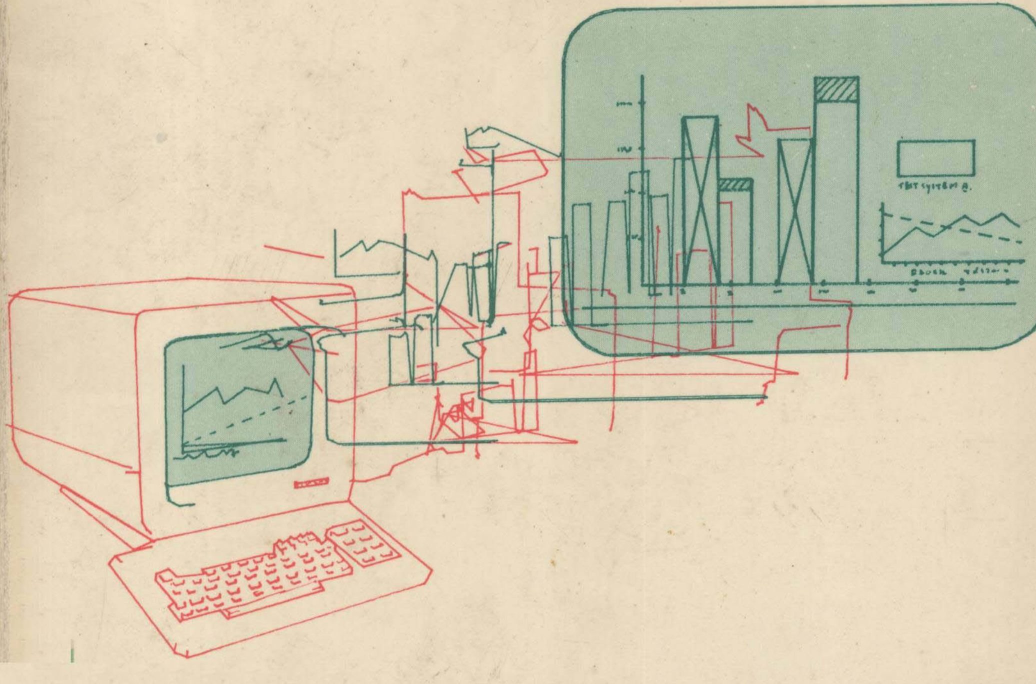
COMPUTER SCIENCE APPLIED TO BUSINESS SYSTEMS

M. J. R. Shave & K. N. Bhaskar



INTERNATIONAL COMPUTER SCIENCE SERIES

Computer Science Applied to Business Systems

M J R SHAVE (University of Bristol)
K N BHASKAR (University of East Anglia)

ADDISON-WESLEY PUBLISHING COMPANY
London . Amsterdam . Reading, Massachusetts
Menlo Park, California . Don Mills, Ontario
Sydney

To Ann, Fenella, Peter and Susan

Composition by Filmtype Services Limited, Scarborough, North Yorkshire.

Printed in Finland by OTAVA 1982. Member of Finnprint.

Library of Congress Cataloging in Publication Data
Shave, M. J. R.
Computer science applied to business systems.

(International computer science series)
Bibliography: p.
Includes index.
1. Business—Data processing. I. Bhaskar, Krish N.
II. Title. III. Series.
HF5548.2.S4412 650'.028'54 81–17603
ISBN 0–201–13794–1 (pbk.) AACR2

British Library Cataloguing in Publication Data
Shave, M. J. R.
Computer science applied to business systems.
(International computer science series; 2)
1. Business—Data processing
I. Title II. Bhaskar, K. N. III. Series

ISBN 0–201–13794–1

ABCDEF 898765432

Computer Science Applied to Business Systems

INTERNATIONAL COMPUTER SCIENCE SERIES

Preface

It has been estimated that 80% or more of all installed computer systems are used for business or commercial applications, and the size of the market is reflected by the large number of books on elementary computing and computing systems which have been written for managers and other business users. By contrast the interests of the computer scientist in business applications have been largely ignored. This book, therefore, is intended for those who already have some expertise in computing, but little experience of business.

Effective commercial computing systems depend on good design, which in turn stems from sound knowledge of technical as well as business matters. It is therefore important that computing science specialists in universities and polytechnics should acquire, as part of their training, some understanding of the technical problems and practical requirements which are involved in the application of their subject to commercial situations.

The book is intended primarily for students studying computer science or data processing, but it should also be helpful for those on business studies courses, or for students in other subject areas who simply wish to extend their understanding of computing systems and their applications. Readers are assumed to have taken a first course in computing which is sufficient to give them a knowledge of elementary programming. For programmers and others already working in the computing industry, the more technical chapters can give a wider appreciation of techniques which underlie their daily work, or the work of their colleagues.

Many computer scientists have a mathematical background to their studies and this is undoubtedly helpful in fostering a logical and analytical approach to problems. Unfortunately it also tends to foster expectations that all problems will be presented with clear and unambiguous facts, and that each will have a uniquely correct solution. One of the aims of this book, therefore, is to show that real data is often fuzzy and unreliable, and that the task in practice is to determine a solution which is in some sense optimal in relation to a number of conflicting interests.

These tasks are, roughly, the job of a systems analyst and the first chapter discusses what is meant by this ill-defined term. There are then three introductory chapters. The first considers aspects of computer systems which may not have been covered in an elementary course (such as the nature of auxiliary storage); the second describes the activities and organisation of a business; and the third introduces basic concepts of accounting.

The central chapters are concerned with the fundamental problems of commercial data processing – file organisation and processing, data capture, the description or specification of a system, the ordering of data by sorted or inverted files, and the use of on-line and real-time systems.

Chapter 10 surveys the database concepts which are steadily gaining importance in data processing technology. The topics included are the aims of the data base approach; data analysis; the principles of hierarchical, network and relational systems; integrity, and data administration; and the concept of a distributed data base. Chapter 11 considers how traditional techniques of auditing must be adapted and developed for the monitoring of computer based systems. Finally, Chapter 12 describes briefly some further and more advanced areas in which computing can be applied to commercial and management problems.

From the business point of view, the book reviews business practice, includes simple but explicit details of accounting systems, and deals with auditing in a practical way which follows the recommendations of the professional bodies. The needs and problems of management are emphasised. From the technical viewpoint, the book includes not only fundamental material such as the nature and use of files, or the range of input devices, but also more advanced techniques such as the use of decision tables, internal and external sorting techniques (including a section on 'B–trees') and the chapter on data base concepts described above.

An important feature of the book is that it can be studied at several levels, and the topics taken in several different orders. For example

- Chapters 1–4 are very basic introductory material, 5–8 are central techniques, 9–12 discuss more specialised applications
- Readers with computing knowledge can skip Chapter 2, while those familiar with business can omit Chapters 3 and 4
- Data capture and System description (Chapters 6 and 7) can be read before or after Files and Ordered access (Chapters 5 and 8), and the four final chapters are all largely independent of each other

It is our hope and belief that this flexibility will enable the book to be of interest and value not only to the computer scientist for whom it is primarily written, but also to many others readers who, whether they are studying formal courses or not, recognise the importance of computing to business in a complex industrial society.

The book originated from a course on information systems which was given by the authors for several years to a joint class of computer science students and accountancy students at Bristol University. We are grateful for the contributions which they made (often unwittingly!) to the clarification of our ideas as presented in this book. A number of exercises are included, many of which are taken from past examination papers, and it is a pleasure to acknowledge the contributions made by City University and Thames Polytechnic to this aspect of the book.

We are also grateful to Willis Computer Services, SDM Computer Services, Data Research Services and National Westminster Bank for providing us with photographs to illustrate the book; also to Donald Sanders, James Martin, J. O. Hicks and W. E. Leininger, Brian Jenkins and Anthony Pinkney, John Page and Paul Hooper, and B. E. Cushing, together with their respective publishers, for permission to republish extracts or illustrations. Each of these contributions is individually acknowledged. Thanks are also due to The British Computer Society and Heyden and Son for permission to base part of Chapter 10 on an article by M. J. R. Shave which was published in *The Computer Journal*.

We have been greatly encouraged by the enthusiasm of Mr Peter Hoenigsberg and all those at Addison-Wesley Ltd who have been concerned with seeing the book through publication. The whole of the final draft was typed with great care and skill by Mrs Diana Pollock, who never failed to meet any of the deadlines for which we asked.

No one was more delighted than our families when the book was finished, for there have been many times when it has preoccupied us. Our last and warmest thanks therefore go to them, for their patience, practical help and unfailing encouragement.

April 1981

M. J. R. Shave
K. N. Bhaskar

Acknowledgements

The publishers wish to thank the following for permission to reproduce photographs, figures and quotations:
Fig. 2.2, SDM Computer Services; Figs. 2.3, 2.5, 2.6, Willis Computer Supplies Ltd.; Fig. 3.5, Barry E. Cushing, ACCOUNTING INFORMATION SYSTEMS AND BUSINESS ORGANIZATIONS, © 1978, Addison-Wesley, Reading, Mass. (Fig. 2.4); Fig. 6.2, National Westminster Bank; Fig. 6.3*a* and *b*, Data Research Services Ltd.; Figs. 11.1, 11.2, Jenkins, B. & Pinkney, A. 1979. *An Audit Approach to Computers: A New Practice Manual*. Bristol: The Institute of Chartered Accountants in England and Wales; Figs. 12.2, 12.3, Page, E. S. & Hooper, P. 1979. *Accounting Information Systems*. Reston, VA: Reston Publishing Co., a Prentice-Hall Co.; Fig. 12.4, Hicks, J. O. & Leininger, W. E. 1981. *Accounting Information Systems*. Minn: West Publishing Co.; Fig. 12.5, Bodnar, G. H. 1980, *Accounting Information Systems*, p. 98, Mass: Allyn and Bacon Inc.; Figs. 12.7, 12.8, 12.9, from Bhaskar, 1978; Fig. 12.10 and quotation p. 165, Sanders, D. H. 1979, *Computers in business: An Introduction*, New York: McGraw-Hill. Cover illustration from Computer Studio, Royal College of Art, London.

Contents

1 What is systems analysis?

1.1 The value and limitations of computers in business

One measure of the complexity of modern society is the quantity of information about **past** events, and the accuracy of prediction about **future** events, which is necessary if an organisation is to operate successfully and efficiently in the present time. A manufacturer uses **facts** such as sales figures, labour and material costs, or stock levels, and **forecasts** of sales demands or economic trends, in deciding the type and quantity of his products. Similarly a public service company such as a water authority will plan its investment programme on the basis of past consumption and meteorological data together with estimates of population growth and industrial development. There is also a considerable volume of data which organisations must make available for external use – tax returns, trade statistics, balance sheets and the like – in addition to their own internal requirements.

As anyone who has ever attempted to make a logical arrangement of his own letters, papers or reports will understand, the collection, organisation and analysis of information – even on quite a small scale – is no trivial task. On any commercial scale it certainly requires a carefully chosen, precise and well managed system. Such a system need not necessarily involve elaborate mechanical or electronic equipment. Straightforward clerical systems have been known and used for hundreds of years, and many still work effectively today. This book will, however, concentrate on systems which are based on some form of electronic computing equipment because these techniques are increasingly necessary as the speed, volume, and complexity of business increases.

Computers were first designed as an aid to the solution of complex mathematical problems, some of which required so many calculations that their solution had previously been impossible within a human timescale. It is hardly surprising that at this time a computer – itself a significant name – was often called an electronic calculator, and used almost entirely as a scientific tool. Of course this was, and still is, a role which it can perform extremely well, but gradually its potential was more widely recognised and the scope of applications extended, first to include routine accounting, such as payroll calculations, and then to the representation, manipulation and analysis of a huge variety of data drawn from commerce, the arts, or the social services, much of which is not overtly numerical in character. Some examples are sorting operations, text processing, or perspective drawings.

For this reason the computer is now more properly regarded as an *information processor* which can rapidly organise and analyse most types of data on which management decisions are traditionally based. However, it cannot be stressed too strongly that the computer should never be more than a tool, however powerful, in this process. The onus of control and decision remains firmly with the senior management. It is they who must set goals, decide priorities, assess results – in short, take all strategic decisions – and their responsibility cannot be delegated to a computer system or those who run it.

Nevertheless, the introduction of these more complex information processing systems may, at least in the planning and installation stages, require specialist knowledge which will be distinct from that required for the management of the host organisation. Experts may therefore be called in, just as accountants have traditionally prepared balance sheets. Furthermore, the speed and storage capacity of computer based systems are such that they can and will be used for a wide variety of information processing applications, many of which were previously the responsibility of separate and largely independent departments, for example stores and accounts. This new mode of operation will usually demand a company-wide review and reappraisal if inconsistency and redundancy of data are to be avoided.

A systems analyst is an individual who can assist a company in these two areas – technical knowledge and the ability to take and assess a wide view of the organisation, independent of any one department or group. Frequently he will be a specialist recruited from outside the organisation, but this is not necessary if existing staff can take a sufficiently dispassionate and original view of their company. In the initial stages, one of the most important tasks is simply to look and listen, collecting information from staff, management, working documents and reports about the current objectives, resources and modes of operation. Only when all the contributory factors have been established can the existing system be assessed and, where necessary, redesigned.

1.2 Information systems

Whatever their purpose, all information systems have many features in common, but three main areas of use can be recognised

(i) to monitor and control transactions as they occur – an operational timescale of minutes, e.g. reservation systems,

(ii) to report and summarise completed activities – a timescale of days, e.g. most accounting systems,

(iii) to project and plan future development – a timescale of months, e.g. simulation modelling.

These areas correspond roughly to the operational, tactical and strategic aspects of administration but, as in business itself, they are not distinct. To gain a worthwhile return on the investment made in them, most information systems will be designed to contribute to more than one area, at least to some degree. For example, a stock control system can be readily extended to provide management with information on trends in purchasing, or capital returns on stock purchase, and so forth. Area (i) – so called *real time* systems – will require special resources such as *on-line* terminals, communication lines and equipment, and fast processing units with good *interrupt handling* facilities to cater for the frequent and urgent requests which are expected. Although the timescale may be less stringent, this type of equipment is also being used increasingly in other areas of work, particularly to eliminate errors and inefficiency in the collection of data, thus contributing further to the unification of data processing methods.

The evolution of any new information system contains a number of distinguishable phases

(i) project or problem definition
(ii) information analysis
(iii) system design
(iv) system development
(v) system implementation
(vi) system monitoring and evaluation.

These phases will overlap to some extent but their identification is worthwhile since the assumption and objectives at each stage will vary. The systems analyst will in some cases be concerned only with the first three or four stages; in other words, with the justification and outline of an overall system plan, leaving its detailed implementation for the expertise of the client organisation. In other cases his responsibility will extend throughout the creation of the system.

1.3 Project definition

The definition, which will include not only the objectives but also the priorities to be attached to different aspects of the system, will be drawn up by a senior management team and serve as the terms of reference to the analyst. It is likely to undergo clarification and modification as the analysis phase progresses, and can therefore properly be regarded as part of the analyst's evolution of the system. In particular, he should try to decide whether the problem he has been given has been posed in the most appropriate form, and whether the questions he has been asked to answer are the best or most correct questions to ask.

For example, a classic problem is whether it is better to aim to minimise costs or to maximise profits, and what constraints must be applied in either case? Or, if the response time in an on-line computer terminal system is poor, does this indicate too many users, too little main store, inadequate communication channels, a poor scheduling algorithm or some other cause? Or again, if a road haulage company receives complaints that its deliveries are late, is this because its lorries are too slow, or its loading bays are too cramped, or its warehouse staff are inefficient or overworked, or traffic has increased and schedules must be revised, or certain clients give insufficient or incomplete notice of their orders? In this situation, any solution will require what is sometimes called a 'total systems approach' and the analyst must clarify how much of the problem, and which aspects, are to be his responsibility.

By the time the design phase has begun, the project specification should certainly be fixed, as any further changes after this point are likely to cause considerable expense, confusion and delay. However, it is perfectly reasonable, and indeed sensible, to include in the specification a number of control or review points at which progress and costs can be assessed and alternative paths of development considered afresh.

1.4 Information analysis

This phase involves a thorough review of all aspects of the problem specified: existing data and methods of collecting and recording it, possible alternative methods, existing channels of communication both for staff and for data, relationships between problem areas which could be exploited, new techniques available with their benefits and costs, legal or commercial constraints (e.g. marketing agreements), forecasts of changes in products, customer base or raw material markets, trade union reactions and so forth.

In this stage of his work, particularly, the systems analyst may need considerable tact. Many people resist change, and are reluctant to abandon long-established methods which they understand well for new ones which force them to rethink and relearn their job. Some will be anxious to retain their present status, but unwilling to accept new responsibility, while others will be ambitious for new empires to build or conquer. Without being deliberately obstructive or untruthful, this can nevertheless result in their placing a gloss on their existing duties which fails to observe inefficiences or asserts constraints which need not exist. In such circumstances the analyst who expresses flat disbelief or disagreement will quickly arouse a barrier of dislike and distrust, and find his work seriously hampered by overt opposition rather than mere inertia.

It may be though that this is to imply that all employees are Luddites, and to paint altogether too uncharitable a portrait of human nature. This is not the intention. Most people are willing to be reasonable and to accept changes in their own job which will benefit their group or organisation as a whole – and ultimately, therefore, themselves – **provided** an attempt is made to place the changes in context and to discuss the necessity for them. The analyst must be both tactful and flexible in his discussions, alert to the personalities involved and imaginative in seeking the best approach to discover and enlist the knowledge which each employee can contribute. The cardinal rule to remember is that, however technologically advanced the system he is proposing, it will serve and be served by individuals who have experience, ideas, fears and aspirations, and who deserve consideration even if they are often inconvenient or irritating. After all, their co-operation or opposition can easily make or break the success of the system so carefully devised!

1.5 System design

System design is a process of synthesis which is complementary to the previous analytical phase. A number of constraints will have been identified, such as

- compatibility with company accounting and management style
- size and expertise of the data processing department
- level of sophistication intended for the system
- level of security and standby facilities necessary

and all of these must be reconciled with the project objectives within the overall budget available.

More constructively, a comprehensive dossier of information will have been assembled, covering the nature, volume, frequency, origin, purpose and distribution of all data obtained or obtainable by the organisation.

The object of system design is to organise and build on this knowledge so that clear guidelines are laid down for the implementation of a system which will satisfy the specification of the project. The guidelines should be sufficiently precise to prevent ambiguity, and estimates should be given of all important features – such as the implementation time, staff needs, running time of the completed system and, of course, costs – which are as realistic as possible. However, precise details – preparation of software, for example – will be postponed until after the system design has been submitted to, and approved by, senior management. Further substantial costs for staff and equipment, over and above those of the system consultancy, will be incurred as soon as detailed work begins, and this is neither justified nor possible until the proposals have been accepted.

1.5.1 Design judgements

With the increase in the capacity of modern computer storage devices, both for main and for auxiliary storage, and the decrease in their cost in real terms, there is a temptation to retain **all** the available data, with the idea that it is certain to be needed at some time for some application. This must be resisted. For one thing, it represents an abrogation of responsibility by the systems analyst, whose job specifically involves the recognition, selection and separation of information (which is relevant) from data (which is available but not necessarily relevant); secondly, although storage space may be becoming cheaper, it is not free and never will be. Any unnecessary data which is stored is also likely to involve extended directories and other access facilities, and to the basic cost of the space required must also be added that of more complicated software routines.

While all-embracing data collection must be avoided, it is also possible to take too narrow or short term a view of the nature, environment or objectives of a system. Companies expand their product ranges, government regulations are altered, management may ask for reports to be broken down by different areas – any such development will mean some changes in the existing information system. The aim of the original design should be to make this process as painless as possible and *transparent* (i.e. unobservable) for the great majority of the people using the system. To achieve this, attempts should be made to incorporate 'hooks' and 'slots' in the system where new data or routines can be inserted if necessary without major disruption in the design as a whole. The precise methods used must be dependent on particular circumstances, though the techniques recently known as *structured programming* encourage a modular mode of thought and design which it is helpful to adopt.

Nevertheless difficulties will remain in deciding just how much flexibility and room for future expansion can be justified against the inevitable pressure for economy and efficiency in current operations.

A similar dilemma can arise over output procedures and the treatment of exceptional cases. The directors of a company, or the manager of a bank, will neither need nor be able to scrutinise every customer's account and the way it is being used, but they will be very anxious to see and consider any account with debts which are long outstanding or which exceed agreed credit limits. In the case of credit it may be quite straightforward to define what is meant by an 'unsatisfactory account', and hence arrange that these accounts and no others shall be delivered for inspection.

More difficult to handle is the type of exception which is a function of the performance of the business in a wider context, for example the sales figures of a particular product which are notably out of line with the trend shown by the company's products as a whole, or with the corresponding figures in a previous period of time. The problem here is to decide just how far out of line the results must be, and over how long a period, before they become the subject of an *exception report* to management. If too few reports are sent then necessary action may be delayed and opportunities lost, yet if the volume of information is too great each item may receive only cursory attention instead of the careful consideration needed to locate and correct the fault.

Computers are adept at handling at high speed large volumes of data which involve repetitive and well defined operations, but the processing of rare cases with unusual circumstances may require a considerable increase in the complexity of the software and operation of the system. However, the mere detection of such cases will often involve no more than simple tests which impose no significant overhead on the system. The use of a computer based information system does not imply that every single problem should (or can) be automated, and it may well be preferable to recognise and extract occasional special cases. These can then be considered individually by staff who have been relieved of routine decisions by the existence of the system. Once again the analyst must use his judgement in deciding to what extent a sophisticated and automated system can be justified as compared with a more simplistic solution backed up by human intervention.

1.5.2 Optimal solutions

The need to assess possible solutions as discussed in the previous sections is perhaps unfamiliar to many students in computing who have, like the subject itself, come from a mathematical background. There they have been trained to look for a uniquely correct solution to any given problem. These students must recognise that such certainty rarely occurs in systems analysis, that benefits in one area will have repercussions in another and that every plan will have disadvantages (of cost, if no other!) which must be weighed against its advantages. The best that can be attempted is an optimal solution amongst several which satisfy or nearly satisfy the specification of the project.

Some of the conflicting interests which will occur are

- delay in implementation
- speed of operation
- simplicity of operation
- flexibility for orderly change when necessary
- uniformity of equipment and/or operation in the company
- extensibility for future plans
- reliability against breakdowns
- security for confidential data
- cost – in almost every aspect

Many of these will be considered in more detail in subsequent chapters. At this stage one can remark that there may be some conflicts which the consultant analyst has no power to resolve, for example, a specified speed of response in the