local AREA NETWORKS

ISSUES, PRODUCTS, AND DEVELOPMENTS

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A Wiley–Interscience Publication

JOHN WILEY & SONS
Chichester · New York · Brisbane · Toronto · Singapore

Library of Congress Cataloging in Publication Data:

Cheong, V. E. (Viv E.)
Local area networks.
(Wiley series in computing)
Bibliography: P.
Includes index.
1. Office practice—Automation. 2. Information networks. I. Hirschheim, R. A. (Rudy A.) II. Title. III. Series.
HF5547.5.C485 1983 651.8'4404 82-23778
ISBN 0 471 90134 2

British Library Cataloguing in Publication Data:

Cheong, V. E.
Local area networks—(Wiley series in computing)
1. Computers networks.
I. Title. II. Hirschheim, R.A.
001.64'404 TK5105.5
ISBN 0 471 90134 2

Printed by Whitefriars Press Ltd, Tonbridge, Kent

Preface

Local area networks (LANs) have aroused a good deal of interest in the last few years because of their potential role in the area of office automation. LANs provide the facility through which the various technologies of the automated office communicate with one another. Yet much of the enthusiasm for LANs comes from what they purport to do rather than what the available products actually do. And there is more than just a little confusion surrounding local area networks.

This text attempts to allay this confusion by synthesizing a number of the important concepts, issues, and approaches put forward by various LAN proponents. In doing so, it is hoped that the reader will become familiar with what local area networks are and what they do, as well as the potential contribution that they may make to the automated office.

The text is divided into two parts: the first somewhat more academic and tutorial in nature, the second more practical and implementation oriented. Part I, entitled 'Concepts, Capabilities, and Comparisons', lays the groundwork for discussing what LANs are, what they are capable of doing (and not doing), how they can be classified, and so on. Part I also presents a comparison of two major LANs: the Cambridge Ring and the Ethernet. Part II, entitled 'Products, Evaluation, and Developments', offers a description of the more common LAN products along with some criteria upon which to evaluate them. Organizational and implementation issues are also treated in this part.

To describe the text in more detail, Part I contains five chapters. The first chapter attempts to define LANs by drawing together those characteristics of LANs which are most generally cited by the various authors who have attempted to define them in the past. This chapter intends to inform the reader of some of the attributes of LANs which distinguish them from wide area networks (WANs). It is noteworthy, however, that due to the recency of the technology there is no internationally agreed definition of a LAN.

Chapter 2 discusses the causal factors which have led to the development of LANs. It highlights the degradation in relative cost/performance of WANs and the technological advances that have accompanied the developments and

maturing of the automated office concepts as well as the trend towards distributed processing. The close proximity of the majority of office communication channels means that LANs can employ simple topologies and control strategies which have been designed and developed to solve local problems.

Chapter 3 considers the capabilities that LANs offer, as well as what they ought to offer any prospective user. Technical requirements such as high data rates, low error rates, and protocol simplicity are among such LAN characteristics. Yet non-technical characteristics need attention as well; in fact, office environments might demand that non-technical aspects take precedence over the technical ones.

Chapter 4 concerns itself with the various classes of LANs. Drawing upon the taxonomies of a number of authors, this chapter puts forward a classification scheme by which to classify LANs based on topologies and control strategies.

Chapter 5 concentrates on a comparison of two major LANs: the Cambridge Ring and the Ethernet. Unfortunately, owing to the limited and often contradictory evidence available on issues such as performance, reliability, and the like, this chapter makes no definitive statement about the superiority of one approach over the other.

Part II also contains five chapters, but its subject matter may be considered to be more practically oriented in nature. Chapter 6 describes a number of LAN products. It must be borne in mind that the products chosen for inclusion in this chapter are those products for which there is relatively easy access to product descriptions and other relevant material at the present time. The LAN products chosen are felt to be representative of what is available on the market. It must be stressed, however, that the number of LANs being offered by different vendors is growing rapidly. Thus, what might be representative today may change in the future.

Chapter 7 introduces a number of other factors that may be relevant when attempting to evaluate LANs. These include such issues as: transmission media, maintenance, security, integrity, extensibility, and so on.

Chapter 8 looks at some future developments which might have a marked effect on LANs. These future developments seem important as they have the potential for dramatically altering what LANs do and the way they do it. Key topics covered in this chapter are high- level protocols and LAN standards. Other issues addressed in this chapter are: the development of the 'super-intelligent' terminal, LAN-LAN and LAN-WAN interconnection, and legal aspects of LANs.

Chapters 9 and 10 are very much more organizational in nature and attempt to look at the potential organizational implications of LANs. Chapter 9 suggests that the implications of LANs, when implemented in organizations, may very well rest on two key organizational factors: (1) the organizational perception of the purpose of a LAN, and (2) the management style of the organization. Chapter 10 addresses the thorny issue of LAN implementation. Given the significant changes in organizational modes of communication made

possible by LANs, implementation takes on great importance. This chapter proposes an implementation approach based on the ideals of socio-technical systems development and operationalized through participation.

In addition to the ten chapters, the book contains a glossary of terms and a number of appendices. The appendices provide detailed information on various specialized topics which are of a more limited interest to the general reader. This permits the main body of the text to concentrate on that subject matter of LANs which is of more general appeal, is less likely to change dramatically, and provides the core to understanding LANs.

Because of the tutorial nature of the text, individuals possessing a modest knowledge of computer technology and wanting to learn about LANs should find it within their range of comprehension. As such, the book should be of interest to advanced undergraduate and/or graduate students in computing or information systems, data processing professionals, individuals involved in planning and/or implementing office automation, and others who want to pick up an appreciation of local area networks.

We wish to acknowledge our many friends and colleagues who have helped us through their offering of suggestions, providing us with pertinent material on LANs, or by reviewing and commenting on portions of this text. We offer our thanks to Tony Cornford, Ian Galbraith, Frank Land, Chris Kennington, Ram Bannerjee, Bob Bird, and Ian Dallas. Particular thanks go to Sheik Yusuff whose painstaking efforts in the form of editorial assistance improved the readability of the text greatly.

Finally, we would like to thank Sue Coles and Leila Alberici for typing the original draft of this book.

London, England
August 1982

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PART III: Appendices

Introduction

Local area networks (LANs) have, with good reason, captured the imagination of many individuals over the past few years. With the growth of interest in the electronic office, local area networks are seen as the glue which would cement together the various information technology components of the automated office. LANs provide the facility through which microcomputers, word processors, workstations, and the like, communicate with one another and other office technologies such as data storage devices, facsimile devices, printers, intelligent copiers, computer output microfilm (COM), optical character readers, phototypesetters, voice and video handling devices, etc. This communication facility permits the implementation of electronic mail and the sharing of expensive resources.

Much of the interest in local area networks seems to have been sparked by the announcement made collectively by Digital, Intel, and Xerox (DIX) in May 1980 of a 'joint project to develop electrical, logical and protocol specifications for a local area communication network which the companies propose to use for many of their future products'. The basis of that announcement was, of course, Ethernet. Since then, numerous other LAN products have been announced: SILK—Hasler, WangNet—Wang, Data Ring—Toltec, Polynet—Logica, Xinet/Xibus—Xionics, Cambridge Ring—Acorn, TransRing 2000—SEEL, Planet—Racal Milgo, ODR-1—Syscon, Net/One—Ungermann-Bass, LocalNet—Sytek and NTL, BIS—Philips, and ARC—Datapoint. These systems all differ from one another in one or more dimensions. For example, some have a bus-based topology, while others are ring-based; most are baseband but a few are broadband; some use coaxial cable, others use twisted pairs; some are token passing systems, others use empty slots, while still others use contention transmission—normally CSMA-CD; SILK has a transmission speed in excess of 16 Mbps, while others have speeds of only 1–2 Mbps. The differences can be very great indeed, causing even more confusion than one might normally expect from a new technology.

But although local area networks can differ internally in a number of ways, they still share a number of common features. First, they are all restricted to a

relatively small geographic area—usually between several hundred metres and a few kilometres. LANs tend to be thought of in terms of one specific building or site. Secondly, LANs differ from wide area networks (WANs) or long haul networks in the size of bandwidths offered. LANs offer considerably greater bandwidths than WANs. (Bandwidths determine the data transmission rate of the communication facility and are based on the group of consecutive frequencies which constitute a band. A further treatment on the relationship between bandwidth and data rate can be found in Appendix D.) LANs use a technology which allows very high bandwidths to be implemented economically, thus permitting data rates in excess of 1 Mbps.[1] These high data rates are operationalized through a variety of media, viz., twisted pair cables, coaxial cables, and fibre optics. Thirdly, local area networks are designed to allow a large number of different devices to communicate with one another, and this would ultimately include products from a variety of manufacturers (this goal however is still some distance away). Additionally, with the peer-to-peer communication provided for by LANs, electronic mail is a much more economic proposition. Previously, electronic mail required the use of a host computer whereby messages had to be transmitted from the sender to a host computer, then from host to destination. This proved slow and costly. Lastly, LANs offer an impressively low bit error rate—1 in 10^{12} according to Cotton [11].

It must be noted that there are alternatives to the LAN approach for linking various devices together. For example, some office automation pundits are advocating the use of an intelligent switch which would handle all communication in an organization. It is, in essence, an enhanced private automatic branch exchange (PABX) and is based on extending the voice handling facilities on a telephone network to include data, text, and image communication. It is a centralized alternative to the distributed approach of the LAN. Unfortunately, since there is no such implemented product available, it is difficult to make meaningful comparisons between this approach and the LAN, except to state that such a system should not be susceptible to the failures that accompany 'traditional' centralized systems. Nevertheless, given the resources of AT&T and other telecommunications giants, this alternative may prove attractive. Additionally, the centralized nature of this approach may make it attractive to IBM, since it mirrors their philosophy towards data processing. And since IBM offers no LAN product at present, yet sells a PABX, this alternative may be the most natural. The one major question surrounding this approach is, will such a product be developed in a time frame which will make it competitive with LANs? The fear is that, by the time this product is available, there may be no market left; the market will have been saturated by LANs.

Another potential alternative is the micronetwork, e.g. Cluster/One, HiNet, Omninet, Z-Net, and Econet. They are smaller, slower, and more restrictive than a LAN, but could prove a cost-effective alternative if the desire is (ostensibly) only to link microcomputers and/or word processors together.

One of the other important issues yet to be resolved in the LAN field is that

of standards. There are a number of bodies looking at standards issues but it seems unlikely that any one particular standard will be adopted universally. The lead organization in this area appears to be the IEEE with its Project 802. Project 802, after much deliberation, is considering two alternative strategies: one based on channel contention (CSMA-CD), the other on some form of token passing scheme. Other standards discussions have been undertaken by the US Department of Defense, the National Bureau of Standards, and the American National Standards Institute, but they are less well developed and fruitful, at the present time, than Project 802. Xerox, in the meantime, has been selling Ethernet licences to just about anyone who wants one at a nominal charge in an attempt to have a large number of vendors supplying Ethernet-compatible components. Wang and others have argued against an Ethernet standard as they feel any baseband standard is too limited. They want a standard which permits broadband systems to be developed. IBM has also been anti-Ethernet in an attempt to stop Ethernet becoming the official standard. Unfortunately, IBM has—at the moment—offered no real alternative, although it is known that they have been experimenting with some form of token passing ring system. For the potential LAN user, the standards debate promises to be an interesting—if not frustrating—issue which will continue to attract a great deal of attention.

In summary, LANs will probably be one of the key elements in the future automated office. As LAN technology develops, so will people's enthusiasm for LANs. Yet, much of the enthusiasm for LANs comes from what they purport to do rather than what the available products actually do. There is still more than just a little confusion surrounding local area networks. For example, what exactly is a local area network, i.e. how can it be defined; how do the various local area network approaches differ; how can local area networks be classified; what do some LAN products look like? These and many other questions continue to remain unanswered in many people's minds as the technology appears to have advanced more rapidly than our educational system's ability to keep abreast of these advancements. We hope to correct this imbalance by offering this two-part tutorial book on local area networks. Part I of this book addresses the thorny issue of defining a local area network by drawing together those characteristics cited most frequently by the various authors who have tried defining LANs in the past. LAN capabilities such as high data rates, low error rates, protocol simplicity, interconnection, etc., will also be discussed. Part I concludes by first offering a LAN classification scheme based on LAN topology and control strategies, and then comparing the two major LANs: the Cambridge Ring and Ethernet.

Part II looks at a number of practical issues related to LANs. These include a description of a number of LAN products, some factors which could be used in the evaluation of LANs, some future developments which could have a marked effect on LANs such as standards development and high-level protocols, and finally some important considerations to be made when implementing LANs in organizations.

Chapter 1
Defining a LAN

There are many LAN definitions proffered by various authors, but none which is generally accepted. Dictionary definitions of 'local' and 'network' make no useful contribution towards clarification either. The vexing issue of a LAN definition will continue unabated unless the parameters of the subject can be more closely confined, an aspect that has not escaped the recognition of Freeman and Thurber [1]. These authors have identified many characteristics upon which LAN definitions have been founded. Such characteristics include speed, distance, transmission medium, switching technology, percentage of traffic not passing through a gateway, single organization proprietorship, single function usage, use of distributed processing, network configuration and/or the relationship to I/O channels. This chapter looks at a number of these characteristics and how they are used by the various authors attempting to define LANs.

Thurber and Freeman [2], who have spent a great deal of time assimilating various LAN definitions, recognize the great difficulty in developing one which would be universally accepted. They note that in the short history of local networks only 'one real attempt has been made to develop a definition of [local area networks]' and that attempt was theirs. Basically, Thurber and Freeman assert that, in order for a LAN to be defined as a class of network-like systems, three basic properties should be satisfied. They are:

(1) single organization proprietorship;
(2) distances involved are of the order of a few miles and in the general locality;
(3) the deployment of some type of switching technology.

Single organization proprietorship means that in general only one organization owns the network. Whether more than one organization can use the network is not apparent, although it does not appear to be precluded. Distances involved of the order of a few miles is meant to distinguish LANs from wide area networks which cover great distances. This appears necessary as LANs often use the same technology, i.e. packet switching, as WANs. The deployment of some type of switching technology refers to the fact that LANs

employ a technology which allows connection of the appropriate stations when messages are to be transmitted and received. (It is noteworthy that based on Thurber and Freeman's definition, PABXs are not necessarily differentiated from LANs.)

The above postulates are imprecise, but are not markedly dissimilar to a definition advanced by Tanenbaum [3]. Tanenbaum defines LANs in terms of 'single ownership by a single organisation, a diameter of not more than a few kilometres, and a total data rate exceeding 1 Mbps'. Here the commonalities with Thurber and Freeman lie in 'single ownership by a single organisation' and 'a diameter of not more than a few kilometres'.[2] The difference in Tanenbaum's definition is that of a total data rate exceeding 1 Mbps as contrasted to 'the deployment of some type of switching technology'.

Another definition of LANs is offered in the Seybold report [4]. Here LANs are defined somewhat loosely:

> A local area network is one that interconnects devices using non public signal conductors within an area of 5–10 miles, often considerably less.

The property of 'single organizational ownership' is conspicuous by its absence in the Seybold definition but the geographical locality has now been quantified as 5–10 miles as opposed to 'a few miles' [2] or 'a few kilometres' [3].

Farber and Larson [5] propose a definition of LANs which indicates the difficulty inherent in LAN definition. They define a LAN as 'typically a packet network, limited in geographical scope'. Note how this definition is very general and may not adequately distinguish LANs from other networks.

Thus far, the four LAN definitions examined have attempted to define LANs from a consideration of the properties possessed by LANs. An alternative approach would be a definition that considers the position that LANs occupy in relation to other arrangements of data communication hardware.

Metcalfe and Boggs regard LANs as filling a 'logical gap' in a gamut which has remote networking and multiprocessing at the extremes [6]:

> Near the middle of this spectrum is local area networking, the interconnection of computers, to gain the resource sharing of computer networking and the parallelism of multiprocessing.

Table 1 shows how Metcalfe and Boggs view LANs as filling this 'logical gap'.

Note that the bit rate offered by Metcalfe and Boggs, which ranges from 0.1 to 10 Mbps, differs from Tanenbaum's definition which states that the bit rate exceeds 1 Mbps [3].[3]

Metcalfe and Boggs' treatment of 'separation' (or distance) as an important aspect in discussing LANs is shared by Clark *et al.* [7] who regard LANs as occupying an intermediate position, as detailed in Table 2.

TABLE 1

Activity	*Separation (km)*	*Bit rate (Mbps)*
Remote networks	<10	<0.1
LANs	10–0.1	0.1–10
Multiprocessors	<0.1	>10

TABLE 2

Category	*Distance (km)*
Long haul networks	10^{-2}–10^{4}
LANs	10^{-2}–10^{1}
Computer system I/O buses	10^{-4}–10^{-1}

Clark *et al.* develop their definition of LANs by starting with Farber and Larson's [5] definition, 'typically a packet communication network, limited in geographical scope', and including three hardware elements (a transmission medium, a transmission control mechanism, and a network interface) plus a set of software protocols (implemented in the host computers or other network devices which control the transmission of information). In the opinion of Clark and his co-authors, it is this combined hardware-software approach to communication that distinguishes networks from other arrangements of data communication hardware, and is therefore necessary in the defining of LANs.

A number of authors have attempted to emphasize the communication aspect of LANs within the context of an organization; see for example Wilkes [8] who discusses LANs in terms of:

> ... a communication system for interconnecting computers within its own building, or its own site (which is what I take local area to signify)...

Similarly, the National Bureau of Standards [9] state:

> A major distinction between local and global networks is the higher degree of control that a single organization is likely to have over the design and operation of a local network.

These two definitions suggest that there is some explicit (and implicit) effort being made to acknowledge the need to consider user-oriented criteria as well as technologically oriented criteria when defining LANs. The recognition that organizations will probably play some part in the design and operation of a LAN is a major step forward. Yet, not everyone would agree that this recognition means very much. McQuillan, for example, maintains that the design of networks has proceeded in reverse, viz. networks are designed before the full acknowledgement of user requirements [10].