Database Research Activities in Russia: a Brief Overview

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Abstract. The paper provides brief analysis of recent research activities in database area in Russia. Activities of the Moscow ACM SIGMOD Chapter are characterized, emphasizing organization of semianars and conferences. Sample analysis of four database research groups from the Russian Academy of Sciences and Universities is provided.

1 Introduction

Intention of this paper is to provide brief analysis of recent research activities in Russia in the database area. The period observed starts in 1992, just after disintegration of USSR. In USSR the database research community was quite well organized. In 70-ies and in the beginning of 80-ies its activity was concentrated around the Data Base Task Group (DBTG). In the middle of 80-ies DBTG was substituted with the more formal Commision on Databases and Information Systems reported to the State Committee on Science and Technology and the Academy of Sciences of USSR. These bodies greatly contributed to consolidation and coordination of database researchers in USSR through the All-Union Conferences (the last conference of this kind took place in September of 1991), Workshops and specific subtask groups devoted to different research issues providing for discussions, identification of new research directions and for wide dissemination of information. At the beginning of 1992 when USSR and respective organizations ceased to exist it was decided to organize a body of the ACM SIGMOD in Russia with a coordinating responsibility similar to previous groups.

The period reported was far from being favourable for science and education in Russia. Unreasonably low funding of these areas resulted in dramatic loss of prestige of research and post-graduate education in the country, giving up many important researches, shrinking of research groups, canceling foreign journal subscriptions. In spite of such unfavourable background, several database research

groups survived and continued their activities. Forming of the Russian Foundation for Basic Research (RFBR) in 1993 greatly contributed to an ability of running scientific conferences in Russia. ADBIS conferences matured to a large extent due to the RFBR support.

The paper is organized as follows. We start with reporting of the results of the Moscow ACM SIGMOD Chapter activities including its monthly seminars and ADBIS conferences. This presentation is similar to that of included into the ACM SIGMOD Record, March 2000. After that a brief analysis of the activity of several database research groups in Moscow and St. Petersburg is given. References to main publications of these groups during the reported period are included.

2 Moscow ACM SIGMOD Chapter: Objectives and Activities

The Moscow ACM SIGMOD Chapter has been chartered by ACM on September 24, 1992. According to the charter, it was formed to operate under the sponsorship of the ACM, the Local Activities Board, ACM SIGMOD, and the SIG Board. The Chapter supports activities complementary to ACM SIGMOD, the ACM, and other ACM activities in Russia. The Chapter is operated exclusively for educational and scientific purposes. General objectives of the Chapter are stated in the charter as:

- Improve scientific contacts between the Moscow (Russian) and worldwide database communities;
- Collect and disseminate relevant technical publications to the Moscow database and broader computer science community;
- Contribute to technical development through support of lectures, professional development seminars and technical briefings;
- Advance database technology and improve technical interchange through conferences and workshops in Russia and in the former USSR.

The Moscow ACM SIGMOD Chapter is attempting to serve as a bridge with the Worldwide Database community across the new economical and organizational barriers primarily intended on improving contacts to scientists and literature. Interests of the Chapter include broad range of advanced issues of database and information systems technologies.

The body of the Chapter includes currently around 70 people. Alongside with the Russian ACM and ACM SIGMOD members, representatives of research institutes of the Russian Academy of Sciences (RAS) and of the industry, professors of the Universities and students are included into the body. The officers running the chapter are Leonid A. Kalinichenko (Chair), Sergei D. Kuznetsov (Vice-chair), Mikhail R. Kogalovsky (Secretary). Information on the Chapter's activity (in Russian) is available at the Web page http://www.ipi.ac.ru/sigmod/.

The following are the main activities of the chapter:

2.1 Monthly Seminar of the Moscow ACM SIGMOD Chapter

Regular work of the Moscow Chapter is organized through its monthly seminar held at the Moscow State University. About 60 seminar meetings devoted to various advanced directions of databases and information systems (such as object-oriented approach in databases, transaction management and workflows, efficient storage structuring, formal aspects of database theory, object design methodologies, compositional information systems development methods, deductive databases, etc.) have been organized during the Chapter's activity. The speakers at the seminars are researchers from Russia and from abroad. The following topics were discussed.

Theoretical Aspects. 25 Years of the Relation Data Model (O. Gorchinskaya, FORS), Object Databases Perspectives (Yu. Kantonistov et al, Inteltech Plus), A Theory of Relational Databases with Incomplete Information (M. Tsalenko, Russian Univ. for Humanities), Algebraic Methods in Database Theory and Knowledge Representation (E. Beniaminov, Russian Univ. for Humanities, Object Calculus based on Combinatorial Logic (V. Wolfengagen, Moscow Institute for Physical Engineering), Relation Database Conversion and Query Translation into Object Database Environment (P. Stanishich, MSU), Third Manifesto and Object-Relation Databases Foundation (L. Kalinichenko, Institute for Informatics, RAS).

Technical Issues. Multimedia Databases; New Trends in Document Management Systems (N. Emeljanov, Systems Analysis Institute, RAS), Full-Text Databases (B. Novikov, Univ. of Spb), Access Methods for Spatial Databases (M. Martinov, Univ. of Spb), Distributed Transaction Monitors (G. Ladyzhensky, Get Infosystems), Database Storage Systems (B. Novikov, Univ. Of Spb), Real-Time Databases (E. Pavlova, Univ. of Spb), Multi-Dimentional Databases (K. Zdiruk, AIST Project), Semistructured Data Systems; Object Models Implementation based on a Deductive Environment (K. Lisovsky, Moscow Technical Univ. of Steel and Alloys), World Wide Web - Information Resources and Access (V. Kamensky, Institute for System Programming, RAS), Object-Deductive Functionality Based on Relation Environment (K. Lisovsky, Curs Company), Database Access by the Web Technology (S. Kuznetsov, Institute for System Programming, RAS), Database Technologies for Economic-Mathematical Modeling (M. Kogalovsky, Market Economy Institute, RAS).

Information System Design. Personalized Information Resources Design based on the Web-sites with Semi-structured Data (N. Skvortsov, L. Kalinichenko et al, Institute for Informatics, RAS), CASE Technologies based on Structured Analysis Approach (G. Kalyanov, Institute for Control Problems, RAS), CASE Technologies for Database Design (B. Posin et al, Wide-Russia Research Institute for Information Technologies and Design Automation), Business Reengineering and Beginning of New System Design (E. Zinder, LVS Company), The Tools for Information Systems Design providing for Component Reuse (D. Brioukhov, L. Kalinichenko, Institute for Informatics, RAS), Piloting, Design and Implementation of Information Systems (E. Lomako, V. Ostroukhov et al, Voskhod

Research Institute), Unified Modeling Language (V. Romanov, MSU Computing Research Center).

Standards. SQL Standard Perspectives (S. Kuznetsov, Institute for System Programming, RAS), SAA Architecture Principles (N. Maximov, Research Center for Computing), Standardization of Object Models and Interoperable Environments (L. Kalinichenko and M. Kuroshev, Institute for Informatics, RAS), Information Resource Interoperability in CORBA 2.0 Standard (L. Kalinichenko, M. Kogalovsky, RAS), IBM's SOM Architecture (S. Kuznetsov, Institute for System Programming, RAS), ODBC Facilities (V. Filippov, RAS Computing Center), Workflow Architecture and Standards (F. Fomenko, MSU), JavaBeans Technology (Yu. Dolbnev, Sun Microsystems), OMG UML Standard (A.Vendrov, Russian Tax Academy).

Database Products. Universal Database Servers of IBM, Oracle and Informix (S. Kuznetsov, Institute for System Programming, RAS), Object Technologies in Database Servers of New Generation (M. Elashkin, Oracle; D. Bezrukov, FORS; A. Grachev, Informix; K. Lisovsky, IBM), Software AG Products for E-Commerce (O. Kitova, Software AG), Choosing DBMS for Large Database System Implementation (E. Zinder, Price Waterhouse; V. Przhijalkovsky, RAS Computing Center; A. Grachev, Informix; V. Sikolenko, Oracle).

Surveys. The Report of NSF Workshop on Basic Directions in Database Research for Next Decade (Asilomar, 1998) was overviewed by S. Kuznetsov (Institute for System Programming, RAS). Proceedings of various database conferences were overviewed, including SIGMOD/PODS Conferences, NATO Summer School, East-West Database Workshop, Distributed Computing Systems Conference (M. Tsalenko, Russian Univ. For Humanities; L. Kalinichenko, Institute for Informatics; V. Zadorozhny, Institute for Informatics; B. Novikov, Univ. of Spb; M. Kogalovsky, Market Economy Institute).

Foreign Speakers at the Seminar. Information Systems Design Methodology (M. Walles, IBM), The Resolution and Sweep Methods (J. Biskup, Hildesheim Univ., Germany), Query Optimization in Object-Oriented Database Systems (A. Dogac, Turkey), Some Client-Server Project (M. Walles, IBM), Programming of the Distributed Object-Oriented Databases by a Tuple Space (B. Bryant, Alabama Univ.), An Introduction to Duration Calculus (Z. Chaochen, United Nations Univ., Macao), Materialized View Maintenance Using Version Numbers (T.W. Ling and E.K. Sze, National Univ. of Singapore).

2.2 Conferences

The most important direction of the Moscow ACM SIGMOD Chapter activity consists in organization of the conferences related to database issues. Immediately after its formation, the Moscow ACM SIGMOD Chapter founded the Annual Workshops **"Advances in Databases and Information Systems" (ADBIS)**. In 1993 - 1996 these Workshops were held as the Workshops of the Moscow ACM SIGMOD Chapter in collaboration with the Russian Foundation for Basic Research. International body of the Program Committees and well-organized paper selection process contributed to the quality of the Conferences.

In 1996 after series of discussions with Dr. Won Kim (the ACM SIGMOD Chair) it was agreed to transform ADBIS into the East European Conference to provide a forum for the exchange of scientific achievements between the research communities of the Eastern Europe and the rest of the world in the area of databases and information systems. These events would continue and consolidate the series of ADBIS workshops existed previously. It was agreed that ACM SIGMOD will actively support the organization of the Symposia and warrant the high quality of the program. The Moscow ACM SIGMOD Chapter continue to serve as a focal point of the event.

In 1997 – 1999 three East European ADBIS Conferences took place in St. Petersburg (Russia),Poznan (Poland), Maribor (Slovenia). In 2000 ADBIS will take place in Prague (Czech Republic, http://www.ms.mff.cuni.cz/adbis2000) as 2000 ADBIS-DASFAA Symposium. This will be the first experience extending ADBIS into cooperation with DASFAA - one of the most prestigeous international DB conferences held in Asia and Australia. The ADBIS Steering Committee includes representatives from different countries of the Eastern and Central Europe: Austria, Bolgaria, Czech Republic, Greece, Estonia, Germany, Jugoslavia, Hungary, Latvia, Lithuania, Poland, Russia, Romania, Slovakia, Slovenia, Ukraine.

Now the Moscow ACM SIGMOD Chapter participates also in organization of the new series of All-Russian National Annual Conferences on Digital Libraries. The second conference in this series will take place in September 2000 near Moscow. These conferences are open for participation of foreign specialists.

2.3 Library

Taking into account difficulties in Russia with getting access to the worldwide computer science and database research literature a Chapter's library is collected to be available for the Moscow database and broader computer science community.

2.4 Collaboration

The Chapter collaborates with the Russian Foundation for Basic Research preparing joint International Conferences, reviewing projects related to information systems development for different branches of science. The Chapter collaborates also with Chapters of other ACM SIGs functioning in Russia and Ukraine.

2.5 Cooperation with ACM SIGMOD

ADBIS Conferences are organized in cooperation with ACM SIGMOD. The Chapter as well as the ADBIS Steering Committee joined the ACM SIGMOD program "SIGMOD Digital Symposium Collection (DiSC)" aiming at collecting symposium Anthologies on compact discs. Concerning ADBIS, the Anthology currently is planned to include papers accepted for ADBIS that took part during four years: 1994 - 1998. Materials of later conferences will follow as soon as the copyright issues with Springer will be resolved.

3 Samples of the Research Groups Activity

3.1 The Database group at the University of St.-Petersburg

The Database group at the University of St.-Petersburg is informal group of researches, post-graduate, and under-graduate students based at the Operations Research Laboratory of the university. The research directions of the St.-Petersburg group are related to different issues related to low-level database structure and functions, including:

- Storage management systems, storage structures, complex object representation;
- Indices and access methods, especially for non-traditional data types;
- Logging and recovery techniques for advanced transaction models;
- Concurrency control for real-time database management systems.

The storage system prototype. The prototype was developed as a tool for research of different structures and as a base for rapid prototyping of systems which need advanced storage structures. The architecture of the storage system prototype, as well as representation of complex objects in the system are discussed in [1]. This work proposed flexible self-tuning dynamic storage structure. The system attempted to maintain balance between clustering of large units of data and flexibility of updates and efficient storage structuring for smaller units of data.

Comparative analysis of indexing techniques. [2] attempted to find out why signature files, very popular among researches, are never used in practical systems. The reason is that overoptimistic estimations for signature files are based on unrealistic assumptions on value distribution.

Spatial joins. A new algorithm for spatial joins is proposed in [4]. It is shown that for certain class of data objects the proposed method outperforms other known algorithms.

Recovery and logging for advanced transactions. [3] describes an extension of ARIES family of logging and recovery protocols for advanced complex transaction models.

Real-time databases. The research of real-time database systems was focused on concurrency control for main-memory real-time databases. The most important results of this research are presented in [5], where new concurrency control protocol is presented. The major advantage of this protocol is that significant part of transactions may be scheduled locally in the node that initiated the transaction. Of course, this scheme is applicable only for very special case of high percentage of read-only transactions, but this protocol appears to be the only possibility to meet very tough deadlines.

3.2 Database Laboratory of the Market Economy Institute of RAS

The laboratory activity started in the beginning of 70ies. The laboratory database group was formed around one of early its projects dedicated to elaborating the

ANSI/SPARC-like DBMS architecture supported multi-model external views. After that a number of research projects were implemented. Main research directions during last years are as follows.

Scientific and statistical databases related to economic-mathematical applications, elaboration of the domain-specific data models and tools. The time series data model (TSR) was specified and implemented on PC platform [7, 8]. TSR is an extension of the relational data model. The model functionality includes a power operation set for time series processing. Periodic time series with different observation periods are allowed. A number of economic research analytical tools based on TSR model and statistical databases of economic indicators were implemented [9, 10].

Object data models mapping. In particular, mapping specifications of ODMG model to SYNTHESIS model [11] were worked out. These specifications provide for the information resources integration using the SYNTHESIS model [14].

Desktop database systems evaluation. Even most popular desktop DBMSs had uncomplete functionality at the early stage of their development. It was important in this period to recognize what was their correlation with the "classical" database principles. The monograph [6] was dedicated to analysis of the topic.

Systematics of information collections in Digital Libraries. Due to information explosion in Webenvironment and intensive development of numerous information collections for digital libraries the necessity arises in collection systematics. In [12] basic general characteristics of information resources collections are discussed, some methods of their systematization are proposed, specificity of scientific collection is analyzed, metadata role in collections and perspective technologies for collection creating are discussed.

Web-sites integrity verification. The tool based on relation algebra technique [13] provides the extraction of an information about site structure and its mapping to relation database. Then the structure is analyzed by means of the relational algebra.

Russian database terminology. Database laboratory participated in activity dedicated to form the Russian terminology and English-Russian translation dictionaries for the database area in collaboration with other groups in Russia. Recently the team has produced large database glossary.

3.3 SYNTHESIS group at the Institute for Problems of Informatics of RAS

SYNTHESIS group (http://www.ipi.ac.ru) was formed in the beginning of 70ies. Now it functions as the "Laboratory for compositional information systems development methods" at the Institute for Problems of Informatics of RAS. Various forms of compositions are studied by the group: interoperable compositions of pre-existing components during the information systems design, heterogeneous multidatabase compositions, database schema and ontology integration, workflow compositions, type compositions in database operations over object collec-

tions, etc. Objectives of this study and the results obtained during the period considered are as follows.

Canonical information modeling for interoperability and integration. To provide for interoperability of heterogeneous information objects a canonical model is required to establish a global, uniform view of the underlying digital collections and services. Alongside with such information mediation objective, the same model should be used for compositional information systems development in wide range of pre-existing heterogeneous components - for requirement specifications, for ontological and analysis modeling, for design modeling as well as for the heterogeneous components specification. To fill-in the existing gap, the SYNTHESIS frame-based and object-oriented model and language has been developed for that [14]. Recently it was shown [23] how the SYNTHESIS modeling facilities can be used for homogeneous representation of various semistructured and hybrid data models (such as, e.g., Ozone and Yat) with orientation on the data contained in Web sites.

Component model mapping method. Mapping of heterogeneous components specifications into the canonical ones preserving information and operations is an important part of compositional development and heterogeneous collections interoperability. Specific component model mapping method based on the refinement concept has been developed [18]. The method provides for verifiable design of the data model mappings handling the models as formal objects in frame of an abstract metamodel. For such metamodel the Abrial's abstract machine notation (AMN) is used. AMN provides an ability to automatically prove important properties of data types and their relationships. To preserve information and operations of types of a specific data model while mapping them into the canonical types the commutativity of data type state and data type behavior mapping diagrams should be established. The required state-based and behavioral properties of the mappings lead to a proof that a source data type is a refinement of its mapping into a canonical type.

Semantic interoperation reasoning (SIR). Semantic aspects of component compositions require serious investigations. Analysis of SIR issues has been undertaken. Such issues include: reaching of the coherence of the ontological contexts [17] of the heterogeneous information resources (services) and of the application; searching for components and their fragments that could serve as the concretizations of the application specification of requirements; creation of the composition of components (or their fragments) that could serve as a consistent, coherent concretization of the application; justifying (proving) that constructed specification is truly a concretization of the application requirements. These investigation has leaded to creation of SIR framework [15].

Compositional information systems development method and tool. Existing component-based development methods (e.g., JavaBeans, ActiveX) does not allow to use potential abiilities of the Internet to accumulate components, are not sclalable, do not allow to construct systems using components of different kinds - program servers (e.g., CORBA-based), information collections (e.g., databases, Web-sites), processes (e.g., workflows), are unsafe. These deficien-

cies were planned to overcome in the new compositional development method that has been elaborated for verifiable composition of pre-existing components semantically interoperable in the context of a particular application. In the SYNTHESIS method the component specifications may be as complete as required by an application (including ontological definitions, type invariants and operation definitions). The method supports resolving contextual and specification discrepancies between components and applications, identification of component fragments refining the constituents of the application specifications, composition of the identified fragments into specifications refining the application. The specification calculus of the method [22] (based on the refinement technique) contains operations specifically designed for the information systems compositional development: they provide for identification of common fragments of different specifications (common reducts) and for their compositions (such as meet and join) forming the lattice of type specifications. Type specification composition operations of the algebra are based on identification of common information in the composed specifications. A tool supporting the compositional information systems development has been constructed [21]. The tool combines conventional (UML-based) facilities of OAD methods with the facilities of the new, compositional method. The tool is oriented on CORBA environment and is being extended for the Web components [24].

Workflow specifications as reusable components. Objective of this research consists in provision of specific process specifications and manipulation suitable for compositional workflow development method. The script-like process specification model of the SYNTHESIS language is based on a high level Petri nets. For the workflow refinement a behavioural abstraction of scripts as patterns of activities (firing sequences) corresponding to their specifications [16] are taken. Such activities are abstracted as process algebras using the notion of bisimulation equivalence. Complete justification of existence of common reduct (reusable fragment) for a pair of workflow specifications is based on the notion of workflow refinement [19]. Workflow specifications are treated as interactive types extending use of compositional operations of specification calculus for such common reducts [20]. This leads to construction of refinement of application requirements in course of the workflow design.

Heterogeneous information collections mediation for Digital Libraries. Objective of this new project in which the SYNTHESIS group is involved is to investigate approaches for constructing integrated virtual digital libraries mediating heterogeneous distributed digital collections of scientific information. SYNTHESIS canonical model, information model mapping technique, SIR framework and compositional information systems development method will be used in the project. An infrastructure of the subject mediators is intended for semantic interoperability of heterogeneous digital library collections. The diversity of information models that should be uniformly represented at the canonical level is characterized by models of Z39.50, XML data bases, existing information retrieval systems, various scientific data collections (e.g., used in life sciences) combined with object and object-relational data modeling. Specific methods

are being developed for the mediator's metainformation representation, federated level metadata creation for unified access to multiple collections in specific subject domains, heterogeneous collection registration, query formulation and planning. Specific scalability measures and DL personalization facilities should also be provided.

3.4 Data Base and Information Systems group at the Institute for System Programming of RAS

During last five years data base and information systems group of the Institute for System Programming of the Russian Academy of Sciences have studied different actual problems of this area:

methods of organization of relational database engines; approaches for compilation and optimization of SQL-statements; directions toward well-formed query languages for object-oriented databases; architectures of heterogeneous information systems based on HTTP, Corba and XML; data model and algebra for XML-based databases. The main results obtained are as follows.

The architecture of relational database engine. The main goal was to propose, design, and implement open, well-structured, simple, efficient architecture. The resulting engine supported two separate log-managers, logical log and page-level microlog; original transaction manager based on predicate log; two levels of interface – microoperations and macrooperations; internal parallelizm [25].

Compilation and optimization of SQL-statements. An efficient approach to SQL-compiler organization was proposed. The parser was based on Bison/Yacc tools, and a special additional tool was designed for different transformations of internal representation of SQL-statements. Several kinds of optimizations were used: lexical, syntactical and semantical. A set of cost-estimation formulars for query plan estimation was designed based on actual distributions of column values. Machineindependent language for executable query plan representation was designed [25].

Object-oriented algebra and query languages. A simple object-oriented algebra based on notions of type and class was proposed. Class was considered as a container of objects of one and the same type. There might be several different classes with the same type of objects. Some problems of query language design and implementation were studied, in particular problems of query optimization [26, 27].

Architectures of distributed heterogeneous information systems based on an integrated technology. To build integrated information system with different data sources (databases, HTMLfiles, XML-files, flat-files) an architecture was designed and implemented with CORBA as a low-level integration facility, XML data storage as common data representation facility, Web-server and HTTP as a common user interface [28].

Data model and algebra for XML-based databases. The goal of this work [29] is to provide a really solid background for XML-based technology for

data management. After that it might be possible to compare different XML query languages and design more strong and flexible language.

4 Conclusion

The paper provides a brief overview of the recent database research activity in Russia. Main activities of the Moscow ACM SIGMOD Chapter consolidating the database community in Russia are characterized. Samples of researches of four database groups from Moscow and St. Petersburg are included. Positive changes in the recent database research in Russia can be summarized as its better integration into international activities. Though many research groups disappeared, the remaining ones produce results of better quality.

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