The ZOG Human-Computer Interface System

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9 May 1983

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A renewal proposal to the Office of Naval Research
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Renewal of grant N00014-76-0874:
ZOG: An Interactive Programming Environment Using a Graph-Structured, Rapid-Response Guidance System

Table of Contents

1. Summary

1.1. Task Objectives

Our main objectives for the current contract period are to close out our role in the development of the ZOG-based system on board the USS CARL VINSON, and to establish new research directions for human-computer interface technology.

1.2. Progress

Our progress since March '82 can be summarized by the following points:

- We have completed the training of four officers from the USS CARL VINSON, and four members of the ZOG Development Group at Mellon Institute.
- We have completed a non-distributed version of ZOG under the Three Rivers POS operating system, and installed it on the ship for trial use (July 82).
- We have completed a final distributed version of ZOG under POS that operates on an Ethernet with fast response to user selections.
- We have installed the distributed version of ZOG on 28 Perqs on board the VINSON, and demonstrated it to a large collection of prominent visitors (late Feb 83).
- We have completed and installed a prototype version of the ZOG interface to the AIRPLAN expert system in the VINSON Air Operations Department.
- We have created a psychological learning experiment for ZOG to be run on board the VINSON with new crew members as subjects.

1.3. Research Plans

Our research plans for the year from March '82 to '83 can be summarized by the following points:

- We will be reporting the scientific results that came out of the VINSON development effort, and following up on research leads that had to be put aside in past years.
- We will be consulting for the ZOG Development Group at the Mellon Institute Computer Engineering Center, to aid them in their task of supporting the system on board the VINSON.
- We will be acting as a clearinghouse for statistics collected by the on-board system, to

aid the evaluation effort by DTNSRDC and NPRDC.

- And, finally, we will resume the effort to bring up the distributed version of ZOG in the new Spice personal computing environment in the CMU Computer Science Department.

2. Background

2.1. What is ZOG?

ZOG is a general human-computer interface system based on menu-selection and operating on a large database with very rapid response. ZOG can structure and provide convenient access to large, complex bodies of information. ZOG can also act as a command interface to software of all kinds, with menu-selections within ZOG being automatically converted to commands interpretable by the other programs. Special application programs, called ZOG Agents, can be written to operate directly on the ZOG database (under the control of ZOG as above) in the service of some particular application. ZOG is particularly appropriate as an interface for beginning, casual and non-programming users, because of its simplicity and uniformity.

2.2. History of the ZOG Project

2.2.1. ZOG1: A summer workshop for cognitive psychologists at CMU

In 1972, a ZOG-like system (now called ZOG1) was developed for a summer workshop held at Carnegie-Mellon University. ZOG1 enabled cognitive psychologists to interact with a wide variety of AI application programs through a single, uniform interface. ZOG1 was a hierarchical network of menus, much like the current ZOG, but it was handicapped by its implementation on slow, hardcopy terminals.

2.2.2. PROMIS at the Univ of Vermont

In 1974, Allen Newell and George Robertson became familiar with a system called PROMIS at the University of Vermont Medical School. PROMIS is a menu-based information system, but, unlike ZOG1, it runs with very fast response on terminals with touch-sensitive screens. Equally important, the PROMIS database consisted of around 50,000 frames (at that time), which made it seem qualitatively different than existing menu interfaces with their far smaller numbers of menus.

2.2.3. Beginning of ONR Contract (1975)

When presented in 1975 with an opportunity to do some research for the Office of Naval Research, Allen Newell and George Robertson decided to try to extract the interface scheme from the PROMIS system and study it as a general communication interface. The main goal of the ONR research has been to find out whether large-network, rapid-response, menu-selection interfaces do indeed have the potential they appear to have. We have been engaged in building many versions of ZOG, on several different computer architectures. We have also been studying the system experimentally, by collecting field data and by controlled experimentation with subjects in a laboratory.

2.2.4. Beginning of joint effort with USS CARL VINSON (1980)

In February 1980, Capt. Richard Martin visited the ZOG project at CMU. He was assuming command of the new nuclear-powered aircraft carrier, USS CARL VINSON, then just launched. He had decided to incorporate whatever he could of the advanced research in computer science and artificial intelligence, making the carrier a test bed for transferring information technology to the fleet. He was visiting many of the ONR-supported research sites, to understand the current state of the art and to see if any systems were ready for application on his ship. His exposure to ZOG and the networked personal computers at CMU convinced him that a networked ZOG system on his ship would take him a long way toward his goal of a test bed. We were skeptical at first, but were eventually convinced to proceed with the CARL VINSON as a driving application for ZOG, after laying down some important contraints to help the chances of success. The joint CMU/ CARL VINSON project actually got under way in July 1980, only a few months after the Captain had first made contact.

2.2.5. Ending of direct responsibility for ZOG system on USS CARL VINSON (1982)

On 1 March, 1982, the end of our previous contract period, we officially handed over responsibility for further development and maintenance of the VINSON ZOG system to the Development Group at Mellon Institute and the shipboard personnel.

3. The Scientific Issues

The general scientific issues of human-computer communication remain basically the same as those described in our original proposal. However, the application of ZOG to the USS CARL VINSON has raised a wide variety of particular issues, some of which are described below. We plan to investigate some subset of these, as permitted by our limited resources.

3.1. Management science

ZOG makes several unique contributions to management science. One is the style of management information system that ZOG yields, where the interface with the user (ZOG) is itself doubling as the database. A second is the attempt with the task management system for the USS CARL VINSON to rationalize many of the tasks of the ship in a single procedural form. Such extreme rationalization has historically been too rigid to survive actual use, but there is hope that ZOG is sufficiently adaptable to avoid repeating history.

3.2. Human-computer interfaces

The issues of human-computer interfaces are central to our endeavor. Some of the most important of these are listed below:

- Is ZOG easy for novice users to learn to use effectively?
- Can ZOG be effective for experts as well as beginners?
- Is ZOG over-general? Will its suboptimality for some specific tasks outweigh its advantages of integration?
- How self-contained is ZOG? Is menu-selection ultimately too limiting?
- Can a large organization use a single ZOG database as an effective communication medium?
- Can high quality on-line ZOG databases be automatically converted to hardcopy documents of comparable quality?

3.3. Computer systems

Although ZOG is a relatively conservative system from the computer science point of view, it does nevertheless raise several interesting computer systems issues:

- Does the structure of ZOG allow simpler solutions to the many problems of distributing a large, integrated ZOG database across a collection of networked personal computers?
- How are active programs (ZOG Agents) to be interfaced to the user via ZOG?
- What are the most appropriate uses of multi-window displays for ZOG?
- How can the needs of Agents for consistent information in a ZOG database be reconciled

with the tendency of human users to introduce inconsistencies during normal use?

- How does one transform ZOG to move it from its current home on centralized time-sharing systems to the powerful, networked personal computers that promise to become the standard of the next decade?

3.4. Human factors: model-driven analysis

We are working to develop methods of model-driven analysis, which avoid the high costs of standard experimental practice, e.g., the need for control groups and the running of many subjects.

3.5. Systems design methodology: iterative design

There is a basic issue about the relative merits of designing systems, such as ZOG, by full planning and specification as opposed to *iterative design*, which relies on constructing primitive versions of the system rapidly and then extending and revising that system based on accumulating user experience.

4. Progress

Since March 1982 there has been substantial progress on a number of fronts, largely related to the pressure of producing a working system for use on board the USS CARL VINSON during its first deployment, beginning in March '83. We describe progress under the following categories:

4.1. Training of support personnel

During the past year there have been four officers from the VINSON at residence at CMU, working with us on the final stages of system development and documentation. Three of the officers were here essentially the entire year, while the fourth was here for a total of about four months. The experience they acquired will enable them to carry on maintenance and development activities -- two of them on board the ship during its deployment (Mar '83 to Oct '83), and two of them remaining in Pittsburgh to work with the ZOG Development Group.

The four people who make up the ZOG Development Group also worked closely with us to complete the system, beginning in May of '82. For the final several months before system installation in late Feb of '83, we totally integrated our project members with those of the Navy and the Development Group at the Development Group site, to facilitate the final integration of the system and the transfer of knowledge. The ZOG Development Group is now in a position to take over full responsibility for support of the system.

4.2. Production of non-distributed version for early use on board ship

In early July of '82 we delivered a PERQ version of ZOG that ran on individual machines with no network interaction. The system included prototype versions of many of the application agents (programs), such as task planning and scheduling, for trial use by the ship. This gave the ship the opportunity to gain early experience with the PERQ hardware, the basic ZOG software, and some aspects of the management applications.

4.3. Completion of distributed ZOG version

The distributed version of ZOG is the version that distributes a large collection of ZOG frames across multiple PERQs on an Ethernet in a way that makes it appear to the user as a single logical database. In November of '82 we determined that we would no longer be able to count on the Spice software as our underlying operating system, due to slippages in the Spice timetable. We decided on a radical shift of strategy -- to abandon Spice and build our system on top of the existing single-process operating system supplied by Three Rivers. This required a good deal of extra work on our part to provide the network communication protocols. However, we were nevertheless able to complete a distributed version of ZOG by early February '83. This allowed a couple of weeks of shakedown and tuning on the PERQ network at the Development Group site before delivery of the system to the ship in late February. The system exhibited remarkably good performance: frames from remote machines could be accessed with an additional overhead of well under one second.

4.4. Installation and demonstration of distributed ZOG version

The total project team of CMU CSD, MI Development Group and Navy spent the last two weeks of February installing the final version of ZOG on the ship, and demonstrating the system to visitors during two days of "Open House". The final configuration of hardware was 28 PERQs, two of which controlled Canon laser printers, and five of which were specialized to the task of interfacing with expert AI systems developed through DARPA-supported projects at CMU. Two people from our group and two from the Development Group sailed with the ship for its first two weeks of deployment, beginning on 1 March, to work out some of the remaining hardware and software problems.

4.5. Completion of prototype ZOG interface to the AIRPLAN expert system

We completed a prototype system called AIRPLAN for the VINSON's Air Operations Department that combined ZOG with a rule-based expert system to provide assistance to the AirOps officer in the launching and recovery of aircraft. This system involved five machines: four of them running ZOG to provide the users with an interface for entry of information and display of results, and a fifth running the expert system itself. Special Ethernet network protocols were developed by the ZOG group to

allow communication between ZOG and the expert system. A large number of application-specific ZOG agents were also written, primarily by one of the Navy officers, to provide a total environment within which the expert system could be free to concentrate on its specialized subpart of the overall system function.

4.6. Creation of automatic statistics gathering mechanisms

During the last week of February and the first two weeks of the cruise in March, we completed and installed an elaborate facility for automatically collecting statistics of ZOG system use. This facility saves detailed summary statistics of each session of ZOG use, in the form of ZOG frames that can then be viewed from within ZOG itself. We also developed procedures for extracting the statistics from the PERQs on a regular basis. The extracted statistics are mailed back to CMU for analysis, and we then forward the relevant information to the groups engaged in evaluation of the system on board the VINSON (NPRDC and DTNSRDC).

4.7. Creation of a psychological learning experiment for use on board ship

We developed an experiment "kit" for running subjects on the ship through a psychological experiment related to learning how to use ZOG. During our visit to the ship in late February '83, we ran several subjects through the experiment, and instructed ship's personnel in how to run experiments on a routine basis during cruise and relay the results to us at CMU.

5. Research Plans

Direct responsibility for the USS CARL VINSON application of ZOG has been transferred to other groups. This permits us to look backward, to reflect and report on our experience, and to return to the fundamental research questions that originally started us down the long path from research ideas to implementation in an operational environment. Our specific tasks include the following:

5.1. Reporting the scientific results of the VINSON effort

Our work over the past three years has not been solely development work -- there is a substantial body of research that has gone on as well. In past years we have been unable to report on this research, due to the tightness of the development schedules. During the coming year we will finally be able to follow up on many unfinished research paths and report on our results. The following are some of the categories of our results:

- Management of documents within ZOG

- Management of software within ZOG (i.e., programming environments)
- A user interface and large database capability for expert systems
- An environment mechanism for interfacing users to application software
- Integration of ZOG with videodisc technology
- Project management using ZOG
- Statistical analysis of ZOG use
- Use of ZOG for group presentations via large-screen projection

5.2. Occasional support for the Development Group

Even though the initiation period for the Development Group was quite intensive, we recognize the need for them to receive occasional help from us. We will be available to provide assistance to them upon request, within reasonable limits. The sharing of the ZOG VAX by the two groups provides a convenient mechanism for such cooperation. We also expect to ourselves be users of the system being maintained for the ship, within our own Department (at least until such time as we have a fully converted Spice version). We will thus be able to provide them with direct advice on improving the system based on our own experience, rather than on distant reports of use by others.

5.3. Acting as a clearinghouse for statistics from the ship

The statistics gathered from the system on the VINSON are an important ingredient for the evaluation effort undertaken by NPRDC and DTNSRDC. We have agreed to take responsibility for receiving statistics from the ship and ensuring that they are relayed to NPRDC and DTNSRDC. We are also interested in doing some of our own analyses of the statistics, for what we can learn about the design of the system and the ways in which it is used by the ship's company. We will share our analyses with NPRDC and DTNSRDC, for whatever use it may be to them. We will also cooperate with NPRDC in the development of tools to process the statistics.

5.4. Resuming the effort to bring ZOG into the Spice environment

Our original plans to build the VINSON ZOG system on top of Spice were ruined when Spice failed to become usable in time. Now that the system based on the Three Rivers operating system is complete and in use on the ship, we can afford to turn again to the task of moving ZOG into Spice.

Spice potentially provides greater power and flexibility to a ZOG user, such as the capability to run one or more ZOG agents (application programs) as background processes while continuing other work in the foreground. However, the price of greater power will be loss of efficiency, and this could be a serious thing because of the crucial importance of fast response time to ZOG users. A difference between, say, one second and three seconds for displaying a frame from a remote PERQ is a difference that can dramatically affect the usability of ZOG. We have a rare opportunity here to draw out detailed comparisons between the specialized but efficient VINSON version of ZOG and the more general but less efficient Spice version.

6. Personnel

6.1. Principle investigators

6.1.1. Allen Newell, University Professor of Computer Science (549-30-9023)

Allen Newell will be on sabbatical from 1 Jan 84 through the end of this contract period, and thus will not receive support from this contract during that period.

6.1.2. Donald McCracken, Research Computer Scientist (160-40-7574)

6.2. Other personnel (full-time support)

- Robert Akscyn, Senior Project Scientist, to collaborate on the research and project management.
- Peter Lieu, Research Programmer, to work on the conversion of ZOG to Spice, and to provide general programming support.

6.3. Other personnel (part-time support)

- C. Kamila Robertson (20%), Research Associate, to do research on the experimental study of users of the system.
- Sandra Esch (25%), Research Assistant, to help with the ZOG user studies, including the running of experiments and analysis of results.
- A secretary (50%), to support the activities of the other project members.

7. Publications

The ZOG Group produced few publications in the period March '82 to March '83, because activity was totally focussed on completing the VINSON application system. The few that were produced are listed below:

- Robertson, C. Kamila, and Akscyn, Robert, *Experimental Evaluation of Tools for Teaching the ZOG Frame Editor*, CMU Computer Science Department Technical Report, 18 May, 1982.

- Newell, Allen, *An On-Going Case Study in Technological Innovation*, to appear in Advances in Information Processing in Organizations, Sproull, L.S. and Larkey, P.D. (eds), 1983.

8. Other Support

- DARPA supports the majority of the personnel costs for the user studies portion of the ZOG research.

- Xerox Corp. funds were used to equip the ZOG user studies lab, and also to support graduate and undergraduate students for work on ZOG.

- DARPA provides partial support for the general computing facilities (especially terminals, printers, etc.) used by the ZOG Project.

- DARPA is funding a ZOG/VINSON-related project on an expert production system to aid VINSON personnel in the landing of aircraft (AIRPLAN).

9. Visits

9.1. Visits and presentations by members of ZOG Group

9 Jul 82 Presentation to USS CARL VINSON Department Heads on board ship [Akscyn and Yoder]

20 Sep 82 Presentation to CMU Social Issues in Computing class [Yoder (with Capt Gary Beck of the VINSON)]

9.2. Visits to ZOG Group at CMU

There have been many visitors to the ZOG Group at CMU in the year since March '82. There are too many to give any details of the visits, so we simply list the date and the visitor's name and affiliation.

9.2.1. Mar, Apr, May '82

- 17 Mar 82: Horace Flatt, IBM Palo Alto Research Lab
- 2 Apr 82: Walt Doherty, IBM Watson Research Center
- 5 Apr 82: Clint Kelly (DARPA), Burt Sutherland, Ivan Sutherland
- 8 Apr 82: Gerhardt Fischer, University of Stuttgart
- 8 Apr 82: Siemens Corporation
- 13 Apr 82: Naval Ocean Systems Center and David Taylor NSRDC
- 14 Apr 83: Adm Kollmorgen (ONR) and Bob Rosen
- 20 Apr 83: Capt Fischer, USN
- 4 May 82: Science Applications Incorporated
- 25 May 82: National Science Foundation

9.2.2. June, July, Aug '82

- 1 Jun 82: Federal Aviation Administration
- 22 Jun 82: Prof. Yasuda and Mr. Kondo, Japan
- 23 Jun 82: Shell International
- 13 Jul 82: Jay Bedell and Dick Reed, U.S. Senate Data Center
- 21 Jul 82: Doug Hoecker, Westinghouse
- 21 Jul 82: Bob Johnston, Naval Ocean Systems Center
- 16 Aug 82: Steve Pollit, Digital Equipment Corporate Research

- 16 Aug 82: Maxime Rockoff, Merrill Lynch
- 18 Aug 82: Demonstration for American Assoc of Artificial Intelligence conference

9.2.3. Sep, Oct, Nov '82

- 21 Sep 82: Representatives of the British Navy
- 28 Sept 82: Westinghouse Instrumentation and Technology Training Center
- 5 Oct 82: Westinghouse Nuclear Power Division
- 7 Oct 82: Unilogic, Limited
- 7 Oct 82: Franklin Institute
- 11 Oct 82: Martin Marietta
- 21 Oct 82: General Electric
- 22 Oct 82: John Hopkins Applied Physics Laboratory
- 26 Oct 82: Royal Institute of Technology, Sweden
- 4 Nov 82: Larry Pfeffer, Jerusalem, Israel
- 8 Nov 82: Westinghouse Lamp Division

9.2.4. Dec '82, Jan, Feb '83

- 9 Dec 82: International Telephone and Telegraph
- 9 Dec 82: Karlene Roberts, USC

10. Biographies

Curriculum Vitae

Donald L. McCracken

Personal

WORK ADDRESS: Computer Science Department
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

HOME ADDRESS: 1017 Savannah Avenue
Pittsburgh, PA 15221
(Wilkinsburg)

MARITAL STATUS: Married, 2 children

BIRTH DATE: 30 October 1946

Education

Ph.D., Computer Science, Carnegie-Mellon University, 1978
Research on the application of production system architectures to building artificial intelligence systems. Designed and implemented a new multiprocess production system architecture, and used it to encode some of the knowledge contained in the Hearsay-II speech understanding system. Thesis advisor: Professor Allen Newell.

B.S., Mathematics, Carnegie-Mellon University, 1968

Work Experience

July 81 - present: Research Computer Scientist, CMU Computer Science Department

July 80 - present: Project Leader of the USS CARL VINSON/ ZOG Project
Primary management responsibility for a major project with the goal to transfer modern human-computer interface technology (in the form of a system called ZOG) to a network of personal computers on board the new aircraft carrier USS CARL VINSON, in an application to high-level management of the ship's tasks. Co-Principal Investigator (with Allen Newell) of the ZOG Project, funded by the Office of Naval Research since 1975.

Sep 77 - July 81: Research Associate, CMU Computer Science Department
Research on large menu-selection databases as man-computer interfaces (the ZOG system), and the application of these techniques to project management, issue analysis, and document production. Also participation in research on the application of information processing psychology to man-computer interfaces.

May 79 - May 80: Co-Director of the CMU Center for the Study of Translation
Research in computer-aided foreign language translation. Visited many private and government organizations in Europe and the U.S. to seek funding for the Center. Developed a prototype version of an integrated system of computer aids for human translators (CAHT).

Sep 74 - Aug 77: Graduate Assistant, CMU Computer Science Department
Participated in the development of the Hearsay-II speech understanding system (Raj Reddy, Victor

Lesser, Lee Erman, Fredrick Hayes-Roth). Key person in a project to build a multiprocess version of Hearsay-II on C.mmp, an experimental multiprocessor.

June 68 - Aug 74: Junior Research Scientist, CMU Computer Science Department
Design, development and maintenance of symbolic list-processing systems for researchers in artificial intelligence; specifically, the series of systems called L* (with Allen Newell and George Robertson). Also support programming for the research on speech understanding.

June 66 - May 68: Part-time Programmer, CMU Computation Center
Implementation and maintenance of the IPL-V list-processing language on an IBM 360.

Other Experience

Dec 81 - May 82: Consultant to Westinghouse Corp., Stategic Systems Division
Demonstration project to show the use of the ZOG system to give on-line computer access to emergency procedures for operators of nuclear power plants.

Mar 80 - Dec 81: Consultant to Harris Corp., Composition Systems Division
Evaluating new raster graphics technologies for incorporation into Harris products.

Dec 78: Served on a Special Study Section of the NIH Scientific Review Branch
Participated in a two-day project site visit at SUNY to evaluate a grant renewal request.

Reviewed several papers for *Computing Surveys* and the *International Journal of Man-Machine Studies*.

Publications

1. Newell, A., McCracken, D., Robertson, G. and DeBenedetti, L. *L*(F) Manual.* Computer Science Department, Carnegie-Mellon University, 1971.

2. McCracken, D.L. and Robertson, G. P.L* -- An L* Processor for C.ai. Computer Science Department, Carnegie-Mellon University, April, 1971.

3. Newell, A., Freeman, P., McCracken, D. and Robertson, G. The Kernel Approach to Building Software Systems. In *Computer Science Research Review 1970-71*, CMU Computer Science Department, 1971, pp. 39-51.

4. Robertson, G., Newell, A. and McCracken, D. On Doing Software Experiments. In *Computer Science Research Review 1973-74*, CMU Computer Science Department, 1974, pp. 7-15.

5. Newell, A., McCracken, D. and Robertson, G. L*: An Interactive, Symbolic Implementation System. Computer Science Department, Carnegie-Mellon University, October, 1977.

6. McCracken, D.L. Representation and Efficiency in a Production System for Speech Understanding. Proceedings of the International Joint Conference on Artificial Intelligence, Tokyo, Japan, August 20-24, 1979. [reviewed]

7. McCracken, D.L. and Robertson, G. Editing Tools for ZOG, a Highly Interactive Man-Machine Interface. ICC '79 Conference Record, IEEE Communications Society, Boston, Mass., June 10-14, 1979.

8. Mantei, M.M. and McCracken, D.L. Issue Analysis with ZOG,a Highly Interactive Man-Machine Interface. Proceedings of the First International Symposium on Policy Analysis and Information Systems, Duke University, Durham, N.C., June 28-30, 1979.

9. Andreyewsky, A. and McCracken, D.L. Automating Translation of Languages in the 1980's. Proceedings of a Workshop on Computer Aids in Translation, KVAL: Institute for Information Science, Brussels, Belgium, Sep 7-10, 1979.

10. Andreyewsky, A. and McCracken, D.L. The Carnegie-Mellon Terminology Data Bank. Proceedings of the Conference on Data Bases in the Humanities and the Social Sciences, Association for Computing in the Humanities, Dartmouth College, Hanover, NH, August, 1979.

11. Robertson, G., McCracken, D. and Newell, A. "The ZOG Approach to Man-Machine Communication." *Int. J. Man-Machine Studies 14* (1979).

12. McCracken, D.L. The User Interface to a System of Computer Aids for Human Translators. presented at the *National Online Information Meeting*, March 25-27, New York; unpublished

13. Strazds, A. and McCracken, D.L. "TARGET: Research in Computer Aids for Human Translators." *babel: International Journal of Translation XXVI*, 2 (1980), 83-92.

14. Robertson, C.K., McCracken, D.L. and Newell, A. Evaluation of the ZOG Frame Editor. Proceedings of the Seventh Conference of the Canadian Man-Computer Communications Society, Canadian Man-Computer Communications Society, Waterloo, Ontario, 10-12 June, 1981.

15. McCracken, D.L.. *A Production System Version of the Hearsay-II Speech Understanding System.* UMI Research Press, 1981.

16. Newell, A., McCracken, D., Robertson, G. and Akscyn, R. "ZOG and the USS CARL VINSON." *Computer Science Research Review, Carnegie-Mellon University* (1980-1981).

Biography
Allen Newell
11 January 1983

Born 19 March 1927
Married 1947 Noel Marie McKenna (1 son, Paul)

U. A. and Helen Whitaker University Professor of Computer Science
Carnegie-Mellon University 1976 -
University Professor Carnegie-Mellon University 1967 - 1976
Institute Professor of Systems and Communication Sciences
Carnegie Institute of Technology 1961 - 1967

Research Scientist Rand Corporation 1950 - 1961

Consultant Palo Alto Research Center (PARC),
Xerox Corporation 1971 -

Navy March, 1945 - October, 1946 S1c

B.S. Physics - Stanford University 1949
Graduate work in Mathematics - Princeton University 1949-50
PhD. Industrial Administration - Carnegie Institute of Technology 1957

American Association for Artificial Intelligence (AAAI) (President, 1980)
American Association for the Advancement of Science (AAAS) (Fellow)
Association for Computing Machinery (ACM)
American Psychological Association (APA)
Cognitive Science Society
Institute for Electrical and Electronic Engineers (IEEE) (Fellow)
Institute for Management Science (TIMS)

Honors:

Harry Goode Memorial Award, 1971, American Federation of Information Processing Societies.

John Danz Lecturer, 1971, University of Washington.

American Academy of Arts and Sciences (elected 1972)

National Academy of Sciences (elected 1972)

A. M. Turing Award (jointly with H. A. Simon), 1975, Association for Computing Machinery

John Simon Guggenheim Fellow, 1976-77

Alexander C. Williams Jr. Award (with William C. Biel, Robert Chapman and John L. Kennedy), 1979, Human Factors Society

National Academy of Engineering (elected 1980)

First President, 1980, American Association for Artificial Intelligence

Computer Pioneer Award, Charter Recipient, IEEE Computer Society, 1982

Prior to 1955 I was involved (with R. L. Chapman, William C. Biel and John L. Kennedy) at the RAND Corporation in the laboratory study of formal human organizations (in particular the Air Defense system), using simulated environments. Out of this work grew the concept of system training of large organizations. The System Development Corporation was created at that time, whose initial mission was to provide system training to the Air Defense Command. I was Assistant Director of that organization while it was still a subpart of RAND, prior to its incorporation.

Since 1955 I have been concerned with artificial intelligence, with the psychology of human thinking and with the construction of programming systems. The initial work resulted in the construction of the first program to prove theorems (Logic Theorist). It also resulted in the development of the technique of list processing and and list processing languages (see A. Newell, et al., IPL-V Manual, Prentice-Hall, 1961). Following this, in 1959, the General Problem Solver (GPS) was developed, which was the first program to work on a range of tasks (summarized in G. Ernst and A. Newell, GPS: A Case Study in Generality and Problem Solving, Academic Press, 1969). GPS also provided the first detailed simulations of human problem solving behavior. (A summary of this and much later work is A. Newell and H. A. Simon, Human Problem Solving, Prentice-Hall, 1972.) The early work was done jointly with H. A. Simon of Carnegie-Mellon University and J. C. Shaw of RAND; the more recent work has been done jointly with H. A. Simon. Most recently I have been engaged in the study of production systems as a model of both the architecture of the human immediate processor and a general intelligent agent.

In the mid sixties, I was also engaged in studying the nature of computer structures and developed a set of notations (PMS and ISP) for describing various levels of computer systems (see C. G. Bell and A. Newell, Computer Structures, McGraw-Hill, 1971; also C. G. Bell, J. Grason, and A. Newell, Designing Computer and Digital Systems Using PDP-16 Register Transfer Modules, Digital Press, 1972). This work was done jointly with C. G. Bell of Digital Equipment Corporation and Carnegie-Mellon University.

In the seventies I became been interested in speech understanding systems, having been involved in a study at that time to see if an intensive research-development effort should be initiated to construct such systems. Out of this grew the ARPA Speech Understanding Research effort. (See A. Newell, et al., Speech Understanding Systems: Final Report of a Study Group, Elsevier, 1973).

Most recently I have been concerned with applying information processing psychology to user-computer communication. I have been developing a rapid response large network menu selection system, called ZOG, which has some interesting features as a communications interface. This work has been done with several others, primarily George Robertson and Don McCracken. Working with Stu Card and Tom Moran of the Palo Alto Research Center of Xerox Parc, I have also developed quantitative models for how long it takes user to accomplish interactive tasks.

I have been a member of several government and national committees at various times. These have included the Computer and Biomathematical Study Section of the National Institutes of Health, the Committee on Research in the Life Sciences of the National Academy of Science and the Advisory

Panel on Computer Innovation in Education of the National Science Foundation. I was chairman of the Steering Committee for the Speech Understanding Research Group through 1976 when the five year project was completed. In 1980 a new professional society was formed, the American Association for Artificial Intelligence, and I became its first president.

CONSULTING

Computer Science Department, RAND Corporation	1961 -
Sanders Associates, Boston (Theodore Mairson)	1963 - 1966
Philco, Philadelphia (Peter M. Kelly)	1964
Autonetics, Los Angeles (J. S. Henry)	1966
System Sciences Laboratry, Palo Alto Research Center, Xerox Corporation (Stu Card & Tom Moran)	1971 -
Computer Science Department, University of Calif. at Irvine (Peter Freeman)	1973 - 1975
Children's Television Workshop, New York City (Lloyd Morrisett & Paul Firstenberg)	1982 -
Children's Computer Workshop, New York City (Paul Firstenberg)	1982 -

COMMITTEES AND PROFESSIONAL ACTIVITIES

Smithsonian Institute (Charles Bray, chm.)	1960
Panel on New Technologies in the Life Sciences (Robert Morrison, chm.), PSAC (President's Scientific Advisory Board)	1961
Computers and the Life Sciences (Walter Rosenblith, chm.), NAS-NRC.	1961 - 1963
Scientific Advisory Committee, RIDC (Regional Industrial Development Corporation), Pittsburgh	1962 - 1966
Advisory Committee, Applied Mathematics Department, Argonne National Laboratory (William Miller, Dir.)	1963 - 1966
Ad Hoc Committee on Artificial Intelligence (Ross Adey, chm.), NIMH (National Institutes of Mental Health)	1964
Panel on Computers in the Life Sciences (chm.), Committee on Research in the Life Sciences (P. Handler, chm.), NAS-NRC (also, member Executive Board)	1966 - 1968

Panel on Applied Mathematics (Stanislaw Ulam, chm.), COSRIMS (Committee on Support of Research in the Mathematical Sciences, L. Bers, chm.), NAS-NRC	1966 - 1967
Computer Science Advisory Committee, Stanford University (to the President)	1967 - 1970
Computer Study Section, NIH (National Institutes Health) (Helen Gee, Secretary)	1967 - 1971

Extramural Research Advisory Committee (L. Wienckowski), NIMH (National Institute of Mental Health)	1968 - 1971
Editorial Board, *Cognitive Psychology*	1969 - 1972
Editorial Board, *Artificial Intelligence*	1969 -
Speech Understanding Study Group (chm.) (Information Processing Techniques, Advanced Research Projects Agency)	1969 - 1976
Advisory Board, Office of Mathematical Sciences (J. K. Goldhaber), NAS-NRC	1975 - 1976
Computer Science Planning Group (Richard Karp, chm.), NAS-NRC	1975
PROMIS Technical Advisory Committee (TAC), National Center for Health Services Research (Norman Weissman)	1975 - 1976
Editorial Board, *Cognitive Science*	1976 - 1980
Biotechnology Resources Advisory Committee, National Institute of Health (Charles L. Coulter)	1977 - 1979
Advisory Committee, Software Metrics Panel (Alan Perlis, chm.), Office of Naval Research	1980
President, American Association of Artificial Intelligence	1980
Advisory Board, J.C. Crimmins Company	1982 -
Editorial Board, *Science*	1983 - 1984

Budget

	03/01/83- 02/28/84	03/01/84- 09/30/84	Total
A. Newell, Principal Investigator			
10% Academic Year			
10% Summer			
D. McCracken, Principal Investigator			
100% Calendar Year			
C. Robertson			
20% Calendar Year			
R. Akscyn			
100% Calendar Year			
P. Lieu			
100% Calendar Year			
S. Esch			
25% Calendar Year			
Secretary			
50% Calendar Year			
Total Salaries	115,577	49,351	164,928
Fringe Benefits	24,706	11,303	36,009
Total Salaries & Fringe Benefits	140,283	60,654	200,937
Office Supplies	1,683	727	2,410
Publications	3,506	1,515	5,021
Copying	700	302	1,002
Telephone	5,610	2,425	8,035
Postage	1,402	605	2,007
Mellon Institute Phone Lines	1,776	1,036	2,812
Travel	13,700	1,200	14,900
Engineering Supplies	6,500	3,500	10,000
Perq Maintenance	8,400	4,900	13,300
Undergraduate Programming	1,950	1,050	3,000
Total Departmental Expenses	45,227	17,260	62,487
Total Direct Cost	185,510	77,914	263,424
Overhead	102,037	42,860	144,897
Computing	20,392	20,392	40,784
Total Sponsor Cost	$307,939	$141,166	$449,105

12. Budget Justification

12.1. Computing costs

The "Computing" line in the budget represents the yearly amortization for the basic VAX-11/780 purchased for ZOG in early 1980 under this ONR contract. This 19 month contract period will budget the final two (of a total of five) yearly payments needed to pay off the VAX. The VAX continues to be our workhorse machine: acting as a central file system for the PERQs, supporting our work on statistics, providing an environment for producing high quality hardcopy documents, and providing a central project management database to coordinate the various subgroups of the overall VINSON/ZOG project via remote ARPAnet access.

12.2. Departmental expenses

Departmental expenses, except travel, are based on the below percentages of total salaries and fringe benefits. These percentages were derived by a comparison of actual expenditures to actual salaries and fringe benefits of all research contracts and grants in the Computer Science Department during the fiscal year 1981-1982. The publication expenditures will be for the in-house printing of technical reports.

Office Supplies	1.2%
Publications	2.4%
Telephone	4.0%
Postage	1.0%
Copying	0.5%

12.3. MI (Mellon Institute) phone lines

Since the ZOG VAX in the Computer Science Department is being used as a central communication medium for all participants in the larger ZOG/VINSON project, the phone lines from the Computer Science Department to the Mellon Institute ZOG Development Group are essential for project communication to and from the Development Group. The lines also are necessary to aid the process of our group providing support to the Development Group for system maintenance and development.

12.4. Travel

The travel budget of $14,900 is estimated as follows:

$3,600	3 researchers each with 3 East Coast trips at $400/trip
$3,300	3 researchers each with 1 West Coast trip at $1100/trip
$8,000	2 researchers for 1 trip to the Far East (Singapore or the Phillipines) to meet the USS CARL VINSON in late Summer of 1983, to work with the then newly arrived Commanding Officer of the ship to help him support the ZOG system on the ship, and to discuss at length any problems encountered by the ship in their use of the system up to that time.

12.5. Engineering supplies

The budget item for engineering supplies covers the cost of video and magnetic tape and disks. These supplies are needed to record and preserve data from experiments in the user studies laboratory. There is also a need for large numbers of floppy disks (small mailable magnetic disks) to collect the statistics from system use on board the VINSON, and to distribute them to the Naval Personnel Research and Development Center for use in the evaluation effort.

12.6. Perq maintenance

The five PERQ computers purchased in earlier years of this contract will continue to be used by ZOG project members throughout this renewal period of the contract. The PERQs are maintained through an agreement with Three Rivers Computer Corporation, at a monthly cost of $140 per machine.

Carnegie-Mellon University Assurances

This proposal has not been and will not be submitted to any other possible sponsor.

The salaries budgeted follow the scales which are consistent with the regular practices of the Carnegie-Mellon University.

Questions concerning administrative details pertinent to this proposal should be directed to the Contracts Office (412) 578-2091. Questions concerning other aspects of this proposal should be directed to the Principal Investigator on (412) 578-2984.

The official responsible for patent matters is the Vice President for Management.

In the event that an award is made in support of the project herein proposed, the agreement instrument should be addressed to the attention of Mr. E. M. Hunia, Treasurer of Carnegie-Mellon University, Room 416 Warner Hall, 5000 Forbes Avenue, Pittsburgh, Pa. 15213; checks in support of the project should be directed to the attention of Mr. R. R. Mall, 16C Warner Hall.

Carnegie-Mellon University, Pittsburgh, Pennsylvania, is engaged in instruction and research as a non-profit institution of higher education, cleared as such by the Treasury Department of the United States Government under the Internal Revenue Code 101 (6) on 4 November 1942. It is incorporated as a First Class Non-Profit Institution in the Commonwealth of Pennsylvania and has over 500 employees. Carnegie-Mellon University represents:

1. That it has not employed or retained any company or person (other than a full-time bona fide employee working solely for the bidder) to solicit or secure this contract, and

2. that it has not paid or agreed to pay to any company or person (other than a full-time bona fide employee working solely for the bidder) any fee, commission, percentage, or brokerage fee, contingent upon or resulting from the award of this contract, and agrees to furnish information relating to (1) and (2) above as requested by the Contracting Officer. (For interpretation of the representation, including the term "bona fide employee" see Code of Federal Regulations, Title 41, subpart 1-1.5 April 1966).

Carnegie-Mellon University certifies that it has:

1. adopted policies and procedures on conflict of interest which comply substantially with the Joint Statement of the Council of American Association of University Professors and the American Council of Education entitled, "On Preventing Conflicts of Interest in Government-Sponsored Research at Universities", and dated December 1964.

2. participated in a previous contract subject to either the Equal Opportunity clause contained in Section 201 of Executive Order 11114 or the clause originally contained in Section 301 of Executive Order 10925; and that it has filed all compliance reports required to have been filed as of the date of this proposal.