New Advances in Distributed Computer Systems

edited by

KENNETH G. BEAUCHAMP

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FOREWORD

This volume contains the papers presented at the NATO Advanced Study Institute of New Advances in Distributed Computer Systems held between 15th and 26th June, 1981 at the Château de Bonas, France.

The aim of the meeting was to promote an interchange of ideas between experts in the interlinked fields of communications and computers in order to determine the essential areas for future development. Its programme was arranged to explore a number of current topics including the public data-communication networks set up by the PTTs or corresponding bodies in various countries, large-scale non-public systems such as ARPANET and its latest developments, international systems such as the airlines' SITA network, the recent and very important developments in local area networks and relevant developments by universities and other higher educational bodies. The recent moves towards formalisation and the laying down of a theoretical basis to guide future developments and standards were discussed with particular reference to the International Standards Organisation "7-layer model for Open System Interconnection" and the development of formal mathematical methods for specifying and analysing communication systems and their protocols. Consideration was also given to the theoretical techniques, and their practical realisation, now becoming available to ensure privacy and security of information transmitted over digital communication systems. Finally the penetration of the concepts of distributed processing into the domain of computer architecture, giving such possibilities as array processors and other non-von Neumann architectures formed the subject of several of the sessions.

K. G. Beauchamp (ed.), New Advances in Distributed Computer Systems, ix–x.

The scope and depth of the papers presented in this volume are an indication of the success of the Institute in meeting this aim and it is hoped that they will provide a valuable contribution to the literature in distributed computer systems.

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The Editor would like to acknowledge this support together with the help of his co-director Dr. Howlett, Professor and Madam Simon of ASCEB and many others who assisted in the organisation of the meeting.

Finally, thanks are due to the authors of the many papers who have provided this extremely valuable compilation.

Lancaster, August 1981. K.G. Beauchamp

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INTRODUCTORY SURVEY

Jack Howlett

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1. Three years ago, at the end of August 1978, Dr Beauchamp and I were co-Directors of a NATO Advanced Study Institute, also here at Bonas, with the title of "Interlinking of Computer Networks". Quite a number of those who took part in that meeting are here to-day and we have the pleasant feeling of meeting old friends again. The proceedings of that meeting form Volume C-32 in the NATO ASI series, and there are copies in the library here; the library, incidentally, has complete runs of the Series B (Physics) and Series C (Mathematical and Physical Sciences) Proceedings, and a selection from the more biologically-oriented Series A.

The program of the 1978 meeting covered a good deal more than the title would suggest and included accounts of the then status of some of the world's major information projects such as ARPANET, TRANSPAC and the Canadian INFOSWITCH and DATAPAC. This meeting is a successor to that; a very great deal has happened in the intervening three years and we chose the new title because of the great broadening of the field. We regret the use of the words "computer" and "computing" in these titles because they still seem to carry with them the ideas of arithmetic and scientific computing, whereas we are concerned with the much more fundamental and all-pervading concept of general information processing. But the words seem to be here to stay.

2. The phrase "convergence of computing and communications" has become a cliché but it expresses a real truth and a process of the greatest importance; and underlies the whole of this ASI. The papers and discussions in the programme fall into three broad classes:

K. G. Beauchamp (ed.), New Advances in Distributed Computer Systems, 1–8.

A. Concerned primarily with communications and dealing with networks of various types and purposes which have already been established or are being developed: their organisation, the standards to which they adhere and the services which they provide.

B. Concerned with systems combining communications and computing equipment and dealing with the interlinking of physically distributed information stores (for example, databases) and processing resources (for example, mini- or micro-computers).

C. Concerned primarily with computers and dealing with the departures from the classical von Neumann architecture made possible by recent technological advances, for example the achievement of truly parallel processing. The concept of "distributed processing" is relevant here because the practical realisation of these new architectures involves the distribution of processing power, possibly in very small units, throughout the whole system.

We do not have papers on hardware or physical technologies as such, for example on micro-electronics, LSI/VISI, optical fibre transmission or communication satellites. But considerations of these enter into many of the papers and we must never forget that developments in these fields have made all the other advances possible, practically and economically, and are still going on at breathtaking rates. My own feeling is that we are in almost a different world from that of the 1978 meeting, even though that was only three years ago.

This short introductory survey is intended as a setting of the scene for the ASI; what I shall now do is to take this broad division of the field and give what seem to me to be the important developments in the three classes: a personal view.

3. Advances in Communications

3.1 The need for public switched data-transmission networks is now completely accepted and in most advanced countries the PIT's or the equivalent bodies either have already implemented systems or are in the process of doing so; most of these use packet switching. In France, for example, TRANSPAC has proved a great success and is being expanded; in Britain the Post Office (now British Telecom), using the experience gained with the Experimental Packet Switched Service (EPSS), has developed and is now bringing into service its Packet Switched Service (PSS).

3.2 There is universal agreement also that the achievement of Open System Interconnection (OSI) is the goal to be striven for; the ultimate, corresponding to the international telephone service now available, is that the user of any piece of data-handling equipment in any part of the world shall be able, given permission, to communicate with any other by means of simple and standard procedures. Along with this has gone the agreement first that this is a long-term objective and second that if it is to be achieved in anything approaching an orderly and economical manner there must be agreement on a framework within which communications systems are designed - usually expressed as an "architectural" basis for design.

Important progress has been made in the formulation and understanding of the principle of a "layered architecture" for communications systems. In this the protocol for communication between two terminals, such as a user entering data at a simple terminal and having it processed by a program running on a distant computer, is sub-divided into a set of "layers", stacked on top of one another. Each layer of protocol is concerned with a precisely-defined part of the total process of the communication and with that only, and any coupling is only between protocols in adjacent layers. The International Standards Organisation (ISO) has proposed a division into seven specific functions which has become known as the ISO 7-layer Model. Intensive and searching discussion is going on over the details of this model, but what I feel is of very great importance is that there is a great measure of acceptance of the model as a whole as a universal standard, and that good progress is being made on agreement on details.

3.3 The importance of standards in data communication has been realised for a long time and a great deal of work has gone into identifying the areas in which standards should be applied and what these standards should be. The CCITT has made important recommendations for standards in public packet-switched digital data networks (the X-series of recommendations) and the past three years have seen acceptance of two in particular which are of very great importance:

X 25 specifying the interface between the terminal (DTE) and the network (DCE); this is already widely implemented in actual equipment on the market

X 75 specifying the interface between two public packet-switched networks

In every technical field, standards help everyone; they make life easier for the users and widen the market for the suppliers. The great danger in a new field, especially one so complex and so fast-developing as information processing and communication, is of attempting to enforce standards too early, before the real issues have become properly understood. It does seem that we have built up enough understanding in this field now to be able to formulate standards with confidence and to be reasonably certain that they will not put its development into a strait-jacket.

3.4 Ultimately we depend on manufacturers to supply the equipment we need and there is no point in specifying formal models and standards unless manufacturers are able and willing to embody these in their products. A most encouraging feature of the past few years has been the announcement by all the main manufacturers of intentions to do just this. All manufacturers are already, or soon will be, offering X-25 interface with their data terminals and there have been a number of proprietary architectures, including Honeywell's DSA and ICL's IPA, based on the ISO 7-layer model. We shall be hearing during the ASI of the relation of IBM's SNA to this.

A very effective way of getting a standard accepted is for a powerful purchasing body - the U.S.A. Department of Defense, for example - to include it in its relevant contractual conditions. I understand that the EEC is taking a strong interest in standards in the information processing field and is considering bringing them, at appropriate moments, into its contract terms.

3.5 The idea of the Integrated Services Data Network (ISDN) is gaining ground, meaning the provision of a variety of non-voice services over a public telecommunication system. Elaborate services over private networks using lines leased from public carriers have of course been in operation for some time, perhaps the best known being the very extensive SWIFT - Society for Worldwide Inter-bank Financial Telecommunications - network. Of the new public services, Viewdata in its various forms such as Prestel in Britain is now well established; others which are being developed include computing and data-processing services using equipment linked to the network and operated by the communications authority, and electronic mail.

3.6 On a very different line, but most important in my view, is the recent questioning of the role, powers and privileges of the national communications authorities such as the Post

Office in Britain and the PTTs in continental Europe. These have been either actually or effectively Government Departments and have held powerful monopolies over the whole field of their operations, including important areas of equipment supply; and have enjoyed strong legal protection. Things are different in North America but even there, where the providers of telecommunication services are competing private companies, strong constraints are imposed by the governments. Whatever view one takes of the desirability or otherwise of the monopolies held up to now by the PO and the PTTs, it is reasonable to question this in the circumstances of to-day, when technology has made such immense changes and advances and when the demands for information transmission and processing are orders of magnitude greater than they were in the early days of the public telephone systems. In Britain, the Post Office has already been split into two parts, British Telecom dealing with telecommunications and the rest with ordinary mail and the many other services such as banking which the Post Office has supplied; and legislation is being drafted which will almost certainly remove some of the monopolistic powers. These questions are very serious indeed, because it has become clear that a modern state is highly dependent on its public telecommunications services. It is therefore most important that they are studied seriously and as objectively as possible and decisions made not just on ideological grounds.

4. Advances in the Communications - Computers Combination.

4.1 The integration of data-processing and other non-voice service into public telecommunications systems is an example, and has been dealt with in para. 3.5 above.

4.2 A striking development of the last few years is that of the local Area Network (LAN). It is now a thoroughly practical and economic possibility to provide a very fast (10 Mbit/sec and more) digital transmission system for something on the scale of a laboratory or office building and to use this to link small, fast, sophisticated and cheap "personal" computers, storage units, visual display units, printers and other digitally-driven equipment. Two names for systems of this type, the Cambridge Ring and the Ethernet, representing respectively ring and straight line topology, have become well known and are discussed at this ASI. In Britain the Science & Engineering Research Council is supplying packaged ring systems to a number of universities and will take much interest in the experience of the users. The falling cost of hardware and the potentialities for greatly simplifying the software are certain to have important effects on suppliers and users, and therefore on the general computing market.

Questions of standards will have to be considered here, to allow for the need, which will certainly arise, for independent LANs to communicate with one another through public networks, and to access services provided on public networks themselves.

4.3 In Britain again the Science Research Council (now Science & Engineering Research Council and one of the 5 Research Councils financed by the government and charged with the responsibility for supporting and stimulating research in broadly-specified fields) initiated a Distributed Computing Systems Programme in 1977. To quote from an SRC document, "The primary objectives are to seek an understanding of the principles of Distributed Computing Systems and to establish the engineering techniques necessary to implement such systems effectively. In particular, this requires an understanding of the implications of parallelism in information processing systems and storage, and devising means for taking advantage of this capability". The programme has been most successful and at present has stimulated and is supporting nearly 50 separate research projects in British universities. Many of these relate to multi-microprocessor projects in which the processing and communications elements are intimately linked.

4.4 A sound theoretical basis is necessary in any technical activity, to enable equipment to be designed to meet specified requirements and to make meaningful analyses of observed performance. The mathematical-statistical treatment of telephone traffic has been developed over the years to a high level of sophistication and the techniques can be taken over to study many problems in digital communication systems. But the formal specification and analysis of protocols and interface conditions, and of parallel distributed systems, require a different type of mathematics and advances in this direction have only recently been made. The SEBC Distributed Computing Systems programme, already referred to, has stimulated much research in this field in the U.K.

4.5 There is now a sharp awareness in all countries that the very large amount of information held in computer-based systems and available for transmission over telecommunication networks is often valuable or sensitive or both and that there should be strong safeguards against unauthorised access. Some very powerful cryptographic processes have been developed during the past few years, aimed at protecting the privacy and security of digitally-stored and transmitted information, about which we shall hear during this ASI.

5. Advances in Computer Architecture

5.1 Modern technology has made possible the production of physically small, fast, simple and cheap processors in very large numbers and of fast, compact and cheap stores in units of from 4K to 64K bits, also in very large numbers. This has made it realistic to consider radical departures from the classical von Neumann architecture of a computer in which there is a clear and physical distinction between the processor and the store. One can now envisage a computer in which there are possibly very many processing and storage units with almost any form of interlinking. The key problem would be how to control such an assembly so as actually to bring its potentially great processing power to bear on any particular problem.

5.2 It is accepted that ultimately the achievement of very high processing power must involve parallelism in some form. The simplest rea isation of this is the Single Instr ction, Multiple Datastream (SIMD) architecture, in which at each beat the same instruction is fed to every one of the processors forming the system and each operates with this on its own item(s) of data. The pioneering machine of this type is the ILLIAC-4, designed and built in the University at Urbana in the late 1960's and installed in the Ames Air Force Base in California. This was built before integrated circuitry was in production and therefore was constrained by the discrete-component technology of its time. It has 64 processors, each quite a powerful machine in itself, and presented considerable problems of control and data routing. The machine with which I am most familiar is the ICL Distributed Array Processor (DAP) which, taking advantage of the possibilities of modern technology, has 4096 processors - which can be regarded as an array of 64 x 64 - each very simple, each with its own store of 4K bits and each connected to its four nearest neighbours. Several have been built and experience now gained shows that such an architecture gives a very powerful and flexible machine, well within the scope of to-day's technology.

Other architectures which are now being studied include the "data-flow" form; here again there are many simple processing elements but they have more autonomy than in the SIMD form and communication between them is more variable. The SERC Distributed Computing Systems programme is supporting studies in this field.

I find it most significant that a recent Japanese official report, the "Interim Report on Research and Development on 5th Generation Computers", which gives a full and exceedingly

interesting discussion of the design criteria for new advanced computers, emphasises the need to move away from the classical von Neumann architecture.

5.3 The introduction of the electronic computer has had a profound effect on the techniques of numerical computation, quite apart from making it almost trivial to do calculations which are far beyond the powers of hand computation. It has led to the development of quite new methods and algorithms - and, to be fair, to the revival of some methods such as the Runge-Kutta and its variants for the integration of ordinary differential equations, which had been known for a long time but were ill-suited to hand computation. It has led also to much deeper studies in numerical analysis, such as convergence and stability of numerical processes and propagation of truncation and round-off errors in an extended calculation. It has already become clear that with a new tool such as an array processor it is profitable to look afresh at numerical problems and not simply to take over algorithms developed and refined for serial processors This can be intrinsically interesting from a purely mathematical point of view and it is my personal belief that these new developments in computer architecture will lead to new and interesting developments in numerical analysis.

DATA COMMUNICATION IN ISRAEL -- PRESENT AND FUTURE

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ABSTRACT

Data Communication, which is the field that combines all the means of forwarding all kinds of data, will be, in the near future, one of the most important fields in the world and Israel.

This paper describes the situation in the Data Communication field in Israel, up to 1981, and the possible developments up to year 2000.

THE IMPACT OF DATA COMMUNICATION AND SCOPE

Data Communication is the link between the technologies of computing and man. Using Data Communication means that distance does not have any more influence on the capabilities and performances of man. The world has become a small place, where information passes immediately from one to another, and there are almost no borders to information.

Data Communication will be the channel through which Information Technology will affect virtually every household and occupation. It will change patterns of employment, create new jobs and new business possibilities.

The scope of this paper deals with all kinds of Data Communications which include:

* Terminal-Terminal
* Terminal-Computer

K. G. Beauchamp (ed.), New Advances in Distributed Computer Systems, 9–24.