

data cube, the operators CUBE and ROLLUP are implemented. If necessary, in data integrated schemas new super-aggregate operators can be define. We use a computationally complete language to create schemas of integrated data. Applying the query language to the integrated data is generated a reduction problem. Supporting the query language over such data requires additional investigations.

Finally, modern trends of the development of database systems lead to the application of different divisions of mathematics to data analysis and management. In the frame of our approach to data integration, this leads to the use of corresponding content dictionaries of the OPENMath.

References

- [1] Abrial, J.-R.: The B-Book: Assigning programs to meaning. Cambridge University Press (1996)
- [2] Briukhov, D. O., Vovchenko, A. E., Zakharov, V. N., Zhelenkova, O. P., Kalinichenko, L. A., Martynov, D. O., Skvortsov, N. A., Stupnikov, S. A.: The Middleware Architecture of the Subject Mediators for Problem Solving over a Set of Integrated Heterogeneous Distributed Information Resources in the Hybrid Grid-Infrastructure of Virtual Observatories. *Informatics and Applications*, 2 (1), pp. 2-34, (2008)
- [3] Date, C. J.: An Introduction to Database Systems. Addison Wesley, USA (2004)
- [4] Drawar, M.: OpenMath: An overview. *ACM SIGSAM Bulletin*, 34 (2), (2000)
- [5] Garcia-Molina, H., Ullman, J., Widom, J.: Database Systems: The Complete Book. Prentice Hall, USA (2009)
- [6] Gevorgyan, G. R., Manukyan, M. G.: Effective Algorithms to Support Grid Files. *RAU Bulletin*, (2), pp. 22-38 (2015)
- [7] Gray, J., Bosworth, A., Layman, A., Pirahesh, H.: Data Cube: A Relational Aggregation Operator Generalizing Group-By, Cross-Tab, and Sub-Tab. *In ICDE*, pp. 152-159 (1996)
- [8] Hindley, J. R., Seldin, J. P.: Introduction to Combinators and λ -Calculus. Cambridge University Press (1986)
- [9] Kalinichenko, L. A.: Methods and Tools for Equivalent Data Model Mapping Construction. *In EDBT*, pp. 92-119, Springer (1990)
- [10] Kalinichenko, L. A.: Integration of Heterogeneous Semistructured Data Models in the Canonical One. *In RCDL*, pp. 3-15 (1990)
- [11] Kalinichenko, L. A., Stupnikov, S. A.: Constructing of Mappings of Heterogeneous Information Models into the Canonical Models of Integrated Information Systems. *In Proc. of the 12th East-European Conference*, pp. 106-122 (2008)
- [12] Kalinichenko, L., Stupnikov, S.: Synthesis of the Canonical Models for Database Integration Preserving Semantics of the Value Inventive Data Models. *In Proc. of the 16th East European Conference. LNCS 7503*, pp. 223-239 (2012)
- [13] Luo, C., Hou, W. C., Wang, C. F., Want H., Yu, X.: Grid File for Efficient Data Cube Storage. *Computers and their Applications*, pp. 424-429 (2006)
- [14] Manukyan, M. G.: Extensible Data Model. *In ADBIS'08*, pp. 42-57 (2008)
- [15] Manukyan, M. G., Gevorgyan, G. R.: An Approach to Information Integration Based on the AMN Formalism. *In First Workshop on Programming the Semantic Web*. Available: <https://web.archive.org/web/20121226215425/http://www.inf.puc-rio.br/~psw12/program.html>, pp. 1-13 (2012)
- [16] Manukyan, M. G.: Canonical Data Model: Construction Principles. *In iiWAS'14*, pp. 320-329, ACM (2014)
- [17] Manukyan, M. G., Gevorgyan, G. R.: Canonical Data Model for Data Warehouse. *In New Trends in Databases and Information Systems, Communications in Computer and Information Science*, 637, pp. 72-79 (2016)
- [18] Nievergelt, J., Hinterberger, H.: The Grid File: An Adaptable, Symmetric, Multikey File Structure. *ACM Transaction on Database Systems*, 9 (1), pp. 38-71 (1984)
- [19] Papadopoulos, A. N., Manolopoulos, Y., Theodoridis, Y., Tsoras, V.: Grid File (and family). *In Encyclopedia of Database Systems*, pp. 1279-1282 (2009)
- [20] Regnier, M.: Analysis of Grid File Algorithms, *BIT*, 25 (2), pp. 335-358 (1985)
- [21] Sharma, S., Tim, U. S., Wong, J., Gadia, S., Sharma, S.: A Brief Review on Leading Big Data Models. *Data Science Journal*, (13), pp. 138-157, (2014). Doi: <http://doi.org/10.2481/dsj.14-041>
- [22] Stupnikov, S. A.: A Varifiable Mapping of a Multidimensional Array Data Model into an Object Data Model, *Informatics and Applications*, 7 (3), pp. 22-34 (2013)
- [23] Stupnikov, S. A., Vovchenko, A.: Combined Virtual and Materialized Environment for Integration of Large Heterogeneous Data Collections. *In Proc. of the RCDL 2014. CEUR Workshop Proceedings*, 1297, pp. 339-348 (2014)
- [24] Stupnikov, S. A., Miloslavskaya, N. G., Budzko, V.: Unification of Graph Data Models for Heterogeneous Security Information Resources' Integration. *In Proc. of the Int. Conf. on Open and Big Data OBD 2015 (joint with 3rd Int. Conf. on Future Internet of Things and Cloud, FiCloud 2015)*. *IEEE 2015*, pp. 457-464 (2015)
- [25] Zakharov, V. N., Kalinichenko, L. A., Sokolov, I. A., Stupnikov, S. A.: Development of Canonical Information Models for Integrated Information Systems. *Informatics and Applications*, 1 (2), pp. 15-38 (2007)
- [26] MongoDB. <https://www.mongodb.org>