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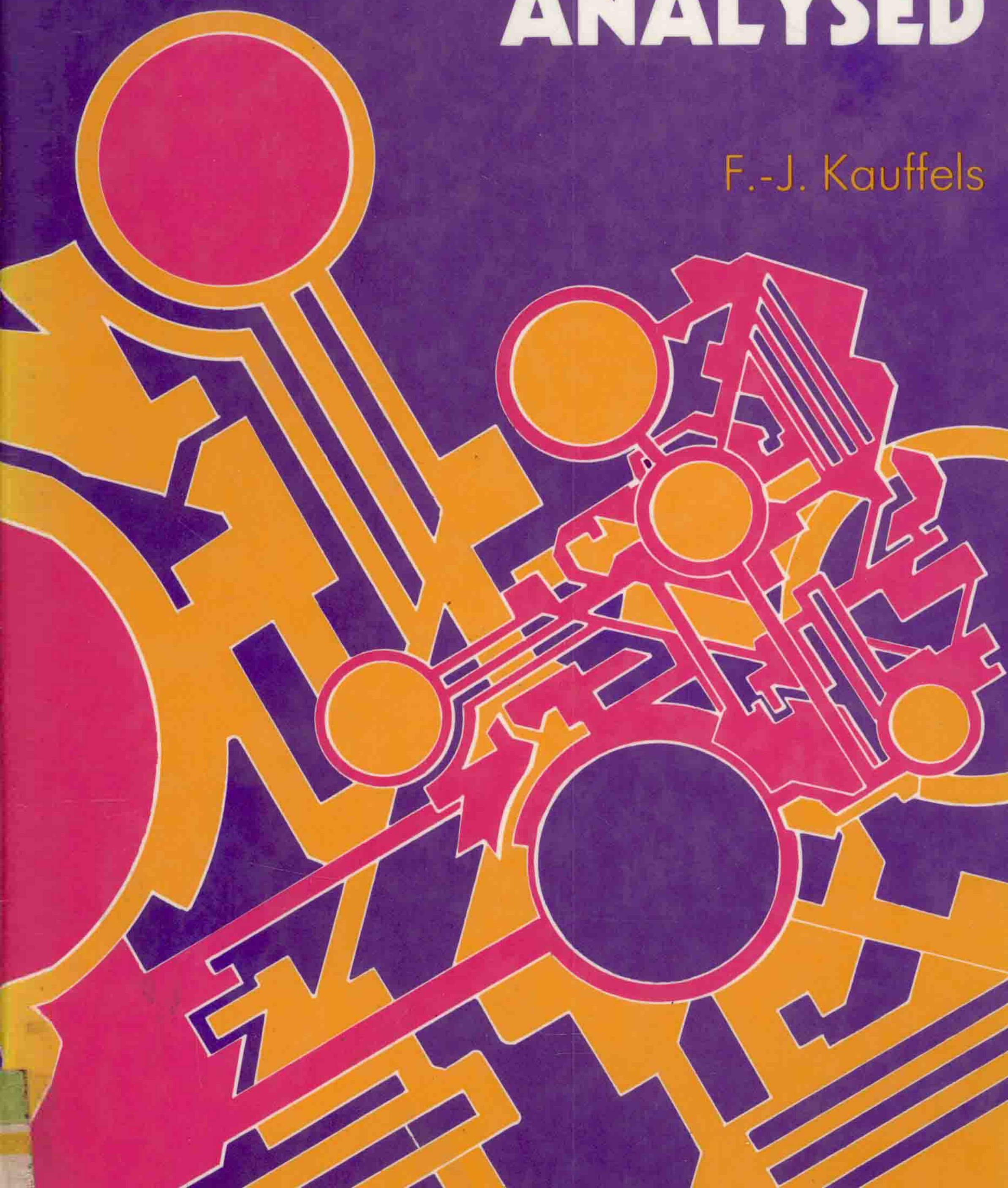
PRACTICAL LANs ANALYSED

F.-J. Kauffels



PRACTICAL LANS ANALYSED

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Preface to the first German edition

Local networks are a highly topical theme. There is hardly an area where uncertainty about technological concepts is so great as here. The reason for this is that problems arise here which are not completely within the scope of pure data processing knowledge. Much more, too, there information technology questions.

I have learnt from lectures, seminars and presentations both within and outside the university that these uncertainties can be cleared up very quickly by suitable didactic treatment.

The literature about the topic on the market is almost exclusively written in English. This in itself is not a hindrance, but the discussion is usually confined to the mathematical solution of performance problems. Of course that is useful and sensible, but of secondary importance for those who are more practically orientated; in this case it is only results which are of interest.

This book arose out of a series of lectures at the University of Bonn. It has, however, been reworked from the lectures such that it can be understood without any great amount of foreknowledge. The mathematical derivations essential to a theoretical treatment have been left out. The chapter on standards and a market overview were added. I hope to address the practitioner and potential user in this way.

To prevent misunderstanding in the discussion of the standards I have often had to follow the original text closely. Notwithstanding that, I hope that I have summarised the wealth of information in the documents in a suitable form.

The book cannot replace an extended seminar or course of lectures. Reference to the literature given in the bibliography is recommended for deeper study of the subject. I am grateful for suggestions as to the content and structure of the book.

At this point I would especially like to thank Professor P. P. Spies of the University of Bonn for the opportunity of studying this subject after completing my PhD and for general encouragement in my work.

I would further like to thank Professor O. Spaniol of the University of Frankfurt for introducing me to the area of computer networks whilst he was at Bonn and for the many useful suggestions which he has given me, and continues so to do. An important scientist in the field of data communica-

tions, he has published many works on performance evaluation, from which this book too profits.

I would also like to thank Dr R. Kröger, GMD St Augustin, for his critical contribution and the publishers for their cooperation in the production of the book.

Bonn/Euskirchen, January 1984 *Franz-Joachim Kauffels*

Preface to the second German edition

I was pleased when the publishers told me that I could revise the book as the first edition had sold out. This has given me the opportunity of changing the book in the light of the most recent developments and — hopefully — of improving it.

Large parts of the book are concerned with products and their implications. Much has happened here in the 21 months since the first manuscript was completed.

This has led me to try to cover these developments in a systematic rather than a symptomatic and selective manner.

Probably the most important and largest new part of the book is the discussion of DEC and IBM local networks and their place in the overall spectrum of products. A brief discussion of the SNA and DNA network architectures could not be avoided here. This discussion is by its nature insufficient and serves only as a sketch of the general area. Particularly as far as SNA is concerned, ten authors have twelve different points of view.

The tabular market overview of the first edition has been omitted in the name of being systematic. It also proved to be useless as it was already out of date when the book came out. This left room to introduce current topics such as MAP (Manufacturing Automation Protocol) as well as current products (such as IBM's token ring).

The large field of PC networks is dealt with in this book as only one of many. For those who are especially interested in this, I have written a book which does not overlap with this one. Applications of local networks are discussed in the book *LAN-Praxis*, also published by Rudolf Müller.

At this point I would like to thank the many participants in my public seminars for constructive suggestions for developing the book further.

I would also like to thank Dr Both of KONTRON for his written criticisms in the journal *Datacom* which have been very helpful.

I would like to thank the firms DEC, IBM and 3M Germany for providing informational material.

Finally I would like to thank the publisher, and in particular Mr Sandscheper and Mrs Jöde, for their cooperation.

Bonn/Euskirchen, November 1985 *Franz-Joachim Kauffels*

Preface to the third German edition and first English international edition

LANs are a rapidly changing field. Many developments have been made and most of them are taken account of in this latest edition. A new chapter on high speed local area networks has been added. For the English edition I would like to thank Ellis Horwood Limited and the translator, Mr Ian Johnson.

Bonn/Euskirchen, 1988 *Franz-Joachim Kauffels*

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Introduction

From about the middle of the 1970s research reports began to appear, first singly, then in greater numbers, dealing with something called 'Local Computer Networks'. This work fell into two spheres. One group of researchers was concerned with designing working experimental systems linking computers to other computers, computers to peripherals, and intelligent peripherals to other peripherals. A significant feature of the communication (sub)system was, and still is, its ability to operate as a stand-alone system. The basis of communication is not the extended computer bus but instead an independent system. The other group of researchers was working along more theoretical lines and laid down performance measures for local computer networks by reference to measures known from the analysis of computational systems. Appropriate models were applied to the analysis of existing systems, and the weaknesses which came to light have been systematically eradicated, giving rise to considerable improvements.

At this time Metcalfe and Boggs developed a taxonomy of general types of computer networks based on bit rates and distances between machines:

	Distance	Bit rate
Remote networks	>10 km	<0.1 Mbit/s
Local networks	0.1–10 km	0.1–10 Mbit/s
Multiprocessors	<0.1 km	>10 Mbit/s

This taxonomy, purely orientated towards computer links, proved to be a useful classification for some time. Its disadvantage is, however, that it encompasses too few actual characteristics.

Somewhat later Franta suggested a definition which goes some way towards overcoming this difficulty. He sees a local network as having three major components:

— a high-performance communications medium for data transmission within a limited area
— different network adapters which are connected to the medium to implement interfaces between the communication medium and the attached machines (LNA)
— computing system components which can themselves be connected to an adapter (RA); see Figure 1.2.1.

This view corresponds far more to what we understand today by a local network.

The separation of the components, however, goes against the general trend towards integration. By contrast, the adapters should be an integral part of the connected systems, one module amongst many.

This is the state of the technology today; in many widely distributed systems a card can simply be plugged in to effect the connection to a local network.

Whilst until now priority has been given to the connections between computers and peripherals, in the last few years there has been a change of attitude towards local networks.

As there is a constant shift in the profiles of user demand among both current and potential users, we have today a situation in which large computers cannot provide optimal working in such areas as access to distributed databanks and often lack the flexibility demanded by users because, among other things, it is a relatively expensive procedure to implement new program packages in the data processing centre.

This situation gives rise to two aspects of progressive development: new, highly efficient small computers are constantly coming onto the market which, when used as desktop computers for particular tasks, are considerably more cost-effective and flexible than access to timesharing on large computers; and economical high performance communications media for short and medium distance use are available.

Constructive and cooperative exploitation of these two aspects leads to a concept of local networks which can be neatly characterised by the following ECMA definition:

> 'Local networks are data communications systems which enable a number of independent pieces of equipment to collaborate by intercommunication at high rates of data transmission over a relatively limited geographical area.'

Today this definition can be seen as correct as it moves away from less important technical details dependent on development and concentrates instead on global functional specifications.

The definition may perhaps be obsolete in a few years. The author does not, however, think so, for after a relatively stormy development phase local networks are now undergoing an establishment phase in which the broad applications of systems are coming to be more important. This establishment phase will be less stormy, if less spectacular, as local networks become more attractive to a wide circle of users on account of the ever more apparent advantages of their price/performance ratio. They are then in a position to act as a basis for integrated information systems, a substantial part of the office of the future. The wheat will be separated from the chaff and performance categories will appear, allowing a fuller conceptual adaptation to profiles of user demand.

As part of the Introduction we want to discuss the aims and applications of local networks in their traditional and current context, including a short outline of their early development phase. Finally we will look at architectural features of local networks.

1.1 AIMS OF LOCAL NETWORKS

The classical aims of computer networks in general were summarised by Händler. We will present them first and then consider them in relation to local networks.

A computer network is the connection of independent computers for the purpose of exchanging data. The network should encompass one or more of the following areas of activity:

Data sharing: Access to spatially separated data items;
Load sharing: Relief of currently overloaded computers by transfer of tasks to other, currently lightly-loaded computers;
Function sharing: Expansion of the functions of participating computers by the use of functions belonging to other computers on the network;
Performance sharing: Connection of several computers for the processing of complex problems as an expansion of the multiprocessor principle;
Availability sharing: Increase in the reliability of the computer system. Even if one or more components fails, a minimum capability will still be available.

A computer network usually consists of processing computers, to which the users (also called hosts) have access, intermediate computers (IMP or Interface Message Processors), which steer data transfer and also carry out internal network management functions, and the connections themselves. The IMPs, all the lines between IMPs, and the connection of the IMPs to a host or a system management terminal together represent the communications subsystem.

This representation has also been carried over to local networks. The communications subsystem is the communications medium together with both the interfaces, which replace the IMPs and sometimes have a name such as 'medium access unit', and the connections between the interfaces and the connected units, which do not themselves need to be actual computers but must have sufficient intelligence for the communication process. In some cases these can be relegated to a simple server command processor.

Now we want to consider these classical aims in relation to local networks.

Even without referring to the taxonomy presented at the beginning, it is clear that local networks fill the gap between multiprocessor systems and the 'Remote Networks' having a greater geographical extent. The problems that the latter suffer from — the transfer of large files, for example — do not apply to local networks, due mainly to the high performance communications medium. Moreover local network connections are usually simple and homogeneous in structure. There are therefore hardly any of the problems of routing or matching capacity with volume of flow that occur with remote networks, and data transfer can be implemented under rather more favourable conditions with local networks.

Data sharing methods can be varied by, for example, the introduction of a special computer for access to distributed databanks on the network, so that everyone can access the data. Furthermore there may be a sharing of functions because some or all of the network stations may gain access to additional functions. The list of examples of function sharing can easily be extended. A manager may have a desktop workstation with a planning program (such as Visicalc), and he can receive the raw data that he needs from other departments via the organisation's network. The data coming from these other local network stations can then be processed with a text editor and be sent somewhere else on the network by electronic mail; and an expensive laser printer would be available to the whole organisation over the network.

The other three aims must be viewed from a different point constituted by the structure and the conception of the network itself. The availability of a minimum capability cannot be independent of the availability of the whole network, which is itself made up of the availability of the user stations, the interfaces and the communications medium. As we will see in later chapters, in these aspects in particular there are dependencies which vary from system to system.

Equally, a peak time for individual user stations can also be a peak time for the network transfer devices, especially if, as is usually the case, the volume of traffic is proportional to the intensity of use of the data and load sharing facilities and this intensity itself is disproportionately high at peak times.

Finally the efficiency with which a task is performed is dependent not only on the adaptability of the relevant algorithm to distributed processing, but also on the lack of delay in communication between active components of the system, something we are familiar with from multiprocessors but which can so easily make itself felt.

A further problem is static and dynamic bottlenecks, if we can call them that. These may occur in all three components, the transfer medium, the adapters and the user stations.

Static bottlenecks can usually be identified easily and can be overcome by an increase in expenditure or by improving the adaptability of the components, unless they are built into the conceptual structure of the system. For this reason it is always worth testing the conceptual structure for such potential bottlenecks.

Dynamic bottlenecks only occur in particular situations. They must be detected or eradicated early on by appropriate adaptive measures distributed throughout the software of the whole system. The same is true of error handling. This matter will be dealt with in the relevant parts of the book, in Chapters 4 and 5.

Lastly the viewpoint developed until now makes the following demands of the conception of the local network:

— high bandwidth in the transfer medium for speedy access to the network and fast information transfer
— suitable topology to achieve the aims set out, including low risk of failure and a high degree of modularity
— suitable network protocols (the agreed communications procedures)
— suitable functional and procedural help for the user to exploit the potential offered by the transfer devices and protocols
— open system architecture in terms of the ISO model to ensure modularity, expandability, flexibility and acceptance.

A truly effective local network only comes about through planned selection and combination of the components.

A further important point arising out of the development of LANs is the use of the local network as an integrated information system: this means not only the connection of computers, but also the integration of all tasks which can use digitally represented information. We will turn to this in Section 1.3.

Before that, however, we will take a look at the short but eventful history of the development of local networks.

1.2 OVERVIEW OF DEVELOPMENT

Local networks have not yet developed what we might call a tradition. As this is true of almost all branches of modern data processing, we will not think of it as a particular deficiency.

However, their development can be traced easily. Particularly interesting is the change in the interest groups: in some places a lot of effort went into finding military and technical solutions. The expected low production volumes meant that cost and efficiency considerations were of secondary importance. Only in certain places was work carried out with an eye to office automation, the giant market of the late 1980s and 1990s, now obviously the most important area.

Even at the beginning of the 1970s the University of Hawaii had a radio-link based network, the ALOHA network, connecting terminals installed in the various University institutions. This is an example of a network with a common transmission medium, where all users have the same access rights to the medium and all can listen in to transmissions on the medium. An early version of the protocols consisted of everyone who had something to send simply putting his data onto the medium and hoping that no other transmissions would take place while his data were being sent, as both transmissions would be interrupted (only one channel with one transmission frequency being available). The transmissions were received by everyone and only used by those interested. The further development of this elementary ALOHA protocol into access management by detecting a busy signal on the carrier — Carrier Sense Multiple Access, or CSMA — which prevents a station sending information if another is already active, is the father of bus transmission protocols, whilst radio networks have developed in the field of satellite transmission.

Beside the bus, the other important topology for local networks is the ring. In 1974 a local network was installed in the University of Cambridge in the form of a ring, the Cambridge ring. This ring comprises a number of so-called ring interfaces connected to each other via cables. Two — or more according to size — data containers circulate serially in this passive loop, at that time at a rate of 10 Mbits/s. Each of these containers has a status indicator showing whether it is full or empty. A container can carry a data packet. When a station wants to send information, it informs the ring interface, which puts the data, along with sending and receiving addresses, into the next free data container. The information then comes to the receiving station, whose ring interface can identify the receiving station as the destination for the information on the basis of the address.

There are a great number of ring and bus systems whose primary interest lies in their communications protocols.

Despite their short period of development, local networks can be clearly divided into four generations:

1st generation: The aim was to improve computer to computer and computer to peripheral connections by means of a high performance communication medium. Previous connection via modems or serial interfaces did not give the required performance.

2nd generation: Similar to the first generation, but with the ability to switch users in and out of the system at will. Communication became more flexible, and the addition of further system components was relatively simple. The 2nd generation can be seen as a relatively mature representative of the concept of a local network.

3rd generation: The use of gateways arose as a further possibility for connection to public or other non-local networks as well as remote local networks. This important feature made the geographical distribution of data and users unimportant. This third generation can be depicted as today's *status quo*. Only digital information, data and text are transmitted.

4th generation: The capabilities of the 3rd generation are expanded such that speech and pictures can be transferred in digital form, representing a challenge to real-time processing and band width. The 4th generation is the basis of a truly high performance integrated multiple service information system. A further property of the 4th generation is the possibility of complete integration of all public and internal services through suitable adaptation modules. Figure 1.3.4 shows an idealised form of such a system.

With the 3rd generation systems and rising public interest as a result of office automation, the degree of component integration is increasing and costs are falling. The adapter for connection to the network has shrunk from a stand-alone device to a card. As the 4th generation develops and the numbers of popular systems rise, the reduction of the adapter from a card to an LSI/VLSI chip is to be expected. The costs should then represent less than 1% of the original costs. That would lead to a situation in which a local network for almost all computers would be as natural an I/O and communi-