Institute of Computing Science
Poznań University of Technology

Annual Report 2006

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Institute of Computing Science
Poznań University of Technology

Piotrowo 2
60-965 Poznań

Phone: +48 61 665 2999
Fax: +48 61 877 1525

office_cs@put.poznan.pl

1   Academic and Research Staff

1.1   Institute authorities

Head
> Jan Węglarz, Dr Habil., Professor

Deputy head, scientific affairs
> Jacek Błażewicz, Dr Habil., Professor

Deputy head, student affairs
> Zbyszko Królikowski, Dr Habil., Associate Professor

**Head of the Laboratory of Operational Research
and Artificial Intelligence**
> Jan Węglarz, Dr Habil., Professor

Head of the Laboratory of Intelligent Decision Support Systems
> Roman Słowiński, Dr Habil., Professor

Head of the Laboratory of Computing Systems
> Jerzy Brzeziński, Dr Habil., Professor

**Head of the Laboratory of Algorithm Design
and Programming Systems**
> Jacek Błażewicz, Dr Habil., Professor

1.2   Faculty and staff by degree/education

Total staff number	124
Staff with the scientific title of professor	5
Staff with the degree of — Dr Habil.	13
Staff with the degree of — Dr	50
Other staff with university degree MSc/MA/BSc	50

2   Scientific research

2.1   Scientific specialization

The Institute of Computing Science, Poznań University of Technology, conducts research in the field of computing and decision sciences. The research conducted at the Institute is unique in its comprehensive treatment of computing systems design and management, with particular attention paid to efficiency. It should be stressed that fundamental research is linked with practical applications.

2.1.1   Research areas

In 2006 the **Laboratory of Operational Research and Artificial Intelligence** conducted research in the following areas:

– design and computational complexity analysis of scheduling and production planning algorithms,

– synthesis of traffic control algorithms,

– design and analysis of control algorithms for complex objects in intelligent buildings,

– development of network technologies in control systems.

In 2006 the **Laboratory of Intelligent Decision Support Systems** conducted research in the following areas :

– intelligent decision support systems,

– decision support based on decision-rule preference model,

4

- approximate reasoning,

- evaluation of data mining results,

- multi-criteria decision support,

- machine learning,

- data mining, information retrieval and document classification,

- mobile medical decision support systems,

- telemedicine,

- pattern recognition and computer vision,

- evolutionary algorithms for synthesis of pattern recognition systems.

In 2006 the **Laboratory of Computing Systems** conducted research in the following areas:

- distributed databases,

- distributed processing,

- computer networks,

- database systems,

- object-oriented and multiversion databases

- data mining,

- data warehouses,

- mobile databases,

- intra- and Internet systems,

- recommendation systems.

In 2006 the **Laboratory of Algorithm Design and Programming Systems** conducted research in the following areas:

- algorithms for *DNA* and *RNA* analysis,

- 3D analysis of protein chains,

- microcontroller systems,

- computer integrated management,

- control systems in research applications,

- algorithm design and computational complexity analysis of combinatorial problems,

– scheduling theory, in particular for multiprocessor systems,

– parallel algorithms design,

– compilers and real-time systems design,

– software engineering methodologies,

– computer aided design of electronic systems,

– combinatorial aspects of molecular biology.

2.2   Institute statutory activities

2.2.1   Laboratory of Operational Research and Artificial Intelligence

1. Research topic: Integration of operational research and artificial intelligence techniques in control of manufacturing processes, environmental protection and urban traffic

2. Research topic coordinator: Prof. Jan Węglarz

3. Main research results.

– The analysis of decision optimization methods used in production planning in *Just-in-Time* systems. Comparison of two approaches to task scheduling in *Just-in Time* systems : with explicit and implicit completion times.

– Analytical solution of coordination of traffic in rectangular street networks, with a quadratic objective function.

– Algorithm for online multi-priority control of traffic flow at crossroads with priority granted to trams, based on the clique-finding algorithm for the agreement graph of traffic users.

– Safety analysis of low speed wireless networks based on *IEEE 802.15.4/Zig-Bee*, especially for the encryption protocol *AES*.

– Analysis of the routing process in low-speed wireless networks *ZigBee*, in particular with the Ad hoc On Demand Vector($AODV$) protocol. Modification of the dynamic source routing (DSR) protocol for wireless sensor networks (WSN).

– Analysis of (especially serial) communication capabilities of the *Alpha XL* programmable logic controller (*Mitsubishi Electric*), conducted by an in-built dedicated protocol . Development of hard-software solutions to increase data transfer efficiency, with a PLC in a wireless network.

– Ways to increase efficiency of data transfer between an *Alpha XL* programmable logic controller and a parent system (using an in-built dedicated protocol provided by the manufacturer) by introducing group conversion and bit–set–to–number and number–to–bit–set conversion methods.

– Analysis of problems in designing real-time distributed systems for industry. Comparison of various communication protocols in distributed systems. Methodology of monitoring and control systems design.

– A new method for solution representation for a certain class of discrete-continuous scheduling problems. When this representation is used in a genetic algorithm, the number of potentially optimal sequences decreases considerably and the genetic algorithm efficiency increases.

– A report on state-of-the-art monitoring and control methods for water supply and waste water treatment processes.

– Study of embedded systems for monitoring and control of environmental engineering devices (based on flow measurement and power transmission system control of e.g. fan or pump).

– Study of development trends in embedded systems in intelligent buildings design.

– The concept of algorithm for control of waste water treatment with the activated sludge method, using fuzzy logics.

– Practical verification of signal energy and periodicity analysis in inter-syllable domain for post-processing of automatic segmentation of recordings.

2.2.2   Laboratory of Intelligent Decision Support Systems

1. Research topic : Software and hardware aspects of intelligent decision support

2. Research topic coordinator : Prof. Roman Słowiński

3. Main research results.

– Tests of new models of classifiers and of the *MODLEM* algorithm based on the rough set approach, on benchmark data sets.

– The description of architecture and functions of the portal ”Telemedycyna Wielkopolska” (The Wielkopolska Region Telemedicine).

– Examination of dependence of time spent on driving in town on time of day, based on measurements taken by car navigation systems.

– Influence of body symmetry on human movement efficiency in various environments.

– Presentation of functions of management systems for capital assets information circulation.

– A proposal for a new, co-evolutionary method for deriving complex notions directly from a teaching raw data set, e.g. visual data.

– Discussion of didactic aspects of sample-based estimation of unknown values of population features.

– Presentation of a multi-criteria solution of the assignment problem under constraints (which restrict job assignment to resources, within groups of mutually exclusive jobs).

– Analysis of a method for dynamic selection of nearest neighbors number (k) in *k-NN* classification systems.

– Description of initial implementation of a framework for testing mobile applications.

– Description of an open runtime environment for decision support and machine learning applications running on *.NET*.

2.2.3 Laboratory of Computing Systems

1. Research topic: Parallel and distributed algorithms for distributed computing systems management

2. Research topic coordinator: Prof. Jerzy Brzeziński

3. Main research results.

– Analysis of available solutions for providing safe access for enhanced safe access to distributed *Web Services*.

– Design and implementation of Internet-based communicator with an interface available through a *WWW* browser; in particular, of the user interface layer and the communication platform which allows easy transfer of text messages and files, and enables dynamic update of interface as a reaction to the events which take place in the system, without the necessity to change the browser window content each time in order to display new information.

– Presentation of state of the art knowledge in data transfer security (authenticity and confidentiality). Design and implementation of a prototype solution enabling secure data transfer, which ensures confidentiality of data transfer, authentication of messages and data access authorization.

– Analysis of available *NAT Traversal* methods and selection of the most appropriate technique for sending messages by Internet communicator. Design and implementation of a user application prototype for a communicator constructed within the scope of this project.

– Design and implementation of a distributed *WWW* service with increased reliability.

– Analysis of implementation of business processes using *BPEL-Web Services*.

– Development of a formal model of a multi-version data warehouse.

– Analysis of changes in the scheme structure and changes in data in warehouses. Presentation of applications in a prototype multi-version data warehouse.

– Analysis of the problems of data access optimization with materialized view methods, especially the choice of the appropriate moment of refreshing the materialized view. Presentation of the solution based on materialized query frequency and past materialized objects.

– Analysis of scheme versions and data versions management in a multi-version data warehouse. Presentation of a metamodel of a multi-version warehouse, with cached versions and queries.
– Research on optimization of processing of batches of data mining queries for discovery of frequent itemsets in databases; the *CCAgglomerativeNoise* algorithm.
– Optimization of processing of batches of data mining queries for discovery of frequent itemsets in databases using an *Apriori* algorithm; a new approach to determining the size of memory structures used by queries.

2.2.4   Laboratory of Algorithm Design and Programming Systems

1. Research topic: Control in discrete systems
2. Research topic coordinator: Prof. Jacek Błażewicz
3. Main research results.

   Research was conducted in four research areas.

   1. Algorithms for analysis of *DNA* structure
   2. Microcontroller systems
   3. Control systems in research applications
   4. Computer integrated management

   ad. a
   – Analysis of properties of quasi-adjoint graphs appearing in combinatorial problems, formulated for computational biology.
   – Research on cooperation of *mRNA* particles with a *PUMILIO2* protein in the human genome.
   – Development of a system for analysis of handwritten drawings of Parkinson's disease patients. The application allows to express numerically the degree of tremor of the patient's hands on the basis of drawn contours.

   ad. b
   – Research on economical aspects of development and exploitation of Internet services.
   – Analysis of equality in traditional and computerized high school admission systems (a computerized high school admission system was introduced in several towns in Poland in recent years).
   – Development of applications and programming tools to research new technologies used in e-economy.

ad. c

- Development and implementation of a system for remote control of devices.
- Analysis of the issue of water resistance, important in designing control systems for intelligent buildings.

ad. d

- Analysis of methods for simulating production processes .
- Design and implementation of a content management system and a computer-based system for quality management support.

2.3 Institute individual research

2.3.1 Laboratory of Operational Research and Artificial Intelligence

1. Research topic: Operational research and artificial intelligence methods used in resource management and control in complex systems

2. Research topic coordinator: Prof. Jan Węglarz

3. Main research results.

- Design of a liquid level detection system using a *Chipon Texas Instruments CC2510* microcontroller. Comparison of different solutions with various kinds of sensors. The system uses wireless data transmission in the 2.4 *GHz* bandwidth.

- A literature-based survey of models and algorithms for production lot optimization. Analysis of existing solutions and formulation of research problems in the area.

- Hierarchical taxonomies such as network catalogues are developed, among others, to facilitate user navigation and access to documents. Using taxonomies to perform such tasks as automatic integration of different schemes or automatic retrieval of network services requires explicit representation of semantics, which is hidden in the structure and labels of taxonomies. Hence, a method for automatic annotation is proposed. The method provides a description, in the form of a logical formula, of each node of a hierarchical taxonomy. Each logical formula is based on the lexemes from the lexical database *WordNet*. A method based on Bayesian networks is used for disambiguation.

- Analysis of problems involved in developing a violin sound database within the scope of international community emphasis on preserving audio-visual cultural heritage. Design and implementation of a prototype violin sound database AMATI. Solutions to problems involved in segmentation and recognition of sounds in the database. Attempts to find metadata for unambiguous identification of instruments and for discovery of the preferences of experts

evaluating the violin sounds. Matching musical instruments on the basis of timbre, using disjunctive semantic categories.

– Development and analysis of purposes, assumptions, design, implementation and perspectives of a digital archive of sounds of the violins participating in the X Henryk Wieniawski International Violinmakers Competition held in Poznań, Poland, in 2001. Registration of sounds and development of a prototype sound database *AMATI*. The database collects information and photographs of instruments, recorded sounds and jury ranking in the second stage of the competition. Plans to place the database in the Wielkopolska Digital Library.

– Analysis of the properties of the *Mitsubishi Electric Alpha XL* programmable controller. Identification of properties which make the controller useful in water treatment. Four areas of application of *Alpha XL* have been considered: control of water intakes, control of water flow in water treatment plants, control in sewage pumping stations, remote control of an automatic purification plant.

– Analysis of the structure of an intelligent building. Control and management systems for an intelligent building - problems and solutions.

– Comparison of efficiency of two implementations of a genetic algorithm for scheduling problems for parallel processors with additional continuous resource. In the assumed model the task processing speed depends on the amount of the continuous resource allocated at a given time.

– Analysis of *SCADA* systems used to monitor and control complex technological processes such as sewage treatment and water treatment. Comparison of methods for determining the number and position of monitoring stations in sewage systems performed in order to optimize investment costs.

2.3.2   Laboratory of Intelligent Decision Support Systems

1. Research topic: Methodological foundations and applications of intelligent decision support systems

2. Research topic coordinator: Prof. Roman Słowiński

3. Main research results.

– A new efficient algorithm for generating decision rules has been proposed.

– The use of ontology for modeling clinical knowledge and information and for automatic generation of user interface in the telemedical portal "Telemedycyna Wielkopolska" (The Wielkopolska Region Telemedicine) has been described.

– A new fuzzy-rough approach to data analysis has been proposed. The approach is rendered less arbitrary thanks to the assumption that no fuzzy conjunct exists.

– It has been shown how pairwise comparison increases efficiency of a multi-criteria memetic algorithm.
– Research on using tablets for objective evaluation of hand tremor before and after one-sided stereotactic surgery in patients with Parkinson's disease has been presented.
– Real-life data have been used to illustrate an enriched algorithm for association rules generation and their characteristics in the support-anti-support space.
– The trends in rough set based rule induction methods have been presented.
– The concept of retrieving contextual sequential patterns has been presented. The concept allows to discover patterns in numerical data.

2.3.3   Laboratory of Computing Systems

1. Research topic : Processing analytical and data mining queries in warehouses and advanced database systems

2. Research topic coordinator : Prof. Tadeusz Morzy

3. Main research results.

– Presentation of a logical and physical structure of a superset query support index. The way of implementing this index in the *Oracle* management system. Ways of avoiding some problems involved in collection indexing.
– Presentation of a *Trie-based* index for a categorical data set sequence.
– A proposal for implementation of data warehouse evolution using a set of nested transactions (schema transactions and size transactions). Implementation of the remaining warehouse activities with nested transactions (e.g. warehouse refreshing and analytical session for warehouse users).
– Analysis of schema and data evolution in data warehouses. Solving the problem of data evolution using a multi-version data warehouse.
– Presentation of the concept and the function set of a multi-version data warehouse. Implementation of a prototype system.

2.3.4   Laboratory of Algorithm Design and Programming Systems

1. Research topic: Current issues in software engineering

2. Research topic coordinator: Dr Habil. Jerzy Nawrocki

3. Main research results.

   The following aspects of software development were considered:

   a) software projects management,
   b) requirements engineering,

c) software maintenance.

ad. a

Managing a complex software project requires balancing between discipline in documenting a highly formalized engineering process and agility necessary to reflect dynamic changes in business aims of the project. The following problems have been analyzed within this field.

– Managing a software project using the *XPrince* (*eXtremePRogramming IN Controlled Environment*) methodology, which combines the agility of *Extreme Programming* with the *PRINCE2* discipline. The role of project manager, analyst and architect is analyzed in detail.

– Analysis of the *Automatic Software Validation* (*ASV*) system capabilities. This system is used for automated testing of applications in *WWW*. It also allows to define application simulators for user training and software testing. The *ASV* tool was developed to shorten the testing time and ensure test repeatability. The system was successfully applied in testing a large computer system used by twelve Polish financial institutions.

– Virtual advertising systems are an important element of numerous portals and websites. Advertisement efficiency usually determines the revenue generated by virtual services. The choice of appropriate tools for Internet advertising is a challenge both for Internet server administrators and marketing staff, as the former and the latter have to consider the risk of losing clients who are tired and put off by aggressive advertising. The current trend displays a tendency for commercial information to be an extension of the information content of the website. Pixel ad systems, in which small graphic ads are placed in the background of a webpage, are gaining popularity. *Pixel Ad* is an attractive development of the concept which appeared on the Internet in 2005. As part of the research, selected techniques and tools for web advertising campaigns were compared, including pixel ads.

ad. b

Use cases are successfully applied in requirements engineering to describe functional requirements of computer systems. Experiments conducted at the Institute have shown that use cases are a good alternative to graphic notation in describing business processes. Use cases are semiformal: a business process is expressed as a sequence of steps described in natural language. Business processes generally last longer than performing particular functional requirements and the description must be modified in order to reflect the nature of the processes. In this area the following results have been achieved.

– Study of research results in applying use cases to model business processes. Presentation of interesting extensions of user cases; these

extensions allow to express the metamorphosis of actors and to show the consecutive steps which must be performed before the main scenario. The proposals have been incorporated in the *UCWorkbench* which is a tool for editing and animating use cases. The tool was devised and developed at the Institute.

– Analysis of the properties of *PERC* programming platform for software development for embedded and real-time systems in Java.

ad. c

Within the scope of software maintenance the following results were achieved.

– Analysis of the code smell issue. A great variety of bad smells in code calls for application of various, and sometimes complex, methods for discovering code errors. It is possible to test object-oriented metrics, particular constructions in the syntax tree, and the code performance. This process may be enhanced by detecting code smells. To this end, relationships between selected bad smells were defined and described. It was shown how this knowledge may be used in detecting subsequent defects in the software.

– Analysis of application of mutation testing. The importance of test suites in software development leads to the problem of verifying the test suites themselves. Mutation testing has been considered as an effective verification technique. It was also checked how test suites react to changes introduced in the source code of the tested application. The drawback of the approach based on numerous test suite modifications consisted in repeated, time-consuming compilation and running of tests. With respect to this deficiency, a so-called aspect approach to mutation generation was proposed. The approach does not require recompilation of the code for each test mutation.

2.3.5   Laboratory of Algorithm Design and Programming Systems

1. Research topic: Solving ordinary and partial differential equations with interval methods in floating-point interval arithmetic

2. Research topic coordinator: Dr Habil. Andrzej Marciniak

3. Main research results.

   The following tasks were performed within the research topic.

   – Examination of the interval methods for solving the initial value problem, and their implementation in the floating-point interval arithmetic.

   – Using interval methods of the symplectic Runge-Kutta type for solving Hamiltonian equations.

14

The publications prepared within the research topic concerned the following issues.

– Explicit interval methods of the Adams - Moulton type.
– Symplectic interval methods for solving Hamiltonian problems.
– *BDF* interval methods for solving the initial value problem.
– A multi-step method for solving the initial value problem.
– Multi-step interval methods of the Nystroem and Milne - Simpson type.
– The Backward Differentiation(*BDF*) method.

The doctoral dissertation written and defended by Małgorzata Jankowska, MSc, entitled *Interval multi-step methods of Adams type and their implementation in the C++ language*, is yet another research result.

2.4   Individual grants

2.4.1   Multi-criteria grid resource management methods

1. Project coordinator: Prof. Jan Węglarz

2. Description of scientific research and achieved results.

One of the most important scientific goals of the project is the development of efficient job and resource management methods for grid environment with multi-user decision processes, aided by multi-criteria analysis and optimization. The first phase of the project involved the analysis and simulation of existing solutions used in distributed grid environments and new generation networks. The results obtained in this phase will allow to identify the areas for development and research. They will also allow to formulate basic assumptions for grid resource allocation models and user requirements in new scenarios of cooperation with grid infrastructure. The project also assumes carrying out simulations with prediction mechanisms and resource reservation mechanisms. This will allow to use more efficient job and resource management methods and to serve users with time and cost constrains. It will also enable efficient scheduling of specific classes of jobs which require resource reservation. The proposed methods will include distributed resources security and local and global policies of resource access control. Advanced authentication scenarios and methods will be developed and used in resource allocation and access control, with security-driven constraints in distributed grid environment. Moreover, new negotiation protocols will be analyzed and simulated and later used in grid job and resource management. Research will also involve classical resource allocation theory and the development and evaluation of new heuristic algorithms for complex optimization problems. Currently an important branch of research is network resource management in new generation networks of distributed com-

putational resources. An important goal of the project is also the verification of research hypotheses in experiments conducted in test grid environments based on the *PIONIER* infrastructure. The new generation *PIONIER* network joins research centers and computing resources in Poland and in several other countries. Test grid environments and real-life simulations of new resource allocation methods and scenarios will be based on existing prototypes of Grid Resource Management Systems (*GRMS*), Grid Authentication Systems(*GAS*) and many more network-grid services developed so far by the Poznań Supercomputing and Networking Center in cooperation with the Institute of Computing Sciences.

Detailed investigations concerned the following topics:

– development of a general grid architecture and resource management model,
– analysis of existing resource management models for new generation networks,
– development of architecture and the realization of the decision module in a grid resource management system,
– design of a grid environment simulator and the implementation of selected modules,
– development of a general model of resource allocation in grid environments, using classical resource allocation theory.

2.4.2   Job scheduling problems - new models, algorithmic approaches

1. Project coordinator: Prof. Jacek Błażewicz

2. Description of scientific research and achieved results.

The project concerned the issues which appear where computing science, discrete optimization and operational research meet. Both computer system management and manufacturing process management must ensure reliability and efficient use of resources. Research conducted by the team in previous years led to the development of a uniform model of deterministic scheduling. The elements of this model are a set of processors representing the computer or manufacturing environment, a set of jobs (computer programs, technological operations, transport operations) and a solution evaluation criterion. The solution consists in assigning jobs to processors as a function of time. Owing to rising complexity of computer and manufacturing processes, such classical models are no longer a sufficient scheduling tool. The aim of the current project was to develop scheduling algorithms for new models of computer and manufacturing systems, which are, in most cases, characterized by communication delays. These are combinatorial problems, therefore

their nature is discrete. In accordance with modern standards, computational complexity theory methodology was applied to analyze such problems. The theory requires that the complexity of the scheduling problem is established, i.e. it is established whether the problem is easy (then a polynomial-time solution algorithm can be found) or hard (for the time being it is assumed that there is no efficient solution algorithm for such a problem). Therefore, research concentrated on identifying the most general problems solvable in polynomial time, and the simplest problems which are computationally hard. In 2006 the following tasks were realized.

– **Scheduling algorithms in flexible manufacturing systems with transport systems.**
  Synchronized scheduling of manufacturing and transport tasks was considered. Existing manufacturing management models were surveyed. Scheduling models with additional resources, such as transportation systems, were analyzed and compared. A new graph representation useful in modeling and analysis of scheduling manufacturing processes was developed.

  Next, the application of scheduling theory in painting car bodies and in car assembly was analyzed. The problem of scheduling cars in the paint shop buffer was considered. Several practical online algorithms were given and compared in a computational experiment with reference to the currently used system. The data for calculations were taken from a current manufacturing system.

  The problem of balancing the car assembly line was also analyzed. The problem consisted in scheduling a sequence of car bodies ahead of the assembly line (where no more changes in the sequence are possible). The proposed schedule evaluation measures involved the model-dependent workload at each workplace. The proposed sorting algorithms optimized these measures. The advantages of these algorithms were shown using real-life data.

– **Scheduling in real-time systems.**
  In real-time systems time constraints are as important as functional constraints. Real-time systems include hard real- time tasks with hard deadlines. Periodic loading used in real-time systems schedules a set of non-preemptable periodic tasks on one processor. In the classical approach, periodic loading does not allow profiting from the speed-up which results from placing jobs (or parts of them) in cache. In the proposed solution, parts of jobs are blocked in cache, which usually leads to significant reduction in job processing time; also, the probability that a feasible solution exists is increased.

  In further research the knapsack lightening problem was defined and it was shown to be strongly NP-hard. The implementation of an exact algo-

rithm was provided. Since it is an exponential time algorithm which can hardly be used in real-life, two heuristic algorithms were proposed and their efficiency was evaluated. However, the exact algorithm is useful in solving small instances of a problem and as a point of reference in evaluation of heuristics. It was also shown how the periodic loading problem for computers with cache memory can be transformed to the knapsack lightening problem.

2.4.3   Intelligent decision support systems based on knowledge discovered from data

1. Project coordinator : Prof. Roman Słowiński

2. Description of scientific research and achieved results.

   Research concentrated on the following tasks.

   Task 1: Development of methods for machine learning and knowledge discovery from nominal and ordinal data – part I.

   Task 2: Development of methods for machine learning and knowledge discovery from nominal and ordinal data – part II.

   Task 3: Development of methods for preference modeling based on logical expressions of the decision rule or decision tree type.

   Task 4: Development of rough set based decision support methods.

   Task 5: Implementation of multi-platform and mobile intelligent decision support systems.

   Task 6: Verification of methods encompassed by the proposed methodology using real-life data and decision problems.

   Publications prepared within the frame of the research topic refer to, among others:

   – experience in using the rough set approach to analysis of clinical data from the emergency room in the Children's Hospital in Ottawa,

   – application of the *rough modus ponens* and *rough modus tollens* inference rules to the case of uncertain premises and conclusions expressed in rough set terms,

   – project, implementation and testing of the prototype version of the *Mobile Emergency Triage (MET)* system, which is a clinical decision support system for triage of emergency room patients,

   – methodology for clinical data analysis, which will allow to choose essential clinical attributes and to create attribute-based decision rules,

   – computational experiment to compare various machine learning methods used in clinical problems,

– using the Bayesian network based decision model to predict the length of hospital stay of patients after prostate gland surgery,

– interactive approach to multiple criteria reporting, based on *DRSA* (dominance-based rough set approach),

– new concept of using data induced decision rules to plan the strategy of intervention and evaluate its expected effects,

– new proposal to generalize rough sets to the fuzzy-rough form,

– generalizing the concept of variable precision rough sets,

– new approach to solving the problem of ordering a set of decision variants; the ordering criterion is a combination of numerous, usually conflicting, evaluation criteria,

– multiple criteria scheduling problem with dedicated processors; there are constraints imposed on the number of tasks performed by each processor, and on assigning tasks to particular processors,

– the advantage of Bayesian confirmation measures over confidence measure, which is a popular rule attractiveness measure,

– the analysis of dominance-based rough set approach.

2.4.4   Effective replication and rollback recovery in distributed mobile systems

1. Project coordinator : Prof. Jerzy Brzeziński

2. Description of scientific research and achieved results.

– **Development of consistency models of replicated services in distributed mobile systems.** The team developed an approach in which the consistency model is selected at the realization stage of the application, since the expectations related to consistency are formulated at the moment an object is accessed. This approach is an extension of the multi-version consistency concept, according to which the system supports various versions of data (objects) corresponding to different consistency models. However, mobile systems are specific in the sense that processing may take place during switching from one replica to another. Therefore, a process performed in a mobile node must properly "see" system operations: both these about which the process knows nothing, and those whose results are already recorded in its state but not in the currently used replica.

The team presented an implementation of file systems preserving session guarantees. The implementation was based on the concepts presented in a doctoral dissertation, which was prepared as part of the research topic. Weak and optimistic replication was assumed. This means that a server stores only a part of data (files), which allows more efficient management of server

space and reduction of server load. A slightly different aspect of consistency was considered with reference to matching software components. The choice of this area of research reflects a belief that future mobile systems will be highly dynamic, e.g. they will be able to adapt themselves to changes in environment or unforeseeable events such as updates of protocols, new versions of software or partial failures. The team designed a class-based parallel object-oriented language which allows dynamic switching between parallel objects, and supports atomicity. The language has been formally described as calculus, with operational semantics which explains how particular constructions of the language work.

– **Epidemic algorithms and speculative techniques in consistency and rollback recovery protocols in distributed mobile systems.** Owing to communication delays in mobile environment, there is growing interest in speculative techniques. The combination of speculative techniques and recovery techniques raises hopes of constructing systems both fault-tolerant and efficient. The conducted research showed, however, that such a combination, if performed carelessly, may lead to decrease, and not increase, in efficiency. Speculative techniques were also considered for use in fault-tolerant distributed mobile systems. A new consistency protocol and rollback recovery algorithm was proposed, based on prefetching and independent checkpointing. The forwarding technique was also considered. This technique, symmetric to prefetching, assumes that the site owner anticipates cases of future access. A corresponding consistency protocol and rollback recovery algorithm was presented.

– **Analysis and development of consistency protocols for replicated services in distributed mobile systems.** Consistency protocol is a distributed algorithm which realizes the assumptions of a particular consistency model. Earlier research showed that client-centric consistency models (session guarantees) are useful in consistency management of replicated data in mobile environments. A solution which prevents monotonic expansion of modification operations was proposed. It consists in using approximate representation of sets, which in turn represents supersets of exact (required) sets. This representation is based on version vectors which are relatively small and stable.

A new consistency protocol $VcSG$ was developed . The $VcSG$ protocol uses client-centric version vectors. The related research allowed to identify some features of client-centric version vector based protocols. Consistency models incorporated in session guarantees find many applications in distributed mobile systems. The prototype distributed file system $FEver$ is one of the examples. This project assumed, among others, practical verification of earlier client-centric consistency models, allowing alternative use of three

different algorithms providing session guarantees. Practical aspects of protocol implementation were also studied. Finally, distributed mobile systems with both mobile computers and mobile processes were considered.

– **Analysis and development of rollback recovery protocols in distributed mobile systems.** As part of further research on rollback recovery protocols, a proposal was made to combine recovery and coherence protocols in such a way that the recovery overhead would not influence greatly the total processing time. The proposed solution consists in using logging and checkpointing techniques closely integrated with consistency protocols. The semantics of user operations and properties following from the definition of session guarantees are taken into account. The analysis of properties of RYW, MW, WFR, MR session guarantees allows to determine the earliest moment for checkpoining for each guarantee, before which recording the server state does not influence preserving required session guarantees. Recovery protocols were modified in order to find the optimal moment for taking a checkpoint from the point of view of a given session guarantee. A correctness proof was provided, showing that the safety and liveness properties were preserved. The protocols were also tested experimentally in order to determine and compare the number of checkpoints, and the overhead related to checkpointing and rollback recovery. The conducted experiments allowed to test the proposed recovery protocols, a consistency protocol without the recovery mechanism and a pessimistic recovery protocol, in which client's operations were logged but checkpoints were created at regular intervals. Processing time was the evaluation criterion in each experiment. The experiments were performed on a dedicated application which simulated a group of servers and clients, the initial parameters of which had been earlier validated. The result confirmed that the proposed protocols are more efficient than pessimistic protocols.

2.4.5   Construction and analysis of exact and heuristic algorithms for resource allocation problems with regular and non-regular optimality measures

1. Project supervisor : Dr Habil. Joanna Józefowska

2. Scientific research and main results.

   The most important results obtained in 2006 are as follows.

   – Development of a model of the resource allocation problem with schedule-dependent set-up time; development and implementation of heuristic algorithms for this problem.
   – Development of a general model of task processing in discrete-continuous scheduling problems for different categories of parallel machines.
   – Development and implementation of a dynamic programming algorithm

for a single machine scheduling problem with linear unit cost functions and minimization of the total earliness-tardiness cost.

– Comparison of fair sequence generation models for mean and maximum deviation from the average production rate.

– Development of inference algorithms in Bayesian networks with knowledge updating. Comparison of efficiency of these algorithms in terms of the number of performed operations.

– Development of a product and service recommendation system for mobile users, with a Bayesian network based learning mechanism.

– Implementation of algorithms for discrete-continuous scheduling problems with machine-dependent and task-independent processing rates; computational experiment.

– Comparison of inference algorithms with knowledge updating in terms of the actual computation time; development of a simulator for inference in Bayesian networks.

– Implementation of algorithms for resource allocation problems with maximization of the *Net Present Value.*

– Conducting computational experiments for resource allocation problems with maximization of the *Net Present Value.*

– Further research on inference algorithms for special cases-inference effectiveness enhancement.

– Development of an instance generator for discrete-continuous scheduling problems with an assumed distribution of uncertain parameters.

2.4.6 Development of methods and tools for single and multi-criteria optimization

1. Dr Habil. Andrzej Jaszkiewicz

2. Scientific research and achieved results.

   The project aims at developing efficient and easy-to-use IT methods and tools for single and multiple objective optimization. The most important results obtained in 2006 are as follows.

   – Development of methodology for systematic design of crossover operators for hybrid evolutionary algorithms. The methodology is used in solving the following problems: vehicle routing, car production scheduling, satellite control and the 2-dimension cut problem (*2-DCP*).

   – Application of the methodology for systematic design of crossover operators in a single and multiple objective scheduling algorithm with resource constraints.

   – Improvement of the currently best results for the multiple objective traveling salesman problem

– A proposal of a new multi-criteria metaheuristic based on path relinking, using both scalarizing functions and dominance relations to evaluate solutions.

– Development of a methodology for experimental evaluation of classical multiple objective metaheuristics. The metaheuristics were used in the interactive process based on partial information about the decision maker's preferences. It was shown that the efficiency of these metaheuristics decrease with the increase in instance size and in the number of criteria.

– A new hybrid evolutionary algorithm using partial information about the decision maker's preferences collected during the computational process. The algorithm was used for to solve comparatively large multi-dimension instances of the traveling salesman problem and the knapsack problem, and proved to be highly efficient.

– Development of the library *MOMHLib++* ; using the library to conduct computation experiments.

– Development and testing of a distributed implementation of a genetic local search algorithm for the vehicle routing problem.

– Development of a prototype version of an open multiple objective optimization platform.

– Development of visualization modules for solutions of the 3-D packing problem and the vehicle routing problem; also a visualization model for the multiple objective metaheuristics in *MOMHLib++* and for the multiple objective interactive Pareto memetic algorithm.

– Performing a number of extended computational experiments for test cases and real-life optimization problems.

2.4.7   New methods for mining complex data types

1. Project coordinator: Dr Mikołaj Morzy

2. Scientific research and obtained results.

   In 2006 (the first year of the project) the following five research tasks were carried out.

   – Development and implementation of new algorithms for generalized association rule mining; computation experiments. The proposed physical structure and the hierarchical bitmap index are a perfect tool for concise representation of data sets from a very large domain. The results of initial experiments are promising. Currently the experiment and implementation phase is taking place.

– Development and implementation of algorithms for incremental data mining with incremental refresh of materialized data mining views; integration of these algorithms with the data warehouse refresh process.

– Development of structures for modeling online auctions; development and implementation of adequate mining algorithms for these structures; development of new methods for assessment of reliability and reputation of participants of online auctions; experimental evaluation of the proposed algorithms. The most interesting results are the development of the notion of credibility of an online auction user; the development of a model for generating automatic recommendations for auction users; the discovery of the implicit feedback phenomenon and examination of its influence on user reputations. A fully functional prototype of an online auction house, which was also developed, implemented the above algorithms.

– Development of a theoretical model representing knowledge discovered in a moving object database. An altogether new mobile object position prediction method has been formulated. Prediction is based on patterns (frequent trajectories) discovered from a very large database of past object movements.

– Development and implementation of new mining algorithms for moving objects databases; experimental evaluation of mobile object position prediction algorithms. The model of mobile object position prediction based on discovered patterns (frequent trajectories) was implemented and tested in a series of computational experiments. The conducted experiments have proved the efficiency of the model and have shown that the model accuracy is satisfactory from the point of view of future applications.

2.5   International grants

2.5.1   *COMPUVAC* - Rational design and standardized evaluation of novel genetic vaccines

1. Project coordinator: Prof. Jacek Błażewicz

2. Description of conducted research and obtained results.

The work in 2006 mainly concerned design and implementation of the *Genetic Vaccines Decision Support System*, *GeVaDS*. This is a system for efficient storage, integration, and computational analysis of biological data related to genetic vaccine production. Available for the whole scientific community and to a limited extent for the general public, it will give the latter access to data from immunological experiments. The system modules which had been identified in the previous year were created this year: the T cell response module, the B cell response module and the safety profile module, involved in the identification of the genes most sensitive to the presence of a given

virus, now called molecular signature. A detailed system scheme for T cell response was implemented and search algorithms for the database of this module were designed and implemented as well. Various techniques for data visualization were implemented based on the information supplied by consortium partners, making it possible to analyze experimental results in an easy, intuitive way.

In 2006 the team from the Institute was involved in the following tasks.

– Analysis, design and implementation of the database subsystem responsible for storing and processing data connected with T cell response observations.
– Analysis and implementation of basic database search algorithms for the T cell responses.
– Identification, analysis and implementation of user requirements regarding visualization of T cell response results.
– Analysis, design and implementation of the subsystem responsible for storing and processing data connected with B cell response observations.
– Analysis and implementation of basic database search algorithms for the B cell responses.
– Analysis, design and implementation of the database subsystem for safety profiles observations.
– Analysis and implementation of basic database search algorithms for the safety profiles.
– Implementation of the initial version of the database management system (*DBMS*).
– Implementation of the content management system for the *COMPUVAC* portal.
– Implementation of the content management system for the *GeVaDS* system.
– Implementation of the user interface module in the *GeVaDS* system.
– Identification of requirements for the security and authorization module in the *GeVaDS* system.
– Implementation of the basic version of the security and authorization module in the *GeVaDS* system.
– Development of the *GeVaDSs* user's manual for the current version of the system.
– Improvement of the *COMPUVAC* and *GeVaDSs* portal.
– Analysis and implementation of the immunization protocol.
– Training session devoted to the T cell response results module.
– Design and implementation of a more detailed version of the data description scheme and entering data for the T cell response result module.

– Standardization of data description.

2.5.2   *BIOPTRAIN* - Training in optimization algorithms in bioinformatics

1. Project coordinator : Prof. Jacek Błażewicz

2. Description of conducted research and obtained results .

The year 2006 has been a year of intensive research on the mathematical model of the simplified partial digest method for genomic mapping (*Simplified Partial Digest Problem, SPDP*). Two new exact algorithms for the error-free case of the *SPDP* problem were developed and implemented. The version of the problem without measurement errors in input data was considered; however, even in this case the problem is strongly NP-hard. The first algorithm is an enumerative algorithm which solves the general version of the problem in $O(n^{2n})$time, where n is the number of restriction sites in the examined section of *DNA*. The second algorithm, a dynamic programming algorithm, in $O(n^{2q}))$ time solves a special case of the problem, in which we assume only q different values of distance between restriction sites (i.e. the algorithm finds the solution in polynomial time if q is constant).

The algorithms have been tested on random data and on data generated from real DNA chains (from the *GenBank* database). They have been also compared with two algorithms known from the literature. Moreover, it was proved that the number of solutions of the *SPDP* problem may be described with an exponential function of the instance size. Two examples of the problem were given, for which the number of different solutions is $2^{(n+2)/3-1}$. This allowed to answer the question earlier formulated in the literature about the number of solutions of the *SPDP* problem. Another research problem concerned an attempt to develop an exact model of human body iron homeostasis, based on the Petri net theory. One aim of the research was to find out whether Petri nets are useful in modeling complex physiological processes. Another goal was to develop an exact Petri net model of human body iron homeostasis. Such formulation of the problem required close collaboration of computer scientists, biochemists and medicine doctors. Therefore it was realized in collaboration with Poznań University of Medical Sciences.

Although many components of the above mentioned physiological process were described in the literature, the exact model of the complete process has not been proposed so far. This motivated the attempt to create such a model and express it in terms of a Petri net. The application of a Petri net means that the created model must be much more precise than the less formal models of biochemical and physiological processes created so far. The

goals mentioned earlier have been reached. The applicability of Petri nets in modeling physiological processes was assessed. In particular, the team pointed out the capabilities and limitations of using variants of Petri nets to describe different aspects of analyzed processes. The first complete qualitative model of human body iron homeostasis has been created and expressed in terms of a Petri net. Detailed analysis of the model allowed to verify some hypotheses concerning the analyzed process. Moreover, the team developed a quantitative model of the main part of the process, which includes the available information on time relationships of process parts. The model used the *deterministic interval timed places Petri net*. Finally, the team pointed out the areas for analysis of this Petri net variant.

2.5.3   *METAFUNCTIONS* – a data mining system for genomics, based on scientific publications

1. . Project coordinator : Prof. Jacek Błażewicz

2. Conducted research and achieved results.

Within the project time schedule, the year 2006 was devoted to analysis of the structure of articles comprising metagenomics information, analysis of the structure of sequence databases and of websites of selected journals, and to development of tools to download sequences from public databases, using information comprised in scientific publications. The team also developed an initial version of a program for automatic download of articles from scientific journal websites. The results of analysis of articles on metagenomes and/or marine bacteria allowed to work out a method for initial classification of articles and will be used in designing the data mining system. In the first phase of the project, the team examined the possibility of classifying articles on the basis of accompanying abstracts. However, the information contained there proved to be insufficient. Therefore the structure of full text articles had to be analyzed.

The team analyzed the *GenBank* record structure, as well as the record structure of a few other sequence databases. Results of this analysis allowed to develop a method for automatic retrieval of *DNA* sequences from information comprised in scientific publications. The method has been implemented as a program which will be integrated with the database prepared by the team from the Max Planck Institute in Bremen. The program uses accession numbers from publications to find respective sequences in *GenBank* and allows to download them on local computers and place in a database. The team also researched the websites of 15 journals, selected earlier by the team from MIT; most articles on metagenomes and marine bacteria are published in these journals. The research results allowed to develop and implement a

system for automatic monitoring of journal websites and for downloading new articles. It may also be used to retrieve articles from journal archives. To sum up, in 2006 the team from the Institute worked on the following tasks within the *METAFUNCTIONS* project.

– A study of abstracts as a potential tool for article classification.
– Examination of applicability of *Whatizit* for data mining.
– Analysis of the structure of articles comprising information about metagenomes or marine bacteria.
– A glossary of marine bacteria, geographical names, physical and chemical parameters and related vocabulary.
– A study of the *GenBank* record structure and of the content of similar databases.
– A method for automatic retrieval of *DNA* sequences from scientific publications.
– A program for automatic retrieval of *DNA* sequences from scientific publications.
– A study of websites of journals which publish articles on metagenomes and/or marine bacteria.
– A method for automatic retrieval of articles from journal websites.
– A program for automatic retrieval of articles from journal websites.

2.6   Habilitation dissertation

2.6.1   Dr Habil. Piotr Formanowicz

1. Dissertation title : Selected combinatorial aspects of biological sequence analysis

2. Main theses of the dissertation.

This dissertation concerns selected problems of computational biology – a modern, dynamic interdisciplinary branch of science which is a meeting ground of biology, computer science and mathematics. Computational biology allows to develop and study computational models of biological objects and processes and to construct algorithms for solving related problems. Naturally, well known computing and mathematical methods are applied in this field; however, biological processes themselves often provide inspiration to study previously unknown mathematical objects. This means that ideas flow freely in all directions within the computational biology field.

The dissertation focuses on selected issues in amino acid and nucleotide sequence analysis - one of the central issues in bioinformatics. The greatest emphasis in the dissertation is laid on *DNA* sequencing, and, specifically,

on improving efficiency of sequencing by hybridization. *DNA* sequencing, or reading the information encoded in a *DNA* molecule, is the initial, indispensable stage in retrieving genetic information; therefore an effective sequencing method is a necessity in molecular biology. On the other hand, studying sequencing by hybridization brings along a number of interesting computing and mathematical problems. The author presented the main disadvantages of sequencing by hybridization and suggested ways of (at least partial) improvement. It involved developing new versions of the method, analysis of their models and constructing appropriate algorithms. An important algorithm presented in the dissertation is the recognition algorithm for de Bruijn graphs. These graphs are of particular importance for many aspects of sequencing since their vertex induced subgraphs are often used to construct sequencing models.

The author also raised the issue of peptide sequencing, for which he gave graph models. Further close scrutiny of the graph led to the discovery of some interesting relations between them.

Finally, the author considered the possibility of using *DNA* molecules in calculations. These considerations are complementary to the main part of the dissertation, in which mathematical and computing methods are used to solve problems in biology. The complementary option consists in biochemical methods being used to solve combinatorial problems. The author gave a few *DNA* based algorithms for combinatorial problems, mainly for scheduling problems. Quite likely these are the first *DNA*-based algorithms.

2.7   Doctoral dissertations

2.7.1   Dr Małgorzata Jankowska

1. Thesis title : Interval multi-step methods of Adams type and their implementation in the C++ language

2. Supervisor : Dr Habil. Andrzej Marciniak

3. Main theses of the dissertation.

   The dissertation concerns a class of multi-step methods for the initial value problem. It includes a description of computer implementation of these methods in floating-point interval arithmetic. The application of interval methods for the initial value problem has a number of advantages.

   – The initial condition may be given as an interval, therefore it may include the error of data.
   – The interval solutions (in the interval form) obtained with interval methods include the error of methods.

– The implementation of interval methods in floating-point interval arithmetic also allows to estimate the round-up errors, since they are included in the obtained interval solutions.

It follows that solving the initial value problem with interval methods in floating-point interval arithmetic allows to achieve interval solutions, which include all possible errors that appear in computerized calculations. This is not the case for classic numerical methods implemented in plain floating-point arithmetic (which is sometimes called naive arithmetic).

The dissertation starts with defining the initial value problem and presentation of selected theorems referring to the existence of the solution. Then follows the presentation of classic multi-step methods of the Adams type, i.e. the explicit interval methods of Adams-Bashforth type, the implicit interval methods of Adams-Moulton type and the interval predictor-corrector methods of Adams type. Next, selected elements of interval analysis are discussed and a list of terms is given.

The main part of the dissertation begins with the definitions of multi-step interval methods of the Adams type: explicit interval methods of Adams-Bashforth type, two different families of the implicit interval methods of Adams-Moulton type and the interval predictor-corrector methods of Adams type, class *P(EC)sE* and *P(EC)s*. For explicit interval methods of Adams-Bashforth type and implicit interval methods of Adams-Moulton type, theorems which show that the exact solution of the Initial Value Problem belongs to appropriate intervals have been proved, as well as theorems which allow to estimate the widths of these intervals.

Then follow the assumptions for a computer system *IMM System* (*Interval Multi-step Methods System*) working under Windows and cooperating with the *InterBase*. The system, written in C++, allows to solve the initial value problem with all multi-step interval methods of the Adams type presented in the dissertation, in floating-point interval arithmetic. The analysis of numerical results obtained by solving a number of initial value problems with the presented interval methods allows to compare the methods and draw final conclusions.

2.7.2   Dr Anna Kobusińska

1. Thesis title : Rollback-Recovery Protocols for Distributed Mobile Systems Providing Session Guarantees

2. Supervisor : Prof. Jerzy Brzeziński

3. Main theses of the dissertation.

The dissertation concerns the problem of reliability of processing and rollback recovery in distributed mobile systems. Such systems are currently a very important area of research since they enable clients to make full use of the potential of new mobile technologies such as *GPRS*, *UMTS*, *Bluetooth*, *Wi-Fi (802.11x)*. In these systems clients are able to process their own data at any time and in any place. High performance, easy access to data and transparency of data management mechanism are required features. A key concept in providing these features is replication. However, replication brings up a number of problems, in particular the problem of providing consistency of replicas. In distributed mobile systems clients switch from one replicated server to another and their requirements should be considered in replication. Consistency models which ensure consistency of data processed by a number of clients and which provide continued processing independent of the client localization are called *session guarantees*. The level of consistency required by clients is ensured by consistency protocols.

The consistency protocols proposed so far did not take into account the failures of the system components, in particular the servers' failures. Therefore an essential implementation problem in distributed mobile systems is to equip the existing consistency protocols with mechanisms that will allow the clients to run their applications in accordance with session guarantees in case of failure of one or more servers. With this in view, the main aim of the dissertation was to develop, verify and evaluate recovery protocols integrated with consistency management of session guarantees. The proposed solution uses logging and checkpointing techniques. The semantics of operations and properties following from the definition of session guarantees are taken into account.

The overhead of the rollback-recovery protocol should have little effect on the total processing time. The thesis of the dissertation is formulated as follows: the rollback-recovery protocols for distributed mobile systems providing session guarantees may effectively integrate rollback-recovery mechanisms with consistency protocols of session guarantees. To prove the thesis, the following tasks were performed.

– The definition of recovery line consistent with respect to all session guarantees was proposed.
– A new rollback-recovery protocol for distributed mobile systems providing session guarantees was proposed.
– The correctness of the proposed protocol was formally proved.
– Additional modifications of the rollback-recovery protocol were proposed, with respect to choosing the optimal moment for checkpointing. The semantics of session guarantee operations *Read Your Writes*, *Monotonic Writes*, *Monotonic Reads*, *Writes Follow Reads* were taken into account.

31

The correctness and progress proofs of the modified protocols were given.

– The protocols were quantitatively evaluated in simulation experiments.

2.7.3 Dr Marcin Lawenda

1. Thesis title : Multi-installment divisible loads scheduling

2. Supervisor : Dr Habil. Maciej Drozdowski

3. Main theses of the dissertation.

   Divisible Load Theory (*DLT*) studies a new model of distributed systems. It assumes that granularity of the computations is small, and that there are no dependencies between the grains of computations. Consequently, the computations, or the load, can be divided into parts of arbitrary size, and these parts can be processed independently in parallel. The sizes of the load parts should be adjusted to the speed of communication and computation such that processing finishes in the shortest possible time. Divisible load model proved to be a versatile vehicle in modeling distributed systems. The purpose of this work is to examine three aspects of the divisible load scheduling problem: single load with single distribution, single load with multiple distributions and multiple loads with single distribution. All three cases are in general computationally hard. However, if the solution of the combinatorial part of the problem is known, i.e. the sequence of communications is given, then these problems can be solved by a reduction to linear programming. In the single load single distribution approach, we consider a single load which is distributed once to a particular processor. In the single load multiple distributions we analyze the situation where a single load (or divisible computation) can be distributed many times to a given processing unit. We analyze two algorithms: an exact branch and bound algorithm and a genetic search heuristic. For both cases we conduct computational experiments and compare the running times and quality of solutions. We observe that optimal solutions are harder to find when heterogeneity of computing environment is growing.

   In the multiple loads single distribution situation many loads (or many divisible jobs) can be scattered in single messages to a given processing unit. It is possible to distribute a single load many times, each time to a different processing unit. Since this problem is computationally hard, we identify special cases solvable in polynomial time and determine bounds of the worst-case behavior of the heuristic algorithms.

2.7.4 Dr Dawid Weiss

1. Thesis title : Descriptive clustering as a method for exploring text collections

2. Supervisor : Dr Habil. Jerzy Stefanowski

3. Main theses of the dissertation.

   The dissertation concerns *information retrieval*, in particular the construction and evaluation of methods for determining the structure of topics in a document set. The author also studied related areas, such as text processing, summarization and *topic detection and tracking* in documents.

   An attempt to find an automatic unsupervised solution to the problem of tracking and detecting the topic in documents makes use, among others, of a family of text clustering algorithms. The analysis of these algorithms leads to the following conclusions.

   – There seems to be a specific type of applications of text clustering in text processing, consisting in tracking and detecting the topic in a given document collection, and in preparing a concise description of this topic to present it to the user.

   – The related research problem is different from original text clustering; the clarity and quality of cluster description is at least as important as its content. This slightly different problem is characterized by different requirements and will be called descriptive clustering.

       Descriptive clustering is a problem of discovering diverse groups of semantically related documents described with meaningful, comprehensible and compact text label.

   – Descriptive clustering lies at the border of text summarization, classification and text clustering but it is not addressed directly by any of these disciplines.

   – Existing methods for labeling clusters are insufficient and often unreliable, especially in case of inflectional languages.

   – Elements of descriptive clustering itself are underspecified and require a more formal description.

   Conducted research allowed to conclude that descriptive clustering is different from the original text clustering . The difference may be expressed in the form of certain requirements. The proposed *Description Comes First* approach and its implementation in the form of algorithms *Lingo* and *Descriptive k-Means* allow to effectively solve the descriptive clustering problem, rendering better experimental results than original text clustering algorithms. The scientific contributions of the thesis include:

   – a description and overview of the requirements of the descriptive clustering problem,

   – introduction of the *Description Comes First* method (*DCF*), which is a meta-method for constructing algorithms fulfilling the requirements of descriptive clustering,

– the algorithm *Descriptive k-Means* which follows the *DCF* approach and deals with thousands of medium documents; this algorithm also allows to demonstrate the possibilities of cluster label candidate discovery (noun phrases, frequent phrases),

– introduction of the contamination measure, which allows to evaluate single clusters and seems to be more natural than previously used cluster quality measures,

– empirical experiments with the two presented algorithms.

Scientific contributions are accompanied by open source technical deliverables:

– *Carrot* - an engine for unsupervised clustering of search results,

– fast hybrid stemming algorithm for the Polish language.

2.7.5   Dr Arkadiusz Zimniak

1. Thesis title : Decision support system for production planning as an example of integrating operations research and artificial intelligence methods

2. Supervisor: Dr Habil. Joanna Józefowska

3. Main theses of the dissertation.

The thesis presents the author's research on a decision support method for production planning which integrates operations research and artificial intelligence methods. Production planning decisions usually consist in finding a compromise solution, taking into consideration a number of optimality criteria. The proposed method uses expert knowledge to increase the efficiency of a multi-criteria optimization algorithm. At the same time, it allows to take into account soft constraints. The rule base may be edited during system operation. Thanks to this feature the user may add or delete soft constraints and rules to improve the algorithm efficiency. It is assumed that the rules are introduced to the system by an expert; however, the system may also operate with an empty rule base. In the selection phase the system interacts with the decision maker. The conducted research involved solving a number of specific problems. The most important ones are as follows.

– Development of the concept of using expert knowledge to reduce the search space and thus increase the efficiency of the multi-criteria meta-heuristics.

– Development and implementation of a multi-criteria genetic algorithm with reduced search space to solve the knapsack problem.

– Development and implementation of multi-criteria genetic algorithm with reduced search space to solve the traveling salesman problem.

– Conducting experiments to examine the influence of the search space reduction mechanism on the efficiency of local search genetic algorithms, for

the multi-criteria knapsack problem and the traveling salesman problem (*TSP*).

– Identification of a particular class of production planning and scheduling problems (supplying production and management conditions and formulating a mathematical model).

– Development of a decision support system for production planning, which integrates operations research and artificial intelligence methods.

– Implementation of the proposed system, i.e. of the following parts:

  - a local search genetic algorithm with reduced search space,
  - a dialogue module which supports choosing the best compromise solution from the set of potentially *Pareto-optimal* solutions,
  - an expert system module,
  - an interface with an *ERP* system.

– Verification of the proposed system, including adaptation to a particular production environment, expert knowledge acquisition and expert evaluation of the quality of generated solutions.

– Examination of the influence of the search space reduction mechanism on the efficiency of multi-criteria genetic algorithms for a specific production environment.

Computational experiments conducted for multi-criteria *TSP* and knapsack problems allow to conclude that appropriate selection of search space reduction rules for a multi-criteria genetic algorithm has the following effect:

 - it enhances the quality of solutions obtained in comparable time,

 - it enhances the quality of solutions obtained in the initial phase of computations,

 - it considerably improves algorithm efficiency for problems with a large solution space,

 - it considerably improves algorithm efficiency in the case of strong reduction of search space.

It was found that experts easily formulate both soft constraints and search space reduction rules. Experiments have shown that expert-generated rules increase algorithm efficiency for tested data. It was also found that integration of operations research and artificial intelligence in the proposed method allows the experts to formulate their preferences effectively. In particular, the experts confirmed that the system is able to generate satisfactory and feasible schedules.

2.8   Conferences

2.8.1   International conferences
 organized by the Institute of Computing Science

In 2006 the Institute of Computing Science organized the Tenth International Workshop on Project Management and Scheduling PMS'2006, Poznań, April 26-28, 2006 (`http://www.pms.put.poznan.pl`). The workshop was organized within the framework of *The EURO Working Group on Project Management and Scheduling - EURO WG-PMS.* Contributions were in the field of:

– project management (project planning, project scheduling, project control),

– machine scheduling (single and parallel processor problems, flow shops, job shops and open shops).

Prof. Jan Weglarz was the Chair of the Program Committee and the Organization Committee. Prof. Jacek Błażewicz and Prof. Roman Słowiński were members of the Program Committee. Prof. Jacek Błażewicz, Prof. Roman Słowiński, Dr Habil. Joanna Józefowska, Dr Tomasz Łukaszewski, Dr Marek Mika, Dr Rafał Różycki and Dr Grzegorz Waligóra were members of the Organizing Committee. Out of the 96 conference participants, 74 were from countries other than Poland.

2.8.2   Other selected international conferences

Below is given a list of selected international conferences, in which the Institute staff members were co-organizers.

Conference name	Location	Participation of ICS staff
Congress EURO XXI	Reykjavik, Iceland, July 2–5, 2006	Prof. J. Błażewicz organized Computational Biology, Bioinformatics and Medicine stream. Prof. R. Słowiński organized and chaired one of the sessions.
Workshop "Scheduling and Sequencing" ICOLE'2006	Lessach, Austria, May 1–6, 2006	Prof. J. Błażewicz co-chaired the Program Committee.
Conference "Scheduling Algorithms for New Emerging Applications"	Marseille, France, May 29 – June 2, 2006	Prof. J. Błażewicz co-chaired the Program Committee.
11th IFAC Symposium on Control in Transportation Systems	Delft, the Netherlands, August 29–31, 2006	Dr M. Kaczmarek was a member of the Program Committee he also chaired a session.
11th Meeting of the EURO Working Group on Transportation "Advances in Traffic and Transportation Systems Analysis"	Bari, Italy, September 27–29, 2006	Dr M. Kaczmarek was a member of the Program Committee.
18th International Conference on Multiple Criteria Decision Making	Chania, Greece, June 19-23, 2006	Prof. R. Słowiński was a member of the Program Committee he also chaired a plenary session.

2.9   Awards and scholarships

Honorary Doctor's Degree   : awarded to Prof. Jan Węglarz by Poznan University of Technology.

Honorary Doctor's Degree   : awarded to Prof. Jacek Błazewicz by Universitaet Siegen, Germany.

Scientific Award of the City of Poznan :
Prof. Jacek Błazewicz.

Scholarship of the City of Poznan   :
Dr Bartosz Walter, Maciej Miłostan, M.Sc.

European Doctoral Dissertation Award   :
Dr Marta Szachniuk, awarded by the European Association of Operational Research Societies EURO.

The best poster award and team project award :
Agnieszka Ławrynowicz, M.Sc., awarded at The Fourth Summer School on Ontological Engineering and the Semantic Web (SSSW'06), Cercedilla, Spain.

The President of PUT award for a habilitation dissertation   :
Dr Habil. Piotr Formanowicz.

2.10   Publications

2.10.1   Institute own publications

The Institute publishes its own quarterly Foundations of Computing and Decision Sciences, with an international Editorial Board. Volume 31 was published in 2006. The 31/1 issue was a special issue devoted to data mining and knowledge discovery. Details are available at `www.cs.put.poznan.pl/fcds`. The Institute also publishes technical reports in English (the RA series) and in Polish (the RB series); 21 reports in English and 16 reports in Polish were published in 2006.

2.10.2   Published results of research work (in numbers)

Kind of publication	Number of pub.
Books published in foreign countries	2
Articles in journals from the ISI Master Journal List	58
Articles in other foreign journals	8
Chapters in foreign books	7
Publications in Polish journals edited in foreign languages	9
Chapters in Polish books	18
Articles in major Polish scientific journals	7
Articles in local journals and magazines	2
Papers in international conference proceedings	33
Papers in Polish conference proceedings	13
Announcements in international conference proceedings	1
Total number of publications	158

2.10.3   Monographs in English

1. J. Józefowska, J. Węglarz (eds.), Perspectives in Modern Project Scheduling, Springer Verlag, Berlin, 2006

2. R. Wrembel, C. Koncilia (eds.), Data Warehouses and OLAP: Concepts, Architectures and Solutions, Idea Group Publishing, USA, 2006

2.10.4   Articles published in journals included in the ISI Master Journal List

1. W. Andrzejewski, T. Morzy, *AISS: An Index for Non-timestamped Set Subsequence Queries*, Lecture Notes in Computer Science, vol. 4081, pp. 503-512, 2006

2. J. Bauman, J. Józefowska, *Minimizing the earliness-tardiness costs on a single machine*, Computers and Operations Research, vol. 33, no. 11, pp. 3219-3230, 2006

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4. J. Błaszczynski, K. Dembczyński, W. Kotłowski, M. Pawłowski, *Mining Direct Marketing Data by Ensembles of Weak Learners and Rough Set Methods*, Lecture Notes in Computer Science, vol. 4081, pp. 218-227, 2006

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3   Implementations

3.1   Eskulap - a module IT system for integrated hospital management

Eskulap is an advanced computer system to support running a hospital. Separate modules may be used by the reception desk, outpatient departments, hospital wards, pharmacies, laboratories, cost calculation department, hospital management and other staff. Owing to modern technologies used in the system, Eskulap is reliable, secure, highly efficient and extensible. It allows to record treatment costs on site, calculate and analyze all treatment costs and prepare statistical information. It provides access to complete, consistent information about a patient and supports the work of medical staff.

The following Eskulap modules are available.

1. Patient Registration and Movement

2. Reception

3. Outpatient Department

4. Surgery

5. Hospital Ward

6. Case History

7. Operating Theatre

8. Pharmacy

9. Ward Dispensary

10. Analytical Laboratory

11. Diagnostic Services (*RTG*, *USG*, *EKG*, etc.)

12. Microbiology

13. Histopathology Laboratory

14. Dialysis Unit

15. Dosimetric Laboratory

16. Genetic Laboratory

17. Catering

18. Storage Room

19. Archive

20. Orders

21. Calculation of Treatment Costs

22. Calculation of Medical Procedures

23. Settlements
24. Management
25. Management Information System
26. Budgeting
27. Central Sterilization Unit
28. Central Register of Genetic Defects
29. Neoplasm Register
30. Finances, Accounting, Costs
31. Personnel
32. Payroll
33. Fixed Assets
34. Stock Management
35. Decision Support System
36. Document Circulation System

All applications in system modules were implemented in the 5th generation programming languages which come in the package *Oracle Developer*, *Oracle Forms* and *Oracle Reports*, using the client-server architecture. Applications work in the runtime environment provided by Oracle. The Oracle system and Eskulap are available for *Unix*, *Microsoft Windows* and *Novell Netware* platforms. The software works on any computer system which supports the selected operating system, and is fully integrated with it. *Oracle SQL*Net* is used to communicate with the database server; it is the middleware between *Oracle Forms Runtime* or *Oracle Reports Runtime* and network services At present it supports most popular network protocols, e.g. *TCP/IP, IPX/SPX, X.25* . All parts of Eskulap are constructed as modules and are equipped with well defined connections and module-to-module interfaces. Their integration is realized on the database management level. Eskulap uses the integrated, multi-version, multi-access Oracle relational database. All Esculap modules work on *PCs* or terminals equipped with web browsers, with centralized or distributed databases.

Eskulap modules are custom-made, taking into consideration the specific character and organization of various healthcare units and various expectations and requirements of buyers, as well as the ever-changing Polish National Health Fund regulations. Similarly, Eskulap may be adjusted to work with specific diagnostic and laboratory equipment.

In 2006 ,27 hospitals bought Eskulap, each with a licence certificate, 801 licence certificates were issued for specific Esculap modules.

4   Didactics

4.1   Programs and Specializations

The Institute of Computing Science offers stationary (regular) and non-stationary programs in Computing Science. In the academic year 2006/07 there were 1241 CS students in all.

4.1.1   Regular studies

Regular studies involve first degree (BSc) courses, which last 7 semesters, second degree courses (MSc - 3 semesters) and doctoral studies (8 semesters). In 2006/07 there were 378 BSc students, 286 MSc students and 25 doctoral students. There are eight options (specializations) offered for MSc students (the figure in brackets indicates the respective number of students in the academic year 2006/07).

E-economy   (30)

Intelligent decision support systems   (34)

Software engineering   (47)

IT systems design and operation   (60)

Computer networks and distributed systems   (43)

IT systems in management   (32)

Software design technologies   (40)

Details about first and second degree courses are available at
www.fcm.put.poznan.pl/platon/dokumenty/studia.

4.1.2   Non-stationary (weekend) studies

Weekend studies involve first degree (BSc) courses, which last 8 semesters, and second degree (complementary) MSc courses, which last 4 semesters. In 2006/07 there were 181 BSc students and 371 MSc students. There are seven options (specializations) offered for MSc students (the figure in brackets indicates the respective number of students in the academic year 2006/07).

E-economy   (45)

Computing science in business processes   (58)

Computer engineering   (37)

IT systems design and operation   (62)

Computer networks and distributed systems   (93)

Embedded systems (25)

Software design technologies (51)

Details about weekend courses are available at
   `www.fcm.put.poznan.pl/platon/dokumenty/studia`.

4.2 Selected laboratories for students

4.2.1 Mobile Systems Laboratory

The Mobile Systems Laboratory supports research in methods, algorithms and system architectures related to mobile applications. Teaching activities take place alongside conceptual work and implementations of selected systems.

The Mobile Systems Laboratory is equipped with wireless infrastructure which provides access to *Wi-Fi* (also long range) *Bluetooth* and *InfraLAN* networks and devices; with portable computers, *Tablet PC*, *PDA*, cellular phones and cellular communicators (also for *UTMS* technology) and numerous accessories. There are several dozen *GPS* receivers, ranking lasers, electronic compasses, inertial systems, ultrasonic systems and cameras with *GPRS* and *Wi-Fi* features. Embedded computers, radio modules and telemetric devices allow to conduct work on remote control of buildings on design and construction of unmanned flying and floating devices. Software includes, among others, spatial information systems *MapInfo* and *ArcInfo*. Software available in the laboratory allows programming and testing all equipment located there.

The course "Mobile Systems" offered by the laboratory staff is very popular with the students, who often write their BSc/MSc dissertations on related topics. Laboratory staff also help students who take part in international IT system design competitions.

Research and development projects conducted in the laboratory are supported by Polish and EU funds. Dr Mikołaj Sobczak has organized the laboratory and is its current supervisor.

4.2.2 Electronic Circuit Prototyping Laboratory

The following aims were considered in designing the laboratory.

1. Educational purposes

 – Support for design and prototyping of hardware components of B.Sc. and M.Sc. dissertations.
 – Support for student projects for competitions (*CSIDC*, *Imagine Cup*).
 – Support for a new course, "Digital Circuits Design".

2. Scientific and research purposes

– Research in practical applications of IT in sound and video processing and analysis, artificial intelligence and decision support.

– Research of capabilities of modern microcontrollers, signal processors , *FPGA* (*Field Programmable Gate Arrays*) and *PSoC* (*Programmable Systems-on-Chips*).

– Human factor research

3. Commercial and implementation purposes

– Commissioned tasks, design preparation and prototype production.

– Developing own projects for further commercial use.

The laboratory is equipped with the following devices.

1. Devices for prototyping printed circuit boards:

– desktop milling machine *ProtoMat S62*,

– through-hole plating system *MiniContac III*,

– press *Multipress II*.

2. Soldering equipment:

– preheaters *Pace ST450, Pace ST325 – BGA* circuits,

– optical microscope x6 for regeneration of *BGA* circuits,

– preheater *Pace ST45 + Nec H7 – SMD* circuits.

3. Test equipment:

– triple output power supply *Agilent E3631A*,

– digital oscilloscope *Agilent MSO6032A*,

– digital multimeter *Agilent 34401A*.

4. Starter Kits:

– *Xilinx Virtex 2 Pro Evaluation Board, FPGA* (3 units),

– *ADSP-BF537 EZ-KIT, DSP*,

– *EVM642 Evaluation Video Module, DSP*.

5. Software:

– *Altium Designer 6.0 with Protel 2006*,

– *Xilinx ISE Webpack 7.1*,

– *TI Code Composer Studio*,

– *Analog Devices Visual DSP++*.

Dr Jacek Jelonek has organized the laboratory and is its current supervisor.

4.3 Student achievements and awards

4.3.1 Ministry of National Education grants

In the 2006/07 academic year the Ministry of National Education grants were awarded to the following CS students: F. Gorski, P. Hołubowicz, P.Lichocki, M. Mamoński, P. Marciniak, M. Płaza, M. Ruciński, S. Stempin, S. Szczepanowski, P. Taront and S.Wąsik.

4.3.2 *CSIDC*

In the 2006 edition of Computer Society International Design Competition, organized by *IEEE Computer Society*, two CS student teams reached the world finals and were awarded honorable mentions:

– Ł. Jaworski, R. Kamyk, P. Klecha, Ł. Plewa, for BirdWatch - environmental monitoring system, mentor: Dr J. Jelonek.

– P. Hołubowicz, Ł. Langa, P. Lichocki, Sz. Wąsik, for: IntelliForest-network-centric system for forest monitoring and protection, mentor: Dr M. Sobczak.

4.3.3 *Imagine Cup*

Imagine Cup, World's Premier Student Technology Competition , is held every year by Microsoft. In 2006 CS students won a number of awards at various stages and in various categories of the competition.

– M. Ignac, M. Stelmach, B. Rapp and W. Świtała, 1st place in the Polish round and 3rd place in the European semifinals in Slovenia, in the Software Design category, for the HeartBIT project, mentor: Dr J. Jelonek

– M.Wronowski, M.Tartanus, M.Zygmunt and S.Wybranski, 1st place in the Polish stage (ex aequo with the former team), in the Software Design category, for the project foodExplorer, mentor: Dr M. Sobczak.

– J. Barcikowski, Poznań University of Technology and J. Garniewicz, Warmiń-sko-Mazurski University, 2nd place in the Polish round, in the Short Film category.

Contents