The Commercialization of Database Management Systems, 1969–1983

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Database management systems were the most important commercial software packages of the 1970s. The authors reconstruct their early history by examining the evolution of their capabilities and installed base. They also document early user experiences, including the sources from which potential users learned about these new technologies, new roles such as the database administrator, and new concepts such as the data dictionary.

One approach to examining the early days of commercial database management systems (DBMSs) is to study the evolution of the leading DBMS packages of the 1970s. Doing so, we can reconstruct the technical issues and management decisions facing information technology managers as they investigated the new world of database software in the early 1970s. This includes not only the DBMS as a productivity aid for application programmers but also the new jobs, such as database administrator, created by the technology and the managerial challenges of creating a shared and consistent database to be used across different departments. Indeed, during the 1970s, the DBMS existed both as a tangible technology (with considerable strengths and pronounced weaknesses) and as the symbol of a movement to raise the status of computing within the managerial world and establish the idea of data as a corporate resource. (See the ''Data Management Definitions'' sidebar for a brief explanation of related terminology.[1])

As historian Martin Campbell-Kelly noted, finding good data on software adoptions and usage is difficult.[2] Our research utilizes various contemporary journal and newsletter articles, consulting reports, and advisory guides to document early DBMS user experiences and the processes by which they evaluated different packages. We also examine some of the major DBMS products of the 1970s, documenting their technical characteristics and exploring the changing dynamics of the DBMS marketplace into the early 1980s. This includes a brief discussion of the commercial threat posed by relational database systems to established products and efforts made to add relational capabilities to traditional products such as IDMS. Our focus is on database management packages for IBM machines, which dominated the mainframe market at that time. We rely here on contemporary market-analysis reports, particularly Datapro's ''Buyer's Guide to Data Base Management Systems'' starting in 1974.[1]

Database beginnings

Life in the data processing departments of the 1960s revolved around applications requiring the storage, updating, and retrieval of large volumes of data. The arrival of disk technology in the mid-1960s posed a huge challenge to application developers.[3] Organizations struggled to exploit the potential of random access data storage and interactive query.

Corporate data processing budgets mushroomed in the 1960s, driven in large part by the rapidly growing cost of maintaining systems and application software. Organizations not wanting to continue to create and maintain large applications had two choices: hire a contractor to develop the software to the organization's specifications or purchase a standard software package from an independent vendor (and in many cases, pay them

Data Management Definitions

To frame our discussion on specific software packages, let's review a pair of definitions from the period:

- *DBMSs* can be defined as those that are intended to manage and maintain data in a non-redundant structure for the purpose of being processed by multiple applications. A DBMS organizes data elements in some predefined structure and retains relationships between different data elements within the database.
- A *data management system*, on the other hand, is intended primarily to permit access to and retrieval from pre-existing files (usually for a single application). Although a data management system might provide the capability to minimize data redundancy

and centralize the data storage, the system's principal intent is to perform such functions as information retrieval, report generation, and inquiry for single applications.[1]

Data-management systems were also known as file-management systems. Although we provide a short discussion of file-management and report-generation software, largely to clarify the continued success these products enjoyed throughout the 1970s, this article focuses on early mainframe database management software. We believe the history of data management systems is sufficiently important to warrant a separate investigation.

to tailor the package to the buyer's environment). In the mid-1960s, however, the software services industry was in its infancy, and almost no commercial market existed for standard software packages such as sort utilities, report writers, and information-retrieval packages. When vendors and user groups did create such software, it was given away without additional charge.

Two factors changed this state of affairs. On 7 April 1964, IBM announced the System/360, a family of compatible computers and operating systems (OSs) that let users migrate to larger computers without throwing out their existing programs.[4] With these, organizations relied heavily on standard OSs provided by computer vendors. Then on 6 December 1968, IBM announced that it was unbundling software products, systems engineering services, and training costs rather than supplying them free of charge to its customers with the hardware lease or purchase.[5]

Together these decisions provided the foundation for the software products and services industry's growth. The creation of compatible computer systems families gave prospective software developers a large and growing market in which to sell their wares. IBM's unbundling meant that early software vendors would not have to compete with free software from IBM.[6] This environment not only motivated software entrepreneurs to create software, it allowed the fledgling industry to flourish. By 1972, there were 82 vendors offering 275 packages for the life insurance industry.[7] Indeed, Cincom (Total), Informatics (Mark IV), and CIM (Datacom/DB) began as software services firms.[8]

DBMS software promised to reduce the organization's hardware burden, speed up

its applications, and save money. *Infosystems*, one of the leading management-oriented data-processing publications, assured its readers in 1973 that database systems were like the aeronautical efforts of the Wright brothers; although carefully planned early efforts had "never developed much lift when applied to the practical realities of processing large files that had to be stored, indexed and sorted with live data," they were now poised to rise majestically into the air.[9] The problem was that no one knew much about them, even the organization that had attempted to write generalized data access software.[10]

Most organizations wanting to explore DBMSs needed training for their technical staff and consultants to guide them. Initially, there was not much help available, so consulting firms and software vendors realized that educating potential clients was an important way to spread their message, sell products, and build market share. Technical training, off-the-shelf software, and various types of support services became part of the growing software industry.

Industry periodicals of the early 1970s contained numerous articles introducing the notion of DBMSs. *Datamation* and *Computerworld* printed tutorials, articles detailing early user experiences, and articles focusing on specific software packages.[11] Some brave authors (and editors) published short case studies as well as articles comparing individual software packages and introduced readers to advanced concepts.[12] We say "brave" because vendors were constantly changing their offerings while working with existing customers to plan future improvements and additions. *EDP Analyzer* brought a new

management and organizational viewpoint to the dialogue.[13] Most users, however, depended on their hardware vendors. Of course, industry periodicals, consultants, and reports were not the only ways for potential users to learn about advances in database technologies and share practical experiences with its implementation. Computer user groups, particularly SHARE and GUIDE, continued to play an important role, with many sessions organized to discuss current and forthcoming software.

As databases emerged as a distinct research area, new specialized interest groups, journals, and professional meetings were created. For example, the ACM created a Special Interest Group on File Description & Translation (SIGFIDET), which from 1969 onward published a newsletter and hosted a series of regular conferences. In 1976, ACM's *Transactions on Database Systems* provided the field with a prestigious academic journal. SIGFIDET and its successor, SIGMOD (Management of Data) were more for researchers and creators of DBMSs than for their users, but database technology was also much discussed within the companion SIGBDP (Business Data Processing) and its newsletter *Data Base: Advances in Information Systems*. Outside ACM, a successful annual series of international conferences on very large databases was launched in 1974.[14]

Making the DBMS selection

To assist beginning DBMS users, Datapro provided a few caveats to guide the selection of a DBMS: "define *in detail* your organization's system and data requirements … and don't be surprised if this definition of requirements takes the efforts of two or more people for up to *six months*."[15] (Italics added to emphasize the report's authors lack of understanding of the difficulty of these new tasks.) For organizations choosing a database package for a single application, this might be a relatively simple task; for organizations choosing a DBMS as the centerpiece of multiple applications, this would be a massive undertaking.

To evaluate a vendor's offerings, the user had to carefully examine existing hardware capabilities—the space available on direct-access storage devices, the CPU time available to process the application, and so on. More important than the technical side of the decision was defining the needs of the application's users and managers. What were the applications' unfulfilled needs? Did users want to access data on an ad-hoc basis rather than rely on (out-of-date) monthly or quarterly hardcopy reports? Identifying these always-changing requirements was not a trivial process and required the attention of senior personnel.

After defining the organization's requirements, the selection team had to compare the hardware and software needed to run the various DBMS packages with their current hardware configuration and operating system and estimate the cost of additional hardware, software, media, training, and personnel. Although all vendors were happy to demonstrate their products, some vendors encouraged users to benchmark their products against their competitors, and this allowed many potential users to test their applications using actual DBMS software. Another common strategy was to visit organizations that were using the hardware and software under consideration and ask questions of their personnel.

An organization's basic strategy was therefore to (1) identify and evaluate present hardware and software capability; (2) examine multiple DBMS packages and identify their hardware and software requirements; (3) analyze the user's present and future processing requirements; (4) identify additional hardware or software required for each potential package; (5) talk to other users, see demonstrations, and run benchmarks; and (6) make a decision on which database management package to buy, lease, or use via a service bureau. Once a decision had been made, the implementation process began. This included (7) acquiring additional hardware and software, (8) technical training for employees, (9) data conversion, (10) database system generation, (11) various levels of testing, (12) creation of linkages between applications, and (13) system refinement and maintenance. To many potential DBMS users, this was a daunting scenario. In addition to costs, users were interested in the system's efficiency, the ease of installation, and the quality of the vendor support and package documentation. So much for Datapro's six-month estimate.

The 1974 marketplace

By the early 1970s, Codasyl's Data Base Task Group's recommendations on database software architecture and preliminary standards for data definition and manipulation languages had begun to appear. (See Thomas Haigh's discussion of the Codasyl's Data Base

Task Group's work elsewhere in this issue.) This led observers to question the need for an industry-wide standard for DBMSs. In 1972, *EDP Analyzer* opined that "it is generally conceded that it is premature to think about a standard data base management facility at this time," but that since "there is nothing comparable to the DBTG proposals" they should be used as the basis for further development of DBMSs.[16]

In October 1974, *EDP Analyzer* revisited Codasyl-type database systems, reviewing implementations by the Minneapolis Star and Tribune Company (DMS 1100 on Univac 1106), Xerox Corporation (EDMS on Sigma 7), Abbott Laboratories (IDMS on IBM/370), and Northern Illinois Gas Company (DM6700 on a Burroughs B6700).[17] Codasyl-type systems were described that "contain many deviations from the CODASYL specifications." *Analyzer* concluded that "CODASYL-type DBMS represent a worthwhile, viable effort" (p. 13).[17]

The only such package available for IBM equipment was Cullinane's IDMS, which was identified as implementing "a subset of the April 1971 DBTG report." B.F. Goodrich, under the direction of DBTG member Richard F. Schubert, implemented a subset of the 1971 DBTG specifications. In 1972 and 1973, Goodrich received permission to convert GE's Integrated Data Store to IBM equipment.[18] Goodrich named the system the Integrated Database Management System (IDMS, p. 6).[16] In 1973, the Cullinane Corporation acquired the rights to further develop and market IDMS.[17]

Although IDMS did not come to market until May 1973, the differences in the packages on the market in the early 1970s highlighted the need for a standard approach to DBMSs:

> It is becoming increasingly apparent that standardization is the best way to ward off the trauma of conversion and major hardware announcements. Just as COBOL has become the standard programming language for business applications, virtually machine- and manufacturer-independent, many experts believe that the CODASYL Data Base Task Group (DBTG) language specifications will become the data base standard of tomorrow—at least in basic principles.[19]

Later, other vendors took notice of the commonality between the DBTG recommendations and their native implementations and marketed their packages as "DBTG-like."[20] The other leading DBMS packages of the mid-1970s for IBM systems were not based directly on the Codasyl specifications.

The 1974 Datapro Buyer's Guide contained data on six packages: Total, System 2000, IMS, Adabas, IDMS, and DL/1. Datapro selected these packages because they were "the ones that generate[d] the most interest from ... our subscribers, and [were] the most widely installed at [that] time."[1] Table 1 shows the range of these packages' operating characteristics, requirements, and capabilities.

IBM had settled on a single architecture for its 360 and 370 series machines, but this did not mean that software selection was simple. Users paid close attention to the different packages' system requirements, in terms of processor demands, memory requirements, languages supported for application development, and OS requirements. For example, the minimum memory requirements were 3 to 30 Kbytes for Total, 160 Kbytes for Adabas, and 256 Kbytes for IMS running under the MVT operating system! Independent vendors generally supported a broader range of options than did IBM, and this explains some of their success in the marketplace. With respect to host languages, IBM's IMS and DL/1 packages supported Cobol, PL/1, and assembler, whereas the other packages also supported Fortran. Only Total supported IBM's RPG II. The situation was more complicated for OSs. In 1970, IBM's IMS did not run under its DOS operating system. Potential users had a choice: upgrade to its full OS (which was time consuming and expensive), wait until December 1973 when DL/1 became available under DOS/VS, or choose one of the packages offered by independent software vendors. Many organizations chose the latter.

An organization's data-processing requirements also influenced system selection. For example, some organizations had a need for frequent and rapid inquiries, which meant that an inverted file system would be beneficial. The availability of a report generator, data dictionary, or checkpoint/restart facility could influence the selection based on user capabilities or goals. More sophisticated users might want to use the package in an online environment and select a package that could be interfaced to a communications package such as CICS, Environ/1, or Intercomm. For other users, the availability of a report generator such as Socrates or IDMS-Culprit might seal the deal. Although numerous software vendors offered report-generator

Table 1. Characteristics of early DBMS packages.

	Total	System 2000	IMS	Adabas	IDMS	DL/1 DOS/VS
Vendor	Cincom Systems	MRI Systems	IBM	Software AG	Cullinane	IBM
First installation	Early 1969	June 1970	March 1971	March 1971	May 1973	Dec 1973
Current users	750+	70+	400+ (est.)	70+	30+	100+ (est.)
CPU requirements (IBM)	S/360/370	S/360/370 40 & 145	S/360/370 40 & 145	S/360/370	S/360/370	S/360/370 125, 135, 145
Operating system (IBM)	DOS, DOS/ VS, OS, VS1, VS2, IBM System/3	OS, OS/VS	OS/MFT, VS1, VS2	DOS, OS, OS/VS	DOS, DOS/VS, OS, VS1, VS2	DOS/VS
Minimum memory (IBM, in Kbytes)	3–30	156	128 (MFT)/256 (MVT)	160	30	98
Application language	Cobol, RPG II, Fortran, PL/1, Assembler	Cobol, PL/1, Fortran, Assembler	Cobol, PL/1, Assembler	Cobol, PL/1, Fortran, Assembler	ANS Cobol, Fortran, PL/1, Assembler	Cobol, PL/1, Assembler
Data structure	Network	Partially inverted hierarchical	Hierarchical, sequential, and hierarchical direct (tree)	Partially inverted network	Hierarchical or network	Hierarchical, sequential, and hierarchical direct (tree)
Checkpoint/ restart	Yes	Yes	Yes	Yes	No	No
Online inquiry	No	Inquiry and update language included	IQF, GIS/VS	ADASCRIPT	No	No
Report generator	*SOCRATES*	Self-contained	GIS/VS, GIS-2	Easytrieve from Pansophic Systems	*IDMS-CULPRIT*	No
Data dictionary	Under development	Procedural language pre-compiler	IMS dictionary system	Report utility had data dictionary functions	Via user defined data definitions and utility programs	No
Telecom interface	ENVIRON/1, CICS, Intercomm	TP2000, CICS, Intercomm, TCAM	Included, also CICS	TSO, CICS, Intercomm	GCI	CICS
User satisfaction	3.6	3.3	2.8	3	3.6	2.4
Response number	46	8	24	5	7	5
Price	$29,500 or lease	$40,000 or lease	DB: $616/mo, DC: $700/mo	$120,000	$37,500 or lease	$330/mo

packages, there was a big advantage in getting additional software from the DBMS vendor rather than having to deal with multiple individual vendors—especially when interface problems were encountered.

Datapro evaluations

In addition to the tables on the individual packages' technical characteristics, the Buyer's Guide on early mainframe DBMSs contained summary comments on the packages. We have excerpted enough of this material to provide an understanding of these early packages and to provide a basis for a later discussion on the evolution of the DBMS marketplace.[21]

As compared to IBM's IMS, **TOTAL** offers a more simplified and streamlined approach to data base management, providing a more satisfactory solution for the majority of users … and using far fewer resources in terms of

personnel and hardware ... TOTAL provides a simple and straightforward set of facilities for organizing a data base and for manipulating the data within an application program ... (and) provides a complete logging, backup, and recovery capability.[22]

As Table 1 shows, Total supported the widest variety of mainframes and OSs, and Datapro concluded that, "TOTAL is one of the most effective high powered software systems in use today and it has been successful in displacing IBM's IMS in numerous installations."[22] The primary reasons why users selected Total were the low memory requirements, the ease of use and implementation, and its high level of performance.[22]

The main feature of **System 2000** was its fast response times resulting from its partially inverted file structure. The user determined the amount of the inversion (i.e., the number of fields that could be used to order a search), and a well-structured database was critical for efficient usage. The more inverted fields, the longer the processing time, and the more storage required to store data and pointers. "The system is well suited for fully integrated data bases as well as simple, more specific applications on subsets of data ... Many of SYSTEM 2000's features are specifically designed to meet information processing requirements in business and scientific communities."[23] For example, System 2000 had a multithreading feature that let multiple users access data in a multiprogramming environment. "System 2000 users think highly of the product."[23]

IMS was also one of the most flexible packages on the market and met a variety of user requirements.

IBM's Information Management System (IMS) is one of the most controversial and talked-about software systems on the market today. It is also one of the most misunderstood and misused of all systems, and has developed the reputation of being everything from the most sophisticated and technologically current system on the market to Godzilla.[24]

IMS was particularly useful to organizations undertaking a centralized approach to the issue of data management. In November 1973, IBM released DL/1 for users running the DOS/VS operating system. Despite its complexity, Datapro believed that IMS had the potential to support management information system development because of its centralized database and the need for

management involvement in the database analysis and design stages. User's reactions to IMS were more favorable than to DL/1.[25]

The Buyer's Guide described **Adabas** as follows:

While ADABAS ranks as a top-notch data base management system, few of its features offer unique capabilities ... Rather, the system has been put together with such thoroughness and skill, that its most impressive features are not directly evident to the end user and appear in the form of reduced system overhead.[26]

Some of this was the direct result of a data-compression algorithm that typically created a database that was 30% smaller than other packages. Adabas also separated the logical relationships from the physical relationships, which allowed more general network structures and provided more flexibility. Adabas was designed to work with extremely large databases, accommodating up to 4.2 billion records. Although designed to handle 255 files (or databases), a "minor internal modification" allowed up to 65,000 files to be used. Although Adabas did not offer a communications monitor, the Adascript query capability used English-like statements and the Adawriter report writer was released in early 1975. Users generally liked Adabas.

Early DBMS users

In a 1975 *Datamation* article, Robert M. Curtice examined "The Outlook for Data Base Management."[27] Curtice stated that, "Data base management packages have been a somewhat surprising success for the independent software houses, with total installations perhaps second only to their cousins, file management packages." He also recognized that each of the existing packages had developed a sizable user base and believed that "it would take until 1980 or beyond to convert all major applications to an integrated data base ... most (users) will stick with their original DBMS software until this conversion is all but complete, rather than switch in midstream."

Adoption of database management software proved to be a boon to application programmers. In administrative applications of the kind traditionally carried out by corporate data processing departments, an enormous amount of programmer time was taken up doing the things that DBMSs were supposed to automate. They made programs cheaper to develop and much easier to maintain, and they

facilitated the integration of different business tasks.

Yet DBMS systems were not panaceas and incurred significant costs. As early as 1973, a report by two Booz, Allen, & Hamilton consultants suggested that the software and hardware needed remained immature, little experience existed in its use, and the generalized features offered by DBMS brought a hefty performance penalty and might well trigger the purchase of more memory or a new processor unit.[28] Most of the true costs were hidden, particularly the staff requirements. As they put it,

> Some DBMS's are as complex as the operating system which services them. Also, (the technical systems) group must continuously apply and test new program fixes and new features to keep the system 'alive and well.' It is not uncommon to see a small systems programming team double or even triple as the result of a DBMS.[28]

Later reports suggest that these problems continued for several years and that many firms installed DBMS packages because of a technical bandwagon effect rather than a careful and informed evaluation.[29] Although the idea of executives directly accessing computer data was a common part of database hype during this era, no surveys of the early 1970s were able to find any firms where managers or analysts directly used the database.[30]

Even among firms acquiring the most advanced DBMS packages, online use was limited and managerial applications rare. Two examples of firms using commercially supplied DBMSs in the early 1970s provide us some insight into these early days of DBMS adoption and usage. McDonnell Douglas, using IBM's IMS system, claimed to have created a centralized database containing all the information previously stored in 264 files covering spare parts, production scheduling, bill of materials handling, and inventory management. This made it much easier to change the 95 existing programs that relied on these files, to set up automatic cross references between different records, and it hoped, to move toward online operation in the future.[31]

A much smaller firm processed accounts receivable for doctors. It used a Codasyl-style DBMS on its Xerox computer to lower its daily processing times, shorten updates, and design its new programs more rapidly. The results pleased the firm, despite the fact that the DBMS consumed a large part of the computer's memory and used 10 times more processor capacity than the tape-based version. It had moved cautiously into online operation; while records were retrieved using terminals, all updates were queued and applied at night while the system was off-line in the belief that this "greatly reduces the possibility of a catastrophic loss of data."[32]

According to a 1975 survey of large industrial firms, about one third were using some kind of advanced file or DBMS.[33] Of that third, approximately half were using systems intended for direct ad-hoc querying by nonprogrammers, such as Mark IV, and half were using DBMSs designed to integrate with the conventional programming languages such as Cobol. Only about a quarter of the systems were used primarily for online access, and only two firms claimed to have implemented a database for the entire firm, though most reported using it for multiple areas of the business. This was very slow to change. Five years later, a survey of management information systems in 32 large corporations found that most of these companies had now installed a DBMS.[34] Yet when the researchers looked at the actual use of these systems they found that, "The users surveyed were only beginning to develop DBMS applications. . . . This is possibly because of the difficulties involved in developing and controlling such activities."[34]

In 1975, Elizabeth Fong and two other employees of the Institute for Computer Sciences and Technology assisted the Federal Aviation Administration in assessing the capabilities of six DBMSs.[35] The purpose was to provide an "objective overview" of the features of these packages. Their report explained the advantages of using a database management package and examined the use of Adabas, IMS, Inquire, Model 204, System 2000, and Total in 11 federal organizations of varying size, technical capabilities, and user needs. The methodology included on-site interviews with users and meetings with vendors.

Their report documents that federal agencies and departments, along with private organizations, were successfully introducing DBMSs. From large agencies such as the Naval Material Command's linking of 40 separate databases for 40 applications using IMS, to the Department of Agriculture's Statistical Reporting Service using System 2000 on a time-sharing basis to search crop and livestock data, federal agencies were taking

advantage of the growing offerings of database vendors. At this early time, the Department of Agriculture had already made System 2000 a departmental standard.[36]

Ian R. Palmer provided documented case studies from the commercial sector, including one which was tailor-made for a facilities management company.[37] In contrast to the Fong report, which contained systems used by small organizations, Palmer's case studies seem to concentrate on "major" corporations and show an abundance of firms in the financial sector, such as banks and insurance companies. Shorter case studies were published in *Datamation*, *Computerworld*, *EDP Analyzer*, and other publications during this period. Palmer's publisher, QED, also published *Data Base Management Systems* by Leo J. Cohen, which became the bible for organizations seeking to take advantage of DBMS.[38] Cohen provided detailed strategies for evaluating and selecting a DBMS and technical summaries of the leading packages.

Data administration

To the computer technician, a DBMS represented an improved mechanism to store and retrieve data; to the application user, the DBMS represented a new way of using the information collected as part of automated applications. One outgrowth of the DBMS environment was an understanding of the actual cost of data storage and, most importantly, the cost of storing redundant data. If an organization has an accounts receivable file with customer name, address, and contact as well as an accounts payable application with essentially the same information, a DBMS could let the user store the common data once and share it between the applications. If other applications use the same or similar data, then the efficiencies multiply and the case for a shared database environment becomes overwhelming. However, the potential for data sharing raises political problems:

- Who owns the data?
- What form should the data be stored in?
- Who should be allowed to access the data?

A whole new set of problems arises when multiple organizations need to modify and maintain shared data.

These quibbles did not stop hopeful accounts of the database as a technological marvel that would finally centralize and control information of all kinds, turning it from an abstraction into a solid organizational power base. This dream was enshrined in a new figure, the database administrator. According to one of the earliest descriptions, the DBA must "at once be technically qualified, if not inventive ... he must encourage the users to work with him willingly and yet he will be forced to rule against their pet projects; he must represent both management and the users simultaneously; he must be all things to all people at all times."[39] This role did "not exist as a formally established function in today's business," but its emergence was considered imminent.[39] Harvard computer management authority Richard Nolan was still bolder; he believed that the DBA would be responsible for "data as a resource ... much broader than just computer-readable data," once the "data resource function [had been] carved out of the general management function."[40] Another observer wrote that the DBA needed to be "something of a superstar."[41]

Discussion of the DBA makes apparent a rift between managerially oriented utopians and programmer-oriented pragmatists. Richard F. Schubert, who had overseen the remarkably ambitious B.F. Goodrich in-house DBMS development project that gave rise to IDMS, noted simply:

> Data base administration is accomplished by one or more technical experts who are knowledgeable in data base design and creation, operation of the data base management system, and the use of one or more data manipulation languages. The data base administrator must also be capable of working well with systems analysts, programmers, and computer operations personnel.[42]

It seems likely that this reflected practice in those firms actually using the technology rather than just talking about it. Certainly, by the time DBMS technology became ubiquitous in the 1980s, the DBA was a technical specialist rather than an information executive.

One IBM advocate of the "data dictionary approach" likened data to money: "Once management realizes the relationship of reliable data to corporate well-being, they will treat their data with the same care used to handle their cash."[43] Nolan made a similar pitch in his book *Managing the Data Resource Function*, the title of which suggested that information, like people and money, is a vital resource of business and therefore deserved similar managerial attention.[40] Indeed, Nolan's claims that the DBA

would be charged with overall responsibility for all corporate information, using computer technology where appropriate but ultimately claiming managerial rather than technical authority, directly prefigure those made more generally for the new chief information officer (CIO) position in the 1980s.[44]

1970s data-management products

The rapid expansion of DBMS use did not kill demand for simpler file-management and report-generation products. Even products designed explicitly for use by non-specialists found their main markets to be among data-processing specialists. Because they cost less and could run on more modest hardware, file-management systems remained more widely used than full DBMSs. A 1975 survey found that 41% of DBMS-using firms reported that information could only be retrieved with the aid of a programmer.[33] Unlike DBMSs used primarily by application programmers to manipulate data on disk, file-management systems were primarily used (in 77% of firms) with files stored on tape rather than on disk. These systems still worked with individual files rather than vast integrated databases—indeed, 55% of their users had not even begun to integrate files to remove redundant information.

During the 1970s, the Mark IV file-management and report-generation system became the most successful single product in the admittedly short history of the industry; it was the first to reach the milestones of $1 million, $10 million, and $100 million in cumulative sales. Compared to the Codasyl specifications, its capabilities were modest. Its initial appeal was straightforward: first it was highly efficient in batch operation, and second it had been designed for use by nonprogrammers. Requests for data were entered onto one of four simple paper forms, and then keypunched for later processing. But even Mark IV found its main audience among programmers. As time went by, Mark IV development focused more on the needs of full-time programmers who used it as a foundation for constructing complex application programs. An official company history credited this process to the influx of data processing specialists into its IV League user group, which ensured that their opinions "overwhelmed the voices of the non-programming end users" in the company's planning.[45] This group's proceedings suggest that non-specialists found advanced work harder than expected. According to an Eastern Airline representative, although most of its 200 users were "a complete new breed of coders ... non-programmers (with) little or no data processing background," attempts to train them in information retrieval techniques without giving an understanding of what went on in the computer's "mysterious black box" had failed. Contrary to their expectations, "The only users able to move into extended capabilities with any degree of success were those with some data processing background."[46]

IBM's RPG family of report generators enjoyed similar popularity. Although there was a substantial demand for products that would let non-specialists produce computerized reports without programmer assistance, the leading DBMSs did not do a good job of meeting this need. In fact, DBMSs actually grew the market for report generators. One of the most successful software products of the 1970s, Pansophic's Easytrieve, was an easy to use report-generation system designed to extract information from files and databases. Easytrieve thrived in competition with more complex DBMS and file-management software, and many firms purchased the optional modules needed to use it in conjunction with the most powerful DBMSs.[47]

Market developments: 1974–1979

The DBMS market too was growing strongly. By 1974, more than 1,400 installations were running one of the six database packages listed in Table 1. The growing market soon attracted additional companies and additional packages. The Buyer's Guides for 1976, 1977, and 1979 included 13, 15, and 18 packages, respectively. Despite this proliferation, the market in 1974 was dominated by two packages: Cincom's Total with 750 installations (53% market share) and IBM's IMS with 400 users (28% market share).

Cincom, as the first vendor, enjoyed a head start on the rest of the field having the earliest installations and the largest number of users. However, more important was Cincom management's decision to adapt Total to a wide range of hardware platforms. Indeed, Total was available for the most mainframe configurations: IBM System/360s and 370s; Honeywell 200s and 2000s; Univac 1106s, 1108s, and 1110s; CDC 6000s; and NCR Century mainframes. Most of the other independent vendors also ported their software to other mainframes, while IBM's IMS only ran on System/360 Model 40 and larger and System/370 model 145 and larger.

Table 2. Installed base of DBMS products, 1974–1979.

IBM systems	First installation	Users in 1974	Market (%)	Users in 1976	Market (%)	Users in 1977	Market (%)	Users in 1979	Market (%)
Total	Early 1969	750	53	1,000	48	2,000	49	2,500	43
System 2000	June 1970	70	5	100	5	150	4	700	12
IMS	Mar. 1971	400	28	500	24	1,000	25	1,200	21
Adabas	Mar. 1971	70	5	150	7	200	5	300	5
IDMS	May 1973	30	2	120	6	300	7	400	7
DL/1	Nov. 1973	100	7	150	7	300	7	600	10
Datacom/DB	1971		*	30	1	60	1	100	2
Model 204	1973		*	22	1	41	1	41	1
Subtotal**		**1,420**		**2,072**		**4,051**		**5,841**	
Non-IBM systems									
Codasyl									
Honeywell				500	52	525	38	660	33
Sperry Univac				300	31	500	37	500	25
Other				10	1	120	10	230	11
Subtotal**				**810**	**85**	**1,145**	**84**	**1,390**	**69**
Non-Codasyl				145	15	220	16	635	31
Subtotal**				**955**		**1365**		**2025**	

 * Not included in the 1974 Datapro *Buyer's Guide.*

** "Subtotal" is used to avoid confusion with the "Total" DBMS.

Indeed, IBM initially only supported the OS and OS/VS operating systems while Cincom's Total could operate under IBM's DOS and DOS/VS.

Table 2 shows the data from the Datapro Buyer's Guide for 1974, 1976, 1977, and 1979 and is ordered by earliest installation to show the growth in installations with respect to the package's time in the marketplace.

Table 2 reveals that the relative positions of the vendors in 1974 continued for the rest of the decade, even as the number of organizations adopting DBMS technology rose sharply. By 1979, the vendors had a total of 5,841 installations using their products. Cincom continued to lead all vendors in the number of hardware environments supported, with a 43% market share.[48] At this point, Cincom had approximately 700 employees, more than any of its independent competitors, and a growing number of offices overseas. IMS remained a strong second place, though its market share slipped to 21% (even as its number of installations tripled). We also included data on non-IBM systems users to provide a more comprehensive picture of the overall DBMS marketplace at this time.

Each new report showed substantial growth in the DBMS market. Growth seems to have been fastest around 1977, with the estimated number of installations almost doubling from the previous year. This rapid growth indicates that the idea of using DBMSs was gaining widespread acceptance across the industry, perhaps due to favorable articles in the technical press and a growing cadre of technical staff with DBMS experience.[49] The importance of DBMS software to the commercial software market was hard to miss. The 1979 Buyer's Guide stated, "data management software of all types will account for over half of the proprietary software market revenues in 1983 (estimated to be about $2.3 billion). A sizable portion of this amount will be spent specifically for data base management systems."[50]

Although none of the other packages managed to challenge IMS for the number two spot, they did increase their market share during the late 1970s as well as dramatically enlarge their customer base. IDMS and System 2000 both flourished, with System 2000's installed base more than tripling between 1977 and 1979, resulting in a 12% market share. IDMS grew rapidly in the mid-1970s to finish the decade with 7% of the market while Adabas retained a stable niche with a 5% market share.

Analysts often rely on guesswork and leaks for many of the details in their reports, but in

Table 3. Database installations and revenues by vendor.[51]						
Vendor	Package	Sites*	Market share (%)	Revenues (millions $)*	Anticipated growth rate*	Employees involved in DBMS sales/service**
IBM	IMS	1,300	21	42	High	—
	DL/1	750	12		High	—
Cincom	Total	2,700	44	30	Low	700
Cullinane/CAI	IDMS	500	8	13.9	Very High	—
Software AG	Adabas	375	6	8	High	200
Infodata	Inquire	100	2	3.5	Low	75
MRI/Intel	System 2000	280	5	10	Medium to high	275
CIM/ADR	Datacom/DB	150	2	1.1	Medium	60–70
CCA	Model 204	50	1	1.5	Low	15
Total		**6,205**		**110**		

* Source: Frost and Sullivan report. Site data and anticipated growth rate are from Table 1, page 20; revenue data is from Table 71, page 203.
** Number of employees are from individual reports.

this case, we are fortunate to have a second source for comparison. In December 1979, Frost and Sullivan published a report that contained financial data on DBMS vendors and made forecasts for the 1980s.[51] This report mirrored the Datapro findings, as Table 3 shows. Cincom led in market share with 2,700 installations. This report also provided some interesting estimates of other aspects of the business. According to Frost and Sullivan, IBM led in terms of database revenues (with $42 million), despite its smaller installed base. Because DBMSs were still used by less than 25% of the IBM market, they predicted that mainframe DBMS would continue to grow rapidly.

Although the main DBMS market was for packages usable on IBM mainframes, each of IBM's major competitors was served by at least one package. Datapro included analysis of systems for these other platforms, primarily self-described Codasyl-type systems. Products for Honeywell and Sperry Univac mainframes were the most important, accounting for 83% of the market for DBMSs to run on non-IBM platforms in 1976. On these platforms, non-Codasyl products held only a 15% market share. By 1979, however, that share had almost doubled to 31% of the non-IBM platform market, so the Codasyl influence was in decline in what had been its strongest niche. This was not fully appreciated at the time; Frost and Sullivan's 1979 report suggested that the future will see "greater adherence to the CODASYL data base specification"

and that eventually "strides in hardware price-performance will eventually make relational data bases practical and more attractive.[51] Frost and Sullivan were wrong on the first prediction and right on the second.

Market developments: 1980–1983

Datapro opened its 1980 Buyer's Guide by saying,

[E]xperts in the field of data base management (predict) the growth of the industry in the 1980's will be nothing short of phenomenal in regards to DBMS acquisition ... Up to a few years ago, only the wealthiest and most sophisticated computer user could or would spend any time evaluating DBMS systems. Now there is a system for almost any size computer and data processing environment. The application of DBMS technology for use with minicomputers and even microprocessor systems has really caught on in the marketplace.[52]

Many new companies entered the market in the early 1980s. International Resource Development completed a report in 1986 that provided an overview of the entire DBMSs market for 1985 stating that nearly 200 US-based firms sold DBMS software, tools, and related products.[53]

Like the DBMS market itself, the product lines of the leading suppliers expanded and offered an array of options and niche products. As early as 1974, some DBMS vendors were offering add-ons such as report generator packages, data dictionaries, and communications

Table 4. Installed base of DBMS products, 1979–1983.

IBM systems	Amount in 1979	Amount in 1980	Market (%)	Amount in 1982	Market (%)	Amount in 1983	Market (%)
Total	2,500	3,000	40	4,000	59	5,750	65
System 2000	700	700	9	700	10	700	8
IMS	1,200	1,500	20	*		*	
Adabas	300	550	7	550	8	1,000	11
IDMS	400	460	6	1,100	16	1,100	12
DL/1	600	1,000	13	*		*	
Datacom/DB	100	250	3	350	5	330	4
Model 204	41	41	1	125	2	**	
Subtotal†	**5,841**	**7,501**		**6,825**		**8,880**	
Non-IBM systems							
Codasyl	1,330	1,430	78%	1,760	42		
non-Codasyl	735	400	22%	2,450	58		
Subtotal†	**2,065**	**1,830**		**4,210**			

* Data not provided by IBM.

** No separate report included.

† "Subtotal" is used to avoid confusion with the "Total" DBMS.

interfaces. However, as organizations realized that they could create ad-hoc reports without writing programs and could run online inquiries against the "corporate database," the demand for these capabilities exploded and spurred the development of additional add-on packages and the incorporation of new capabilities. One result was that by the late 1970s most vendors adopted a "total systems" concept, in which "a modular set of programs were combined to handle inquiry/response, accounting and billing, report writing, and other functions in a single integrated system."[54] Although Datapro opined that this was "nothing more than a clever packaging approach to marketing a DBMS," vendors continued to push this new modular approach. For example, Cullinane offered the following optional packages: IDMS-DC (an integrated telecommunications monitor), Culprit (a report writer), Interact (an interactive program development facility), On-Line English (a query facility), and an Integrated Data Dictionary.

The trend accelerated in the 1980s. Cincom announced that "TOTAL had evolved into a much more sophisticated system: the TOTAL Information System (TIS)."[55] The first TIS installation was in 1979 when Total was installed at more than 4,000 mainframe and 1,200 minicomputer sites; the 1982 Buyer's Guide shows TIS with 30 installations.[57] Applied Data Research's Datacom/DB

consisted of separately priced components, including Datadictionary, Dataquery, Datadesign ADR/D-Net, and ADR/Ideal for applications development.[56] Cullinane offered it's IDMS Data Dictionary and the Culprit report writer, which was later renamed EDP/Auditor. Cullinane also interfaced IDMS to applications software from other vendors. Not to be left out, MRI Systems integrated MSA's financial application packages and SAS Institute's SAS statistical analysis and graphics package with System 2000. Computer Corporation of America did something similar with Model 204, including offering an interface to SAS.[56]

Starting at the end of the 1970s, the DBMS industry grew in synch with the computer hardware market—which now included minicomputers. Table 4 shows how this growth continued during the early 1980s.

Datapro estimates suggest that Total was stronger than ever in the early 1980s, increasing its market share to approximately 65% in 1983. Adabas also strengthened its position, while System 2000 seemed to plateau. Unfortunately, IBM refused to provide installation data to Datapro Research Corporation in 1982, and there was no separate report for Model 204. This lack of data limits the value of the data in Table 4 and skews the market shares shown.

In other developments, Cullinane changed its name to Cullinet in 1983 and was the first

independent DBMS vendor to make the *Datamation* 100 list of the leading US data processing companies—at number 94 in 1983 with revenues of $108 million.[57] Stephen T. McClellan attributed Cullinet's success to a superior marketing organization and referred to John Cullinane "as a master marketer," who convinced McClellan that Cullinet will be the first billion dollar software company.[58]

In 1984, Cullinet rose to number 77 on the *Datamation* 100 list based on revenues of $143 million.[59] Three other independent DBMS vendors also made the l984 list of leading US companies: Applied Data Research at number 83 with $128.2 million, Software AG at number 91 with $115 million, and Cincom Systems squeaked in at number 99 with revenues of $89 million.[60] Intel (which acquired System 2000 in 1979) was at number 61 with revenues of $180 million.

Enter the relational model

Relational DBMSs became an important commercial force during the 1980s. Originated in the 1970s, the relational model gradually gained acceptance among database researchers.[61] The relational model was far more conceptually elegant and flexible than the network model Codasyl endorsed, which proved both restrictive (because relationships must be specified when the database is designed) and insufficiently abstracted from the physical storage of data (programmers were still forced to write code to navigate explicitly from one record to another when working with linked data). Because the relational model shifted the responsibility of specifying relationships between tables from the person designing them to the person querying them, it permitted tables to be joined in different ways for different purposes. This turned out to be necessary (if insufficient) for establishing large, general-purpose databases shared between different departments and computer systems. The relational model has also been praised for its nonprocedural nature—further separating the user from the physical storage mechanisms involved.[62] This simplified programming and insulated application code from changes in the database structure. Accepting a Turing award in 1981 for his development of the relational database model, Edgar F. (Ted) Codd suggested that the Codasyl network model had forced the programmer to become too much of a navigator, at too low a logical level.[63]

Acceptance of the relational model brought forth a number of database packages, among them Oracle and Ingres. A full discussion of relational packages falls outside this article's scope (though a future Annals special issue is planned), but we cannot consider the market for conventional hierarchical and network systems in the 1980s without acknowledging the influence of the sudden vogue for relational technology. Existing vendors had three basic options when faced with the flood of favorable coverage of relational database technology: ignore it, add "relational" features on top of their existing products, or develop entirely new packages. IBM and Cincom developed new relational products, DB2 and Supra, respectively. Datapro's reports show that IBM's relational offerings grew rapidly in popularity during the early 1980s and have contributed to the decline of the navigational packages. DB2 started with a single installation in 1983 and then exploded to 109 sites in 1986. SQL/DS, a similar product for the VM mainframe, added 305 new sites during this period, for a total of 365 installations.

Other vendors responded by developing new relational capabilities for their existing packages, though fundamental differences between relational and navigational approaches made this problematic. Cullinet offered IDMS/R, and Model 204 added some relational features. Datacom/DB also acquired relational features; it was sold as "relational-like" as early as 1979 and, by 1982, as "fully relational" although Datapro characterized it as "an inverted file structure with relational characteristics."[64] Computer Corporation of America marketed Model 204 as relational in 1979 as well.[65] These hybrid products were initially more successful commercially than the truly relational systems. By 1982, there were 3,135 installations claiming to be relational or relational-like, an 81% growth over 1980. But the same year Datapro concluded that "DBMSs that are truly relational have yet to proliferate (although) ... Relational Software's Oracle and Relational Technology's Ingres have been on the market since 1979 and 1976, respectively."[66]

Instead of claiming (sometimes on shaky evidence) to be Codasyl based, vendors now promoted their products (sometimes on even shakier evidence) as being relational. Even in the DBMS market for non-IBM compatible mainframes, previously dominated by Codasyl packages, the share of the installed base held by packages that claimed to be

Codasyl-like dropped from 78% in 1980 to 42% in 1982. Controversy raged, as relational database experts, most vocally Ted Codd and C.J. Date, sought to debunk the claims of traditional systems, such as IDMS, to have somehow become relational. In the end, customers with a genuine need for relational capabilities adopted truly relational systems, but the performance advantages of network and hierarchical systems for well-optimized transaction processing application ensured that they retained a significant niche within the mainframe DBMS market.

Epilogue

Of the seven main early vendors of DBMS software for IBM mainframes we have discussed here, three are still in the software marketplace: IBM, Cincom, and Software AG. Computer Corporation of America offers Model 204 and System 2000 is now offered by SAS. IDMS and Datacom/DB are sold by Computer Associates.

Hierarchical and network systems remain a significant presence and are still used by many large organizations, such as airlines, telephone companies, and financial firms for mainframe systems processing high transaction volumes. These products still bring in significant revenues, and programmers continue to develop and maintain applications built on them. Indeed, 12 users of Cincom's Total paid license fees in 2008 and 10 others were using Total in compatibility mode.[67] However, since the late 1980s, the mainstream DBMS market has shifted unmistakably toward relational systems. This transition accompanied an architectural shift away from mainframes and toward minicomputers, Unix systems, and eventually inexpensive commodity servers as the most common RDBMS platforms. The leading commercial DBMSs during the past decade have been Oracle, IBM's DB2, and Microsoft SQL Server.

Although these first-generation commercial DBMS products have been eclipsed by newer technologies, they demand historical attention for two main reasons. First, they were the mainstays of the independent packaged software business during the 1970s and did more than any other class of product to prove the viability of software product companies. Second, they established the DBMS as the default foundation for administrative application software. A generation of programmers, analysts, and managers learned a new style of application development in which data was manipulated via a DBMS interface rather than directly manipulating files. These early packages laid a vital foundation for later developments and the success of the relational systems that thrive today.

Acknowledgments

References and notes

1. Datapro Research, ''A Datapro Feature Report: A Buyer's Guide to Data Base Management Systems (ADABAS, IDMS, IMS, DL/1 DOS/VS, System 2000, TOTAL),'' report 70E-010-61a, 1974. The individual parts of the guide have separate report numbers, and pages are indicated by lowercase letters.

2. M. Campbell-Kelly, ''Development and Structure of the International Software Industry, 1950-1990,'' *Business and Economic History,* vol. 24, no. 2, 1995, p. 78.

3. See also M. Campbell-Kelly, ''Origins of the Software Products Industry: 1965–1970'' and ''The Shaping of the Software Products Industry, the 1970s,'' *From Airline Reservations to Sonic the Hedgehog,* MIT Press, 2004.

4. E.W. Pugh, L.R. Johnson, and J.H. Palmer, *IBM's 360 and 370 Systems,* MIT Press, 1991, p. 167.

5. B. Grad, ''A Personal Recollection: IBM's Unbundling of Software and Services,'' *IEEE Annals,* vol. 24, no. 1, 2002, pp. 64–71.

6. Although IBM only reduced its prices by a small fraction and IBM software was ''inexpensive'' compared to software offered by independent software vendors, it was no longer free.

7. M. Campbell-Kelly and W. Aspray, *Computer: A History of the Information Machine,* Basic Books, 1996, p. 204.

8. According to Walter Bauer, software package sales in 1970 amounted to $70 million, while the comparable figure for software contracting was $650 million. M. Campbell-Kelly, ''Development and Structure of the International Software Industry, 1950–1990,'' *Business and Economic History,* vol. 24, no. 2, 1995, reference 1, p. 87.

9. B.W. Romberg, ''Data Bases: There Really Is a Better Way to Manage Your Files,'' *Infosystems,* vol. 20, no. 5, May 1973, pp. 56–58.

10. For an excellent overview of the early efforts, see J.P. Fry and E.H. Sibley, ''Evolution of Data-Base

Management Systems,'' *ACM Computing Surveys,* vol. 8, no. 1, 1976, pp. 7–42. This is a special issue devoted to the development of database technology containing three other articles of interest.

11. For example, the July 1972 *Datamation* issue (vol. 18, no. 7) contained three introductory articles: R.F. Schubert, ''Basic Concepts in Data Base Management Systems, pp. 42–47; A.C. Patterson, ''Data Base Hazards,'' pp. 48–50, and R.A. McLaughlin, ''Building a Data Base,'' pp. 51–55.

12. The 27 Feb. 1974 issue of *Computerworld* contained a special report, ''Charting a course with Data Base Management Systems,'' that had 12 articles, including ''Data Base Systems the Wave of the 1970s,'' ''For the Unwary, DBMS Can Bring Unbridled Disaster,'' and ''Generalized DBMS Not for All.''

13. Technical Publishing began *Datamation* in 1958; Canning Publications began *EDP Analyzer* in 1963, and CW Communications began publishing *Computerworld* in 1967. *Datamation* was an example of a controlled-circulation periodical that was mailed free to qualified individuals; thus, most people in the ADP community subscribed to it. Most organizations' technical libraries had paid subscriptions to *Computerworld* and *EDP Analyzer.*

14. D.K. Hsiao, ''Will the Real VLDB Conference Please Stand Up,'' *SIGMOD Record,* vol. 12, no. 3, Apr. 1982, pp. 8–14.

15. Datapro Research, ''Buyer's Guide,'' report 70E-010-61b, 1974.

16. ''The Debate on Data Base Management,'' *EDP Analyzer,* vol. 10, no. 3, 1972, pp. 1–16. This issue contains an extensive discussion of the Codasyl-Guide/Share controversy including ''Some Arguments against the DBTG Proposals,'' ''Rebuttals to Arguments,'' and a letter from Gene Altshuler, Manager GUIDE Information Management Group commenting on the draft of the *Analyzer* article.

17. ''What's Happening with CODASYL-Type DBMS?'' *EDP Analyzer,* vol. 12, no. 10, 1974, p. 10.

18. The Integrated Data Store (IDS) was developed at General Electric under the direction of Charles Bachman, as outlined in Bachman's contribution to this issue.

19. Datapro Research, ''Buyer's Guide,'' report 70E-272-02a–02c, 1974.

20. In 1980, a *Computerworld* analysis showed that of the 11 systems available for IBM System/360/370 systems, only Cullinane's IDMS and a version of Cincom's TOTAL were Codasyl compliant. See M. Rosenberg, ''DBMS Offerings Defy Comparison,'' *Computerworld,* vol. 14, no. 28, 14 Jul. 1980, pp. 8–11.

21. This section does not include IDMS, which we discussed in the previous section.

22. Datapro Research, ''Buyer's Guide,'' report 70E-132-01a–01d, 1974.

23. Datapro Research, ''Buyer's Guide,'' report 70E-652-01a–01d, 1974.

24. Datapro Research, ''Buyer's Guide,'' report 70E-491-01a–01g, 1974. This is the longest and most technical of the individual reports.

25. For additional information, see K.R. Blackman, ''Technical Note—IMS celebrates thirty years as an IBM product,'' *IBM Systems J.,* vol. 37, no. 4, 1998; http://www.research.ibm.com/journal/sj/374/blackman.html.

26. Datapro Research, ''Buyer's Guide,'' report 70E-757-01a–01d, 1974.

27. R.M. Curtice, ''The Outlook for Data Base Management,'' *Datamation,* vol. 22, no. 4, 1975, pp. 46–49.

28. D.E. Cuozzo and J.F. Kurtz, ''Building a Base for Data Base: A Management Perspective,'' *Datamation,* vol. 19, no. 10, 1973, pp. 71–75.

29. G Schussel, ''When Not To Use a Data Base,'' *Datamation,* vol. 21, no. 11, 1975, pp. 82, 91, 98.

30. R.L. Nolan, ''Computer Data Bases: The Future is Now,'' *Harvard Business Rev.,* vol. 51, no. 5, 1973, pp. 98–114.

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33. V. Powers, ''Implementing Generalized Data Base Management Systems,'' *Data Management,* vol. 13, no. 5, 1975, pp. 36–40.

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39. J.K. Lyon, ''The Role of the Data Base Administrator,'' *Data Base,* vol. 3, no. 4, 1971, pp. 11–12.

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41. J.W. Luke, ''Data Base Systems: Putting Management Back in the Picture,'' *CSC Report,* vol. 9, 1975, p. 9.

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55. Cincom, ''Courage, Creativity and Commitment: 25 Years in the Pursuit of Excellence,'' [no date], p. 113. According to Datapro, Total was upward compatible to TIS: Datapro Research, ''Buyer's Guide,'' report 70E-10-61p, 1982.

56. Datapro Research, ''Buyer's Guide,'' report 70E-010-61p, 1982.

57. In the early 1980s, *Datamation* magazine started publishing the revenues of ''The Leading U.S. DP Companies,'' including total revenue, DP Revenue (present and previous year), and growth rates. For 1983, a company had to have data processing revenues of at least $94.5 million dollars (up 27% from the 1982 minimum of $74.3 million). IBM headed the list with $35.6 billion in revenues for 1983, and the only database vendor was Cullinet at number 94 with revenues of $198 million.

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