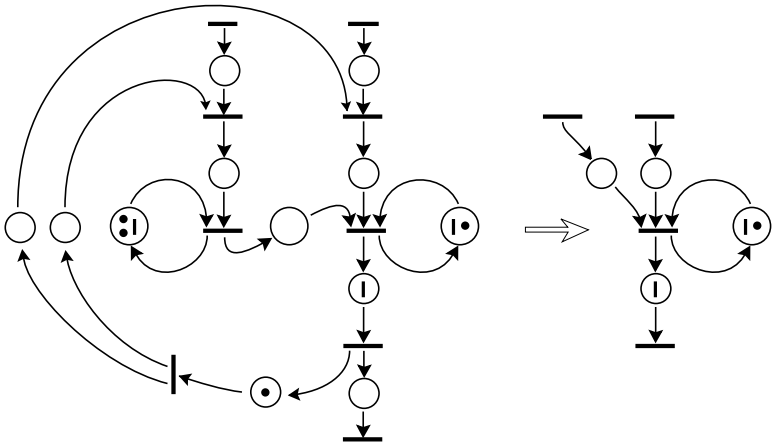
PROJECT OVERVIEW

The theory of discrete event systems (DES) deals with dynamic systems that are event-driven as opposed to time-driven.

Unlike in the classical systems theory it is not the behaviour in time which is being described, but it is the timing and ordering of events that is important in discrete event systems. Thus questions are being studied like: 'Can certain sequences of events being realised or avoided?' and 'How often do certain events occur?'.

Though older traces exist, the real breakthrough of the theory came in the mid-eighties. It was and is stimulated by the development of new technological and/or 'man-made' manufacturing systems, communication networks, transportation and logistic systems. Nowadays a discrete event systems theory exists, which parallels the classical linear systems theory in several ways. The relationship with (timed) Petri nets and stochastic extensions are well understood.

The project has three objectives: 1. a cross fertilization on the theoretical level; 2. applications; and 3. software development. Each of these objectives induced a number of subprojects. With respect to applications, these subprojects are transportation systems, manufacturing systems and communication networks. Within each of the three objectives, the training component of the appointed young researchers is an essential aspect.



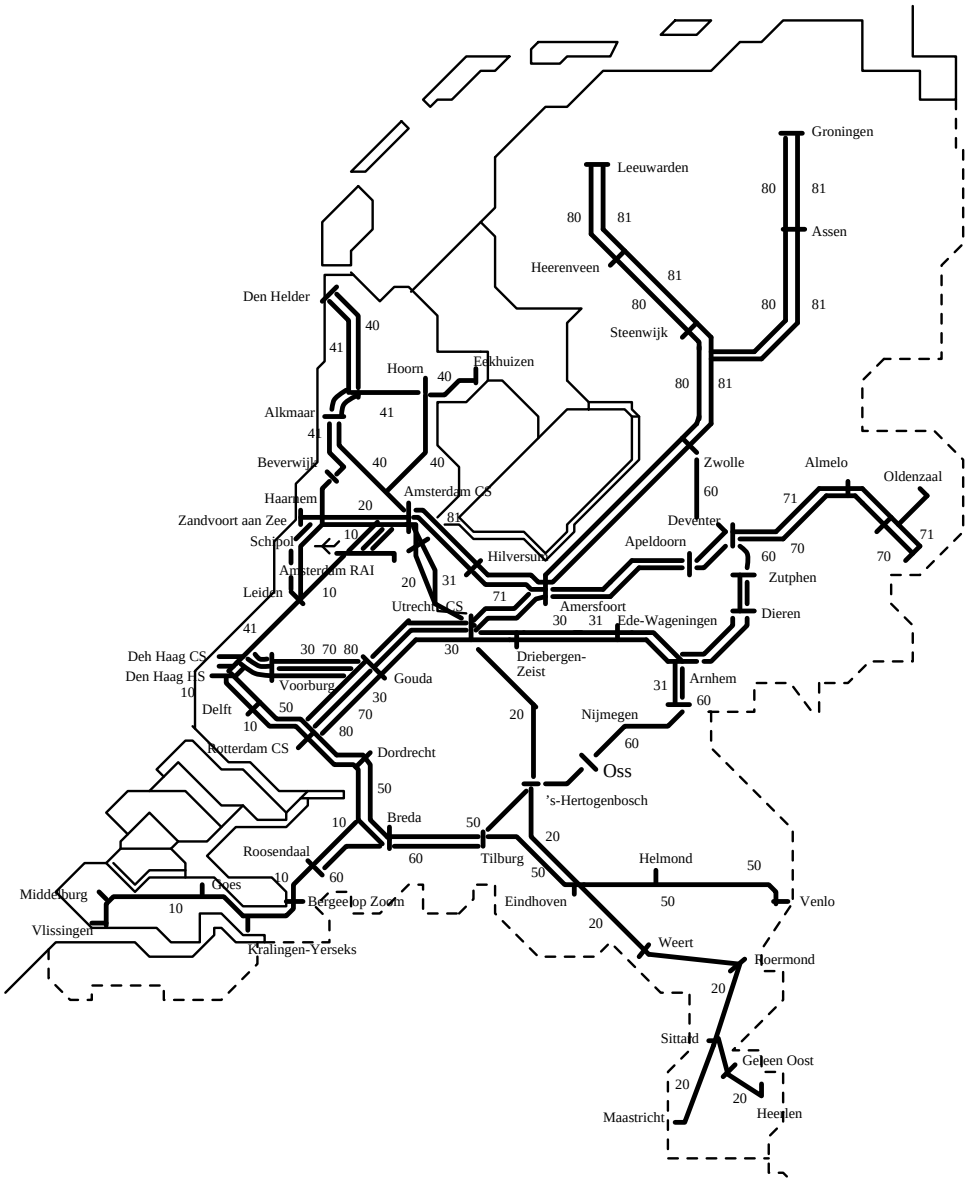
Cyclic behaviour in e.g. production lines can concisely be described by Petri nets.

PARTNERSHIP

The primary objective of the project is to bring together active European groups working on the algebraic approach to the (temporal) analysis of discrete event systems, in order to deepen their mutual understanding and to cross-fertilize the techniques which they currently develop. The expertise of the partners can be split up into two main streams.

- The ‘logical’ approach, based on automata and formal languages, in which only the precise *ordering of the events* is of interest; this ordering must satisfy a given set of specifications imposed on it. The theory addresses the synthesis of controllers (‘supervisors’) for DES in order to satisfy a set of (qualitative) specifications. LITP (Paris) has developed extended theoretical research on the formal aspects of automata theory and semigroups, including idempotent semirings. At the RUG (Groningen) supervisory theory and traces are studied. At HP (Bristol) one studies automata, control and identification problems in communication networks. At ULG (Liège) a small research group on DES has recently been launched, with amongst others an interest in automata theory and software development.

- The ‘timed’ or max-plus algebra approach, in which, in addition to the ordering, the *timing of the events* plays an essential rôle. The starting point is a ‘linear’ model, linear in the sense of the so-called max-plus algebra. INRIA (Rocquencourt) and ARMINES (Paris) own a lot of expertise on fundamental aspects of such systems. At INRIA (Sophia-Antipolis) the emphasis is on stochastic aspects and the relationships with queuing theory. At TUD (Delft) explicit experience exists with applications to time tables of railway systems. KUL (Leuven) is specialized in numerical approaches. HP (Bristol) has a lot of expertise on algebraic idempotent methods and their relations with nonexpansive mappings.



The Netherlands intercity railway network. Modelled in a max-plus framework cycle times and bottlenecks can be identified.

POTENTIAL APPLICATIONS

ALAPEDES hopes to demonstrate the industrial relevance of the new algebraic approach. This will be based on the extension of ongoing industrial contacts of some of the partners and on the partnership of HP (Bristol). The following three areas offer good opportunities for applications.

- **Transportation systems** (optimisation of railway scheduling). The relation between railway connections and time tables has already quite successfully been described by means of the max-plus algebra. The propagation of disturbances in the system is also well understood.
- **Manufacturing systems** (resource optimisation in production lines). In the field of manufacturing systems, we are interested in performance evaluation and resource optimisation of flexible workshops. Once the design and the performance of resources (machines, storage capacities, human resources), and scheduling policies (routing, priorities) are fixed, the problem of performance evaluation reduces to that of a synchronized system modelled as a DES.
- **Communication networks**. Important automata, control and identification problems in communication networks can also be approached within the max-plus algebraic framework.

TRAINING ASPECTS

ALAPEDES will fund 335 man-months of employment of young researchers with an opportunity to (further) specialize in discrete event systems theory. Ideally such young researchers should change their 'home base' at least once, i.e. they will work for a longer time in at least two research teams of ALAPEDES. These young researchers will learn about theoretical developments (mainly mathematically oriented), applications of the theory of DES, as well as software developments. The theoretical developments certainly include mathematical disciplines related to algebra, probability theory and linear systems theory.

Contract reference

ERB-FMRX-CT-96-0074

Coordinator

1. Prof. Geert Jan OLSDER
   Technische Universiteit Delft
   Fac. Technische Wiskunde en Informatica
   Postbus 5031
   2600 GA DELFT
   Nederland
   Tel. +31 15 2781912
   Fax +31 15 2787209
   E-mail g.j.olsder@math.tudelft.nl

Other participants

2. Guy Cohen – ARMINES (ENSMP/CAS), Fontainebleau (F)
3a François Baccelli – INRIA (Mistral), Sophia-Antipolis (F)
3b Jean-Pierre Quadrat – INRIA (META2), Le Chesnay (F)
4. Bart De Moor – KU Leuven (ESAT-SISTA), Leuven (B)
5. Jeremy Gunawardena – Hewlett Packard (BRIMS), Bristol (GB)
6. Daniel Krob – Université Pierre et Marie Curie (LITP), Paris (F)
7. Rein Smedinga – Rijksuniversiteit Groningen, Groningen (NL)
8. Vincent Blondel – Université de Liège (MATHAPP), Liège (B)

Starting date

1 October 1996

Duration

48 Months