COMPUTER BASED INSTRUCTION

Current development of Computer Based Instruction (CBI) systems seem
to be directed toward two types of system:

   1.) Small to medium scale, dedicated, stand alone systems (such
   as the IBM 1130, 1500, 1800 complexes) or medium scale systems
   with dedicated network implications (such as TICKET), and

   2.) Large, centralized, dedicated systems with dedicated network
   implications (such as PLATO).

Some attention has been given to the application of the resources of
a General Purpose Computer Network to CBI (e.g., the EDUCOM efforts),
however the full implication of the use of such resources do not
generally seem to be understood by either the CBI development centers
(at academic institutions or at the Armed Forces training or
development centers), where most of the current activity takes place,
or at ARPA Network Nodes, where most of the resources reside.

This Request For Comment has two purposes To:

   1.) Solicit comments from the Network Working Group, and others,
   on how selected classes of (and what specific) resources of a
   General Purpose Network might be applied to the field of Computer
   Based Instruction and

   2.) Initiate a dialog between interested parties on the problems
   of Computer Based Instruction, not limited to, but including, the
   uses of General Purpose Computer Network resources.

The attached paper discusses some of the applications of the
resources of a large General Purpose Network to computer Based
Instruction systems. Response and discussion are encouraged through
the NIC system.

                        GENERAL PURPOSE COMPUTER NETWORKS
                                      AND
                        COMPUTER BASED INSTRUCTION

INTRODUCTION

   A high level of Computer Based Instruction (CBI) activity exists both
   in the academic and armed service communities, with the promise of a
   substantial amount of early development of instruction courses and
   instructional management facilities. The major functional areas of
   interest can be described as follows:

      1.) Design and Development
      2.) Field Tests
      3.) Distribution and Operational Use
      4.) Evaluation and Modification

   Specific computer support requirements are function of the philosophy
   and reflected strategy of implementation for each of the functional
   areas of interest. Design and development activities may focus on
   overall curriculum development or on specific training or educational
   goals involving a specific course. The focus of attention will have
   an effect on the support requirements, e.g., the type and size of
   data base, specialized processing capabilities, etc. Support
   requirements for Field Tests will be a function of whether they are
   to be performed at a central location, or are geographically
   distributed, particularly with respect to data collection procedures,
   computer support and terminal clusters, and communications.
   Solutions to the problems of the distribution and operational use of
   CBI systems and programs will be a function of the extent to which
   the training activity is proliferated (i.e., geographically or
   organizationally distributed). Both the level of activity, and the
   solution to problems, in the area of Evaluation and Modification will
   depend on the goals of the instructional process, the extent of
   dynamic change in the technology or specific application involved,
   and the degree to which the course(s) developed meet the needs for
   which they were intended.

   The above discussion has a heavy emphasis on Computer Aided
   Instruction (CAI) component of CBI, where the computer is directly
   used in the instructional process for lesson presentation, test,
   drill and practice, etc. Another component of CBI, Computer Managed
   Instruction (CMI), uses the computer as a management tool to guide
   the instructional process. CMI may be used in conjunction with CAI,
   or as an aid in guiding instructional processes of a more traditional
   nature. CMI, in addition to providing assistance in student
   selection, scheduling, and followup on past course performance, may
   provide guidance to instructors in the form of diagnostics of student

weaknesses, prescriptions for strengthening student understanding,
and guidance in the redirection of students. In addition, CMI can
provide management with evaluations of course and instructor
effectiveness. CMI has corollaries to the discussion of CAI resource
requirements and their relation to the philosophy and related
strategy employed.

Bearing in mind the effects on resource requirements of the complex
considerations involved in CBI, there seem to be several areas in
which the resources of a large General Purpose Computer Network, such
as the ARPA Network, could be of high utility if properly applied.
These include:

    1.) The Network itself
    2.) Centralized Data Storage
    3.) Language processors
    4.) Dialogue Support Systems

As questions of philosophy and general strategy are resolved, or
assumed, the hard questions of implementation come into play.
Tradeoffs between competing approaches of the instructional strategy
or model, techniques of measurement, languages, hardware, etc., must
be made. It appears that both in resolving the tradeoffs, and in the
implementation stage, network resources could prove to have high
utility.

THE NETWORK

    The network itself seems to have utility for CBI that goes beyond the
    function of providing a communications base for linking terminal(s)
    (individual or clustered) to processors dedicated to CBI.

    The latter function, however, is important. The communications
    network exists, and can be tied into efficiently from many parts of
    the country. If there were dedicated CBI systems on the network, it
    would facilitate:

        1.) Evaluation of a single system (or its several components) for
        adequacy, or of competing systems for relative utility, by an
        interested user center, to assist in the selection of a system for
        a specific use;

        2.) Early use by a geographically isolated user center, through
        use of clustered terminals, of the full power of a major CBI
        center,

a.) For a continuing period of low level use, or

b.) Building over time until total usage by the isolated
center justifies the installation of a full CBI center of its
own.

Existing network resources also hold promise of utility. Many
manufacturers' systems, with associated varieties of operating system
software, are available on the ARPA Network. Within most of these, a
variety of application software is available, some supporting CBI and
data base applications. Therefore, even without the presence of a
dedicated CBI system available as a service center on the network,
use could be made in support of CBI interests.

1.) Testing of existing language and data base systems for
appropriateness to CBI problems.

2.) Development of CBI systems or components for demonstration
and/or test.

3.) Testing of existing courses, lessons, or lesson segments to
determine if they meet specified performance criteria, eliminating
potential duplication of course development effort.

4.) Development of CBI systems to be operated under a specific
set of hardware and software resources available in the network in
anticipation of delivery of a dedicated operational system.

5.) Greater flexibility in selection of test sites for field test
of courses developed, and performance of those tests prior to the
delivery of operational hardware.

6.) Formalization of hardware support and associated software
protocols to clustered terminals to provide continuing service to
geographically remote training activities.

Even the interests of dedicated CBI systems can be served, since the
network has established communications and terminal support protocols
that could tend to reduce the software efforts required to establish
contact between a large dedicated service center, and clusters of
user center terminals. In addition, terminal types not normally
supported by the CBI service center machine might be accommodated by
accessing the network through a compatible port, and getting into the
service center through established network protocols.

Terminal access to the ARPA Network could be provided in the
following ways:

    1.) Single Terminals - over common carrier facilities to the
    nearest compatible HOST or TIP.

    2.) Large Clusters - Simple single purpose TIP, or simple mini-
    computer supported in the network as far distant HOST.

    3.) Small clusters - either of the above two depending on the
    length and intensity of expected use and the number or terminals
    in the cluster.

In addition to the above general uses of a large General Purpose
Computer Network, there are several specific classes of network
resources that may be useful.

CENTRALIZED DATA STORAGE

    The effect of economy of scale could reduce costs for smaller CBI
    systems if they make use, through the network, of mass storage on
    larger systems. If duplicate smaller systems are distributed in the
    field, then the centralized storage would have a multiplying effect
    on savings for lessons and lesson material, but special attention
    would have to be given to the file structure to permit efficient use
    of look ahead techniques for lessons, lesson segments, and individual
    student pages.

    For CMI data there are savings that go beyond the economy of scale.
    A single management system could be selected or built on a large
    service center machine to be used by CBI systems on the network, even
    though the operational CBI systems are supported by different
    manufacturers' hardware. This would not only reduce the cost for
    programming and maintaining CMI systems, but also facilitate cross
    system analysis and intersystem comparison, even though each using
    system would have its own set of files. The user of the network data
    reconfiguration service and data transfer protocol should make such
    operations feasible.

    This approach to CMI would assist in early development stages of
    course material by easing the problem of accessing data on past
    performance and norms. In the case of geographically distributed
    testing, the evaluation team would have faster access to performance
    data. Both the distribution and modification tasks seem cleaner
    since there is only one copy of the released version to be updated.

    If the trillion bit laser memory proposed for AMES becomes a reality,
    then the economy of scale argument can be expected to be dramatic.

LANGUAGE PROCESSORS

   A basic characteristic of a large General Purpose Computer Network is
   that it is capable of providing support from various manufacturers'
   machines. That is, such a network can be comprised of a number of
   special purpose processors that can be distributed geographically and
   organizationally to locations where the best support exists for each
   process.

   This characteristic makes it possible to select and join the best
   match of capabilities for a complex application . It is no longer
   necessary to settle for a hardware/software system that does a
   reasonable job in most areas of the applications need.

   CBI is a complex application. In addition to a good management
   system and associated data base, it requires heavy text handling for
   lesson material, table lookup and branching logic for acting on the
   student selected answers to multiple choice questions, a student
   arithmetic problem solving language for drill and practice,
   simulation capability of both physical processes (for laboratory and
   circuit simulation), and of decision processes (for gaming
   experience), and a future need for natural language processors to
   permit evaluation of free form student responses. In addition, there
   may be need for heavy statistical and arithmetic processing for
   course, student, and instructor evaluation.

   Depending on the course, various mixes of languages to support the
   above activities will be needed. Some believe that the language
   required for presentation of course material and evaluation of
   student response (and associated appropriate action) may be heavily
   dependent on the type of course being given. As we develop a deeper
   understanding of the learning process, we are likely to require
   expansion of languages to provide new functions and perform processes
   not yet identified.

   To provide expandability of languages, Meta-compiler techniques can
   be applied. Meta-compilers are in an early stage of development;
   however, several are available on the network. In addition to
   facilitating language expansion with minimum effort while preserving
   the workability of code written in the previous versions of the
   changing language, the Meta-compiler can be made to produce either
   compiler or program object code that will operate on several
   different target machines. This feature can give both programs and,
   in some cases, compilers that are transportable across machines,
   eliminating the need to settle on a single manufacturer's hardware
   when it is expected that a CBI compiler or interpreter, or a course
   or set of courses is going to be used in a way that requires

substantial geographic distribution. Hardware decisions can be based
on the most cost-effective hardware for the combinations to be run at
one time.

Use of Meta-compilers will permit the development and debugging of
new course material in advance of the delivery of the system selected
for operations, even though the selected machine is not yet
represented in the large General Purpose Computer Network. Field
test can also proceed before the selected hardware arrives.

Experience to date in the use of Meta-compilers indicates that the
use of their high order languages to implement compilers and
interpreters result in dramatic savings in both turnaround time and
the absolute cost of producing a finished language product.

DIALOGUE SUPPORT SYSTEMS

In a field developing as rapidly as CBI, and at a time when
substantial implementation is about to take place, dialogue between
theoreticians, developers, and users is an important issue. New
tools for supporting dialogue among members of a distributed group
are currently in experimental use in the ARPA network. These new
techniques not only support dialogue more rapidly than the
distribution of papers, notes, and memos, but in some cases tend to
sharpen the thought process and yield a better result.

The application of such facilities, when ready, will be helpful
beyond the early planning stages or projects. After plans are set,
during the development of a project, a broader group of experts will
be able to be called on to work on problems and questions as they
occur. Later, as the product is being field tested (especially if
testing is distributed or separated from the evaluation group), these
new tools can be used to allow the test implementors to interact with
each other and with evaluators in a more timely manner than a post-
mortum meeting, resolving problems and questions as they occur, and
as a side benefit producing more complete documentation of test
progress.

After the tests, when the product is being used operationally, these
same tools can provide an excellent vehicle for tapping the ideas,
suggestions, and enrichments contributed by the more creative
instructors, and facilitate acting on them more rapidly than is
currently possible.

Meanwhile, as these tools are being developed, present ARPA Network
procedures for supporting the dialogue in a distributed group in more
traditional ways may prove helpful. The Network Information Center
(NIC), in addition to supporting the general ARPANET community, is

supporting special interest groups such as the Speech Understanding
Research (SUR) group. The application of these procedures could
establish a valuable link between the academic-nonprofit institutions
working on CBI, the centers in the Armed Forces where development and
operations are taking place, and members of the network community who
have an intimate understanding of the network resources available.

CONCLUSION

This paper has argued that there are resources in a large General
Purpose Computer Network that can be applied to CBI with high
utility. The argument can be extended to suggest that large
dedicated CBI systems can have greater utility to users (and in the
other direction, greater use), if tied into a General Purpose
Computer Network, with respect to current network capabilities,
future network developments, and in some cases provide backup during
periods of overload or system failure.

There are certainly important CBI issues outstanding in areas of
pedagogy, strategy, curriculum development, testing, etc. As CBI
systems are developed there are important issues of control (of the
development process, of the distribution of material, and of
modification of those materials). However, these issues seem to be
independent of the question of whether CBI takes advantage of the
resources of a large General Purpose Network.

There are important problems to be solved on the computer side
dealing with better tools to handle and evaluate masses of data,
language, and protocols for network utilization.

However, there seems to be sufficient promise in what we know of
present network capabilities to warrant serious consideration by the
developers of CBI of how General Purpose Networks fit in, and by
network people of how their resources apply to this important large
application area.

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