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Computer Networks and Simulation II

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INTRODUCTION

This is a second volume on computer networks, a discipline becoming increasingly more complex on the one hand and more visible in our daily life on the other. This is also a book on simulation, that remarkable melting pot of science, art and magic.

COMPUTER NETWORKS

Since the first edition of 'Computer Networks and Simulation' in 1978, a number of problems have been tackled in computer networking and solved. One can say that with the proliferation of computer networks, from Local Area Networks in an office automation environment to Long Haul Networks, a larger number of problems are raised. One can classify these problems into three different areas; problems related to standards, problems related to specific communication protocols and problems related to different communication architectures in general.

Standards

The Open Systems Interconnection Reference Model, originated by the International Standards Organization is a draft standard which is followed and committed to by a large number of organizations, including vendors. However, there are more standards in the open systems area than only the ISO Reference Model. IEEE, NBS, ANSI, ECMA, CCITT and DoD are active as well. De facto standards are also set by the various vendors and suppliers of network services; private organizations as well as government regulated agencies such as the PTT's in Europe.

This leads to a number of questions for the developers of network capabilities:

- Is a new product or service following the acknowledged or de facto standards?
- If not, is the new product or the new service an innovation in relation to the standards? Can it be incorporated in the standard trend later on or is there a risk the standards will evolve in another direction thereby making the product obsolete?

and questions for the suppliers of network capabilities:

- Does the newly offered capability fit into the existing network standards?
- If not, can it be made to fit into the standards? Or is it an innovation not yet subject to standards? What effect will it have on the future of networking in relation to the standards?
- Is the new customer conforming to the network standards on all conceivable levels? How can a customer interface be checked against a standard in iso-

lation in order to not disturb the network as the customer is integrated into a network?

and questions for the standards organizations:

- Is the standard well enough defined?
- Is there enough incorporated in the standard to lead to a unique interpretation and to still leave some freedom to the implementation?

D. Cronin, The communications environment generator
G. Le Moli, A 'reference model' for the formal description of entities which perform protocols
A. Faro, Formal description techniques of protocols and services in view of the theory of colloquy

Protocols

Nearly all communication models build upon a layered structure of communicating peer entities. Between the peer entities protocols are defined reflecting the functionality of the communication layers. In any layer, functions (and support functions) are incorporated which are mutually dependent but which together appear as a unity. In actual implementations within the functional layers, groups of functions tend to differentiate into subgroups or classes within layers.

- Is there a formal description available which can be validated to serve as a communication standard?
- What means are available for protocol validation?

C. Sunshine, Formal modeling of communication protocols
R. Razouk, G. Estrin, Modeling and evaluation of communication protocols
B. Wolfinger, O. Drobnik, Simulation of protocol layers of communication in computer networks

Architectures

Although the ISO reference model is a widely followed standard, a number of other standards exist, especially those focusing on the Local Area Networks in office automation environments. De facto standards are being discussed and changing. Over 100 companies are reported looking for a license agreement on ETHERNET. ETHERNET is emerging as a de facto standard, but alternatives are still competitive. ETHERNET was based upon a two layer design as against ISO's seven layer design. Nevertheless an ISO compatible four layer ETHERNET draft has been announced. Possible connections of networks are under discussion as well. Linkage via 'gateways' or hierarchical structures are possible.

What is Local Area Networks in an adequate architecture: a system based on CSMA-CD, an active ring with some kind of token system, a mixture or something else?

What are the emerging standards and their compatibility with ISO? In some application areas, the ISO reference model is reported to cause difficulties.

W. Price, Simulation of a hierarchically connected computer network
A. Remes, Simulation techniques in network design
J. Haenle, A. Giessler, Simulation of packet switched datacommunication networks
T. Røgeberg, TETRASIM, a program system for the simulation of telephone networks

SIMULATION

In the area of computer simulation, a lot of things are happening. Although definite standards are not yet set, discussions on the validity of computer simulation are still alive. It can be said that computer simulation has a reason to exist. In the future development of simulation methodologies, the proliferation of computer networks will play a significant role.

- Will totally distributed simulation (and gaming) supported by a distributed communication infrastructure be feasible? If so, what applications can be envisaged?
- What standards can be set and what directions will simulation methodologies and applications take?

S. Schoemaker, A review of simulation
H. Lipinski, R. Adler, Electronic communication for interactive group modeling
T. Utsumi, J. DeVita, The GLOSAS project

COMPUTER NETWORKS AND SIMULATION

The idea that computer networks and simulation might benefit from each other can be found in various places. Reasons for using software in the solution of network puzzles are the complexity of the design process, the intricacy of the requested user interface, the verification and validation of the network, rules of the thumb and past experiences unable to cope with complex requirements. Planners and designers tend to overdesign a network.

- In what way can simulation be applied to the establishment and maintenance of a communication infrastructure?
- What form can the simulation tool take?

A number of commercially available packages currently exist. The Teletraffic Optimizer Program and ANDMS of the DMW group, the Network Optimizer/2 of the TELCO Research Corporation, MIND and GRINDER of the Network

Analysis Corporation, and PLANET of Kranzley and Company are examples. Most suppliers of datacommunication equipment provide an analysis and simulation tool with their software.

Not all of the above questions can be answered. However, they are being examined and answers are emerging.

The book is divided into three parts. The first part, FOUNDATIONS, starts with an introduction on CCITT and its view on the use of computers for network planning and circuit group dimensioning. A reference model for the formal description of protocols is given and a survey of description techniques of protocols and services, both in the perspective of the theory of colloquy. A state-of-the-art survey of protocol specification and verification concludes the first part. The second part, SIMULATION IN NETWORKING, starts with a review of simulation in general and an introduction to network simulation. The simulation of different variants of transport systems in packet networks is addressed. The next paper discusses the possibilities of simulation in the tuning of protocols in a complex hierarchy and presents the modeling system MOSAIC. The computer-aided-design system for modeling and evaluation of protocols SARA is presented with an analysis of CCITT X.21. A report on a hierarchically connected computer network simulation is given followed by a description of TETRASIM, a telephone network simulator. A simulator of communication environments concludes this section. Part three discusses the role of NETWORKING IN SIMULATION. In a treatment on interactive group modeling, the HUB computer conferencing system is presented. The second contribution comprises a discussion on the GLOSAS project (Global Modeling and Simulation).

Although nearly all contributions are independent this sectioning creates a logical pathway through our overview of the many innovative developments within networking and simulation.

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THE AUTHORS

Richard P. Adler has been studying the social and psychological effects of media for the past decade. He is the former director of the Aspen Institute Workshop on Television and has taught communications at UCLA and Stanford University. His recent work has focused on the development of innovative applications involving broadcast television, cable, and computers. At the Institute for the Future he has work on analyzing current and future uses for videotex and has been responsible for the final evaluation of the HUB teleconferencing system. Mr. Adler is the editor of a number of books, including *The Cable and Continuing Education* (Praeger 1972), *The Electronic Box Office* (Prager 1973) and *Understanding Television* (Praeger 1980).

D.E. Cronin studied Physics and Mathematics at Oxford University. He joined ICT (later ICL) in 1964 and worked for three years on systems support for the Atlas computer. He then became responsible for technical support activities for ICL computer installations in universities and research establishments. In 1974 he joined Logica Ltd. and is now a Principal Consultant in Logica's Communications Group. He has worked mainly in the areas of computer networks, communication system design, network management and communication protocols. During 1979 and 1980 he was responsible for the development of the Communications Environment Generator for CCTA, as well as a number of other projects involving networks and terminal protocols.

Joseph DeVita has a diverse background in areas related to the applications of Operations Research and Management Science. Within a major U.S. chemical corporation, he has been intimately involved with educating staff in the use of Decision Support Systems for Financial, Marketing and Manufacturing Planning. He has taught Operations Research and Macroeconomics at a business school, and holds a B.E. in Engineering Science from SUNY at Stony Brook, an M.S. in Operations Research from Stanford University, and a Ph.D. in Mineral Economics from the Colorado School of Mines.

Oswald Drobnik received a PhD in Computer Science from Karlsruhe University in 1977. He worked (1972-1980) for the Nuclear Research Center Karlsruhe and during 1979 as post doctoral fellow for the IBM T.J. Watson Research Center, Yorktown Heights. Since 1981 he is professor at Karlsruhe University. His research interests include the design of distributed systems, protocol engineering, performance analysis and prediction.

Gerald Estrin was born in New York, NY. He received the B.S., M.S. and Ph.D. degrees from the University of Wisconsin, Madison, in 1948, 1949 and 1951 resp. He served as Research Engineer at the Institute for Advanced Study, Princeton, where he participated in the design of one of the earliest large digital computers. Subsequently, he served as the Director of the Electronic Computer Project at the Weizmann Institute of Science, Israel, where he led the development of WEIZAC, the first large-scale electronic computer outside of the United States or Western Europe. In 1956 he became a member of the faculty at the University of California, Los Angeles and in 1979 received University-wide recognition when the Regents approved his appointment as an Above Scale Professor. Since July 1979 he has been Chairperson of the UCLA Computer Science Department. He is leading research projects in the computer architecture area including the modeling, measurement, and synthesis of computer systems and programs, multilevel simulation of computers, and microprocessor-based networks. Dr. Estrin is Guggenheim Fellow, a member of the Scientific Advisory Council of Gould Inc., and a member of the Board of Governors of the Weizmann Institute of Science, Rehovot, Israel.

Alberto Faro was born in Agrigento (Italy) in 1946. He received the degree in nuclear engineering from the Politecnico of Milano in 1971. He is associate professor in computer science at the University of Catania, where he is presently director of the computing center of the engineering faculty. His interests involve both theoretical and experimental aspects of computer communications. Professor Faro is active in ISO WG1-FDT on formal description techniques, in ISO WG4 on computer network management and in IFIP TC6.1 on protocol specification and validation.

Alfred Giessler was born in 1947. Study of Physics at the Technische Hochschule in Darmstadt, Germany. Main subjects were optical spectroscopy and structural phase transitions of crystals. In 1975 he joined the Institut für Datanfernverarbeitung in Darmstadt and worked in the fields of network protocols and network simulation. Since 1980 he is involved in a project whose purpose is the development of a testing center for high level protocols.

Jürgen O. Haenle was born in 1943. Diplom in Mathematics in 1970 at the Würzburg University, Germany. Until 1972 member of the department of statistics at the Deutsches Rechenzentrum, Darmstadt, Germany. Since then a member of the Institut für Datenfernverarbeitung of the GMD (Geselschaft für Mathematik und Datenverarbeitung) in Darmstadt being in charge of network simulation. In 1977 he joined SESA - Deutschland, as the head of the Department for Teleprocessing and Computer Networks.

Hubert Lipinski received a B.S. degree in mathematics and physics from Stanford University in 1965, and a Ph.D. degree in theoretical physics from the University

of California at San Diego in 1969. He joined the Institute for the Future in 1971. Dr. Lipinski's present interests include telecommunications, modeling methodologies, and their applications to problems involving interactions of technological, economic, and societal factors. At the Institute, Dr. Lipinski played a major role in the design and implementation of a computer-based conferencing system (FORUM/PLANET) intended to facilitate communication among geographically separated persons. More recently he has been co-principal investigator in a project designed to extend computer-based conferencing to support communication needs of groups undertaking modeling and problem-solving activities. At the same time he has also been involved in a technology assessment project examining the role of teletext and videotex in the U.S.

Gesualdo Le Moli was born in November 1940. He took his degree in electronic engineering in July 1963, at the Politecnico di Milano, where he entered in the same year as assistant professor. In 1976 he became full professor at the University of Catania. Since 1978 he is full professor at the Politecnico di Milano. He is also director of the Centro Rete Europea di Informatica (CREI) which is a center for research on computer networks.

W.L. Price received his B.Eng. degree with first class honours in electrical engineering in 1951 and his Ph.D. degree in 1955, both from the University of Liverpool. From 1954 he has been on the staff of the National Physical Laboratory, Teddington, U.K., working on various computing projects. From 1970 to 1978 he was leader of a project for the simulation of data communication networks, concentrating on problems of routing and flow control. His present project is a study of data security in networks. He is a Member of the Institution of Electrical Engineers, a Fellow of the British Computer Society and a Senior Member of the Institute of Electrical and Electronics Engineers. He is the author of numerous papers on networking subjects, a co-author of the book *Computer Networks and their Protocols* and has also lectured frequently in the network field.

Thomas Røgeberg graduated from the University of Oslo (nuclear physics) in 1958. He worked in applied physics at the University of Oslo and the Institute for Atomic Energy from 1958 to 1967. Since 1967 he is employed by the Norwegian Computing Centre in Oslo. He has worked on applications of the language SIMULA in the construction of models for telecommunication networks, and on the development of user oriented software for microcomputers. Mr. Røgeberg is manager of the TETRASIM (Tele-traffic-simulation) project.

Rami R. Razouk was born in Cairo, Egypt, in 1953. In 1975 he received the B.S. degree in engineering, and the M.S. degree in computer science, both from the University of California, Los Angeles. In 1980 he received the Ph.D. in computer architecture, also from the University of Calfifornia, Los Angeles. From 1977

to 1980 he led the SARA design group under the direction of Dr. Gerald Estrin. In 1981 he was an assistant professor in Residence in the Computer Science Department of the University of California, Los Angeles. Presently he is an assistant professor in the Information and Computer Science Department of the University of California, Irvine. His research interests include modeling, simulation and analysis of computer systems. Dr. Razouk is a member of Phi Beta Kappa and Tau Beta Pi.

Antero Remes was born in 1948 in Helsinki. M.Sc. in Technology from Helsinki University of Technology in 1972, majoring in applied electronics and data processing. Worked since 1971 for KOP (the greatest commercial bank in Finland) in its real-time banking project, especially in the design and the realisation process of the communication network. Line and network layout design, simulation of lines and procedures, communication computers and software are the main objects in this process.

Steve Schoemaker graduated in physics from the Eindhoven University of Technology (Ir degree) and joined Sperry Univac in 1972. After two years in the Scientific Application Department and two years in the Pre-sales Department he became project manager for the Dutch Ministry of Public Works and Shell. In 1979 he became manager of Information Management Support, responsible for distributed data processing, data management, computer languages and special processors. He took part in simulation projects and lectured for Sperry Univac on modelling and simulation throughout Europe.

Carl Sunshine is with the University of Southern California Information Sciences Institute where he is engaged in research on computer networks and their protocols. He is particularly interested in protocol design, modelling, and analysis, and network interconnection. Dr. Sunshine received a Ph.D. in computer science in 1975 from Stanford University where he worked on the first major network interconnection projects within the ARPA and IFIP communities. From 1975 to 1979 he worked at the Rand Corporation on various protocol design and network planning projects. Dr. Sunshine is active in IFIP, ISO, and ANSI network groups and is Vice Chairman of the ACM Special Interest Group on Data Communication. He serves on the editorial board of the Computer Neworks journal, and is Associate Editor for Protocols of the IEEE Transactions on Communications. He lectured and published widely.

Takeshi Utsumi is President of Global Information Services, Inc. in New York, U.S.A. He studied at Tokyo Institute of Technology (B.S.Ch.E. in 1953), University of Nebraska and Montana State University (M.S.Ch.E. in 1957) as a Fulbright exchange student, Polytechnic Institute of New York (Ph.D.Ch.E. in 1964), and post doctoral studies at the University of Michigan, MIT, etc. He was instrumental in the success of Summer Computer Simulation Conferences. He has diversified

experiences with several American and Japanese firms (Mitsubishi Research Institute, Stone & Webster Engineering Corporation, Mobil and Shell Oil Companies, Asahi Chemical Industries, etc.), where he specialized in energy policy analysis, computer simulation and optimization of petrochemical and refinery processes. He has published over 100 papers in various fields and delivered them at professional conferences throughout the world. He holds honors and memberships of various professional organizations.

Bernd Wolfinger received a 'Maîtrise de Mathématiques et Applications Fondamentales' (Applied Mathematics) in 1974 from University Claude Bernard in Lyon, France, a Diplom in Mathematics (1975) and his Ph.D. (1979) in Computer Science both from Karlsruhe University. After having worked at the Nuclear Research Center in Karlsruhe (1975-1980) he joined the Department of Computer Science of Karlsruhe University and he is presently as Professor in the Department of Computer Science in Hamburg University. His primary research interests are in the design of distributed systems, formal description of communication protocols, analytical and simulative modeling of performance evaluation.

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NETWORKING IN SIMULATION

FOUNDATIONS

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INTRODUCTORY REMARKS ON CCITT

1. The CCITT (International Telegraph and Telephone Consultative Committee) is one of the four permanent organs (1*) of the International Telecommunications Union (ITU) which is the United Nations specialized agency responsible for International Telecommunications with more than 150 Member countries. The ITU originated in 1865 when the International Telegraph Union was founded, which was enlarged in 1885 to include the Telephone Service. Later, in 1906, the International Radio Telegraph Union was formed and in 1932, in their common Conferences in Madrid, both Unions agreed to merge to constitute the present International Telecommunications Union.

2. The CCITT derives from:

   - The CCIF (Consultative Committee, International Fernsehen) established in 1924 as an independent organ by the Telecommunications Administrations of 20 European countries, and
   - the CCIT (Consultative Committee, International Telegraphy) created in 1925.

   The CCIF and the CCIT became part of the International Telegraph Union in 1925, remaining separate of one another. In 1956 the CCIF and the CCIT were combined to constitute the present CCITT.

3. According to the present ITU Convention (Malaga, Torremolinos, 1973), the duties of the CCITT shall be to study technical, operating and tariff questions relating to telegraphy and telephony and to issue recommendations on them.

   To perform these duties the CCIs (CCITT and CCIR) operate via Plenary Assemblies, which meet roughly every three years, and Study Groups, which carry out investigations requested by the Assemblies, in the form of "Questions", in the intervals between Plenary Assemblies.

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*) The other three permanent organs are:

- The General Secretariat
- The International Frequency Registration Board (IFRB)
- The International Radio Consultative Committee (CCIR)

Participation in the work of the CCIs is open to all Members of the Union as well as to private telecommunications operating agencies, scientific and industrial organizations and international organizations which satisfy certain conditions. The international experts representing these organizations participate in the work of the various Study Groups by submitting contributions and/or by attending their meetings.

At the end of a Study Period the replies to the various questions, which embody the result of this international research, are submitted to the Plenary Assembly mainly in the form of recommendations. If the Assembly adopts these recommendations, they are published in what are known as the "CCIs Books" (at present the VIIth CCITT Plenary Assembly, Geneva, November 1980, has approved the recommendations contained in the Yellow Book), which are published by the ITU.

The CCITT Recommendations are not mandatory but are well observed around the world as they sum up the latest knowledge and experiences in all fields studied.

4. Important fields of activity for the present study period (1981 - 1984) are:

(i) The establishment of the general principles of the future Integrated Services Digital Networks (ISDN), including the access of customer to the ISDN

(ii) the study of dedicated digital networks (IDN), in which the integration of the switching and the transmission is performed

(iii) optical fibres transmission systems and possible alternative coding methods

(iv) public data networks and new telematic services

(v) new common channel signalling system for integrated digital networks

(vi) integration of maritime and mobile systems into the fixed terrestrial networks

(vii) international network planning models, etc.

This list gives only an example and can not be considered at all exhaustive.

5. Several Study Groups are considering questions more or less related with the use of computers in telecommunication networks. In particular some Questions of Study Group II (Telephone operation and Quality Service) could be mentioned. These Questions deal, amongst others, with the following:

- models for international network planning
- methods and procedures for traffic measurements