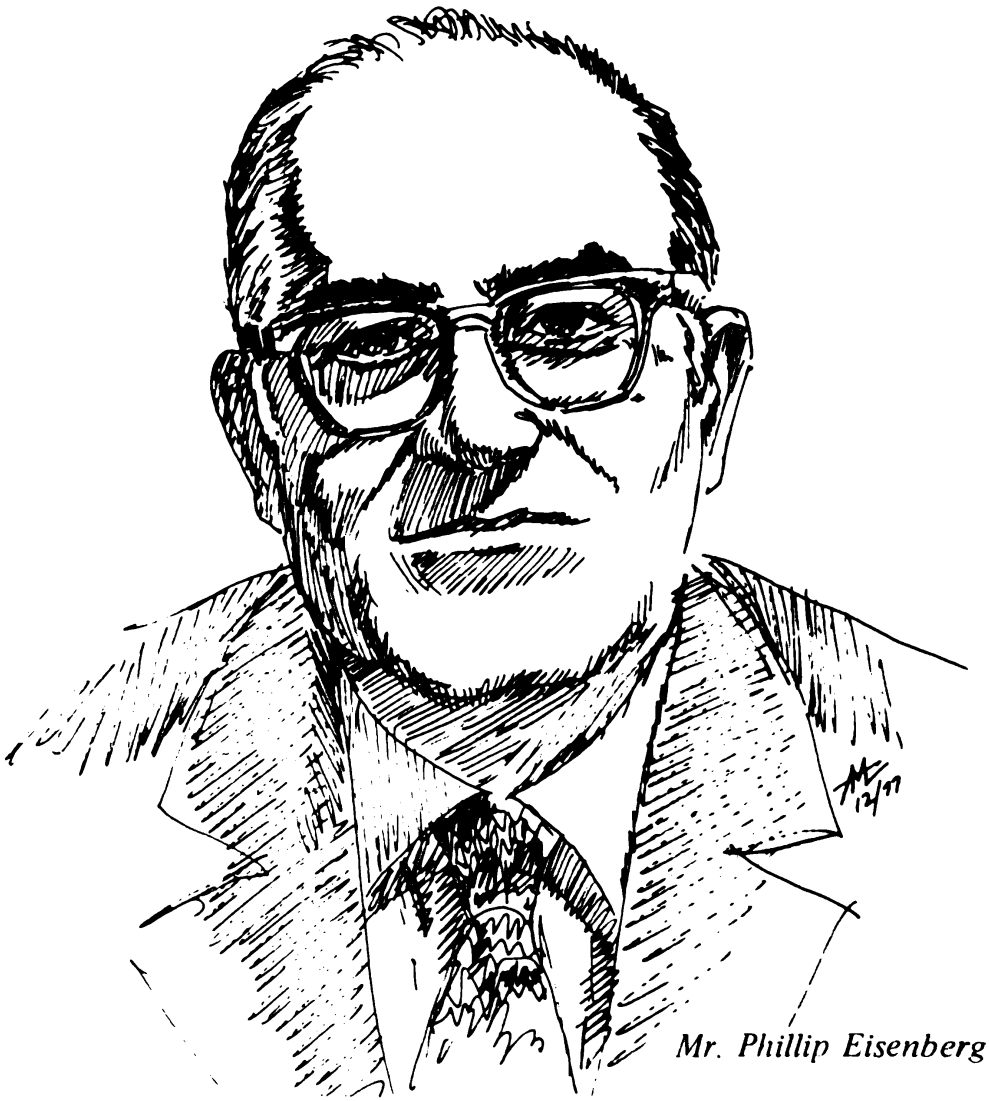
NAVAL RESEARCH

REVIEWS

NOVEMBER 1977

PROFILES IN SCIENCE



Mr. Phillip Eisenberg

Phillip Eisenberg is Chairman of the Executive Committee of Hydronautics Incorporated and was President of the company since 1959. From 1953 to 1959 he was Head of the Mechanics Branch of the Office of Naval Research; and prior to that he was Head of the Fluid Phenomena Branch at the David Taylor Model Basin. Mr. Eisenberg is world renowned for his many publications in the field of hydrodynamics ranging from instrumentation to investigation of the many aspects of cavitation. Mr. Eisenberg produced a well known film on cavitation for the National Committee for Fluid Mechanics Films. He is President of the Marine Technology Society, an Honarary Member and Fellow of the Society of Naval Architects and Marine Engineers, and a member of the National Academy of Engineering.

Technological Transfer of Basic Research to Practice

by

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Webster's Dictionary defines research as "the examination of some field of knowledge and the establishment of facts or principles of certain matters...". But in most cases research is motivated by the desire to satisfy one's curiosity. Indeed, if one knows the outcome of the research, then one will probably see no need for further examination. In support of this view are statistics which reveal that only 20% of all basic engineering research has been transferred to practice for the purpose of improving our quality of life. Requirements for practical implementation of such research are: 1) the research result presents a unique method for solving a real world problem that needs solutions, and 2) the research result represents a major breakthrough in cost/performance improvement (an order of magnitude improvement) of the existing techniques for problem solution.

At UCLA we have had for many years a research grant from the Office of Naval Research for the purpose of carrying out basic research in the field of information processing. The specific areas of investigation are computer communications, memory management, distributed computing and distributed data bases. During the past five years we have studied several projects; and two of the projects, one in computer communications and the other in memory management, have been successfully used in engineering applications. We shall briefly describe these two projects.

Computer Communications

In computer communications the communication cost from the user terminal to a remote computer has often been found to be higher than its computer cost. In order to reduce the communications cost in time-sharing systems and multicomputer communication systems multiplexing techniques have been introduced to increase channel utilization. A commonly used technique is Synchronous Time Division Multiplexing (STDM). Consider, for example, the transmission of messages from terminals to computer. Using STDM, each terminal is assigned a fixed time duration. After one user's time duration has

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elapsed, the channel is switched to another user. With synchronous operation, buffering is limited to one character per user line and addressing is usually not required. The STDM technique, however, has certain disadvantages. As shown in Figure 1, it is too inefficient in capacity and cost to permanently assign a segment of bandwidth that is utilized for only a portion of the time. A more flexible system that efficiently uses the transmission facility on an "instantaneous time-shared" basis could be used instead. The objective would be to switch from one user to another user whenever the one user is idle and to asynchronously time multiplex the data. With such an arrangement each user would be granted access to the channel only when he has a message to transmit. This technique is known as an Asynchronous Time Division Multiplexing System (ATDM) or statistical multiplexing. A segment of a typical statistical multiplexing data stream is shown in Figure 2. The crucial attributes of such a multiplexing technique are:

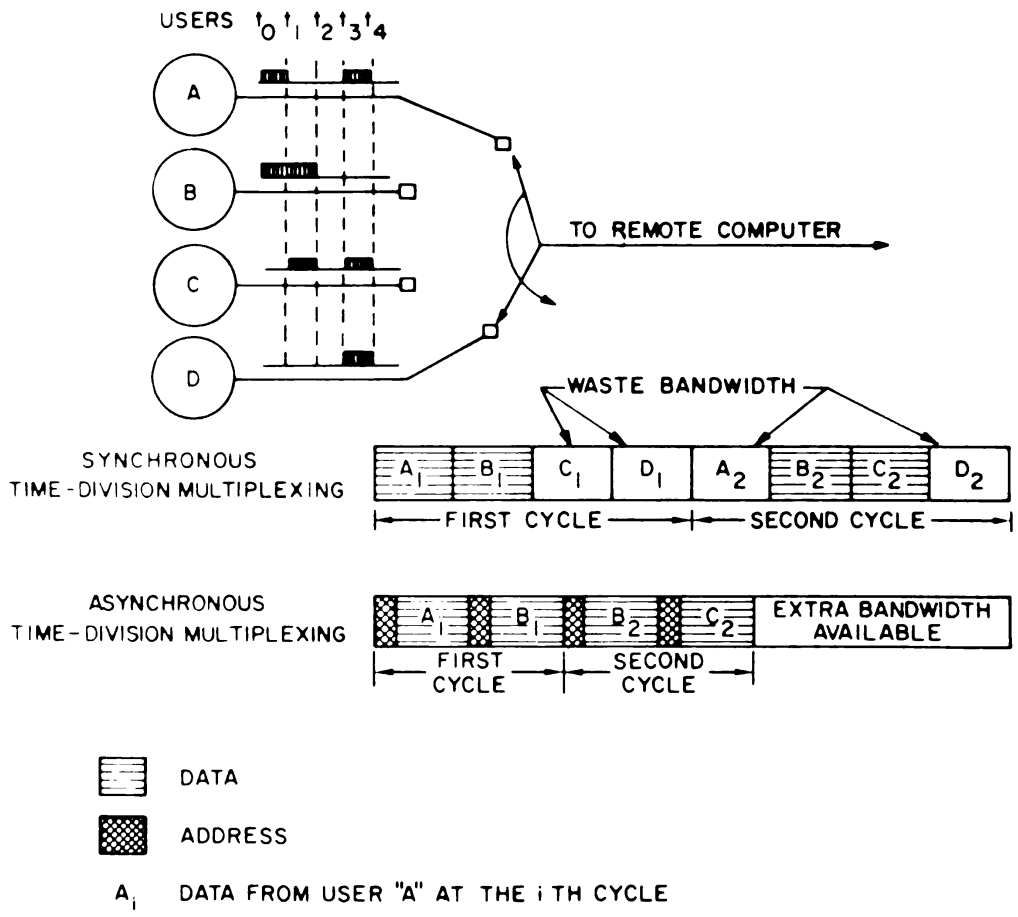

Figure 1 – Time-division multiplexing

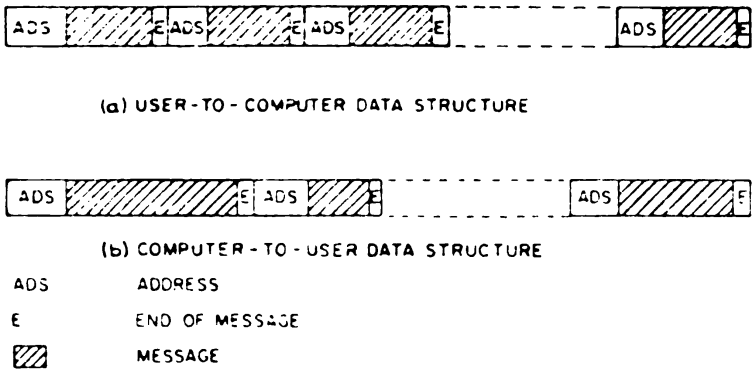

Figure 2 – Statistical multiplexing data stream

- An address is required for each transmitted message, and
- Buffering is required in order to handle the random message arrivals. If the buffer is empty during a transmission interval the channel will be idle for this interval.

The feasibility of the statistical multiplexing system depends on: (1) an acceptably low overflow probability (of the same or lower order of magnitude as the line error rate) that can be achieved by a reasonable buffer size, and (2) an acceptable expected message queuing delay due to buffering. In order to estimate these parameters analysis of the statistical behavior of the buffer are studied.

We have studied the buffer behavior for many types of input data structure such as character input and burst input (1), mixed input (2), and demultiplexing buffer behavior (3) as well as its dynamic buffer management policy (4). We have also constructed such a multiplexor using microcomputers (e.g. Intel 8080) as a controller to perform and to show the feasibility of such multiplexing functions and to validate our theoretical results.

For most terminals, user-to-computer traffic constitutes only 3-5% of the time during which the terminal is actively connected with the computer and more than 95% of the time is idle time. The computer-to-user traffic constitutes about 30% of the time. It is clear that STDM does not efficiently utilize the channel bandwidth; employing the statistical multiplexing technique could improve the channel utilization three to four times. In other words, by using the statistical multiplexing technique one could increase by three or four times the number of the terminals sharing the same communications channel with the STDM technique. It is thus capable of reducing the communication cost to 1/3 or 1/4 of original cost without significant increases in response delay. As a result of these savings the statistical multiplexing technique was first implemented in the INFONET (a time shared computer communication network) of the Computer Science Corporation (5) and later developed into a series of hardware multiplexor products

by the Codex Corporation (6) (now merged with the Motorola Company), Western Union, and several other companies. Such multiplexing techniques are also being used in a communication processor currently being developed at Naval Oceanic Systems Laboratory, San Diego. Statistical multiplexing, as evidenced here, definitely finds its place in computer communications.

During the course of studying statistical multiplexing we noted that one of the major cost components of such multiplexing is the buffer memory cost. This was particularly true during the late sixties when semiconductor devices were fairly expensive. For this reason we expended considerable effort in understanding the buffer management strategy in attempting to reduce buffer memory requirements; which, in turn, led us to the investigation of memory management policies.

Memory Management

The basic memory management problem consists of deciding which information would be kept in the main memory in order to allow efficient operation without wasting space. Obviously, information should only be removed from the main memory if there is a very low probability that it will be used in the near future. The difficulty lies in determining which information to remove without at the same time incurring difficult implementation problems.

From our initial survey on this subject we found that the currently available memory management policies are either inefficient for managing multiprogramming systems or too costly. Many replacement algorithms have been proposed and studied in the past, such as Random, First-in First-out, and Least Recently Used (LRU) algorithms (7). These replacement algorithms are usually operated with a fixed size memory allocation. Such a fixed size memory replacement algorithm necessitates prior knowledge about program behavior. Let us consider the case of a paged memory system, i.e., a system whose physical and logical address space is partitioned into equal sized blocks of contiguous address spaces. For example, in the LRU case we need to have an estimate for the number of page frames which must be allocated for each individual program. Further, program behavior is usually data dependent and changes during execution. An efficient replacement algorithm should therefore automatically adapt to the dynamically changing memory requirements. The working set algorithm (8) keeps exactly those pages in main memory that have been accessed during the last τ references. The working set model of program behavior takes into account the varying memory requirements during execution. But the Working Set Algorithm is expensive to implement. We were therefore motivated to develop an adaptive replacement algorithm which is largely independent of program behavior and input data and is simple to implement.

An "ideal" replacement algorithm should not make use of prior knowledge about program behavior; instead, all of the information needed to assure efficient memory allocation should be gathered during program execution. We shall use the page fault frequency (the frequency of those instances at which an executing program requires a page that is not in main memory) as an adaptive parameter to control the decision process of the replacement algorithm. Since the page fault frequency reflects the actual memory requirements of a program at execution time, the Page Fault Frequency (PFF) algorithm can be applied to arbitrary programs without prior knowledge about program behavior (9).

The basic policy of the PFF algorithm is whenever the page fault frequency rises above a given critical page fault frequency level P, all referenced pages which were not in the main memory, therefore causing page faults, are brought into the main memory without replacing any pages. This results in an increase in the number of allocated page frames, which in turn usually reduces the page fault frequency. On the other hand, once the page fault frequency falls below P, those page frames which have not been referenced since the last page fault occurred are freed. The same operation will be repeated whenever the page fault frequency rises above P again. Thus the PFF replacement algorithm provides very rapid response to a sudden increase or decrease in memory requirements. The PFF parameter $P = 1/T$ is measured in the number of page faults per millisecond (1 msec = 1000 page references), where T is the critical interpage fault time. The reciprocal of the interpage fault time is used as a running estimate of the page fault frequency. We note that T is somewhat similar to the working set parameter τ. However, there is an important difference. While T indicates when a page should be freed, T represents only a lower limit. Furthermore, in contrast to the working set algorithm, page frames in the main memory are freed only at the time of a page fault. Therefore, the time at which a page frame is freed depends not only on T but also on the page fault frequency. Simulation results indicated that the PFF algorithm yields better performance (in terms of space time product) than the LRU algorithm, and comparable performance with that of the Working Set algorithm (Figure 3). However, the implementation of the PFF algorithm is much simpler than that of the Working Set algorithm [9].

In a multiprogramming environment, the obvious advantage of the fixed memory partitioning (e.g. LRU) scheme is its easy implementation. The dynamic memory partitioning scheme (e.g. PFF), on the other hand, is more flexible and efficient. The number of allocated page frames may grow and shrink according to the dynamically changing memory requirements. For the fixed memory partitioning scheme, new processes are usually started when a block of memory becomes free. For the dynamic memory partitioning scheme, on the other

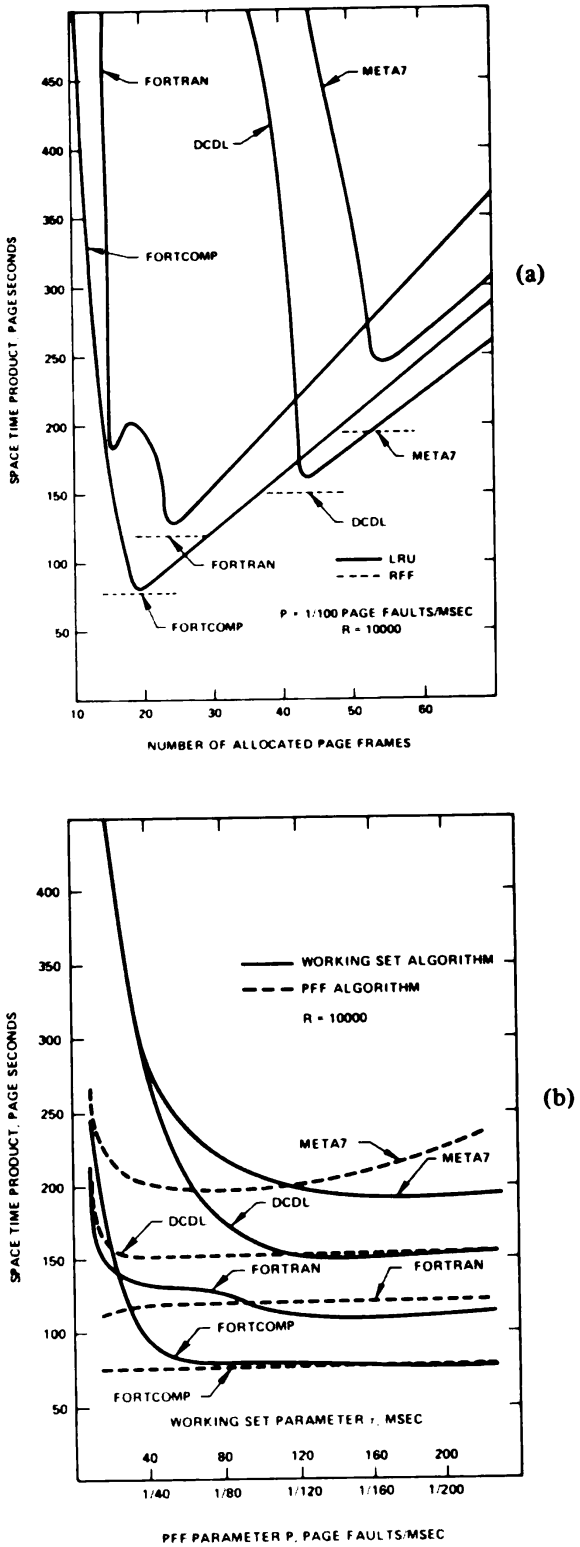

Figure 3 – Performance comparisons between (a) the LRU and PFF algorithms and (b) the working set and PFF algorithms. R = access time of secondary memory/access time of main memory.

hand, a new process is not automatically started after the termination of a process. There is a separate activation decision which depends on the current state of the system. Also a process may be deactivated when the pool of available page frames is empty and an additional page frame is demanded by some process. Therefore, dynamic storage partitioning schemes such as the PFF algorithm provide higher throughput than the fixed partitioning scheme in a multi-programming system (10) as shown in Figure. 4. The throughput is rather insensitive to the value of critical interpage fault time (Figure 5).

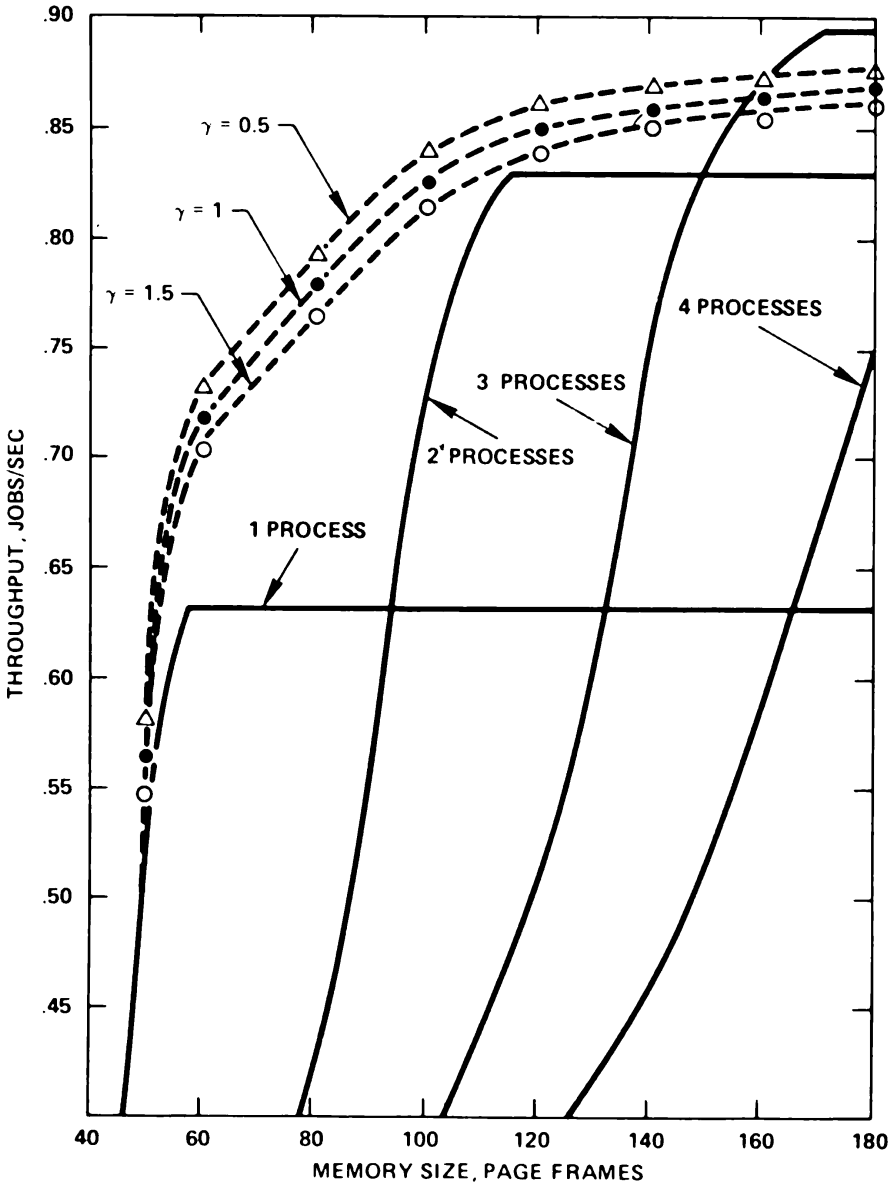

Figure 4 – Throughput comparison between LRU (solid lines) and PFF algorithm (dashed lines) in a multiprogramming environment. γ = overhead per page fault (PFF algorithm)/overhead per page fault (LRU algorithm).

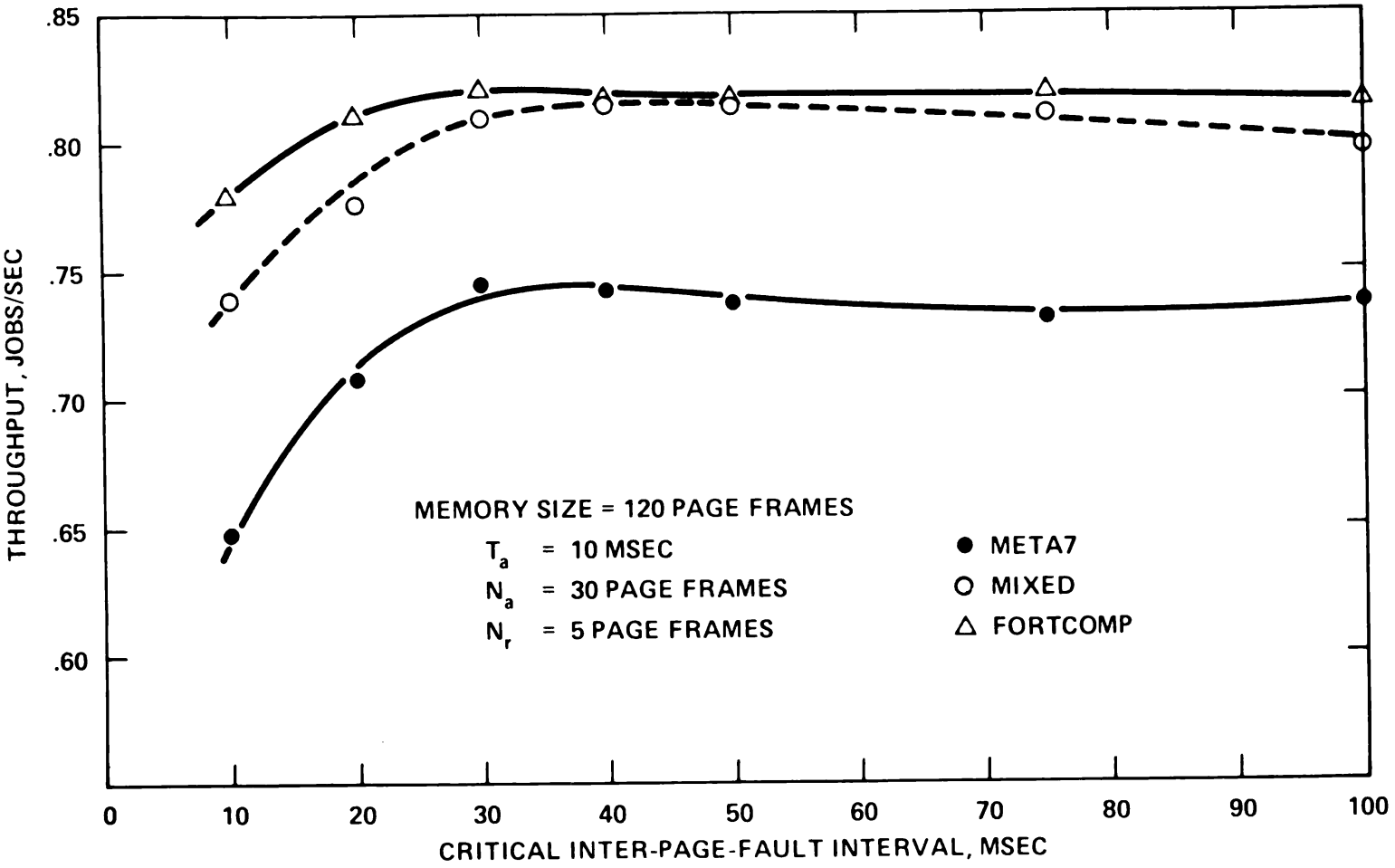

Figure 5 – Throughput of the PFF algorithm as a function of the critical interpage-fault interval.

Due to the simple implementation and good performance provided by the PFF algorithm (11), it has been implemented in the Hewlett-Packard 3000 Series II Computer System (12). Preliminary results indicate that the Hewlett-Packard 3000 Series II Computers provide a significant performance improvement over that of Series I Computers which use the global LRU algorithm.

My current research interest is in the area of distributed data bases and distributed processing. In the distributed data base area we have investigated file allocation (13), deadlock avoidance (14), and directory design (15). In the distributed processing area, we are participating in a joint project with Naval Oceanic Systems Center, San Diego, on a multi-micro-computer base distributed processing project to study interprocessing communications, bus structure, and fault tolerant design problems.

It is a very satisfying experience to see one's research work being implemented in practice. To achieve such a goal one must select a research area with high breakthrough potential and have a competent research sponsor.

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Technique to Measure Specific Properties of Materials

A team of scientists at the Naval Research Laboratory has developed an ultrasonic technique to measure the thermodynamic and acoustic properties of liquids and solids.

Simultaneous measurements of sound velocity and density of a material are important in various engineering applications using hydraulic fluids and transducer materials. For materials used in underwater transducers, values of the acoustic impedance (the product of sound velocity and density) are needed.

To obtain these data, a special device made of Invar was developed, which contains an 18 cubic centimeter liquid-filled chamber, connected to a small, vertical bore by a conduit. The device is placed in a temperature-controlled pressure vessel.

Parameters are determined and data are obtained by precise measurements of the time-of-flight of ultrasonic signals using the NRL instrument. the technique was used to determine the adiabatic compressibility of selected hydraulic liquids, at temperatures of -50° to +25°C and pressures up to 1000 atmospheres (1 kbar).

The device also may be used to obtain data on solids. For example, to determine the acoustic impedance of different kinds of rubber being considered for use in underwater transducers, a specimen was placed in the sample chamber and immersed in a liquid of known compressibility and thermal expansivity.

Sample volume changes alter the height of the liquid column and are detected by a corresponding change in the time-of-flight of the ultrasonic echo.

Design of a Coastal Information System

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INTRODUCTION

Scientists at the University of Virginia have developed a coastal information referral system under a research program with the Office of Naval Research. The system is not complete but is operational. Anyone desiring to place their research data into the system or to use the system for determining data sources may contact Drs. R. Dolan and B. P. Hayden of the University of Virginia Charlottesville, Va., phone (804)924-3809 or Dr. J. S. Bailey, Code 462, Office of Naval Research, Arlington, Va., (202)692-4125. The first two sections of this paper deal in general with Naval data management. Next, the design and implementation of the data inventory are examined. Finally, the development of a geophysical model file and the question of data transfer between data rich and data poor areas are discussed.

Naval Data Management

Data, measurements of specific variables, are the lifeblood of science, the means whereby hypotheses are tested, new phenomena discovered, and substance given to scientific thought. The Navy, through its research laboratories and through outside contractors, is heavily committed to many forms of data acquisition. Most of these data are never seen by the fleet; they are used in the testing of new weapons systems, and the development of new policies, and tactics. A portion of the data are used in the production of fleet forecast of meteorological and oceanographic conditions. These and other data collected by or for the Navy may not be fully used to benefit Naval operations directly because of storage, retrieval, and delivery problems. Some Navy science program managers have estimated that there is a five year delay in transmission of raw scientific data from the research contractor to the fleet.

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*Dr. Dolan, Mr. Felder, and Mr. Hayden are Professor, Research Associate, and Assistant Professor, respectively, Department of Environmental Sciences, University of Virginia. Dr. Dolan's research career has centered on the physical processes of the coastal environment. Mr. Felder and Dr. Hayden have concentrated their efforts over the past several years on the synthesis of data structures of coastal environemtnal information.

The tempo of data acquisition is increasing. With the sophisticated weapons systems and platforms of the modern Navy, the need for precise and plentiful technical information is becoming increasingly important to the field commander as well as traditional data users. Ideally, there should be a well organized system for deciding when and where to collect data, how to store and summarize them, and ultimately an efficient flow of data from collector to user, whether the intended use is in the field or in the laboratory. At present, we have no easy way of knowing what data have been collected, where it is stored, or what its quality is. One reason for this is the traditional handling of data by primary collectors. When researchers collect data, they use them to test an hypothesis, publish the results, and store the data in a safe place. The data may be stored in many forms: magnetic tape, punched cards, stacks of notebooks, piles of maps, or rolls of chart paper.

It is common to call these storage places banks, especially if they are organized so that the data can be rapidly accessed by computer. Naval laboratories and contractors have their own data banks, which contain data they have collected or acquired. There have been attempts to consolidate, standardize, and exchange certain types of data for Naval use. Notably, the National Oceanographic Data Center and the Fleet Numerical Weather Central (Monterey) have a cooperative program for the handling of oceanographic data, while acoustic data are consolidated in the Naval Acoustic Data Bank NAVDAB (1). The National Oceanographic Data Center (NODC) has the statutory mandate to collect and disseminate all unclassified oceanographic data collected by or for the Navy. Unfortunately, the process is at best a slow one. For example, material from the period 1960-1966 was listed in the June 1976 *quarterly report* of new data (2). The Naval Oceanographic Office serves the same function as NODC with respect to classified oceanographic data. NAVOCEANO, in theory, possesses the entire NODC data set, at least insofar as salinity and temperature data are concerned, and the NAVOCEANO file has a reputation for being easier to use.

The Navy has no provision for the centralized control and storage of data, nor should there be such a provision. Different users have differing needs, and of necessity, each will and must construct his own local data bank. What is needed is a unified, standarized means for reporting the existence of data, perhaps to the NODC/NAVOCEANO files, and a central data referral system to avoid duplication of effort in data collection.

This referral system must have two characteristics if it is to be successful: accessibility and integrity. Accessibility means that the information about location, format, etc. of data is sufficient to allow users to determine which data may be useful and to gain access to them with a minimum of additional effort. Accessibility also means that the potential user can tailor his data search to select records of high quality

only, or take all records of whatever quality. Large data search systems generally do not provide the option for finely tailored queries. As an example, the ENDEX/OASIS system, run by NODC, provides data referrals, but the eclectic nature of the file and the diverse user community served by the system result in bulky responses which are indigestible to most users, especially in an operational context.

Along with accessibility, the utmost importance must be given to preserving the integrity of the data referral system. Interviews with users and purveyors of Naval data have demonstrated that the quality of the data is of the greatest importance. Individuals prefer to collect their own data, being sure of its quality, rather than trust data collected by someone else. A data referral system must overcome this reluctance to use unfamiliar data, otherwise the usefulness of such a system will never be maximized. For this reason, an accurate statement or set of statements about the quality of data must be included in every product response. In addition, the system itself must be safeguarded against duplications, omissions, and inaccurate entries.

Several benefits accrue from a central data referral system; almost immediately, its existence enables the Navy to identify gaps in data coverage. Further, the system encourages the standarization of data reporting by increasing the frequency of data exchange among researchers. Finally, in some cases, the system fosters a better understanding of the data themselves through the use of up-to-date methods of analysis.

It is unrealistic to attempt bringing all data under the umbrella of one referral service. To do this inundates the user with unwanted information. Instead, broad areas of operational and scientific interest should be grouped under separate data referral systems: Oceanographic, Acoustic, Meteorological, Coastal. Individual data items and data banks could be referred to by those specialized information systems for which the data would have relevance. The information systems would provide a bridge between the purveyors and bankers of data on the one hand and the activities responsible for providing data to the operating Navy on the other.

Functional Design of the Coastal Information System

The coastal zone is one operational area of considerable interest. Coastal data are important to the Navy because knowledge of the behavior of variables such as wave height, bottom slope, and beach trafficability is essential to amphibious, coastal patrol, and UDT/SEAL operations. The Navy may also become involved in coastal engineering works in the course of a prolonged amphibious assault. Operational planners need accurate, timely information on the condition of hostile shores and nearshore areas. The Navy has provisions for supplying information to the operational planner; however, the pathway from data

collector to user is circuitous and slow. A coastal data referral service can facilitate and speed up the delivery process, making the extensive Navy coastal data collections available for full utilization in future operations. The handling of coastal data is thus an excellent example of data management problems encountered by the Navy.

What should be the goals of a coastal data referral system? To understand how such a system might work, we must first understand what the user is looking for. Most operational planners and scientific researchers will access the referral system because they are planning a particular operation, weapons tests or scientific experiment. The potential users of coastal data are not, for the most part, interested in reviewing historical data, although most retrieval requests will be for data collected over months and years at a particular locality. The user is really interested in what conditions will be at a locality at the time of the planned operation or experiment. By looking at the way a variable has behaved through time, the user gains some understanding about how that variable may behave in the future.

A coastal data referral system can help in several ways in this evaluation. Statistical summaries of the data available, some of which exist and some of which will be generated as part of the information system itself, give an indication of the mean conditions, and some idea of the variance in the data. The seasonality of local conditions can also be explored statistically. These provide one type of estimate of future conditions.

Regional classifications can also lead to better understanding of how variables behave. We can assume, in the absence of data about a particular place that conditions there will be similar to those in localities which share the same characteristics. Techniques for performing this type of analysis could easily be applied to data located through the information system. Both statistical summaries and regional classification systems belong to a group of techniques, generally known as models, for generating synthetic, or estimated, data. The use of models allows the planner to construct an estimate of the conditions to be encountered during the proposed operation or experiment.

Other types of synthetic data generators exist which a data referral system should cite. These include numerical models in which basic physical equations are solved on a computer for a particular time and place; hindcasts in which data for earlier times are estimated from a knowledge of atmospheric or other general conditions at those times; and simulation models in which a simple scheme of calculations gives results which resemble the expected conditions. All of these types of information should be made available to the user of the coastal data referral system. It is precisely these synthetic data that in many cases are needed, therefore, a prediction for the time and place of interest should be given if possible. If no such prediction can be made, then a statistical summary or regional characterization should be offered. If neither of these are available, then the raw data, if any, must suffice.

System Design — Data Management

The University of Virginia is designing and implementing with ONR support, a data referral system of the type described. The University of Virginia Information System (UVAIS), as it is now called, provides a high level accessibility to the relevant data sets. This is achieved not only through the methods discussed earlier, but also through careful characterization of data sources. It is possible for trained technicians to evaluate the sources and tailor the referral entries so that little extraneous information is produced by a query because the inventory contains references to data sources within a restricted operational area, the coast. Primarily for this reason, the system is superior to larger multipurpose data access systems with diverse goals. The referral system will provide three types of services in its planned final configuration: a data inventory, a file of geophysical models, and a data transfer system providing statistical estimates of data in inaccessible areas. Each of these services, and the data management system presently used to implement them, is described in the following sections.

Computerization of the coastal information system is essential for efficient storage, retrieval, and update of the large volume of material involved. A Navy system called Ship Analysis and Retrieval Program (SHARP) is presently being used which is a generalized data base management system developed at Naval Ship Research and Development Center (NSRDC), Carderock, Maryland (3). This system was developed and is controlled by the Navy, and is operational on several different computer systems — CDC 6700 at NSRDC, Univac 70/45 at DPSCPAC and DPSCLANT, planned conversion to Burroughs 4700 at DPSCPAC. SHARP allows on-line and off-line access to data bases. Nontechnical persons can easily define, build, maintain, and interrogate their own data bases using a user oriented English like language for retrieval and report generation. This language is highly suited to interactive use from remote terminals. The user is able to check the input and can change the data base definition without rebuilding the data base. SHARP also permits on-line file maintenance, on-line interactive and batch retrieval and variable length records, and multiple record types are allowed within a single file. Finally, coded input data can be translated to plain language on output, and tutorial retrieval programs can be written for use by persons who have no knowledge of the system.

The tutorial search mode, which was programmed specifically for UVAIS, provides an easy means for using the UVAIS system for the new or inexperienced user. It allows formation of a question based on geographic location, environmental variables, and data collection program status. Users of the tutorial feature are given the option of receiving an information section. This service provides background information for users who are not familiar with the literature and data

collection methods of a particular parameter. The methods reference describes the operation and characteristics of the instruments and techniques most frequently used to measure the parameter queried.

If the user needs additional assistance, personal references are available. The persons listed are recognized experts. The final section references other data indices which contain coastal information and which may be of some assistance.

SHARP in the advanced mode allows a broad range of logic conditions and question construction. The user may search on any combination of elements and enter up to 75 questions. There is also the option of interactive or batch searches. The latter, although slower, costs less.

As the information system grows in complexity and size, the use of other more sophisiticated data management systems, will have to be investigated.

System Design: Inventory

The UVAIS coastal inventory considers only physical coastal variables because they are of greatest importance in military planning and operations. Biological factors, while important in assessing environmental impact, play a lesser role. For the purposes of this project, nearshore (transformation zone) and beach variables are most significant; some offshore observations, however, such as waves, must be included. Measurements within small bays, sounds, and estuaries are of lesser value and have been given a lower priority.

Primary variables are those generally recognized by coastal investigators to be of major importance in determining the condition of the coastal environment. These variables include the driving forces, (wind, waves, tides, and currents) and those geological/morphological factors (bathymetry, shore and bottom geology) that determine the reaction of the coastline to the driving forces. These variables are of sufficient importance to be included as essential to inshore tactical and strategic planning and are usually included in long-term systematic measurement programs. All other variables are classed as secondary. Data records are also classed as primary or secondary depending on the parameters measured. Any record can be placed in a third category (complementary) if the length or quality of the data recorded is such that it would be of little value for prediction purposes by itself, but could be used as a complement to a longer or higher quality record of the same variable at the same or a nearby location. Table I compares UVAIS primary and secondary variables with the priority list issued by the Naval Coastal Systems Lab (4).

Variables and records in UVAIS are also classified as real and synthetic. A real variable/record refers to an actual measurement of a physical variable. A synthetic variable/record represents an estimate, using a data generating scheme, of a measurement similar to those

Table 1

Comparison Between UVAIS and NCSL Parameter Lists

	UVAIS*	NCSL**
PRIMARY	Surface waves	Surface waves
	Currents	Ice/icing
	Tides	Currents
	Bathymetry	Bathymetry
	Beach and nearshore sediments	Tides
	Beach profiles	Underwater Obstacles
	Wind	
SECONDARY OF HIGH PRIORITY	Atmospheric visibility	Precipitation/fog
	Water temperature	Visibility (atmosphere)
	Salinity	Environmental catastrophies
	Beach trafficability	Visibility (underwater)
	Channel geometry	Wind
	Barometric pressure	Sound propagation (uw)
		Bottom sediments
		Channel geometry
		Trafficability (beach)
OTHER SECONDARY	Underwater visibility	Marine animals
	Internal waves	Land vegetation
	Marine animals	Vegetation (uw)
	Land vegetation	Fouling
	Vegetation (uw)	Internal waves
		Salinity
		Acoustic background
		Magnetics
		Gravity

*UVAIS parameters are divided into groups.

**NCSL list is ranked in order of priority.

There are also derived variables/records which are ob-
ation of real or synthetic data. These are reported in
derivation is unique, costly or time consuming, or if
perform the derivation are not available through
three-day means of wave height are not in-
data are available and the manipulation re-
storm track data are included, be-
observations at many stations, not

AIS

the data inventory in two forms:
record per study. Each of these
as the name of the princi-
the data, and a list of publica-
the record prepared for each
location as part of each
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the site specific
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Model File

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is
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Table 2

Information System Inventory Contents
by Ocean

Parameter	Gulf of Mexico	N. Atlantic	N. Pacific	Med.	Carib.	N. Sea	Arctic	Total
Waves	52	204	128	1	4	2	6	397
Tides	18	33	33	-	-	-	-	84
Currents	16	20	42	-	-	-	-	78
Winds	184	324	281	-	-	-	1	792
Bathymetry	23	92	5	-	-	-	-	120
Sediments	17	88	70	-	-	-	-	175
Beach morphology	38	152	64	-	-	-	-	254
Water temperature, density, and salinity	10	32	72	-	-	-	3	117
Meteorological parameters	181	322	228	-	1	-	-	732
Total	539	1267	923	1	5	4	10	2749

(Figures are numbers of records satisfying each criterion)

classed as real. There are also derived variables/records which are obtained by manipulation of real or synthetic data. These are reported in UVAIS only if the derivation is unique, costly or time consuming, or if the data required to perform the derivation are not available through our system. For example, three-day means of wave height are not included, because the original data are available and the manipulation required is trivial. On the other hand, storm track data are included, because they are derived from pressure observations at many stations, not all of which are included in the UVAIS.

Sources of data are entered into the data inventory in two forms: 1) general study information, with one record per study. Each of these common data records lists information such as the name of the principal investigator, the cost of obtaining the data, and a list of publications, and 2) site specific records, with one record prepared for each primary variable measured at one geographic location as part of each study listed in a common data record. All secondary variables measured at a site as part of one study are listed together in one site specific record. The data inventory now contains approximately 2000 records as shown in Table 2, and is growing at a rate of 200-300 records per month.

System Design: Geophysical Model File

The UVAIS data inventory satisfies the Navy's requirements for a coastal data referral system. While building of the inventory is proceeding, emphasis is being added to the geophysical model file and data transfer file, which are now in the preliminary design phase.

The important task of collecting synthetic data generators consists of three phases: a) collection of models, b) evaluation, c) implementation. Phase (a) consists simply of recording the model's existence, input requirements and output. Phase (b) involves a more thorough investigation of a selected number of models of probable Naval significance, including visits to the primary sources. Phase (c) consists of in depth work with a small number of data generators which are of clear importance to prediction of primary variables, are readily accessible and easily used, and can make the most beneficial impact on the information system.

The collection, codification, and assessment of synthetic data generator information for the UVAIS depends on definition of the model types to be included in the system, establishment of a protocol under which key input, output and control variables can be rapidly identified, and collection and assessment of the information.

In the absence of a clear working definition, it is possible to encompass in UVAIS the entire body of scientific thought, since the business of science is primarily the design and testing of models.

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(Figures are numbers of records satisfying each criterion)

Therefore the following criteria was established for selection of geophysical models: conceptual and physical models are excluded, but models of the numerical, mathematical and simulation varieties will be included in the system. Many mathematical models exist only in published form as sets of equations. This type of model (the bulk of the available source material) is in general to be excluded from our system. What remains are numerical, simulation, and some mathematical models, along with hybrids of these types, which depend on digital (or perhaps analog) computing equipment to produce synthetic data of the same type as the data stored in the UVAIS inventory. Simple models using graphical or tabular methods (such as the Sverdrup-Munk-Bretschneider-hindcast model) (5) are also to be included.

A further requirement for the inclusion of models in this file is that they be readily available in usable form. Many models exist for which there is little or no documentation, and which are useless except in the hands of the designer. Models of this type can be included in the system, but an appropriate notation is required.

A set of guidelines, based primarily on experience working with synthetic data generators, along with the consensus of others locally working with numerical methods of various types, enables the identification of input, output, and most importantly, key control variables for inclusion in the listings. Most models of the numerical/empirical type have dozens of control variables which enable calibration of the model to local conditions. Some of these, such as π, the gravitational constant, or the angular velocity of the earth, are trivial constants. Others vary, but are known to a high degree of certainty, and need only be looked up in a set of tables (viscosities, densities, and so forth). The most important variables, however, are those which must be locally, empirically determined. The user must be given a clear idea of which variables are of this type.

The task of model collection and assessment involves first an extensive and systematic review of the published literature. Following the identification of promising source material, the assessment phase begins for any given model. For each model a personal contact is identified, not necessarily the designer, but someone who has extensive personal experience working with the particular model.

System Design: Data Transfer Mode

Development of the data transfer mode requires: 1) a definition of similarity between source and target areas; 2) an information transfer mechanisms; and 3) an estimate of predictability.

Based on preliminary maps of coastal (6, 7, 8) landforms, coastal wave climates, (9) and regional offshore slopes, there are many possibilities for transfer of data from the data rich East and West Coasts of the U.S. to other more poorly understood coastlines. The East coast of

the U.S. for instance, could be used as an analog for the Sourthwest African coast, portions of the coast of Argentina, and the coasts of Germany and the Netherlands.

The U.S. possesses coastlines in all wave climate classes, all regional steepness classes, and all coastal landform classes (if coral development and mangroves in Hawaii and Florida are included). It remains to be determined whether each of the 36 possible combinations can be found in the U.S. Nonetheless, this brief look at the geography of the principal coastal attributes demonstrates that data transfer should succeed where appropriate and reliable models can be defined.

One type of transfer mechanism utilizes the multivariate statistical properties of the source area. For example, if for our data-rich coast we have information on 10 environmental variables and for the data-poor coast we have 5 common variables, the following may be done: 1) using the data-rich coastal data, the 10 variables (source set) are divided into the 5 held in common (base set) and the 5 unique to the data-rich coast. This forms a multivariate dependent set and a multivariate independent set. 2) Using a canonical matrix solution the independent set may be expressed as a function of the dependent set. 3) Once the canonical equations are found, the dependent data set for the data-poor coast may be substituted in order to calculate a synthetic suite of the desired independent data (target set).

This technique has been used to generate paleoclimatic data based on tree-ring measurements (10). The similarity of the problems strongly suggests that good results can be expected from application to the coastal information system.

Using the transfer scheme outlined above, it is further possible to estimate the errors involved in the analysis, i.e., a quantitative description of predictability can be given.

The error due to the transfer function itself is related to the amount of variance explained by the first p canonical variate pairs selected and used. This would represent the total error if the unknown variables in the target set were part of the source set, or, put another way, if the addition of the target data to the source set resulted in no change to the first p canonical functions. The degree of similarity between the source and target contributions to the base set is used implicitly by the canonical analysis scheme to estimate the amount of error introduced due to the dissimilarity of the target and data sets themselves.

This presumes that the variables in the base set accurately reflect the total process environment, i.e., that the source and target areas are identical in all respects whenever these variables are all equal. Therefore, this source of error will be typically underestimated, but careful analysis of the overlap variables should indicate the gross magnitude of the underestimation.

This investigation has led to a general review of Naval data management requirements and to the design and implementation of a prototype coastal data inventory system. This report is intended as an introduction to UVAIS in its present prototype form, and as such is an invitation to potential users to contact us and make use of the system.

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Research Notes

Measurements of Molecular Stretching in Flows of Drag Reducing Polymer Solutions

An exciting development in recent years has been the convincing demonstration of the significant reductions in frictional resistance which can be achieved in turbulent liquid flows by the addition of very small quantities of high molecular weight polymer additives. A number of applications of polymer drag reduction have already been studied, but achievement of a clear understanding of the mechanism involved is essential to optimization of its use.

Despite the joint efforts of hydrodynamicists and chemists over many years, the complex interaction between macromolecules and turbulent flows is still not well understood although many explanations of this phenomenon have been offered.

Extreme stretching of polymer molecules has been postulated by some investigators as the basic drag-reducing mechanism in turbulent flows of dilute polymer solutions. Previous direct measurements of changes of molecular size of polymers in dilute solutions in simple shear flow, however, have shown only a disappointingly small amount of stretching. A few years ago Professor John Lumley at the Pennsylvania State University supported by the Office of Naval Research showed that under these conditions no significant expansions of the polymer molecule should occur because in simple shear flow the vorticity and strain rate are equal and the molecules tend to rotate too fast past the principal axis of strain rate for the molecules to stretch. In general, however, turbulent flow contains all combinations of vorticity and strain rate so that a significant portion of the flow will be sufficiently rotation-free, to allow molecular stretching.

Based on the above fact, Mr. G. L. Dennison, working on a graduate theisis under Professor Lumley, has just carried out an investigation to determine the elongations of the polymer molecules in a relatively rotation-free, pure straining flow at a strain rate above the threshold value to confirm the existence of molecular stretching as a possible drag-reducing mechanism. This was done by obtaining distributions of molecular size from measuring the pattern of light scattered by illuminated polymer molecules flowing along the centerline of a two-dimensional, irrotational contraction. Elongations of up to approximately four times the original molecular size were measured in this way. These measurements verify for the first time the actual existence of molecular stretching long enough to account for the anomalous reductions in turbulent drag experienced by flowing dilute polymer solutions.

Navel Ship Boiler Cleaning Technique

Naval Research Laboratory scientists have combined efforts with other Navy scientists to develop a unique and versatile system that cleans ships' boilers and other closed systems without interrupting their operations.

Dr. David Venezky of NRL says the new technique, developed in cooperation with the Naval Research and Development Center, Annapolis, and the Naval Ship Engineering Center, Philadelphia Division, involves the application of an organic chelating agent to a boiler's feedwater.

The chelating action draws unwanted metallic ions in the boiler into solution and keeps them in solution through the use of an organic reagent, such as the tetrasodium salt of ethylenediamine-tetraacetate (EDTA).

Existing procedures for cleaning boilers require that the system be routinely shut down for mechanical or chemical cleaning. But the continuous use of a chelating agent in the feedwater can prevent the buildup of deposits in a ship's boilers, which greatly increases the time between overhauls and lengthens maintenance-free periods at sea.

EDTA which is strongly chelated to metal ions such as calcium, iron and copper is very stable under the extreme conditions in a boiler. The unchelated or unused EDTA exhibits a rapid hydrolysis, and the rate of hydrolysis is greatly accelerated by an increase in the acidity of the solution and by the presence of dissolved oxygen.

The hydrolysis products resulting from the use of the new technique are nontoxic and are not detrimental to the steam generating plant.

New applications for the use of chelating agents are now being investigated for the decontamination of radioactive residues in industrial nuclear-fueled boilers, the cleaning of sludge formations from refrigeration piping, and the removal of rust from difficult-to-reach bilge areas.

The research of hydrolysis at high temperatures and pressures and chelation in aqueous systems is being supported by the Office of Naval Research. The research concerning the various applications of chelating agents is supported by the Naval Sea Systems Command and Naval Supply Systems Command.

The Prediction of Microstructure and Acoustic Variability Near Bermuda

In the Winter-Spring of 1976, the Office of Naval Research sponsored a "Fine and Microstructure Experiment" (FAME) near the island of Bermuda. In this experiment, several devices were deployed to look at temperature, density and velocity fine and microstructure near a mid-ocean island. The results have now been analyzed to the point where the following conclusions can be made:

(1) A substantial increase in fine scale variability of temperature and velocity shear was observed near the island as two mesoscale eddy fields collided around Bermuda.

(2) A single current meter mooring offshore measured what may be a trapped planetary wave moving around the island.

Planetary waves are those wave-like motions that have a sufficiently large scale and low velocity to be affected by the earth's rotation. *Trapped waves* of this type are waves that "phase couple" near a boundary, the wave having an integer number of cycles in a closed loop. A familiar example from meteorology is the upper level Rossby wave, which executes an integer number of cycles around the earth's circumference.

Both Kelvin and Rossby waves can be visualized as a surface tide with an oscillating amplitude rotating around the island, and an exponentially decaying amplitude with distance offshore.

Around Bermuda, two classes of trapped planetary waves are possible, Kelvin and Rossby waves. One wave (the Kelvin wave) can rotate its phase pattern around the island, while the other cannot. The inference drawn from the FAME expedition was that the mesoscale eddys impinging on Bermuda excited one of these two types of waves, causing locally high shears, bottom topographically-induced mixing, and the generation of an overly-saturated internal wave field.

In the FAME experiment, the offshore current meter mooring was too far from shore to discriminate between the two types of trapped waves. The Office of Naval Research will continue to study a set of mooring arrays this year (FY78) to determine which of the two waves occurs during the passage of a mesoscale eddy.

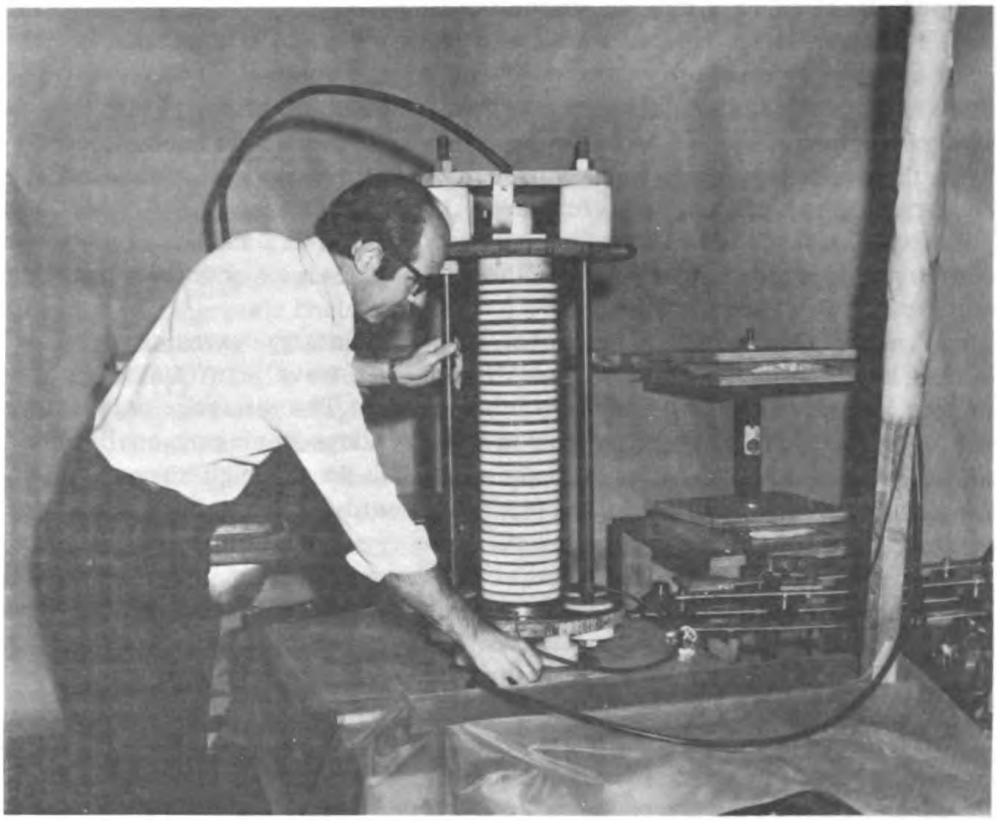
The anticipated goal for this experiment is the possibility in the future of predicting a month or so in advance the acoustic variability around Bermuda based on satellite imagery of the mesoscale eddy field. If a mesoscale eddy is observed to be heading in the direction of Bermuda, and if the type of wave excited is predictable, then there is an excellent chance of predicting acoustic variability around Bermuda.

Quick Action, High Power Interrupting Switch

Naval Research Laboratory scientists have developed an explosively actuated, quick opening, high power electrical switch for controlled fusion research, which may be useful in preventing commerical power line "blackouts". Continuing research on the switch is being sponsored by the Office of Naval Research.

The new switch, which is actuated by a detonating cord containing a special explosive mixture, generates high arc voltages so rapidly (within microseconds), it could be used to control electrical surges in power transmission lines and prevent widespread "blackouts".

The device has been laboratory-tested, and it is already being used in research at NRL. Its application includes electron beam experiments and driving flash lamps in laser fusion studies and in magnetically confined plasma experiments by making possible the use of inductive storage systems.



New high power interrupting switch

One commercial manufacturing company has already found ways to incorporate the switch into high power electrical transmission lines and is in the process of planning the development of a commerical switch system.

The NRL science team says that the mechanical disruption of current-carrying conductors in use today, using controlled separation of electrodes in circuit breaking devices, is far too slow for many high power applications. In addition to being sluggish, traditional circuit breakers are also expensive. The switch is very inexpensive, simple, and easy to install.

Large Object Salvage System

Recently operational demonstration of the Large Object Salvage System (LOSS) was successfully completed at the Naval Coastal Systems Laboratory, Panama City Florida. The test culminated seven years of development effort by scientists and engineers at the Laboratory and successfully demonstrated LOSS' capability in salvaging large objects from the oceans' depths by lifting a 150-ton object from the ocean floor.

One of the major problems facing the U.S. Navy today is salvaging large objects which descend to depths beyond the reach of divers. The LOSS sys-

tem was developed to improve the Navy's capability to recover large objects in depths to 850 feet. Configuration of the objects to be recovered is unspecified, but displacements can be as high as 3000 tons. Within this weight range are such objects as submarines and submersibles, surface ships, missiles, airplanes, etc.

The Laboratory's initial proposal of a salvage system concept (LOSS) was made in 1969 to provide an integrated salvage system that would greatly simplify operations and logistics.

The concept of LOSS, as developed by NCSL, consists of large pontoons with rigid shells which are remotely controlled by use of an umbilical cable, and a Pontoon Implacement Vehicle (PIV) that "flies" the pontoons down to the exact location of the object to be recovered. Once down, the pontoons can be adjusted to fit the object being recovered by use of adjustable arms, fitted with automatic grappling or explosive stud attachments, which rigidly attach the pontoons to the sunken object. When the pontoons are attached to the object, remotely controlled self-contained liquid nitrogen systems generate gas, forcing water out of the pontoons and providing the necessary lifting force to bring the object to the surface in a controlled ascent. After the object/pontoons reach the surface, the control Umbilical is disconnected and the object/pontoons are towed to port.

In shallow waters, where the PIV is not needed, the pontoons can be lowered directly from the salvage ship and attached to the object. All controls of the pontoons and PIV are executed from the salvage ship through control umbilicals.

Buoyancy generation for the LOSS is provided by the self-contained liquid nitrogen system (LN_2) or air. The LN_2 is stored in cryogenic dewars, and heat is extracted from the ocean to vaporize the LN_2 to provide dewatering gas. The entire pontoon system is operated at depth near ambient pressure, eliminating the need for heavy pressure hulls. To demonstrate capability at even greater depths, a hydrogen gas generating system, using a hydrogen generator developed and built by the Naval Civil Engineering Laboratory, was tested during the development program.

The pontoon attachment arms were designed to be easily modified to meet the configuration of the object to be lifted. Other methods of attachment used explosive studs fired into the recovery object, and shaped charge welding of pad eyes. Vacuum chucks were tested and discarded because of gasket failure caused by irregularities on recovery object surface.

Controlling the lift of a system is a major problem in salvage operations, particularly at great depth. An overbuoyant condition is required to break an object free of the bottom. When the breakout occurs, however, conventional systems start a rapid, uncontrolled ascent to the surface. In previous salvage operations, this uncontrolled ascent, with subsequent broaching, resulted in loss of buoyancy. When this occurs, the object returns to the bottom where lift operations must be started again.

The LOSS pontoons have a 100-ton lift capability per pontoon and use a rigid shell to control the amount of gas and water which maintains a constant buoyancy and thereby eliminates uncontrolled ascent. The system uses ballast chain as anchors. As the object/pontoons rise, they lift links of the anchor chain off the bottom until the suspended chain compensates for the lift forces of the overall system and neutral buoyancy is achieved. The LOSS pontoons and object are then brought to the surface by paying out cable attached to the anchor chain which retains control of the lift.

The recent successful tests of LOSS demonstrated the attachment arms with and without stud gun operation; lowering of the pontoon from a recovery ship; placing the pontoon in position, using the PIV; and lifting the salvage object to the surface in a completely controlled manner.

Step Forward in Fusion Research

Plasma physicists at the Naval Research Laboratory report the development of a new device that reduces loss of energy in the production of pulsed, high current ion beams.

The new invention, called a reflex tetrode, is based on the reflex triode which has been used to produce ion beams. But, unlike the reflex triode, the reflex tetrode diminishes the backflow of the ion energy considerably through the use of an additional anode. As a result, 95% of the ion current propagates unidirectionally toward the virtual cathode, increasing efficiency of ion generation by 50%.

The new device improves considerably the possibility of forming field reversed ion rings in the near future. Such rings have important applications in the fusion program. This is another step toward the development of a workable fusion system based on the Astron concept and is of particular importance to the Department of Energy, which is supporting the research.

The plasma physicists at NRL have made remarkable progress in the past three years in the development of pulsed, high current ion sources, achieving power levels in excess of 200,000,000,000 watts. This effort led to the development of the new NRL device.

Ultra Sensitive Radioiodine Detector

A radioiodine monitor capable of detecting minute quantities of radioactive $^{129}I_2$ in an atmosphere of air has been developed and tested at the Naval Research Laboratory.

The new device detects less than 10^{-11} g/cm^3 of $^{129}I_2$ in the presence of one atmosphere of air, and can have immediate important monitoring applications at nuclear fuel reprocessing plants.

$^{129}I_2$ is a radioactive isotope of iodine which must be monitored at nuclear reprocessing plants during the processing of material for storage and fuel recovery.

Radiocounting techniques are difficult to apply in this case because of the long half-life and low specific activity of this isotope and because it is present in conjunction with "hot," short-lived isotopes and iodine.

The device is based upon a coincidence between radioiodine, $^{129}I_2$ absorption lines and a helium-neon laser (operating with a particular neon isotope, ^{22}Ne).

Research on the project was conducted through the use of the Office of Naval Research and the Department of Energy funds.

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Cover Caption

An atoll showing wave refraction pattern. Typical data set from the information referral system from this area would be wind direction, wind speed, wave direction, wave height, wave period, wave refraction, water depth bottom sediment type, and negetation.

(See page 11).

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