STATE OF THE ART AND TRENDS IN DESIGN AUTOMATION IN ITALY.

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INTRODUCTION

A paper, which wants to deal, in the most comprehensive way, about the state of the art in Italy of Design Automation, that is a field which has a direct impact with the industrial reality of the country, presents some difficulty in the acquisition of the informations, which often are confidential or secret.

Therefore most of the informations, on which this paper is based, are from the open literature, and therefore report the situation of one or two years ago.

The topics, which are dealt in this paper, are subdivided in two sections. In the first section the classical problems of D.A. are reviewed: logic synthesis; partitioning, placement and routing; wiring; logic simulation and fault test generation and diagnosis.

The second section deals with the problems developed in non electronic companies, as motor companies, for what concerns the design of car bodies and dies, building companies, for what concerns the design of ferro-concrete structures and naval building companies, for what concerns the design of hulls.

At least, the authors wish to apologize if some activity, in D.A. has not been considered, even if they have tried to make the maximal effort in getting informations from the largest number of companies.

1. DESIGN AUTOMATION OF DIGITAL SYSTEMS.

1.1 Logic Synthesis.

The activity in this field has developed principally at the I.E.I. of National Council of Research in Pisa by G.B. Gerace [1]. He has studied a language for the description of digital systems which allow the automatic synthesis of the Operating part and Control part of a system as a network of sequential machines.

Moreover it has been implemented by I.E.I. and the Istituto Elettrotecnico Nazionale "Galileo Ferraris" of Torino the TOPI Computer [2] [3] for the solution of the following problems:

a) Determination of the prime implicants of boolean functions of no more than 15 variables.
b) Classification of the prime implicants in classes of essential prime implicants of first and second order and absolutely eliminable ones.
c) Determination of one or more irredundant normal forms of the switching function.

Relating to these problems E. Morreale [4][5][6][7] has developed an efficient implementation of the Quine-McCluskey algorithm for the covering of switching functions.

1.2. Partitioning placement and routing.

These problems have been largely studied in the companies due to the direct impact they have on the production of printed circ. boards and of masks for integrated circuits. Moreover the interest has been stimulated by the first Lee-like algorithms which were computer implementable and by the availability of systems (UNIVAC 1108-IBM 360) capable of support them.

The first experimental study of the algorithms has been, at our knowledge, developed at the Politecnico of Milano [8][9][10], and has been followed by the activities at the University of Genova [12], [13] and at I.E.I. of Pisa [15][16]. The research at University of Genova has centered on the theme of placement of LSI circuit elements: at first, attention was focused to the problem for elements of any shape, then elements arranged along stripes were considered. At I.E.I. of Pisa has been considered the problem of the automatic design of P.C. boards for what concerns the placement of I.C. on P.C. boards and the tracing among the pins of the modules. The proposed procedure has the advantage of being supported by a limited amount of memory space and computing time, and it is implementable on small computers.

The first industrial steps in this field were made at Olivetti [17], where, little before 1970, a complete D.A. System for the realization of P.C. boards was designed. Such system was implemented on IBM machines and was composed of:

- a topological input language with the description of the circuit at gate level
- creation of a data bank of the printed board.
- dinamic simulation programs
- programs for partitioning, placement and routing
- production of paper tapes for wiring, and component insertion
- documentation

In 3/4 years the leading companies in the field (SGS, SIT-Siemens, Telettra and Selenia) settled teams so to create their own system for D.A. However afterward the initial trend in large packages towards completely automatic D.A. systems has been reconsidered. Actually, despite the implementation of new algorithms, the availability of powerful computer systems, and the possibility of experience exchanges, till now it has happened that the problem of the automatic tracing of P.C. boards, quite apart a research point of view, in the industrial reality, imposes such severe limitations to the electrical and topological carachteristics of the circuits that it can be employed cheaply only where a great standardization and low technological innovations are present.

Therefore in Italy, even if algorithms are studied and packages for placement and routing are experienced, semiautomatic digitalization systems has been placed in the documentation rooms. And as Italians are known for their individualism and as the number of companies is slightly superior to the available digitalization

systems, in a case (Selenia) the system has been ad hoc designed [19] and in another (FIAT) an interactive graphic package implemented on minicomputer and graphic display of refresh type has been chosen.

This shows that even for a very known module like P.C. board, the different applications (and the different history of the companies) condition the dimension, the packaging and the type of components etc., such that it is impossible the standardization of the design and production phases.

However the digitalization systems are not but the first step. The following step of the companies, which have experienced and the automatic system and the one with digitalizators, is to link in a brief time the two systems, making therefore a trade off between the high computational speed of big computer systems and the decision capability of man.

At long term the third step will be the linkage of graphic displays managed in groups by a real-time minicomputer linked to a central computer system.

1.3 Wiring.

The use of numerically controlled (N.C.) machines for the wiring of the leads in the back panels and their automatic test of quality is nowadays a common thing. Therefore the different Italian companies have implemented the packages for the generation of punched paper tapes and of documentation. The reliability of the wire-wrap (w.w.) techniques and the tecnique for fixing the pins on the support of the P.C. boards by the same side of the components, makes the wiring by w.w. be used even for bread-board cards, low production prototype, and therefore is in many cases a real alternative to P.C. boards. In Selenia, as an example, the central services guarantee to the designers a week execution time among the reception of the electric schema of the circuit (tipical or I.C.) and the wired card.

Naturally automatic wiring does not means only to study algorithms for the connection of the components but it means to study languages for the coding and the check of the input data, to create libraries for connectors, formats, back panels, and therefore to create and manage data bases.

1.4 Logic simulation, fault test generation and diagnosis.

As the preceeding topic, the simulation of logic circuits and the fault detection are topics which have stimulated the researchers, as it offered a field not yet very investigated, and the companies as they are techniques which can bring to many savings in the production phase. The research teams which, in Italy, are more active in the field are the I.E.I. of Pisa and the Politecnico of Torino.

In the companies, original research is developed in Olivetti Telettra and SIT.Siem particularly in the field of dynamic logic simulation and in fault test generation. In this field the systems which are used are composed by gate level simulators with three levels in which the components are described in groups of logic elements (NAND, NOR, etc) and in some cases of more complex logic elements (POM, SHIFT, etc.).

The simulators which are used in Italy

can handle circuits made by 1500-2000 gates. However it is felt the necessity to handle more complex logic with a greater number of equivalent gates. At this aim studies are in progress in Telettra and Selenia. The aim is to be able to test not only logic circuits at module level, but also at unit level. These systems run in batch mode on big computer systems, as the packages need a great amount of memory space and need high execution times. Studies are in progress to make them interactive, expecially in Selenia. The problems which are faced are: the coding and the editing of the data relative to the logic network in a user oriented way; the execution times must be less; the presentation of the data of simulation in user oriented way. In the field of register transfer languages the work is at an experimental level. There is no original work, but only studies on appliability of existing languages and packages. In Selenia the language CDL for verifying the microprograms of a processor for a naval computer system has been used.

A field which is very actively pursued in Italy is the one of self-diagnosis. Concrete applications has been realized in Olivetti [23] [24] for desk calculator, in Honeywell Information System of Italy [25], [26] [27] for process control systems, in Telettra for electronic switching systems and in Selenia for processors for radars.

This field is largely pursued at the I.E.I. of Pisa for what concern the theoretical models of self diagnosis [28] [29] [30] [31]. This topic is generally confidential, and there is not a great lot of open literature.

1.5 Tools, interactive graphic devices etc. for D.A..

In the definition of techniques and D.A. systems, the tools and the components of the system are very important, that is techniques for C.A.D., languages, media for man-machine interaction, instrumentation, I/O devices etc.

Particularly the role with which man uses or "converses" with the computer system, together with the way of the resolution of the problem of the user, more than the algorithm quality, conditions the good or bad result of a D.A. System.

Therefore there is a trend in decentralization of D.A. systems, for what concerns and the study promotion and the final users of the system. Since some years the naive computer system concept has been introduced.

The new implementations, sometimes spectacular, in the field of technology of mini or micro computer and of memory, together with the lot of peripherals and the time-sharing systems on big computer systems, induce to decentralize the D.A. systems towards the user, at least for what concerns the man machine interfaces. Moreover the grow in power of minicomputer will allow the running of D.A. packages on them, while till now they were only implemented on big computer systems.

This is a very actual trend in Italy. Worthy is the realization in FIAT of the network STU (Stazione Terminale Universale) [34] which is an intelligent terminal organized with a minicomputer under DOS with emulation ability of batch terminals Univac IBM, CDC, and able to drive all the existing

peripheral units, from tablets to plotters from magnetic units to displays.

In Selenia it is in progress the realization of a similar terminal in a modular way and able to drive the peripherals in real time (RTS).

In the field of interactive graphics great effort is in Fiat where it has been set a Computer Aided Design Laboratory [35] composed by a PDP 15/40 of 32 k of 18 bits linked to an ADAGE Graphic Terminal AGT-130 of 16 k of 30 bits, disks, tapes, a Tektronix 4002 A alphanumeric dispaly and a full set of conventional displays and computer peripherals. All this is connected to a Univac 1108.

Other applications of the CAD Laboratory have been made in the field of design of electrical schemata [36], of plant layout etc.

2. DESIGN AUTOMATION IN OTHER FIELDS.

As D.A. is most of all a goal aimed to reduce, possibly eliminate, the repetitive and not creative work, D.A. techniques can be applied in other fields different from the traditional one of logic circuits.

Therefore in the following these new fields will be reviewed.

2.1 Design of Car Bodies and Dies.

Mechanical Engineering applications reported to date include:

1) interactive curve fitting for surface description;
2) design of mechanical parts and graphic generation of the cutter paths for N.C. machines;
3) interactive structural design of automobile bodies and frames using analysis of strenghts and deformations.

The effort, expecially made in FIAT [41] [42], has been towards the introduction of some degree of automation in the design phase of car bodies.

The package which must be developed must be necessarily interactive due to the creative factors the stylist need to impose in the design.

Moreover such package must be very flexible in the management of peripheral units.

In fact due to the tridimensionality of the shapes, peripheral equipments are needed of the type of two or three dimensional digitizers, plotters, CRT displays with joystick or light pen, model cutting N.C. machines etc., while the handling policies vary from simple data acquisition or moving head positioning, to very sophisticated automatic countoring or line following policies. Moreover an appropriate combination in the use of such devices and handling policies can grant a very convenient degree of interactivity to the system.

The system which is developed in FIAT is along these lines and is named P.A.C.S. an abbreviation that stands for Automatic Design and Manufacturing of Car Bodies and Dies.

2.2 Civil Engineering.

In the Civil Engineering industry C.A.D. procedures are used in various degree. The applications here described refer to means for error free preparation of input data, to the design of structures either in semi concrete cement or in steel and to the graphical rapresentation of output results.

To be specific mention is made to the C.A.D. in RDB a manufacturer of prefabricated structures and to CDA an engineering design service bureau.

In the past years in RDB a set of programs has been developed for the analysis, design, detailing and rescheduling for reinforcement and production of reinforced concrete structures.

CDA has developed packages for structural analysis in two and three dimensions which starting from the input contractual specification data arrive to a complete detailed structural design. The mathematical approach taken is based upon the stiffness method with the ability of subdividing a structure in substructures via the definition of the rigidity at the boundary points or joints. This subdivision method greatly reduces the computing time and, most importantly, allows the analysis of very large structures.

These programs are widely used in several design procedures. As an example let us consider the design of a truss. From a general specification of the truss as input data, the package computes a detailed structure layout which takes into account manufacturing and mounting requirements as well as the structural specifications concerning allowed stresses (σ_{max}, τ_{max}, bearing stresses and various cases of instability analysis). At various stages of the computations, logic consistency of the data is verified in order to avoid useless computations.

These programs are in daily use for the design in the field of metallic carpentry, of industrial hangars, power stations, chemical plants, electrical lines, telphers, etc., in the field of ferroconcrete structures, of buildig structures, beams and bridges for viaducts, and in the field of electrical machines (transformers, motors, etc.)

2.3 Naval Engineering.

In the field of naval shipbuilding one of the leading activity in C.A.D. techniques is that of ITALCANTIERI.

In this company structure stress analysis using packages like SESAM and NASTRAN have been augmented by graphical means of data output. Projects in progress are dealt with the AUTOKON software package which was acquired outside the company. The existing procedure comprises today the field of structural drawing, the specification of raw materials, the N.C. supports for machines and the workshop documentation.

It operates on three data bases: a) design data bases, b) raw material data bases, c) workshop data bases. Sheet metal cutting is also digitally handled via N.C. machines.

Software packages help the preparation of the "basic system components" and the design of the ship electrical system layout. For what concerns the piping, the procedure which is nowadays used gets its topographic input data by a semi automatic procedure (coordinate reader) from several general arrangment drawings and works them out by an interaction with the standard material data base till all material flow documentation and workshops data are obtained. These data supplies all informations necessary for the working both graphic and digital for the already automated lines with N.C. building machines.

Future plans refer to interactive design procedure via graphics terminals, either

with TEKTRONIX storage tubes or with a more advanced high performance graphic terminal Adage 340, particularly devoted to interactive nesting of metal sheets.

3. CONCLUSIONS

The concluding remarks are essentially two folded.

The first remark is that, as usually in Italy in the field of the applications of systems, the companies have shown an initial inertness to adopt and study D.A. techniques. However, after this phase, a great activity has grown up, and has brought to results and theoretical and applicative which are very important even in an international context.

The second remark is related to the fact that the major development in these applications is in big companies, and among them there has not been a real experience exchange, which would have allowed a minor effort and a faster reaching of the actual state of the art.

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