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4.4 Database Services

Responsibility: Sandra Swearingen

4.4.1 Overview and Rationale

This subclause describes an overview of an architectural framework for discussing database management. It also describes the services provided to application programs and users, and it describes standards, current and emerging, that standardize those database services.

Database management is an important component of the POSIX Open System Environment; in a large class of application programs, especially those used in business, database access through a database management system plays a key role. For portability and interoperability, an application using a database must be isolated from the hardware and software retrieval methods as much as possible. Otherwise the application must have the data manipulation capability coded in its own programs. This might be done if performance is a key issue and the data is very unique. The cost is portability and interoperability.

The following metrics can be used to measure the performance of specific implementations of Database Management Systems. In some cases there are standardized benchmarks, such as the Transaction Processing Council (TPC-A) performance benchmark, that allow rigorous comparison of competing products.

— Time to load a database

— Time to recover a database after a failure

— Database throughput in ‘‘transactions per second’’

— Maximum size database in bytes

— Maximum size of a table in rows

— Service response time

— Concurrency

— Maximum number of concurrent users

— Maximum number of concurrent transactions

4.4.2 Scope

Included within the component of database management are various structured ‘‘data models,’’ including indexed files and network, relational, semantic, and object-oriented databases. Specifically excluded from consideration are services for accessing data that is not part of a database. This subclause discusses database management services from both the application program and user points of view.

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Database services provided to application programs by this component, for example, include the ability to create, alter, or drop tables, records, and fields and the ability to insert, select, and update data included in the structures above.

Included within this component are also utility capabilities such as database administration services.

The list of standards below is comprehensive: there are no standards or emerging standards in the database area that are excluded from the POSIX OSE. There are no standards in this area that are known to be inconsistent with POSIX.1 {2}.

4.4.3 POSIX OSE Database Services Reference Model D

4.4.3.1 Reference Model D

In this subclause, the conventional view of Database Management is related to the POSIX reference model described earlier.

The application programmer's view of the database model is introduced first. Quite simply, an application program, through a *Database API*, requests database services. For convenience in the following discussion, the agent responsible for providing those services is called the *Database Manager* . The database manager is responsible for providing the application access to the *Database* . See Figure 4-11.

This figure also demonstrates the concept of a *Database Utility Program* : one or more special application programs, usually provided by a database vendor, that perform utility services on the database. Such utilities might reorganize the database, recover the database after a system failure, etc.

The traditional database model can be incorporated into the POSIX reference model, as in Figure 4-12. This depiction of the model shows that the database manager is really just part of the overall POSIX Open System Environment and is available to the application through the POSIX OSE API.

The model depicted in Figure 4-12. is sufficient to describe an application developer's view of the POSIX OSE API in general, and the database API specifically. The four lines labeled ''Database API'' represent the Database Applications Program Interface services, which are discussed in 4.4.4.1.

4.4.3.2 Implementation Aspects D

Some real world considerations of the POSIX Reference Model were discussed in 3.6. One of the real-world approaches described is ''layering.'' Note that in the marketplace, Database Managers are often independently purchasable components that are effectively implemented as layers. Another consideration is Database Manager portability. It is not a requirement that a a database manager sit on top of a POSIX OSE API, but there is very important value to the user in terms of portability if the database manager implementation does indeed sit on a POSIX API. This means that the database manager itself is portable. It should be

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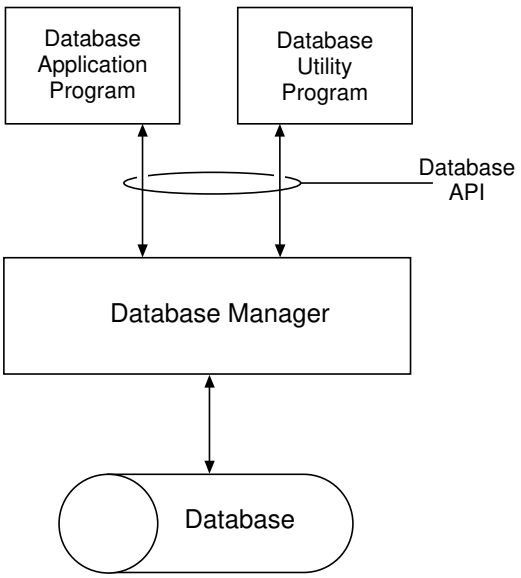

Figure 4-11 – The Traditional Database Model

noted that there will probably be implementations available of database managers that do not, in fact, sit on top of a POSIX API (or sit only partially on top of a POSIX API), that nonetheless provide the user the same database API. Such an implementation, using both POSIX API services and non-POSIX API services was described as ''expansion'' (see 3.6.1). Note that even though the model is drawn with only a single database manager, that does not imply that there may only be a single database manager available to an application. In fact, the coexistence of several database managers on the same system is consistent with this model, as is the ability of a single application to access two or more different database managers. The following extensions to the above model are specifically accommodated:

— There may be more than one database API. For example, there may be an ''SQL'' API and an ''ISAM'' API.

— There may be more than one database manager implementation for each different API. (For example, by two competing database vendors.)

— Applications may access more than one database manager.

This document has not described how a database manager is implemented in a POSIX Open System Environment, nor is it within the scope of this document to do so. It should be noted, though, that this model is very general and does not constrain the implementor. This model supports a number of varying real world implementation techniques, including:

— Application and database manager linked into a single process.

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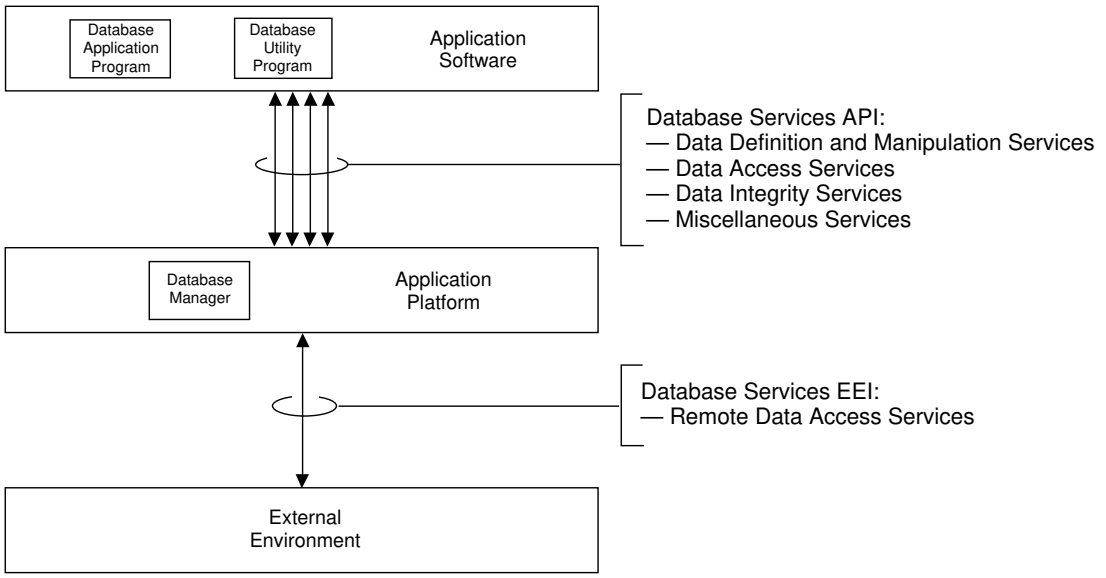

Figure 4-12 – POSIX Database Reference Model

— Database manager consisting of more than one process.

— Database manager consisting of a client part linked into the application process and a server part running as a process on the same or another system.

4.4.4 Service Requirements

The Database Manager described in the previous subclause provides services to the Application Program via the Database API, and the Database Utility Programs provide other services (e.g., to human users such as a ‘‘Database Administrator’’). This subclause describes the service requirements of all service users of the system. It is intended to be a complete list of service requirements rather than examples. Database Services are the specialized data services required to create, access, and manage databases located on a processor node. A uniform use of database services shall be available across POSIX-compliant machines. Users of these services include end users and those charged with the ongoing management of the information processing and database infrastructure.

4.4.4.1 Application Program Interface Services

This subclause describes the major categories of database services available at the POSIX Application Program Interface (API). These services include:

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— Data Definition and Manipulation Services

— Data Access Services

— Data Integrity Services

— Miscellaneous Services

The following paragraphs clarify that these services should be provided for a large class of objects, access methods, and types of database systems.

Types of Data Objects
: Ability to perform the above operations on a variety of types of data objects, such as text, graphics, image, documents, and voice.

Types of Access Methods
: Ability to perform the above operations using a variety of access methods, such as indexed sequential access, nonindexed sequential access, and direct access.

Types of Database Management Systems
: Ability to perform the above operations on a variety of types of file and database management systems, and database management systems, such as relational, network, semantic, and object oriented databases, and heterogeneous combinations of these database management systems.

4.4.4.1.1 Data Definition and Manipulation Services

These services relate to the ability of application programs to define and manipulate data. These services are:

— Data definition — ability to create, alter, or drop tables, views, records, fields, and/or data

— Data Manipulation — ability to insert, select, update, and delete tables, views, records, fields, and data

4.4.4.1.2 Data Access Services

These services relate to the ability of application programs to interrogate databases. These services are:

— Data Query Facilities — ability to specify search conditions, consisting of a combination of select lists, predicates, and comparison operators

— Data Transparency — ability to transparently access data regardless of the location of that data.

— Remote Data Access — ability to access and update remote data

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4.4.4.1.3 Data Integrity Services

These services relate to the ability of database management systems to protect the databases from hardware and software malfunctions.

- — Locking — ability to specify locking of data to some degree of granularity
- — Consistency — ability to specify and execute check and referential constraints that help ensure data correctness
- — Transaction Control — ability to specify commit and rollback commands and guarantee serializability
- — Synchronous Writes (Durability?) — ability to force the writing of data to nonvolatile storage

4.4.4.1.4 Miscellaneous Services

These services relate to other services required for the automated management of databases.

- — Privilege Administration — ability to grant and revoke privileges for accessing and administering data
- — Exception Handling — ability to have applications that are interrupted and notified of exception conditions, to receive control of the machine and take action in response to these exception conditions—even if the action is to ''continue''
- — Screen Definitions — ability to create screen definitions, and define, display, and/or paint screens
- — Reporting — ability to create formatted reports.
- — Dynamic Facilities — ability to temporarily turn control of a database to the end user for interactive access and manipulation of data, and then return control to the application.
- — Data Dictionary Services — ability to get data about the data (i.e., metadata) stored in the database. This allows users and applications to use the database contents in a much more flexible way. These services allow a user to create, access, and manage this metadata much in the same way as other databases are maintained.

4.4.4.2 External Environment Interface Services

External Environment Interface services are required for distributed database management systems. Also, to enable two or more databases to communicate with each other, a common interchange format is required. See 4.5.

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4.4.4.3 Database Resource Management Services

These services are not visible to the application programmer at the Database API. These services are usually provided by Database Utility Programs. These services include:

— Database Administration Services

— Database Recovery Services

— Distributed Database Management Services

— Heterogeneous Environment Support Services

4.4.4.3.1 Database Administration Services

Ability for a designated data administrator to structure and configuration manage a database as a whole. The administrator allocates resources and monitors utilization to assure that authorized users receive the proper services. Archive functions, journaling, and logging services are available to the user and administrator on a selective basis.

4.4.4.3.2 Database Recovery Services

Ability to decide that there has been a failure, allow recovery from failure, and permit a slave copy to become a master copy.

4.4.4.3.3 Distributed Database Management Services

Supports the partitioning and partial replication of the databases.

4.4.4.3.4 Heterogeneous Environment Support Services

Permits local database systems to be of different types (e.g., inverted list, hierarchical, network, relational) by providing translators between the local database form and a general ‘‘network language.’’

4.4.4.3.5 Flagger

Ability for programmers to be alerted about any code that does not conform to the standard in question, or about any code that is not processed in a conforming manner.

4.4.5 Standards, Specifications, and Gaps

There are currently four database standards, either completed or under development. These are the relational data language SQL, a network data language called NDL, the Information Resource Dictionary System (IRDS) for data dictionary work, and a Remote Data Access (RDA) protocol. Table 4-7 summarizes the service requirements provided by the various standards.

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Table 4-7 – Database Standards

Service		Specification	Subclause
Data Definition and Manipulation Services Data Access Services Data Integrity Services	SQL:	ISO 9075 ANSI X3.135 ANSI X3.168	4.4.5.1
Data Definition and Manipulation Services Data Access Services Data Integrity Services	NDL:	ISO 8907	4.4.5.1
Miscellaneous Services (Data Security and Integrity, Exception Handling, Screen Definitions, Reporting, Dynamic Facilities, Data Dictionary Services) Database Resource Management Services (Database Administration, Recovery From Failure)	IRDS:	ISO DP 10027.N2642, (IRDS Framework) ISO DP 8800 N2132, (IRDS Interfaces) ANSI X3.138	4.4.5.2
External Environment Interface Services	RDA:	ISO/IEC DP 9759	4.4.5.2

4.4.5.1 Current Standards in the POSIX OSE

This subclause describes the current accepted standards that apply to this area.

SQL Standard Database Language

ANSI X3.135.1 (ISO 9075, FIPS 127)

ANSI X3.168

There is a lot of activity by ANSI and ISO in this area. The standards referenced above are all related, but may not all be ''current'' at the time you read this guide. The base document is the 1989 ANSI document. ISO and FIPS documents based on it should be used. Earlier ISO and FIPS documents are based on earlier versions of the ANSI document and consequently may not be consistent with the latest ANSI document. Beware of this in making decisions about which of the standards are relevant to your decisions. These standards, developed in 1982-1989 by the ANSI X3H2 Database Committee, specify data access capabilities based on ''structured query language'' and the relational database model.

The X3.135 standard provides for many of the services described in 4.4.4, including Data Definition, Manipulation, and Integrity. It provides for two levels of compliance: the weaker Level 1 and the more capable Level 2.

While X3.135 deals with SQL independently of programming language, X3.168 binds, or embeds SQL within the programming languages COBOL, FORTRAN, Pascal, PL/1, C, and Ada.

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Work is currently planned by ANSI and ISO to include ''generalized triggers,'' ''generalized assertions,'' ''recursive expressions,'' ''escape from SQL,'' subtables, and support tools for object oriented and knowledge-based systems.

NDL Standard Database Language

ISO 8907

ANSI X3.133

This standard, developed in 1981-1986 by the ANSI X3H2 Database Committee, specifies a data definition language (DDL) and data manipulation language (DML) for network model databases. This work is an outgrowth of the 1978 CODASYL specifications.

This standard provides for many of the services described in 4.4.4, including Data Definition, Manipulation, Access, and Integrity. The above services apply only to network databases (i.e., not to relational or semantic databases.)

No follow-on NDL activities are being conducted by ISO or ANSI.

4.4.5.2 Emerging Standards in the POSIX OSE

This subclause describes the activities currently in progress to further standardize this area.

Remote Data Access (RDA) Protocol

ISO DP 9579:

Part I, *Generic Remote Database Access* — DP 2

Part II, *SQL Specialization* — DP 1

This standard, developed by the ECMA Technical Committee on Database Standards, TC22, submitted to ISO in 1985, specifies a protocol that allows remote access and updating, via OSI communications protocols, of relational databases or of database systems that support SQL.

This standard provides for the Data Transparency, Remote Data Access, and Support for Heterogeneous Environment requirements described in 4.4. This protocol is aimed at relational databases and other database types that provide access via relational interfaces such as SQL.

Much work is planned on in this area by the ISO committee ISO TC97/SC21/WG3. A specific area of current interest is a generic RDA that uses a nonspecific database language (i.e., not SQL.)

Information Resource Dictionary System (IRDS)

ANSI X3.138 FIPS Pub 156, April 5, 1989

ANSI X3H4/90-28 (draft, 4 Apr 90)
IRDS Export/Import File Format

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ISO DP 10027 N2642 (1988) IRDS Framework

ISO DP 8800 N2132 (1988) IRDS Services Interfaces

These standards are being developed by the ANSI X3H4 Database Group and the ISO/IEC /JTC 1/SC21 Working Group 3. Both groups are addressing the general area of data dictionaries, but, as described below, the emphases of the activities differ.

The ANSI group addresses, primarily, the user interface area, that is, how does a human user access the Data Dictionary Services described in 4.4.4.

The ISO groups concentrate more on the service interfaces (APIs) among lower level components and utilities of the database model.

Differences in scope and incompatibilities exist between the model being developed by ISO and the model approved by ANSI. They are independently developing the Services Interface, and an export/import facility.

4.4.5.3 Gaps in Available Standards

There are two significant areas described in 4.4.4 as requirements that are not addressed by standards:

— Methods to access data such as hashing and indexed sequential access to data is not currently standardized. There is no consensus in the standards community as to whether such standardization would be beneficial.

— Standardization of semantic and object oriented models have also not taken place, though groups like the ANSI Database system study group (DBSSG) are currently investigating the feasibility of standardization in these areas.

— I/O Services such as screen generation.

— Management and control of database services. Also include all gaps (all services without standards).

4.4.6 OSE Cross-Category Services

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4.4.6.1 Security

Ability to specify access control mechanisms.

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4.4.7 Related Standards

The standards and activities described in this subclause are related to the above and may also be relevant to your activities.

There are several areas closely related to the Database area that are worth considering with respect to standardization.

The first area to consider is the communications and networking area. Interoperability for distributed applications or the use of distributed databases may indicate the use of communications software adhering to networking standards. See 4.3 for further discussion of that area. (Specifically consider the following standards described in that subclause:

ISO/IEC 9804.3	(OSI CCR services)
ISO/IEC 9805.3	(OSI CCR protocol)
ISO 8824	*Information Processing Systems— OSI — Specification of Abstract Syntax Notation One (ASN. 1)*
ISO 8825	*Information Processing Systems— OSI — Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN. 1)*

The second area to consider is transaction processing. That area goes further in addressing the total requirements for distributed applications. See 4.10.

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4.5 Data Interchange Services

Responsibility: Richard Scott

4.5.1 Overview and Rationale

The Data Interchange/Information Exchange components of the POSIX Open System Environment provide specialized support for the exchange of data between applications or components of applications. Without support for data interchange, problems can arise when attempts are made to move data between different operational environments or between two related applications. More specifically, data interchange problems arise in each of the five following situations:

— Movement of a single application program and its associated data between operational environments,

— Movement of data between cooperating application software within the same operational environment,

— Movement of data between cooperating application software operating in differing operational environments,

— Movement of data between related, but not cooperating, application software within a single operational environment, and across differing operational environments.

From the global view, the data interchange components can provide the means to satisfy the needs in each of these situations. These standards need to define physical formats, data formats, code sets, and data descriptions that are consistent across all implementations of the POSIX Open System Environment.

4.5.2 Scope

The data interchange component of the POSIX Open System Environment includes standard services, protocols, and data formats required to ensure that data can be interchanged between related application software. Physical media formats are beyond the scope of the POSIX Open System Environment.

4.5.3 Reference Model

The Data Interchange Services relate directly to the POSIX Open System Environment reference model that was presented in Figure 3-1. Figure 4-13 shows the components of the reference model that are significant for data interchange. The reference model defines the conceptual relationships required to provide these facilities. It should not be viewed as a description of an implementation. The key entities within the figure are the Application Software, the Application Platform, and the External Environment. To satisfy the data interchange service requirements, the POSIX Open System Environment must permit application software to transfer data to and from the external environment.

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