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A SELECTED ANNOTATED BIBLIOGRAPHY FOR SPACEBORNE MULTIPROCESSING STUDY

31 MAY 1966

PREPARED BY

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ABSTRACT

32432

This bibliography is prepared to provide readily available references on the work which has been accomplished in industry related to the application of multiprocessor systems to space missions.

The bibliography includes references in the following categories: check-out and fault isolation, control systems, distributed logic and SOLOMON computer; space missions and spaceborne processing; time-sharing and multi-processing multicomputers, and associated subjects.

There are 115 references which include reports, papers, periodical articles, and books covering the period 1960 through February 1966.

Author

INTRODUCTION

This selected annotated bibliography is prepared to provide readily available references on the work which has been accomplished in industry related to the application of multiprocessor systems to space missions. This effort is in support of a NASA study contract to Autonetics entitled, "Spaceborne Multiprocessing Study."

The objective of this study is to develop new concepts of multiprocessing oriented towards the computational requirements of future long-range manned space missions. The results of the study are expected to provide a technological base for future development of a flexible general purpose multiprocessing computer system for space application. The bibliography, therefore, includes references in the following areas: checkout and fault isolation, control systems, distributed logic and SOLOMON computer; space missions and spaceborne processing; time-sharing and multiprocessing multicomputers, and associated subjects.

The entries are listed alphabetically by title under the categories listed above.

The literature search covers the period 1960 through February 1966. The following principal sources were consulted during the search:

Applied Science & Technology Index
Current periodicals, books and proceedings pertinent to the subject.
Defense Documentation Center TAB (DDC)
Engineering Index
Information Processing Journal (Index)
Scientific and Technical Aerospace Reports (STAR & CSTAR)
ARB 033 087 - "Digital Recording and Storage Systems, A Report Bibliography," (DDC Report), 20 April 1965, Unclassified.

ARB 034 000 - "Computer Time-Sharing, A Report Bibliography," (DDC Report), 14 May 1965, Secret.

ARB 036 583 - "Computer-To-Computer Communications, A Report Bibliography," (DDC Report), 2 July 1965, Confidential.

T5-1397/3111 - "A Selected Bibliography on Techniques for the Sequential Manipulation of Digital Data," by C.F.G. Lyau, (Autonetics Report), 30 July 1965, Unclassified.

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A SELECTED ANNOTATED BIBLIOGRAPHY FOR SPACEBORNE MULTIPROCESSING STUDY

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*CONTROL SYSTEMS, *FAULT ISOLATION, CHECKOUT, *SOLOMON, TIME-SHARING, SPACE MISSIONS, COMPUTERS, LOGIC.

ABSTRACT

THIS BIBLIOGRAPHY IS PREPARED TO PROVIDE READILY AVAILABLE REFERENCES ON THE WORK WHICH HAS BEEN ACCOMPLISHED IN INDUSTRY RELATED TO THE APPLICATION OF MULTIPROCESSOR SYSTEMS TO SPACE MISSIONS.

THE BIBLIOGRAPHY INCLUDES REFERENCES IN THE FOLLOWING CATEGORIES: CHECKOUT AND FAULT ISOLATION, CONTROL SYSTEMS, DISTRIBUTED LOGIC AND SOLOMON COMPUTER; SPACE MISSIONS AND SPACEBORNE PROCESSING; TIME-SHARING AND MULTIPROCESSING MULTICOMPUTERS, AND ASSOCIATED SUBJECTS.

THERE ARE 115 REFERENCES WHICH INCLUDE REPORTS, PAPERS, PERIODICAL ARTICLES, AND BOOKS COVERING THE PERIOD 1960 THROUGH FEBRUARY 1966.

ASSOCIATED SUBJECTS

1. AN ADAPTIVE INFORMATION TRANSMISSION SYSTEM EMPLOYING MINIMUM REDUNDANCY WORD CODES. E.S. Schwartz. (Aeronautical Systems, Div. of the Air Force Systems Command, Wright-Patterson AFB, ASD -TDR62-265, Contract AF 33(616)-7882, April, 1962, UNCLASSIFIED) AD 274 135

DESCRIPTORS: *Coding, *Communication Theory, *Language, Communication Systems, Computer Logic, Computers, Construction, Detection, Dictionaries, Errors, Programming (Computers), Pulse Communication Systems, Synchronization (Electronics), Synthesis.

2. APPLICATION OF LINEAR GRAPHS TO ELECTRICAL NETWORKS, SWITCHING NETWORKS AND COMMUNICATION NETS. W. Mayeda. (Coordinated Science Lab., University of Illinois, Urbana, R-203, April, 1964, 150 pp., UNCLASSIFIED) AD 601 197

This paper is divided into three parts: The first part shows how linear graphs are used in analysis of electrical networks. The proof for the topological formulas of transfer functions of passive networks without mutual couplings given here is the first formal and precise proof in this field. By the use of topological formulas, such a passive network can be analyzed by a digital computer. The second part discusses the application of linear graphs to switching networks by starting with exploration of the properties of paths in a linear graph. Then the necessity of realizing a cut set matrix (or circuit matrix) is discussed. The third part discusses a rather new field which is many-ports flow problems which is called the theory of communication nets.

3. ARTRAC SYSTEM. (Range Instrumentation Systems Office, White Sands Missile Range, New Mexico, Summary Report, January 1964, 71 pp., UNCLASSIFIED) AD 465 273

ARTRAC is an organization of men and machines to perform range testing at White Sands Missile Range. It represents an integration of data collection, transmissions, computation, and reporting, under centralized management. All data collection instruments are under the control of area data centers (ADC). The ADC's are communications switching centers which collect, store, route and transmit data to a centralized data processing center (DPC) and to instrument sites. The coordination of range activities is performed at operation control centers (OCC).

4. AUTOMATIC SELECTION OF DIGITAL ELECTRONIC COMPUTERS. (ASDEC II) M.H. Weik, et al, (Ballistic Research Labs., Aberdeen Proving Ground, Md., Report No. BRL-1247, March 1964, 47 p., UNCLASSIFIED) AD-601 532

The engineering and programming descriptions of 406 electronic digital computing and data processing systems have been placed on punched cards. A technique for automating the selection and comparative evaluation of all systems for any given application is described. A print-out of the punched cards for manual selection, the evaluation flow chart, the users form for citing selection criteria, and a description of the evaluation technique are included.

5. CODED FEEDBACK COMMUNICATIONS SYSTEMS. J.J. Metzner and K.C. Morgan, New York University. (Proceedings of National Electronics Conference, Volume 16, 1960, p. 250-257)

From the field of error correcting-coding, solutions to the problems of equipment complexity and system vulnerability to changes in channel conditions are presented. The new methods are: employing long codes with feedback; correcting only very small numbers of errors; and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. The resulting system yields excellent reliability, "fail safe" (e.g. an error probability of 10^{-10} when the signal-to-noise ratio falls to zero), and operates at a relatively high per-symbol information rate. This approach is particularly effective in those situations where less efficient procedures fail-namely, when severe burst-type noise or heavy fading is encountered. The cost, in terms of computing and storage requirements, is far less than that of comparable unidirectional systems.

6. CODING FOR MULTIPLE ASYMMETRIC ERRORS IN ONE CHANNEL OF MULTI-CHANNEL SYSTEM. C.H. Wolff. (IRE Transactions on Electronic Computers, Volume EC-11, Number 5, October 1962, p. 655-658)

Variations of efficient code for multiple error correction in one channel of multichannel system; examples to illustrate possible ways this coding scheme may be used; completely asymmetric channel, in which only one type of error occurs, is assumed.

7. CLOCK MARKS TIME FOR COMPUTERS. (Electronics, Volume 38, November 15 1965, p. 194)

8. THE COLINGO SYSTEM DESIGN PHILOSOPHY. J.F. Spitzer, et al. (Mitre Corporation, Bedford, Mass., Contract AF 19(628)-2390, Report No. Mitre SR-126, ESD-TDR64-159, November 1964, 48 p. UNCLASSIFIED) AD 608 833

This report describes the design and operation of COLINGO (Compile On-line and Go), a program system embodying a computer control and query language that provides the operator with a grammar and vocabulary approximating English to control program data and equipment in a data processing system.

9. A COMPUTER SIMULATION OF AN INFORMATION-GATHERING SYSTEM. J.H. Moss and F.J. Harris. (Research Analysis Corp., McLean, Va., UNCLASSIFIED) AD-254 737

The problem investigated was that of deriving a methodology for examining certain characteristics (completeness, accuracy, and pertinence) of intelligence information in the light of the various random factors that enter into a tactical situation. The method employed is a computer simulation. The relative values to the decision maker of amount, pertinence (importance), and accuracy of the information available to the decision maker are examined in the simulation.

10. CONNECTIVITY AND CAPACITY COMPUTER PROGRAM. (ITT Communication Systems Incorporated, Paramus, New Jersey, Final Report, 64-TR-511, Contract AF 19'628)-3358, October, 1964, UNCLASSIFIED) AD 451 044

This report presents the final documentation of connectivity and capacity computer program developed by ICS for the Defense Communications Agency. The connectivity and capacity computer program was developed to obtain more meaningful parameters for evaluating performance of surviving network by extending the outputs of the survivability models utilized by DCA. Two mathematical approaches were considered in the development of this computer program: The Matrix Approach and the Graph-tracing Approach.

11. DIGITAL SIMULATION TECHNIQUES APPLIED TO A COMMUNICATIONS SYSTEM. R. Archambault, et al. (System Development Corporation, Santa Monica, California, TM-632-000-01, August, 1963, 32 pp., UNCLASSIFIED) AD 417 830

Digital simulation techniques applied to a communications system.

12. EXPERIMENTAL INCREMENTAL COMPUTER. K. Millington. (Radio & Electronic Engineer, Volume 25, Number 5, May 1963, p. 461-473)

Experimental incremental computer using time-shared equipment is described; basic operation provides approximate numerical integration by adding rectangular areas; there are 45 integrators in computer, integrands being represented serially by up to 22 bits at digit rate of 500 kc; number of bits representing values of increments in computer is easily varied.

13. HIGH RESOLUTION SURVEILLANCE, ACQUISITION, TRANSMISSION, RECEPTION, AND DISPLAY STUDY (U). (Whittaker Controls, Los Angeles, California, Final Report, December, 1963, 272 pp., CONFIDENTIAL) AD 351 329

Classified abstract.

14. IMPLEMENTATION PLAN AUGMENTATION COMPUTER PROGRAMS. (System Development, Corporation, Santa Monica, California, TM-L751-000-01, Contract AF 04(695)-40, October, 1962, 50 pp., UNCLASSIFIED) AD 452 818

Implementation plan for augmentation computer programs for satellites.

15. INVESTIGATION OF PROPAGATION-LIMITED COMPUTER NETWORKS. B. Elspas, et al. (Stanford Research Institute, Menlo Park, California, Final Report, AFCRL 64-376, Contract AF 19(628)-2902, April, 1964, 134 pp., UNCLASSIFIED) AD 603 165

This report summarizes research on techniques for the logical analysis and design of computer networks in which the propagation delays on the lines connecting logic blocks within the network are appreciable compared to the delays within the blocks. The first part is concerned with basic techniques for the transfer of information between blocks. The problem of preserving the separation of pulses propagating in a cascade of delay elements is shown to be fundamental.

The second part is concerned with communication in large systems, and with special logical arrays.

An analogy is made between propagation-limited networks and topological graphs, and the relation between graph size (Number of nodes) and maximum distance (number of connecting branches in the shortest path) between nodes, is analyzed.

16. JOSS: A DESIGNER'S VIEW OF AN EXPERIMENTAL ON-LINE COMPUTING SYSTEM. J.C. Shaw. (Rand Corp., Santa Monica, California, Report No. P-2922, August 1964, 36 p., UNCLASSIFIED) AD-603 972

JOSS (Johnniac Open-Shop System) is an experimental on-line, time-shared computing service. It is in daily use by staff members of the Rand Corporation for the solution of small numerical problems. The users compose stored programs and interact with JOSS through remote typewriter consoles by using a single, high-level language. The system is described with emphasis on those features which have led users to accept it as a convenient new tool.

17. THE LITTON FLIGHT DATACOMPUTER AS A RE-ENTRY CONTROL DIRECTOR. D. O. Dommasch and C. W. Laudeman. (Litton Systems Inc., Woodland Hills, California, Supplement to Final Report AD-425 655, November 1963, 136 p., UNCLASSIFIED) AD-429 157

The results are summarized of the investigations carried out during approximately the past year involving utilization of the Doliac logic and associated systems for programming the Litton Flight Data Computer (FDC) to provide for safe re-entry and landing of advanced flight vehicles.

18. A MAGNETIC COMPUTER STUDY. (Burroughs Corp., Paoli, Pa., Contract No. AF 04(695)-320, Final Report. SSD-TR64-208, September 1964, 68 p., UNCLASSIFIED) AD-447 910

The primary objective of this magnetic computer study was to determine and demonstrate the feasibility of a digital computer, which emphasized magnetic devices for logic and memory, surviving and operating under sever missile and space environments. Components, modules, and subsystems were studied and tested. Finally, a magnetic computer test vehicle was assembled and tested.

19. MILDATA STUDY. D.F. Zimmerle. (National Cash Register Co., Dayton, Ohio, Contract DA36 039AMC03277E, Quarterly Progress Report, No. 3, 25 January - 15 April 1964, April 1964, 192 p., UNCLASSIFIED) AD-447 021

The purpose of the Mildata study is to explore advanced digital computer system concepts and techniques which can be utilized to achieve 'modularity in depth' in the Army Command Control Information Systems (CCIS) of TFE 1975-1985 time period. A brief review of the general pronect status and the future plans of the Mildata study are offered. A computer organization structure, using the phased memory, is outlined. Associated with this design is a study of peripheral processor techniques which enhance the capability of the central processing unit. The investigation of ultra high-speed computer organizations was continued. Studies of high-speed circuits and the logical design of high-speed arithmetic units were completed.

20. MILDATA STUDY. D.F. Zimmerle, et al. (National Cash Register Co., Dayton, Ohio, Contract DA36-039AMC03277E, Report No. NCR 24-40, Report No. 4, Final, August 1963-August 1964, October 1964, UNCLASSIFIED) AD-457 809

Projections are made for all areas of the digital computer state-of-the-art. From these projections, a design concept is established for a modular digital computer system for the Army Command Control Information System of the 1975 to 1985 time period.

The recommended design is a multiprocessor, multimemory system in which the basic processor is a simple, high speed microprogrammed module. The system prossesses a high degree of modularity, survivability, flexibility, and reliability. Supporting the recommendations are detailed studies of multiprocessor executive control systems, memory multiaccess control methods, microprogramming control, etc.

21. MILDATA STUDY. A FEASIBILITY STUDY OF FUTURE MILITARIZED DIGITAL COMPUTER REQUIREMENTS. (Sylvania Electronic Systems, Needham, Mass., Contract DA36-039AMC03276E, Quarterly Progress Report No. 2, for period ending 31 January 1964, January 1964, 134 p., UNCLASSIFIED) AD-600 284

This report documents the progress to date on the system organization studies and hardware techniques projection phases on the Mildata study. Topics covered under system organization studies include: survey of software problems in multiprocessor configurations, such as interchangeability of modules, memory allocation and protection, executive control requirements, and intermodule switching problems.

Development of system performance evaluation and design methodology in the areas of cost-effectiveness of high speed memories, feasibility of common processor design, and reliability analysis of modular configurations.

22. MILDATA STUDY. AN OPTIMIZING STUDY OF A MODULAR DIGITAL COMPUTER SYSTEM. VOLUME I. N. Nisenoff. (Honeywell Electronic Data Processing, Wellesly Hills, Mass., Contract DA36 039AMC03275E, Final Progress Report, 12 August 1963 - 30 September 1964, April 1965, UNCLASSIFIED) AD-462 042

The objective of this study was to examine approaches and select an optimum approach to the design of a highly modular data processing system forutilization by the United States Army in the 1975-1985 time frame. In complying with this objective four unique designs were postulated and discussed in the third quarterly progress report. During the final quarter year's effort, each of these designs was examined in depth. Out of these investigations emerged the specific recommendations and design approach presented in Chapter 4 of this volume.

23. MILDATA STUDY. AN OPTIMIZING STUDY OF A MODULAR DIGITAL COMPUTER SYSTEM. VOLUME II. N. Nisenoff. (Honeywell Electronic Data Processing, Wellesley Hills, Massachusetts, Final Progress Report 12 August 1963-30 September, 1964, April, 1965, UNCLASSIFIED) AD 462 043

Mildata - Optimizing study of modulat Digital Computer System.

24. MISSILE-PROPULSION SUBSYSTEM EFFECTIVENESS. A.W. Hardy and W.W. Holmes, Thiokol Chemical Corp., Wasatch Division, Brigham City, Utah. (Fourth Annual Reliability and Maintainability Conference, 1965, p. 689-703, 2 refs.)

25. ON DISTRIBUTED COMMUNICATIONS NETWORKS. P. Baran, Rand Corporation. (IEEE Transactions on Communications Systems, March 1964, p. 1-9)

This paper briefly reviews the distributed communication network concept in which each station is connected to all adjacent stations rather than to a few switching points, as in a centralized system. The payoff for a distributed configuration in terms of survivability in the cases of enemy attack directed against nodes, links or combinations of nodes and links is demonstrated.

26. ON THE CONSTRUCTION OF HIGH SPEED CONTROL COMPUTERS. I.N. Bukreev. (Foreign Technical Division., Air Force Systems Command, Wright-Patterson AFB, Ohio, Report Nos. FTD-TT-64-755, TT 65-61018, December 1964, 12 p., UNCLASSIFIED) AD-610 345

Various aspects of using TSVM digital computers in automatic control systems are discussed.

27. A PARALLEL MULTIPLIER ADDER SUBTRACTOR UNIT FOR THE DRTE COMPUTER. D.P. Henderson and J.G. Cook. (Defence Research Telecommunications Establishment, Ottawa (Canada), DRTE-1096, November 1962, 30 p., 4 refs., UNCLASSIFIED) X63-15114

NOTICE: Available to NASA offices and NASA Centers only.

This report reviews the design and development of a combined quasi-parallel shift multiplier, subtractor, and adder apparatus for use in the conversion of the DRTE Computer from serial to parallel operation. The manipulation and combination of the relevant Boolean expressions as the basis of design, as well as the evolution of the logical and electronic circuitry, are described. Performance waveforms from a printed circuit subtradder card employed in a 8-digit experimental model are presented. These results demonstrate that the digital information is available at the output in less than 1 μs after the binary words are presented to the input.

28. QUANTITATIVE METHODS OF INFORMATION PROCESSING SYSTEM EVALUATION. P. W. Abrahams, et al. (ITT Data and Information Systems Div., Paramus, N. J., Contract No. AF 19(628)-2842, ESD-TDR63-670, October 1963, 105 p., UNCLASSIFIED) AD-433 220

The objective of this study was to develop practical methods for specifying the characteristics of a data processing system and for comparing the performance of different systems. The methods cover both functional characteristics and engineering characteristics. The functional characteristics are specified in terms of macro operations that represent particular sample problems. Associated with these macro operations are parameters that serve to specifiy the macro operation completely. The engineering characteristics include factors such as configuration, word length, overlap, time for various operations, and logic.

29. THE ROLE OF SIMULATION AND DATA REDUCTION PROGRAMS IN THE DEVELOPMENT OF REAL-TIME SYSTEMS. E.L. Lafferty. (Mitre Corporation, Bedford, Massachusetts, Mitre SR-125, Contract AF 19(628)-2390, December 1964, 31 pp., UNCLASSIFIED) AD 609 500

This report deals with the valuable use of simulation and data reduction computer programs in the acquisition and engineering of command and control systems. The value of simulations, especially in facilitating the learning process and in expediting system design, is described. Data reduction is shown to be an evolutionary process and the design of a data reduction system should be considered in the very early stages of system acquisition.

30. SUBIC COMPUTER CONCEPT STUDY. VOLUME I. (Computer Usage Co., Inc., New York, Contract NonR251200, Final Report, October 1963, 42 p., UNCLASSIFIED) AD-430 115

The Subic computer concept study was undertaken to determine the computer system which would meet the requirements of an integrated submarine control system. Phase I determines data processing tasks which are representative of the types of processing which might be performed by the Subic computer system. Phase II dtermines the overall computer requirements based on the processing requirements defined in Phase I. Problems inherent in the development of a real time computer control system are also discussed. Phase III develops a methodology for evaluating computer control systems.

31. SUPERSPEED COMPUTERS: A MAJOR TOOL IN THE SPACE SCIENCES. R. Jastrow and A. Arking. (National Aeronautics and Space Administration, Goddard Inst. for Space Studies, New York, NASA-TM-X-56433, 22 April 1965, 11 p.) N65-25451

The prospect of using the computer as a laboratory for the performance of experiments is discussed. Knowing the laws of the physical sciences and programing these data into the computer allows the machine to be used as a laboratory for the solution of any physical problem for which basic data have been put into the machine. This can be done in a fraction of the time it would take to perform the calculation by other means, if indeed, it could be solved at all. Application to weather calculations, the solar system, and to nuclear study is given as illustrative of the types of experiments which can be done.

32. SURVEY OF STATISTICAL AND ADP TECHNIQUES. D. Curry, et al. (General Electric Co., Washington, D. C., Contract DA18-119AMCO-1176X, April 1964, UNCLASSIFIED) AD-441 801

Four specific topics have been reviewed in detail by a team of systems analysts and systems programmers. These topics are: computer independent programming languages, information storage and retrieval devices and techniques, analytical tools and data gathering techniques and tools. The material is organized in three major sections. Combined, they establish a set of reference data for use in system design and second, relate these data to specific problems in system design.

33. SURVIVABILITY OF REDUNDANT COMMUNICATIONS SYSTEMS. S.D. Levine. (Aerospace Corporation, Los Angeles, California, TDR-269(4922)-3, Contract AF 04(695)-269, September, 1964, 13 pp., UNCLASSIFIED) AD 607 116

A computer program is developed which is capable of investigating the survivability of a class of redundant communications systems. The systems simulated by the computer program are characterized by large numbers of communicating elements dispersed over an operations area. Each element has potentially perfect switching capabilities for relaying messages to neighboring elements. These systems are modeled by nodes, links, and zones. Nodes represent the communicating elements of the Model; zones and links are used to describe the command and control organization.

CHECKOUT AND FAULT ISOLATION

34. AN AUTOMATIC SELF-CHECKING AND FAULT-LOCATING METHOD. F. Lee, Sylvania. (IRE Transactions of Electronic Components, Volume EC-11, October 1962, p. 649-654)

A method of designing systems which automatically check themselves and give indications by which internal faults can be located quickly and accurately is described. Relatively little circuitry is required and performance of the test and fault location procedure is easy. Theproposed method entails the arrangement of a sequence of events which can be completed properly only if no malfunction extists. Applied to a 555-transistor digital system, the method yielded the following results: an indicator-light test and a 2.27 sec self-check provide 100 per cent of the trouble indications isolate faults to one or two plug-in cards, each holding one to six transistor circuits. This checking capability is provided by only 18.1 per cent of the transistors in the system.

35. COMPUTER ALGORITHM FOR FAULT ISOLATION AND TEST POINT SELECTION. S.M. Fisch and G.R. Brigida, RCA, Van Nuys, California. (Wright-Patterson AFB, Ohio, Contract AF 33(615)-1347, Technical Report, 15 February - 5 December 1964, Report Numbers AFAPL-TR-65-12, AD-613 960, 1965, 191 p.) N65-22380

This report presents the methods and results of a study to develop a computer algorithm for automatically selecting test point locations in an electronic circuit, for generating test measurements, and for designing a corresponding test procedure. The algorithm is oriented towards analog circuits where piece-part fault isolations are made using sequential tests which can be performed either manually or on tape-controlled automatic test equipment. The algorithm was tested by introducing faults into the test circuit and then tests were made in accordance with the computer generated test procedure.

36. COMPUTER RELIABILITY STUDY, VOLUME 1 - SUMMARY. Final Report, October 1962 - September 1963. T.J. Burns, et al. (Hughes Aircraft Co., Culver City, Calif., Los Angeles, Calif., Space Systems Div., Contract AF 04(695)-210, P63-59; SSD-TDR-63-271, Volume 1; AD-421 763, 1963, September, 19 p., UNCLASSIFIED) X64-13071

This report is concerned with reliability synthesis techniques that are based upon the unique characteristics of control computers, as opposed to those of data processors, and that are realizable with present-day computer construction technology. These techniques are based on the assumptions that control systems can tolerate some wrong stimulations from the control computer, but cannot tolerate long downtime, and that degradations in computer capability can be tolerated. These assumptions allow for the use of software, in addition to hardware, for the generation of the reliability synthesis techniques, and thus minimize the hardware penalty commonly associated with "hardware only" techniques (redundancy).

37. COMPUTER RELIABILITY STUDY, VOLUME II. Technical Report, October 1962 - September 1963, T.J. Burns, et al. (Hughes Aircraft Co., Culver City, Calif., Los Angeles, Calif., AF Systems Command, Contract AF 04(695)-210, P63-59; SSD-TDR-63-271, Volume 2, AD-429 094, September 1963, 228 p., UNCLASSIFIED) X64-12101

This report is concerned with reliability synthesis techniques, which are based upon the unique characteristics of control computers as opposed to those of data processors, and which are realizable with present-day computer-construction technology. These techniques are based on the assumptions that control systems can tolerate some wrong stimulations from the control computer, but cannot tolerate long downtime, and that degradations in computer capability can be tolerated. These assumptions allow for the use of software, in addition to hardware, for the generation of the reliability synthesis techniques, and thus minimize the hardware penalty commonly associated with hardware-only techniques (redundancy). However, due to the use of software in these techniques that are applied at the subsystem level, there is generally a degradation in accuracy of computation and/or computational capability, which is associated with the occurence of each failure.

38. DERIVATION OF OPTIMUM TESTS TO DETECT FAULTS IN COMBINATIONAL CIRCUITS. J.F. Poage. (Princeton University, Department of Electrical Engineering, Digital Systems Lab., Princeton, N. J., Technical Report Number 18, March 1962, 75 p.)

Permanent component failures or faults within a combinational logic network may cause a network to produce an output function different from that for which it was designed. Boolean algebra, while sufficient to describe the normal operation of a network, gives no indication of the effect that a fault will have upon a network output function. To overcome this deficiency, an analysis procedure is developed for combinational logic networks which yields an output expression incorporating network structure in addition to input variables. From this one output expression it is possible to obtain the network output function when any permanent fault, single or multiple, exists within the network.

A second method, developed in this paper, uses the output expression to list the set of faults, single and multiple, which a particular input combination may detect.

39. DESIGN AND TESTING OF REDUNDANT SYSTEMS. H. Brinker and A.R. Helland, Westinghouse Electric Corp., Baltimore, Md. (Research on Failure Free Systems, November 1964, 94 p.) N65-11344

Results of a study on the implementation of majority logic redundancy are presented. Most of the work concerns spaceborne systems, but some portions are applicable to ground support equipment. A discussion of the possible use of magnetic logic to reduce the total power consumption and to provide nonvolatile storage includes a description and comparison of various types of semiconductor logic for redundant systems. Integrated diode-transistor elements are chosen as the most suitable for general use. A discussion of the detection and location of failures includes several methods of testing redundant systems.

40. IMPROVING THE RELIABILITY OF DIGITAL SYSTEMSBY REDUNDANCY AND RESTORING ORGANS. J.K. Knox-Seith. (Stanford Electronics Labs., Stanford University, California, NonR22544, August 1964, 73 p., UNCLASSIFIED) AD-449 371

The use of redundant circuits and restoring organs as a technique for improving the reliability of digital systems has been evaluated, and guidelines for a near-optimum use of this technique in practical systems have been established. Two types of restoring organs, majority vote takers and simple adaptive vote takers, have been considered. Several conventional measures of reliability were considered.

41. THE NEED AND MEANS FOR SELF-REPAIRING CIRCUITS. Interim Technical Report. J.B. Angell, Stanford University, California. (1963 IEEE Convention Record, Part 2, Automatic Control, Circuit Theory, Contract AF 33(616)-7726, Technical Report 4654-2; SEL-63-115; AD-425 649, October 1963, 11 p., UNCLASSIFIED) X64-12176

This paper describes the use of redundant, adaptive structures capable of limited self-repair, and presents various members of a new family of components particularly suited for such adaptive networks. Such small, low-power components also provide linear integration with permanent memory.

42. PROCEEDINGS 6TH JOINT MILITARY - INDUSTRY GUIDED MISSILE RELIABILITY SYMPOSIUM, VOLUME 2. (Army Missile Command, Redstone, Arsenal, Ala., February 60, 438 p., UNCLASSIFIED) AD-454 675

CONTENTS: An analytical method for concept optimization and reliability planning in space systems; some applications of Monte Carlo methods to failure predictions; composite reliability; operational reliability and maximum safe operating levels for expensive equipment; a mathematical model for finding the best frequency of tests on static alert system; mathematical models for optimizing strategic reliability and for minimizing cost; examination of reliability theory and practice; the use of reliability estimates in the design of missile prelaunch checkout equipment; predicting drift reliability of digital circuits.

43. A PROPOSED SYSTEM OF REDUNDANCY TO IMPROVE THE RELIABILITY OF DIGITAL COMPUTERS. W.H. Pierce. (Stanford Electronics Labs., Stanford University, California, UNCLASSIFIED) AD 241 645

DESCRIPTORS: *Digital Computers, Communication Systems, Reliability.

44. RESEARCH ON FAILURE-FREE SYSTEMS. Second Quarterly Report. (Westinghouse Electric Corp., Baltimore, Md., NASA Contract NASw-572, NASA-CR-52036, September 1963, 4 p., UNCLASSIFIED) X63-17047

NOTICE: Available to NASA Offices and NASA Centers Only.

Design research of electronic systems which are essentially free from the effects of internal failures is discussed as follows: (1) implementation--the development of suitable electronic circuits to implement certain available network models of redundant digital systems; (2) advanced voting techniques--Adaline-Neuron type restoring circuits for use as voting elements in redundant systems, and Transor decision rules and decision devices for restoration; and (3) self-repair.

45. RESEARCH ON FAILURE FREE SYSTEMS. QUARTERLY REPORT NO. 3, 20 April - 20 JULY 1964. (Westinghouse Electric Corp., Baltimore, Md., Contract NASw-572, NASA-CR-58861; WGD-38521) N65-32097

The four major tasks considered in this report are: statistical measure of quality, adaptive voter, failure responsive system organizations, and medium communication. A brief summary of the work proposed for each of these tasks is presented with a review of the progress made. The objective of this research is to develop new techniques that will advance the state-of-the-art concerned with ultrareliable reliable electronic systems. A detailed study was made in estimating system reliability under various test conditions.

46. RESEARCH ON FAILURE FREE SYSTEMS WITH SUPPLEMENTAL INFORMATION, FINAL REPORT. (Westinghouse Electric Corp., Baltimore, Md., Contract NASw-572, NASA-CR-57011, December 1963, 225 p., UNCLASSIFIED) X65-11320

The implementation studies as part of the research on failure free systems are concerned with efficient initial design and the diagnostic testing of multiple-line, majority logic redundant systems. Several techniques are described for detecting and locating failures within an operating reundant system, and a method for prediction of mission reliability is discussed. In the study of advanced voting techniques, the Adaline-Neuron adaptive voter with continuously variable input weighting, the Transor restoring circuit, and the Hamming Distance restoring circuit were investigated. The third portion of the research on failure free systems is devoted to the study of self-repair techniques. Using these techniques, a systme may be designed to absorb more internal failures without system failure. A computer simulation program is described which is used to compare the effectiveness of various switching strategies employed in self-repairing systems.

47. SELF-DIAGNOSIS OF ELECTRONIC COMPUTERS: AN EXPERIMENTAL STUDY. E.G. Manning. (Illinois University, Urbana, Grant NSF GK-36, R-259; AD-620 248, July 1965, 80 p.) N65-36784

The problem considered is the development of design principles which will permit the design of self-diagnosing computers. A self-diagnosing computer is one for which there exists a self-diagnosis procedure, defined as an experiment having one of two outcomes: (1) all transistor-diode logic is entirely failure-free; or (2) card or module x has a failure of type y. Also, the procedure must be sufficiently fast to permit execution every few hours, using non-technical personnel.

48. SELF-ORGANIZING SYSTEMS AND THEIR POTENTIAL APPLICATION TO COMBAT SURVEILLANCE. P. Metzelaar. (Institute of Science and Technology, University of Michigan, Ann Arbor, 2900-90-R, October, 1959, UNCLASSIFIED) AD 227 535

DESCRIPTORS: *Military Communications, Communication Systems, Communication Theory, Computers, Machine Translation, Mathematical Analysis.

49. SELF-REPAIRING DIGITAL COMPUTERS--INVESTIGATION AND SIMULATION WITH APPLICATION TO AEROSPACE GUIDANCE AND CONTROLS. VOLUME III: APPLICATION OF DIGITAL COMPUTERS WITH DEGRADED MODE OPERATION TO AEROSPACE GUIDANCE AND CONTROLS. FINAL REPORT, MAY 1964 - JUNE 1965. I. Terris. (Hughes Aircraft Co., Culver City, California, Contract AF 04(695)-544, P65-64; SSD-TR-65-52, Volume III; AD-466 124, June 1965, 163 p., UNCLASSIFIED) X65-20244

Studies were made to determine whether the failure-tolerant or self-repairing computer could be realistically used for space guidance problems. The impact of degraded operation resulting from word-split of the guidance computer was considered for two postulated representative space missions by observing the effects of degradation in computational accuracy or speed on the determination of the local position and velocity.

51. A STUDY OF THE USE OF REDUNDANT INFORMATION ON SPACE GUIDANCE SYSTEMS TO ACHIEVE MALFUNCTION DETECTION AND CONTROL. H.B. Haake, et al. (General Electric Co., Johnson City, N. Y., Contract No. AF 33(657)-11654, Report Number A1-TDR64-60, April 1964, 166p., UNCLASSIFIED) AD-436 110

A theoretical orbital navigation system was synthesized that employs techniques for achieving a high degree of reliability through the application of redundant equipment, and malfunction detection capability. Malfunction detection is used to implement standby redundancy, or to reorganize the system to permit continued operation with fewer sensors, subsequent to measurement subsystem failures. The latter case results in progressive performance degradation. The resulting potential modes of operation are defined, and the level of performance, in terms of orbit determination accuracy, has been evaluated for each.

50. SELF-REPAIRING DIGITAL COMPUTERS--INVESTIGATION AND SIMULATION WITH APPLICATION TO AEROSPACE GUIDANCE AND CONTROLS. VOLUME IV: SELF-REPAIRING DIGITAL COMPUTER SIMULATION PROGRAM. FINAL REPORT, May 1964-June 1965. (Hughes Aircraft Co., Culver City, California, Los Angeles, Space Systems Div., Contract AF 04(695)-544, P65-64; SSD-TR-65-52, Volume IV; AD-466-125, June 1965, 297 p., UNCLASSIFIED) X65-20199

A computer program is presented which was used to simulate the operation of a digital computer which had been designed with self-repair capability to replace failed circuitry.

52. A SURVEY OF ADAPTIVE COMPONENTS FOR USE IN FAILURE-FREE SYSTEMS. S.E. Lomax. (Westinghouse Electric Corp., Baltimore, Md., Special Technical Report No. 1, NASA Contract NASw-572, Report Number NASA-CR-55039, August 1963, 18 p., UNCLASSIFIED) X64-11600

A survey of electrochemical devices (the memistor, solion, and mercury cell) and magnetic devices (Multiaperture, orthogonal core, second harmonic and magnetorestrictive integrators) for use in failure-free logic systems was made. As a result of the survey it became apparent that none of the suggested adaptive devices were sufficiently developed to justify the selection of a practical approach for immediate circuit implementation of an adaptive voter (an Adaline neuron).

NOTICE: Available to NASA Offices and NASA Centers only.

53. SYSTEM SURVIVAL IN THE NONOPERATIVE STATE. W.L. Hadley and R.T. Patterson, Martin Company, Orlando, Florida. (Fourth Annaul Reliability and Maintainability Conference, 1965, p. 719-725)

CONTROL SYSTEMS

54. THE ANALYSIS OF A CERTAIN CLASS OF NONLINEAR SYSTEMS. A.Y. Bilal. (Institute of Science and Technology, University of Michigan, Ann Arbor, Contract No. DA36 039SC78801, Report No. 2900-392T, September 1963, 153 p., UNCLASSIFIED) AD-418 193

In nonlinear analysis, the partitioning technique has been used to analyze a certain class of nonlinear systems whose dynamic behavior can be represented by a nonlinear differential equation with time-varying parameters. When suitable restrictions were placed on the linear, nonlinear, and forcing function terms, the system equation presented a unique solution which existed to the right of the initial state. The system solution was given as a limit of a sequence of picard iterates x sub N which are well defined in a given domain and which belong to L sub 2 space. A formula was developed which permits determining the number of iterates necessary for the approximation of the solution in the mean square sense.

55. AN INTRODUCTION TO ESTIMATION THEORY FOR DYNAMICAL SYSTEMS. F.C. Schweppe. (Lincoln Lab., M.I.T., Lexington, Contract No. AF-19(628)-500, Report Number AF-ESD-TDR63-549, August 1963, 48 p., UNCLASSIFIED) AD-417 777

Estimation (filtering) theory for dynamical systems is reviewed. Emphasis is on time varying systems and nonstationary stochastic processes. The basic ideas for linear systems are presented in an intuitive manner using time domain techniques and the state variable concept. Both continuous and discrete time systems are discussed. A control problem and the principle of least squares curve fitting are related to the basic estimation problem. In addition to the presentation of fundamental principles for linear systems, brief discussions on a wide variety of related subjects are included in an appendix.

56. MODERN SYNTHESIS OF COMPUTER CONTROL SYSTEMS. J. Tou and P.D. Joseph. (Purdue University, Lafayette, Ind., NONR1100-16, October 1961, 1 p., UNCLASSIFIED) AD-447 235

Reprint from Application and Industry, May 1963 (Copies not supplied by DDC)

This paper is concerned with the synthesis of computer control systems by modern techniques. In this approach, the dynamics of the process is characterized by state variables and transition equations, and the optimum design of the system is carried out by use of the dynamic programming theory. It is demonstrated that the modern approach to the design of digital control systems is capable of handling a wider variety of problems and of producing more realistic results than conventional design approaches. This paper discusses such topics as performance indices, optimum control law, constraints at the output, and optimum estimation. The synthesis procedure is illustrated by an example.

57. MULTI-COMPUTER CONTROL SYSTEM. (Electronic Industries, Volume 23, December 1964, p. 109)

58. MULTI-COMPUTER CONTROL SYSTEM OFFERS PUSH-BUTTON AUTOMATION. (Power Engineering, Volume 68, November 1964, p. 47)

59. MULTI-COMPUTER CONTROL SYSTEM USES UNIT-MANAGEMENT CONCEPT. (Automation, Volume 11, November 1964, p. 24)

60. A STUDY OF DIGITAL ADAPTIVE CONTROL SYSTEMS. PART II. J.T. Tou and P.D. Joseph. (Purdue University, School of Electrical Engineering, Naval Research Contract Nonr 1100(18), NR 049-150, PRF 2327, Technical Report No. 102, Control and Information Systems Laboratory Report No. TR-EE61-7, August, 1961, 102 p.)

A method for determining the optimum linear digital control system with respect to a quadratic performance criterion when additive disturbances are present, is described. Previous workers in this area found it necessary to assume that the state of the system is precisely known at all times. The elimination of this assumption extends the applicability of optimization theory to more realistic models of actual systems. It also allows non-white noise disturbances and problems other than the regulator problem to be considered.

61. A STUDY OF NONLINEAR DIGITAL CONTROL SYSTEMS. J.T. Tou and J.B. Lewis. (Purdue University, School of Electrical Engineering, Prepared under National Science Foundation Contract G-14609, PRF 2626, Technical Report No. 201, July 1961, 144 p.)

A method of design is developed for nonlinear sampled-data systems in which the single control input signal to the linear plant is quantized to 3, 5, 7*** levels. Time responses for certain designs have been computed, and these responses are compared with the well-known "bang-bang" or two-level systems. The use of five or more levels enables the designer to obtain good static accuracy as well as good dynamic performance.

DISTRIBUTED LOGIC AND SOLOMON COMPUTER

62. BULK PROCESSING IN DISTRIBUTED LOGIC MEMORY. B.A. Crane and J.A. Githens, Bell Telephone Labs., Inc., Whippany, N. J. (IEEE Transactions on Electronic Computers, April 1965, p. 186-196, 18 refs.)

Use of a content-addressable memory as a highly parallel digital computer is described. The ability to perform any arithmetic operation on many sets of data at the same time is shown. The memory organization and the storage of data are such that many operations are performed parallel by bit as well as parallel by word, resulting in more efficient algorithms and shorter execution times.

63. CONTENT-ADDRESSABLE DISTRIBUTED-LOGIC MEMORIES. R. Edwards, Sperry Rand. (Proceedings of the IEEE, Volume 52, January 1964, pp. 83-84(L).

Cell memory programs are discussed, with regard to the formulations of C.Y. Lee and M.C. Paull (Proc. IEEE, Vol. 51, pp. 924-932, June 1963). Consideration is given to bracketed structures and addressing in general. The cells themselves should guide the flow of information, abolishing the distinction between programs and data.

64. A CONTENT ADDRESSABLE DISTRIBUTED LOGIC MEMORY WITH APPLICATIONS TO INFORMATION RETRIEVAL. C. Lee and M. Paull. Bell Labs. (Proceedings of the IEEE, Volume 52, March 1964, p. 312L)

The relationship between the authors' paper (Proc. IEEE, Vol. 51, pp. 924-932, June, 1963) and the work of S. Unger (Proc. IRE, Vol. 46, pp. 1744-1750, October, 1958) is pointed out. An aspect of the apparatus described by the authors that resembles one of the Unger's ideas is the concept of controlling a regular array of identical modules containing logic and memory with a sequence of orders issued from a central controller.

65. A CONTENT ADDRESSABLE DISTRIBUTED LOGIC MEMORY WITH APPLICATIONS TO INFORMATION RETRIEVAL. E. Spiegelthal. C.E.I.R. (Proceedings of the IEEE, Volume 52, January 1964, p. 74(L))

Several modifications are proposed for the string-processing programs presented by CY. Lee and M.C. Paull (Proc. of IEEE, Vol. 51, pp. 924-932, June 1963). In the retrieval programs: all three possible terminal symbols should be matched for, instead of just one; only those cells lying to the left of the string just retrieved need be X-active; and, the first instruction of each program must be changed to MKAR, X, (a_2, X = 1, Y = 0). Furthermore, the multiple-match flip-flop can be used to determine whether a string is the final matching one in cell memory.

66. CONTENT-ADDRESSABLE MEMORY SYSTEMS. R.H. Fuller. (University of California, Contract Nonr-23352, Report No. 63-25, June 1963, 549 p.) AD-417 644

The utility of content-addressable memories (CAM's) within a general purpose computing system is investigated. Word cells within CAM may be addressed by the character of all or a part of the cell contents. Multimembered sets of word cells may be addressed simultaneously. The distributed logical capabilities of CAM are extended to allow simultaneous transformation of multimembered sets and to allow communication neighboring word cells. A novel set of logical and arithmetic commands is proposed for the extended CAM and algorithms are given for execution of these commands.

67. INTERCOMMUNICATING CELLS, BASIS FOR A DISTRIBUTED LOGIC COMPUTER. C.Y. Lee, Bell Telephone Laboratories, Inc., Holmdel, New Jersey. (Proceedings - Fall Joint Computer Conference 1962, p. 130-136, 10 refs.)

68. MULTILAYER ITERATIVE CIRCUIT COMPUTER. R. Gonzalez. (IEEE Transactions on Electronic Computers, Volume EC-12, Number 6, December 1963, p. 781-790)

Multilayer iterative circuit computer is described, which is capable of dealing with problems involving spatial relationships between variables, in addition to inherent multiprogramming capabilities of this type of machine organization; novel features are path-building method which retains short-time access characteristics of common bus system, specialization in functions of individual layers separating flow of control signals from flow of information, and 3-phase operation with each phase simultaneously active in each layer operating on different instructions.

69. PARALLEL NETWORK COMPUTER (SOLOMON), Solomon Breadboard Technical Report. (Westinghouse Electric Corp., Baltimore, Md., Contract AF 30(602)-2724, Report 406A2; RADC-TDR-63-261, Volume 1, April 15, 1963, 118 p., UNCLASSIFIED) X63-15317

Section 1 of the report is a brief introduction to the concept of parallel network computers. The second section is intended for the operator and programer. Section 3 describes the logical and circuit design of the breadboard system. The evaluation of the machine operation is included in Section 4. The final section contains a brief description of several problems programed for the breadboard.

70. PARALLEL NETWORK COMPUTER (SOLOMON) APPLICATIONS ANALYSES. (Westinghouse Defense and Space Center, Baltimore, Maryland, Final Report, Volume 3, WDSC-406A2, Contract AF 30(602)-2724, August, 1964, 313 pp., UNCLASSIFIED) AD 606 578

The volume presents the study of the applicability of the Solomon parallel network computer system to ten varied problem areas. The report, where possible, contrasts the running time of Solomon with the running time of a commonly-used conventionally-organized computer in the solution of each problem. The conclusions drawn indicate that the Solomon system offers speed advantages of from one to three orders of magnitude in these major data processing problem areas.

71. THE SOLOMON COMPUTER. D.L. Slotnick, et al, Westinghouse Electric Corporation, Baltimore, Md. (Workshop on Computer Organization, ed. A.A. Barnum and M.A. Knapp, Spartan Books, Washington, D.C., 1963, p. 97-107; see also, Proceedings - Fall Joint Computer Conference, 1962)

72. A STUDY OF ITERATIVE CIRCUIT COMPUTERS. FINAL REPORT, OCTOBER 1961 - DECEMBER 1963. H.L. Garner, et al, Michigan University, Ann Arbor. (Wright-Patterson AFB, Ohio, AF Avionics Lab., Contract AF 33(657)-7391, AL-TDR-64-24; AD-601 212, April 1964, 321 p.) N65-19498

This research investigated the problems and possibilities generated by the idea of a computer built as an iterative array of elementary self-contained processors. The following areas of study were treated in detail: (1) programming aspects--decomposition of a program to obtain maximum concurrency, a translation algorithm to facilitate programing, and algorithms for path-building; (2) proposed organisations--a multilayer computer, and an iterative circuit computer with n-dimensional geometry; (3) statistical evaluation of accessiblity for different geometrical structures; (4) reliability problems and new possibilities; (5) a theoretical model, linking the iterative circuit computer structure to that of an n-head automaton.

73. STUDY TO DETERMINE THE APPLICABILITY OF THE SOLOMON COMPUTER TO COMMAND AND CONTROL, VOLUME I. INFORMATION STORAGE, RETRIEVAL AND COMMUNICATION SYSTEM CONTROL. F.M. Rybak. (Westinghouse Electric Corp., Baltimore, Md., Contract No. AF 19(628)-2846, Final Report Number ESD-TDR64-184, Volume 1, October 1964, 194 p., UNCLASSIFIED) AD-454-765

During an 8-month's study, research was performed to determine the applicability of the Solomon I computer, a highly parallel, network organized machine, to processing functions encountered in command and control systems. To illustrate the potential of parallel organized computers, especially Solomon I, in command and control systems, specific application examples are provided. It is concluded that computers employing the organizational concepts of Solomon I can yield speed advantages over conventional sequential machines, of up to several hundred times. In addition, application of redundancy to the basic Solomon I system can yield substantial reliability and cost advantages over conventional duplex configurations for critical command and control functions.

74. STUDY TO DETERMINE THE APPLICABILITY OF THE SOLOMON COMPUTER TO COMMAND AND CONTROL, VOLUME IV, SUMMARY. F. M. Rybak. (Westinghouse Electric Corp., Baltimore, Md., Contract AF 19(628)-2846, Final Report, ESD-TDR64-184, Volume 4, October 1964, UNCLASSIFIED) AD-450 214

During an 8-month's study, research was performed to determine the applicability of the Solomon I computer, a highly parallel, network organized machine, to processing functions encountered in command and control systems, Specific tasks pursued were: (1) investigation into the benefits to be gained in information storage and retrieval systems through file maintenance and search with Solomon I, (2) consideration of the control of large communication networks through real-time simulation on Solomon I, and (3) study of the control and processing functions in radar sensor subsystems as well as in radar oriented weapons control systems.

It is concluded that computers employing the organizational concepts of Solomon I can yield speed advantages over conventional sequential machines, of up to several hundred times. Application of redundancy to the basic Solomon I system can yield substantial reliability and cost advantages over conventional duplex configurations forcritical command and control functions.

75. A UNIVERSAL COMPUTER CAPABLEOF EXECUTING AN ARBITRARY NUMBER OF SUB-PROGRAMS SIMULTANEOUSLY. John Holland, University of Michigan, Ann Arbor, Michigan. (1959 Proceedings of the Eastern Joint Computer Conference, p. 108-113)

SPACE MISSIONS AND SPACEBORNE PROCESSING

76. ADAPTION FOR SPACE VEHICLES THROUGH ON-BOARD DIGITAL COMPUTER CONTROL. A.S. Buchman, et al. (RCA Defense Electronic Products, Burlington, Massachusetts, Final Report for March 1963-March 1964, April, 1964, 309 pp., UNCLASSIFIED) AD 602 608

Space mission effectiveness can be increased by providing vehicles with the ability to adapt to equipment failures and to unexpected events. The characteristic of adaptiveness can be incorporated into a vehicle through proper organization of data/command flow combined with preplanning of responses to abnormal situations. The study has verified that these functions can be implemented in an on-board digital computer-controller. Concepts and terminology, system organization, methodology and measures of effectiveness were developed and applied to two model missions.

77. AEROSPACE COMPUTERS DO MORE AND MORE. W.L. Still, Deco Electronics, Inc. (Control Engineering, Volume 13, Number 2, February 1966, p. 61-65)

Computers have long established a primary role in aerospace vehicles. The trend is to absorb more vehicle and mission functions into the computer. It begins with aircraft avionics and is accelerated by control problems in missiles and space vehicles. The optimistically predicted shoe-box size universal computer, which would be common to all vehicles and all missions by change of programming and peripherals, has not come to pass. Nor is it likely. The luxury of overdesign inevitable in a universal computer cannot be achieved while specialized vehicle and mission requirements are outstripping even the fantastic developments in computer miniaturization.

78. BALLISTIC MISSILE AND SPACE TECHNOLOGY. VOLUME I. BIOASTRONAUTICS AND ELECTRONICS, AND INVITED ADDRESSES. (TRW Space Technology Labs., Los Angeles, California, UNCLASSIFIED) AD 255 320

For reference only. DDC does not supply copies.

DESCRIPTORS: *Astronautics, *Space Flight, *Symposia, Communication Systems, Computers, Data Processing Systems, Guided Missiles, Inertial Guidance, Telemeter Systems.

79. CIRCUITS AND CIRCUIT TESTING FOR SPACEBORNE REDUNDANT DIGITAL SYSTEMS. H. Brinker and A.R. Helland. (Westinghouse Electric Corp., Baltimore, Md., Contract NASw-572, NASA-CR-55424, Special Technical Report No. 3, September 1963, 92 p., UNCLASSIFIED) X65-20762 see also X64-12004

This report describes the results of the study on the implementation of majority logic redundancy. Most of the work concerns spaceborne systems, but some portions are more applicable to ground support equipment. The report is concerned with the initial design of the system as well as the testing of redundant systems. The possible use of magnetic logic to reduce the total power consumption and provide non-volatile storage is discussed. Several methods of testing redundant systems are discussed and described in the section on detection and location of failures. Various solutions to the failure detection problem are discussed in this section.

80. DESIGN CONCEPTSOF THE APOLLO GUIDANCE COMPUTER. A. Hopkins. (M.I.T., Cambridge Instrumentation Lab., NASA Contrac NAS9-152; NASA CR-52555, R-408, June 1963, 41 p., UNCLASSIFIED) X64-10233

NOTICE: Available to NASA Offices, NASA Centers and NASA Contractors only.

After a brief review of the nature and history of digital computers, the design and use of the Apollo Guidance Computer (AGC) are discussed. To ensure both reliability and flexibility, three types of memory circuits are being incorporated in the AGC: (1) a permanent-storage memory which is indestructible short of actual mechanical damage, but which requires a new memory module to be built when a change in the stored information is required; (2) a temporary-storage memory for data that must be changed during in-flight computations, which is designed on the rope principle so that the information cannot be changed electrically; and (3) a temporary or erasable memory which operates at mircosecond speeds. The instructions, increments and interrupts, and inputs and outputs of this system are described.

81. EXTENDED APOLLO SYSTEMS UTILIZATION STUDY, APOLLO X. VOLUME 16: GUIDANCE COMPUTER. (Raytheon Co., Sudbury, Mass., Contract NAS9-3140, Report Numbers NASA-CR-57365; SID-64-1860-16; FR-41-507, Final Report, 16 November 1964, 93 p., CONFIDENTIAL) X65-13436

Classified Abstract

82. INDEX TO AEROSPACE CORPORATION REPORTS, PART I. CONTRACT-GENERATED REPORTS. B. Griffie. (Aerospace Corporation, Los Angeles, California, January, 1963, 59 pp., UNCLASSIFIED) AD 459 804

This publication reflects all aerospace corporation contractual reports indexed to date. The entries in this index are arranged alphabetically by title within general subject categories. Multiple indexes have been provided to assist the user in locating desired information. The cross-reference indexes permit the user to locate documents by primary or secondary report numbers, personal authors, or by specific subjects.

83. PROJECT GEMINI DIGITAL COMPUTER/DATA TRANSMISSION SYSTEM INTERFACE CHARACTERISTICS. G.G. Hayward. (McDonnell Aircraft Corp., St. Louis, Mo., Contract NAS9-170, Report Number NASA-CR-67834, 10 September 1964, 13 p., UNCLASSIFIED) X65-21159

The characteristics of the interface between the Gemini digital computer and the data transmission system are described. There are two signal inputs from the data transmission system to the digital computer; the request signal and the sync-signal. Characteristics of these signals and pulses are prescribed and the circuitry is diagrammed.

84. PROJECT GEMINI DIGITAL COMPUTER SYSTEM--GEMINI LAUNCH VEHICLE INTERFACE CHARACTERISTICS. R.E. Schulz. (McDonnell Aircraft Corp., St. Louis, Mo., Contract NAS9-170, Report Number NASA-CR-67836, 6 July 1964, 11 p., UNCLASSIFIED) X65-21158

The characteristics of the interface between the spacecraft digital computer and the Gemini launch vehicle (GLV) are described. There are five inputs from the computer to the GLV second stage engine cutoff, stage I autopilot gain change discrete, pitch attitude error, yaw attitude error, and roll attitude error. The one input from the GLV to the computer is the backup guidance fade-in discrete. The interface circuitry is shown, and the characteristics of each of the input signals are given in detail.

85. PULSED RADIATION EFFECTS ON AEROSPACE DIGITAL COMPUTERS. (IBM, Owego, N. Y., Kirtland AFB, New Mexico, Contract AF29(601)-5399, RTD-TDR-63-3051; AD-423083, October 1963, 223 p.) N65-10336

The test objectives were to observe and analyze the behavior of components and circuits used in aerospace digital computers during short, high-intensity, nuclear radiation pulses. Several types of burst sensors are compared, and the dosimetry for both the SPRF and flash X-ray radiation environments is discussed in detail.

86. RADIATION-RESISTANT COMPUTER FEASIBILITY STUDY. FINAL REPORT, 1 JULY 1961 - 31 AUGUST 1962. (IBM, Owego, N. Y.; Wright-Patterson AFB, Ohio, AF Avionics Lab., Contract AF 33(657)-7475, ASD-TDR-63-161, Volume 1; AD-449 682, Report No. 63-928-13, July 1964, 273 p., OFFICIAL USE ONLY) X65-20370

Design specifications for a high speed, low power, radiation resistant aerospace computer are summarized. Areas covered in this feasibility study include: materials and components, circuits, magnetic core memory, structures, logic and machine organization, skeletal laboratory breadboard model description, radiation effects studies, and I/O circuits and components.

87. ROCKET TELEMETRY AND SPACE ELECTRONICS. A BIBLIOGRAPHY. A.V. Aho. (National Research Council,of Canada, Ottacal Engineering, UNCLASSIFIED) AD 286 789

CONTENTS: Antennas communication and propagation communication and multiplexing components data handling guidance and control; Space navigation instrumentation packaging techniques ranging and tracking reliability telemetering techniques telemetry systems.

88. SPACECRAFT DIGITAL COMPUTER SYSTEMS COMPONENTS RESEARCH. J.V. Christensen and G.R. Marchant, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California, (NASA, Wash., D.C., Intercenter Technical Conference on Control, Guidance and Navigation Research for Manned Lunar Missions, Ames Research Center, July 24-25, 1962 (U) (Confidential Report) p. 456-463, UNCLASSIFIED) X63-14597

A small digital computer system is being procured to provide a laboratory capability for investigating spacecraft computer requirements and subsystem integration requirements as related to the navigation and guidance of lunar spacecraft. This system will allow analysis of computer requirements such as speed, accuracy, memory, logic, and mathematical techniques which are basic to the design, selection, and integration of the hardware. It will also allow analysis of the computation and interface requirements with respect to such subsystems as the space sextant, inertial measuring unit, pilot's control, and pilot's display. This laboratory will be easily expandable to provide a capability of investigating all computation and input-output required by a complete onboard guidance and navigation system.

TIME-SHARING AND MULTIPROCESSING MULTICOMPUTER

89. ADVANCED PROGRAMMING DEVELOPMENTS: A SURVEY. (Electronic Systems Div., Bedford, Mass., Prepared jointly with Computer Associates, Inc., ESD-TDR-65-171; AD-614 704, February 1965, 108 p.) N65-27316

This document constitutes a representative survey of twenty computer software systems which have been developed within the last decade. The surveyed systems have been grouped into six major categories: (1) general purpose programming and executive systems; (2) functional systems; (3) man-machine interface systems; (4) special purpose programming systems; (5) time-sharing systems; (6) generalized data management systems.

90. ANALYSIS OF A BASIC QUEUING PROBLEM ARISING IN COMPUTER SYSTEMS. P.E. Boudreau and M. Kac. IBM Production Devlopment Lab. (IBM Journal of Research and Development, Volume 5, April 1961, pp. 132-140)

A model which describes a basic junction, or queuing structure, arising in a general computing system is subjected to a mathematical analysis. The results consist of several formulas describing the performance of various parts of the system. The feasibility of analyzing general queuing problems in this manner is stated, together with the results of a Monte Carlo simulation used for comparison purposes.

91. ANALYSIS OF COMPUTING-LOAD ASSIGNMENT IN MULTI-PROCESSOR COMPUTER. M. Aoki, et al. (American Federation of Information Processing Society (AFIPS)--Joint Computer Conference, Volume 24, Fall 1963, p. 147-160)

Computer system with 2 processing units is analyzed; certain amounts of information move from processor 1 to processor 2; effectiveness of algorithm for work load assignment, which determines amount of information transfer between processing units, is investigated; criterion of system performance is taken to be expected time required to complete given task.

92. AN/FSQ-27 POLYMORPHIC DATA PROCESSING SYSTEM STUDIES. (Rome Air Development Center, Griffiss AFB, New York, C24-2U4, Contract AF 30(602)-1814, January, 1962, UNCLASSIFIED) AD 274 550

A definitive record of work performed in the exploitation of multiple computer concepts embodied in the AN/FSQ-27 data processing central is given.

93. AN ARCHITECTURAL STUDY FOR A SELF-REPAIRING COMPUTER. P.W. Agnew, etal. (International Business Machines Corp., Rockville, Md., Contract AF04(695)-769, SSD TR-65-159, Final Technical Documentary Report 3 May - 1 November 1965, Report No. 65-928-91, November 1965, 214 p., UNCLASSIFIED) AD-474 976

This report presents the work resulting from Phase I of an Architectural Study for a Self-repairing Computer. In particular, the technique of "partitioning" was investigated as a means for achieving a computer capable of self-repair. Partitioning is the technique of essentially dividing a computer into diagnostic subsystems. Design of a hypothetical (but realistic) aerospace computer is given. Partitioning and formation of diagnostic subsystems, including the investigation of appropriate diagnostic procedures, is described. This report shows that the partitioning technique provides the means for self-diagnosis.

94. CTSS TECHNICAL NOTES. J.H. Saltzer. (Massachusetts Institute of Technology, Cambridge, Contract Nonr-4102(01); Project MAC, MAC-TR-16; AD-612 702, 1963, 83 p.) N65-25788

The 7094 Compatible Time Sharing System in use at Project MAC and M.I.T. Computation Center is described. It is designed to acquaint a system programer with the techniques of construction which were used in this particular time-sharing system. Discussions include overall supervisor program flow, console message input and output, and scheduling and storage algorithms; a thumbnail sketch is given of each of the subroutines which make up the supervisor program. This report was prepared with the aid of the compatible time-sharing system and the TYPSET and RUNOFF commands.

95. DATA PROCESSING CENTRAL AND ELECTRONIC DATA TRANSMISSION COMMUNICATION COMPLEX INTERACTION FOR MULTIPLE COMPUTER COMPLEX. I.D. Davis and E.F. MacWilliams. (System Development Corp., Paramus, N.J., Command Control Div., Contract AF 19(628)-1648, TM-LO-918/000/00; AD-440 892, 31 December 1963, 87 p., UNCLASSIFIED) X64-15318

A compilation of Data Processing Central (DPC) and Electronic Data Transmission Communication Complex (EDTCC) interactions (with respect to computer terminology) for the Multiple Computer Complex (MCC) is presented. The following areas of interaction, involving the symbols used in intercommunication, are considered: (1) message handling, (2) display meaasage handling; (3) alert receive message handling; (4) error control between the DPC and the EDTCC; (5) DPC start-over-switchover; (6) bulk data handling; (7) simulated data handling; and (8) control of classified data.

96. ENGINEERING DESIGN ANDIMPLEMENTATION OF A MULTI-COMPUTER DATA PROCESSING SYSTEM FOR A NAVY COMMAND AND CONTROL CENTER. R.C. Gunderson and J.D. Johnson. (Seventh National Convention on Military Electronics, New York; Institute of Electrical and Electronic Engineers, 1963, p. 265-267)

The technical problems encountered in operating four CDC 1604-A and five CDC 160-A computers as a complete data processing system are described. A considerable part of the paper is devoted to the physical design of the sub-system selection switching.

97. EVALUATION OF A BUILDING-BLOCK COMPUTER SYSTEM. R.L. Ringo. (General Precision, Inc., Glendale, California, Contract No. AF 33(616)-5757, Report No. AL-TDR64-104, June 1964, 64 p., UNCLASSIFIED) AD 605 311

The report describes, briefly, the physical equipment and evaluation testing of an electronic digital computer fabricated to demonstrate the feasibility of the buildingblock computing concept, in particular, the computer is a developmental test model intended for laboratory environment, bench testing, The purpose of the evaluation was to demonstrate the feasibility of the building-block computer concept, utilizing a developmental test model of a building-block computer. The conclusion is that the computing system fulfilled the design goals and successfully proved the feasibiliby of the building-block computer concept.

98. AN EVALUATION OF THE EFFECTIVENESS OF PARALLEL PROCESSING. B. Bussell and G. Estrin, University of California, Los Angeles. (IEEE Pacific Computer Conference, Proceedings, Number T-147, 1963, p. 201-220)

A feasible control unit for parallel computation is described. This unit described was organized to implement a particular parallel form of the AD algorithm. Choice of the parallel procedure was made by timing analyses of several possible methods of computation.

99. EXECUTIVE CONTROL PROGRAM (ECP-1A) FINAL REPORT, FEBRUARY - SEPTEMBER 1964. Informatics, Inc., Sherman Oaks, California. (Griffiss AFB, New York, RADC, Contract AF 30(602)-3045, Report 4-576-2, Report Nos. RADC-TDR-64-460; AD 610 817, January 1965, 273 p.) N65-18626

The first phase of the Executive Control Program developed for the experimental computing complex is described. The complex consists of such things as multiple user consoles, multiprogramming in one computer, multicomputers, and a variety of peripheral equipment from different manufacturers, all interconnected through an electronic switching network.

100. GUS MULTICOMPUTER SYSTEM. W.F. Miller and R. Aschenbrenner. (IEEE Transactions on Electronic Computers, Volume EC-12, Number 6, December 1963, p. 671-676, 15 refs.)

GEORGE Unified System (GUS) designed and built at Argonne National Laboratory and currently being used to explore problems of multicomputer systems is described; programming systems that were developed to permit full use of multiplicity of machines in system are reviewed; input-output units are compatible with Laboratory's IBM 704 and CDC 3600 systems.

101. A MATHEMATICAL ANALYSIS OF COMPUTER TIMESHARING SYSTEMS. N. R. Patel. (Operations Research Center, M.I.T., Cambridge, Contract DA-ARO D31-124G158, Report Number AROD 968-37, July 1964, 1 p., UNCLASSIFIED) AD-605 825

Two important and popular time-sharing systems were analysed for the expected waits of requests. These were the round-robin and the dynamic-priority multiple-level systems. The round-robin is very complex in all its generality, however with the aid of a realistic simplifying assumption the desired expected waits were calculated. The round-robin under worst considtions (i.e. 'full load') was analyzed rigorously. The dynamic-priority multiple-level system considered was slightly different from the one implemented by Professor Corbato of M.I.T. Here again results were complex in general, but were derived generally nevertheless. Specialization of these results should simplify them somewhat.

102. MATHEMATICAL PROGRAMMING TECHNIQUES FOR INFORMATION SYSTEM DESIGN. U.O. Gagliardi, et al. (Dunlap and Associates Inc., Darien, Connecticut, Contract AF 19(628)-2830, July, 1964, 72 pp., UNCLASSIFIED) AD 605 826

The problem of establishing the effectiveness of an information system is considered. An effectiveness measure suggested by recent development in statistical decision theory is presented. Sample evaluations or system designs are used to illustrate here the adoption of such a measure which allows selecting the parameters of the system in a manner consistent with the user preference.

103. MICROPROGRAMMING AND STORED LOGIC. L.D. Amdahl. (Datamation, Feburary 1964, p. 24-26)

Three computers with stored logic are compared--the TRW-133, the PB 440, and the C-8401. The main program, consisting of a set of macroinstructions which are interpreted, is referred to as a calling sequence. Each call, or macroinstruction, represents data to the interpretive subroutine--it is not directly executed from the instruction register of the computer. The way in which the calling sequence is handled in each of the compared computers is described. This followed by a description of the command structures.

104. MULTIPLE COMPUTER SYSTEMS. W.A. Curtin. (Advances in Computers, Volume 4, 1963, p. 245-303, 28 refs.)

Definition is given of multiple systems and motivation for their development is outlined; significant features of systems are listed and exemplified in detail through description of hypothetical design; consideration is given to methods for scheduling programs on multiple computers; 4 existing machines, PILOT, LARC, GAMMA 60, and RW-400 are described.

105. NEW CONCEPTS IN COMPUTING SYSTEM DESIGN. G.M. Amdahl. IBM. (IRE Proceedings, Volume 50, Number 5, May 1962, p. 1073-1077)

New concepts in the design of large, high-speed digital computing systems are discussed which include multiprogramming (time-sharing) and multiprocessing (load sharing) for greater concurrent utlization of system hardware.

106. PROBLEMS OF STORAGE ALLOCATION IN A MULTI-PROCESSOR MULTIPROGRAMMED SYSTEM. R.J. Maher, Burroughs Corporation. (Communications, Association for Computing Machinery, Volume 4, October 1961, pp. 421-422)

107. SCHEDULING INDEPENDENT TASKS ON ONE OR MORE PROCESSORS. M.H. Rothkopf. (Massachusetts Institute of Technology, Cambridge, Contract No. NonR1841-87, January 1964, 110 p., UNCLASSIFIED) AD-428 857

The problem concerns the scheduling M independent, immediately available tasks on N processors. Each task has a service time and a waiting cost rate that is a function of time. There are no feasability restrictions on the order in which the tasks are to be processed. The problem is related to the job shop scheduling problem and the problem of optimally assigning priorities in a queueing system.

Several algorithms are presented for scheduling tasks with absolute deadlines on one or more processors. For certain classes of problems, the unprofitability of splitting tasks in time or between processors is proved. Scheduling when service times and cost rates are known only stochastically is discussed.

108. SIMULATION OF A TIME-SHARING SYSTEM. G.H. Fine and P. V. McIsaac, System Development Corp., Santa Monica, California. (Presented at the Institute of Management Science Meeting (TIMS), San Francisco, 3-5 February 1965, Contract ARPA SD-97, Report Nos. SP-1909; AD-611 868) N65-22422

The paper describes the use of simulation techniques in the analysis of time-share system operation. The purpose and goals of this research effort are briefly outlined and some comments on the advantages and disadvantages of direct simulation for this type of work are given. The existing simulator models are described in terms of inputs, general flow, and outputs; and the results of initial investigations with these models are given. Work currently in progress is discussed, and some related problems that may possibly be studied in the future by similar methods are noted.

109. SIMULTANEOUS MULTIPROGRAMMING OF ELECTRONIC COMPUTERS. J.L. McKenney. (University of California, Los Angeles, Contract Nonr-233(02), Research Report No. 69, February 1961, 221 p.) AD 252 957

Certain aspects of parallel processing are studied. An estimate of the economic implications of parallel processing compared to serial processing is made. Parallel processing is defined as the simultaneous operation of several components of a system processing two or more different jobs.

110. SPACEBORNE MULTIPROCESSING STUDY. (Autonetics, Division of North American Aviation, Inc., Report Number T5-2255/33, 14 December 1965)

The purpose of this study is to objectively evaluate the multiprocessing approaches available and to define the multiprocessing concept which will provide a basis and goals for future spaceborne computer development.

111. A STUDY OF INFORMATION FLOW IN MULTIPLE-COMPUTER AND MULTIPLE-CONSOLE DATA PROCESSING SYSTEMS. V.L. Wallace, et al. (Cooley Electronics Lab., University of Michigan, Ann Arbor, Final Report, RADC TDR64-427, Contract AF 30(602)-2661, August 1964, UNCLASSIFIED) AD 460 815

Multidimensional markovian and regenerative stochastic classes of mathematical models are used to represent traffic in multi-computer and multi-console data processing systems. Solution methods for numerically determining the limiting state probabilities and other statistical measures of the markovian models are described and illustrated. A measure of the advantage of numerical solution over simulation is derived. The problem of optimum scheduling of shared computer systems is discussed, and a solution involving price-market control is offered.

112. SYSTEM REQUIREMENTS FOR MULTIPLE ACCESS, TIME-SHARED COMPUTERS. F.J. Corbato. (Massachusetts Institute of Technology, Cambridge, Contrac NonR4102-01, Report No. MAC-TR-3, 1964, 14 p., UNCLASSIFIED) AD 608 501

Relocation examples and solutions were elaborated in considerable detail to expose the reader to the difficulties encountered with contemporary machines when multiple user multiple-processor systems are considered. The fact that each program may perform unexpectedly, even to the user, demands that running programs be able to be moved as well as to grow and to shrink. As man-machine interaction becomes faster, each program task becomes more intimately connected with secondary storage and with common subprograms; thus effective multi-programming is essential for efficient use of a multiple access computer system.

113. TIME-SHARING COMPUTERS. (Electronics, Volume 38, November 29, 1965, p. 71-89)

114. TIME SHARING ON LEO III. J.W. Lewis. (Computer Journal, Volume 6, Number 1, April 1963, p. 24-28, 33-36)

Method is described by means of which time sharing is organized, and how more than nominal 100% efficiency can be obtained from computer when operating 2,3 or more programs on time sharing basis.

115. TIME-SHARING SYSTEMS: REAL AND IDEAL. L. Gallenson and C. Weissman. (System Development Corp., Santa Monica, California, Conference on the Impact of Batch Fabrication on Future Computers, Los Angeles, 6-8 April 1965, Contract ARPA SD-97, SP-1872; AD-612 940, 11 March 1965, 22 p.) N65-26094

To aid in future design for large-scale, general-purpose time-sharing systems, an appraisal of the existing time-sharing system showed that improvements for increased user satisfaction can be made in continuity of system operation, responsiveness of the system to interrogation, and accessibility to users programing through many different languages and at input-output consoles located remote fromthe computer.

An ideal time-sharing system for the late 1960's is derived to service double or triple the number of users and to allow user programs to be three times as large as current programs. Remote input-output keyboards dand display consoles using electroluminescent panels are also discussed.