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FINAL REPORT

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Research on the Translation and Standardization of
Relational and Network Type Database Management Systems *

by

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(This detailed report is presented at the request of AIRMICS)

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Management Information and Computer Sciences (AIRMICS).

The findings of this report are not to be considered as an official
Department of the Army position unless so designated by other authorizing documents.

1. Statement of the Problem Studied

The research was proposed [R1] to investigate the modelling and processing of relational and network (CODASYL) databases within one DBMS architecture, as suggested by the ANSI/SPARC DBMS architecture. In addition to investigating issues in database definition and translation, the research was intended to contribute to the efforts towards a family of DBMS standards that includes both relational and network approaches to databases.

The research involved both theoretical and practical aspects of defining and translating between relational and network databases. The research had four main subproblems:

1.1 Theoretical Basis

Using positional set notation as a formal tool, establish a theoretical basis for defining and translating between relational, network and other types of databases (i.e., can it be done?).

1.2 Conceptual Schema

Investigate the nature of a practical conceptual schema by considering data semantics. What are the practical concepts, tools and techniques needed to define and maintain the semantic integrity of the conceptual schema?

1.3 Relational Approach to Databases

For more than ten years, the CODASYL data model and supporting DBMSes have been developed by development (CODASYL) and standards (ANSI) committees. No standard definition of the relational data model (RDM) and supporting relational DBMSes (RDBMSes). Hence, investigate and develop such definitions.

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1.4 Architectural Aspects

What is needed in a DBMS architecture that supports both relational and network databases?

2. Summary of Research Results

This section summarizes the research results made under this ARO research agreement. The main contribution of the research was to provide the technical basis and direction for the work of the Relational Database Task Group (RTG). Dr. Brodie has chaired the RTG since it was established in July 1979 by the ANSI/X3/SPARC-Database System Study Group. The RTG's task (see [13,15]) was to investigate the potential standardization of the relational approach to databases. In October 1981, the RTG will propose (in the form of an SD-3) that ANSI initiate a standards development activity for the relational approach to databases. The results of the ARO sponsored research reported here will provide the technical basis for the proposal.

2.1 Theoretical Basis

It was reported to ARO [R2] that positional set notation (PSN) was both an analytical [1] and definitional tool for various data models. Also, PSN provided a theoretical basis for translating between data models [2] and for DBMS architecture and standards [2,3]. In theory, PSN (a version of set theory) could be used to define and translate between data models. This approach is now being used by the National Bureau of Standards for the development of a family of DBMS standards.

2.2 Conceptual Schema

It was proposed [R2] to investigate the use of an extended subset of the CODASYL model as a conceptual data model, e.g., to

define relational databases. This turned out to be very complex and unsatisfactory (see [5,6,7,8,9,13,15]).

The nature of the conceptual schema was investigated in terms of data semantics [4]. These results were reported to ARO in [R3].

As a result of this work, the research concentrated on the two remaining issues: the relational data model and a DBMS framework (see [R3]).

2.3 Relational Approach to Databases

The ARO sponsored research by Drs. Brodie and Sibley directed the RTG work as reported in [5-10, 13-16] and to ARO in [R4, R5]. The main research result was the RDBMS Feature Catalogue [10,11]. Since the last report to ARO [R5], Drs. Brodie, Sibley, and Schmidt with the help of the RTG have:

- (i) completed extensive analyses of eleven RDBMSes
(SYSTEM/R, MRS, MRDS/LINUS, INGRES, PRTV, PASCAL/R,
PRTV, RAPID, RAPPORT, IDM, NOMAD/NOMAD2).
- (ii) completed a survey of over 60 RDBMSes, and
- (iii) directed a comparison of the analyzed RDBMSes.

It was found that the Feature Catalogue was an adequate characterization of an RDBMS.

Drs. Brodie and Schmidt are completing a definition of the RDM based in part, on the results of the feature catalogue research.

2.4 Architectural Aspects

The most difficult problems concern DBMS architecture and data-base (schema) translation. Problems with the ANSI/SPARC architecture were identified and a functional DBMS framework was proposed [12].

The functional framework emphasises the functionality of DBMS components rather than system structure and data models. This approach is similar to that subsequently followed in the Strawman Architecture (proposed by the Computer Corp. of America for the National Bureau of Standards). The functional and component-oriented approaches to DBMS architecture are being used by the ANSI/SPARC DBSSG to investigate a family of DBMS standards.

Specific issues concerning the relational approach to databases and DBMS architectures are outlined by Sibley in [17]. In essence, Sibley uses the results of the feature analyses to identify the nature of a DBMS architecture that must include both relational and network databases. The paper addresses the issues raised in [R2] such as binding time differences between different data models and their DDL's and DML's. An alternative architecture, similar to the Strawman Architecture, is proposed and discussed. It is shown how the architecture supported RDBMSes.

In [18] Sibley extends the results of the ARO sponsored research to distributed databases. Methods of architecting a distributed DBMS are presented and related to existing and potential standards efforts.

2.5 Summary

The research achieved its goals of producing results in the area of database definition and translation. It also contributed substantially to the relational standards effort and towards a family of DBMS standards and DBMS architecture research.

3. Publications, Technical Reports and Working Documents
(in chronological order of writing)

1. Hardgrave W.T. Ambiguity in processing Boolean queries on TDMS tree structures: A study of four different philosophies. Proc. Fifth Int'l Conf. on Very Large Databases, Rio de Joniero, Brasil, Sept. 1979, also appeared in IEEE Trans on Software Engineering, Vol. SE-6, No. 4, July 1980.
2. Sibley, E.H. and Hardgrave W.T. The positional set processor as a model for three schema architecture. IFSM T.R. 38, Department of Information Systems Management, University of Maryland, College Park, Maryland 20742, January 1979.
3. Hardgrave W.T. and Sibley, E.H. Data model processing: An approach to standardization of database management systems. IFSM T.R. 45, Department of Information Systems Management, University of Maryland, College Park, Maryland 20742, July 1979.
4. Brodie, M.L. On the specification of database semantic integrity. IFSM T.R. 50, Department of Information Systems Management, University of Maryland, College Park, Maryland 20742.
- 5.* Brodie, M.L. Relational Task Group Report #3, RTG-79-37, October 25, 1979.
- 6.* Brodie, M.L. Relational Task Group Report #4, RTG-79-50, December 6, 1979.
- 7.* Brodie, M.L. Relational Task Group Report #5, RTG-80-26, February 25, 1980.
- 8.* Brodie, M.L. Relational Task Group Report #6, RTG-80-63, April 14, 1980.
- 9.* Brodie, M.L. Relational Task Group Report #7, RTG-80-80, May 19, 1980.
- 10.+ Brodie, M.L. and Schmidt, J.W. Feature Catalogue of Relational Concepts, Languages and Systems, RTG-80-81, May 1980.
- 11.+ Brodie, M.L. Notes on Completing an RTG Feature Anaylsis, RTG-80-90, May 1980.
12. Brodie, M.L. A Functional Framework for Database Management Systems. (revised September 1980) Technical Report, Dept. of Computer Science, University of Maryland. Presented at the National Bureau of Standards Conference on DBMS Standards, Gaithersbutg, MD. September 1980. Abstract to appear in conference Proceedings. Full article to appear in a book on DBMS standards edited by E.H. Sibley and to be published by North-Holland Publishing Co., Amsterdam.

13. Brodie, M.L. and Schmidt, J.W. Issues in Investigating a Standard for the Relational Approach to Databases. To appear Proc. NBS Conference on DBMS Standards, Gaithersburg, MD., Sept. 1980. (revised from original)
- 14.* Brodie, M.L. Relational Task Group Report #8, RTG-80-112, September 20, 1980.
15. Brodie, M.L. Standardization and the Relational Approach to Databases, Proc Sixth Int'l. Conference on Very Large Data Bases, Montreal, Canada, October 1980.
- 16.* Sibley, E.H. Relational Task Group Report #9, RTG-80-122, December 8, 1980.
17. Sibley, E.H. The ANSI/SPARC Database Architecture and Relational DBMS, Technical Report, College of Business and Management, University of Maryland, March 1981. (To be submitted for publication.)
18. Sibley, E.H. Standardization and Distribution Processing, to appear in Fisher P. (Ed.) Advances in Distributed Processing, Vol. II, Heyden Press. The single credit on this article states that the work is based on the research sponsored by this ARO grant.

* These documents (i.e., 5,6,7,8,9,14,16) have been published under the auspices of the Relational Database Task Group and ANSI/X3/SPARC-Database Systems Study Group. They have been submitted to ANSI and as such are now public documents available from ANSI and CBEMA.

+ These documents (i.e. 10 and 11) are being treated as working documents internal to the RTG. They contain the substance of an RDBMS characterization which is now completed. These documents will be the basis of technical support material for the RTG's proposal to commence a relational standards activity.

4. Previous Reports to ARO

- R1. Edgar H. Sibley, Further Investigation in the Translation and Standardization of Relational and Network Type Data Base Management Systems: A Proposed for a Two Year Grant, mid 1978.
- R2. Edgar H. Sibley, First Year Progress Report for the period September 1, 1978-August 31, 1979
- R3. Michael L. Brodie and Edgar H. Sibley, Progress Report for the Period September 1, 1979-December 31, 1979.
- R4. Michael L. Brodie, Brief Report for the Period January 1, 1980-May 30, 1980.
- R5. Michael L. Brodie, Progress Report for the period January 1, 1980-June 1, 1980

5. Participating Scientific Personnel

Dr. Michael L. Brodie, Principal Investigator on this ARO grant. Assistant Professor, Department of Computer Science, University of Maryland, cross appointed to the College of Business and Management, University of Maryland. Co-chairman of the Relational Database Task Group (RTG) of ANSI/X3/SPARC's Database System Study Group.

Dr. Edgar H. Sibley, Research Associate on this ARO grant. Research Professor, College of Business and Management, University of Maryland. RTG member.

Dr. Joachim W. Schmidt, Chairman, Fachbereich Informatik, Universitait Hamburg, Hamburg West Germany, RTG co-chairman contributor (unpaid) to this ARO contract.

6. Related Funding

This research required attendance by both Drs. Brodie and Sibley at ten RTG meetings, eight DBSSG meetings, an European RTG standards forum

and several conferences (to present papers). Hence, funding for travel support in addition to the generous ARO support was sought. Dr. Brodie's travel expenses were covered by the Environmental Protection Agency from July 1979 to May 1980 and by the National Bureau of Standards for the December 1980 meeting. Some of Dr. Sibley's travel expenses were covered by the National Bureau of Standards and by himself personally.

ARO supported all research and administrative contributions of Drs. Brodie and Sibley to the RTG.

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