ADVANCED RESEARCH PROJECTS AGENCY

April 15, 1963

MEMO FOR   ~~Mr. Hessely~~

~~Mr. Godel~~ *[handwritten]*

Dr. Herzfeld *[handwritten]*

Dr. Ruina *[handwritten]*

Dr. Ruina has seen [handwritten]

This new ARPA Order No. 471 requests the Director of Administrative Services Division to award two information processing contracts as follows:

a. Univ. of Calif. (Los Angeles)

> 3 Years   Computer network and
> time-sharing research
> $675, 000

b. Univ. of Calif. (Berkeley)

> 3 Years   Remote stations and
> programs for computer
> network
> $797, 000

These new contracts put Dr. Licklider $666, 000 over his FY 63 program in information processing. This amount plus an additional $200, 000 to support another prospective new requirement in the month of May has been transferred into his program from AGILE.

H. Test

ARPA Order No. 471
Program Code No. 3880
Industrial Priority Rating: DO

MAY 3   1963_____Date

TO: Director
Administrative Services Division
Office of the Secretary of Defense

1.   You are requested to initiate two new contracts under this ARPA Order as follows:

Task No. 1 - Award a 3-year contract to the University of California (Los Angeles) for computer network and time-sharing research.   The cost of this contract will not exceed $675,000.   The work statement will read as follows:

a.   The contractor will conduct research on computer network problems and computer time-sharing problems.   This research will include:

(1) Identification of problems.

(2) Development of computer programming, control and monitoring languages to facilitate effective interaction between the users and the network of computers.

(3) Development of computer programs to govern interactions of computers and other devices in a network, compile and/or interpret statements in the aforementioned languages, to govern the sharing of time of computers in the network among several or many remote users, and to facilitate the programming, editing, correcting, and operation of computer programs.

b. This research will be conducted with the aid of the network of computers and telecommunication devices (or major subsets thereof) operated by the Western Data Processing Center and, in addition, with the aid of interconnections between WDPC's network and the AN/FSQ-32 Computer in Santa Monica, California, and such other computers netted with the AN/FSQ-32 as shall be deemed useful in identification or solution of network and time-sharing problems. Insofar as is feasible within the constraints of time and funds, and contributory toward the identification and solution of network and time-sharing problems, the contractor will cooperate with other organizations engaged in research under support from the Advanced Research Projects Agency to promote language and format compatibility and to optimize allocation and scheduling of computer facilities.

c. The research described in the foregoing subparagraphs will be conducted during a period of three years beginning June 1, 1963.

Task No. 2 - Award a 3-year contract to the University of California (Berkeley) for a program of research on remote stations and programs for computer networks. The cost of this contract will not exceed $797,000. The statement of work will read as follows:

a. The contractor will supply the materials and services required to install a remote station, on the Berkeley campus with a patch panel at the Berkeley Computer Center connected by data link to the AN/FSQ-32 computer in the Los Angeles area. Provision will be made on the patch panel for a link (suitable for future implementation) to Stanford University. In addition, the contractor will provide the materials and services to augment the 7090 computer at Berkeley and to adapt it for the time-sharing operation, and to add, to the netted 7090 and AN/FSQ-32 computers, a small- or middle-scale satellite computer, capable of operating teletype and display units.

b. With the aid of existing information-processing equipment and the augmentations mentioned in the preceding paragraph, the contractor will conduct research and effect developments in computer-language design, heuristic programming, man-computer interaction, and command information processing. The research and development will be designed to identify and solve problems that arise in the interaction of netted computers operated in part from remote stations. In this work, advantage will be taken, not only of the netted computers already mentioned but also of one or more other digital computers, on the Berkeley campus, that will be integrated into the system. Throughout the program, efforts will be made to improve the efficiency with which the preparation of large computer programs can be accomplished.

c. The contractor will supply the materials and services necessary to bring into operation three complex input-output stations, including teletype and display units. One of these will be used mainly in computer language research, a second mainly in heuristic programming, and a third in exploration of a variety of remote-station applications.

2. This Order makes available $1,472,000 under appropriation and account symbol "97X0400.1311 Research, Development, Test, and Evaluation, Defense Agencies," for obligation by OSD on behalf of the Advanced Research Projects Agency, only for purposes necessary to accomplish the work specified herein. These funds are immediately available for direct obligation. The funds made available herein are not for the construction of facilities.

3. It is requested that the Advanced Research Projects Agency be kept informed of the status of work under this Order by a semiannual technical summary report and a quarterly letter report. These reports will be prepared and submitted in accordance with Items I-C and II-B contained in the attachment to ARPA Memorandum of January 23, 1963, Subject: ARPA Orders - General Requirements. In addition, technical papers or reports will be published by the contractor whenever warranted by accomplishments of interest to other researchers in the field. Each such report should be published in a recognized technical journal and should include, in addition to title and abstract carefully formulated to

facilitate information retrieval, a brief characterization of content (a series of descriptors) designed specifically for use in information retrieval. Informal reporting such as through early distribution of mimeographed copies, is at the contractor's option.

4. The General Requirements as stated in the attachment to the above-referenced ARPA Memorandum of January 28, 1963, are included in this ARPA Order by reference, with the exception of paragraph 2.

5. The Director of ARPA or his designated representative will provide the necessary over-all policy and technical guidance for the work. You are responsible for arranging the detailed administrative direction necessary to accomplish the objectives of the ARPA Order and to comply with the management and technical guidance provided.

/S/

J. P. Ruina
Director

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ADVANCED RESEARCH PROJECTS AGENCY
Washington 25, D. C.

Case No 526
AC#471

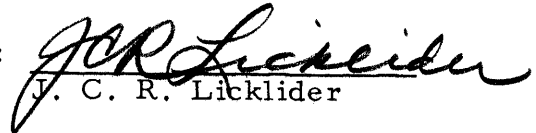Program Plan No. 93

Date: April 5, 1963

Program Title :   COMPUTER NETWORK
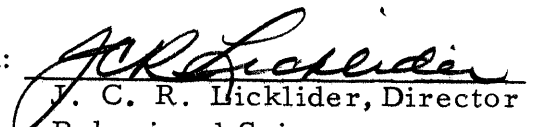AND
TIME-SHARING RESEARCH

Contractor   :   UNIVERSITY OF CALIFORNIA (Los Angeles)

Project from which Funded: Command & Control Research (8800)

Prepared by :   *[signature]*
J. C. R. Licklider

Concurred in: *[signature]*
J. C. R. Licklider, Director
Behavioral Sciences
Command & Control Research

Approved by :   *[signature]*
J. P. Ruina
Director

Date   :   _____

Type of Work: Basic Research

Field of Work: Informational Sciences

ARPA Control No. 2653

COMPUTER NETWORK AND TIME-SHARING RESEARCH

A. Objective of the Program

The objective of this program is to identify and solve problems that arise when a number of digital computers, some of them remote from others, are operated together in a network, and when the information-processing capabilities of a network of computers are distributed among several or many users operating at consoles, some of which are remote from the computers. Among the problems that are expected to arise are: dynamic memory allocation, language compatibility, format compatibility, use of common files by several operators (some of whom may change the content of files being used by others), telecommunication over channels of restricted information-handling capability, priority assignment, record keeping, and incremental compilation (not requiring recompilation of statements not affected by the program increment). It would not be reasonable to say that the objective is to solve all those problems, or to say that those are the only problems. The object, basically, is to gain experience in the use of computer networks, including time-shared computer networks, to identify problems such as those listed and to devise solutions to as many of them as possible.

B. Technical Need for Program

The technical need for the proposed research stems from the fact that computer networks, including time-shared computer networks, in a very few years will be operating in important defense systems, that the fund of technical knowledge and techniques relevant to the operation of such systems is grossly inadequate and that several of the problems that are sure to arise demand fundamental research of a synthesizing and problem-solving nature that can best be done in a university environment in which there is a vigorous, on-going interest in computer network, language, communication and utilization problems.

C. Relevance to ARPA Mission

The computer network problem and the computer time-sharing problem are two of the most crucial, if not the most crucial, information-processing problems in the field of command and control--which it is ARPA's mission to advance. In particular, the National Military Command System will have interfaces with command and control systems operated by unified and specified commands, and by other agencies and organizations. At first, some of these interfaces and, in due course, most of these interfaces, will involve computer-computer communication. As soon as time-sharing techniques have been developed to the point at which they can be used effectively, they will in all probability be incorporated into some of the command-control systems. It is essential to develop a body of experience, knowledge and techniques to pave the way for these events.

D. Background

The Western Data Processing Center, from which an unsolicited and informal letter proposal was received on March 20, 1963, serves the University of California at Los Angeles and a large group (more than 30) of participating institutions, with six of which it has teleprocessing interconnections (Dataphone). Five additions to the network are expected during the next few months.

Several commercial organizations (e.g., Westinghouse) have computers in geographically separated plants, and use digital telecommunications to transfer information from one of their computers to another in the interest of efficient data processing. Computer telecommunication networks are used in airline ticketing. The Thompson-Ramo-Wooldridge Polymorphic system involves a network of small computers. Many systems use two computers, back-to-back, in the interest of reliability. Many organizations have two or more computers in one location that communicate with one another. All of the foregoing provide some experience in the handling of computer networks. However, in none of the cases mentioned is the problem anything like it will be when several or many computers in a network are engaged in their own individual activities and, at the same time, placing demands upon one another for information and for allocations of processing capability.

The situation is a little better when it comes to the time-sharing of the capability of a single digital computer. Rudimentary time-sharing systems

are in operation at MIT, Bolt Beranek & Newman, Inc., and Carnegie Institute of Technology. These systems all make use of program-interrupt or sequence-break techniques, and at least the first two are true, sensibly simultaneous, time-sharing systems. "Multiprogramming" which introduces some of the problems of time sharing, has fairly wide spread use in university and industrial computing. Many systems, even as old as the Sage System, employ a kind of round-robin technique to permit a single computer to react to inputs from, and supply information to, several or many operators. However, even in the time sharing of a single digital computer, techniques that provide great flexibility and permit each of a number of remote users to work with unconstrained initiative--even when a single computer is involved, such systems are on the research frontier. ARPA has contracts at Carnegie Institute of Technology and System Development Corporation, and is negotiating a contract with the Massachusetts Institute of Technology, to advance the art and develop effective systems. Time sharing in coordination with computer network intercommunication--the subject of the proposed work--is truly on the far research frontier.

E. Statement of Work

The contractor will conduct research on computer network problems and computer time-sharing problems. This research will include:

1. Identification of problems.

2. Development of computer programming, control and monitoring languages to facilitate effective interaction between the users and the network of computers.

3. Development of computer programs to govern interactions of computers and other devices in a network, compile and/or interpret statements in the aforementioned languages, to govern the sharing of time of computers in the network among several or many remote users, and to facilitate the programming, editing, correcting, and operation of computer programs.

This research will be conducted with the aid of the network of computers and telecommunication devices (or major subsets thereof) operated by the Western Data Processing Center and, in addition, with the aid of interconnections between WDPC's network and the AN/FSQ-32 Computer in Santa Monica, California, and such other computers netted with the AN/FSQ-32 as shall be deemed useful in identification or solution of network and time-sharing problems.

Insofar as is feasible within the constraints of time and funds, and contributory toward the identification and solution of network and time-sharing problems, the contractor will cooperate with other organizations engaged in research under support from the Advanced Research Projects Agency to promote language and format compatibility and to optimize allocation and scheduling of computer facilities.

The research described in the foregoing paragraphs will be conducted during a period of three years beginning 1 June 1963.

F. Administrative Considerations

1. Level of Effort and Time to Complete

The level of effort is $225,000 per year. The present funding, from FY 1963 funds, should be $675,000 for three years. The best present estimate is that the program will continue for a total of six years. It is viewed as a long-term program because it is evident that advanced problems will be encountered as presently visible ones are clearly formulated and solved.

2. Cost by Year

The cost will be approximately $225,000 per year for the first three years. The cost beyond the first three years cannot now be foreseen accurately.

Inasmuch as the Western Data Processing Center has its own computing equipment and has plans for obtaining such additional equipment as will be necessary to keep its facility up to date, the main items of cost are salaries, overhead, interconnection with the AN/FSQ-32 Computer and miscellaneous. An estimated break down of the $225,000 budget (first year) follows:

Salaries at Western Data Processing Ctr, UCLA	$ 88,000
Salaries at Health Sciences Computing Facility	24,000
Salaries at UCLA Computing Facility	20,000
Total Salaries	$132,000
Overhead	44,000
Intercommunication with AN/FSQ-32 Computer	27,000

Miscellaneous (travel, computer supplies, publications, telephones, desks, etc.)	$ 22,000
Total	$225,000

3. Source of Funds within Project Budget

This program should be funded from FY 1963 funds of the ARPA Command-Control Research Project (8800).

4. Reporting Requirements

Management Letter Reports, including significant management information such as funding status, management problems, and assignment of new personnel, will be submitted quarterly. Brief Technical Progress Reports, summarizing technical accomplishments and difficulties, will be submitted semi-annually. In addition, Technical Reports should be issued whenever warranted by accomplishments of interest to others engaged in research, development or application in the field of the project. Each such Technical Report should be published in a recognized technical journal and should include in addition to title and abstract carefully formulated to facilitate information retrieval, a brief characterization of content (e.g., a series of descriptors) designed specifically for use in semi-automated information retrieval. Informal reporting, as through early distribution of mimeographed copies, is at the contractor's option.

5. Contractor and Selection Justification

The University of California (Los Angeles) is selected as the sole source for the particular research described in this plan. Other contractors will make related and coordinated contribution to the solution of the overall problem. UCLA is selected for this particular work.

(a) because UCLA has unique experience in the operation of a computer service network based on digital intercommunication,

(b) because UCLA has outstanding capability in the design of executive and monitoring programs to manage the interactions of the several computers in a network,

(c) because UCLA's three foci activity in digital computation offer a favorable context for the development of computer-network techniques, and

(d) because UCLA is favorably located with respect to the AN/FSQ-32 Computer in Santa Monica. Whereas other organizations will be able to make significant contributions in the development of time-sharing and computer-network techniques relevant to command-control computer networks, UCLA has a unique capability to handle the broad range of such problems.

6. Agent

The agent should be the Office of the Secretary of Defense. This contract is one of the group of contracts under the heading, California Computer Network. It is appropriate for all these contracts to be handled through the same agent.

7. Special Considerations

As indicated in the estimated cost break down, three sub-divisions of UCLA figure in the proposed contract. Overall management for the contractor will be provided by the Western Data Processing Center. The Health Sciences Computing Facility and the UCLA Computing Facility will operate computers and input-output stations in the network and participate in the solution of computer-organization, programming and man-computer interface problems. Elements of the Western Data Processing Center's remote network are expected to provide realistic loading and exercise, but are not, at the present time, seen as contributing directly to the problem-solving and programming efforts.

The communication link between UCLA's network and the AN/FSQ-32 Computer in Santa Monica will be handled, at first, by Dataphone, but it appears likely that a link with higher capability will be required in due course. Requirements for the advanced link will be determined by experience gained during the initial part of the program. The link may require additional funding in FY 1964.

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This contract and all reports and papers produced thereform should be UNCLASSIFIED.

JCRL:rs

ADVANCED RESEARCH PROJECTS AGENCY
Washington 25, D. C.

Case No 526
AO#471

Program Plan No. 95

Date :   April 5, 1963

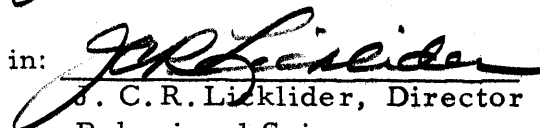Program Title :   REMOTE STATIONS AND PROGRAMS
FOR
COMPUTER NETWORK

Contractor   :   UNIVERSITY OF CALIFORNIA (Berkeley)

Project from which Funded: Command & Control Research (8800)

Prepared by: *[signature]*
J. C. R. Licklider

Concurred in: *[signature]*
J. C. R. Licklider, Director
Behavioral Sciences
Command & Control Research

Approved by :   *[signature]*
J. P. Ruina
Director

Date   :   _____

Type of Work: Basic Research

Field of Work: Informational Sciences

ARPA Control No. 2780

ADVANCED RESEARCH PROJECTS AGENCY
Washington 25, D. C.

Program Plan No. 95

April 5, 1963

REMOTE STATIONS & PROGRAMS FOR COMPUTER NETWORK

A. Objective of the Program

The main objective of this program is to contribute to the solution of a complex of problems that arise in on-line use of netted computers from remote control and display stations. These problems concern the control, by executive, managerial, and monitoring routines, of the operation of the computer network, the design of remote stations and working procedures for them, and the economical preparation of very large computer programs. The present contractor will work with other contractors toward the accomplishment of those objectives. Specific objectives to be achieved by the present contractors include the establishment of effective intercommunication between a 7090 computer and its satellites in Berkeley and the AN/FSQ-32 computer and its satellites in the Los Angeles area, the development of techniques and programs that will permit operational access to the resulting complex from three separate locations on the Berkeley campus, and the development of programming-language and compiler techniques that will make it possible to prepare and test computer programs on the 7090 and Q-32 computers from remote stations during intervals in which the computers are operating, also, upon other programs, controlled either from remote stations or from the computer centers.

B. Technical Need for the Program

The technical need for this program stems from the fact that computer networks are fast approaching a stage of great operational importance while the "software" technology--the technology of computer programs, managerial techniques, and operational doctrine--remains primitive and incapable of supporting the required applications. The cost of the development of programs for ordinary computers to handle relatively simple problems has been found extremely expensive and slow. There is a widely appreciated need to decrease the cost and to increase the speed of programming, and at the same

time there is an evident requirement to move into areas of more complex computer application in which the problems of programming and control will be more difficult. The need is doubly great, therefore, to conduct a vigorous program of exploratory research to identify and formulate the critical problems and to find effective solutions to them.

C. Relevance to ARPA Mission

A proposed program in support of the ARPA mission in Command and Control Research. In particular, it is relevant to the ARPA objectives in the problem areas: computer networks, heuristic programming, on-line programming, and programming languages and systems.

D. Background

This work is closely related to, and will be coordinated with, the proposed program at UCLA and the on-going work at the System Development Corporation. It is relevant, also, to ARPA-supported research at Carnegie Institute of Technology, Massachusetts Institute of Technology, Information International, Inc., Stanford Research Institute, and Stanford University. There is a more distant relation to work supported by the Air Force at the Mitre Corporation and at the Ohio State University Research Foundation.

ARPA-supported research in the topics listed above is coordinated through frequent visits and communications with and among the contractors, and through an informal technical group consisting of leading members of the contractor teams. The proposed program at Berkeley is supplementary to the other ARPA-supported efforts and is designed to mesh with them in such a way as to accelerate the solution of problems already formulated and the identification and solution of further problems that are sure to arise.

E. Statement of Work

The contractor will supply the materials and services required to install a remote station, on the Berkeley campus with a patch panel at the Berkeley Computer Center connected by data link to the AN/FSQ-32 computer in the Los Angeles area. Provision will be made on the patch panel for a link (suitable for future implementation) to Stanford University. In addition, the contractor will provide the materials and services to augment the 7090 computer at Berkeley and to adapt it for the time-sharing operation, and to add, to the netted 7090 and AN/FSQ-32 computers, a small- or middle-scale satellite computer, capable of operating teletype and display units.

E. Statement of Work (Cont'd)

With the aid of existing information-processing equipment and the augmentations mentioned in the preceding paragraph, the contractor will conduct research and effect developments in computer-language design, heuristic programming, man-computer interaction, and command information processing. The research and development will be designed to identify and solve problems that arise in the interaction of netted computers operated in part from remote stations. In this work, advantage will be taken, not only of the netted computers already mentioned but also of one or more other digital computers, on the Berkeley campus, that will be integrated into the system. Throughout the program, efforts will be made to improve the efficiency with which the preparation of large computer programs can be accomplished.

The contractor will supply the materials and services necessary to bring into operation three complex input-output stations, including teletype and display units. One of these will be used mainly in computer language research, a second mainly in heuristic programming, and a third in exploration of a variety of remote-station applications.

F. Administrative Considerations

1. Level of Effort and Time to Complete

The level of effort is $797,000 for three years. Our estimate is that within three years the main network and language problems for netted computers of the presently modal (von Neumann) type will have been identified and largely solved. It is evident, however, that developments such as parallel processing will introduce further complications, and that research along the general lines of this proposed program will have to be carried out over a consideraly longer period than three years.

2. Cost by Year

The costs for the first three years will be approximately $527,000, $135,000 and $135,000. The cost for the initial year is greater than the cost for the others, mainly because of purchase of equipment required to get the program under way.

The breakdown of costs (in thousands of dollars) will be approximately as follows:

A. Administrative Considerations (Cont'd)

2. Cost by Year (Cont'd)

	1st year	2nd year	3rd year
Salaries and wages	70	75	75
Overhead	24	25	25
Supplies and expenses	140	35	35
Equipment and facilities	294	--	--

No definite equipment and facilities costs are foreseen for the second and third years, although it does not seem unlikely that some will arise and call for additional funding.

3. Source of Funds

The funds should be made available from the ARPA Command and Control Project (8800) FY 1963 funding.

4. Reporting Requirements

Management Letter Reports, including significant management information, such as funding status, management problems, and assignment of new personnel, will be submitted quarterly. Brief Technical Progress Reports, summarizing technical accomplishments and difficulties, will be submitted semiannually. In addition, Technical Reports should be issued whenever warranted by accomplishments of interest to others engaged in research, development or application in the field of the project. Each such Technical Report should be published in a recognized technical journal and should include, in addition to title and abstract carefully formulated to facilitate information retrieval, a brief characterization of content (e.g., a series of descriptors) designed specifically for use in semi-automated information retrieval. Informal reporting, as through early distribution of mimeographed copies, is at the contractor's option.

5. Contractor Selection and Justification

The University of California (at Berkeley) is selected as sole-source contractor for the proposed program for three main reasons: (1) Professor Harry Huskey is in the field of programming language and compiler design, and Professors Edward Feigenbaum and Julian Feldman are outstanding in the field of heuristic programming, (2) the University of

5. Contractor Selection and Justification (Cont'd)

California (Berkeley) already has a computer center with active research orientation and suitable equipment, a center capable of providing critically needed augmentation of the California Computer Network, and is at approximately the correct distance from Los Angeles to make manifest several critical problems in computer intercommunication, and (3) there are several active groups at the University of California (Berkeley), engaged in research in computer language and programming areas, that will contribute in the course of their regular work (and without ad hoc ARPA support) to the development of the necessary system of programs and the necessary volume of time-shared computer use. For that trio of reasons, the University of California (at Berkeley) is viewed as a uniquely valuable addition to the California Network group.

6. Agent

The contract should be let through the Office of the Secretary of Defense.

7. Special Considerations

The proposal (unofficial proposal dated 12 March 1963, and received on 26 March 1963) specifies a PDP-1 computer as the satellite computer for use in the proposed work. It appears that several ARPA contractors may specify PDP-1 computers for use in their programs. If that situation develops, it will be desirable to coordinate the purchases in the interest of obtaining a favorable price from the manufacturer.

The proposed research will require rental, for the IBM-7090 computer, of a second 32,000-word memory at approximately $100,000 (per year) the first year. It is expected that this additional memory will find other users and that its rental will be handled as part of the over-all computer rental during the second and third years.

*   *   *   *

This contract and all reports and papers produced therefrom should be UNCLASSIFIED.