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INTRODUCTION

The A. P. Ershov Institute of Informatics Systems (IIS) was founded in April, 1990. The main research directions of the Institute determined by the resolution of the Prezidium of the Siberian Branch of the Russian Academy of Sciences (SB RAS) are as follows:

- theoretical basis of informatics;
- methods and tools of constructing programs of higher efficiency and reliability;
- methods and systems of artificial intelligence;
- software for promising computers, systems, networks, and complexes.

In 1998, the Institute conducted fundamental investigations in the following directions:

- the federal target program "Integration";
- the program of SB RAS aimed at the development of scientific directions of high-priority;
- projects supported by the Russian Foundation for Basic Research (RFBR);
- international scientific projects;
- contest projects of SB RAS.

In 1998, 80 works were published, including 1 monograph, 39 papers in central and 25 papers in foreign editions, and 3 manuals; 3 candidate theses were defended and 4 state scholarships obtained.

A total of scientific trips was 12, among them 5 supported by RFBR.

In 1998, the staff of the Institute consisted of 125 members. The staff of the scientific divisions was 104 members, among them 63 researchers, including 8 doctors of science and 29 Ph.D holders.

THE MOST IMPORTANT SCIENTIFIC RESULTS

Implementation of the problem-oriented environment for constraint programming NeMo+

Authors: Dr. Shvetsov I. E., Dr. Ushakov D. M., Dr. Telerman V. V., Lipskii S. V., Sidorov V. A., and Zagorul'ko G. B.

The programming environment (NeMo+) of the next generation has been elaborated and implemented. It allows complex mathematical models to be de-

3

scribed declaratively in a high-level language and, on this basis, various problems (direct, inverse, optimizing, and so on) to be solved. NeMo+ is particularly efficient when used for the case of heterogeneous models with various kinds of constraints (linear and non-linear equations, inequalities, relationships, logical statements, tables, etc.) and data types (integer and rational numbers, symbols, sets, structures, and others). The other advantage of the system is its feasibility to work with partially determined information on the basis of original apparatus of subdefinite computations developed in IIS. The most promising application area for NeMo+ is the solution of engineering problems in CAD systems.

Elaboration of methods for integration between logical programming and subdefinite models

Authors: Prof. Yakhno T. M. and Petrov E. S.

In the constraint programming paradigm, the authors have proposed the novel methods for integration between logical programming and subdefinite models. These methods formed a basis of the Interval Library (IL) for solving nonlinear constraints in the logical programming system ECL^{i}PS^e.

IL is intended to solve nonlinear equations and inequalities (constraints) written in a common mathematical language. For every variable, IL calculates an interval containing a projection of the set of all solutions of the constraint system onto this variable and starts the automatic search for separate solutions.

A number of applications based on IL have been implemented. In particular, IL was used to solve the problem of diversification of investments in securities.

Graph-theory methods and visual processing

Authors: Prof. Kasyanov V. N., Prof. Evstigneev V. A., Boyarshinov V. A., Lisitsyn I. A.

A formalism of hierarchical graphs and graph models has been developed. It is oriented to the hierarchical representation and visual processing of complex informational models. Possible applications of graph-theory methods to programming have been investigated; a number of results have been achieved on the following problems: complexity of graph models of reconstructable commutation schemes, recognition of types of chordal and interval graphs by local algorithms, and edge and total colouring of interval graphs. It has been proved that the class of problems polynomially solvable by finite automata networks coincides with the class of problems polynomially solvable by graph rewriting systems. A tool

system HIGRES has been implemented to support constructing, visualizing and analysing various objects within their hierarchical graph models. The system runs under Microsoft Windows 95/NT without any additional requirements to hardware; it supplies a user with animation tools of visual processing and specializing of the system and is available at http://pco.iis.nsk.su/higres.

Logical methods for program verification and net models of distributed systems.

Authors: Dr. Nepomniaschy V. A., Dr. Virbitskaite I. B., Dr. Shilov N. V., Bodin E. V., and Pokozy E. A.

Program models presented by specifications in the REAL language and net models presented by time PN's are considered as distributed systems' models. To verify the REAL specifications, a method has been proposed which combines model checking with principles of inductive proof. Using this method, the progress properties have been proved for some of REAL specifications of communication protocols with infinite number of states. The model checking algorithms have been constructed and their estimations have been obtained for different classes of time PN's where the network properties are presented by the formulas of real-time temporal logics. In order to increase the algorithms' efficiency, the partial order technique is used; this allows us to reduce the number of states being analyzed at the cost of concurrency of the time PN.

In 1998, the Institute conducted investigations within the program of SB RAS on new generations of computer engineering, mathematical modeling, and information technologies covering the following research themes.

The theme "Investigation and elaboration of methods for integration between logic and set-theoretic computation paradigms"

Supervised by Prof. Yakhno T. M.

Investigations on the theme were conducted within 4 projects.

The project "*Investigation and elaboration of methods for integration between logic and set-theoretic computation paradigms*"

In 1998, the Interval library 2.0 (IL) and the "Finite sets" library were implemented within this project for the ECL^{i}PS^e system.

IL is intended to solve nonlinear equations and inequalities written in a common mathematical language using variables, constants, arithmetic operations, direct and inverse trigonometric functions, and the functions ln, exp, min, max, as well. For every variable from such equations, IL calculates an interval of all its admissible values.

There is a possibility of specifying the initial range of a variable, computation accuracy, and the range of arguments of trigonometric functions. The predicates combining a dichotomic search with subdefinite computations are included into IL.

The ECL^{i}PS^e system together with IL is a convenient tool for solving problems where nonlinear dependences are combined with combinatorial aspects, i.e. the problems of design, financial planning, and so on.

In 1998, the first version of the "Finite sets" library (FS) was implemented. It was mainly aimed at increasing the level of the language of set specification in the ECL^{i}PS^e system. A finite set is an extended object from the problems of combinatorial nature (planning, design, etc.). A tool support for the language of set specification and set processing substantially simplifies constructing the applications aimed at solving such problems.

FS is designed to solve, in the ECL^{i}PS^e system, set-theoretic relationships between variables, constants, and finite extensional sets. The variables may denote both unknown finite sets and unknown integers. IL is used in integer calculations.

An original approximated algorithm known as "unification of extensional sets" has been developed for FS. It gives good approximate results (precise in some cases) and is rather effective in distinction to the NP-complete precise algorithm.

The complexity of set unification was a decreasing factor for their specification level in the Conjunto library embedded into ECL^{i}PS^e: it was forbidden to specify a set intensionally, to denote a set element by a variable and to refine then its value. The set specification language supported by FS removes these restrictions and provides satisfactory efficiency.

FS has been tested on standard combinatorial problems. In combination with IL, it was used in a search for Steiner trees of a given topology (a modeling problem). To work with FS, OS Linux and the system ECL^{i}PS^e with IL are needed.

A number of applications have been constructed on the basis of IL. In particular, it was used to solve the problem of diversification of investments in securities. Let us consider this problem in more details.

Investments in securities relate both to an average income and to some risk showing how our real income may deviate from this average value. The portfolio theory states that an income received from a combination of securities (portfolio) varies less than that of one of them. The following question arises: what a portfolio should we choose in order to minimize our risk?

Each security i is characterized by a mean square deviation σ_i of its return. In addition, for each pair of securities (i, j), a correlation coefficient ρ_{ij} is defined to specify mutual deviation of the return of these securities. For all i and j, the following holds: $-1 \leq \rho_{ij} \leq 1$ and $\rho_{ij} = 1$

To construct a portfolio of minimal risk is in general case a problem of quadratic programming. IL is used in construction of a portfolio of minimal risk without short sales or interest-free loans. Fig. 1 shows a screen of a session with an application calculating a portfolio's "form" (distribution of funds between separate securities). There are three windows: one of them shows the graphs of yield; the second shows return, risk, and matrix of correlation coefficients; and the last, the search control panel. The current portfolio's form and the correspondent risk (minimal in this case) and return can also be seen.

The application allows one to automatically solve the problem for 30 securities in 10—15 minutes. In the semi-automatic mode, the number of securities is not restricted. The automatic mode of running the application requires OS Linux and the ECL^{i}PS^e system with IL, and, additionally, the interpreter of the Tcl/Tk language (to support the dialog), for the semi-automatic mode.
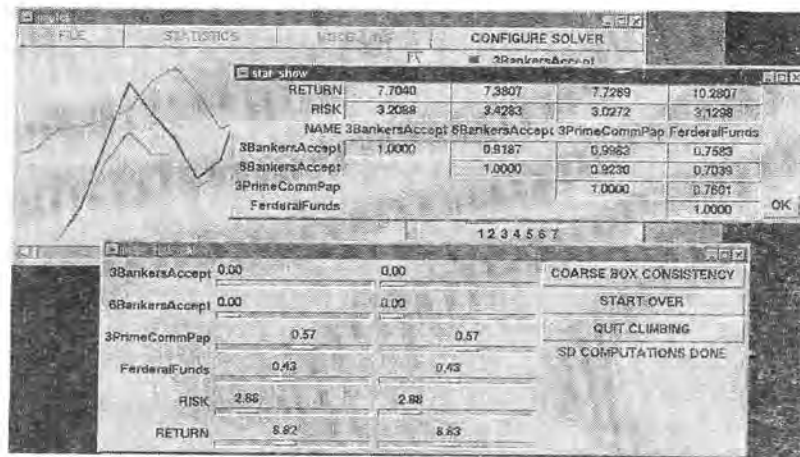
Fig. 1. Solving the problem of diversification of investments in securities by the ECL^{i}PS^e system and IL

The project "*Elaboration of a software environment based on an integrated model of knowledge representation*"

In 1998, work was performed on further development of the object-oriented software environment SemP-TAO intended to construct a wide spectrum of intelligent systems. In particular, it allows one to construct systems which require a logical inference in combination with computations on subdefinite values. Most attention was paid to efficiency and flexibility of knowledge representation tools and to the best usage of the feasibilities provided by object-oriented approach and integrated model of knowledge representation.

To make the processing of subdefinite values more efficient, we have developed means of a search for precise values under given constraints, minimization and maximization of a specified target function included.

To provide more close and natural interaction between a user and a system constructed in SemP-TAO, tools for constructing a user interface have been developed and a possibility of processing multimedia objects has been added.

Besides, means have been implemented to integrate the applications constructed using SemP-TAO with other soft- and hardware tools. In particular, means of data interchange with standard data bases have been included into SemP-TAO.

With the help of SemP-TAO, a number of applications have been designed for various domains. For example, in collaboration with the German Institute FAW on the project of constructing a speech control system for an intelligent robot, a program simulator of a robot has been designed. Implemented by means of SemP-TAO, this simulator is considered as a system kernel to which soft- and hardware modules of speech processing, recognition, and synthesis are connected. The user interface of the robot speech control system (Fig. 2) was also implemented by means of SemP-TAO.
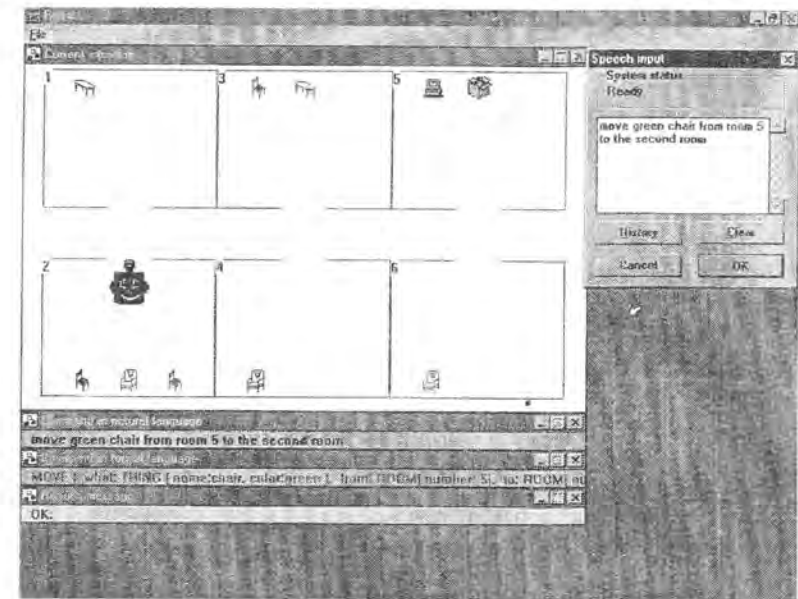

Fig.2. A window of the user interface of the robot speech control system

The project "*The active object technology of multiagent system design (TAO)*"

In 1998, specification of a new version of the language of active objects was completed. Its main distinctions are as follows:

- structured data types (arrays, lists, sets) are introduced;
- means for active object's behaviour control have been extended;
- a possibility of constructing a hierarchy of active objects has been added;

– means for dynamic reconfiguration of the active object environment have been introduced;

– time processing mechanisms have been developed.

The software system has been designed to implement the language of active objects. Its basic modules are the incremental compiler, the active object network interpreter, the solver for a system of constraints, the user screen interface, the system of graphic visualization, etc.

The project "The development of software tools on the basis of subdefinite models"

In 1998, the object-oriented environment for constraint programming NeMo+ was implemented and debugged. It is intended to solve problems based on subdefinite models and includes means for specifying and solving various constraint satisfaction problems. In addition to the libraries containing a wide spectrum of data types which realize various kinds of subdefiniteness, a specialized library has been designed and implemented to provide interface to standard databases.

The NeMo+ environment is successfully applied to solving geometric problems and engineering computations, as well. In Dassault Systemes company (France), it is used in CAD systems.

In 1998, NeMo+ was awarded by a diploma of honour and got a prize of the Russian Association for Artificial Intelligence as "The best system presented at the Exhibition of RCAI-98".

Moreover, in 1998 a new version of the environment NeMo+ was designed which is more effective and contains means for integration with other software systems, CAD included.

The main publications:

Narinyani A. S., Telerman V. V., Ushakov D. M., and Shvetsov I. E. Constraint programming and subdefinite models // Information technologies. — 1998.— N 7. — P.13—22.

Telerman V. V. and Ushakov D. M. Constraint satisfaction in the problems of mathematical programming // Computing technologies. — 1998. — Vol. 3, N 2. — P.45—54.

Petrov E. An experience of integration between logical and constraint programming // Programmirovanie. — 1998. — N 3. — P.40—49.

Yakhno T., Petrov E. Constraint programming for knowledge representation // Knowledge-Based Software Engineering / P.Navrat, H.Ueno (eds.) // Proc. 3rd Joint Conf., Smolenice, Slovakia. -Amsterdam: IOSPess, 1998. — P.116—123.

Zagorulko Yu.A., Popov I.G. Object-oriented language for knowledge representation using dynamic set of constraints // Ibid. — P.124—131.

Telerman V., Lipski S., Ushakov D. Object-oriented constraint-based database processing // Intern. Conf. on Practical Application of Constraint Technology (PACT'98). — London, 1998.

Zagorulko Yu.A., Popov I.G. Knowledge representation language based on the integration of production rules, frames and a subdefinite model // Joint Bulletin of the NCC&IIS. Ser. Computer Science. — 1998. — N 8. — P. 58—76.

Zagorul'ko Yu. A., Mirzaeva E. M., and Popov I. G. On creation of an extendable robot simulator by means of integrated software environment // Proc. 6th Nation. AI Conf. (RCAI'98). — Puschino, 1998. — P.373—379.

Dinenberg F. G., Zagorul'ko Yu. A., Zhigalov M. A., Levin D. Ya., and Popov I. G. The system of speech control for an intelligent robot // Ibid. — P.503—509.

The theme "The theory of program optimization and construction of effective and reliable programs using functional and logical specifications, and methodology of creating tools of transformational programming for computers of advanced architectures."

Supervised by Prof. Kasyanov V. N.

Investigations have been completed in methods of construction and optimization of parallel programs and in exploration of experimental systems within the PROGRESS project. The results are as follows.

Formalism of hierarchical graphs has been elaborated. It is oriented to hierarchical representation of stuctural objects and their visual processing. The planar graphs have been studied and the planarity criterion has been stated for a simple connected hierarchical graph. A general notion of a hierarchical graph model has been introduced and studied; its versions connected with simulation of operator programs and parallel systems have been considered; methods for a graph model semantics specification with the help of invatiants and systems of equivalent transformations have been studied.

Local and distributed computations have been studied. It has been proved that the class of problems polynomially solvable by finite automata networks coincides with the class of problems polynomially solvable by graph rewriting systems. The problem of type determination of a graph, such as interval and

chordal graphs, has been considered. These types admit an effective solution of NP-complete problems for graphs of a general type (for example, the problem of vertex colouring). Some interesting results generalizing earlier known ones on graph vertex colouring have been achieved on edge and total colouring of interval graphs.

Methods and systems of optimizing translation and program construction for computers of parallel architecture have been investigated. A survey has been prepared on stuctures of vectorizing and parallelizing compilers (CFT, CFT2, KAP/205, Fortran-77VP, Fortran77/SX, FORT 77/HAP, Convex, IBM 3090VF, Pascal-XT of Siemens, Parafrase-2, etc.) and tool systems oriented to automatic parallelizing of programs (PAT, SUIF, Faust, FALCON, PTOPP, PEPP).
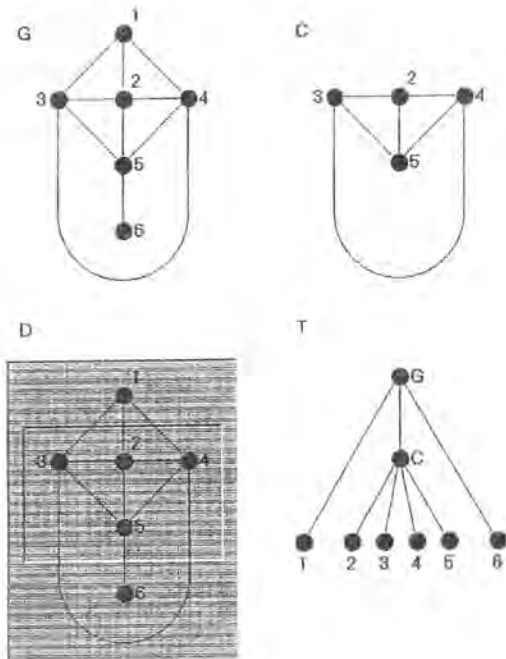

Fig.3 A hierarchical graph H=(G, T) and its plane nonstructural representation D.

The questions of effective parallelizing methods, known as PIC-methods (Particles In Cells) and widely used in computational mathematics for modeling of various processes, have been discussed.

The simplest parallel architecture with a commutator of a definite type has been considered, and the process has been proposed for representation of an algorithm on a computational system of this architecture. Within some natural assumptions, time estimates have been obtained for running the algorithm in a parallel and sequential cases and for the acceleration coefficient, as well.

The question of parallelizing a 3D-variant of the PIC-method has been considered in application to the problem of interaction between rarefied plasma flows in self-coordinated electromagnetic fields. Studies have been conducted on parallelizing the method of discrete whirls; it has been shown that these problems can be effectively parallelized.

Within the PROGRESS project, work has been continued on implementation of experimental subsystems (TRANSFORM, SFP, HIGRES, etc.) supporting compilation, analysis, visualization and transformation of imperative and functional programs, as well as the storage of information on transformations. The PROGRESS system is oriented to the support of fast prototyping of compilers, optimizing included, for target architectures and specific computers (VLIW and superscalar, multiprocessors with distributed memory, and so on). It can also be used in investigations of efficiency of application of various systems of transformations to different classes of programs and computers, including the question how the efficiency of the system of transformations changes according to different forms of internal representation of a program, transformation sets, their context conditions and the strategy of application.

A comparative implementation has been made for three graph-theory representations of programs, namely, for a graph of program dependencies, an ideograph, and a hierarchical graph of tasks. The structure of a subsystem with an extendable library of tests intended to detect operator dependencies has been designed; on the basis of the Shostak algorithm, a test of a solution for systems of inequalities has been constructed and included into the library. The algorithms of optimization of SISAL-programs have been explorated at the level of intermediate graph-theory representations.

An experimental system HIGRES has been designed. It is intended to support constructing, visualizing, and studying various objects and phenomena in the framework of their graph models. The system has a convenient up-to-date graphical interface and allows one not only to construct and edit the structure of the hierarchical graph, but to define its semantics, either. As for its graphical fa-

cilities and interface, the system is comparable with its foreign analogs running at more powerful computers. The system provides that it can be specialized, as well as the library of algorithms of graph model processing and their full-scale dynamic visualization (animation) can be extended.
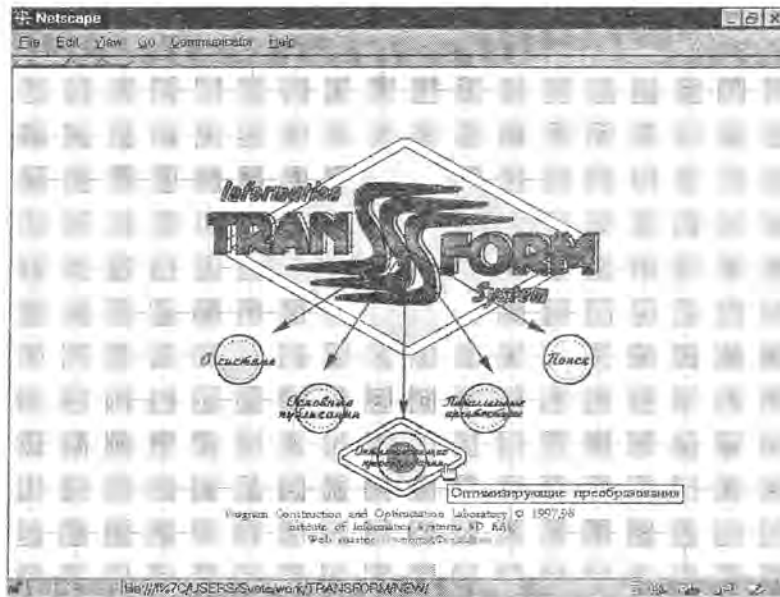

Fig. 4. Web-page of an experimental version of the information system TRANSFORM.

The HIGRES system runs under Microsoft Windows 95/NT without additional requirements on hardware and is available at <http://pco.iis.nsk.su/higres>.

The main publications:

Evstigneev V. A. and Kasyanov V. N. Graph theory: processing algorithms for acyclic graphs. — Novosibirsk: Nauka, 1998.

Kasyanov V.N. Iterative switching networks // Recent Advances in Information Science and Technology. – London: World Scientific, 1998. — P.68—72.

Kasyanov V.N. Hierarchical graphs and visual processing // Intern. Congress of Mathematicians (ICM98). Abstracts of Short Communications and Poster Sessions. – Berlin, 1998. – P.292.

Kasyanov V. N. and Lisitsyn I. A. Methods and tools of visual processing for hierarchical graph models // New informational technologies in the university education. — Novosibirsk: Research Inst. of Math.-Inform. Basis for Education, NSU, 1998. — P.135—136.

Kasyanov V.N. Graph methods in program construction and optimization // Seventh Intern. Colloquium on Numerical Analysis and Computer Science with Applications. Abstracts of Invited Lectures and Short Communications. — Plovdiv, 1998. – P.62.

Kasyanov V. N., Evstigneev V. A., Malinina Yu. V., Birjukova Yu. V., Markin V. A., Kharitonov E. V., and Tsikoza S. G. Support of supercomputations and Internet-oriented technologies // Distributed processing of information. — Novosibirsk: SD RAS Publ. House, 1998. — P. 410—414.

Boyarshinov V. A. Edge and total colouring of interval graphs // Operations research and discrete analysis. — Vol. 5, N 4. — P.18—24.

The theme "Methods and tools of teaching informatics and programming within multilevel education".

Supervised by Prof. Kasyanov V. N.

Work has been completed on educational Internet-oriented software and on further development of functional and transformational approach to creating the remote access systems.

Experiments have been carried out on compilation of GNU Linux programs for various platforms. Most attention has been given to compilation of the source texts of Clisp (GNU Common Lisp) for Linux, Windows, and MS DOS.

A minimal "kernel" of the file system of GNU Linux has been extracted, and a minimal set of files has been prepared for normal functioning of Linux with mc and Clisp programs. The set is used in the "Centaur" environment and in the Linux set, as a help for students' projects in Clisp+Linux.

The source texts of the Clisp system have been changed, which results in the Russian version of Clisp. This made it possible to use it more widely in courses on functional programming at the NSU and Higher College of Informatics.

In the field of methods of compilation and debugging of functional programs, experiments were performed on implementation of the Lisp self-definition by means of Clisp; a replica of the author's (J. McCarty's) implementation has been made in a new (Clisp) environment; the possibilities and operation characteristics of the earlier implementation of the Rapira language have been improved.

Fig. 5. The dictionary on graph-theory

The "Centaur" environment intended to defend the system resources of the DOS and Windows users of common access computers, for example, at schools, has been created. The system is based on the Polyakov's idea to use the disc sectors of Linux not visible from DOS and Windows as a place for reserve copies of educational environment, which allows us to promptly and safely restore the affected OS or to change the environment. The programs for "Centaur" have been implemented in Clisp, GNU Linux system. The user characteristics of the system are available at <http://www.iis.nsk.su/edu/Centaur/index.htm>.

Work has been continued on the dictionary of graph theory for programmers. The initial Web-version of the dictionary has been completed. It supports the interaction with the user via HTML-documents with built-in scenarios in the Java and C++ languages. It is available at <http://pco.iis.nsk.su/grapp>.

A manuscript version of the dictionary essentially extended and illustrated has been prepared. This is a collection of the most usable terms of graph theory and its applications to informatics and programming. The manuscript was a winner of the SD RAS contest of publishing projects and is to be published in "Nauka", Moscow.

The main publications:

Kasyanov V. N., Evstigneev V. A., Malinina Yu. V., Birjukova Yu. V., Markin V. A., Kharitonov E. V., and Tsikoza S. G. Support of supercomputations and Internet-oriented technologies // New informational technologies in the university education. — Novosibirsk: Research Inst. of Math.-Inform. Basis for Education, NSU, 1998. — P.162—163.

Gorodniaia L. V. and Kharitonov E. V. The problems of using OS Linux at school and other educational institutes // Information technologies and the methods of applied mathematics in interdisciplinar researches and projects. — Inst. Math. SD RAS, the Omsk branch, 1998.

The project "*Educational informatics*"

A number of problems of methodological and technological support of teaching informatics at different educational levels have been solved, including installation and correction of information technologies used in educational process, from primary school up to professional courses for teachers.

An experimental and methodological justification has been presented for the system of projects and courses oriented to early programming and studying the basic notions of informatics at school, for example, teaching parallel programming to schoolchildren.

Solutions of some problems connected with Boolean algebras at specific domains have been modernized (the FABULA system). The problems of teaching computer algebra and programming paradigms to students have been considered.

The question of including functional languages and software systems on their basis, starting from GNU-Clisp, into the educational system has been studied. A transformational approach to program transformation has been modified and applied to transformation of information forms (the project of the Friend-2 system).

A concept of the design and development of the INFOstructure of an educational institute has been formulated, including a concept of continuous teaching informatics. A concept of mass teaching informatics to everybody has been elaborated; an approach to methodical and technological support of teaching informatics and programming has been proposed, as well as soft- and hardware for computer classes at schools. A number of manuals have been prepared.

Besides, a system of training courses for teachers of informatics has been written. Within this system, attempts were made of teaching programming on the basis of shareware and of early teaching parallel programming to schoolchildren, either.

A proposal was made on organization of interschool events, such as contests, conferences, etc., intended to raise interest in advanced lessons of informatics and information technologies. Work has been continued on the project "High-level object-oriented environments". The monograph "On foundations of informatics and their justification" is in work.

Contacts have been established with the administrative system of education of the Novosibirsk region.

The A. P. Ershov Foundation started functioning.

The theme "Elaboration of methods and experimental tools of program constructing and specializing in the reliable programming environment"

Supervised by Prof. Pottosin I. V. and Dr. Bulyonkov M. A.

Researches on this theme and on the project "Program understanding for its construction" have much in common, so the results obtained on them are presented jointly. A model has been elaborated for estimation of a quality of information flows; an algorithm of checking the program quality has been constructed; an initial version of a processor verifying a criterion of structural non-redundancy has been implemented.

Within the context-sensitive data flow analysis, an algorithm has been constructed for static computation of values of scalar type variables, which substantially increased the accuracy of analysis and reliability of error messages in the static analyzer of errors OSA. On the basis of a hypergraph representation of a program being analyzed, algorithms of the data flow analysis have been constructed for Java-programs, processing of extraordinary situations included.

The problem of application of the static data flow analyzer to gathering the necessary (and accessible) information has been studied for the case of automatic test generation. The system of gathering such information has been constructed on the basis of the OSA analyzer.

Based on the proposed model of regular schemes, an optimal algorithm of the regular scheme cleaning has been implemented and justified. It includes such transformations as elimination of redundant operators, boot-strapping of trivial cycles, and hammock and cycle cleaning.

Some systems connected with this research direction have been implemented or modified.

A system of parallel programming SuperPascal is ready to be put into operation, and a new version of the system with a function of parallelism conflict control has been designed.

A set of files in the HTML-format presenting the feasibilities of the constructed hypertext environment has been prepared.

Within the international freeware project (the GNU system), the system Ispell for spell-checking and the shell-interpreter Bash have been adapted to a specific language.

A manual on the Modula-2 standard has been prepared and is to be published.

The main publications:

Pottosin I. V. The quality of programs and information flows // Open systems. — 1998. — N 6.

Katkov S. I. and Pottosin I. V. A parallel programming system based on Super-Pascal // Proc. 6th Intern. Seminar "Distributed processing of information". — Novosibirsk, 1998. — P.127—131.

Chernonozhkin S. K. and Kaufman A. V. Criteria of testing and a system for estimation of completeness of a validation suit // Programmirovanie. — 1998. — N 6. — P. 44—59.

Uvarov D. L. An optimal algorithm for cleaning of regular hammocks // Programmirovanie. — 1998. — N 2. — P.68—80.

Kuksenko S. V. and Shelekhov V. I. A static analyzer of run-time semantic errors // Programmirovanie. — 1998. — N 6.

The project "The sortware reengineering system RescueWare"

This is a joint project with the System Programming Department of the St-Petersburg State University, State Enterprize "Tepkom", and Relativity Technologies, Inc., USA.

RescueWare Workbench is an integrated reengineering environment that takes into consideration all aspects of the source system. First of all, deep analysis is performed for each program, including its interaction with other programs. RescueWare provides a powerful toolset for visual decomposition of a source program, so it can be treated as a system of reverse engineering. But this is not the point of primary attention.

The reengineering process in RescueWare is considered as a solution of three basic problems. The first is data conversion from old DBMS and "plane" files into up-to-date relational databases. The second is generation of modern GUI based on old alphanumerical screen forms. The third is conversion of the programs themselves with due account for the above transformations. The general scheme of the product can be illustrated as follows.
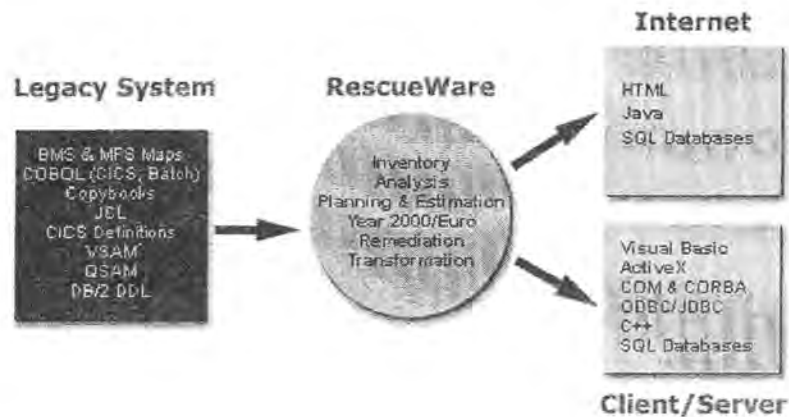
Fig. 6. The general scheme of the product.

A special part of RescueWare is intended to solve the Y2K problem.
In 1998, the following software tools have been created:

- GlobalBRE — a program which allows, on the basis of a dialog with a user, a "monolith" program to be broken into several components taking into account both structural and informational dependences;
- DataMap — a tool for forming screen forms on the basis of data structure description;
- LegacyDictionary — a tool for so-called "name rationalization" which allows one to correctly rename objects of a heterogeneous software system;
- Callie — a component of visualization of a call graph for Cobol programs;
- HyperTrace — a program for "abstract" tracing of Cobol programs which allows one to start a program from an arbitrary program point, to choose one of the branches of a conditional statement, and, when necessary, to move both along the trace and the call stack;
- W3HC — a program for conversion of a specialized databases to HTML-files which can be visualized with the help of standard HTML-browsers.

Work has been continued on reorganization of the HyperCode system in order to extend it and make it independent of the source data representation. A specializer for Cobol programs is being designed.

Fig. 7. A typical RescueWare session.

The main publications:
Bulyonkov M. A. and Kochetov D. V. Visualization of the program properties. — Novosibirsk, 1998. — 38 p. — (Prepr./SD RAS, IIS; N 51).

The project "*The analyzer of semantic properties for Modula-programs*"

Work has been continued on efficient implementation of the analyzer of semantic properties which performs analysis of the equality relations on program terms. The main efforts were devoted to a search for and implementation of the algorithm of alias analysis which would make it possible, at its preliminary stage, to find effectively a nontrivial upper bound of the alias sets. Although the Deutsch alias analysis earlier implemented is rather "expressive", it is very complicated to use it as a preliminary analysis. Most attention was paid to a newly proposed Steensgaard algorithm. Based on a fast algorithm UNITE/FIND, it al-

lows a nontrivial upper approximation of the alias sets to be built at almost linear time.

Further research was being performed on integration of the analyzer of properties into the HyperCode system.

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Emelianov P.G. Analysis of equality relations: proofs and examples //Joint NCC & IIS Bulletin, Ser. Computer science. – 1998. – № 9 (to be printed).

The project "*Snake-in-the-Box problem*"

A widely-known combinatorial problem "Snake-in-the-Box" has been considered. The problem is to find out the length and effective construction of the maximum cycle without chords in the n-dimensional unit cube. At present, only the first 5 precise values of length are known. An HTML-page has been worked out to present a review on equivalent statements of the problem, estimations, and bibliography consisting of 58 papers [2]. A new upper bound of the snake's length has been obtained [1]. A program has been written for constructing long snakes in the cubes of small dimensions. New record snakes' lengths have been found for cubes of dimension 8 and 9 being 90 and 164, respectively.

The main publications:

Emelianov P.G. and Solovjeva F.I. New upper bound for length of snake in unit n-dimensional cube // Discrete Mathematics (to be printed).

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The project "*The diagnosis systems for Y2K problem*"

This is a joint project with the System Programming Department of the St-Petersburg State University, State Enterprize "Tepkom", and the Relativity Technologies, Inc., USA.

A toolset has been designed to detect the Y2K problem for different language platforms. All the similar systems include the stage of finding the suspicious places usually performed by means of a text pattern search. Unfortunately, they do not obtain satisfactory results and do not provide interactive means for a pattern specification, program annotation, and so on.

The system Scan2k is intended for program analysis in order to find variables, string literals, and integer constants considered as Y2K suspicious. The main advantage of the system is its easy adaptation to a specific programming language, which makes it possible to analyze programs in almost any regular language. At present, we have adapted the system to C/C++ and Visual Basic. The system has up-to-date interface; Fig. 8 presents its basic window.
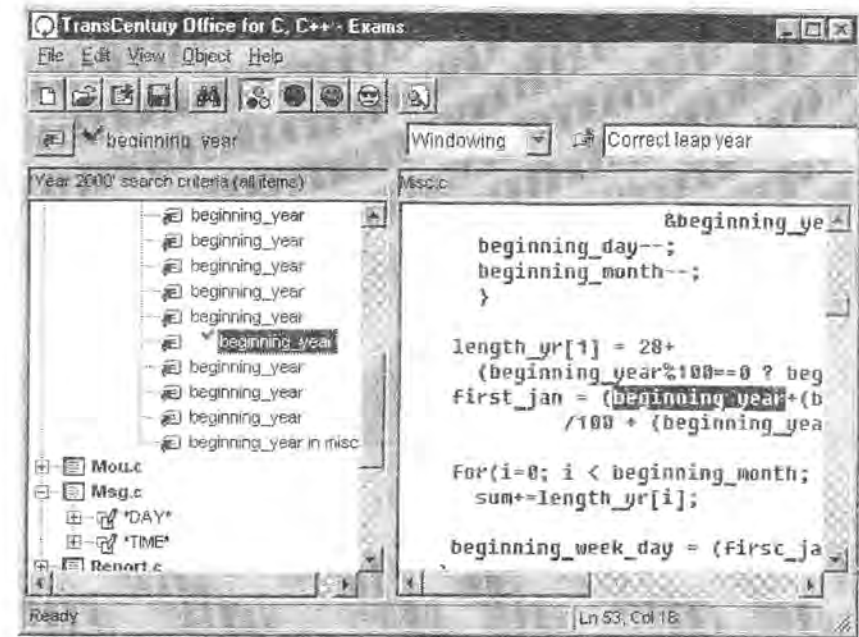
Fig. 8. The basic window of the Scan2k system

The system See2k is constructed for more profound analysis within the project consisted of one or several interconnected programs in C/C++. The system provides the automatic propagation of information about a Y2K suspicious variable over the whole application. The C dialects, such as ANSI C/C++, Microsoft Visual C++, Borland C++, and GNU C/C++, are supported. Its interface is close to that of Scan2k.

The project "*Schedule composing system*"

Work has been continued on the Schedwin system intended to compose a schedule of lectures for high school. It supports all stages of the job, from input of the programme of lectures up to print of the final schedule. The system can process some specific requirements to the source data, such as division of a group into subgroups, different schedule for even and odd weeks, and so on.
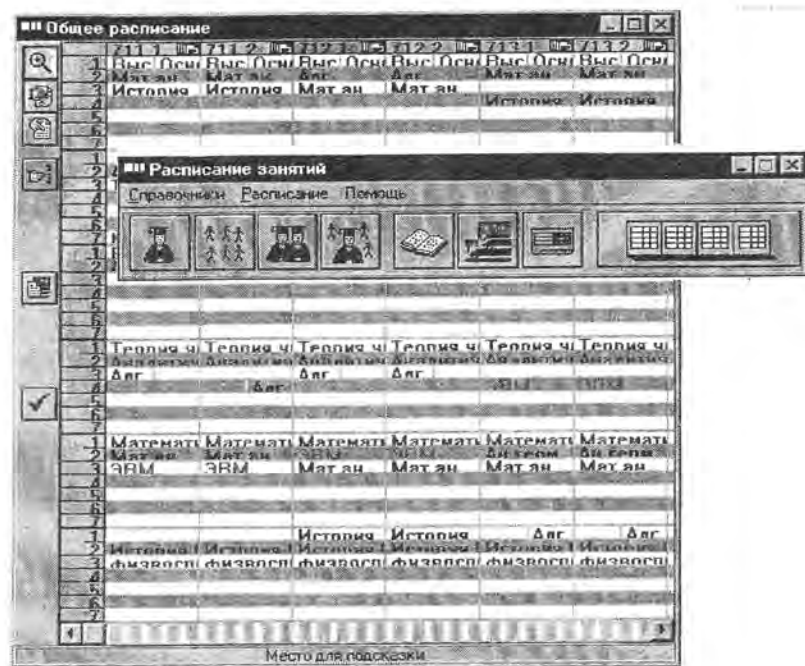
Fig. 9. A screen of the Schedwin session

The system provides a simultaneous correctness check-up. Tools for export of data in HTML-format have been created, which supports a remote access to a schedule.

The system runs under MS Windows (3.11 and higher) and has up-to-date interface easy to learn and use. Schedwin has been put into operation at the Novosibirsk State University, Novosibirsk State Academy of Economy and Management, and Novosibirsk University of Trade.

The theme "Information and telecommunication systems and networks"

Supervised by Prof. Marchuk A. G.

The project "*Integration of Java-programs with database management systems*"

Investigations have been pursued in the direction of creating applied software systems (ASS) and computer-aided information systems (IS) on the basis of CLIENT/SERVER architecture.

The work is aimed at elaboration of methods, approaches, and technology of constructing IS to provide upgrade of ASS during the life-time of an application, from the statement of the problem to the maintenance of the system.

The step-by-step method of constructing IS has been chosen as one of the solutions of the problem. In this case the application system is built from the set of universal and incapsulated component-applications and subsystems with consistent tools of integration. As for the part of the system that cannot be built from this set, it is constructed in a traditional way but with account for its further inclusion into the set of reusable components.

The method has been used for constructing a number of IS and proved to be efficient and promising, especially at the stages of design and implementation.

In particular, work has been initiated on experimental implementation of a prototype of the set of subsystems for constructing IS implemented in 2- and 3-unit CLIENT/SERVER architecture, Internet/Intranet technology included. To do this, a wide spectrum of database management systems (Informix, Oracle, sybase) and tool sets (Borland Delphi, Microsoft Visual C++, Microsoft Visual J++, PowerDesigner, Allaire Cold Fusion) for MS Windows NT and UNIX platforms has been used. A number of universal subsystems have been elaborated, such as a management subsystem for applied IS, a subsystem for remote data processing in the Internet environment, a documentation subsystem, etc.

Students of the Mathematical Department of the NSU took active part in this research project.

The theme "CAD and programming systems"

Supervised by Prof. Marchuk A. G.

The project "*Tools for automatized generation of the VLSI layout*"

The purpose of this research is to investigate the possibilities of automatic transformation of the VLSI layout according to new industrial technologies and

requirements. This problem is of particular importance for modernization of out-of-date chip layouts.

The approach is in the following. Given a "flat" chip layout as the input data, a list of chains of the scheme is made at the first stage. At the second stage, a "flat" layout is to be decomposed into a hierarchy of blocks and subblocks, which leads to reducing the dimension of the problem for the next stages of transformations.
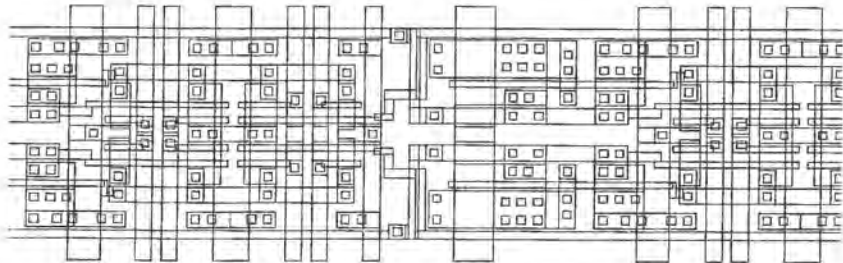

Fig. 10. A fragment of a VLSI layout.

After that the transformation of blocks into a symbolic representation (symbolization) is performed, i.e. elementary objects and their geometric, functional, and scheme attributes are determined.
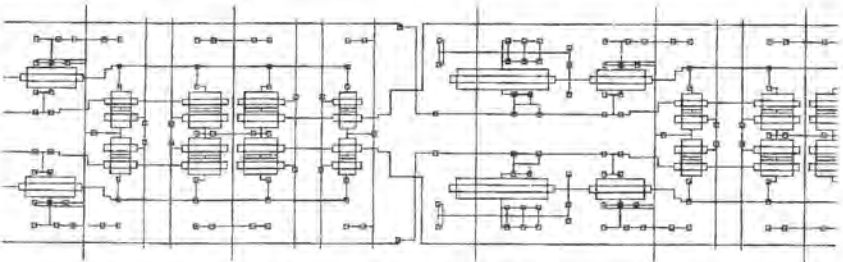

Fig. 11. The fragment in the symbolic representation.

Next, the symbolic layout is to be transformed and compressed according to new requirements of design and technology. The set of transformations includes various kinds of elimination of redundant connections and chains, and other nontrivial scheme transformations. The compression algorithm used here is rather simple, because more complex algorithms give worse results on big layout fragments.
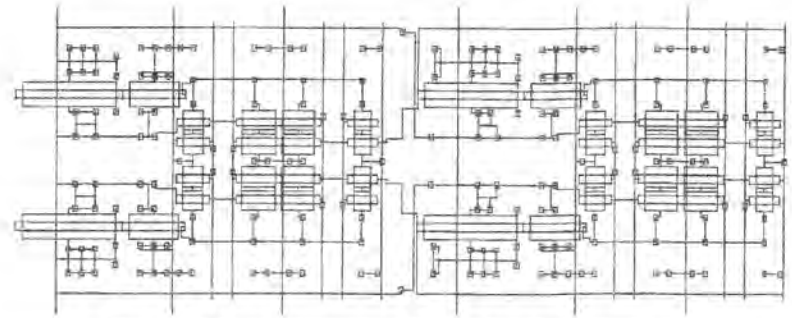

Fig. 12. The compressed variant of the above fragment.

The symbolic representation obtained is deformed so that the technological requirements are preserved, and its direct transfer into the set of rectangulars in different layers is possible.
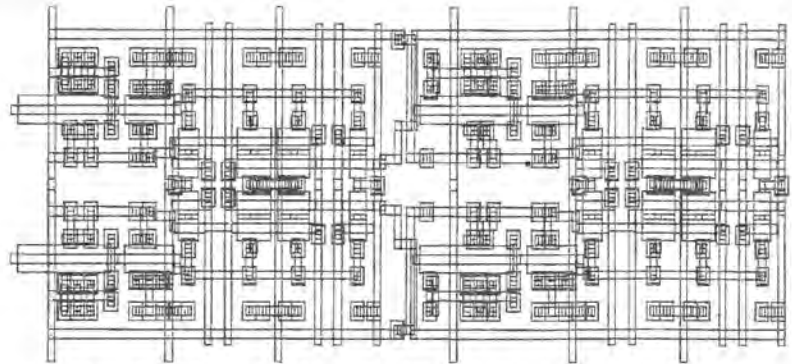

Fig. 13. The generated layout of the fragment in consideration.

At the final stages, the fragments' layouts are normalized in order to meet specific requirements and to be combined into the whole layout by the process "replacement-tracing" that can be fulfilled in a standard way.

All the needed algorithms have been elaborated and implemented.

Tests were made on a real chip layout. Experiments and investigations have shown that it is really possible to solve the problem of VLSI technology migration.

The theme "Support and development of information-telecommunication environment for SD RAS"

Supervised by Prof. Shokin Yu. I.

The project *"Tools for maintenance and management of databases via WWW using HTTP-SQL interface"*

The aim of the project is to create tools of a unified access to different collections and information resources on the basis of CORBA technology.

The approach proposed allows us to connect the available library systems into an integrated information space.

When solving this problem, we should take into account the following:

— data stored in the library systems may be of different incompatible formats;
— our system should provide the user with a convenient search for various kinds of resources;
— it should be flexible and extensible as much as possible;
— resourses remote from each other should be integrated.

Standard approaches cannot solve the problem completely, so we have chosen the CORBA technology as a basis for constructing the system. CORBA has been created by Object Management Group (OMG), whose members are such corporations as Sun, IBM, Cray, etc., in order to improve the technology of constructing distributed information systems, distributed computations systems and so on. It allows a program to use an object from a remote server as if it were on a local computer. In addition, CORBA can be successfully used in solving the problem of integration of heterogeneous information resources into a unified network.

From the system's viewpoint, all information stored in the library is represented by a collection of documents, a set of documents unified according to some specific feature. This is a basic notion of the system which permits various libraries with specific data formats to be treated as sets of a universal structure. The only function it should maintain is, according to some request, to search for and to send a set of documents. A request is a unified criterion of a search for particular documents. There are several types of requests and a special processor for each of them. A list of references obtained from libraries is presented as a document in a convenient format (HTML-page, Adobe Acrobat (PDF) and so on).
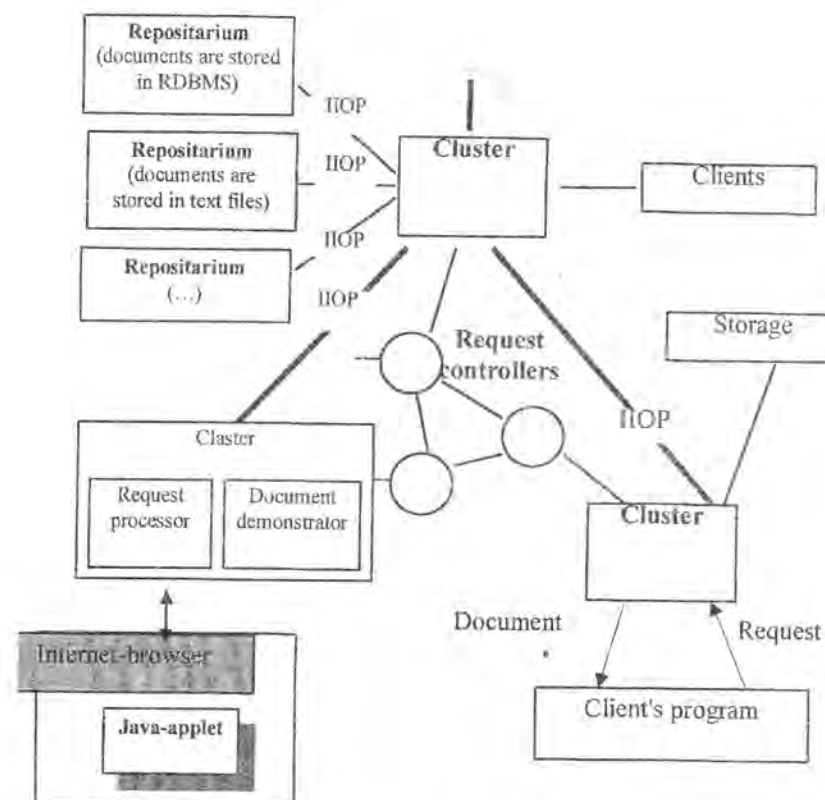

Fig. 14. The general scheme of the system

The general scheme of the system is presented in Fig. 14. All the collections are to be integrated into librarian clusters by location or by themes of information, and the same collection may be included into different clusters which, in turn, are integrated in a network with the help of a request controller. As a result of the request processing, the user obtains a list of references to documents and can view any of them via a demonstrator in a convenient format.

The project *"The IIS WWW-server"*

A database has been constructed for information on the staff member of IIS SD RAS. Its structure is given in Fig. 15.
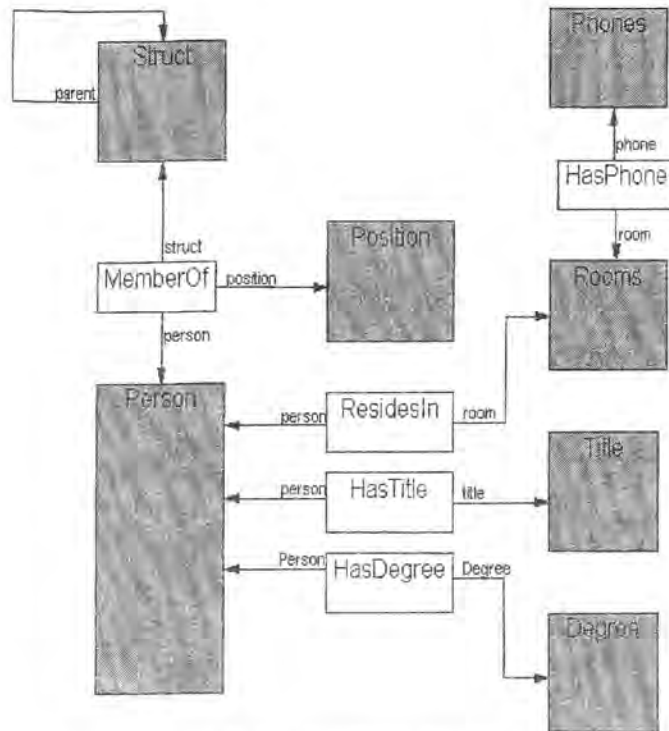

Fig. 15. The database structure.

To represent data in the format accessible for WWW, a programming language QHTL has been designed as the HTML language extended with tools for database processing. QHTL essentially simplifies the design stage for uniform pages, since it is sufficient for the designer to use only the HTML and SQL languages; the page's parameters results from SQL-requests included into the document's structure. This technology is essentially efficient when applied to small and rarely changing databases, as well as to constructing a static "frame" of access to large databases.

The theme **"Investigation in formal models and methods for describing semantics, specification and verification of concurrent and distributed systems"**

Supervised by Dr. Nepomniaschy V. A.

Net models covering the time and coloured PN's, event structures, cause-effect structures, and program models based on constructions of the standard language of executable specifications SDL have been considered as formal models of concurrent and distributed systems.

Within the model-checking method, an algorithm has been proposed for verification of behavioural properties of models of distributed real-time systems.

A notion of a parametric time net has been introduced. This is the Merlin time net extended with parametric variables inserted into restrictions on firing time of net transitions. The behavioural properties of a system are represented by the formulas of parametric temporal real-time logic PTCTL. The verification algorithm is in finding the conditions on values of time parameters for which the network being analyzed meets the specified property.

For time PN's a compositional approach to equivalence checking with the use of the time detalization operation has been proposed. It was established what equivalences are preserved under this operation, which allows us to use them in top-down construction of distributed systems.

A notion of a time event structure as a model of concurrent undetermined real-time processes has been introduced. Different variants of time testing equivalence for this model have been studied, and necessary and sufficient conditions have been found for their existence.

For formalism of cause-effect structures, its extension on the semantics of colored tokens is being considered. It has been found that the classes of colored two-level cause-effect structures and colored one-safe PN's are strongly equivalent, i.e., equipowerful in expressiveness.

A new version Elementary-REAL has been designed for the specification language of distributed systems REAL based on the specification language SDL and branching time logic CTL. For the Elementary-REAL specification language, a formal semantics has been described, a theorem on the absence of concurrent access to channels has been proven, and a verification method combining the model-checking method with the inductive proof principles has been proposed. Using this method, progress properties have been proven for the Elementary-REAL specifications of some communication protocols with infinite number of states.

Work has been continued on an experimental tool ESPV (Estelle/SDL Protocol Verifier) for verification of communication protocols presented in standard languages of executable specifications Estelle and SDL. Within this project, a method has been elaborated for translation of SDL-specifications into colored PN's. Figs. 16 and 17 present SDL-specifications of the Station_Ini block of the protocol INRES consisting of the processes Initiator and Coder_Ini, as well as the PN corresponding to this block. Note that the ISAP channel is presented by two places of the PN (isap1 is an input and isap2 is an output) for a transition which models the Initiator process. Similarly, there are two places for channels IPDU and MSAP, and the transitions and places are connected by arcs whose direction is the same as that of the communication transfer. The initial marking of these places is empty, and tokens may occur in it in the process of functioning of the PN completely constructed.

An experimental system SPECTRUM for verification of Pascal/C programs is under development. Within this project, a method of automatic proof based on formula rewriting systems has been elaborated. Correctness and the Noether property of the formula rewriting systems have been studied. Based on this method, a prototype of the automatic proof block has been implemented; experiments have been carried out to a success.

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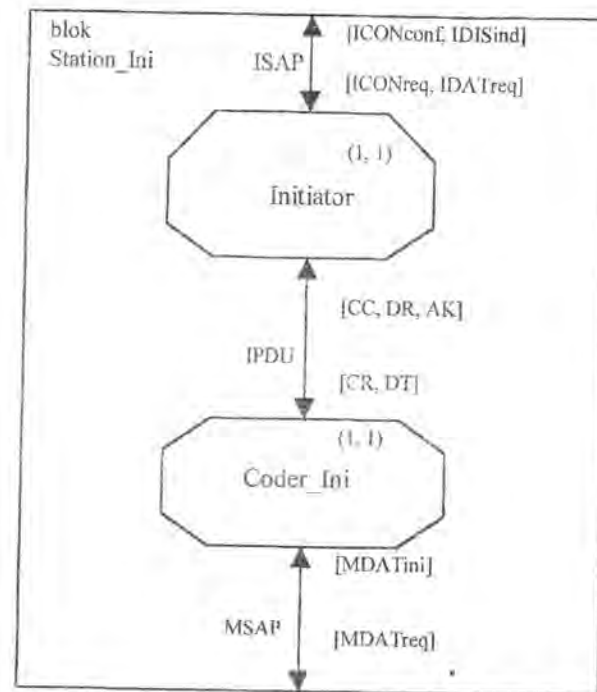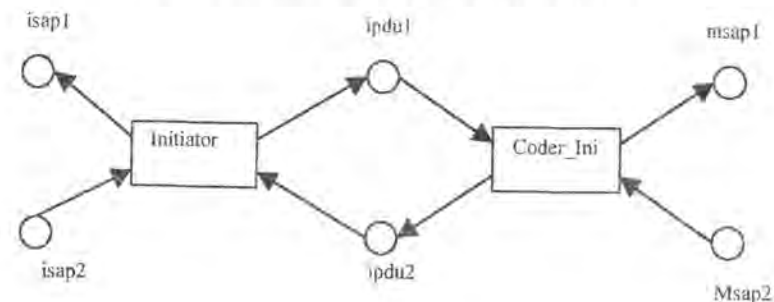
Fig. 16. The Station_Ini block of the INRES protocol

Fig. 17. The net for the Station_Ini block

The project "Algebraic specification of dynamic systems"

Supervised by Prof. Zamulin A. V.

The basis for the tecnique of typed abstract states machines (TAMSs) serving for the abstract description of programming systems' algorithms has been developed. The technique includes

- means of algebraic specification of the system's invariant preserved in various its states (specification of the data types and static functions),
- means of definition of dynamic functions and constants which have different values in different states of the system,
- a number of formal transition rules which define the transition of the system from one state to another according to input data.

As a result, the programming system can be represented as a set of algebras describing its various states and a set of algebra transformation rules specifying its algorithm. An object-oriented version of TAMSs has been created.

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